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Passive microwave dry snow detection

Comparison of algorithms and application to SWE retrieval

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Motivation

Dry Snow Detection:

- Brightness temperature difference(s)
  → Attenuation due to scattering
  → 18/19 GHz (Ku-band), 37 GHz (Ka-band)
- Implementation in SWE retrieval:
  - Restriction of retrieval
  - Limiting sources of input data

1. Comparison of approaches
2. Validation for SWE retrieval

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Dry Snow Detection Algorithms

Chang et al. (1987)	Decision tree: precipitation, cold desert, frozen ground
Grody and Basist (1996)	
Foster et al. (1997)	
Armstrong and Brodzik (2001)	
GLOBSNOW Hall et al. (2002)	Snow mapping
EUMETSAT H SAF Pulliainen et al. (2010)	Snow status product (H11)

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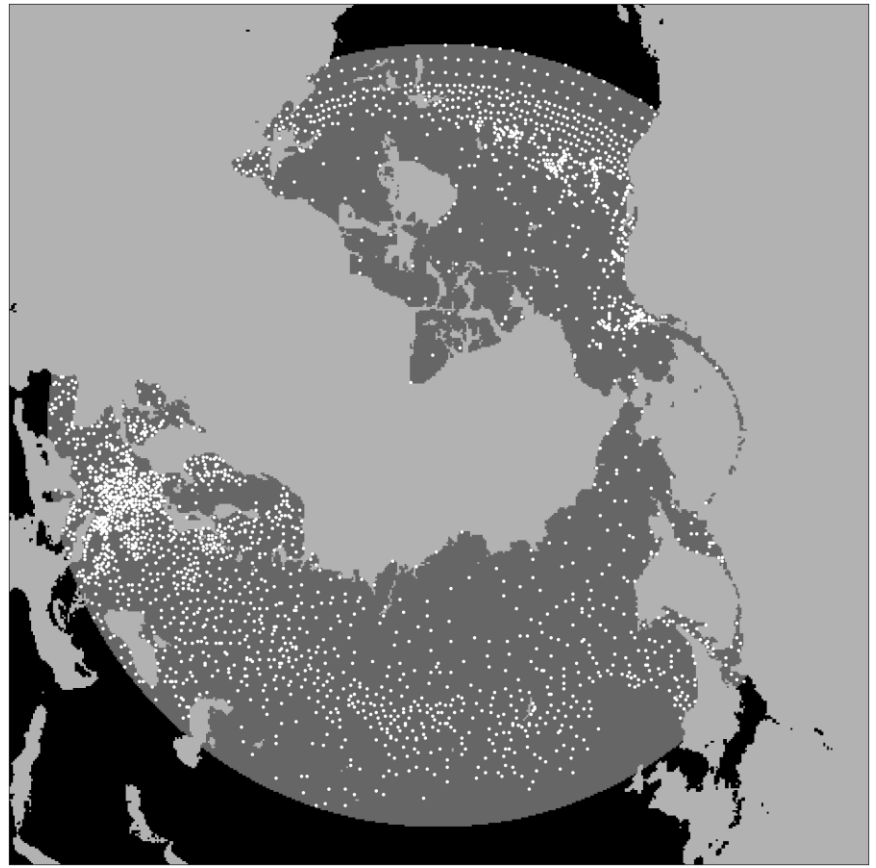
Methods

In situ data (39 years)

IMS snow maps (10 winter seasons)

- EASE-Grid SMMR, SSM/I, SSMIS
- Northern Hemisphere (above 40°N)
- Snow accumulation: Sep-Feb

