Overview GOCE+ Studies

Johannes Bouman
with contributions from
Eelco Doornbos, Pavel Novak &
Reiner Rummel

ESA's STSE

- STSE: Support To Science Element
  - Scientific support for future and on-going missions
  - Ocean, atmosphere, cryosphere, land surface, **solid earth**, water cycle, carbon cycle, earth system
- GOCE+ has four themes
  - Theme 1: HSU (height system unification)
  - Theme 2: GeoExplore and GDC (solid earth)
  - Theme 3: Air Density
  - Theme 4: Time-Variations

Theme 1: Height System Unification with GOCE (STSE-HSU)

- kick-off: 19.4.2011
- team:

  IAPG, Technical University Munich (coordination)

  University of Calgary

  BKG, Frankfurt/Main

  NOC Liverpool

  consultants (national agencies (US, Canada, UK, Mexico)

  and experts from science

Objectives of STSE-GOCE+ HSU

The **nine items** of this study:

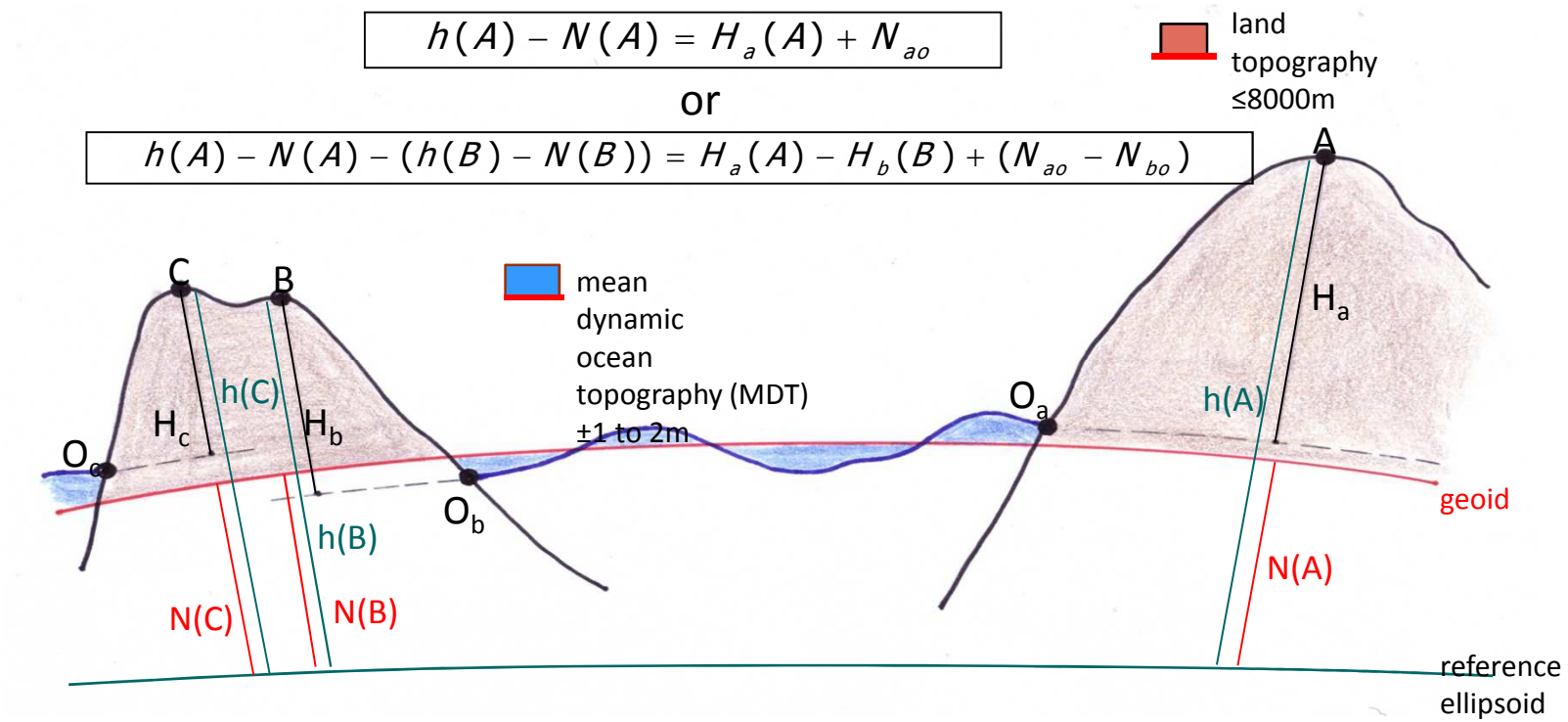
- State-of-the-art in height systems and their unification
- Quantification of known differences
- Review, evaluation and improvement of methodology
- Attempt of global height (and tide gauge) unification
- Selection of two test regions – effect of GOCE
- Effect of unification on local gravity and topographic heights
- Geophysical interpretation: dynamic ocean topography, currents,…
- Involvement of local/ national authorities
- Roadmap for future work using GOCE: world height system and vertical datum

