AI4SAR – project results

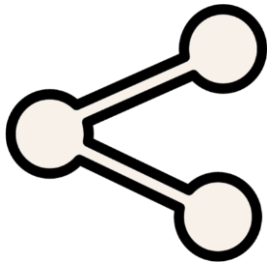
EODC: Alena Dostalova, Senmao Cao, Christian Briese
JR: Karlheinz Gutjahr, Sead Mustafic, Katharina Hofer-Schmitz, Ana Gregorac
TUW: Anice Jahanjoo, Maximilian Thiessen, Thomas Gärtner
Airbus: Wolfgang Koppe, Tatjana Bürgmann, Anna-Lena Erdmann

AI4SAR introduction

Project objectives

1. Develop an advanced pre-processing of SAR data based on AI to reduce the speckle effect.
2. Concept utilisation to filter the complex-value SAR data for advanced interferometry.
3. Develop sub-pixel SAR-to-optical matching techniques based on AI resp. ML methods.

To **demonstrate** the usability and to **validate** the products via UCs:



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1. **Data Cube ingestion** to facilitate distribution of the data.
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4. **GCP transfer** from SAR to optical images.

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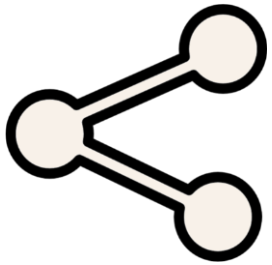

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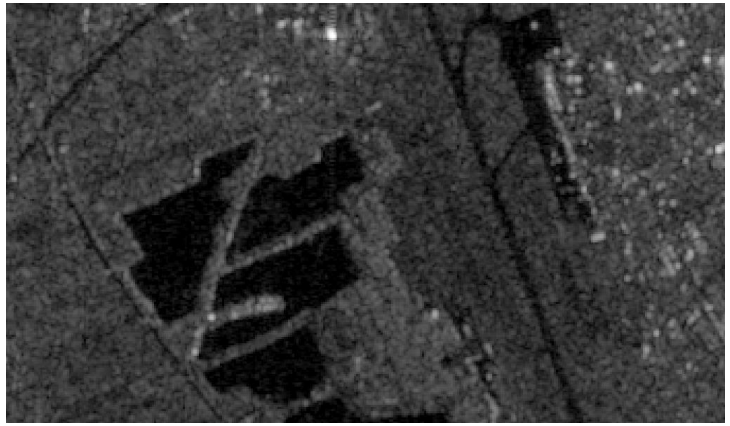
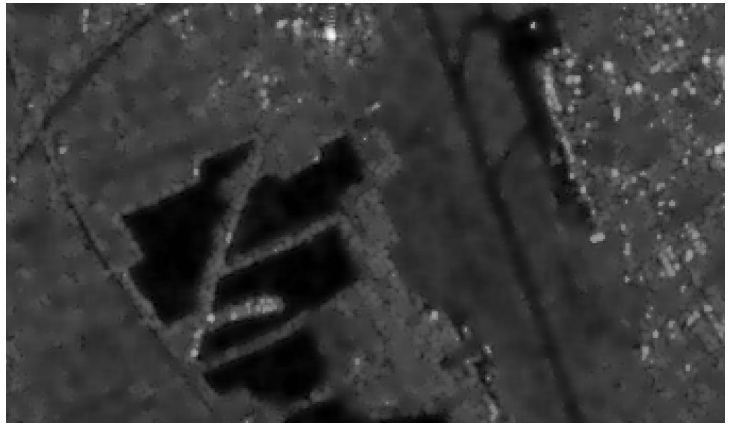
Advanced SAR pre-processing

- SAR images contain speckle: arises from local constructive or descructive interference -> homogenous areas appear „noisy“
- Many methods for reducing speckle – some can lead to oversmoothing/blurring the image
- Goal: develop AI based speckle filter for SAR backscatter images and publish this dataset



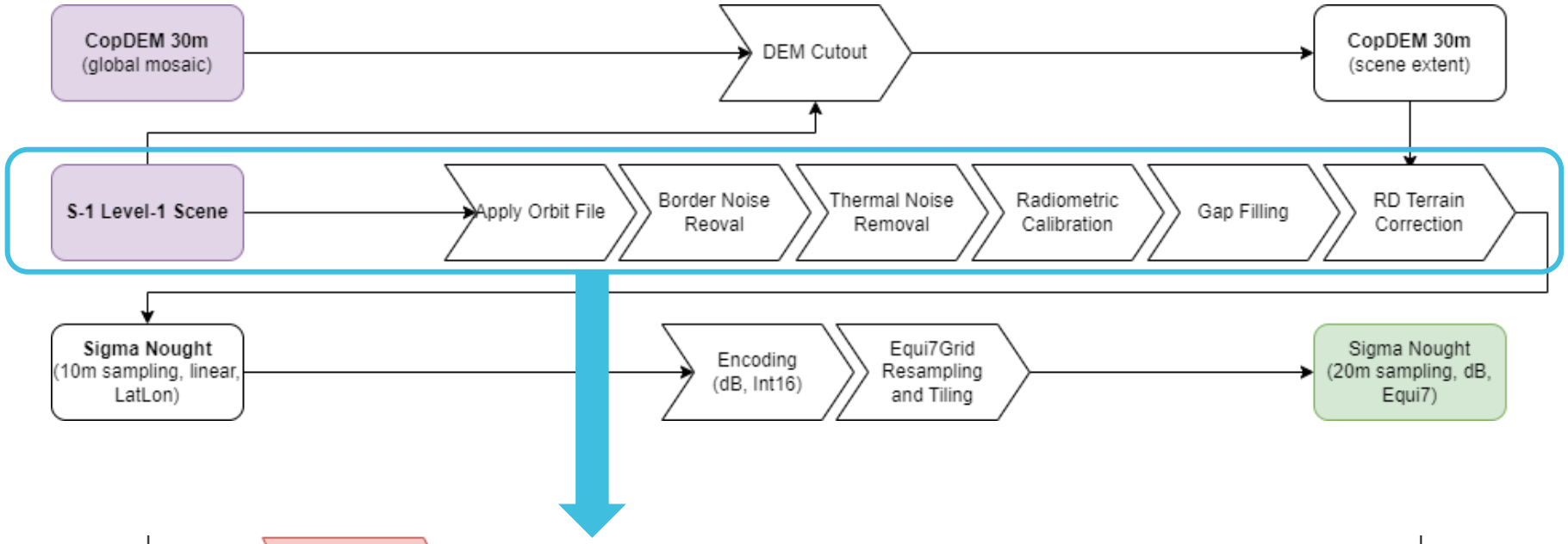
Example image from 1st March 2021



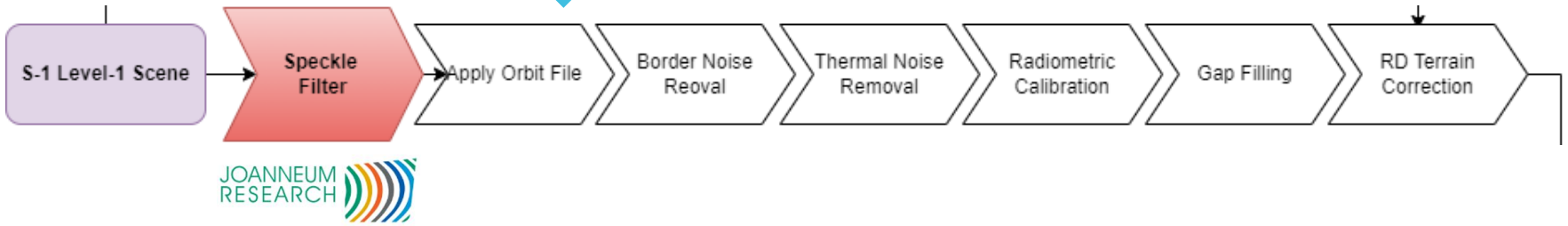
Applied Lee filter (speckle filter based on local statistics)