Weather stations



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Comparison

SMMR and SSM/I-SSMIS

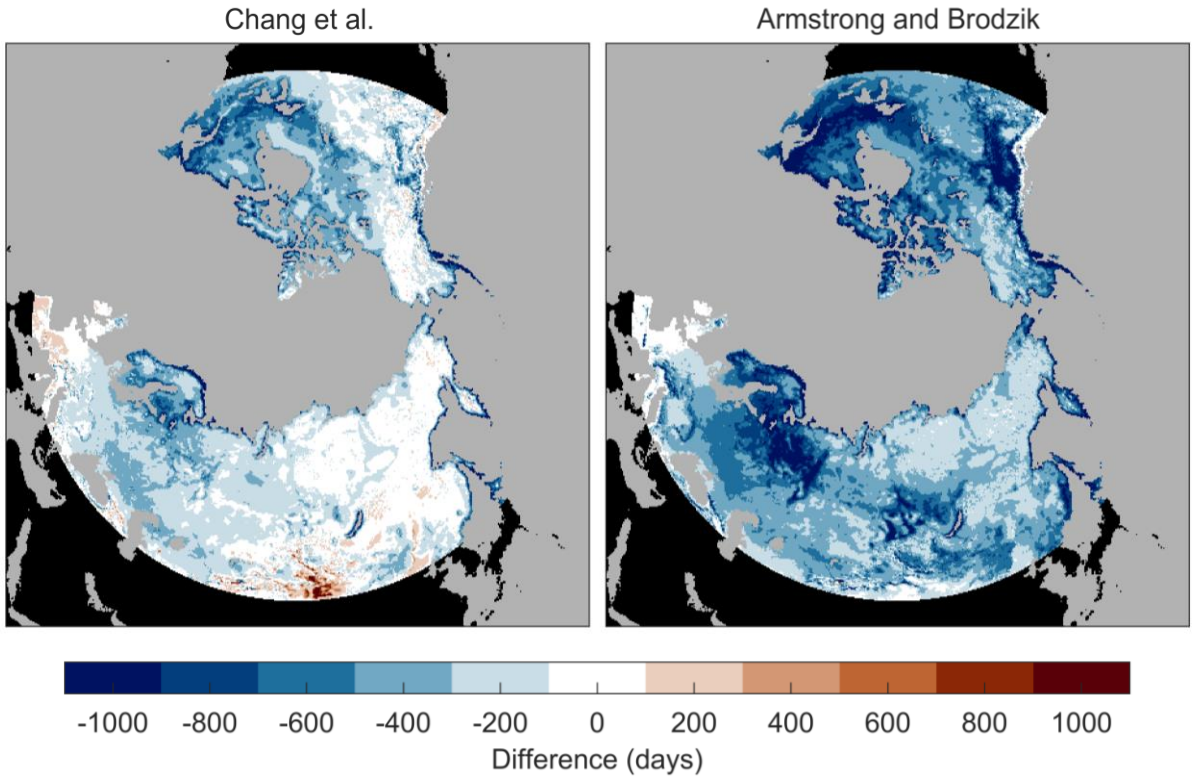
Chang et al.	SMMR (18 GHz)
Armstrong and Brodzik	SSM/I (19 GHz)

