

Assessing GOCE Gravity Models using Altimetry and Drifters.

Per Knudsen and Ole Andersen,
 Technical University of Denmark, DTU Space
 2800 Kgs Lyngby, Denmark.

Abstract.
 The improved gravity models provided by the GOCE mission have enhanced the resolution and sharpened the boundaries of those features and the associated geostrophic surface currents reveal improvements for all of the ocean's current systems. There are still important signals to be recovered and issues related to errors in the models have been identified.
 In this study, a series of newer gravity models including observations from GRACE and GOCE are compared with the DTU15MSS mean sea surface to analyse resolution capacities and to identify issues caused by errors in the models. The comparisons are carried out in regional analyses using Fourier techniques to derive the spectral characteristics as well as anisotropic patterns to identify differences and to quantify quality measures associated with the models. In addition, regional analyses are carried out using in-situ observations of the geostrophic surface currents from drifters. This is done to analyse correlations and to derive resolution capacities associated with the ocean circulation.

Assessment using DTU15MSS

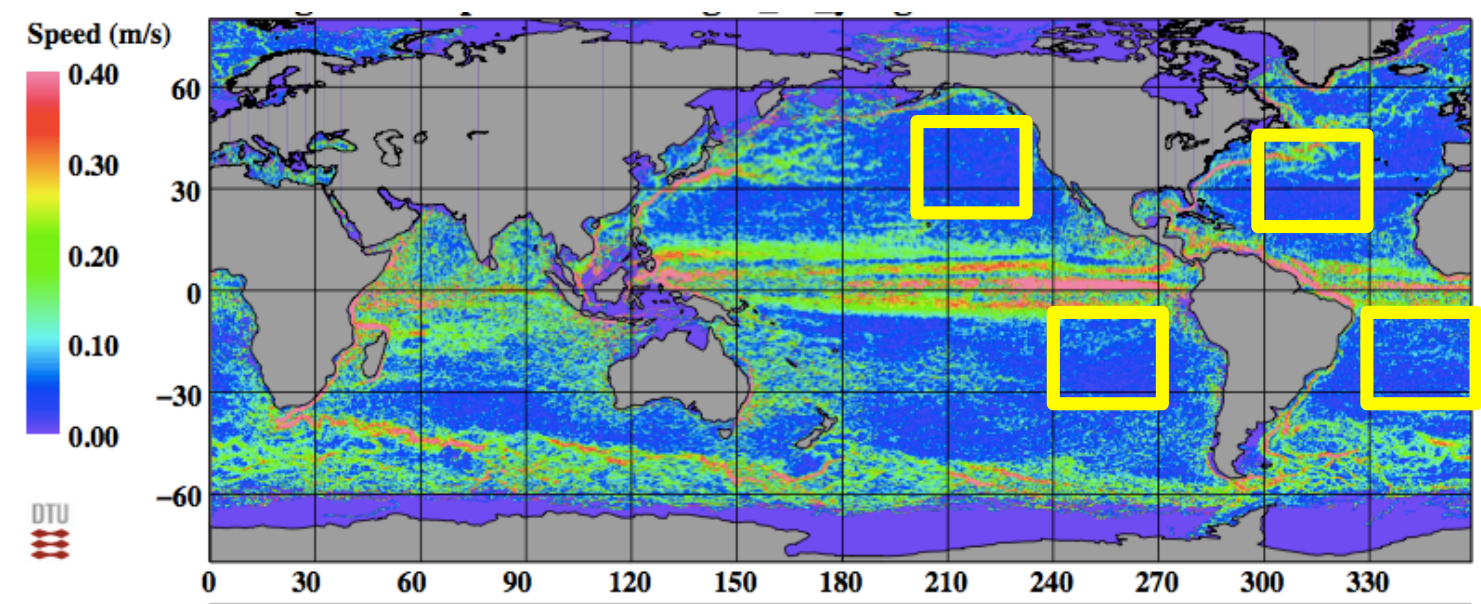
In "quiet" areas in the Pacific and Atlantic oceans, 29 models were used:

- spw_r2
- tim_r2
- dir_r2
- goco02s
- dgm1s
- eigen6s
- eigen6c
- tim_r3
- dir_r3
- goco03s
- eigen6c2
- tim_r4
- gogra02s
- jyy_goce02s
- eigen6c3
- gogra04s
- jyy_goce04s
- Eigen6c4
- Spw_r4
- goco05s
- GGM05g
- GGM05c
- GECO
- Goco05c

The assessment of the models is carried out using Fourier spectra of differences with the DTU15MSS model in

- 30x30 deg areas (frequency spacing: 0.033 cy/deg ~ d/o 12),
- 1/4x1/4 deg grids (Nyquist frequency: 2.0 cy/deg ~ d/o 720),
- up to Nmax,
- no filtering.

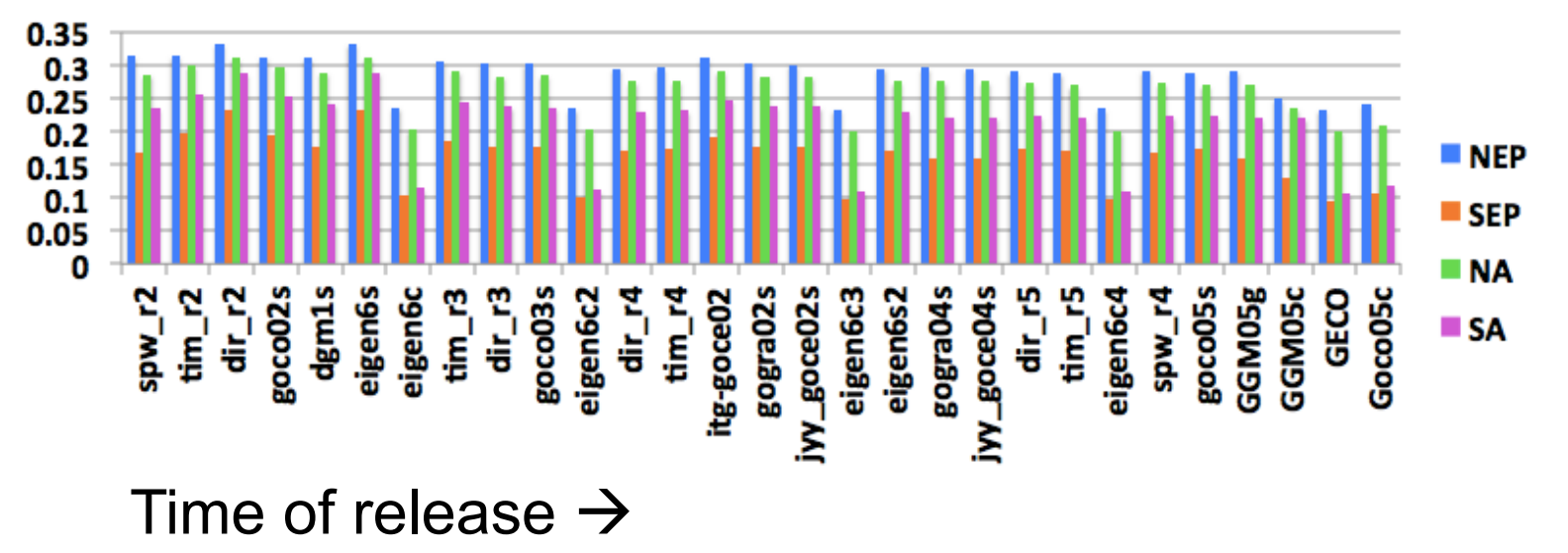
4 areas:



