Randomized parallel algorithms for data assimilation in numerical weather prediction.

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Data assimilation is a mathematical technique used to update a computer model forecast using the latest observational data. It is a fundamental part of modern-day weather forecasting, allowing measurements from satellites and ground-based instruments to keep the forecasting models close to reality. At the European Centre for Medium-range Weather Forecasts (ECMWF) observations of the atmosphere are used to initialize a model forecast several times each day. The data assimilation algorithm used at ECMWF formulates the problem mathematically in terms of the minimization of a function that measures how far the model solution is from the actual measurements. This function depends on millions of variables and so must be minimized approximately using numerical optimization methods. However, the current optimization methods cannot be easily used in a parallel computing environment. As weather prediction systems move towards a higher spatial resolution we need to solve for more variables, so it is essential that we are able to fully exploit parallel computers. Otherwise, the lack of parallelization in the optimization methods will result in a computational bottleneck, reducing the speed at which the forecasts can be produced and issued. Hence there is a need for new optimization methods that can be applied in a parallel setting.

Recently a class of numerical methods known as randomized methods has been applied to solve the optimization problem in data assimilation. These methods are highly parallelizable, but not always computationally efficient. The aim of this project is to combine randomized methods with standard numerical optimization algorithms to produce new approaches that are both efficient and can be run on parallel computers. The project will involve developing new theory for such algorithms using numerical linear algebra and demonstrating their usefulness in computational experiments. Such experiments will include the use of an idealized assimilation system on which different ideas can be tested, followed by the application of the most promising methods to the ECMWF numerical weather prediction system.

Training opportunities:

This studentship is a joint project with ECMWF. The student will have the opportunity to spend time working at ECMWF during the project. The student will also have the opportunity to attend ECMWF training courses on data assimilation and advanced training courses at the University of Reading organized by the Data Assimilation Research Centre.

Student profile:

The candidate should have a good honours degree in a subject with strong mathematical content. Some experience of programming would be an advantage.

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