DLR

esa

living planet symposium | BONN 23–27 May 2022

TAKING THE PULSE OF OUR PLANET FROM SPACE

EUMETSAT ECMWF EUSPA

CryoSat: Calibration and Validation activities throughout 12 years of outstanding performance

Laura Fioretti and Andrea Recchia, Aresys
laura.fioretti@aresys.it

Tânia G.D. Casal (ESA)
tania.casal@esa.int

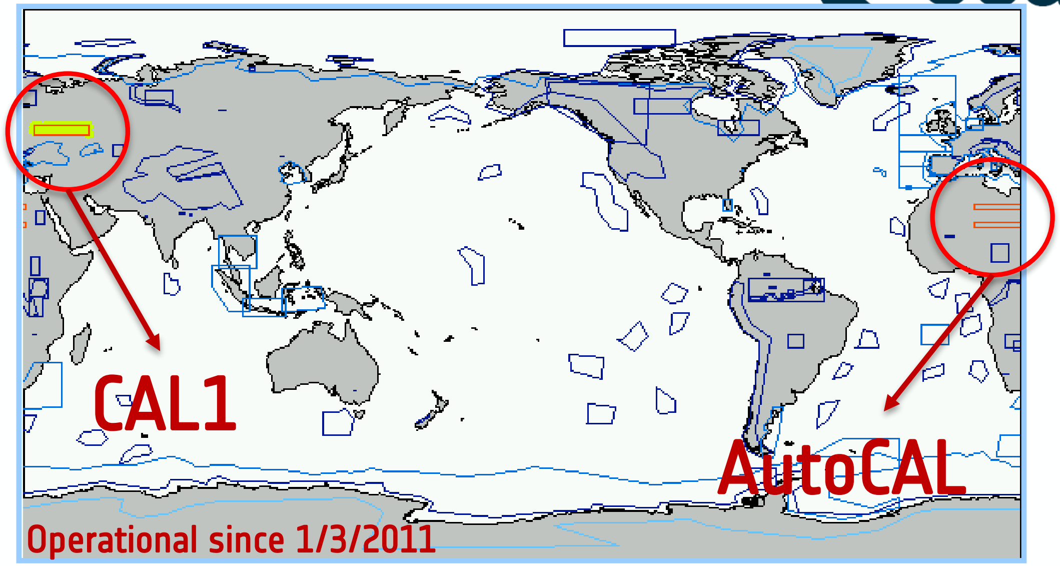
CryoSat: 12 years in space of ESA's ice mission

23 May, 2022

Calibration Activities

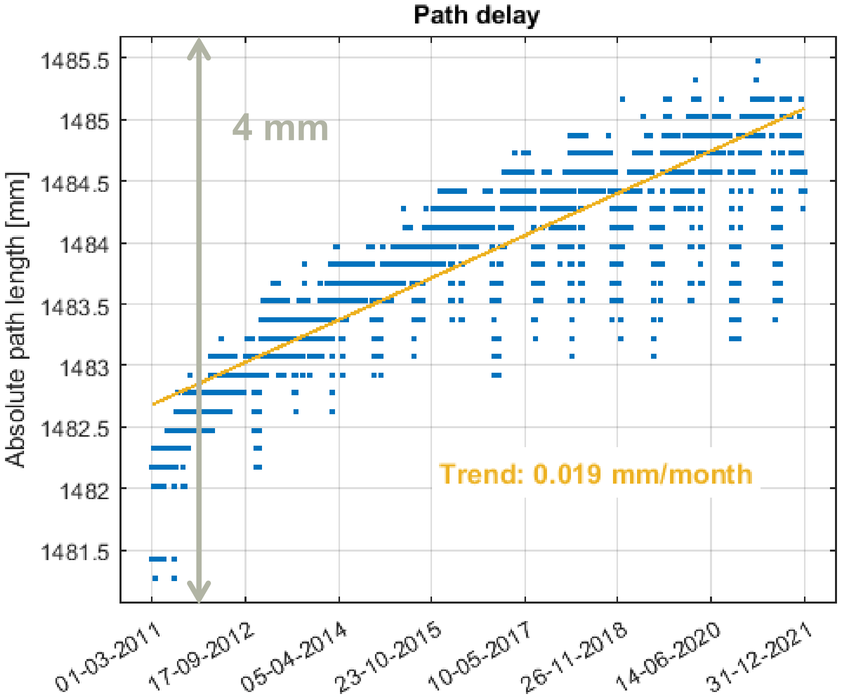
Calibration Overview

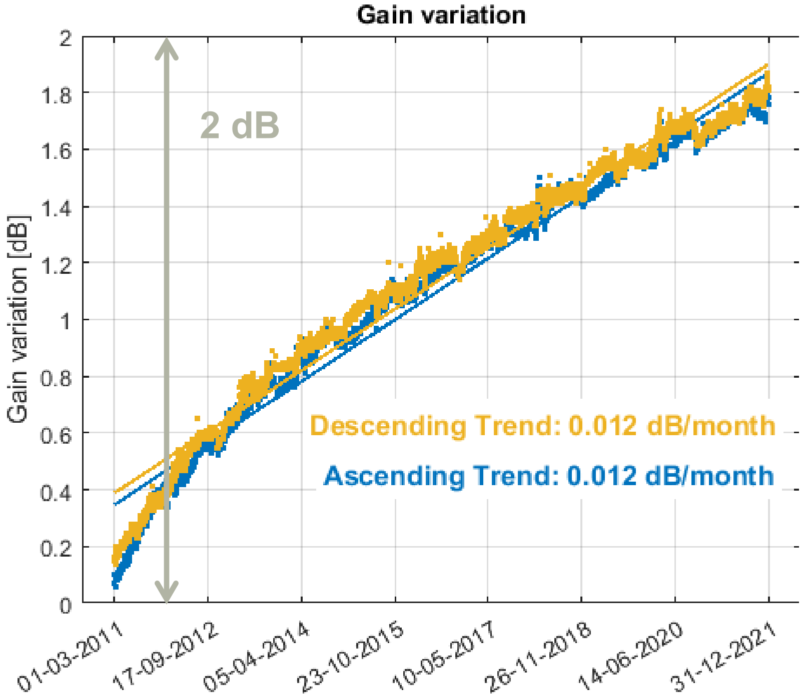
- Aresys is in charge of monitoring Level1b calibrations corrections since 2011.
- Calibration parameters are used by the science processors and thus require monitoring
- The following quality parameters are also monitored:
  - → CAL1 PSLR (peak to side lobe ratio)
  - → CAL1 main lobe -3dB width

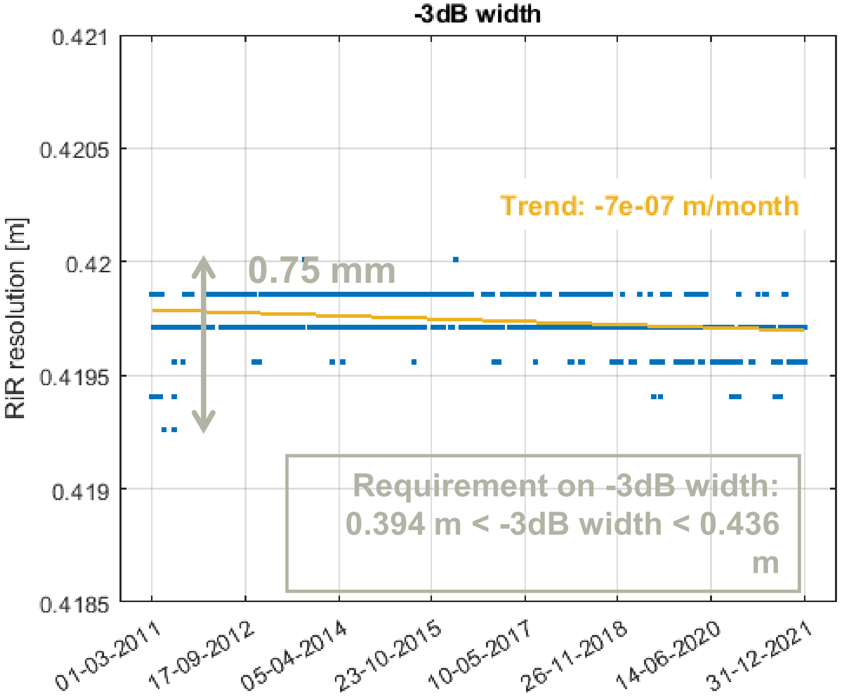


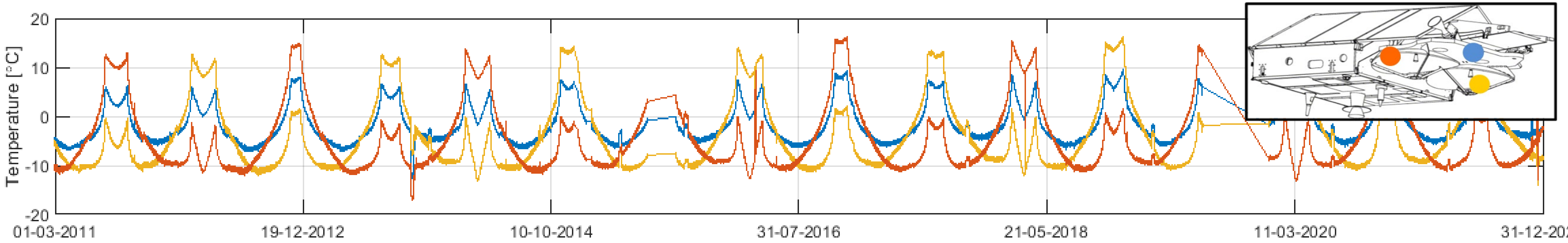
Calibration	Correction	SIRAL Mode	Strategy	Frequency
CAL1	Gain variation and path delay	LRM/SAR/SARIn	Based on zone: over Asia	1-2/day
	Pulse-to-pulse amplitude and phase corrections	SAR/SARIn		
CAL2	LPF correction mask	SAR/SARIn	Based on frequency	2/month
AutoCAL	Gain for each AGC setting	SAR/SARIn	Based on zone: over Sahara	1-2/day
	Phase difference for each AGC setting	SARIn		
CAL4	Phase difference	SARIn	Based on frequency	1/second
ADC	Autocal ADC phase difference corrections	SARIn	Based on frequency	1/month

