The Object-Oriented Prediction System — a Flexible Framework for Data Assimilation

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Data assimilation algorithms can typically be expressed mathematically by a few generic equations involving a small set of abstract vectors and operators. These equations do not depend on the details of a specific numerical forecast model, and can be applied to many different systems. By contrast, the implementations of most data assimilation algorithms are highly model specific, so that it is impossible to take an algorithm implemented for one model and apply it to another.

The ECMWF Integrated Forecasting System (IFS) is a world-leading data assimilation system for NWP. It has developed organically, in collaboration with Météo-France, over more than 20 years. During this time, the data assimilation algorithm has become so intertwined with the numerical model, and with the particular representation of the state and observations, that it would be impossible to separate the algorithm from the model. Moreover, the code makes many implicit assumptions, for example about the order in which certain calculations are performed. This makes it extremely difficult to implement new algorithms that may, for example, require computations to be performed in a different order. The sheer complexity of the code has become a barrier to scientific development and collaboration.

To address these issues, ECMWF is developing the Object-Oriented Prediction System (OOPS). The aim is to use modern computer techniques and languages (specifically, object-oriented programming and C++) to provide a clean, and above all flexible framework for data assimilation that separates the algorithm from its specific implementation in any one model. We believe that such a framework will improve productivity, encourage scientific collaboration, and provide a valuable tool that will allow the rapid transfer of research developments into practical applications.

OOPS currently incorporates a selection of data assimilation algorithms, including strong- and weak-constraint 4D-Var, 4D-Ens-Var and 3D-Var, together with two different simple models: the Lorenz 1996 model and a quasi-geostrophic channel model. OOPS has already proved itself to be a useful tool with which to investigate novel data assimilation algorithms and minimization techniques. It has also clearly demonstrated that algorithms developed using one model can be readily transferred to another model without any recoding. Work to incorporate ECMWF's IFS model into the OOPS framework is well underway.

We will present an overview of the OOPS system. We will demonstrate how, through careful design, data assimilation algorithms can be separated from the details of any particular model. We will also show how OOPS allows models implemented in Fortran to be interfaced in a clean, machine independent way, to an object-oriented data-assimilation layer written in a different computer language.