CURRENT STATUS OF JASON-1 SAA CORRECTION MODEL

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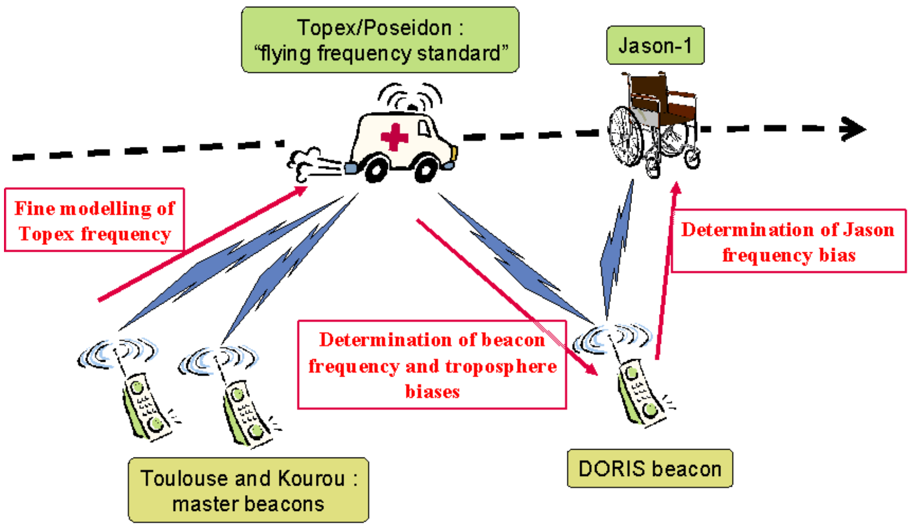
• SAA correction model: Basic principles

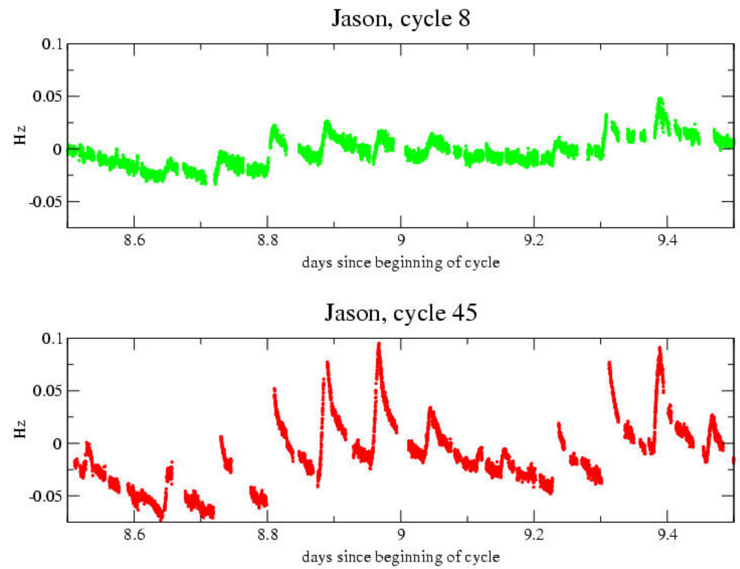
➢ Observe, analyse and model the short-term (period < 1 day) frequency variations of the DORIS instrument on-board Jason-1, related to the South Atlantic Anomaly (SAA)

First step: Observation of Jason-1 short-term frequency offsets.

Method:

1. Model the long and medium-term evolution of Topex/Poseidon and Jason frequencies.
2. Compute orbit arcs of Topex/Poseidon, solving for one troposphere parameter and one frequency bias per pass for each station. Since the Topex frequency has been modelled to a high accuracy these parameters can be trusted as very close to the true station parameters.
3. Use precise orbits of Jason, impose the station parameters determined by Topex and interpret the residuals as DORIS receiver frequency offsets. Conversion factor from residuals (in m/s) to Hz (/2 GHz): Hz ~ -6.7922 * Res





Jason on-board frequency variations, reconstructed per measurement

• SAA correction model: Modelling the SAA perturbation

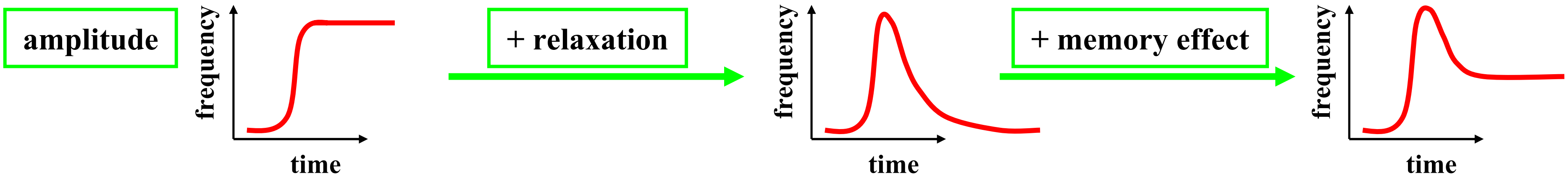
Second step: Analysis and modelling of Jason-1 short-term frequency offsets.

