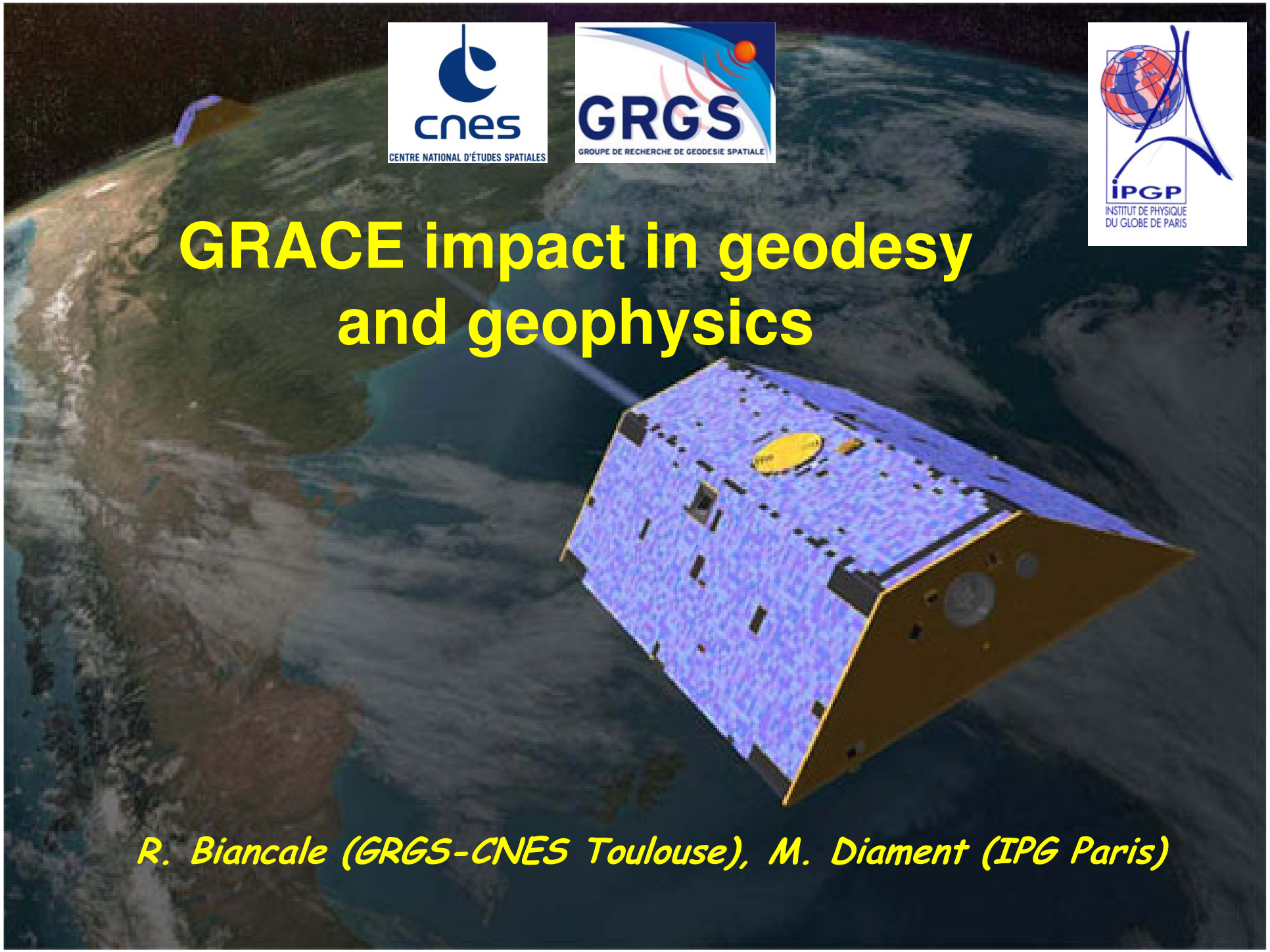


GRACE impact in geodesy and geophysics

R. Biancale (GRGS-CNES Toulouse), M. Diament (IPG Paris)

Improvement of gravity models

Since 2002 the GRACE mission has changed some goals in geodesy. It has become possible to observe from the space gravity field variations other than of the Earth's flattening (from LAGEOS satellites).

Earth gravity field models have been improved by a factor 100.

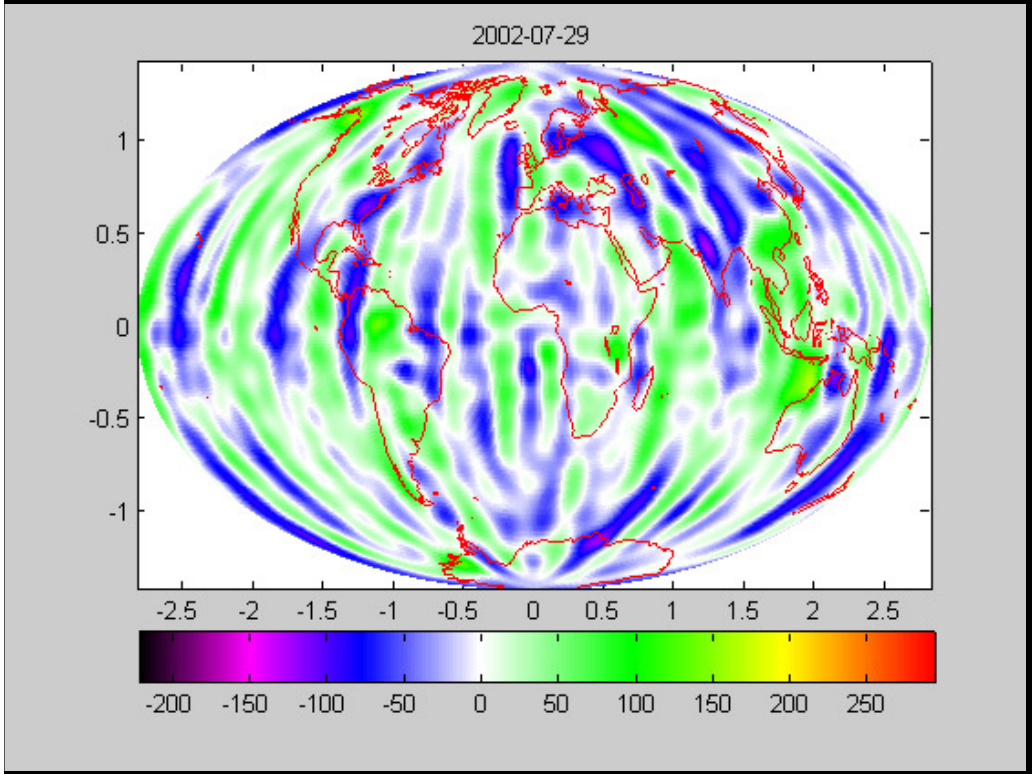
Models compared to EIGEN-GRGS.RL02 (2009)	***date***	***max. sh degree***	***Geoid height up to deg. 50*** *(mm)*	***Gravity anomaly up to deg. 50*** *(μGal)*
EIGEN-CHAMP03S	2003	140	60	400
EIGEN-GRACE01S	2003	140	5	30
EIGEN-GRACE02S	2004	150	2.5	15
EIGEN-GRACE03S	2005	150	1.5	7
EIGEN-GL04S	2006	150	0.6	3
EIGEN-GL04S1	2007	150	0.6	3
EIGEN-5S	2008	150	0.5	3

Methods

GRACE has motivated research in methods and modelling:

- **surface harmonics (CSR, JPL, GFZ, CNES)**
- **mascons (GSFC)**
- **accelerations (DEOS)**
- **splines (ITG models / Univ. Bonn)**
- **wavelets (IPGP/IGN)**
- **EOF (IPGP)**
- **energy balance**
- **regularization**
- **…**

What is in the data?



