Geostatistical analysis of Local versus Regional Feedback on Regional Climate: Synthesis of Insitu Observations and Global Analysis over Senegal, Western Africa

Souleymane Fall, Dev Niyogi*, Fredick Semazzi, Richard Anyah, Jared Bowden

Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University, Raleigh, NC

Climate variability over Senegal and its relationships with global climate is examined for the period 1971-1998. Monthly observed rainfall for 20 stations over Senegal, monthly mean temperature for 12 stations and monthly average CMAP data were averaged for the months of June July, August and September, to generate seasonal rainfall totals for the wet season and climate indices averaged over the study period. The monthly SST data is the NOAA Extended Reconstructed SST data (ERSST) provided by the NOAA-CIRES Climate Diagnostics Center in Boulder, Colorado.

The monthly, seasonal and annual temperature and precipitation distributions are mapped analyzed using ArcGIS Spatial Analyst. Rainfall distribution over Senegal is dominated by a N-S gradient, and temperature distribution by an E-W gradient.

The mapping of the coefficient of variation for all stations reveals that for both rainfall and the number of rainy days, June is the month that exhibits the greater variability, especially in the West and North of the country. As regard to temperatures, the months from January to April are accountable for most of the variability, especially in the sub-arid areas of the North and Northwest.

Trends in precipitation and temperature are estimated using a linear regression analysis and interpolation maps for the slopes. Areas of positive slopes are limited for rainfall (Northeast and Southwest of Senegal), but important and statistically significant for temperature throughout the country.

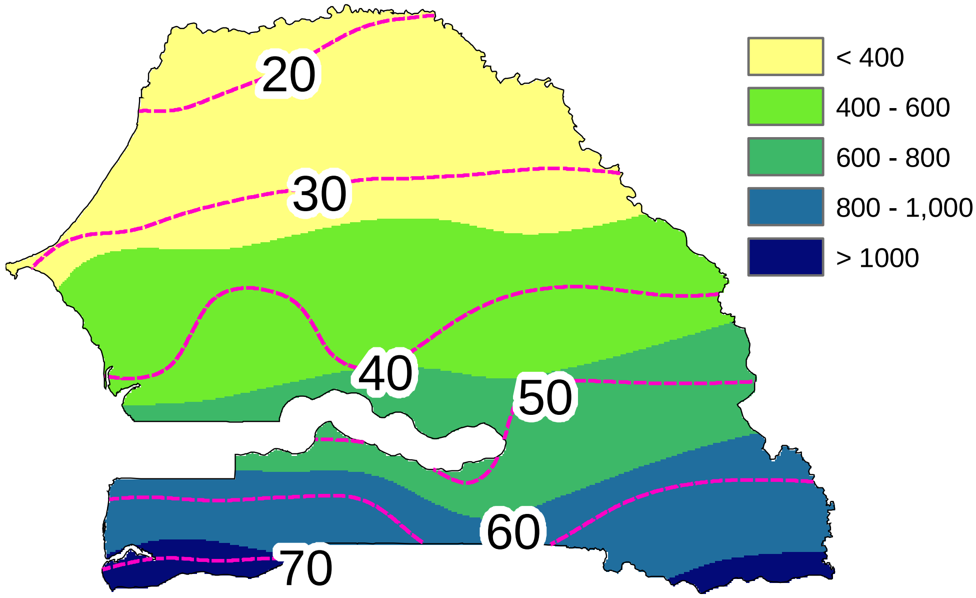
To investigate the climate variability over Senegal two EOF analyses are performed: for 1971-1998 using observations, and for 1979-7998 using additional CMAP data. The first analysis reveals a strong domination of the first EOF mode for rainfall over Senegal. The corresponding time series mostly fluctuates on a high frequency mode. Its correlations with Atlantic and Pacific SST don't show a strong relationship leading to predictability. However, the second mode for September is well correlated with North Atlantic SST. Despite modest coefficients, the best results are found with Pacific Ocean SST (lag correlation).

