

GPS-only gravity field determination from GOCE data

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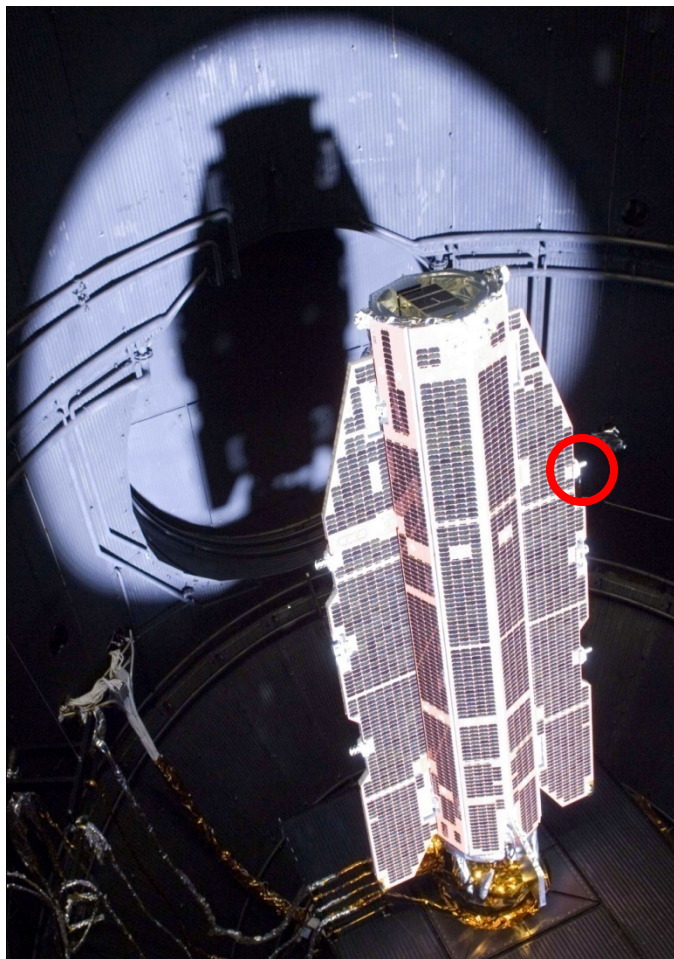
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of Technology*

