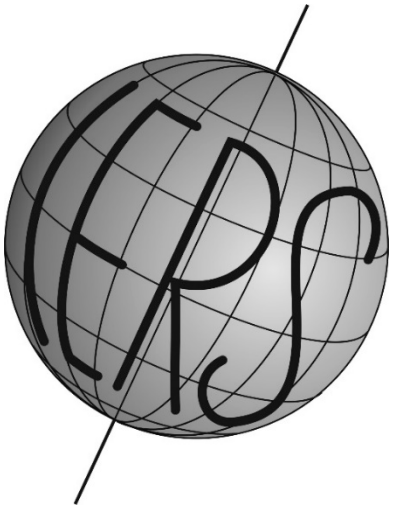


The International Earth Rotation and Reference Systems Service

Robert Heinkelmann

Analysis Coordinator / GFZ Potsdam

Brian J. Luzum

Chair, IERS Directing Board / USNO

Daniela Thaller, Wolfgang R. Dick

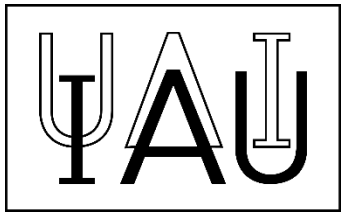
IERS Central Bureau / BKG

Implementation of the Global Geodetic Reference Frame (GGRF) in Latin America

Buenos Aires, Argentina September 18, 2019

History of the IERS

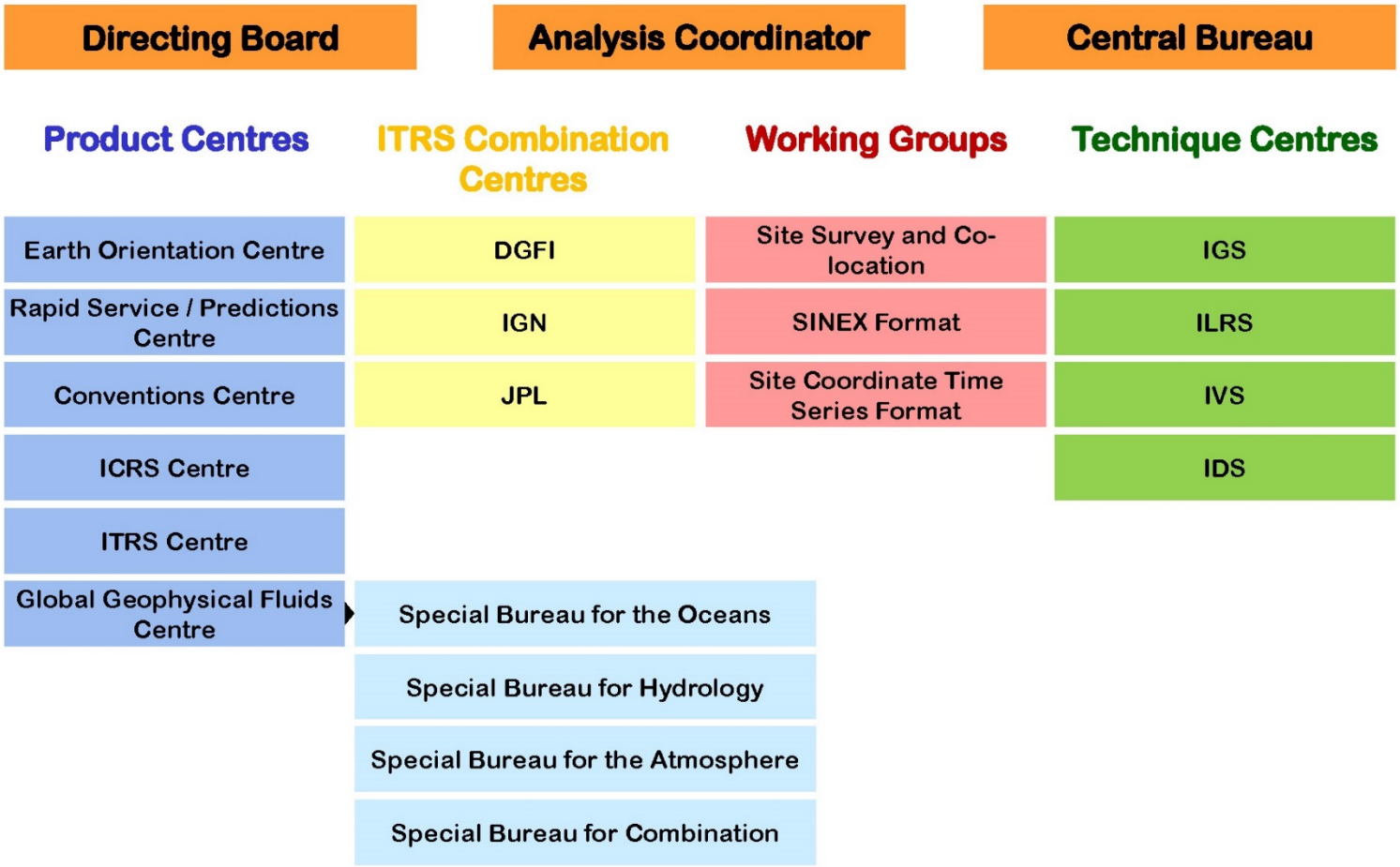
- The International Earth Rotation Service (IERS) was created in 1987
  - Responsible to the International Astronomical Union (IAU) and the International Union of Geodesy and Geophysics (IUGG)
- IERS began operations on 1 January 1988 replacing the International Polar Motion Service (IPMS) and the Earth Rotation Section of the Bureau International de l'Heure (BIH)
- IERS changed its name to International Earth Rotation and Reference Systems Service in 2003 to better represent its responsibilities
  - Earth orientation relies directly on having accurate, well-defined reference systems
- IERS functions as an IAG Scientific Service



