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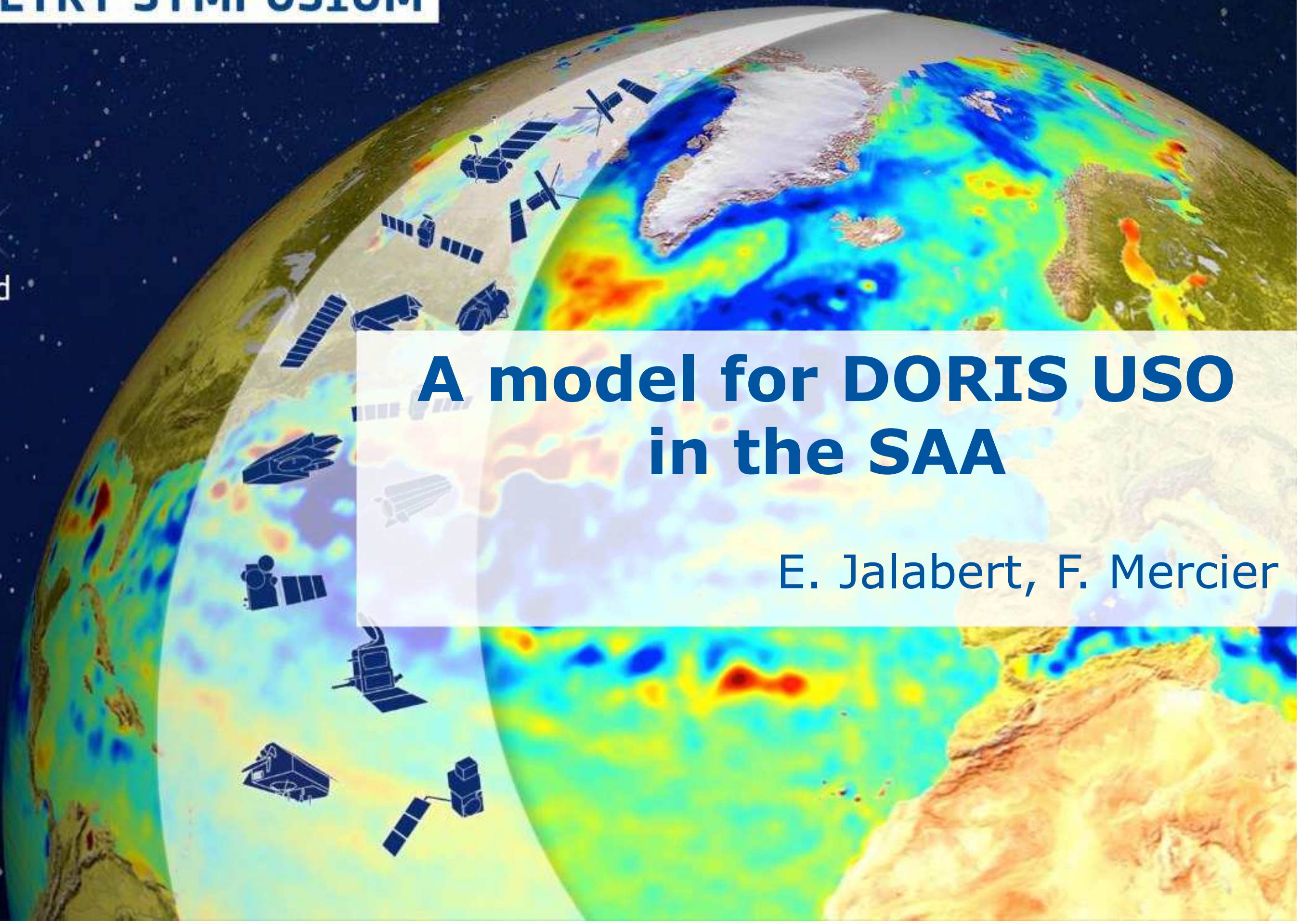
→ 25 YEARS OF PROGRESS IN RADAR ALTIMETRY SYMPOSIUM

IDS WORKSHOP

24–29 September 2018
Ponta Delgada, São Miguel Island
Azores Archipelago, Portugal



A model for DORIS USO in the SAA

E. Jalabert, F. Mercier

IDS

Introduction

- DORIS measurements processing relies on a precise knowledge of the Ultra Stable Oscillator (USO)

- The important radiations in the South Atlantic Anomaly (SAA) produce rapid variations of the USO frequency