IAG Scientific Assembly

September 1–6, 2013, Potsdam, Germany

Background and motivation

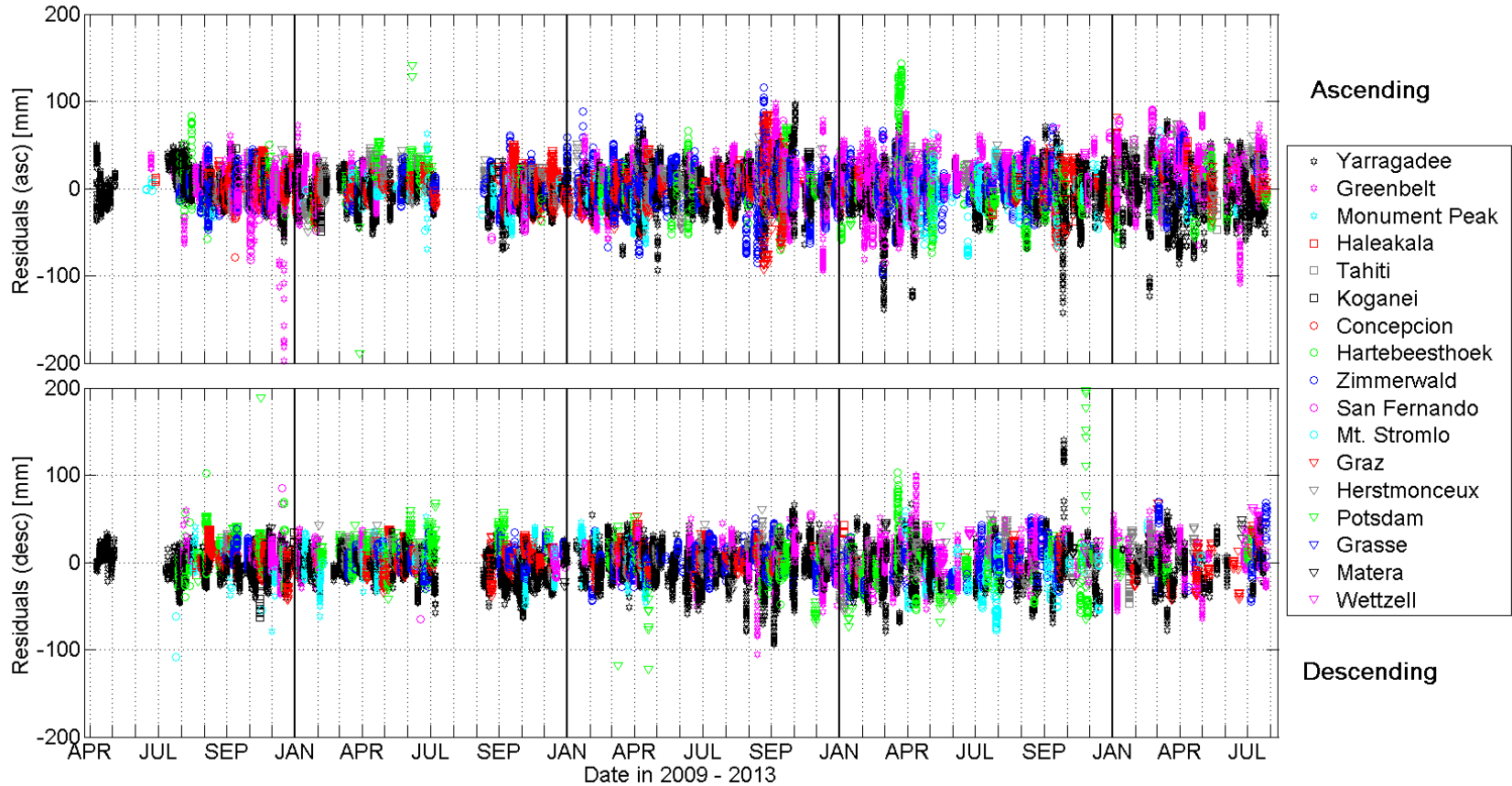


Courtesy:ESA

- 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

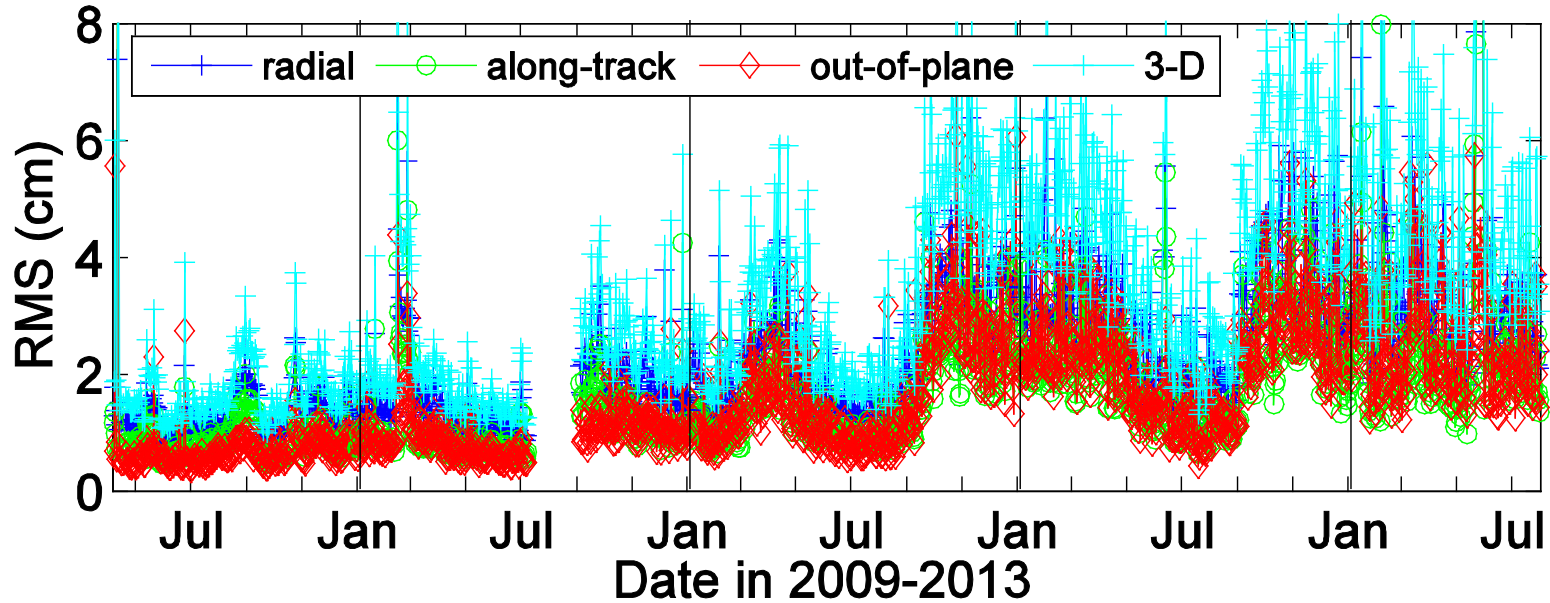
Kinematic orbits – SST_PKI



Mean: 0.08 cm

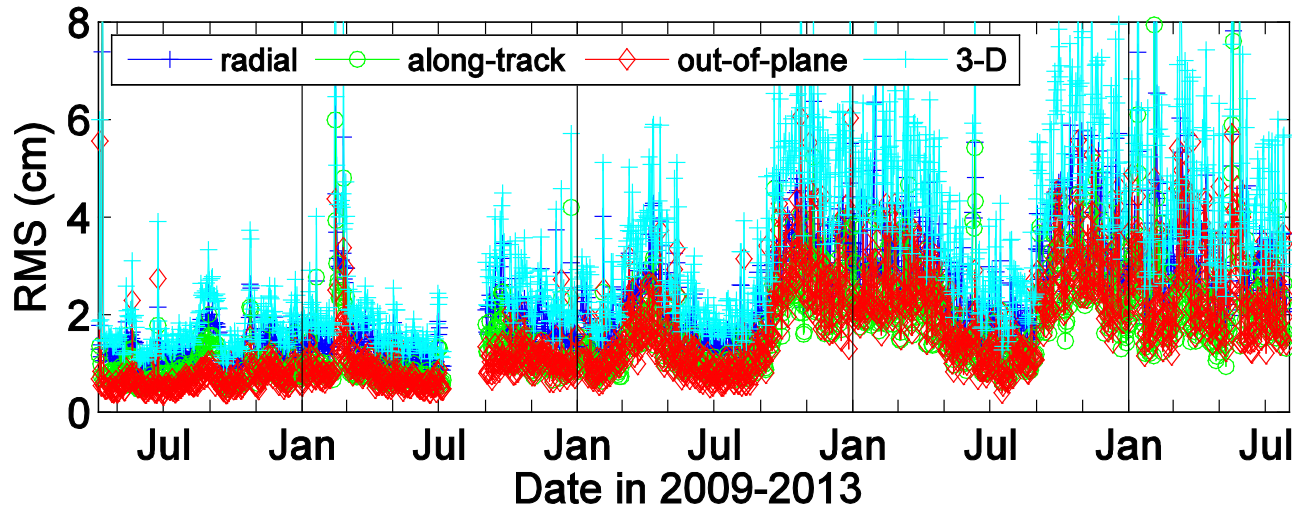
RMS: 2.36 cm

GOCE orbit determination – results



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

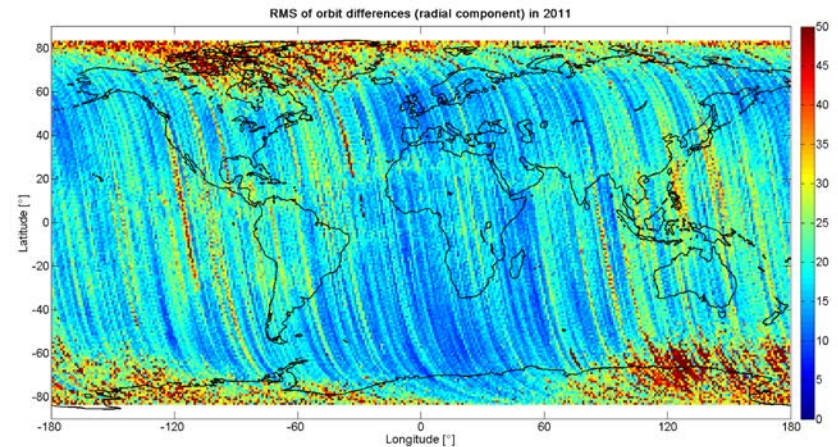
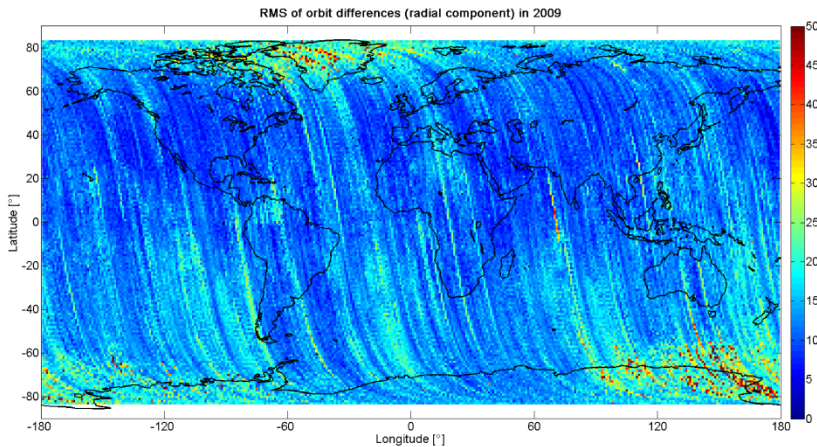
GOCE orbit determination – results



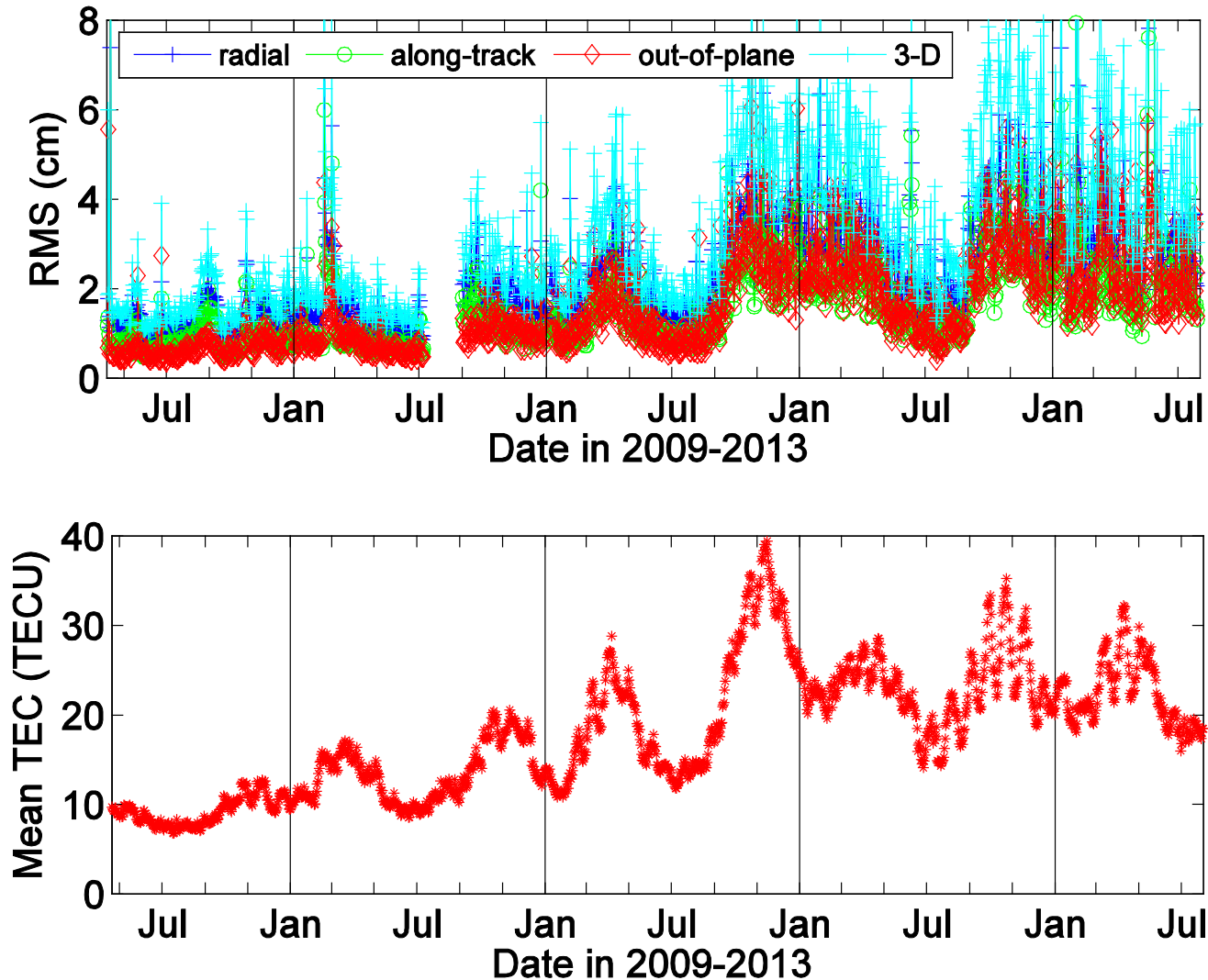
2009

Radial RMS (ascending arcs)

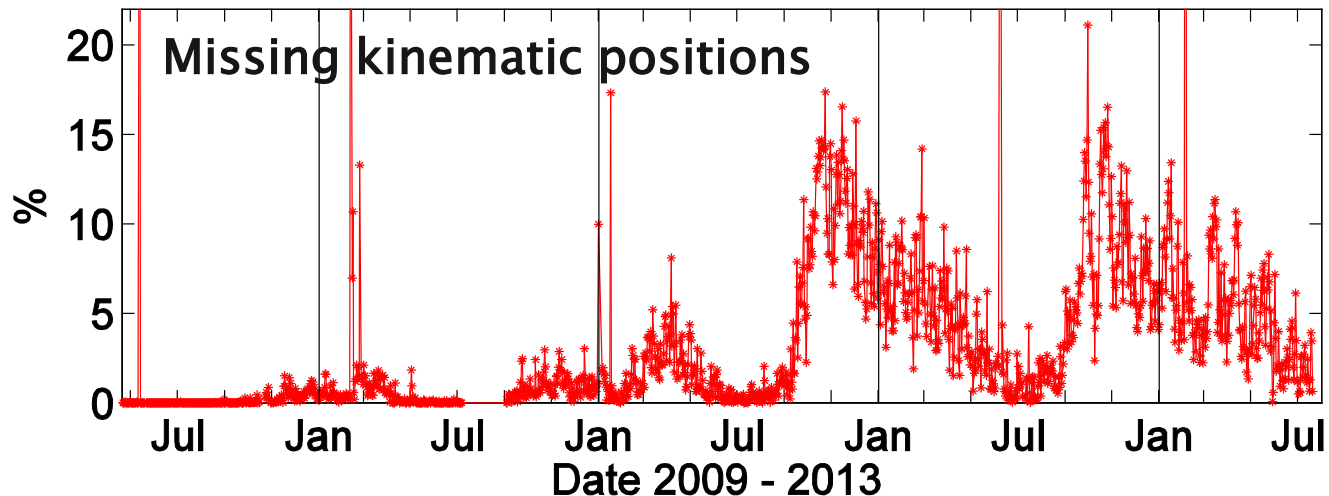
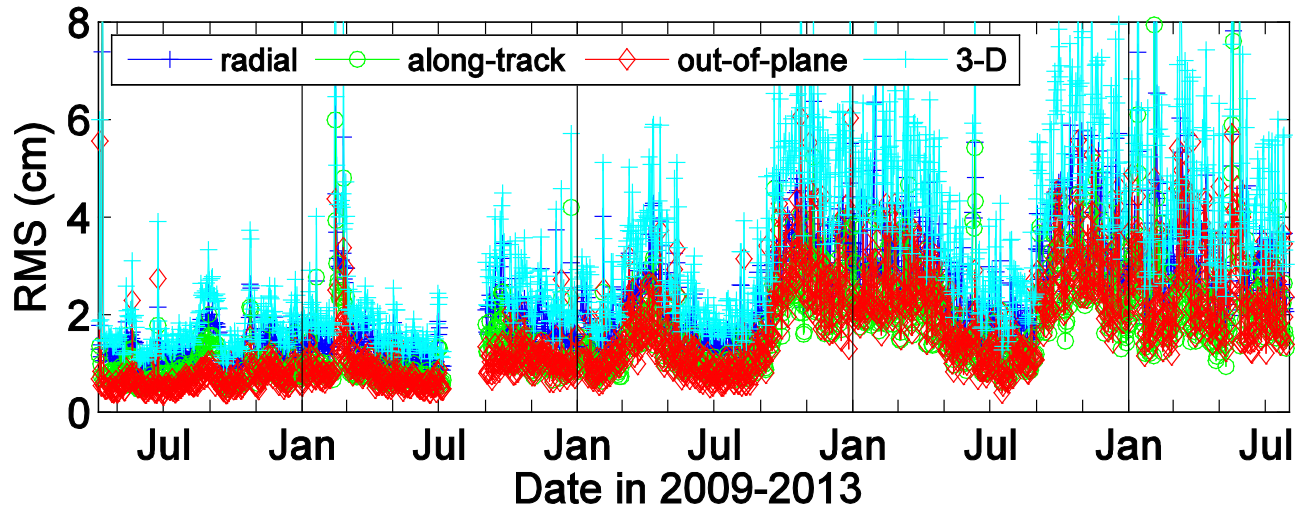
2011