What is the IERS

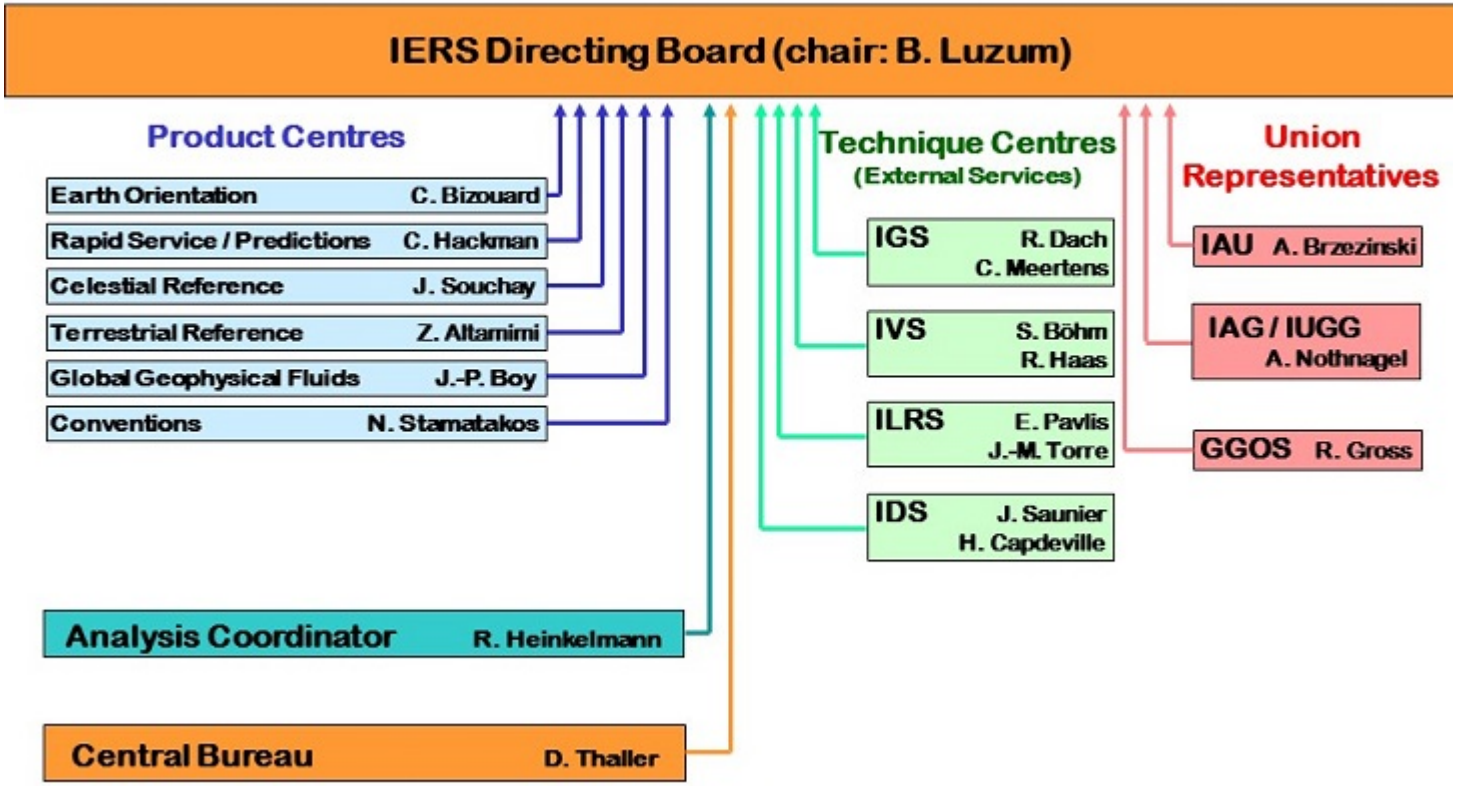
- The International Earth Rotation and Reference Systems Service (IERS) provides the following to the international scientific communities:
  - International Celestial Reference System (ICRS) and its realization the International Celestial Reference Frame (ICRF)
  - International Terrestrial Reference System (ITRS) and its realization the International Terrestrial Reference Frame (ITRF)
  - Earth orientation parameters (EOP) that transform between the ICRF and the ITRF
  - Conventions (i.e. standards, models, and constants) used in generating and using reference frames and EOP
  - Geophysical data to study and understand variations in the reference frames and the Earth's orientation
- Due to the nature of the data, there are many operational users

