Sentinel 3 USO observation with GNSS

F. Mercier, CNES DCT/SB/OR

S3A Doris USO observation

Summary :

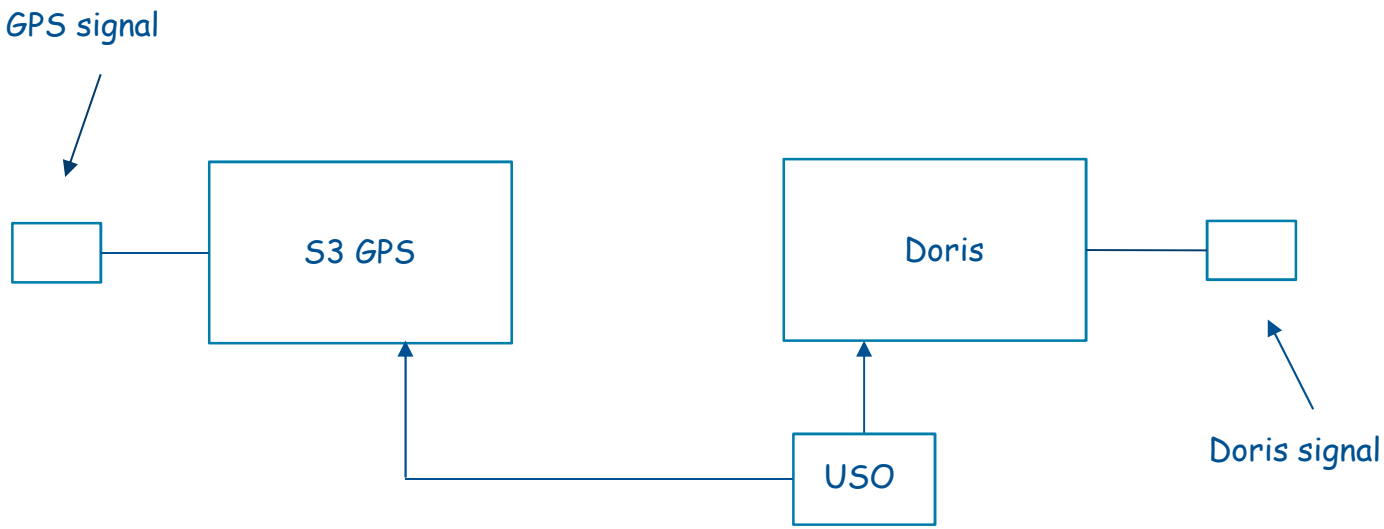
- S3A configuration
  - USO observation using GNSS
  - ground tests results
- first flight results
- observed characteristics
  - high frequency anomaly in the observed USO data
  - evolution during a Doris pass, observation of the SAA effect
  - consequences on Doris performance

S3A satellite

USO monitoring for altimetry

Sentinel 3 : USO reference frequency must be characterized using the S3 GPS receiver

(usually Doris is used for this, cf Jason, Cryosat, Saral)



USO monitoring :

Doris : pseudo range measurements, synchronization, mean term frequency identification (degree 3 polynomial fitting on 2 days), delivery of mean observed frequency on each reference beacon pass.

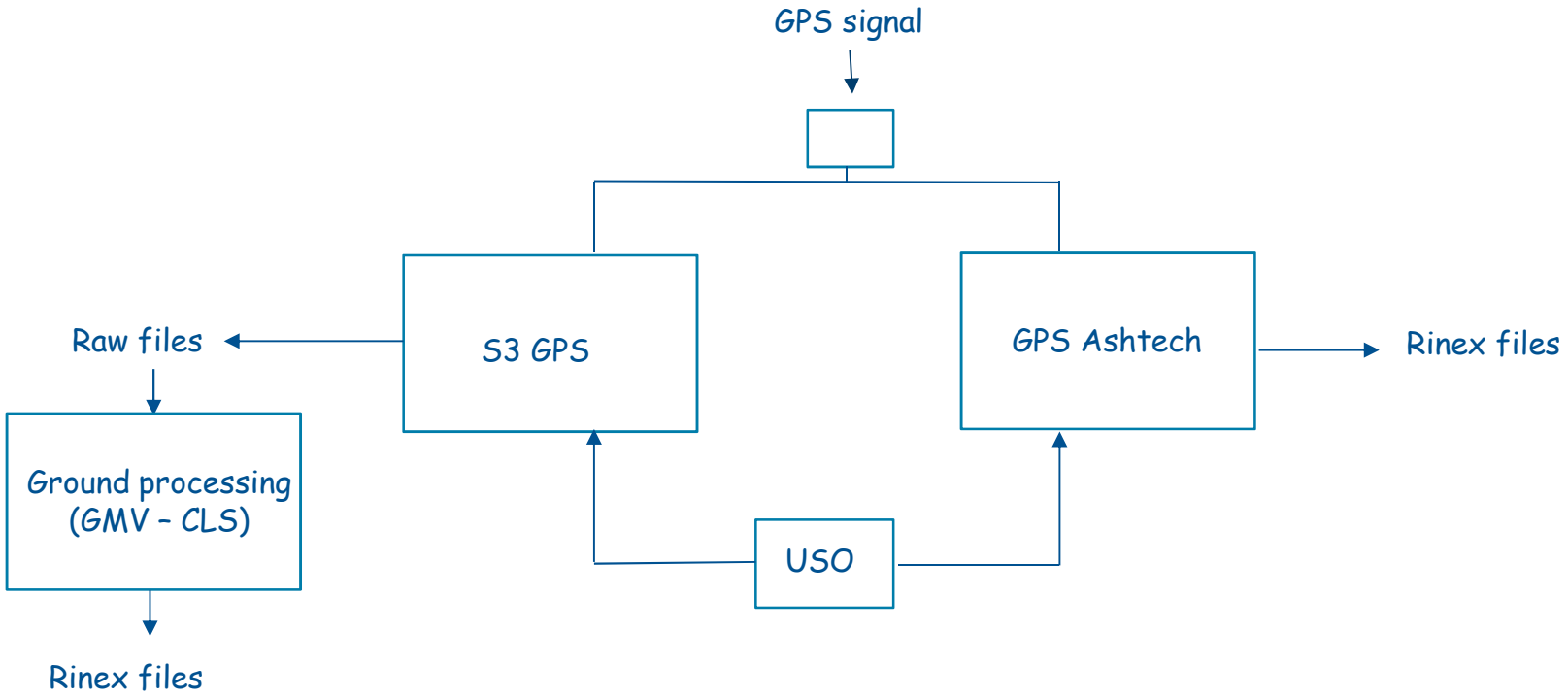
GPS : continuous monitoring of pseudo range and phase, possible to have an estimation of the frequency over short intervals (sampling 1 s to 10 s)