GOCE orbit determination – results



GOCE orbit determination – results



GPS-only gravity field determination

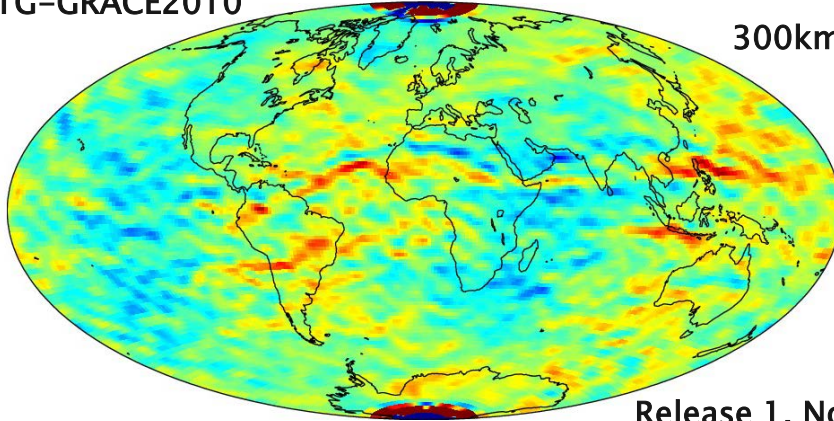
- **Celestial Mechanics Approach**
- **Pseudo-observations: kinematic GOCE positions (SST_PKI) with variance-covariance information (SST_PCV) (+ common-mode accelerometer data)**
- **Parameters:**
 - **6 initial orbit elements**
 - **Constant and once-per-revolution terms in R, S, and W**
 - **Pseudo-stochastic 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

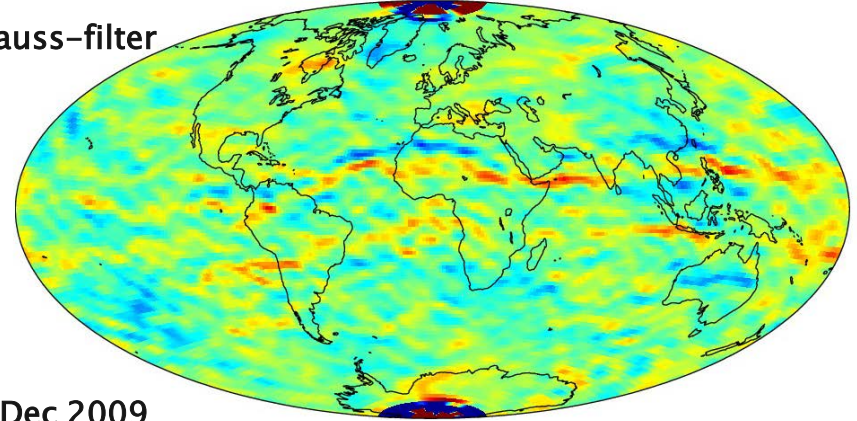
Geoid differences to
ITG-GRACE2010

Colour scale -0.05 ... 0.05 m

300km Gauss-filter



Standard



+ common-mode accelerometer data

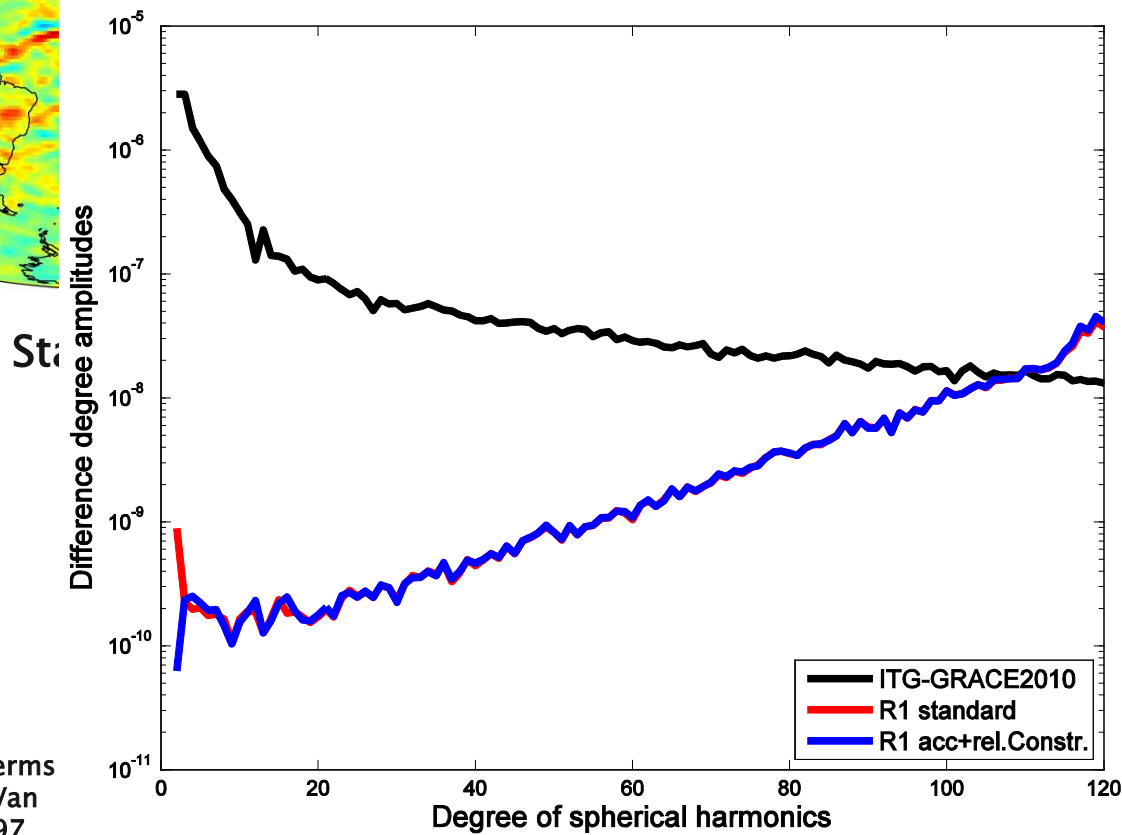
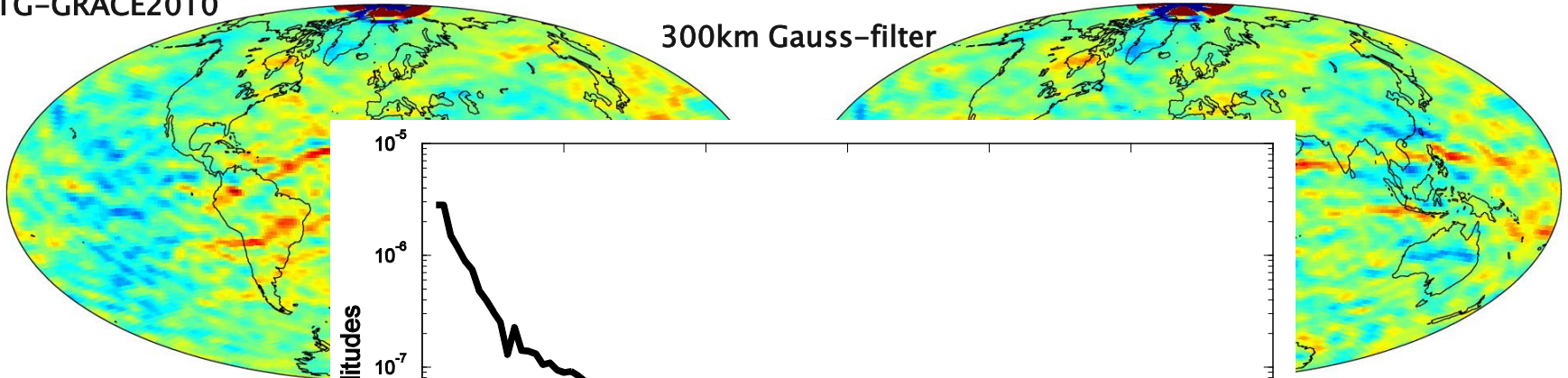
Release 1, Nov/Dec 2009

