Numerical Modelling of Non-Tidal Ocean Dynamics for the Reduction of Spatio-Temporal Aliasing in Global Grids of Sea-Level Anomalies From Radar Altimetry

Henryk Dobslaw and Saskia Esselborn

German Research Centre for Geosciences (GFZ)
Department 1: Geodesy
dobslaw@gfz-potsdam.de

GFZ Helmholtz-Zentrum Potsdam

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Background

- Mature barotropic de-aliasing product for altimetry
- Known issues regarding baroclinic component, oceanic loading …
- GFZ in Potsdam (Germany) operates the global numerical ocean model MPIOM for particulary geodetic applications:

  1. Crustal surface deformations due to non-tidal oceanic loading
  2. Time-variations in the gravity field due to ocean mass changes
  3. Excitations of Earth orientation changes due to ocean dynamics

- data products routinely span period 1976 – present
- data is provided every 3 hours

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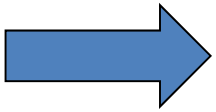
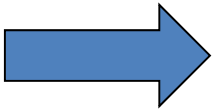
Relevance for OSTST Community

- GFZ model data provides non-tidal HF time-variable gravity field and crustal surface deformations due to loading at tracking stations: POD



On the effect of non-tidal atmospheric loading on altimetry orbits (talk on POD splinter, König et al.)
On the long-term stability of altimetry satellites orbits (Poster POD01, Rudenko et al.)

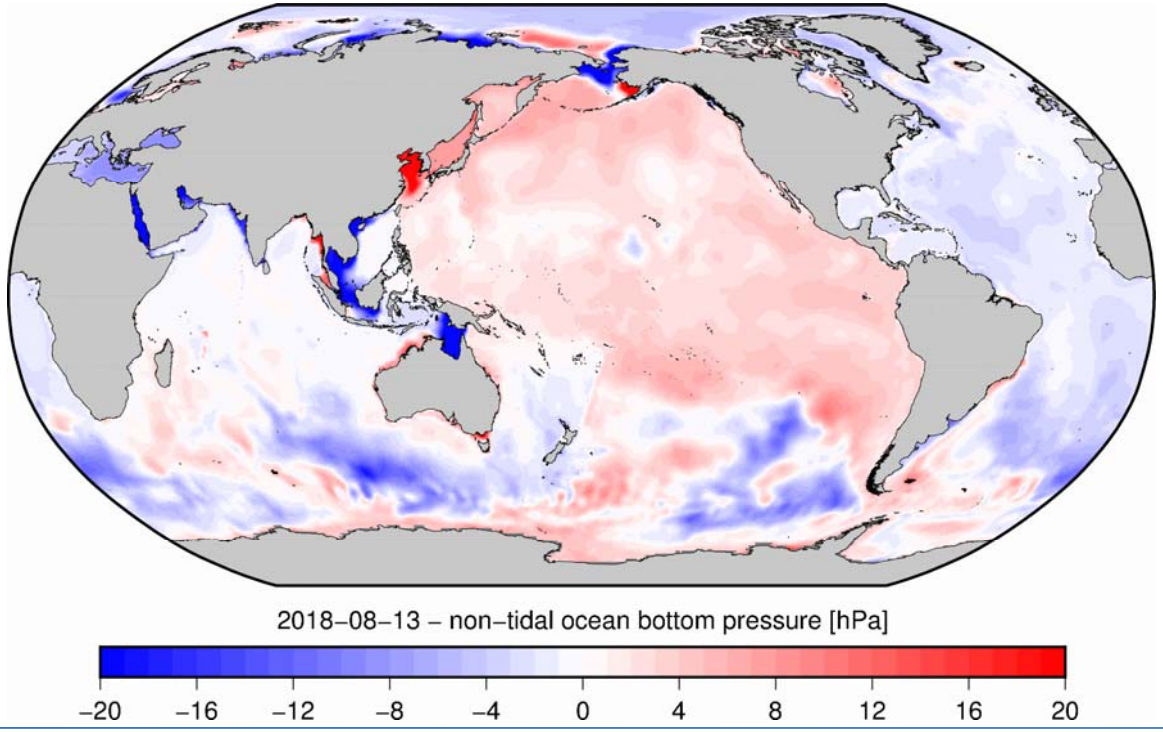
- GFZ model data provides alternative dynamic atmospheric corrections for the de-aliasing of high-frequency sea level variations including steric and loading effects (this talk).