Advanced **SAR pre-processing**

Standart SAR pre-processing chain

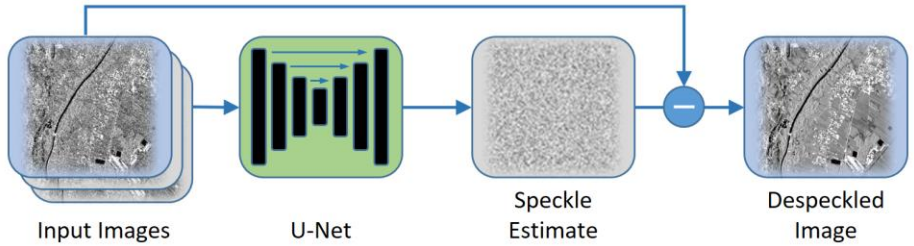


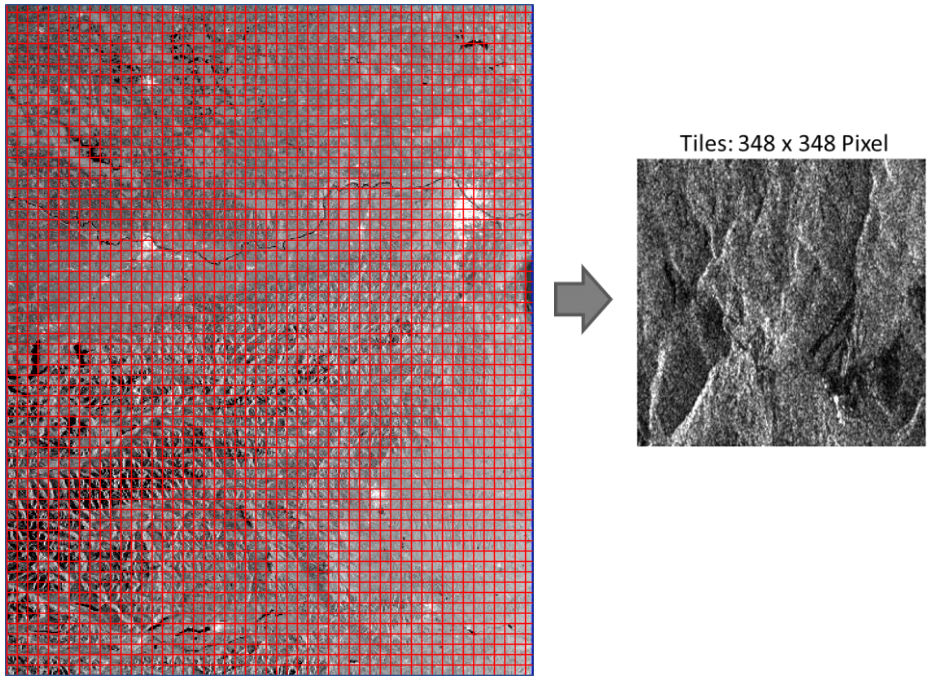
Advanced SAR pre-processing chain



Speckle filter

- U-Net Neural Network adaptions for SAR despeckling
  - Learn speckle noise
  - U-NET depth
  - Loss function
  - U-NET n (more input images)
- Improve training
  - Select tiles using additional thresholds
  - Include LULC map
- Train VV and VH separately

