Current Research Acitvities at GOP DORIS analysis center

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Current Research activities at GOP

- **Routine data processing (Free network solutions)**
  - Weekly solutions delivered in SINEX format
  - Analyses of the time-series in Moreaux et al. : Research activities at the IDS Combination Center
- **Evolution of LEO dynamical orbital modeling (together with TUM Munich)**
  - Implementation into Bernese GPS Software
  - See also Rodriguez-Solano et al.: Comparison of Earth radiation pressure models for DORIS satellites
- **South Atlantic Anomaly (SAA) effect on the SPOT-5 DORIS observations**
  - See also Capdeville et al.: Update of the SAA corrective model for Jason-1 DORIS data and discussion about a SAA corrective model for Spot5

SPOT-5 and South Atlantic Anomaly –what is known

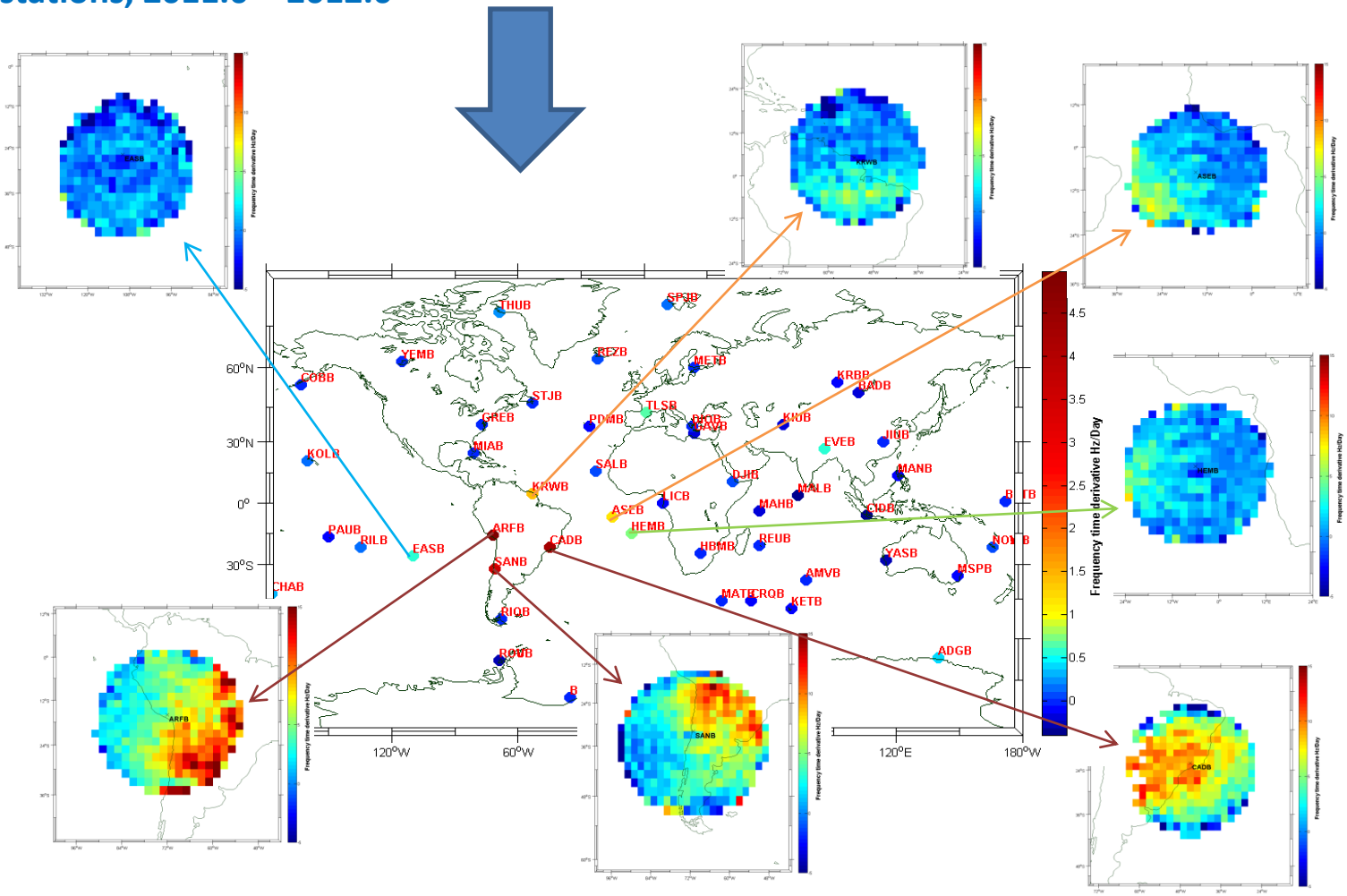
- ❑ SPOT-5 oscillator is affected by SAA, confirmed by many tests
- ❑ Size of the effect is lower than for Jason-1 (about one order of magnitude?)
- ❑ Effect is far from being negligible
- ❑ Strongly affected observations of stations in Brazil (CADB),Peru (ARFB) and Chile (SANB)
- ❑ In extreme case (CADB) decimeter offset of station height for single satellite solution
- ❑ How to deal with this problem: station selection or data corrective model

Empirical data corrective model

- To be considered as first approach to confirm the possibility to process the corrected data
- We need to model an onboard frequency behavior during the satellite pass
- Frequency offset is not a problem (estimated per pass)
- Jason-1 data corrective model developed by Lemoine and Capdeville (2006) –starting point
- Motivation: effect is much smaller for SPOT-5, even a simple model could work well
- Model then simplified for SPOT-5(no memory and recovery effects)
- At current step, model developed for 1 year (2011) – SAA effect considered constant
- Corrections applied only for stations from SAA region