→ no improvement

Accuracy wrt in situ data

Chang et al.		Armstrong and Brodzik
70%	SMMR	–
73%	SSM/I–SSMIS	73%

Difference wrt IMS maps



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Comparison

Forest Cover

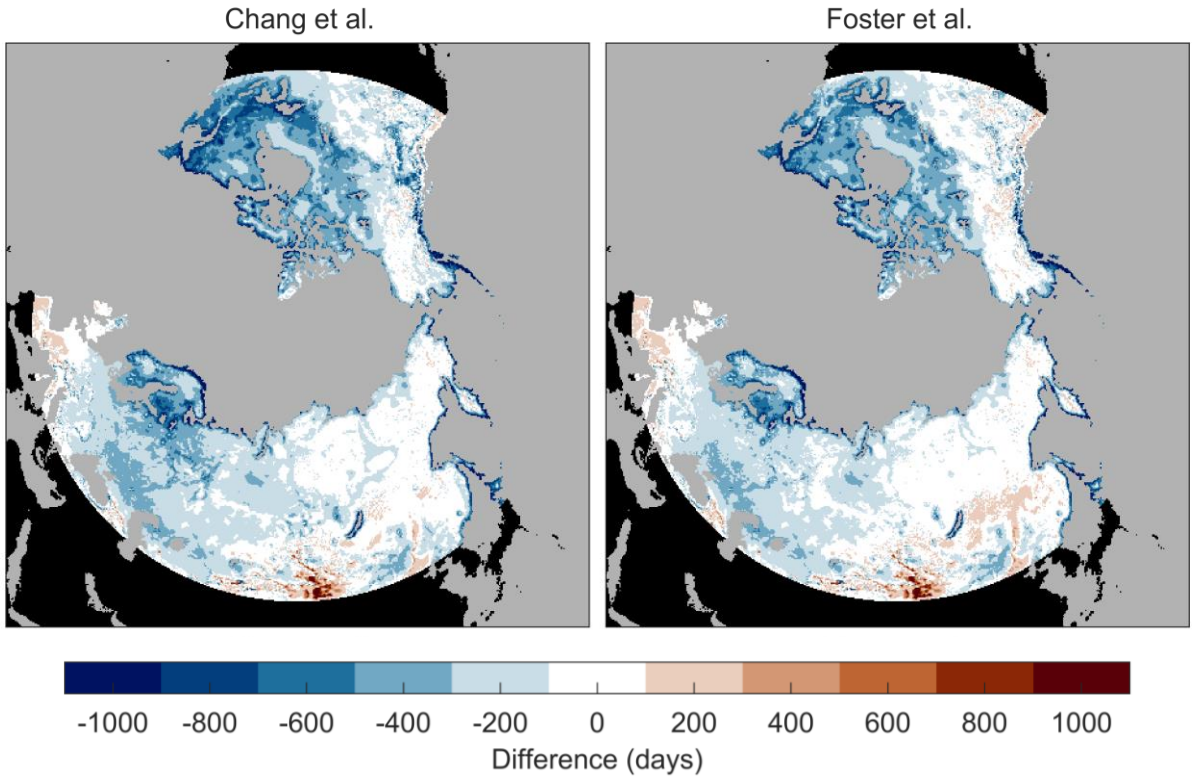
Chang et al.	–
Foster et al.	Forest cover fraction