Annual signal has been removed

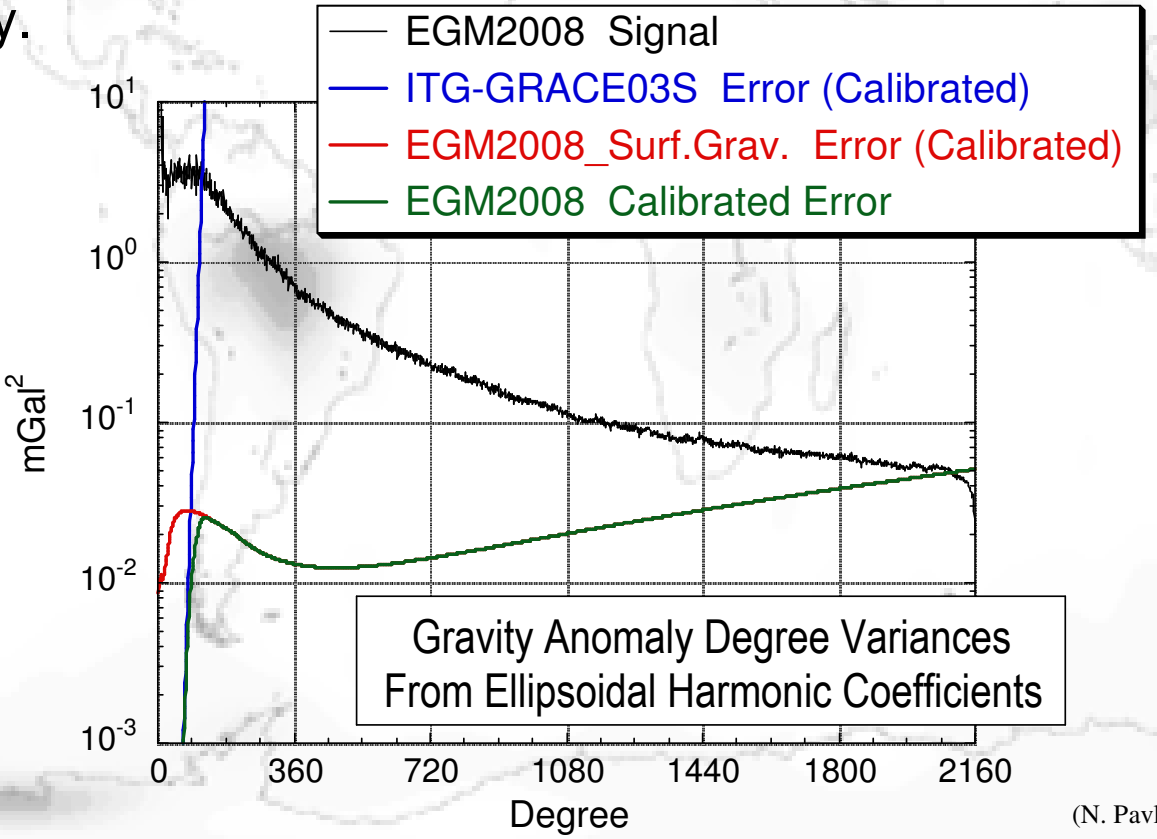
- Hydrology
- Ocean
- Atmosphere + ocean dealiasing residuals
- Geodynamic signal
- Noise

How to extract the interesting signal ?

Impact in geodesy

GRACE geoid models bring a precise and homogeneous long-wavelength base to high resolution models (e.g. EGM2008).

GRACE-GOCE combination models will serve calibrating and unifying surface data sets (like of terrestrial anomalies) and altitude reference consequently.

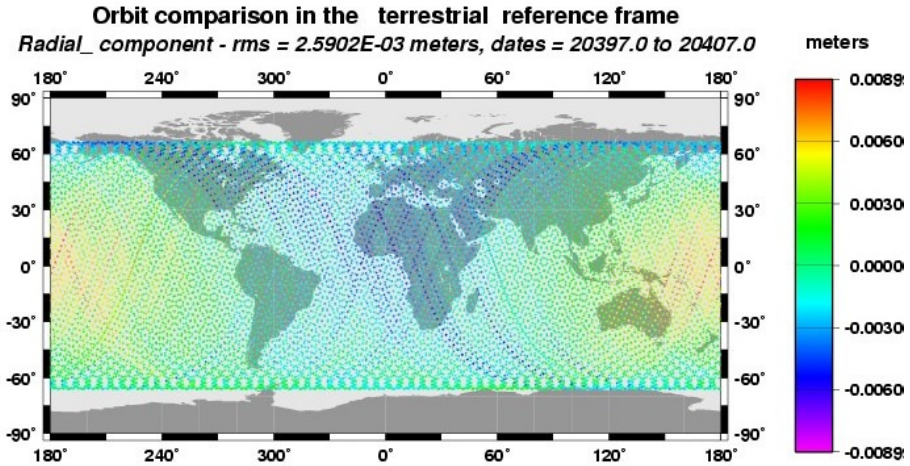


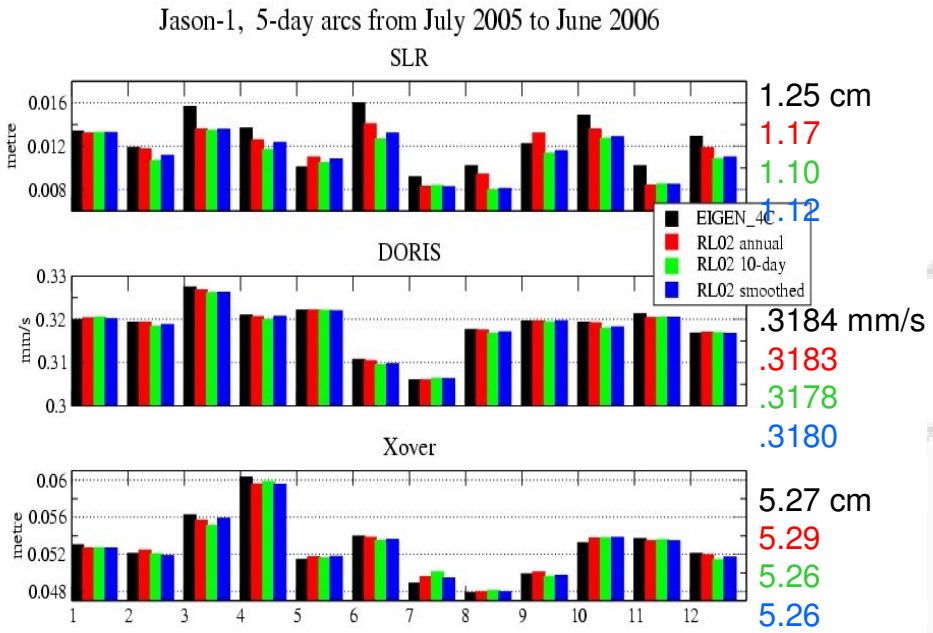
(N. Pavlis & al., EGU 2008)

