P1.4 SIMULATED SURFACE HYDROLOGY AND ENERGY BALANCE OF WEST AFRICA USING SSIB WITH OBSERVED PRECIPITATION AND SATELLITE-DERIVED VEGETATION

Daniel Kahan, Yongkang Xue
University of California at Los Angeles

Stephen Prince
University of Maryland

Arona Diedhiou
Laboratoire d'Etudes des Transferts en Hydrologie et Environnement

Peter J. Lamb
University of Oklahoma

This study utilizes the offline Simplified Simple Biosphere Model (SSiB) (Xue et al., 1991) to analyze the surface fluxes of West Africa. The model will be run using available observed precipitation data as the main driver. An analysis of land surface properties is conducted that compares the difference in results when satellite data or data from a vegetation map is used for leaf area index (LAI) and fractional vegetation cover (FV). Also, the effects of heterogeneity in the prescribed surface characteristics will be considered.

For this study, measured precipitation within West Africa was provided at 13 locations by the University of Oklahoma and at 1,504 locations by the Laboratoire d' E`tudes des Transferts en Hydrologie et Environnement in France. From these stations, 28 sites were selected based on having a complete record for an eleven-year study period, from 1982 to 1992. The selected sites lie between 4º and 16º north latitude and between 9º west and 19º east longitude. The three stations chosen from the University of Oklahoma dataset lie in the more northern part of the study area, extending into the Sahel region, while the 25 remaining stations lie between there and the Atlantic coast. The data in both sets was divided evenly from daily totals into 24 hourly time steps.

Daniel S. Kahan, University of California, Los Angeles, CA 90024, dkahan@ucla.edu

Yongkang Xue, Geography, UCLA, 1225 Bunche Hall, UCLA, Los Angeles, CA 90095-1524, yxue@geog.ucla.edu

Stephen D. Prince, Geography, University of Maryland, 2131 LeFrak Hall, College Park, MD 20742, sp43@umail.umd.edu

Arona Diedhiou, LTHE/HMET/IRD, LTHE/IRD, 1025 rue de la Piscine, Domaine Universitaire, Cedex 9, Grenoble, 38041, France, arona.diedhiou@hmg.inpg.fr

Peter J Lamb, University of Oklahoma, plamb@ou.edu

The remaining forcing variables, air temperature, wind, air pressure, humidity, and incoming shortwave and longwave radiation, were derived from National Center for Environmental Protection (NCEP) reanalysis data (NCEP, 2002). The forcing variables were interpolated from 6-hour values to hourly values. Since the reanalysis data has a resolution of 1.9047º latitude by 1.875º longitude and the rainfall data is scattered randomly, the nearest reanalysis data point to each rainfall station was used at that station.

One purpose for the spatial analysis is to evaluate the advantages of satellite-derived vegetation parameters. The satellite data used for leaf area index and vegetation cover is of 8-kilometer resolution and was derived from AVHRR NDVI data (Los et al., 2001). The vegetation map used to determine which standard surface parameter values to use was part of the global land cover database of Hansen et al. (2000). Figure 1 shows the location of the rainfall stations, indicated by the vegetation type present at that location.

Figure 2 shows the seasonal latent heat flux across the study area, exhibiting a north-south gradient that reflects the precipitation pattern, with the greatest values occurring in the southwestern region of the study area. In general, the latent heat

