



## **Slab Ocean El Niño atmospheric feedbacks in Coupled Climate Models and its relationship to the Recharge Oscillator**

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Dommenget (2010) found that El Niño-like variability, termed Slab Ocean El Niño, can exist in the absence of ocean dynamics and is driven by the interaction of the atmospheric surface heat fluxes and the heat content of the upper ocean. Further, Dommenget et al. (2014) report the Slab Ocean El Niño is not an artefact of the ECHAM5-AGCM coupled to a slab ocean model. In fact, atmospheric feedbacks crucial to the Slab Ocean El Niño can also be found in many state-of-the-art coupled climate models participating in CMIP3 and CMIP5, so that ENSO in many CMIP models can be understood as a mixed recharge oscillator/Slab Ocean El Niño mode.

Here we show further analysis of the Slab Ocean El Niño atmospheric feedbacks in coupled models. The BCCR\_CM2.0 climate model from the CMIP3 data base, which has a very large equatorial cold bias, has an El Niño that is mostly driven by Slab Ocean El Niño atmospheric feedbacks and is used as an example to describe Slab Ocean El Niño atmospheric feedbacks in a coupled model. In the BCCR\_CM2.0, the ENSO-related variability in the 20°C isotherm (Z20), a measure of upper ocean heat content, is decoupled from the first mode of the seasonal cycle-related variability, while the two are coupled in observations, with ENSO being phase-locked to the seasonal cycle.

Further analysis of the seasonal cycle in Z20 using SODA Ocean Reanalysis reveals two different regimes in the seasonal cycle along the equator: The first regime, to which ENSO is phase-locked, extends over the west and central equatorial Pacific and is driven by subsurface ocean dynamics. The second regime, extending in observations only over the cold tongue region, is driven by the seasonal cycle at the sea surface and is shifted by roughly six months relative to the first regime.

In a series of experiments with the Kiel Climate Model (KCM) with different mean states due to tuning in the convection parameters, we can show that the strength of the equatorial cold bias and the coupling strength between the seasonal cycle of Z20 and ENSO are anti-correlated, i.e. a strong equatorial cold bias suppresses recharge oscillator dynamics and enhances Slab Ocean El Niño atmospheric feedbacks, supporting the results from the BCCR\_CM2.0. This can be explained as with a stronger cold bias the second regime of the seasonal cycle in Z20, which extends in observations only over the small cold tongue region, expands westward and becomes more important, so that it decouples ENSO from the seasonal cycle in Z20. This has implications for some major characteristics of the ENSO like the propagation of SST anomalies, the phase locking of SST to the seasonal cycle, or the nonlinearity of ENSO.

Dommenget, D., 2010: The slab ocean El Niño. *Geophys. Res. Lett.*, 37, L20701, doi:10.1029/2010GL044888.

—, S. Haase, T. Bayr, and C. Frauen, 2014: Analysis of the Slab Ocean El Niño atmospheric feedbacks in observed and simulated ENSO dynamics. *Clim. Dyn.*, doi:10.1007/s00382-014-2057-0.