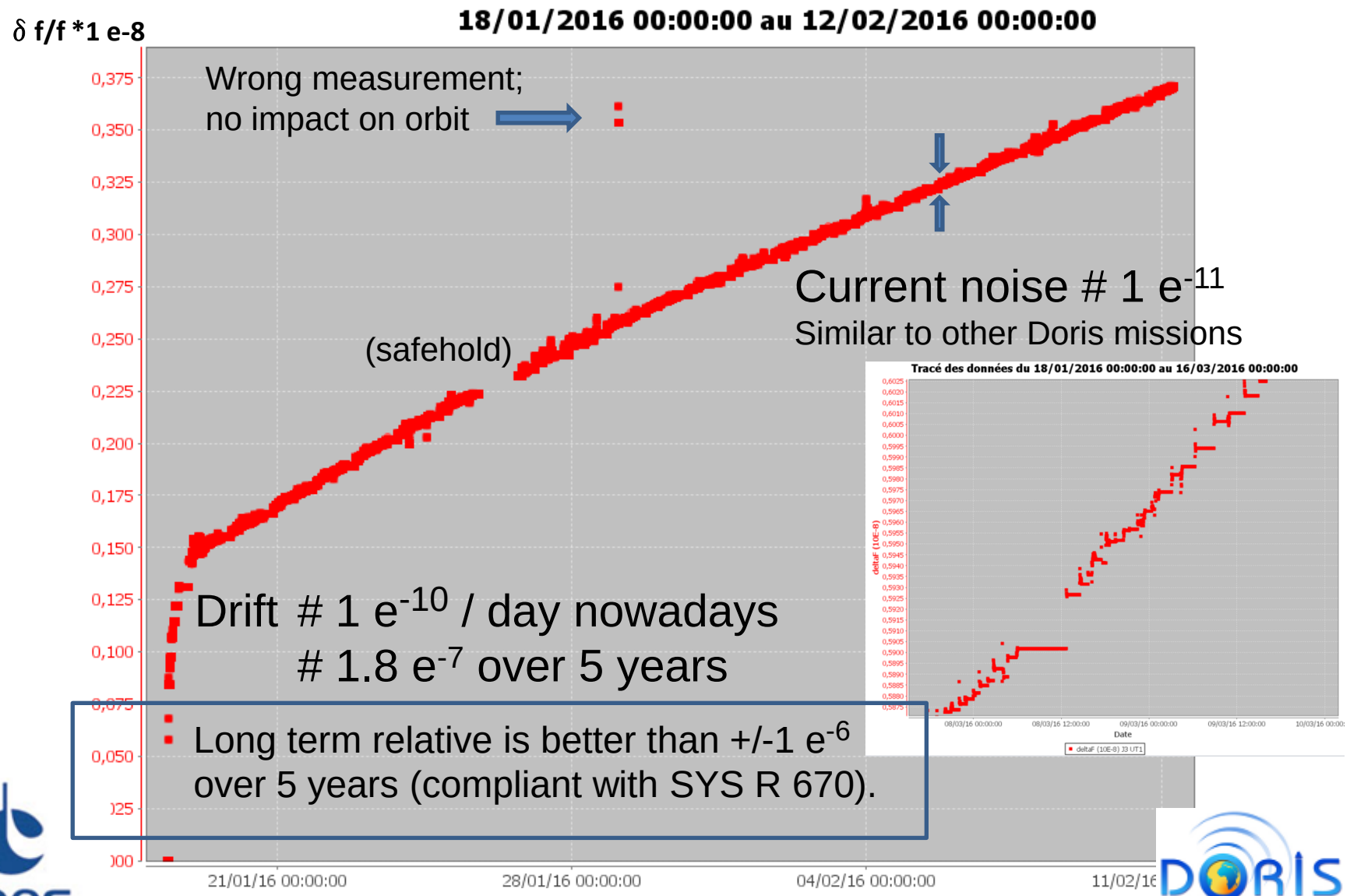
Behavior of DORIS / Jason-3 USO

With insights from :

François Didelot, Flavien Mercier, Philippe Yaya, Jean-Pierre Chauveau, Eric Lorfevre, Albert Auriol, Jean-François Dutrey, Pierre Buzon, Sabine Houry, Hugues Capdeville, Jean-Michel Lemoine, Olivier Dumond, Véronique Couderc, Cécile Manfredi, Jean-Marc Walter, Gérard Zaouche, Gilles Tavernier

