

# ESA mission GOCE for Gravity field and steady-state Ocean Circulation Explorer

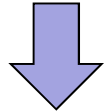
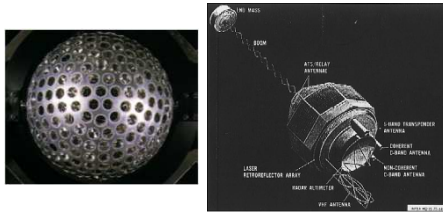
B. Christophe (ONERA)



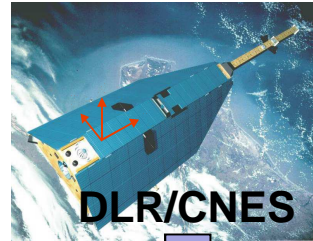
return on innovation

# Improvement of geoid

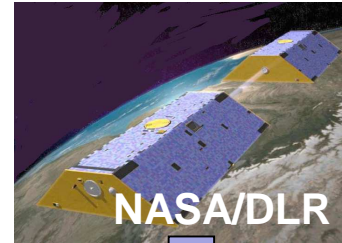
## LAGEOS-GEOS3



## CHAMP



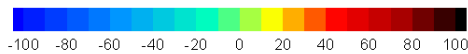
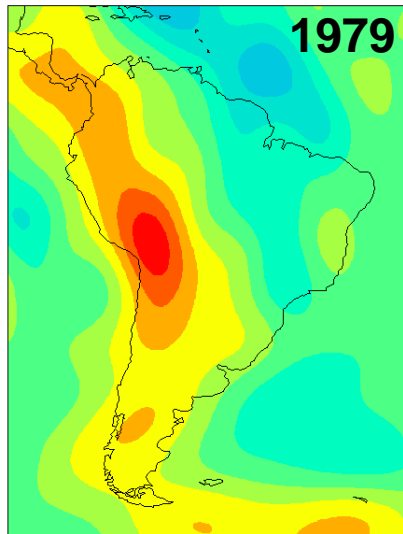
## GRACE



## GOCE

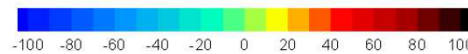
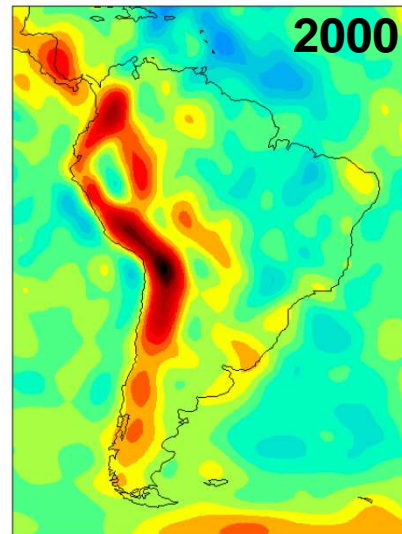


Free air gravity anomalies of South America (mGal)



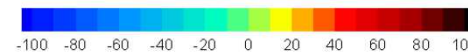
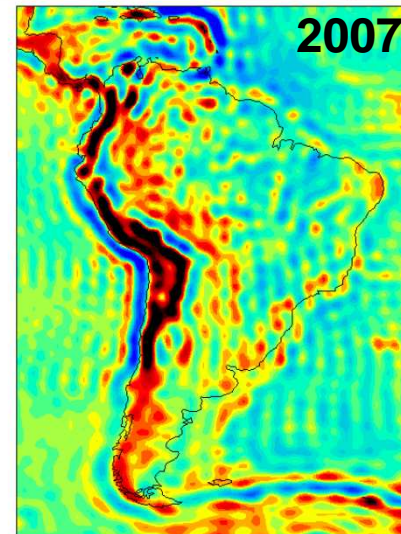
GEM9

*Lerch FJ et al. 1979*



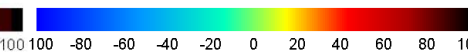
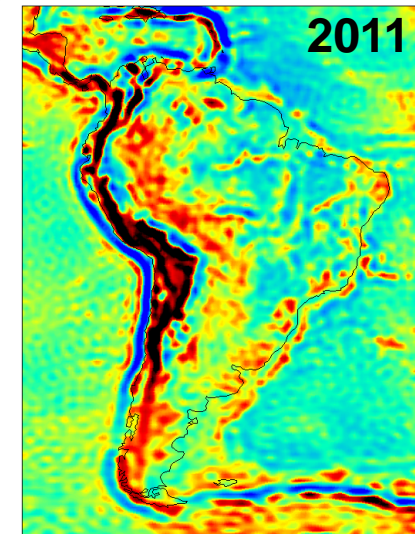
GRIM 5s

*Biancale R et al., 2000*



GGM03s

*Tapley et al 2007*



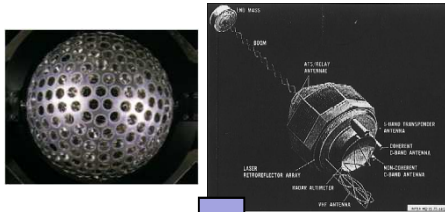
GOCE TIM4

*Pail et al 2011*



# Interest of the accelerometers

## LAGEOS-GEOS3



5 900 km

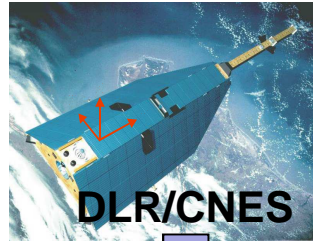
Altitude

Accelerometer

ONERA  
THE FRENCH AEROSPACE LAB

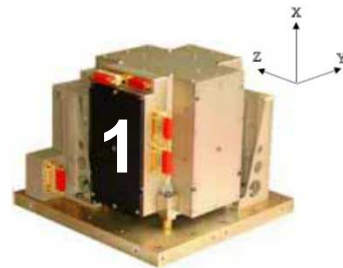
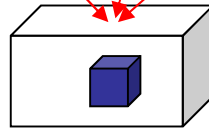
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## CHAMP

