DTRF2013: Results of the analysis and impact of the contribution of the International DORIS Service

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Motivation

Many model improvements for DORIS

Infrastructure
- Development of space and ground infrastructure
- More data collected from DGXX receiver (on Jason-2 first) – seven stations observed in parallel

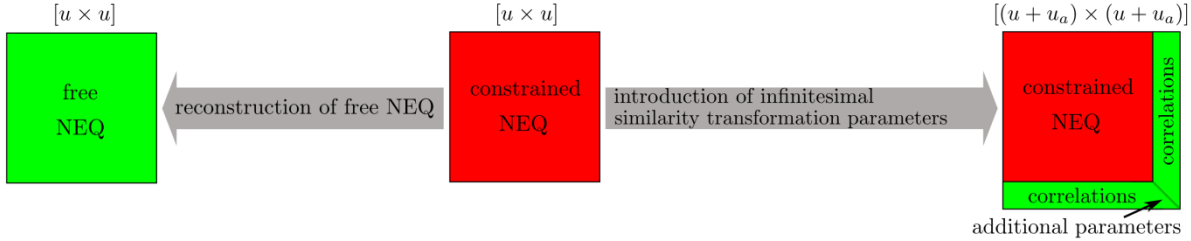
Modelling: satellites
- Physical models of satellites
- Improved solar radiation pressure modelling
- Improved air drag parameterization
- Gravity field: EIGEN-6S2 which includes annual variations

Modelling: station antennae
- Frequency offset considered (difference between actual admitted frequency and the nominal value)
- antenna phase center corrections

Willis, P.; Lemoine, F.G.; Moreaux, G.; Soudarin, L.; Ferrage, P.; Ries, J.; Otten, M.; Saunier, J.; Noll, C.; Biancale, R.; Luzum, B., in press. The International DORIS Service (IDS) - Recent developments in preparation for ITRF2013, IAG SYMPOSIA SERIES, 143

Input data and parameterization (I)

- Input data
  - SINEX files between 1993.0 and 2014.0
  - Weekly solutions (minimum constraints, not booked in SINEX → cannot be removed; need to introduce 7 similarity transformation parameters)



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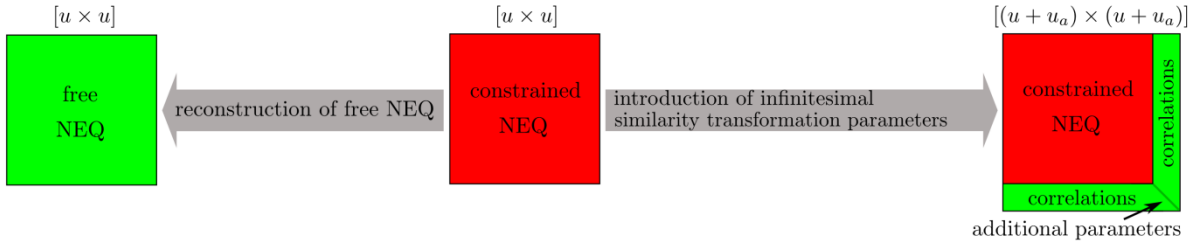
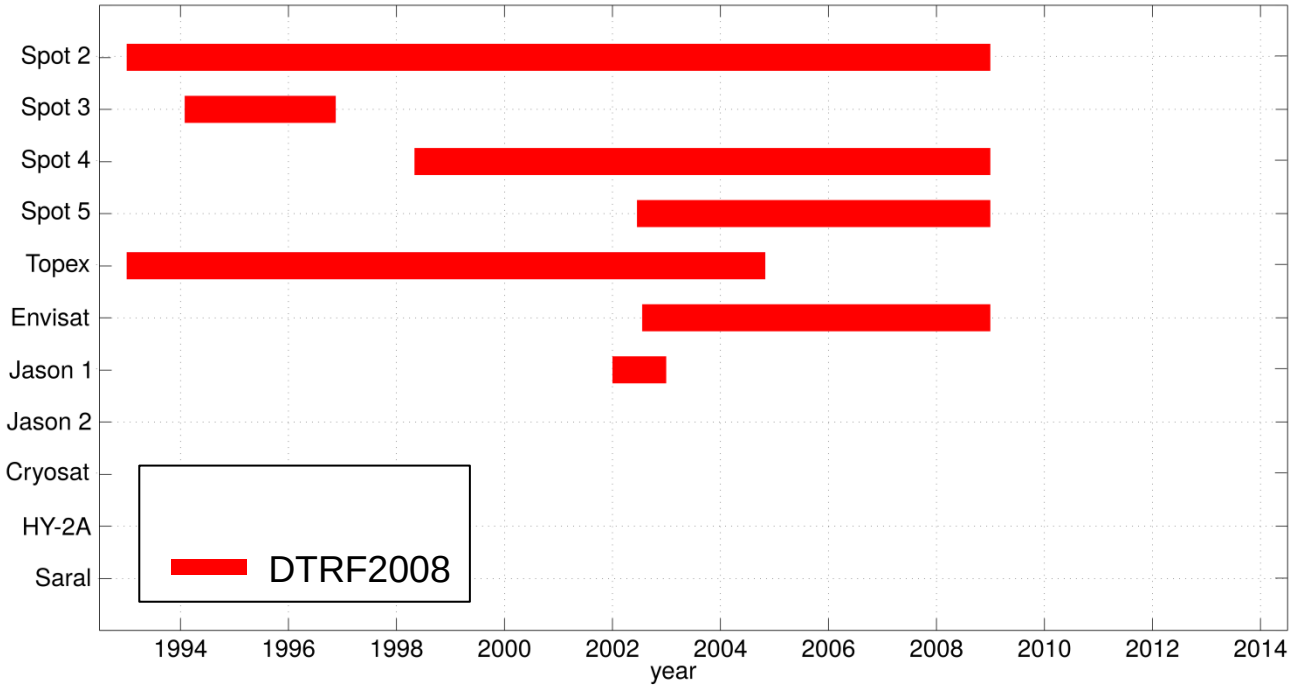


  - Satellite constellations (changes might have an effect on many time series)



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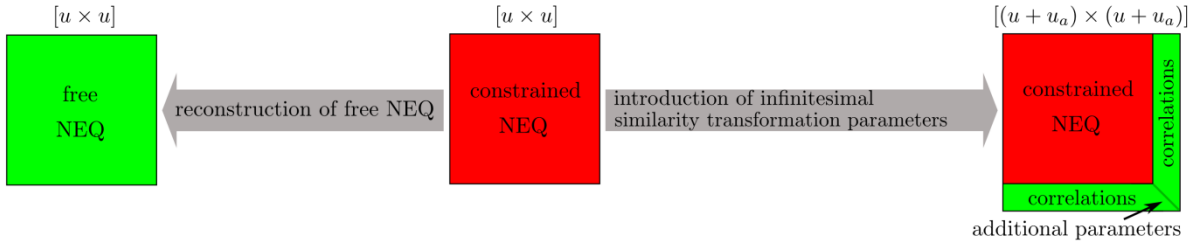