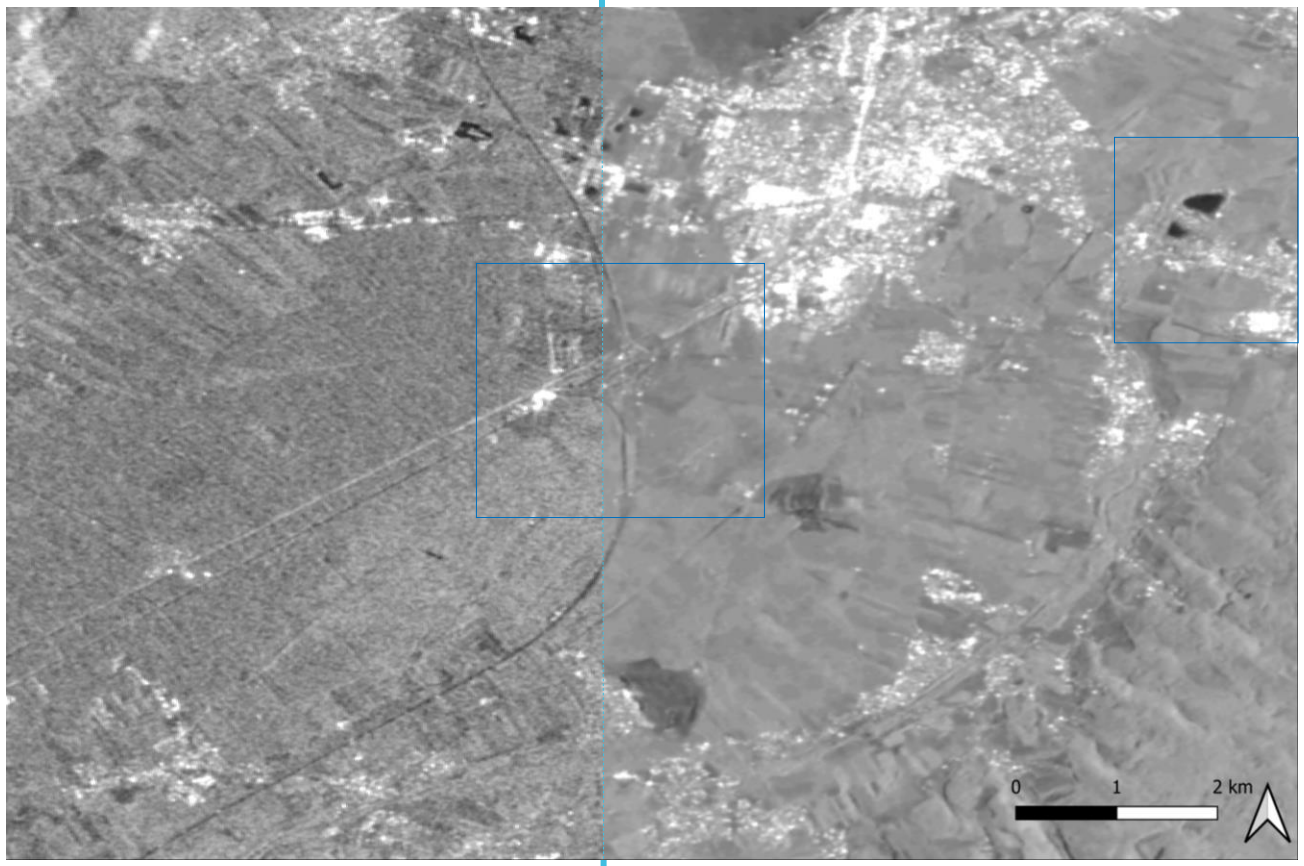


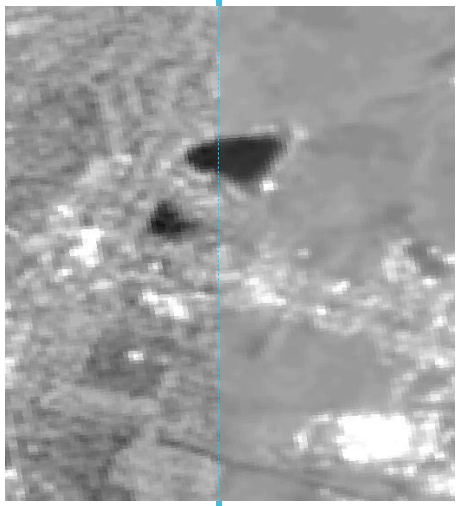


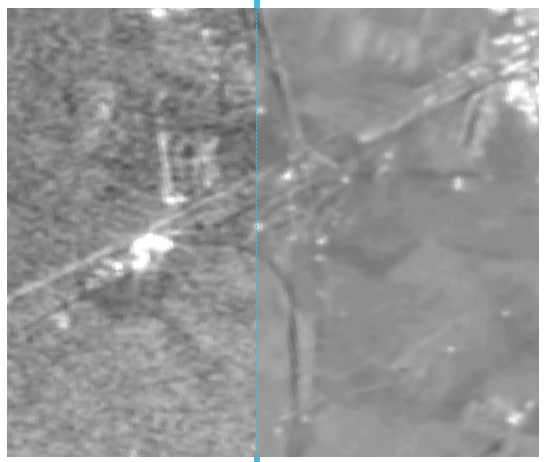
Advanced SAR pre-processing

Original

Including the AI4SAR speckle filter

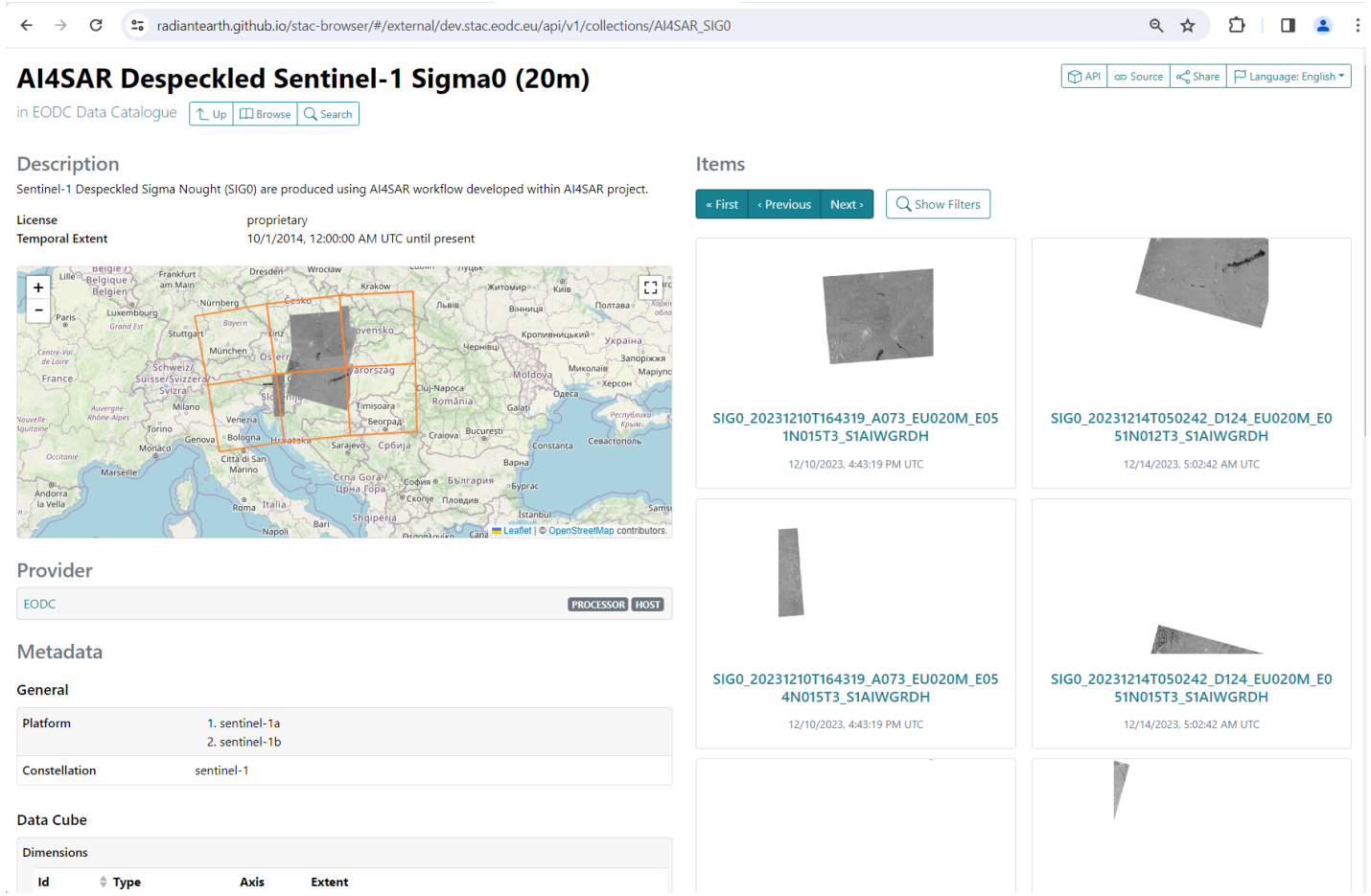






Sentinel-1, 02/12/2023, VV polarization

Dataset publication



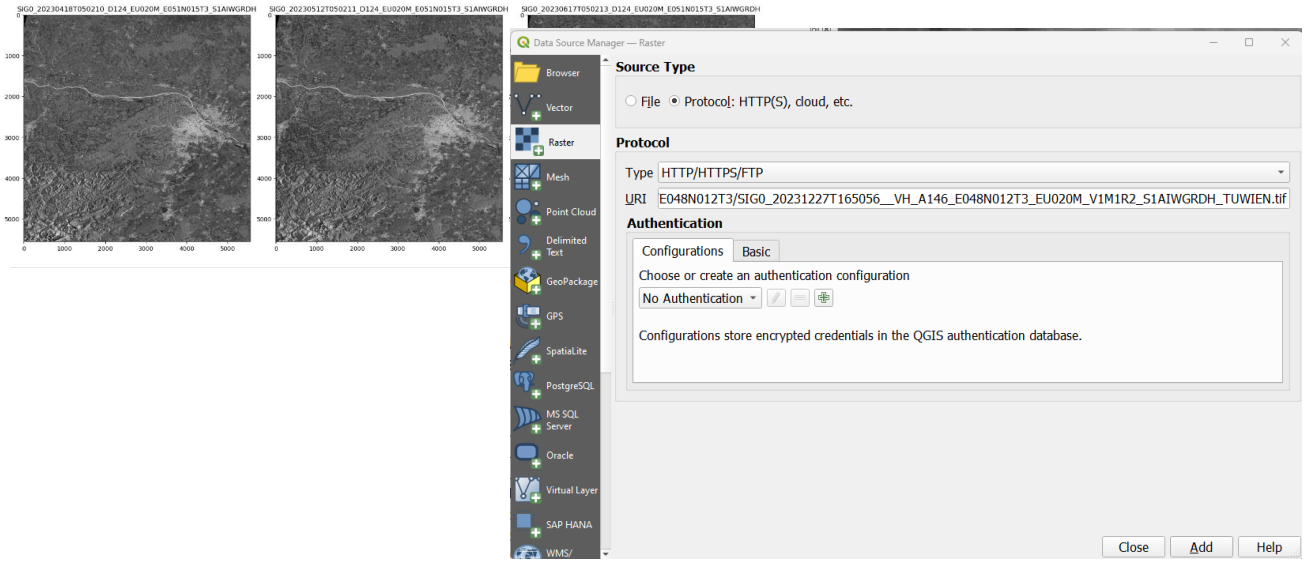
STAC
SpatioTemporal
Asset Catalog

- STAC: SpatioTemporal Asset Catalog:
  - STAC is a specification to describe geospatial raster data using JSON
  - Focus on search and discovery
  - Physosophy of STAC: simple, yet flexible and extensible

Dataset publication

- STAC collection: AI4SAR_SIG0[1]:
  - AOI: Eastern Austria, year 2023
- Exploring options:
  - Search and download
  - Importing to QGIS without download by copying the item URL
  - Jupyter Notebook showing how to access/load/plot dataset[2]

```
In [12]:
fig1 = plt.figure(figsize=(18, 6))
#fig1.suptitle('AI4SAR Sigma0 VV', fontsize=16)
nodata = -9999

for i in range(3):

    img = sig0_ds.VV[i,:,:].to_numpy()
    name = q_items[i].id

