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RELATING MULTITEMPORAL METEOROLOGICAL SATELLITE DATA TO CLIMATOLOGICAL DATA FOR AFRICA

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The questions of surface-atmosphere interaction and effects of land surface changes have been investigated by studying the energy balance over Africa. The energy and mass balance model being developed is an adaptation of the Lettau climatonomy model. The climatonomic approach is a systems approach which encompases (1) a process, (2) an input to the process (forcing function), (3) an output from the process (response function), (4) feedback and (5) control or management of the system. Steady-state climate is described and parameterized using a series of one-dimensional differential continuity and balance equations for energy and mass.

The basic three-part regional surface climatonomy model consists of a shortwave radiation submodel, an evapotranspiration submodel and a thermoclimatonomy submodel. As details of the model have been published elsewhere, and are commonly available, they will not be reiterated here. The basic forcing function is the regional extra-atmospheric irradiation, which is an external function of time and latitude. The shortwave submodel parameterizes atmospheric attenuation processes and derives as output the reflection to space, atmospheric absorption and ground absorption. The latter, combined with precipitation rate, provides energy and mass forcing functions for the evapotranspiration submodel. The response function of this submodel includes exchangeable soil moisture and mass fluxes like runoff and evapotranspiration rate. The forcing of the thermo-submodel is ground-absorbed insolation minus latent heat release to the atmosphere, as determined by the second submodel. The response function of the third model is the time series of subsurface and air temperatures and surface energy fluxes. The data requirements are satisfied by a combination of conventional meteorological station data, global (often satellite-derived) data sets (e.g., top albedo) and, in some cases, parameters estimated from the regional climatology, soils and vegetation.

We are developing a regional climatonomy model for a central Sahelian region in Niger, where field and AVHRR observations made by Justice et al. (1985). This will be the first complete development of a climatonomy model for a semi-arid region and the model will be appropriately modified to deal with the extreme seasonal changes of exchange parameters.

The shortwave radiation submodel has been completed and tested against satellite-derived values. The model has been developed for both cloudy and cloud-free conditions. We are conducting sensitivity tests at present. It has been shown that the shortwave balance is highly insensitive to surface albedo and atmospheric composition (non-aerosol) and most sensitive to cloud conditions. This is an important result, as it clearly refutes Charney's drought hypothesis. We have also simulated the influence of increased dust content in the atmsophere, and found that it's influence is considerably greater than that of albedo.

Once all three submodels are complete, several tests are anticipated:

1. variation of mass forcing (i.e., rainfall) in the evapotranspiration submodel (and subsequent influence on the thermo-submodel).

2. surface albedo variations (with and without corresponding rainfall changes in the second submodel);

3. variation of soil moisture in the absence of rainfall changes (i.e., as a result of "desertification" processes such as erosion of moisture-retaining fine materials, or reduction of vegetation cover);

4. surface temperature variations with and without rainfall changes as a causal factor (the latter being a potential effect of denuding the land surface and consequently also reducing the soil moisture).

Progress in the area of vegetation index has been slow, as we have experienced difficulties in obtaining the NDVI data and reading the tapes. Also, the rainfall data set we are producing was not yet complete. Nevertheless, some interesting results have been obtained from a preliminary analysis of data for eastern Africa. These are described in a Masters thesis by Michael Davenport which deals with a comparision of rainfall, water balance and NDVI over East Africa. Two of the most interesting results are derivation of maps of the lag time of vegetation response to rainfall conditions, which varies with vegetation type, and the finding that the vegetation boundaries are closely correlated with a "rainfall efficiency parameter", which is basically a ratio of NDVI to rainfall.