Evolution of dynamical orbit model

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Traditional Bernese orbit modeling is based on the empicical and pseudo-stochastic modeling. Dynamical model has been developed in GOP and TUM

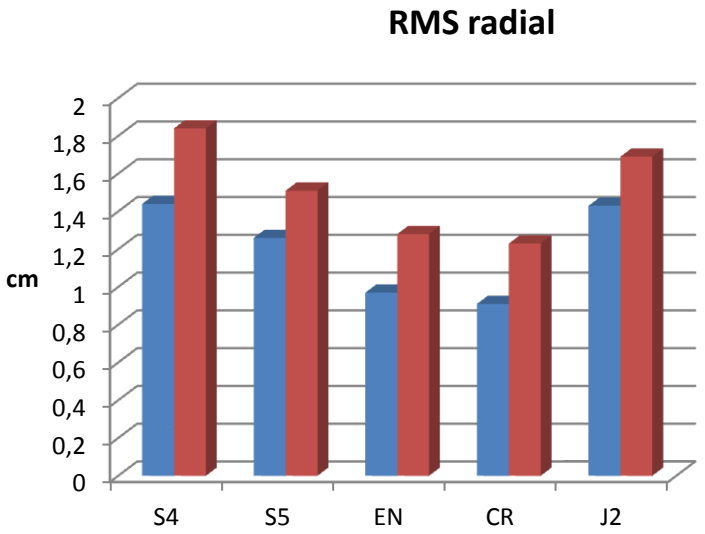
Modeling	**Empirical-Stochastic (reduced-dynamical)**	**Dynamical**
Satellite attitude and geometry	Not considered	Nominal Box-Wing model
Atmosphere density model	Not applied	MSIS-86
Atmosphere drag	Absorbed by along track stochastic parameters and Y-constant empirical parameter	Scaling coefficient estimated
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)

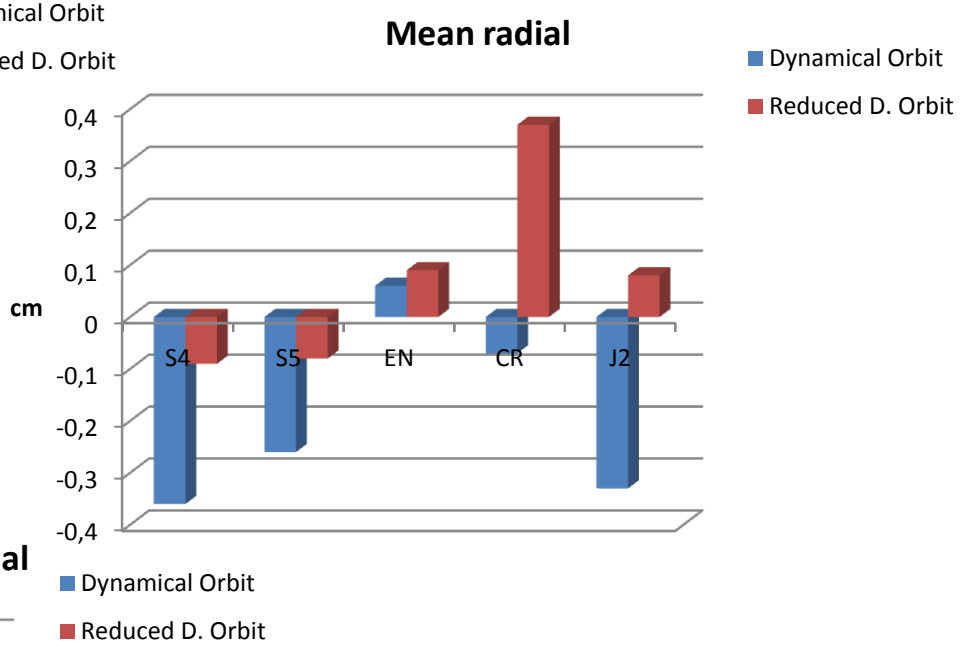
TESTING

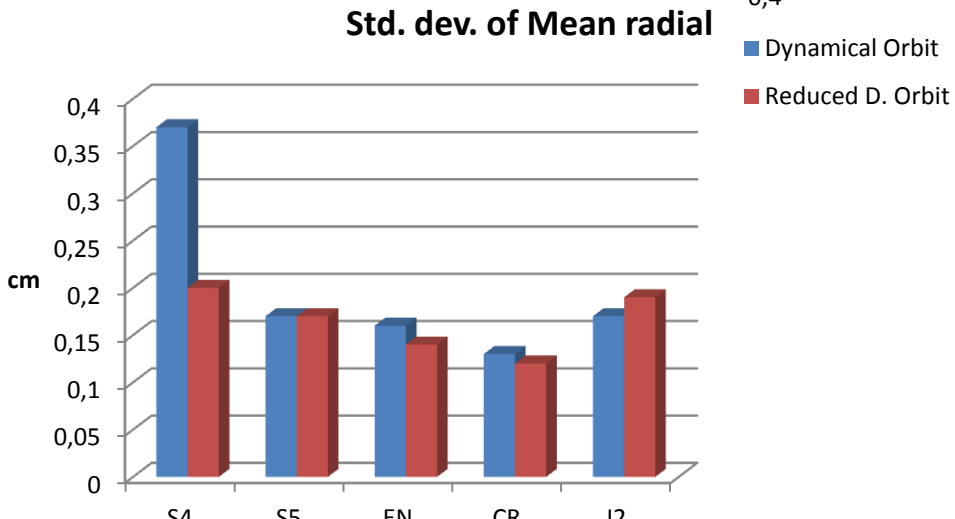
- First results presented at AGU Fall meeting (december 2011) , detected a signal of 14-15 days
- Problem related to ocean tidal modeling, recently corrected
- Preliminary comparison with CNES/SSALTO orbits (40 days)
- Preliminary comparison of weekly free network solutions (quarter a year)
- To be confirmed by longer time series and other tests

Comparison of the estimated DORIS orbits and CNES/SSALTO multitechnique orbits - RADIAL direction

