SAA corrective model for Jason-1 and for Spot-5 Status and Impact on the Orbit and on the Positioning

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SAA corrective model for Spot-5

Determination of a SAA map at the fly altitude of Spot-5

•Determination of the SAA onboard frequency signal obtained from measurements DORIS

SAA onboard frequency obtained from ~3 years of data (20/02/2009 to 27/12/2011)

•Using the Jason1 approach

1) Determination of precise orbits of all DORIS satellites

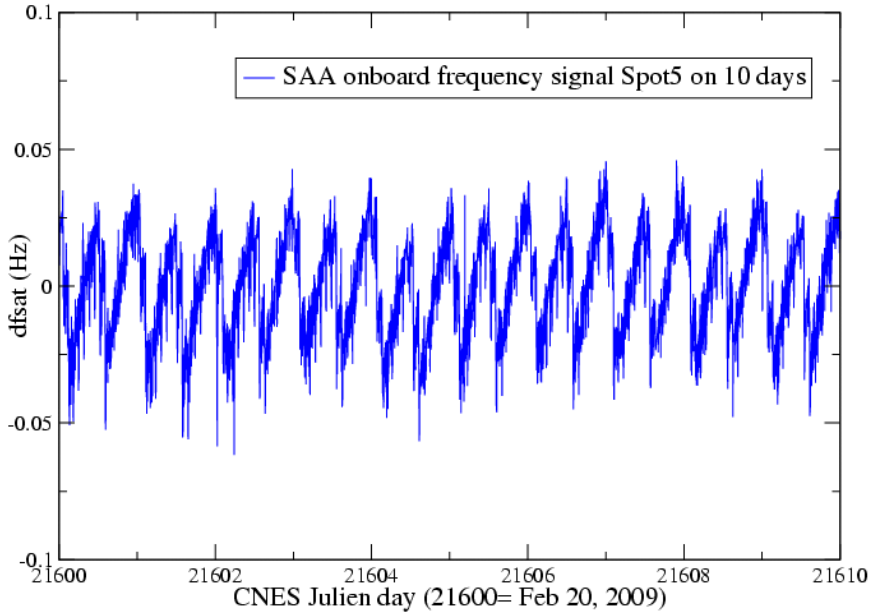
combination of all satellites except Spot-5 → station parameters (MZB,MFO)

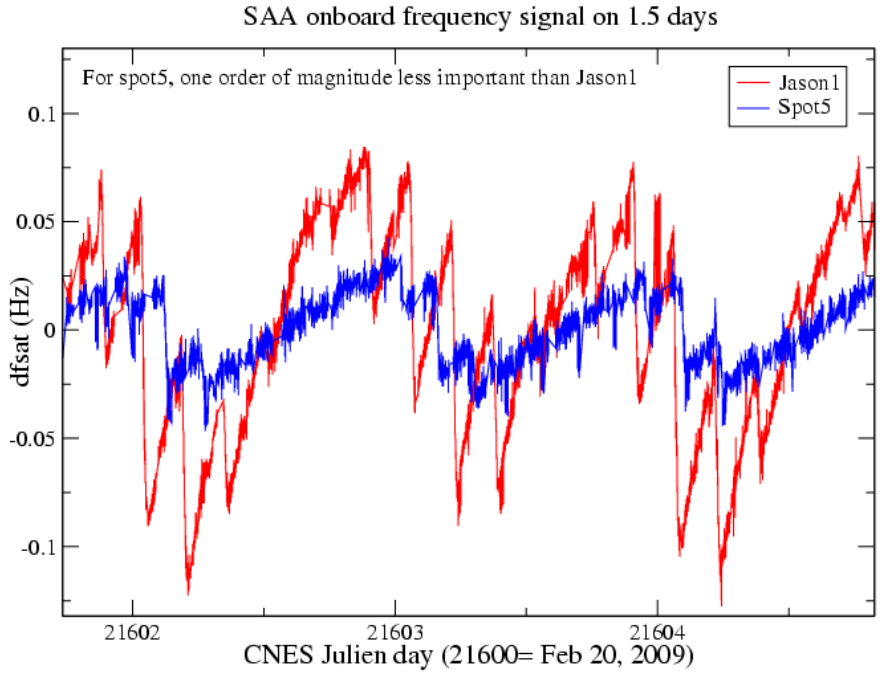
Spot-5 → orbit dynamical parameters

2) Determination of measurement residual

we have fixed station parameters (from combination) and Spot-5 orbit (of step1)

3) Conversion of measurement residual in offset frequency Δfsat (*in Hz on 2GHz)*





-size of the effect on Spot5 is lower than for Jason-1 (about one order of magnitude)

