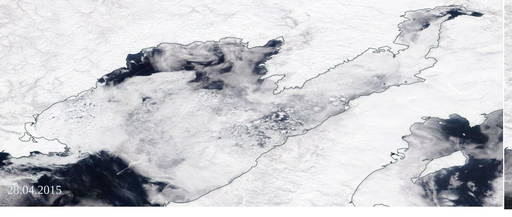
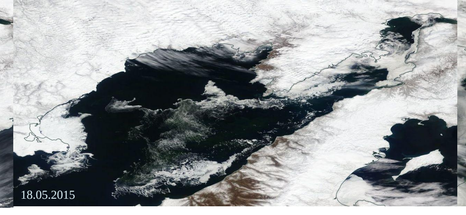
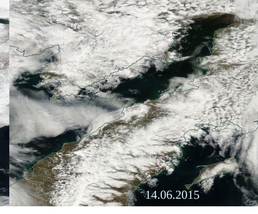
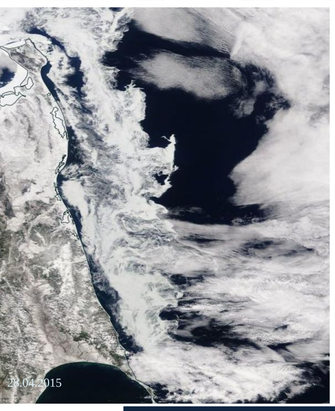






The First Results of Monitoring the Ice Cover of the Sea of Okhotsk in 2015-2016 according to the Measurements of the Radar Cross Section at Small Incidence Angles



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Introduction

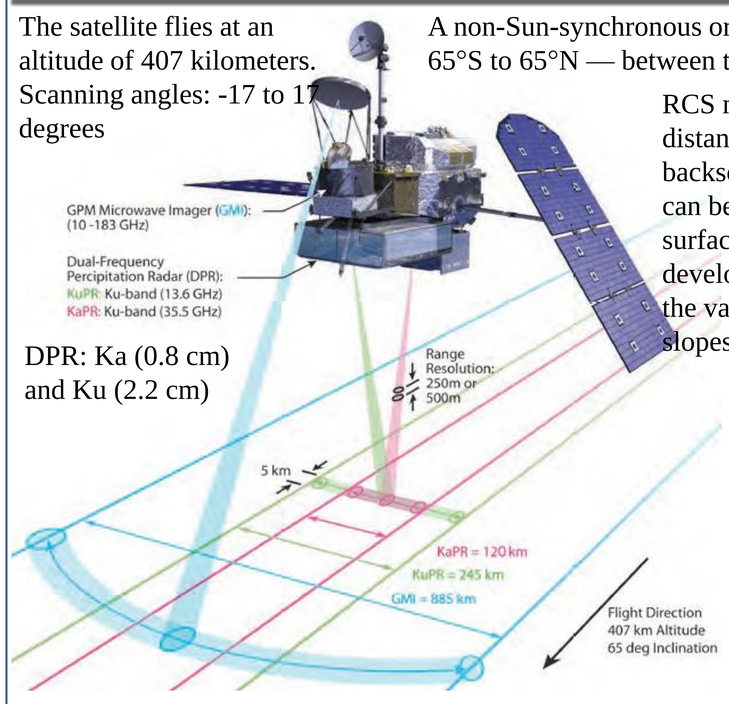
Monitoring of sea ice state in the coastal area is important for insuring safety of shipping and offshore oil and gas production, especially in the autumn and spring, when ice is very unstable. Modern remote sensing techniques are extensively used for ice monitoring, but they are not always capable of solving this problem in full scale, e.g., during heavy rains, the investigated area is covered with a dense layer of clouds, thus optical methods are inefficient.

