Comparison of soil moisture in the FSU climate model coupled to a land model CLM2 to soil moisture from NCEP/DOE Reanalysis 2.

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Soil moisture is a key component in controlling the exchange of water and heat energy between the land surface and the atmosphere. Given that the soil moisture is prescribed in the FSU climate model, the implementation of the CLM2 model as the land parameterization in the FSU climate model allows us to obtain an explicit treatment of soil moisture into ten layers.

Given that the soil moisture is difficult to measure accurately in both time and space, reanalysis is a good substitute to supply with global soil moisture data set on a long time series. We compare our soil moisture outputs to one of the most well known global reanalysis: NCEP/DOE Reanalysis 2 (R-2). In both coupled model and R-2, the soil moisture takes soil liquid water and soil ice into account.

In order to compare soil layers of similar thicknesses, we added the soil layers of the coupled model. Thus, the first layer is 0-10 cm for R-2 and 0-16.6 cm for the coupled model and the second layer is 10-200 cm for R-2 and 16.6-229 cm for the coupled model. The coupled model layers are thicker than these of R-2.

The global distribution of soil moisture for the coupled model, for R-2 and the difference between the coupled model and R-2 over 5 years (1992-1996) is shown in figure 1 for the first layer and figure 2 for the second layer.

The coupled model shows high values in regions with ice (Polar Regions, west Siberia …) compared to R-2 for both layers. This difference comes from the fact that the soil ice amount becomes an important component of soil moisture in the frozen regions for the coupled model. Indeed, over west Siberia (55º-65ºN), the mean percentage of soil ice is about 60% whereas the mean percentage of soil ice in the northern hemisphere (0º-60ºN) is only 20% for the first layer. For the Polar Regions (90º-60ºS and 60º-90ºN) the mean percentage of soil ice reaches about 78%. The effects of frozen soil on the hydrologic process can be very important. Frozen soil stores more soil liquid water through the winter which cannot be evaporated. Ice changes also the thermal properties of the soil. When water freezes it releases latent heat.

For the latitudes from 60ºS to 60ºN global wetness and dryness areas agree with expectations in both model and R-2: the driest places are Sahara Desert, Arabian Peninsula and Central Australia, whereas the wettest regions are typically at higher latitudes. Despite the fact that for the coupled model, the layers are thicker and the soil ice component is more important in the regions where the ground is frozen, the coupled model is drier (global mean soil moisture for the latitudes from 60ºS to 60ºN over 5 years is 0.21 m3/m3) than R-2 (0.26 m3/m3) in the first layer. In the second layer, the soil moisture content of the coupled model (0.231 m3/m3) is more similar to that of R-2 (0.235 m3/m3), but still drier in regions without ice and wetter in regions with ice.

To conclude, the coupled model compares well with R-2 in most regions but tends to give a dry bias under a dry climate (Australia, Sahara desert) and a wet bias when the soil is frozen (west Siberia, Polar Regions). The wet bias in frozen regions is due to the fact that the soil ice contribution to the soil moisture is more important in the coupled model than in R-2. This difference can have important consequences on the hydrologic process and the thermal properties of the soil.

