SIRGAS Reference Frame Analysis at DGFI-TUM

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Journal of Geophysical Research: Solid Earth / Volume 127, Issue 10 / e2021JB023880

Research Article | Open Access

Combination Strategy for the Geocentric Realization of Regional Epoch Reference Frames

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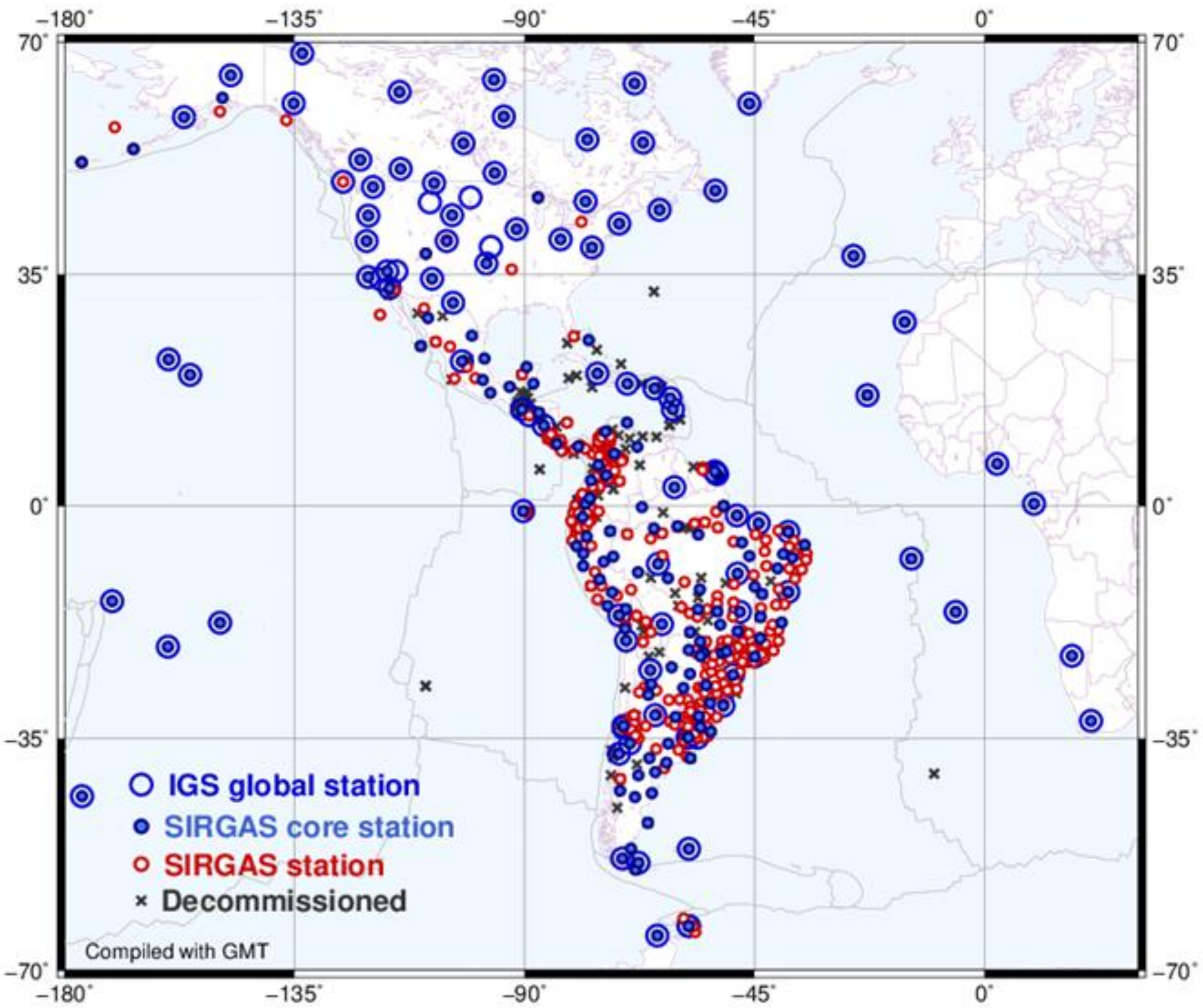
First published: 03 October 2022
https://doi.org/10.1029/2021JB023880

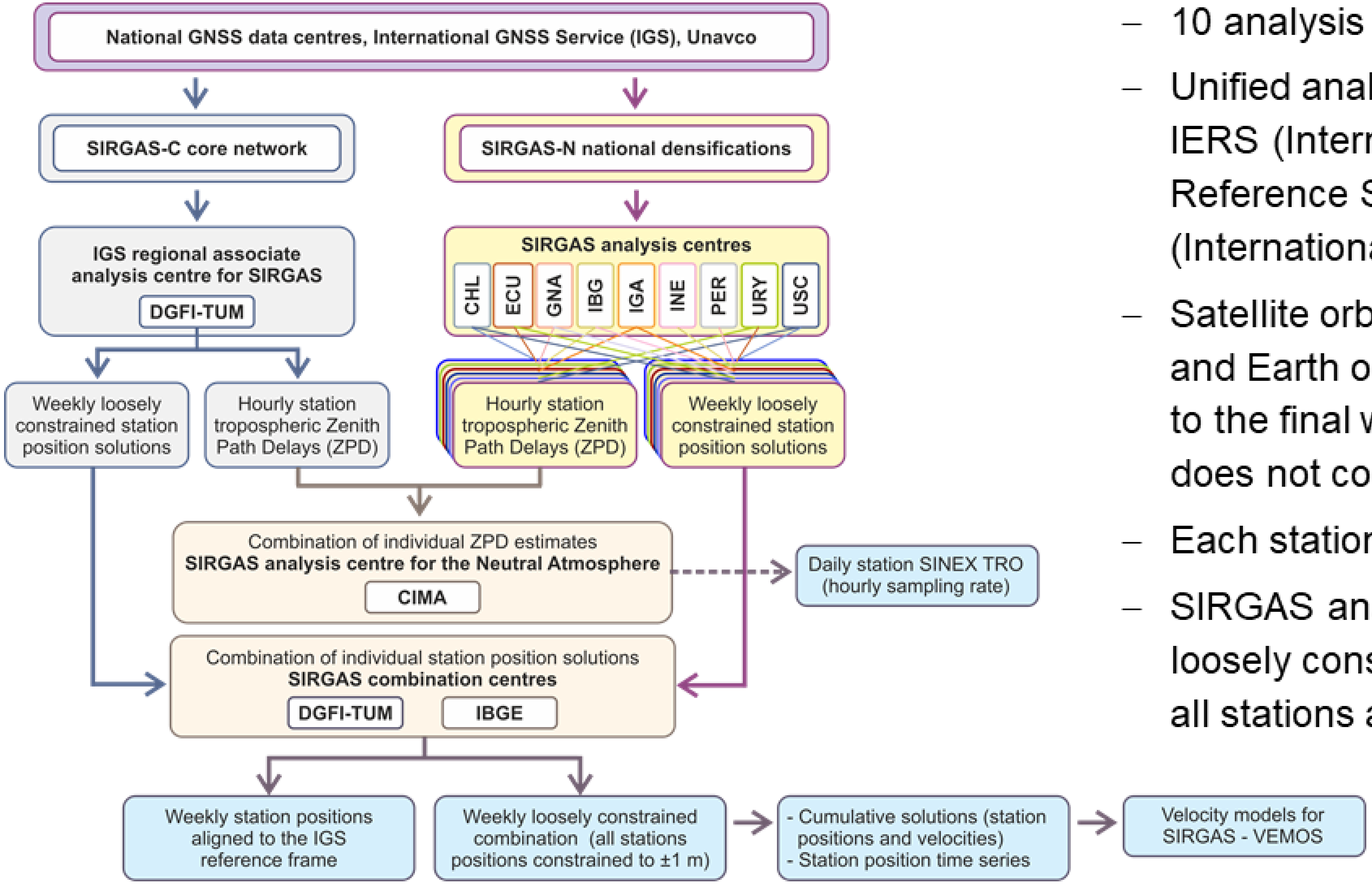
Symposium SIRGAS2022, Santiago de Chile, Chile
08-11-2022

