



2022 SAR ANALYTICS SYMPOSIUM



Advanced solutions for SAR processing and analytics using AI

Nicolas LONGEPE

European Space Agency (ESA), ESRIN, Φ -lab

Nicolas.Longepe@esa.int

Accelerate the future of Earth Observation
via **transformational innovation***
strengthening Europe's world-leading **competitiveness**

Discover

Creation of “Blue-sky”
transformative ideas



Nurture

Nurture good ideas
“Fail fast” ethos



Develop

Mature “the solution”



Invest

Foster entrepreneurial
initiatives



Accelerate
European EO
competitiveness



***transformational innovation**: with the ability to completely
transform or create entire industries via new technologies

AXIS I

Artificial Intelligence and Machine Learning

AI4EO

Detection & Classification, Physic-aware AI, Data Fusion, Prediction, Super-resolution, Quality Control, Calibration, Inversion, Virtual reality

AXIS II

Quantum Computing

QC4EO

AI-enhanced Quantum Initiative for EO

To solve demanding Earth observation problems by using artificial intelligence

AXIS III

Internet of Things, Blockchain, Cognitive Space

Flight HW

Flight SW
applications

Downstream
applications

End to end
systems

Business
models

An non-exhaustive set of projects supported

- A Machine Learning Approach to Automatic Azimuth Ambiguity Filtering in SAR data – Iceye
- Automatic Sea Ice Charting using Sentinel-1 – DMI, DTU, NR, PolarView, NERSC
- Crop type detection using optical + SAR time series – highlight on Tracasa solution as part of AI4EO challenge

Azimuth ambiguities: how to get rid?

Large antenna

Not applicable for a micro-SAR

Higher PRF

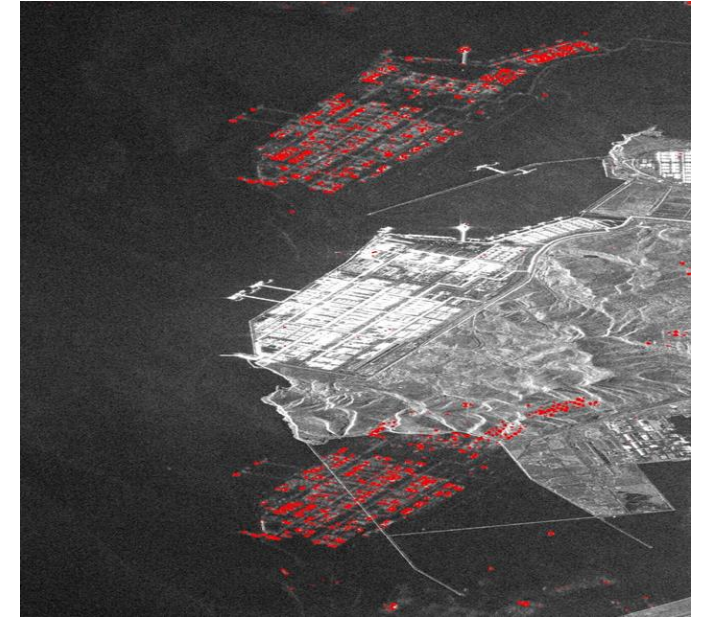
Lower swath width and higher range ambiguity

Detect and suppress the ambiguity

Filtering

Degradation of the azimuth resolution

Ineffectiveness when ambiguity is large



Iceeye imagery



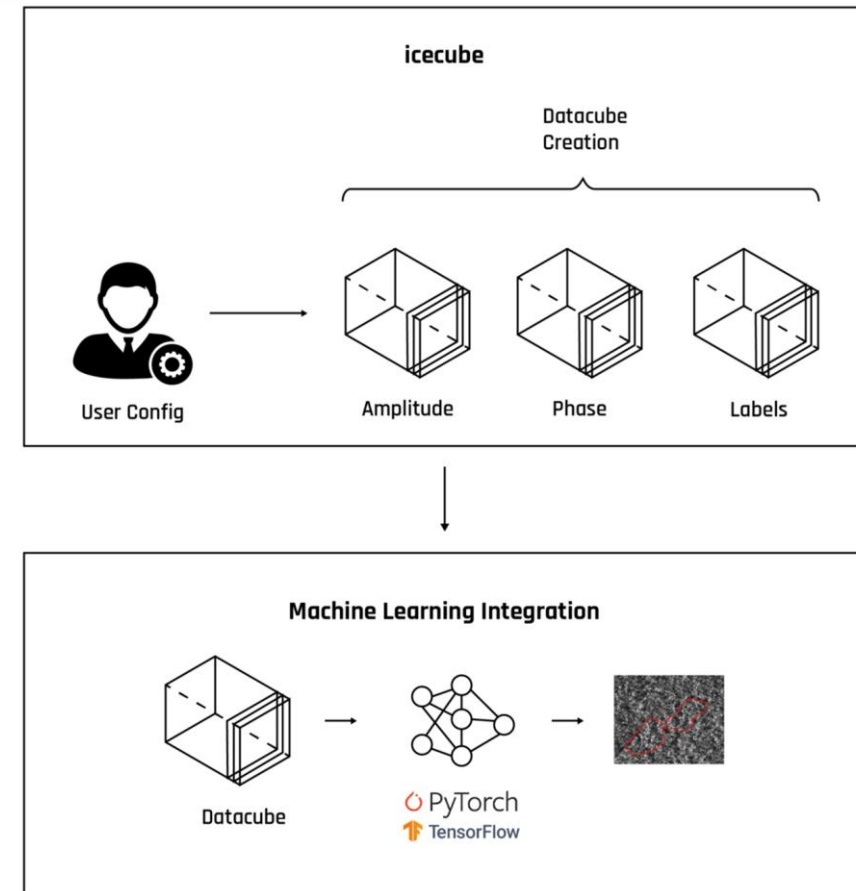
Azimuth ambiguities: how to get rid? Machine learning ...