Current structure of IERS



https://www.iers.org/IERS/EN/Organization/About/OrgChart/chart.html

IERS Directing Board



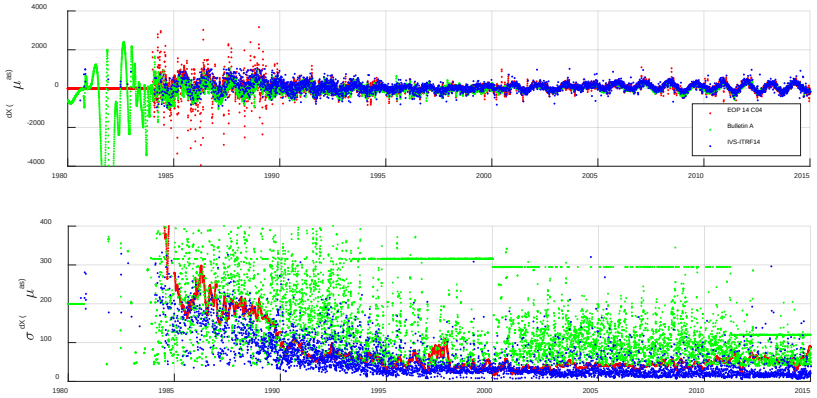
https://www.iers.org/IERS/EN/Organization/DirectingBoard/IERSDirectingBoard.html

IERS EOP Product Centres

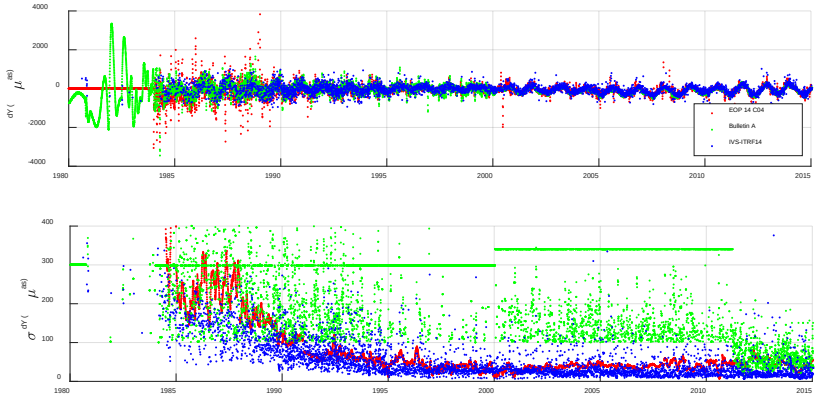
- Earth Orientation Centre / Observatoire Paris
  - Responsible for monitoring of long-term Earth orientation parameters
  - Publications of time disseminations
  - Leap second announcements
- Rapid Service & Prediction Centre / USNO
  - Implemented a new system in Bulletin A
- Since Feb. 2017: IERS EOP series aligned to ITRF2014 and 08 C04 replaced by 14 C04

IERS EOP Products (1)

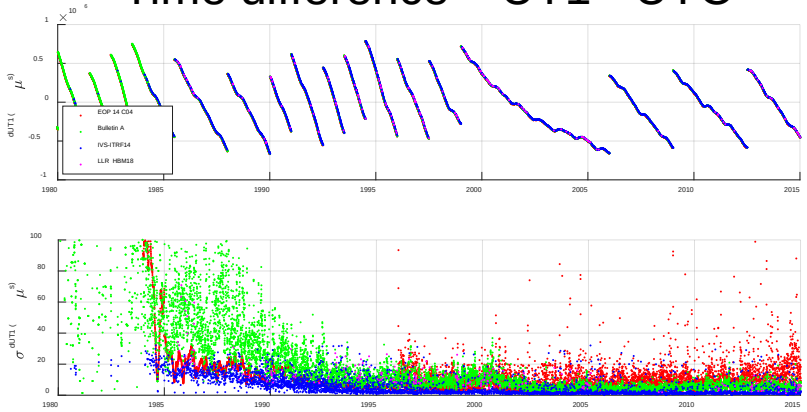
Celestial pole, offset* dX



Celestial pole, offset* dY



Time difference** UT1 - UTC



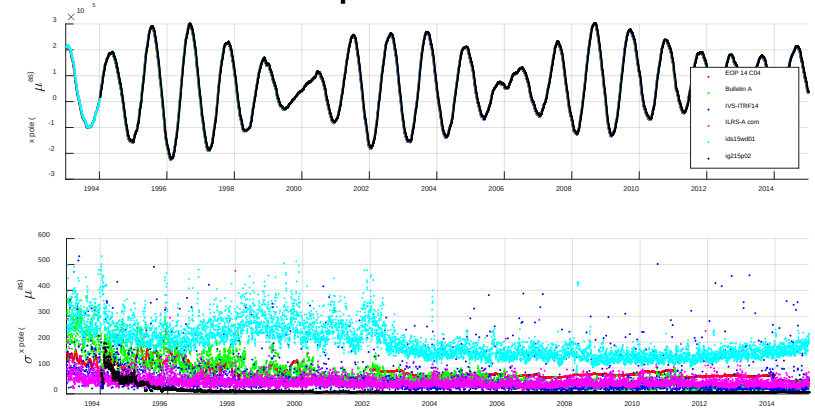
*: offset w.r.t. IAU 2006/2000A precession – nutation model

