Modeling Studies of the Indo-Pacific Warm Pool

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We are conducting a wide variety of modeling[a] studies aimed at understanding the interactions of clouds, radiation, and the ocean in the region of the Indo-Pacific warm pool, the flywheel of the global climate system. These studies are designed to understand the important physical processes operating in the ocean and atmosphere in the region. The modeling studies should help with the design of the Atmospheric Radiation Measurement (ARM) site in this region and also put the eventual measurements from the site into large scale perspective.

A stand-alone Atmosphere General Circulation Model (AGCM), forced by observed sea surface temperature (SST), has been used for several purposes. We evaluated the radiative aspects of the code against Earth Radiation Budget Experiment (ERBE) observations. The comparisons were generally excellent. The most serious disagreement was found with the structure of the low clouds in the model. Members of our group are working to improve this aspect of model performance. For instance, a new convection scheme is being introduced to the AGCM to see if it improves response of the Hadley cell. At the same time, a revised radiation/cloud parameterization for the AGCM is being tested with pre-ARM data—a prelude to more comprehensive testing with the fully operational ARM site in both Oklahoma and the Indo-Pacific warm pool site.

Another study with the AGCM shows the high sensitivity of the tropical circulation to variations in mid- to high-level clouds. Changes in warm pool cloud distribution are not balanced by (local) convective-radiative adjustments. Rather, the entire Walker and Hadley cells are altered by the cloud changes. The balances are thus affected by dynamic processes, which emphasizes the need to place warm pool ARM measurement into the context of a good AGCM (or coupled GCM).

A stand-alone ocean general circulation model (OGCM) is being used to study the relative role of shortwave radiation changes in the buoyancy flux forcing of the upper ocean. The shortwave flux, normally ignored by oceanographers, is large and plays a significant role during El Nino events. Interestingly, it is somewhat balanced by associated changes in precipitation and longwave radiation fluxes, leaving evaporative flux as the dominant process affecting the buoyancy forcing over much of the tropical ocean. These results suggest that many of the encouraging OGCM simulations of tropical ocean variability obtained to date may have appeared correct for the wrong reasons.

Complete studies of the warm pool can only be conducted with a full coupled ocean/atmosphere model (CGCM). With that in mind, we are just bringing on line now the latest version of the Hamburg CGCM. The model produces realistic simulations of the ocean/atmosphere system in the Indo-Pacific without use of a flux correction scheme. We plan to use a spinup of the model and the seasonal cycle of the model to explain the dynamic and thermodynamic processes that maintain the warm pool and that cause it to move seasonally.

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