Ground test

Receiver/USO ground test

Test performed at Ruag, 10,11,12 january 2012

Objectives : USO interface and compatibility with Ruag Receiver Sentinel 3
verify that the USO frequency can be observed using the GPS measurements (Rinex file)



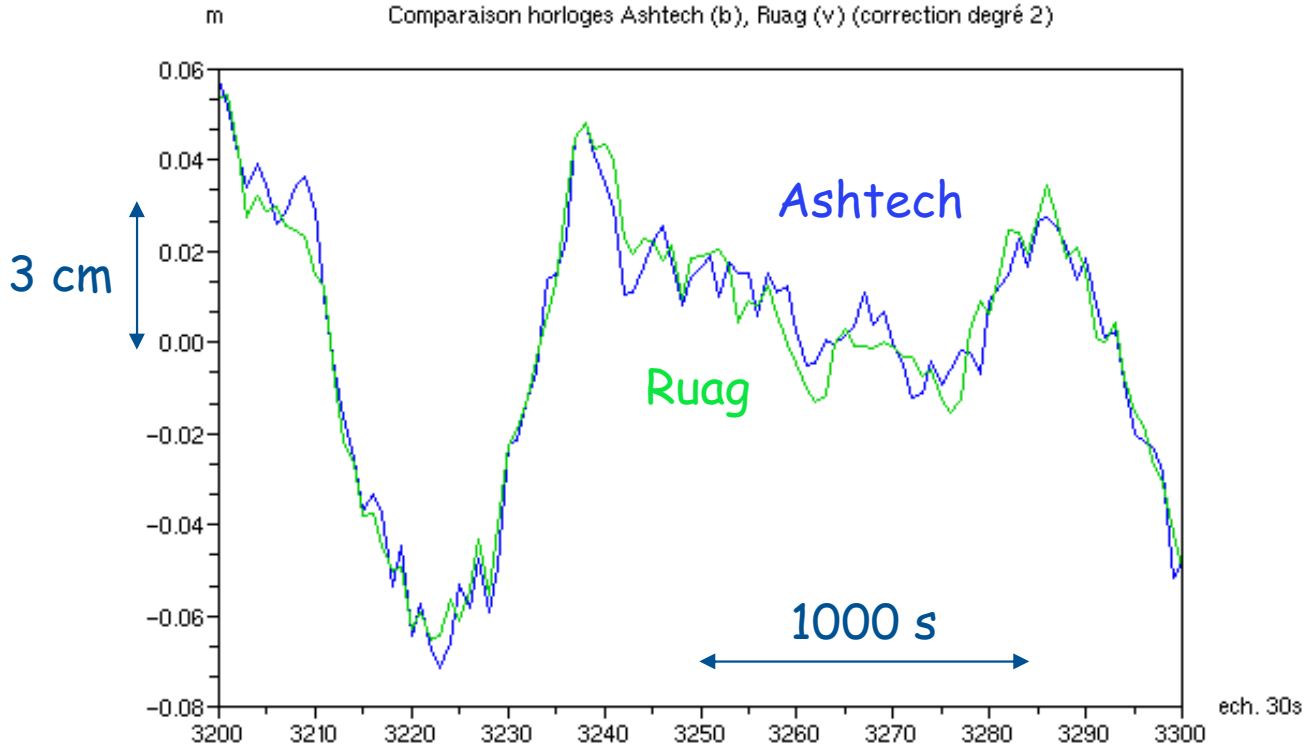
Reference receiver Ashtech, operated by CNES

Availability of the correct rinex files for the Ruag receiver : end of 2013

Ground tests clock comparison, after PPP processing

S3 GNSS receiver in parallel with Ashtech receiver, same antenna,
both receivers connected on the same reference frequency (Doris USO)

PPP processing and comparison of the observed receiver clocks



Sampling 30 s (IGS orbits/clocks for the constellation)
Common degree 2 polynomial removed for the plot, and bias between the two clocks