The SAA is modelled by a 1°×1° static grid, plus time-dependant parameters:

✓ a “sensitivity factor” (or “amplitude of response”) of DORIS/Jason to the SAA: *amp*

✓ a time constant corresponding to a relaxation effect after a pass in the SAA: *тau*

✓ a “memory effect” corresponding to the fact that the frequency does not come back to its initial value after a SAA “boost” but remains at an intermediate level: *me*



Jason-1 frequency offset at date *t* is given by the following formula:

$$\frac{\Delta f_{Jas}}{f_{Jas}}(t) = (1-\mathrm{me}) * current\_dose(t) + \mathrm{me} * cumulated\_dose(t)$$

where *current_dose* and *cumulated_dose* at date *t* are obtained by numerical integration along the orbit of the satellite, according to the differential Eqs.:

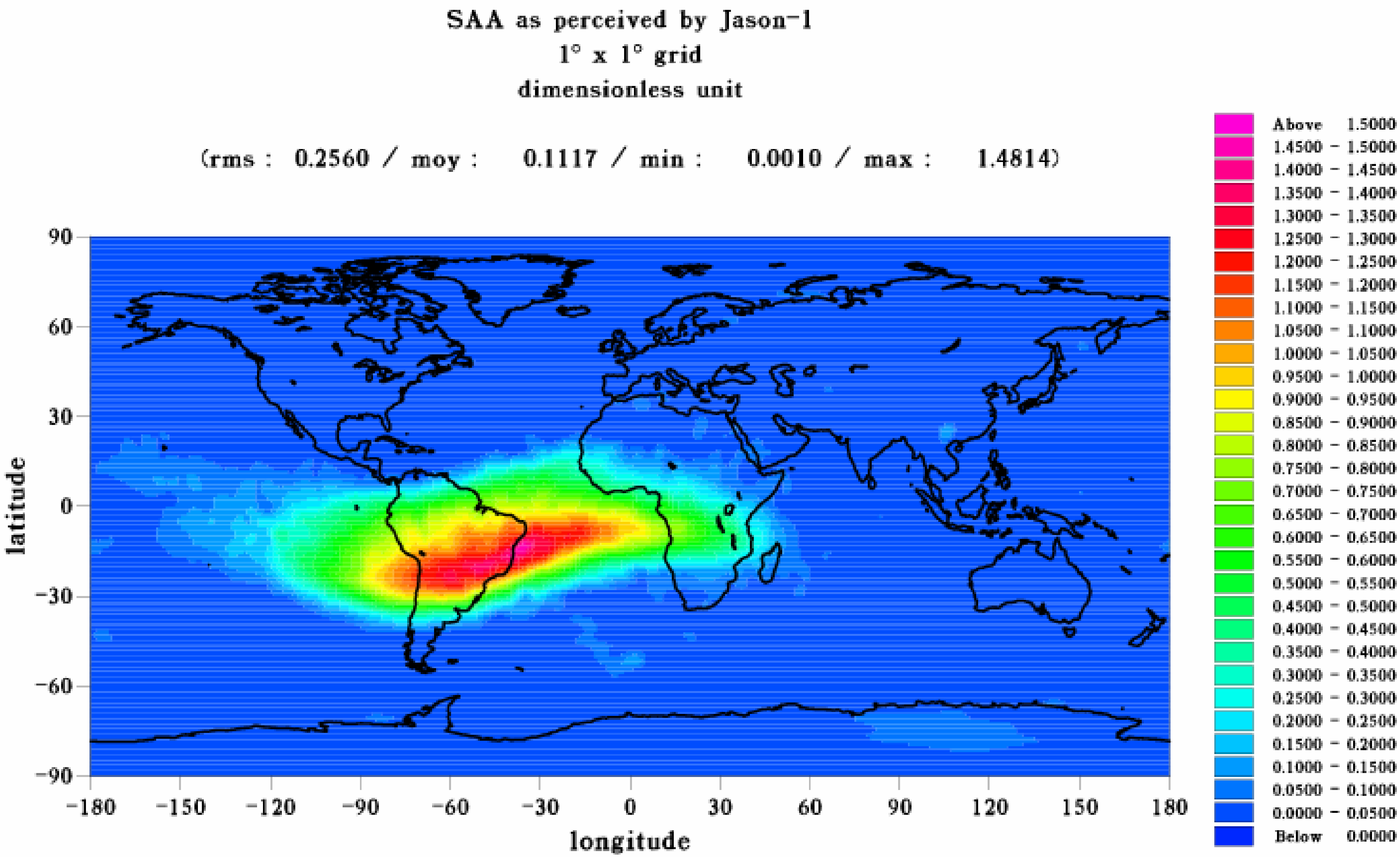
$$\frac{d(cumulated\_dose)}{dt} = dose\_flux$$

$$\frac{d(current\_dose)}{dt} = dose\_flux - \frac{current\_dose}{\tau}$$

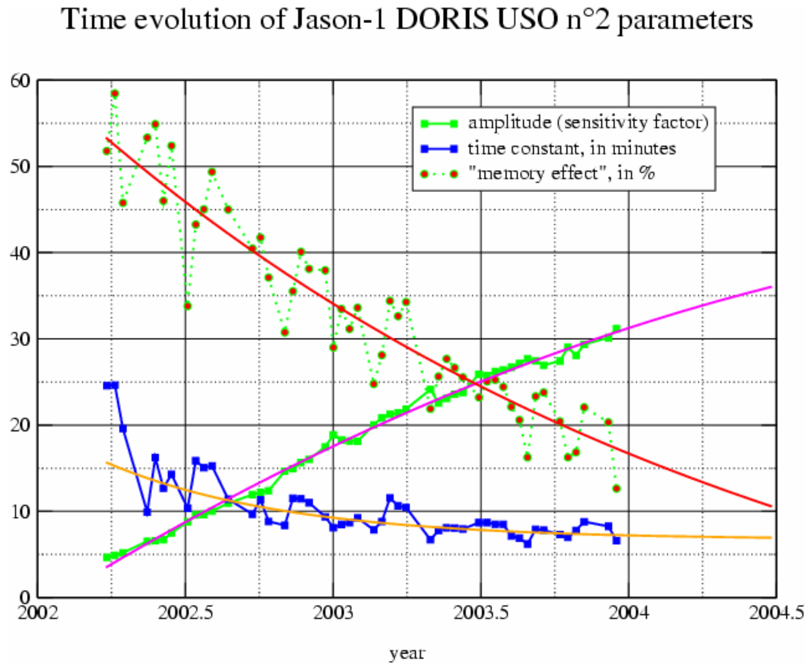
with :

$$dose\_flux = \mathrm{amp} * \mathrm{dose\_exposure} \qquad \text{(dose\_exposure is read from the } 1° \times 1° \text{ grid)}$$

