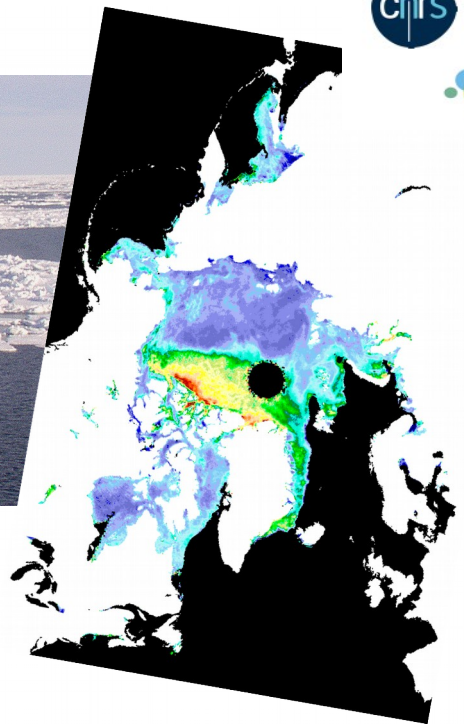
Using CFOSAT scatterometer for sea ice application: preliminary results from Ifremer/LOPS

Fanny Girard-Ardhuin and Jean-François Piollé
Ifremer, LOPS, Brest, France



CFOSAT second International Science Team Meeting - March 2021

Outline

- Scatterometry for sea ice monitoring
- CFOSAT scatterometer backscatter data over sea ice
  - Spatial coverage
  - Times series of backscatter maps over the 2020-2021 winter
  - Comparison with ASCAT backscatter data
- Scatterometer applications in polar areas
- Conclusions and next steps

Backscatter data times series over sea ice at C and Ku-bands at CERSAT archive center

Advantages of the microwave : does not depend on solar illumination nor cloud coverage → benefit to monitore poles during winter

Polar orbit enables a full or almost full coverage of the sea ice areas <u>daily</u>

MetOp polar orbit

ERS-1&2 : 1991-2001

NSCAT : 1996-1997

QuikSCAT : 1999-2009

ASCAT : 2007-present

- Grid resolution : 25 km, 12.5 km
- Daily, weekly
- Since 1991

Arctic &

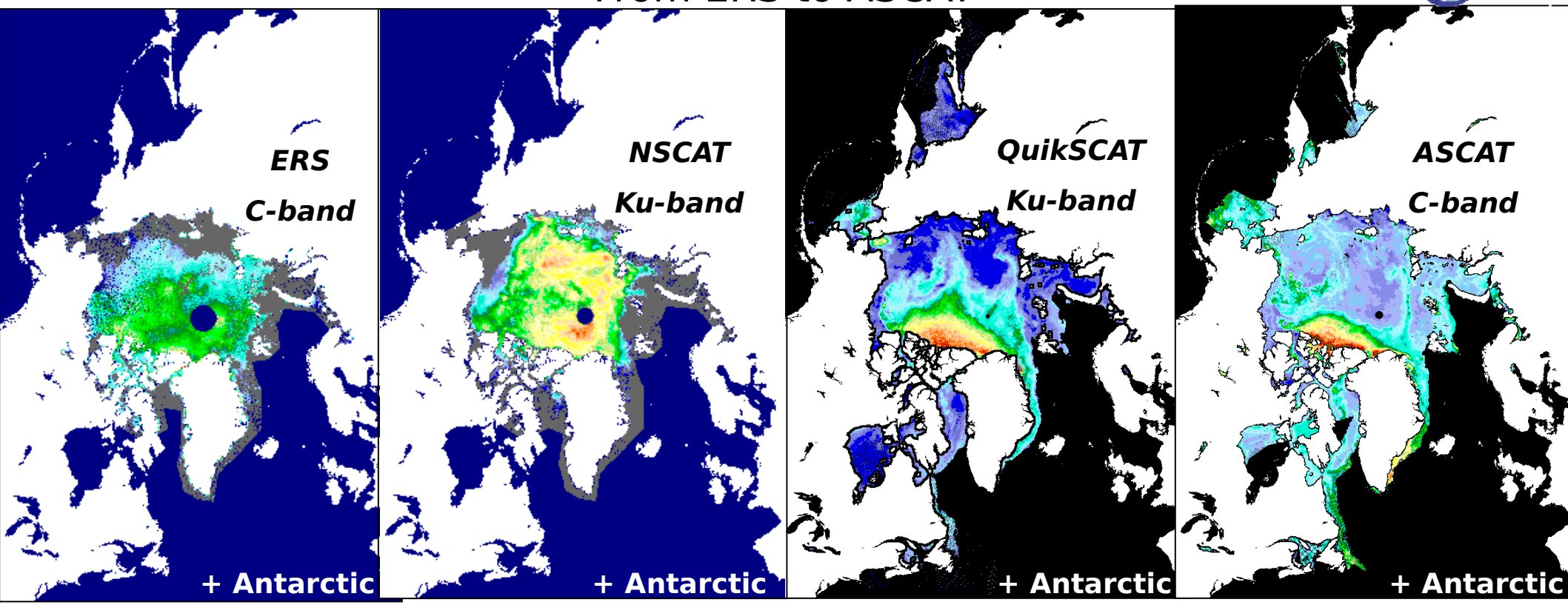
Antarctic

ASCAT onboard 3 satellites mission

→ 15 years dataset !

Backscatter data times series over sea ice

From ERS to ASCAT



1991-2001	**1996-1997**	**1999-2009, fan-beam**	**2007-present**
Grid res.: 25 km	**Grid res.: 25 km**	**Grid res.: 12.5, 25 km**	**Grid res. = 12.5, 25 km**
1 map = 1 week	**1 map = 3 days**	**1 map = 1 day**	**1 map = 1 day**
average	**average**	**average**	**average**
Big blind area	**Blind area reduced**	**Blind area reduced with the outer beam**	**Blind area reduced**

- Improvement of the data since the 1990's
- Add CFOSAT data to this C & Ku-band time series (to be provided through the IWWOC processing center)-→ **daily maps at 12.5 km grid res.**

CFOSAT scat. spatial coverage over sea ice

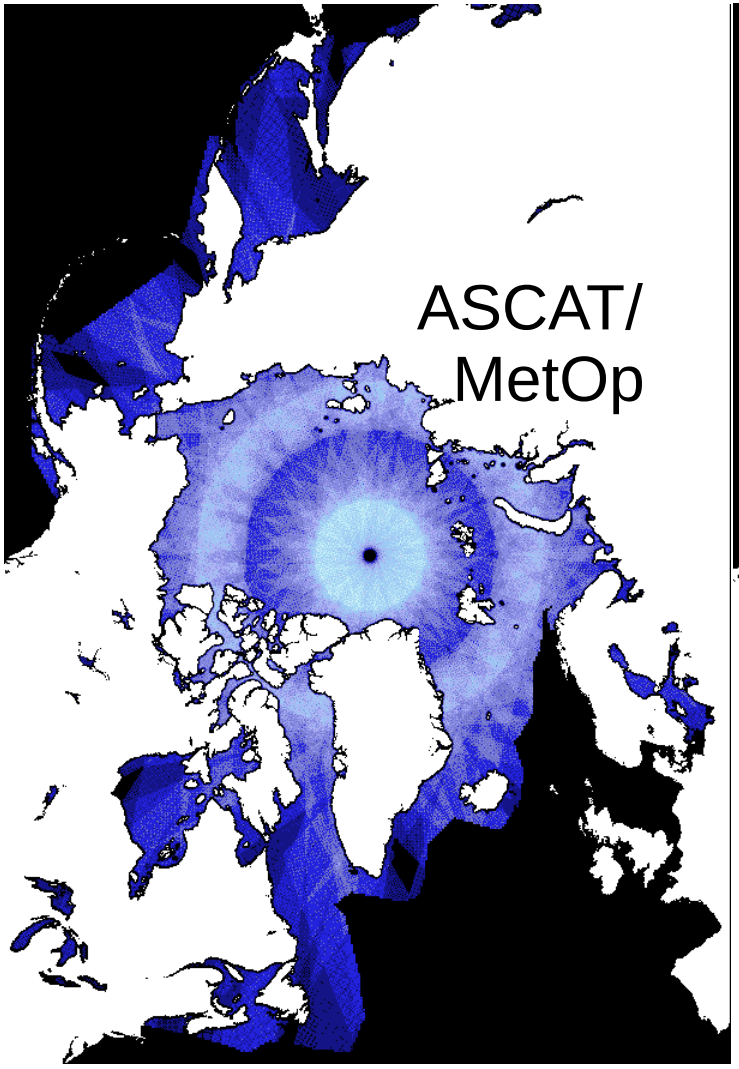
Distribution of number of data

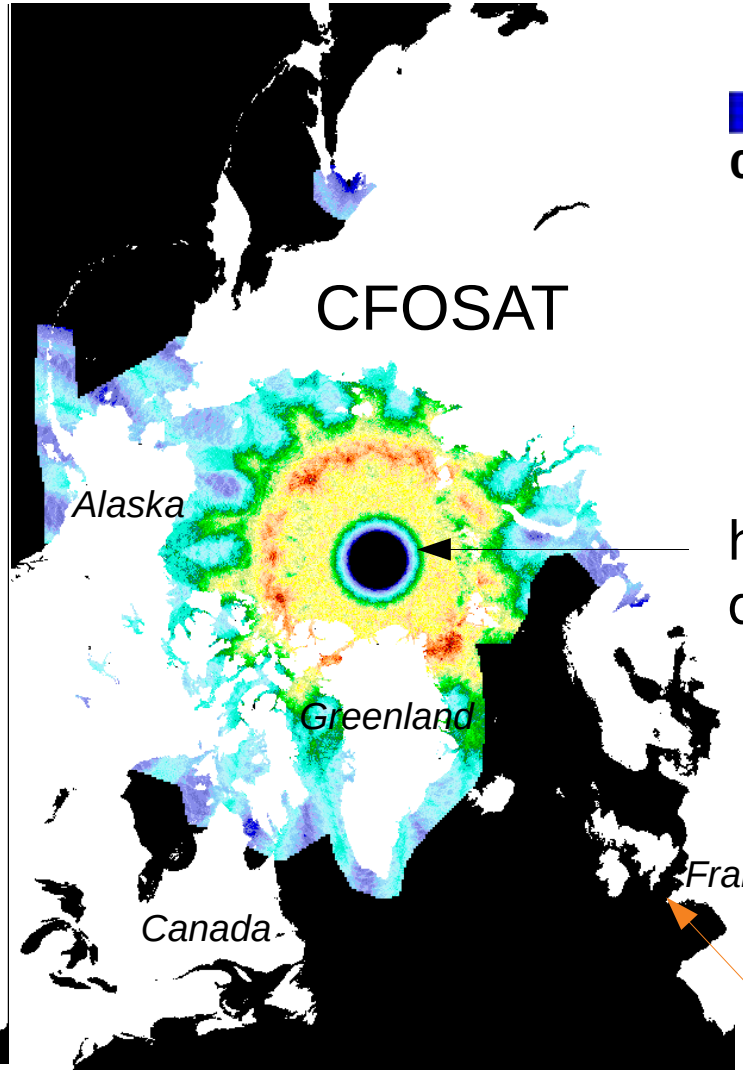
1 single day

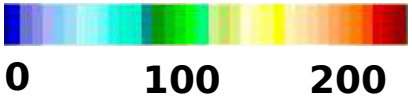
data distributed as rings

Stereo-polar projection 12.5 km x 12.5 km *(Pearson 1990)*

Arctic







Number of data for a single day

hole (missing data at the pole)

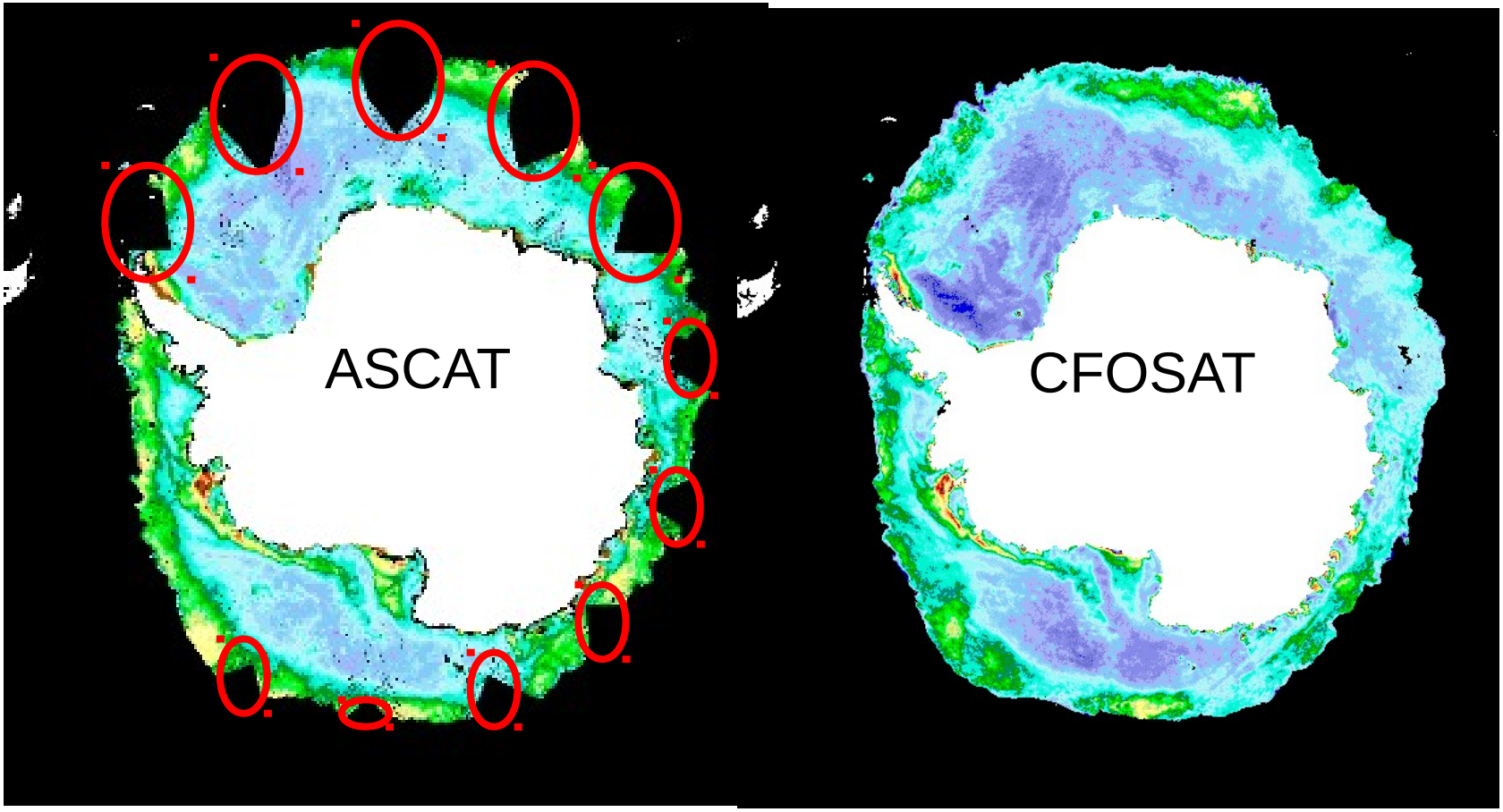
CFOSAT enables 200 or more data per pixel a day in the central Arctic wheras ASCAT has about 30 maximum