**: UT1 second is fraction of the Earth rotation and orbital motion period (solar time), it is directly proportional to ERA (Earth Rotation Angle); the UTC second is TAI-compatible, additionally UTC contains irregular leap seconds

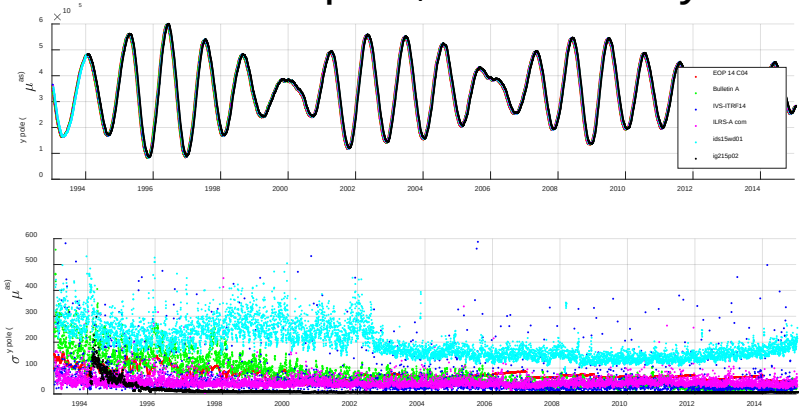
Heinkelmann et al. (2019) IUGG General Assembly, Montreal, Canada

IERS EOP Products (2)

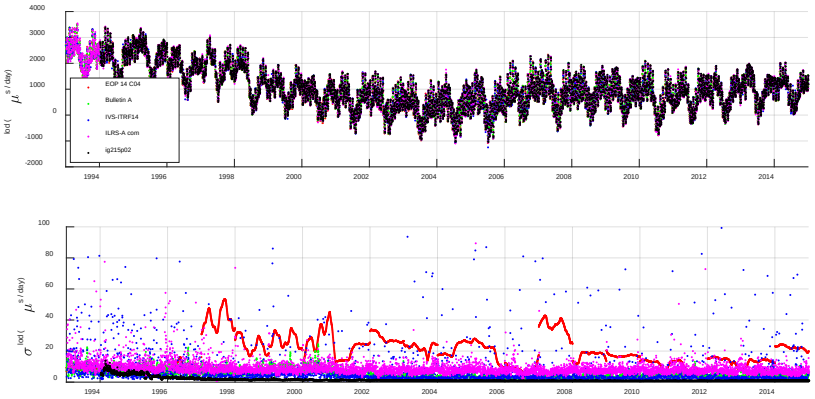
Terrestrial pole, coordinate x



Terrestrial pole, coordinate y



Length of day* (lod)



*: currently the DORIS technique does not provide reliable lod as this parameter is highly correlated with the once-per-revolution across track empirical correction
Stepanek, Hugentobler, Buday, Filler (2018), 10.1016/j.asr.2018.04.038