Internal Calibration – CAL1 SAR

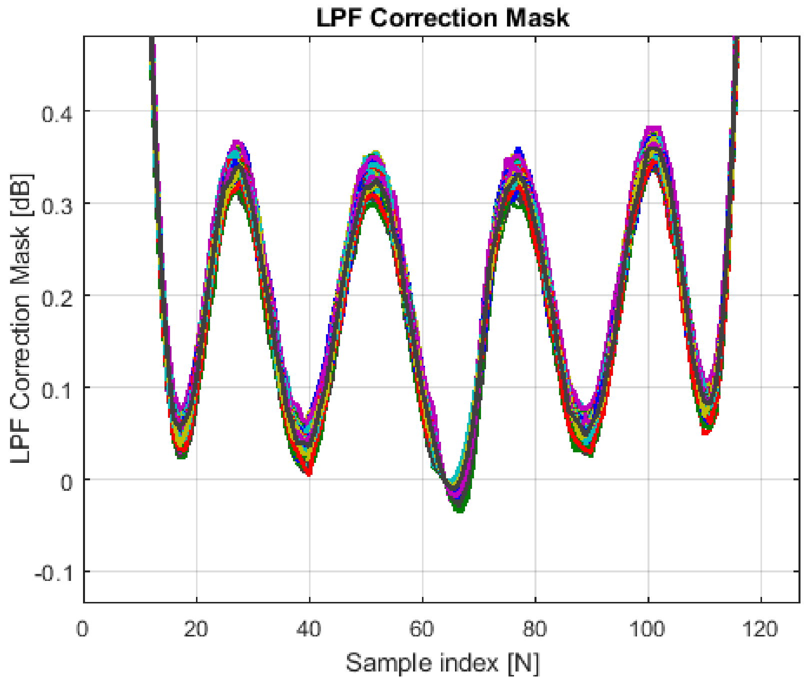


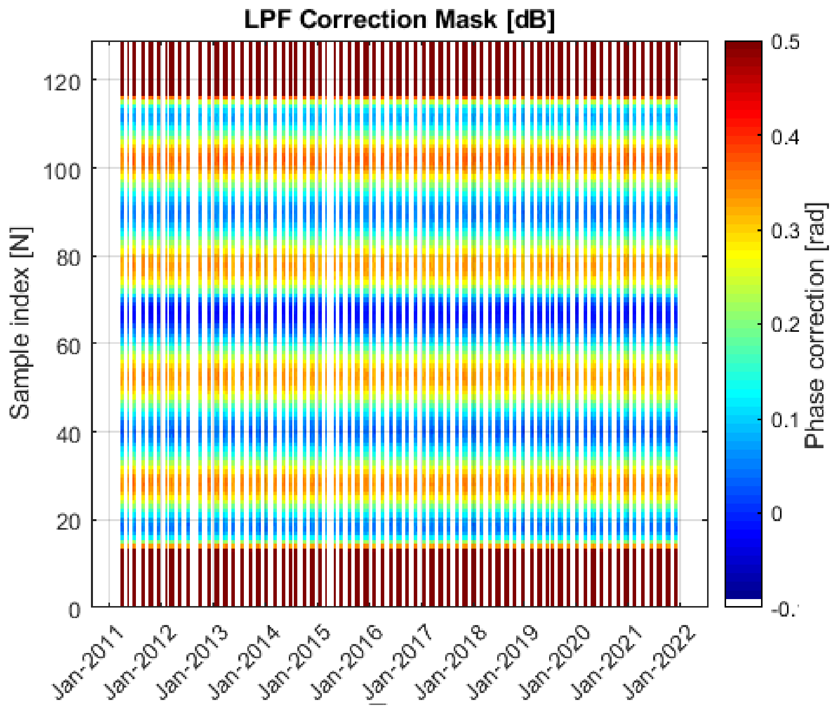


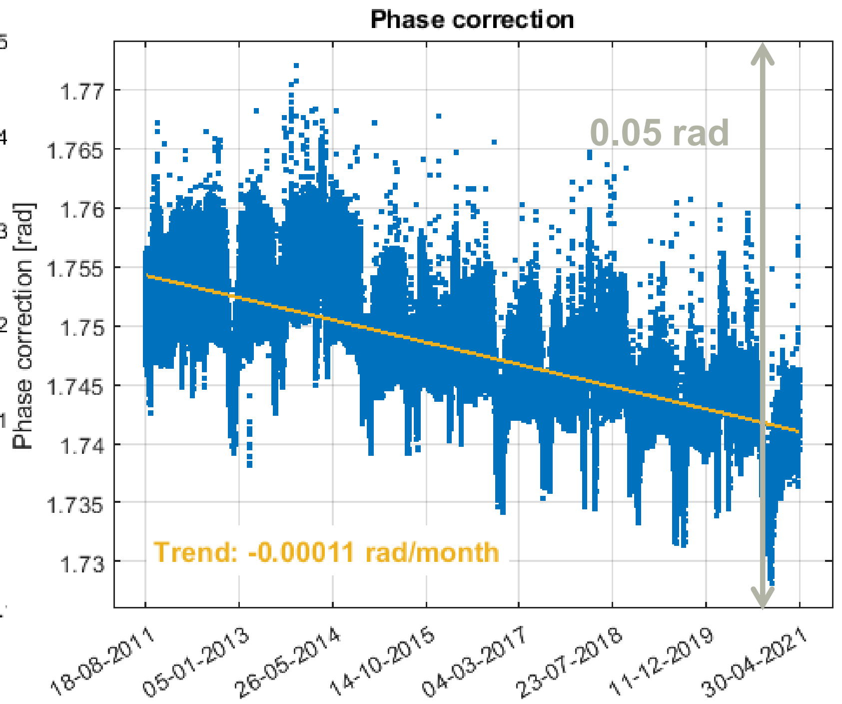


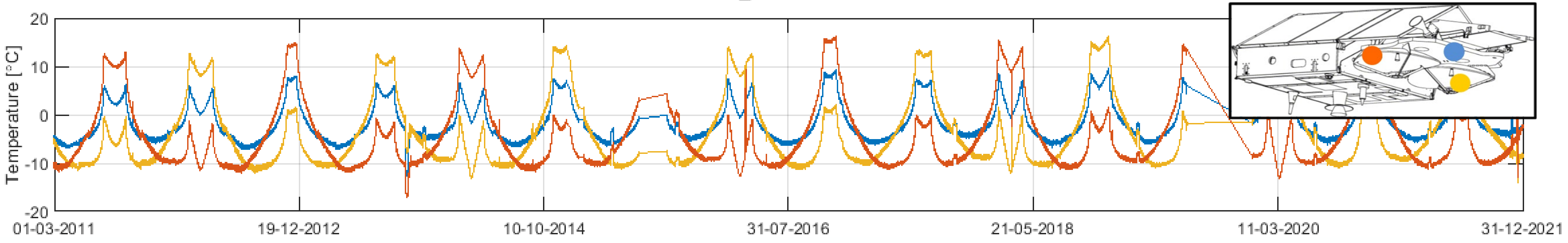


Internal Calibration – CAL2 SAR & CAL4 SARIn



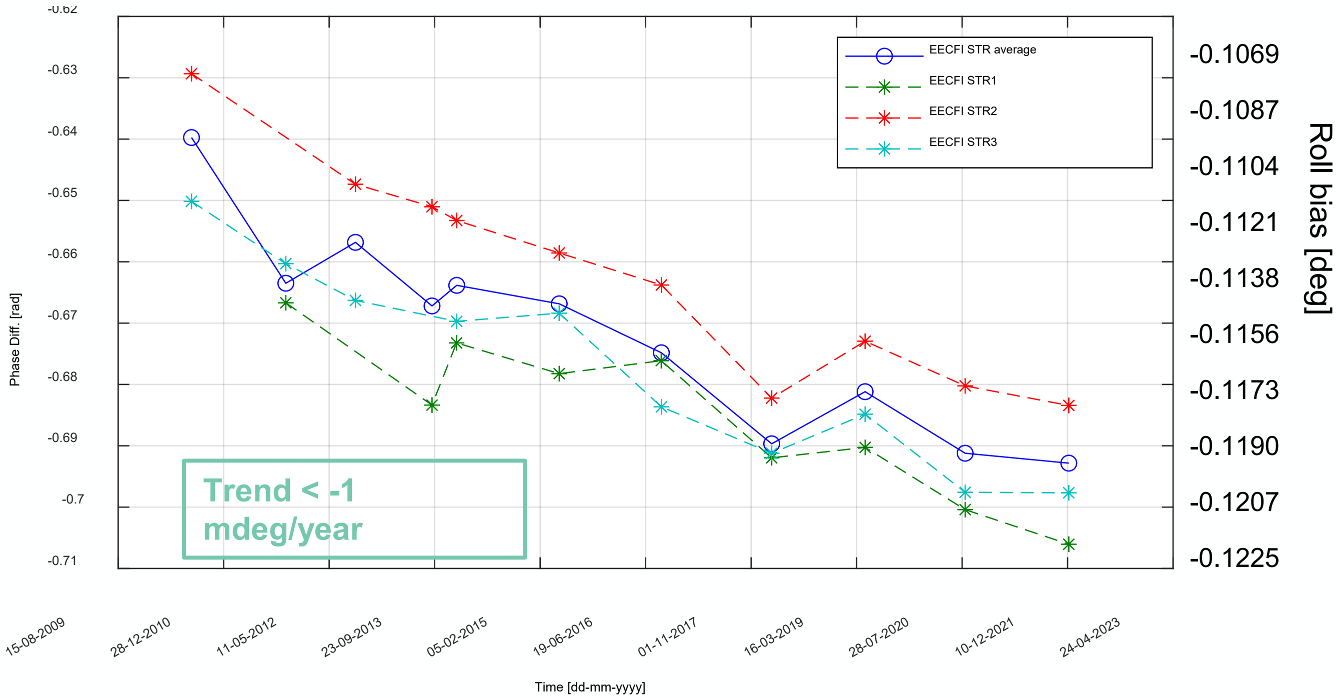


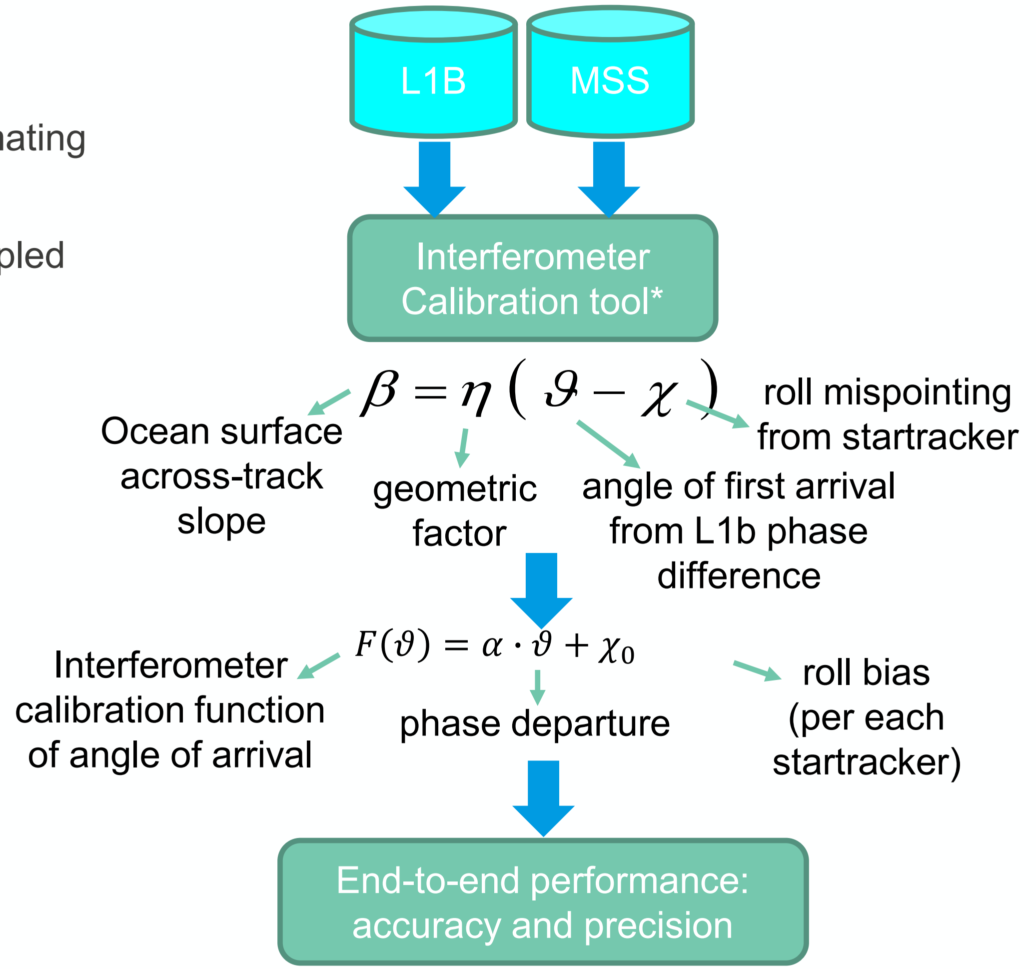




End-to-end Calibration of CryoSat Interferometer

