The ESA/ESOC Analysis Center Progress and Improvements

Tim Springer[1], Cristina Garcia-Serrano[2], Mark van Kints[2], Florian Dilssner[3], Joachim Feltens[4], Claudia Flohrer[1], Francesco Gini[1], Ignacio Romero[5], Erik Schönemann[1], Werner Enderle[1]

[1]ESA/ESOC, Darmstadt, Germany
[2]GMV S.A @ESA/ESOC
[3]CGI @ESA/ESOC
[4]Vega GmbH @ESA/ESOC
[5]SAC S.L @ESA/ESOC

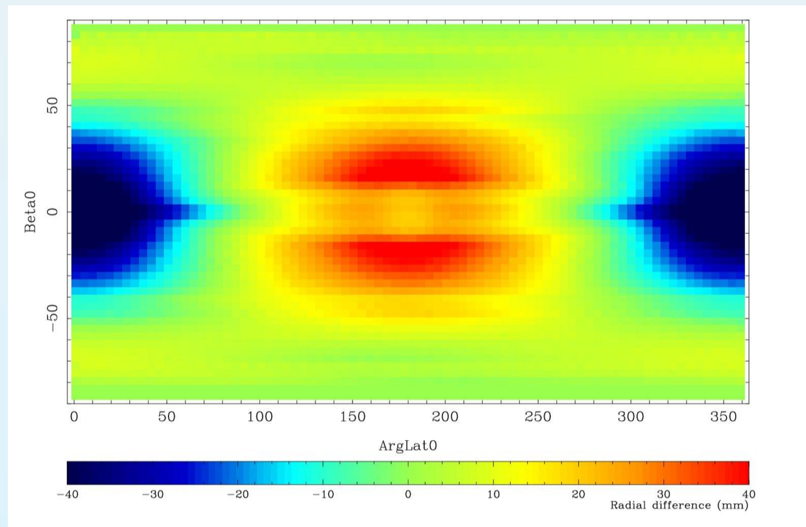
Abstract

ESA/ESOC is one of the most active Analysis Centers within the IGS and it is providing some of the best products available. This poster highlights some of the changes, developments and improvements that were made in recent years.

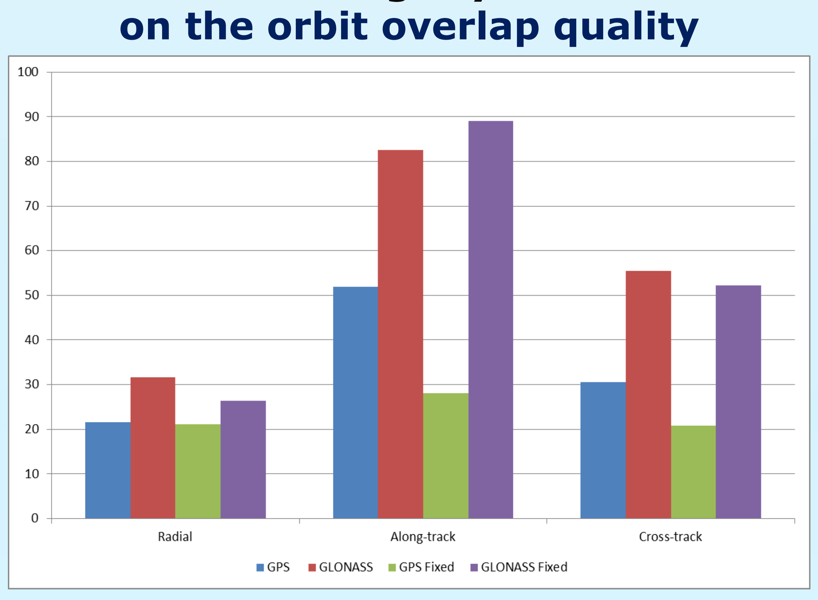
Multi-GNSS: The modernization of the existing and the deployment of new Global Navigation Satellite Systems introduces new satellites, new orbits, new signals and additional frequencies. Improvements in the IGS products will strongly depend on our understanding of these new systems. We are focusing on: satellite force models, handling of different attitude modes, satellite PCO/PCV values, and the handling of the different signals and biases.

