ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

Evaluation and validation of the updated GlobSnow SWE product

Pinja Venäläinen[1], Kari Luojus[1], Juha Lemmetyinen [1], Jouni Pulliainen [1], Mikko Moisander [1], Matias Takala[1]

[1]Finnish Meteorological Institute, PO Box 503, FIN-00101 Helsinki, Finland.

Snow water equivalent (SWE) is an important property of the seasonal snow cover and estimates of SWE are required in many hydrological and climatological applications, including climate model evaluation and forecasting freshwater availability. Spaceborne microwave radiometer observations can be used for estimating SWE on global scale.

The GlobSnow SWE retrieval procedure uses microwave radiometer observations and synoptic snow depth observation for retrieving SWE. GlobSnow product version 3 (GS3) produces good SWE estimates when compared to other passive microwave based SWE retrievals. An updated GlobSnow SWE product (CCI2) has improved resolution of 12.5 km compared to the older product with 25 km resolution. Additionally, spatially and temporally varying snow densities are used to post-process the updated product.

Objectives

The objectives of this work are to validate the updated SWE product in Finland and compare the updated product (CCI2) and the older product (GS3).

Data

EO data

The SWE products use satellite passive microwave (PMW) data from the SMMR, SSM/I and SSMIS instruments on board NIMBUS-7 and the Defense Meteorological Satellite Program F-series satellites F8, F11, F13 and F17, respectively. The GS3 product uses PMW data in 25 km EASE-grid 1.0 and the CCI2 product utilizes recalibrated data in 12.5 km EASE-grid 2.0.

Additional synoptic weather station snow depth measurements are used in both products.

Validation data

Validation of the products is done using SWE measurements from snow transect in Finland, see location on figure 1 (left). Right side of the figure 1 illustrates different snow classes present in Finland (Sturm et al. 1995).

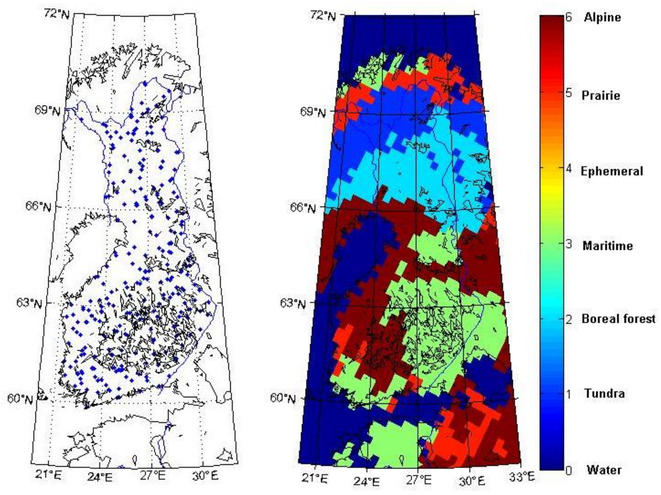

Figure 1. Locations of snow transects (left) and snow classification in Finland (right).

Methods

To validate the SWE products, the retrieved SWE values are co-located with snow transect SWE measurements and validation parameters are calculated. Validation is done for period of 1979-2018.

Validation parameter are root-mean-square error (RMSE), mean-absolute error (MAE), bias and correlation coefficient.

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(\widehat{x_i} - x_i)^2}$$

$$MAE = \frac{1}{N}\sum_{i=1}^{N}|\widehat{x_i} - x_i|$$

$$Bias = \frac{1}{N}\sum_{i=1}^{N}(\widehat{x_i} - x_i)$$

$$C = \frac{\sum_{i=1}^{N}(x_i - \tilde{x})\,(y_i - \tilde{y})}{\sqrt{\sum_{i=1}^{N}(x_i - \tilde{x})^2\,(y_i - \tilde{y})^2}}$$

