Status of snow cover validation

Existing global scale remote sensing products

- Snow cover area products, including FSCA (MODIS, IMS, AVHRR)
- Snow water equivalent products (NSIDC Global SWE products, ESA GlobSnow, CMA GlobalSWE)
- Blended snow cover products (Foster et. al., 2011)

Snow data for validation:

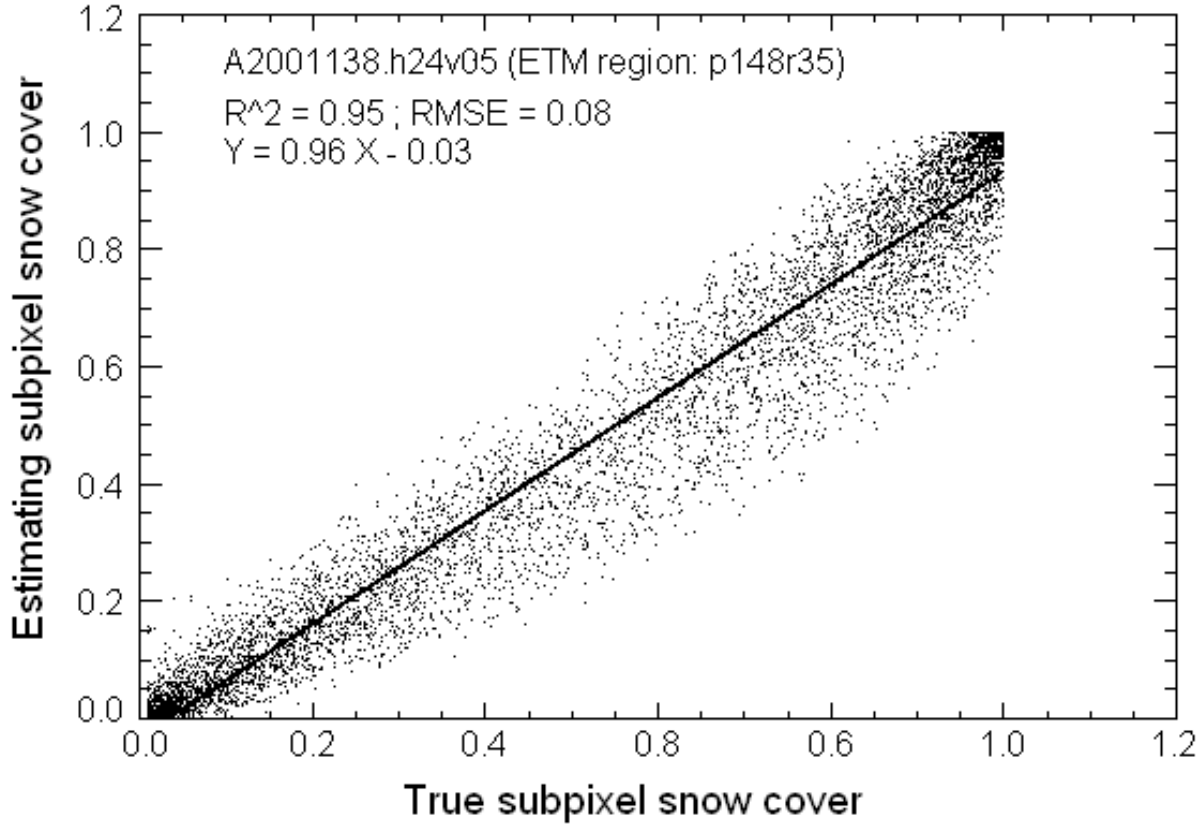
- Snow depth measured in the stations/sites/snowcourse from WMO, hydrological department, …
- Snow cover area derived from the high-resolution images (ASTER, TM/ETM+, HYPERION, HJ, CBERS, et. al.)
- Inter-comparison