2X2 deg. grid map of the onboard frequency time derivative – see Capdeville et al. presentation

Average frequency time derivative calculated for each station and 2X2 deg. Grid map for the SAA stations, 2011.0 – 2012.0

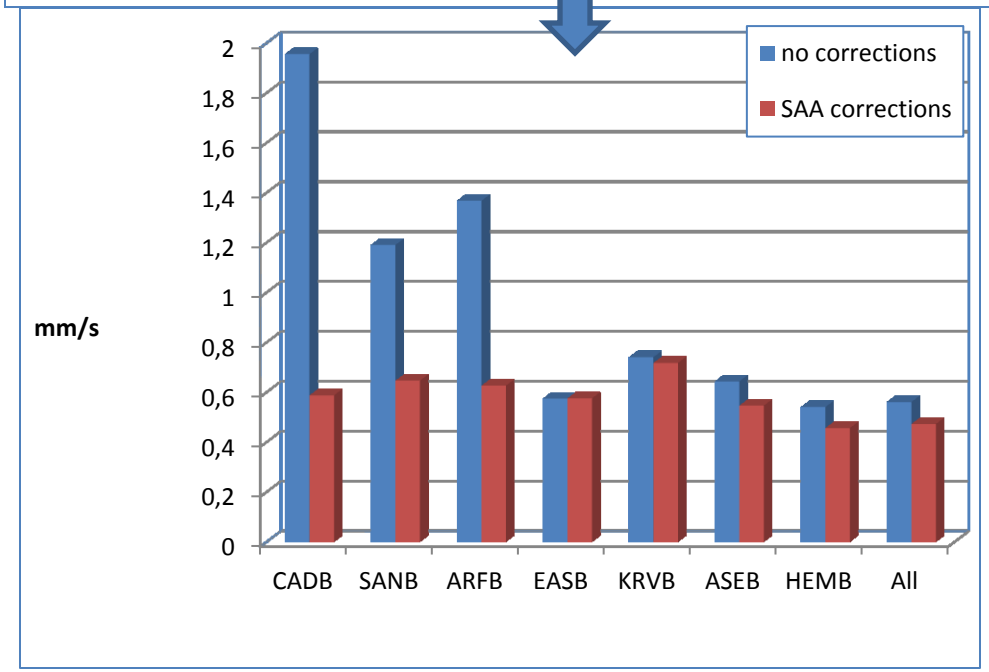


Residuals reduction applying the frequency time derivative from the grid map

- ❑ (March-April 2011)
- ❑ Grid map from data 2011.0-2012.0

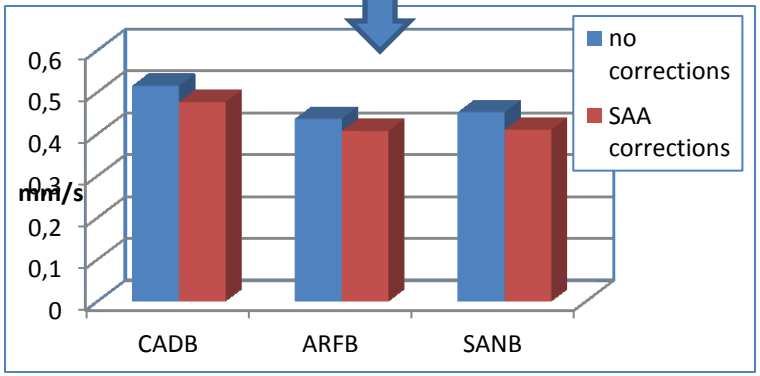
Solution with fixed orbit, troposphere and network

- Strong residuals reduction for CADB,SANB,ARFB (40-70%
- Small residuals reduction for KRVB,EASB,HEMB (up to 15%)



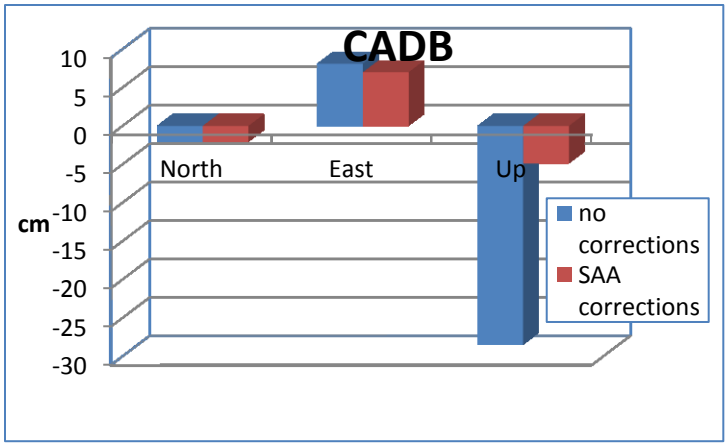
Free network Solution

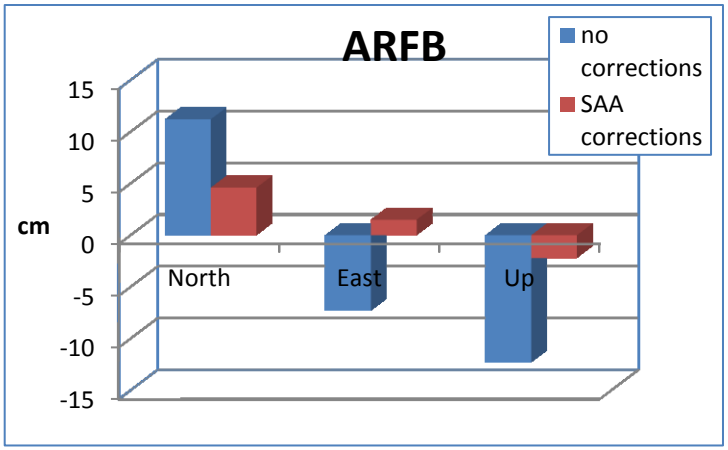
- Small residuals reduction for CADB,SANB,ARFB (40-70%)
- Not significant for the others

