



<https://geodesy.science/com3/meetings/tiger-symposium-2026/>

TENTATIVE

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Sponsors

- Lantmäteriet (Swedish mapping, cadastral and land registration authority)
- Carl Trygger Foundation
- University of Gävle (Sweden)
- National Science Foundation (NSF)
- International Union of Geodesy and Geophysics (IUGG)
- International Association of Cryospheric Sciences (IACS)
- International Association of Geodesy (IAG)
- International Association of Seismology and Physics of the Earth's Interior (IASPEI)
- International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI)



CARL TRYGGERS
STIFTELSE
FÖR VETENSKAPLIG FORSKNING



IACS



International Association of Seismology
and Physics of the Earth's Interior

IASPEI



IAVCEI

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Committees

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Anna Riddell (Geoscience Australia, Australia)

TENTATIVE

Schedule

Monday - September 28, 2026

All times in CEST (Central European Summer Time) - UTC+2. Presentations are held at Konserthuset - Bo Linde-salen.

08:30 - 09:00 Welcome Addresses, Logistics and Safety

Session: Earth rotation - Modelling and Prediction

Session convener: Christian Bizouard

09:00 - 09:30 A New Precession Model based on the Improved Earth's J2 Long-term Variation

Liu, J.C., Huang, C., Yao, J.

09:30 - 10:00 Short-term EOP forecasting: insights from the 2nd PCC and its ML-oriented follow-up

Sliwińska-Bronowicz, J., Partyka, A., Nastula, J., Michalczak, M., Wińska, M., Dobslaw, H., Dill, R.

10:00 - 10:15 Discussion time

10:15 - 10:45 **Coffee & Tea break**

10:45 - 12:30 **Poster session presentations - Earth rotation**

12:30 - 13:30 **Lunch break** - Lunch is served at Konserthuset

13:30 - 14:30 **Poster viewing time - Earth rotation**

Session: Earth rotation - Geophysical Excitation of Earth Rotation

Session convener: Chengli Huang

14:30 - 15:00 A journey from ocean dynamics to the excitation of low-frequency polar motion variability

Börger, L.

15:00 - 15:30 Recent advances in the field of Earth rotation: new geophysical insights

Kiani Shahvandi, M., Soja, B.

15:30 - 16:15	Discussion time
16:15 - 16:45	Coffee & Tea break
16:45 - 17:30	Summary of the day

Poster session - Earth rotation

- (1) Status of the IERS Conventions Updates
Byram, S., Stamatakis, N., Davis, M.
- (2) Performance of IERS conventional models for diurnal and semidiurnal variations in UT1 and polar motion, assessed using a VLBI global solution
Böhm, S., Krásná, H.
- (3) Preliminary Results of Updated EOP Combination Methodology from IERS Rapid Service / Prediction Centre
Davis, M., Page, J., Byram, S.
- (4) Using VLBI delay rate for estimation of the Earth's instantaneous rotation pole
Titov, O.
- (5) Determination of the Earth's dynamical flattening using VLBI observations and the IAU precession-nutation models
Huda, I. N., Liu, J., Liu, N., Yao, J.
- (6) Reassessment of geophysical fluid contributions to Earth rotation changes at subseasonal time scales
Nastula, J., Partyka, A., Śliwińska-Bronowicz, J., Wińska, M.
- (7) The role of GNSS data in unveiling the impact of crustal deformation on polar motion
Nowak, A., Kur, T., Zajdel, R., Sośnica, K.
- (8) Lunar Laser Ranging for the Determination of Earth Orientation Parameters
Zhang, M., Müller, J.
- (9) A Machine Learning Ensemble Approach for Short-Term Polar Motion Prediction Using Rapid EOP and EAM Forecasts
Partyka, A., Nastula, J., Śliwińska-Bronowicz, J., Wińska, M.
- (10) Basic Earth Parameters from VLBI observations using Bayesian inversions in the time domain: updated insights of the Earth's interior
Cheng, Y., Déhant, V., Rivoldini, A., Requier, J., Bizouard, C.

- (11) Comparison of Two Liouville-Based Computational Frameworks for Short-Term Earth Rotation Parameter Prediction
Michalczak, M., Ligas, M., Nastula, J., Śliwińska-Bronowicz, J., Wińska, M.
- (12) On the rapid EOP combination and evaluation
Zhang, S., Lian, L., Huang, C.
- (13) Towards a new nutation model
Déchant, V., Folgueira, M., Requier, J., Triana, S. A., Laariara, D.
- (14) Core Flow Contribution to Intradecadal Polar Motion from Rotation and Gravimetric Observations
Laariara, D., Couhert, A., Requier, J., Déchant, V., Reinquin, F., Lemoine, J.
- (15) Advanced Provision of Stable Earth Orientation Parameters (AdvEOP) for Reference Frames
Thaller, D., Kehm, A., Belda, S., Blossfeld, M., Dill, R., Karbon, M., Modiri, S., del Nido Herranz, L., Flohrer, C., Dobslaw, H., Seitz, F., Ferrandiz, J., Schoenemann, E., Berton, J., Bruni, S., Otten, M.
- (16) German Research Unit RING (Rotations IN Physics, Geophysics, and Geodesy) for exploiting the potential of highly-accurate ring lasers for Earth rotation and seismology
Igel, H., Thaller, D., Stellmer, S., Glaser, S., Heinkelmann, R., Müller, J., Schuh, H., Bernauer, F., Forbriger, T., Gerberding, O., GÄijntner, A., Hadziioannou, C., Isleif, K., Klügel, T., Kodet, J., Schreiber, U., Wziontek, H.
- (17) Complete resolutions of polar motion and geodetic excitation equation for Earth's rotation
Xu, X., Shi, Q., Huang, C., Zhou, Y., Liao, X.
- (18) Preliminary Results on Coseismic Polar Motion Excitation: GRACE Forward Modeling and Multi-Method EOP Analysis for Four Megathrust Earthquakes
Liu, L., Xu, X., Yan, Z., Wu, H., Liu, T., Zhang, B., Xiong, C., Ran, J.
- (19) Diurnal and sub-diurnal Earth Rotation variations observed using VLBI
Nilsson, T.
- (20) On the Gravitational Coupling Between the Inner Core and the Mantle in Space Gravimetry
Rosat, S., Lecomte, H., Saad, T., Barrois, O., Boy, J.
- (21) Excitation of the free core nutation: an updated analysis over the period 1986-2026
Bizouard, C., Paniagua, R.
- (22) Regional atmospheric contributions to ENSO-driven interannual variations in Earth's rotation (LOD)
Wińska, M., Śliwińska-Bronowicz, J., Nastula, J., Staniszevska, D.
- (23) Bridging Multi-Band VLBI Networks: A Comparative Insight into Earth Orientation Parameters
Dhar, S., Kitrapacha, C., Heinkelmann, R., Beyerle, G., Schuh, H.

- (24) Determination of Celestial Pole Offsets Using Intensive Sessions
Urunova, R., Kurdubov, S.
- (25) Performance of the VGOS-INT-B/C sessions for UT1-UTC determination
Haas, R., Wolfs, R.
- (26) Chandler wobble and LOD variations in recent epochs
Zotov, L., Sidorenkov, N., Bizouard, C.

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Tuesday - September 29, 2026

All times in CEST (Central European Summer Time) - UTC+2. Presentations are held at Konserthuset - Bo Linde-salen.

Session: Earth rotation - Progress of techniques and observations

Session convener: Sigrid Böhm

08:30 - 09:00 Progress in Inertial Earth Rotation Sensing utilizing Large Ring Lasers
Schreiber, U., Kodet, J., Hugentobler, U., Kluegel, T.

09:00 - 09:30 On the progress of VGOS network and UT1 intensive observation in China
Shu, F.

09:30 - 10:15 Discussion time

10:15 - 10:45 **Coffee & Tea break**

10:45 - 12:20 **Poster session presentations - Tidal and non-tidal loading & Hydrologic signature in geodetic observations**

12:20 - 12:30 **Group picture**

12:30 - 13:30 **Lunch break** - Lunch is served at Konserthuset

13:30 - 14:30 **Poster viewing time - Tidal and non-tidal loading & Hydrologic signature in geodetic observations**

Session: Tidal and non-tidal loading

Session convener: Xiaoming Cui, Severine Rosat

14:30 - 15:00 Self-Consistent Models of Earth's Mantle and Core From Long-Period Seismic and Tidal Constraints
Munch, F., Kemper, J., Khan, A., Helffrich, G., Giardini, D.

15:00 - 15:30	Improved hydrodynamical modelling of shallow-water tides by an updated bottom friction approach <i>Sulzbach, R.</i>
15:30 - 16:15	Discussion time
16:15 - 16:45	Coffee & Tea break
16:45 - 17:30	Summary of the day
18:00 -	ECS Event

Poster session - Tidal and non-tidal loading

- (1) Influence of Atmospheric Tides on Celestial Pole Offsets and Its Modulation by Climate Variability
Cui, X., Yang, W., Sun, H.
- (2) Characterizing ocean tide aliasing errors for improved gravity field recovery
Varadaganahalli Anandagowda, C.
- (3) Upper mantle anelasticity and its frequency dependence resolved by GPS in 3-D ocean tide loading displacements
Huang, P., Penna, N.T., Clarke, P.J., Klemann, V., Martinec, Z., Tanaka, Y.
- (4) Integrated Altimetry and Tide Gauge Analysis of Sea Level Change and Land Subsidence in Alexandria (1993-2026)
Elwan, M.
- (5) Evaluation of non-tidal loading effects derived from a high-resolution barotropic ocean model TiME with timeseries from superconducting gravimeters
Antokoletz, E.D., Sulzbach, R., Wziontek, H., Dobsław, H.
- (6) Solid Earth Tide Residuals as Indicators of the 18.6-Year Lunar Nodal Cycle in GNSS Time Series
Md Bokhtiar Abid, N., Lutsenko, V., A, K.A.
- (7) Ocean Tide Loading in East Antarctica: A Comparison of SPOTL and LoadDef Solutions Using GNSS Observations
Schulz, A., Raja-Halli, A., Ejigu, Y.G., Näränen, J., Nordman, M.
- (8) Optimization of Stochastic Models in Kinematic PPP for Ocean Tidal Loading Detection in East Antarctica
Ejigu, Y.G., Nordman, M., Näränen, J., Raja-Halli, A., Koivula, H.

- (9) Constraining Mantle Rheology with Long-Period Tides: comparison of modelled responses with superconducting gravimeters, low-degree time-variable space gravity, and length-of-day observations
Saad, T., Rosat, S., Boy, J.P.

Poster session - Hydrologic signature in geodetic observations

- (1) GNSS-Based Insights into Topographic Effects on Rainfall-Induced Crustal Deformation During an Extreme Typhoon Event
Arief, S.
- (2) Hydrologically Induced Viscoelastic Deformation in the Amazon Basin
Kruse, A., Broerse, T., Riva, R.
- (3) Hydrology-deformation coupling in the Central-Northern Apennines, Italy, from integrated satellite and in situ observations
Silverii, F., Bowier, C., Pezzo, G., Serpelloni, E., Tolomei, C., Borghi, A., Martelli, L., Calamita, C., Werth, S., Gualandi, A., Zaccarelli, L., Shirzaei, M., Pintori, F.
- (4) Estimation of the Hydrological Mass Balance in Europe from GNSS Observations
Borghi, A., Barletta, V. R.
- (5) Groundwater Crisis and “Day Zero” Vulnerability in Bengaluru, India: A Multi-Source Hydro-Geophysical and Geodetic Study
Shastri, A., Dixit, M., Ojha, C.
- (6) GRACE-derived land uplift model in Fennoscandia: Assessing the impact of hydrological loading on land uplift rates and uncertainty
Bagherbandi, M., Amin, H., Tenzer, R.
- (7) Towards Self-Consistent GNSS and GRACE Trends Across Canada
Parang, S., Crowley, J. W.
- (8) Joint inversion of GRACE and GRACE-FO for simultaneous estimation of terrestrial water storage anomalies and water fluxes
Karimi, S., Rietbroek, R., Penning de Vries, M., Shakya, A., van der Tol, C.
- (9) FEATS-G: Quantifying the Potential of Quantum Space Gravimetry
Schachtschneider, R., Dobslaw, H., FEATS-G Consortium
- (10) Augmenting the ESA Earth System Model 3.0: Auxiliary datasets for geodetic method development
Dobslaw, H., Shihora, L.
- (11) Threats of Relative Sea Level Rise in Coastal Communities: InSAR and GNSS Measurements for Decadal Time Scales surrounding Lake Pontchartrain
Hurtado-Pulido, C., Donnellan, A., Jones, C. E.

- (12) Underestimated loading-driven land subsidence by Earth models amplifies relative sea-level rise
Li, F., Klos, A., Kusche, J.
- (13) Present-to-Future Wetland Vulnerability to Relative Sea-Level Rise along the Gulf of Khambhat, India
Sharma, S., Ojha, C.
- (14) Statewide Land Subsidence Using InSAR Analysis and Aquifer Storage Loss in Punjab, India
Chawla, S., Ojha, C.
- (15) Multi-sensor InSAR-Derived Vertical Land Motion and Infrastructure Risk Assessment in Mumbai, India
Moolchandani, A., Ojha, C.

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Wednesday - September 30, 2026

All times in CEST (Central European Summer Time) - UTC+2. Presentations are held at Konserthuset - Bo Linde-salen.

Session: Hydrologic signature in geodetic observations

Session convener: Grace Carlson, Carla Braitenberg

08:30 - 09:00 Multi-Sensor Geodesy for Quantifying Water Storage Change, Groundwater Depletion and Recharge

Werth, S., Shirzaei, M., Carlson, G., Sadhasivam, N., Khorrami, M.

09:00 - 09:30 Towards a better understanding of GNSS-inferred TWS changes over Europe

Klos, A., Bogusz, J., Lenczuk, A., Mikocki, J.

09:30 - 10:15 Discussion time

10:15 - 10:45 **Coffee & Tea break**

10:45 - 12:30 **Poster session presentations - Cryospheric deformation of the solid Earth**

12:30 - 13:30 **Lunch break** - Lunch is served at Konserthuset

13:30 - 14:30 **Poster viewing time - Cryospheric deformation of the solid Earth**

Session: Cryospheric deformation of the solid Earth

Session convener: Matthias Willen, Karen Simon

14:30 - 15:00 Constraining Earth structure and rheology beneath the Antarctic Peninsula: insights from GNSS data in a low viscosity region

Nield, G.

15:00 - 15:30 Modelling the GIA contribution to secular geocentre and polar motion

Riva, R., Klemann, V., Martinec, Z., Melini, D.

15:30 - 16:15 Discussion time

- 16:15 - 16:45 **Coffee & Tea break**
- 16:45 - 17:30 **Summary of the day**
- 19:00 - 22:00 **Conference dinner at Lilla Gasklockan**

Poster session - Cryospheric deformation of the solid Earth

- (1) GIAMachine: a community-driven rescue and recovery initiative for legacy sea level and glacial isostatic adjustment modeling data
Creel, R.C., Kodama, S.T., Tulenko, J. P., Steffen, R., Steffen, H., Riva, R., Quinn, J., Briner, J.P.
- (2) Geodetic Separation of Land Motion and Sea-Level Change in a GIA-Dominated Region
Erkoç, M.H.
- (3) Climate-Driven Crustal Deformation on Svalbard
Kierulf, H.P.
- (4) Time dependent Glacial Isostatic Adjustment in Iceland
Bellagamba, G., Schmidt, P., Givens, T., Geirsson, H., Magnússon, E., Druin, V., Munos Cobo Belart, J., Hreinsdóttir, S., Ofeigsson, B. G., Sigmundsson, F.
- (5) Understanding Jakobshavn's mass-transport variability from observations of ice, land, and ocean
Berg, D.L., Khan, S.A.
- (6) The Greenland GNSS Network (GNET): Long-Term Stability and Validation of Geodetic-Grade GNSS Measurements of Greenland's 3D Bedrock Displacement from 1995-2025
Solgaard, C., Winther-Dahl, M., Nylen, T.H., Madsen, F.B., Berg, D.L., Bjerregaard, O., Hassan, J., Knudsen, P., Bevis, M.G., Khan, S.A.
- (7) How is GRD affecting the Ice Dynamics and Sea-Level Rise Potential of the Northeast Greenland Ice Stream?
Ertel, G., Coulson, S., Seroussi, H., Morlighem, M., Caron, L.
- (8) Turning GNSS Stations into Virtual Scales for Glaciers: A Paired Approach to Monitor Outlet Glacier Mass Change and Constrain GIA
Barletta, V.R., Gong, C., Bordonì, A., Berg, D.L., Khan, A.S.

- (9) Rethinking GIA: An Empirical Estimate of GIA-Induced Vertical Motion in the Great Lakes Basin
Guerra Neto, H.L., Freymueller, J.T.
- (10) Multi-scale Post-Fire Permafrost Deformation Revealed by InSAR, Onsite Survey and LiDAR in North Yukon, Canada
Furuya, M., Zetao, C., Yanagiya, K.
- (11) Reconciling inferences of mantle viscosity and late Quaternary ice history – the importance of an asthenosphere and 3-D viscosity
Yuan, T., Zhong, S., Milne, G.A., dePolo, D.L.
- (12) Modelling Canada’s complex 3D crustal motions using GNSS data and geophysical models
Simon, K.M., Bond, J., Bremner, M., Goudarzi, M.A.
- (13) Unmasking the Signal Masquerade: Case studies of Surface Loading and Tectonic Aliasing for each Other
Freymueller, J.T.
- (14) Thermal characterization of the upper mantle in the region of the Patagonian Icefields
Granovsky, P., Gómez Dacal, M.L., Richter, A.
- (15) Absolute gravimetry in South Patagonia for geodynamic applications
Gebauer, A., Brachmann, E., Pasquaré, A., Rülke, A., Scheinert, M., Richter, A., Goebel, B., Marderwald, E., Antokoletz, E.D., Wziontek, H., Gende, M., Connon, G., Welsch, S.
- (16) Multi-decadal changes in the Karakoram and Himalayan region glaciers since the 1970s
Halder, S., Bhambri, R.
- (17) Sensitivity of Antarctic GPS-derived bedrock motion to surface mass balance loading corrections and reference-frame realisation strategies
Rajavarathan, J., King, M.A., Watson, C.
- (18) Tectonic strain in the Antarctic plate: constraints from GNSS, GRACE observations, and GIA models
Pandey, D.N., Gahalaut, V.K., Catherine, J.K.
- (19) How to account for ice sheets’ mass changes and GIA within a global inversion for sea-level contributions from satellite data?
Willen, M., Uebbing, B., Horwath, M., Kusche, J.
- (20) 3D vs. 1D viscosity structures when interpreting GIA induced VLM in Antarctica
Klemann, V., Wolf, C., Schachtschneider, R., Wullenweber, N., Albrecht, T., Scheinert, M.
- (21) Geodetic observations in West Antarctica reveal geodynamically consistent 3-D mantle viscosity
dePolo, D.L., Yuan, T., King, M.A., Zhong, S.

- (22) Observing surface elevation change in Dronning Maud Land using satellite altimetry data
Tomić, M., Nordman, M., Sallila, H., Seppänen, J., Riihelä, A.
- (23) Constraining viscosity structures for GIA modelling
Wolf, C., Schachtschneider, R., Klemann, V., Steinberger, B.
- (24) The Geodynamics In ANTarctica based on REprocessing GNSS DATA INitiative (GIANT-REGAIN) Phase 2
Scheinert, M., King, M.A., Wilson, T., Clarke, P.J., Gómez, D., Koulali, A., Kendrick, E., Kupriyanov, A., Buchta, E.

TENTATIVE

Thursday - October 1, 2026

All times in CEST (Central European Summer Time) - UTC+2. Presentations are held at Konserthuset - Bo Linde-salen.

Session: Seismogeodesy

Session convener: Jean-Mathieu Nocquet

08:30 - 09:00 Evaluation of Subduction Zone Slip Behavior Through Multidisciplinary Data Sets: The Example of Alaska
Elliott, J., Grapenthin, R., Xiao, Z., Freymueller, J., Parameswaran, R., Wei, S., Zhuo, Z., Abers, G., Nicolisky, D., Bennett, A., Travers, A.

09:00 - 09:30 Rethinking Intraplate Earthquakes: The Role of Inelastic Deformation in Stress Build-up
Meneses-Gutierrez, A.

09:30 - 10:15 Discussion time

10:15 - 10:45 **Coffee & Tea break**

10:45 - 12:30 **Poster session presentations - Seismogeodesy & Volcanogeodesy**

12:30 - 13:30 **Lunch break** - Lunch is served at Konserthuset

13:30 - 14:30 **Poster viewing time - Seismogeodesy & Volcanogeodesy**

Session: Volcanogeodesy

Session convener: Susanna Ebmeier

14:30 - 15:00 Crustal deformation around volcanoes and glaciers in a rifting environment
Geirsson, H.

15:00 - 15:30 Monitoring active volcanoes with kinematic GNSS positioning
Aoki, Y.

15:30 - 16:15 Discussion time

16:15 - 16:45	Coffee & Tea break
16:45 - 17:00	Summary of the day
17:00 - 17:30	Wrap up and Closing

Poster session - Seismogeodesy

- (1) Seismogeodetic Analysis of Intraplate Deformation Along the Delhi-Aravalli Ridge Using a Geoid-Anchored Framework
Nath, S., Dikshit, O.
- (2) Post-seismic off-fault moment tensor solutions after the 2023 Türkiye-Syria co-seismic mainshock (Mw 7.8, 7.7) and early on-fault aftershock sequence (SE-Anatolia, Türkiye)
Toker, M., Yavuz, E.
- (3) AI-Based Multi-Source Integration of GNSS-Derived TEC for Pre-Seismic Ionospheric Anomaly Detection
Abdelkebir, L., Beldjilali, B.
- (4) Postseismic Deformation in Andaman Nicobar Islands following the 2004 Sumatra-Andaman Megathrust Earthquake
Parashar, N., Gahalaut, V., Catherine, J.K., Naidu, M.S., Rajeshwara Rao, V.
- (5) Assessment of the network operation of high-resolution Lippmann tiltmeters installed for the monitoring of the Mur-Mürz fault line (Austria)
Barbély, E., Benedek, J., Horn, N., Meurers, B., Leonhardt, R., Papp, G.
- (6) The Role of Co-seismic Model Specifications in Constraining Andean Geodynamics
Figueroa, M.A., Gómez, D., Bevis, M.G., Smalley Jr., R.
- (7) Assessing GNSS Detectability of Transient Tectonic Deformation Under Cascadia-Constrained Observational Conditions.
García, C., Männel, B., Hohensinn, R., Wickert, J., Bedford, J.
- (8) Experimental Assessment of a Low-Cost GNSS Receiver for Dynamic Displacement Monitoring in Seismic Applications
Velasquez, M., García, F., Solís, O., Estrada, M., Gonzales, C., Lopez, L., Estacio, L.
- (9) Benchmarking Low-Cost and Geodetic-Grade GNSS and Accelerometer Systems for Seismogeodesy: The Shake Table Experiment Dataset
Kudłacik, I., Kapłan, J., Nastase, I. E., Tiganescu, A., Elias, P., Kaczmarek, A., Nistor, S., Zuliani, D.

- (10) EPOS-GNSS Data and Products for Geodynamics
Fernandes, R., Bruyninx, C., Carvalho, L., Crocker, P., Janex, G., Legrand, J., Menut, J., Ravanelli, M., Socquet, A., Steffen, H., Vergnolle, M., EPOS-GNNS Members

Poster session - Volcanogeodesy

- (1) A multiparametric and unsupervised-learning approach to characterize seismic and deformation variability during Villarrica's eruptive cycle (2018-2019)
Santori, C., Potin, B., Ruiz, S., González-Vidal, D., Baez, J C.
- (2) Flank instability of Mauna Loa Volcano, Hawai'i, modulated by magma intrusion and eruption
Matsuda, M., Aoki, Y.
- (3) Integration of EGMS and GNSS Data for Strain Mapping and Uplift Acceleration Analysis at Campi Flegrei
Pintori, F., Borghi, A., Passarelli, L.
- (4) The Government of Canada's Dedicated InSAR-Based Volcano Monitoring System
Sond, M., Rotheram-Clarke, D., Lam, C., Ackerley, N., Kelman, M., LeMoigne, Y.
- (5) Detecting transient ground deformation associated with the 2015 magma intrusion event at Sakurajima Volcano, Japan, with GNSS kinematic positioning
Kemmochi, T., Itoh, Y., Aoki, Y., Nakamichi, H., Iguchi, M.
- (6) Galeras volcano slow deformation detected by ALOS-2 and Sentinel-1 interferometry (2016-2022) and BEM modeling of the deformation source
Lizarazo, S., Albino, F., Cayol, V.
- (7) Monitoring of the Santorini 2025 volcano-tectonic unrest: contribution of GNSS data and international networks
Ganas, A., Sakkas, V., Bonforte, A., Vernant, P., Briole, P., Liadopoulos, E., Doerflinger, E., Consoli, S., Elias, P., Madonis, N., Mintourakis, I., Goutsos, G.

Keynote abstracts

TENTATIVE

Monitoring active volcanoes with kinematic GNSS positioning

Yosuke Aoki¹

1 - Earthquake Research Institute, The University of Tokyo, Japan

Geodetic data has been playing a crucial role in understanding volcanic activity. In particular, the development of space geodetic techniques, such as Global Navigation Satellite System (GNSS) and Synthetic Aperture Radar (SAR), in the last few decades has revolutionized volcano monitoring. However, the temporal resolution of these techniques is often insufficient to fully capture volcanic activity. For example, static GNSS positioning measures the antenna position once a day, preventing the capture of deformation on a time scale shorter than a day. To address these limitations, this study demonstrates the utility of kinematic GNSS positioning for gaining deeper insights into volcanic activity by examining two events: the 2015 Sakurajima, Japan, magma intrusion event and the 2022 eruption of Mauna Loa volcano, Hawai'i. Turning first to Sakurajima Volcano, it has been active in the last few decades, with 2918 explosions between 2016 and 2025. Among these explosions, an intrusion on 15 August 2015 is unique in that it produced significant deformation without an eruption. Previous studies show that a single dike intrusion explains the deformation data with coarse temporal resolution. However, this study using GNSS time series with a 5-minute temporal sampling shows that two dike intrusions, first at shallow depths and then at greater depths, are required to be consistent with the observations. After 38 years of dormancy, Mauna Loa erupted in November and December 2022. Dike intrusions along the Northeast and Southwest Rift Zones were responsible for the observed ground deformation. Kinematic GNSS positioning indicates that intrusion into the Southwest Rift Zone occurred before that into the Northeast Rift Zone. This approach allows detailed imaging of dike intrusion and advances understanding of volcanic dynamics.

Keywords: GNSS · Kinematic positioning · Dike intrusion

Presenter: Yosuke Aoki (Earthquake Research Institute, The University of Tokyo, Tokyo, Japan)

Session: Volcanogeodesy

Presentation time: Thursday, 15:00 - 15:30 (CEST)

A journey from ocean dynamics to the excitation of low-frequency polar motion variability

Lara Börger¹

1 - Institute of Geodesy and Geoinformation, University of Bonn, Germany

Variations in Earth rotation are driven/caused by external torques and internal processes such as mantle deformations or mass redistributions in geophysical fluids. In particular, large-scale mass redistributions in the ocean lead to oceanic angular momentum (OAM) changes that can excite rotational fluctuations.

In this contribution, I address the processes involved in the oceanic excitation of polar motion on interannual time scales. Specifically, the excitation induced by (i) the El Niño-Southern Oscillation (ENSO) and (ii) intrinsic oceanic variability is quantified. Previous studies have demonstrated that ENSO strongly impacts the length-of-day component through atmospheric angular momentum changes, but a comparable effect on polar motion remains to be quantified. Here, the hypothesis is tested whether ENSO excites polar motion through changes in OAM. The ENSO-induced polar motion excitation is derived from the output of four climate models, with a particular focus on monthly ocean bottom pressure (pb) changes over a 165-year period. The mass term excites polar motion mainly along 90°E with amplitudes of ± 4 mas, particularly via basin-wide mass exchanges between Pacific and Indian oceans. During three ENSO cycles (1997/98, 2009/10, 2015/16), OAM changes account for 40-50% of the variance of the residual observed polar motion excitation, but co-occurrence with other broadband signals complicates a clear attribution to ENSO. In addition, excitation signals associated with intrinsic ocean variability are presented. Recent studies have shown that chaotic intrinsic ocean variability, generated through non-linear local processes, can cause notable large-scale fluctuations in pb. To examine the matter, daily OAM series from pb and velocity fields of a 50-member ensemble of eddy-permitting global ocean simulations over the period 1995-2015 are computed. The intrinsic OAM fluctuations explain $\sim 46\%$ of interannual oceanic excitation, with mass variability dominated by the first mode of intrinsic bottom pressure fluctuations, which appears to originate from Drake Passage.

Overall, the results in this work provide a valuable contribution to understanding ocean-induced low-frequency polar motion variability. Accurate OAM estimates and consideration of model

uncertainties due to intrinsic variability are crucial when analysing rotation data for more subtle effects, e.g., terrestrial hydrology and the Earth's interior. In addition, knowledge of the ENSO-induced oceanic excitation signals creates an opportunity to improve the accuracy of both OAM estimates and long-term polar motion predictions.

Keywords: Earth rotation variations · Polar motion variability · Oceanic angular momentum · El Niño-Southern Oscillation · Oceanic intrinsic variability

Presenter: Lara Börger (University of Bonn, Bonn, Germany)

Session: Earth rotation

Presentation time: Monday, 14:30 - 15:00 (CEST)

Evaluation of Subduction Zone Slip Behavior Through Multidisciplinary Data Sets: The Example of Alaska

Julie Elliott¹, Ronni Grapenthin², Zhuohui Xiao³, Jeffrey T. Freymueller¹, Revathy Parameswaran², Songqiao Wei¹, Zechao Zhuo¹, Geoffrey Abers⁴, Dmitry Nicolsky², Anthony Bennett¹, Abigail Travers¹

1 - Michigan State University, USA

2 - University of Alaska Fairbanks, USA

3 - Kuming University of Science and Technology, China

4 - Cornell University, USA

The Alaska-Aleutian convergent margin stretches 3500 km from the collisional St. Elias Range in southeast Alaska to the Russian far east. The margin exhibits an exceptional range of properties and behaviors including large variations in interseismic coupling, slip events from great earthquakes to multi-year transients, and contrasts in upper plate motion. The margin is extremely active, with more than 50 M7 or greater events occurring over the past century, including five M7-8+ events along the Alaska Peninsula between 2020 and 2025. These recent events were captured by multiple types of instrumentation, producing static GNSS offsets, high rate GNSS waveforms, local and teleseismic waveforms, relocated aftershocks, and InSAR displacements. The multidisciplinary data sets provide increased spatial and temporal density which allows investigation of rupture dynamics, slip extent, relationships between earthquakes, and relationships between earthquakes and long-term coupling.

