GCOM-W Workshop
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Toward the creation of a global dataset of sea ice production for 40 yrs, by developing thin ice thickness algorithm of AMSR, SSM/I, & SMMR

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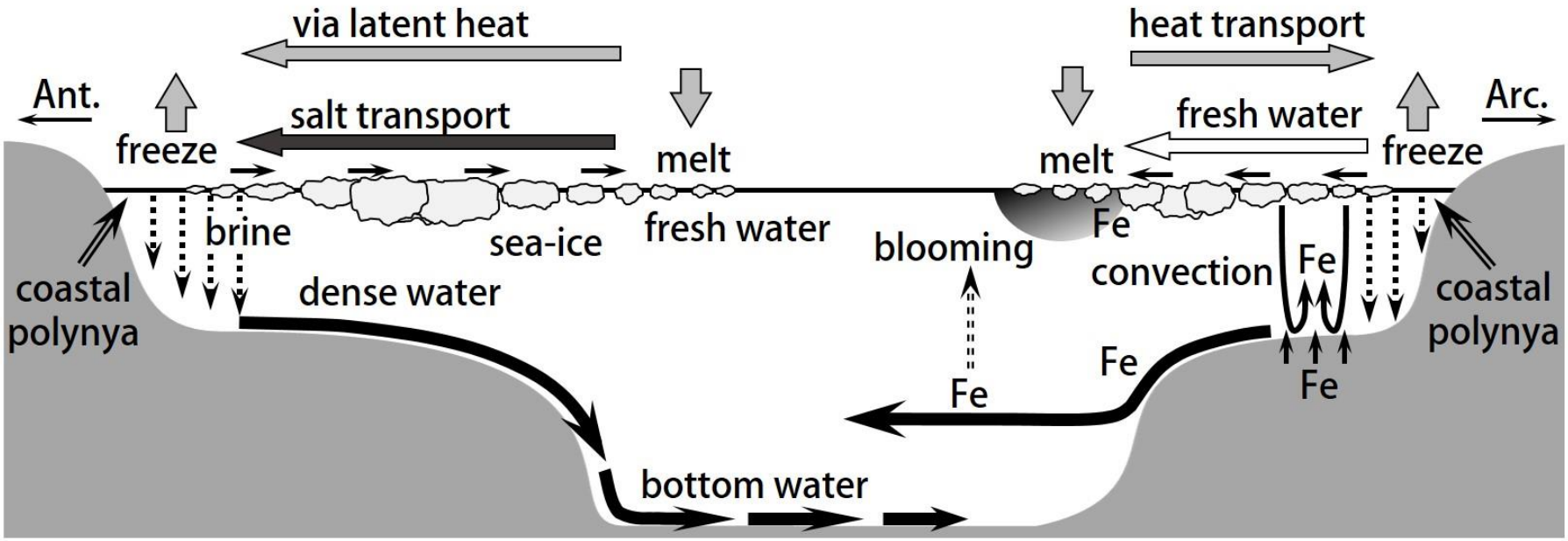
Background and purpose

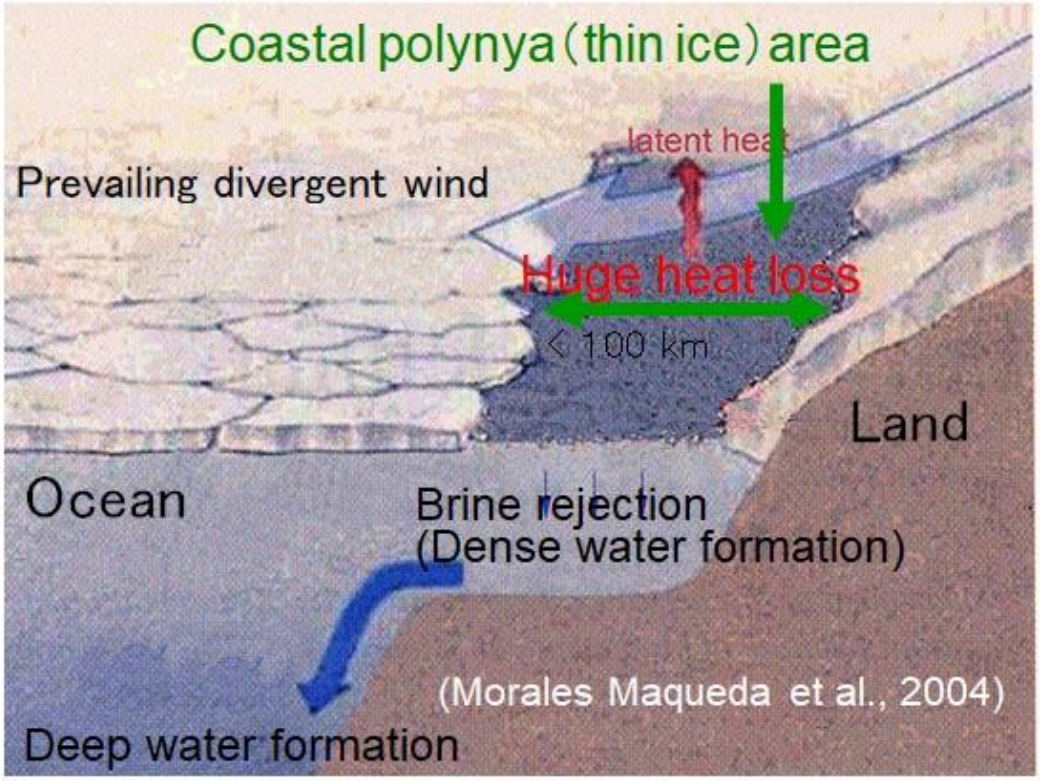
- Dense water formed by sea-ice production sinks & drives global thermohaline circulation.
- High ice production occurs in coastal polynyas (thin ice) regions.
- Antarctic Bottom Water formed by high ice-production has decreased (IPCC, AR5).
- Deep/intermediate water change is possibly linked with variation of sea-ice production.
- The purpose of this study is to create a global 40-yr data set of sea-ice production by developing AMSR, SSM/I & SMMR algorithms of ice type classification & ice thickness.

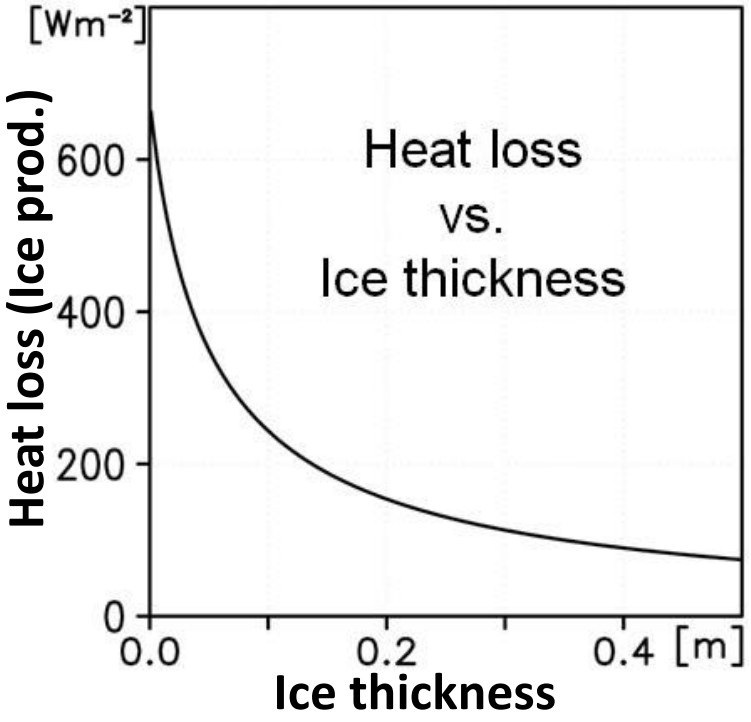


Global transport of heat, salt & materials (iron etc.) by sea-ice production and melt

Background and purpose

- Coastal polynyas are regions of intensive heat loss to the atmosphere & regarded as ice production factories.
- A large amount of brine rejection by ice production generates dense shelf water.





