Comparison of statistical downscaling methods of satellite-based snow water equivalent product

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Motivation and objectives

Motivation:

- Ground snow observation network is scarce and can not provide detailed information on regional variations of snow cover characteristics.
- Passive microwave satellite instruments can provide daily information on snow water equivalent (SWE), but application of these products on the regional scale is limited by the low spatial resolution (about 25 x 25 km).
- Daily snow water equivalent product is desired for hydrological applications.

Objectives:

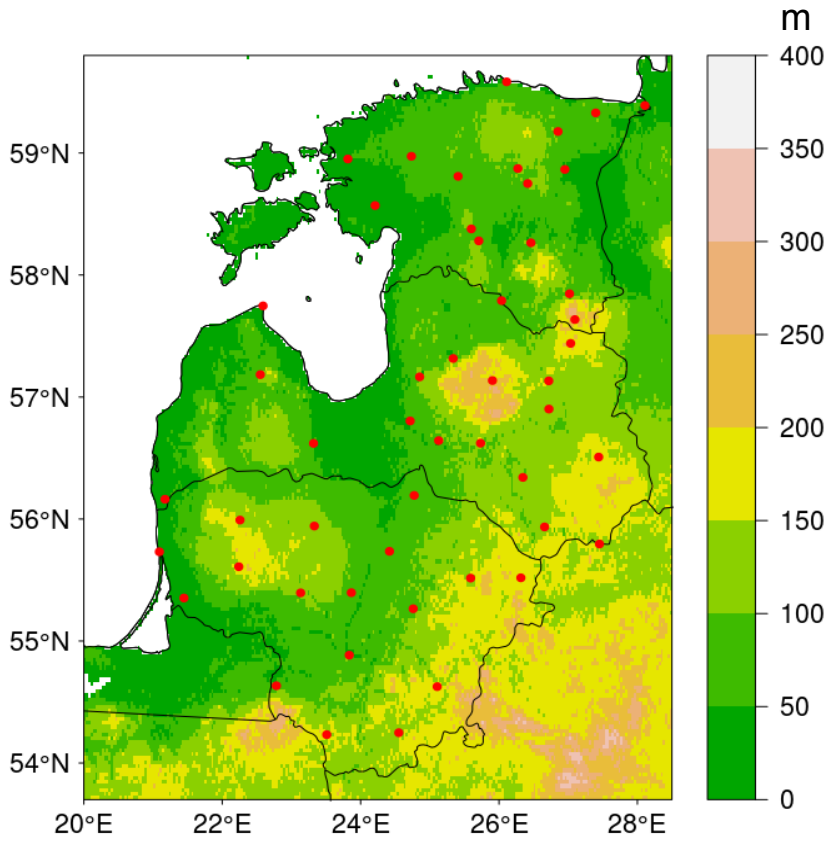
- Use statistical downscaling to produce 0.05 x 0.05° resolution SWE product.
- Asses accuracy of downscaled SWE product using insitu data.
- Compare different statistical methods (Multiple Linear Regression vs Artificial Neural Network).

Data

- Study period: October 2012 – April 2018.
- EUMETSAT Facility on Support to Operational Hydrology and Water Management (HSAF) SWE product based on AMSR-E, SSM/I and SSMIS radiometers (SN OBS 4 - H13).
- SRTM 90 m Digital Elevation Database v4.1 from CGIAR-CSI.
- MODIS Land Cover global mosaic 0.08° x 0.08° from Global Land Cover Facility (GLCF).
- Daily minimum temperature (Tmin), E-OBS 0.25° grided data, v17.0 (provided by ECA&D).

Insitu data and study region

- In situ SWE measurements were acquired from Lithuanian, Latvian and Estonian national meteorological service. Data from 51 meteorological stations.



Methodology (1)

- Downscaling was performed using two methods: multiple linear regression model (MLR) and artificial neural network (ANN).
- Elevation (DEM), land cover types, Tmin were used as predictors in MLR and ANN. SWE and elevation, Tmin were normalized using min/max values. Land cover categories were separated to binary variables (0-1).
- HSAF SWE was resampled from 0.25 x 0.25° to 0.05 x 0.05° grid. While land cover cover, DEM was aggregated to the same 0.05° x 0.05° grid and constituted a homogeneous database.
- Part of the dataset (~7 %) was left for validation, while most of the data was used to build the linear regression model and train the ANN.