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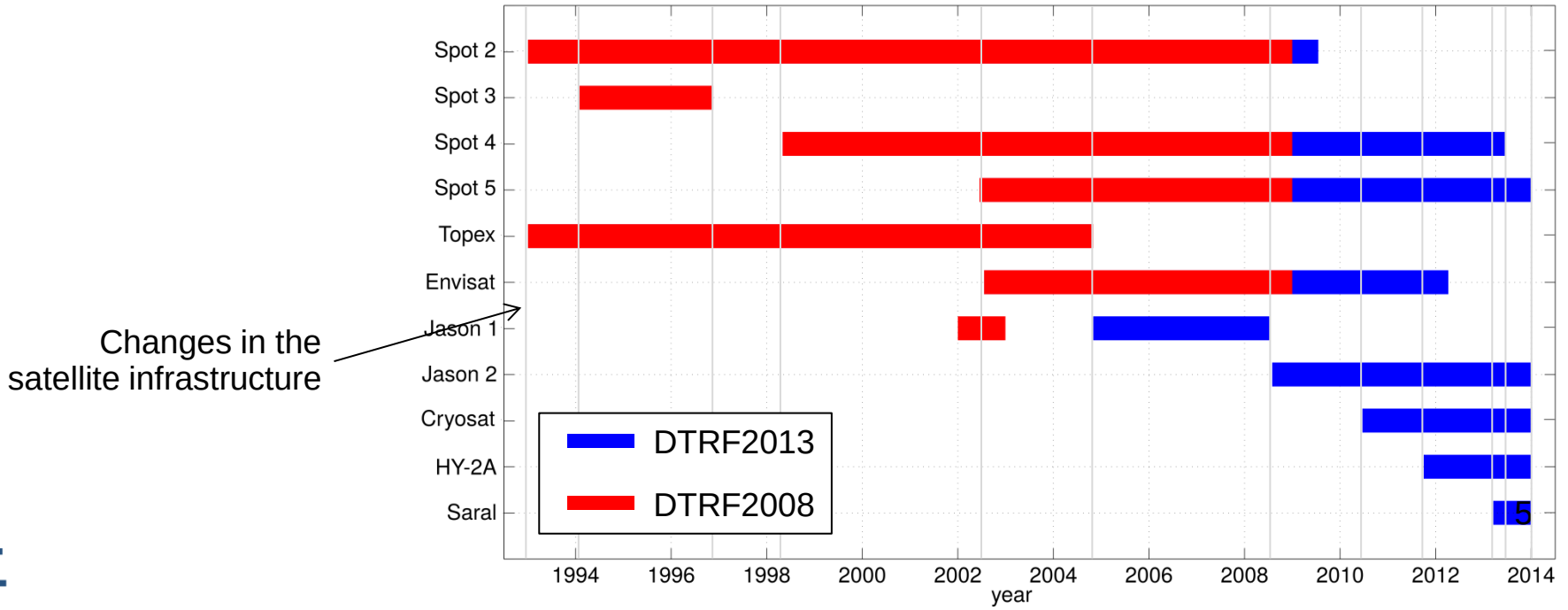
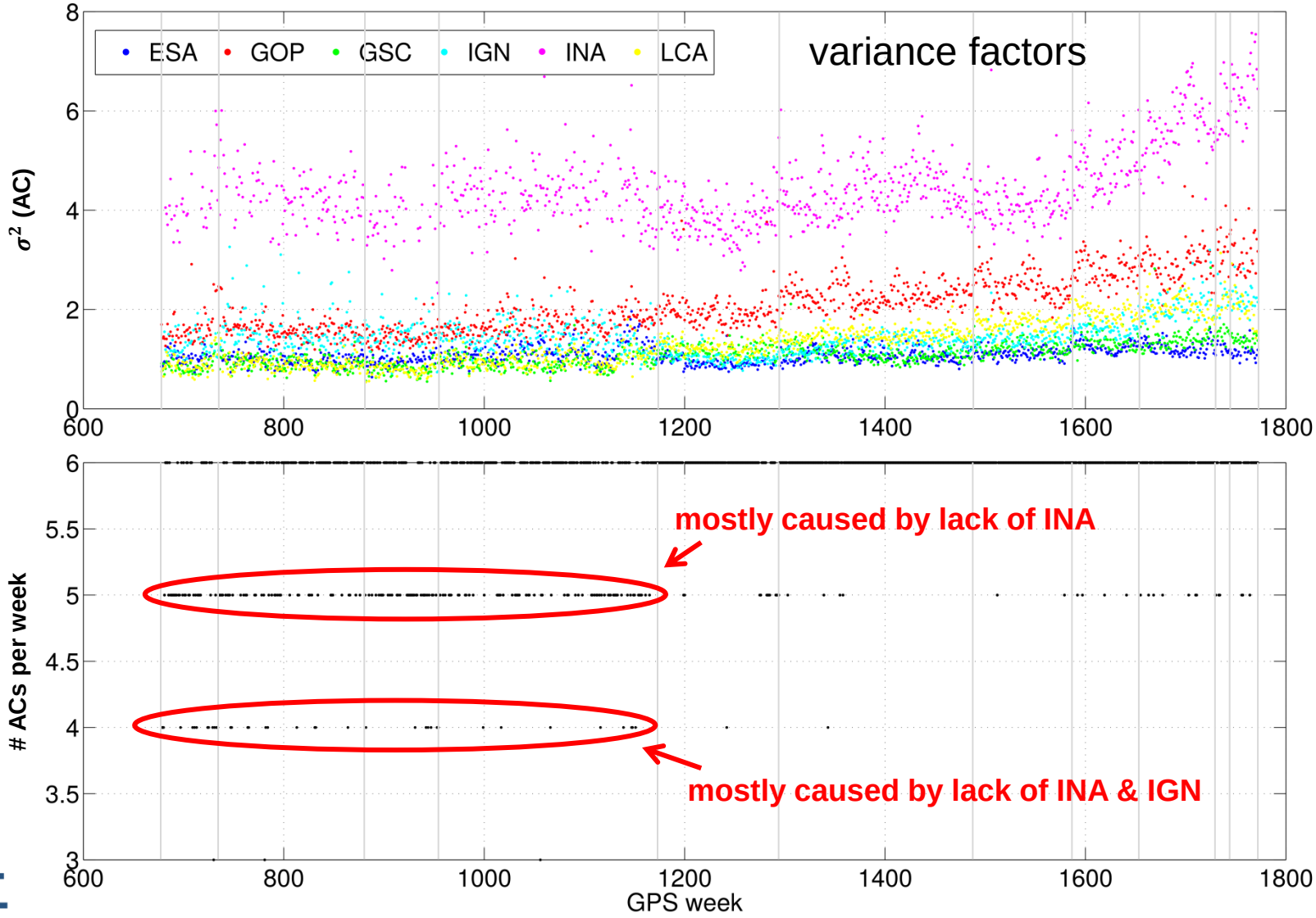


Input data and parameterization (II)

- Input data
  - 6 different Analysis Centers (ACs) using 5 different software packages



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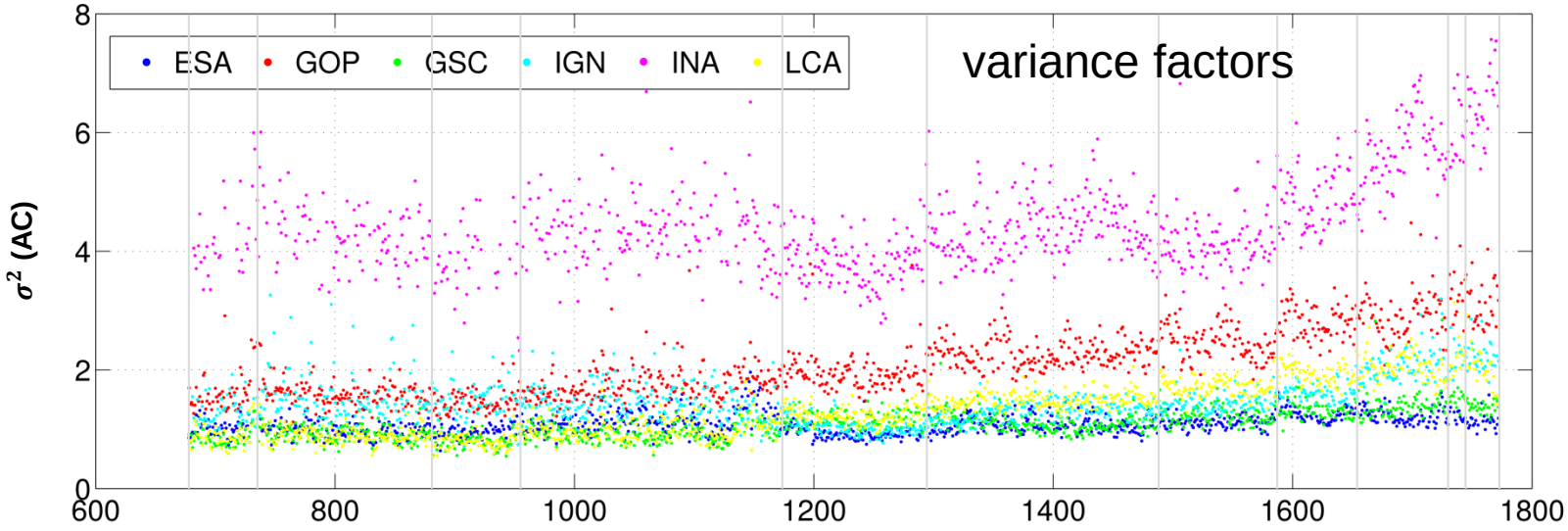
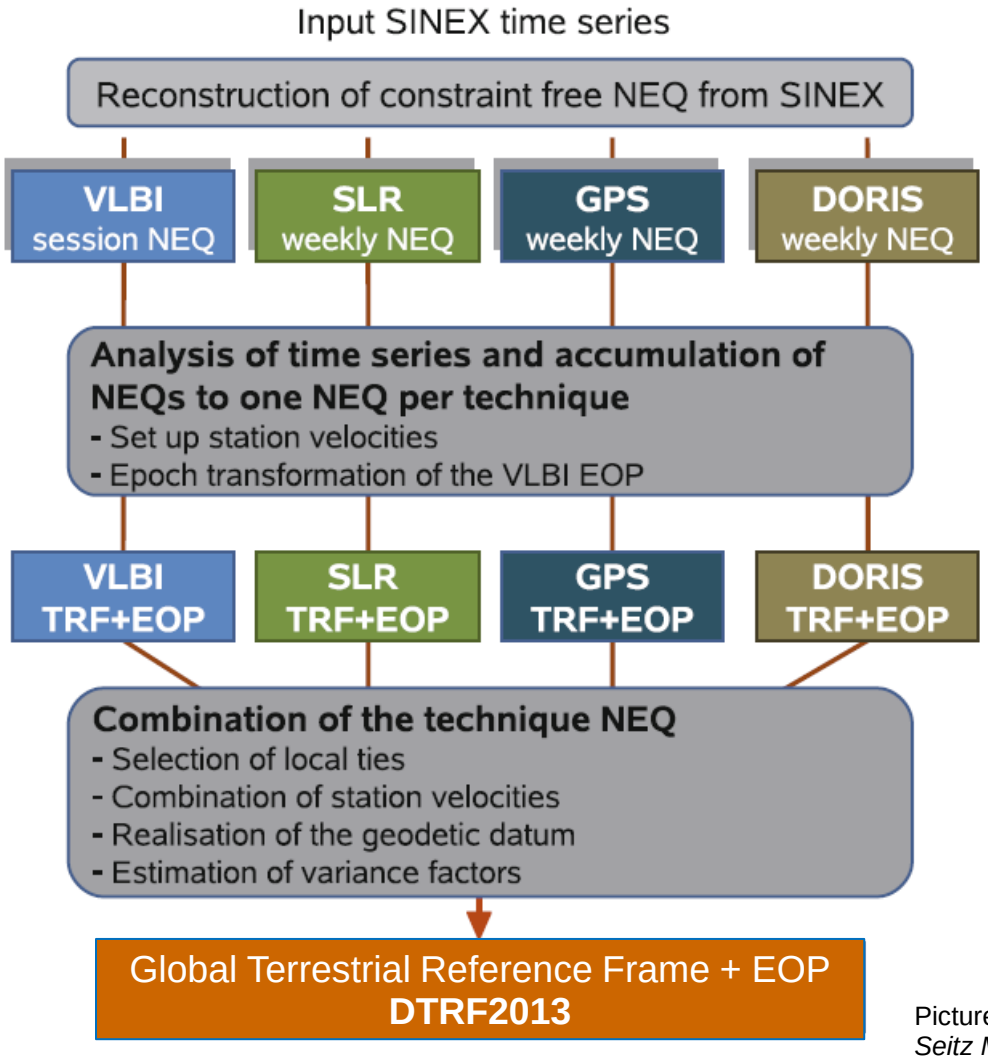