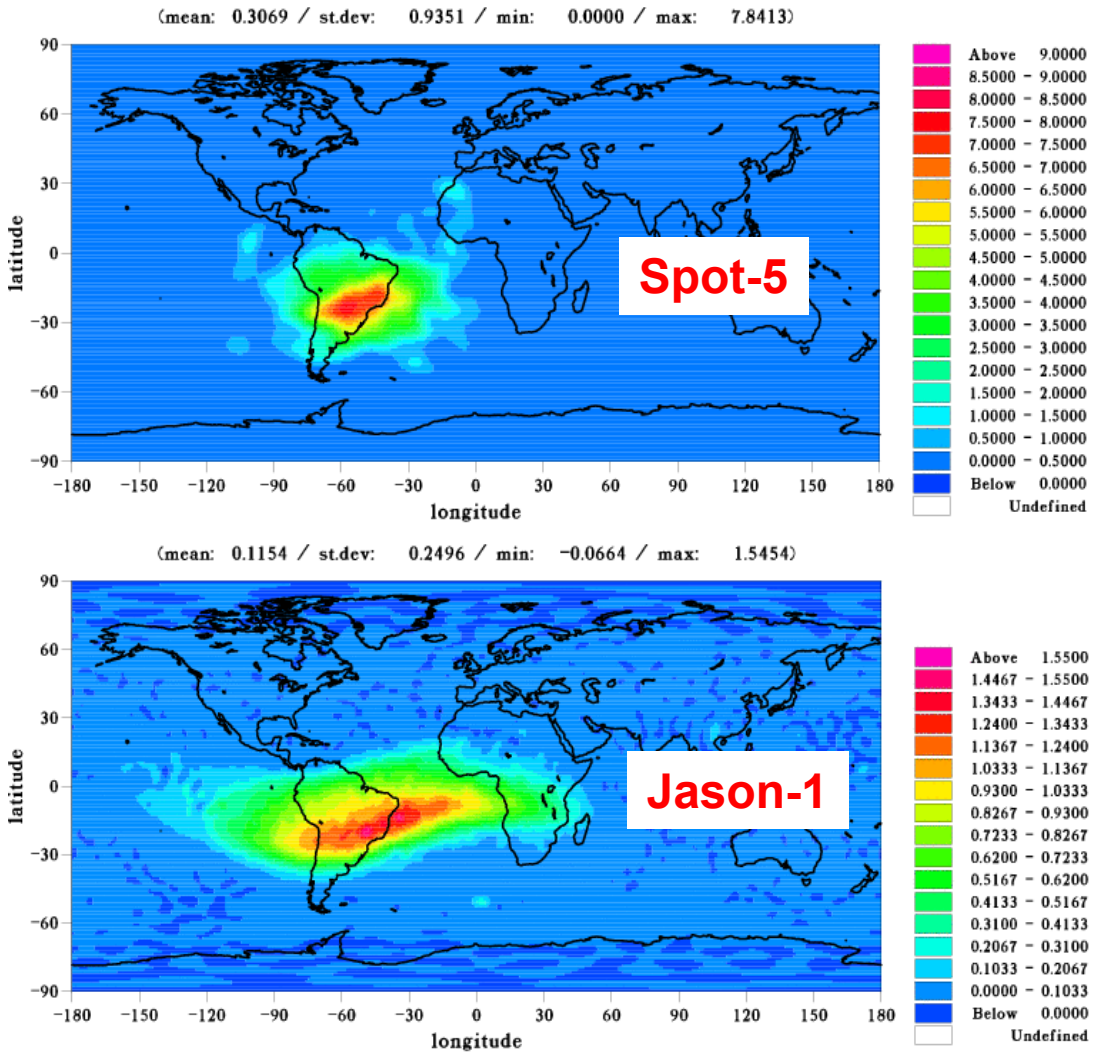
SAA corrective model for Spot-5

•Determination of the Spot-5 SAA map from the SAA onboard frequency time derivative

1) Time derivative of Δfsat (20/02/2009 to 27/12/2011)

2) Mean of the cumulated derivatives values by cell of 2°x2° on the three years period

3) Interpolation to obtain a grid 1°x1°



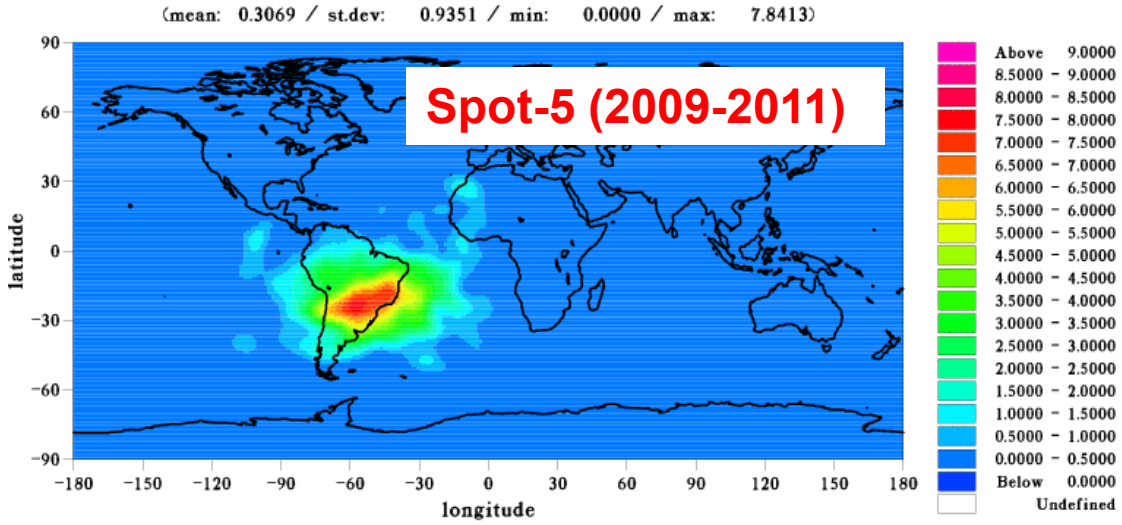
- The SAA area is less expanded at the fly altitude of Spot-5 than the one of Jason-1

