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Oceanic Origin of the Precipitation Jump in the Sahel

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The socioeconomic vulnerability of the agricultural societies in the Sahel region of West Africa to the vagary of summer rainfall has received world recognizance. The recently initiated international endeavor of the African Monsoon Multidicispline Analysis underscores the fundamental gaps in our knowledge of the coupled atmosphere-ocean-land system in this region and the large systematic errors in dynamical models used for prediction. Spacebased sensors, whose observations are not limited by geopolitical boundaries, could alleviate the historical deficiency and neglect of the monitoring systems in this region.

Observations by the Tropical Rain Measuring Mission (TRMM) show a rather abrupt transition of rainfall at 8°N in the West African Monsoon (WAM) area. Rainfall peaks in June south of this latitude, but in August north of this latitude and no satisfactory explanation was postulated through observation or model. Many studies have postulated that the rainfall in northern region (Sahel) is controlled by high-frequency instability in the westward propagating Easterly Waves (EW), but there is no clear evidence of phase coherence between rainfall and EW in annual and interannual variations. There is no clear explanation on how easterly waves from the continent over the dry soil of the Sahel could trigger monsoon onset.

We have developed and validated a method to estimate the moisture transport integrated over the depth of the atmosphere (IMT), using ocean surface wind vector from the scatterometer QuikSCAT, cloud-drift winds from NOAA, and the integrated water vapor from the Special Sensor Microwave Radiometer. We observed that the IMT coming onshore from the Atlantic has significantly high contemporary correlation with rainfall in the Sahel region but not with rainfall in regions near the Gulf of Guinea (GG). On contrary the northward IMT from GG has strong correlation with rain just north of GG but not the rainfall further north in the Sahel. The IMT coming onshore from the Atlantic only around August and lags those coming from the Gulf of Guinea, which peaks in June, by two months. While the IMT from the Atlantic is positive (onshore) only for the short period of a month, the surface wind is positive almost entire year except for January. The implication of our observation is that the onshore moisture transport from the Atlantic is confined to the surface with off shore transport aloft, except for a summer month. During the August, the on shore transport extends far up in the troposphere supplying moisture and instability for heaviest rainfall in the Sahel. Reanalysis from the National Center for Environmental Prediction confirms a sharp weakening the easterly jet at 600-700 mb level during this month. The rainfall jump may be the result of the phase difference between the IMT from the Atlantic and the GG.

The interannual anomalies of rainfall in the Sahel region is positively correlated with IMT from the Atlantic, but not with IMT from the GG. The anomalous wet season in 1999 is caused by the positive (eastward) anomalies of IMT from the Atlantic and the anomalous dry summer of 2005 is associated with negative (westward) anomalies of IMT over the Atlantic.