Ashtech and S3 GPS observed frequencies

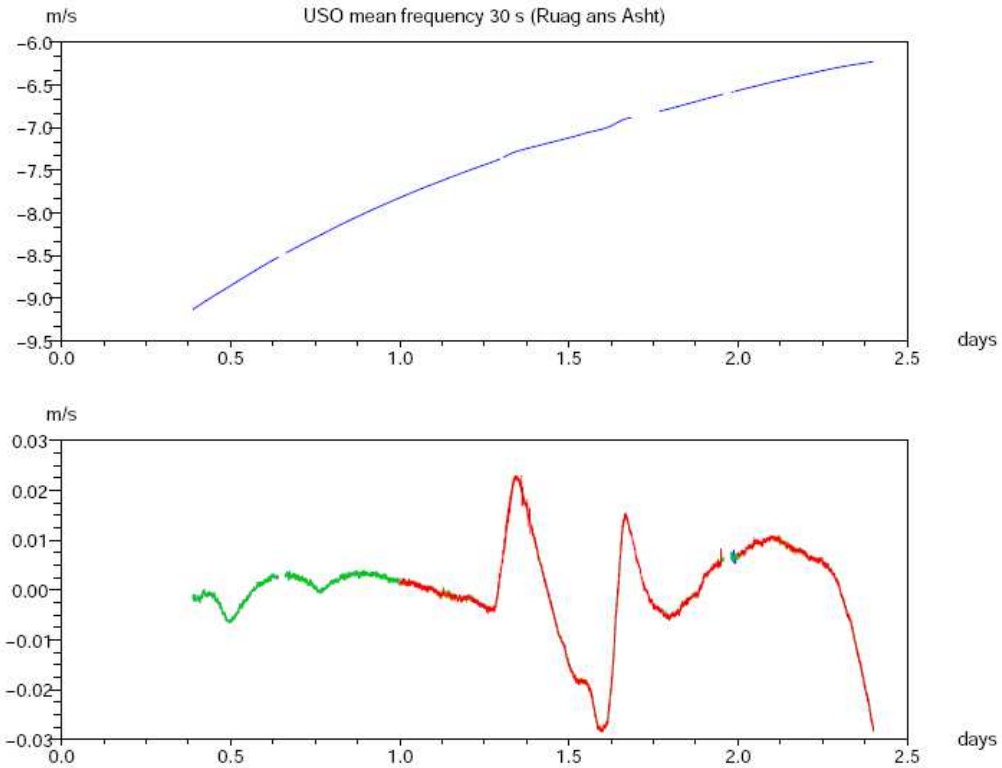
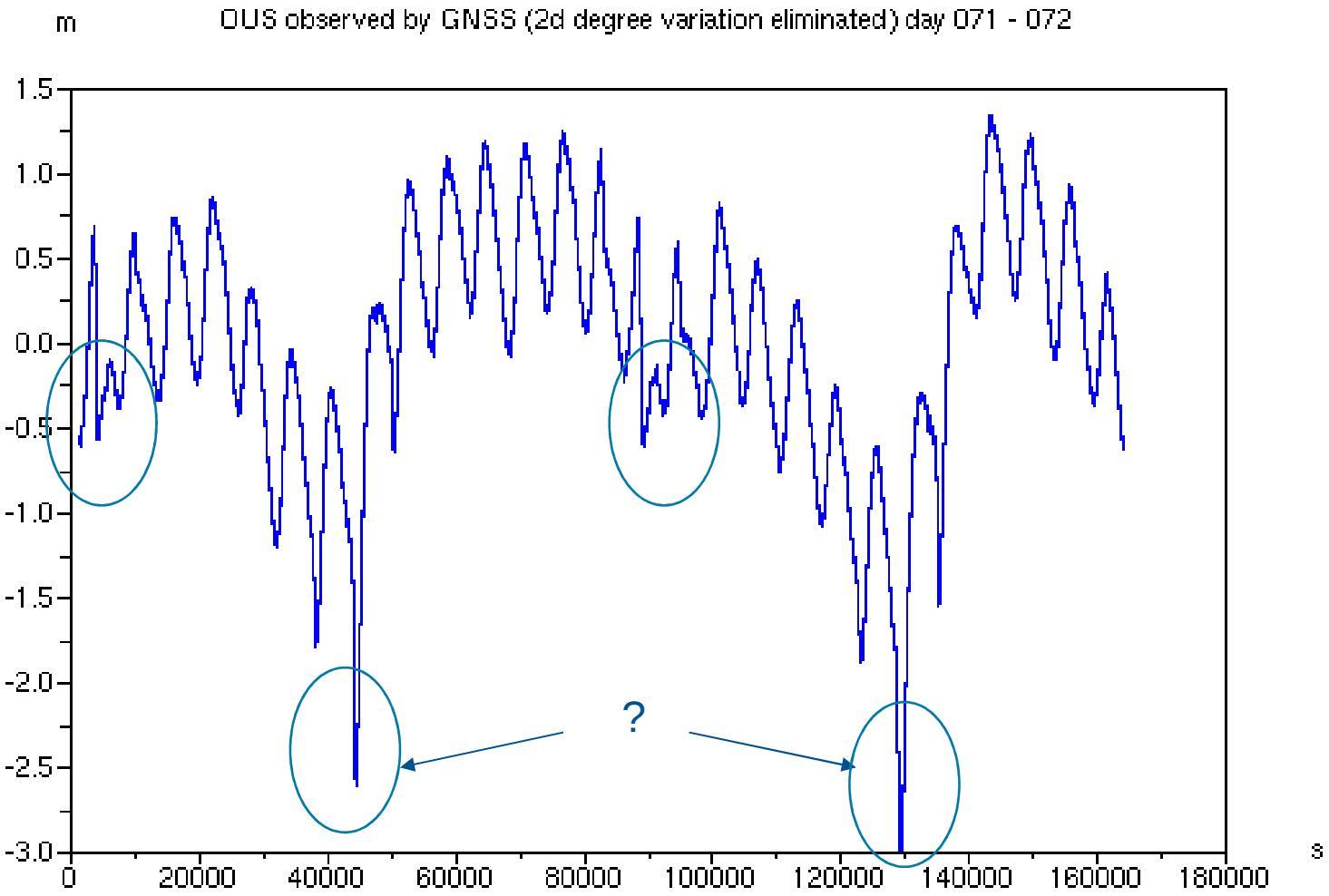


FIG. 7 – Identified oscillator frequency (in m/s), and errors relative to a third degree model, C1P,C2P case (blue), C1C, C2P+C2S case (green), Ashtech (red)