Multiple linear regression model

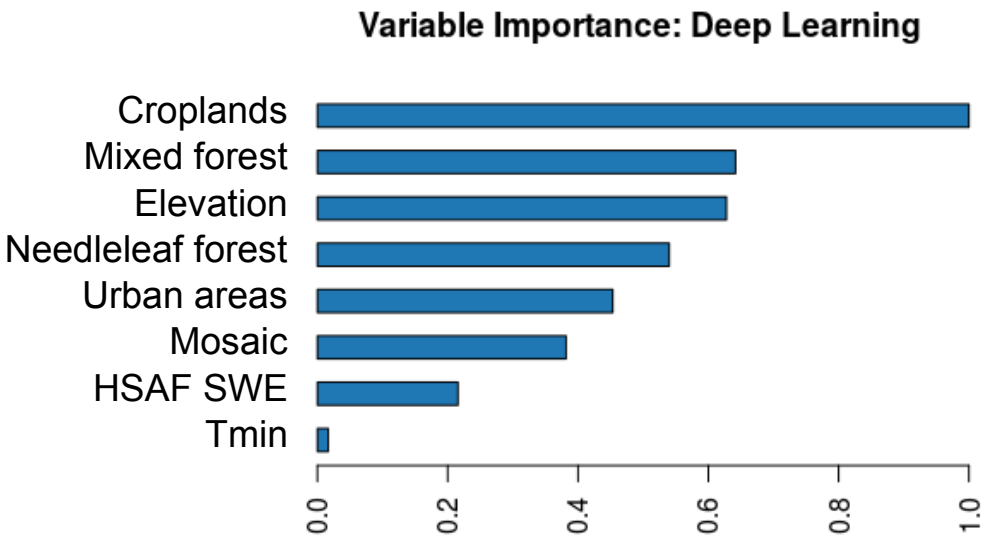
- Multiple regression model fitting was performed stepwise. The predictors that passed the significance test (p value < 0.05) were incorporated in the final model.
- *Water, Wetlands, Grasslands, Mosaic* land cover types and *Tmin* were dropped out as predictors.
- R-squared (R^2) = 0.89.

The variables which were used in MLR, rated by their t-statistic value

Predictor	t-value
HSAF SWE	< 2e-16
Elevation	4.16e-15
Mixed forest	0.000741
Croplands	0.003354
Urban areas	0.003738
Needleleaf forest	0.031935

