On the Nature of Buoyancy-Driven Interannual Tropical Sea Level Changes

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I. Introduction and Motivation

➢It is held that interannual tropical sea level (ζ) represents oceanic response to wind driving while effects of buoyancy forcing usually are either ignored or assumed to be dynamically passive.

➢Using a set of modeling approaches to test these assumptions, we address the following three questions:

1. ***Is buoyancy forcing important to interannual ζ patterns?***
2. ***If so, does buoyancy-driven ζ represent ocean transport processes or local atmospheric forcing effects?***
3. ***If transports are important, what are the dynamics?***

II. Patterns & Forcing of Interannual ζ

➢Observed **ζ** patterns are reproduced by a physically-consistent ECCO ocean state estimate [Wunsch et al. 2007] (Figs. 1a-b).

➢ECCO **ζ** patterns are ascribed to wind and buoyancy driving *via* numerical experiments [Piecuch and Ponte 2012] (Figs. 1c-d).

➢Buoyancy-driven **ζ** contributes in extra-equatorial regions (Fig. 1d) and shows signs of westward propagation (Fig. 2a-e).

III. Budgets of Buoyancy-Driven ζ

➢Budgets of buoyancy-driven **ζ** (Figs. 2a-e) are formulated in terms of advection, diffusion, and local atmospheric forcing [Piecuch and Ponte 2011] (Fig. 2f-t) .

➢Buoyancy-driven **ζ** represents effects of local atmospheric forcing as well as dynamical ocean transports (Fig. 2).

➢ Transport contributions are mostly from advection, but diffusion can contribute in some regions (Figs. 2k-t).

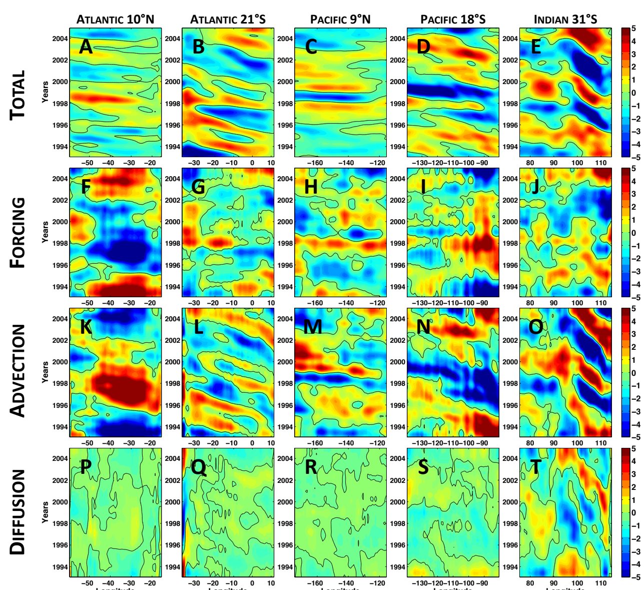

*Figure 2: Hovmöller plots (in cm) of buoyancy-driven steric sea level (**first row**) from ECCO—with contributions from forcing (**second row**), advection (**third row**), and diffusion (**fourth row**)–along representative latitudes in each basin. Black lines are zero crossings. Budgets close exactly and, for each column, the sum of second through fourth rows equals the first row.*

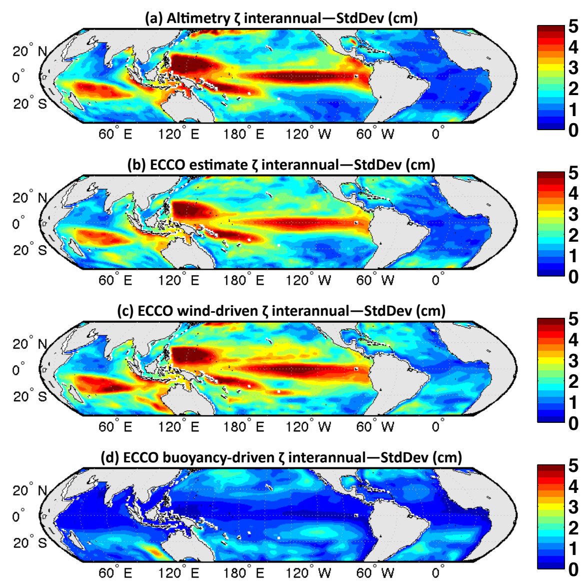

*Figure 1: Standard deviation (in cm) of interannual sea level time series over 1993-2004 from **(A)** altimetry (TOPEX/Poseidon/Jason-1 with 5° smoothing) and **(B)** ECCO. Standard deviation (in cm) of interannual sea level components from ECCO produced by **(C)** anomalous wind forcing and **(D)** anomalous buoyancy driving. Contributions to **(B)** from intrinsic variability and nonlinear response are not shown.*

IV. Baroclinic Rossby Wave Model

➢We also consider a linear model of baroclinic **ζ** response to buoyancy forcing [Piecuch and Ponte, in review] (Fig. 3).

➢Linear model solutions reproduce major characteristics of ECCO buoyancy-driven **ζ** in many places (cf. Figs. 2a-e and 3a-e).

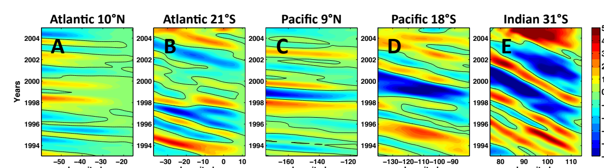

Figure 3: Hovmöller plots (in cm) of damped linear first baroclinic mode Rossby wave solutions computed along representative latitudes in each basin. Black contours are zero crossings. Panels in Fig. 3 should be compared directly to corresponding panels in Fig. 2.

V. Main Findings and Conclusions

1. **Buoyancy fluxes contribute to interannual sea level in the off-equatorial tropics (Fig. 1)**
2. **Dynamical ocean transports and local atmospheric forcing both contribute to buoyancy-driven sea level (Fig. 2)**
3. **Buoyancy-driven tropical sea level dynamics can be understood to first order using a baroclinic Rossby wave model (Fig. 3)**

***References**: (1) Piecuch, C. G. and R. M. Ponte, Geophys. Res. Lett., 38, L15605 (2011); (2) Piecuch, C. G. and R. M. Ponte, Geophys. Res. Lett., 39, L05607 (2012); (3) Piecuch, C. G. and R. M. Ponte, J. Phys. Oceanogr., (in review); (4) Wunsch, C., et al., J. Climate, 20, 5889-5911 (2007).*