

# ESA Snow Activities

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# Summary

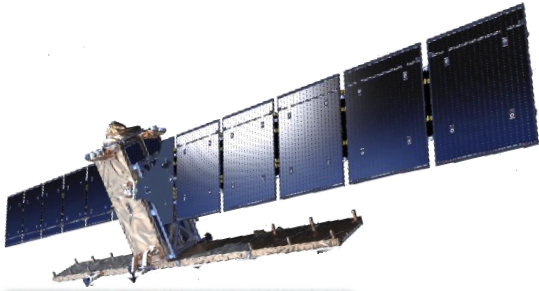


- Overview of ESA EO missions
- The Next High Priority Candidate Copernicus Sentinel missions
- ESA snow missions, campaigns and studies
- Living Planet Session
- ESA data campaigns archive





# Sentinels and the Cryosphere



## Sentinel-1

Sensor:

C-band SAR (5.405 GHz)

Modes:

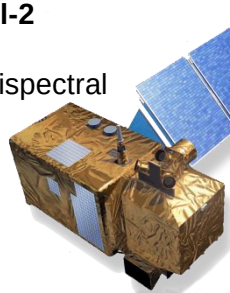
1. Interferometric wide-swath
2. Wave-mode
3. Strip map
4. Extra wide-swath



## Sentinel-2

Sensor:

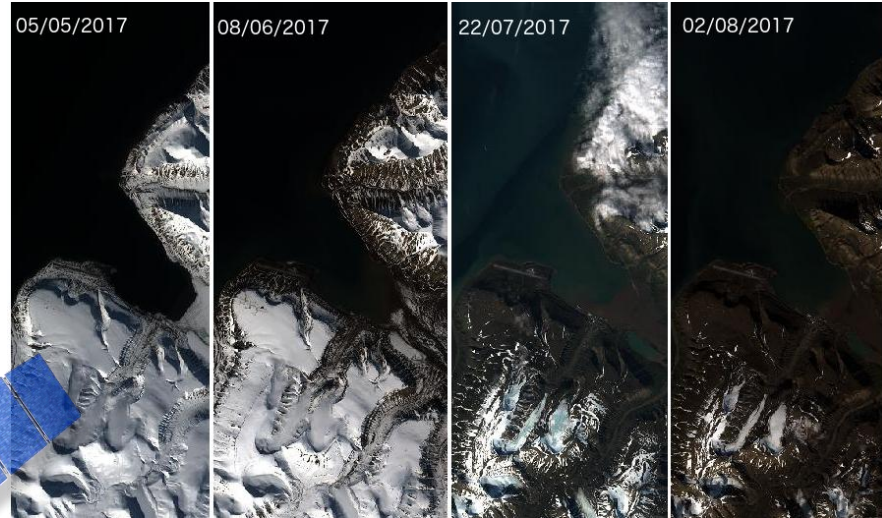
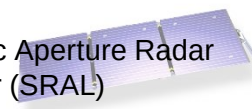
Multispectral



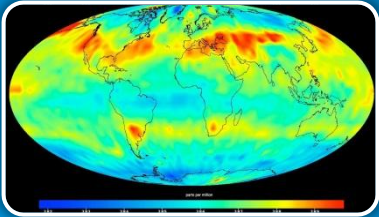
## Sentinel-3

Sensors:

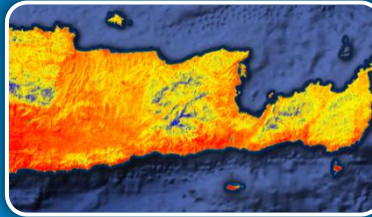
1. Ocean and Land Colour Instrument (OLCI)
2. Sea and Land Surface Temperature Radiometer (SLSTR)
3. Synthetic Aperture Radar Altimeter (SRAL)
4. Microwave Radiometer (MWR)



## 6 High Priority Candidate Missions



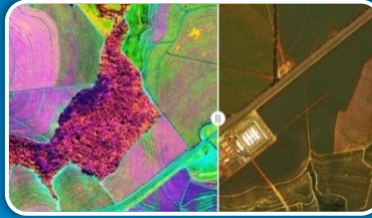
Anthropogenic CO<sub>2</sub>  
Imaging Spectrometer



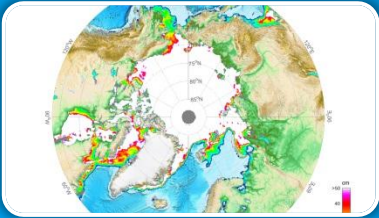
High Resolution  
Surface Temp.