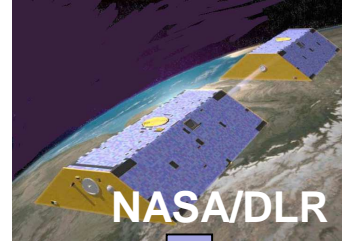


454 km

GPS GPS GPS

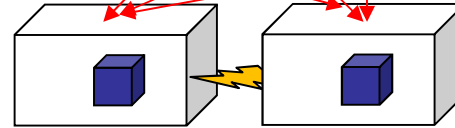


## GRACE



500 km

GPS GPS GPS

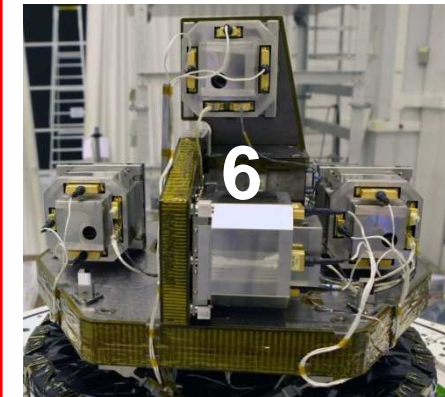
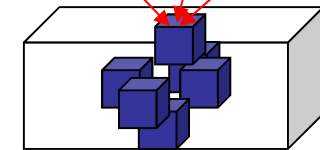