• **SAA correction model: 1°×1° grid of SAA "dose exposure"**

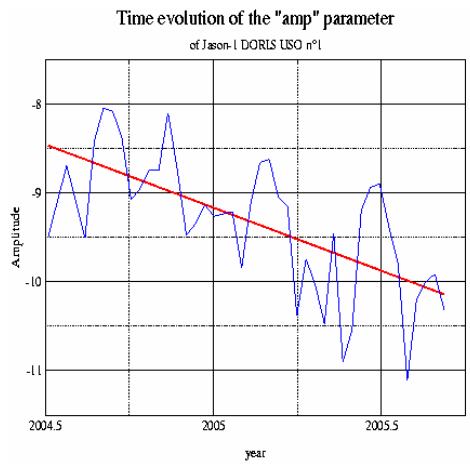


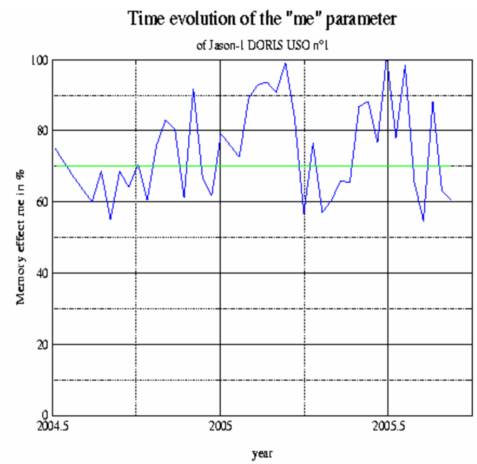
• SAA correction model: time-dependant parameters



FIRST OSCILLATOR (USO n°2): cycles 1-90

- quasi-linear increase of the amplitude from 5 to 36
- exponential decrease of the time constant, from 20 to 7 minutes
- quasi-linear decrease of the "memory effect", from 50 to 10 %