→ no significant improvement

Accuracy wrt in situ data

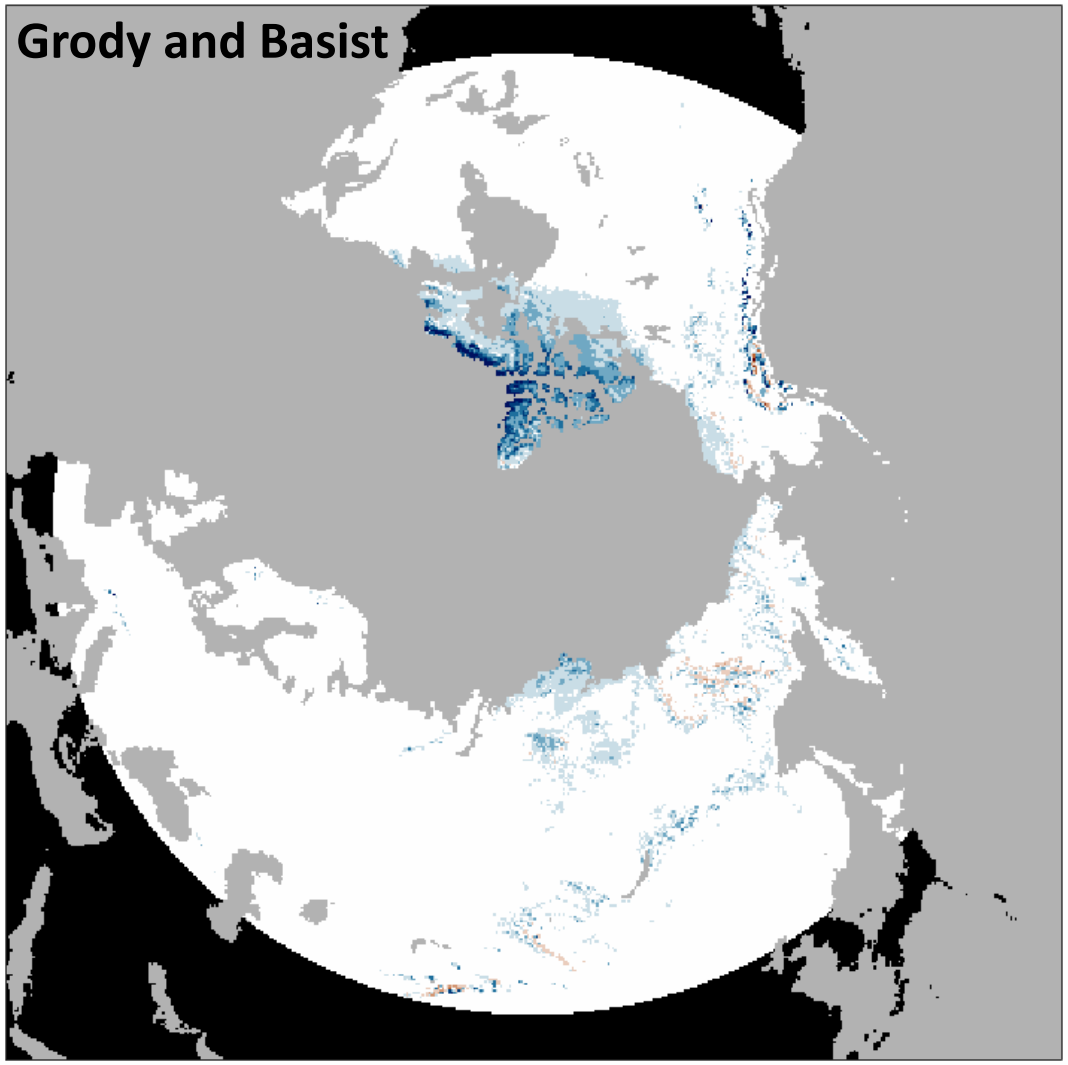
Chang et al.		Foster et al.
70%	SMMR	71%
73%	SSM/I–SSMIS	71%