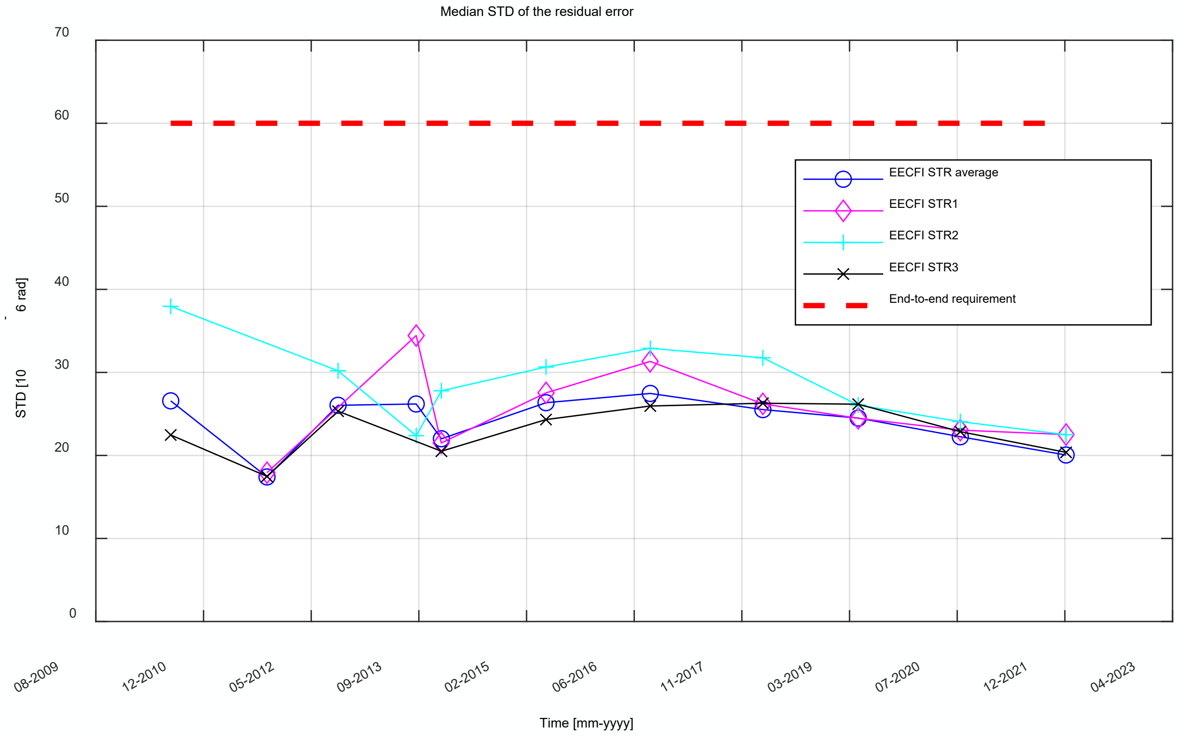
- Dedicated ocean roll campaigns every 16 months
- Ocean surface across-track slope derived from L1B products exploited for estimating error on angle of arrival and calibration function
- For each STR, the roll bias has been approximated with a linear fitting and sampled every 6 months due to its slow variation in time

