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Topics of the Newsletter

Special Issue on GlobSnow SWE

Prototype GlobSnow SE for the Northern Hemisphere under production

esa

FINNISH METEOROLOGICAL INSTITUTE

European Space Agency
DUE - GlobSnow (2008–2011)

Development of Global Snow Monitoring Services

The different SWE product releases

GlobSnow SWE development has seen three different release versions of the product labelled 0.9, 0.9.1 and 0.9.2.

The first SWE product version "0.9" was processed using the development version of the production chain running on Matlab. The version 0.9 was used within the algorithm evaluation phase of GlobSnow It was released to Users, but due to issues on the production chain, contained several gaps in data for the years 2003 – 2008. The data for 1994 to 1997 utilized Russian weather station data for production (only used within v0.9); the weather station data for 2003 – 2008 were from ECMWF.

The second release version of the SWE product "0.9.1" utilized the production chain modified for the Cray XT5m processing environment at FMI and included a lot of improvements for data handling. The results showed an improved version of the product and the data gaps evident in the previous version were closed. The product utilized the wet snow mask that was determined using the satellite data to reduce the wet snow estimated SWE values to zero.

The third version of the SWE product "v0.9.2" is based on the productionchain of the previous version with additions to calculate the new aggregated products: weekly average and monthly average and maximum SWE. In addition to that, the masking of wet snow was deemed to be too aggressive and for the v0.9.2 the areas with wet snow were determined by interpolation of the weather station data. This reduced spatial gaps in the data. Additionally the v0.9.2 is already very close to the final production algorithm, and shows the snowline determined using the available radiometer data. The snow line is determined using a time-series algorithm to detect the off-set of snow melt.

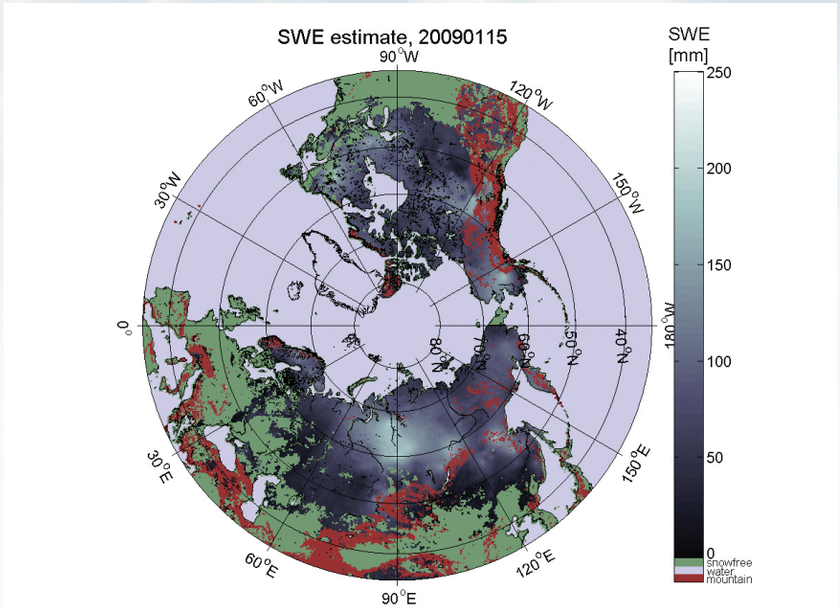


Figure 1. Daily SWE estimate for 15 January 2009.

SWE v0.9.2 description

The snow water equivalent (SWE) product version 0.9.2 now starts from the year 1992 and extends all the way to 2009. The data include:

- Daily SWE estimates and SWE variances
- Weekly average SWE
- Monthly average and maximum SWE
- Quicklook images for daily, weekly and monthly products
- An example of the images are seen in figures 1-3.