Impact of accelerometer data

Geoid differences to
ITG-GRACE2010

Colour scale -0.05 ... 0.05 m

300km Gauss-filter



Accelerometer data

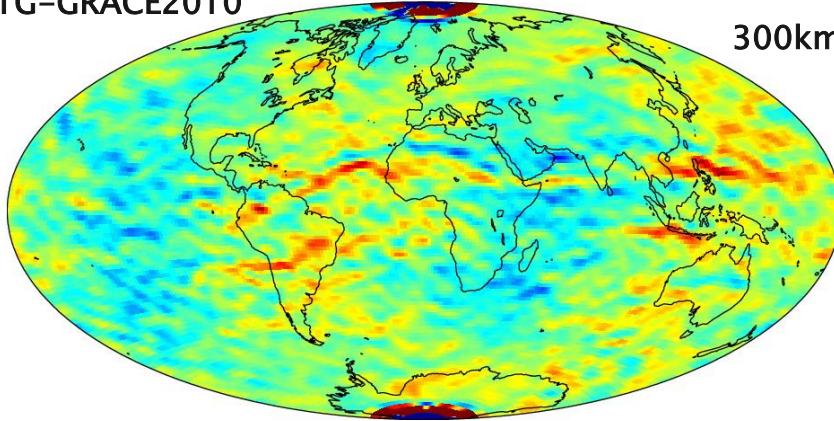
Zonal and near-zonal terms
excluded according to Van
Gelderén and Koop, 1997

Release 1 and Release 4 solutions

Geoid differences to
ITG-GRACE2010

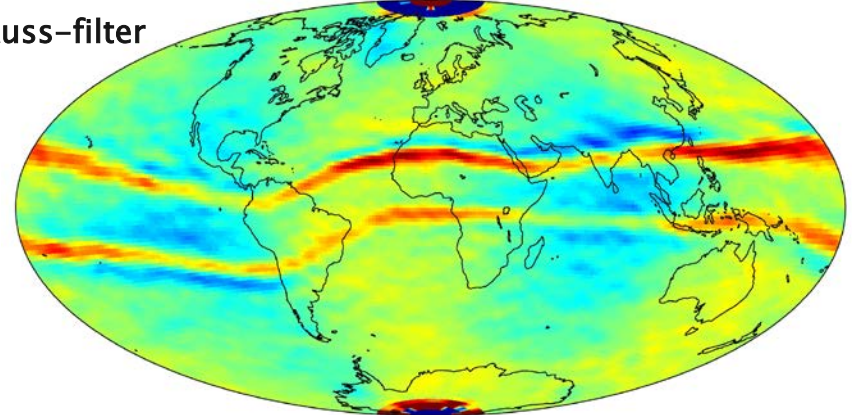
Colour scale -0.05 0.05 m

300km Gauss-filter



Release 1

Nov-Dec 2009



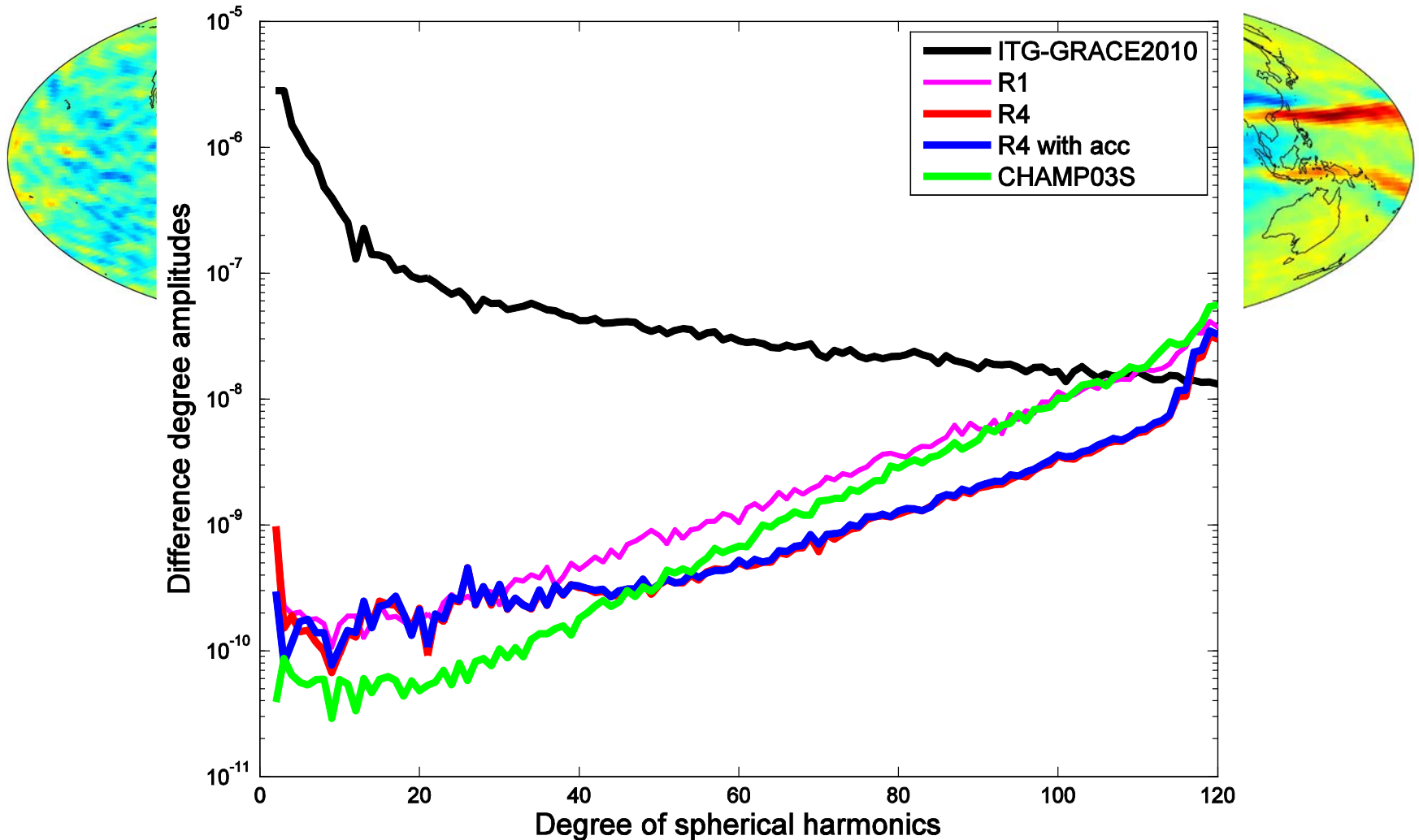
Release 4

Nov 2009 - Jun 2012

Release 1 and Release 4 solutions

Geoid differences to
ITG-GRACE2010

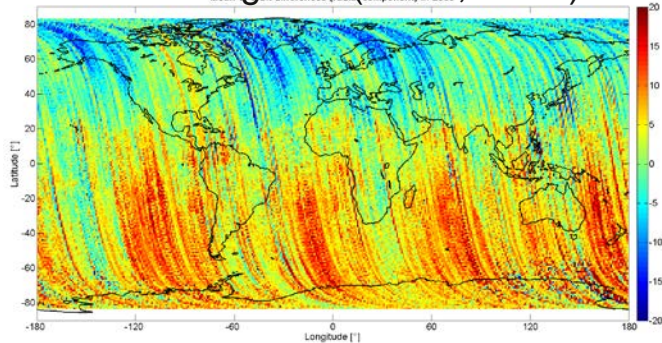
Colour scale -0.05 0.05 m



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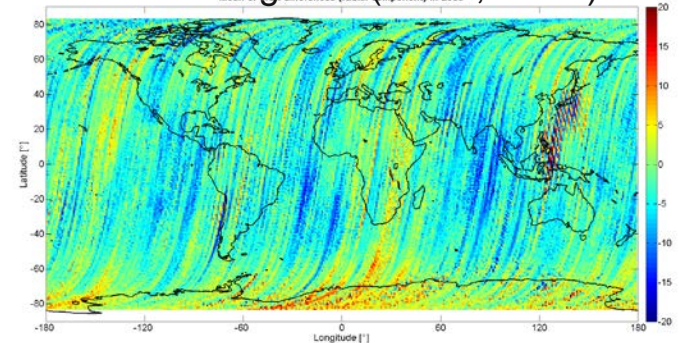
Differences red.-dyn \leftrightarrow kinematic orbits

Ascending arcs (mean, radial)

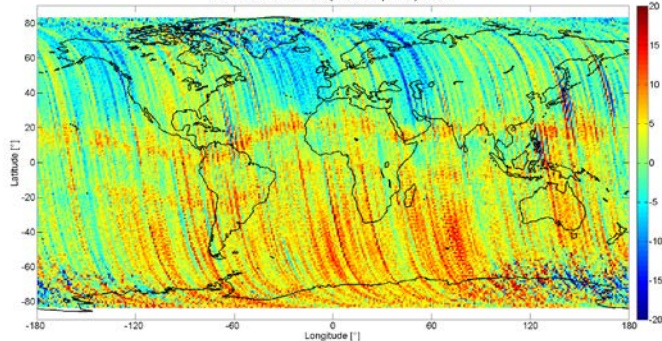


2009

Descending arcs (mean, radial)