Heat flux (and thus ice production and salt flux) is very sensitive to sea ice thickness
→ Detection of polynya (thin ice) areas and estimation of ice thickness there is crucial
→ Use of Satellite Microwave

Outline

1. Background and purpose

2. In-situ validation of AMSR algorithm of ice-type classification
   and sea-ice production from mooring observation
   in an Antarctic coastal polynya (Cape Darnley polynya)

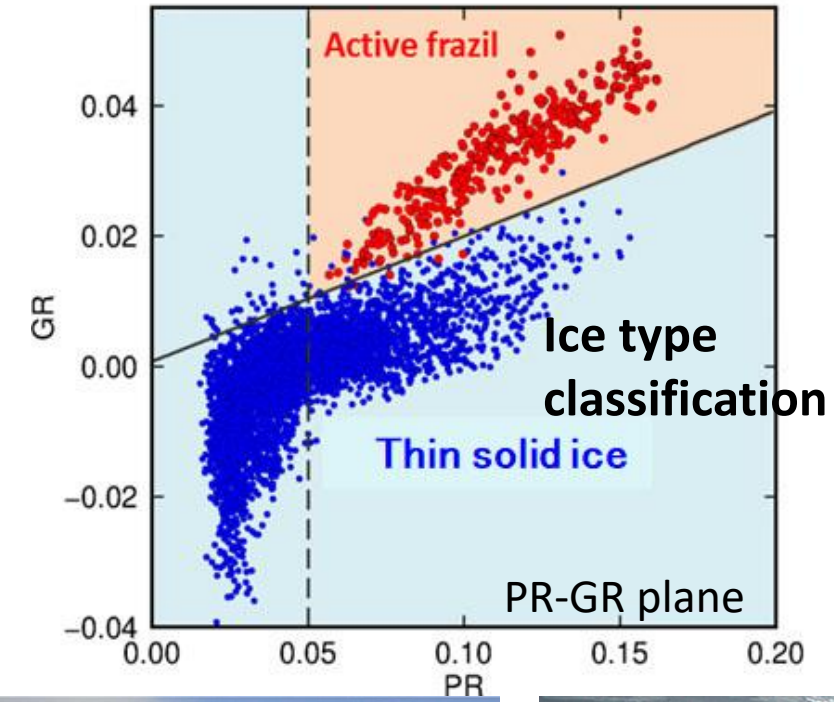
3. Development of SSM/I & SMMR algorithms
   of ice type classification & ice thickness
   toward creation of 40-yr data set of ice production

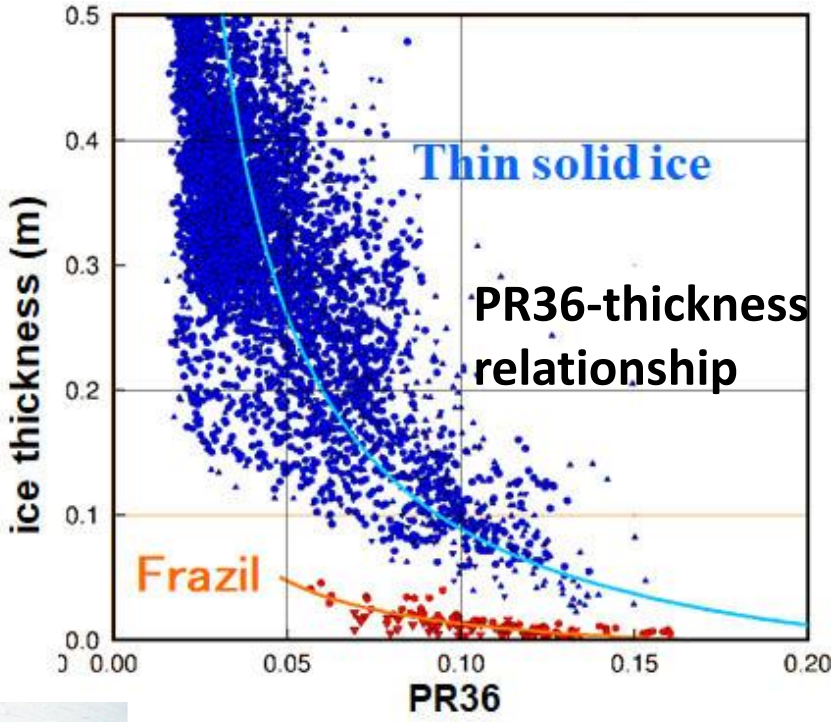
4. Global mapping & estimation of sea-ice production
   using the unified algorithm from 40-yr microwave data

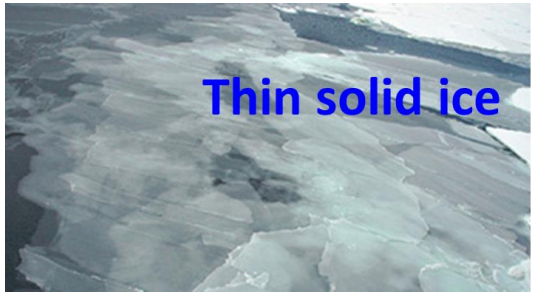
AMSR thin ice algorithm

Nakata, Ohshima, Nihashi (2019)

- First, ice type (active frazil or thin solid ice) is discriminated on PR-GR plane.
- Then ice thickness is derived from the PR-thickness relationships.
- As validation data , ice type & Ice thickness is derived from SAR, MODIS surface temp. & heat budget.







Sea ice production is calculated using AMSR-derived ice thickness & heat budget.

Validation of AMSR algorithm for ice-type & sea-ice production

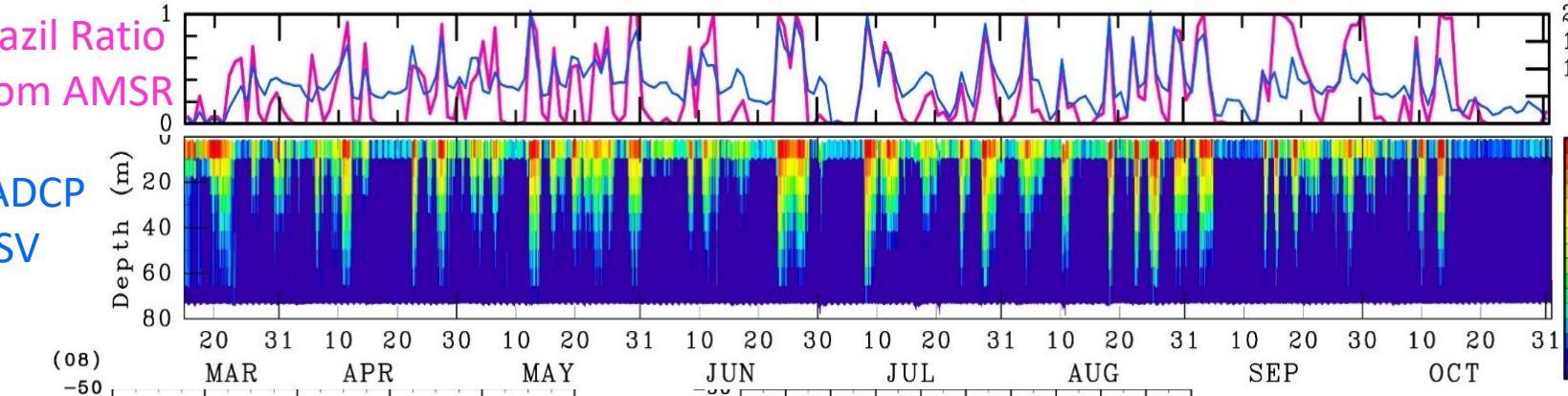
Acoustic & salinity measurements were conducted at a polynya