Jason-3 USO frequency monitoring

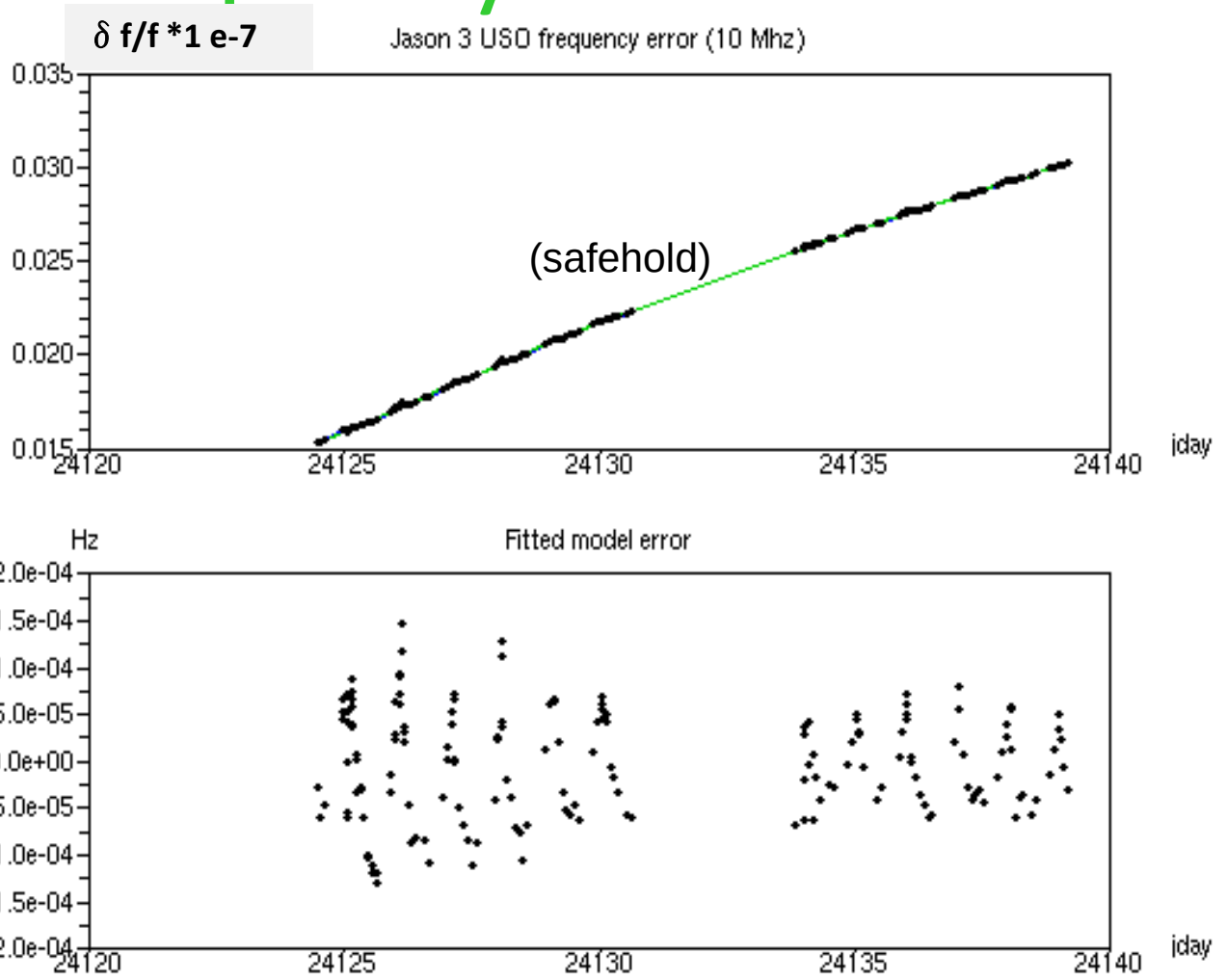


DORIS USO / Jason-3 : on-board frequency

Upper graph : estimation of the on-board frequency, estimated at each pass over a Reference Beacon

(green curve is a smoothed trend)

Lower graph : after removing the trend, one-day oscillations are present on the frequency estimation