Principle of Height System Unification

$$h(A) - N(A) = H_a(A) + N_{ao}$$

or

$$h(A) - N(A) - (h(B) - N(B)) = H_a(A) - H_b(B) + (N_{ao} - N_{bo})$$



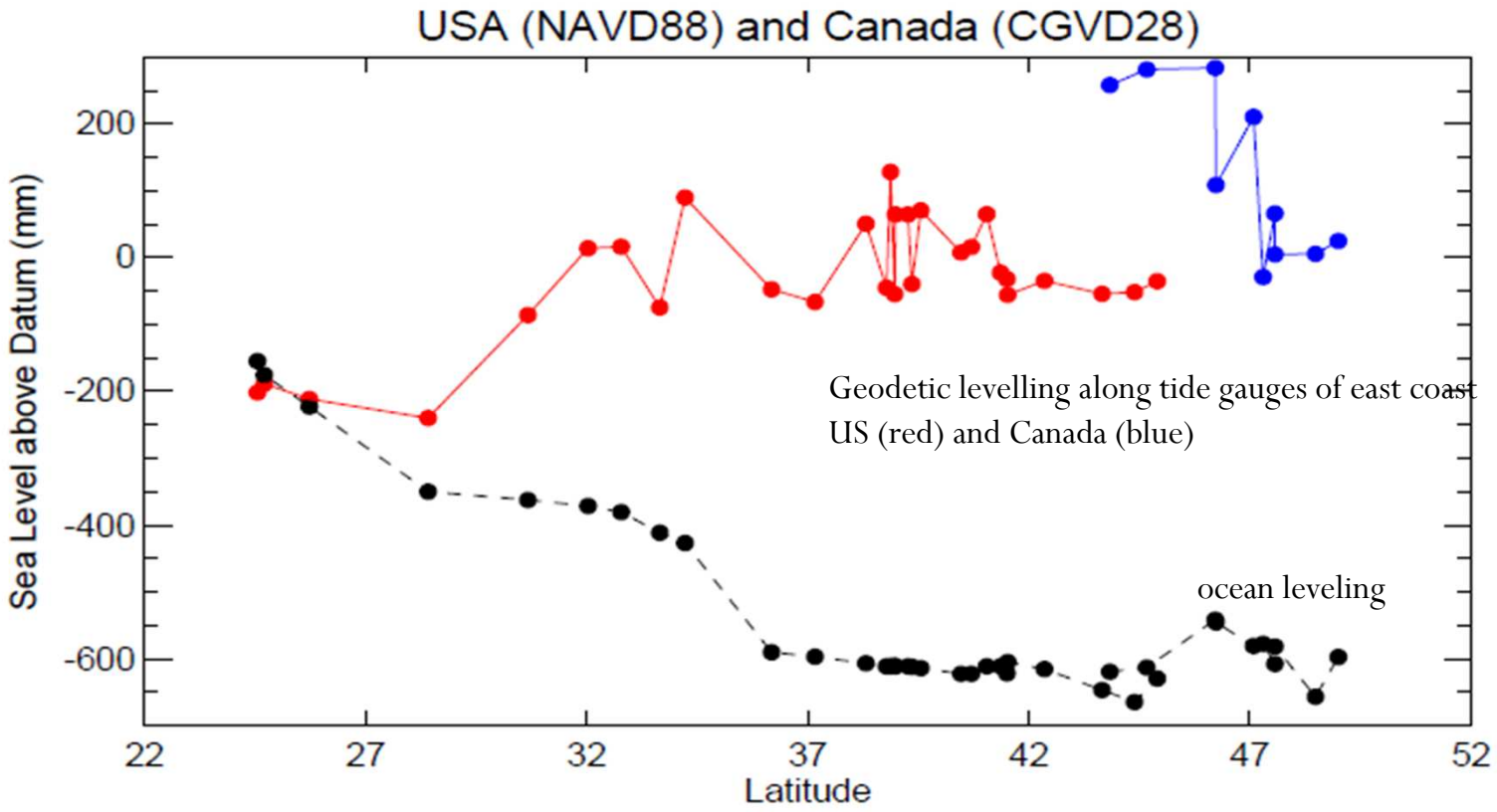
- apply principle of "GPS-levelling", i.e. *h* from GNSS or SLR and *N* from GOCE
- take into account short-wavelength geoid part (omission part)
- identify existing height off-sets
- create unified global height system

some preliminary results of STSE-GOCE+ HSU

- both height unification applying the GBVP-approach and the ocean method have been tested
- GBVP-approach: with the GOCE geoid model up to d/o 200 available the height off-set biases in the free air gravity anomalies may be neglected
- stochastic model: due to the error isotropy of GOCE its error variance-covariance matrix may be simplified (m-symmetry only)
- ocean method: a decennia old discrepancy between geodetic and ocean levelling along the East coast of North America could be resolved (Fig.A+B)
- height connection between USA, Canada, Europe, Japan and Australia could be successfully demonstrated (Fig.C)

highlight: sea level slope - geodetic versus ocean levelling

historical controversy: see (Sturges W, 1974 & Fischer I, 1975)

