

GPS–only gravity field determination from GOCE data

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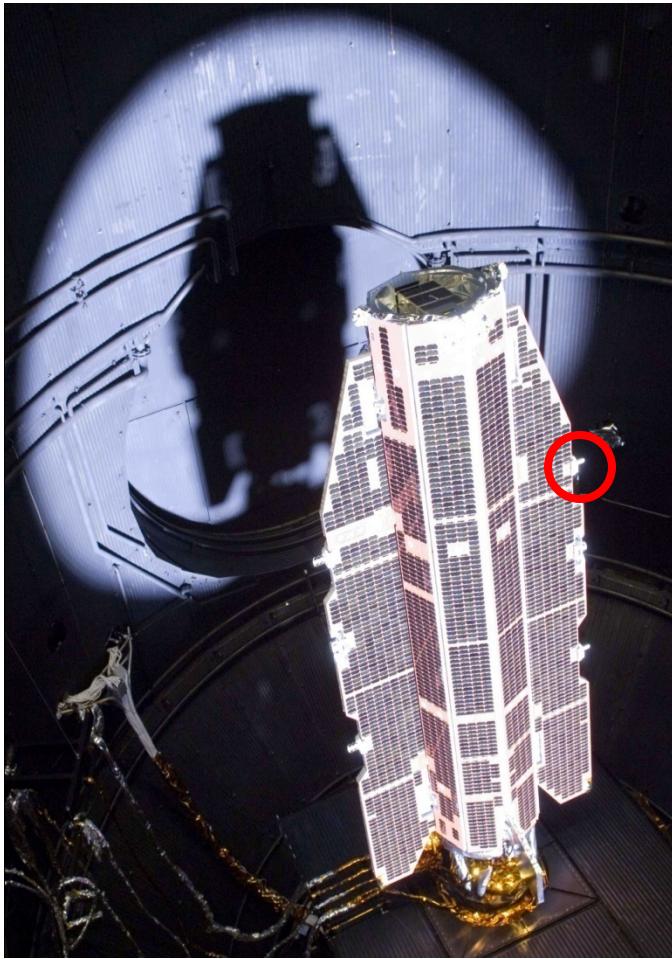
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of Technology*

IAG Scientific Assembly

September 1–6, 2013, Potsdam, Germany

Background and motivation



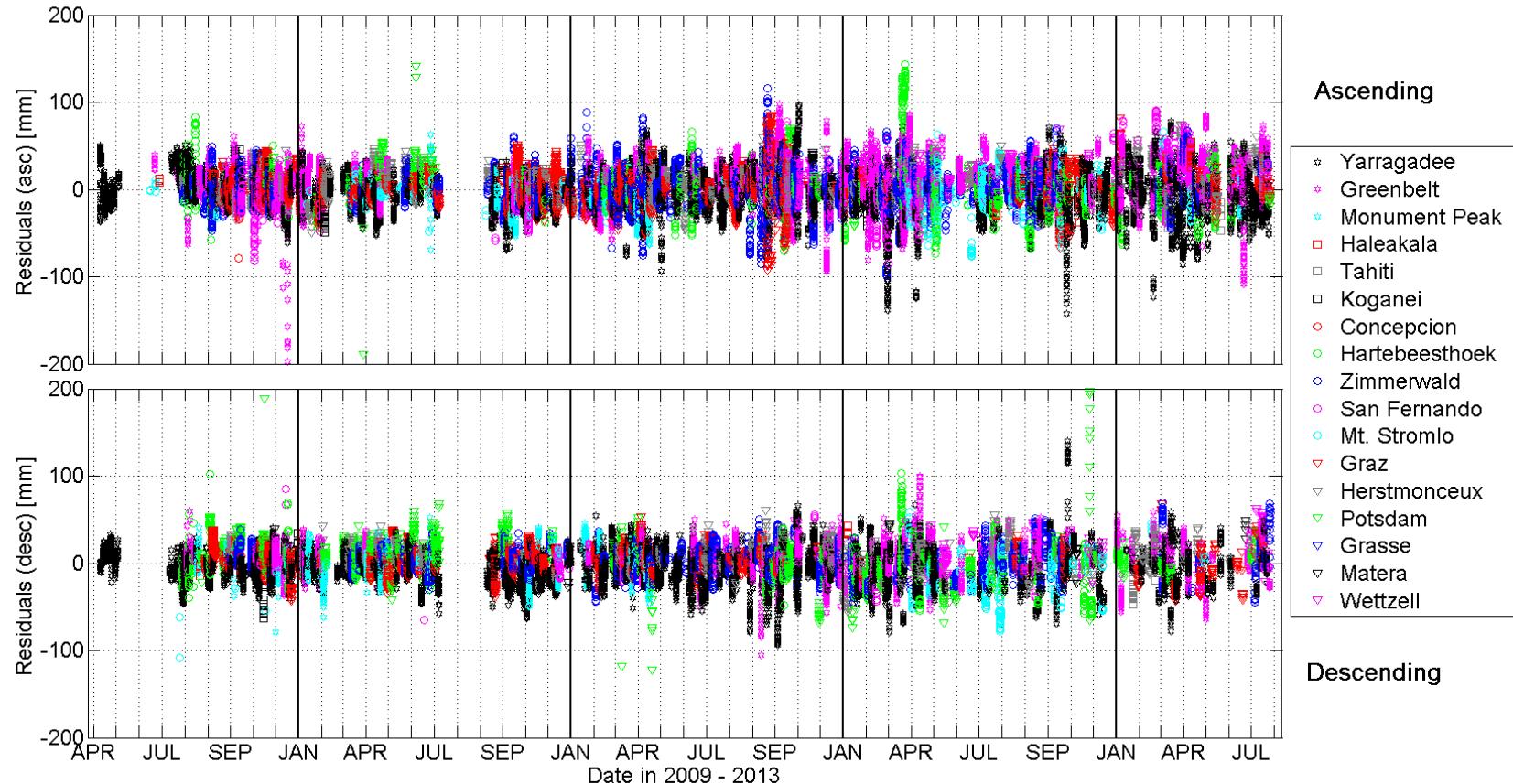
Courtesy:ESA

- AIUB is responsible for the determination of the Precise Science Orbit (SST_PSO) product within the GOCE HPF consortium
- The kinematic orbit product (SST_PKI) is used for the determination of the low degrees of the Earth's gravity field => GPS-only gravity field solutions
- The “Celestial Mechanics Approach” (CMA) developed at AIUB allows it to directly test the performance of the GPS-only gravity field solutions

GOCE orbit determination – SLR validation

H. Bock et al.: GPS-only gravity field determination from GOCE data
IAG Scientific Assembly, September 1–6, 2013, Potsdam, Germany

