The geodetic mission phase of Jason-1:
Benefits for regional marine gravity field modeling

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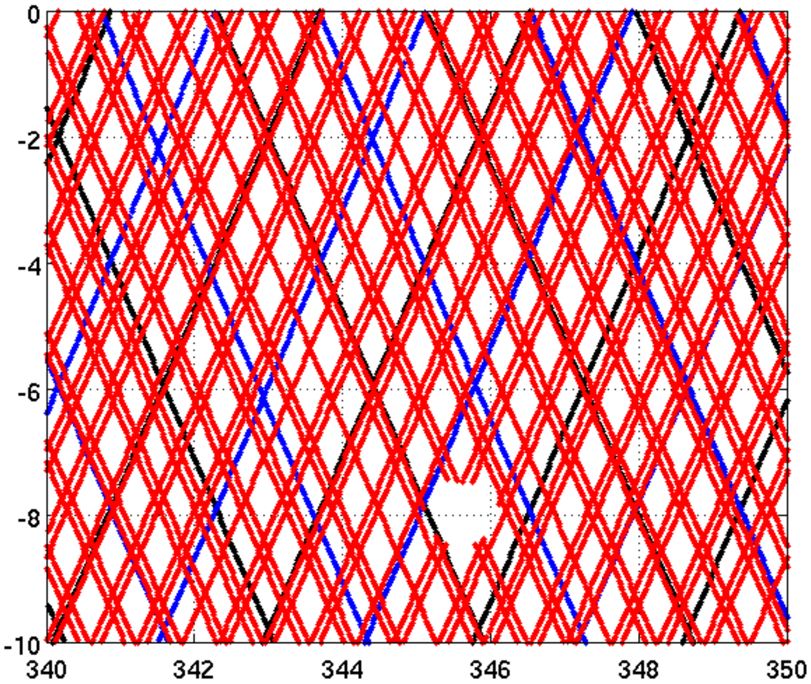
Orbit characteristics:

- Semi major axis 7702.437 km
- Eccentricity 1.3 to 2.8e-4
- Altitude equator 1324.0 km
- Orbital period 6730 sec
- Inclination 66.042°
- Cycle 406 days
- Subscyle 10.9 days

Ground track pattern:



Jason-1 (10 day repeat)
Jason-1 extended mission (10 day repeat)
Jason-1 geodetic mission (~100 days of 406 day repeat)

Data availability:

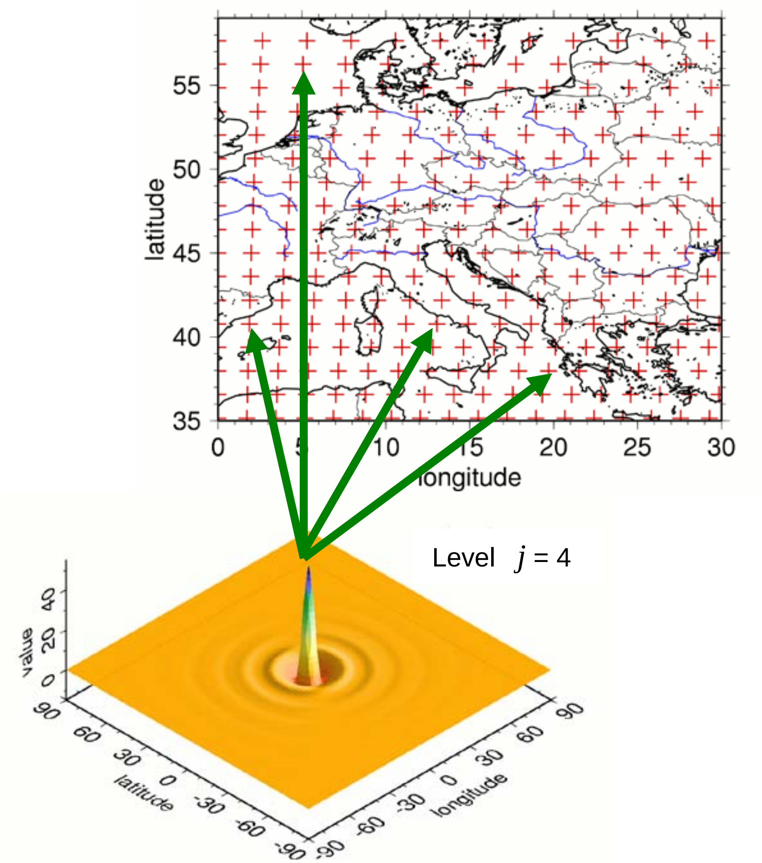
IGDR data (cycle 500-510)

2012, May 07 - August 26 (3.5 month)

We use 1Hz data with models included in IGDR and EOT11a ocean tides

Schmidt et al., (2007):
Regional Gravity Modelling in Terms of Spherical Base Functions
J Geod, 81

- We model differences to a given background model.
- We use spherical base functions (scaling functions) which are isotropic.
- The shape of the function is given by its level j. The higher the level the sharper the function and the more functions are needed to cover the region. For a high spatial resolution a high level is necessary.
- Each scaling function is located at a fixed position on the sphere.
- These positions are defined on a grid, e.g. a Reuter grid.