SIRGAS reference network

- 493 stations (169 decommissioned)
- 109 IGS stations (about 45 fiducial points)
- Station classification in
  - A core network and
  - National networks



Operational analysis of the SIRGAS reference frame



- 10 analysis centres
- Unified analysis standards according to the IERS (International Earth Rotation and Reference Systems Service) and the IGS (International GNSS Service)
- Satellite orbits, corrections to satellite clocks and Earth orientation parameters are fixed to the final weekly IGS values (SIRGAS does not compute these parameters)
- Each station in three individual solutions
- SIRGAS analysis centres deliver weekly loosely constrained solutions (positions for all stations are constrained to ± 1 m)

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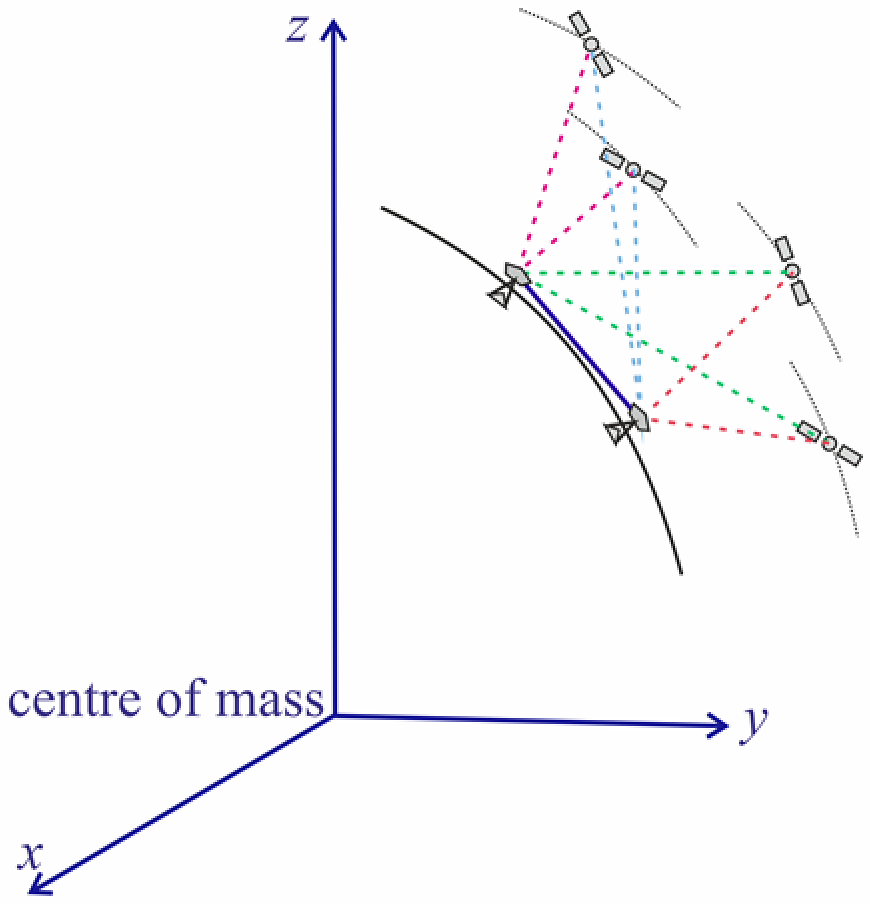

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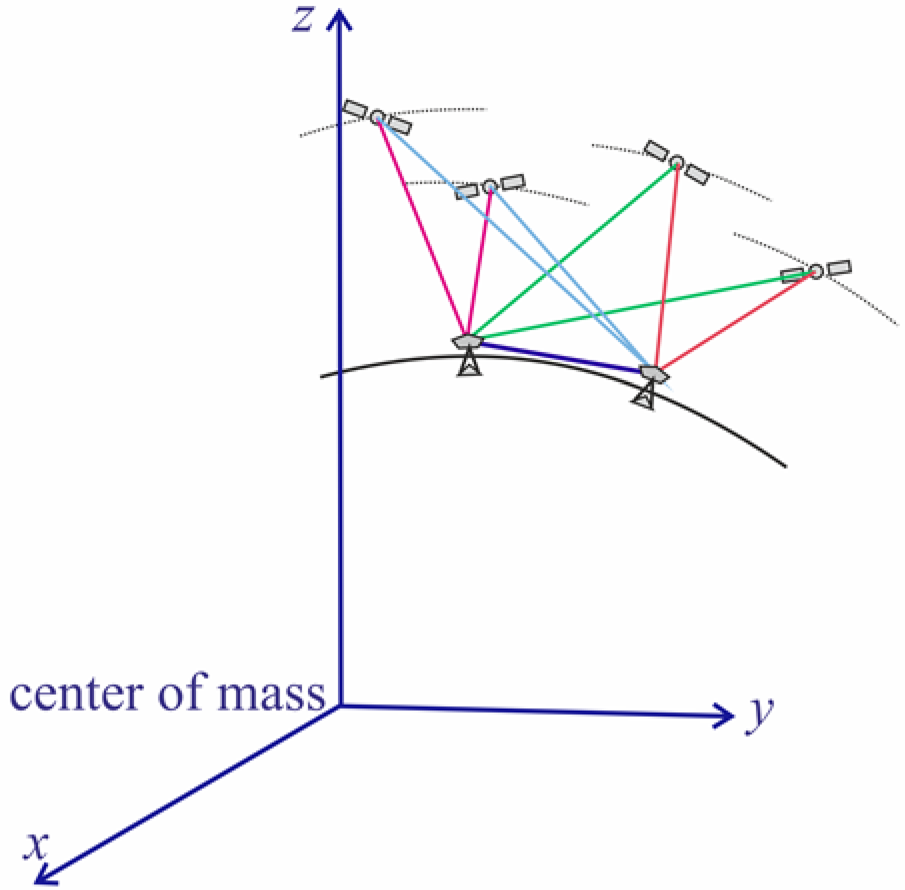