Impact in space geodesy

Variable GRACE gravity field models have helped in:

- better adjusting orbits for geodetic satellites such as altimetry (Jason, Envisat…)
- determining reference systems (from SLR and DORIS satellites)

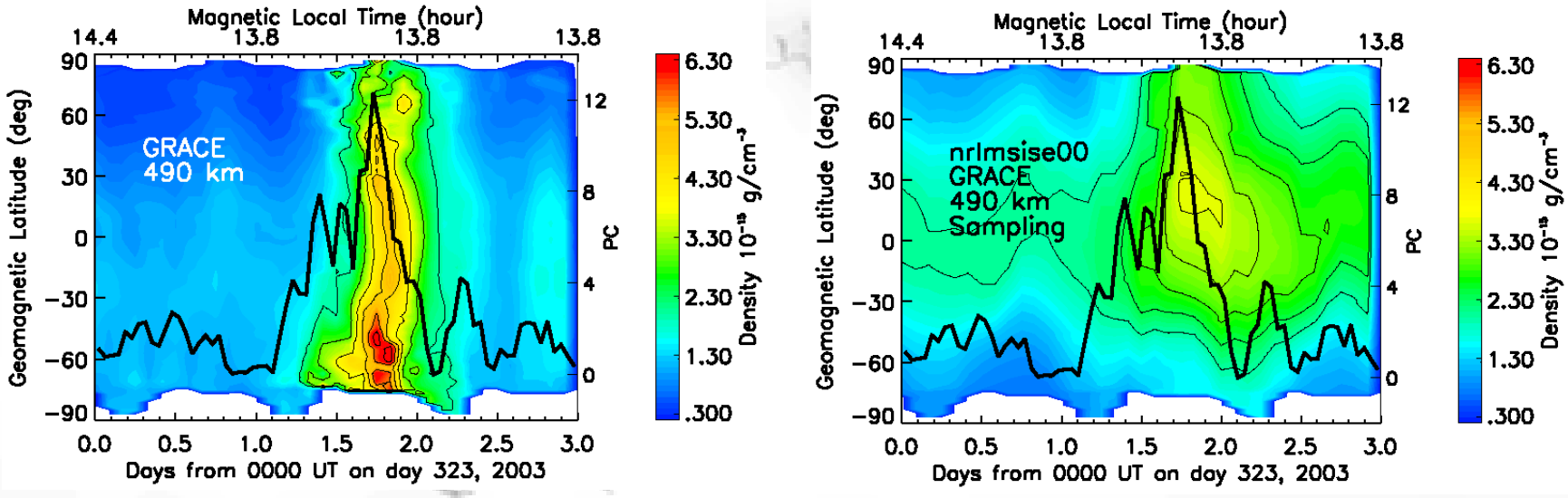




Impact in thermospheric studies

GRACE (and CHAMP) accelerometer data are very pertinent for surface forces studies.

They are used to improve thermospheric models for drag perturbation computation.

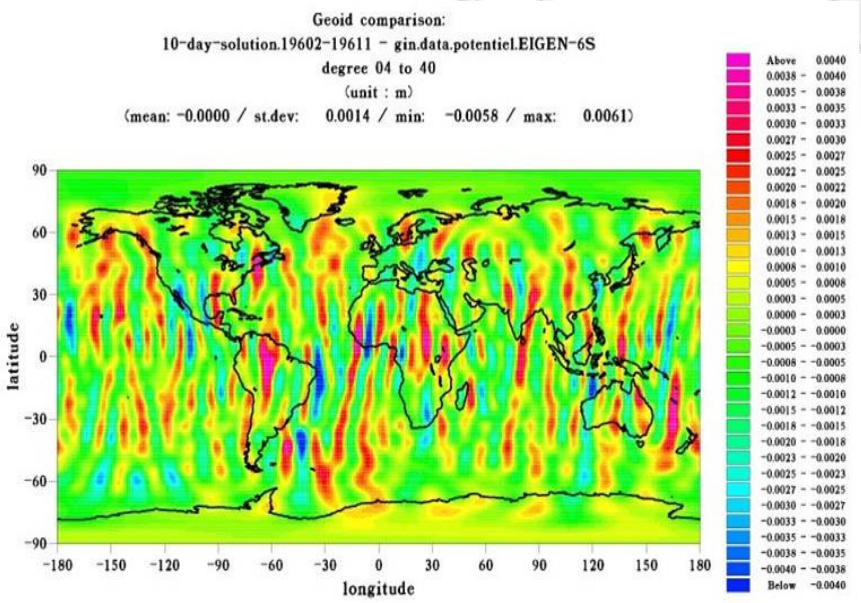


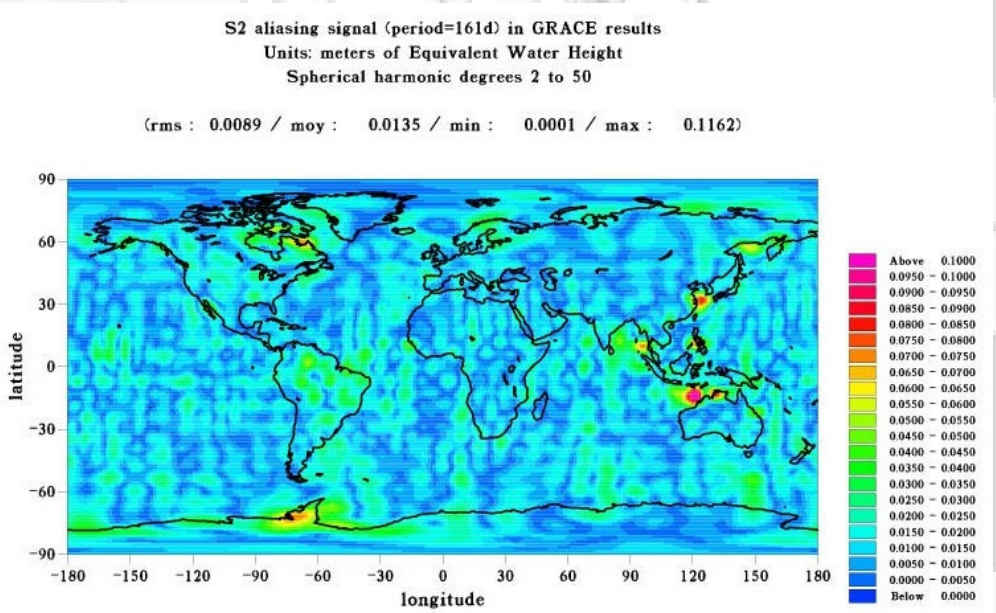
(S. Bruinsma, SIDC 2007)

Aliasing problem

GRACE time variable models integrate errors of high frequency temporal variations of masses (mainly from tides). This has led to :

- regularizing or (a posteriori) smoothing meridian artefacts;
- studying aliasing effects on the long term.