Difference wrt IMS maps



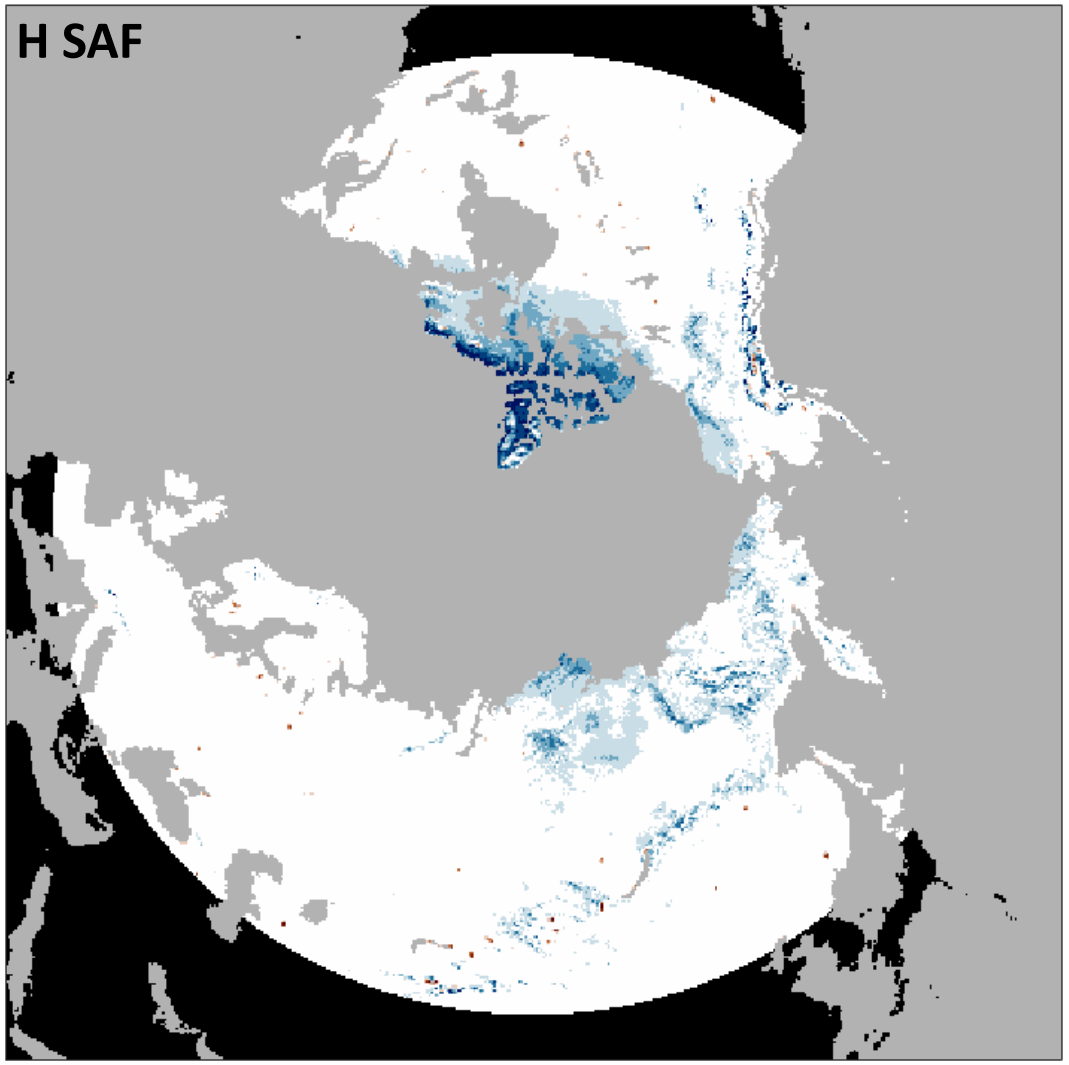
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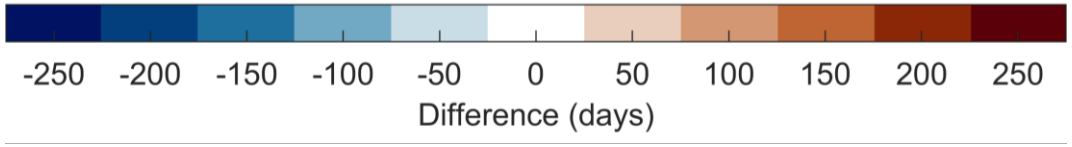