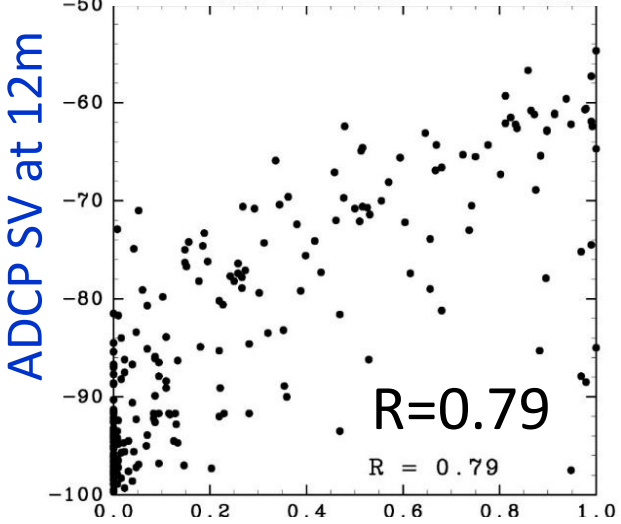
Frazil Ratio from AMSR

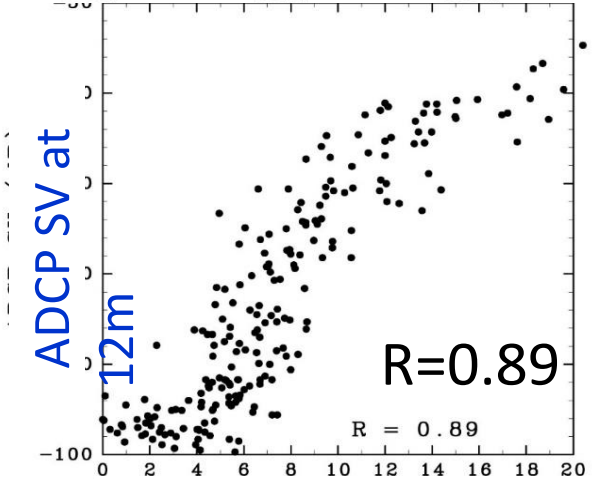
Ice prod. from AMSR

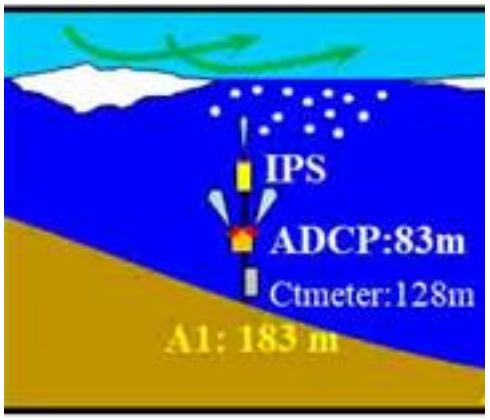
ADCP SV

High SV ↓ Frazil ice







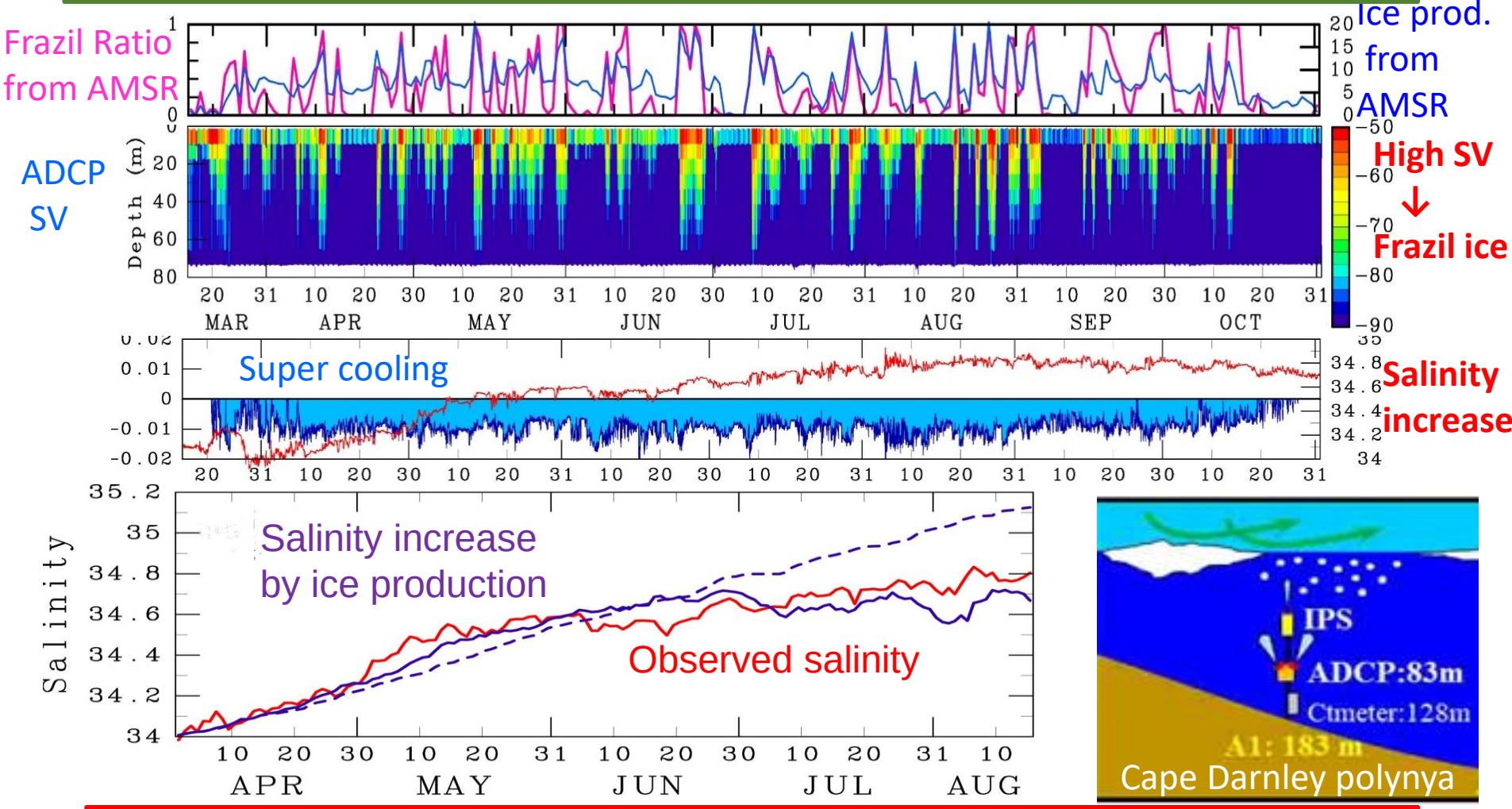


ADCP mooring at the Cape Darnley polynya

ADCP Backscatter vs. AMSR product (Frazil ratio, Ice production)
High correlation → Excellent performance of AMSR algorithm !