- If these variations are not modelled : systematic errors

Objective : construct a model of the frequency variations due to the SAA

developed for Sentinel3a
application on Jason 3

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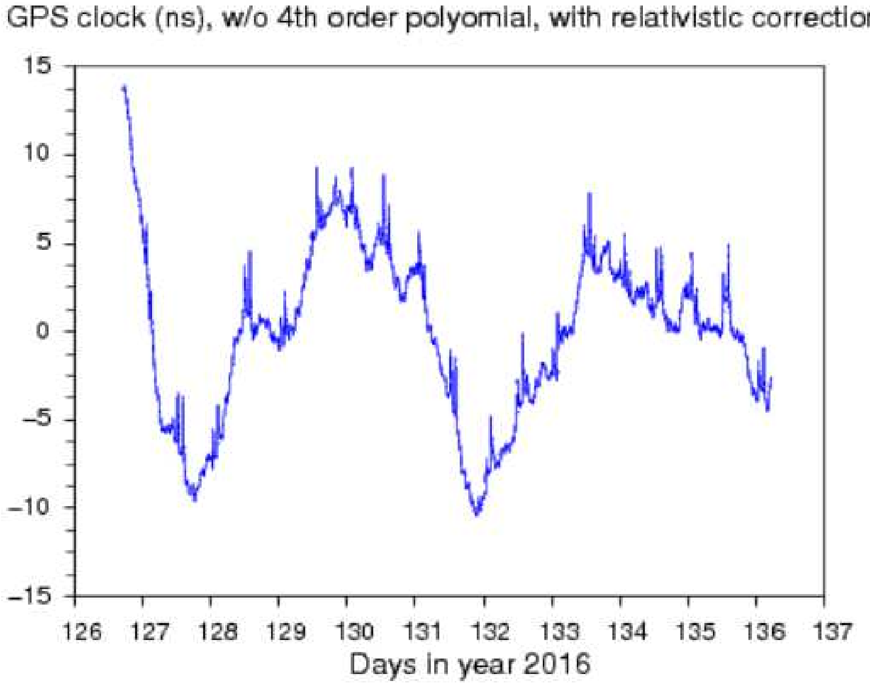
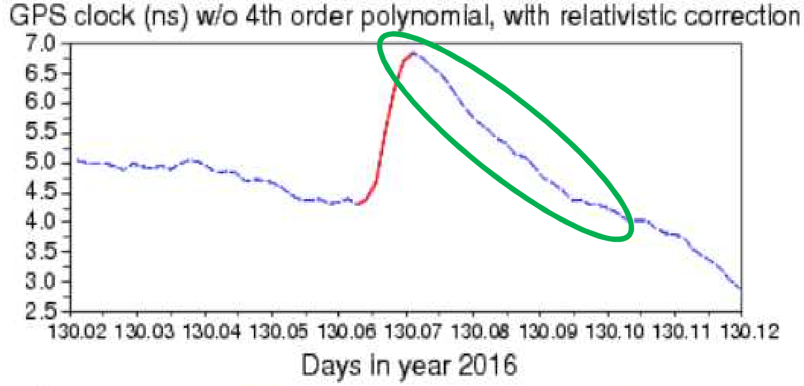
Impact on Doris measurements and station positioning

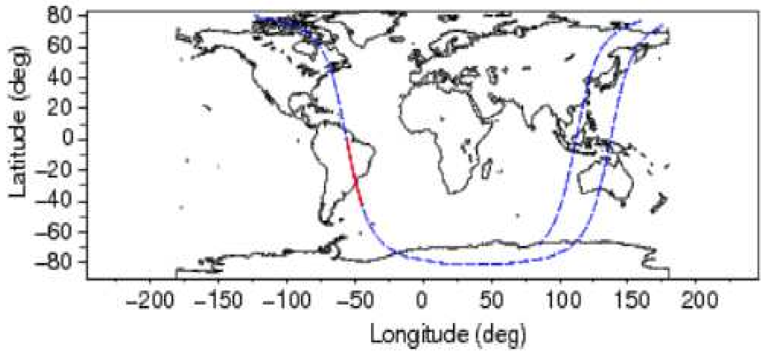
Sentinel3B results (tandem phase)

Conclusion

•Model based on observations of Sentinel3A USO



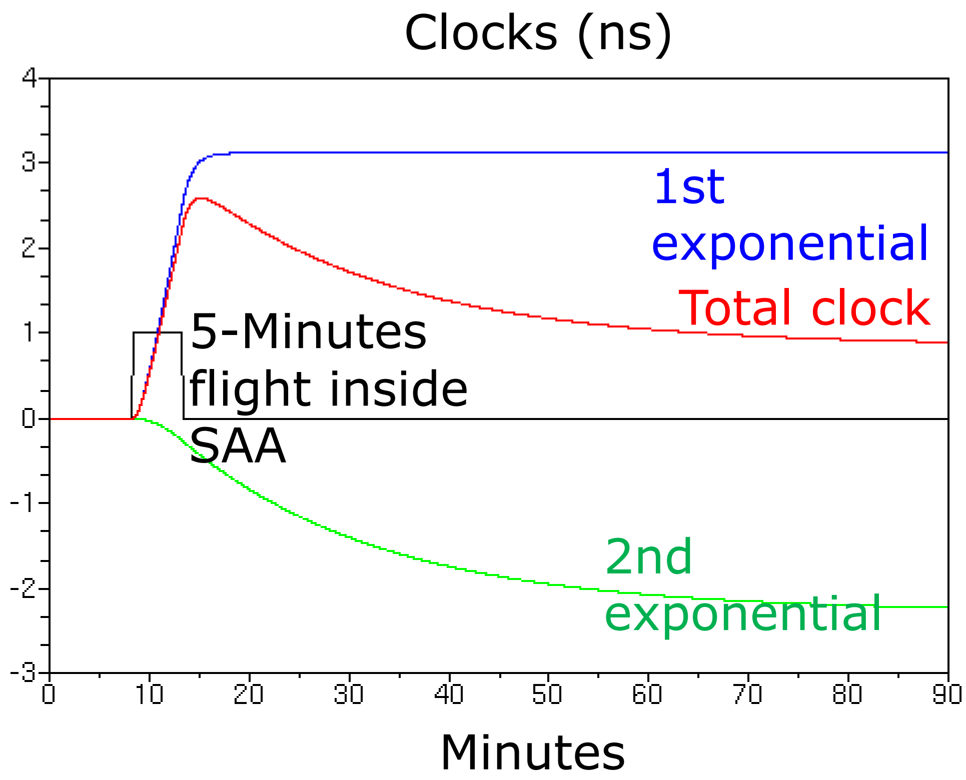




•Two phenomena :

- •Drift when entering the SAA
- •Relaxation aftern exiting the SAA

- In order to reproduce the behaviour observed on Sentinel3A USO, two exponentials are added :
  - One describing the drift when the satellite enters the SAA
  - One describing the relaxation of the USO



MODELLING : clock offset (3)

- Model : USO frequency is the sum of two exponentials

$$df_1 = -\alpha_1 f_1 + \beta_1 a(t)$$
$$df_2 = -\alpha_2 f_2 + \beta_2 a(t)$$

With :