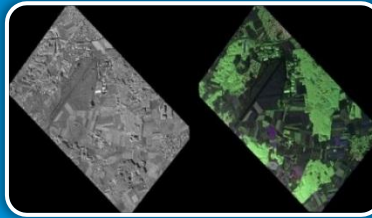
Polar Ice & Snow  
Topography



Hyperspectral Imaging



Passive Microwave  
Imaging



L-band  
SAR

# What do we want out of snow?

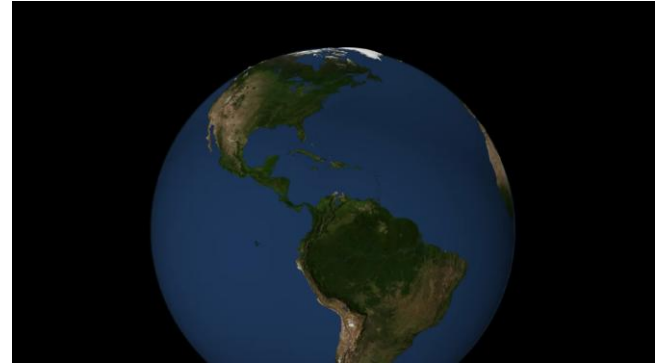
Snow parameter	ESA mission/ Copernicus Sentinels	ESA campaign(s)
Depth	CryoSat/SMOS/IceTopo/CIMR	DOMEX/CryoVex-KAREN/SnowLab/MOSAIC
Snow Water Equivalent	CoReH2O/Rose-L	NosRex/SnowLab/SnowSum
Surface Albedo	ERS-1/-2/Envisat/S-3	MOSAIC
Snow extent/fraction	S-2/S-3	
Accumulation (snowfall)	MetOp, EarthCare	DOMEX/SnowLab/SnowSum/MOSAIC
Snow melt extent (wet or dry)	MetOp/S-1/CIMR	
Snow/Ice Surface temperature	ERS-1/-2/Envisat/S-3	DOMEX/MOSAIC
Snow characterization		NosRex/SnowLab/MOSAIC

ESA U  Not selected  past  on-going  future

# Copernicus Polar Ice and Snow Topographic Mission

**Mission Objectives:** Addressing top priority parameters identified in the **Copernicus PEG I and II reports** and responding to the *Integrated EU Arctic Policy* this mission has the following objectives:

- PRIMARY**
  - To measure and monitor variability of Arctic and Southern Ocean sea-ice thickness and its **snow depth**.
  - To measure and monitor the surface elevation and changes therein of glaciers, ice caps and the Antarctic and Greenland ice sheets.
- Secondary**
  - To contribute to the observation of global ocean topography as a continuum up to the polar seas.
  - To support applications related to coastal and inland waters.
  - To support applications related to snow cover and permafrost.



**Mission Concept:** A) The satellite embarks a payload forming a complete measurement system, comprising of a **high spatial resolution Ku-band and Ka-band interferometric radar altimeter**, a laser retro-reflector array, a GNSS receiver **and a microwave radiometer**. B) The mission draws from the heritage experience of several in-orbit missions and from the on-going development of the Sentinel-6 and MetOp-SG programmes.