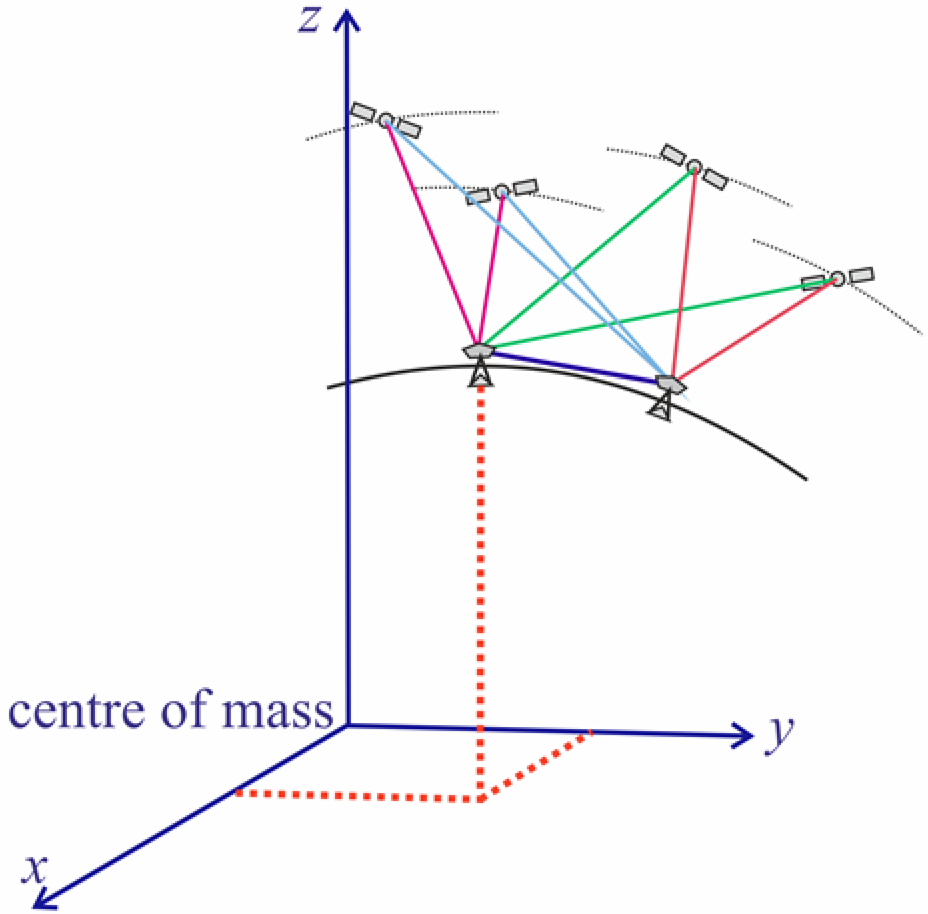

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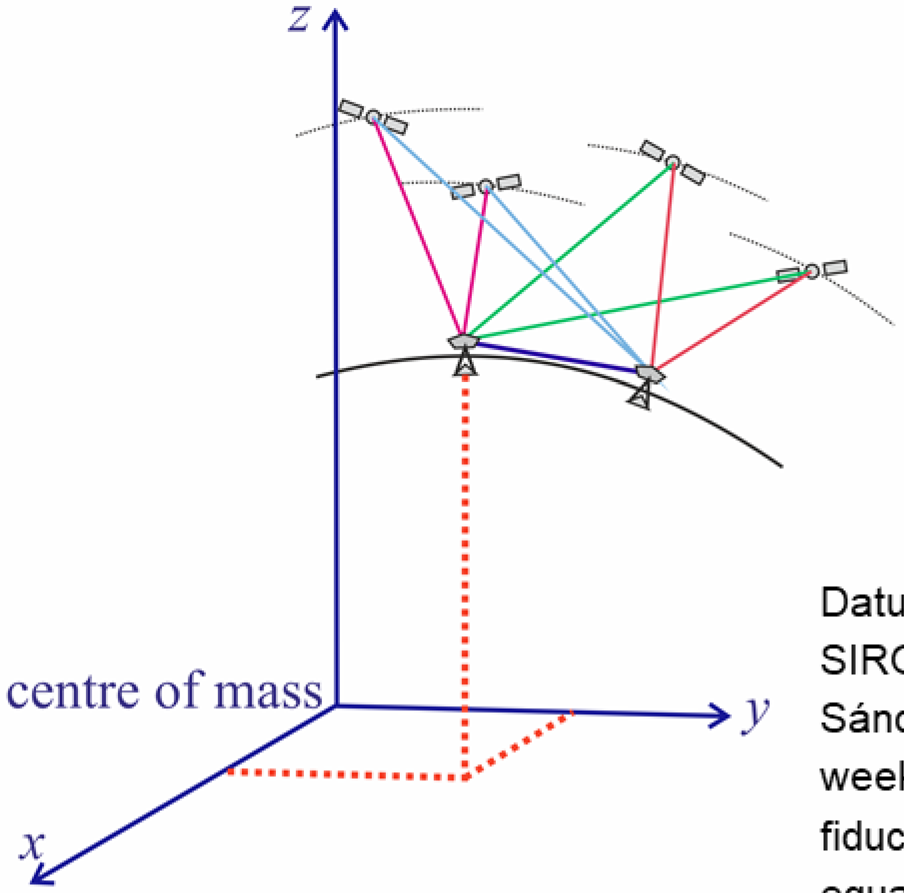


Coordinates of fiducial points have to be given

- in the same reference frame in which the satellite orbits are given (IGS reference frame)
- at the same epoch when the GNSS data is obtained

$$X(t) = X(t_0) + \dot{X}(t - t_0) + \delta X_{PSD}(t) + \delta X_f(t)$$

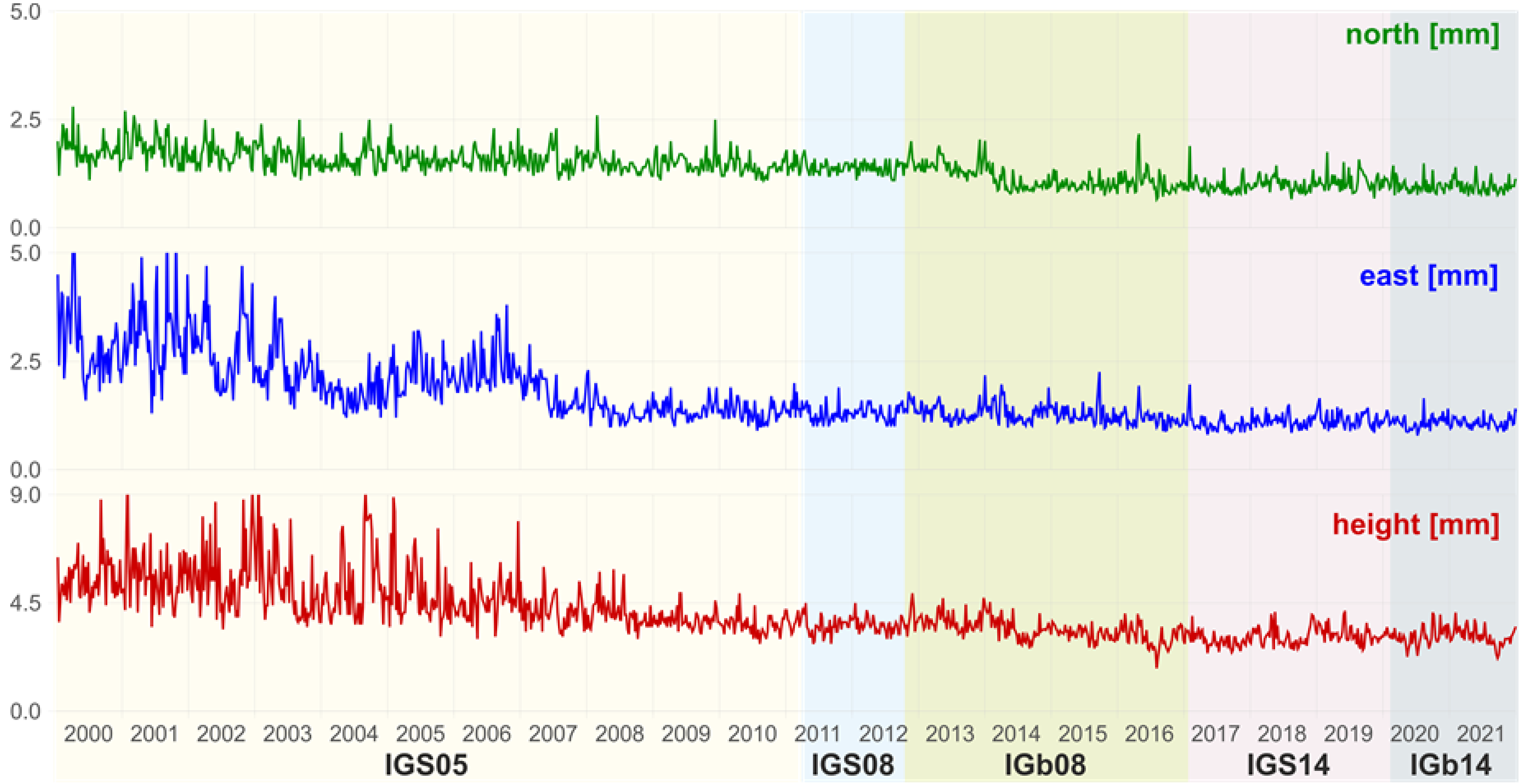
Datum definition in SIRGAS (Mackern and Sánchez, 2009): IGS weekly coordinates of IGS fiducial points with weights equal to the inverse of their standard deviations