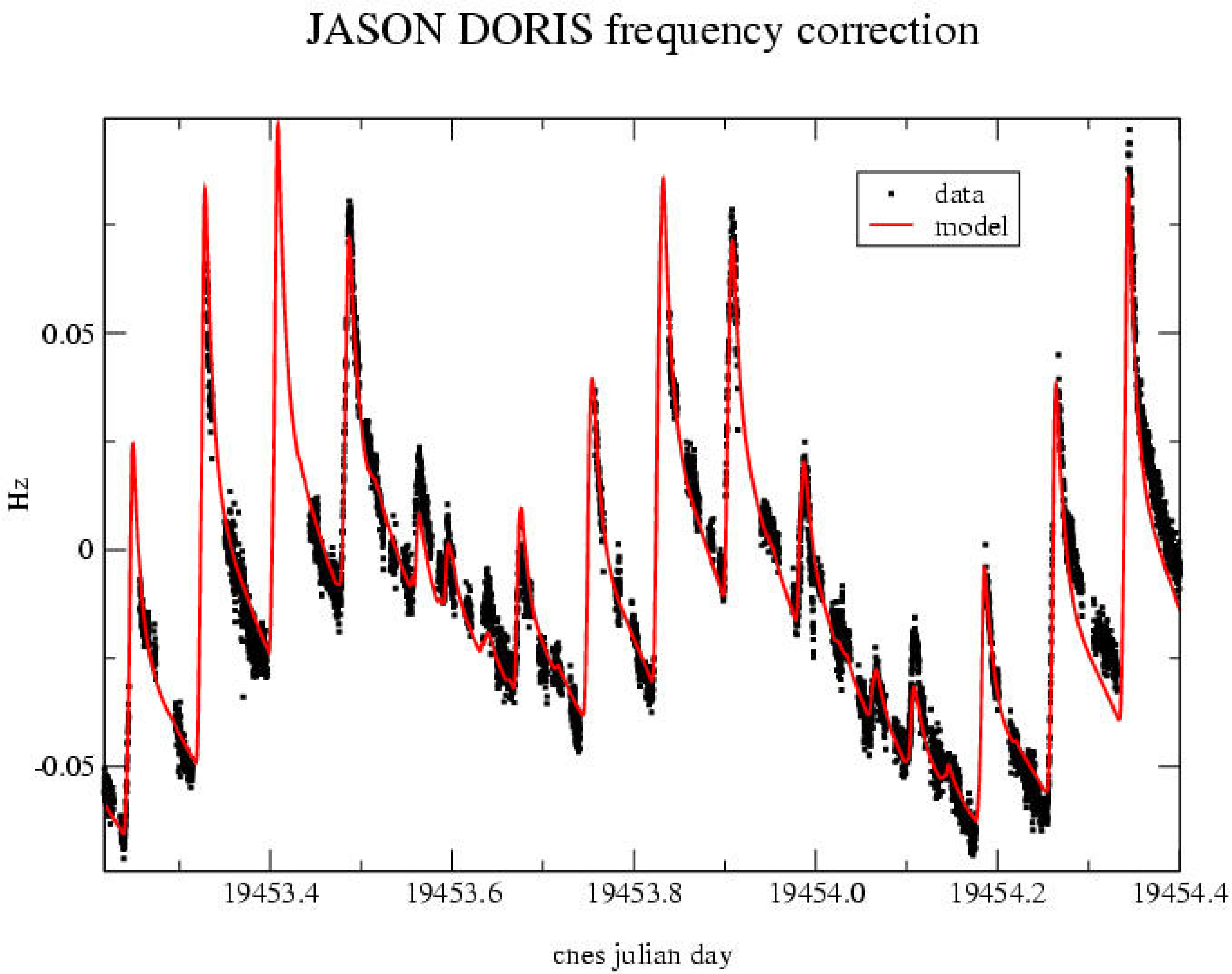




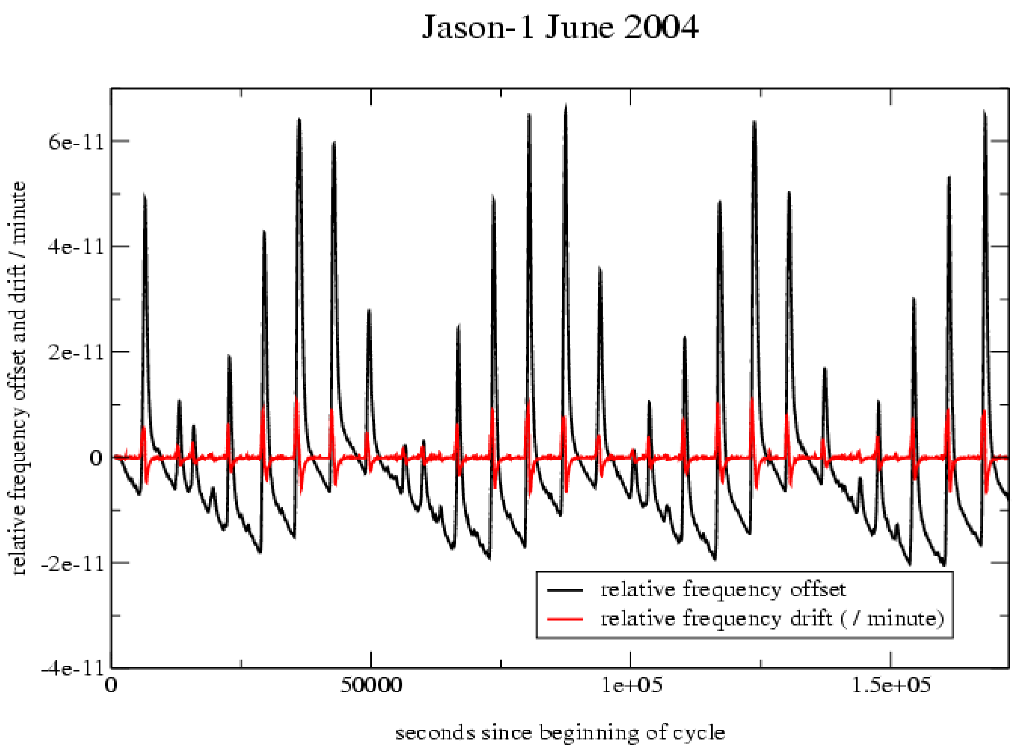
SECOND OSCILLATOR (USO n°1): cycles 90-…

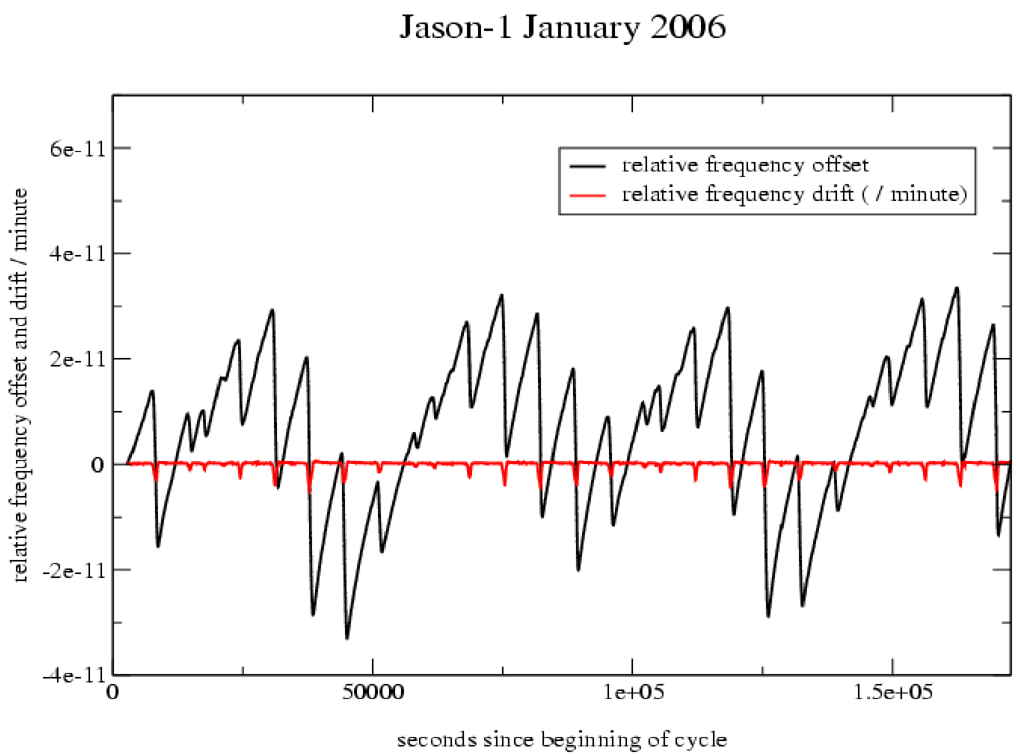
- time constant fixed to 40 minutes
- linear decrease of the amplitude from: -8.5 to -10.5
- "memory effect" modelled by a constant = 70%

