The CFOSAT project

China
France
Oceanography
SATellite

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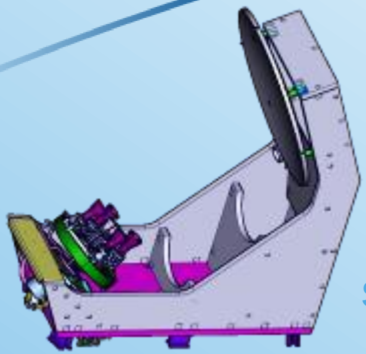
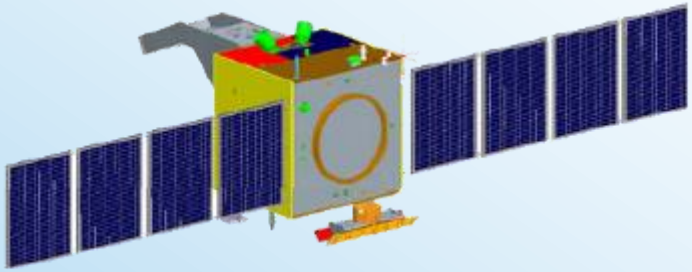
Overview

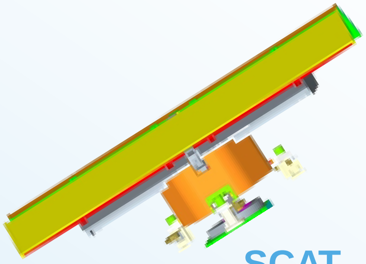
- ▸What is the CFOSAT mission?
- ▸Mission objectives and scientific requirements
- ▸Description of CFOSAT satellite
- ▸CFOSAT products

  Focus on Ice applications

The CFOSAT mission





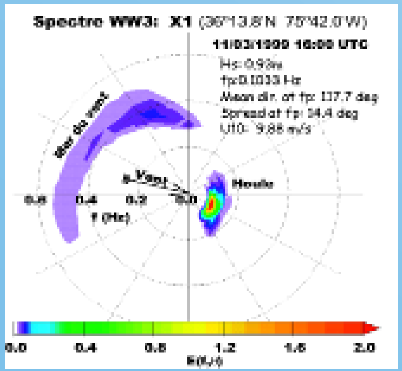


- ▶**CFOSAT: an innovative China/France mission for oceanography**
- ▶**Launch: mid-2018**
- ▶**Joint measurements of oceanic wind and waves**

  SWIM: a wave scatterometer (new instrument)

  SCAT: a wind scatterometer (fan beam concept)

This mission is a “world première”



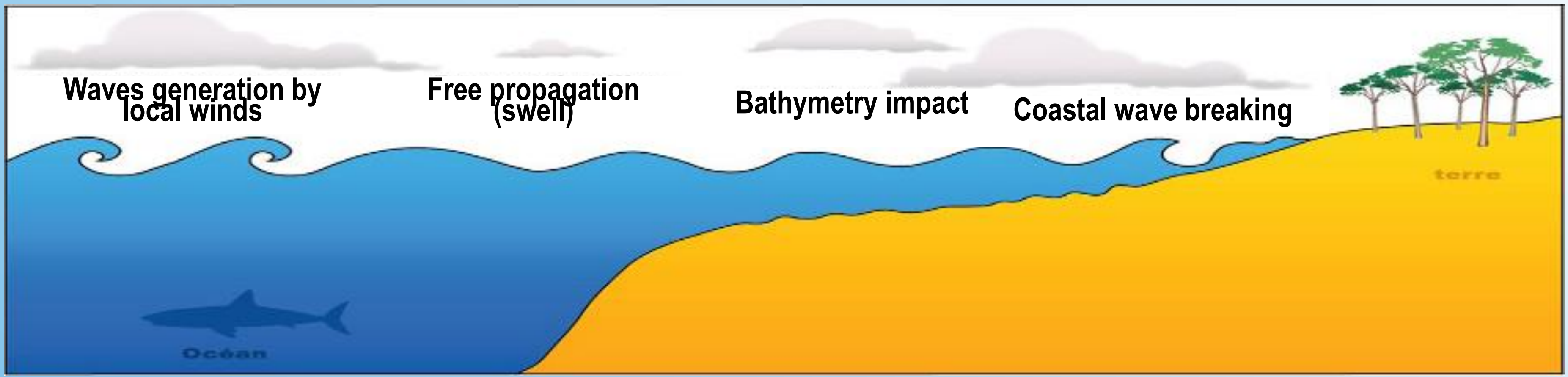
- ▶SWIM, new spaceborne instrument with technology innovations (antenna, on-board digital processing)
- ▶SCAT, new concept of wind scatterometer
- ▶Access to 2D wave spectrum with high angular resolution and with global scale
- ▶Joint measurements of winds and waves

