CNES/CLS IGS Analysis Center:Contribution to MGEX and recent activities

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Introduction

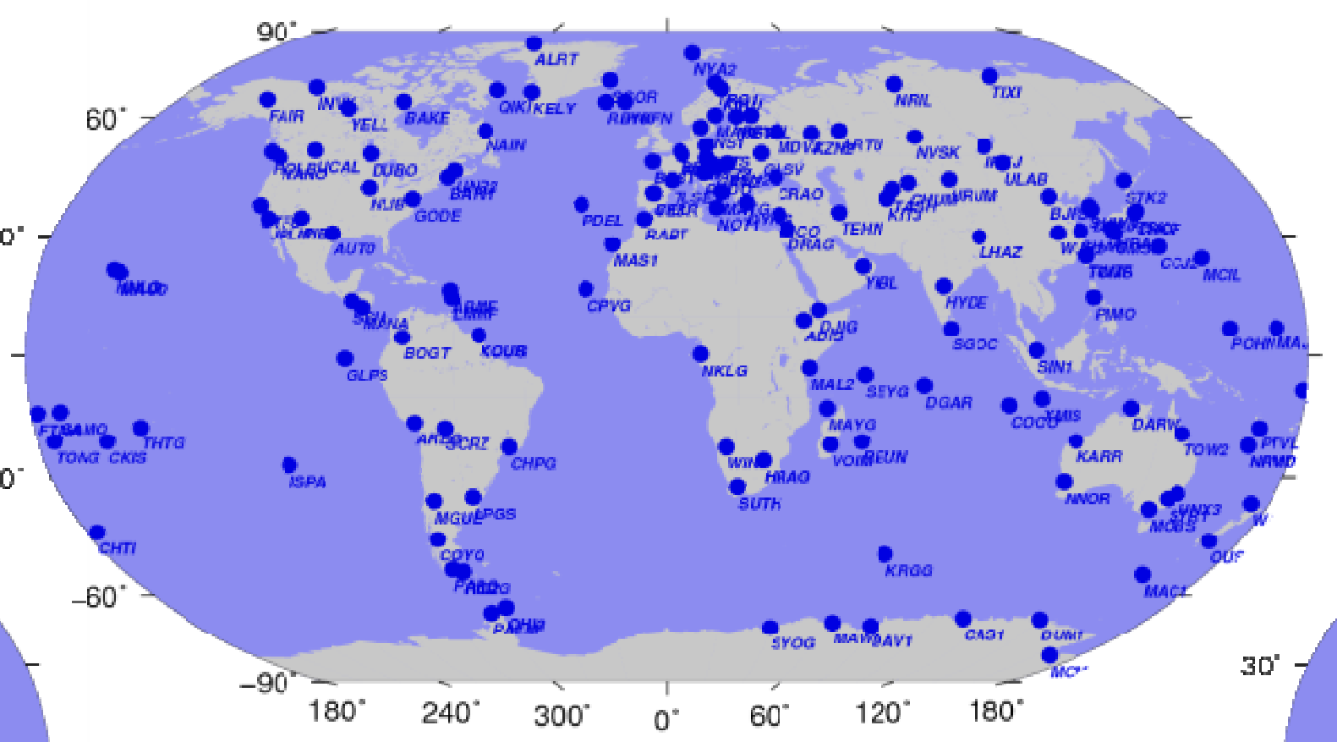
CNES participates as Analysis Center since 2009 in the International GNSS Service (IGS). GNSS data are processed by its subsidiary CLS with the software package GINS/DYNAMO.
This presentation describes the main recent evolutions of the processing strategy of the CNES/CLS IGS Analysis center (grg products). Since beginning of year 2015 our contribution to MGEX and to IGS final products is based on the same combined GPS-GLONASS-Galileo solution. This evolution implying software and network changes is described more precisely below. Some impact on our products is also discussed. Two studies initiated by the users needs are also presented: one on 5s clock multi-constellation densification and one on Wide Lane GPS satellite biases.