Days 001-040 of 2011

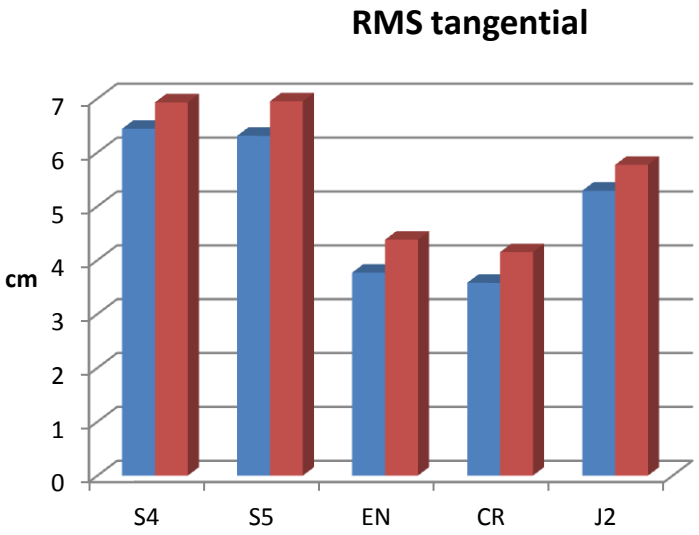


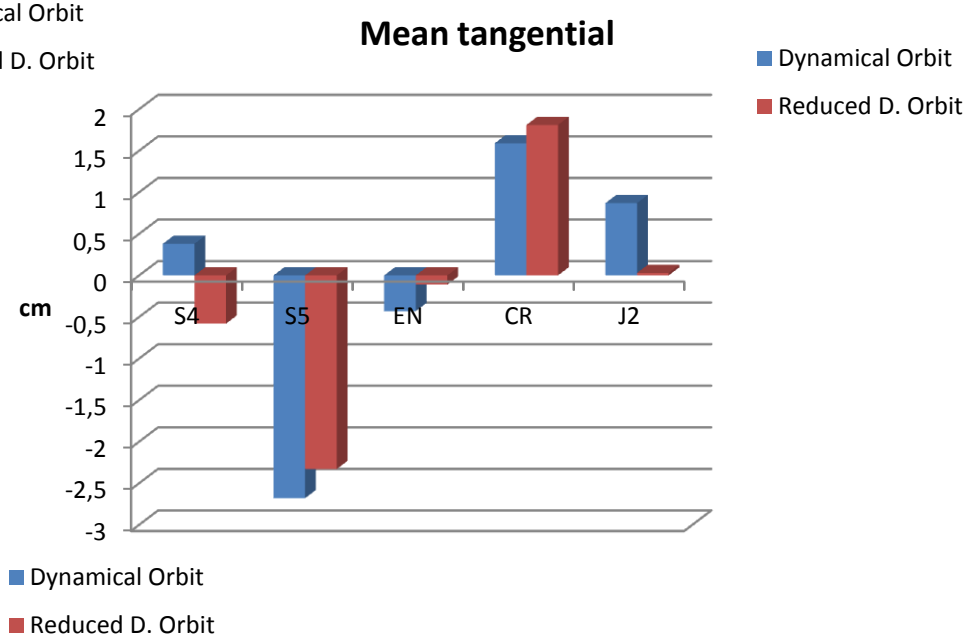


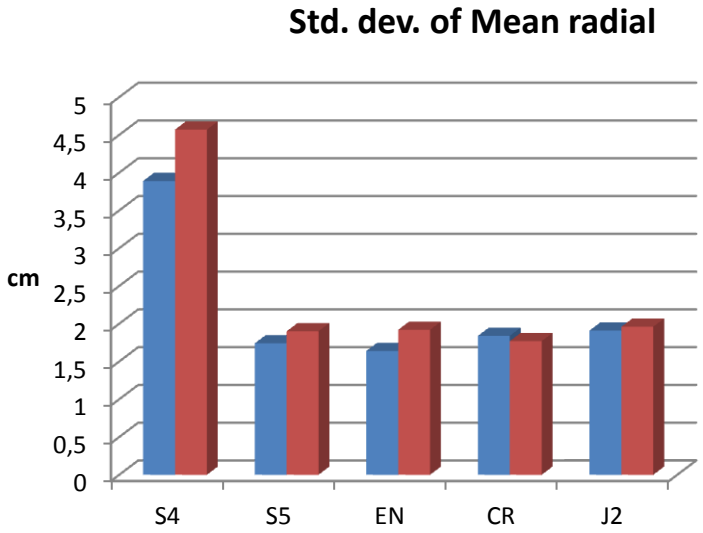


Comparison of the estimated DORIS orbits and CNES/SSALTO multitechnique orbits - TANGENTIAL direction

