Review of “Local versus farfield control on South Pacific mode water variability”
By
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Main summary and recommendation

This study uses the MITgcm and its adjoint modeling capabilities to study the processes that lead to mode water formation in the South Pacific. The authors use adjoint-based sensitivities together with surface flux anomalies to isolate and quantify the impact on mode water formation resulting from surface heat, wind stress, and freshwater flux sources. It is shown that heat fluxes dominate, followed by zonal wind stresses, where impacts typically follow forcing at <1 and ~1.5 year lead times, corroborating previous work. Notably, the work relies on a density based objective function which allows the model to more accurately track mode water pools than previous depth based approaches. Nonlinear forward model perturbation experiments are used to further probe the evolution of heating and cooling.

The paper is well organized and while I have more of a background relevant to the modeling aspects of this paper rather than one relevant to the South Pacific mode water conclusions, I think the study is well motivated and provides useful conclusions to the community. Additionally, I want to additionally congratulate the authors on contributing the density objective function capabilities to the MITgcm code base - this is a highly technical effort which will help to advance the community.

I have reviewed a prior version of this work, and most of my major comments during that review have been addressed. I am therefore recommending minor revisions at this point, given that I only have 1-2 substantive comments at this point.

-Tim Smith

Conceptual Comments

- Section 3.1: I totally agree that it is useful to use “impacts” as a way to quantify the sources of variability in SAMW mode water formation (or any other quantity of interest). However, I’m not used to looking at these quantities, so it’s hard for me to understand the scales of each of these impact plots (e.g. Figure 3). For example, within the first year local surface heat fluxes generate ~4x10^12 m^3 of SAMW mode water formation. Is this a lot? How does this compare to the seasonal cycle or recent amplitudes of interannual variability? If it’s possible to provide any context for these numbers, that would be very helpful.

- Figure 4: I’m still not totally following the interpretation of these plots. Are these generated by accumulating in time from lead_time to 0? Or by simply looking at the “snapshot” of (sensitivity_at_lead_time) * (anomaly_at_lead_time)? Some clarification (or pointing me to the description, in case I missed it) would be very helpful here.

Small grammatical comments

- Line 34: At this point in the text there has been no mention of or build up to the use of adjoints, so it feels like it comes out of nowhere. I would recommend moving it to line 65
- Line 163: fromt he -> from the
- Line 164: aand -> and
- Line 272: “both regions local and upstream regions” -> “both local and upstream regions”