Relations between resolution level j, max. deg. n of SH, and spatial resolution r [km] $n = 2^j - 1$

j	1	2	3	4	5	6	7	8	9	10	11	12
n	1	3	7	15	31	63	127	255	511	1023	2047	4095
r[km]	20000	6667	2857	1333	645	317	157	78	39	20	10	5

Input Data:

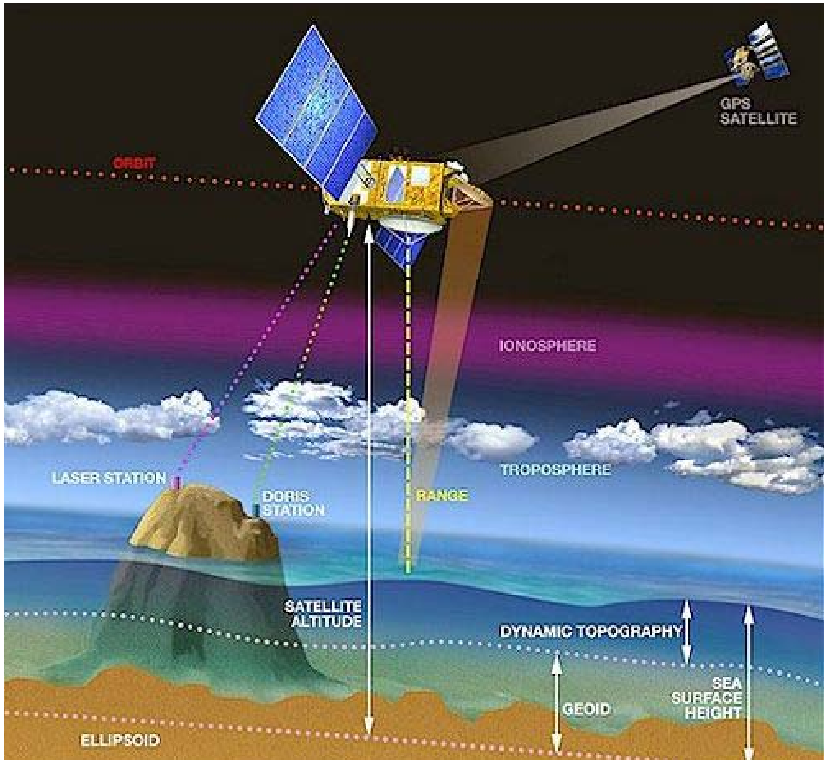
- Sea Surface Height ***SSH***
  [corrected & cross-calibrated]
- Dynamic Ocean Topography ***DOT***
  [Profile Approach: Bosch & Savcenko (2010)]

=> Geoid N

$$\boldsymbol{N} = \boldsymbol{SSH} - \boldsymbol{DOT}$$

=> Perturbation potential T

$$\boldsymbol{T} = \boldsymbol{\gamma N}$$



Credits: CNES/D.Ducros

Observation equation:

$$T(\boldsymbol{x^i}) + e(\boldsymbol{x^i}) = T_{back}(\boldsymbol{x^i}) + \sum_{q=1}^{N_J} d_{J,q}\, \widetilde{\Phi}_{J+1}\,(\boldsymbol{x^i}, \boldsymbol{x_q})$$

background model

unknown coefficients

scaling functions

$$\widetilde{\Phi}_{J+1} = \frac{1}{\gamma} \sum_{l=0}^{l_{J'}} \frac{2l+1}{4\pi} \left(\frac{R}{r}\right)^{l+1} \Phi_{J+1,l} P_l(\boldsymbol{x^i}, \boldsymbol{x_q})$$

γ … *normal gravity*
x^i, x_q … *position vector of observations i and grid points q*
e … *measurement error*

South Atlantic (SA1)

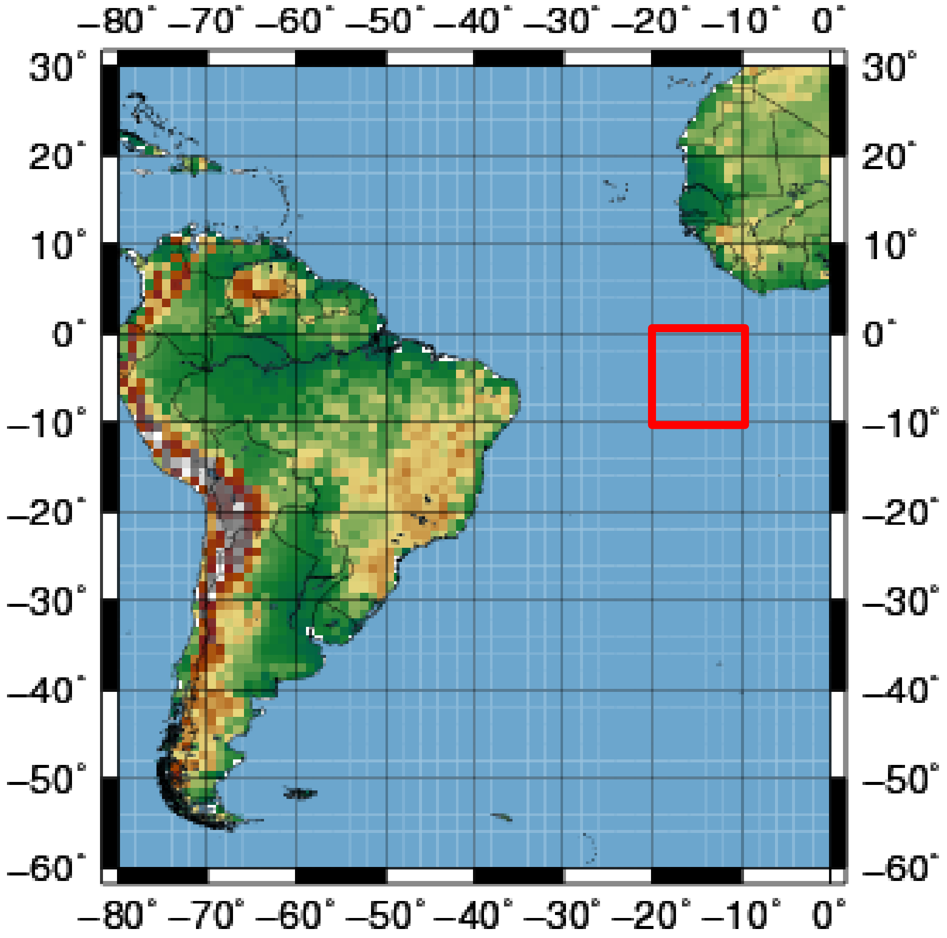
10 x 10° open Ocean
Including the Mid-Atlantic Ridge
Gravity Anomalies: ± 150 mgal

