Arctic Sea Ice Mapping Using KOMPSAT-5 Enhanced Wide Swath SAR Images

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Outline

I. Introduction

II. Study area and data

III. Sea ice mapping technique

IV. Results

V. Conclusion

Introduction

- **Importance of Arctic sea ice**
  - **Strong indicator of global climate change**
  - **Important for biological habitats**
    - **arctic mammals (seals, polar bears) hunt, breed, and feed on the ice**
  - **Important for human activities**
    - **Shipping, exploration of resources, development of North Pole Route**

High-resolution & Accurate mapping of Arctic sea ice

Introduction

- **Remote sensing for sea ice mapping**
  - **Aerial photography**
    - **accurate detection by very high resolution images**
    - **limited by local weather conditions**
  - **Satellite optic sensors**
    - **reasonable detection over very wide area**
    - **limited by weather conditions and sun altitudes**
    - **not enough to observe small scale ice, especially in melting peak season**

Introduction

- **Remote sensing for sea ice mapping**
  - **Synthetic Aperture Radar (SAR)**
    - **all weather, day and night imaging**
    - **melt onset/freeze onset, sea ice characteristics**
    - **can detect small scale ice by present-day X-band SAR systems**

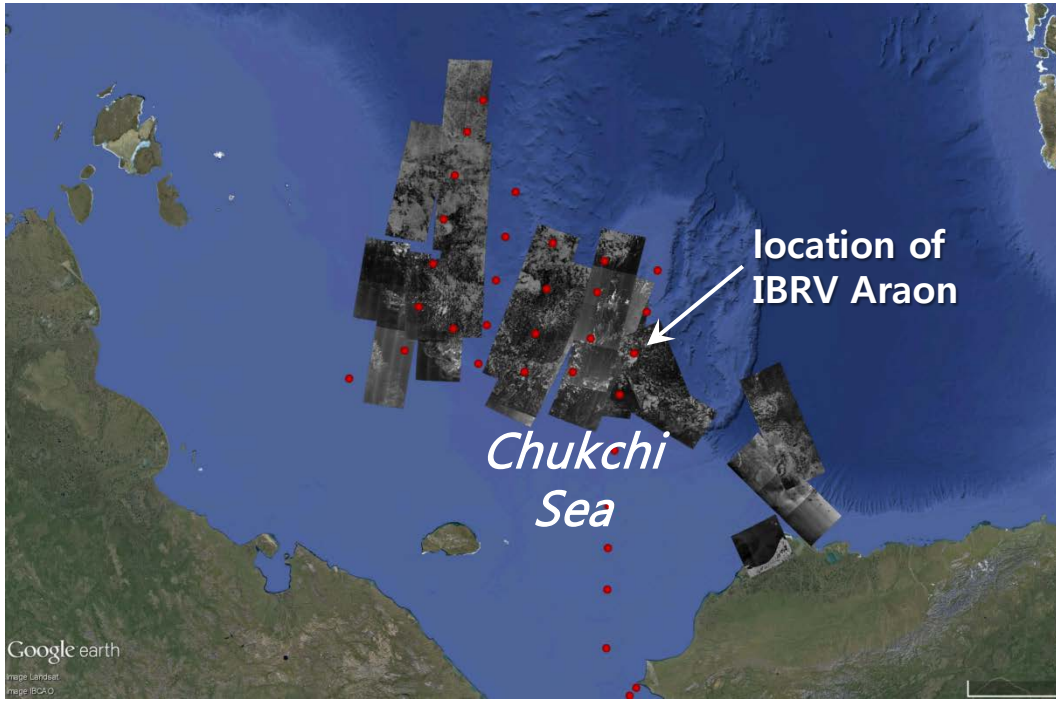
Objectives

- **To develop sea ice mapping model based on KOMPSAT-5 Enhanced Wide Swath (EW) SAR images and machine learning approach**

