The Cryosphere Discuss., 3, C573–C575, 2010
www.the-cryosphere-discuss.net/3/C573/2010/

The Cryosphere Discussions

Interactive comment on "Surface melt magnitude retrieval over Ross Ice Shelf, Antarctica using coupled MODIS near-IR and thermal satellite measurements" *by* D. J. Lampkin and C. C. Karmosky

Anonymous Referee #2

Received and published: 11 February 2010

This study attempts to estimate absolute melt amount from MODIS thermal infrared measurements by comparing the satellite signal with liquid water content in the upper snow layer calculated using a 1D snow model forced by a variety of meteorological data. This is a very important topic, because until now satellite products could only reliably detect melt occurrence, not magnitude. Because the occurrence of melt is often weighted with surface area, the large areas high on ice sheets with small melt amounts dominate the statistics, while they are not necessarily representative for the absolute meltwater production, which occurs mainly near the ice sheet margins.

Unfortunately, in spite of the fact that it is well written, this paper in my perception does not give the desired solution. In my comments I will focus on the evaluation of the MODIS derived melt. For absolute melt amount from MODIS to be calibrated in a useful way (AND to determine whether calibration is possible at all) requires accurate determination of actual melt at the surface and liquid water content in the subsurface snow layers. To do that requires an accurate determination of all components of the surface energy budget (net shortwave radiation, net longwave radiation, turbulent fluxes of sensible and latent heat, subsurface heat flux). Because melting in Antarctica is usually weak and short-lived (around noon in summer only), i.e. associated with small energy fluxes (~10-50 W m-2), these terms must be determined with high accuracy, better than ~5-10 W m-2, to be able to determine their sum and hence melt energy and rate. Moreover, they must be determined at high temporal resolution (hourly) to capture the short-lived melt events. In addition, surface temperature must be known in order to ascertain that melting really takes place. Finally, penetration of meltwater in the snowpack and subsequent refreezing takes place in Antarctica, which also influences the liquid water content and must be taken into account. This requires assumptions about the initial temperature of the snowpack (needed to initialize the 1D snow model), the retention capacity of the snow, i.e. the open pore space.

Unfortunately, the authors do not have the disposition over snowpack characteristics, nor do they have sufficiently accurate radiation measurements. The problem of reliable input data is exemplified by the large errors in the NCEP/NCAR reanalysis shortwave downwelling radiation, which differs from nearby observations by a factor of two, representing an uncertainty of > 100 W m-2, far larger than the above-mentioned precision. This precludes any accurate assessment of surface energy exchange and melt rate. At least as important is an accurate assessment of surface albedo, which determines how much of the downwelling radiation is absorbed and can be used to heat the surface to the melting point or, when melting has started, how much shortwave radiative energy is used for melting. For instance, assuming an albedo of 0.75 or 0.85 makes a 67% difference in absorbed solar radiation, usually the most important source of melting

TCD

3, C573–C575, 2010

energy. Albedo is used from NCEP/NCAR, but it's value is not mentioned nor how it is determined in that model.

The authors use AWS data, and average them to 6-hourly values. I do not see how this can be used to calculate the highly-nonlinear stability corrections for the turbulent fluxes, which requires a much higher temporal resolution. This may sound as second order effect, but it is not: on the Brunt ice shelf, it has been shown that sublimation is an important heat loss for the surface preventing or limiting melt (King, J. C., S. A. Argentini, and P. S. Anderson, 2006: Contrasts between the summertime surface energy balance and boundary layer structure at Dome C and Halley stations, Antarctica, J. Geophys. Res., 111, D02105, doi:10.1029/2005JD006130). This likely is also the case for Ross ice shelf, where sublimation has been demonstrated to be important in the surface energy budget (Stearns, C. R. and G. A. Weidner, 1993: Sensible and Latent Heat Flux in Antarctica, Antarctic Research Series 61, 109-138).

So, before the satellite data can be usefully linked to surface melt rate, the latter must be calculated with a certain degree of precision. This requires a dedicated surface experiment, or the use of existing high-quality meteorological data, including radiation measurements, such as from Neumayer or Syowa stations (both Baseline Surface Radiation Network stations). Only then can a convincing case be made that MODIS data can be used to assess melt rate.

Interactive comment on The Cryosphere Discuss., 3, 1069, 2009.