Session III – CAL/VAL Part I

# SARAL POD Status

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# POD Standards

## Towards the Geophysical Data Records (GDR) version E standards

- **GDR-D Precision Orbit Determination (POD) standards** are applied in the SARAL operational processing since March 14, 2013 (start of cycle 1)
- 2014 (TBD): **GDR-E standards (currently being defined)**

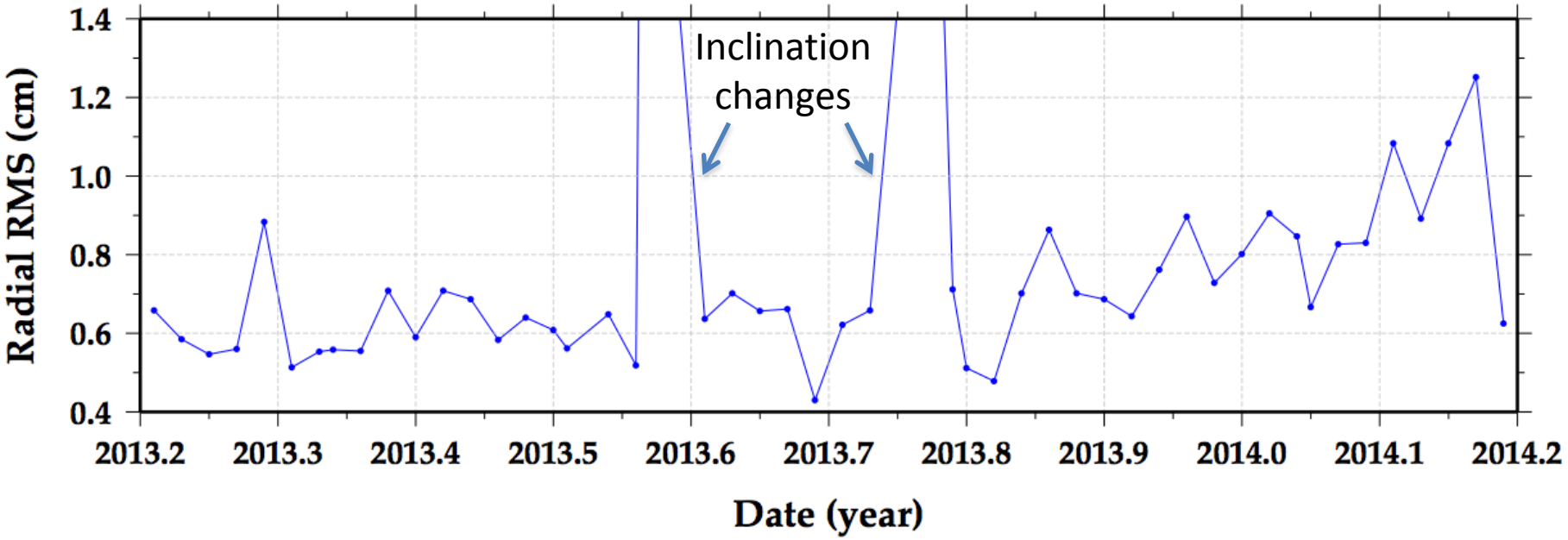
# MOE/POE Events

## Maneuvers affecting the Medium precision Orbit Ephemerides (MOE) and Precise Orbit Ephemerides (POE)

- **2013/07/29:** Orbital inclination change
  - Arc 20 (cycle 4) impacted
- **2013/10/03:** Orbital inclination change
- **2013/10/07:** Orbital inclination change
  - Arcs 29 and 30 (cycle 6) impacted

# MOE Status

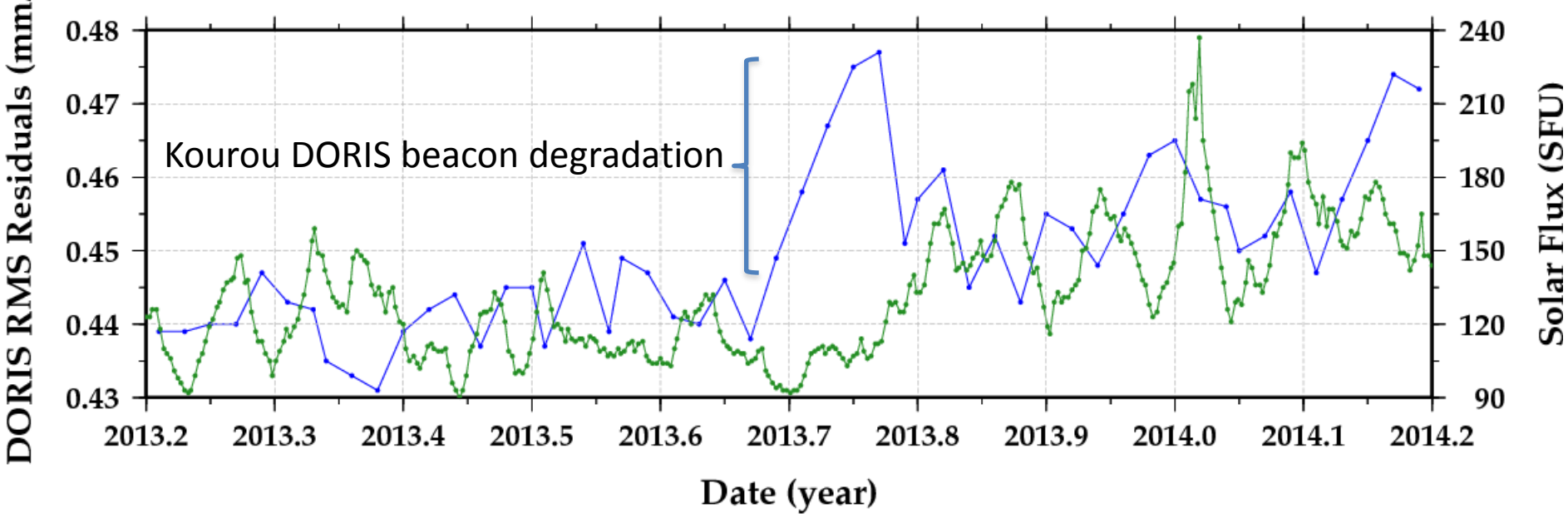
## RMS of radial orbit differences between POE and MOE