## GOCE

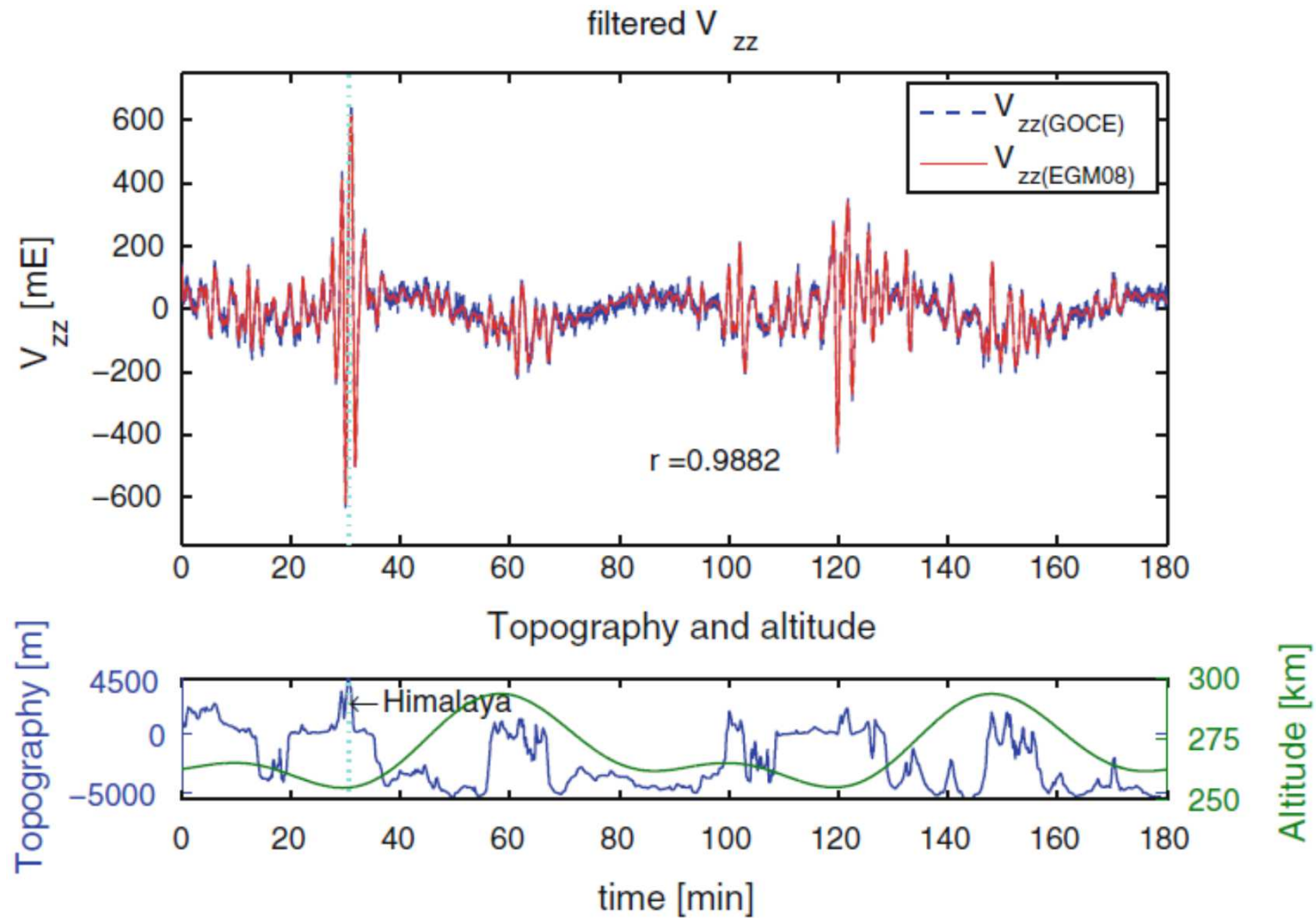


255 km

GPS GPS GPS



# Gravity gradient measurement and topography



Rummel, *Journal of Geodesy*, 2011

# GOCE, an industrial consortium for a technical challenge

**Satellite** ThalesAlenia Space  
A Thales / Finmeccanica Consortium

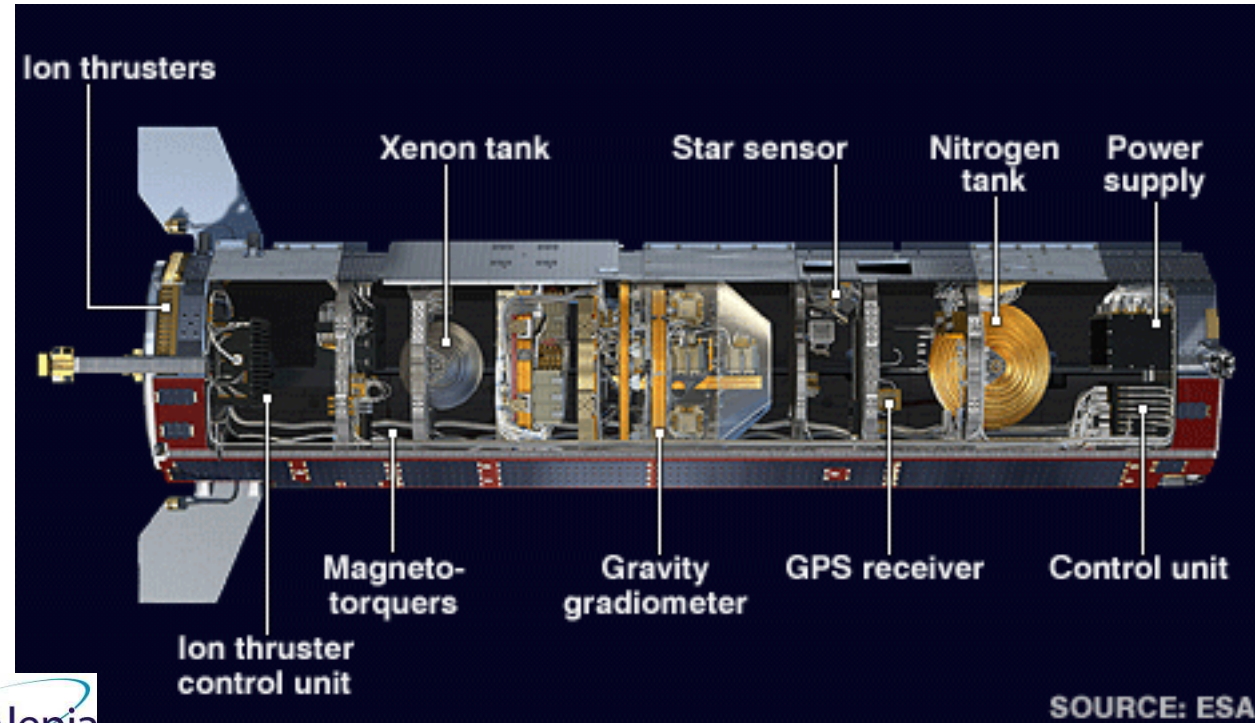
The Ferrari of space

**Platform**

AIRBUS  
DEFENCE & SPACE

Stable structure

**Ion Thruster**  
Drag-Free Actuator



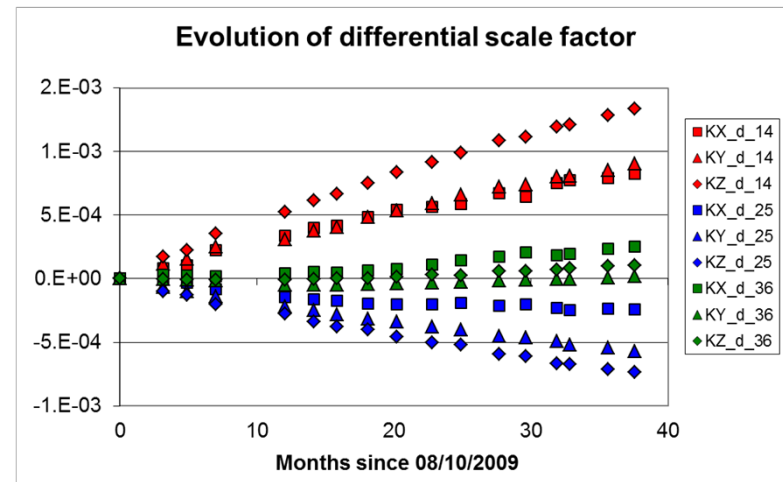
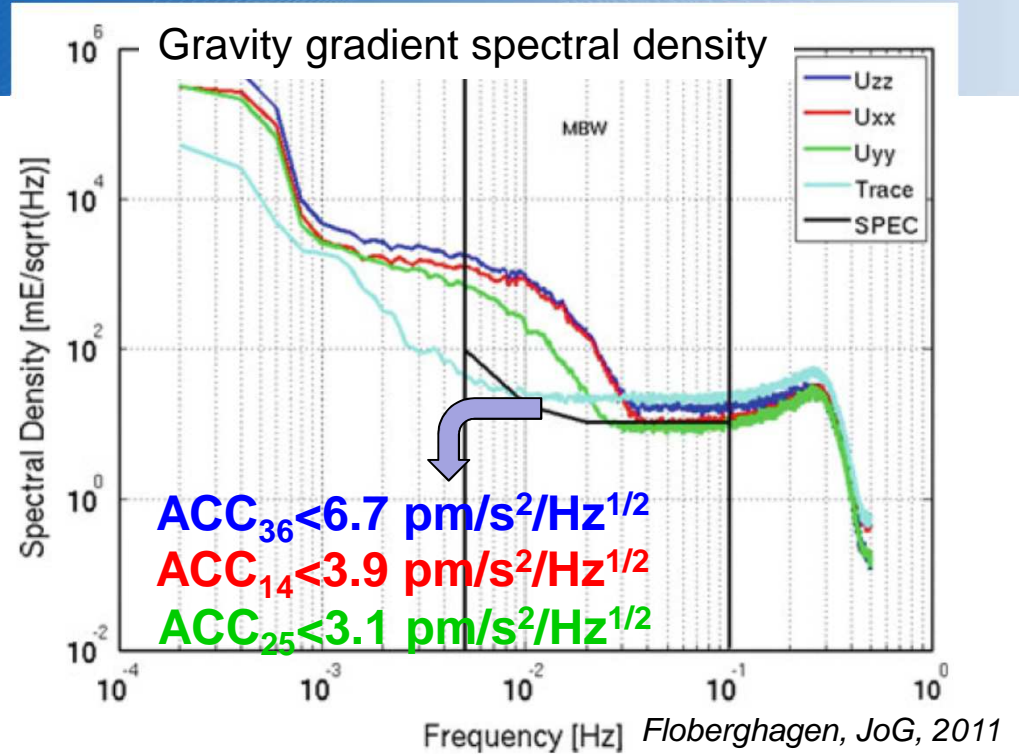
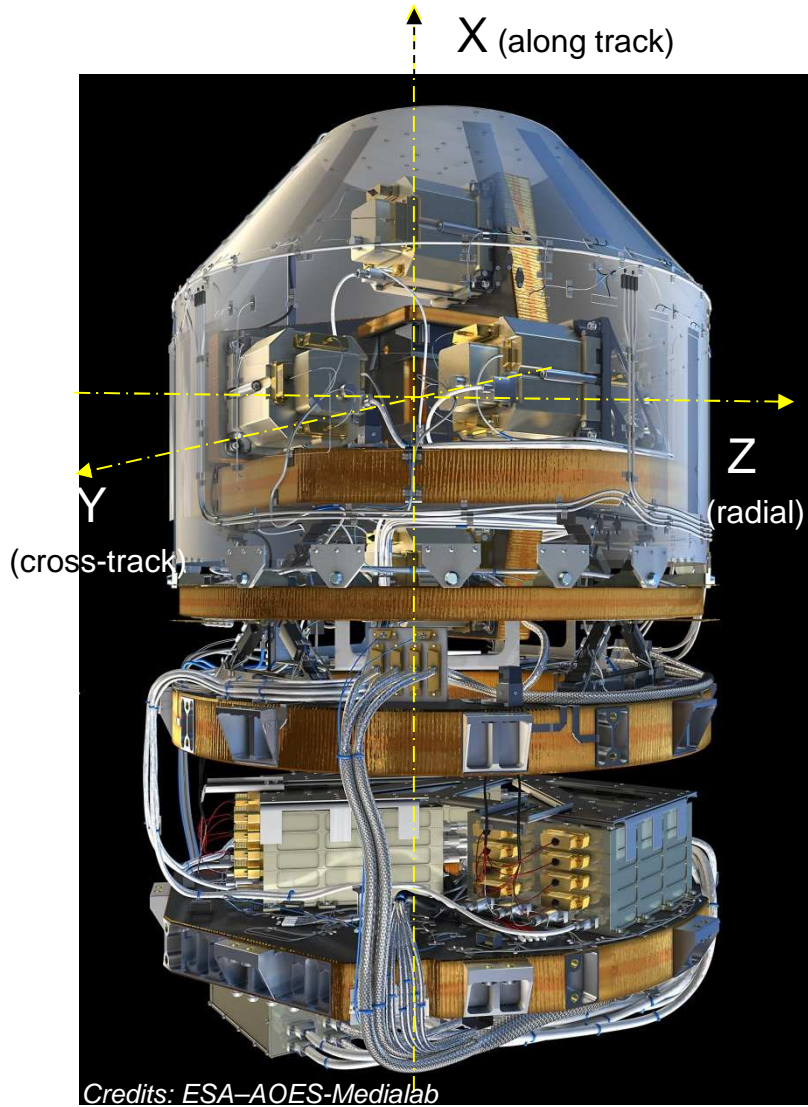
**Drag-free** ThalesAlenia Space  
A Thales / Finmeccanica Consortium  
Drag control loop