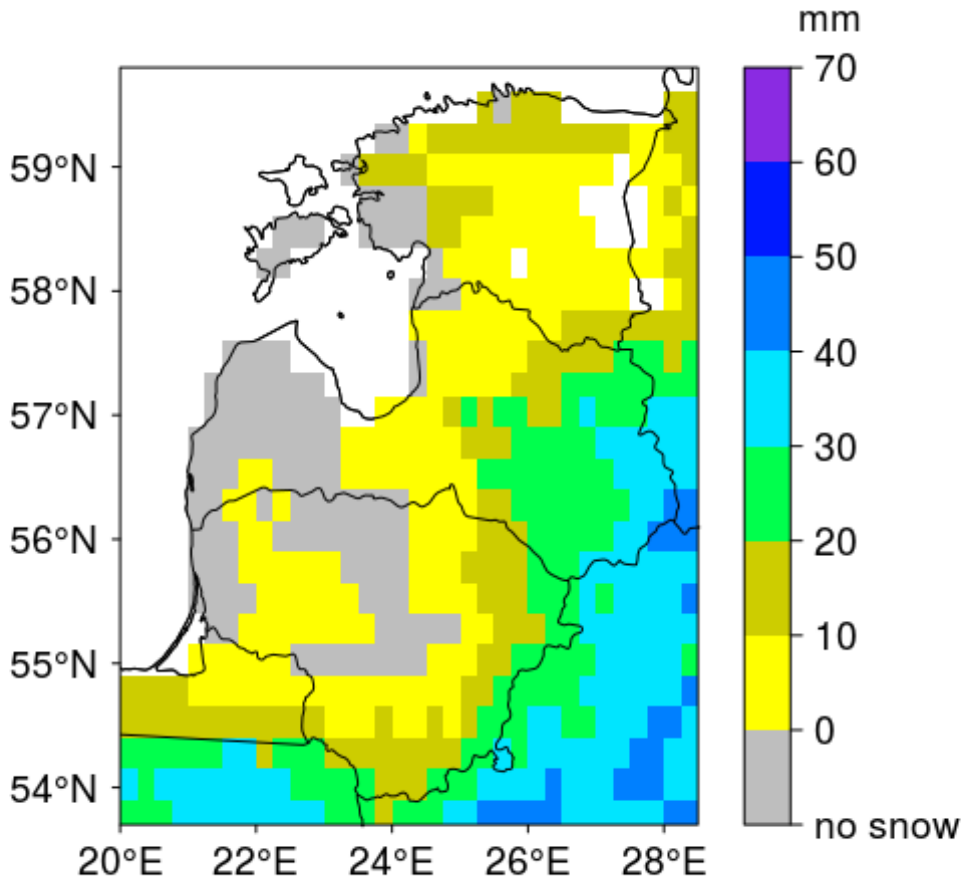
Artificial neural network training

- ANN consisted of the input layer, two hidden layers and one output layer. 12160 data pairs were used to train the ANN.
- ANN dropped *Water, Wetlands, Grasslands* land cover types as irrelevant.
- 500 epochs were choosen to avoid overfitting.