Snow cover area products

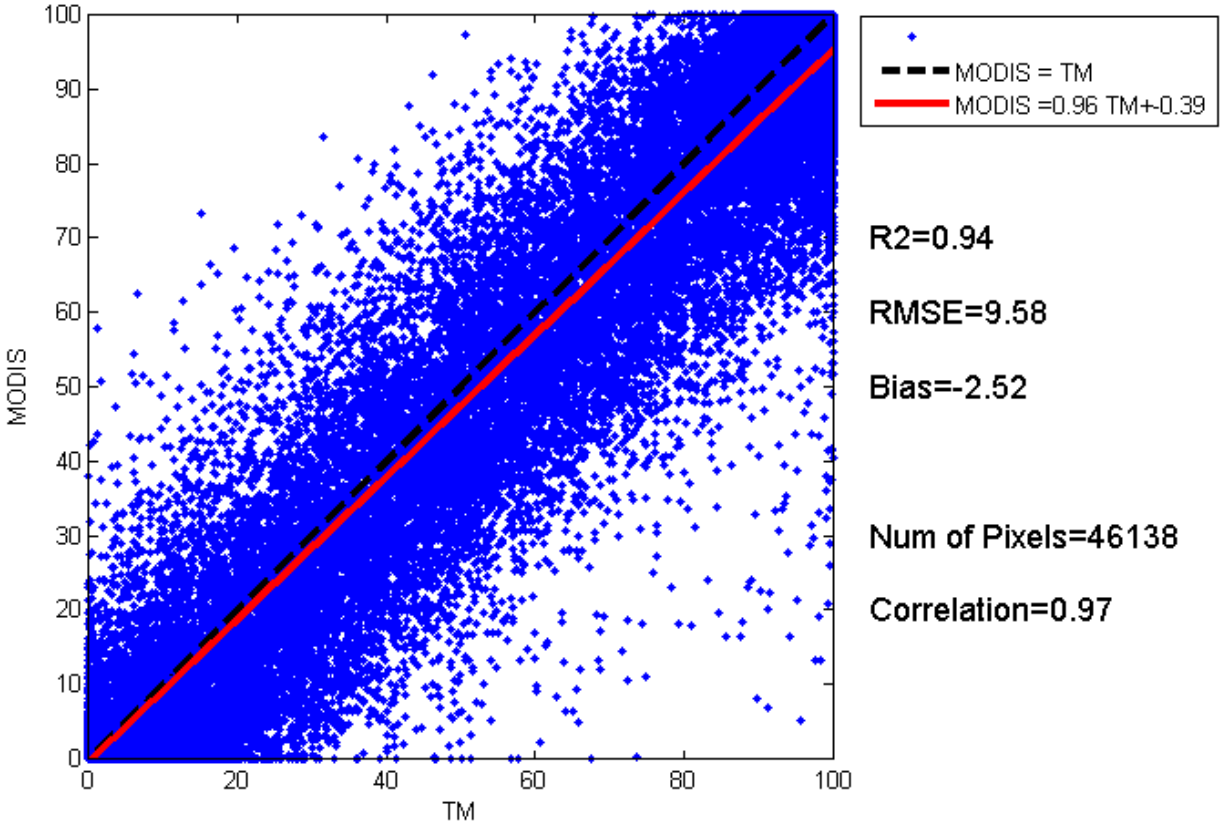
- Snow cover area products
  - MODIS, ~1km (Hall et. al., 2002)
  - IMS, ~4km, (Ramsay, 1998; Helfrich et. al., 2007)
  - IMS, Fractional SCA 500m in ENVEO/SYKE (TBD)
  - AVHRR Pathfinder 5km 1982-2004, CCRS (Zhao, 2009)
  - MODIS Fractional snow cover area products
    - SNOWMAP (Salomonson and Appel, 2004; 2006)
    - Spectral Mixture Analysis (Painter et. al., 2003; 2009)

Status

- Dr. D. K. Hall has made significant progresses in snow cover area products validation.
- Generally, snow cover product has a good accuracy (>90% for cloud free condition). A lower accuracy occurs in the forest regions.
- Current work is focusing on
  - Reconstructing the cloud-free snow cover products.
  - Developing the high-quality fractional SCA, grain size and albedo integrated products.