ICEYE collaborated with ESA ϕ -lab on the Artificial Intelligence for SAR at High Resolution (AI4SARHighRes) project to exploit some ML techniques that mitigate the problem of azimuth ambiguities.

During the project a dedicated infrastructure to facilitate AI-oriented datacubes with time series ICEYE SAR data has been implemented (ICECUBE)



github.com/iceye-ltd/icecube



Deep Learning with physic prior

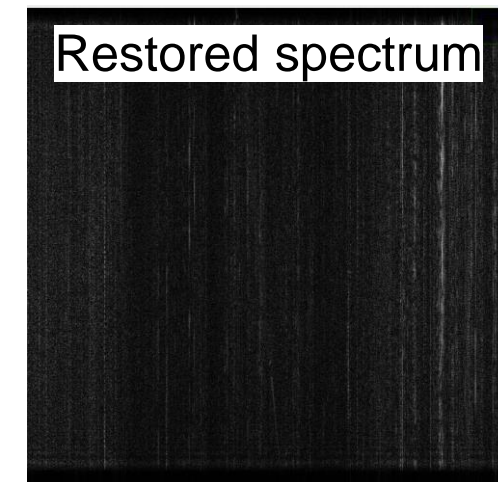
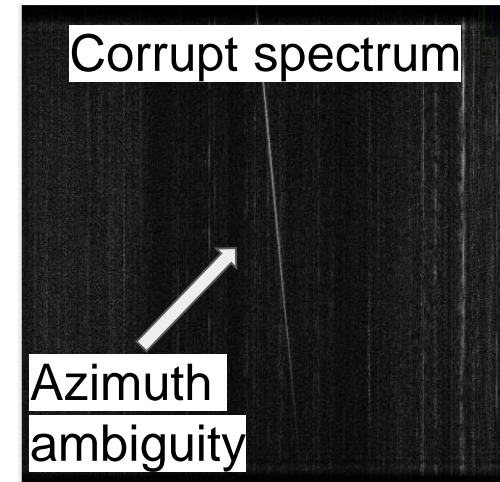
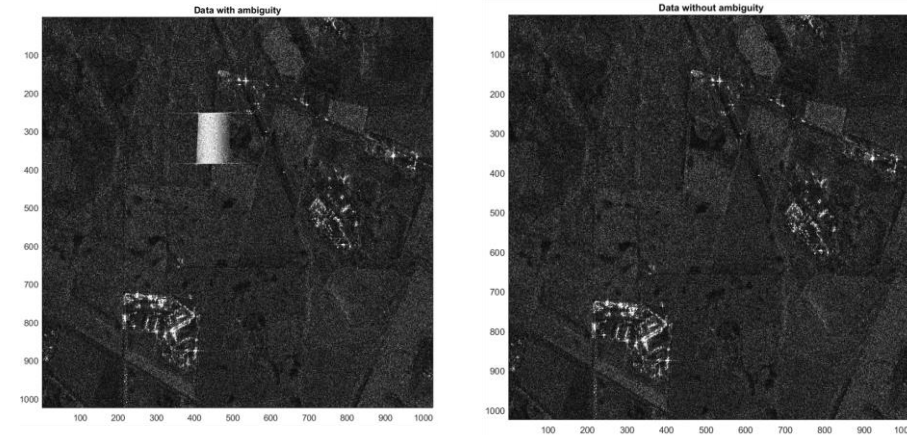
Supervised ML algorithms for azimuth ambiguity detection and suppression:

Significant amount of labeled data for training and validation -> painful and costly

Proposed solution:

ICEYE SAR data simulator tool developed and validated to generate a proper simulated training dataset with ground truth.

Build Deep Learning algorithms to 1) detect ambiguous signatures in the Doppler spectrum and 2) remove them



