CIRFA
CENTRE FOR
INTEGRATED REMOTE SensING
AND FORECASTING FOR ARCTIC OPERATIONS

UNIVERSITY OF TROMSØ

sfi Senter for forskningsdrevet innovasjon

Monitoring Sea Ice with Space-borne Synthetic Aperture Radar

Torbjørn Eltoft

UiT- the Arctic University of Norway

CIRFA – A Centre for Research-based Innovation

cirfa.uit.no

Sea ice & climate

Some basic facts

- Sea ice covers the polar oceans in the Arctic and the Antarctic
- The area covered by ice varies seasonally; the Arctic sea ice extent in winter is about 3 x larger than in summer (in 2012: factor 4...)
- Sea ice is from a few cm to several meters thick
- Ridging and rafting due to dynamics can lead to very thick ice
- Two main classes: *First-year ice* and *multiyear ice*
- The ice gets covered by snow, which when melting forms melt ponds

Sea Ice Types

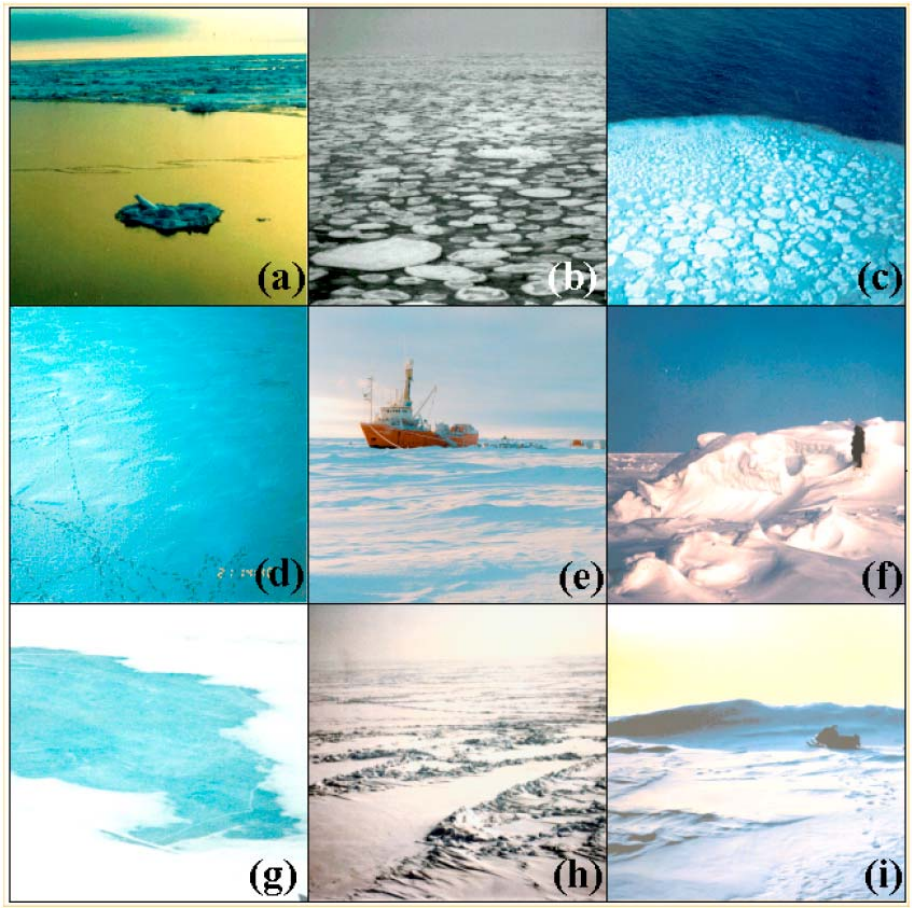
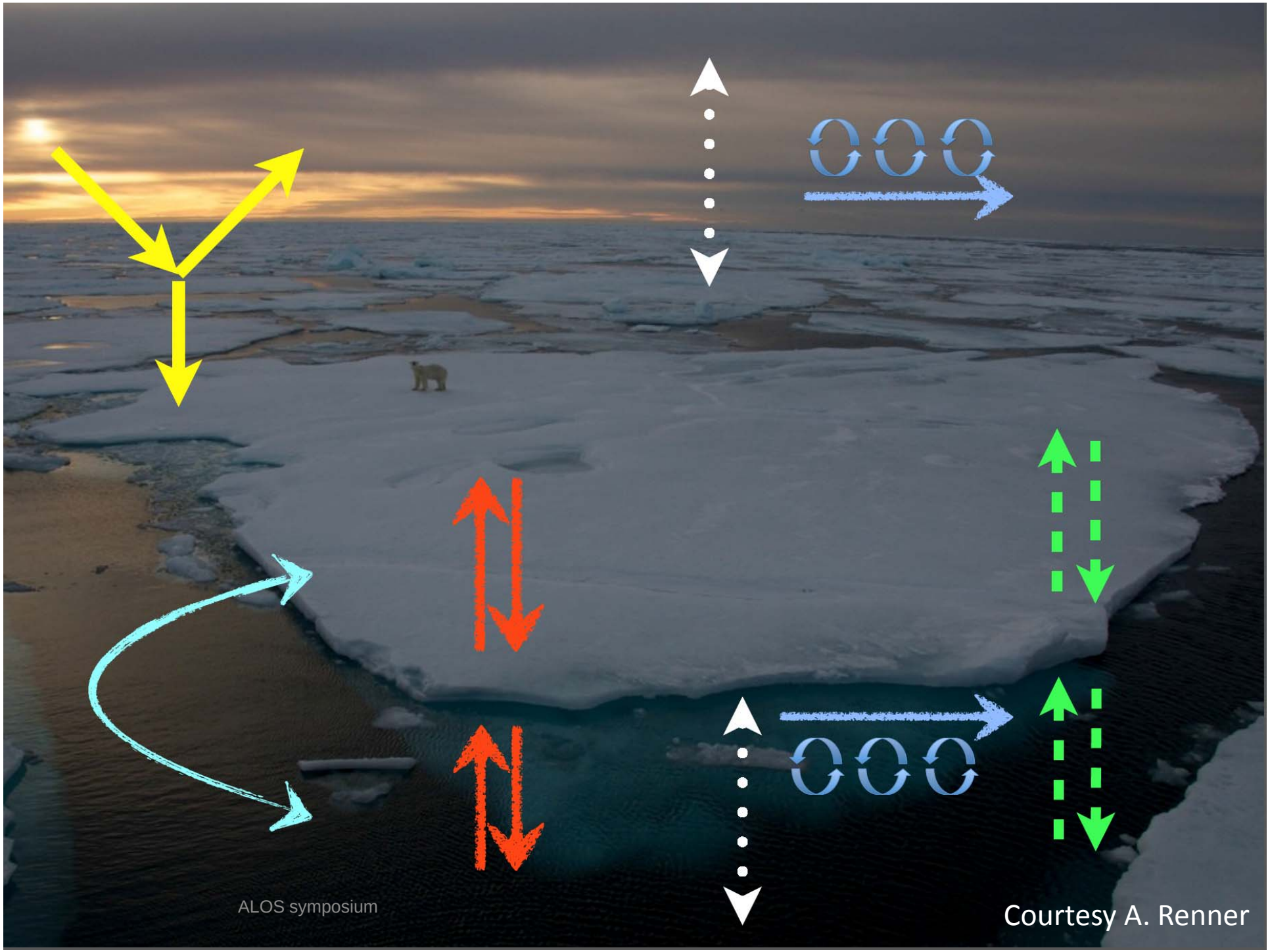


Figure 3.1. Photographs of a variety of sea ice types and forms: (a) new, (b) pancake, (c) marginal ice zone, (d) first year, (e) multiyear, (f) multiyear hummock, (g) multiyear meltpool, (h) first year pressure ridges, and (i) old multiyear pressure ridge ice.