- Weekly SINEX files contain
  - 3D station coordinates at mid-week epoch
  - Terrestrial pole coordinates as offsets at 12h epochs (7 per week)
- Up to now, four iterations with IDS Combination Center, last iteration is expected for mid of November

DGFI CGE

Combination strategy at DGFI

- Combination at DGFI is performed on normal equation (NEQ) level



Changes w.r.t. DTRF2008 processing:

- Correction for non-tidal atmospheric loading (NT-ATML) at NEQ level using an unique model provided by GGFC
- A posteriori estimation of annual/-semi-annual signal of station position time series

Picture taken from
Seitz M., Angermann D., Bloßfeld M., Drewes H., Gerstl M.:
The 2008 DGFI Realization of the ITRS: DTRF2008.
Journal of Geodesy, Volume 86, Issue 12, pp 1097-1123 ,
doi: 10.1007/s00190-012-0567-2

DGFI

Stochastic model

$$\mathbf{N} = \frac{1}{\sigma_1^2}\mathbf{N_1} + \ldots + \frac{1}{\sigma_m^2}\mathbf{N_m} \qquad \mathbf{N}\ u\ x\ u$$

$$\mathbf{y} = \frac{1}{\sigma_1^2}\mathbf{y_1} + \ldots + \frac{1}{\sigma_m^2}\mathbf{y_m} \qquad \mathbf{y}\ u\ x\ 1$$

$$\mathbf{b^T P b} = \frac{1}{\sigma_1^2}\mathbf{b_1^T P b_1} + \ldots + \frac{1}{\sigma_m^2}\mathbf{b_m^T P b_m}$$

$$n = n_1 + \ldots + n_m$$
$$u = u_1 + \ldots + u_m$$

→ Reduced by the number of common parameters

Solution of NEQ
pseudo-observations are necessary

↓

Solution TRF+EOP

Solution of combined system

$$\hat{\boldsymbol{x}} = \boldsymbol{N^{-1}y}$$

$$\sigma^2 = (\hat{\boldsymbol{v}}^T\boldsymbol{P}\hat{\boldsymbol{v}})/(n - u) \text{ with } \boldsymbol{v^T P v} = \boldsymbol{b^T P b} - \hat{\boldsymbol{x}}^T\boldsymbol{b}$$

$$\boldsymbol{C_{\hat{x}\hat{x}}} = \sigma^2\boldsymbol{N^{-1}}$$

with $\boldsymbol{C_{\hat{x}\hat{x}}}$ is the variance-covariance matrix of the estimated variables.

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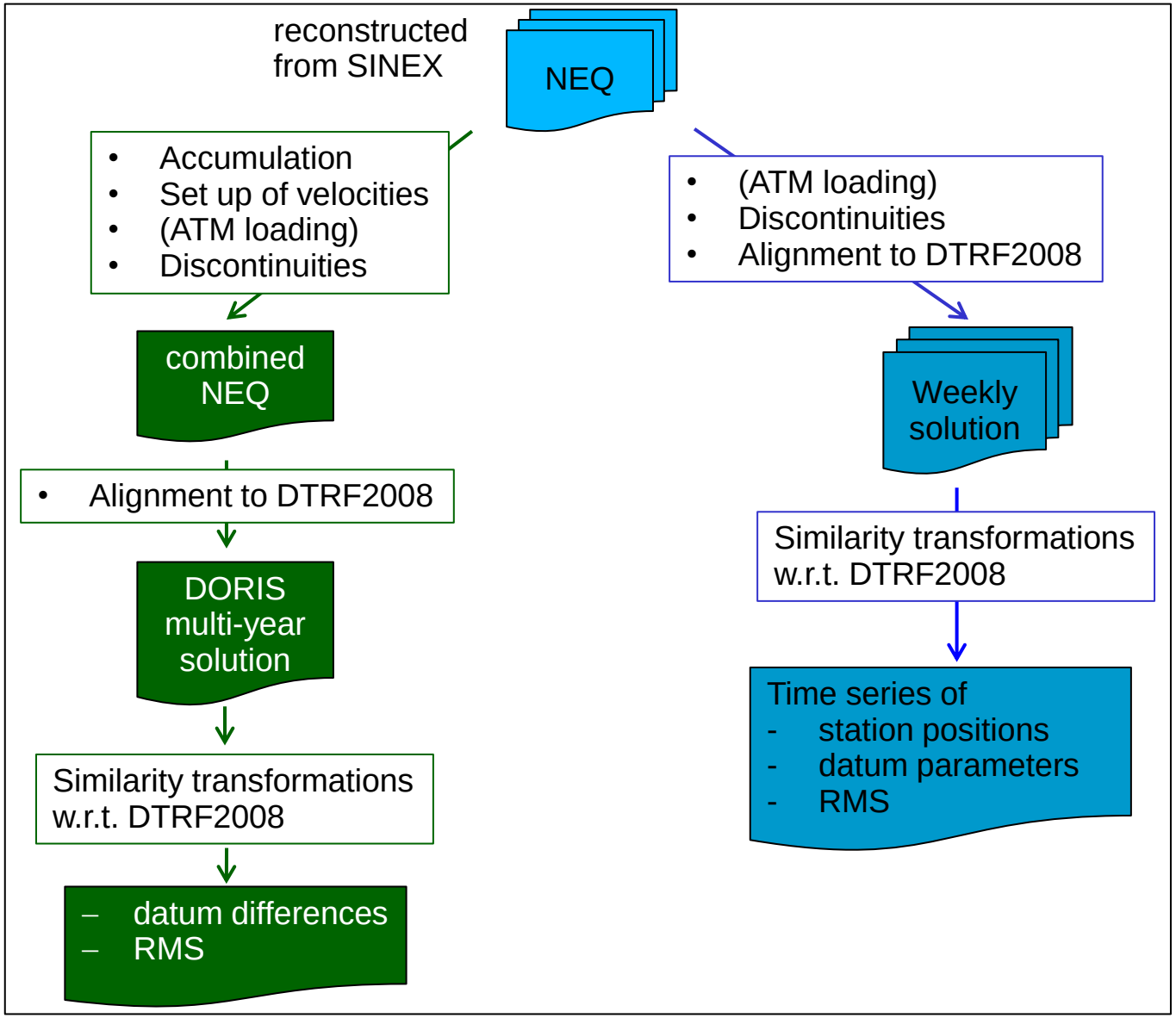
Solution
TRF+EOP