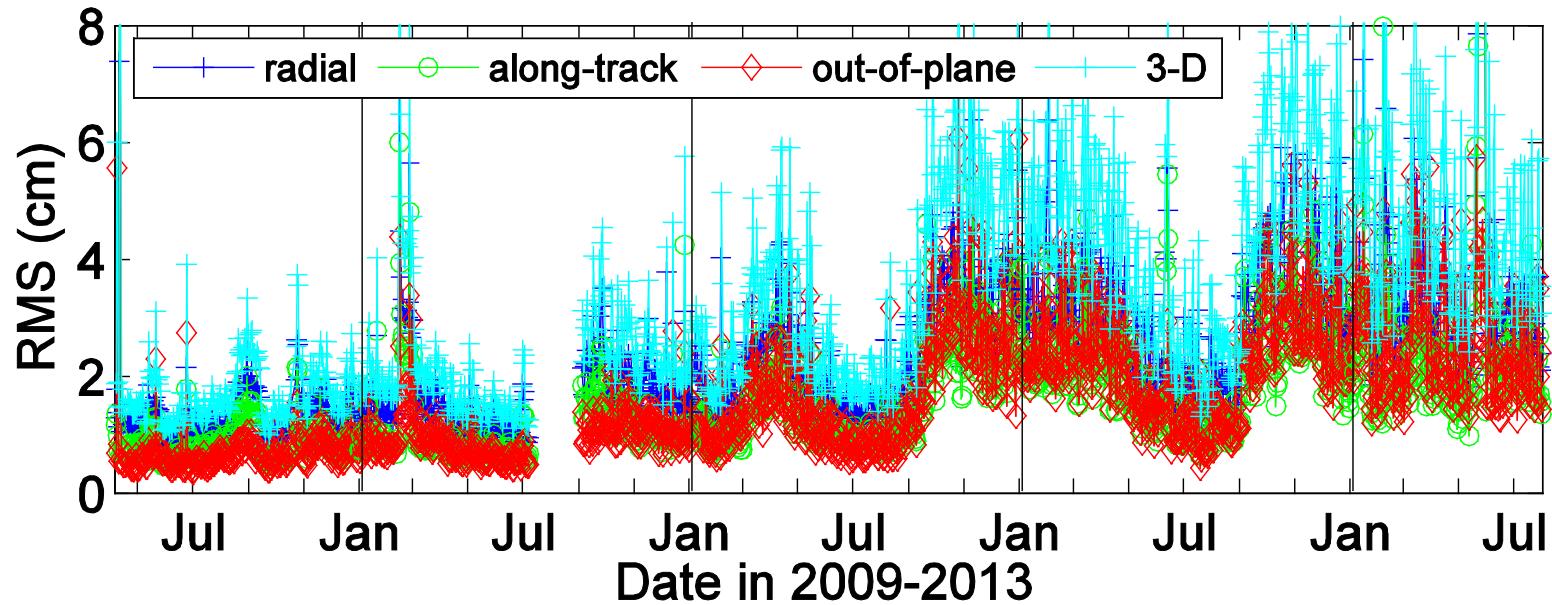
Kinematic orbits – SST_PKI



Mean: 0.08 cm

RMS: 2.36 cm

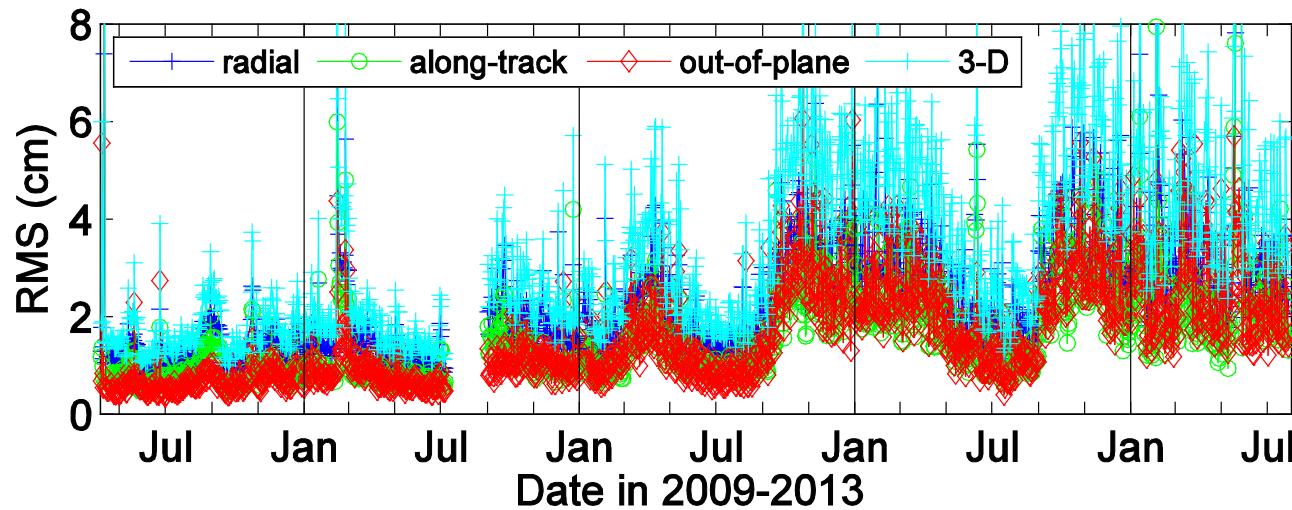
GOCE orbit determination – results



- RMS of the differences between reduced-dynamic and kinematic orbits
- RMS values are growing during the mission

GOCE orbit determination – results

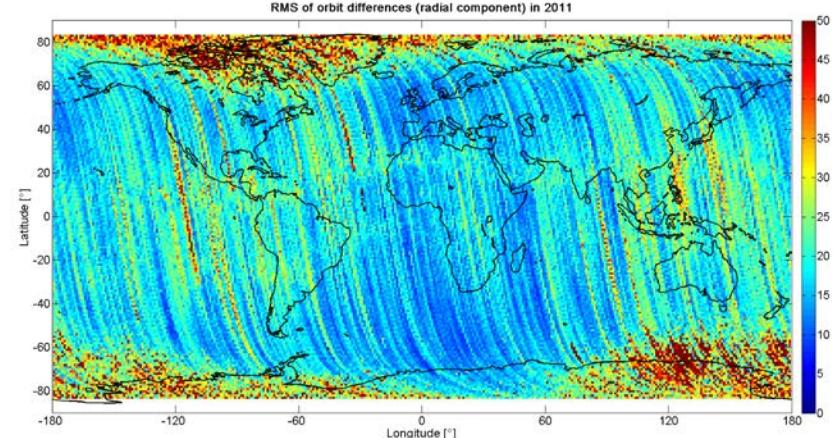
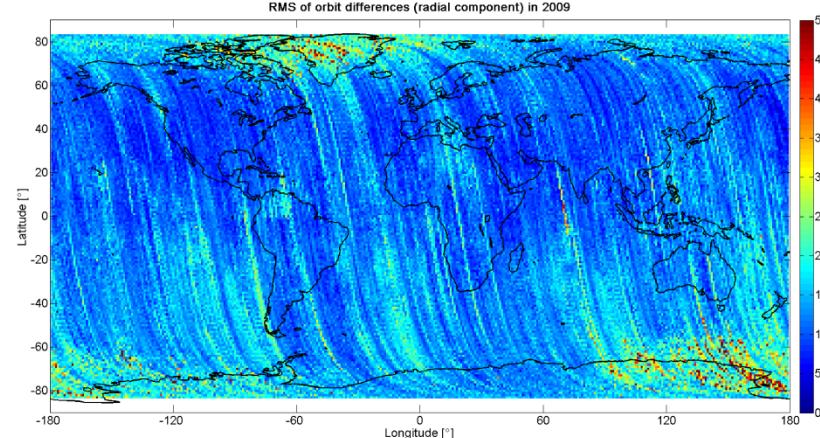
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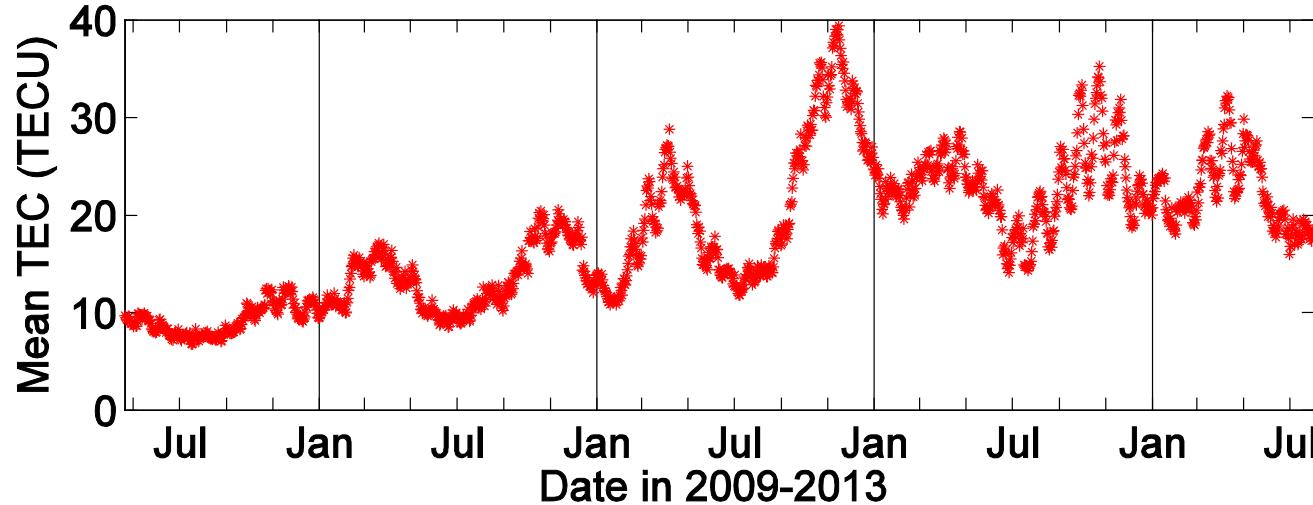
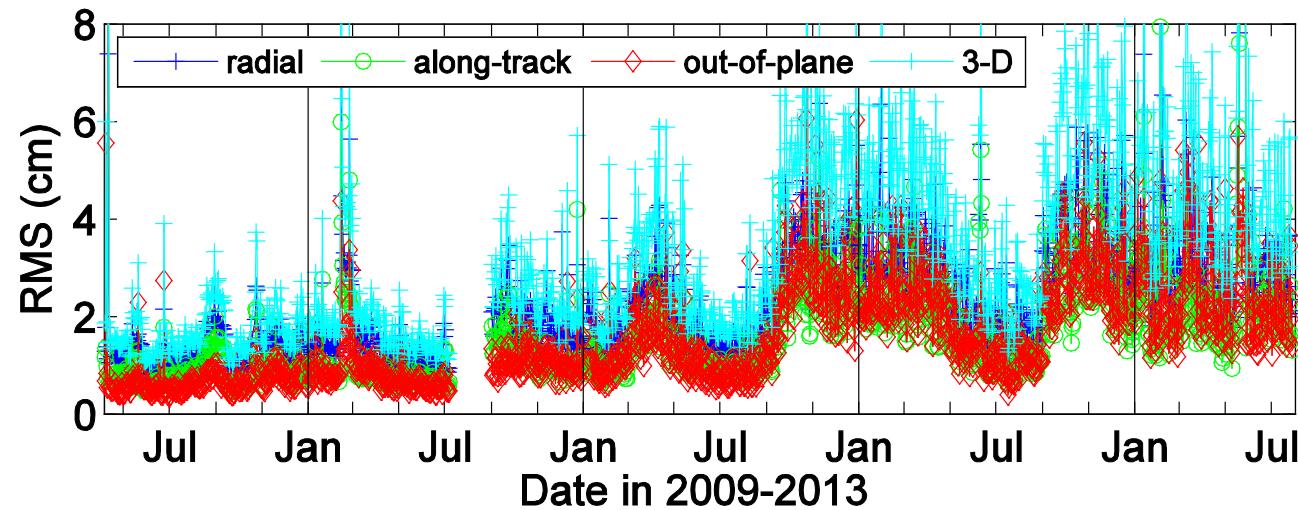
2009