(a) September

Zschenderlein et al. (2023)
Supplementary Material 3 and 5



(a) September



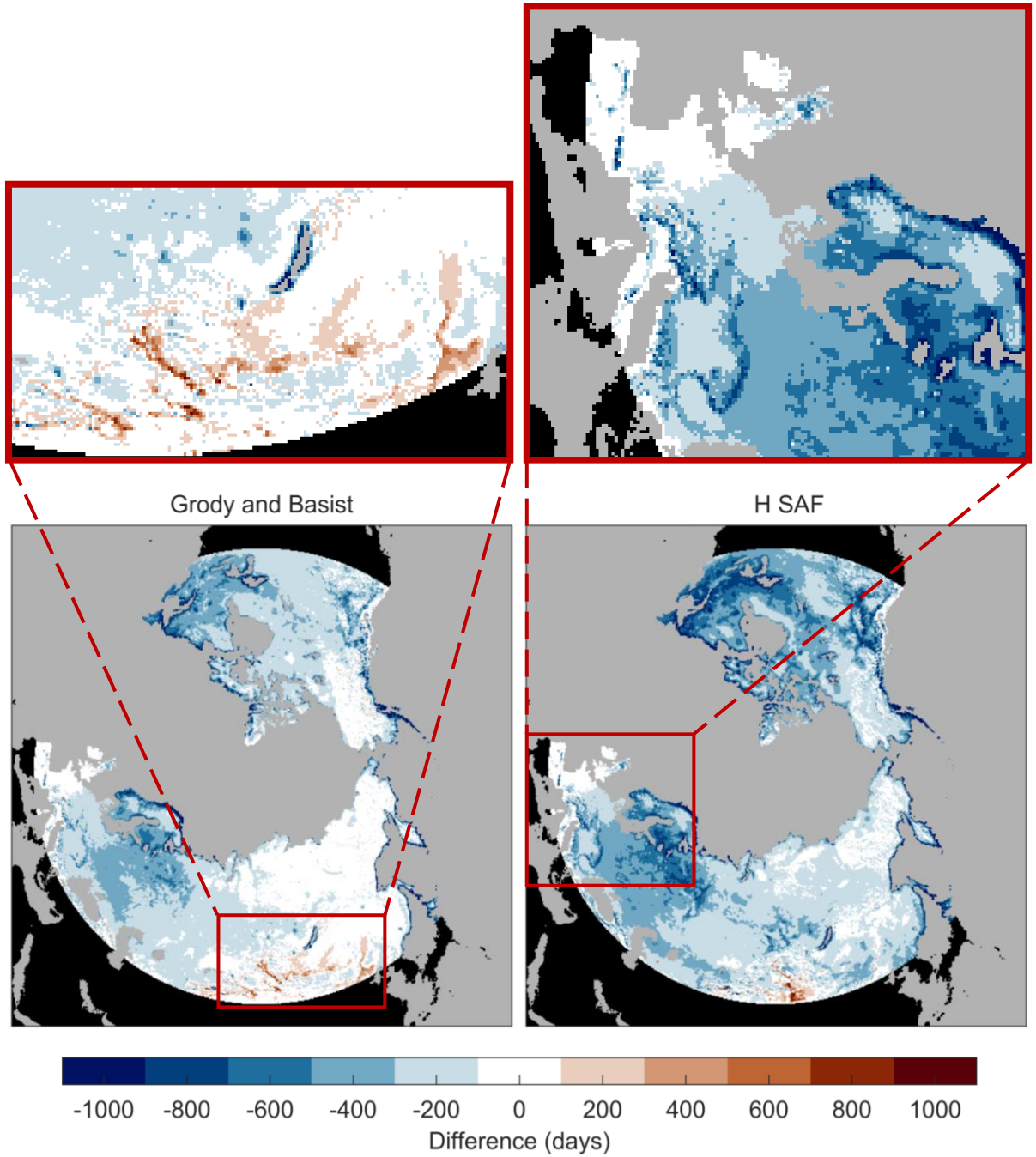
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Comparison

Under- and Overestimation

- Underestimation:
  mountain ranges, coasts
- Overestimation:
  cold desert, small lakes

