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中国科技部-欧洲空间局“龙计划”合作
2017 DRAGON 4 SYMPOSIUM
2017年“龙计划”四期学术研讨会
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ARCTIC SEA ICE MONITORING BY SPACEBORNE SAR

The collaboration team from DLR and RADI, CAS :

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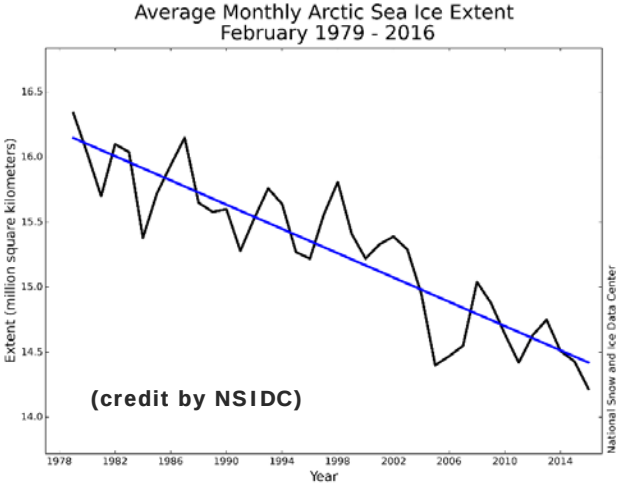
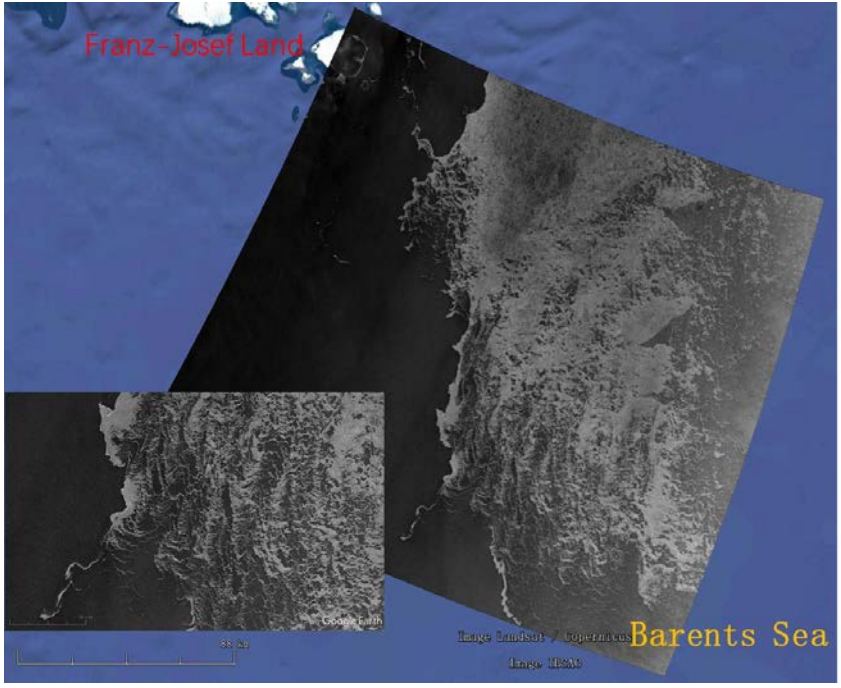
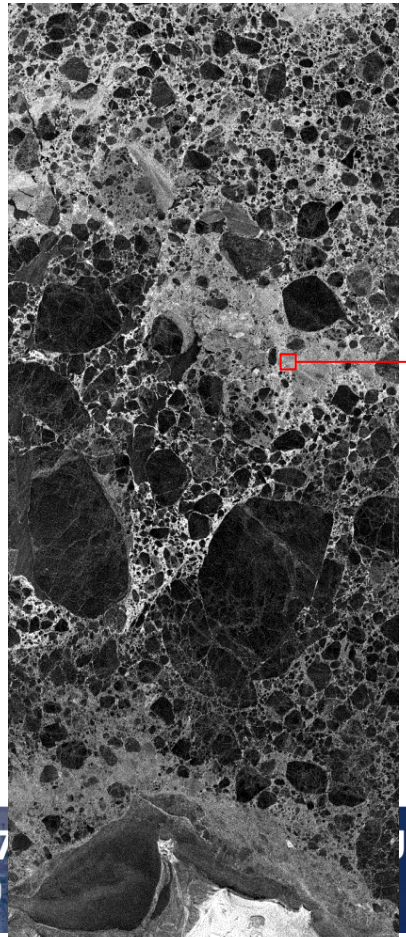

Average Monthly Arctic Sea Ice Extent
February 1979 - 2016
Extent (million square kilometers)
16.5
16.0
15.5
15.0
14.5
14.0
1978
1982
1986
1990
1994
1998
2002
2006
2010
2014
Year
National Snow and Ice Data Center
(credit by NSIDC)


Franz-Josef Land
Barents Sea

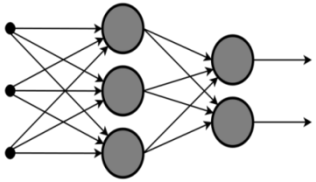
Topics

- Sea ice classification based on TerraSAR-X polarimetric data
- Ice-water discrimination based on Chinese GF-3 polarimetric SAR data
- Estimation of sea ice drift based on multi-temporal SAR data
- Detection of iceberg based on single SAR image