Validation of AMSR algorithm for ice-type & sea-ice production

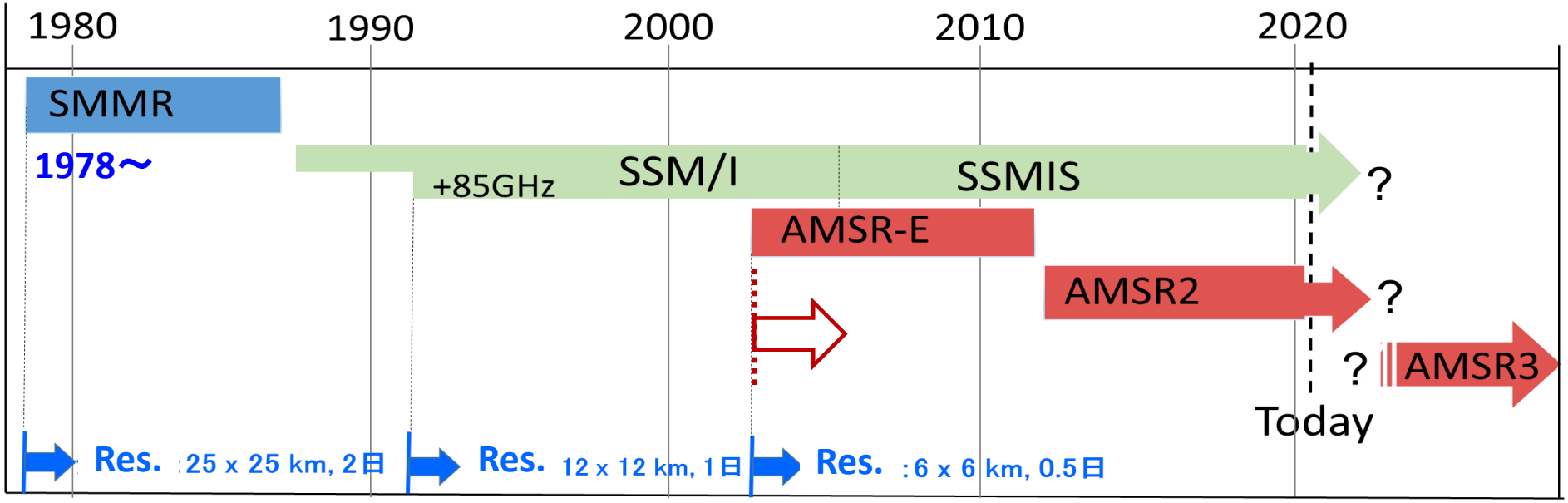
Acoustic & salinity measurements were conducted at a polynya



Salinity increase by sea-ice production using AMSR-derived ice thickness well corresponds with the observed salinity increase

40-yr observation of satellite passive microwave radiometers

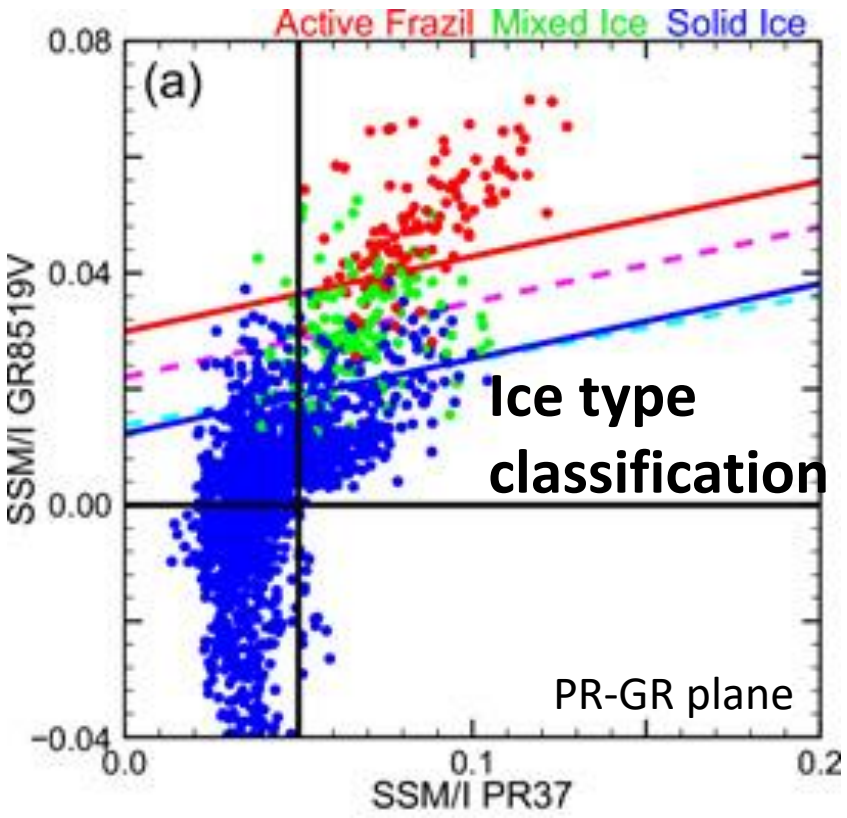
- Data sets of sea ice production have been made only for limited areas & mainly after 2003 with the AMSR sensor.
- We develop pan-global algorithms of sea-ice production for four generation's microwave sensors to create seamless 40-yr data set since 1978.

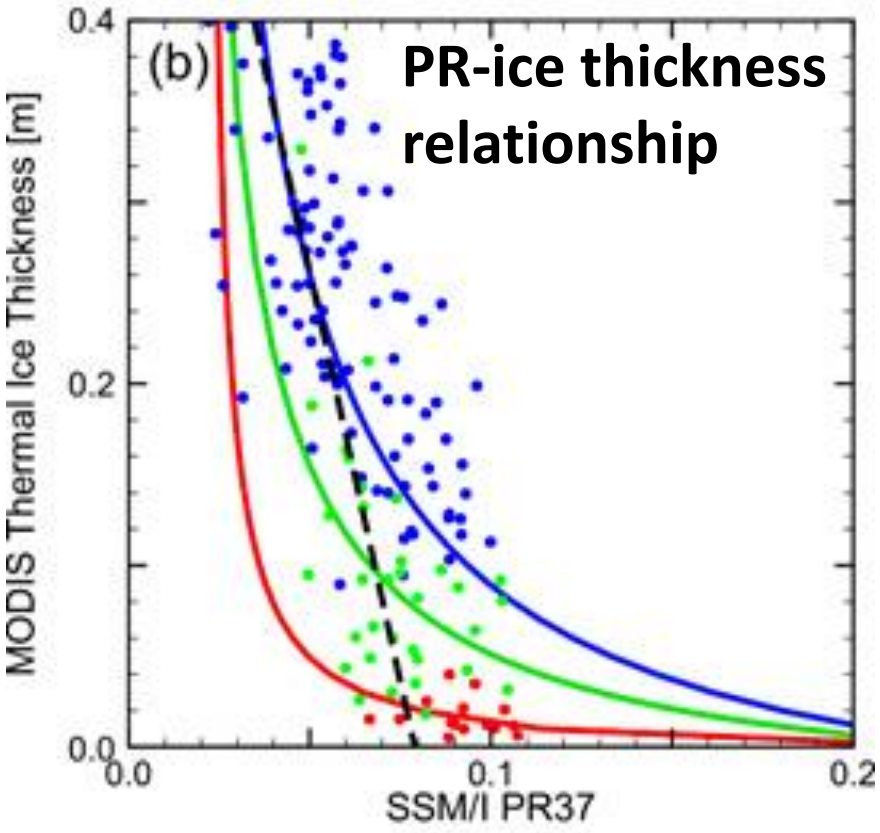


Development of SSM/I algorithm: 1988～present

For ice-type classification, in addition to active frazil & thin solid ice, their mixture is newly categorized to resolve the low resolution.

Regarding the ice thickness, we use the same PR- thickness relationship as that of AMSR.



