GLOBSNOW

Newsletter

no. 8 / 2011

www.globsnow.info

Topics of the Newsletter

GlobSnow at EARSeL LISSIG 8 February 2011

GlobSnow SWE and SE Full Product sets

esa

FINNISH METEOROLOGICAL INSTITUTE

European Space Agency
DUE - GlobSnow (2008–2011)

Development of Global Snow Monitoring Services

GlobSnow at EARSeL LISSIG 8 February 2011

The GlobSnow project will be presented during the European Association of Remote Sensing Laboratories (EARSeL) "Remote Sensing of Snow and Glaciers: Cryosphere, Hydrology and Climate Interactions" Workshop held in Bern, Switzerland, 7 - 9 February 2011. A dedicated afternoon session is arranged during the workshop where the GlobSnow results will be presented along with a few presentations given by the GlobSnow user community. The presentations by the GlobSnow consortiunm will focus on presenting the full long-term data records of both SE and SWE along with the validation results for them. Presentations by the user community will be given by Mr. Bernard Bilodeau of Environment Canada, Dr. Steven Hancock of Durham University and Dr. David Robinson of Rutgers University.

Additional information on the workshop can be found on the official workshop web page http://www.earsel.org/SIG/Snow-Ice/workshops.php.

GlobSnow SWE and SE Full Product sets

30-year record on snow water equivalent released

The complete 30-years SWE dataset was released to users in November 2010. The SWE record is based on the methodology by Pulliainen (Pulliainen, J. 2006. Mapping of snow water equivalent and snow depth in boreal and sub-arctic zones by assimilating space-borne microwave radiometer data and ground-based observations. Remote Sensing of Environment. 101(2): 257-269, 2006.), utilizing satellite-based passive microwave measurements combined with ground-based weather station data, beginning from 1979 and extending to present day. The GlobSnow SWE product is the first satellite-based data set of snow water equivalent information on a daily basis at a hemispherical scale for 30 years. The SWE data is based on the time-series of measurements by three different space-borne passive microwave radiometers (SMMR, SSM/I and AMSR-E).

The passive microwave data for 1979 to 1987 were acquired from the Nimbus-7 Scanning Multichannel Microwave Radiometer (SMMR) sensor which was operating every other day and thus can be used to derive the daily SWE time-series for every second day. The weekly aggregated SWE dataset, however, was calculated for every day. The Special Sensor Microwave/Imager (SSM/I) family of sensors have been flown aboard several DMSP satellites, covering an impressive data record starting from 1987 and extending all the way to present day. SSM/I data are available for every day, and the daily SWE data was generated starting from fall 1987. EOS Aqua Advanced Microwave Scanning Radiometer (AMSR-E) data are available starting from June 2002. The GlobSnow SWE product was generated using the AMSR-E data from 2003.