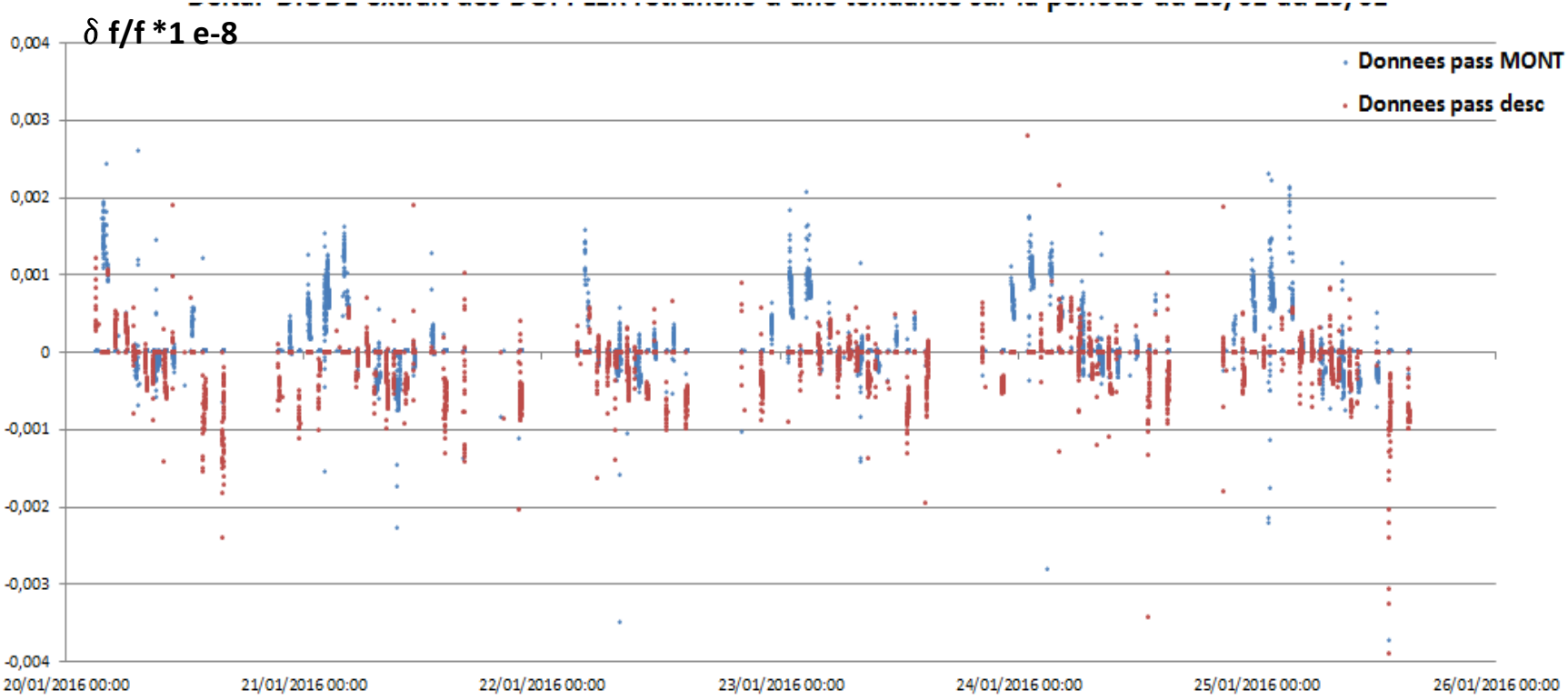


(Reference Beacons are Tlse Kru (HBK) Papeete Terre Adélie)

DIODE sees the same variations

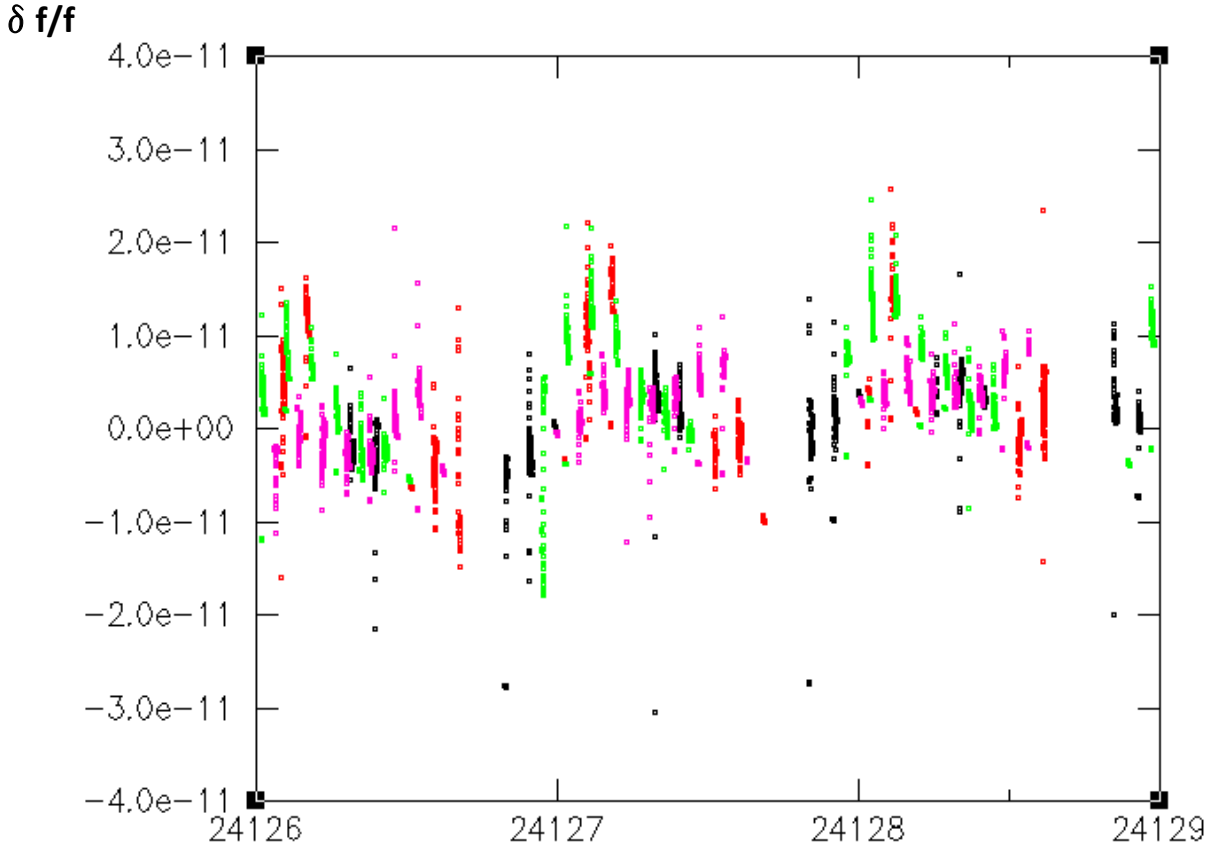
Same oscillations are seen through DIODE navigation software