Spatial coverage of the data

1 single day

Antarctic

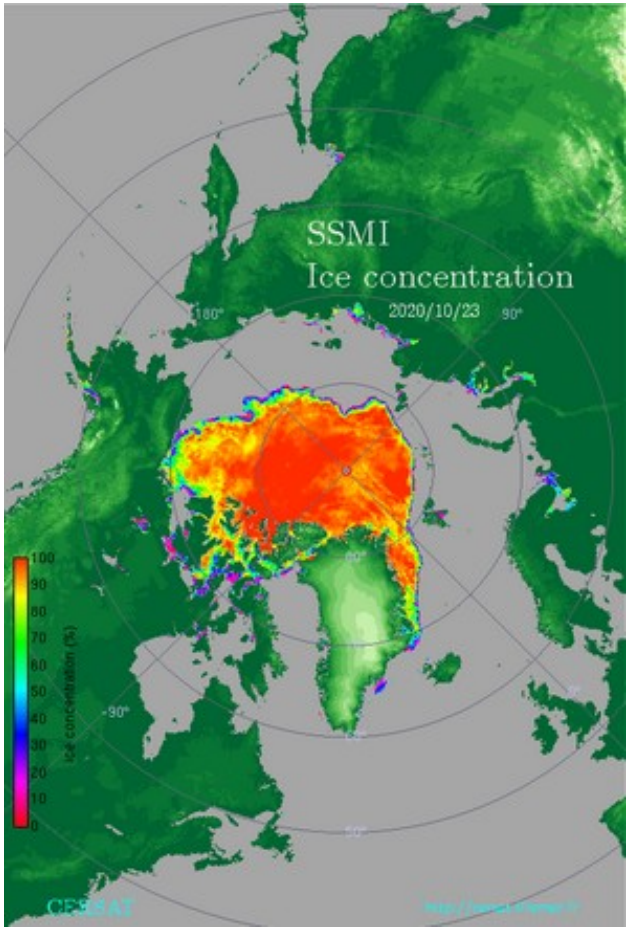
Backscatter map



CFOSAT enables to cover the whole Antarctic sea ice in winter whereas there are missing data gaps with ASCAT at « low polar latitudes » (which is solved using ASCATs on MetOp-A & -B together)

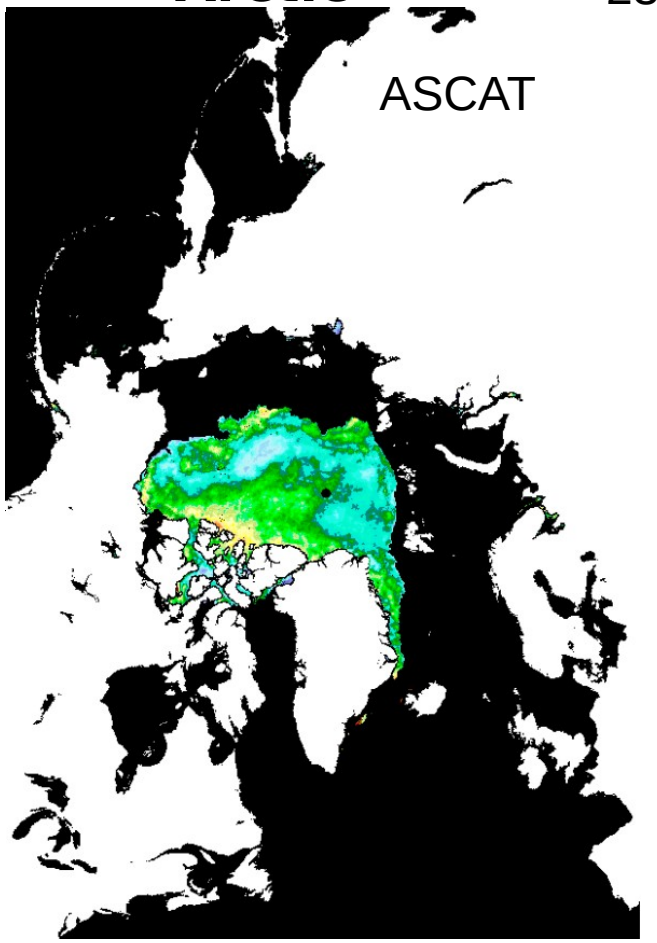
Backscatter over sea ice

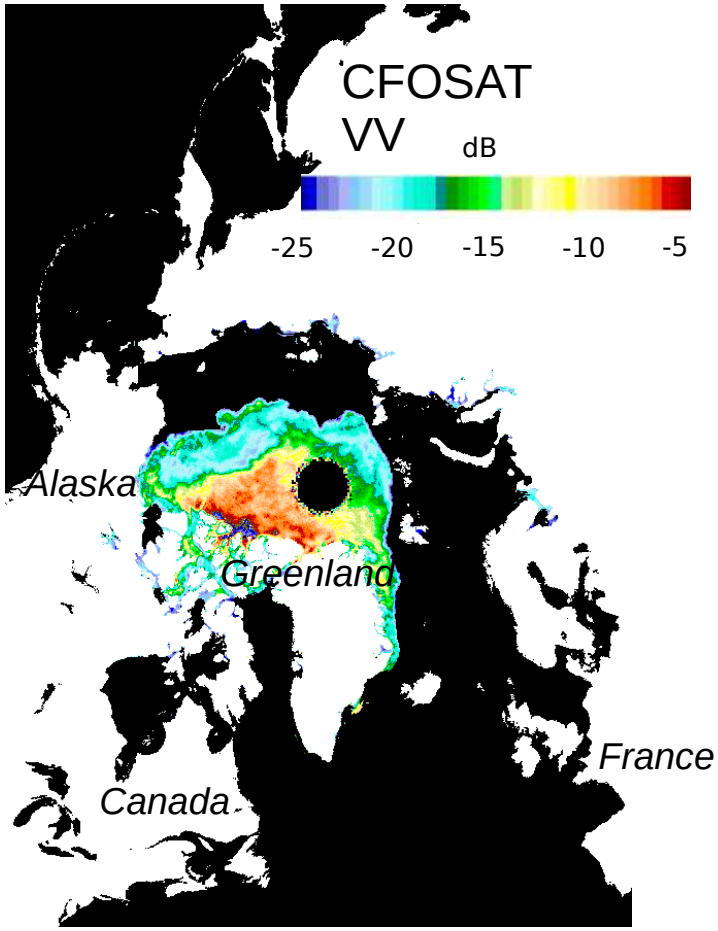
Backscatter maps at C & Ku-band



Arctic

23 October 2020

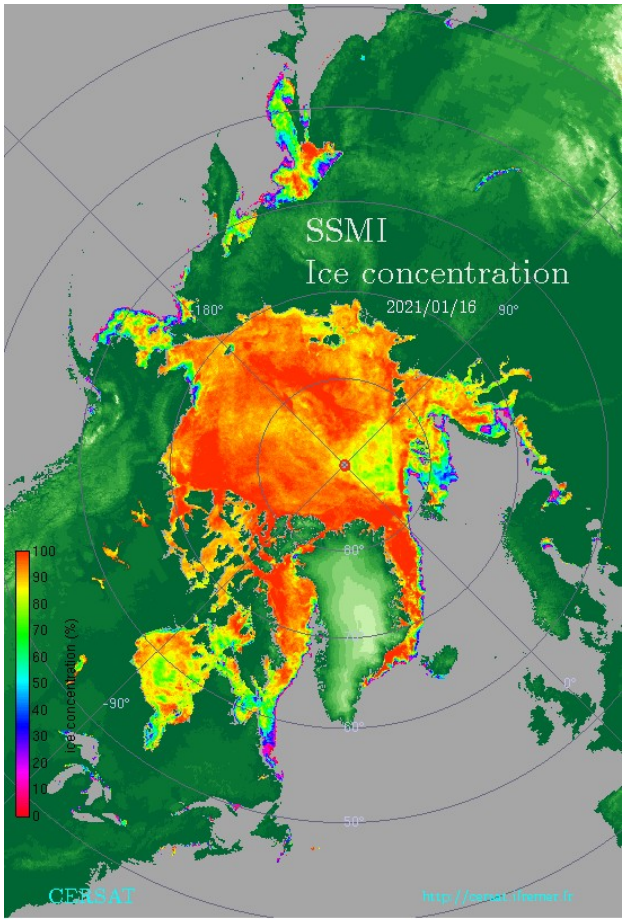


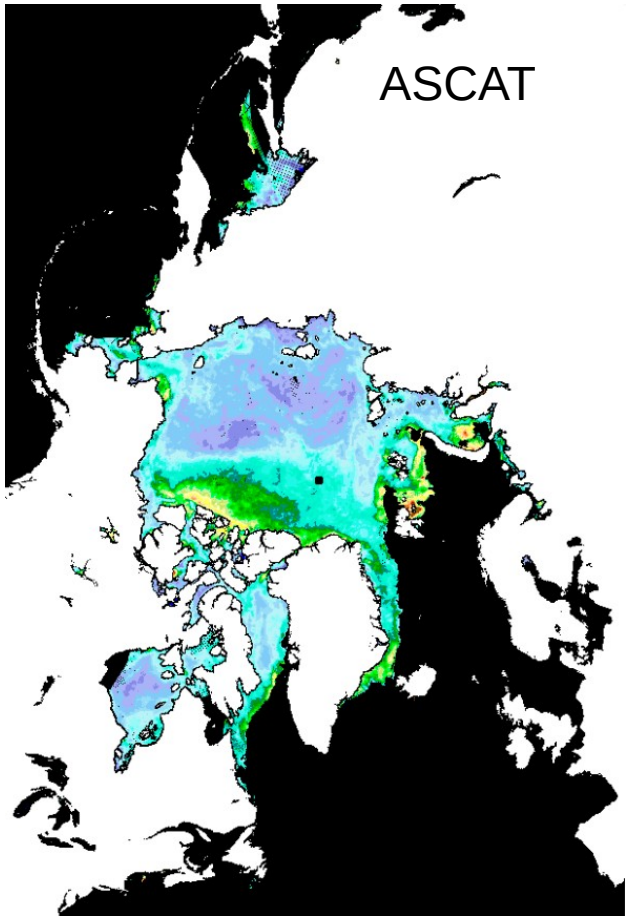


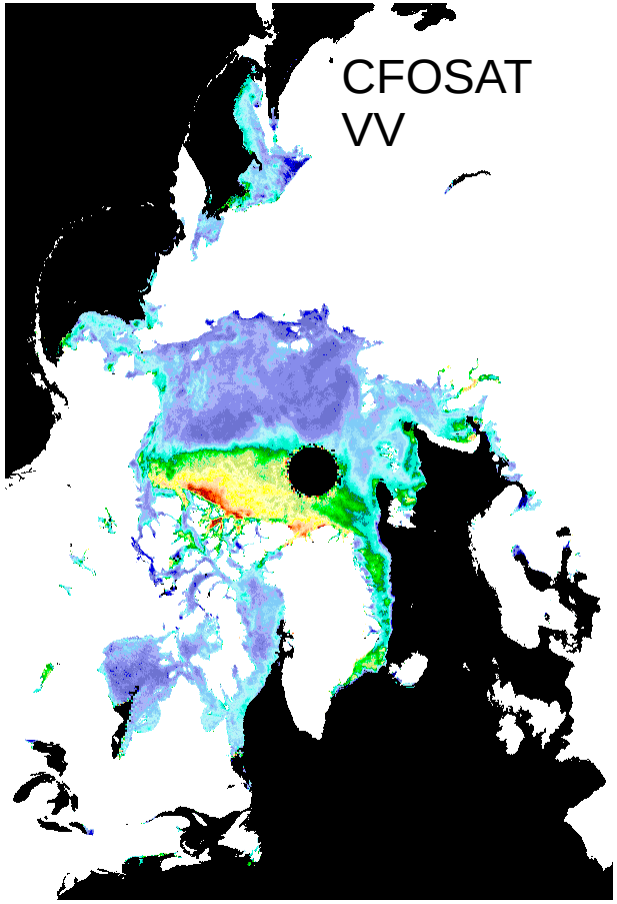
Backscatter values over sea ice depend on frequencies, polarisation, incidence angle but also on **ice type, roughness,** ice properties, porosity, salinity, etc...