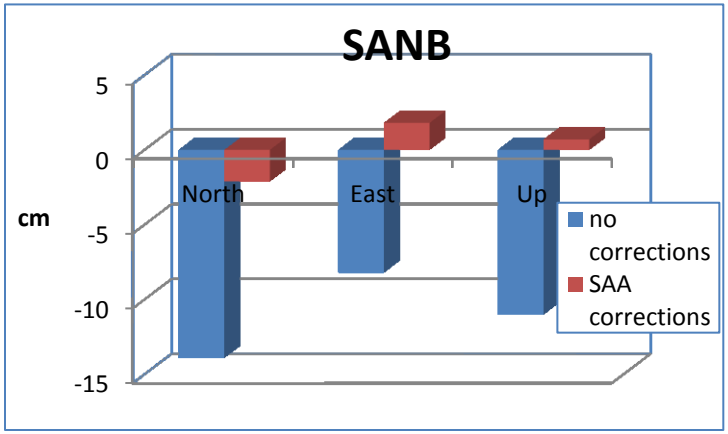


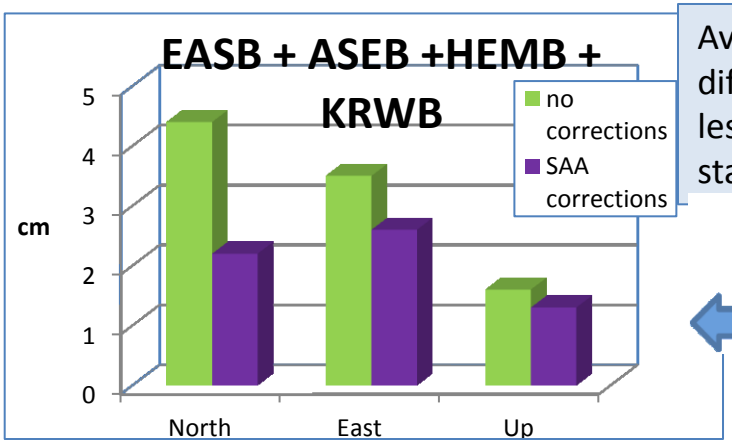
Station coordinates

- Differences between SPOT-5 solution and multi-satellite solution (excluding SPOT-5)
- March-April 2011
- Differences strongly decreased applying SAA corrections