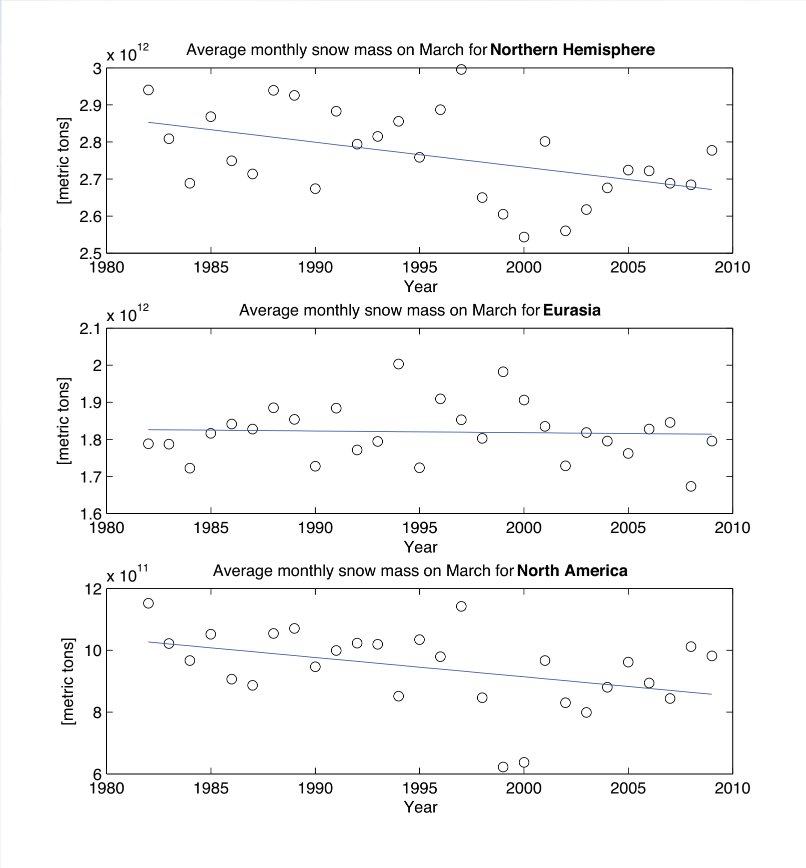

Figure 1: Average monthly snow mass and trends for March 1982-2009 for the Northern Hemisphere, Eurasia and North America.

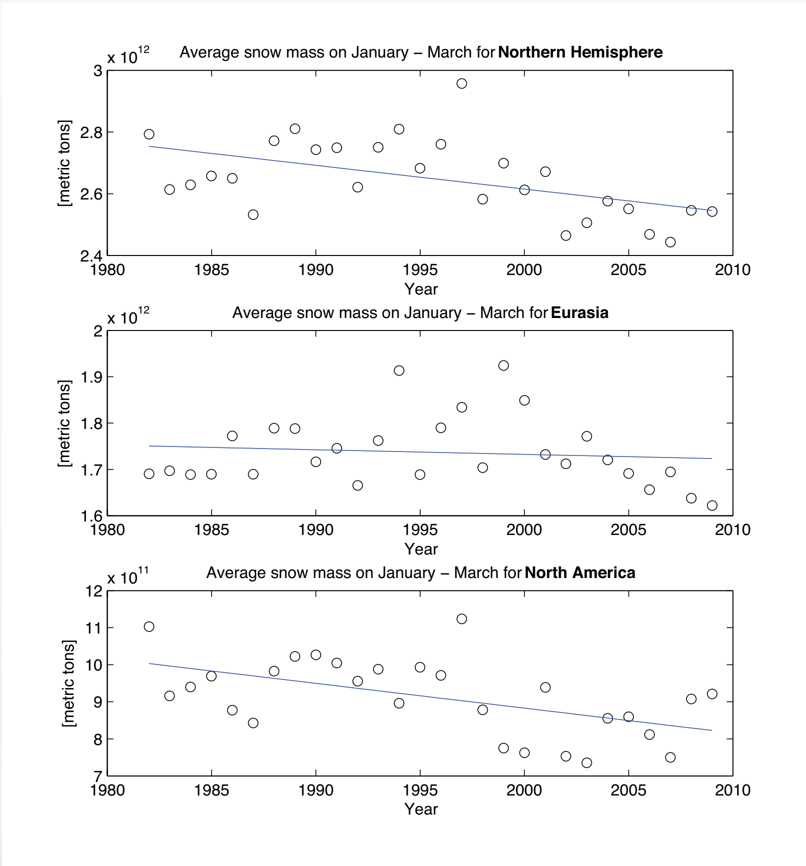

Figure 2: Average snow mass and trends for the winter period January-March 1982-2009 for the Northern Hemisphere, Eurasia and North America.

An evaluation of the released SWE data record was carried out using ground-based snow path data collected from the former Soviet Union and Russia extending from 1978 until 2000. The measurements, carried out at 1264 different snow path locations, range from 35° to 85° northern latitude and 14° to 179° eastern longitude and contain 424,600 samples. The evaluations compared the GlobSnow SWE record utilized a weekly aggregate SWE product (sliding window average) with the Russian snow path data. The results show very good agreement with the Russian data: the RMS error for SWE values ranging between 0–150 mm, for the years 1979–2000 (consisting of 178,554 samples) was 32.8 mm. The bias for the same dataset was +3.0 mm. Consideration of all the samples (all SWE values, consisting of 202,221 samples) showed a bias of -6.4 mm and RMS error of 46.7 mm (both values are a significant improvement over the previously available SWE records considering a hemispherical extent).

