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International Terrestrial Reference Frame - Latest Developments

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GGOS-D
http://www.ggos-d.de
DGFI
FGS

Situation after ITRF2005

The fact that ITRF2005 showed a scale difference of about 1ppb between SLR and VLBI and the fact that SLR did not contribute to the ITRF2005 datum definition has started a vital discussion.

- The ITRF scale could not be used for SLR analysis
  - ITRF2005 rescaled
  - SLRF2005
- Detailed analysis of the various techniques
  - A few sources for the scale discrepancy could be detected
- Activitities to produce longer and harmonized timeseries
  - SLR back to 1983
  - VLBI, GPS reprocessing with better models
  - New stations with longer time series
- Discussion on the processing strategy
  - DGFI ITRF solution on free normal equation level did not show this scale problem
  - Combination on observation level (Biancale, 2007)

Reasons for Scale Problems

- VLBI
  - Wrong polar tide correction
    (up to 1 cm in height ~ 0.54 ppm)
- SLR
  - Bias problems (Stanford counters, CoM, ..)
  - Short time series (1993-2005)
- GPS, DORIS
  - Not used for scale definition
- Local Ties
  - distribution and weighting
  - co-location between SLR and VLBI is problematic
- Processing Strategy
  - Different concepts at IGN and DGFI

Data sets in ITRF2005

ITRF2005: Time series of station positions and EOP

Techn.	Service / AC	Data	Time Period
GPS	IGS / NRCan	weekly solutions	1996 - 2005
VLBI	IVS / IGG	24 h session NEQ	1984 - 2005
SLR	ILRS / ASI	weekly solutions	1993 - 2005
DORIS	IGN - JPL/LCA	weekly solutions	1993 - 2005

ITRF2005 data sets are not fully consistent, the standards and models were not completely unified among analysis centers

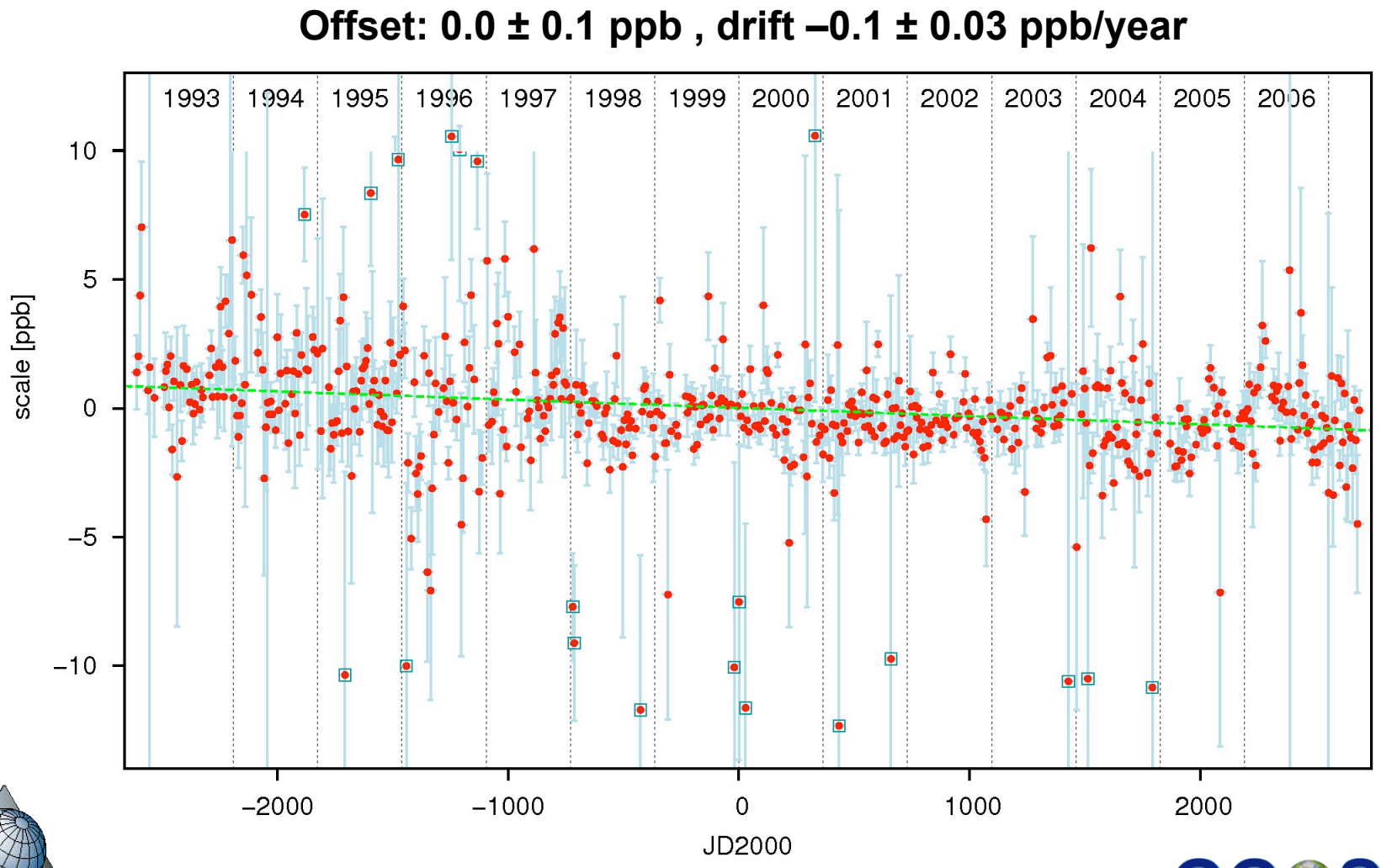
Shortcomings concerning GPS:

- IGS solutions are not reprocessed (e.g., model and software changes)
- Relative antenna phase center corrections were applied

Recent Improvements

- ILRS
  - Reprocessing back to 1983 (not yet ready)
  - Biases under investigation (1993-now)
- IVS
  - Reprocessing with corr. polar tide
  - New trop. models
- IGS
  - New homogeneous time series (only individual GPS series, PDR)
  - Absolute antenna phase centres
- IDS
  - Reprocessing ?

Transformation: ITRF2005 (DGFI SLR Solution) – new corr. DGFI SLR solution



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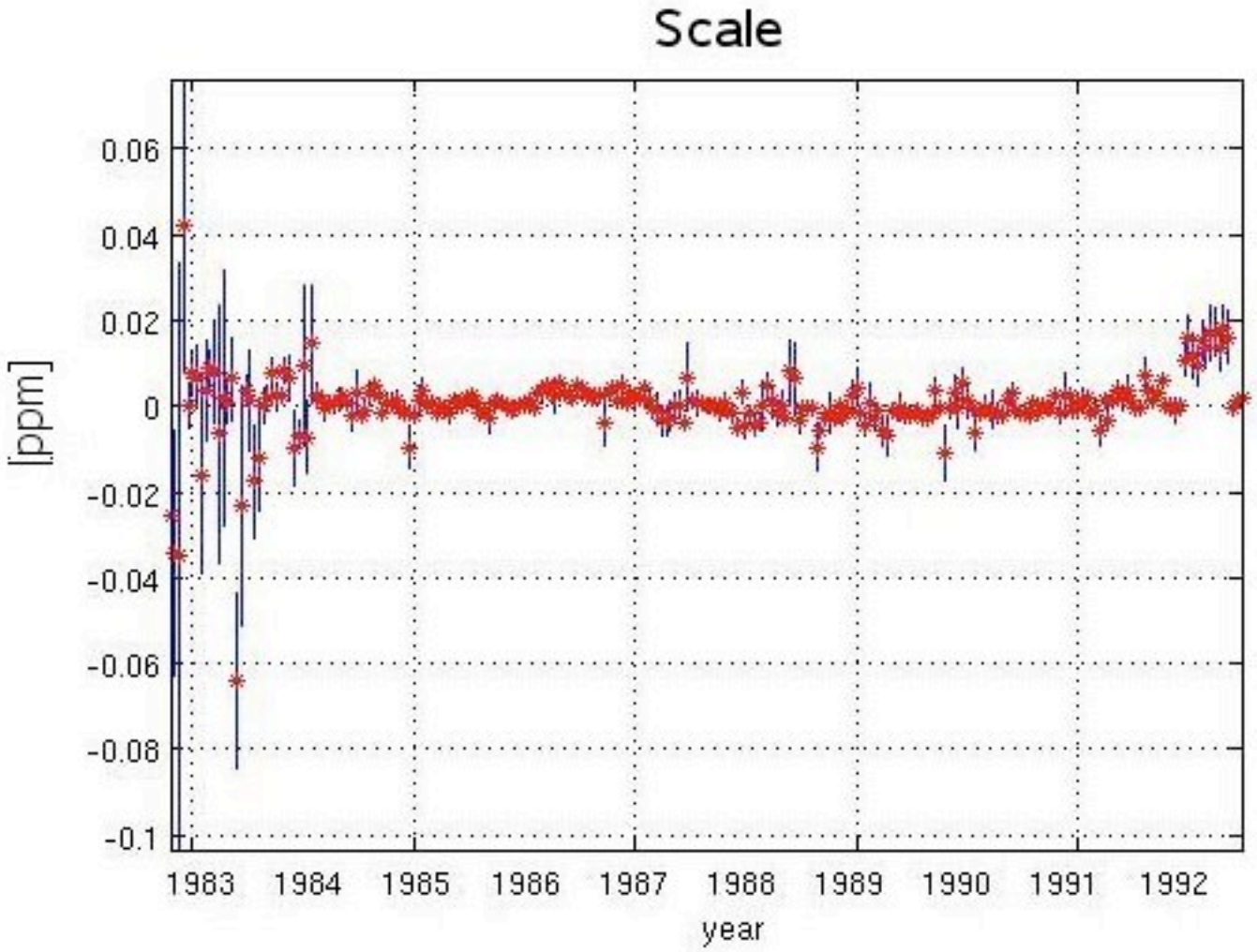
ILRS „Backward“ Processing