! **Erroneous or missing $b^T Pb$, n and u lead to incorrect standard deviations and affect the relative weighting of the techniques!**

! **Correct SOLUTION/STATISTICS are required!**

→ **Now, IDS SINEX contain n, u and dof values.**

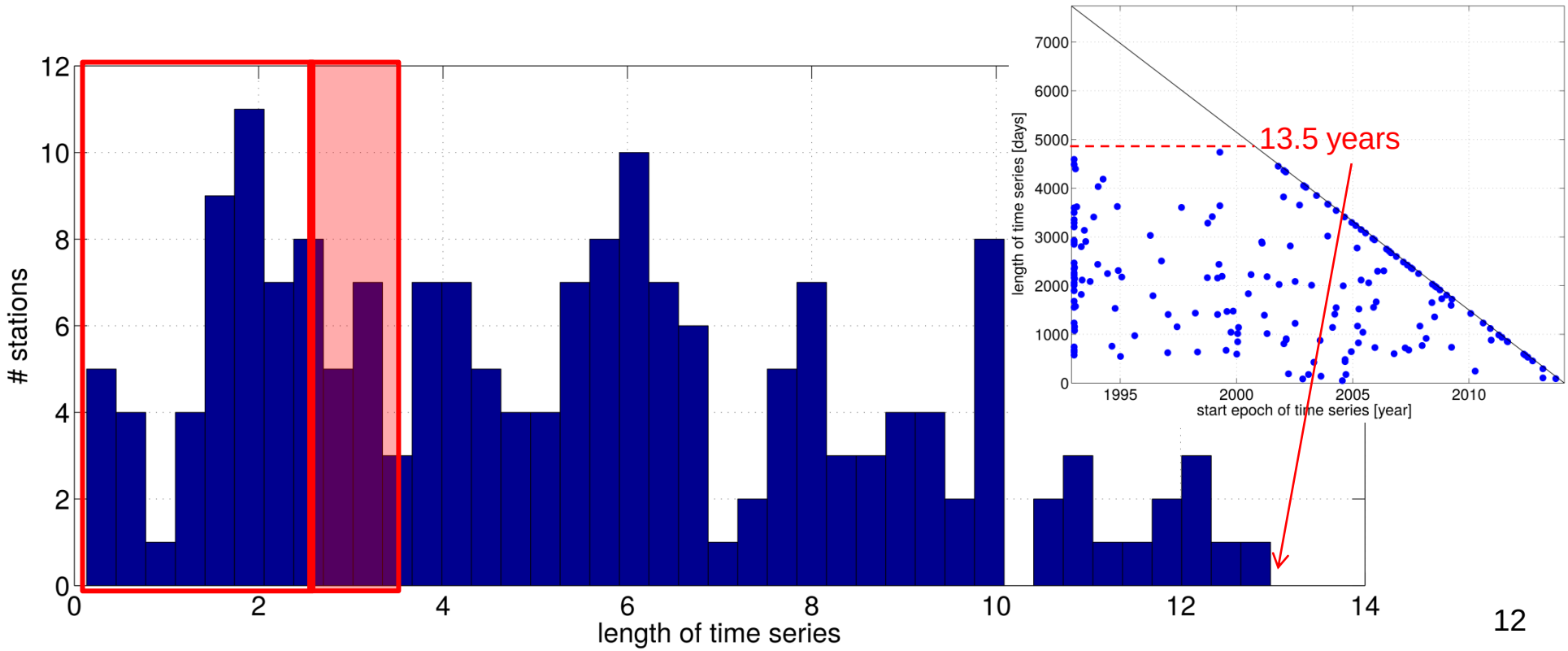
Analysis of DORIS input data



Analysis results

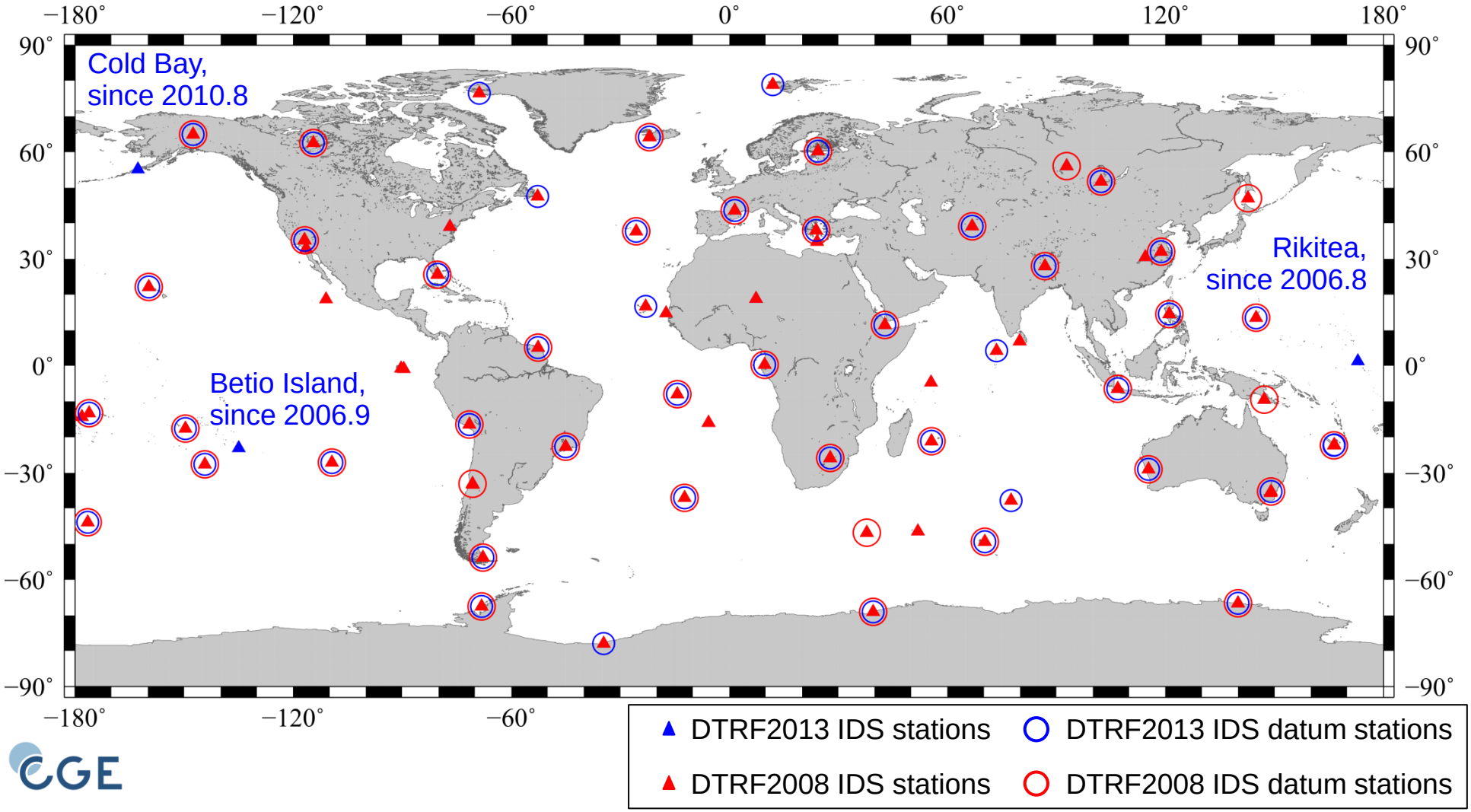
- Histogram of length of station time series (many short-terms?)
  - 149 stations in total (DTRF2008: 136)
  - 182 solution numbers → 33 jumps (DTRF2008: 48)
  - 35% of stations contain less than 3.5 years of data (25% less than 2.5)

  → Estimation in DTRF2013? Final decision after a detailed analysis of the remaining signals in station position time series (correcting for NT-ATML may allow shorter length of time series (<2.5 years?)).