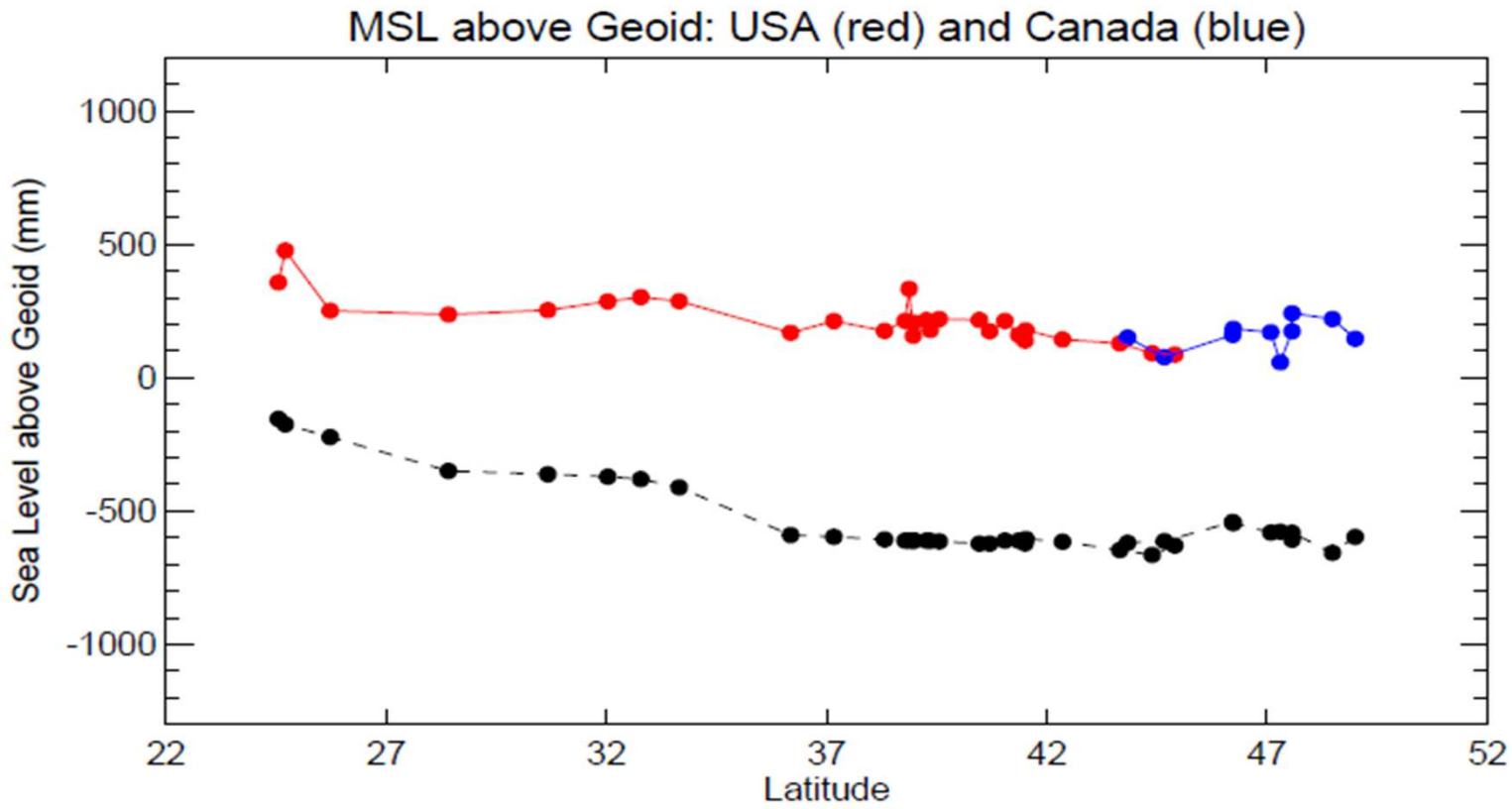


Comparison of geodetic leveling with Liverpool-MIT ocean circulation model

from ESA STSE-GOCE+ study: Height System Unification with GOCE // courtesy: Ph Woodworth

