Preparations for the IGS realization of ITRF2014

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Introduction

The International GNSS Service (IGS) currently derives its own realization, called IGS14, from the latest release of the International Terrestrial Reference Frame (ITRF2014). This includes:

- a selection of the most suitable reference frame (RF) stations from the complete set of GNSS stations in ITRF2014,
- the design of a well-distributed core network of RF stations for the purpose of aligning global GNSS solutions,
- a re-evaluation of the GPS and GLONASS satellite antenna phase center offsets (PCOs) based on the SINEX files provided by the IGS Analysis Centers (ACs) in the frame of the second IGS reprocessing campaign (repro2).

IGS14 and IGS14 core network design

A first selection of the potential IGS14 RF stations from the full set of IGS stations in ITRF2014 was made according to the following criteria:

- ITRF2014 time series longer than 5 years; at least 1000 (daily) data points
- WRMS of ITRF2014 residual time series (including seasonal signals) < 2.5 mm (horizontal) / < 7.5 mm (vertical)
- maximum formal error of ITRF2014 coordinates over expected IGS14 lifetime < 1.5 mm (horiz.) / < 3 mm (vert.)
- ignore stations whose antenna calibration will be upgraded from non-robotic to robotic in igs14.atx

In “dense” areas, multi-GNSS and real-time, but also previous IGS08 RF stations were favored, while in “sparse” areas, a few stations had to be retained that do not strictly meet all criteria.

A notification was then sent to the operators of the pre-selected stations (thanks to D. Maggert and N. Romero), resulting in slight adjustments of the station selection according to the answers received. The current list of selected IGS14 RF stations comprises 247 stations (compared to 235 in IGb08) whose distribution is shown in Fig. 1.

A preliminary well-distributed IGS14 *core* network was additionally designed. It is composed of 51 clusters of stations (i.e., 51 primary stations, each with possible substitutes). The main goals of the selection were:

- to ensure a homogeneous global distribution (see Fig. 2),
- to ensure the best possible temporal stability of the core network (see Fig. 3, bottom right).