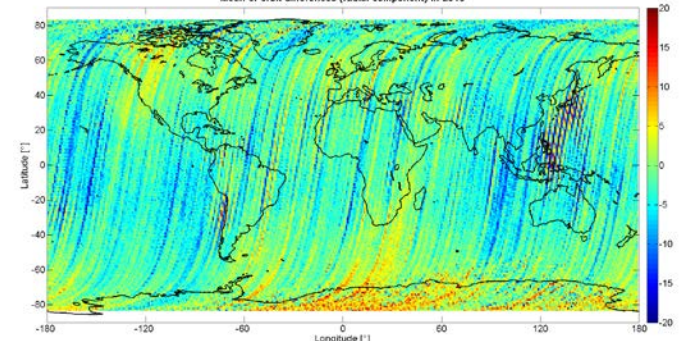


Mean of orbit differences (radial component) in 2010

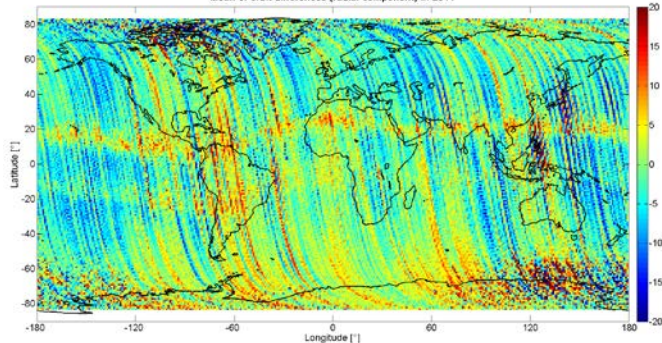


2010

Mean of orbit differences (radial component) in 2010

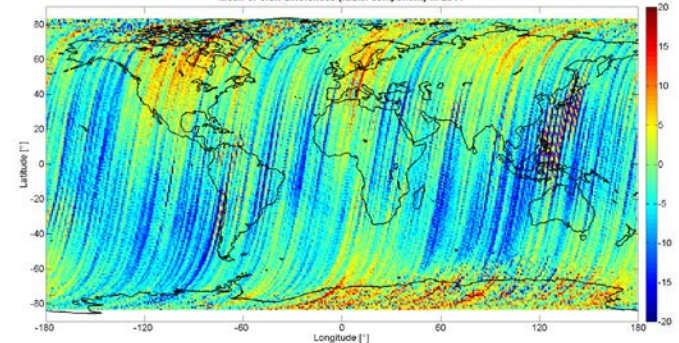


Mean of orbit differences (radial component) in 2011



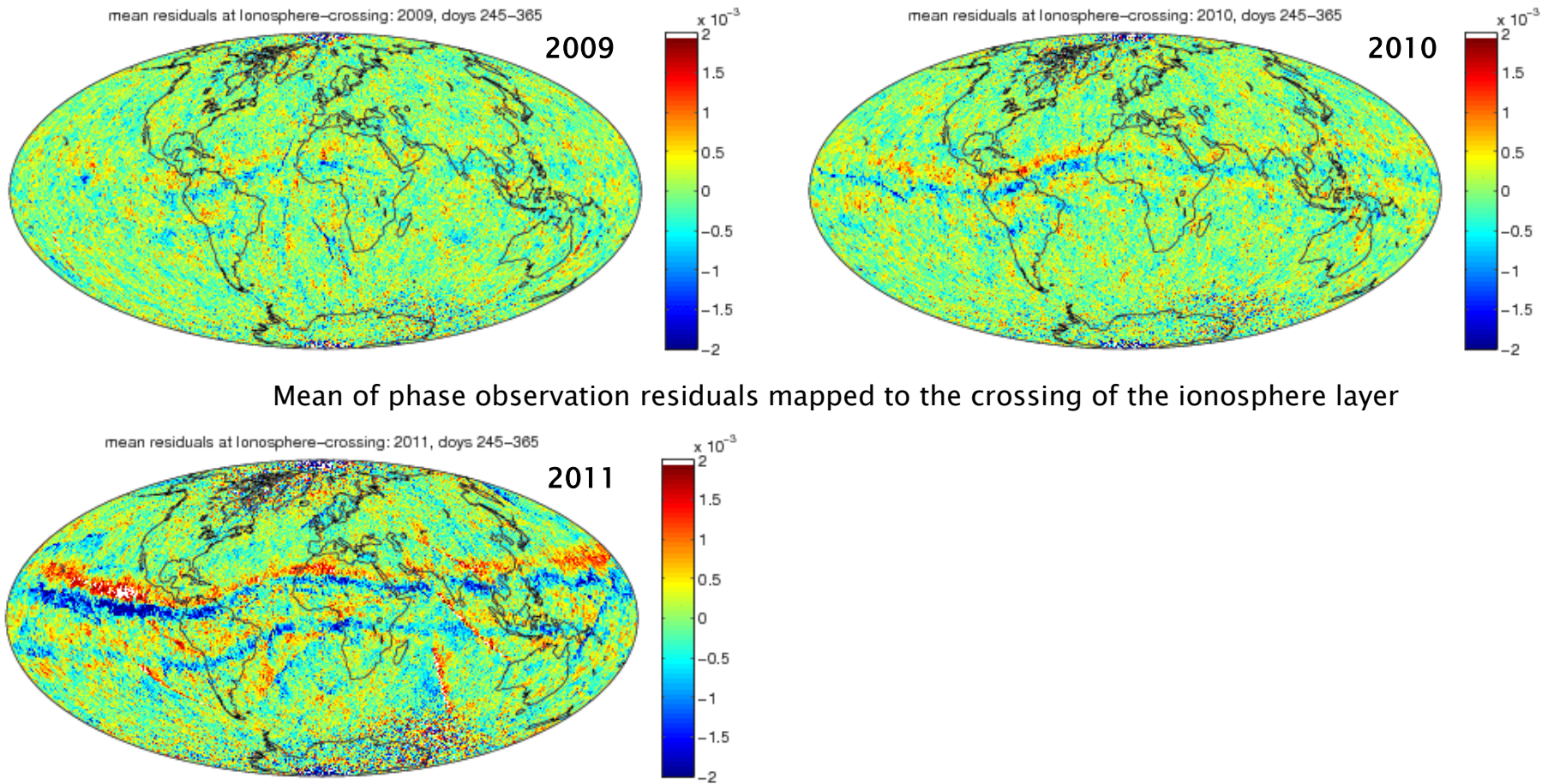
2011

Mean of orbit differences (radial component) in 2011

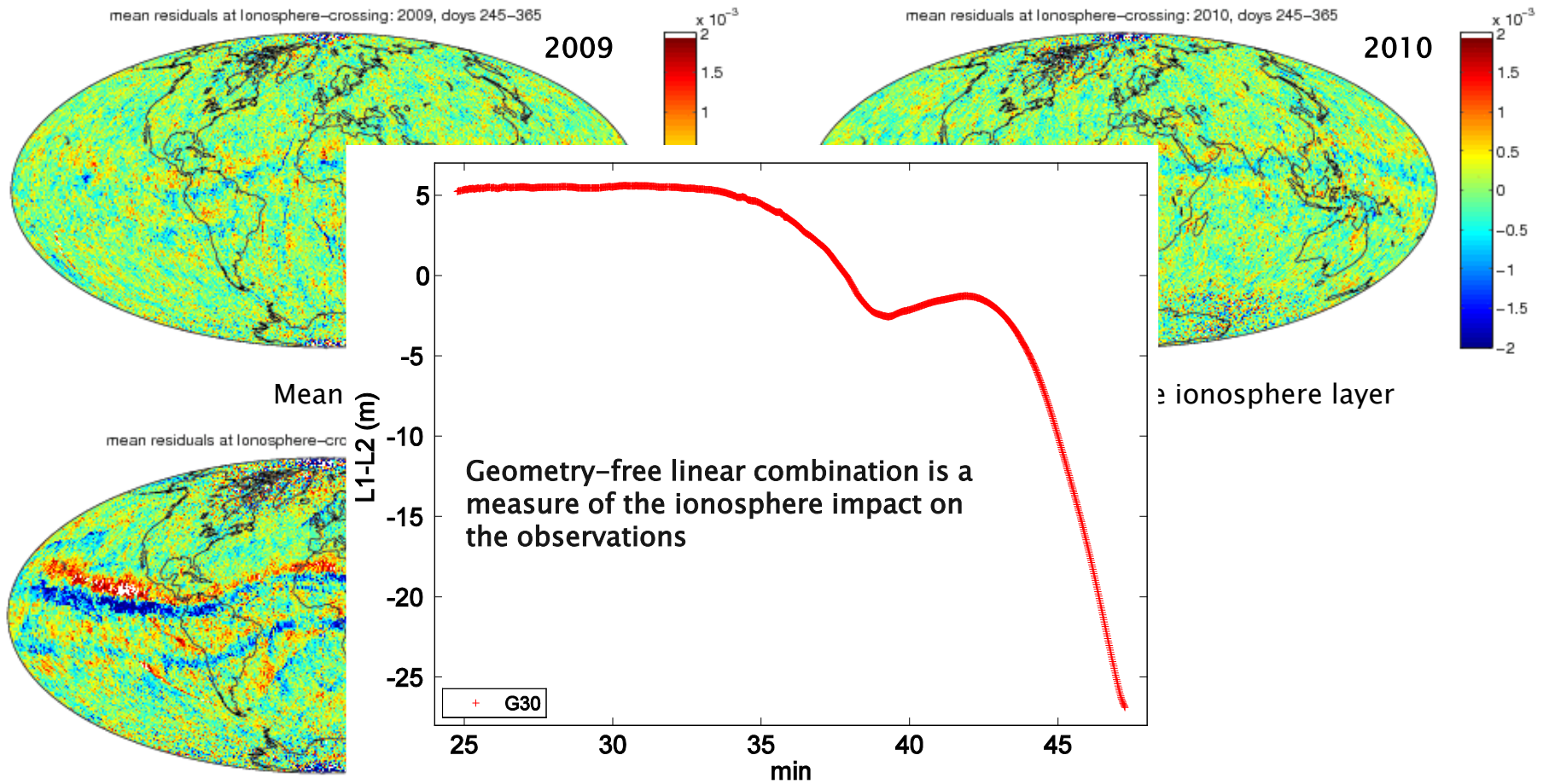


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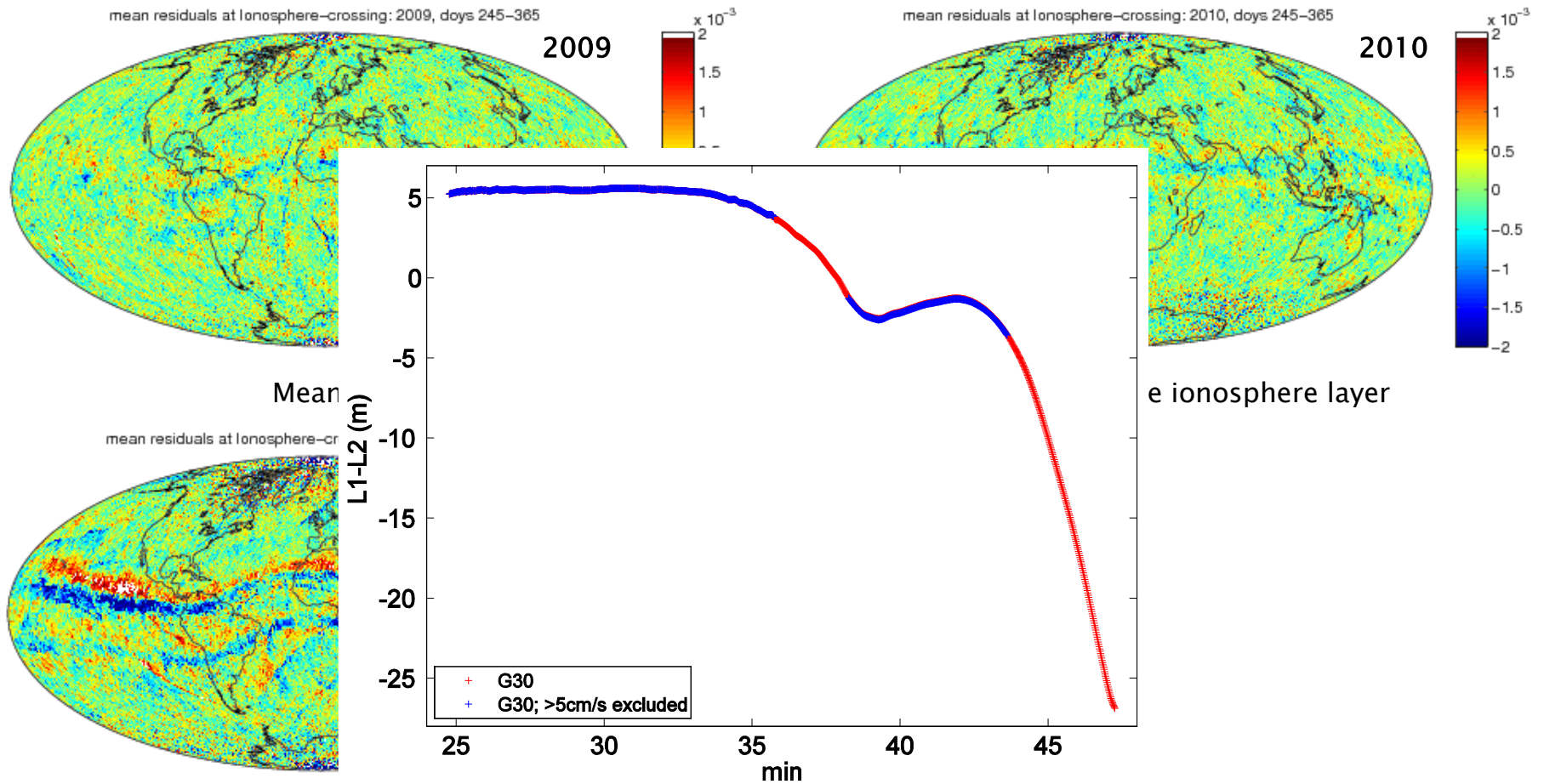
Phase observation residuals



Phase observation residuals



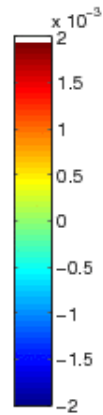
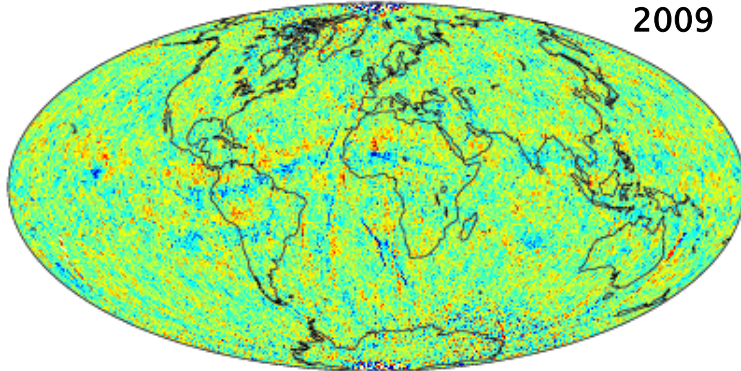
Phase observation residuals



