# SPOT-5 and South Atlantic Anomaly

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South Atlantic Magnetic Anomaly

❑ Magnetic and Rotation poles are not identical -Earth magnetic field intensity is not symetrical with respect to the Earth surface
❑ Current minimal intensity on the Earth surface is located in South Atlantic
❑ Van Allen Belts are areas around Earth trapping protons (inner) and protons+electrons (outer)
❑ Van Allen Belts are symetrical to the magnetic field -> get closer to the Earth surface in the South Atlantic area

Magnetic field intensity on the earth surface 1600-2000 *(Simulation by http://bbs.keyhole.com)*

Van Allen Belts
(*Figure by http://www.aero.org*)
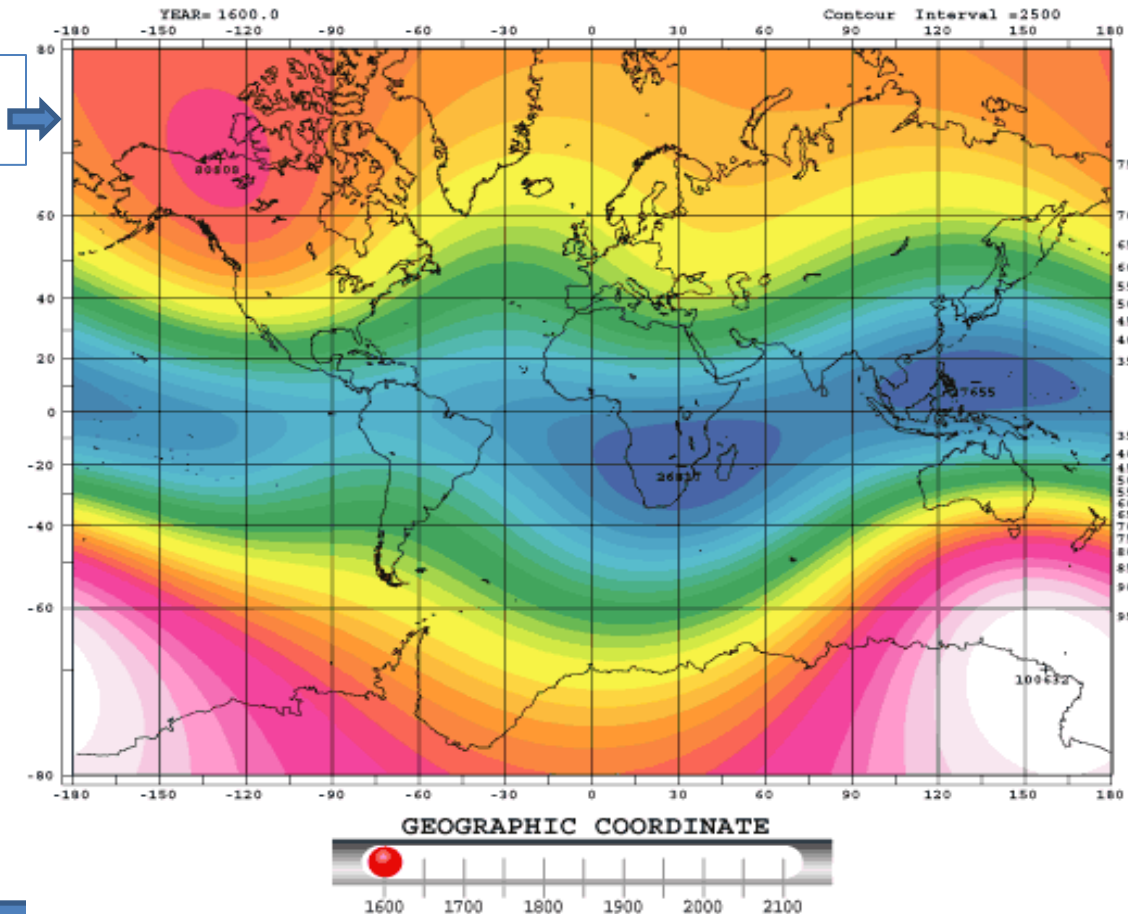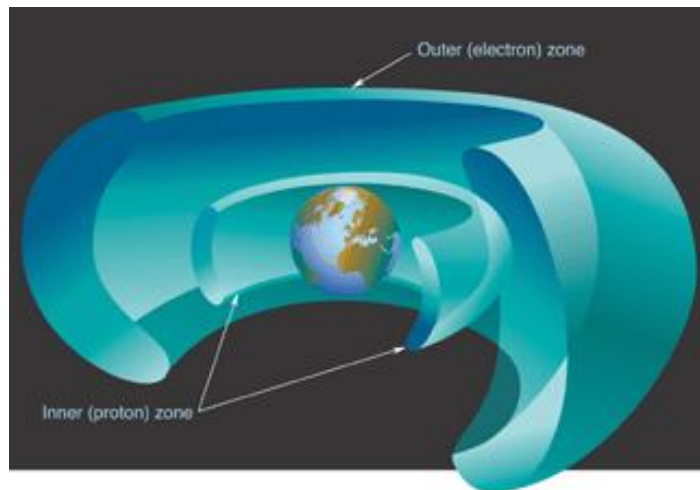
Earth low orbit Satellites and SAA

