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THE DEPENDENCE OF INTRSEASONAL VARIABILITY ON MIXED LAYER DEPTH IN AN AGCM COUPLED TO A SLAB OCEAN.

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1. INTRODUCTION

Sensitivity of tropical intraseasonal variability to oceanic mixed layer depth is examined in the modified National Center for Atmospheric Research Community Atmosphere Model 2.0.1 (NCAR CAM2.0.1) with relaxed Arakawa-Schubert convection (Moorthi and Suarez 1992), coupled to a slab ocean model (SOM). SOM depths of 50 meters, 20 meters, 10 meters, 5 meters, and 2 meters are employed.

We extend the experiments of Watterson (2002), who demonstrated an increase in intraseasonal atmospheric variability as oceanic mixed layer depths were decreased to 10m in a coupled model. Sobel and Gildor (2003) used a highly idealized model to show that intraseasonal variability should not be a monotonic function of mixed layer depth, and that the reduced thermal inertia of the ocean renders the model stable to convection at SOM depths less than 10 meters. Our study also provides interesting insights on the role of wind-evaporation feedback to the Madden-Julian oscillation.

2. MODEL

The modified NCAR CAM2.0.1 with relaxed Arakawa-Schubert convection scheme is coupled to a simple slab ocean model that is formulated as follows:

$$\rho_o C_o h \frac{\partial T}{\partial t} = F + Q \qquad (1)$$

where T is the slab ocean temperature, ρ_o is the density of sea water (constant), C_o is the heat capacity of seawater (constant), h is the slab ocean depth, F is the net atmosphere to ocean heat flux, and Q is the oceanic mixed layer heat flux. Q is calculated as the oceanic heat flux satisfying the heat balance in (1) using climatological monthly surface heat fluxes derived from a control simulation forced by observed climatological SSTs. This framework is similar to that employed in Maloney and Kiehl (2002).

A 15-year CAM2.0.1 control simulation forced by observed climatological seasonal cycle SSTs was conducted. The climatological surface fluxes from this simulation were used to determine the oceanic Q-flux for 15-year SOM simulations with ocean depths of 50 meters, 20 meters, 10 meters, 5 meters, and 2 meters. An additional 15-year CAM2.0.1 simulation was conducted that used observed seasonal cycle SSTs in which surface latent heat fluxes are set to the climatological seasonal cycle from the control simulation. We refer to this simulation as the "No-WISHE" simulation, although technically more than just the influence of wind speed variations on surface latent heat flux is removed.

3. RESULTS

The amplitude of December-May equatorial-averaged west Pacific precipitation variations at 30-90 day timescales is found to be a non-monotonic function of mixed layer depth (Figures 1 and 2). Precipitation variations are enhanced relative to the fixed-SST (infinite mixed layer depth) simulation for mixed layer depths of 5

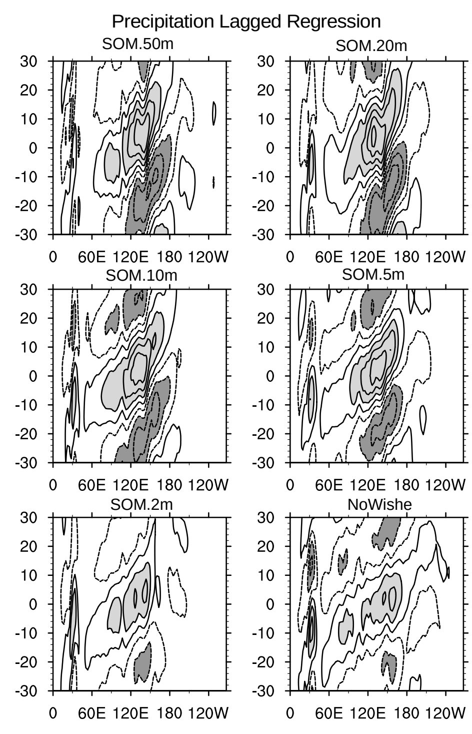

Fig 1. Lagged regression plot of equatorial 30-90 day precipitation during December-May. Fields are regressed onto the principal component timeseries of the leading equatorial 850 hPa extended EOF mode, and correspond to a 1σ value of the reference timeseries. Precipitation contours are plotted every 0.4 mm day^{-1}, starting at 0.2 mm day^{-1}. Neg. values dashed.