Backscatter maps at C & Ku-band

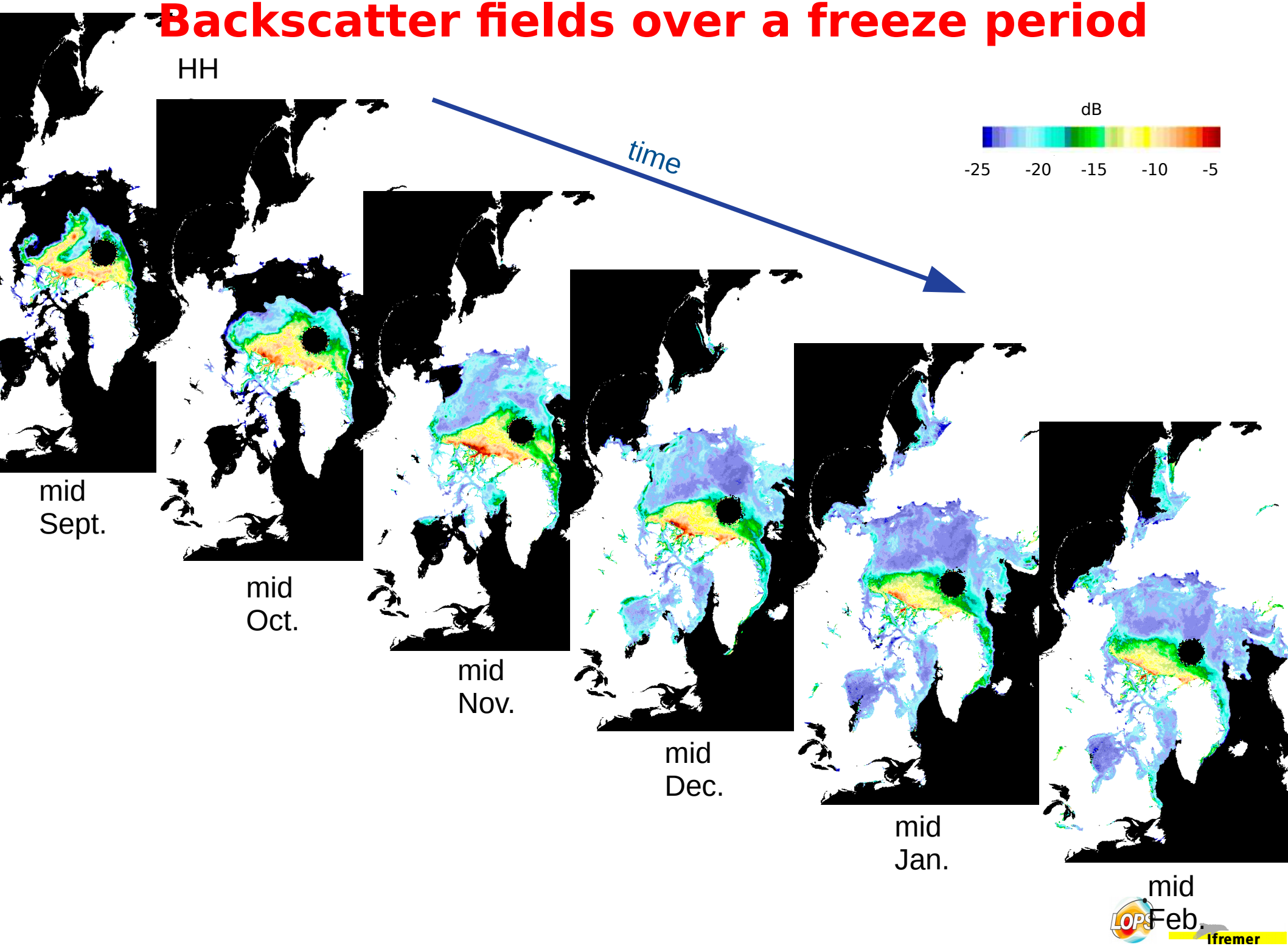
Arctic 16 January 2021



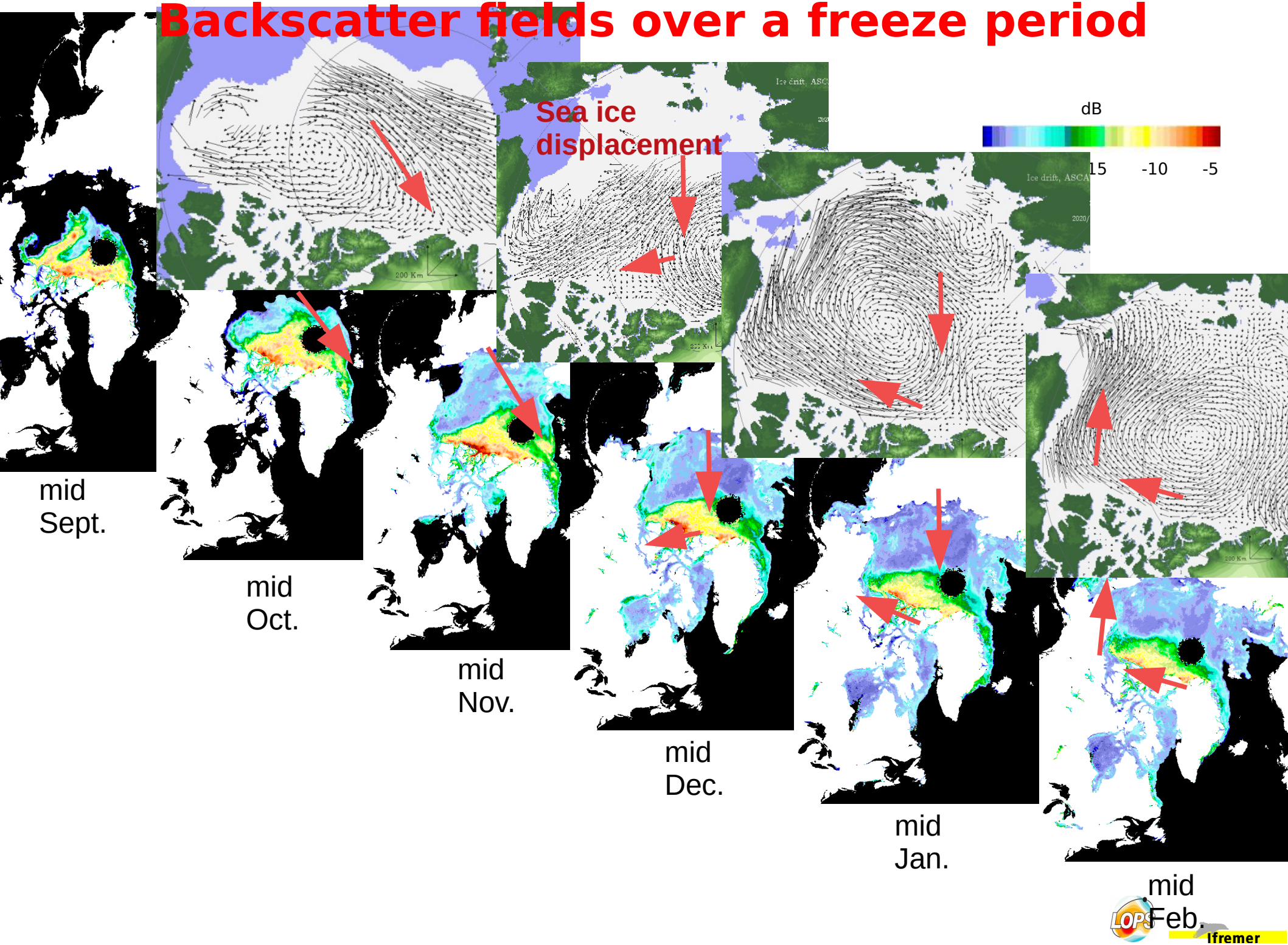




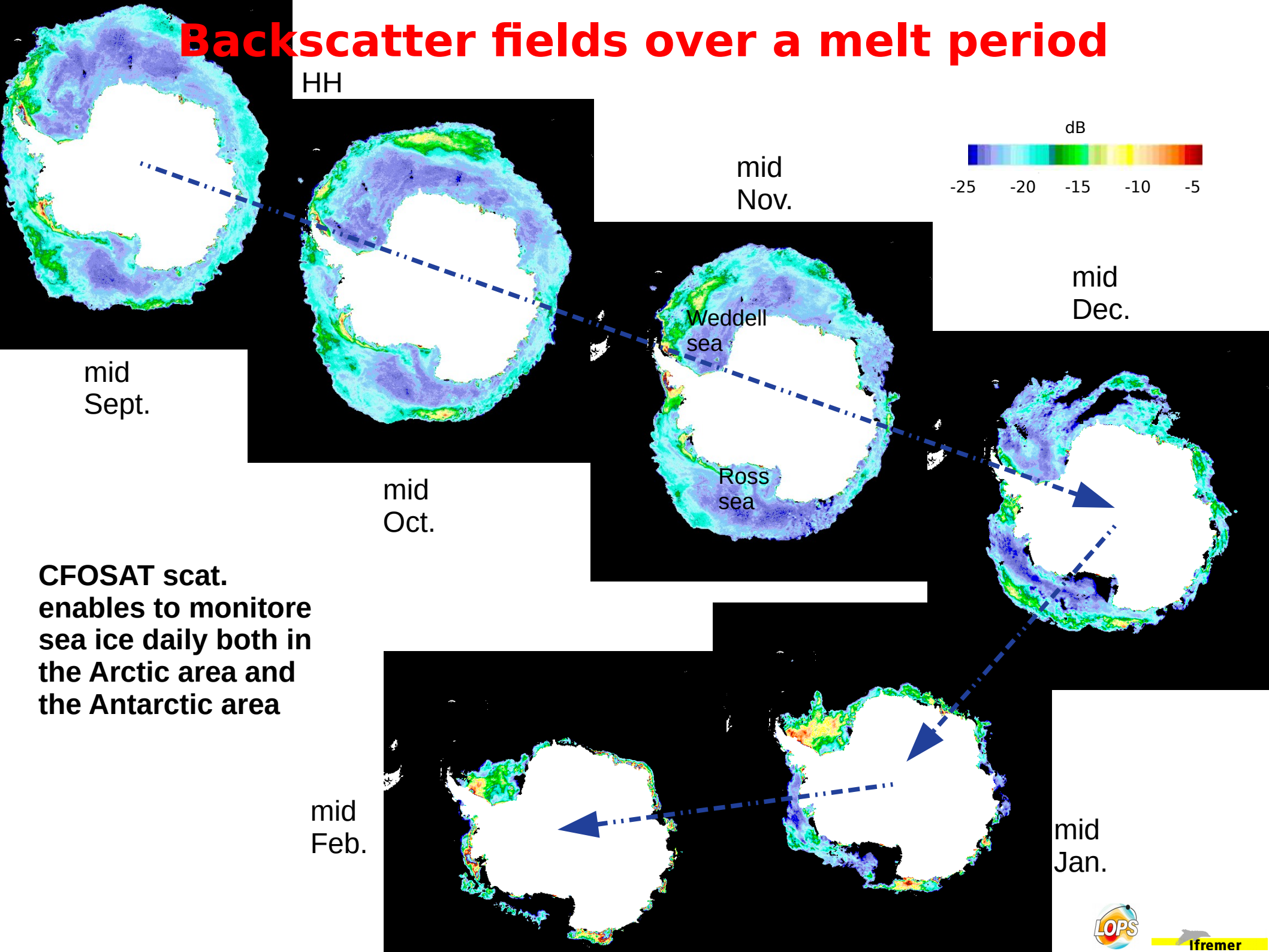
Backscatter fields over a freeze period



Backscatter fields over a freeze period



Backscatter fields over a melt period

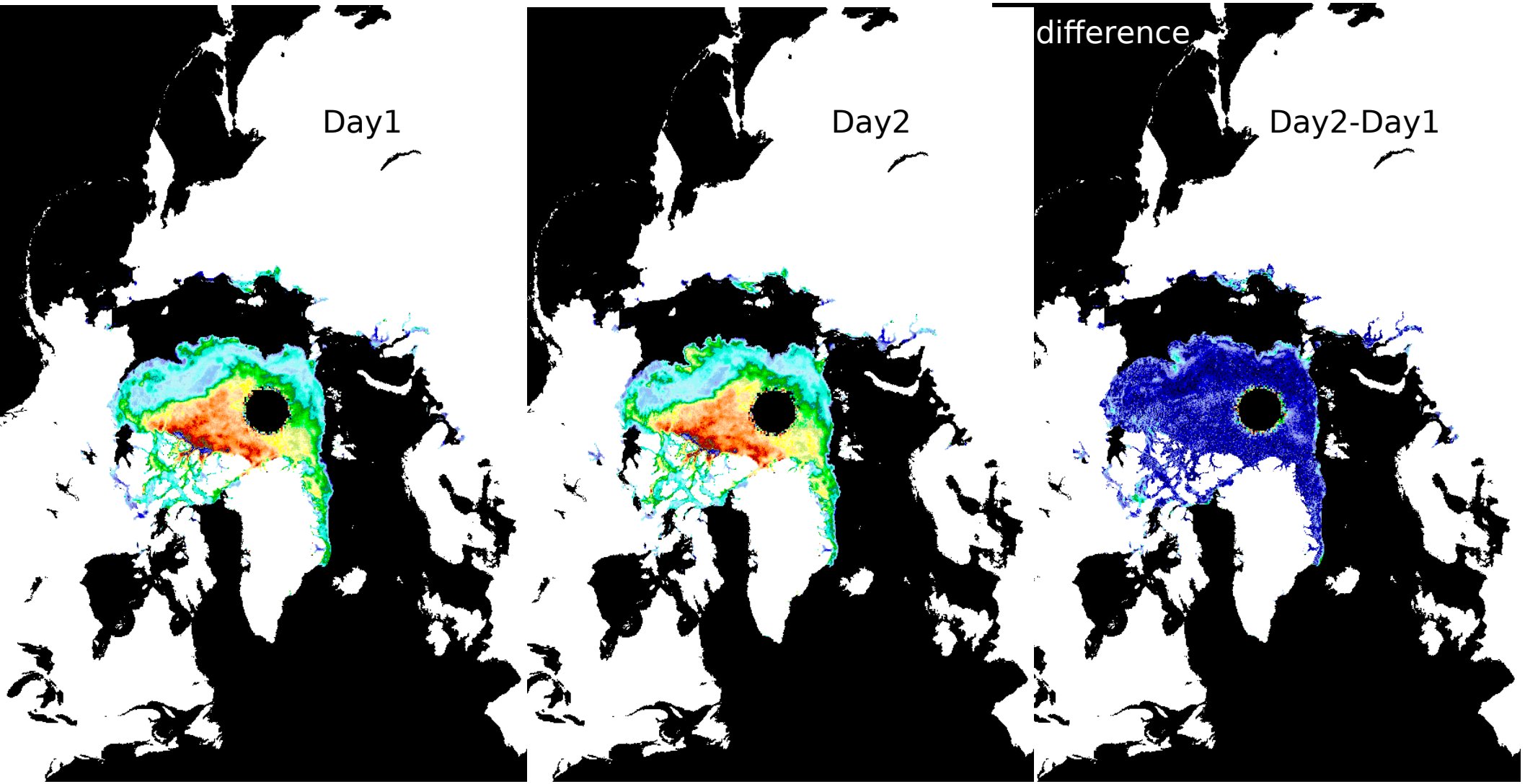


CFOSAT scat. enables to monitore sea ice daily both in the Arctic area and the Antarctic area