• SAA correction model: comparison “observations”- model

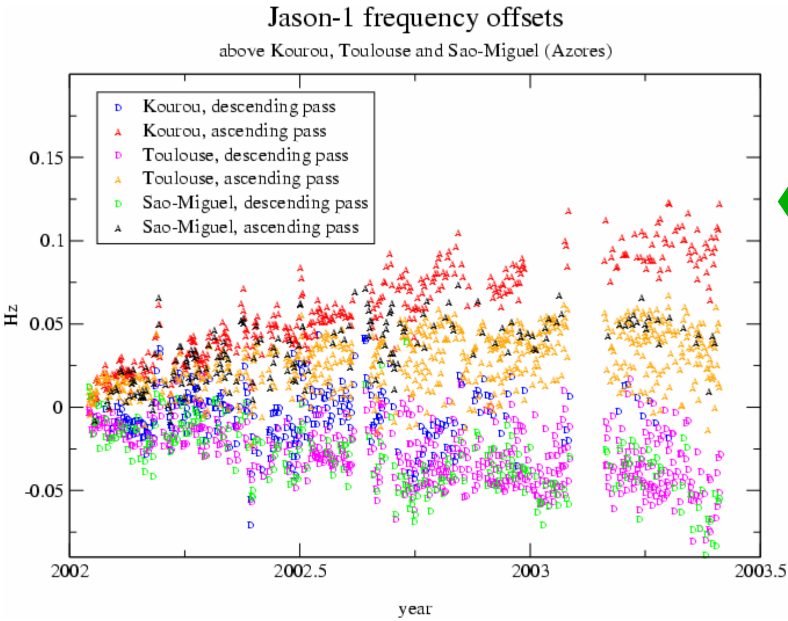


• SAA correction model: comparison model USO n°2 – USO n°1





• SAA correction model: impact on station positioning

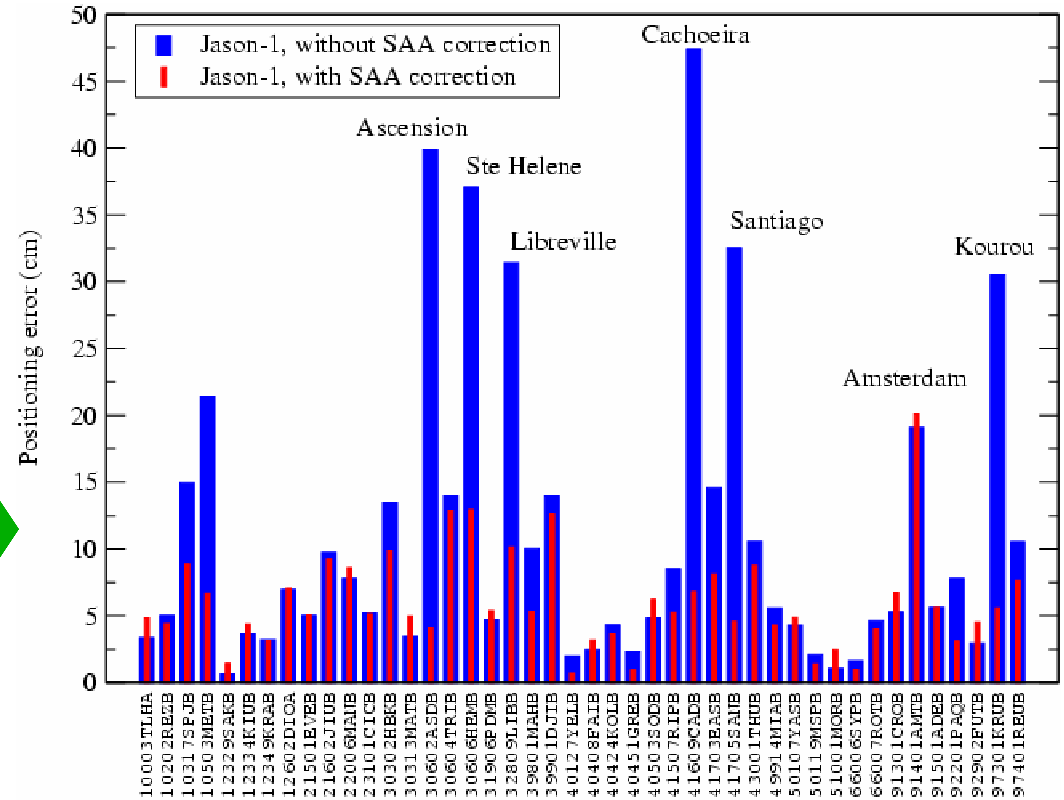


Station frequency offset per pass, without SAA correction, for three stations: Kourou, Toulouse and Sao-Miguel.

The SAA was greatly perturbing the station positioning in and around the SAA area: the discrepancy between ascending and descending pass frequency offsets increased quasi-linearly.

