Validation of the ASI Ice Concentration Algorithm using Landsat-7 ETM+ and SAR Imagery

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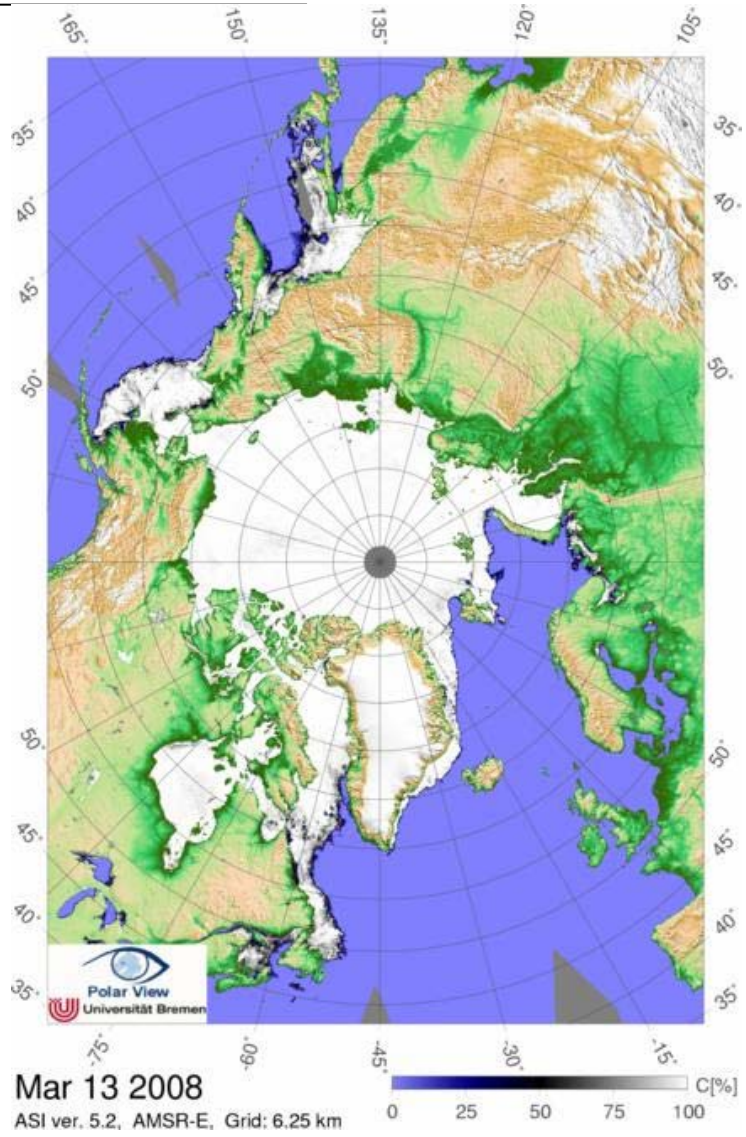
Outline

- Motivation
- ASI Ice concentration
- Comparison ASI – Landsat
  - Landsat-7 data set
  - results
- Comparison ASI – SAR
  - SAR data set
  - results
- Summary and Conclusion

Motivation

- Sea ice maps
  - ASI algorithm, 89 GHz (AMSR-E)
  - validation of ASI with NASA Team and Bootstrap algorithm
  - no validation with data from visual sensors

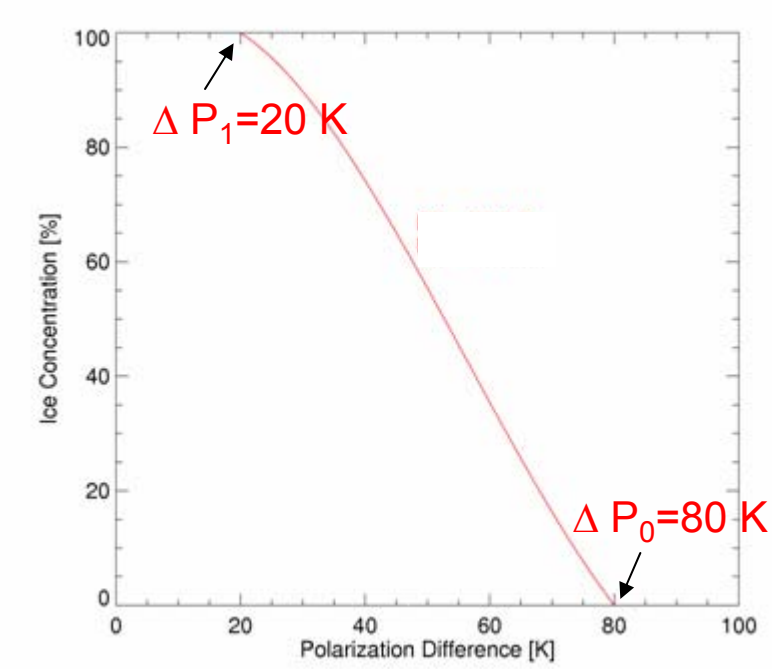


ASI Ice Concentration

- **A**RTIST **S**ea **I**ce (Arctic Radiation and Turbulence Interaction STudy)
  - after Svendsen et al. (1987)
  - modified by Kaleschke et al. (2001)
  - based on polarization differences ΔP (vert. – horiz.)
    - 89 GHz channels
    - two tie points:

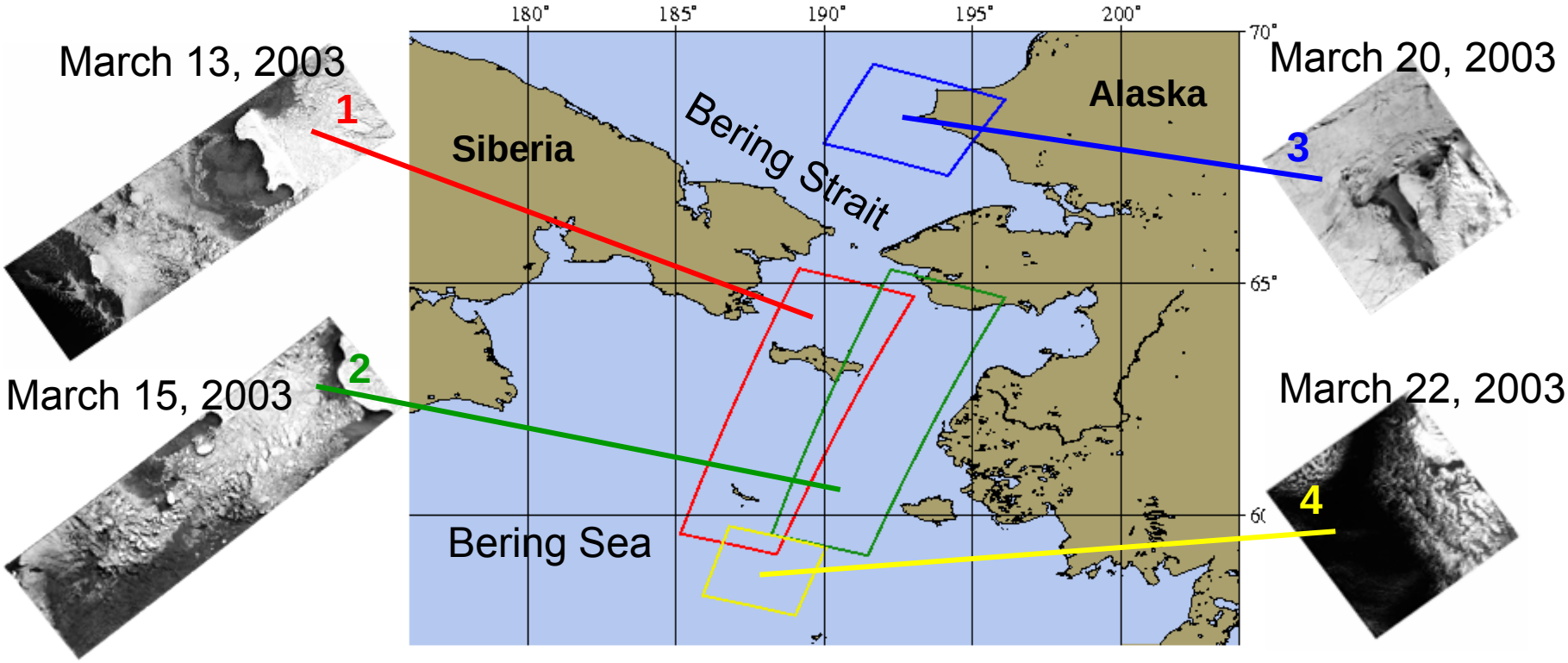
      ΔP_0 (open water)

      ΔP_1 (100% ice)



Landsat-7 ETM+ Data Set

Markus et al. 2006

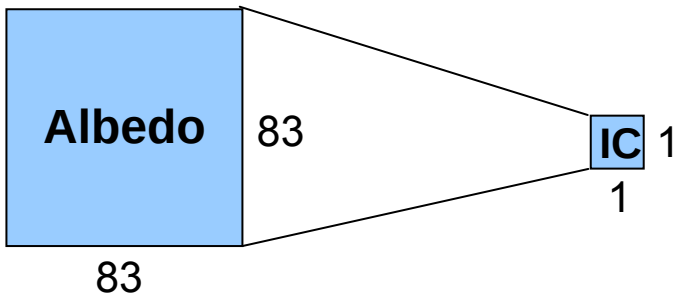


Data: Albedos calculated from panchromatic band of ETM+

(Enhanced Thematic Mapper)

Co-Location and Resolution Matching

- Data Sets
  - ASI: IC on 12.5 km grid
  - Landsat: albedos on 150 m grid
  - both: polar stereographic projection
- Mapping Landsat albedos to IC on ASI grid
  - ice-water albedo threshold: 0.1
  - gaussian mean (83 x 83) = $IC_{Landsat}$ (1 x 1)
    (sigma=40)