Analysis results

- Number of stations vs. DTRF2008
  - Three new stations
  - Replacement of all Alcatel antennae with Starec generation (Willis et al., 2014)

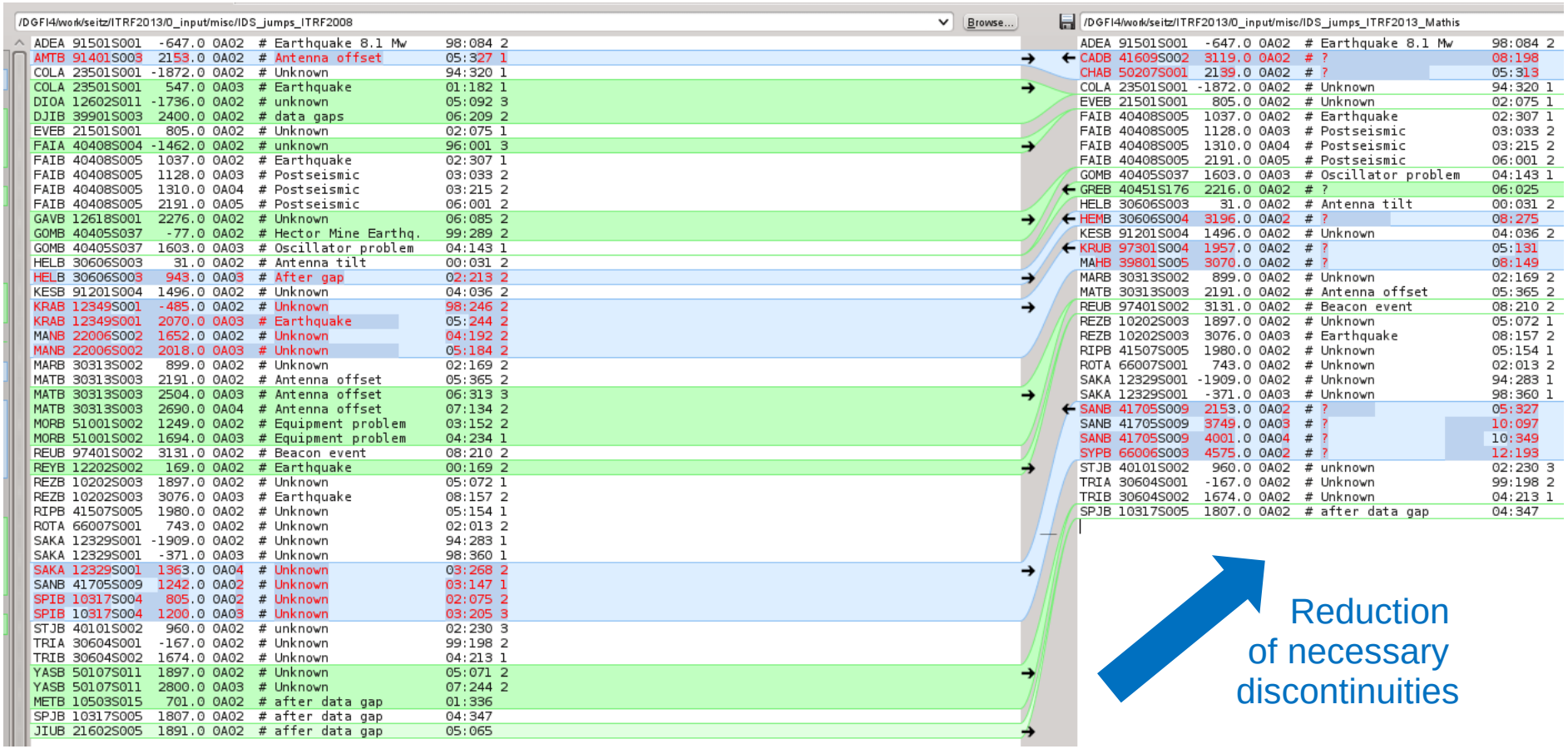


DGFI

EGE

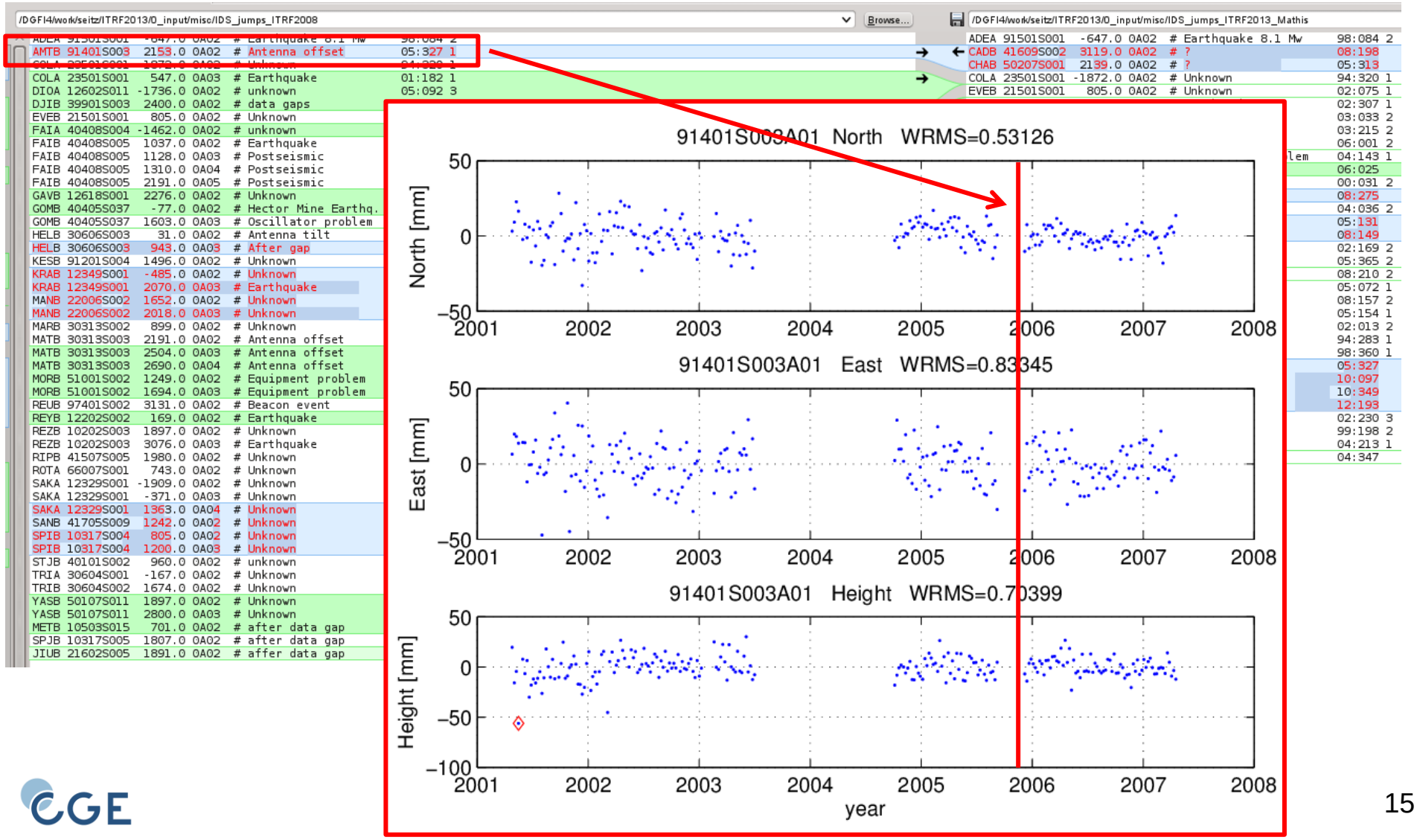
Analysis results

- Number of discontinuities; Which of DTRF2008 can be removed?