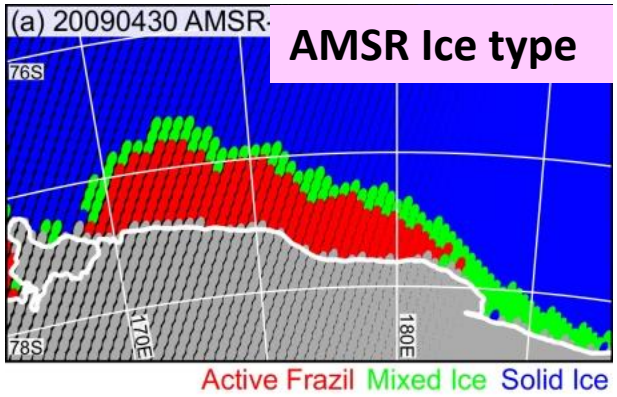


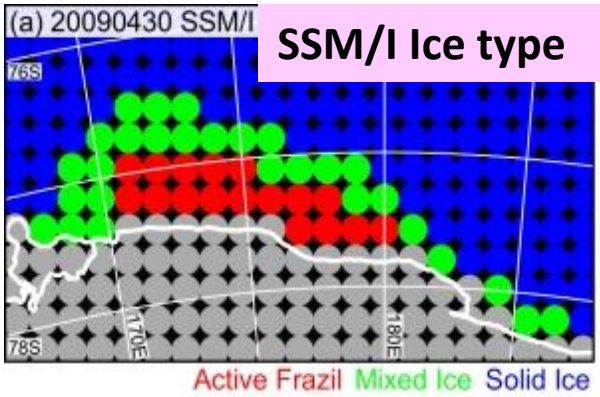
Kashiwase, Ohshima, et al. (Jtech. 2021)

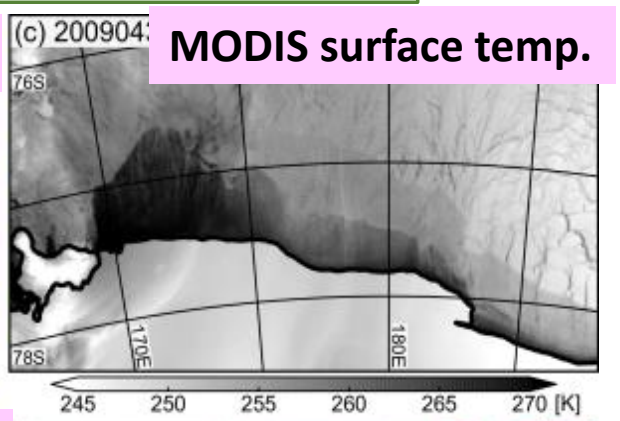
Development of SSM/I algorithm

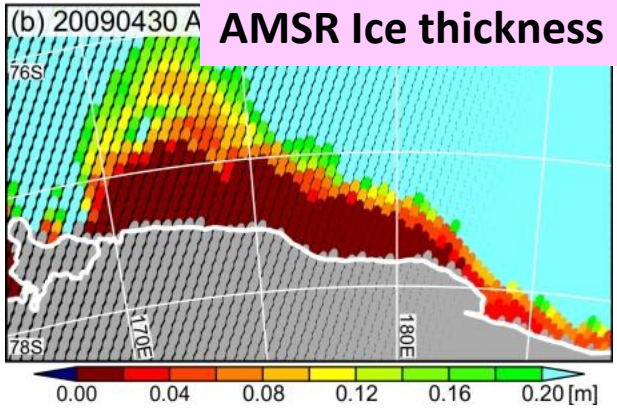
Ice type and thickness off the Ross Ice Shelf on 30 April 2009

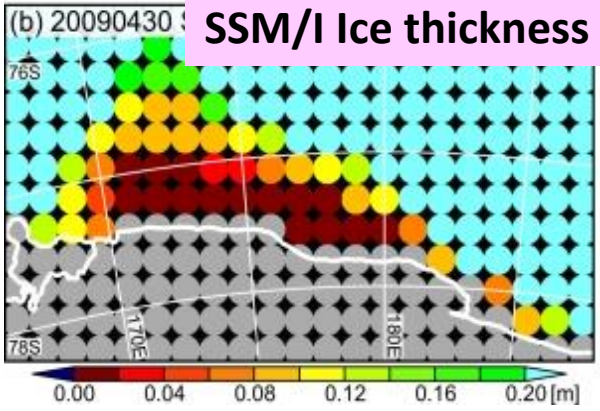
↓ SSM/I ice type classification well corresponds with AMSR one

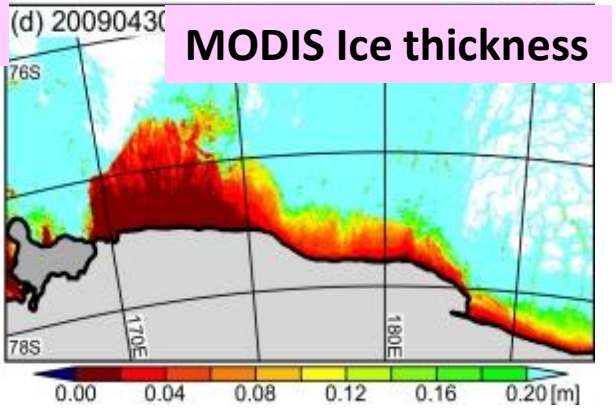












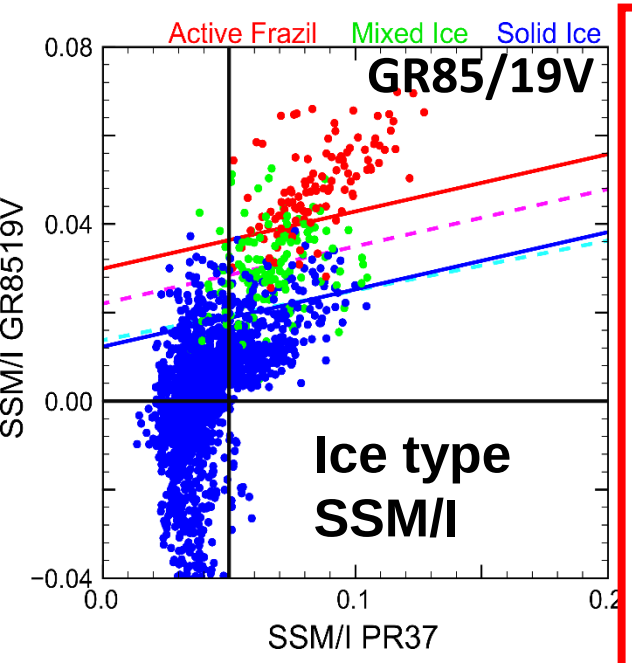
↑ SSM/I & AMSR ice thickness well coincides with MODIS ice thickness

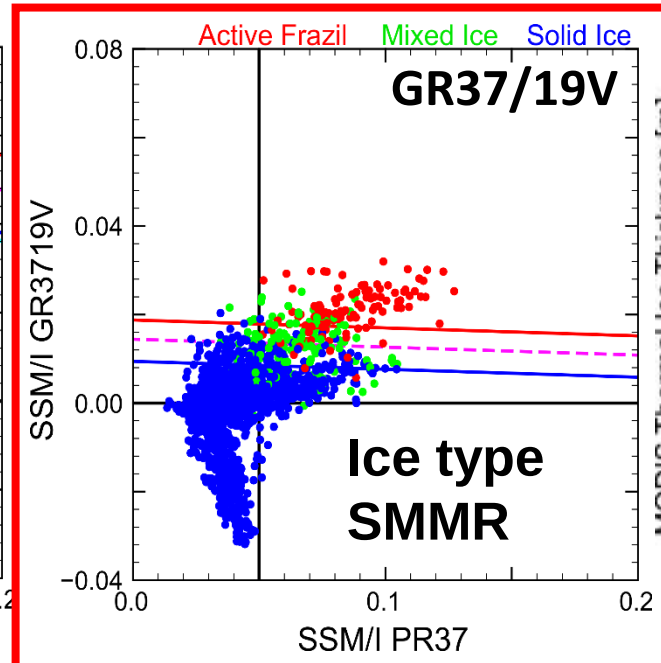
Kashiwase, Ohshima, et al. (2021)