Multi-GNSS products

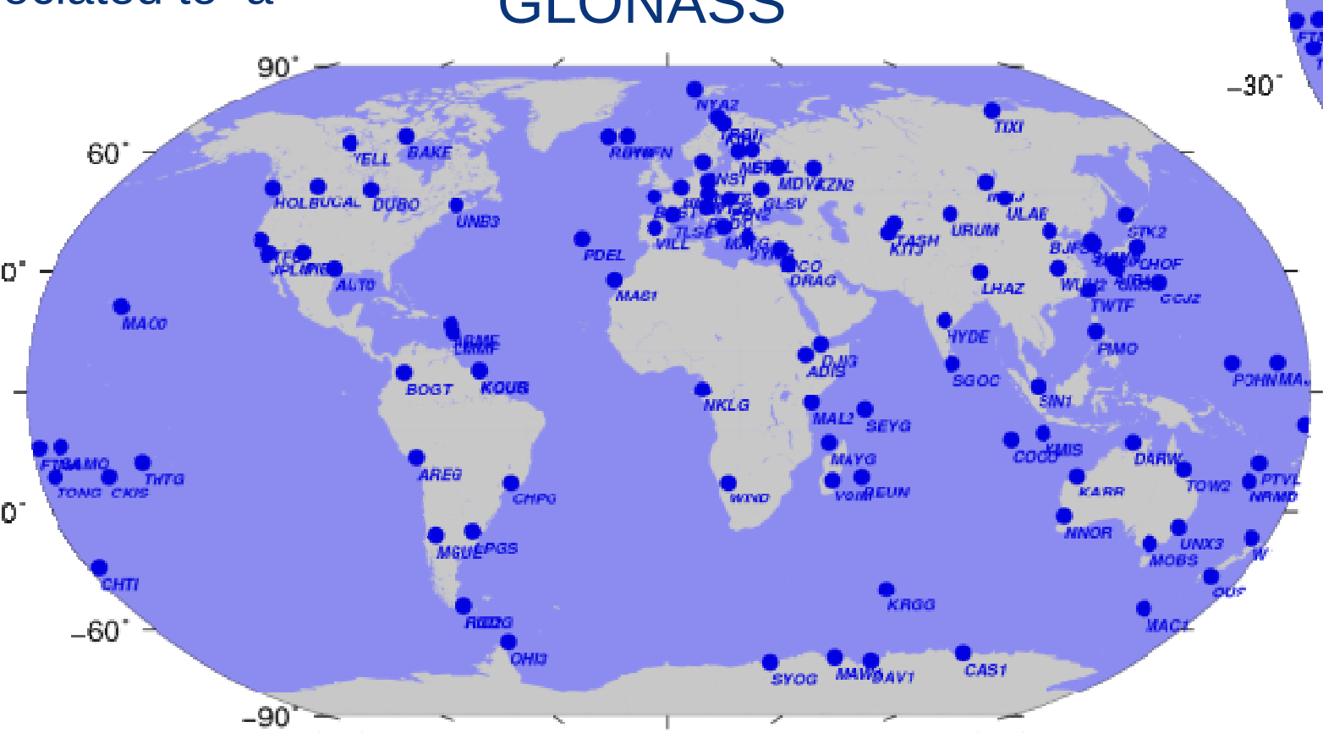
Multi-GNSS processing

Year 2015 corresponds to a significant evolution on our final products generation. To avoid the maintenance of two redundant & different processing chains it was decided to merge IGS finals & MGEX processing together. On GPS week 1840 (12 Apr. 2015) we started a new common processing including the three GPS GLONASS & Galileo constellations (see figure 1 and Table 1) .This change was also associated to a complete revision of the tracking network we were using.
The total number of stations used is also indicated on this figure; we decided to reduce the network from ~200 to ~120 stations to compensate the extension of the number of measurements and parameters. The number of measurements reaches now around 8 billion of ionosphere free observations for a one day arc at a 30 seconds sampling (clocks generation step).
Reduction in computation time were needed to include more satellites or stations.
A significant part of these stations are from the new multi-GNSS network.
We made our best to keep well distributed sub-networks as well as a good link to Igb08 reference frame (see figure 2).
This prepared us for the transition to a true multi-GNSS IGS in the future.