Orbit Modeling: The new GNSS satellites, Galileo, GPS IIF, GLONASS, BeiDou, QZSS, are posing some interesting new challenges. The key issue here is the increasing area to mass ratio and the physical characteristics of the satellite bodies which makes them more sensitive to the radiation pressure. Furthermore, the different attitude modes that are being used to handle the satellite eclipse phases are posing some new and interesting challenges.

GLONASS Radial Orbit Differences due to box-wing model



Effect of Ambiguity Resolution on the orbit overlap quality

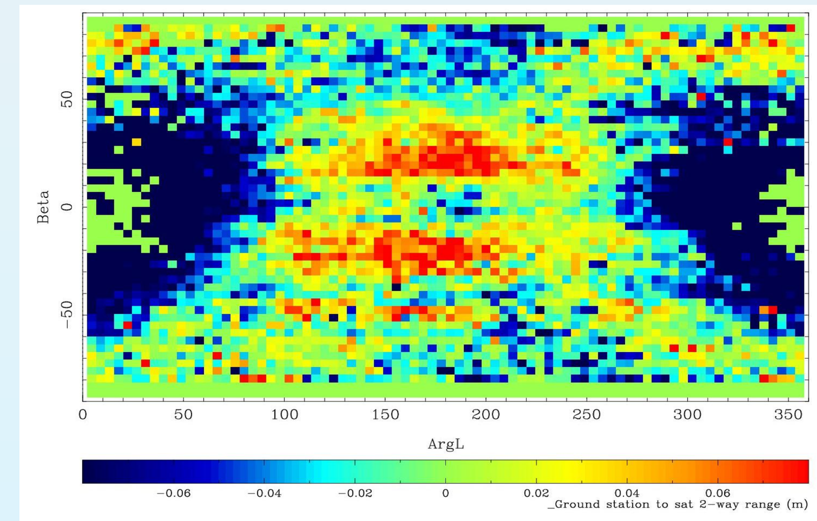


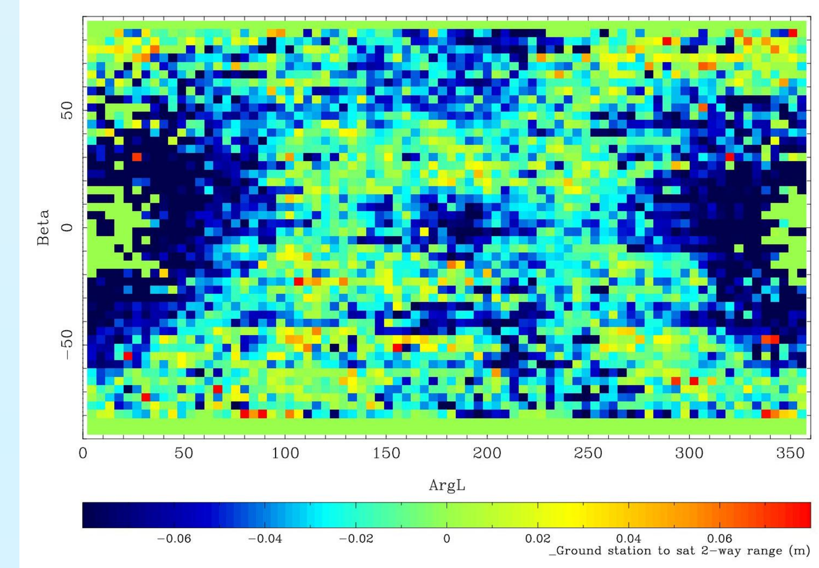
ESA IGS Final Quality Control

We closely monitor the quality of our ESA IGS final solutions to capture any unexpected and/or overlook side effects of model changes. At the IGS workshop in 2014 we have shown the effects of our box-wing modelling on the GPS satellites in detail. Meanwhile the SLR tracking of the GLONASS satellites has intensified and improved significantly and we have now taken a closer look at effects of our box-wing modelling on the GLONASS satellites. The radial orbit effect is of similar magnitude as for GPS with an amplitude of approximately 40 mm (see top left figure). Thanks to the much denser and improved SLR tracking of the GLONASS satellites we can now also see the box-wing improvement in the SLR residuals (two figures on the right).