1.5 e^{-11} before the Safe-Hold (1 e^{-11} after)



(Reference Beacons are Tlse Kru (HBK) Papeete Terre Adélie)

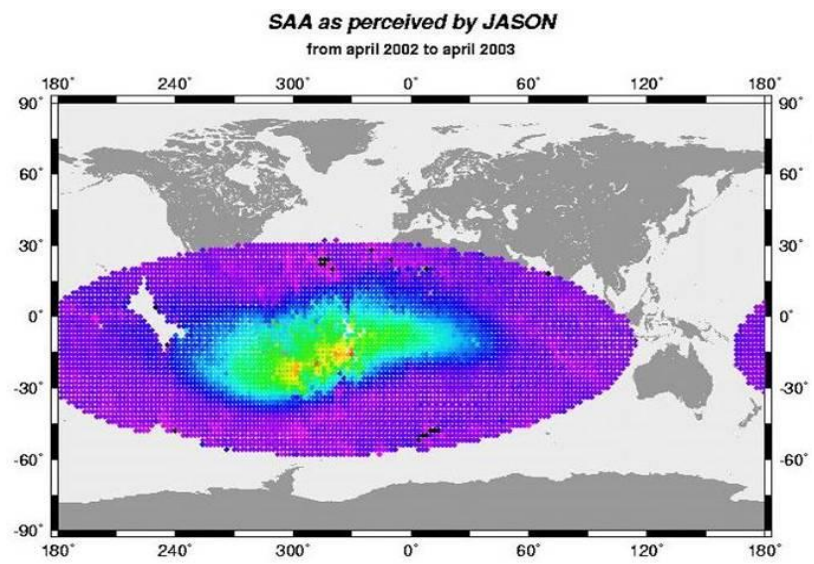
DIODE sees the same variations (zoom)



Papeete
Kourou
Toulouse
Terre Adélie

(HARTEBEESHTOEK in maintenance)

- « Mid-TAI-day » passes are closer to zero

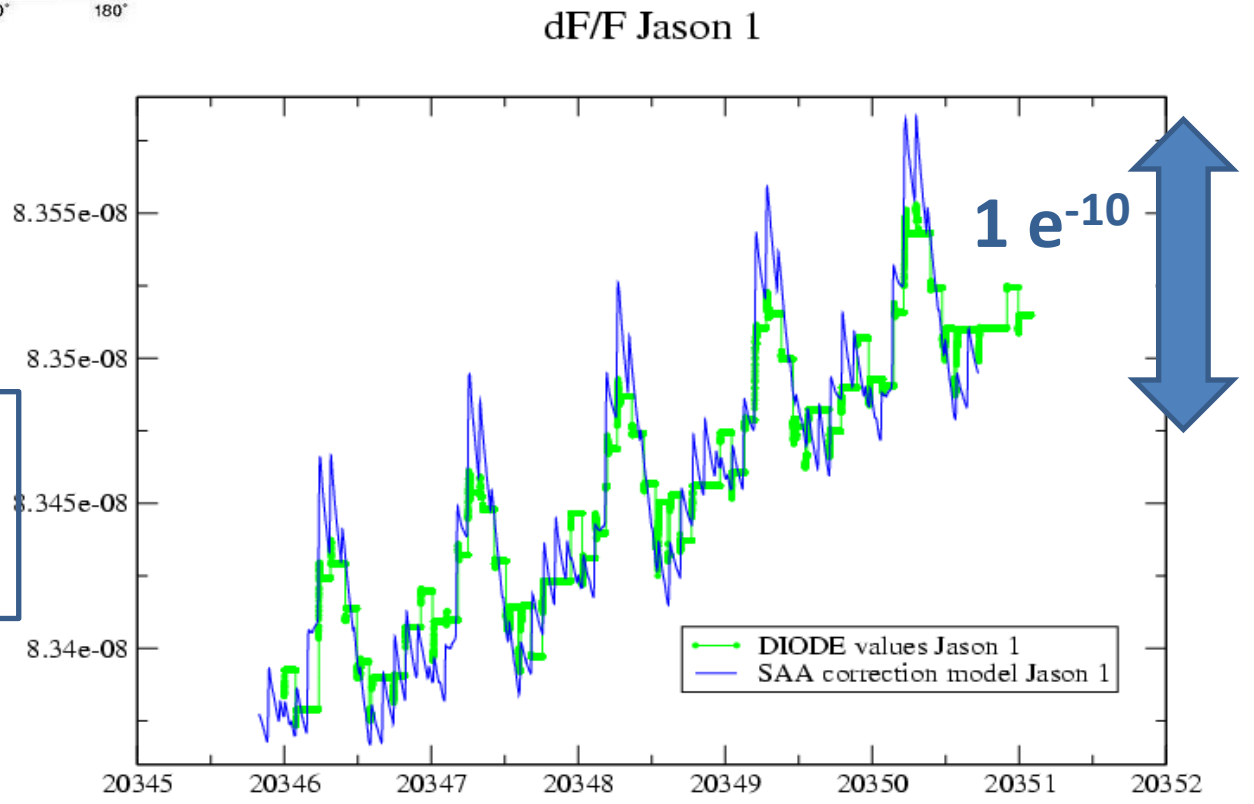


Reminder

On-board USOs are sensitive to thermal variations, accelerations, humidity, ***radiations***, magnetic fields