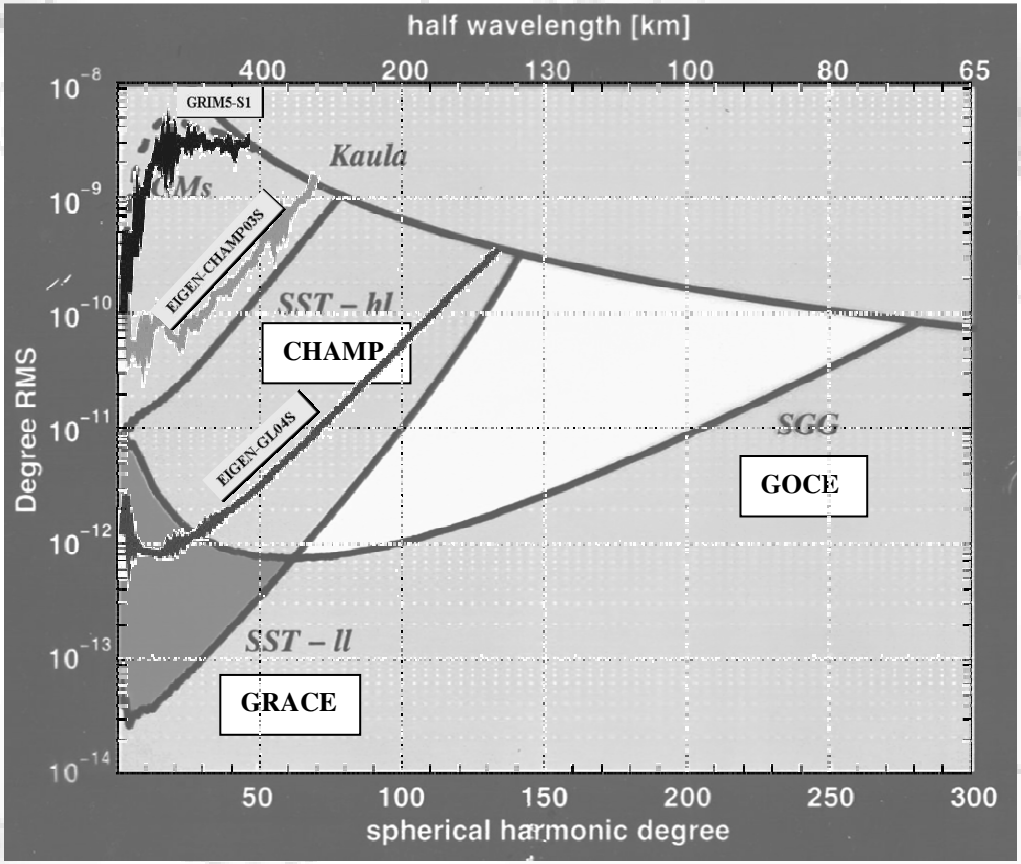




GRACE-GOCE completion

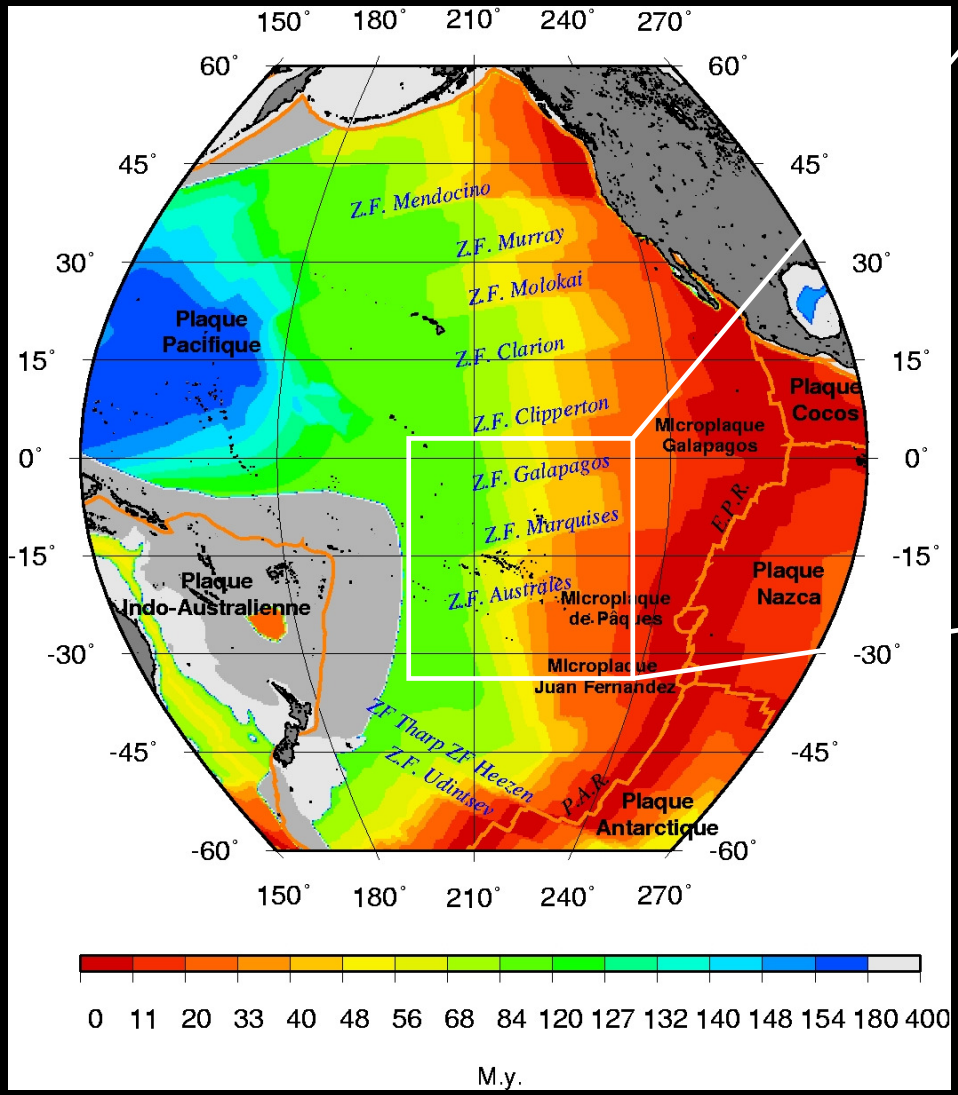
Low degrees (2 to 60) are better obtained by SST (low-low) than by SGG (according to simulation)