(R.G.Onsott & R. Schuchman)


ALOS symposium
Courtesy A. Renner

What do we want to know about sea ice

- ❑ - Sea ice segmentation
- ❑ - Sea ice type classification
- ❑ - Physical characterization of sea ice
- ❑ - Retrieval of geophysical parameters
  - Concentration, thickness
  - Roughness
  - Ice floe size distribution
  - Lead & ridge fraction
  - Melt pond fraction
  - Sea ice drift estimation

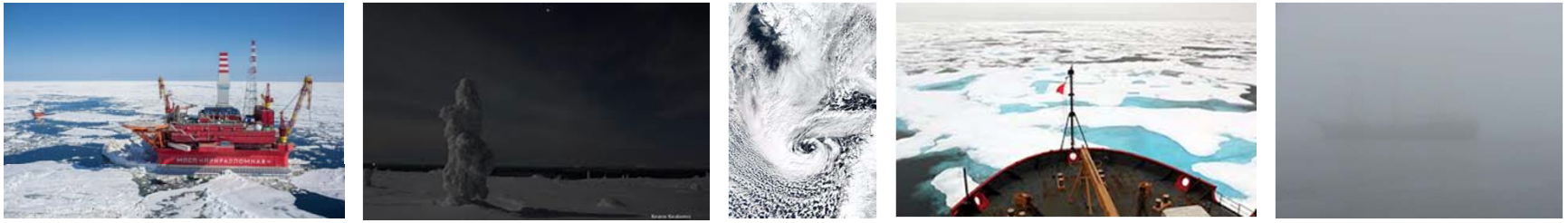
Sea Ice and Arctic Operations

- Oil & gas

- Shipping

- Tourism

Challenges related to Arctic industrial activities

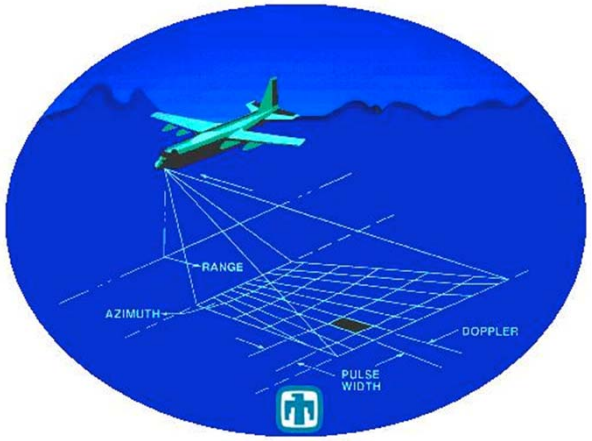


- Low temperatures
- Icing
- Remoteness
- Sea Ice
- Darkness
- Low visibility
- Polar lows and arctic storms

Arctic surveillance: Requirements

- Independent of weather and light conditions
- Image at multiple scales
- High spatial resolution
- Frequent imaging of ”Areas of Interest”
- Provide large information contents

Combine sensors !
Combine platforms !
’Synthtic Aperture Radar’ !