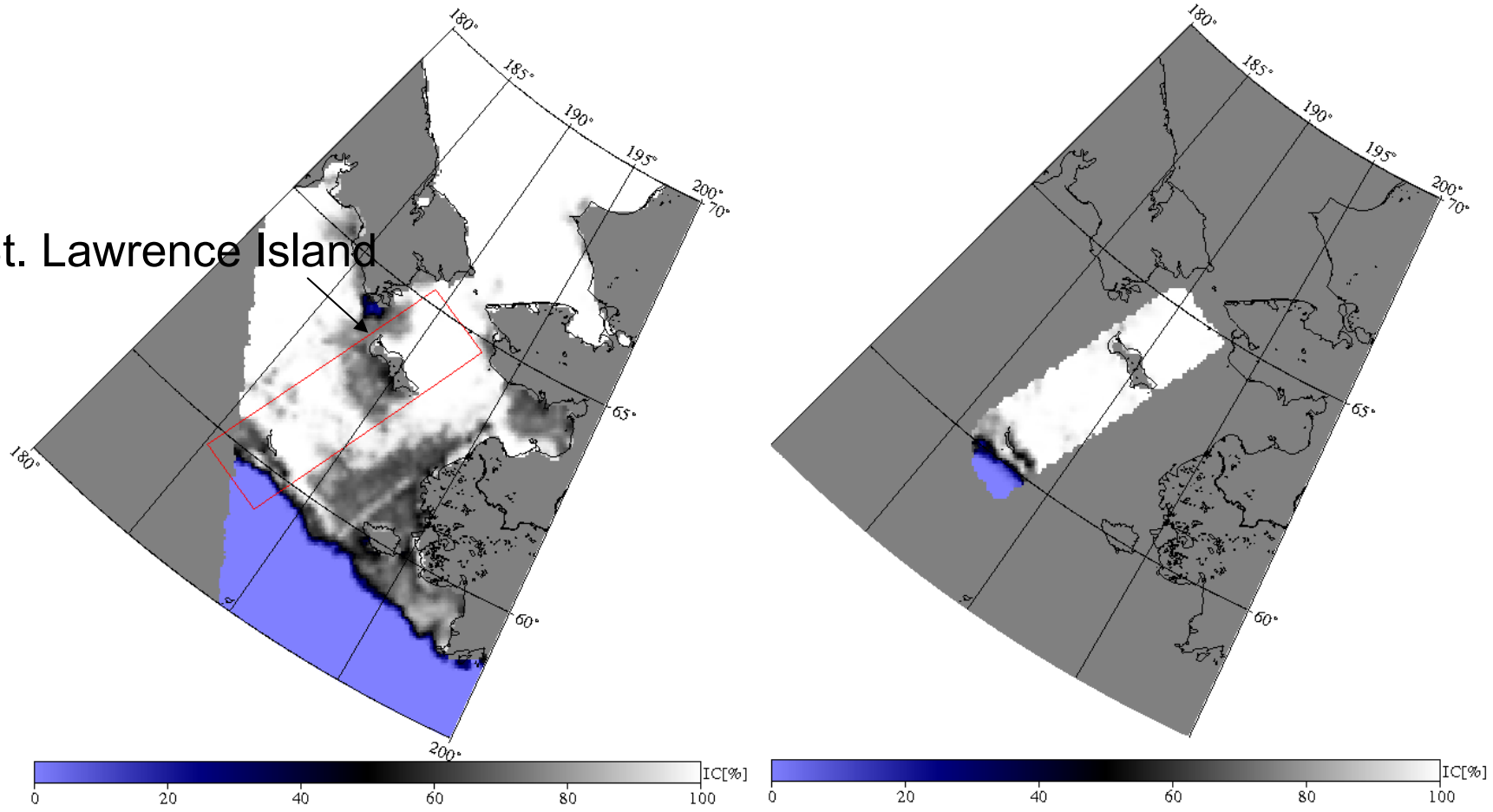


ASI – Landsat Comparison

IC_{ASI}

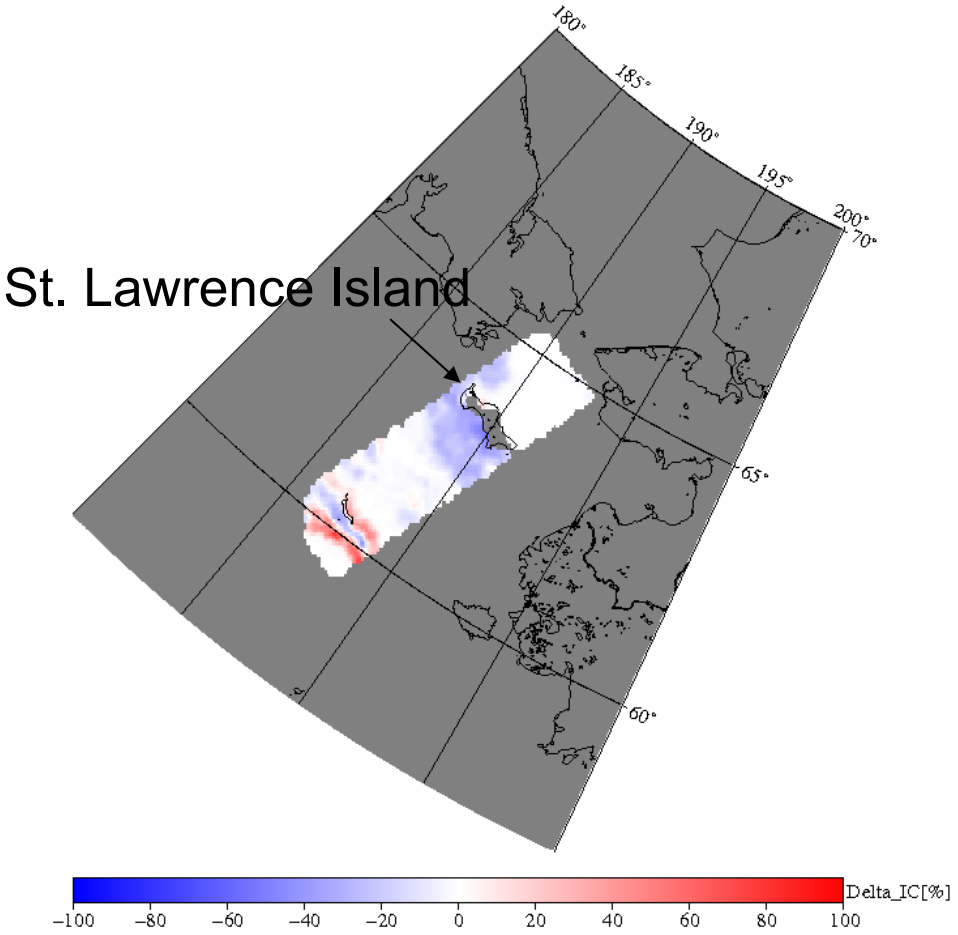
$IC_{Landsat}$

St. Lawrence Island



ASI – Landsat Comparison

$\Delta IC_{(ASI - Landsat)}$



- $IC_{ASI} < IC_{Landsat}$
  - polynya
- $IC_{ASI} > IC_{Landsat}$
  - ice edge

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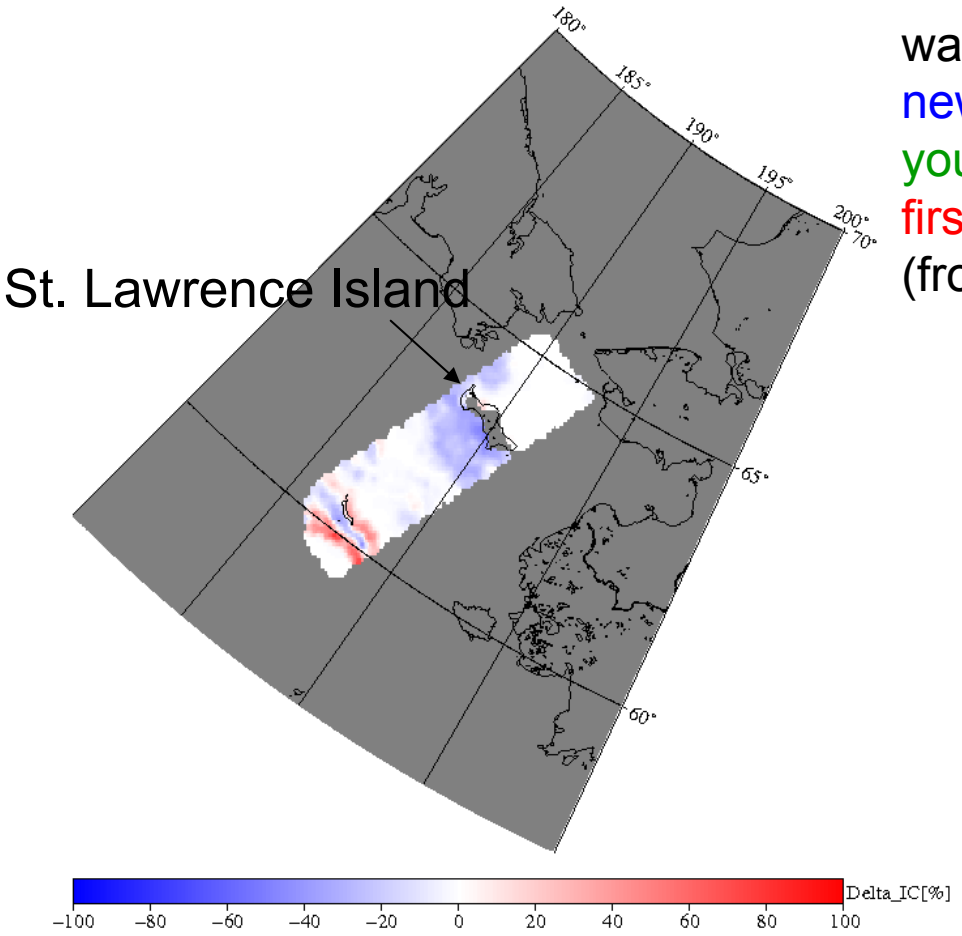


