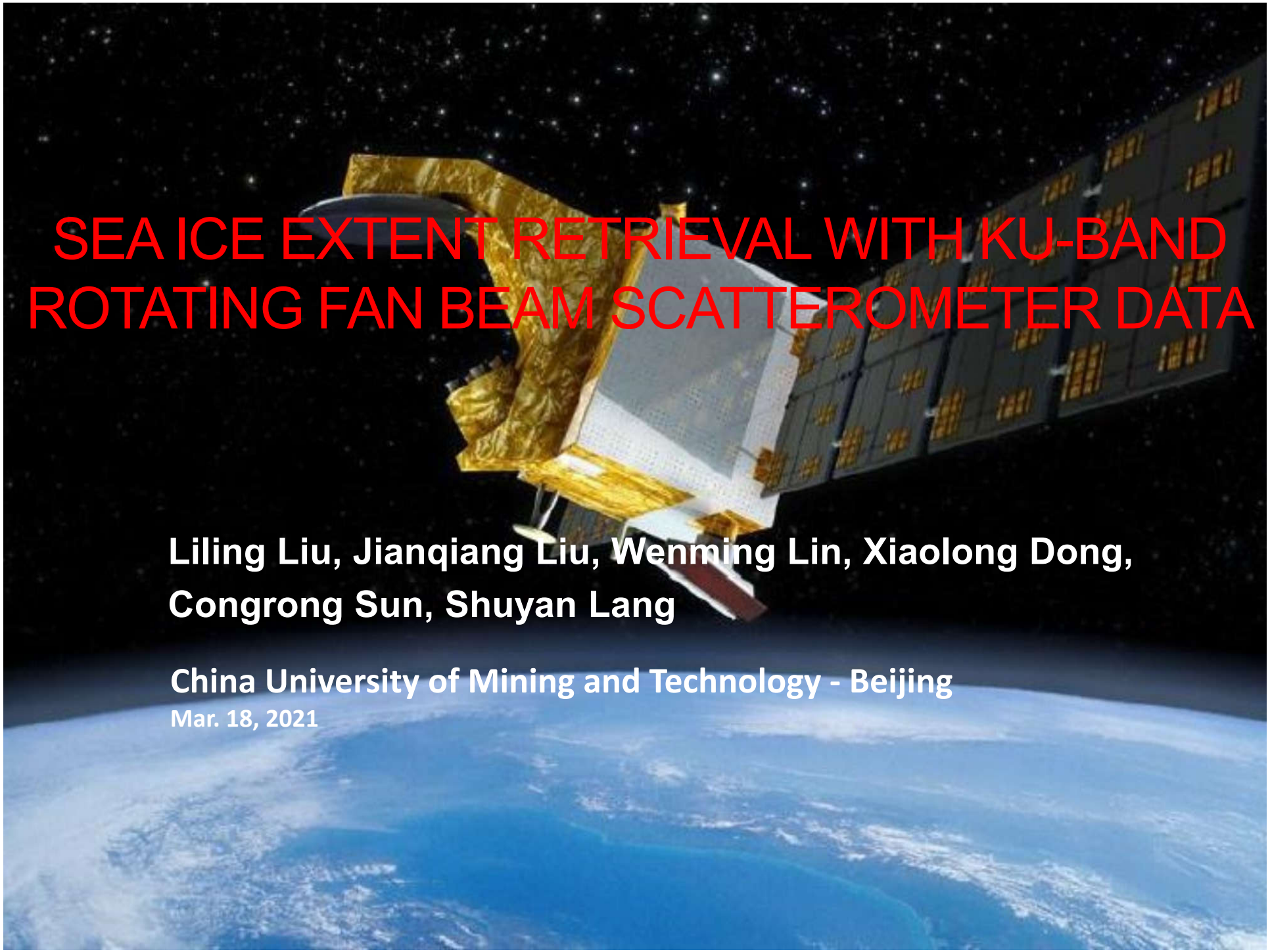

SEA ICE EXTENT RETRIEVAL WITH KU-BAND ROTATING FAN BEAM SCATTEROMETER DATA

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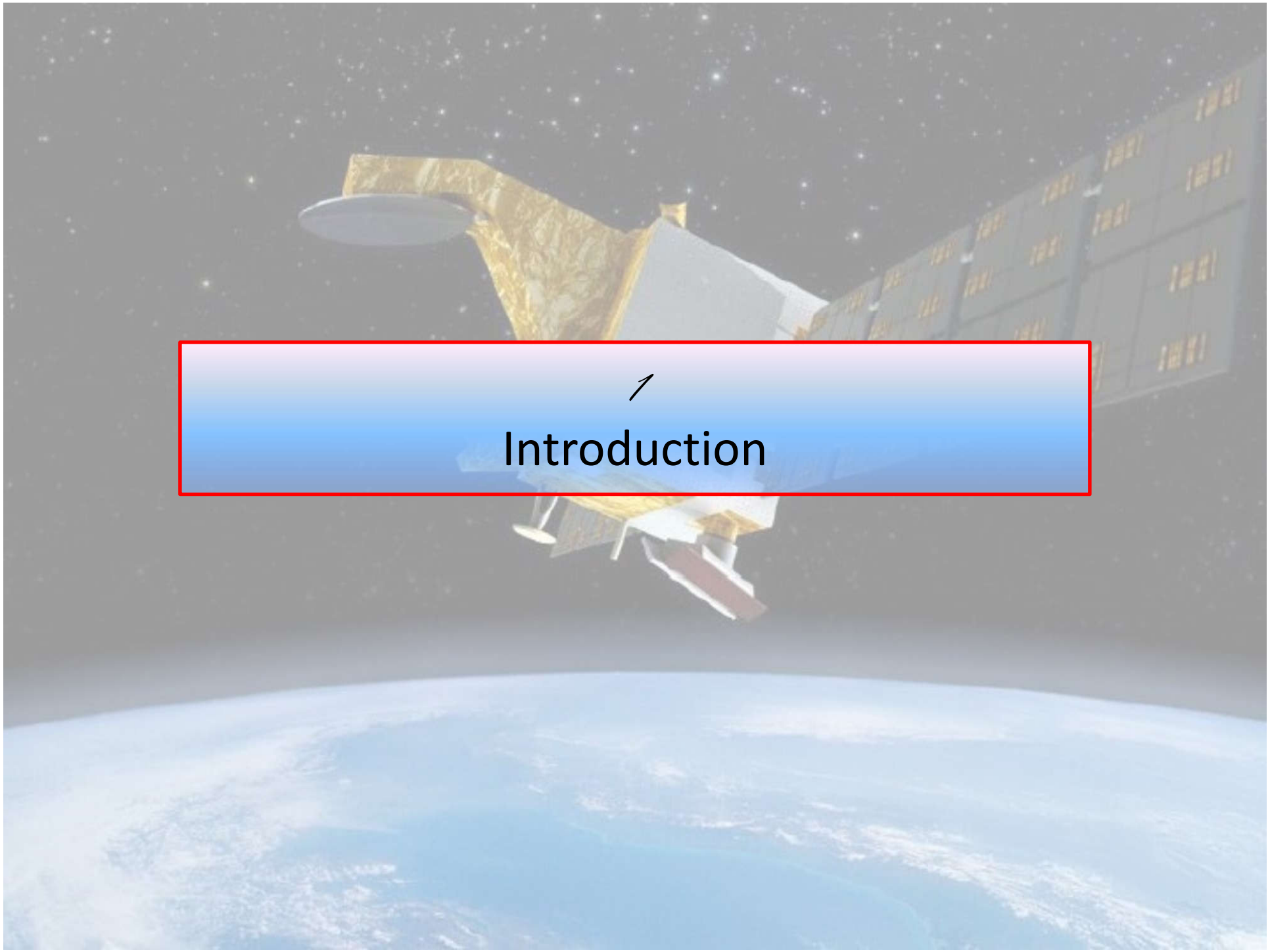
China University of Mining and Technology - Beijing

Mar. 18, 2021

Outlines

- Introduction
- CFOSCAT Bayesian Sea Ice Discrimination Processing
- Algorithm Validation and Discussion
- Conclusions