Based on geodetic estimates, coupling between the slab and the upper plate varies widely along the margin and undergoes relatively sharp transitions in both the along-strike and down-dip directions. The July 2020 M7.8 Simeonof earthquake nucleated near a transition from low to moderate coupling along the megathrust and propagated to the southwest, with the majority of slip occurring at intermediate depths (20-40 km). The July 2021 M8.2 Chignik event originated at the northeast edge of the 2020 rupture (in an area that experienced increased stress due to the earlier event) and ruptured to the northeast. As with the Simeonof event, the majority of slip was between 20-40 km on the megathrust. The October 2020 M7.6 Sand Point event ruptured within the subducting Pacific slab along a north-south striking plane that roughly aligns with a coupling transition and was likely advanced by stress changes from the Simeonof earthquake.

While the Sand Point earthquake was dominantly strike-slip, it generated a larger tsunami than the Simeonof event. Tsunami data might be explained by limited slip on the megathrust, but the geodetic displacements are not consistent with significant megathrust slip in the hypocentral region. An evaluation of the earthquake using all of the available data sets suggests that there may have been delayed triggered slow rupture along the shallow megathrust.

Keywords: GNSS · Earthquake · Subduction Zone · InSAR

Presenter: Julie Elliott (Michigan State University, East Lansing, MI, USA)

Session: Seismogeodesy

Presentation time: Thursday, 08:30 - 09:00 (CEST)

Crustal deformation around volcanoes and glaciers in a rifting environment

Halldór Geirsson¹

1 - Institute of Earth Sciences, University of Iceland, Iceland

Several highly active volcanoes in the world are fully or partially covered by ice. Hazards from such environments include increased explosivity and glacial outburst floods or other mass-wasting accompanying eruptions. Glaciers on and surrounding volcanoes and rifting environments cause added geodetic challenges for measuring volcano deformation: decreased accessibility and loss of signals for radar satellites. Here I will report on deformation signals and deformation processes of several of Iceland's subglacial and subaerial volcanoes. Primary observation tools for present-day geodesy in Iceland are continuous GNSS (cGNSS) and InSAR. Over 160 cGNSS stations are in operation in Iceland today. Recent improvements in sampling rate and quality of InSAR data have made us question usefulness of additional campaign and "semicontinuous" GNSS observations, although for small signals and temporal continuity they continue to be of importance. Other techniques, such as levelling and continuous tilt measurements still have limited applicability to maintain long and uninterrupted time series, for early warning purposes, and to capture all possible signals at mostly subglacial volcanoes, where only a small Nunatak may stick out of the ice. Repeat gravimetry and radio echo soundings have been carried out in an experimental manner to record deka-meter scale deformation of the caldera floor of the Bárðarbunga central volcano. The glaciers of Iceland, covering approximately 11% of its surface are retreating fast, leading to as much as 3.5 cm/yr of glacio-isostatic adjustment (GIA) uplift rates. Along with these we measure up to 8 mm/yr of horizontal motion, which is almost on par with the tectonic plate motion, greatly affecting stresses and magmatic processes at volcanoes under and near the glaciers. These GIA signals are highly time-variable, due to the response to decadal changes in climate, requiring detailed time-dependent GIA models to study small deformation signals of volcanoes under or near the glaciers.

Overall, volcano geodesy in Iceland has allowed us to quantify in great detail location, depth, and volume changes of magma domains and dikes at many of our volcanoes. The results show varying periods of inflation and deflation, episodic (e.g. Svartsengi) or continuous (e.g. Hekla, Grímsvötn): in some cases supporting simple conceptual models of the volcano cycle. Other volcanoes may have non-eruptive periods of subsidence, interrupted by short periods of uplift

(Hengill, Torfajökull, Krafla), indicating either more complex magmatic processes, or processes involving the hydrothermal system. No simple model seems to suffice to encompass the different deformational behavior of the volcanoes in Iceland.

Keywords: Volcano deformation · Volcano cycle · Dike deformation · Glacio-volcano interactions

Presenter: Halldór Geirsson (University of Iceland, Reykjavík, Iceland)

Session: Volcanogeodesy

Presentation time: Thursday, 14:30 - 15:00 (CEST)

Recent advances in the field of Earth rotation: new geophysical insights

Mostafa Kiani Shahvandi¹, Benedikt Soja²

1 - Department of Meteorology and Geophysics, University of Vienna, Austria

2 - Institute of Geodesy and Photogrammetry, ETH Zurich, Switzerland

Understanding the causes of Earth rotation irregularities is a classic problem in geodesy. These irregularities occur in both the direction of the rotation axis and in the Earth's spin rate—representing the so-called polar motion and the length of day variation (ΔLOD). Polar motion and ΔLOD are caused by a multitude of geophysical processes, from those happening in the Earth's core and mantle to the ones entrained by its surface climate dynamics. The purpose of this talk is to present an overview of the recent advances in the geophysical interpretation of polar motion and ΔLOD .

First, we focus on the geophysical excitation of long-period polar motion (periods longer than that of the Chandler wobble). We discuss how this long-period polar motion in the range 1900-2018 can be explained using physics-informed neural networks and by four different geophysical processes: (1) core dynamics—torque and pressure variations at core-mantle and inner core boundaries, (2) mantle dynamics—convection and Glacial Isostatic Adjustment (GIA), (3) seismic processes—earthquakes, and (4) barystatic processes—continental-ocean mass redistribution caused by the melting of polar ice sheet, mountain glaciers, and terrestrial water storage anomalies. Our results show that the most important contributors to long-period polar motion are the barystatic processes, GIA, and mantle convection. The core dynamics and seismic processes are less significant, although we argue that the former generates some non-negligible secular trend and multidecadal fluctuations.

Then we focus on explaining the causes of ΔLOD . The astronomically-observed ΔLOD in the last 2700 years contains a prominent secular trend as well as numerous long-period fluctuations. We show that the secular trend is explained entirely by the sum of tidal friction and GIA, while the mentioned fluctuations are caused primarily by flows at the top of the Earth's core. The contribution of other geophysical processes is found to be negligible.

Keywords: Earth rotation · polar motion · length of day variations · geophysical excitation

Presenter: Mostafa Kiani Shahvandi (University of Vienna, Vienna, Austria)

Session: Earth rotation

Presentation time: Monday, 15:00 - 15:30 (CEST)

TENTATIVE

Towards a better understanding of GNSS-inferred TWS changes over Europe

Anna Klos¹, Janusz Bogusz¹, Artur Lenczuk¹, Jan Mikocki¹

¹ - Military University of Technology, Warsaw, Poland

Networks of permanent stations of Global Navigation Satellite System (GNSS) antennas continuously record vertical displacements of the Earth's crust at the point of their location. This dataset can then be used for a wide variety of analyses, including estimating gridded changes in Terrestrial Water Storage (TWS) using the elastic loading theory. A comparison of the final TWS changes with the corresponding estimates obtained from the Gravity Recovery and Climate Experiment (GRACE) missions shows that the GNSS-inferred TWS changes are closely aligned to the GRACE estimates in terms of the observed changes. However, an analysis of the temporal and spatial resolution of the gridded TWS changes obtainable via GNSS significantly outperforms the GRACE estimates, but this can be only achieved with a proper number of highly accurate displacement observations available for the region. In this presentation, we showcase a set of more than 6,000 GNSS vertical displacements available for Europe and provided by the Nevada Geodetic Laboratory (NGL). We discuss in detail how to process them reliably to obtain high-quality vertical displacements at three temporal resolutions: short-term, seasonal and long-term. We demonstrate how to classify GNSS vertical displacements for use in hydrogeodetic analyses and present two datasets that we are providing to the geodetic community: a dataset of benchmarked GNSS vertical displacements for hydrogeodetic analyses and a collection of gridded GNSS-inferred TWS changes. Both are provided based on 4,443 GNSS stations across Europe, for a period of 1994-2023. We perform several comparisons on regional and local spatial scales with GRACE, hydrological models, and other datasets, and prove that both datasets may enhance future analyses of regional hydrological changes. We conclude the presentation by outlining future prospects for further improving the spatial resolution of TWS changes using InSAR (Interferometric Synthetic Aperture Radar) technology.

Keywords: GNSS displacements · TWS changes · Europe · GRACE

Presenter: Anna Klos (Military University of Technology, Warsaw, Poland)

Session: Hydrologic signature in geodetic observations

Presentation time: Wednesday, 09:00 - 09:30 (CEST)

TENTATIVE

A New Precession Model based on the Improved Earth's J2 Long-term Variation

Jia-Cheng Liu¹, Chengli Huang², Jun Yao¹

1 - Nanjing University, China

2 - Shanghai Astronomical Observatory, China

The IAU 2006 precession model has served as a standard in fundamental astronomy for nearly two decades. However, the linear J2 trend adopted in the original model, valid at that time, is no longer a sufficient approximation and currently limits the accuracy of the theory. In this work, we utilize the most recent satellite laser ranging (SLR) data to model the Earth's J2 long-term variation with a more realistic parabola function. This refinement was then incorporated into the integration of the precession quantities following a methodology consistent with the IAU 2006 approach.

The new precession solution, designated IAU2006J2, was validated against high accurate VLBI data over 45 years. The new model demonstrates superior consistency with observations: the overall discrepancy in Celestial Intermediate Pole (CIP) positions is reduced by approximately 20%, and curvature signals in the Celestial Pole Offset (CPO) series are significantly mitigated. Besides the basic precession variables, the comprehensive set of operational quantities (X, Y, s, EO ...) compatible with the IAU2006J2 model were developed, for both classical and CIO-based transformations from the GCRS to the ITRS. Given its significant improvement over the current IAU2006 model, we propose that the IAU2006J2 precession solution be adopted in the update of the IERS Conventions which is currently in progress, thereby ensuring that the Earth's rotation theory remain aligned with the highest observational precision available today.

Keywords: Earth's rotation · Precession and Nutation · Reference systems · Astrometry

Presenter: Jia-Cheng Liu (Nanjing University, Nanjing, China)

Session: Earth rotation

Presentation time: Monday, 09:00 - 09:30 (CEST)

Rethinking Intraplate Earthquakes: The Role of Inelastic Deformation in Stress Build-up

Angela Meneses-Gutierrez¹

1 - National Research Institute for Earth Science and Disaster Resilience, Japan

Our understanding of the earthquake cycle has long been based on the elastic rebound theory, which explains how strain energy is stored in the lithosphere before earthquakes and then released during rupture. In this context, geodetic strain in intraplate regions has traditionally been attributed to elastic loading driven by plate-boundary processes. However, the mechanism controlling the generation of intraplate earthquakes remains poorly understood, reflecting in part our limited knowledge of the crust's mechanical properties. The 2011 Mw9.0 Tohoku-oki earthquake provided a unique opportunity to study crustal deformation in inland Japan under different boundary conditions, effectively serving as a natural experiment for investigating the intraplate seismogenic stress field. Analysis of dense GNSS observations before, during, and after the quake showed persistent localized strain ($4-10 \times 10^{-8}$ /yr) within the Niigata-Kobe Tectonic Zone along the Japan Sea coast, approximately 200-300 km from the Tohoku-oki rupture area. This localized deformation is consistent with long-term inelastic deformation. These results demonstrate that long-term deformation can be extracted from short-term geodetic data and that a significant portion of the geodetic strain observed in inland Japan comes from localized inelastic sources in the lower crust intrinsic to the crustal mechanical properties. This implies that interpretations based only on interplate elastic strain buildup can lead to biased estimates of stress accumulation and seismic potential.

Our findings provide the first observational constraints distinguishing elastic and inelastic deformation in inland Japan and mark a shift in how the stress build-up process of intraplate earthquakes is understood. Localized inelastic deformation in the lower crust contributes significantly to the observed surface signals and may act as a persistent loading mechanism for the seismogenic crust. This shift in perspective underscores the importance of dense geodetic observations for capturing both elastic and inelastic deformation across different spatial and temporal scales, and emphasizes the need to better understand the role of inelastic processes in stress buildup and earthquake generation in intraplate regions.

Keywords: Intraplate deformation · The 2011 Tohoku-oki earthquake · Inelastic deformation · GNSS

Presenter: Angela Meneses-Gutierrez (National Research Institute for Earth Science and Disaster Resilience, Tsukuba, Japan)

Session: Seismogeodesy

Presentation time: Thursday, 09:00 - 09:30 (CEST)

TENTATIVE

Self-Consistent Models of Earth's Mantle and Core From Long-Period Seismic and Tidal Constraints

Federico Munch¹, Johannes Kemper¹, Amir Khan², George Helffrich³, Domenico Giardini¹

1 - Institute of Geophysics, ETH Zürich, Zürich, Switzerland

2 - Institute of Geochemistry and Petrology, ETH Zürich, Zürich, Switzerland

3 - Earth-Life Science Institute, Tokyo Institute of Technology, Tokyo, Japan

Here we illustrate the use of parameterized models to address fundamental questions about Earth's mantle and core structure. For this, we invert a large set of normal-mode center frequencies and quality (attenuation) factors, along with astronomic-geodetic data, for the radial anelastic seismic structure of the Earth. We consider two distinct parameterizations that rely on physically and polynomially parameterized models. In the first approach mantle models are constructed using petrologic phase equilibria in combination with a laboratory-based viscoelastic model connecting dissipation from seismic to tidal periods (~ 100 s - 20 years), whereas seismic properties for a homogeneous and adiabatic core are computed using equations-of-state. The polynomially parameterized models follow the Preliminary Reference Earth Model (PREM) and rely on a polynomial representation of density, P- and S-wave velocity, attenuation, and anisotropy. To quantify uncertainty estimates on the derived structure—a feature absent from radial seismic reference models—we employ a stochastic sampling-based approach in solving the inverse problem. To further constrain mantle and outer-core seismic wave velocity structure, we also inverted globally-averaged P- and S-wave and multiple core-mantle boundary underside-reflected S-wave travel times, respectively. The results indicate considerable deviations from PREM, including a denser outer core and less dense inner core, and thus a diminished density contrast across the inner-core boundary. Also, outer-core stratification, associated with the E' layer, appears not to be required to match data.

Keywords: Earth's normal modes · astronomic-geodetic data and tidal response · Geophysical inversion

Presenter: Federico Munch (ETH Zurich, Zurich, Switzerland)

Session: Tidal and non-tidal loading

Presentation time: Tuesday, 14:30 - 15:00 (CEST)

TENTATIVE

Constraining Earth structure and rheology beneath the Antarctic Peninsula: insights from GNSS data in a low viscosity region

Grace Nield¹

1 - Durham University, UK

Antarctica is undergoing glacial isostatic adjustment (GIA) - the viscoelastic response of the solid Earth to past and present changes in the ice sheet. GIA typically happens on millennial timescales, however, in regions where the upper mantle viscosity is low, GIA is much more rapid. In the Antarctic Peninsula, the upper mantle viscosity is thought to be up to several orders of magnitude lower than the global average, meaning that viscoelastic deformation following ice-sheet change happens on decadal to centennial timescales, or even shorter.

At the same time, stress from large earthquakes around Antarctica causes viscoelastic relaxation of the upper mantle which happens in the years to decades following an earthquake. This postseismic deformation is superimposed onto the GIA signal, meaning careful interpretation of observed displacement is required. GNSS networks that have been in operation since the 1990s have recorded the Earth's fast response to short term ice sheet fluctuations and large earthquakes. Using forward viscoelastic models and comparing model predictions to GNSS-observed time series, upper mantle viscosity and rheology has been inferred. In this talk I will present several examples from across the Antarctic Peninsula, as well as ongoing work to investigate what these short-term constraints on Earth structure can tell us about the longer-term ice history.

Keywords: Antarctica · GIA · GNSS · Mantle Rheology · Postseismic Deformation

Presenter: Grace Nield (Durham University, Durham, United Kingdom)

Session: Cryospheric deformation of the solid Earth

Presentation time: Wednesday, 14:30 - 15:00 (CEST)

Modelling the GIA contribution to secular geocentre and polar motion

Riccardo Riva¹, Volker Klemann², Zdeněk Martinec³, Daniele Melini⁴

1 - Delft University of Technology, Netherlands

2 - GFZ Helmholtz Centre for Geosciences, Germany

3 - Dublin Institute for Advanced Studies, Ireland

4 - Istituto Nazionale di Geofisica e Vulcanologia, Italy

Glacial isostatic adjustment (GIA) is one of the main contributors to secular changes in the Earth's shape and gravity at global scale. In particular, the signature of GIA is of the same order of magnitude as the effects of surface mass redistributions in the cryosphere and the oceans. Hence, the attribution of the observed signals directly depends on the availability and accuracy of numerical models of all earth system spheres, including the Solid Earth. The contribution of GIA to geocentre motion (GCM) is well understood but reaches only less than 1 mm/yr. As it is nearly directed along the z-axis, which is not well constrained in ITRFs, it could so far not be identified as a secular component by geodetic methods. Furthermore, GIA-induced relative sea level variations are invariant to GCM and do not affect palaeo sea level reconstructions or ice sheet dynamics. About the influence of GIA on earth rotation, LOD changes are well understood, whereas our view of its effect on polar motion has significantly evolved through time. Although the term GRD (Gravity Rotation and Deformation) is gaining popularity and is currently used synonymously to GIA, it is not yet clear how to model gravitational rotational deformations. In the early years, polar motion was modelled by directly solving Liouville's equation. Since the late 1990s, models have also included the feedback between earth rotation and sea level. In the early 2010s, the presence of an additional feedback between earth rotation and the linear-momentum balance has been demonstrated, but since then rarely implemented.

After reviewing the state of the art in GIA models of geocentre and polar motion, we will show some numerical results to highlight how different modelling choices affect various geodetic observations. We will also suggest some actions and foster discussion for both the dynamic modelling and the geodetic communities to possibly reduce GIA model uncertainties in those components.

Keywords: Glacial isostatic adjustment · Geocentre motion · Earth orientation parameters

Presenter: Riccardo Riva (Delft University of Technology, Delft, Netherlands)

Session: Cryospheric deformation of the solid Earth

Presentation time: Wednesday, 15:00 - 15:30 (CEST)

TENTATIVE

Progress in Inertial Earth Rotation Sensing utilizing Large Ring Lasers

Ulrich Schreiber¹, Jan Kodet¹, Urs Hugentobler¹, Thomas, Kluegel²

1 - Technical University of Munich, Germany

2 - Federal Agency of Cartography and Geodesy, Germany

Ring lasers are now resolving the rate of rotation of the Earth with 8 significant digits. Technically they constitute a Sagnac interferometer, where a traveling wave resonator, circumscribing an arbitrary contour, defines the optical frequency of two counter-propagating resonant laser beams. Subtle non-reciprocal effects on the laser beam however, cause a variable bias, which reduces the long-term stability. Over the last two years, we have improved the performance of the G ring laser to the point, that we obtain long-term stable conditions over more than a year. Advances in the modeling of the non-linear behavior of the laser excitation process as well as some small but significant improvements in the operation of the laser gyroscope are taking us now right to the point, where the periodic part of the Length of Day variation of the Earth rotation can be recovered. Since a ring laser gyroscope is an inertial sensor, it is sensitive to the precession and nutation motion of the earth. This corresponds to a motion of 50 seconds of arc per year. It is the first time that this has been achieved by an inertial sensing technique. A laser gyroscope is a local sensor, but we extract a global quantity from it. How accurate are these measurements and where are the persisting error sources? This talk outlines the current state of the art of inertial rotation sensing in the geosciences and points out the remaining challenges. Furthermore, we discuss promising ways for a further enhanced sensor stability.

Keywords: Sagnac Interferometry · ring laser gyroscope · inertial earth rotation sensing

Presenter: Ulrich Schreiber (Technical University of Munich (TUM), Munich, Germany)

Session: Earth rotation

Presentation time: Tuesday, 08:30 - 09:00 (CEST)

On the progress of VGOS network and UT1 intensive observation in China

Fengchun Shu¹

1 - Shanghai Astronomical Observatory, China

UT1 is recognized as one of the essential geodetic variables, reflecting Earth's irregular rotation and playing a critical role in orbit determination, precise positioning and deep space navigation. Over the past 40 years, Very Long Baseline Interferometry (VLBI) has been the only space geodetic technique used for directly measuring UT1. Coordinated by the International VLBI Service for Geodesy and Astrometry (IVS), daily UT1 observations are performed and fast turnaround UT1 products are delivered to the international community. In recent years, the IVS observing system has been transitioning from legacy S/X-band VLBI to the VLBI Global Observing System (VGOS), with an increased number of stations worldwide. Equipped with broadband receivers and fast-slewing antennas, VGOS is capable of providing UT1 measurements with significantly improved precision and much higher temporal resolution, thus enabling near-real-time monitoring of rapid variations in Earth's rotation.

In China, Seshan25 is the first radio telescope for geodetic VLBI with its observations dating back to 1987. Since 2011, it has contributed to the IVS-INT-3 UT1 intensive sessions. As the geodetic VLBI community moves into the VGOS era, China has established three VGOS antennas in Shanghai and Urumqi, followed by four antennas overseas. Since 2023, a domestic UT1 Intensive observing program has been regularly conducted using the Seshan13 and Urumqi VGOS antennas. In parallel, the Seshan13 VGOS antenna has also participated in the VGOS-INT-G observing sessions since 2024.

In addition, a major new project has been funded to construct seven additional antennas: twin telescopes at each of the three core stations (Urumqi, Shigatse, and Changbai Mountain) and a single antenna at Kunming. All new telescopes are fully compatible with the standard VGOS frequency bands. Integrating this network nationally and internationally will enable key scientific objectives, including contributions to a multi-band celestial reference frame and the determination of high-resolution Earth Orientation Parameters. Currently, the first two antennas at the Urumqi site are under construction and are expected to be completed by the end of 2026.

This presentation will provide an overview of China's efforts in UT1 measurements, along with an outlook on its potential contribution to the IVS UT1 product supply chain, with emphasis on

the progress of VGOS station construction and the status of domestic UT1 observations.

Keywords: Very Long Baseline Interferometry · UT1 · VLBI Global Observing System · IVS

Presenter: Fengchun Shu (Shanghai Astronomical Observatory, Shanghai, China)

Session: Earth rotation

Presentation time: Tuesday, 09:00 - 09:30 (CEST)

TENTATIVE

Short-term EOP forecasting: insights from the 2nd PCC and its ML-oriented follow-up

Justyna Śliwińska-Bronowicz¹, Aleksander Partyka¹, Jolanta Nastula¹, Maciej Michalczak²,
Małgorzata Wińska³, Henryk Dobsław⁴, Robert Dill⁴

1 - Centrum Badań Kosmicznych Polskiej Akademii Nauk (CBK PAN), Poland

2 - AGH University of Krakow, Poland

3 - Warsaw University of Technology, Poland

4 - GFZ Helmholtz Centre for Geosciences, Germany

Reliable measurements of Earth Orientation Parameters (EOP) are crucial for numerous operational applications including spacecraft navigation, astronomical observations, and satellite-based navigation systems on Earth. Many of these applications require EOP values in real time; however, obtaining them immediately is not possible because observational data from different measurement techniques must first undergo processing, which introduces delays. To overcome this limitation, several organizations worldwide, including the International Earth Rotation and Reference Systems Service (IERS), produce and distribute EOP forecasts.

Over the past decade, substantial progress has been achieved in the processing of EOP observations, the development of new forecasting approaches, and the understanding of how variations in the distribution of surface fluids influence EOP variability. The number of research groups engaged in EOP prediction has also grown, with different teams employing diverse input datasets, prediction techniques, and forecast horizons. In recent years, particularly rapid development has been observed in forecasting methods based on machine learning (ML) algorithms.

The Second EOP Prediction Comparison Campaign (2nd EOP PCC), organized under the auspices of the IERS, rigorously compared the accuracy of various internationally available EOP prediction algorithms. Based on additional data collected during the currently running post-operational phase of the campaign, as well as sub-campaign dedicated ML-based prediction approaches, we will discuss emerging opportunities to further improve EOP forecasts. This can be achieved by combining enhanced predictions of geophysical excitations with advanced forecasting algorithms leveraging data science and artificial intelligence methods. We will present the current levels of accuracy attainable in EOP predictions and highlight the most effective forecasting approaches. Challenges and future prospects for achieving more reliable and timely

forecasts will also be addressed. Special emphasis will be placed on the potential of machine learning techniques, although our discussion will not be limited to these methods alone.

Keywords: Earth rotation · EOP prediction · Machine learning

Presenter: Justyna Śliwińska-Bronowicz (Centrum Badań Kosmicznych Polskiej Akademii Nauk (CBK PAN), Warsaw, Poland)

Session: Earth rotation

Presentation time: Monday, 09:30 - 10:00 (CEST)

TENTATIVE

Improved hydrodynamical modelling of shallow-water tides by an updated bottom friction approach

Roman Sulzbach¹

1 - GFZ Helmholtz Centre for Geosciences, Germany

Tidal signatures are quasi-ubiquitous in geodetic observations. While tides exist in each subsystem of the Earth, e.g., the ocean, the atmosphere, and the solid Earth, they are not independent but excite and affect one another. In general, tidal signatures from one Earth sphere can be detected in other subsystems of the Earth. Ocean tides and solid Earth tides are closely related and strongly affect each other; for example, the body tide of the solid Earth strongly forces the ocean tide, modifying the effective Tide-Generating Potential (TGP) by up to 30%. In turn, tidal ocean loading induces Earth tides, modifying the gravity field and inducing surface deformation. Thus, predicting and subtracting ocean tide signatures is essential to fully exploit the potential of many geodetic techniques. Strongly owing to satellite altimetric observations, modern ocean tide atlases possess the skill to predict TGP-excited (or linear) tides to very high accuracy.

In contrast to linear ocean tides, shallow-water tides (SWTs) are not generated due to direct forcing by the TGP. They originate entirely from hydrodynamical nonlinearity inherent to ocean tidal dynamics. Dominant processes are of second and third order, leading to the creation of SWTs occurring at frequencies obtained from recombining two or three parent tides. Considering only major ocean tides, a true multitude of shallow-water tides from long periods (e.g., M_{sf}) to sub-semidiurnal periods (e.g., 3MK₃, M₄, and M₆) is generated, enriching and complicating the tidal spectrum. Generally, SWTs are most prominent in shelf oceans, where they are generated, with amplitudes of up to 10+ cm. However, there are SWTs with a non-negligible signal in the deep ocean (e.g., M₄ or 2MS₂). Therefore, SWT signatures are present in terrestrial and remote observations of, e.g., ocean mass (by gravity) or sea surface height.

To complement those observations, skillful ocean tide models are required. However, satellite altimetric observations are of limited use to monitor SWTs and are typically only provided for M₄ and MS₄. On the other hand, purely hydrodynamical predictions suffer from reduced accuracy compared to linear tides. Typical model weaknesses include significant phase errors on the shelf that are hard to reconcile with available TG and altimetry observations. Among other reasons, a likely reason for that is the insufficiently constrained nonlinear shelf-hydrodynamics. Here, we

present novel modelling results from the ocean tide model TiME for a multitude of nonlinear tides. Implementing a novel bottom friction parametrization, the model partially rectified phase errors on the European shelf and notably improves its accuracy with respect to geodetic observations.

Keywords: Ocean Tides · Numerical Modeling · Ocean Loading · Gravimetry · Nonlinear Tides

Presenter: Roman Sulzbach (GFZ Helmholtz Centre for Geosciences, Potsdam, Germany)

Session: Tidal and non-tidal loading

Presentation time: Tuesday, 15:00 - 15:30 (CEST)

TENTATIVE

Multi-Sensor Geodesy for Quantifying Water Storage Change, Groundwater Depletion and Recharge

Susanna Werth¹, Manoochehr Shirzaei¹, Grace Carlson², Nitheshnirmal Sadhasivam¹,
Mohammad Khorrami¹

1 - Virginia Tech, Blacksburg, USA

2 - Indiana University, Bloomington, USA

Hydrologic processes leave measurable signatures in geodetic observations, yet accurately translating them into physically meaningful estimates of water storage change and subsurface dynamics remains challenging. Water-driven deformation reflects elastic loading from water mass redistribution and poroelastic deformation from aquifer-system stress changes. These processes can overlap spatially, differ in sign and amplitude, and vary across climatic and hydrogeologic settings. This presentation highlights hydrologically driven deformation patterns across diverse regions worldwide, showing how GNSS, InSAR, and satellite gravimetry provide complementary constraints on terrestrial water storage (TWS), groundwater storage (GWS), and aquifer-system response. High-resolution vertical land motion reveals management-relevant aquifer behavior, while GRACE and GRACE-FO constrain integrated regional mass change. Together, these observations can assess water depletion, identify recharge signals, and improve the interpretation of overlapping deformation signals.

Developed from multiple case studies, I present a physics-informed joint inversion framework that co-analyzes deformation and gravity observations within a shared model rather than separating signals a priori. The framework represents both elastic loading and poroelastic aquifer deformation, enabling mechanically consistent estimates of TWS and GWS changes across sensors. This approach integrated GNSS elastic vertical displacements, GRACE-FO TWS, and InSAR-derived poroelastic deformation to estimate high-resolution water storage loss during the 2020-2021 California drought and resolve groundwater loss in semi-confined-to-confined aquifer systems. An expanded time-series implementation extends this concept from drought-rates to multi-year time-series, capturing drought and recovery cycles, seasonal-to-interannual recharge dynamics, and spatially variable aquifer responses. This approach is relevant not only to California but also to other groundwater-stressed regions where elastic loading and aquifer-system compaction overlap, including parts of India, Mexico, Australia, the Middle East, and other intensively

managed aquifer systems worldwide.