ThalesAlenia Space **Gradiometer** ONERA  
A Thales / Finmeccanica Consortium THE FRENCH AEROSPACE LAB

Gravity Gradient Measurement  
Drag-free Detector

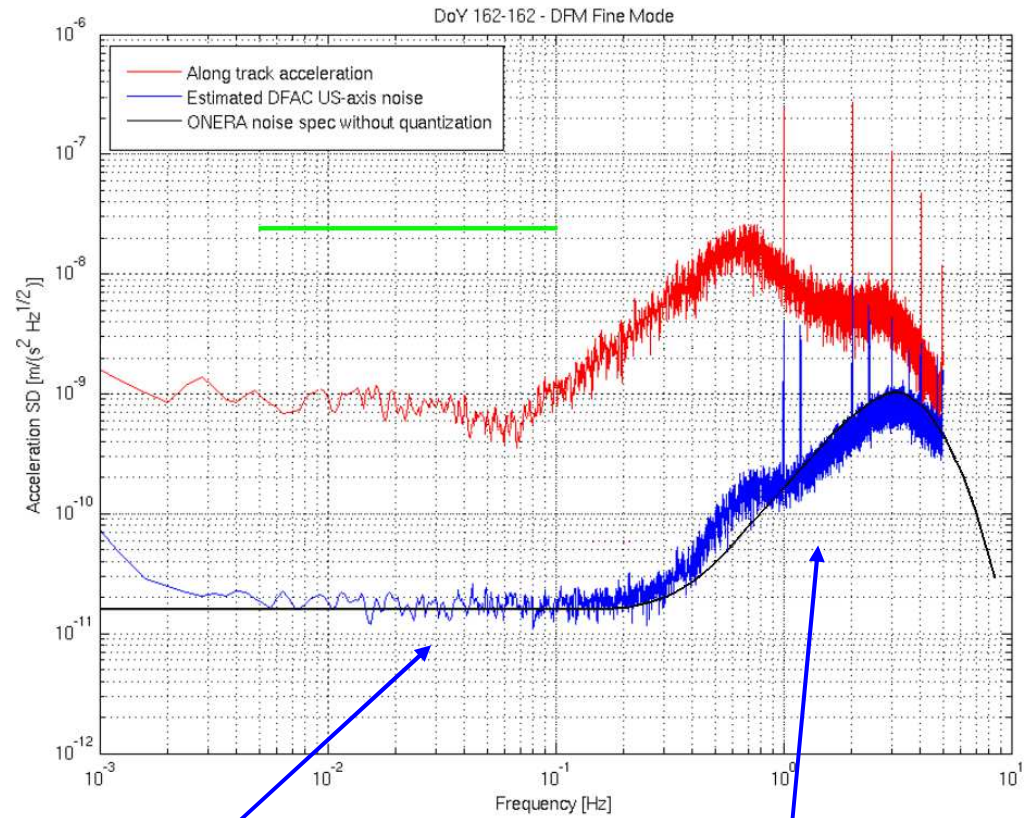
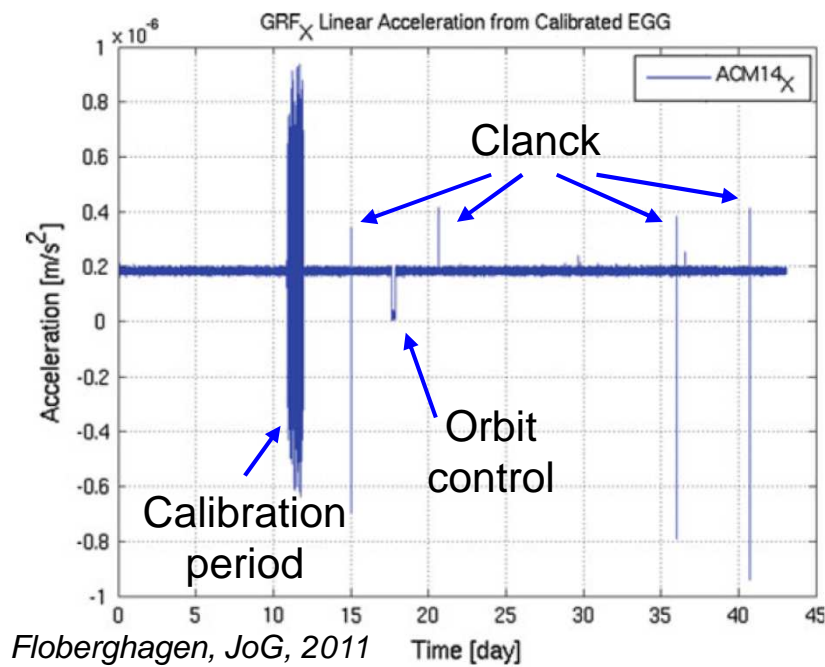


