Global Ocean Tides from GRACE Satellite Accelerations

Bryan Killett[1], John Wahr[2], Shailen Desai[1], Dah-Ning Yuan[1], Michael Watkins[1], Cecilia Peralta-Ferriz[3], James Morison[3]

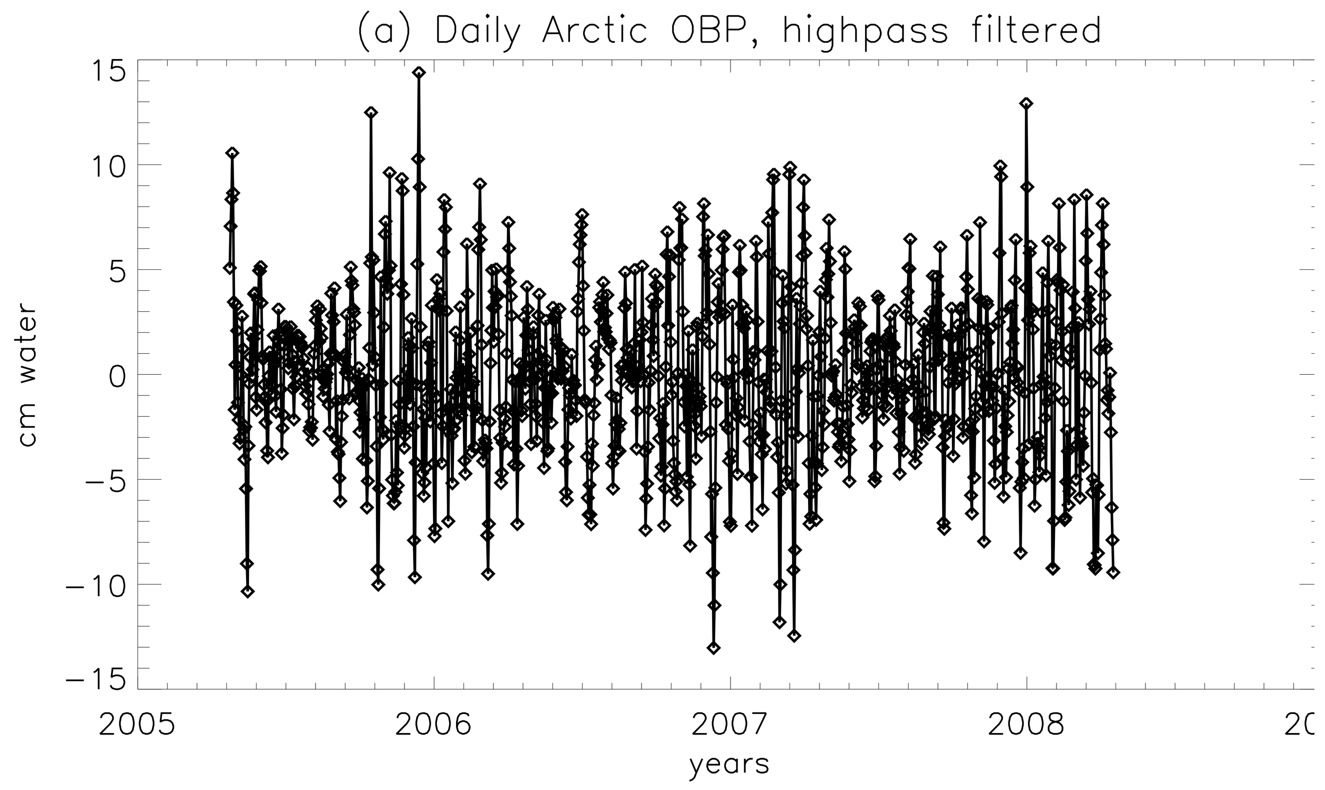
[1]Jet Propulsion Laboratory, [2]University of Colorado at Boulder, [3]Polar Science Center, Seattle