A2001138.h24v05 (ETM region: p148r35)
R^2 = 0.95 ; RMSE = 0.08
Y = 0.96 X - 0.03
Estimating subpixel snow cover
True subpixel snow cover
0.0
0.2
0.4
0.6
0.8
1.0
1.2

(J C Shi, 2012)


MODIS = TM
MODIS =0.96 TM+-0.39
R2=0.94
RMSE=9.58
Bias=-2.52
Num of Pixels=46138
Correlation=0.97
MODIS
TM
0
10
20
30
40
50
60
70
80
90
100
0
20
40
60
80
100

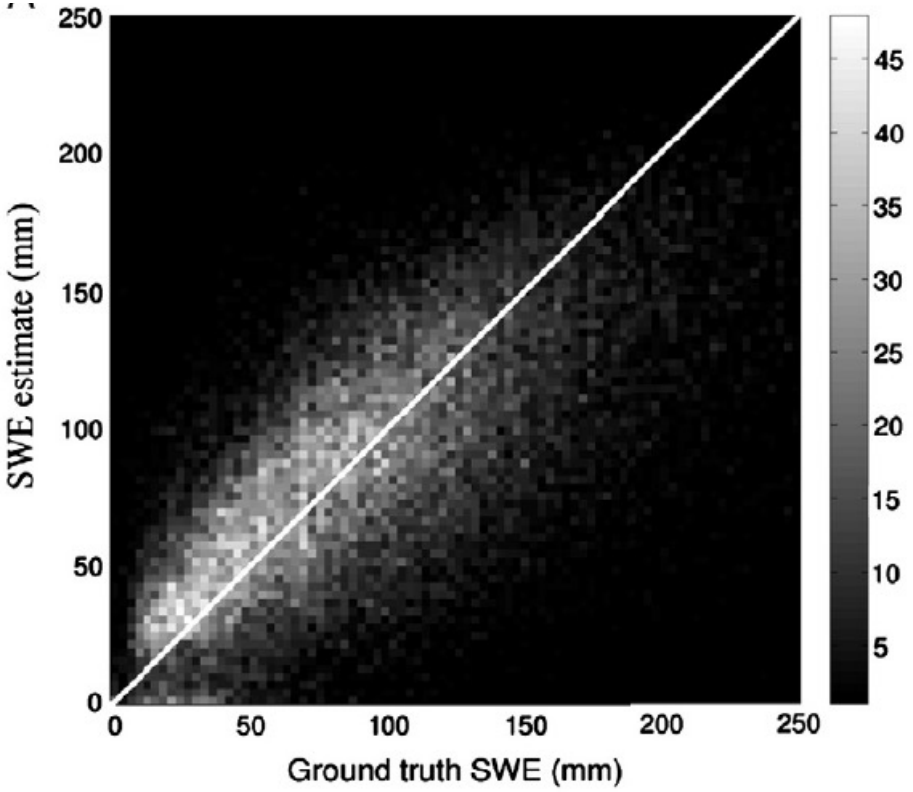
(Hao, 2014)

Snow water equivalent

- NSIDC, Global SWE, ~25km
- ESA, GlobSnow,~25km
- CMA, Global SWE, ~25km

Status

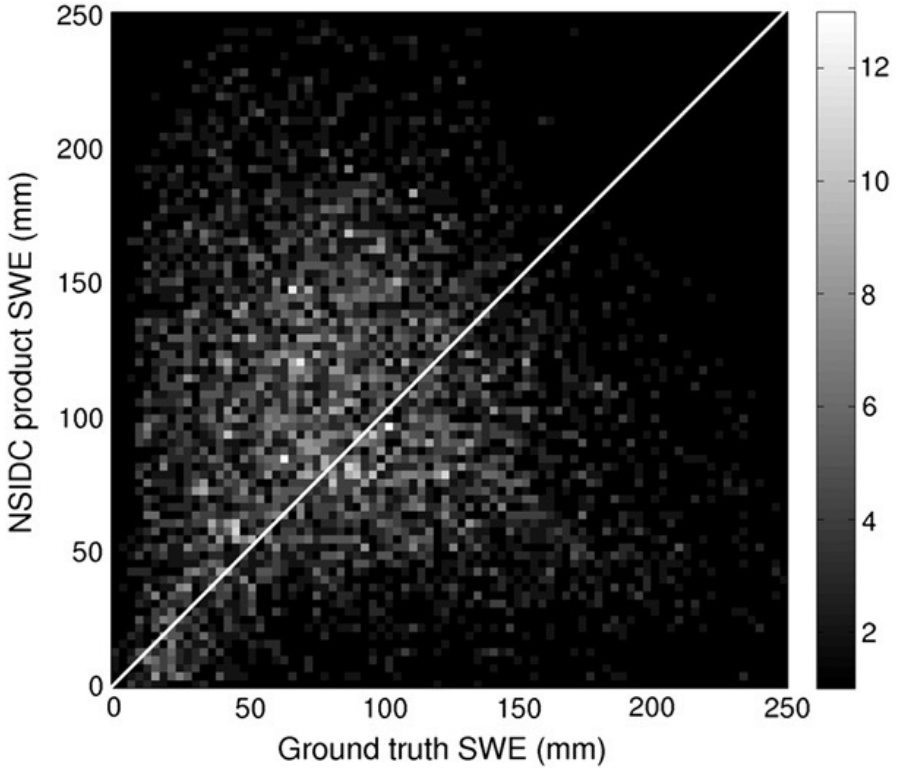
- SWE has not been validated very well. The validation results are available from the author/producer of SWE products.
- Very large differences in different regions.
- The largest challenge to validate the SWE is the low spatial resolution of passive microwave remote sensing data (~25km).