DGFI results only: Transformation Parameters to SLRF2005



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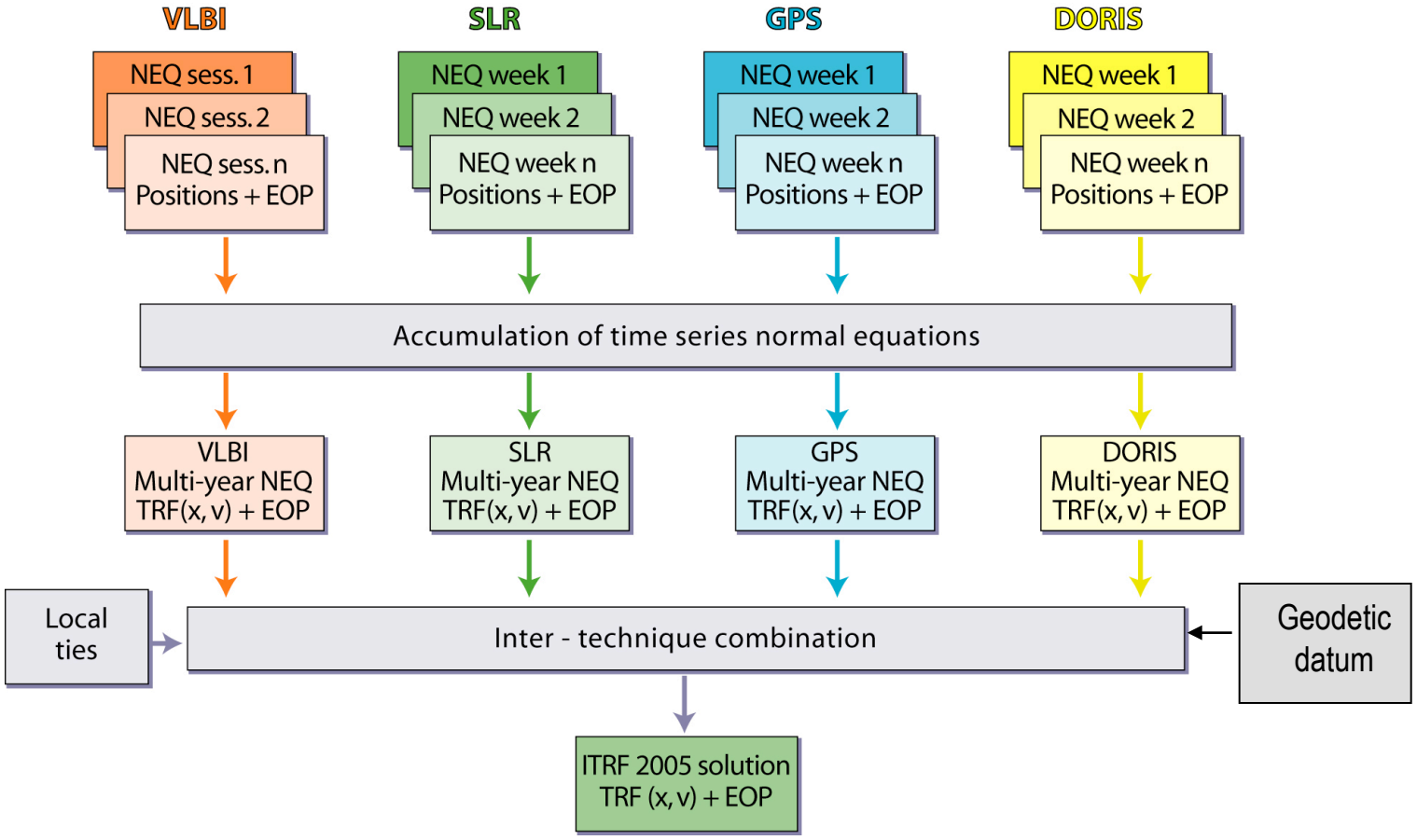
Processing Strategies DGFI TRF