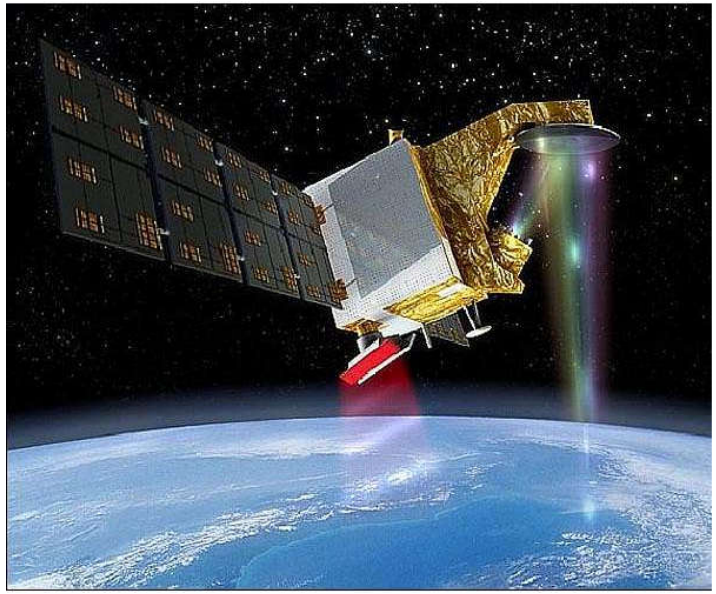


1 Introduction

Sea Ice Extent Retrieval with Scatterometer

Polar sea ice is an important input to global climate models and is considered to be a sensitive indicator of climate change. While originally designed only for wind estimation, radar backscatter measurements collected by wind scatterometers have proven useful for estimating the extent of sea ice.

In the past few decades, the development of satellite remote sensing techniques has provided new solutions and valuable data for monitoring the vast expanse of sea ice in the polar region. The **satellite scatterometer**, which is able to measure the backscatter characteristics of surface coverage, has been verified as a useful tool for polar sea ice monitoring.

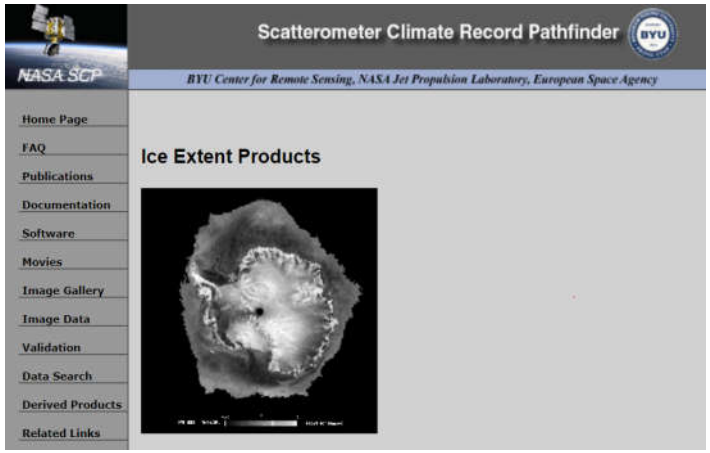


Sea Ice Extent Retrieval Methods

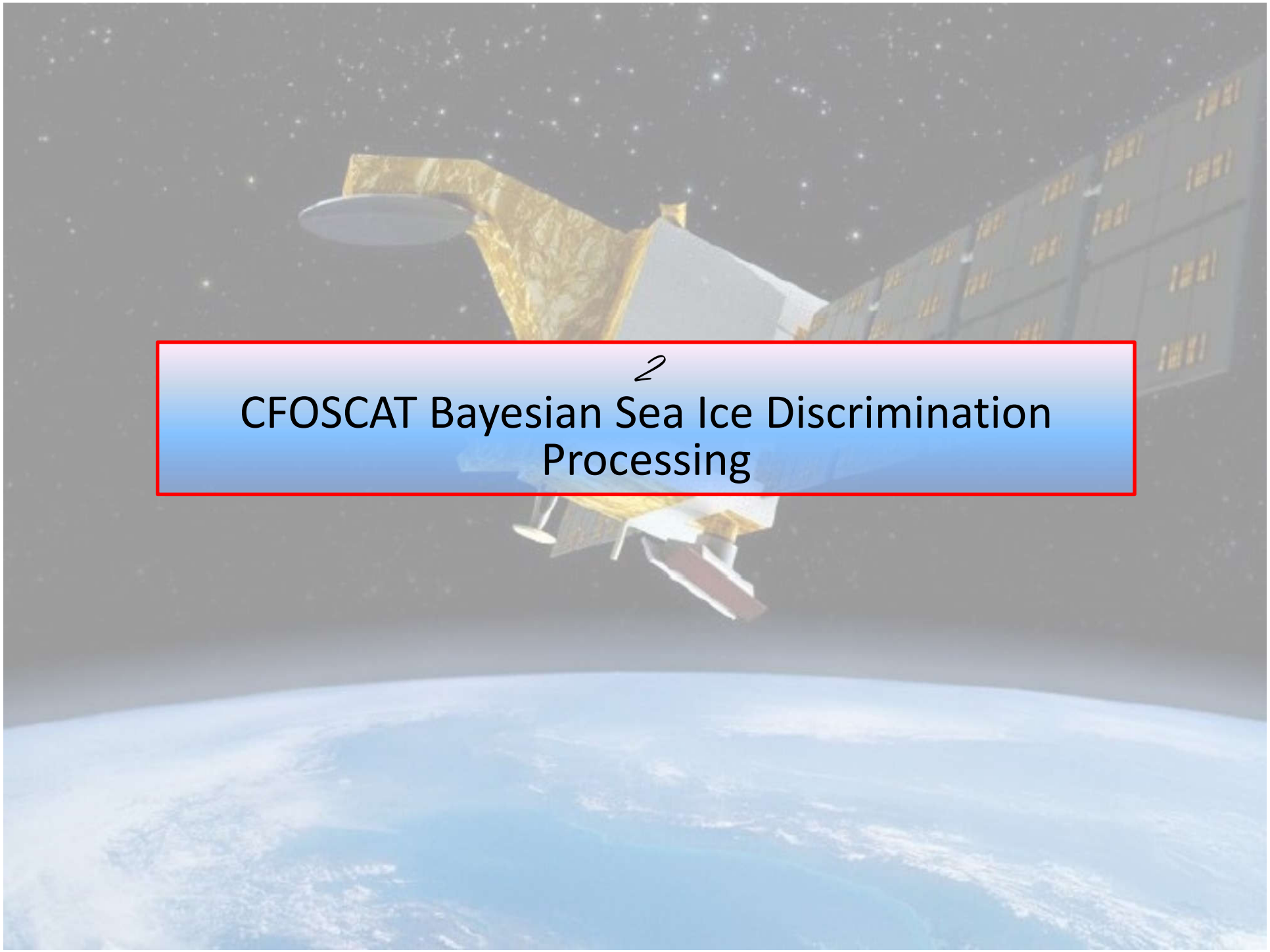
- KNMI Daily Arctic and Antarctic sea ice extents
  http://projects.knmi.nl/scatterometer/ice_extents/

- ASCAT: 2007.1-2017.12
- ERS1/2: 1992.3.-2001.1
- OSCAT: 2009.12-2014.2
- SeaWinds: 1999.7 -2009.11
- CFOSCAT: 2019-

- SCP Daily Arctic and Antarctic sea ice extents
  https://www.scp.byu.edu/data/iceextent.html



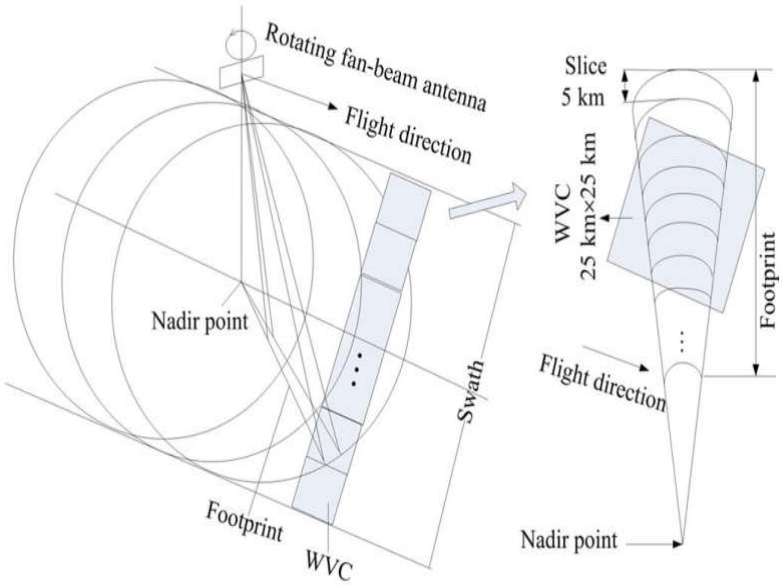
- QSCAT: 1999.1-2009
- OSCAT: 2009.12-2014.2
- CFOSCAT?