Days 001-040 of 2011

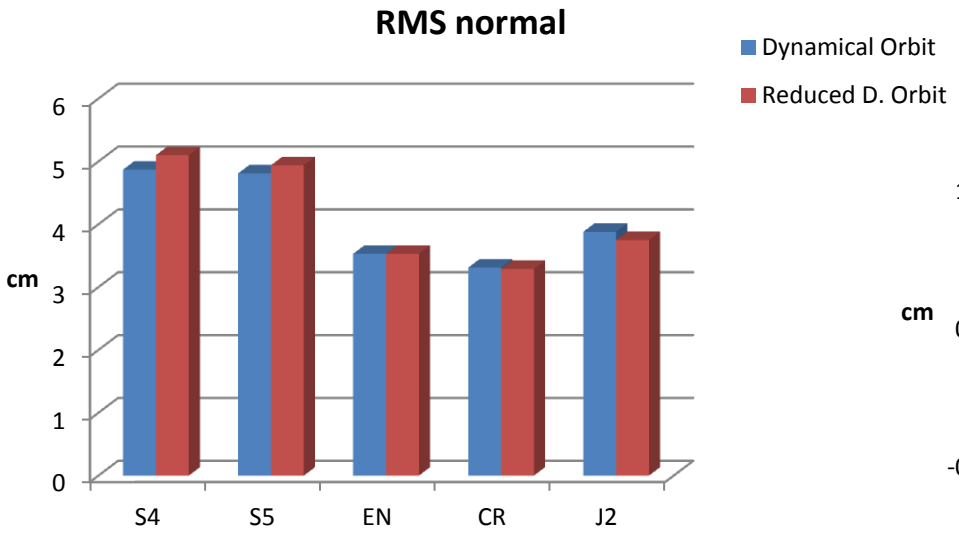


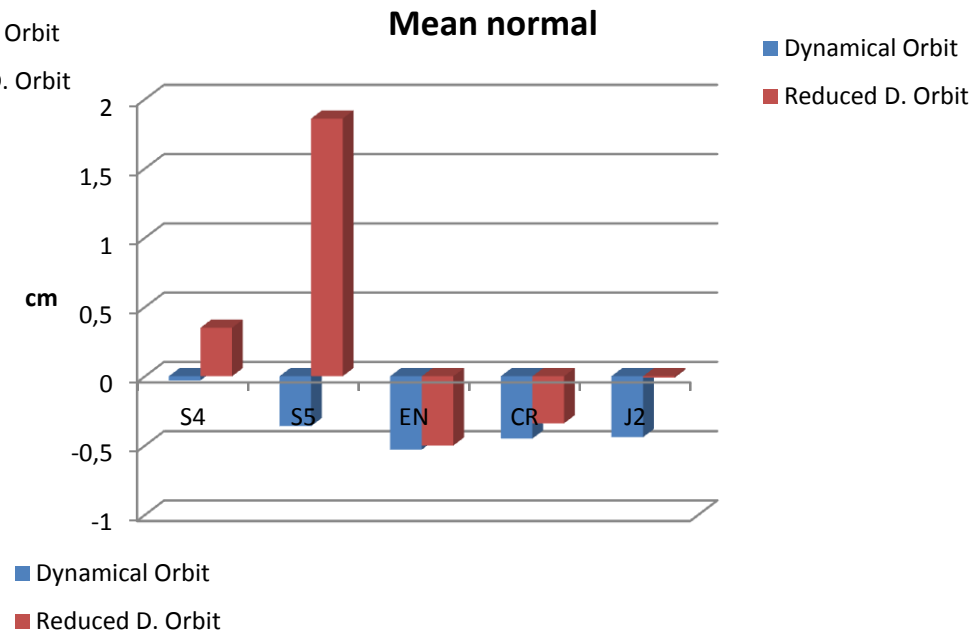


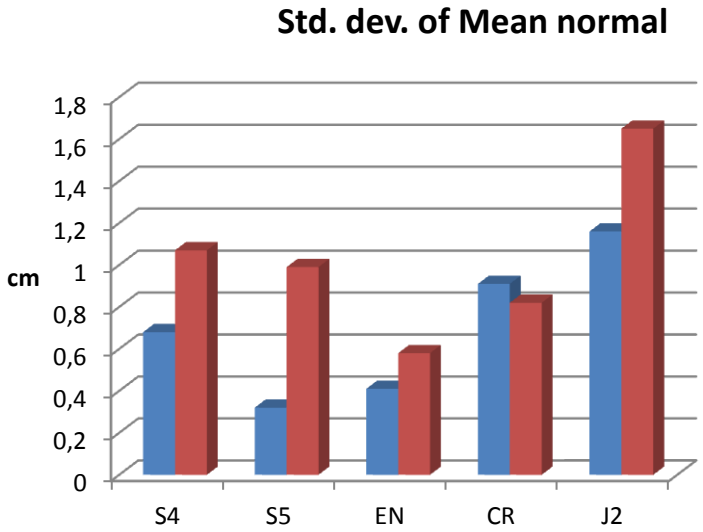


Comparison of the estimated DORIS orbits and CNES/SSALTO multitechnique orbits - NORMAL direction

Days 001-040 of 2011







RMS reduction of the orbit using dynamical modeling in comparison to reduced-dynamical. RMS with respect to SSALTO/CNES orbits as a reference

green – RMS decrement, red- RMS increment

	Radial	Tangential	Normal
SPOT-4	**18%**	**7%**	**6%**
SPOT-5	**16%**	**6%**	**9%**
Envisat	**24%**	**14%**	**0%**
Cryosat	**28%**	**12%**	**1%**
Jason-2	**13%**	**7%**	**0%**
average	20%	9%	3%