1. MPIOM Model Configuration
2. Atmospheric Tides
3. Skill of model for Envisat, Saral, Jason-1 and Jason-2

MPIOM Configuration

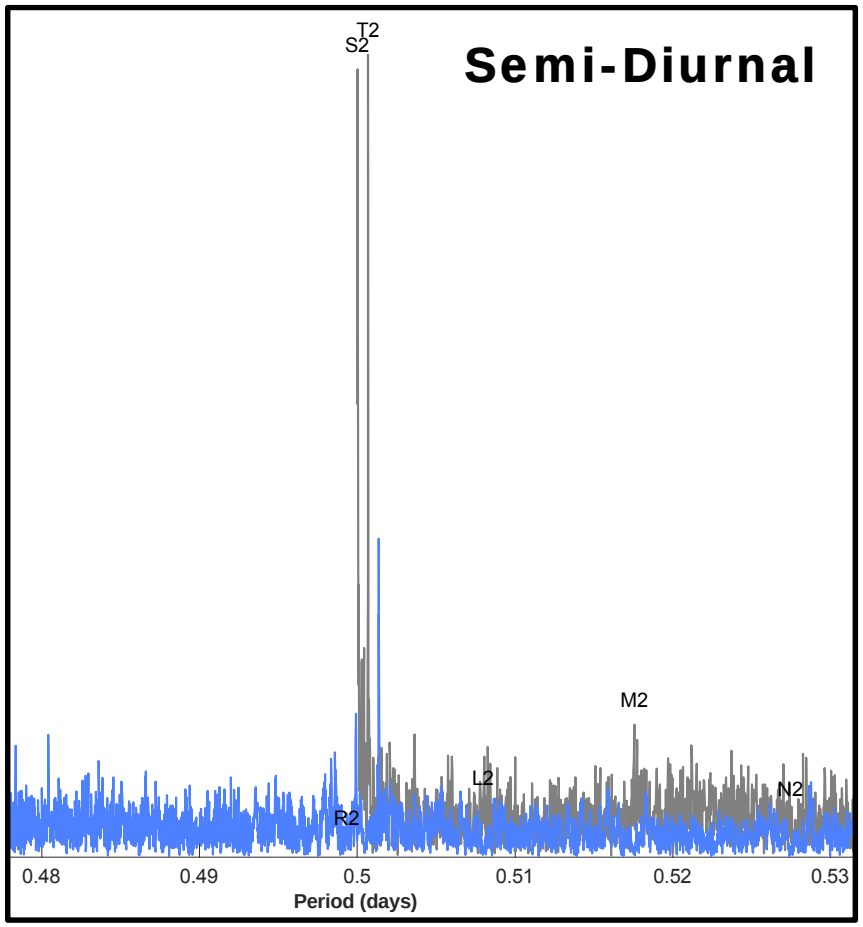
- MPIOM from MPI-M Hamburg, Germany (Jungclaus et al., 2013)
- TP10L40 configuration: tri-polar grid with 1° spacing and 40 levels
- 3-hourly atmospheric forcing from ERA-Interim (1979-2006) and operational ECMWF data (since 2007)
- Considers also atmospheric surface pressure forcing
- No data assimilation!

