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Applying a fully nonlinear particle filter on a coupled ocean-atmosphere climate model

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It is a widely held assumption that particle filters are not applicable in high-dimensional systems due to filter degeneracy, commonly called the *curse of dimensionality*. This is only true of naive particle filters, and indeed it has been shown much more advanced methods perform particularly well on systems of dimension up to $2^{16} \approx 6.5 \times 10^4$. In this talk we will present results from using the *equivalent weights particle filter* in twin experiments with the global climate model HadCM3.

These experiments have a number of notable features. Firstly the sheer size of model in use is substantially larger than has been previously achieved. The model has state dimension approximately 4×10^6 and approximately 4×10^4 observations per analysis step. This is 2 orders of magnitude more than has been achieved with a particle filter in the geosciences. Secondly, the use of a fully nonlinear data assimilation technique to initialise a climate model gives us the possibility to find non-Gaussian estimates for the current state of the climate. In doing so we may find that the same model may demonstrate multiple likely scenarios for forecasts on a multi-annular/decadal timescale.

The experiments consider to assimilating artificial sea surface temperatures daily for several years. We will discuss how an ensemble based method for assimilation in a coupled system avoids issues faced by variational methods. Practical details of how the experiments were carried out, specifically the use of the EMPIRE data assimilation framework, will be discussed. The results from applying the nonlinear data assimilation method can always be improved through having a better representation of the model error covariance matrix. We will discuss the representation which we have used for this matrix, and in particular, how it was generated from the coupled system.