Satellite Precise Orbit Determination Using Real Time Service products

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Introduction — Toward a faster Precise Orbit Determination (POD) for LEO satellites using GPS data

- CNES POD team computes two different orbits for altimetry satellites :
  - MOE (Medium precision Orbit Ephemeris) : low-latency orbit, computed on a daily basis, accuracy of less than 2cm on the radial component
  - POE (Precise Orbit Ephemeris) : reference orbit, computed within a month, accuracy of less than 1cm on the radial component, using several types of measurement : DORIS, laser (and GPS when available)
- A good illustration of the usefulness of such altimetry projects is their decisive participation to the IPCC work on global warming. Such scientific applications have a constant need to get the products as early as possible (preferably as soon as the altimeter telemetry is available). Standard rapid or ultra-rapid IGS products do not suit, because their latency is too high, which is why MOE orbits only use DORIS measurements until now.
- IGS Real-Time Service products perfectly suit these needs and are freely available. This study assesses the quality of Jason-2 POD using IGS Real-Time Service products.

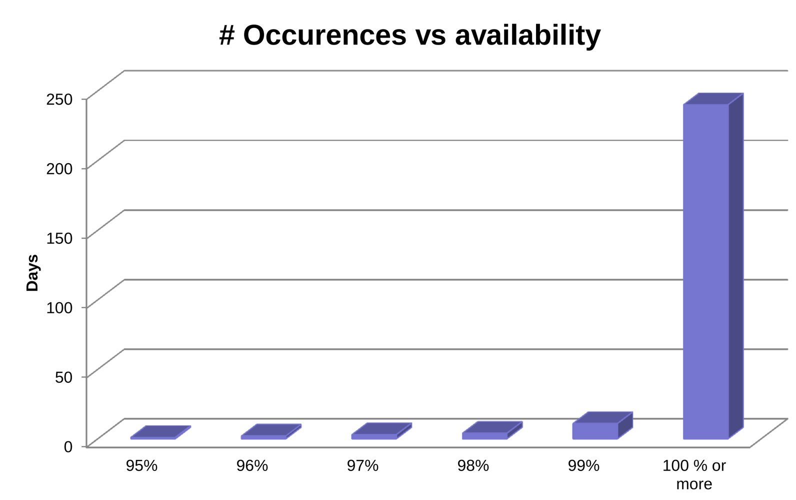
Background — About MOE

- MOE delivered on day D+1 contains the estimated orbit of day D, plus some extrapolated orbit depending on the mission
- Traditional MOE
  - Until now, only DORIS measurements are used to estimate MOE. But using different types of measurement ensures more robustness and redundancy. It also enables cross-comparison.
- GPS products were not available soon enough to be used in the computation of MOE
  - Jason 2 : MOE of day D is to be delivered on day D+1 at 8h TU
  - Sentinel 3 : MOE of day D is to be delivered on day D+1 at 12h TU
  - Therefore GPS orbits and clocks must be available on day D+1 at 6h TU at the latest
- Some recently created GPS products meet these requirements
  - SGU (IGN ultra-rapid solution, low latency)
  - RTS (Real time IGS solution)
- RTS MOE: MOE computed using RTS products

RTS products

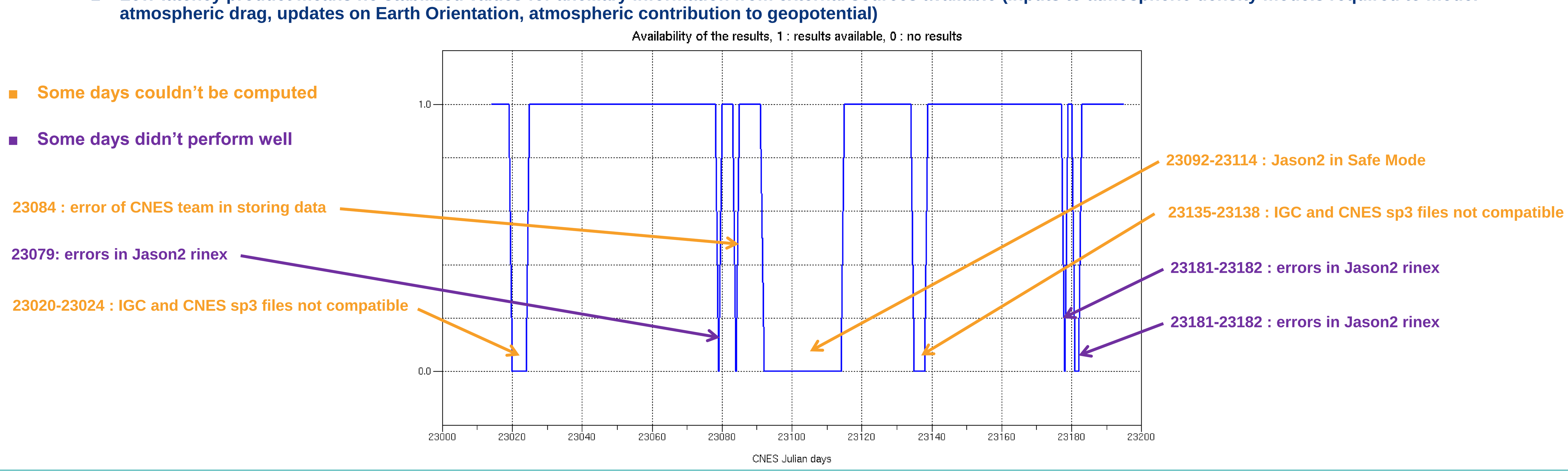
- Real-Time service
  - Provides clocks and orbits in real time
  - Dissemination using RTCM standard
  - Production by several analysis centers
  - Combination of the different centers products
  - Official service since summer 2013
- CNES is one of the analysis centers IGS RT since 2011
  - Produces orbits and clocks for GPS and Glonass
  - Phase biases for ambiguity resolution on GPS available thanks to new proposed RTCM message type