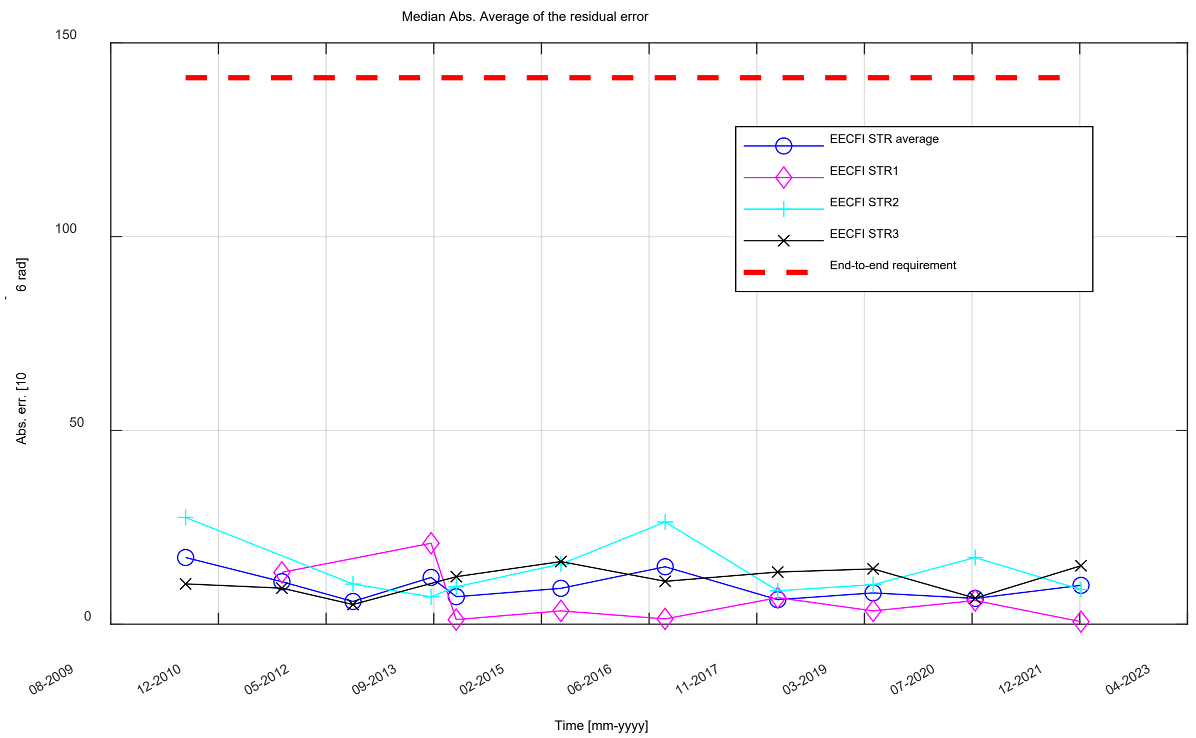




**The CryoSat interferometer: End-to-end calibration and achievable performance*, Michele Scagliola, Marco Fornari, Jerome Bouffard, Tommaso Parrinello, 2017

End-to-end Calibration of CryoSat Interferometer





- The CryoSat interferometer performance can be evaluated on the Angle of Arrival residual error after the application of the phase correction
- The end-to-end performance, in terms of accuracy and precision, is stable and below the requirements

Validation Activities

CryoVex Heritage (2002-present -> 20 years of campaigns!)

2002

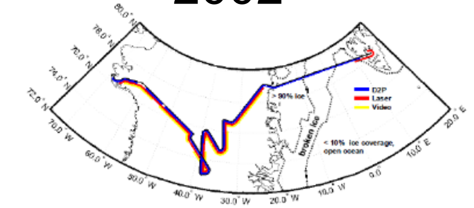
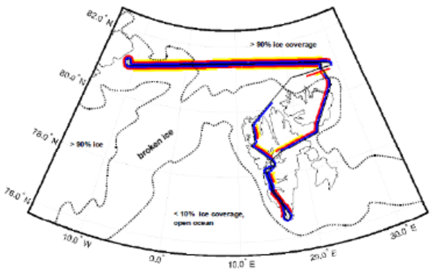
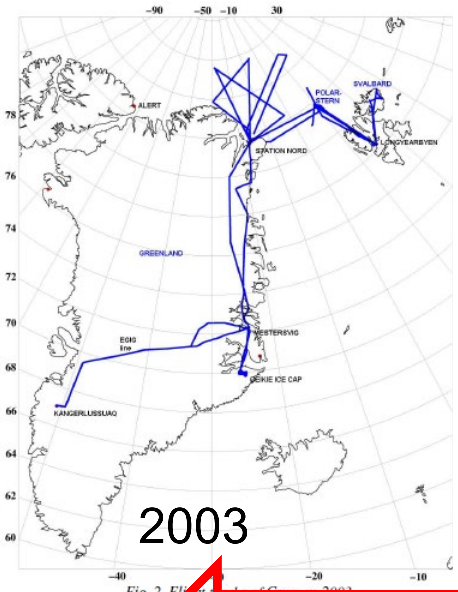
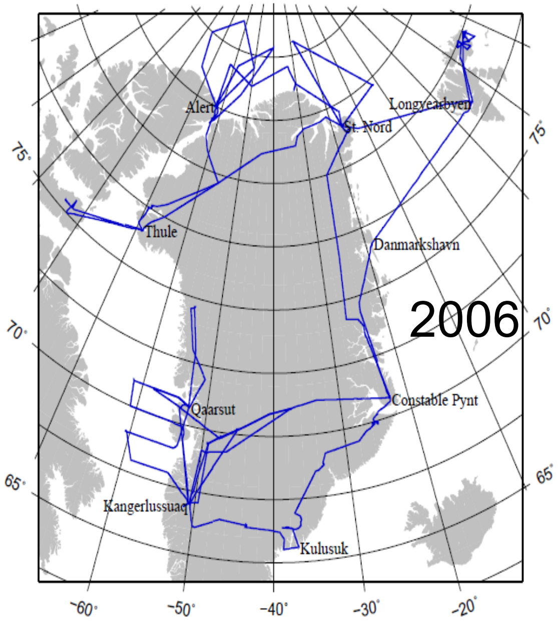


Figure 3a. May 18, 2002: Transit from Thule to Svalbard.