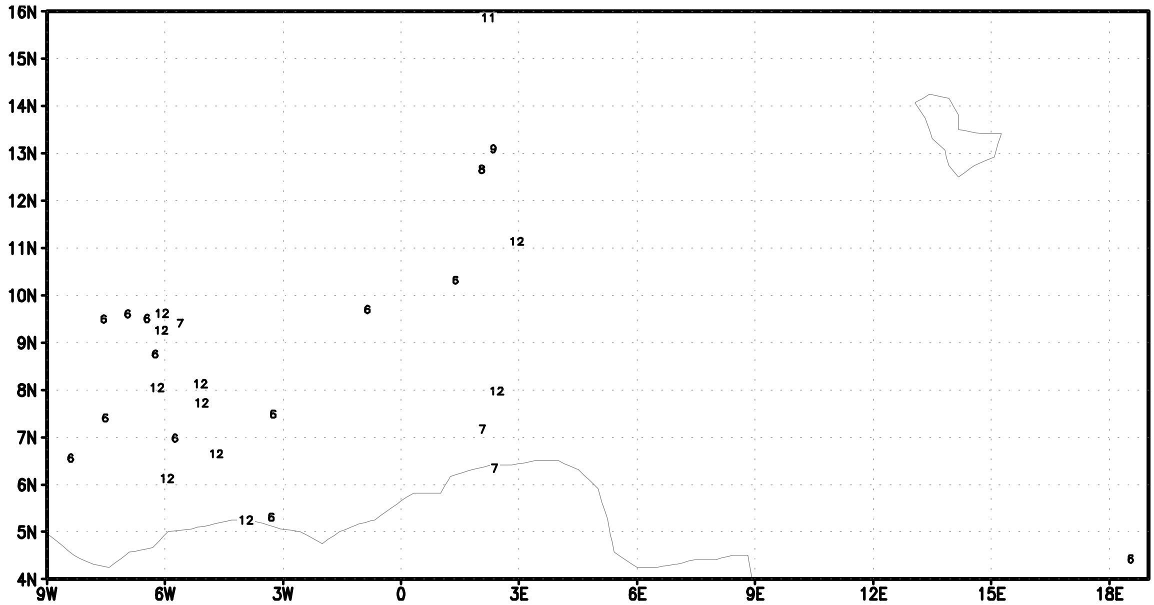

Figure 1: Location of rainfall stations in spatial analysis, identified by vegetation type

flux seems to be controlled primarily by the precipitation forcing, but the LAI and other vegetation parameters seem to have some secondary effects.

This analysis tests the difference in results when standard vegetation parameters are substituted for the satellite-derived leaf area index and fractional vegetation cover used in the previous figure. It will compare two model runs: the control run (Run S) from the prior sections, and an experimental run (Run T) that will utilize standard values and the vegetation map for all parameters, including LAI and FV (Table 1).

Figure 3 shows the average monthly LAI for Run S and Run T at a typical type-6 station, Odienne, and a typical type-12 station, Dimbokro. The plot for Odienne shows the LAI in Run T to be higher than the LAI in Run S for a significant portion of the year. By contrast, the LAI from run T at Dimbokro is clearly lower by at least 1 or 2 throughout the entire year. Similarly, any change in the output variables such as latent heat, temperature, or runoff would also be dependent upon the site selection. Figure 4 shows the resulting latent heat flux at Odienne and Dimbokro. During the summer and autumn at Odienne, the latent heat flux based on standard data (Run T) is greater than that from satellite LAI (Run S). By contrast, the latent heat flux at Dimbokro is clearly less in Run T throughout most of the year. The majority of these differences occur during the day, when the latent heat flux is at its maximum.

The runoff (figure 5) shows a clear dependence on this difference in vegetation type, with an average of 9 percent less runoff at type-6 sites in Run T. Type-12 sites show as much as a 34 percent increase during summer and 19 percent during autumn, with an average difference of 18 percent more in Run T. The difference between satellite LAI and standard LAI for either vegetation type is most pronounced during a single season of the year.

If satellite data is to be implemented, the question arises of how precise the data must be. What resolution of satellite data is necessary to accurately portray the surface conditions? In the preceding experiment, 8-km resolution data was used, with one pixel being used at each rainfall station. To investigate this issue, the model was run at 16 sites, coincident with the reanalysis data (reanalysis data will be used for rainfall as well) between 10.476º and 4.76184º north latitude and

Table 1: Land Surface Characteristics Experiment

Run	S	T
Source of LAI & FV	Satellite	Standard
Source of other parameters	Standard	Standard