The second EOF analysis (1979-1998) includes CMAP data and is conducted over Senegal and West Africa. The first West African mode agrees strongly with Lamb's rainfall index. One of our major findings is that EOF2 for West Africa is well correlated with EOF1 for Senegal rainfall. Series for CMAP rainfall over Senegal show good correlation with the South Atlantic SST. Good coefficients are observed during the pre-wet season (January through May) and may offer some predictability for the rainy season. In the Pacific Ocean, the greatest coefficients (up to -0.72) are observed during the April-July period, which can provide hints for the coming rainy season.

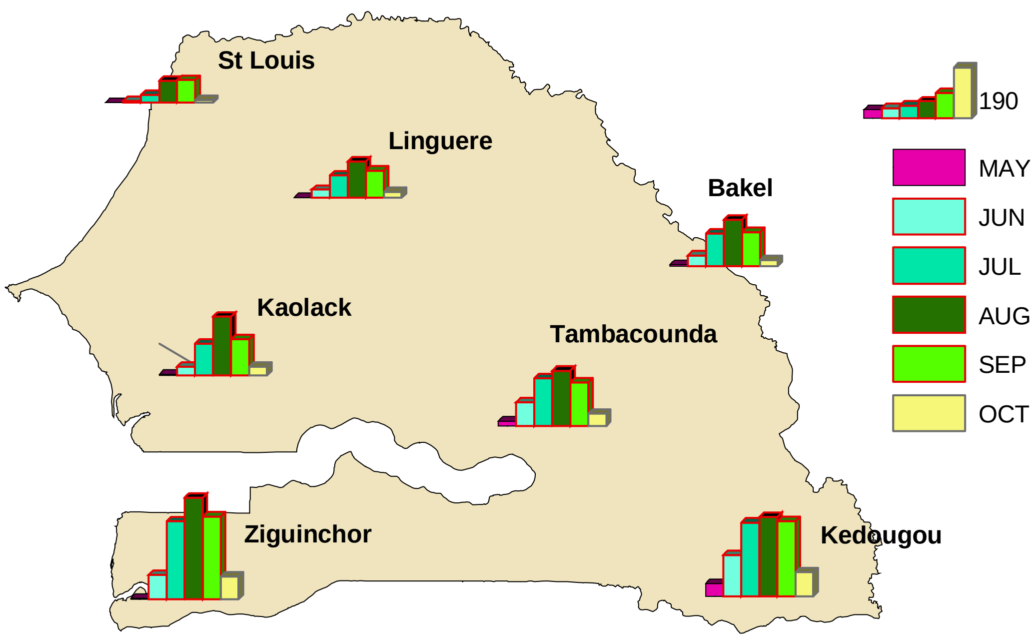
The different results obtained in the two analyses suggest an evolution in the relationship between SST fields and Senegal or West African rainfall. The correlations show that the relationships between the South Atlantic and Senegal or West Africa were stronger in the 1979-1988-period, especially for CMAP rainfall over Senegal and West Africa. The CMAP data is robust and suitable for analyses over West Africa. Based on this liability, it has been possible to use CMAP data in a second EOF analysis, as a validation for the first analysis only based on observed precipitation.

* Communicating Author: Dev Niyogi, Email: dev_niyogi@ncsu.edu; Tel: 919 515 7912; Box 8208, NCSU, Raleigh.