Accuracy		
Grody and Basist		H SAF
–	SMMR	70%
82%	SSM/I–SSMIS	79%



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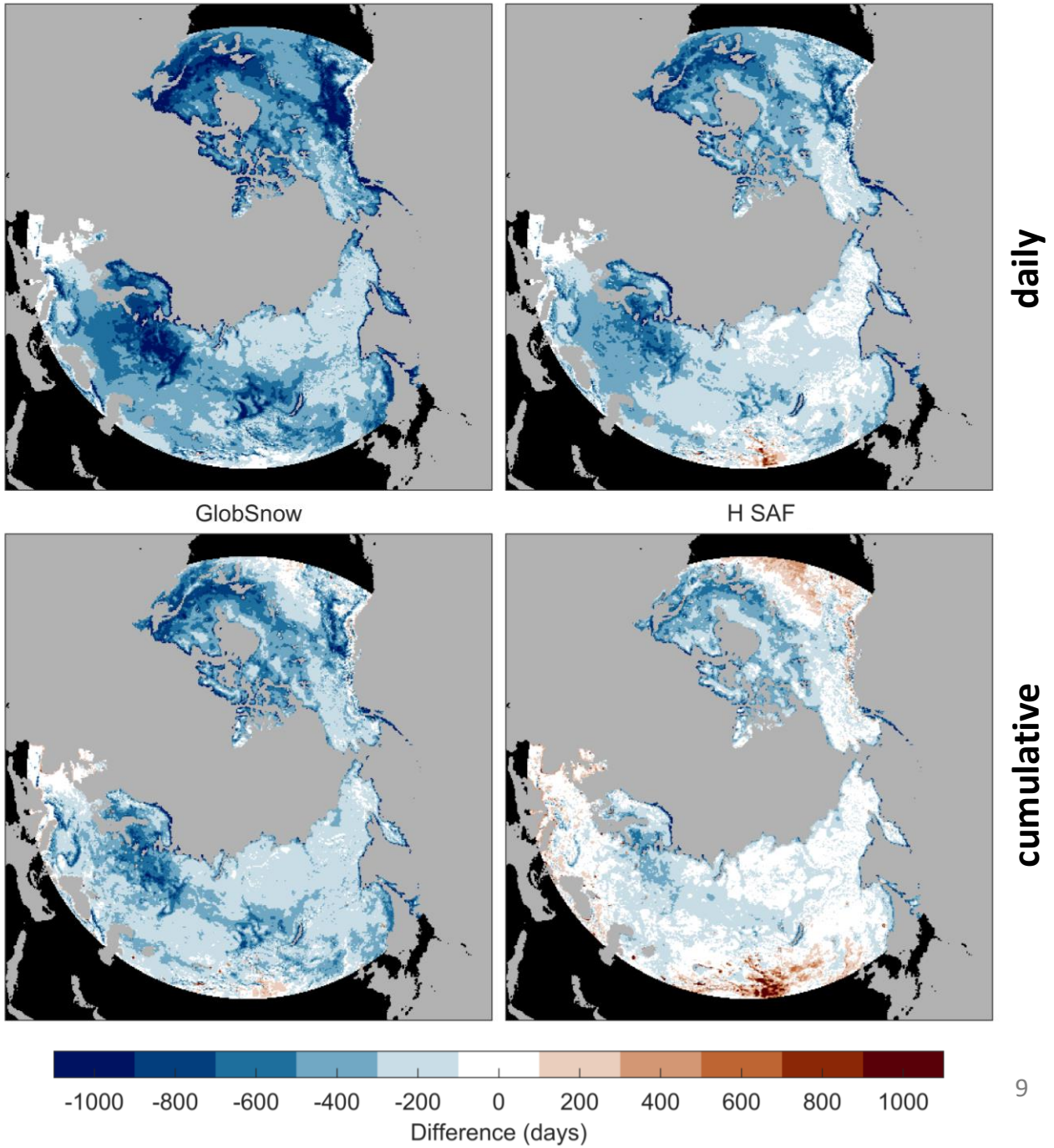
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Comparison

Daily vs. Cumulative

- Cumulative: retain detected snow throughout season
- Counteract underestimation