Phase observation residuals

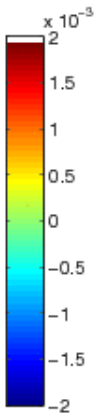
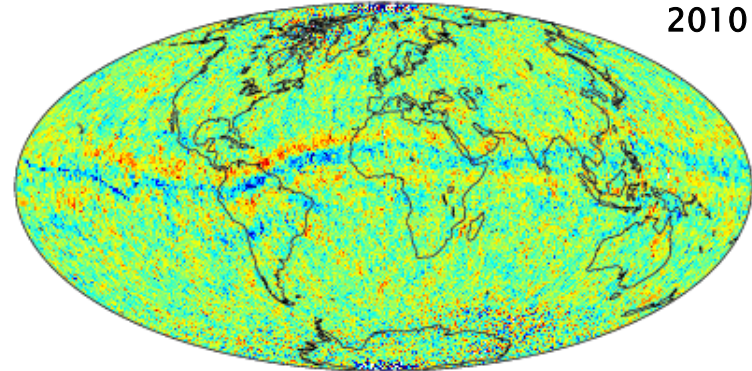
mean residuals at Ionosphere-crossing: 2009, doys 245-365

2009



mean residuals at Ionosphere-crossing: 2010, doys 245-365

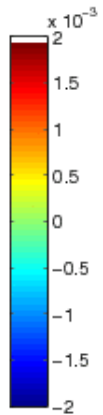
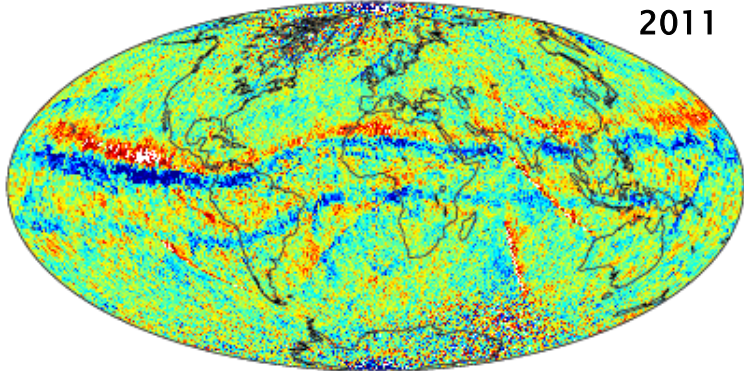
2010



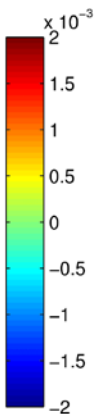
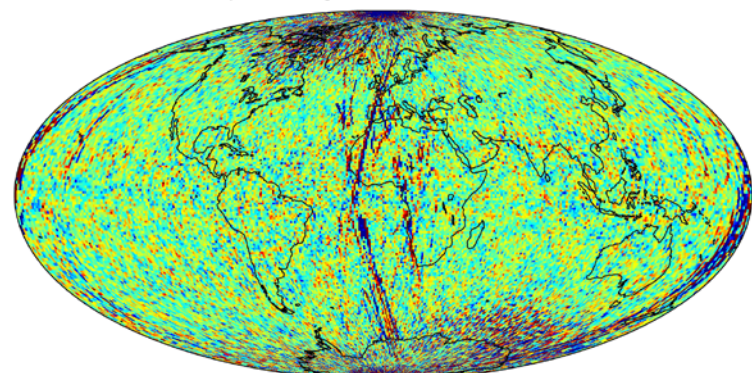
Mean of phase observation residuals mapped to the crossing of the ionosphere layer

mean residuals at Ionosphere-crossing: 2011, doys 245-365

2011



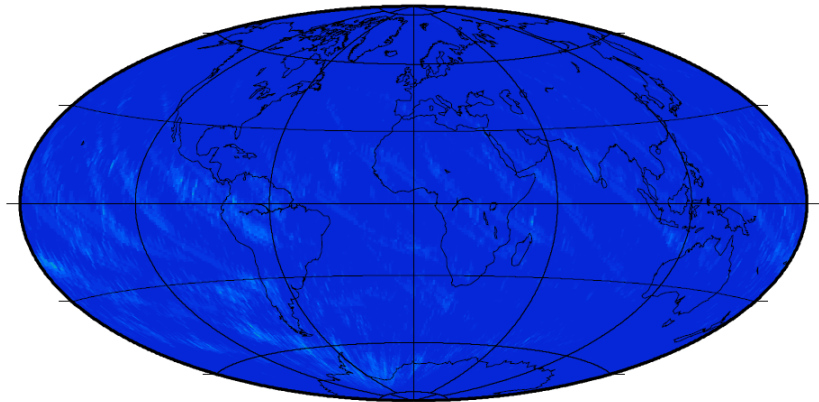
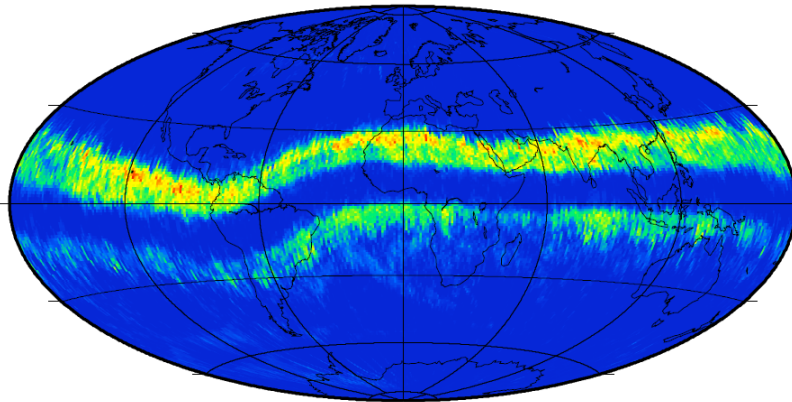
Ionosphere change >5cm/s excl, 300-365, 2011



