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Model Sensitivity to Parameters in the Simple 1-D Land-Atmosphere Model

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Large scale effects are generally more important to the regional climate than local effects, such as land cover. However there is rarely any comparison of the two types of effects due to the complexity of the land-atmosphere system and the difficulties in controlling different climate drivers. Here we look into this matter from a model perspective.

The modified simple 1-D land-atmosphere model based on *D'Andrea* (2006) and *Baudena* (2008) is used to investigate the relative sensitivity of climate variables (air temperature and precipitation) to the external forcing and local forcing. The model has two properties: firstly, it is an equilibrium model and secondly, it requires a small set of parameters. Therefore, this model is suitable for sensitivity analysis in which the effect of change in one factor can be isolated. In this study, we perform sensitivity analysis on the effects of four parameters. External forcing is represented by solar radiation (100 - 800 W m^2) and moisture influx (0 - 1 mm hr^{-1}) to the region. Local forcing is represented by the initial leaf area index (LAI, 0 - 10) and the initial soil wetness (0.13 - 0.63). A normalized index is used to access the sensitivity of the model outputs to the parameters. The index is defined as

$$SI = \frac{d_{max} - d_{min}}{D_{mean} \cdot r},$$

where d_{max} and d_{min} represent the local extremes; D_{mean} is the mean value for the whole domain and r is the proportion of the whole domain from which the local extremes are taken.

Precipitation and air temperature output both responded nonlinearly to the tested parameters. Precipitation is resistant to changes when parameters are near to the lower end of value ranges until a threshold is hit. On the other hand, temperature is more sensitive to the low parameter values than the high parameter values. Hence, precipitation is suppressed and temperature remains high due to lack of vegetation cover, or low soil moisture, or negligible moisture influx from outside the region. Both precipitation and temperature are low when radiation is insufficient (in this case, < 456 W m^2). For the tested range, the system reveals that both the initial soil moisture as shown by *D'Andrea* (2006) and other conditions can lead to multiple equilibriums. The sensitivity indexes show that precipitation is generally more sensitive to the changes in radiation and moisture influx, both with SI > 2 in the middle ranges. The sensitivity of precipitation to the changes in soil wetness and LAI are below 0.5. This could be an indication that external forcing is more important than local forcing in determining the local climate. However, the results also suggest the local effects can contribute to the local climate variation.