**Mission status and launch date:** Currently in Phase A/B1. Anticipated launch date is 2025.

# Copernicus L-band SAR mission (ROSE-L)

## Mission Objectives:

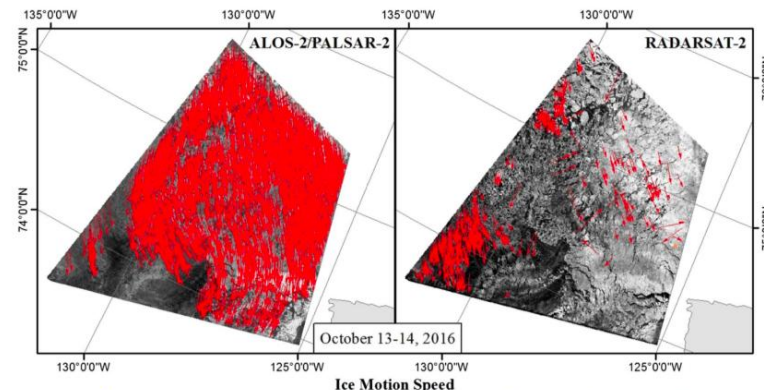
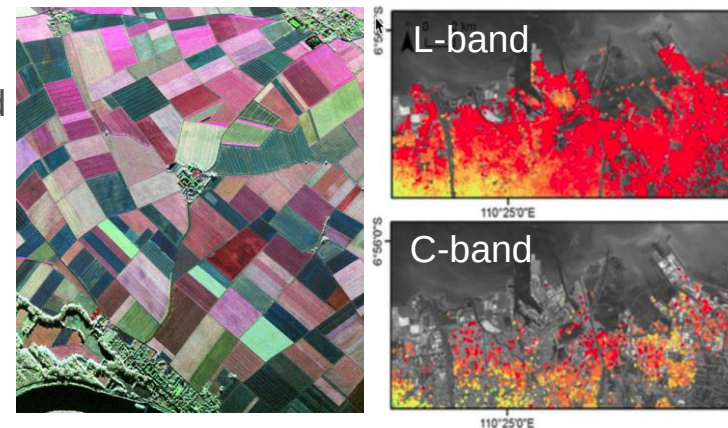
- New information for services in Disasters and Geohazards, Forests and Agriculture and high-resolution monitoring of Arctic and Cryosphere

## Mission Concept:

- L-band SAR payload (reflector or planar array) with high-resolution & high-duty cycle

## New information:

- Surface motion (vegetated areas, rapid subsidence)
- Forest biomass & forest change with time
- Land cover and agriculture
- Soil moisture at field scale
- **Snow water mass** (amount of water in snow pack)
- Hi-res sea ice type and velocity
- Hi-res land ice surface velocity
- Ship detection and maritime surveillance



# Copernicus Imaging Microwave Radiometer (CIMR)



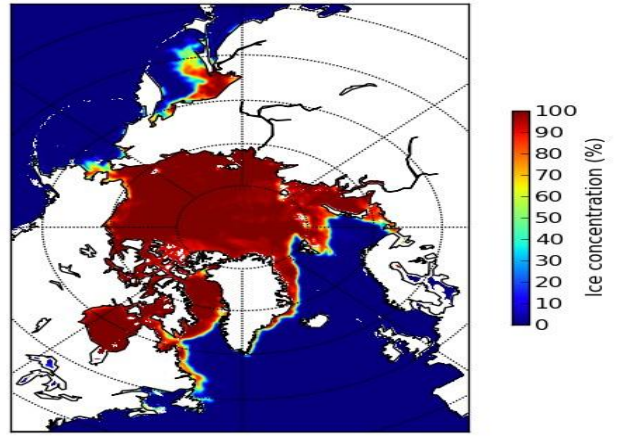
## Mission Objective

Respond's directly to the *Integrated EU Arctic Policy*

- Climate Change and Safeguarding the Arctic
- Environment Sustainable Development in and around the Arctic
- International Cooperation on Arctic Issues

## Characteristics

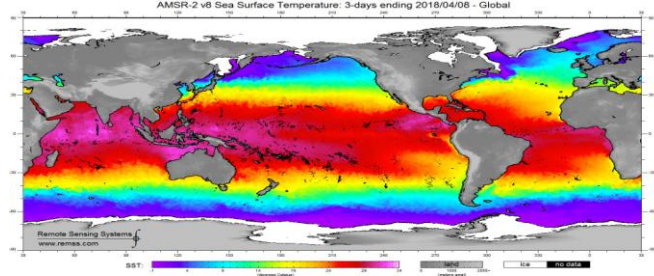
- Conically scanning Multifrequency Microwave radiometer
- Loose convoy flight with MetOp-SG(B)
- Single satellite
- 99% global coverage every day, mean 6 hourly -revisit in Arctic Areas
- In Phase A/B1, Launch: 2025



## Products

- Sea Ice Concentration
- Sea Surface Temperature
- Thin Sea Ice Thickness
- Sea Ice Drift
- Ice Type
- Sea Surface Salinity Extreme
- Wind

**Support to CEOS**  
Direct Response to SST-VC Sustains AMSR2 type capability  
Prevents gap in MW capability @~7GHz Sustains SMAP/SMOS capability Integrate and enhance performance of Sentinel-1 and Sentinel-3 in high latitudes



Additional land products (eg. soil moisture, precipitation..)