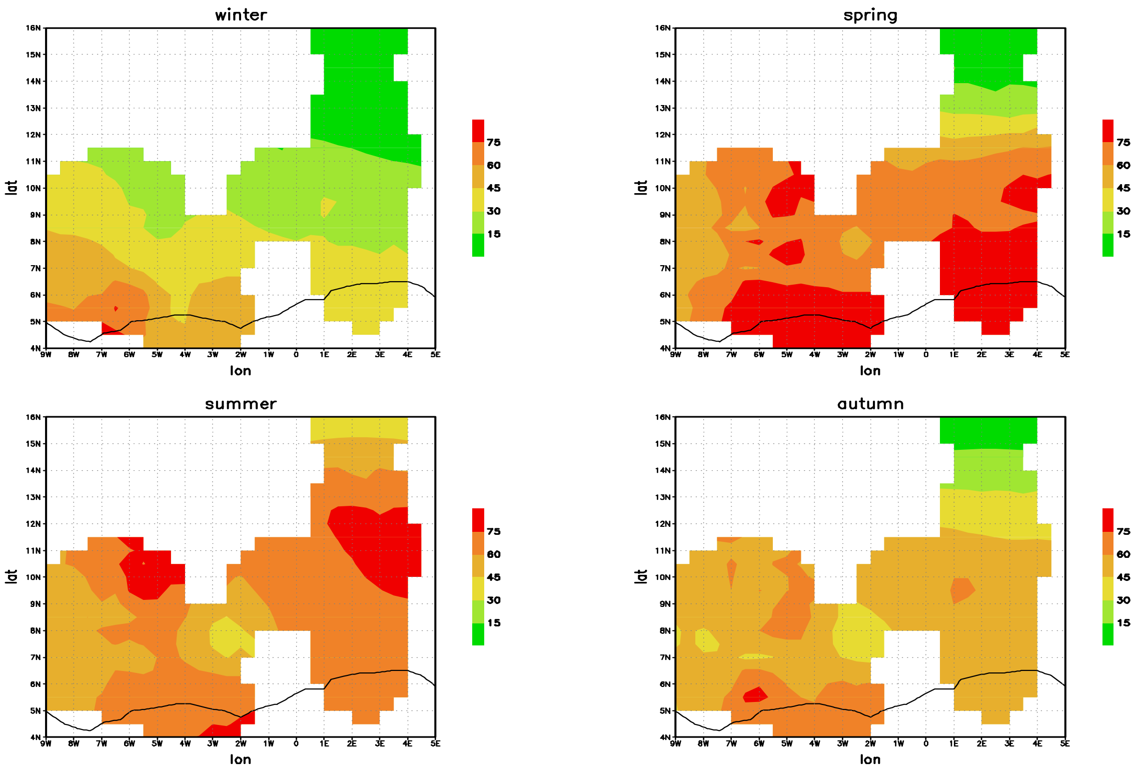

Figure 2: Seasonal latent heat flux (W/m^2)

9.375º and 1.875º west longitude.

Table 2 summarizes the three model runs. For the first run, referred to as H1, the model was run at each reanalysis point, using only whichever land cover type was dominant within the grid box for that point. Because satellite data contains no single dominant value for a parameter, leaf area index and vegetation cover were simply taken from the same table as the other vegetation parameters. For the second run, labeled H2, all the vegetation parameters, including LAI and FV from satellite data, were aggregated before running the model at the reanalysis point. For the third run, labeled H3, the model was run at all points within the grid box that were 40 km apart. Thus, each grid box contains results from 36 points. Although the model could have been run at 841 points per grid box, based on the 8 km satellite data, the amount of computing time would have been excessive.

Fluxes from run H1 and H2 show a visible north-south gradient, but the rest of the land surface features are not visible. Fluxes from H3, however, begin to show some variety in the landscape. The north-south gradient is still apparent, but additionally there are localized patches of different-magnitude fluxes that become visible. The average values for the simulated fluxes and prognostic variables tend to remain the same. In general, this experiment shows that it is preferable to have greater resolution of data when examining an area spatially. Although the temporal averages may work out to be the same, spatial variability may be lost with lower resolutions of data.

Africa as a whole has been studied to determine what impact the management of land may have in affecting climate. Because of its vast areas of landscape, it is a natural choice for the

Table 2: Overview of Heterogeneity Experiment

	Source of LAI & FV	Type	Resolution	# of sites per grid box
H1	Table	1 dominant type	1.90472° lat X 1.875° lon	1
H2	Satellite	Aggregated	1.90472° lat X 1.875° lon	1
H3	Satellite	One point	40 km	36

