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The State of Radiation and Clouds in Global Climate Models: Improved Visibility

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Much of what makes Earth's climate so complex, difficult to predict, and worthy of study arises from the four-dimensional interaction between radiation and the three phases of water. Within the global climate modelling community, it is generally agreed that the most elusive of these interactions involve clouds. Difficulties arise because many fluctuations in cloud properties that are important for radiative transfer occur over a wide range of scales that are unresolved by global climate models (GCMs). First, within a conventional GCM, information regarding unresolved cloud structure is not modelled explicitly so it is usually ignored or at best highly parametrized. It is well documented that omission of this information and reliance on plane-parallel solutions of the radiative transfer equation leads to biases that manifest themselves as surreptitious forcings generated within the GCM. Second, it has only been in the last couple of years that a numerical methodology emerged that could utilize this information generally and properly. Add to this the difficulties involved in verifying cloud properties simulated by GCMs, because of the complexities associated with inference of cloud properties on a global scale from satellite-based measurements, and it is easy to appreciate the sense of morass often felt by cloud-radiative transfer modellers.

This seminar focuses on two recent advances in modelling radiative transfer and clouds in GCMs. The first involves an efficient and flexible stochastic approach to modelling broadband, mean-field irradiances. Although this method produces conditional random noise at the inner-scale of a GCM, it is unbiased and appears to be a sufficient stopgap method until full 3D radiative transfer computations can be performed in GCMs. The second involves replacement of a GCM's conventional 1D cloud parametrization with a multi-dimensional, high resolution, cloud system-resolving model. This type of GCM requires far more computer resources than conventional GCMs. Presumably, however, it provides the most realistic climate simu-

lations to date as it alleviates parametrization of interactions between moist physics, convection, and radiation over roughly two-orders of magnitude in the spatial domain.