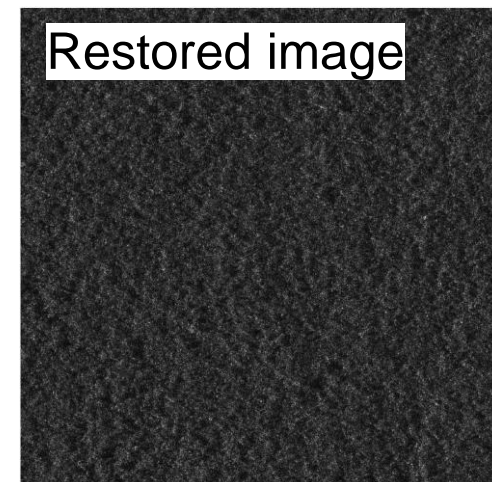
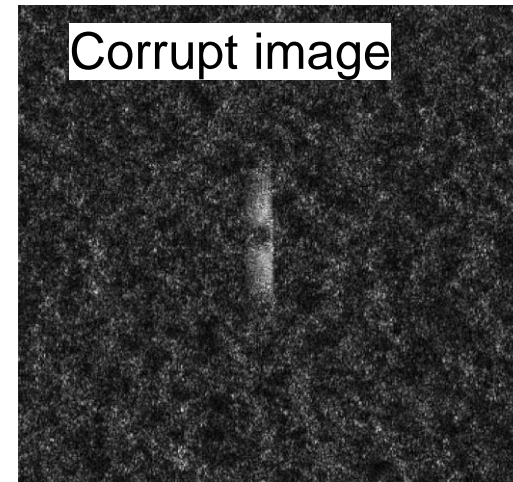
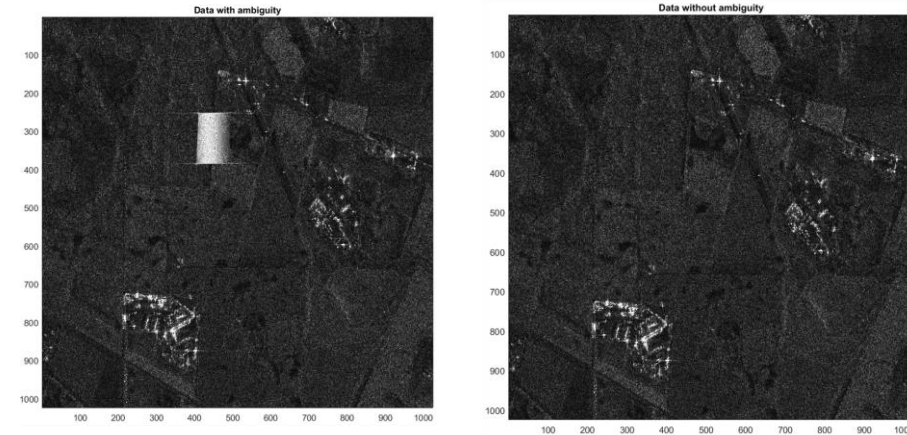
Supervised ML algorithms for azimuth ambiguity detection and suppression:

Significant amount of labeled data for training and validation -> painful and costly

Proposed solution:

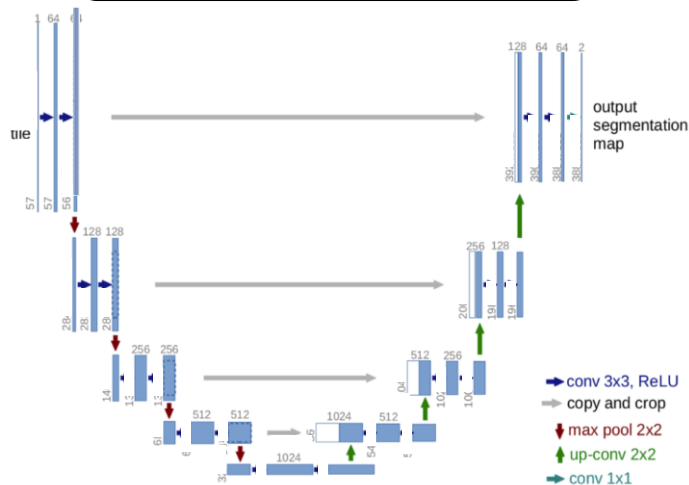
ICEYE SAR data simulator tool developed and validated to generate a proper simulated training dataset with ground truth.

Build Deep Learning algorithms to 1) detect ambiguous signatures in the Doppler spectrum and 2) remove them

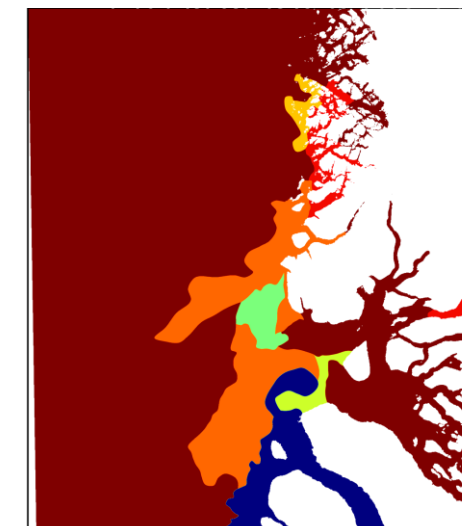
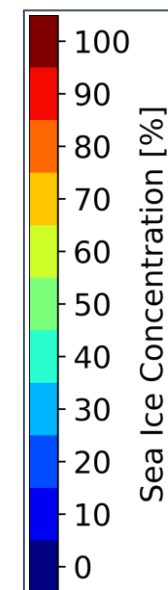
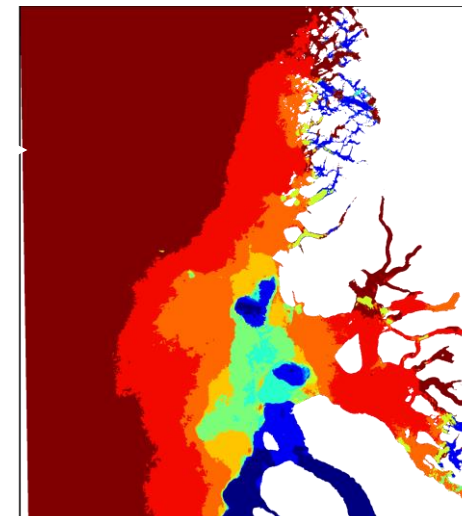