Number of removed observations

ascending

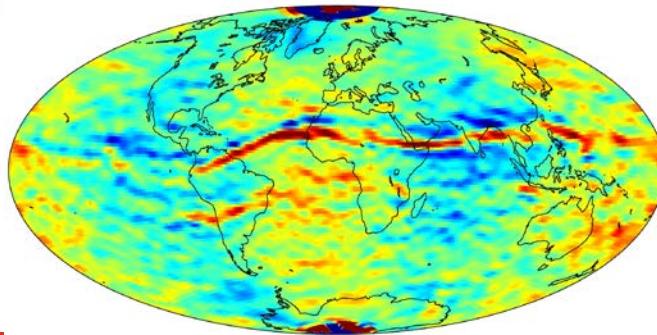
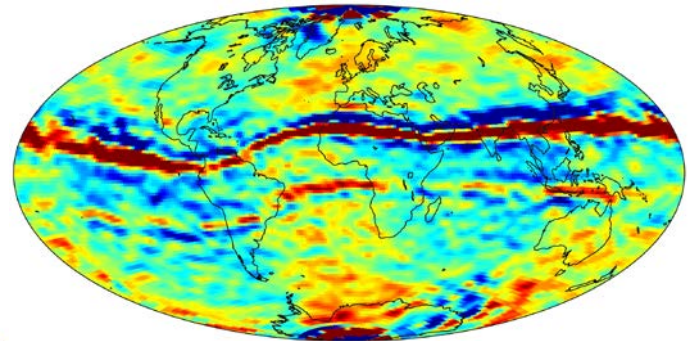
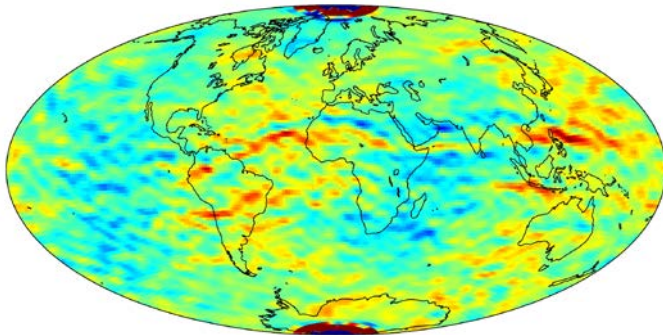
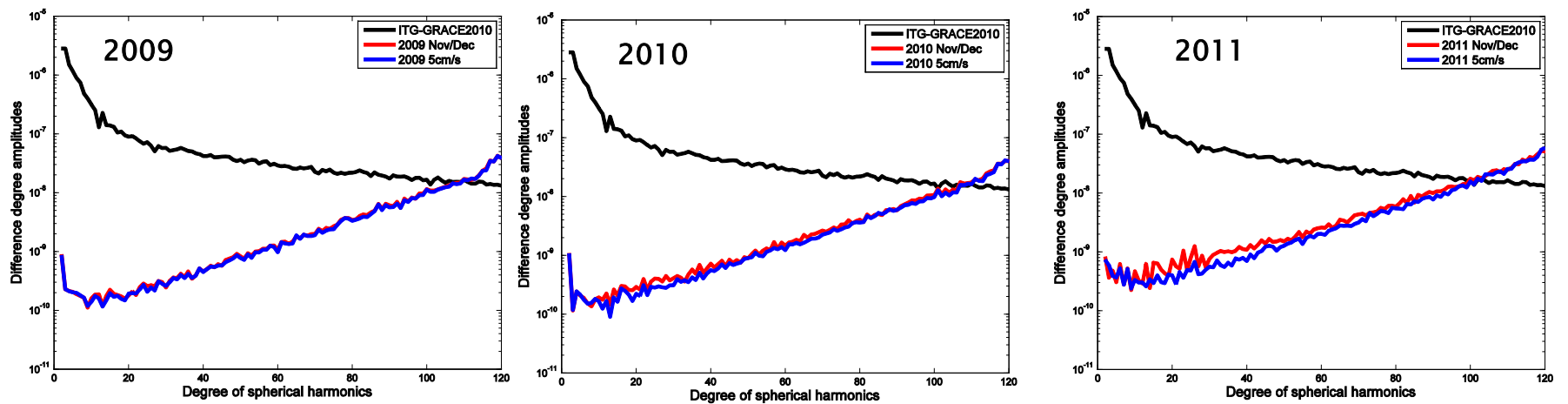
descending



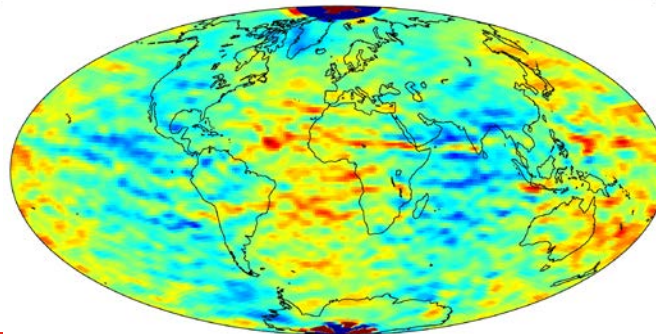
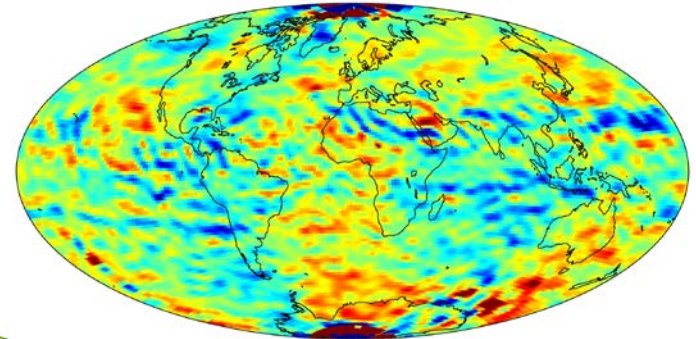
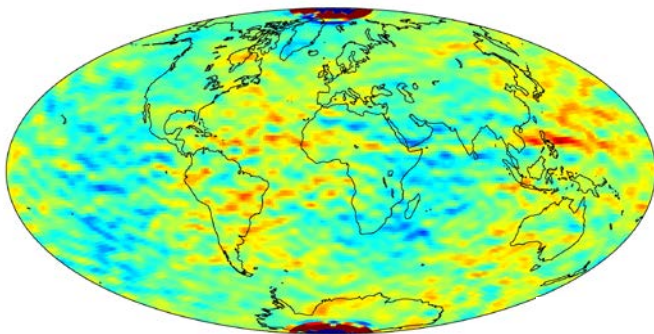
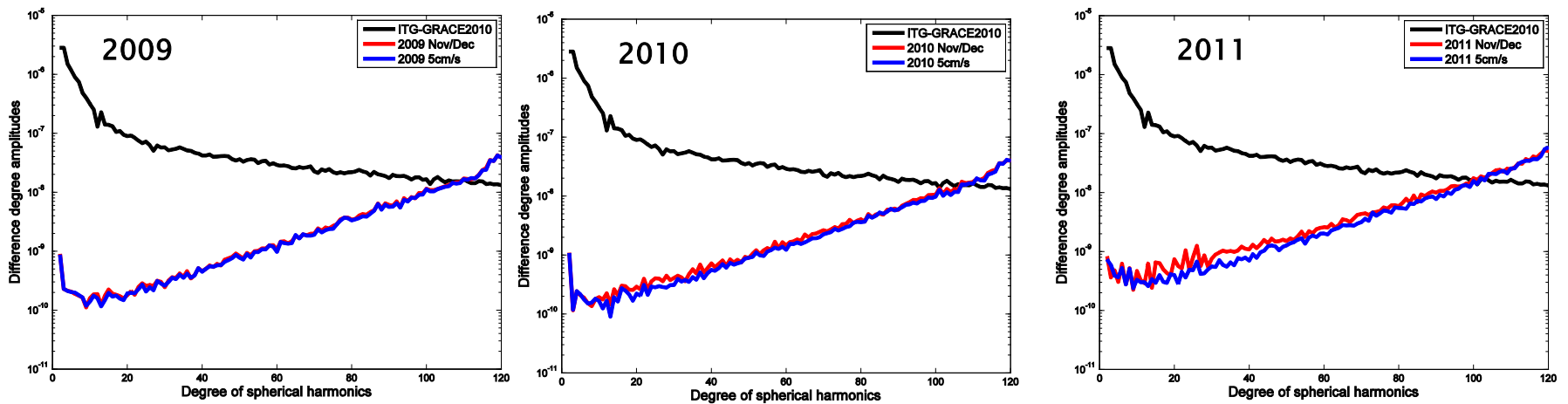
0 100 200 300 400

nr of removed points in 1 x 1 bins for doy 300-365 in 2011

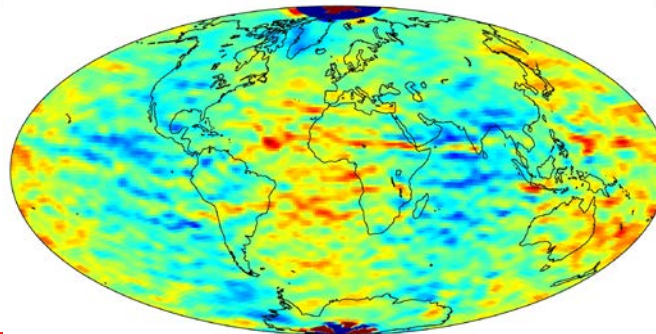
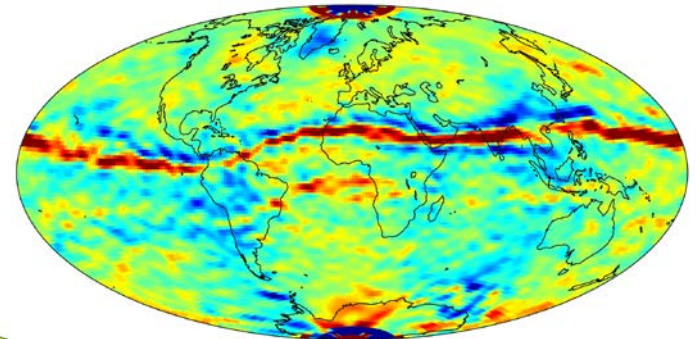
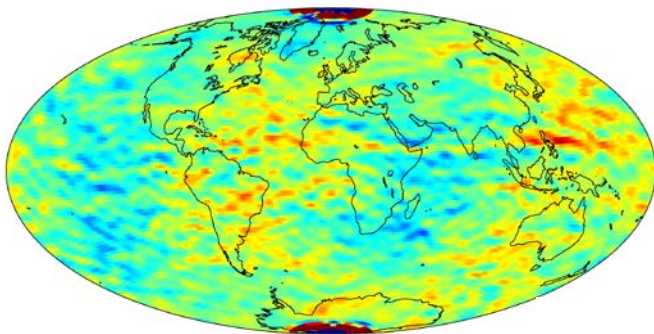
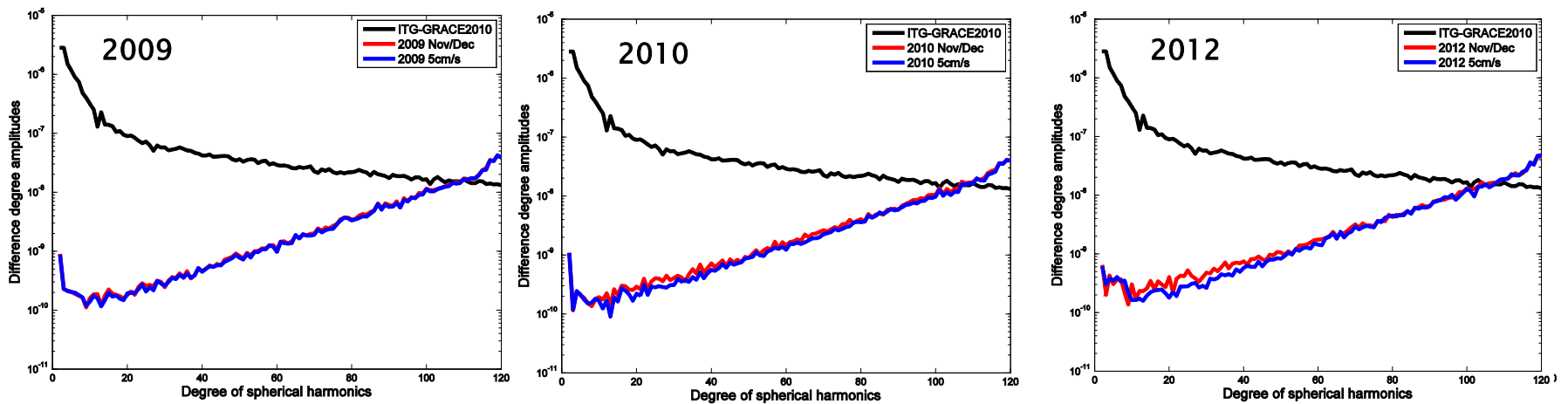
Removal of systematic orbit errors