2003



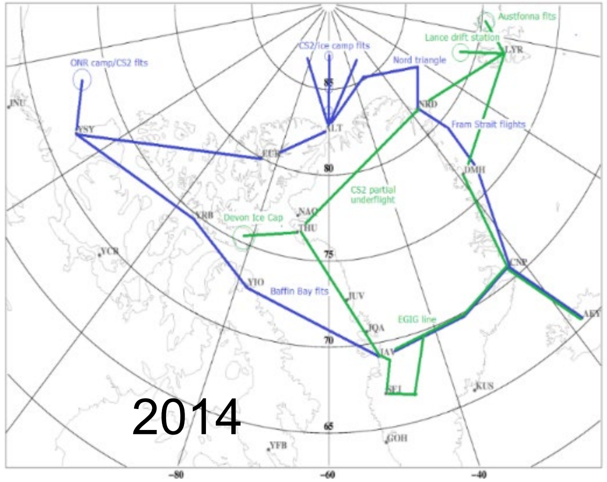
2006

2011

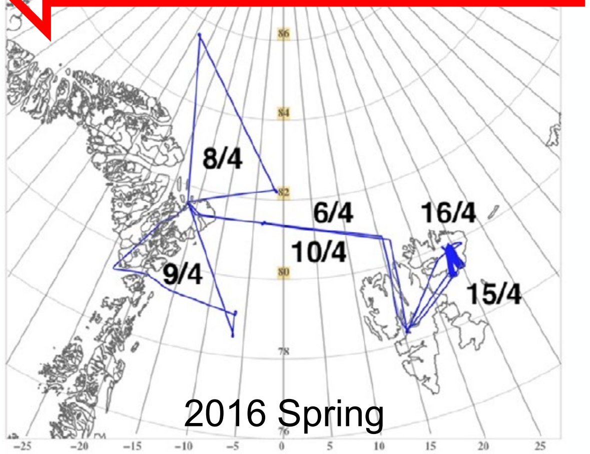
2012

Ku & laser

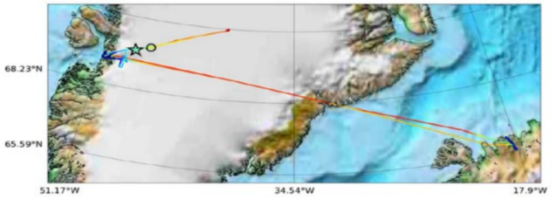
With Ka-Band



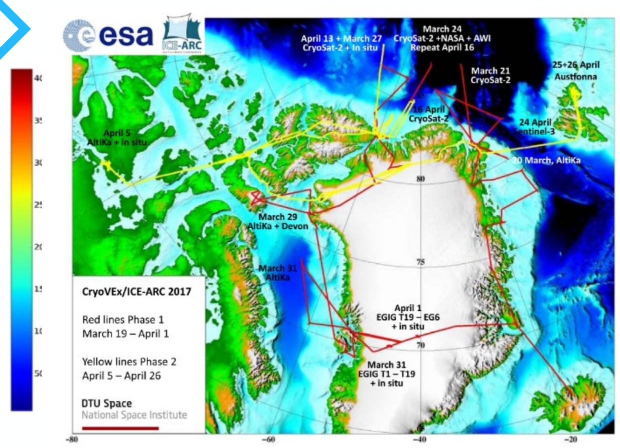
2014



2016 Spring



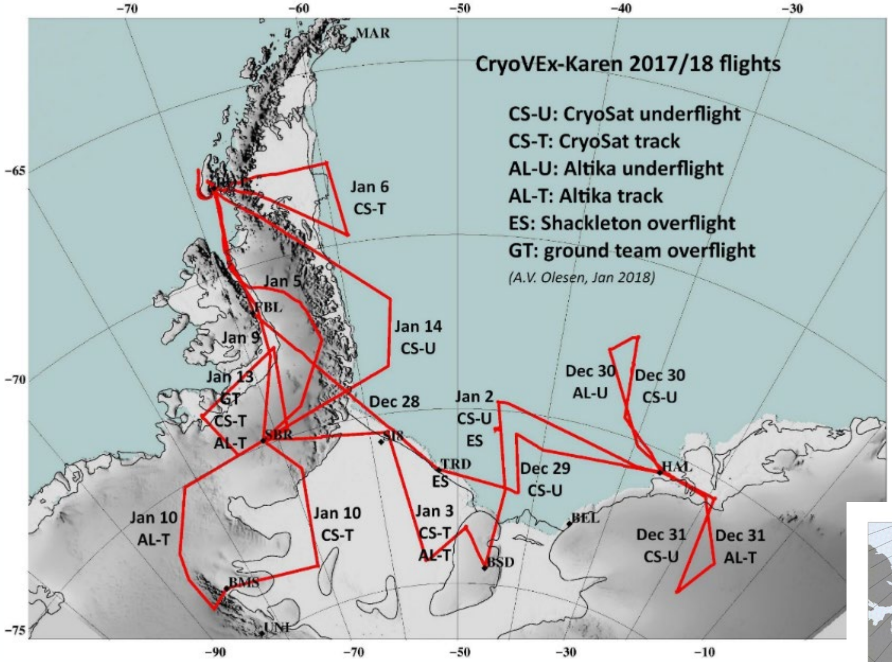
2016 Fall



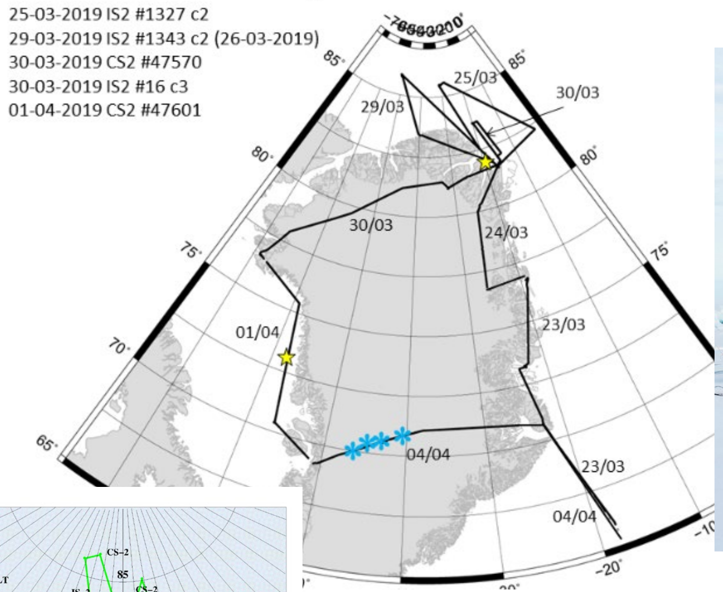
2017

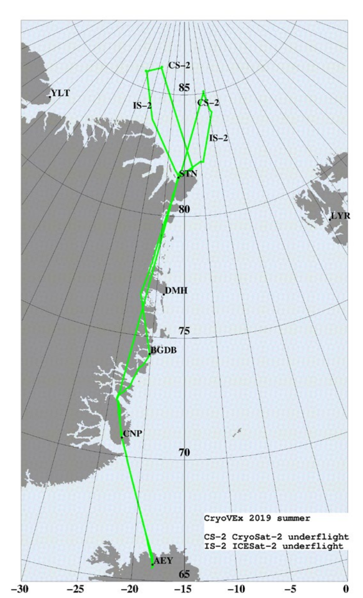
CryoVex Heritage (2002-present)

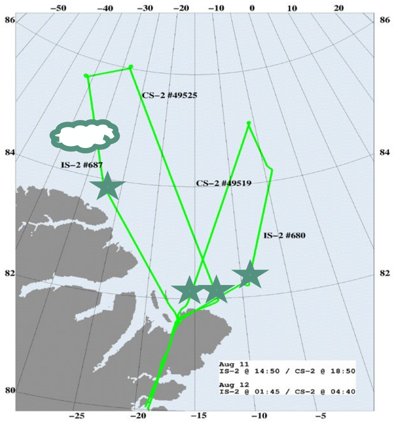
Dec 2017/Jan 2018



Spring 2019



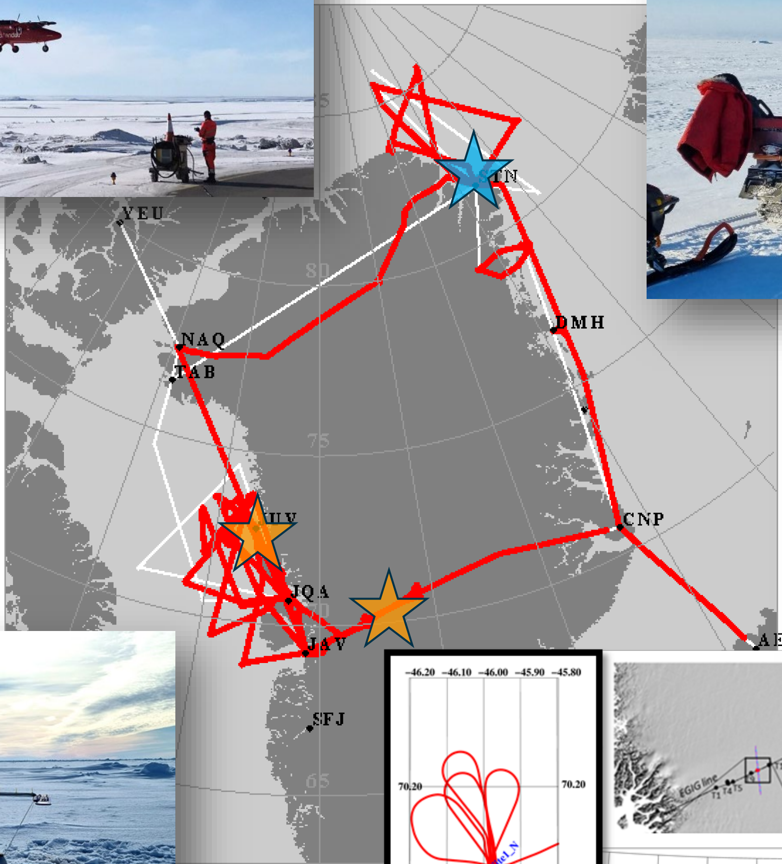




Summer 2019

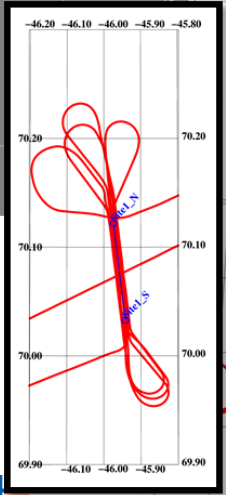
CryoVEx/CRYO2ICE/SILICE 2022

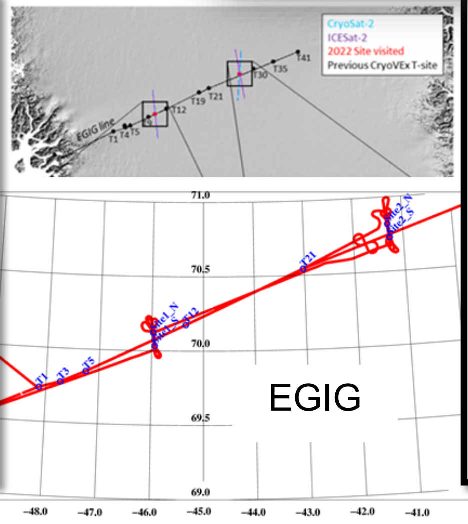
Baffin Bay:
CryoSat-2
ICESat-2
AltiKa
Sentinel-3 A & B