Altimeter missions:
- Jason-1 GM
- Cryosat-2 LRM
- ERS-1 GM

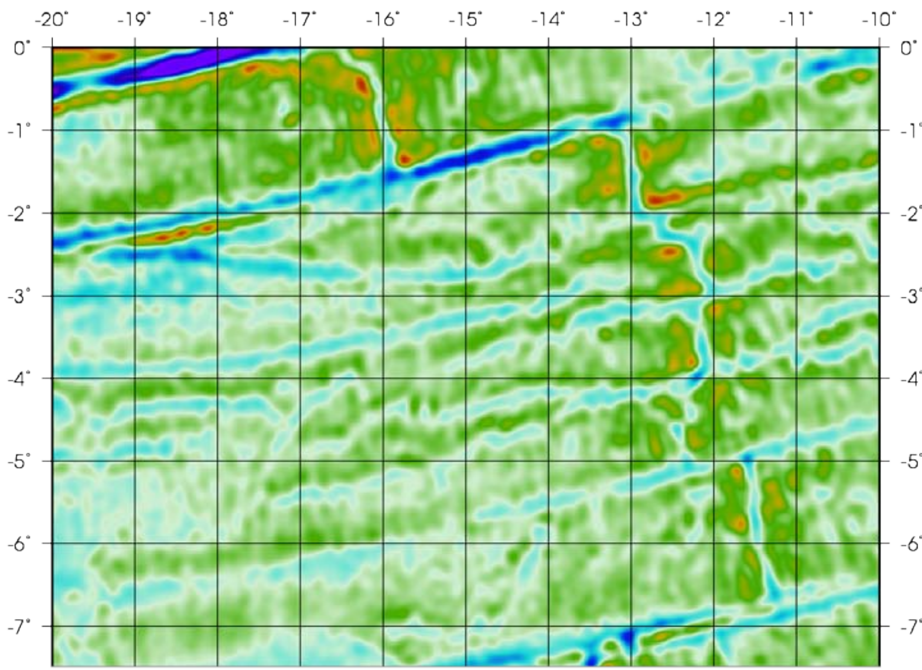
Background modell:
- GOCO02S (up to 180)

Modeling up to level 11 (n=2047)

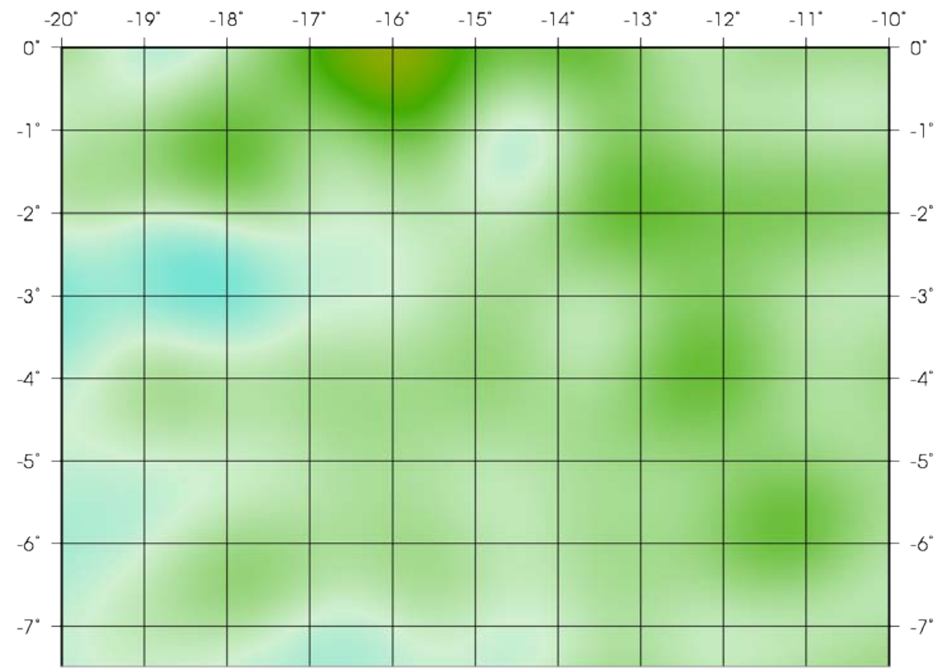
Input data type: T
Output functional: variable (Δg and N)