- **To evaluate passive microwave sea ice concentration in melting peak season**

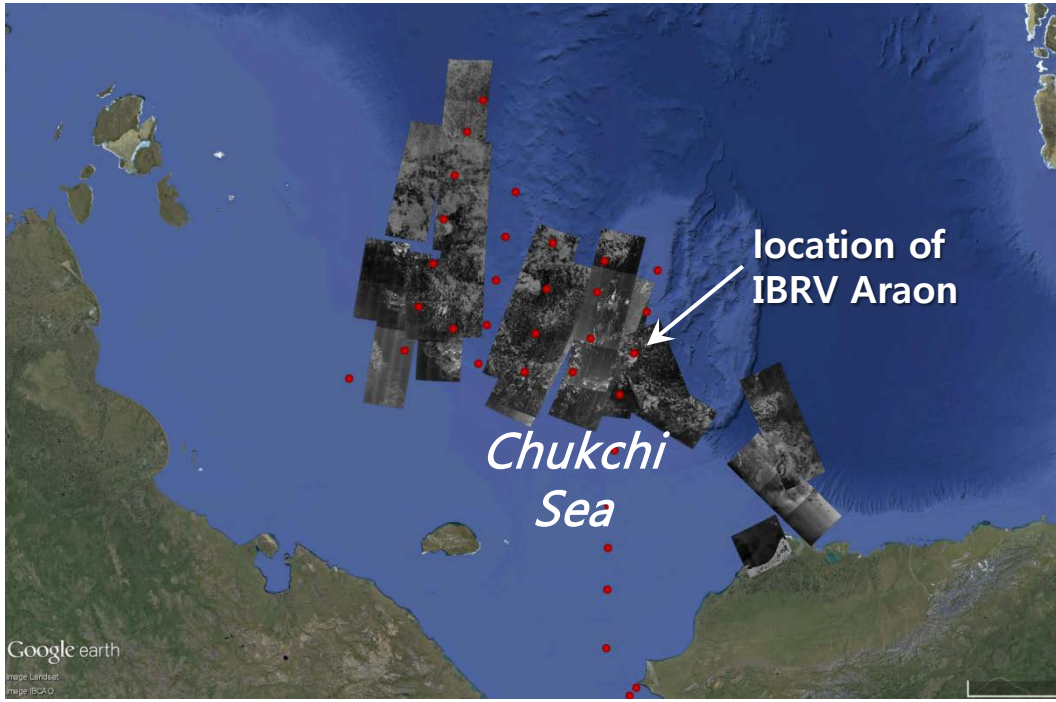
Study area

- **Chukchi Sea**
  - **Araon expedition in 2015**
  - **Marginal ice zone**
  - **Some section of MYI**
  - **Sea ice with numerous ponds and leads**