Conventional realisation related to a secular centre of mass

log or exp

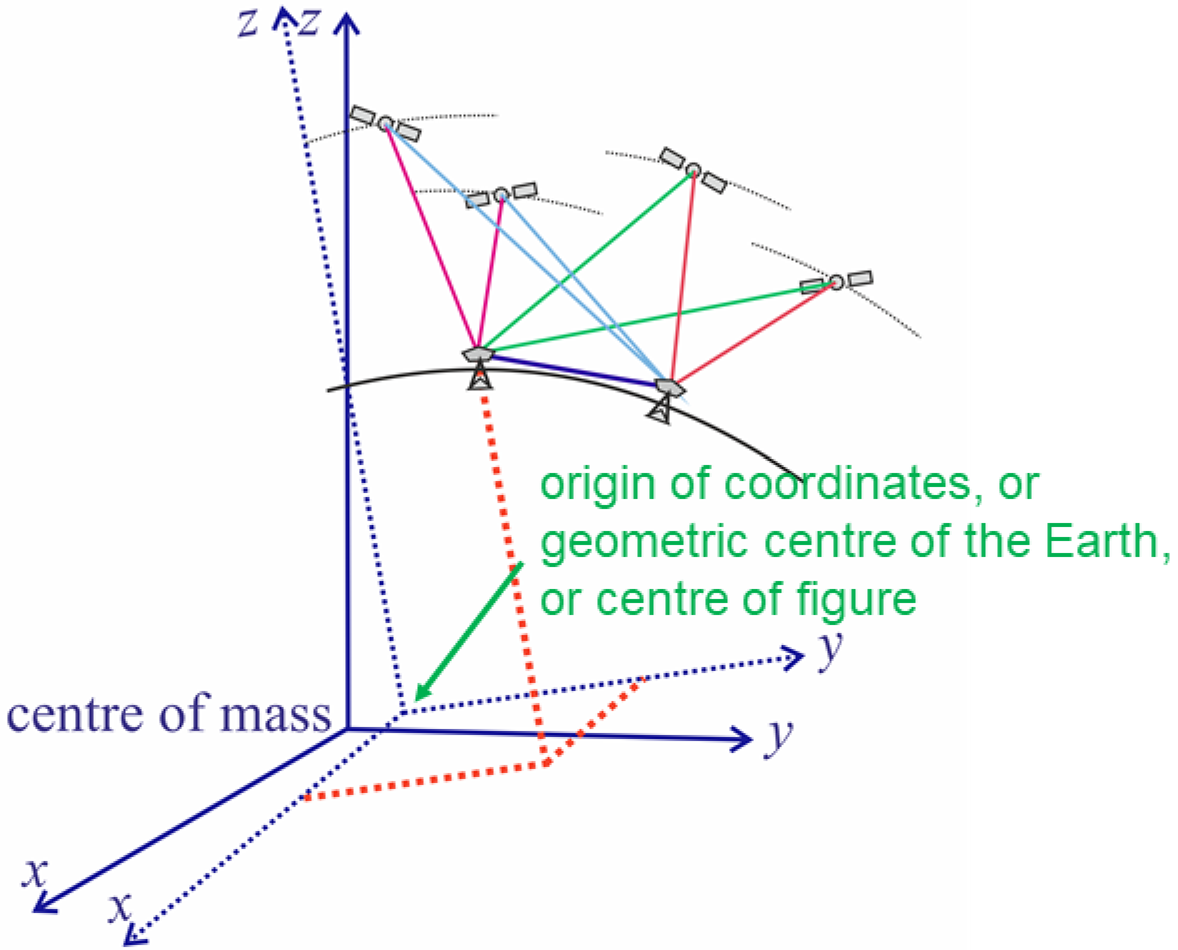
Mathematical approximation (harmonic functions) or non-tidal loading modelling

Weekly station position repeatability in operational SIRGAS analysis



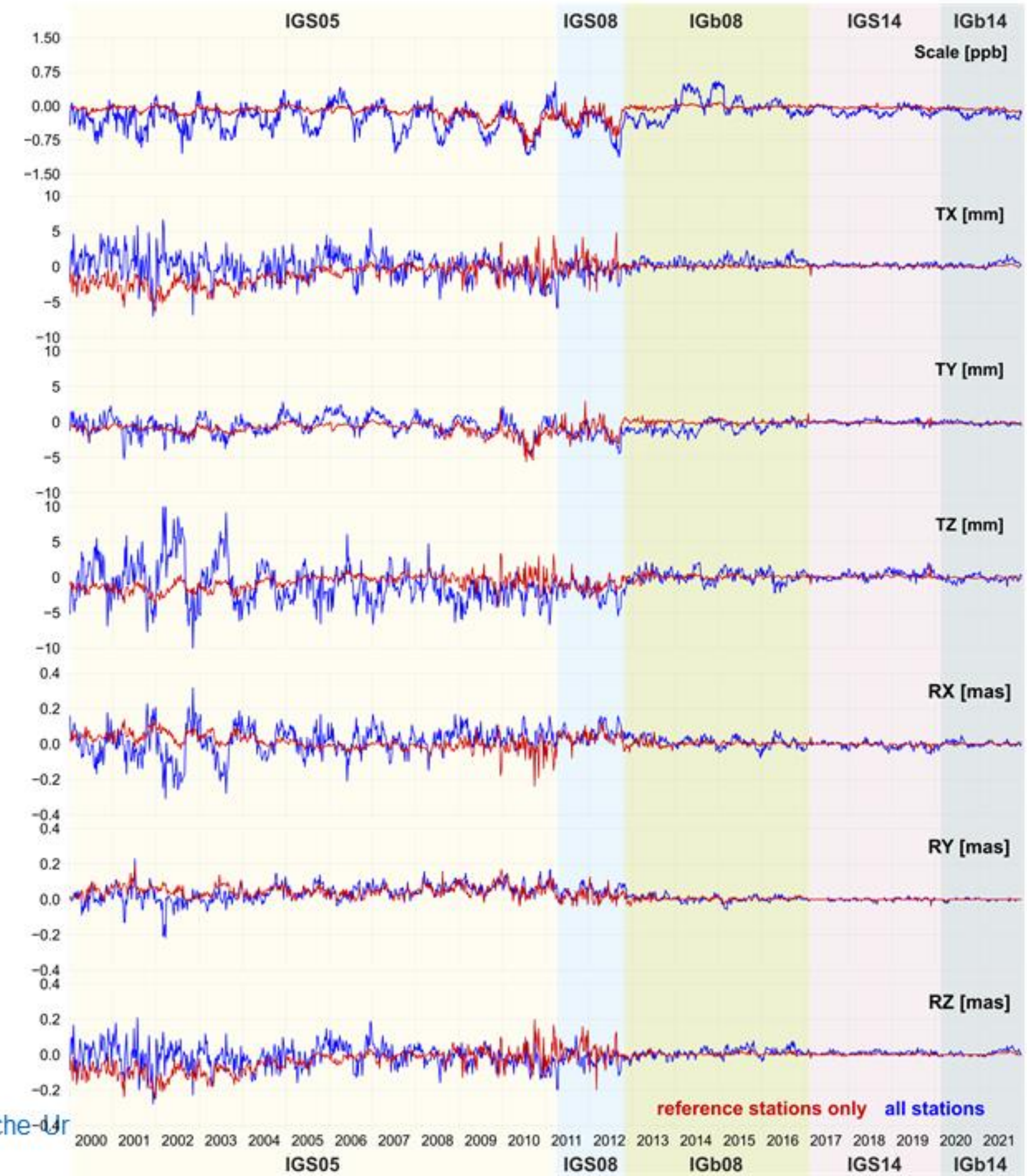
- IGS05:
  N/E: ±2.8 mm, h: ±6.0 mm
- IGS08/IGb08:
  N/E: ±1.8 mm, h : 3.5 mm
- IGS14/IGb14:
  N/E: ±0.8 mm, h: ±2.6 mm