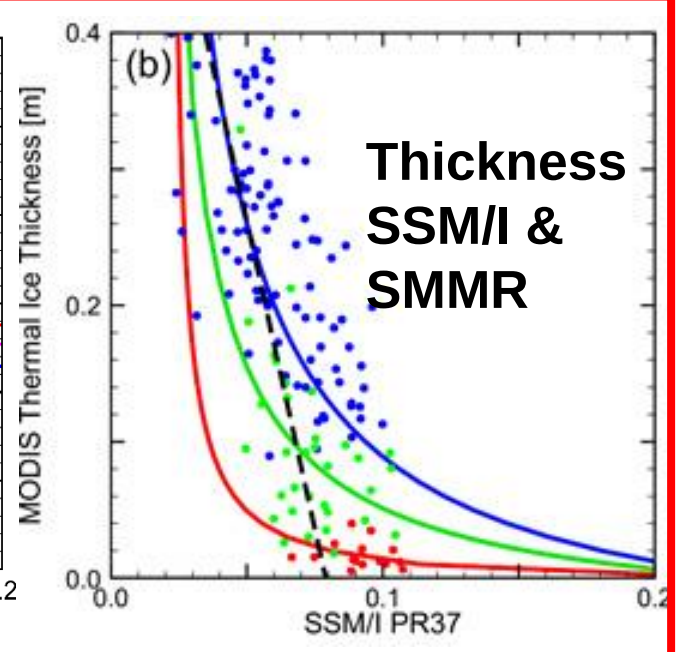
Development of SMMR algorithm: 1978～1987

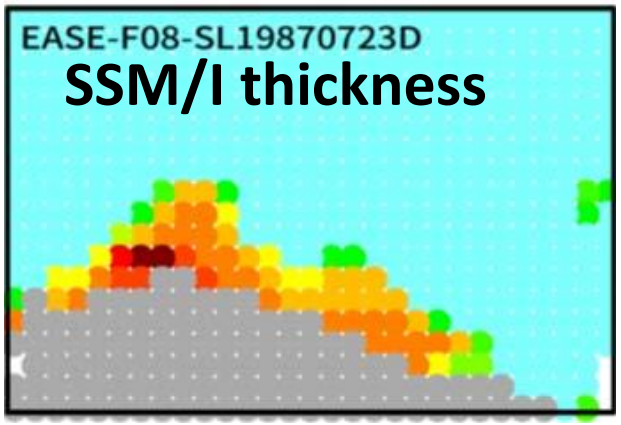
Classification into active frazil, thin solid ice & their mixture