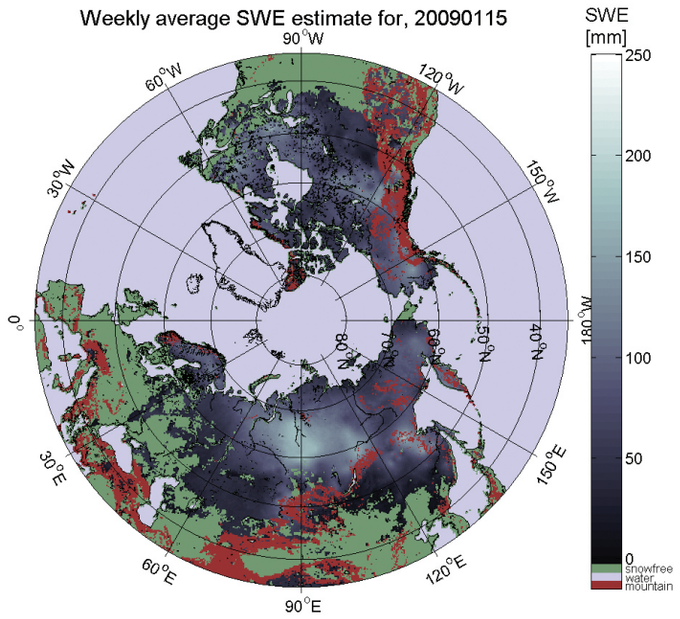


Figure 2. Aggregated Weekly SWE estimate for 15 January 2009, data acquired between 9 January and 15 January 2009.

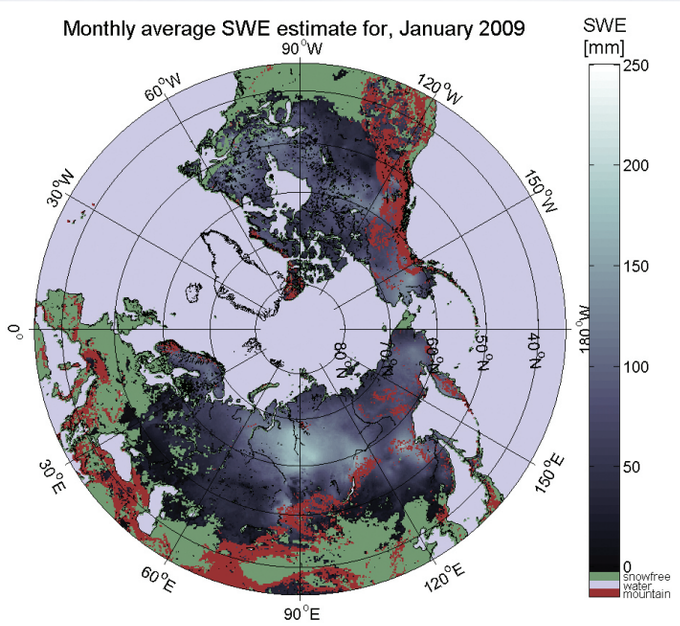
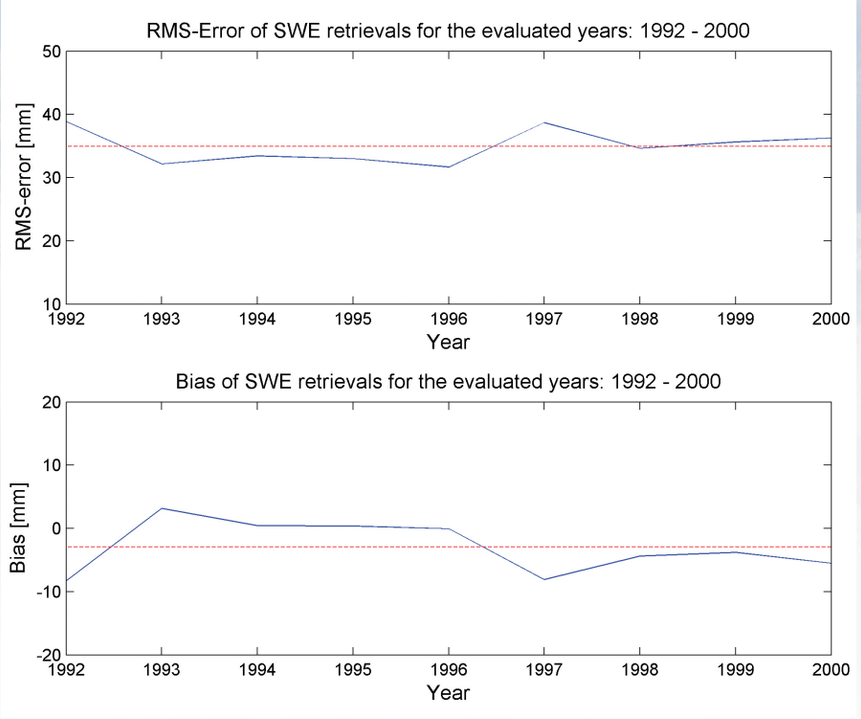