The 30-year GlobSnow SWE record was used to look at SWE trends within the Northern Hemisphere. The hemispherical average snow mass for March, when the typical SWE maximum is observed annually, showed a decreasing trend. For Eurasia the decreasing trend was very modest, but for North America it was pronounced.

As an example, the hemispherical average snow mass for March, when the typical SWE maximum is annually observed, is shown in Figure 1. The snow mass is shown for the Northern Hemisphere, Eurasia and North America separately. The average snow mass for the winter months of January, February and March is shown in Figure 2.

Examples of the monthly average SWE conditions are shown in Figure 3. Top panel shows the average SWE for March 1994 when the snow mass in Eurasia was significantly above average and the snow mass in North America significantly below average. Middle panel shows the average SWE for March 1997 when the highest SWE (of the 30 years SWE record) was retrieved across the Northern Hemisphere. Lower panel shows the average SWE for March 2000 when the lowest monthly SWE (of the 30 years SWE record) was retrieved across the Northern Hemisphere.

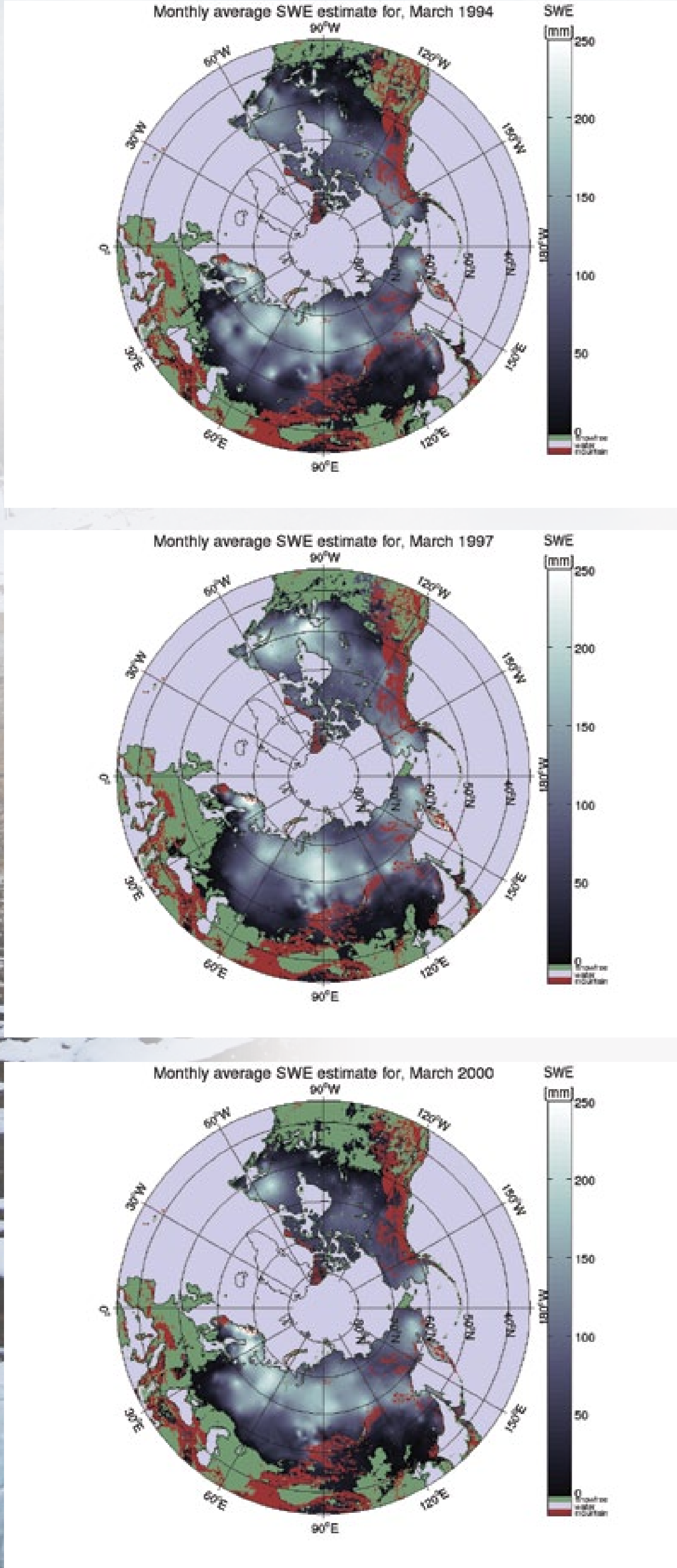

Figure 3: Monthly average of SWE estimate in the Northern Hemisphere for March 1994, 1997 and 2000.