- **Differences between MOE and POE orbits are generally well below 1 cm RMS** (outside inclination maneuvers)
- MOE and POE orbits are calculated with very similar model assumptions

# POE: Performance of the Tracking Systems
## *DORIS Measurements*

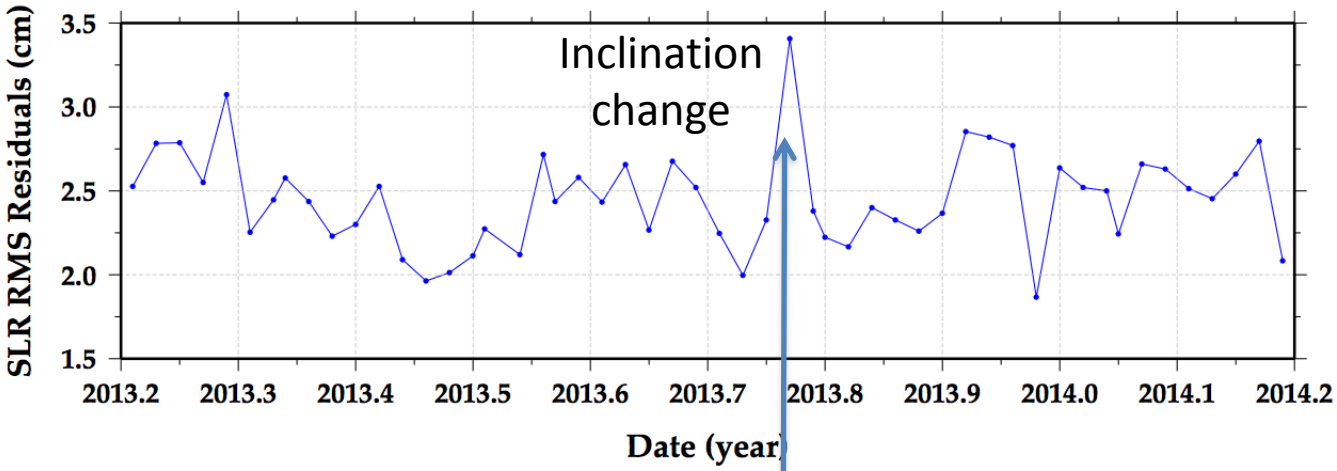
### RMS of DORIS post-fit residuals



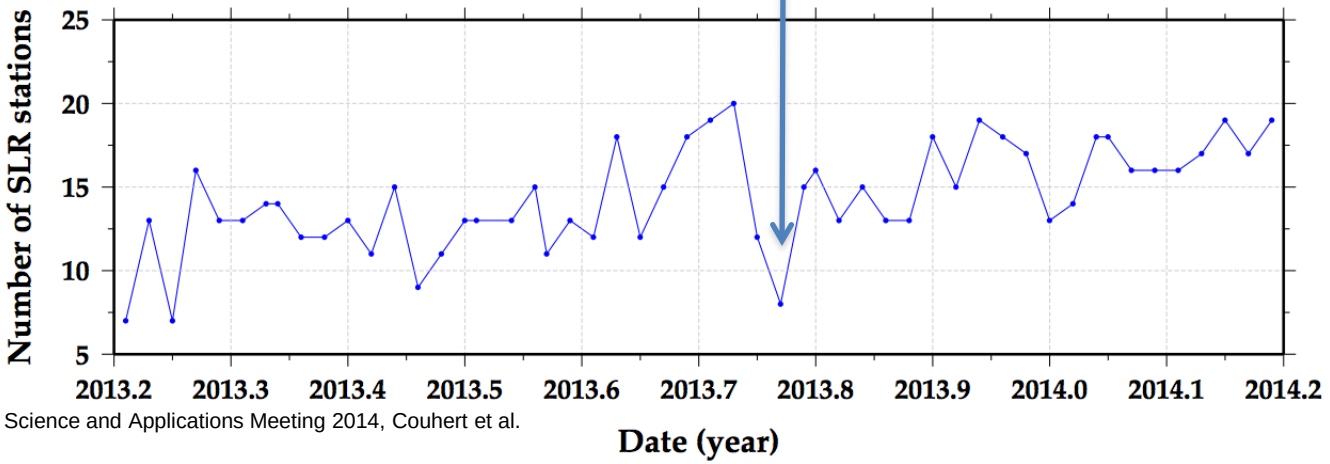

- DORIS RMS residuals slightly increased after October 2013
- It seems to be the **effect of increasing solar activity**