General approach of sea ice classification

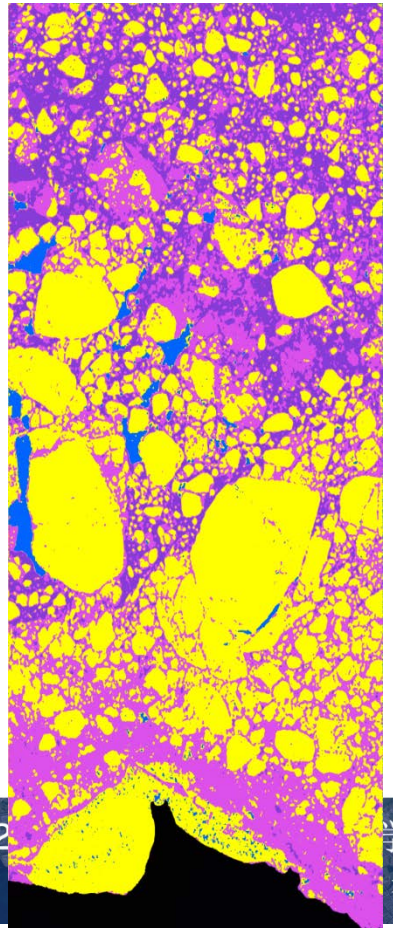


$$\begin{pmatrix} f_1 \\ f_2 \\ f_3 \end{pmatrix}$$



local feature vector

ANN

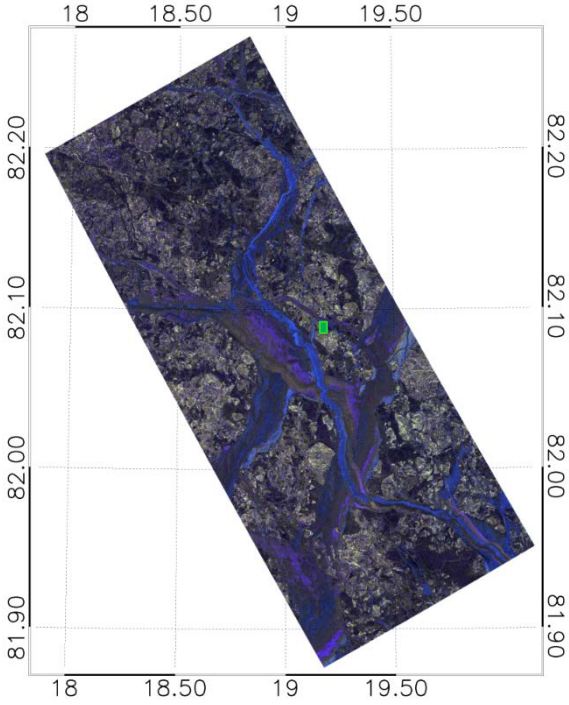


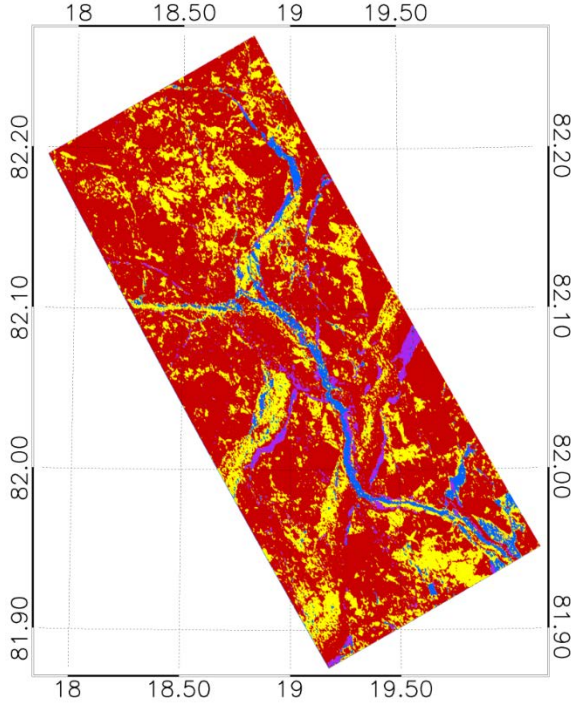
Sea ice classification in NRT based on TerraSAR-X data

Lance Research Vessel, © NPI/N-ICE

Ice classification

- Open Water/Nilas
- Smooth First Year Ice
- Rough First Year/ Multi-Year Ice
- Young Ice