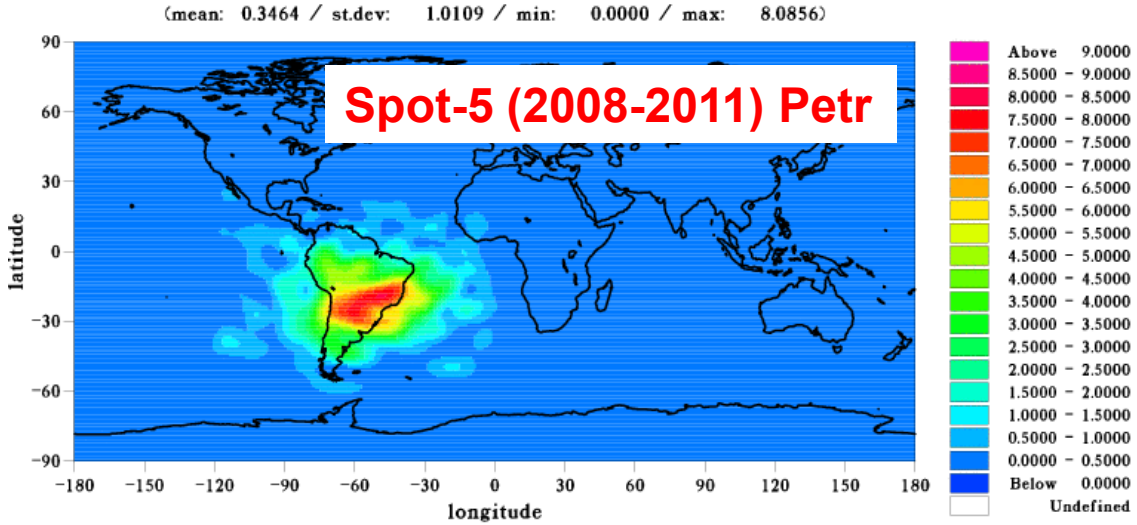
-For Spot-5 the observations of 3 stations are strongly affected:
Cachoeira, Arequipa and Santiago

and 3 stations less affected:
Kourou, Ascension and Saint-Helene

SAA corrective model for Spot-5

- **Determination of the SAA map from the SAA onboard frequency time derivative**





We determined several maps:
-one calculated from data [2009-2011]
-one from the measurements of 2011

Petr provided us several maps
in particular:
-one calculated from data [2008-2011]
-one from the measurements of 2011

After several tests we chose our Spot-5 map [2009-2011]

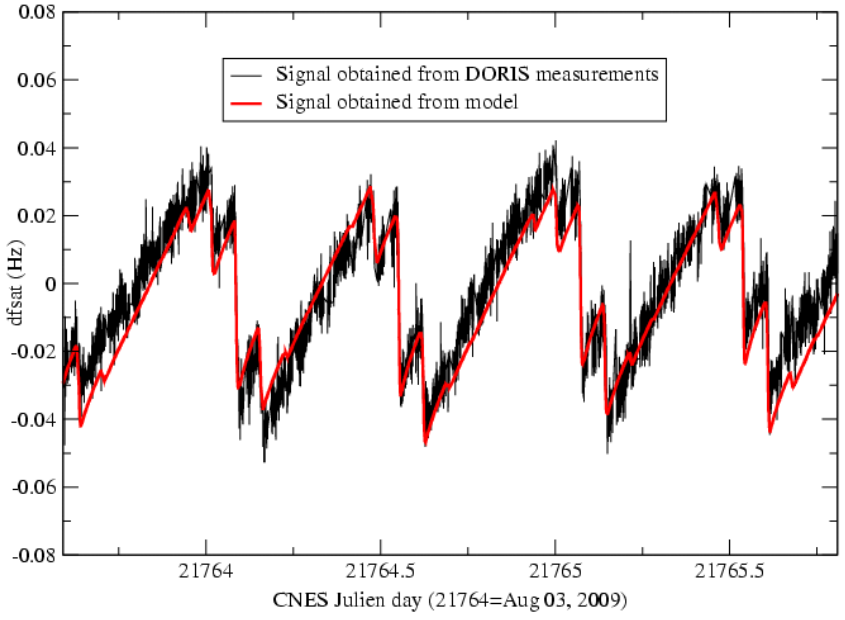
SAA corrective model for Spot-5

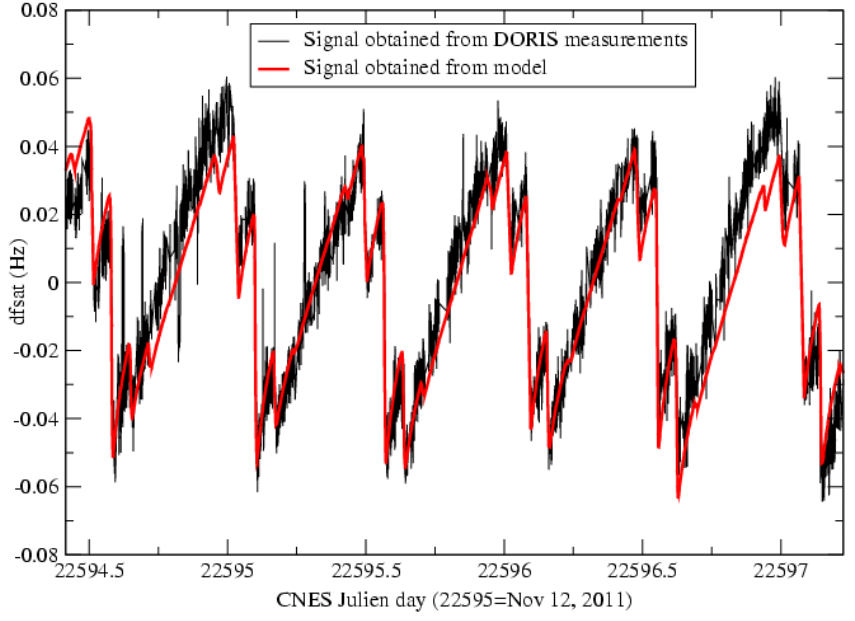
Determination of the SAA model

- **Determination of the model parameters using the Spot5 SAA map**
  model parameters adjusted over a period of 3 years (20/02/2009 to 27/12/2011)

