The Auto-tuned Land Data Assimilation System (ATLAS) for land data assimilation

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Two unique challenges of land data assimilation systems are: 1) uncertainty in the definition of observation operators due to large climatological differences between satellite-retrieved and model-forecasted surface states and 2) the complexity and diversity of modeling error sources. Off-line land surface prediction is not an initial value prediction problem and is instead impacted by dynamic errors in external forcings (principally precipitation and incoming radiation) which must be applied to the prognostic calculation of terrestrial water and energy balances. On the other hand, land models lack unstable modes and are notably less nonlinear than atmospheric and oceanic models. These issues are shaping recent efforts to develop data assimilation systems uniquely designed to handle the problem of assimilating satellite-based soil moisture retrievals from the upcoming NASA Soil Moisture Active/Passive mission into terrestrial water balance models driven by precipitation estimates derived from the Global Precipitation Mission constellation.

In response to challenge #1, it has become common practice to empirically define observation operators using long time series of open loop model predictions and assimilated observations. However, recent work has clarified the neither linear regression nor moment-matching techniques provide an optimal empirical solution [1]. Instead, either ancillary signal-to-noise information (for the open loop model and/or the assimilated observations) or a third, observation data set (with wholly independent errors) is required [2]. In addition, challenge #2 has motivated the application of adaptive filtering techniques to better constrain error models applied in land data assimilation systems [3]. However, the expected limitations of innovation-based adaptive filtering approaches in the presence of auto-correlated observation errors have been noted [4].

This presentation will detail development and application of the Auto-tuned Land Data Assimilation System (ATLAS) to the simultaneous assimilation of both active radar and passive radiometer-based SMAP soil moisture retrievals into a simple terrestrial water balance model. By coming aspects of triple collocation estimation with classical innovation analysis, ATLAS can simultaneously solve for: the full observation error covariance matrix (including cross-covariance information), the model forecast error covariance and the auto-correlation of observation errors. This error information can, in turn, be used to define optimal observation operators and provide the basis for an efficient Colored Kalman filter analysis. The theoretical basis of the approach will be established using a synthetic twin experiment, and real data results using existing ASCAT (active radar-based) and AMSR-E (passive radiometer-based) soil moisture products will presented.

References

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