    gray_img = scale_image(img, nodata, vmin=-170, vmax=20)

    ax = fig1.add_subplot(1, 3, i+1)
    ax.set_title(name)
    ax.imshow(gray_img, cmap='gray')


plt.tight_layout()
```



[1] https://radiantearth.github.io/stac-browser/#/external/dev.stac.eodc.eu/api/v1/collections/AI4SAR_SIG0?.language=en
[2] https://github.com/senmao/eodc-examples/blob/main/tutorials/AI4SAR_access_data.ipynb

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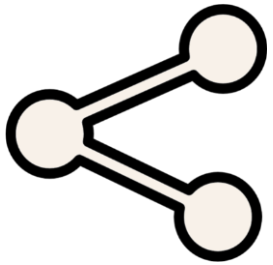

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Forest Monitoring Workflow

Set-up
- Specification of main processing parameters
- Once per orbit / stack

Prepare
- Import, **AI based speckle filtering**, coregistration preparation
- Dynamic update per scene

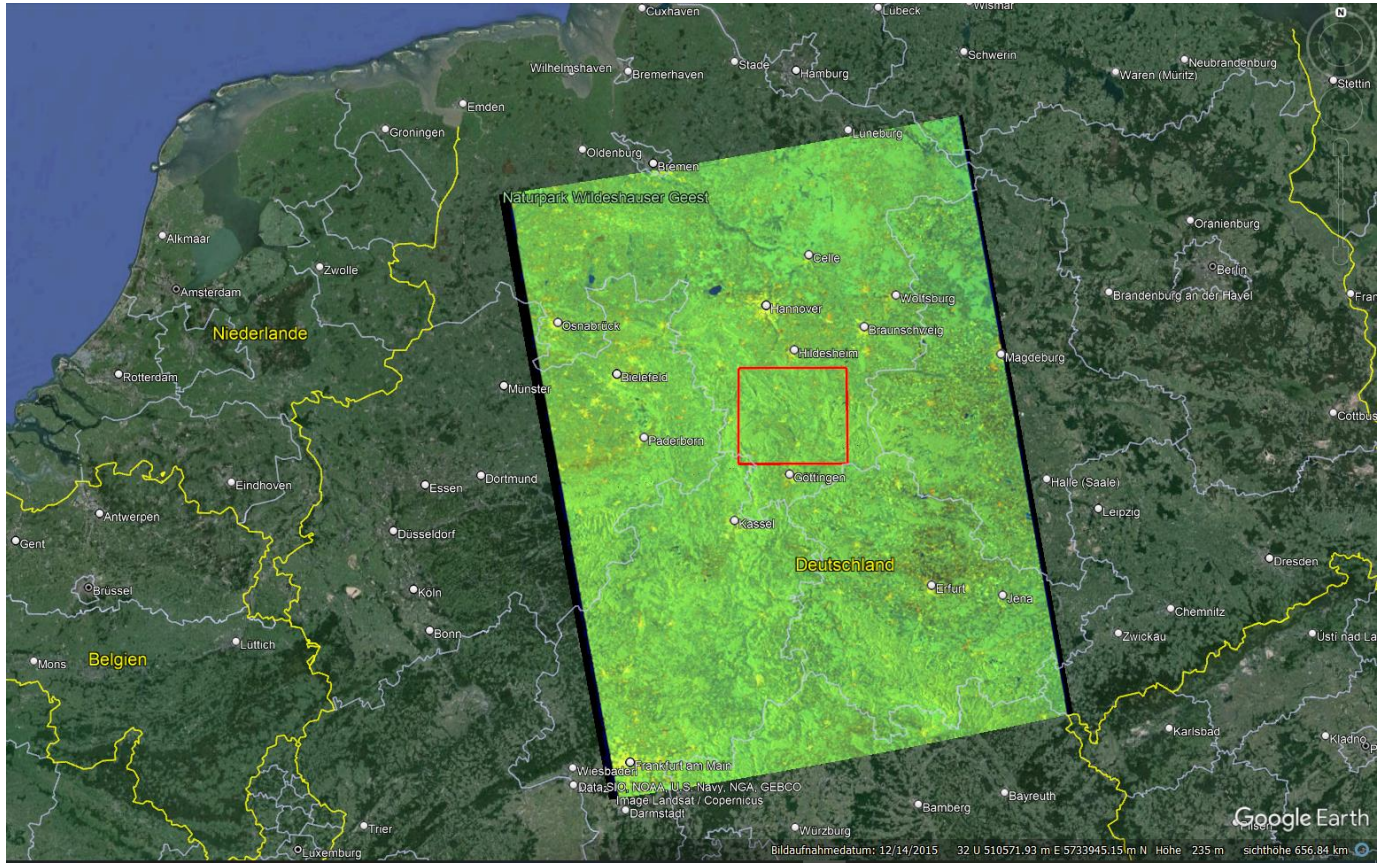
Coreg
- Coregistration, radiometric calibration
- Dynamic update per scene

Stack
- Stacking and **modified** time series analysis
- „Full“ reprocessing in certain intervals

Change
- **Modified** change detection
- „Full“ reprocessing in certain intervals

