Maintenance and improvement of sea ice concentration algorithm and thin ice area extraction algorithm for AMSR2

GCOM-W Session
Joint PI Meeting of
JAXA Earth Observation Missions

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1. Outline

(1) Sea ice concentration (IC) accuracy evaluation.

(2) Weather effect evaluation in AMSR2 IC and parameter modification proposal.

(3) **Thin ice area extraction algorithm** validation.

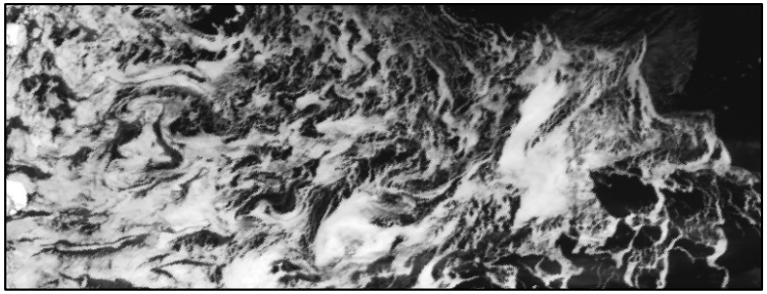
(4) **Thin ice area extraction algorithm using MODIS**

(5)The **sea ice tank experiment** result

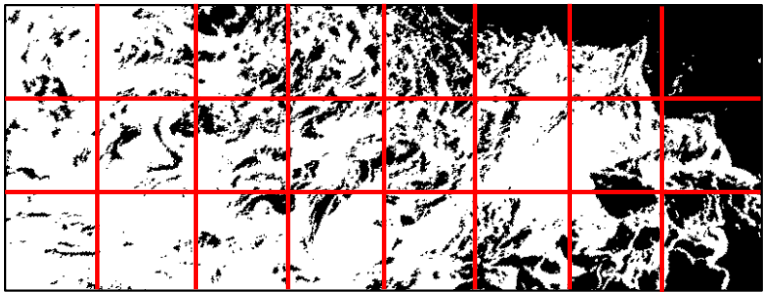
2. IC accuracy validation using MODIS data

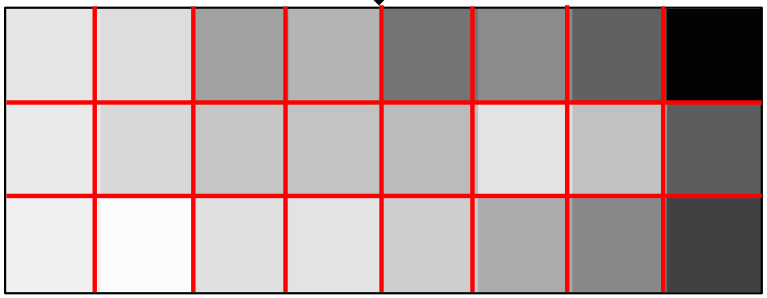
(1) Method(Original)

MODIS image（IFOV：250m）

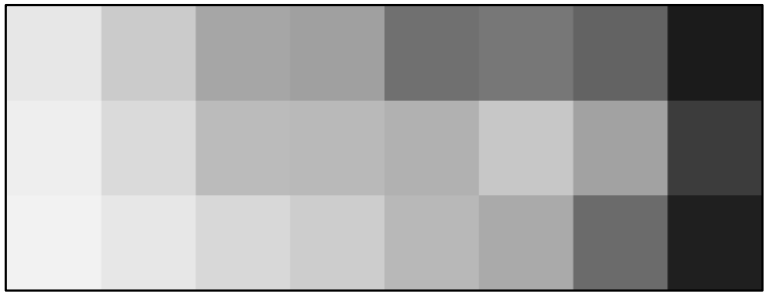


binarize

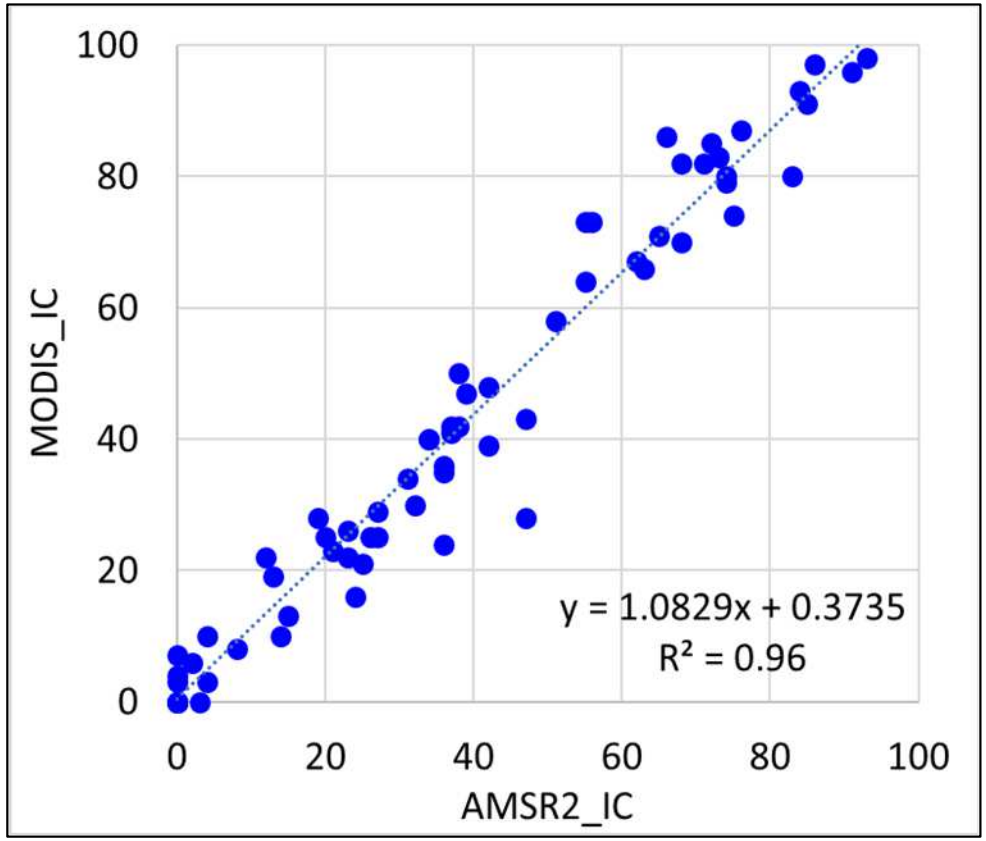




Comparison

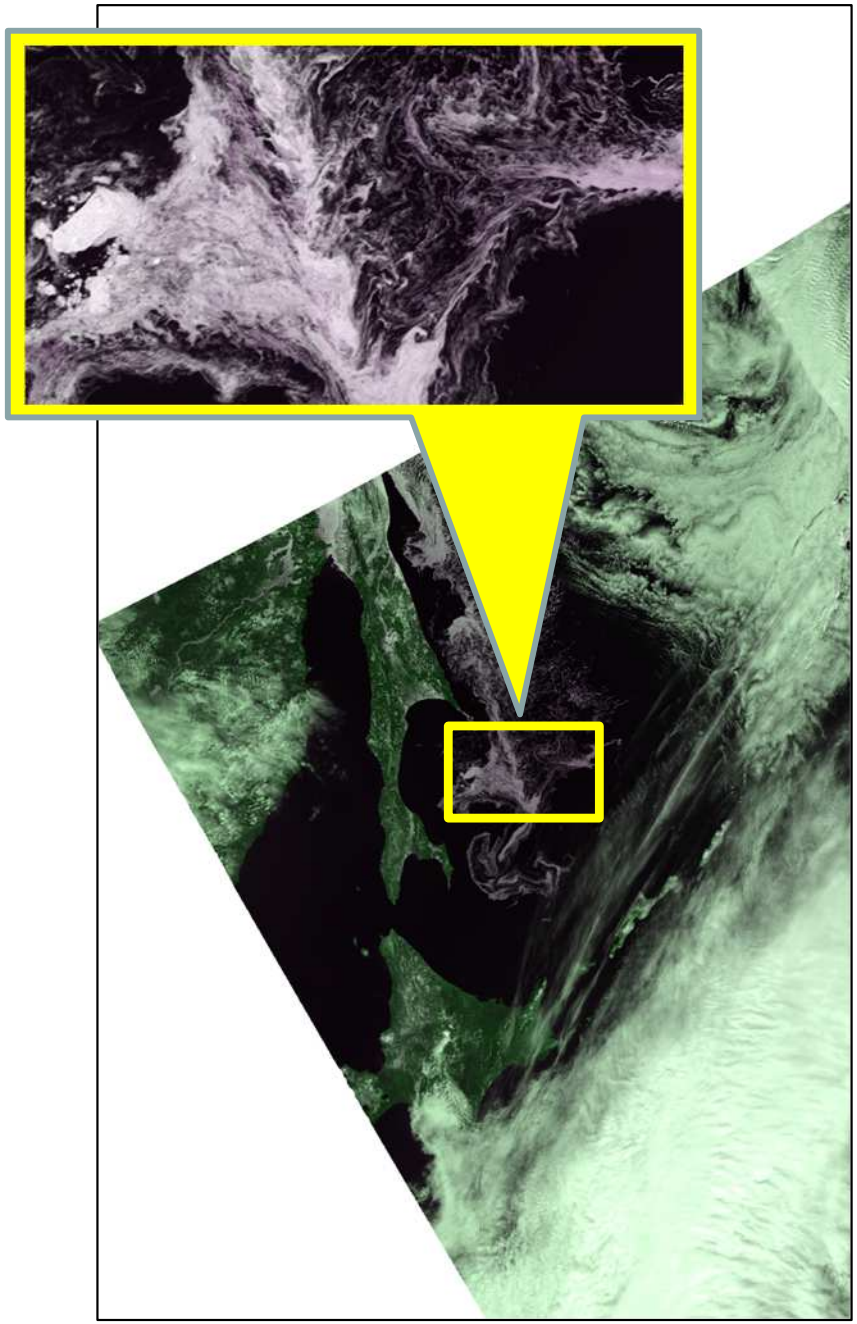


AMSR2 IC Image
（IFOV：25km）



Calculate the percentage of ice included in one pixel size of AMSR2 image.
This will be MODIS IC. (IFOV:25km)

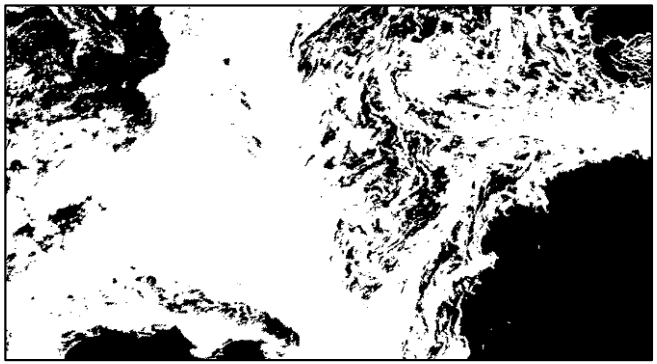
(2) Test Data Example: Sea of Okhotsk(2021/4/5)



