ECMWF NEMO mid to long term perspectives.

1. Introduction.

The primary mission of ECMWF is to produce weather forecasts for the medium range and extended range. The ocean modelling activities are mainly to support these activities by providing a lower boundary for the atmosphere via a coupled model and initial ocean conditions to this coupled model. These ocean initial conditions should ideally be consistent with the atmospheric initial conditions so close integration of the analysis systems for producing atmospheric and oceanic initial conditions are desirable.

In the following text NEMO means the OPA ocean model and a sea ice model with the precise sea ice model to be determined.

2. The coupled system.

We are currently working on a highly integrated system consisting of our IFS atmosphere model, the WAM wave model and NEMO. This system will be introduced operationally into medium range forecast ensemble system during 2013. Initially it will only have a low resolution ocean component and no interactive sea ice model, but we plan to improve this in the near future. At some point this system will be used for our seasonal forecasting system as well.

We are favouring a tightly coupled system where all components run as a single executable developed in house without the use of an external coupler. The main advantage of this approach is that we can tailor the coupled system to our exact needs without being limited to the application programming interface (API) of the coupler.

3. The ocean analysis system.

To provide ocean initial conditions we use the NEMOVAR system which is a variational data assimilation for the NEMO model. This system relies heavily on the NEMO infrastructure and developments on observation operators and application of assimilation increments done by the NEMOVAR consortium has been introduced into the NEMO system. We plan to continue working on improving the assimilation system together with the other NEMOVAR partners.

It is envisaged that the atmospheric and ocean assimilations systems will be joined in a coupled data assimilation system. Initial versions for this system will probably be "weakly" coupled in the sense that we will compute observations misfits with a coupled model, but for the variational minimization we will not use cross model covariances.

4. Next generation modelling at ECMWF: OOPS.

The Object Oriented Prediction System (OOPS) is the next generation modelling framework at ECMWF. It originates from the requirement of more flexibility in our modelling system to allow more advanced data assimilation algorithms to be implemented. An identified shortcoming of our IFS model is that it relies

heavily of Fortran-90 modules for storing data meaning that a lot of data is global in nature. By packing data into data structures a more modular system can be implemented. For the control layer we plan to apply an object oriented approach. Both Fortran-2003 and C++ has been investigated as choices for this layer. It was found that C++ was a better supported language that F2003 so it was chosen.

Both the coupled model and the ocean data assimilation system is expected to be included into the OOPS framework. In order to do so we will have to created software layer this means that we can call NEMO and NEMOVAR from the C++ interface. Both NEMO and NEMOVAR suffers from similar problems to the IFS model that they are not really modular codes. A lot of data is really global which means that have multiple model integrations (possible at different resolutions) in one execution is difficult to do and this is one of the main requirement for some of the data assimilation applications be developed.

5. Parallelization aspects in the future.

It is likely that in the near future we will have 100k+ cores for running of our operational models. Various accelerator (GPU's, INTEL MIC etc) technologies seem to be unavoidable on high end computers. It is therefore important to embrace multi-level parallelism in our models.

For many years the IFS model has had a 2 level parallelism with a mixture of message passing (MPI) and shared memory (OpenMP) parallelization. Within the CRISTA project we are currently pursuing a 3rd level parallelism by using Fortran-2008 co-arrays on top of MPI/OpenMP for the IFS model and we are considering if accelerators can give us yet more performance.