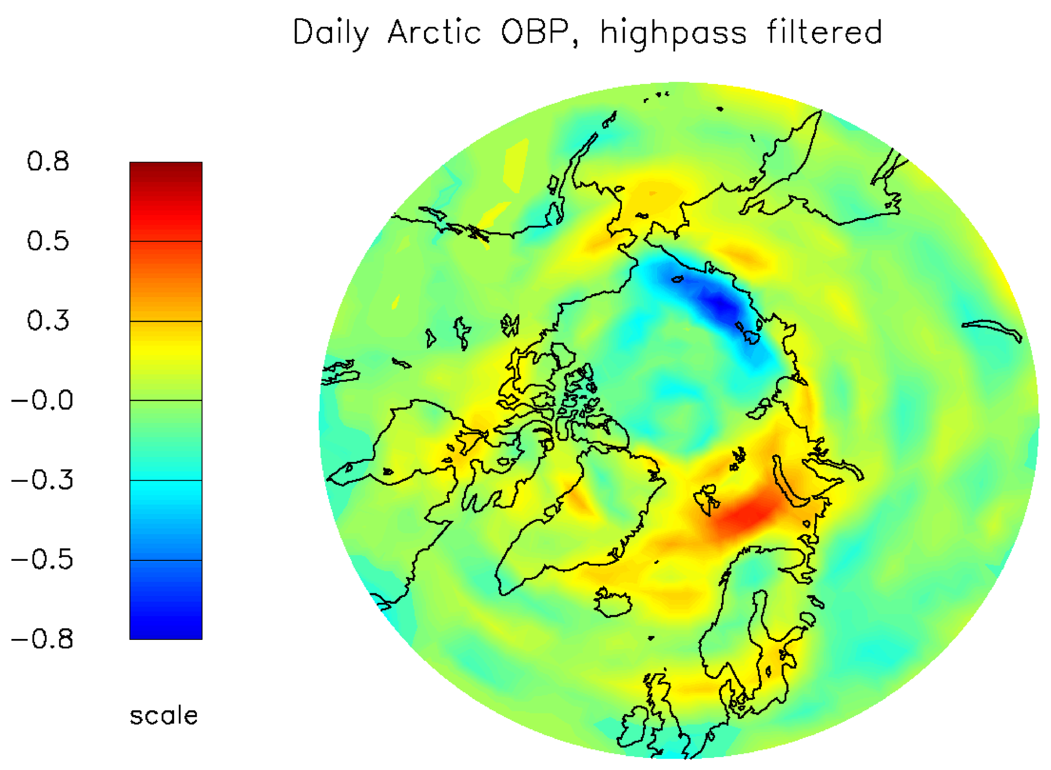
Introduction

GRACE measures gravity fluctuations using two satellites in the same low-earth orbit. One satellite is $\sim$ 220 km ahead of the other, and the two satellites are connected by a microwave ranging system that continuously measures their relative separation distance. Because the first satellite is ahead of the second, it's affected by differences in local gravity before the second satellite. This delay can be used to deduce the underlying gravity variations. Many GRACE projects describe these gravity variations using spherical harmonics, but we chose to use mass concentrations (or "mascons") to parameterize variations in local gravity. More information is available in [1].

