Wednesday, May 22, 2019 to Friday, May 24, 2019 in Tallinn, Estonia

Combining IGb08 and IGS14 normal equations: Impact on the cumulative time series caused by the switch from igs08.atx to igs14.atx antenna calibration models

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2. IGS models: IGS08 to IGS14 position offsets.
3. ARA Densification Network.
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5. Conclusions/recommendations.

Introduction:

As of 2017-01-29 (GPS week 1934), the IGS adopts a new Terrestrial Reference Frame: IGS14. The new IGS14 comes together with an updated set of satellite and ground antenna calibrations: igs14.atx

The new IGS14 replaces the IGS08 frame (valid since 2011-04-17 to 2012-10-06) and IGb08 (an update of IGS08 valid since 2012-10-07 to 2017-01-28). In former campaigns, one can get advantage of IGb08 by using repro2 products.

This datum switch poses the following problem when combining the equations:

- IGb08 compliant (< GPS week 1934)
- IGS14 compliant (>= GPS week 1934)

Both sets (IGb08 and IGS14) are computed using different antenna calibration files (igs08.atx and igs14.atx). This may imply an offset at the IGb08-IGS14 switch epoch.

IGS provides latitude-dependent models allowing to compute the position offsets due to the switch from igs08.atx to igs14.atx and that can be used to make IGb08 solutions compliant with IGS14 solutions at the SINEX level.

In this presentation we show some results of the impact of applying or not such offsets.

IGS models: IGS08 to IGS14 position offsets (I)

IGSMAIL 7399: https://lists.igs.org/pipermail/igsmail/2016/001233.html
At: ftp://igs-rf.ign.fr/pub/IGS14

- IGS14.snx : IGS14 SINEX file
- IGS14.ssc : IGS14 SINEX file without covariance matrix
- IGS14.png : map of the full IGS14 network
- psd_IGS14.snx : post-seismic deformation models to be used with IGS14
- soln_IGS14.snx : discontinuity list to be used with IGS14
- IGS14_core.txt : list of IGS14 core stations
- IGS14_core.png : map of the IGS14 core network
- igs14_1926.atx : latest version of igs14.atx (will be updated, if needed)
- ITRF2014_to_IGS14.txt : position offsets applied to the ITRF2014 coordinates of IGS14 stations affected by ground antenna calibration updates
- igs08_to_igs14_offsets.txt : position offsets estimated for all IGS stations affected by ground antenna calibration updates
- lat_models.txt : latitude-dependent models of position offsets expected from ground antenna calibration updates

IGS models: IGS08 to IGS14 position offsets (II)