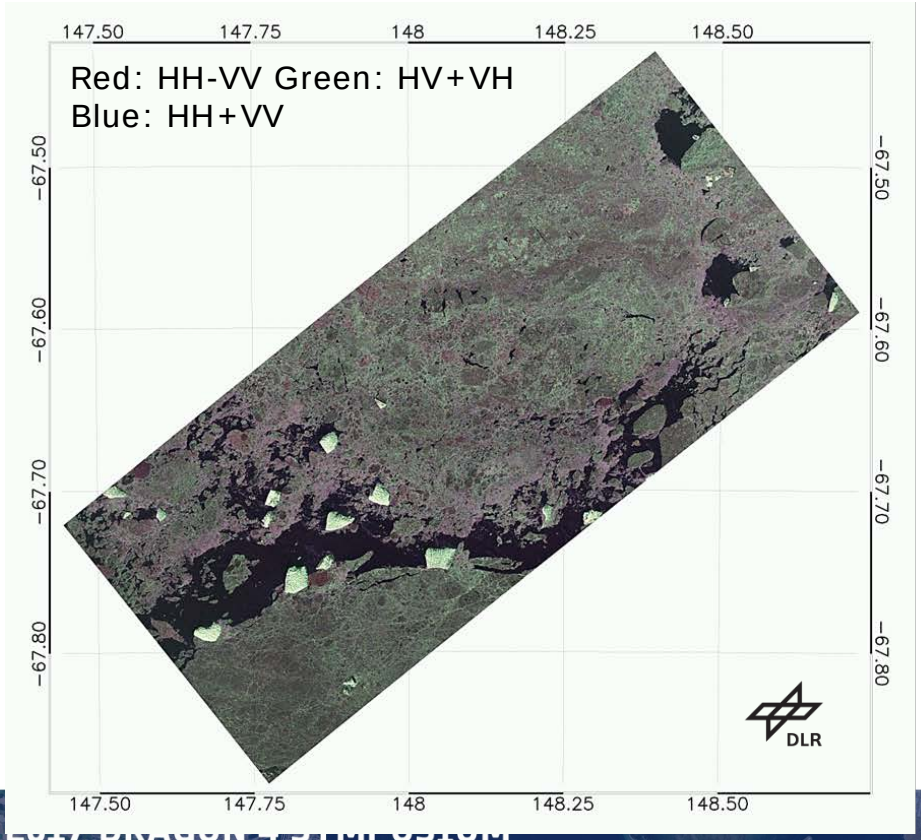


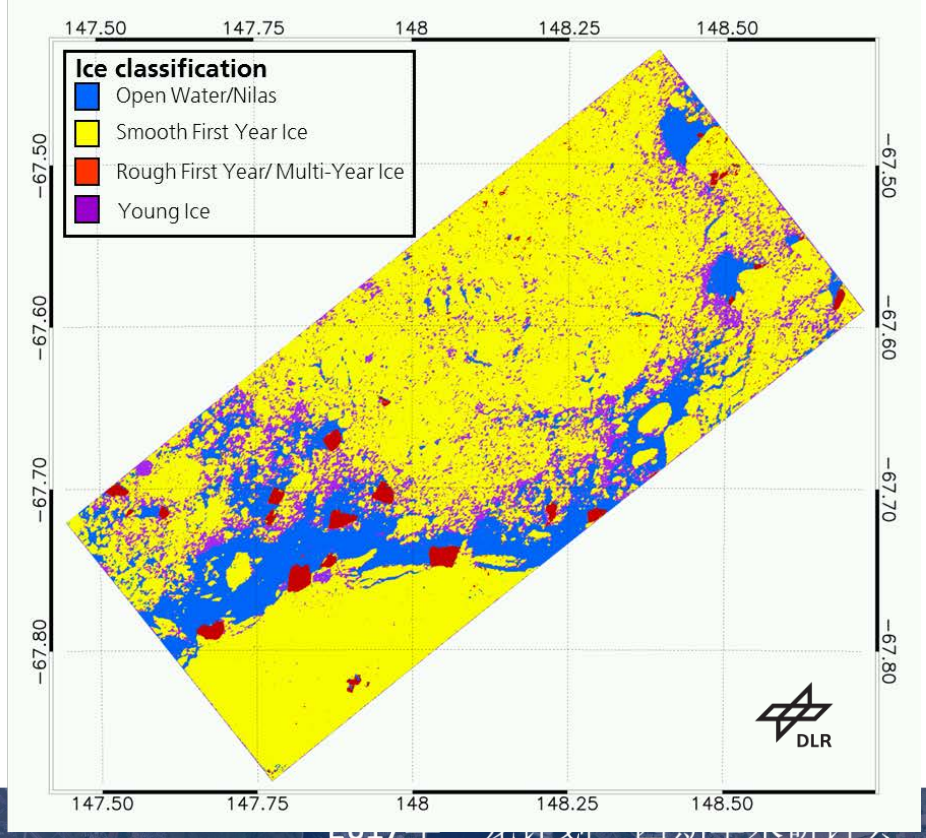


TerraSAR-X HHVV StripMap, 2015/02/12, 14:51 UTC, Arctic Ocean

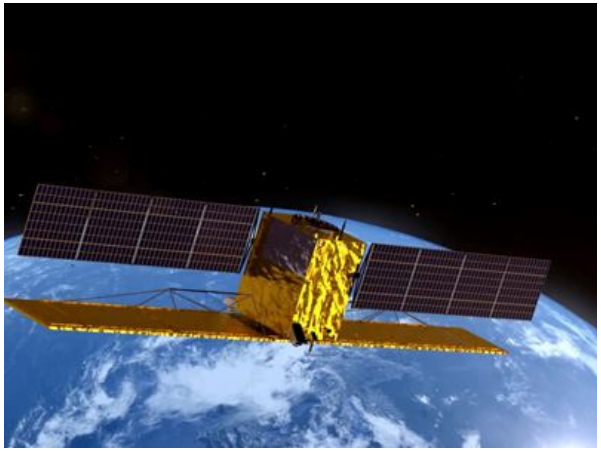
R. Ressel, S Singha, S. Lehner, A. Rösel and G. Spreen, "Near Real Time Automated Sea Ice Classification using Polarimetric TerraSAR-X Images", *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, 2016

Sea ice Classification based on R2 Quad Polarization data





Ice-water discrimination based on GF-3 cross-polarization data

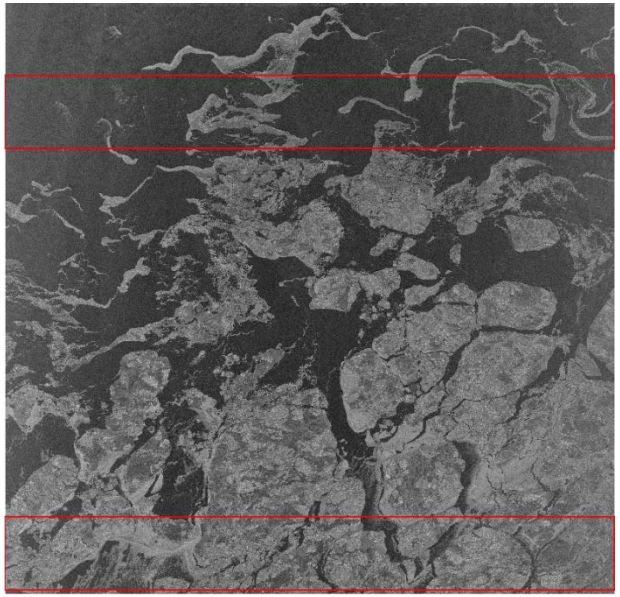


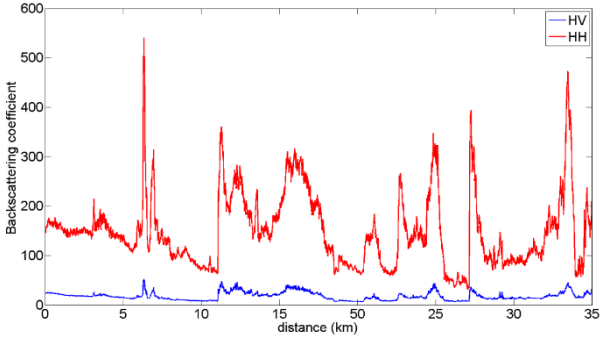
- GaoFen-3 is a SAR of China's GaoFen constellation satellites, which was successfully launched on August 10, 2016.
- It is the first civil C-band SAR of China with spatial resolution up to 1 m.
- It has capability of single, dual and full polarimetry, as well as various imaging modes.

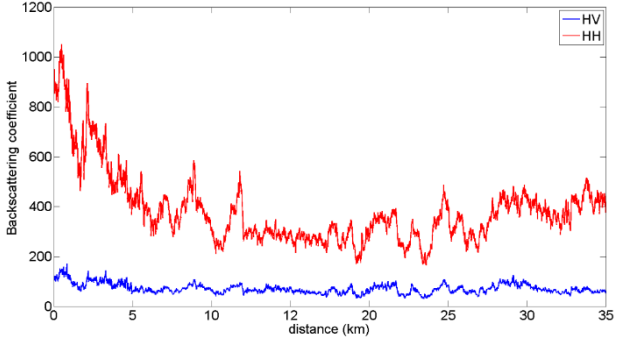
Ice-water discrimination based on GF-3 cross-polarization data

GF-3 HV data are used for ice-water discrimination because:

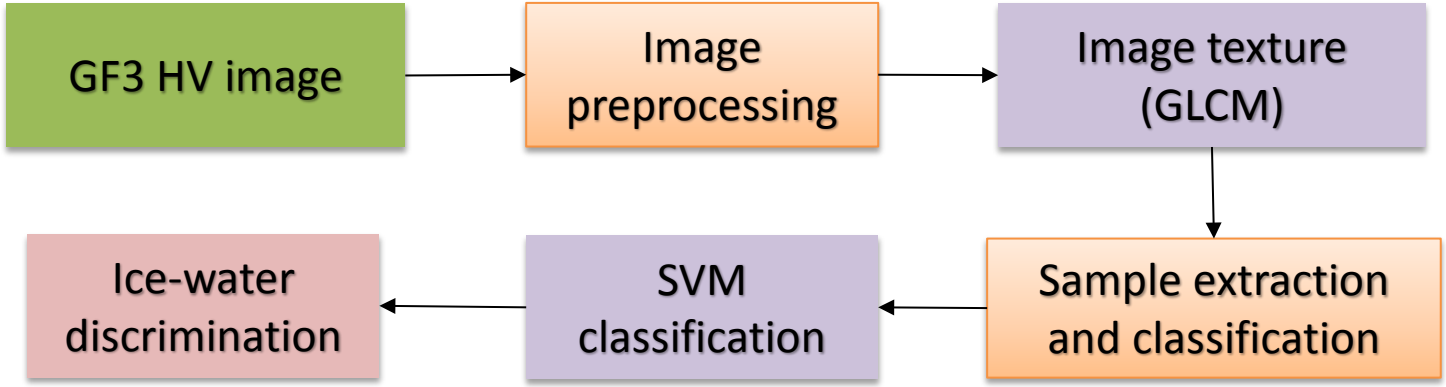
- HV polarization is less sensitive to wind speed compared with the HH or VV polarization data.
- NRCS variation in HV polarization to incident angle is not as sensitive as that in HH.