# GOCE, the gradiometer



# GOCE, Drag-free control

**GOCE is the first satellite with a drag-free control**



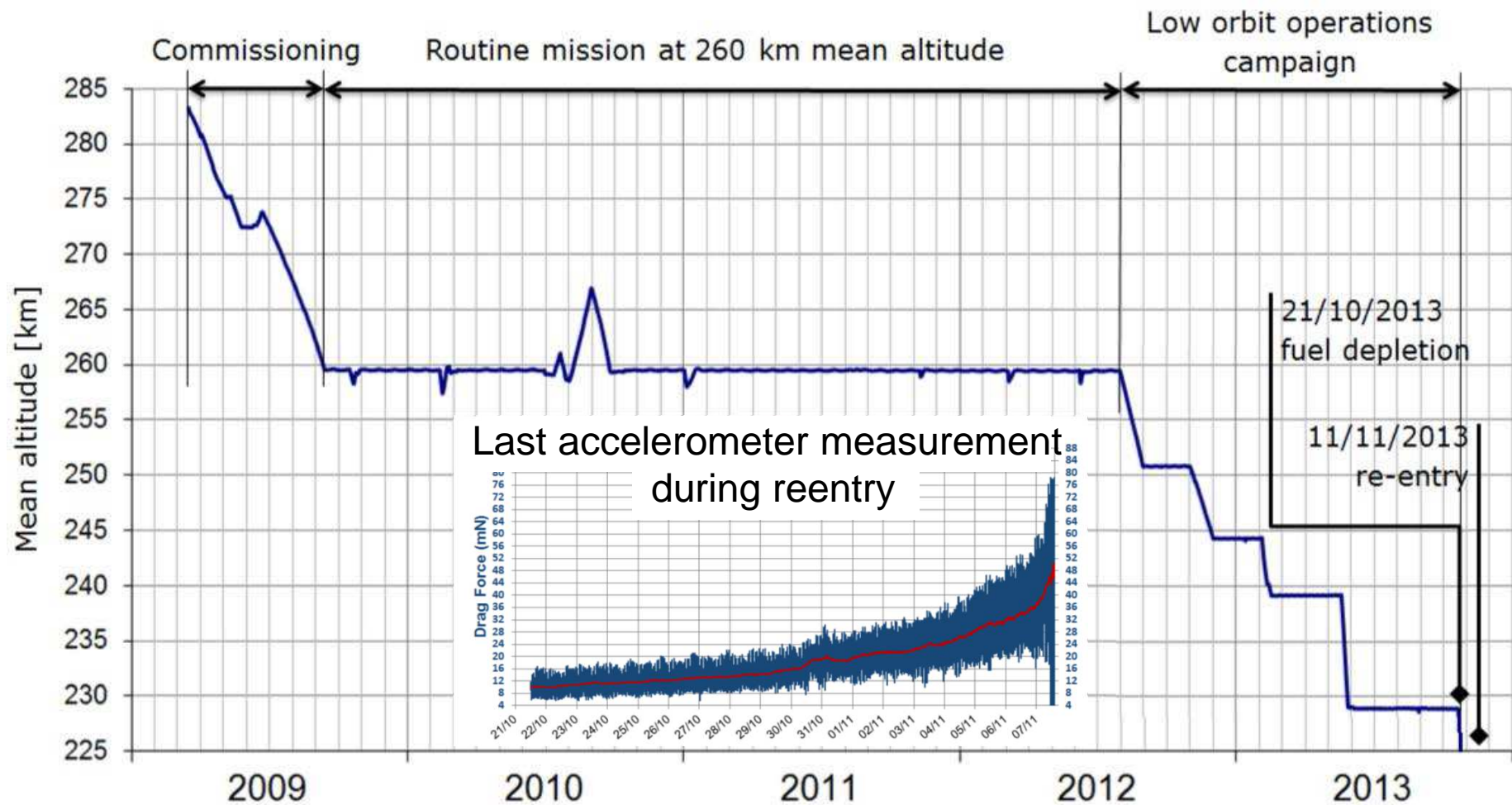
Actuation noise (DAC + DVA)  
main contributor  
in [ 10 mHz – 100 mHz ] MBW