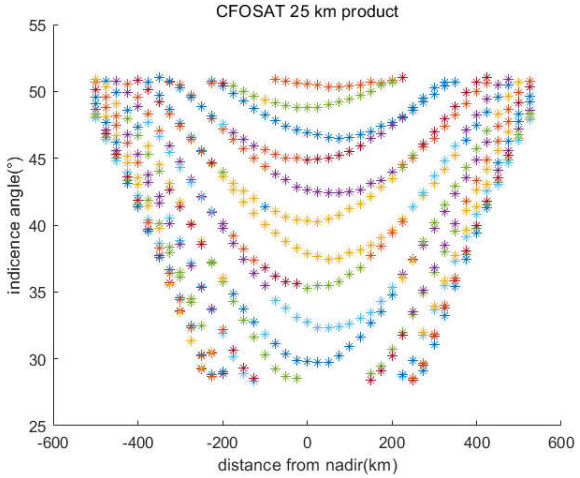
2

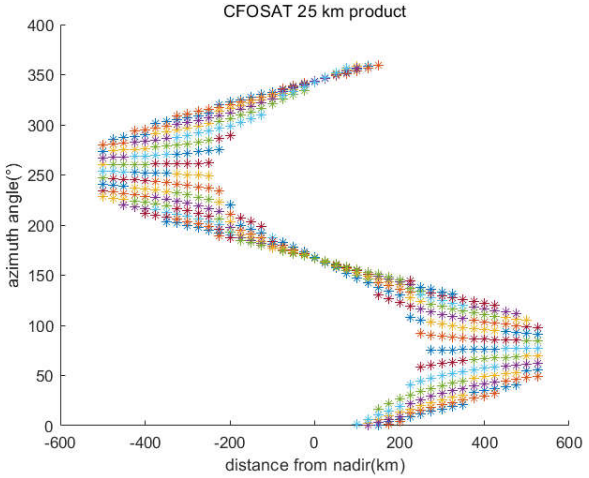
CFOSCAT Bayesian Sea Ice Discrimination Processing

Rotating Fan Beam Scatterometer - CFOSCAT

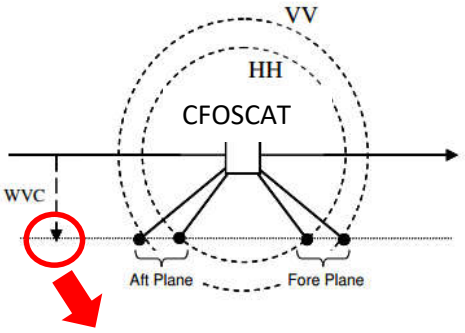


Specification	Value
Frequency	13.256 GHz
Bandwidth	0.5 MHz
Polarizations	HH and VV
Swath width	>1000 km
Orbit height	519 km
Inclination	97°
Incidence angles	26°~51°
Wind vector cell (WVC) resolution	12.5Km/25Km
Rotation rate	3.3 rpm
Pulse width	1.35 ms
Pulse repetition frequency (PRF)	150 Hz
Noise figure and losses within instrument	5 dB





Bayesian Sea Ice Discrimination Algorithm



$$\{\sigma^0\}=\{\sigma^0_{\text{VV-fore}},\ \sigma^0_{\text{HH-fore}},\ \sigma^0_{\text{VV-aft}},\sigma^0_{\text{HH-aft}}\}$$

Two classes: ice and water $p_0(\text{ice})+p_0(\text{wind})=1$

Distribution of Ice MLE

Distribution of Wind MLE

$$p(\text{ice}\,|\,\sigma^0)=\frac{p(\sigma^0\,|\,\text{ice})\,p_0(\text{ice})}{p(\sigma^0\,|\,\text{ice})\,p_0(\text{ice})+p(\sigma^0\,|\,\text{wind})\,p_0(\text{wind})}$$

Posterior Probability

Prior Probability

$$p(\sigma^0|\text{wind})=p(\text{MLE}_{\text{wind}})=\chi^2_{Q=2}(\text{MLE}_{\text{wind}})=\frac{1}{2}\exp(-\text{MLE}_{\text{wind}}/2)$$

$$\text{MLE}_{\text{wind}}=\min\left\{\sum_{i=1,\ldots,N}\left(\sigma^0_i-\sigma^0_{wind,i}\right)^2\Big/\text{var}\left[\sigma^0_{wind,i}\right]\right\}$$

$$p(\sigma^0|\text{ice})=p(\text{MLE}_{\text{ice}})=\chi^2_{Q=1}(\text{MLE}_{\text{ice}})=\sqrt{\frac{\text{MLE}_{\text{ice}}}{2\pi}}\exp(-\text{MLE}_{\text{ice}}/2)$$

$$\text{MLE}_{\text{ice}}=\min\left\{\sum_{i=1,\ldots,N}\left(\sigma^0_i-\sigma^0_{\text{ice},i}\right)^2\Big/\text{var}\left[\sigma^0_{\text{ice},i}\right]\right\}$$

$$p_0(\text{ice})=1-p_0(\text{wind})\qquad p_0(\text{ice})=p(\text{ice}\,|\,\sigma^0)\qquad p_0(\text{ice})=\begin{cases}0.5, \text{ if } p(\text{ice}\,|\,\sigma^0)>0.30\\0.15, \text{ if } p(\text{ice}\,|\,\sigma^0)<0.30\end{cases}$$

CFOSCAT Bayesian Sea Ice Discrimination Processing

- Read input data

SCA_L2A、SCA_L2B NetCDF data

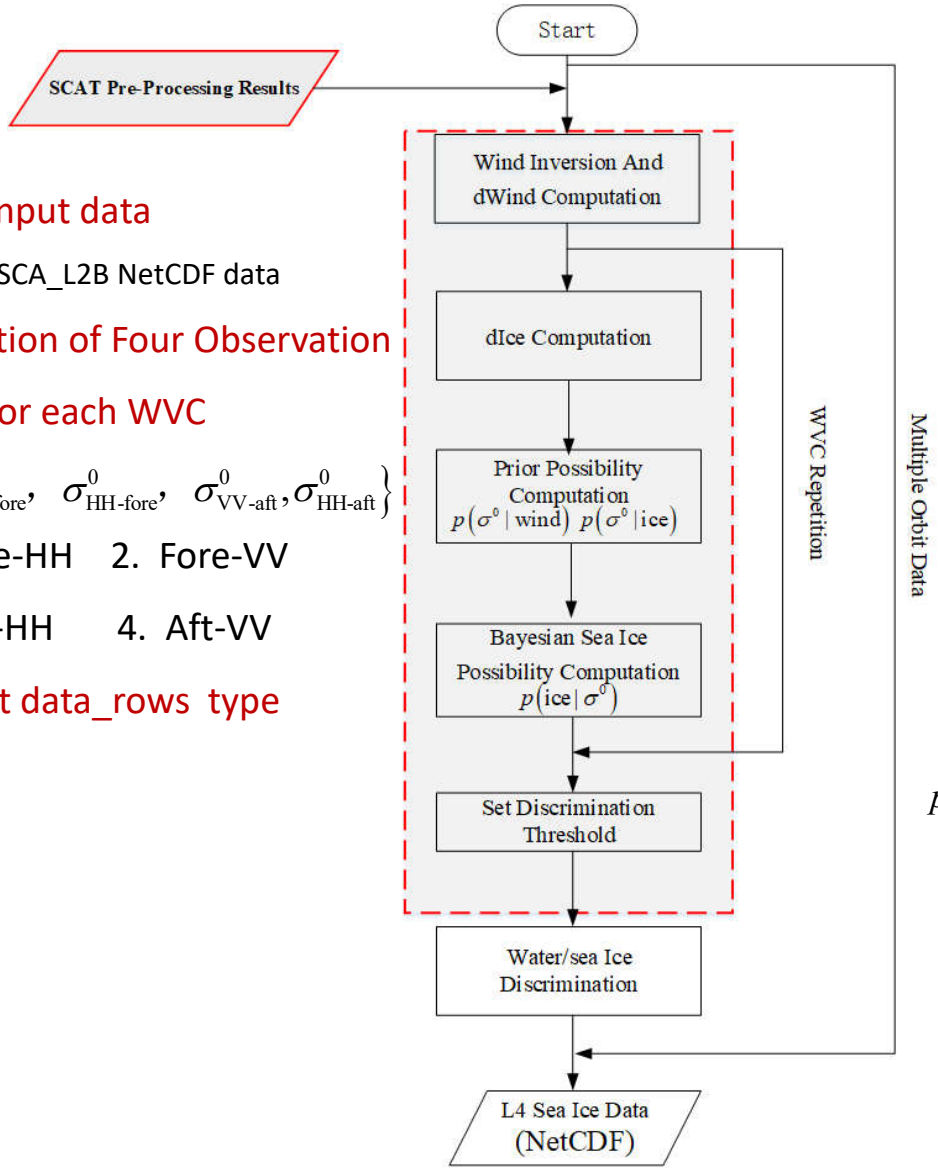
- Extraction of Four Observation Data For each WVC

$$\{\sigma^0\}=\{\sigma^0_{\text{VV-fore}},\ \sigma^0_{\text{HH-fore}},\ \sigma^0_{\text{VV-aft}},\sigma^0_{\text{HH-aft}}\}$$