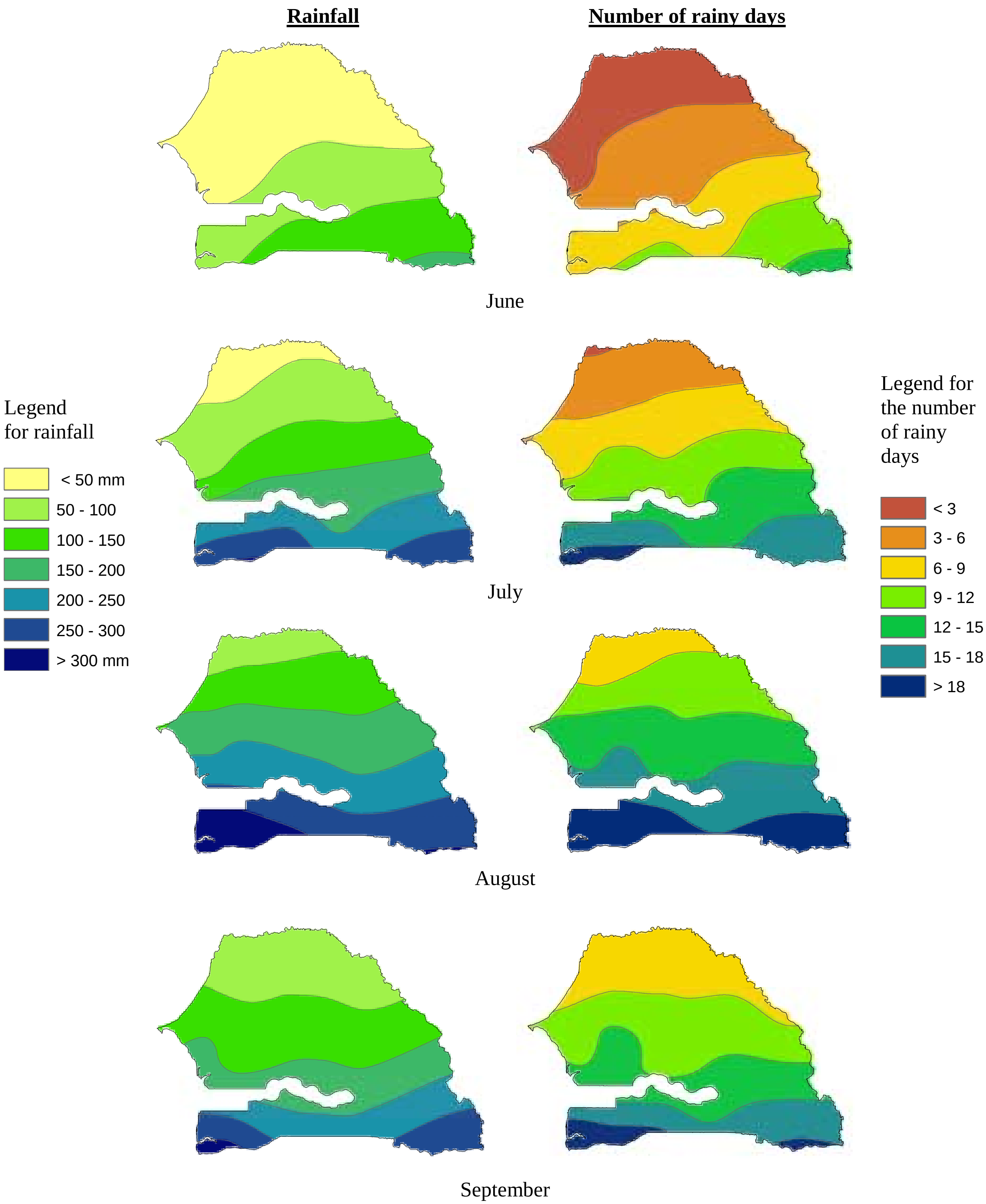
a)



b)