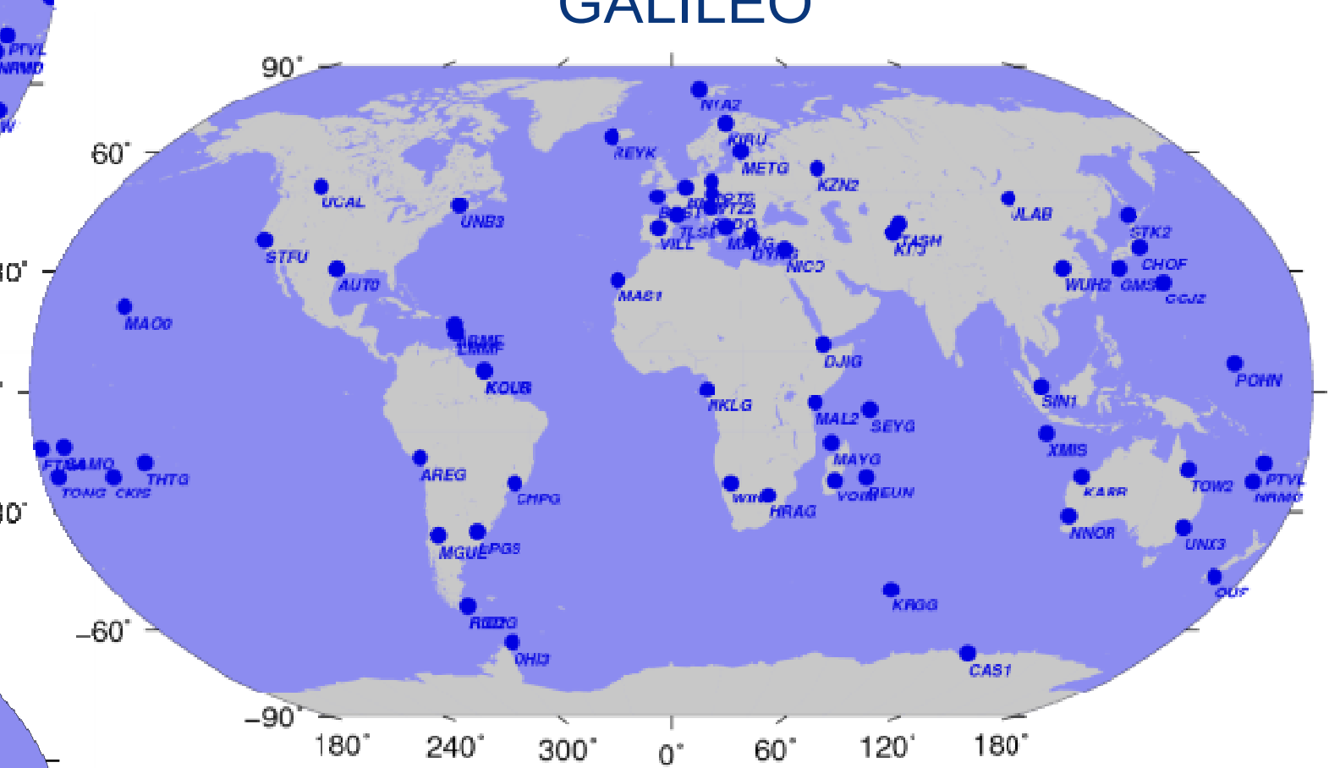
GPS



GLONASS



GALILEO



Link with IGb08 core network

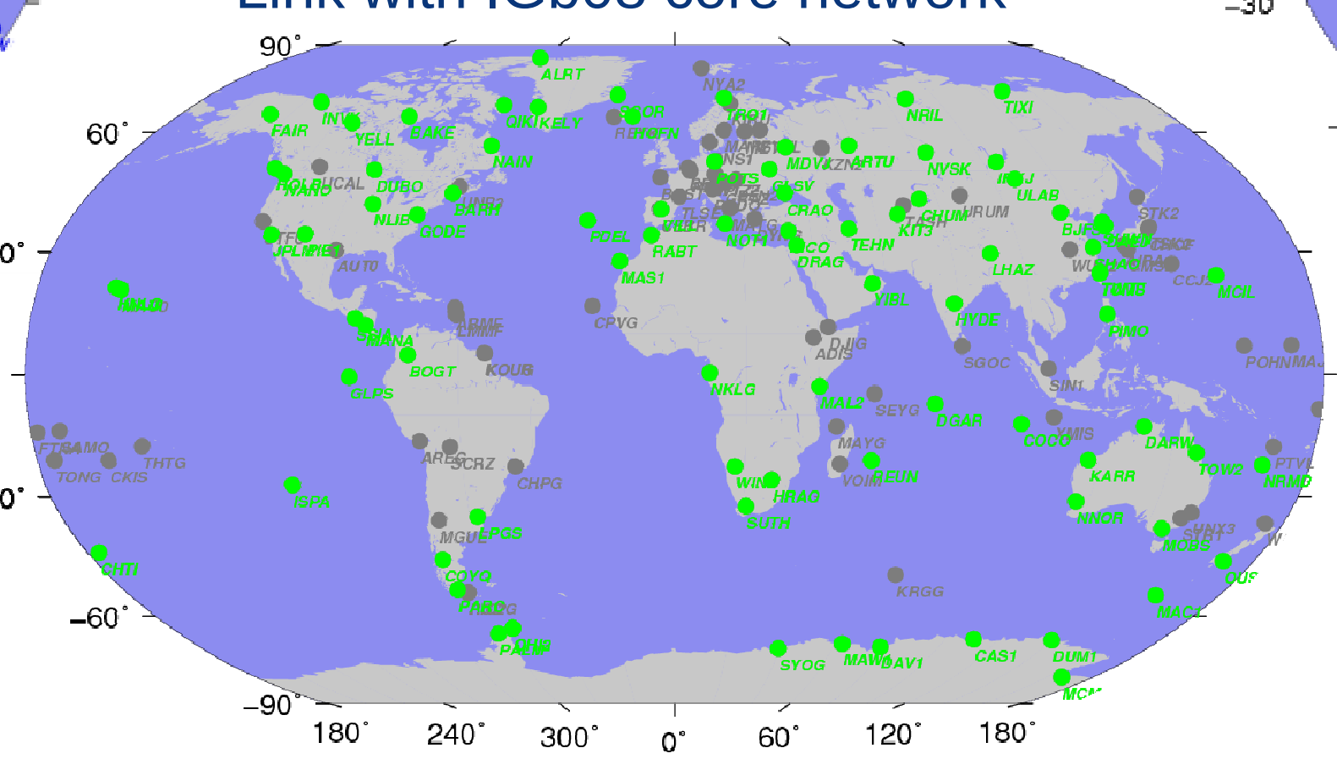


Figure 2: Network and sub-networks used in our current products. The number of data used differ for each constellation.