Backscatter noise level estimation

Difference of the backscatter of D1 and D2

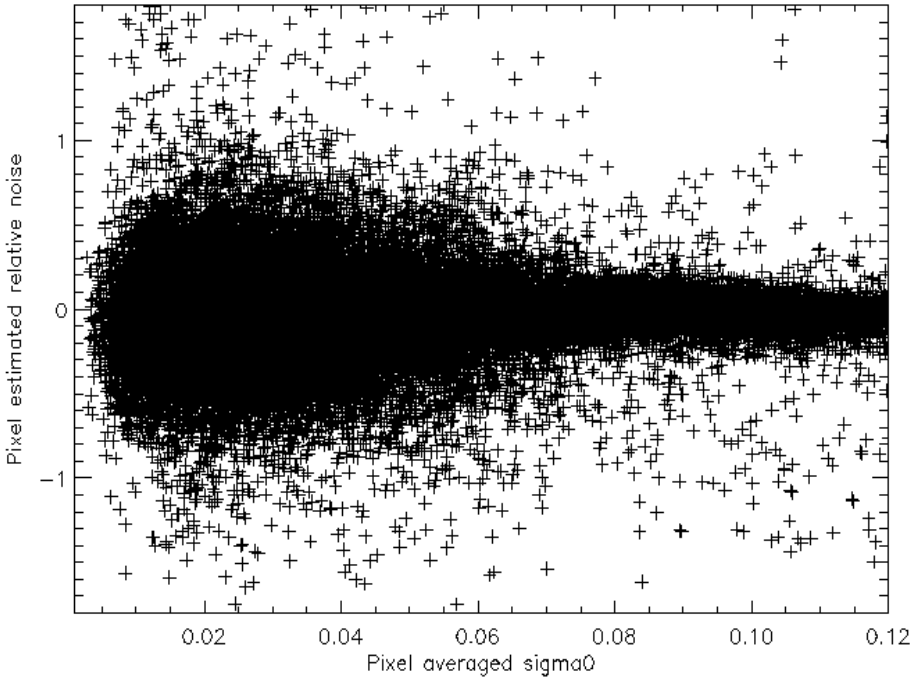
assuming that the differences observed are only due to uncertainties in the determination of the sigma0 (no ice drift or backscatter evolution within each pixel)



Backscatter relative noise level estimation

Arctic

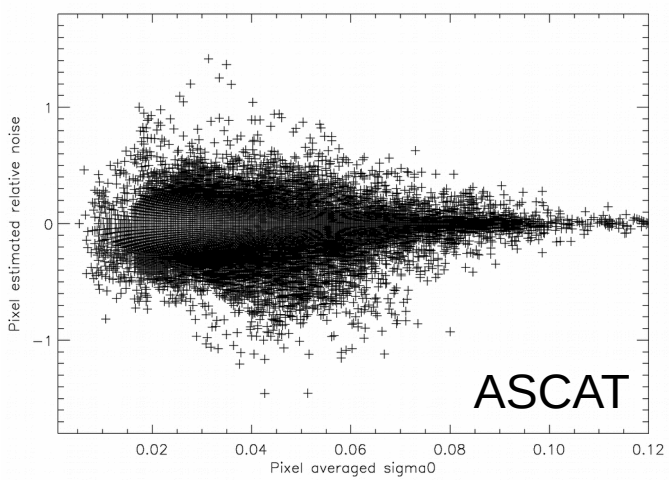
20210114-20210115

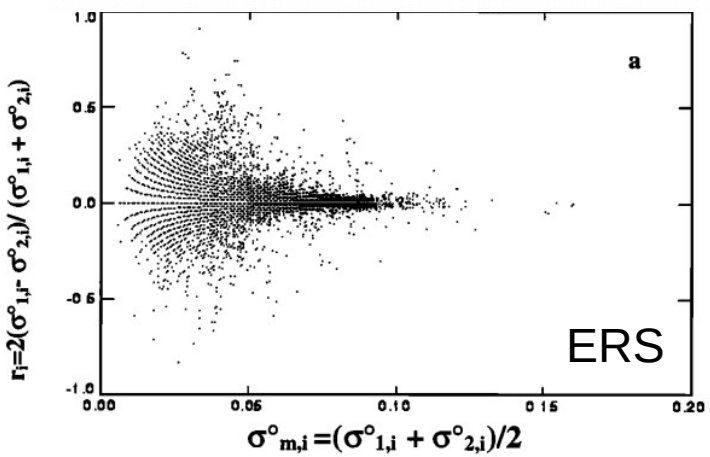


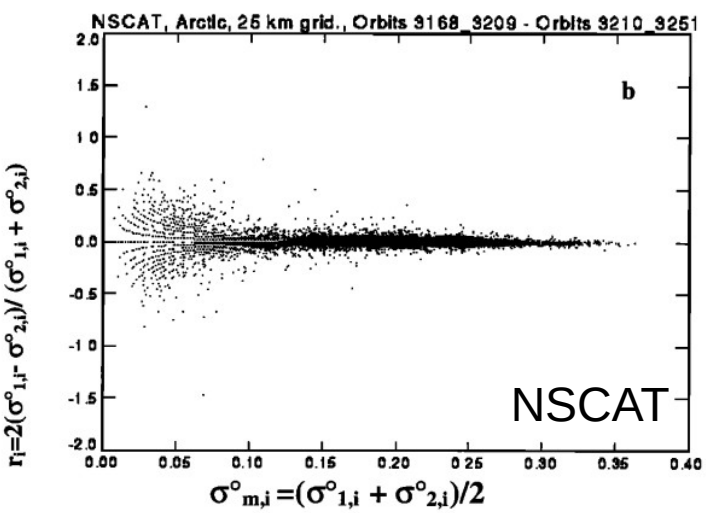
CFOSAT VV

Higher noise values for low sigma0 than for high sigma0

Backscatter rel. noise level estimation

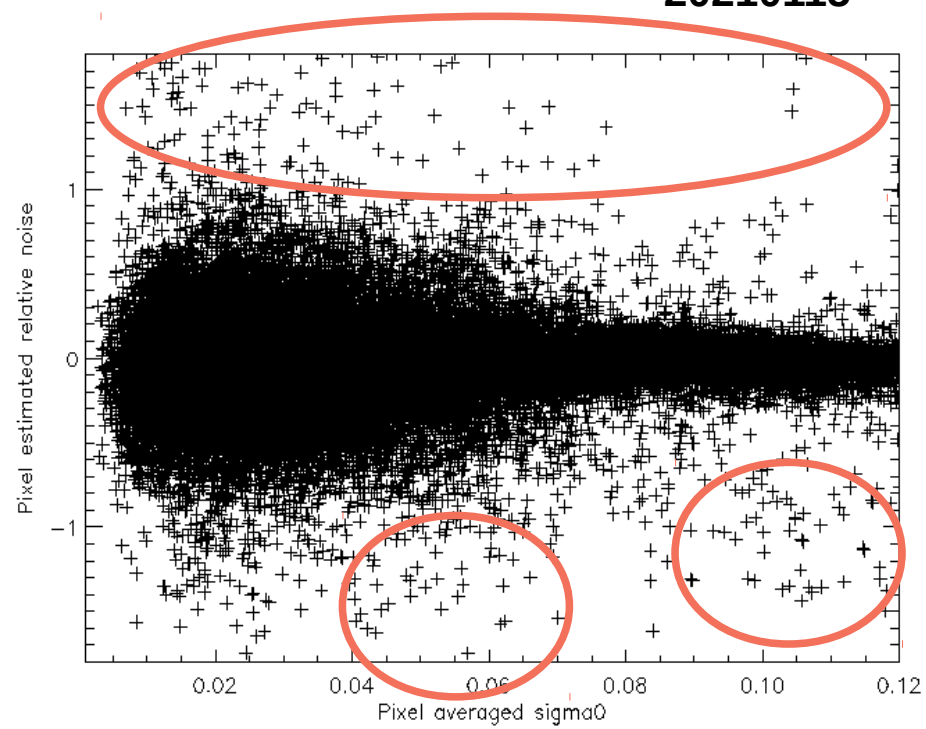






Arctic

20210114-20210115



CFOSAT VV

Same pattern : higher noise values for low sigma0 than for high sigma0
but some high relative noise level estimated from the diff. between Day1 and Day2 baskscatter fields for CFOSAT compared to ASCAT, ERS & NSCAT
→ need to be investigated, in particular if it depends on specific incidence angles

Several applications of sea ice backscatter maps

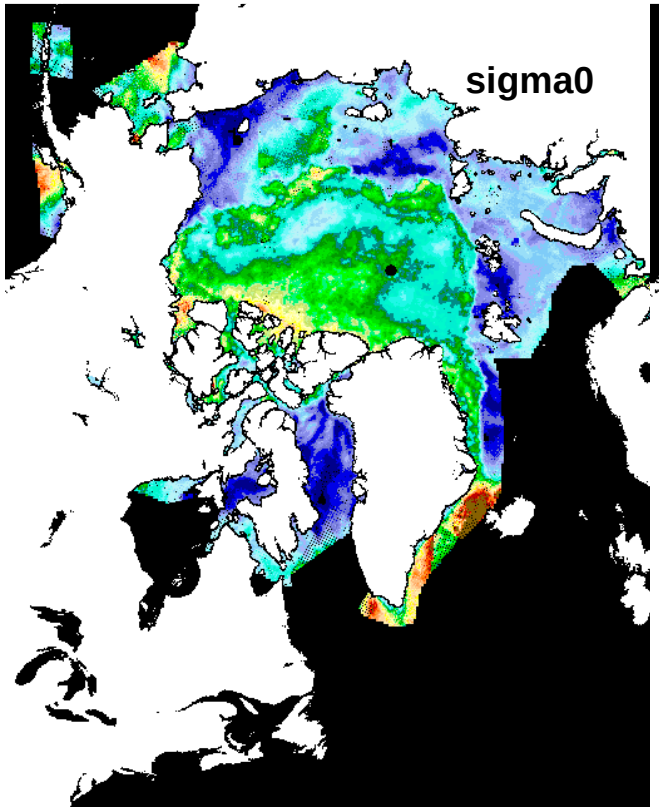
- Sea ice edge/open ocean detection
- Sea ice type estimate (FY from MY ice)
- Sea ice displacement estimate

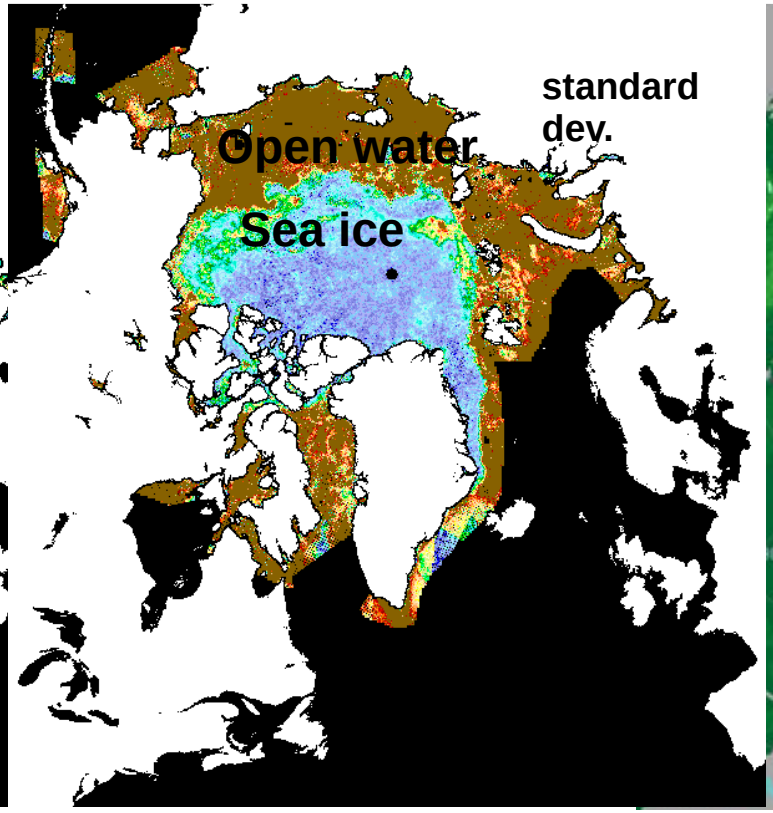
Sea ice/open water detection

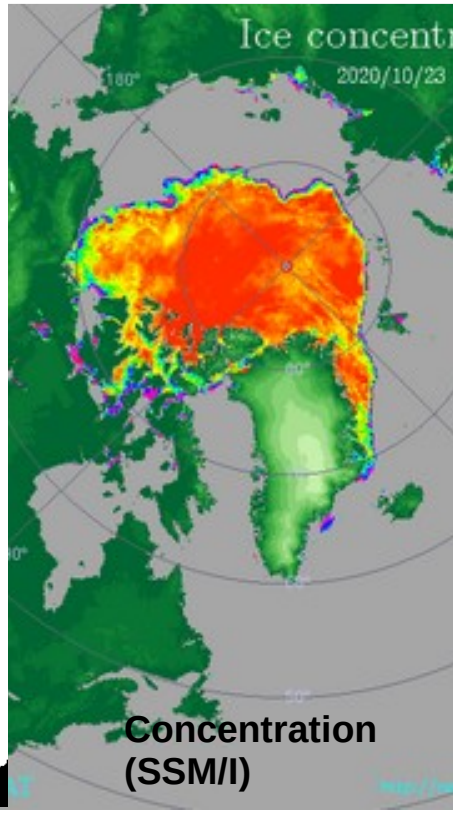
Sea ice/open ocean detection : example using ASCAT

ASCAT

20201023







1 single day

Arctic

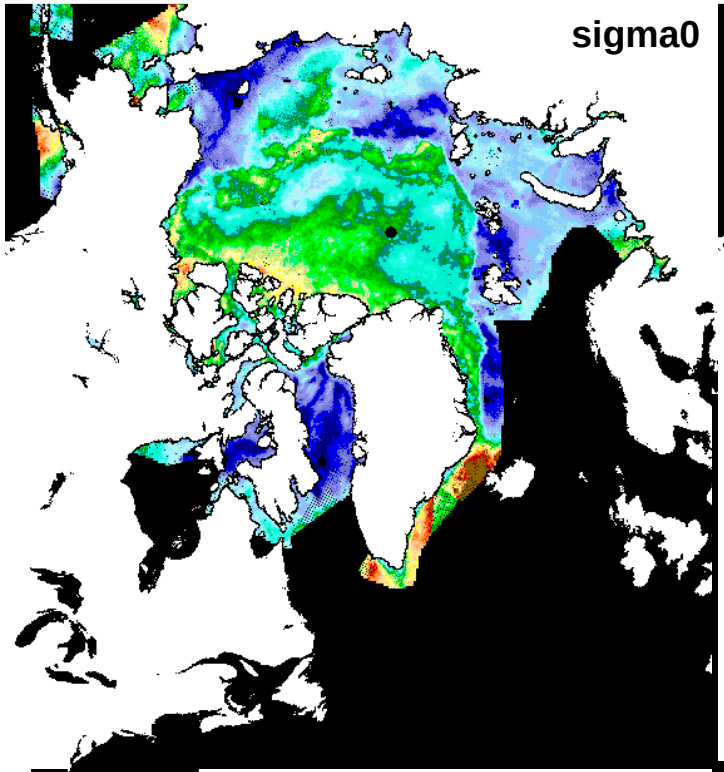
The standard deviation of the backscatter can be used as a sea ice/open water index with ASCAT data