Some current & future radar Satellites

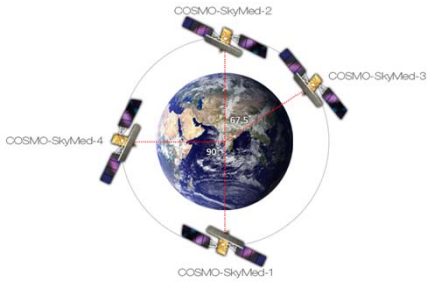
Current

Radarsat 2

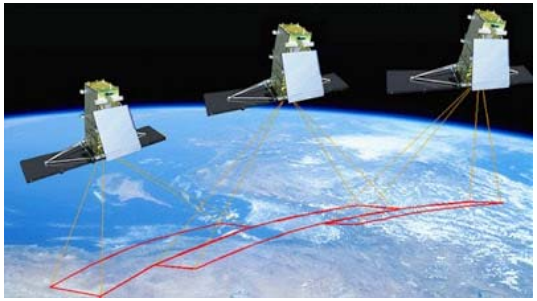
TerraSAR-X

ALOS Palsar 2

Sentinel 1



COSMO-SkyMed

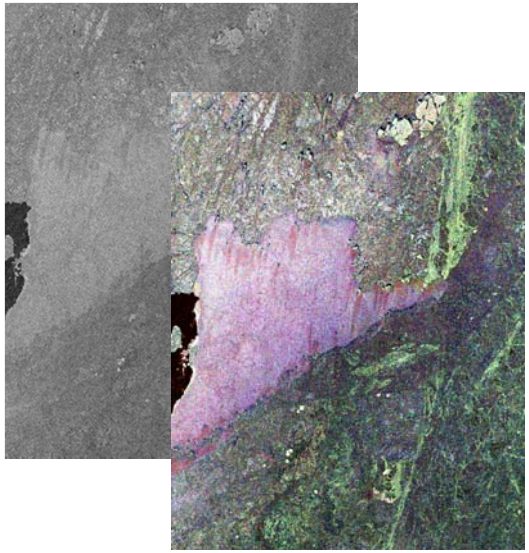


Radarsat Constallation

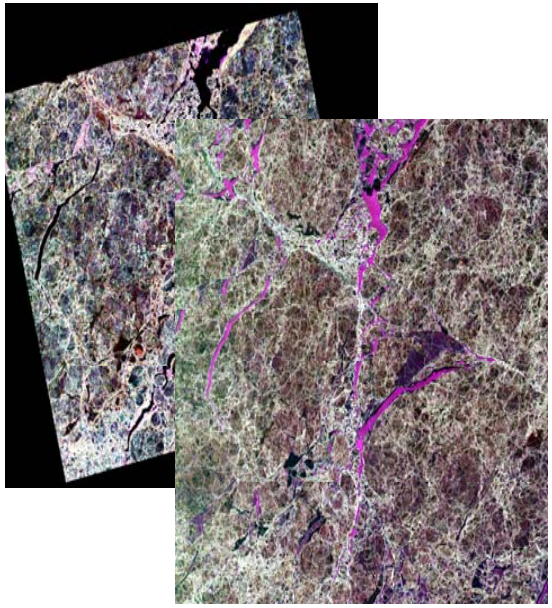
Sentinel family

New opportunities