- $\alpha_i = {}^{1}/_{\tau_i}$: inverse of the time constant of the exponentials
- a(t) : the radiation exposure due to the SAA at time t
- β_i : gain linked to the exposure

MODELLING : parameters (1)

- α_i : cannot be estimated
  depends on the USO device

- Sentinel3a : the USO behaviour is known, and so are the time constants. (see « Analysis of South Atlantic Anomaly perturbations on Sentinel-3A Ultra Stable Oscillator. Impact on DORIS phase measurement and DORIS station positioning. » Jalabert and Mercier)
  - $\alpha_1 = 1$ minute
  - $\alpha_2 = 20$ minutes

- Jason3 : the hypothesis is that the time constants are similar to those of Jason1. The values are obtained from : « A corrective model for Jason-1 DORIS Doppler data in relation to the South Atlantic Anomaly », JM Lemoine and H. Capdeville
  - $\alpha_1 = 1$ minute
  - $\alpha_2 = 90$ minutes

MODELLING : parameters (2)

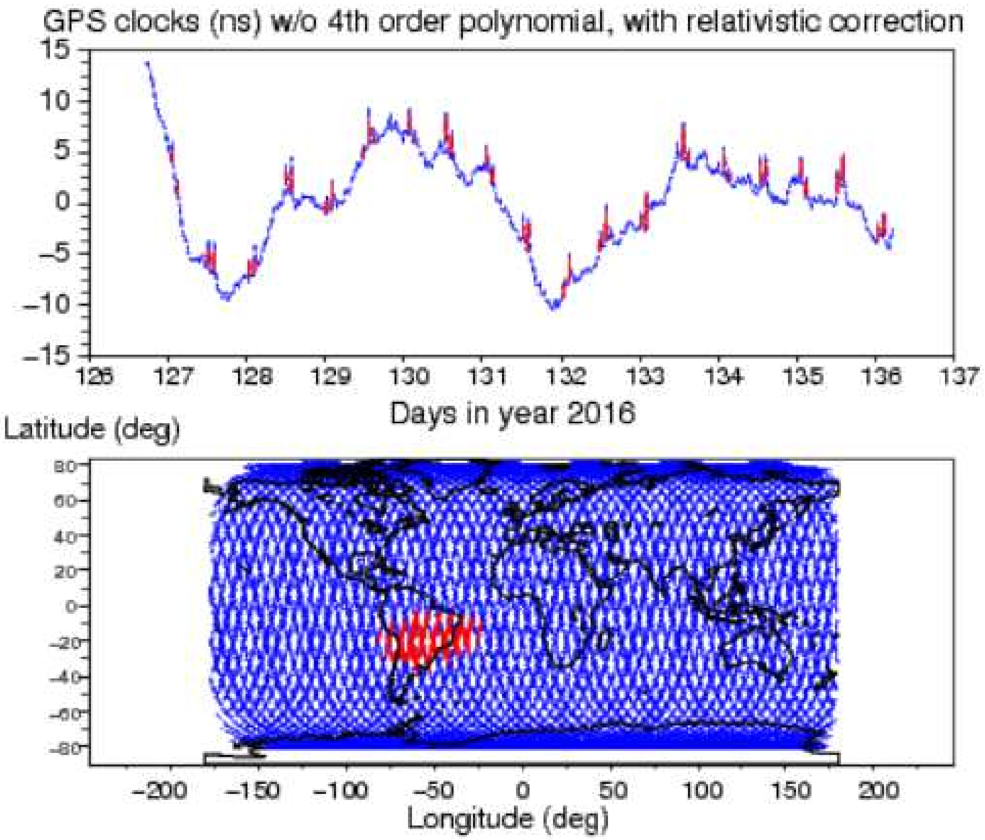
- β_i : estimated during the orbit determination process

- a(t) : geographical grid from « A corrective model for Jason-1 DORIS Doppler data in relation to the South Atlantic Anomaly », JM Lemoine and H. Capdeville

$$\exp\left(-\frac{1}{2}\left[\frac{lat - lat_{SAA}}{SAA\_lat\_extend}\right]^2\right) * \exp\left(-\frac{1}{2}\left[\frac{lon - lon_{SAA}}{SAA\_lon\_extend}\right]^2\right)$$

- The difficulty is to properly represent the SAA area.
  - for Sentinel3a, the USO behaviour is directly observed : OK
  - for Jason3, the SAA area was placed empirically.

•The area where the drift in the USO occurs can be observed.