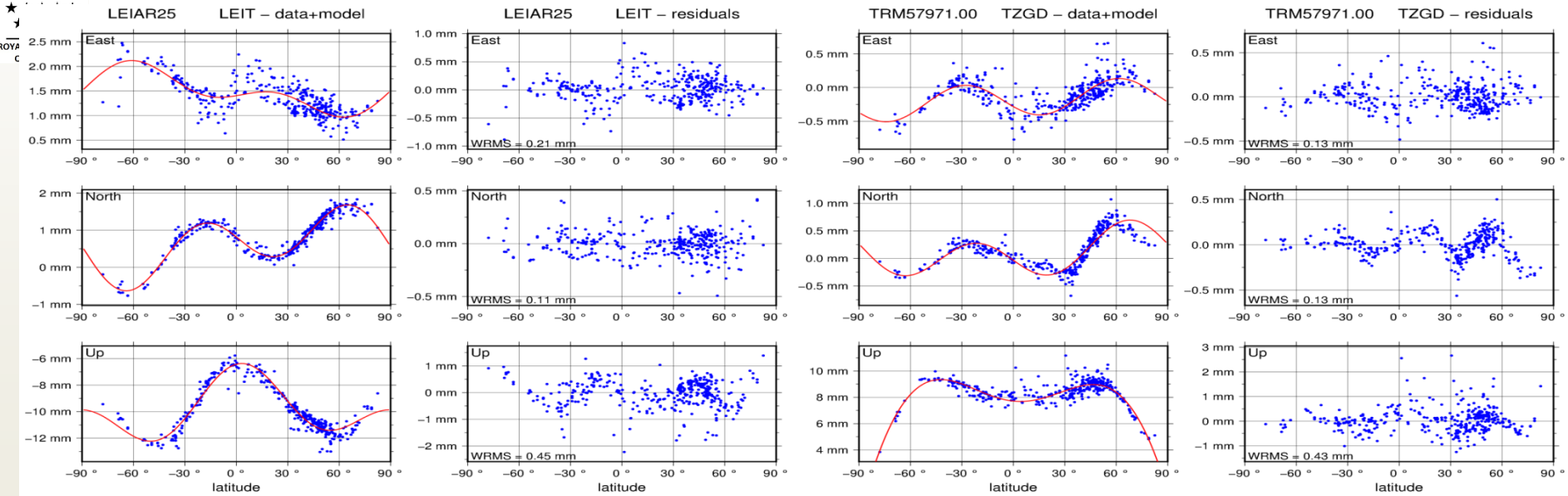
IGSMAIL 7399: https://lists.igs.org/pipermail/igsmail/2016/001233.html
ftp://igs-rf.ign.fr/pub/IGS14/lat_models.txt

```
# Method : For each antenna type whose calibration was updated, two sets of station
#          coordinates were estimated using the Napeos software, a static PPP strategy
#          and 24h of data: one set using the igs08.atx calibration of the antenna, the
#          other using its igs14.atx calibration. The same set of 384 stations was used
#          for all antenna types. It was assumed in each case that all 384 stations were
#          equipped with the antenna of interest, which was of course not true. Both sets
#          of coordinates were then differentiated. Latitude-dependent functions were
#          finally fitted to the sets of East, North and Up position differences.
#
# Model  : The generic latitude-dependent function used as model is the following:
#          dX = a + c1*cos(phi) + s1*sin(phi) + c2*cos(2*phi) + s2*sin(2*phi)
#             + c4*cos(4*phi) + s4*sin(4*phi)
#          with phi the latitude in radians and dX denoting either an East, North or Up
#          "igs14.atx-igs08.atx" position shift in mm. In general, not all terms of the
#          model were retained, but only the most significant ones. Coefficients of the
#          fitted models as well as WRMS of the fits are given in the table below.
First lines of the offsets:
#    Antenna type       axis  |    a      c1     s1     c2     s2     c4     s4    WRMS |
#--------------------------------|-----------------------------------------------------|
 AERAT2775_43     SPKE   East  |  -4.48   0.00   0.00   0.19   1.60  -0.17  -1.49   0.39 |
 AERAT2775_43     SPKE   North |   2.93   0.00   0.00   0.07  -0.55  -0.04   1.00   0.19 |
 AERAT2775_43     SPKE   Up    |  -1.24   0.00   0.00  -2.44  -0.01  -1.43  -0.15   0.60 |
…
```

IGS models: IGS08 to IGS14 position offsets (III)

IGSMAIL 7399: https://lists.igs.org/pipermail/igsmail/2016/001233.html

Some antenna models (model+residuals):