Scientific objectives

▸ **Global observation of ocean wind and waves with high temporal coverage**

▸ **Why?**

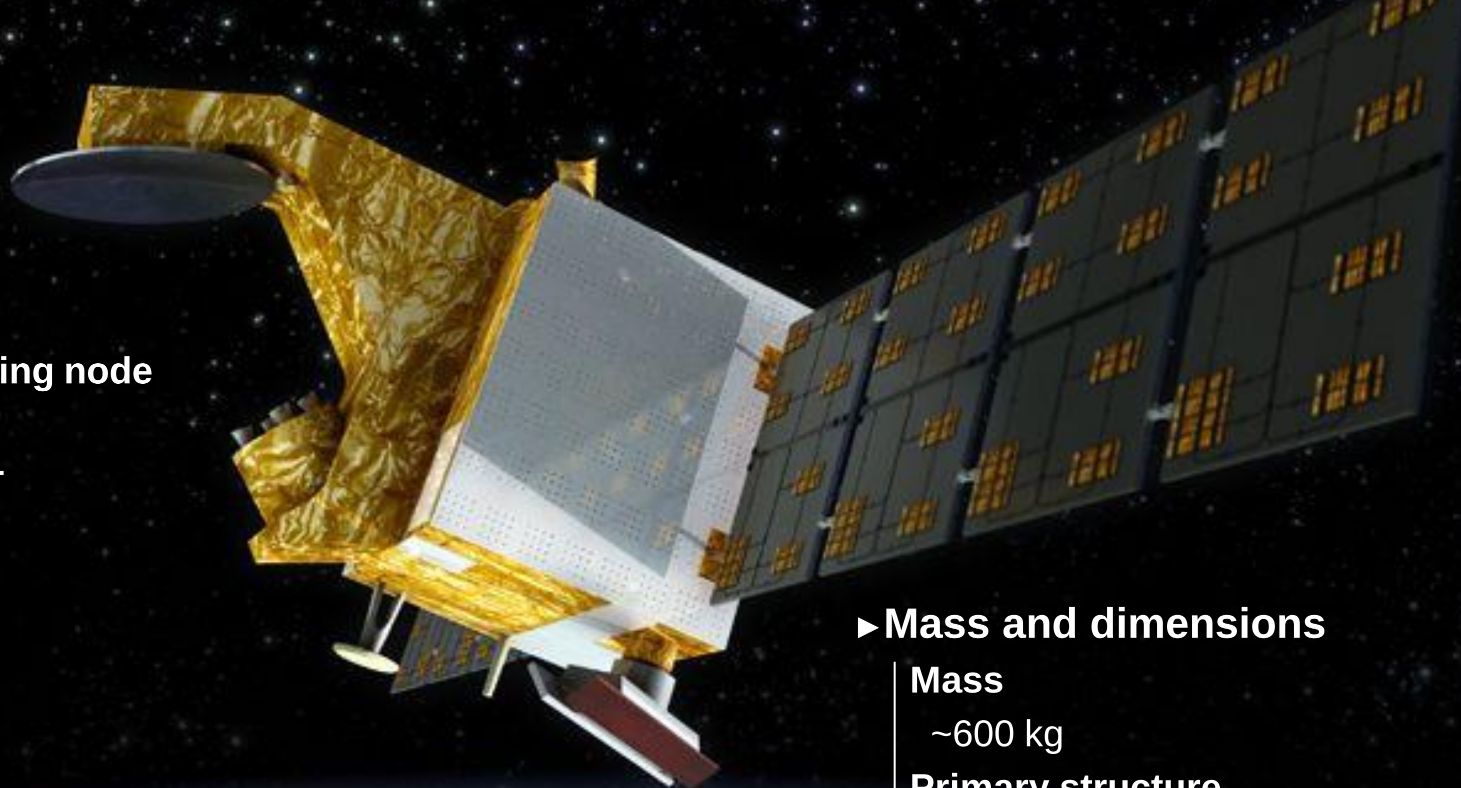
- **T**o improve wind and wave forecast and sea-state monitoring
- **T**o improve the knowledge and the modeling of sea-surface processes
- **T**o get a simultaneous wind and wave measures for coupling effects characterization



▸ **Secondary objectives (for SWIM)**

- **L**and surface monitoring (soil moisture and soil roughness)
- **Polar ice sheet characteristics**

Satellite



▸Orbit

Sun synchronous

Local time at descending node

AM 7:00

Altitude at the equator

519 km

Cycle duration

13 days

▸Mass and dimensions

Mass

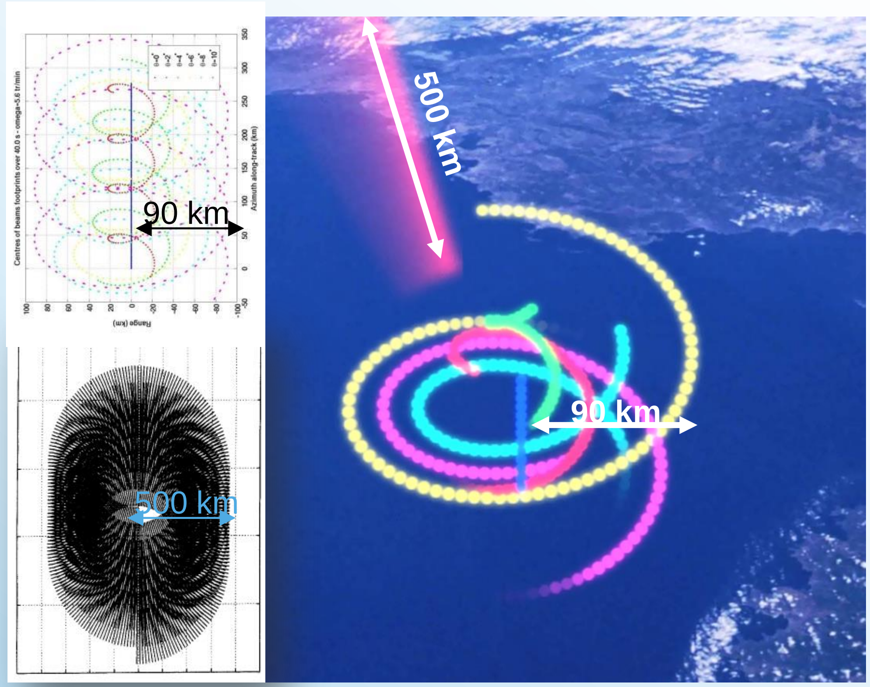
~600 kg

Primary structure

~1.5mx1.5mx1.5m

Scientific requirements

- **Mission**
  - **M**inimum duration of 3 years
  - **G**lobal coverage over the oceans (**polar orbit**)
  - **D**ata available in near-real time



- **SWIM**
  - **D**irectional wave spectra from incidences 6° to 10°
    - To be measured in the wavelength range 70m-500m
    - With a 10% accuracy on wavelength, 15° accuracy on wave propagation direction
    - With a 15% accuracy on spectral level around the peak of the spectrum
  - **S**ignificant wave height and wind speed from nadir
    - 10% on SWH (or 50 cm whichever is better)
    - rms <2 m/s on wind speed
  - **N**ormalized radar cross-section form 0° to 10°
    - Absolute accurcay of ±1 dB
    - Relative accuracy between incidences ± 0.1 dB