Detection noise (detector + ADC1)  
main contributor  
in [ 0.5 Hz – 5 Hz ] MBW



# GOCE, 4.5 years of life

Nominal lifetime = 2 years

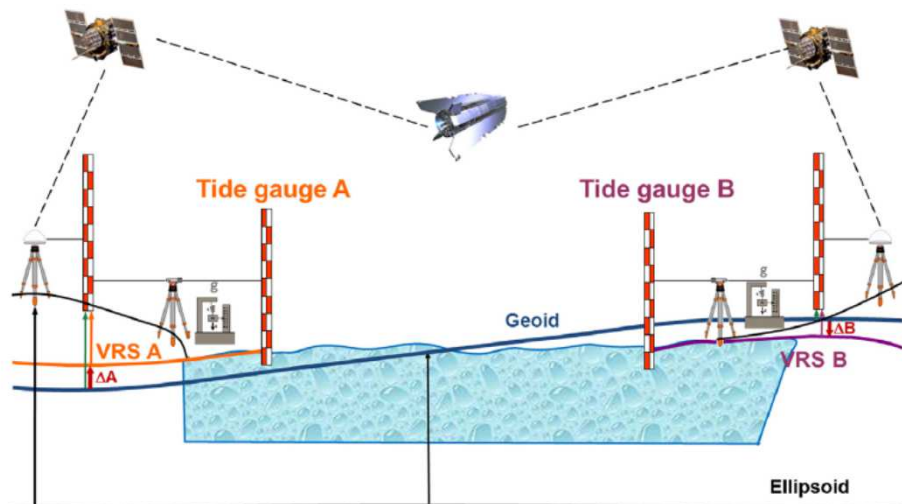


Floberghagen, GOCE Workshop, 2014



# GOCE Applications : Geodesy

## Global unification of height system



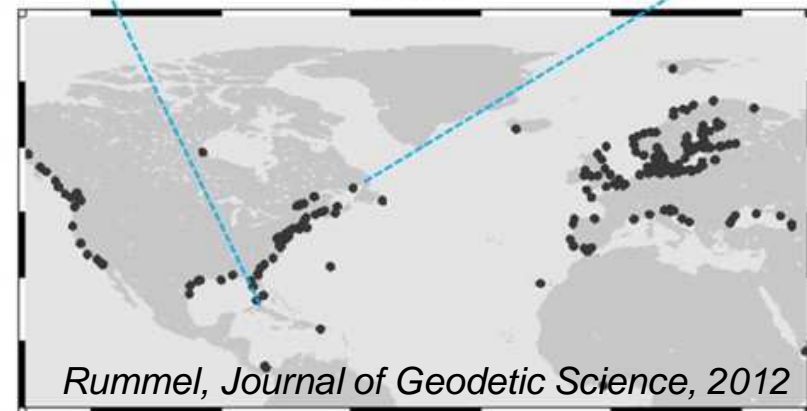
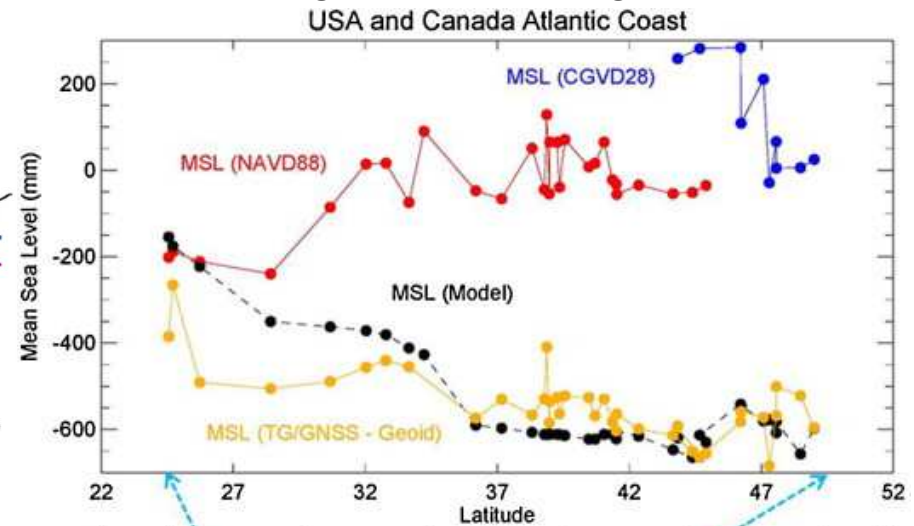
*Meide, Int. J. Appl. Earth Observ. Geoinf, 2013*

Difference between  
2 different national height systems :  
**2 m**

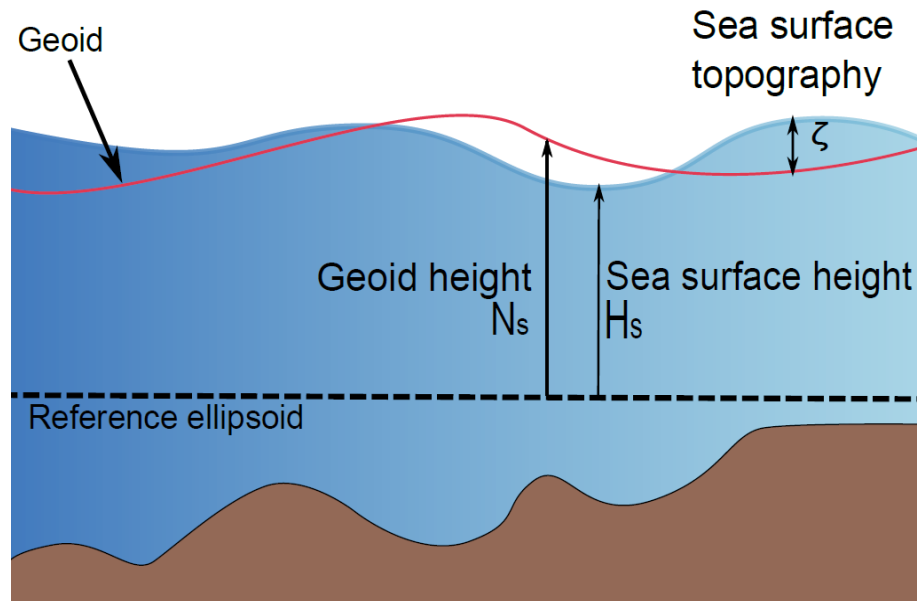
**With GOCE:**

- 4 cm well surveyed area
- 20/30 cm sparsely surveyed area

Historical controversy between  
oceanographers and geodesists

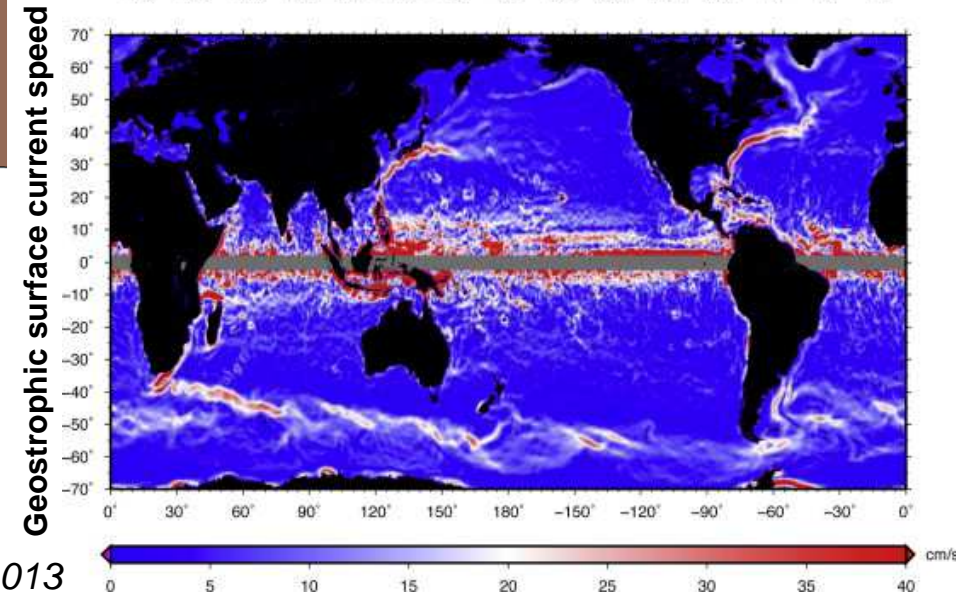
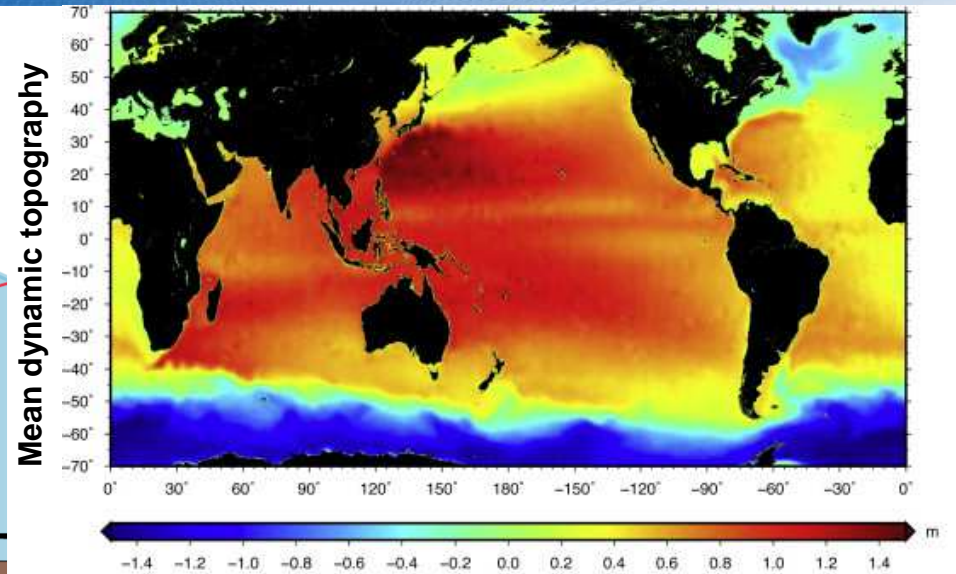