Figure 3. Average SWE estimates for January 2009.

SWE evaluations for 1992 - 2010

The original algorithm evaluations, reported within the project documentation (DJV-v1), were carried out using the product v0.9 for the years 1994 to 1997. Completion of the long term data set v0.9.2 allowed the re-evaluation of the SWE data between the years 1992 – 2000 (the range of years determined by the availability of reference data). The comparison show that the RMS-error for SWE values ranging between 0 – 150mm, for the years 1992 – 2000 (consisting of 56294 samples) was 34.9mm. The bias for the same dataset was -2.6mm. Considering all the samples of the full data set (SWE values ranging between 0mm to 500mm) showed a bias of -13.8mm and RMS-error of 52mm (both values are a significant improvement over the alternative evaluated algorithms).



The RMS-errors and biases for the different evaluated years are shown in Figure 4.

Figure 4. The RMS-errors and biases for the evaluated years. SWE estimates compared with snow path measurements from former USSR.

Land Cover	Reference Dataset	Year	n	Mean SWE (mm)	RMSE (mm) 0.9.0	RMSE (mm) 0.9.2	r 0.9.0	r 0.9.2	Mean Bias (mm) 0.9.0	Mean Bias (mm) 0.9.2
Tundra	Intensive Sites	2005-2007	3	129	28	32			-9	6
	SnowSTAR 2007	2007	25	119	50	43			-46	-38
Northern Boreal	EC Snow Surveys	2005/06	48	92	22	26	0.69	0.28	-13	6
		2006/07	57	169	102	92	-0.01	-0.45	-78	-63
		SWE <150 mm	73	211	25	21	0.70	0.52	-17	3
		All	105	134	77	70	0.24	0.00	-48	-32
Southern Boreal	EC Snow Surveys	2005/06	22	65	25	24	0.77	0.71	-15	-11
		2006/07	16	84	27	36	0.61	0.08	-13	-20
		2007/08	19	79	21	24	0.67	0.25	1	5
		All	57	75	24	28	0.70	0.43	-10	-8
Southern Boreal	Boreal Ecosystem	2005/06	180	52	30	34	0.87	0.90	-20	-22
	Research and Monitoring Sites	2006/07	144	67	21	21	0.80	0.82	0	-5
		2007/08	144	87	22	20	0.85	0.87	13	16
		All	468	70	24	25	0.84	0.87	-1	-3
Prairie	EC Snow Surveys	2005/06	26	46	32	19	0.34	0.63	3	2
		2006/07	15	49	32	23	-0.17	0.06	16	12
		All	41	47	32	21	0.23	0.51	7	6

Table 1. Comparison of the evaluation results of GlobSnow SWE version 0.9.0 and 0.9.2 for Canada.

SWE evaluations for Canada

The version 0.9.2 GlobSnow SWE product was evaluated using various reference datasets from Canada, spanning the 2005/06 through 2007/08 snow cover seasons. This assessment was compared to a similar evaluation of previous versions (0.9.0 and 0.9.1) of the GlobSnow SWE product. A comparison with the version 0.9.1 assessment is hampered by the fact that the wet snow mask employed in V0.9.1 was very conservative, resulting in a greatly reduced sample size of SWE retrievals compared to version 0.9.0 and 0.9.2. A more direct assessment of any improvements in the product can be made by comparing version 0.9.0 with 0.9.2.

