Using MODIS Products to Calculate Maximum Snow Albedo

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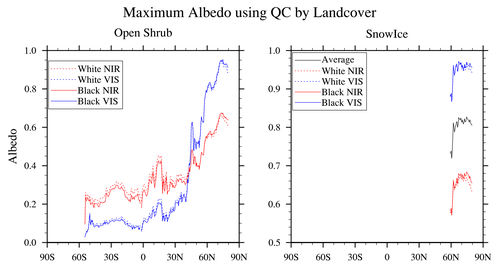
Maximum Snow Albedo Methodology

Maximum snow albedo is an important specified parameter in several land surface models (e.g., the NCEP NOAH model). The existing dataset of maximum snow albedo used in the operational NOAH model is from 1985, uses only one year of data, uses data only from northern high latitudes, and is available at 1° resolution. Using global MODIS albedo data, we create a new maximum snow albedo database at 0.05° resolution.

MODIS "good quality" global 0.05° albedo data(3 broadbands) are used from FEB 2000 – JUN 2004. Latitude dependence of maximum snow albedo is shown in the following figure and the spectral differences are used to determine the presence of snow.

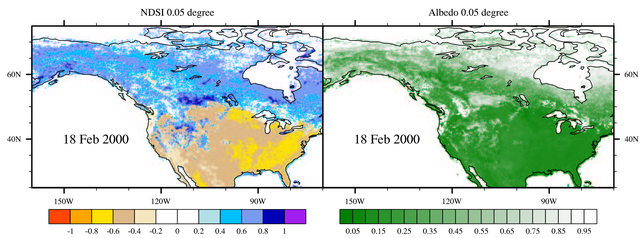


Maximum broadband albedo for different land types as a function of latitude. The spectral differences can be used to determine the presence of snow.

To discriminate snow vs. non-snow, we calculate NDSI using individual channel albedos.

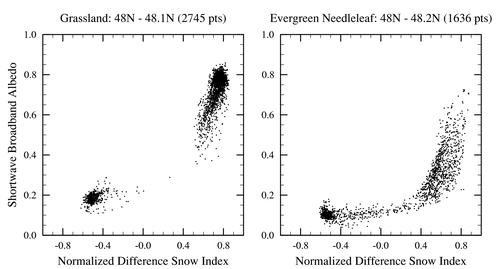
$$NDSI = \frac{chan4 - chan6}{chan4 + chan6}$$

NDSI > 0.4 is considered snow-covered. MODIS IGBP land cover type at 1km resolution is used to determine vegetation dependence on maximum snow albedo. Further restrictions using MODIS band 2 are used to eliminate water.

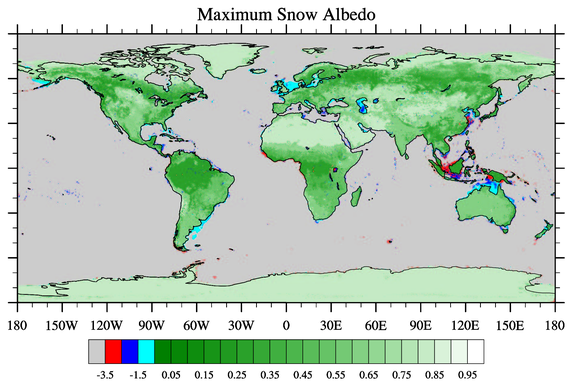


North American NDSI and albedo for February 2000. Grids with NDSI greater than 0.4 are considered snow-covered.

Using MODIS IGBP land cover type at 1km resolution, we can determine latitudinal dependence of maximum snow albedo for different vegetation types. Locations never covered by snow and locations that are cloud-covered during snow periods are replaced with the median values for snow-covered pixels of the same land cover and latitude.



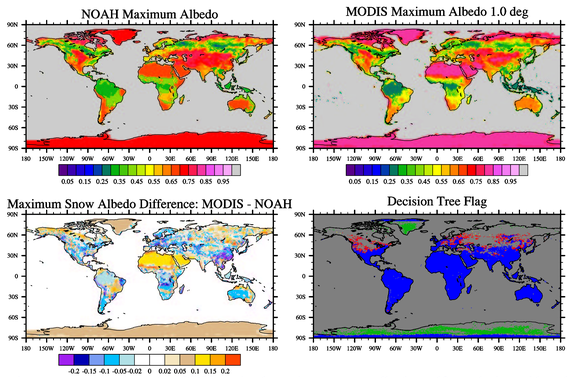
Shortwave broadband albedo versus NDSI for different land use types. This procedure is used to determine substitute values for regions without snow or with cloud cover.



The final 0.05° albedo product. This high resolution product allows us to scale to any current operational model resolution.