Non-Sinusoidal Signals

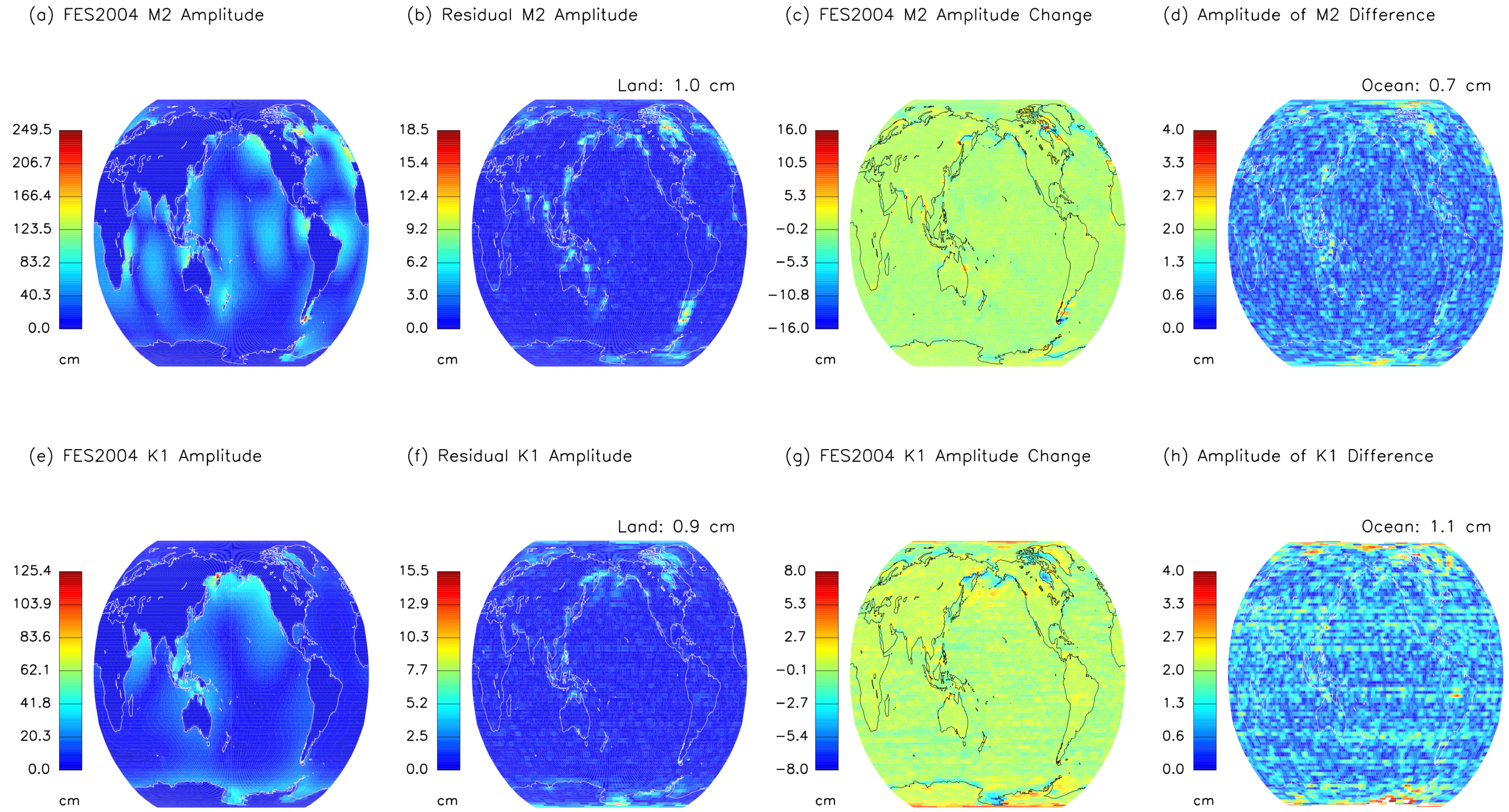
Ocean bottom pressure data from the North Pole and the Beaufort sea are smoothed and averaged to obtain this time series with significant power at sub-monthly periods, which Peralta-Ferriz et al. [2] show is coherent across the Arctic basin. GRACE data were inverted for a scale factor multiplying this time series at each mascon. Positive (negative) scale factors indicate that mascon is (anti-)correlated with the time series; scale factors near zero indicate that mascon isn't correlated with the time series. Note that non-zero scale factors are predominantly in the oceans.





Tidal Residuals

9 years of GRACE inter-satellite accelerations are inverted to solve for corrections (b and f) to the FES2004 tide model (a and e). The average tide amplitudes on land are shown for each correction. Amplitudes and phases for M2 (top row) and K1 (bottom row) are solved separately; each inversion also estimates the annual cycle and secular trend. Next, the corrections are added to FES2004 to show the change in FES2004 amplitude (c and g), which accounts for the phases between FES2004 and the corrections. Finally, the GRACE accelerations are split in two 4.5 year segments, each is inverted for tides separately, then those solutions are subtracted to obtain uncertainty estimates (d and h). Note that the average ocean amplitudes in these uncertainty estimates agree with the land tide uncertainty estimates.



Conclusions

1. The mascon fields have much larger tide amplitudes in the ocean than on land, and are mostly larger where FES2004 is also larger.
2. Two independent solutions (each using 4.5 years of data) are subtracted to provide another estimate of the uncertainty in the inversions which agrees with the land tide estimate.
3. Non-sinusoidal signals with significant power at sub-monthly periods can be recovered using GRACE accelerations.

The source code is available at

`http://bryankillett.com`

References

1. Killett, B., J. Wahr, S. Desai, D. Yuan, and M. Watkins (2011), Arctic Ocean tides from GRACE satellite accelerations, J. Geophys. Res., 116, C11005, doi:10.1029/2011JC007111
2. Peralta-Ferriz, C., J. H. Morison, M. Wallace, and J. Zhang (2011), A basin-coherent mode of sub-monthly variability in Arctic Ocean bottom pressure, Geophys. Res. Lett., 38, L14606, doi:10.1029/2011GL048142