Results and Discussion

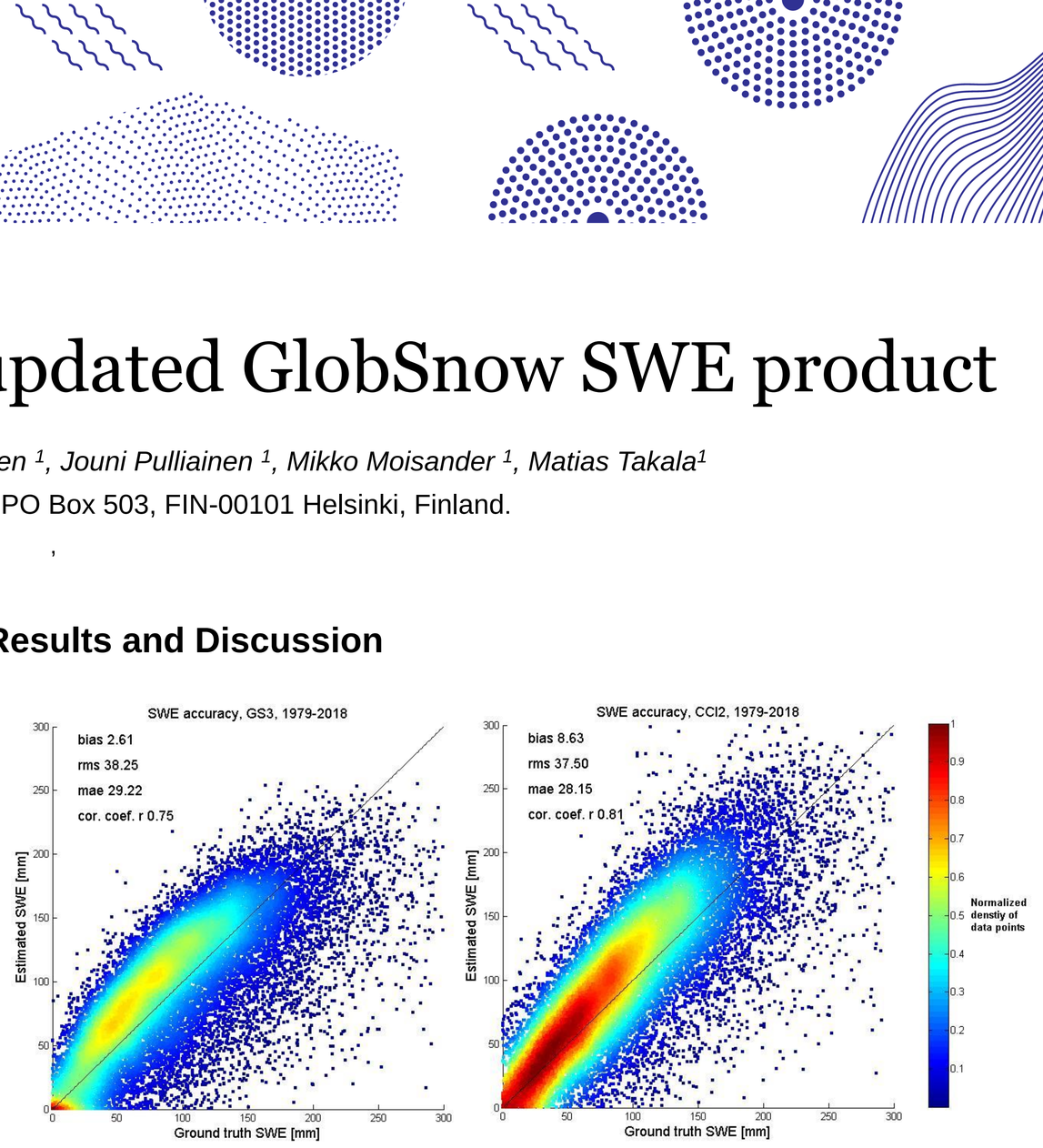

Figure 2. Density scatter plots of GS3 and CCI2 SWE products for 1979-2018.

The GS3 product overestimates small (early winter) SWE values and underestimates large (late winter) SWE values as seen in figures 2 and 3.

Figure 4 shows how December values are larger (overestimated) in GS3 product and smaller (underestimated) in March product than the CCI2 values.
The improved resolution of the CCI2 product is also visible in the figures.

The constant density used in the GS3 product tends to be too large in early winter and too small in late winter. Post-processing used in CCI2 product improves results.

