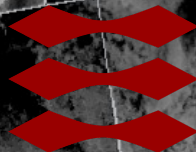
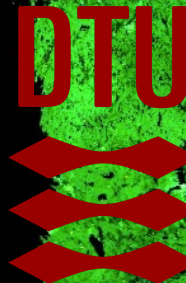


DTU



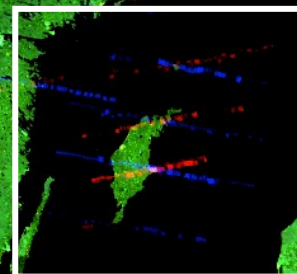
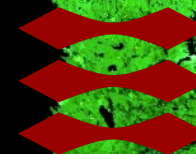
SCI-329
NATO unclassified



RGB composite: 1/1 2022 - 1/5 2022

SCI-329
NATO unclassified

DTU

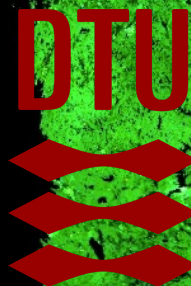


RGB composite: 1/1 2022 - 1/5 2022

SCI-329
NATO unclassified

RGB composite: 1/1 2022 - 1/5 2022

SCI-329
NATO unclassified



RGB composite: 1/1 2022 - 1/5 2022

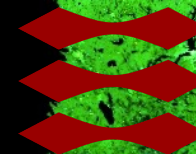
SCI-329
NATO unclassified



RGB composite: 1/1 2022 - 1/5 2022

SCI-329
NATO unclassified

DTU



RGB composite: 1/1 2022 - 1/5 2022

SCI-329
NATO unclassified



RGB composite: 1/1 2022 - 1/5 2022

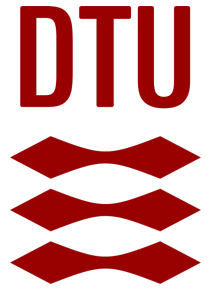
SCI-329
NATO unclassified

Detect on-ground radars in SAR images

Kristian Aalling Sørensen, Anders Kusk, Peder Heiselberg, Henning Heiselberg
National Space Institute of Denmark,
Center for Security

Detect on-ground radars in SAR images

RFI in Sentinel-1 IW images

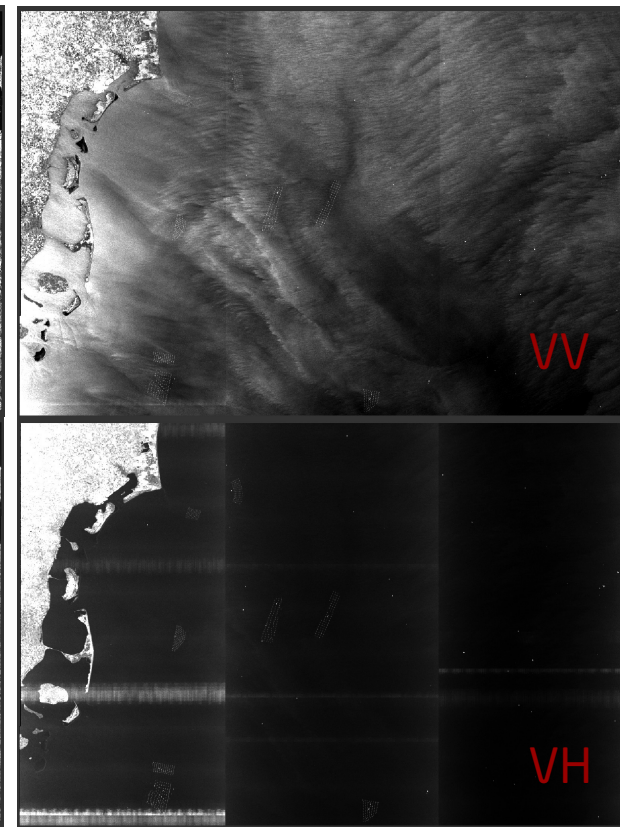
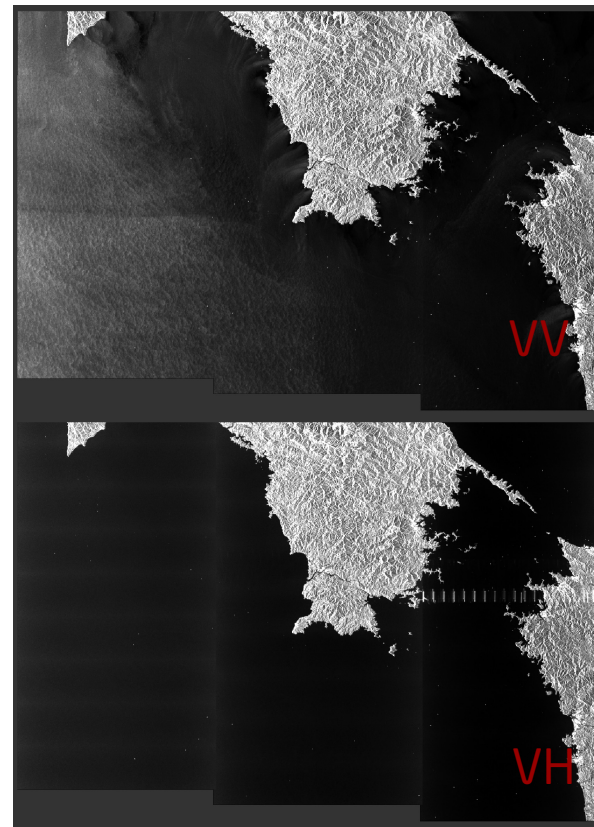
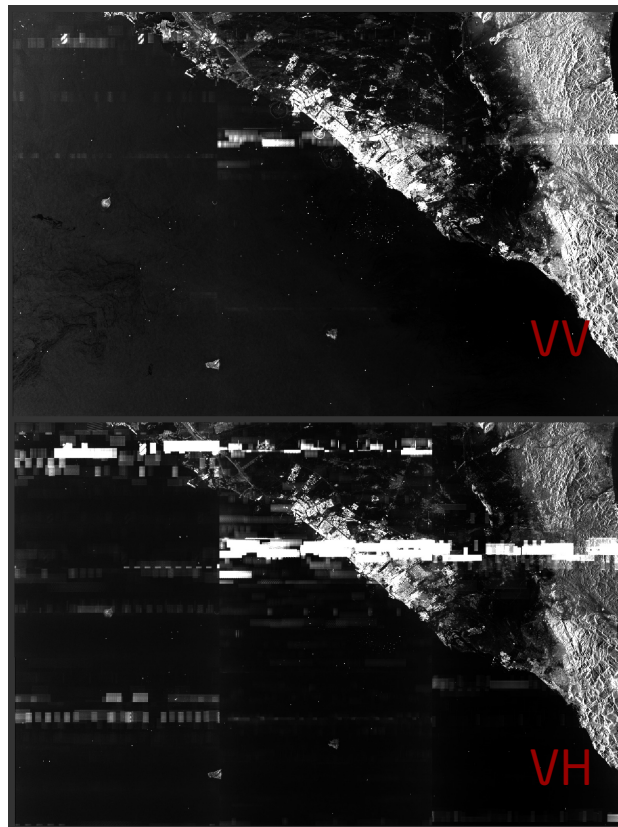
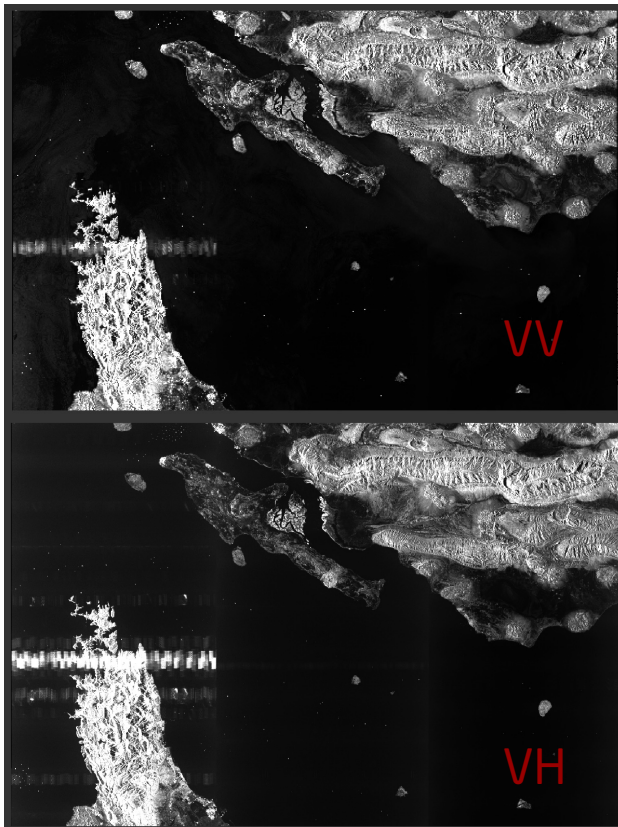


United Arab Emirates

United Arab Emirates

Japan

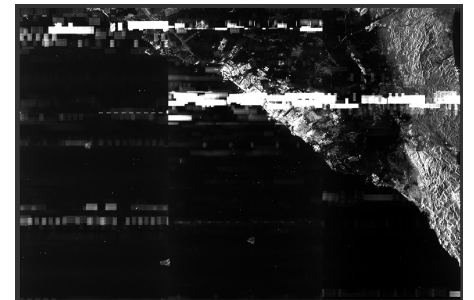
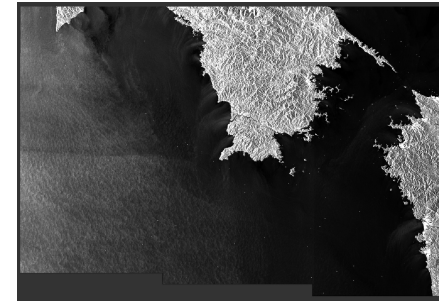
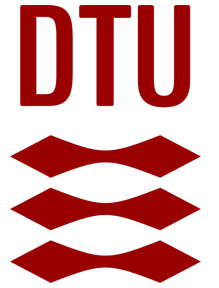
Denmark



