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New surface model contributes to long-term precipitation forecasting.

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Soil moisture is a difficult component to integrate into many larger scale climate models. Often, the parameters are too specific for large models, or models underestimate the temporal nature of soil moisture evolution, or they neglect the effects of wet and dry spells in land surface processes. In an attempt to address these issues, researchers at the European Centre for Medium-range Weather Forecasts (ECMWF) have developed and tested a new surface model with an improved ability to reflect soil conditions, leading to more accurate precipitation forecasting.

By comparing a previous model with the First ISLSCP Field Experiment (FIFE) field observations, researchers discovered improvements could be made in the areas of subsurface hydrology and evaporation, particularly on temporal scales. Another goal of this study was to develop parameters that are not site-specific, but can be used in different climatological conditions with values that can be used in global models.

Feedback

The new surface model includes data from FIFE, which is distributed by the Oak Ridge National Laboratory (ORNL) DAAC. "FIFE for us was unique because of the particular ecosystem it represents -- natural prairie -- and more importantly, because it covers a very interesting meteorological period," says Pedro Viterbo of ECMWF. The data from 1987 specifically exhibit a transition from a wet spring to a series of dry spells with intermittent precipitation during the summer, making it possible to understand processes on longer time scales.

FIFE field studies took place on a 15 by 15 kilometer area in and around the Konza Prairie Reserve near Manhattan, Kansas, from 1987 through 1989. More than 100 scientific investigators and support staff worked at the site during the field campaigns. Six aircraft gathered radiometric measurements and flux measurements over the site during more than 400 flight hours. Ground measurements and airborne data were combined with satellite overpasses to provide a more comprehensive view of the subsurface, surface, and surface-atmosphere processes.

Viterbo used meteorology data from Portable Automated Mesonet stations at the FIFE site, which collected practically continuous surface observations on wind, temperature, humidity, ground surface temperature, radiation, and rainfall. After being processed into a single time series, this data set was compared with and verified against more detailed data gathered during four intensive field campaigns at the site.

Combining FIFE data with Cabauw (Netherlands) data and Amazonian Rainforest Meteorological Experiment (ARME) data, the new surface model relies on forcing of near-surface weather parameters. To incorporate the improvements and validate the land surface hydrology without complications from other model parameters or feedback from atmospheric forcing, the researchers run the model for individual grid-cell columns, and validate them using field measurements from each data set.

In the new surface model, soil depth is divided into four layers to accurately represent time scales ranging from one day to one year, with temperatures defined at each layer and heat fluxes defined between each adjacent layer. The formulation of soil hydraulic properties was revised to increase the downward infiltration of precipitation from a saturated surface. Additional features of the model include a skin temperature and evapotranspiration that represent a combined effect of an interception layer, bare ground, and plant transpiration (through a prescribed soil root profile).

The new surface model has already simulated the 1993 Mississippi Basin flooding situation in an ECMWF model run. The results indicate a coupling in the hydrological process by which precipitation increases when evaporation increases. However, this is not simply a local effect, for the model produces more reliable precipitation forecasts because it more accurately simulates evaporation that takes place upstream. Consequently, the study found an improvement in long-term precipitation forecasting based on the condition and depletion rate of the soil moisture reservoir.

"The survival of the new model through the dry spells was essential to build our confidence on the behavior of the new model on long -- several weeks -- time scales." Viterbo explains. The model produces more reliable precipitation forecasts because the parameters maintain accuracy over longer time scales.

Reference(s)

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