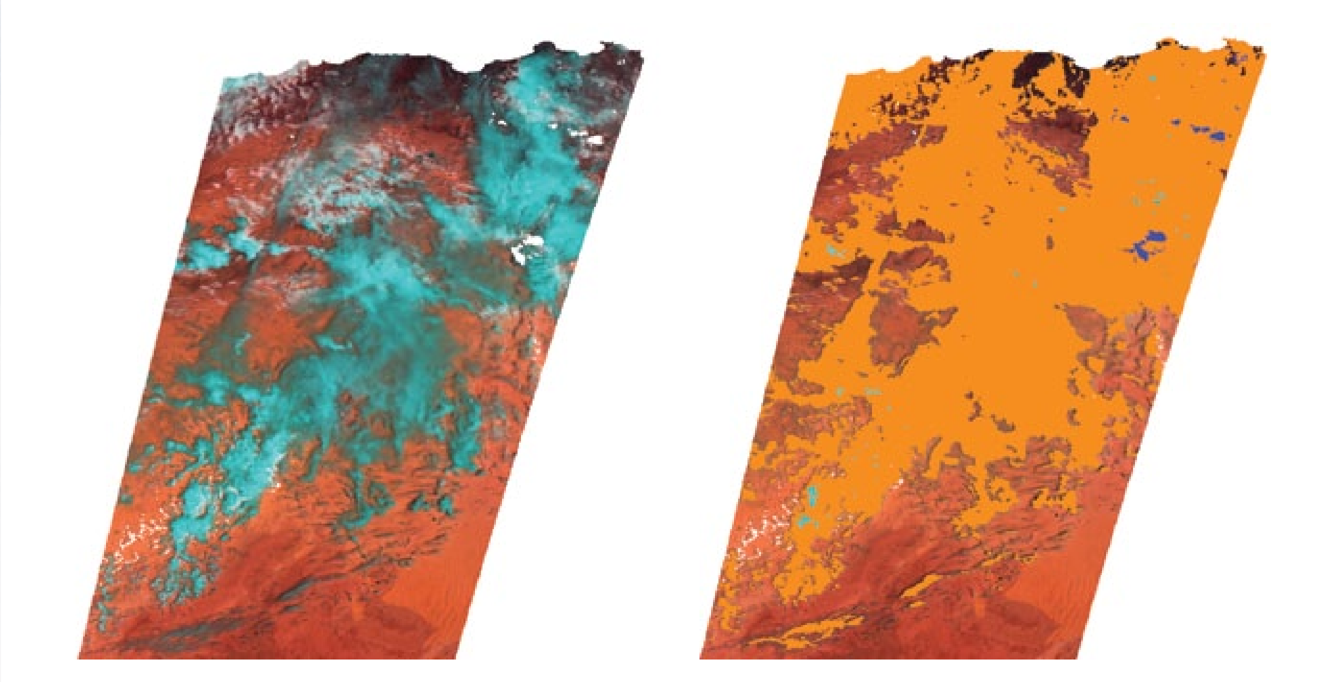

Figure 4: Evaluation of cloud masks retrieved by the SCDA algorithm. The left image shows an RGB colour composite based on AATSR bands at 1600, 670 and 550 nm for Algeria on 25 May 2003. The image on the right shows the SCDA cloud mask in orange put on top of the image at the left. The agreement is very good in general. However, a few cold cloud tops could not be detected (dots in cyan in the right image).

First evaluation results for GlobSnow Snow Extent Version 1.0 products

The GlobSnow Snow Extent (SE) Full Product Set (FPS) version 1.0 for the Northern Hemisphere is currently being produced on a Cray computer hosted by FMI, and the processing has been going on for many weeks. The 15 years data set represents information on snow cover retrieved from ERS-2, ATSR-2 and Envisat AATSR from 1995 until present.