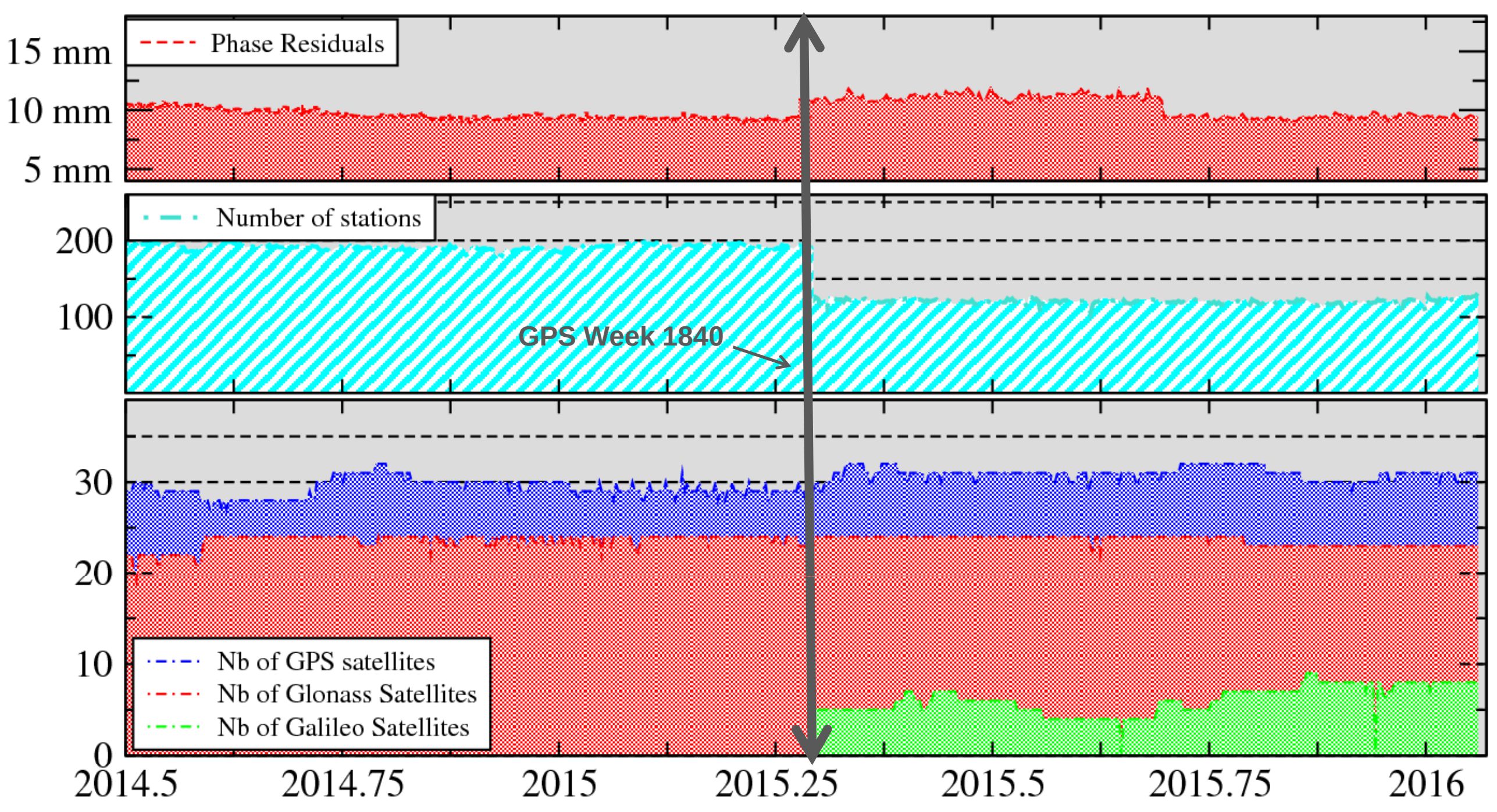


***Figure 1:** Main statistics of the CNES/CLS Analysis Centers products during last year. Since week 1840 our final processing include Galileo satellites as for MGEX contribution.*

Product	files
Daily GPS, GLONASS (grg) & GALILEO (grm) ephemeris/clock at 15-min intervals	**[grg/grm]wwwwn[0-6].sp3**
Daily GNSS clock at 30-sec intervals (allowing GPS integer PPP fixing)	**[grg/grm]wwwwn[0-6].clk**
Daily Normals Equations for EOP and Stations coordinates in SINEX format	**[grg/grm]wwww[0-6].snx**
Analysis summary for 1 week	**grgwwww7.sum**
ERP (pole, UT1-UTC) solution for 1 week in IGS IERS ERP format	**grgwwww7.erp**

Table 1: Our products contain now fully coherent GPS/GLONASS & GALILEO solutions and allow for multi-GNSS PPP/IPPP at 30 seconds rate.

Frame alignment

No significant impacts associated to the processing strategy change are visible for orbit and Earth Orientation Parameters in the analysis made by the IGS coordinator each weeks, but some others parameters have noticeable signature. Unfortunately during last summer we did not pay sufficiently attention to our a priori coordinates and the stations solutions alignment relatively to the reference frame Igb08. During the months following this change we experienced several degradations on our products associated with an increase of phase measurements residuals (Figure 1). The maximum effect observed was on the global translation in Z at the level of one centimeter and impacting the PPP users of our products. This was corrected at the end of year 2015 (week 1874). Effects of this misalignment and the corrections made are visible on the clocks standard deviations vs IGS final, at a level of 20 picoseconds (figure 3). They are also visible on the global network translations as seen with the PPP solutions using our products made by the analysis coordinator (figure 4).