GlobSnow vs Ground SWE

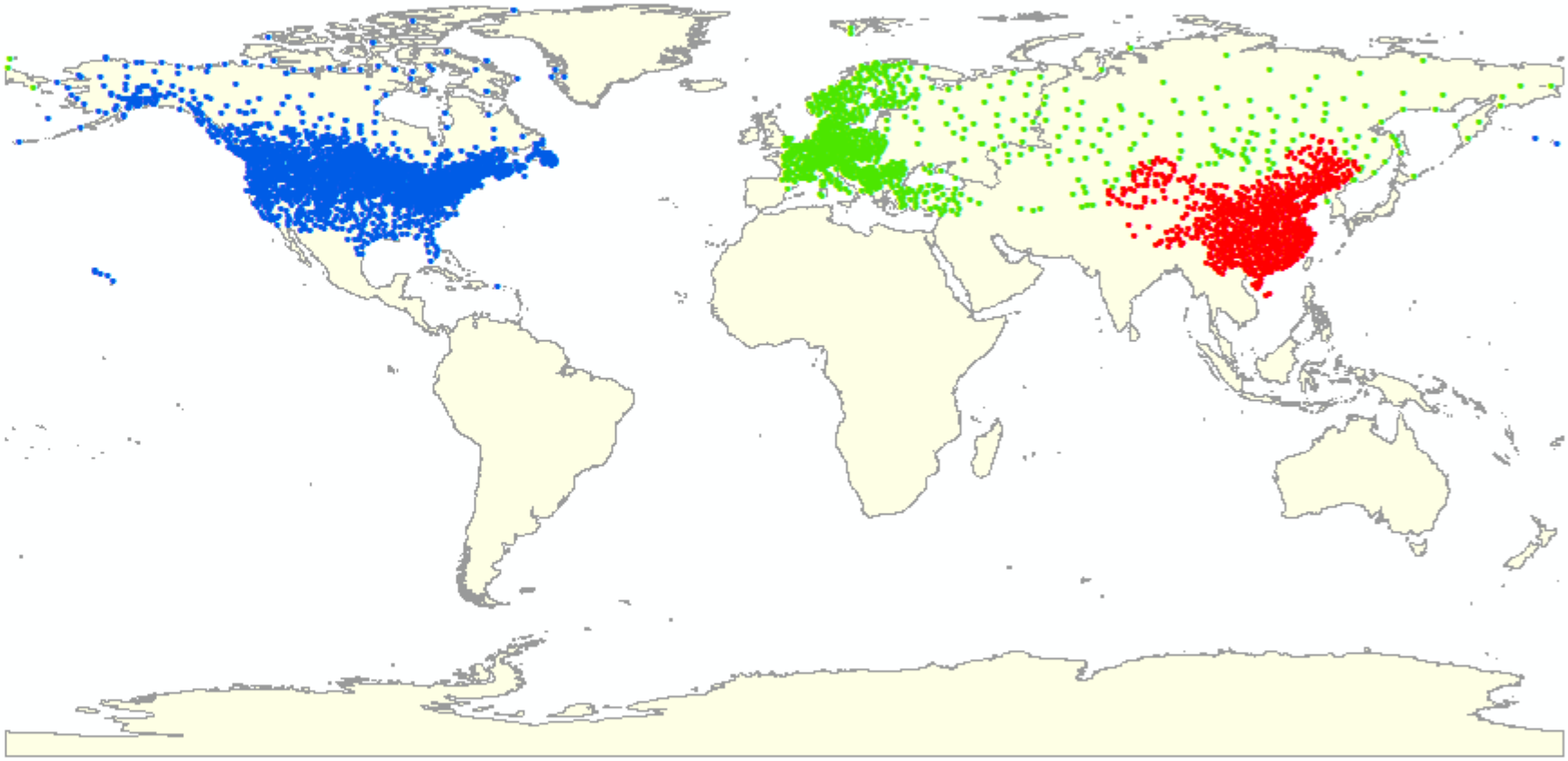
Season	RMSE (mm)	bias(mm)	Corr. coeff	Samples
Fall	23.0 (21.7)	5.8 (6.5)	0.69 (0.70)	35197 (34943)
Winter	37.7 (28.9)	1.7 (7.7)	0.72 (0.72)	165784 (150405)
Spring	72.5 (47.3)	−37.6 (−19.3)	0.53 (0.47)	42843 (33189)