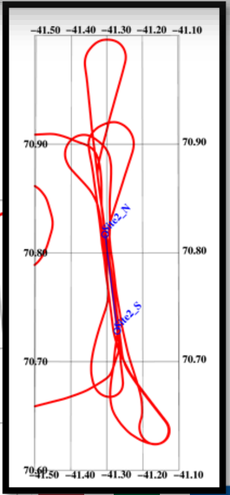


Station Nord

St3TART
FRM for Sentinel-3 Land Altimetry



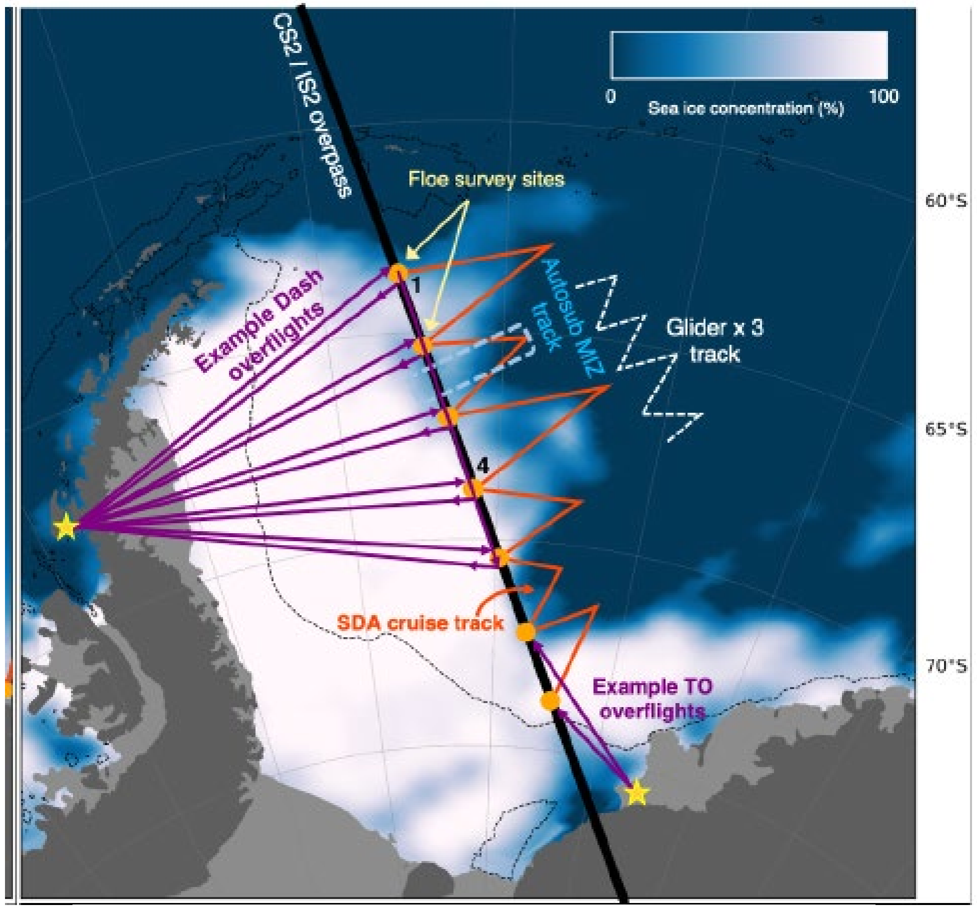




Credits: H. Skourup (DTU)

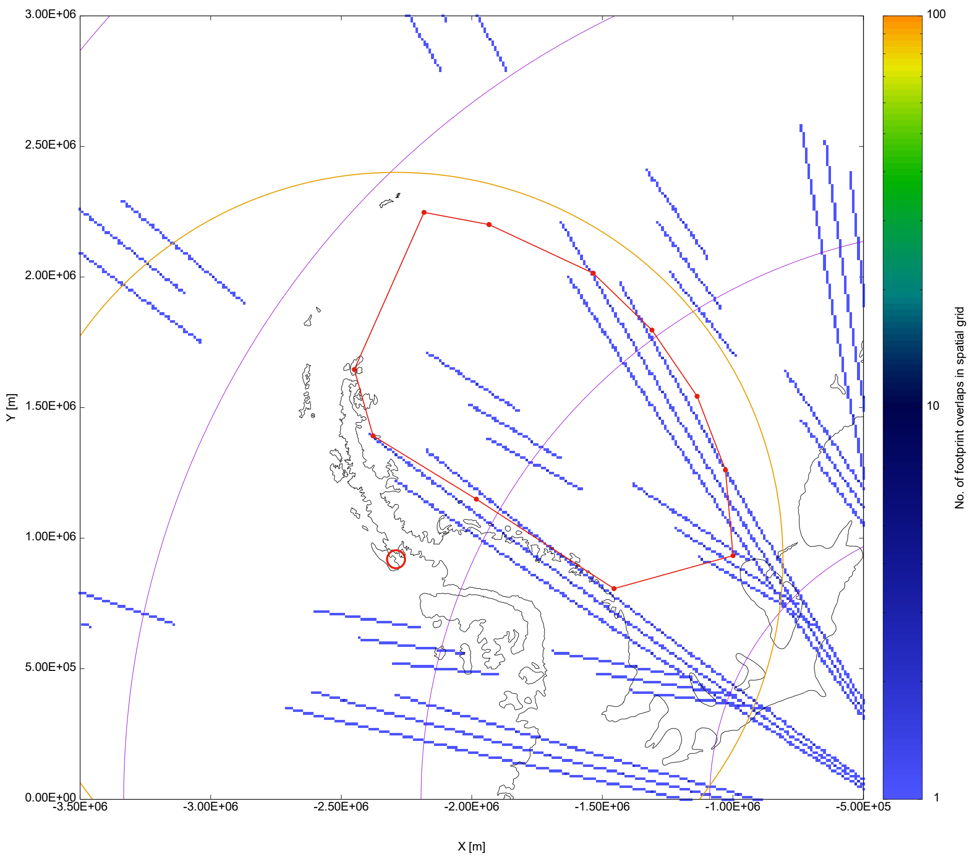
Antarctica Dec 2022: Final CS-2 airborne/ground campaign

Antarctica Dec 2022



BAS: DEFIANT (Drivers and Effects of Fluctuations in sea Ice in the ANTarctic)

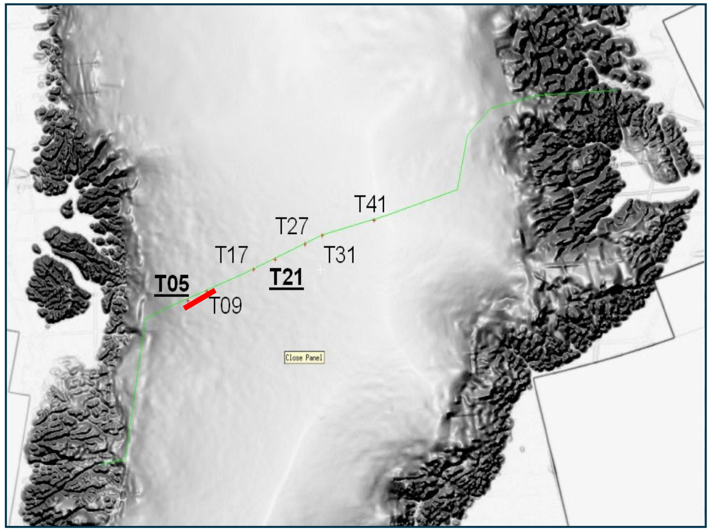
Analysis of coincidences Dec 2022 – Jan 2023



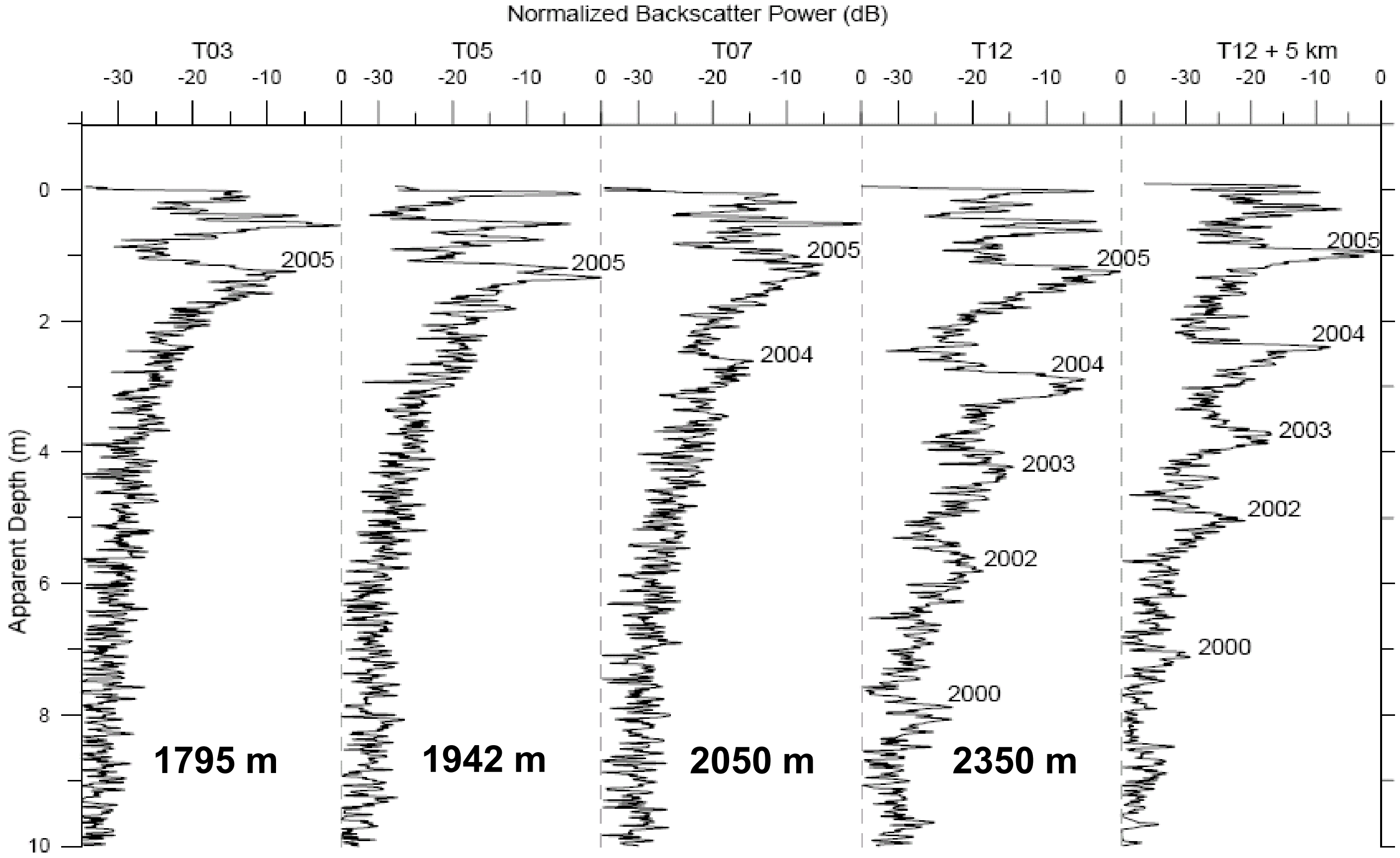
Credits: J. Sanchez (ESA)