A set of product samples from the FPS has recently undergone an evaluation study to better understand the quality of the products. The main focus of the study has been cloud-snow discrimination (a challenging task in general) and snow retrieval accuracy. The detection results from the cloud algorithm have been evaluated visually against colour composite AATSR images for selected sites globally. The snow information in the SE product was evaluated against National Snow and Ice Data Center (NSIDC) MODIS Fractional Snow Cover (FSC) maps and Landsat imagery.

The cloud algorithm

Cloud-snow discrimination has been one of the key foci of the SE work in GlobSnow phase 2. As an algorithm for accurate cloud detection over snow-covered surfaces could not be found, the project developed an own algorithm – the Simple Cloud Detection Algorithm (SCDA). The algorithm was improved through several iterations of experiments. Based on the visual evaluation of the cloud mask on a global domain with colour composite AATSR images as reference data, the main findings were:

- A dynamical threshold for the difference between the brightness temperatures in the 11 μm and the 3.7 μm channel is an effective way to identify cloud cover
- The algorithm does not completely detect cold, high cloud tops (see Figure 4)
- When a thermal band is saturated due to high ground temperatures, the use of the maximum possible digital value proved to be a good solution to reduce the areas which were not analysed previously due to such saturation
- In certain cases the algorithm detects clouds along the snow line, probably caused by mixed pixels.

Overall, the evaluation results reveal that SCDA provides a predominately reasonable cloud mask for most ground surfaces and is also suitable for an operational environment due to the low computational costs. The misbehaviour described above will cause some false detection only for small areas. If detecting high and cold cloud tops is given priority at a later stage, data from other sources could be used to determine whether there most likely is snow or not on the ground, e.g. surface temperature maps as provided by numerical weather models or satellite data.

The snow algorithms

The work on Fractional Snow Cover (FSC) evaluation has focussed on an inter-comparison of Glob-