1. Fore-HH 2. Fore-VV

3. Aft-HH 4. Aft-VV

- Output data_rows type



- Wind inversion and dWind computation

$$\text{MLE}_{\text{wind}}=\min\left\{\sum_{i=1,\ldots,4}\left(\sigma_i^0-\sigma^0_{wind,i}\right)^2\Big/\text{var}\left[\sigma^0_{wind,i}\right]\right\}$$

- dIce computation

$$\text{MLE}_{\text{ice}}=\min\left\{\sum_{i=1,\ldots,N}\left(\sigma_i^0-\sigma^0_{\text{ice},i}\right)^2\Big/\text{var}\left[\sigma^0_{\text{ice},i}\right]\right\}$$

- Prior possibility computation

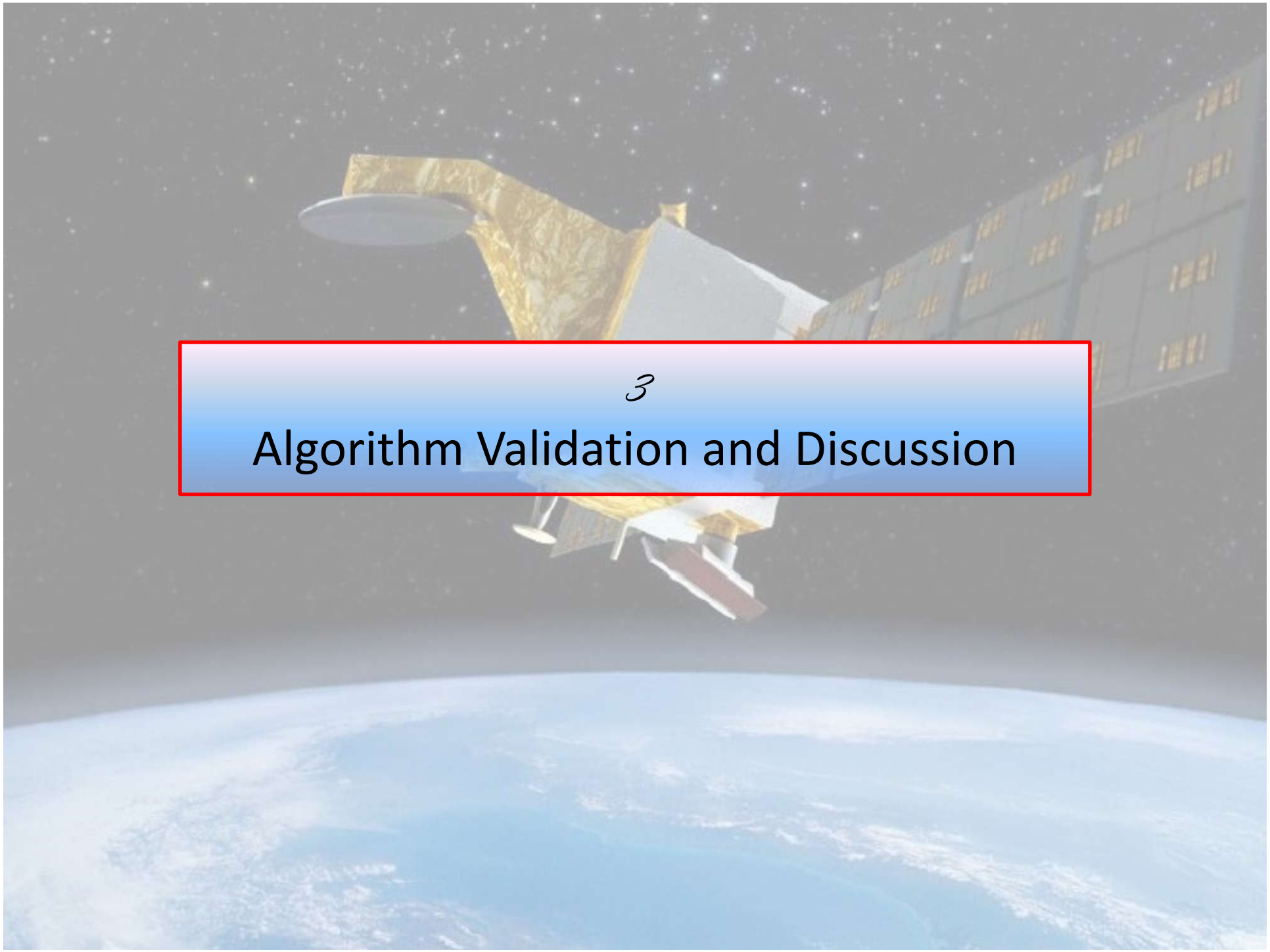
$$p\left(\sigma^0|\text{wind}\right)=\frac{1}{2}\exp(-\text{MLE}_{\text{wind}}/2)$$

$$p\left(\sigma^0|\text{ice}\right)=\sqrt{\frac{\text{MLE}_{\text{ice}}}{2\pi}}\exp(-\text{MLE}_{\text{ice}}/2)$$

- Bayesian sea ice possibility computation

$$p\left(\text{ice}|\sigma^0\right)=\frac{p\left(\sigma^0|\text{ice}\right)p_0\left(\text{ice}\right)}{p\left(\sigma^0|\text{ice}\right)p_0\left(\text{ice}\right)+p\left(\sigma^0|\text{wind}\right)p_0\left(\text{wind}\right)}$$