# POE: Performance of the Tracking Systems
## *SLR Measurements*

RMS of SLR post-fit residuals, all stations included

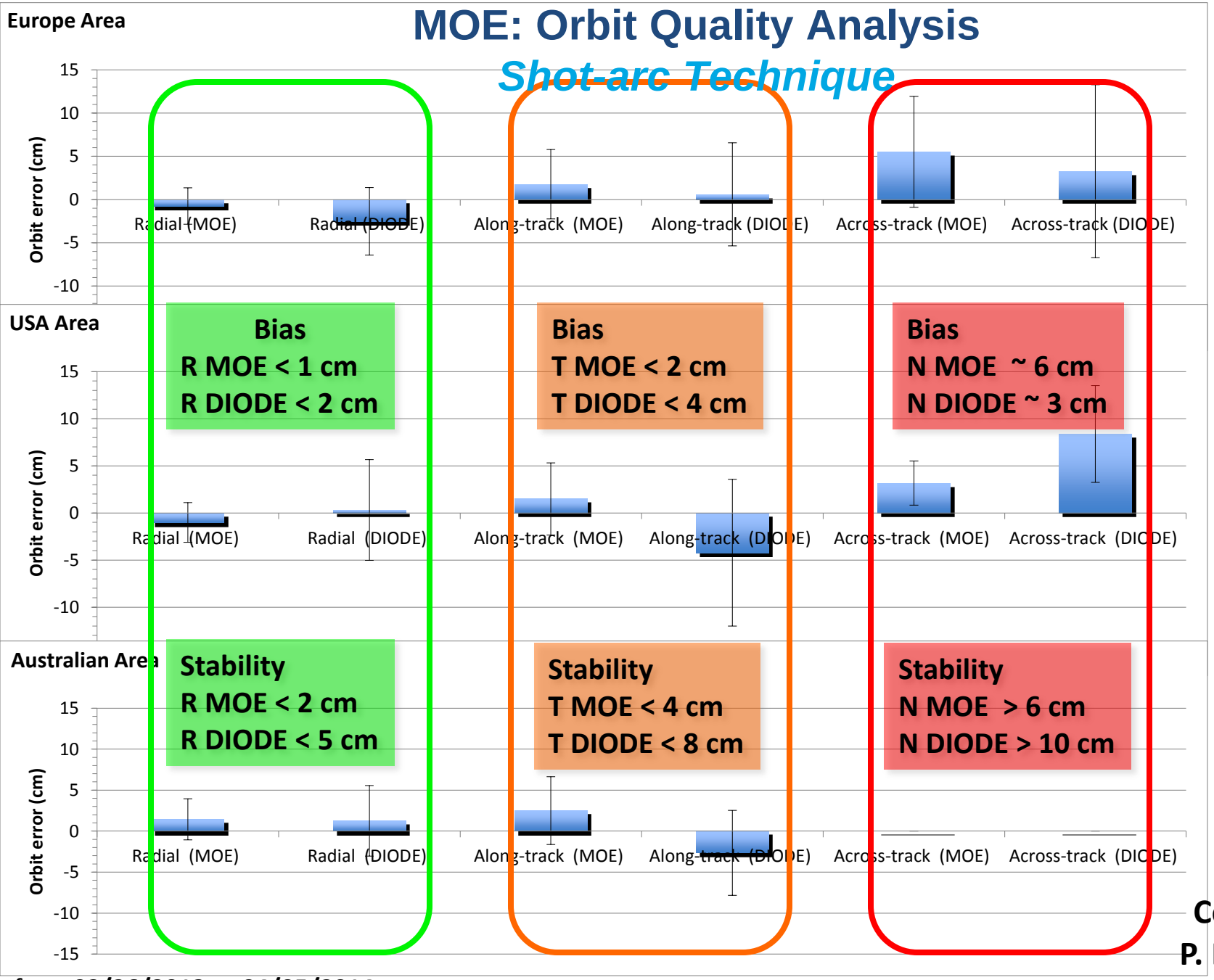



- **RMS of SLR residuals is stable** (close to 2.0 cm) throughout the 1-year time span of the mission and tracking is getting comparable to ENVISAT's