Radial RMS (ascending arcs)

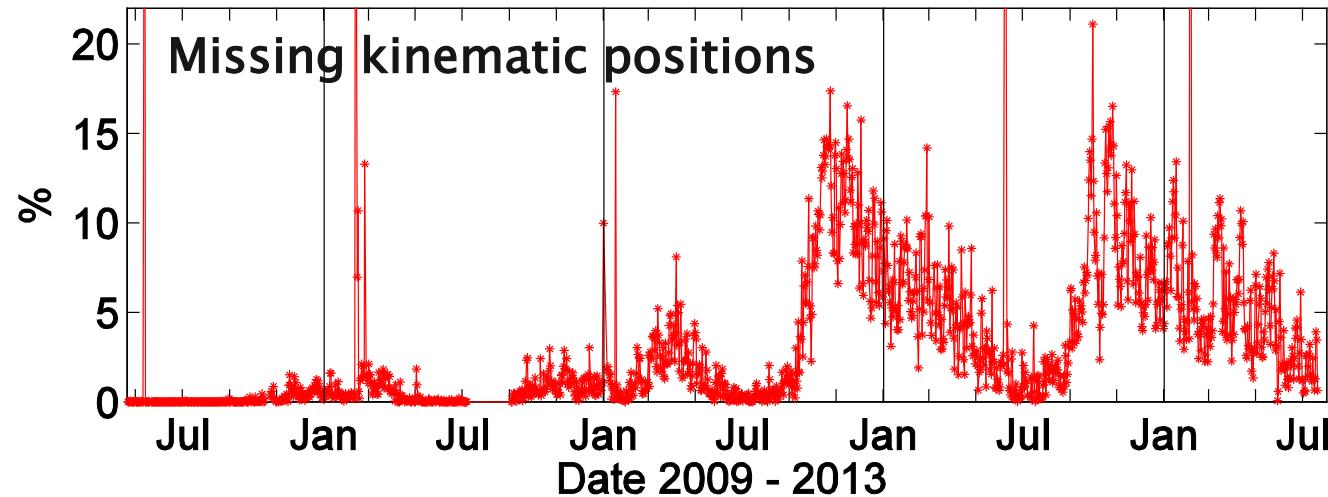
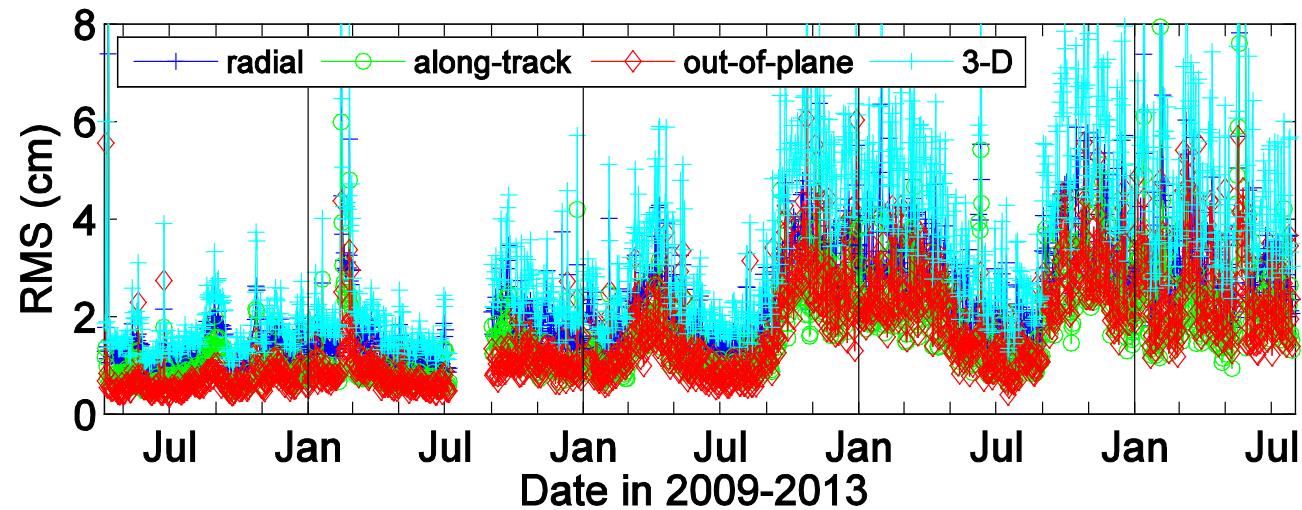
2011



GOCE orbit determination – results



GOCE orbit determination – results

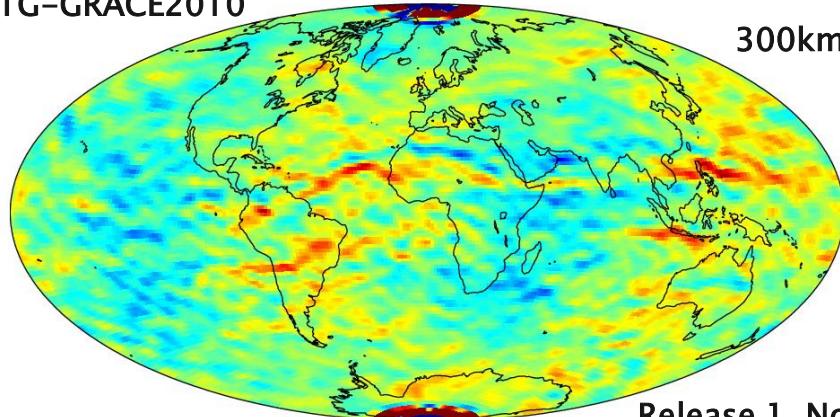


GPS–only gravity field determination

- Celestial Mechanics Approach
- Pseudo-observations: kinematic GOCE positions (SST_PKI) with variance-covariance information (SST_PCV) (+ common-mode accelerometer data)
- Parameters:
 - 6 initial orbit elements
 - Constant and once-per-revolution terms in R, S, and W
 - Pseudo-stochastic pulses in R, S, and W every 6 min ($\sigma = 0.1 \text{ mm/s}$)
 - Gravity field parameters up to degree/order 120