Ice-water discrimination based on GF-3 cross-polarization data

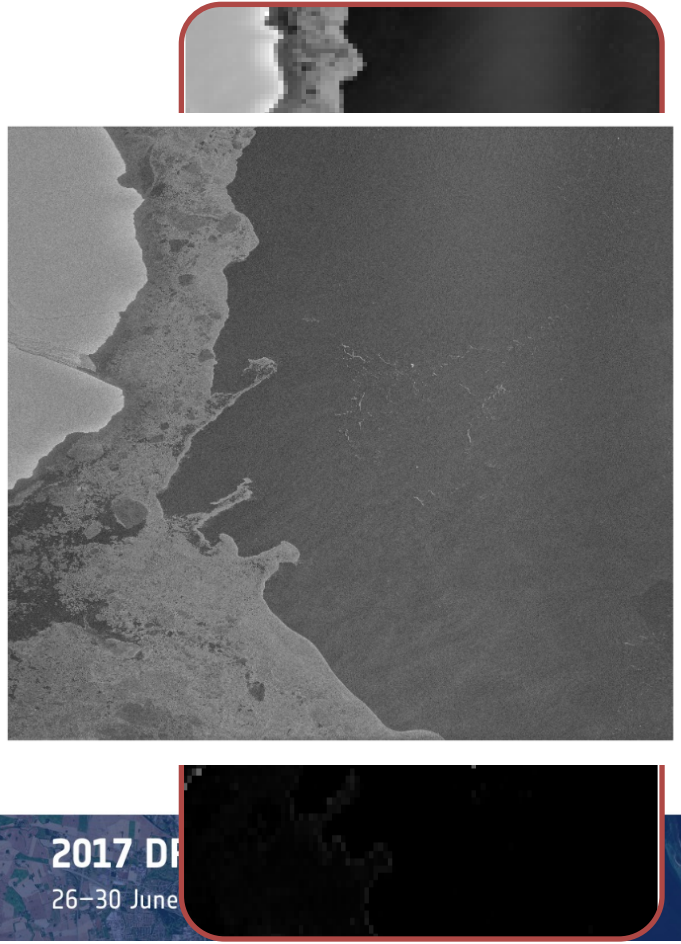


- The general idea is to use the **support vector machine** (SVM) classification method;
- Image texture extraction is based on the Gray Level Co-currency Matrix (**GLCM**)

$\overline{\sigma_0}$

Energy

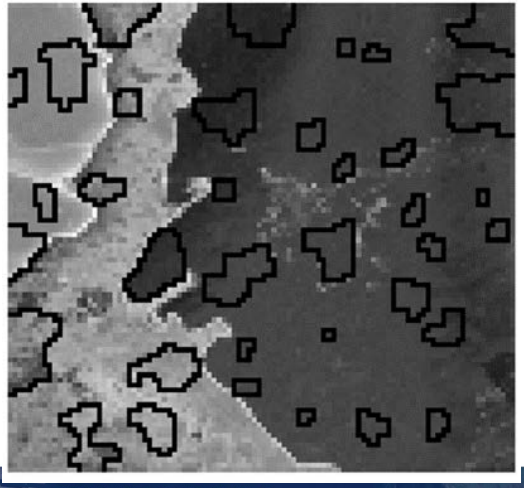
Entropy



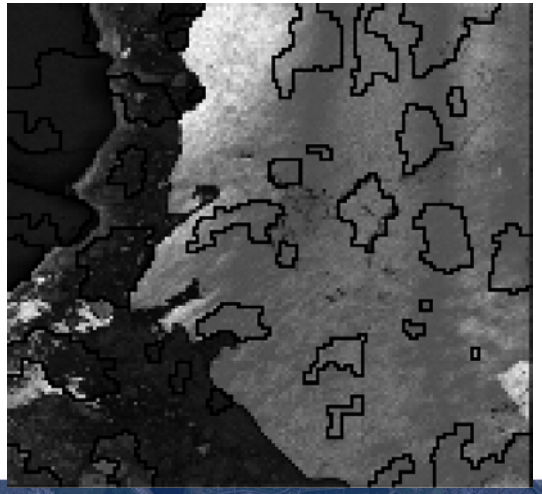
Correlation

Homogeneity

- Getting the threshold on energy and entropy by the adaptive threshold method;
- Calculate the average values of the samples on energy and entropy;
- **Energy value** greater than a threshold is water, and **entropy value** greater than a threshold is ice.