Automatic Sea Ice Charting

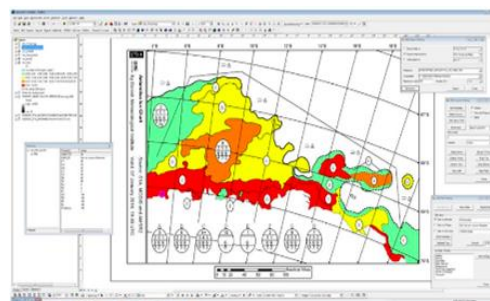
U-Net Convolutional Neural Network



Automatic sea ice chart



Handcrafted sea ice concentration chart



The AI4Arctic - ASIDv2 Dataset

461 scenes, from March 2018- May 2019

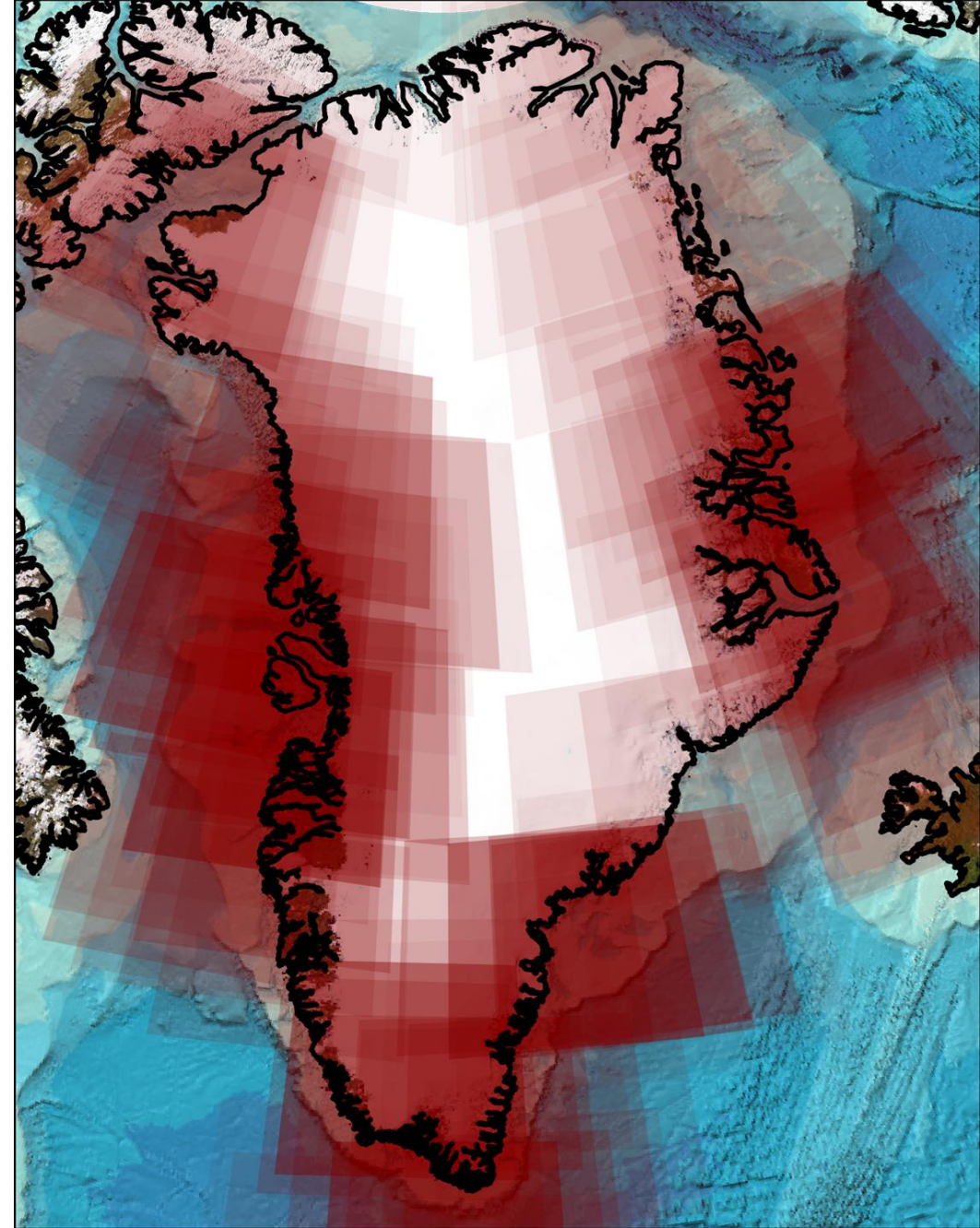
Each scene contains:

Sentinel-1 EW Level-1 GRDM SAR image, HH + HV,
Misc. variables e.g. incidence angle, 2 noise correction
processing chains (ESA + NERSC)

