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Evaluation of Reanalysis Soil Moisture Simulations Using Newly Updated Soil Moisture Observations from the Ukraine and China

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Using newly updated observed soil moisture for the top 1 m, 19 years of data from China for 1981-1999 and 45 years of data from the Ukraine for 1958-2002, we evaluate soil moisture in three reanalysis outputs: ERA40, NCEP/NCAR reanalysis (R-1), and NCEP/DOE reanalysis 2 (R-2). For China, R-2 shows better interannual variability and seasonal patterns of soil moisture than R-1 as the result of incorporation of observed precipitation. ERA40 produces a better mean value of soil moisture for most Chinese stations and good interannual variability. ERA40 and R-1 have a temporal time scale comparable to observations, but R-2 has a memory of nearly eight months, three times the temporal scale of observations. The unrealistic long temporal scale of R-2 can be attributed to the deep layer of the land surface model, which is too thick and dominates the soil moisture variability. R-1 has the same land surface scheme as R-2, but shows a temporal scale close to observations. This, however, actually is a response to the effects of soil moisture nudging, which reduces interannual variability in R-1.

For the Ukraine, the observations show a positive soil moisture trend for the entire period of observation, with the trend leveling off in the last two decades. Although models of global warming predict summer desiccation in a greenhouse-warmed world, there is no evidence for this in the observations yet, even though the region has been warming for the entire period. While the interannual variations of soil moisture simulated by both the ERA40 and NCEP/NCAR reanalyses are close to the observations, neither reanalysis simulates the observed upward trend. Climate model simulations for the period show the same general shape as the observations, but differ quite a bit

from each other and from the observations. An observed downward trend in insolation (global dimming) may have produced a downward trend in evaporation and may have contributed to the upward soil moisture trend.

None of the reanalyses do a good enough job of simulating soil moisture to treat them as “data” for the purposes of analysis of climate change or evaluation of other model simulations of soil moisture. Future progress, however, can come from using improved land surface models which have been tested by comparison with observations. Incorporating them into data assimilation schemes, and using remote sensing of land surface forcing and skin soil moisture, have the promise of producing global soil moisture “data sets.”