RMSE= 47 mm

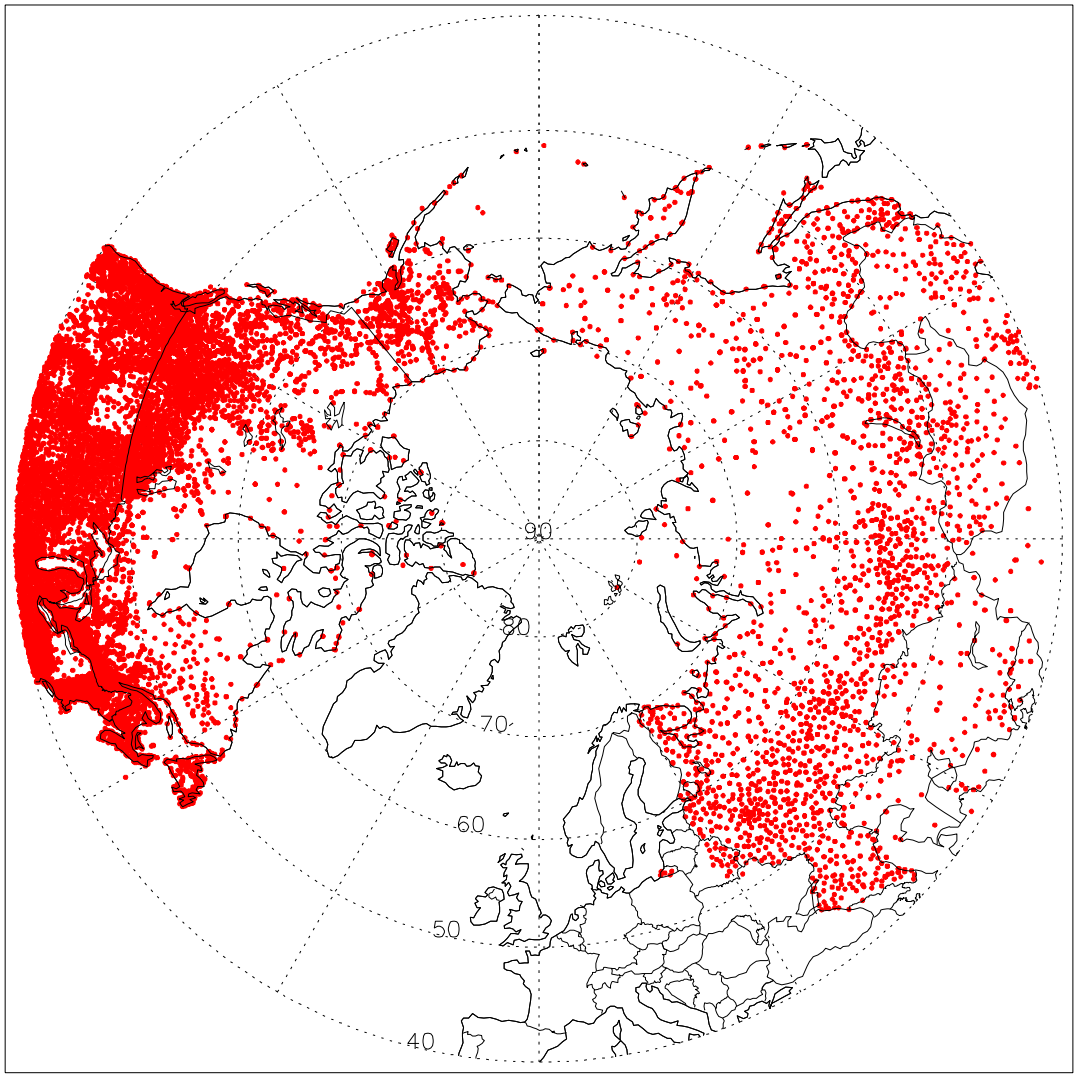


RMSE= 92 mm

NSIDC SWE vs Ground SWE



Blue and green sites has been used in GlobSnow products
Red sites not be included.



We are collecting snow measurements from these sites.

- The principal purpose of this paper is to describe the development and validation of an algorithm to estimate the fraction of snow cover within a 500-m pixel of the Moderate Resolution Imaging Spectroradiometer (MODIS) operating on the Earth Observing System Aqua spacecraft. The performance of this algorithm and algorithms applicable to the MODIS on the Terra spacecraft are compared. Validation efforts show that both pixel-level, fractional snow cover relationships for the Terra and Aqua MODIS instruments work well as quantified by such measures as correlation coefficient (r) and root-mean-square error when compared to Landat-7 Enhanced Thematic Mapper ground-truth observations covering a substantial range of snow cover conditions. Over all the scenes used herein, the correlation coefficients were near 0.9 and the RMSE near 0.10. However, somewhat better performance was found for the Terra MODIS versus the Aqua MODIS over nearly concurrently observed scenes. Furthermore, it is clear that more improvements in fractional snow cover estimates within MODIS pixels should be pursued to better account for variability in slope and aspect, atmospheric effects, snow cover types, and land cover.
- V. V. Salomonson and I. Appel, "Development of the Aqua MODIS NDSI fractional snow cover algorithm and validation results", IEEE Transactions on Geoscience and Remote Sensing, vol.44, no.71, pp.1747-1756, 2006.

- A joint US Air Force/National Aeronautics and Space Administration (NASA) blended global snow product that uses Earth Observation System Moderate Resolution Imaging Spectroradiometer (MODIS), Advanced Microwave Scanning Radiometer for the Earth Observing System (AMSR-E) and Quick Scatterometer (QuikSCAT or QSCAT) data has been developed. Existing snow products derived