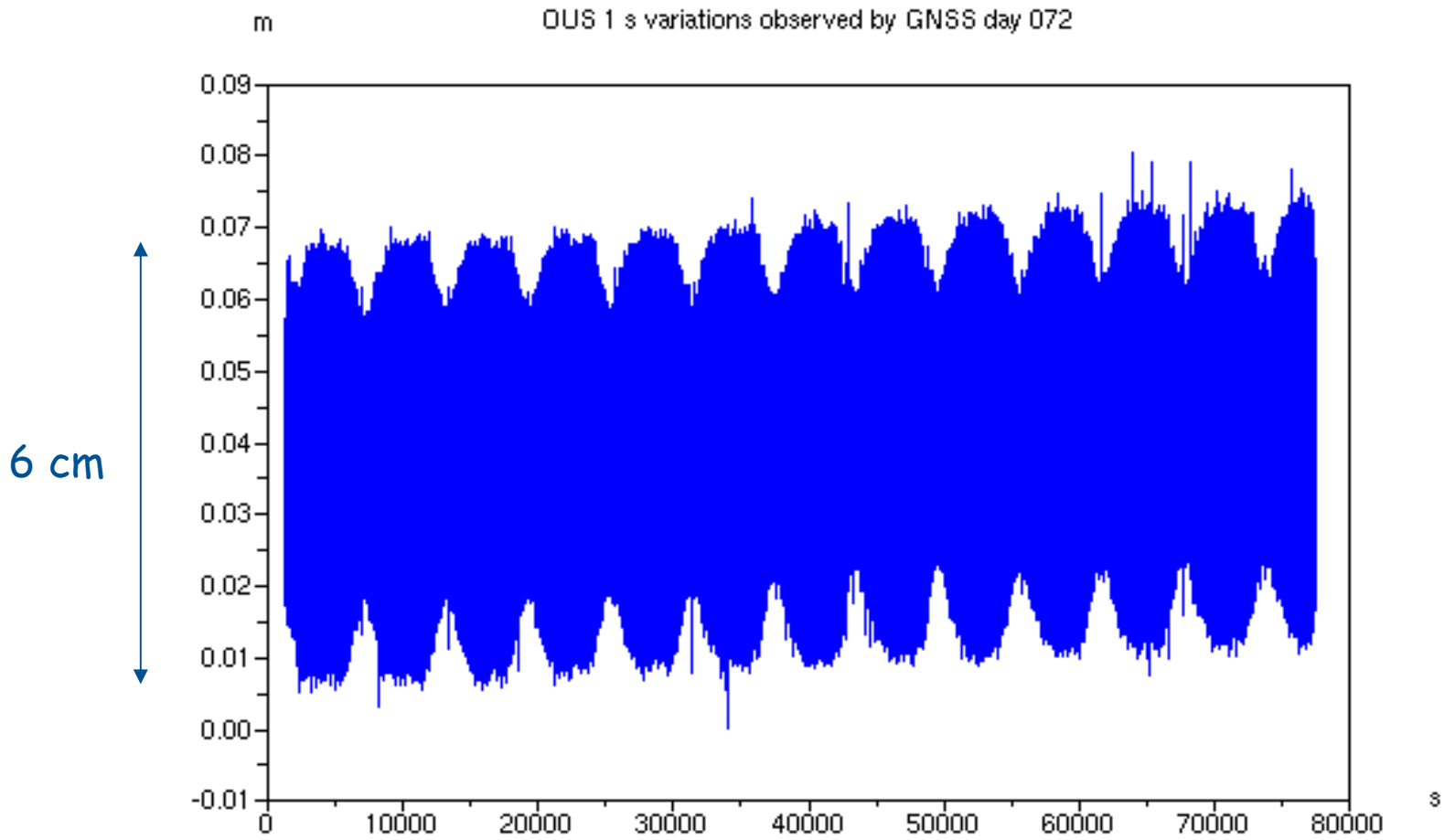
Flight results

Clock (2d degree polynomial removed) days 071 - 072



Relativistic effect not modelled --- > periodic orbital oscillations, constant amplitude
Some anomalies not due to relativity effects

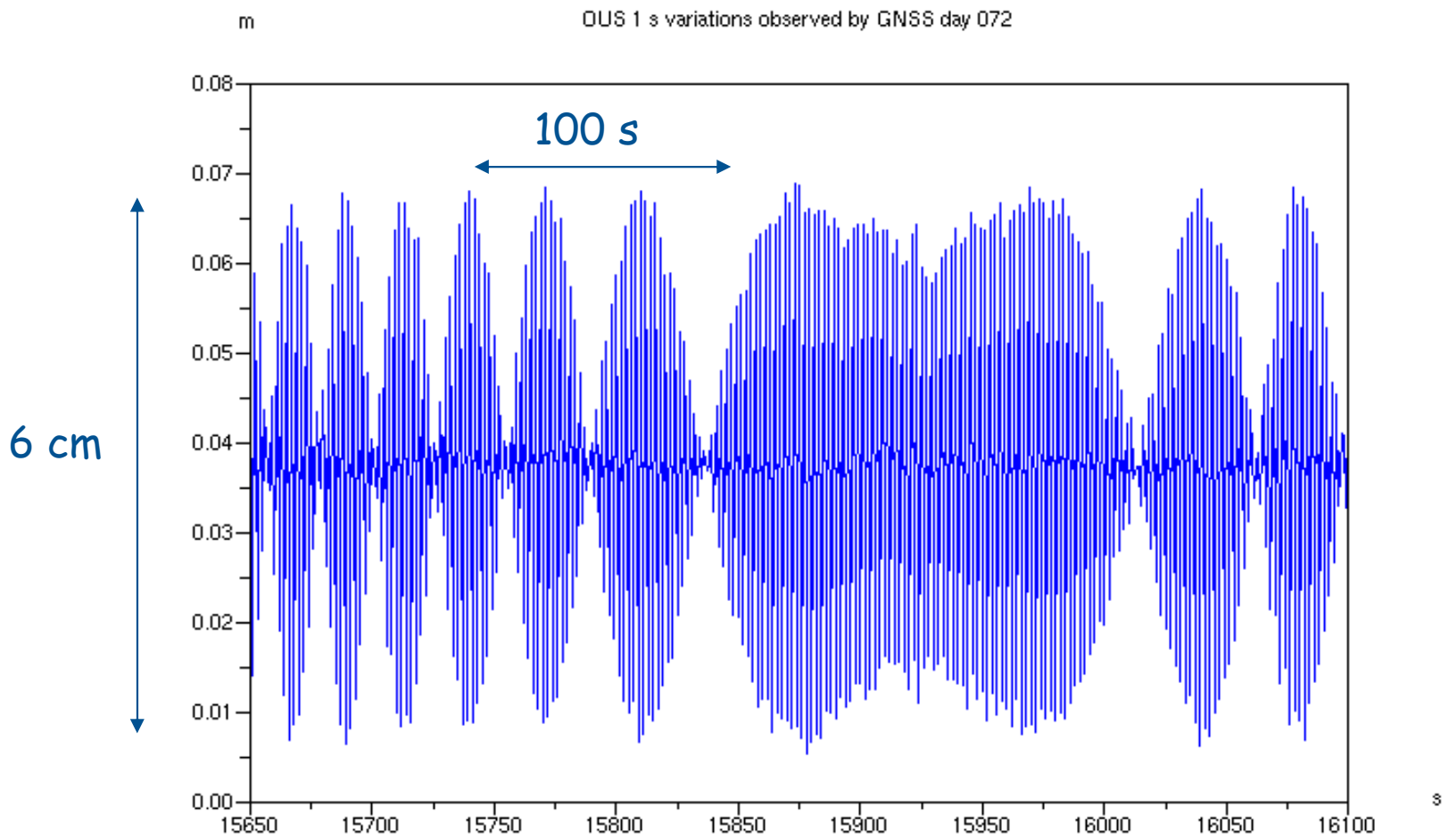
Clock 1 s variations, day 071



Anomaly : the 1 s oscillations are too important (6 cm peak to peak)

