Predictability of Wet and Dry Summers in West Africa

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Abstract: This study examines the role of various synoptic and dynamic factors in regulating rainfall along the Guinea Coast of West Africa during a particularly wet rainy season, 1997 and a consistently dry one, 1999. In addition, I assess the degree to which the ECHAM 3.6 and ECHAM 4.5 AGCM simulate these features using persisted May SSTs (forecast) and using perfect JJA SSTs (simulation). This analysis, focusing on the months of June through August, is carried out using the National Centers for Environmental Prediction-National Center for Atmospheric Research (NCEP-NCAR) 40-Year Reanalysis Project dataset. The strength and latitude of the African Easterly Jet and the strength of the low-level monsoonal southwesterlies were found to be important to rainfall patterns in both years. The African Easterly Jet and monsoonal southwesterlies interact to create a horizontal zonal shear zone, along and just to the south of which the horizontal temperature gradient, east-west surface pressure gradient, and barotropic instability are maximized in both years. In both years, the maximum rainfall belt is located about 2 degrees latitude to the south of the shear zone. The shear zone and the horizontal pressure and temperature gradient is significantly stronger in 1999.

Three features which appear to “telegraph” the rainy season in West Africa in 1997 and 1999 are the horizontal temperature gradient from 20N to the Gulf of Guinea in May, the moisture profile of the atmosphere in West Africa in April and May, and the strength of the African Easterly Jet in April and May. The atmosphere over the Gulf of Guinea is observed to be moister in April and May of 1999, and a stronger African Easterly Jet appears as early as April in 1999, creating a weak horizontal zonal shear zone two months before the onset of the rainy season. In addition, a stronger heat low and higher lower-tropospheric temperatures appear over the Sahel in May 1999 vs May 1997. This heat low grows through JJA 1999, enhancing the monsoonal southwest flow and increasing the moisture advected into easterly waves over the Gulf of Guinea.

Given that the Gulf of Guinea SST is highly correlated (0.83) with rainfall over the Gulf of Guinea, the forecast ECHAM based on a persisted May SST can indirectly incorporate these features into its forecast. However, the ECHAM model has a northward bias with the position of the shear zone and zone of maximum precipitation over West Africa.

The forecast ECHAM shows remarkably good skill for 1997 and 1999 and identifies the large-scale patterns of heavy and light rainfall. However, there are errors in the positioning of rainfall maxima and in the latitude of the heaviest rainfall swath, particularly in 1999. I assess the degree to which these errors are related to model biases and the degree to which they are related to the limitations of the persistence technique.