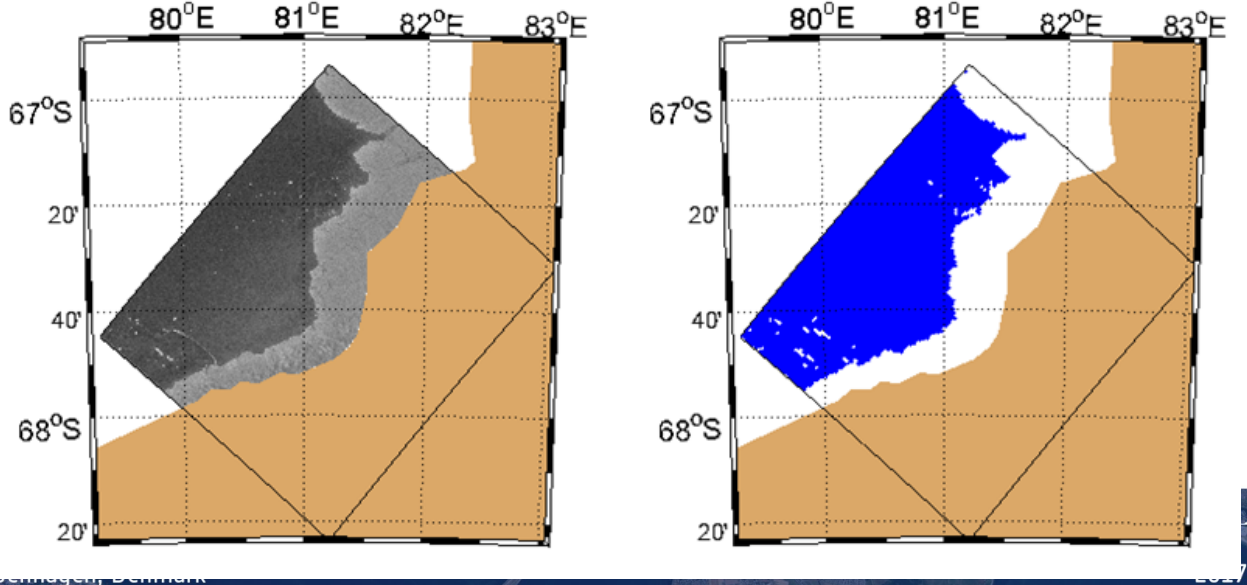
Samples from entropy



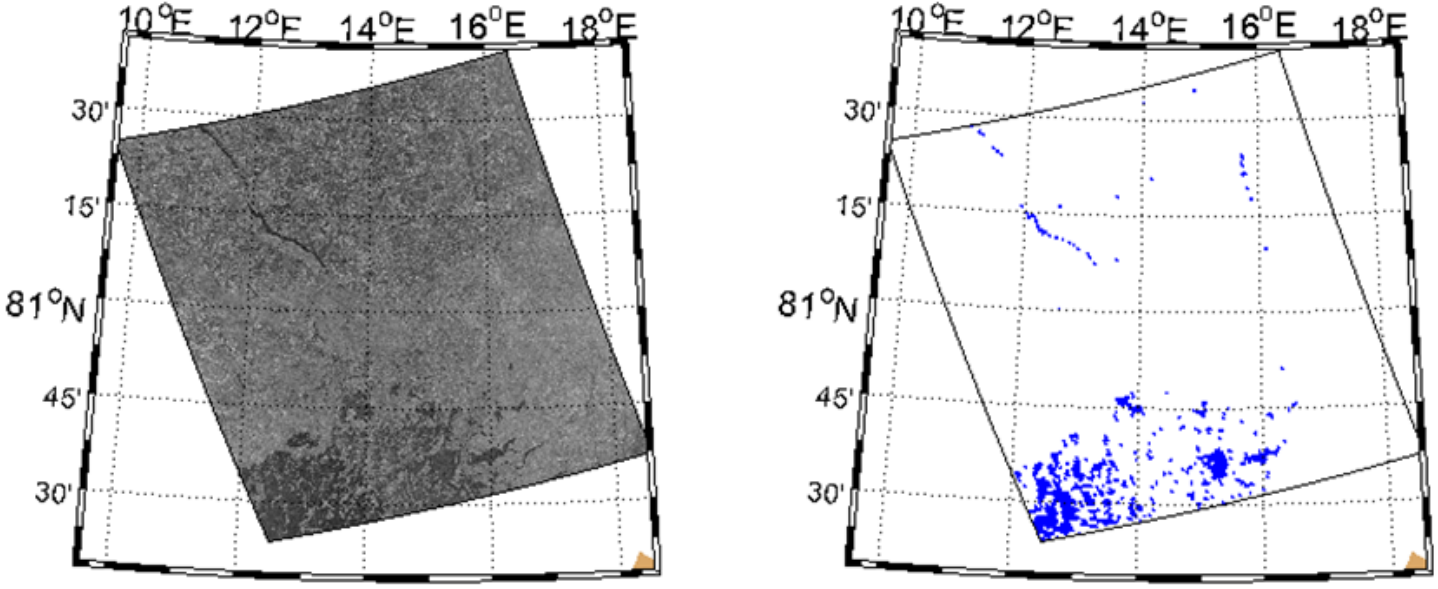
Samples from energy

Ice-water discrimination based on GF-3 cross-polarization data

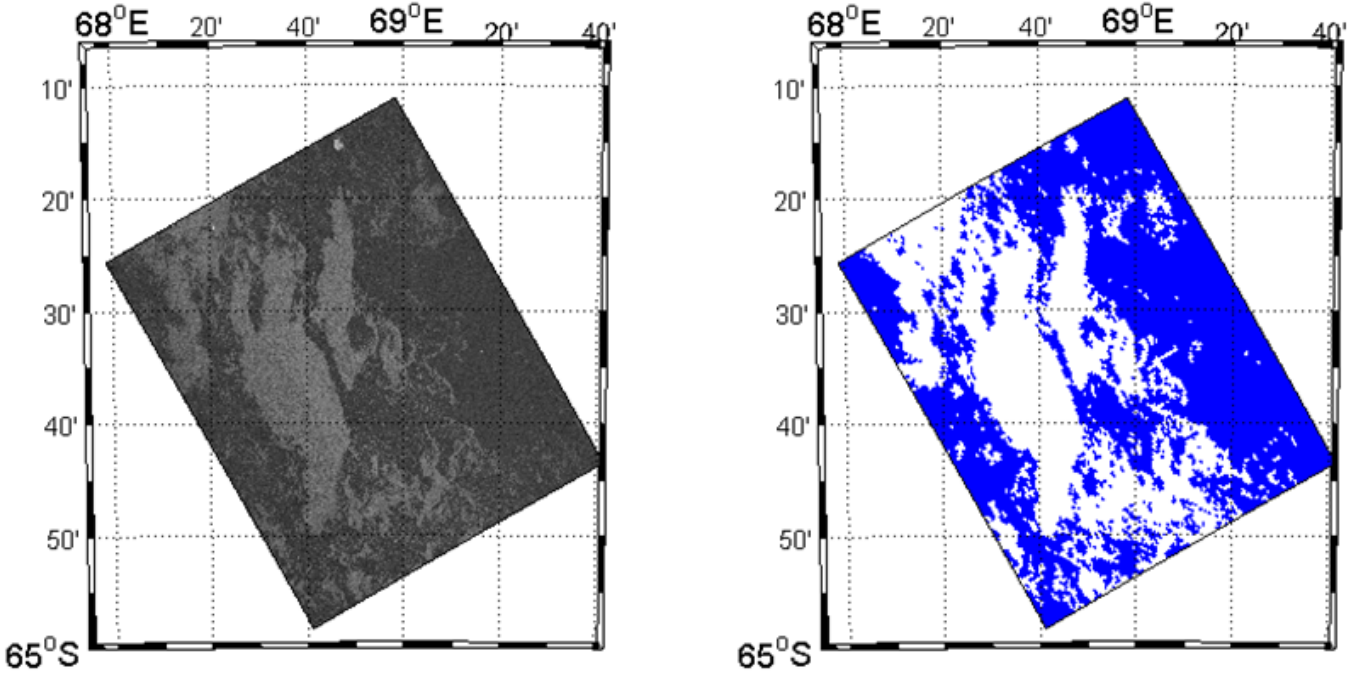
- The six image textures of the ice and water samples are used for training.
- The LibSVM software is used for the SVM classification.



- **There is a large amount of sea ice and they are less broken.**

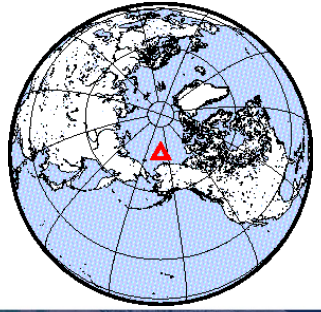


- **Sea ice is broken and sea water is mixed with sea ice.**



Estimation of ice drift

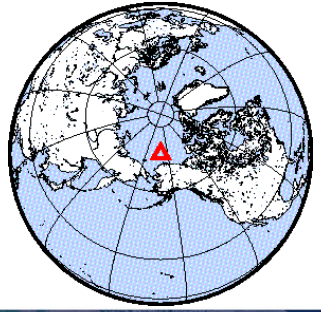
With two SAR images from different missions – TSX and Radarsar-2



Sikuliaq campaign

Estimation of ice drift

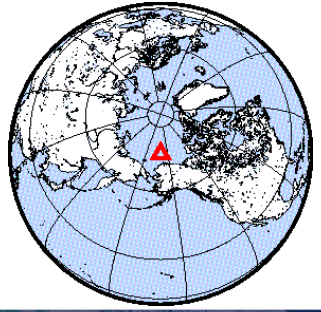
With two SAR images from different missions