Impact of accelerometer data

Geoid differences to
ITG-GRACE2010



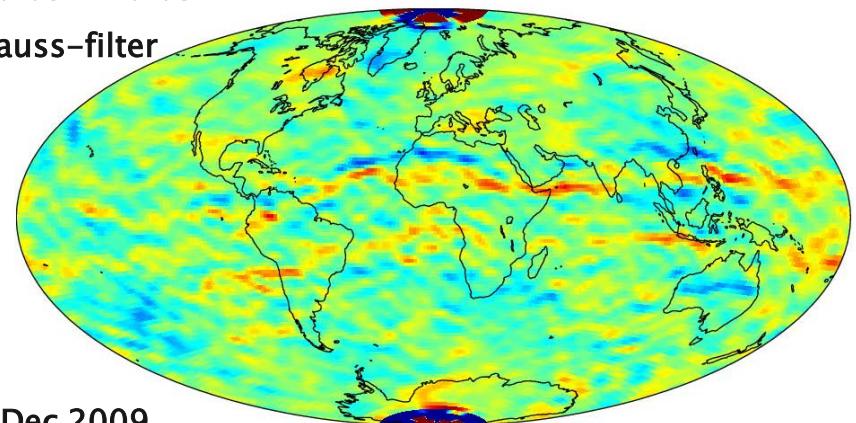
Standard

Colour scale -0.05 0.05 m

300km Gauss-filter

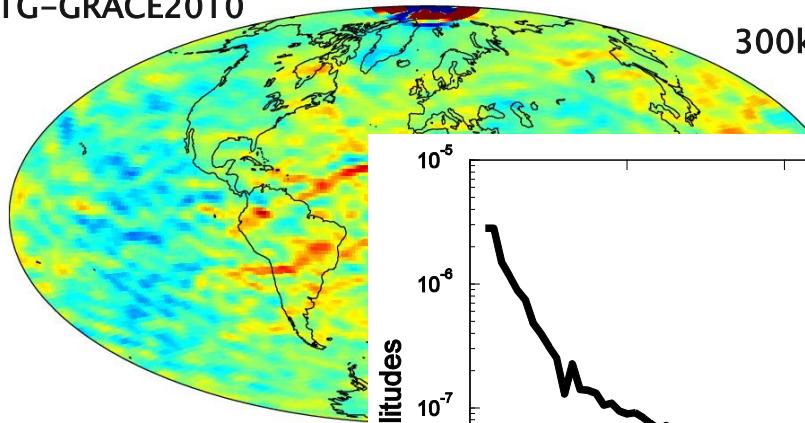
Release 1, Nov/Dec 2009

+ common-mode accelerometer data



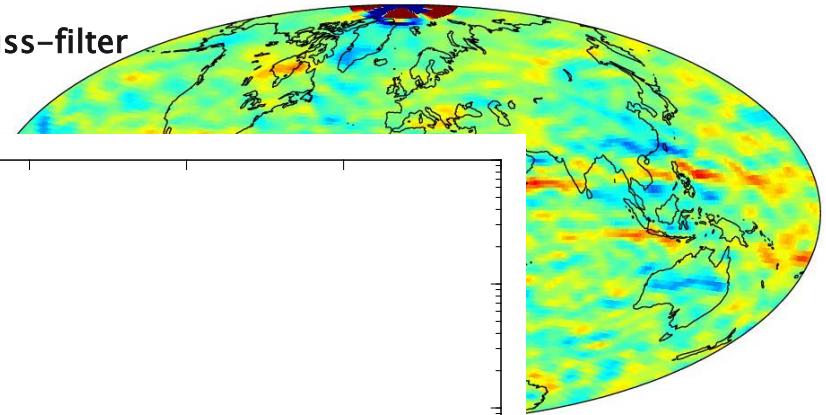
Impact of accelerometer data

Geoid differences to
ITG-GRACE2010



Colour scale -0.05 0.05 m

300km Gauss-filter



Sta-

Difference degree amplitudes

10^{-6}
 10^{-8}
 10^{-10}
 10^{-11}

Degree of spherical harmonics

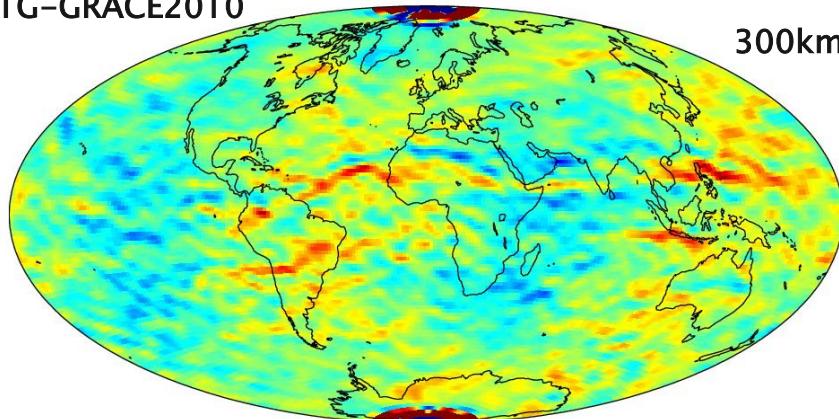
ITG-GRACE2010
R1 standard
R1 acc+rel.Constr.

Zonal and near-zonal terms
excluded according to Van
Gelderden and Koop, 1997

rometer data

Release 1 and Release 4 solutions

Geoid differences to
ITG-GRACE2010

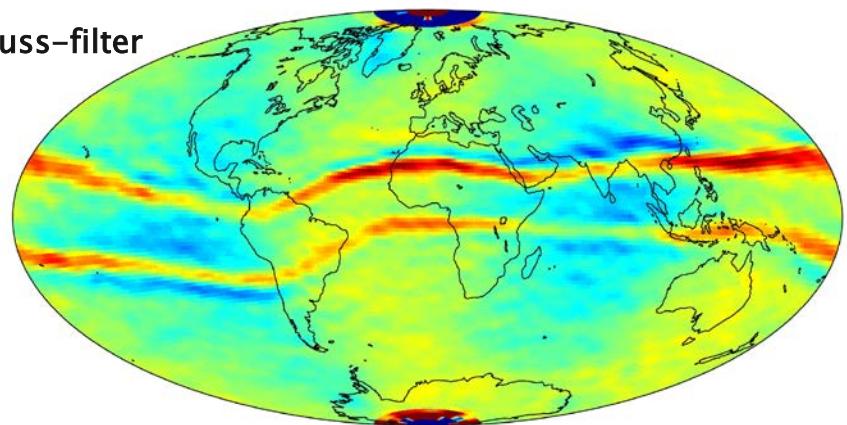


Release 1

Nov-Dec 2009

Colour scale -0.05 0.05 m

300km Gauss-filter



Release 4

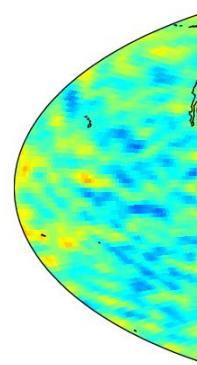
Nov 2009 – Jun 2012

Release 1 and Release 4 solutions

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Geoid differences to
ITG-GRACE2010

Colour scale -0.05 0.05 m

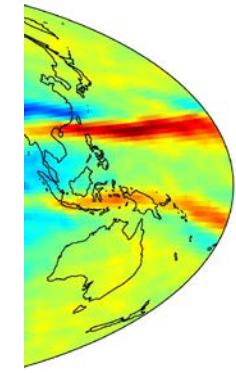


Difference degree amplitudes

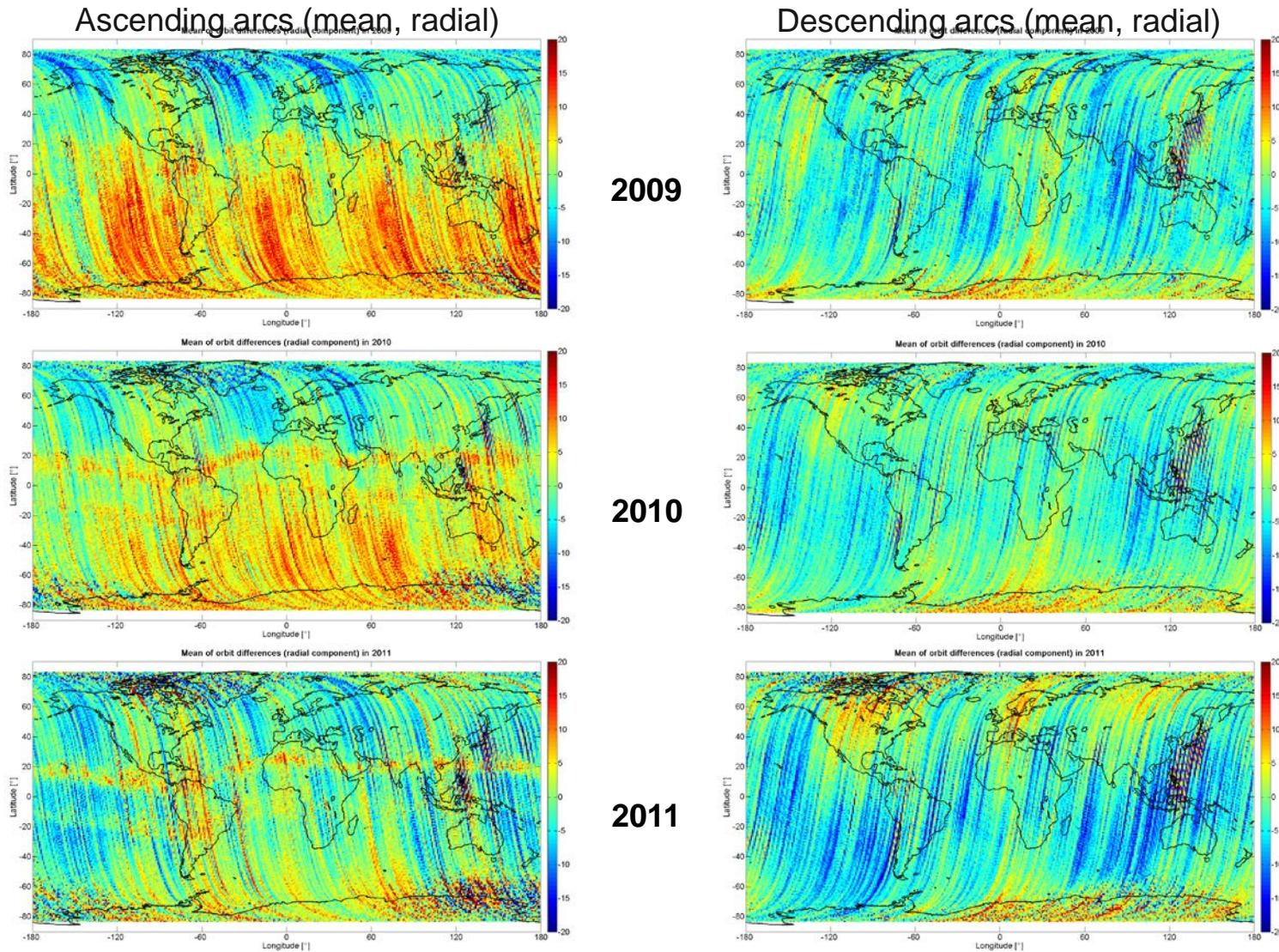
10^{-5}
 10^{-6}
 10^{-7}
 10^{-8}
 10^{-9}
 10^{-10}
 10^{-11}

Degree of spherical harmonics

- ITG-GRACE2010
- R1
- R4
- R4 with acc
- CHAMP03S



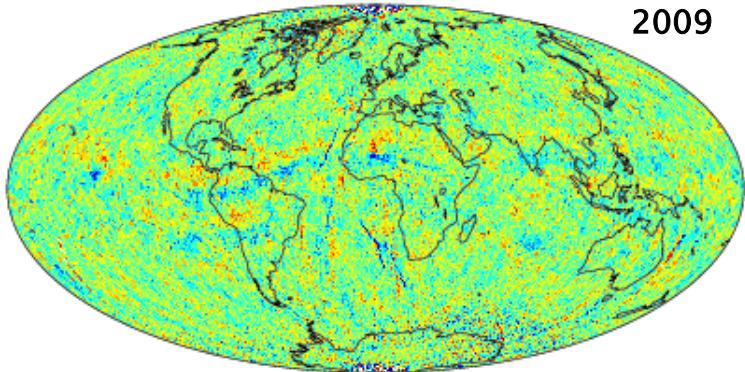
Differences red.-dyn \leftrightarrow kinematic orbits