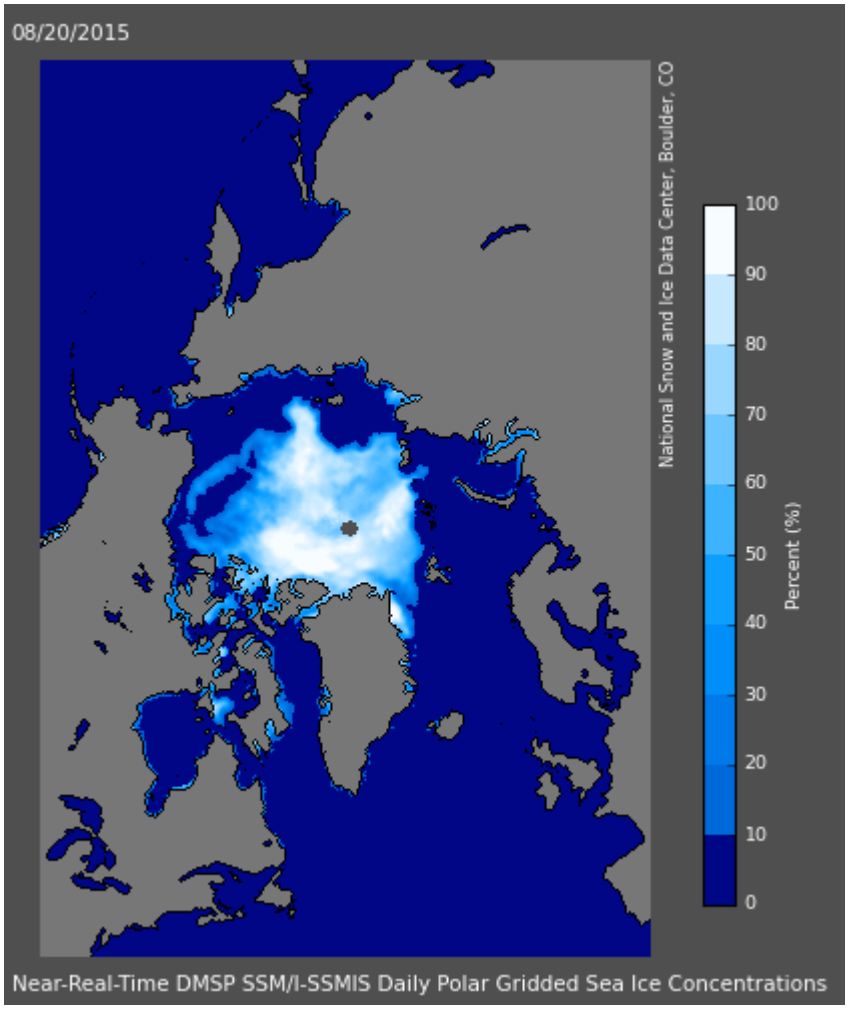
Data

- **KOMPSAT-5 SAR data**
  - **6 Aug.~9 Sep. 2015**
  - **84 Enhanced wide swath images (100 × 100 km)**
  - **HH-polarization, 6.25 m-grid spacing**
    - **1-look, GEC products**
  - **Ascending/descending orbits**
  - **Various radar look angle**
    - **17~49° by tilting radar look**

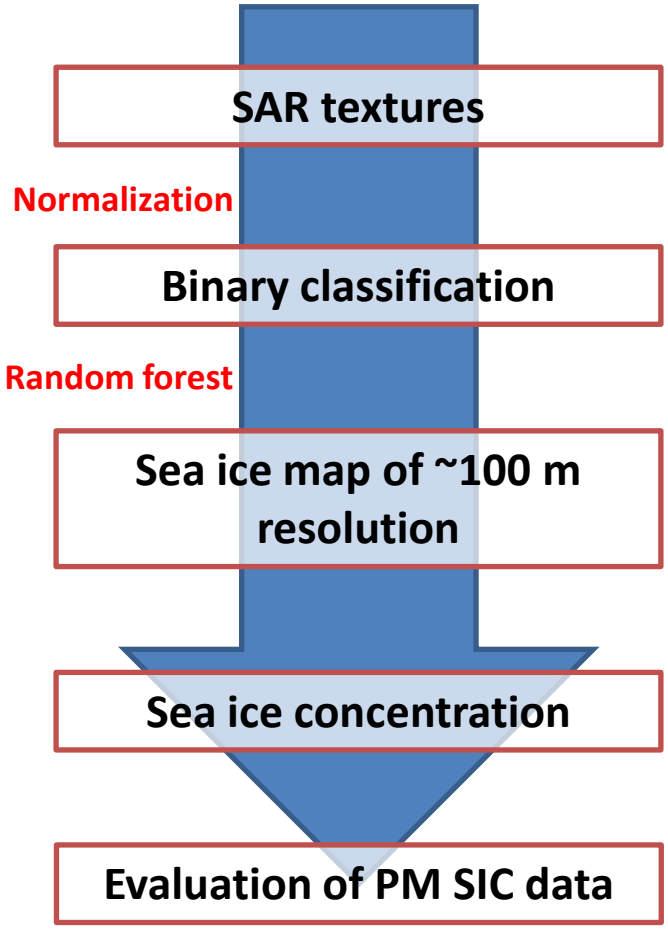


Data

- **SSMIS sea ice concentration**
  - **6 Aug.~9 Sep. 2015**
  - **NASA Team algorithm**
  - **Using 19V, 19H, 37V**
  - **25 km grid**