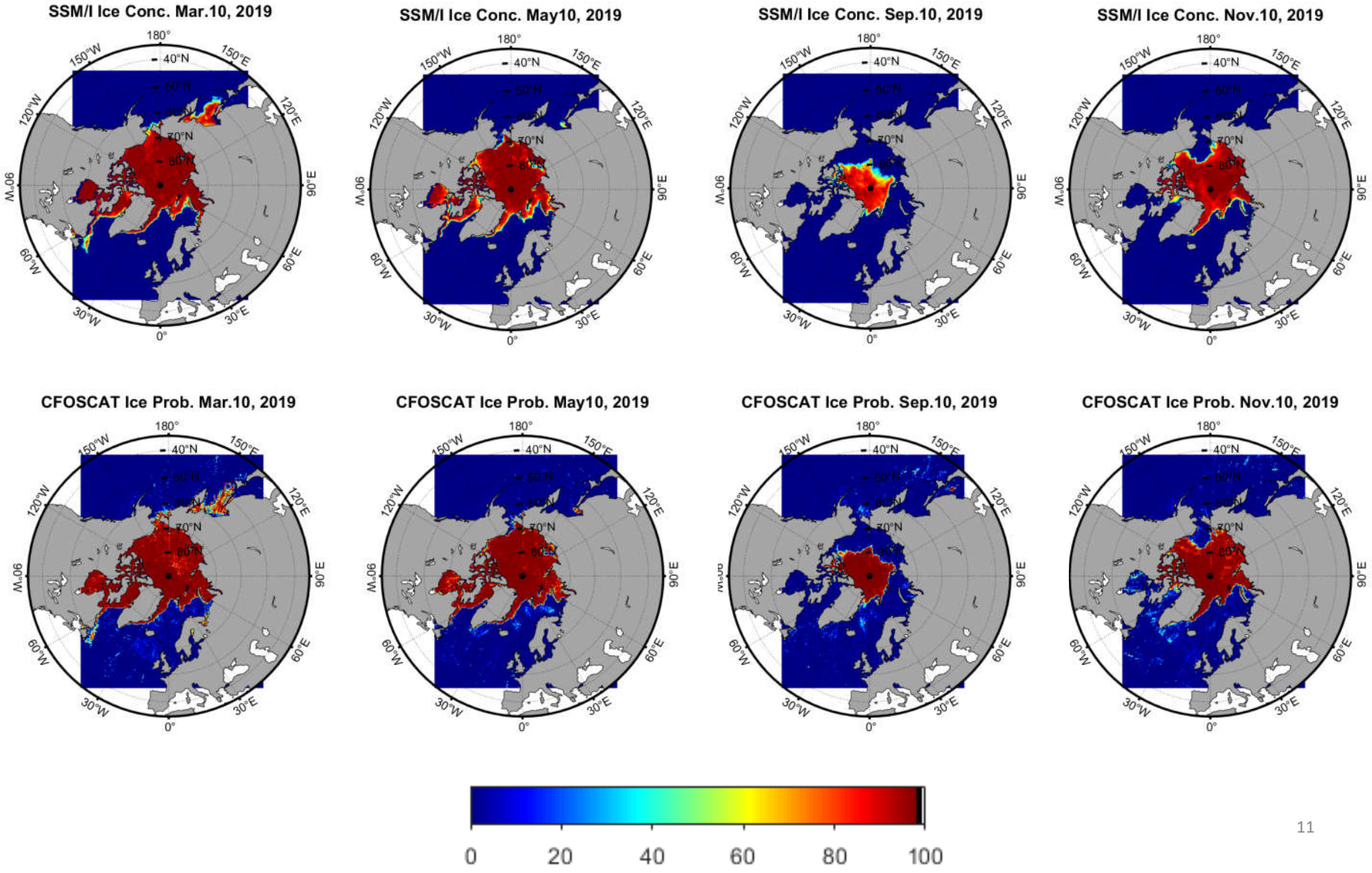
- Set discrimination threshold 55%



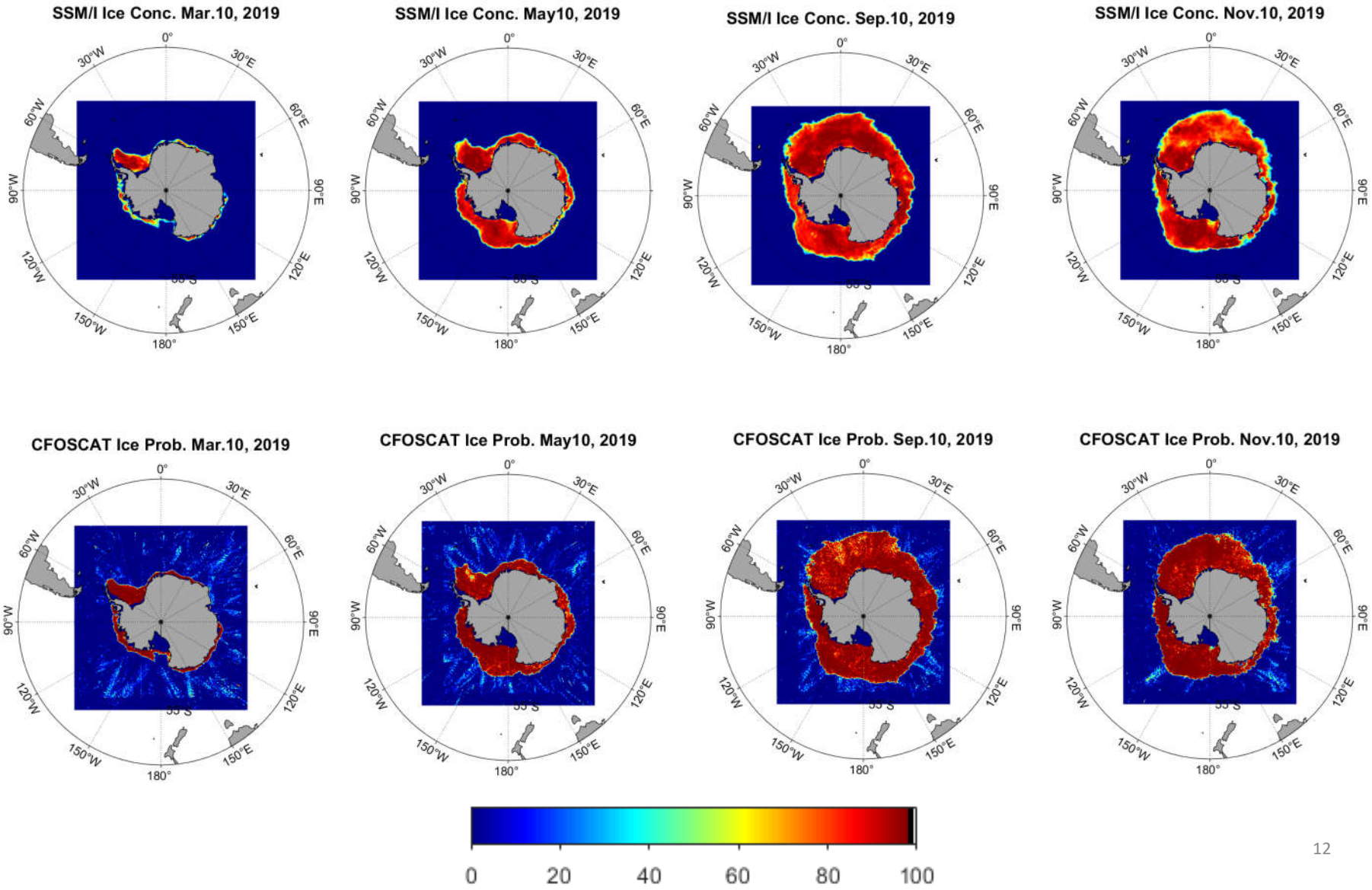
3

Algorithm Validation and Discussion

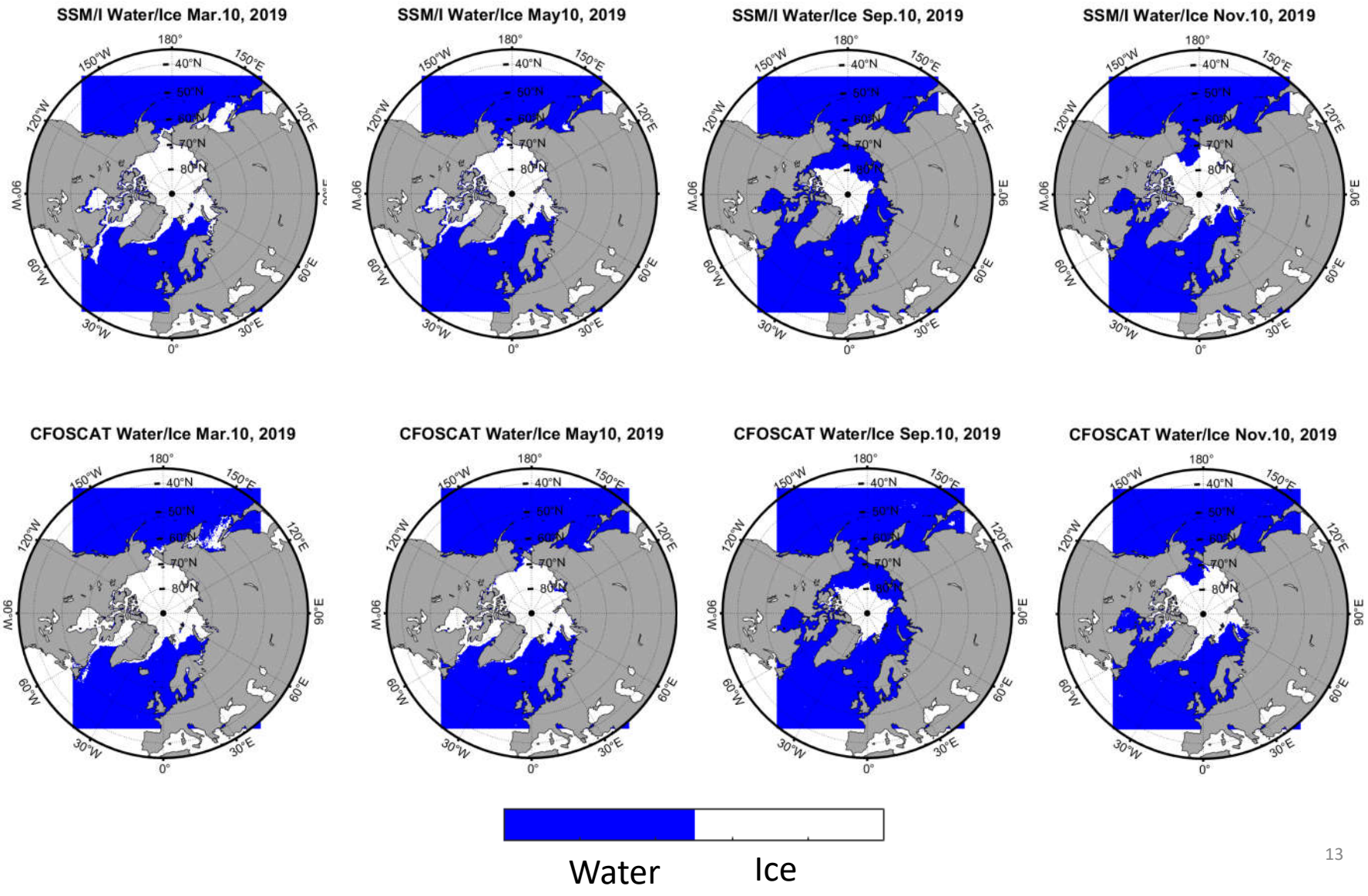
Bayesian Sea Ice Probability vs Ice Concentration(SSMI)