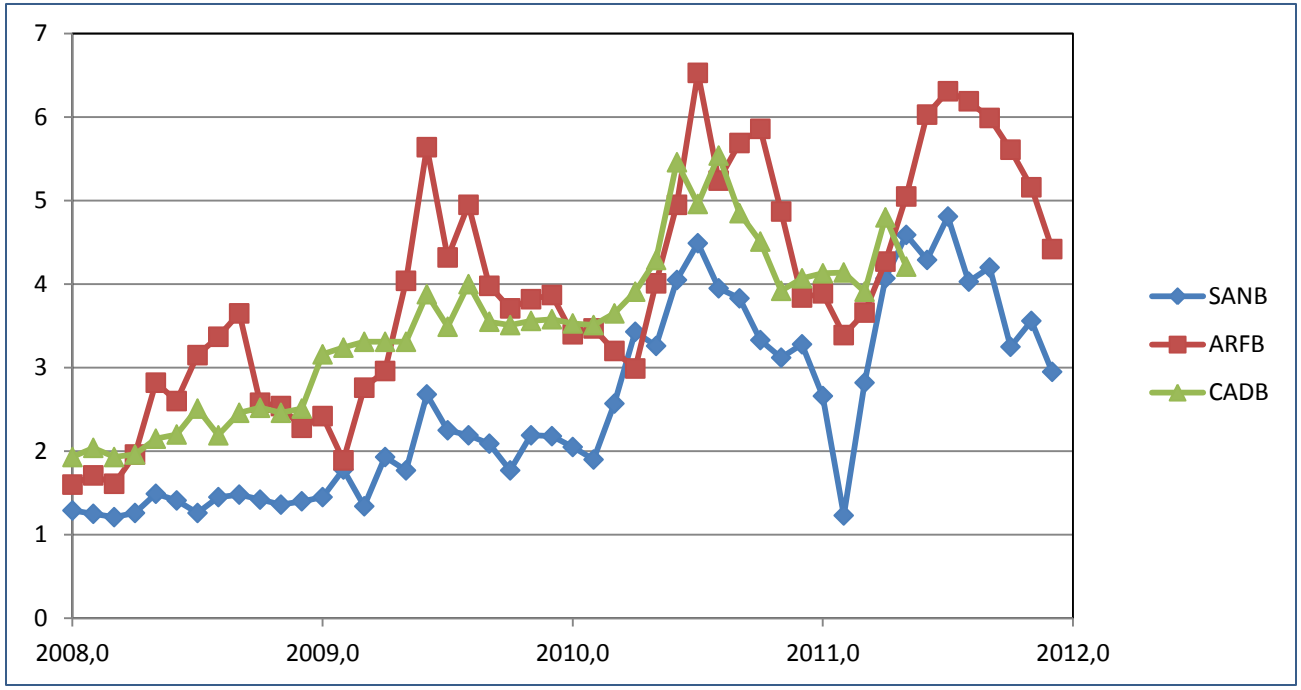




Average absolute differences for less affected SAA stations

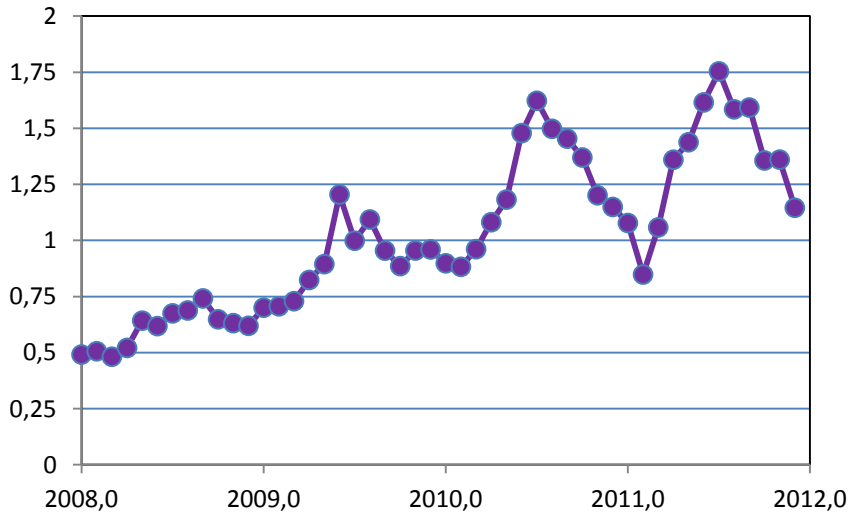
The time derivative frequency offset estimated per station 2008-2011

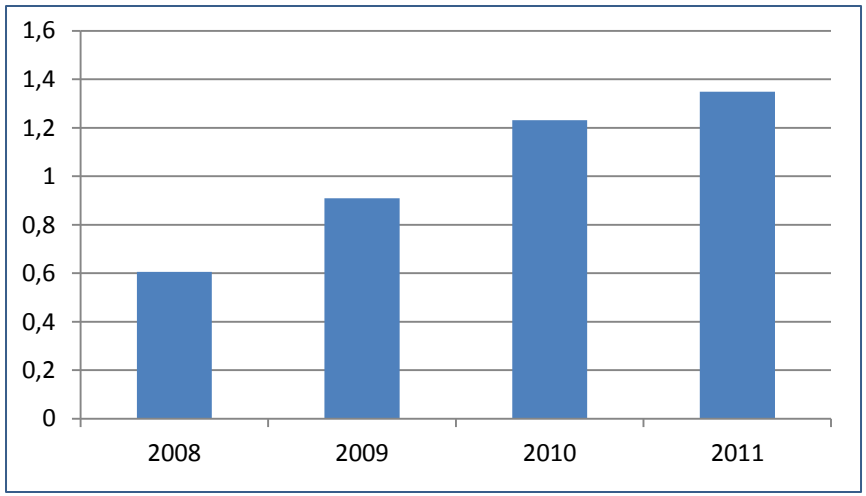
- Monthly average time derivative for each station (Hz/Day)
- Possible drift and seasonal variations



The time derivative frequency offset estimated per station 2008-2011

- ❑ Average from the CADB,SANB,ARFB frequency time derivative expressed in relative unit (1=average for whole 4 years period
- ❑Monthly average time derivative –LEFT plot
- ❑ Annual average time derivative for each station –RIGHT plot
- ❑ Drift more significant than from single station plots
- ❑ Significant Seasonal variations – stronger for last two years 2010-2011
- ❑ Drift corresponds to previous study of station height time series 2003- 2009, where hight differences for CADB,SANB, ARFB are rising after 2007.0





Comparison of the Reduced-Dynamical and Dynamical orbit model

-Classical Bernese orbit modeling is based on pseudo-stochastic and empirical models
-Dynamical model developed in cooperation of GOP and TUM

Modeling	**Empirical-Stochastic (reduced-dynamical)**	**Dynamical**
Satellite attitude and geometry	Not considered	Nominal Box-Wing model
Atmosphere density model	Not applied	MSIS-86
Atmosphere drag	Absorbed by along track stochastic parameters and Y-constant empirical parameter	Scaling coefficient estimated
Solar radiation Pressure	Absorbed by empirical constant parameter in sun-satellite direction	Scaling coefficient estimated or fixed value closed to “1”.
Earth radiation	Not applied	A priori model, reflexivity and emissivity
1-per revolution empirical modeling	Sun-Satellite and Y-direction	Along and cross track (optional)

Comparison of the Reduced-Dynamical and Dynamical orbits

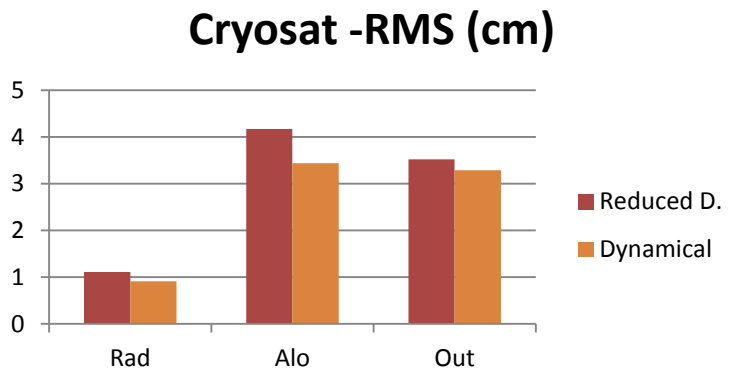
- Compared daily Arcs 1st of February -3rd of March 2011

