Cloud Characteristics Determined from Solar Irradiance Data

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For nearly the past three decades the downwelling component of solar irradiance at ground level has been measured at four CMDL baseline observatories. These measurements were initiated and sustained for two primary reasons related to climate research: (1) to detect changes in solar irradiance that would be directly attributable to anthropogenically changed atmospheric composition, and (2) to provide a continuous measure of the principal component of the surface energy budget. Clouds were not of specific interest. The direct effects of changes in anthropogenic constituents on solar irradiance are detectable only in clear-sky cases, thereby rendering clouds merely a contaminant in the investigation. As for measuring the downwelling solar component of the energy budget, the distinction between clear or cloudy skies is mostly irrelevant because the total temporal energy integral is what is required. As a result, a wealth of cloud effect information buried in the continuous high-time-resolution solar irradiance data collected by CMDL has been largely neglected. With the growing awareness that anthropogenically forced climate change would be intimately entwined with the evolving radiative state and extent of clouds, more than 110 station-years of 1- to 3-min average solar irradiance data for the CMDL sites have been analyzed. Cloud effects, and hence their presence in the hemispheric field of view of the radiometer, are objectively distinguished as departures in magnitude and variance from signals expected for clear-sky conditions. This analysis technique's ability to identify the presence of clouds and to make reasonable estimates of cloud transmission is validated with other more sophisticated and shorter-term cloud detection and quantification schemes. We have determined the frequency of cloud occurrence and the effective solar transmission of the detected clouds over the past 28 years at the CMDL observatories and have detected both statistically significant trends and oscillations in the annual mean time series (Figure 1). Other harmonics and curious modulations were found and will be discussed, along with the inferred spatial representativeness of cloud characteristics.

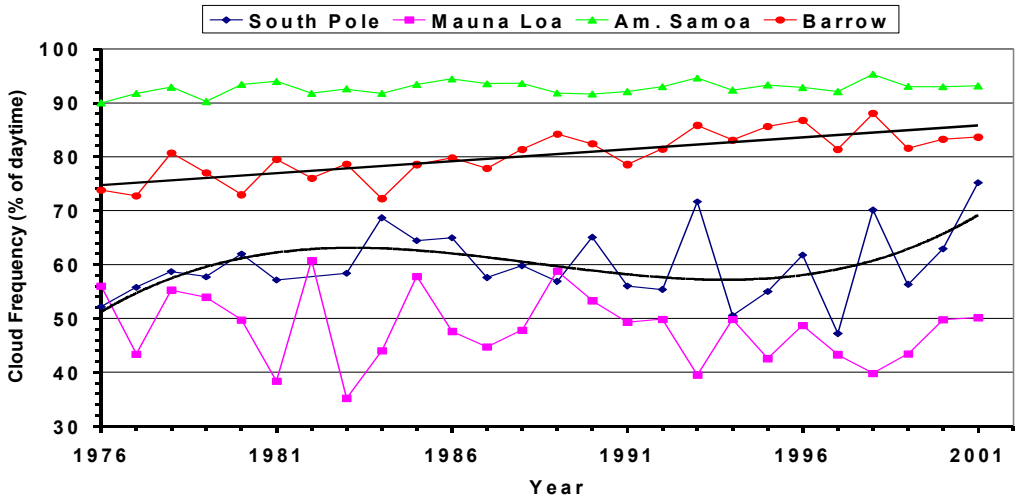

Figure 1. Annual average cloud frequency at the CMDL observatories. Fitted curves indicate coherent statistical variation.