Operational analysis of the SIRGAS reference frame

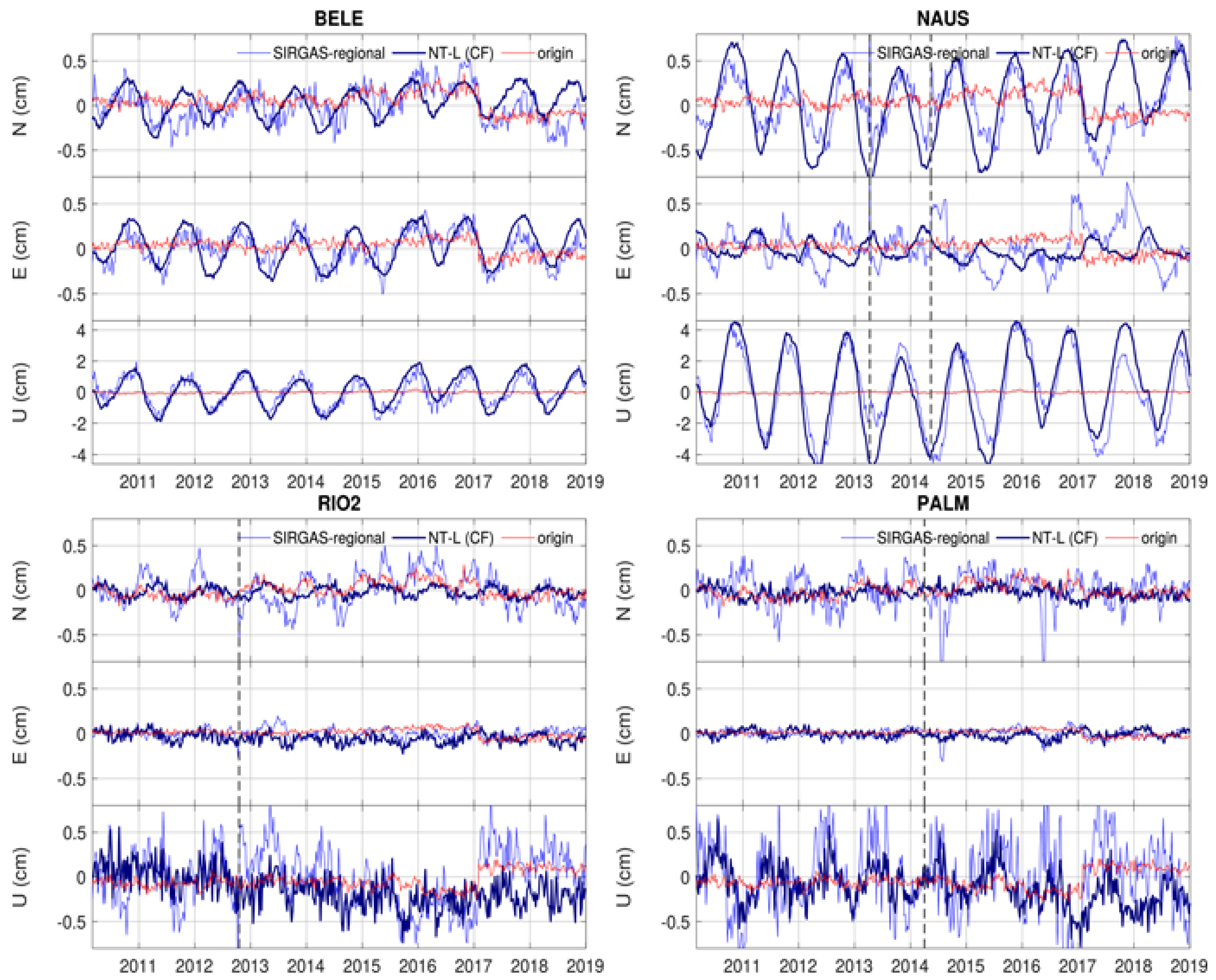


– The dislocation between centre of mass (CM) and centre of figure (CF) is sometimes called "geo-centre motion".
– A CF realisation is inherent to GNSS-only-based epoch reference frames with a datum aligned to a multi-year ITRF/IGS solution

Differences in scale, translation and rotation parameters between SIRGAS (operational) and IGS weekly position solutions