Ice types

Ice thickness ↓

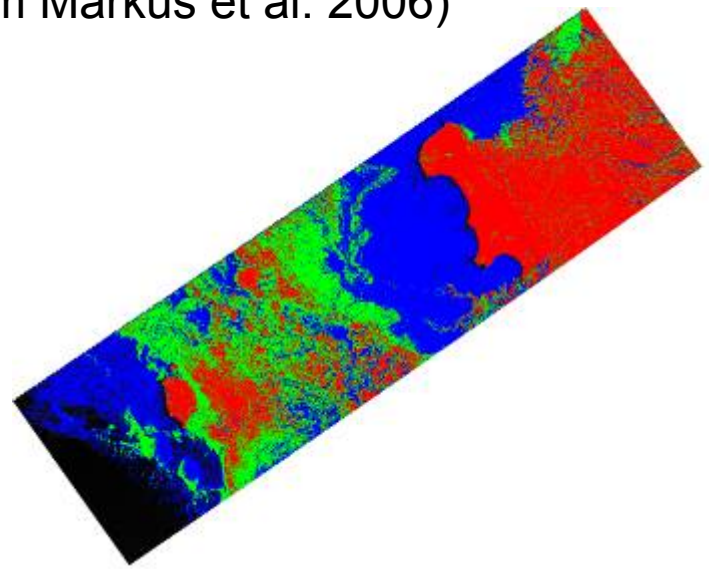
water: albedo ≤ 0.1

new ice: 0.1 < albedo ≤ 0.4 (<10 cm)

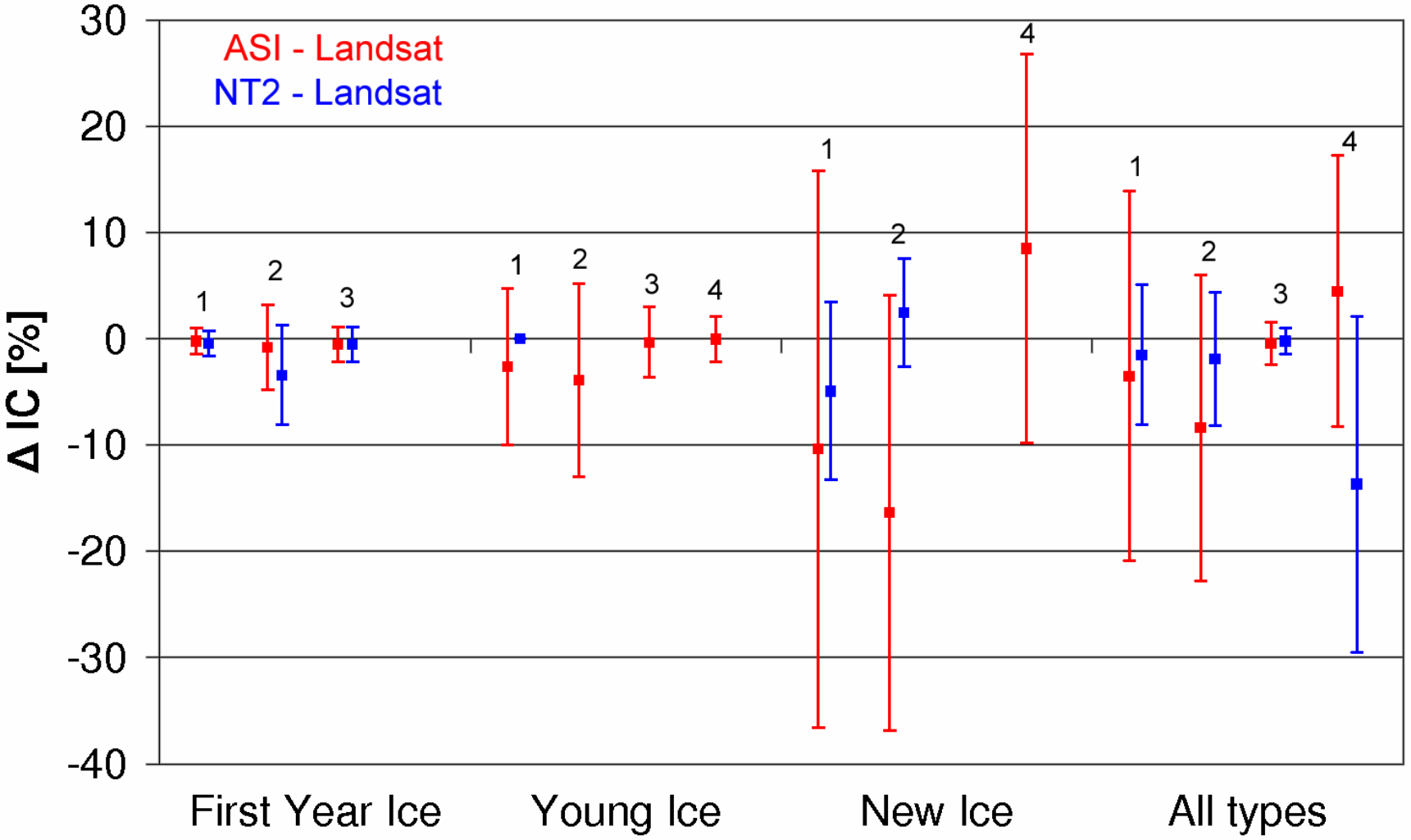
young ice: 0.4 < albedo ≤ 0.6 (<30 cm)

first year ice: albedo ≥ 0.6 (>30 cm)

