EOT08a – Empirical Ocean Tide Analysis for Improving GRACE de-aliasing

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Introduction

- In open ocean global tide models are accurate up to a few cm, exhibit, however significant errors in shallow water.
- EOT08a (Empirical Ocean Tide Model obtained from altimeter data) is a new global ocean tide model, developed by empirical analysis of altimetry data. Correlation problems, due to alias effects, are minimized by combining data of different altimeter missions.
- EOT08a was validated by altimetric time series at crossover points, by comparison with tide gauge data, and by analyzing GRACE data

Altimetry data:

Mission (Phase)	Cycles	Period	Source	Replacements
TOPEX/Poseidon	001-481	1992/09/23-2005/10/08	MGDR-B NASA	Chambers SSB correction, FES2004
Jason1	001-135	2002/01/15-2005/09/14	GDR-B PODACC	FES2004
ERS-1 (C & G)	083-101 144-155	1992/04/14-1993/12/20 1995/03/24-1996/04/28	OPR-V6 CERSAT	DEOS orbits, FES2004, pole tide, 1.5ms time bias
ERS-1 (D, E & F)	102-143	1993/12/25-1995/03/21	OPR-V3 CERSAT	DEOS orbits, FES2004, pole tide, 1.5ms time bias
ERS-2	000-085	1995/04/29-2003/07/02	OPR-V6 CERSAT	DEOS orbits, FES2004, pole tide, 1.3ms time bias
ENVISAT	009-040	2002/09/24-2005/09/19	GDR ESA/CNES	FES2004
GFO	037-159	2000/01/07-2005/10/04	GDR NOAA	FES2004

Development and Validation of EOT08a

1. Preprocessing of multi-mission-altimeter data
   - Homogenisierung (ellipsoid, time scale, FES2004, DAC)
   - updates (e.g. satellite orbits, radiometer correction)
   - relative cross-calibration by crossover analysis
2. Least squares harmonic analysis (w.r.t. FES2004) on a 15´×15´ grid
   - mean, trend, annual and semi-annual variations
   - diurnal tides: O1, K1, P1 und K1
   - semi-diurnal tides: M2, S2, N2, K2 und 2N2
   - non-linear tide: M4
3. Interpolation to FES2004 grid (7.5´×7.5´) and addition of the reference model FES2004
   - at high latitudes (|φ| > 62°) transition from EOT08a to FES2004
4. Validation by
   - time series of bottom pressure gages
   - time series of sea surface heights at crossover points
   - tidal constants from external sources
   - analysis of GRACE data and monthly GRACE solutions

Residuals in open ocean

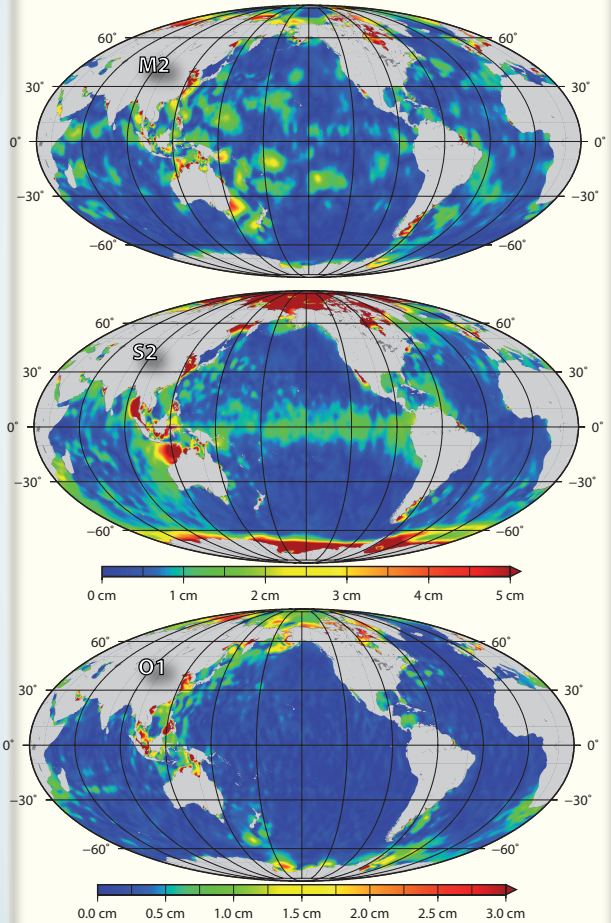

Fig. 1: Residual amplitudes for M2, S2 and O1 constituents

Shallow water residuals

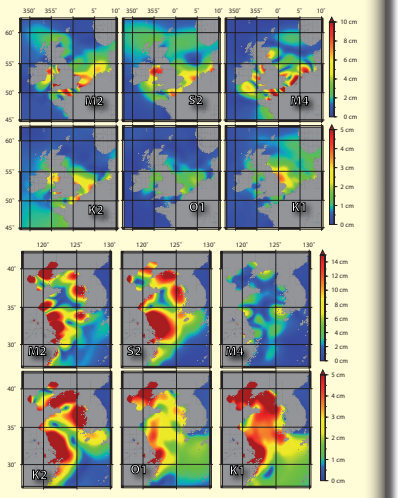

Fig. 2: Residual amplitudes for the North-West-European shelf and in the Yellow Sea