Detect on-ground radars in SAR images

Objectives

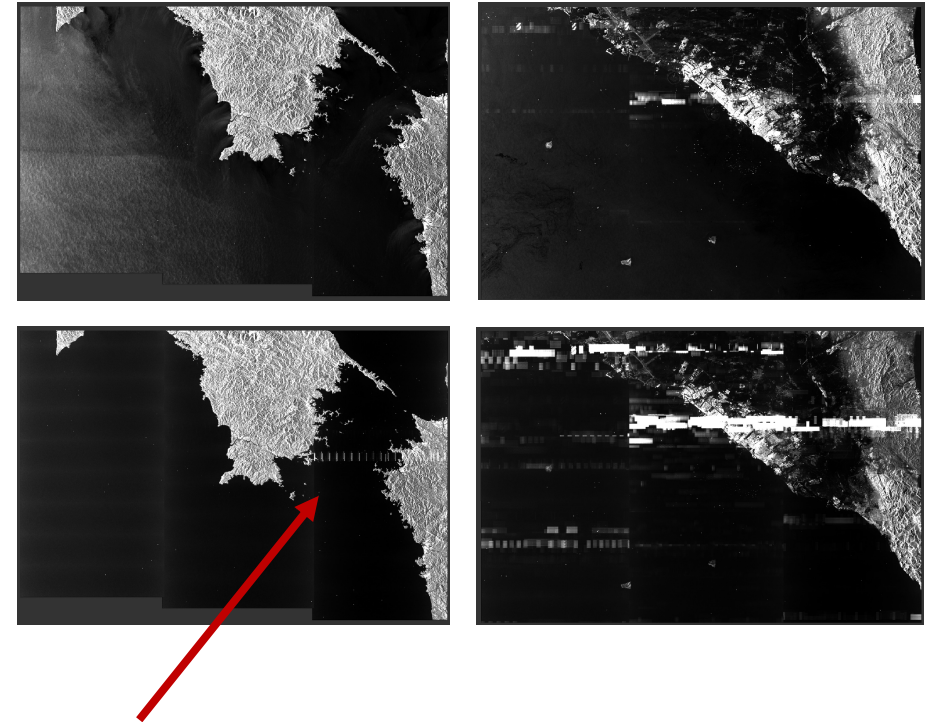
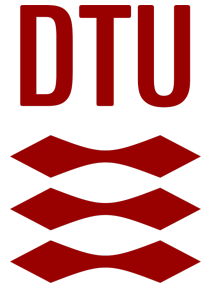
- Automatically classify images with RFI signals.
- Automatically localise the RFI signals.
- Extract some information about the on-ground Radar



Detect on-ground radars in SAR images

Objectives

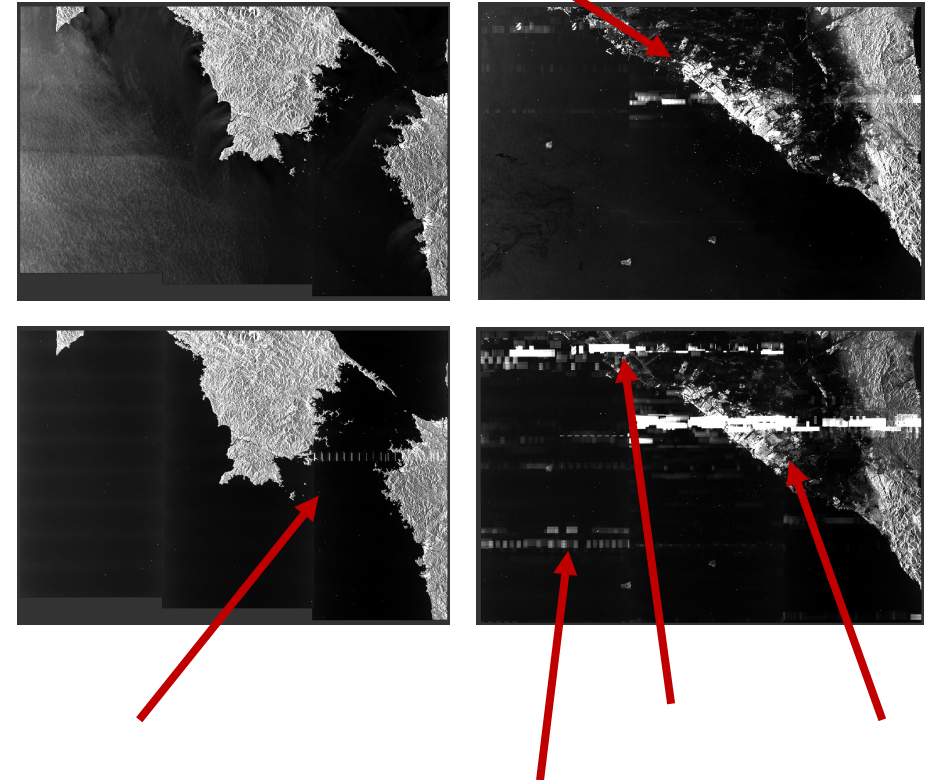
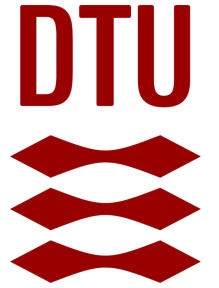
- Automatically classify images with RFI signals.
- Automatically localise the RFI signals.
- Extract some information about the on-ground Radar



Detect on-ground radars in SAR images

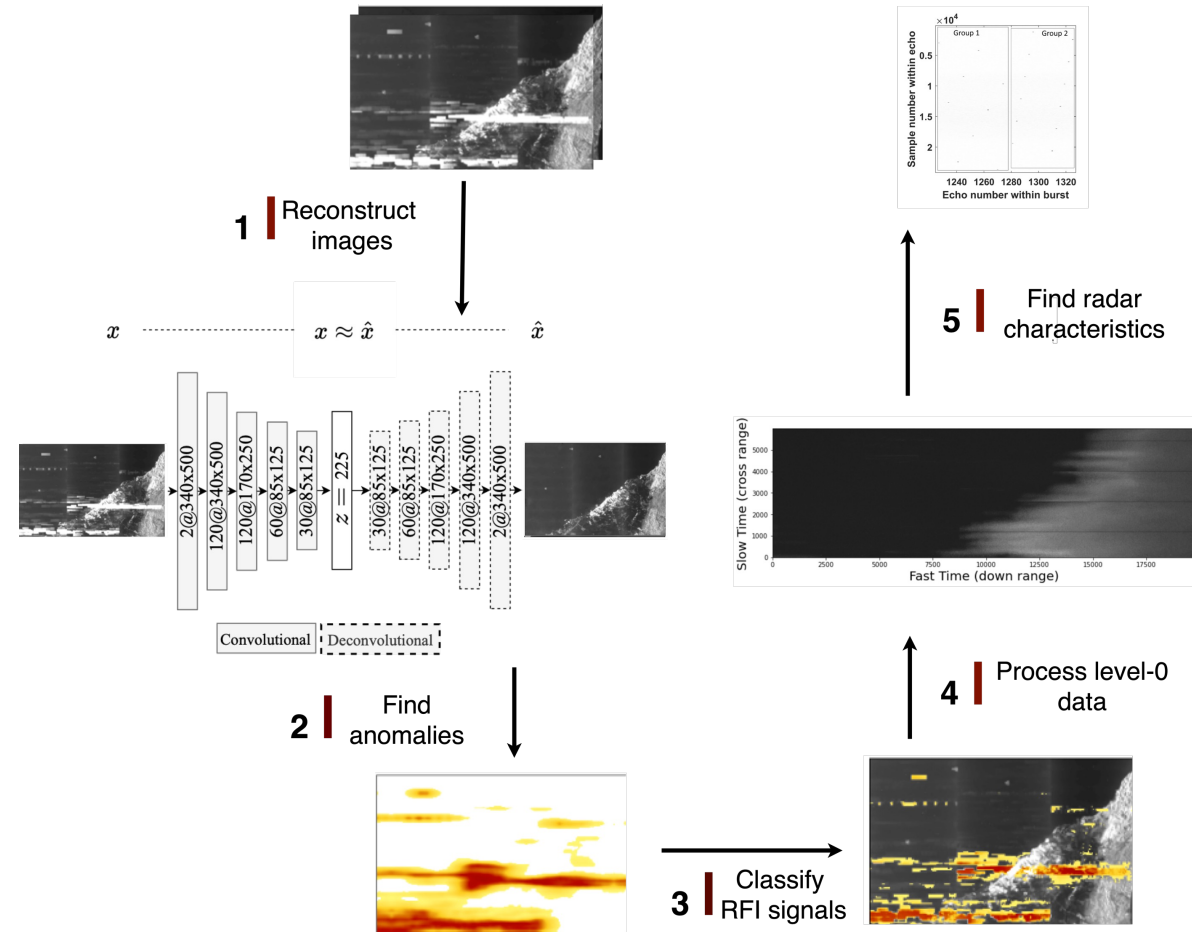
Objectives

- Automatically classify images with RFI signals.
- Automatically localise the RFI signals.
- Extract some information about the on-ground Radar



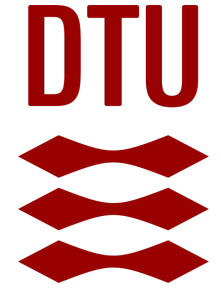
Detect on-ground radars in SAR images

General workflow



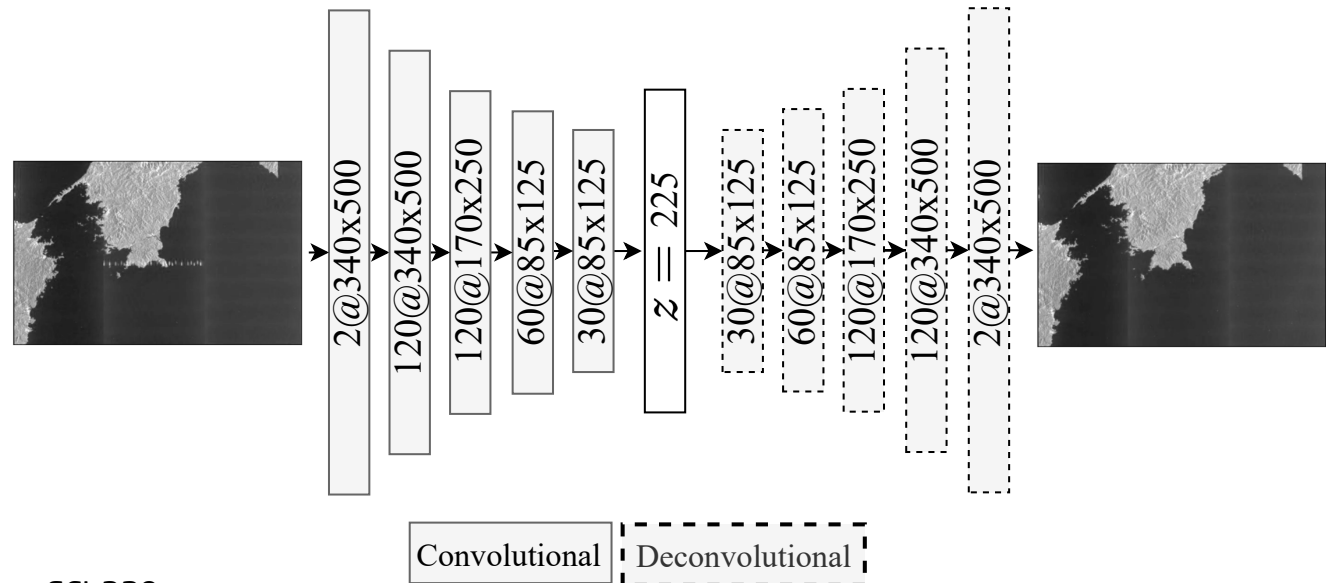
Detect on-ground radars in SAR images

1. Reconstruct images

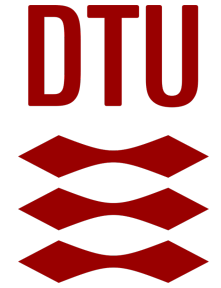


Convolutional Autoencoder (CAE)

