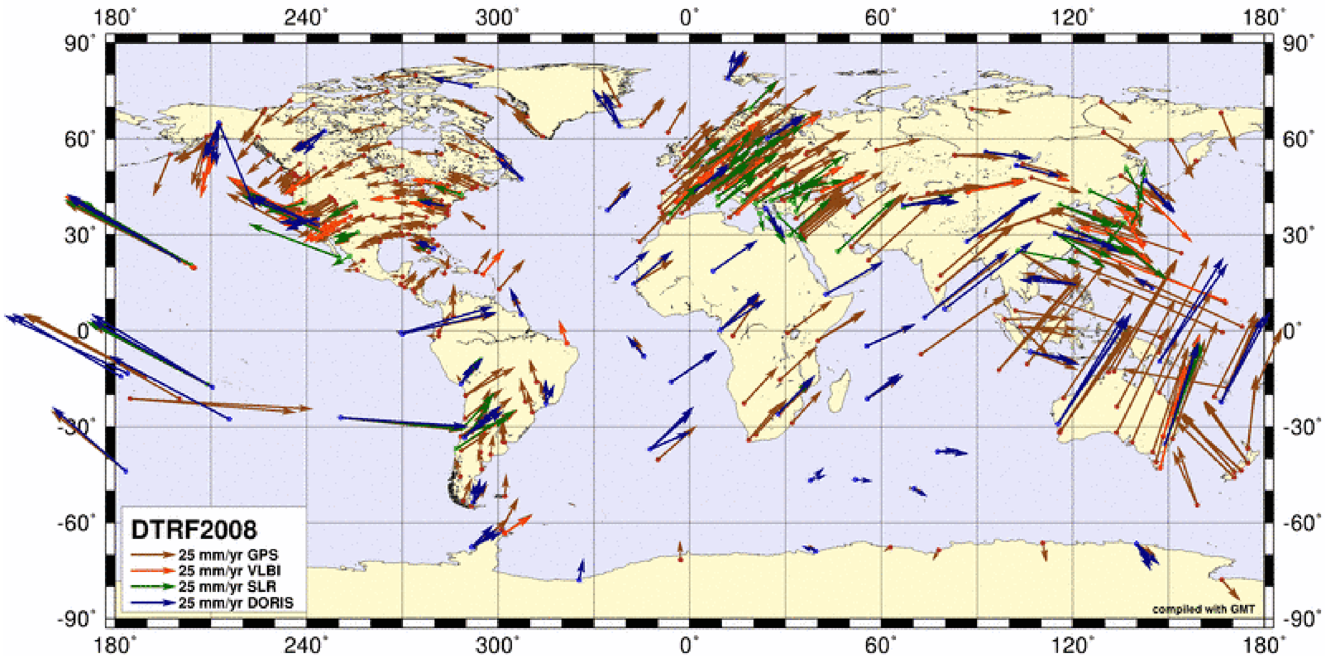
Impact of non-linear station motions

Ralf Schmid, Mathis Bloßfeld, Detlef Angermann

Deutsches Geodätisches Forschungsinstitut (DGFI)
München
e-mail: *angermann@dgfi.badw.de*

Motivation

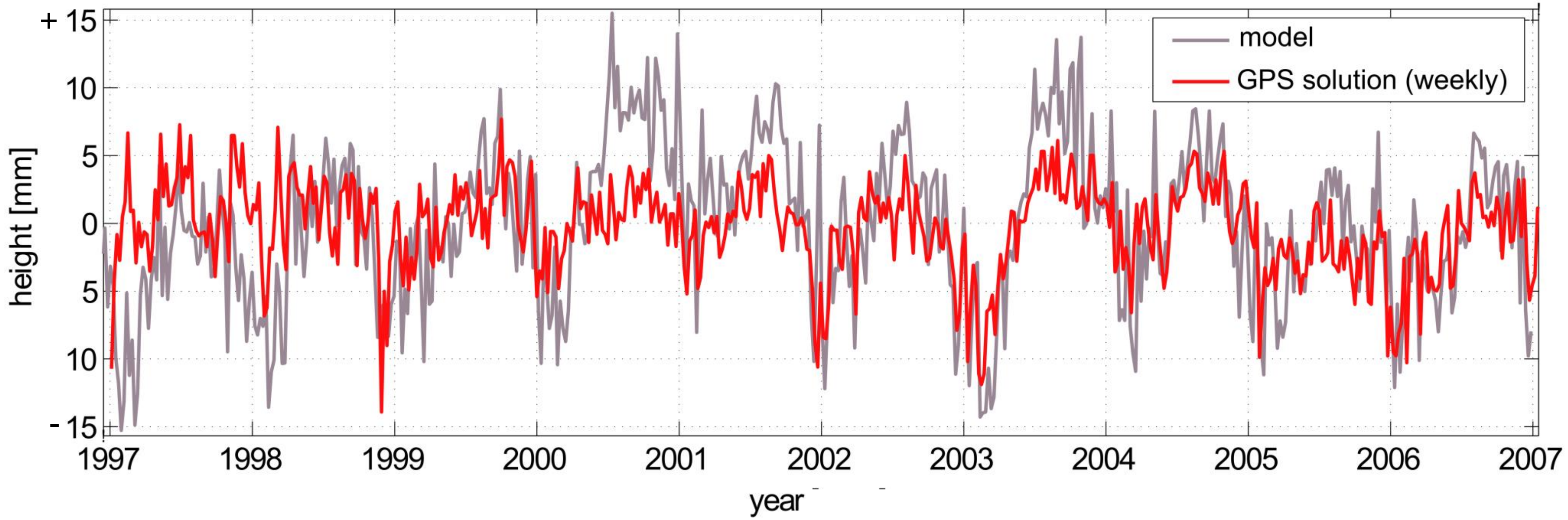
- Accuracy of space geodetic observations much higher than that of current reference frame realizations
- Current station parameterization (coordinates and linear velocities) can only cover secular station motions
- Neglected non-linear station motions are a major error source in current reference frame realizations



Seitz et al. (2012)

Non-linear station motions (1)