The results illustrate how multi-sensor geodesy can advance hydrologic interpretation of Earth deformation toward high-resolution monitoring of water storage change, improved understanding of recharge and aquifer mechanics, and stronger integration of geodetic constraints into hydrologic and groundwater models. These capabilities are increasingly important for tracking water stress, interpreting subsurface change, and informing groundwater management during a new era of water bankruptcy.

Keywords: Hydrogeodesy · Groundwater · InSAR · multi-sensor combination · inversion

Presenter: Susanna Werth (Virginia Tech, Blacksburg, USA)

Session: Hydrologic signature in geodetic observations

Presentation time: Wednesday, 08:30 - 09:00 (CEST)

TENTATIVE

Poster abstracts

TENTATIVE

AI-Based Multi-Source Integration of GNSS-Derived TEC for Pre-Seismic Ionospheric Anomaly Detection

Layachi Abdelkebir¹, Bilal Beldjilali¹

¹ - National Higher School of Geodesy and Space Techniques (ENSGTS), Algeria

Earthquake prediction remains a major scientific challenge due to the complex and multi-scale nature of geophysical processes. In recent years, ionospheric disturbances derived from Global Navigation Satellite System (GNSS) observations, particularly Total Electron Content (TEC), have been investigated as potential earthquake precursors. However, these disturbances are not unique to seismic activity and can also be influenced by external factors such as solar activity, geomagnetic storms, and atmospheric dynamics.

Most existing studies rely on single-source data, limiting their ability to reliably distinguish seismic-related anomalies from background variability. This highlights the need for integrated approaches combining multiple geodetic and geophysical datasets.

In this study, we propose a hybrid framework, SeismoAI-QSS, for the detection of pre-seismic ionospheric anomalies through multi-source data integration and artificial intelligence techniques. The framework combines GNSS-derived TEC observations with seismic catalogs, satellite-based deformation data (InSAR), and space weather parameters. Machine learning models are applied to identify complex spatio-temporal patterns associated with potential earthquake precursors.

The proposed approach aims to enhance the reliability of ionospheric anomaly detection and contribute to the development of AI-driven earthquake forecasting systems within the context of seismogeodesy.

Keywords: GNSS · Total Electron Content · Seismogeodesy · Ionospheric disturbances · Artificial Intelligence

Presenter: Layachi Abdelkebir (National Higher School of Geodesy and Space Techniques (ENSGTS), M'Sila, Algeria)

Session: Seismogeodesy

Presentation day: Thursday

Evaluation of non-tidal loading effects derived from a high-resolution barotropic ocean model TiME with timeseries from superconducting gravimeters

Ezequiel D. Antokoletz¹, Roman Sulzbach², Hartmut Wziontek¹, Henryk Dobslaw²

1 - Federal Agency for Cartography and Geodesy (BKG), Germany

2 - GFZ Helmholtz Centre for Geosciences, Germany

Superconducting gravimeters (SGs) are known as the most sensitive and stable gravity sensor. Although they provide information at single stations, they allow for a reliable census of mass variations in the Earth system. Therefore, SGs contribute to an accurate validation of atmospheric, ocean and hydrological models.

Besides Earth and ocean tides, atmospheric and non-tidal ocean loading effects represent a significant contribution to gravity variations. Especially for coastal stations, loading effects in the oceans are mainly driven by atmospheric pressure and winds for periods from a few days up to several weeks. At longer periods, the ocean mostly reacts as an inverted barometer, although deviations of this assumption at seasonal periods do exist.

In this study, we evaluate non-tidal ocean loading effects derived from an extended version of the barotropic Tidal Model forced by Ephemerides (TiME) additionally driven by atmospheric pressure and winds from the ECMWF Reanalysis v5 (ERA5), with superconducting gravimeter timeseries at selected stations. Results are also compared with non-tidal ocean loading effects as provided by the Atmospheric attraction computation service (Atmacs), based on ocean-bottom pressure (OBP) anomalies of the Max-Planck-Institute for Meteorology Ocean Model (MPIOM). Although we expect a good agreement between non-tidal ocean loading effects from TiME with the SG records at short periods, we also assume attenuation at seasonal scales. Therefore, we consider a combined approach with MPIOM to benefit from its baroclinic component in order to provide a more precise and most complete correction for terrestrial gravimetry.

Keywords: superconducting gravimetry · non-tidal ocean loading effects · Atmacs

Presenter: Ezequiel D. Antokoletz (Federal Agency for Cartography and Geodesy (BKG), Leipzig, Germany)

Session: Tidal and non-tidal loading

Presentation day: Tuesday

TENTATIVE

GNSS-Based Insights into Topographic Effects on Rainfall-Induced Crustal Deformation During an Extreme Typhoon Event

Syachrul Arief¹

1 - Geospatial Information Authority of Indonesia, Indonesia

Extreme rainfall associated with tropical cyclones generates significant transient surface loads that induce measurable crustal deformation. In this study, we investigate the geodetic response to a major typhoon event in Japan using the dense GEONET GNSS network. We reconstruct the spatiotemporal evolution of atmospheric water vapor from GNSS-derived tropospheric delays and compare it with independent precipitation datasets to characterize water transport processes during the event.

GNSS observations reveal clear vertical crustal subsidence of up to several centimeters along the typhoon track, with rapid post-event recovery. However, surface loads inferred from geodetic inversion significantly exceed precipitation estimates over land, indicating a systematic discrepancy between observed deformation and hydrological input.

We show that this mismatch is strongly influenced by topographic effects. GNSS stations are predominantly located in valleys and basins, where local accumulation of rainwater enhances surface loading and amplifies subsidence signals. Statistical analysis indicates that deformation sensitivity to precipitation is substantially higher in concave terrains compared to relatively flat regions.

These results demonstrate that small-scale topographic variability plays a critical role in modulating geodetic responses to hydrological forcing. The study highlights the importance of integrating terrain-dependent processes in interpreting GNSS-derived deformation and suggests broader implications for monitoring extreme weather impacts and improving geodetic-based hydrological assessments.

Keywords: GNSS · crustal deformation · hydrological loading · topography · extreme rainfall

Presenter: Syachrul Arief (Geospatial Information Authority of Indonesia, Bogor, Indonesia)

Session: Hydrologic signature in geodetic observations

Presentation day: Tuesday

GRACE-derived land uplift model in Fennoscandia: Assessing the impact of hydrological loading on land uplift rates and uncertainty

Mohammad Bagherbandi^{1,2}, Hadi Amin¹, Robert Tenzer³

1 - University of Gävle, Sweden

2 - Royal Institute of Technology (KTH), Stockholm, Sweden

3 - The Hong Kong Polytechnic University, Hong Kong

Studying the Glacial Isostatic Adjustment (GIA) and land uplift modeling can be carried out utilizing geodetic observations (GNSS and precise leveling measurements), and geophysical methods. The GRACE satellite missions' data has not been formally used in this context in Fennoscandia. If there is insufficient coverage of offshore or onshore data, existing estimates of GIA might be partially biased (by means of spatial pattern and magnitude). To inspect this issue, we incorporated the GRACE data in estimates of the land uplift rate due to GIA. Despite satellite gravitational information having a low resolution (~ 300 km) it can be used for this purpose because the GIA in Fennoscandia has a large-scale regional pattern. Our findings confirmed a bias in existing estimates. According to our results, the maximum land uplift rates reach 9.1 mm/year in the northern part of the Gulf of Bothnia, while previous estimates indicate that the maximum value is shifted westward towards land. Since GRACE data also comprises hydrological signals, we assessed its effect on the satellite gravitational information by applying different hydrological models. Our results ascertained that land uplift estimates in Fennoscandia were not significantly affected by long-term hydrological mass variations. According to our estimates over the period between 2003 and 2017, the hydrological loading effect was approximately 0.1 mm/year or less (in terms of the RMS differences when compared to the reference land uplift model). Hydrological signal variations (over the investigated period of two decades) were, therefore, dominated mainly by seasonal variations without the presence of secular trends. The results show that the land uplift model from GRACE has some discrepancies compared to existing models, so the main idea of this article is to combine land and satellite data. Therefore, we studied a combined land uplift model using GRACE and the latest land uplift model in Fennoscandia.

Keywords: Land uplift · GRACE · Glacial Isostatic Adjustment · satellite gravimetry · Earth observation

Presenter: Mohammad Bagherbandi (University of Gävle, Gävle, Sweden)

Session: Hydrologic signature in geodetic observations

Presentation day: Tuesday

TENTATIVE

Assessment of the network operation of high-resolution Lippmann tiltmeters installed for the monitoring of the Mur-Mürz fault line (Austria)

Enikő Barbély^{1,2}, Judit Benedek², Nikolaus Horn³, Bruno Meurers⁴, Roman Leonhardt³, Gábor Papp²

1 - Department of Geodesy and Surveying, Faculty of Civil Engineering, Budapest University of Technology and Economics, Budapest, Hungary

2 - HUN-REN Institute of Earth Physics and Space Science, Sopron, Hungary

3 - Geosphere Austria, Vienna, Austria

4 - Department of Meteorology and Geophysics, University Of Vienna, Vienna, Austria

Based on the decadal scientific cooperation between researchers of Geosphere Austria and the HUN-REN Institute of Earth Physics and Space Science, Hungary, a small network of Lippmann's nanoradian-resolution 2D vertical pendulum type tiltmeters was established for the monitoring of ground tilts related to tectonic processes in the Mur-Mürz fault zone. Since the beginning of the year 2023, five stations have been operational at 5 Hz sampling rate. Although tiltmeters are applied for detecting low frequency deformations, in addition to long periodic signals (e.g. tidal tilt), waveforms of several local and plenty of distant seismic events also were recorded by them. The synchrony and consistency of tilt waveforms observed during local events stimulated the idea of testing the performance of the network by estimating epicentre locations of the events, independently from seismological data. This contributes to the knowledge of the performance, limitations, etc., of the tilt network as a whole system, and of the high-frequency characteristics of the applied Lippmann-type tiltmeters. Since no standard procedure is available to process tilt data for seismological applications, two methods are provided for epicentre positioning. The geometric and the time delay inversion methods apply the plane and spherical wave front approaches, respectively. Both solve the problem of event localization in 2D based on the concept of apparent phase velocity of primary seismic waves. The external positioning accuracy defined as the average deviation between the epicentres estimated by the applied time delay inversion method and the well-established seismological data processing is ~ 4.5 km (median: 2.3 km). The inner and the external positioning accuracy estimates suggest proper network operation and high consistency between recorded ground tilt and ground velocity data. It may give a chance to integrate the high-frequency tilt waveforms in further local seismo-tectonic investigations.

Keywords: 2D Lippmann tiltmeters · Mur-Mürz monitoring network · assessment of network operation · epicentre determination · seismo-tectonic investigations

Presenter: Enikő Barbély (HUN-REN Institute of Earth Physics and Space Science, Sopron, Hungary)

Session: Seismogeodesy

Presentation day: Thursday

TENTATIVE

Turning GNSS Stations into Virtual Scales for Glaciers: A Paired Approach to Monitor Outlet Glacier Mass Change and Constrain GIA

Valentina R. Barletta¹, Cheng Gong², Andrea Bordoni³, Danjal L. Berg¹, Shfaqat A. Khan¹

1 - DTU Space, Technical University of Denmark, Denmark

2 - Department of Earth Sciences, Dartmouth College, United States of America

3 - DTU Compute, Technical University of Denmark, Denmark

GNSS networks in glaciated regions traditionally measure bedrock uplift, and in turn constrain Glacial Isostatic Adjustment (GIA). We propose a different perspective: once calibrated, the GNSS-Earth system becomes a virtual “scale”, monitoring individual outlet glacier mass change in near real-time.

Standard mass-balance products are very inaccurate near glacier termini, leading to large errors in both mass balance and GIA estimates. To overcome this, we introduce a model-independent "paired GNSS" strategy for Greenland's three largest outlet glaciers—Helheim, Jakobshavn Isbræ, and Kangerlussuaq. We use the difference of two continuously operating stations per glacier (one proximal to the terminus, one downstream), which allow us to remove common-mode background signals like regional GIA and broad ice-sheet variations. This isolates the localized elastic response to mass changes at the glacier “gate”. This signal is reproduced quite well by the output of physics-based ice-flow models tuned to each glacier. The calibration is bidirectional: the GNSS residual constrains model parameters like basal friction, while the calibrated model provides the elastic correction needed to extract the GIA signal. Our analysis confirms that seasonal and interannual bedrock variability is driven by ice-front advance and retreat within a 10 km zone of the termini, a dynamic poorly captured by other products.

While developed for three Greenland glaciers, this methodology is generalizable to any glacier worldwide. In regions with strong GIA signals, such as Antarctica and Patagonia, the paired approach simultaneously delivers the elastic correction for GIA estimation and a real-time mass-change proxy, making GNSS infrastructure doubly rewarding. We argue that this reframes GNSS in geodesy: from a passive witness of crustal deformation to an active, continuous monitor of cryospheric mass change.

Keywords: GNSS · glacier mass balance · glacial isostatic adjustment · elastic deformation

Presenter: Valentina R. Barletta (DTU Space, Lyngby, Denmark)

Session: Cryospheric deformation of the solid Earth

Presentation day: Wednesday

TENTATIVE

Time dependent Glacial Isostatic Adjustment in Iceland

Greta Bellagamba¹, Peter Schmidt², Thomas Givens³, Halldór Geirsson¹, Eyjólfur Magnússon¹,
Vincent Druin³, Joaquín Muñoz-Cobo Belart³, Sigrún Hreinsdóttir⁴, Benedikt Gunnar
Ofeigsson³, Freysteinn Sigmundsson⁵

1 - University of Iceland, Institute of Earth Sciences, Iceland

2 - University of Uppsala, Department of Earth Sciences, Geophysics, Sweden

3 - Icelandic Meteorological Office, Iceland

4 - Earth Science New Zealand

5 - University of Iceland, Institute of Earth Sciences

Glacial Isostatic Adjustment (GIA) is a major contributor to ongoing ground deformation in Iceland, driven by the response of the solid Earth to past and present changes in ice mass.

Iceland's geodynamic setting, characterized by a mantle plume in proximity to a plate spreading boundary, results in unusually low mantle viscosity and a thin lithosphere. These conditions promote rapid uplift and lead to high present-day uplift rates, reaching up to ~ 35 mm/yr beneath and near Vatnajökull, and lower uplift rates or subsidence in coastal regions, based on InSAR and GNSS observations. The uplift rates further vary on decadal timescales, highlighting the need for updated GIA models capable of capturing present-day deformation patterns.

In Iceland, active deglaciation is occurring, thus elastic and viscoelastic responses both contribute to the ground motion. As Iceland is also a place of tectonic spreading, subsidence of several millimeters per year can occur near the plate boundaries, affecting vertical deformation patterns both near the north coast and in the southwest.

GIA models predict vertical (and horizontal) land motion associated with ice mass change, including uplift beneath former ice loads. We perform updated numerical modelling of GIA, applying glacial load history from 1890 and on. We constrain the model by InSAR, GNSS, and historical levelling data, to better estimate Earth rheological parameters and to isolate the GIA signal from other localized deformation sources. We explore how the presence of a low-viscosity layer can influence the Earth response to glacial changes, comparing the model result to a long-term geodetic dataset.

Our main purpose is to output gridded time series of deformation for the entire country and islands, that may be used for corrections in future studies of local or regional deformation.

Keywords: Glacial Isostatic Adjustment · Long-term deformation · Iceland

Presenter: Greta Bellagamba (University of Iceland, Reykjavík, Iceland)

Session: Cryospheric deformation of the solid Earth

Presentation day: Wednesday

TENTATIVE

Understanding Jakobshavn's mass-transport variability from observations of ice, land, and ocean

Danjal L. Berg¹, Shfaqat A. Khan¹

1 - DTU Space, Denmark

Jakobshavn Isbræ, one of Greenland's fastest-flowing glaciers, experienced rapid mass loss between 2010 and 2016, followed by a period of slowdown and mass gain until 2019. To better understand this reversal in mass change pattern, we combined multiple Earth observation datasets, including annual elevation change from merged ArcticDEM strips, land deformation from the local GNET station KAGA, ocean temperature observations in Disko Bay, ice velocity profile of Jakobshavn Isbræ, and surface mass balance from MAR. The GNET station KAGA works like a compass as the horizontal movement is oriented away from the center of mass loss. The land motion caused by elastic deformation at KAGA shifted direction from 2016 to 2019 and pointed toward the glacier as it gained mass. The timing is correlated with the ocean temperature observations in Disko Bay as warm water could no longer enter the fjord. This caused the glacier to slow down and gain mass near the terminus. We conducted cross-correlation among key observables to identify lagged relationships between ocean temperature, glacier mass loss, and induced solid Earth deformation. Given the ongoing increase in ocean temperatures over the past couple of years, we expect Jakobshavn to exhibit more pronounced dynamic behaviour in the next few years.

Keywords: Cryosphere · Solid Earth deformation · Glacier dynamics

Presenter: Danjal Berg (Technical University of Denmark, Kongens Lyngby, Denmark)

Session: Cryospheric deformation of the solid Earth

Presentation day: Wednesday

**Excitation of the free core nutation: an updated analysis over the period
1986-2026**

Christian Bizouard¹, Robin Paniagua²

1 - Observatoire de Paris, France

2 - Paris Observatory LTE, France

The free nutation of the Earth's fluid core, which has a period of 430 days, not only perturbs the luni-solar nutation up to 50 mas, but also generates a pseudo-harmonic signal reaching an amplitude of 0.4 mas, and called Free Core Nutation (FCN). Until now, the mechanism maintaining the FCN is poorly modeled. With respect to a ground-fixed system it can be searched in the equatorial angular momentum exchanges occurring in the retrograde diurnal band between the solid Earth and its fluid layers. Unless hydro-atmospheric forcing can account for the FCN power, it cannot reconstruct its phase correctly. We shall address this issue in light of the most recent time series of the ocean and atmospheric angular momentum, and explore possible explanations for this discrepancy.

Keywords: free core nutation · atmospheric and ocean angular momentum · excitation

Presenter: Christian Bizouard (Observatoire de Paris, Paris, France)

Session: Earth rotation

Presentation day: Monday

Estimation of the Hydrological Mass Balance in Europe from GNSS Observations

Alessandra Borghi¹, Francesco Pintori¹, Valentina R. Barletta²

1 - Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Bologna, Italy

2 - DTU Space, Technical University of Denmark, Lyngby, Denmark

During the summer of 2022, many European countries experienced severe hydrological drought conditions due to an unusually warm and dry winter and spring. GNSS technology has proven effective in monitoring water levels in individual river basins in such exceptional circumstances (Pintori & Serpelloni, 2023), as well as after major storms (Serpelloni et al, 2018). Therefore, we know that a regional GNSS network with tailored signal analysis can monitor a single basin. Here, we intend to use the entire continental GNSS network (Serpelloni et al, 2022) to investigate variations in water content on a much larger scale and in a more general way, covering the whole of Europe. Something similar has been done in Greenland (Barletta et al, 2024) using the whole GNET network, and then compared with time-variable gravity data provided by the satellite missions GRACE and GRACE-FO. In Europe, tectonic deformations and the differing behaviour of river basins make this task more difficult, so the analysis begins with the identification of a subset of GNSS stations that are not subject to very local phenomena, such as charge and discharge of springs in karst aquifers. This does not affect the work, as the density of stations in Europe still allows us to obtain estimates of mass variation over homogeneous areas, unlike the GNSS network in Greenland, for example, where the stations are located along the coast. These estimates can be calibrated with hydrological models and validated with GRACE/GRACE-FO derived mass changes. The latter can also help us distinguish between surface and groundwater components.

A good knowledge of hydrological loading masses can help assess solid Earth elastic parameters more reliably at a regional scale.

Keywords: GNSS · hydrological loading · GRACE · Europe

Presenter: Alessandra Borghi (Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Bologna, Bologna, Italy)

Session: Hydrologic signature in geodetic observations

Presentation day: Tuesday

TENTATIVE

Status of the IERS Conventions Updates

Sharyl Byram¹, Nicholas Stamatakis¹, Maria Davis¹

1 - US Naval Observatory, USA

The International Earth Rotation and Reference Systems Service (IERS) Conventions describes the reference systems realized by the IERS, in addition to developing and maintaining the models and procedures used to support this endeavor. The IERS Conventions Centre has been preparing to release a major update to the conventions from the current Conventions (2010). This presentation will discuss the proposed changes to the chapters and their technical content as well as the changes in the associated experts and editors. A timeline for the proposed release of the updated conventions will also be discussed. Additionally, we will give a general overview of the procedure and criteria for requesting and releasing minor and moderate updates to the conventions that happen in between major releases.

Keywords: Conventions · IERS · Earth Rotation · standards

Presenter: Sharyl Byram (US Naval Observatory, Washington DC, USA)

Session: Earth rotation

Presentation day: Monday

Performance of IERS conventional models for diurnal and semidiurnal variations in UT1 and polar motion, assessed using a VLBI global solution

Sigrid Böhm¹, Hana Krásná¹

1 - Department of Geodesy and Geoinformation, TU Wien, Austria

High-precision analysis of the observations of space geodetic techniques requires the consideration of high-frequency, namely diurnal and semidiurnal, variations in the Earth rotation parameters (ERP) used a priori. The main drivers of such variations are the ocean tides; small contributions come from atmospheric tides and the impact of the lunisolar tidal potential on the triaxial figure of the Earth, also known as libration. The conventions of the International Earth Rotation and Reference System Service (IERS) provide models to predict the effects of ocean tides and libration. In geodetic VLBI, we now have more than forty years of observational data at our disposal. This allows for the clear separation of model terms that differ by only one cycle after 18.6 years (lunar nodal period). Therefore, terms like the sidelobes of the principal tidal constituents become resolvable without further constraints. The length of the observation time series also enables us to exclude the early years, during which sessions were conducted less frequently and the networks were more sparse. Using the VLBI module of the Vienna VLBI and Satellite Software, VieVS, we employ our own TRF and CRF solutions to estimate the residuals to the IERS high-frequency ERP models within a global solution. These models are applied in the calculation of the computed delay at each observation epoch. We then stack the normal equations of single session solutions, with Earth orientation parameters set up as daily estimates and diurnal and semidiurnal variations in UT1 and polar motion as sine and cosine coefficients, representing amplitudes and phases of the tidal variations. We base the global solution on our in-house Vienna TRF and CRF and solve for the coefficients of the ERP variations as global parameters. The resulting residual coefficients will be presented and compared to the results of previous VLBI solutions.

Keywords: Earth rotation parameters · subdiurnal tidal variations · VLBI

Presenter: Sigrid Böhm (TU Wien, Vienna, Austria)

Session: Earth rotation

Presentation day: Monday

TENTATIVE

Statewide Land Subsidence Using InSAR Analysis and Aquifer Storage Loss in Punjab, India

Shivam Chawla¹, Chandrakanta Ojha¹

¹ - Indian Institute of Science Education and Research (IISER) Mohali, India

Groundwater depletion in the Indo-Gangetic Basin (IGB) has been well documented. Among the IGB states, Punjab is the most affected due to heavy irrigation. The thick alluvial deposits, along with ongoing groundwater withdrawal, cause compaction of the aquifer system, leading to land subsidence. However, a few regional assessments capture differences in deformation and aquifer response across the area. In this study, we investigated land subsidence across the entire Punjab state (about 50,000 km²) using multi-temporal Sentinel-1 C-band SAR data from 2016 to 2023. Following the Small Baseline Subset (SBAS) technique implemented in the open-source software GMTSAR, we processed 1,023 ascending SLC scenes for deformation in the line-of-sight (LOS), which was converted to vertical land motion using unit-vector projection. The eastern Punjab region has a localized deformation of more than 100 mm/year. Southern areas have moderate subsidence of 20 to 30 mm/year, and western districts have lower deformation. To further understand how the aquifer behaves, we integrated the InSAR-derived deformation data with groundwater-level observations within the period of observation using poroelastic model. We linked changes in effective stress to the observed compaction to estimate skeletal storativity, separating it into elastic and inelastic parts using time-series analysis. Our findings indicate a total permanent loss of groundwater storage of about 3 km³ during the study period a volume comparable to the entire gross storage capacity of the Rana Pratap Sagar reservoir in India. These results highlight how Sentinel-1 InSAR, along with groundwater-level data, can provide insights into variations in aquifer compaction and measure permanent storage loss at the regional scale.

Keywords: Multi-Temporal InSAR · Land Subsidence · Groundwater Depletion · Aquifer-System Compaction · Sentinel-1

Presenter: Shivam Chawla (IISER - Indian Institute of Science Education and Research, Mohali, India)

Session: Hydrologic signature in geodetic observations

Presentation day: Tuesday

TENTATIVE

Basic Earth Parameters from VLBI observations using Bayesian inversions in the time domain: updated insights of the Earth's interior

Yuting Cheng¹, Véronique Dehant^{1,2}, Attilio Rivoldini¹, Jérémy Requier¹, Christian Bizouard³

1 - Royal Observatory of Belgium, Belgium

2 - Université Catholique de Louvain, Belgium

3 - LTE, Observatoire de Paris, France

We present updated estimates of Basic Earth Parameters (BEP) from VLBI Celestial Pole Offset (CPO) time series spanning 1980-2025 using an ensemble Markov Chain Monte Carlo (MCMC) Bayesian inversion. Building upon Koot et al. (2008), we incorporate recent advances in ocean tidal modeling (Cheng & Bizouard, 2025) and update several aspects of the algorithm. Key improvements include: (1) implementation of a cubic spline representation for Free Core Nutation (FCN) amplitude variations, which significantly reduces multimodality in FCN-related parameter in MCMC sampling compared to a linear representation; (2) integration of updated Ocean Tidal Angular Momentum (OTAM) values from FES2014 ocean tidal atlas (Lyard et al., 2021), without the empirical 0.7 scaling factor previously applied in the construction of the last adopted nutation model MHB2000; and (3) utilization of five diverse CPO series from different analysis centers spanning up to 45 years of observations.

The results clearly suggest the necessity of a thorough revision of the nutation model, which will improve our understanding of the Earth's interior, and at the same time, improve geodetic observations by providing a better a priori model of nutation. This is relevant for the upcoming high-precision geodetic missions such as Genesis and similar missions in the future.

Keywords: Basic Earth Parameters · Celestial Pole Offsets · Earth Rotation · Core-Mantle Coupling · Very Long Baseline Interferometry

Presenter: Yuting Cheng (Royal Observatory of Belgium, Uccle, Belgium)

Session: Earth rotation

Presentation day: Monday

GIAMachine: a community-driven rescue and recovery initiative for legacy sea level and glacial isostatic adjustment modeling data

Roger C. Creel^{1,2,3}, Samuel T. Kodama^{4,5}, Joseph P. Tulegenko⁶, Rebekka Steffen⁷, Holger Steffen⁷, Riccardo Riva⁸, Justin Quinn⁹, Jason P. Briner⁶

1 - Department of Geology

2 - Geophysics, Texas A

3 - M University, College Station, TX, USA

4 - Department of Earth

5 - Planetary Sciences, University of California, Santa Cruz, USA

6 - Department of Earth Sciences, University at Buffalo, Buffalo, USA

7 - Lantmäteriet, Sweden

8 - Delft University of Technology, Delft, The Netherlands

9 - Tidbit Software, California, USA

The glacial isostatic adjustment (GIA) and sea level modeling communities have historically lagged other fields in adhering to the FAIR principles of making model outputs findable, accessible, interoperable, and reusable - a delay that has slowed scientific discovery. While sharing model outputs has improved recently, usability of available outputs continues to be hindered by lack of standardization. Meanwhile, legacy model outputs can be lost as the technology storing them grows obsolete and their creators retire or leave academia.

The GIAMachine initiative addresses this problem. GIAMachine aims to make accessible as many published GIA and sea level model outputs as are retrievable by (i) cataloguing and standardizing published GIA and sea level model outputs, (ii) contacting authors of published-but-inaccessible models to encourage them to upload their outputs to DOI-minting repositories, (iii) partnering with the GHub science gateway to make a long-term home for these newly available outputs, (iv) building Jupyter notebooks on GHub that make these models interoperable and easy to use, and (v) encouraging the GIA and sea level modeling communities to follow the FAIR principles.

Our poster will introduce the GIAMachine online portal and outline outstanding challenges. We appreciate community input for designing a living resource that meets the specific needs of current and future scientists.

Keywords: Glacial isostatic adjustment · Sea level change · Modelling · FAIR data · Open access

Presenter: Holger Steffen (Lantmäteriet, Gavle, Sweden)

Session: Cryospheric deformation of the solid Earth

Presentation day: Wednesday

TENTATIVE

Influence of Atmospheric Tides on Celestial Pole Offsets and Its Modulation by Climate Variability

Xiaoming Cui¹, Weiwei Yang¹, Heping Sun¹

1 - Innovation Academy for Precision Measurement Science and Technology, Chinese Academy of Sciences, China

The atmosphere plays an important role in exciting different components of Earth's rotation variations. Key signals in celestial pole offsets (CPO), including free core nutation (FCN) and nutation residuals, appear in the seasonal to interannual frequency band in the celestial reference frame. However, when transformed to the terrestrial reference frame, these signals shift to the diurnal frequency band. Tides are the dominant dynamic process in this diurnal band, and the oscillations they generate in the atmosphere and ocean system therefore have a significant impact on CPO. We found correlations between certain climate phenomena and the time-varying characteristics of CPO. The underlying mechanism likely involves climate variations modulating atmospheric tides, which in turn excite changes in CPO. Using the Earth's Rotation excitation theory and numerical analysis, we conducted a joint analysis using CPO data, atmospheric reanalysis data, and surface fluid angular momentum data to estimate the influence of temporal variations in atmospheric tides on the excitation of different components within the CPO. Furthermore, considering that certain climatic phenomena can induce responses in atmospheric tides, we discussed the modulating effect of climate change on the CPO through atmospheric tides.