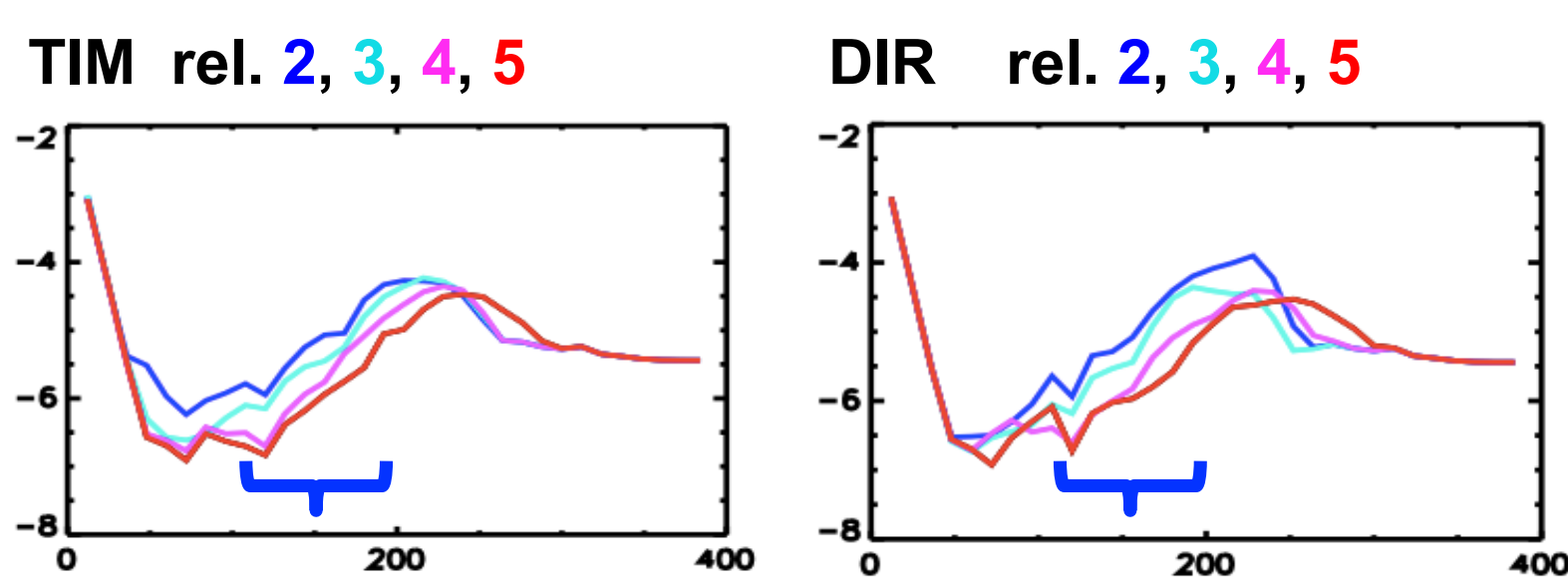
Standard deviations of residuals:
 NE Pacific: 23 – 30 cm; N Atl: 20 – 28 cm
 SE Pacific: 10 – 17 cm; S Atl: 11 – 23 cm

We need to distinguish between satellite only and combination models.

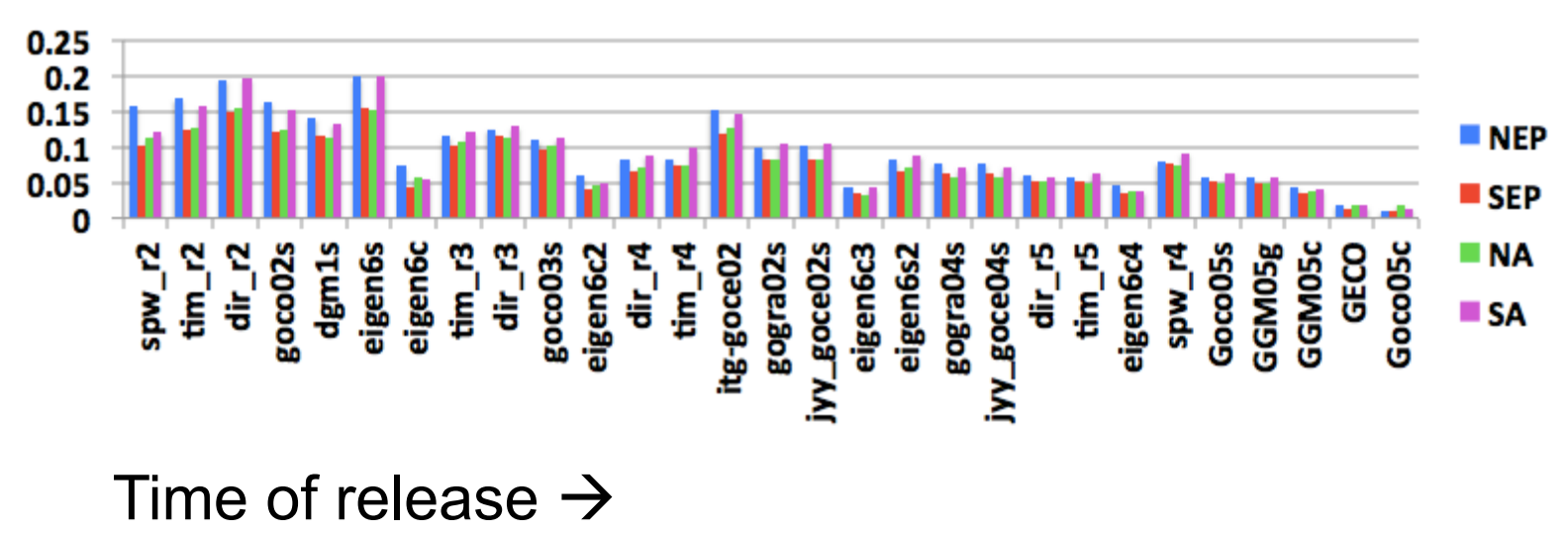
Lower values are associated with the "C" models.