However, in our in depth analysis we have noticed that we have a small, but significant, modelling issue in the along-track direction for GLONASS (see figure on the left). We believe this may be due to imperfect PCO/PCV values for the GLONASS satellites due to the fact that the PCO/PCV values were estimated without box-wing modelling!

GLONASS SLR Residuals without box-wing (top) and with box-wing model (bottom)



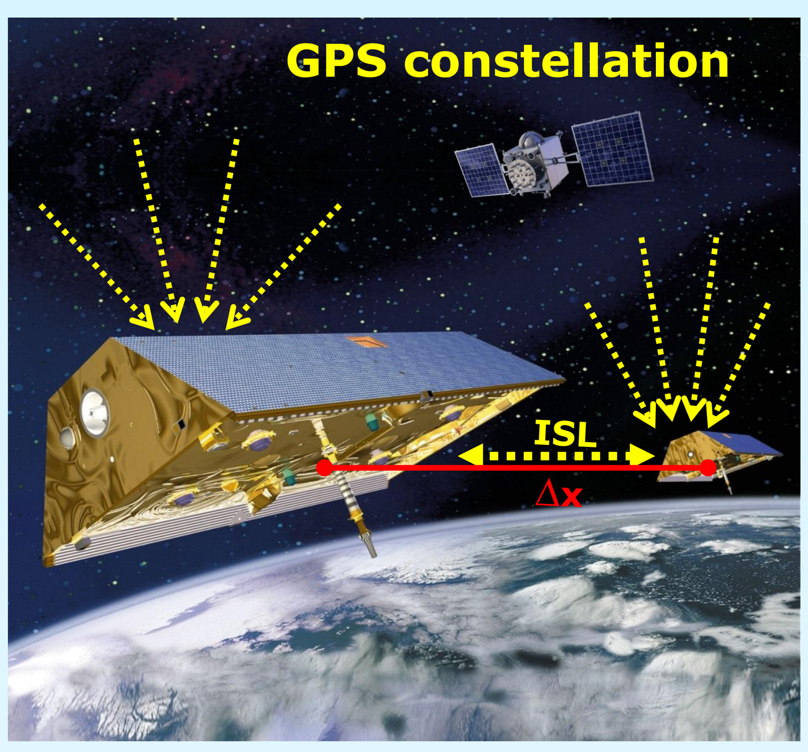


GNSS LEO Processing using GRACE

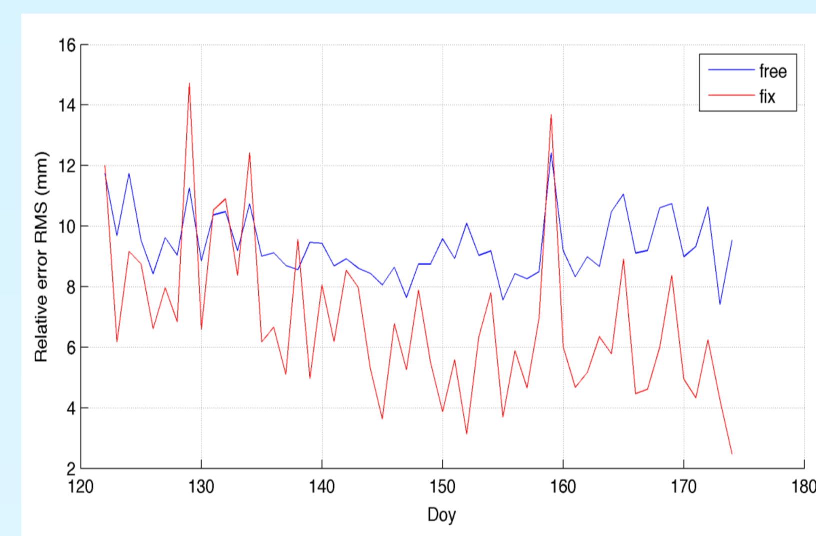
GRACE mission
2 LEOs at 400km altitude, separated by 250km in the along track, carrying dual-frequency GPS receivers and a K-band inter-satellite link for ranging (payload always active)