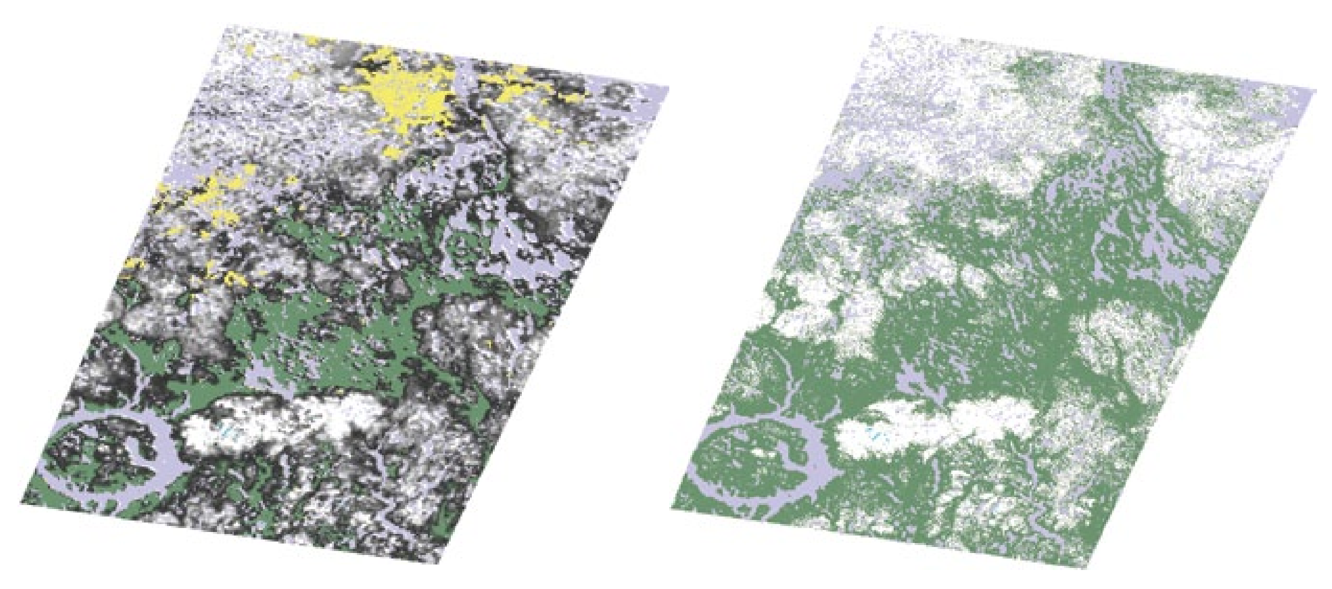

Figure 5: Comparison between GlobSnow fractional snow cover map (left) and a binary snow map derived from a Landsat 7 ETM+ scene for comparison (right). The area is in the north-east Canada, and images were acquired on 15 May 2003.

Snow SE and MODIS Fractional Snow Cover products for the northern hemisphere in order to identify systematic differences between the two products. Additionally, snow maps from high-resolution optical sensors (Landsat) were generated for different environments and climate zones in order to study the capabilities and limitations of the GlobSnow algorithms (see example in Figure 5).

The following main conclusions were drawn:

- The analysis of several statistical parameters, e.g. bias, root-mean-square difference, correlation coefficient and total snow coverage (in terms of pixels) of the inter-comparison of the two products showed good overall agreement and confirms the performance studies carried out for the pan-European domain at an earlier stage of the project
- During the mid winter the limitation of the GlobSnow algorithms to solar zenith angles above 72° limits the evaluation to lower latitudes
- During the summer it seems that the GlobSnow SE 1.0 product is overestimating the snow extent for mountains. When the ground-cover is bright, snow-free areas could be interpreted as partly snow covered
- When retrieving the fractional snow cover in the forest, a forest transmissivity map (a measure of how transparent the forest is seen from above) is used. Observations show that when coniferous forests are dense, the retrieved snow fraction is too low (see example in Figure 7)
- The concept of applying different algorithms in the product requires further improvement in the inter-calibration of the two algorithms, as in several areas a discrepancy in the calculated snow fraction along the boundary of the mountain mask is observed.

In summary, SE mapping at the northern hemispheric coverage was successful and demonstrated that maps of FSC can be retrieved at this scale (Figure 6). The correspondence between GlobSnow products and NSIDC MODIS snow maps as well as snow maps derived from Landsat 7 seems to be quite good in general.

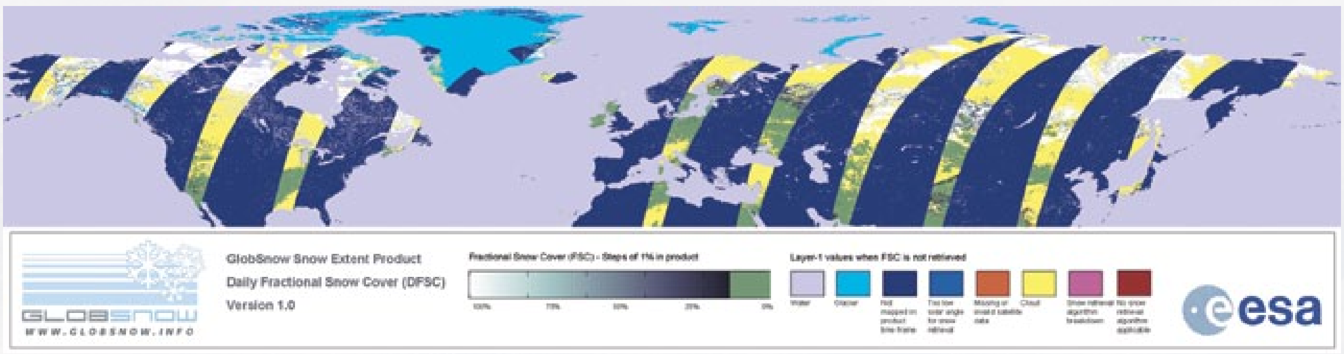

Figure 6: GlobSnow Fractional Snow Cover (FSC) product sample ('quick-look' image) based on all Envisat AATSR acquisitions in the Northern Hemisphere on 1 April 2007.

The combination of two algorithms for mountains and flat terrain shows some discrepancies and is recommended for further attention by the SE team.