The present study uses data from Dual–frequency Precipitation Radar (DPR), that was originally developed to measure precipitation intensity but can also be used for other applications [1-6]. GPM (Global Precipitation Mission) satellite with on-board DPR of wavelengths of 2.2 cm and 0.8 cm [7] has been in orbit since 2014. It senses the Earth surface at small incidence angles (<18.5). There we try to estimate the prospects of DPR data for monitor of the sea ice in the coastal area. In this paper, we first study this effect in the DPR image by the example of sea ice melting in the spring of 2015. For our study of the sea of Okhotsk we used ice maps that were constructed by meteorologists based on optical images and radiometer data available for an area of interest, those maps are made every 5-7 days by SRC “Planeta”.

GPM: DPR and GMI

The satellite flies at an altitude of 407 kilometers. Scanning angles: -17 to 17 degrees

A non-Sun-synchronous orbit that covers the Earth from 65°S to 65°N — between the Antarctic and Arctic Circle.

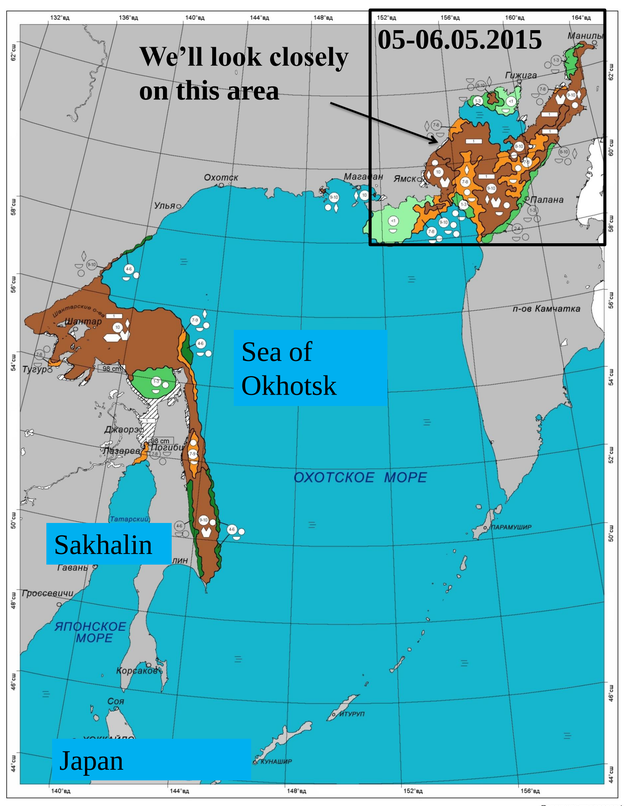


DPR: Ka (0.8 cm) and Ku (2.2 cm)

RCS measured at the maximum distance corresponds to the backscatter from surface and therefore can be used to determine the scattering surface parameters. Our team has developed algorithms for retrieving the variance of large-scale sea wave slopes and surface wind speed [4, 8].

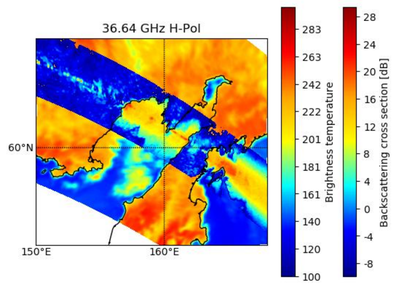
The high spatial resolution of DPR allowed our group to conduct a study of ice cover of the internal waters. The original algorithm for separation of the open water and ice cover was suggested in [9]. Here we verify the suitability of suggested algorithm for the sea ice detection.

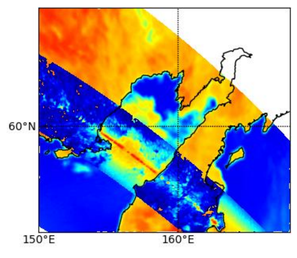
Ice maps



Blue – water
Light green – rare ice floes
Green – rare ice
Dark green – rarefied ice
Orange – solid drifting ice
Brown – solid ice

DPR: Ku (2.2 cm)
GMI: 36.64 GHz
H-Polarization





КАРТА-СХЕМА ЛЕДОВОЙ ОБСТАНОВКИ В ОХОТСКОМ МОРЕ

составлена по данным ИСЗ “МЕТЕОР-М” №1 / МСУ-МР, TERRA / MODIS, NOAA-18 / AVHRR 05-06.05.2015