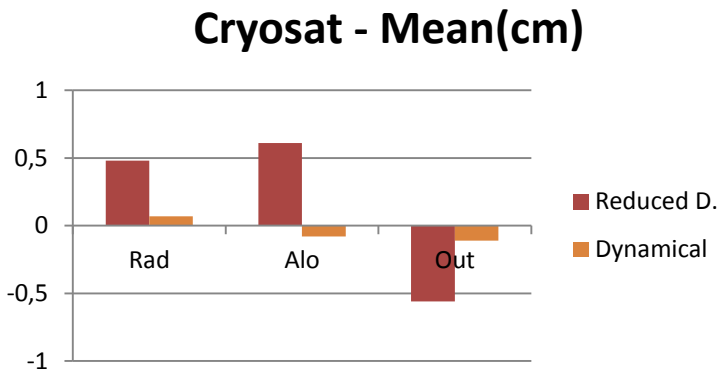
- External Orbit comparison
  - Compared with SSALTO multi-technique orbit
  - Comparison on daily bases – Mean (Average), Std. Dev. of the Mean (Mean variations from day to day)
  - RMS (daily Mean removed)

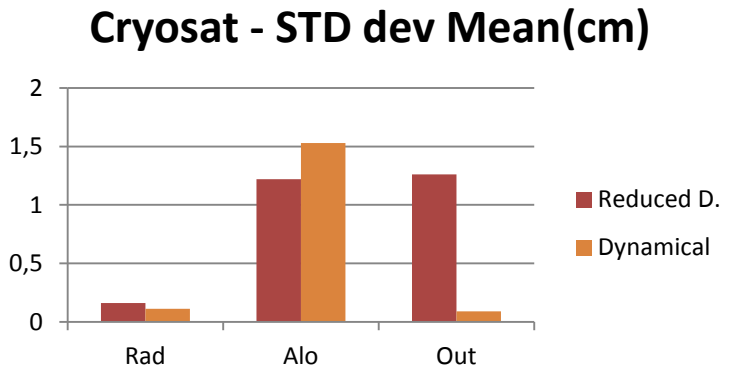
- Internal Orbit comparison
  - Midnight orbit overlaps

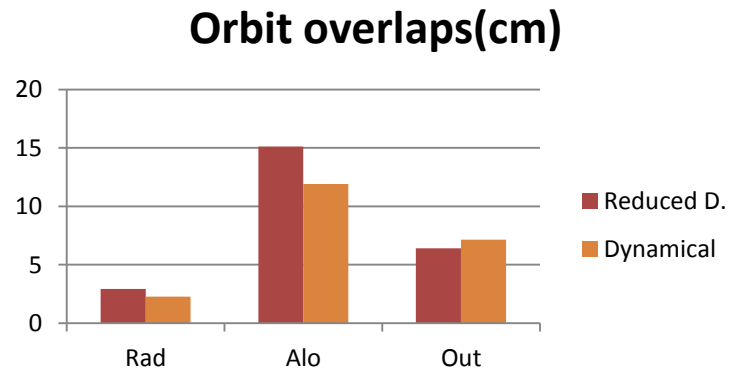
- Results
  - Per satellite in following slides
  - Dynamical orbits better in the most of the observed indicators
  - Radial and Tangential RMS lower for Dynamical orbits – all the satellites
  - Radial and Tangential Overlaps lower for Dynamical orbits – all the satellites
  - Normal Std. Dev. Of the Mean much lower for Dynamical orbits