Further work

As can be expected for such a first version of a hemispherical geophysical satellite product, there are certain issues that will need improvement. This will be the focus in upcoming new releases of the SE product followed by comprehensive evaluation of the upgraded products. Furthermore, it is recommended to:

- Study Fundamental Climate Data Record (FCDR) issues in the SE FPS, including inter-sensor stability for overlapping observations by Envisat AATSR and ATSR-2
- Develop an FSC uncertainty model and evaluate the performance under different conditions
- Work together with a few active key users to obtain information on their experience with the product. Deficits should be considered for further improvements.

Upgrades of the SE product will probably be done in at least two iterations during project phase 3 in order to obtain user experience with the products in parallel with further product improvements.

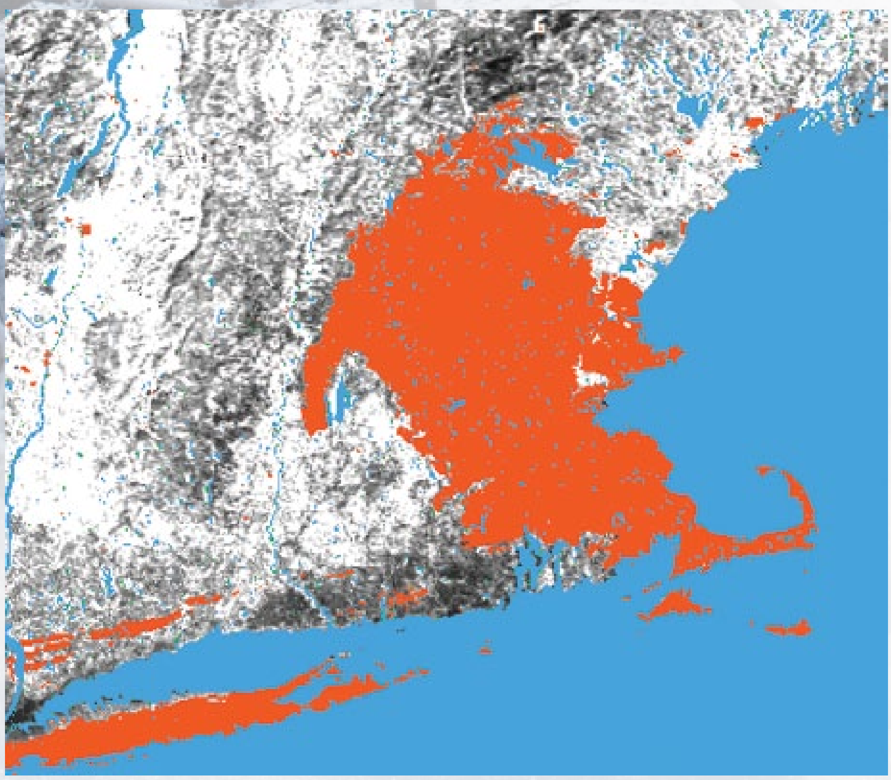

Figure 7: Examples of very dense forests in Canada creating problems with retrieval of the snow cover on the ground. The snow map is from 30 January 2003. The whole area is likely fully snow covered. Blue is open water, red is clouds.

esa FINNISH METEOROLOGICAL INSTITUTE

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

Finnish Meteorological Institute (FMI)
www.fmi.fi

ENVEO IT GmbH
www.enveo.at

Environment Canada (EC)
www.ec.gc.ca

Finnish Environment Institute (SYKE)
www.ymparisto.fi

GAMMA Remote Sensing AG
www.gamma-rs.ch

Norwegian Computing Center (NR)
www.nr.no

Co-operative partners

Northern Research Institute (Norut)
www.norut.no

Contact information

Prof. Jouni Pulliainen
Project Principal Investigator
Finnish Meteorological Institute
tel: +358 50 589 5821
email: jouni.pulliainen@fmi.fi

Dr. Kari Luojus
Project Manager
Finnish Meteorological Institute
tel: +358 40 505 8417
email: kari.luojus@fmi.fi

Dr. Bojan Bojkov
Project Technical Officer
European Space Agency
tel: +39 06 941 80543
email: bojan.bojkov@esa.int