# MOE: Orbit Quality Analysis

## *Shot-arc Technique*



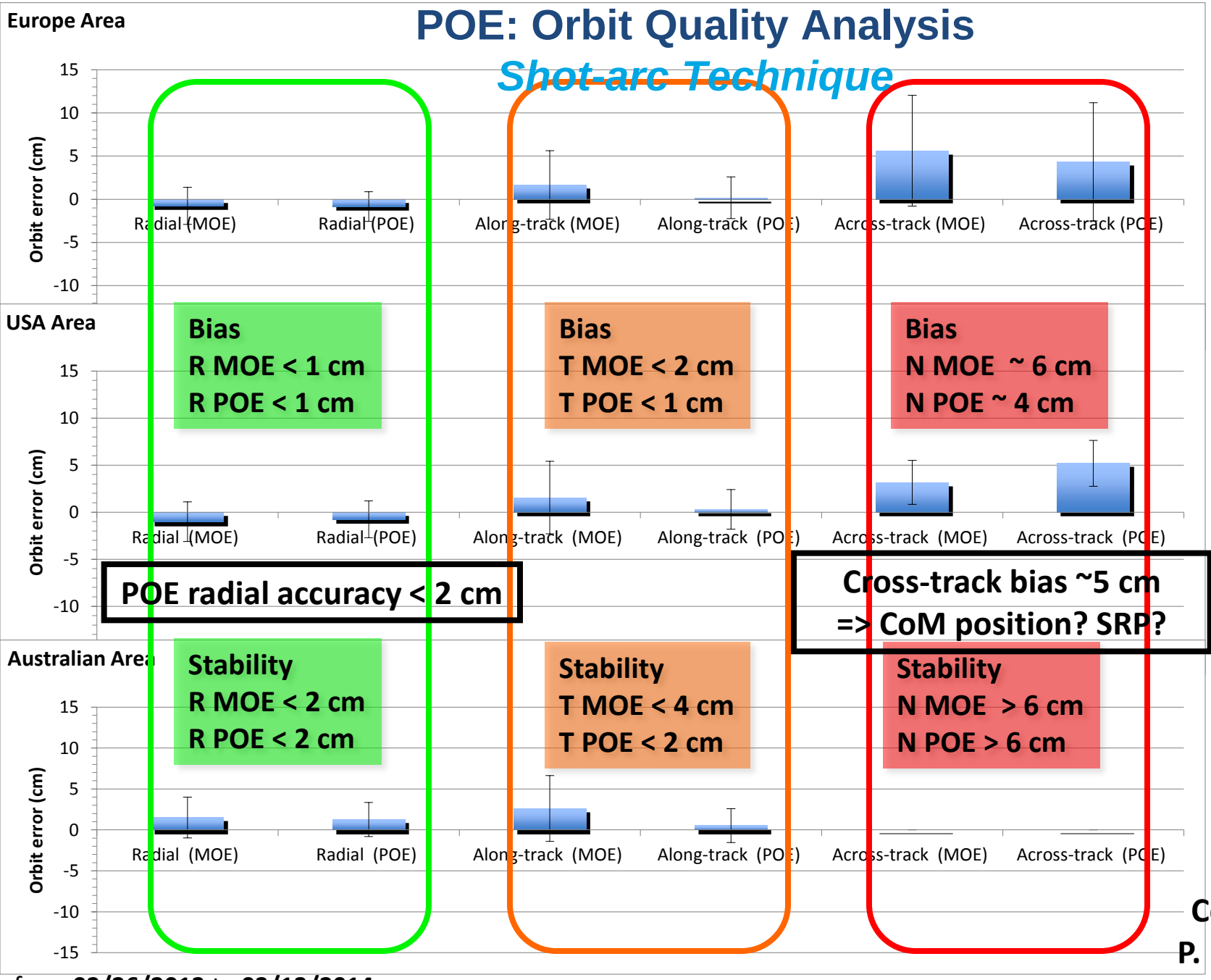

ORBIT ERRORS MOE/DIODE

Courtesy of
P. Bonnefond

from **02/26/2013** to **04/05/2014**

# POE: Orbit Quality Analysis

## *Shot-arc Technique*




ORBIT ERRORS MOE/POE

Courtesy of
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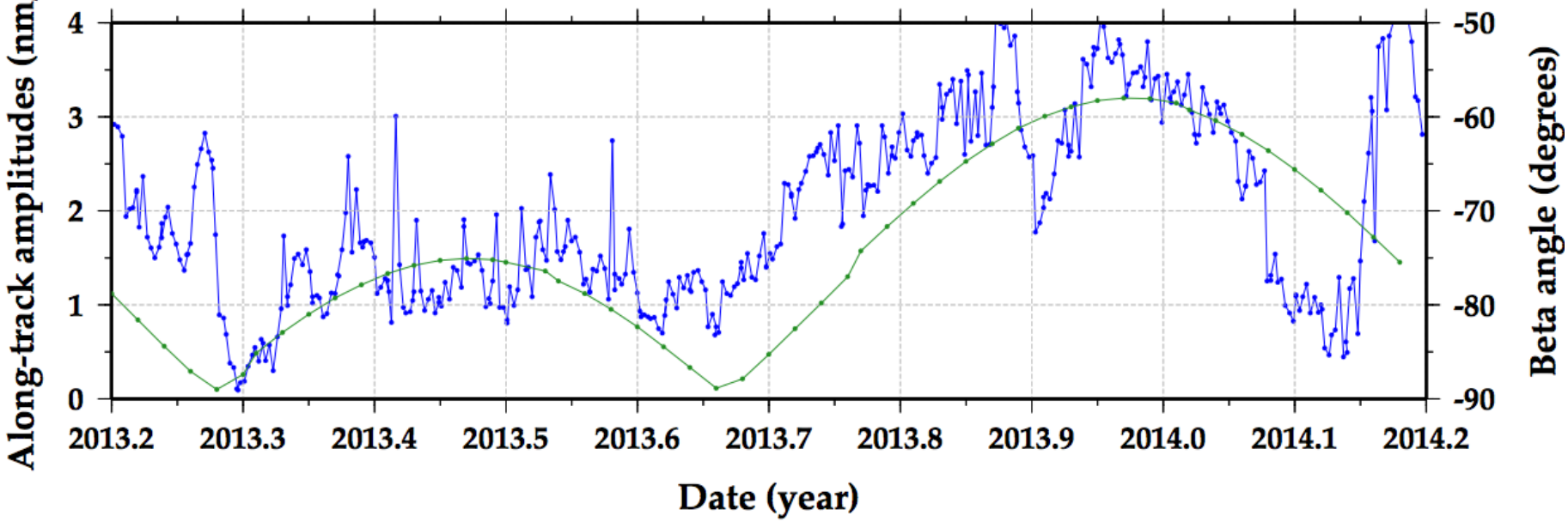
from **02/26/2013** to **03/13/2014**