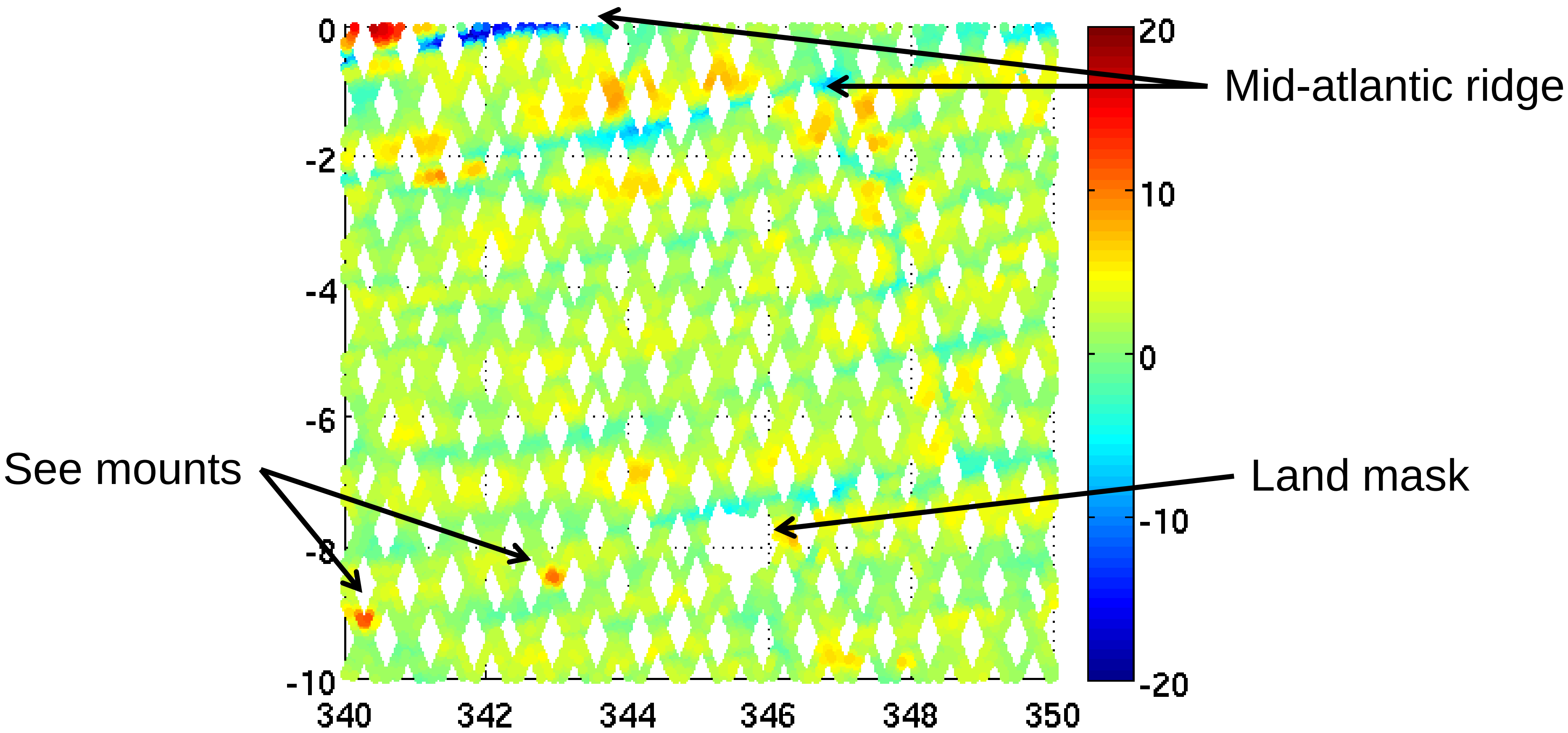
EGM 2008 (n_{max}=2047)



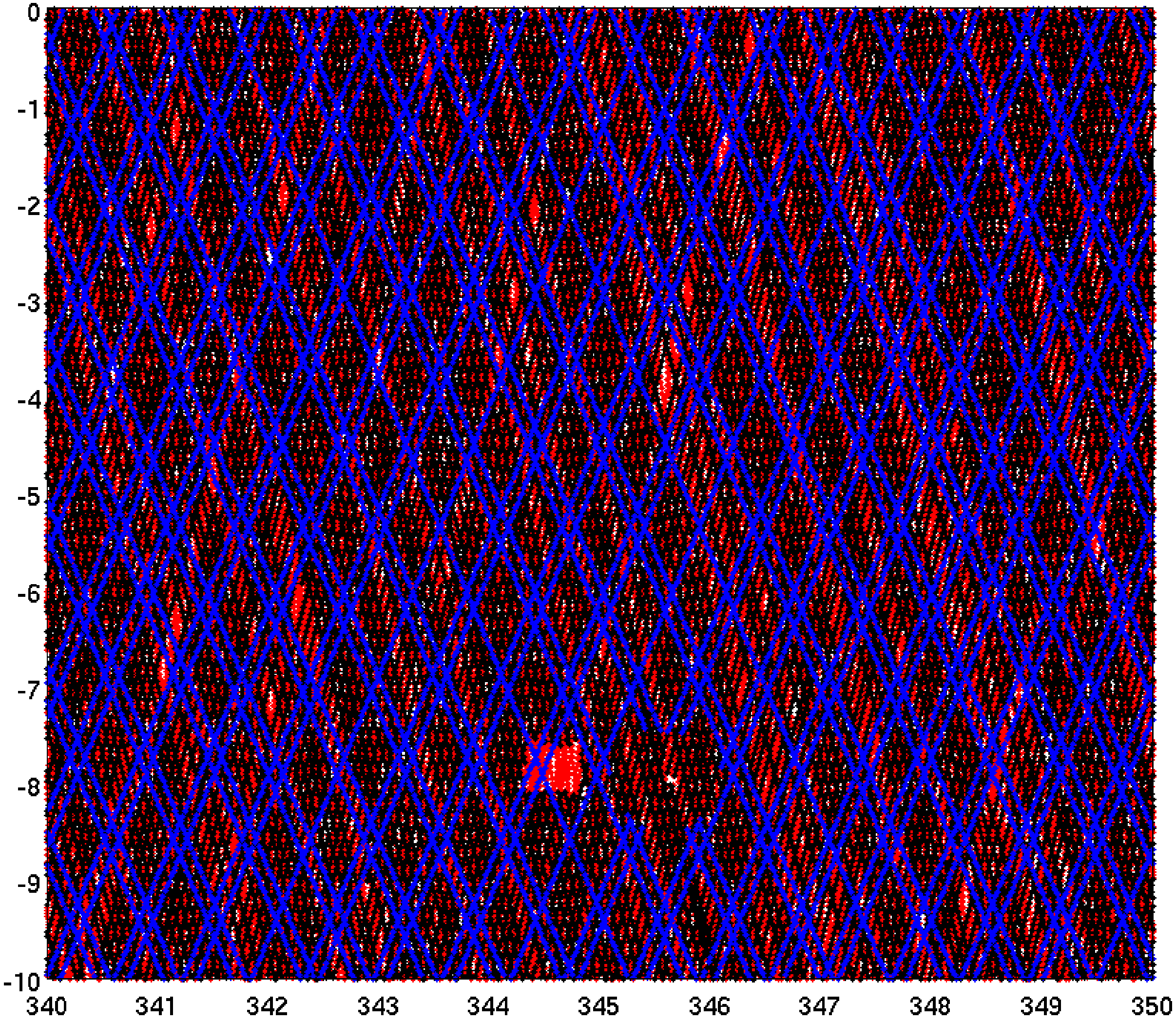
Background model
GOCO02S (n_{max}=180)