GGOS-D processing 1

GGOS-D: Time series of station positions and EOP

Techn.	Institutions	Data	Time Period
GPS	GFZ	daily NEQ	1994 - 2007
VLBI	IGG / DGFI	24 h session NEQ	1984 - 2007
SLR	DGFI / GFZ	weekly NEQ	1993 - 2007

Improvements of GGOS-D data compared to ITRF2005:

- Homogeneously processed data sets
  - Identical standards, conventions, models, parameters
  - GPS: PDR (Steigenberger et al. 2006, Rülke et al. 2008)
- Improved modelling
  - for GPS: **absolute** instead of relative **phase centre** corr.
  - for VLBI: **pole tide model** was changed

GGOS-D: German project of BKG, DGFI, GFZ and IGG funded by BMBF

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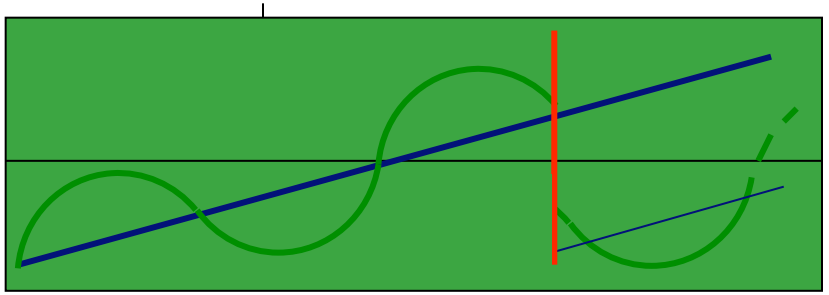
GGOS-D processing 2

Analysis of station coordinate time series and computation of a reference frame per technique

Modelling time dependent station coordinates by

- epoch positions
- linear velocities
- seasonal signals
- discontinuities



Example: Number of discontinuities that were introduced for the accumulation of the GPS time series:

- ✓ ITRF2005: 221 discontinuities in 332 GPS stations (1996 - 2005)
- ✓ GGOS-D: 95 discontinuities in 240 GPS stations (1994 - 2007)