ESA UNCLASSIFIED - For Official Use



# Snowlab: A multi-frequency/-polarisation/-annual microwave and in-situ snow dataset



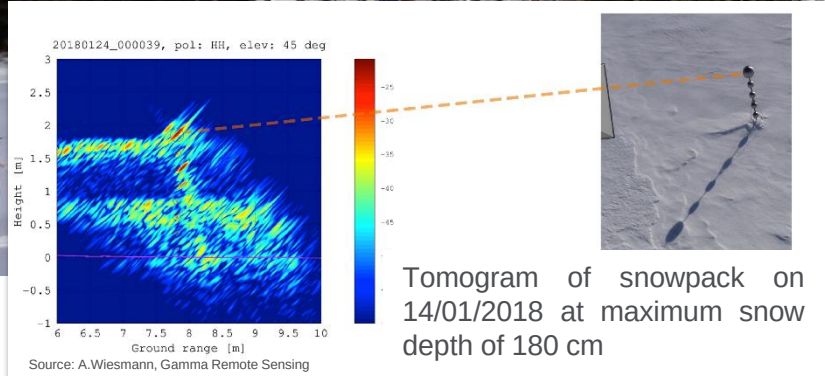
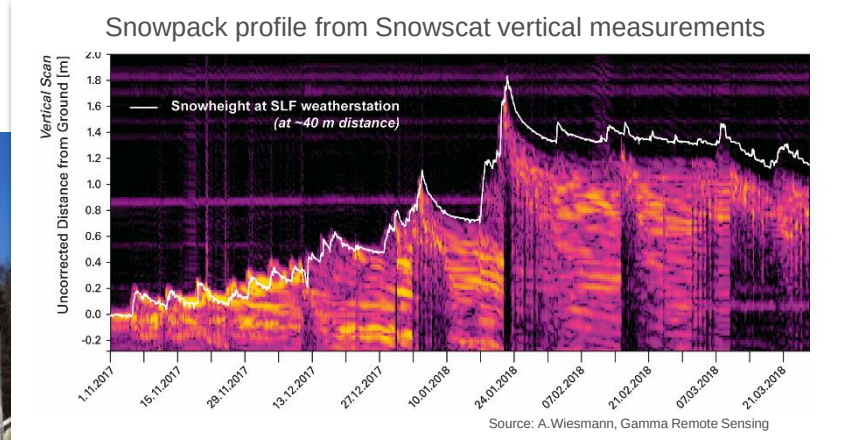
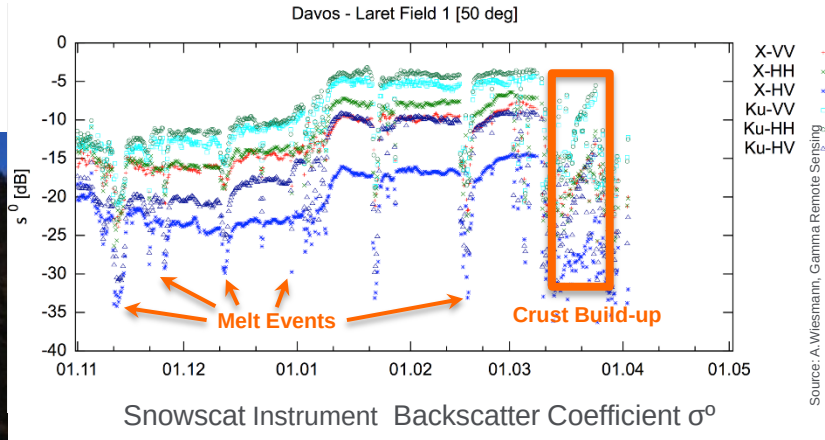
## Objectives:

- Multi-frequency, -polarisation, -temporal dataset of active and passive microwave measurements over snow
- Relation of snow/ground parameters with  $\mu$ -wave Radar
- Three measurement winters:
  - 2015/16: Gerstenegg, CH
  - 2016/17, 2017/18: Laret/Davos, CH
  - 2018/19 currently under preparation: Laret/Davos, CH

## Instrumentation and datasets

- SnowScat
  - Nominal Mode & Tomographic Mode
- Snow Characterisation
  - Micro CT, Snow Profiles and Snow Micro Pen
- Meteorological Data
- Photographic Documentation (several webcams)
- DEM (including stereographic DEM generated from UAV images)
- ELBARA (L-Band radiometer) measurements