ΔT [m²/s²] – w.r.t. background model GOCO02S



- Spatial data distribution allows resolution of ~55 km => level L=8 (78 km)
- Combination with other missions advisable



Jason-1 GM (#13635)

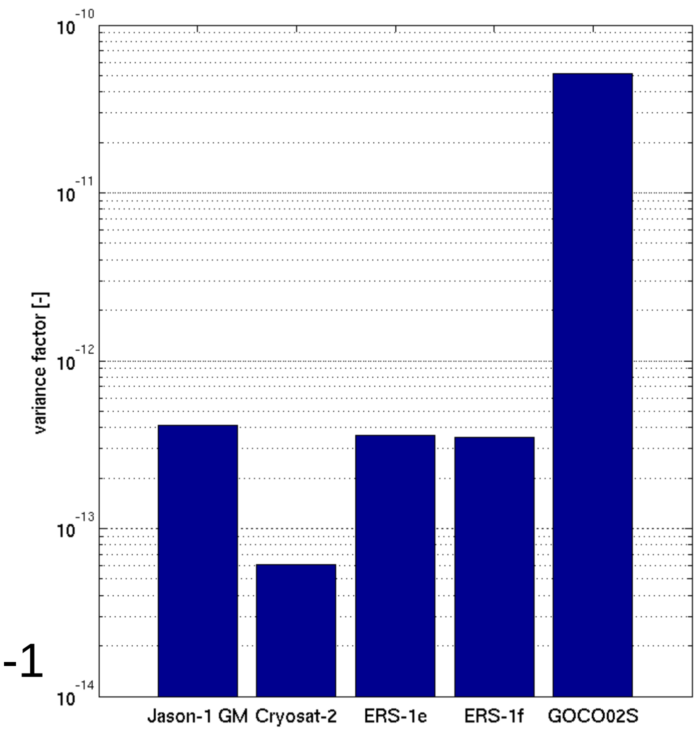
ERS-1 (#45196)

Cryosat-2 (#78429)

137260 observations
15264 unknowns

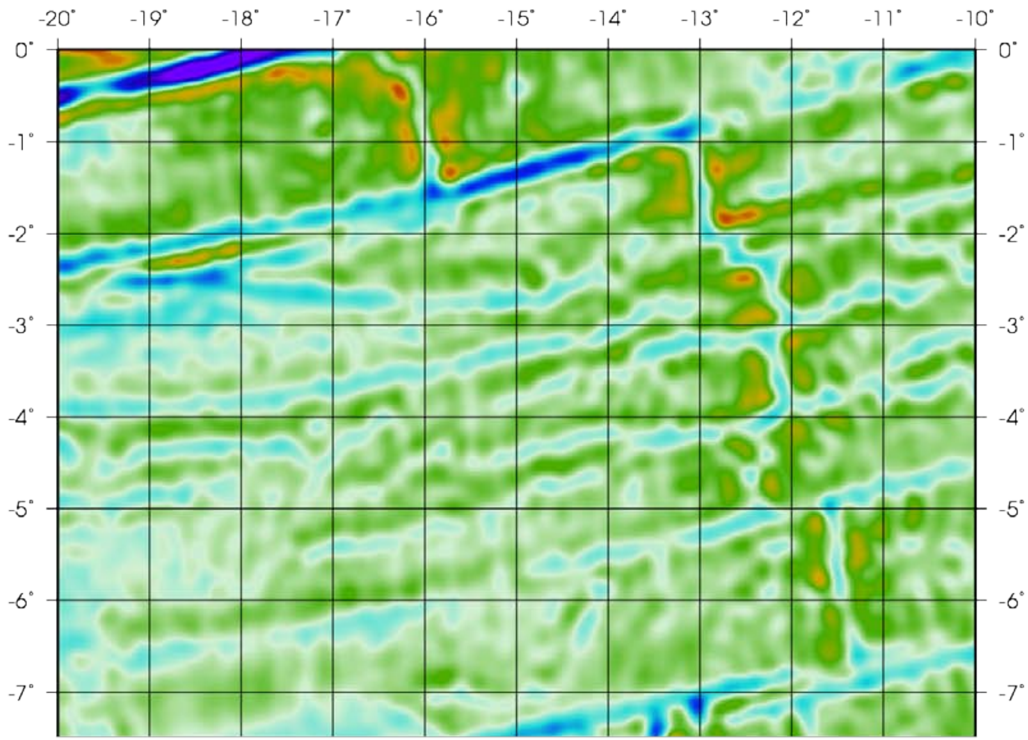
- Combination of Jason-1 GM IGDR with ERS-1 and Cryosat
- Weighting of the missions is done automatically by means of a variance component estimation (VCE)
- Approach: Monte-Carlo Solution; *Koch & Kusche (2002)*
- Constant weights within one observation group **P**=**I**

