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Soil Moisture and Temperature Measuring Networks in the Tibetan Plateau and Their Hydrological Applications

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Multi-sphere interactions over the Tibetan Plateau directly impact its surrounding climate and environment at a variety of spatiotemporal scales. Remote sensing and modeling are expected to provide hydro-meteorological data needed for these process studies, but in situ observations are required to support their calibration and validation. For this purpose, we have established two networks on the Tibetan Plateau to measure densely two state variables (soil moisture and temperature) and four soil depths (0∼5, 10, 20, and 40 cm). The experimental area is characterized by low biomass, high soil moisture dynamic range, and typical freeze-thaw cycle. As auxiliary parameters of these networks, soil texture and soil organic carbon content are measured at each station to support further studies. In order to guarantee continuous and high-quality data, tremendous efforts have been made to protect the data logger from soil water intrusion, to calibrate soil moisture sensors, and to upscale the point measurements. One soil moisture network is located in a semi-humid area in central Tibetan Plateau (Naqu), which consists of 56 stations with their elevation varying over 4470∼4950 m and covers three spatial scales (1.0, 0.3, 0.1 degree). The other is located in a semi-arid area in southern Tibetan Plateau (Pali), which consists of 25 stations and covers an area of 0.25 degree. The spatiotemporal characteristics of the former network were analyzed, and a new spatial upscaling method was developed to obtain the regional mean soil moisture truth from the point measurements.

Our networks meet the requirement for evaluating a variety of soil moisture products, developing new algorithms, and analyzing soil moisture scaling. Three applications with the network data are presented in this paper.

1. Evaluation of Current remote sensing and LSM products. The in situ data have been used to evaluate AMSR-E, AMSR2, SMOS and SMAP products and four modeled outputs by the Global Land Data Assimilation System (GLDAS).

2. Development of New Products. We developed a dual-pass land data assimilation system. The essential idea of the system is to calibrate a land data assimilation system before a normal data assimilation. The calibration is based on satellite data rather than in situ data. Through this way, we may alleviate the impact of uncertainties in determining the error covariance of both observation operator and model operation, as it is always tough to determine the covariance. The performance of the data assimilation system is presented through comparison against the Tibetan Plateau soil moisture measuring networks. And the results are encouraging.

3. Estimation of Soil Parameter Values in a Land Surface Model. We explored the possibility to estimate soil parameter values by assimilating AMSR-E brightness temperature (TB) data. In the assimilation system, the TB is simulated by the coupled system of a land surface model (LSM) and a radiative transfer model (RTM), and the simulation errors highly depend on parameters in both the LSM and the RTM. Thus, sensitive soil parameters may be inversely estimated through minimizing the TB errors. The effectiveness of the estimated parameter values is evaluated against intensive measurements of soil parameters and soil moisture in three grasslands of the Tibetan Plateau and the Mongolian Plateau. The results indicate that this satellite data-based approach can improve the data quality of soil porosity, a key parameter for soil moisture modeling, and LSM simulations with the estimated parameter values reasonably reproduce the measured soil moisture. This demonstrates it is feasible to calibrate LSMs for soil moisture simulations at grid scale by assimilating microwave satellite data, although more efforts are expected to improve the robustness of the model calibration.