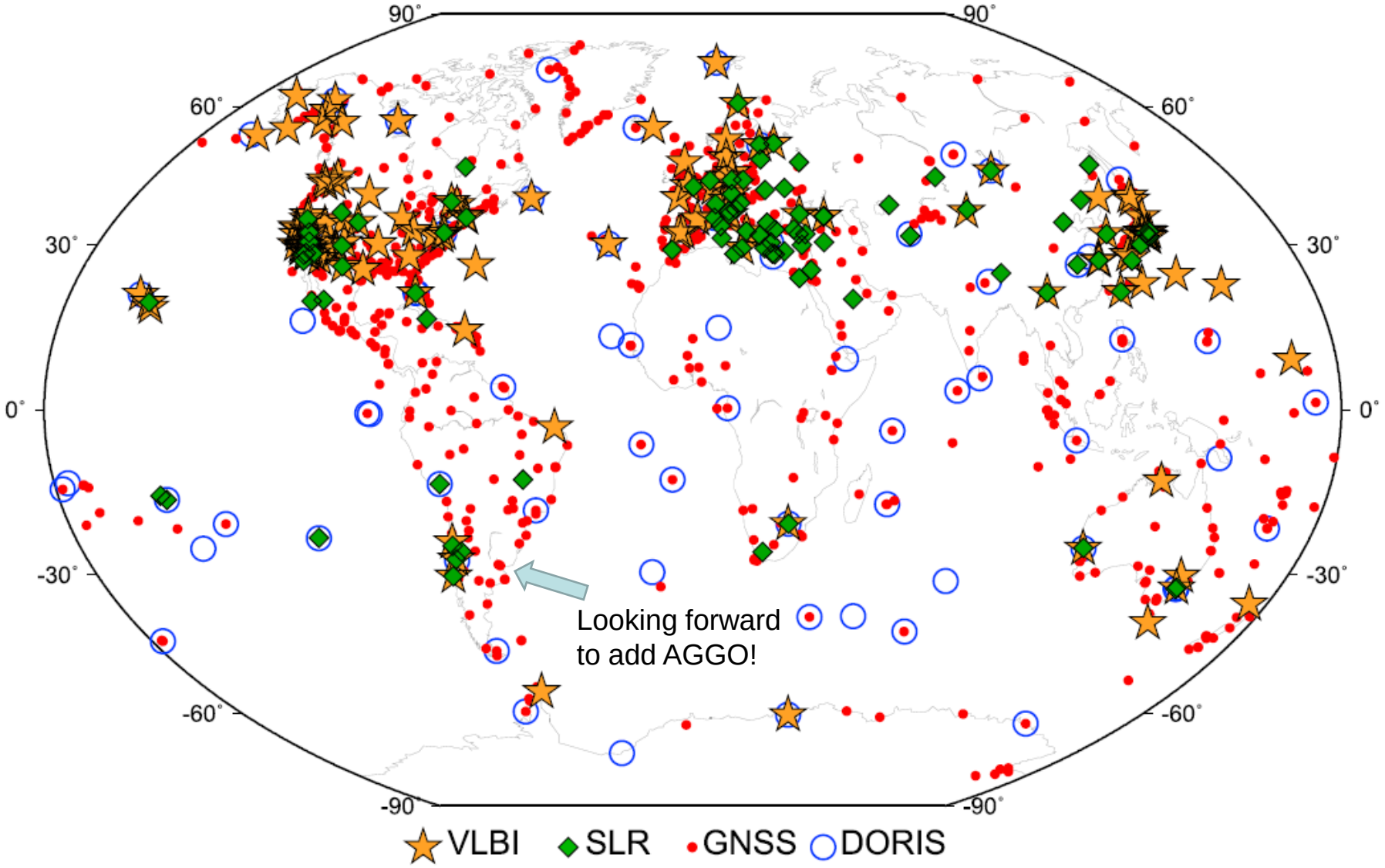
Heinkelmann et al. (2019) IUGG General Assembly, Montreal, Canada

IERS TRF Product Centre

- ITRS Centre and ITRS Combination Centres
  - ITRS CCs (DGFI-TUM, IGN, JPL) finalised the combination of the long-term data provided by Technique Centres
  - ITRF2014 published by ITRS Centre in Jan. 2016
  - ITRS CCs realized DTRF2014 and JTRF2014
  - Studies on scale differences between the ITRF2014 and DTRF2014 systems for the VLBI and SLR stations
- Work on next ITRF (ITRF2020) started

➢ Contribution by Z. Altamimi on ITRF

IERS TRF Products (1)



1499 stations at 975 sites - after Altamimi et al., 2016

IERS TRF Products (2)

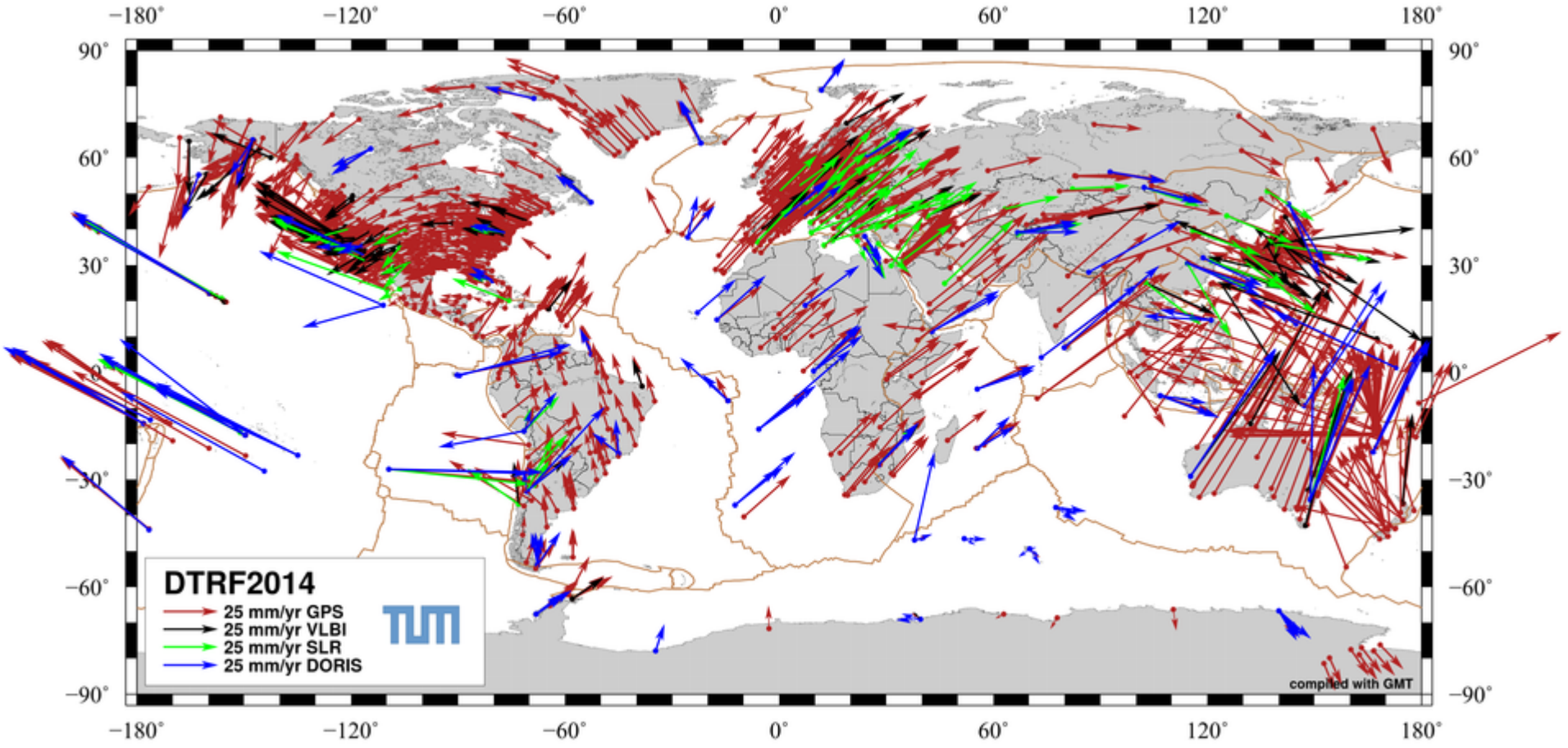
Given by ITRF2014 are the **position** vector r_0 **at the catalogue epoch t_0**, **the linear velocity** vector v, a model of **seasonal variation** (not distributed) and **non-linear functions following seismic events** (such as Earthquakes):