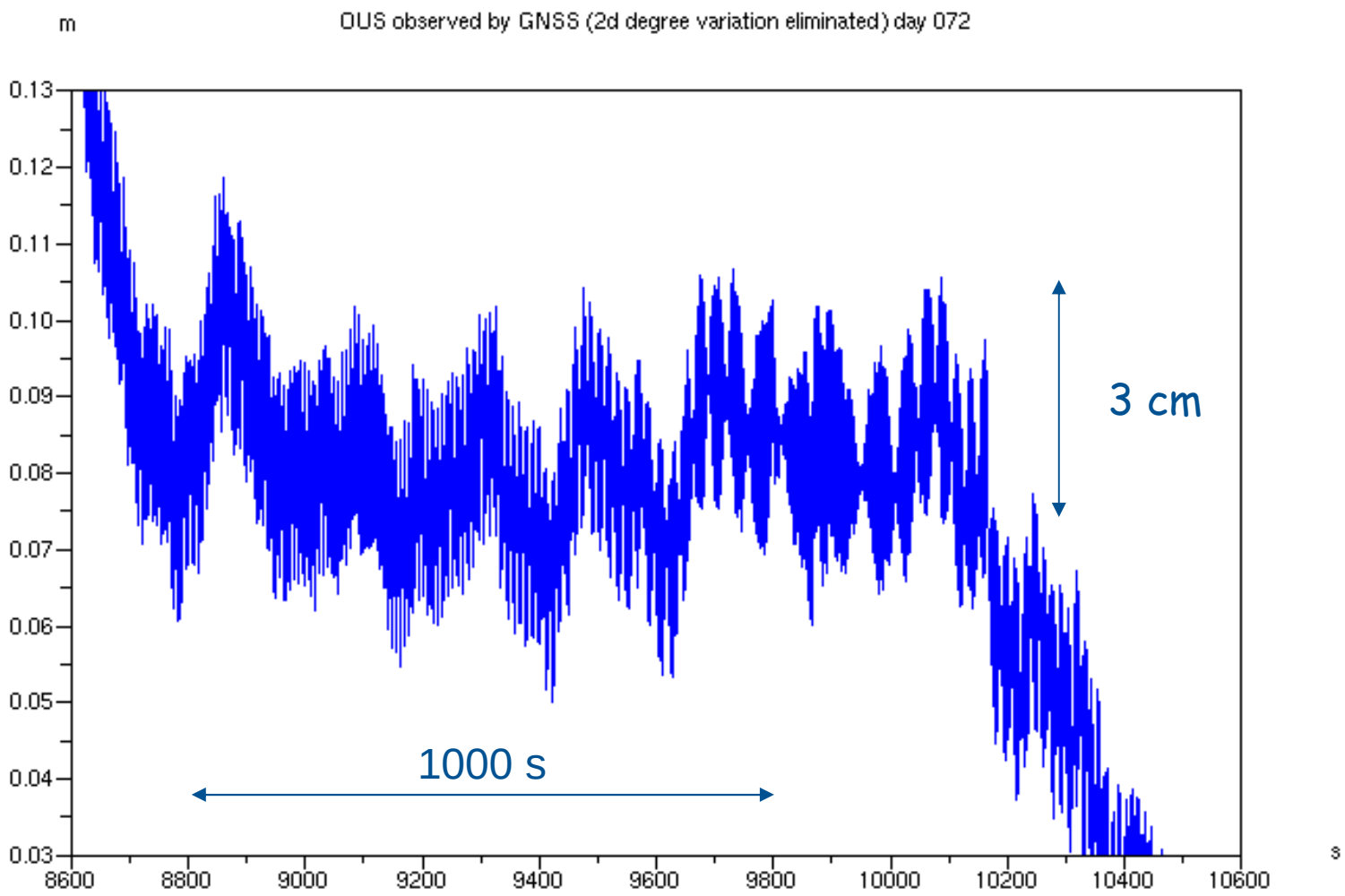
- a millimeter value is expected
- the Doris residuals are correct (such amplitudes are not observed in the 10 s Doris measurements)
- stable and systematic effects (orbital period amplitude variations)

Clock 1 s variations, day 071, zoom



Beating between two close 1 Hz frequencies
or aliasing of higher frequencies

Clock, mid term evolutions (~1000s)



Mid term variations : ~2-3 cm for a Doris pass duration : effect of the Doris USO