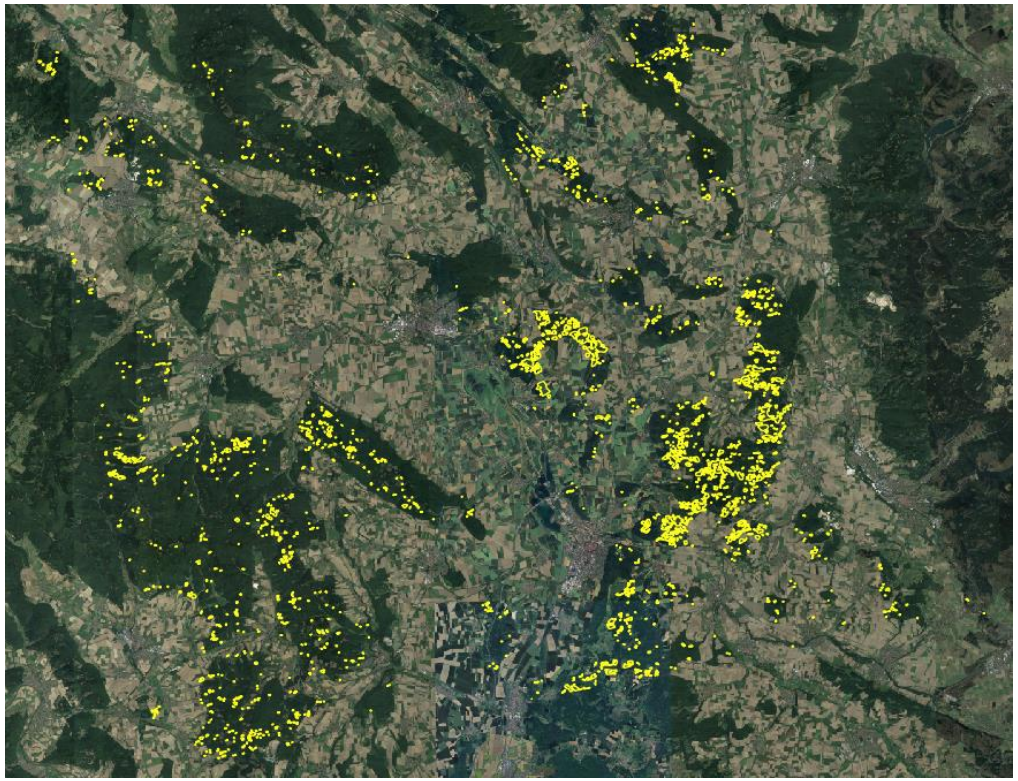
Test Site Germany

- Sentinel-1 data:
  - Ascending orbit 117
  - GRD: 07/2017-09/2018 (25 acquisitions without winter season)
- Reference data:
  - COPDEM 30m
  - Copernicus HRL forest mask 2015 and 2018
  - Forest damage assessment
  - Damage assessment from two flight campaigns

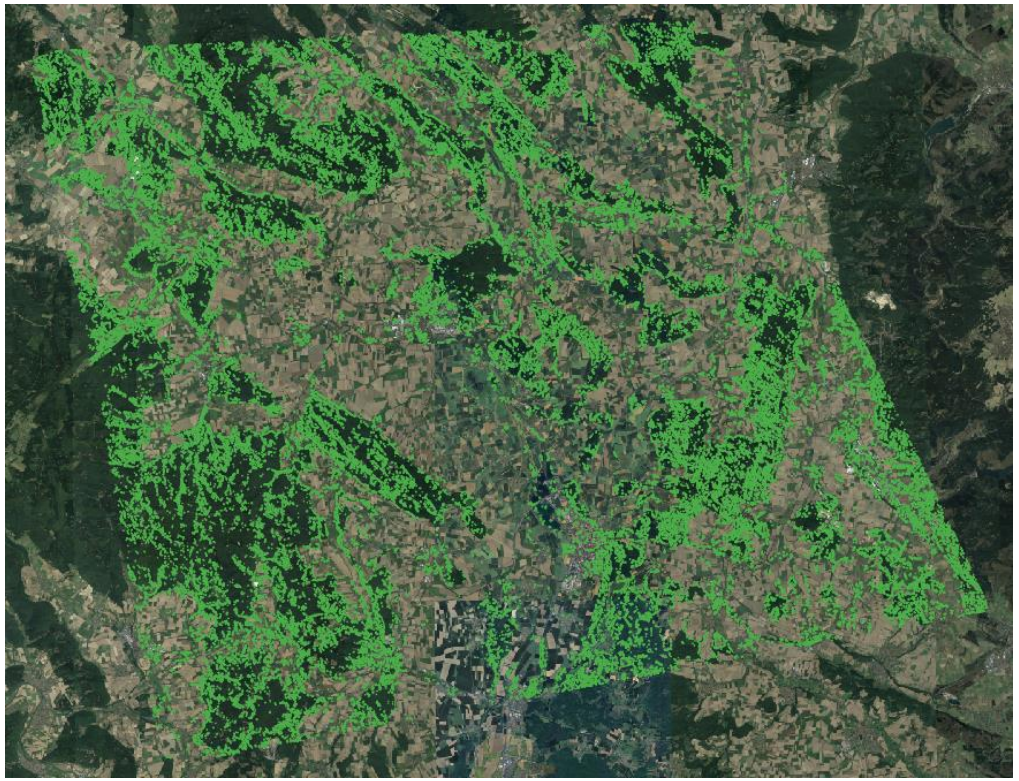


Sentinel-1 VV – AI Speckle Filter – Test AOI

Reference forest damage mask



Detected S1 changes VV – AI filter in forest mask 2015



Confusion Matrix VV Polarization

Without Speckle Filter

Accuracy = 94,30%

			Sentinel-1 VV	
			No Change	Change
		21417126	20339268	1077858
Airborne surveys	No Change	21066877	20092400	974477
	Change	350249	246868	103381

With Speckle Filter

Accuracy = 95,01%

			Sentinel-1 VV	
			No Change	Change
		21417126	20974697	442429
Airborne surveys	No Change	21066877	20707216	359661
	Change	350249	267481	82768

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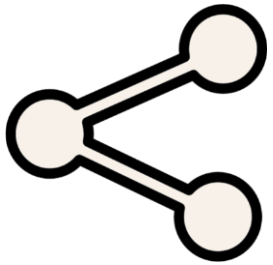

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SuLaMoSA Workflow

Set-up
- Specification of main processing parameters
- Once per orbit / stack

Prepare
- Import, coregistration preparation
- Dynamic update per scene

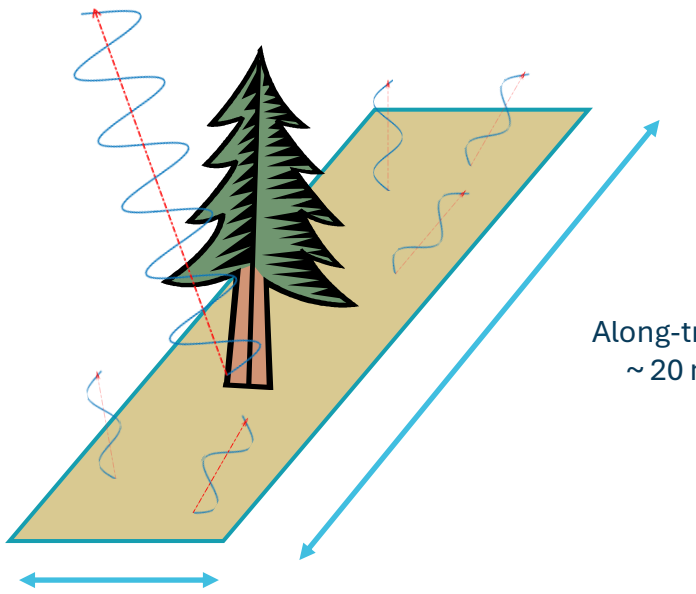
MTI
- Coregistration, PS interf. generation, **sibling detection** and SB interf. generation **using siblings**
- „Full“ reprocessing in certain intervals

