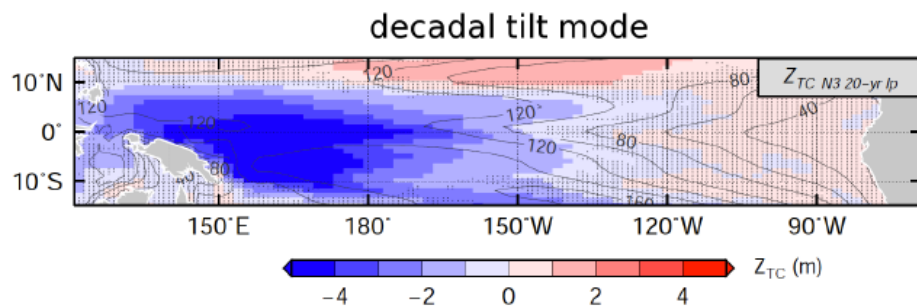


This is a very nice paper, and a nice contribution to the topic of tropical Pacific Climate during the Pliocene. The approach is quite complementary to the previous studies using coupled GCMs to explore possible states of the tropical Pacific. I have several comments, most of which can be handled in changes/additions to the text, and two main comments that suggest some further analysis. I would like to sign this review, and am happy to discuss my comments with the authors.

### **Main comments:**

(1) The thesis of my graduate student, Pedro DiNezio, has shown that the equilibrated response of the equatorial Pacific thermocline to increased zonal wind stress has very little signal in the eastern Pacific. The figure below shows the regression of thermocline depth on zonal mean wind, filtered at a decadal timescale. You get similar results with a shallow water model forced with strengthened zonal winds. The result goes back to the Cane and Sarachik papers, and has also recently been shown in Clarke et al. (JPO, 2010). Von der Heydt et al argue that coupled feedbacks can give you a thermocline response in the east in their model and hence move the cold tongue, but I don't understand how one can get around the equilibrated thermocline response. Perhaps calculating the heat budget, or even showing  $T_s$  may help. Could it be that the upwelling is actually the cause of the stronger cold tongue with stronger winds? This would be consistent with what is in Pedro's first and last Chapter of his thesis. This can be found at <ftp://ftp.aoml.noaa.gov/phod/pub/dinezio/amy/phd/>



(2) I don't understand why the cold tongue contracts eastward with warmer  $T_o$ . It seems intuitive, but some additional analysis of the simulations might help show the mechanism.

### **Other comments:**

1. Two papers have come out just in the last 2 months with proxies showing little change in ENSO variability in the Pliocene (Watanabe et al., Nature 2011, and a paper that is about to come out in Paleocyanography, 2011- I don't have it handy, but it on the journal website as about to appear).

2. In the model description, it would help the reader if the authors provided more discussion about the fact that their model actually simulates the mean SST – I got all the way through the model description before I realized this distinction from the ZC model. It would be nice to just add a few sentences about what  $T_o$  means, and how the model can simulate temperatures that deviate from this.
3. The authors suggest that weaker equatorial trade winds could result from a weakened equator to pole gradient. However, there is another mechanism which can produce weaker surface winds in a warmer climate: that of Held and Soden (2006). Because atmospheric humidity goes up according to the Clausius – Clapeyron scaling, but precipitation is constrained by radiation budget, the overturning circulation must weaken in a warmer climate. Held and Soden (2006) and Vecchi and Soden (2007) show that this takes place in the zonally asymmetric component of the circulation.
4. DiNezio et al (Chapter 4 in the thesis) provided an argument for why ENSO doesn't change much in response to GHG forcing in a multi-model mean sense. Weakened upwelling associated with the weaker atmospheric circulation with a warmer climate (Held and Soden 2006) tends to weaken the strength of ENSO events, while a sharper thermocline (associated with stronger radiative forcing- perhaps akin to  $T_o$  in your paper) tends to strengthen the events. These opposing influences mean that ENSO doesn't change much, and the inter-model differences in ENSO behavior can be explained by differences in the balance between these mechanisms. I wonder to what extent something similar happens in the ZC model, which explains why there is little change in ENSO over a wide range of climates.
5. In the figure captions, the authors note that there is no physical solution for a certain range of parameters- this should be discussed in the text. What does that mean?
6. It looks to me like there are 3 'regimes' for cold tongue position. Or is this just related to the resolution?
7. I have not seen the PRISM data plotted in the way it is shown in Figure 7. It looks pretty strange compared to modern observations, and in fact more like the simple model results. Why? Why in the model is there an increase of SST near the eastern boundary? Absence of coastal phenomena? Perhaps this could have some bearing on the interpretation of the PRISM data.

Signed,  
Amy Clement