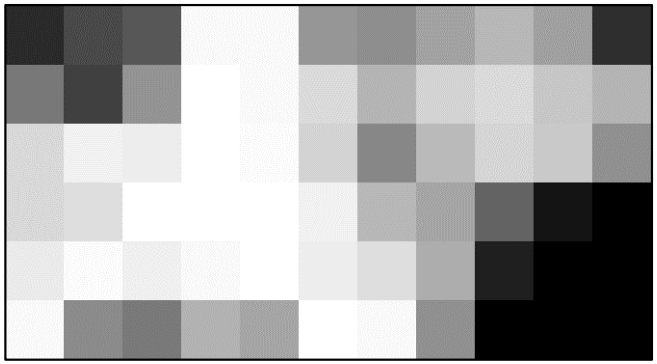
MODIS Band2 image

AMSR2 IC image

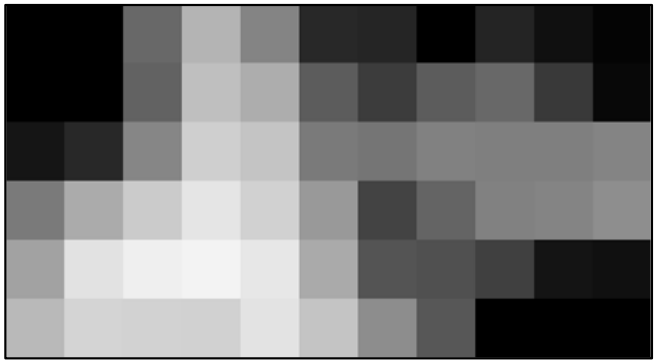
IC comparison of AMSR2 and MODIS



MODIS binarization
Threshold:10%

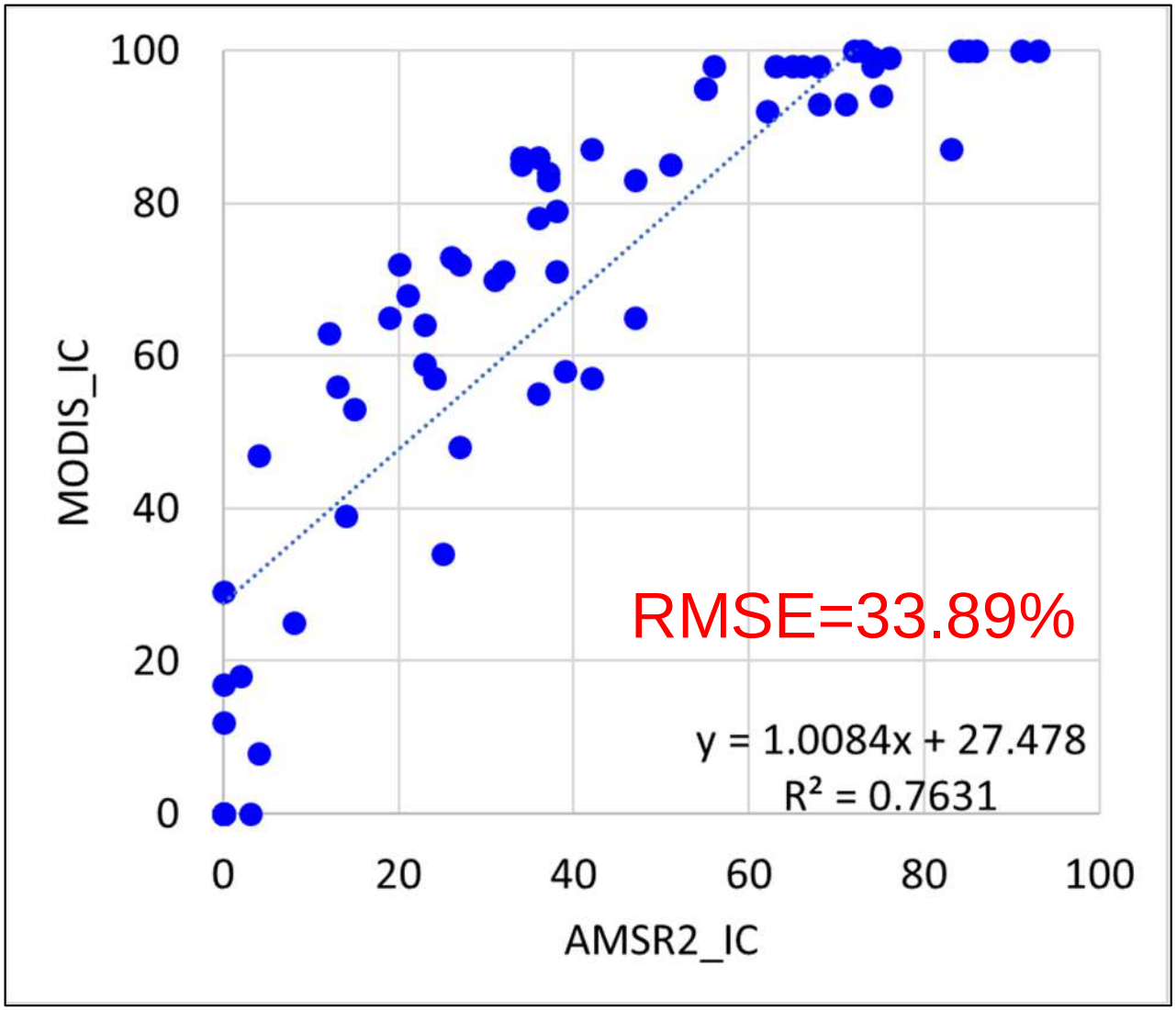


MODIS IC image

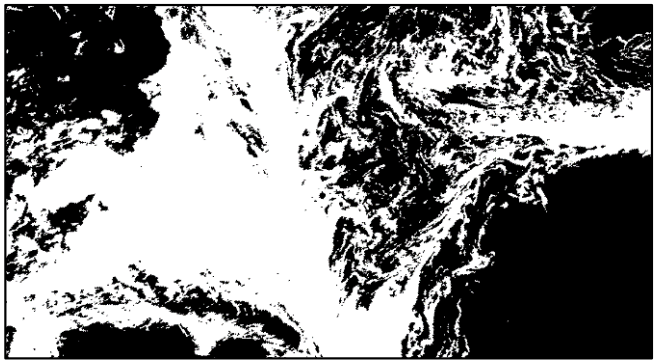


AMSR2 IC image

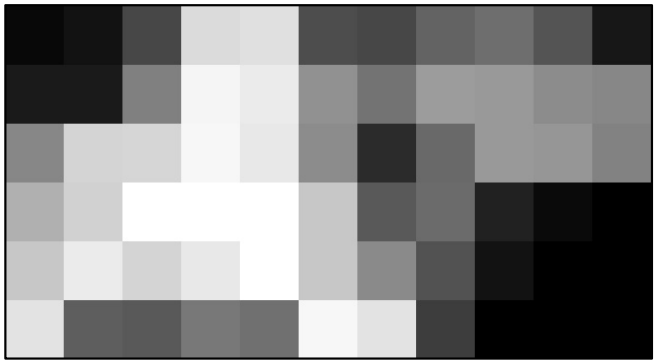
Sea of Okhotsk(2021/4/5)



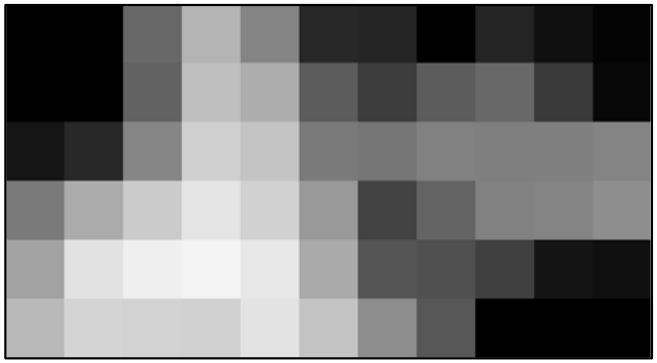
IC comparison of AMSR2 and MODIS



MODIS binarization
Threshold:20%

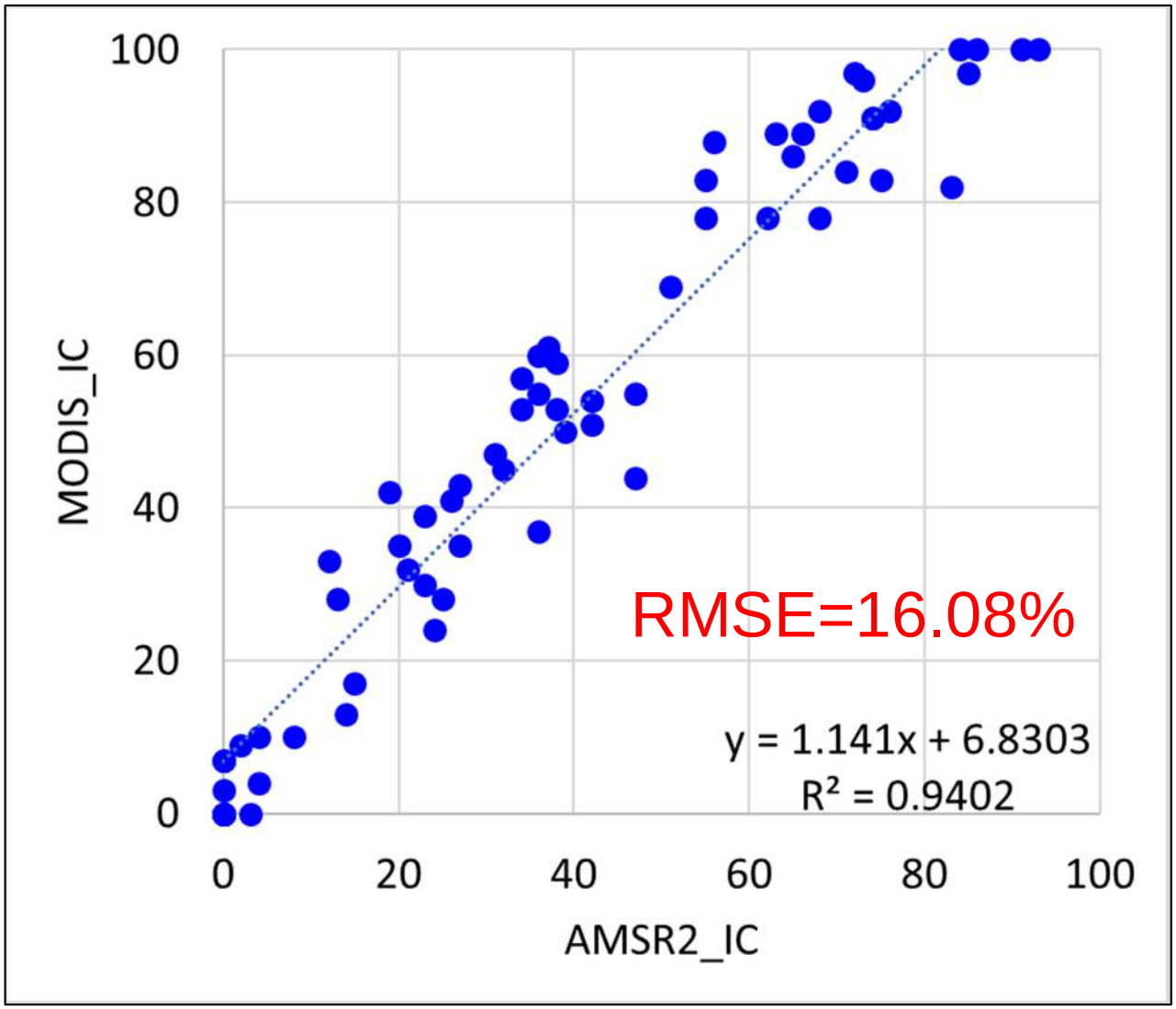


MODIS IC image

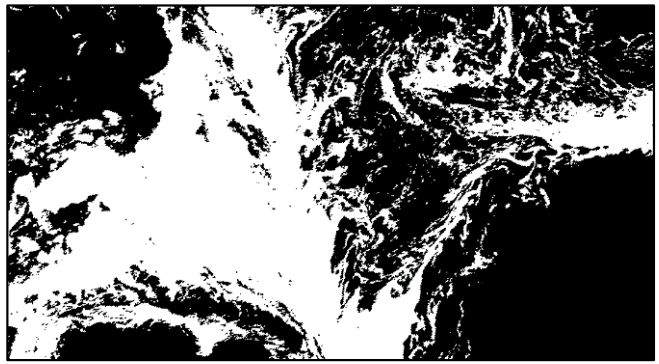


AMSR2 IC image

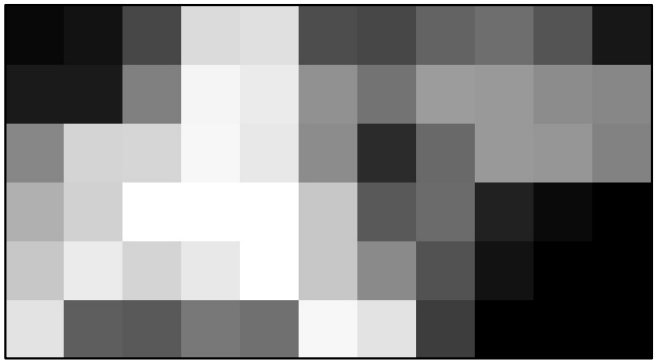
Sea of Okhotsk(2021/4/5)



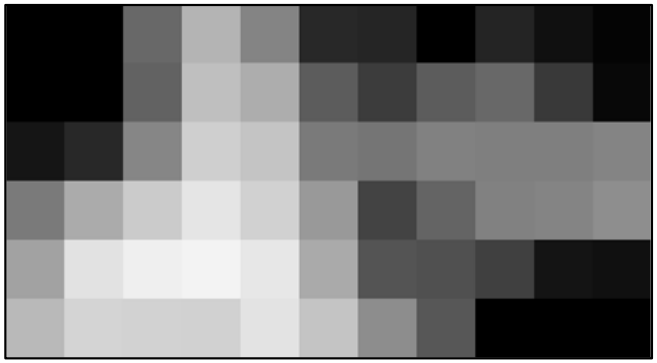
IC comparison of AMSR2 and MODIS



MODIS binarization
Threshold:25%

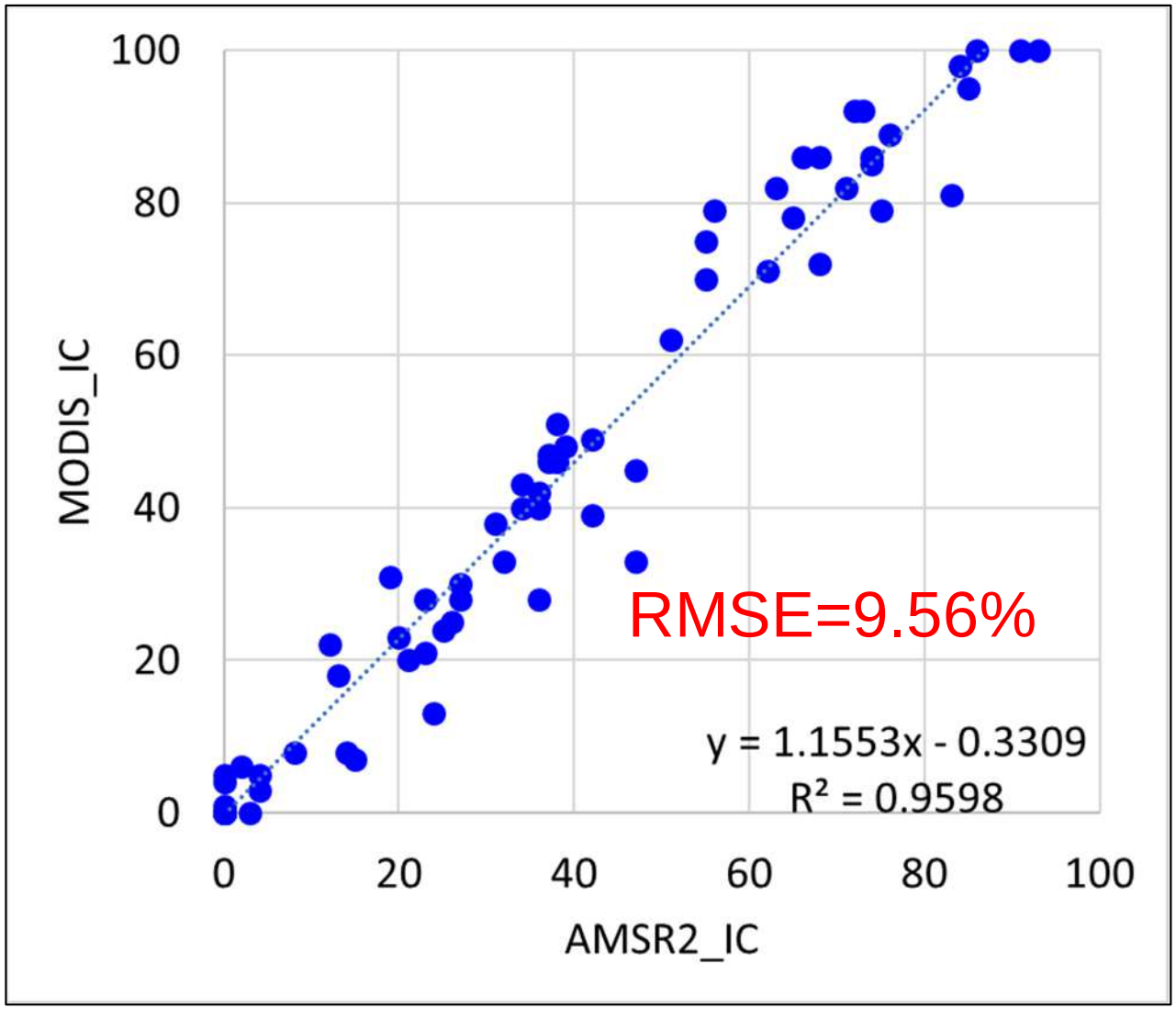


MODIS IC image

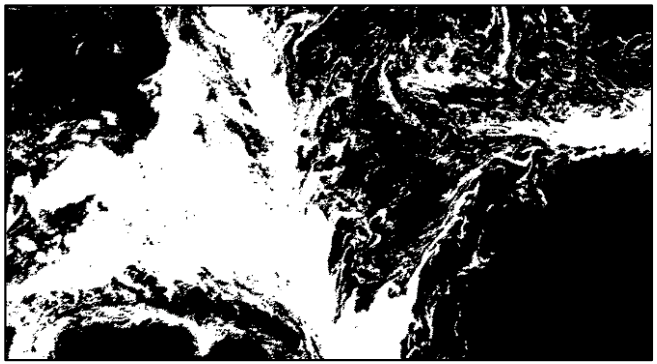


AMSR2 IC image

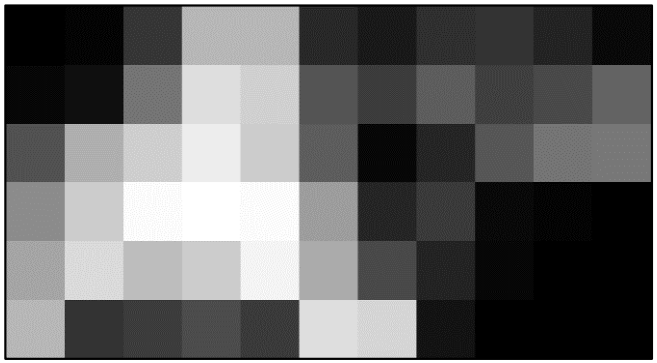
Sea of Okhotsk(2021/4/5)



