A Non-isostatic Global Sea Level Response to Barometric Pressure Near 5 Days

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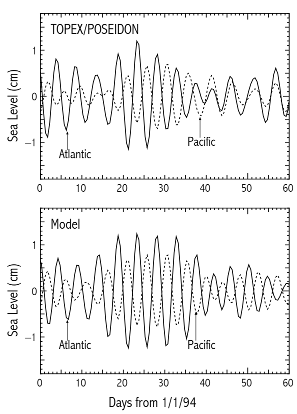
Changes in surface atmospheric pressure usually induce an isostatic response (h_{IB}) in the sea level at the rate of approximately 1 cm/hPa. Nonisostatic signals (h_p) are, however, observed at many tropical tide gauges at periods near 5 days. Our analysis of TOPEX/POSEIDON altimeter data reveals the global nature of these signals, involving nonisostatic sea level fluctuations with nearly uniform phase within separate basins and an out-of-phase oscillation between the Atlantic and Pacific Oceans. Comparisons with a barotropic model link the observed response to a 5-day Rossby-Haurwitz wave in the atmosphere and show that constrictions between basins prevent an isostatic response from being established. The apparent importance of forced, nonresonant modes in the nonisostatic response contrasts with the predominantly resonant dynamics at higher frequencies and may be relevant to explain the behavior of the long period tides.

Background

- High-frequency sea level variability (h_{IB}+ h_p) is caused by barometric pressure.
- Tide gauge data analyses indicate resonant excitation of vorticity modes around 5-day period (Luther, *JPO,* 1982).
- 5-day Rossby-Haurwitz wave can drive the global h_p (Ponte, *JPO,* 1997).
- Tierney *et al.* (*GRL,* 2000) detected h_p of 5-20 day period from T/P.

Model

- Barotropic, shallow-water model (Ponte, *DAO,* 1993)
- ETOPO5 averaged over 1.125 deg (unsmoothed beyond model's resolution)
- Forced by 12-hourly NCEP operational surface pressure from 7/1992 to 12/1995
- Optimal friction parameter, *b*=2cm/s

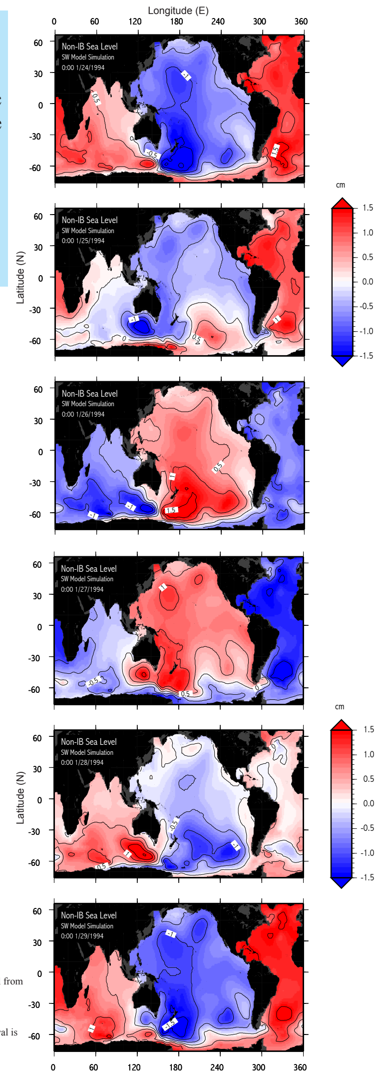


(mm^2)	Atlantic	Pacific	Indian
Model	12.3	7.2	2.2
IB	18.9	10.2	5.8
Non-IB	17.1	7.7	5.3
T/P data	18.3	22.1	5.9
T/P model	11.5	20.7	4.5
T/P IB	20.3	24.4	7.4

(Above) Basin-scale sea level variances (in mm^2), 4-6 day band-pass filtered (1993-1995).

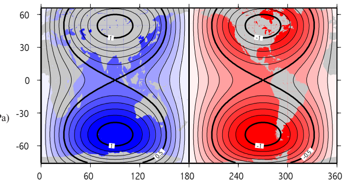
(Left) Time series of the 4-6 day basin-scale non-IB sea level variation (in cm) of the T/P and the SW model from January 1 to March 1, 1994. Estimated error is within 0.15cm.

(Right) Instantaneous sea level variations simulated by the barotropic shallow water model for 0:00 GMT, January 24 through 29, 1994. A 4-6 day band-pass filtering was performed on hourly output. Contour interval is 0.5 cm.



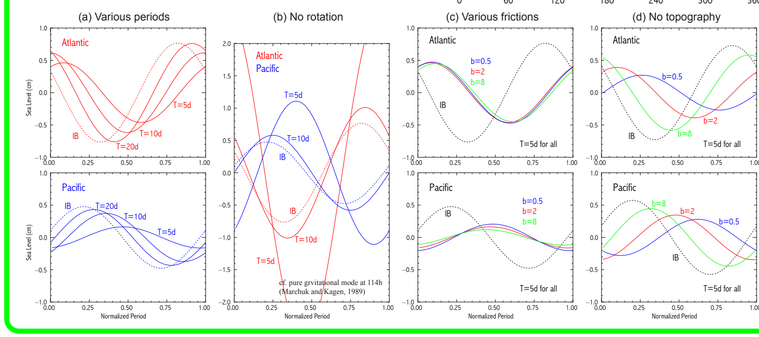
Idealized Experiments

- Forced by analytical Rossby-Haurwitz wave (Madden and Julian, *JAS,* 1972; Ponte, 1997)



(Right) Spatial structure of the 5-day analytical Rossby-Haurwitz wave in atmospheric pressure (hPa)

(Below) Basin-scale sea level responses to the Rossby-Haurwitz wave with (a) various periods of forcing, (b) no earth's rotation, (c) various friction parameters, and (d) an aqua planet with constant depth of 5000m, respectively.



Remarks

- A 5-day, basin-scale, non-isostatic sea level variation is detected from T/P and SW model.
- 5-day Rossby-Haurwitz wave is highly responsible for the observed non-IB signal.
- The response of the barotropic ocean is smaller than and lags the equilibrium solution.
- The response is non-resonant.
- Earth's rotation prevents a pure gravitational mode from being established.
- Bottom topography and coastal geometry control the response.

Future

- Non-isostatic response of the ocean must be considered to improve the accuracy of altimeter measurements.
- T/P data assimilation can provide more accurate estimates of h_{IB}+ h_p.
- Results may be relevant to the non-equilibrium response of long-period tides.

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