S2 from Altimetry and GRACE

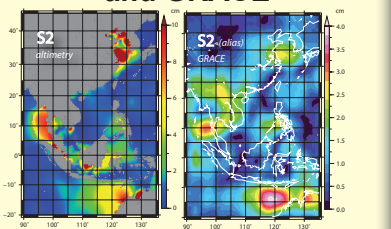

Fig. 3: Residual amplitudes of S2 from altimetry (left) and harmonic analysis of GRACE monthly solutions (right) show high affinity. Note, GRACE senses also hydrological mass variationen over land.

RMS reduction in monthly GRACE solutions

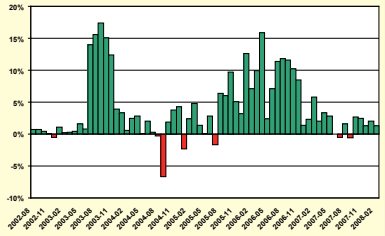

Fig. 5: Percentage reduction in RMS of equivalent water heights (ocean areas only) if FES2004 is replaced by EOT08a for the monthly GRACE solutions, generated by IGG, Bonn (Mayr-Gürr).

Correlation analysis

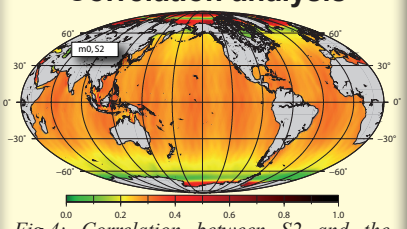

Fig.4: Correlation between S2 and the mean. In general, correlation at high latitude are larger (no T/P and Jason data). The mean correlation between all parameters (tides, mean, etc.) remain < 0.3.

Comparison with external tidal constants

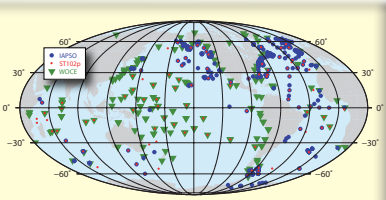

Fig. 6: Tide gauges with tidal constants

WOCE

Tide	EOT08a	FES2004	num
2N2	0.6	0.6	196
K1	4.1	4.3	181
K2	1.6	1.7	179
M2	12.5	12.2	181
M4	1.3	1.5	181
N2	2.7	2.6	181
O1	3.1	3.1	181
P1	1.4	1.4	181
Q1	0.7	0.7	181
S2	4.5	4.5	181

IAPSO

Tide	EOT08a	FES2004	GOT4.7	TPXO7.1	num
K1	1.7	1.8	1.4	1.2	412
K2	0.8	0.9	0.7	0.7	372
M2	2.5	2.6	3.0	2.7	412
N2	0.9	0.9	0.9	0.9	406
O1	1.4	1.4	1.0	1.0	411
P1	2.6	2.8	2.6	2.5	372
Q1	0.5	0.5	0.4	0.4	373
S2	1.9	1.9	1.6	1.6	411

ST102p

Tide	EOT08a	FES2004	GOT4.7	TPXO7.1	num
2N2	0.3	0.3	n.a.	n.a.	98
K1	1.1	1.1	1.0	1.0	102
K2	0.4	0.5	0.4	0.4	98
M2	1.5	1.6	1.7	1.5	102
N2	0.7	0.7	0.7	0.6	99
O1	0.8	0.8	0.7	0.8	102
P1	0.4	0.4	0.4	0.4	98
Q1	0.3	0.3	0.3	0.3	96
S2	1.1	0.9	1.0	0.9	102

Tables: nearest neighbour interpolation was used.

Reduction of variances

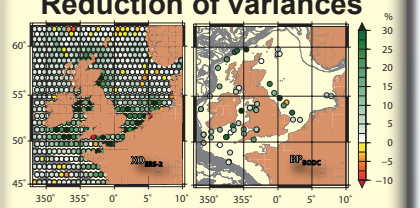

Fig. 7: Reduction of variances (%) for time series at ERS-2 crossover points (left) and bottom pressure gages (right) for the North-West-European shelf.

Results:

- The global ocean tide model EOT08a was derived by empirical analysis of multi-mission altimeter data
- In shallow-water and shelf areas the improvements against the reference model exceed 10 -15 cm.
- In deep ocean large scale pattern with residual amplitudes of 1-2 cm were identified.
- ftp://ftp.dgfi.badw.de/pub/EOT08a

Savcenko & Bosch (2008): EOT08a – empirical ocean tide model. Report No. 81, DGFI, München

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