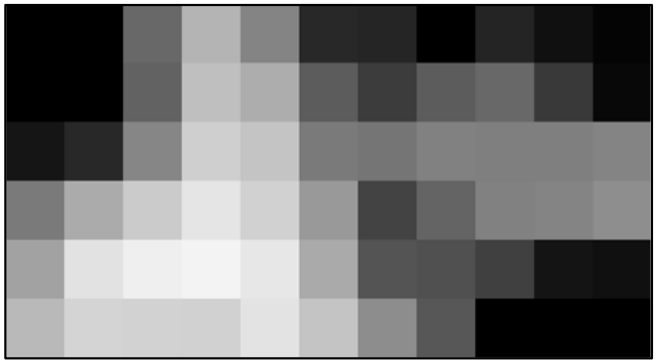
IC comparison of AMSR2 and MODIS



MODIS binarization
Threshold:30%

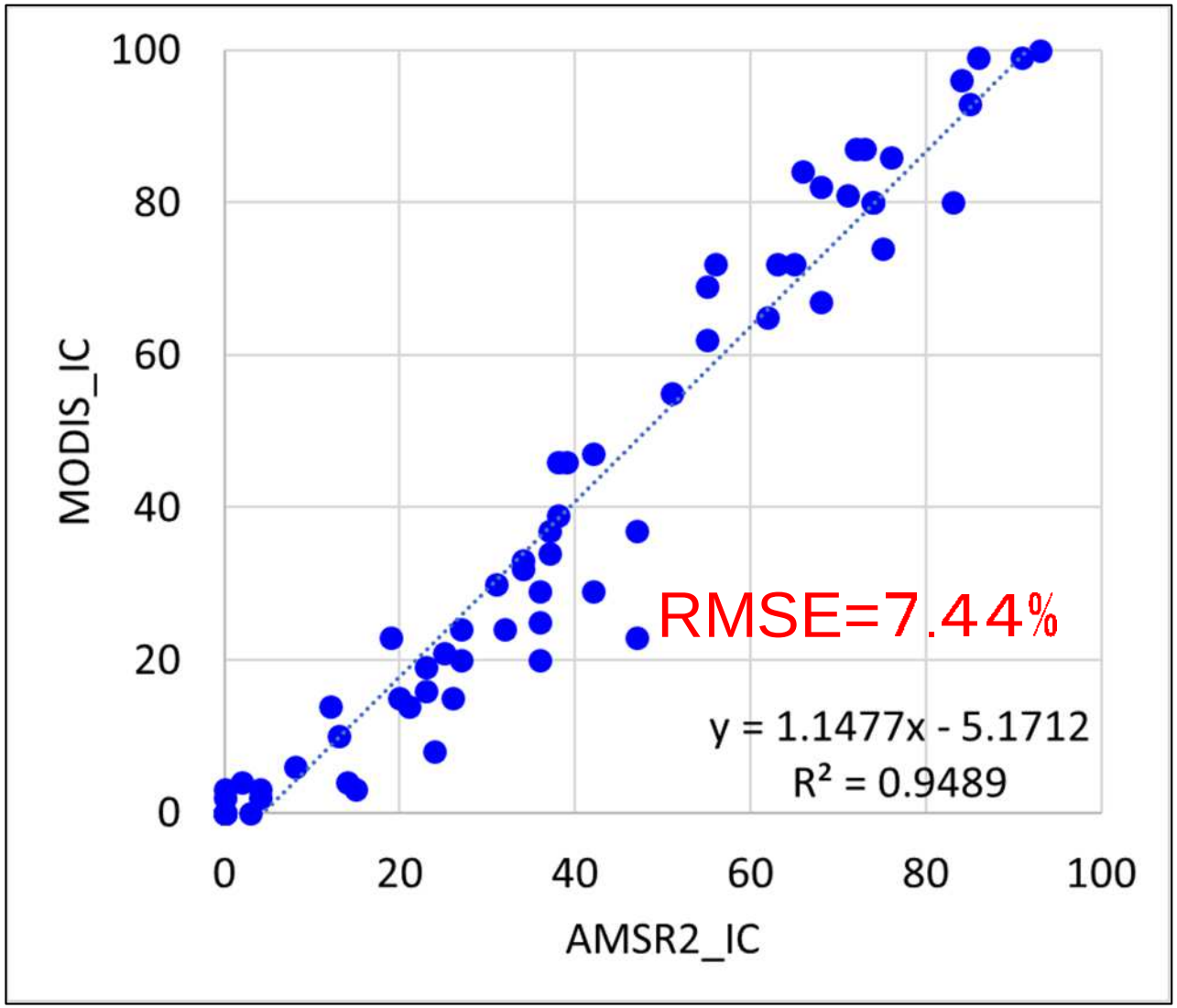


MODIS IC image

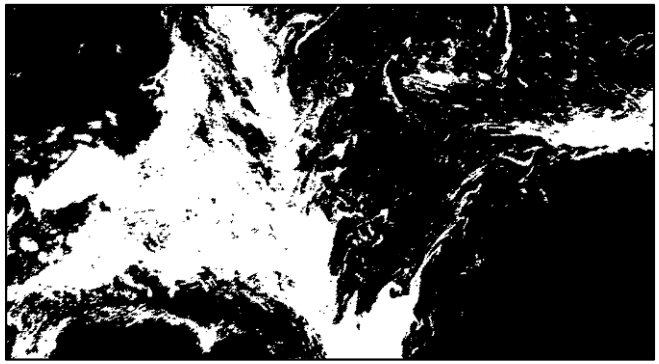


AMSR2 IC image

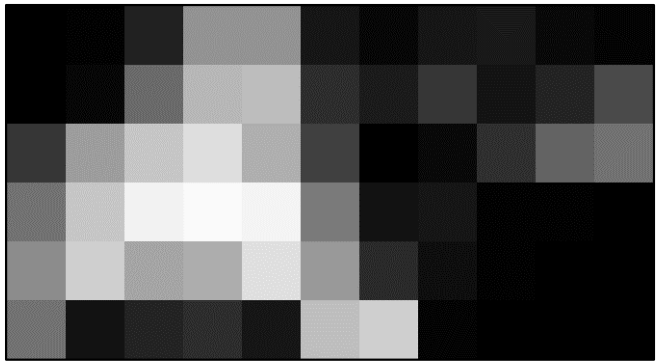
Sea of Okhotsk(2021/4/5)



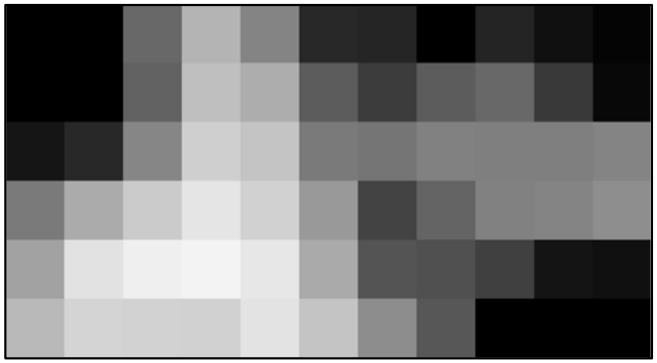
IC comparison of AMSR2 and MODIS



MODIS binarization
Threshold:40%

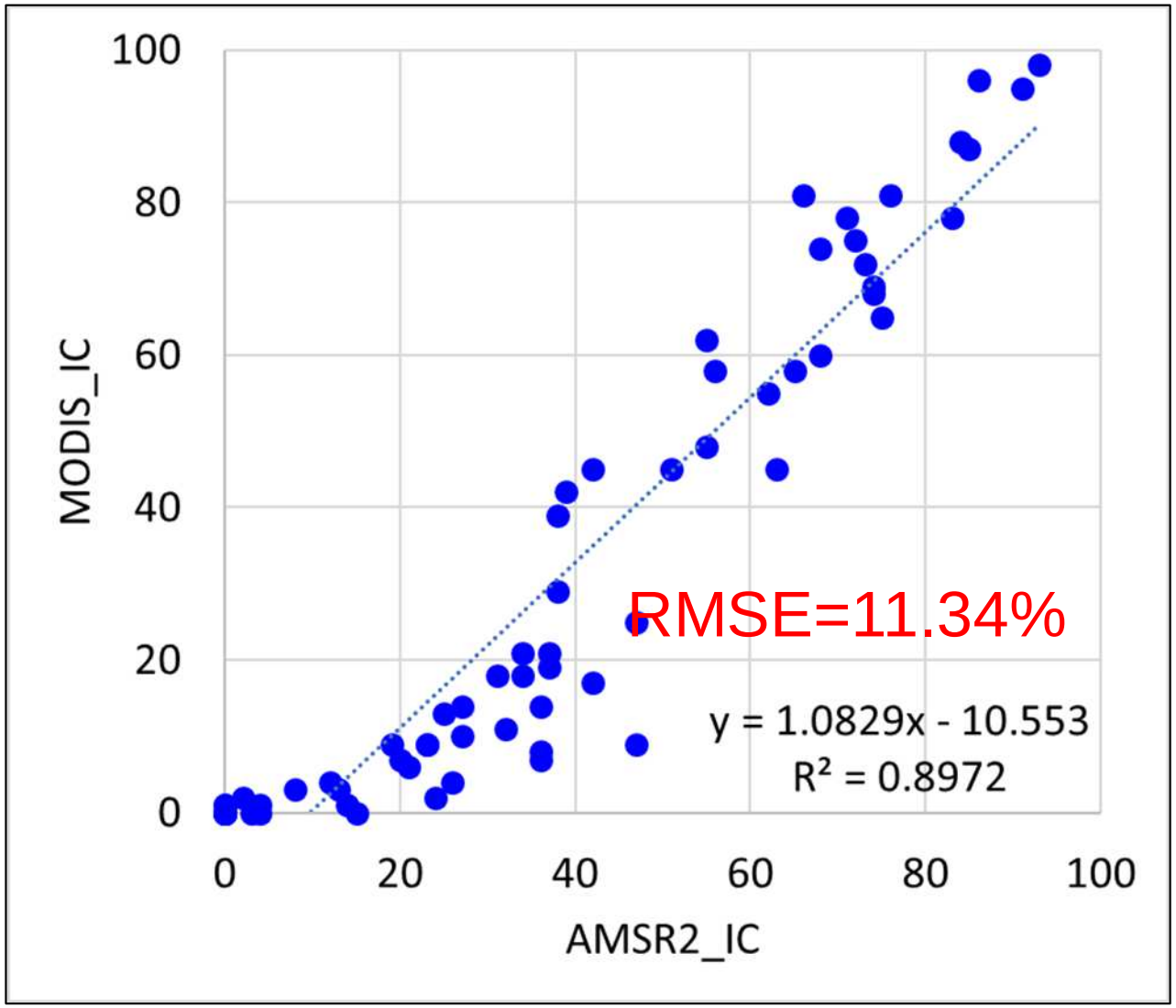


MODIS IC image



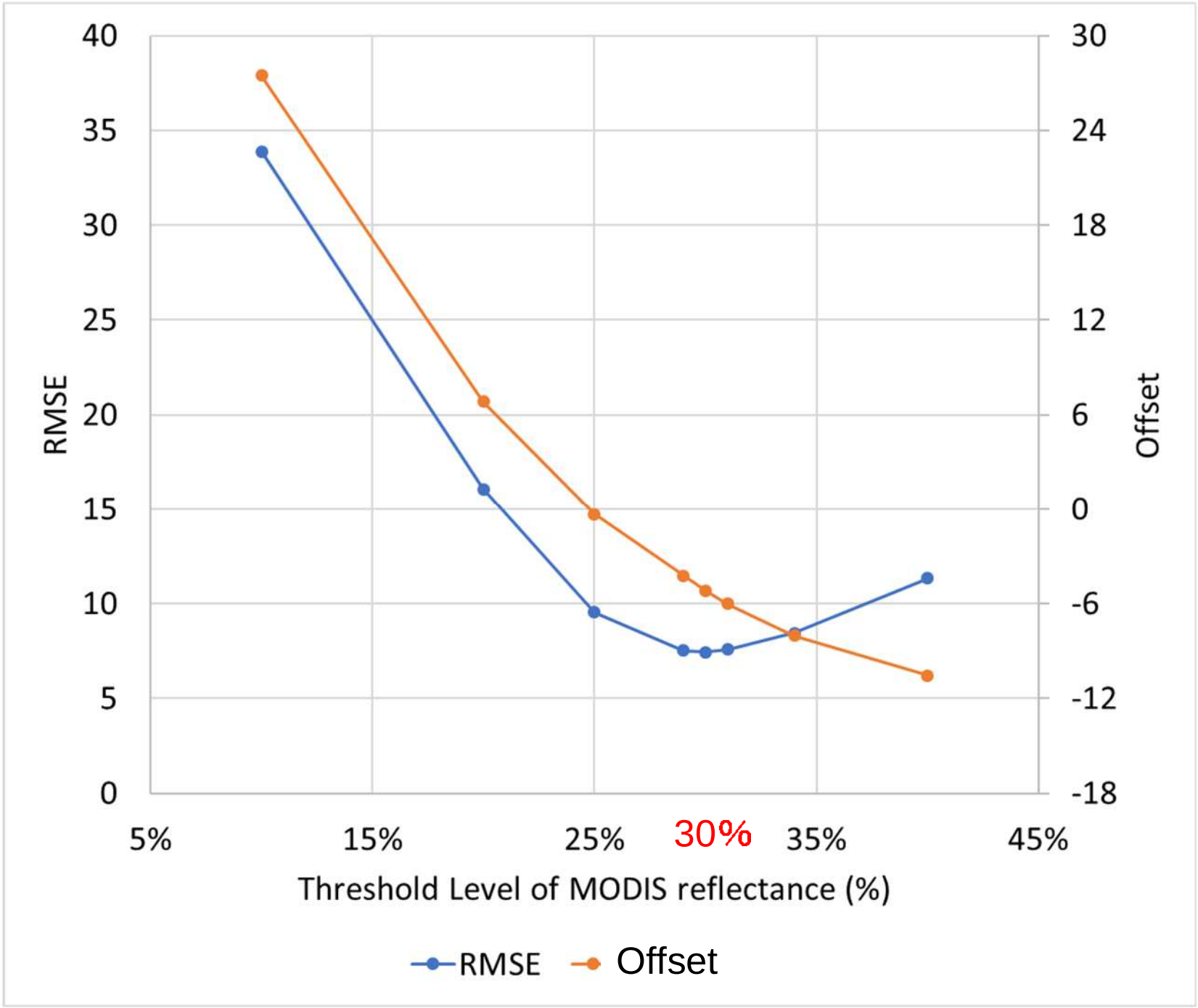
AMSR2 IC image

Sea of Okhotsk(2021/4/5)



Relationship between threshold level and RMSE

Sea of Okhotsk(2021/4/5)