Scientific findings from 20 years of CryoVEx Campaigns

Julian B. T. Scott,[1] Peter Nienow,[2] Douglas Mair,[3] Victoria Parry,[2] Elizabeth Morris,[4] and Duncan J. Wingham[5]



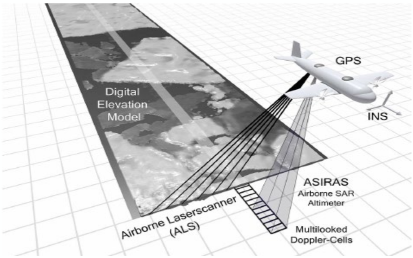
SPRING 2006



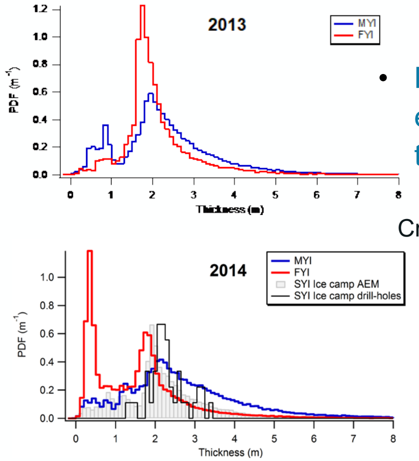
1) The depth of meltwater percolation and refreezing horizons will ***impact elevation estimates*** made by radar altimeters.

2) The strength of surface and volume reflections change dramatically between spring and autumn and with high spatial variability across the percolation zone.

Scientific findings from CryoVEx Campaigns

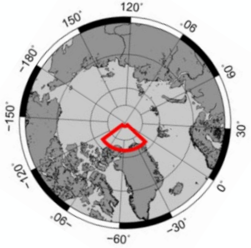


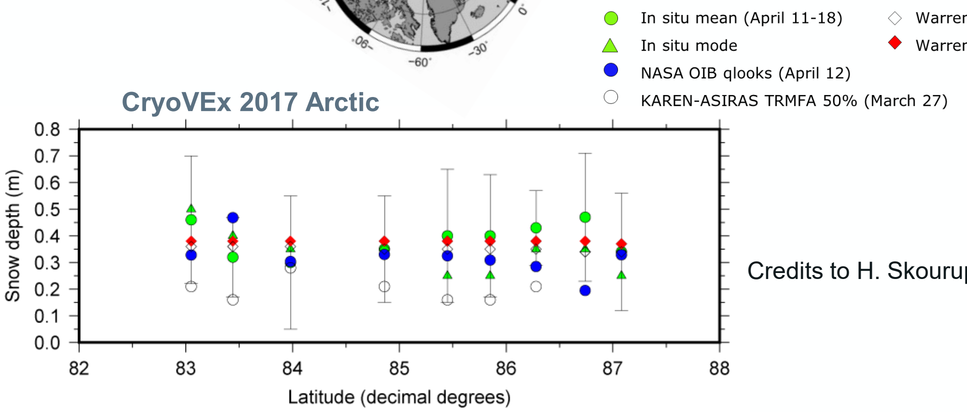
Hendricks, et al. (2010)



- Disappearance of extensive thick MYI in the Arctic

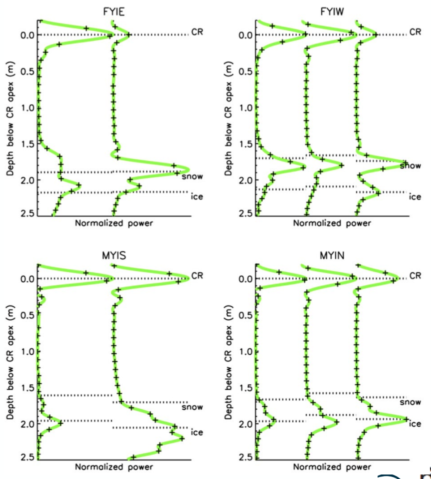
Credits to C. Haas(AWI)





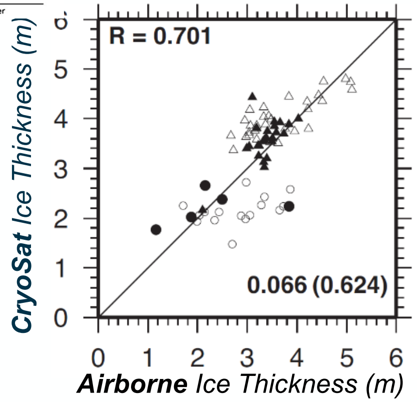
Credits to H. Skourup (DTU)

- Ka-Ku is less than the expected snow depth
- Depends on snow conditions and choice of re-tracker

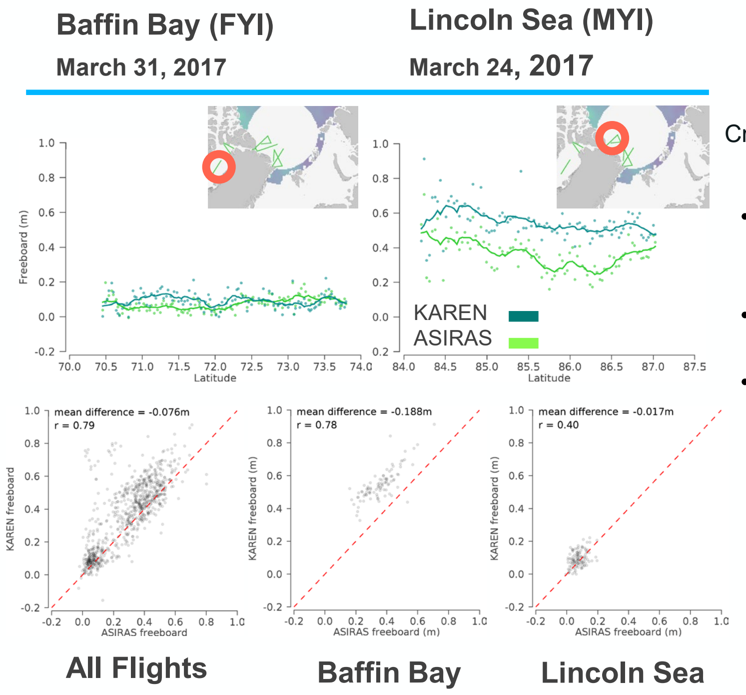


Willatt, et al. (2011)

- Bay of Bothnia -> bare ice case the air/ice interface is the dominant scattering surface
- CryoVEx -> a mixture, temperature very likely affected where the returns were coming from

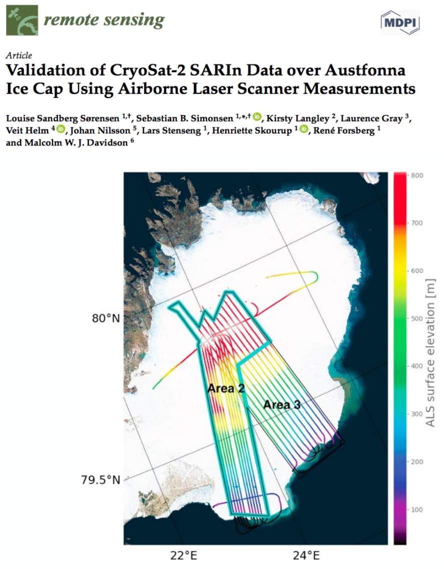


Laxon et al., 2013



Credits to R. Ricker (AWI/ NORCE)

- Over (thin) snow layer on FYI, KAREN and ASIRAS freeboard are similar
- Snow layer on MYI, KAREN exceeds ASIRAS freeboard by ~19 cm
- Difference between KAREN and ASIRAS freeboard does not seem to represent the full snow depth over MYI in the Lincoln Sea (~ 28 cm), if OIB snow depth is considered as the reference.