Figure 1 *Distribution of selected IGS14 and former IGS08 RF stations*

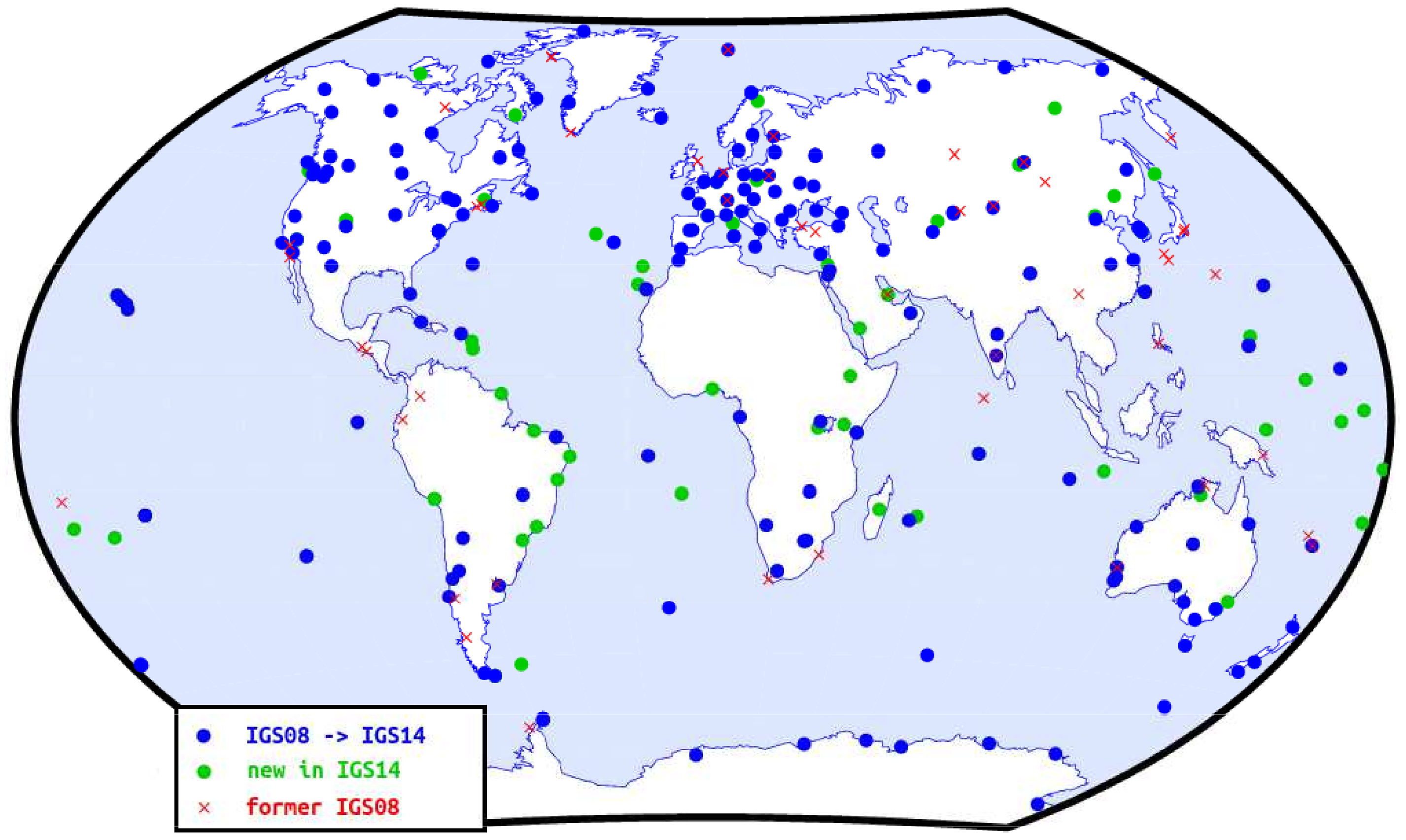
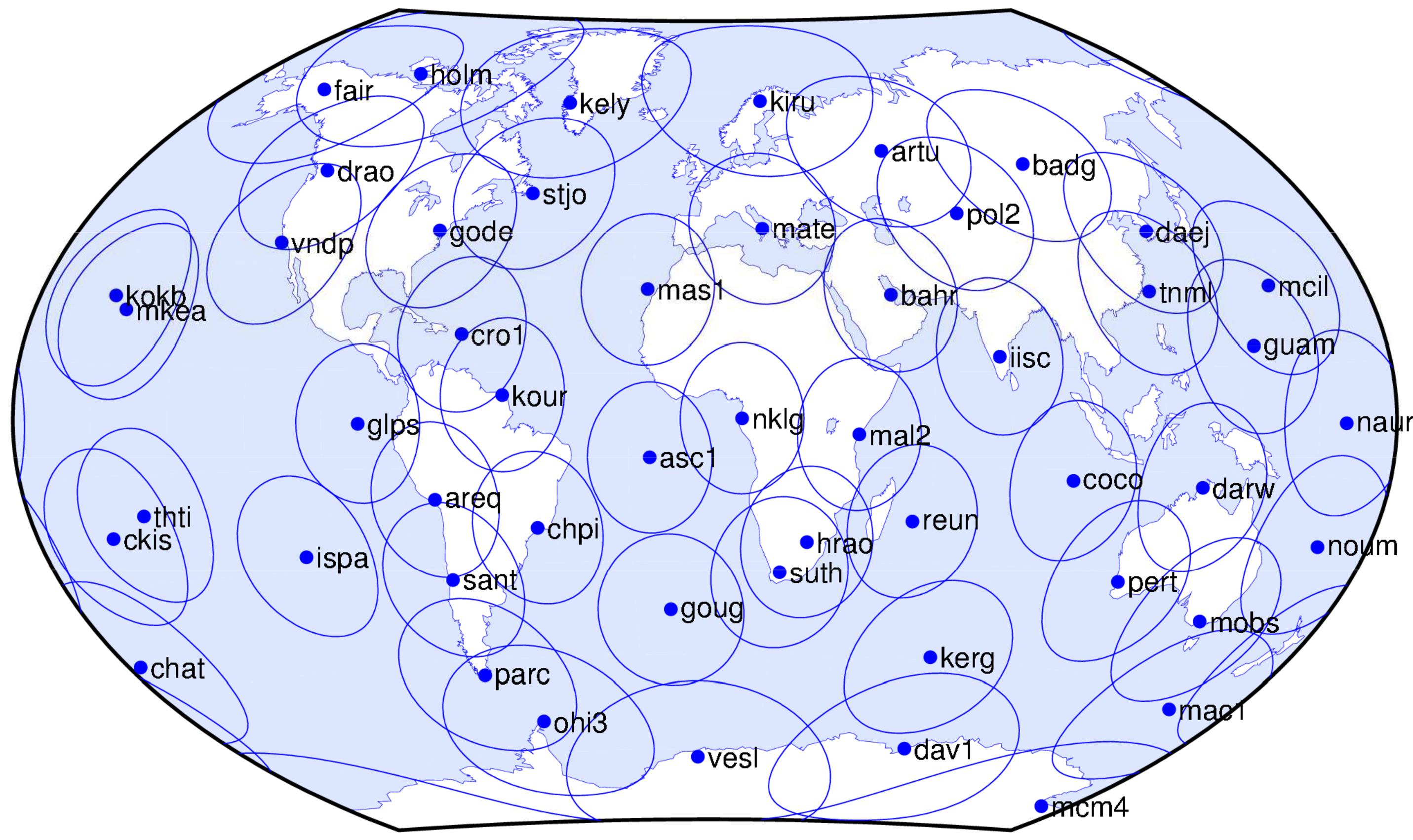