highlight: sea level slope - geodetic versus ocean levelling

discrepancy is resolved now

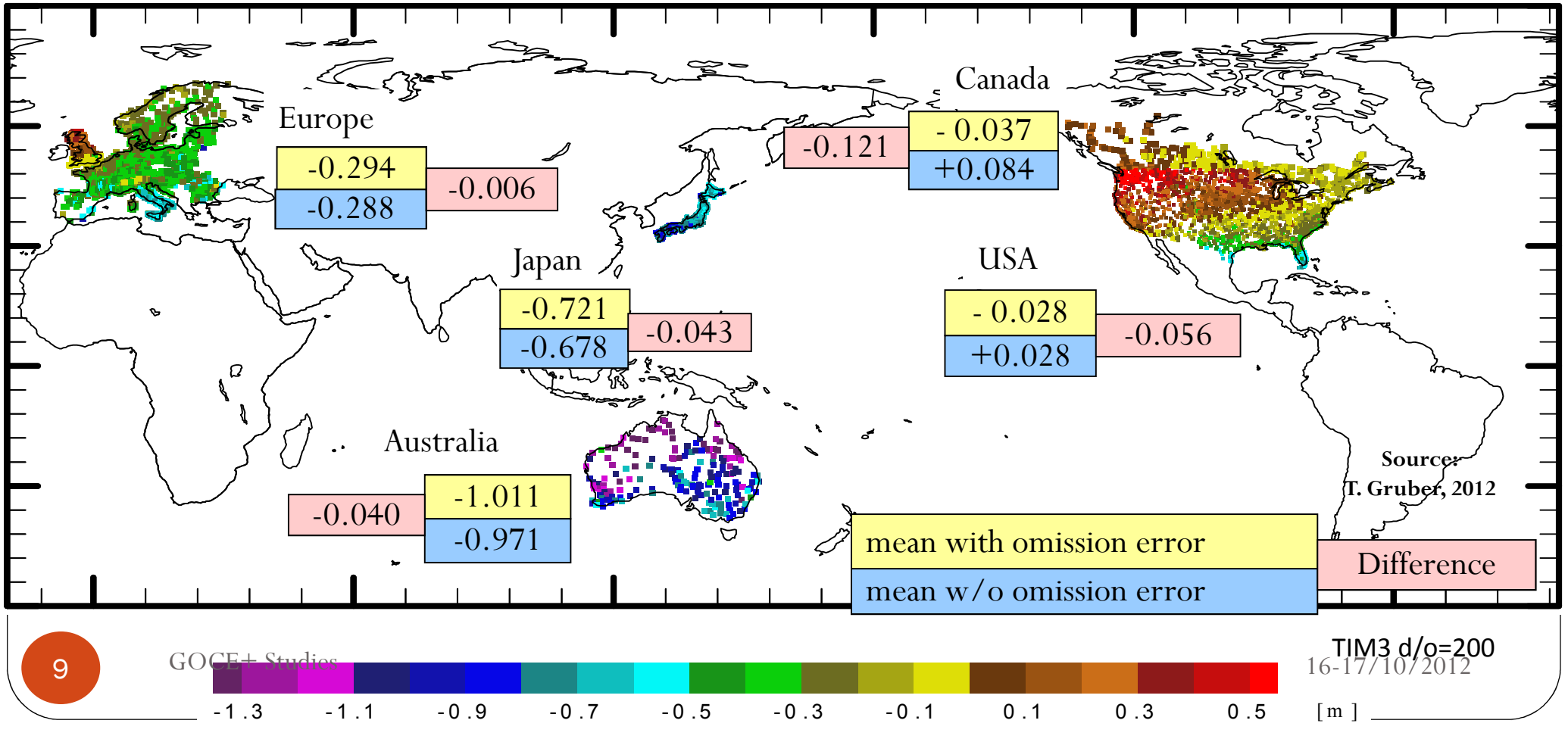


Comparison of GPS-levelling (using extended GOCO03s) with Liverpool-MIT OCM

from ESA STSE-GOCE+ study: Height System Unification with GOCE // courtesy: Ph Woodworth

highlight: height off-sets between well surveyed regions

preliminary tests show: using the GOCE geoid and modeling of the omission part with EGM2008 in well surveyed countries leaves an uncertainty of below 10cm (Gruber et al., 2012)



Towards a better understanding of the Earth's interior and geophysical exploration research – "GOCE-GDC"

ESA GOCE+ Theme 2 project

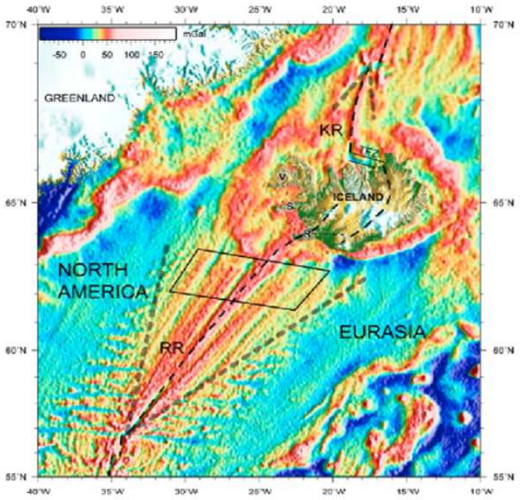
consortium of 6 institutes

geodesy: estimation of gravitational gradients at mean satellite and ground levels

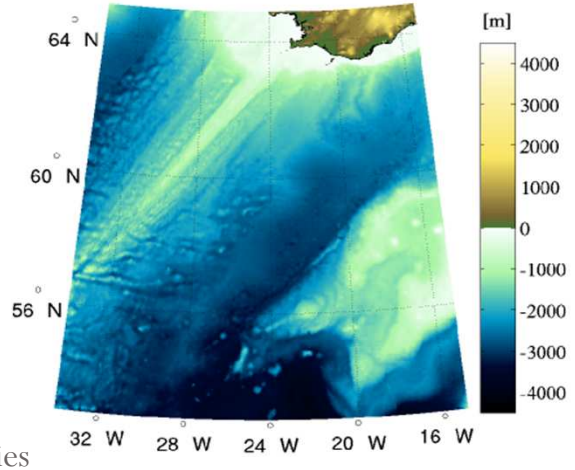
geophysics: improved crustal modelling over two geographical areas