Processing setup:

GNSS constellation:	GPS only
# of stations:	100
# of LEOs:	2 (GRACE A & B)
Arc duration:	24 hours
Data sampling:	60 s



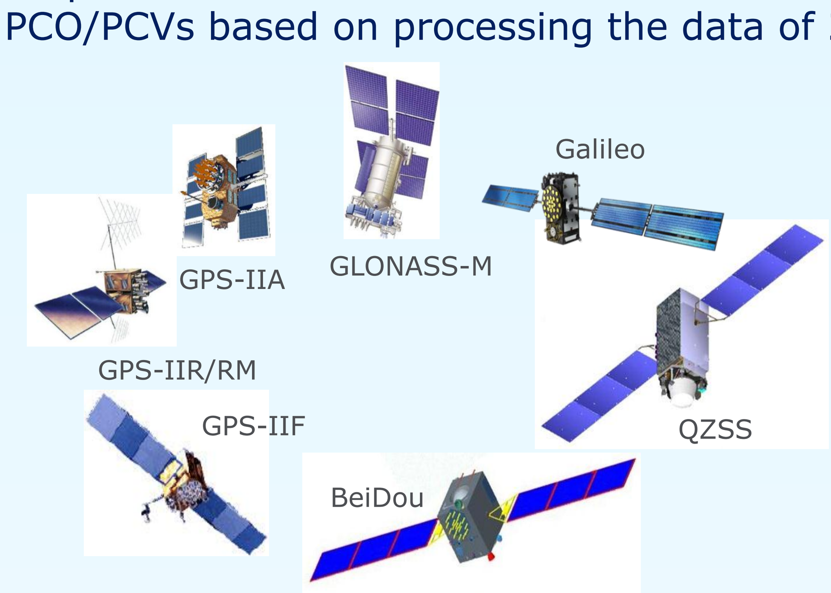
Objective
Demonstrate that the integer ambiguity resolution is improving the global solution when both ground station and LEO (GRACE) ambiguities are integer resolved. As validation we make use of the inter-satellite link between GRACE-A and GRACE-B. The RMS of these inter-satellite observations gives us an independent measure of the orbit quality, in particular the along-track component (see figure on the right). To keep GRACE-A and –B independent the ambiguities on the GRACE baseline were NOT resolved. Only station-station and station-GRACE ambiguities were integer resolved.

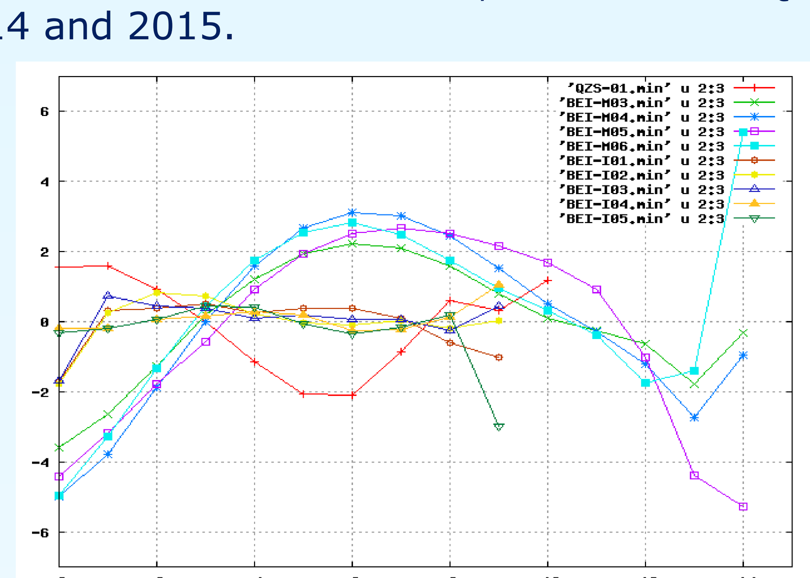


The smaller RMS of the ISL residuals when using integer ambiguity resolution demonstrates that the solution improves