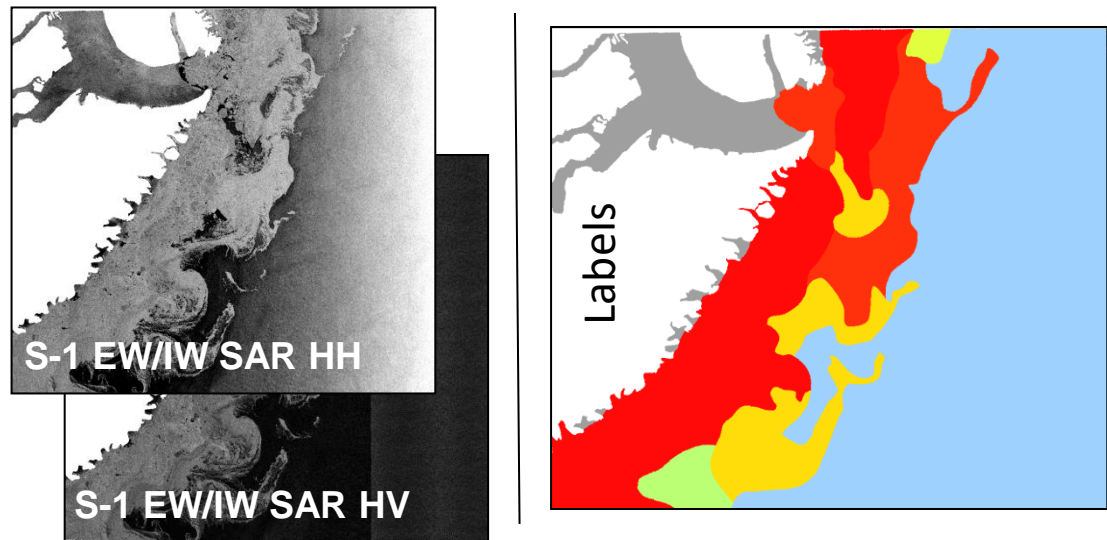
AMSR2, Passive Microwave Radiometer (PMR)
brightness temperatures, 7 frequencies (6.9GHz - 89
GHz)

Danish (DMI) operational sea ice charts

[https://data.dtu.dk/articles/dataset/AI4Arctic ASIP Sea Ice Dataset - version 2/13011134/2](https://data.dtu.dk/articles/dataset/AI4Arctic_ASIP_Sea_Ice_Dataset_-_version_2/13011134/2)
<https://www.aireo.net/>



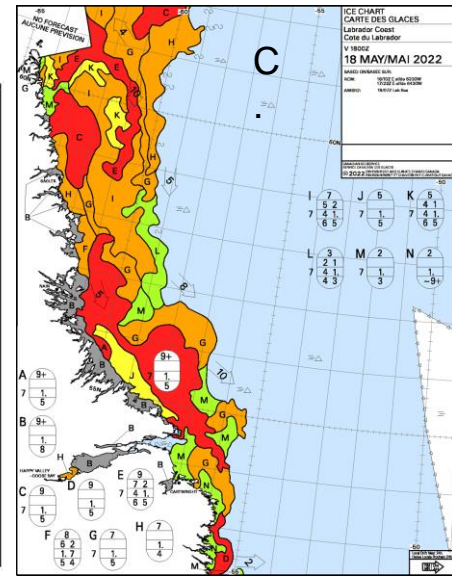
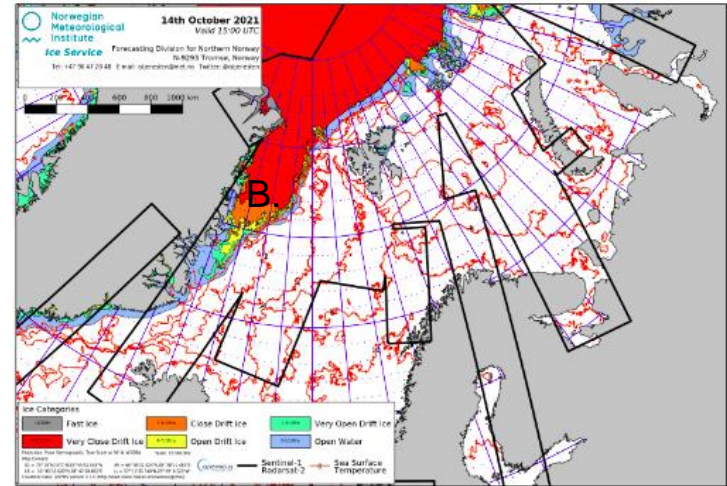
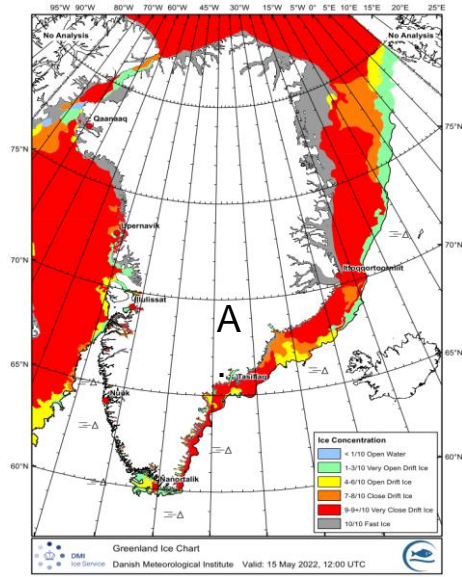
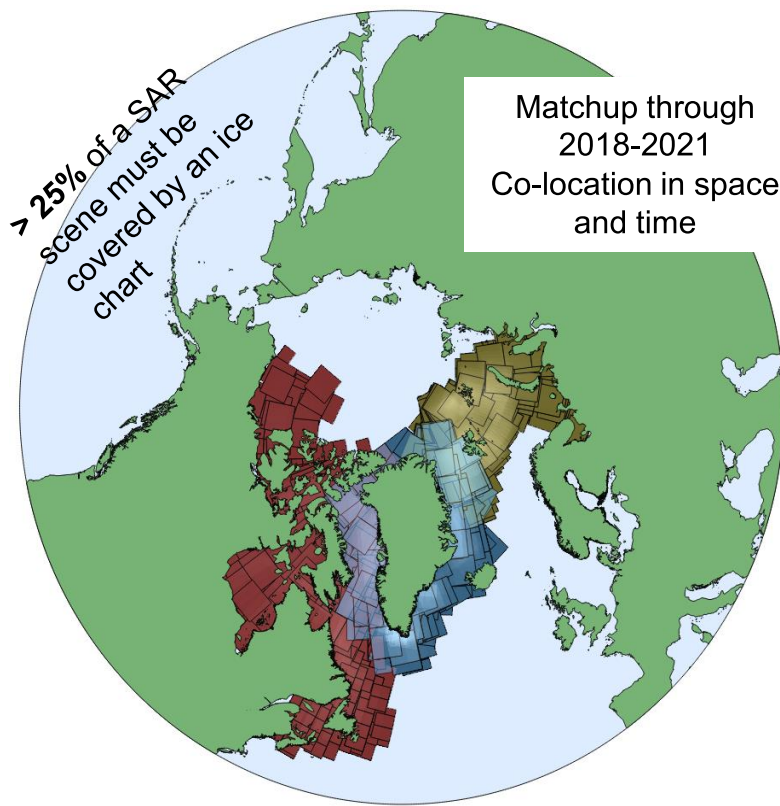
Towards time and space expansion