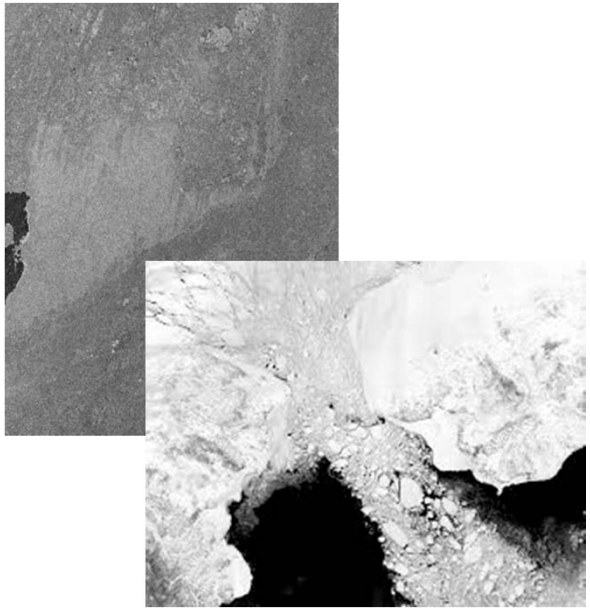
Multiple polarizations



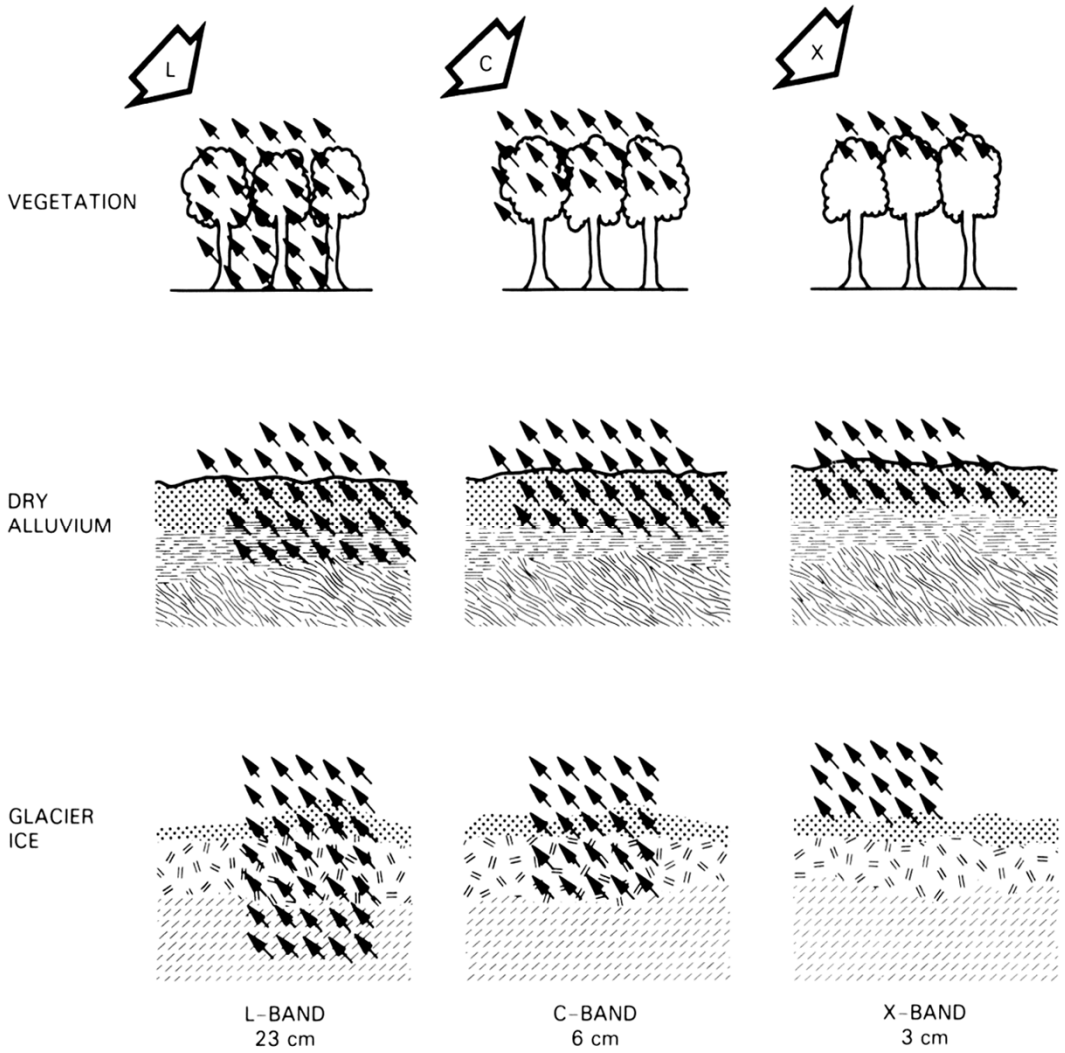
Multiple frequencies



Combined Radar/optical

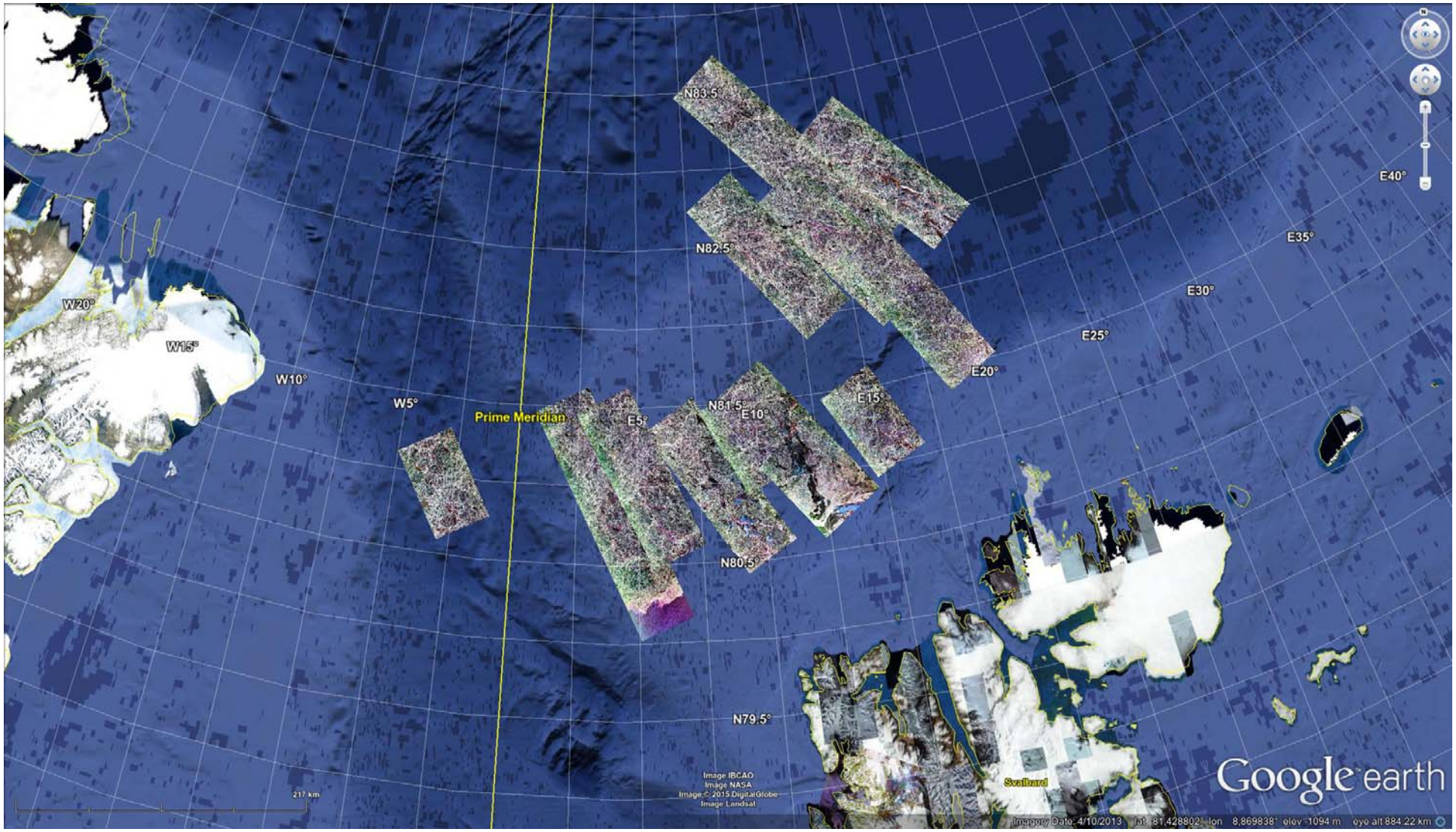


Penetration of microwave signals in vegetation, soils and ice

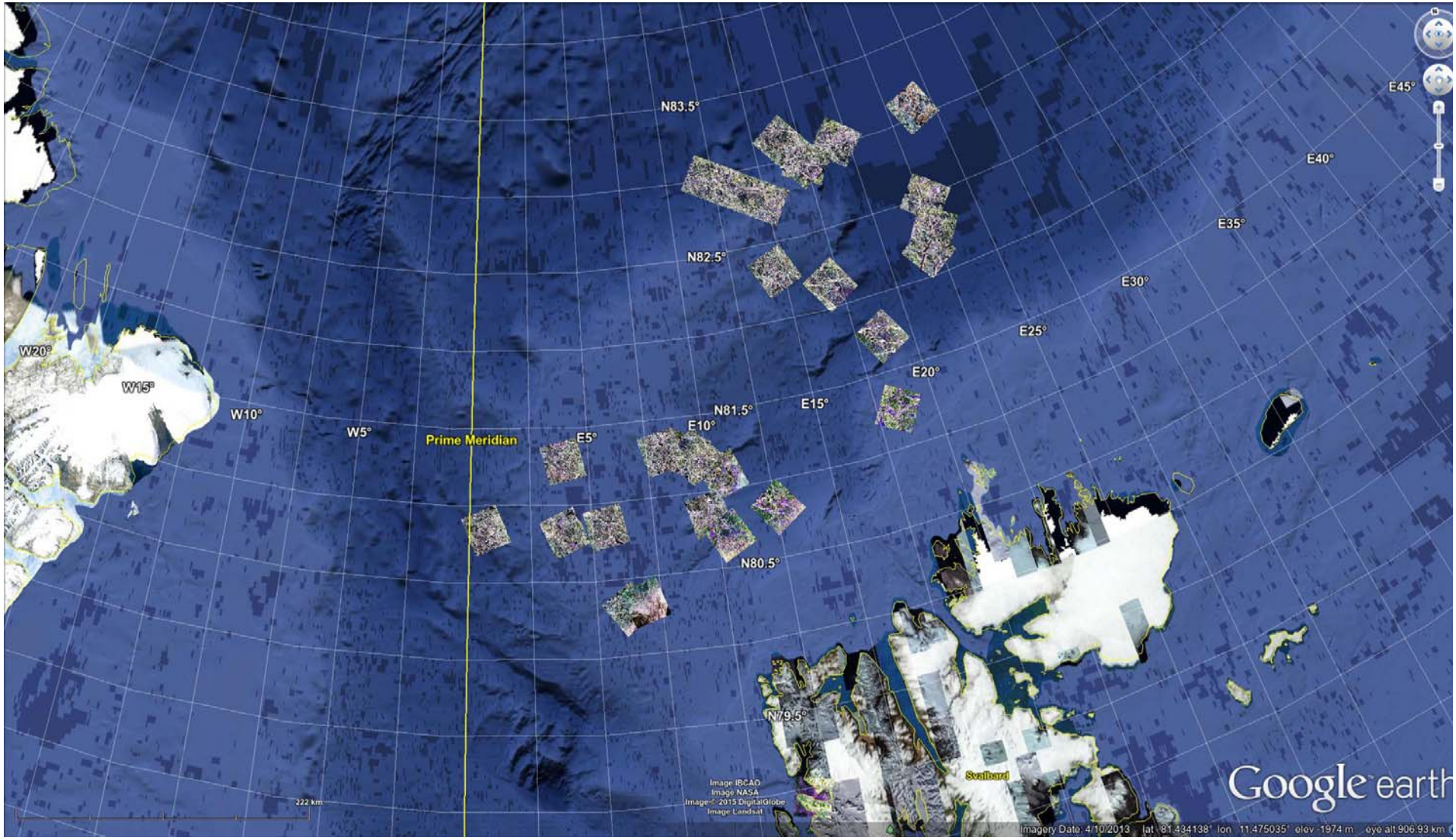


(after NASA, 1987)