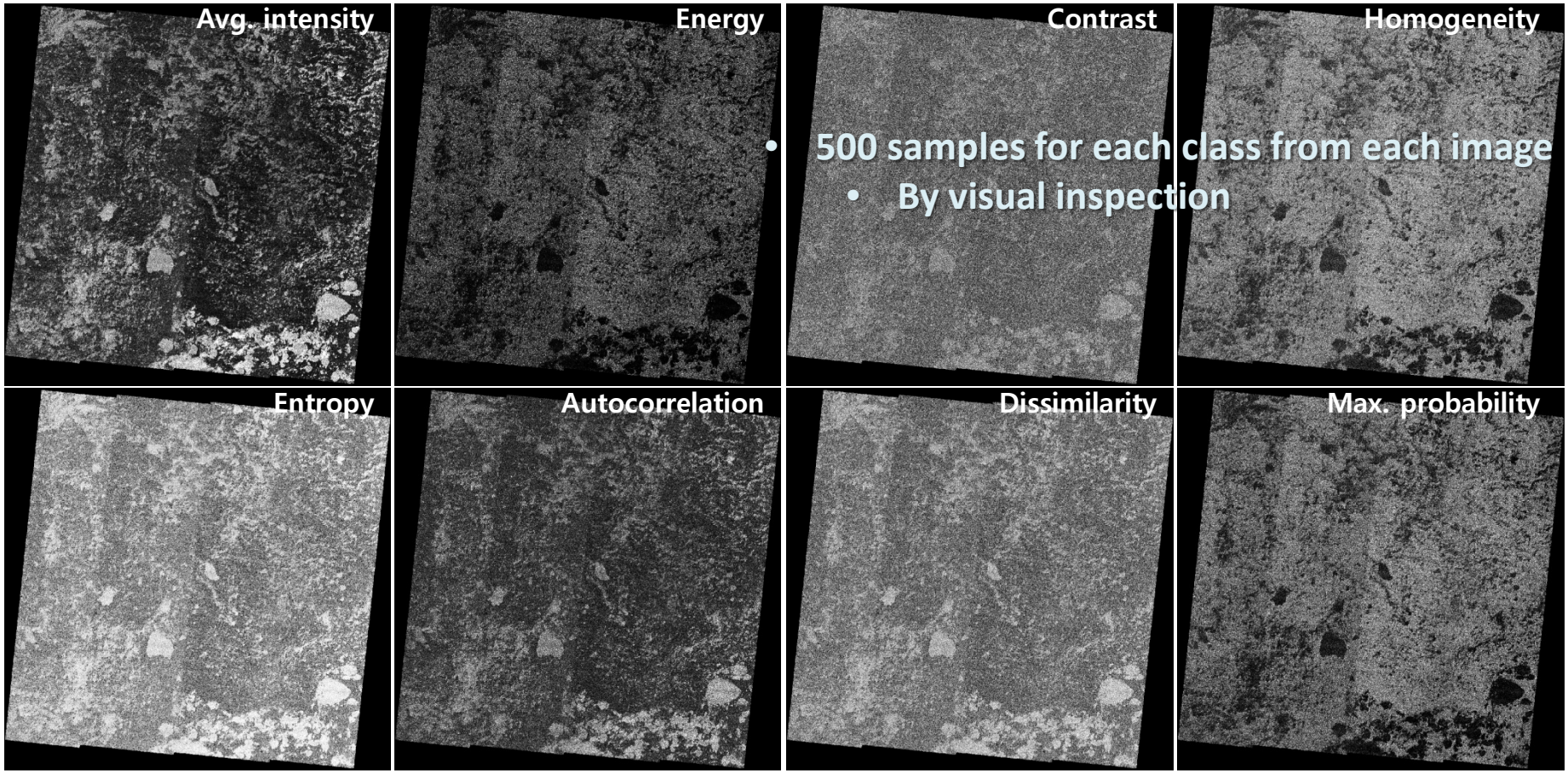
Sea Ice/Open Water Mapping process



- Intensity statistics and GLCM textures within a pixel window
  - Normalizing in each image