Phase observation residuals

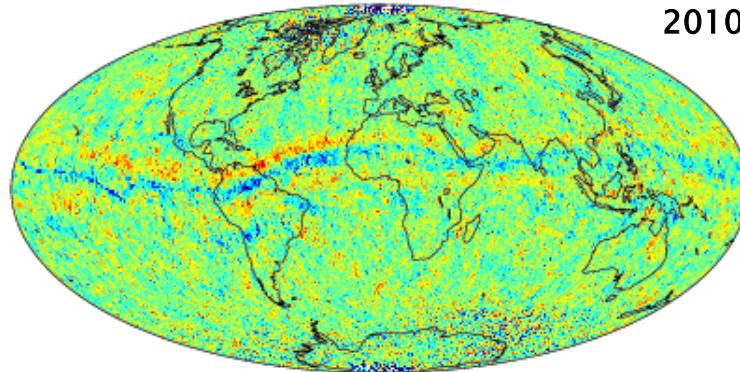
mean residuals at ionosphere-crossing: 2009, doys 245–365

2009



mean residuals at ionosphere-crossing: 2010, doys 245–365

2010



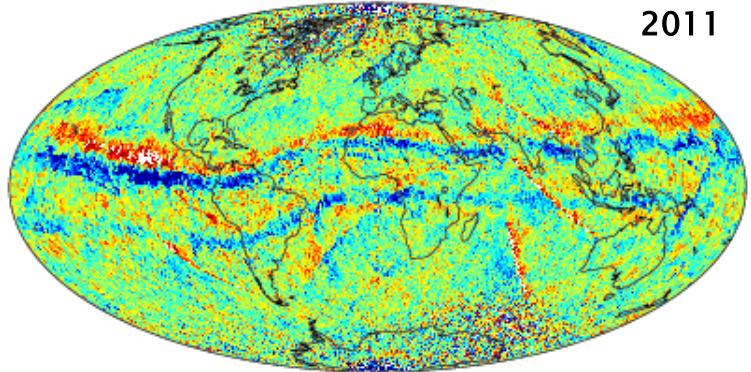
$\times 10^{-3}$

2
1.5
1
0.5
0
-0.5
-1
-1.5
-2

Mean of phase observation residuals mapped to the crossing of the ionosphere layer

