Title : The Role of Soil Moisture Initialization in Sub-seasonal and Seasonal Streamflow Prediction

Author list with email addresses:
Sarith P.P. Mahanama Sarith.P.Mahanama@nasa.gov
Randal D. Koster Randal.D.Koster@nasa.gov
Rolf H. Reichle Rolf.H.Reichle@nasa.gov
Lareef Zubair lareef@iri.columbia.edu

ABSTRACT

The two main contributors to streamflow predictability at subseasonal to seasonal time scales in tropical regions are: (i) the predictability of meteorologic (particularly precipitation) anomalies, and (ii) the land surface soil moisture state at the start of the forecast period. Meteorological predictions at subseasonal time scale are usually fraught with error and may not be dependable. The accurate initialization of soil moisture, as obtained through real-time land data analysis, may provide skill in subseasonal to seasonal streamflow prediction, even when the prediction skill for rainfall is small.

A series of experiments using the Catchment Land Surface Model (CLSM) is performed to characterize the contribution of accurate soil moisture initialization to the skill of streamflow prediction in Sri Lanka at timescales up to 2 months. We find that at the monthly timescale, accurate soil moisture initialization provides between 10% and 60% of the total runoff prediction skill that could be obtained under a perfect prediction of meteorological forcing. Some contributions to streamflow forecast skill are also found for the second month of forecast.

POPULAR SUMMARY

Accurate predictions of precipitation and other meteorological variables can contribute to accurate predictions of streamflow anomalies. At subseasonal timescales, however, meteorological predictions are usually fraught with error and may not be dependable. The other main contributor to streamflow prediction skill (outside of mean seasonality), particularly in snow-free tropical regions, is the soil moisture state -- higher soil moistures ``precondition" the soil to convert a higher fraction of the rain falling on a region into runoff. This opens an important pathway to water resources planners. Because soil moisture has some memory at the monthly timescale, knowledge of soil moisture at the beginning of a forecast period, as obtained through real-time land data analysis, may provide some skill in sub--seasonal to seasonal streamflow prediction, even if the prediction skill for rainfall is negligible.

A series of offline experiments using the Catchment Land Surface Model (CLSM) is performed to characterize the contribution of accurate soil moisture initialization to the skill of streamflow prediction. Gridded 0.25 degree monthly precipitation observations for Sri Lanka were merged with a 0.5 degree 6-hourly bias-corrected global reanalysis dataset for the period 1979-1993, and the merged data were used to force the CLSM over Sri Lankan watersheds having contemporaneous stream gauge measurements. Eight watersheds were identified for which the model performs particularly well, implying small model errors and reliably consistent observational forcing and streamflow validation data. The contribution of soil moisture initialization to streamflow prediction is then quantified in these watersheds in the complete absence of rainfall prediction skill. We find that at the monthly timescale, accurate soil moisture initialization provides between 10% and 60% of the total runoff preduction skill that could be obtained under a perfect prediction of meteorological forcing. Of course, in practice, the skill of predicting such forcing is typically low at monthly timescales, so the contribution of accurate soil moisture initialization to streamflow prediction relative to that which can be obtained with a true forecast system is correspondingly higher.

An island-wide study of soil moisture as a predictor in streamflow forecasts was then performed. Streamflow during boreal summer (AMJ and JAS) is particularly well correlated with earlier soil moisture (lag up to 3 months).