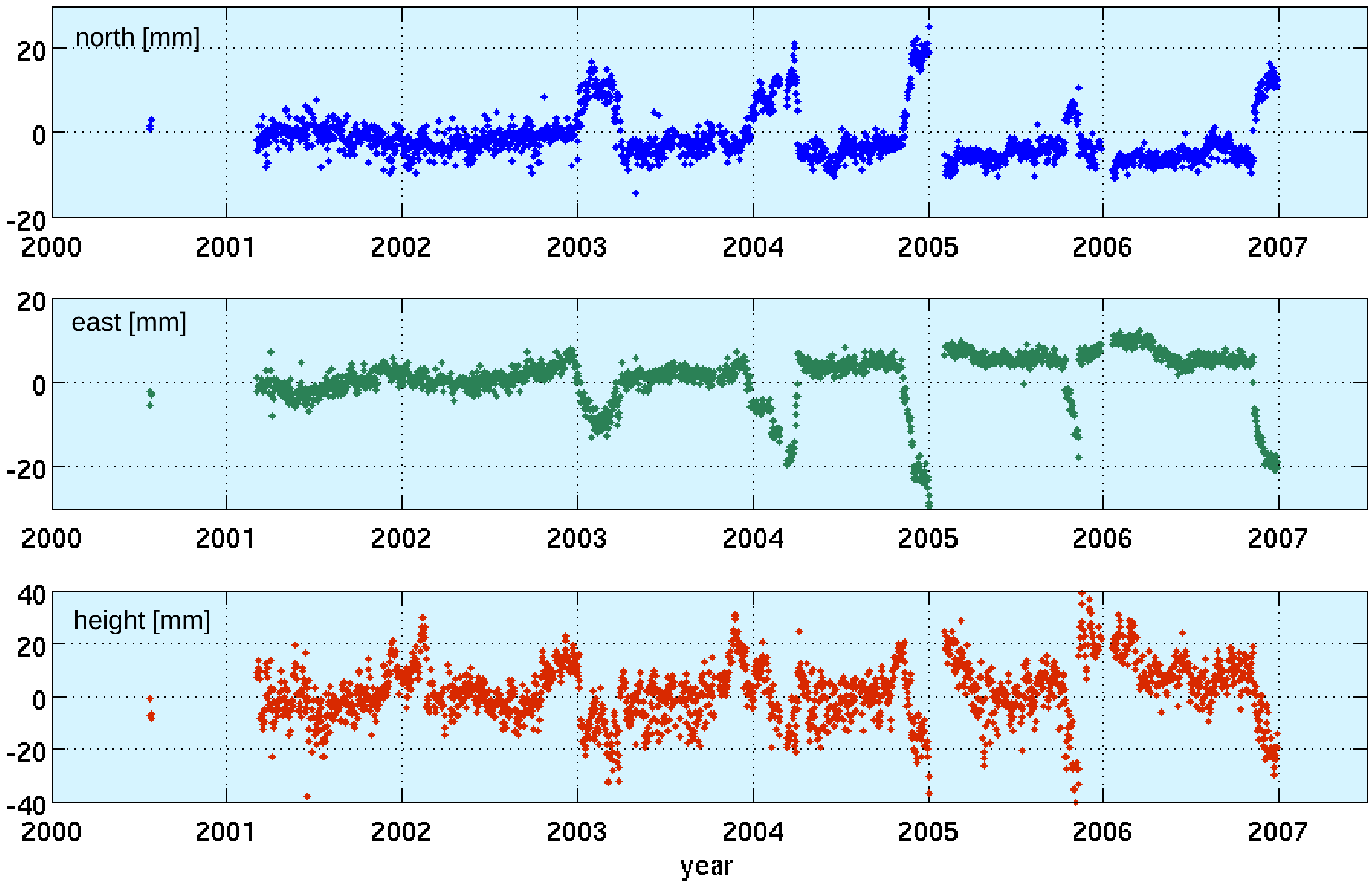
Time series of station height variations for Wettzell



- Observed (GPS) vs. modeled (atmospheric and hydrological loading) weekly height variations
  - atmospheric loading derived from NCEP
  - hydrological loading from GLDAS
- Unmodeled effects (like atmospheric or hydrological loading) cause **periodic signals** in coordinate time series

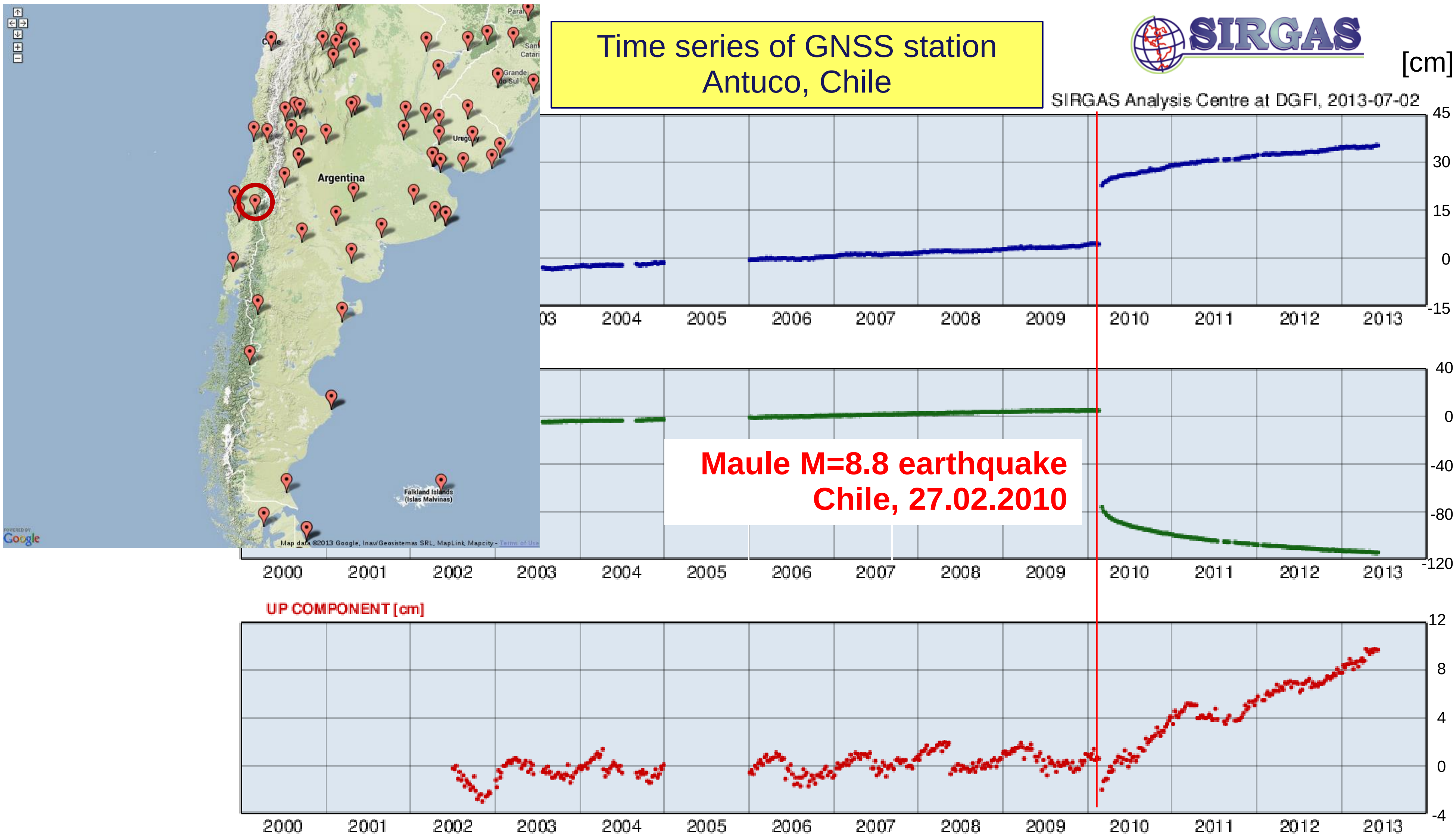
Non-linear station motions (2)