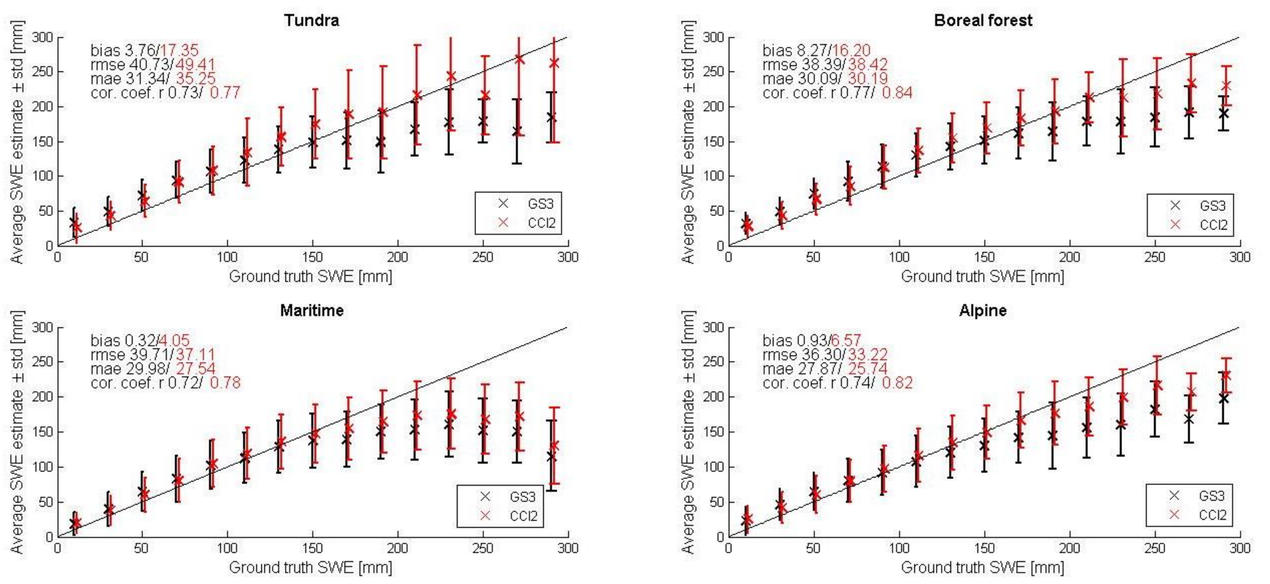

Figure 3. SWE accuracy with standard deviation for different snow classes for 1979-2018.

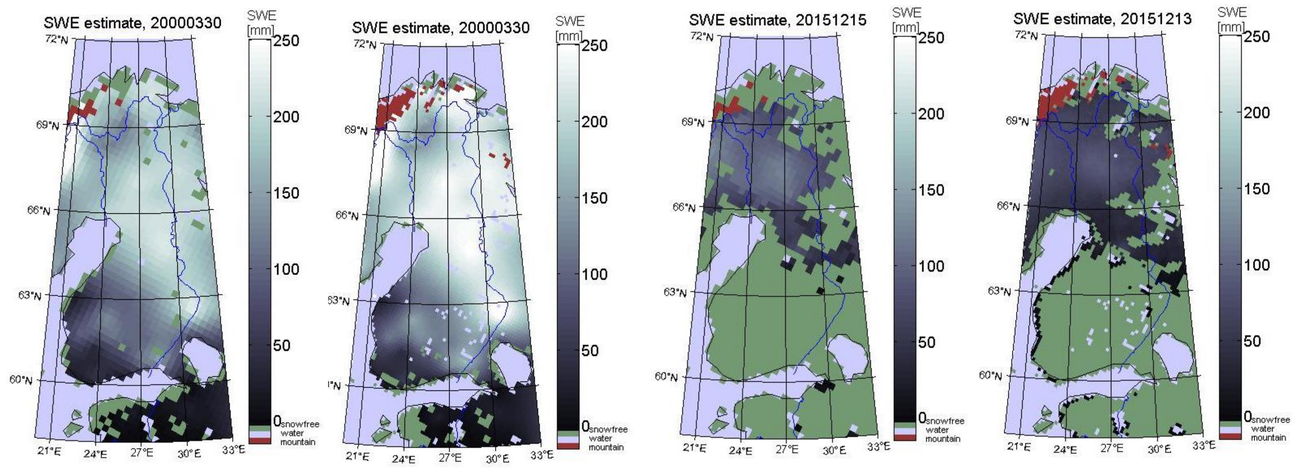

Figure 4. The GS3 (left) and CCI2 (right) products for 30 March 2000 and for 15 December 2015.

Conclusion

The updated SWE product produces better results than the older GS3 product. Post-processing with dynamic snow densities improves underestimation of large SWE values and overestimation of small SWE values. The RMSE and MAE are improved from 38.25 mm to 37.50 mm and from 29.22 mm to 28.15 mm, respectively. Improved resolution of the updated product is also visible.

References

Pulliainen, J., Luojus, K., Derksen, C., Mudryk, L., Lemmetyinen, J., Salminen, M., Ikonen, J., Takala, M., Cohen, J., Smolander, T., Norberg, J.: Patterns and trends of Northern Hemisphere snow mass from 1980 to 2018, Nature 581, 294–298, https://doi.org/10.1038/s41586-020-2258-0, 2020.

Luojus, K., Pulliainen, J., Takala, M., Lemmetyinen, J., Mortimer, C., Derksen, C., Mudryk, L., Moisander, M., Hiltunen, M., Smolander, T., Ikonen, J., Cohen, J., Salminen, M., Norberg, J., Veijola, K., Venäläinen, P.: GlobSnow v3.0 Northern Hemisphere snow water equivalent dataset, Sci Data, 8, https://doi.org/10.1038/s41597-021-00939-2, 2021.

Venäläinen, P., Luojus, K., Lemmetyinen, J., Pulliainen, J., Moisander, M., Takala, M.: Impact of dynamic snow density on GlobSnow snow water equivalent retrieval accuracy, Cryosphere, 15, https://doi.org/10.5194/tc-15-2969-2021, 2021.