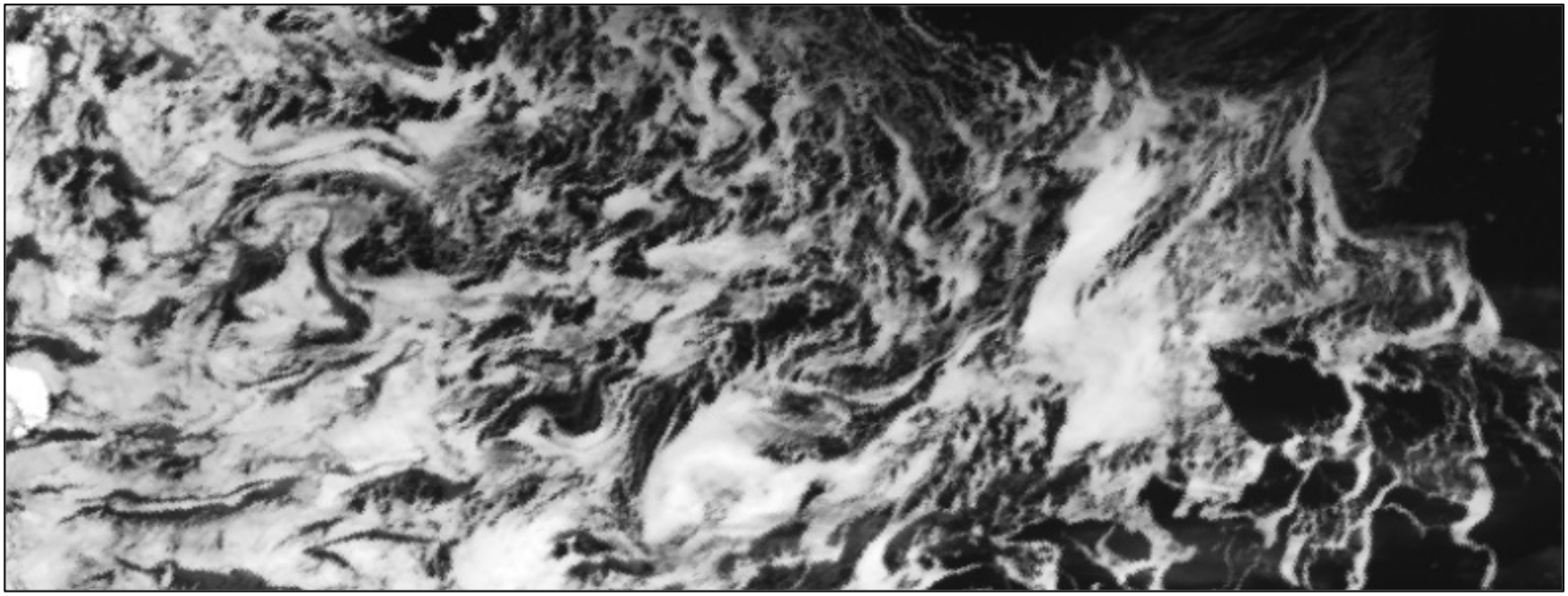
(3) Result

Sea of Okhotsk

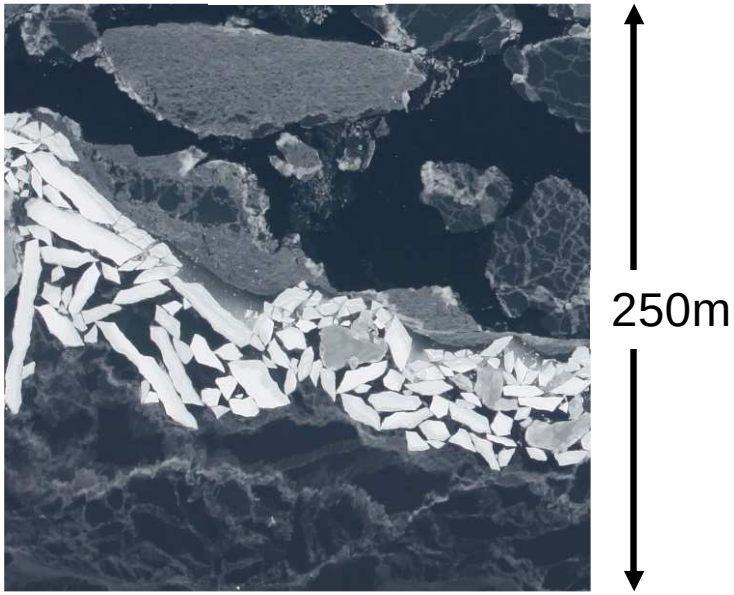
Date	RMSE	Threshold Level
January 25, 2015	9.3%	20%
March 14, 2015	6.8%	15%
March 13, 2016	6.7%	5%
March 18, 2016	6.4%	23%
January 1, 2017	6.3%	28%
February 28, 2019	9.9%	21%
March 28, 2019	12.1%	10%
January 16, 2020	9.6%	14%
January 18, 2020	7.5%	19%
April 5, 2021	7.4%	30%

- In most of the cases RMSE was less than 10%
- The optimum threshold level was not constant: 5 ~30%

Spatial Resolution Difference



MODIS image IFOV=250m

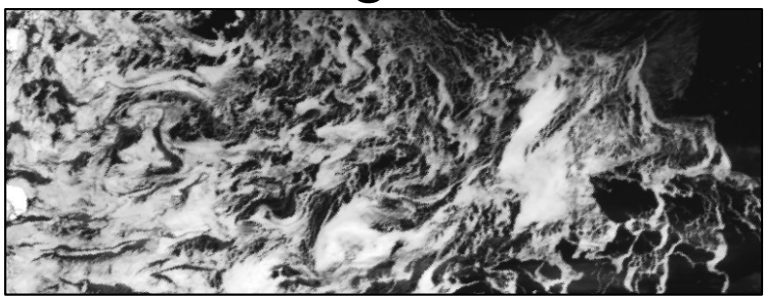


Aerial Photo IFOV=22.8cm （Saroma Lake)

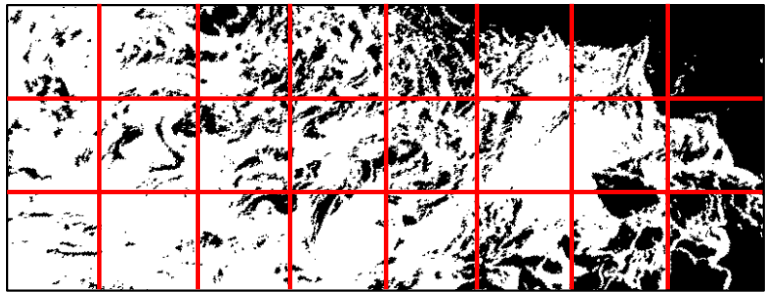
Reflectance of one MODIS pixel is
An average of various types of ice
A nd Ice concentration.

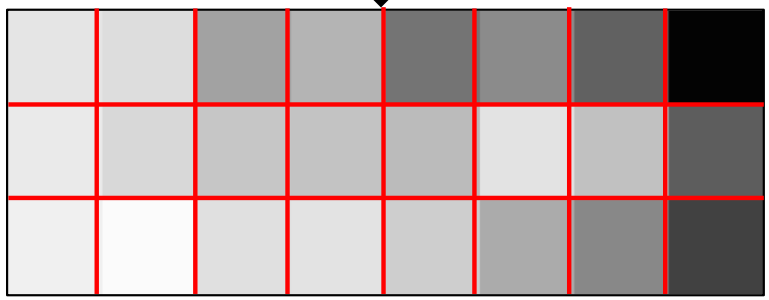
Modification of IC calculation with MODIS

MODIS image（IFOV：250m）



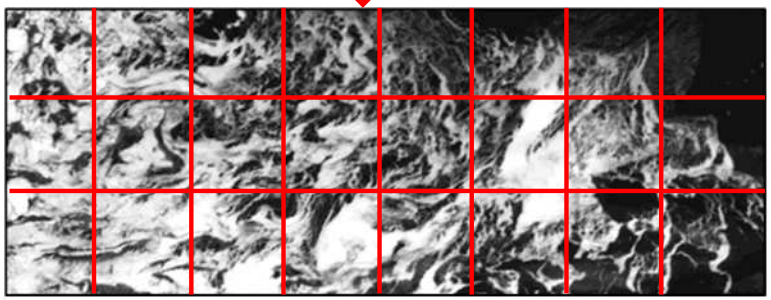
binarize

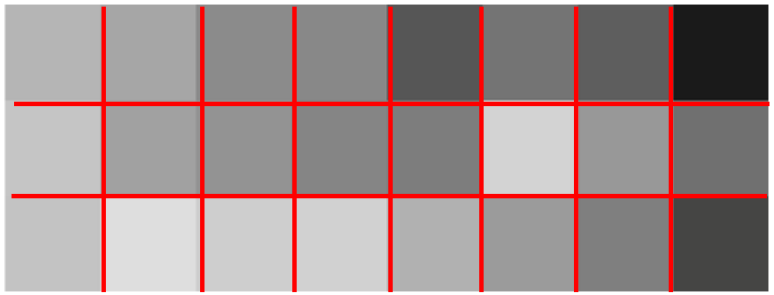




MODIS IC. (IFOV:25km）

Stretch



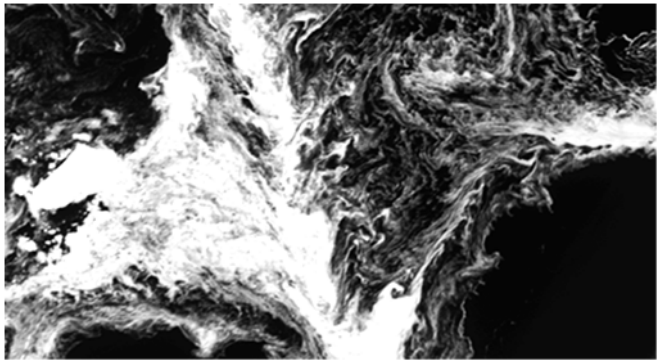


MODIS IC. (IFOV:25km）

(1) Original Method

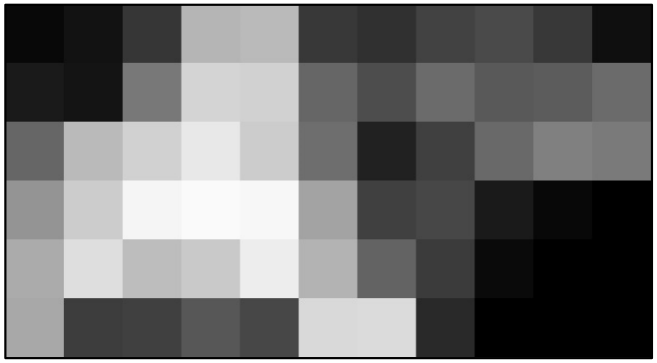
(2) Modification of Method

IC comparison of AMSR2 and MODIS

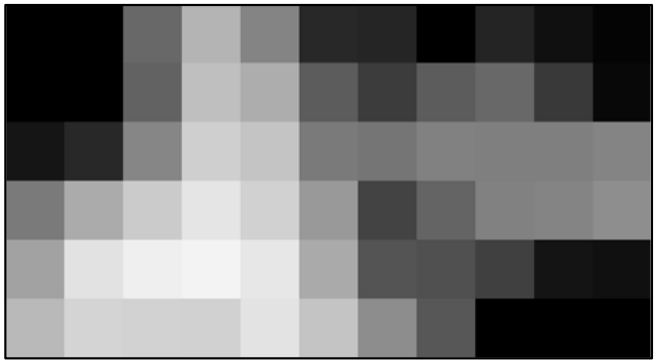


MODIS

3-20 stretched

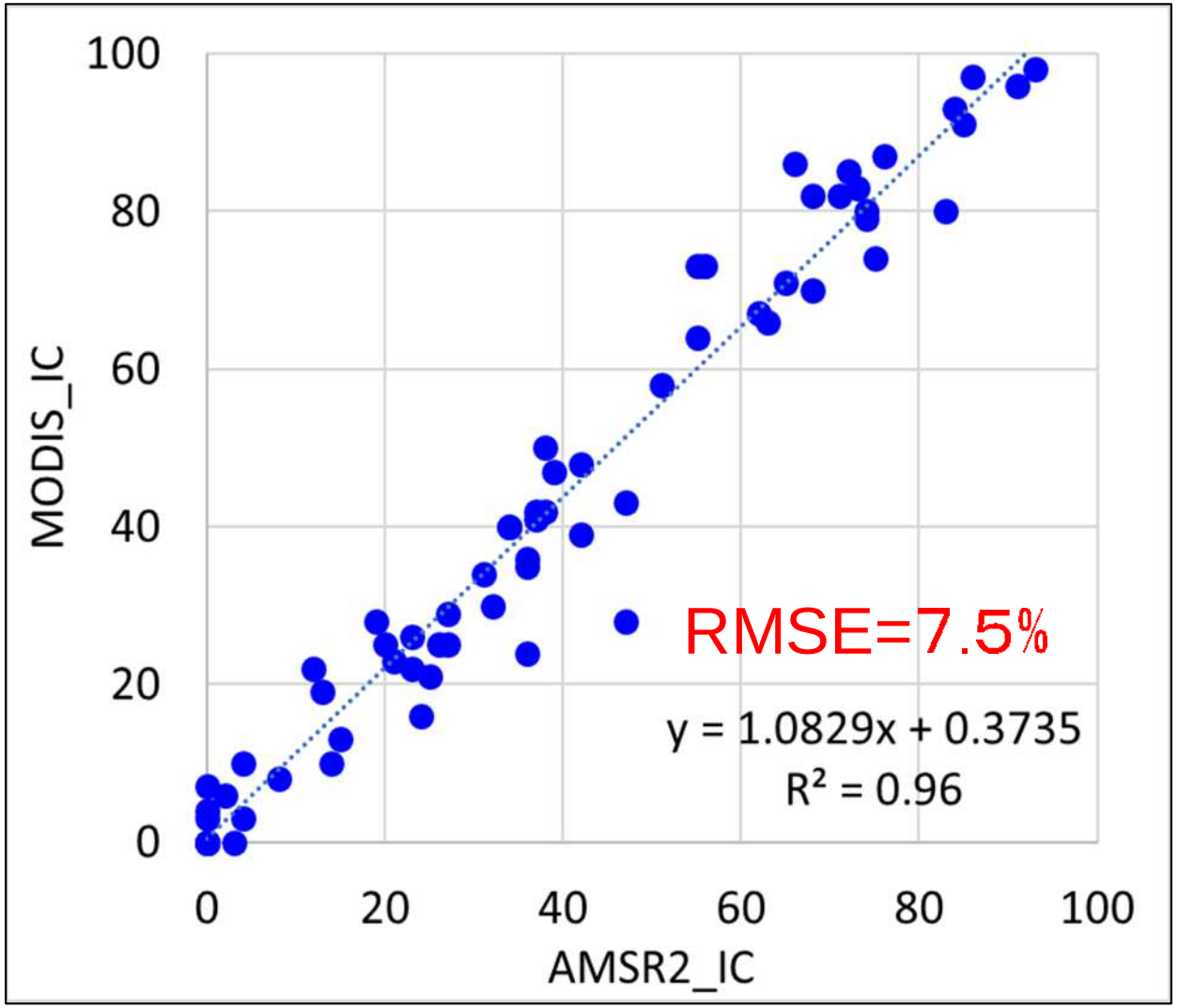


MODIS IC image

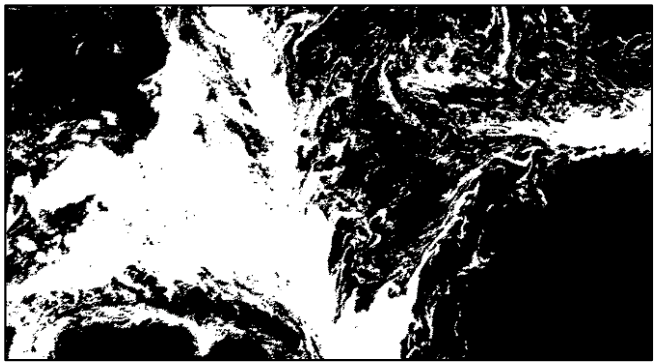


AMSR2 IC image

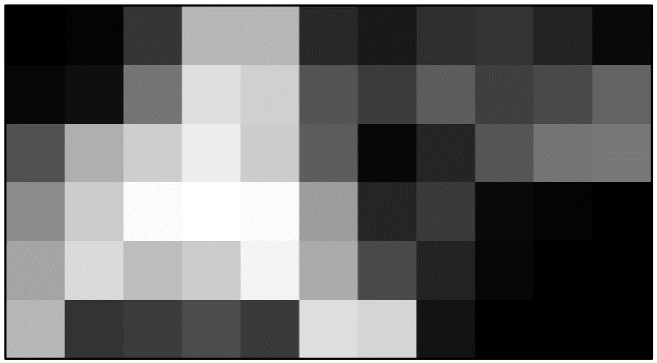
Sea of Okhotsk(2021/4/5)