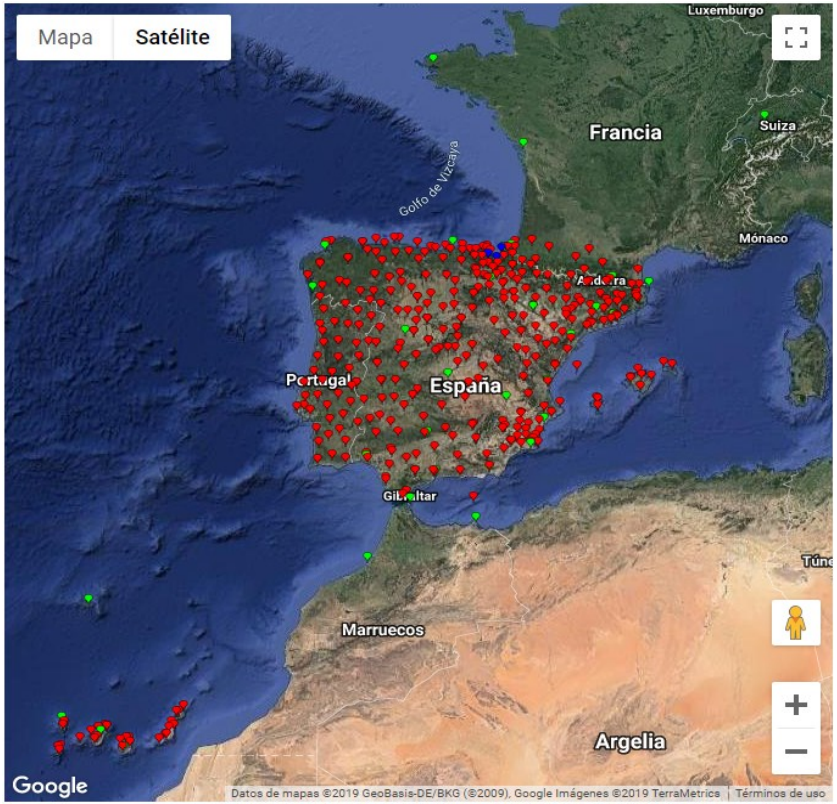


ARA Densification Network

Daily (RAPID and FINAL): about 350 sites
31 different antenna models used
41 (if the radome is considered)

Latitude varies from 27.5N to 48.3N
Longitude varies from 31W to 7.5E

With such latitude variation, the antenna
Latitude-dependent model of IGS must be
Considered: a simple offset will not work



ARA Densification Network

Some position offsets (E, N, Up) for stations in our Network:

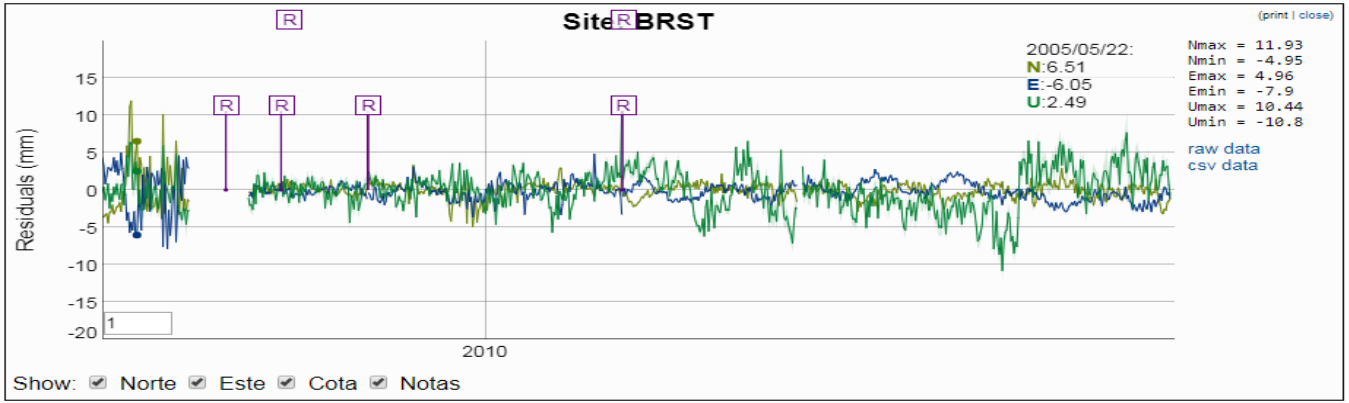
#CODE	PT	LON_____	LAT_____	ANTENNA_____	DOME	FROM_____	TO_____	NUM__	E_CORR	N_CORR	U_CORR
ARDU	**A**	**356.257**	**41.666**	**LEIAR25**	**LEIT**	**0000:000:00000**	**0000:000:00000**	**-----**	**1.22**	**0.89**	**-10.75**
BIAZ	**A**	**358.463**	**43.472**	**LEIAR25**	**LEIT**	**0000:000:00000**	**0000:000:00000**	**-----**	**1.19**	**0.98**	**-10.92**
BELL	A	1.401	41.600	TRM57971.00	NONE	0000:000:00000	0000:000:00000	-----	-0.31	-0.03	6.43
BRST	**A**	**355.503**	**48.380**	**TRM57971.00**	**NONE**	**0000:000:00000**	**0000:000:00000**	**-----**	**-0.14**	**0.09**	**6.49**
CASE	A	2.904	41.883	TRM57971.00	NONE	0000:000:00000	0000:000:00000	-----	-0.30	-0.02	6.43
PLAN	A	1.987	41.419	TRM57971.00	NONE	0000:000:00000	0000:000:00000	-----	-0.32	-0.03	6.42
TN02	A	343.449	28.418	TRM57971.00	NONE	0000:000:00000	0000:000:00000	-----	-0.64	-0.21	6.13
GUDI	A	352.875	42.059	TRM57971.00	TZGD	0000:000:00000	0000:000:00000	-----	-0.08	0.13	8.93
HERT	A	0.334	50.867	ASH701946.2	NONE	0000:000:00000	0000:000:00000	-----	1.75	-0.40	8.67
LROC	**A**	**358.781**	**46.159**	**ASH701945B_M**	**NONE**	**0000:000:00000**	**0000:000:00000**	**-----**	**2.52**	**2.23**	**8.40**

In LROC and HERT, for example, we find jumps of +8 mm in the Up component. They are EPN A class sites.

