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Improving land surface soil moisture and energy flux simulations over the Tibetan plateau by the assimilation of the microwave remote sensing data and the GCM output into a land surface model

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ABSTRACT

The land surface soil moisture is a crucial variable in weather and climate models. This study presents a land data assimilation system (LDAS) that aims to improve the simulation of the land surface soil moisture and energy fluxes by merging the microwave remote sensing data and the general circulation model (GCM) output into a land surface model (LSM). This system was applied over the Tibetan Plateau, using the National Centers for Environmental Prediction (NCEP) reanalysis data as forcing data and the Advanced Microwave Scanning Radiometers for EOS (AMSR-E) brightness temperatures as an observation. The performance of our four data sources, which were NCEP, AMSR-E, LDAS and simulations of Simple Biosphere Model 2 (SiB2), was assessed against 5 months of *in situ* measurements that were performed at two stations: Gaize and Naqu. For the surface soil moisture, the LDAS simulations were superior to both NCEP and SiB2, and there was more than a one-third reduction in the root mean squared errors (RMSE) for both of the stations. Compared with the AMSR-E soil moisture retrievals, the LDAS simulations were comparable at the Gaize station, and they were superior at the Naqu station. For the whole domain intercomparison, the results showed that the LDAS simulation of the soil moisture field was more realistic than the NCEP and SiB2 simulations and that the LDAS could estimate land surface states properly even in the regions where AMSR-E failed to cover and/or during the periods that the satellite did not overpass. For the surface energy fluxes, the LDAS estimated the latent heat flux with an acceptable accuracy (RMSE less than 35 W/m^2), with a one-third reduction in the RMSE from the SiB2. For the 5-month whole plateau simulation, the LDAS produced a much more reasonable Bowen Ratio than the NCEP, and it also generated a clear contrast of the land surface status over the plateau, which was wet in the southeast and dry in the northwest, during the monsoon and post-monsoon seasons. Because the LDAS only uses globally available data sets, this study reveals the potential of the LDAS to improving the land surface energy and water flux simulations in ungauged and/or poorly gauged regions.

1. Introduction

The soil moisture is an essential variable that governs the interactions between the land surface and the atmosphere (Betts et al., 1996; Entekhabi et al., 1996). The soil moisture controls the ratio of the runoff to infiltration (Delworth and Manabe, 1988; Wagner et al., 2003), controls the surface energy partition (Entekhabi et al., 1996; Prigent et al., 2005), and influences the development of vegetation and the carbon cycle. The soil moisture-precipitation feedback tendency has been identified by Koster et al. (2003), Koster (2004) and Pal and Eltahir (2002).

The soil moisture profile can be observed at a point scale using gravimetric methods or a Time Domain Reflectormetry (TDR). However, these point information are insufficient for research and applications at regional scales, and are not available in the remote regions that are difficult to access because building and maintaining such stations is costly and difficult. Conversely, satellite remote

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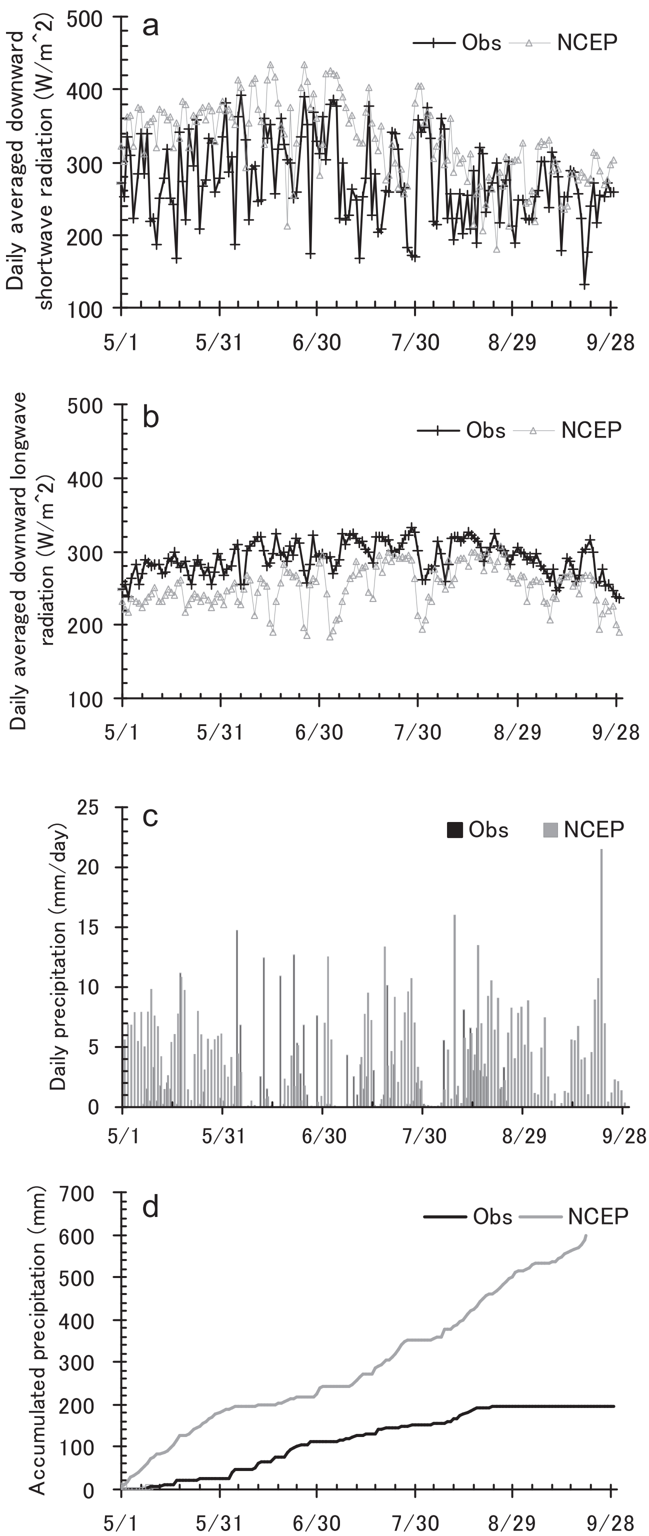