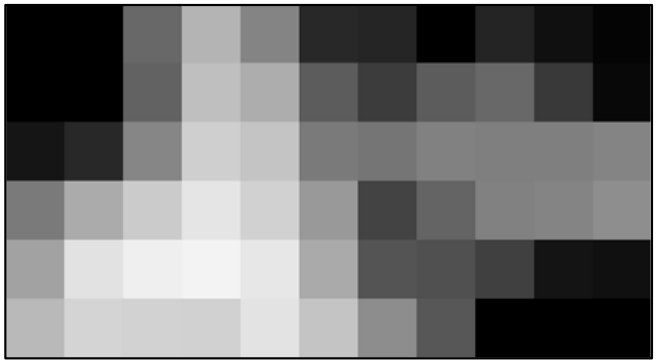
IC comparison of AMSR2 and MODIS



MODIS binarization
Threshold:30%

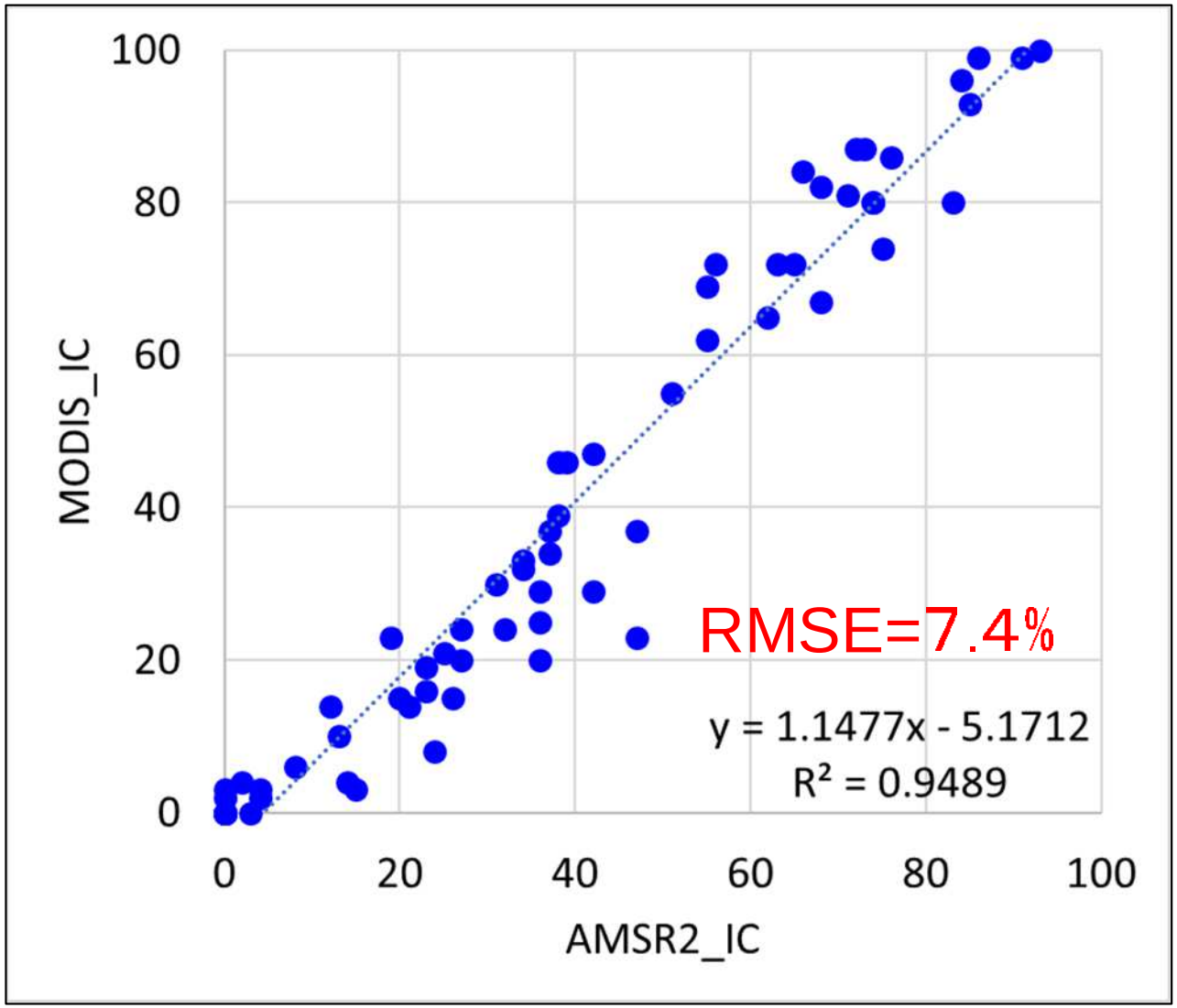


MODIS IC image

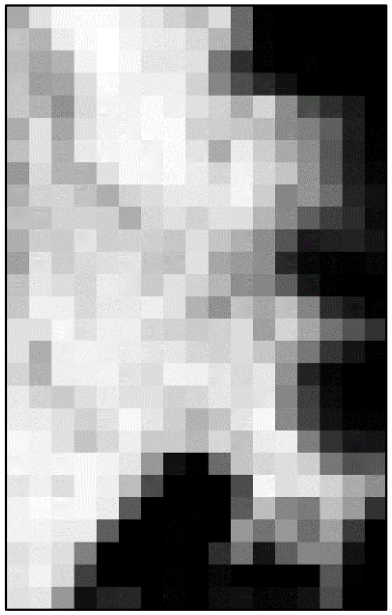


AMSR2 IC image

Sea of Okhotsk(2021/4/5)

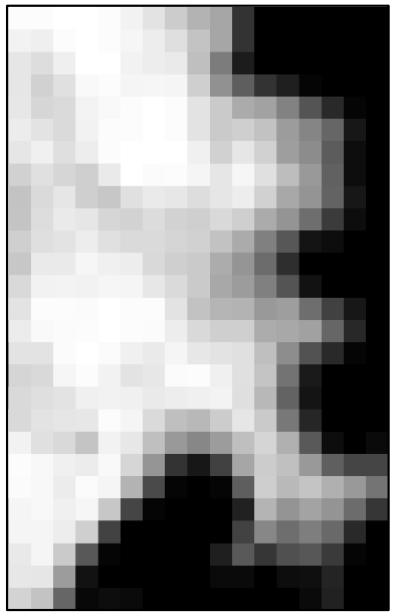


IC comparison of AMSR2 and MODIS



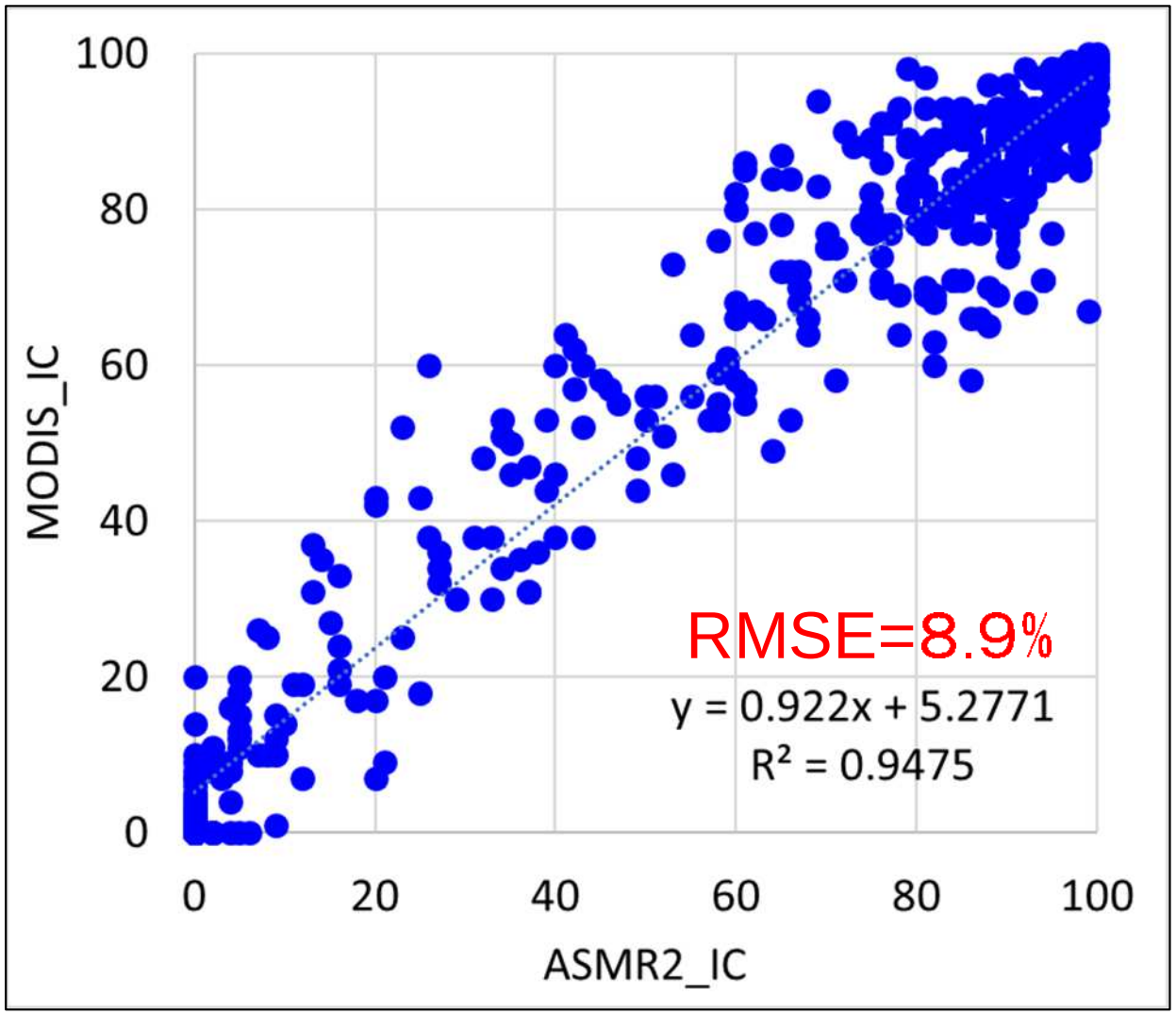
MODIS IC image

3-20 stretched



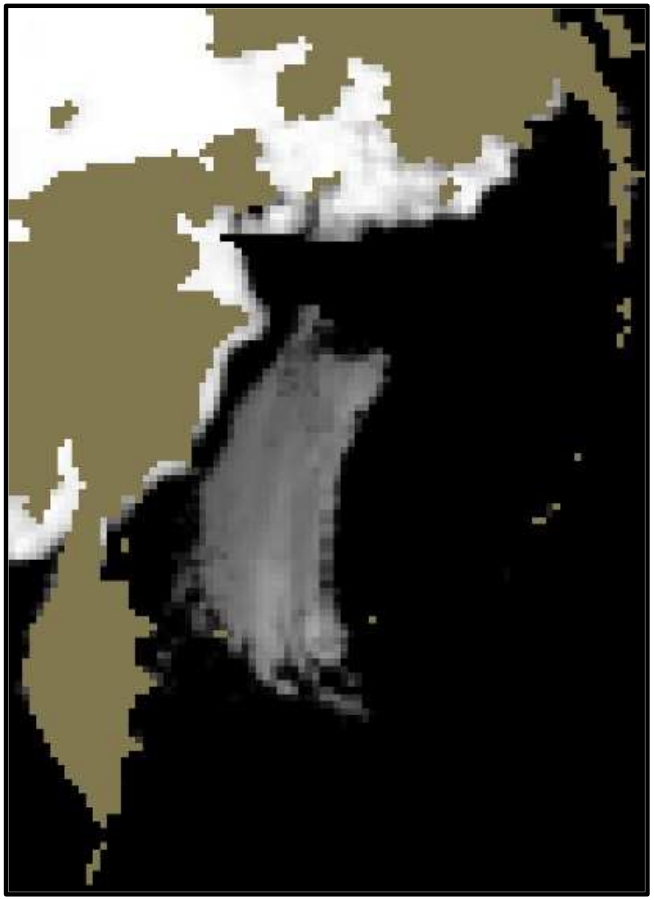
AMSR2 IC image

Sea of Okhotsk(2021/4/5)