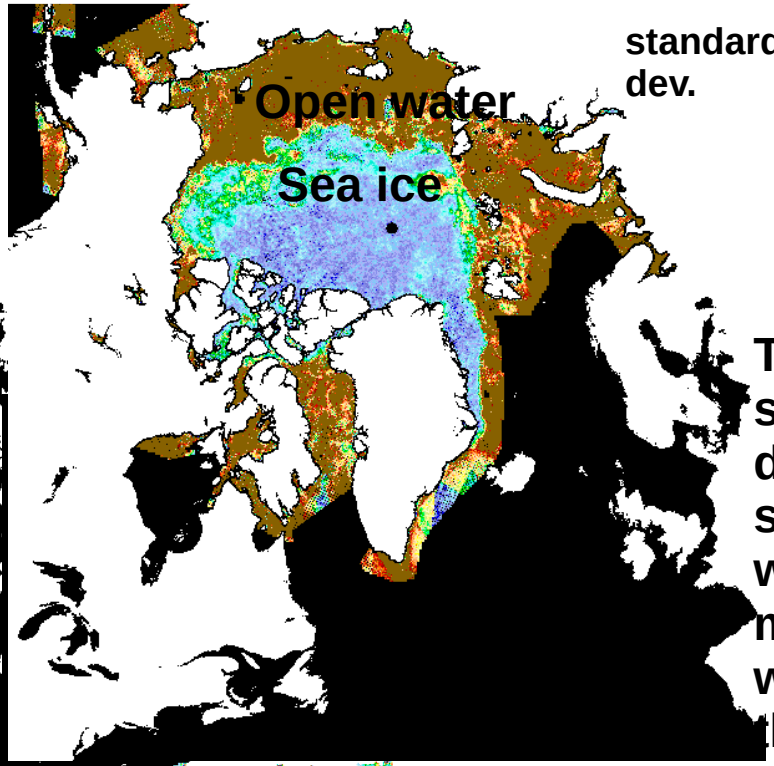
Sea ice/open ocean detection

ASCAT

20201023

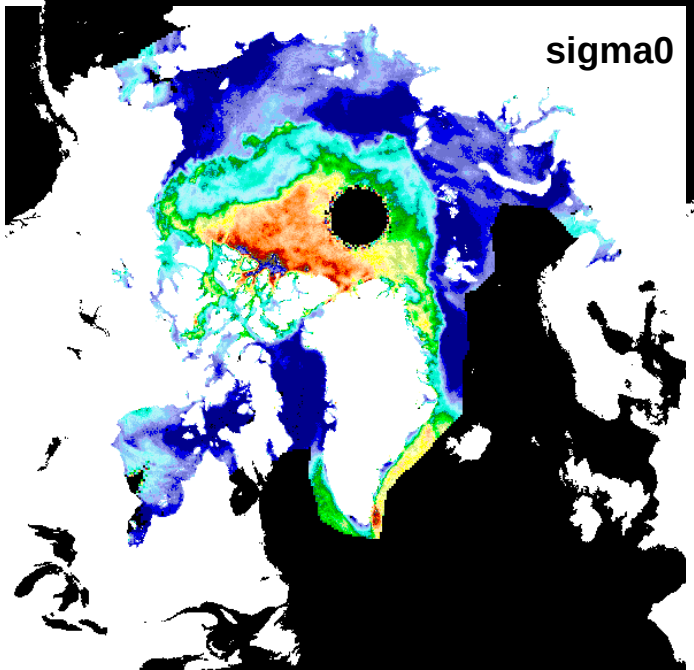
Arctic

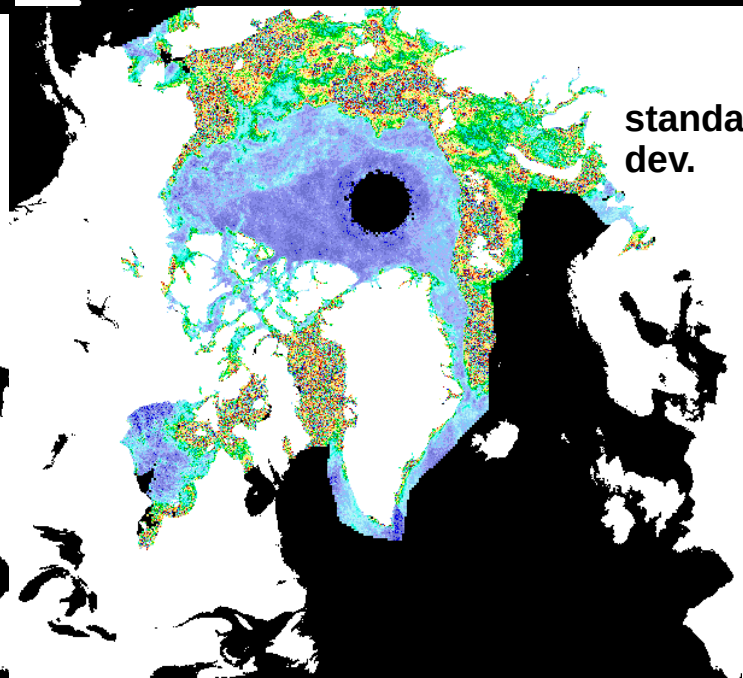




The use of the standard deviation as a sea ice/open water index is more efficient with ASCAT data than CFOSAT ones

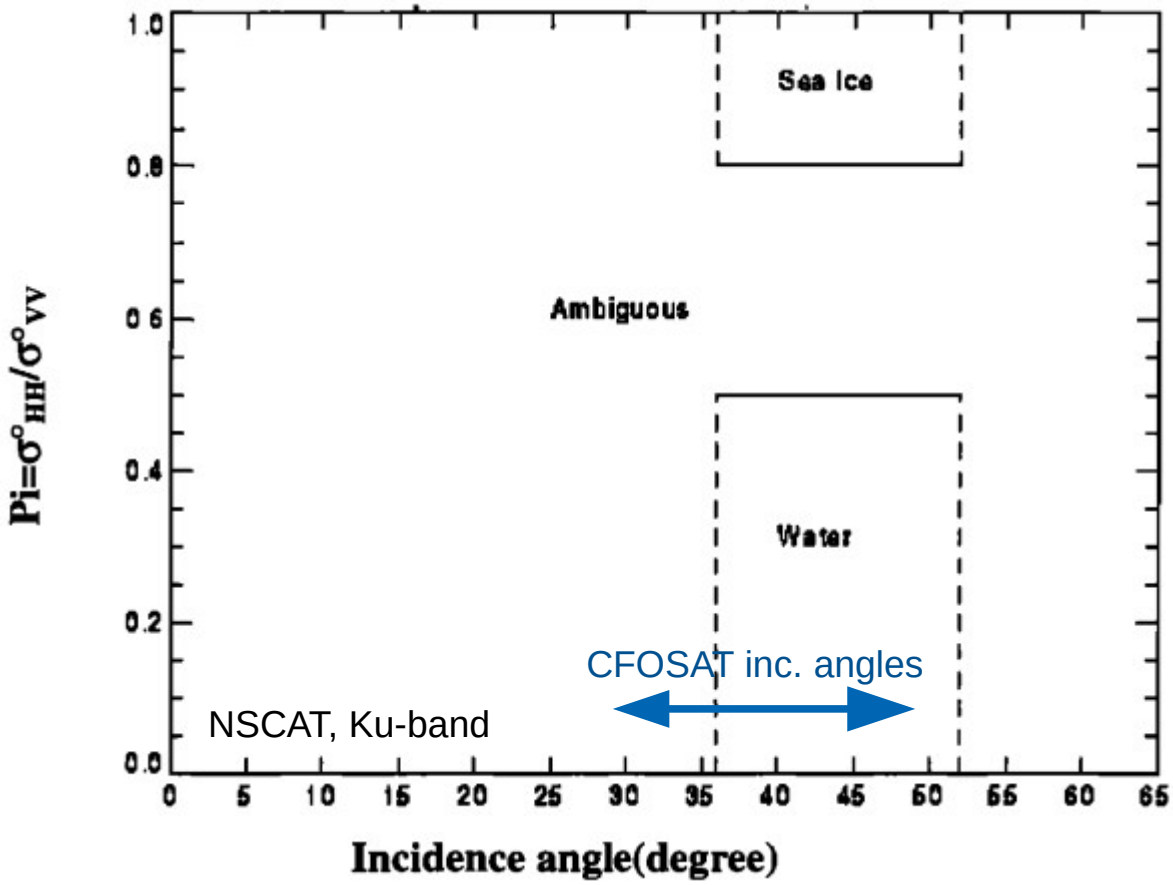
CFOSAT
VV





Sea ice/open ocean detection

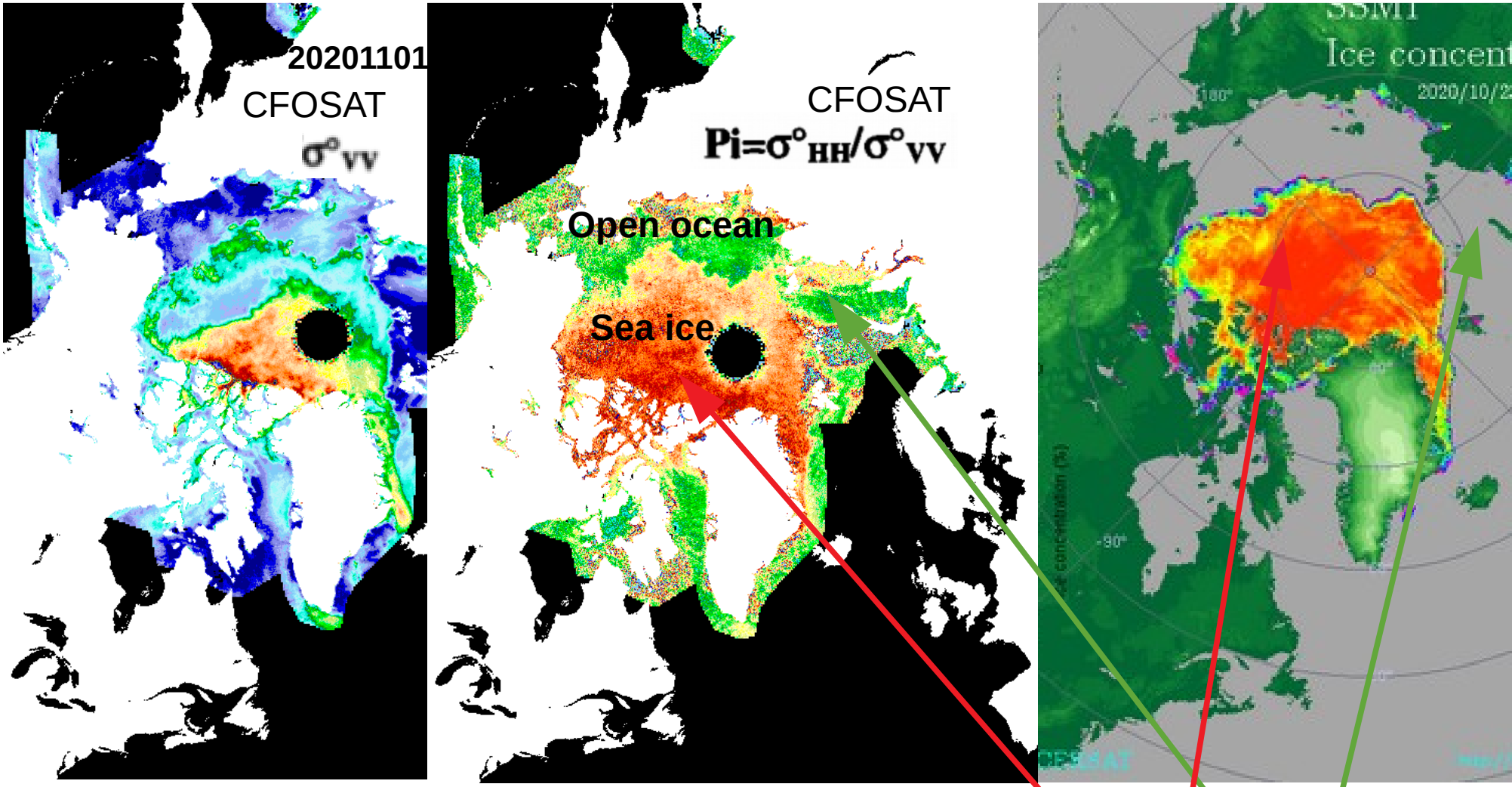
Use of the $Pi=\sigma^{o}_{HH}/\sigma^{o}_{VV}$ ratio



Ezraty & Cavanié, 1999

At the incidences CFOSAT uses, there is a possibility to separate sea ice from open ocean using the ratio Pi as it was done with NSCAT

