Drought Monitoring and Prediction Based on the Climate Forecast System Reanalysis and Reforecasts

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Recently, the National Centers for Environmental Prediction/Environmental Modeling Center (NCEP/EMC) has completed the Climate Forecast System Reanalysis (CFSR). The CFSR is a global atmosphere-land-ocean coupled data assimilation system with a horizontal resolution of spectral T382 truncation, which is about 35 km in mid-latitudes. In comparison to the NCEP Climate Data Assimilation System (CDAS), the new system has improved physics and consistent ocean and atmosphere circulations. The Global Land Data Assimilation System (GLDAS), based on the Noah model, is running along with the CFSR. The GLDAS is driven by analyzed precipitation (P) from raingauge observations. The land variables, such as soil moisture (SM), are injected into the analysis-forecast cycle at 0 Coordinated Universal Time (UTC) each day. P, evapotranspiration (E), soil properties, and runoff are taken from the 6-hour forecasts. For every five days, 9-month reforecasts (CFSRR) are performed using the CFSR as initial conditions. The consistency among land and atmosphere is expected to increase the forecast skill.

The purposes of this paper are (1) to address whether the CFSR products can be used to improve drought monitoring over the contiguous United States (CONUS) by comparing drought indices derived from the CFSR with the North American Land Data Assimilation System (NLDAS). For the NLDAS, land surface models are driven by observed P and surface temperature; and (2) to assess whether SM and runoff from the CFSRR can be used to predict droughts on seasonal time scales. We compare monthly mean SM and runoff directly from the CFSRR after bias correction and spatial downscaling with those from the ensemble streamflow forecasts (ESP) and the hydroclimate forecasts from the Variable Infiltration Capacity (VIC) model driven by forcing derived from error-corrected daily P and surface temperature based on the CFSRR.

In the United States, CFSR has positive P biases over the western mountains, the Pacific Northwest, and the Ohio Valley in winter and spring. In summer, it has positive biases over the Southeast and large negative biases over the Great Plains. These errors limit the ability to use the Standardized Precipitation Indices (SPI) derived from the CFSR to measure the severity of meteorological droughts. To compare with the P analyses, the Heidke score for the 6-month SPI derived from the CFSR is on average about 0.5 for three-category classification of drought, flood, and neutral months. In addition, CFSR has positive E biases in spring due to positive biases in downward solar radiation and high potential evaporation. The negative E biases over the Great Plains in summer are due to less P and SM in the root zone. The correlations of soil moisture percentile between CFSR and the ensemble NLDAS are regionally dependent. The correlations are higher over the eastern United States and lower over the western interior region.

On seasonal time scales, forecast skill of CFSRR is seasonally dependent. The skill is higher during winter than summer when convective processes are difficult to model. For SM forecasts, the monthly mean SM forecasts from CFSRR after bias correction and spatial downscaling have lower skill than persistence over the western region for one to two month leads. The SM forecast skill comes from the initial conditions. Spinup errors in the CFSR SM impact the CFSRR SM forecasts. For winter months, CFSRR contributes to forecast skill after two months when the impact of initial conditions decreases.

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