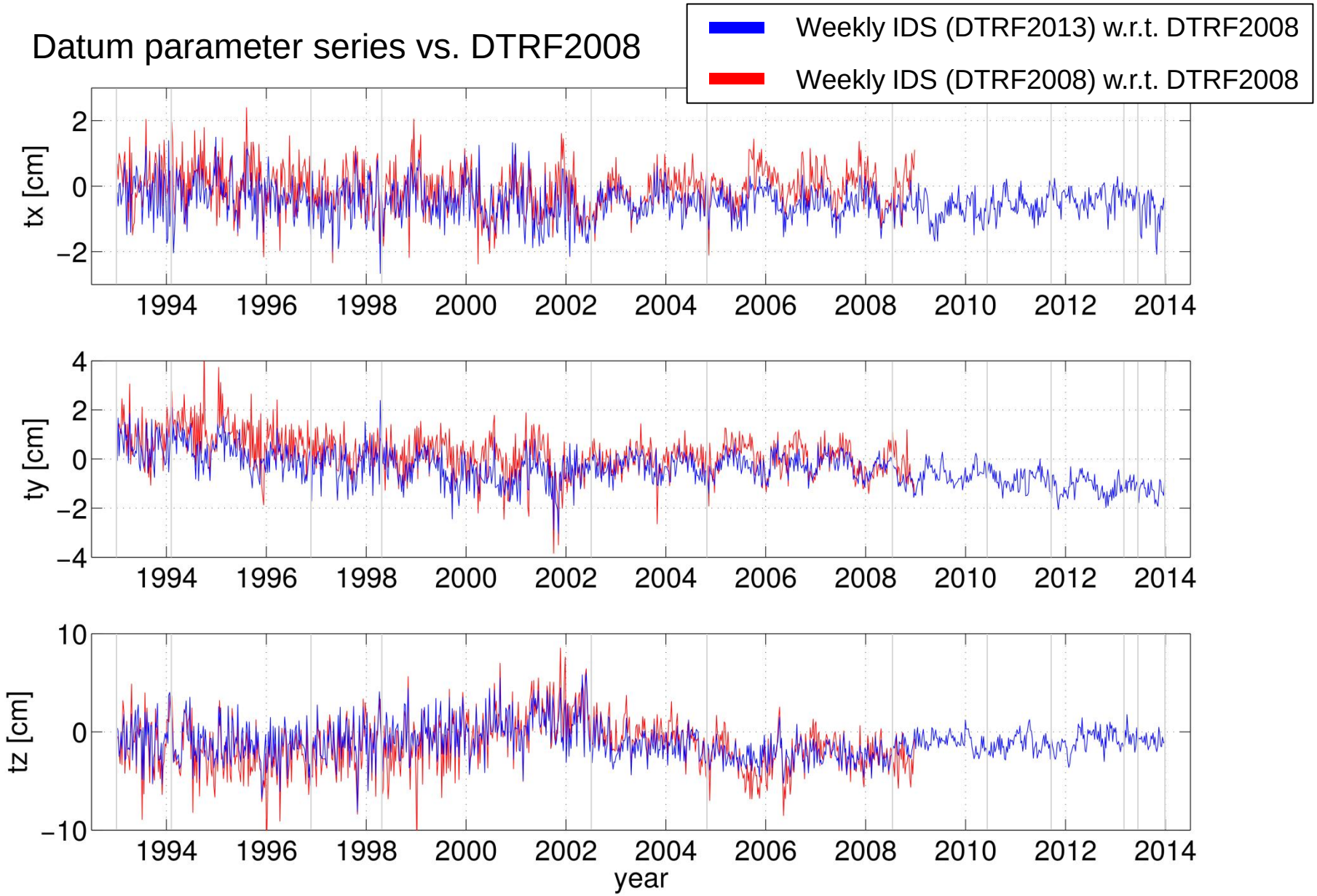
Analysis results

- Number of discontinuities; Which of DTRF2008 can be removed? → unify with IGN, JPL!
- e.g., Station AMTB (Amsterdam Islands)



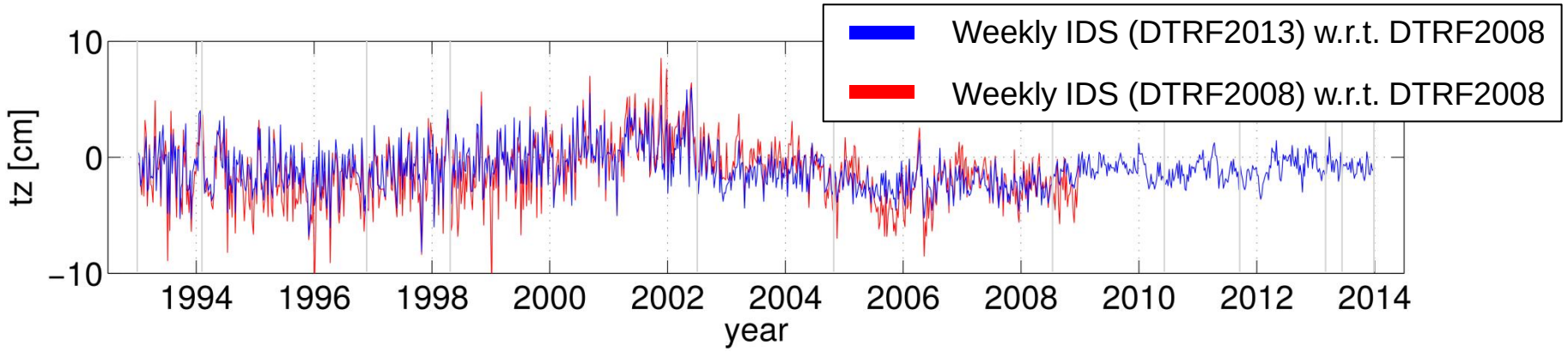
Analysis results

- Datum parameter series vs. DTRF2008

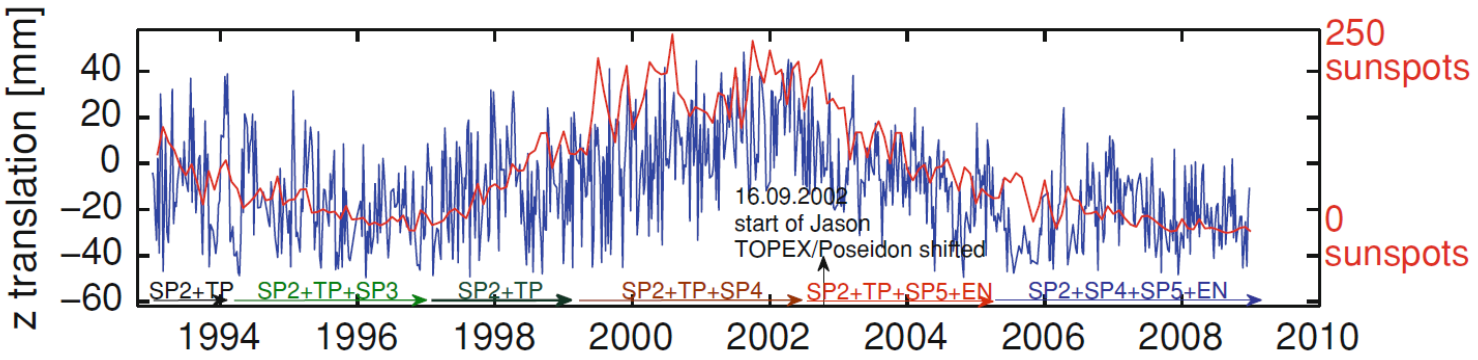


Analysis results

- Datum parameter series vs. DTRF2008 – z translation



- Datum time series of IDS weekly (DTRF2008) vs. IDS multiyear (DTRF2008)

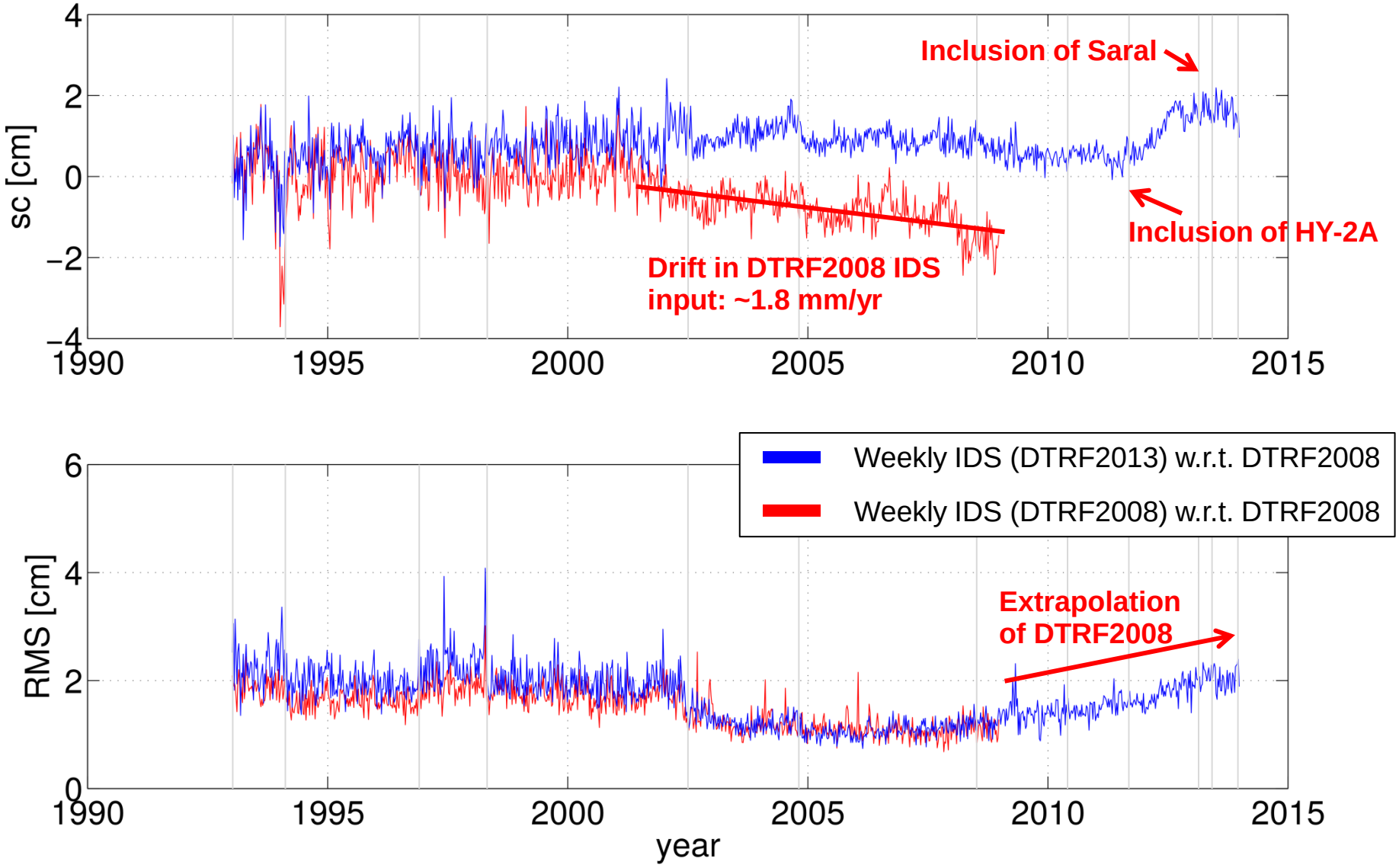


Picture taken from *Seitz M., Angermann D., Bloßfeld M., Drewes H., Gerstl M.:* **The 2008 DGFI Realization of the ITRS: DTRF2008**. Journal of Geodesy, Volume 86, Issue 12, pp 1097-1123 , doi: 10.1007/s00190-012-0567-2

