

***Interactive comment on* “On the relation between Meridional Overturning Circulation and sea-level gradients in the Atlantic” by H. Kienert and S. Rahmstorf**

Anonymous Referee #2

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This paper considers whether sea surface height can act as a useful proxy for changes in the overturning circulation. It finds that while on short periods of time changes in Southern Ocean winds or freshwater forcing do produce an apparently linear response, the results do not carry over to longer time scales or to radiative forcing perturbations. This is an important results with implications for observational strategies and model dynamics, and is definitely worth publishing. However, I would like to suggest a number of revisions that would bring out the results more clearly.

Major comments

A. p. 327-329 Discussion setting up potential connection between height gradients

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and overturning is a bit confused. Suggest rewriting this discussion along the following lines. 1. Insofar as the overturning depends on the integrated geostrophic flow (as in Bryan, 1987 and Gnanadesikan, 1999) it can be represented as the surface height difference times a scale depth for integration, divided by a frictional resistance parameter. (Expand eqn 1 to show this). 2. If this scale depth and resistance parameter relatively constant (as assumed in Stommel, 1961 and found to first order by Hughes and Weaver and Thorpe et al.) then surface height alone may be a good proxy- on short enough time scales one would even expect this to be so as it takes a long time to alter the pycnocline depth. 3. Previous work suggests that SSH within subpolar gyre may be a good measure for overturning. 4. However, there are reasons to believe that surface height alone may not be a good proxy (wind forced runs of de Boer et al., 2010 show an increase in overturning but a decline in density contrast, implying that scale height must increase or “frictional resistance” must decrease). Griesel and Levermann also showed that the overturning in a coupled model where sinking can move around doesn’t obey nice scaling laws. 5. If this is true, better data about stratification, i.e. from Argo floats, would be necessary to properly characterize the overturning. 6. So it makes sense to evaluate whether the “natural variability” we might see over decadal scales is a good proxy for different forcing mechanisms. . .

B. p. 333: The linear relationship is presented as “confirming” earlier work, however, the point of the paper is that this is either accidental or true only for particular forcing cases. As such the discussion should talk about the “apparent robustness” of the relationship or its’ “consistency” with earlier work.

C. p . 334: Either put some discussion in of Figure 5 or eliminate it. (I suggest more discussion).

D. Insofar as you see different responses over different timescales it would be good to think about what’s changing. Vertical structure? Apparent efficiency between depth-integrated pressure gradient and overturning?

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E. Conclusions: Would be good to have some discussion about whether these results suggest different “fingerprints” for different forcing mechanisms (winds, freshwater, CO₂). For example, what’s the cross-correlation between the patterns produced by the different RCP pathways?

Minor comments

I’m told that German makes very little distinction between past perfect and straight past tense. In English there’s a subtle distinction that when we say “A has shown X” it is still relevant today, whereas if we say “A showed X” it might not be (though it might). So it’s a bit confusing when the author says effectively “A has shown X but B has shown not X”

p. 326, Lines 20-21: It has already been suggested -> It was suggested

p. 326, Line 23: has been later confirmed -> was later confirmed

p. 326 Line 26: “as e.g.” -> “e.g as”

p. 327 , Line 5: “concluding” -> “who found”

p.329, line 25: “Pacanowsky”-> “Pacanowski”

p. 330, line 14, “motivated” -> “motivated”

p. 330, line 17, “may constitute an indicator” -> “may indicate”

p. 331, Over what latitudes are Southern Ocean winds set to zero?

p. 333, last line, “worsens the linear relation”, “does not produce the apparently robust linear relations seen in Fig 3a and b”

p. 334, Line 17: “vertical structure of density changes gets a different profile” -> “vertical structure of density changes” or “scale length for density has sufficient time to change”

Fig 6 caption should state that the lines follow Fig. 3.

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p. 335, Line 8: “has been suggested already” -> “was suggested

p. 335, Line 12: “compensation of” -> “compensation between”

p. 336: Lines 4,5 “having not come back” -> “rather than returning”

p. 336, line 8, “Only later, overall” –“Later in the run”

p. 336, line 9, comma after “400 m”

p. 336, Lines 10: “While initially”-> “While initial”

p. 337, line 5: “Its quantity is highly uncertain so that ” =>” As its magnitude is highly uncertain,”

p. 338, line 11: “Then,->“If this were true”

p. 338, line 20 “exemplary” ->“example”

p. 340, line 4: “the considered” ->“using the”

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