- **Comparison between the signal from measurements and the signal from model**

SAA onboard frequency signals on 2 days





- The signals modeled and measured are very close
- The effect of SAA increases between 2009 and 2011

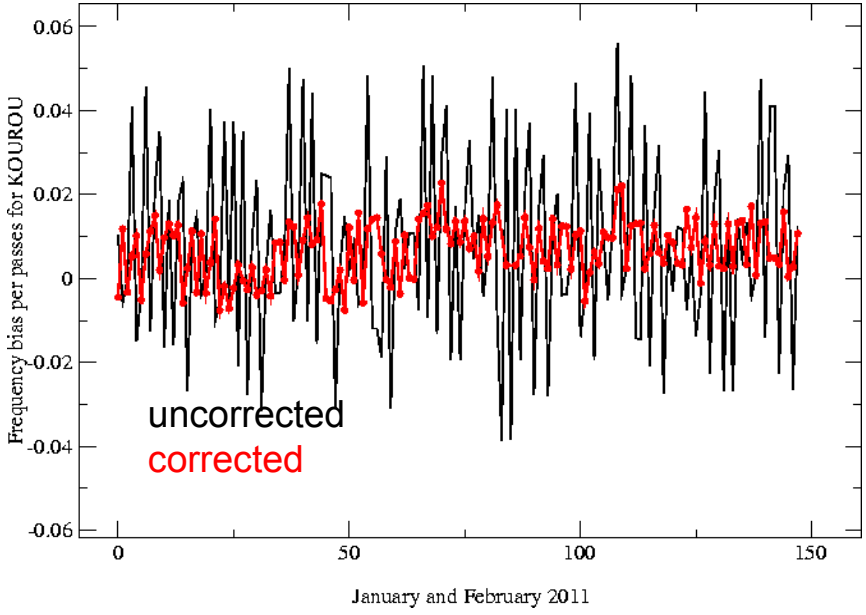
SAA corrective model for Spot-5

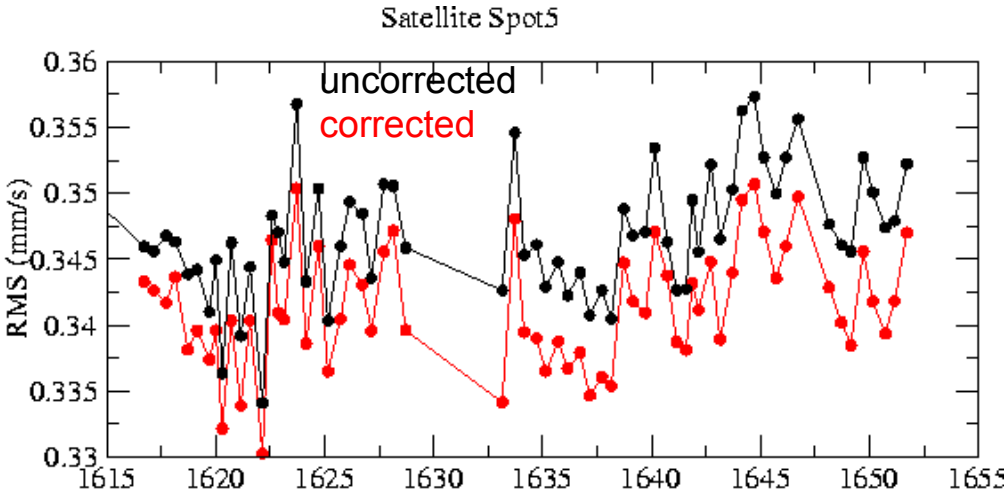
Impact on the orbit and on the positioning

- **Impact on the orbit**

Data span: year 2011 (GPS weeks 1617-1654)

Spot-5 with and without data corrected by the SAA model





- frequency bias per passes for Kourou decreases when using Spot-5 corrected
- residuals are systemically lower for Spot-5 corrected
- slight increase of validated measurements for Spot-5 corrected

SAA corrective model for Spot-5

Impact on the orbit and on the positioning

•Impact on the positioning

Spot-5 single satellite solution (weekly solutions for year 2011)

Comparison to a multisatellite solution without Spot-5 (Spot-4+Envisat+Cryosat+Jason-2)

(values are calculated after the application of the Helmert transformation parameters)

RMS3D and RMS by component (Mean values on 50 weeks)

Solutions	RMS3D (mm)	Lat (mm)	Lon (mm)	Up (mm)
Sp5 uncorrected	30.4	29.9	26.4	34.1
Sp5 corrected	23.5	17.2	30.4	20.5

- The global RMS3D is lower for Spot-5 corrected solution
- The global RMS by component is lower except for longitude

SAA corrective model for Spot-5

•**Impact on the positioning**

Spot-5 single satellite solution (weekly solutions for year 2011)

Comparison to a multisatellite solution without Spot-5 (Spot-4+Envisat+Cryosat+Jason-2)

RMS3D and Bias by component (Mean values on 50 weeks)

Station	Uncorrected in mm				Corrected in mm			
	RMS3D	lat	lon	Up	RMS3D	lat	lon	Up
Cachoeira	117.6	-22.6	108.4	-167.5	84.5	10.5	129.4	-2.3
Santiago	86	-113.5	-20.9	-88.2	56.7	-4.6	58.6	-28.1
Arequipa	81.2	96.5	-12.2	-96.6	37.6	33.7	29.9	-20.7
Kourou	48.2	63.8	-24.7	17.0	39.0	5.8	-43.7	2.4
Ascension	46.1	54.3	33.0	-36.0	29.8	23.9	-32.4	-4.2
St-Helene	42.2	-4.7	57.2	-13.0	30.0	-20.7	20.4	-18.5