3. Evaluation of the weather effect observed in AMSR2 IC images

(a) 2018/12/29

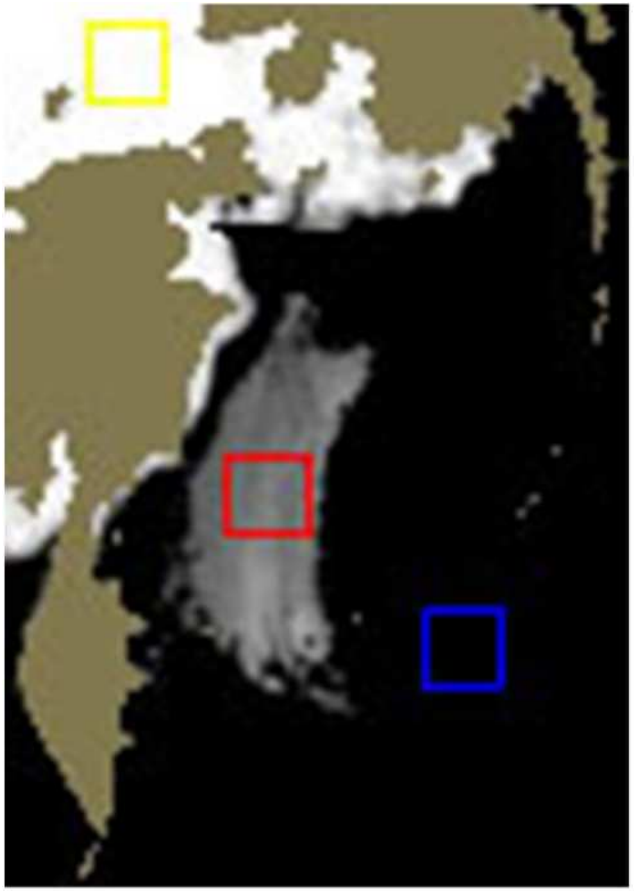


(b)2018/12/30

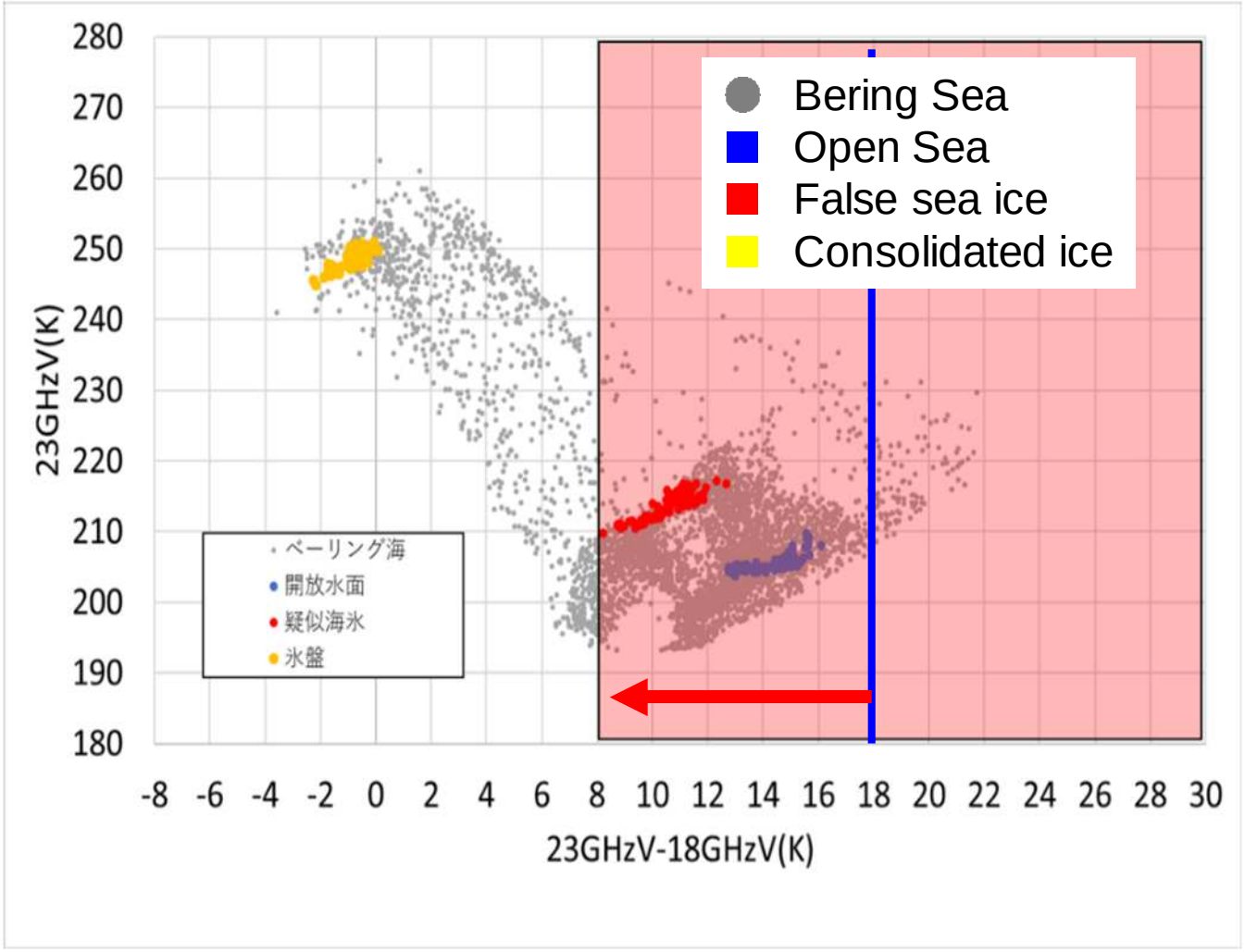
(c)2018/12/31

< Weather filter adjustment is needed>

$$T_B(23V) - T_B(18V) > 18K \rightarrow 8K$$



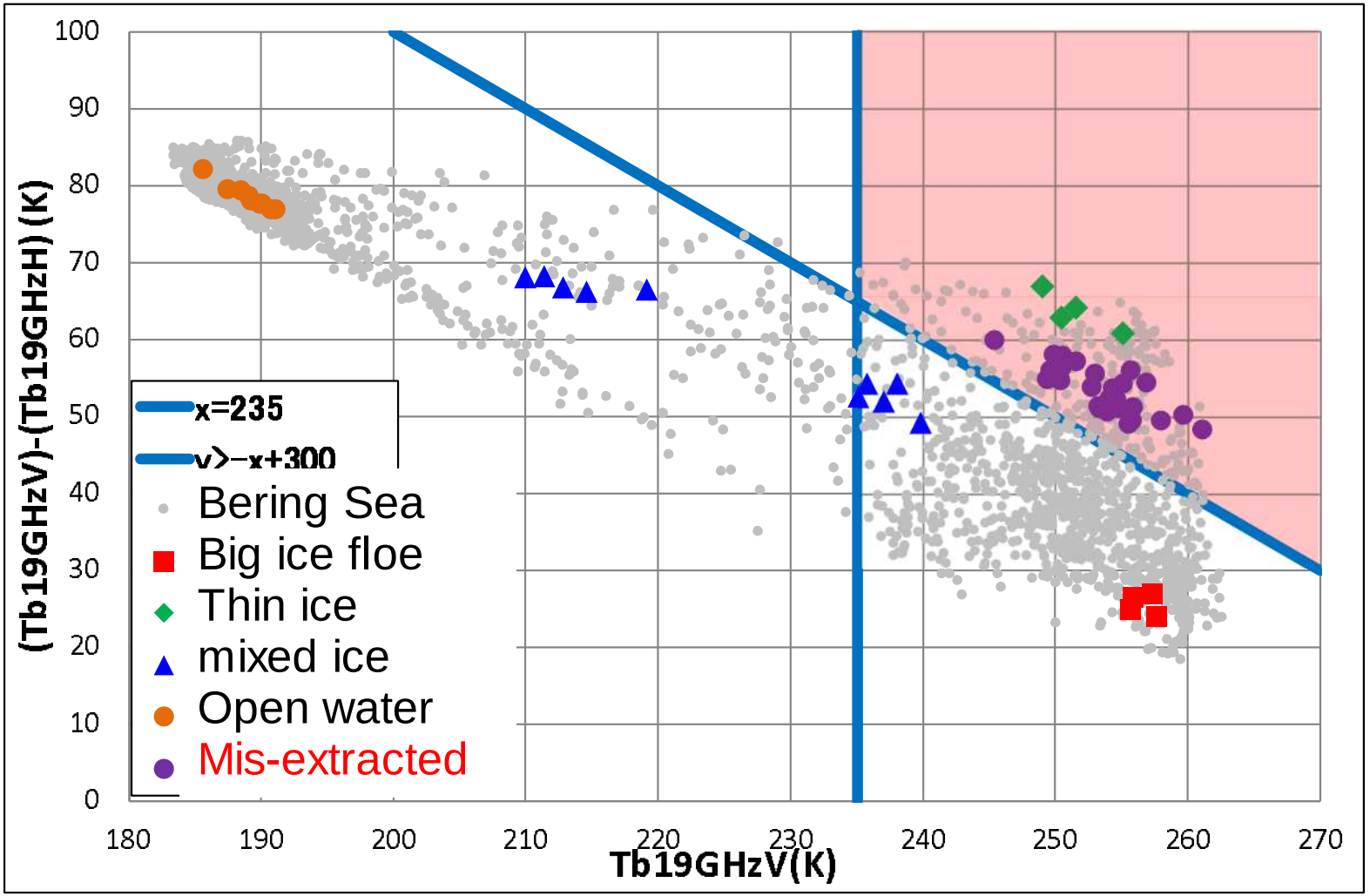
2018/12/30



4. Thin ice area extraction algorithm（No Change）

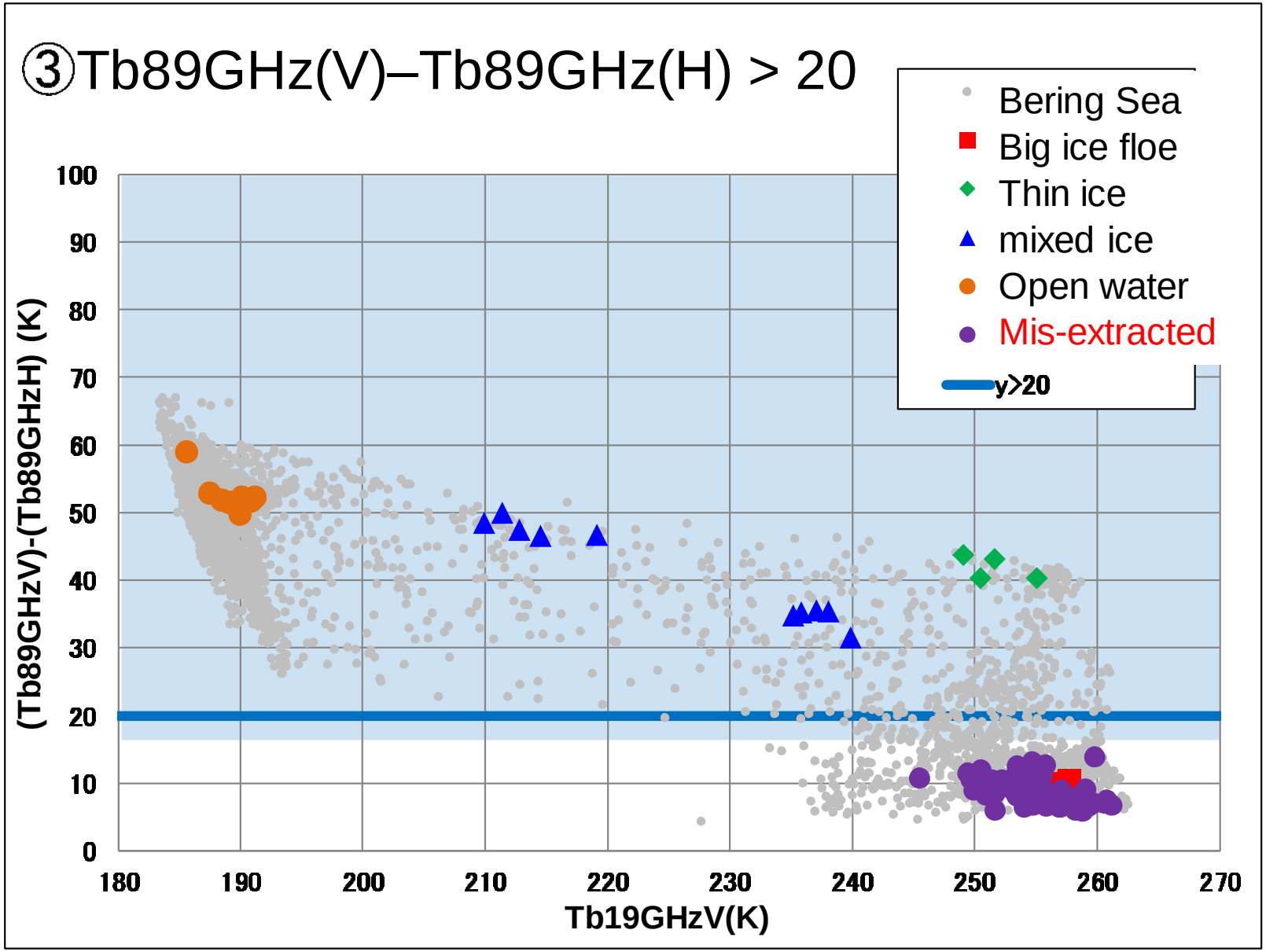
①Tb19GHz(V) > 235

②Tb19GHz(V)–Tb19GHz(H) > 300 – Tb19GHz(V)



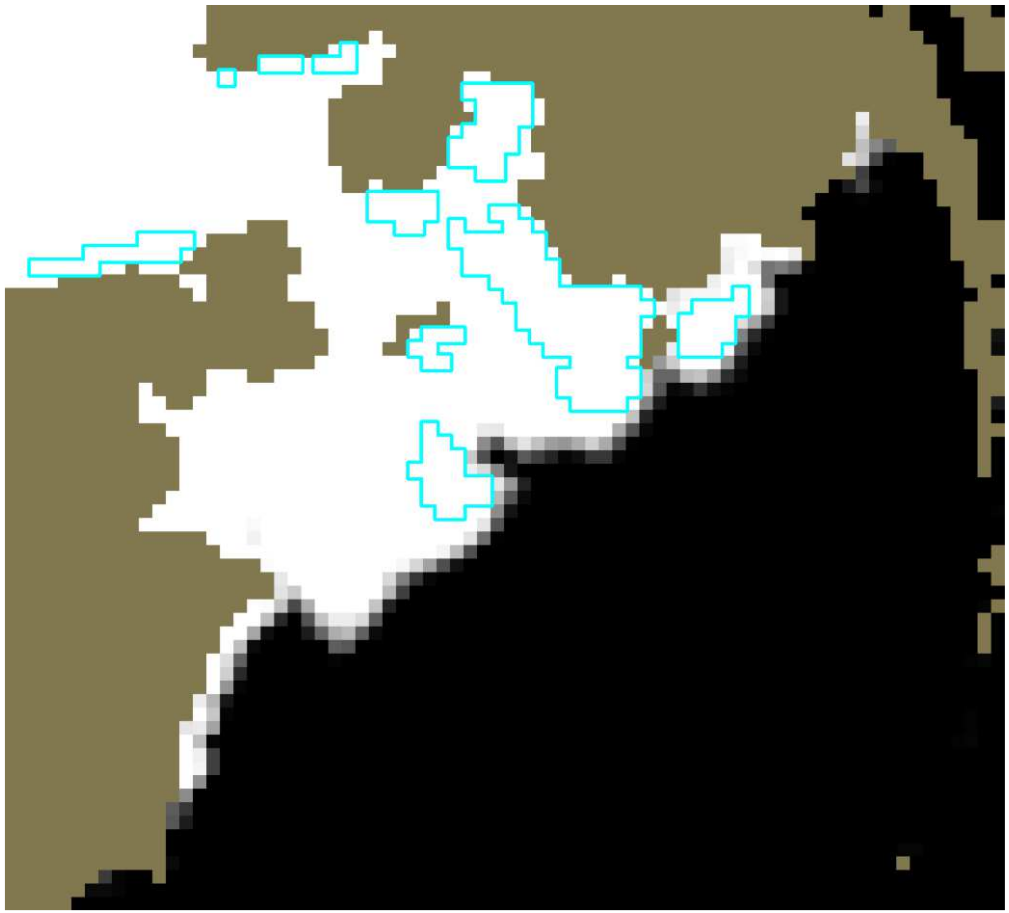
(Bering Sea February 10, 2014)

(2) Rejection of mis-extracted thin ice areas

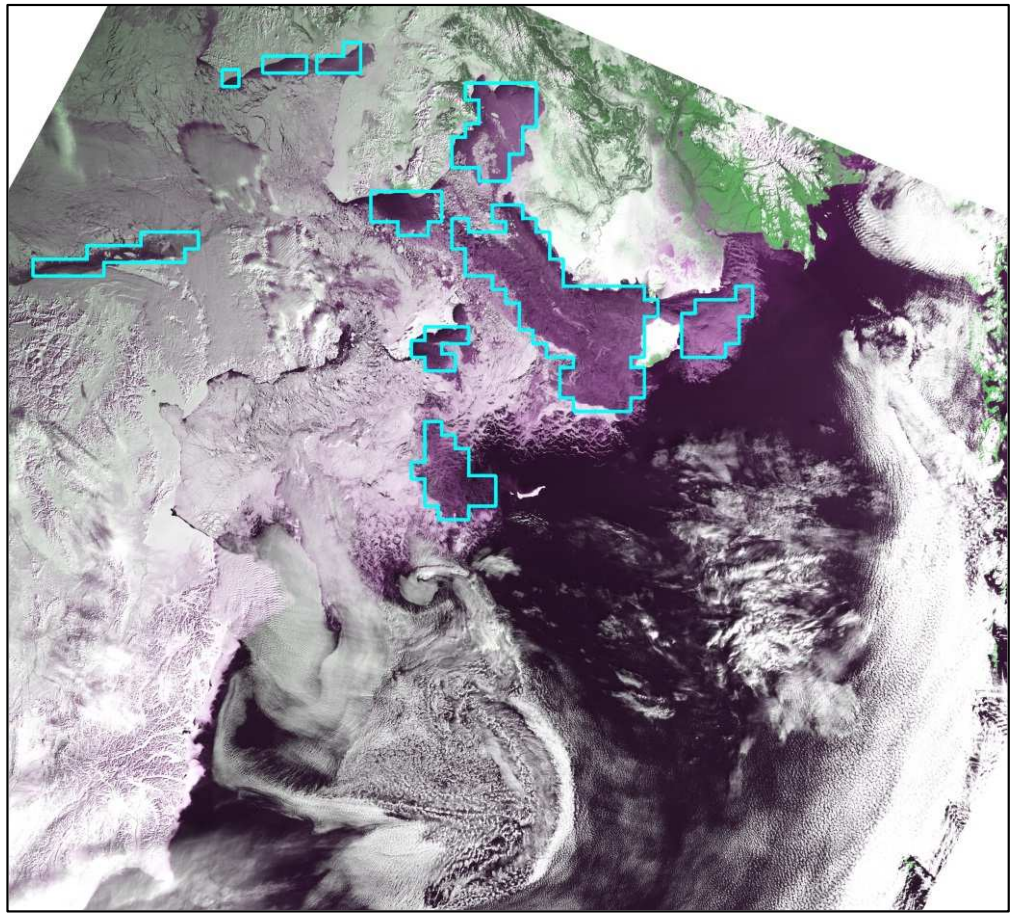


(Bering Sea February 10, 2014)