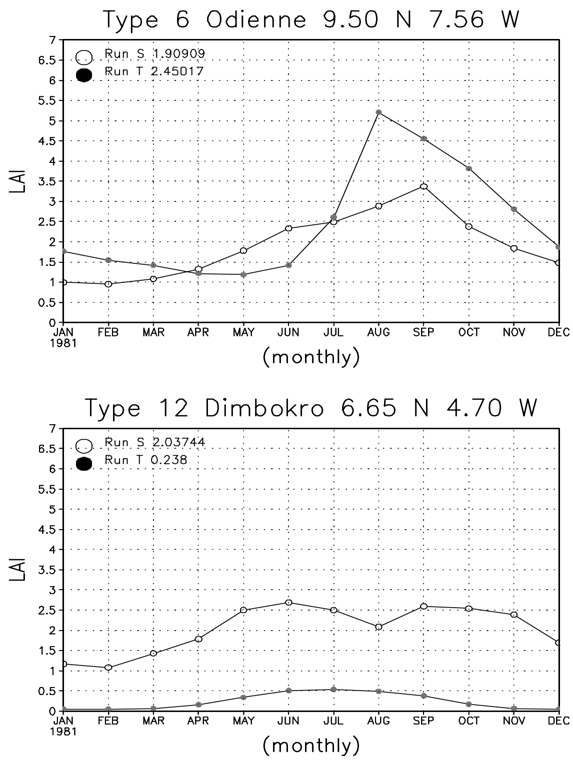

Figure 4: Leaf area index at stations Odienne and Dimbokro from satellite/table data

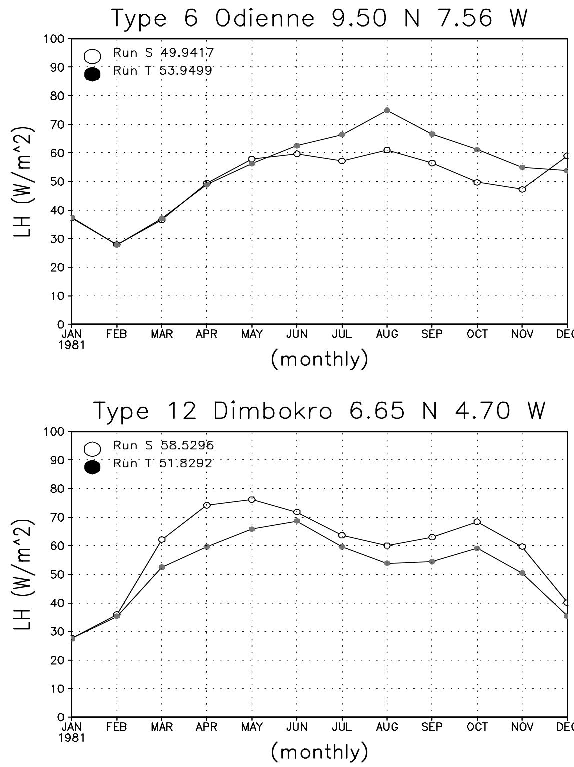

Figure 3: Latent heat flux at stations Odienne and Dimbokro based on satellite/table LAI&FV

study of land surface-climate interaction. Results from this study indicate that incoming radiation and precipitation have the primary impact on the surface fluxes. The interannual variability of rainfall, for example, clearly affects the resulting water balance each year. The land surface conditions play a secondary role. Where croplands, grasslands, or rainforest exists in place of savannah, there is an evident difference in the resulting fluxes. The greater the resolution of information from the study area, the more this pattern stands out.

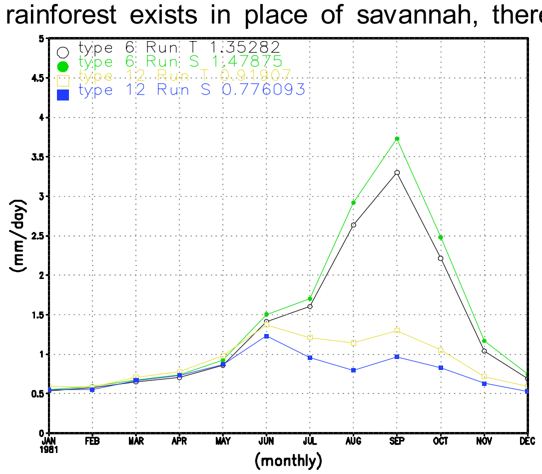

Figure 5: Monthly mean average runoff for types 6 and 12 in runs S and T

References

Hansen, M.C., et al., 2000. Global land cover classification at 1 km spatial resolution using a classification tree approach. *International Journal of Remote Sensing*. 21: 1331-1364.

Los et al., 2001. AVHRR NDVI data

NCEP, 2002. NCEP reanalysis data provided by the NOAA-CIRES Climate Diagnostics Center, Boulder, Colorado, USA, from their website at http://www.cdc.noaa.gov/

Xue et al., 1991. A Simplified Biosphere Model for Global Climate Studies. *Journal of Climate*. 4: 345-364.