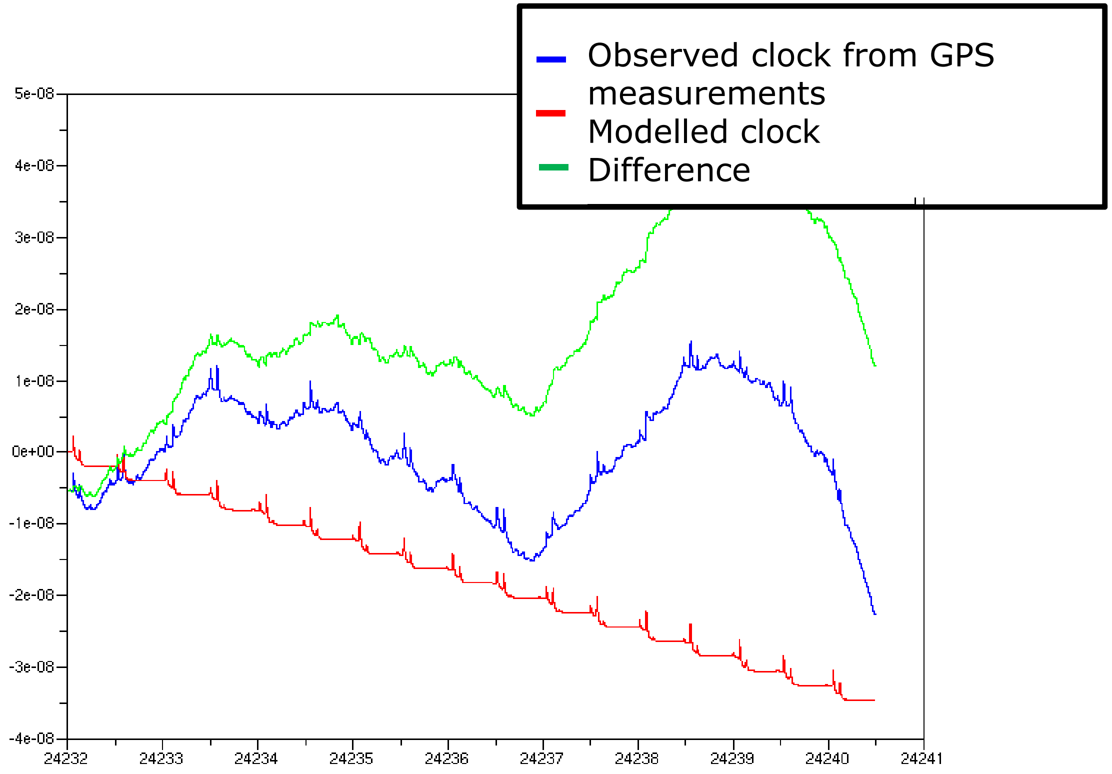
Latitude (deg)

Longitude (deg)

```
milieulongSAA=-53 ;
milieulatSAA=-20  ;
envergurelong=15  ;
envergurelat=10  ;
A=0*%pi/180;
```

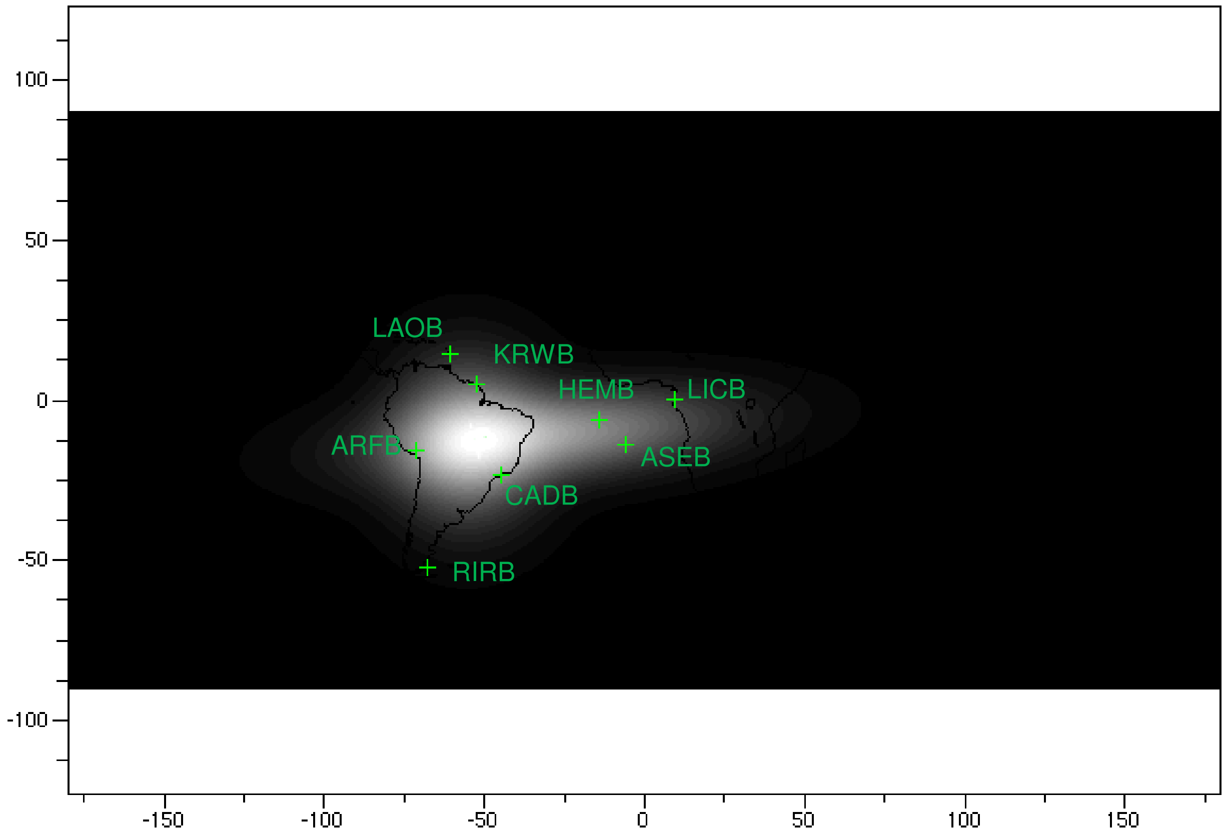
MODELLING : Sentinel3A SAA grid (2)

- Validation : the observed SAA peaks in the clock are correclty removed.