# POE: Orbit Quality Analysis
## *1-cpr Empirical Accelerations*

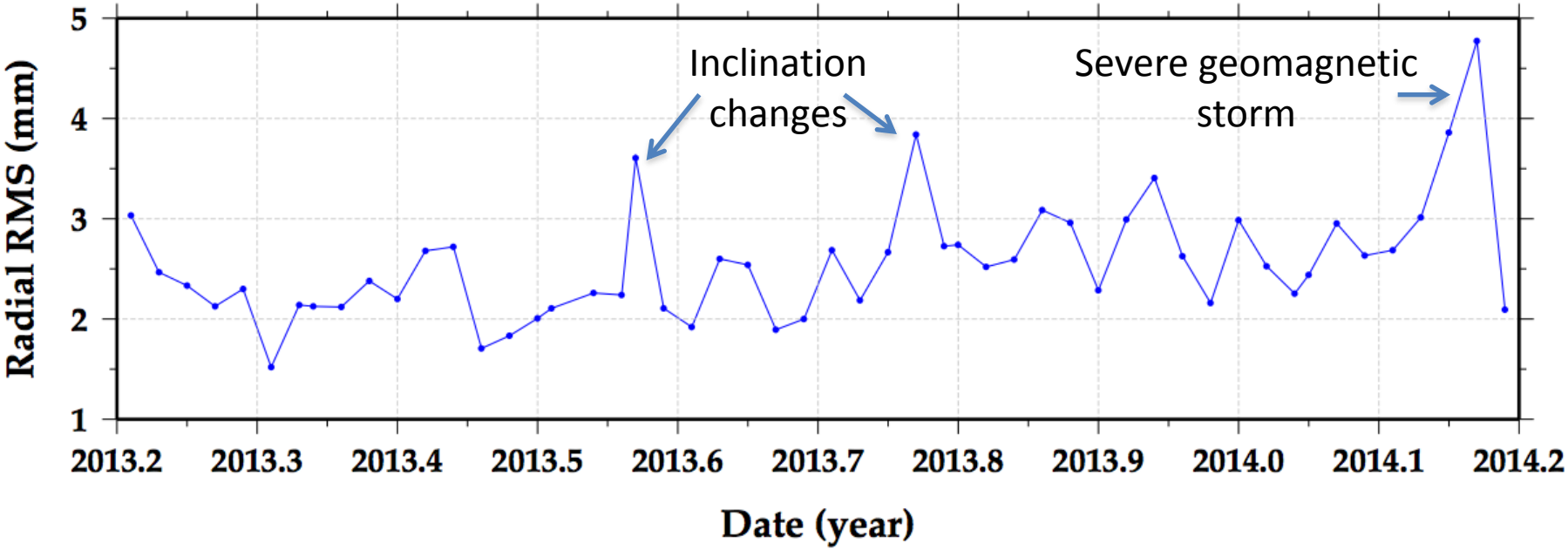
Amplitude estimated 1-cpr empirical accelerations along-track




- Beta-dependent patterns reveal unmodeled Solar Radiation Pressure (SRP) effects **=> Improvements (by calibration) expected in the next GDR-E POD standards**, now a complete beta prime cycle (~1 year) is available