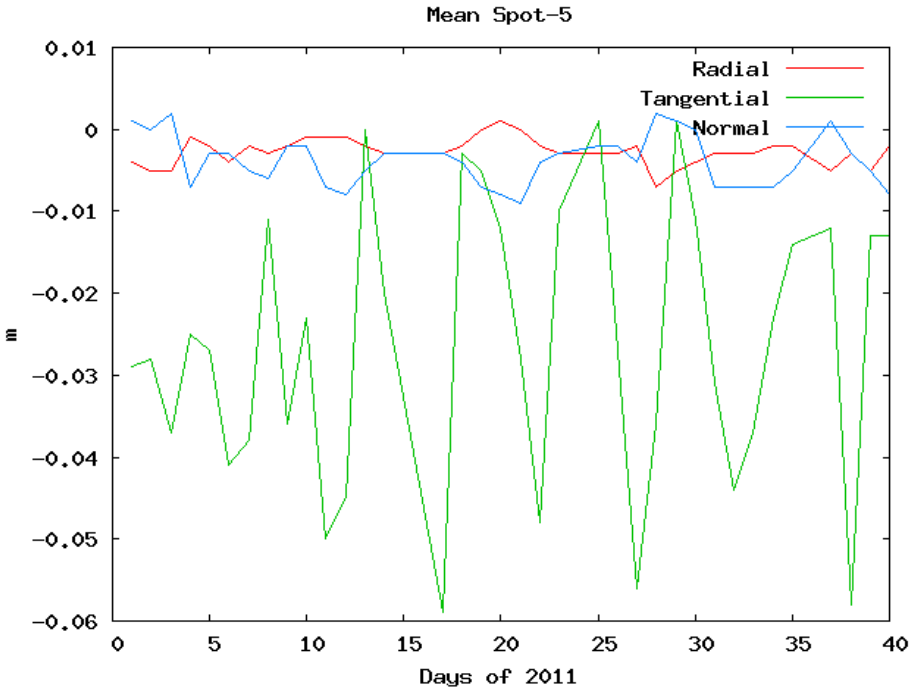
RMS total

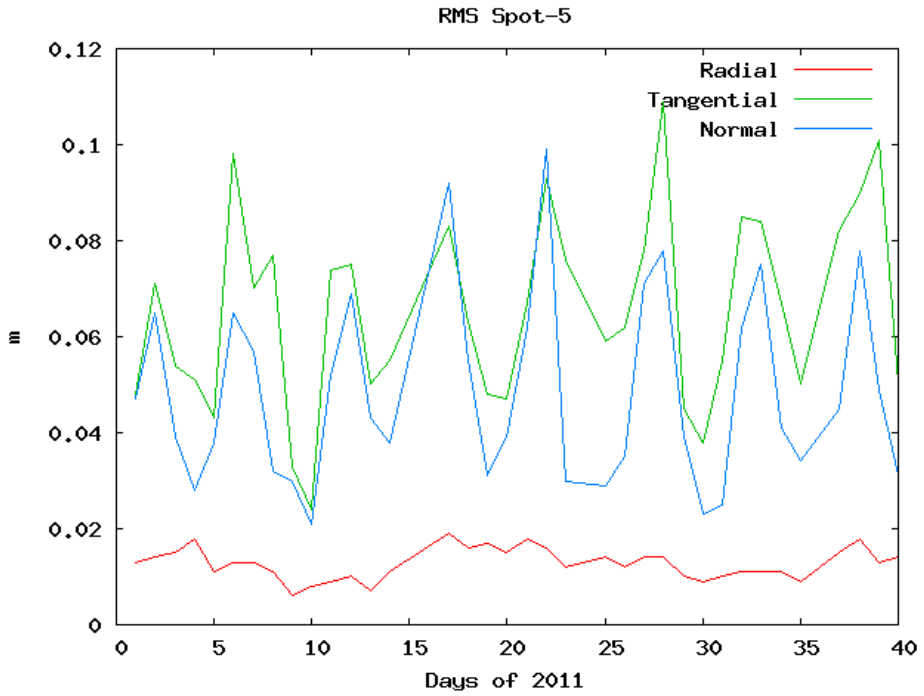
	Radial	Tangential	Normal
SPOT-4	**22%**	**7%**	**5%**
SPOT-5	**17%**	**9%**	**3%**
Envisat	**24%**	**14%**	**0%**
Cryosat	**26%**	**14%**	**1%**
Jason-2	**15%**	**8%**	**3%**
average	21%	10%	1%

RMS after Mean removal

Comparison of the estimated DORIS orbits and CNES/SSALTO multitechnique orbits

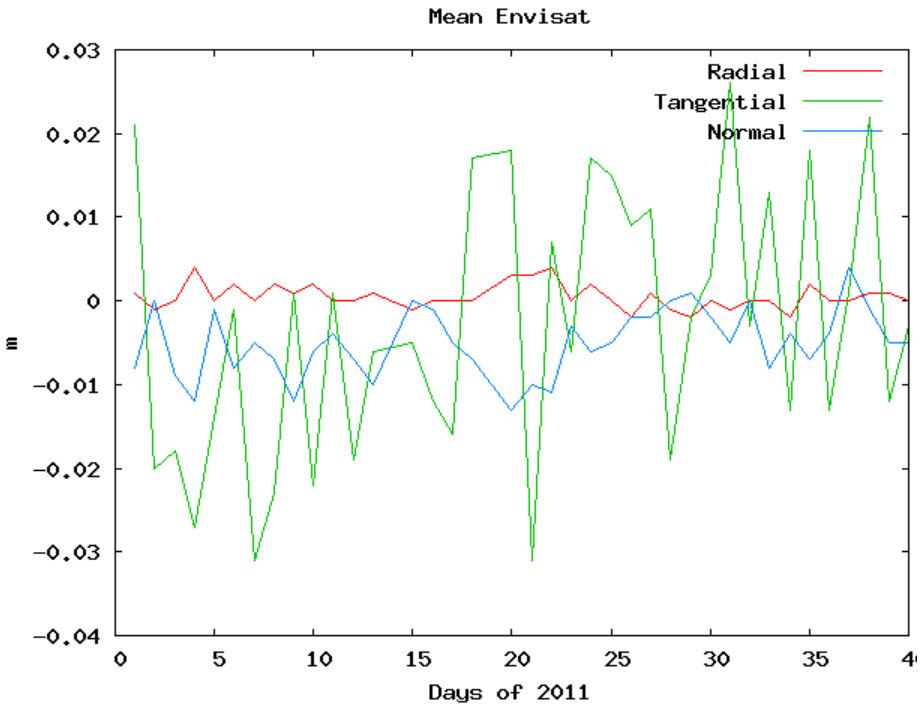
- Days 001-040 of 2011
- Signal with period about 5 days strongly singnificant for SPOT-5, slightly for SPOT-4.
- Figure –daily Mean and RMS for SPOT-5