As summarized in Table 1 there is overall improvement in performance statistics for the 0.9.2 product relative to version 0.9.0. Some challenges remain under deep snow conditions, as evident in the northern boreal forest for 2006/07, when mean ground measured SWE was nearly 170 mm. The reduced uncertainty in the V0.9.2 dataset is illustrated in Figure 5, through the calculation of the change in absolute error values (0.9.2 minus 0.9.0) for SWE estimates matched with in situ observations. In 75% of the cases, there was either no change or a reduction in absolute error for version 0.9.2 compared to 0.9.0.

The Boreal Ecosystem Research and Monitoring Sites (BERMS) operated by Environment Canada in the southern boreal forest of Saskatchewan represents a valuable reference dataset for GlobSnow SWE retrievals. Hourly snow depth measurements are made a network of sites in various classes of forest cover including jack pine, black spruce, aspen, and a chronosequence of sites that were harvested between 1975 and 2002. In most cases, there are multiple BERMS sites within a single 25 km GlobSnow SWE grid cell. Figure 6 illustrates the time series of BERMS measurements (snow depth converted to SWE using density measured bi-monthly at each site) plotted with pentad (5-day) averaged GlobSnow retrievals. The BERMS measurements illustrate the range in SWE that is typical within a coarse footprint SWE retrieval due to snow interactions with the mixed forest vegetation. In spite of this heterogeneity, the GlobSnow SWE retrievals agree well with the BERMS measurements through each season. There is a tendency for early season shallow snow to be missed in the GlobSnow product, and for the retrievals to ablate the snow cover too rapidly in the spring.

Further assessment of the GlobSnow SWE product will continue at Environment Canada, with a focus on the recently available 1992 through 2009 time series.

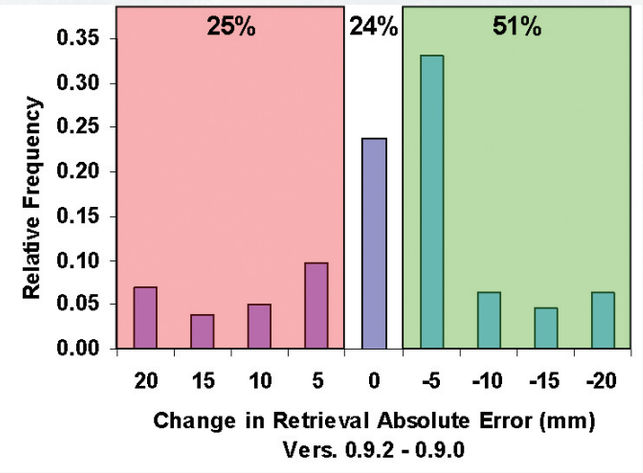
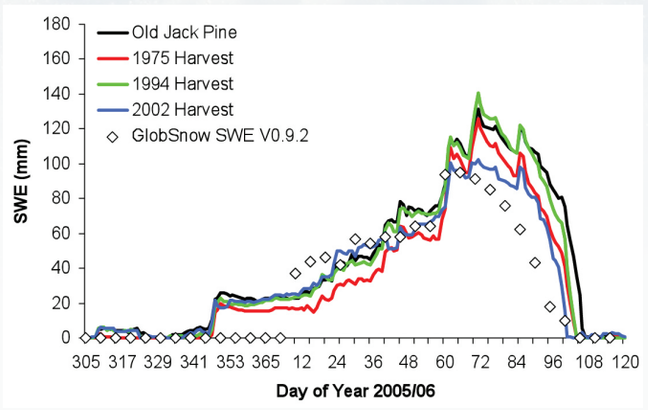
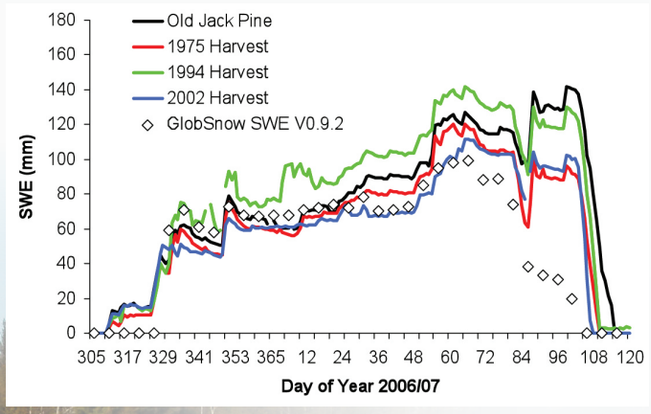