Figure 3 : PPP with IGS Final Orbits and Clocks

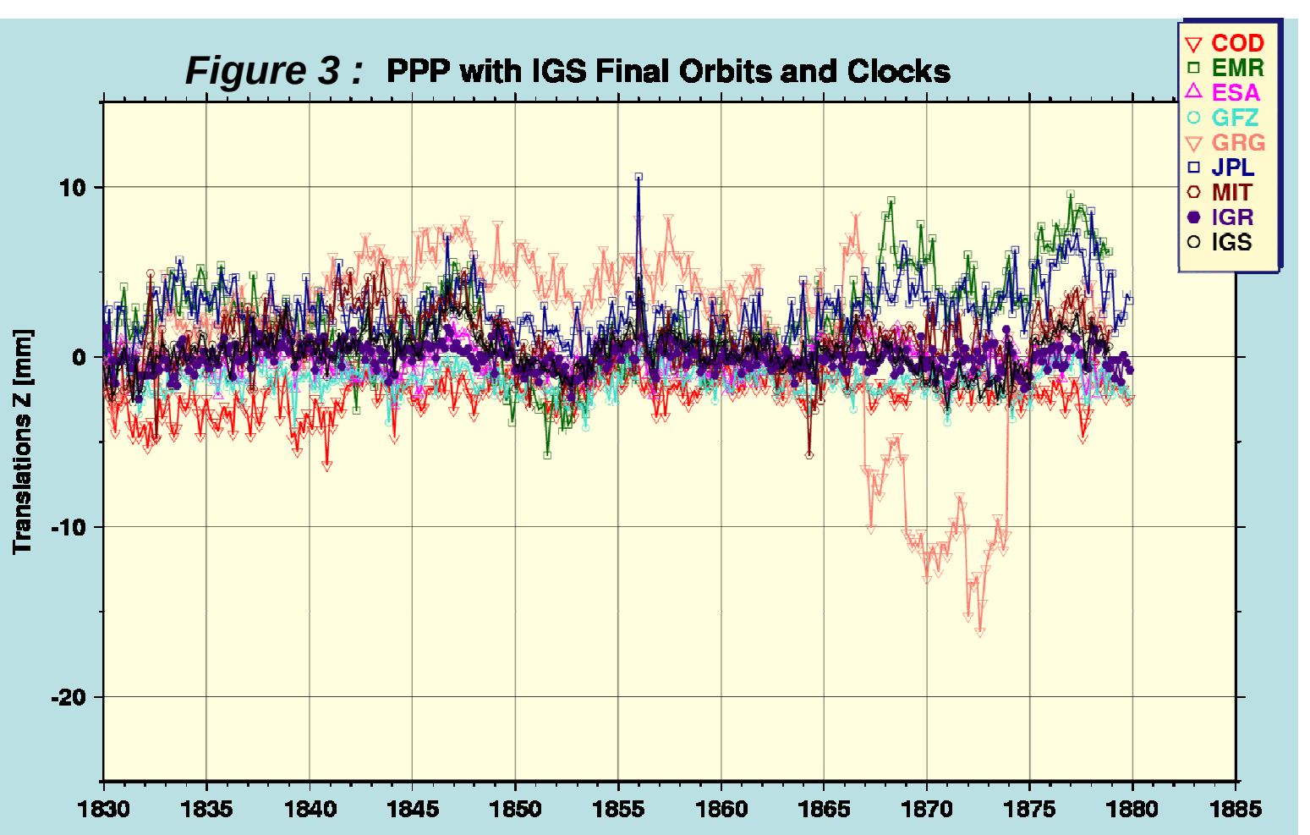
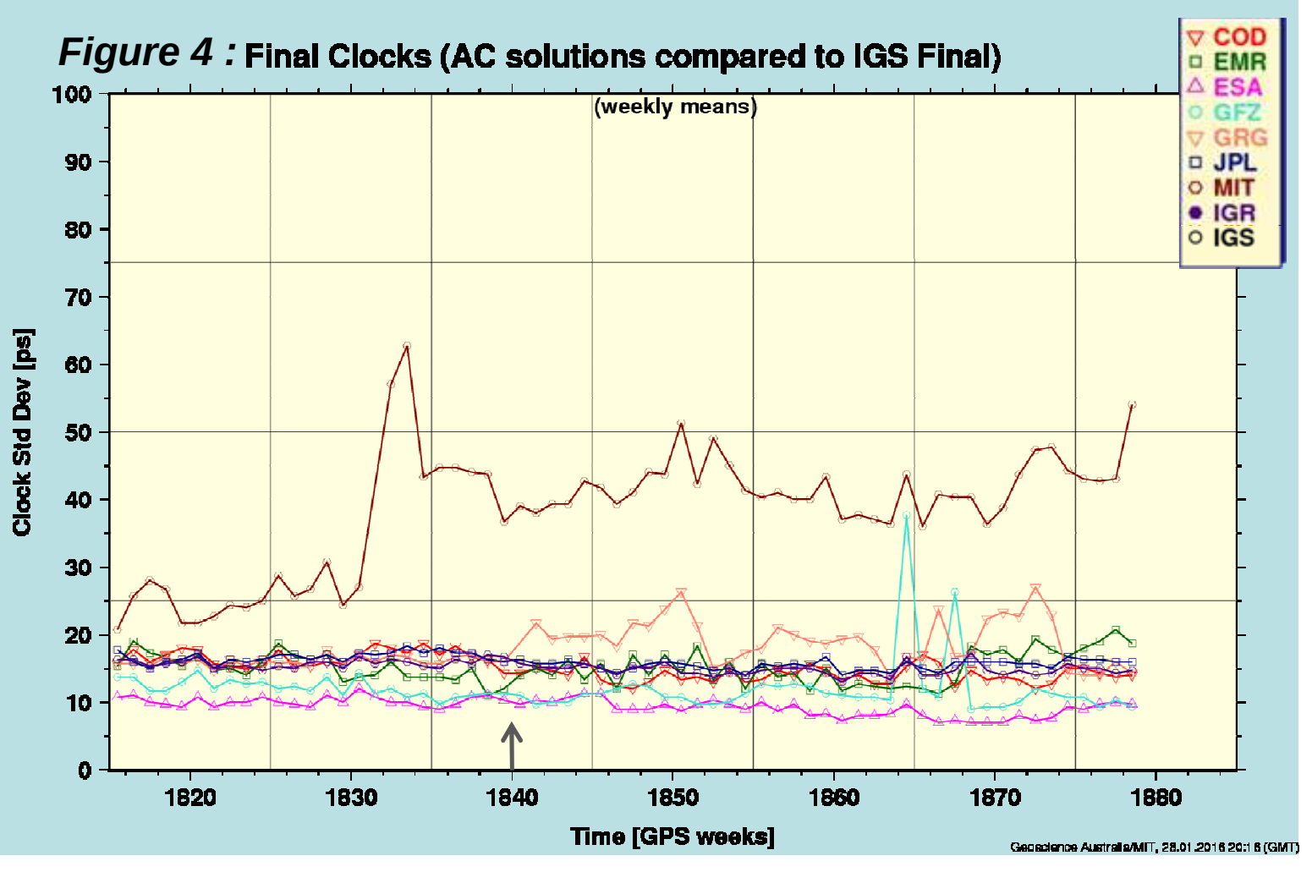


Figure 4 : Final Clocks (AC solutions compared to IGS Final)



High rate clocks

Some integer PPP applications for which receivers have rapid and erratic motions (like GNSS receivers on buoys or boats) need high rate integer clocks. Interpolation of 30 s clocks at higher rate being not sufficiently accurate we need in this case at least 5 seconds clocks. We are now able to produce such dense clocks solutions at 5 seconds interval for Glonass & GPS using the high rate IGS network delivering 1 Hz data and available at IGS data centers.