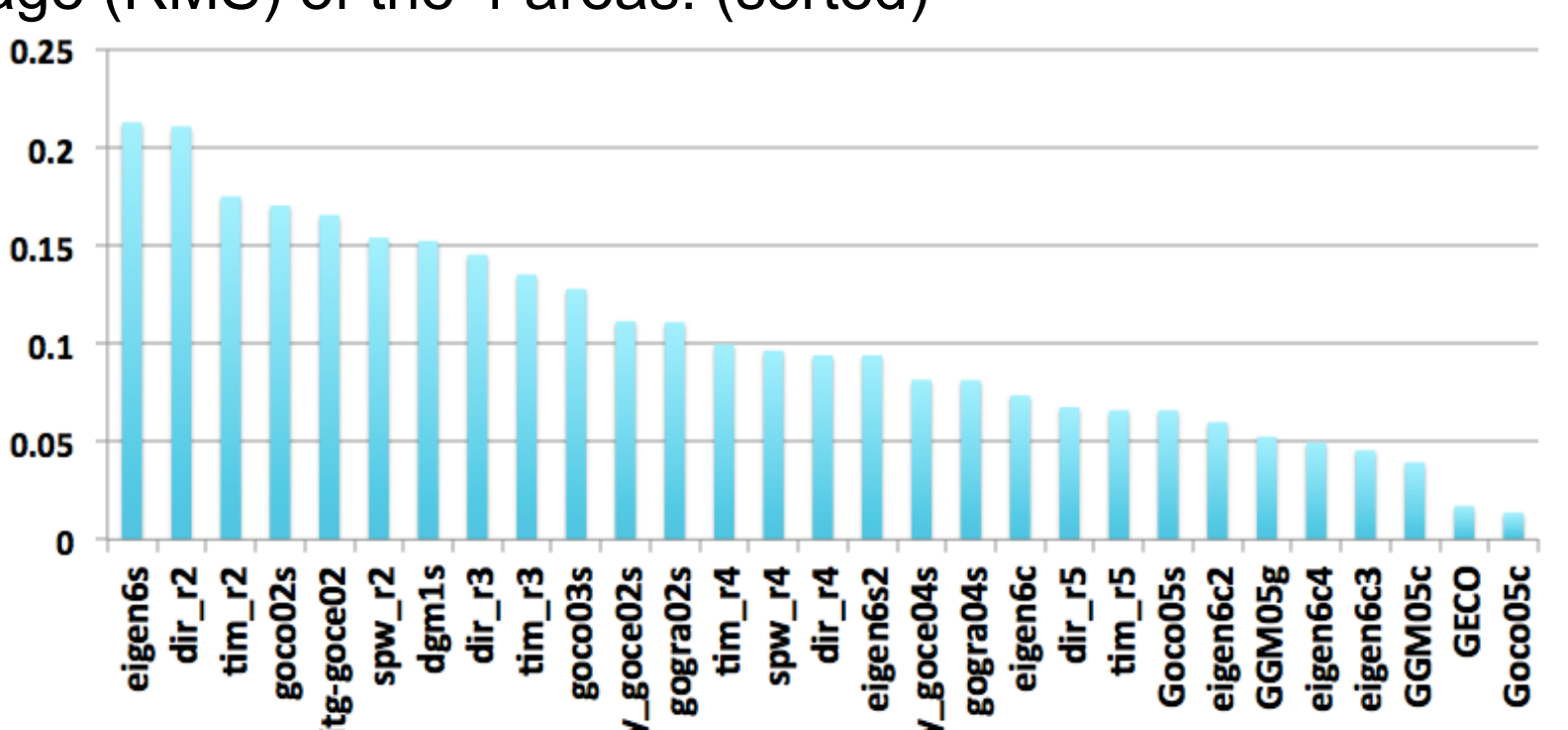
Power spectra of TIM and DIR GOCE models (SE Pacific area):



Accumulated errors of interval d/o 100-200. Clearly quantify the improvements:



Average (RMS) of the 4 areas: (sorted)