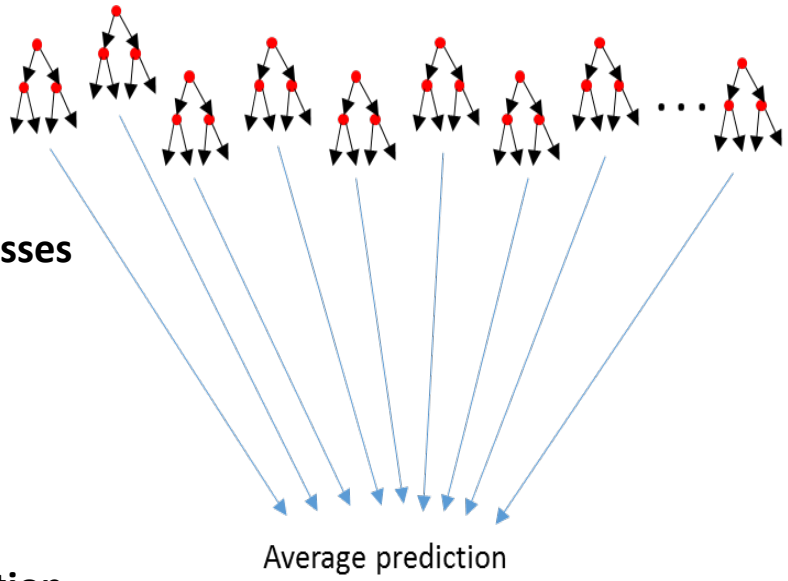
Example of textures from KOMPSAT-5 EW SAR

- 2×2 block averaging (12.5 m)
- texture calculation on 8×8 window (100 m)



Binary classification

- **Random forest**
  - **A rule-based machine learning approach**
  - **constructing a multitude of decision trees**
  - **outputting the class that is the mode of the classes of the individual trees**
  - **correct for decision trees' habit of overfitting**



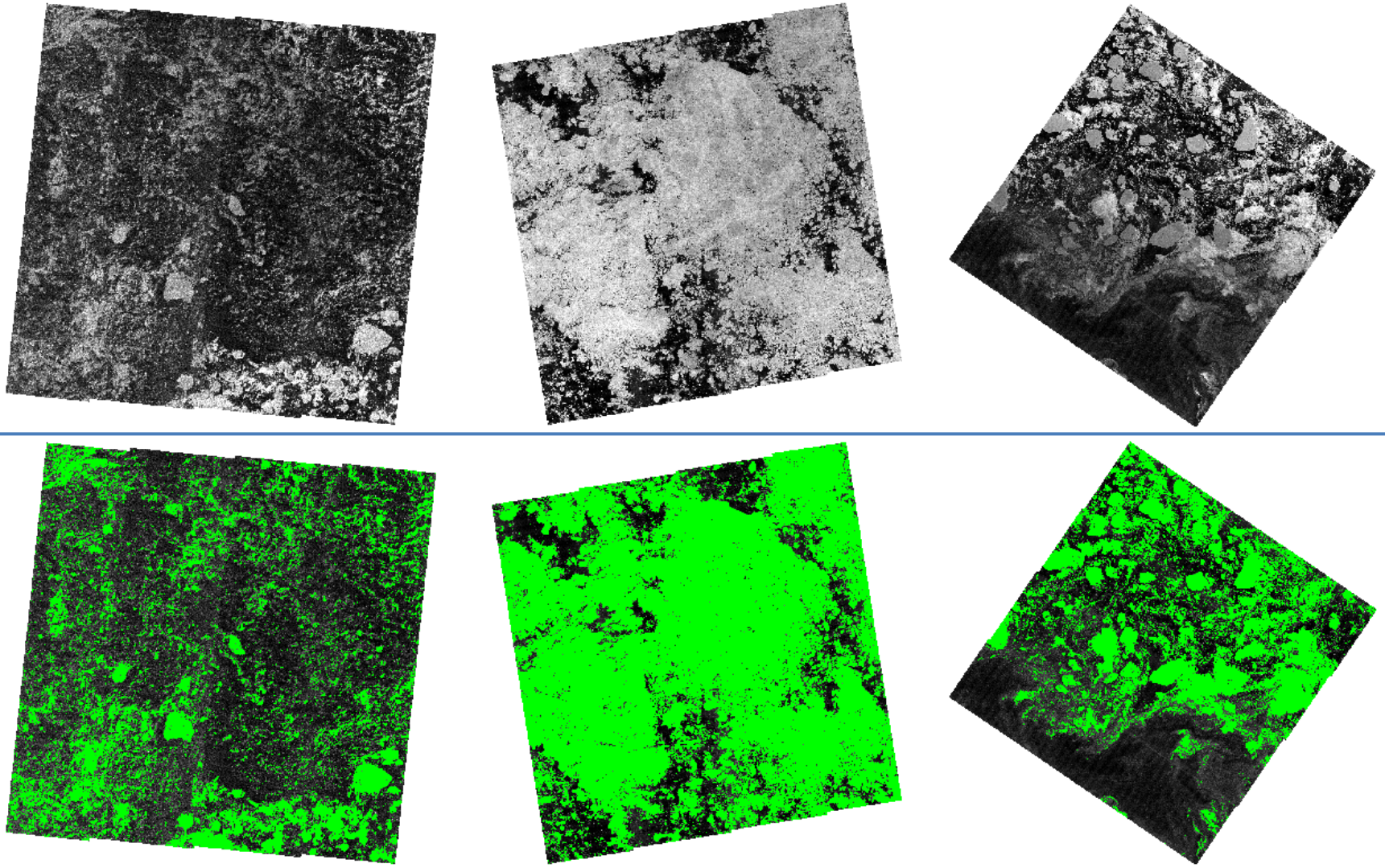
  - **Samples used for sea ice/open water classification**
    - **70% for training model (58798 samples)**
    - **30% for validation (25202 samples)**