(from Markus et al. 2006)

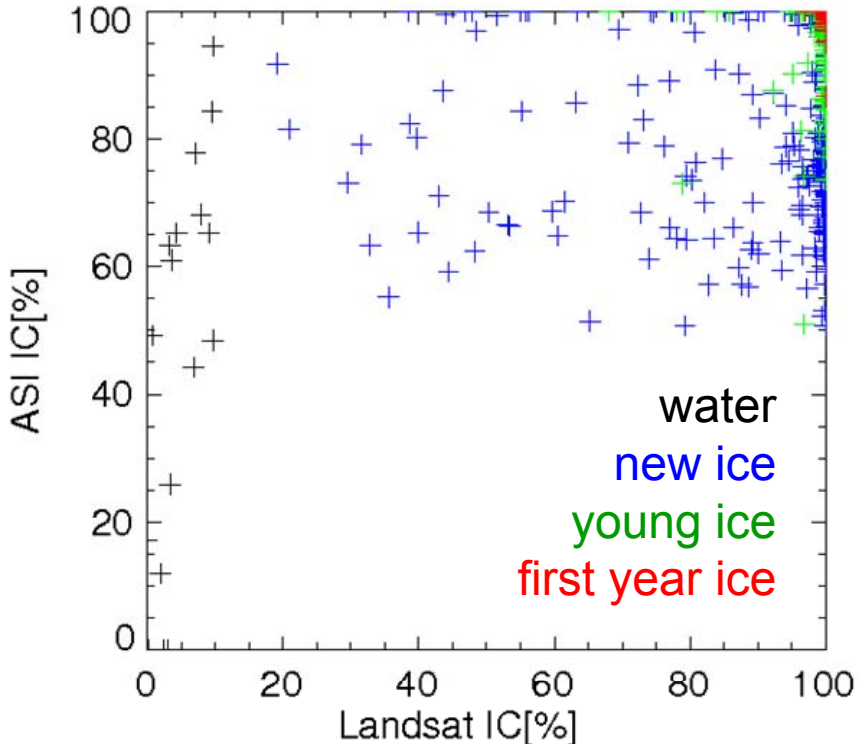


Results: Bias and RMS of ΔIC



Discussion of Results

- Difficulty of recognizing new ice correctly
  - large variability of IC
  - various types of new ice: frazil, grease, nilas, pancake



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- Underestimation of IC_{ASI} (polynya)
  - snow on the ice (Markus et al., 2006)
    - looks brighter in albedo image => higher $IC_{Landsat}$
    - not seen in microwave range

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- Underestimation of IC_{ASI} (polynya)
  - snow on the ice (Markus et al., 2006)
    - looks brighter in albedo image => higher $IC_{Landsat}$
    - not seen in microwave range
- Overestimation of IC_{ASI} (ice e
  - ice type: dark nilas
    - may not be seen in visible range
    - causes lower ΔP => higher IC_{ASI}

http://nsidc.org/glossary/images/nilas.jpg

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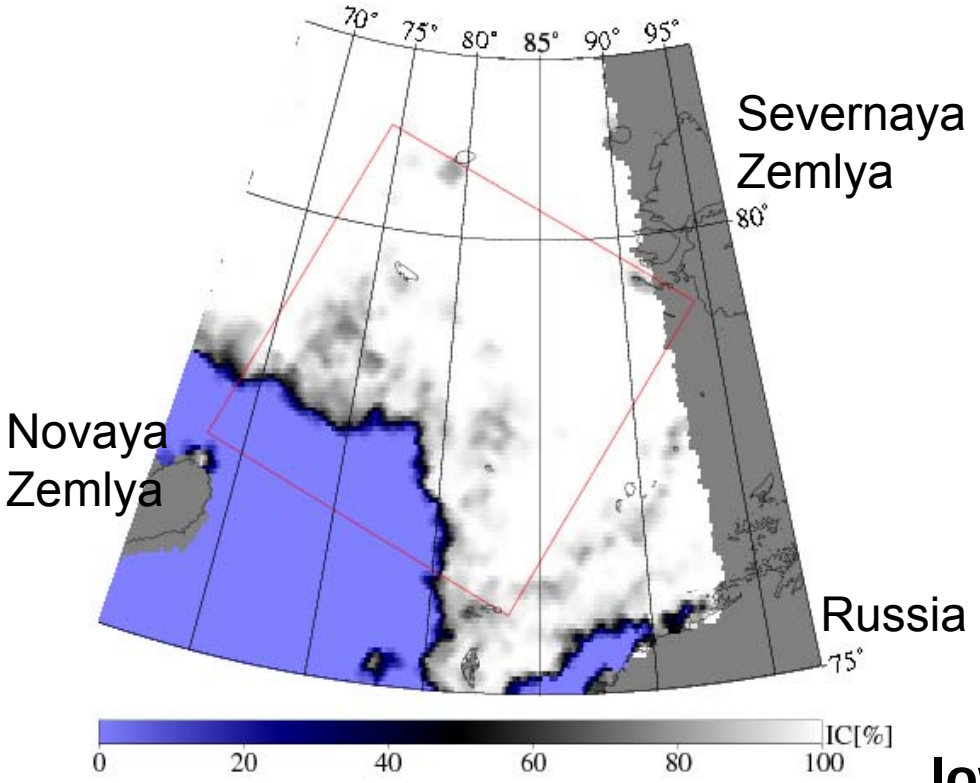
SAR data set