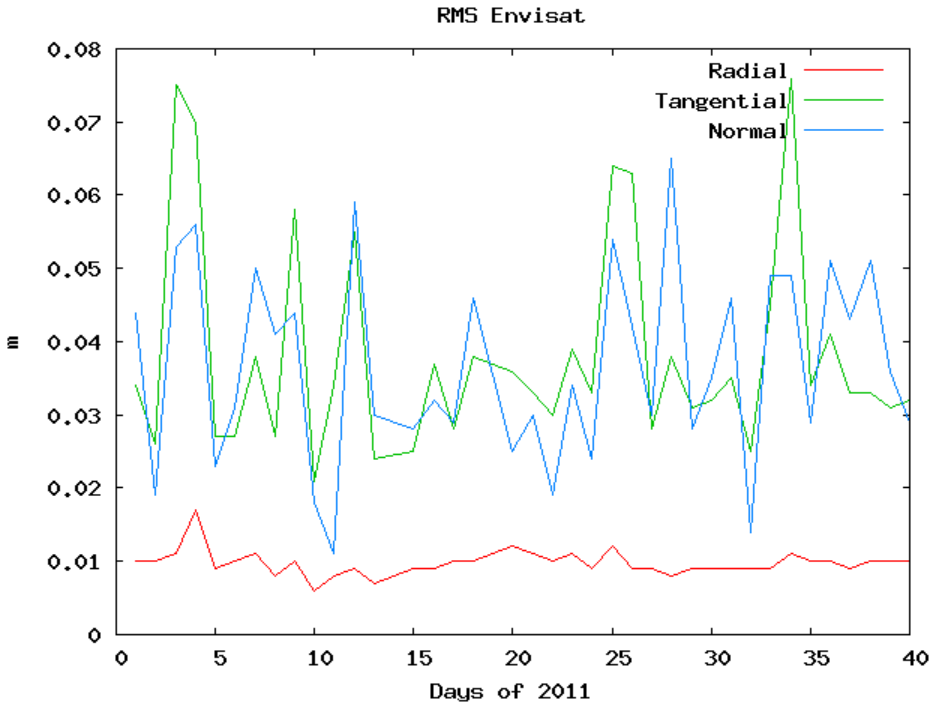




Comparison of the estimated DORIS orbits and CNES/SSALTO multitechnique orbits

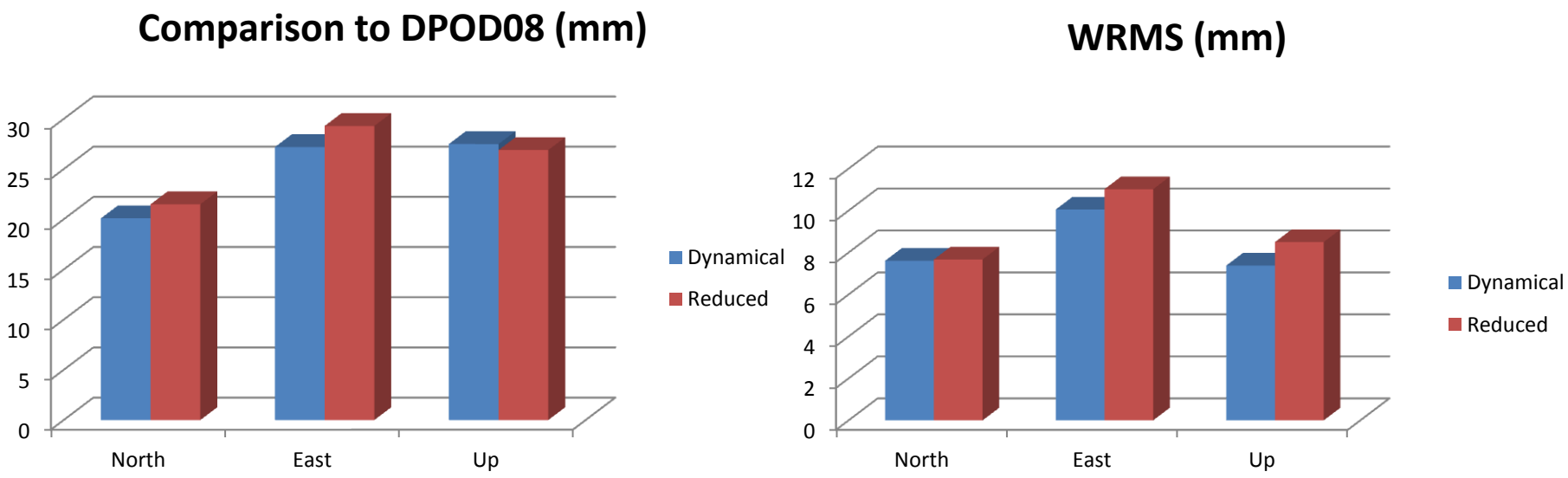
- Figure –daily Mean and RMS for Envisat





Free network solutions

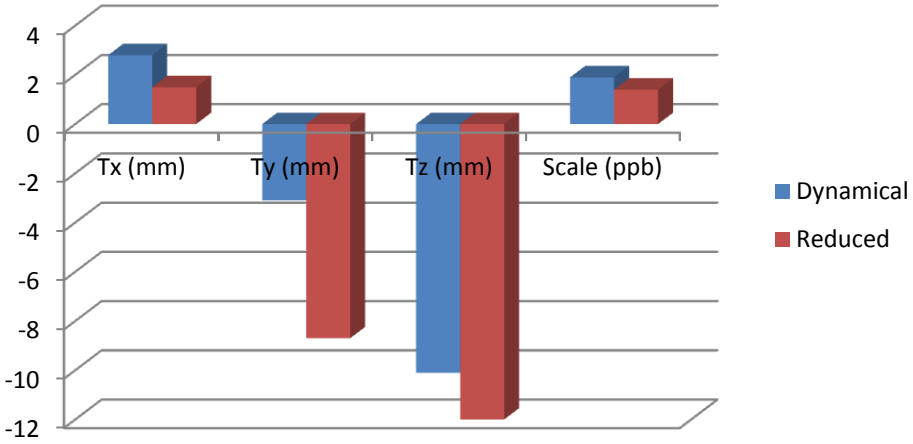
- Weekly multi-satellite solutions
- third quarter of 2011



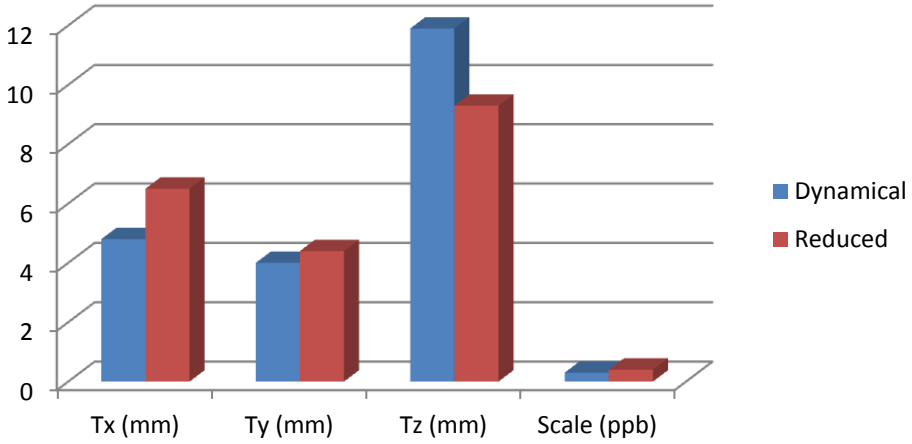
Free network solutions, TRF parameters vs. DPOD08

- Weekly multi-satellite solutions
- third quarter of 2011

Mean value of TRF par.



Variations of TRF par.



Earth Radiation Model

- Computation of Irradiance [W/m^2] at satellite position, assuming:
  - Earth scattering properties approximated as a Lambertian sphere
  - Earth reflected radiation in the visible (albedo)
  - Earth emitted radiation in the infrared

- Types of models:
  - Analytical: Constant albedo, Earth as point source ➔ large satellite altitude

$$\vec{E}_{ERM-A}(\psi,h)=\frac{A_E E_{sun}}{(R_E+h)^2}\left[\frac{2\alpha}{3\pi^2}\left((\pi-\psi)\cos\psi+\sin\psi\right)+\frac{(1-\alpha)}{4\pi}\right]\hat{r}$$

$A_E = \pi R_E^2$, R_E = 6378 km, E_{SUN} = 1367 W/m^2, h = satellite altitude, α = albedo (≈ 0.3)