Условные обозначения

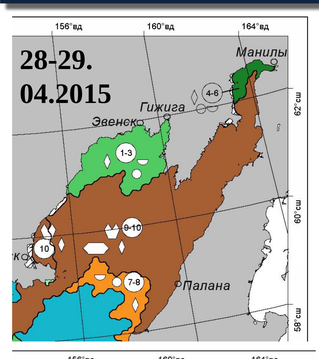
Сплоченность льда:
- чистая вода
- отдельные льдины (<1/10)
- редкий лед (1-3/10)
- разреженный лед (4-6/10)
- сплоченный лед (7-8/10)
- сплошной и очень сплоченный дрейфующий лед (9-10/10)
- припай

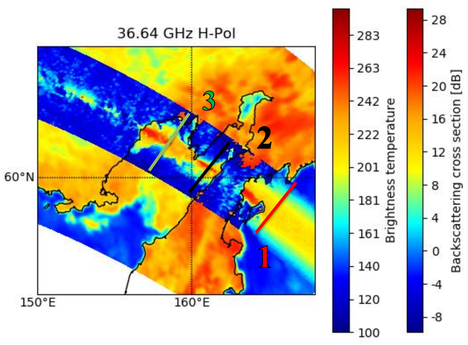
Формы плавучего льда:
- блинчатый лед
- тертый лед, ледяная каша (<2 м)
- мелкобитый лед (< 20 м)
- крупнобитый лед (20-100 м)
- обломки ледяных полей (100-500 м)
- большие ледяные поля (500-2000м)
- обширные ледяные поля (2-10 км)

Обобщенные характеристики льда:
- 1-3 - сплоченность льда в баллах
- 3-4 - разрушенность льда (от 0 до 5 баллов)
- разрежение льда
- 70-85 - показатель толщины льда (см)
- 3 - торосистость льда (от 0 до 5 баллов)
- 2 - показатель сжатия льда (от 1 до 3 баллов)

ФГБУ “НИЦ “ПЛАНЕТА” Россия, 123242, Москва, Б.Предтеченский пер., 7, Тел.: (499) 2523717, Факс: (499) 2526610, E-mail: asmus@planet.iitp.ru

Results



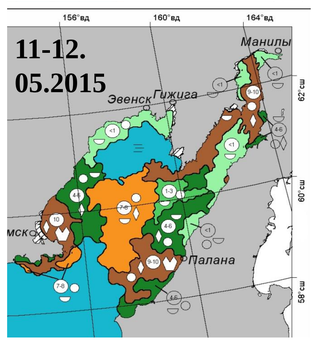


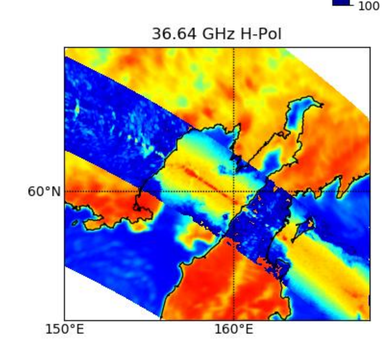
1 – water

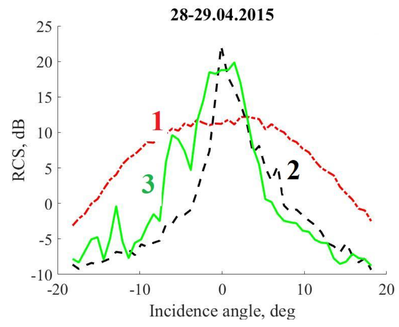
$$RCS \propto \exp(-tg^2\theta / 2\sigma_{xx}^2)$$