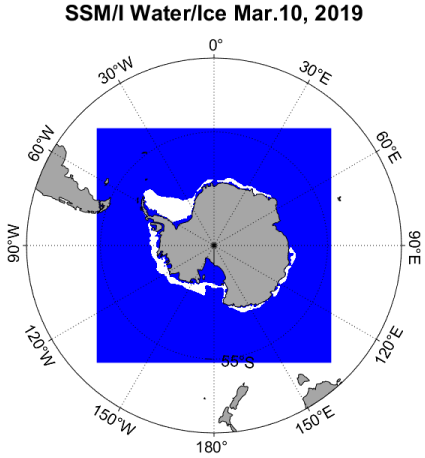
Bayesian Sea Ice Probability vs Ice Concentration(SSMI)

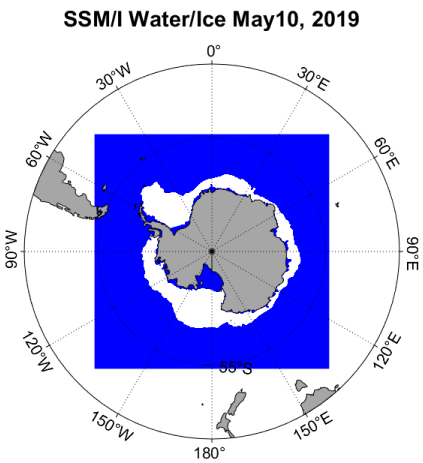


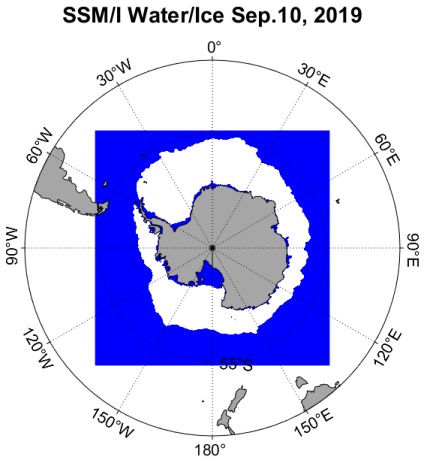
CFOSCAT@55% ice Probability vs SSMI@15% ice concentration

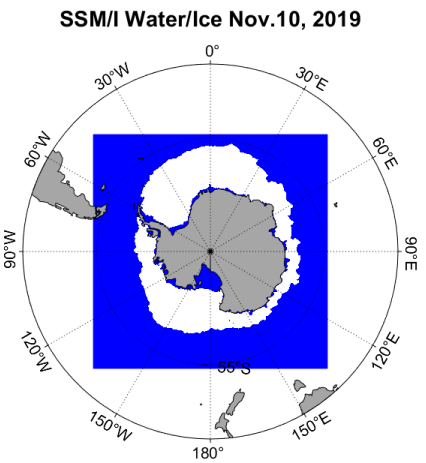


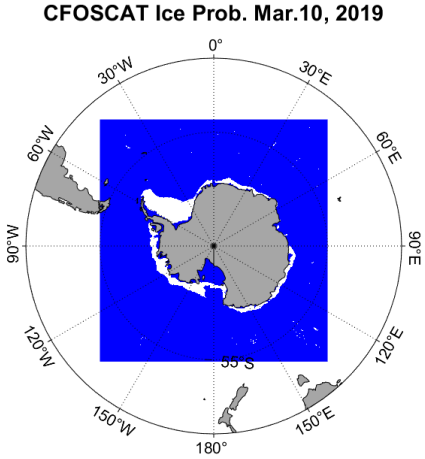
CFOSCAT@55% ice Probability vs SSMI@15% ice concentration