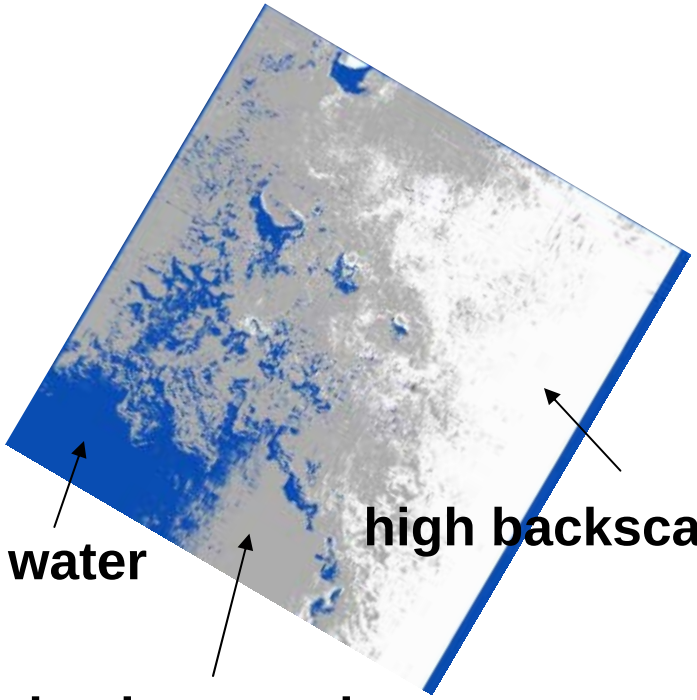
- 4 scenes from Radarsat-1 / Envisat
  Davis Strait, Baffin Bay / Kara Sea, Greenland Sea
  Jun 2004 Jun 2004 / Oct 2003 Aug 2003
  - polar stereographic grid: 100 m / 75 m
  - area: ≈ 500 km x 500 km
- IC derived by classification
  - method by Andersen et al. 2005:
    - high / low backscatter sea ice => 100% ice
    - rough / calm water => 0% ice
  - down sample to resolution of ASI
    => IC_{SAR}