$$x \text{ ----- } x \approx \hat{x} \text{ ----- } \hat{x}$$



Detect on-ground radars in SAR images

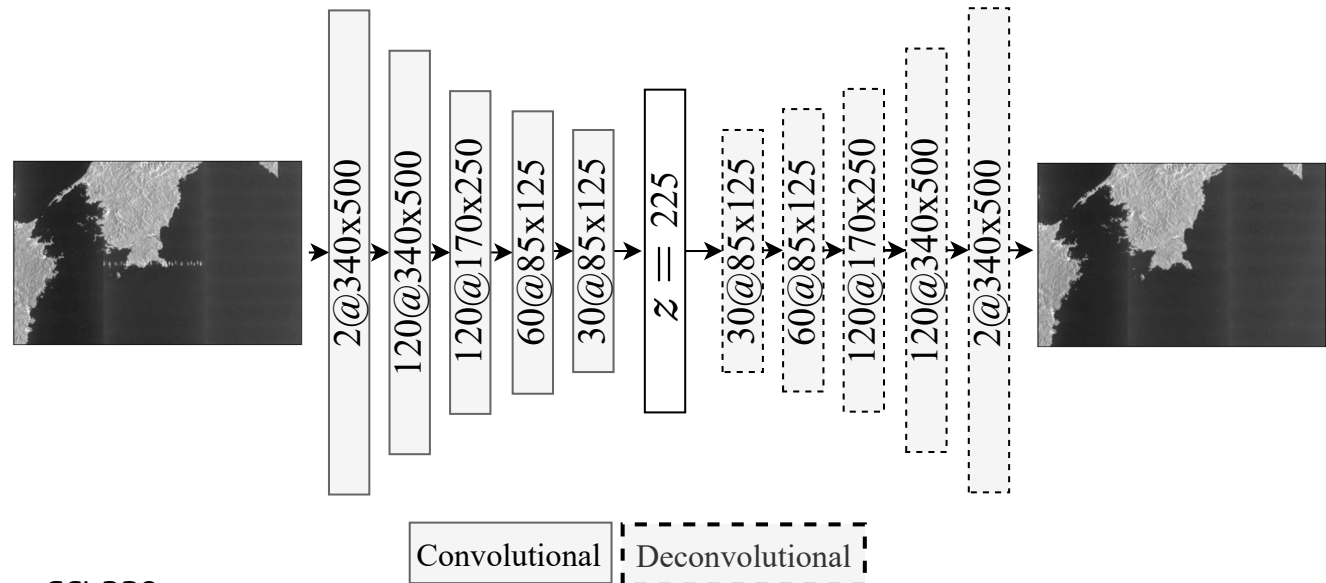


1. Reconstruct images

1. **Reconstruct** SAR image with a CAE
2. Model can not reconstruct **anomalies**
3. Classify anomalies as, *e.g.*, **RFI signals**

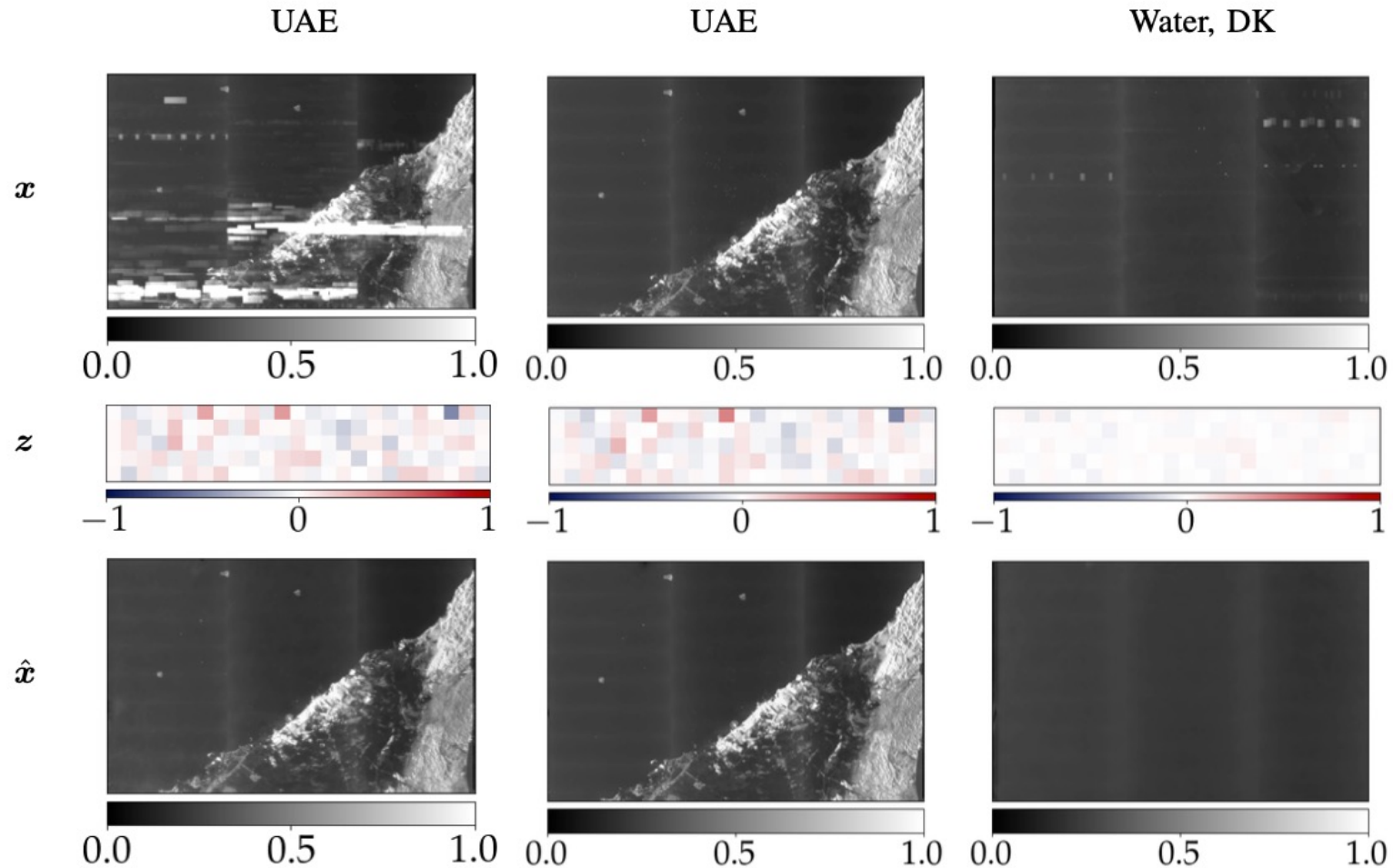
Convolutional Autoencoder (CAE)

$$x \text{ ----- } x \approx \hat{x} \text{ ----- } \hat{x}$$



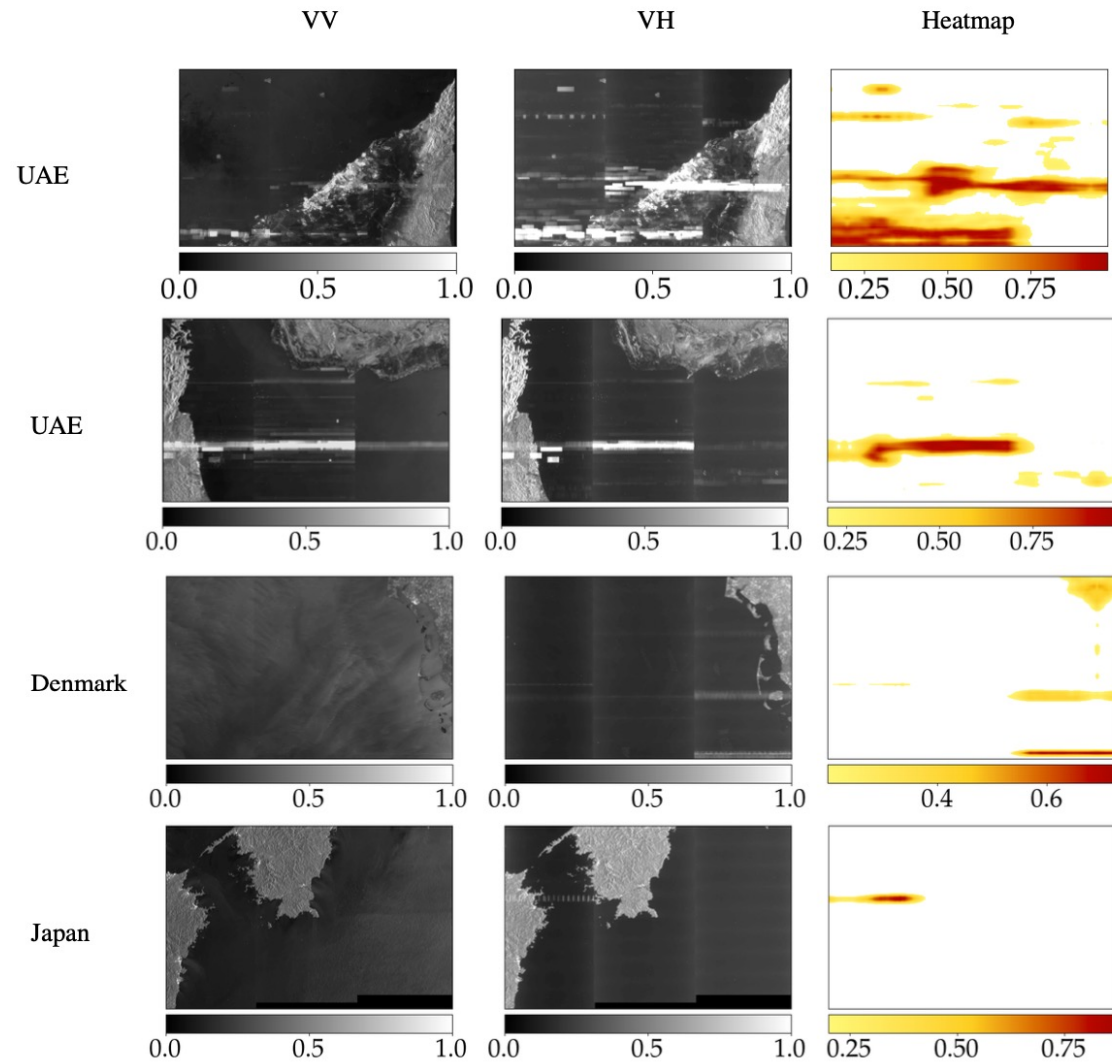
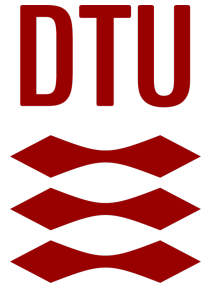
Detect on-ground radars in SAR images