❑ Many LEO satellite missions effected

❑Hubble telescop (569 km) and Rosat (550 km) : no observation during the pass

❑International Space Station (278-460 km): special shields

❑Jason-1 (1300 km): problems with USO stability

❑ROSAT, NOAA POEs, NASA Terra Spacecraft, Jason-1(DORIS),.....: studies of SAA

Jason-1 DORIS USO and SAA

❑ Well known studies (Willis et al. 2004)

❑ In extreme case meter level error in station height

❑ Data corrective model (Lemoine & Capdeville 2006)

Other DORIS satellites and SAA

❑ T/P and Jason-2 USO not significantly sensitive to SAA

❑ No tests for other satellites

➢ Problems of the "Jason-2 level" not observed

➢their (lower) attitude considered as not dangerous

Comparison ZTD DORIS X GNSS (2006.0-2009.0)

❏ DORIS ZTD estimated per Satellite pass

❏ Single-satellite DORIS solutions

❏ GNSS PPP product as reference

❏ offset for following stations (SPOT-5 only):
  ➢ -48 mm for Cachoeira Paulista (Brasil)
  ➢ -35 mm for Arequipa (Peru)
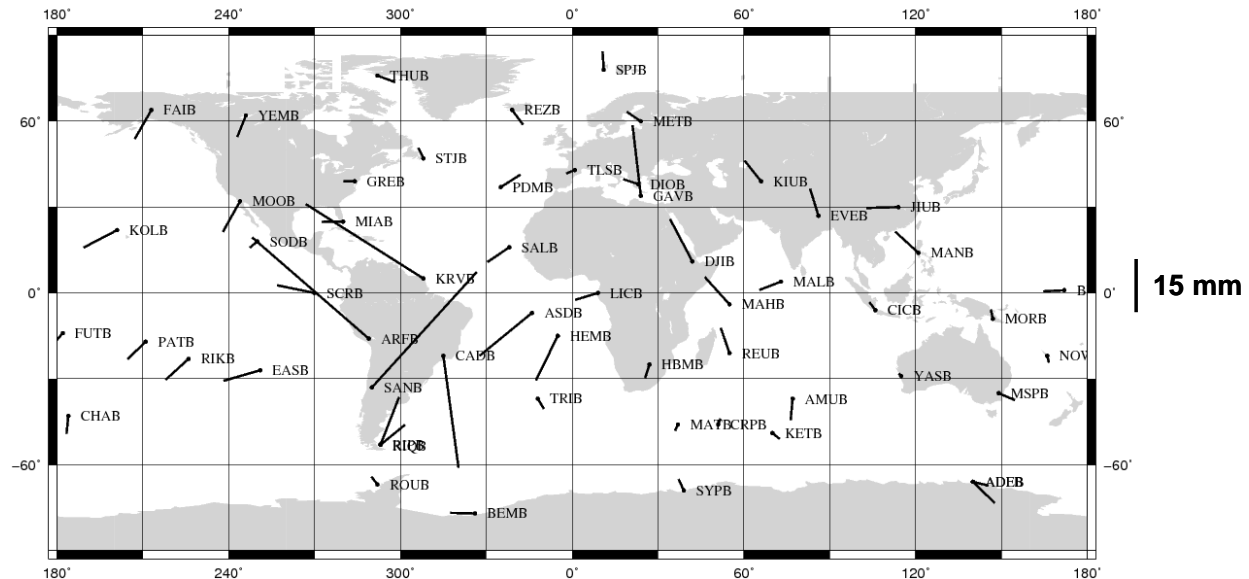 ➢ -30 mm for Santiago (Chile)