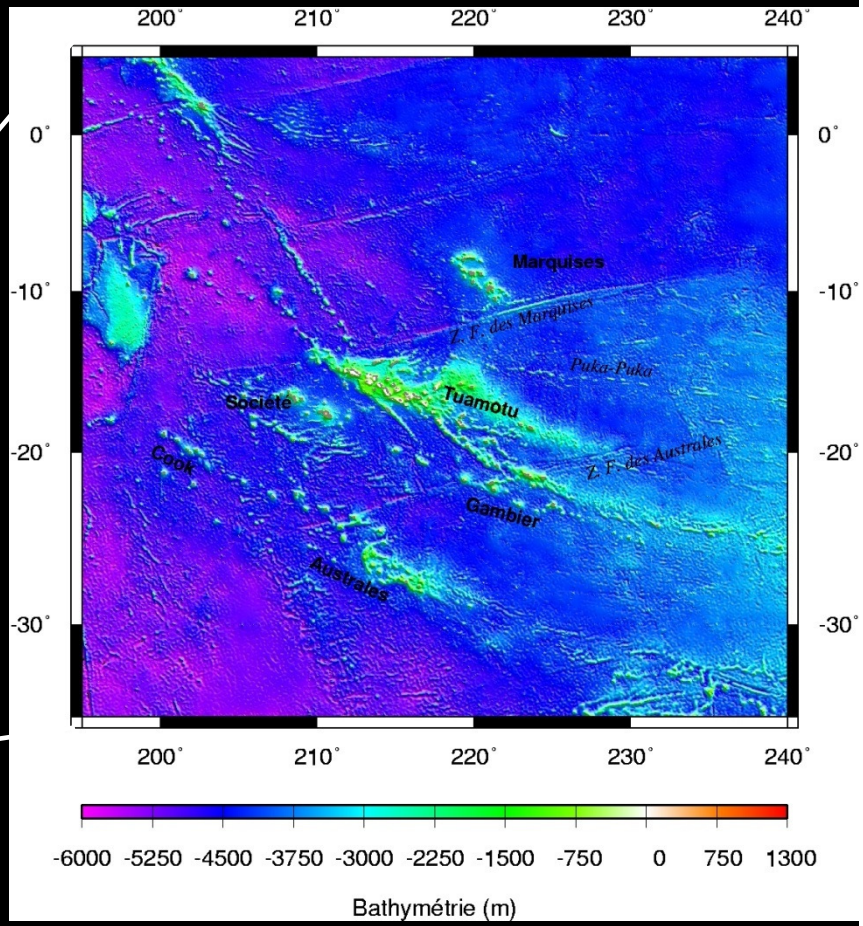
SST and SSG methods are nowadays complementary