CRYOSAT


Cryosat -RMS (cm)
5
4
3
2
1
0
Rad
Alo
Out
Reduced D.
Dynamical

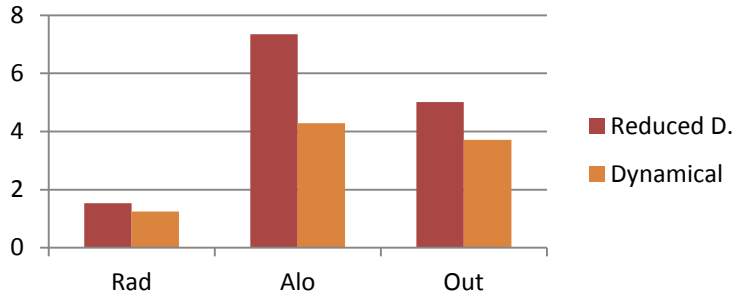

Cryosat - Mean(cm)
1
0,5
0
-0,5
-1
Rad
Alo
Out
Reduced D.
Dynamical


Cryosat - STD dev Mean(cm)
2
1,5
1
0,5
0
Rad
Alo
Out
Reduced D.
Dynamical

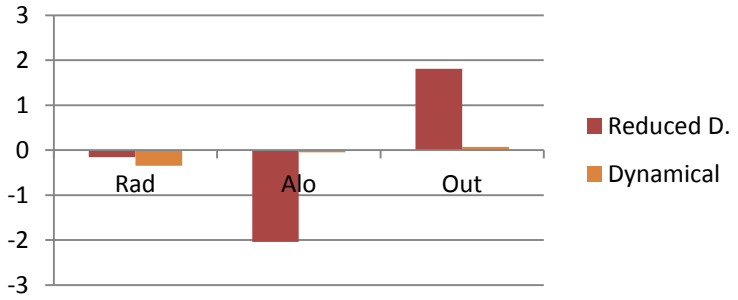

Orbit overlaps(cm)
20
15
10
5
0
Rad
Alo
Out
Reduced D.
Dynamical

SPOT-5

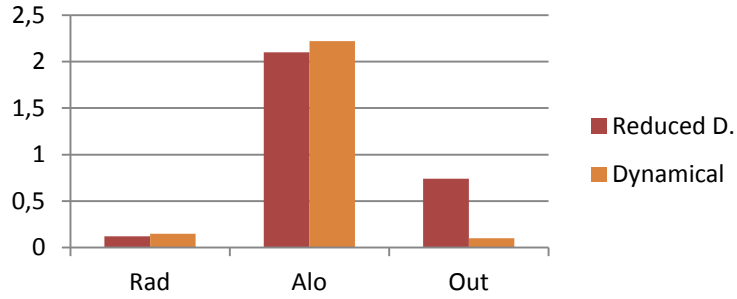
SPOT-5 RMS (cm)



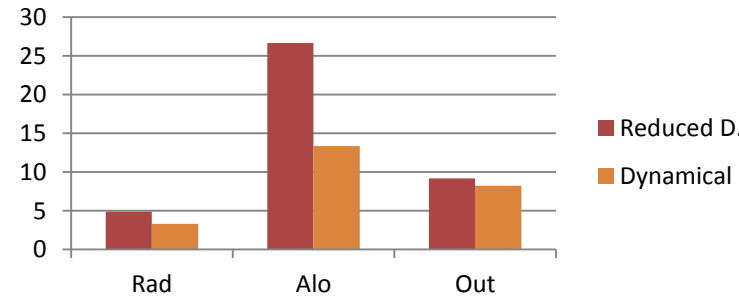
SPOT-5 Mean(cm)



SPOT-5 - STD dev Mean(cm)

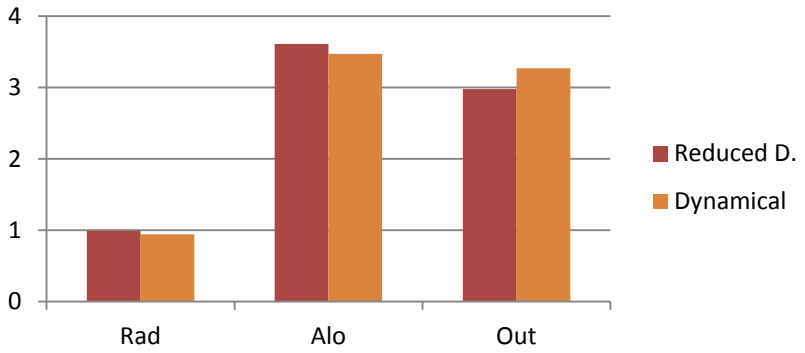


SPOT-5 Orbit overlaps(cm)

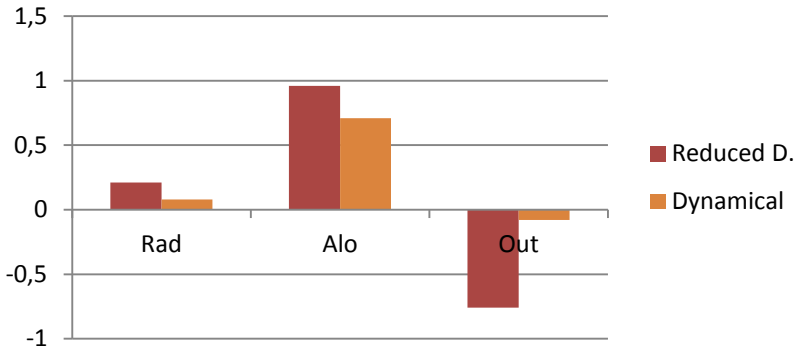


ENVISAT

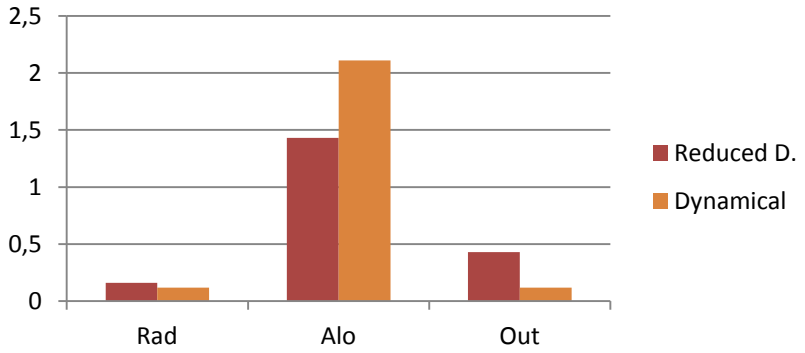
ENVISAT RMS (cm)



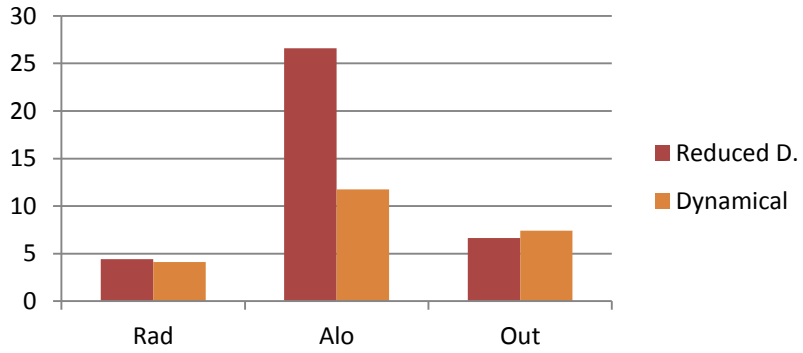
ENVISAT Mean(cm)