ALOS 2 Scenes from the N-ICE campaign

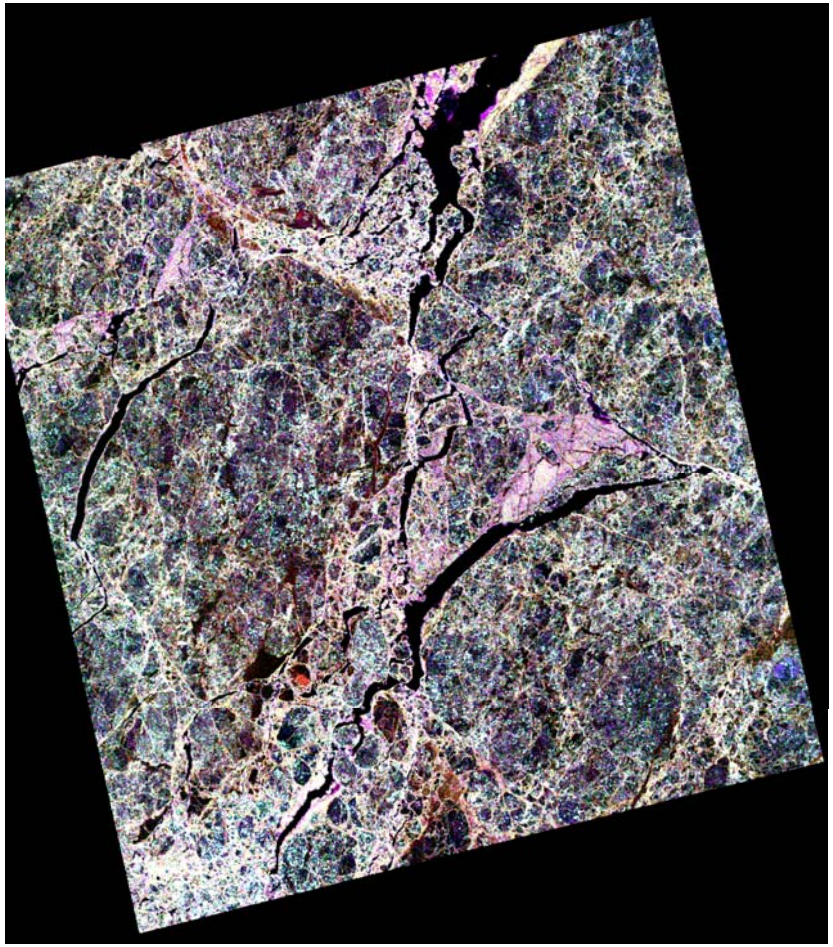


Radarsat 2 Scenes from the N-ICE campaign



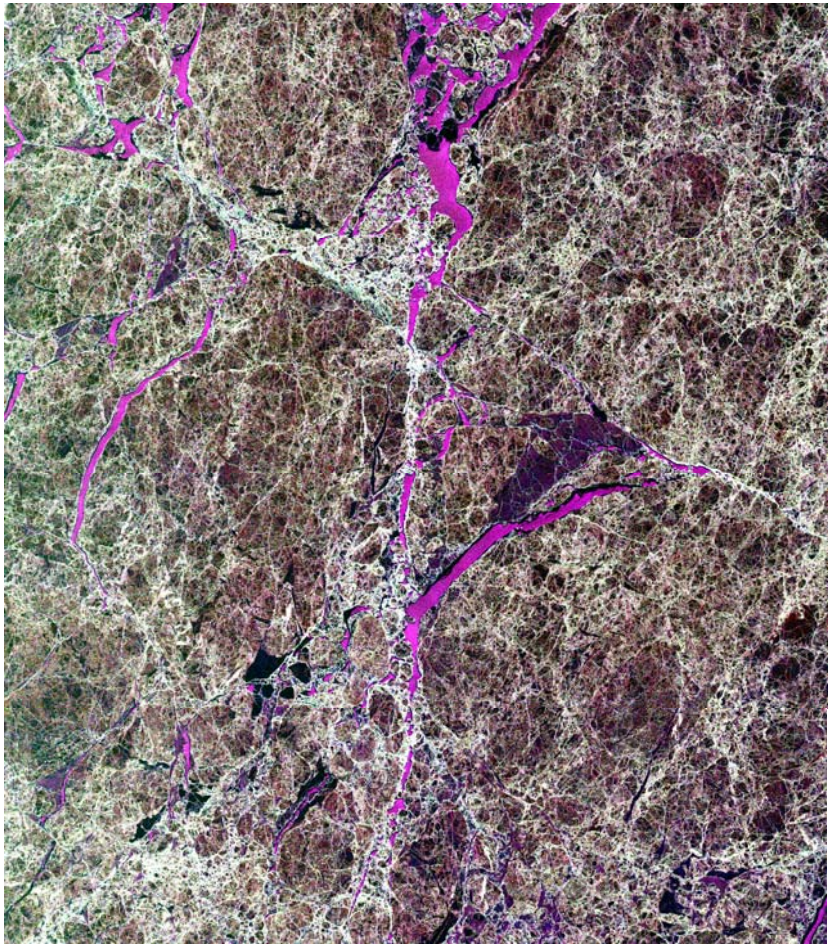
Pauli-decomposition

RS2: C-band -26. mai, 2015



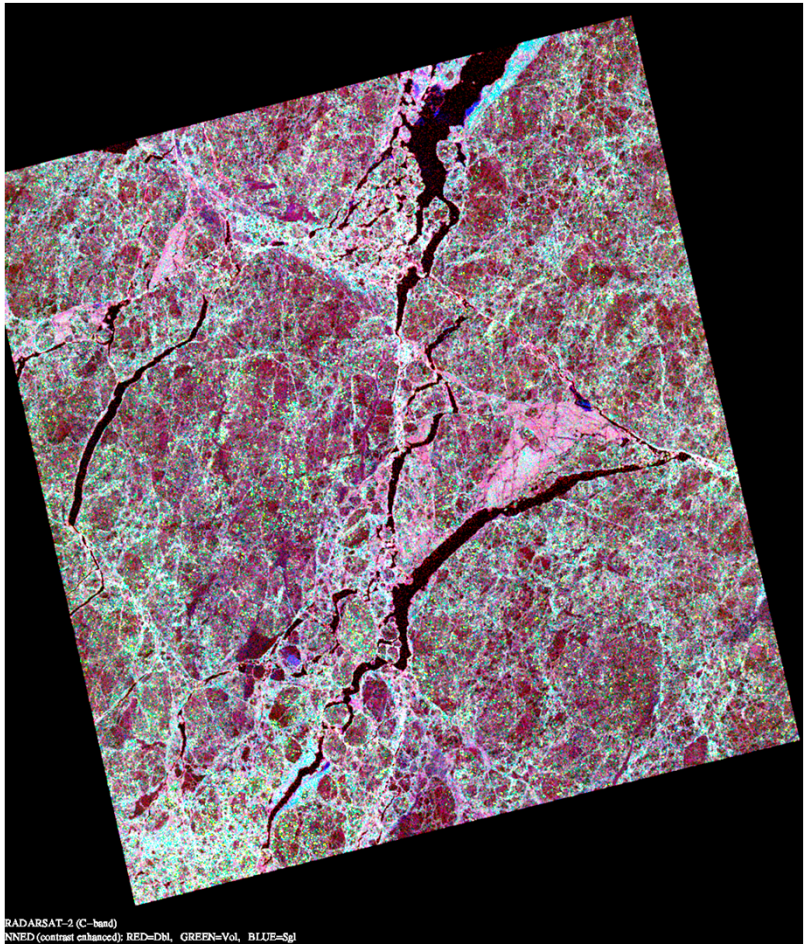
Copyright raw data MDA, 2015. Processed by KSAT