1. Reconstruct images



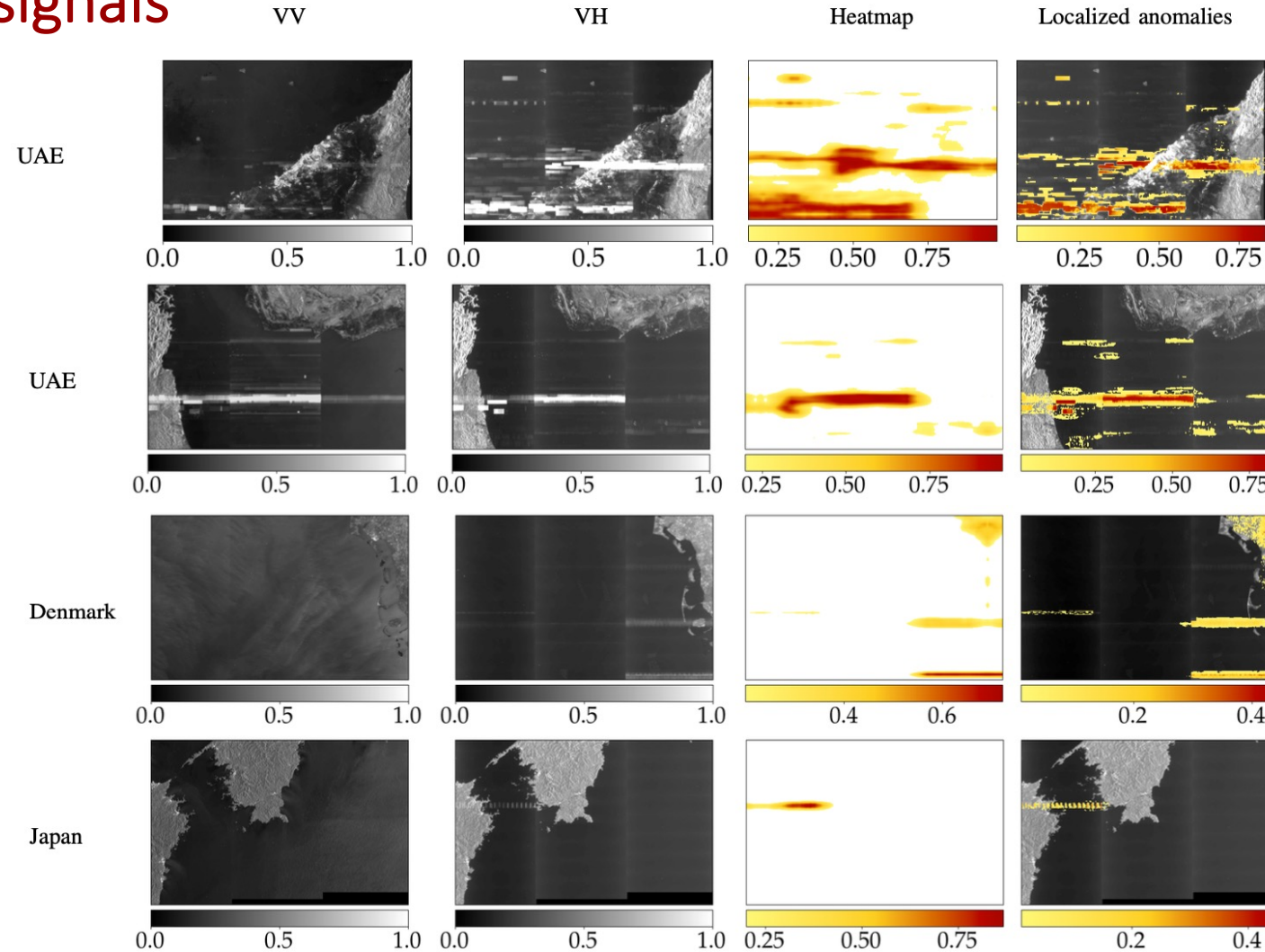
Detect on-ground radars in SAR images

2. Find anomalies



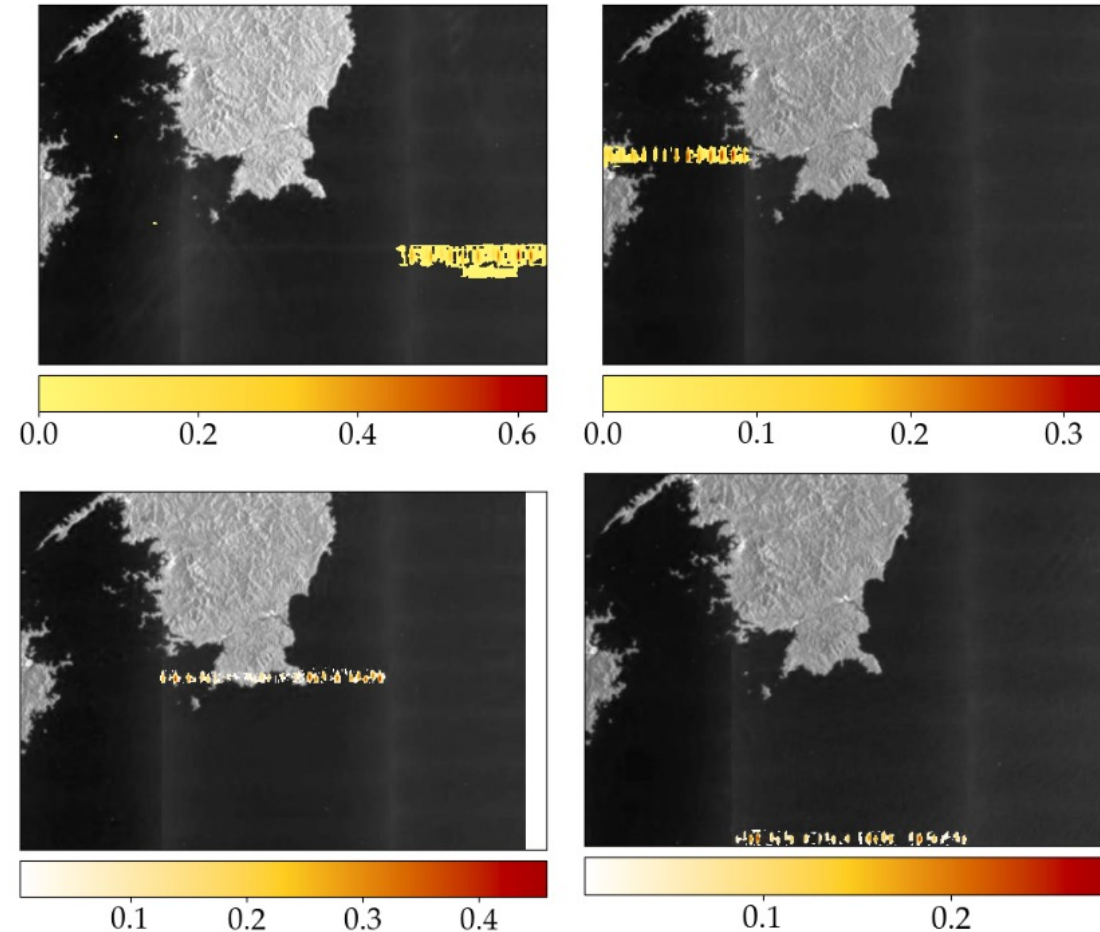
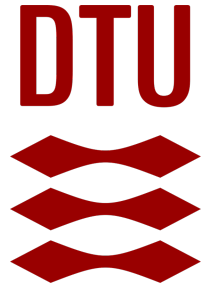
Detect on-ground radars in SAR images