Mid term frequency drift analysis

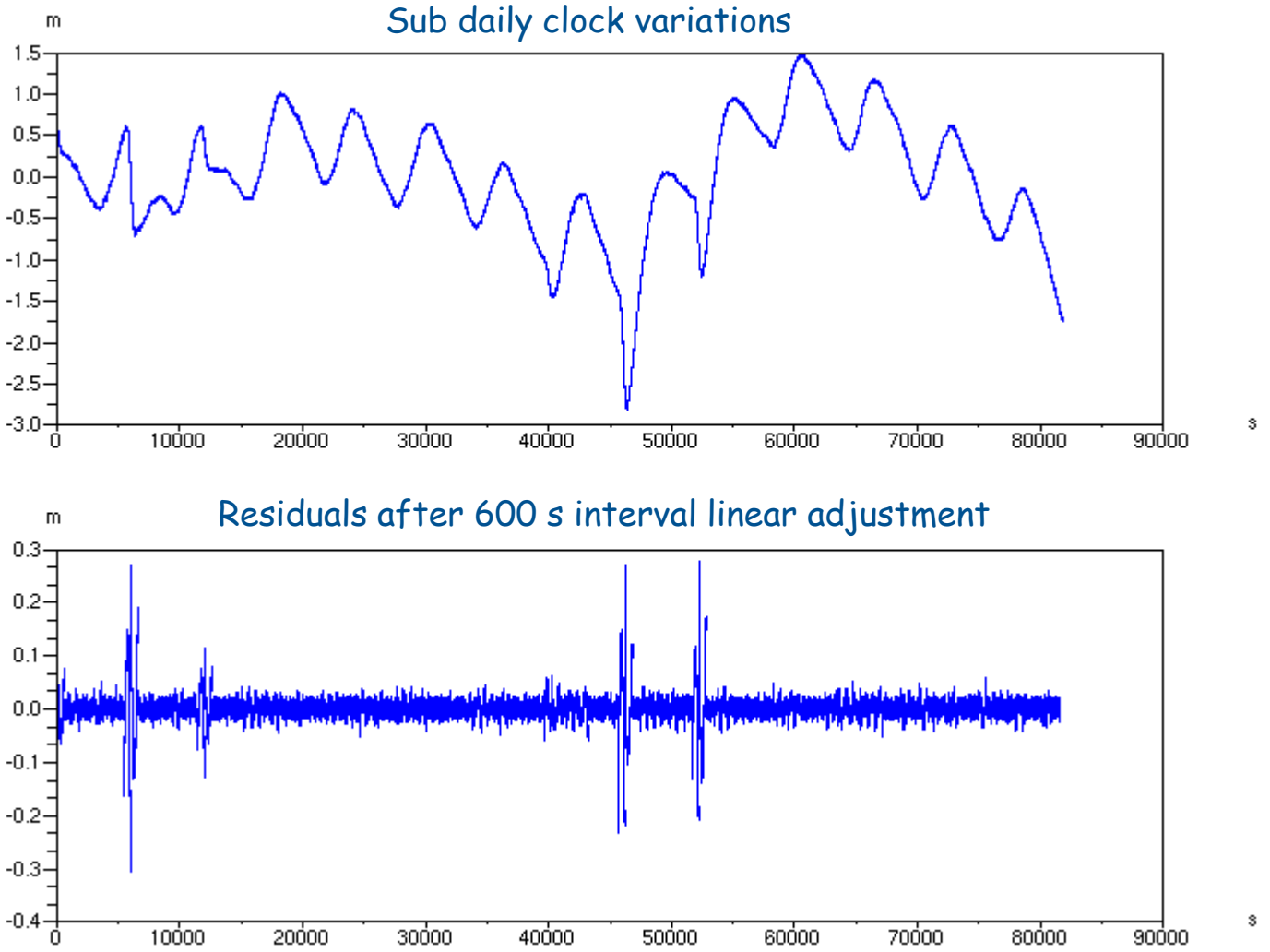
For the clock contribution, the Doris processing is equivalent to :

- remove the long term effect for the on board clock
  (here : second degree polynomial on one or two days)

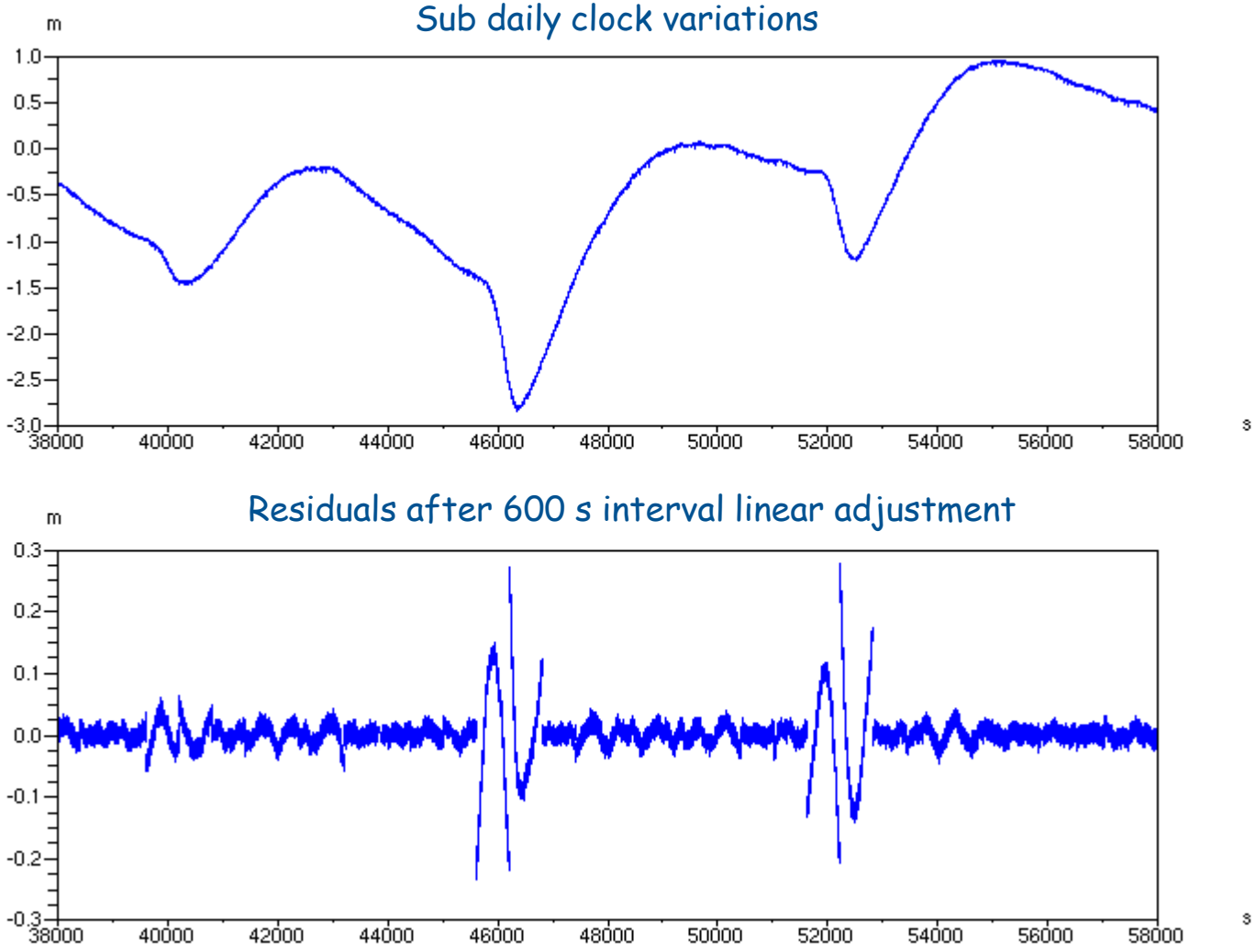
- adjust a linear variation for a pass (typically 600 s duration)
  equivalent to the classical beacon frequency bias adjustment