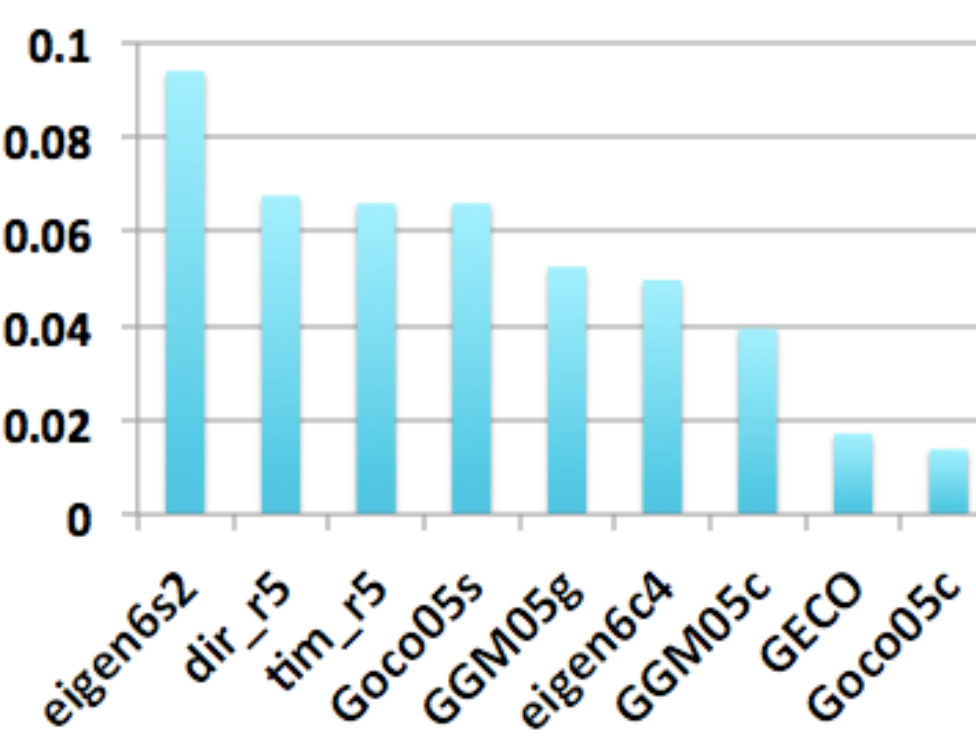
Focus on these nine models:

Sat-only:

- eigen6s2
- dir_r5
- tim_r5
- Goco05s
- GGM05g
- eigen6c4
- GGM05c
- GECO
- Goco05c

Combination:

- Eigen6c4
- GGM05c
- GECO
- Goco05c



Fourier spectra of Geoid-MSS residuals and Geoid-MSS correlations: (SE Pacific)

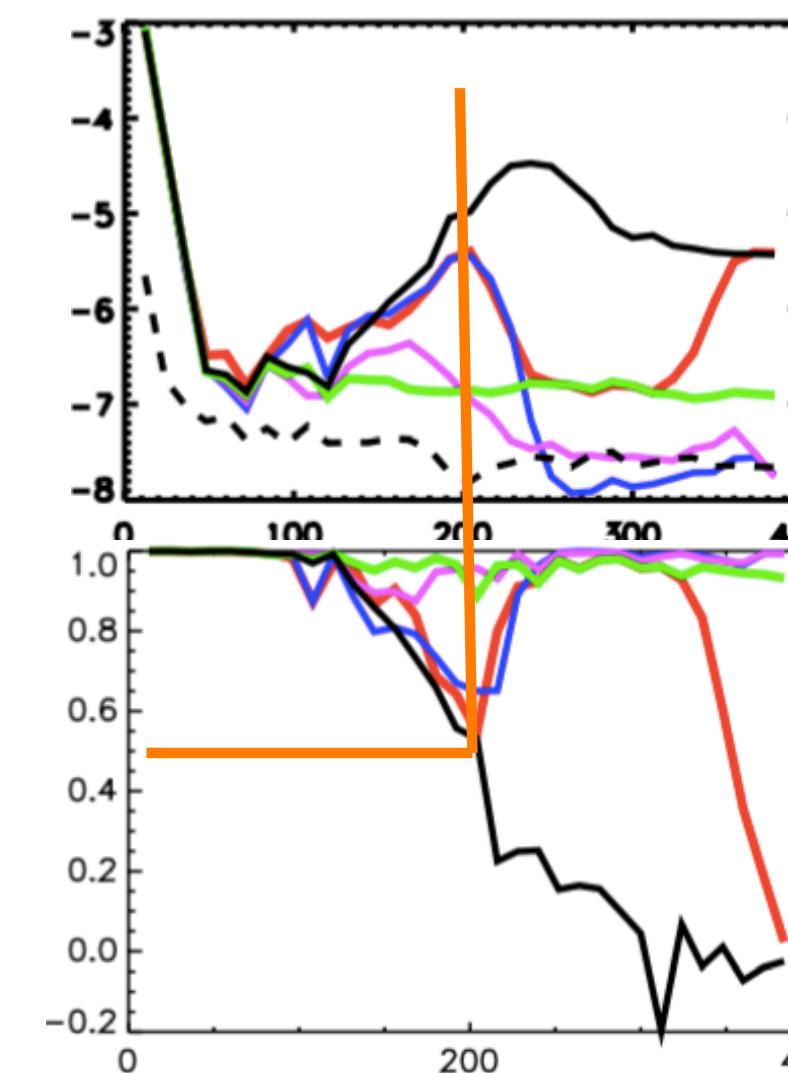
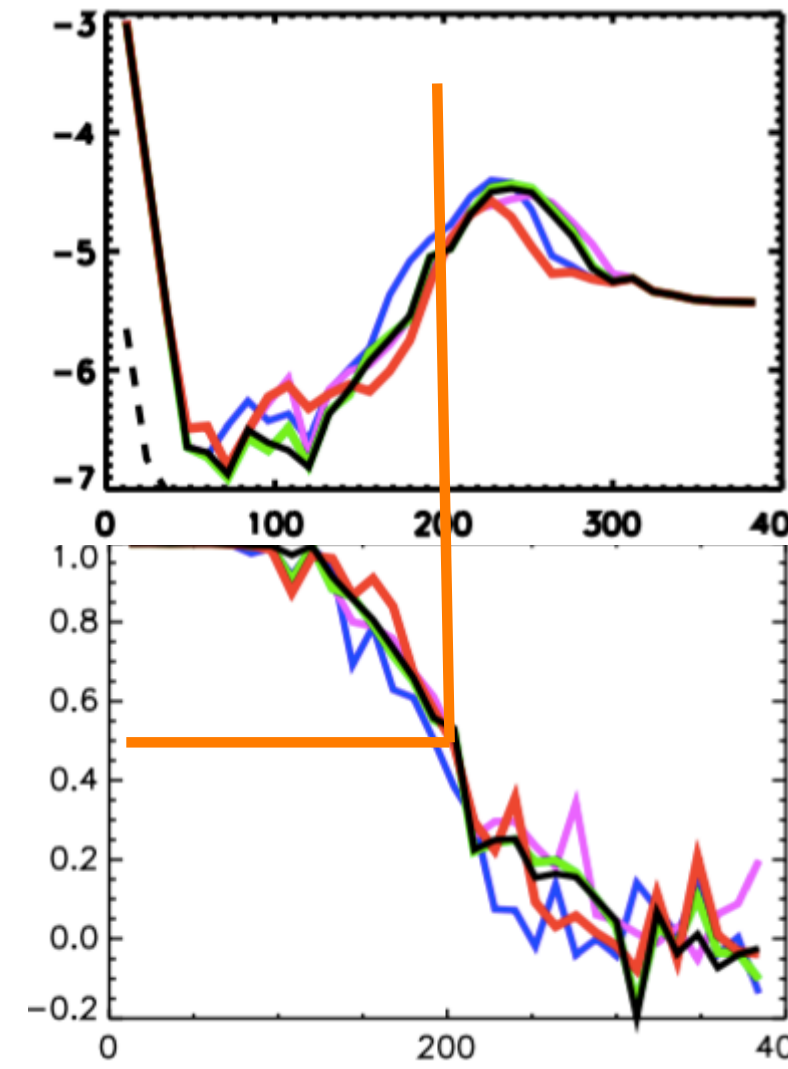
Sat-only:

- eigen6s2
- dir_r5
- tim_r5
- Goco05s
- GGM05g

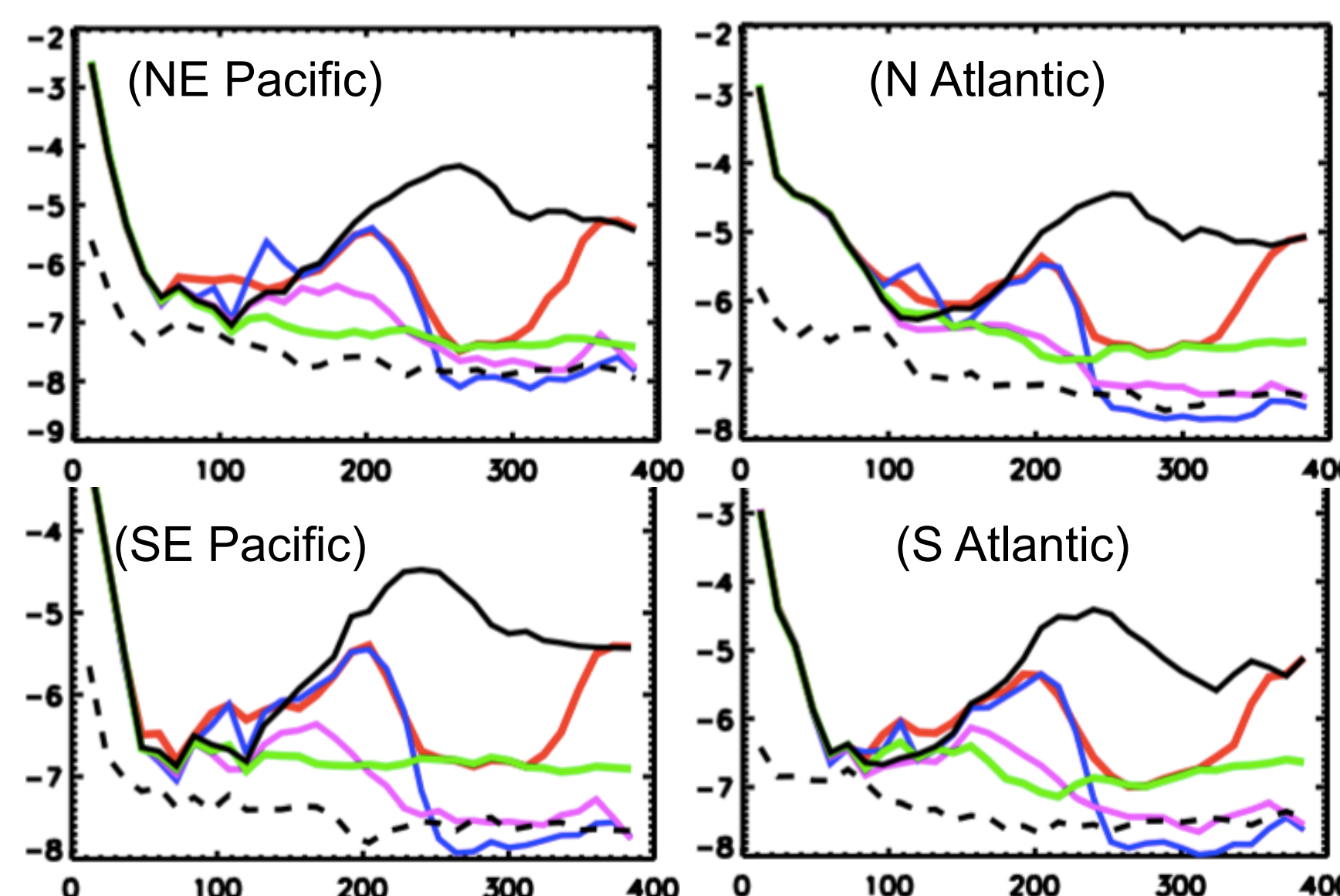
Fourier spectra of Geoid-MSS residuals and Geoid-MSS correlations: (SE Pacific)

Sat-only:

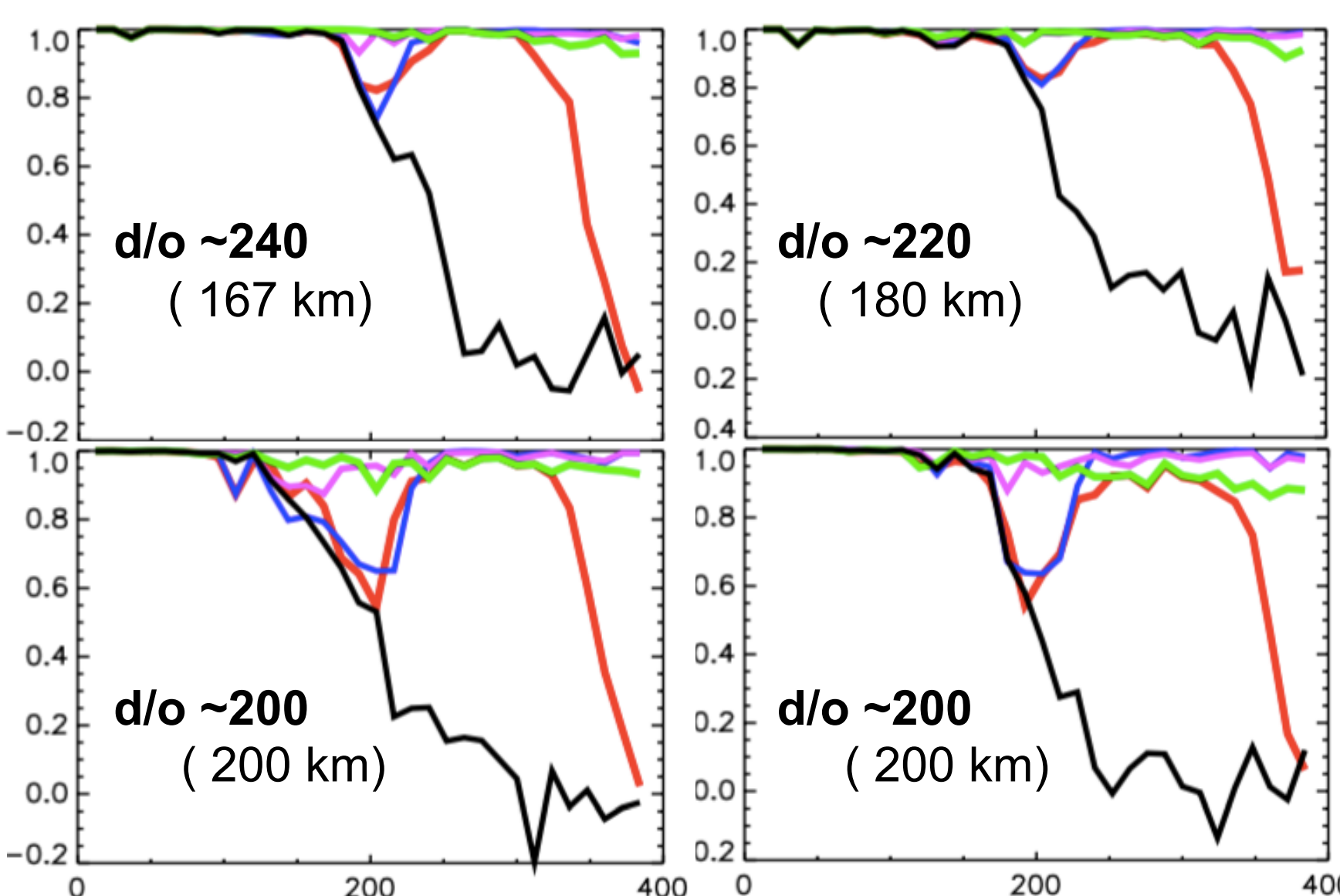
- tim_r5
- Eigen6c4
- GGM05c
- GECO
- Goco05c



The Fourier spectra of the differences for the TIM_r5 and the combination models for the four areas are shown below.



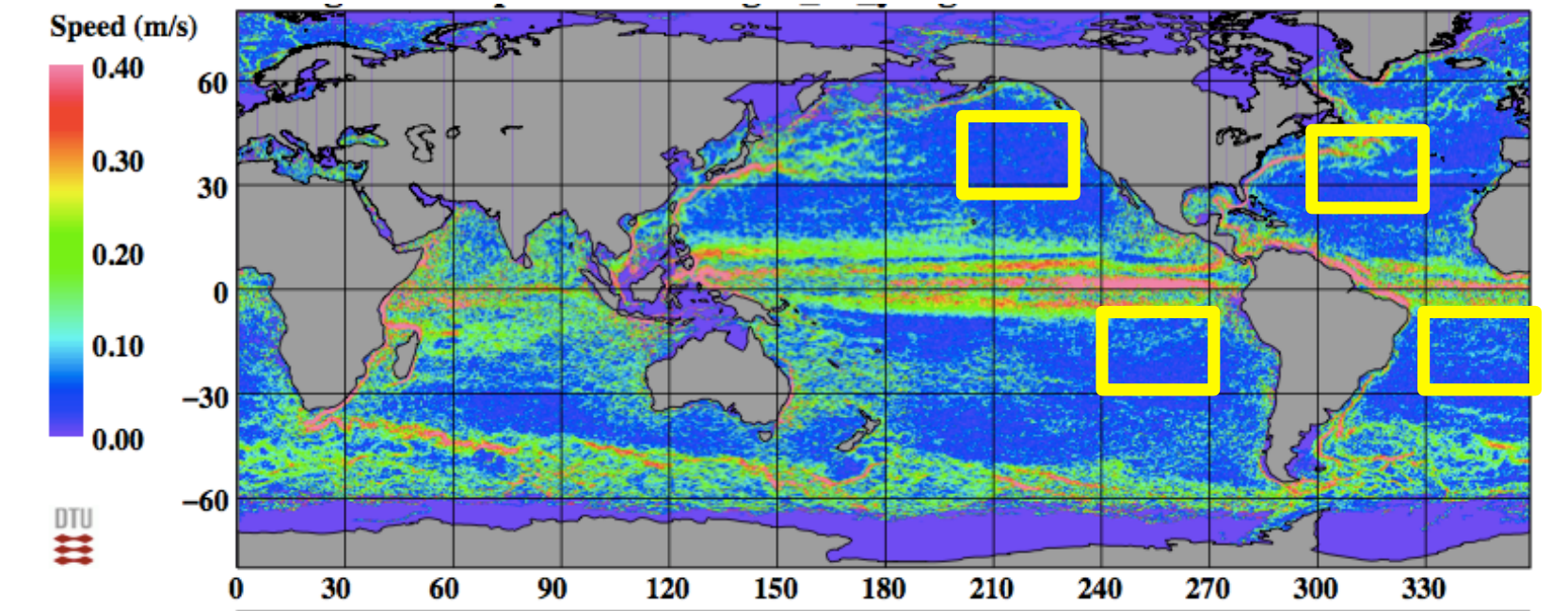
The Fourier spectra of the correlations for the TIM_r5 and the combination models for the four areas are shown below.



