

## Using Soil Moisture Observations to Evaluate Land Surface Models

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Soil moisture is an important variable in the climate system. Understanding and predicting variations of surface temperature, drought, and flood depend critically on knowledge of soil moisture variations, as do impacts of climate change and seasonal forecasting. An observational data set of actual in situ measurements is crucial for model development and evaluation, and as ground truth for remote sensing. We describe the Global Soil Moisture Data Bank, a web site (<http://www.envsci.rutgers.edu/~robock>) dedicated to collection, dissemination, and analysis of soil moisture data from around the globe. The Global Soil Moisture Data Bank is a resource for the remote sensing, climate modeling and climate analysis communities. We currently have soil moisture observations for over 400 stations from a large variety of global climates, including from the former Soviet Union, China, Mongolia, India, and the US. Here we describe the use of several of these data sets to analyze interseasonal, interannual and interdecadal variations in soil moisture and determine the important scales of soil moisture variations. We apply this result to the representativeness of our current soil moisture network and to recommendations about spatial and temporal scales of climate modeling and satellite remote sensing of soil moisture. We also use these data to evaluate calculations of soil moisture by land surface models, including PILPS Phase 2(d), the recent ECMWF reanalysis, and the Global Soil Wetness Experiment. In addition, we use these data as ground truth for passive microwave remote sensing of soil moisture.

While long time series of soil moisture in Iowa and Illinois do not exhibit any trends, upward trends of summer soil moisture are observed in Russia and Mongolia. The upward trend in Mongolia also appears in the ECMWF reanalysis. The scale of temporal variation of soil moisture observed in Illinois, Russia, China, and Mongolia is about 2 months in all cases and the spatial scale in all these regions is about 500 km. These scales are controlled by atmospheric forcing. Therefore, the new soil moisture network in Oklahoma is exceedingly dense for climate applications, but may be fine for initializing short-term weather forecasts. Most land surface schemes have a hard time simulating the actual observed seasonal and interannual variations of soil moisture, but produce anomalies that are close to observations. However the ECMWF reanalysis produces incorrect seasonal cycles and interannual variations, probably because of nudging, although further investigation is warranted. Remote sensing using SMMR data over Illinois produces quite good results.