$$r_c(t) = r_0 + v(t - t_0) + \underbrace{\sum_{i=1,2} \left(A_{i,1} \sin(2i\pi t) + A_{i,2} \cos(2i\pi t) \right)}_{\text{seasonal signal}} + r_{nl}(t)$$

The non-linear coordinate model is either a logarithmic function, an exponential function, or a combination of both (logarithmic plus exponential functions) starting after the epoch of the event t_{event} and continuing until decay (decay factors l_r, e_r):

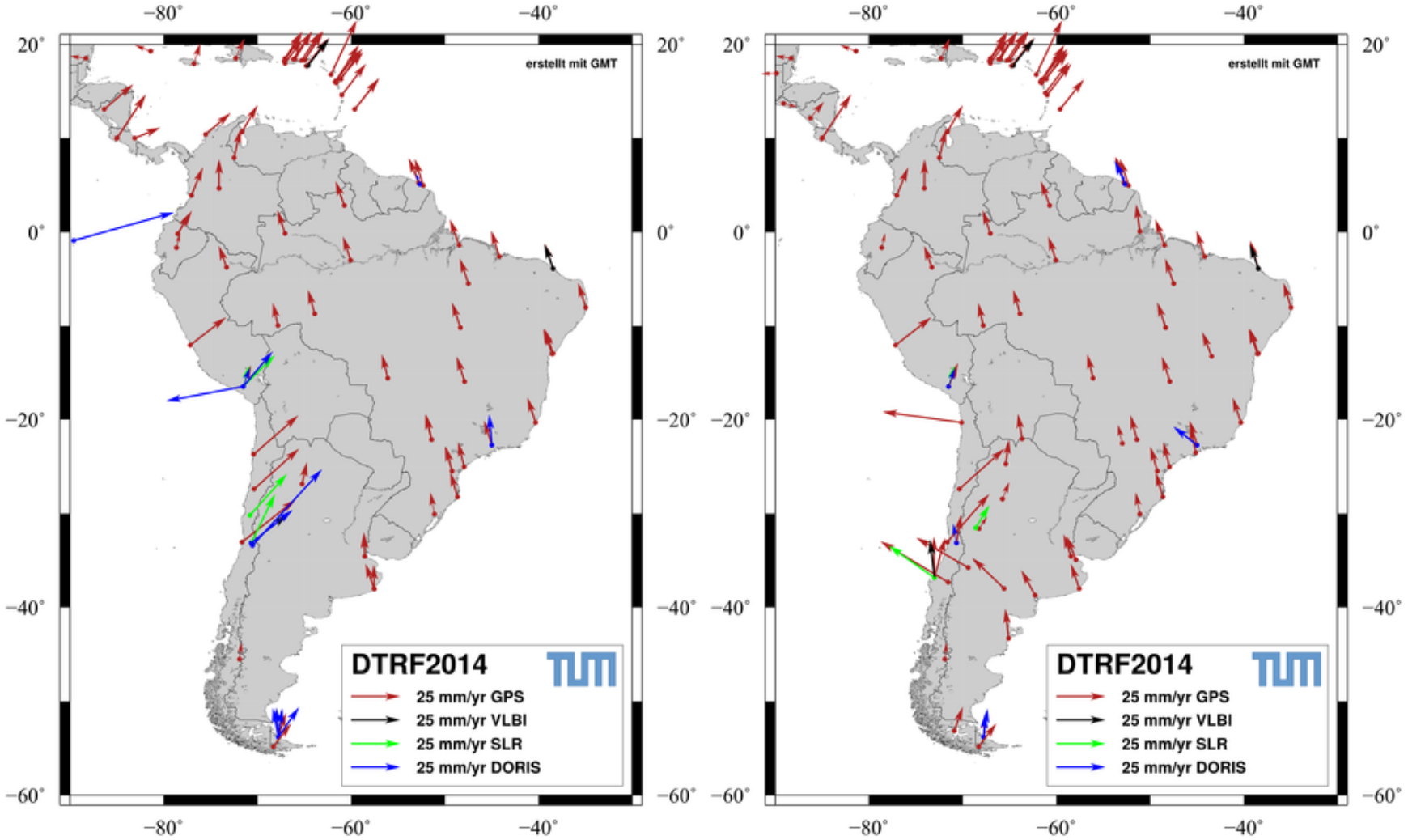
$$r_{nl}(t) = a + \underbrace{b \cdot \log\left(1 + \frac{t - t_{event}}{l_r}\right)}_{\text{logarithmic deformation}} + \underbrace{c \cdot \left(1 - exp\left(-\frac{t - t_{event}}{e_r}\right)\right)}_{\text{exponential deformation}}$$