ENVISAT STD dev Mean(cm)

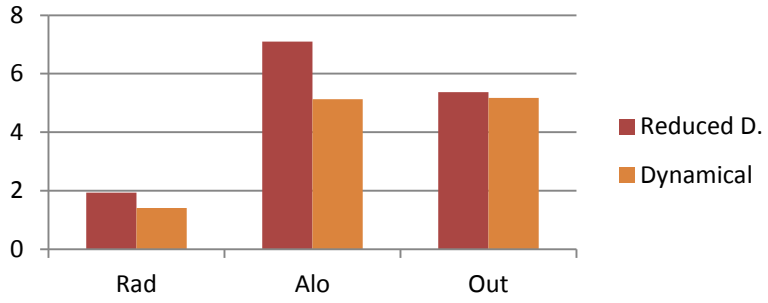


ENVISAT Orbit overlaps(cm)

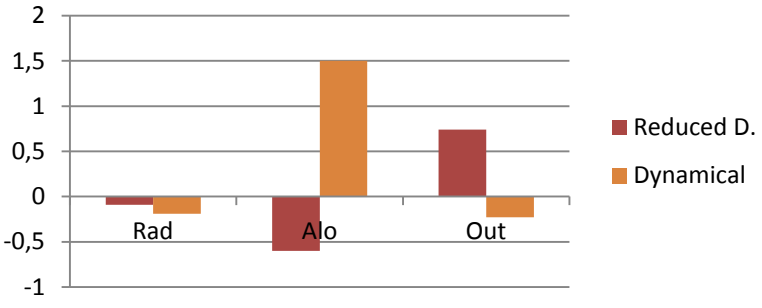


SPOT-4

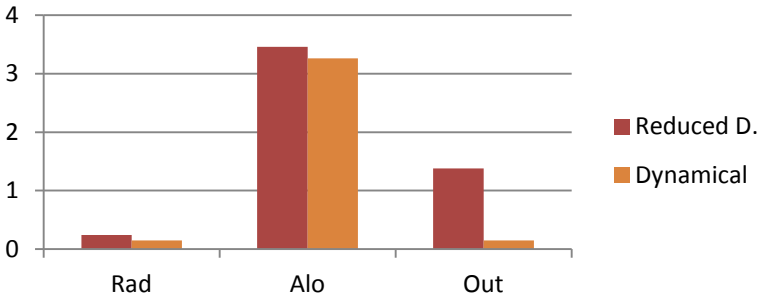
SPOT-4 RMS (cm)



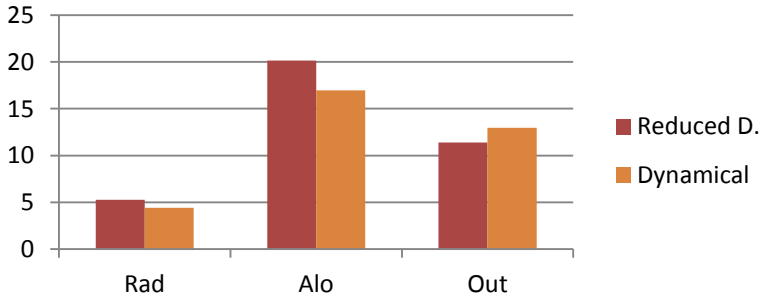
SPOT-4 Mean(cm)



SPOT-4 - STD dev Mean(cm)

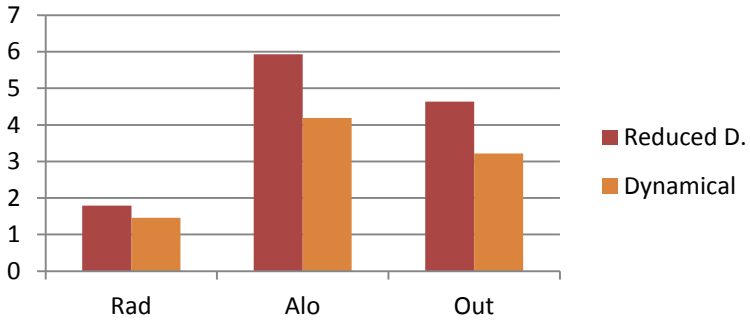


SPOT-4 Orbit overlaps(cm)

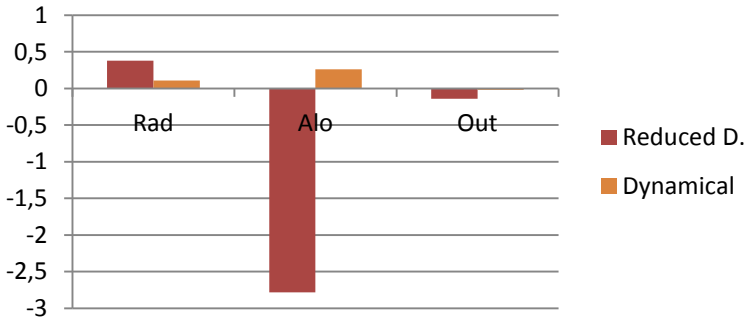


JASON-2

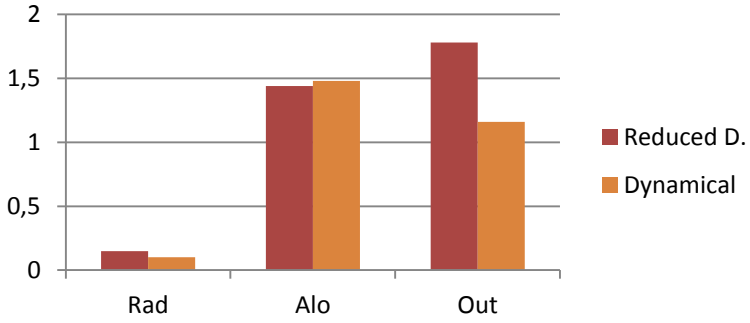
Jason-2 RMS (cm)