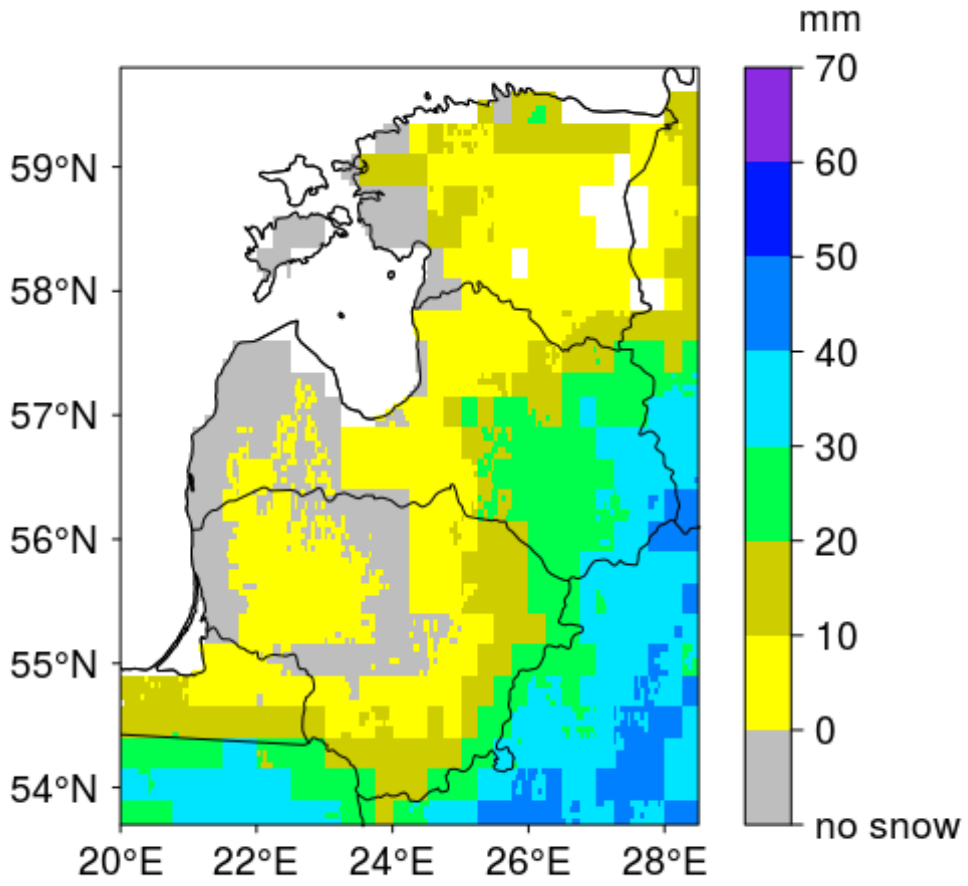
Original HSAF SWE product

SWE
10th February 2017



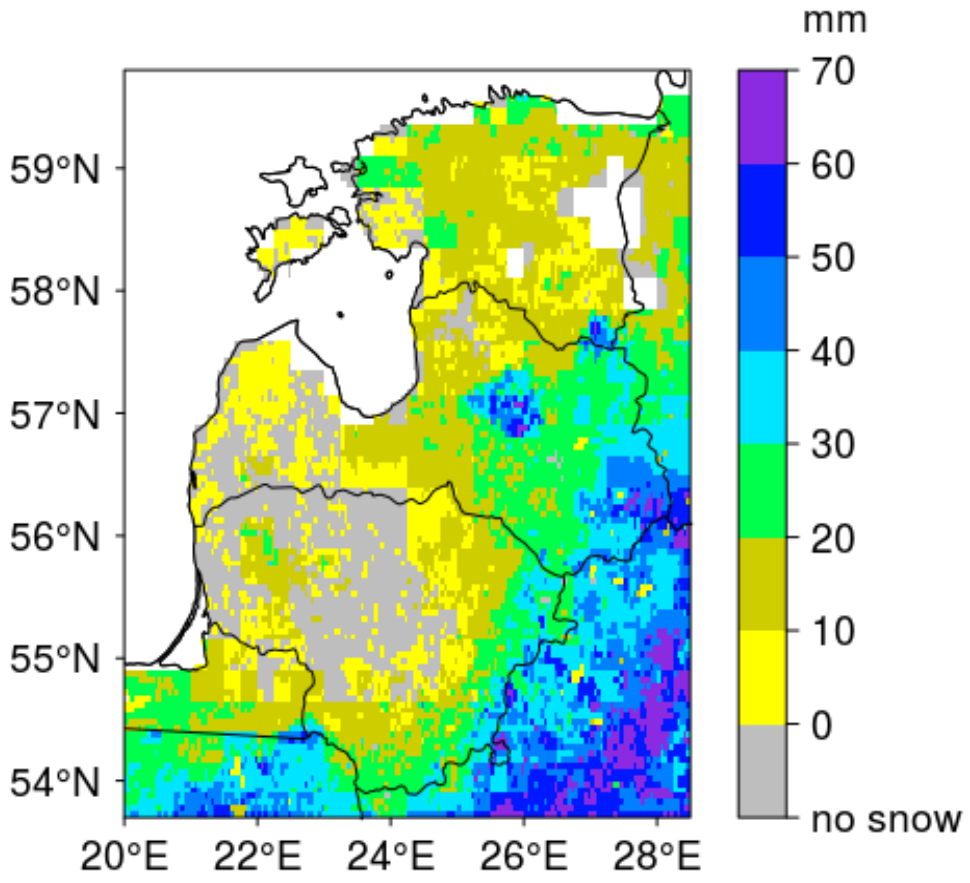
Downscaled with MLR

SWE
10th February 2017



Downscaled with ANN

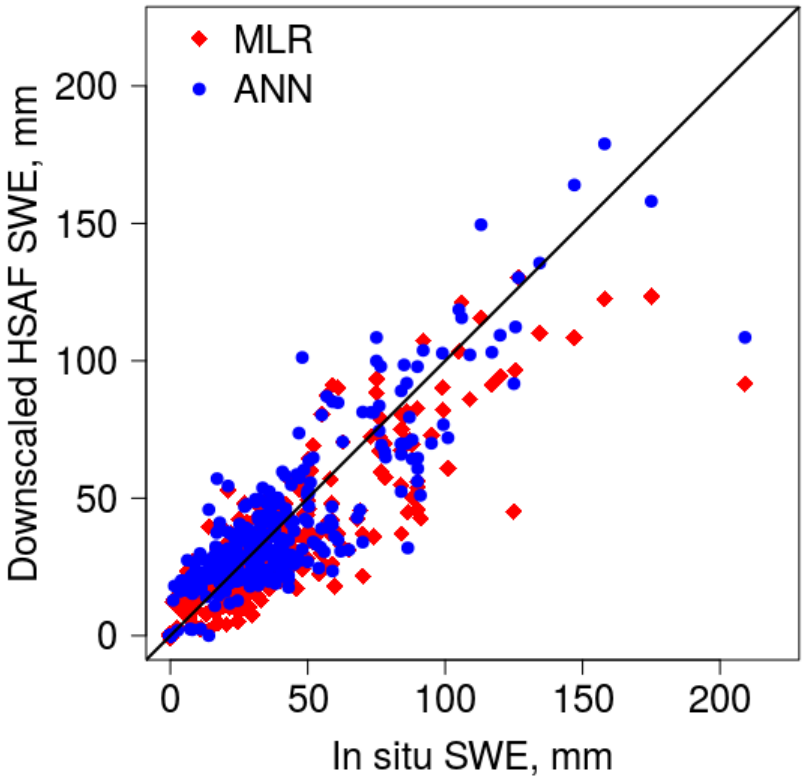
SWE
10th February 2017



Verification

Statistical Score	HSAF	MLR	ANN
Corelation	0.93	0.94	0.94
Bias	-0.94	-1.08	0.03
MAE	2.41	2.73	2.33
RMSE	7.81	7.79	7.04

- Verification is based on 2188 cases.



Conclusions

- This study showed that SWE data downscaled with ANN had higher overall accuracy compared to the MLR.
- The accuracy of downscaled SWE product is dependent on the quality of original HSAF product.
- The uncertainty for downscaled predictions is determined by the method adopted, and by the data available for training.

Thank you for your attention!

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