IERS TRF Products (3)



1712 stations - Seitz et al., 2016, doi: 10.1594/PANGAEA.864046

IERS TRF Products (4)



Horizontal velocities before and after the Maule Earthquake (2010-2-27)

http://www.dgfi.tum.de/research/reference-systems/determination-of-reference-frames/global-terrestrial-reference-frames/dtrf2014-en/

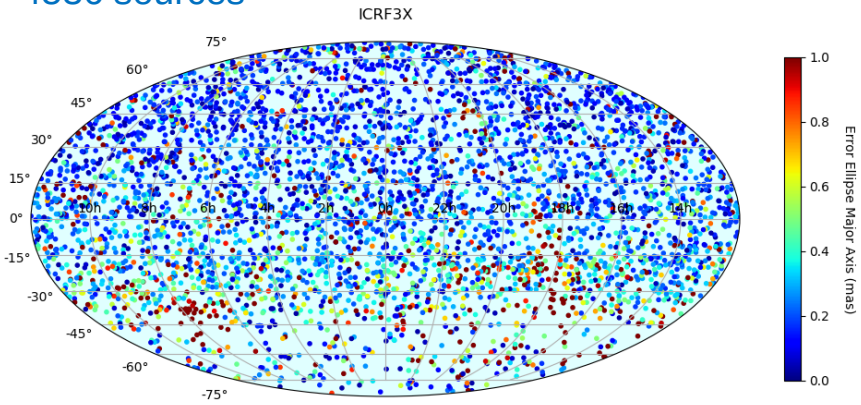
IERS CRF Product Centre

- ICRS Centre / Observatoire Paris
  - The IERS ICRS Centre is responsible for the maintenance of ICRS and ICRF
  - ICRS (Arias et al. 1995)
  - Together with IAU Division A Working Group on ICRF3, the ICRS Centre prepared the ICRF3, which was adopted at the IAU GA in Vienna 2018 and became effective on January 1st, 2019
  - Comparisons were made between the ICRF3 and the Gaia (Data Releases 1 and 2) optical reference frames.

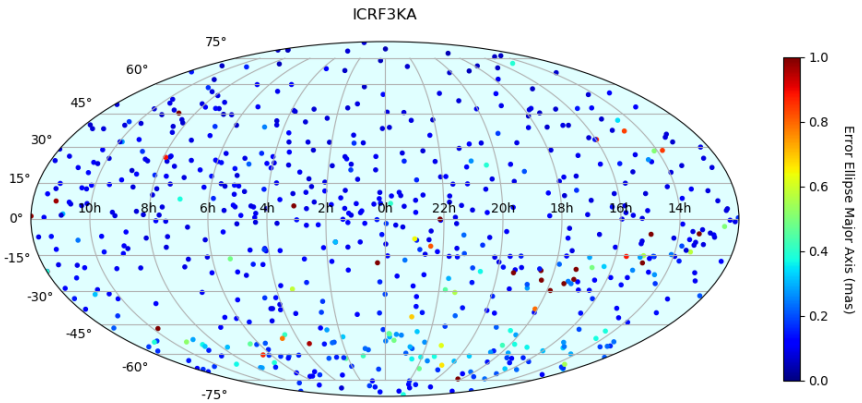
http://hpiers.obspm.fr/icrs-pc/newwww/icrf/index.php