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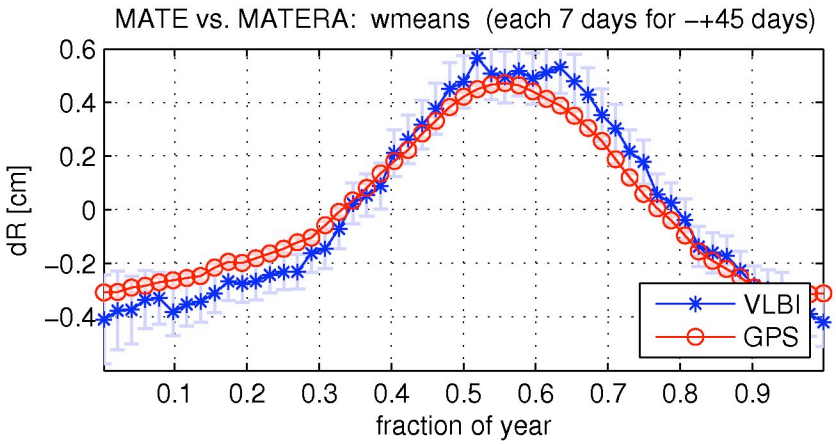
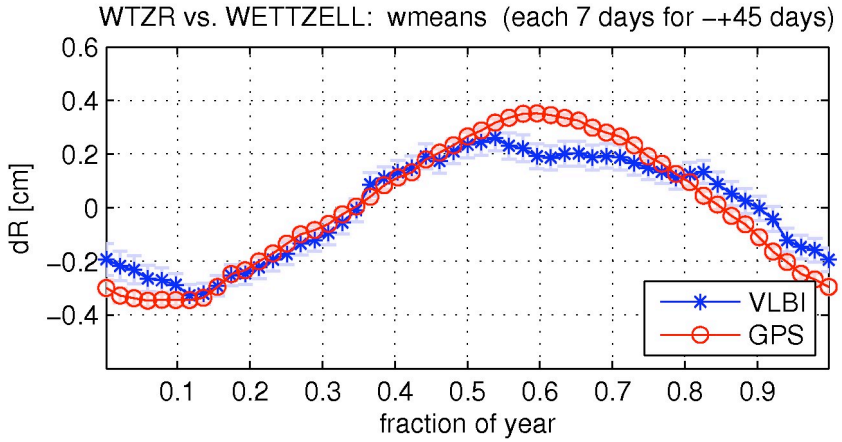
GGOS-D Technique Comparison 2

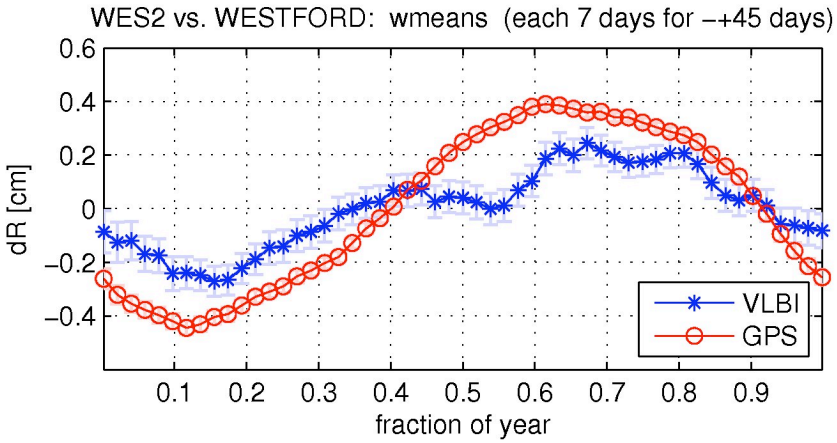
Mean annual MATERA



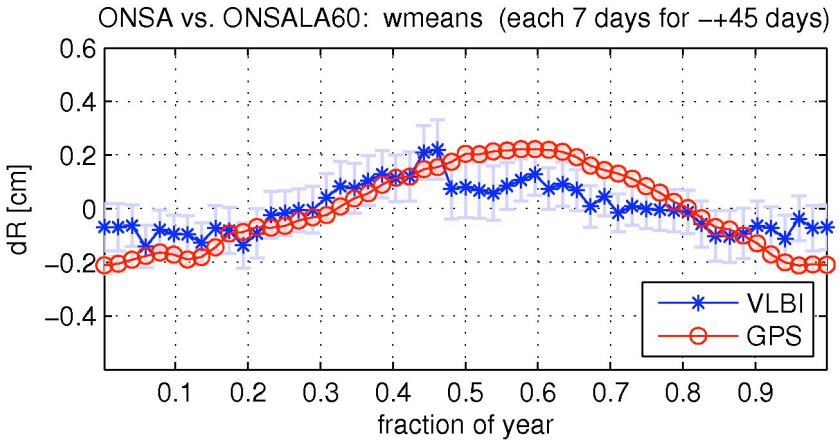
Mean annual Wettzell



Mean annual Westford



Mean annual ONSALA



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Future Strategies

- Unified Models
  - The platform for this activies is GGOS, a component of the IAG
  - First step: Unified Analysis Workshop, Monterey, 2007
- Low degree harmonics
  - Annual signals in the transformation parameters can be gravity induced
- Loading effects (e.g. atmosphere, hydrology)
  - Loading effects are station dependent, can sum up to 2 cm (Brasilia)
  - Blue sky effect; SLR stations observ at clear sky with normally higher air pressure, this can produce a systematic error in height; max 1.45 mm for Borowiec (M. Seitz, 2008)
- Annual station variations?
  - Not all effects can be explained by loading effects
- Local Ties
  - For some sites a resurvey is necessary
  - A better global distribution is required