❏ South Altantic anomaly ?
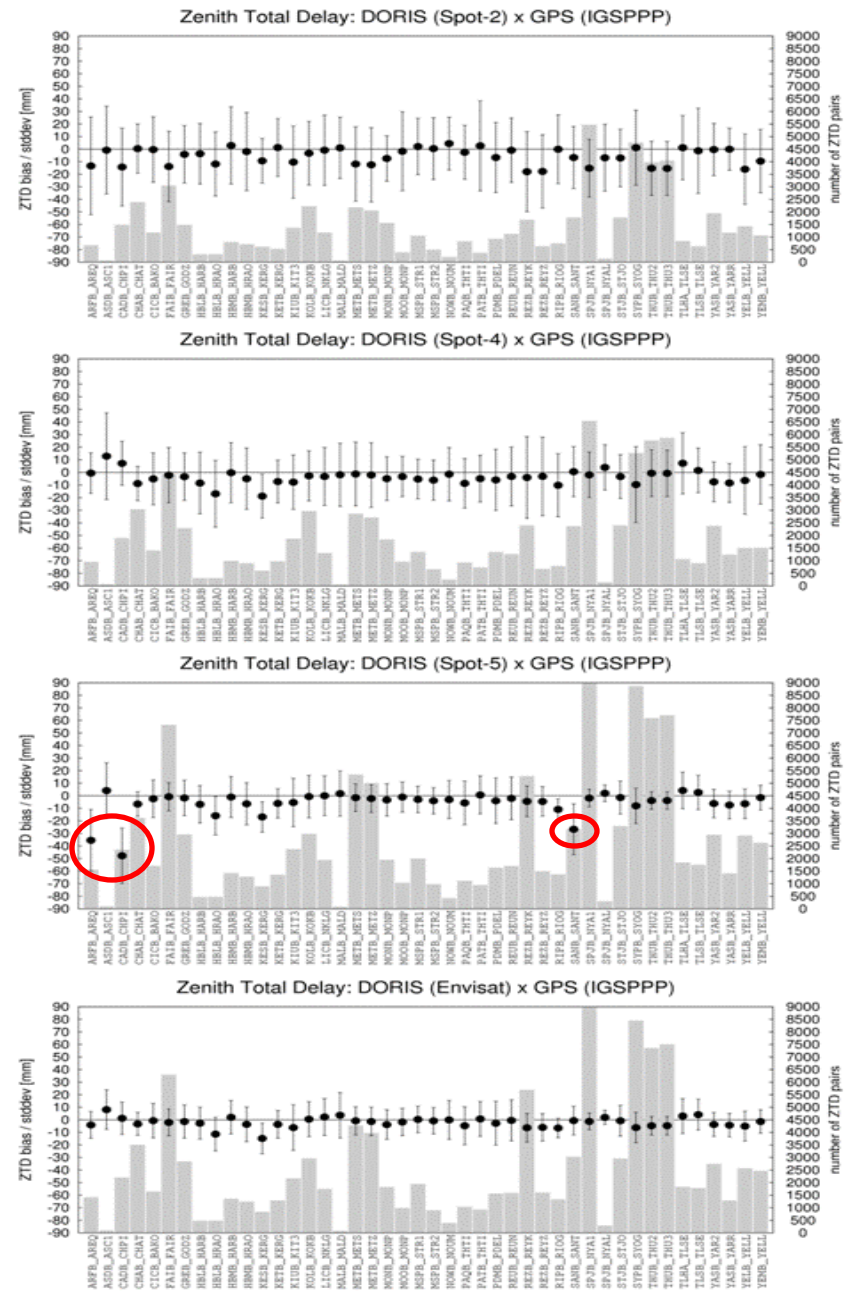
Coordinates differences
## SPOT-5 single satellite solution vs. Combination (averages from 2008)

Height
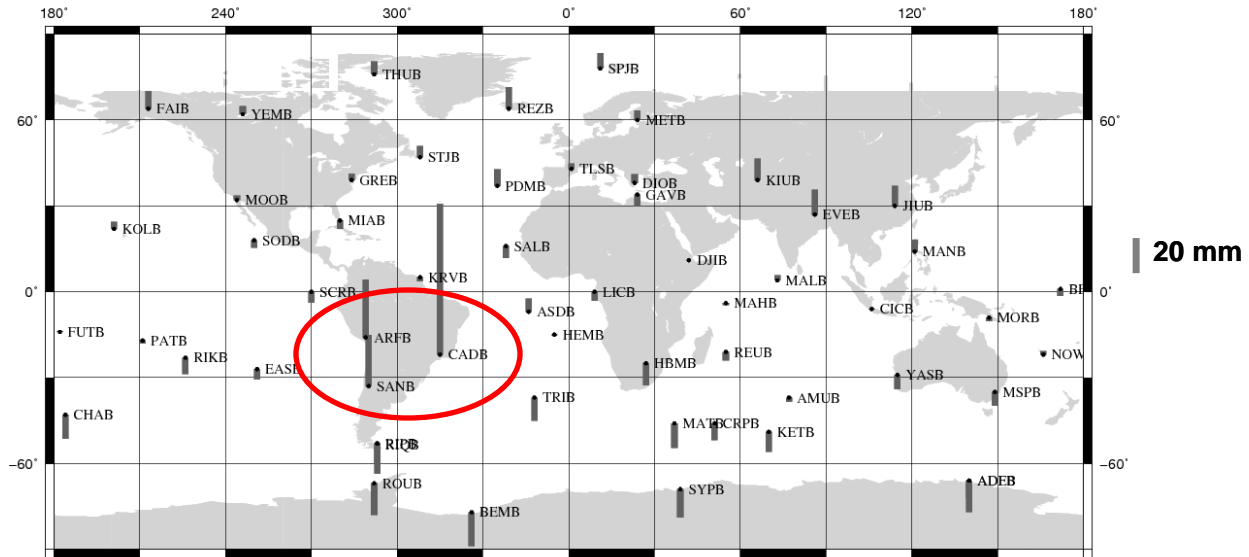
Position

# Weekly comparison of estimated station height

- ❑ SPOT-5 X multi-satellite combined solution

- ❑ Multi-satellite solution - all available satellites except Jason-1; Jason-2 after 2009.0