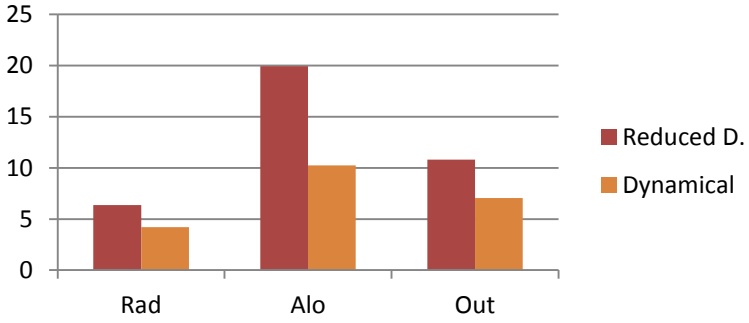
Jason-2 Mean(cm)



Jason-2 STD dev Mean(cm)



Jason-2 Orbit overlaps(cm)



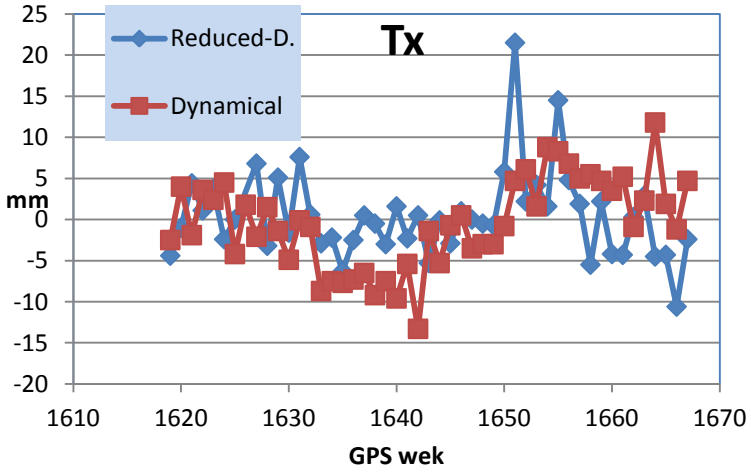
Free network weekly solutions

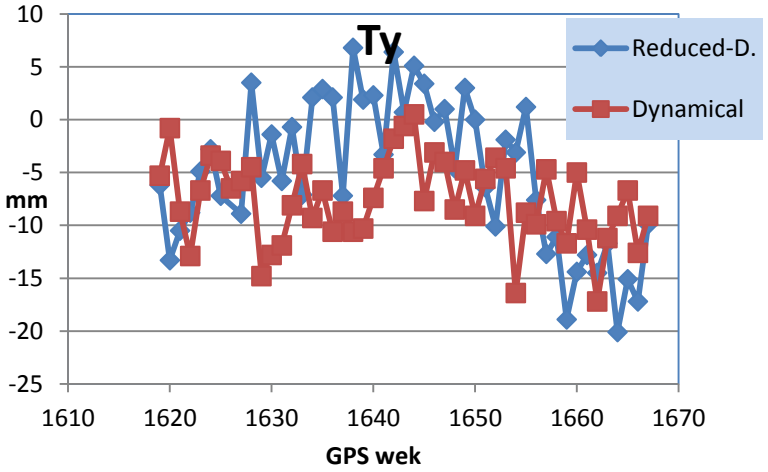
- ❑ 1 year of data (2011)
- ❑ Comparison of the estimated network and pole using reduced-dynamical and Dynamical orbit

Transformation parameters vs. ITRF2008

	Tx(mm) Aver.	Tx(mm) Std.d.	Ty(mm) Aver.	Ty(mm) Std.d.	Tz(mm) Aver.	Tz(mm) Std.d.	Sc (ppb) Aver.	Sc(ppb) Std.d.		
Red.d.	0.4	5.3	-5.1	7.0	7.2	10.7	0.5	0.3		
Dyn.	-0.2	5.5	-7.6	4.0	-0.4	12.3	0.1	0.3		

TX seasonal variations more significant for Dynamical, TY more significant for Reduced dynamical





Free network weekly solutions (2)

STATION RMS vs. DPOD2008

	North (mm)	East (mm)	Up (mm)
Reduced-d.	16.1	19.8	19.5
Dynamical	14.5	17.1	19.0

WRMS

	North (mm)	East (mm)	Up (mm)
Reduced-d.	9.1	11.8	10.0
Dynamical	9.5	11.4	9.4

Estimated Polar coordinates Xp,Yp vs. IERS C04 (solution with fixed rotations vs. ITRF2008)

	Xp Mean (mas)	Xp RMS (mas)	Yp Mean (mas)	Yp RMS (mas)
Reduced-d.	-0.40	-0.20	0.689	0.657
Dynamical	0.27	0.27	0.785	0.657

Thanks for the attention ……