Contribution of GPS to Earth Orientation Monitoring

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Summary

One of the main tasks of the IERS Earth Orientation Centre is to compute a long-term homogenous Earth Orientation Parameters (EOP) solution from the combination of the various astro-geodetic techniques.

The C04 series is the reference for various applications connected to reference frames metrology as well as for geophysical investigations.

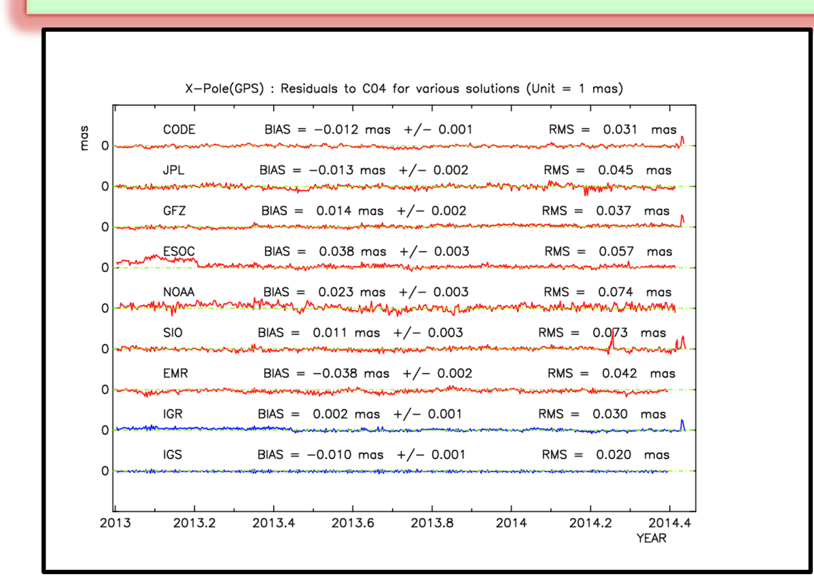
The combination task is not straightforward since techniques are different, evolving with time, and allowing to derive all or a part of Earth Orientation Parameters which are in addition affected by systematic errors at different time scales. UT1 and nutation offsets are mainly based on VLBI technique whereas pole components and LOD essentially rely on GPS products.

An alternative method of the current combination is based on a multitechnique combination at the level of observations in which EOP are simultaneously computed with the terrestrial reference frame. The strength of the method is the use of a set of identical up-to-date models and standards in a unique software. In addition the solution is taking advantage of the mutual constraints brought by the various techniques.

The IERS « C04 » solution

The 'C04' solution is an optimal combination of intra-technique solutions derived by the various Technique Centers, IGS, IVS, ILRS and IDS.

Polar motion series is mainly based on both final IGS and rapid IGR solutions whereas UT1 and nutation offsets are determined by VLBI techniques with some contribution of GPS. Figures below, show the differences of analysis centers and combined IGS and IGR with respect to the C04 for pole components and LOD over 1.5 years. Consistency between the various solutions is at the level of 40-50 mas,