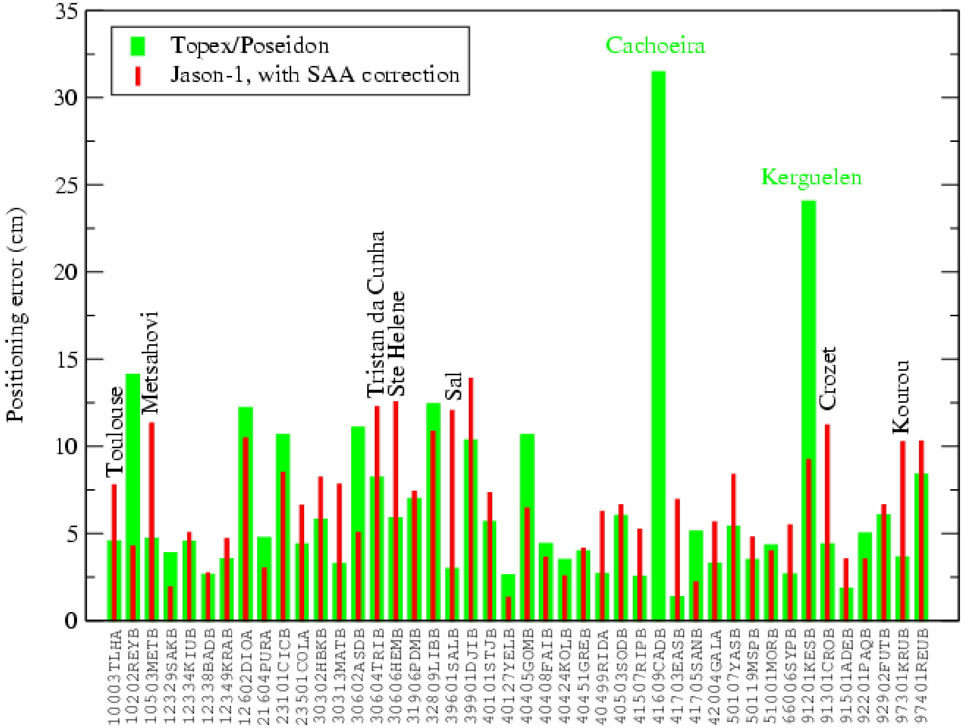
Comparison between a Jason-1 monthly network solution (June 2005) and the ITRF2000.

The station positioning is improved in most cases, particularly for the stations of the SAA area.

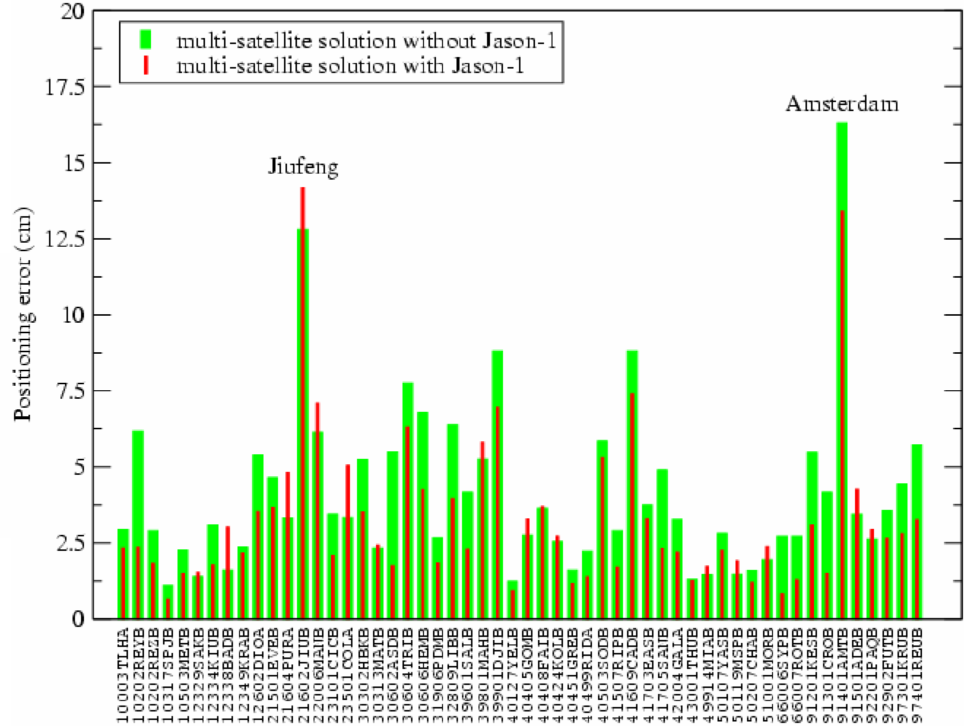


• SAA correction model: station positioning compared to Topex

Comparison between the ITRF2000 and a monthly network solution (September 2004) from T/P and Jason-1



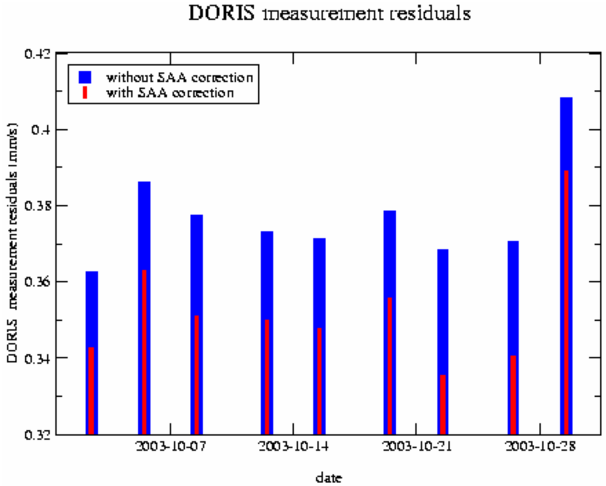
Comparison between a multi-satellite monthly network solution with/without Jason-1 (June 2005) and the ITRF2000

