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27-day solar forcing of mesospheric temperature, water vapor and polar mesospheric clouds from the AIM SOFIE and CIPS satellite experiments

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Solar cycle variations of ultraviolet radiation have been implicated in the 11-year and 27-day variations of Polar Mesospheric Cloud (PMC) properties. Both of these variations have been attributed to variable solar ultraviolet heating and photolysis, but no definitive studies of the mechanisms are available. The solar forcing issue is critical toward answering the broader question of whether PMC's have undergone long-term changes, and if so, what is the nature of the responsible long-term climate forcings? One of the principal goals of the Aeronomy of Ice in the Mesosphere satellite mission was to answer the question: "How does changing solar irradiance affect PMCs and the environment in which they form?" We describe an eight-year data set from the AIM Solar Occultation for Ice Experiment (SOFIE) and the AIM Cloud Imaging and Particle Size (CIPS) experiment. Together, these instruments provide high-precision measurements of high-latitude summertime temperature (T), water vapor (H_2O), and PMC ice properties for the period 2007-present. The complete temporal coverage of the summertime polar cap region for both the primary atmospheric forcings of PMC (T and H_2O), together with a continually updated time series of Lyman-alpha solar irradiance, allows an in-depth study of the causes and effects of 27-day PMC variability. The small responses of these variables, relative to larger day-to-day changes from gravity waves, tides, inter-hemispheric coupling, etc. require a careful statistical analysis to isolate the solar influence. We present results for the 27-day responses of T, H_2O and PMC for a total of 15 PMC seasons, (30 days before summer solstice to 60 days afterward, for both hemispheres). We find that the amplitudes and phase relationships are not consistent with the expected mechanisms of solar UV heating and photolysis – instead we postulate a primarily dynamical response, in which a periodic vertical wind heats/cools the upper mesosphere, and modulates PMC properties via the strong T and H_2O sensitivity of ice microphysics. We propose that the wind acting on the strong H_2O gradient in the 80-85 km region causes water vapor to be vertically transported, amplifying the temperature effect. Supporting evidence of a ~27-day mode of oscillation will be presented. PMC height is also shown to have a 27-day periodicity, presumably a result of rising/falling of pressure surfaces. Implications of these results for the 11-year variability of PMC will be presented.