3. Classify RFI signals



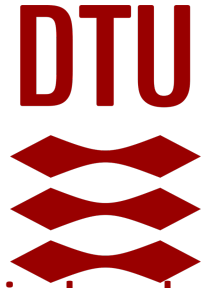
Detect on-ground radars in SAR images

Examples: Ship borne air surveillance radars

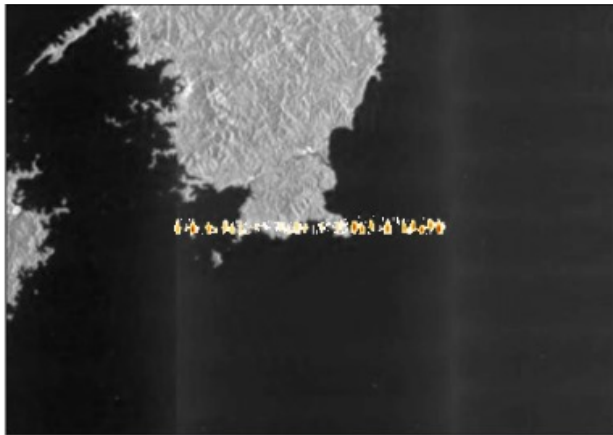


Extract some information

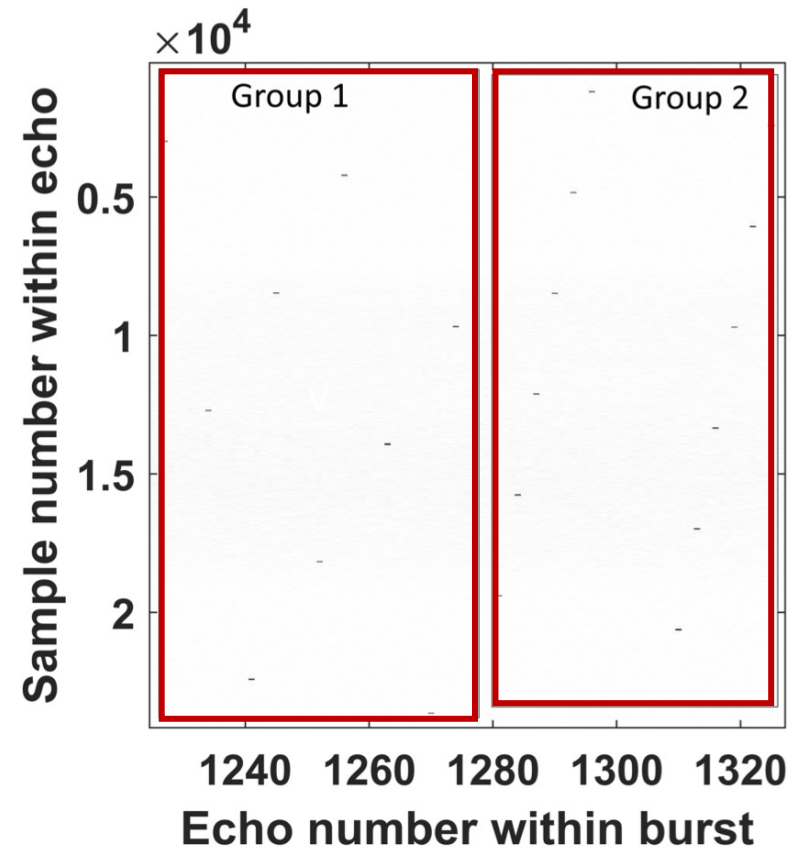
Find radar characteristics



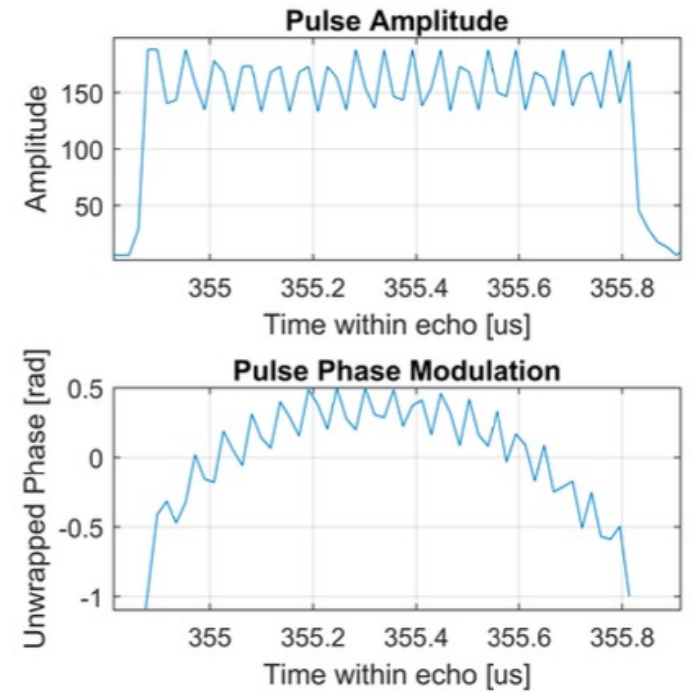
1. Find burst with RFI



2. Locate RFI groups in level-0 data

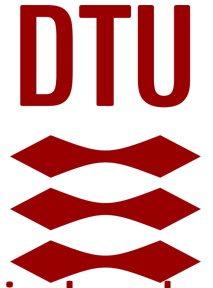


3. Manually analyse single pulse in group

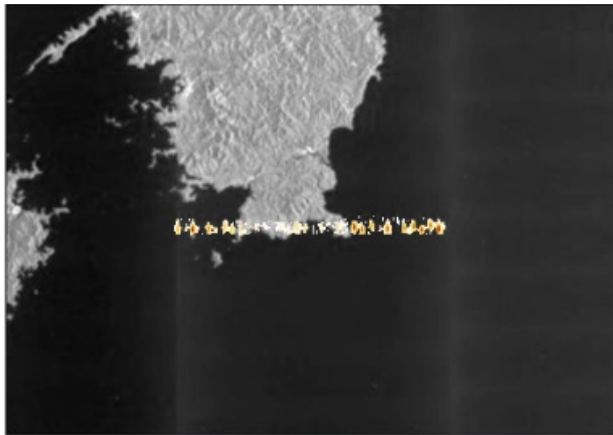


Extract some information

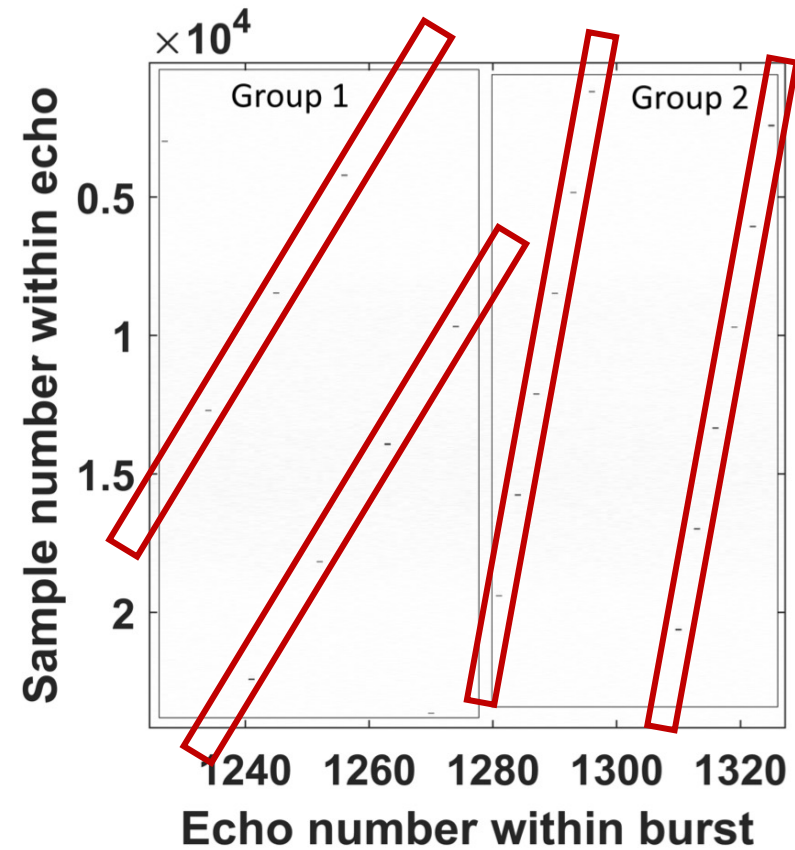
Find radar characteristics



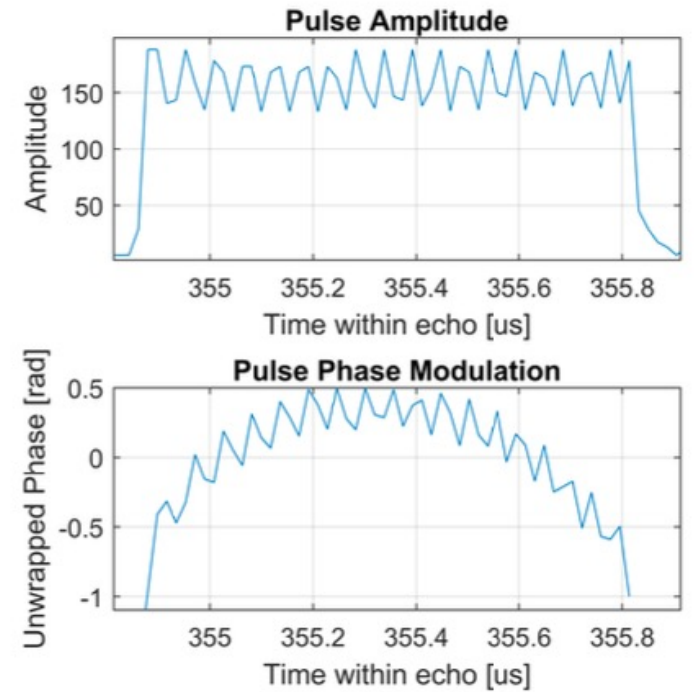
1. Find burst with RFI



2. Locate RFI groups in level-0 data

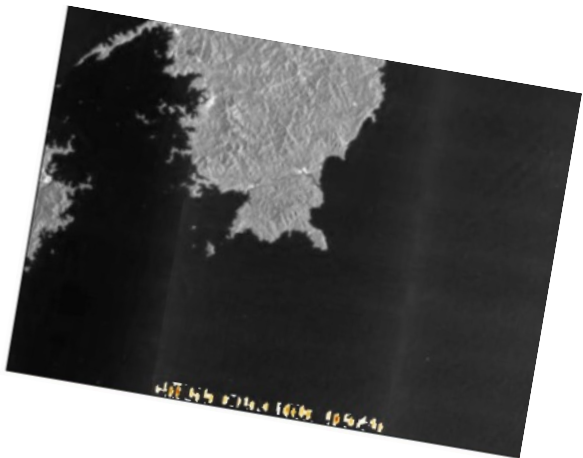
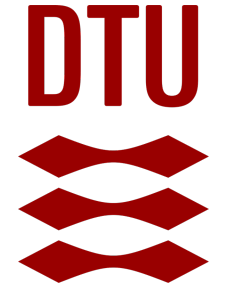


3. Manually analyse single pulse in group



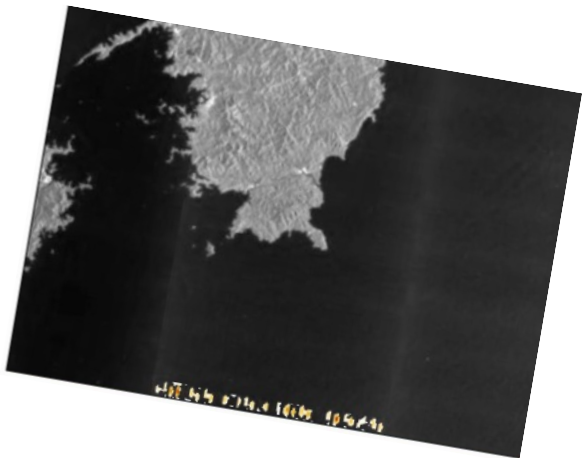
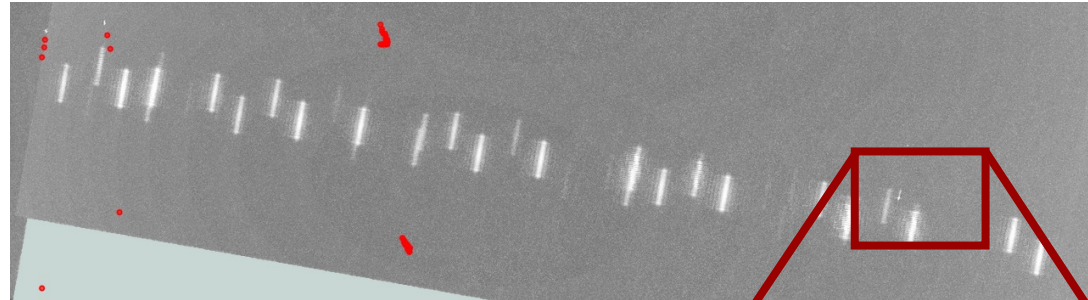
Finding Ship Radars in SAR images:

Example of RFI signal near Japan



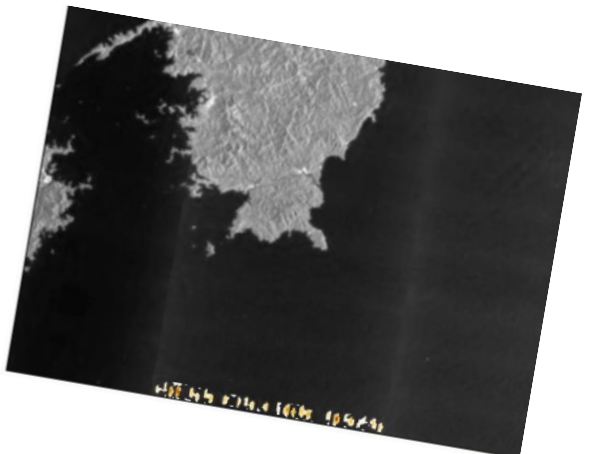
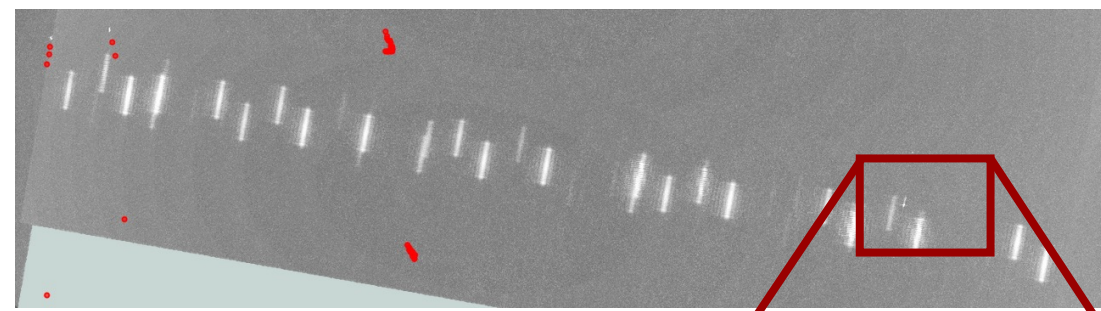
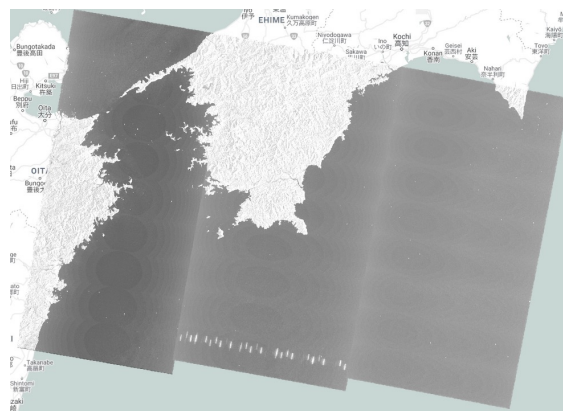
Finding Ship Radars in SAR images:

Example of RFI signal near Japan



Finding Ship Radars in SAR images:

Example of RFI signal near Japan



Comparing AIS with SAR:

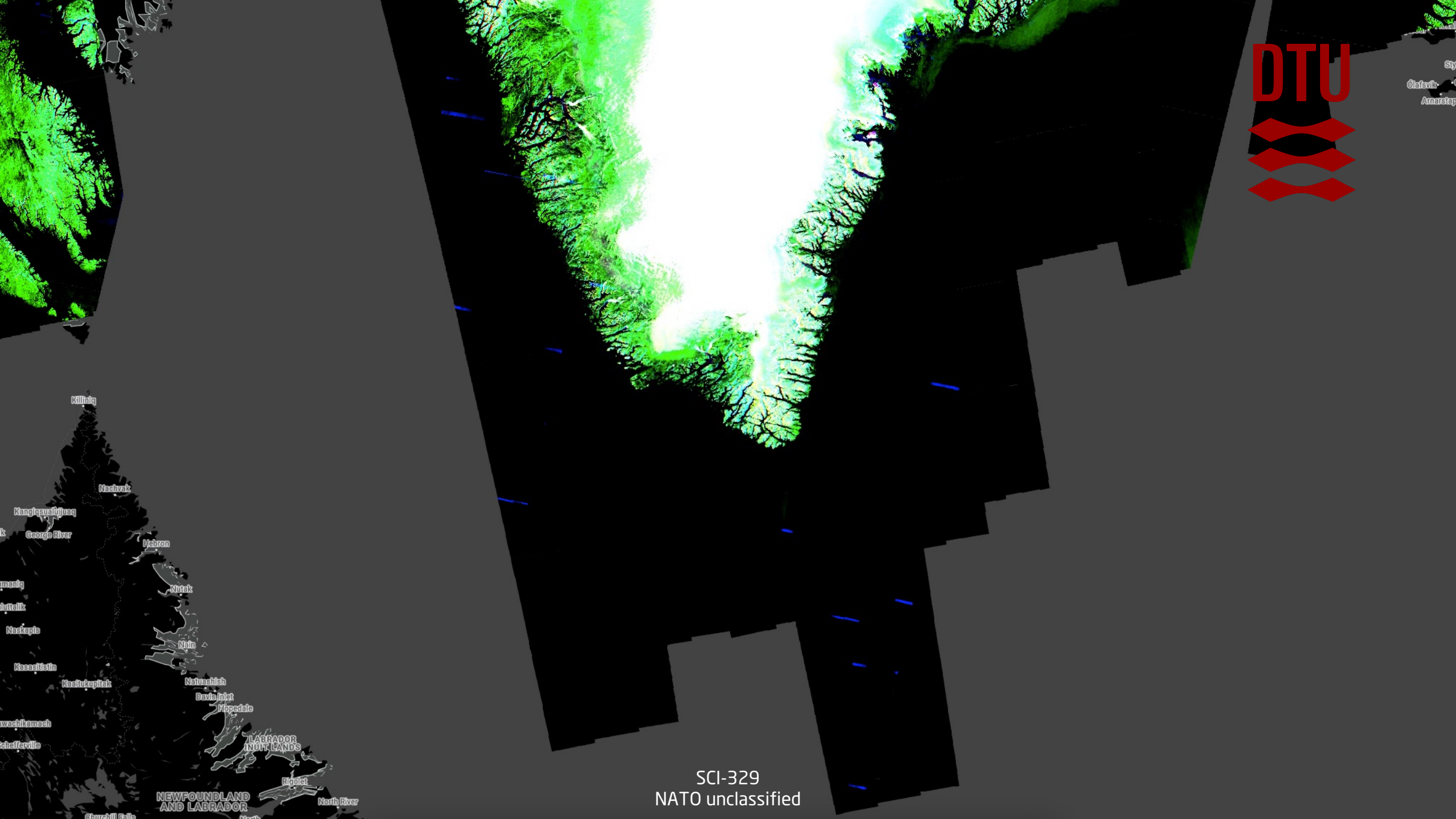
- Dark ship

Analysing SAR image:

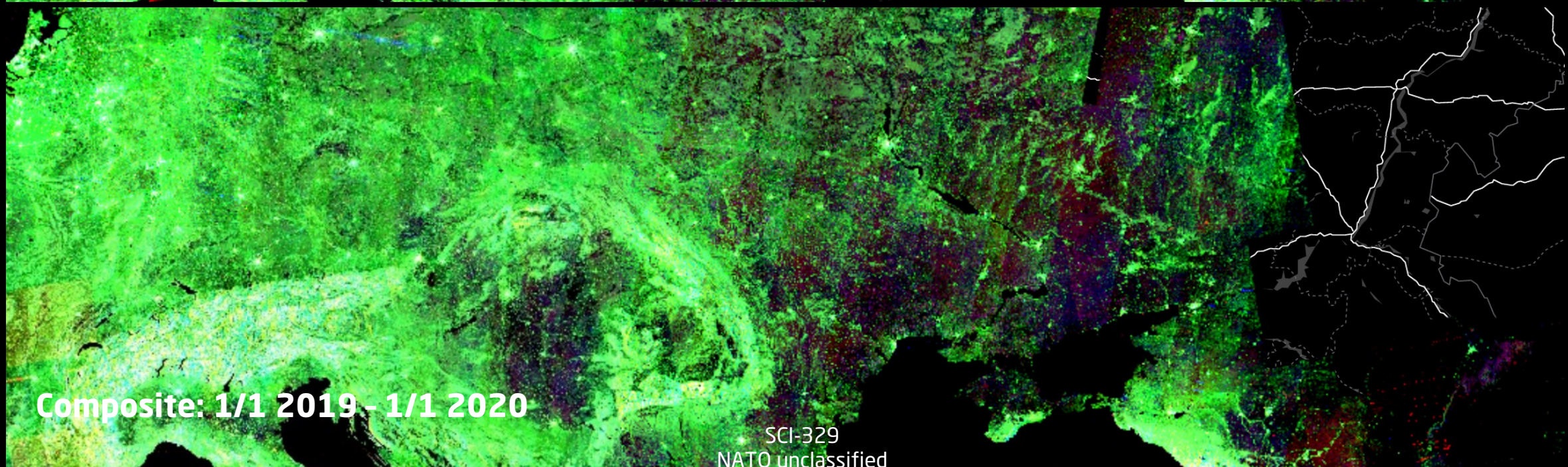
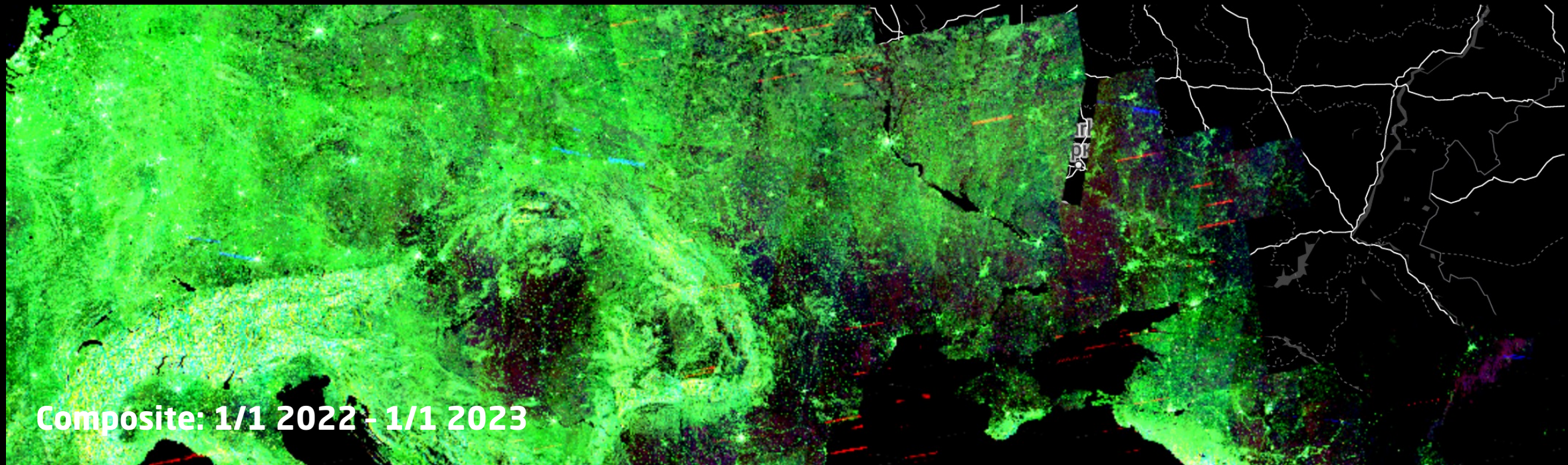
- Approx. length of 240 m