Station position time series for GNSS station Yakutsk, Siberia



- **Episodic motions** due to snow accumulated on GPS antenna

Non-linear station motions (3)

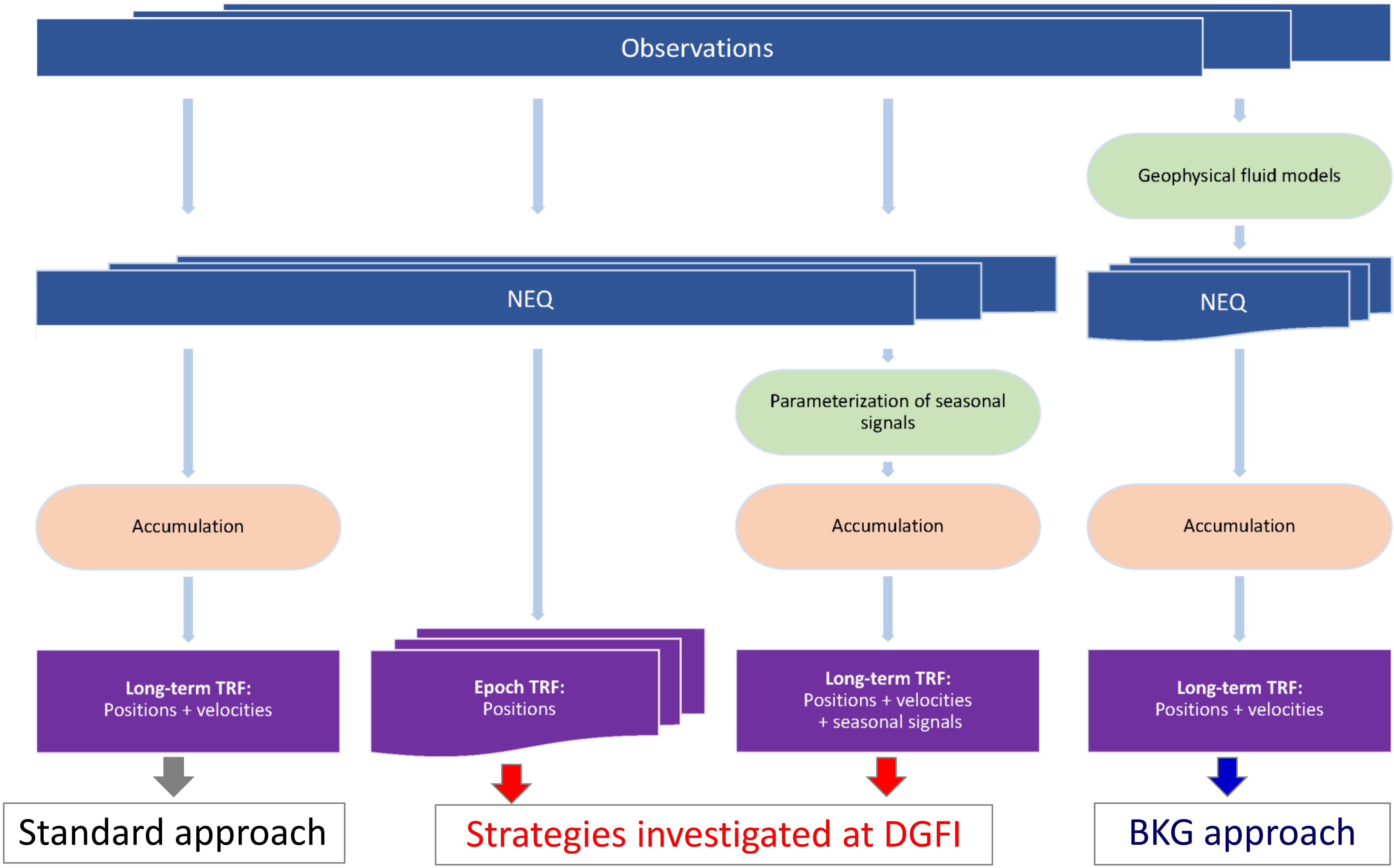


- Site displacement and non-linear **post-seismic deformation**

Treatment of non-linear station motions

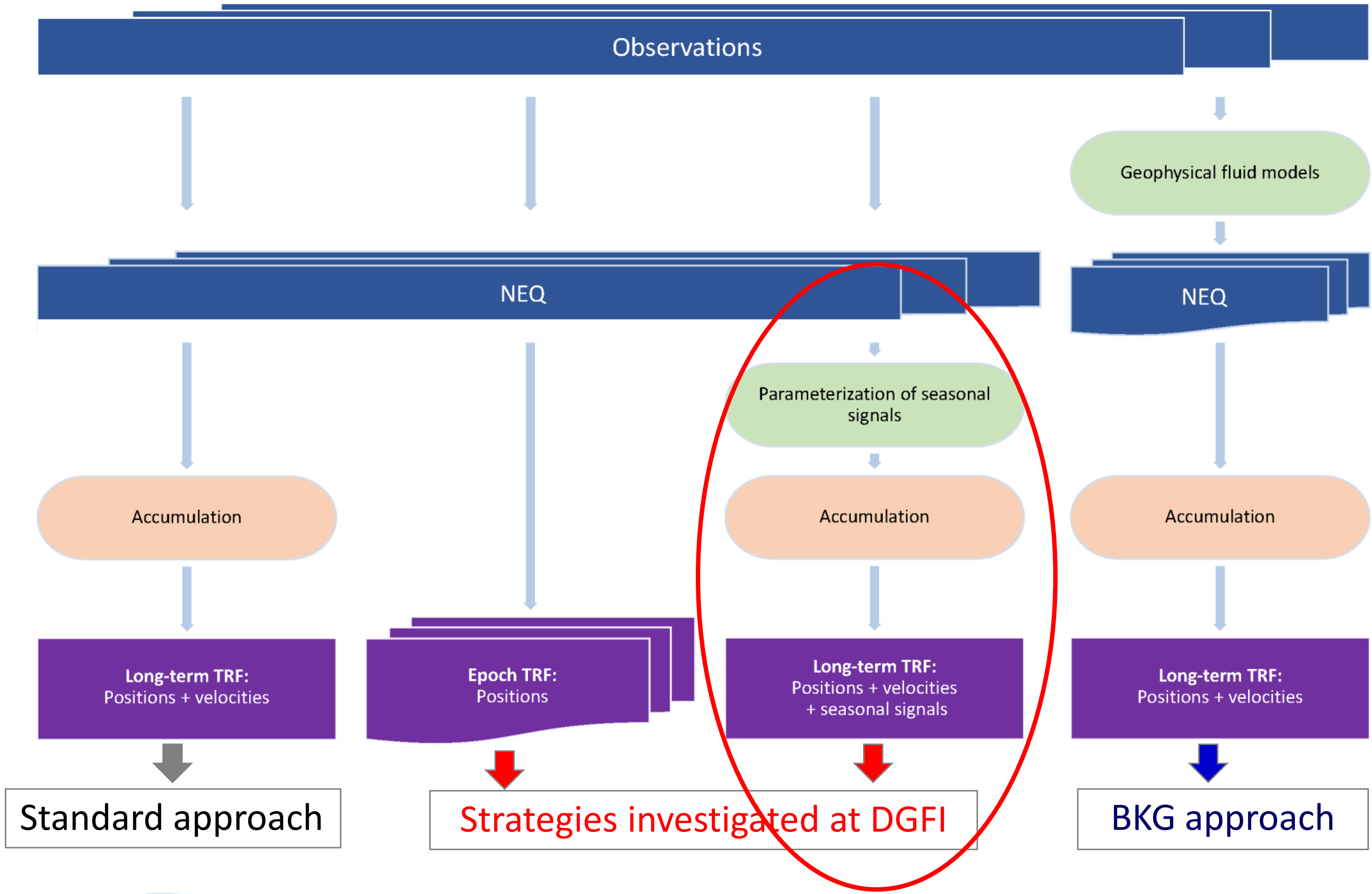
- **Geophysical modeling**
  - IAG/IERS JWG 1.2 „Modeling environmental loading effects for reference frame realizations
  - Focus area of BKG within DFG Research Unit FOR 1503 „Space-time reference systems … "
- **Sampling** (e.g., epoch reference frames)
  - IAG/IERS JWG „Strategies for epoch reference frames"
  - DGFI research activities (see Bloßfeld et al., 2014)
- **Extended parameterization** of station motions
  - Focus area of DGFI within DFG Research Unit FOR 1503 „Space-time reference systems … "
  - This presentation