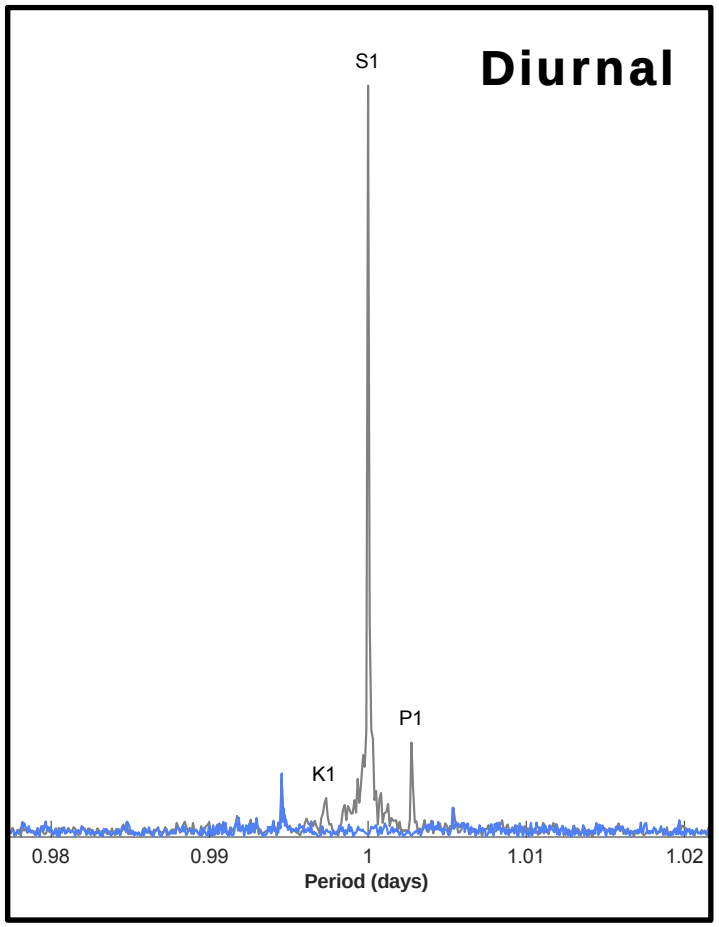


Spectral Analysis of Low-Degree Spherical Harmonics

6-hourly forcing including atmospheric tides