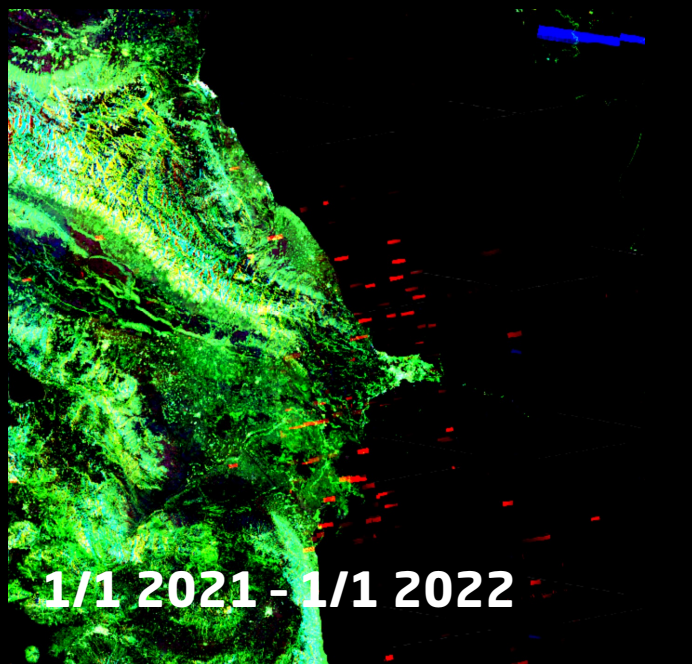
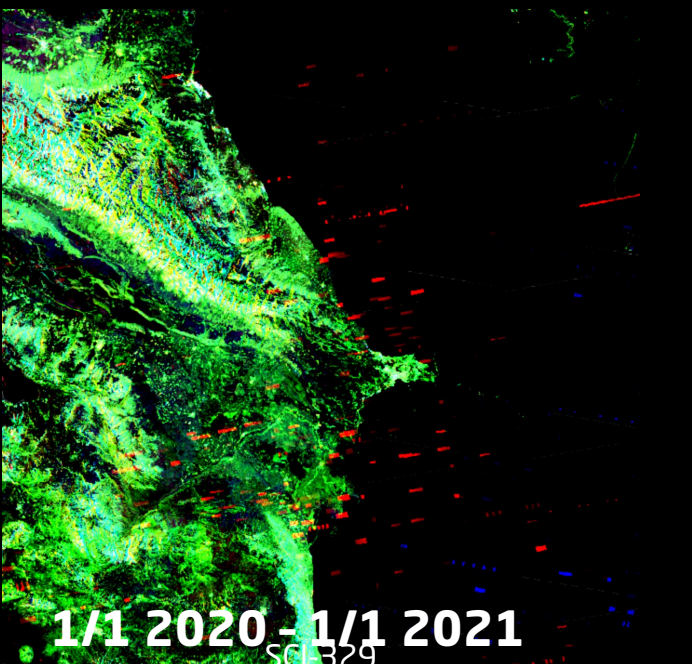
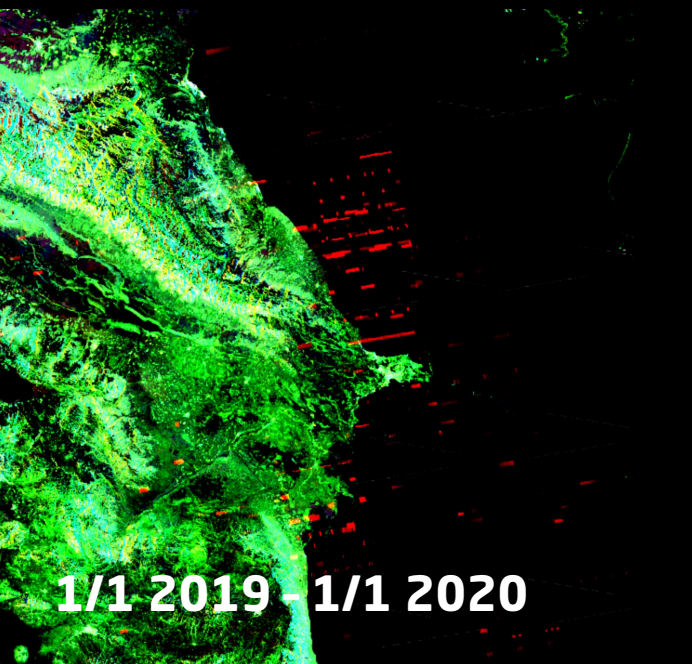
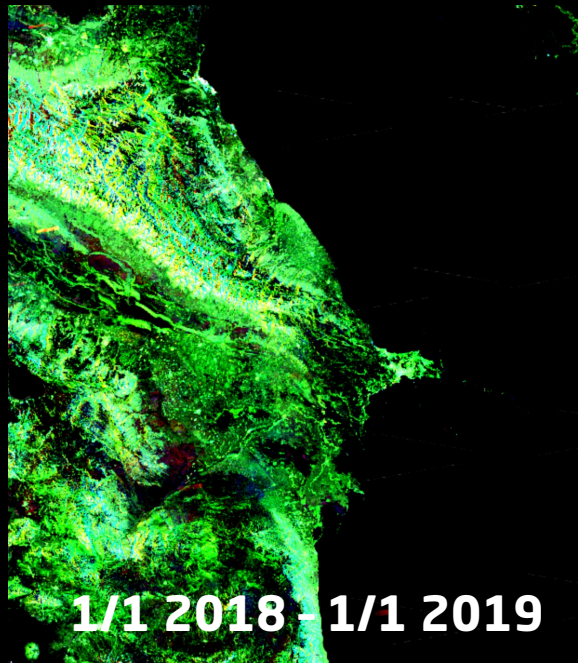
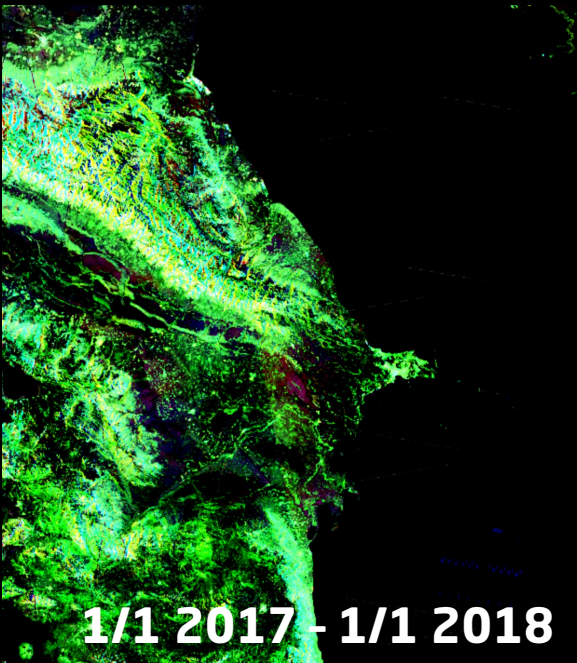
Analysing raw data:

- Horizontally polarized radar
- Pulse width: 1 μ s
- Varying Pulse Repetition Frequency 400/500 Hz



SCI-329
NATO unclassified



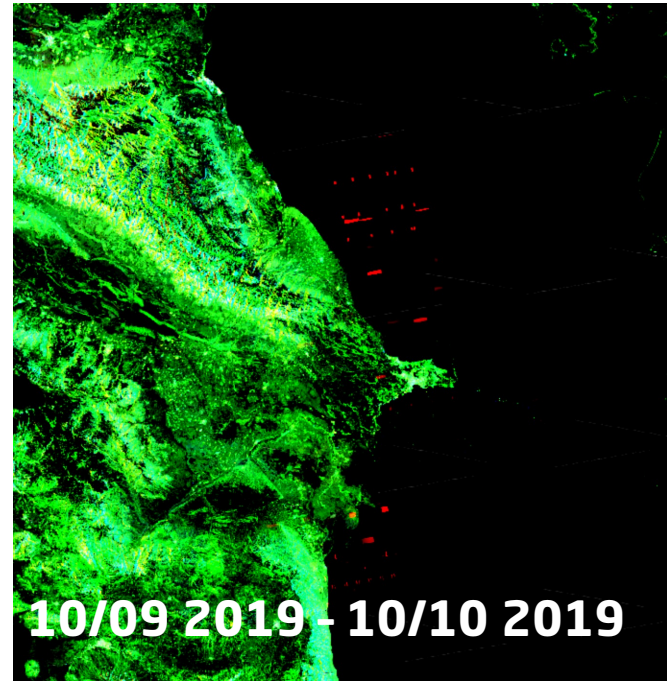
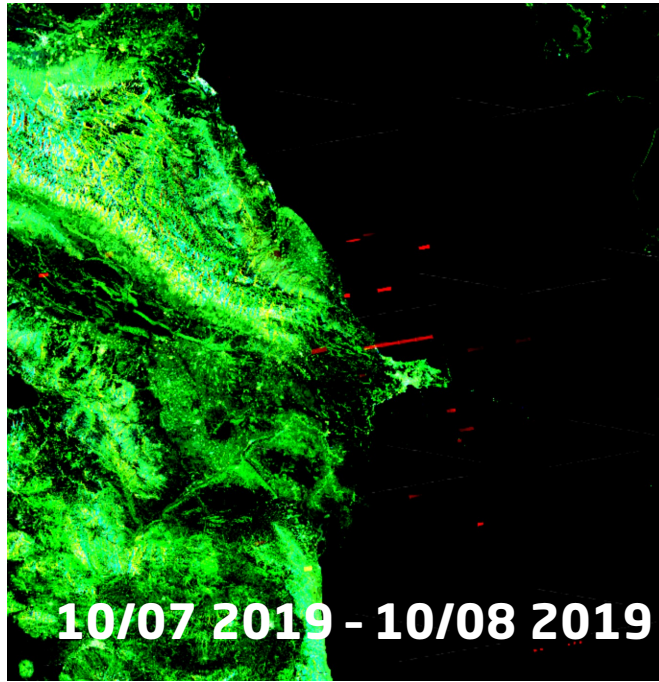
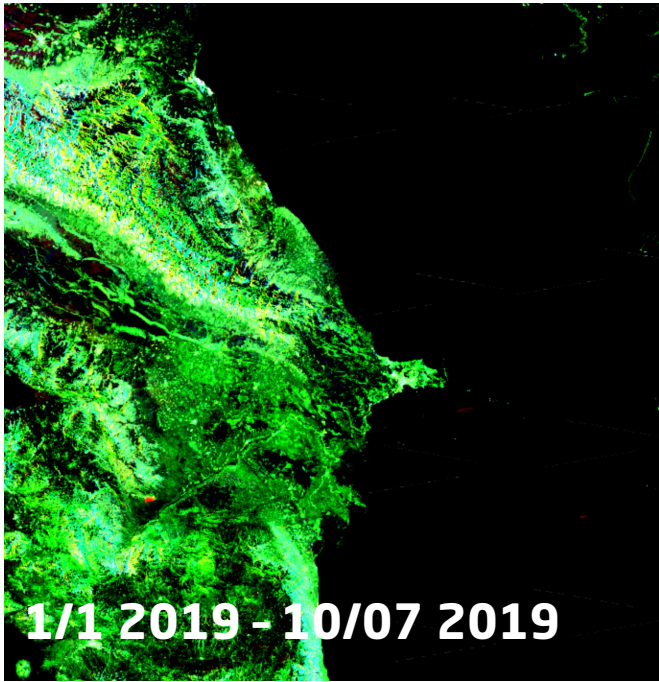