- **SCAT**
  - **W**ind vector
    - Wind speed range and precision: 2m/s or 10% (larger) @5~24m/s
    - Wind direction precision: 20 °
  - **B**ackscattering coefficient precision : 0.5dB
  - **S**urface resolution
    - 50km (standard product)
    - 25km(experimental product)

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Payloads

- Two scientific payloads
  - **SWIM: Surface Waves Investigation and Monitoring**
  - **SCAT: wind SCATterometer**

- SWIM

Surface Waves Investigation and Monitoring

Real aperture radar in Ku-band

6 incidence angles: 0°, 2°, 4°, 6°, 8° et 10°

Antenna diameter: 90 cm (~2° aperture)

Polarization VV

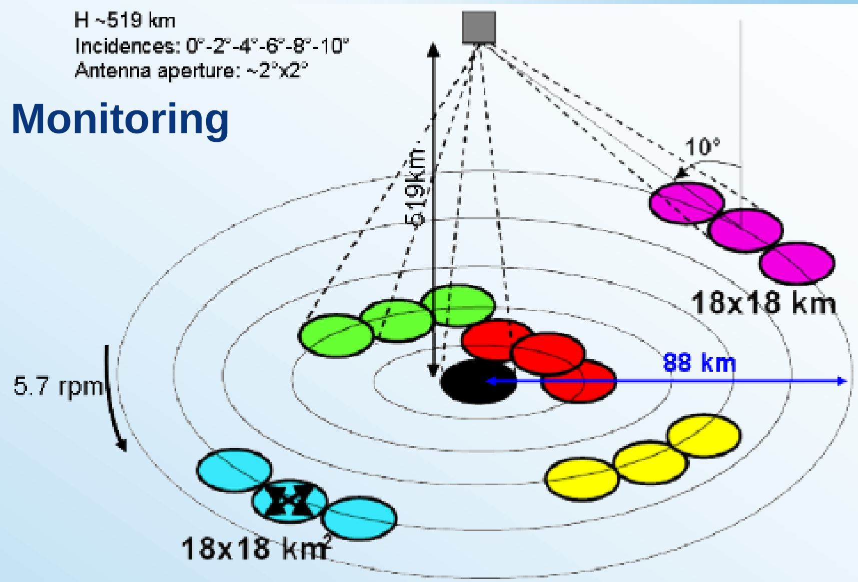
Rotation speed: 5.7 rpm

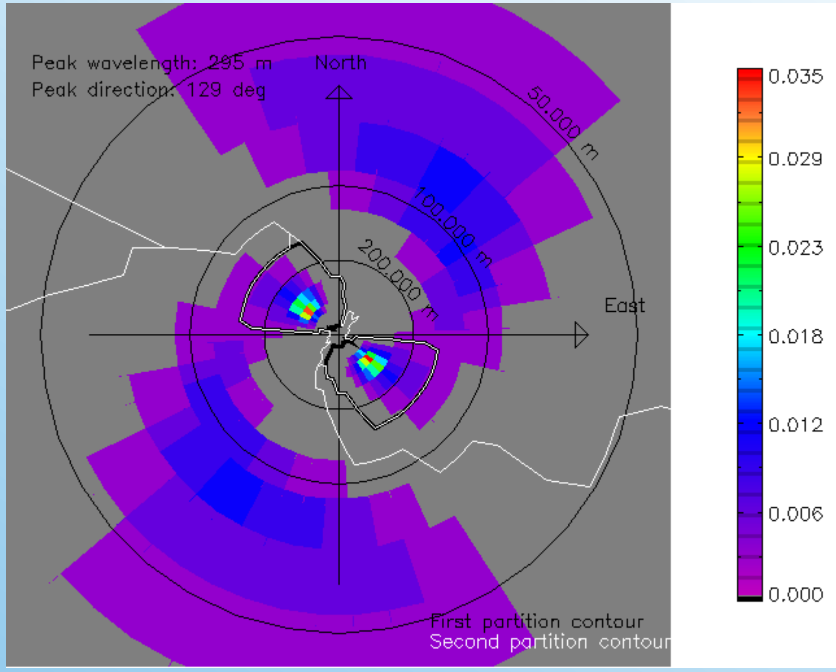
Power: 120 W

Useful bandwidth: 320MHz

Pulse duration: 50 μs

PRF: 2 - 7 kHz





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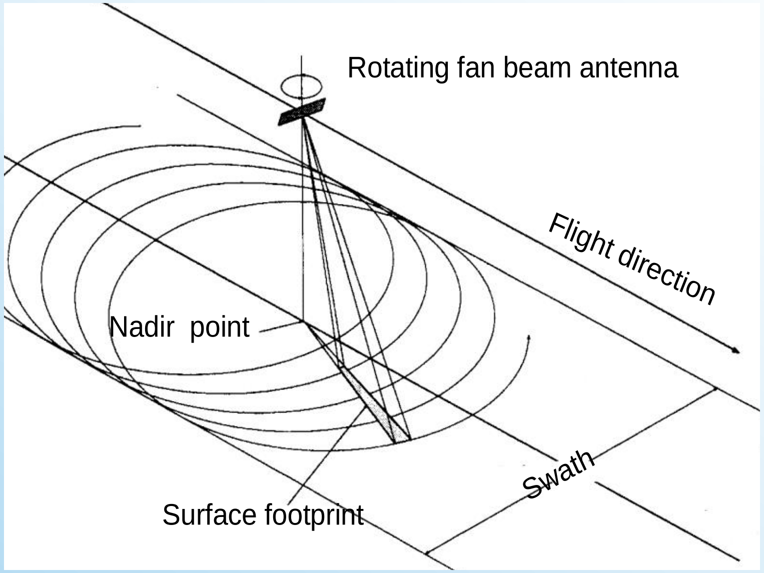
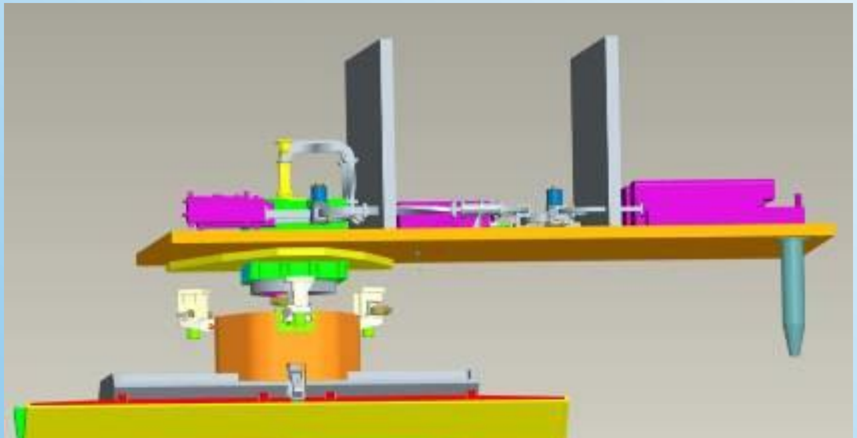
CFOSAT