Model performance

- ***High performance*** **for sea ice/open water mapping based on KOMPSAT-5 EW SAR and machine learning approach**

Reference / Classified as	Open Water	Sea Ice	Sum	User's Accuracy
Open Water	12568	152	12720	98.81%
Sea Ice	33	12449	12482	99.74%
Sum	12601	12601	25202	
Producer's Accuracy	99.74%	98.79%		
Overall Accuracy	99.27%			
Kappa Coefficient	98.53%			

Examples of KOMPSAT-5 EW SAR sea ice map



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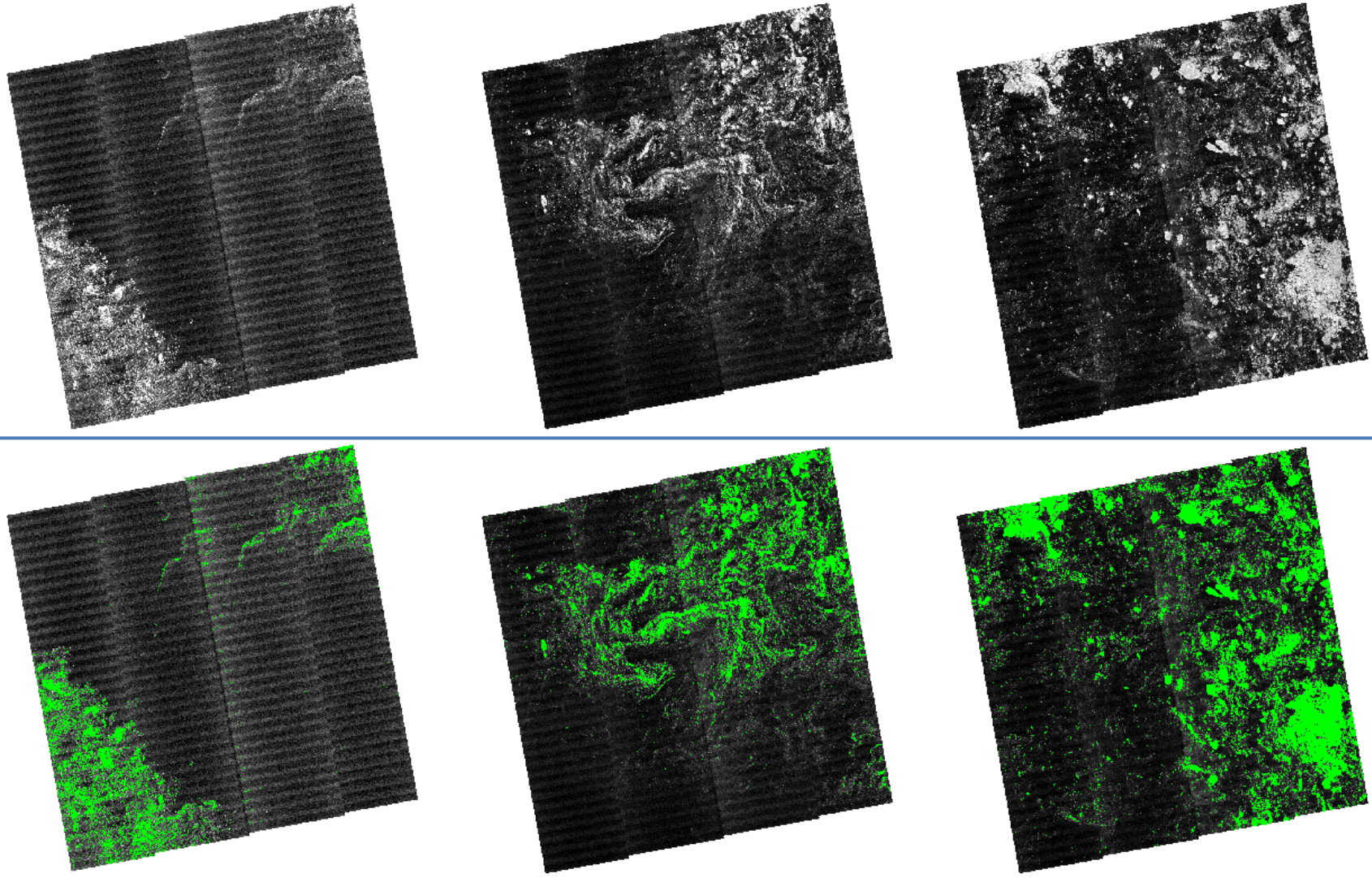


Comparison of SICs

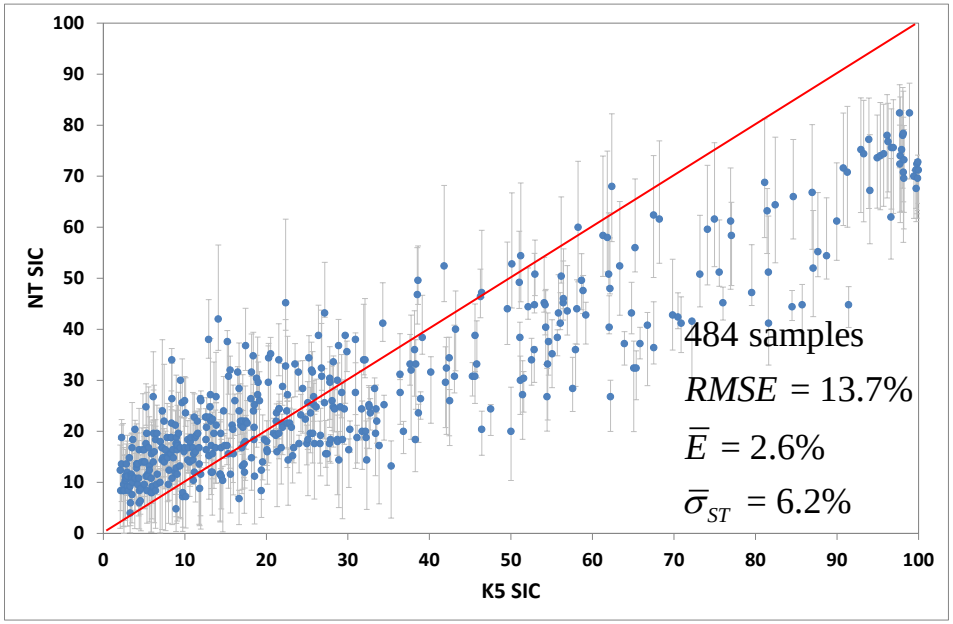
- **Time difference between KOMPSAT-5 and SSMIS data**
  - **SSMIS NT SIC – 24-hour composite**
  - **Sea ice can move fast in summer season (MIZ)**
  - **Cannot compare KOMPSAT-5 SIC with SSMIS NT SIC**