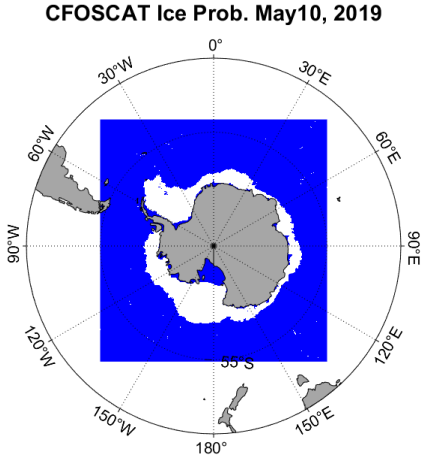


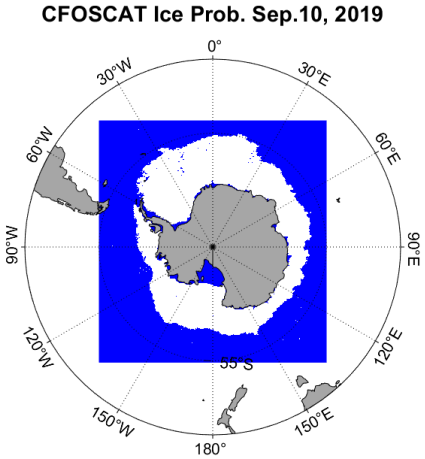


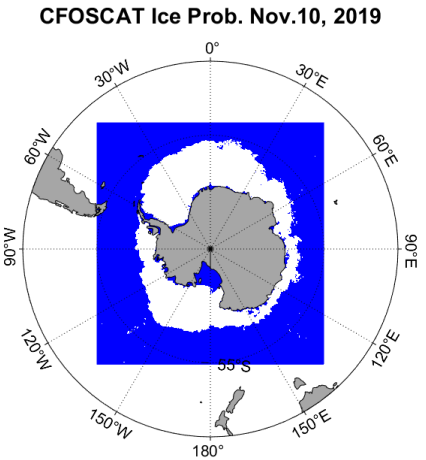




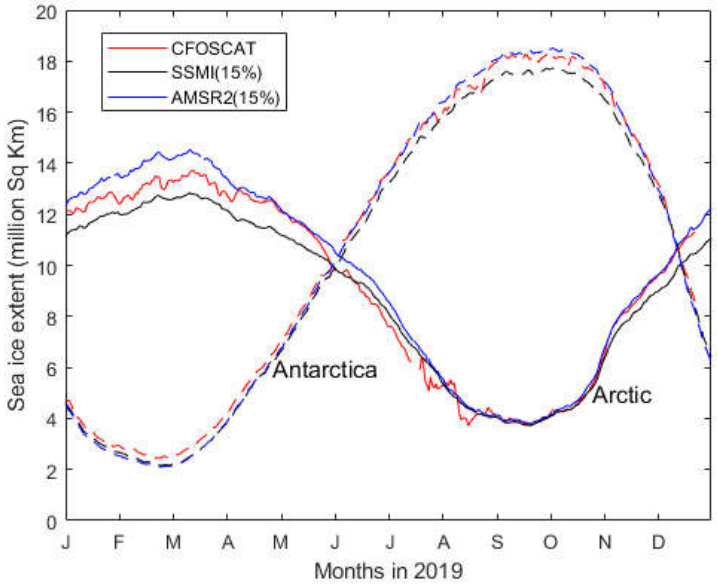


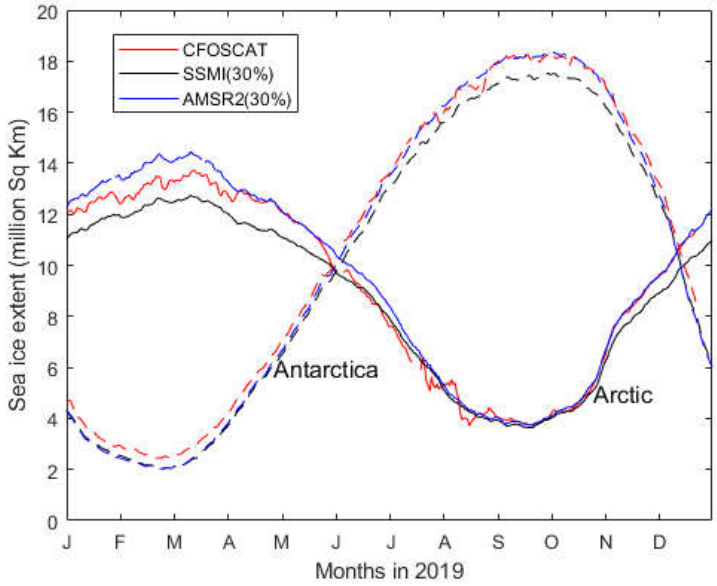


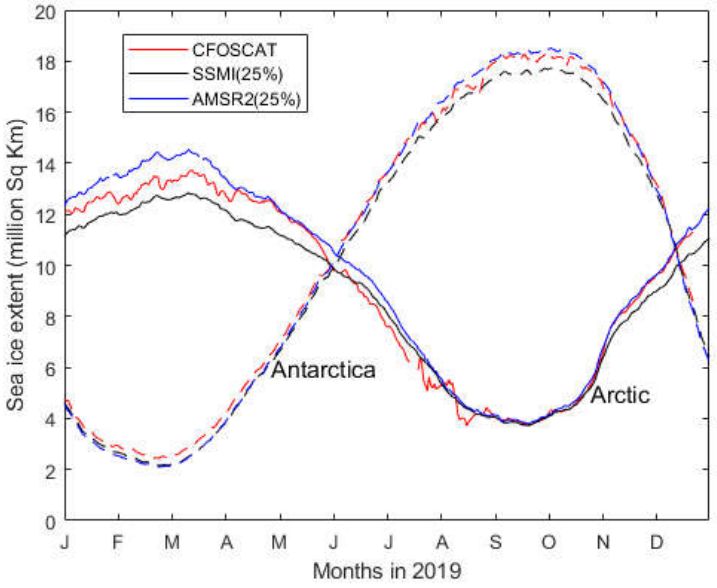




Daily sea ice extent of 2019

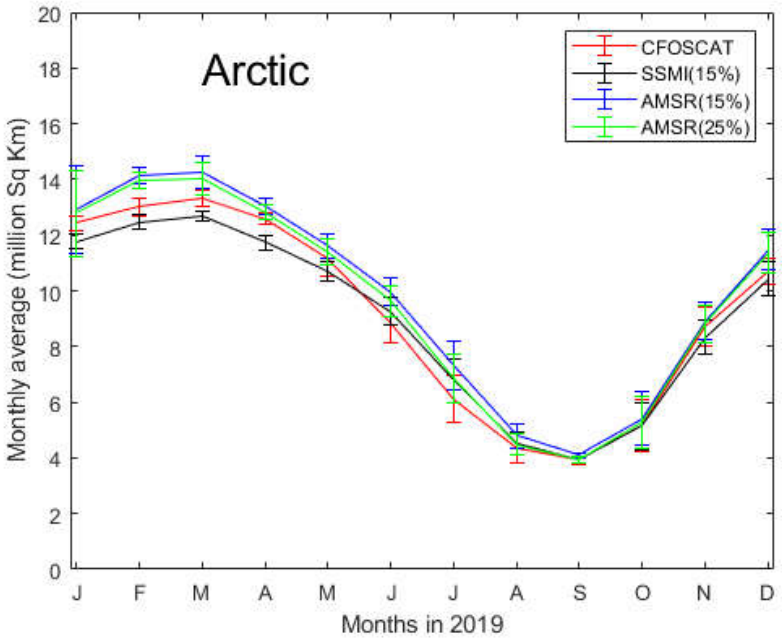


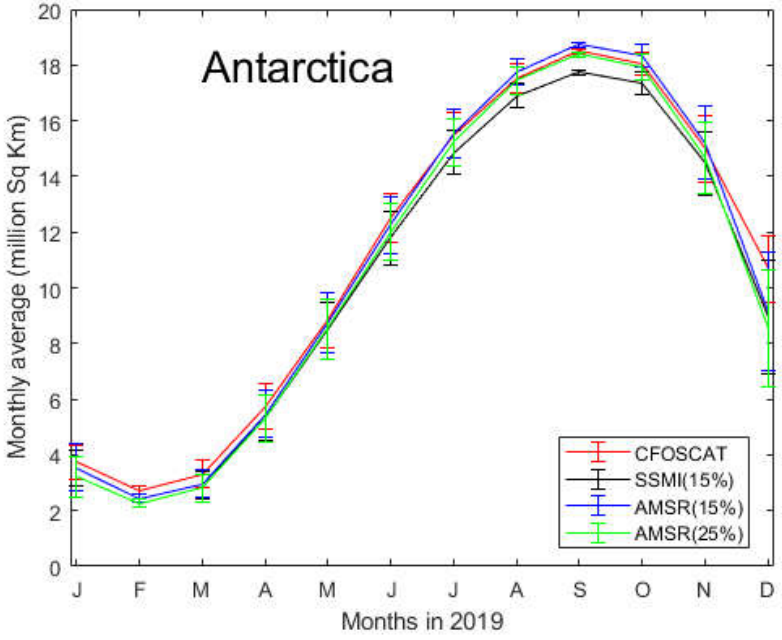




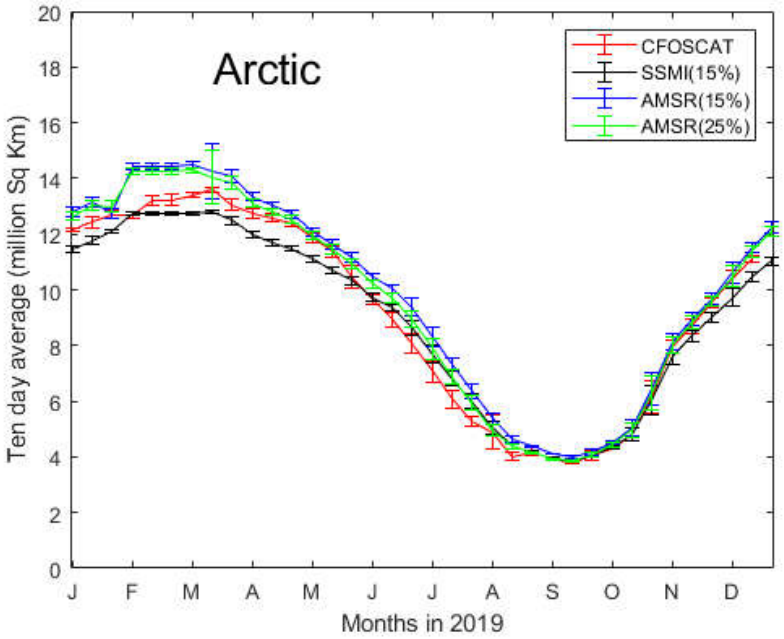
	Arctic		Antarctic	
	CFOSCAT vs SSMI	CFOSCAT vs AMSR2	CFOSCAT vs SSMI	CFOSCAT vs AMSR2
15%	**0.48±0.30**	0.61±0.42	**0.25±0.13**	0.34±0.25
25%	0.50±0.32	0.42±0.35	0.38±0.16	**0.25±0.14**
30%	0.55±0.35	**0.34±0.32**	0.57±0.18	0.30±0.17

