OpenDA, a generic toolbox for data-assimilation in numerical modelling with applications to calibration of river roughness parameters

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Most applications of data-assimilation make use of a dedicated implementation of the data-assimilation algorithm and processing of the observations. Often, this is not really a problem since implementing an Ensemble Kalman filter for one application is not a huge amount of work. And e.g. 4D-VAR requires an adjoint, and most of the work usually goes into the construction of the adjoint code. However, if one tries to compare several algorithms, develop new algorithms or implement data-assimilation methods for a larger number of models and geographically varying applications, it becomes worthwhile to develop a generic toolbox for data-assimilation.

OpenDA is a flexible toolbox or software environment for data-assimilation. It provides an interface specification of a model and various other components together with the data-assimilation algorithms that use these interfaces to work with the model and observations. In this object oriented framework the algorithms can be programmed independent of any particular model, as they all implement the same interface. Efforts have been made to make coupling of a model to the data-assimilation algorithms efficient and easy. The system also provides methods to handle parallel processing. For some algorithms parallel processing is possible even if the model itself does not provide this feature. It is possible e.g. to distribute the computations of an Ensemble Kalman filter around a cluster, without additional programming for the user. If the model itself can run in parallel then this can be taken into account.

In addition to a reduction of the programming effort, a tool like OpenDA also increases the reliability of the software because algorithms can easily be tested for many models. Simple tests allow for frequent testing during the development and application to multiple models increase the probability of finding the remaining bugs. It is also intended that the easy use of other data-assimilation algorithms will speed up application of new algorithms.

OpenDA has been applied to calibration of hydrodynamic models (Delft3D-Flow, Sobek, WAQUA) and wave models (based on SWAN). In fact, the calibration tool has been constructed such that it can be modified with little effort to any model with ASCII input files. OpenDA Kalman filtering has been applied to various models, ranging from hydrodynamics to atmospheric chemistry. Ongoing research efforts aim at including variational data assimilation, model reduction and new Kalman filtering algorithms. At the same time we intend to widen the range of applications, e.g. to rainfall-runoff models, ground water models, morphodynamic models and petroleum reservoir models.

Here we will illustrate the capabilities of OpenDA for the calibration of roughness parameters for river hydrodynamics. For this application we compare several calibration strategies and the impact of these on accuracy and performance. Parallel computing is examined to further reduce the computation times. Ongoing and future work concerns the use of these models for operational forecasting. For this purpose FEWS will be used to control the computations, store the results and show observations and model input and output to the user. OpenDA will be used as an interface with the model and through Kalman filtering further increase the forecast accuracy.

The OpenDA toolbox is available to interested modelers and assimilation code developers as open source software under LPGL (www.openda.org)
Note: OpenDA is the new name for the merger of the COSTA developments initiated by TUDelft and VORtech and the DATools developments started by Deltares/Delft Hydraulics.


