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Using observations, NWP analyses and short forecasts to understand the cause of precipitation errors in a climate model

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Compared to TRMM data the high resolution (0.25 degree) NCAR Community Atmosphere Model (CAM) over-predicts precipitation in the tropical eastern Pacific by 50% in climate simulations. This over-prediction error sets up early in 5-day forecasts initialized from ECMWF and GMAO YOTC analyses. We attempt to identify the cause of this systematic error in the 5-day forecasts and thus in the model climate. Comparison with 3-hourly 0.25 degree TRMM data shows that the standard CAM forms small scale precipitation events that are much too intense and too long lived. The cause of these events is identified and eliminated. However, these events are not the cause of the average over-prediction which remains when they are eliminated. They are too small in area and, while always present somewhere in the domain, not frequent enough to contribute to the over-prediction. Conditional averaging shows that in the regions with rain, the model precipitable water is too large compared to both ECMWF and GMAO analyses whereas in the rain-free regions the model precipitable water is close to both analyses. Excessive model rainfall is often ascribed to precipitation parameterization deficiencies, but that may not be the case here because the model rains too much in regions where it is too wet. The parameterization is trying to remove the excess water vapor. Analysis of the evolution of the water balance in the forecasts shows that water vapor is transported from rain-free regions to rainy regions by the resolved dynamical component. The transport through the lateral boundaries into the region being examined is not significant. It is the lateral exchange within the region that is dominant. Perhaps the water vapor source is too strong. The surface evaporation might be too large because of a parameterization deficiency. On the other hand, the parameterization might be formulated correctly but creates too much evaporation because the surface winds are too strong. Strong surface winds might arise from too strong dynamical convergence forced by too strong heating from release of latent heat in forming the rain, or from incorrect vertical distribution of condensation and heating. The dynamical transport and parameterized processes locally feedback on each other with a very fast time scale making it difficult to untangle the cause and effect in model forecasts. We will present a series forecasts with modifications to the model that weaken selected feedbacks to try to break the contributory interactions. We note that such experiments can be done in short forecasts but such a modified model might not survive long simulations. This is another advantage of examining climate model errors in forecast mode.