Extracted thin ice area from AMSR2 data
（2014/2/10　Bering Sea)

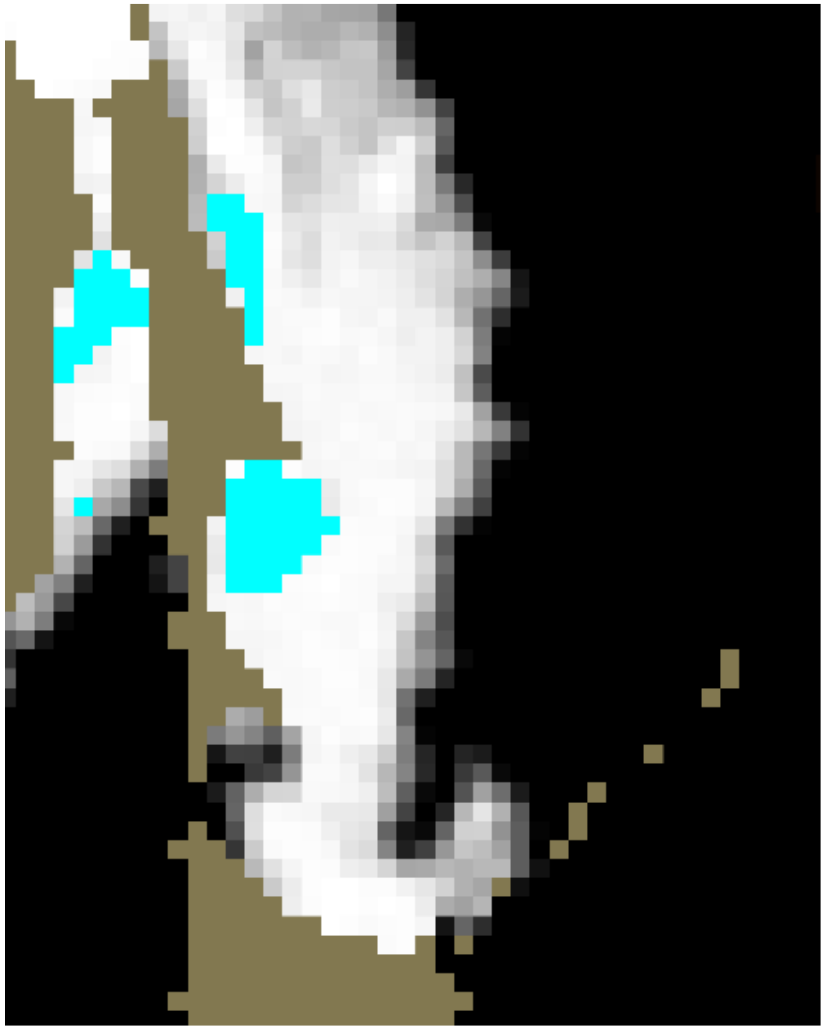


Extracted thin ice area from AMSR2 data

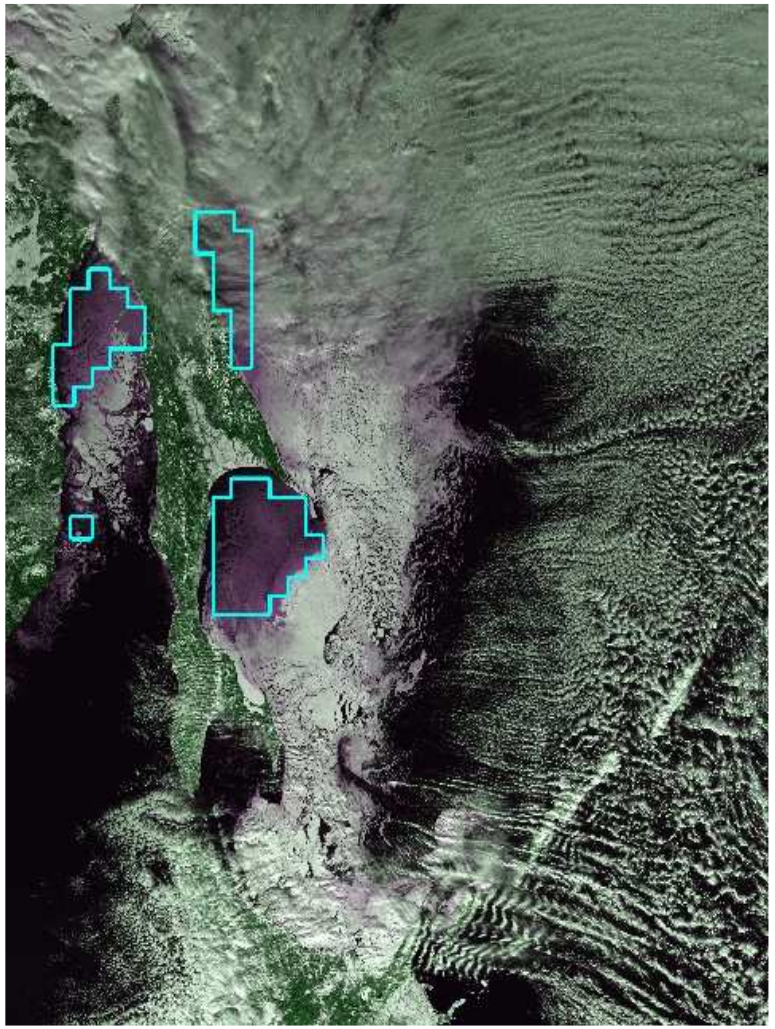


Extracted area overlaid on MODIS image

Extracted thin ice area from AMSR2 data
（2018/2/9　Sea of Okhotsk)



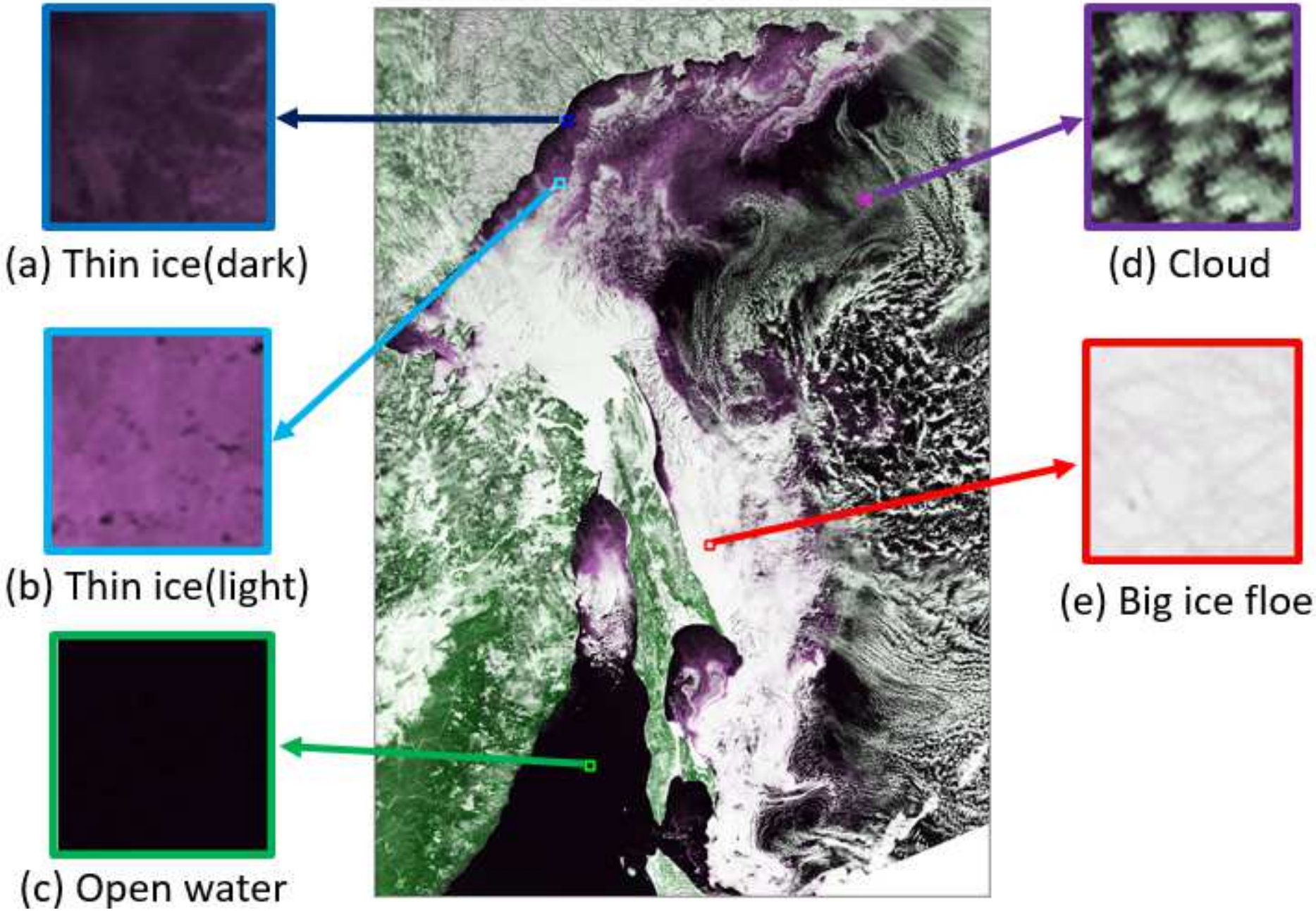
Extracted thin ice area from AMSR2 data



Extracted area overlaid on MODIS image

4‘. Thin ice area extraction algorithm（MODIS）

(1) Sample area selection

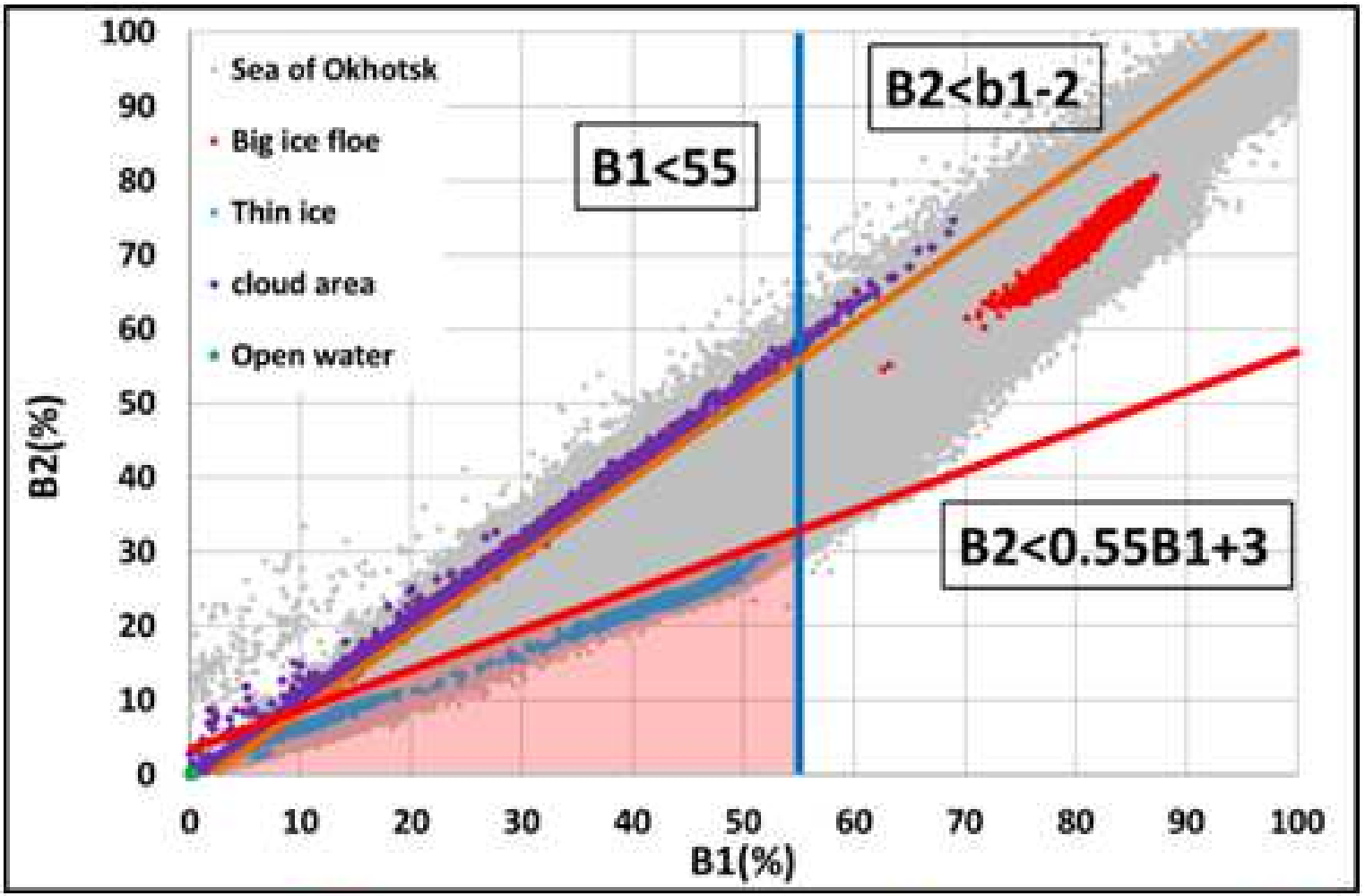


Scatter plots of MODIS Band 1 & Band2

B2<0.55 × B1+3 (1)