Keywords: atmospheric tide · climate change · Celestial pole offsets

Presenter: Xiaoming Cui (Innovation Academy for Precision Measurement Science and Technology, Chinese Academy of Sciences, Wuhan, China)

Session: Tidal and non-tidal loading

Presentation day: Tuesday

Preliminary Results of Updated EOP Combination Methodology from IERS Rapid Service / Prediction Centre

Maria Davis¹, Jessica Page¹, Sharyl Byram¹

¹ - U.S. Naval Observatory, USA

The IERS Rapid Service / Prediction Centre (RS/PC) recently deployed an updated Earth Orientation Parameter (EOP) combination algorithm that produces a more robust daily and weekly EOP solution for the Finals and Bulletin A products, respectively. This new algorithm incorporates expanded functionality and improved software, allowing new EOP Analysis Centers and observing techniques to be integrated into the combined solution more easily. The RS/PC has also adopted an enhanced AAM pre-processing methodology previously presented by Page et al. (2026) that we anticipate will improve short-term UT1-UTC predictions. Additional improvements to the combined solution are planned to be implemented in the next year. The RS/PC will provide performance results for the new algorithm from hindcast simulations and preliminary production results.

Keywords: Earth Orientation Parameters · combination algorithm · IERS

Presenter: Maria Davis (US Naval Observatory, Washington, D.C., USA)

Session: Earth rotation

Presentation day: Monday

Towards a new nutation model

Veronique Déhant^{1,2}, Marta Folgueira³, Jérémy Rekier^{1,2}, Santiago A. Triana^{1,2}, Daoud Laariara^{2,4}

1 - Université Catholique de Louvain (UCLouvain) - Earth and Life Institute

2 - Royal Observatory of Belgium (ROB)

3 - Universidad Complutense de Madrid, Spain

4 - UCLouvain - Institute of Mechanics, Materials and Civil Engineering

Earth's orientation varies through long-term and periodic motions of its rotation axis, known as precession and nutation. These motions are driven by luni-solar and planetary forcing and shaped by coupled processes within the Earth system, including core dynamics, mantle deformation, resonances, and atmosphere-ocean interactions.

We aim to develop a next-generation model of Earth's orientation that meets the stringent accuracy requirements of modern geoscience and space applications. Millimetre-level precision is now required for both Earth-based observations of space and space-based observations of Earth, demanding a fundamental shift from empirical to fully physical modelling.

Our approach addresses five key aspects: (i) high-precision gravitational forcing; (ii) Earth's internal response, including fluid core dynamics and solid-Earth deformation; (iii) atmospheric and oceanic contributions; (iv) resonance phenomena; and (v) their integration into a unified model surpassing IAU2000A. Unlike IAU2000A, which relies on simplified analytical formulations with empirically adjusted parameters, we construct a fully physical model of nutation by integrating Earth's dynamics from the deep interior to the surface.

We will compute high-precision gravitational forcing from the Moon, Sun, and planets using updated ephemerides, including geocentre motion. Earth's internal response will be described through a transfer function capturing the coupled behaviour of the deformable inner core, fluid outer core, and inelastic mantle. A central innovation is the use of our in-house software KORE to incorporate magnetic, topographic, and viscous effects and to simulate realistic core flows, including inertial waves so far neglected.

The outcome is a coherent, physically consistent model of nutation with unprecedented accuracy. These developments will be pursued in close interaction with the scientific community.

Keywords: Nutation · Core · Earth rotation

Presenter: Daoud Laariara (UCLouvain, Belgium)

Session: Earth rotation

Presentation day: Monday

TENTATIVE

Geodetic observations in West Antarctica reveal geodynamically consistent 3-D mantle viscosity

Donna L. dePolo¹, Tao Yuan¹, Matt A. King², Shijie Zhong¹

1 - University of Colorado Boulder, USA

2 - University of Tasmania, Australia

The recent rapid ice loss in West Antarctica has led to significant ice surface lowering, regional bedrock uplift, and gravity reduction, as measured by geodesy. The bedrock (crustal) motions and gravity changes result from glacial isostatic adjustment (GIA), a process controlled by Earth's viscoelastic properties and deglaciation history. In this study, we present GIA models with geodynamically consistent three-dimensional mantle viscoelastic structures and reconstructed ice history for Antarctica from 1900 to 2020 which explain both the observed GNSS crustal motions and GRACE gravity changes in West Antarctica. We will additionally explore the effect of transient viscosity on these results. Our study demonstrates that a mantle rheology including a weak asthenosphere and temperature-dependent viscosity is applicable to both mantle convection at million-year timescales and ongoing decadal GIA occurring in West Antarctica.

Keywords: Glacial isostatic adjustment · West Antarctica · Global Navigation Satellite Systems (GNSS) · Gravity Recovery And Climate Experiment (GRACE)

Presenter: Donna dePolo (University of Colorado Boulder, Boulder, CO, United States of America)

Session: Cryospheric deformation of the solid Earth

Presentation day: Wednesday

Bridging Multi-Band VLBI Networks: A Comparative Insight into Earth Orientation Parameters

Sujata Dhar¹, Chaiyaporn Kitrapacha², Robert Heinkelmann³, Georg Beyerle³, Harald Schuh¹

1 - Technische Universität Berlin, Berlin, Germany

2 - Faculty of Engineering, Chulalongkorn University, Bangkok, Thailand

3 - German Research Centre for Geosciences (GFZ), Potsdam, Germany

Following the determination of the Terrestrial Reference Frame (TRF) and Celestial Reference Frame (CRF) through a combined analysis of Very Long Baseline Interferometry (VLBI) observations at three different frequency bands, Earth Orientation Parameters (EOP) are estimated and analyzed. The analysis integrates the VLBI data provided by the International VLBI Service for Geodesy and Astrometry (IVS) at S/X-bands (8.4 and 2.3 GHz) and VGOS broad bands (3-12 GHz) and by the K-band Astro2Geo VLBI Project at K-band (24 GHz). A statistical assessment is carried for EOP series derived from S/X-only, VGOS-only, K-band-only, and combined datasets. In addition, EOP estimates obtained from 24-hour S/X, VGOS, and K-band sessions conducted on the same day is directly inter-compared. In principle, EOP values corresponding to identical observation epochs are expected to be consistent across all datasets. However, any detected discontinuities in the EOP series is identified and quantified. Such differences may provide valuable insight into band-dependent modeling assumptions and the a- priori constraints applied in the analysis.

Keywords: Earth Orientation Parameters · Very Long Baseline Interferometry · Legacy S/X · VGOS · K-band

Presenter: Sujata Dhar (Technische Universität Berlin, Berlin, Germany)

Session: Earth rotation

Presentation day: Monday

Augmenting the ESA Earth System Model 3.0: Auxiliary datasets for geodetic method development

Henryk Dobsław¹, Linus Shihora¹

1 - GFZ Helmholtz Centre for Geosciences, Potsdam, Germany

The ESA Earth System Model (ESA ESM) provides synthetic data on the time-variable global gravity field from realistic mass variations in atmosphere, oceans, terrestrial water storage, continental ice masses, and the solid Earth on a wide set of spatial and temporal scales. The latest version 3.0 of the ESA ESM includes a small ensemble of co- and post-seismic earthquake signals; an updated GIA model; mass balance signals from high-mountain glaciers; and a more realistic representation of ice sheet dynamics. The ESM also provides ocean bottom pressure variations along the western slope of the Atlantic basin, representing variations in the meridional overturning circulation as a critically important component of the interactively coupled global climate system. ESA ESM 3.0 is available as Stokes Coefficients expanded up to degree/order 180 with 6-hourly resolution from January 2007 until December 2020. While ESA ESM is widely applied as a source model in end-to-end simulation studies for future gravity missions, it has been also used to study novel gravity observing concepts on the ground, and could potentially be utilized for other geodetic tasks as well. In this contribution, we will discuss possible options to augment the ESA ESM 3.0 with further auxiliary datasets that are consistent with the Stokes Coefficients in order to facilitate simulation studies for other space geodetic techniques, the development of advanced signal separation methods, or the evaluation of spatial downscaling algorithms tailored to satellite gravimetry data.

Keywords: satellite gravimetry · time-variable gravity · future missions

Presenter: Henryk Dobsław (GFZ Helmholtz Centre for Geosciences, Potsdam, Germany)

Session: Hydrologic signature in geodetic observations

Presentation day: Tuesday

Optimization of Stochastic Models in Kinematic PPP for Ocean Tidal Loading Detection in East Antarctica

Yohannes Getachew Ejigu¹, Maaria Nordman², Jyri Näränen¹, Arttu Raja-Halli¹, Hannu Koivula¹

1 - Finnish Geospatial Research Institute, Finland

2 - Aalto University, Finland

Accurate recovery of sub daily geophysical signals from kinematic Precise Point Positioning (PPP) depends critically on stochastic parameterization. In Antarctica, where mass change modeling remains limited by sparse satellite altimetry and ground observations, refining GNSS based signal extraction is essential for evaluating regional loading models. This study assesses how position and tropospheric process noise settings influence the detectability of ocean tidal loading (OTL) signals using one year of GNSS data from six stations in Dronning Maud Land (DML), East Antarctica. Data are processed with GipsyX 2.5, and a two dimensional sweep of position and zenith wet delay (ZWD) random walk parameters are performed. Solutions are evaluated using multiple diagnostics, including vertical RMS, tidal amplitude stability, correlation with kinematically estimated ZWD, and coherence with OTL displacements predicted by the FES2014 and FES2022 models. Results show that stochastic parameterization controls a fundamental trade off between signal suppression and tropospheric leakage. An optimal parameter region is identified (position $RW \approx 3 \times 10^{-4} - 4 \times 10^{-4} \text{ m}/\sqrt{s}$; ZWD $RW \approx 3 \times 10^{-5} - 2 \times 10^{-4} \text{ m}/\sqrt{s}$), maximizing coherence with modeled OTL while minimizing vertical noise and atmospheric contamination. These findings demonstrate that environment specific stochastic tuning is essential and that globally recommended parameter values are not universally transferable, particularly in polar regions where atmospheric dynamics and loading signals differ markedly from mid latitude conditions.

Keywords: Kinematic PPP · Ocean Tidal Loading · Stochastic Parameterization · East Antarctica

Presenter: Yohannes Getachew Ejigu (Finnish Geospatial Research Institute, Espoo, Finland)

Session: Tidal and non-tidal loading

Presentation day: Tuesday

Integrated Altimetry and Tide Gauge Analysis of Sea Level Change and Land Subsidence in Alexandria (1993–2026)

Mostafa Elwan¹

1 - National Research Institute of Astronomy and Geophysics (NRIAG), Helwan, Cairo, Egypt

Reliable estimates of sea level change are crucial for supporting coastal planning and flood risk management in low-lying regions such as Alexandria. Tracking sea level rise in Alexandria remains challenging due to the gap in local tide gauge records after 2006. To overcome this limitation, this study integrates historical in-situ observations (1993-2006) with satellite radar altimetry data extending to early 2026. Using missions from TOPEX/Poseidon to Sentinel-6, satellite-derived Virtual Tide Gauges were developed to reconstruct coastal sea-level variability in the absence of ground measurements.

A key aspect of the methodology is the separation of absolute sea-level change from vertical land motion along the western Nile Delta. Focusing on the geodynamic behavior of the Alexandrian shelf, the results reveal a mean absolute sea-level rise of approximately 3.4 mm/year over the 1993-2026 period. When combined with an estimated regional subsidence rate of 2.1 mm/year, the relative sea-level rise increases to about 5.5 mm/year, highlighting the combined impact of oceanic and land-based processes.

This integrated approach provides a continuous multi-decadal record despite the absence of recent tide gauge data. The findings offer a robust geodetic reference for coastal risk assessment in Egypt and emphasize the growing importance of satellite geodesy in regions with limited ground-based observations.

Keywords: Sea Level Rise · Satellite Altimetry · Tide Gauge · Land Subsidence · Alexandria, Nile Delta

Presenter: Mostafa Elwan (National Research Institute of Astronomy and Geophysics (NRIAG), Helwan, Cairo, Egypt)

Session: Tidal and non-tidal loading

Presentation day: Tuesday

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Geodetic Separation of Land Motion and Sea-Level Change in a GIA-Dominated Region

Muharrem Hilmi Erkoç¹

1 - Department of Geomatic Engineering, Yildiz Technical University, Āřstanbul, Turkey

The understanding of the interaction between vertical land movement (VLM) and changes in sea level is a crucial step for interpreting geodetic observations appropriately, especially in areas that are significantly influenced by glacial isostatic adjustment (GIA). In this study, we focus on the relative variations in sea level in the Gulf of Bothnia through the use of tide gauge and satellite altimetry, and other independent geodetic observations.

The results indicate that changes in relative sea level (RSL) are not constant and are influenced by different factors, especially those that are significant over different time scales. The results also indicate that absolute and relative variations in sea level can be used to determine consistent estimates of VLM, while also highlighting differences that are attributed to GIA deformation.

The results also indicate that the estimates for VLM are consistent with other independent geodetic observations, and this is a crucial step in understanding the use and application of different observation systems. The results also highlight the need to consider temporal variations to improve the understanding and application of geodetic analysis for sea level, especially in areas that are significantly influenced by GIA.

Keywords: Glacial Isostatic Adjustment · Vertical Land Motion · Relative Sea Level · Satellite Altimetry · Baltic Sea

Presenter: Muharrem Hilmi Erkoç (Yildiz Technical University, Istanbul, Turkey)

Session: Cryospheric deformation of the solid Earth

Presentation day: Wednesday

How is GRD affecting the Ice Dynamics and Sea-Level Rise Potential of the Northeast Greenland Ice Stream?

Grace Ertel¹, Sophie Coulson¹, H el ene Seroussi², Mathieu Morlighem², Lambert Caron³

1 - University of New Hampshire, USA

2 - Dartmouth College, USA

3 - Jet Propulsion Laboratory, California Institute of Technology, USA

The Northeast Greenland Ice Stream (NeGIS) drains ~12% of the Greenland Ice Sheet's total discharge and is the largest submarine drainage basin in Greenland by sea-level rise potential (1.1 m; Morlighem et al. 2017, An et al. 2020). This ice stream drains into two marine terminating glaciers: Zachariae Isstr om (ZI) and Nioghalvfjerdingsfjorden (79N). These glaciers have recently experienced rapid retreat and thinning (Khan et al. 2022). As ice mass loss continues, feedback from changing bedrock topography and changing local sea level has the potential to alter ice sheet dynamics at the grounding line of ZI and 79N. Accurately accounting for GRD (gravitational, deformational, and rotational changes in solid earth and sea-surface height) in future projections is therefore important to understanding their contribution to sea-level rise. To determine the effect GRD will have on the future stability of this region, we use the Ice-sheet and Sea-level System Model (ISSM; Larour et al. 2012). ISSM includes a coupled model component that incorporates any GRD-induced perturbations to geocentric sea-level and bedrock elevation as the ice sheet evolves. This coupled model allows us to assess and quantify the feedback mechanisms between ice-sheet stability and GRD effects, which have previously been identified as key interactions in other regions, such as the Amundsen Sea Embayment. Using CMIP6 climate forcing, we estimate how including GRD feedback affects the evolution of ZI and 79N and their contribution to global mean sea-level rise, out to the year 2300.

Keywords: GIA · Marine Ice Sheet Instability · Greenland Ice Sheet

Presenter: Grace Ertel (University of New Hampshire, Durham, NH, USA)

Session: Cryospheric deformation of the solid Earth

Presentation day: Wednesday

EPOS-GNSS Data and Products for Geodynamics

Rui Fernandes¹, Carine Bruyninx², Luís Carvalho^{3,4}, Paul Crocker^{3,4}, Gaël Janex⁵, Juliette Legrand², Jean-Luc Menut⁶, Michela Ravanelli⁶, Anne Socquet⁵, Holger Steffen⁷, Mathilde Vergnolle⁶, EPOS-GNSS Members⁸

1 - University of Beira Interior (UBI), Instituto Dom Luiz / Collaboratory for Geosciences, Portugal

2 - Royal Observatory of Belgium (ROB), Reference Systems and Planetology, Belgium

3 - University of Beira Interior (UBI), Instituto Dom Luiz

4 - Collaboratory for Geosciences, Portugal

5 - Université Grenoble Alpes, ISTerre, France

6 - Université Côte d'Azur, Observatoire de la Côte d'Azur, Géoazur, France

7 - Lantmäteriet, Sweden

8 - EPOS-GNSS, Europe

EPOS provides integrated access to data, services, and expertise for Solid Earth science. Within EPOS, the GNSS Thematic Core Service (EPOS-GNSS) disseminates quality-controlled GNSS data and products that support the study of crustal deformation and its temporal variability. EPOS-GNSS currently integrates data from more than 2,100 permanent GNSS stations across Europe, providing access to station metadata, daily GNSS observations, coordinate time series, velocity fields, strain rate maps, and long-term data-quality information through distributed data nodes, dedicated portals, APIs, and the GLASS software suite. These services provide a consistent basis for analysing deformation signals associated with tectonic processes, volcanic activity, loading effects, and environmental mass redistribution. In the context of TIGER, EPOS-GNSS can contribute to several research themes by enabling homogeneous access to GNSS observations and derived products relevant to Earth rotation studies, tidal and non-tidal loading, hydrological and cryospheric deformation, volcanogeodesy, and seismogeodesy. Coordinate time series and velocity fields are essential for separating secular deformation from transient signals, identifying regional strain patterns, and supporting the interpretation of geodynamic processes across different spatial and temporal scales. Although EPOS-GNSS currently provides daily data and products, future high-rate GNSS products would further strengthen its role in multi-disciplinary applications, particularly through closer interaction with the EPOS Seismology and Volcano Observations TCSs. Such developments would support rapid co-seismic displacement estimation, volcano monitoring, and improved characterization of short-period deformation

processes. This presentation summarizes the current status of EPOS-GNSS services and discusses their relevance for TIGER-related geodynamic studies.

Keywords: GNSS · EPOS · geodynamics · geodetic products

Presenter: Rui Fernandes (University of Beira Interior, Covilhã, Portugal)

Session: Seismogeodesy

Presentation day: Thursday

The Role of Coseismic Model Specifications in Constraining Andean Geodynamics

Mara A. Figueroa^{1,2}, Demián Gómez¹, Michael G. Bevis¹, Robert Smalley Jr.³

1 - Division of Geodetic Science, School of Earth Sciences, The Ohio State University, Columbus, OH, USA

2 - Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA

3 - Center for Earthquake Research and Information, The University of Memphis, Memphis, TN, USA

The South-Central Andes are best described as a three-plate system in which the Andean block is compressed between the Nazca plate and the South American craton. Using constraints from the 2010 Mw 8.8 Maule and 2015 Mw 8.3 Illapel earthquakes, we identify a consistent coseismic response: basal décollements beneath the eastern fold-and-thrust belts slip in a normal sense during rupture, reversing their interseismic motion and reflecting transient stress redistribution following megathrust failure.

We show that this signal is systematically overlooked in conventional coseismic inversions. Models based on simplified Earth structure, megathrust-only geometries, and forearc-limited GNSS datasets tend to absorb forearc-backarc coupling into spatially coherent residuals rather than resolving it explicitly. Reanalysis of the Maule earthquake using a physically consistent three-plate model, incorporating a spherical, layered, self-gravitating Earth, full-orogen GNSS coverage extending into the backarc, and geometrically robust fault discretization, reveals coherent slip on the basal décollement that accounts for these residual patterns.

By integrating these coseismic results with independent interseismic observations, we develop a unified framework for Andean orogenic-wedge dynamics that links short-term rupture with long-term tectonic evolution and resolves persistent discrepancies in megathrust slip models. These findings demonstrate that simplified inversion frameworks can mask fundamental deformation processes, and that three-plate representations are required to capture the full earthquake cycle in Andean subduction systems.

Keywords: Coseismic deformation · Andean geodynamics · GNSS

Presenter: Mara A. Figueroa (Jet Propulsion Laboratory, Pasadena, California, United States)

Session: Seismogeodesy

Presentation day: Thursday

TENTATIVE

Unmasking the Signal Masquerade: Case studies of Surface Loading and Tectonic Aliasing for each Other

Jeffrey T. Freymueller¹

1 - Michigan State University, USA

Accurate modeling of deformation depends on correctly isolating the signal that you wish to model, screening out other effects. Here I show case studies in which long-wavelength deformation caused by Glacial Isostatic Adjustment (GIA) and/or present-day surface loading may be confused for a tectonic deformation signal, and thus potentially bias tectonic model inferences.

GIA produces a horizontal strain signal that spans much of the North American continent. In the forebulge region and outside of it, the general pattern of present-day horizontal deformation shows motion inward toward the load center, with a peak horizontal signal on the order of 1 mm/yr. In Mexico, the GIA horizontal velocities are oriented toward the north to north-east, a direction very similar to the orientation of velocities that result from the slip deficit at the Mid-America Trench. In the far field, the bias due to GIA is not negligible. Explaining a far-field motion away from the trench requires a very deep locking depth, so a failure to remove the GIA signal can bias estimates of locking depth, or create inconsistency between models that fit the horizontal and vertical observations.

In the Lesser Antilles subduction zone, there is an inconsistency between observed horizontal and vertical deformation. Horizontal observations show a lack of contractional strain resulting from the slip deficit on the subduction zone. However, both GPS and coral paleogeodesy show subsidence in the subduction zone, which has in the past been interpreted solely in the context of tectonic and postseismic models. However, the combination of GIA and surface loading due to present cryospheric change predicts a substantial part of the observed subsidence. While the subsidence signal is not entirely explained by present models, removal of the non-tectonic deformation substantially reduces the inconsistency between observed horizontal and vertical deformation.

Keywords: GIA · subduction · Aliasing · deformation · models

Presenter: Jeff Freymueller (Michigan State University, East Lansing, MI, USA)

Session: Cryospheric deformation of the solid Earth

Presentation day: Wednesday

TENTATIVE

Multi-scale Post-Fire Permafrost Deformation Revealed by InSAR, Onsite Survey and LiDAR in North Yukon, Canada

Masato Furuya¹, Cao Zetao¹, Kazuki Yanagiya²

1 - Hokkaido University, Japan

2 - Japan Aerospace Exploration Agency, Japan

Wildfires are impacting permafrost in circum-Arctic regions, yet the post-fire evolution of permafrost and its spatial variability have been uncertain. Here, we integrate Sentinel-1 (C-band) and ALOS-2 (L-band) InSAR data with the onsite survey in September 2025 as well as LiDAR data acquired in 2013 and 2021 along the Dempster Highway in North Yukon. Our observations from InSAR and fieldwork confirm the three-stage evolution (Cao & Furuya 2025). In the first 5 to 10 years after fire, we detected rapid subsidence by InSAR, which reaches 20-50 mm during thawing seasons and exceeds 100 mm in the first few post-fire years. In the next recovery stage of 15 to 30 years post-fire, InSAR indicates net uplift of up to 40 mm per year. Finally, three to four decades after fire, we observe ground stabilization, indicated by limited seasonal deformation and cumulative deformation similar to unburned areas. The onsite measurements at the 8 sites largely confirm the recovery of the active layer and the ground ice reformation under the regrowth of vegetation. We measured thaw-depth by probing, soil temperature profile, and thickness of the surface organic layer. Unexpectedly, at the 1991 and 2005 fire scars where InSAR indicated uplift signals, we encountered “hole” and “crack” known as thermokarst. InSAR cannot detect their development because of its coarse resolution.

To capture the signals of these collapse scars, we used LiDAR data with 1 m resolution acquired in 2013 and 2021 by the Yukon Government. The LiDAR-based elevation change reached 1 m in the cracks, demonstrating that microscale collapses were an order of magnitude larger than the fire-scar-scale deformation detected by InSAR. Nonetheless, the 2013-2021 elevation changes also indicate an overall ground uplift by up to 15 cm, consistent with InSAR. Deformation from both LiDAR and InSAR implies an overall permafrost recovery with the development of smaller-scale thermokarst possibly due to the loss of ground ice.

Keywords: Permafrost · Wildfire · InSAR · LiDAR · Onsite survey

Presenter: Masato Furuya (Hokkaido University, Sapporo, Hokkaido, Japan)

Session: Cryospheric deformation of the solid Earth

Presentation day: Wednesday

TENTATIVE

Monitoring of the Santorini 2025 volcano-tectonic unrest: contribution of GNSS data and international networks

Athanassios Ganas¹, Vasilis Sakkas², Alessandro Bonforte³, Philippe Vernant⁴, Pierre Briole⁵, Efstratios Liadopoulos¹, Erik Doerflinger⁴, Salvatore Consoli³, Panagiotis Elias⁶, Nikolaos Madonis⁷, Ioannis Mintourakis⁷, George Goutsos⁸

1 - National Observatory of Athens, Institute of Geodynamics, Athens, Greece

2 - Department of Geology and Geoenvironment, National and Kapodistrian University of Athens, Zografou, Greece

3 - Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio Etneo, Catania, Italy

4 - Laboratoire Géosciences Montpellier, Université de Montpellier, Montpellier, France

5 - CNRS, École Normale Supérieure, PSL Research University, Paris, France

6 - Department of Geology, University of Patras, Rio, Greece

7 - National Technical University of Athens, School of Rural, Surveying and Geoinformatics Engineering, Athens, Greece

8 - National and Kapodistrian University of Athens/National Observatory of Athens, Athens, Greece

Since late summer of 2024 the Santorini Volcanic Complex (SVC) in South Aegean Sea (Greece) entered another phase of unrest as GNSS data indicated the start of strong deformation onshore Thera Island followed by increased seismic activity, offshore, NE of the island in late January - February 2025. The seismicity pattern indicated swarm characteristics of mainly tectonic origin that culminated during February 2025, and subsequent seismic activity declined but remained above the unrest levels during the rest of 2025 and early 2026. In terms of ground deformation, cm to dm-size displacements were recorded during the period August 2024 - December 2025. In early 2025 several groups led by NOA installed new permanent GNSS equipment on Thera and surrounding islands. This GNSS instrumentation reached 32 sites at mid-April 2025. Those stations provide a wealth of open data that we use to study the evolution of the deformation in the broad South Cyclades Islands. Overall, the GNSS data showed an inflation of the Thera volcano since August 2024 that ended in January 2025 (Briole et al. 2025). The modelled magma source was located near the inflation centre of 2011-2012 unrest. During February 2025, the ground displacements in South Cyclades islands depicted a NE-SW converging pattern between Thera and Anydros, and a NW-SE diverging pattern between Ios-Naxos and Astypalaia Islands. During March - December 2025, the deformation continued with the positive, 3D baseline rate changes between GNSS stations exceeding the pre-unrest rates thus indicating a nearly-aseismic

opening of the Santorini - Amorgos graben. This implies that new magma continued to arrive at shallow crustal depths and/or tectonic relaxation (slow slip) of normal fault close to Anydros.

Briole, P., Ganas, A., Serpetsidaki, A., et al. (2025). Volcano-tectonic interaction at Santorini. The crisis of February 2025. Constraints from geodesy, *Geophys. J. Int.* 242(3), ggaf262, doi:10.1093/gji/ggaf262.

Keywords: Santorini Volcano Complex · Seismic unrest · GNSS · Ground deformation

Presenter: Athanassios Ganas (National Observatory of Athens, Athens, Greece)

Session: Volcanogeodesy

Presentation day: Thursday

Assessing GNSS Detectability of Transient Tectonic Deformation Under Cascadia-Constrained Observational Conditions.

Cristian Garcia^{1,2}, Benjamin Männel¹, Roland Hohensinn¹, Jens Wickert^{1,2}, Jonathan Bedford³

1 - GFZ Helmholtz Centre for Geosciences, Germany

2 - Technische Universität Berlin, Germany

3 - Ruhr University Bochum, Germany

Transient tectonic signals such as slow slip events (SSEs) often produce surface displacements close to the noise level of Global Navigation Satellite System (GNSS) observations, making their detection strongly dependent on temporal resolution, stochastic noise behavior, and positioning strategy. Although Cascadia represents one of the most extensively monitored environments for episodic tremor and slip, the observational limits controlling the detectability of transient deformation remain insufficiently quantified.

In this study, we present a synthetic-experimental framework designed to evaluate the detectability of transient tectonic signals under realistic GNSS observational conditions constrained by Cascadia displacement time series. Rather than reproducing specific historical events, the framework generates controlled synthetic deformation scenarios representative of transient signals commonly observed in the region, including displacement amplitudes and temporal characteristics consistent with Cascadia slow slip activity.

The synthetic transients are combined with realistic GNSS stochastic behavior and temporal sampling characteristics representative of Cascadia GNSS displacement time series. The framework is designed to investigate how transient duration, signal amplitude, sampling interval, and GNSS positioning strategy influence the detection of short-duration tectonic deformation signals and their discrimination from stochastic GNSS variability. Particular attention is given to comparative observational scenarios associated with PPP- and RTK-based positioning approaches. This work aims to provide a controlled framework for assessing observational limitations in GNSS-based transient deformation monitoring and for improving interpretation of subtle tectonic signals near the GNSS detectability threshold.

Keywords: Transient Tectonic Deformation · Slow Slip Events · GNSS · PPP · RTK

Presenter: Cristian Garcia (GFZ Helmholtz Centre for Geosciences, Potsdam, Germany)

Session: Seismogeodesy

Presentation day: Thursday

TENTATIVE

Absolute gravimetry in South Patagonia for geodynamic applications

André Gebauer¹, Erik Brachmann¹, Alfredo Pasquaré², Axel Rülke¹, Mirko Scheinert³, Andreas Richter⁴, Benjamin Goebel³, Eric Marderwald^{4,5}, Ezequiel D. Antokoletz¹, Hartmut Wziontek¹,
Mauricio Gende², Gerardo Connon⁵, Steffen Welsch⁶

1 - Federal Agency of Cartography and Geodesy, Germany

2 - Argentine-German Geodetic Observatory (CONICET), Argentina

3 - TUD Dresden University of Technology, Germany

4 - Universidad Nacional de La Plata, Centro MAGGIA, Argentina

5 - Estación Astronómica Río Grande, Argentina

6 - Glaciarium, El Calafata, Argentina

The project “Gravimetric determination of the solid Earth reaction to mass changes in southern Patagonia”, funded by the German Research Foundation, investigates the viscoelastic properties of the upper mantle and its response to stress changes caused by variations in ice mass in the Patagonian ice fields. This should help to constrain present-day ice mass balance estimates derived from GRACE and GRACE Follow-On.

GNSS observations over the past decade reveal high uplift rates at small spatial scales, mainly driven by glacial mass loss since the Little Ice Age. However, using GNSS alone one cannot separate elastic and viscoelastic deformation. Therefore, the project incorporates gravity changes from absolute gravimetry as an independent geodetic observable of the response of the solid Earth. By integrating gravimetric and GNSS data with seismic observations and modelling, the project improves constraints in a region undergoing rapid deformation. The goal is to better understand mantle rheology and support improved glacial isostatic adjustment modelling.