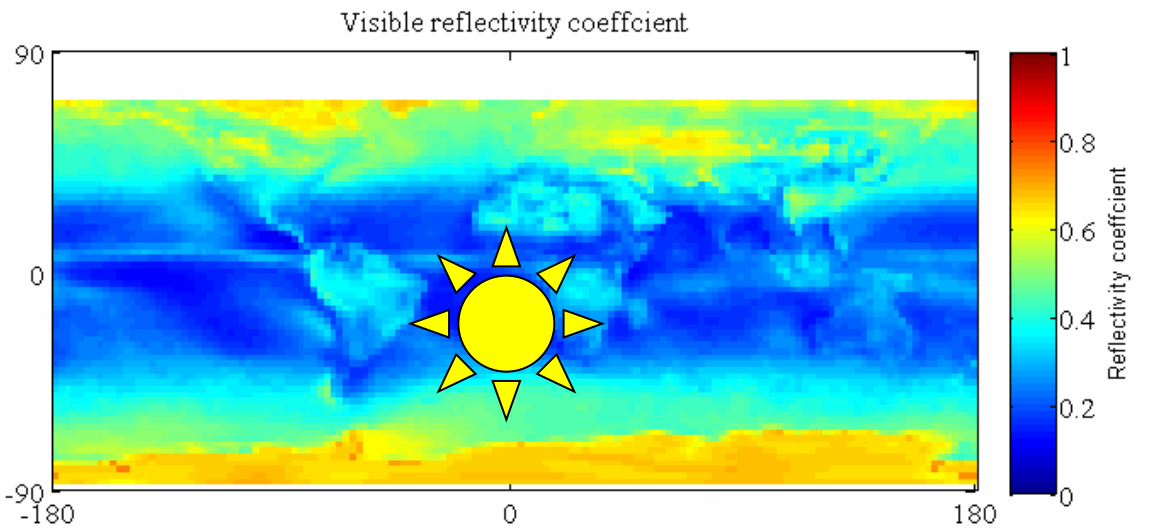
For LEO satellites:

- Latitude- and time-dependent reflectivity and emissivity (Knocke et al.,1988)
- Latitude-, **longitude-** and time-dependent reflectivity and emissivity from NASA CERES project

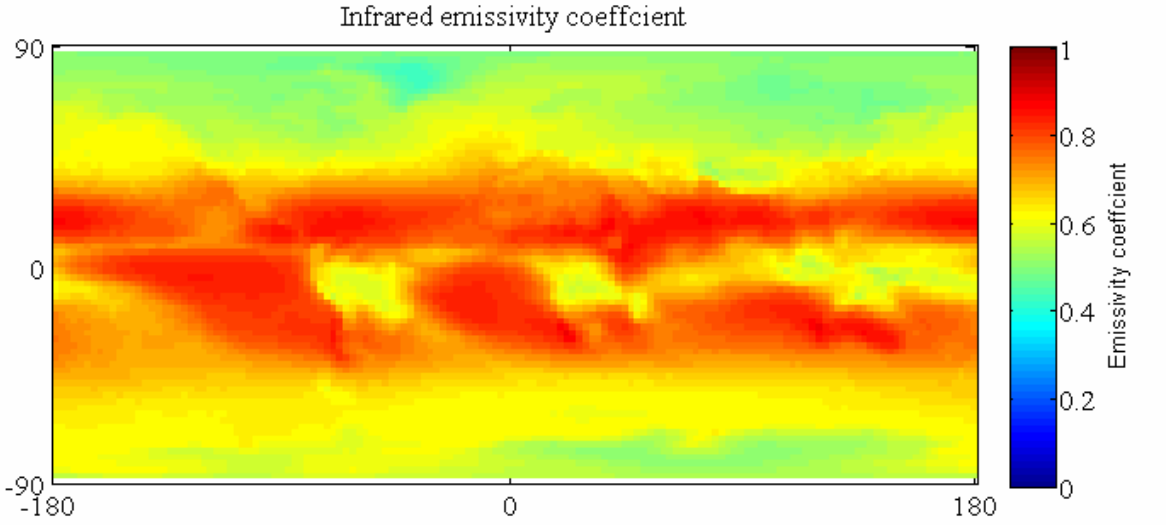
Earth Radiation Model

CERES
(Clouds and Earth´s Radiant Energy System)
NASA EOS project

Reflectivity (visible) ➔



Emissivity (infrared) ➔



CERES data, average (2000-2010) for January

Earth Radiation Model

Irradiance [W/m²]

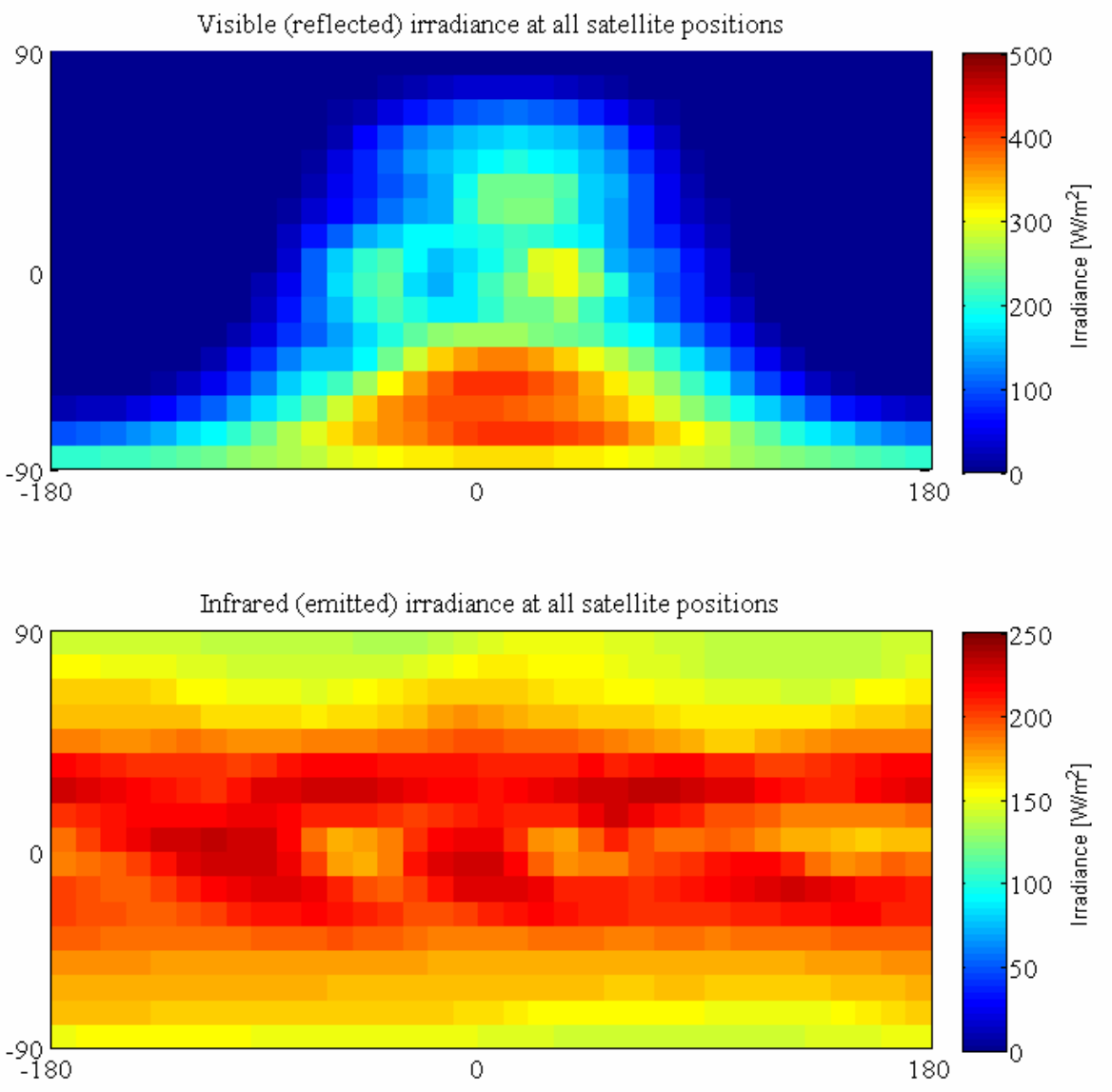
Average values for 12:00 UTC, January 2000-2010