Area A: Reykjanes Ridge

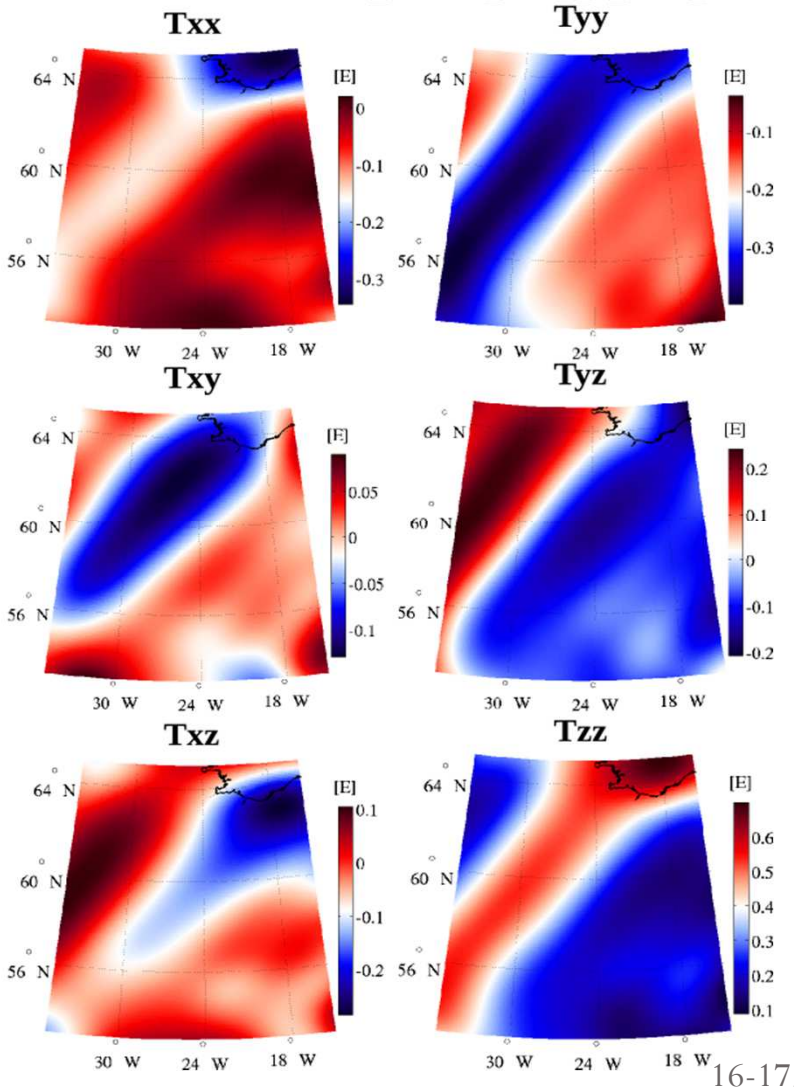
Gravity anomaly in mGal



Topography from ETOPO1



GG from GOCE model GO_CONS_GCF_2_DIR_R3

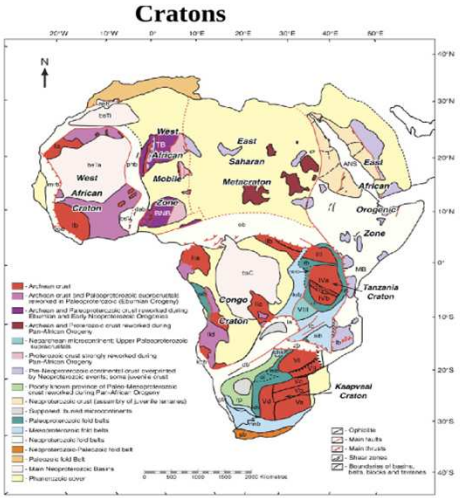


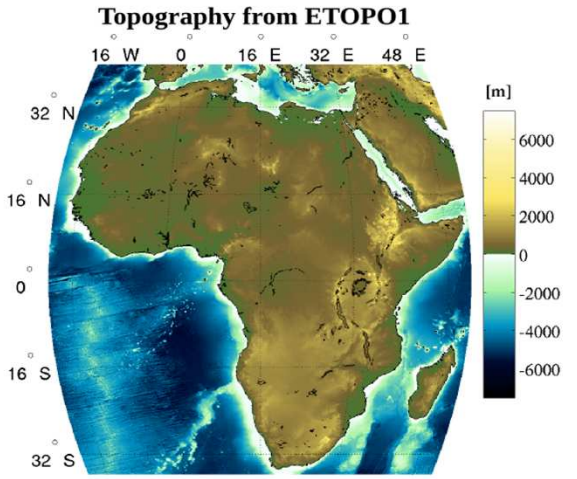
Geophysics over the area A

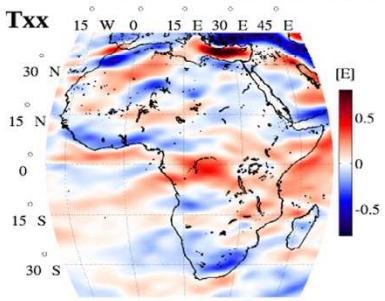
Research objectives:

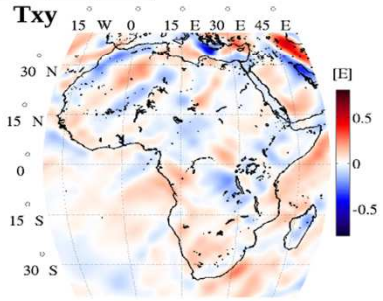
- forward modelling using the spectral method and CRUST 2.0 model crustal densities for sensitivity analysis
- advanced forward modelling by taking into account the finer crustal structure
- improving parameters in the advanced model in an iterative fashion
- Scientific interpretation in terms of structure and dynamics of the mid-ocean ridge.