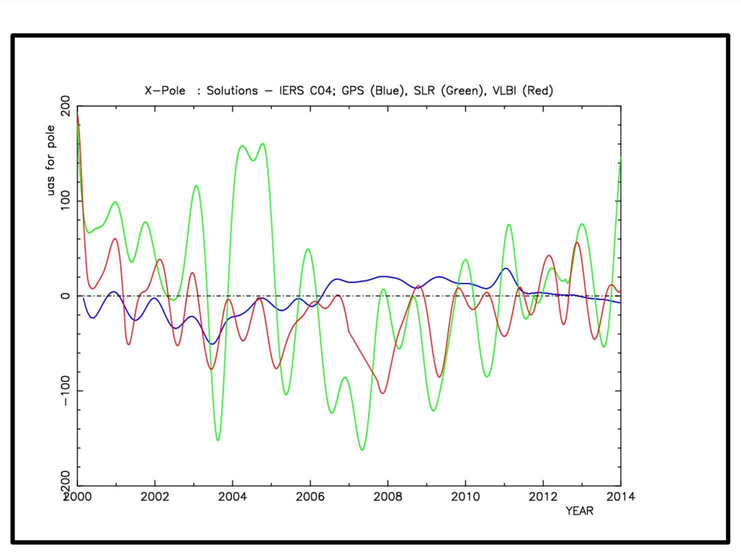


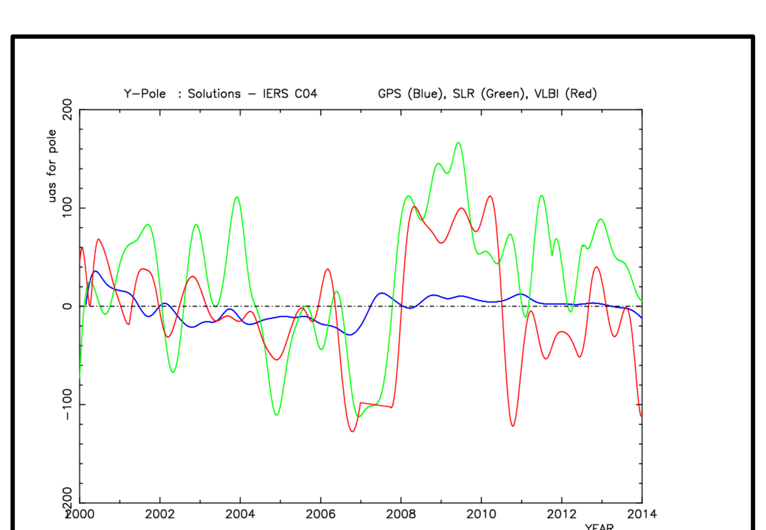
	RMS	BIAS
X-Pole	20 µas	13 µas
Y-Pole	23 µas	10 µas
LOD	2 µs	7µs

Statistics of the differences IGS – C04

Long-term stability

The high weight attributed to the combined IGS solution in the C04 leads to a fair agreement between both solutions. However possible long-term systematic variations in the IGS affect the long-term C04. This is apparent on the Figures below showing differences in the long-term variations over some intervals for which there is a good agreement between IVS and ILRS solution which may point out the systematic effects of the IGS solution at the level of 100 µas,





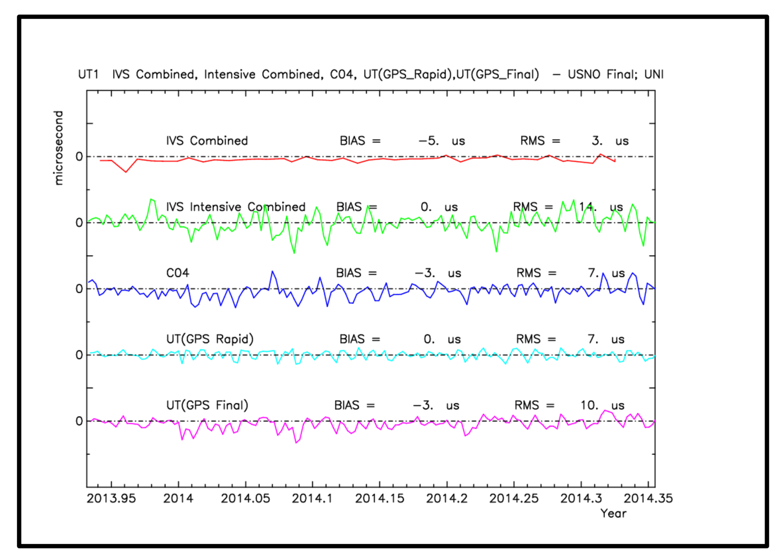
Contribution of GPS to UT1

VLBI is the only inertial technique able to derive UT1 on a regular basis and with a good accuracy. The celestial frame realized by satellite techniques is affected by systematic effects linked to deficiencies in the modelling of the orbit node. That prevents satellite techniques to accurately derive UT1.

However, satellite techniques and GNSS in particular can provide accurate estimates of LOD which can give valuable information on the short term variations of UT1. The Earth orientation Center currently makes use of the LOD(GPS) series, integrated, corrected for the systematic drift and calibrated by the IVS solution to give a so called « UT(GPS) » solution.

The Figure below shows differences of various UT1 solutions with an independant reference series, i.e. the final Bulletin A series derived by the rapid service and prediction service.