Thus, using the FG5-227 absolute gravimeter, measurements were carried out at 9 sites near the southern Patagonian ice field and extending toward the Atlantic coast to capture east-west asymmetry. We will discuss the observational set-up, the instrumental performance and the results obtained so far, accounting for the uncertainties of the observations of three campaigns in 2020, 2022 and 2026. With the gravity reference function derived at AGGO (Argentinean-German Geodetic Observatory) from the continuous record of the superconducting gravimeter, the stability and traceability of the absolute gravity observations is proved. The expected trends obtained from GNSS observation are confirmed by the absolute gravity observations.

Keywords: Absolute Gravity · Crustal deformation · GIA · Patagonien

Presenter: André Gebauer (Federal Agency for Cartography and Geodesy, Leipzig, Germany)

Session: Cryospheric deformation of the solid Earth

Presentation day: Wednesday

TENTATIVE

Thermal characterization of the upper mantle in the region of the Patagonian Icefields

Pedro Granovsky¹, María Laura Gómez Dacal¹, Andreas Richter¹

1 - Facultad de Ciencias Astronómicas y Geofísicas, Universidad Nacional de La Plata, CONICET, Argentina

The Patagonian Icefields represent a region of very intense solid-earth response to ice-mass changes. Uplift rates of up to 4 cm/yr have been observed by GNSS. This deformation combines the response to rapid present-day ice-mass loss with the viscoelastic glacial-isostatic adjustment (GIA) to ice-mass wasting since the Little Ice Age. A remarkable gradient of increasing intensity of the deformation is observed from the southern to the northern limits of the Southern Patagonian Icefield. Regional GIA models identify the peculiar thermo-mechanical structure beneath the icefields as key to explain the intensity and observed latitudinal variation of the ice-load induced deformation. From the Chile Triple Junction to the east and south opens the Patagonian Slab Window (PSW). This tectonic setting conditions the upwelling of hot mantle material through the window, causing thermal erosion of the lithospheric mantle from beneath. The mantle viscosity, which determines the intensity and relaxation time scales of viscoelastic loading response, is tightly related to the temperature of the mantle material. This work explores upper mantle temperature distribution in the PSW using regional seismic tomography and a global model as input. The chemical composition of the mantle material is characterized using published analyses of mantle xenoliths. The software package V2RhoTGibbs is used to derive the 3D distribution of temperature, melt fraction and density of the uppermost mantle. The temperature variation patterns within a depth range between the crust-mantle discontinuity and 250 km are analyzed with the aim to derive new constraints on the regional rheological structure, the dynamic processes active in the upper mantle, and the geometrical and thermal evolution of the PSW. This work contributes to the improvement of regional viscoelastic earth models as a basis for a better understanding of GIA effects at the Patagonian Icefields.

Keywords: Glacial isostatic adjustment · Patagonia · Mantle temperature · Solid-earth rheology

Presenter: Pedro Granovsky (Universidad Nacional de La Plata, Buenos Aires, Argentina)

Session: Cryospheric deformation of the solid Earth

Presentation day: Wednesday

TENTATIVE

Rethinking GIA: An Empirical Estimate of GIA-Induced Vertical Motion in the Great Lakes Basin

Helio Lopes Guerra Neto¹, Jeffrey T. Freymueller¹

1 - Michigan State University, USA

Vertical land motion in the Great Lakes Basin arises from the combined effects of ongoing Glacial Isostatic Adjustment and shorter-term environmental and hydrological loadings. Accurate separation of these signals is essential, as the GIA hinge line traverses the region and minor errors can propagate into geophysical interpretations. An analysis of GRACE/FO data indicates minimal Total Water Storage changes across the GLB during 2002-2012, a period of relative lake-level stability during which vertical motions observed by continuous GNSS stations are presumed to reflect GIA alone. In contrast, pronounced lake-level fluctuations occurred thereafter, providing an opportunity to isolate the GIA component. Comparisons between pre-2012 GNSS velocities and existing GIA models reveal a systematic bias: all models position the hinge line too far south, although the modeled deformation gradient aligns closely with observed curvature. To address this, we developed a spatial optimization framework that applies horizontal translations and planar rotations to 84 GIA realizations derived from diverse ice histories and Earth rheologies, yielding 672 model-configuration combinations evaluated using RMS misfit, concordance correlation, and 5-fold cross-validation. The best-fitting models achieve the lowest misfits (approximately 0.40 mm/yr), and highest concordance ($ccc > 0.90$). We introduced hierarchical ensemble approach grouping optimized configurations into four tiers based on post-alignment RMS: ELITE (≤ 0.49 mm/yr), GOOD (≤ 0.59 mm/yr), MEDIUM (≤ 0.79 mm/yr), and ALL (> 0.80 mm/yr). The ELITE and GOOD ensembles yield nearly identical uplift geometries with substantially reduced uncertainties-representative values below 0.18 mm/yr and 0.26 mm/yr for Michigan, respectively. These results demonstrate that tightly constrained multi-model ensembles provide more robust GIA estimates than any individual realization, enabling improved separation of GIA from hydrological signals.

Keywords: Glacial Isostatic Adjustment · GNSS · Vertical Land Motion · Great Lakes Basin

Presenter: Helio Lopes Guerra Neto (Michigan State University, East Lansing, MI, USA)

Session: Cryospheric deformation of the solid Earth

Presentation day: Wednesday

TENTATIVE

Performance of the VGOS-INT-B/C sessions for UT1-UTC determination

Rüdiger Haas¹, Rimsky Wolfs¹

1 - Chalmers University of Technology, Sweden

The two VGOS intensive series VGOS-INT-B and VGOS-INT-C, involving the Onsala twin telescopes in Sweden and the Ishioka VGOS telescope in Japan, were started in December 2019 and March 2021, respectively. These sessions are traditional 1-hour long intensive sessions with the goal to provide rapid UT1-UTC determinations, and are observed on weekends using automated operations. While the observing times initially were on Saturday and Sunday mornings with the two sessions following each other with a 30 minutes break, since April 2025 the observations are on a regular 12 hour schedule. The VGOS-INT-B are observed UT 23:30-00:30 and the VGOS-INT-C at UT 11:30-12:30. We give an overview of the VGOS-INT-B/C sessions and their performance compared to other VLBI intensive sessions. We study in particular the consistency of the two basically parallel baselines that are formed by the three stations, and investigate the impact of combining VGOS observations and co-located GNSS observations on the observation level on the final UT1-UTC results.

Keywords: VGOS intensives · UT1-UTC · combination on the observation level

Presenter: Rüdiger Haas (Chalmers University of Technology, Gothenburg, Sweden)

Session: Earth rotation

Presentation day: Monday

Multi-decadal changes in the Karakoram and Himalayan region glaciers since the 1970s

Sarmistha Halder¹, Rakesh Bhambri²

1 - Wadia Institute of Himalayan Geology, Dehradun, India

2 - Department of Geography, Delhi School of Economics, University of Delhi, Delhi, India

High Mountain Asia glaciers play a very important role in the ecosystem and the lives of millions of people. The water discharge from the Himalayan and Karakoram glaciers is the primary source of freshwater and contributes to the perennial river systems, as well as supports agriculture and hydropower generation. Also, these glaciers are a key indicator of climate change. However, these glaciers are losing mass, accelerating their melting and causing substantial retreat due to global warming. Hence, it is essential to monitor these glaciers continuously. Therefore, this study aims to understand the multi-decadal changes in major glaciers in the Eastern Karakoram and the Garhwal Himalaya through spatial and ground-based observations since the 1970s. The study analyses glacier surface thinning, mass balance, and frontal retreat rate using multi-temporal imagery and digital elevation models. All observed glaciers in both regions are experiencing greater surface thinning rates during the 2020s than during the 1970s. Such as Mamostong Glacier, the primary contributor to the Upper Thalam Buti valley in Eastern Karakoram, showed a substantial surface thinning rate of -0.64 ± 0.002 m yr⁻¹ (2016-2022) as compared to an earlier thickening rate of 0.13 ± 0.11 m yr⁻¹ between 1980 and 2000. The longest glacier of the Garhwal Himalaya, Gangotri Glacier (30 km long) of Upper Bhagirathi Valley experienced increased mass loss from -0.17 ± 0.01 m w.e.a⁻¹ (1973-2000) to -1.03 ± 0.58 m w.e.a⁻¹ (2020-2024), as well as a receding retreat rate of ~ 1.7 km between 1935 and 2022. Whereas the Khatling Glacier, the source of the Upper Bhilangana River, was comparatively smaller in size (~ 10 km long in 2024) and showed a terminus retreat rate of $\sim 5.33 \pm 0.04$ km from 1973 to 2024. The majority of glaciers in both the Garhwal Himalaya and the Karakoram region are in imbalance, with heterogeneous thinning rates.

Keywords: Geodetic mass balance · Digital Elevation Model · Eastern Karakoram · Garhwal Himalaya · Terminus Retreat

Presenter: Sarmistha Halder (Wadia Institute of Himalayan Geology, Dehradun, Uttarakhand, India)

Session: Cryospheric deformation of the solid Earth

Presentation day: Wednesday

TENTATIVE

Upper mantle anelasticity and its frequency dependence resolved by GPS in 3-D ocean tide loading displacements

Pingping Huang¹, Nigel T. Penna¹, Peter J. Clarke¹, Volker Klemann², Zdeněk Martinec^{3,4},
Yoshiyuki Tanaka⁵

1 - Newcastle University, UK

2 - GFZ Helmholtz Centre for Geosciences, Germany

3 - Dublin Institute for Advanced Studies DIAS, Dublin, Ireland

4 - Charles University, Czech Republic

5 - The University of Tokyo, Japan

Ocean tide loading (OTL) represents the Earth's deformational response to periodic ocean mass redistributions driven by astronomical tides. This transient deformation involves anelasticity, which is associated with energy dissipation and is essential for understanding Earth's deformation across various temporal scales. However, detecting and isolating anelastic OTL deformation remains challenging because its contributions are minor (submillimetre-to-millimetre scale) and often masked by the influence of lateral heterogeneities in crust and upper mantle elasticity. To address this difficulty, we analysed high-accuracy (0.2 - 0.4 mm) Global Positioning System (GPS) data from 255 sites across western Europe and compared these observations with OTL forward modelling results from advanced 3-D elastic and anelastic Earth models. This comparison unambiguously demonstrates anelastic OTL displacements, in both horizontal and vertical directions. Utilizing these GPS observations and realistic 3-D models, we further constrained anelastic parameters for Earth's upper mantle, revealing that the upper-mantle shear modulus weakens or disperses by up to 20% at semi-diurnal tidal frequencies compared to its 1 Hz value in the Preliminary Reference Earth Model (PREM). These results also constrain the frequency dependence of this weakening. Our findings highlight the necessity of incorporating anelasticity into geodynamic models and a unifying viscoelastic law for modelling Earth deformations, supporting the application of OTL observations to constrain Earth's anelasticity in the sub-seismic frequency range.

Keywords: ocean tide loading · anelasticity · Global Positioning System · 3D modelling · Elasticity

Presenter: Pingping Huang (Newcastle University, Newcastle Upon Tyne, UK)

Session: Tidal and non-tidal loading

Presentation day: Tuesday

TENTATIVE

Determination of the Earth's dynamical flattening using VLBI observations and the IAU precession-nutation models

Ibnu Nurul Huda^{1,2}, Jia-Cheng Liu¹, Niu Liu¹, Jun Yao¹

1 - Nanjing University, China

2 - National Research and Innovation Agency, Indonesia

The dynamical flattening of the Earth (H_d) is a fundamental parameter in Earth's rotation theory. This parameter is commonly estimated from the observed precession rate, which is composed of several theoretical components, with the majority of them depending on H_d . However, previous studies considered the dependence of H_d only on the first-order lunisolar precession rate due to its dominant role. In this study, we propose to estimate H_d rigorously by considering its dependence on several known components of the precession rate. We also consider the dependence of the main nutation terms on H_d . The value of H_d is estimated directly using the observed Celestial Intermediate Pole coordinates obtained from the IAU2006/2000 precession-nutation model plus the celestial pole offsets observed by VLBI. Our estimation is $H_d = 0.00327380936 + (5 \times 10^{-11})$, which corresponds to a difference of 4.54 ppm with respect to the adopted value in the IAU2006 precession model. This value unifies the H_d for precession and nutation theories. In addition, we estimated the so-called frame bias: $-16603 \pm 8 \mu\text{as}$ for the X component and $-7033 \pm 8 \mu\text{as}$ for the Y component. This is in good agreement with the current values. Furthermore, we investigated a long-term variation of J_2 , which is linearly related to that of H_d using the method developed in our paper. We found that in recent decades the secular variation of J_2 generally follows a parabolic trend. This result is consistent with the long-term variation of J_2 derived from the Satellite Laser Ranging observations.

Keywords: Earth's rotation · precession-nutation · dynamical flattening · VLBI

Presenter: Jia-Cheng Liu (Nanjing University, Nanjing, China)

Session: Earth rotation

Presentation day: Monday

Threats of Relative Sea Level Rise in Coastal Communities: InSAR and GNSS Measurements for Decadal Time Scales surrounding Lake Pontchartrain

Carolina Hurtado-Pulido¹, Andrea Donnellan¹, Cathleen E. Jones^{2,3}

1 - Purdue University, USA

2 - Purdue University

3 - Jet Propulsion Laboratory, California Institute of Technology, USA

Coastal areas are threatened by accelerating sea level rise and are often affected by natural and human-related subsidence, which can vary across different temporal and spatial scales. The sum of these two processes is known as relative sea level rise and better describes the hazards that sea level rise represents in coastal areas than either one alone. We use InSAR geodetic data from Sentinel-1 and GNSS data acquired between 2016- 2025 to estimate subsidence across the area surrounding Lake Pontchartrain including the greater New Orleans, Louisiana, metropolitan area. This study area is known for its large subsidence and land loss rates during the last decade. InSAR data is open source and covers the globe with high spatial resolution, while GNSS provides information daily, but the stations are very sparse. InSAR and GNSS are often used together as the latter serves to tie InSAR to an absolute reference frame and to validate its results. We compared the time series amplitude and phase, and the velocity of time series from both InSAR and GNSS. The spatial trend between both methods is similar, with subsidence decreasing from west to east. However, the time series amplitude and rates are different between the methods. These differences seem to relate to the location of the GNSS station. We are investigating whether these differences are caused by factors such as Holocene sediment thickness or GNSS foundation depth. Defining the causes of these differences can help us to understand the processes that each tool can detect in coastal areas.

Keywords: InSAR · GNSS · Coastal subsidence · Louisiana

Presenter: Carolina Hurtado-Pulido (Purdue University, West Lafayette, Indiana, USA)

Session: Hydrologic signature in geodetic observations

Presentation day: Tuesday

German Research Unit RING (Rotations IN Physics, Geophysics, and Geodesy) for exploiting the potential of highly-accurate ring lasers for Earth rotation and seismology

Heiner Igel¹, Daniela Thaller², Simon Stellmer³, Susanne Glaser³, Robert Heinkelmann⁴, Jürgen Müller⁵, Harald Schuh⁶, Felix Bernauer¹, Thomas Forbriger⁷, Oliver Gerberding⁸, Andreas Güntner⁴, Celine Hadziioannou⁸, Katharina Isleif⁹, Thomas Klügel¹⁰, Jan Kodet¹¹, Ulrich Schreiber¹¹, Hartmut Wziontek¹²

1 - Ludwig-Maximilians-Universität München, Germany

10 - BKG Wettzell, Germany

11 - Technische Universität München, Germany

12 - BKG Leipzig, Germany

2 - BKG Frankfurt, Germany

3 - University Bonn, Germany

4 - Helmholtz-Zentrum für Geoforschung (GFZ), Germany

5 - Leibniz Universität Hannover, Germany

6 - Technische Universität Berlin, Germany

7 - Karlsruhe Institute of Technology (KIT), Germany

8 - Universität Hamburg, Germany

9 - Helmut-Schmidt-Universität Hamburg, Germany

On our planet Earth, rotational motions are present at any time and at any place. On a global scale, these rotations are measured by geodesy. The rotation rate and the orientation of the axis of the Earth's rotation are permanently changing due to a variety of phenomena such as the gravitational attraction of Moon and Sun, tidal deformations, oceanic currents, large air circulation patterns, hydrological effects, as well as mass movements due to climate change. Space-geodetic techniques GNSS, VLBI, SLR, LLR and DORIS have a long tradition in observing the rotation of the Earth and its orientation in space with high quality on a daily basis. On a local (i.e. seismological) scale, rotational ground motions are present as seismic waves that are traveling continuously through the Earth's body.

With the new technology of ring lasers, high-precision measurements of rotational motions become available. With data of the G-Ring located at Wettzell, it has been already demonstrated that high-quality determination of Earth rotation is feasible, however, the full potential of the ring laser data still needs to be exploited in a fully consistent combination with the classical

space-geodetic techniques.

A consortium of ten German institutions has been successful with setting up a research unit funded by the German Research Foundation (DFG) called RING (Rotations IN Physics, Geophysics, and Geodesy). This research unit will start in July 2026 and will bring together scientists from physics for further improvements of ring lasers at various sizes, as well as geodesists and geophysicists for exploiting the scientific use of ring laser data. We will present the setup of the research unit, the work plan, and the science questions intended to be answered during the project. First results regarding Earth rotation determination from ring laser data compared to space-geodesy estimates will be shown.

Keywords: Ring laser · Earth rotation · Space geodesy · Combination

Presenter: Daniela Thaller (BKG, Frankfurt, Germany)

Session: Earth rotation

Presentation day: Monday

Joint inversion of GRACE and GRACE-FO for simultaneous estimation of terrestrial water storage anomalies and water fluxes

Sedigheh Karimi¹, Roelof Rietbroek¹, Marloes Penning de Vries¹, Amin Shakya¹, Christiaan van der Tol¹

1 - ITC Faculty of Geo-Information Science and Earth Observation, University of Twente, Enschede, the Netherlands

Terrestrial water storage anomaly (TWSA) derived from GRACE and GRACE-FO is one of the official Essential Climate Variables and a key variable for understanding variations in the water cycle. Changes in TWSA are linked to the balance among fluxes of precipitation, evapotranspiration, and river discharge over a given period. The interpretation of TWSA variations becomes increasingly important for monitoring and explaining water cycle changes across regions as climate change intensifies water fluxes. However, conventional approaches initially estimate TWSA and then post-process to compute the rate of change in TWSA by numerical differencing, which can amplify noise and lead to unstable estimates of water fluxes. This study proposes a joint inversion scheme to directly estimate watershed-wide TWSA globally and water fluxes locally from GRACE and GRACE-FO observations. This is achieved by embedding the water balance equation into the observation equations, so that mass changes and fluxes (precipitation minus evapotranspiration (P-ET) and river discharge) are interpreted simultaneously. ERA5 reanalysis and GEOGLOWS river discharge are additionally considered as observational datasets to support the separation and interpretation of these fluxes.

The scheme will be applied to the under-gauged watersheds in the North Sea and the Greater Horn of Africa regions. This framework is expected to provide a physically consistent interpretation of mass changes and fluxes and to improve the quantification of regional water cycle fluxes under a changing climate.

Keywords: Terrestrial water storage · Evapotranspiration · Precipitation · River discharge · GRACE/GRACE-FO

Presenter: Sedigheh Karimi (University of Twente, Enschede, Netherlands)

Session: Hydrologic signature in geodetic observations

Presentation day: Tuesday

TENTATIVE

Detecting transient ground deformation associated with the 2015 magma intrusion event at Sakurajima Volcano, Japan, with GNSS kinematic positioning

Takumi Kemmochi¹, Yuji Itoh¹, Yosuke Aoki¹, Haruhisa Nakamichi², Masato Iguchi³

1 - Earthquake Research Institute, The University of Tokyo, Japan

2 - Disaster Prevention Research Institute, Kyoto University, Japan

3 - Kagoshima City Office, Japan

GNSS kinematic analysis is a powerful tool to capture the detailed temporal evolution of ground deformation. However, coordinate time series obtained by kinematic analysis often contain noise, such as multipath and common-mode errors, necessitating rigorous noise reduction. Here, we attempt to reduce the noise in kinematic GNSS measurements at Sakurajima Volcano, southwest Japan, associated with the August 2015 unrest, which lasted only about 1 day. Because of the short duration of the deformation, daily solutions are insufficient to resolve the temporal resolution. We utilized GNSS data from stations operated by the Disaster Prevention Research Institute (DPRI), Kyoto University, the Japan Meteorological Agency (JMA), and the Geospatial Information Authority of Japan (GSI). Sampling rates were 1 Hz for DPRI stations and 30 s for others. We performed the GNSS kinematic processing using the TRACK package of GAMIT/GLOBK v10.71 (Herring et al., 2018). The GNSS kinematic positioning gave coordinates every 30 seconds. To mitigate coordinate offsets at midnight caused by standard 24-hr batch processing, we generated 36-hour RINEX files, including data for 12 hours on the previous day. We modeled station motion as a random walk process, estimated its evolution using the Kalman Filter, and applied median filtering to remove outliers.

We explored noise contamination, including multipath and common-mode errors. Although the time series contains multipath effects, they were neither modeled nor removed because the environment around the station was unstable over time. Then we modeled common-mode errors by stacking time series from stations far from the volcano and removing them from the time series (Wdowinski et al., 1997). Horizontal displacements in the study were consistent with static positioning. The onset times of displacements varied across components at some observation sites.

Keywords: GNSS · Kinematic positioning · Sakurajima Volcano

Presenter: Takumi Kemmochi (Earthquake Research Institute, The University of Tokyo, Tokyo, Japan)

Session: Volcanogeodesy

Presentation day: Thursday

TENTATIVE

Climate-Driven Crustal Deformation on Svalbard

Halfdan Pascal Kierulf¹

1 - Norwegian Mapping Authority, Norway

The geodetic observatory in Ny-Ålesund, together with the broader geodetic infrastructure on Svalbard, forms a unique natural laboratory for studying geodetic responses to climate-driven mass changes. As part of the global geodetic observing system, these installations play a central role in the realisation of the global geodetic reference frame and provide exceptional insight into Arctic geophysical processes, particularly hydrologic and cryospheric deformation signals. However, climate-driven processes, particularly glacier melt, pose challenges to the stability of the observatory. The Earth's crust responds elastically to changes in glacier mass, and on Svalbard the resulting uplift can reach several centimetres per year. Ny-Ålesund exhibits variations in uplift on seasonal, inter-annual, decadal, and longer timescales. Since the early 2000s, the uplift rate has more than doubled and now exceeds 12 mm/yr. These changes have implications for the realisation and stability of global geodetic reference frames, potentially introducing biases into other geophysical applications such as studies of glacial isostatic adjustment, seismogeodesy and volcanogeodesy. To ensure stable global reference frames, accurate models of crustal deformation processes are essential. We have modelled the elastic crustal response to glacier mass changes using glaciological datasets. However, the predicted deformation underestimates the uplift observed in Svalbard and Ny-Ålesund. This discrepancy indicates that additional processes may be contributing and underscores the need for closer collaboration with other geophysical disciplines to identify the missing components. These findings, along with potential explanations and their implications for global reference frame stability, will be presented and discussed.

Keywords: Climate-driven crustal deformation · Glacier mass change · Elastic uplift · Arctic geodesy · Svalbard

Presenter: Halfdan Pascal Kierulf (Norwegian Mapping Authority, Oslo, Norway)

Session: Cryospheric deformation of the solid Earth

Presentation day: Wednesday

3D vs. 1D viscosity structures when interpreting GIA induced VLM in Antarctica

Volker Klemann¹, Christine Wolf¹, Reyko Schachtschneider¹, Nellie Wullenweber², Torsten Albrecht^{3,2}, Mirko Scheinert⁴

1 - GFZ Helmholtz Centre for Geosciences, Germany

2 - Max Planck Institute of Geoanthropology, Germany

3 - Potsdam Institute for Climate Impact Research (PIK), Germany

4 - TUD Dresden University of Technology, Germany

The interpretation of vertical land motion (VLM) in Antarctica requires an appropriate consideration of glacial isostatic adjustment (GIA), which contains a loading signal from the last Pleistocene glaciation, a possible Holocene readvance and mass change during the last decades to centuries. The strong dichotomy of Antarctica's lithosphere manifests in the thick cratonic eastern part and the thinner and magmatically active western part. In addition to a much thinner lithosphere the western part shows mantle provinces with strong viscosity reductions reaching more than one order of magnitude.

VLM observations support such viscosity reductions and shift the focus from glacial to more recent ice-mass loss. As recent ice-mass change processes are of small scale, spatial variations in the regional mantle-viscosity structure are often neglected when modelling this local GIA process. Here, we discuss the validity of this 1D (one-dimension) assumption and a possible bias towards higher viscosities, when not considering guided or rather constrained material flow due to the 3D mantle structure.

This study contributes to the German Climate Modeling Initiative PALMOD as the DFG Priority Program 1158 Antarctic Research.

Keywords: Glacial isostatic Adjustment · Antarctic mantle structure · 3D viscoelastic modelling · vertical land motion corrections

Presenter: Volker Klemann (GFZ Helmholtz Centre for Geosciences, Potsdam, Germany)

Session: Cryospheric deformation of the solid Earth

Presentation day: Wednesday

Hydrologically Induced Viscoelastic Deformation in the Amazon Basin

Antonio Kruse¹, Taco Broerse¹, Riccardo Riva¹

1 - TU Delft, Netherlands

The Amazon Basin undergoes large-scale deformation in response to hydrological loading. GNSS observations show centimetre-scale uplift and subsidence that closely follow the seasonal water cycle. This deformation is commonly interpreted as an instantaneous, purely elastic response of the lithosphere to surface water-mass changes. In the past two decades, the hydrological regime of the world's largest watershed exhibited pronounced multi-year anomalies in water storage, associated with more frequent and persistent extreme floods and droughts. These events produce stress changes on the time scale of multiple years that may excite time-dependent mantle flow. With GNSS and GRACE time series now long enough to resolve annual to decadal signals, these non-linear deformation effects can be investigated.

We calculate elastic deformation from GRACE/GRACE-FO mascon solutions and compare it with vertical displacements from GNSS stations across the Amazon Basin on interannual to decadal timescales. GNSS uplift departs from the predicted elastic deformation after sequences of major floods and droughts: persistent floods are followed by delayed subsidence, and prolonged droughts by delayed uplift. To explain these delays, we adopt a Burgers rheology for the upper mantle in a numerical loading model, which parameterizes both transient and steady-state flow. We then infer mantle viscosities that reproduce the delayed GNSS response to water loads.

Our study constrains the short-term rheological strength of the upper mantle, reducing uncertainty in hydrogeodetic applications. Accounting for transient deformation in loading corrections improves GNSS-derived estimates of terrestrial water storage and enhances GNSS-based monitoring of floods, droughts, and regional water resources in the Amazon Basin.

Keywords: Earth Deformation · Transient Rheology · Hydrogeodesy

Presenter: Antonio Kruse (TU Delft, Delft, Netherlands)

Session: Hydrologic signature in geodetic observations

Presentation day: Tuesday

Benchmarking Low-Cost and Geodetic-Grade GNSS and Accelerometer Systems for Seismogeodesy: The Shake Table Experiment Dataset

Iwona Kudłacik¹, Jan Kapłon¹, Ilie Eduard Nastase², Alexandru Tiganescu², Panagiotis Elias³,
Adrian Kaczmarek¹, Sorin Nistor², David Zuliani⁴

1 - Wrocław University of Environmental and Life Sciences, Poland

2 - National Institute for Earth Physics, University of Oradea, Romania

3 - University of Patras, Greece

4 - National Institute of Oceanography and Applied Geophysics, Italy

High-rate GNSS is a vital complement to traditional seismic sensors for earthquake and tsunami early warning. We present the results of a cross-disciplinary collaboration between EPOS Thematic Core Services: Near-Fault Observatories (TCS-NFO), Anthropogenic Hazards (TCS-AH), and GNSS Data and Products (TCS-GNSS) within the TRANSFORM² project. In October 2025, we simulated a comprehensive set of motions using an ANCO R-303 triaxial shake table at the Seismological Observatory in Timișoara, Romania.

The experimental campaign included 88 variants of motion, including synthetic signals and natural records from Poland (2019 mining-induced), Italy (2016 Norci), Romania (Vrancea 1986), and Greece (2020 Samos, 2021 Damasi). To ensure high-resolution, multi-sensor observations, the tabletop was instrumented with GNSS antennas simultaneously connected to eight receivers, ranging from low-cost to geodetic-grade, with several units synchronized to external atomic clocks. The setup was further augmented with professional and low-cost accelerometers and inclinometers.

We introduce a fully documented dataset to be shared publicly via Zenodo, supporting EPOS and IAG open science objectives. This presentation discusses the experimental setup, sensor calibration, and the integration workflow developed to combine multi-sensor measurements into a coherent seismogeodetic dataset. Preliminary analyses compare low-cost and high-grade GNSS/accelerometer configurations and visualize motions across various seismic scenarios. This dataset enables the geoscience community to validate high-frequency GNSS algorithms, accelerometric processing, and fusion techniques, bridging the gap between controlled experiments and real-world hazard mitigation.

Keywords: earthquake simulation · high-rate GNSS · seismogeodesy · low-cost GNSS · triaxial shake table

Presenter: Iwona Kudłacik (Wrocław University of Environmental and Life Sciences, Wrocław, Poland)

Session: Seismogeodesy

Presentation day: Thursday

Core Flow Contribution to Intradecadal Polar Motion from Rotation and Gravimetric Observations

Daoud Laariara^{1,2}, Alexandre Couhert^{3,4}, Jérémy Requier^{5,2}, Véronique Dehant^{5,2}, Franck Reinquin^{3,4}, Jean-Michel Lemoine^{3,4}

1 - Université Catholique de Louvain (UCLouvain), Institute of Mechanics, Materials and Civil Engineering, Belgium

2 - Royal Observatory of Belgium, Brussels, Belgium

3 - Centre National d'Etudes Spatiales, Toulouse, France

4 - Univ Toulouse (CNES/CNRS/IRD/UT), GET, Toulouse, France

5 - Université Catholique de Louvain (UCLouvain), Earth and Life Institute, Belgium

The dynamics of Earth's liquid outer core cannot be observed directly and must instead be inferred from their effects on measurable geophysical quantities. In this regard, the analysis of variations in Earth's rotation is valuable as core flows can influence it through coupling with the mantle. This study evaluates the plausibility of a contribution from core flow to polar motion (PM) at intradecadal timescales. Identifying PM variability that cannot be attributed to changes in atmosphere, ocean, and hydrosphere (AOH) relative angular momentum, nor to mass redistribution, would indicate a potential contribution from core dynamics.