Overview of computation strategies



DGFI CGE DFG Forschergruppe Referenzsysteme

Overview of computation strategies

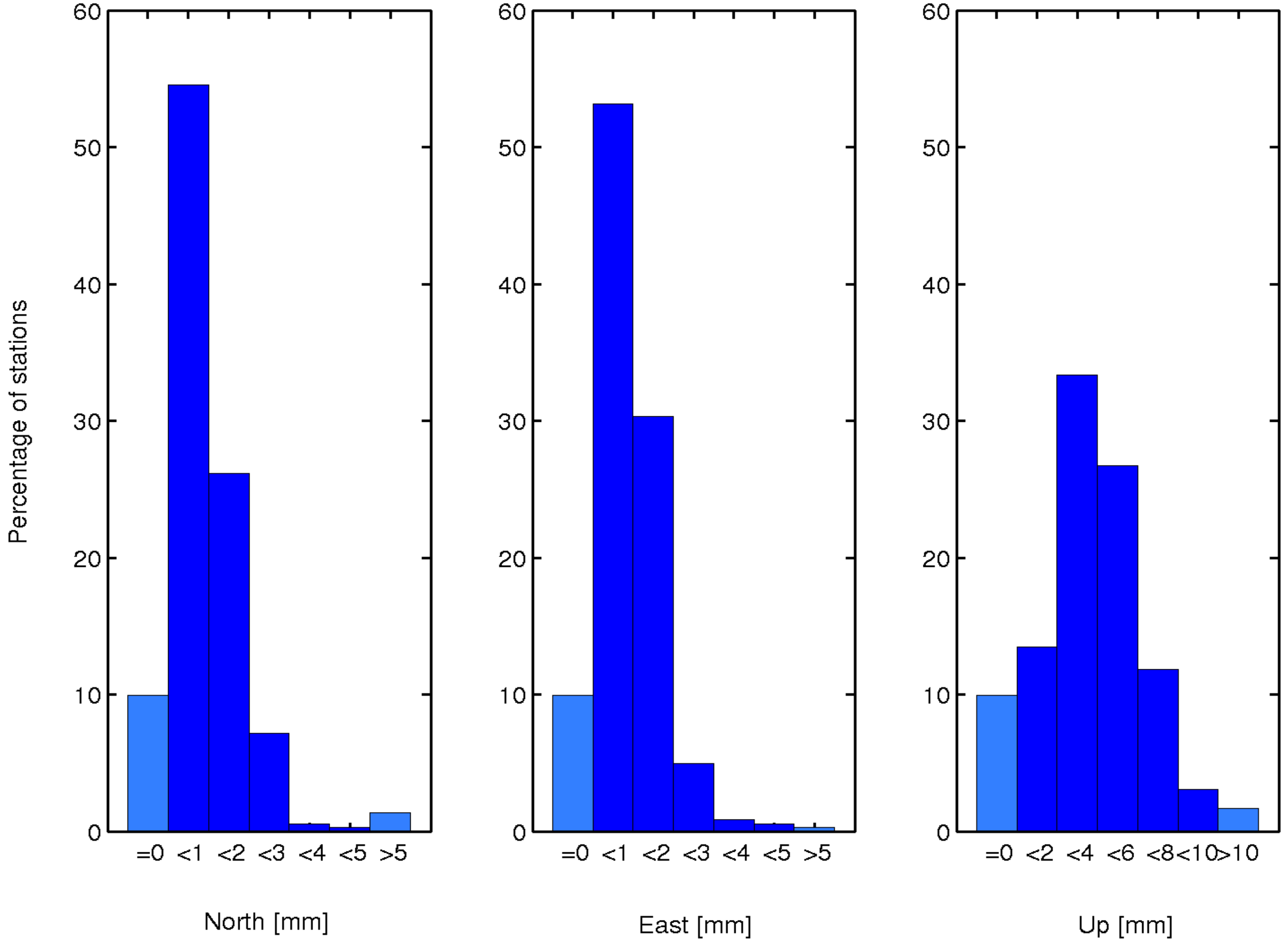


Geodätische Woche, 7. Oktober 2014, Berlin

Data and solution characteristics

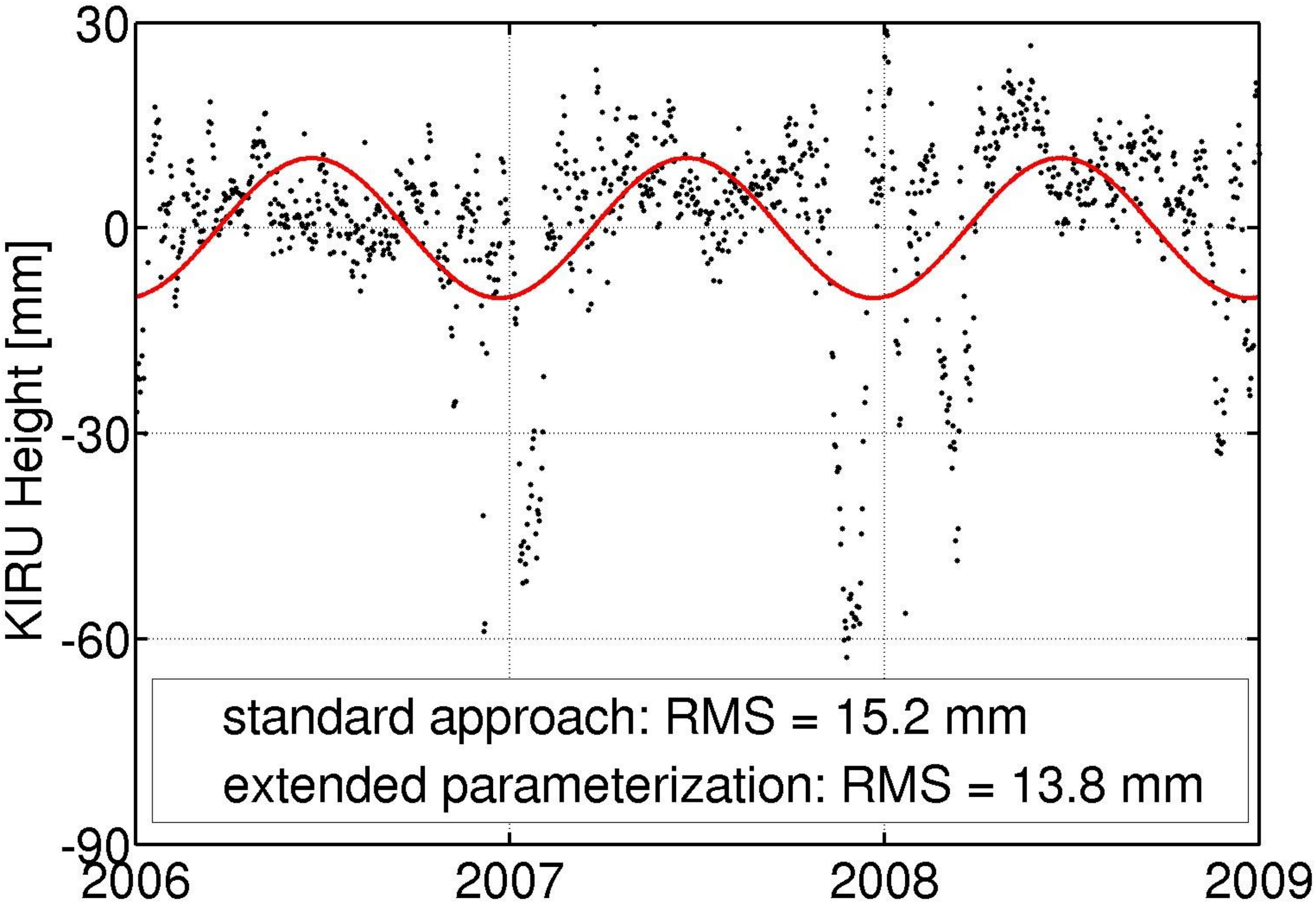
- Data: 5 years of GPS data (2006.0 until 2011.0)
- More than 300 stations
- Estimated parameters: station coordinates, velocities and **sine/cosine amplitudes** (see below!), pole coordinates
- Datum realized via NNR/NNT/NNS conditions w.r.t. IGS08
- Different solution types:
  - **daily**/epoch solutions
  - **multi-year** solutions:
    - zero amplitudes for all stations (standard solution)
    - zero amplitudes for 3 datum stations (globally distributed)
    - *non-zero amplitudes for all stations (requires dedicated datum conditions that are presently under progress!)*
    - amplitudes not estimated for “poorly observed” stations