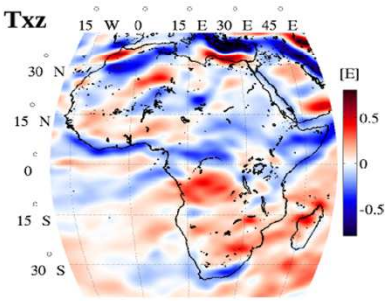
Area B – African continent

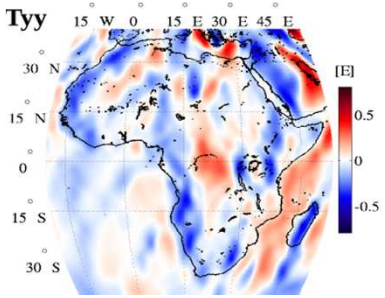


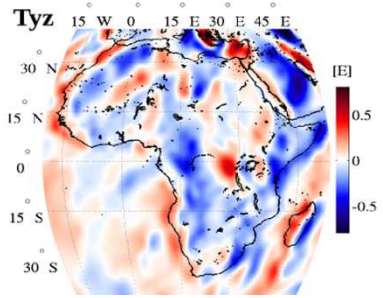


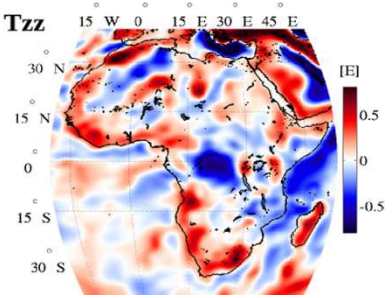












Geophysics over the area B

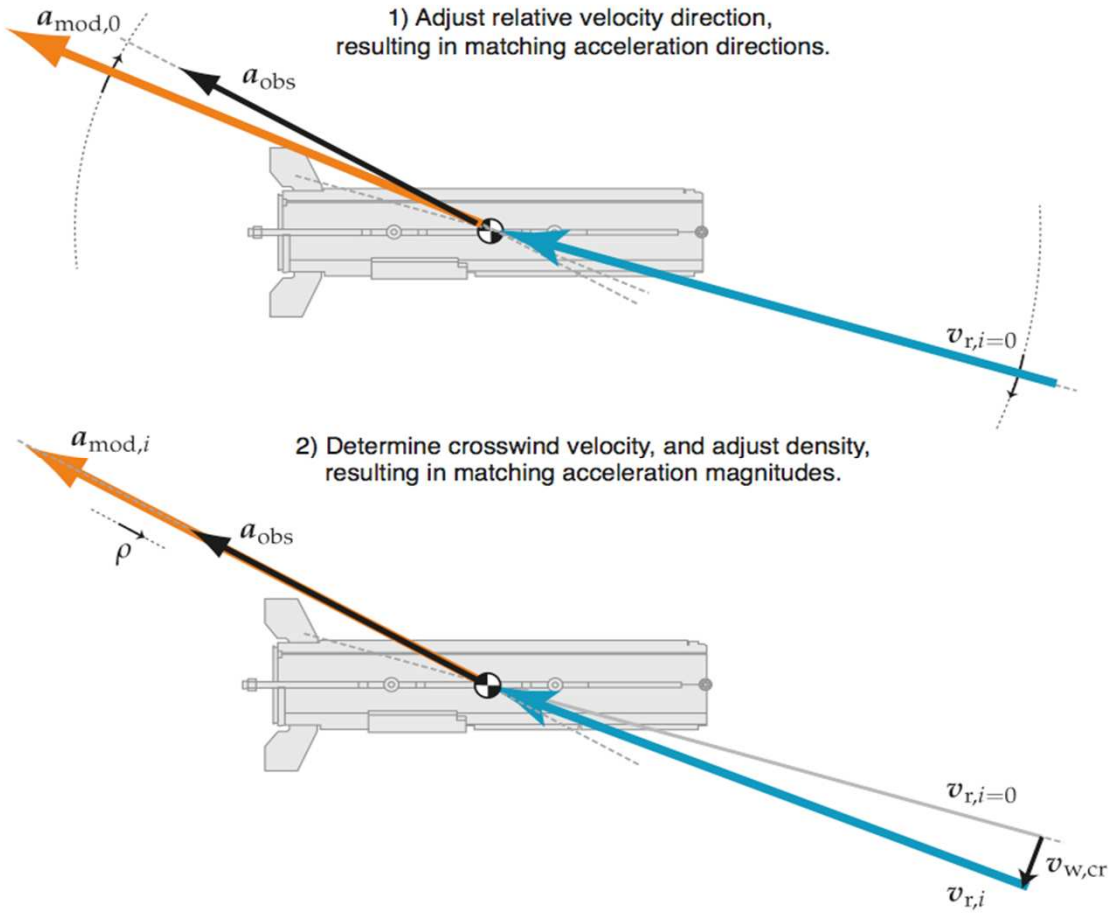
Research objectives:

- The African continent as an application area where gravitational gradients complement other data that have already been used for geophysical modelling (topography, crustal thickness, seismic tomography, conversion from seismic tomography to densities).
- To demonstrate and assess benefits of combined spaceborne gravitational gradients with near surface data in simulation experiments and to model geophysical phenomena based upon real gravitational gradients.

