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DasPy – Open Source Multivariate Land Data Assimilation Framework with High Performance Computing

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Data assimilation has become a popular method to integrate observations from multiple sources with land surface models to improve predictions of the water and energy cycles of the soil-vegetation-atmosphere continuum. In recent years, several land data assimilation systems have been developed in different research agencies. Because of the software availability or adaptability, these systems are not easy to apply for the purpose of multivariate land data assimilation research. Multivariate data assimilation refers to the simultaneous assimilation of observation data for multiple model state variables into a simulation model. Our main motivation was to develop an open source multivariate land data assimilation framework (DasPy) which is implemented using the Python script language mixed with C++ and Fortran language. This system has been evaluated in several soil moisture, L-band brightness temperature and land surface temperature assimilation studies. The implementation allows also parameter estimation (soil properties and/or leaf area index) on the basis of the joint state and parameter estimation approach. LETKF (Local Ensemble Transform Kalman Filter) is implemented as the main data assimilation algorithm, and uncertainties in the data assimilation can be represented by perturbed atmospheric forcings, perturbed soil and vegetation properties and model initial conditions. The CLM4.5 (Community Land Model) was integrated as the model operator. The CMEM (Community Microwave Emission Modelling Platform), COSMIC (COsmic-ray Soil Moisture Interaction Code) and the two source formulation were integrated as observation operators for assimilation of L-band passive microwave, cosmic-ray soil moisture probe and land surface temperature measurements, respectively. DasPy is parallelized using the hybrid MPI (Message Passing Interface) and OpenMP (Open Multi-Processing) techniques. All the input and output data flow is organized efficiently using the commonly used NetCDF file format. Online 1D and 2D visualization of data assimilation results is also implemented to facilitate the post simulation analysis. In summary, DasPy is a ready to use open source parallel multivariate land data assimilation framework.