- For each SAA stations the RMS3D is lower for Spot-5 corrected solution
- The bias is lower for each component except for longitude

SAA corrective model for Spot-5

•**Impact on the positioning**

Multisatellite with Spot-5 satellite (weekly solutions for year 2011)

Comparison to a multisatellite solution without Spot-5 (Spot-4+Envisat+Cryosat+Jason-2)

(values are calculated after the application of the Helmert transformation parameters)

RMS3D and RMS by component (Mean values on 50 weeks)

Solutions	RMS3D (mm)	Lat (mm)	Lon (mm)	Up (mm)
w Sp5 uncorrected	10.4	9.4	11.5	10.2
w Sp5 corrected	9.6	7.6	12.1	8.4

- The RMS3D is lower for a mutilsatellite solution with Spot-5 corrected
- The RMS by component is lower except for longitude

SAA corrective model for Spot-5

•**Impact on the positioning**

Multisatellite with Spot-5 satellite (weekly solutions for year 2011)

Comparison to a multisatellite solution without Spot-5 (Spot-4+Envisat+Cryosat+Jason-2)

RMS3D and Bias by component (Mean values on 50 weeks)

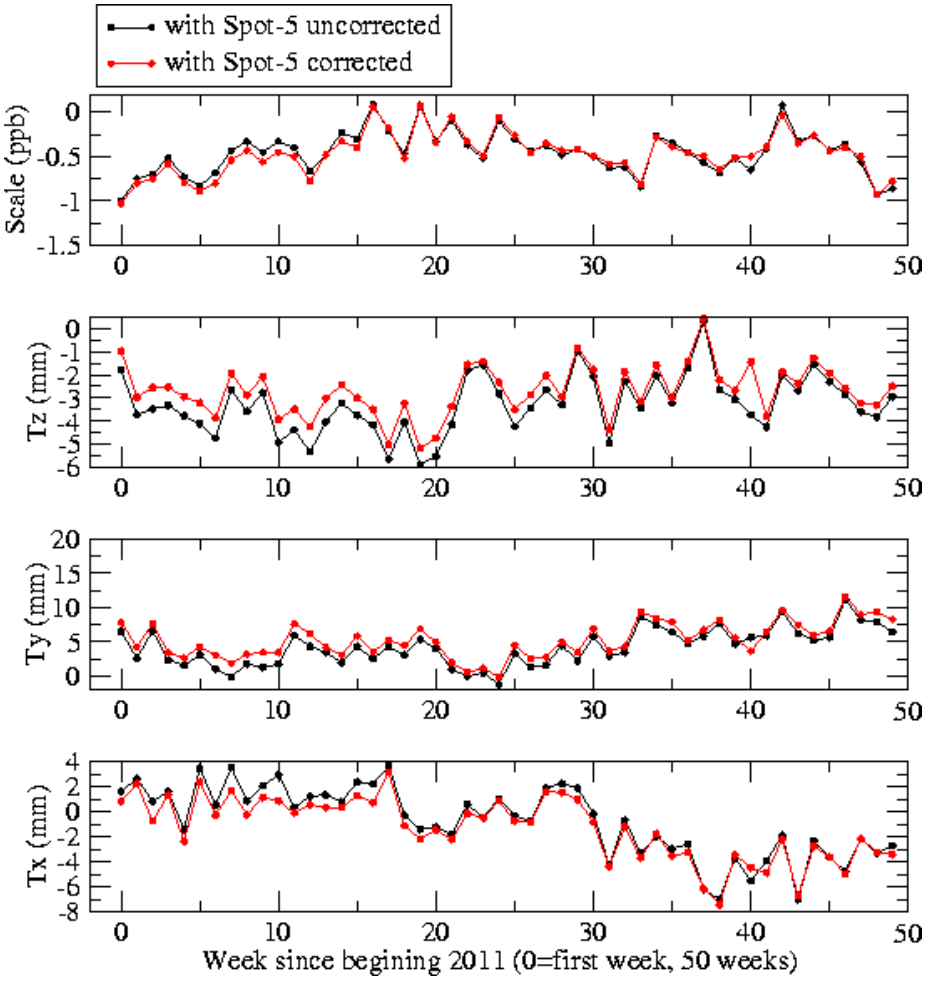
Station	Uncorrected in mm				Corrected in mm			
	RMS3D	lat	lon	Up	RMS3D	lat	lon	Up
Cachoeira	21.2	-2.5	16.5	-27.1	19.6	4.1	27.9	-1.2
Santiago	21.1	-26.4	-1.9	20.0	14.7	0.9	12.6	-7.3
Arequipa	20.6	22.4	0.2	-20.7	13.1	8.1	9.3	-5.3
Kourou	17.4	13.0	-3.8	2.3	16.5	1.7	-11.0	-0.1
Ascension	15.1	11.8	9.3	-8.2	12.0	4.9	-5.7	-1.0
St-Helene	18.8	-1.3	12.3	-4.3	17.9	-4.5	5.0	-4.7

- For each SAA stations the RMS3D is lower for a multisatellite solution with Spot-5 corrected
- The bias is lower for each component except for longitude

SAA corrective model for Spot-5

- **Impact on the positioning**

Multisatellite with Spot-5 satellite (weekly solutions for year 2011)
Comparison to a multisatellite solution without Spot-5 (Spot-4+Envisat+Cryosat+Jason-2)
Helmert parameters