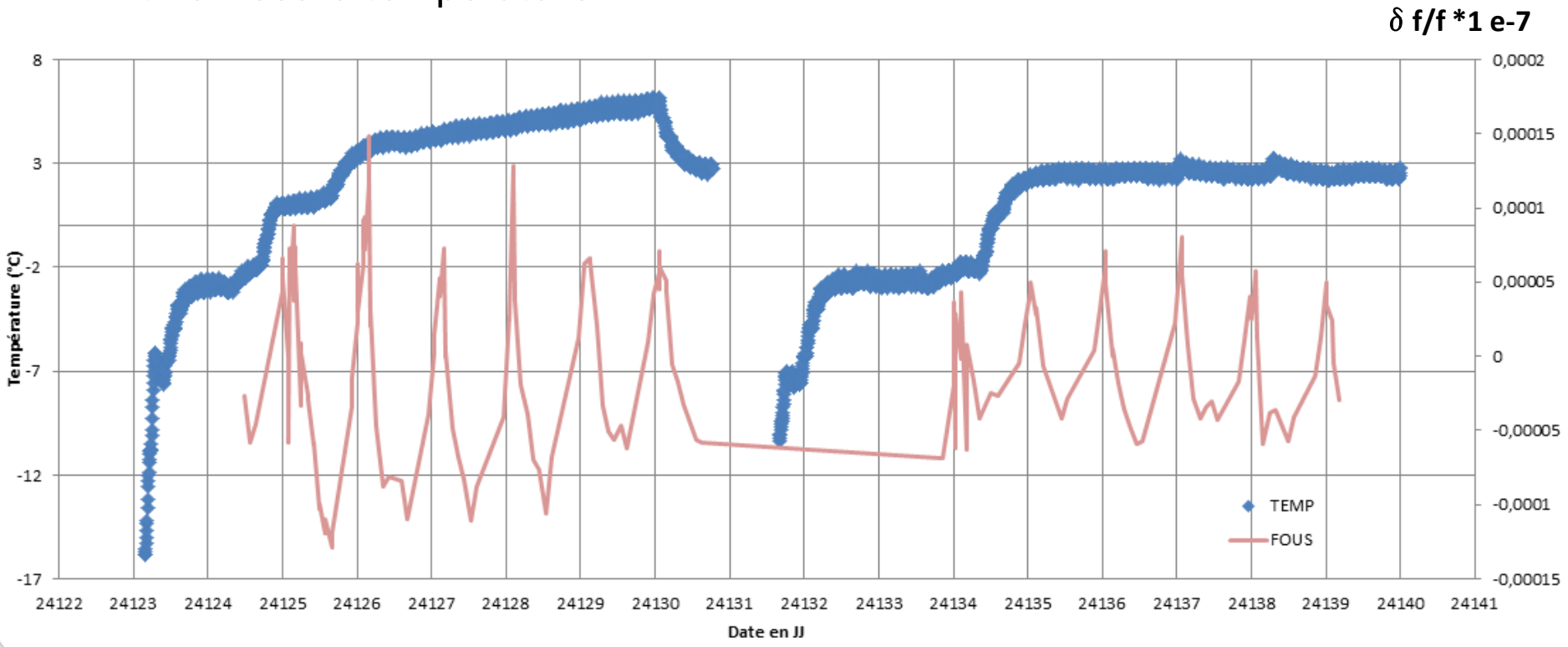
Jason-1 USO was very sensitive to South Atlantic Anomaly (SAA) and its radiations