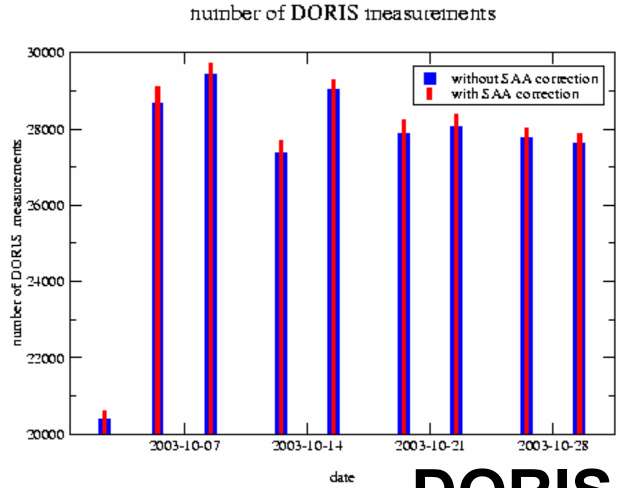


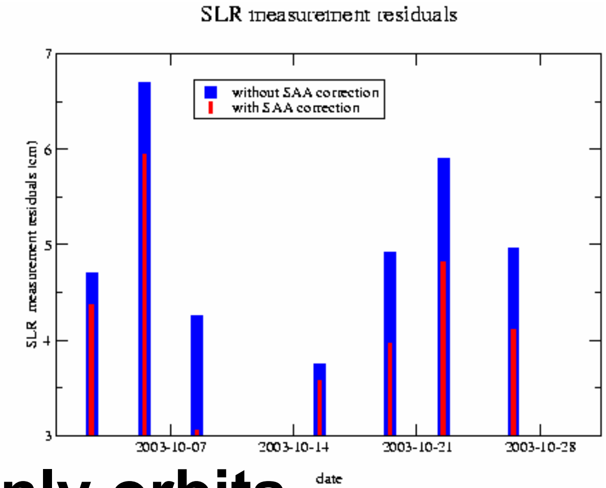
➢Jason-1 reaches now a quality of station positioning comparable to that of T/P, except for a few stations in the SAA area.

➢The addition of Jason-1 to multi-satellite solutions brings an improvement in positioning accuracy for most stations.

• SAA correction model: impact on Jason-1 orbit computation







DORIS-only orbits

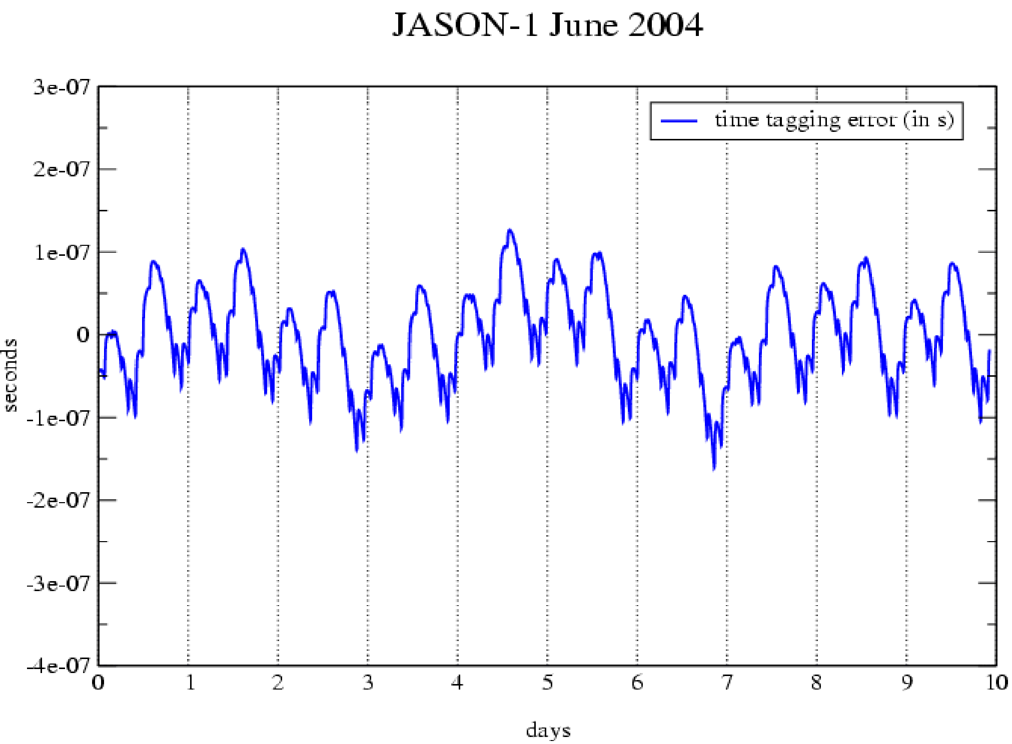
Average residuals over 40 Jason-1 cycles (mid-2003 – mid-2004)	***WITHOUT* SAA correction model**	***WITH* SAA correction model**
DORIS residuals *(average measurements weighting = 0.36 mm/s)*	***0.401 mm/s***	***0.362 mm/s***
SLR residuals *(average measurements weighting = 1.2 cm)*	***1.14 cm***	***1.13 cm***
Xover residuals *(average measurements weighting = 1.3 m)*	***5.49 cm***	***5.48 cm***