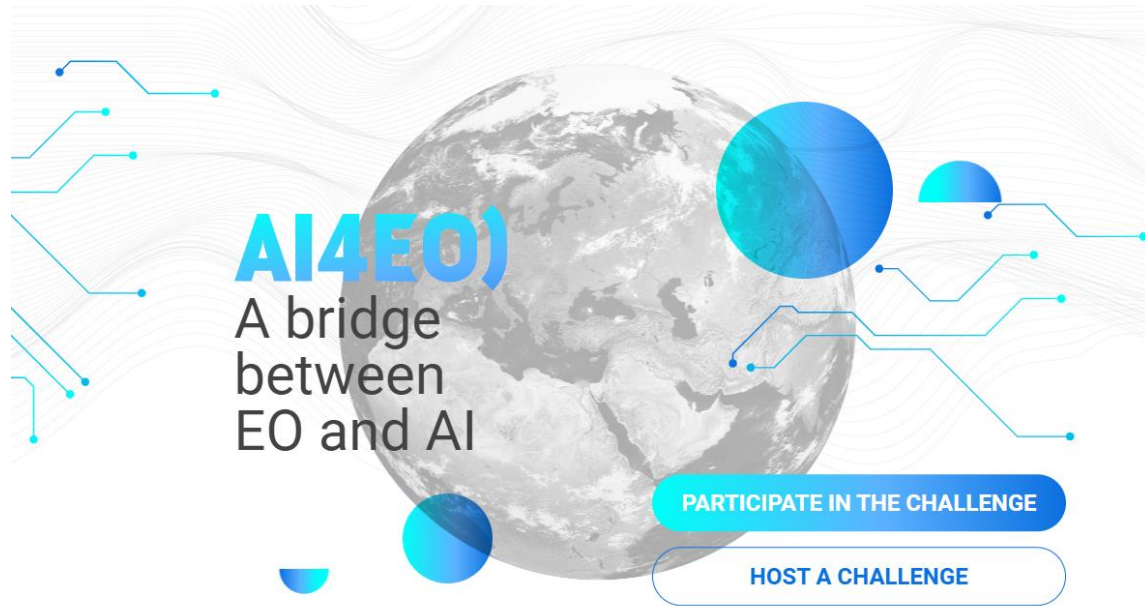
- CIS – 2599 matchups (SAR scenes/corresp. ice charts)
- DMI – 3387 matchups (SAR scenes/corresp. ice charts)
- MetNo – 2251 matchups (SAR scenes/corresp. ice charts)

Total matchups: **8237**
 18 times larger than the previous dataset!
 SAR scene up to 10,000 x 10,000 pixels
 Size: 6-7 TB?