SBAS
- Extraction of displacement
- „Full“ reprocessing in certain intervals

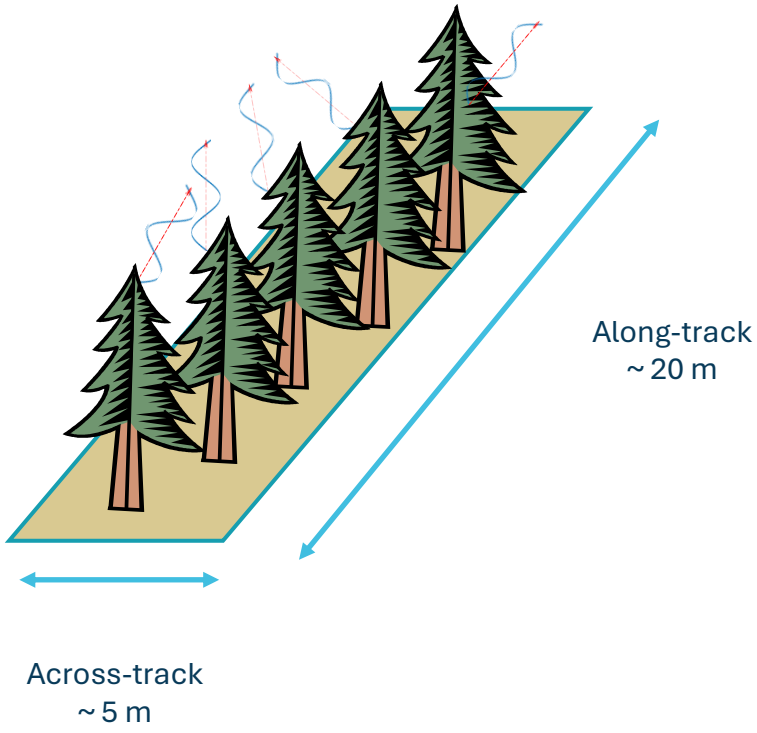
Merge
- Combination of asc&dsc displacement
- „Full“ reprocessing in certain intervals

Scattering Mechanism (Resolution Cell)

Point scatterer



Distributed scatterer

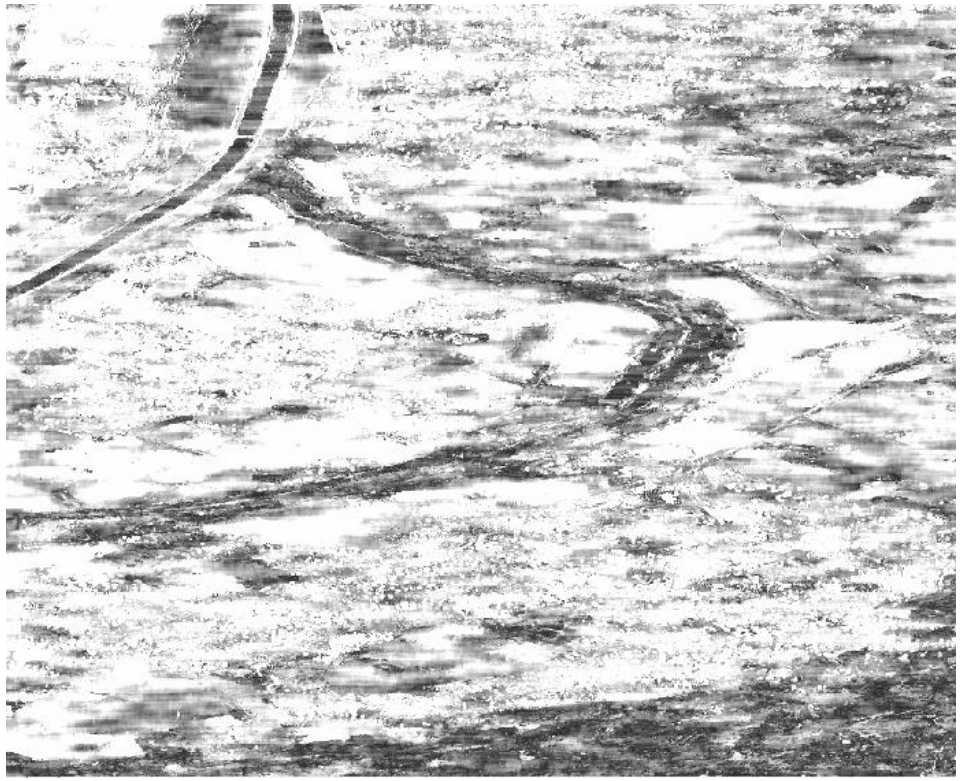


Wave length: 5.5 cm

Coherence 7 x 31: Zoom-in

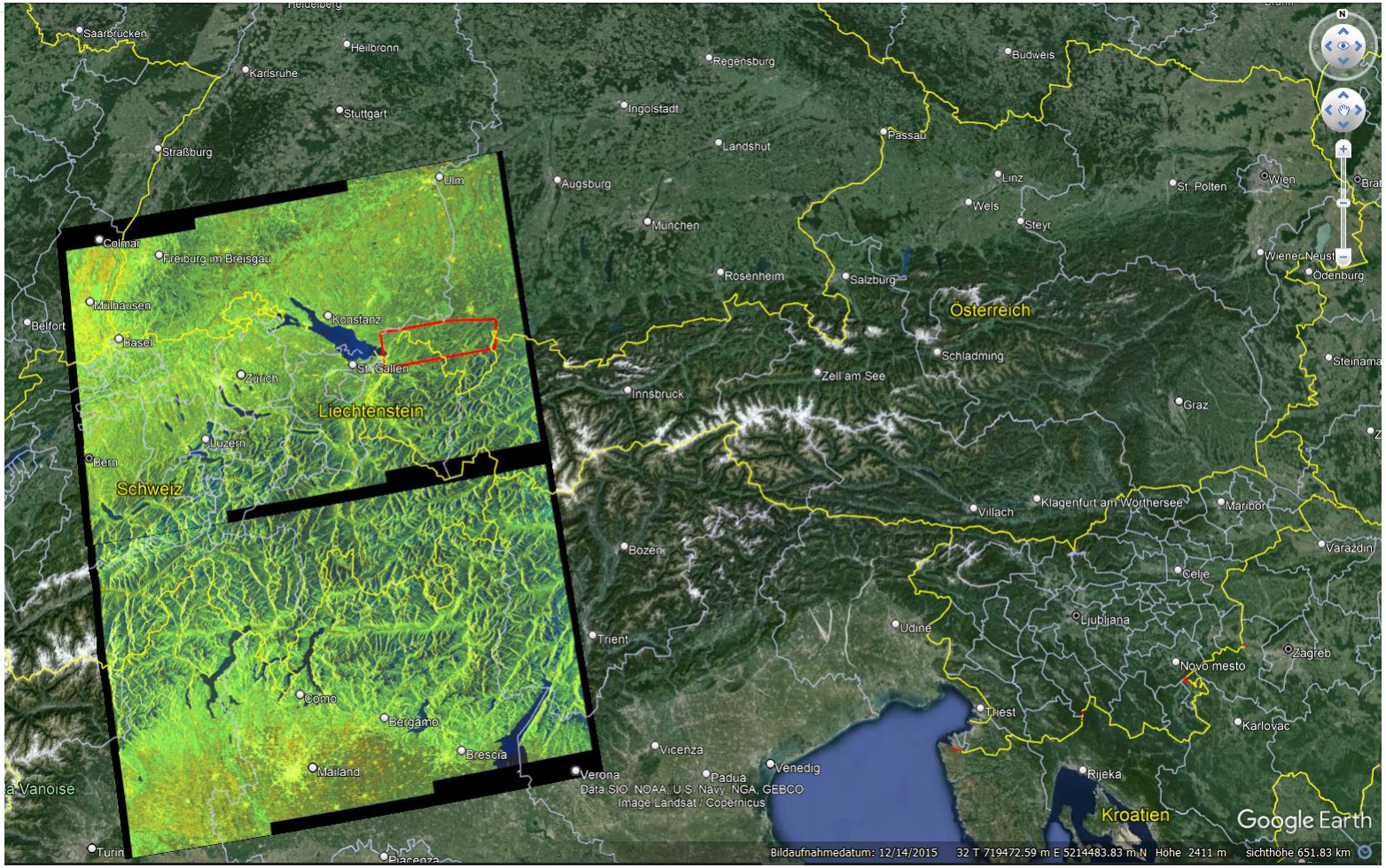
Boxcar (single look)