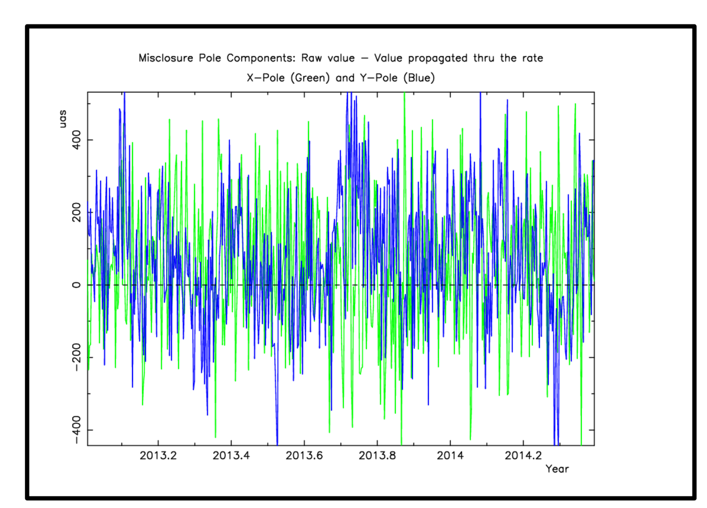
It appears that UT(GPS) is significantly less noisy than the IVS intensive combined solution. UT(GPS) is entering the C04 solution with a significant weight, contributing to a fair regularization in the stability of the C04.

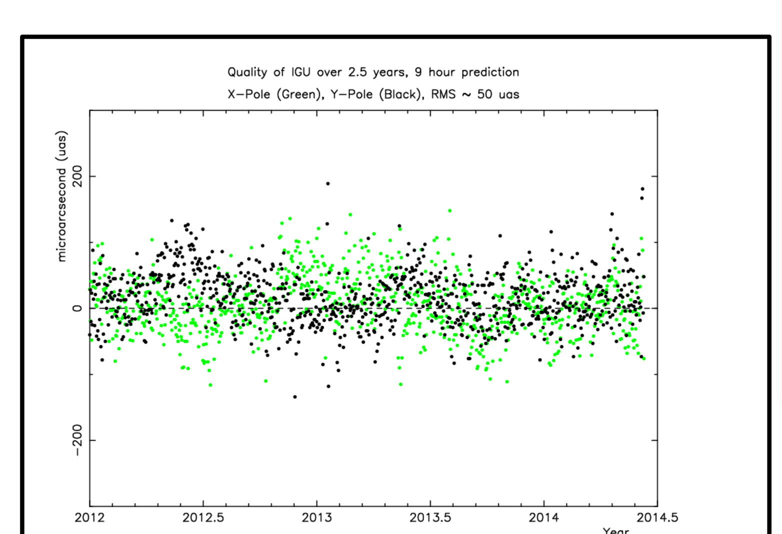


IVS Combined : main UT1 VLBI series based on R1 and R4 sessions
IVS Intensive : internal combination of VLBI intensive series
UT(GPS_rapid): internal UT series based on LOD(IGR) integrated and calibrated by IVS series
UT(GPS_final): internal UT series based on LOD(IGS) integrated and calibrated by the long-term IVS UT1 series

Polar motion rate

The pole rates are derived by the individual IGS analysis centers and there are available in the IGS combination. They are not currently used in the C04 combination for interpolation according to previous studies. The Figure below shows recent results obtained. It shows a misclosure at the level of 100 to 200 µas for both pole components when estimates given at 12h are transported to the next day. Using the pole rates leads a degradation of the pole components accuracies.





IGU for real time prediction

The Ultra-rapid EOP solution (IGU) is available for real time and near real time use. The Ultra-rapid products are released four times per day, at 03:00, 09:00, 15:00, and 21:00 UTC. The Figure shows the difference of the 9 hour IGU prediction compared to definitive C04 estimates. The accuracy is at the level of 50 µas. The IGU pole components are now used for real-time applications.

Combination of Space Geodetic Techniques at the Observation Level

Earth Orientation variations are monitored by different astro-geodetic techniques: VLBI, satellite and lunar laser tracking, DORIS and GNSS.