3-hourly forcing excluding atmospheric tides





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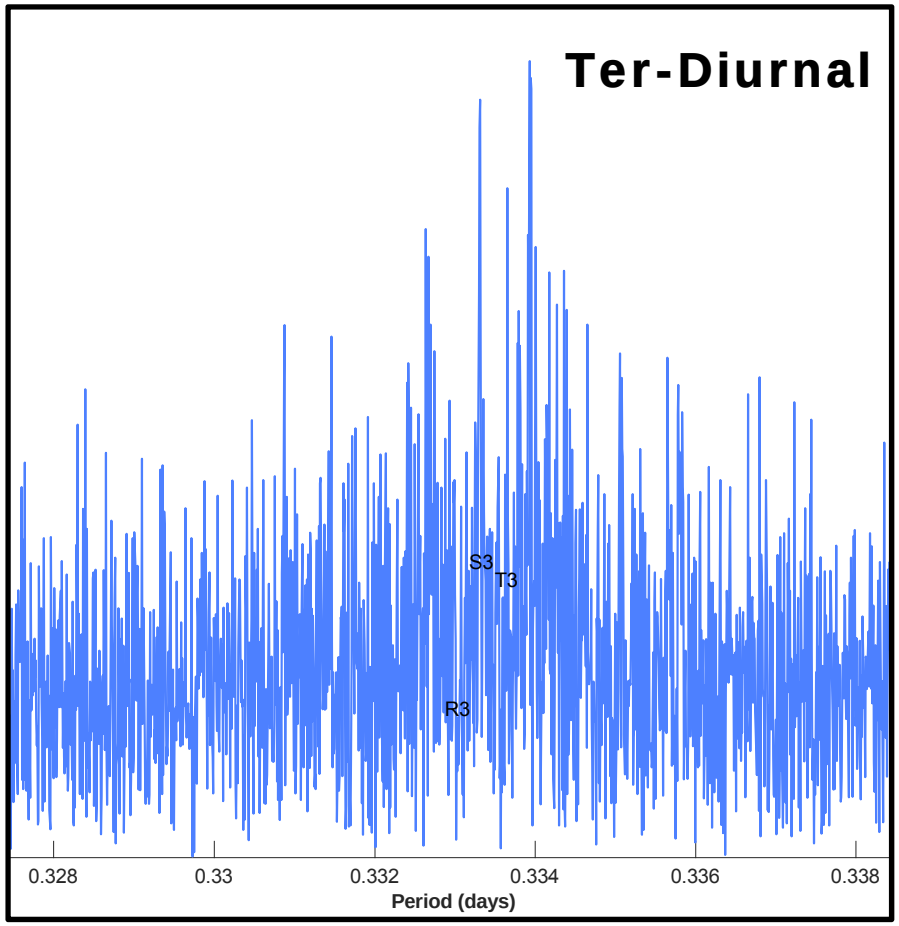
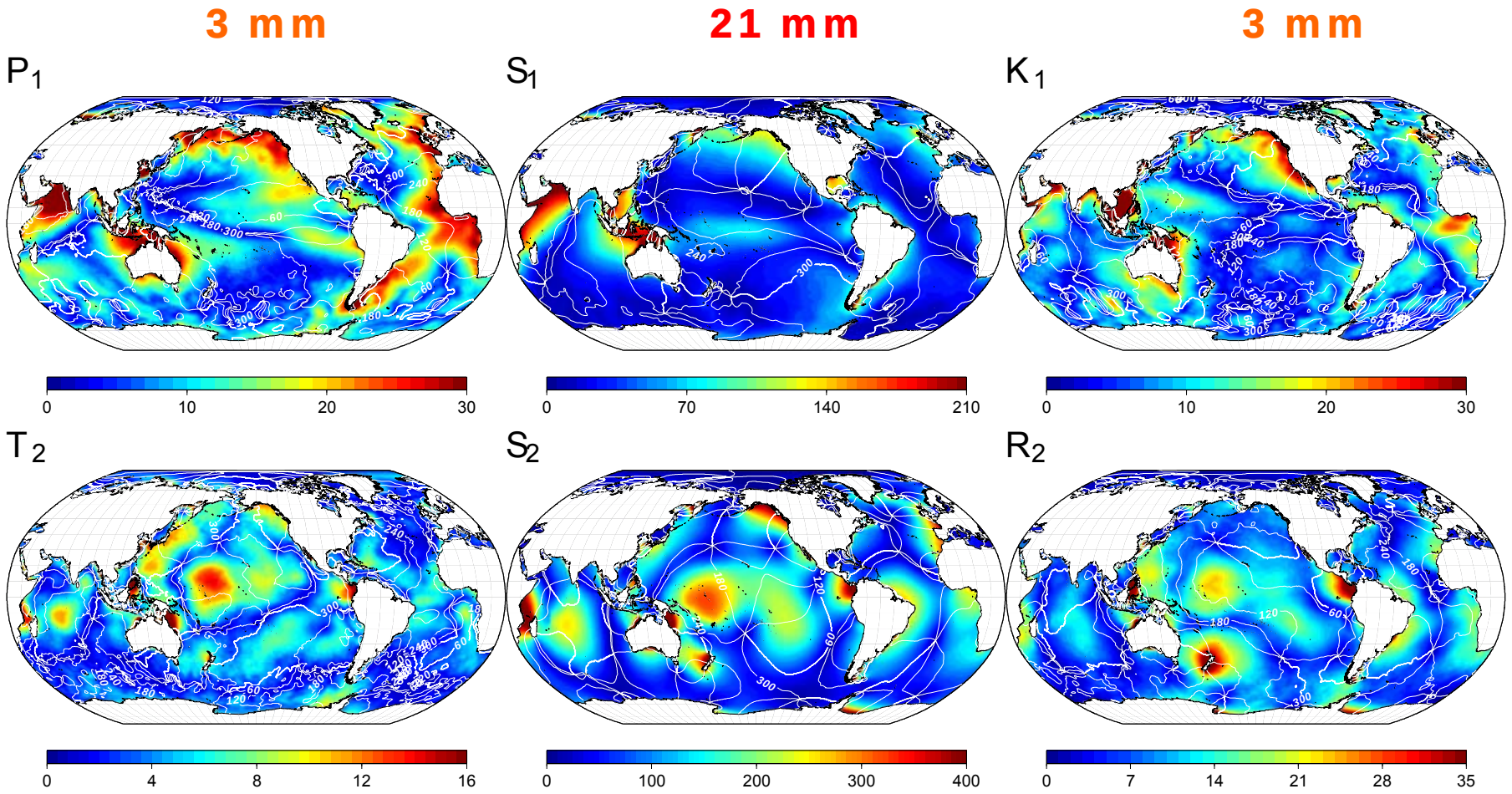


