Does Outgoing Radiation Constrain Climate Feedbacks?

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Project background

Projections of climate change are very uncertain partly due to uncertainty in climate models. This projects aims to quantify how small this uncertainty is for a model if it does a good job of simulating satellite observations of outgoing radiation (Kato et al, 2015). Climate models need to represent the effects of many unresolved processes of which the most important processes are those related to clouds. Models represent these unresolved processes through parameterisation – which are simplifications of the actual processes occurring. These parameterisations contain many uncertain parameter and changes in which affect both the simulation of present climate and future climate change (Stainforth et al, 2005). Uncertainties in future climate change arise, from amongst others, uncertainty in the magnitude of climate feedback processes (Flato et al, 2013). Uncertainties in feedback arise largely, but not entirely, from uncertainty in how clouds respond to climate change.

Using an old, but still good, climate model Tett et al, 2013a showed it was possible, using inverse methods, to generate multiple variants of a model with different parameter choices but having a reasonable simulation of the outgoing radiation. They found that uncertainties in climate feedbacks were small when restricted to model variants which had a plausible simulation of the outgoing radiation (Tett et al, 2013b). Recently this work has been extended to a larger set of parameters and observations (Tett et al, 2017).

The aim of this PhD project is to apply new inverse algorithms to find the model parameters, which minimize model error. Specifically, to find one or more parameter sets that minimize the difference in simulated Earth’s outgoing radiation from observations. From the minimisation and knowledge of the observational uncertainties, the parameter uncertainties can be computed. In turn, these uncertainties can be translated into uncertainty in climate feedbacks. The feedback strengths and mechanisms of feedback will be assessed using idealised simulations.

Timetable

Year 1 – student to familiarise themselves with existing literature and trial approaches using HadAM3/HadCM3 and existing software. Year 2 – Student to write paper on HadAM3 work and identify relevant parameters in CESM. Year 3 – Student to generate perturbed CESM configurations, test their feedback strengths and write paper on results. Year 4 (6 months) – Student to write Thesis.
Key research questions
- Are there a small set of climate model parameters that matter for either outgoing radiation or climate feedbacks?
- Which parameters, if any, are particularly important
- Do global-scale outgoing fluxes provide a significant constraint on the magnitude of climate feedbacks?

Methodology
The project envisages the novel application of algorithms to find multiple parameter sets in a climate model that minimize simulated minus observational differences. These will be trialled on HadAM3: an old but fast climate model. Parameter screening, for HadAM3, will be informed by existing work. Having produced an algorithm that appears effective the student will then screen likely parameters from the Community Earth System Model (CESM) for impact on simulated outgoing radiation and climate feedbacks. Selection of parameters will be informed by existing work carried out by collaborators at Lawrence Livermore Labs, US. The new algorithm will then be applied to CESM. The strength of climate feedbacks will be estimated using idealised coupled models.

Training
A comprehensive training programme will be provided comprising both specialist scientific training and generic transferable and professional skills. The student will develop expertise in meteorology, inverse methods, climate modelling, use of super-computers and the joint analysis of models and observations.

Requirements – A strongly numerate student with an interest in Climate Science.

Further reading
Stainforth et al, 2004 “Uncertainty in predictions of the climate response to rising levels of greenhouse gases”, Nature, doi: 10.1038/nature03301

A project summary
The novel application of inverse methods to a state-of-the-art climate model to see if observed outgoing radiation is a constraint on future climate change.