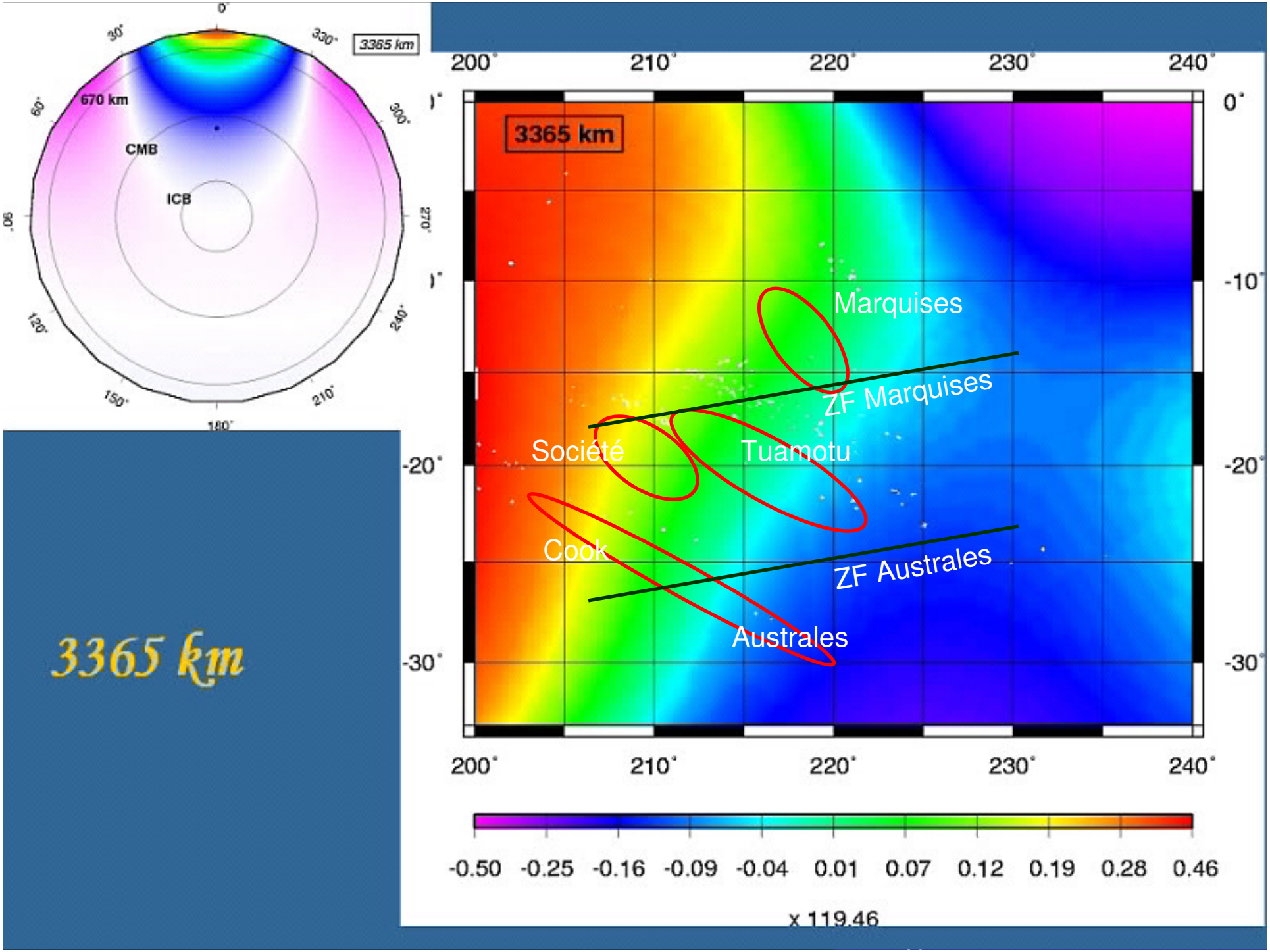
Impact in geophysics : deep structure

Pacific plate…





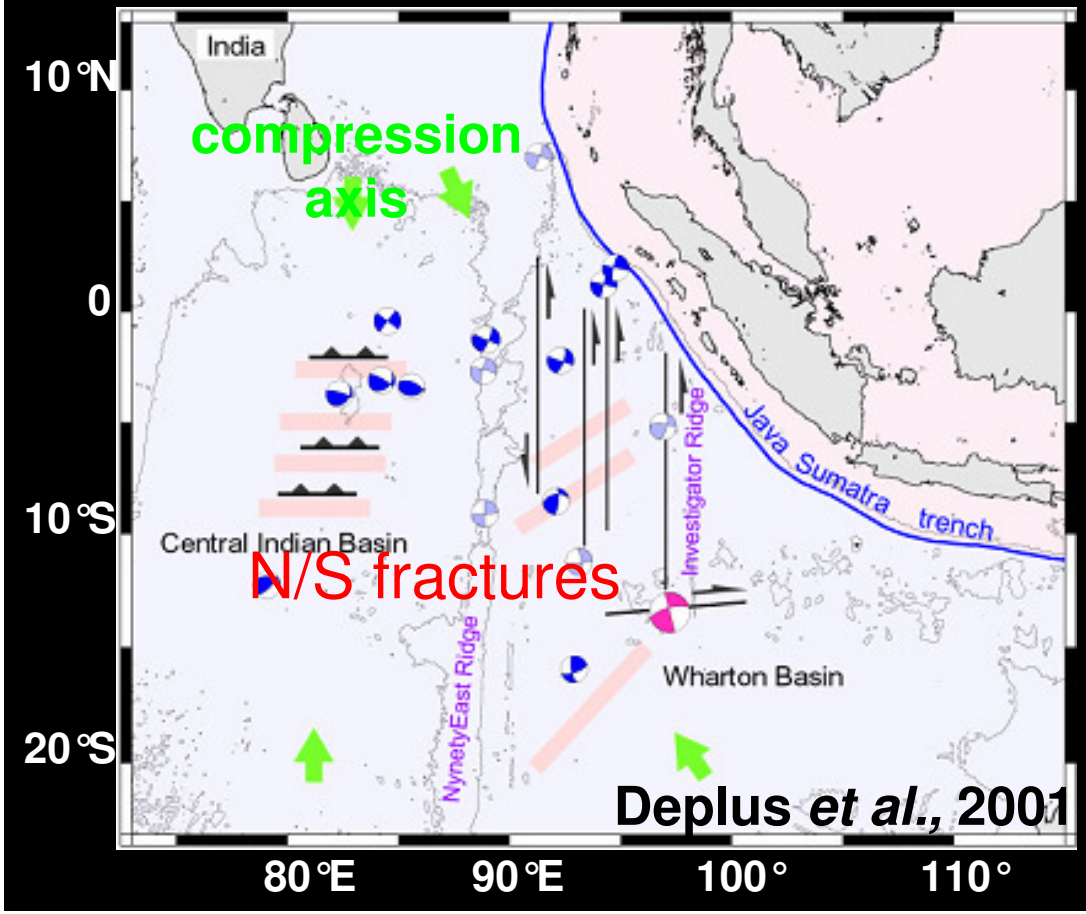
… and French Polynesia

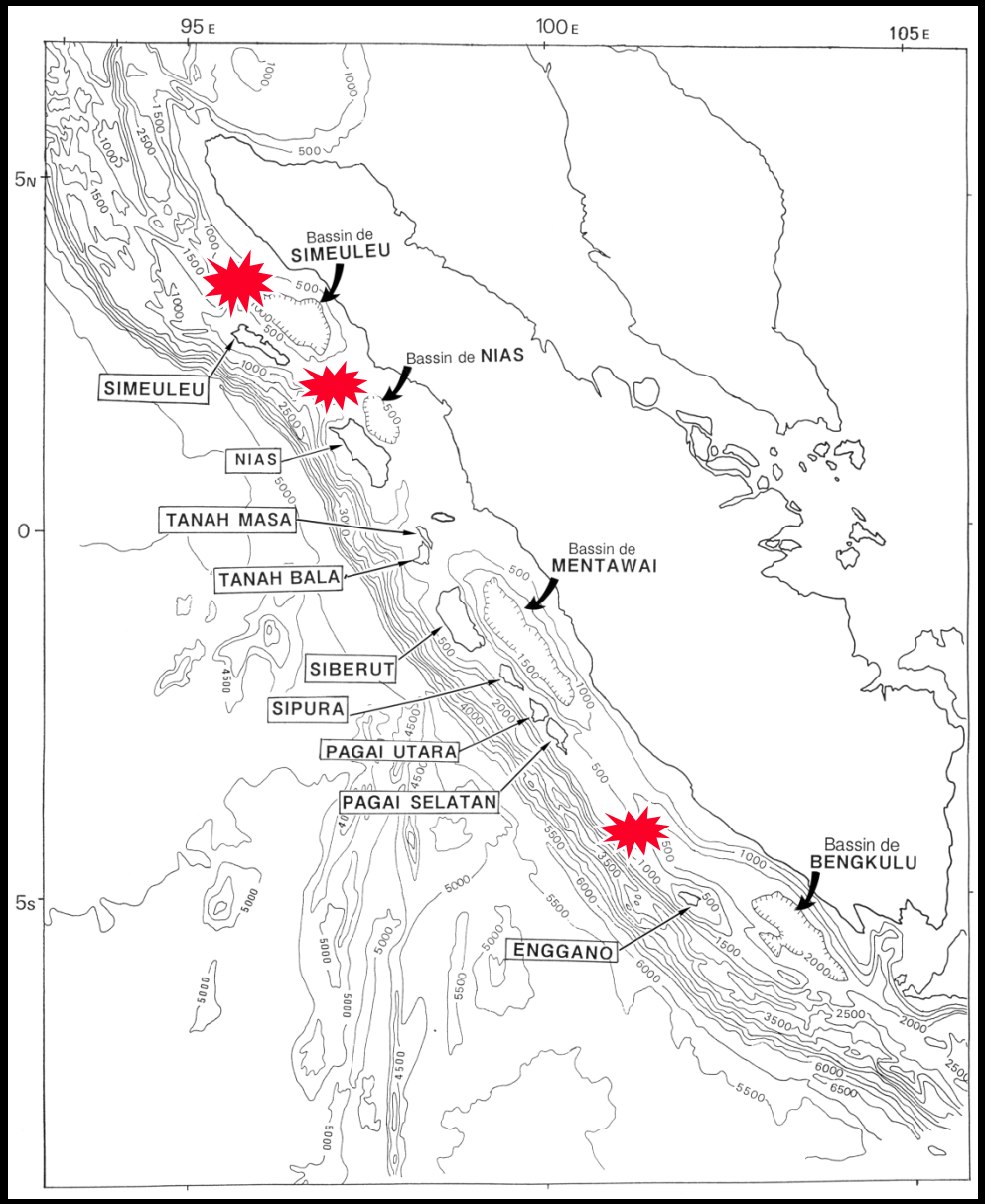

3365 km
670 km
CMB
ICB
3365 km
200°
210°
220°
230°
240°
0°
-10°
-20°
-30°
Marquises
ZF Marquises
Société
Tuamotu
Cook
ZF Australes
Australes
-0.50 -0.25 -0.16 -0.09 -0.04 0.01 0.07 0.12 0.19 0.28 0.46
x 119.46
3365 km

Sumatra geodynamic context

- **A complex subduction zone**: oblique convergence, large strike-slip faults and deformations, complex structure of the over-riding plate

- An oceanic subducting lithosphere with important **intra-plate deformation** (active N/S fractures, gravity undulations…)





The yesterday Padang earthquake was expected to occur !!