Relevant Frequencies of Atmospheric Tides

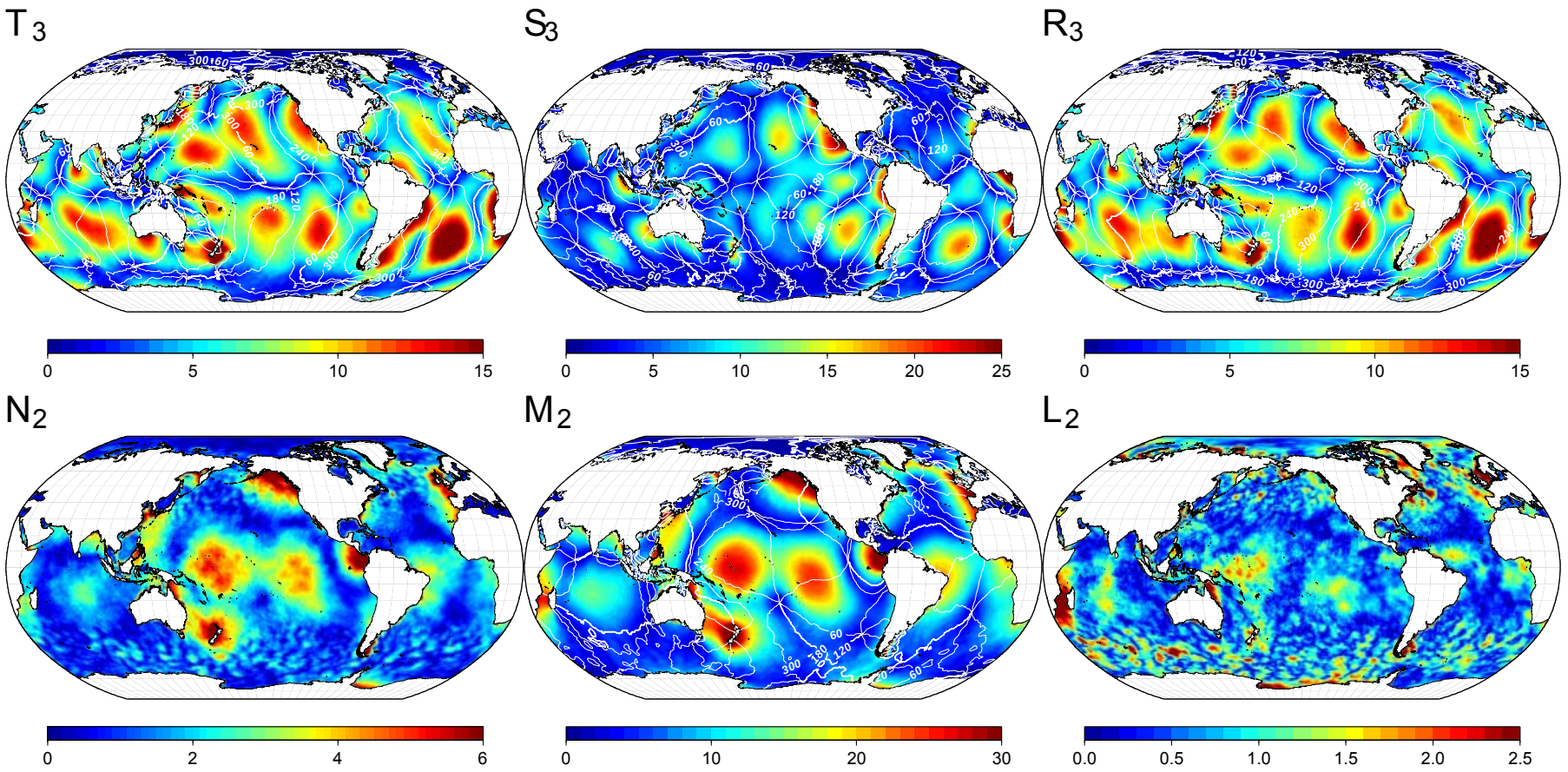
Doodson Code	Name	Argument	Frequency ($^\circ h^{-1}$)
163.555	P_1	$t - h - 90^\circ$	14.9589314
164.555	S_1	$t + 180^\circ$	15.0000000
165.555	K_1	$t + h + 90^\circ$	15.0410686
245.655	N_2	$2t - 3s + 2h + p$	28.4397295
255.555	M_2	$2t - 2s + 2h$	28.9841042
265.455	L_2	$2t - s + 2h - p + 180^\circ$	29.5284789
272.556	T_2	$2t - h + p'$	29.9589333
273.555	S_2	$2t$	30.0000000
274.554	R_2	$2t + h - p' + 180^\circ$	30.0410667
381.555	T_3	$3t - h$	44.9589300
382.555	S_3	$3t$	45.0000000
383.555	R_3	$3t + h$	45.0410700

Removed Ocean Response to Atmospheric Tides (1)



Removed Ocean Response to Atmospheric Tides (2)