received by a satellite at 700 km altitude at all possible positions

Reflected irradiance ➔ (reflected sunlight) in the visible

Emitted irradiance ➔ in the infrared

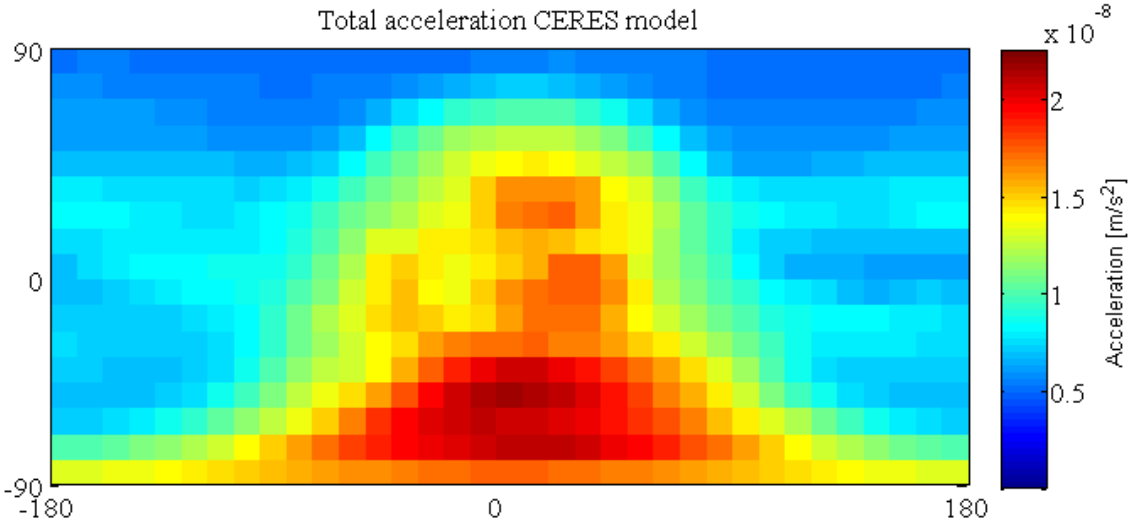
Integration of irradiance over the area of the Earth visible by the satellite

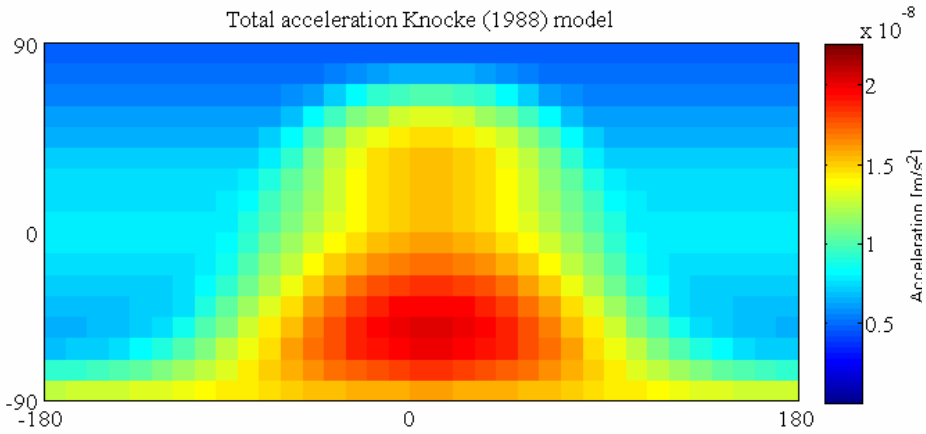


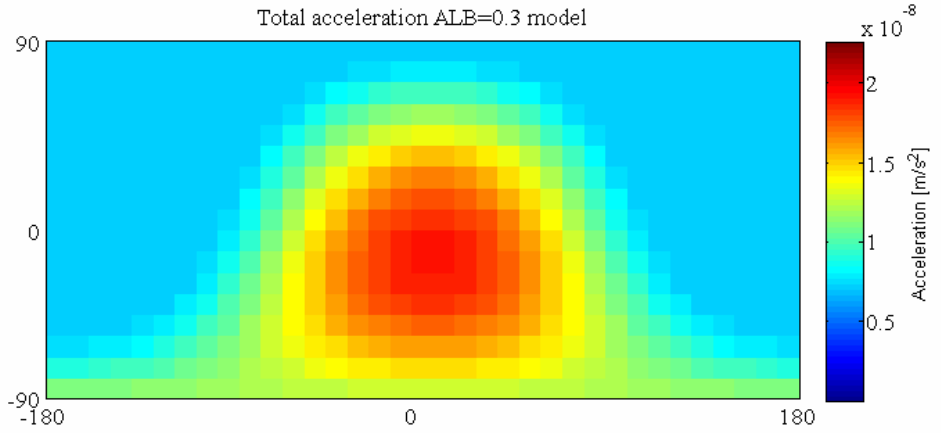
Acceleration due to Earth Radiation

Radial acceleration using: area-to-mass ratio of 0.011 m^2/kg (CRYOSAT-2)