IERS CRF Product – ICRF3

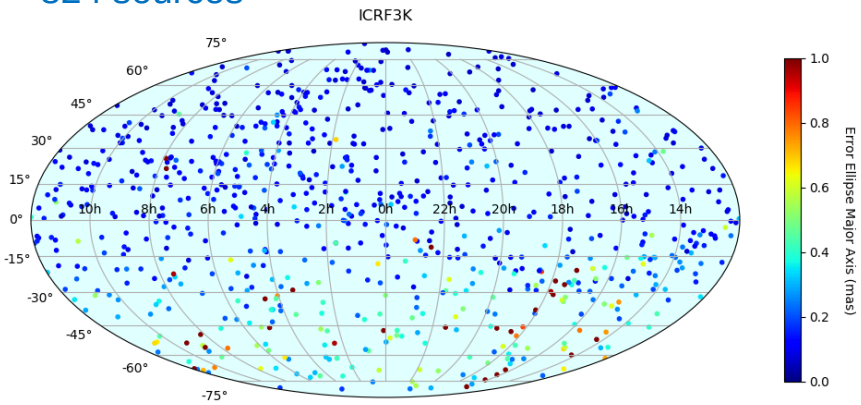
4536 sources



678 sources



824 sources



Galactic aberration

Acknowledgement: IAU WG ICRF3 and Susanne Lunz (GFZ)

IERS Conventions Centre

- IERS Conventions Centre / USNO & Obs. Paris
  - The IERS Conventions Centre is responsible for the maintenance of the IERS conventional models, constants and standards
  - Call for Participation in the next IERS Conventions issued in Feb. 2018
  - IERS Conventions now under IERS Conventions Editorial Board
  - Current version IERS Conv. 2010 has been updated, last update 2019-04-01

http://iers-conventions.obspm.fr/conventions_material.php

IERS Global Geophysical Fluids Centre

- Global Geophysical Fluids Centre (GGFC) / Univ. Strasbourg
  - 3 Special Bureaus for
    - Atmosphere,
    - Ocean,
    - Hydrology
  - 1 Special Bureau for mass changes in combined systems
  - New GGFC products were evaluated in terms of latency and reliability

http://loading.u-strasbg.fr/GGFC/

IERS Analysis Coordinator

- Analysis Coordinator (R. Heinkelmann GFZ)
  - Responsible for the long-term and internal consistency of the IERS reference frames and other products
  - Responsible for the appropriate combination of the single technique products into the official IERS products
- In preparation: Joint Working Group on Consistent Realization of TRF, CRF, and EOP
  - Under IERS, IAU (Comm. A2) and IAG (SC 1.4)
  - Chair: R. Heinkelmann
  - Vice-Chair: M. Seitz (DGFI-TUM)

IERS Central Bureau

- IERS Central Bureau / BKG Frankfurt
  - General Management of the IERS
  - Executive arm of the IERS Directing Board
  - Coordinates activities, meetings, reports and communication
  - Archives products
  - Maintaines documentation and the IERS Website

https://www.iers.org/IERS/EN/Organization/CentralBureau/bureau.html

IERS Working Groups

- Site Survey and Co-location / S. Bergstrand
  - Participated in several local tie measurement campaigns
  - Worked on automated monitoring with terrestrial instruments
- SINEX Format / D. Thaller
  - Modifications and revisions: representation of non-linear station motions due to post-seismic movements; more information on radio source positions
- Site Coordinate Time Series Format / L. Soudarin
  - Definition of a common exchange format for coordinate time series for all geodetic techniques

https://www.iers.org/IERS/EN/Organization/WorkingGroups/WorkingGroups.html

Recent Publications

- IERS Technical Note 38 (2017): Z. Altamimi et al.: Analysis and results of ITRF2014
- IERS Technical Note 39 (2017): J.-C. Poyard et al.: IGN best practice for surveying instrument reference points at ITRF co-location sites
- IERS Annual Reports 2014, 2015, 2016, 2017; in preparation 2018
- IERS Bulletins A, B, C, and D
- IERS Messages Nos. 277 to 382

IERS Meetings

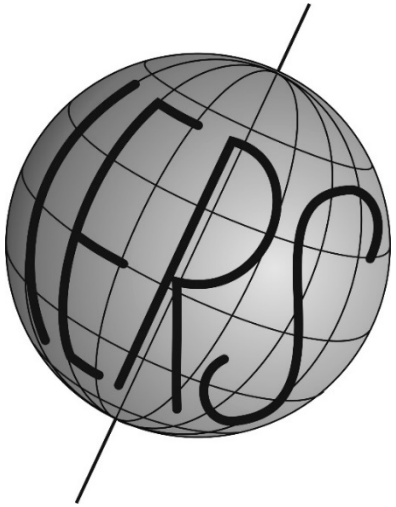
The IERS Directing Board meets twice per year.

IERS co-organized:

- Joint IAU/IAG/IERS Symposium on Earth Rotation, July 18–23, 2016 in Wuhan, China
- IAG/GGOS/IERS Unified Analysis Workshop (UAW), July 10–12, 2017 in Paris
- GGOS/IERS Unified Analysis Workshop (UAW), October 2–4, 2019 in Paris

https://www.iers.org/IERS/EN/NewsMeetings/ForthcomingMeetings/forthcoming.html

Thank you for attention



heinkelmann@gfz-potsdam.de