# GOCE Applications : Oceanography



$$\zeta = H_s - N_s$$

Altimetry (JASON) ←  $H_s$        $N_s$  → Gravimetry (GOCE)

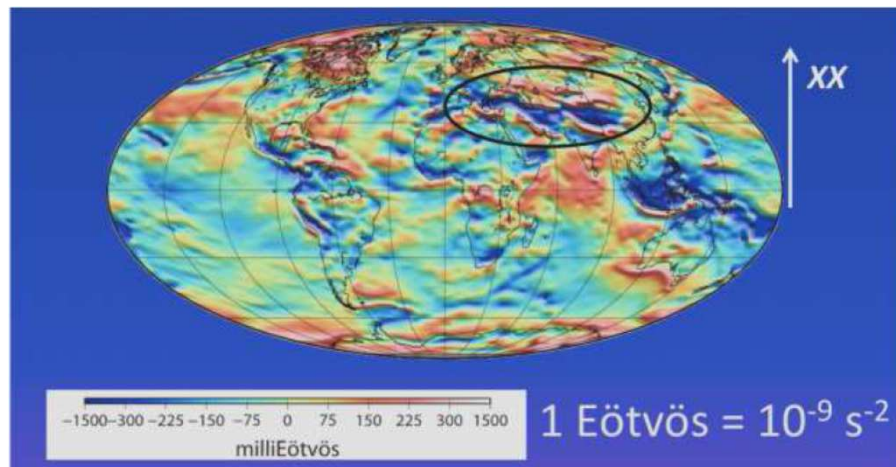
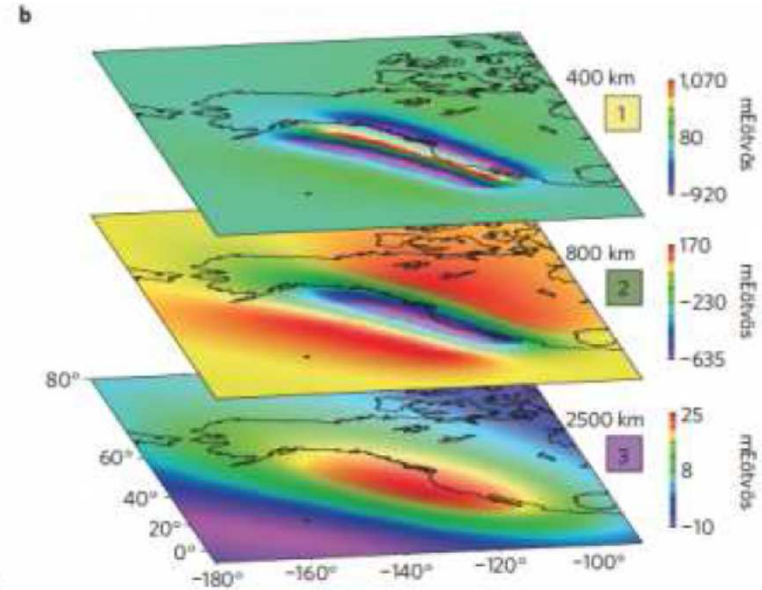
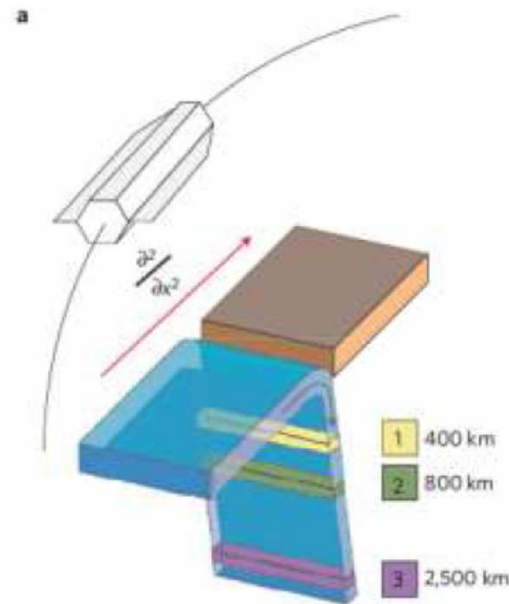


Meigde, *Int. J. Appl. Earth Observ. Geoinf*, 2013



# GOCE Applications: Solid Earth

Principle schematic of gravity gradient observation due to subduction plate.



