# IGS Activities at ESA / ESOC

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## Abstract :

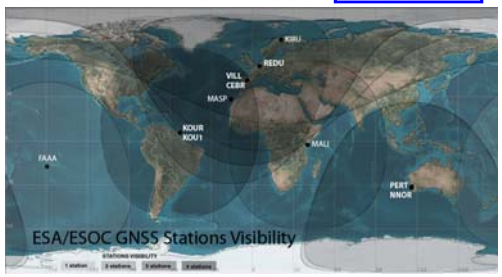
ESA/ESOC is one of the main contributors to the IGS participating in all facets of the IGS activities. This presentation will focus on the analysis aspects of our contributions. As analysis centre ESOC contributes to all the IGS products: Ultra-Rapid, Rapid, Final, as well as the IGLOS, combined GPS and Glonass, processing. Over the course of the last two years several improvements have been made in our procedures, which have lead to a significant improvement in the consistency and quality of our products. The changes we made can be divided in four areas, namely: data retrieval, orbit modelling, data cleaning, and ionosphere. This presentation will highlight the most important changes made and show the positive effect these have had on our contributions to the IGS products.

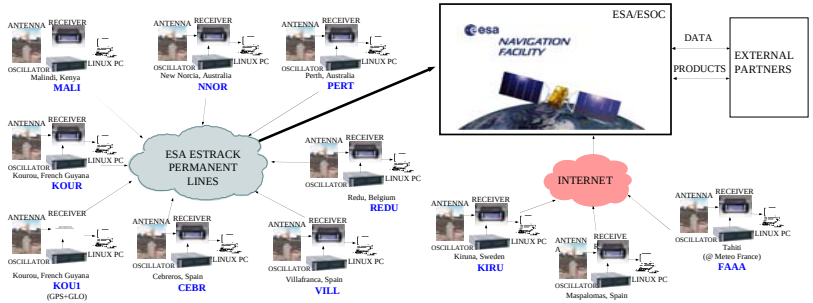
At the same time ESOC is in the process of replacing the IGS analysis software. The new software, called NAPEOS, should be operational for all IGS activities before the end of this year (2006). NAPEOS will by fully compliant with the IERS2003 conventions and will follow all the IGS recommendations, e.g., ANTEX and will ensure full internal consistency of our final products. With NAPEOS we expect a significant further improvement of our contributions to the IGS, which should bring us to the same quality level as the best IGS analysis centres. Furthermore, with NAPEOS we will be able to contribute significantly to the IGS reprocessing efforts. For testing purposes NAPEOS is being used routinely since November 2005 for processing a 100 station GNSS network. This routine process is similar to our IGLOS processing activities. Initial results from this routine processing will be presented. One unique feature in this process is that we estimate one bias per day for each receiver-Glonass satellite pair. The interesting results from these estimates will be presented showing the significant biases between the receivers and between the Glonass satellites.

## ESA stations

### Data Contributions:

ESA/ESOC now operates 11 permanent GNSS stations. We have recently improved the GNSS data transfer by making as much use as possible of the operational lines to the stations, and upgrading all the software at the stations to the latest Real-Time IGS streaming software. This has meant the upgrade of all the stations to Real-Time 1Hz data streams (except the GPS/GLONASS station KOU1). As backup the stations also supply 15 min 1 Hz files.
Additionally two new installations have taken place at Cebreros, Spain at the site of the new ESA Deep Space Antenna, and at Tahiti in cooperation with Meteo France, to support EUMETSAT's Metop satellite. These new stations add coverage to sensitive areas (FAAA) and continue the policy of deploying a permanent GNSS station at every new or existing ESA Satellite Tracking site (CEBR). The CEBR station has a timing system derived from a hydrogen maser.



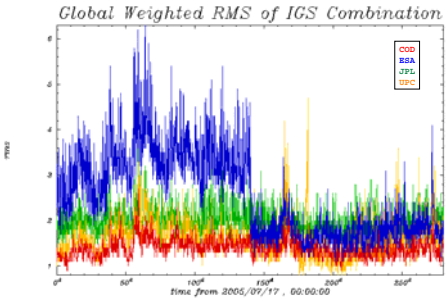




## Ionosphere Modelling Improvements since 2004

- TEC maps time resolution enhanced from 24 hours to 2 hours, higher time rates are possible.
- Spherical harmonics surface functions, Modified Single Layer Mapping Function and others.
- **The weekly combination results show that the ESA TEC maps are now at the same accuracy level as those of the other IAACs. (see Figure)**
- Since 2004: Contribution to the IGS Ionosphere rapid service.
- Since 2004: Weekly validations of final IAACs and combined IGS TEC maps with Envisat dual-frequency altimeter data.
- Routine processing of local TEC maps for the ESA tracking sites will commence soon.