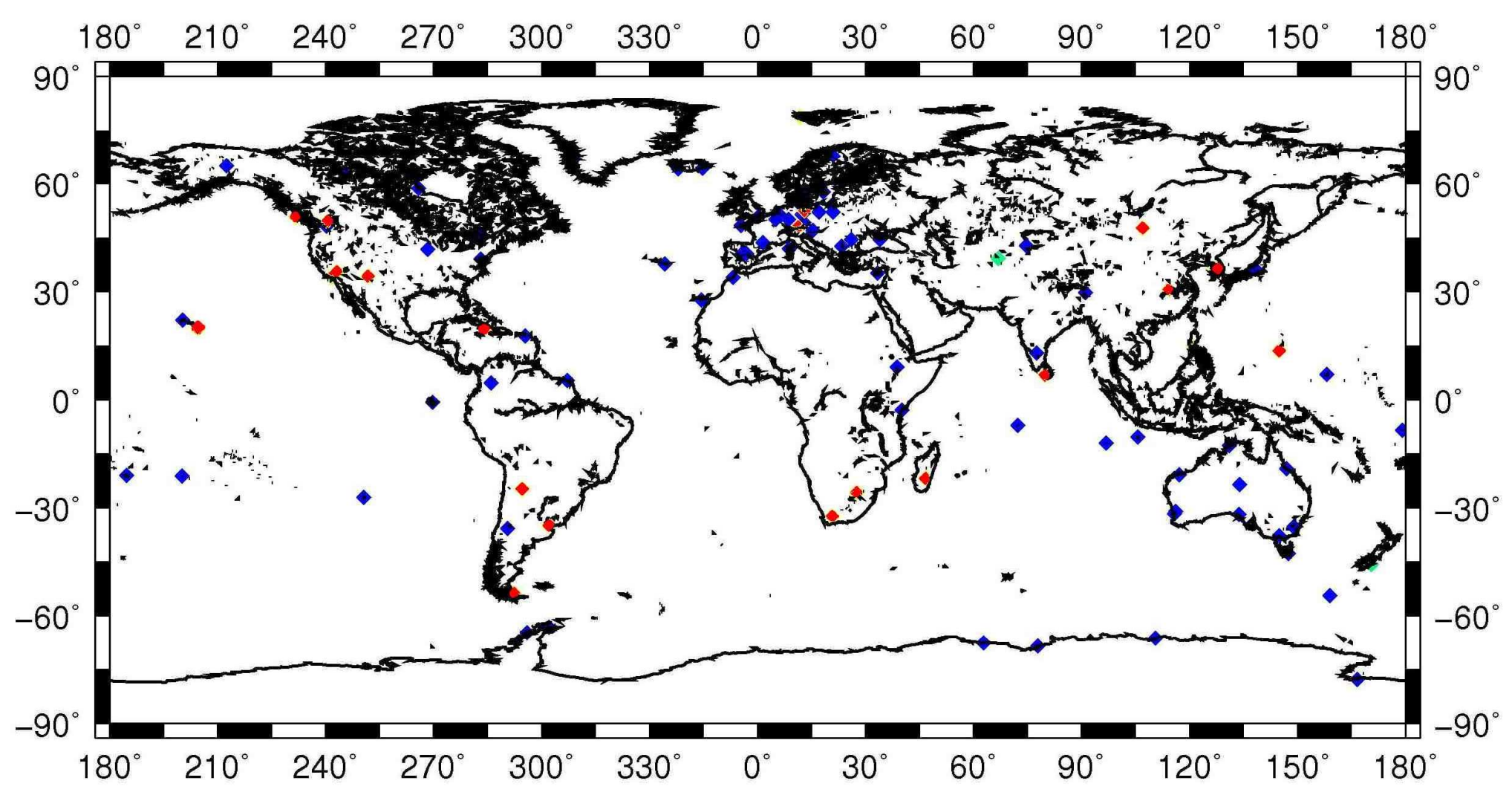


***Figure 5:** The highrate (1Hz) network for doy 150/2015 : Green: GLONASS only ; blue: GPS only ; red: GPS + GLONASS*

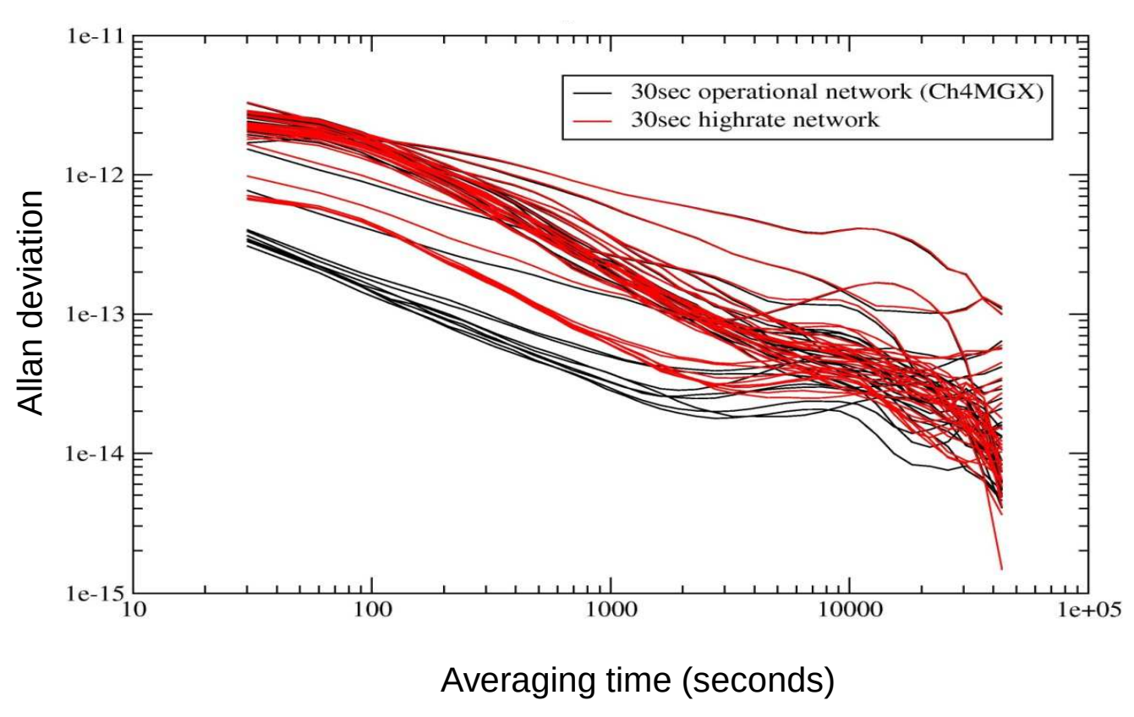


***Figure 6:** Allan standard deviation for the 30 seconds network and to the high rate network .*

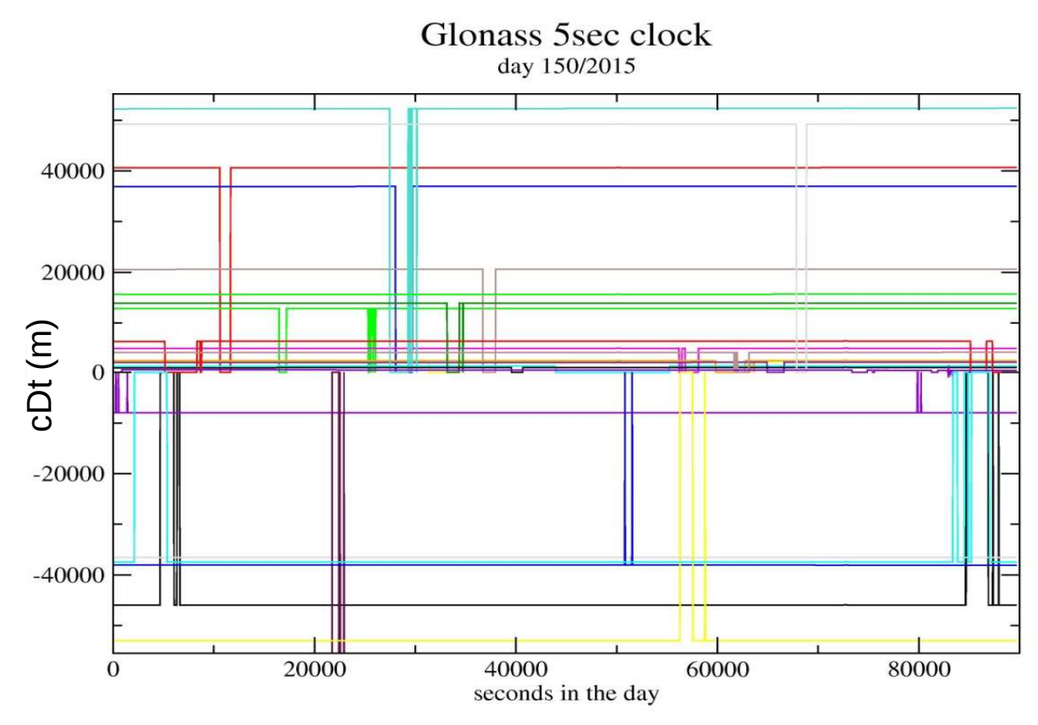


***Figure 7:** Glonass clocks values (5 seconds) for doy 150/2015.*

This 1Hz network is not as dense as the 30 seconds one (see figure 5 comparatively to figure 2). We consequently do not obtain high rate clocks of the same quality as for the 30 seconds ones. The high rate clocks can suffer from lack of coverage, especially for GLONASS (figure 7) and may have a bigger noise (figure 6). It is expected that the 1Hz network will grow in the near future to overcome these difficulties.

Receiver types dependant Wide Lane biases

Recently we studied the receiver dependant part of GPS wide lane satellites Biases (WSB). These biases are derived from the Melboune-Wübbena combination (eqn. 1) of the code and phase observables and are used to fix the wide lane ambiguities at the undifferenced level. They are needed for our Analysis Center orbit and clock products computation and are also useful for various user-side applications(1).