# POE: Orbit Quality Analysis
## *Internal Orbit Comparison*

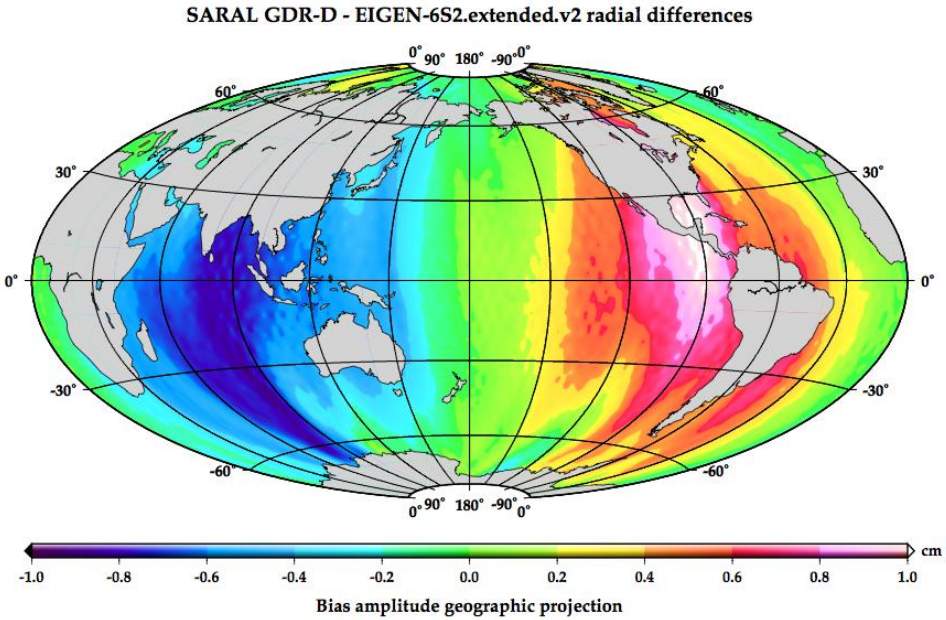
RMS of radial orbit differences between final POE and intermediate dynamic DORIS+SLR orbit




- **The stochastic process added in final POE orbits accommodates modeling errors in the order of 2-3 mm RMS** (especially during high levels of solar and geomagnetic activity)

# POE: Time Varying Gravity Effects

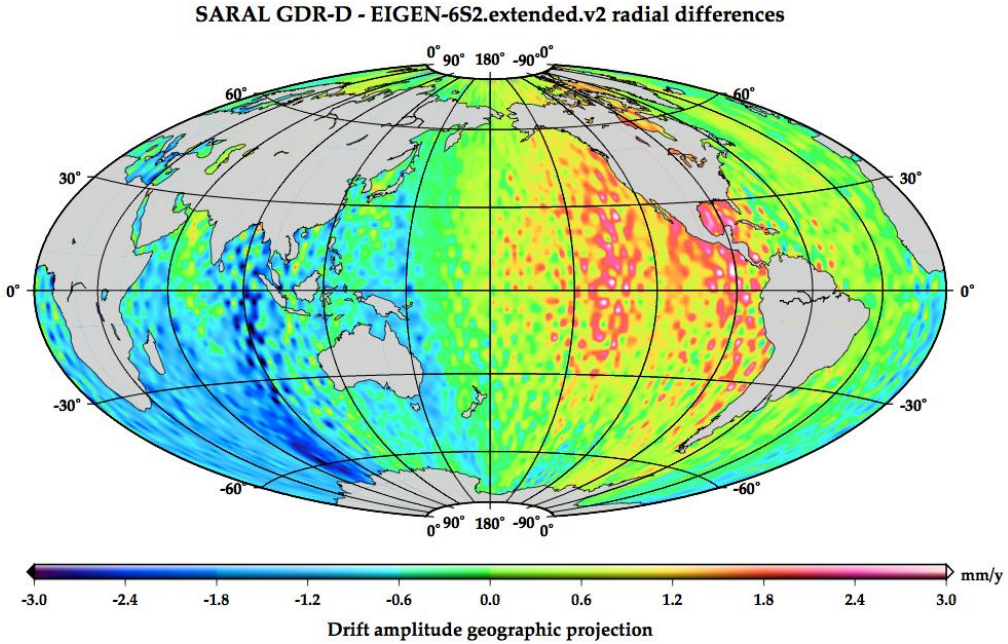
Mean geographically correlated radial differences between POE and the same orbit using an updated mean gravity field model




- EIGEN-6S2.extended.v2: mean field proposed for the ITRF2013 analysis
- **TVG-induced orbit errors map mainly into a longitudinal "order-1" pattern (< 1 cm)**, that could impact tide gauge calibration analysis

# POE: Time Varying Gravity Effects

Linear rates of the radial orbit differences between POE and the same orbit using an updated mean gravity field model




- Residual radial orbit differences exhibit geographically correlated drifts below 3 mm/y over the 1-year lifespan of the SARAL mission
  **=> Improvements expected (by update) in the next GDR-E standards**

# Prospects for Next GDR-E Standards

## Measurement models

- **Terrestrial Reference Frame and Earth Orientation**
  - ITRF2013 based (DORIS, SLR, GPS: ITRF2008 -> ITRF2013)
  - Earth orientation: IERS2010/ITRF2008 -> IERS2010/ITRF2013
- **Displacements of reference points**
  - Ocean loading (FES2004 -> FES2012)
  - S1-S2 atmospheric pressure loading, implementation of Ray & Ponte (2003) by van Dam
- **Orbits around the center-of-mass of the total Earth system**
  - Seasonal non-tidal geocenter motion (“Climatological model” SLR-only; from J. Ries)
  - Ocean tidal geocenter motion + S1-S2 atmospheric tidal geocenter motion
- **Models for propagation delays**
  - DORIS beacons phase correction