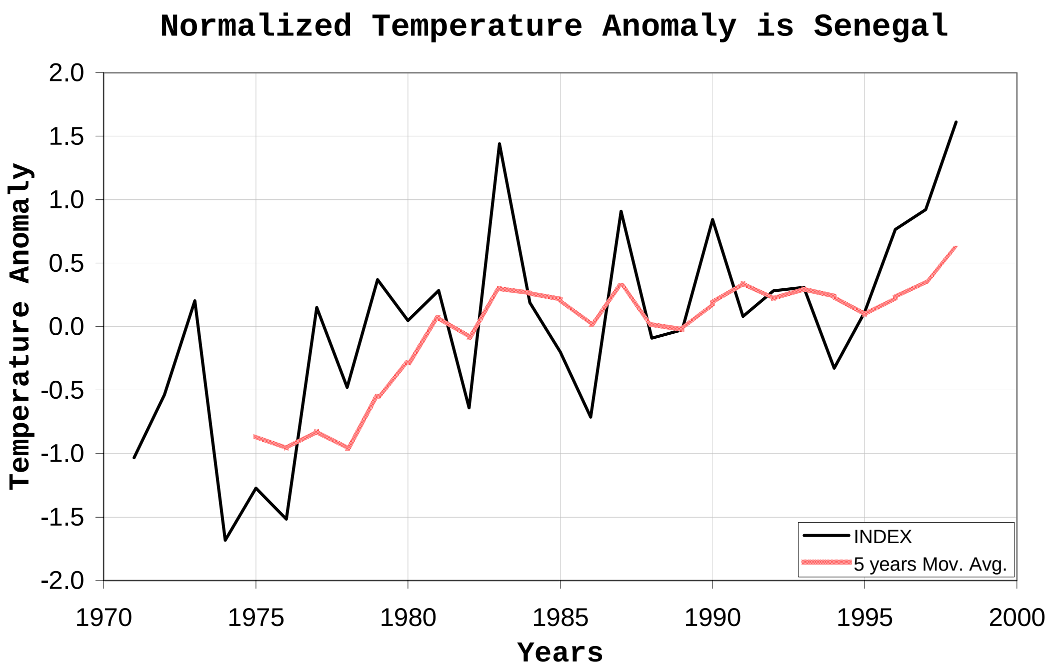


Seasonal rainfall distribution (JJAS) for the period 1971-1998.
Rainfall in mm (colors) and number of rainy days (isolines); b) monthly distribution for the rainy months. The north-south gradient is evident. The southern Senegal is the first and the last region which records rainfall, in accordance with the seasonal shift of the monsoon

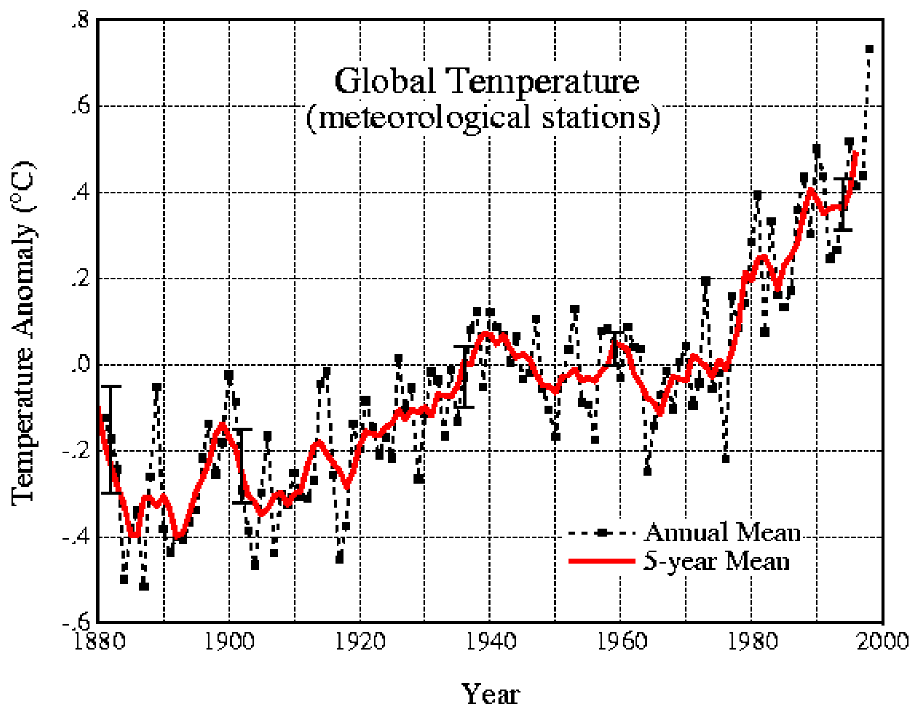


Mean monthly rainfall and number of rainy days for the period 1971-1998. There is a strong agreement between rainfall amounts and the number of rainy days (see also figure 4.6) and both spatial patterns reveal the N-S gradient of distribution.

a)



b)



a) *Normalized temperature anomalies relative to the period 1971-1998 (Senegal). A 5-years moving average curve is fitted;* ***b)*** *Global mean temperature in degrees Celsius relative to the mean temperature for the period 1951-1980 based on measurements at meteorological stations (the mean for 1951-80 is about 14°C). The vertical lines at several dates indicate the estimated uncertainty in the annual-mean temperature due to the incomplete coverage of stations. The figure was obtained from GISS. (http://www.giss.nasa.gov/research/observe/surftemp/1998.html). There is a good agreement between the two trends*