Payloads

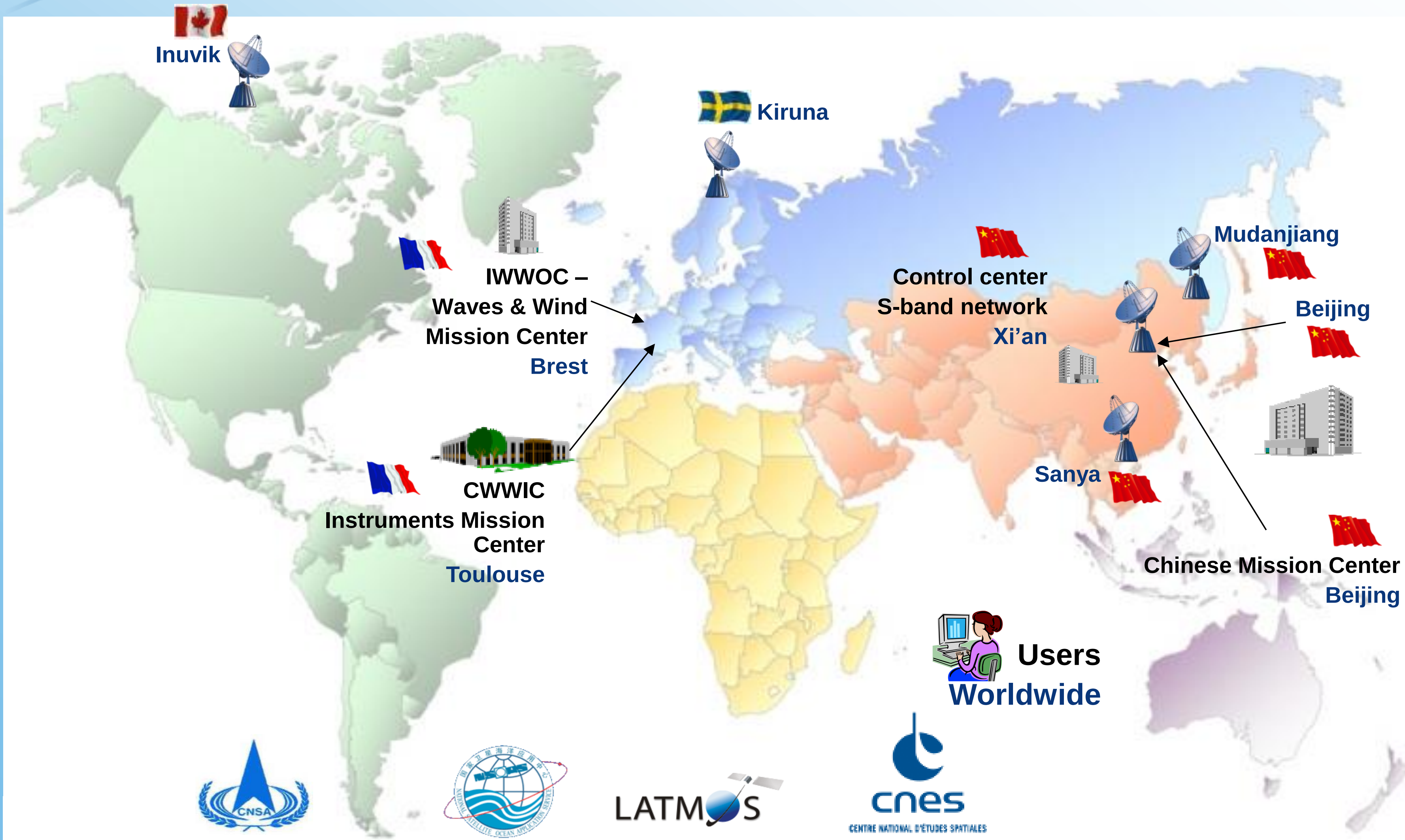
- Two scientific payloads
  - SWIM: Surface Waves Investigation and Monitoring
  - SCAT: wind SCATterometer



- SCAT
  - Wind **SCAT**terometer
  - **Real aperture radar in Ku-band**
    - **Fan beam concept**
    - **Incidence angles (on ground): 20° -65°**
    - **Antenna size: 1.2mx0.4m**
    - **Alternate polarization: HH-VV**
    - **Rotation speed: 3.2 rpm**
    - **Power: 120 W**
    - **Useful bandwidth: 0.5 MHz**