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to 50 meters, with a maximum at 20 meters, but strongly diminished relative to the fixed-SST simulation in the 2 meter depth simulation (Fig 2).

The control simulation, and the SOM coupled simulations with mixed layer depths greater than 2 meters, produce near-equatorial intraseasonal precipitation variations that more closely resemble observations than the 2 meter or No-WISHE simulations. The amplitude of precipitation anomalies in the 2-meter SOM simulation is very similar to that in the No-WISHE simulation.

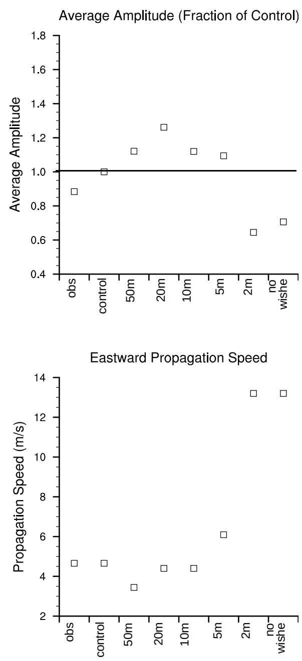

Fig 2. The a) RMS amplitude and b) the average propagation speed of regressed equatorial 30-90 day precipitation anomalies within the domain: longitudes, 105E-165E, lags, -30 days to 30 days. Amplitudes are expressed as a fraction of the control simulation.

Besides the amplitude differences, propagation of west Pacific equatorial precipitation anomalies in the No-WISHE and 2 meter SOM simulations is eastward at around 13 m s^{-1}, as compared to near-observed values of 4-5 m s^{-1} in the control and deeper SOM simulations.

Although intraseasonal SST variations are stronger in the 2 meter SOM simulation than in any of the other simulations (not shown), these SST variations act in such a way as to diminish the amplitude of equatorial latent heat flux variations (Fig 3). Reducing the mixed layer depth is thus nearly equivalent to eliminating WISHE, which in this model has the effect of weakening equatorial convective variability.

Our results are broadly consistent with those of Watterson (2002), who found an increase in intraseasonal atmospheric variability as mixed layer depths were decreased to 10m in a coupled model. The slope of the variability as a function of mixed layer depth changes sign at smaller mixed layer depths in the NCAR CAM2.0.1, however. This behavior was predicted by Sobel and Gildor (2003) using a highly idealized model.

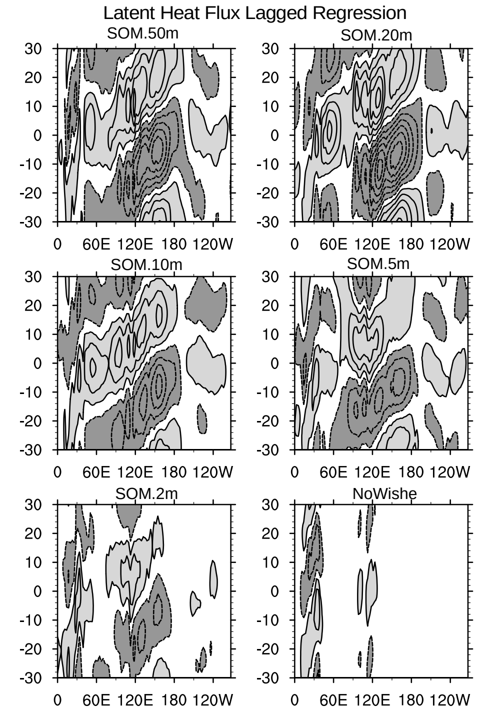

Fig 3. Same as Fig 1, except for surface latent heat flux. Contours are plotted every 2 W m^{-2}, starting at 1 W m^{-2}.

Further experiments with the same idealized model are described in a paper submitted to *Journal of Climate* (Maloney and Sobel 2004), which help to interpret results derived from the modified NCAR CAM2.0.1.

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4. REFERENCES

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