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Comparison of Longwave and Shortwave Cloud Effects on Equilibrium Surface Temperature Using a Radiative-Convective Model and a Decade of MISR Observations

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With over a decade of consistent measurements of reflected solar radiances by the Multiangle Imaging SpectroRadiometer (MISR) on the Terra satellite we notice a reduction in reflectivity at north polar latitudes. This is due to the reduction in summer-time sea ice, modulated by interannual variations in cloud cover, and of course represents a warming component of the climate system, quite likely as positive feedback to the background global warming. There is little change in reflectivity at other latitudes, so the global impact of the observed reduction in albedo is modest.

MISR uses its stereo capability to also measure the effective height of clouds and detects an overall reduction in effective height of about 44 m/decade globally, with larger reductions at low latitudes. By contrast, this implies a cooling component, since the effective altitude of emission of longwave radiation to space is lowered. The interannual changes in cloud height are closely correlated with the Southern Oscillation Index, but may also hint at a weakening Hadley Circulation.

The contrasting effects of these warming and cooling components — the reduction in top-of-atmosphere albedo at high (northern) latitudes and the lowering of global effective cloud height, respectively — are examined using a radiative-convective equilibrium climate model. This model takes the detailed distribution of cloud heights and albedos measured by MISR as inputs. Thin cirrus is generally not well measured, but is a significant greenhouse component, and the uncertainty that this causes is addressed. The model is also capable of contrasting the effects on equilibrium surface temperature of the observed changes in albedo and cloud height with that due to the increased concentration of carbon dioxide over the same time period. The CO_2 increase has the smallest of these effects, but that is just over the last decade, highlighting the interest in obtaining measurements of cloud height and albedo over much longer time periods!