- ❑ Significant difference is "optimistic" (SPOT-5 also included in the multi-satellite solution)

- ❑ Observed drift aproximately after 2007.0

- ❑ "jump" in 2009.0 -> Jason-2 included in combination, less sensitive to SPOT-5
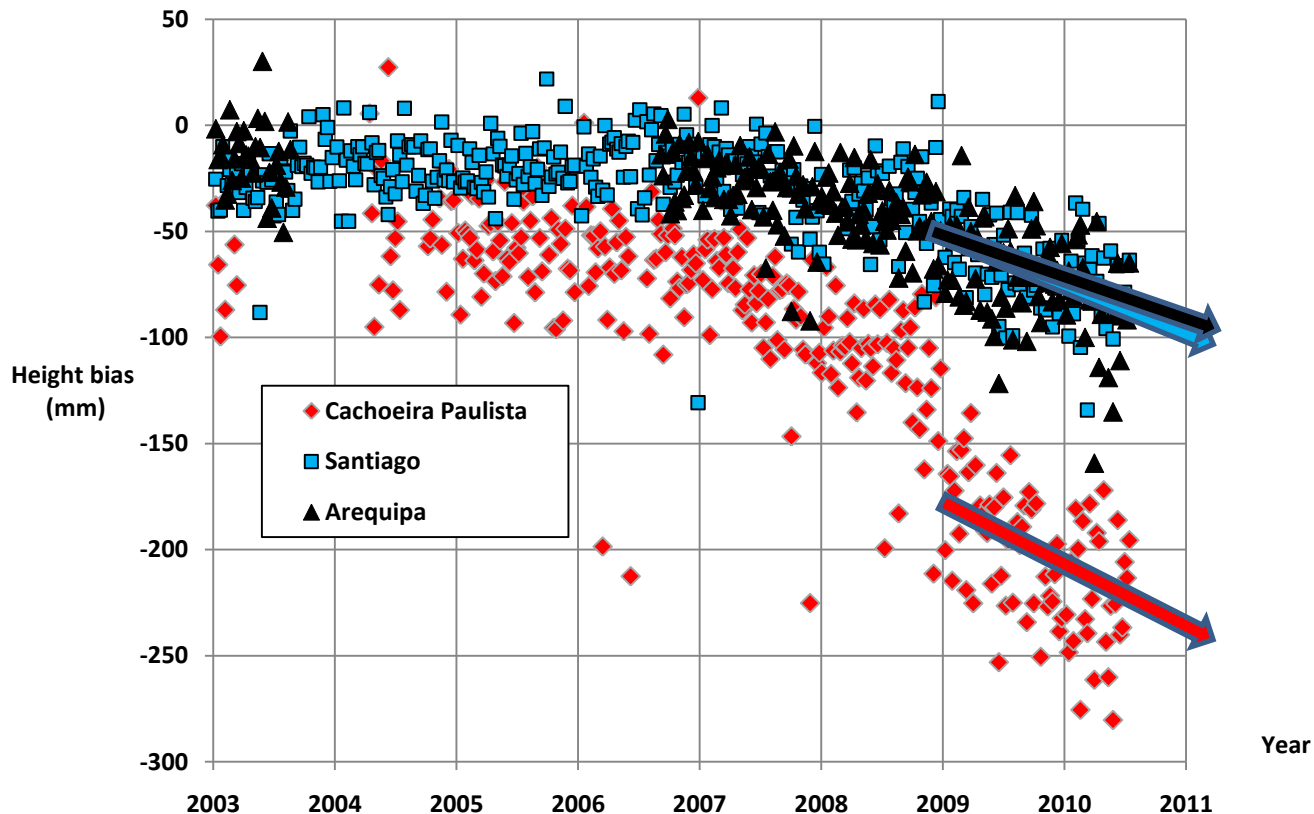
Weekly comparison of estimated station height