mean residuals at ionosphere-crossing: 2011, doys 245–365

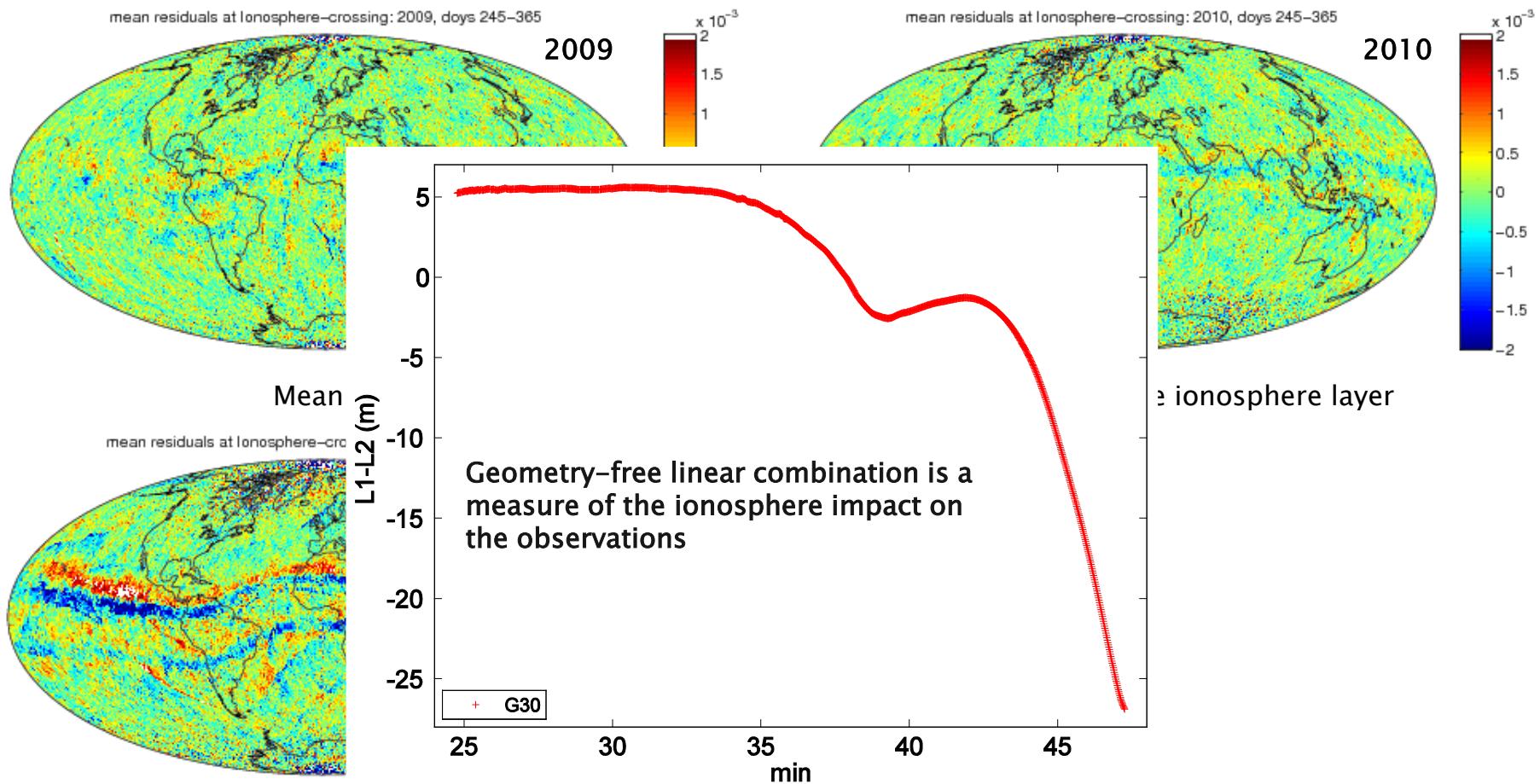
2011



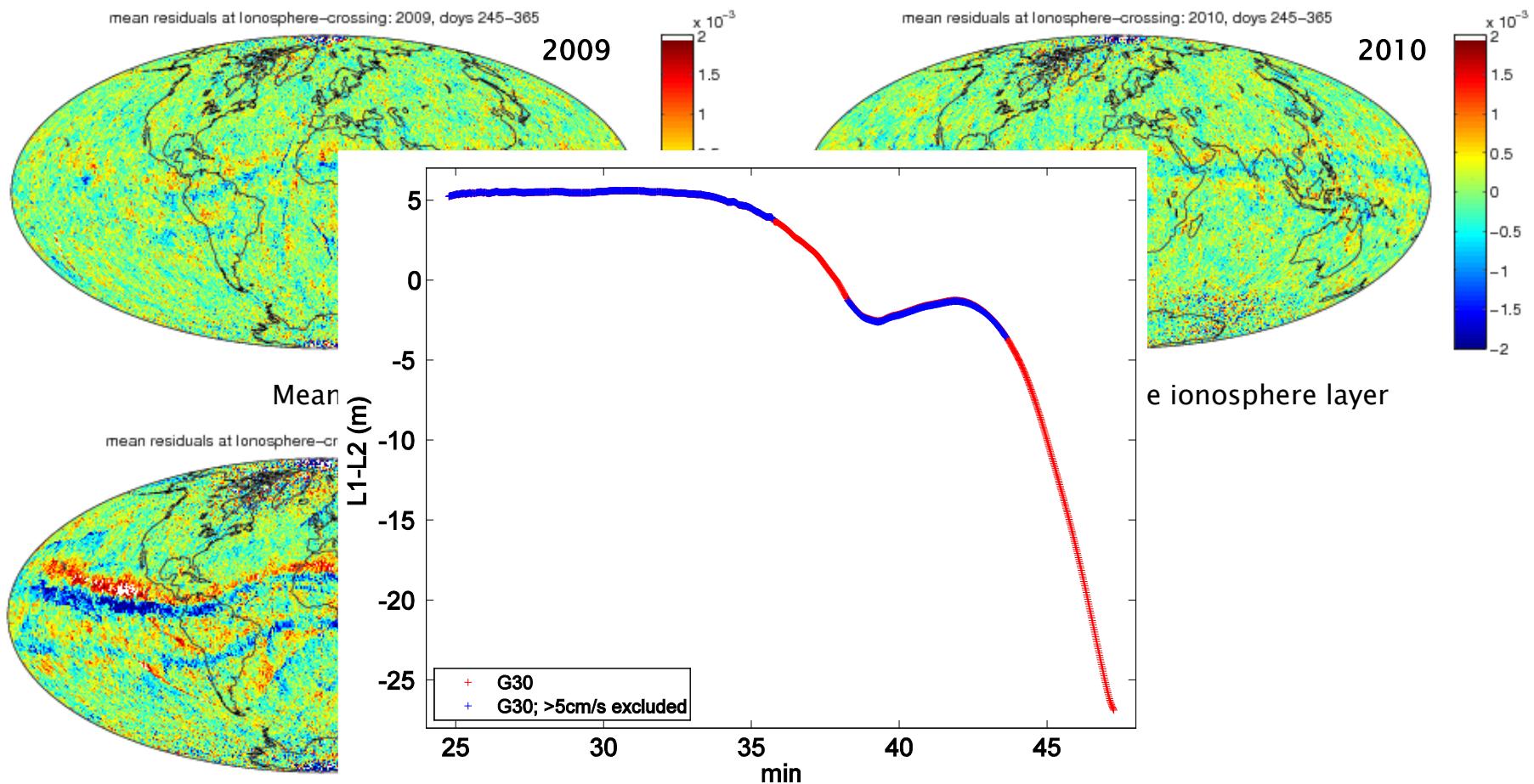
$\times 10^{-3}$

2
1.5
1
0.5
0
-0.5
-1
-1.5
-2

Phase observation residuals



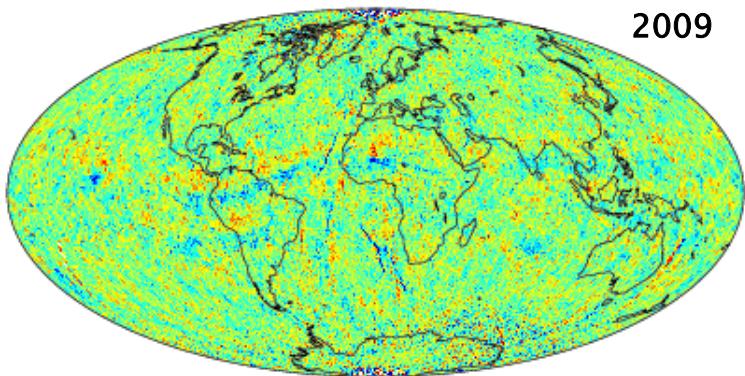
Phase observation residuals



Phase observation residuals

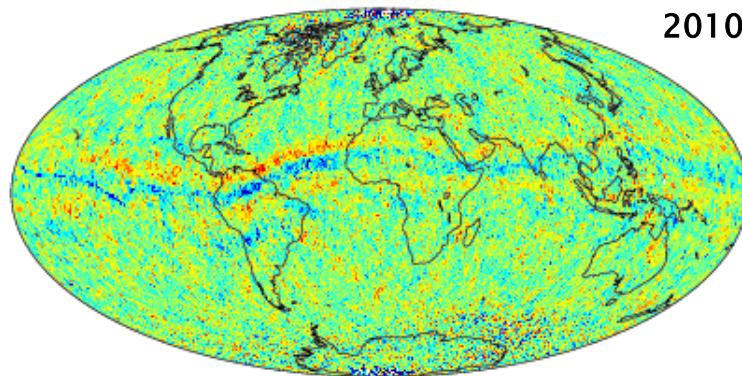
mean residuals at ionosphere-crossing: 2009, doys 245–365

2009



mean residuals at ionosphere-crossing: 2010, doys 245–365

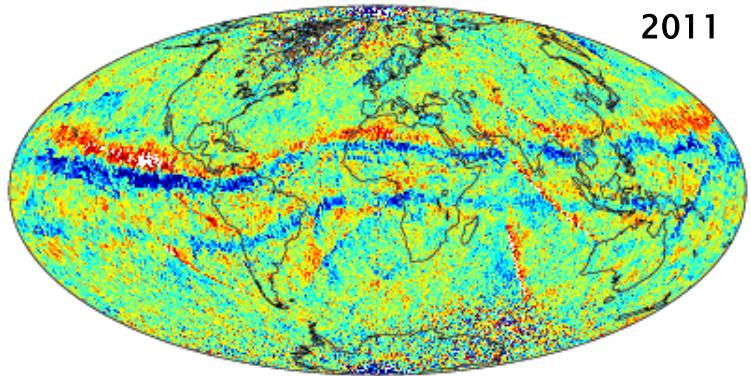
2010



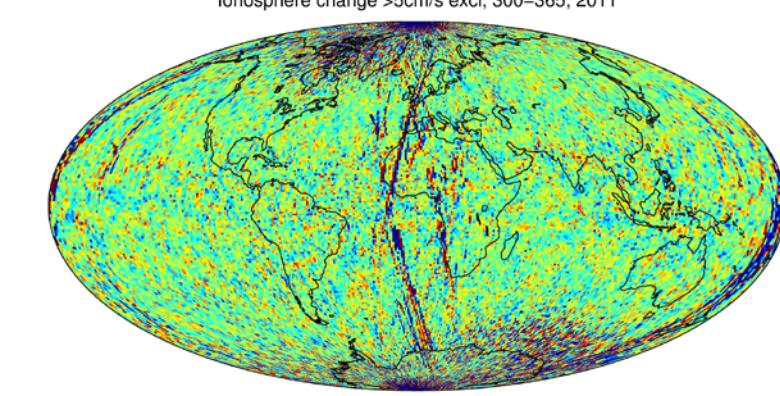
Mean of phase observation residuals mapped to the crossing of the ionosphere layer