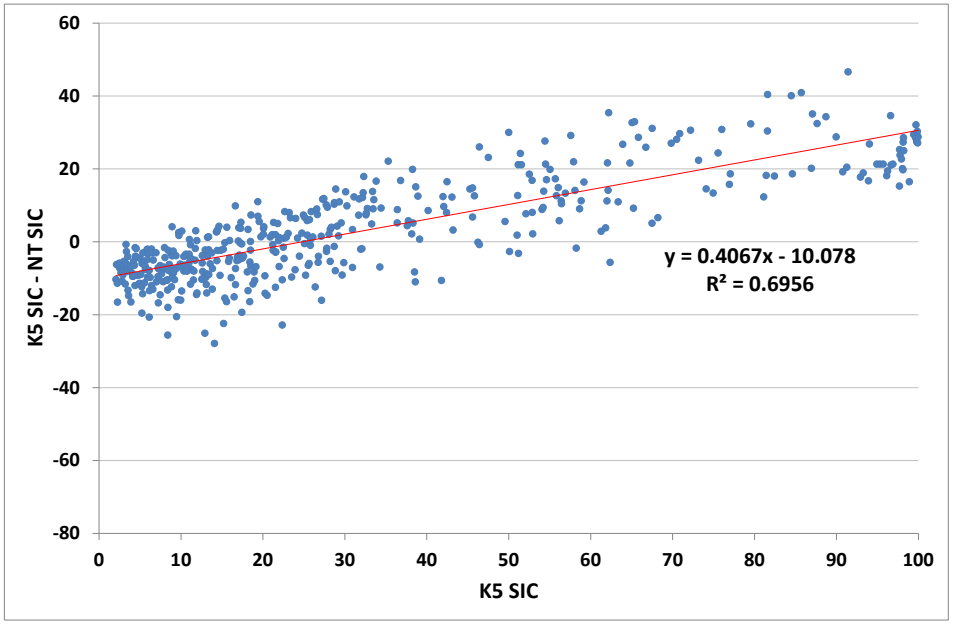
- **Spatiotemporal mean and standard deviation of PM SICs** **(Lee and Han, 2008)**

$$\overline{S}_{\mathrm{ST}} = \frac{1}{27}\sum_{i=1}^{3}\sum_{j=1}^{3}\sum_{k=1}^{3}\mathrm{SIC}_{ijk}$$

$$\sigma_{\mathrm{ST}}^{2} = \frac{1}{27}\sum_{i=1}^{3}\sum_{j=1}^{3}\sum_{k=1}^{3}(\mathrm{SIC}_{ijk} - \overline{S}_{\mathrm{ST}})^{2}$$

KOMPSAT-5 SIC vs. SSMIS NT SIC





- **SSMIS NT SICs are overestimated in MIZ, but underestimated in MYI**
- **Inaccuracy in SSMIS NT SIC increases as real SIC increases (due to melt pond?)**

Conclusion

- **Sea ice and open water in Arctic summer season were successfully classified from KOMPSAT-5 EW SAR images using SAR textures and RF approach.**
  - **High-resolution (100 m) sea ice maps**
- **SSMIS sea ice concentration in summer was evaluated using KOMSAT-5 sea ice maps.**
  - **Positive bias for MIZ, negative bias for MYI**
- **All the operational sea ice concentration algorithm will be evaluated using the KOMPSAT-5 sea ice maps.**
  - **Find out error sources**

Thank you for your listening