Nontidal ocean loading effects in GPS height time series

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Goal

Compare observed GPS height coordinate residuals generated as a byproduct of ITRF08 with radial surface displacements predicted using the ECCO OBP product.

OBP - Ocean Bottom Pressure

Sum of the mass of atmosphere and ocean in a column above seafloor.

ECCO - Estimating the Circulation and Climate of the Ocean

• Primary product is a global OGCM driven by atmospheric pressure and winds.
• The model data sets assimilates altimetric heights, XBT profiles, and other ocean in-situ data.
• OBP (byproduct) is produced twice daily between 78.5 N to 79.5 S.
Method

• OBP data is interpolated to a 1° grid (1993-2009)

• Trend & long-term mean removed

• Surface displacements for 344 IGS (ITRF08) sites are estimated using the fundamental technique outlined in van Dam and Wahr (1987) in which global grids of surface mass are convolved with Farrell’s Green’s functions

• The 12-hourly predictions are averaged into weekly effects centered on the GPS week.
  • reduces the RMS by about 20% on average confirming that most of the variability in the model is at periods shorter than a week.
Predicted surface displacement

- RMS & Max of predicted surface displacement in 1° grid units based on 5 yr ECCO OBP

- Largest scatter & greatest amplitudes are found in the region of the ACC

- In the interior of continents scatter & amplitudes are usually very small

- At some coastal locations scatter can be greater than 6 mm, with maximum displacements reaching well over 10 mm.

- Largest surface displacements would be expected near enclosed or semi-enclosed basins
Predicted surface displacement at IGS stations

- RMS & Max at 344 continuously operating IGS stations calculated using OBP data from the entire 17 year period

- The scatter in height ranges between 0.20 and 3.67 mm (av. 0.76 mm.)

- Only 10% of the stations (26) exhibit a scatter in the height component greater than 1.5 mm

- For these stations OBP height changes between 5 and 10 mm over a couple of days are frequent
For all sites, an annual signal is prominent, with amplitude, up to 2 mm.
Removing an annual signal from each station time series reduces the scatter on the predicted height effects by 15% on average.
Correlation between predicted OBP heights & ITRF2008 residuals

- For most coastal and island sites, the signals are positively correlated.
- 70% of the correlations are significant.
In all cases the scatter in the GPS observations is much larger than the predicted effects due to OBP loading.

The difference in the amplitude of the predicted and observed scatter in height is less pronounced for the coastal sites.

Removing predicted OBP heights from GPS residuals reduces RMS on 70% of the stations.

ECCO OBP product must be accurately capturing the true load.

Removing annual OBP signal from GPS residuals reduces RMS on 58% of the stations.
Not a strong correlation between a station’s distance from the coast and the reduction in the scatter when the model is applied.
Conclusions

• OBP loading in geodetic time series is a zero sum effect: averages to zero over time

• OBP predicted loading effects are much smaller than effects predicted from atmospheric loading & continental water storage changes, but fall within the precision of GPS height observations

• ECCO’s OBP product is good at capturing real changes in bottom pressure loading.
  • Removing predicted OBP heights from GPS residuals reduces RMS on 70% of the stations
  • Removing predicted annual OBP signal from GPS height observations reduces RMS on 58% of the GPS height time series
  • Little correlation between the amount of scatter that is reduced and a station’s proximity to the coast

• Regions close to (semi-) enclosed bays/seas are affected to a greater extent than other locations by OBP loading > Interpretations of coordinate time-series in these regions should consider the extent to which OBP loading affects their data.