mean residuals at ionosphere-crossing: 2011, doys 245–365

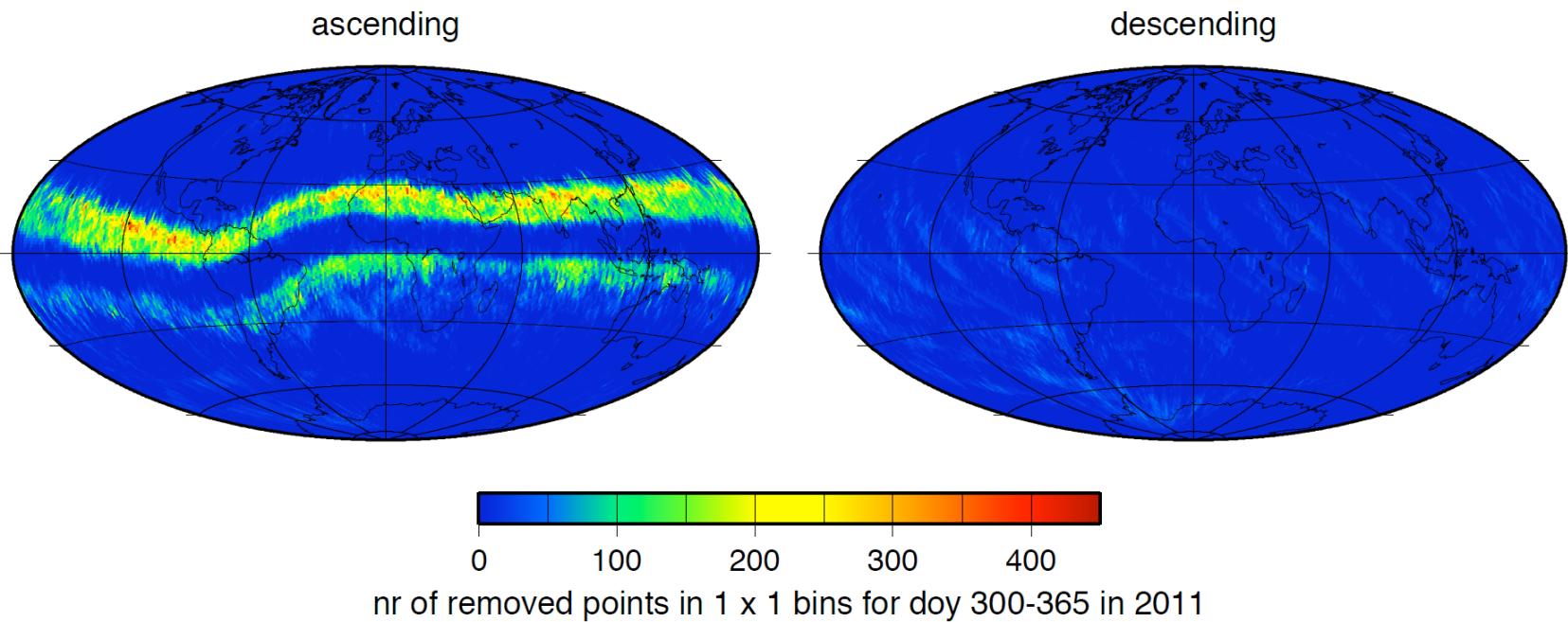
2011



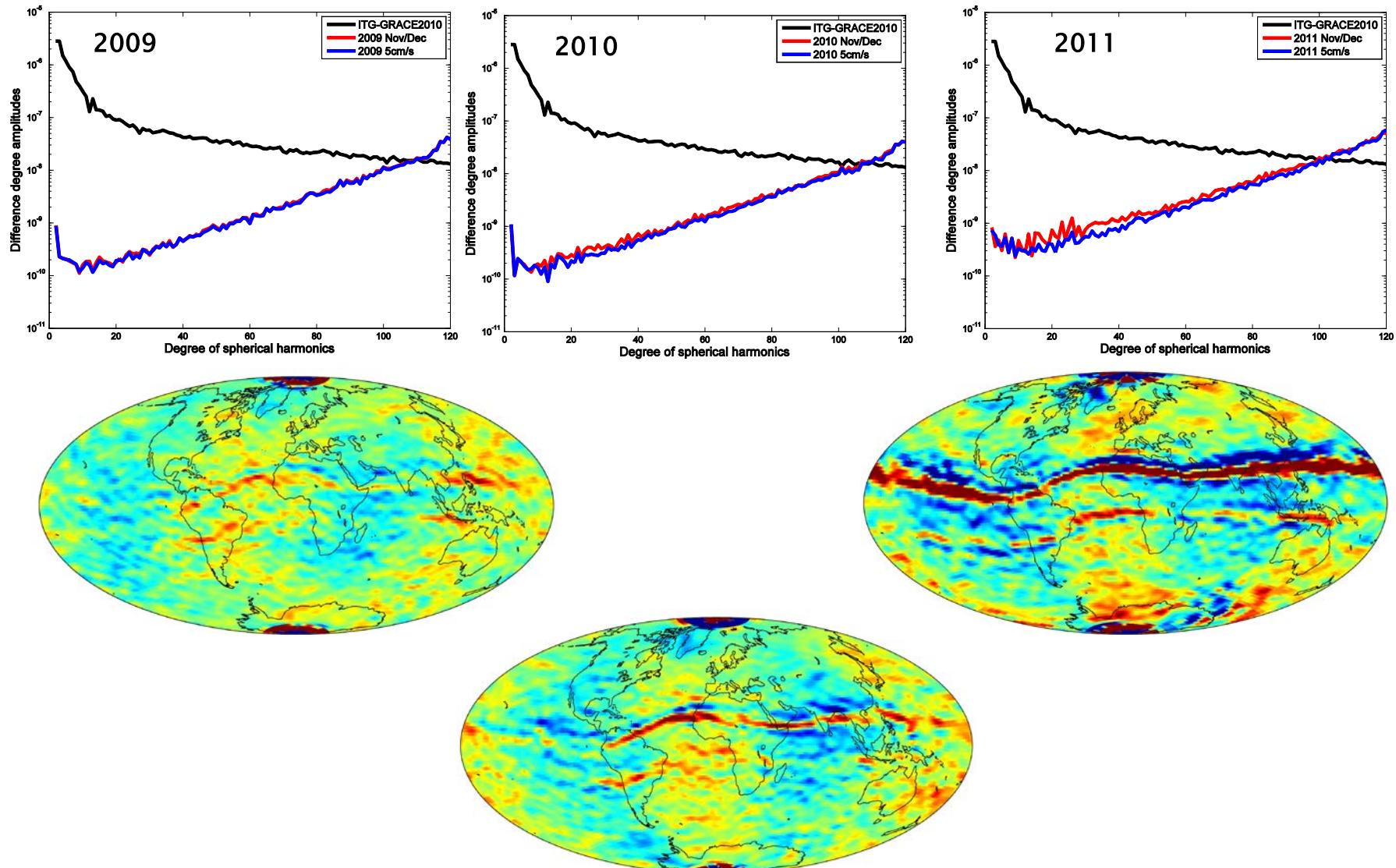
ionosphere change >5cm/s excl. 300–365, 2011