Jason-3 oscillations are 10 times smaller than SAA effect on Jason-1

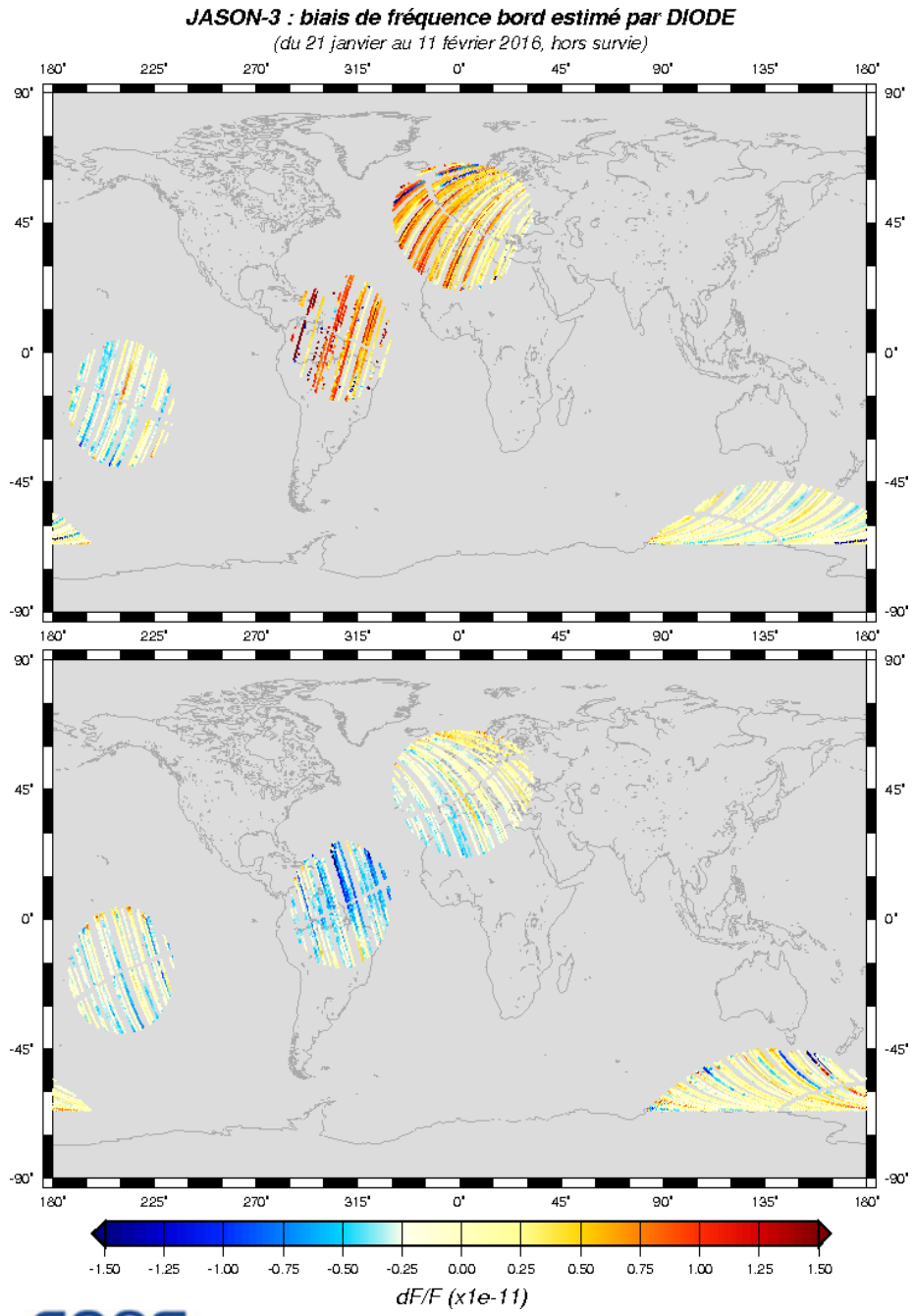


Back to Jason-3 :

- oscillations on the estimated frequency do not appear to be correlated with on-board temperature :



- No correlation with acceleration,
- no correlation with magnetic on board fields



Geolocalisation of perturbed passes

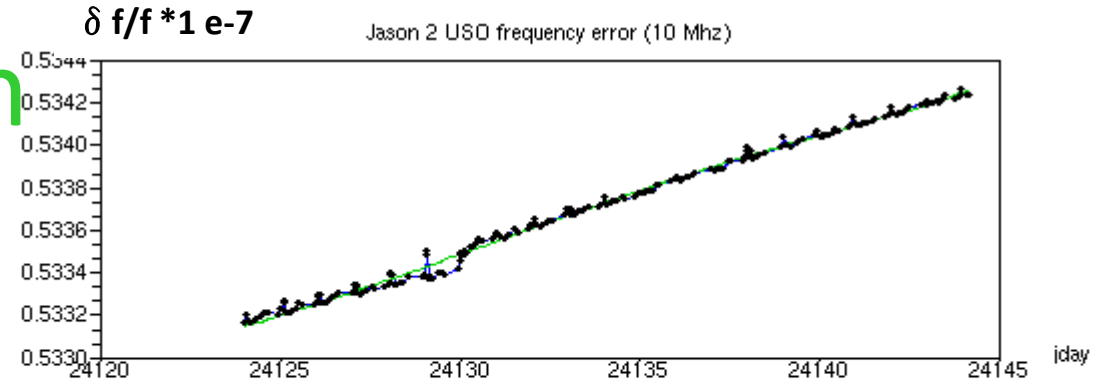
On-board frequency is estimated during each pass over a Reference Beacon

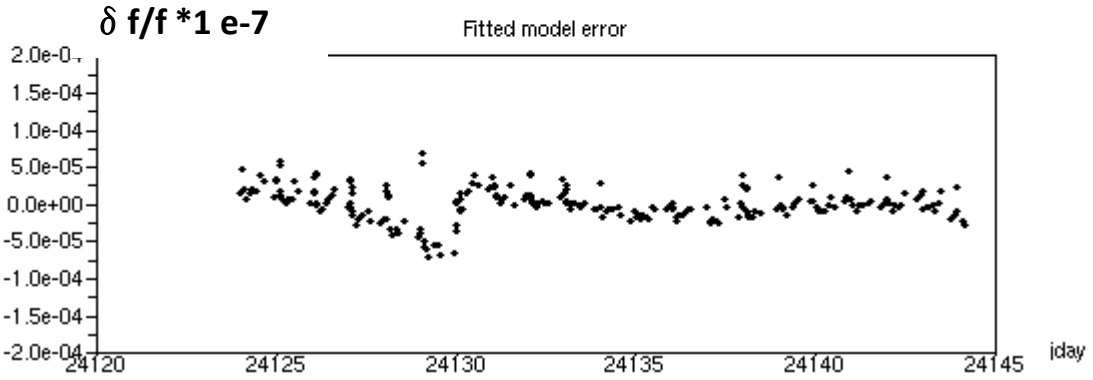
KRWB and TLSB strongly biased (positively) on ascending passes.