Magnitude of annual station signals



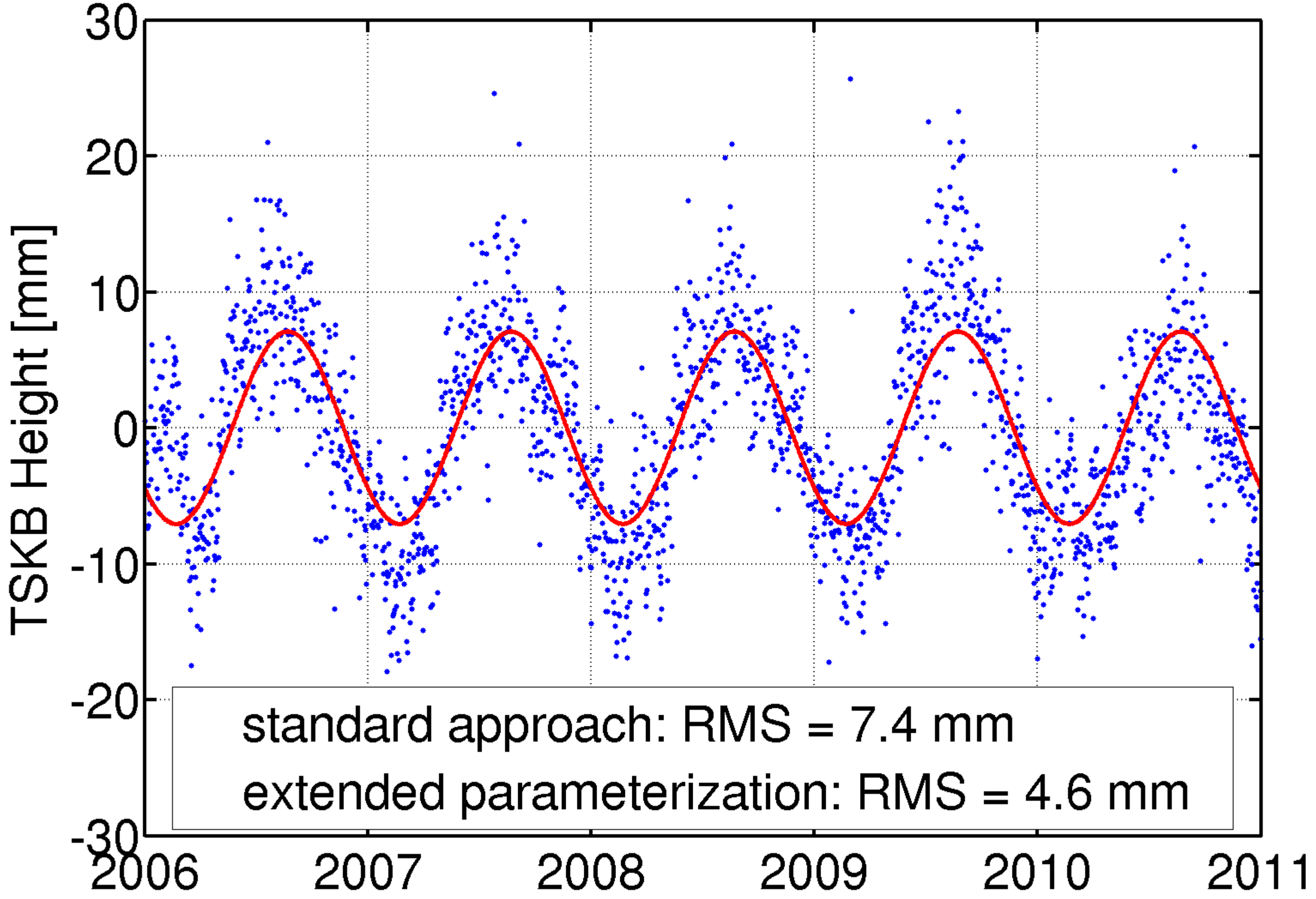
DGFI CGE DFG Forschergruppe Referenzsysteme