# Prospects for Next GDR-E Standards

## Dynamic models

- **Geopotential**
  - EIGEN-GRGS.RL02bis.MEAN-FIELD (based on 8 years of GRACE/LAGEOS RL02 data, static field, time-variable terms up to degree and order 50: annual, semi-annual and drift terms) -> EIGEN_03series (based on 11 years of GRACE/LAGEOS RL03 data, GRACE+GOCE static field, time-variable terms up to degree and order 80: annual, semi-annual terms, one bias and drift for each year) => accounts for interannual variability)
  - C21/S21 modelled according to the IERS 2010 Conventions
  - Ocean tides: FES2004 -> FES2012
- **Surface forces**
  - Calibrated semi-empirical solar radiation pressure models
  - Drag from atmospheric density model: DTM-94 -> DTM-2013
- **Estimated dynamical parameters**
  - Tuning of empirical accelerations and 1st order Markov process

# Conclusion

- **POE/MOE radial orbit error below 2 cm RMS** and stable throughout the mission
- **Cross-track bias (~5 cm)** of unknown origin (Z CoM offset or bias in SRP model cannot be distinguished) and **TVG mismodeling errors (< 1 cm)** are expected to be **reduced in the next GDR-E standards**

- Orbits reprocessing tentative schedule
  - **End of July 2014:**
    - GDR-E standards are finalized and implemented in CNES POD software
    - Operational orbits remain in GDR-D standards
    - GDR-E reprocessing will start at the same time
  - **October 2014:**
    - Results obtained using the available GDR-E orbits are presented at next OSTST, a change towards the GDR-E standards will be proposed to the science community
  - **December 2014:**
    - Operational orbits switch to GDR-E, reprocessed GDR-E orbits are made available, GDR-D standards are abandoned

# Backups

# Orbit Quality Analysis Through Short-arc Technique

**SLR data:**

Number of normal points increased since the first months (from 33 to 53 NP/day over Europe)
Remains low in average for USA (~22 NP/day) and Australia (~35 NP/day)

**Radial orbit errors:**

Stability better than 2 cm for MOE and POE
Stability better than 4 cm for DIODE
Small geographically correlated errors (below 1 cm for MOE and POE, 2 cm for DIODE)
Maybe a small hemispheric effect: -8 mm (Europe/USA) / +13 mm (Australia)

**Along-track orbit errors:**

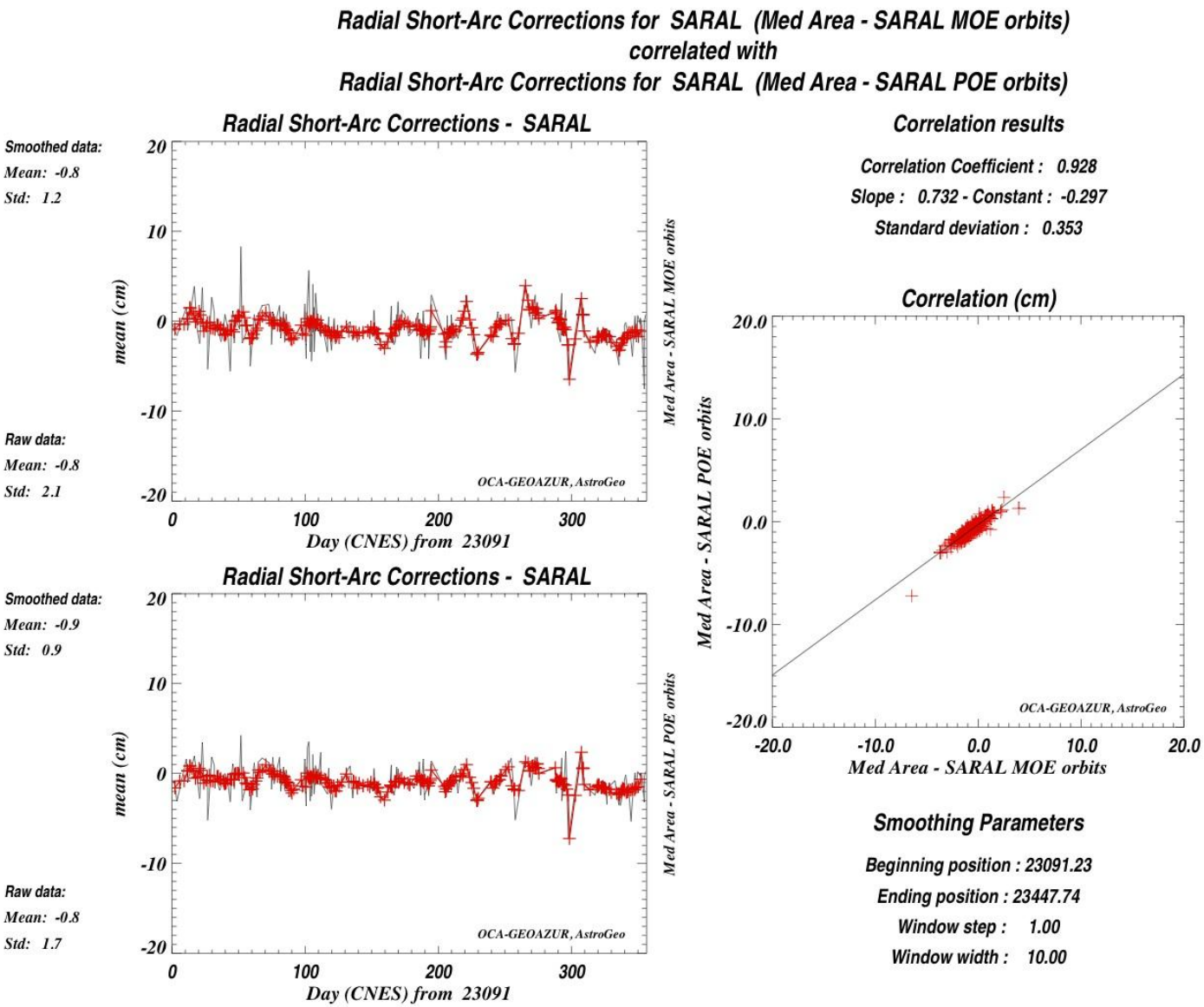
Stability better than 2 cm for POE
Stability better than 4 cm for MOE
Stability better than 8 cm for DIODE