→ **Correlation with solar cycle is still visible.**

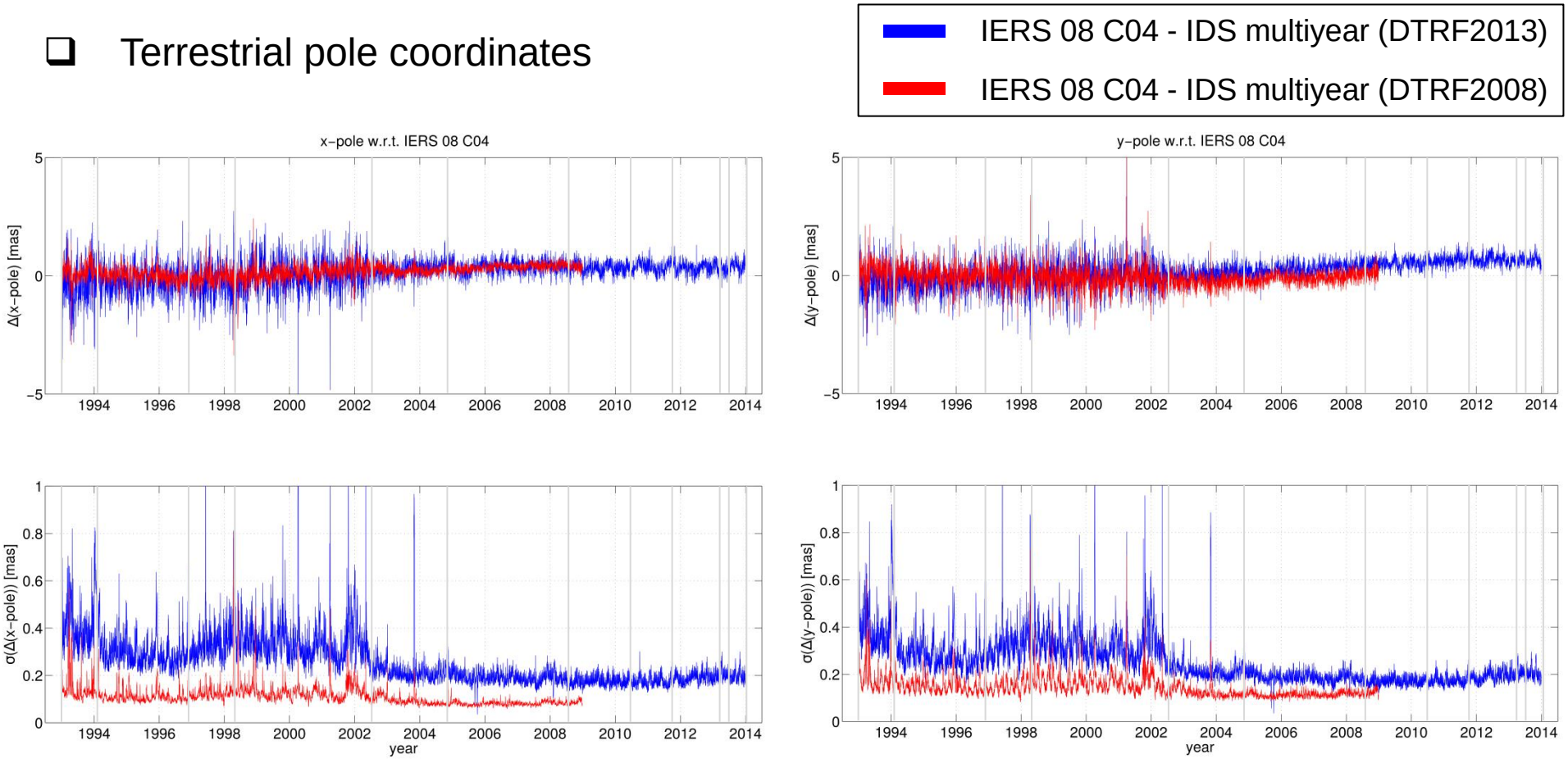
Analysis results

- Datum parameter series vs. DTRF2008 - scale and RMS of transformation



Analysis results

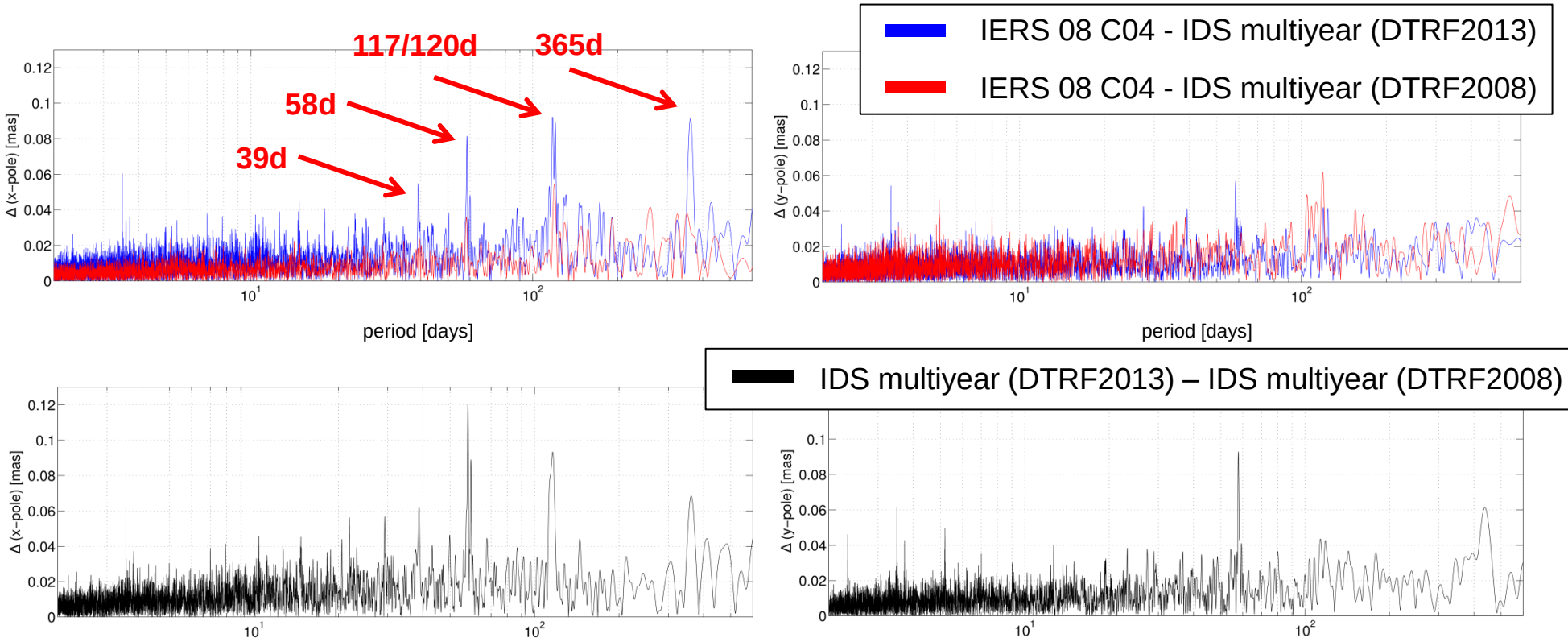
- Terrestrial pole coordinates



  - Why is scatter of DTRF2013 IDS input higher than DTRF2008 IDS input?
  - What cause higher STDs in DTRF2013 IDS input? Can the effect be just related to the more realistic stochastic model?

Analysis results

- Terrestrial pole coordinates - Frequency analysis



– GPS draconitics in x-pole; good agreement in y-pole

– Why are the GPS draconitics for the IDS DTRF2013 input higher than for the IDS DTRF2008 input?