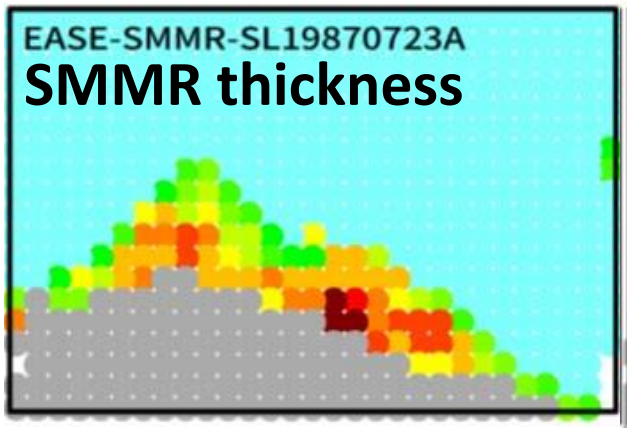
PR–thickness relationship

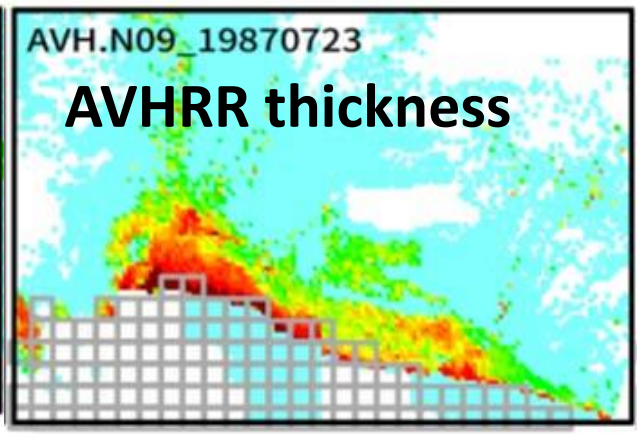








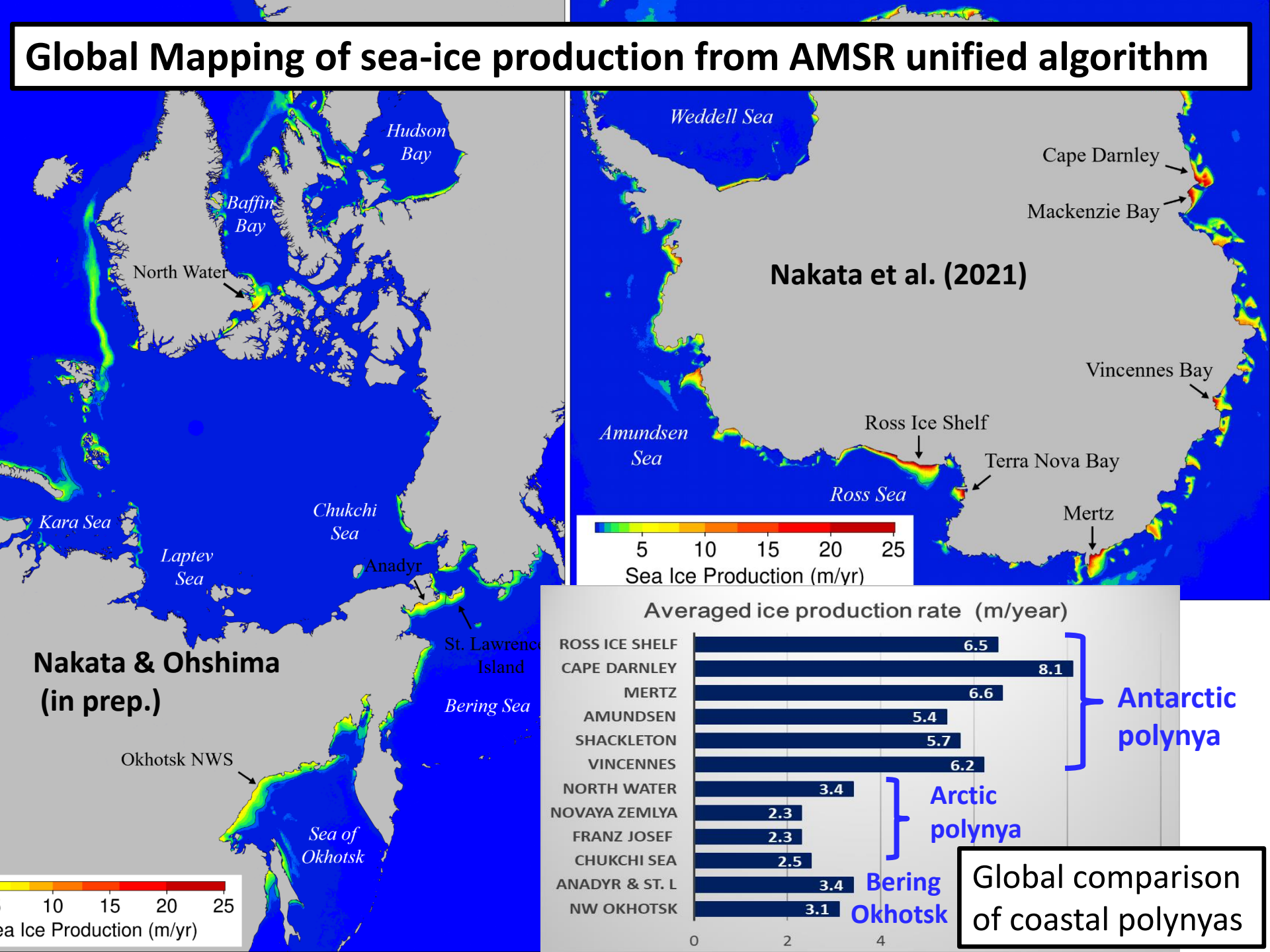


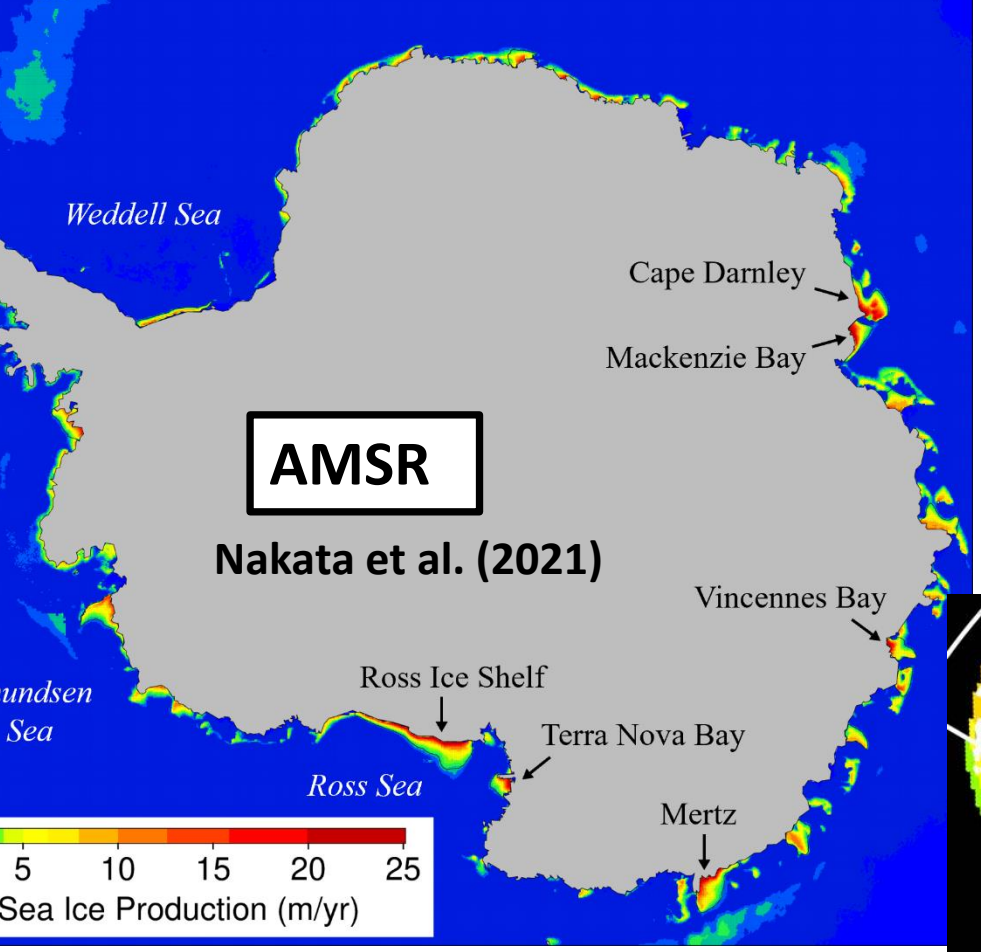


Overlapped period of SMMR & SSM/I: **1987**

Kashiwase et al. (in preparation)

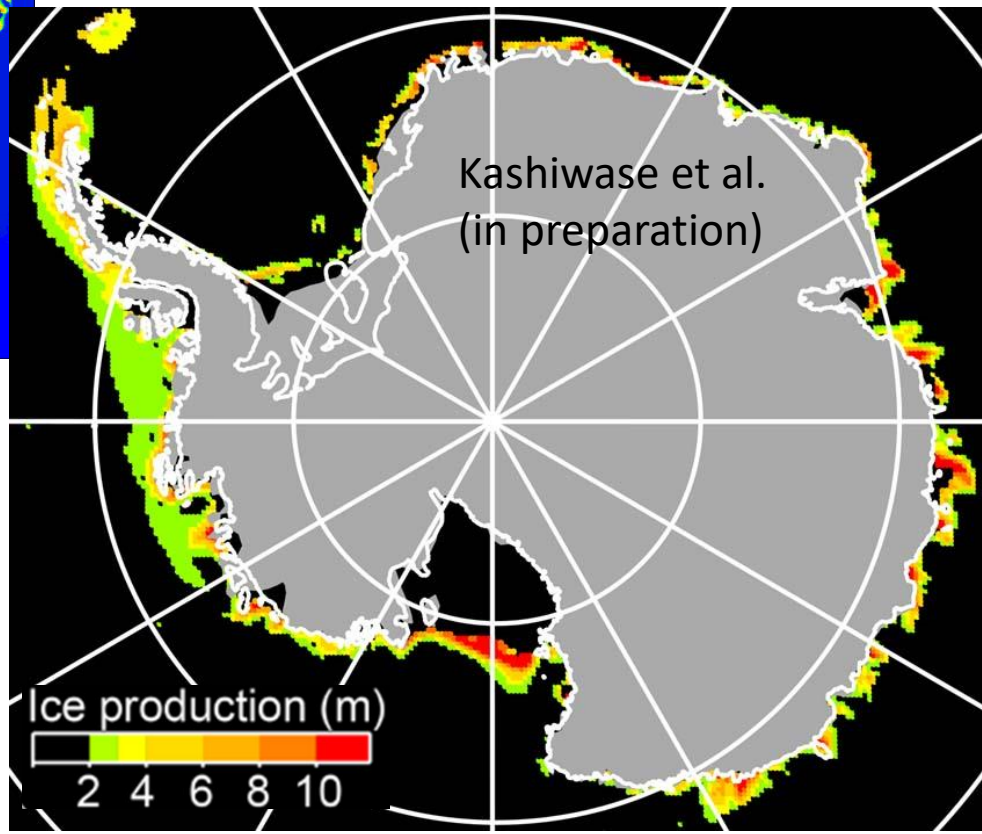
Global Mapping of sea-ice production from AMSR unified algorithm