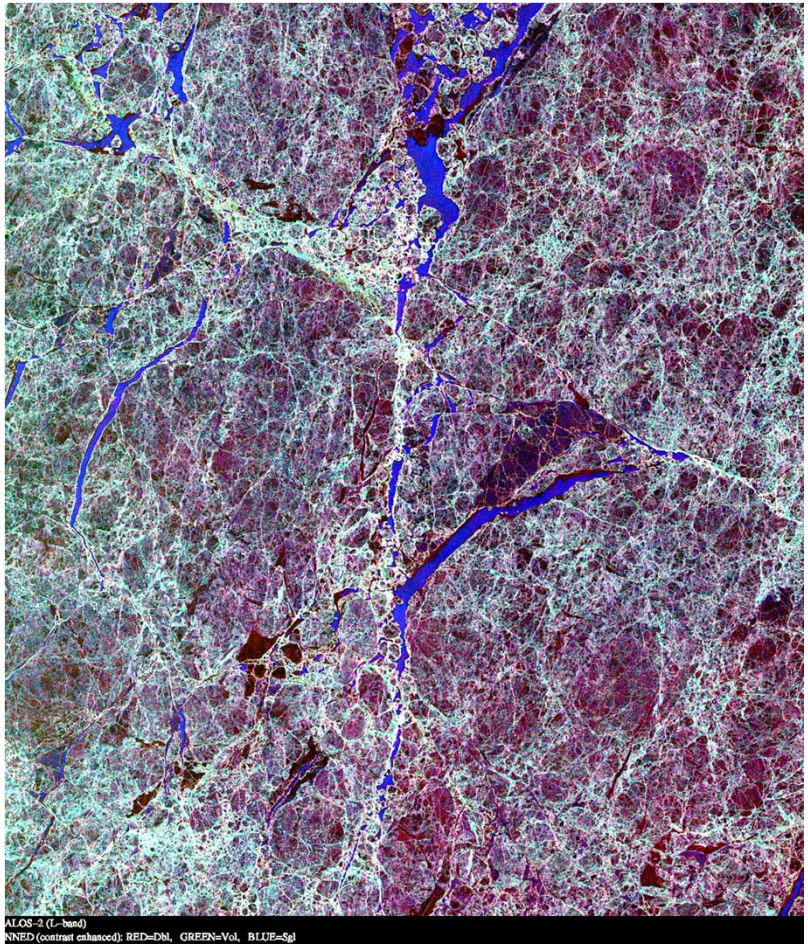
ALOS 2: L-band -26. mai, 2015



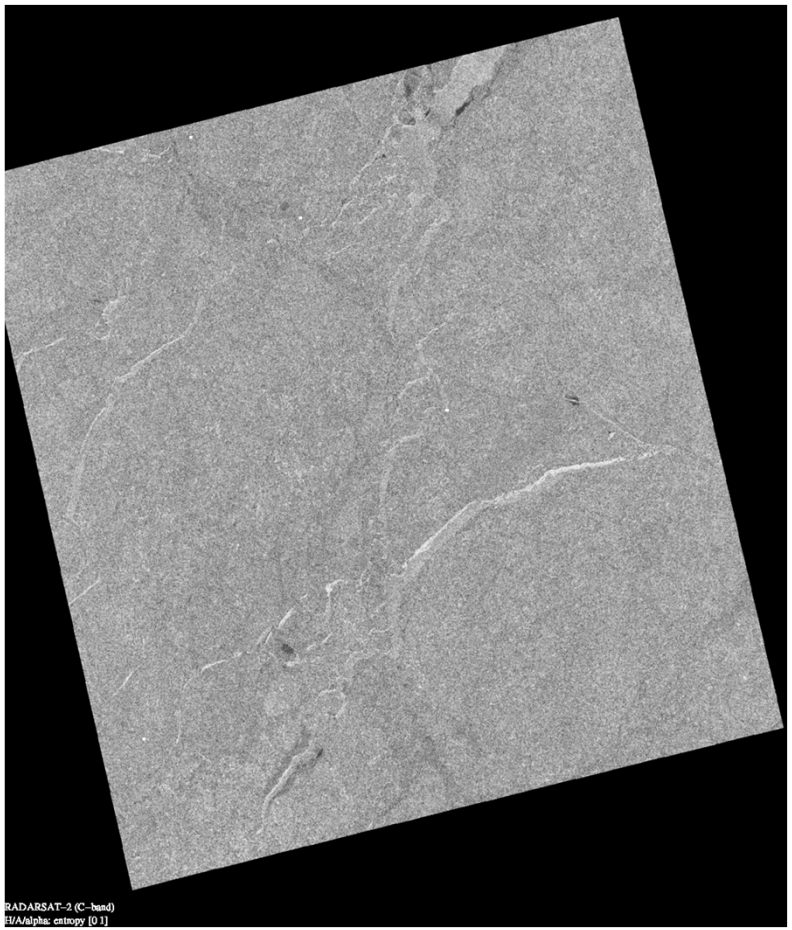
Copyright raw data JAXA, 2015

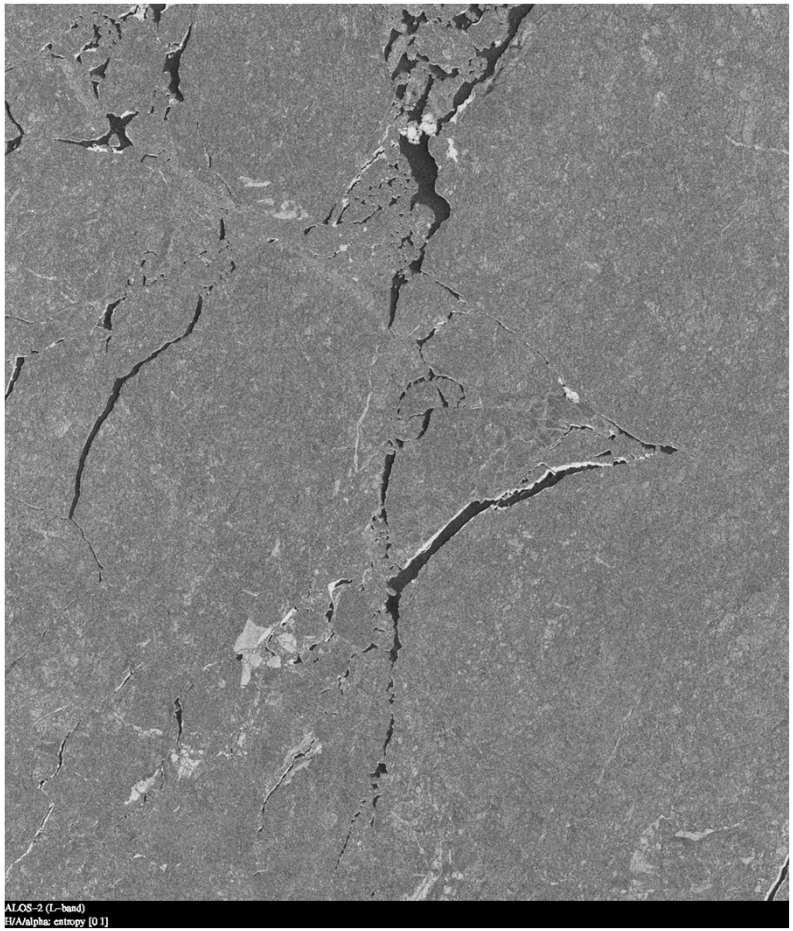
NNED decomposition



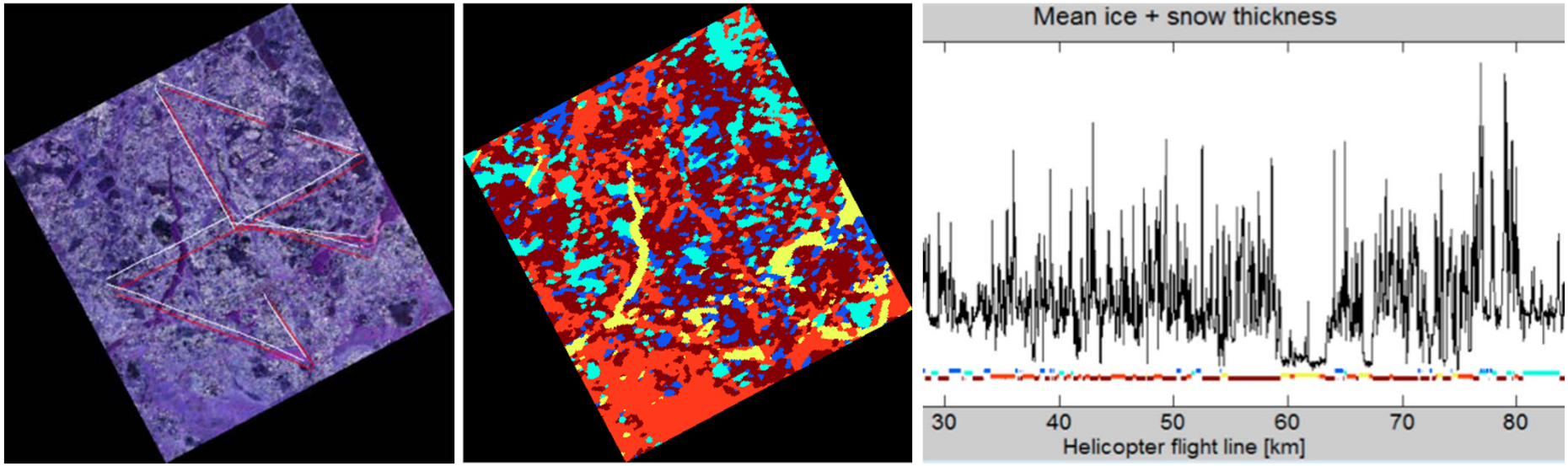


Polarimetric Entropy





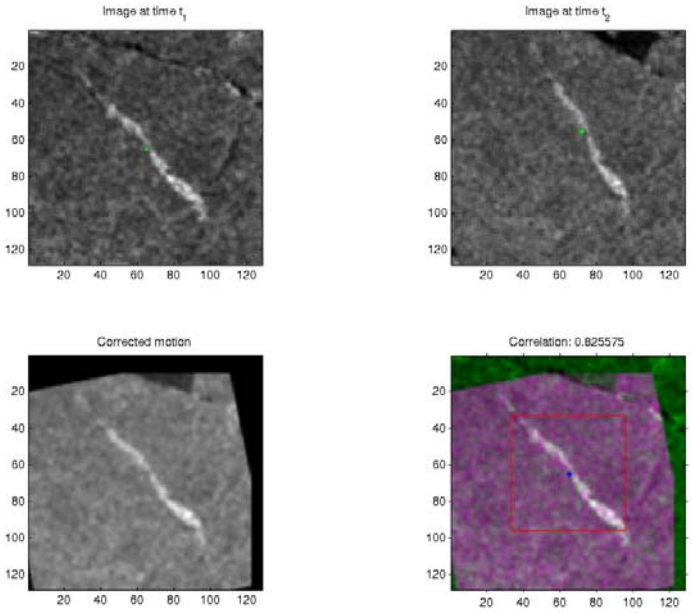
Sea ice classification

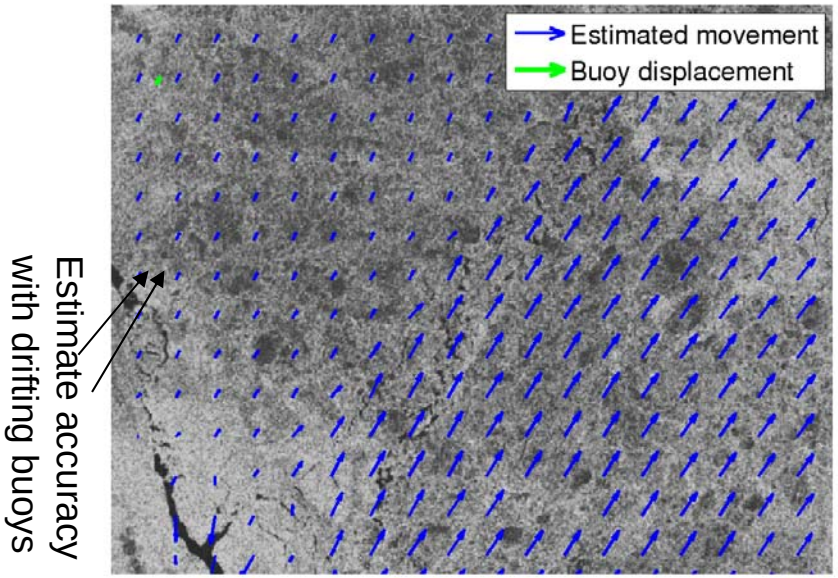


Moen, M.-A.N., A.P. Doulgeris, S.N. Anfinsen, A.H.H. Renner, N. Hughes, S. Gerland and T. Eltoft: “Comparison of automatic segmentation of full polarimetric SAR sea ice images with manually drawn ice charts”, *The Cryosphere*, vol. 7, no. 6, pp. 1693-1705, November, 2013.

