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Evaluation of MODIS-Derived Cloud Fraction Using Surface Observations at Low-, Mid- and High Latitude DOE ARM sites

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Clouds play essential roles in the Earth's energy and water cycle, and Cloud Fraction (CF) is one of the most important cloud parameters. The CF from Moderate Resolution Imaging Spectroradiometer (MODIS) has been widely used, whereas the time representation of these instantaneous CF values is not clear. In this study, we evaluate MODIS-derived CF by using continuous, day-and-night radar/lidar CF from the Atmospheric Radiation Measurement (ARM) program Active Remote Sensing of CLouds (ARSCL) product and the total sky cover (TSC) day-time CF datasets. Inter-comparisons between MODIS and surface CFs for time period from 2000 to 2011 are performed for three climate regimes as represented by the ARM sites of Southern Great Plains (SGP), Manus, Papua New Guinea (PNG) and North Slope of Alaska (NSA).

We first choose both the TSC and ARSCL CFs averaged over 1 hour around the two passing time of satellite, which are around 10:30 AM and 1:30 PM local time. Then two kind of analyses have been done. One is the spatial variation analysis and the other is temporal variation analysis. For the spatial variation analysis, we compare the 1-hour averaged cloud fractions from TSC and ARSCL around 10:30 AM and 1:30 PM with the instantaneous cloud fractions from MODIS but with different spatial resolution. By obtaining the RMS errors and ratio of average values of CFs for these inter-comparisons, the optimal CF-matching spatial resolutions for MODIS regarding to TSC and ARSCL are obtained which are both 30 km radius of circle. We also find that the optimal matching spatial resolution increases when the ground observation average time increases. For the temporal analysis, we first analyze the diurnal variation of the cloud fraction based on the surface CFs from TSC and ARSCL from which we can see the daily representation of cloud fraction observed at 10:30 AM and 1:30 PM. Then we make a statistical comparison of daily and monthly cloud fraction between using all time observation and using the 1-hour averaged observations at both 10:30 AM and 1:30 PM. Comparison results will be shown in our paper. It shows a high correlation coefficient of 0.95 (0.93) for observations from TSC (ARSCL). The ratios of daily (monthly) averaged cloud fraction between using all time and using the time satellite passes are 0.87(0.92) and 0.86(0.97) for TSC and ARSCL, respectively. This suggests that considerable errors could be introduced while using the cloud fraction at two fixed time points (10:30 AM and 1:30 PM) to represent the daily cloud fraction.