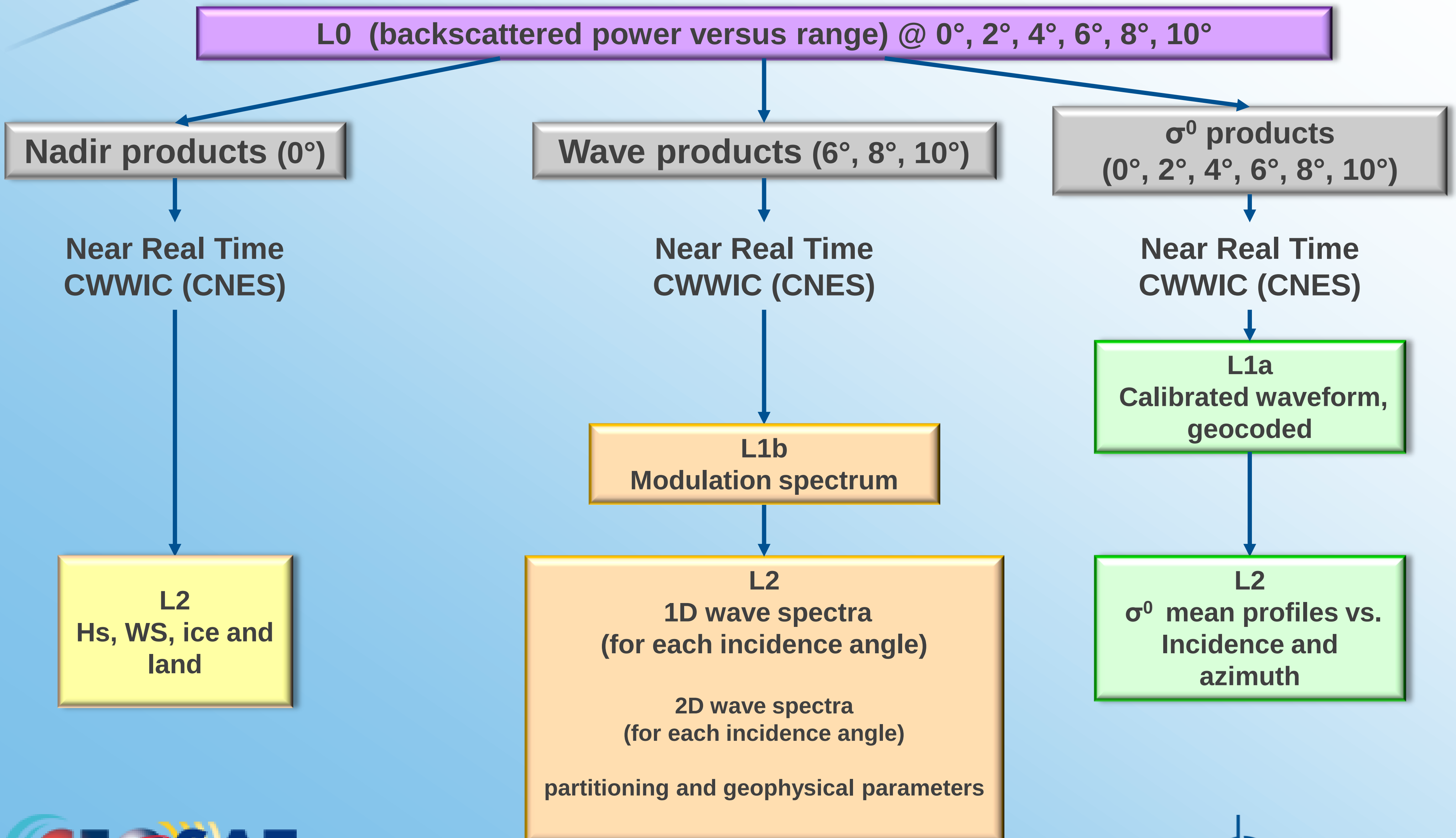
Ground system



SCAT products

Level		Definition	Associated processing
Level 1	**1b**	Normalized radar cross section Backscatter power (Time-Ordered Earth-Located Sigma0s)	- Internal calibration - Apply time difference correction - Assignment of ephemeris and attitude information to each frame
Level 2	**2a**	**Sigma0** (grouped by wind vector cell (WVC) rows, 25 km x 25 km swath grid) **Kp** Sigma0 over land and ice	- Calculate cell location& geometry - Calculate surface flags - Calculate the quality and the uncertainty of the sigma0 values - Calculate sigma0 and associated - Quantities (Calibrated data for wind retrieval)
	2b	**Wind Vector** (Ocean Wind Vectors grouped by rows of WVC, in 50 x 50 km Swath Grid)	- Perform sigma – 0 Grouping - Calculate wind vectors - Perform ambiguity removal

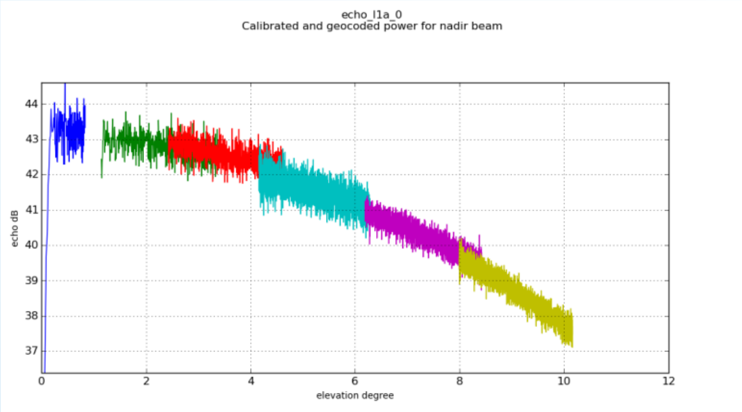
SWIM products at CWWIC



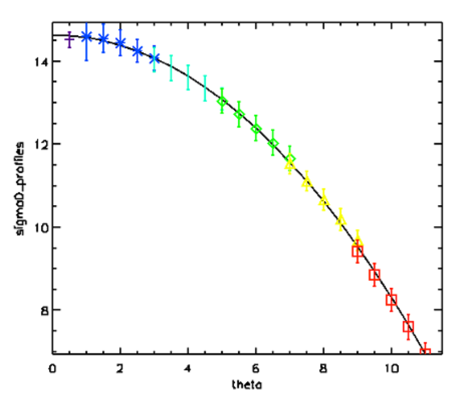
Products suitable to ice studies

▸ For ice studies, the following products will be available:

- SWIM L1a:
  - **σ^0 for each radar gate with associated geolocalisation**
  - **Nadir waveform**
- SWIM L2:
  - **Nadir wave form retracking outputs:**
    - ICE-NEW outputs on sea ice
    - ICE1 on continental surface
  - **σ0 profiles (averaged in elevation and azimuth)**
- SCAT L1b:
  - **HH and VV σ^0 averaged over cells of 50 x 50 km –tentatively 25 x 25 km)**

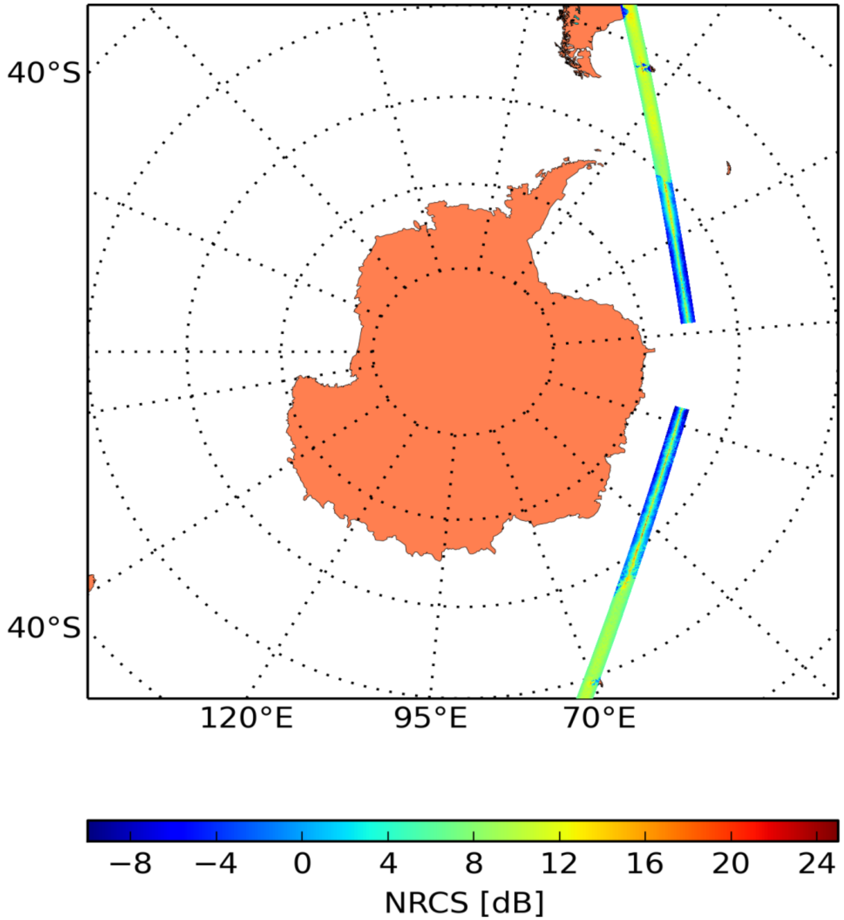


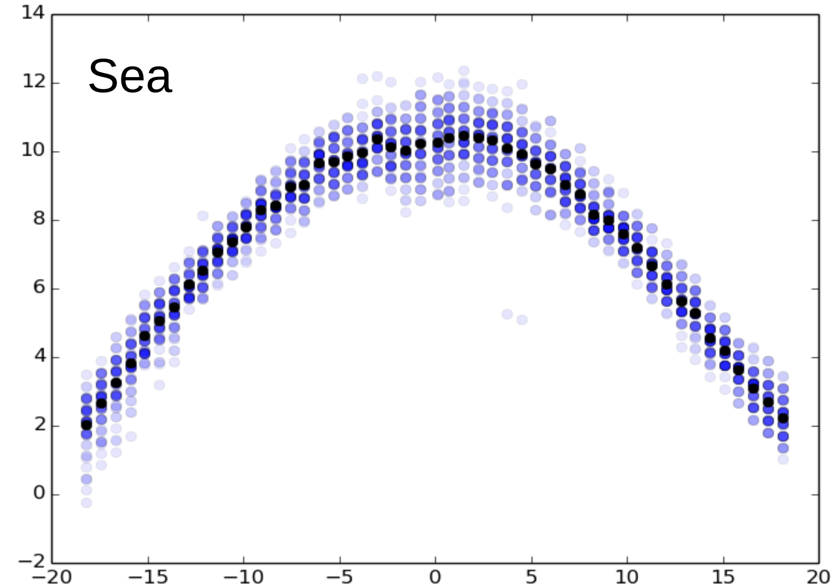
Examples of L1a σ^0 data over **sea** surface