	Variance Factor σ
Jason-1 GM (IGDR)	$0.41 \cdot 10^{-12}$
Cryosat-2	$0.06 \cdot 10^{-12}$
ERS-1e	$0.36 \cdot 10^{-12}$
ERS-1f	$0.35 \cdot 10^{-12}$
Background model	$0.51 \cdot 10^{-10}$



⇒ smallest σ (highest weight) for Cryosat

⇒ Jason-1 GM in the same order of magnitude than ERS-1 (maybe due to the use of IGDR instead of GDR or due to the data distribution)

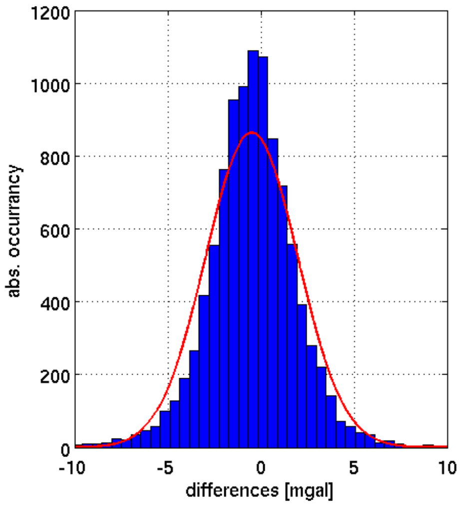

-20°
-19°
-18°
-17°
-16°
-15°
-14°
-13°
-12°
-11°
-10°
0°
-1°
-2°
-3°
-4°
-5°
-6°
-7°