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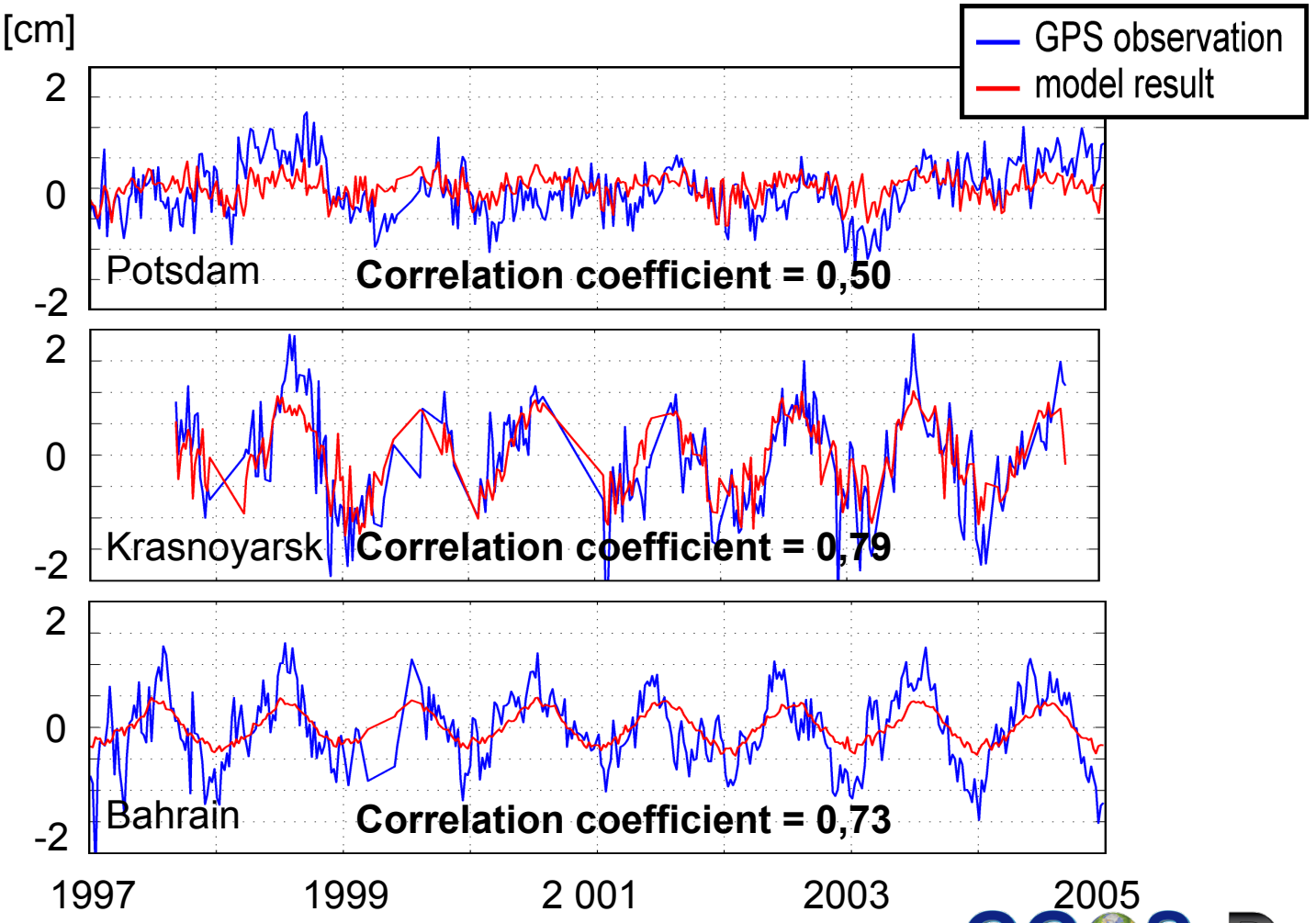
Annual Signals