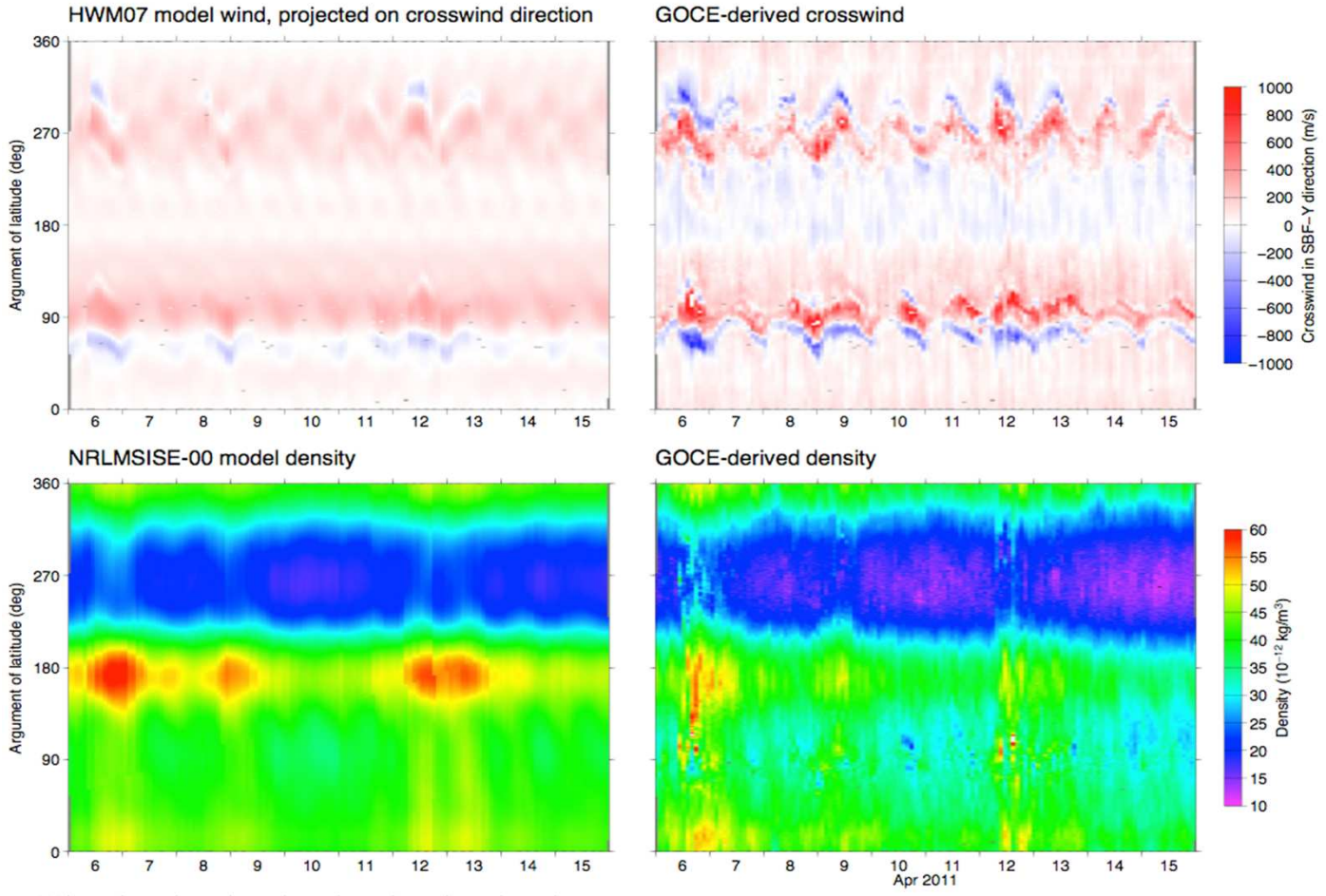
Theme 3: GOCE+ AirDensity

- Derive algorithms to retrieve thermospheric density and winds using GOCE common-mode accelerations and DFAC data
- Team:
  - TU Delft: Delft University of Technology, Netherlands
  - CNES: Centre National d'Etudes Spatiales, France
  - HTG: Hyperschall Technologie Göttingen, Germany

