Modelling Aspects of Land-Atmosphere Interaction: Thermal Instability in Peatland Soils and Land Parameter Estimation Through Data Assimilation

Submitted by

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I certify that all material in this thesis which is not my own work has been identified and that no material is included for which a degree has previously been conferred upon me.

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Abstract

The land (or 'terrestrial') biosphere strongly influences the exchange of carbon, energy and water between the land surface and the atmosphere. The size of the land carbon store and the magnitude of the interannual variability of the carbon exchange make models of the land surface a vital component in climate models. This thesis addresses two aspects of land surface modelling: soil respiration and phenology modelling, using different techniques with the goal of improving model representation of land-atmosphere interactions.

The release of heat associated with soil respiration is neglected in the vast majority of large-scale models but may be critically important under certain circumstances. In this thesis, the effect of this heat release is considered in two ways. Firstly, a deliberately simple model for soil temperature and soil carbon, including biological heating, is constructed to investigate the effect of thermal energy generated by microbial respiration on soil temperature and soil carbon stocks, specifically in organic soils. Secondly, the mechanism for biological self-heating is implemented in the Joint UK Land Environment Simulator (JULES), in order to investigate the impacts of the extra feedback in a complex model.

With the intention of improving estimates of the parameters governing modelled land surface processes, a data assimilation system based on the JULES land surface model is presented. The ADJULES data assimilation system uses information from

the derivative of JULES (or adjoint) to search for a locally optimum parameter set by calibrating against observations. In this thesis, ADJULES is used with satellite-derived vegetation indices to improve the modelling of phenology in JULES.

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