Figure 2 *Distribution of the 51 primary stations of the IGS14 core network*



Re-evaluation of GPS and GLONASS satellite antenna phase center offsets

Methodology

Daily estimates of the GPS and GLONASS satellite antenna PCOs were obtained from 8 series of IGS AC repro2+operational SINEX files. Those were unconstrained and inverted applying NNR+NNT+NNS constraints wrt. the preliminary IGS14 (augmented with annual and semi-annual station motions). Figure 4 shows, as an example, the time series of daily PCO estimates for GPS satellite SVN34.

A linear regression was then performed for each of the PCO time series, where points with normalized residuals > 3 iteratively were rejected. Thus, the β-(elevation of the Sun above the orbital plane) and eclipse-related signals present in the X- and Y-PCO time series could be partially cut. Mean increments to the igs08.atx values were finally computed for each satellite and AC by weighted averaging of the cleaned time series (Figure 5).

Additionally, we computed AC-specific weighted mean trends from the Z-PCO time series of all satellites. In Table 1, these are compared with weighted mean trends obtained using the IGb08 reference frame instead of IGS14. The mean trends indicate how the « intrinsic GNSS scale rate » (governed by the assumed stability of the satellite Z-PCOs) agrees with the corresponding reference frame scale rates.

Figure 4 *X-, Y-, and Z-component of daily PCO estimates for GPS satellite SVN34 (increments to igs08.atx values)*