→ impact of the actual on board frequency errors (w.r.t. long term model)
  on the residuals

600 s interval linear adjustment



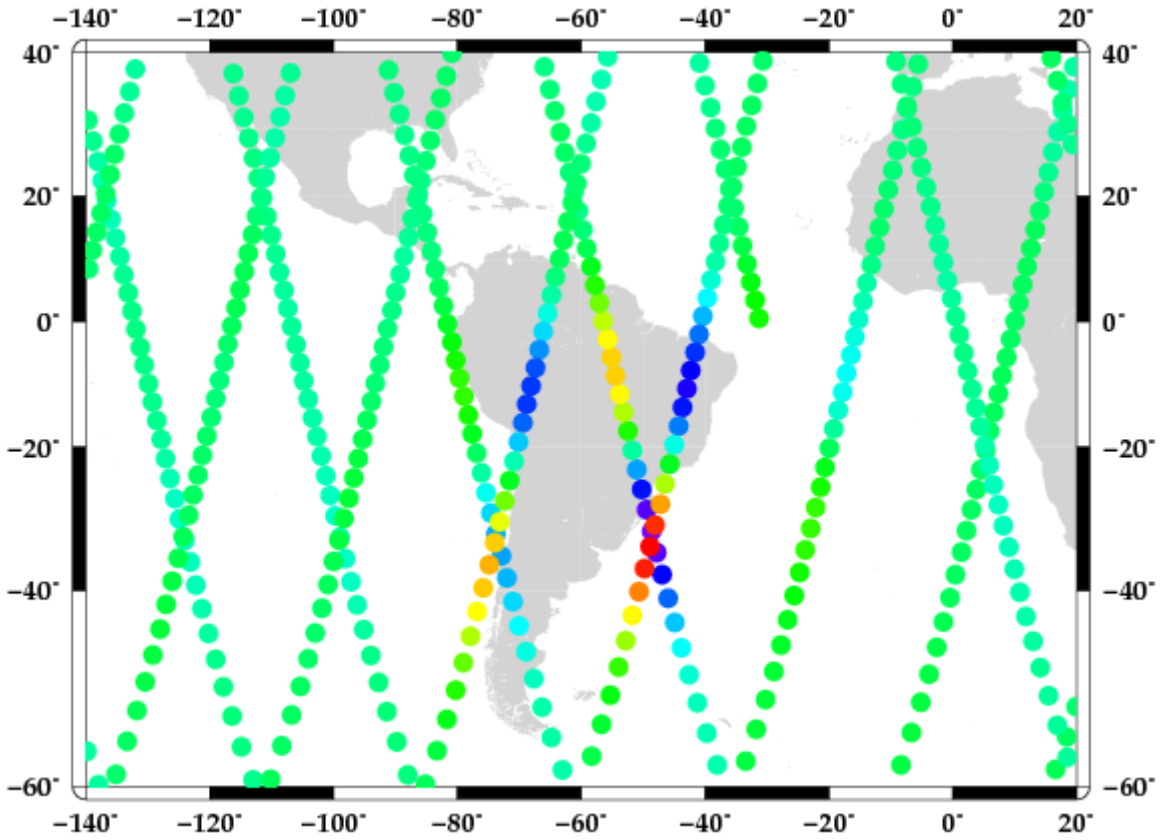
600 s interval linear adjustment (zoom)



30 cm

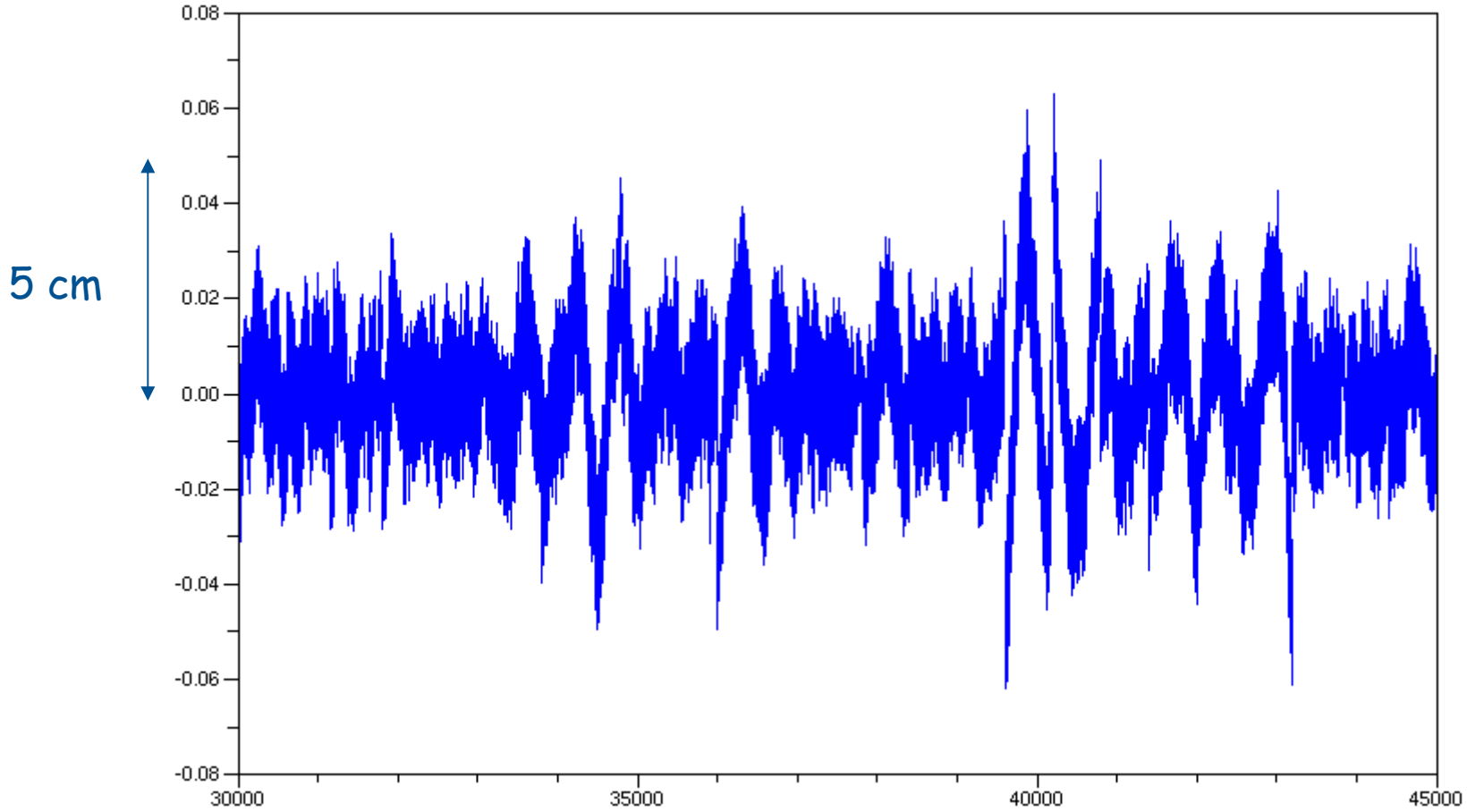
Important parabolic signatures are remaining (~ 30 cm on one pass)