Sea ice/open ocean detection

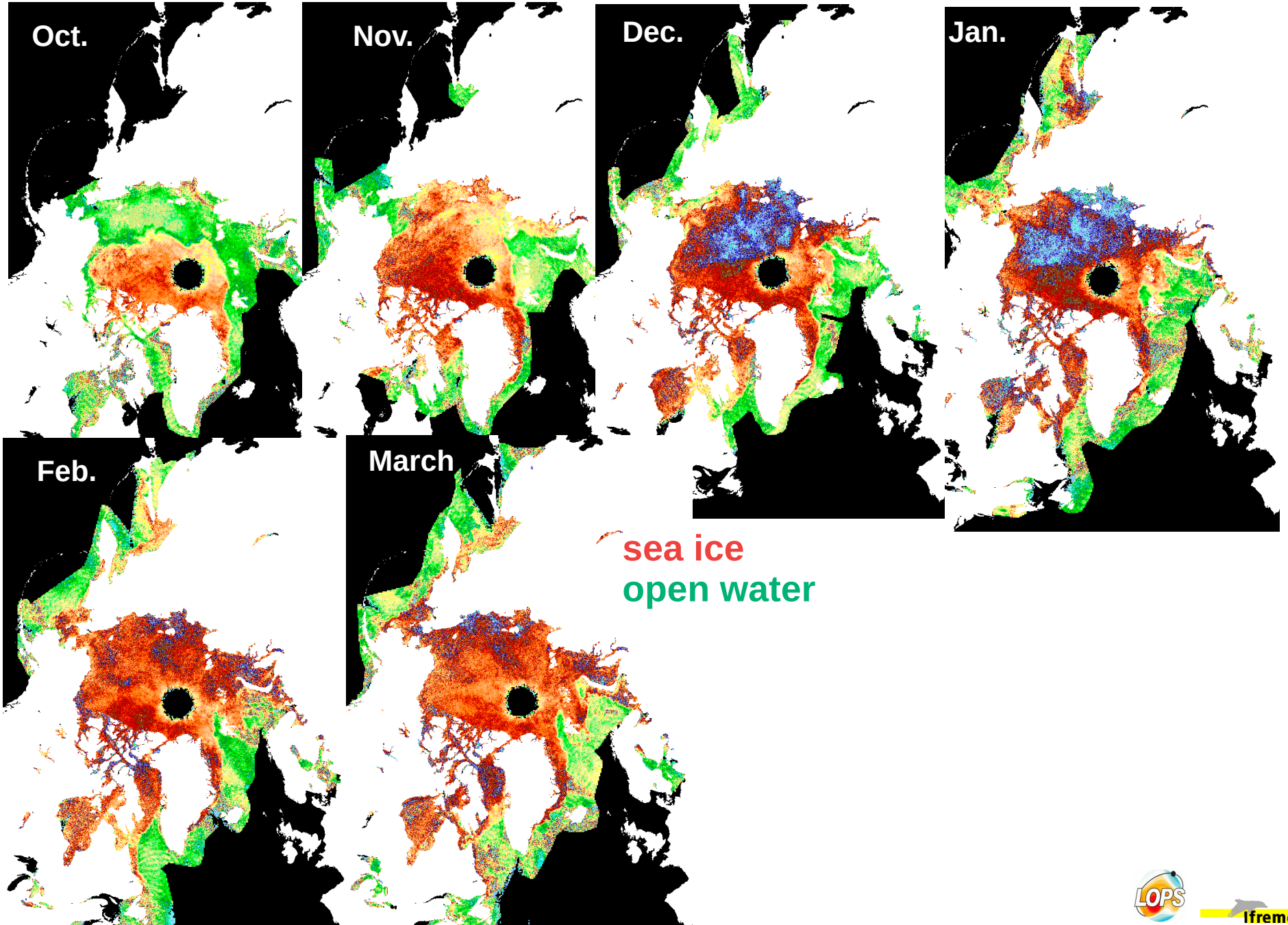


Using the ratio of the polarizations backscatter as a sea ice/open ocean index is more efficient than the use of the standard deviation of the backscatter for CFOSAT

Sea ice/open ocean detection time series

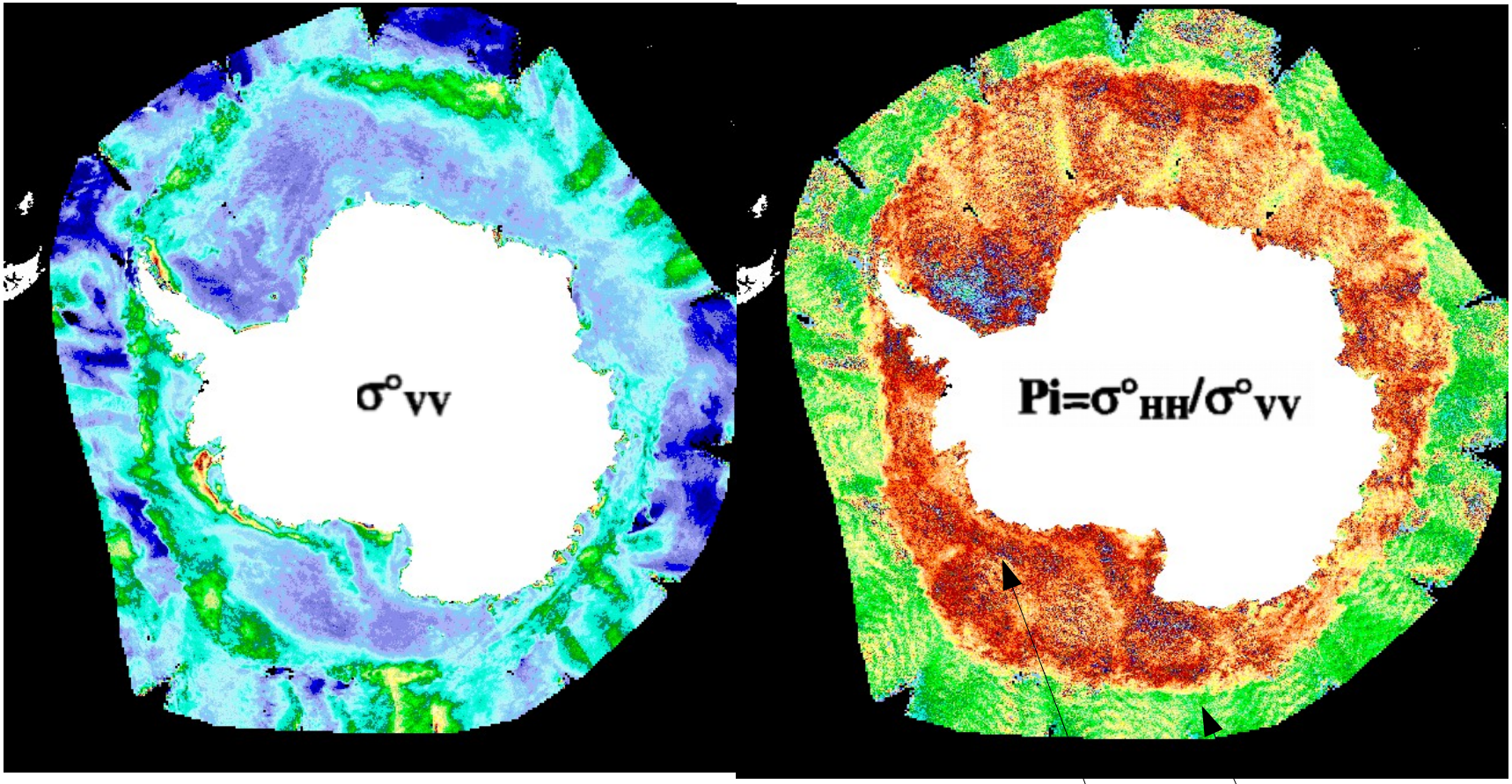
Arctic

$$Pi = \sigma^{\circ}_{HH} / \sigma^{\circ}_{VV}$$



Sea ice/open ocean detection

Antarctic

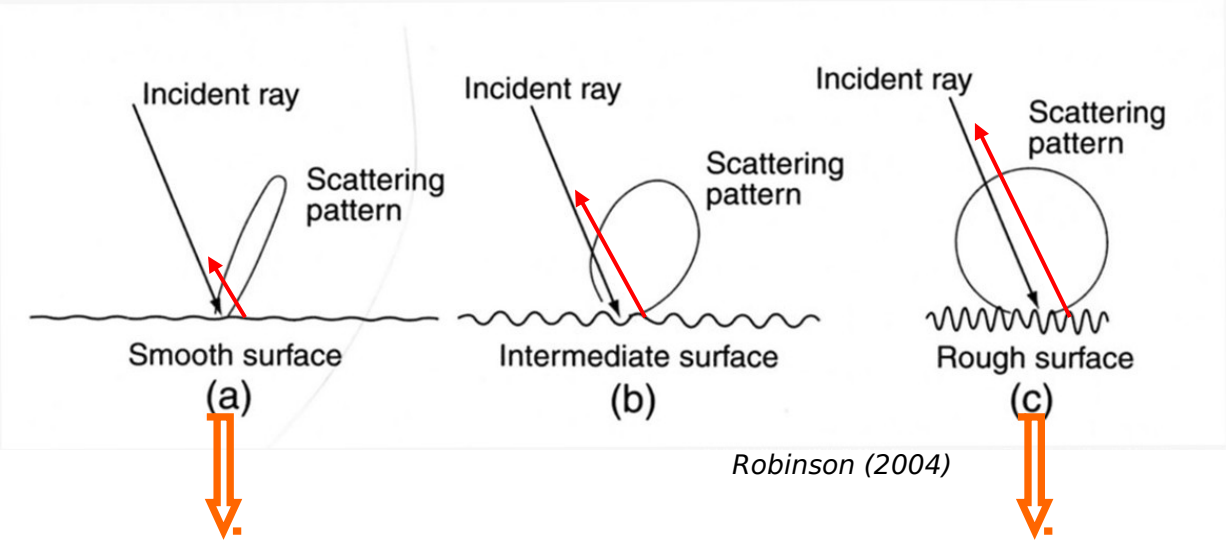


20201027

sea ice/open ocean

Sea ice type discrimination

MY/FY detection from scatterometry



Robinson (2004)

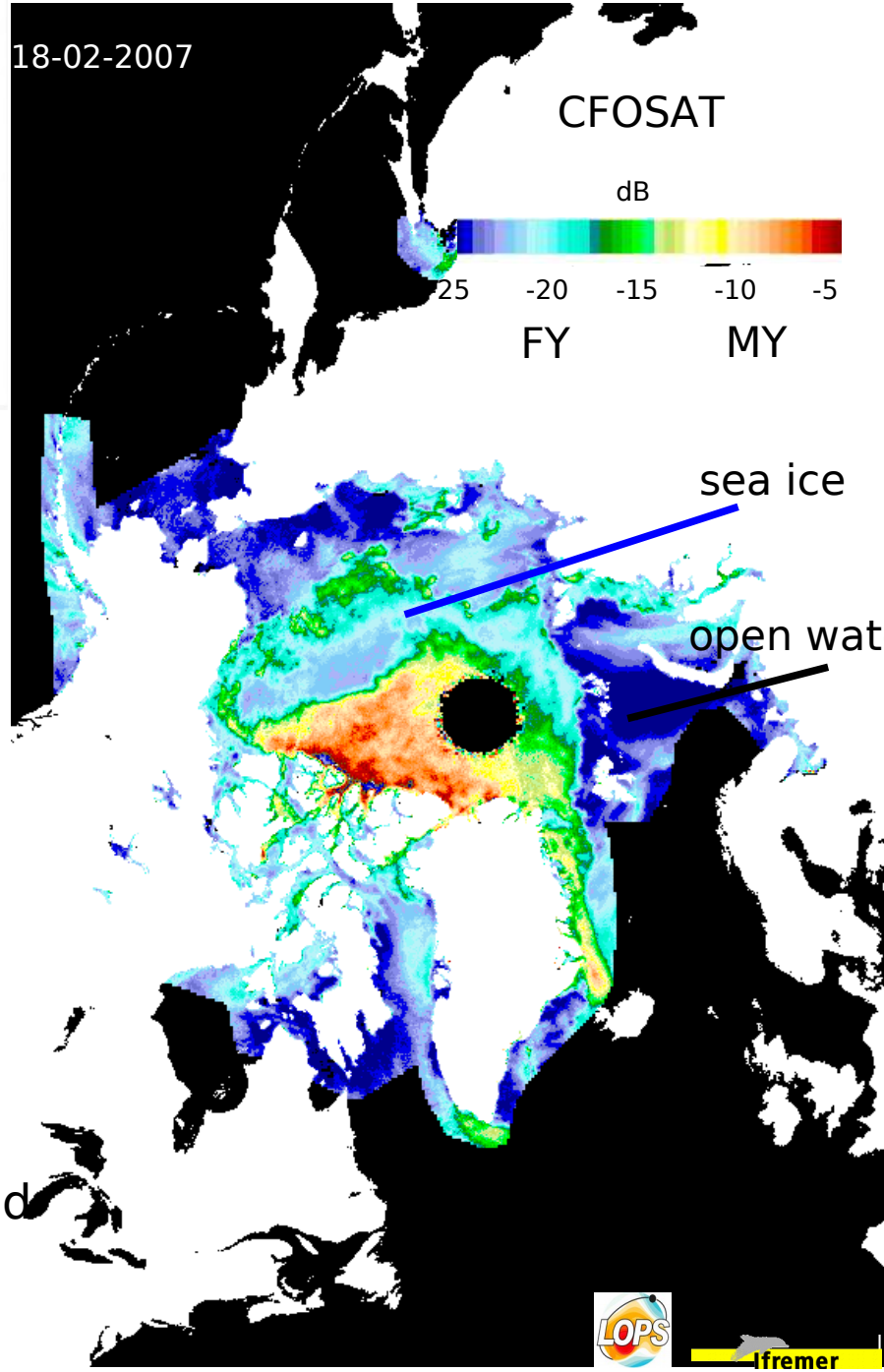
First year ice (FY)

Multi year ice (MY)
= thick sea ice

MY ice = sea ice that has survived to at least one summer melt

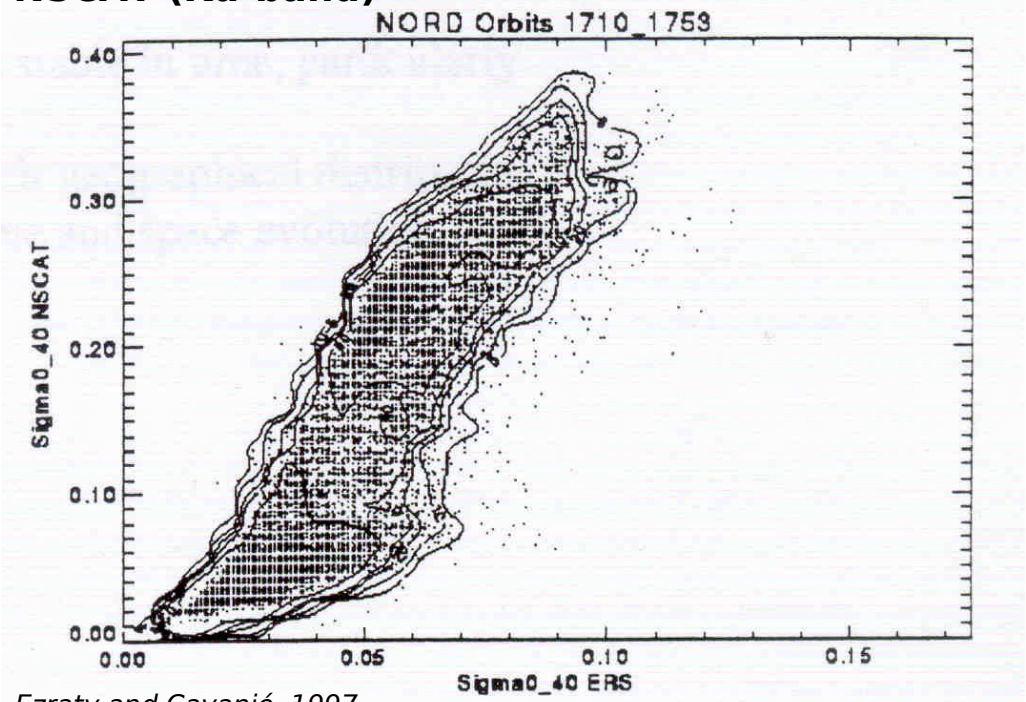
Backscatter values over sea ice depend on frequencies, polarisation, incidence angle but also on **ice type, roughness,** ice properties, porosity, salinity, etc...