AI Sibling (single look)



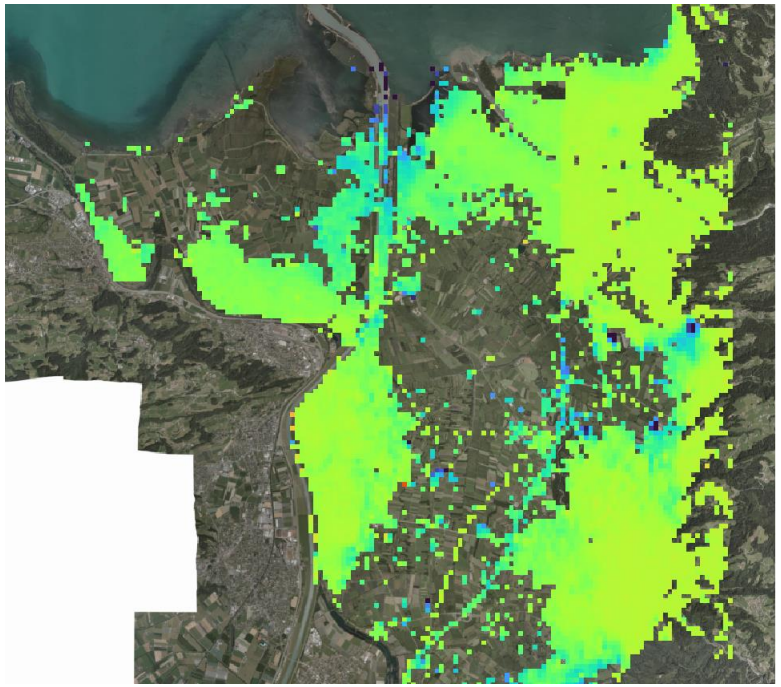
Test Site Austria

- Sentinel-1 data:
  - Ascending orbit 15
  - SLC: 03/2017-09/2022 (304 acquisitions)
- Reference data:
  - DEM
  - EGMS

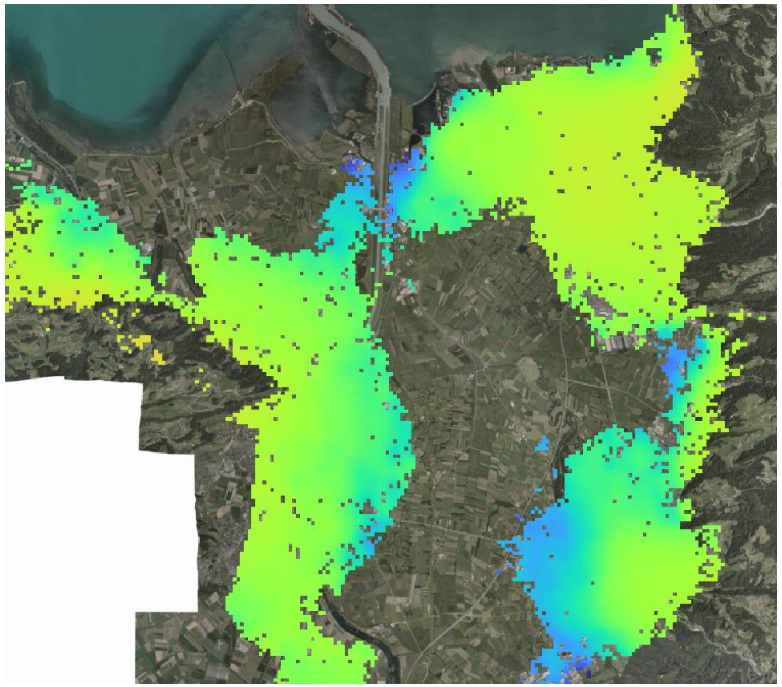


Mean Deformation

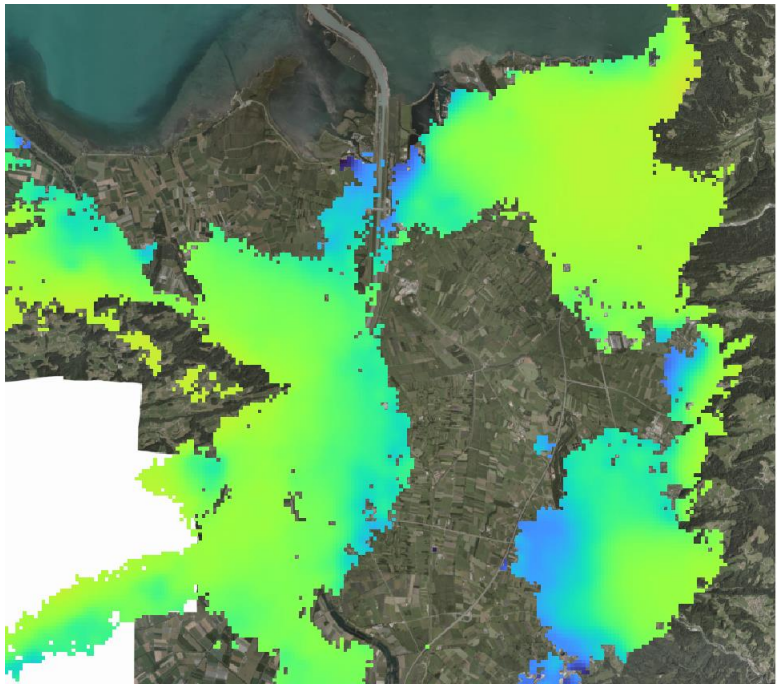
EGMS L3



SuLaMoSA



SuLaMoSA + AI4SAR



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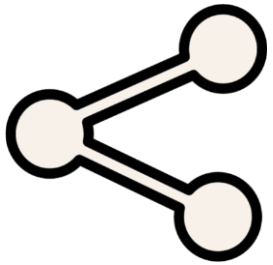

