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Evolutionary hydrologic data assimilation using in-situ soil moisture

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Soil moisture is an important hydrological variable controlling the partition of rain into runoff and infiltration. As a result, accurate estimate of soil moisture can improve streamflow forecasts. But challenges remain in integrating in-situ soil moisture into hydrological models to improve streamflow forecasts. A recurring issue is a search for a framework to simultaneously propagate model state and improve model parameterizations while finding an optimal merger between simulations and observation dataset.

This presentation will demonstrate an evolutionary algorithm in variational data assimilation (DA) approach to incorporate in-situ soil moisture into hydrological streamflow prediction. The method uses the Non-dominated Sorting Genetic Algorithm-II (NSGA-II) in a DA framework to merge two imperfect estimates of streamflow from the Soil and Water Assessment Tool (SWAT). For any time step, the first estimate of streamflow was generated with no update of soil moisture into SWAT, whereas the second estimate was generated with in-situ soil moisture update for SWAT. The two streamflow estimates were merged by propagating soil moisture state through several time steps to generate a new estimate of streamflow that is better than either of the two individual estimates. The in-situ soil moisture allows state parameterizations of SWAT which were then applied to simulate ensemble of streamflows. The distribution and deviation of simulations from observation are used as a penalty function to properly merge background estimate of streamflow with observation dataset.

The method is applied in Spencer Creek watershed in southern Ontario, Canada to illustrate the utility of the evolutionary data assimilation approach. The catchment has 4 years (2007–2010) of in-situ soil moisture from Time Domain Reflectivity probe measurements and stream gauged data for 4 different locations. A comparison between the assimilated streamflow and observed dataset shows improved accuracy that is accomplished using the assimilation framework. The stochastic capability and in-built memory of the coupled NSGA-II/SWAT assimilation are appealing as they can facilitate streamflow forecasts in real-time when soil moisture data are available. The assimilation approach provides a better estimate of streamflow by improving model state and parameterizations of SWAT.