Detection and analysis of the Sumatra earthquakes

From Panet et al., Geophys. J. int. 2007

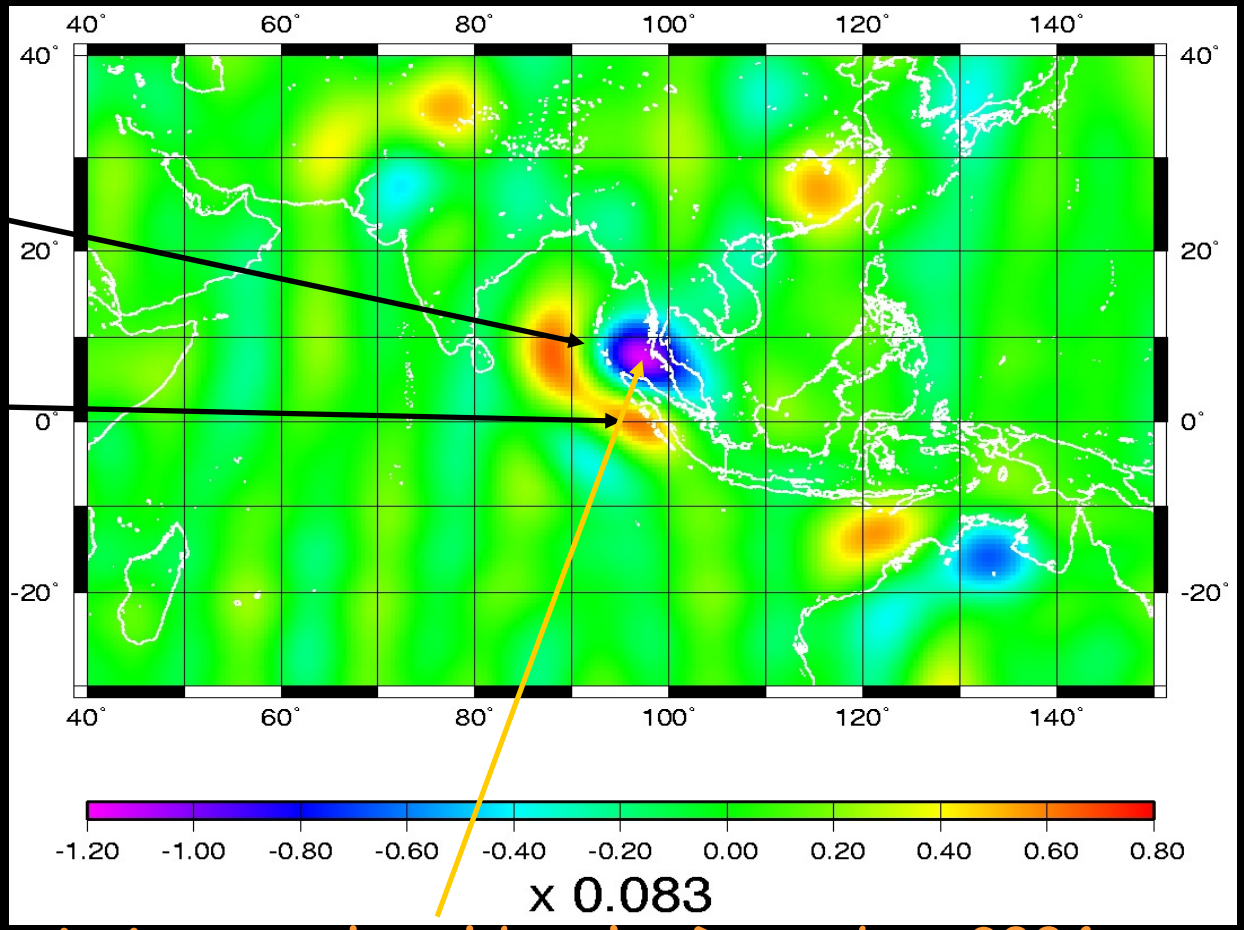
Decembre 2004 earthquake

March 2005 earthquake

Wavelet Analysis

scale 500 km

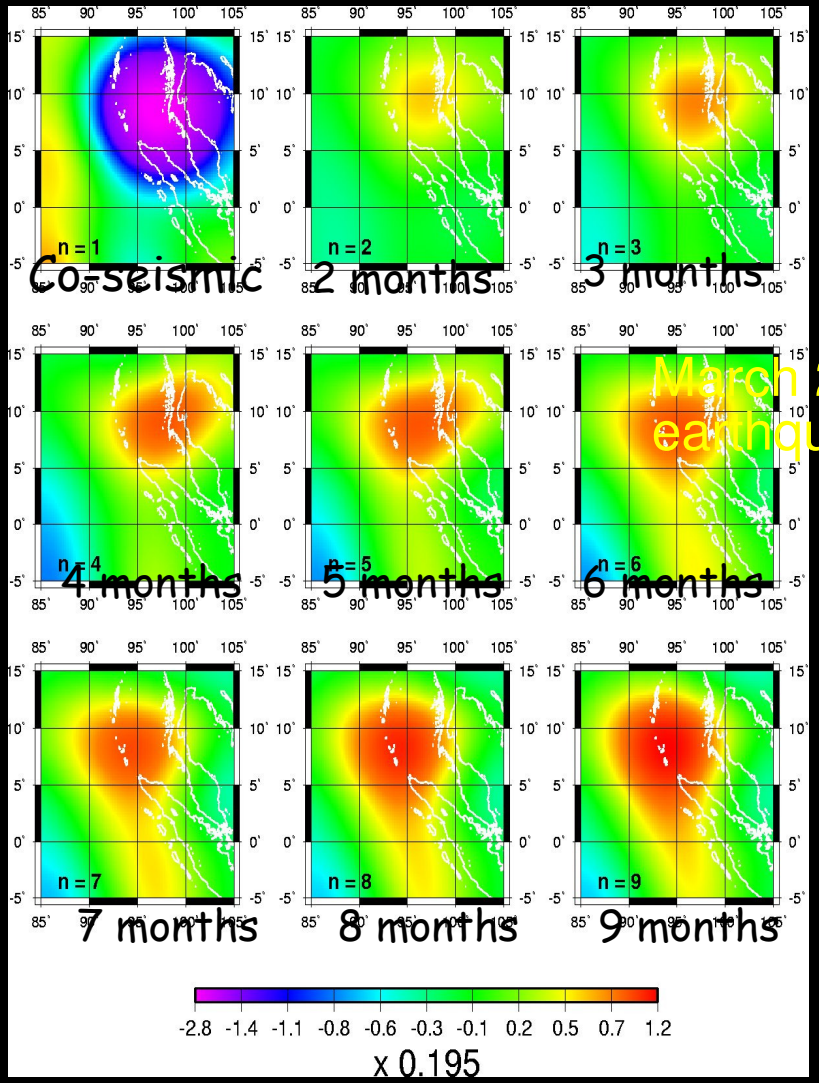
difference (jan-sept 2005) – (jan-sept 2004)



➢ Co-seismic variations produced by the Decembre 2004 event: 15-20 cm of additional subsidence in the Andaman Sea