Fig. 1. Daily averaged meteorological forcing variables at Gaize: the downward shortwave radiation (a), downward longwave radiation (b), rain rate (c), and accumulated rainfall (d).

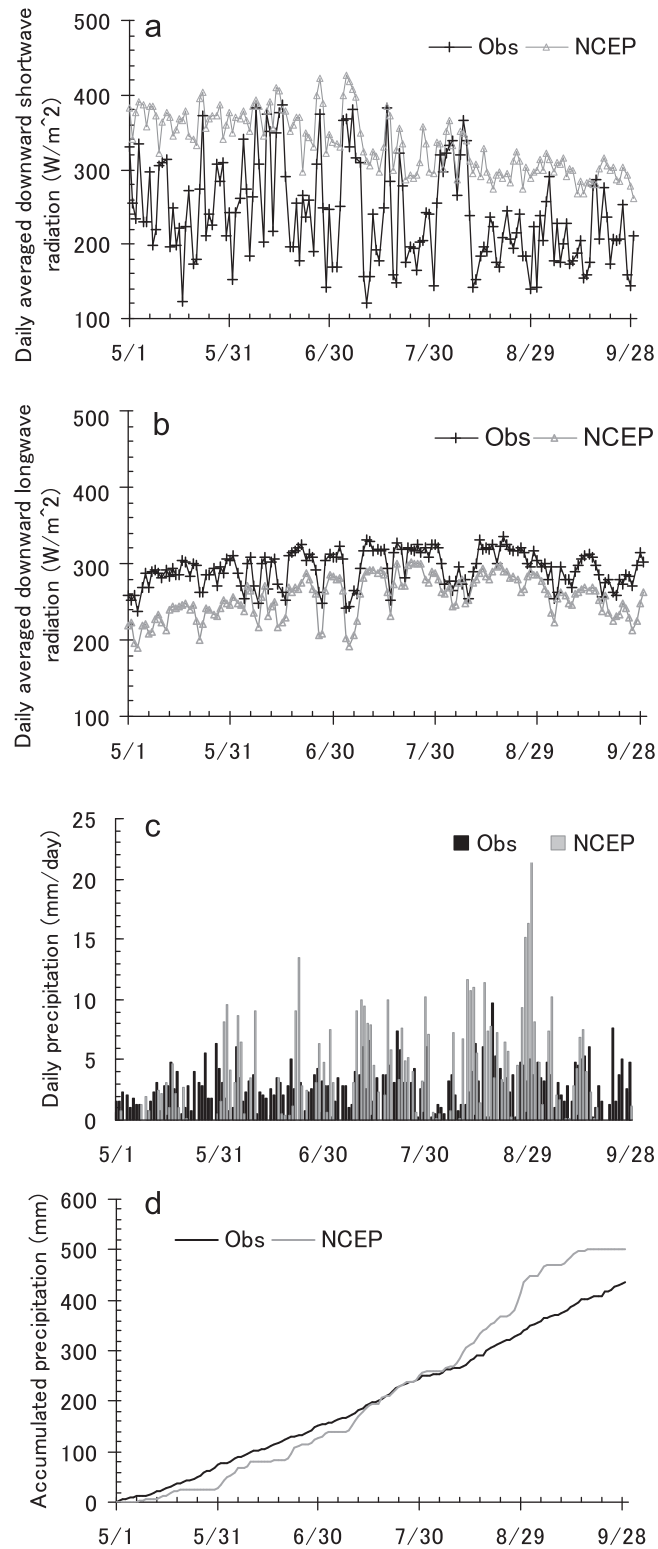

Fig. 2. Same as in Fig. 1, but for the Naqu station.

sensing provides the opportunity to measure the surface soil moisture at the regional, continental and even global scales. Passive microwave remote sensing provides a means for the direct measurement of the surface soil moisture (Njoku and Entekhabi, 1996) at a coarse resolution (which is on the order of approximately 50 km) and with a frequent temporal coverage (daily or bi-daily), which can partially satisfy the temporal resolution that is required for meteorological modeling. However, in the field of weather forecast and hydrology modeling, a finer temporal resolution would obviously improve the accuracy and reliability of the forecast.

Contrary to the limitations of *in situ* measurements and satellite remote sensing, numerical models can provide continuous estimates of soil moisture over the entire soil profile at any scale.