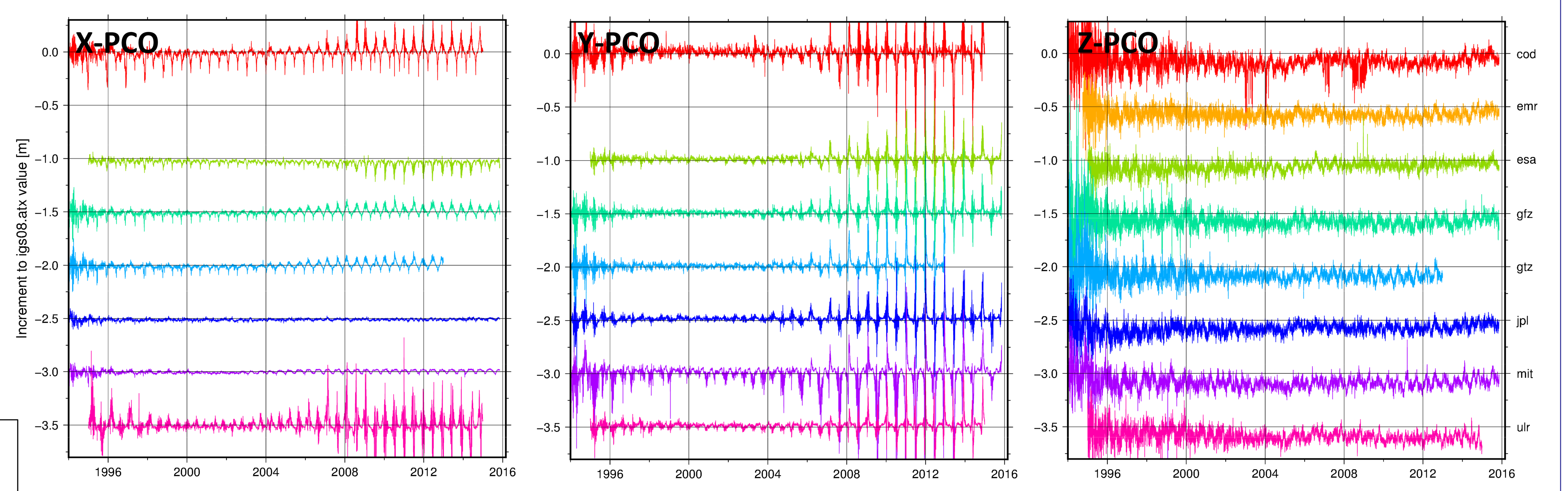


Figure 5 *Average increments to igs08.atx values for each satellite and AC*

— cod — emr — esa — gfz — gtz — jpl — mit — ulr

x *Values derived by Dilssner et al. (2016) from manufacturer measurements*

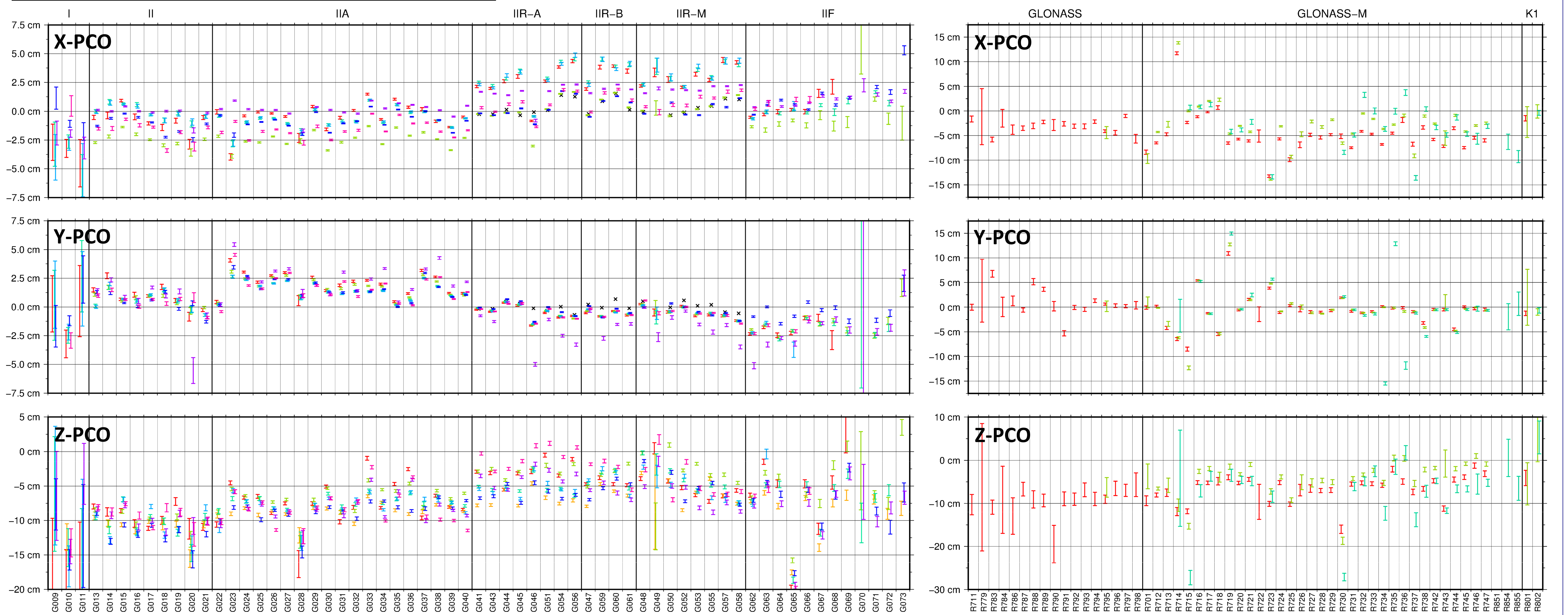


Figure 3

Top and bottom left: WRMS of the residuals of 6-parameter similarity transformations between the IGS repro2 daily combined SINEX solutions and (a) the IGb08 core network, (b) the preliminary IGS14 core network

Bottom right: Numbers of available IGb08/IGS14 [core] stations in the IGS repro2 daily combined SINEX solutions (light colors: full RF station networks; dark colors: core RF station networks)