❑ multi-satellite combined solution with and without SPOT-5

❑ from 2009.0 to 2010.5
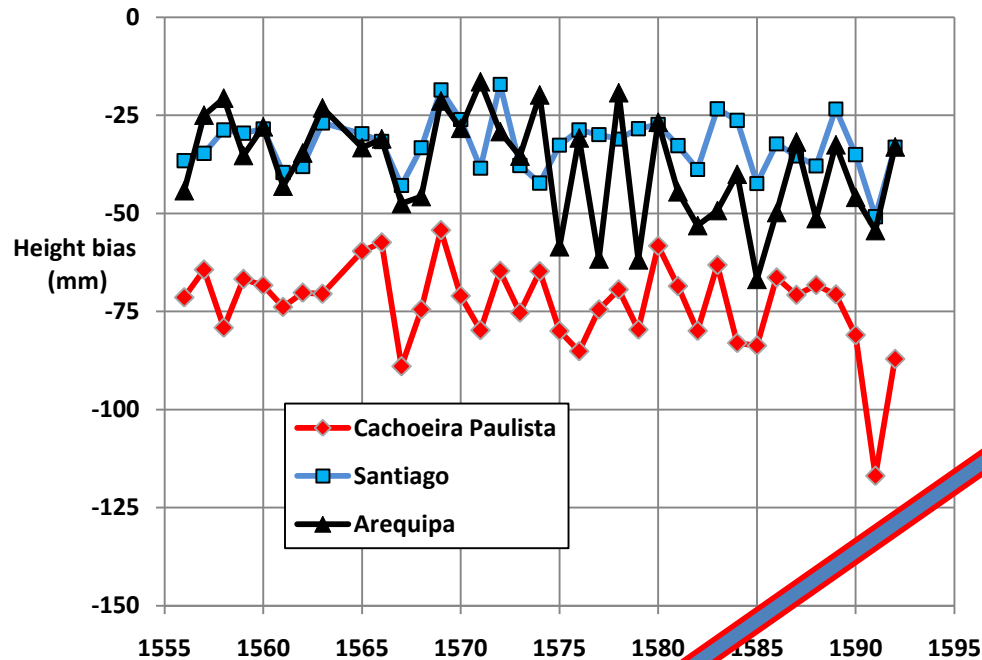
SAA effect on station estimated height from multi-satellite combination including SPOT-5

SAA effect on station estimated height from SPOT-5

station/sat.	All-S5 All	All S5 only	All-S5 S5 only
CADB	**-6.6±1.2 cm**	-20.6±3.4 cm	**-27.1±3.9 cm**
ARFB	**-3.4±1.3 cm**	- 7.4±2.4 cm	**-10.8±3.4cm**
SANB	**-2.9±0.7cm**	- 6.8±1.9 cm	**- 9.7±2.4cm**

Estimated frequency offset

❑ long and middle terms removed by CNES
❑ Only the short terms could be analyzed from the DORIS exchange format data
❑2009.0-2010.0
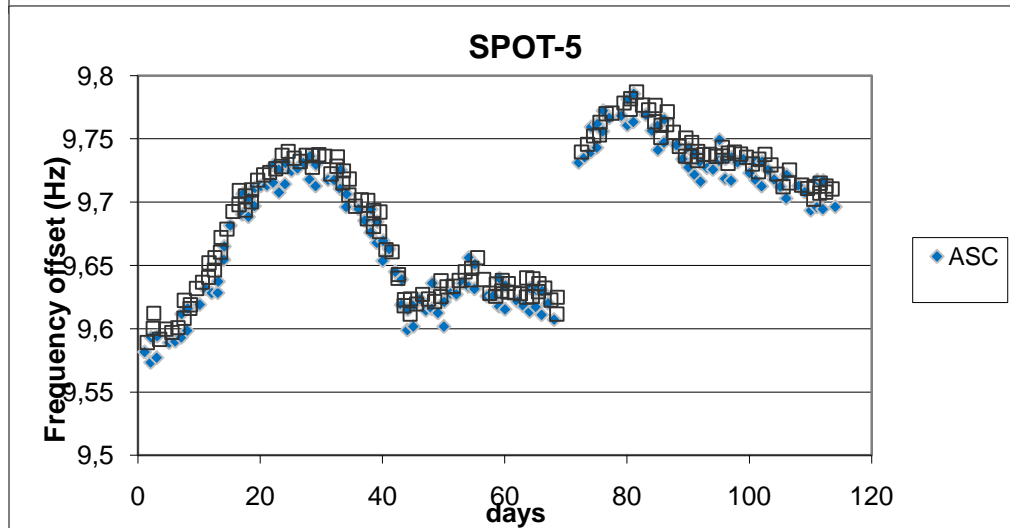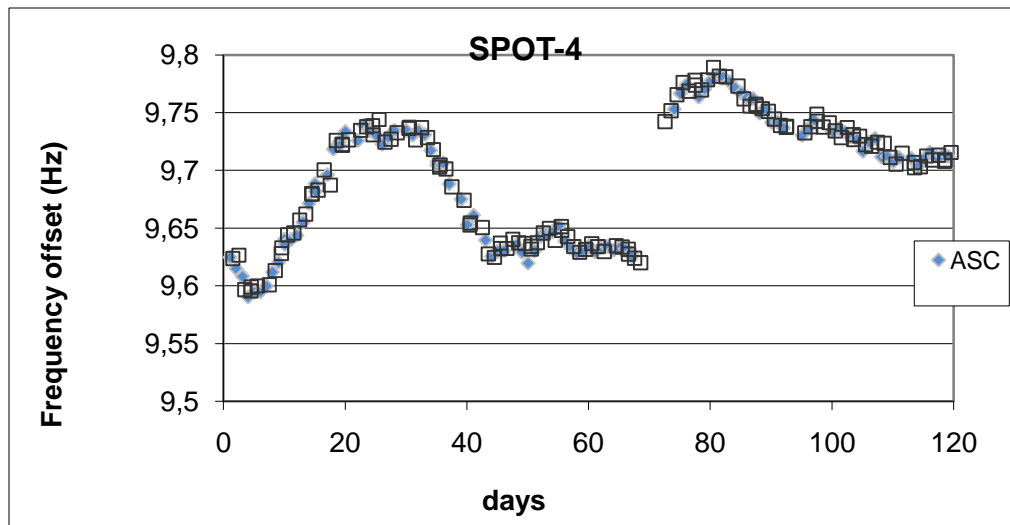