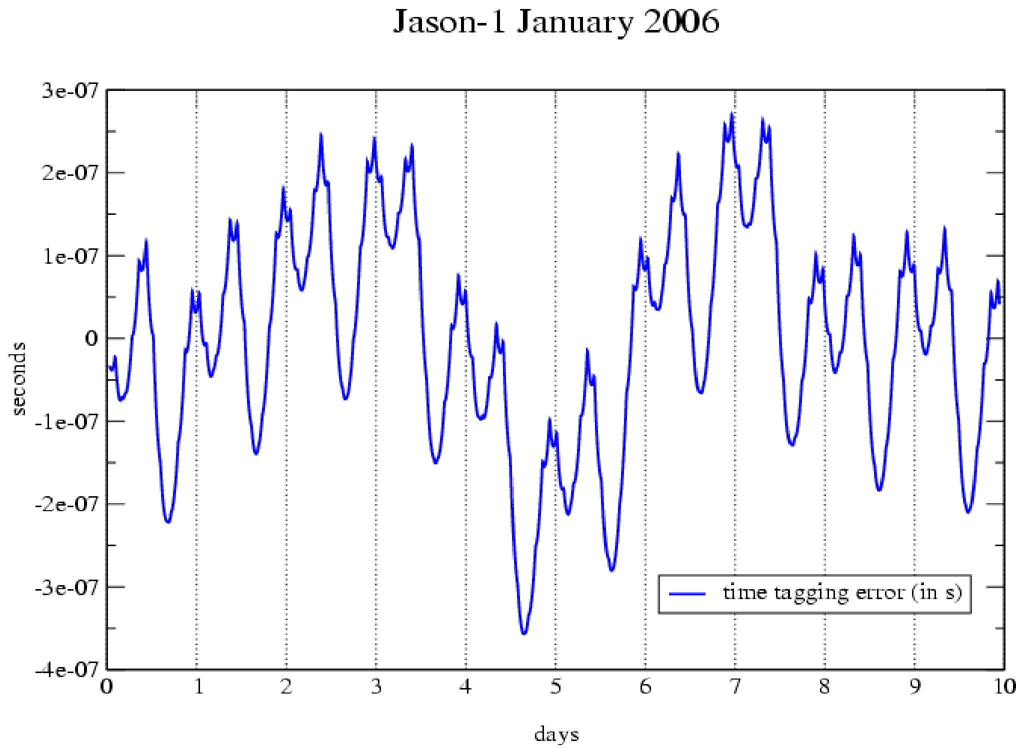
DORIS+SLR orbits

• SAA correction model: mean orbital differences without/with SAA

	TREND over 40 cycles (2003.5 – 2004.5)	Average BIAS over 40 cycles (2003.5 – 2004.5)	Minimum / maximum values observed
Xover measurements, mean differences between ascending and descending passes:			
WITHOUT SAA model correction	*NO*	*0.*	*+/- 12 mm*
WITH SAA model correction	*NO*	*0.*	*+/- 12 mm*
Comparison of orbits computed WITHOUT / WITH SAA model correction:			
Orbit off-centering in the X-Y inertial plane	*NO*	*0.*	*+/- 12 mm*
Orbit off-centering along the Z inertial axis	*NO (USO change ?)*	*- 4.0 mm*	*+/- 12 mm*
Radial orbit differences	*NO*	*0.*	*0.*
Along-track orbit differences	*NO*	*- 5.6 mm*	*+/- 12 mm*

• SAA correction model: impact on Jason-1 time-tagging error





	JASON-1 (USO 2) June 2004	*JASON-1 (USO 1) January 2006*	*JASON-2 (Nominal)*
Relative frequency offsets (min/max)	**-2. / +6. 10^{-11}**	**-4. / +4. 10^{-11}**	**-2. / +2. 10^{-12}**
Time tagging error (min/max) and equivalent along-track error	**-0.15 / +0.15 10^{-6} s ± 1 mm**	**-0.3 / +0.3 10^{-6} s ± 2 mm**	**-10. / +10. 10^{-9} s ± 0.07 mm**

• SAA correction model: conclusions

- The behaviour of the second DORIS USO seems to be more stable than the one of the first USO.
- The maximum, short-term, relative frequency offsets observed are -2. / +6. 10^{-11} for USO2 and -4. / +4. 10^{-11} for USO1.
- The main impact of the SAA correction model is on the quality of the station positioning which becomes comparable to that of Jason-1 for most stations. Consequently Jason-1 data can now be used in conjunction with data from the other DORIS satellites and improve the positioning of a vast majority of stations.
- In terms of precise orbit determination, the following features have been observed:
  - Important reduction of the DORIS residuals (0.401 → 0.362 mm/s)
  - hardly noticeable reduction of SLR and Xover residuals on the DORIS+SLR orbits
  - mean along-track orbit difference between non-SAA-corrected and SAA-corrected orbits: -5.6 mm
  - mean Z-axis orbit difference between non-SAA-corrected and SAA-corrected orbits: -4 mm
  - strictly no mean radial orbit difference between non-SAA-corrected and SAA-corrected orbits
- The impact of the SAA perturbations on the Jason-1 DORIS time-tagging is negligible, amounting to 0.15 to 0.3 µs, i.e. 1 to 2 mm along-track.
- The SAA correction model is available on the IDS web site.
- The model will be periodically revised (every 6 months) by H. Capdeville to follow USO1 evolution.
- All evaluations, remarks, comments, suggested improvements… are welcome.