Usability of SIRGAS products in Earth system research

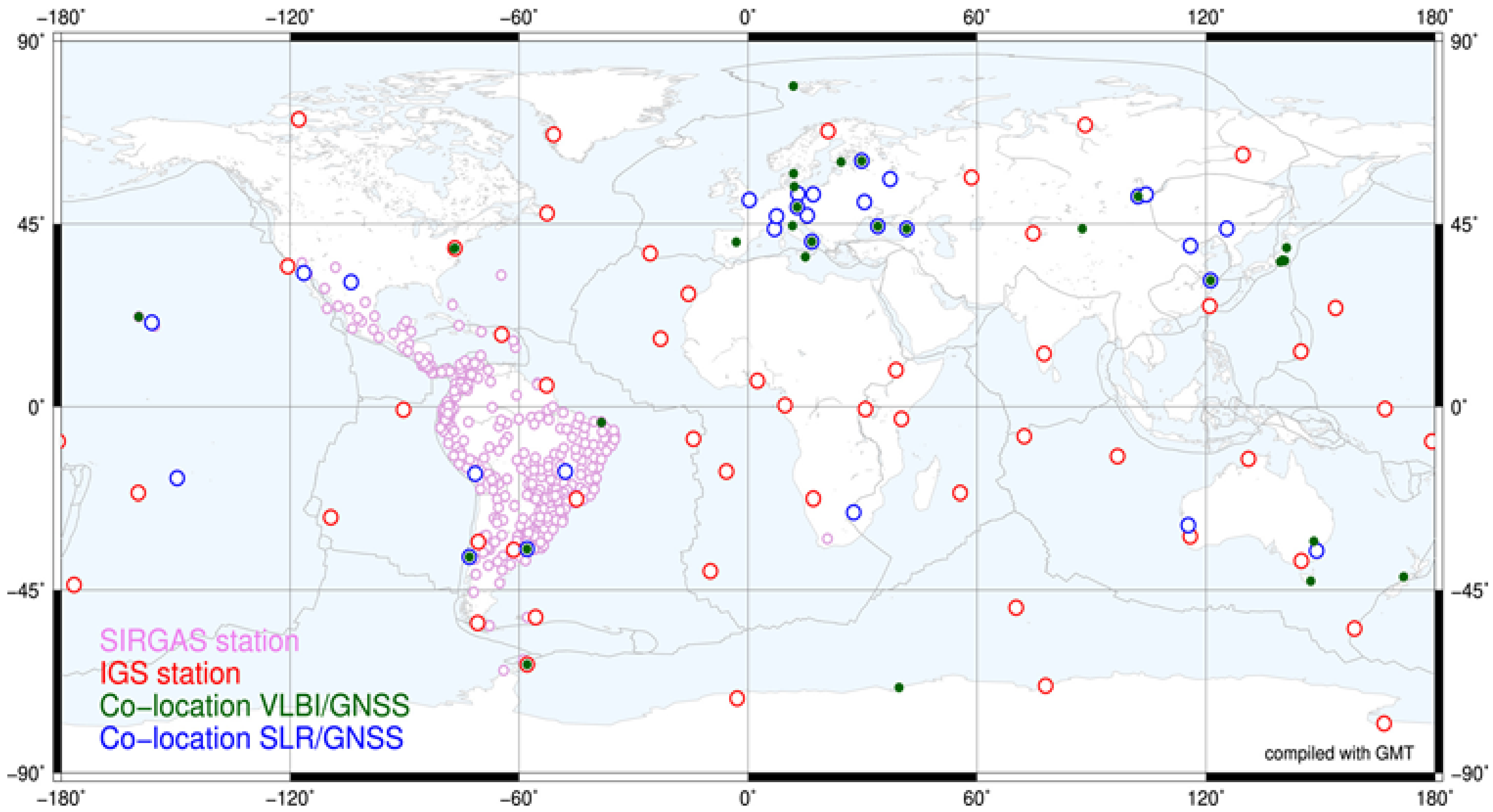


- To support Earth System research it is necessary to assess how much of the detected motion at a geodetic station is attributable to uncertainties associated with the datum realisation and data processing, and how much is caused by mass variations or geophysical effects.
- Systematic variations in the datum realisation directly map into the differences between modelled non-tidal loading (NT-L, ESMGFZ, Dill and Dobslaw, 2013) and measured site displacements.
- These systematic variations add up with geophysically induced motions.

→ **Solution**: a direct epoch-wise geocentric realisation of the regional network datum (epoch reference frames – ERFs), resulting in coordinates related to the centre of mass at each epoch.

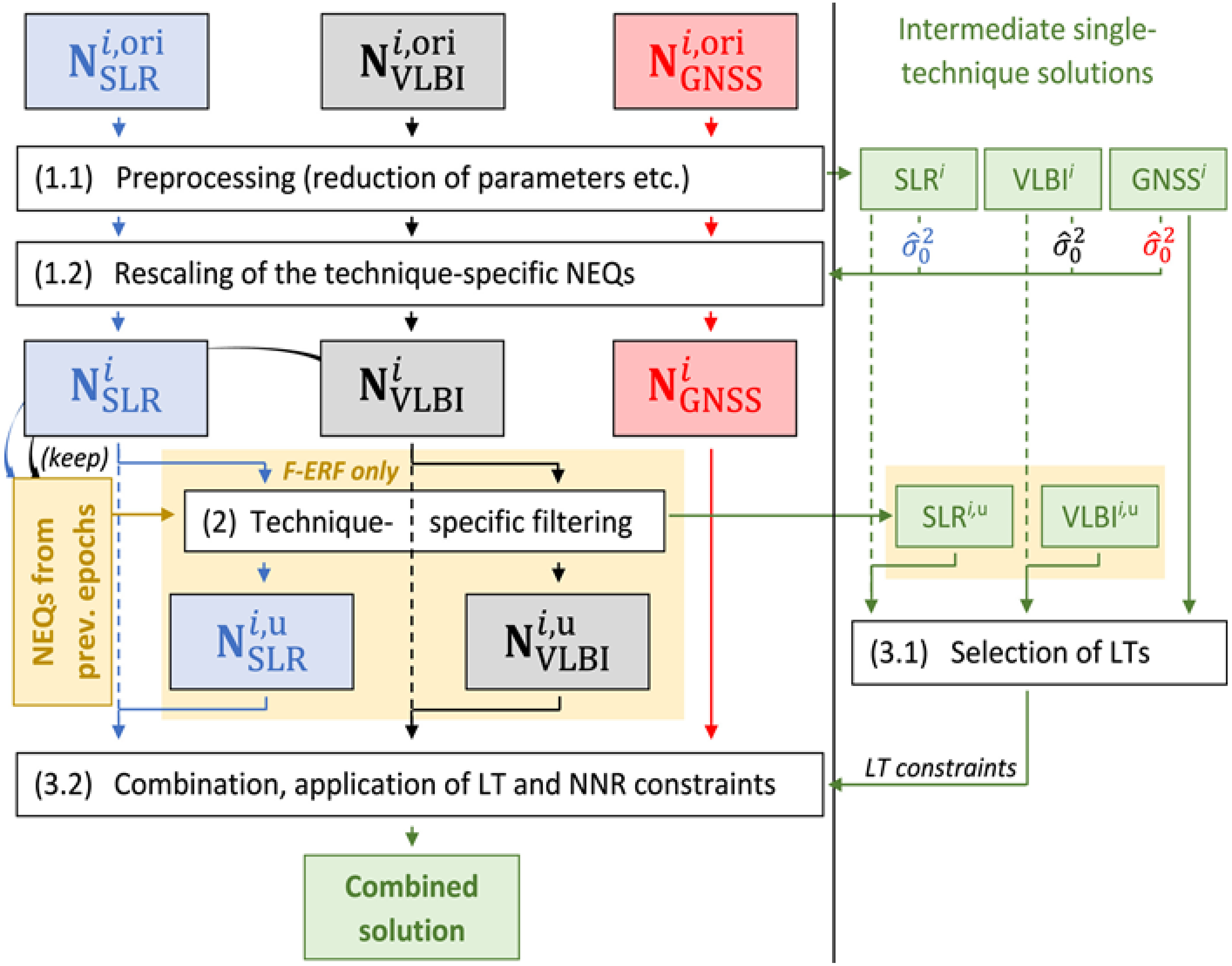
Direct geocentric realisation in a regional reference frame

- Combination of Satellite Laser Ranging (SLR), Very Long Baseline Interferometry (VLBI), and GNSS.
- The origin is realised by SLR (the only technique permitting the determination of the centre of mass with highest accuracy)
- The scale is realised as a weighted mean by SLR and VLBI
- The orientation is realised by a not-net-rotation constraint over a global GNSS (IGS stations) network



- The datum transfer between the techniques is performed by introducing local ties at co-located sites
- To compensate data gaps in SLR and VLBI, the corresponding single-technique normal equations are filtered by weighted accumulation over a limited number of weeks before the combination