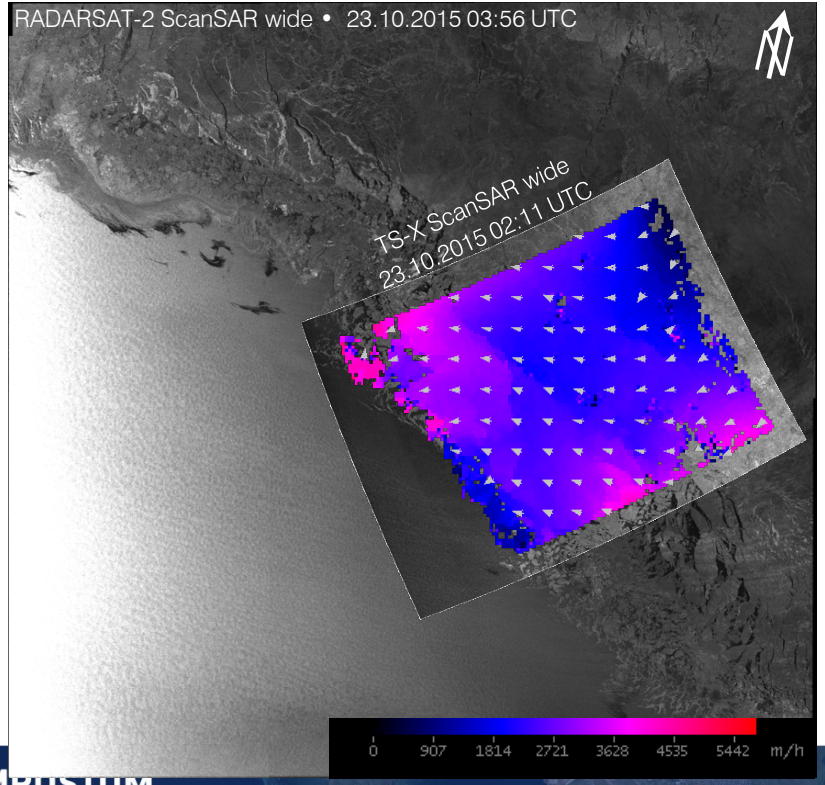


Sikuliaq campaign

Estimation of ice drift

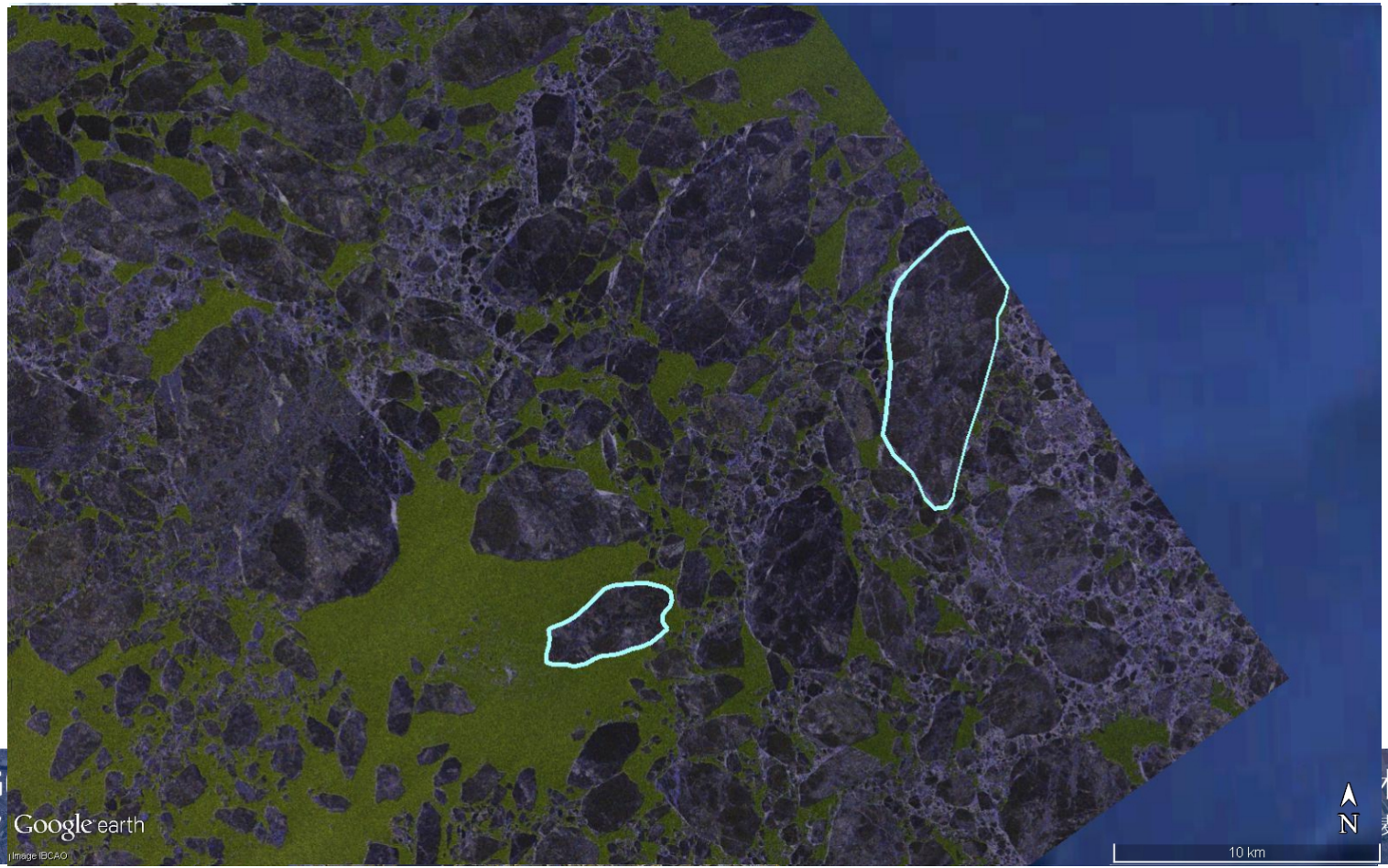
With two SAR images from different missions