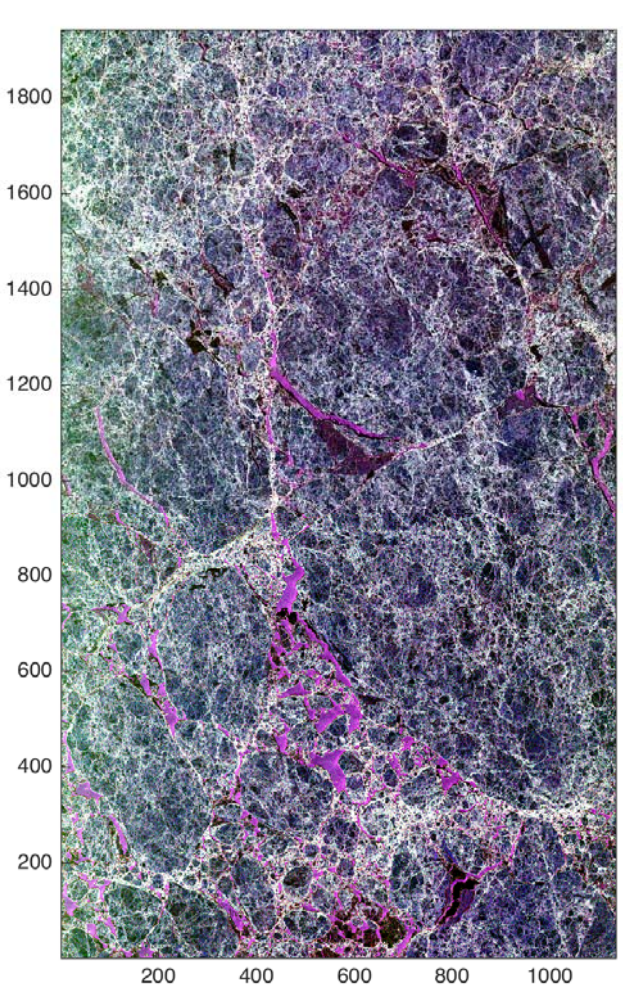
Sea ice velocity estimation from image time series

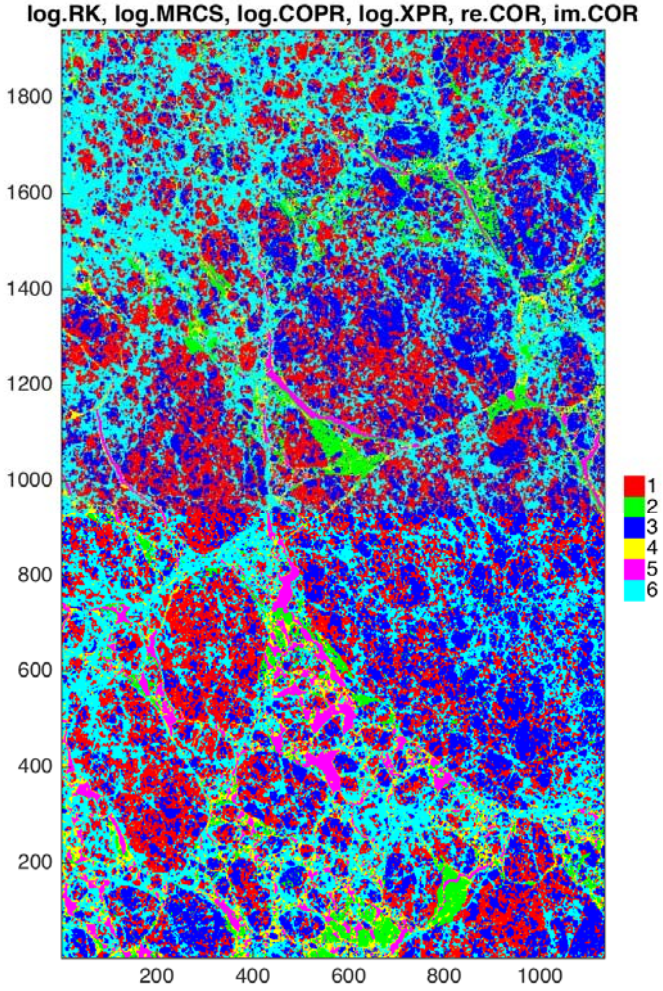
Correlation methods:



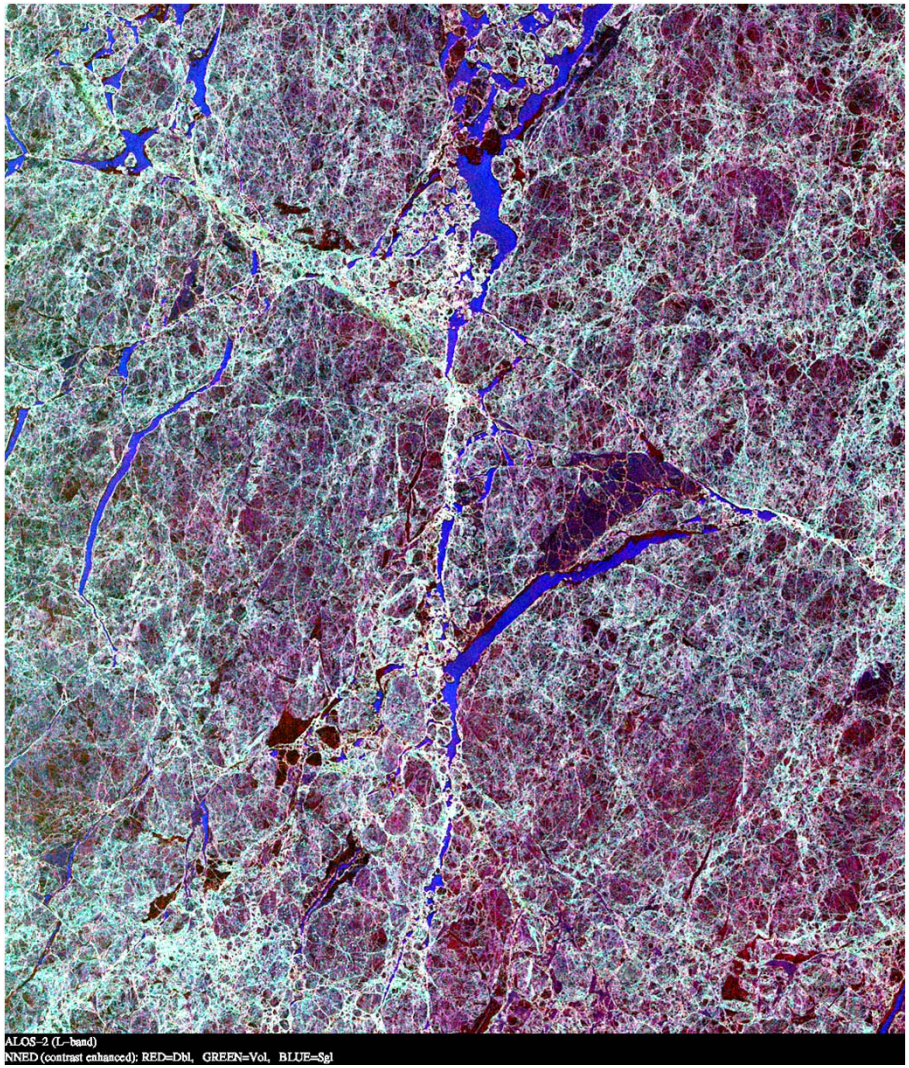


ALOS-2: Example of sea ice segmentation





ALOS problems?



ALOS problems?