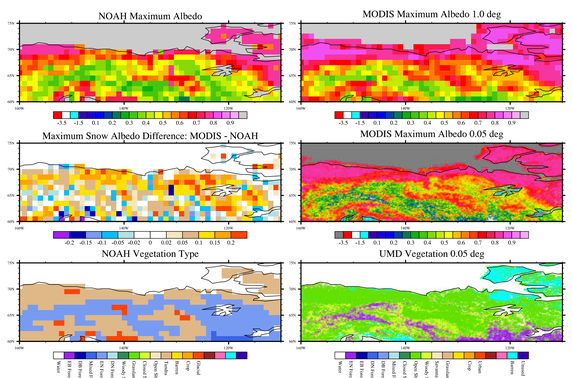
Comparison with 1° Maximum Snow Albedo

The new dataset is rescaled to 1° and compared with the 1° NOAH dataset. Significant regions of up to 0.2 difference can be seen throughout the northern high- and mid-latitudes. These differences will affect the surface energy budget, snow depth and snow-melt timing.



The NOAH maximum snow albedo and MODIS-derived maximum snow albedo at 1° resolution. Also shown are the difference between the snow albedos and the 0.05° decision tree used to generate the MODIS-derived product (Gray indicates "good" snow-covered albedo was used, red indicates a 2° region around the point was used to determine the albedo, blue indicates a latitude band value of that vegetation type was used to determine the albedo, and green indicates points where the albedo was decreased to 0.84.

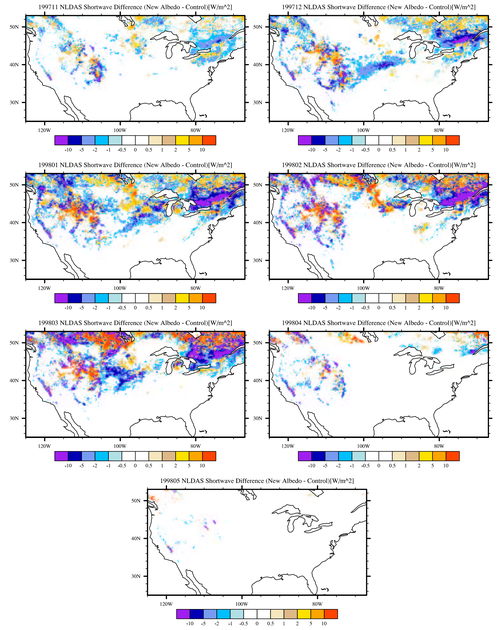
Use of a low resolution dataset omits much small-scale land surface heterogeneity. This is clearly seen in the following figure which shows both the high and low resolution datasets.



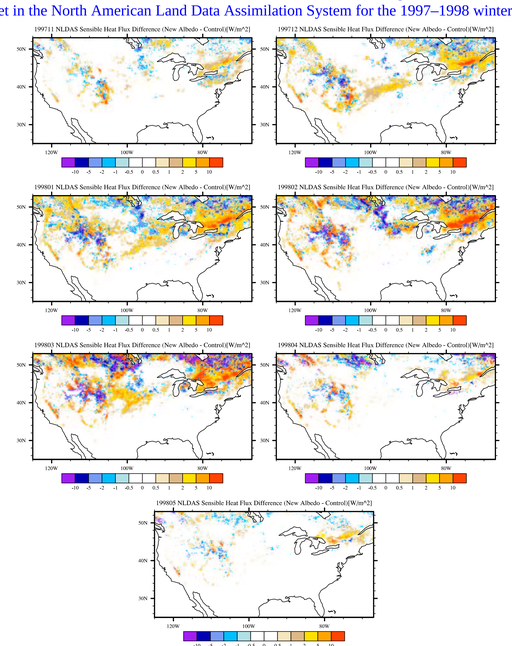
A zoomed-in region of nothern Alaska and Canada. Top row is the 1° values of maximum snow albedo for the original NOAH dataset and the new MODIS-derived dataset. The difference is shown in the middle-left panel. The middle-right panel is the 0.05° version of the new MODIS-derived dataset. The bottom row contains land cover from the 1° NOAH dataset and the 0.05° MODIS UMD dataset.

Results of NLDAS Simulation

The North American Land Data Assimilation System(NLDAS) is used to test the NOAH model sensitivity to the new maximum snow albedo dataset. The albedo dataset is coverted to the NLDAS resolution of 0.125° using simple averaging. The model is run for the 1997-1998 snow season. Results shown below indicate up to 10 W/m^2 changes in shortwave radiation that are compensated for almost entirely by changes in sensible heat flux. Simulations are planned to test the effects in a atmosphere-land coupled system.



Monthly mean difference[W/m^2] in reflected shortwave surface radiation resulting from the addition of the new snow albedo dataset in the North American Land Data Assimilation System for the 1997–1998 winter.



Monthly mean difference[W/m^2] in surface sensible heat flux resulting from the addition of the new snow albedo dataset in the North American Land Data Assimilation System for the 1997–1998 winter.