ASI – SAR Comparison

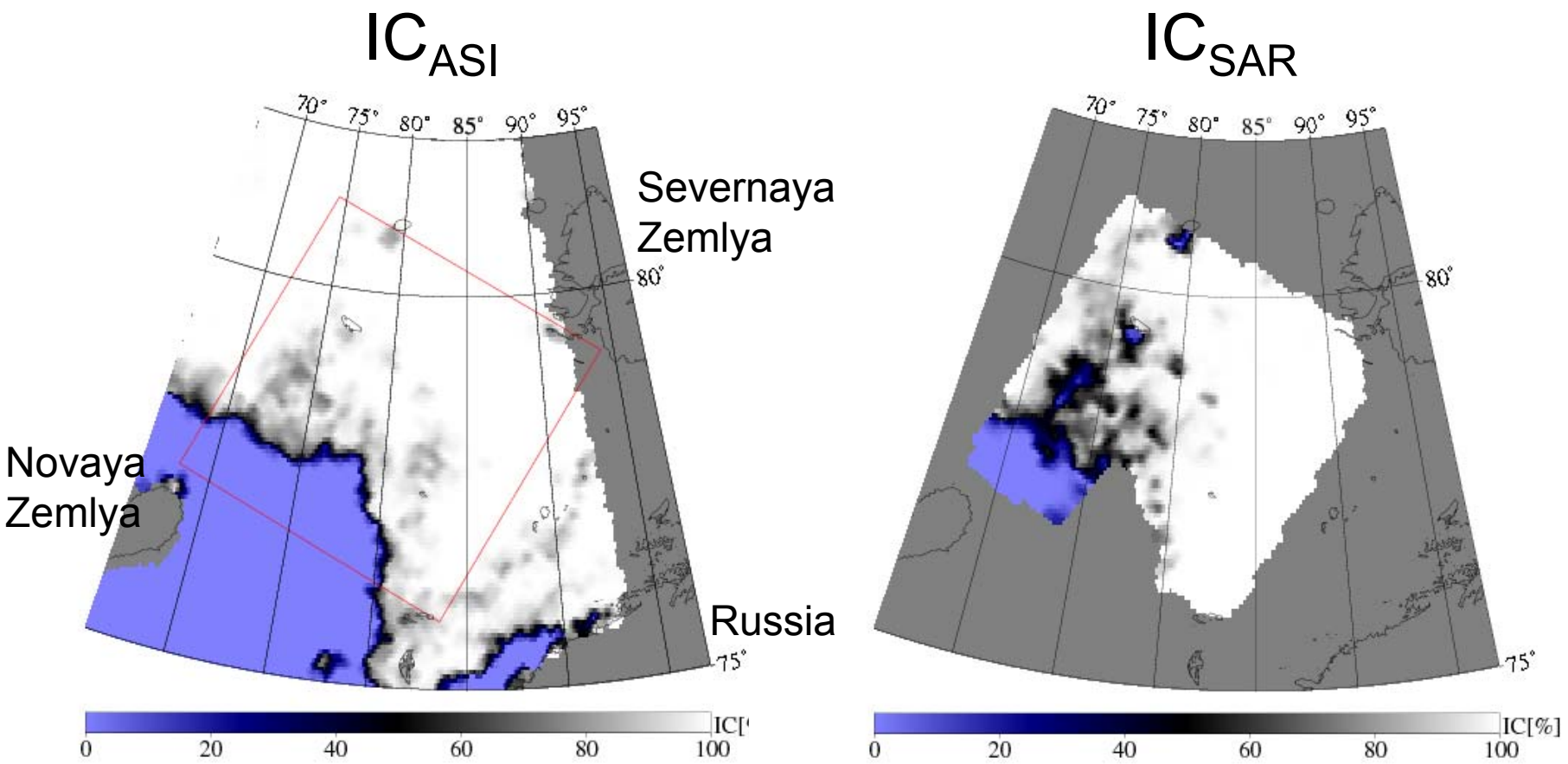
IC_{ASI}



Classified SAR

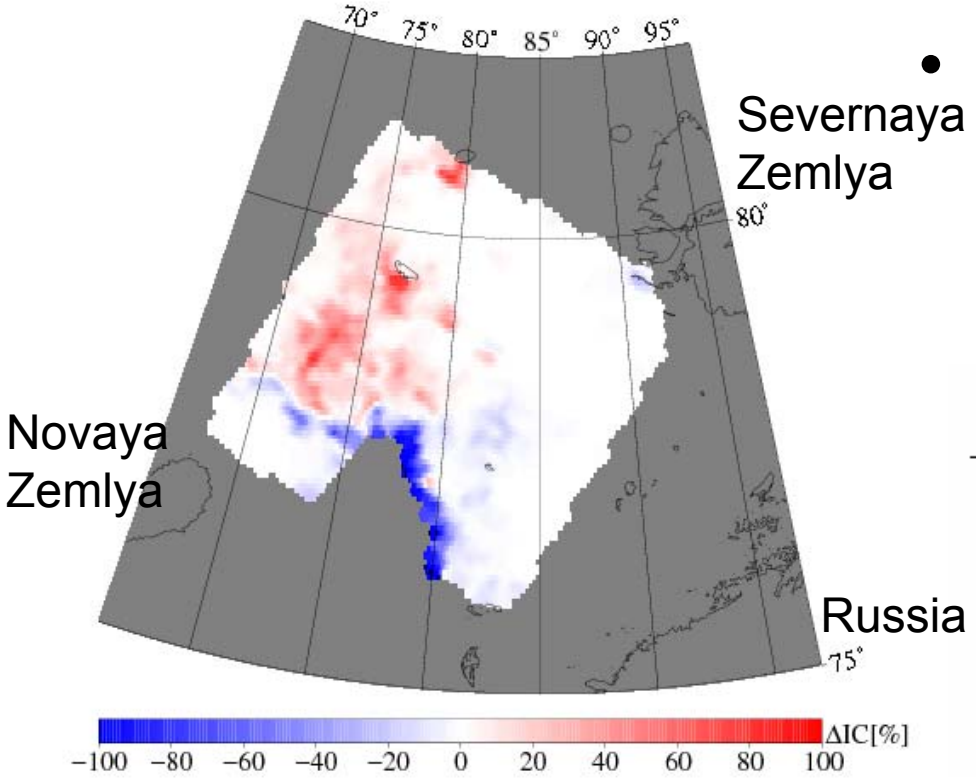


ASI – SAR Comparison



ASI – SAR Comparison

$\Delta IC_{(ASI - SAR)}$



- $IC_{ASI} < IC_{SAR}$
  - ice edge
- $IC_{ASI} > IC_{SAR}$
  - ice interior

$\Delta IC_{(ASI - SAR)}$

Scene	Bias	RMS
Scene 1	−2.9%	17.0%
Scene 2	1.4%	20.1%
Scene 3	1.4%	18.0%
Scene 4	2.5%	16.9%

Summary and Conclusions (1)

- ASI – Landsat comparison:
  - ice interior: $IC_{ASI} < IC_{Landsat}$
  - ice edge: $IC_{ASI} > IC_{Landsat}$
  - young ice / first year ice: well recognized
  - new ice: large bias / errors (high variability of IC)
- ASI – SAR comparison:
  - ice interior: $IC_{ASI} > IC_{SAR}$
  - ice edge: $IC_{ASI} < IC_{SAR}$

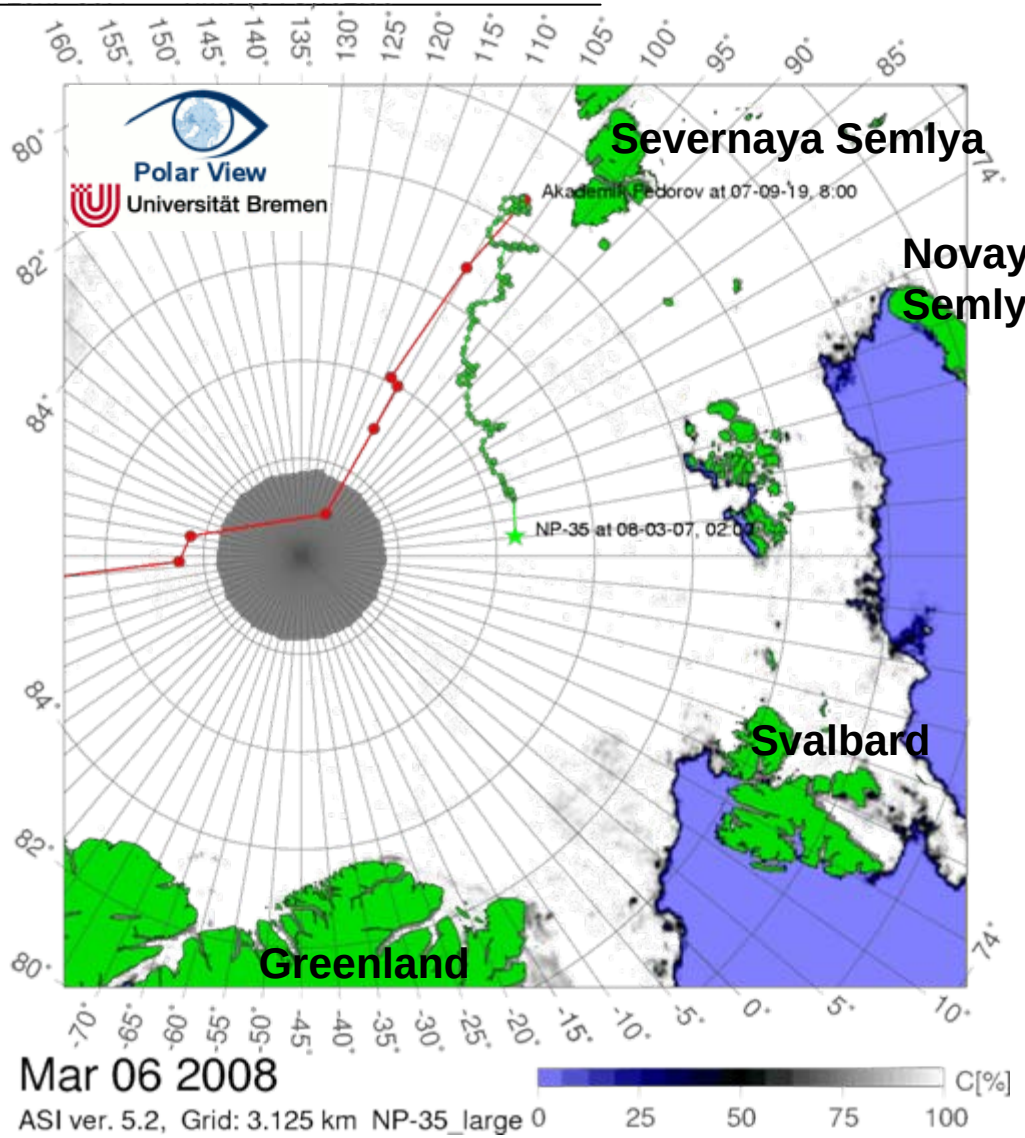
=> Each sensor detect IC differently

- IC_{ASI} between $IC_{Landsat}$ and IC_{SAR}

Summary and Conclusions (2)