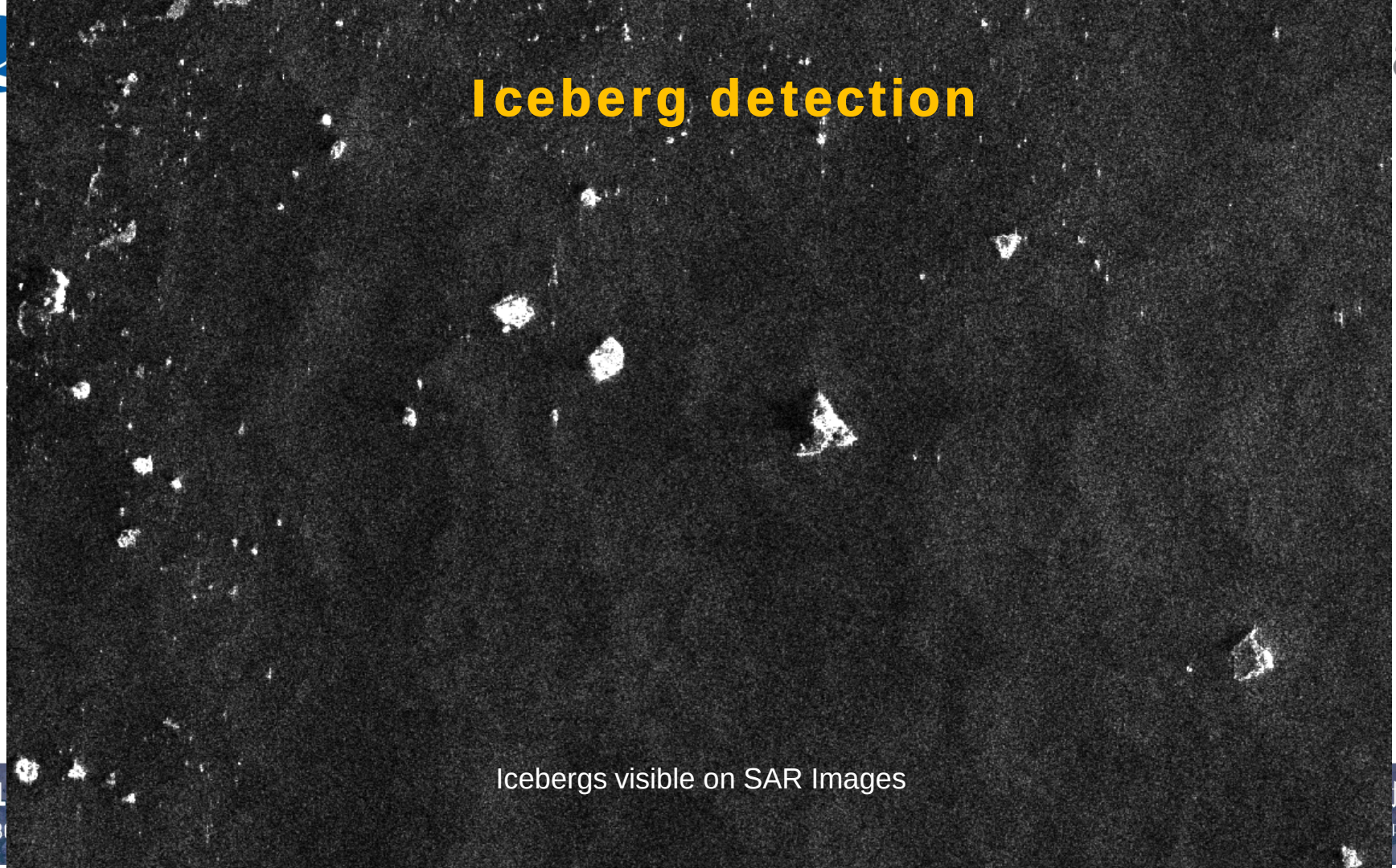


Sikuliaq campaign

Estimation of ice drift



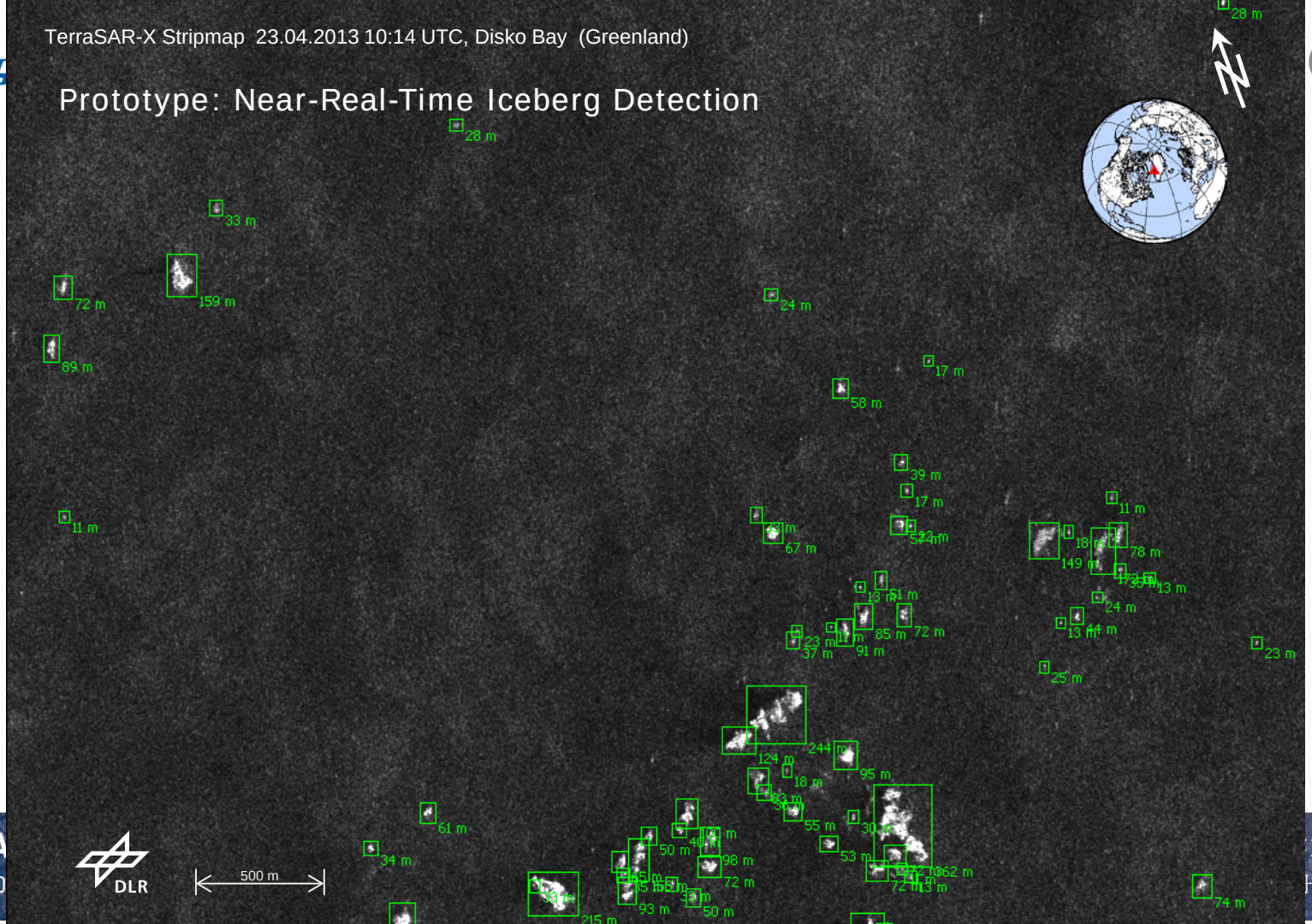
Iceberg detection

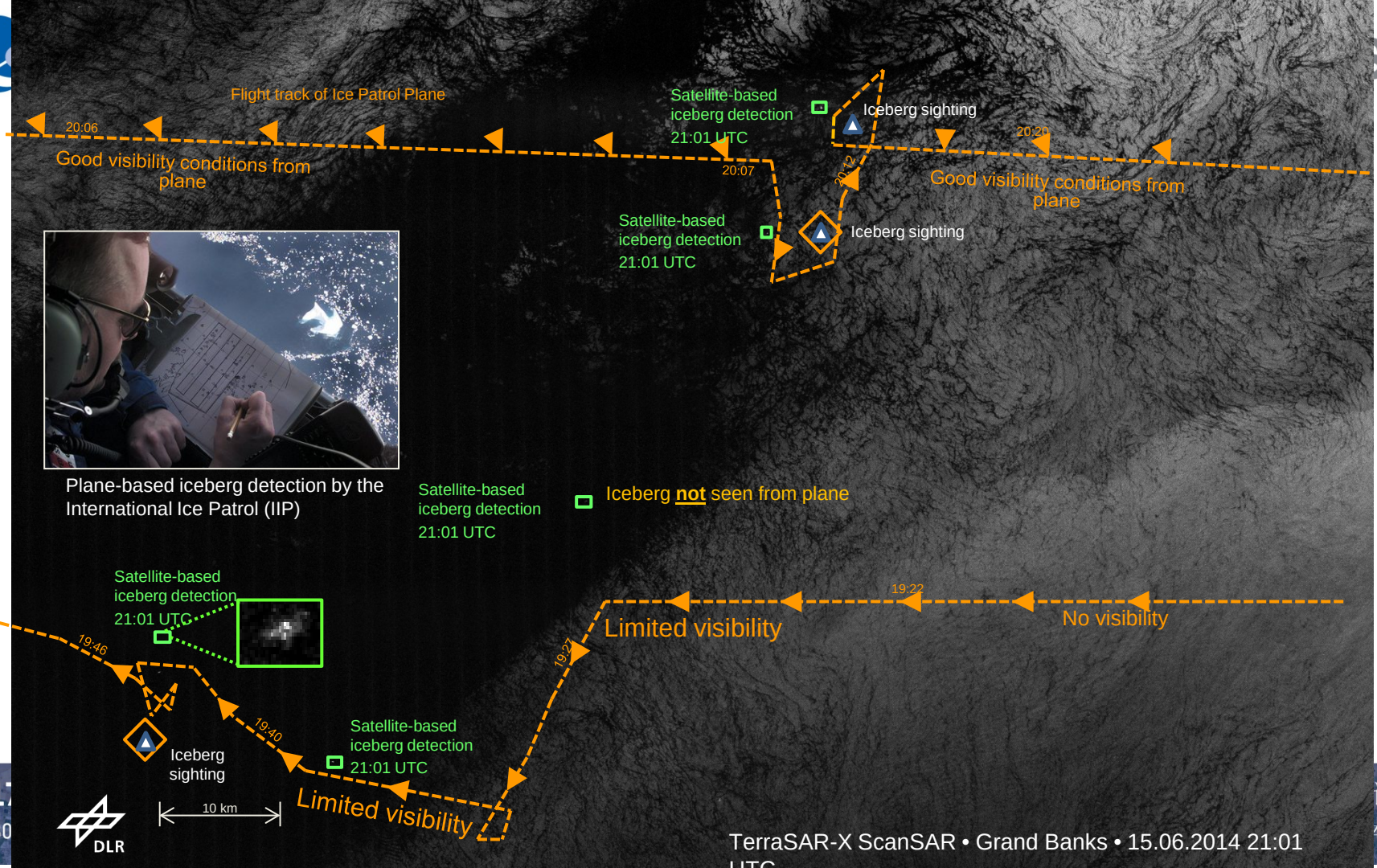


Icebergs visible on SAR Images

TerraSAR-X Stripmap 23.04.2013 10:14 UTC, Disko Bay (Greenland)

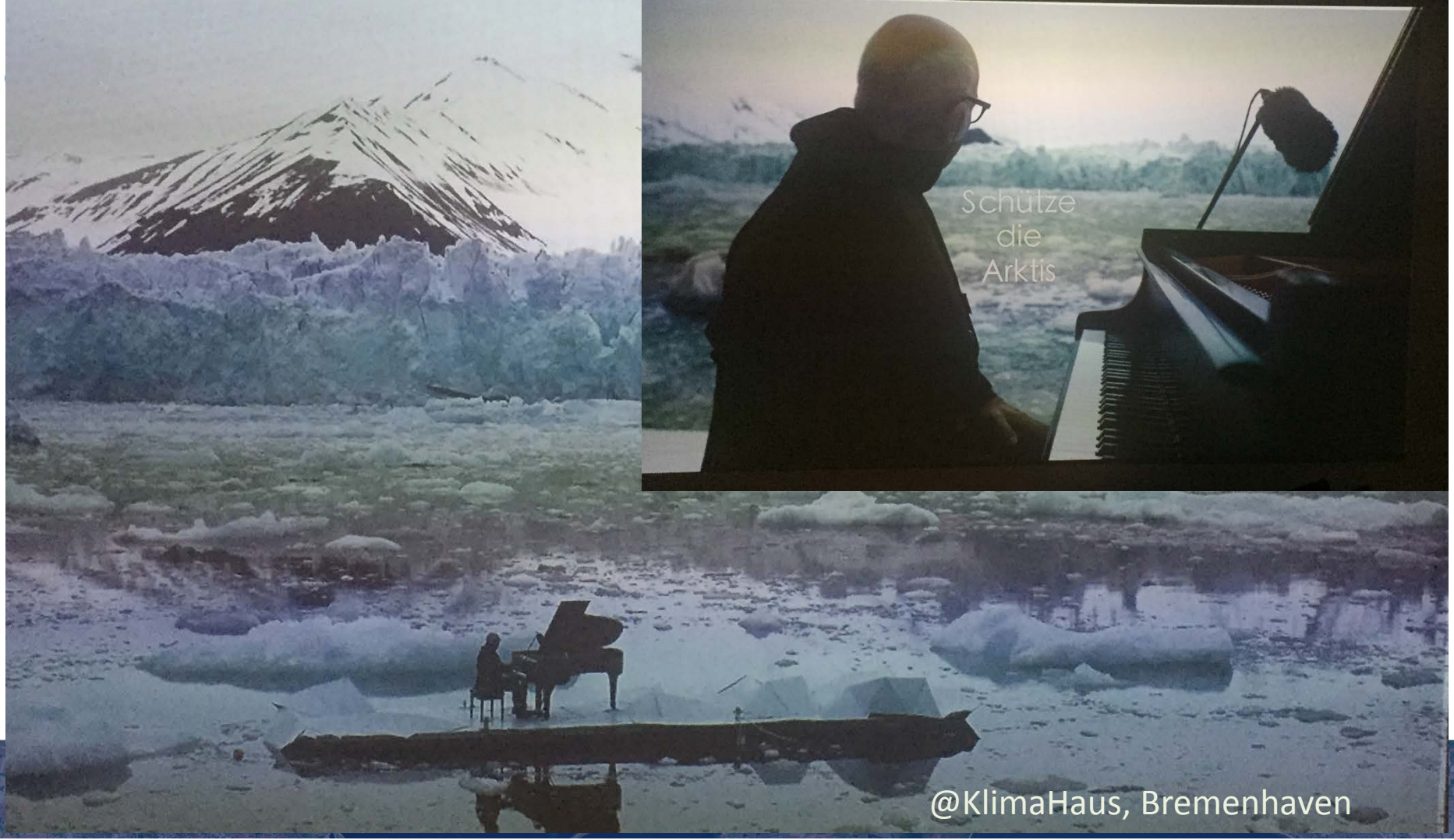
Prototype: Near-Real-Time Iceberg Detection




Flight track of Ice Patrol Plane
20:06
Good visibility conditions from plane
Satellite-based iceberg detection 21:01 UTC
20:07
Iceberg sighting
20:12
20:20
Good visibility conditions from plane
Satellite-based iceberg detection 21:01 UTC
Iceberg sighting
Plane-based iceberg detection by the International Ice Patrol (IIP)
Satellite-based iceberg detection 21:01 UTC
Iceberg not seen from plane
Satellite-based iceberg detection 21:01 UTC
19:46
19:40
Iceberg sighting
Satellite-based iceberg detection 21:01 UTC
Limited visibility
19:27
19:22
Limited visibility
No visibility
10 km
DLR
TerraSAR-X ScanSAR • Grand Banks • 15.06.2014 21:01 UTC

Short summary

- Polarimetric SAR data are good at sea ice classification and ice-water discrimination, particularly the dual-polarization (HH+VV, HH+HV/VH+VV) SAR has relatively large swath, which is of great potential for operation service in Arctic ocean.
- Along with more spaceborne SAR in orbits, multiple SAR missions can certainly provide accurate and high-spatial resolution estimation of sea ice drift in regional seas for better understand of ice-ocean dynamics.
- Single-polarization SAR images in large swath provide good view of iceberg distribution, which is of great help for shipping security in Arctic ocean.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