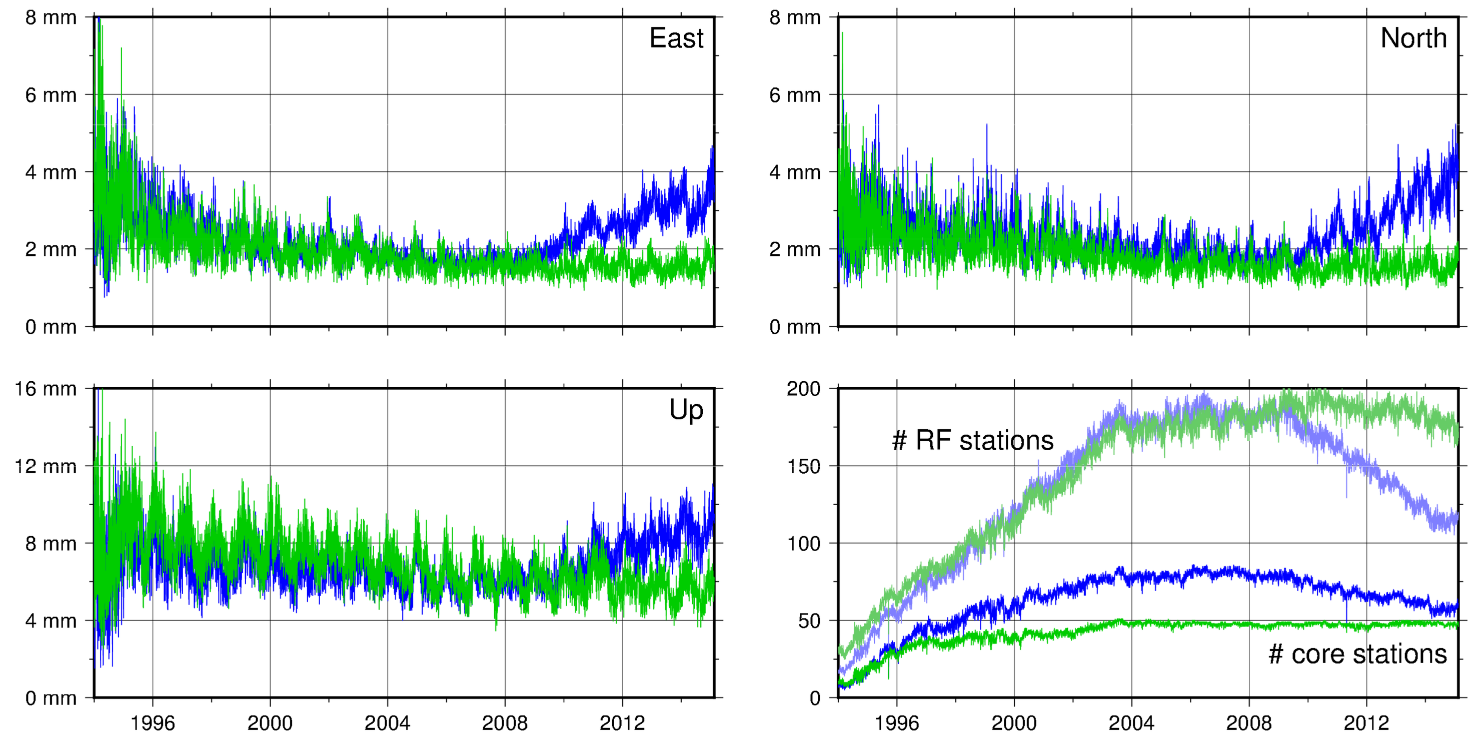


Table 1 *Weighted mean trends* ***[mm/yr]*** *of the Z-PCO time series obtained for each AC using either the IGS14 or the IGb08 reference frame*

	IGS14	IGb08
COD	4.8 ± 0.5	-0.4 ± 0.6
EMR	2.9 ± 0.5	-0.6 ± 0.5
ESA	4.8 ± 0.4	0.2 ± 0.4
GFZ	3.5 ± 0.6	-0.9 ± 0.6
GTZ	4.0 ± 0.8	-0.3 ± 0.8
JPL	4.0 ± 0.5	-1.8 ± 0.5
MIT	2.6 ± 0.5	-2.2 ± 0.5
ULR	1.6 ± 0.7	-1.7 ± 0.8
W. Avg.	3.7 ± 0.4	-0.9 ± 0.4

Summary

- The X- and Y-PCO time series are contaminated by large β- and eclipse-related signals, making it complicated to obtain reliable mean values. The mean X- and Y-PCO increments shown in Figure 5 are generally small (a few cm), except for a few GLONASS satellites.

→ Should X- and Y-PCO values be updated in igs14.atx?

- The Z-PCO values need to be updated by about -5 to -10 cm so that future IGS products are consistent with the ITRF2014/IGS14 scale.
- The weighted mean trends of the Z-PCO time series (see Table 1) are significantly smaller when using IGb08 instead of IGS14.

→ The “intrinsic GNSS scale rate” given by the assumed stability of the satellite antenna Z-PCOs is therefore closer to the ITRF2008 scale rate than to the ITRF2014 scale rate.

→ The trends in the satellite antenna Z-PCO time series derived using IGS14 will somehow have to be taken into account in order to refer the final igs14.atx values to a common epoch.

Reference Dilssner F, Springer T, Schönemann E, Enderle W (2016) Evaluating the pre-flight GPS Block IIR/IIR-M antenna phase pattern measurements, IGS Workshop 2016