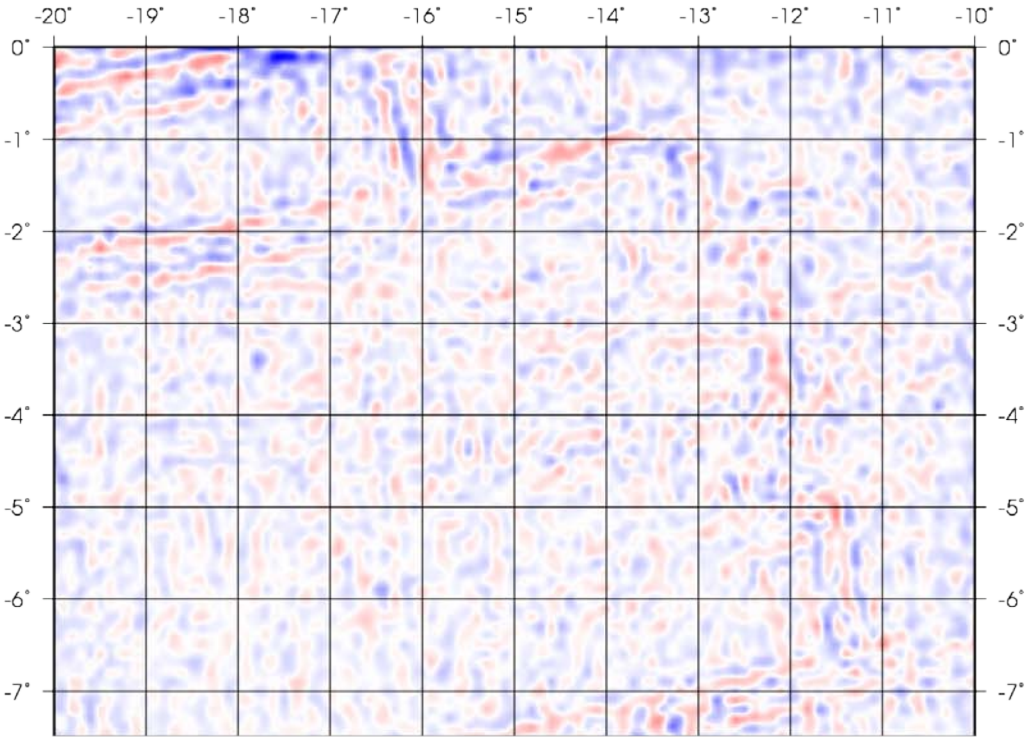
Gravity Anomalies

Differences

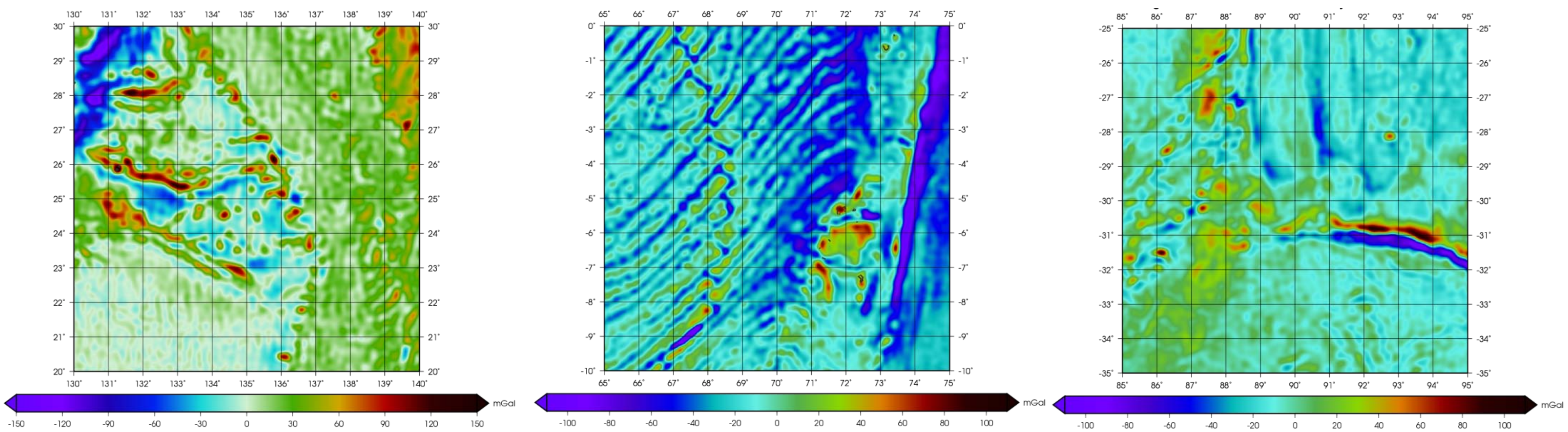
L11 - EGM2008 (2047)