Geographic position of the anomalies



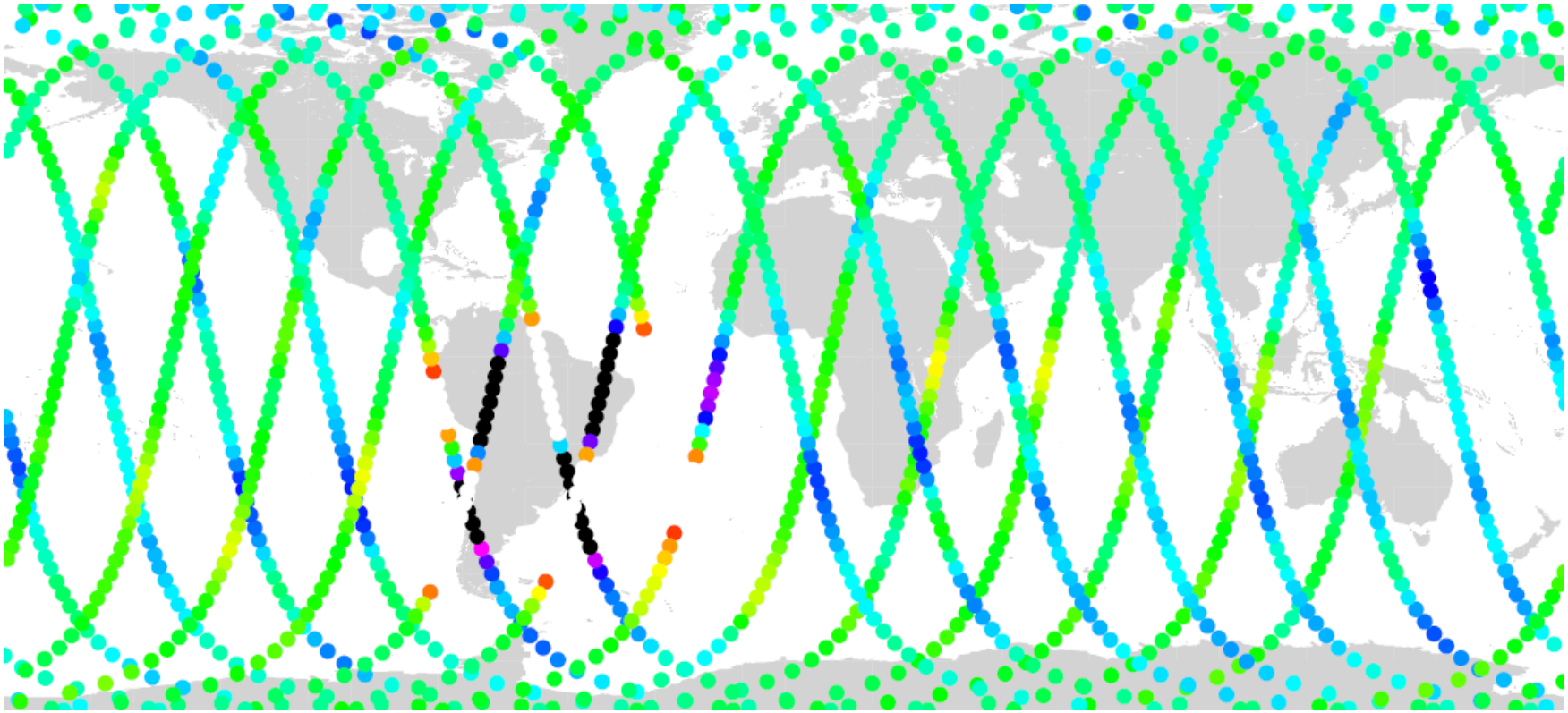
Estimation of the residuals curvature (600 s duration)
normalized in [-1,1] ⟶ very clear SAA effect on the USO

600 s interval linear adjustment (small amplitudes)



Amplitudes of a few centimeters are frequent

Smaller geographic effects



Visualisation of the smaller amplitude effects (green corresponds to 0)

to be studied ….

Conclusion

The observation of the Doris USO with the GNSS is very promising for future improvements of the system

There are still some unexplained signals (at 1 hz) in the GNSS solution but the precision is sufficient to monitor the USO on intermediate durations (Doris pass duration)

These high frequency perturbations are not present in the USO signal directly delivered to Doris

The USO shows clearly frequency variations related to the South Atlantic Anomaly, and these variations could induce more than 10 cm vertical errors on a single pass.