SAA corrective model for Jason-1

Impact on the orbit and on the positioning

•Impact on the orbit

In the past we showed that the SAA model leads to decrease significantly the RMS of orbit residuals (5%) and to increase the validated measurements

•Impact on the positioning

Multisatellite (weekly solutions) with and without Jason-1 satellite

Comparison to DPOD2008 (values are calculated after the application of the Helmert transformation parameters)

RMS3D and RMS by component (Mean values on 51 weeks)

Solutions 2011	RMS3D (mm)	Lat (mm)	Lon (mm)	Up (mm)
With Ja1 corrected	14.9	12.3	17.1	14.7
Without Ja1	9.6	7.6	12.1	8.4

Solutions 2005	RMS3D (mm)	Lat (mm)	Lon (mm)	Up (mm)
With Ja1 corrected	15.6	11.4	19.8	14.2
Without Ja1	15.5	11.3	20.2	13.4

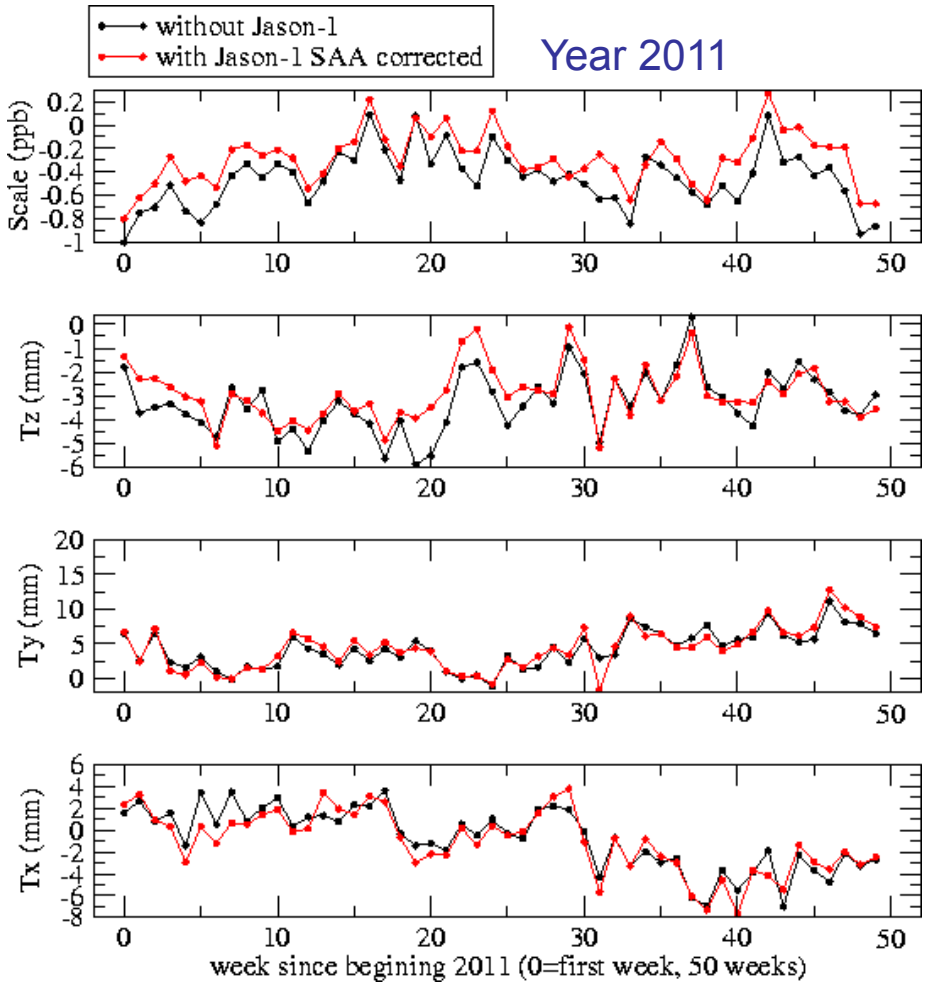
When we add Jason-1 (corrected) to the multisatellite solution:

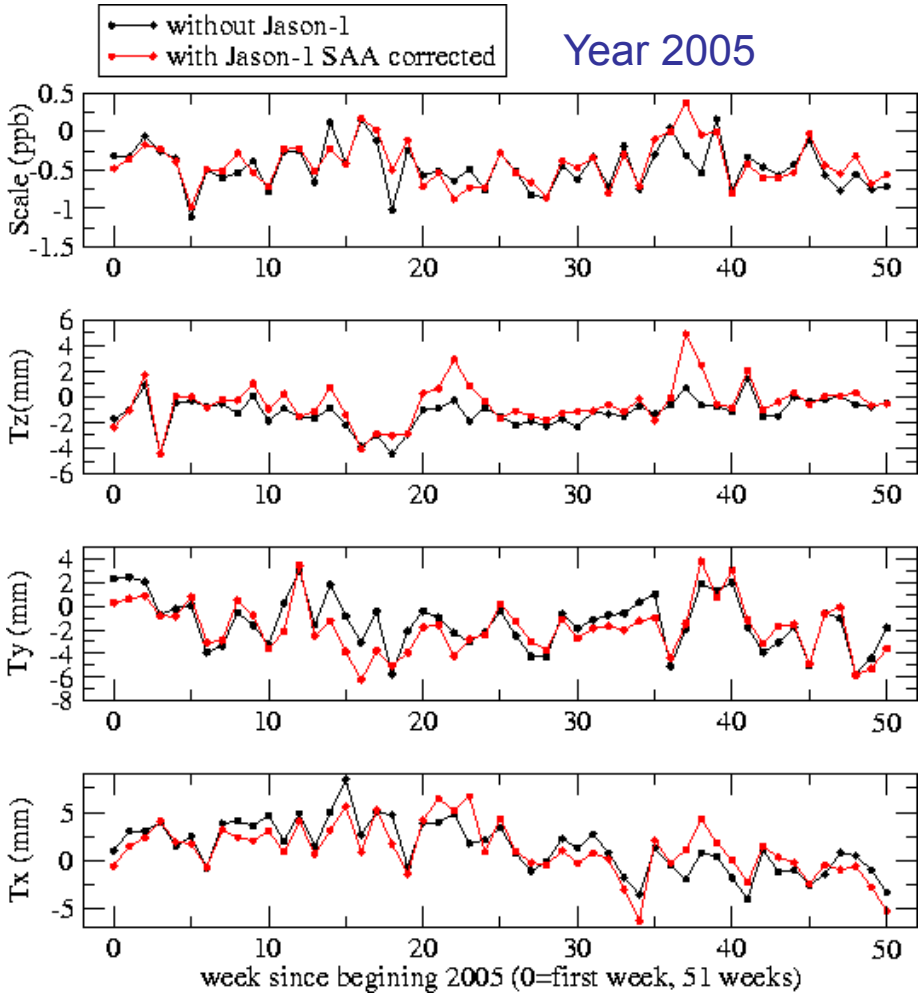
- in 2011, the RMS3D and RMS by component is worse
- in 2005, the RMS3D and RMS by component is very close to the multisatellite solution wo Jason-1

SAA corrective model for Jason-1

- **Impact on the positioning**

Multisatellite (weekly solutions) with and without Jason-1 satellite
Comparison to DPOD2008
Helmert parameters

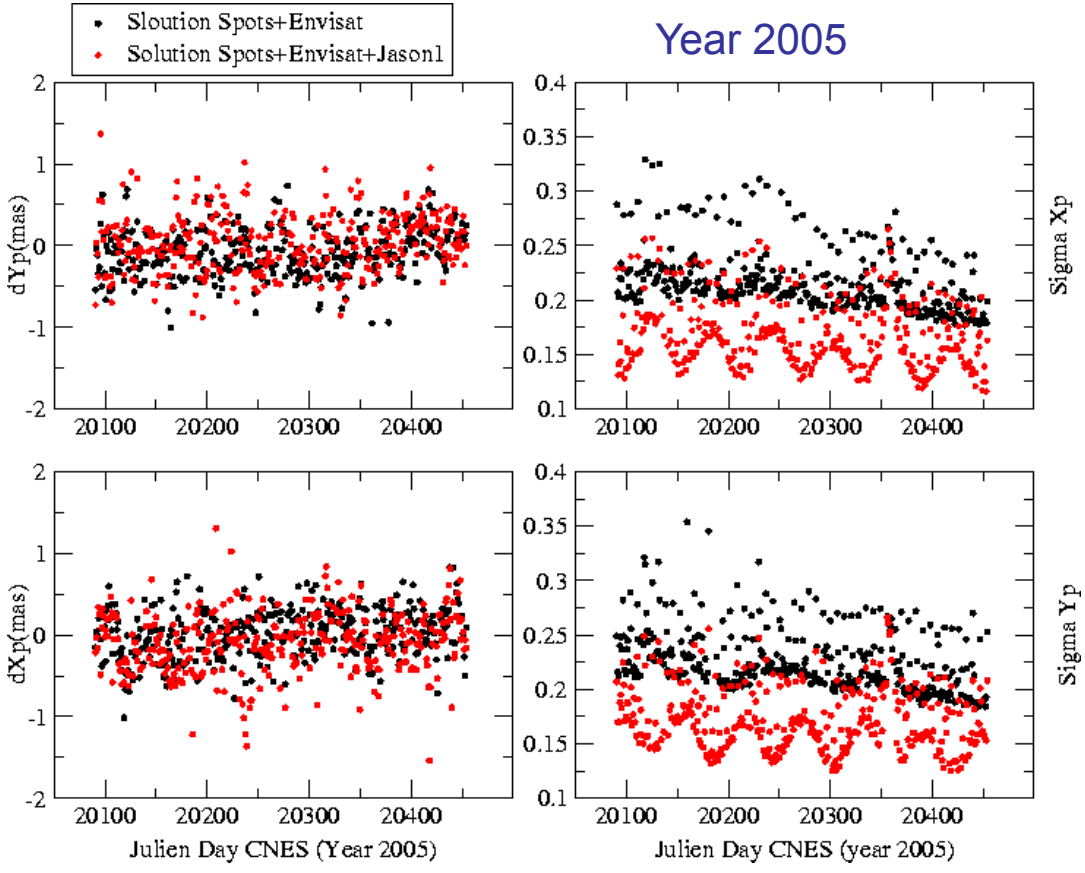




SAA corrective model for Jason-1

•Impact on the pole estimate

Multisatellite (weekly solutions) with and without Jason-1 satellite (corrected by SAA model)
Comparison to the IERS pole (EOP98C04)



For year 2011:
-no significant impact

For year 2005 when we add Jason-1
-difference to the IERS pole very close of the solution wo Jason-1
-best estimate of the pole coordinates sigma lower but introduces a signature (60 days)

SAA corrective model for Jason-1 and Spot-5

Conclusions

About the Spot-5 SAA model:

by using the data corrected by the model SAA we note

- a slight decrease of the RMS of orbit residuals and an increase of the validated measurements
- an improvement of the positioning
  by a comparison to a multisatellite solution without Spot-5 (Spot-4+Envisat+Cryosat+Jason-2)
  the global RMS3D of the monosat Spot-5 and multisat (w Sp5 corrected) solutions are lower
  the global RMS by component is lower except for longitude
  for each SAA stations the RMS3D is lower when using Spot-5 corrected
  the bias is lower for each component except for longitude

About the Jason-1 SAA model:

-we know and we showed in the past that the measurements of the SAA stations even after correction by the model are too affected by the SAA effect so they could take part in the combination.