- We have used the RTS combination
  - IGC, courtesy RT analysis center coordinator
  - 6 month study
  - When combination not available : CNES solution
    - happened 4 times over 189 days computed
  - Availability of 99.8%
    - Period with more than 25 GPS satellites in the solution



Context

- RTS MOE was computed every day from January 4, 2013 to July 4, 2013 (6 months) on Jason 2 satellite
- Low-latency product means no stabilized values for ancillary information from external sources available (inputs to atmospheric density models required to model atmospheric drag, updates on Earth Orientation, atmospheric contribution to geopotential)

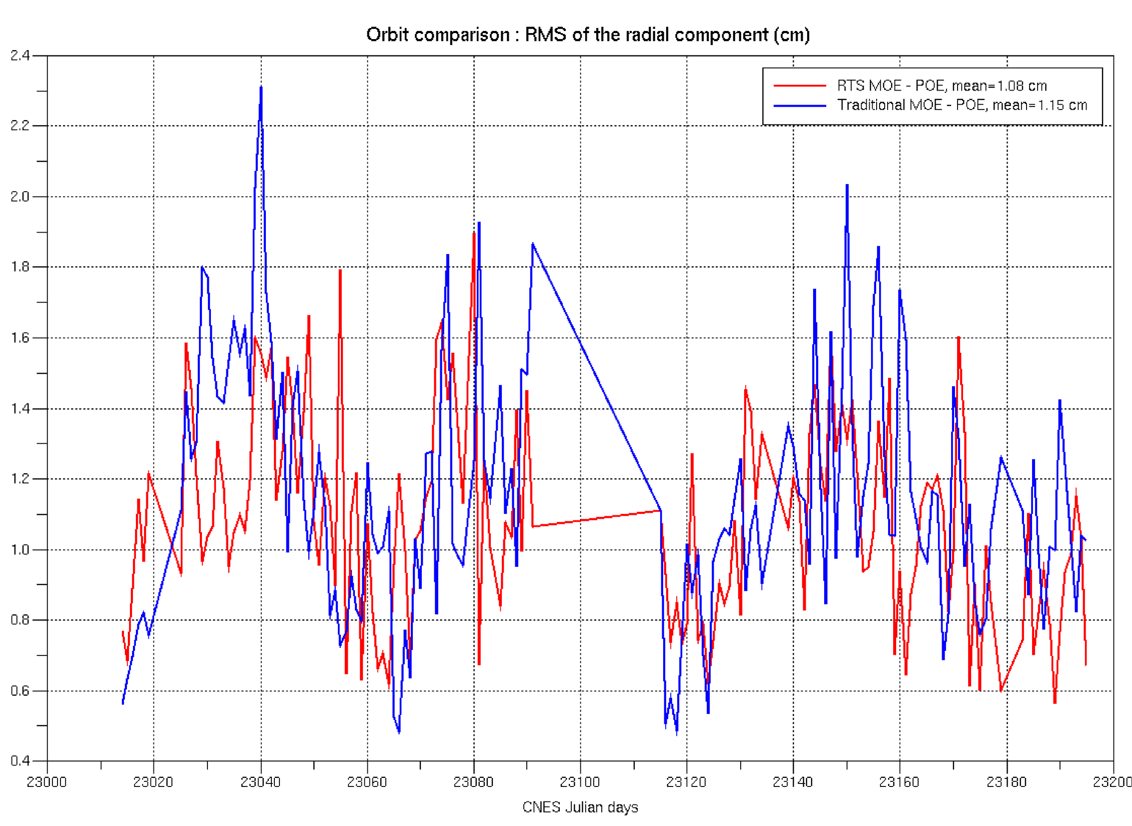


- Models used (GDRD standard) [2] :