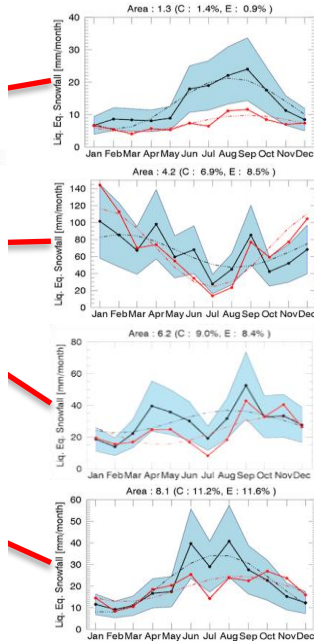
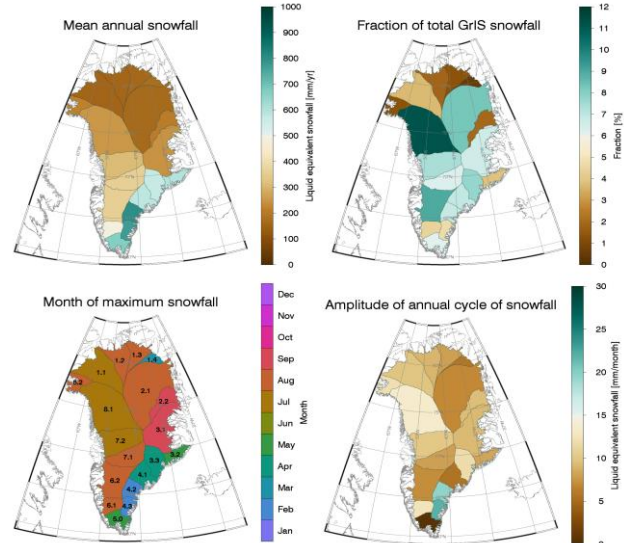
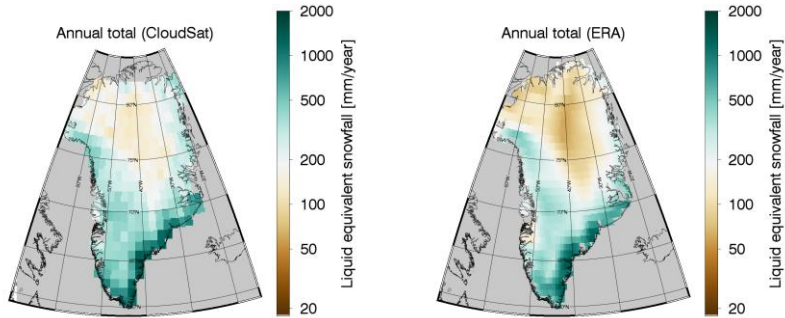
Weekly profiles:

- Snow  $\mu$ -pen
- Snow Density
- Snow Temp.
- IceCube (SSA)
- Total SWE

Micro CT probe

Source: A. Wiesmann, Gamma Remote Sensing

- Evaluate various ground-based datasets for use as reference for snowfall observations over the GrIS
- Evaluate and validate CloudSat observations
- Create climatology of snowfall over GrIS from 10 years of CloudSat
- Comparison with ERA-Interim reanalysis
- Issues and recommendations going forward



