IRS2012-195-1
International Radiation Symposium 2012
Dahlem Cube, Berlin, Germany, 06 – 10 August 2012

Observed effects of sastrugi on CERES top-of-atmosphere clear-sky reflected shortwave flux over Antarctica

J.G. Corbett (1), W. Su (2), and N.G. Loeb (2)

(1) Science Systems and Applications Inc, Hampton, Va, United States (joseph.g.corbett@nasa.gov), (2) Climate Science Branch, NASA Langley Research Center, Hampton, Va, United States

Determining the clear-sky top-of-atmosphere (TOA) albedo over snow from space requires knowledge of the surface bi-directional reflectance, which itself is strongly influenced by the surface roughness of the snow. Sastrugi, a common element of surface roughness on Antarctica, tend to have a preferred azimuth direction, meaning the bi-directional reflectance distribution depends on the location and time of sampling. In this study we demonstrate that a sastrugi signal is present in the Clouds and the Earth's Radiant Energy System (CERES) reflectance measurements and TOA albedo estimates, leading to a spurious variation in instantaneous albedo as a function of solar azimuth of up to 0.08. Furthermore, by using the difference in flux between nadir and oblique views, we estimate the biases in monthly- and annual-mean 24-hour energy weighted clear-sky TOA fluxes caused by sastrugi at different spatial scales over Antarctica. At the grid box level, statistically significant monthly-mean biases of between $\pm$15 Wm^{-2} are found. For the entire Antarctic continent, monthly-mean biases are determined to be between 0.2 $\pm$ 0.9 Wm^{-2} to -1.7 $\pm$ 1.1 Wm^{-2}, and, on an annual basis, the Antarctic bias is between -0.9 $\pm$1.1 Wm^{-2} and -1.0 $\pm$ 1.1 Wm^{-2}. For the global annual mean clear-sky TOA flux, the bias caused by the presence of sastrugi is insignificant, -0.01 $\pm$ 0.02 Wm^{-2}. We also find that there is a relationship between the sign of the flux bias and the anisotropy of the reflected shortwave radiance. Grid boxes with a positive bias have a higher forward scattering maximum and lower back scattering maximum than grid boxes with a negative bias. Based on reports of the observed effects of sastrugi on reflectance at the surface, this result suggests that negative biases are caused by regions with sastrugi that are mostly perpendicular to the solar azimuth at time of sampling, whereas positive biased regions either contain sastrugi that are mostly parallel to the solar azimuth or have no sastrugi. We examine this further by using wind direction as a proxy for the sastrugi direction. We find that the difference between albedos estimated from off-nadir and nadir viewing angles is positive when the difference between the wind and sun azimuths is between 0° and 30° (i.e. parallel) and negative when the difference between the wind and sun azimuths is between 60° and 90° (i.e. perpendicular). This suggests that the biases we see in the TOA flux estimates are indeed caused by sastrugi. To remove the effects of sastrugi we propose implementing a third-order polynomial fit in each grid box, for different solar zenith and scattering directions to correct the off-nadir albedo estimates.