- Advantages of ASI:
  - high resolution of 5 km (89 GHz)
  - reliability of first year / young ice similar to NT2
- Limitations of ASI
  - relatively high RMS errors for new ice (compared to NT2)
- Trade-off: horizontal resolution – RMS errors
- Main application area
  - ship navigation away standard routes
  - ice drift stations

Russian ice drift station: NP-35



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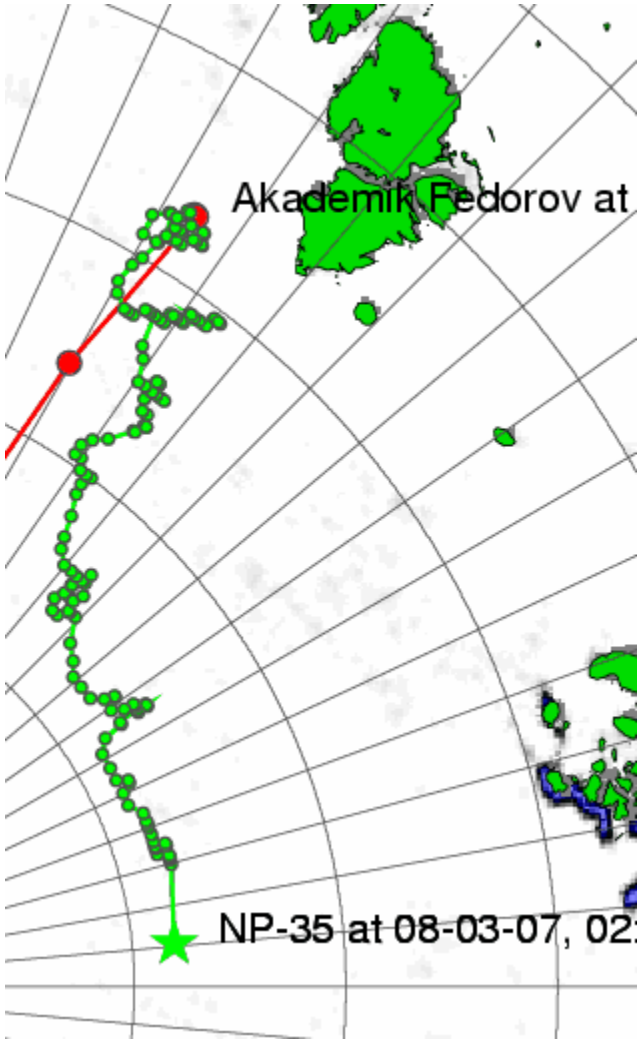

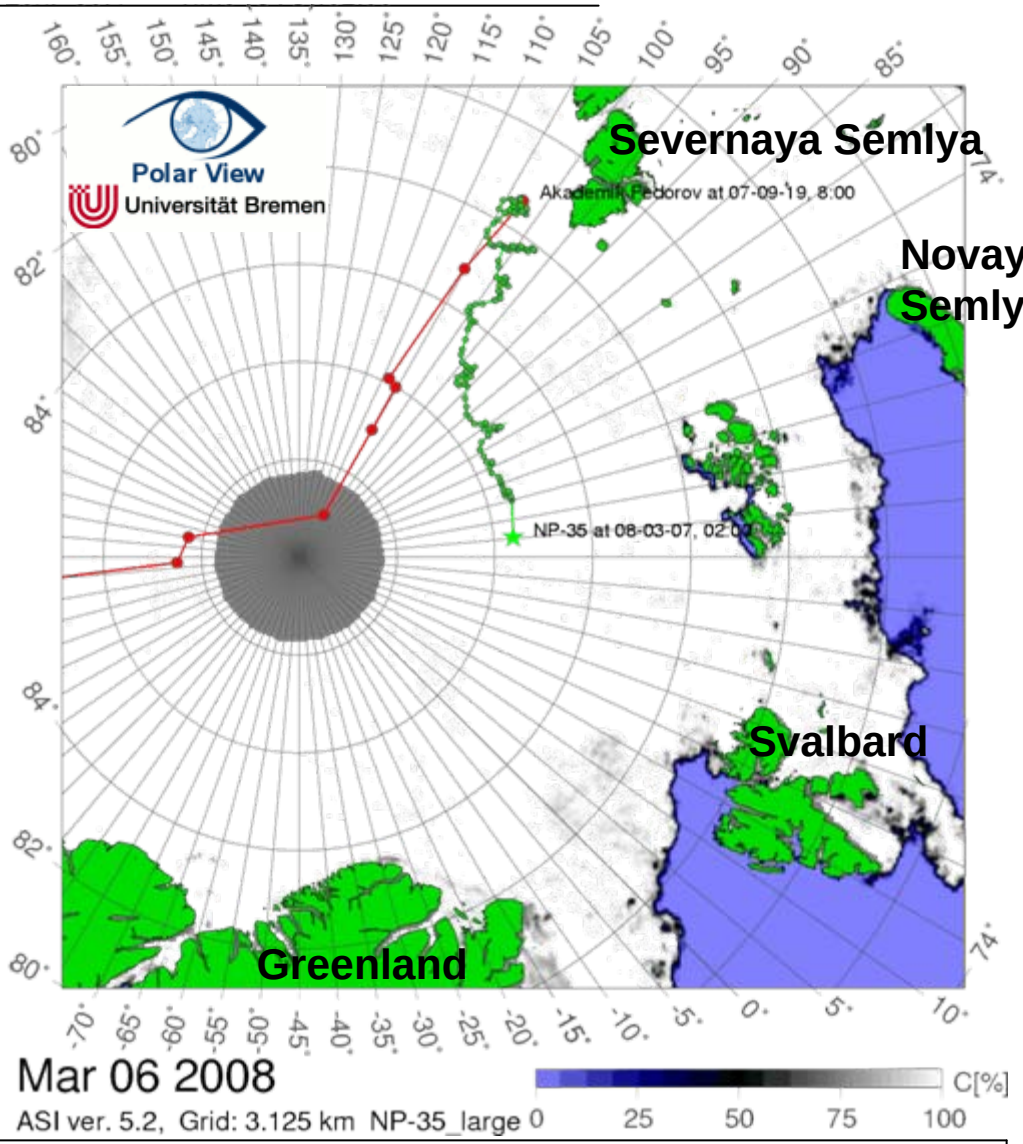

Thank you for your attention

Acknowledgements

- Dr. Thorsten Markus for providing the Landsat scenes
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