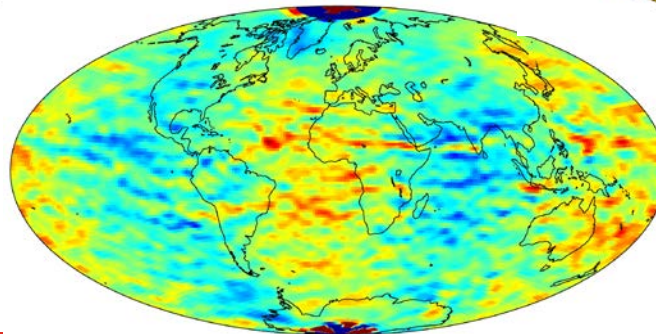
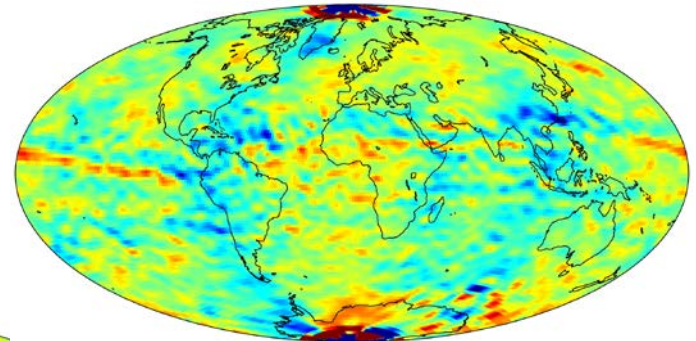
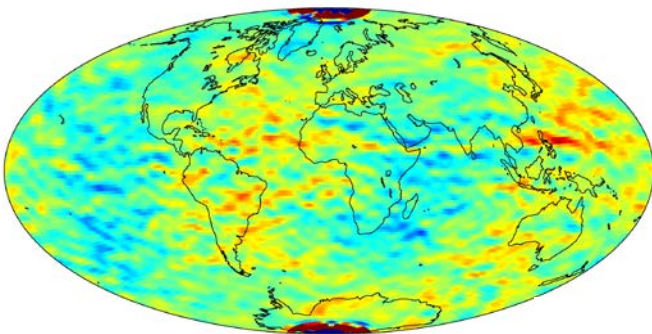
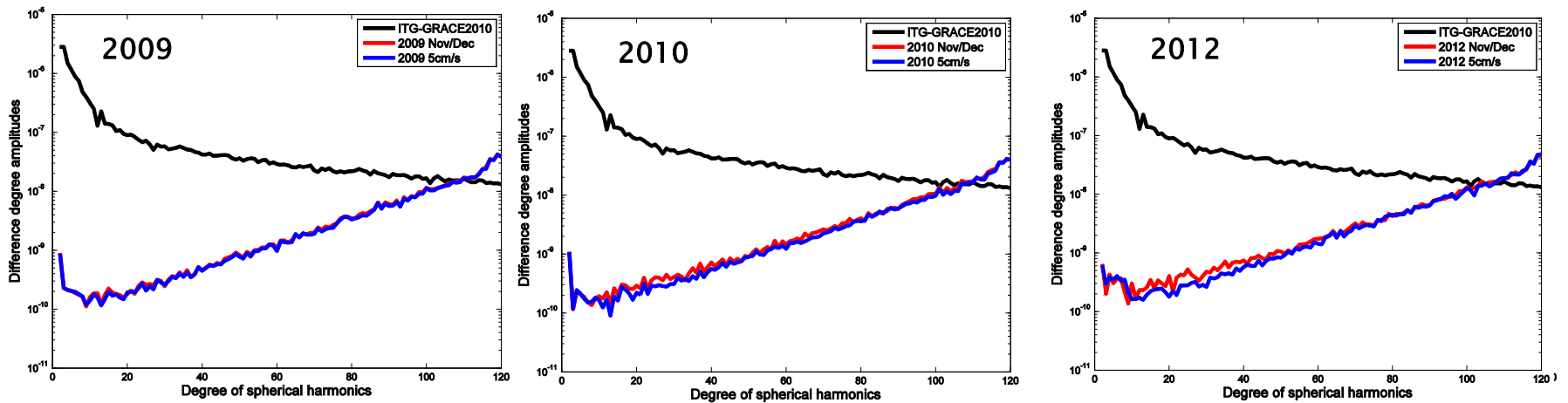
Removal of systematic orbit errors



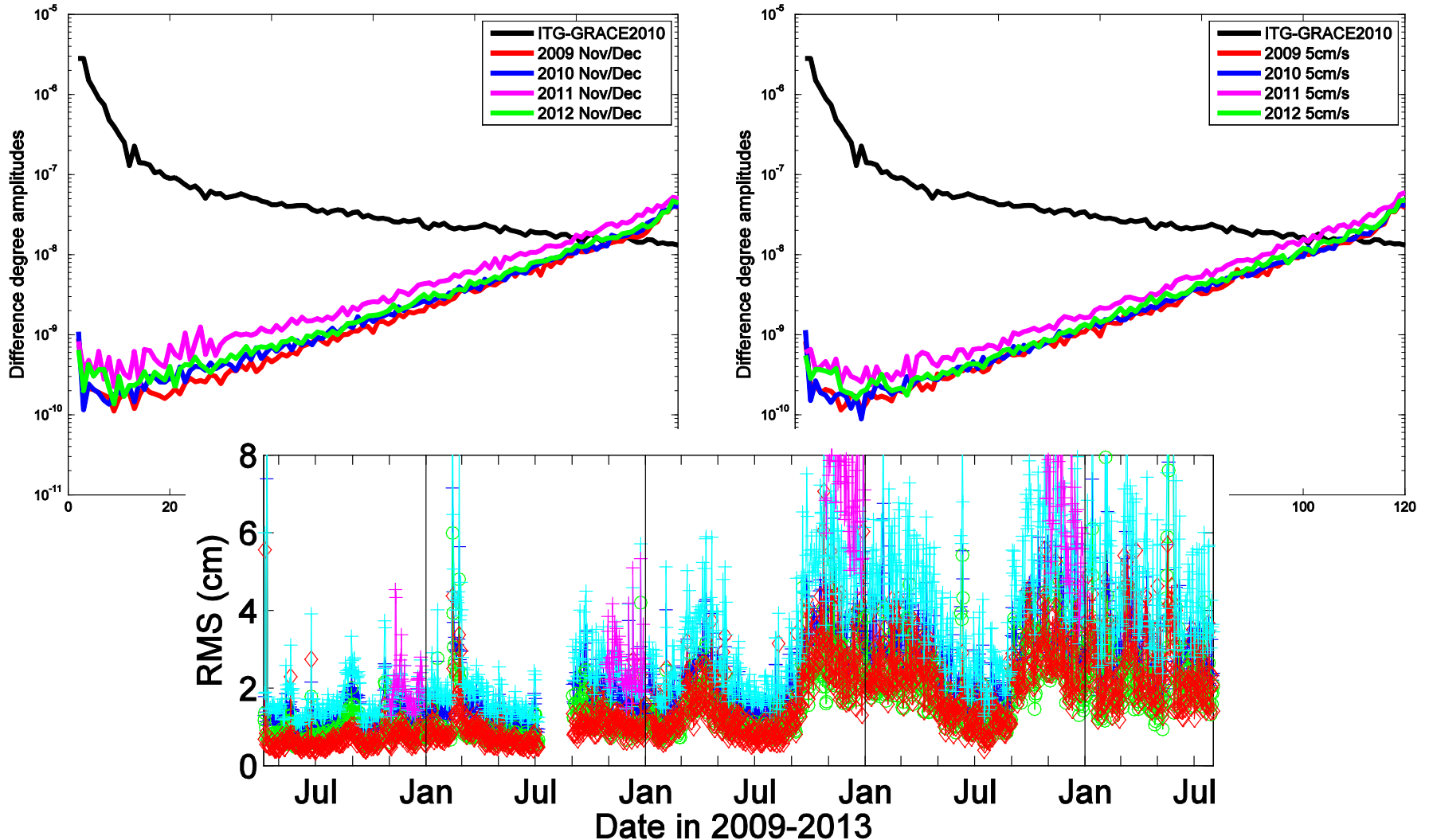
Removal of systematic orbit errors



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 \Rightarrow more investigations necessary