# Collaborative Proposal: Impacts of Aerosols and Air-Sea Interaction on Community Earth System Model (CESM) Biases in the Western Pacific Warm Pool Region

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**PROJECT DESCRIPTION:**

The realistic simulation of clouds and precipitation over the Tropical Western Pacific warm pool (WPWP) region remains a challenge in this new era of higher resolution climate models (horizontal spatial resolution of 1° and higher). Coupled model simulations typically show biases in the zonal sea surface temperature (SST) gradient as well as the meridional SST gradient over the equatorial/tropical Pacific ocean, both of which might lead to biases in the SST-sensitive tropical atmosphere via air-sea coupled processes. However, atmosphere-only simulations with prescribed observed SST also suffer from negative biases in total cloud amounts and biases in the location and intensity of the inter-tropical convergence zone (ITCZ). DOE's ARM sites over the tropical Western Pacific (TWP) region provide vast continuous multivariate observations of meteorological conditions since 1996 over the region - including those related to tropospheric aerosols, clouds, surface radiation and precipitation - presenting an opportunity to carefully analyze atmospheric and air-sea coupled processes and improve their representation in climate models.

Contrary to assumptions in most of the IPCC AR4 models, the relationship between aerosols and clouds/precipitation is non-monotonic, because of the simultaneous direct, semi-direct and indirect effects of aerosols on the surface, clouds and precipitation. The microphysical interactions between aerosols and clouds have only recently been incorporated into global climate model (GCM) simulations. It is important to understand these simulated interactions and compare them with observations to improve the representation of climate processes in GCMs and hence improve climate predictions.

The WPWP regions bears an influx of aerosols from Southeast Asia along with local sources from the Western Pacific islands and can play an important role in the regional climate. Furthermore, the WPWP region exhibits strong air-sea coupling, and any study of the origin of regional biases needs to take these interactions into account.

We propose to conduct a hierarchical coupled modeling study using a suite of experiments conducted with a high-resolution configuration of CESM1.0 to understand the impact of major aerosol species on the WPWP region and compare model output with observations from ARM surface instruments as well as multi-sensor satellite observations. In addition to the coupled CESM integrations, we also intend to carry out additional mechanistic integrations using the uncoupled CAM5 atmospheric model, intermediate coupled models where CAM5 is coupled to simplified ocean models and the single column atmospheric model (SCAM) configuration in CESM1.0. In particular, we will couple CAM5 to a slab ocean model (SOM) and a reduced-gravity ocean model (RGOM) that can be configured to simulate both the mean state as well as important features of tropical variability such as the El Nino-Southern Oscillation (ENSO). This hierarchy of mechanistic integrations will facilitate the understanding of the interaction between aerosols and the atmospheric column, as well as the interaction between the atmospheric column and the underlying ocean, in determining the tropical climate state. Insights gained from analyzing these integrations can be used to improve model parameterization of aerosol effects, and thus help alleviate model biases associated with clouds and precipitation.