Large Scale Modes of Bottom Pressure Variability from GRACE and the ECCO2 model - revisited.

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ABSTRACT

The **ECCO-2** high resolution baroclinic model (cube 78) shows basin-scale modes in bottom pressure (BP), with energy at annual and other periods, as did its lower resolution predecessor, **ECCO** vJPL-kf066f. Similar modes were discusse version JPL-kf066f d by Stepanov and Hughes (2006) using a barotropic model, and explained in terms of a mass exchange between the Pacific and Southern Oceans. We use **GRACE** monthly data, interpreted as equivalent bottom pressure variations, and find that these modes are indeed present in the data, which is totally independent of the modelling studies. This work takes advantage of the latest releases of GRACE data, with much improved accuracy and corrections, and also seeks to understand weaker non-seasonal components in these signals.

INTRODUCTION. DATA

Stepanov and Hughes (2006) used a barotropic model, and discussed two classes of basin mass exchanges: one near 5 day periods, and one with a broad spectrum and a peak at the annual cycle. They concluded that the dominant mass exchange was between the Southern ocean and the rest of the Pacific basin. With focused numerical experiments they pinpointed the cause as form drag associated with Drake Passage in the wind response and 'leakage' due to the absence of closed f/h contours.

Here we use **the ECCO-2** baroclinic model, 'cube78' (a version identifier), configured as described at this Meeting (OSM-08) by Menemenlis et al. Other Posters at OSM-08 address the interactions of short and long spatial scales, the MOC, Arctic sea ice components, Antarctic ice shelves, as represented in this model. Briefly:

- 18-km horizontal grid spacing, 50 vertical levels
- volume-conserving, C-grid
- bathymetry: ETOPO2
- KPP mixing [Large et al., 1994]
- Mixed forcing (see)
- First data synthesis using Green's functions
- (more, much more)

The **GRACE** data are based on the **Jet Propulsion Lab** release **04.1** version, with crucial postprocessing steps by **Don Chambers (UT-CSR, 11/2007)**

- destriping (Chambers, 2006)
- gaussian smoothing
- Adding a model of spherical harmonic deg 1 variations (Swenson, Chambers & Wahr, 2007)
- adding a model of postglacial rebound (Paulson et al., 2007)
- Removing the effect of land contamination over ocean areas

For this work the ocean-average at each time step in both GRACE data and ECCO2 were removed. This is important to keep in mind, as always an increase *somewhere in these grids* must be balanced by a decrease somewhere else, with zero lag.

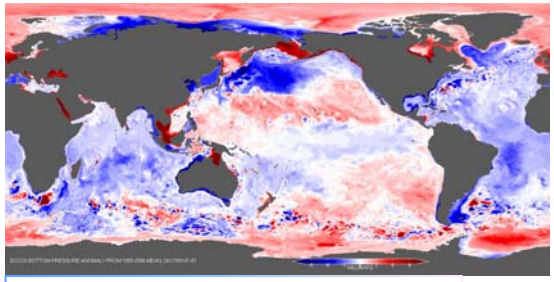


FIGURE 1 above

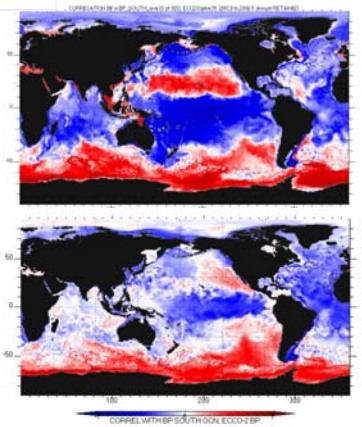
Shows the bottom pressure anomaly for a particular day (1/1/2003) in the **ECCO-2** model (cube 78) . Note
-High resolution features tied to bathymetry (f/h), such as NinetyEast ridge, or the trenches NE of New Zealand.
-- Large scale differences: the Pacific tends to be 'red' (high) on this day, while the Atlantic and Indian are 'blue' (low).

REFERENCES

Chambers, D. P (2006) Evaluation of new GRACE time-variable gravity data over the ocean, *Geophys. Res. Ltrs, 33, L17603, doi:10.1029/2006GL027296*

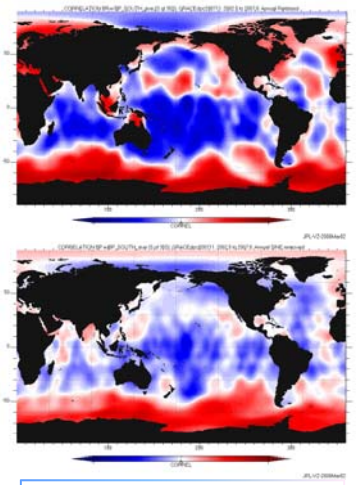
Stepanov, V. N., and C. W. Hughes (2006), Propagation of signals in basin-scale ocean bottom pressure from a barotropic model, *J. Geophys. Res., 111, C12002, doi:10.1029/2005JC003450*

Paulson, A., S. Zhong, and J. Wahr, Inference of mantle viscosity from GRACE and relative sea level data, *Geophys. J. Int. (in press), 2007*



FIGURES 2a,b

above, show the correlation (no lag) between the ECCO2 bottom pressure, averaged over the Southern Ocean (defined as the ocean region South of 35S), and the time series at each one degree grid node (spatially averaged from the full resolution model). (a, top): includes all periods 2 months to 4 yrs; (b, bott): excludes sine annual cycle. Note that the subtropical gyre in the N. Pacific and the southern ocean both correlate with zero lag. The shape of the southern ocean region that is 'red' is not the shape of the region over which the spatial average was taken.