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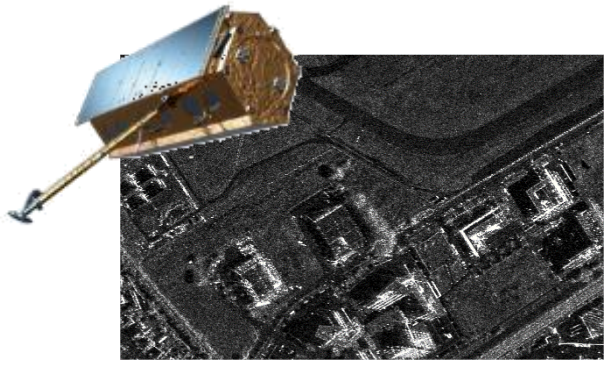
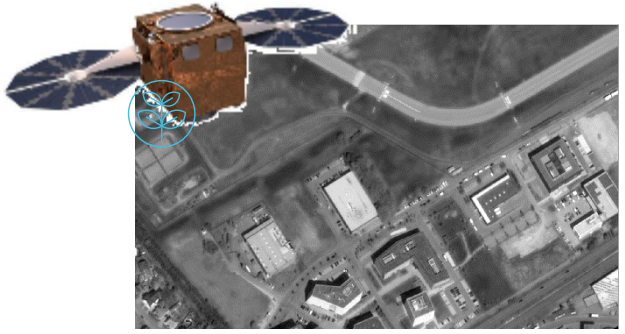
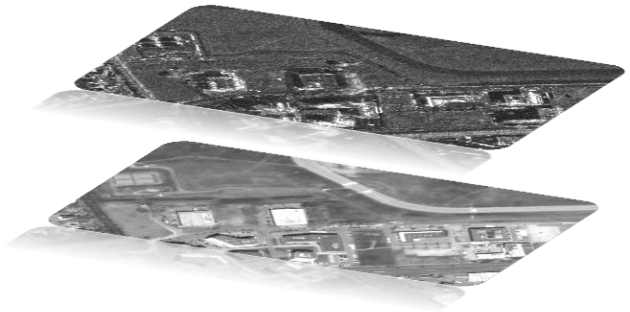
Complementary Information of SAR and Optical Satellite Imagery

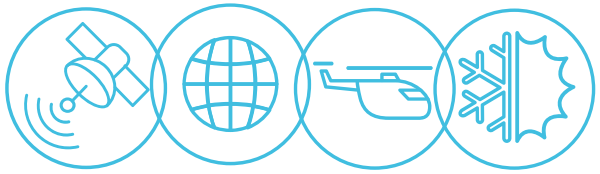


- Independent of clouds
- Physical surface properties
- Geolocation accuracy



- Intuitive interpretation
- Chemical surface properties
- Multispectral

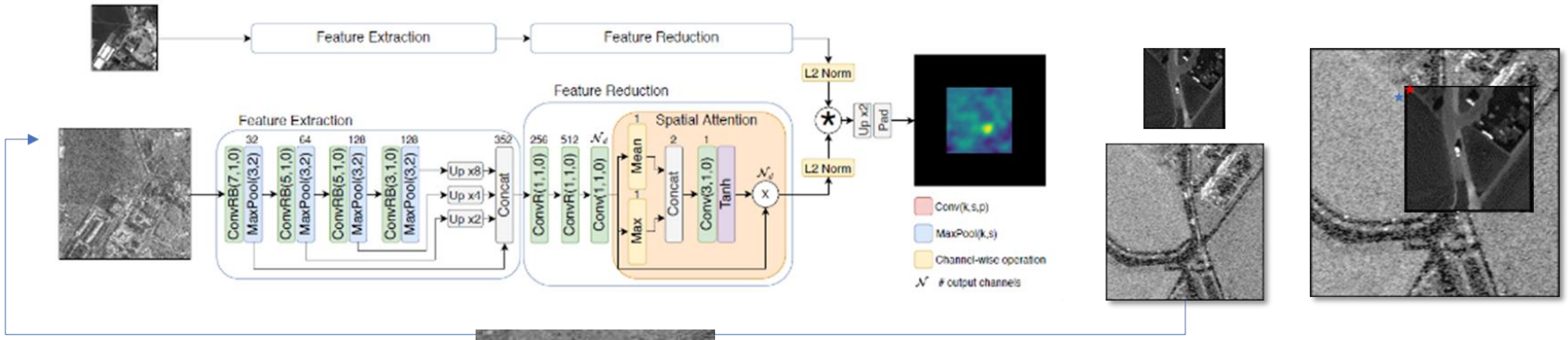


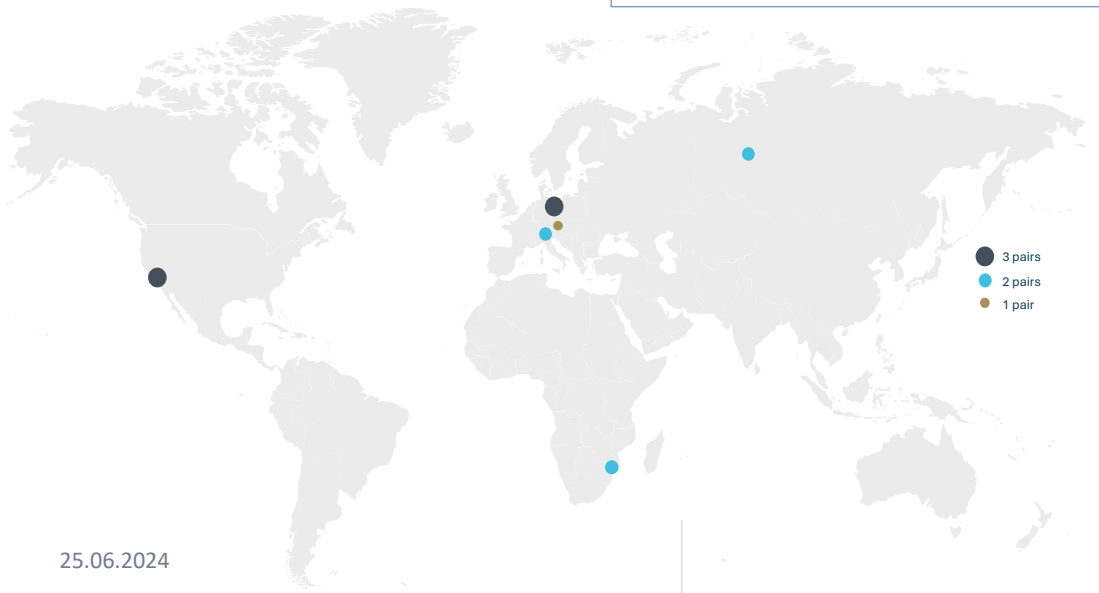


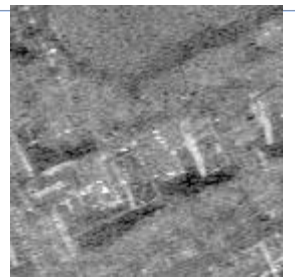
Deep Learning Approach

Training Dataset → Train the Neural Networks "from scratch" → Inference on Test Dataset → Matched Images

SOMatch by Hughes et al. (2019)







- 13 Image Pairs across 6 locations
- TerraSAR X GEC SE Staring Spotlight 0.22 m
- Pleiades Pan (0.2m) / Pleiades Neo (0.5m)
- Co-registration residual: 1.2 m

Location of Well-matched Patches


eodc
Earth Observation
Data Centre
Thank you for your attention