mean: -0.5 mgal
RMS: 2.5 mgal

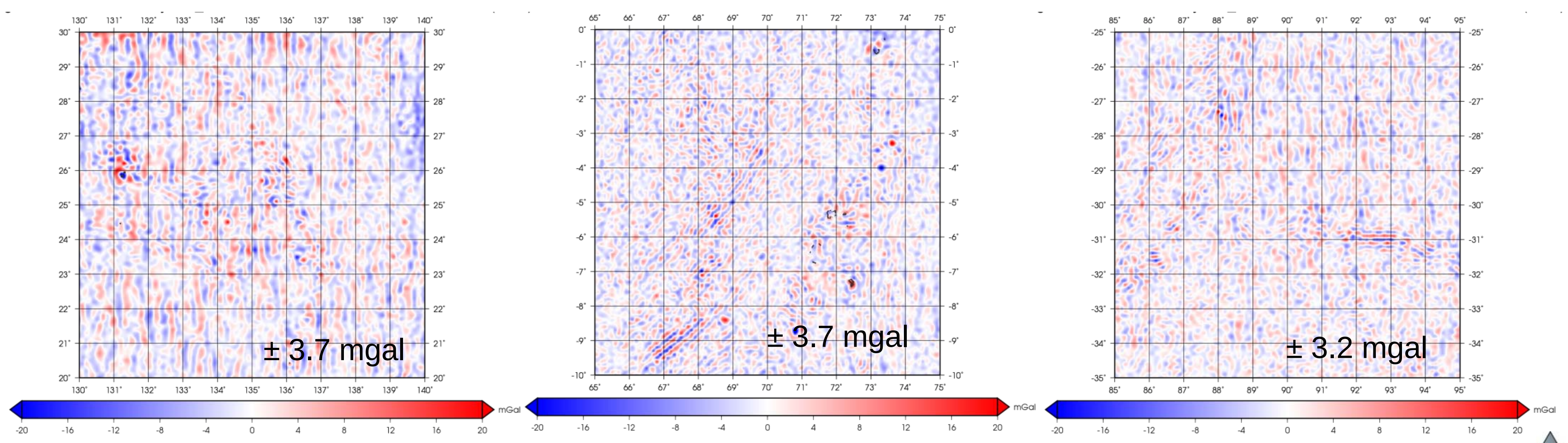


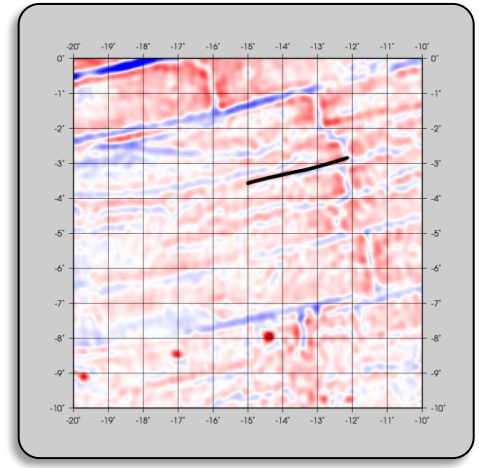


Gravity Anomalies L11

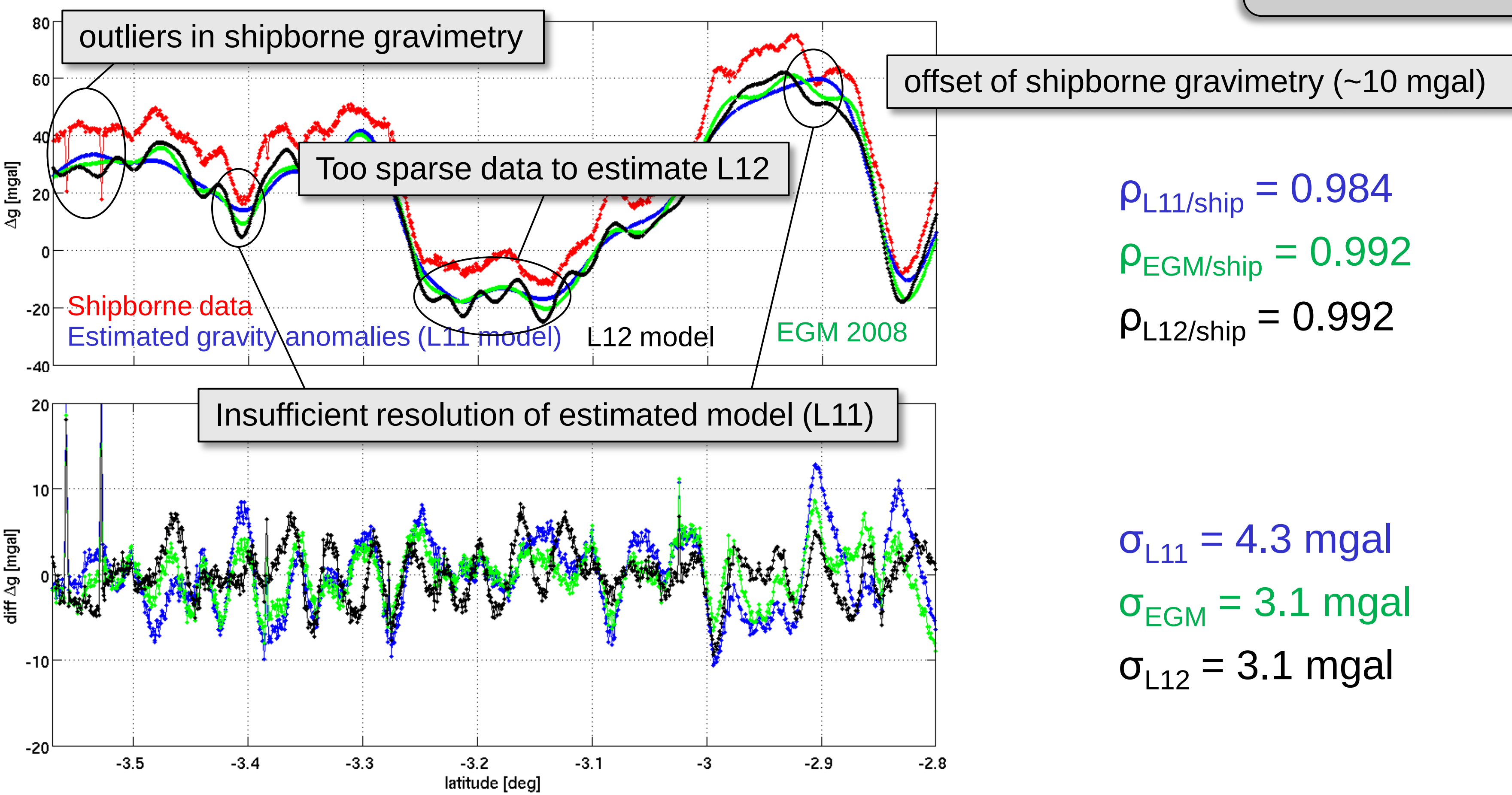


Differences to EGM2008





Platform: Robert D. Conrad, 1987
Institution: Lamont-Doherty Geological Observatory
Survey ID: RC2806 (partly), Data Source: NOAA NGDC



$\rho_{L11/ship} = 0.984$

$\rho_{EGM/ship} = 0.992$

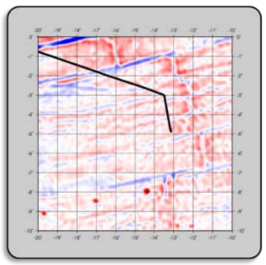
$\rho_{L12/ship} = 0.992$

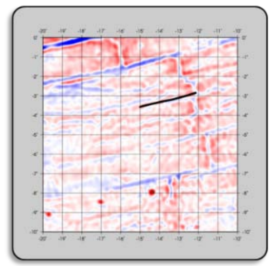
$\sigma_{L11} = 4.3$ mgal

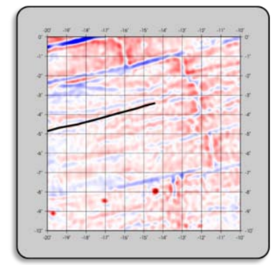
$\sigma_{EGM} = 3.1$ mgal

$\sigma_{L12} = 3.1$ mgal

RMS of differences to shipborne gravimetry [mgal]







	RC2602 T1	RC2806 T1	RC2806 T2
L11	± 3.9	± 4.2	± 3.5
L12	± 3.6	± 3.1	± 3.5
EGM 2008	± 2.8	± 3.1	± 2.3

=> DGFI approach reaches the same level of accuracy than EGM2008 (a little bit worse)

- Jason-1 GM provides valuable input for regional marine gravity modeling
- Jason-1 GM data distribution is not yet able to provide high resolution gravity field information without combination with other missions
- Jason-1 GM IGDR data show similar variance components than ERS-1 mission (Cryosat is slightly better)

- Regional model approach provides good results, which are close to EGM2008
- Differences to EGM2008 (same resolution): RMS ~3 mgal (Δg) / 2 cm (N)
- Validation with ship-borne gravity anomalies shows RMS values of 3-4 mgal

- Multi-Resolution Representation (MRR) is possible
- Combination with other observations types possible (satellite/terrestrial gravimetry)

Next steps:

- Utilization of high-frequency data (instead of 1 Hz), maybe own retracking
- Use of Cryosat SAR data
- Program extension: Allow for more resolution levels (between L11 and L12)
- Improved validation (larger comparative sample)