Strong negative biases for KRWB descending passes (wrt tendancy)

NB. Measurement with elevation < 15° are suppressed

What is seen on DORIS/Jason-2 (same period)

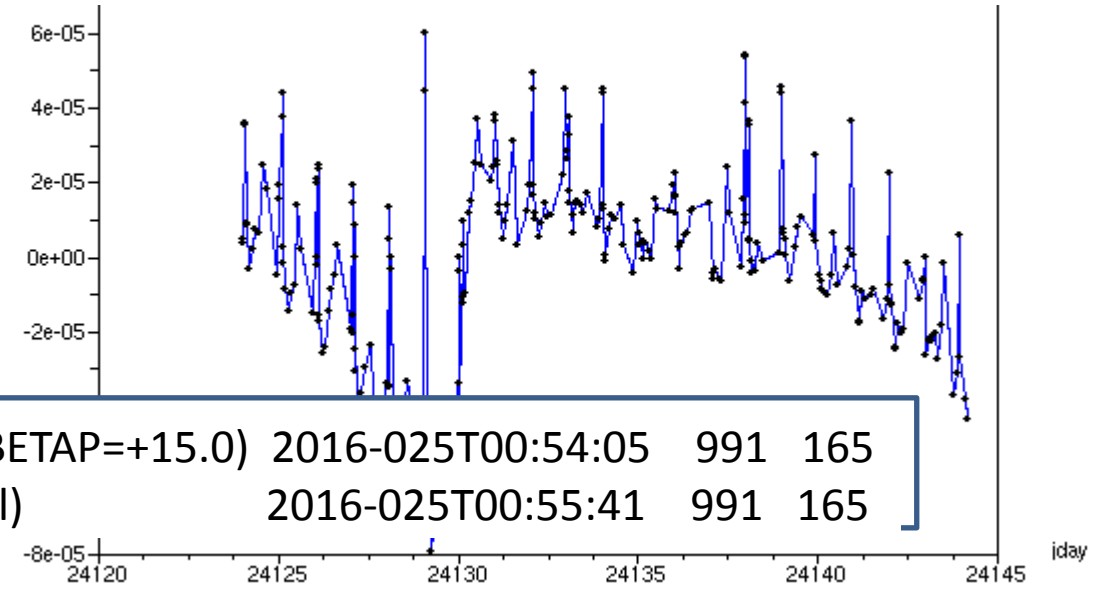




- (drift = 1 e^{-11} /day)
- Daily peaks too, amplitude = 2-4 e^{-12}

- Seems to have been present for a long time.

- Day 24130 = 25/01/2016 ramp-up Jason-2, (and Jason-3 safehold).