# Cryosat/Altika/IceSat-2 validation:CryoVex/KAREN Spring 2019

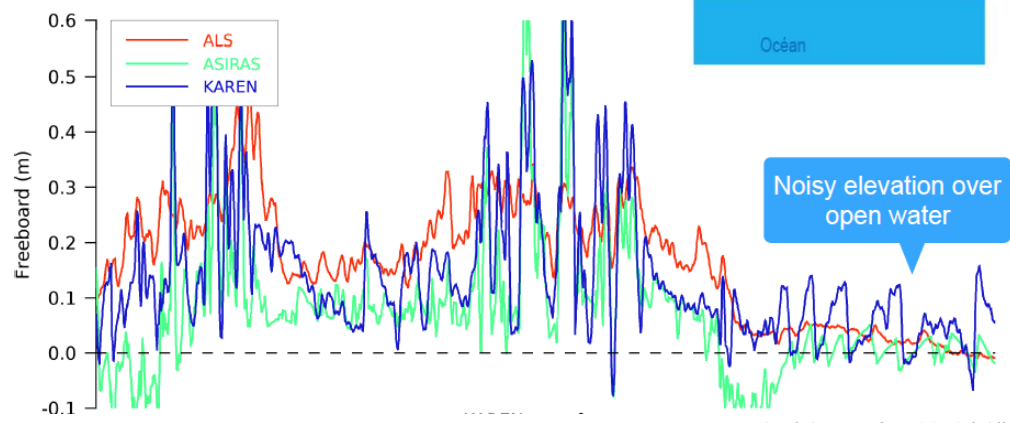
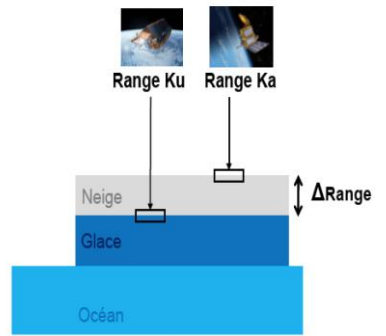
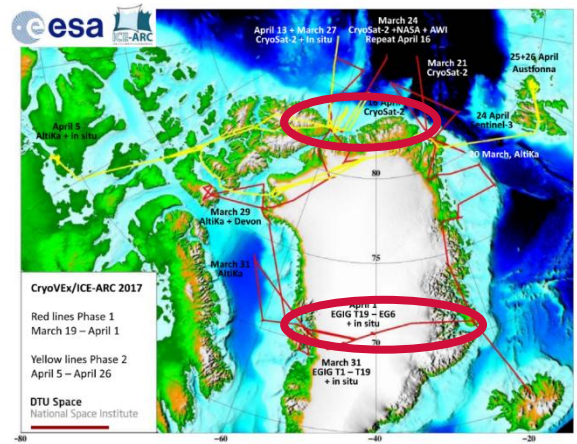
Sea-ice campaign in the Arctic for ICESat-2 validation

**Payload:**

- ASIRAS (Ku-Band altimeter)
- KAREN (Ka-Band altimeter)
- ALS
- Nadir imagery
- Green laser (not certain yet...)

**Setup:**

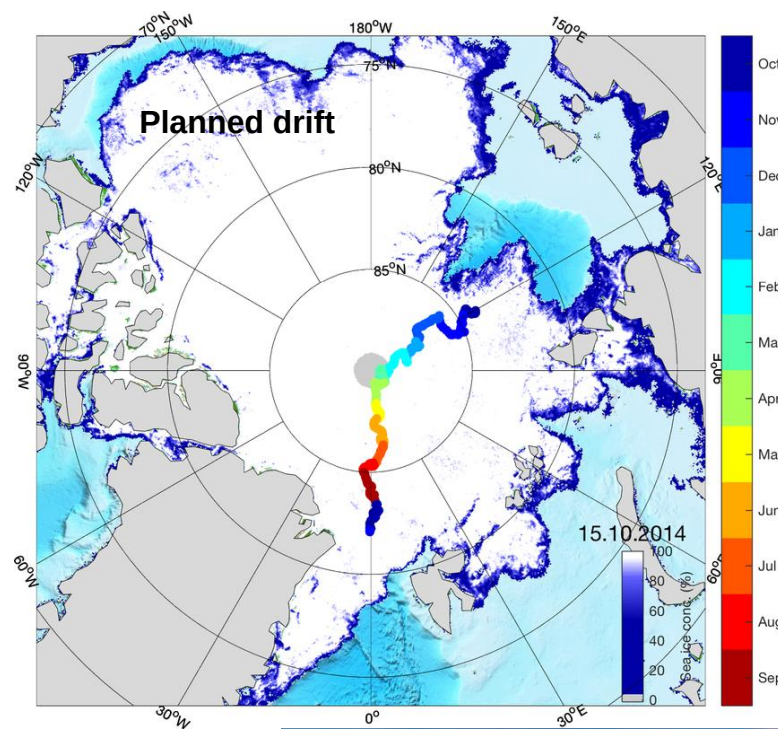
- Sea-ice airborne measurements and EGIG line for continuity (no expected ground measurements)
- Timeframe: April 2019



# MOSAIC



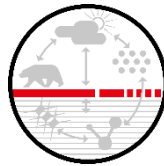
- German research icebreaker Polarstern will depart from Tromsø, Norway in Sept 2019 and spend one year drifting through the Arctic Ocean, trapped in the sea-ice
- A full annual cycle of sea-ice, atmosphere and ocean measurements
- A total of 600 people from 17 countries will participate in the expedition



# MOSAIC Remote Sensing Research Questions



- How well do satellite algorithms perform in the Central Arctic for parameters such as sea ice thickness distribution, **snow depth**, ice type, floe sizes, ice concentration, and ice drift and deformation?
- Can co-located ground-based sea ice/**snow**, optical and microwave measurements help to develop improved satellite retrieval methods for ice area, thickness, melt pond parameters, albedo and **snow** depth?
- Can satellite observations be used to upscale detailed regional information to pan-Arctic domains?