1.5 mm 2.5 mm 1.5 mm



0.6 mm 3 mm 0.3 mm

Dynamic Atmospheric Correction from MPI-OM: DAC_{GFZ}

SLA from model:

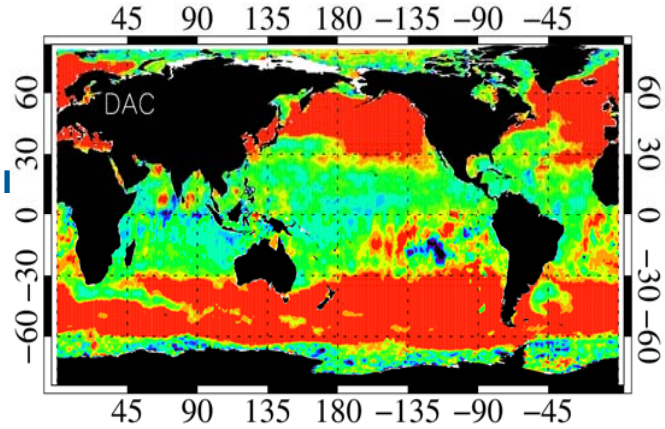
- wind- and pressure-driven bottom pressure anomalies
- anomalies of steric height
- deformations of the sea-floor due to bottom pressure variations
- 12 tidal components estimated and removed
- long-term mean 2003 – 2014 subtracted

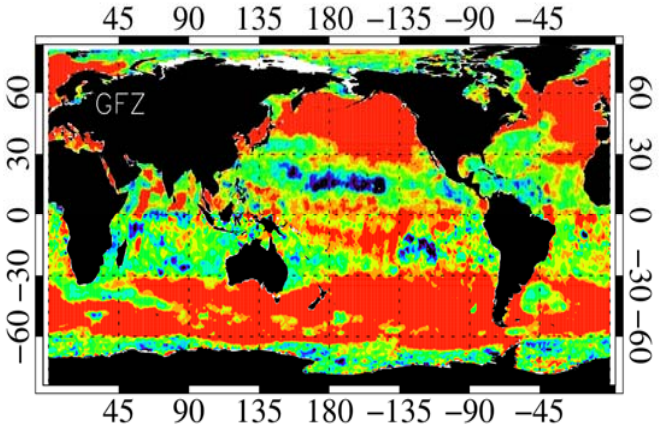
Test of model data

- 2 Test periods:
  03/2009-02/2010 (Envisat, Jason-1, Jason-2)
  01/2014-12/2014 (Jason-2, Saral)
- Colinear analysis for each mission applying: no atmospheric correction, inverse barometer correction, DAC_{CCI}, DAC_{GFZ}
- interpolation to daily SLA maps (1° x 1°)
- apply high-pass filter with cut-off frequency of 20 days (3rd order Butterworth)
- calculate skill of the three models to explain uncorrected data

Skill of DAC_{CCI} and DAC_{GFZ}
(Envisat & Jason-1 & Jason-2, 3/2009-2/2010)