- Note : the drift produced the integration of the model doesn’t impact the time tagging ($3\ 10^{-8}$ sec effect on 9 days)

- The positioning of the SAA area is empirical.
- Two ellipses are necessary to correctly represent the effects.




```
// 1er patch
milieulongSAA=-29 ;
milieulatSAA=-11  ;
envergurelong=36  ;
envergurelat=9  ;
A=-5*%pi/180;

// 2e patch
milieulongSAA2=-55 ;
milieulatSAA2=-13 ;
envergurelong2=15  ;
envergurelat2=17  ;
B=0*%pi/180;
```

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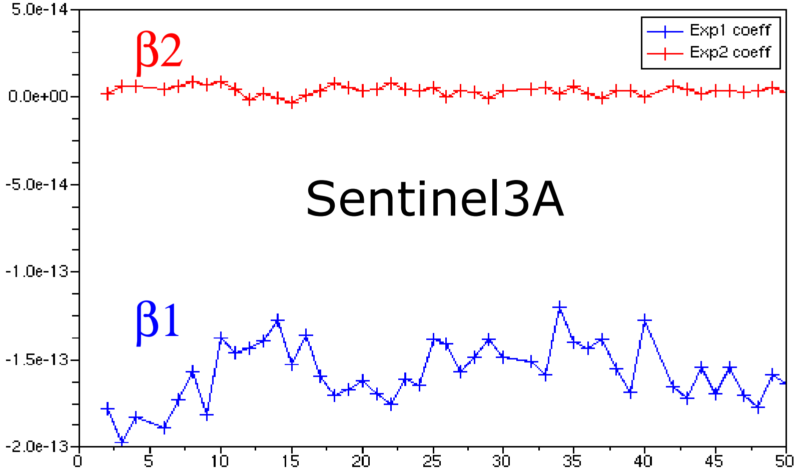
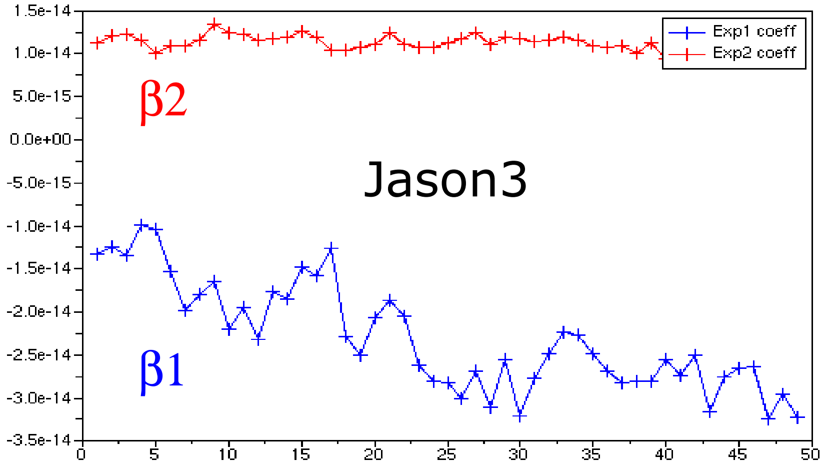
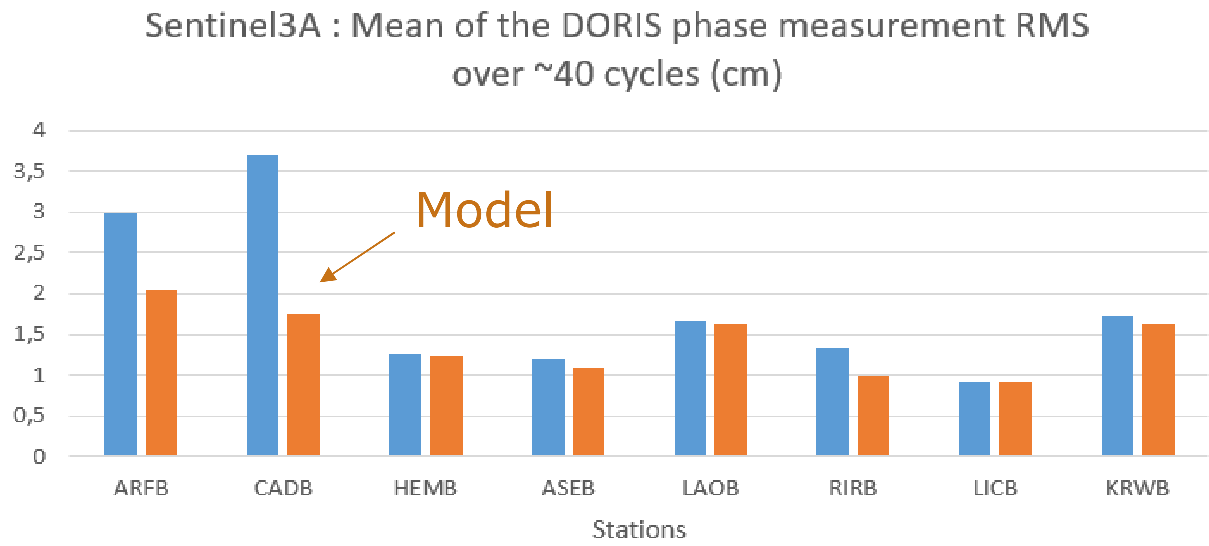
- During the orbit determination process, only β_i are estimated. The other parameters for the model are fixed.