**Across-track orbit errors:**

A large bias of ~5 cm for both POE (4 cm), MOE (6 cm) and DIODE (3 cm)
also large standard deviation (6-10 cm)
Instrument referencing (CoM position)? Correlation with beta angle (Radiation pressure)?

**Orbit precision is very close for both MOE and POE**
**Especially for the radial component: Correlation = 93% / Slope = 0.7**

Courtesy of
P. Bonnefond

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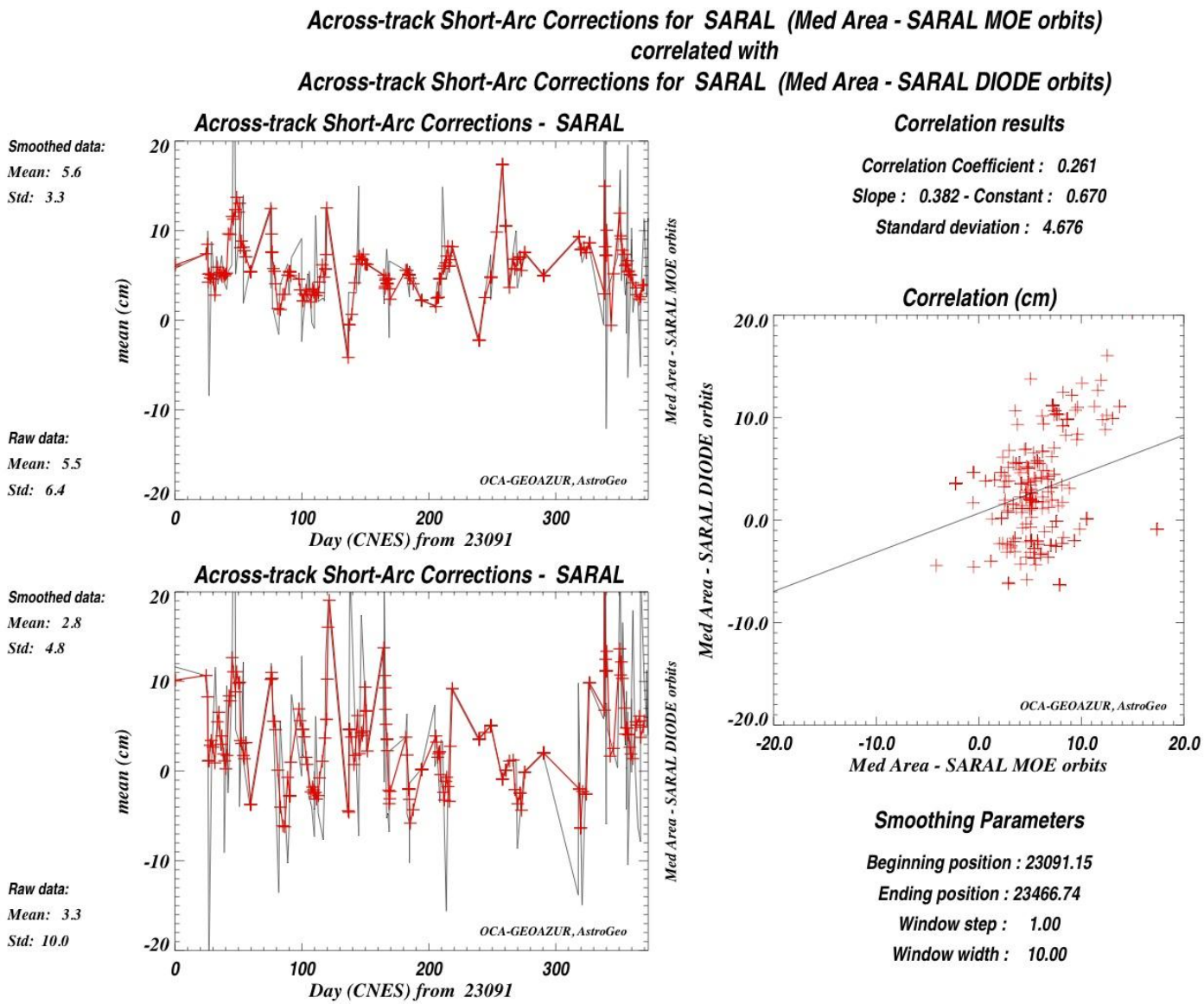


**Courtesy of P. Bonnefond**