Theme 3: GOCE+ AirDensity



Theme 3: GOCE+ AirDensity



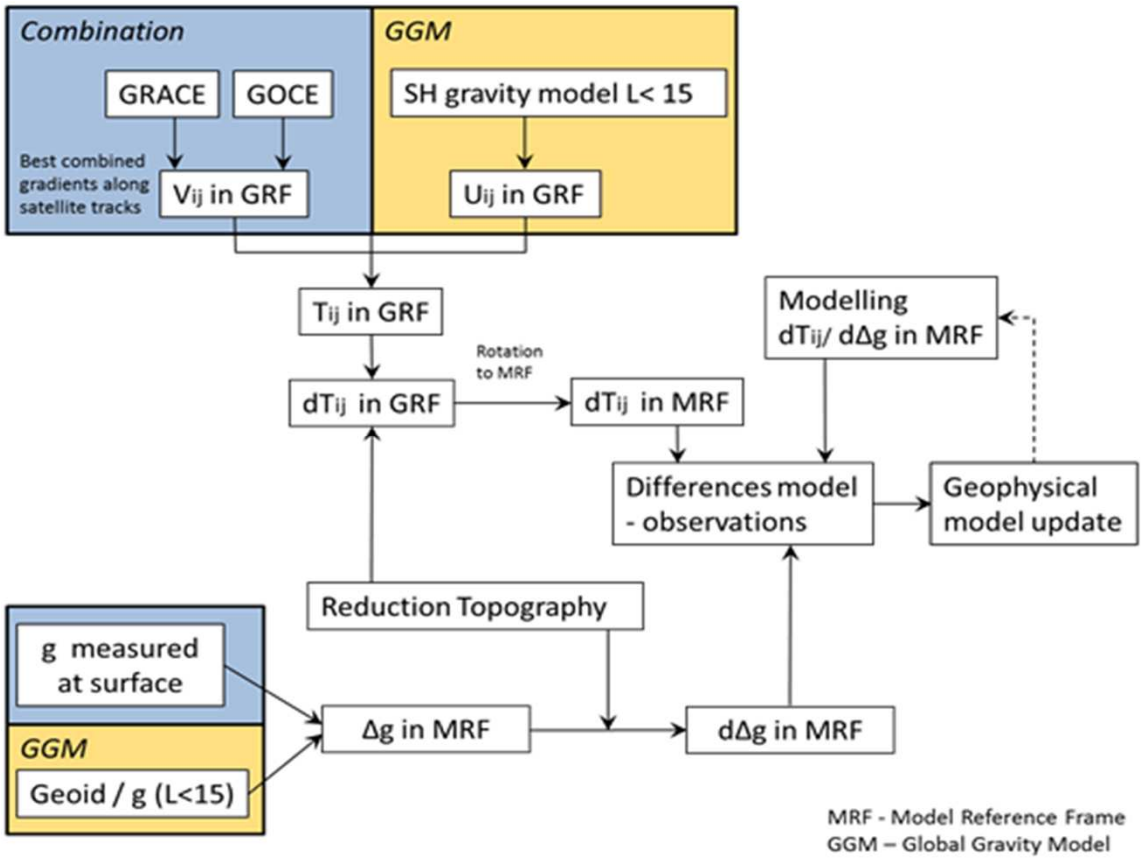
Theme 4: GOCE+ Time-Variations

- Greenland Ice Masses
- Megathrust earthquakes
- Team
  - DGFI (Gradient and gravity field analysis)
  - TU Delft (Forward modelling and interpretation)
- April 2011 – October 2012
- More details in last presentation of this session

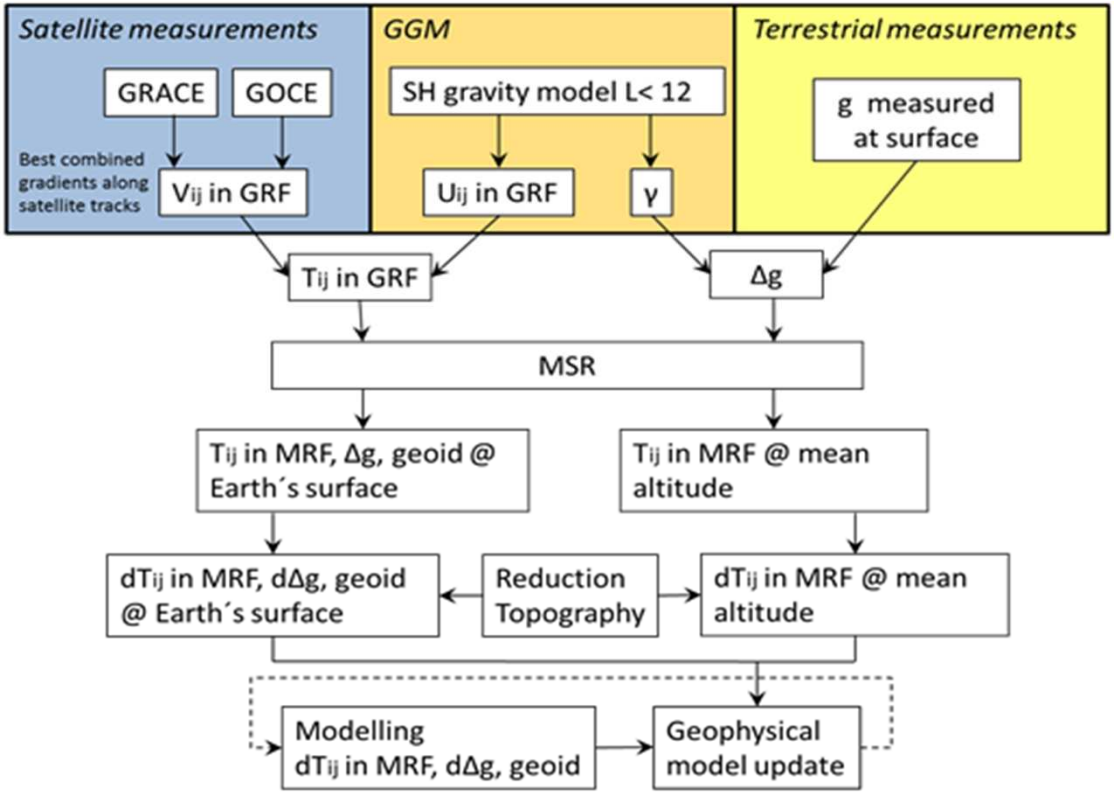
Theme 2: GOCE+ GeoExplore

- GOCE gravity gradients
  - improved modelling of lithosphere and mantle composition
  - better understanding of Earth's dynamic processes
- Impact assessment for North-East Atlantic margin
  - Well surveyed area (gravity, seismics, magnetics, …)
  - Reliable lithospheric models exist
- Application to Rub' al Khali (Saudi Arabia)
  - Frontier area
  - Knowledge transfer from NEA

Direct use of GOCE and other data



Using regional gravity fields



Theme 2: GOCE+ GeoExplore

- Team
  - DGFI (GG preparation, combination with terrestrial gravity data) [GG data sets discussed yesterday], [Lieb et al., Greenland]
  - NGU (Impact assessment case study North-East Atlantic margin) [See next presentation]
  - TNO (Application to Saudi Arabian Peninsula) [See presentation Abdul Fattah et al.]
- April 2011 – April 2013