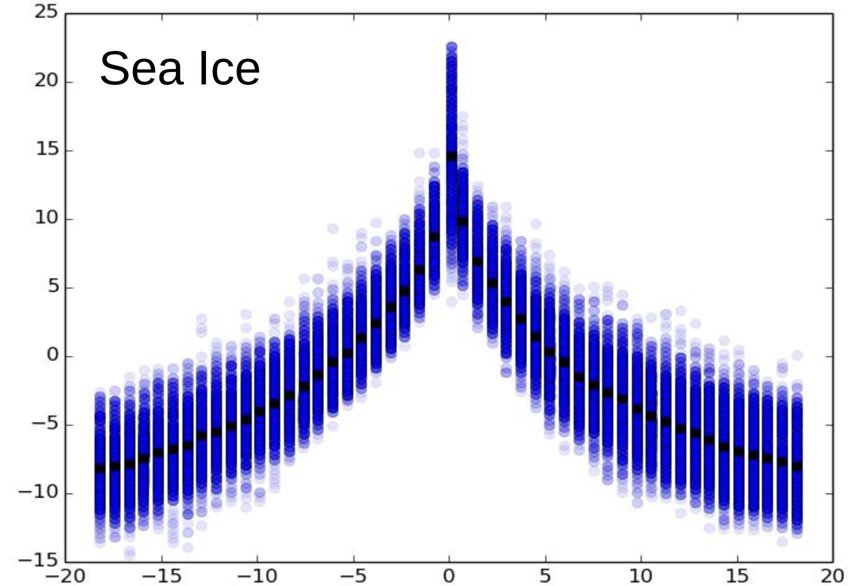


Examples of L2 data over **sea** surface

Example of GPM Acquisition over Sea Ice







NRCS fall-off over sea ice is faster than over seas

→ Strong specular contribution for sea ice. Less Roughness than over seas

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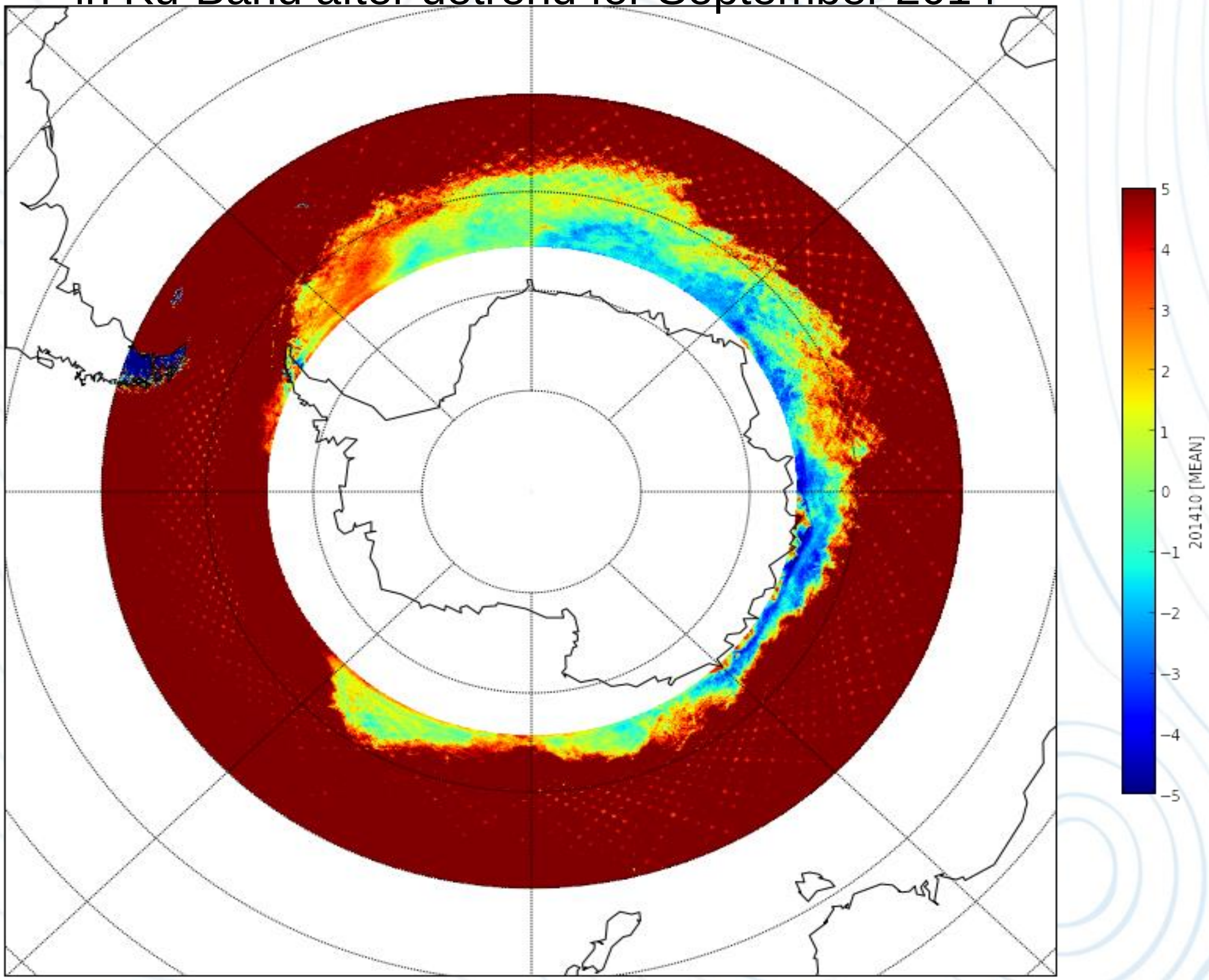
Analysis

Monthly map of averaged GPM NRCS as obtained in Ku-Band after detrend for September 2014



Both sea ice-extent and NRCS spatial variability are observed in Ku and Ka-Band (not shown) at low incidence angles

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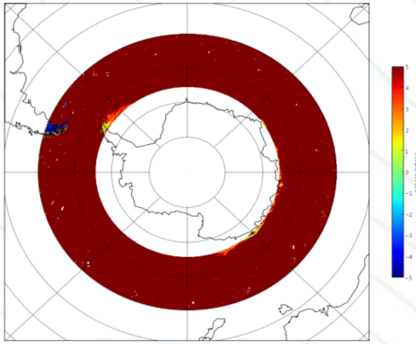
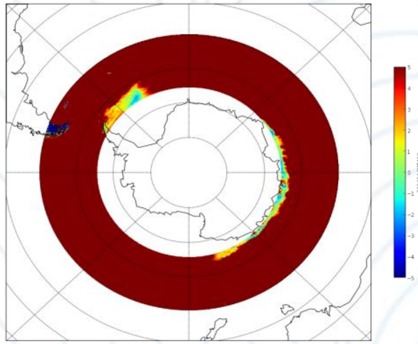
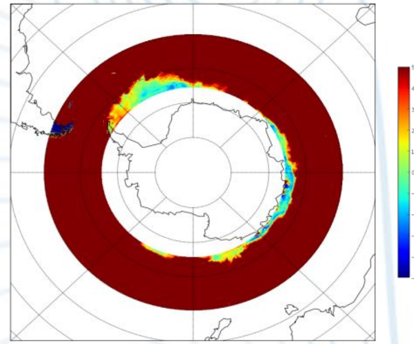
Analysis