Accuracy		
GlobSnow	SSM/I–SSMIS	H SAF
71%		79%
79%		82%



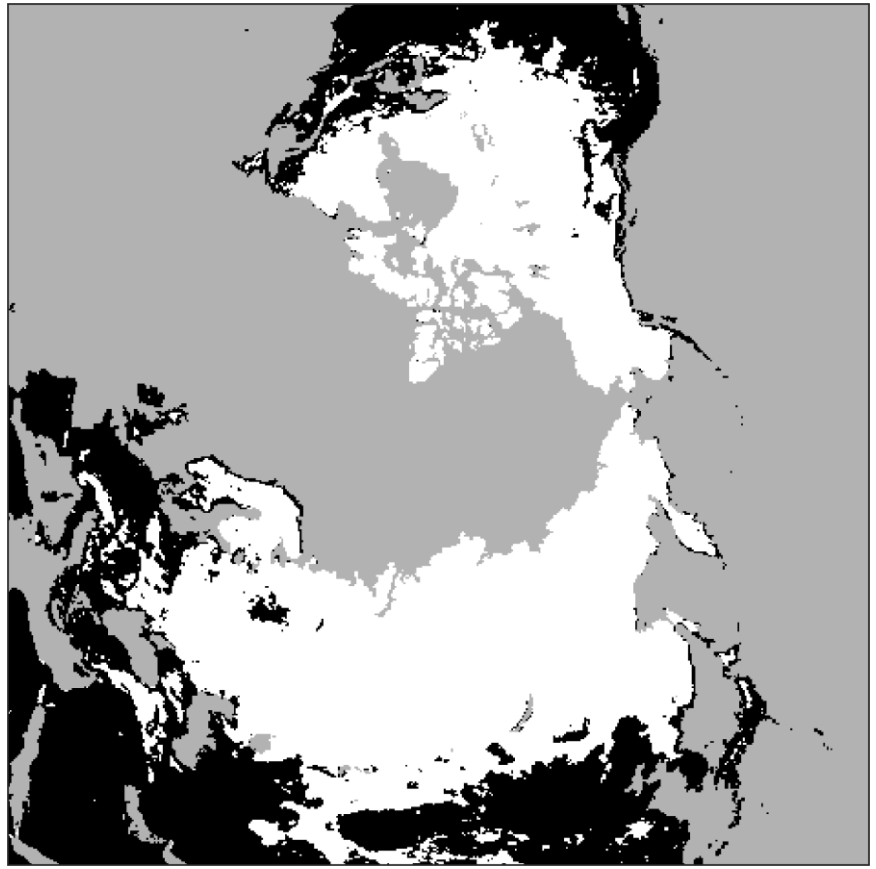
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SWE Retrieval

- Dry snow detection = processing step
- Cumulative snow masks
  - SMMR, SSM/I, SSMIS
- Snow melt detection
  - Based on passive microwave data

Cumulative snow mask (binary)



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SWE Retrieval

Validation

- In situ snow course SWE data
- Reduction in bias and RMSE → especially during early season (Sep-Dec)

	Deep (SWE ≤ 500 mm)		**Shallow** (SWE < 50 mm)	
	Bias	RMSE	Bias	RMSE
Grody and Basist 1987–2016	-1.6 mm	-1.9 mm	**-2.2 mm**	**-2.0 mm**
H SAF 1980–2016	-1.5 mm	-1.3 mm	**-2.2 mm**	**-1.7 mm**

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Conclusion

- Discrimination between scattering sources beneficial
- Counteract underestimation through cumulative masks (with melt detection)
- Improvement of SWE retrieval: shallow snowpacks in autumn
  → GlobSnow v3.0 NH SWE dataset

CIMR Algorithm Development (DEVALGO): Terrestrial Snow Area (TSA)

→ Ka and Ku-band for H SAF

→ Expand to Northern Hemisphere

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Thank you!

Zschenderlein, L., Luojus, K., Takala, M., Venäläinen, P., Pulliainen, J., 2023.
Evaluation of passive microwave dry snow detection algorithms and application to SWE retrieval during seasonal snow accumulation.
Remote Sens. Environ. 288, 113476. https://doi.org/10.1016/j.rse.2023.113476

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