Here, the excitation of PM by mass redistribution is obtained based on degree-2, order-1 geopotential coefficients derived from Satellite Laser Ranging (SLR) over the past forty years. This allows us to isolate the part of PM excited by relative angular momentum changes, which can then be compared with AOH angular momentum models to highlight a possible signature from the Earth's interior. The residual excitation reveals a statistically significant prograde oscillation with an amplitude of approximately 1 mas and a period of 2.8 years, suggesting a core flow origin, as it cannot be fully explained by mass processes, nor by AOH motion excitations. To further support this hypothesis, we find that the torque at the core-mantle boundary (CMB) required to produce this signal can be realistically provided by core-mantle coupling mechanisms. In addition, we compute the expected signature in magnetic secular acceleration (SA) associated with an oscillatory core flow capable of exciting the detected PM signal. Although SA observations exhibit variability with a comparable period, its amplitude is one order of magnitude larger than our estimate. Despite the absence of conclusive evidence, our results together support the plausibility that the 2.8-year PM signal originates from core dynamics.

Keywords: Polar Motion · Core-Mantle Coupling · Core Dynamics · Satellite Laser Ranging · Magnetic Secular Acceleration

Presenter: Daoud Laariara (Université Catholique de Louvain (UCLouvain), Louvain-la-Neuve, Belgium)

Session: Earth rotation

Presentation day: Monday

Underestimated loading-driven land subsidence by Earth models amplifies relative sea-level rise

Fupeng Li¹, Anna Klos², Jürgen Kusche¹

1 - Institute of Geodesy and Geoinformation, University of Bonn, Bonn, Germany

2 - Faculty of Civil Engineering and Geodesy, Military University of Technology, Warsaw, Poland

Relative sea-level rise threatens hundreds of millions of coastal residents and is governed not only by ocean change but also by vertical land motion (VLM). Current estimates of loading-driven VLM rely on elastic or viscoelastic Earth models, yet their ability to represent the solid Earth's response to surface mass redistribution remains uncertain. Here we integrate 17,376 GNSS (Global Navigation Satellite System) observations with multiple loading drivers-including GRACE (Gravity Recovery and Climate Experiment)-derived mass redistribution, atmospheric pressure and glacial isostatic adjustment (GIA)-within a data-driven framework to reconstruct a global, observation-constrained VLM field at 0.5° resolution, enabling a global evaluation of existing Earth model simulations. We show that widely used Earth models systematically underestimate loading-driven land subsidence across 74% of the global land surface, including more than 58% of coastal areas and 66% of populated coastal regions. These discrepancies indicate that the solid Earth response to surface mass redistribution is not fully captured by conventional elastic or viscoelastic models, likely owing to unresolved non-elastic processes such as groundwater-induced subsidence. Because current sea-level projections (e.g., by IPCC) primarily account for only GIA-driven land motion from Earth models, our results reveal unaccounted coastal subsidence that may amplify relative sea-level rise but is underestimated in current projections. This study provides a global, observation-constrained framework to reconcile model-data discrepancies in vertical land motion and to improve projections of relative sea-level rise.

Keywords: GNSS · GRACE · Hydrological loading

Presenter: Fupeng Li (University of Bonn, Bonn, Germany)

Session: Hydrologic signature in geodetic observations

Presentation day: Tuesday

Preliminary Results on Coseismic Polar Motion Excitation: GRACE Forward Modeling and Multi-Method EOP Analysis for Four Megathrust Earthquakes

Li Liu¹, XueQing Xu², Zhengwen Yan³, Haotian Wu³, Tong Liu⁴, Bing Zhang⁴, Cheng Xiong¹,
Jiangjun Ran³

1 - Shenzhen Polytechnic University, China

2 - Shanghai Astronomical Observatory, Chinese Academy of Sciences, China

3 - Southern University of Science and Technology, China

4 - The Hong Kong Polytechnic University, China

Great earthquakes excite polar motion through degree-2 gravitational changes, yet EOP-based detection remains controversial after decades of effort. We present an ongoing analysis of four megathrust events—the 2004 Sumatra (Mw 9.1), 2010 Chile (Mw 8.8), 2011 Tohoku (Mw 9.0), and 2025 Kamchatka (Mw 8.8)—reconciling satellite gravimetric constraints with multi-method EOP observations. Using GRACE/GRACE-FO RL06 coefficients and spherical-Earth dislocation theory, we forward-model the equatorial excitation function. For Tohoku 2011, the elastic forward estimate is ~ 5 mas, consistent with Gross & Chao (2012), establishing an independent gravimetric benchmark. GRACE 1-month differences reveal amplification factors ranging from 1.2 to 2.8 relative to elastic theory, capturing early post-seismic relaxation omitted by dislocation models. We apply three independent estimators—AR-Z spectral modeling, SSA, and Butterworth bandpass filtering—to EOP residuals after removing atmospheric, oceanic, hydrological, and cryospheric backgrounds. Preliminary results show SSA and GRACE spherical-harmonic estimates agree within ~ 1 -2 mas, while AR-Z and bandpass methods show larger discrepancies. Our analysis shows residual EOP discrepancies exceed elastic predictions by a factor of approximately 2-3, because raw apparent jumps conflate coseismic, post-seismic, and Chandler signals. The background noise floor buries the 1-7 mas earthquake signals.

Keywords: coseismic polar motion · GRACE coseismic excitation · Multi-method EOP analysis

Presenter: Li Liu (Shenzhen Polytechnic University, Shenzhen, Guangdong, China)

Session: Earth rotation

Presentation day: Monday

Galeras volcano slow deformation detected by ALOS-2 and Sentinel-1 interferometry (2016-2022) and BEM modeling of the deformation source

Sindy Lizarazo¹, Fabien Albino², Valerie Cayol¹

1 - Laboratory Magmas and Volcanoes, University Clermont-Auvergne, France

2 - Institute of Earth Sciences University of Grenoble, University Grenoble Alpes, France

Galeras stratovolcano is one of the most active volcanoes in Colombia with a long record of vulcanian eruptions characterized by cycles of rest, conduit-opening, dome emplacement and destruction. The detection of deformation via InSAR analysis has been challenging due to dense flank vegetation, strong topography gradient, and changing atmospheric conditions. To address these limitations we combine ALOS-2 and Sentinel-1 interferometric data corrected by tropospheric noise using empirical approaches, and external datasets such as weather models and GNSS-derived data. The results revealed a slow and stable LOS displacement rate of 10 mm/yr away from the satellite between 2016 and 2022 at the summit of the active cone. The decomposition of LOS motions indicate a mixed pattern characterized by vent-convergent horizontal motions and subsidence of the crater area. We model these displacements using the Boundary Element Method tool DefVolc to image the deformation source below the volcanic edifice. Our results indicate that a variety of geometries (sphere, planar ellipsoid, triaxial ellipsoid and Okada-type source) will reproduce the observations to a similar degree. The shallow deflating sources share the common features of location at shallow depths (<0.5 km) centered below the main crater with a volume loss on the order of 10^4 cubic meters. This is interpreted mainly as the cooling effect of a former intrusion in the volcano conduit which is supported by low seismicity and gas emissions.

Keywords: Slow summit deformation · Boundary Element Modeling · Tropospheric noise mitigation · ALOS-2 · Sentinel-1

Presenter: Sindy Lizarazo (Laboratory Magmas and Volcanoes, Aubiere, France)

Session: Volcanogeodesy

Presentation day: Thursday

Flank instability of Mauna Loa Volcano, Hawai'i, modulated by magma intrusion and eruption

Mizuki Matsuda¹, Yosuke Aoki¹

1 - Earthquake Research Institute, The University of Tokyo, Japan

Mauna Loa, the largest volcano on earth, erupted in 2022 for the first time in 38 years. The volcano's structure consists of a summit caldera, two rift zones, and a basal décollement located approximately 10 km below sea level. Previous studies have identified continuous seaward shear slip on the southeastern décollement, which drives flank instability and interacts with magma intrusion (Varugu and Amelung, 2021). In this study, we modeled ground deformation before and after the 2022 eruption using GNSS (Global Navigation Satellite System) data to determine how the eruption influenced this instability.

We employed a model consisting of a spherical source, a dike, and a shear dislocation on the décollement. Modeling results indicate that the depths of the spherical source and dike became significantly shallower after the eruption. Notably, the slip rate of the décollement decreased drastically from approximately 32.8 cm/yr before the eruption to 3.44 cm/yr immediately after, indicating a near-cessation of the slip.

To investigate the cause of this cessation, we calculated the Coulomb stress change on the décollement caused by the eruption. The analysis yielded a negative Coulomb stress change of approximately -0.067 MPa, suggesting that the eruption mechanically suppressed the décollement slip. This interpretation is further supported by a significant decrease in seismic activity around the décollement. Subsequent analysis revealed that the décollement slip resumed around 2024, with the slip rate recovering to approximately 27.4 cm/yr. This resumption correlates with positive Coulomb stress changes induced by subsequent magma intrusions. These findings demonstrate that the behavior of the décollement is controlled by the balance between the negative stress change caused by the eruption and the positive stress changes from later magma intrusions.

Keywords: Flank instability · Dike intrusion · GNSS

Presenter: Mizuki Matsuda (Earthquake Research Institute, The University of Tokyo, Tokyo,

Japan)

Session: Volcanogeodesy

Presentation day: Thursday

TENTATIVE

Solid Earth Tide Residuals as Indicators of the 18.6-Year Lunar Nodal Cycle in GNSS Time Series

Nabil Md Bokhtiar Abid¹, Vadim Lutsenko², Kalybekova A. A³

1 - Department of Space Engineering and Technology, Al-Farabi Kazakh National University, Almaty, Kazakhstan

2 - Head of the Laboratory of Space and Geophysical Research, Ionosphere Institute, Almaty, Kazakhstan

3 - Faculty of Mechanics and Mathematics, Al-Farabi Kazakh National University and Ionosphere Institute, Almaty, Kazakhstan

In GNSS time series, Solid Earth tides stand out with high precision model in geodetic signals, the residuals that remain in GNSS time series continue to hint at unresolved long-period dynamics. The small residual that remains even after conventional tidal correction is not just noise - they may contain signatures of long-period geophysical processes hidden within geodetic observations. The 18.6-year lunar nodal cycle is particularly important in this context, as it can affect deformation patterns over long periods of time by changing the pattern of tidal forcing. The present study seeks to determine whether the small residual signals left after standard tidal correction in GNSS time series may encode the long-period variability of the 18.6-year lunar nodal cycle. Using long-term GNSS time series, this study will extract low-frequency geophysical information that is hidden beneath short-term noise and environmental fluctuations. After correcting for major tidal signals and other known periodic effects, the residual displacement record will be analyzed using spectral analysis and time-series decomposition. One of the main challenges of this research is to separate the potential 18.6-year nodal signal from other low-frequency variations such as hydrological loading and atmospheric effects. Comparative analysis of long-term GNSS stations will show how stable and detectable this nodal signal is in different geodetic environments. By revealing, this study aims to clarify how long-term unresolved tidal effects can affect decadal geodetic observations. If the 18.6-year lunar nodal cycle is detected in residual GNSS signals, it would be strong evidence that these effects need to be explicitly included in precision geodesy.

Keywords: Solid Earth Tides · 18.6-year lunar nodal cycle · Residual Geodesy · GNSS time series · Hydrological Effects

Presenter: Nabil Md Bokhtiar Abid (Al-Farabi Kazakh National University, Almaty, Kazakhstan)

Session: Tidal and non-tidal loading

Presentation day: Tuesday

TENTATIVE

Comparison of Two Liouville-Based Computational Frameworks for Short-Term Earth Rotation Parameter Prediction

Maciej Michalczak¹, Marcin Ligas¹, Jolanta Nastula², Justyna Śliwińska-Bronowicz²,
Małgorzata Wińska³

1 - AGH University of Krakow, Poland

2 - Centrum Badań Kosmicznych PAN, Poland

3 - Warsaw University of Technology, Faculty of Civil Engineering, Poland

This study investigates the short-term prediction of Earth Rotation Parameters (ERP) using Effective Angular Momentum (EAM) data, focusing on a comparative analysis of two computational frameworks. The primary objective is to assess the predictive performance of polar motion components (PMx, PMy), Length of Day (LOD), and UT1-UTC over a 10-day horizon using a method based on the fundamental principles of the Dynamic Mode Decomposition (DMD) algorithm, with particular emphasis on comparing two computational frameworks that incorporate transformations based on the Liouville equations.

In the first approach, predictions are performed based on residual time series representing the difference between modeled EAM and Geodetic Angular Momentum (GAM), which is derived from geodetically observed ERPs based on the Liouville equations. In the second approach, the methodology is reversed: EAM series are transformed into ERP space using the inverse transformation, and predictions are performed directly in the ERP domain. This dual-framework strategy enables a systematic assessment of how transformations between ERP and EAM spaces influence prediction accuracy and stability.

Both approaches employ a method based on the DMD due to its capability to capture underlying dynamical structures in complex geophysical time series. The prediction performance was evaluated in accordance with the guidelines of the 2nd Earth Orientation Parameters Prediction Comparison Campaign (EOP PCC), enabling direct benchmarking against publicly available solutions from other research groups.

This setup allows for a consistent comparison of the two Liouville-based representations within a unified forecasting framework, providing a basis for further investigation of data transformation strategies in ERP prediction.

Keywords: Earth Rotation Parameter · Prediction · Dynamic Mode Decomposition · Effective Angular Momentum

Presenter: Maciej Michalczak (AGH University of Krakow, Kraków, Poland)

Session: Earth rotation

Presentation day: Monday

TENTATIVE

Multi-sensor InSAR-Derived Vertical Land Motion and Infrastructure Risk Assessment in Mumbai, India

Astha Moolchandani¹, Chandrakanta Ojha¹

¹ - Indian Institute of Science Education and Research, Mohali, India

Mumbai has undergone rapid urban growth, resulting in a diverse urban morphology, making it susceptible to urban land subsidence. According to NCRB, Mumbai accounted for 10% of the total structural collapses that occurred between 2001 and 2015. Regional land subsidence rates of up to 26 mm/year are reported in Mumbai's dense informal settlements. However, large-scale estimates cannot capture land motion at the individual infrastructure scale. Therefore, this study employs high-resolution SAR data to map vertical land motion (VLM) and assess spatial variability in subsidence-related risk at the building scale across Mumbai. In this context, we explore 243 descending-track Sentinel-1 C-band images (September 2016 and May 2025) and 219 descending-track TerraSAR-X X-band Stripmap images (February 2012 to July 2023) for InSAR deformation monitoring. We used the ISCE2 platform to generate interferograms for phase unwrapping using the SNAPHU. A multi-look factor of 3:1 was applied along the range and azimuth directions using a small baseline subset (SBAS), resulting in a total of 942 Sentinel-1 and 800 TerraSAR-X suitable interferograms for analysis. Our preliminary Sentinel-1 results depict two prominent subsidence zones, namely Govandi West and Antop Hill, with a maximum subsidence rate of -25 mm/year. A higher subsidence rate of up to -45 mm/year was observed using TerraSAR-X data, mainly concentrated in the densely urbanized south-coastal regions. The VLM results strongly co-occur with urbanization regions, underscoring the need to assess the effect of subsidence on infrastructure. We combined VLM estimates with socio-economic proxies, such as population density, building morphology, and property value, in a GIS environment to get the risk exposure of critical infrastructure to land deformation. The multi-layered analysis maps the spatial patterns linking deformation and urban characteristics, further escalating the need to investigate the distinct driving factors.

Keywords: InSAR · Sentinel-1 · TerraSAR-X · ISCE2 · Mumbai

Presenter: Astha Moolchandani (Indian Institute of Science Education and Research Mohali,

Mohali, India)

Session: Hydrologic signature in geodetic observations

Presentation day: Tuesday

TENTATIVE

Reassessment of geophysical fluid contributions to Earth rotation changes at subseasonal time scales

Jolanta Nastula¹, Aleksander Partyka¹, Justyna Śliwińska-Bronowicz¹, Małgorzata Wińska²

1 - Centrum Badań Kosmicznych PAN, Warsaw, Poland

2 - Warsaw University of Technology, Faculty of Civil Engineering, Warsaw, Poland

Time-dependent Earth Orientation Parameters (EOP) describe variations in Earth's rotation and link terrestrial and celestial reference frames. They also provide insight into geophysical processes related to large-scale mass redistribution within the Earth system.

Earth's rotation varies due to gravitational forcing by celestial bodies and mass redistribution in the atmosphere, oceans, hydrosphere, and cryosphere. These effects are quantified using effective angular momentum (EAM).

This study reassesses the influence of surface fluid mass redistribution and transport on Earth's rotation at subseasonal time scales (1976-2024). We analyze the equatorial components (χ_1, χ_2), which describe polar motion excitation, and the axial component (χ_3), representing length-of-day variations. EAM is calculated as the sum of atmospheric (AAM), oceanic (OAM), hydrological (HAM), and sea-level angular momentum (SLAM), based on reanalyses and numerical models constrained by observations.

We also compare EAM with geodetic angular momentum (GAM) derived from observations. Results show strong agreement between EAM and GAM in both correlation and amplitude for axial and equatorial components. This confirms a strong coupling between surface fluid processes and Earth's rotation variability. The consistency of these models highlights their potential for integration into climate models to improve predictions of future changes in Earth's rotation.

Keywords: Earth's rotation variations · Effective Angular Momentum variations · Geodetic angular momentum (GAM)

Presenter: Jolanta Nastula (Centrum Badań Kosmicznych PAN, Warsaw, Poland)

Session: Earth rotation

Presentation day: Monday

Seismogeodetic Analysis of Intraplate Deformation Along the Delhi-Aravalli Ridge Using a Geoid-Anchored Framework

Somalin Nath¹, Onkar Dikshit¹

1 - National Centre for Geodesy, IIT Kanpur, India

Seismogeodesy enables the integration of geodetic deformation and subsurface mass distribution to understand earthquake processes in slowly deforming intraplate regions. This study applies a geoid-anchored multi-sensor framework to investigate active tectonics along the Delhi-Aravalli Ridge (DAR), a Precambrian orogenic belt within the Indian Shield characterized by persistent seismicity despite low deformation rates.

GNSS observations reveal horizontal deformation rates generally below 2 mm/yr, indicating long-term elastic strain accumulation along reactivated Proterozoic faults and shear zones. Gravity and geoid analyses highlight pronounced lithospheric heterogeneities beneath the DAR. Positive Bouguer and free-air gravity anomalies correspond to uplifted basement blocks, mafic intrusions, and possible lower-crustal underplating that influence stress localization and earthquake nucleation, while negative anomalies delineate sedimentary basins.

InSAR time-series over the Delhi-NCR region reveal localized vertical deformation reaching ~15 mm/yr. Although largely driven by anthropogenic groundwater extraction, its spatial correspondence with mapped faults suggests tectonic modulation of surface deformation. Integrating GNSS, InSAR, and gravity data allows separation of elastic strain, hydrological loading, and long-term tectonic deformation within a unified seismogeodetic framework.

The results indicate that deformation and seismicity are controlled by differential motion between the Bundelkhand and Marwar cratons, reactivation of inherited structures, and stress transfer from the Himalayan collision. The study demonstrates the value of geoid-centered seismogeodesy for improving intraplate seismic hazard assessment and strengthening India's geodetic infrastructure.

Keywords: Intraplate tectonics · GNSS deformation · InSAR time-series · Gravity anomalies

Presenter: Somalin Nath (National Centre for Geodesy, IIT Kanpur, Uttar Pradesh, India)

Session: Seismogeodesy

Presentation day: Thursday

Diurnal and sub-diurnal Earth Rotation variations observed using VLBI

Tobias Nilsson¹

1 - Lantmäteriet, Sweden

This work investigates diurnal and sub-diurnal variations in the Earth Orientation Parameters (EOP) estimated from VLBI data. This is done using the whole history of VLBI data from 1979 until present; a period spanning more than 45 years. The results are compared to the predictions from various models for high frequency EOP variations. For this, both models based on ocean tide models or empirical models estimated from VLBI or GNSS data are used. Furthermore, the impact of various models and settings used in the VLBI data analysis - like models for geophysical loading and atmosphere delays - on the estimated diurnal and sub-diurnal EOP estimates are investigated.

Keywords: Earth rotation · VLBI · Earth Orientation Parameters · sub-diurnal variations

Presenter: Tobias Nilsson (Lantmäteriet, Gävle, Sweden)

Session: Earth rotation

Presentation day: Monday

The role of GNSS data in unveiling the impact of crustal deformation on polar motion

Adrian Nowak¹, Tomasz Kur¹, Radosław Zajdel², Krzysztof Sośnica¹

1 - Wrocław University of Environmental and Life Sciences, Poland

2 - Geodetic Observatory Pečný (GOP), Czechia

Polar motion (PM) is a sensitive indicator of mass redistribution and angular momentum exchange within the Earth system. Its variability reflects atmospheric, oceanic, and hydrological forcing, superimposed on solid-Earth deformation. Despite advances in geophysical excitation modeling and satellite gravimetry, discrepancies between observed geodetic and model-based excitation functions remain, particularly in the seasonal band, where the annual wobble shows amplitude and phase modulation. We quantify the contribution of elastic crustal deformation inferred from Global Navigation Satellite Systems (GNSS) to the equatorial PM excitation functions (χ_1 , χ_2). We employ the inverse GNSS method, interpreting residual station displacements as load-driven elastic deformation caused by surface mass redistribution. Using a 21-year series (2002-2022) of daily SINEX files with normal equations from the Center for Orbit Determination in Europe products, released in the 3rd reprocessing campaign of the International GNSS Service, we estimate surface load density coefficients of degree-2 and order-1 (C_{21} , S_{21}), which we then convert into χ_1 and χ_2 . The resulting series are compared with Geodetic Angular Momentum excitation functions derived from PM observations (IERS EOP 20u24 C04 solution), geophysical effective angular momentum excitation series from the Earth System Modelling group at Deutsches GeoForschungsZentrum, and gravimetric excitation functions from Satellite Laser Ranging and GRACE/GRACE-FO. We further assess how surface loading and associated crustal deformation retrieve seasonal PM excitation. To analyze the non-stationary annual signal, we use time-adaptive signal decomposition and assess agreement using spectral and time-domain metrics. Our results show that GNSS-derived excitation functions provide an independent, observation-driven assessment of PM excitation and help reconcile seasonal variability between geodetic observations and geophysical models.

Keywords: Polar motion · GNSS · Excitation functions · IGS repro · Geodetic Angular Momentum

Presenter: Adrian Nowak (Wrocław University of Environmental and Life Sciences, Wrocław, Poland)

Session: Earth rotation

Presentation day: Monday

TENTATIVE

Tectonic strain in the Antarctic plate: constraints from GNSS, GRACE observations, and GIA models

Dwijendra N. Pandey^{1,2}, Vineet K. Gahalaut^{1,2,3}, Joshi K. Catherine¹

1 - CSIR-National Geophysical Research Institute, Hyderabad, India

2 - Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, India

3 - Wadia Institute of Himalayan Geology, Dehradun, India

The Antarctic continent undergoes significant deformation due to diverse processes (namely, hydrological loading, volcanic activity, tectonic forces, glacial isostatic adjustment, and contemporary mass changes) and varying lithology across the continent. We investigate internal deformation of the continent using 97 continuous GNSS sites distributed across Antarctica. Additionally, we incorporated deformation data derived from GRACE measurements. To understand the geodynamics and overall deformation processes of the Antarctic continent, we estimated the strain rate using GNSS and GRACE measurements, as well as from 1D & 3D Glacial Isostatic Adjustment (GIA) model predicted displacements. Our analysis reveals substantial regional variations in strain. The highest strain rates, around 20 nstrain/year, are observed in the Antarctic Peninsula, while those in West Antarctica range from 2 to 6 nstrain/year. In contrast, the interior of East Antarctica exhibits minimal strain with some anomalous behaviour in the peripheral regions. The GRACE data reveal notable deformation, with strain rates of ~ 3 nstrain/year. Strain rates derived from the 1D GIA model shows significant deformation around Victoria Land and the Antarctic Peninsula, whereas 3D GIA models show considerable variations in strain rates depending on the rheological structures adopted in different models. In West Antarctica, these variations range from ~ 1.5 to 3.5 nstrain/year. To assess the contribution of seasonal strain to the Antarctic Plate, we also estimated seasonal strain using GNSS and GRACE data. The maximum seasonal strain derived from GNSS is ~ 9 nstrain/year, while the corresponding estimate from GRACE is ~ 1.7 nstrain/year.

Overall, the results improve our understanding of the geodynamic processes operating in Antarctica and highlight the critical role of both tectonic forces and mass-driven changes in shaping the continent's ongoing deformation.

Keywords: Antarctica · GNSS & GRACE · GIA

Presenter: Dwijendra N. Pandey (CSIR- National Geophysical Research Institute, Hyderabad, Telangana, India)

Session: Cryospheric deformation of the solid Earth

Presentation day: Wednesday

TENTATIVE

Towards Self-Consistent GNSS and GRACE Trends Across Canada

Soran Parang¹, John W. Crowley¹

¹ - Canadian Geodetic Survey, Natural Resources Canada, Ottawa, ON, Canada

Glacial isostatic adjustment (GIA) is a dominant long-term signal in geodetic observations across Canada and must be removed consistently to isolate present-day mass redistribution and vertical land motion (VLM). We present a framework to obtain self-consistent GNSS and GRACE trends across Canada by integrating GNSS, GRACE, and GIA models. The analysis uses 490 GNSS stations with long, high-quality records (≥ 10 years, $\dot{VLM} \leq 1$ mm/yr). GNSS time series are modeled using robust regression with linear, seasonal, and step components, while iteratively reducing outlier influence. Undocumented discontinuities from equipment changes, earthquakes, and environmental effects are identified using a sliding-window method optimized with machine learning. GNSS time series are corrected for GIA using ICE6G-VM5a and adjusted for non-tidal loading. GRACE observations are used to estimate present-day mass change and elastic response using three solutions: the Canadian Geodetic Survey (CGS) approach, which estimates mass change and vertical displacement using a joint parametric model that accounts for spatially correlated errors and significant temporal trends, and the CSR and JPL RL06.3 mascon solutions. For the mascon-based mass change grids, elastic surface displacement is computed by convolving the load field with Green's functions derived from load Love numbers. The three GRACE-based solutions are broadly consistent at most sites. Residuals between GNSS-derived VLM and GRACE-based elastic displacement are analyzed across Canada. Residual patterns identify regions where discrepancies likely reflect unmodeled hydrological loading, local/regional signals or limitations in the GIA corrections applied to GNSS and GRACE. Regionally constrained GIA models are tested at selected locations against ICE6G-VM5a to quantify improvements in reducing discrepancies. A national residual-trend map provides a metric to evaluate geodetic consistency and identify regions requiring improved modeling.

Keywords: GNSS · GRACE · Glacial Isostatic Adjustment · Vertical Land Motion · Surface Mass Loading

Presenter: Soran Parang (Canadian Geodetic Survey, Natural Resources Canada, Ottawa, ON,

Canada)

Session: Hydrologic signature in geodetic observations

Presentation day: Tuesday

TENTATIVE

Postseismic Deformation in Andaman Nicobar Islands following the 2004 Sumatra-Andaman Megathrust Earthquake

Nidhi Parashar^{1,2}, Vineet K. Gahalaut^{1,2,3}, Joshi K. Catherine^{1,2}, M. S. Naidu^{1,2}, V. Rajeshwara
Rao^{1,2}

1 - CSIR - National Geophysical Research Institute, Hyderabad, India

2 - Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, India

3 - Wadia Institute of Himalayan Geology, Dehradun, India

The Sumatra-Andaman subduction zone is one of the most seismically active plate boundaries, where the Indo-Australian Plate subducts obliquely beneath the Sunda Plate. This complex convergence has produced many large earthquakes like 2005 (Mw 8.6), 2007(Mw 8.4, 7.9), 2008(Mw 7.4), 2012 (Mw 8.6), and the third largest recorded earthquakes in modern times: 2004 Sumatra-Andaman megathrust earthquake (Mw 9.1), which ruptured ~ 1500 km of the Sunda Trench over ~ 10 minutes, also generating a catastrophic tsunami. Owing to its large magnitude, this earthquake triggered long-lasting postseismic deformation across a broad region. Postseismic deformation is well explained using different models in far-field sites, whereas near-field sites remain less well understood.

In this study, we model the postseismic deformation at near-field sites in the Andaman and Nicobar Islands using VISCO1D. We consider a spherical, layered, compressible, self-gravitating, viscoelastic Earth model, based on the Preliminary Reference Earth Model. We have taken a 62 km thick elastic lithosphere, underlain by a biviscous (Burgers body) asthenosphere and a Maxwell viscoelastic upper mantle. We model the coseismic rupture source using STATIC1D, incorporating both the 2004 (Mw 9.1) Sumatra-Andaman and the 2005 (Mw 8.7) Nias earthquakes. The modeled time series are compared with the continuous GPS measurements from sites on the Andaman and Nicobar Islands, which produces very good fit for the far field sites, consistent with the previous models, however the near field sites are not adequately explained, with the exception of Campbell Bay (CBAY) in the Nicobar Islands. The result underlines the need for incorporating lateral heterogeneity in the earth model for a complex subduction zone such as the Sumatra Andaman to produce consistently good results in both near and far field sites.

