Evaluating Cloud Feedback

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Cloud feedback remains the biggest uncertainty in predictions of climate change (Cubasch et al 2001). Large intercomparison projects such as AMIP (Gates 1992) and FANGIO (Cess et al. 1996) have been restricted to documenting the spread of model simulated cloud feedback rather than a more detailed analysis of the causes of the spread. However, it has been speculated that a possible method to reduce the uncertainty is to relate the cloud changes that are projected to occur under climate change to cloud changes as part of present-day climate variability, which can then be validated against observations. Recently, a number of authors (e.g. Bony et al. 1997; Lau and Crane 2000; Tselioudis et al. 2000; Norris and Weaver 2001, Webb et al. 2001) have presented new techniques or diagnostics for using observational data to validate aspects of cloud behaviour in present day climate that may be important for accurate modelling of climate change. These include the use of compositing techniques which allow evaluation of cloud physical processes whilst removing possible errors in the large-scale dynamical circulation. Using such a technique, Bony et al. (2002) aim to make the link (and show some broad agreement) between cloud processes under present day climate variability and those under an idealised climate change forcing. New work at the Met Office's Hadley Centre (Williams et al 2002) has extended this pioneering work. Our method is illustrated by comparing the effect on the climate response of several new developments to the Hadley Centre atmosphere model coupled to a mixed-layer ocean. It is shown that the cloud response over tropical oceans to a doubling of CO_2 depends more upon the change in vertical velocity and whether the local sea surface warms more or less than the tropical mean, rather than the absolute value of the surface temperature, as has been assumed in earlier studies. Given this stratification, we show an excellent agreement between the model cloud response to doubling CO_2 and the model cloud response to present-day spatio-temporal sea surface temperature anomalies. The use of special model diagnostics to take account of cloud overlap assumptions allows comparison of the modelled present-day variability with satellite data to validate the cloud response. This evaluation of cloud feedbacks then permits a preference to be made for the simulation of climate change from particular physical schemes. It is found that overall our new model developments improve the simulation of present-day cloud processes and, by implication, the cloud response to increasing GHGs.

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