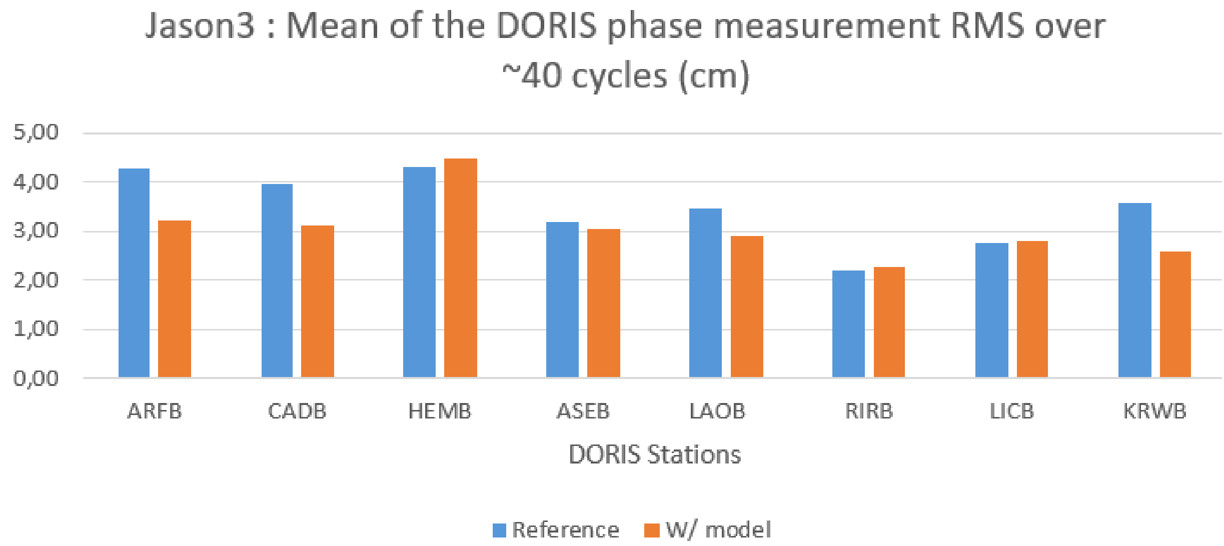
- β_2 (relaxation) : stable with time
- β_1(short term) : small variations, drift for Jason 3





Residuals rms

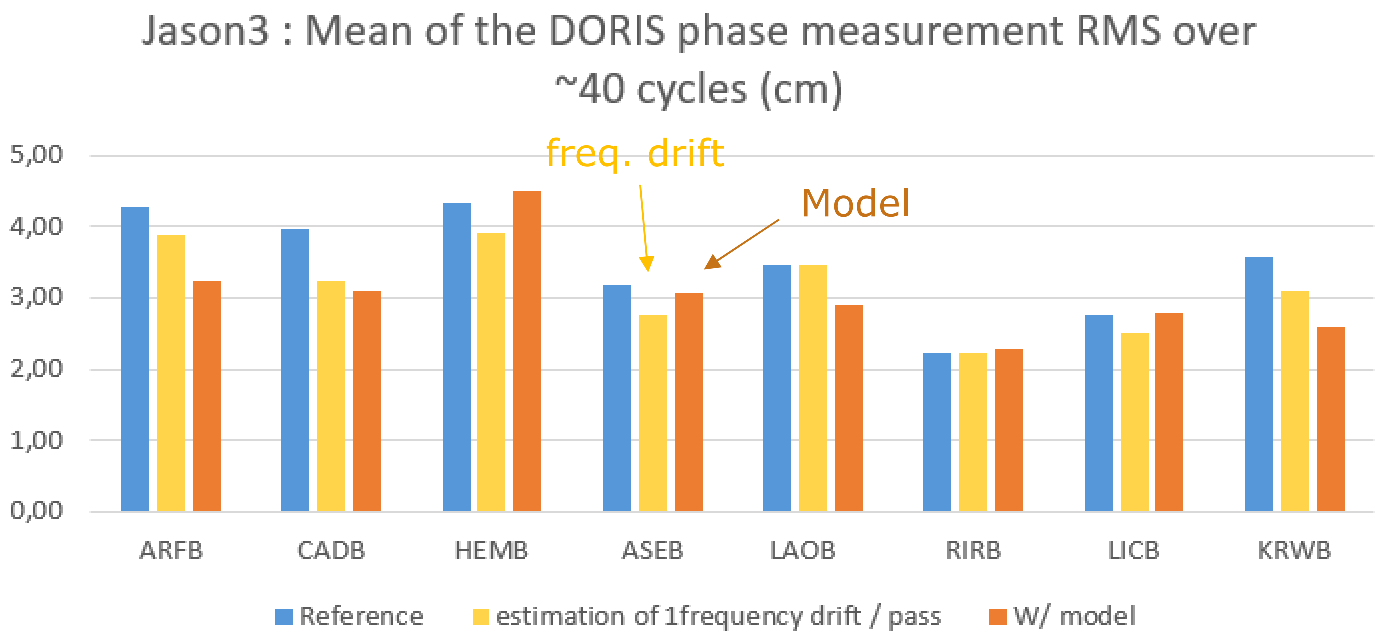




Residuals rms

- OSTST 2016 : estimation of a drift in frequency for each pass of stations inside the SAA area.