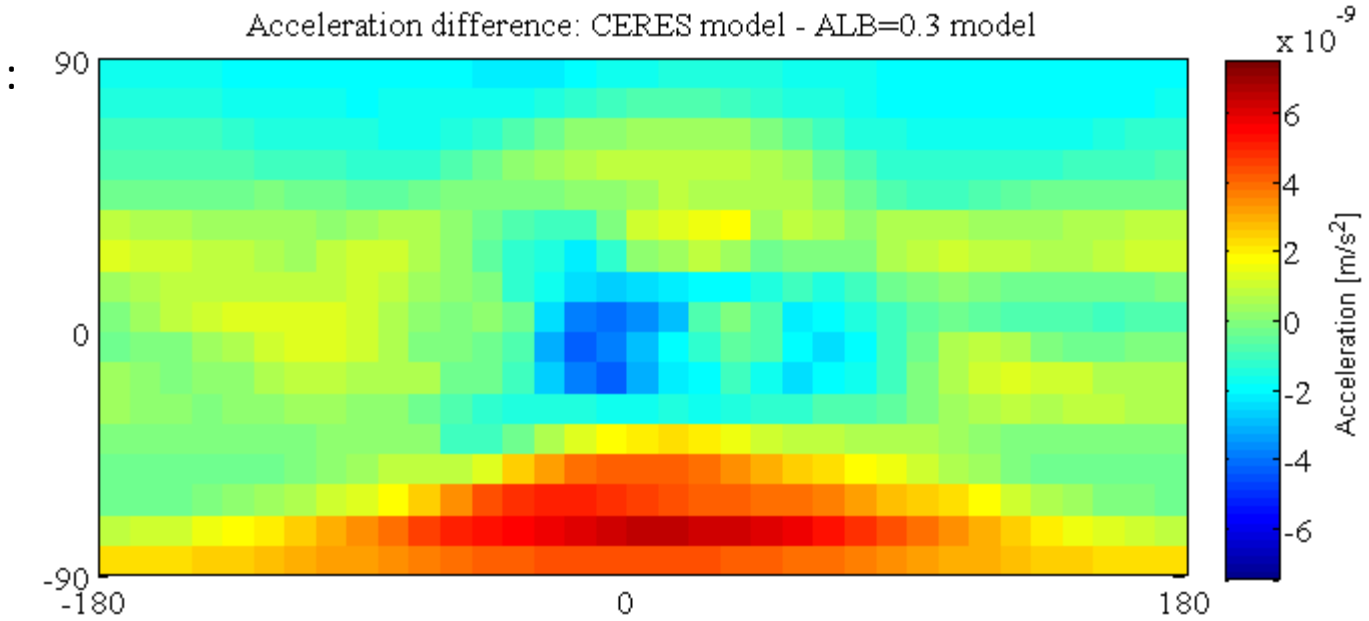
Average values for 12:00 UTC, January 2000-2010

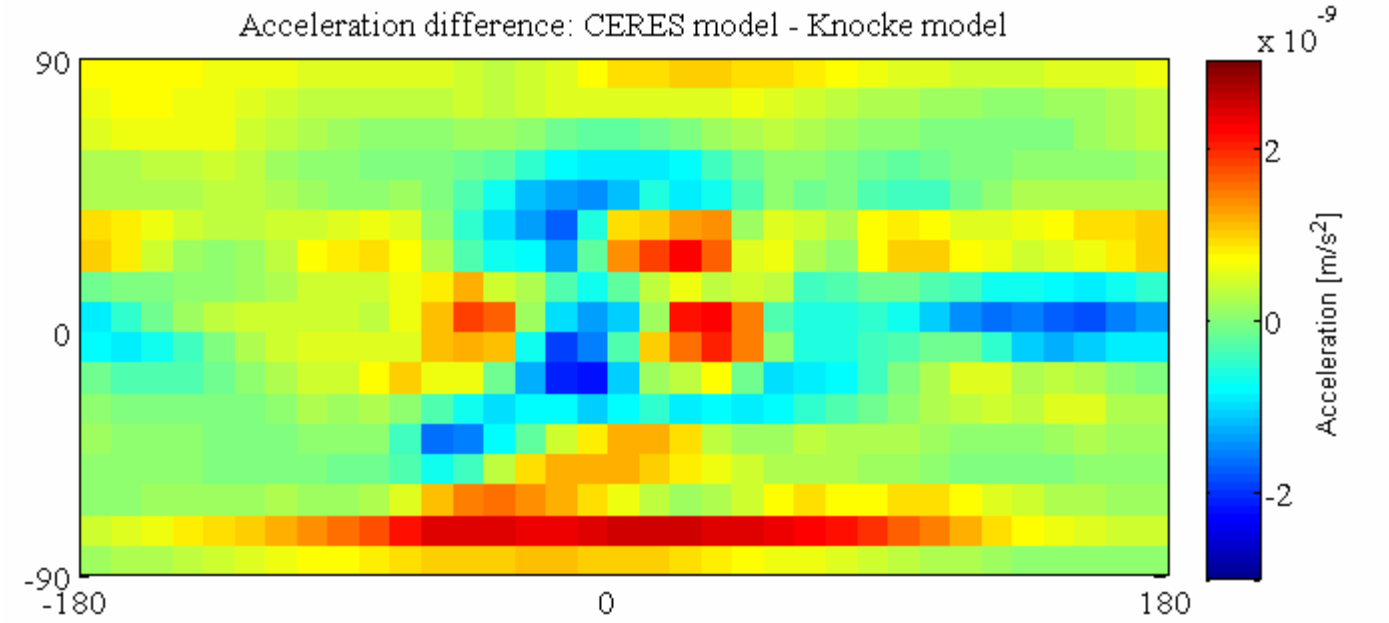






Acceleration due to Earth Radiation – model differences





FUTURE prospects

Dynamical orbit modeling

- complex testing, long time series
- comparison with external orbits (SSALTO and others)
- internal orbit overlaps
- SLR validation
- Impact on the free network solutions
- Results will be partially presented at IDS DORIS workshop (September 2012), complex presentation planned for AGU Fall meeting (December 2012)

Earth radation

- Studies of Analytical, Knocke and CERES models
- To be presented at IDS DORIS WORKSHOP (September 2012)