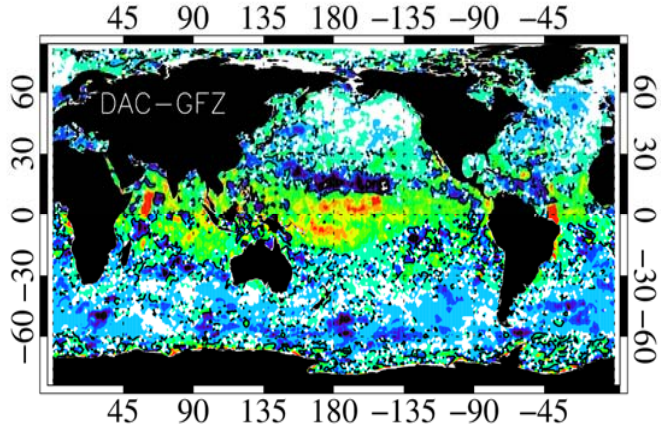
DAC_{CCI}

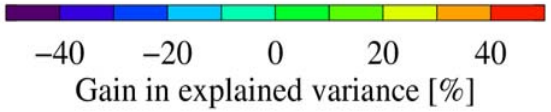




DAC_{GFZ}

DAC_{CCI} minus DAC_{GFZ}



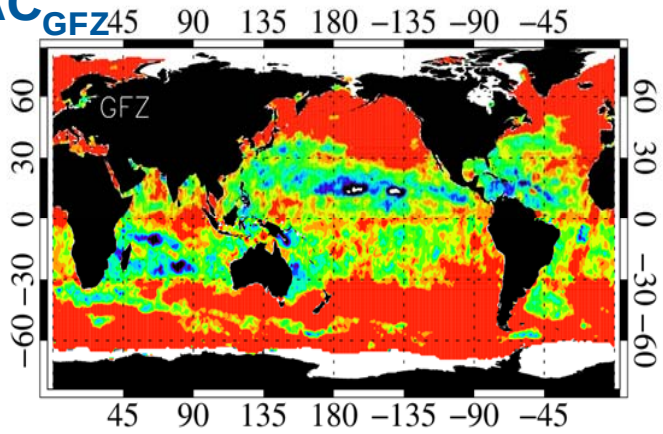


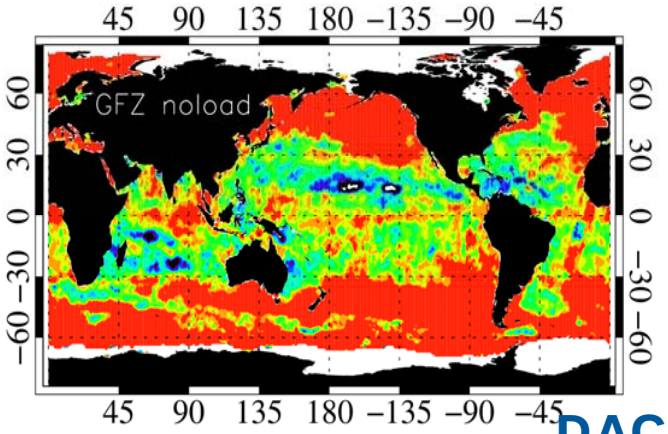
Global mean skill (area weighting) to explain uncorrected data

<1/20 d	Jason-1	Jason-2	Envisat	Saral
in.Baro.	34%	34/34%	33%	33%
DAC_{CCI}	40%	41/40%	38%	39%
DAC_{GFZ}	42%	44/42%	40%	42%

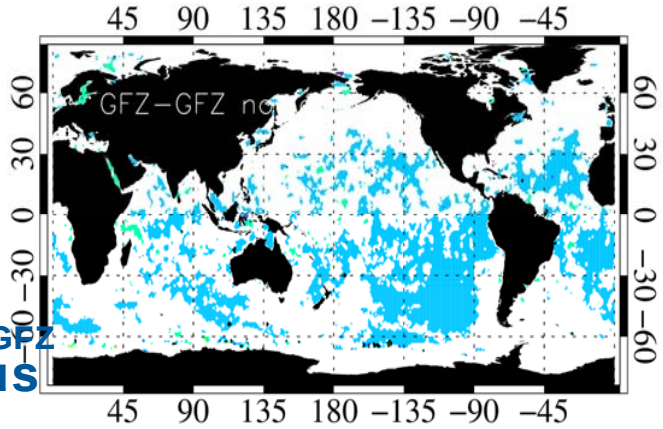
Skill of DAC_{GFZ} and $DAC_{GFZ\_no\ loading}$ (Saral, 1/2014-12/2014)

DAC_{GFZ}

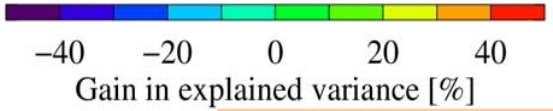




$DAC_{GFZ\_no\ loading}$



DAC_{GFZ} minus $DAC_{GFZ\_no\ loading}$



<1/20 d	skill
loading	42.1%
no loading	41.3%

Summary

- GFZ routinely provides numerical model data to account for non-tidal ocean signals in observations from various geodetic techniques: surface deformations, gravity field, Earth orientation

- 12 frequencies of atmospheric tides are routinely removed: (P_1-S_1-K_1), (N_2-M_2-L_2), (T_2-S_2-R_2), (T_3-S_3-R_3)

- the effects of the inclusion of steric and loading components for de-aliasing of Envisat, Jason-1, Jason-2 and Saral altimeter data have been studied

- Loading: small improvements over most ocean areas

- Steric: considerable improvements in Tropical regions, degradation in most other areas, probably related to spatial resolution of model

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Thank You for Your Attention