Ascending X Descending passes

❑ CADB (example figure on the left)

    ➢ significant offset for SPOT-5

❑ Master beacons

    ➢ no significant offset for TLSB

    ➢ at the level of 0.01 Hz for for KRVB

   and HBMB for SPOT-5

Estimated frequency offset (2)

❑ 2010.0 -2010.5

❑ Estimated frq. Offset in dependence on the hour of the day

❑ Drift for SPOT-5, not for the other satellites

❑ Plotted values from SPOT-5 (left) and Envisat (right)

❑ High positive drift for Kourou (satellites is passing the SAA regional almost during the same revolutions)

❑ Negative drift for the other master beacons
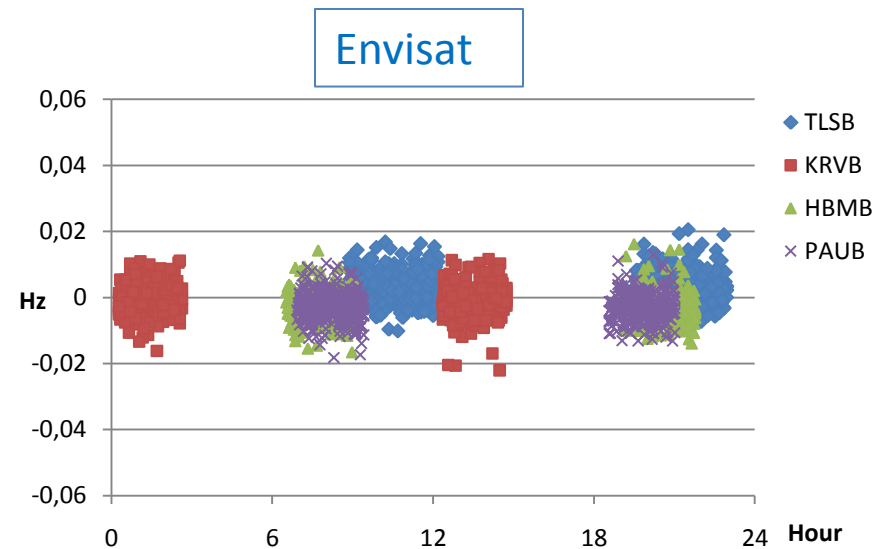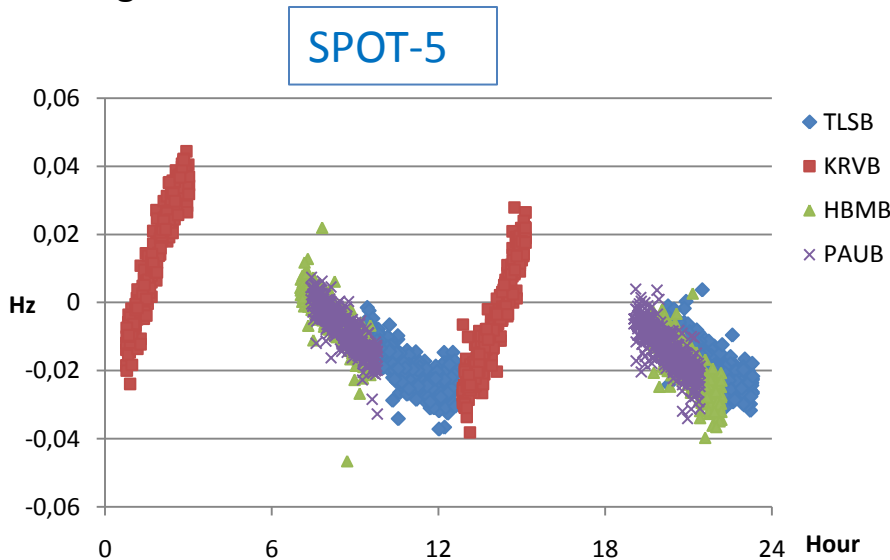
Estimated Time derivative of Frequency