Seasonal signals - Comparison with geophysical data

Models consider **atmospheric, oceanic** and **hydrologic** mass loads:

NCEP, ECCO, GLDAS



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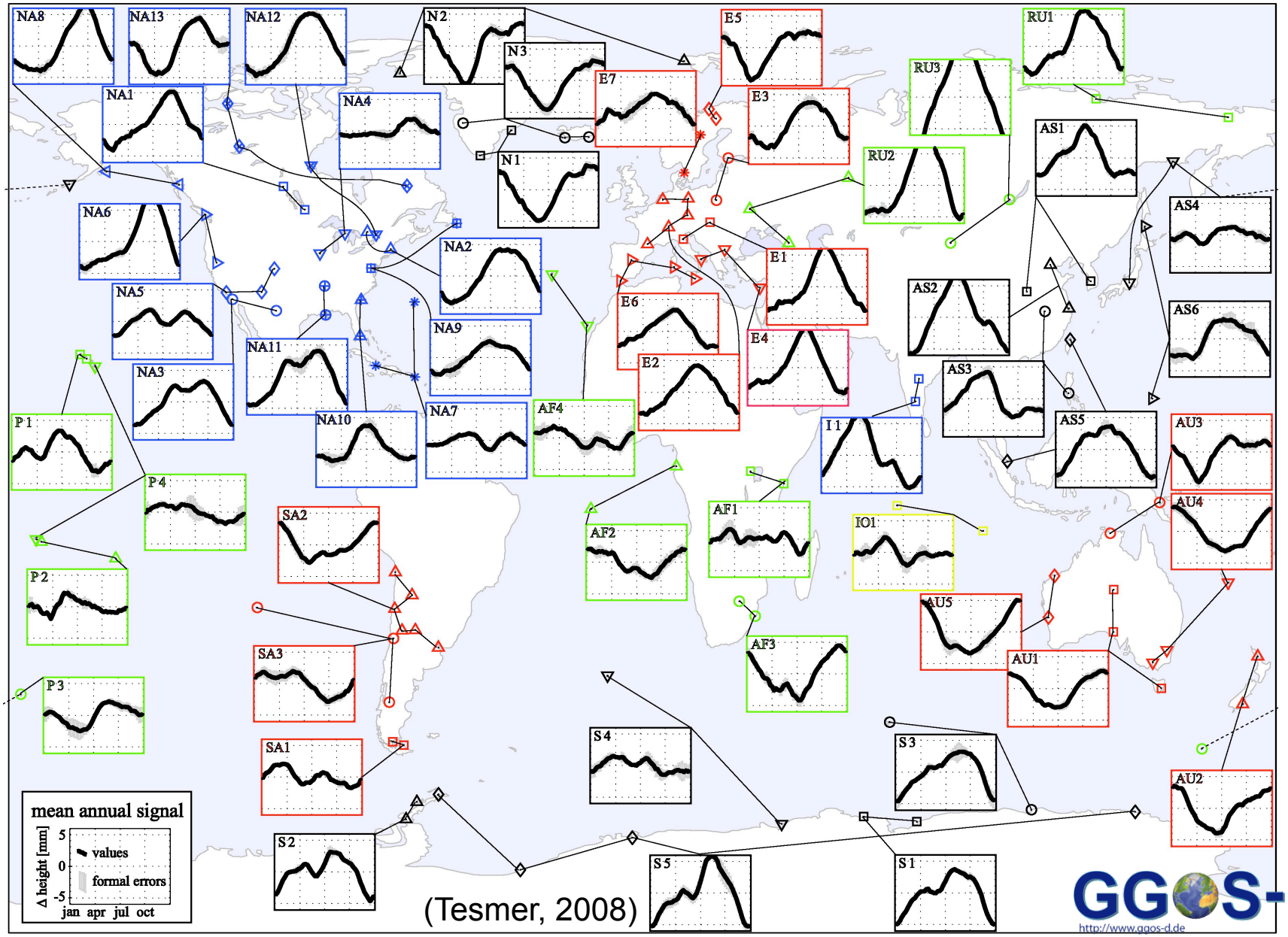
Average Mean Annual Regional Behavior



Conclusion

- A lot of efforts were done to solve the problems discovered in the last ITRF
- Next ITRF will benefit from these investigations
- New concepts are is the test phase
- New models needs to be implemented
- Harmonisation of standards and models is mandatory for the nextITRF