-we also showed that the model leads to decrease significantly the RMS of orbit residuals (5%) and to increase the validated measurements

-by a comparison to the DPOD2008 the global RMS3D of the multisatellite with and without Ja1 corrected are very close for the year 2005. For 2011, the global RMS is better without Ja1

-pole estimate is slightly better when adding Jason-1 in 2005

SAA corrective model for Jason-1 and Spot-5

Proposals and delay of delivery corrected measurements

For spot-5

Maybe, like the Cachoeira station is too affected by the SAA effect, we could rename it for Spot-5 for the combination

we propose to use the corrected measurements by the SAA model since the beginning of 2006

Before, we can suppose that the SAA effect is negligible

[2002-2005] without correction by the SAA model

[2006-2013] with correction by the SAA model

For Jason-1 we recommend to use the following strategy :

use the data corrected by the SAA model and rename the following list of SAA stations for Jason-1 for the combination:

-Ascension (ASDB/ASEB)
-Saint-Helene (HELA/HELB/HEMB)
-Libreville (LIBA/LIBB/LICB),
-Cachoeira (CACB/CADB)
-Santiago (SANA/SANB/SAOB)
-Galapagos (GALA),
-Santa Cruz (SCRB)
-Arequipa (AREA/AREB/ARFB)
-Kourou (KRUA/KRUB/KRVB/KRWB)
-Easter Island (EASA/EASB)
-Sal (SALB)
-Tristan Da Cunha (TRIA/TRIB)

SAA corrective model for Jason-1 and Spot-5

Proposals

For Jason-1

The period where Jason-1 could bring something is after the end of life of Topex and before the Jason-2 launch. Indeed, during this period there are only polar satellites flying.
So, we propose to introduce Jason-1 (corrected) after the end of life of Topex 11/2004 until Jason-2 arrives (07/2008)
Furthermore, the OUS has shifted on the chain1, in July 2004. So, considering only the chain1 OUS, we remove a possible inconstancy (between the two chains). The behavior of the OUS chain1 and chain2 to the SAA effect being very different .
So the proposed period for Jason-1 is:
[11/2004-07/2008] with correction by the SAA model

Delay of delivery corrected measurements

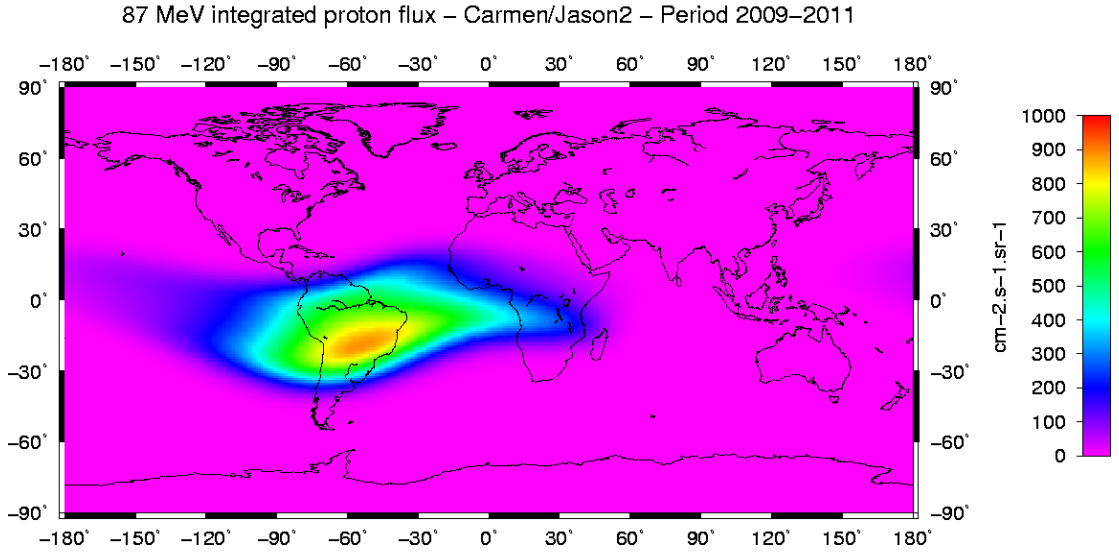
It will take me one week to produce and provide these doris2.2 corrected files for the two satellites
Because:
I have to improve and to validate Spot-5 SAA model for the others years of 2011
I have to verify all the doris2.2 corrected files produced before sending

SAA corrective model for Jason-1 and Spot-5

Perspectives

Jason-1

- we could use the maps of energetic particles obtained by the dosimeter CARMEN onboard of Jason2 (to improve the model and to update the model regularly)
- we began this work by a correlation study between DORIS map and CARMEN map and we found a good correlation with this one:



Spot-5

- extend the impact study of the model on several years
- if the CARMEN maps give good results contact ONERA to see if they can provide SAA map obtained by a dosimeter onboard of satellites flying at the Spot-5 altitude

Backup

SAA effect on Jason-1 in 2002

not sure we can use Jason-1 in 2002 without correction by the model

the SAA onboard frequency signal at the end of 2002 is not so negligible than the one in April 2002