Multi-sensor model-data assimilation for improved hydrologic forecasting

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Model-data assimilation methods are being increasingly used in hydrology to improve estimates of soil moisture, evapotranspiration and runoff at catchment to regional scales for application in stream flow forecasting and hydrometeorology. In this talk, I will present an application of data assimilation methods to the estimation of soil profile moisture content, runoff and stream flow in headwater sub-catchments of the Murrumbidgee River. A particular focus of this talk will be on the integration of multiple satellite observations with radiative transfer and surface energy balance models to improve estimation of soil moisture initial conditions from which infiltration and runoff can be predicted. The data assimilation scheme comprises a forward model, observation operators, multiple observation datasets and an optimization scheme. The forward model couples a Penman-Monteith evapotranspiration equation with a six-layer water budget scheme to calculate infiltration and runoff as a function of rainfall, canopy leaf area, and soil hydraulic properties. The observation operators calculate modeled land surface temperature and microwave brightness temperatures from the state variables; profile soil moisture and soil surface layer soil moisture (< 2.5 cm). Satellite observations used are surface brightness temperatures from AMSR-E (passive microwave at 6.9GHz at horizontal polarization) and from AVHRR (thermal channels 4 & 5 from NOAA-18), and land surface reflectances from MODIS *Terra* (channels 1 and 2 at 250m resolution). These three sensors overpass at approximately the same time of day and provide independent observations of the land surface at different wavelengths. The observed brightness temperatures are used as constraints on the coupled energy balance/microwave radiative transfer model, and a canopy optical model is inverted to retrieve leaf area indices from observed reflectances. Results show that the multiple constraints approach is effective in identifying and reducing the influence of bias on the resultant analysis that arises when only single observation data sets are used. Reductions in error and bias lead to improved prognoses of soil profile water store and forecasts of multi-day runoff and stream flows. The deployment of these methods as an operational system for the assimilation of multi-sensor satellite observations will assist with river operations, policy planning and landscape management decision making.