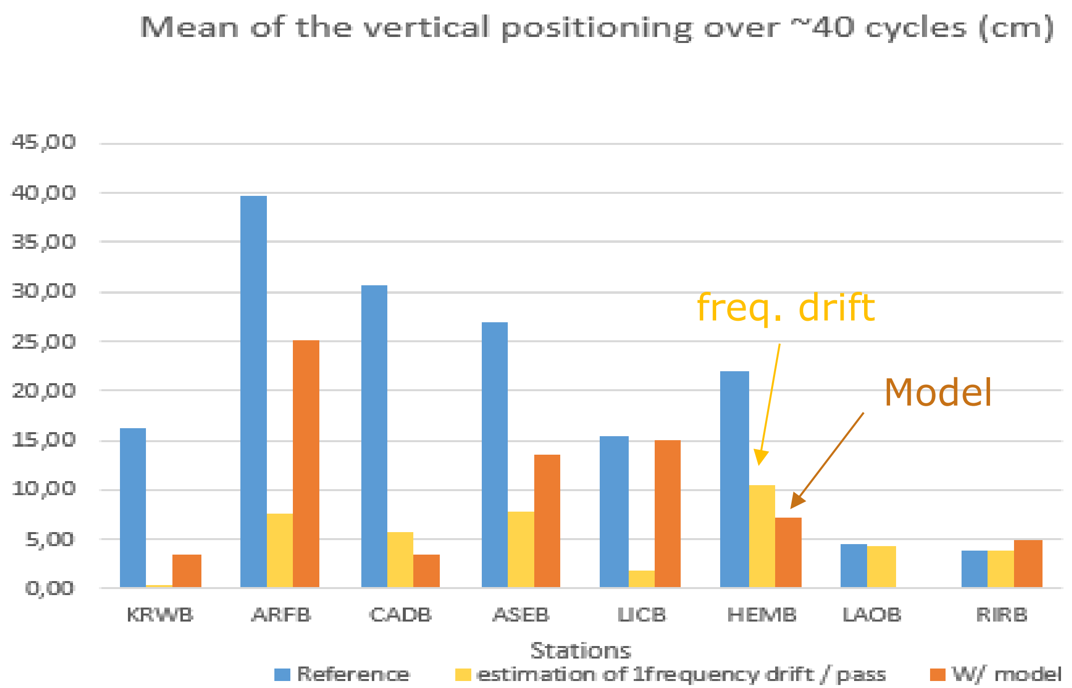
- Similar results, depends on station



Results on station positioning (Jason3)

•Model : improves the vertical positioning.
but not as efficient as the freq. drift (OSTST 2016).

•However, the model represents better the actual behaviour of the USO, rather than just estimating a parabolic parameter on each pass, to minimise signatures.



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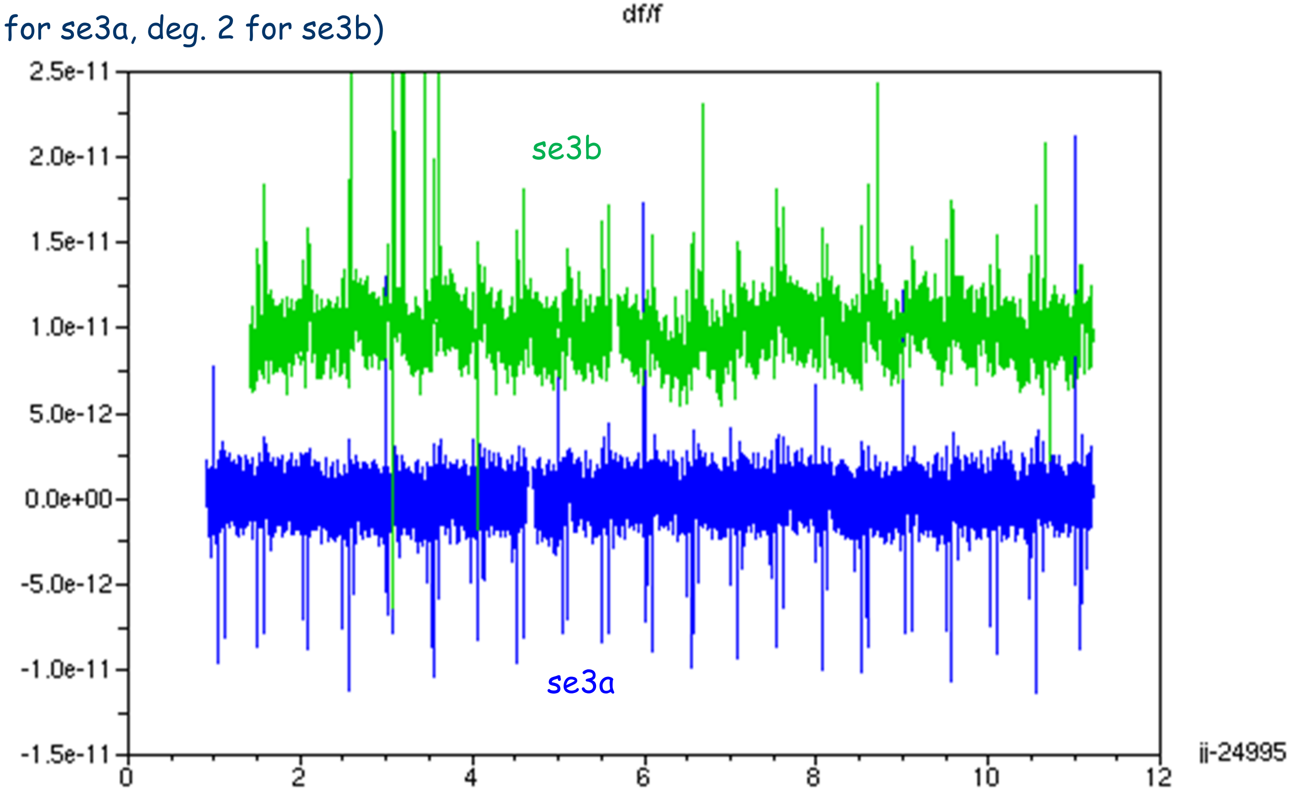
Sentinel3A and 3B USO observation

Sentinel 3A and 3B tandem phase, USO frequency observed by GPS

STC orbits observed USO df/f (added offset for se3b plot)