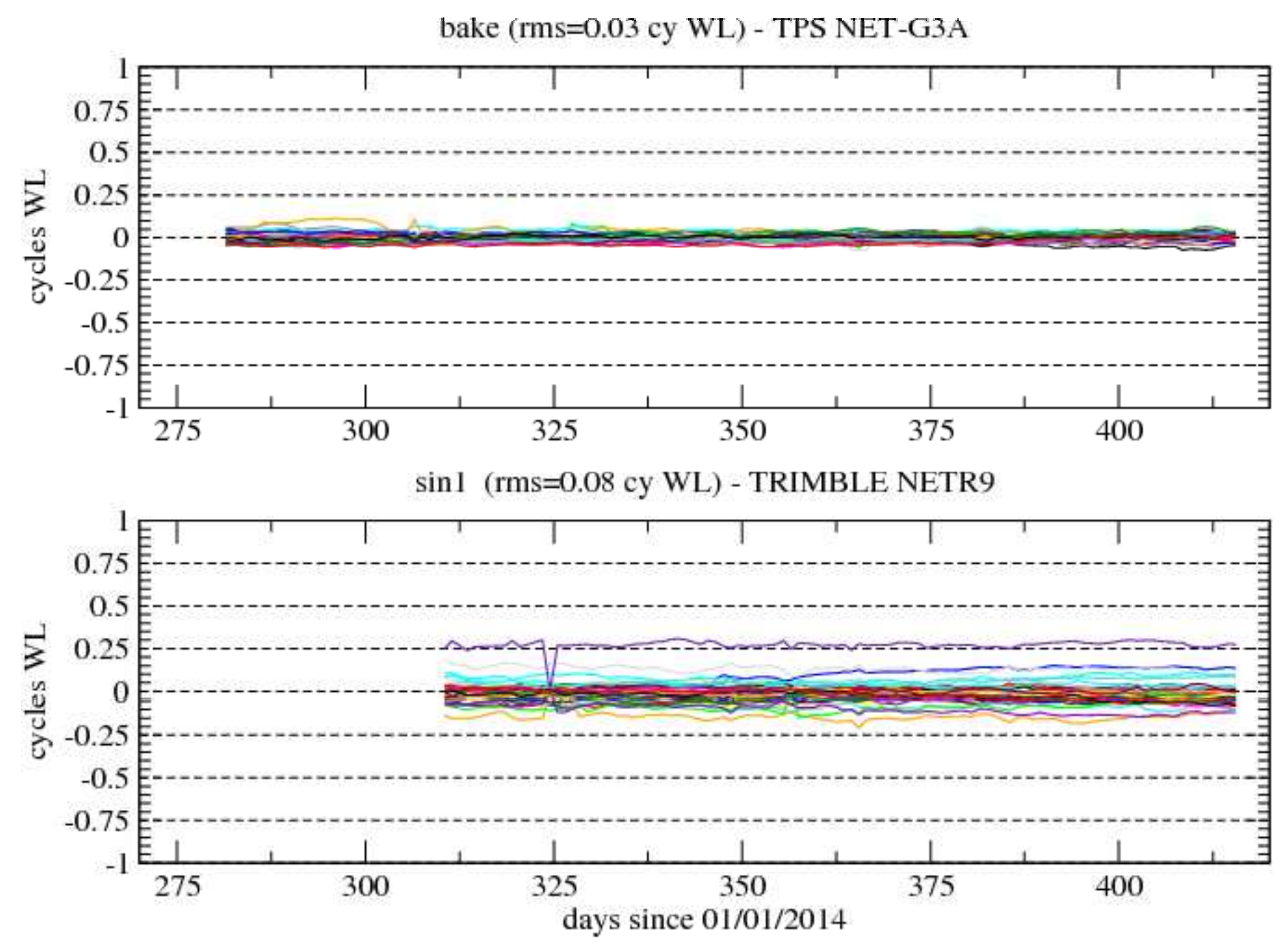


***Figure 8:** Two examples if single-receiver WSB sets: One good and one bad agreement with reference set (mean).*

$$MW = N_{WL} + b_{WLrec}(t) - WSB(t) + \varepsilon_{noise} \qquad (eqn.1)$$

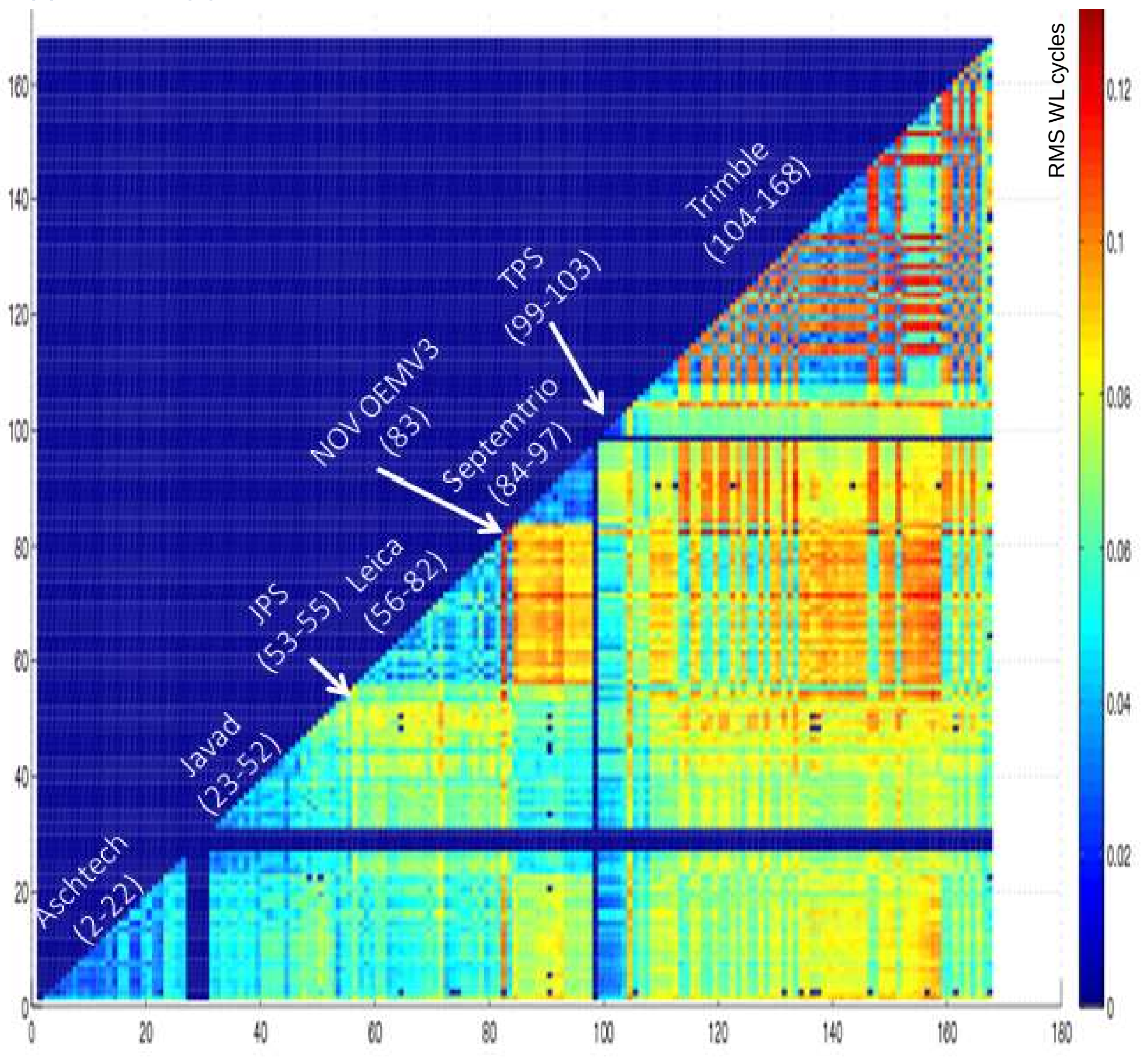


***Figure 9:** GPS Wide Lane biases RMS differences between individual receivers of the MGEX network (sorted by receiver types)*

As presented during the second workshop on GNSS biases in Bern last autumn, we observed noticeable receiver type dependent biases [2]. Constant offsets are visible between individual series (see figure 8). The receivers families can be easily detected on figure 9 that plots all together the differences observed between all receivers of the MGEX network (available in the first part of 2015). Moreover two families can be seen for the Trimble receivers ; this is not understood today.

The maximum discrepancy is around 0.13 RMS in WL cycles. A logical consequence is to maintain and use receivers type dedicated values. But our tests shown that there is no noticeable gain on WL fixing if we use receivers dedicated values instead of mean values. This obviously depend on the robustness of the algorithms used. Such behavior could be more problematic for others GNSS signals as GALILEO L1L5 for example.

(1) see the poster "A review of «integer PPP» applications", Félix Perosanz et al., in Use of IGS Products/Tide Gauge session.
(2) Receiver type depending part of observed satellite wide lane delays, S. Loyer, 2015 (www.biasws2015.unibe.ch)