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A Climatology of Midlatitude Continental Clouds from the ARM SGP Central Facility: Part II: Cloud Fraction and Surface Radiative Forcing

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Data collected at the Department of Energy Atmospheric Radiation Measurement (ARM) Southern Great Plains (SGP) Central Facility (SCF) are analyzed to determine the monthly and hourly variations of cloud fraction and radiative forcing between January 1997 and December 2002. Cloud fractions are estimated for total cloud cover and for single-layered low (0-3 km), middle (3-6 km), and high clouds (>6 km) using ARM SCF ground-based paired lidar-radar measurements. Shortwave (SW) and longwave (LW) fluxes are derived from up- and down-looking standard precision spectral pyranometers and precision infrared radiometer measurements with uncertainties of ˜10 Wm-2. The annual averages of total, and single-layered low, middle and high cloud fractions are 0.49, 0.11, 0.03, and 0.17, respectively. Both total and low cloud amounts peak during January and February and reach a minimum during July and August, high clouds occur more frequently than other types of clouds with a peak in summer. The average annual downwelling surface SW fluxes for total and low clouds (151 and 138 Wm-2, respectively) are less than those under middle and high clouds (188 and 201 Wm-2, respectively), but the downwelling LW fluxes (349 and 356 Wm-2) underneath total and low clouds are greater than those from middle and high clouds (337 and 333 Wm-2). Low clouds produce the largest LW warming (55 Wm-2) and SW cooling (-91 Wm-2) effects with maximum and minimum absolute values in spring and summer, respectively. High clouds have the smallest LW warming (17 Wm-2) and SW cooling (-37 Wm-2) effects at the surface. All-sky SW CRF decreases and LW CRF increases with increasing cloud fraction with mean slopes of -0.984 and 0.616 Wm-2 %-1, respectively. Over the entire diurnal cycle, clouds deplete the amount of surface insolation more than they add to the downwelling LW flux. The calculated CRFs do not appear to be significantly affected by uncertainties in data sampling and clear-sky

screening. Traditionally, cloud radiative forcing includes, not only the radiative impact of the hydrometeors, but also the changes in the environment. Taken together over the ARM SCF, changes in humidity and surface albedo between clear and cloudy conditions offset ˜20% of the NET radiative forcing caused by the cloud hydrometeors alone. Variations in water vapor, on average, account for 10% and 83% of the SW and LW CRFs, respectively, in total cloud cover conditions. The error analysis further reveals that the cloud hydrometeors dominate the SW CRF, while water vapor changes are most important for LW flux changes in cloudy skies. Similar studies over other locales are encouraged where water and surface albedo changes from clear to cloudy conditions may be much different than observed over the ARM SCF.