Detect on-ground radars in SAR images

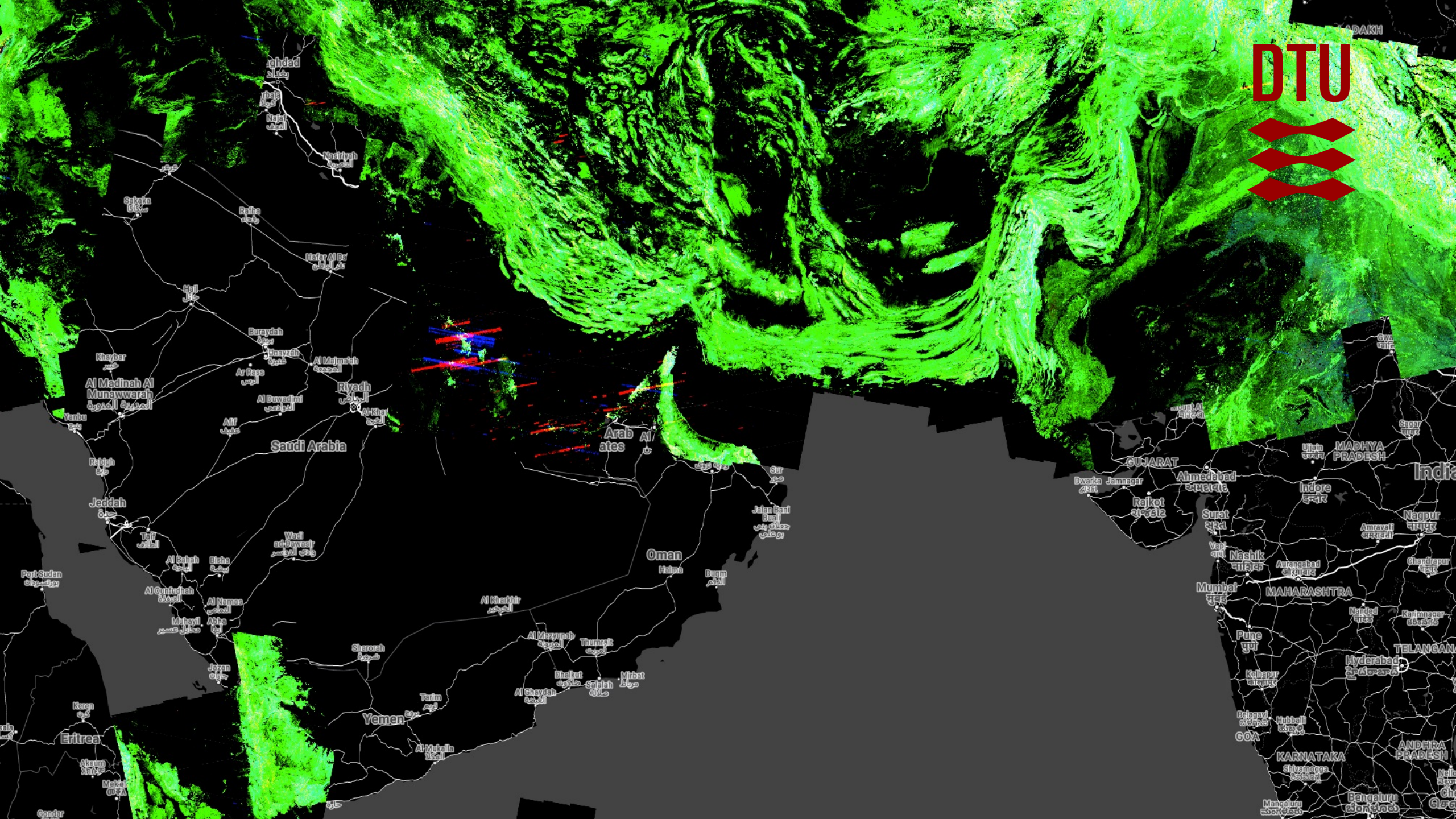
Kristian Aalling Sørensen, Anders Kusk, Peder Heiselberg, Henning Heiselberg
National Space Institute of Denmark,
Center for Security

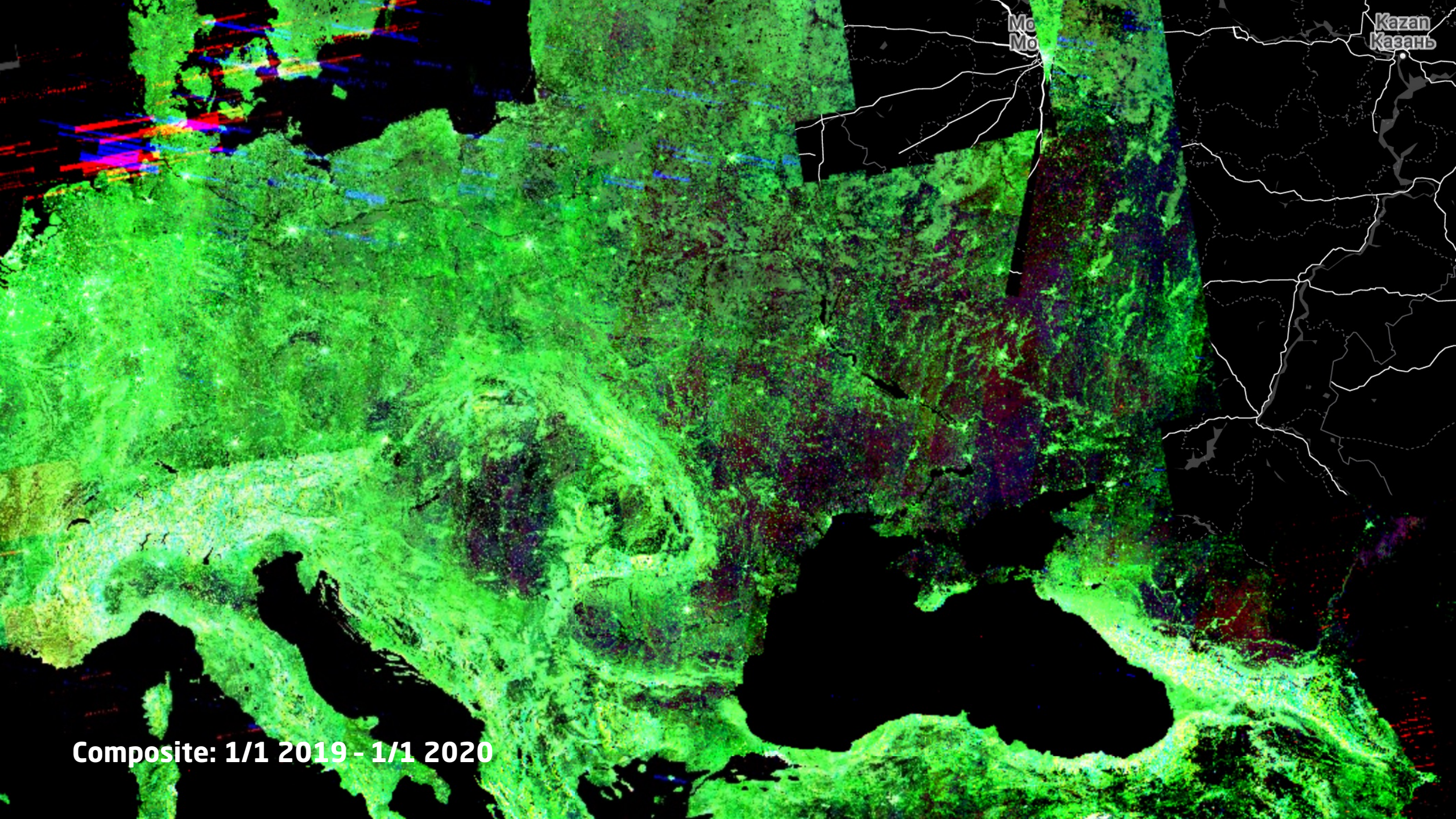
Detect on-ground radars in SAR images

Kristian Aalling Sørensen, Anders Kusk, Peder Heiselberg, Henning Heiselberg
National Space Institute of Denmark,
Center for Security

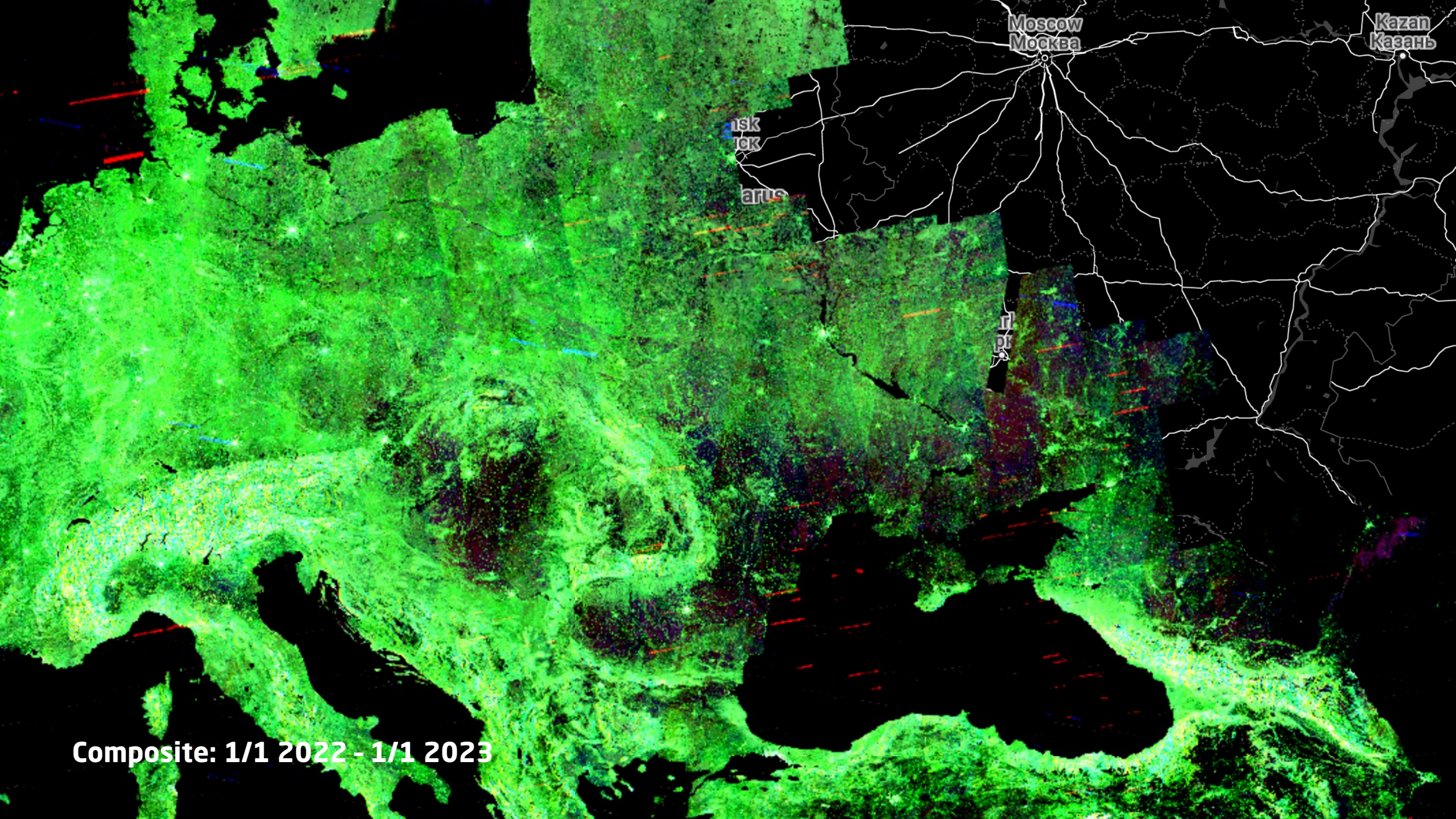


DTU





Composite: 1/1 2019 - 1/1 2020



Moscow
Москва

Kazan
Казань

Nizhny
Новгород

Yaroslavl

Pr
Pr

Composite: 1/1 2022 - 1/1 2023

Extract some information

Pulse group characteristics

