Estimation of summer sea ice concentration in the Chukchi Sea using AMSR2 observations and numerical weather prediction data

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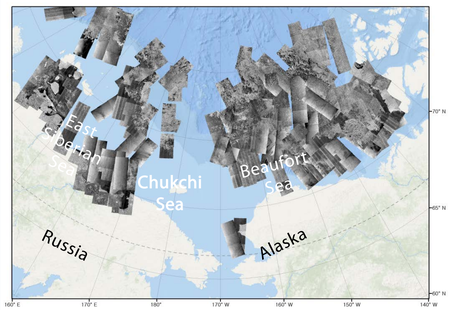
1. Introduction

Sea ice concentration (SIC) from passive microwave sensor such as Advanced Microwave Scanning Radiometer 2 (AMSR2) is the primary data for research of climate change. The AMSR2 SIC is typically inaccurate in Arctic summer due to similar microwave radiation characteristics of sea ice and open water, which is attributed to the effects of atmosphere and ice surface condition on the AMSR2 observations (Han and Kim, 2018). The aim of the present work is to develop superior summer SIC estimation models for the Chukchi Sea in Arctic Ocean by considering atmospheric effects on the AMSR2 observations based on machine learning approaches (Decision Tree (DT), Random Forest (RF), Multi Layer Perceptron (MLP), and Convolutional Neural Network (CNN)).

2. Materials

Study area and Data



KOMPSAT-5 SAR wide swath images
- 339 images obtained in summer (Jul. ~ Sep.) from 2015 to 2017
- Used to compute SIC (training and test data for SIC estimation models)

AMSR2 & ERA-Interim reanalysis data
- AMSR2 brightness temperature (TB)
- ERA-Interim Atmospheric parameters
- Used as input variables for SIC estimation models

Fig. 1. Examples of KOMPSAT-5 SAR images obtained for the study area (a mosaic of the images in Aug. 2017).

Method

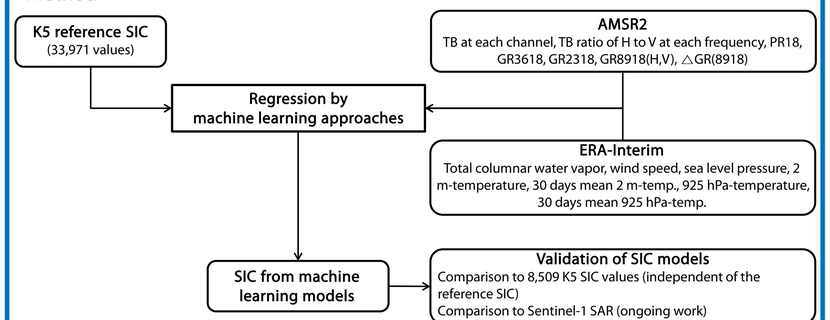
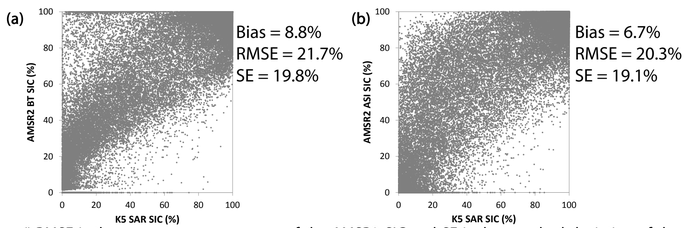


Fig. 2. Flowchart of summer SIC estimation using AMSR2 observations and ERA-Interim reanalysis based on machine learning.

3. Results



* RMSE is the root mean square error of the AMSR2 SIC and SE is the standard deviation of the AMSR2 SIC error, respectively.

Fig. 3. Comparison of K5 SAR SIC with AMSR2 SIC from (a) Bootstrap (BT) and (b) ARTIST Sea Ice (ASI) algorithms in summer in the Chukchi Sea

- BT and ASI SIC show very large RMSE and SE, possibly due to the effects of atmospheric conditions and melt ponds on the AMSR2 TB observations.

- SIC estimation models based on DT, RF, MLP, and CNN were developed using 33,971 samples.
- The models were validated by 8,509 samples that are independent of the training samples.
- All models show lower bias, RMSE and SE than the BT and ASI algorithms.