These techniques have strengths and weaknesses for recovering geodetic (earth orientation parameters, station positions) and other parameters (zenithal troposphere delay ZTD)

Combinations are made at the level of normal equations (NEQs).

The strength of the method is the use of a set of identical up-to-date models and standards adopted by the different softwares. In addition the solution benefits from mutual constraints brought by the various techniques.

A Working Group (COL-WG) was set up in 2009 in the frame of the IERS to review the interest in combining techniques at the level of observations.

Its main objective is to bring together groups from various countries able to do combinations at the observation level in order to improve the accuracy, the time resolution and the overall consistency of the products.

Strategy

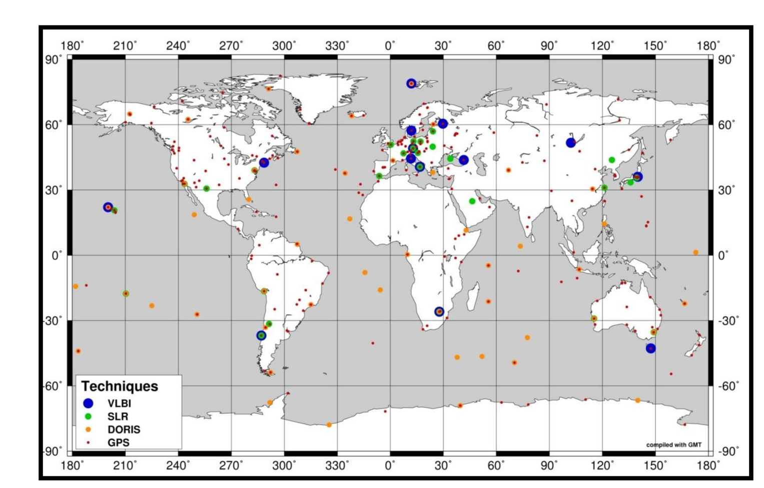
Observations of the different techniques are separately processed at each analysis centres. Weekly datum-free unconstrained normal equations are derived in the processing,

Combination of the Normal Equations, the different steps:

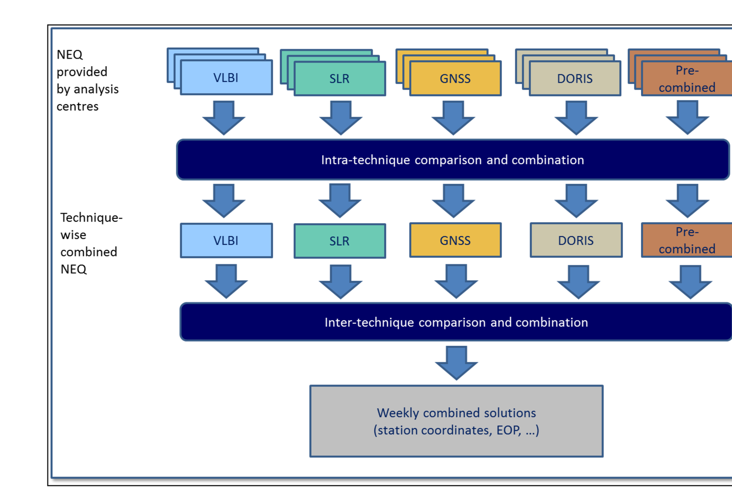
Normal equations are reduced to the selected parameters.

Weekly normal equations of the different techniques are weighted and stacked to generate a global weekly normal equation.

The global normal equation is inverted using different constraints



Station networks



Combination procedure for weekly combined solutions

Participation to the ITRF2013 project

The next realization of ITRF, ITRF2013 is expected to be achieved in 2014. Calling participation mainly concerns technical centers associated with geodetic techniques (IVS, ILRS, IDS, IGS). The results for combinations multi-technical level of the normal equations will not directly contribute to the combination of ITRF2013 but will be compared and assessed in a second time. The Groupe de Recherche de Géodésie Spatiale (GRGS) is organized to participate in this project. Data of all geodetic techniques (LLR included) are expected to be processed over 12 years using the GINS software. DORIS and GPS processings are part of respectively the IDS and IGS contributions for the ITRF2013 (by CNES/CLS). SLR data are separately processed from ILRS (by IMCCE) because of different modeling required. VLBI is being processed at the Observatoire de Bordeaux,