Keywords: Postseismic · Viscoelastic · Sumatra-Andaman · Megathrust · Crustal Deformation

Presenter: Nidhi Parashar (CSIR - National Geophysical Research Institute, Hyderabad, Telangana, India)

Session: Seismogeodesy

Presentation day: Thursday

TENTATIVE

A Machine Learning Ensemble Approach for Short-Term Polar Motion Prediction Using Rapid EOP and EAM Forecasts

Aleksander Partyka¹, Jolanta Nastula¹, Justyna Śliwińska-Bronowicz¹, Małgorzata Wińska²

1 - Centrum Badań Kosmicznych PAN, Warsaw, Poland

2 - Warsaw University of Technology, Poland

Short-term prediction of Earth Orientation Parameters (EOP) is critical for precise satellite navigation and deep-space tracking. While the IERS EOP C04 series provides highly accurate EOP data, its multi-week latency limits its utility in real-time applications, necessitating the use of rapid products and prediction models. This study proposes a robust machine learning (ML) ensemble framework for short-term Polar Motion (PM_x, PM_y) prediction up to 10 days ahead. We integrate daily rapid EOP observations (finals.daily) with Effective Angular Momentum (EAM) forecasts from the GFZ German Research Centre for Geosciences, including atmospheric, oceanic, hydrological, and sea-level components. The methodology employs an ensemble comprising Least-Squares Boosting (LSBoost) and Gaussian Process Regression (GPR). To maximize prediction performance and avoid the risk of overfitting, we optimize historical window lengths and hyperparameter configurations. Furthermore, feature engineering, incorporating moving averages and daily variations of EAM components, is applied to extract the physical signal from the EAM data without overfitting the prediction models with the noise present in the data.

The models are trained on a ten-year dataset and their performance is verified through a simulated annual forecasting campaign. Their accuracy is assessed against reference EOP time series (the input Rapid series and the IERS EOP C04 20 series) by calculating the Mean Absolute Errors (MAE). The results show that incorporating EAM forecasts into EOP prediction models significantly improves accuracy compared to models based solely on historical EOP data. Moreover, the ensemble approach yields a lower MAE over the 10-day forecast horizon than any single component model, confirming the usefulness of such a method.

Keywords: Polar Motion · Prediction · Machine Learning · Effective Angular Momentum

Presenter: Aleksander Partyka (Centrum Badań Kosmicznych PAN, Warsaw, Poland)

Session: Earth rotation

Presentation day: Monday

TENTATIVE

Integration of EGMS and GNSS Data for Strain Mapping and Uplift Acceleration Analysis at Campi Flegrei

Francesco Pintori¹, Alessandra Borghi¹, Luigi Passarelli¹

1 - Istituto Nazionale di Geofisica e Vulcanologia - Sezione di Bologna, Italy

The Campi Flegrei caldera is currently experiencing a significant unrest phase. Since 2010, the area has transitioned from long-term subsidence to progressive uplift, with a marked acceleration in deformation rates observed since 2019. This study leverages European Ground Motion Service (EGMS) data integrated with Global Navigation Satellite System (GNSS) measurements to provide a high-resolution characterization of the current deformation field. EGMS data offer unprecedented spatial density but are inherently limited to a 2D geometry, providing only deformations along East-West and vertical components. Therefore, to better constrain the North-South component, integration with GNSS is essential, despite its lower spatial resolution. Given the time-dependent nature of the Campi Flegrei deformation, depicted by the non constant site velocities, we focused on the careful analysis of uplift acceleration both in the near- and far-field. We identified the spatial boundaries where ground velocities transition from a linear to a quadratic trend, treating these as a direct indicator of a non-stationary pressurized source. Defining this “boundary” is crucial for characterizing the effective extent of the current unrest and investigating the relationship with the spatial distribution of seismicity. High-resolution seismic catalogs indicate that while the backbone of seismicity is primarily controlled by caldera-scale uplift, specific earthquake clustering can be attributed to non-stationary and transient phases of the deformation pattern. Preliminary results suggest how the integration of high-density EGMS data with the 3D precision of GNSS provides a refined view of the strain-rate field. This integrated approach offers essential constraints for monitoring volcanic unrest, contributing to a better understanding of the interplay between ground deformation and the intensification of seismic activity in one of the world’s most critical volcanic systems.

Keywords: Campi Flegrei · EGMS · GNSS · Volcanic unrest · Deformation-seismicity coupling

Presenter: Francesco Pintori (Istituto Nazionale di Geofisica e Vulcanologia, Bologna, Italy)

Session: Volcanogeodesy

Presentation day: Thursday

TENTATIVE

Sensitivity of Antarctic GPS-derived bedrock motion to surface mass balance loading corrections and reference-frame realisation strategies

Jenan Rajavarathan^{1,2}, Matt A. King^{1,2}, Christopher Watson^{1,2}

1 - University of Tasmania

2 - The Australian Centre for Excellence in Antarctic Science, Hobart, Tasmania, Australia

Antarctic GPS time series are used to constrain models incorporating Glacial Isostatic Adjustment (GIA), ice-mass change, and Earth rheology. Their interpretation is impacted by several sources of uncertainty, among which Surface Mass Balance (SMB) loading corrections and terrestrial reference frame realisation are particularly important. Differences between SMB models show substantial spatial and temporal variations, introducing additional uncertainty into the elastic loading corrections when used to correct bedrock-fixed GPS observations. At the same time, frame realisation choices can introduce network-dependent artefacts that may bias estimated coordinates, velocities, and formal uncertainties.

In this study, we combine these two aspects by first evaluating a range of SMB products, including RACMO2.3p2, RACMO2.4p1, MAR, GEMB, HIRHAM5, and MERRA2, by comparing them with estimated GPS-derived vertical deformation. We then quantify the impact of different reference-frame realisation strategies on Antarctic GPS timeseries, including the use of IGS20, JTRF2020 as well as alternative realisation approaches such as estimating global Helmert transformation parameters using a robust estimator, inclusion or exclusion of a daily scale parameter, or alternate geographical weighting of reference stations. Results show that, for most Antarctic GPS sites considered, all SMB models reduce long-period (>1.5 years) GPS variance on average, although performance varies across regions and individual stations. Among the models, the RACMO variants perform best, with RACMO2.3p2 (2 km) and RACMO2.4p1 showing the largest variance reduction and scale factors closest to unity across several regions of Antarctica. RACMO2.3p2 (27 km), GEMB, and MAR show moderate overall performance, while MERRA2 and HIRHAM5 perform weakest. Preliminary analysis of different frame realisation strategies suggests an important contribution to the seasonal and power-law noise properties of the GPS time series.

Keywords: Global Positioning System · Surface mass balance loading · Crustal deformation ·

Reference frame realisation

Presenter: Jenan Rajavarathan (University of Tasmania, Hobart, Tasmania, Australia)

Session: Cryospheric deformation of the solid Earth

Presentation day: Wednesday

TENTATIVE

On the Gravitational Coupling Between the Inner Core and the Mantle in Space Gravimetry

Severine Rosat¹, Hugo Lecomte², Thiziri Saad¹, Olivier Barrois¹, Jean-Paul Boy¹

1 - ITES-CNRS, France

2 - National Land Survey of Finland, Finland

The Earth's solid inner core (IC), being an oblate body, is not rigidly locked to the mantle but can reorient under the influence of varying coupling torques. Gravitational coupling with mantle density anomalies—particularly the Large Low Velocity Provinces (LLVPs) beneath the Pacific Ocean and Africa—drives the realignment of the tilted IC to maintain the planet's hydrostatic equilibrium. The surface gravity signature induced by IC reorientation depends on three key factors: the amplitude of the IC's surface topography, the tilt angle between the IC and the degree-2 density anomalies in the mantle, and the IC's viscosity. Additionally, the IC's rotation generates a gravitational torque on the mantle, counteracting the electromagnetic torque at the core-mantle boundary. This results in a net torque on the mantle, which manifests as variations in the Earth's length of day. Numerical geodynamo models suggest that long-term differential rotation of the IC, driven by electromagnetic coupling at the core boundaries, may be negligible. Consequently, gravitational coupling between the IC and the mantle could be the primary mechanism behind long-term IC reorientation. In this work, we show how geodetic observations can constrain the gravitational coupling between the IC and the mantle at interannual timescales. However, detecting these geodetic signatures of IC reorientation remains challenging, as larger surface processes often obscure them.

Keywords: inner-core rotation · gravitational coupling · space gravimetry · length-of-day variations · core flows

Presenter: Severine Rosat (ITES - CNRS, Strasbourg, France)

Session: Earth rotation

Presentation day: Monday

Constraining Mantle Rheology with Long-Period Tides: comparison of modelled responses with superconducting gravimeters, low-degree time-variable space gravity, and length-of-day observations

Thiziri Saad¹, Severine Rosat¹, Jean-Paul Boy¹

1 - ITES-CNRS, France

Tidal forcing induces significant deformation of the Earth, investigated as early as the 19th century by Kelvin and later formalized by Love through the Love number formalism. The viscoelastic response of Earth's mantle is traditionally modelled using the Maxwell rheology, and more rarely using the Burgers rheology. This work presents a comparative analysis of four viscoelastic rheological models: the Maxwell, Burgers, Andrade, and Sundberg-Cooper models. Although rarely used for the Earth, the Andrade and Sundberg-Cooper models have proven to be relevant for other planetary bodies. Theoretical responses have been developed for these models over a broad frequency range, from the seismic band to very long periods. Model predictions are compared with observations from the IGETS (International Geodynamics and Earth Tide Service) worldwide network of superconducting gravimeters, low-degree time-varying space gravity measurements, and length-of-day variations to better constrain Earth's mantle rheology and viscosity.

Keywords: Viscoelastic rheological models · Potential Love numbers · Long-period tides

Presenter: Thiziri Saad (ITES - CNRS, Strasbourg, France)

Session: Tidal and non-tidal loading

Presentation day: Tuesday

A multiparametric and unsupervised-learning approach to characterize seismic and deformation variability during Villarrica's eruptive cycle (2018-2019)

Constanza Santori¹, Bertrand Potin², Sergio Ruiz¹, Diego González-Vidal³, Juan Carlos Baez⁴

1 - Departamento de Geofísica, Facultad de Ciencias Físicas y Matemáticas, Universidad de Chile, Chile

2 - Programa Riesgo Sísmico, Facultad de Ciencias Físicas y Matemáticas, Universidad de Chile, Chile

3 - Departamento de Geofísica, Universidad de Concepción, Chile

4 - Centro Sismológico Nacional, Universidad de Chile, Chile

Villarrica volcano in southern Chile is a persistently active open-vent system characterized by continuous degassing, sustained tremor, and episodic eruptive activity. These conditions generate complex and highly variable signals, where traditional event-based approaches may fail to capture subtle transitions in system dynamics. In this context, integrating geodetic and seismic observations is essential for improving the characterization of volcanic processes and their temporal evolution.

This study investigates the eruptive cycle between December 2018 and September 2019, a period marked by alternating eruptive pulses and quiescent phases. Continuous broadband seismic data (100 Hz) are segmented into 3-minute and 1-hour windows, from which a large set of statistical and spectral features is extracted using the *tsfresh* framework, enabling a high-resolution representation of seismic variability. In parallel, a GNSS network provides the geodetic framework to interpret the analysed interval within the volcano's broader deformation patterns, including inflation-deflation cycles. This integration allows linking changes in seismic signal properties with underlying magmatic processes and conduit dynamics.

Unsupervised learning techniques are applied to identify latent structures without predefined classes. Results reveal clear distinctions between eruptive and quiescent states, as well as intermediate regimes that may reflect transitional stages in the volcanic system. These findings suggest that changes in the statistical structure of seismic signals are associated with variations in fluid dynamics and pressure conditions within the conduit.

This work highlights the potential of combining GNSS observations, high-frequency seismic analysis, and data-driven approaches for multi-sensor volcanic monitoring, contributing to improved detection of transitional states and supporting hazard assessment in open-vent systems.

Keywords: Unsupervised machine learning · Volcano geodesy · Volcano seismology · Open-vent system

Presenter: Constanza Santori (Universidad de Chile., Santiago de Chile, Chile)

Session: Volcanogeodesy

Presentation day: Thursday

FEATS-G: Quantifying the Potential of Quantum Space Gravimetry

Reyko Schachtschneider¹, Henryk Dobslaw¹, FEATS-G Consortium^{2,3}

1 - GFZ Helmholtz Centre for Geosciences, Germany

2 - Europe

3 - Japan

FEATS-G will quantify the potential of a future quantum space gravimetry (QSG) mission by detailed simulation experiments for various real-world applications related to the monitoring of underground changes over time, e.g., geophysics, climate research, and Earth sciences in general. By bringing together researchers from 13 European and 7 Japanese institutions as well as experts in space mission design, geodetic gravity field processing, and numerous application areas, we will quantify and illustrate the added value of novel QSG mission concepts based on either gravimetry and gradiometry configurations over already existing (GRACE/-FO) or firmly planned gravity satellite constellations (GRACE-C and NGGM/MAGIC). By building on the latest sensor specifications from CARIOQA and other industry-lead research activities, we will perform detailed end-to-end satellite simulation studies to develop new (or refined) retrieval algorithms for various applications that are specifically tailored towards capitalizing on the enhanced sensitivity of the quantum sensors. The project will prepare the scientific community for the new QSG data and aims to significantly enhance European competitiveness in quantum technology and satellite-based gravity monitoring. In the long-run, FEATS-G shall pave the way towards realizing the space component of a full-scale network of ground, airborne and space-based gravimeters for Earth observation purposes tailored towards research, commerce, and security applications by consolidating user requirements across different disciplines for a highly precise and global gravity field monitoring from space. Here, we give an overview of the project structure and its foreseen products.

Keywords: quantum sensors · satellite geodesy · simulation experiments

Presenter: Reyko Schachtschneider (GFZ Helmholtz Centre for Geosciences, Potsdam, Germany)

Session: Hydrologic signature in geodetic observations

Presentation day: Tuesday

The Geodynamics In ANTArctica based on REprocessing GNSS DATA INitiative (GIANT-REGAIN) Phase 2

Mirko Scheinert¹, Matt A. King², Terry Wilson³, Peter J. Clarke⁴, Demián Gómez³, Achraf Koulali⁴, Eric Kendrick³, Alexey Kupriyanov¹, Eric Buchta^{1,5}

1 - TUD Dresden University of Technology, Dresden, Germany

2 - University of Tasmania, Hobart, Australia

3 - The Ohio State University, Columbus, USA

4 - Newcastle University, Newcastle, United Kingdom

5 - Federal Agency for Cartography and Geodesy, Leipzig, Germany

For more than three decades, geodetic GNSS measurements have been used to infer bedrock displacement in Antarctica. Within the SCAR-endorsed project GIANT-REGAIN (Geodynamics In ANTArctica based on REprocessing GNSS DATA INitiative), for the first time geodetic GNSS data have been compiled for as many Antarctic bedrock stations as possible, covering the period from 1995 to 2021. The analyses of the data of about 280 permanent and episodic GNSS sites was accomplished by four processing centres. The details and results were reported by Buchta et al (2025, ESSD). As final products we provided combined (mean) coordinate time series for all stations involved, time series of tropospheric zenith path delay (as four individual AC solutions), site information (IGS log files) and a list of events (Buchta et al. 2025, PANGAEA). Now, we aim to include recently recorded GNSS data to extend the observational basis by four years (until the end of the Antarctic season 2025/2026) and add new stations as much as possible. A data call has been published in May 2026 and continued to be advertised during the SCAR Meeting and Open Science Conference in Oslo, August 2026. We will also update processing standards (e.g. linkage to ITRF2020) to ensure a maximum level of consistency. The resulting coordinate time series will allow to investigate the Antarctic bedrock displacement pattern in much more detail than before, enlarging the time base to partly more than 30 years. Thus, they will further foster detailed investigations to advance our knowledge of glacial isostatic adjustment and geodynamics in Antarctica.

Keywords: GNSS · Antarctica · GIA

Presenter: Matthias Willen (TUD Dresden University of Technology, Dresden, Germany)

Session: Cryospheric deformation of the solid Earth

Presentation day: Wednesday

TENTATIVE

Ocean Tide Loading in East Antarctica: A Comparison of SPOTL and LoadDef Solutions Using GNSS Observations

Aino Schulz¹, Arttu Raja-Halli², Yohannes Getachew Ejigu², Jyri Näränen², Maaria Nordman^{1,2}

1 - Department of Built Environment, School of Engineering, Aalto University, Finland

2 - Finnish Geospatial Research Institute, National Land Survey, Finland

Ocean tidal loading (OTL) induces vertical surface displacements of up to several centimeters at Antarctic GNSS stations. However, global ocean tide models used to correct for this effect have historically been poorly constrained in the Antarctic region due to sparse tidal observations, uncertainties in bathymetry, and limited knowledge of grounding line geometry. In this study, we evaluate the performance of several upgraded global OTL models: TPXO10-atlas-v2, FES2022b and GOT5.5, and a regional circum-Antarctic model CATS2008-v2023, in comparison to the widely used older model FES2004. Total OTL displacements and harmonic coefficients for the main diurnal and semidiurnal constituents are computed for several GNSS stations in East Antarctica focusing on Dronning Maud Land. We use two independent software packages, SPOTL and LoadDef, allowing us to assess both model-related and computational differences. The modeled displacements are compared with observed GNSS vertical time series using both time-domain analysis and frequency-domain (harmonic constituent) evaluation. Additionally, we investigated the influence of different Earth models with LoadDef on the resulting loading estimates. Our results show that differences between SPOTL and LoadDef solutions are generally small and can primarily be attributed to differences in numerical implementation, including Green's function discretization in the near field, as well as variations in land-sea masking. Differences between the OTL models are subtle and vary between the stations and constituents. Our findings indicate that differences between ocean tide models dominate over computational differences between SPOTL and LoadDef in OTL predictions in East Antarctica.

Keywords: Ocean tidal loading · Antarctica · GNSS

Presenter: Arttu Raja-Halli (Finnish Geospatial Research Institute, National Land Survey, Espoo, Finland)

Session: Tidal and non-tidal loading

Presentation day: Tuesday

TENTATIVE

Present-to-Future Wetland Vulnerability to Relative Sea-Level Rise along the Gulf of Khambhat, India

Sona Sharma¹, Chandrakanta Ojha¹

¹ - Indian Institute of Science Education and Research (IISER) Mohali, India

Gulf of Khambhat (GoK), along the west coast of Gujarat, has the highest tidal range in India (up to 11 meters) and is projected to experience an average sea-level rise (SLR) of about 9.5 mm/year under the high-emission climatic scenario (i.e., SSP5-8.5), according to the IPCC-AR6 report. Along the GoK coast, wetlands include mudflats, creeks, salt pans, mangroves, and sand beaches, with mudflats being the most dominant. Such wetlands along the GoK serve as natural buffers against erosion and flooding, but they are increasingly vulnerable due to SLR, coastal land subsidence (CLS), and human activities. These cause gradual degradation and shrinkage of wetlands in many low-lying coastal areas of the Gulf Bay region. To understand the current and future vulnerability of the wetland across GoK and enable effective monitoring, we measure relative sea-level rise (RSLR) by integrating CLS with the mean SLR under different climatic scenarios (using SSP5-8.5 as the worst-case SSP scenario). In this analysis, we further projected the extent of wetland submergence by quantifying the area of different wetland classes affected for 2030, 2050, and 2100, considering both SLR-only and combined SLR and CLS. CLS is monitored using satellite-based Interferometric Synthetic Aperture Radar (InSAR) techniques, a well-established approach for deformation monitoring over the past decades, and crucial for accurate RSLR measurements. Our analysis indicates that RSLR will affect more than 1%, 3%, and 13% of wetlands by 2030, 2050, and 2100, respectively. In particular, the salt pan types will submerge by more than 23%, 80%, and 300% due to the RSLR for 2030, 2050, and 2100, respectively. We also noticed that, by 2100, approximately 4 km², 11 km², 20 km², and 7 km² area of the salt pan, creek, mudflats, and mangroves will be underwater, whereas the sand beach area will increase by approximately 7% due to RSLR, suggesting shoreline instability that aggravates coastal geohazards along the GoK.

Keywords: Subsidence · Wetlands · Vulnerability · RSLR · InSAR

Presenter: Sona Sharma (Indian Institute of Science Education and Research (IISER), Mohali,

India)

Session: Hydrologic signature in geodetic observations

Presentation day: Tuesday

TENTATIVE

Groundwater Crisis and “Day Zero” Vulnerability in Bengaluru, India: A Multi-Source Hydro-Geophysical and Geodetic Study

Arpan Shastri¹, Mayank Dixit², Chandrakanta Ojha¹

1 - Department of Earth and Environmental Sciences, IISER Mohali, Punjab, India

2 - Central Ground Water Board, South Western Region, Bengaluru, Karnataka, India

Bengaluru, India’s “Silicon Valley”, has experienced rapid urbanization, industrialization, and population growth, placing severe stress on groundwater resources. This study integrates hydrogeophysical, hydrogeological, geodetic, and climatic datasets to evaluate groundwater sustainability and associated geohazards in the region. We analyze data from 682 vertical electrical soundings conducted between 1990 and 2023 to estimate geo-electric and Dar-Zarrouk parameters, along with groundwater information from 680 exploratory and 100 observatory wells monitored between 2000 and 2024. To investigate long-term deformation patterns, we use ALOS-1 observations (2007-2011), which indicate no significant land subsidence during that period, and Sentinel-1 InSAR data (2020-2024), which reveal localized subsidence rates reaching \sim -17 mm/yr in several parts of the city. Monthly GRACE observations (2002-2023) and rainfall datasets are further incorporated to assess groundwater storage variability and recharge conditions.

Our results show that nearly 47% of observation wells exhibit statistically significant declining groundwater levels over the past two decades. Although aquifers in parts of eastern, western, and southern Bengaluru support localized recharge due to thick weathered zones, groundwater storage trends display strong temporal variability ranging from 145 cm to -132 cm, with an overall negligible increase of only \sim 0.0034 cm/month, indicating that groundwater extraction continues to exceed recharge. The transition from negligible deformation during 2007-2011 to measurable subsidence after 2020 suggests increasing anthropogenic stress and groundwater overexploitation in recent years. These findings highlight the urgent need for sustainable groundwater management and integrated urban water planning to mitigate long-term environmental and infrastructure-related risks in Bengaluru.

Keywords: InSAR · Groundwater Depletion · Land subsidence · Bengaluru · Hydrogeophysics

Presenter: Arpan Shastri (Indian Institute of Science Education and Research Mohali, Mohali

(Punjab), India)

Session: Hydrologic signature in geodetic observations

Presentation day: Tuesday

TENTATIVE

Hydrology-deformation coupling in the Central-Northern Apennines, Italy, from integrated satellite and in situ observations

Francesca Silverii¹, Clara Bouvier², Giuseppe Pezzo¹, Enrico Serpelloni¹, Critiano Tolomei¹,
Alessandra Borghi¹, Leonardo Martelli¹, Carlo Calamita¹, Susanna Werth³, Adriano Gualandi⁴,
Lucia Zaccarelli¹, Manoochehr Shirzaei³, Francesco Pintori¹

1 - Istituto Nazionale di Geofisica e Vulcanologia, Italy

2 - University Gustave Eiffel, Géodata Paris, France

3 - Department of Geosciences, Virginia Tech, USA

4 - University of Cambridge, Department of Earth Sciences, UK

We investigate the coupling between terrestrial water storage (TWS) and crustal deformation in the Central-Northern Apennines (Italy), a tectonically active region with moderate strain rates ($\sim 40\text{-}80$ nstrain/yr) and fractured, karstified carbonate aquifers. These aquifers represent the main groundwater reservoirs and are hydraulically connected to surrounding alluvial systems. Previous studies have shown that TWS variations and related surface loading and pore pressure changes significantly influence surface deformation.

This work aims to further analyse these hydrosphere-lithosphere interactions through the integration of multi-source datasets, including GNSS, InSAR, and both global products and in situ hydrological measurements. GNSS and InSAR are used to derive displacement time series with high temporal and spatial resolution. GRACE provides regional-scale TWS variations, while local-scale information is obtained from hydro-climatic data, including publicly available datasets and sensors deployed specifically for this study. The latter include soil moisture measurements at multiple depths, complemented, where applicable, by GNSS reflectometry. The methodology we use involves data harmonisation and time series analysis to identify spatial and temporal patterns in both geodetic and hydrological datasets. We apply parametric approaches and data-driven multivariate statistical techniques, such as Principal and Independent Component Analysis, to isolate the main physical sources of deformation. These are then compared with deformation induced by surface hydrological loading derived from GRACE (regional scale) and in situ observations (local scale).

Thanks to the different spatio-temporal observation scales, this integrated approach enables regional-scale and high-resolution characterisation of hydrological processes and their impact on

crustal deformation, helping us to better understand the effects of TWS variability on geodetic signals in tectonically active regions.

Keywords: Hydrosphere-lithosphere interaction · Central-Northern Apennines · Multiparametric observations · Time series analysis

Presenter: Francesca Silverii (Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy)

Session: Hydrologic signature in geodetic observations

Presentation day: Tuesday

TENTATIVE

Modelling Canada's complex 3D crustal motions using GNSS data and geophysical models

Karen M. Simon¹, J. Bond¹, M. Bremner¹, M. A. Goudarzi¹

¹ - Canadian Geodetic Survey, Natural Resources Canada, Canada

This work presents the most recent updates to Canada's GNSS-derived velocity field and resulting crustal velocity model and discusses ongoing improvements to the model formulation. The GNSS dataset is reprocessed to the end of 2025 and includes sites from continuously observing stations in Canada, repeated, high-accuracy Canadian campaign data, as well as continuous GNSS data from Alaska, the northern contiguous United States, and Greenland. Relative to the previous versions, the updated velocity field includes two more years of data, incorporates more stations, uses updated GNSS timeseries discontinuity information, and is determined for all sites using IGS repro3 products, processing standards and models, and Bernese GNSS Software 5.4. The updated velocity model is primarily constrained by the velocity field, while supplemental constraints are provided by predictions from GIA and elastic deformation models. Coinciding with these updates is the implementation of the new North American Terrestrial Reference Frame of 2022 (NATRF2022) which Canada and the United States are adopting in 2027 to replace the North American Datum of 1983 (NAD83). Differences between the velocity model in NAD83 and NATRF2022 show that residual velocities present in NAD83 are significantly reduced in NATRF2022 using new Euler pole parameters determined for the North American plate. While the velocity model to date focuses primarily on long-term secular trends, future versions of the model will also more closely consider processes with non-linear and shorter-term velocity variations. As we discuss with initial results, this approach is particularly useful in regions with significant time-varying components in motion, such as the tectonically active west coast, and regions experiencing cryospheric and hydrological surface load changes. Finally, as a means of model validation, we compare the velocity model to a commercial RTK dataset that was not included in the constraining velocity field.

Keywords: lithospheric deformation · velocity model · GNSS · North America · NATRF2022

Presenter: Karen Simon (Canadian Geodetic Survey, Natural Resources Canada, Sidney, BC,

Canada)

Session: Cryospheric deformation of the solid Earth

Presentation day: Wednesday

TENTATIVE

The Greenland GNSS Network (GNET): Long-Term Stability and Validation of Geodetic-Grade GNSS Measurements of Greenland's 3D Bedrock Displacement from 1995-2025

Christian Solgaard¹, Malte Winther-Dahl², Thomas Henry Nylen¹, Finn Bo Madsen¹, Danjal L. Berg¹, Ole Bjerregaard¹, Javed Hassan¹, Per Knudsen¹, Michael G. Bevis³, Shfaqat A. Khan¹

1 - DTU Space, Denmark

2 - Agency for Climate Data, Denmark

3 - School of Earth Sciences, Ohio State University, USA

GNET consists of 71 geodetic-grade bedrock mounted GNSS stations located along the perimeter of the Greenland Ice Sheet, with the oldest stations dating back to 1995.

Operating cGNSS stations in the remote high Arctic is challenging and can give rise to downtime for stations in the network. In this project, we aim to publish the most comprehensive, fully processed positional time-series from GNET up to date, provided as geodetic coordinates and in a local ENU frame, along with metadata documenting station history. The processing is performed using the PPP methodology implemented in the GipsyX 2.5 software.

To evaluate the quality and performance of the processed time series, two analyses are performed. First, a long-term stability analysis is carried out by fitting and removing a trajectory model from each ENU component. The residuals are then used to estimate power-law noise characteristics, derived from Lomb-Scargle periodograms. The analysis shows that all stations can be expected to operate within the flicker-noise region; $-1 < \kappa < 1$.

Second, we compare our positional time series with two previously published products from other processing centers, JPL and NGL. The comparison, based on 39 of 71 stations, uses inter-metric correlation analysis of trajectory model parameters fitted to the ENU time series. The JPL and NGL products exhibit a small, non-zero seasonal signal in the horizontal components, which is not expected. The low amplitudes of these signals, suggest that these signals likely originate from specific modeling and processing choices during the PPP processing. Consequently, while the vertical seasonal signals can be interpreted confidently, then the horizontal should be treated with caution when using time series from NGL or JPL compared to the DTU product. Overall, the results highlight the importance of processing strategy, noise characterization, and validation for high-precision GNSS time series in geoscience applications.

Keywords: Polar GNSS Network · Geodynamics · Glacial Isostatic Adjustment · Validation

Presenter: Christian Solgaard (Technical University of Denmark, 2800 Kongens Lyngby, Denmark)

Session: Cryospheric deformation of the solid Earth

Presentation day: Wednesday

TENTATIVE

The Government of Canada's Dedicated InSAR-Based Volcano Monitoring System

Mandip Sond¹, Drew Rotheram-Clarke², Chloe Lam², Nicholas Ackerley¹, Melanie Kelman²,
Yannick LeMoigne²

1 - Canadian Hazards Information Service, Canada

2 - Geological Survey of Canada, Canada

The west coast of Canada is home to 348 known volcanic vents grouped into 28 volcanic fields, some of which pose a high or very high threat. Historically, routine monitoring of magmatic unrest in these regions has been limited due to their remoteness and challenging terrain. However, this has recently become feasible through high-revisit Satellite Synthetic Aperture Radar (SAR) observations from the RADARSAT Constellation Mission (RCM), launched in 2019, which enable systematic monitoring of volcanic deformation and ground displacement.

In response, the Canadian Hazards Information Service (CHIS), in collaboration with the Geological Survey of Canada (GSC), developed a dedicated InSAR-based volcano monitoring system for detecting magmatic unrest at volcanic systems in western Canada. The system is being integrated into operational workflows within CHIS to support near-real time monitoring of ground deformation and hazard assessment associated with volcanic activity. To support this capability, we implemented a fully automated, cloud-based InSAR processing system that routinely searches for newly acquired RCM SAR data, ingests and processes the data to generate deformation products, and delivers these products through a dedicated interface supporting scientific analysis, manual annotation, and operational decision-making, enabling early identification of volcanic unrest.