from these sensors have been blended into a single, global, daily, user-friendly product by using a newly developed Air Force Weather Agency (AFWA)/NASA Snow Algorithm (ANSA). This initial blended snow product uses minimal modelling to expeditiously yield improved snow products, which include, or will include, snow-cover extent, fractional snow cover, snow water equivalent (SWE), onset of snowmelt and identification of actively melting snow cover. The blended snow products are currently 25-km resolution. These products are validated with data from the lower Great Lakes region of the USA, from Colorado obtained during the Cold Land Processes Experiment (CLPX), and from Finland. The AMSR-E product is especially useful in detecting snow through clouds; however, passive microwave data miss snow in those regions where the snow cover is thin, along the margins of the continental snowline, and on the lee side of the Rocky Mountains, for instance. In these regions, the MODIS product can map shallow snow cover under cloud-free conditions. The confidence for mapping snow-cover extent is greater with the MODIS product than with the microwave product when cloud-free MODIS observations are available. Therefore, the MODIS product is used as the default for detecting snow cover. The passive microwave product is used as the default only in those areas where MODIS data are not applicable due to the presence of clouds and darkness. The AMSR-E snow product is used in association with the difference between ascending and descending satellite passes or diurnal-amplitude variations (DAV) to detect the onset of melt, and a QSCAT product will be used to map areas of snow that are actively melting.
- J. L. Foster, D. K. Hall, J. B. Eylander, G. A. Riggs, S. V. Nghiem, M. Tedesco, E. Kim, P. M. Montesano, R. E. J. Kelly, K. A. Casey and B. Choudhury, "A blended global snow product using visible, passive microwave and scatterometer satellite data", International Journal of Remote Sensing, vol.32, no.5, pp.1371-1395, 2011.