Direct geocentric realisation in a regional reference frame



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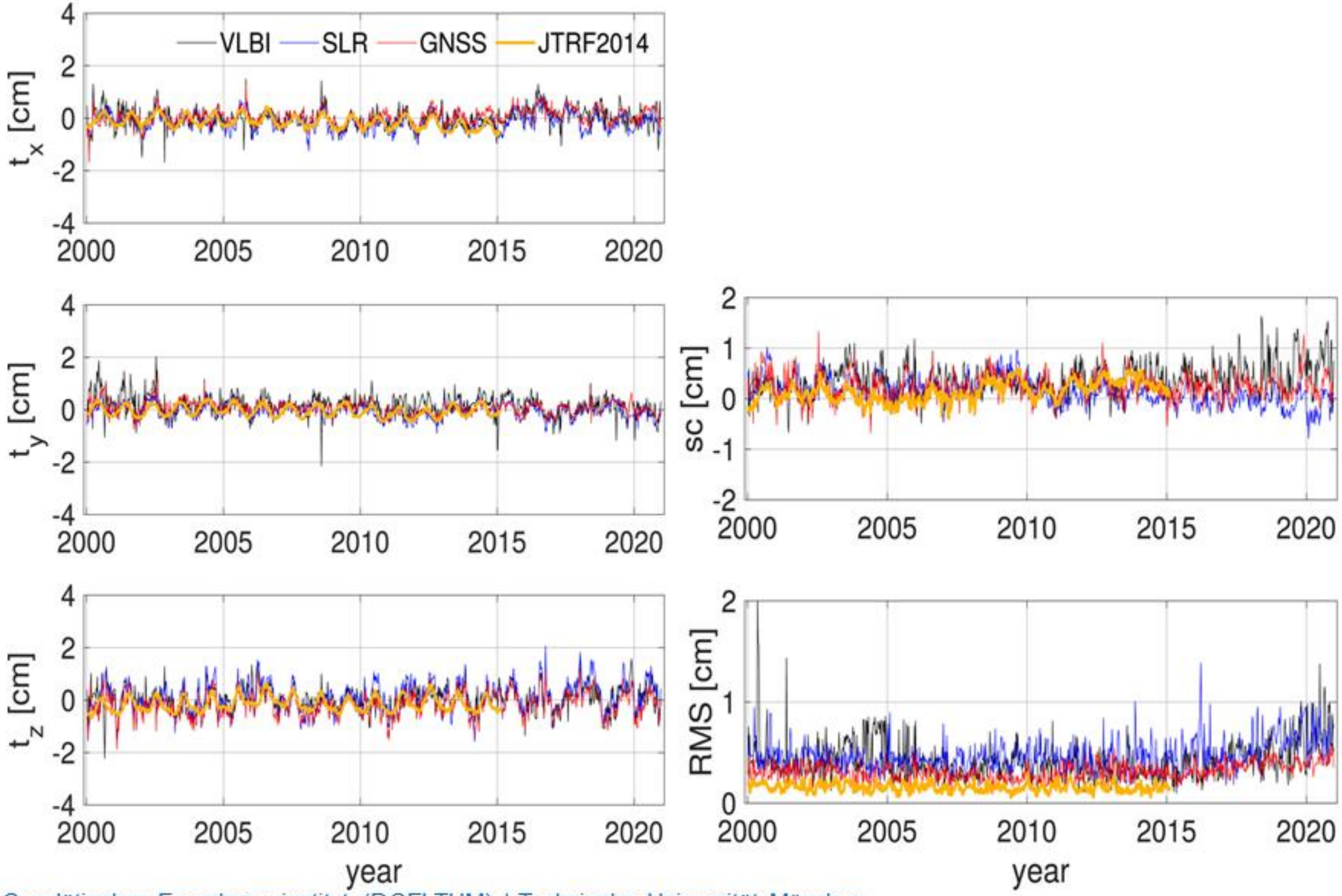
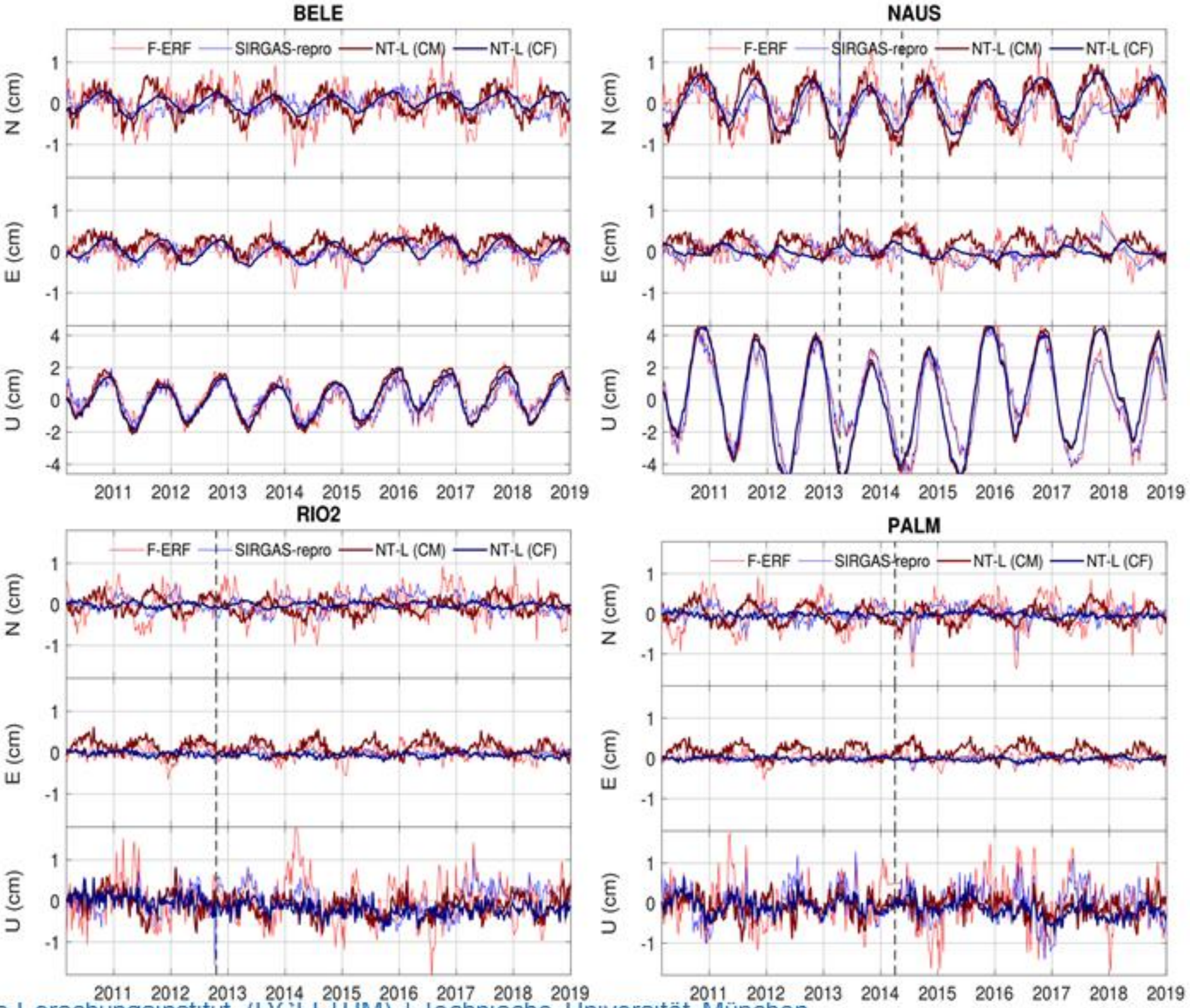
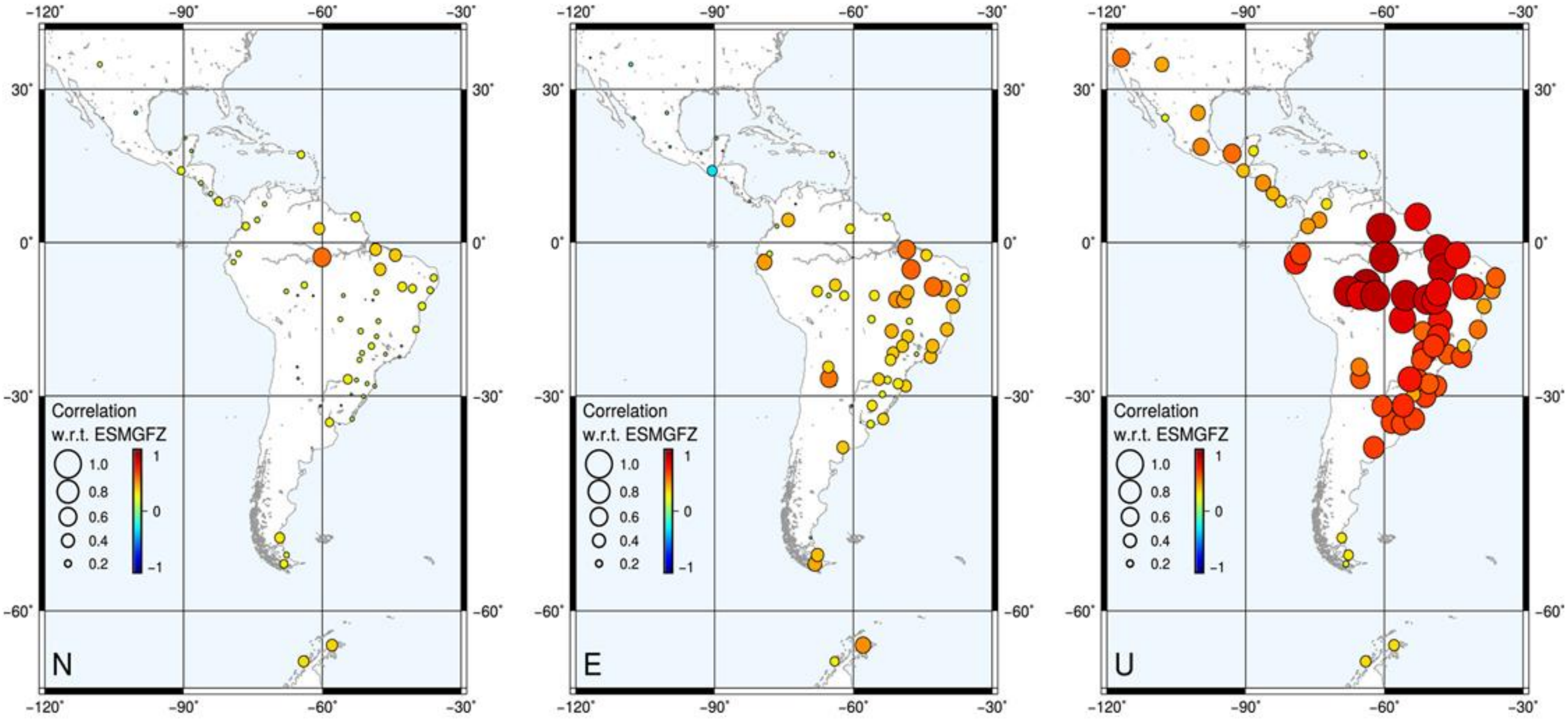