Multi-GNSS Activities

We periodically analyze the data from the IGS Multi-GNSS Experiment (MGEX) as at the current stage we prefer a detailed analysis of the MGEX data over routine analysis. In the scope of these activities we have derived a consistent set of Galileo, BeiDou and QZSS PCO/PCVs based on processing the data of 2014 and 2015.

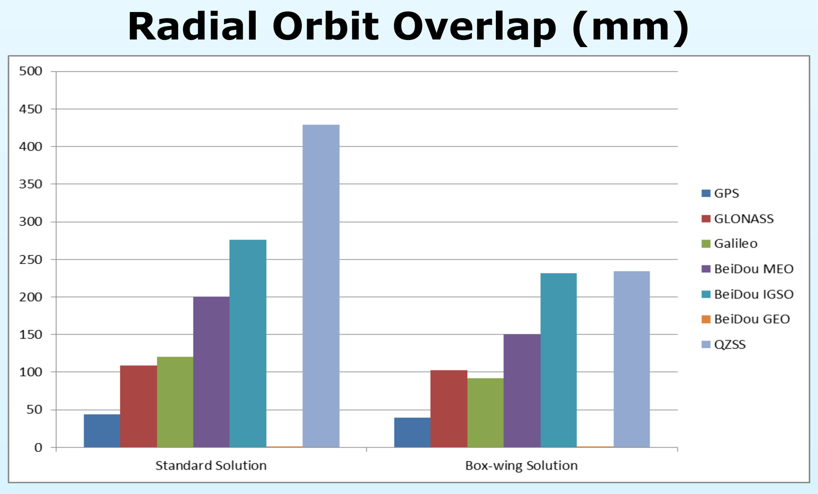


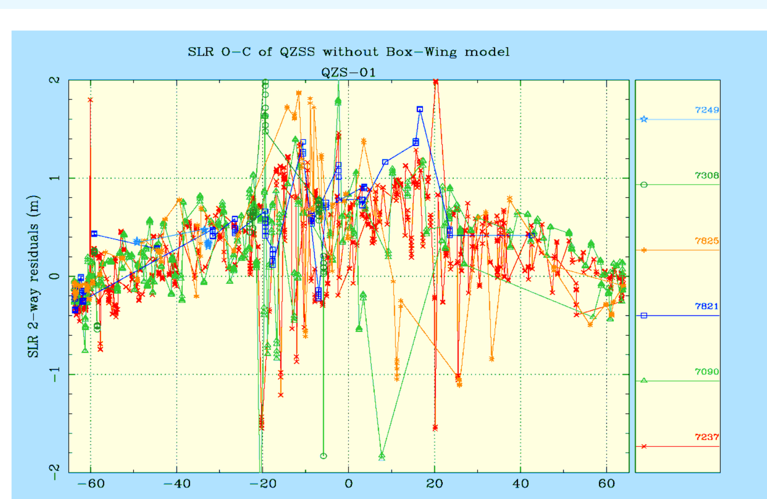


Box Wing Modelling

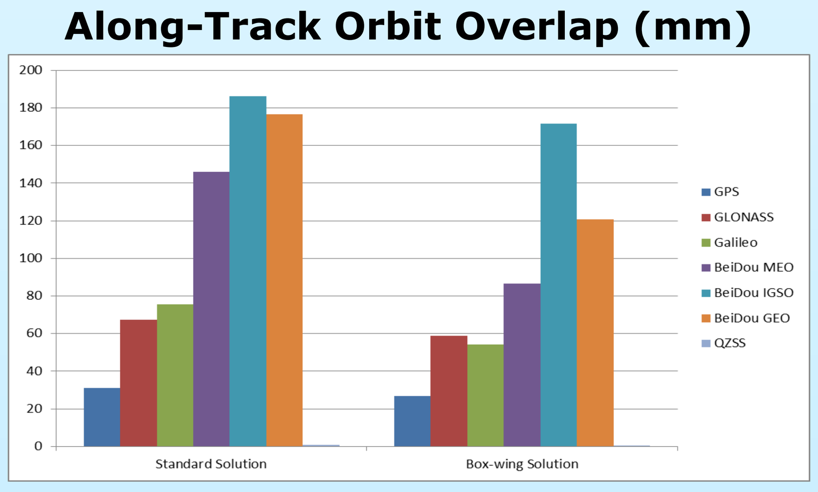
We have extended our activities in this area now also to the satellites of the "new" constellations, i.e., Galileo, BeiDou and QZSS. We believe that for BeiDou and QZSS an accurate model of the