- Reanalysis v5 (ERA-5) Wind
- 2 m Surface temperatures



Stay tuned for our upcoming data challenge

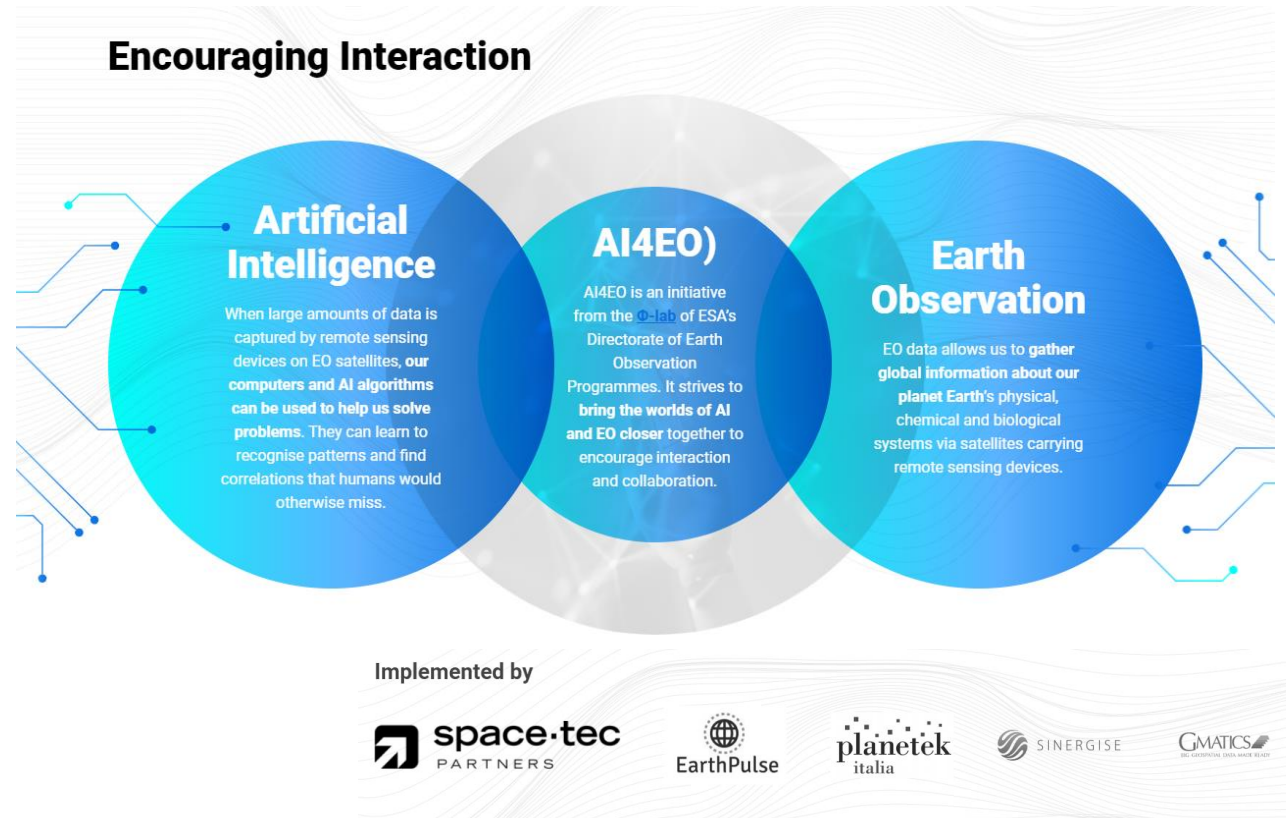


To be launched shortly in 2022
(early November)

on <https://platform.ai4eo.eu/>

Many attractive prizes for the winners ...

Targeting not only sea ice concentration,
but also sea ice types and floes size



Planet data fusion challenge

Goal of this challenge: classify crop types based on time series data from Sentinel-1, Sentinel-2 and Planet Fusion Monitoring Data.

Challenge closed in Q2-2022

Provided dataset:

Combination of harmonized, de-clouded, daily Planet Fusion data at 3m resolution together with Sentinel-1 and 2 time series for high-quality field boundaries and crop ids in Brandenburg, Germany

Nine classes (frequencies in brackets):

Wheat (305), Rye (276), Barley (137), Oats (45), Corn (251), Oil Seeds (201), Root Crops (23), Meadows (954) and Forage Crops (339).

Planet Fusion Imagery, based on the Planetscope constellation

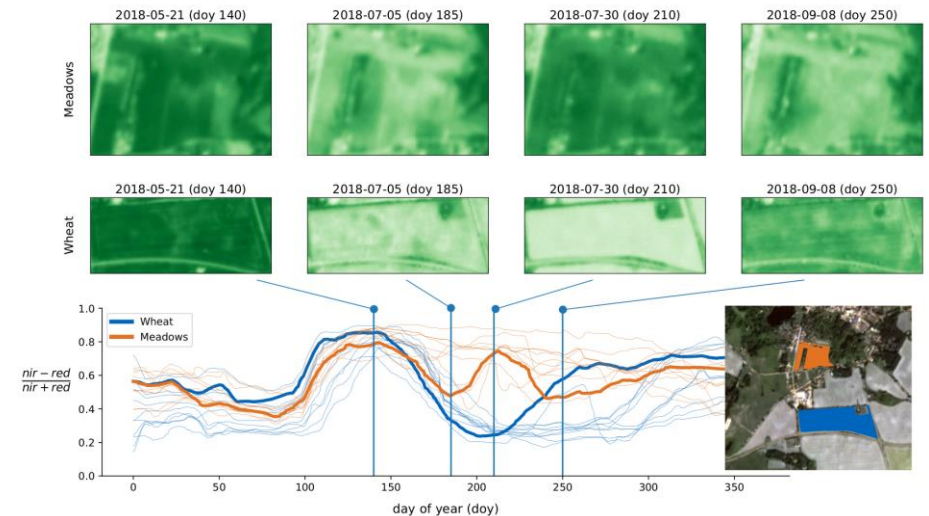
Spatial resolution of 3m and collects 4 spectral bands (RGB + Near-infrared (NIR)).

Temporally consistent collection of daily images with removed clouds and shadows

Harmonized Landsat Sentinel-2 (HLS) time series, meaning that the data is interoperable with Landsat and Sentinel-2 data.