120 s average frequency receiver clock relativity term not removed

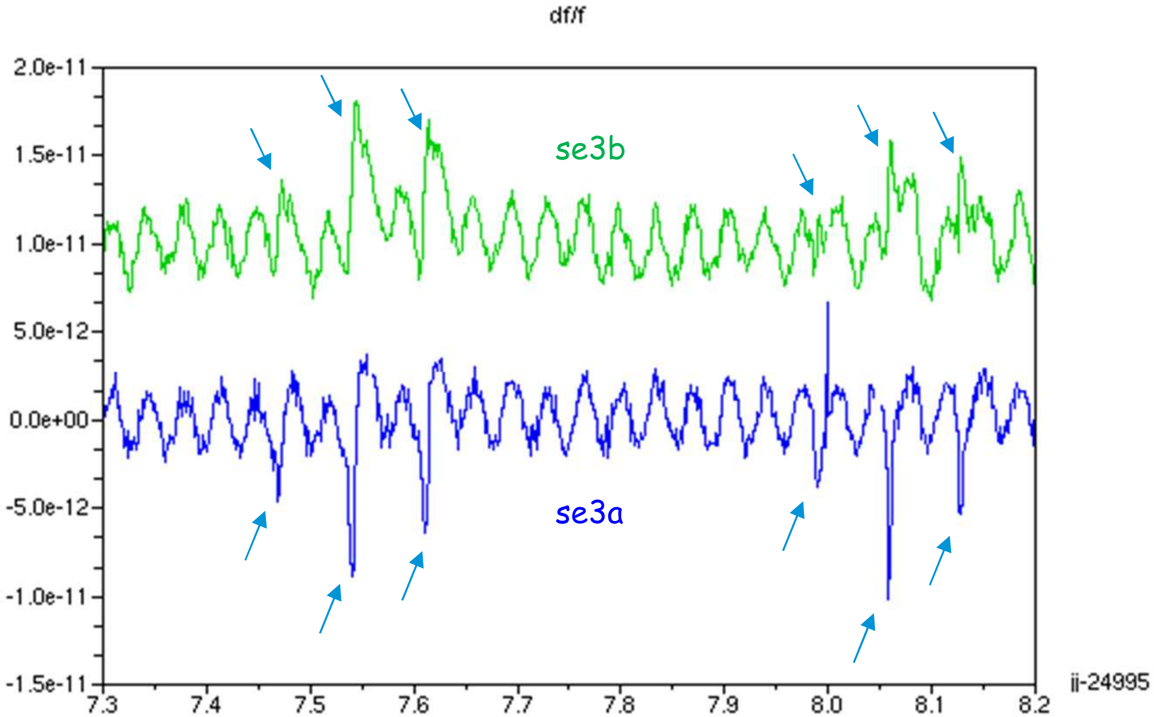
Long term evolution removed (deg. 1 for se3a, deg. 2 for se3b)



SAA effect on Sentinel 3B USO

Perturbations due to SAA
observed also on se3b

USO sensitivity of opposite sign



USO frequency (for the altimeter)

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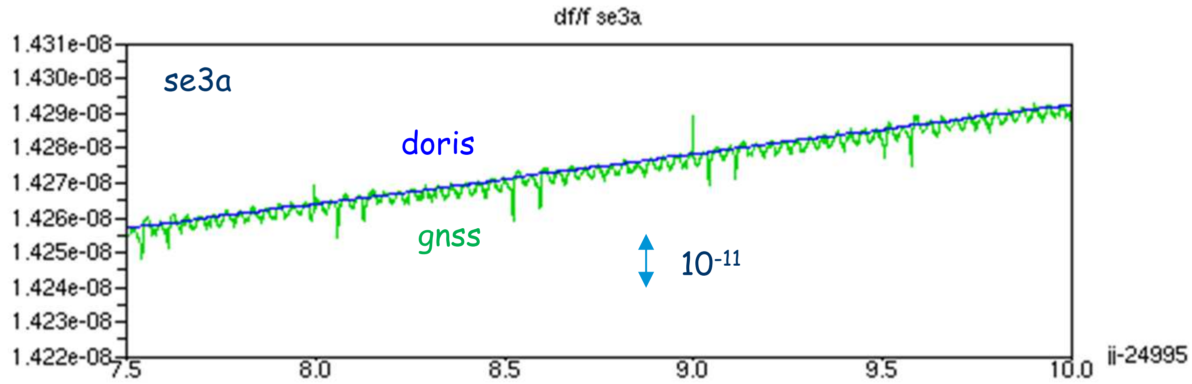
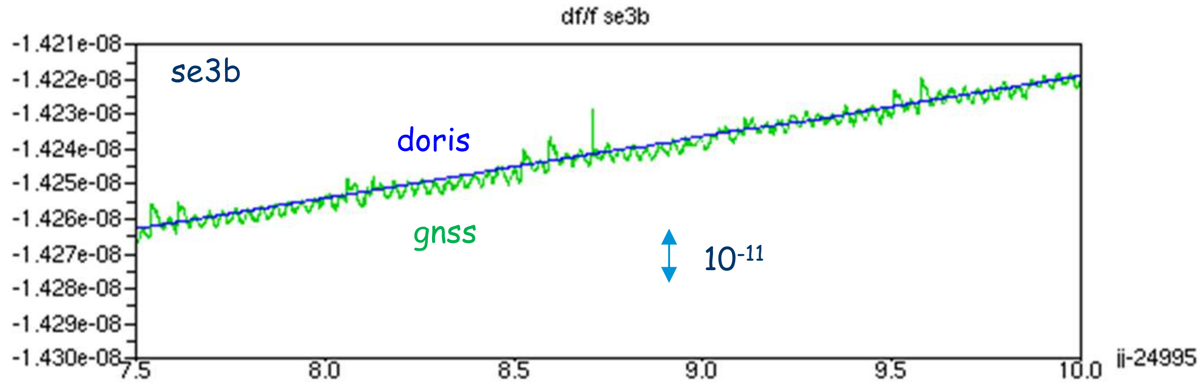
Direct comparison of the clock frequency

- GNSS observation
  (120 s average frequency)
- Doris USO frequency file
  (long term average frequency)



0.2 mm error on altimeter
<-->
10^{-10} for df/f



A precise observation of the frequency for the altimeter processing is possible using the GNSS measurements

Conclusion

The model improves the Doris processing

The model parameters are adjusted simultaneously with orbit determination

Difficulties to determine a correct SAA area, specifically for Jason 3

Sentinel 3B has similar behaviour as Sentinel 3A, but opposite sign of the sensitivity.

To do :
- Improve the SAA area definition on Jason3
- Tests on Jason 1