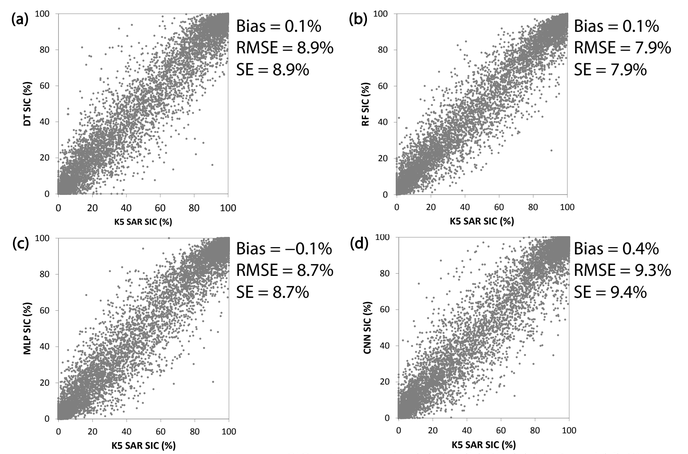


Fig. 4. Validation results of summer SIC estimation by (a) DT, (b) RF, (c) MLP, and (d) CNN.

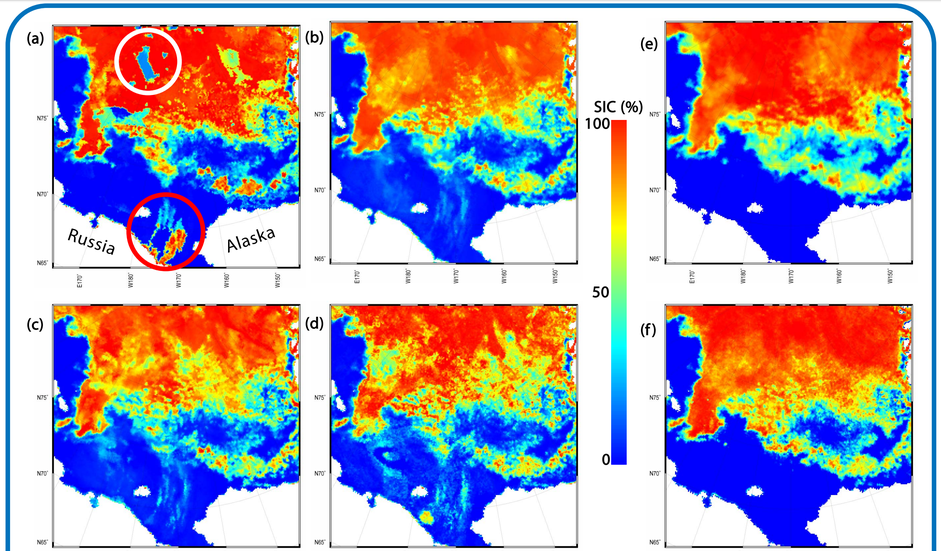


Fig. 5. SIC on 6 August 2015 in the Chukchi Sea estimated by (a) DT, (b) RF, (c) MLP, (d) CNN, (e) BT, and (f) ASI algorithms.

- The DT model is erroneous in the high latitude region (white circle in (a)) owing to simple rule-based learning.
- The RF model shows similar results to the BT and ASI algorithms.
- The MLP and CNN models produced a spatially homogeneous SIC at high latitude region.
- All models detect sea ice in areas where there is defined as open water by the BT and ASI algorithms (red circle in (a)). Such areas are investigating by using Sentinel-1 SAR images.

4. Summary and Ongoing work

- The summer SIC estimation models for the Chukchi Sea were developed using AMSR2 and ERA-Interim reanalysis data based on machine learning approaches.
- The models showed smaller error than BT and ASI algorithms compared to KOMPSATS-5 SAR SIC, but they could be over-fitted.
- The SIC from the machine learning models is validating through Sentinel-1 SAR images obtained at different times and areas from KOMPSAT-5 SAR.

5. References

- Han, H., Hong, S.-H., Kim, H.-c., Chae, T.-B., and Choi, H.-J. (2017). A study of the feasibility of using KOMPSAT-5 SAR data to map sea ice in the Chukchi Sea in late summer. *Remote Sensing Letters*, 8 (5), 468–477.
- Han, H. and Kim, H.-c. (2018). Evaluation of summer passive microwave sea ice concentrations in the Chukchi Sea based on KOMPSAT-5 SAR and numerical weather prediction data. *Remote Sensing of Environment*, 209, 343–362.

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