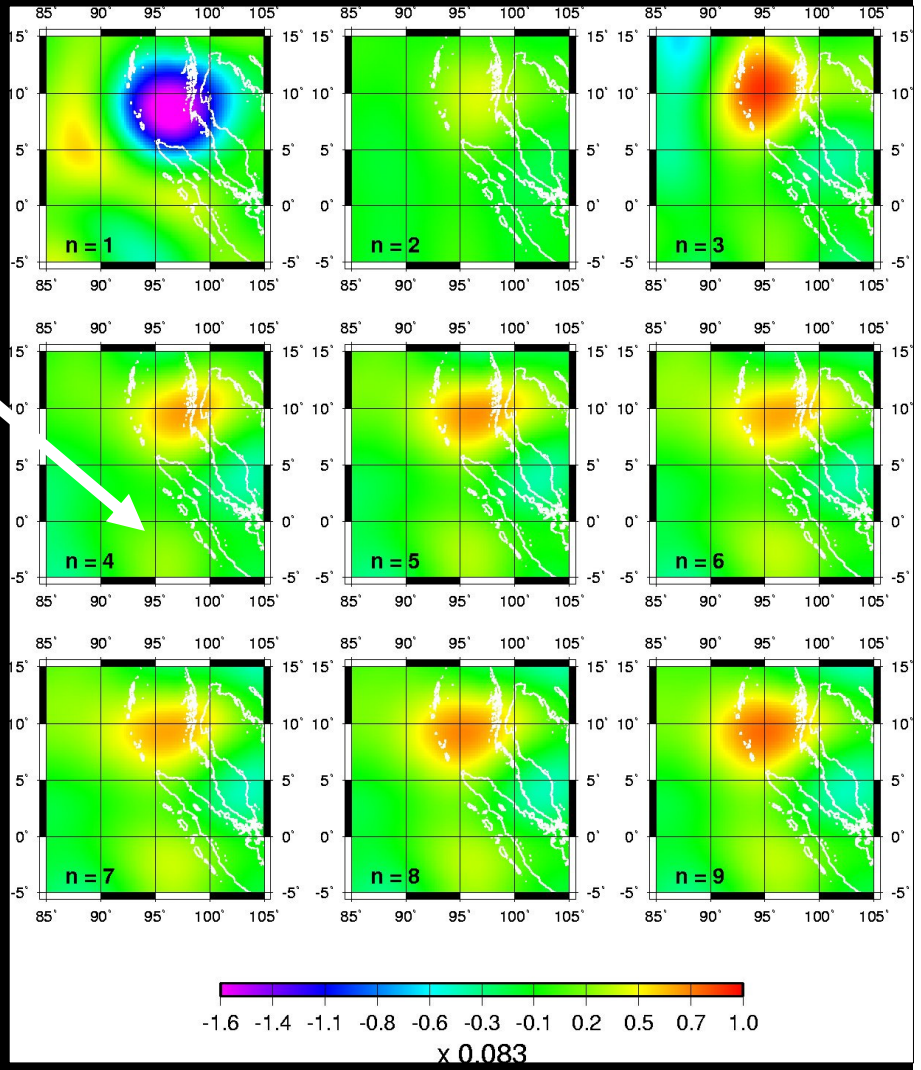
Decembre 2004 earthquake: post-seismic signal

- large scale



March 2005 earthquake

- medium scale

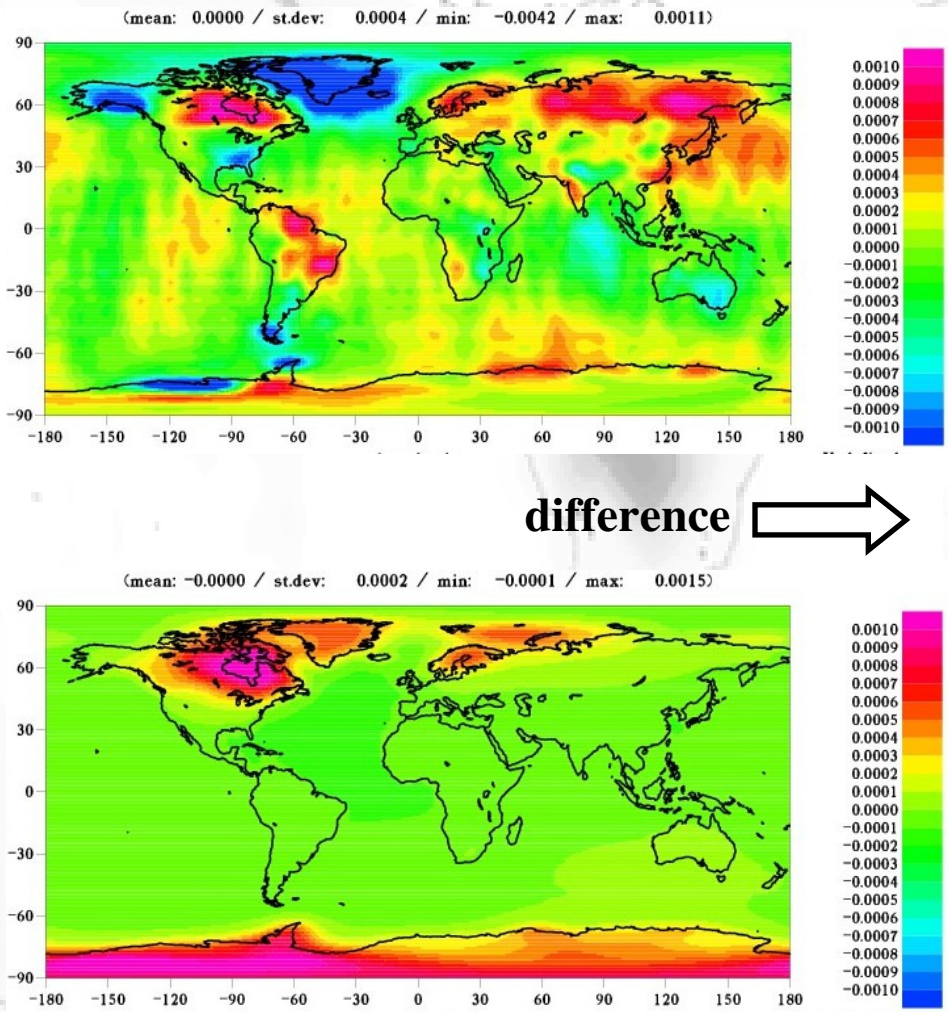


Do we really need gravimetry to study large earthquakes?

- We get additional information:
  - Post - seismic relaxation,
  - Mass redistribution,
  - Ocean or difficult to access areas.
- We do not need to have fast motion (silent earthquakes).
- Data accuracy/resolution will increase in the future (towards smaller magnitudes).

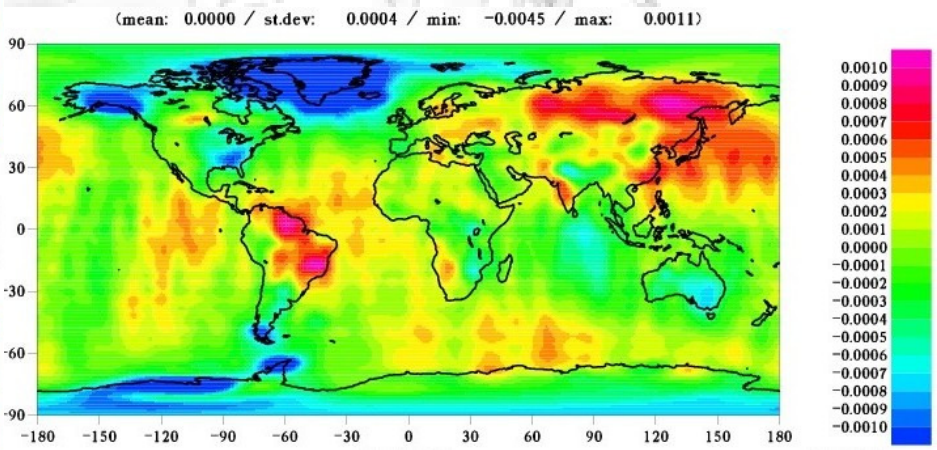
Glacial Isostatic Adjustment

Interpretations are very dependent on models used



Trend in geoid height (m/a)
from 6 years of GRACE data

EIGEN-GRGS model (2009)



Trend in geoid height (m/a)
from GIA

ICE4G model (Peltier & al., 1996)

Some concluding remarks

- We need to provide to other communities not only "traditional" gravity models in spherical harmonics/mascons… but "directly usable" products.
- This requires to better understand the requirements of these communities.
- Products are not really data but a combination of observations and model outputs. Their quality depends upon observations accuracy AND of model pertinence.
- Studies on data/methods combination and on sources separation should be pursued.