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## ABSTRACT

The properties of clouds that may be observed by satellite instruments, such as optical depth and cloud top pressure, are only loosely related to the way clouds are represented in models of the atmosphere. One way to bridge this gap is through "instrument simulators," diagnostic tools that map the model representation to synthetic observations so that differences between simulator output and observations can be interpreted unambiguously as model error. But simulators may themselves be restricted by limited information available from the host model or by internal assumptions. This paper considers the extent to which instrument simulators are able to capture essential differences between MODIS and ISCCP, two similar but independent estimates of cloud properties. The authors review the measurements and algorithms underlying these two cloud climatologies, introduce a MODIS simulator, and detail data sets developed for comparison with global models using ISCCP and MODIS simulators. In nature MODIS observes less mid-level cloudiness than ISCCP, consistent with the different methods used to determine cloud top pressure; aspects of this difference are reproduced by the simulators running in a climate model. But stark differences between MODIS and ISCCP observations of total cloudiness and the distribution of cloud optical thickness can be traced to different approaches to marginal pixels, which MODIS excludes and ISCCP treats as homogeneous. These pixels, which likely contain broken clouds, cover about 15% of the planet and contain almost all of the optically thinnest clouds observed by either instrument. Instrument simulators can not reproduce these differences because the host model does not consider unresolved spatial scales and so can not produce broken pixels. Nonetheless, MODIS and ISCCP observation are consistent for all but the optically-thinnest clouds, and models can be robustly evaluated using instrument simulators by excluding ambiguous observations.