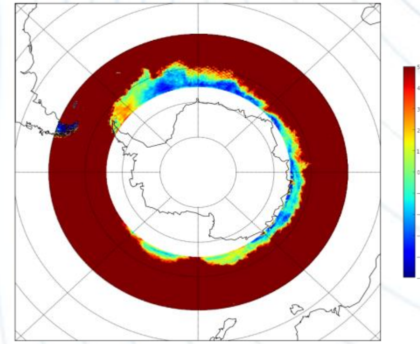
2014/03



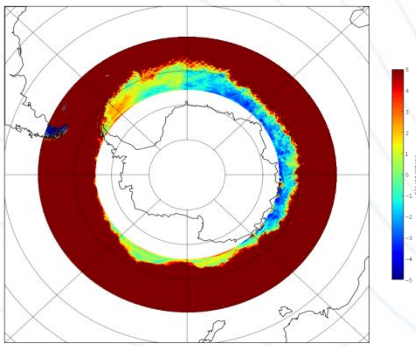
2014/04



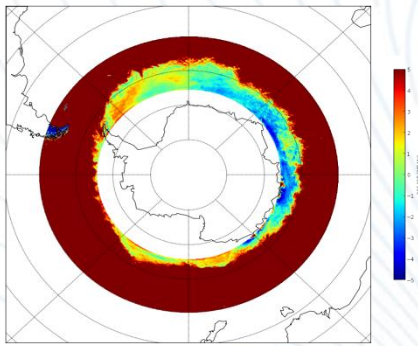
2014/05



2014/06



2014/07



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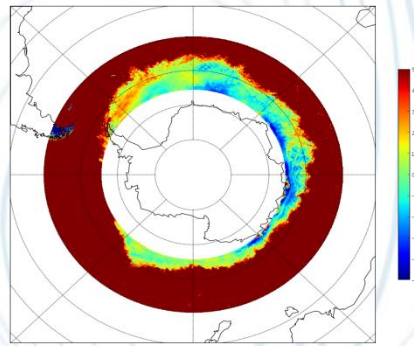
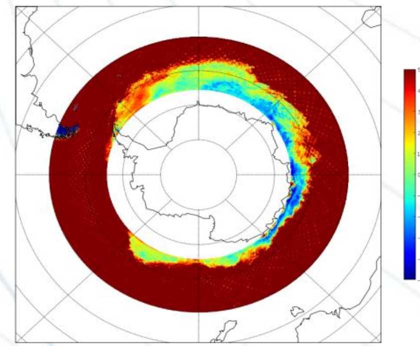
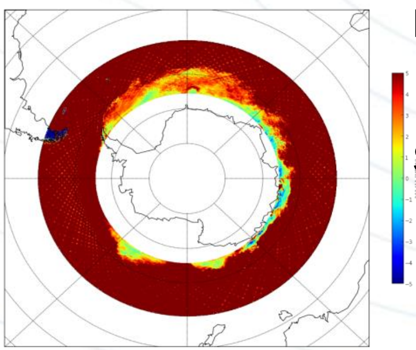


2014/09

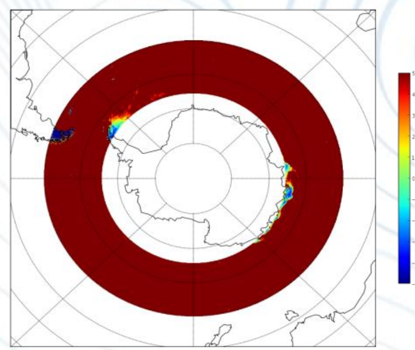


2014/10

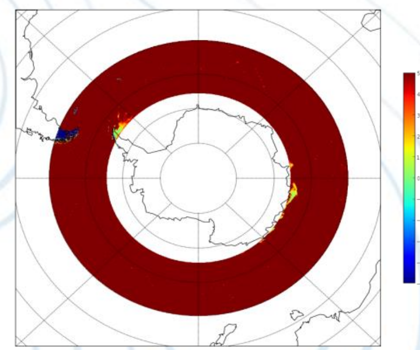


2014/11

- Ku-Band Band maps **along the year**
- Sea ice extent evolution and NRCS variability in space and time can be monitored with respect to time



2015/01



2015/02

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Some potential objectives in glaciology(1/2)

B. Legresy, F. Remy, M. Dechambre, F. Ardhuin, A. Mouche, D. Hauser

▸ **Sea ice**

CFOSAT: interesting **complement to other missions** (SCAT, in C and Ku, Microwave Radiometry, C-S-Ku-Ka Band altimetry)

→ diversity of incidence and azimuth (0-10 and 20-50°)

→ sigma0 at high resolution

- Better characterize ***sea-ice edge detection***
- Better characterize ***sea ice properties*** (age?, roughness- deformation, presence of snow over ice ?)
- Investigation on **sea ice deformation** due to underlying long waves travelling from the free ocean surface to the ice-covered region
- ***Ice thickness*** information from the evolution of the long ocean wave properties (dominant wave length) at the transition between open ocean and ice zone
- ***Interactions between waves and ice edge*** (breaking,…)

Some potential objectives in glaciology(2/2)

B. Legresy, F. Remy, M. Dechambre, F. Ardhuin, A. Mouche, D. Hauser

▸ **Polar Ice cap**

- Document ***anisotropy of ice sheet*** linked to catabic winds (diversity of azimuth angles)
- Better estimate ***penetration depth of the e.m. wavelength*** (TBC)
- Add new observations (in addition to radiometry and altimetry) to constrain electromagnetic models based on ***description of the snow cover*** (density, grains, roughness,..)

▸ **Icebergs**

- ***Detection in the signal*** (resolution cell of about 30 m x 20 km)?
- If yes, study of interaction with wind and wave fields,..

Participation of specialists in glaciology is welcome!!

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谢谢, Merci