Annual signal for GNSS station Kiruna, Sweden



DGFI CGE DFG Forschergruppe Referenzsysteme

Annual signal for GNSS station Tsukuba, Japan

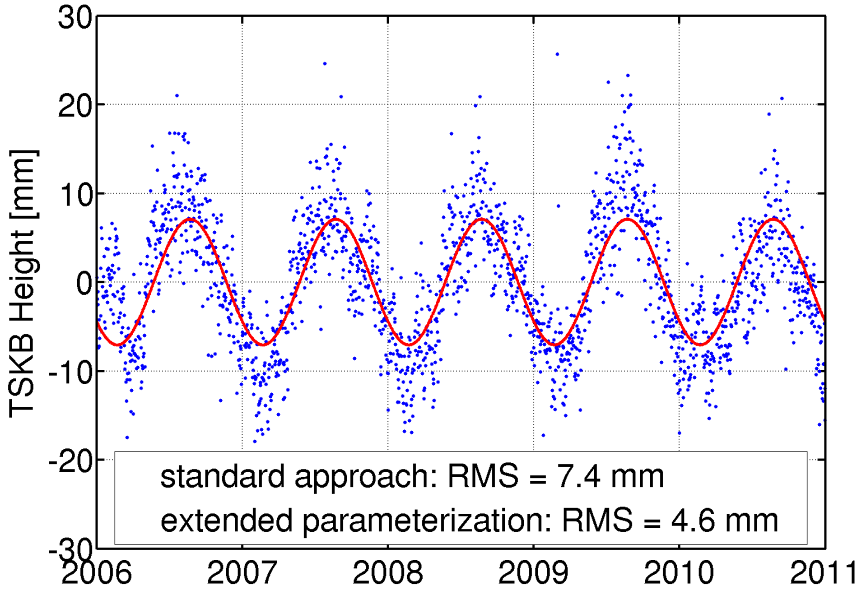


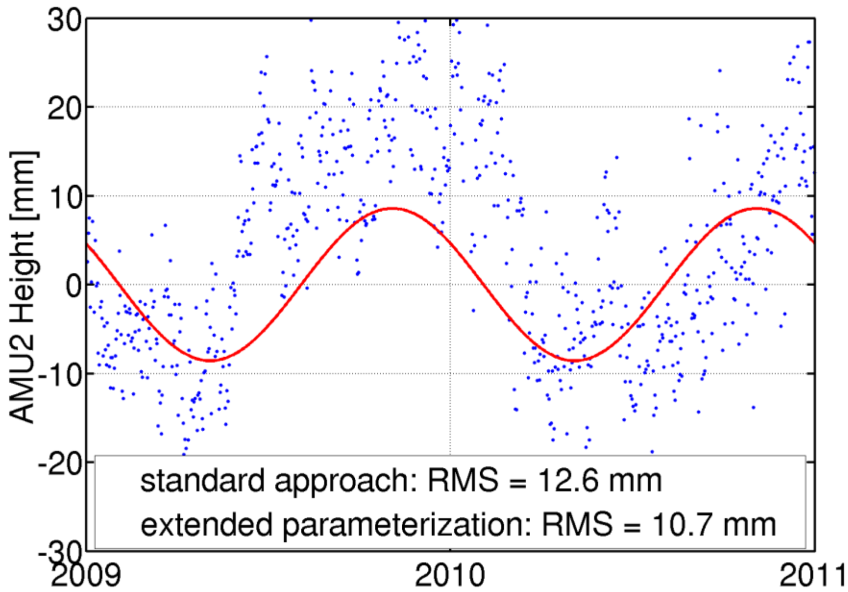
DGFI CGE DFG Forschergruppe Referenzsysteme

Impact of seasonal signals on station velocities

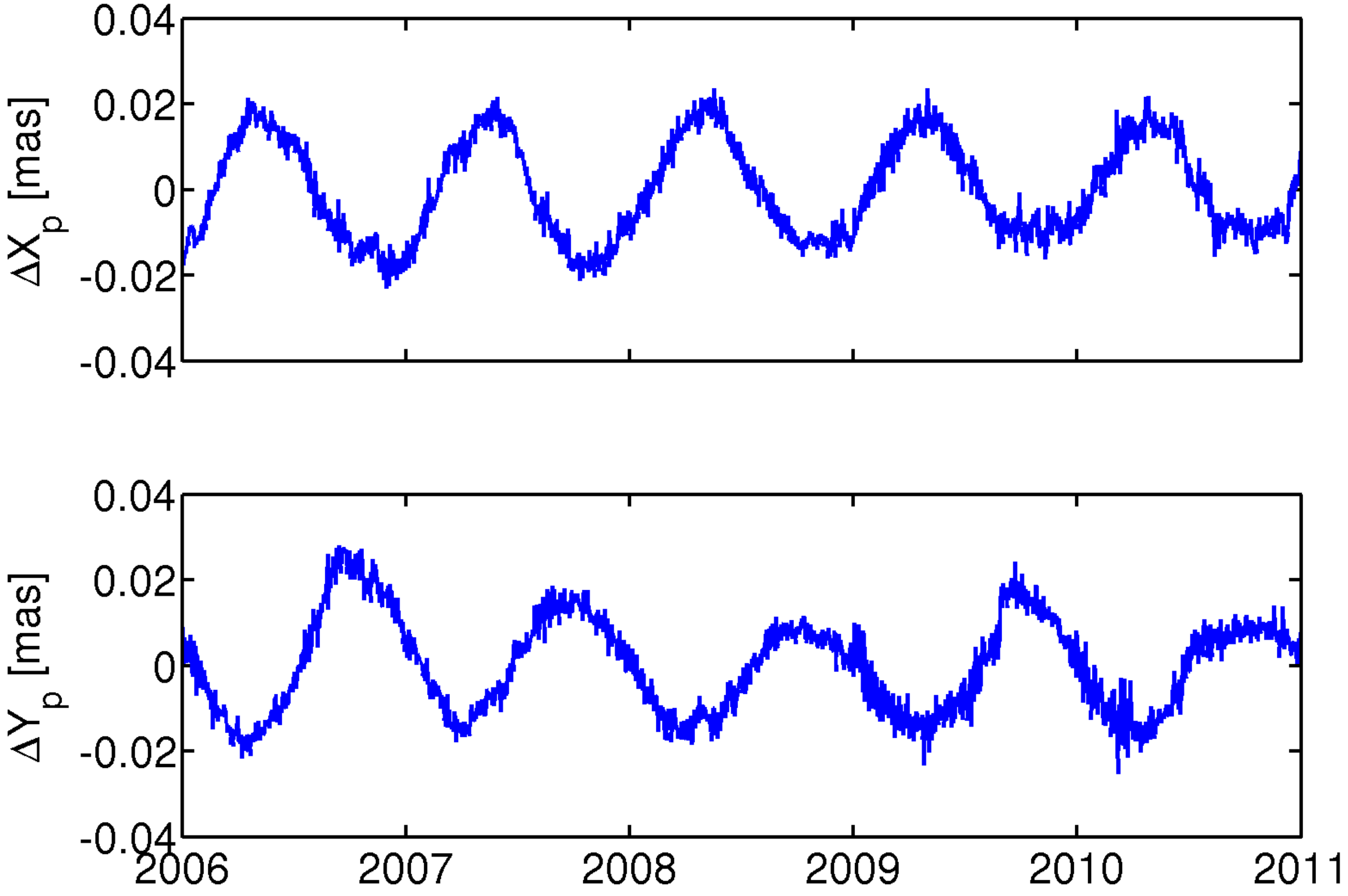
Solution with estimated seasonal signals vs. standard solution

Station	Amplitude [mm]	Velocity difference [mm/yr]		
		North	East	Up
TSKB, Japan	7.1	0.1	0.1	0.2
AMU2, Antarctica	8.6	1.2	0.1	3.3