Figure 5. Histogram of change in the absolute retrieval error, Version 0.9.2 versus 0.9.0.





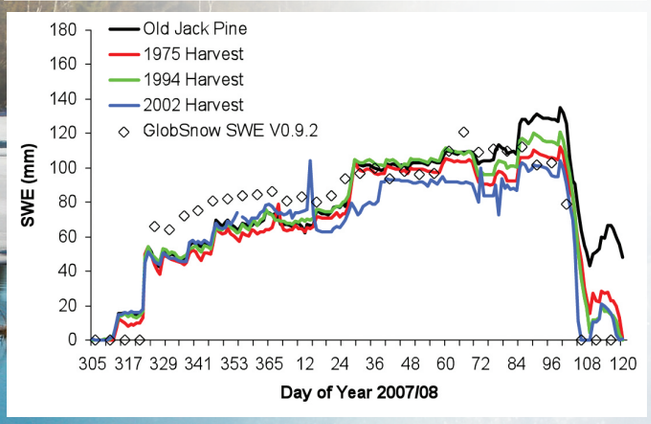


Figure 6. Time series of BERMS measurements compared to GlobSnow retrievals, 2005/06 (top) through 2007/08 (bottom).

Snow Extent v0.9.4 for Northern Hemisphere under production

One of the goals of the GlobSnow project is to develop a global product and a near-real-time service for Snow Extent (SE) and carry out snow mapping of the whole seasonally snow covered Earth for the years 1995–2010 based on ERS-2 ATSR-2 and Envisat AATSR optical satellite data. The global and final SE product set spanning 15 years is expected to be ready by October 2010 and will be made freely available. A prototype pan-European product was developed in 2009 to obtain crucial experience on global mapping. The pan-European product, version 0.9.2, covers the years 2003-2006 (3.5 years). An extended SE product, version 0.9.4, covering the Northern Hemisphere for a full year (2003) is under production, and will be released to users during summer 2010.

The snow cover information is retrieved by two algorithms, one for high-mountain areas of steep topography above the tree line (NLR) and another developed for forested and open areas (SCAmod). The retrieval results from the two algorithms are merged into one product. Clouds are detected by a cloud-cover retrieval algorithm and masked out. Large water bodies (ocean and lakes) are also masked out. The resulting product is provided in a latitude-longitude grid of 0.01 × 0.01 degrees.

The SCAmod algorithm is based on a semi-empirical reflectance model, where reflectance from a target is expressed as a function of the snow fraction. The average generally applicable reflectance values for wet snow, forest canopy and snow-free ground serve as model parameters. A transmissivity map provides the amount of reflected sunlight from the ground that could be observed from a satellite in forested areas. FSC can then be derived from observed reflectance based on the given reflectance constants and the transmissivity values. The algorithm is applied in forested and non-forested, non-mountainous regions. Transmissivity is estimated from a land cover map from the ESA GlobCover project.

The Norwegian Linear-Reflectance-to-snow cover (NLR) algorithm is based on the assumption that there is a linear relationship between snow coverage and measured top-of-atmosphere (TOA) reflectance (or radiance). When this relationship is established, the snow cover is retrieved as Fractional Snow Cover (FSC) percentage values. The algorithm is actually a two-endmember case of linear spectral unmixing. It was originally developed for analysis of NOAA AVHRR data, and has later been tailored to MODIS data. A special version of the NLR algorithm has been developed in the GlobSnow project for ATSR-2 and AATSR data.