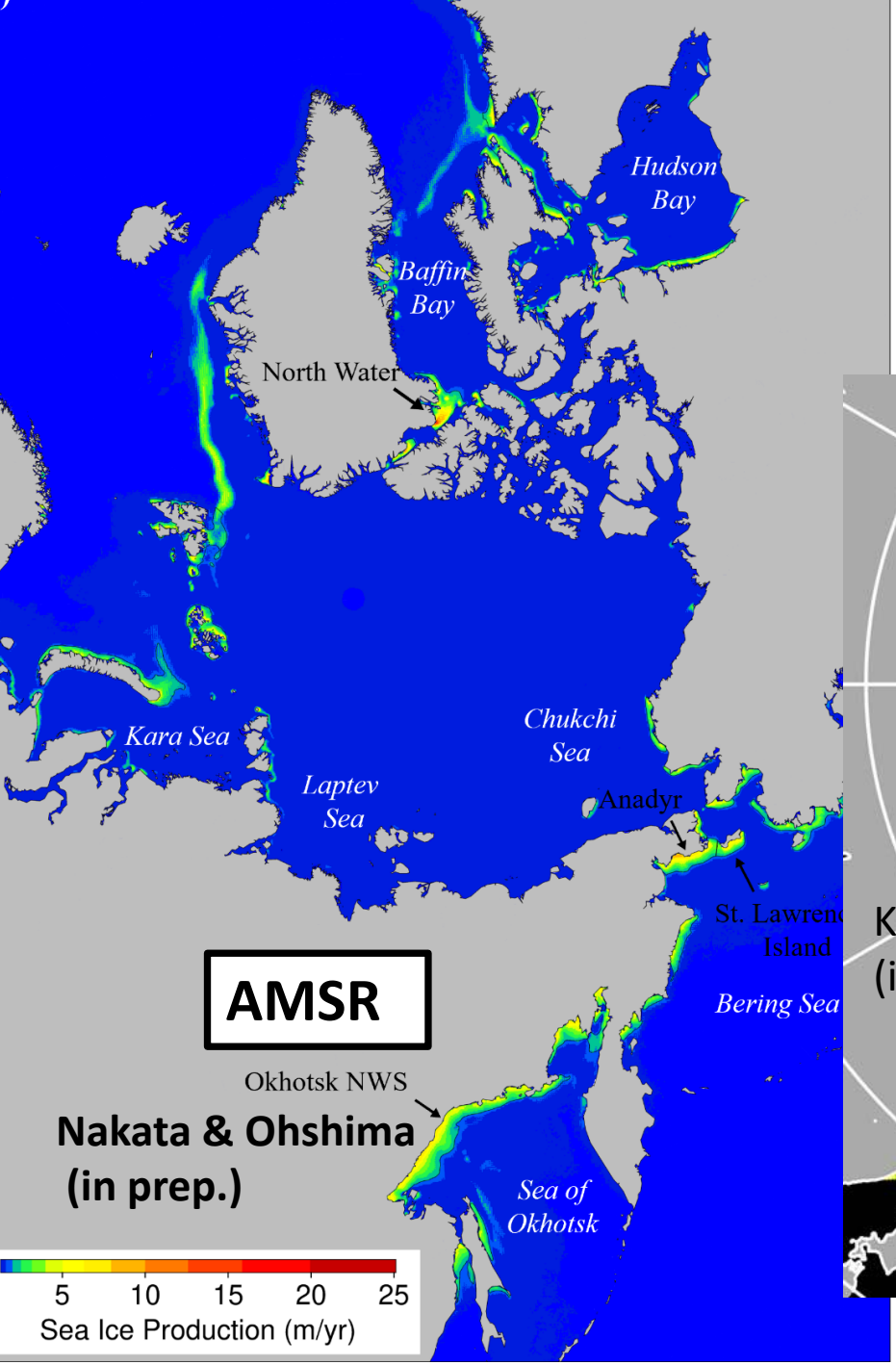
Sea-ice production from SSM/I : 1992-2018

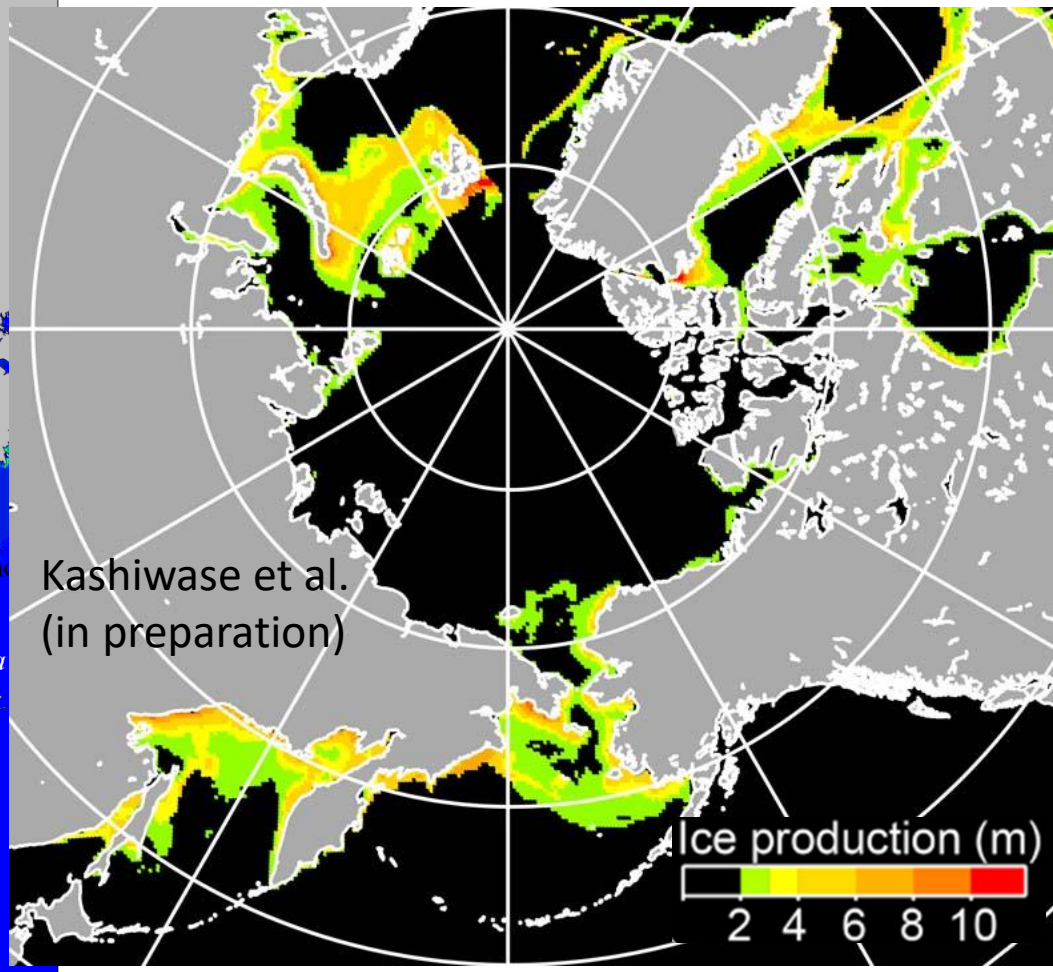
～30-yr data set can be made from SSM/I



Sea-ice production from SSM/I : 1993-2017

～30-yr data set can be made from SSM/I





Summary

1. AMSR algorithm for frazil detection & ice-production has been validated from ADCP backscatter in an Antarctic polynya for the first time → Excellent performance

2. SSM/I & SMMR algorithms of ice type & ice thickness have been developed
   → Sea-ice production data set is possible back to 1978

3. Global mapping & estimation of sea-ice production has been conducted, using the unified thin ice algorithm.

Outcome from this project

Kashiwase, H., K. I. Ohshima, K. Nakata, and T. Tamura (2021): Improved SSM/I thin ice algorithm with ice type discrimination in coastal polynyas. Journal of Atmospheric and Oceanic Technology, 38, 823-835.

Kashiwase, H., K. I. Ohshima, Y. Fukamachi, S. Nihashi and T. Tamura (2019): Evaluation of AMSR-E thin ice thickness algorithm from a mooring-based observation: How can the satellite observe a sea ice field with non-uniform thickness distribution? Journal of Atmospheric and Oceanic Technology, 36, 1623-1641.

Nakata, K., K. I. Ohshima and S. Nihashi (2021): Mapping of Active Frazil for Antarctic coastal polynyas, with Estimation of Sea-Ice Production, Geophysical Research Letters, 48, e2020GL091353.

Nakata, K., K. I. Ohshima and S. Nihashi (2019): Estimation of thin ice thickness and discrimination of ice type from AMSR-E passive microwave data. IEEE Transactions on Geoscience and Remote Sensing, 57(1), 263-276.

Ohshima, K. I., N. Tamaru, H. Kashiwase, S. Nihashi, K. Nakata and K. Iwamoto (2020): Estimation of sea ice production in the Bering Sea from AMSR-E and AMSR2 data, with special emphasis on the Anadyr polynya. Journal of Geophysical Research, 125, doi:10.1029/2019JC016023.

Preußer, A, K. I. Ohshima, et al. (2019): Retrieval of wintertime sea-ice production in Arctic polynyas using thermal infrared and passive microwave remote sensing data. Journal of Geophysical Research, 124, 5503-5528.