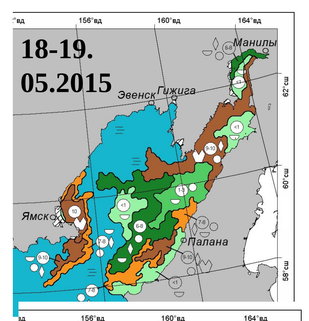
2 - ice

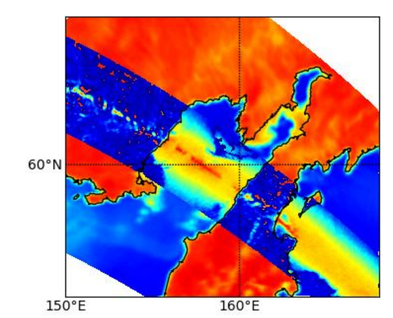
$$RCS \propto 1/(1+a\theta^2)$$

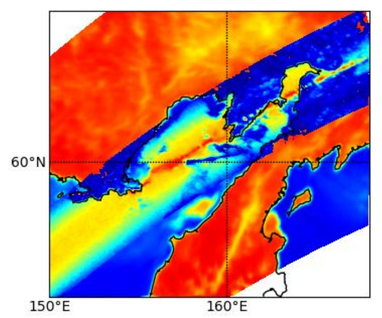


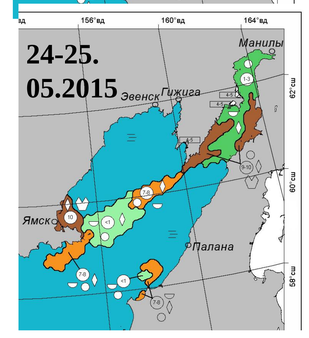


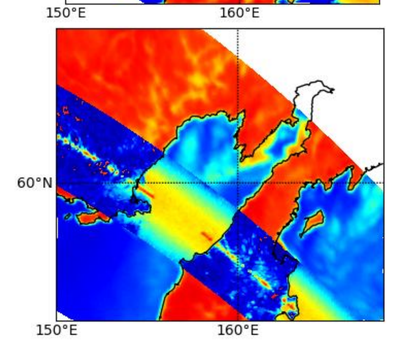


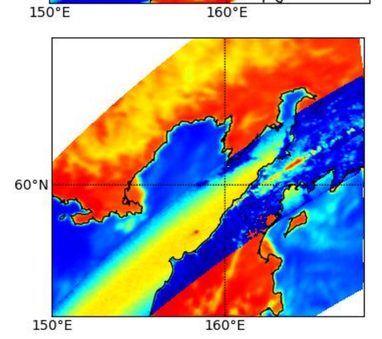


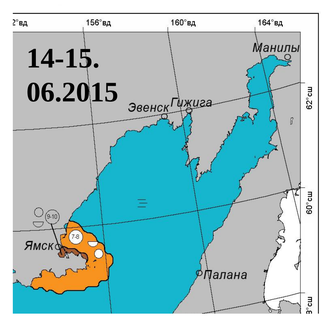


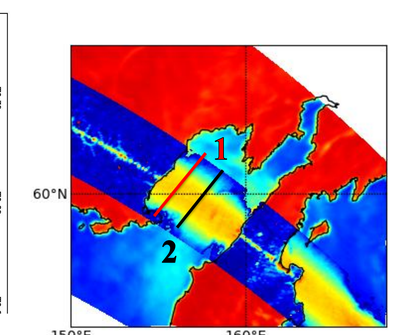


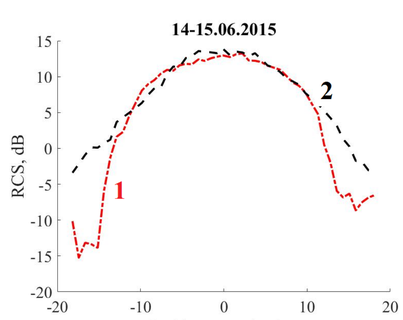












Conclusions

DPR can be used for monitoring of the sea ice in the coastal zone. The RCS dependency on incidence angle for sea ice is the same as for inland waters ice.

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Acknowledgments

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