satellites will be of great benefit, if not even mandatory. This is due to the fact that for small beta angles these satellites switch their attitude mode from yaw-steering (the normal attitude mode used by GPS, GLONASS and Galileo) to orbit normal mode. In the orbit normal mode the satellite are no longer oriented towards the Sun and thus the solar radiation pressure becomes very hard to model. In the orbit normal mode phase the widely used ECOM model, and also the enhanced ECOM2 model, fail to properly model the radiations forces.

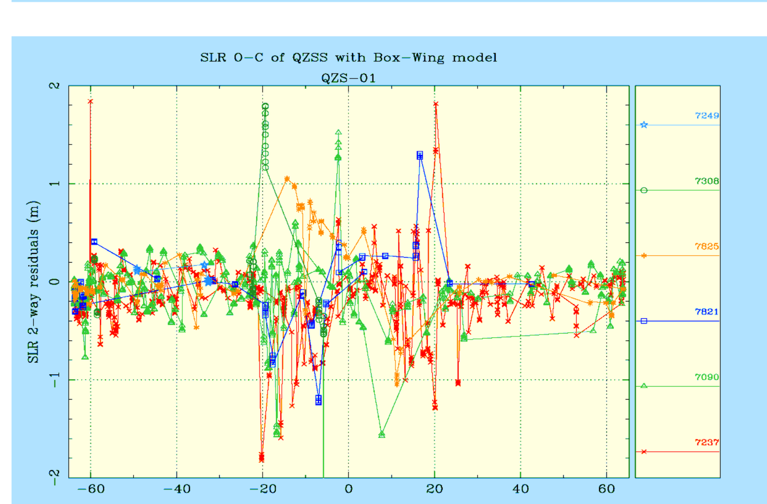
Radial Orbit Overlap (mm)





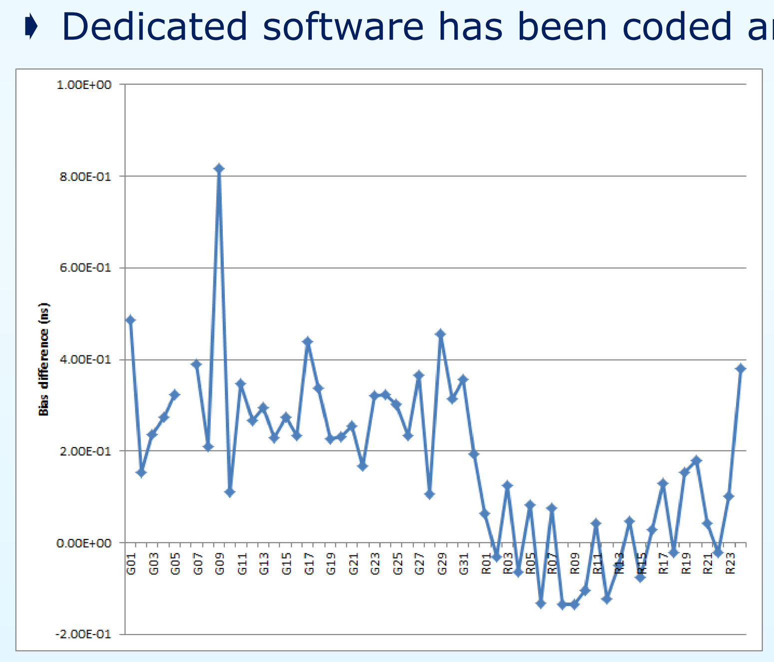
Along-Track Orbit Overlap (mm)