Analysis results

- DORIS multi-year solution

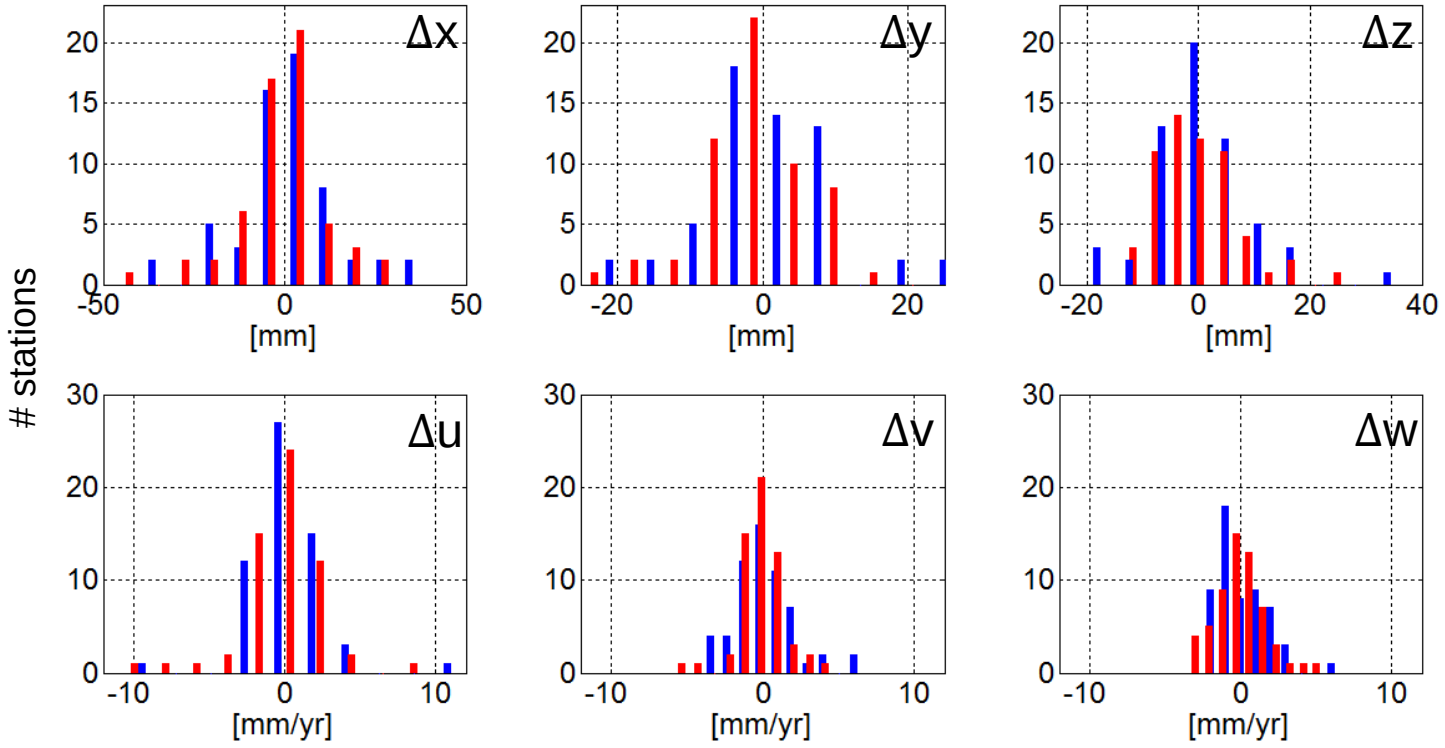
  RMS of transformation → Agreement of network geometries

  – IDS multiyear (DTRF2013) w.r.t. DTRF2008: 7.9 mm (coord), 1.6 mm (vel)

  – IDS multiyear (DTRF2008) w.r.t.

  IDS multiyear (DTRF2008): 7.0 mm (coord), 1.5 mm (vel)

- Histogram of transformation residuals



Summary & Outlook

- Many model improvements for DORIS since DTRF2008
- Realistic stochastic model due to the availability of stochastic values
- Annual signal in translation time series is reduced vs. DTRF2008
- Correlation of Tz with solar cycle still visible but with a slightly smaller amplitude
- Scale drift seen in DTRF2008 input data is removed but scale jump in 2012 needs to be further investigated. Correlation with HY-2A and Saral?
- Pole coordinates of DTRF2013 input show higher scatter and STDs than DTRF2008 input. Can the increased STD be explained by the more realistic stochastic model only?

Outlook

- Unification of discontinuity list with IGN and JPL
- Application of a posteriori NT-ATML correction at normal equation level
- Please keep in mind that another iteration will be provided by the IDS CC.

  Therefore, results may slightly change!

Thank you very much for your attention!

Many thanks to the IDS for providing the data!

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For more details on DTRF2013, please visit ***http://dgfi.badw.de/en/products/dtrf2013***

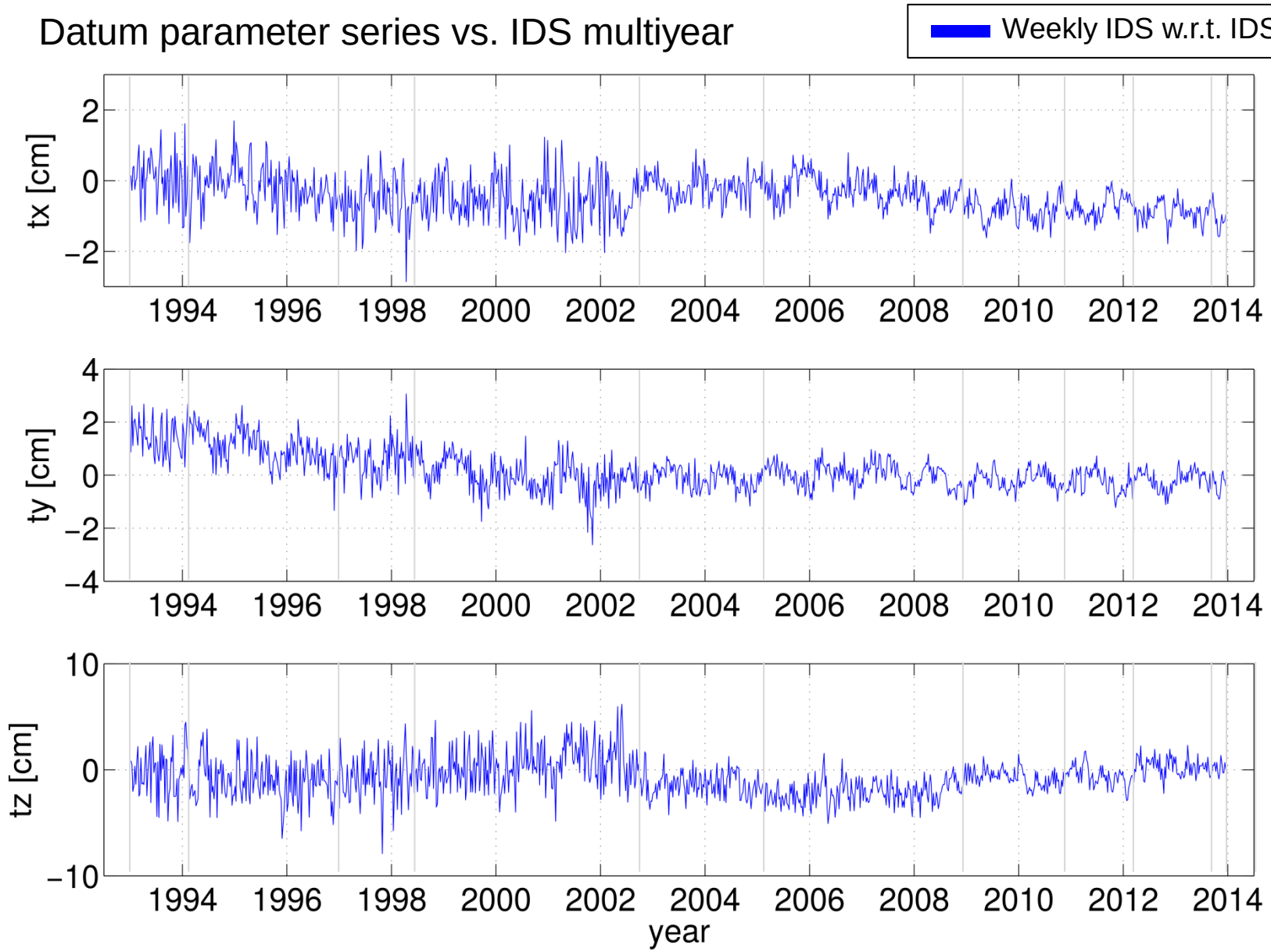
DGFI

CGE

Centre of Geodetic Earth System Research

Analysis results

- Datum parameter series vs. IDS multiyear



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