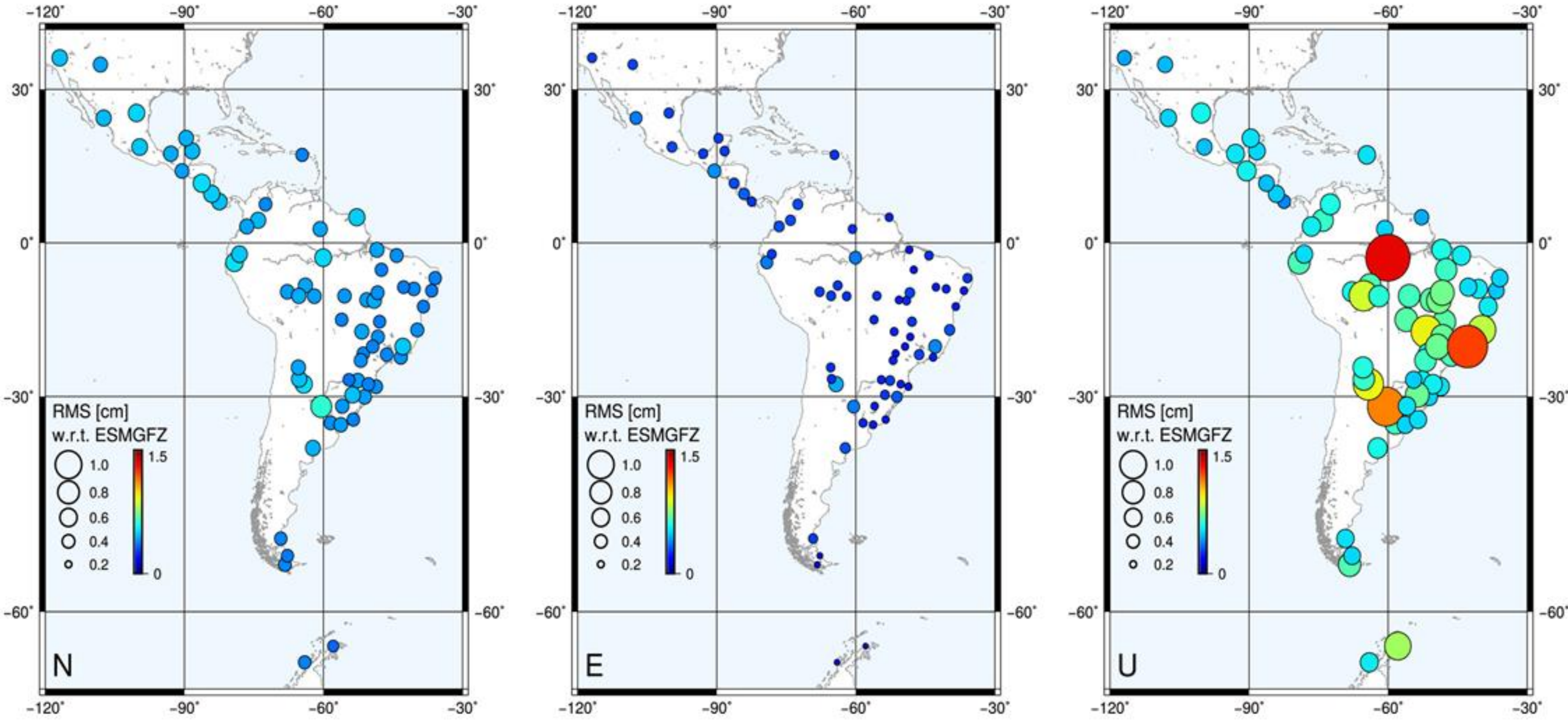
Direct geocentric realisation in a regional reference frame



Correlations between the site displacement time series derived from the combined F-ERF solution and the ESMGFZ NT-L time series in CM-frame



RMS difference between the site displacement time series derived from the combined F-ERF solution and the ESMGFZ NT-L time series in CM-frame



Closing remarks

- Our goal is to realise the datum of a regional geocentric reference frame directly and epoch-wise (i.e., instantaneously for each solution), without the alignment to a global reference frame, but by combining normal equations of global GNSS (regionally densified), SLR and VLBI networks using a minimum but sufficient global network configuration on a weekly basis.
- The geocentric origin of the combined network is realised from SLR, the scale is realised from both SLR and VLBI, and the orientation is kept consistent with that of the ITRF via a not-net-rotation w.r.t. the global GNSS network.
- The main gain is that the station position time series are related to the centre of mass at any epoch and they are not affected by the dislocation between the origin of coordinates and the geo-centre (as it is inherent to epoch reference frames based on GNSS only).
- This ensures reliable detection, modelling and interpretation of Earth-system-associated signals in GNSS data time series.
- The next step is to evaluate the feasibility of implementing this approach in the routine analysis of the SIRGAS reference frame at DGFI-TUM.