FIGURES 3 a and b

above, are the equivalent of 2a, 2b using GRACE data. Note that the agreement with the model, although the subtropical N. Pacific is weak in the GRACE maps.

SUMMARY & DISCUSSION

ECCO2 bottom pressure shows modes similar to those analyzed by Stepanov and Hughes (2006) in the Pacific and Indian oceans. The GRACE data used here verifies the exchanges of mass between the Southern Ocean and those ocean basins on monthly scales, and also shows that the strongest signals are those of the Southern and Pacific basins (and Arctic, not discussed, but see Figure 5 below). The correlation with Atlantic bp is different than that found by Stepanov and Hughes (2006) in both ECCO2 and GRACE data.

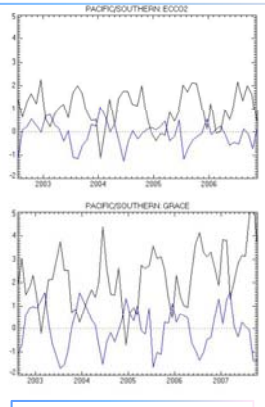


FIGURE 4

above, shows the time series of area-averaged bottom pressure over basins: the Pacific N of 35S, the Southern ocean. It is evident that there is near-zero lag balance of these sigtnals in BOTH GRACE and ECCO2.

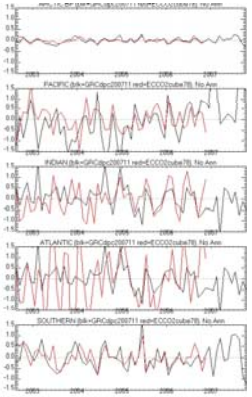
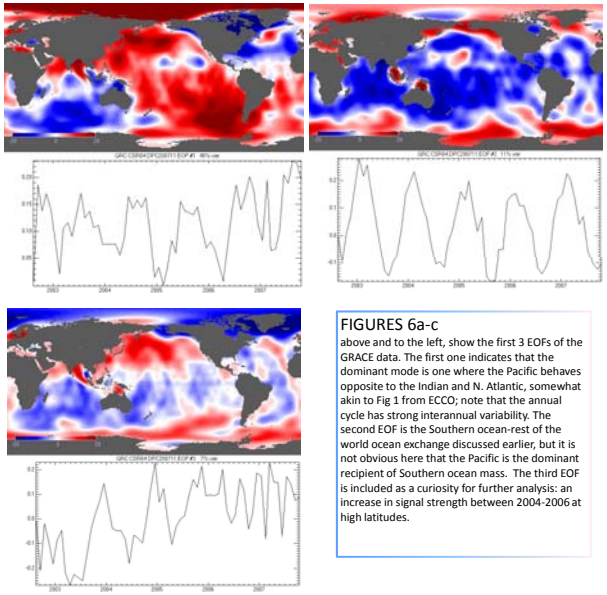


FIGURE 5

Above: GRACE and ECCO2 basin-averaged bottom pressure over their common duration. Note that they are more strongly correlated over the Southern and Arctic oceans, and least over the Atlantic. Also note that the strongest signals are the Southern and Pacific basins, thus their exchanges dominate.

CORRELATION, BASIN-AVE, minus ANNUAL

CORREL ECCO2 BP SOUTH v PAC: -0.43	CORREL GRACE BP SOUTH v PAC: -0.37
CORREL ECCO2 BP SOUTH v IND: -0.07	CORREL GRACE BP SOUTH v IND: -0.10
CORREL ECCO2 BP SOUTH v ATL: -0.11	CORREL GRACE BP SOUTH v ATL: -0.08
CORREL ECCO2 BP SOUTH v ARC: 0.88	CORREL GRACE BP SOUTH v ARC: 0.81



FIGURES 6a-c

above and to the left, show the first 3 EOFs of the GRACE data. The first one indicates that the dominant mode is one where the Pacific behaves opposite to the Indian and N. Atlantic, somewhat akin to Fig 1 from ECCO; note that the annual cycle has strong interannual variability. The second EOF is the Southern ocean-rest of the world ocean exchange discussed earlier, but it is not obvious here that the Pacific is the dominant recipient of Southern ocean mass. The third EOF is included as a curiosity for further analysis: an increase in signal strength between 2004-2006 at high latitudes.