Assessing the contribution of GOCE and altimetry to improvements in geodetic MDT determination

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The geodetic method

The ocean's mean dynamic topography (MDT):



MSS products:

- CLS01, CLS11
- DTU10, DTU13

GOCE products:

- DIR1, DIR2, DIR3, DIR4, DIR5
- TIM1, TIM2, TIM3, TIM4, TIM5
- SPW1, SPW2

The geodetic method

The ocean's mean dynamic topography (MDT):



Some questions:

- How much has GOCE improved geodetic MDT determination?
- How do the GOCE flavors compare?
- How realistic are the GOCE formal errors?
- What are the relative error contributions from the geoid and MSS?
- How much have newer MSS products improved geodetic MDT determination?

The geodetic method

The gravity field is given as a set of spherical harmonic coefficients The pointwise approach

The gravity field is given as a set of spherical harmonic coefficients



Truncation of spherical harmonic series of geoid at degree and order *L*

The pointwise approach

The gravity field is given as a set of spherical harmonic coefficients



The pointwise approach



The spectral approach

The gravity field is given as a set of spherical harmonic coefficients

 $\eta = H - N_L$

Truncation of spherical harmonic series of geoid at degree and order *L* Truncation of spherical harmonic series of geoid and MSS at degree and order *L*

 η_L

Maximum degree and order *L*:

Spatial resolution:



 $=H_{L}$

The spectral approach



The spectral approach



The GOCE models



CLS01-GTIM1 (d/o=224)



CLS01-GTIM2 (d/o=224)



CLS01-GTIM3 (d/o=224)



CLS01-GTIM4 (d/o=224)



CLS01-GTIM5 (d/o=224)



CLS01-GTIMx MDTs (d/o=224): Agulhas region











Global mean informal errors for CLS01-TIMx MDTs at d/o=224



Global mean informal MDT errors at d/o=224



Global mean informal errors for CLS01-GOCE5 MDTs



GTIM5 GDIR5

MDTs based on GOCE release 5 gravity models have very similar informal error spectra.

LW component of informal error includes 2.5 cm due to residual geoid omission error (<3%) plus LW error in reference (CLS09).

Global mean informal errors for CLS01-GOCE5 MDTs



GTIM5 GDIR5

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Informal MDT errors in wavelength bands



release

Informal MDT errors in wavelength bands



The performance of GOCE relative to GRACE



The performance of GOCE relative to GRACE



Formal geoid errors

Formal geoid error for GTIM5 at d/o=280



https://earth.esa.int/web/guest/software-tools/gut/gut-resources/gut-variance-covariance-matrix-tool

Formal geoid errors



Informal vs formal global mean errors



Informal vs formal global mean errors



Informal vs formal global mean errors



Informal vs formal geoid errors



Formal scaled geoid (solid thick)

Formal vs. informal SW GTIM3 errors



Formal errors appear too smooth.

Assessment of MSS products



Newer MSS products have little overall impact.

The effect of the newer MSS: CLS11



Conclusions

• How well can we measure the ocean's MDT from space?

resolution (km)	LW: > 250	MW: 133-250	SW: 89-133
error (cm)	1.2	2.7	5.4

- Little difference between R5 (42 months of data) TIM (GOCE) and DIR (GOCE, GRACE, Lageos) solution
- Compared to DIR, the TIM solutions have shown the greatest improvement in the LW and MW components
- Formal errors: global mean values reasonable but do not reflect geographical variations due to steep gradients in gravity field
- MSS products have little overall impact:
 - Swamped at LW by residual geoid omission error
 - Swamped at SW by geoid commission error

Long-wavelength MDT comparison: BHL14 vs. CLS09