# MOSAIC ESA endorsed projects



1. Support to the 3 scatterometers (L/C/Ku) for snow and ice in collaboration with University of Waterloo, Victoria and Calgary. Proposal from G. Spreen.
2. Procurement and operations of new Ku-Ka ground radar for snow and ice vertical profiles. Proposal R. Ricker
3. Support of an L-band radiometer (EMIRAD) & or ELBARA-III for snow and sea-ice concentration. Proposal from L. Kaleschke
4. Funding of one scientist for 2 months operations (1 leg) on-board PolarStern
5. CryoVEX/KAREN flights in Spring 2020

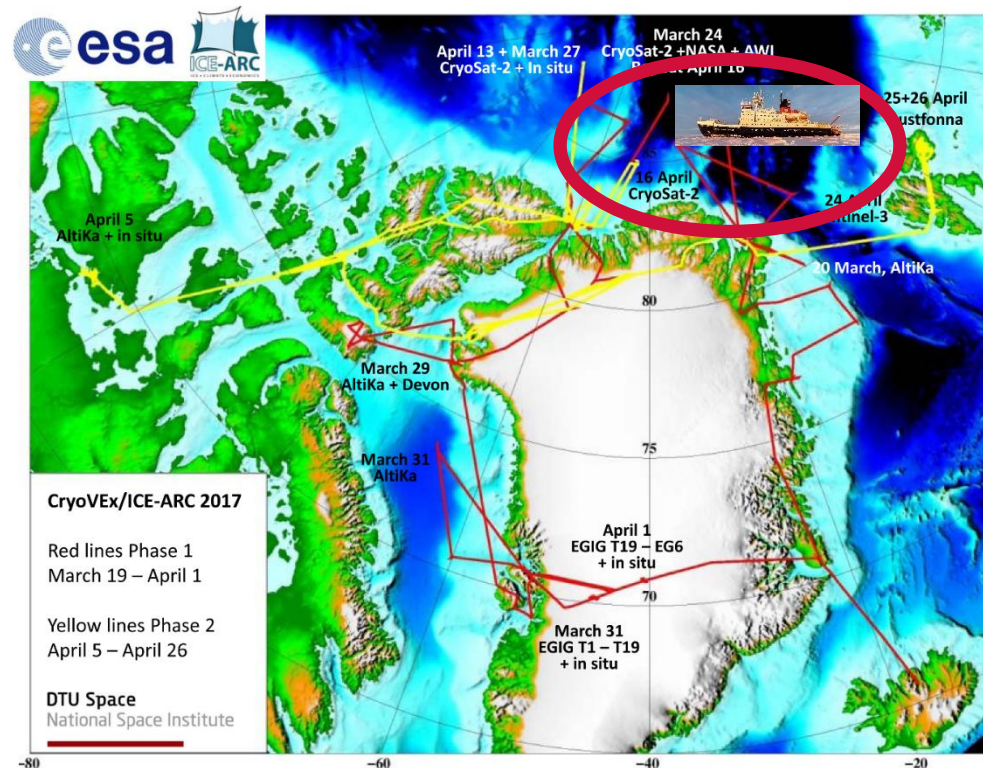


# CryoVex/KAREN 2020 during MOSAIC

Overflights of the Polarstern in Mar/Apr 2020

Payload:

- ASIRAS (Ku-Band altimeter)
- KAREN (Ka-Band altimeter)
- ALS
- Nadir imagery
- Coincident flights for ice thickness (EM-bird)/snow radar (TBD)



- Microstructural origin of electromagnetic signatures in remote sensing of snow  
(Initially 18 months but extending to snow on sea ice at L-band)
- Satellite Snow Product Intercomparison and Evaluation Experiment (SnowPex)  
(Finishing but looking at an SnowPex-II)
- SnowSAR campaign data analysis study (SCADAS) (On-going)
- SnowConcepts (Recently finished)
- Sentinel-3 for Science (S34SCI): Snow albedo (On-going)

# Snow and Ice in ESA's Climate Change Initiative



Since 2010 CCI has been working on cryosphere ECVs (Essential Climate Variables):

- **Sea Ice**
- **Glaciers**
- **Ice Sheets (Greenland and Antarctica)**

CCI+ (2018-2024) will continue R&D on Sea Ice, Glaciers and Ice Sheets ECVs.