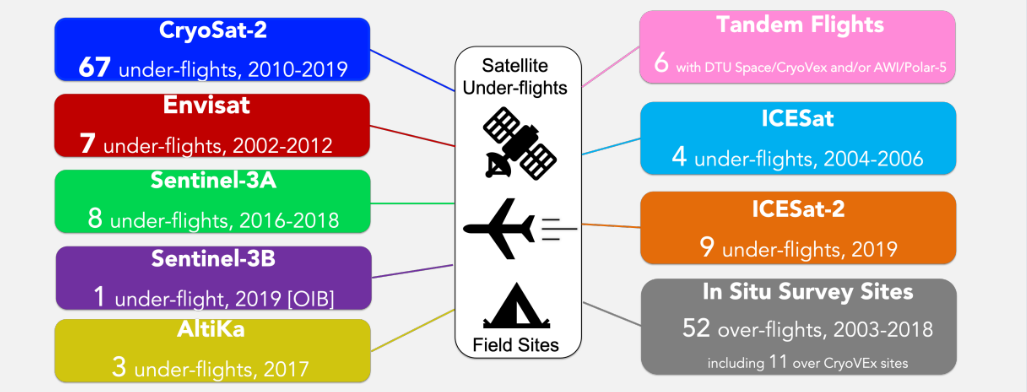


Credits to L. Sandberg (DTU)

Collaborations

- 20 years of CryoVex campaigns have demonstrated the importance of international collaboration and their essential role in the continued success of altimeter missions

- Collaborations have taken the form of:
  - Joint flights
  - Simultaneous ground work and field camps
  - Satellite data sharing
  - Support accessing the most updated satellite ground tracks
  - Logistic support, scientific support, etc …

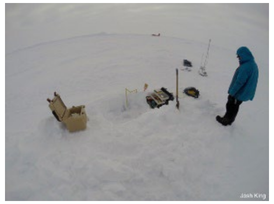


Airborne validation flights over Arctic sea ice conducted by ESA CryoVEx / DTU-Space, NASA Operation IceBridge and AWI/Polar-5 during the last two decades.

www.star.nesdis.noaa.gov/socd/lsa/SeaIce/ArcticAirborneSeaIceSurveys.php

Credits to S. Farrell (Univ. Maryland)

But above all: 20 years of CryoVEx campaign's successes have only been possible due to the hard work and enthusiasm of all the scientists involved!



Thank you!!

AWI

Helm, Veit
Hendricks, Stefan
Herber, Andreas
Steinhage, Daniel

DTU Space

Forsberg, Rene
Skourup, Henriette

Finnish Meteorological Institute

Haapala, Jari
Heiler, István
Lensu, Mikko

Geological Survey of Canada

Burgess, Dave
Demuth, Michael
van Wychen, Wes

Laboratoire d'Oceanographie de Villefranche

Doble, Martin

NASA

Studinger, Michael
Easmunt, Dave
McKee, Rick
Sonntag, John
Krabill, William

NOAA/NESDIS/ORA Lab for Satellite Altimetry

McAdoo, David

Norwegian Polar Institute

Gerland, Sebastian
Kohler, Jack
Brandt, Ola
Forsström, Sanja
Gjerland, Audun
Granskog, Mats
Goodwin, Harvey
Hansen, Edmond
Renner, Angelika
Tårand, Anna
Tronstad, Stein

Scott Polar Research Institute

Morris, Liz

University College London

Laxon, Seymour
Giles, Katherine
Willatt, Rosemary

University of Alberta

Haas, Christian
Sharp, Martin
Beckers, Justin
Danielson, Brad
Gascon, Gabrielle
Geai, Marie-Laure
Tremaine, Terry

University of Edinburgh

Nienow, Pete
de la Peña, Santiago

University of New Hampshire

Fahnestock, Mark
Milliman, Tom

University of Oslo

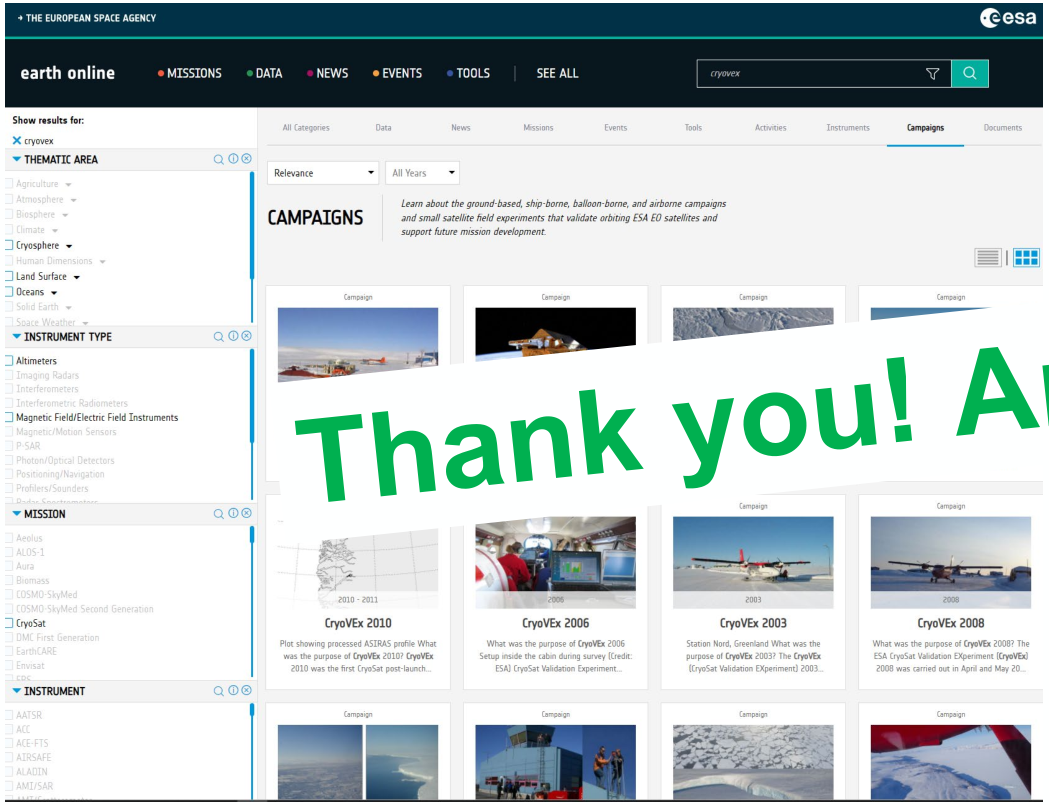
Hagen, Jon Ove
Eiken, Trond
Schuler, Thomas
Ims, Torbjørn
Dunse, Thorben

University of Ottawa

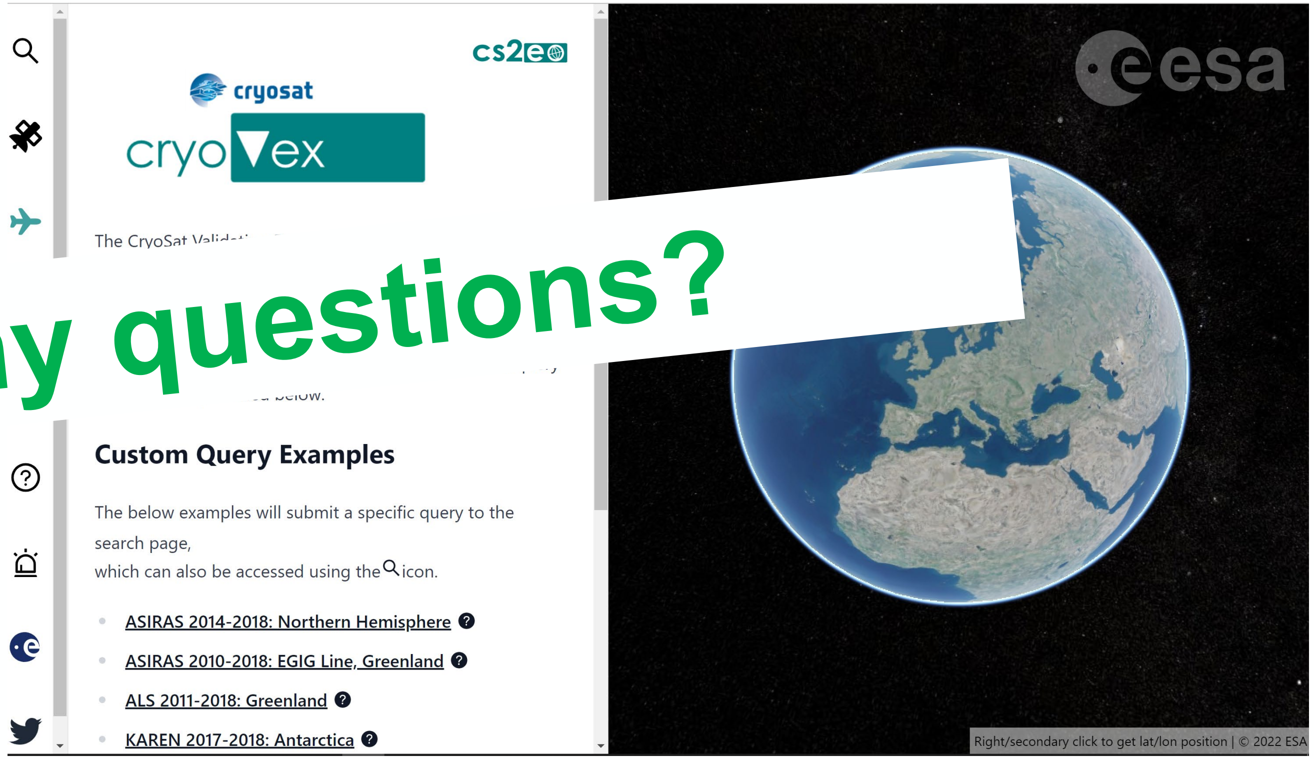
de Jong, Tyler

Campaigns data archive, DOI and new EarthWave platform

https://earth.esa.int/eogateway/search?category=Campaigns



Cryovex.org



Thank you! Any questions?

- ✓ All CryoVEx campaigns up to Antarctica 2017/2018 available in the ESA archives
- Data from 2019 spring and summer will be available by next month (June 2022)

- ✓ Same CryoVex data files as in ESA archives but converted to NetCDF

DOI's assigned to all datasets in both platforms