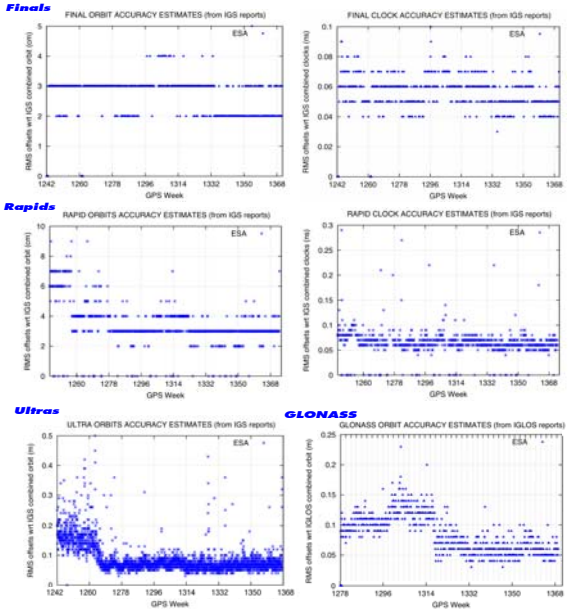
**Current developments**
3-d ionosphere model:
- Incorporating classical TEC data (GPS, Glonass, Galileo)
- Incorporating electron density data (Champ, Cosmic, Swarm, ionosondes)
- Modelling ionosphere as composed of several layers
- New profile functions, height dependent Scale Height, plasmasphere, etc

## Iono processing




esa OPS-GN

## POD processing




### Improvements in POD processing since 2004

- ☑ **Jul '04** : Implemented SRP Extended Force Model (EFM) with estimation by intervals, not just one estimation per batch process.
- ☑ **Aug '04** : Automatic exclusion of satellites being repositioned from Ultra-rapid processing.
- ☑ **Sep '04** : Increased number of integration steps per orbit from 120 to 720 to better estimate the enter/exit of eclipsing satellites.
- ☑ **Feb '05** : Implemented SRP ROCK + EFM in processing.
- ☑ **Jul '05** : Implemented new algorithms to improve detection of cycle-slips and removal of outliers in pre-processing.
- ☑ **Sep '05** : Lowered the elevation angle for double differences from 20º to 10º
- ☑ **Oct '05** : Implemented APC-COM offsets correctly for Glonass satellites.
- ☑ **Jan '06** : Implemented satellite-receiver specific intersystem biases in GLONASS processing, instead of the general GPS-GLO constellation biases used until now.

### Future Enhancements

The main activity for the future of the AC activities involves switching the IGS routine processing to the new tool **Napeos**, under final implementation and testing by the department (see section below).

ESA/ESOC will continue to contribute to all IGS products including the new Reprocessing effort which aims to reprocess all the IGS products in Final mode from 1994 to the present.

## NAPEOS processing

NAPEOS is the new software at ESOC which will be operational for all our IGS activities before the end of 2006. Some key features are:
- Written in Fortran 90
- Undifferenced processing
- Double difference ambiguity fixing based on undifferenced ambiguity estimates
- Normal Equation stacking
- Fully compliant to IERS 2003 conventions
- Fully compliant to the IGS standards
- Estimation of satellite dependent intersystem biases

Since November 2005 Napeos is being tested by routinely running an IGLOS like process.
Key features are:
- 100 GNSS stations
- 24 hour arc (no NEQ-stacking yet)
- No ambiguity fixing yet

Two solutions are regularly calculated
Solution 1: GPS orbits fixed but Glonass estimated
Solution 2: Everything estimated

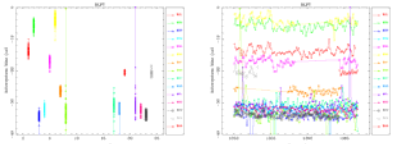
### NAPEOS Orbit Results

Comparing 1-day IGS orbit results with those from NAPEOS, CODE, and ESA to get an impression of the accuracy and also the reference frame stability (7-parameter transformation).

| | TX (m) | TY (m) | TZ (m) | RX (mas) | RY (mas) | RZ (mas) | Scale (ppm) | RMS (m) | MED (m) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean | -0.001 | -0.001 | 0.000 | -0.05 | 0.02 | 0.01 | 0.0002 | 0.016 | 0.010 | igs | cod |
| St.Dev | 0.001 | 0.001 | 0.004 | 0.02 | 0.02 | 0.03 | 0.0001 | 0.001 | 0.002 | | |
| Mean | -0.001 | -0.001 | -0.002 | -0.02 | 0.02 | 0.02 | -0.0003 | 0.026 | 0.016 | igs | esa |
| St.Dev | 0.002 | 0.002 | 0.004 | 0.07 | 0.06 | 0.06 | 0.0001 | 0.004 | 0.004 | | |
| Mean | 0.000 | 0.006 | 0.010 | 0.08 | -0.03 | -0.02 | 0.0002 | 0.049 | 0.030 | igs | napeos |
| St.Dev | 0.004 | 0.004 | 0.004 | 0.06 | 0.04 | 0.07 | 0.0001 | 0.005 | 0.007 | | |

**Conclusion**: The Napeos orbits are well aligned to the IGS orbits (no significant transformation parameters). The quality of the orbits is at the 49mm level which we expect to improve to the level of CODE once we can do integer ambiguity resolution and generate longer arcs with our normal equation stacking.

### NAPEOS Intersystem bias Estimates (for DLFT)




**Conclusion**: there are significant satellite specific biases in today's GNSS receivers. GNSS combined receivers tracking Glonass may be a "worst" case but similar effects may occur for other GNSS combinations, e.g., GPS and Galileo.

IGS Workshop 2006
Darmstadt, DE. 8th – 11th May, 2006.