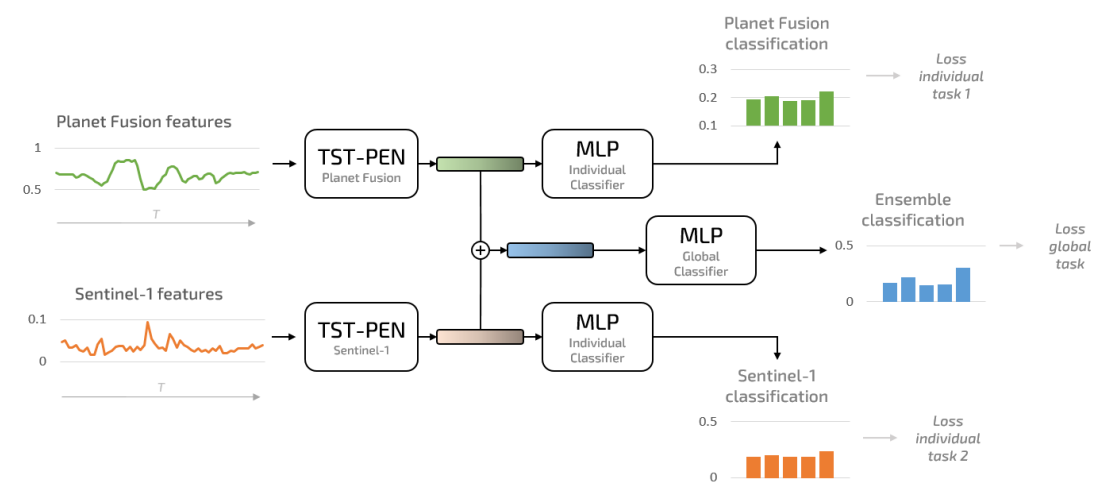
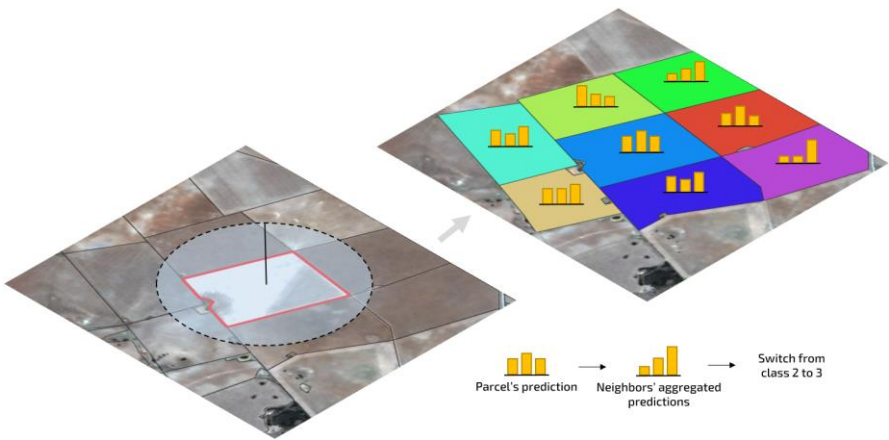
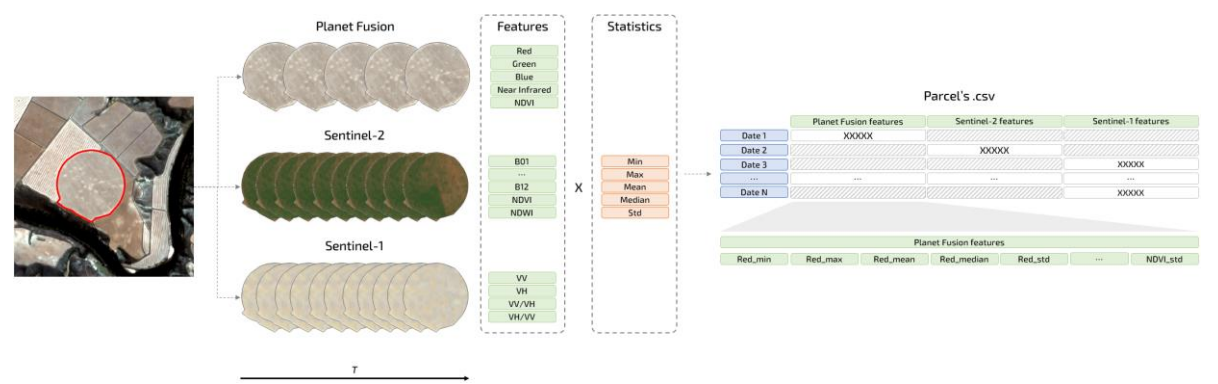
+

All available Sentinel-1 and Sentinel-2 images in 2018 and 2019



Kondmann et al. DENETHOR: The DynamicEarthNET dataset for Harmonized, inter-Operable, analysis-Ready, daily crop monitoring from space, NeurIPS Track on Datasets and Benchmarks, 2021

Best solution provided by Tracasa-I (ES)



- In addition to daily Planet information
- Gain when introducing Sentinel-1
 - No gain when adding Sentinel-2

Courtesy: Christian Ayala Lauroba <cayala@itracasa.es>

Again just an non-exhaustive set of projects supported

please contact me

Nicolas.Longepe@esa.int

Thank you