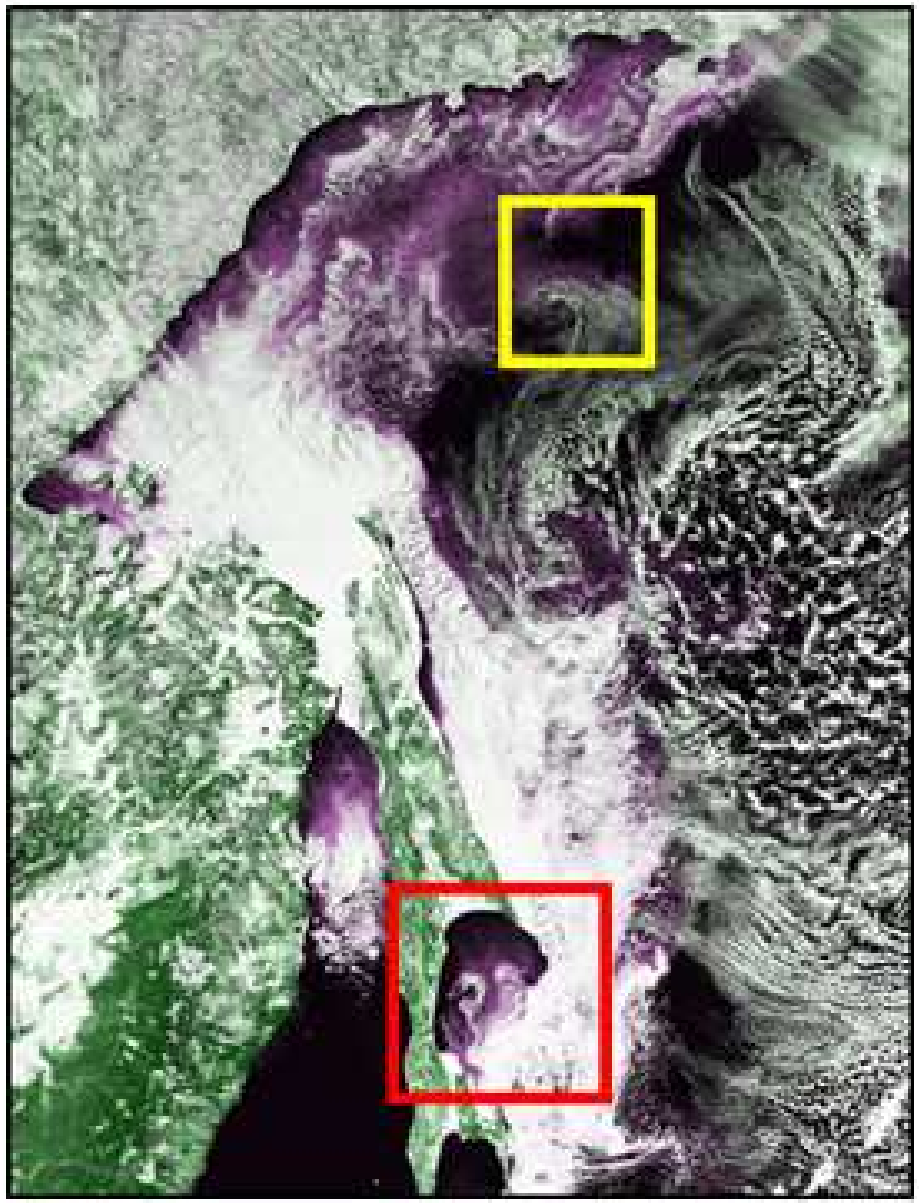
B1<55 (2)

B2<B1-2 (3)

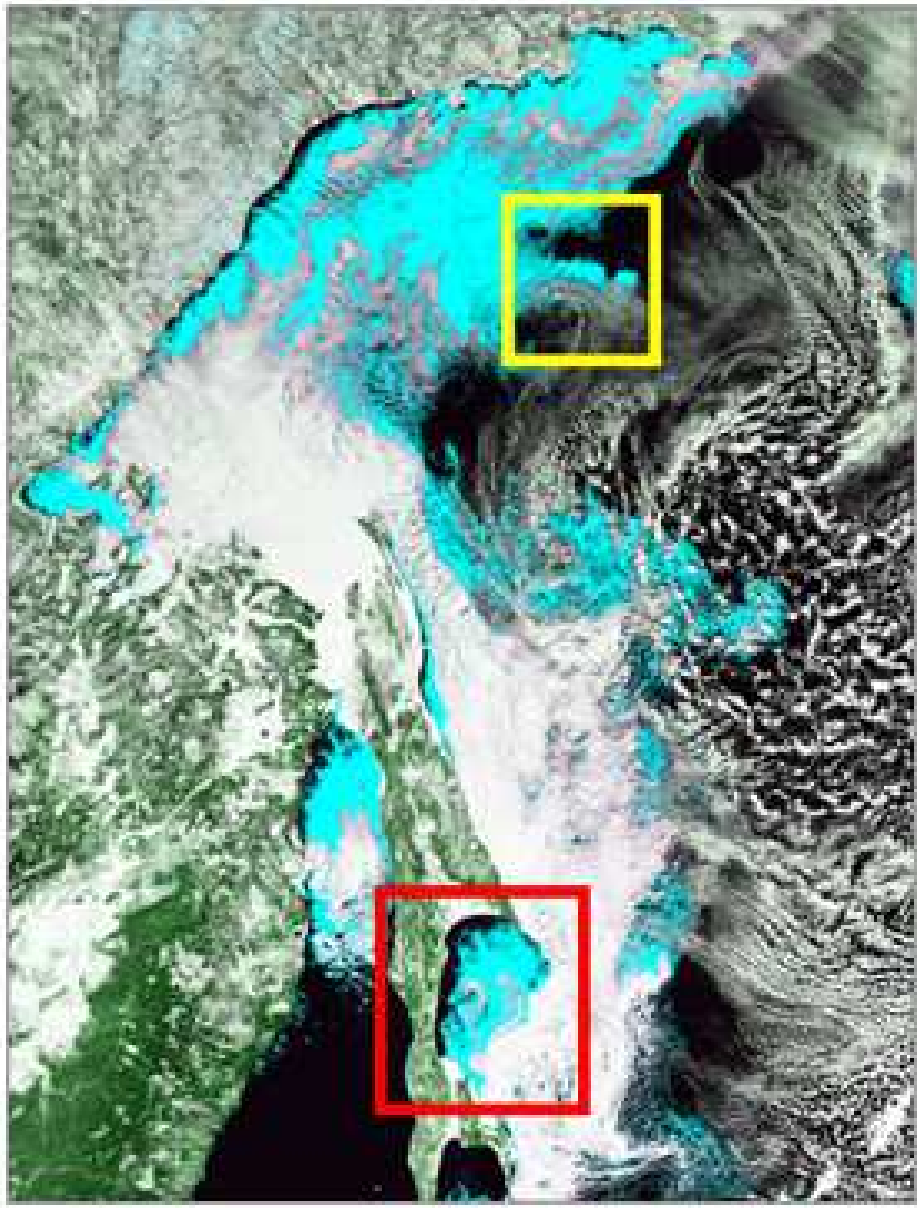


big ice floe(■), thin ice(▲), cloud(◆), open water(●)

Thin ice area extracted result with MODIS

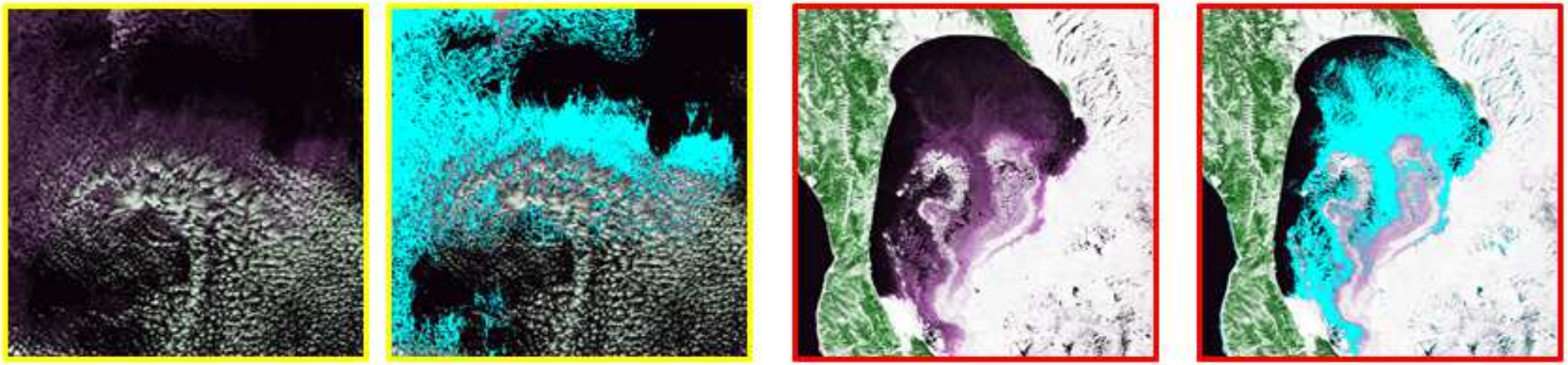


(a) MODIS image



(b) Extracted result

Thin ice area extracted result with MODIS



(c) MODIS image (zoom up of area1) (d) Extracted result (zoom up of area1) (e) MODIS image (zoom up of area2) (f) Extracted result (zoom up of area2)

Figure5. Thin ice area extraction result from MODIS image (Sea of Okhotsk, February 23,2014)

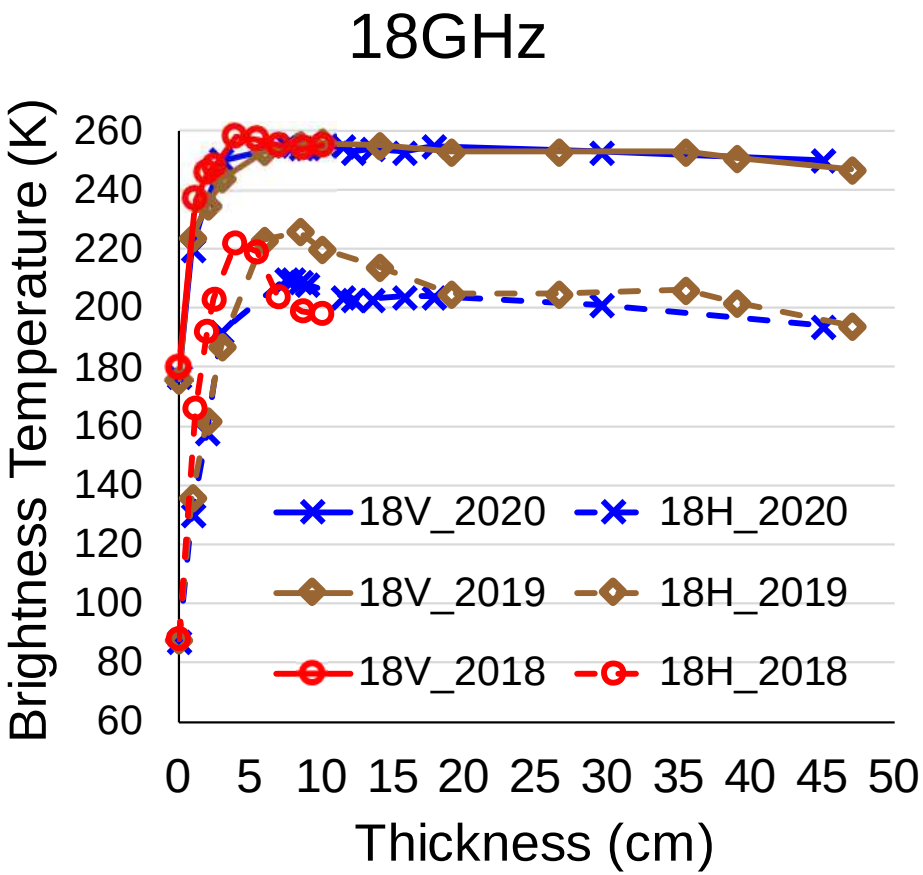
5. Sea Ice tank experiment

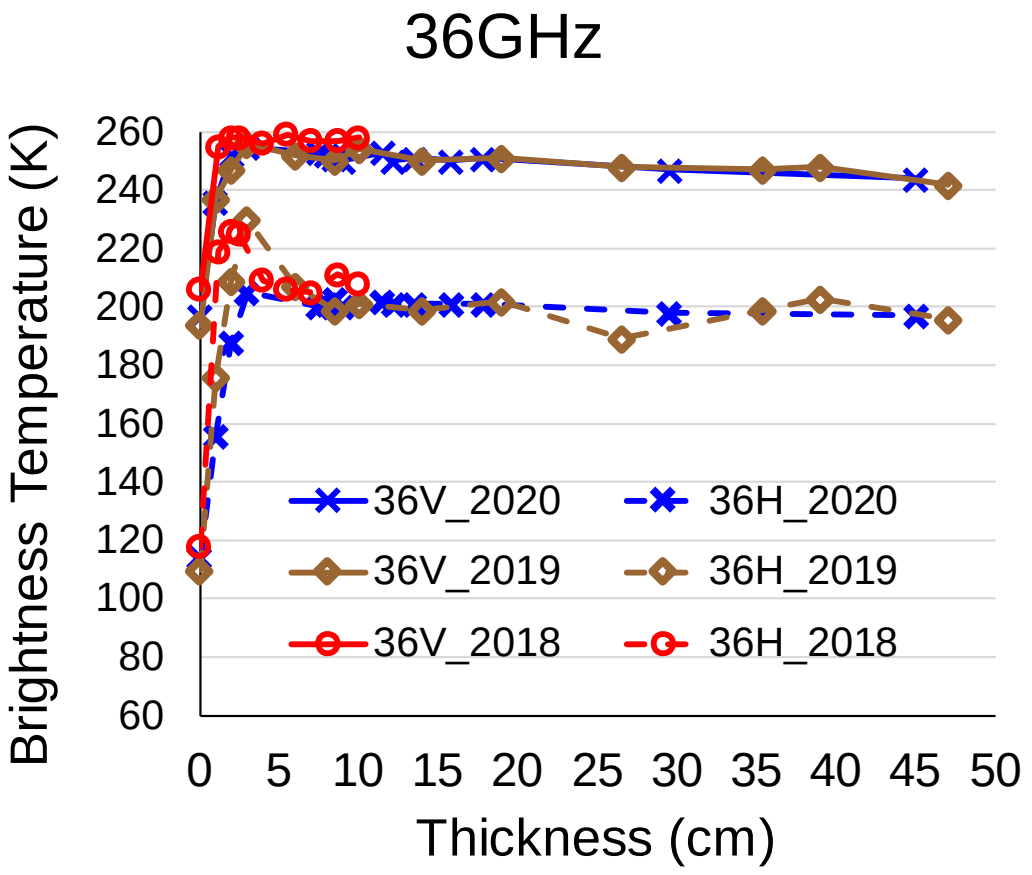
- A tank was set up outdoor on the roof of a building of Hokkaido University of Education.
- The tank was filled with seawater acquired from the Pacific Ocean along the coast of Hokkaido.(Salinity :33ppt)

Portable Radiometer

Parameter	Spec	Spec
Center Frequency	18.7GHz	36.5GHz
Polarization	Single (V or H)	Single (V or H)
Accuracy	1K Typ.	1K Typ.
Beam width	10deg	7deg
Incident angle	55deg.	55deg.

Result of the measurement





- TB of all channels jumped high soon after the sea ice formation.
- TB of 36 GHzV saturated at the sea ice thickness grew of 2 cm.
- TB of 18 GHzV saturated at the sea ice thickness of 6 cm.

Conclusion

- Sea ice concentration calculation accuracy
  RMSE were less than 10% in most of the test areas.
  The verification method using MODIS was improved.

- Weather filter
  The weather filter parameter should be modified to reduce the weather effects. $T_B(23V) - T_B(18V) > 18K \rightarrow 8K$

- Validation of Thin Ice Algorithm
  The thin ice area algorithm is working properly for the Northern Hemisphere.

  Thin ice area extraction method using MODIS was developed.

- Sea ice tank experiment
  The result suggested the certain limitation of measuring sea ice thickness using passive microwave radiometers at frequencies of 18 GHz and 36 GHz. However, lower frequency was more sensitive to ice thickness.