The results obtained the four areas are similar. The spectra of the residuals clearly show the effects of integrating the surface gravity in the modelling. Also, for the combination models effects of the different weighting of the surface gravity are seen, ie. The Goco05c produce smaller residuals around d/o 150-200. The spectra of the correlations show that high correlation at long wavelengths (as expected). Above the resolution capacity around d/o 200 the correlations vanish for the satellite-only models. For the combination models, the correlations increase again, simply because the models reproduce the mean sea surface. Hence, for evaluating the combination model an independent data set such as the drifter data, is needed

Assessment using MSS and drifter velocities

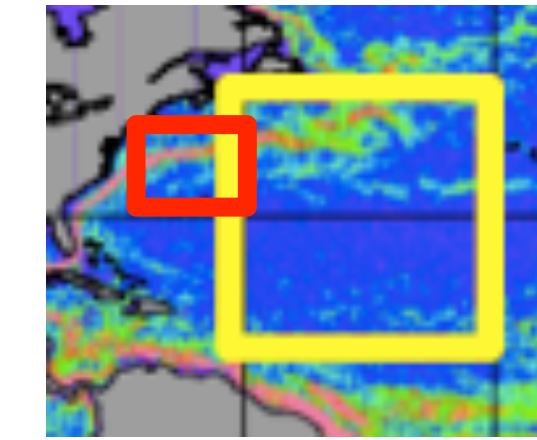
An assessment of mean gravity models is carried out using the DTU15MSS model and recently renovated Mean drifter velocities.



1/4 x 1/4 deg. means, Ekman drift removed, meso-scale correction from AVISO.

Correlations:

New area (NW Atlantic):



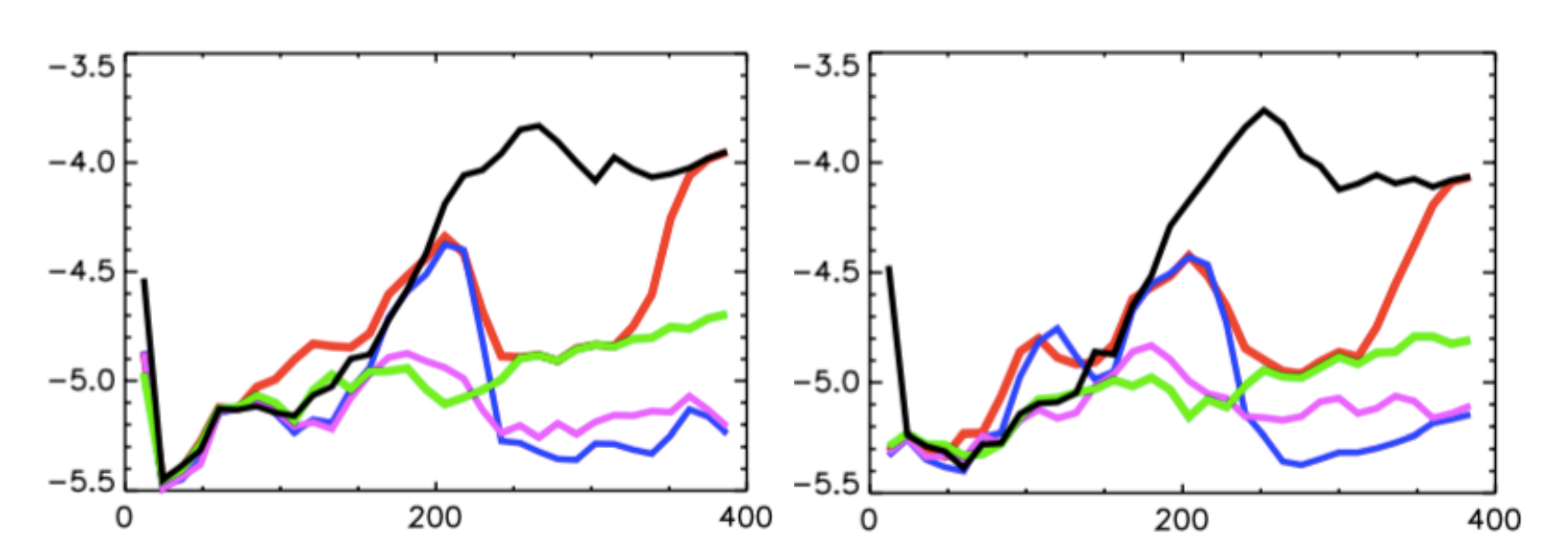
Sat-only:

- tim_r5

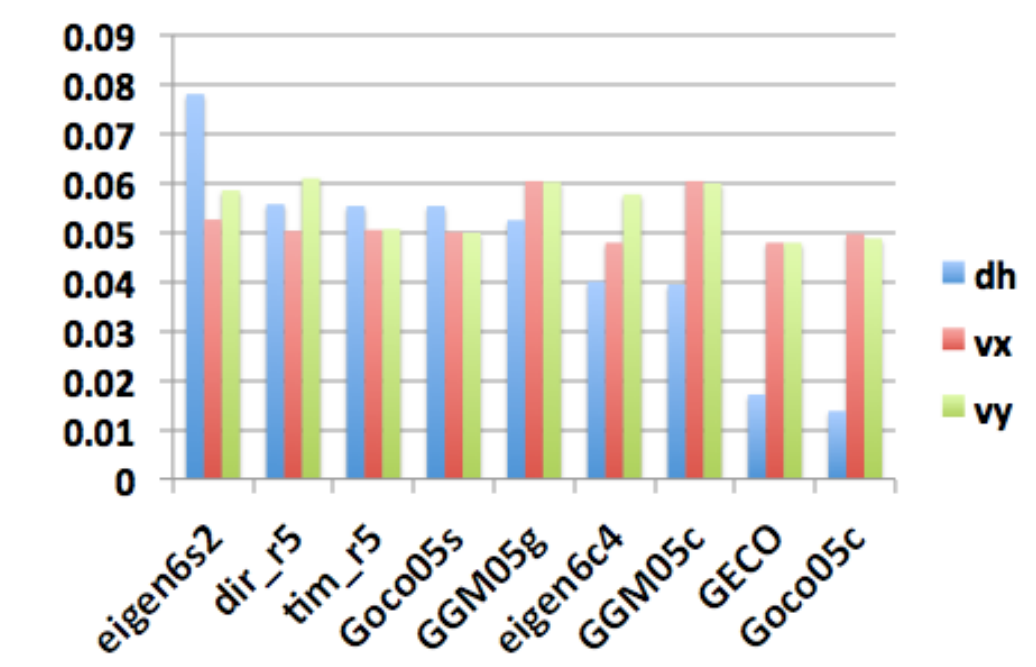
Combination:

- Eigen6c4
- GGM05c
- GECO
- Goco05c

Spectra for vx and vy in NA:



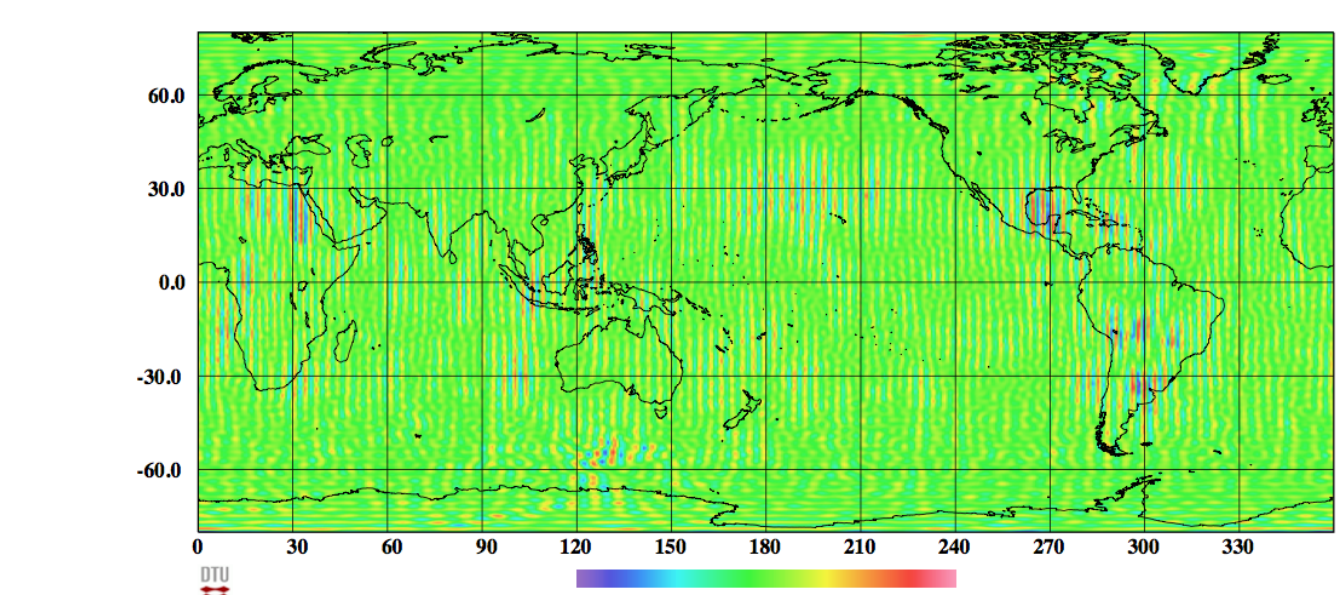
Accumulated errors of interval d/o 40-140: (averages over 4 areas)



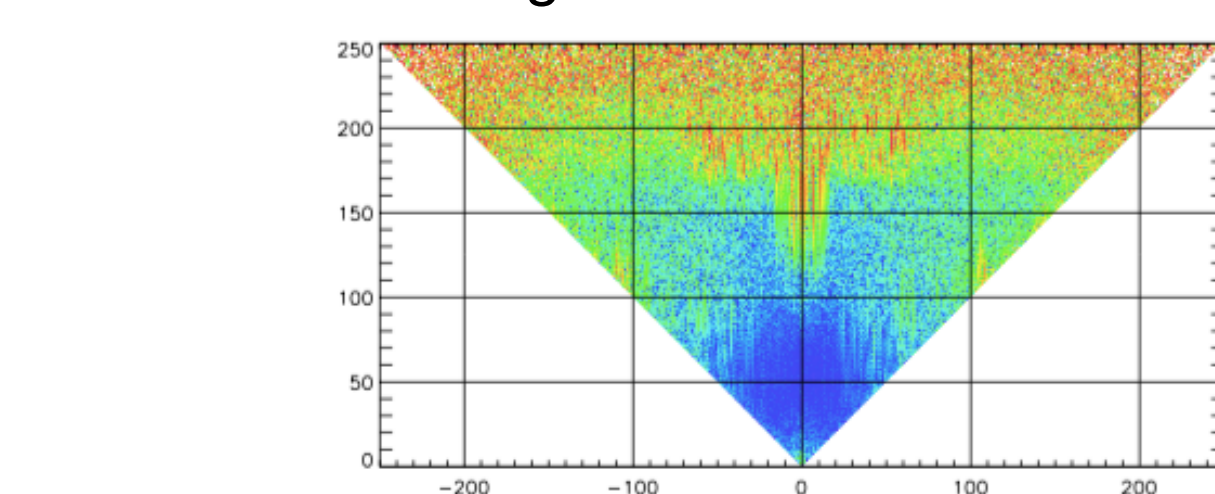
The spectra for the vx and vy residuals in the N Atlantic show that there are some discrepancies for the vy component around harmonic degree and order 100-120 associated with the Eigen6c4 and the GGM05c models.

Geoid model differences

Differences Eigen6c4 - GOCO05s up to d/o 175 (with a linear cut from 125) to display stripes at d/o 100-120.



Differences of Eigen6c4 - GOCO05s coefficients.



Conclusions

29 gravity models have been assessed using the DTU15MSS mean sea surface by analysing Fourier spectra of differences.

We have found that:

- Geographical variations are recovered,
- Main differences occur at d/o 100-200,
- Accumulated differences of d/o 100-200 drops from about 20 cm to 5 cm during the mission. 1-2 cm for combination models. (include MSS errors)

The assessment of the 9 newer models using MSS and surface currents from drifters showed that:

- Geographical variations are recovered,
- Correlations found at scales down to 285 km in areas with higher ocean dynamics / variability (such as the NWA),
- Accumulated differences of d/o 40-140 are 5-6 cm/s (include MSS and drifter velocity errors)