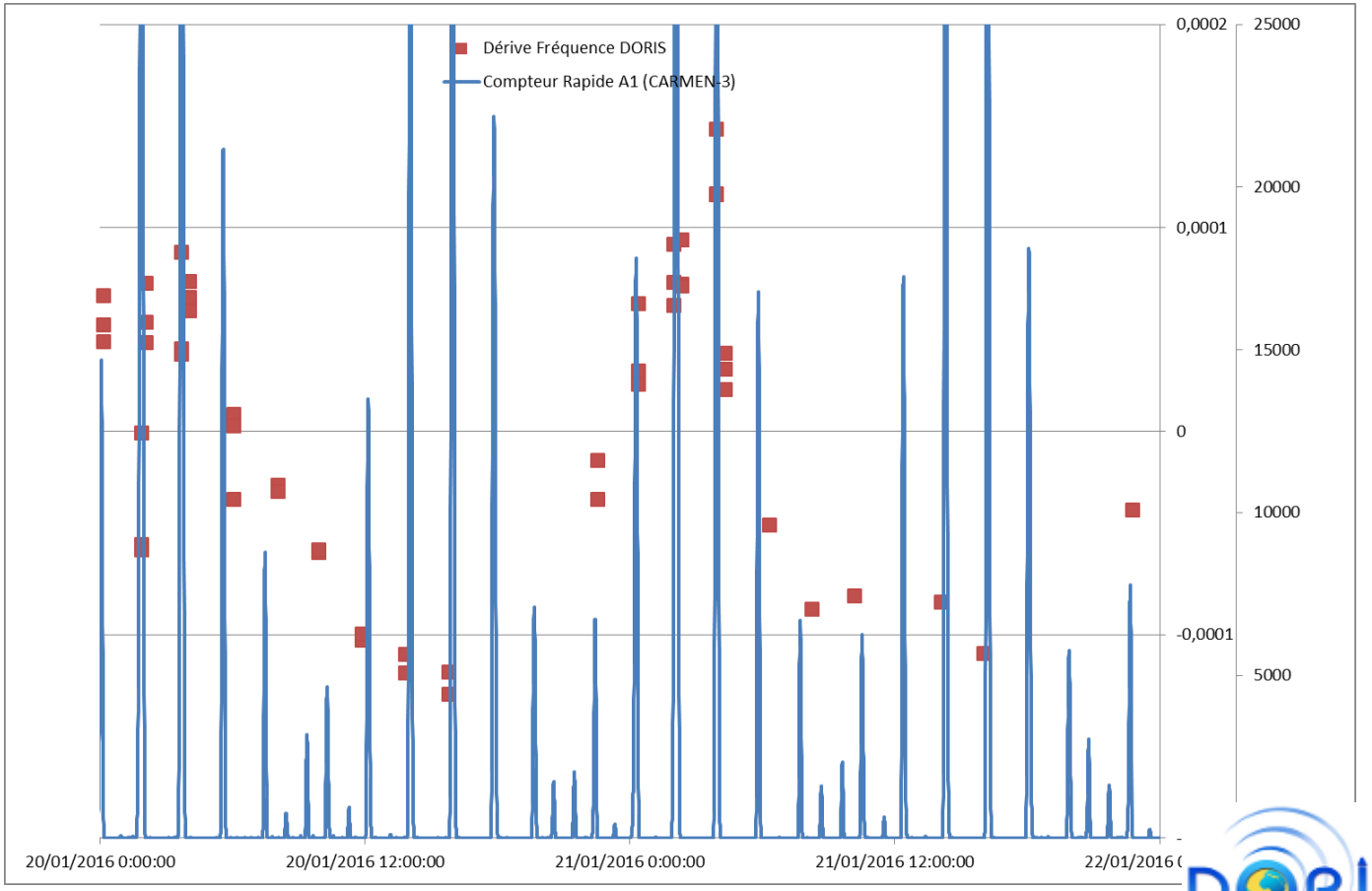


- Start Yaw Ramp (Fixed to Sinusoid BETAP=+15.0) 2016-025T00:54:05 991 165
- Stop Yaw Ramp (Fixed to Sinusoidal) 2016-025T00:55:41 991 165

What does Carmen see over that period ?

CARMEN counts radiations on-board Jason-3 : here a fast counter totalizes the number of ionizing particles, whatever their energy, during a 14 seconds integration time and this every 16 seconds.

(on-board accomodation : what CARMEN counts is not exactly what the crystal receives)



USO pre-irradiation and characterization (1/2)

Used on Jason-3 : **FM58** USO (on the back-up chain, FM 57)

Pre-irradiation of the component (resonator) : **done** (30kRad)

=> Which is the right dose ? On Jason orbit, around 20 Krad received over 10 years
After Jason-1, DORIS USOs have been pre-irradiated with 30 Krad
1 MRAD considered by US specialist John R. Vig.
(« At a 1 MRad dose, frequency change ranges from pp 1 e^{-11} per rad for natural quartz to pp 1 e^{-14} per rad for high quality swept quartz. » , p190/305, Ed. 2014)

Characterisation of the sensitivity of the component wrt radiations after pre-irradiation : **not done** (an event occured at the ONERA test laboratory, leading to closure of the only available laboratory at this time for this kind of low dose irradiation)

=> Future projects are informed of this lack of characterization, and the process will be improved for future USOs. A DORIS document was initialized to provide the information to IDS scientists.

=> For Jason-3, a correction model will be necessary to improve science processings : DORIS measurement for SAA stations show frequency anomalies

USO pre-irradiation and characterization (2/2)

Since year 2005 (after analysis of Jason-1 sensitivity and design of the fixing method), each DORIS USO was pre-irradiated. From this 10 to 12 series, our specialists tell us :

- Before pre-irradiation the sensitivity is between 5 and 30 e^{-12}/Rad,
- After pre-irradiation the sensitivity is divided by 5 to 10, so 1 to 5 e^{-12}/Rad.

For **Jason-2**, we have probably **taken the best** with a sensitivity of **1 e^{-12}/Rad**. With 12 passes of 10 minutes (mean) each day within SAA with a rate of 1Rad/heure, USO receives around 2Rad/day. Thus we obtain daily variations around 2 e^{-12}, which is very low, near DORIS system noise.

For **Jason-3**, we have probably **taken a second choice** with a **5 e^{-12}/Rad** sensitivity, this leads to variations around 1 e^{-11} : it is nearly what we see.

Message towards IDS scientists

We kindly inform the users of DORIS/Jason3 data that from first observations of USO frequency behavior performed in the frame of in-flight commissioning, CNES experts suspect a slight sensitivity to radiations :

much lower than the one of Jason1 (ten times less),

but a bit higher than the one of Jason2.

Further investigations are going on to appreciate this sensitivity and its long term trend.

This sensitivity induces :

no consequence on altimetry,

almost no impact on orbit computation,

probably a few centimeters perturbation on Beacon Positionning for beacons in visibility of the South-Atlantic Anomaly.

Jason-3 / DORIS are well within their specifications, and even inside their objective goals for NRT altimetry (OGDR), high accuracy Altimetry and POE orbits determination.

For station positioning, a model will be necessary

For your attention …

Thank You !