ESA is planning to initiate work on new ECVs, potentially including:

- **Snow**
- **Lakes (including lake ice)**
- **Permafrost**

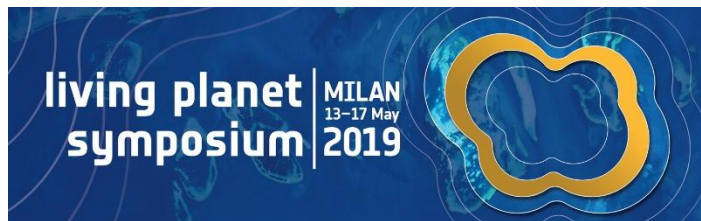
Contract finalised for Snow and Permafrost, negotiations ongoing for Lakes

All ECV data products are freely available from the CCI Open Data Portal ([cci.esa.int](https://cci.esa.int))



- ESA supports the scientific community through studies and campaigns
- Significant advances made in understanding snow-microwave interactions
- Scientific studies will in general also feed back into mission development:  
Further experimental data collections and (SnowSAR and other campaign) data analysis needed to define and consolidate future snow mission concepts
- 'Snow research' is highly relevant in view of ESA's EO strategy:  
Addresses scientific questions and challenges with a direct bearing on societal issues

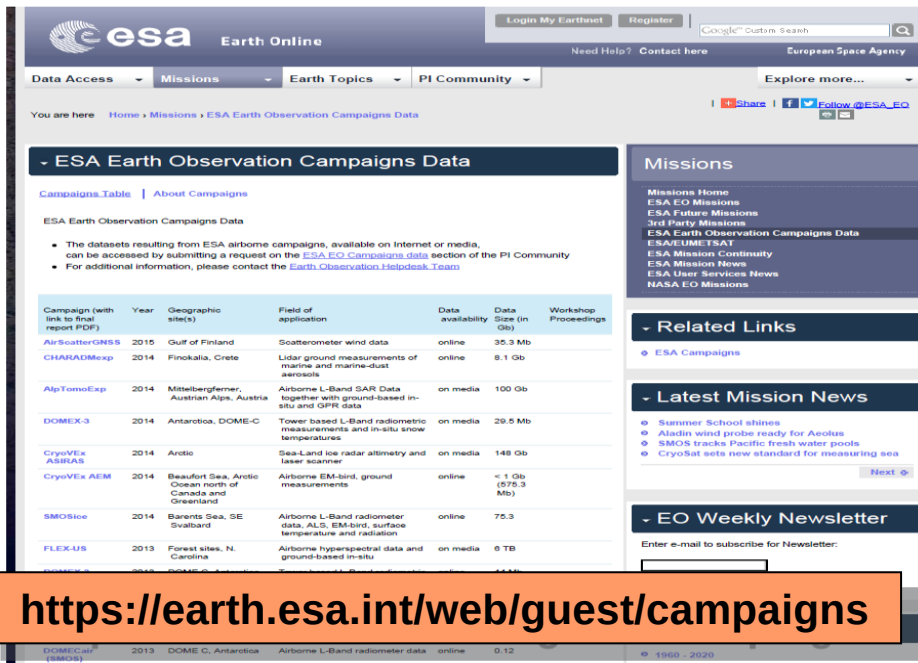
International cooperation, coordination is key to mature science and development and satellite technology needed for a (potential) future snow mission.



## B6.06 Exploring new ways of measuring the changing Arctic and Antarctic with airborne campaigns

### Access to ESA Campaign Data

1. ESA campaign data available to interested PIs
  - a. Formatted and documented datasets
  - b. Data Inventory
  - c. Final report with full description of campaign activity and analyses
2. Final report accessible directly through web
3. Access to datasets provided through Category 1 mechanism (short proposal incl. identification of desired datasets)
4. Currently **72** campaign datasets available



<https://earth.esa.int/web/guest/campaigns>

A photograph of plants covered in white frost, with a red car visible in the blurred background.

**Thank you!**