Backscatter data can be used to detect MY ice and follow the MY surface during the winter



Ku-band vs C-band backscatter

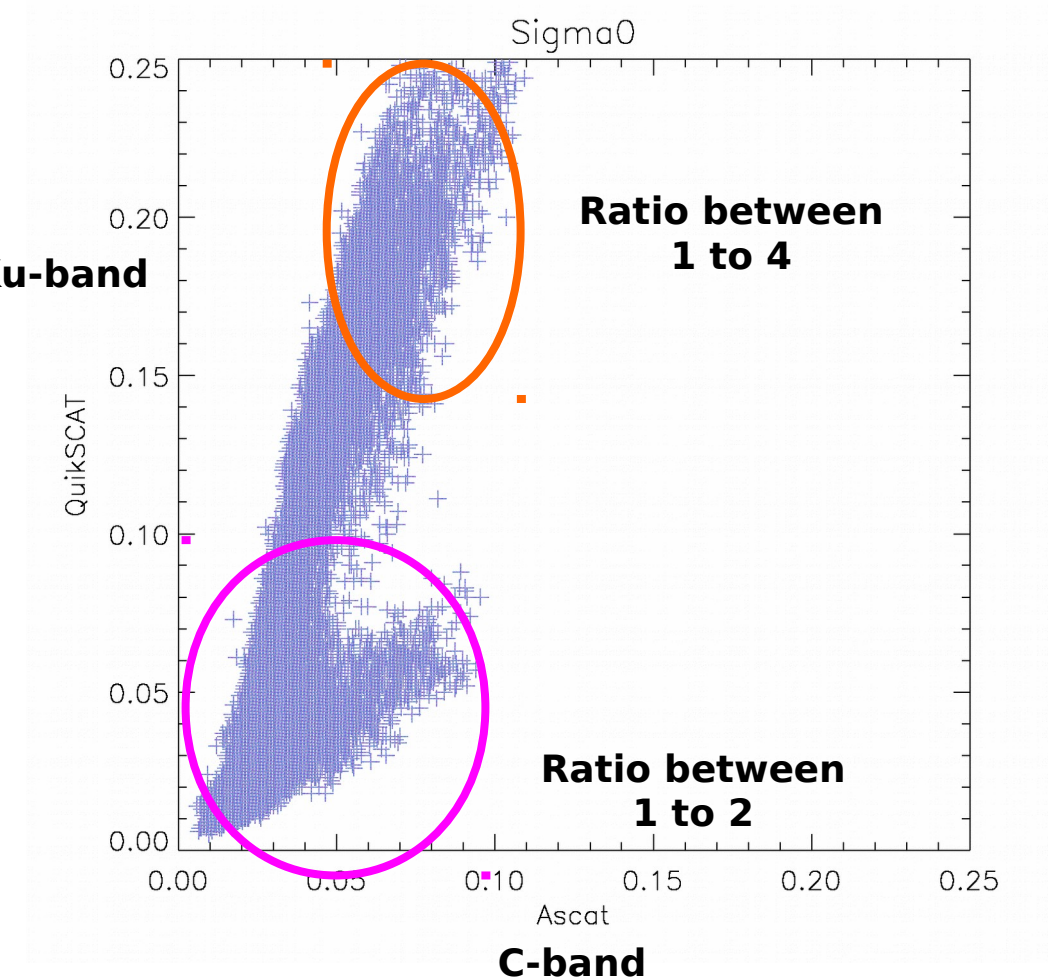
NSCAT (Ku-band)



Ezraty and Cavanié, 1997

ERS (C-band)

Ku-band



C-band

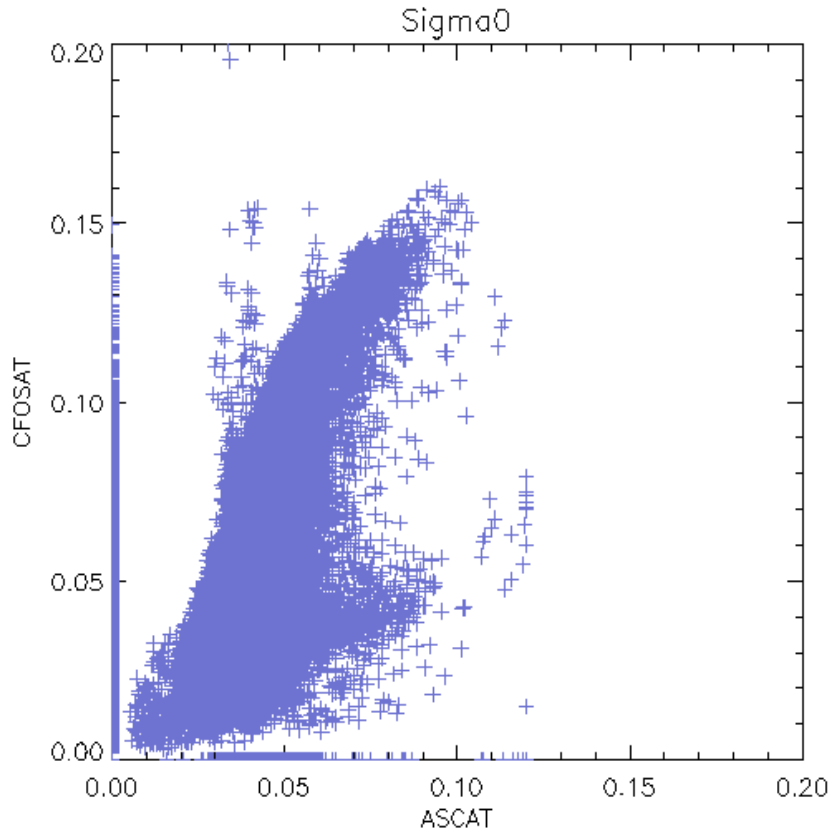
Ku-band backscatters are higher than C-band backscatters

Results similar NSCAT/ERS and QuikSCAT/ASCAT studies

Ku-band vs C-band : CFOSAT/ASCAT

20201023

CFOSAT
HH



ASCAT

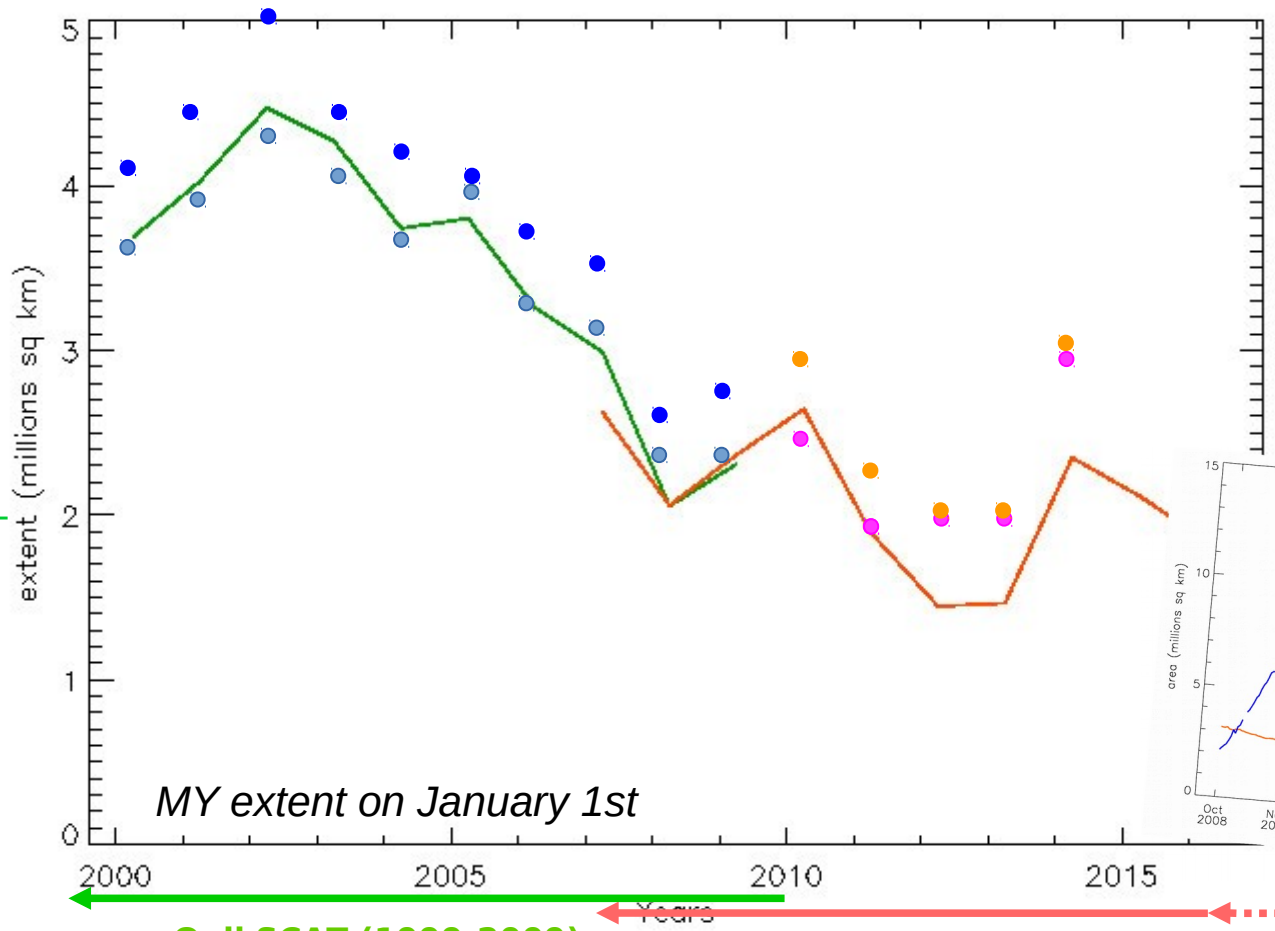
The C/Ku pattern is similar to previous QuikSCAT/ASCAT & ERS/NSCAT and is a good point for ice type detection

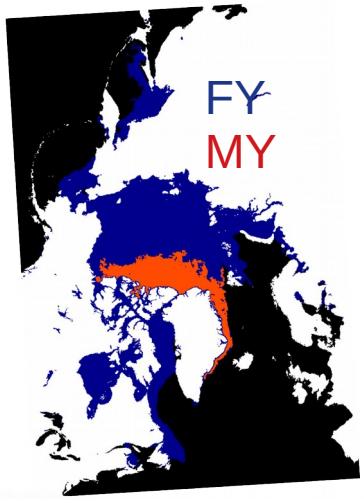
MY ice extent time series

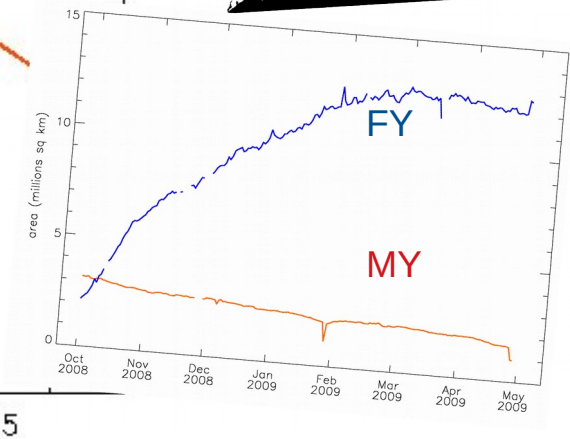
- Kwok with QuikSCAT
- Lindell & Long with QuikSCAT
- Lindell & Long with OSCAT
- Lindell & Long with ASCAT & SSMIS

— Ifremer QuikSCAT

— Ifremer ASCAT







QuikSCAT (1999-2009)
Ku-band

ASCAT (2007-...)
C-band

CFOSAT (2018-...)
Ku-band

QuikSCAT estimate consistent with other studies (in trends), ASCAT estimate lower than the other studies, consistent for the beginning of the period → still need comparison/validation & **add CFOSAT estimate to continue the time series**