We validate system performance using both Canadian and global volcanic targets, including a detailed case study of the 2023-2024 magmatic unrest on the Reykjanes Peninsula, Iceland. Results are compared with GNSS measurements from the Icelandic Meteorological Office, showing strong agreement in both the timing and magnitude of deformation. This work demonstrates the potential of RCM-based InSAR for operational volcano monitoring, providing a scalable and cost-effective approach for tracking volcanic unrest in Canada and globally.

Keywords: InSAR · Ground deformation · Satellite Remote Sensing · Magmatic unrest ·

Geohazard monitoring

Presenter: Mandip Sond (Canadian Hazards Information Service, Ottawa, Ontario, Canada)

Session: Volcanogeodesy

Presentation day: Thursday

TENTATIVE

Advanced Provision of Stable Earth Orientation Parameters (AdvEOP) for Reference Frames

Daniela Thaller¹, Alexander Kehm¹, Santiago Belda², Mathis Blossfeld³, Robert Dill⁴, Maria Karbon², Sadegh Modiri¹, Laura del Nido Herranz², Claudia Flohrer¹, Henryk Dobsław⁴, Florian Seitz³, Jose-Manuel Ferrandiz², Erik Schoenemann⁵, Jean-Christophe Berton⁵, Sara Bruni⁶, Michiel Otten⁶

1 - BKG, Germany

2 - University of Alicante, Spain

3 - DGFI-TUM, Germany

4 - GFZ, Germany

5 - ESA, Germany

6 - PosiTim UG@ESOC, Germany

High-quality Earth Orientation Parameter (EOP) are of crucial importance for various Earth and space-scientific investigations and applications, e.g., navigation on Earth and in space, satellite orbit determination, Earth system monitoring. In the context of global reference frames, the knowledge of the EOPs is crucial for describing the relative orientation between the international terrestrial and celestial reference frames, i.e., ITRF and ICRF, respectively.

In the frame of its responsibility, ESA's Navigation Support Office at ESOC is contributing to the realisation of the ITRF and of the combined EOP provided by the IERS with products resulting from data analysis for GNSS, SLR and DORIS, and in the near future also for VLBI. In addition, daily multi-technique ERP estimates and predictions are routinely generated by the Office by combining the four geodetic contributions mentioned above at the normal equation level, complemented by forecasts derived from geophysical fluid models from external providers. Thereby, the multi-technique estimates and the predictions are generated as a single product with seamless transition between combined and predicted EOPs. The initial setup for this estimation and prediction procedure was restricted to polar motion coordinates and UT1-UTC. Recently, ESA's Navigation Support Office at ESOC started a project to advance the EOP activities and include also Celestial Pole Offsets, as well as the polar motion rates and Length of Day into the EOP combination and prediction setup. This project named "AdvEOP" is conducted together with a consortium of BKG, DGFI-TUM, GFZ and University of Alicante. The overall objective to be achieved is to make the generation of EOP independent, more robust and more accurate

for future European missions.

We will summarize the activities within the AdvEOP project and present results for improved combined EOP estimates as well as predictions for the full set of five EOPs including their time-derivatives.

Keywords: Earth orientation parameters · multi-technique combination · EOP prediction

Presenter: Daniela Thaller (BKG, Frankfurt, Germany)

Session: Earth rotation

Presentation day: Monday

TENTATIVE

Using VLBI delay rate for estimation of the Earth's instantaneous rotation pole

Oleg Titov¹

1 - Shanghai Astronomical Observatory, Shanghai, China

Traditionally, the influence of Earth's rotation on celestial coordinates has been described using precession and nutation matrices, with the equinox serving as the zero point for measuring right ascensions. However, these changes in celestial coordinates could be also represented through the position of the instantaneous rotation pole (IRP) of the Earth, using two angles (X,Y). VLBI technology allows obtaining the position of the IRP with high accuracy. We used a large set of VLBI observations since 1983 to calculate the position of the Earth's instantaneous rotation pole, estimate the annual precession, and the amplitudes of the main nutation harmonics.

More careful planning of the IVS observational programs will help to estimate the X and Y angles with better formal errors, and, finally, to improve our model of the Earth rotation.

Keywords: Earth rotation · VLBI delay rate · precession · nutation · instantaneous rotation pole

Presenter: Oleg Titov (Shanghai Astronomical Observatory, Shanghai, China)

Session: Earth rotation

Presentation day: Monday

Post-seismic off-fault moment tensor solutions after the 2023 Türkiye-Syria co-seismic mainshock (Mw 7.8, 7.7) and early on-fault aftershock sequence (SE-Anatolia, Türkiye)

Mustafa Toker¹, Evrim Yavuz²

1 - Yuzuncu Yil University, Van, Turkey

2 - Istanbul Metropolitan Municipality, Directorate of Earthquake and Geotechnical Investigation, Istanbul, Turkey

Studying the relationships between geodetic and seismic deformations is one of the most important and long-lasting problems along the North and East Anatolian Fault Zones (NAFZ and EAFZ) across the Anatolian region (Türkiye). The latest earthquake phenomenon, on the 6th February 2023 in the Maras Triple Junction (MTJ) area of the Anatolia, catastrophic earthquake doublet (Mw 7.8, 7.7), promoted a series of answered questions. The 2023 events distorted plate motions, disrupted existing strain patterns, distributed stress-strain, and framed diffuse aftershock patterns across the Anatolian plate. Previous geodetic research responded to some of the previous questions and clarified that; the 2023 doublet was prepared by the stages linked with the previous earthquakes along the EAFZ. The events were geodetically expanded and scattered by off-fault aftershocks. Thus, the 2023 events were evolved from co-seismic multi-faulting along the EAFZ and MTJ to post-seismic off-fault seismic deformations. In this study, the results derived from previous geodetic analyses are complemented by well-constrained off-fault focal solutions resolved from regional Centroid Moment Tensor (CMT) inversion for 41 located off-fault aftershock events (Mw 3.7-5.3) recorded by Kandilli Observatory and Earthquake Research Institute (KOERI) during the subsequent seven months after the 2023 mainshocks. The off-fault aftershock CMT solutions reflect interactively repeated and widely distributed strike-/oblique-slip faulting patterns at the shallow centroid depths in the regional scale to accommodate the Anatolian plate motion to the W. The resolved CMT inversions combined with the geodetic displacement-strain patterns conclude an enormous strain-extending area into diffused deformation of seismic activation zone within the Anatolian plate.

Keywords: 2023 earthquake doublets · Maras triple junction · Anatolian plate, · Geodetic precursors · off-fault aftershock solutions

Presenter: Mustafa Toker (Yuzuncu Yil University, Van, Turkey)

Session: Seismogeodesy

Presentation day: Thursday

TENTATIVE

Observing surface elevation change in Dronning Maud Land using satellite altimetry data

Matea Tomić¹, Maaria Nordman^{1,2}, Heidi Sallila³, Jaakko Seppänen³, Aku Riihelä³

1 - School of Engineering, Aalto University, Espoo, Finland

2 - Department of Geodesy and Geodynamics, FGI, National Land Survey of Finland, Espoo, Finland

3 - Finnish Meteorological Institute, Helsinki, Finland

Although West Antarctica ice sheet is of greater interest for scientists due to its contribution to the global sea level rise driven by the significant mass loss there, East Antarctica sheet contains most of Antarctica's ice mass. Therefore, even small changes could have colossal consequences. In our study, we are interested in monitoring surface elevation change in the Dronning Maud Land in East Antarctica using the combination of radar CryoSat-2 and laser ICESat-2 satellite altimetry missions. In the first part of the study, altimetry-derived elevations are validated against drone-based laser scanning elevation data, collected during the field campaign between November 2022 and February 2023. The field campaign was part of the LAS3R (Low orbit altimetry, albedo, and Antarctic Snow and Sea-ice Surface Roughness) project, conducted by the Finnish Meteorological Institute (FMI). Thereafter, altimetry observations are used to derive surface elevation change covering the period from 2018 to 2025. The expected results will eventually contribute to a better understanding of vertical ice-sheet motion driven by mass changes in the East Antarctic Ice Sheet.

Keywords: Cryosphere · East Antarctica · Laser scanning · Satellite altimetry · Surface elevation change

Presenter: Matea Tomić (Aalto University, Espoo, Finland)

Session: Cryospheric deformation of the solid Earth

Presentation day: Wednesday

Determination of Celestial Pole Offsets Using Intensive Sessions

Renata Urunova¹, Sergei Kurdubov¹

1 - Institute of Applied Astronomy, Russian Academy of Sciences, Russia

VLBI is the only technique capable of determining celestial pole offsets (CPO) with high accuracy and investigating the Earth's free core nutation. Traditionally, Earth orientation parameters (EOP) are obtained from 24-hours VLBI-observation programs, which provide highly accurate and internally consistent solutions. However, the relatively long processing time required for such sessions limits the timeliness of the results, which is especially important for EOP forecasting and support of navigation and geodetic applications. So using Intensive VLBI sessions, which allow rapid estimation of celestial pole offsets, is of particular interest. This study considers the possibility of determining CPO from Intensive sessions and evaluates the accuracy of the obtained estimates. An analysis of long-term IVS VLBI-observations series covering the period 1992-2026 was carried out, including comparison between results obtained from 24-hours and Intensive sessions. It is shown that the combination and joint processing of Intensive sessions can improve the efficiency of CPO estimation while maintaining an acceptable level of accuracy.

Keywords: Celestial Pole Offsets · Earth orientation parameters · Global solution · VLBI

Presenter: Renata Urunova (Institute of Applied Astronomy of the Russian Academy of Sciences, St. Petersburg, Russia)

Session: Earth rotation

Presentation day: Monday

Characterizing ocean tide aliasing errors for improved gravity field recovery

Chethan Varadaganahalli Anandagowda^{1,2}

1 - Interdisciplinary Centre for Water Research, Indian Institute of Science, India), Bramha D. Vishwakarma

(Interdisciplinary Centre for Water Research, Indian Institute of Science, India

2 - Centre for Earth Sciences, Indian Institute of Science, India

Satellite gravimetry missions such as GRACE, GRACE-FO, and the planned NGGM provide essential observations of Earth's time-variable gravity field. Several factors constrain the accuracy of these products, including temporal aliasing caused by inadequately sampled high-frequency mass variations, such as non-tidal atmospheric and ocean variability and ocean tides. Various background models were used to remove these effects, but significant inter-model differences exist. In the current study, the impact of eight different ocean tide models (OTMs) on GRACE-FO gravity field recovery was evaluated through a detailed analysis of spatial and spectral features and post-fit KBR range acceleration residuals. The TiME22 model showed a largest global RMS of 1.211 nm/s² and MiXED2025 with the minimum of 0.709 nm/s² post-fit range acceleration residuals. Similarly, the variance differences with respect to FES2022 showed that the TiME22, EOT11, EOT20, FES2014, and TPXO10 models performed poorly. In contrast, the GOT5.6 and MiXED2025 models performed slightly better, with a mean global RMS of 0.076 nm²/s⁴, especially in bays, Weddell Sea, the Kamchatka Peninsula, and the Timor Sea. Additionally, we found that the inter-model differences between the FES2022 and GOT5.6 models along the GRACE-A footprints at the orbit scale (at the time of measurement) are an order of magnitude larger than monthly mean differences. The inter-model differences estimated at the orbit-scale provide a more realistic understanding of errors, showing higher deviations over the Antarctic ice sheets, the Kamchatka Peninsula region, the eastern part of the Greenland Ice Sheet, and Baffin Bay. To conclude, this study explores OTM errors between various models at the monthly mean as well as along the orbit to better understand the aliasing error characteristics. Takeaways from this study will improve processing strategies for current and future gravimetry missions.

Keywords: Satellite gravimetry · Ocean tide models · Aliasing · Post-fit residuals

Presenter: Chethan Varadaganahalli Anandagowda (Interdisciplinary Centre for Water Research

(ICWaR), Indian Institute of Science, Bangalore, Karnataka, India)

Session: Tidal and non-tidal loading

Presentation day: Tuesday

TENTATIVE

Experimental Assessment of a Low-Cost GNSS Receiver for Dynamic Displacement Monitoring in Seismic Applications

Marcos Velasquez¹, Fernando García², Oscar Solis², Miguel Estrada², Carlos Gonzales², Luis Lopez³, Lucio Estacio⁴

1 - Geomatics Laboratory, Centro Peruano Japonés de Investigaciones Sísmicas y Mitigación de Desastres, Universidad Nacional de Ingeniería, Peru

2 - GeoGiRD Research Group, Facultad de Ingeniería Civil, Universidad Nacional de Ingeniería, Peru

3 - Centro Peruano Japonés de Investigaciones Sísmicas y Mitigación de Desastres, Universidad Nacional de Ingeniería, Peru

4 - Facultad de Ingeniería Civil, Universidad Nacional de Ingeniería, Peru

Peru is among the most seismically active countries worldwide due to the subduction of the Nazca Plate beneath the South American Plate. This tectonic setting makes continuous monitoring of crustal deformation and dynamic ground motion essential for seismic risk assessment. However, dense monitoring networks based exclusively on high-grade geodetic and seismic instrumentation remain limited by economic and logistical constraints.

This study presents an experimental assessment of the Septentrio Mosaic X5 low-cost GNSS receiver for dynamic displacement monitoring. The experiment was conducted on a unidirectional shaking table capable of reproducing harmonic motions and real seismic waveforms. A geodetic antenna was connected to both a low-cost Mosaic X5 receiver and a high-grade Trimble NetR9 receiver, enabling a direct comparison under identical dynamic conditions. In addition, a high-precision accelerometer and a velocity sensor were installed on the same platform to provide complementary acceleration and velocity records.

The objective was to evaluate the capability of the Mosaic X5 to retrieve dynamic displacements and dominant frequencies in comparison with high-grade GNSS and seismic sensors. GNSS observations were analyzed in post-processing mode, while the seismic sensors characterized the imposed ground motion. Rather than proposing full sensor integration at this stage, the study focuses on performance comparison and complementarity between low-cost GNSS, geodetic-grade GNSS, and seismic instrumentation.

This work contributes to the evaluation of affordable technologies for seismic and geodetic monitoring in Peru. The results provide evidence of the potential of low-cost multi-frequency GNSS receivers to support national monitoring networks and provide useful information for crustal

deformation studies, seismic hazard assessment, early warning systems, and post-earthquake damage evaluation.

Keywords: Low-cost GNSS · Dynamic displacement · Seismic monitoring · Shaking table

Presenter: Marcos Velasquez (Universidad Nacional de Ingeniería, Lima, Peru)

Session: Seismogeodesy

Presentation day: Thursday

How to account for ice sheets' mass changes and GIA within a global inversion for sea-level contributions from satellite data?

Matthias Willen¹, Bernd Uebbing², Martin Horwath¹, Jürgen Kusche²

1 - Chair of Geodetic Earth System Research, Dresden University of Technology, Dresden, Germany

2 - Institute of Geodesy and Geoinformation, University of Bonn, Bonn, Germany

Measuring variations in sea level yields a global indicator of the effect of climate change in the Earth system. Satellite geodesy provides data with global coverage to analyze sea level changes in space and time, but also to investigate the individual contributions from oceans, continental hydrology, glaciers, ice sheets, and the solid Earth. Particularly valuable for this are time-variable satellite gravity (GRACE & GRACE-FO), and satellite altimetry over the oceans (e.g. Jason-1/-2/-3 and Sentinel-6). However, previous studies show that the uncertainty of the estimated Antarctic Ice Sheet's (AIS) contribution to sea level remains large, primarily due to errors in the glacial isostatic adjustment (GIA) correction.

We use a global fingerprint inversion that evaluates satellite geodesy data in a globally consistent framework and enables the quantification of individual contributions to sea level on a monthly basis on global grids. The parametrization of the sea-level contributions is realized by time-invariant sea-level fingerprints obtained from a priori information. This includes, e.g., the locations of mass changes or statistically obtained information from geophysical models. By extending the inversion methodology, we have implemented a new parametrization of the ice mass changes (IMC) of the AIS. Previously, Antarctic IMC has been estimated for 27 drainage basins. However, this coarse parametrization prevents from better resolving errors in the GIA correction in upcoming inversion implementations. We have therefore introduced a parametrization based on grid points with a resolution of up to 50 km, resulting in up to 4755 Antarctic mass balance parameters to be estimated. In order to solve this inverse problem, we introduced altimetry over ice sheets as an additional observation. We present and discuss results from different variants of parametrizations of ice mass changes and GIA as well as different variants of implementation of ice altimetry observations.

Keywords: sea level · Antarctic ice sheet · GIA · satellite geodesy

Presenter: Matthias Willen (TU Dresden, Dresden, Germany)

Session: Cryospheric deformation of the solid Earth

Presentation day: Wednesday

TENTATIVE

Regional atmospheric contributions to ENSO-driven interannual variations in Earth's rotation (LOD)

Małgorzata Wińska¹, Justyna Śliwińska-Bronowicz², Jolanta Nastula², Dominika Staniszweska³

1 - Warsaw University of Technology, Faculty of Civil Engineering, Poland

2 - Centrum Badań Kosmicznych PAN, Poland

3 - Warsaw University of Technology, Faculty of Geodesy and Cartography, Poland

Interannual changes in Earth's rotation reflect large-scale exchanges of mass and angular momentum within the atmosphere-ocean system. Numerous studies have established that variations in the Length of Day (LOD) are closely linked to Atmospheric Angular Momentum (AAM) and strongly influenced by the El Niño-Southern Oscillation (ENSO). Nevertheless, most studies interpret LOD variability in terms of total, globally integrated AAM, which masks the role of regional atmospheric circulation anomalies in shaping the rotational response.

Here, we revisit the ENSO-LOD relationship from a regional perspective. Instead of treating atmospheric forcing as spatially uniform, we investigate how circulation and climate anomalies during ENSO periods across different latitude bands and climate domains influence interannual LOD variability. The analysis combines geodetic LOD observations from the IERS with reanalysis-based atmospheric angular momentum fields and ENSO indices. By decomposing axial AAM into spatially defined regional contributions, we assess contributions to total LOD excitation. The study focuses on variability within the 2-8 year band characteristic of ENSO and relies on spectral and time-frequency analyses.

Our findings suggest that Earth's interannual rotational variability cannot be attributed to a single dominant regional contribution to axial atmospheric angular momentum and its associated LOD excitation. Instead, it reflects the combined influence of axial AAM variability in distinct latitude bands, with different amplitudes, phases, and timing. These contrasts are particularly evident during pronounced El Niño and La Niña episodes. While LOD acts as a global integrator of climate variability, it also retains information about the regional structure of atmospheric forcing. This regional perspective highlights the importance of spatially resolved atmospheric forcing for understanding ENSO-related variations in Earth's rotation.

Keywords: Earth rotation · Length of Day (LOD) · Atmospheric Angular Momentum (AAM) ·

ENSO · Regional atmospheric circulation

Presenter: Małgorzata Wińska (Warsaw University of Technology, Warsaw, Poland)

Session: Earth rotation

Presentation day: Monday

TENTATIVE

Constraining viscosity structures for GIA modelling

Christine Wolf¹, Reyko Schachtschneider¹, Volker Klemann¹, Bernhard Steinberger¹

1 - GFZ Helmholtz Centre for Geosciences, Germany

Accurate mantle viscosity structures are essential when modelling glacial isostatic adjustment (GIA). In principle there are two strategies to constrain the viscosity structure. The first one is to invert it from the GIA process itself, which results generally in a radial stratification into upper and lower mantle viscosities and an effective elastic thickness of the lithosphere. These values are usually obtained for the cratonic regions of Laurentide and Fennoscandia, or are further adjusted to represent regions of a different tectonic settings. The second one is to obtain such structures from seismological tomography models, where variations in velocity are transferred to temperature and then to viscosity variations. Whereas the conversion from velocity to temperature is constrained from geodynamics, the conversion of temperature to viscosity involves uncertainty parameters in the Arrhenius law, i.e. the activation enthalpy. In this study we investigate the dependency of GIA signals on the choice of the activation enthalpy factor. We present constraining viscosity structures based on agreement with paleo sea level observations and current deformation rates with focus on the West-Antarctic.

This work contributes to the German Climate Modeling Initiative PALMOD.

Keywords: mantle viscosity · glacial isostatic adjustment · uncertainty · modelling

Presenter: Reyko Schachtschneider (GFZ Helmholtz Centre for Geosciences, Potsdam, Germany)

Session: Cryospheric deformation of the solid Earth

Presentation day: Wednesday

Complete resolutions of polar motion and geodetic excitation equation for Earth's rotation

XueQing Xu¹, Qiqi Shi¹, Chengli Huang¹, Yonghong Zhou¹, Xinhao Liao¹

¹ - Shanghai Astronomical Observatory, Chinese Academy of Sciences, China

The polar motion (PM)'s forthcoming directives for investigation and observation suggest a focus on high precision and high resolution. Observation programmes such as VGOS and GGOS have advanced significantly; nevertheless, the theoretical equations have not progressed correspondingly. To attain the goal of PM examination at hourly intervals with $\hat{\mu}$ accuracy, we sequentially derive the complete resolutions of the polar motion and geodetic excitation (CLE), thereby perfectly establishing the interconversion between the dynamical PM and geodetic excitation within the CLE theoretical framework and supporting future high-frequency PM analysis with sub-daily temporal-resolution space geodetic measurements. Our test results demonstrate that the recovery errors remain far less than $1\mu\text{as}$ at a 1-h time sampling interval, which can fully achieve the applied analysis based on future high-resolution PM observations at hourly intervals with $\hat{\mu}$ accuracy, even taking into account real observations that typically exhibit broadband energies. These simulation experiments with sub-daily time resolution offer valuable insights and serve as preliminary guidance for future high-resolution PM data analysis. To meet the future needs for high-frequency PM research, we provide a theoretical framework for dynamical PM and its excitations, while high resolution and high-precision direct observations of dynamical PM still require further advancements.

Keywords: Earth's rotation variations · Polar motion · Geodetic excitation · Numerical solutions

Presenter: XueQing Xu (Shanghai Astronomical Observatory, Chinese Academy of Sciences, Shanghai, China)

Session: Earth rotation

Presentation day: Monday

Reconciling inferences of mantle viscosity and late Quaternary ice history – the importance of an asthenosphere and 3-D viscosity

Tao Yuan¹, Shijie Zhong¹, Glenn A. Milne², Donna L. dePolo¹

1 - University of Colorado at Boulder, USA

2 - University of Ottawa, Canada

Deglaciation history models from the last glacial maximum (LGM) and accompanying mantle viscosity structures have been jointly constrained by fitting the paleo-sea level data through glacial isostatic adjustment (GIA) modeling. However, some GIA-inferred 1-dimensional (1-D) viscosity models, including the widely used VM5a, contradict the mantle viscosity structure inferred using other approaches, such as seismic imaging, mineral physics and geodynamics. Here we show that GIA models with realistic 3-D mantle viscosity derived from seismic structures with an effective activation energy of 300-400 kJ/mol and a weak asthenosphere fit paleo-sea level data in North America better than several widely used 1-D GIA models. Our results also demonstrate that the inclusion of the asthenosphere and lateral viscosity variations permits a larger range of North American ice sheet reconstructions that produce quality fits to the sea-level data, including models with substantially greater volume at LGM, thus identifying a potential solution to balancing the sea level budget during this key climate event. To fit far-field sea level data, the ice volume at LGM in North America is required to be 10% - 20% larger than that in ICE-6G, if ice models outside North America are unchanged.

Keywords: Mantle viscosity · Glacial Isostatic Adjustment · Deglaciation history

Presenter: Shijie Zhong (University of Colorado at Boulder, Boulder, United States)

Session: Cryospheric deformation of the solid Earth

Presentation day: Wednesday

Lunar Laser Ranging for the Determination of Earth Orientation Parameters

Mingyue Zhang¹, Jürgen Müller¹

1 - Institute of Geodesy (IfE), Leibniz University Hannover, Germany

Lunar Laser Ranging (LLR) has measured the Earth-Moon distance continuously for over 56 years. In recent years, it has benefited from higher-precision observations, improved data coverage of lunar reflectors and the lunar orbit, and upgrades to ground instrumentation. More recently, the new NGLR-1 reflector has been successfully tracked by multiple stations, further densifying the network on the Moon. As the longest geodetic data record, LLR contributes to a wide range of research fields, including the realization of terrestrial reference systems and Earth Orientation Parameters (EOP), such as nutation coefficients, ΔUT1 , and polar motion. Although present results still trail other space-geodetic techniques, LLR remains the only technique besides VLBI that delivers ΔUT1 and nutation estimates with useful accuracy, thus offering an important independent cross-check of VLBI results. In addition to LLR and VLBI, which provide the long-term stable basis for connecting the Earth-fixed and celestial reference systems, ringlasers can directly measure short-term variations of Earth rotations in near real time. As part of the new DFG-funded research unit RING (Rotations IN Physics, Geophysics, and Geodesy), the combination of these three techniques will improve EOP determination, which in turn helps constrain various fundamental physics parameters. We will present the most recent EOP solution from LLR data and illustrate the idea for the combination with ringlaser and VLBI data.

Keywords: Lunar Laser Ranging · Earth Orientation Parameters · Terrestrial and Celestial Reference Systems

Presenter: Mingyue Zhang (Leibniz University Hannover, Hannover, Germany)

Session: Earth rotation

Presentation day: Monday

On the rapid EOP combination and evaluation

Simeng Zhang^{1,2}, Lizhen Lian³, Chengli Huang^{1,2}

1 - Shanghai Astronomical Observatory, Chinese Academy of Sciences, China

2 - University of Chinese Academy of Sciences, China

3 - Shanghai Astronomical Observatory, Chinese Academy of Sciences, China

Earth Orientation Parameters (EOP) play a fundamental role in geodetic and related applications. However, EOP estimates derived from different space geodetic techniques often exhibit systematic discrepancies, making their combination essential for obtaining precise and stable EOP series. To meet the demand for rapid and near-real-time EOP products, a combination strategy based on weighted cubic spline smoothing and ordinary cross-validation is proposed in this study to generate rapid EOP solutions.

The performance of the proposed method is evaluated, based on approximately six months of continuous testing, by comparing daily 90-day sliding-window solutions with the IERS C04 series. The root mean square (RMS) differences over the most recent 30 days are computed. The results indicate that the discrepancies with respect to C04 are approximately $50 \mu\text{s}$ and $40 \mu\text{s}$ for polar motion (x and y), and about $20 \mu\text{s}$ and $10 \mu\text{s}$ for $\text{UT1} - \text{UTC}$ and LOD, respectively. The above tests and results show that the proposed method demonstrates good stability and accuracy, showing close agreement with the IERS C04 series.

Keywords: EOP · rapid combination · method

Presenter: Chengli Huang (Shanghai Astronomical Observatory, Shanghai, China)

Session: Earth rotation

Presentation day: Monday

Chandler wobble and LOD variations in recent epochs

Leonid Zotov^{1,2}, N. Sidorenkov³, Christian Bizouard⁴

1 - Lomonosov Moscow State University, Russia

2 - HSE University

3 - Hydrometeorological Center of Russia

4 - Laboratoire Temps Espace (SYRTE & IMCCE), Paris Observatory, France

In 2020s the greatest minimum of the length of day (LOD) since 1930s and Chandler wobble (CW) disappearance have been recorded. The amplitude of the Free Core Nutation (FCN) reached minimum as well. Some researchers relate these anomalies to the processes at the core-mantle boundary, to the deceleration of the inner core, and to global warming, others - to the mutual destruction of the atmospheric and oceanic excitations. Indeed, variations of the magnetic field, some seismic evidences, and development of the eigen modes theory of Earth rotation point to the credibility of such explanations.

We point out to another circumstance: the correspondence of the epochs of alignment of the line of lunar nodes, line of apse, and line of equinoxes, occurred in 1930s and 2020s to the episodes of greatest minima in the decadal LOD and CW amplitude. We found out asymmetry of the distribution of big moon in perigee events over celestial hemispheres and orientation of the plane of lunar orbit with respect to equator, able to change the amplitude of tides and produce effects in the ocean, atmosphere, and core, responsible for CW decay and some other global geophysics.

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Keywords: LOD · Chandler wobble · Tides

Presenter: Leonid Zotov (Lomonosov Moscow State University, Moscow, Russia)

Session: Earth rotation

Presentation day: Monday

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TENTATIVE

	Monday, September 28	Tuesday, September 29	Wednesday, September 30	Thursday, October 1
08:30	Welcome Addresses, Logistics and Safety	Earth rotation - Progress of techniques and observations	Hydrologic signature in geodetic observations	Seismogeodesy
09:30	Earth rotation - Modelling and Prediction	Coffee & tea break	Coffee & tea break	Coffee & tea break
10:15	Coffee & tea break	Poster presentations - <i>Tidal and non-tidal loading</i> - <i>Hydrologic signature in geodetic observations</i>	Poster presentations - <i>Cryospheric deformation of the solid Earth</i>	Poster presentations - <i>Seismogeodesy</i> - <i>Volcanogeodesy</i>
10:45	Poster presentations - <i>Earth rotation</i>	Group picture		
12:30	Lunch	Lunch	Lunch	Lunch
13:30	Poster viewing time - <i>Earth rotation</i>	Poster viewing time - <i>Tidal and non-tidal loading</i> - <i>Hydrologic signature in geodetic observations</i>	Poster viewing time - <i>Cryospheric deformation of the solid Earth</i>	Poster viewing time - <i>Seismogeodesy</i> - <i>Volcanogeodesy</i>
14:30	Earth rotation - Geophysical Excitation of Earth Rotation	Tidal and non-tidal loading	Cryospheric deformation of the solid Earth	Volcanogeodesy
15:30	Coffee & tea break	Coffee & tea break	Coffee & tea break	Coffee & tea break
16:15	Summary of the day	Summary of the day	Summary of the day	Summary of the day
16:45				Summary of the symposium
Evening		ECS Event	Conference dinner	

White: Listen	Yellow: Listen to presentations and discuss	Orange: Discuss a lot	Red: Look at posters and discuss
	Green: Eat/drink a little	Blue: Eat a lot	