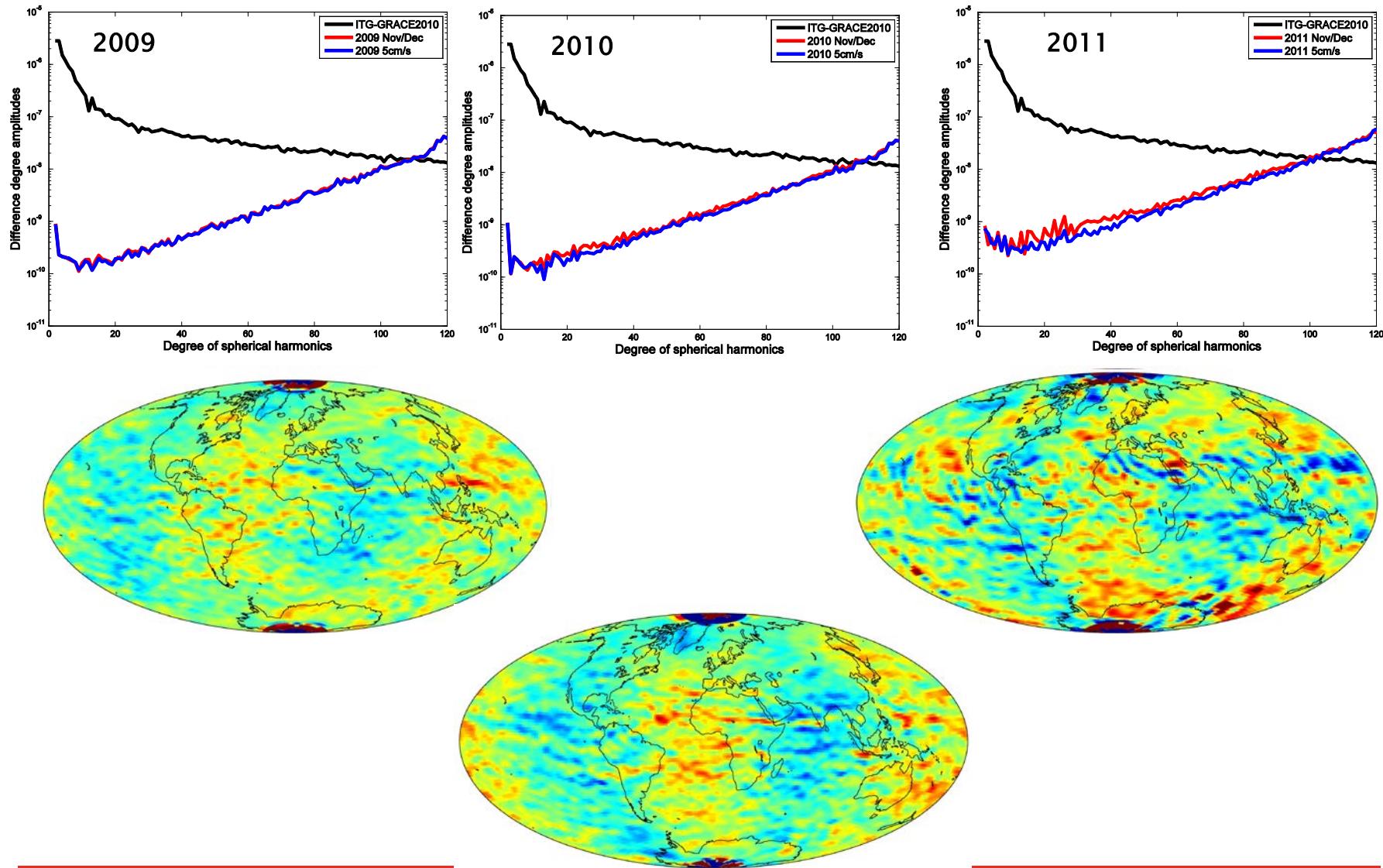
Number of removed observations



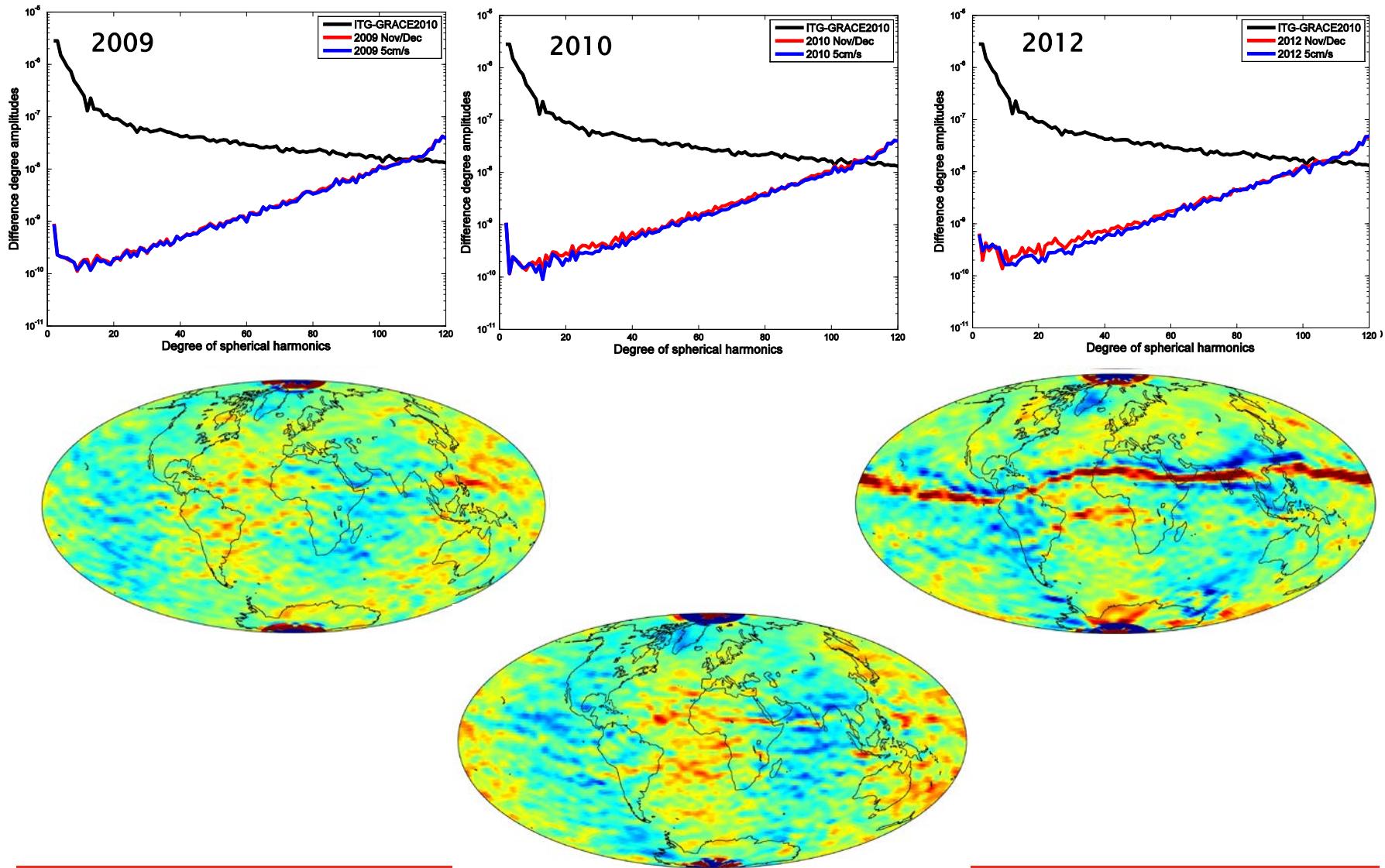
Removal of systematic orbit errors



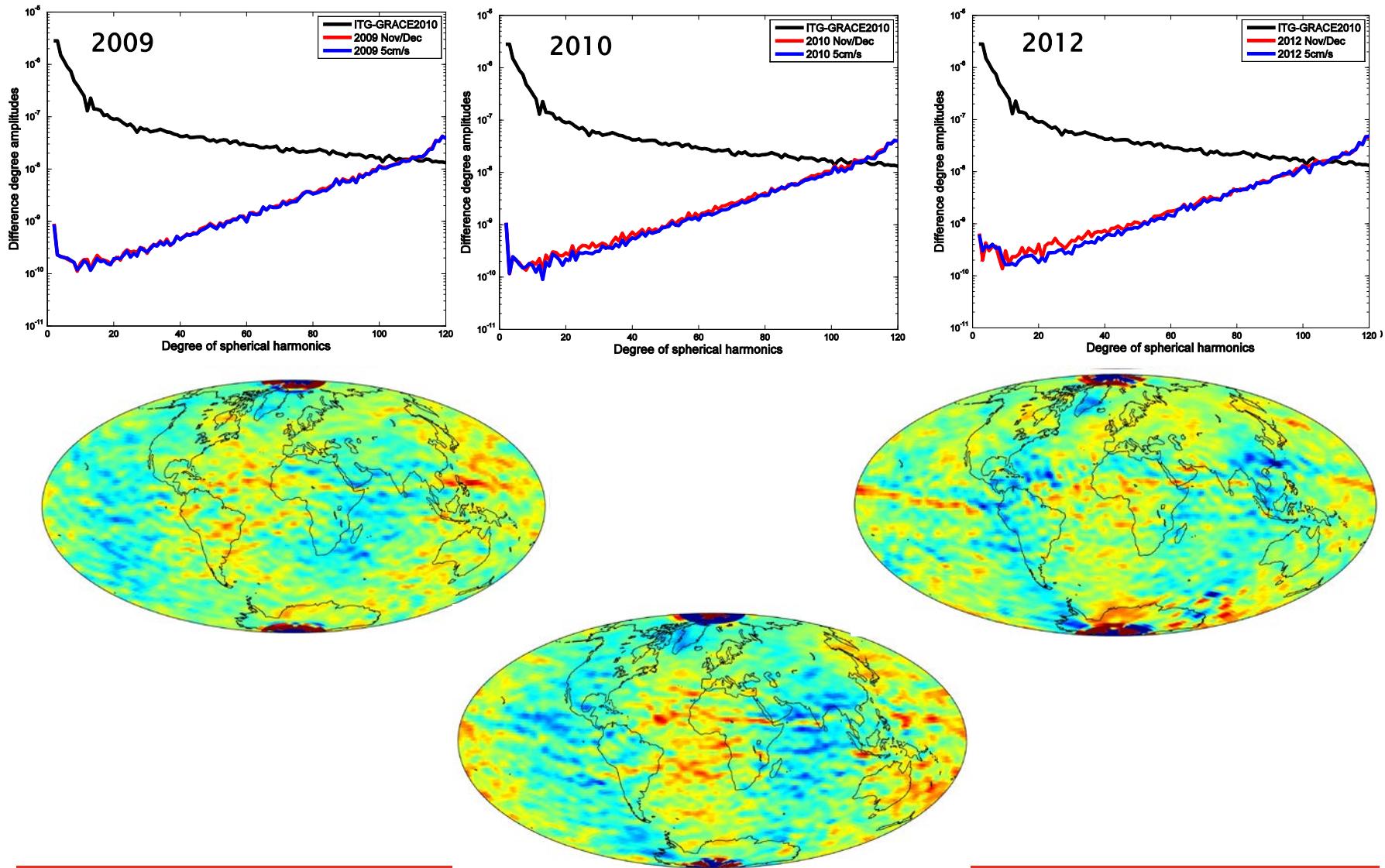
Removal of systematic orbit errors



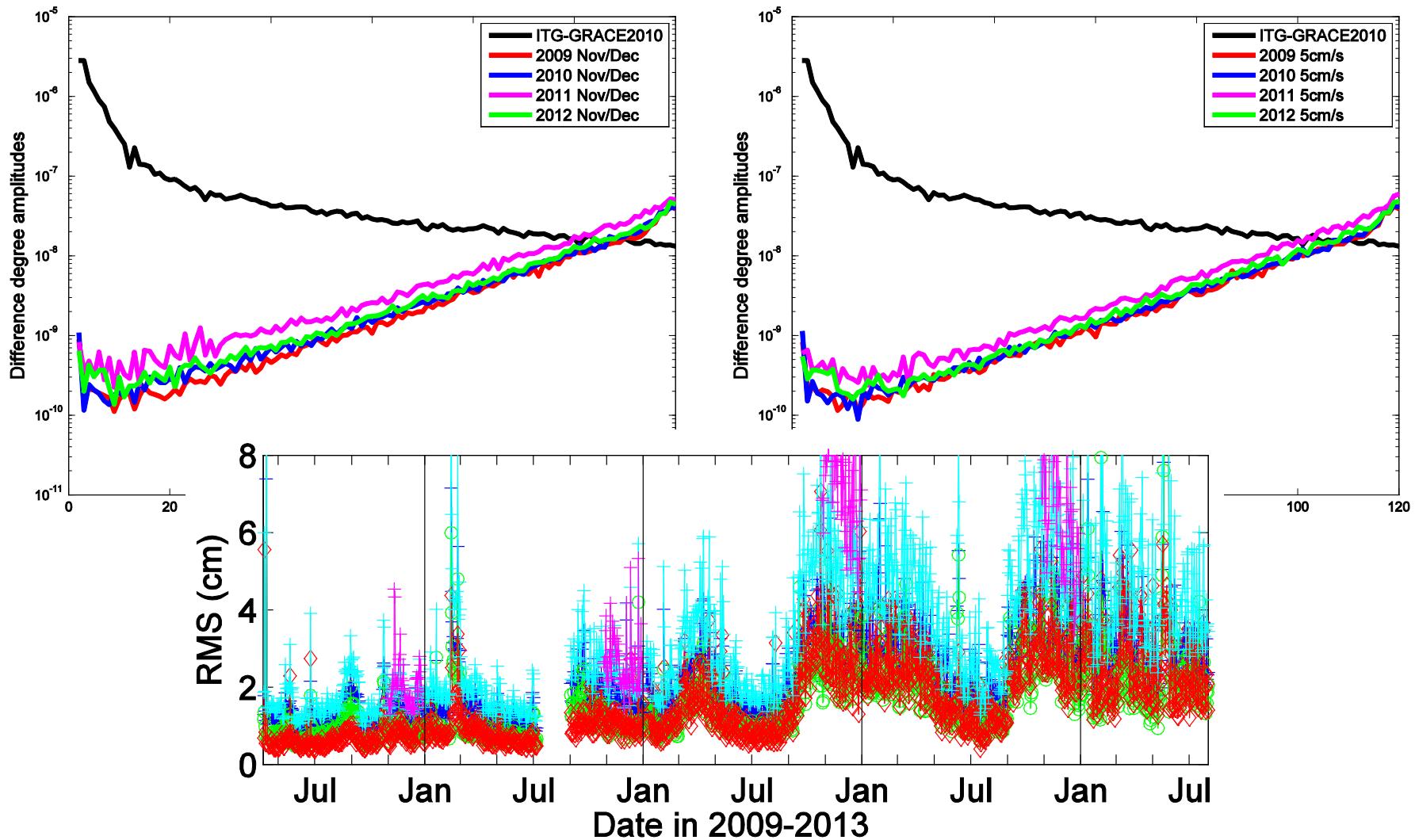
Removal of systematic orbit errors



Removal of systematic orbit errors



Removal of systematic orbit errors



Summary

- AIUB is providing the Precise Science Orbit product for the GOCE satellite
- The Celestial Mechanics Approach is applied to derive GPS-only gravity field models from the GPS-derived precise kinematic orbits
- Systematic orbit errors around the geomagnetic equator are mapped into the gravity field solutions
- Removal of GPS observations, which are affected by a ionosphere change of $>5\text{cm/s}$ from one observation epoch to the next
- Systematic errors are removed but orbit quality suffers => more investigations necessary