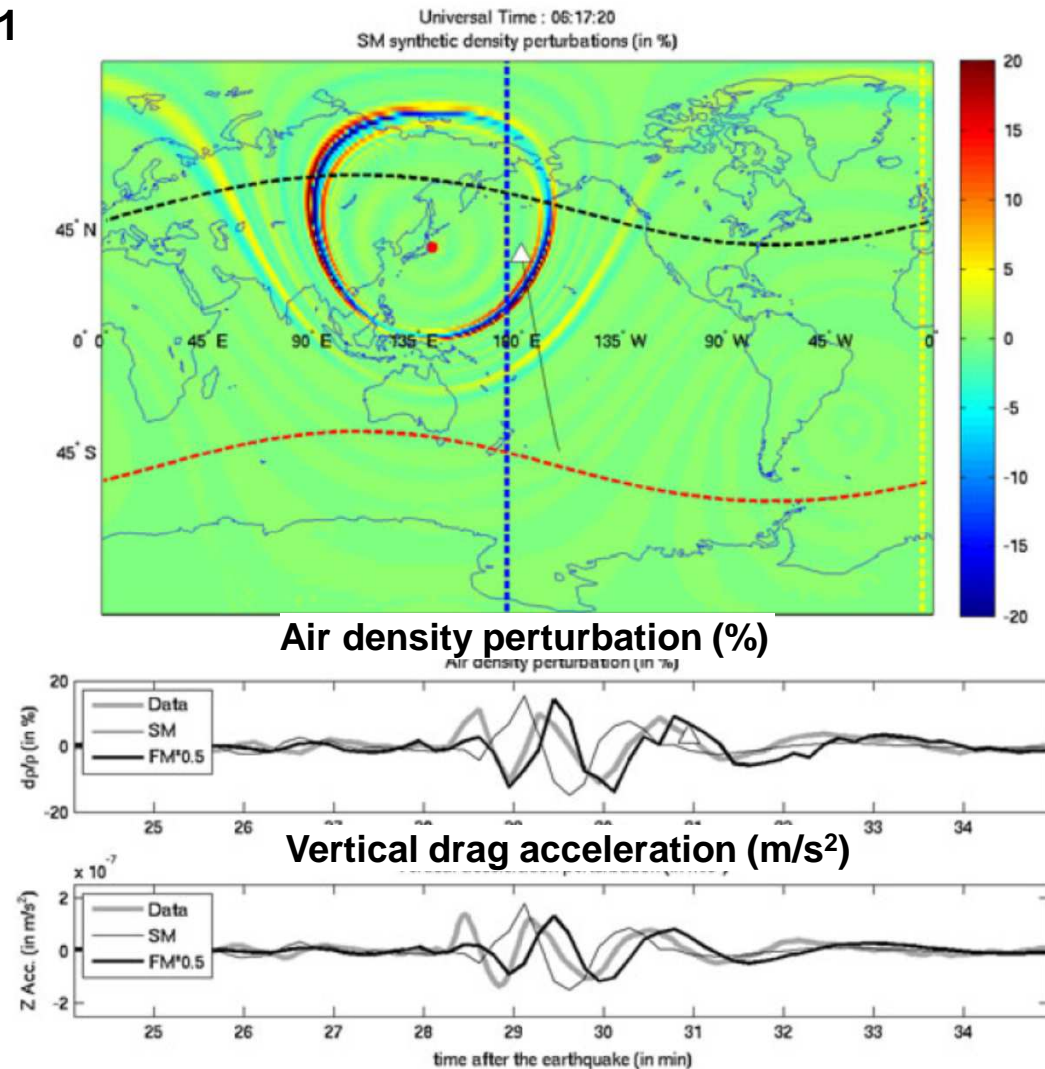
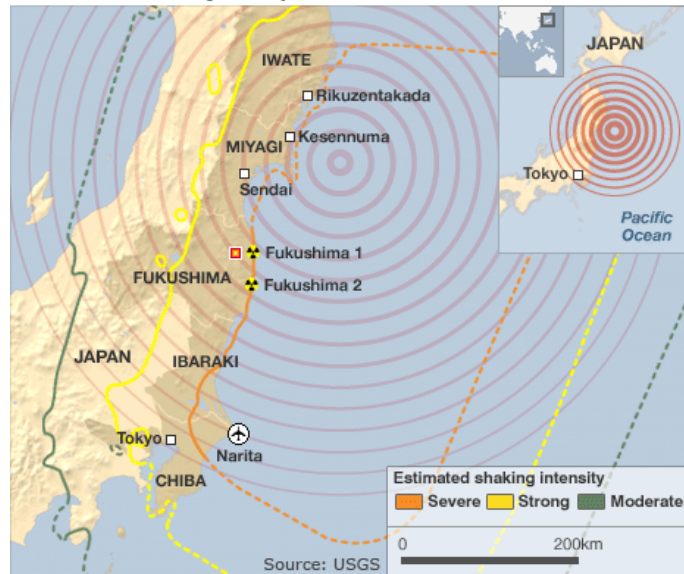
North-North gravity gradient anomalies  
Evidence of structures related to the ancient Téthys ocean.

*Panet et al. Nature Geoscience jan. 2014*

# GOCE, a seismometer in space

## Tohoku earthquake – 11 March 2011

Areas affected by the quake



Garcia, *Geophysical Research Letters*, 2013



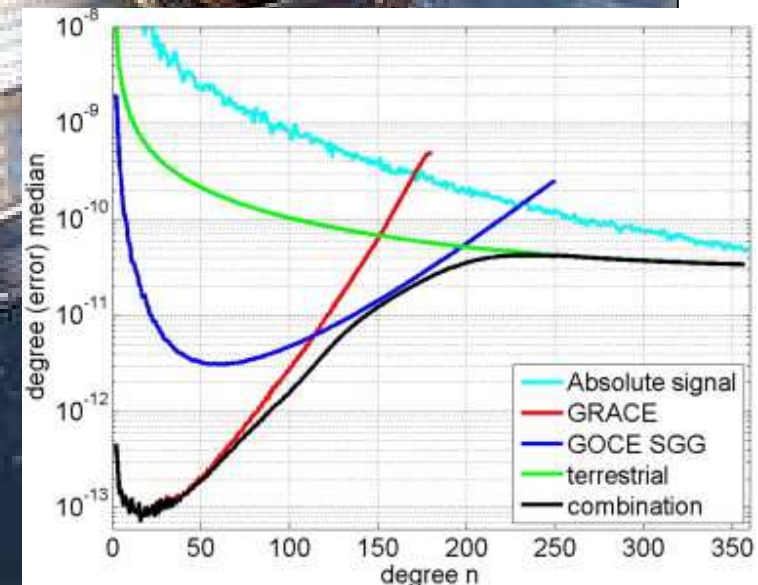
# Conclusions

## GOCE was a technical challenge

- Best accelerometers from the world
- Quietest satellite needed to exploit the gradiometer accuracy
- First drag free satellite, allowing 4.5 years at 255 km

## With several applications

- Improvement of the gravity field model
- Global unification of the height system
- Geostrophic surface current speed
- Detection of deep structure in the Earth



**A great adventure for the engineers who built GOCE**