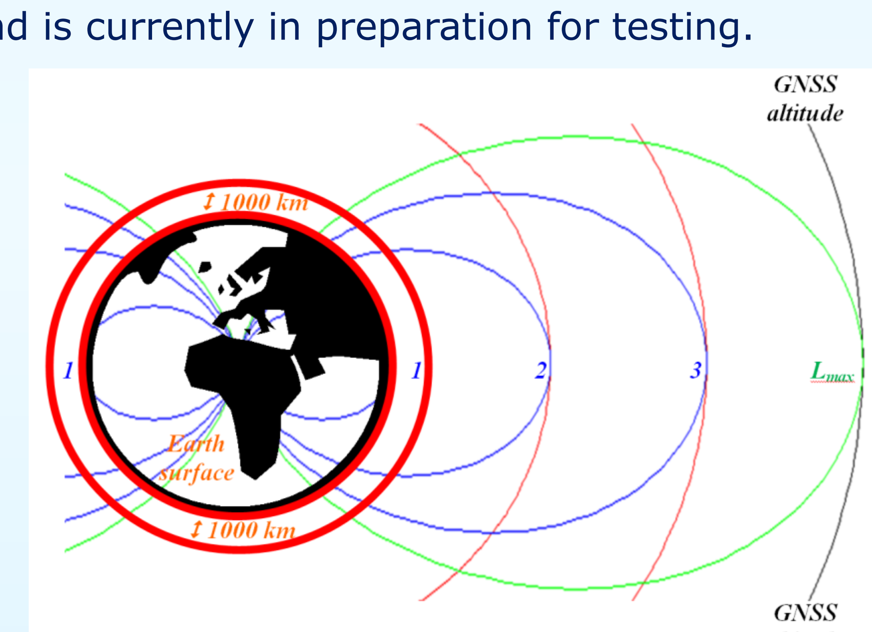


Ionosphere Modelling

- Routine contributions to the IGS with Iono products: 2h IONEX files in final & rapid mode, 1h IONEX files in rapid mode, 1 and 2 days ahead predicted IONEX files.
- Plasmasphere / plasmapause model: After conclusion of a coincidence analysis of CHAMP topside reconstructions with IMAGE RPI data, current activities concern the development of mathematical algorithms, cooperation project with DLR Neustrelitz, Germany.
- Routine IONMON runs in 1h rapid mode at ESA's Space Situational Awareness (SSA) Space Weather Data Centre (SWE DC) at Redu, Belgium, since April 2012.
- Media calibration service (troposphere & ionosphere) for ESOC Flight Dynamics, troposphere part is quasi-operational, ionosphere part is in final development phase.
- 3D Modelling is being developed (will replace the current processing):
  - Algorithms for 3D background model.
  - Algorithms for assimilating TEC and Ne data from very different sources into the background model, few minutes update intervals should be possible.
  - Dedicated software has been coded and is currently in preparation for testing.



GNSS DCBs: ESA vs. CODE biases



Ionosphere and the Earth magnetic field

Conclusions

- The ESA/ESOC Analysis Center remains fully dedicated to the IGS
- Despite 20 years of service still significant progress can be made
- GPS and GLONASS can be combined without any issues. Combined solutions are outperforming GPS-only solutions
- Significant activities are taking place at ESA/ESOC with respect to multi-GNSS processing and modeling
  - A lot of different signals and biases
  - PCO/PCV estimation from multiple ACs needed, for all frequencies
  - Very challenging satellite modeling issues, in particular the orbit normal mode regimes of BeiDou and QZSS but also GPS IIF issues
- For multi-GNSS more effort needed from more ACs and AACs!

European Space Agency