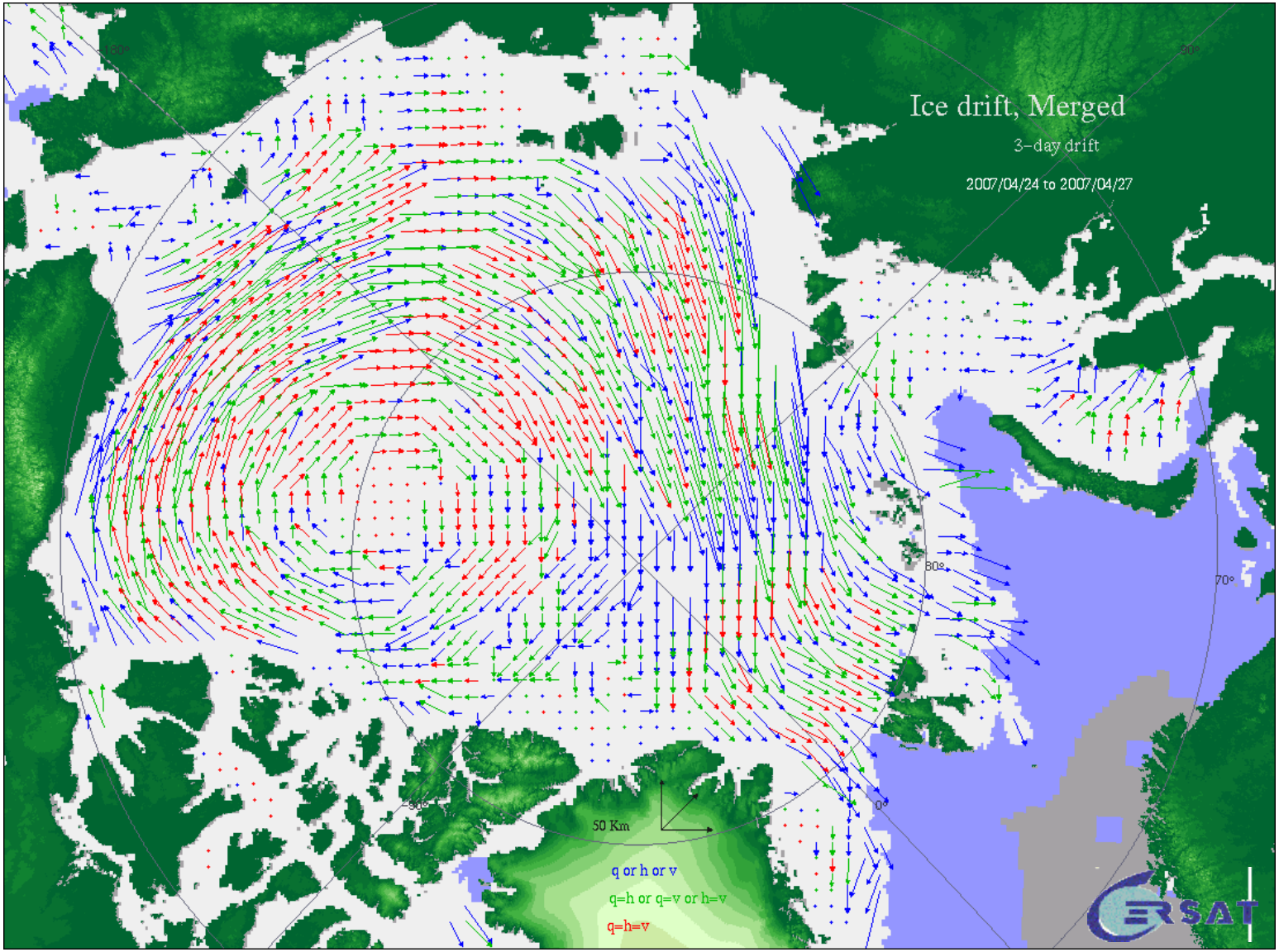
Sea ice displacement

Arctic sea ice drift maps

Combination of QuikSCAT and SSMI radiometer

- Grid resolution: 62.5 km
- Daily in winter
- **Since 1992**

  - 3 days lag
  - 6 days lag
  - 30 days lag



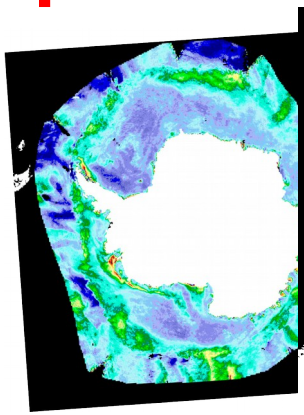
From cross-correlation technics on backscatter fields

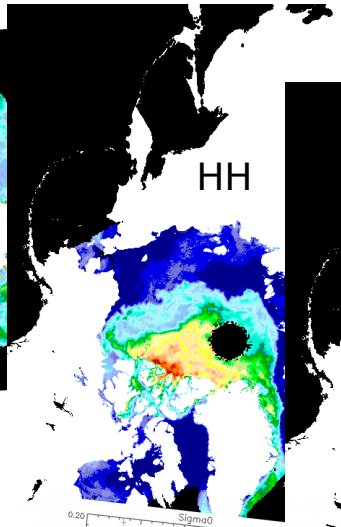
Method and validation in *Girard-Ardhuin and Ezraty, TGRS 2012*

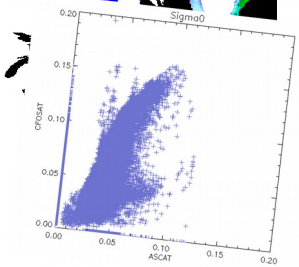
Possibility to infer sea ice displacement maps from CFOSAT scatt. fan-beam data and to merged them with radiometry → to be tested

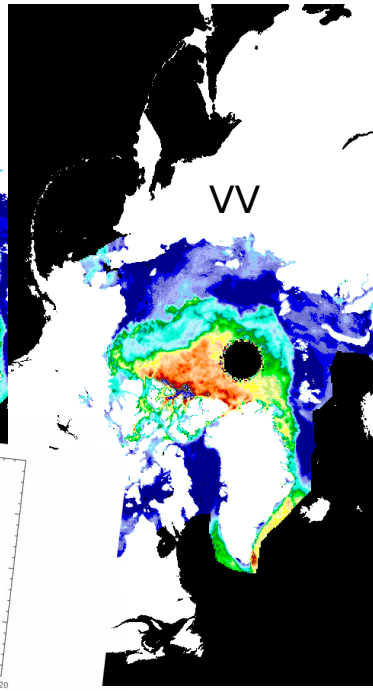
Summary of sea ice parameters

Backscatter maps, daily and for both Arctic and Antarctic areas

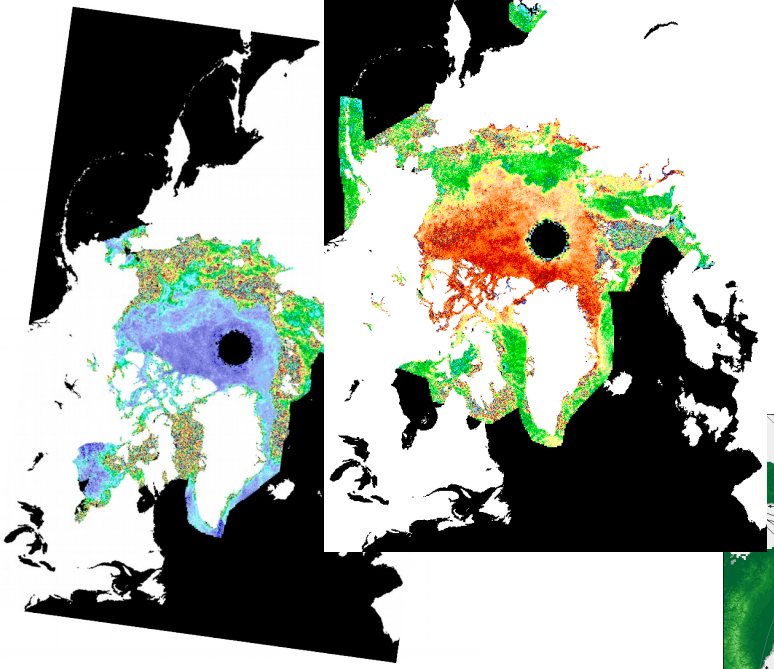


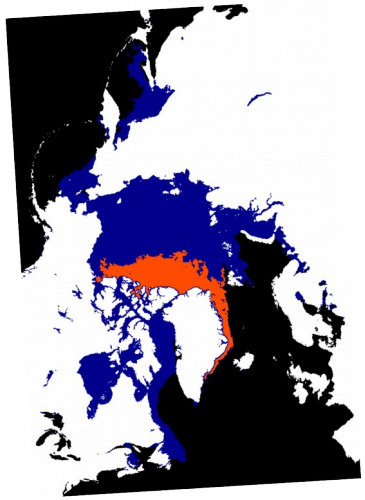




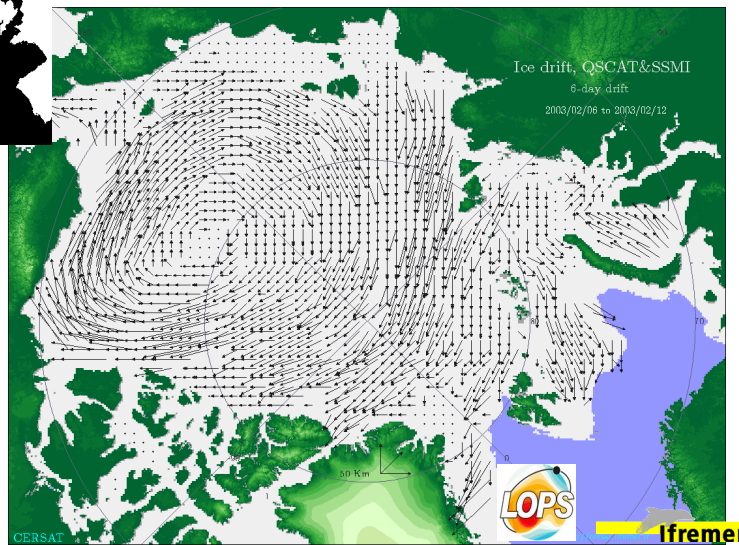


Sea ice edge detection from two methods → **benefit to have the 2 polarizations !**





Detection of multiyear and first year sea ice → to be tested



Arctic sea ice drift → to be tested

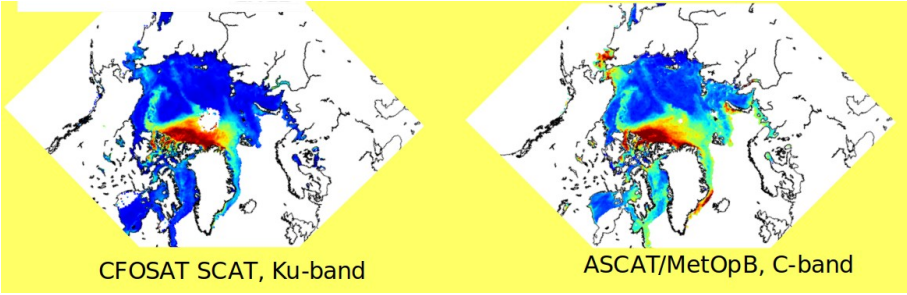
Summary

SCAT

- Expertise of the lab on scattometer for sea with NSCAT (1997) data at multiple incidence angles over sea ice but sea ice are now very different than during the 1990's, work on QuikSCAT (Ku)/ASCAT (C)→ qualification of the CFOSAT data over sea ice
- We are at the beginning of the study of the scat. data : data tested on October-February 2021, March (now) is the most interesting period to test the data in the Arctic-→ more results soon
- Very interesting **spatial coverage** of the data (except the Arctic pole hole)

  Good comparison with ASCAT data

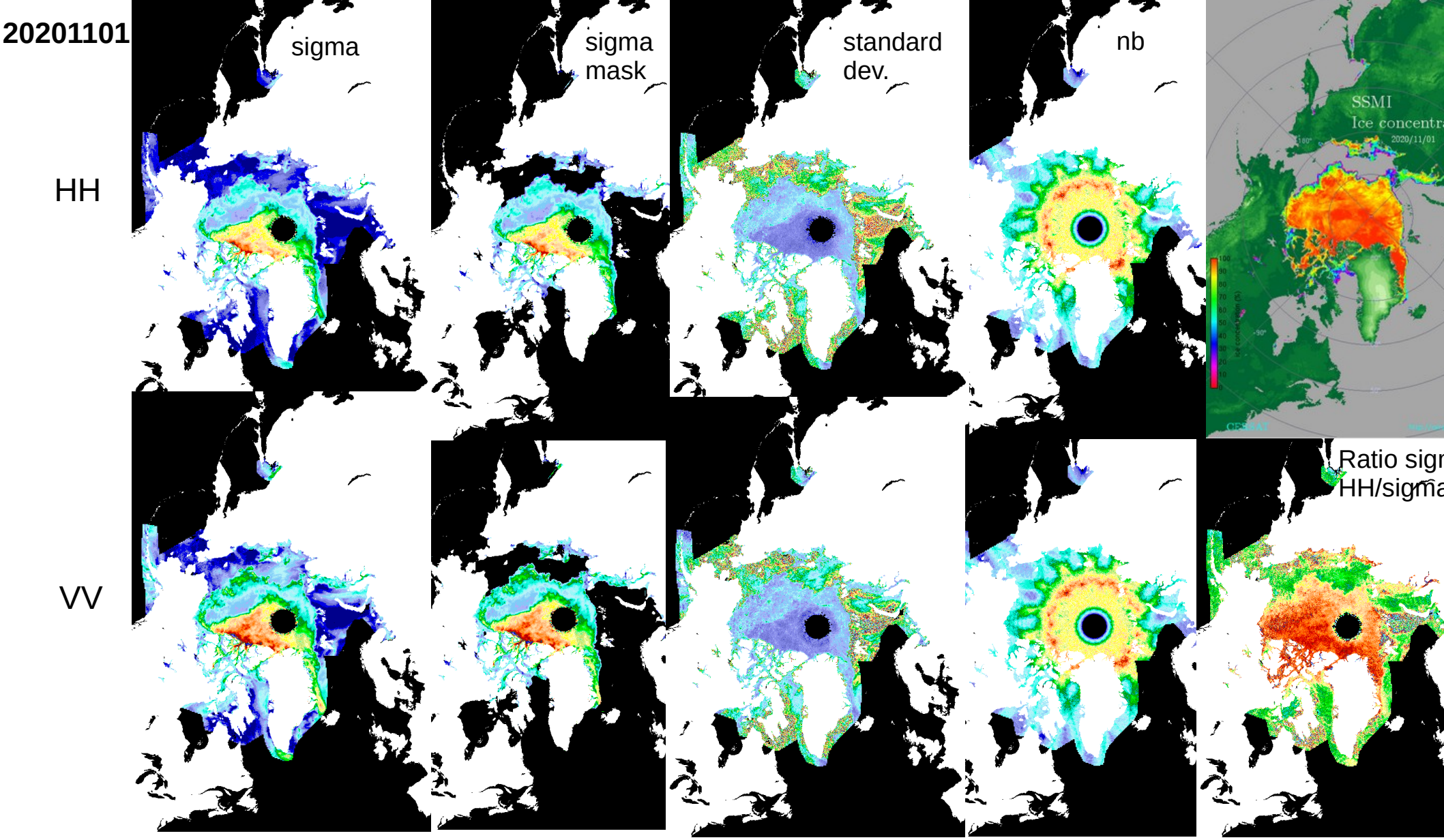
  Work to be continued on incidence angles and quality of the data/noise level, also on stability of the data during the cold season
- Benefit of the VV and HH beams shown with the **detection of sea ice /open ocean**
- Several applications of the CFOSAT data :
  - Detection of open ocean/sea ice
  - Ice type (FY/MY)
  - Sea ice displacement estimate



SCAT&SWIM

- Study of the signal **at weak incidence angle** and **synergy** with the SCAT -benefit of the 2 sensors !- in particular, interest for ocean wave-sea ice interactions


Thank you



Examples of parameters in the CFOSAT files which will continue the C& Ku-band scatt. time series (to be available through the IWWOC data processing and archiving center)

One file per day, for both polar areas, and for both polarizations