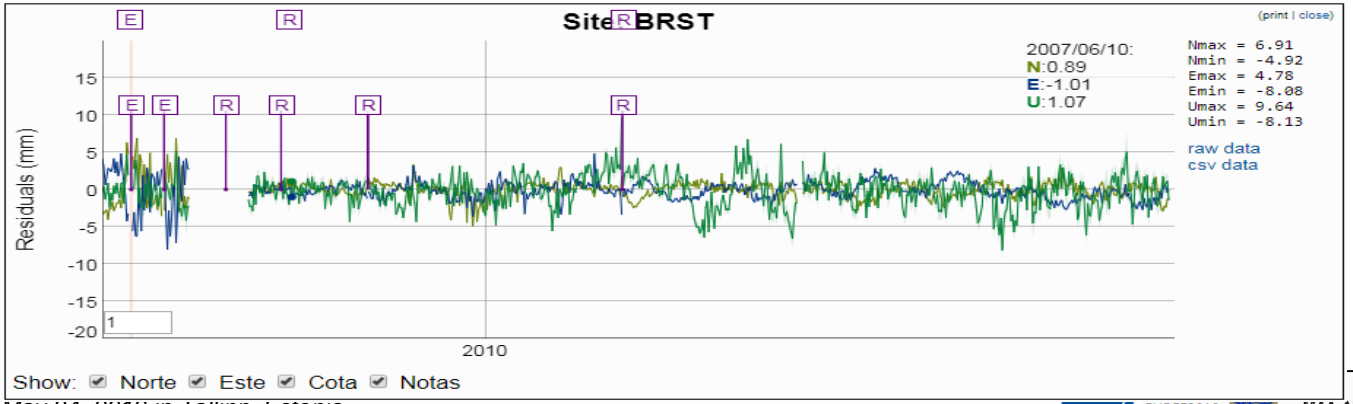
Results: to correct or not to correct the positions?

BRST (EPN): TYPE MEAN antenna calibration

NO OFFSETS:



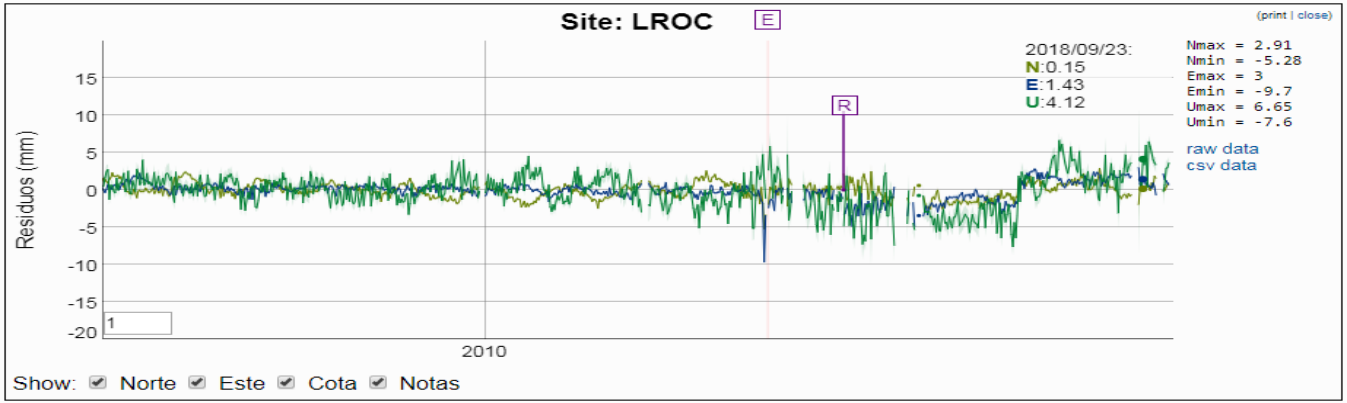
OFFSETS applied:



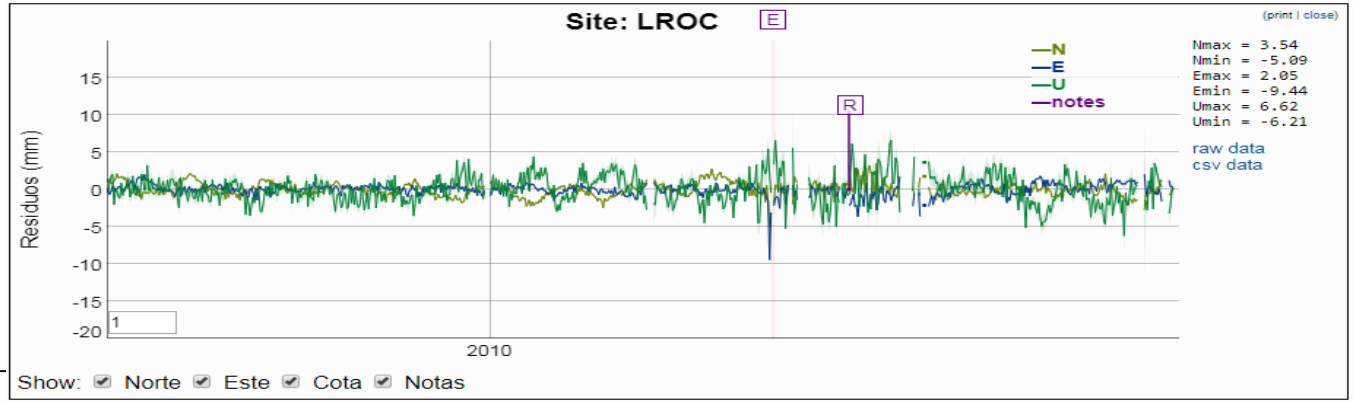
Results: to correct or not to correct the positions?

LROC (EPN): TYPE MEAN antenna calibration

NO OFFSETS:



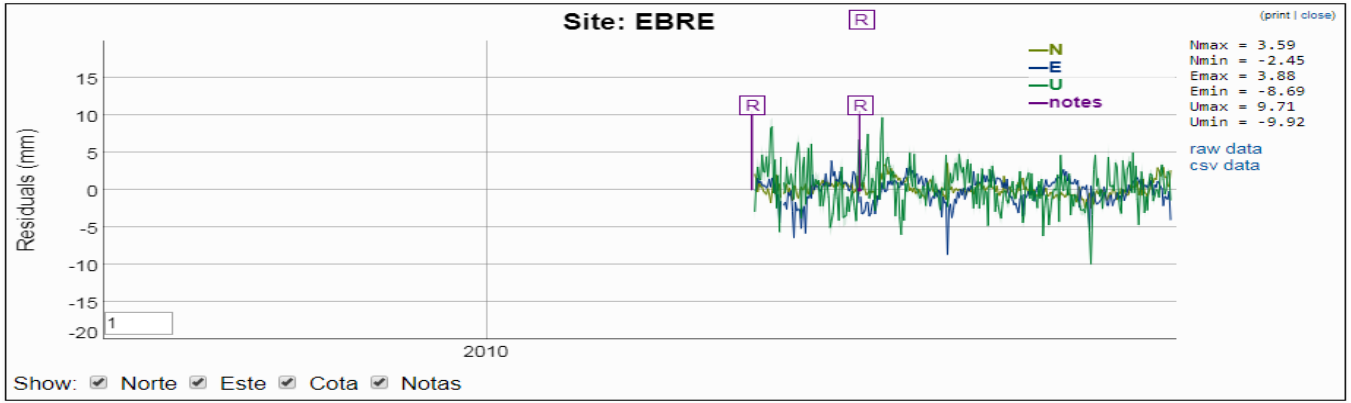
OFFSETS applied:



Results: to correct or not to correct the positions?