A comprehensive evaluation of the prototype products has been carried out within the pan-European region. However, the region – limited as it is in its extent – does not necessarily cover all natural variability worldwide. Therefore, the following results on accuracy are only preliminary. Validation work for the Northern Hemisphere is undergoing and will be available when the full product set is released in the autumn. For non-mountainous terrain in the pan-European region and FSC using the SCAmod algorithm, the root-mean-squared deviation (RMSD) were typically around 15-25%. For mountainous terrain and NLR algorithm the RMSD values for the summer months were typically in the interval 10-15%, and around 15-25% in the winter (dark months).

Figure 7. Daily Snow Extent product for Northern Hemisphere for 10 March 2003.

Figure 8. Weekly Snow Extent aggregate for Northern Hemisphere for 10 March 2003, data acquired between 4 March and 10 March.

SWE vs. SE snow lines

Figures 9 show preliminary comparisons between the snow line determined from the SWE product and the 10-day composite of SE data for the spring melt season of 2003.

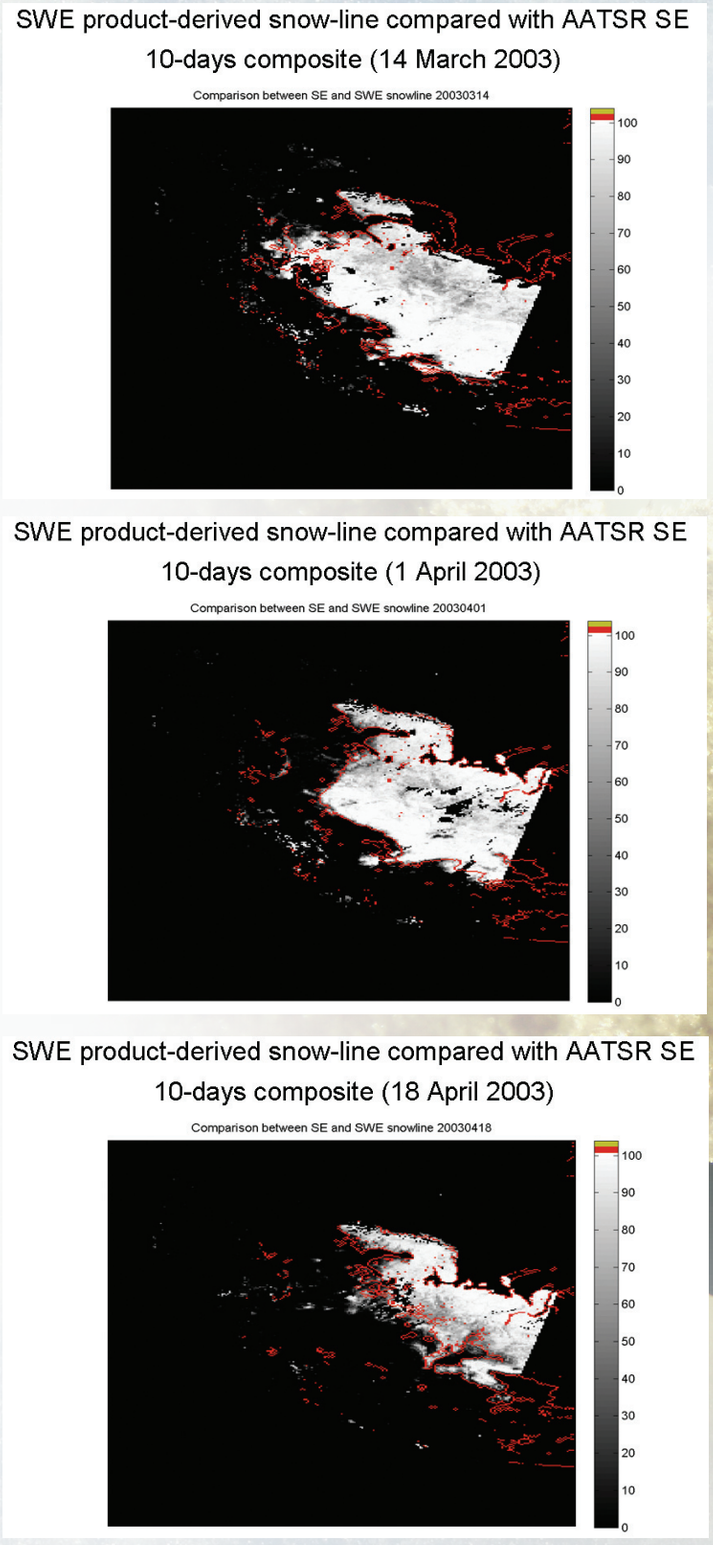
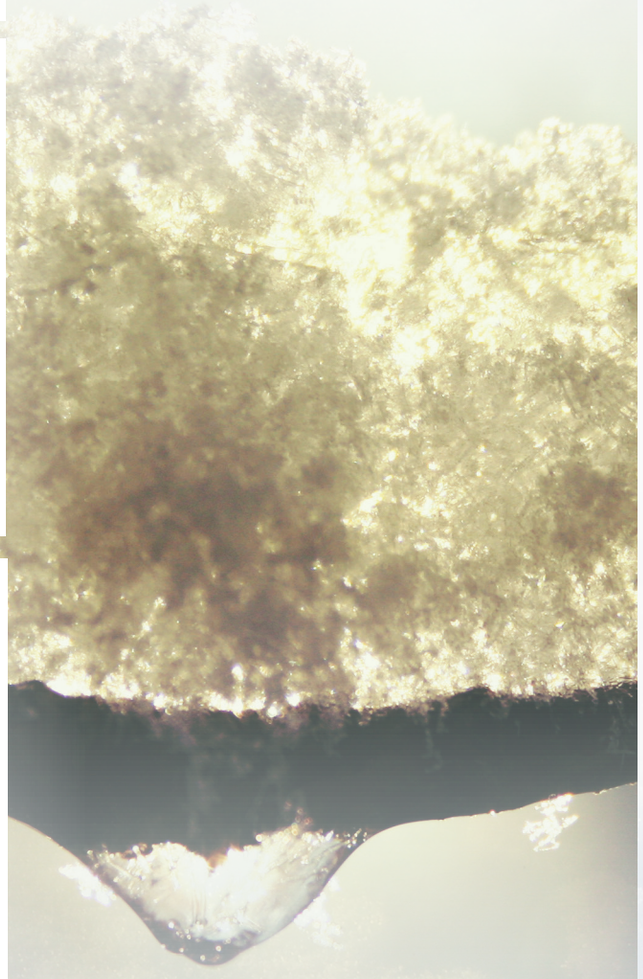


Figure 9. The comparison between the snow-line derived from SWE data and SE estimates from AATSR data shown for the spring melt season of 2003. Red line shows the snow line from SWE data, the snow extent from optical data are shown using shades of grey.

GlobSnow product access through WWW-pages

The GlobSnow SE and SWE products can still be downloaded via the GlobSnow FTP-site (requiring user authentication). An alternative way to get access to the data without user restrictions has been opened through the Litdb-WWW-pages. The data can be accessed from: (http://litdb.fmi.fi/globsnow/).



Project overview

The European Space Agency (ESA) funded GlobSnow project aims at creating a global database of snow parameters for climate research purposes. In addition to a historical data set comprising of 15 to 30 years of snow data an operational near-real time snow information service will be constructed. Information on two essential snow parameters: snow water equivalent (SWE) and areal snow extent (SE) will be provided. The archive and the demonstrated snow service will be based on data acquired from active and passive, optical and microwave-based spaceborne sensors combined with ground-based weather station observations.

GlobSnow consortium

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ENVEO IT GmbH
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Environment Canada (EC)
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Finnish Environment Institute (SYKE)
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Norwegian Computing Center (NR)
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