❑ 2009.0 – 2010.0

❑ Approach similar to (Lemoine and Capdeville 2006)

❑ First step: SPOT-5 Orbit estimation, save orbit

❑ Second step: fixing frequency offset and troposphere values interpolated from SPOT-4, Envisat and Jason-2 solutions

❑ Third step: SPOT-5 solution with all fixed parameters

❑ Frequency offset time-derivative calculating from obtained observation residuals

Estimated Time derivative frequency (1)

SAA[Hz/day]

Time derivative of frequency offset

Estimated Time derivative frequency (2)

Time derivative of frequency offset

SAA[Hz/day]
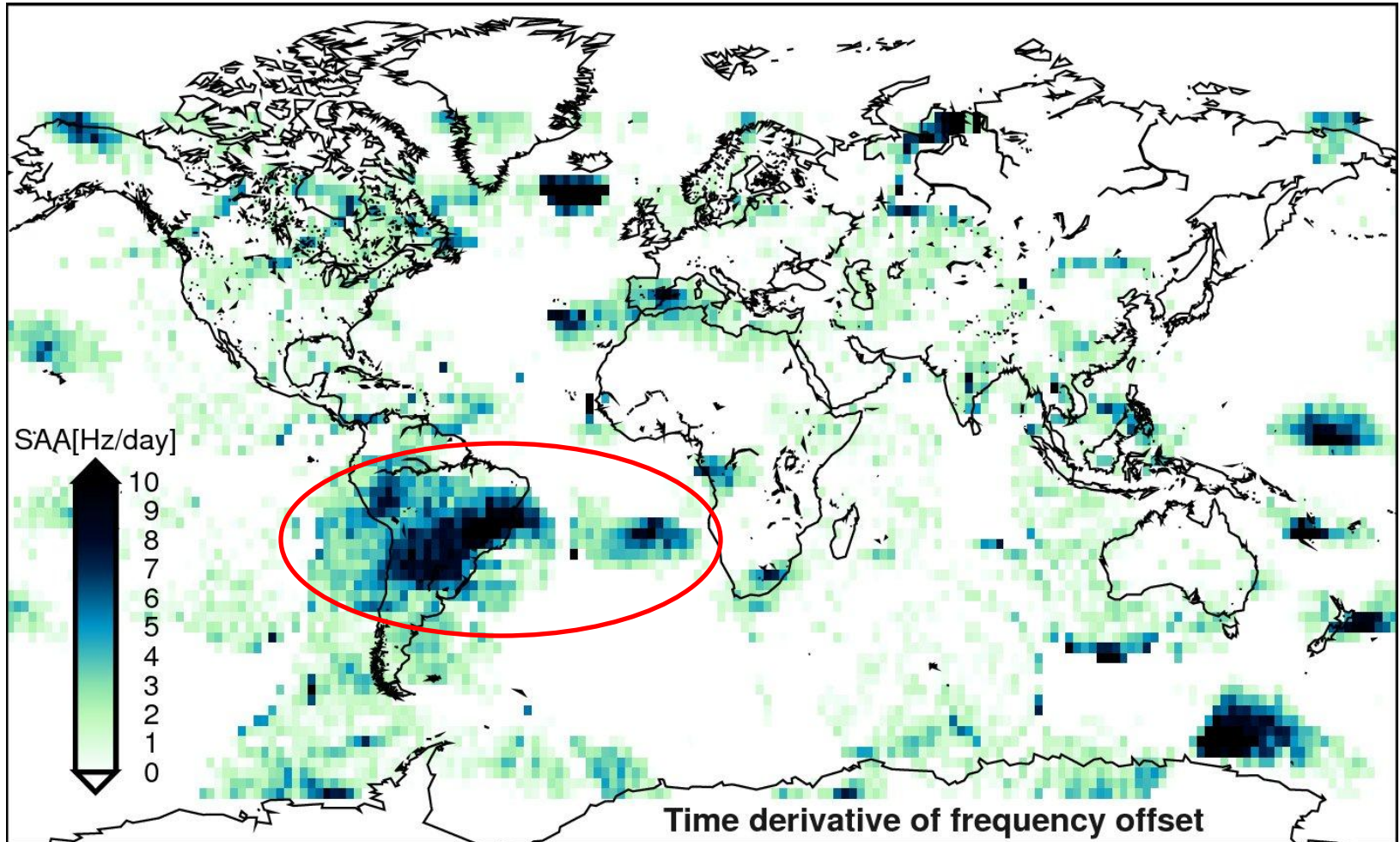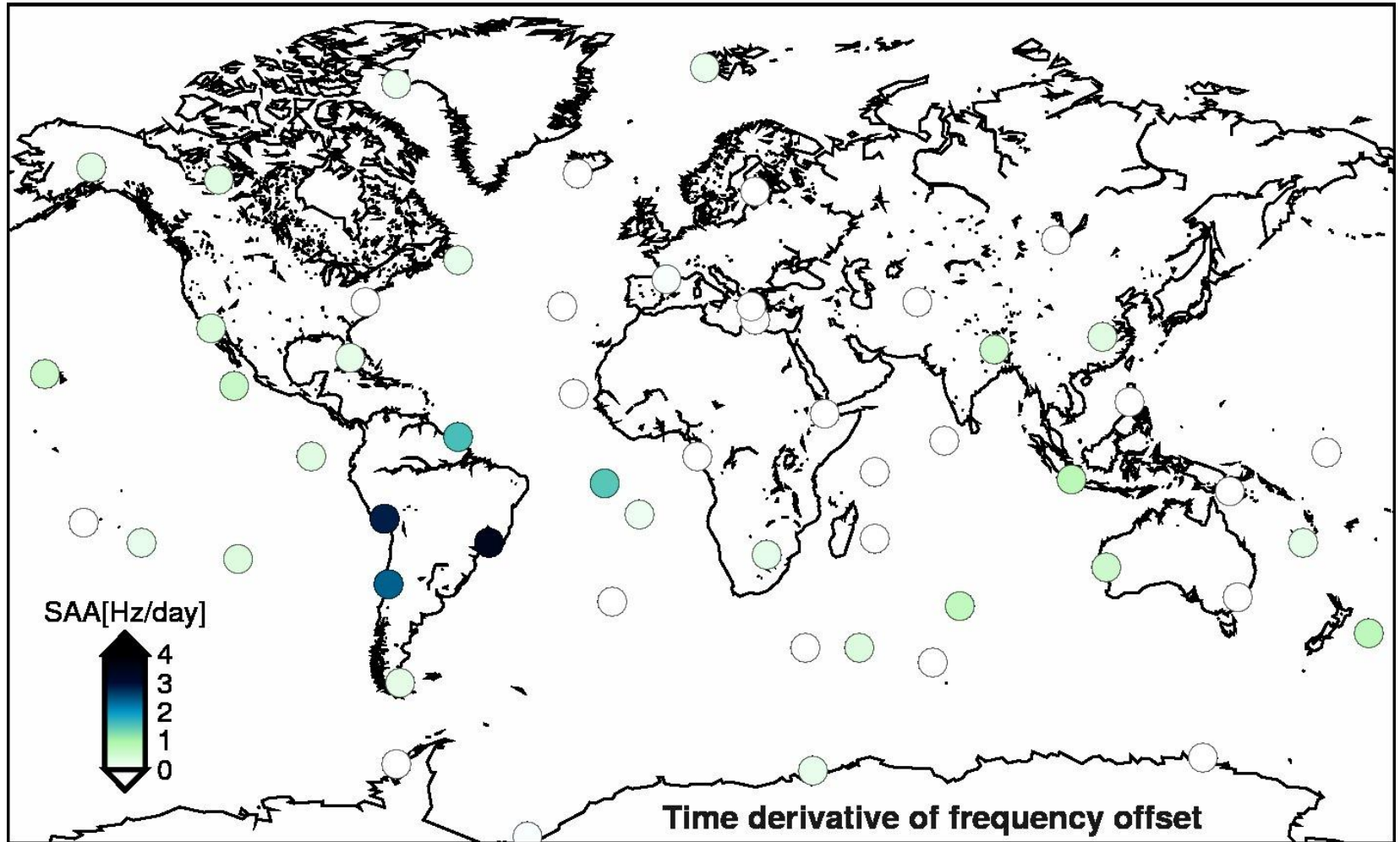
Conclusions and discussions

❑ SPOT-5 is known as DORIS satellite with good quality of the observations

  ➢ At least outside SAA

  ➢ In contrary to Jason-1, SPOT-5 should stay included in combination

❑ Are the presented results proving the SAA effect on the SPOT-5 data?

  ➢ All the presented results are derived only from the GOP solution

❑ It is hard to believe any alternative explanation, but

  ➢ Confirmation by other group(s) would be profitable

  ➢ Group from CNES could confirm the long-term SPOT-5 frequency drift

  ➢ Recent IGN ZTD DORIS/GNSS comparison (based on DORIS multi-satellite combination) detected a „SAA related effect"

❑ What to do now? Station selection or corrective model?

References

Willis et al.: Behaviour of the DORIS/Jason oscillator over the South Atlantic Anomaly, CR Geosci 2004

Lemoine and Capdeville: A corrective model for Jason-1 DORIS Doppler data in relation to the South Atlantic Anomaly, JOG 2006