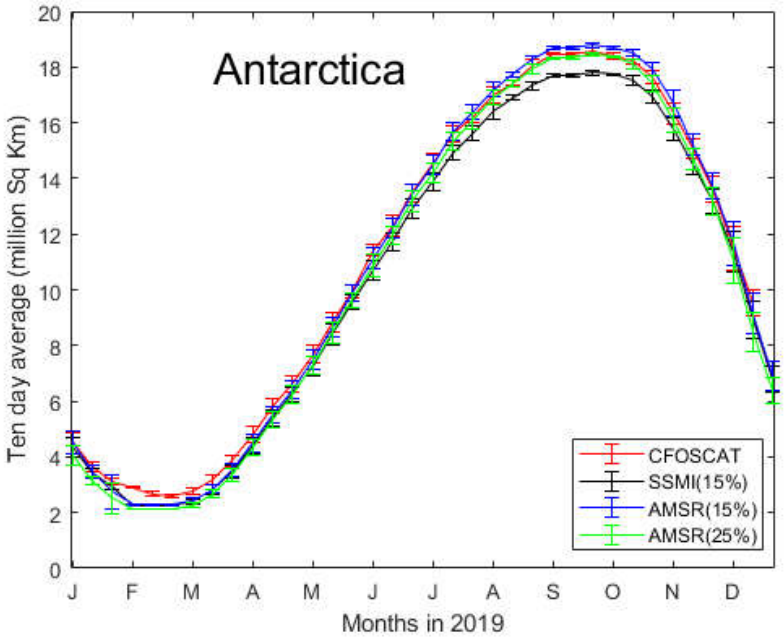
Monthly Average of Sea Ice Extent



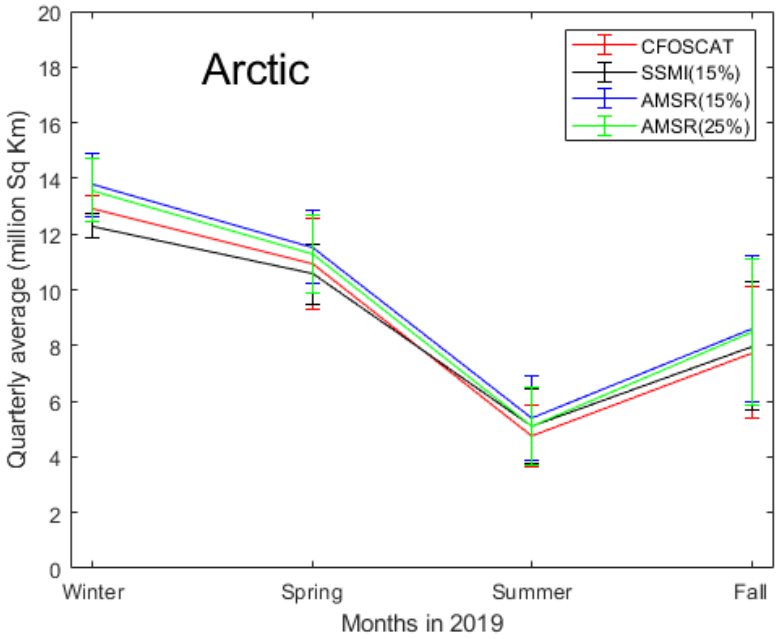


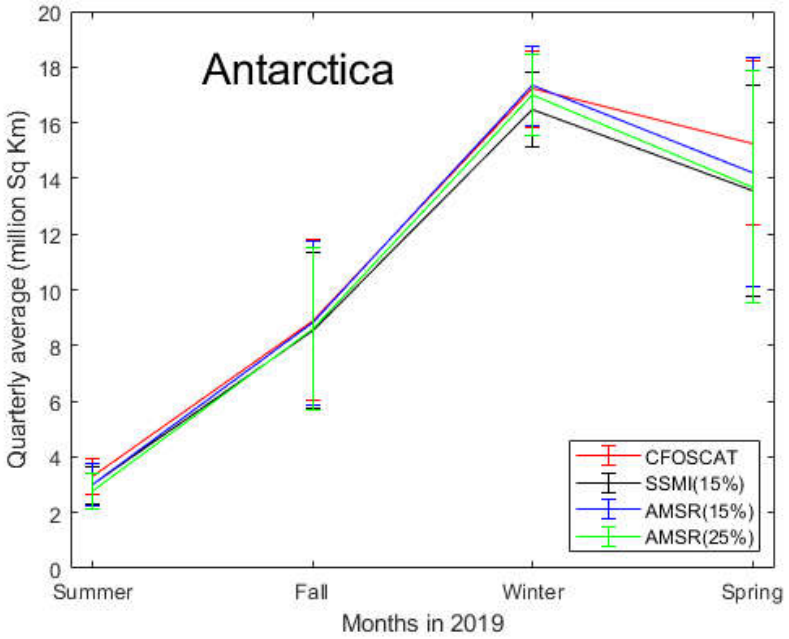
Ten Days Average of Sea Ice Extent

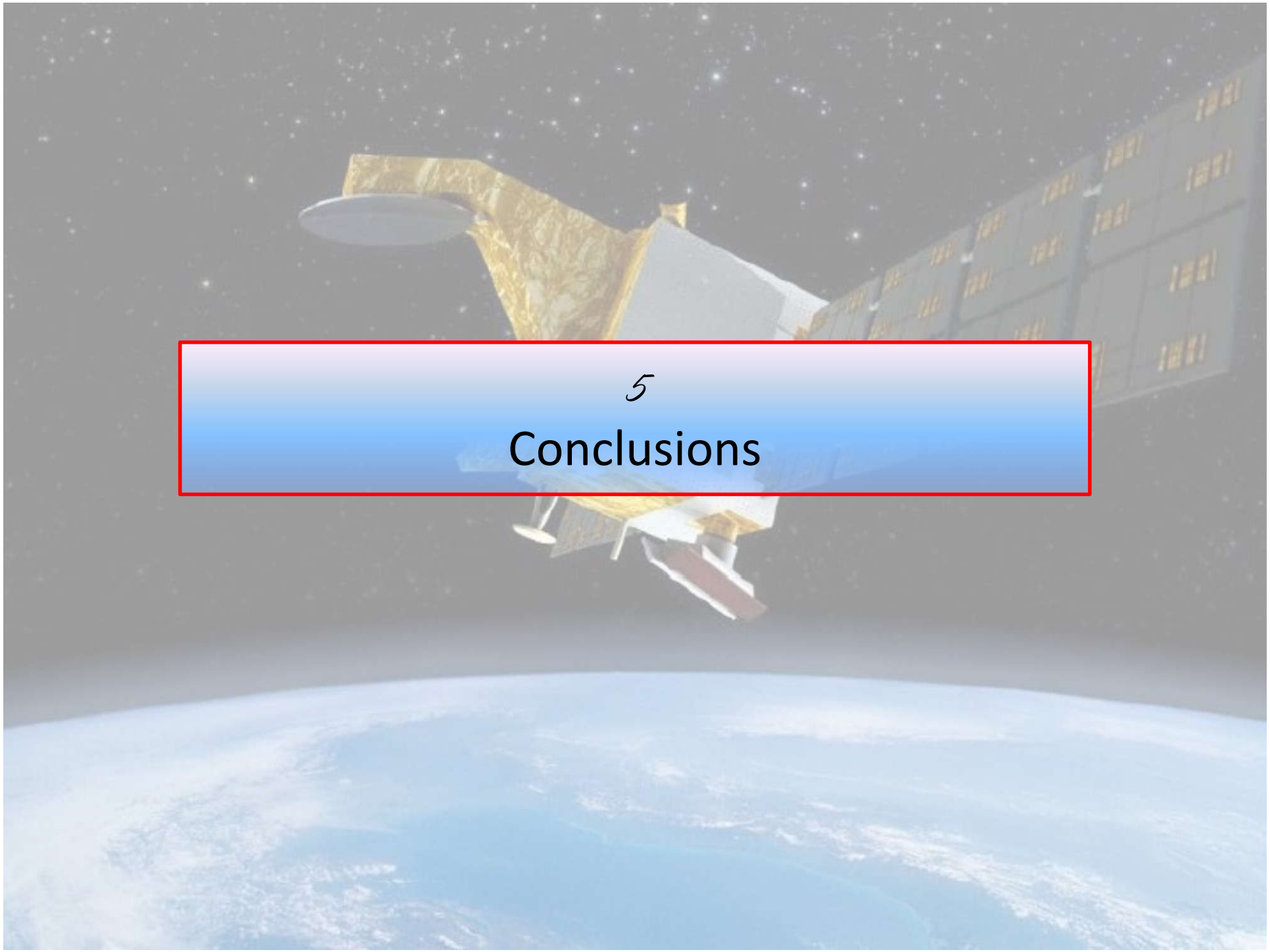




Quarterly Average of Sea Ice Extent







5
Conclusions

Conclusions

- The CFOSCAT Bayesian sea ice discrimination algorithm provides valuable information for the characterization of sea ice during the difficult melting season.

- The algorithm is validated against existing passive microwave ice concentration product on a global scale.

- The sea ice extent retrieval of CFOSCAT is discussed, and more validation will be done continuously.


Thank you for your attention.