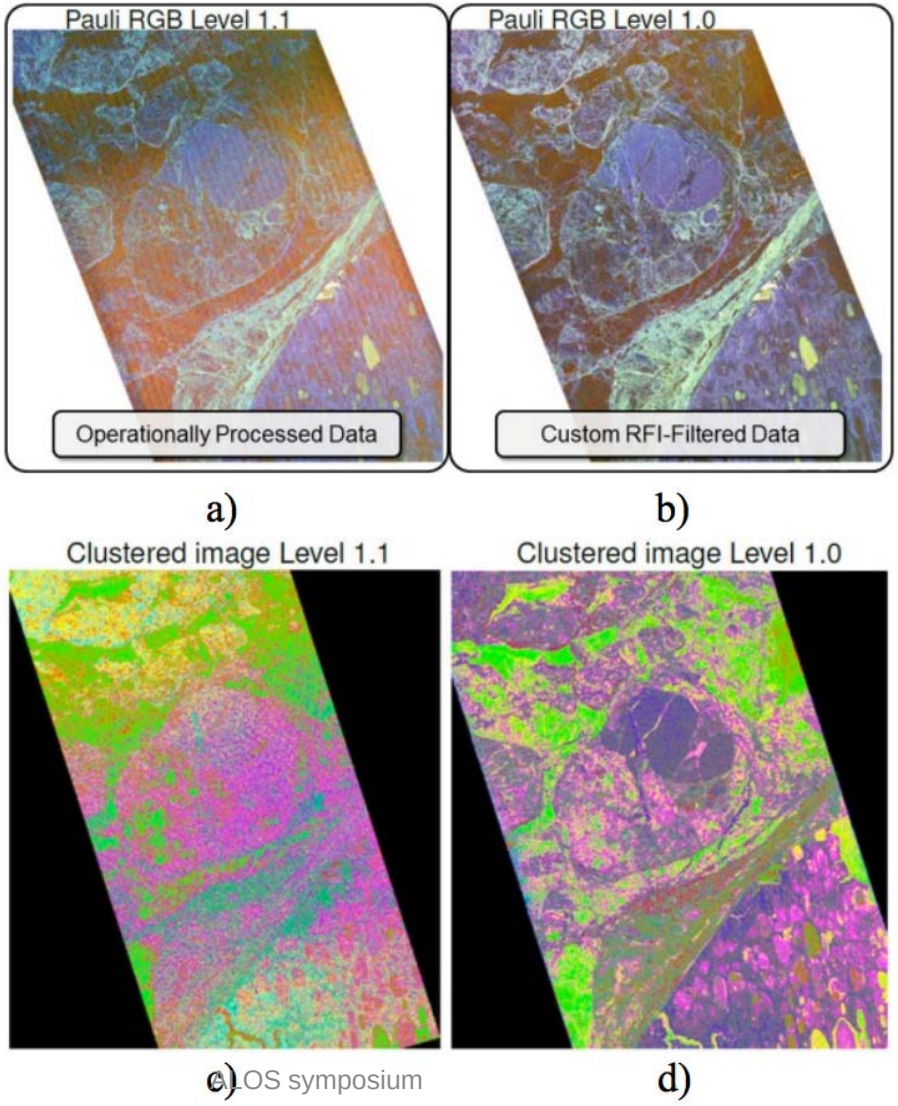
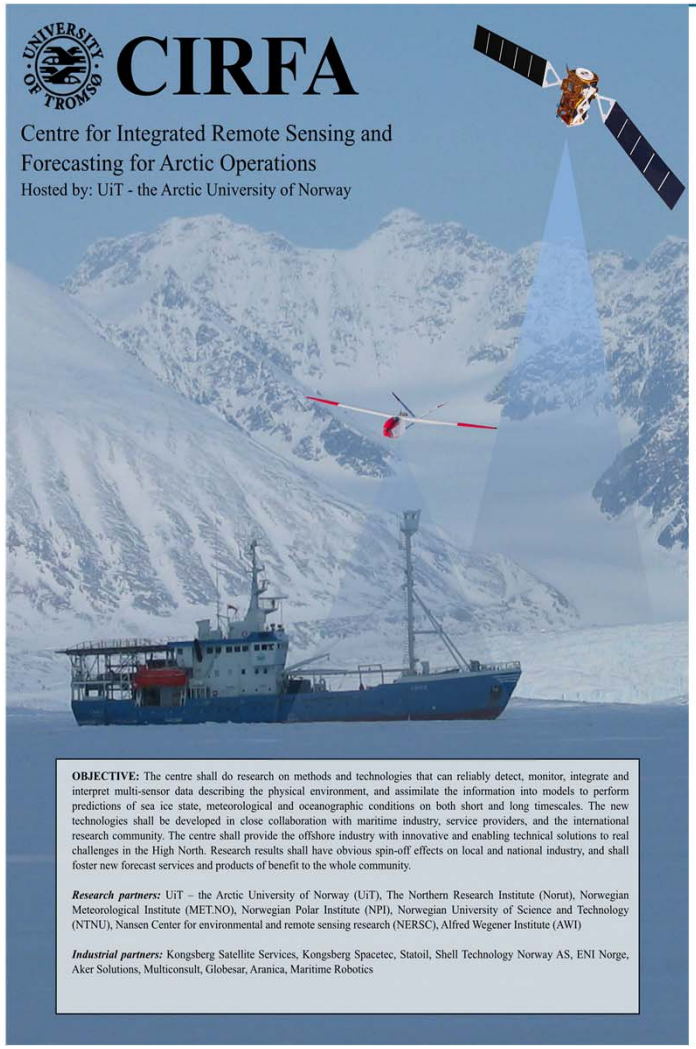


Figure 7 Improvement of polarimetric signature exemplified by a polarimetric clustering example: a) and b) before-and-after Pauli RGB images; c) and d) before-and-after segmented class images. The proposed filtering algorithm results in flatter response, sharper detail and better defined clusters.

Meyer, F.J., J. Nicoll and A.P. Doulgeris:
"Characterization and correction of residual RFI signatures in operationally processed ALOS PALSAR imagery",
Proc. EUSAR 2012, Nuremberg, Germany,
pp. 84-86, 23-26 April, 2012 (Best Paper Award).

Centre for Integrated Remote Sensing and Forecasting for Arctic Operations (CIRFA)



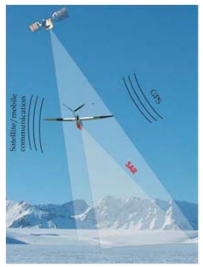
Objectives:

Long term research on integrated remote sensing from satellites and airborne platforms for Arctic operations

Requests for ALOS data:

Satellite data is needed in algorithm development and in dedicated validation campaigns related to the various work packages

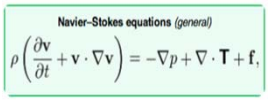
Work packages



WP1: Ocean Remote Sensing

PI: Norut

1.1 Retrieval of ocean winds
1.2 Retrieval of ocean surface currents
1.3 Detection and tracking of polar lows



WP5: Drift Modelling and Prediction

PI: Met.no

5.1: Data assimilation
5.2 Sea ice drift modelling and prediction
5.3: Oils spill drift modelling and prediction
5.4 Iceberg drift and deterioration

WP2: Sea Ice, Iceberg and Growler Remote Sensing

PI: UiT

2.1 Classification & characterization of sea ice
2.2 Estimation of sea ice drift velocity field
2.3 Iceberg detection & characterization in open waters
2.4 Iceberg detection & characterization in sea ice
2.5 Tracking methodologies

WP6: Field Work

PI: NPI

6.1 Yearly cruises to collect in-situ data
6.2 Yearly helicopter flights with EM sounder
6.3 Freeze-in of "Lance" winter 2015

WP3: Oil Spill Remote Sensing

PI: UiT

3.1: Detection & characterization in open water
3.2: Detection & characterization in sea ice

WP7: Pilot Service Demonstration

PI: KSAT & Met.no

7.1 Arctic surveillance services design
7.2: System and data integration
7.3: Pilot service demonstration
- **7.3.1 Iceberg services**
- **7.3.2 Sea ice services**
- **7.3.3 Oil spill services**
- **7.3.4 Polar Lows services**

WP4: RPAS Technology

PI: Norut

4.1: Technology for RPAS operation
4.2: Sensors for sea ice and iceberg mapping
4.3: Sensors for oil spill mapping
4.3: Technology for geo-tagging of icebergs

Thank you for your attention

cirfa.uit.no