Impact of seasonal signals on pole coordinates



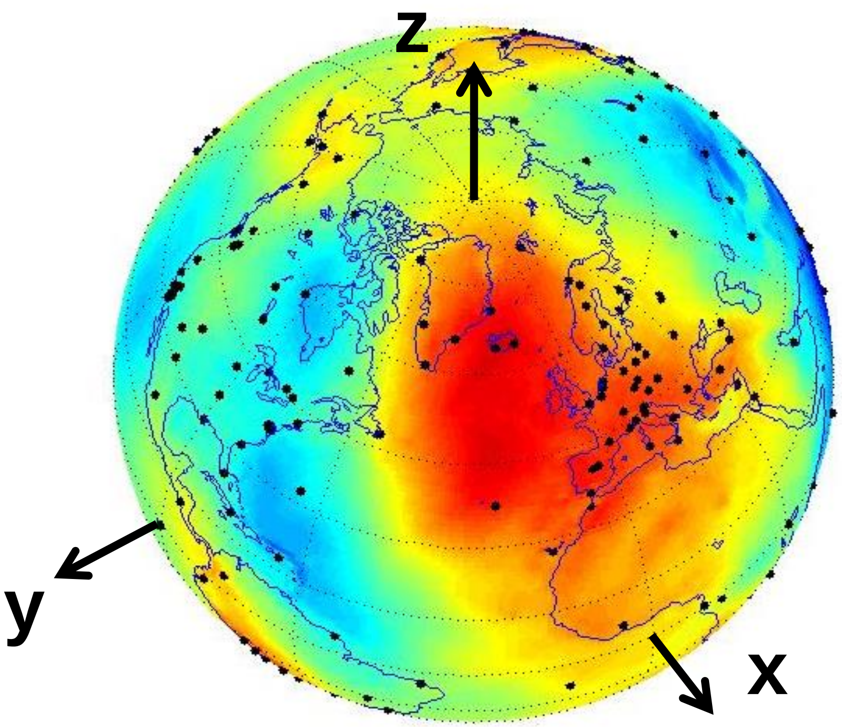
Pole coordinates from standard solution are affected by suppressed non-linear station variations (Bloßfeld et al., 2014)

Summary and outlook

- The estimation of seasonal station variations has been studied using 5 years of data of a global GPS network
- Estimated amplitudes for the horizontal components are mostly below 3 mm, but much larger for the height component
- The estimation of seasonal signals has an impact on other parameters (e.g., station velocities, pole coordinates)
- The estimation of seasonal signals is critical for short observation time spans and/or for stations with irregular behavior
- Next steps:
  - Implementation of datum conditions for seasonal signals
  - Check significance of estimated seasonal signals
  - Estimation of seasonal signals in the inter-technique combination
  - Comparisons at co-location sites
  - Study impact on ITRF results

Back-up slides

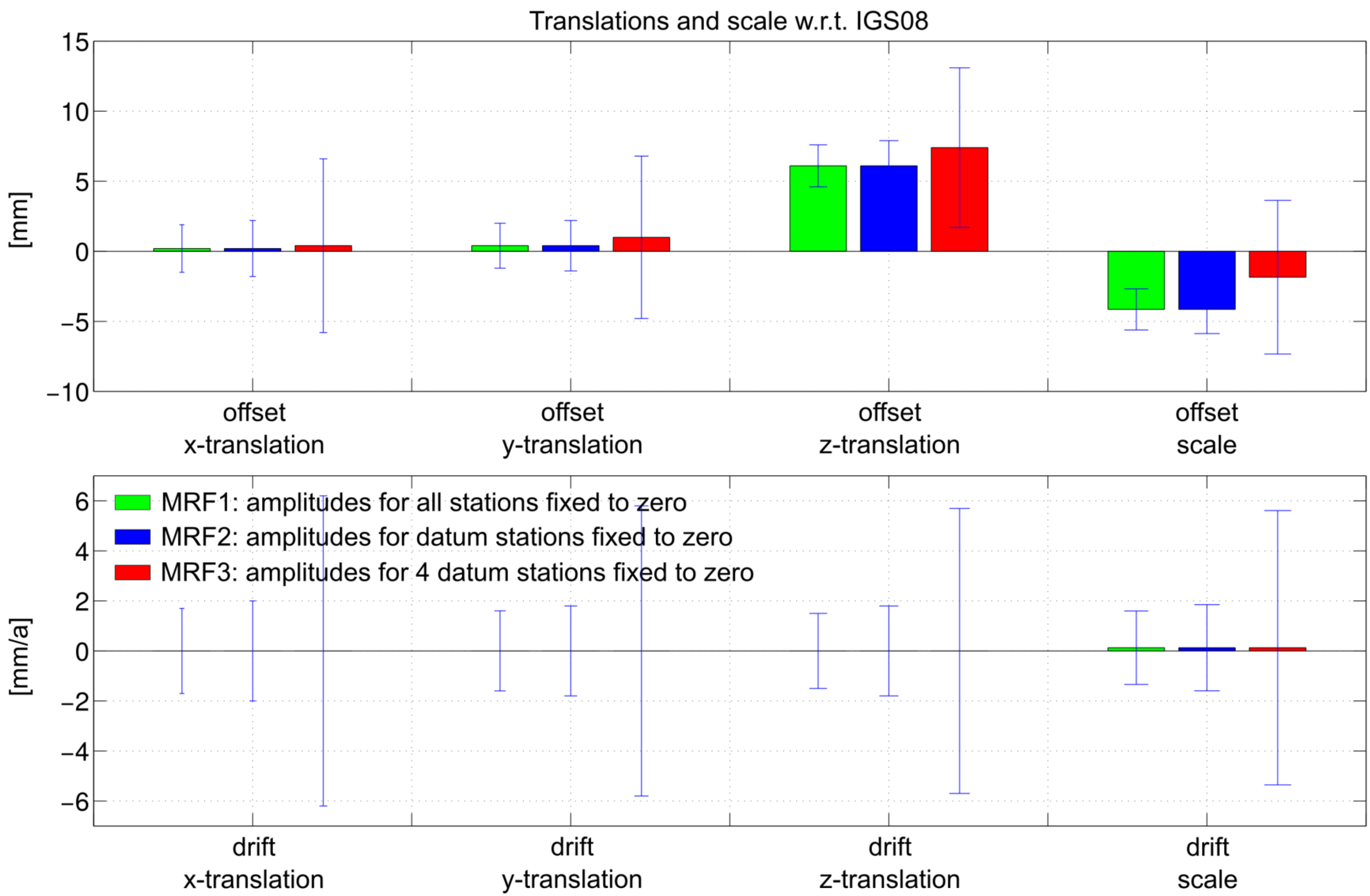
Impact of seasonal signals on pole coordinates



Network orientation (x) ⇔ y pole

Network orientation (y) ⇔ x pole

Validation of multi-year solutions w.r.t. IGS08 (1)



DGFI CGE DFG Forschergruppe Referenzsysteme

Validation of multi-year solutions w.r.t. IGS08 (2)