Settings	Comment
Static gravity field	EIGEN-GRGS_RL02bis_MEAN-FIELD
Time varying gravity field	Drift+Annual+Semiannual 50x50
3rd body gravity	Analytical series expansions of luni-solar coordinates and planets
Solid Earth tides	IERS 2003
Ocean tides	FES 2004
Earth radiation	Knocke-Ries albedo and IR model
Polar motion	IERS
Satellite model	Box and wings model
Direct Solar radiation pressure	Fixed
Atmospheric drag	DTM94 density model, solar activity from NOAA (daily 10.7 cm solar flux) and geomagnetic activity from GFZ (3-hour planetary Kp-index)
Atmospheric gravity	NCEP-derived 20x20 field at 6 hrs interval (AGRA service at GSFC)
Empirical forces	tangent and cross-track once per revolution every 12 hrs, tangent constant every 3,7 hrs (2 orbits)
Measurements	ionosphere-free combination for pseudo-range and phase, 300-second sampling, one floating ambiguity per pass
GPS orbits and clocks	Reference orbits are taken from JPL. Clocks are floating, JPL GPS maps used
GPS antenna maps	JPL maps extended to 17°
Problem parameters	6 orbital components, drag coefficients, hill coefficients, stochastic clocks at each epoch

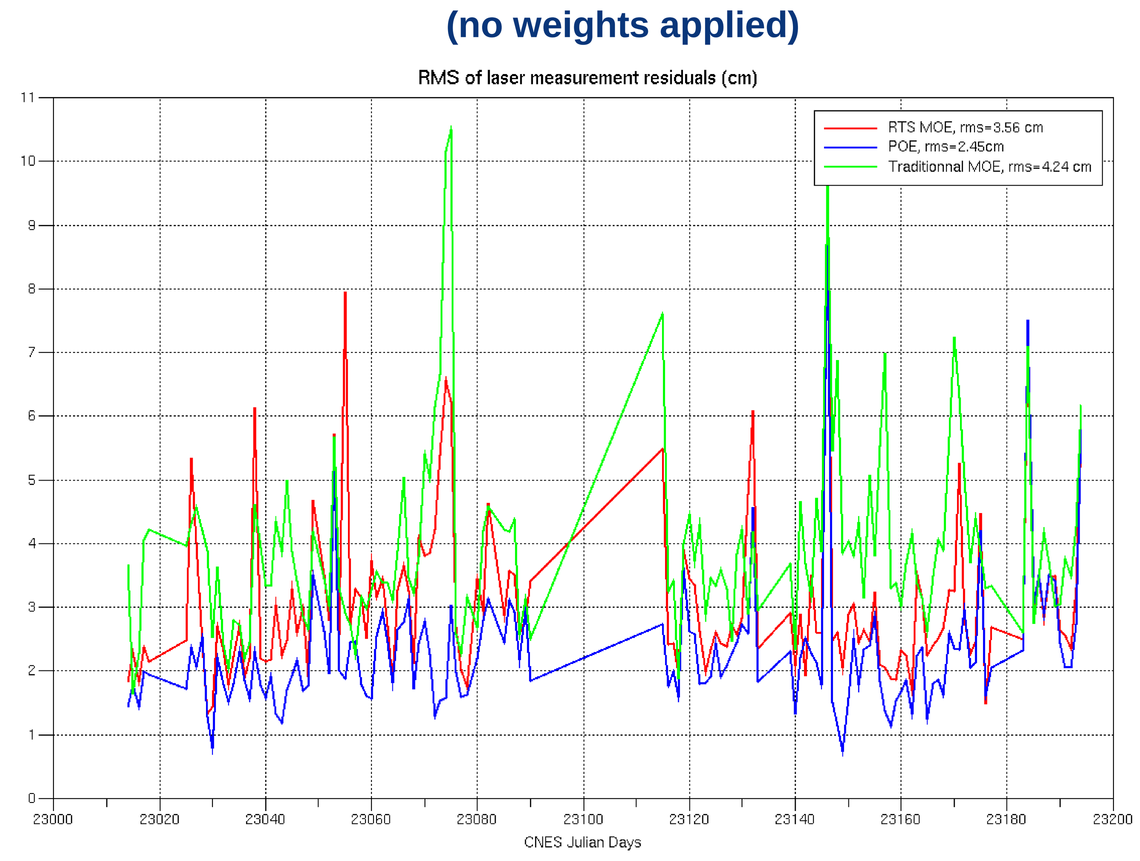
Results (comparison and independent validation)

