An inter-comparison of ocean tide loading estimates for Antarctica from models and GPS

Matt King, Craig Allinson and Peter Clarke, School of Civil Engineering and Geosciences, University of Newcastle upon Tyne, UK • email m.a.king@ncl.ac.uk

Introduction
The periodic redistribution of ocean mass due to ocean tides results in a periodic loading of the Earth known as ocean tide loading (OTL). Here we report on OTL on the Antarctic continent, comparing direct measurements from GPS data with estimates from several numerical tide models. Furthermore, we examine the effect of mismodeled OTL on altimetric measurements from ICESat. Accurate estimates of OTL are required for the determination of accurate geodetic coordinate time series, altimetric height measurements and GPS estimates of tropospheric zenith delay parameters. Independent OTL estimates from ~100-3000 days were combined using a Kalman filter, outliers removed and astronomical argument and nodal factors applied. Model estimates were obtained from the SPOTL software using each of the TPXO.2, CSR3, FES95.2, FES99, NAO99, GOT00.2 and TPXO.6 global numerical tide models, plus the regional CATS02.01 and FES99 and GOT00.2 models supplemented by TPXO.6.

Model-GPS Differences

- GPS data processed using Precise Point Positioning (PPP; GIPSY-OASIS II) directly estimating the eight major diurnal and semi-diurnal constituents (K1, O1, P1, Q1, M2, S2, N2, K2) along with site coordinates and tropospheric zenith delay parameters
- Permanent and campaign GPS sites used with the IGS, SCAR and other institutes kindly providing data
- Independent OTL estimates from ~100-3000 days
- Differences between the complex GPS and model estimates were computed according to (Figure 1):

\[ S^2 = \sum_{i=1}^{n} (\xi_{GPS} - \xi_{Model})^2 \]

OF and ICESat
Laser Altimeter measurements from ICESat are affected by OTL. The model variability near the large ice shelves is significantly greater than in other regions (Figure 2). To test the worst-case scenario, we computed the differences in OTL estimates from FES99 and GOT00.2 for a non cross-over point on Berkner Is. (Figure 1) under the ICESat 91-day ground-track following the proposed 33-day on, 6-month off cycle. This produced a series of vertical rates depending on the chosen initial time of over-flight and the duration over which vertical rates were computed. For the point tested we found vertical rates in the range ±2.4 mm/yr over the lifetime of the satellite, showing that until OTL can be verified in this region point measurements of ice thickness change may be biased at up to these levels. Temporal averaging at crossover points will reduce the bias, and with spatial filtering it may be negligible, although the degree of filtering required needs further investigation.

Conclusion
- Overall, the GPS OTL estimates fit best with TPXO.6, CATS02.01 and FES99
- Large misfits in West Antarctica suggest that tidal modelling is currently inaccurate in this region
- Model variability is greatest in the regions near the large Ross and Filchner-Ronne ice shelves where the coastlines are less well known and tidal observations are sparse.
- Unverified OTL model estimates may leave significant biases in the elevation time series derived from ICESat observations.

References

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