EBRE (EPN): INDIVIDUAL antenna calibration (`TRM57971.00 NONE`, same model as BRST)

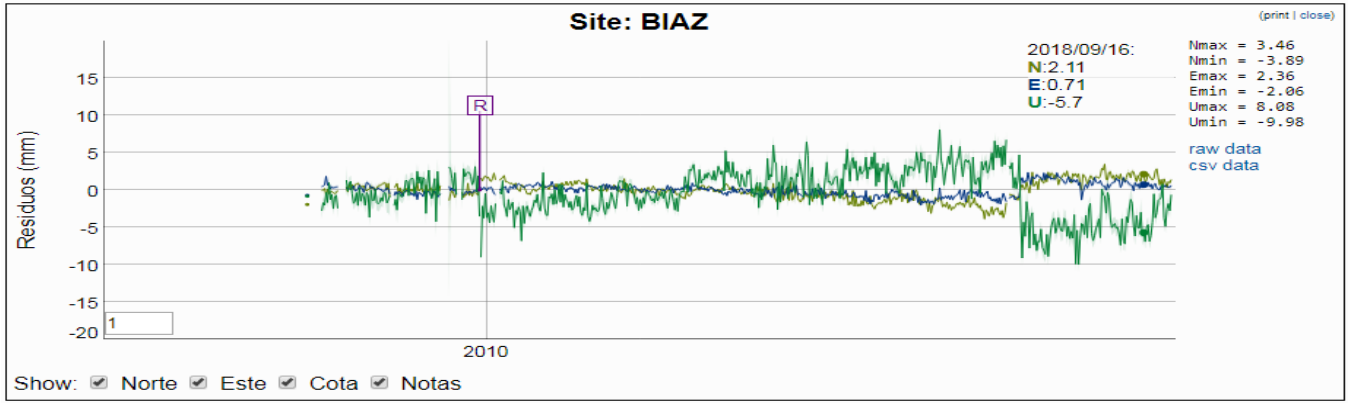
We see no offsets are needed when Individual Calibration values are used.



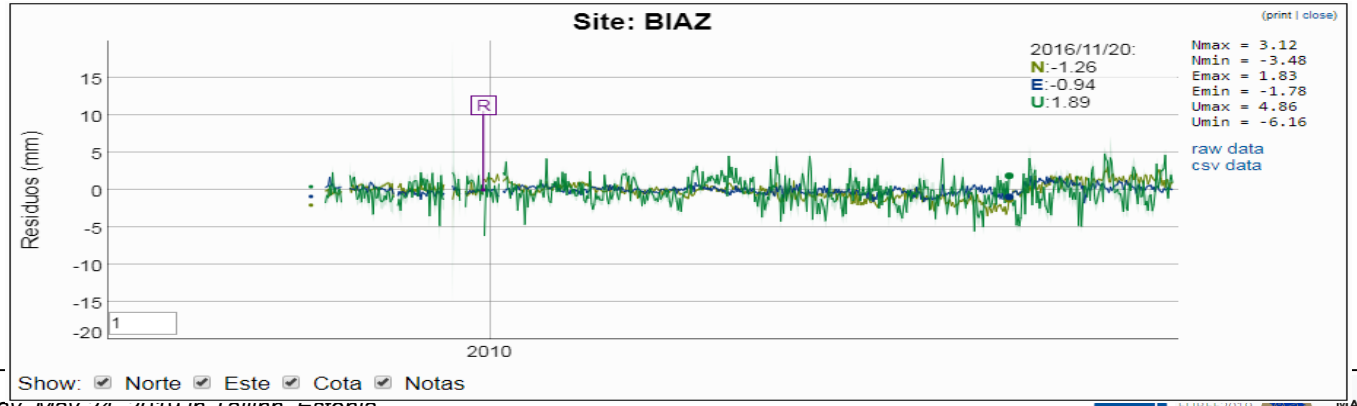
Results: to correct or not to correct the positions?

BIAZ (Densification): TYPE MEAN antenna calibration

NO OFFSETS:



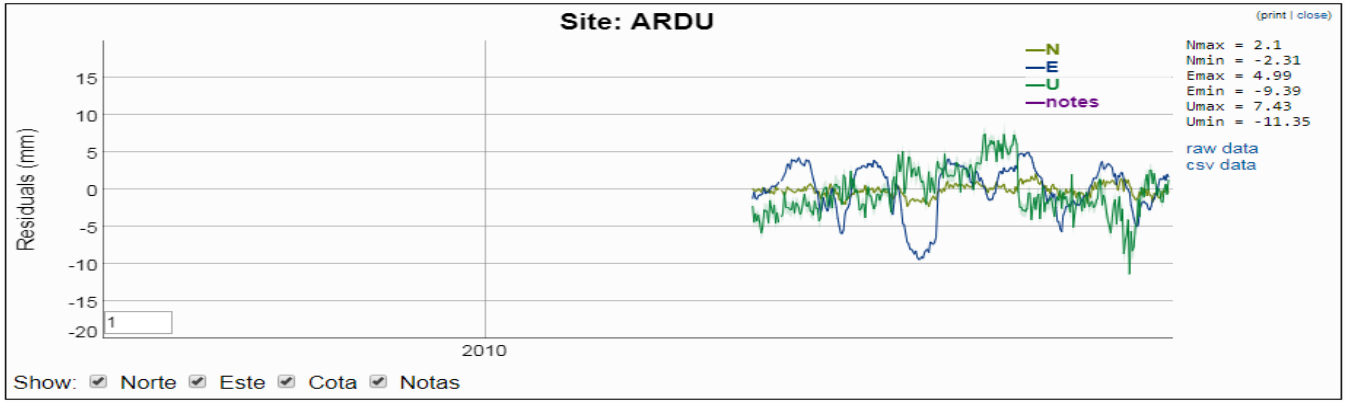
OFFSETS applied:



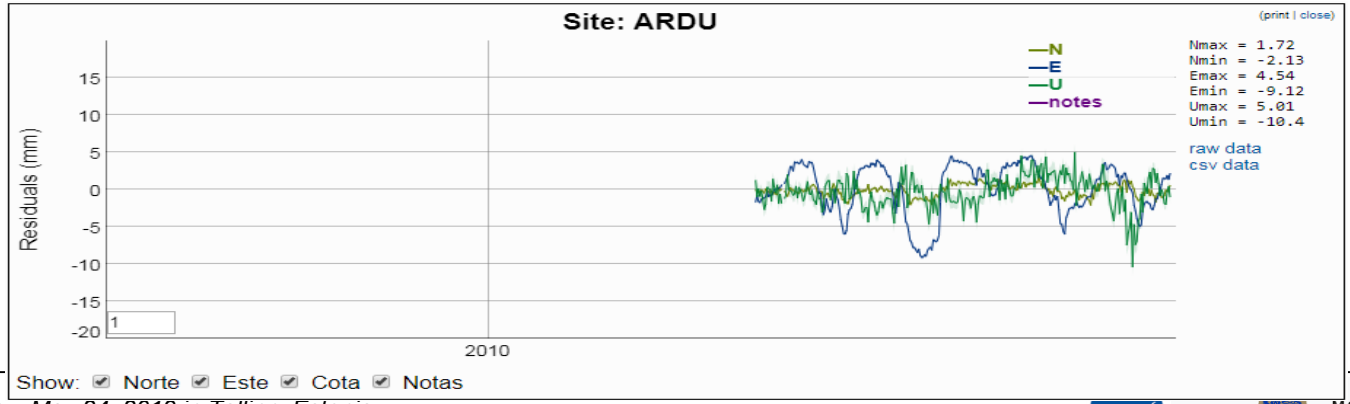
Results: to correct or not to correct the positions?

ARDU (Densification): TYPE MEAN antenna calibration

NO OFFSETS:



OFFSETS applied:



Conclusions/recommendations

- When we combine normal equations, all of them MUST refer to the same datum.
- Moreover, all the NEQs to be combined should rely on the adjustment of GNSS observations computed in the same [or very similar] way. Same parameters should be used: individual calibrations (yes/no), loading, troposphere,… to avoid jumps due to biases when any parameter is modified.
- When this is not possible (commonly in all the cumulative solutions) we need to make all the NEQs be consistent with each other.
- One could introduce discontinuities, but as a result, we would have not consistent solution numbers with others, such as EPN, other Analysis Centers (ACs),…
- Jumps of up to 10 mm in the up component mean that we can be computing unrealistic vertical velocities.
- Smaller jumps (like 2.52 mm in LROC for the E) must be correctly handled as well.
- All ACs computing cumulative time series with combined IGb08 and IGS14 should apply the position offsets to the IGb08 NEQs to have continuous time series and correct velocity estimations, comparable to other solutions.
- For other reference frames (igs05.atx->igs08.atx), make sure the published corrections are applied in order to have all the normal equations to be further stacked in a common frame.

Thank you for your attention

Questions? Comments? Suggestions?