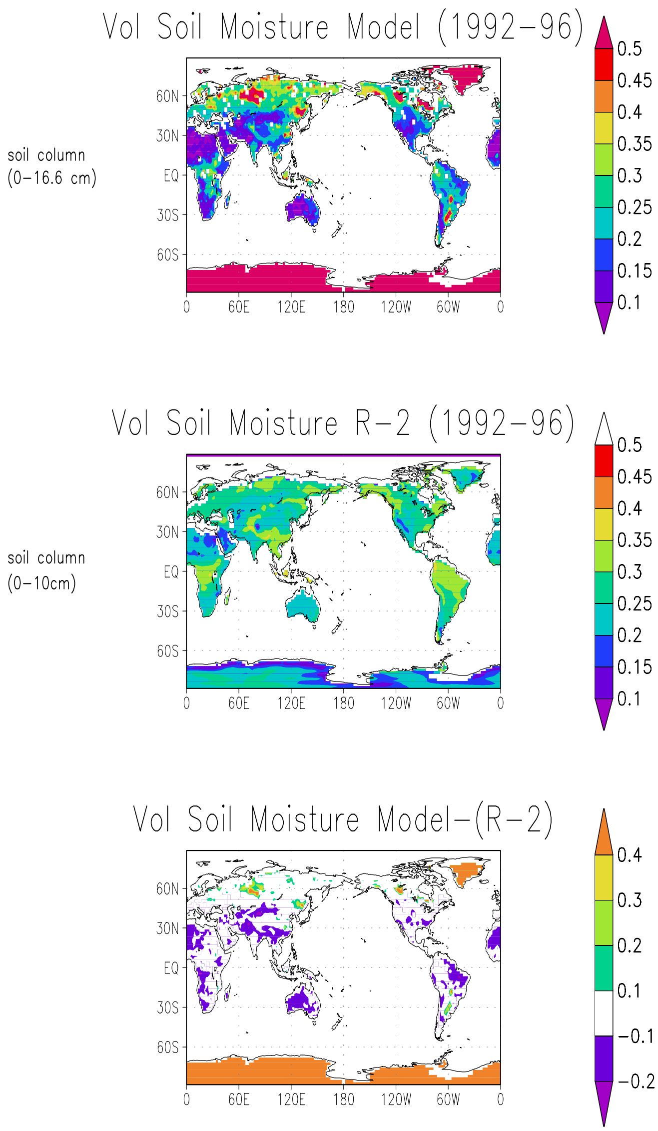

Figure 1: Global distribution of soil moisture for the coupled model (top), R-2 (middle) and model - (R-2) (bottom).

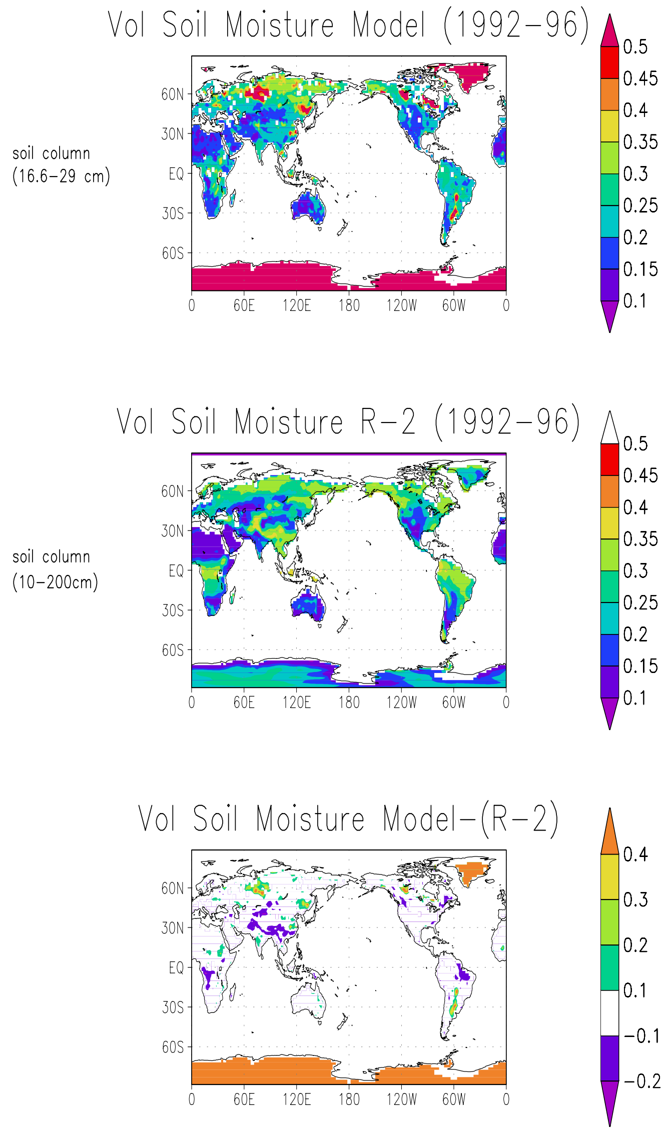

Figure 2: Same figure for the second layer.

References:

Kanamitsu, Masao, Wesley Ebisuzaki, Jack Woollen, Shi-Keng Yang, J. J. Hnilo, M. Florino,and G. L. Potter, 2002: NCEP-DOE AMIP –II reanalysis (R-2). *Bull. Amer. Meteor. Soc.*, **83**, 1631-1643.

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