MOE orbits comparison to POE



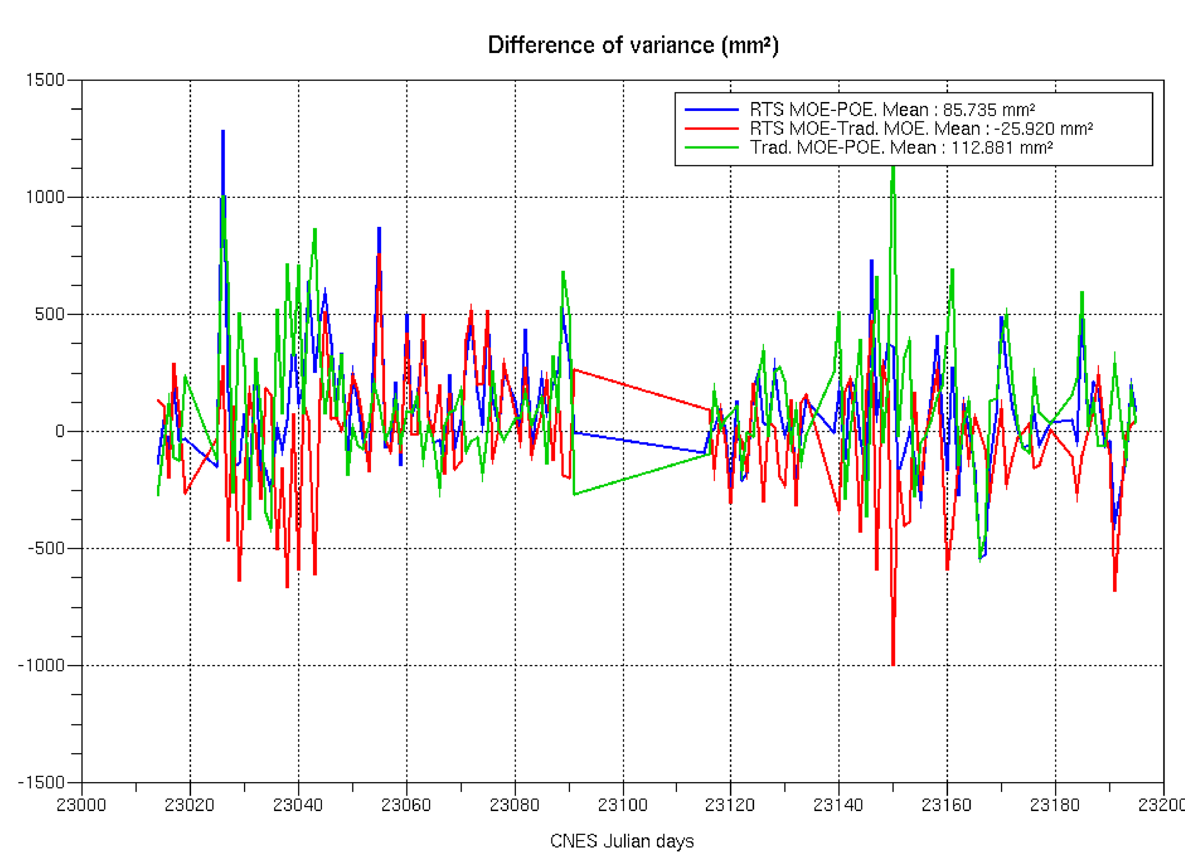
- RTS MOE performs as well as traditional MOE

Laser RMS of the measurement residuals (no weights applied)



- RTS MOE has lower RMS of laser residuals than the traditional MOE.
- As expected, POE has the best results.

Crossover residuals



- Negative value means improvement.
- RTS MOE has lower crossover points residuals than the traditional MOE.
- As expected, POE has the best results.

References

1. M. Caissy and al. « "The International GNSS Real-Time Service", GPS World, June 2012»
2. J.-P. Dumont, V. Rosmorduc, N. Picot et al., « OSTM/Jason 2 Products Handbook », 29-31, 2011
3. Cerri, L. and al .(2010) 'Precision Orbit Determination Standards for the Jason Series of Altimeter Missions', Marine Geodesy, 33: 1, pp 379 — 418