SAR2CUBE- AN OPEN FRAMEWORK FOR AN EFFICIENT SETUP OF INSAR APPLICATIONS IN ANALYSIS READY DATA CUBES

FRINGE 2023

Authors

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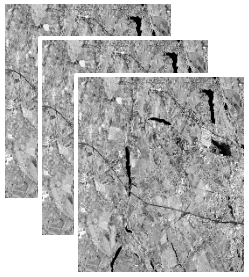
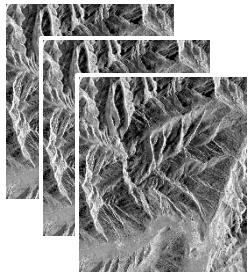
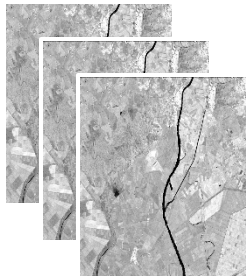
ESA SEOM SInCohMap project

Datasets


West Wielkopolska (Poland)

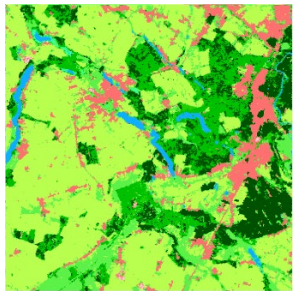

South Tyrol (Italy)

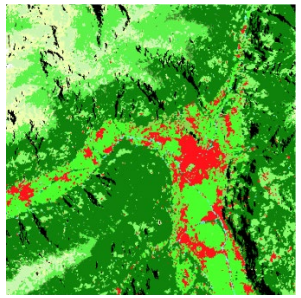

Doñana (Spain)

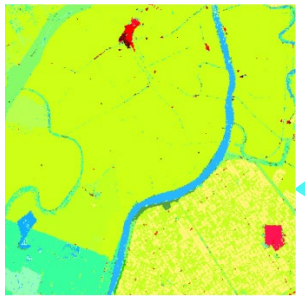
Full SLC and Interferometric dataset stored on disk

- More than 1000 ifg
- More than 1000 coh maps
- More than 1000 ifg phases

Land-cover maps







European Space Agency

eurac research

Universitat d'Alacant
Universidad de Alicante

LIST

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

IGiK

UNIVERSITÉ DE RENNES 1

SAR2Cube
Project definition

DARES

DATA PROVISIONING

Copernicus Open Access Hub

S-1 Quality Control

esa

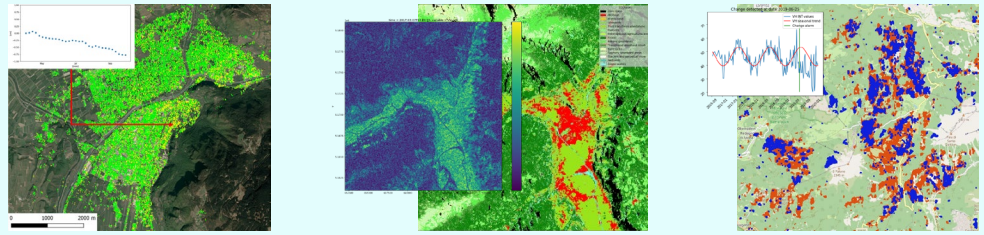
SAR2CUBE

DARES

eurac research

APPLICATIONS DEMONSTRATION

Displacement | Land Cover | Change Detection



JavaScript

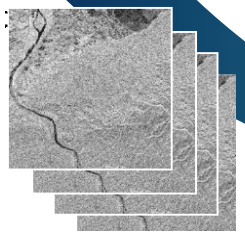
R

python

S-1 Data Acquisition Interface

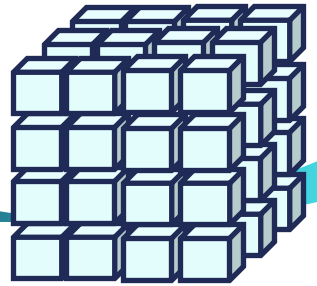
SNAP

Data Pre-Processing



Data Indexing

OPEN DATA CUBE



Applications Interface

OTF Operators

DASK

openEO

DATA PROVIDER PERSPECTIVE

USER PERSPECTIVE

SAR2Cube
Significant Information

List of presentation and other interesting information

- SAR2CUBE in ESA project:
- SAR2CUBE webpage
- SAR2CUBE preprocess gitlab
- Notebook with updated OTF operators
- openEO web editor

List of presentation and other interesting information

- ESA Fringe 2021: "SAR2CUBE: A Data Cube Concept for Providing Both Interferometric and Intensity Based Products through an Open Source Framework" A. Jacob, M. Claus, G. Centolanza, F. Moral, F. Vicente-Guijalba, P. Mougnaud

- Living Planet 2022: "Exploring Time Series of Sentinel-1 Interferometric Coherence in Land Cover Mapping: A Step Forward" J.M. Lopez-Sanchez, M. Busquier, A. Jacob, M. Claus, B. Ventura, C. Lopez-Martinez, L. Yam, G. Centolanza, A. Faridi, E. Makhoul, M. Engdahl

- IGARSS 2023: "SAR2CUBE - AN OPEN FRAMEWORK FOR AN EFFICIENT SETUP OF SAR IMAGERY IN ANALYSIS READY DATA CUBES" M. Claus, A. Jacob, EURAC Research, Italy; G. Centolanza, DARES Technology, Spain; J. M. Lopez-Sanchez, University of Alicante, Spain

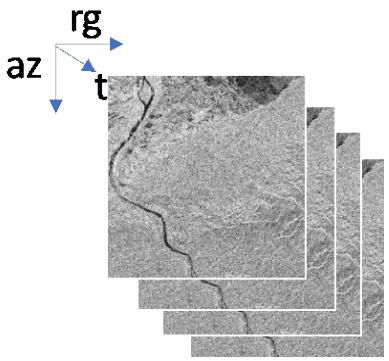
SAR2Cube
Output Unitary Data

DARES

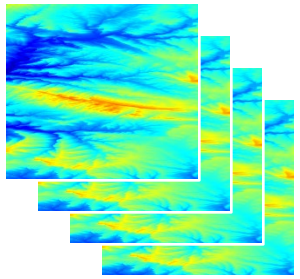
Complex S-1 A/B IW SLC data

Temporal stack of co -registered SLC images as the fundamental unit of the datacube .

- Image alignment
- Radiometric calibration
- S-1 IW mode requires de-swathing and de -bursting
- Dual VV-VH polarizations



SAR2CUBE

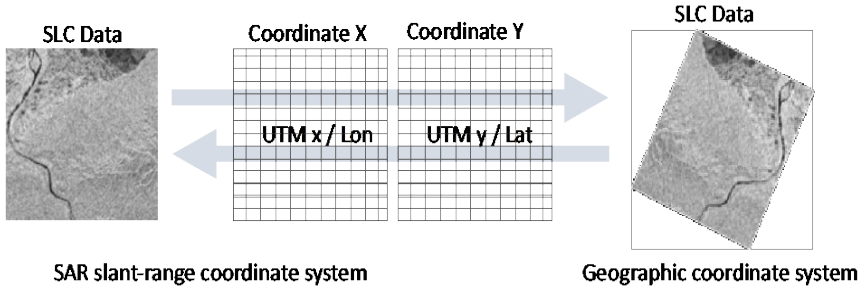


Geometrical phase component

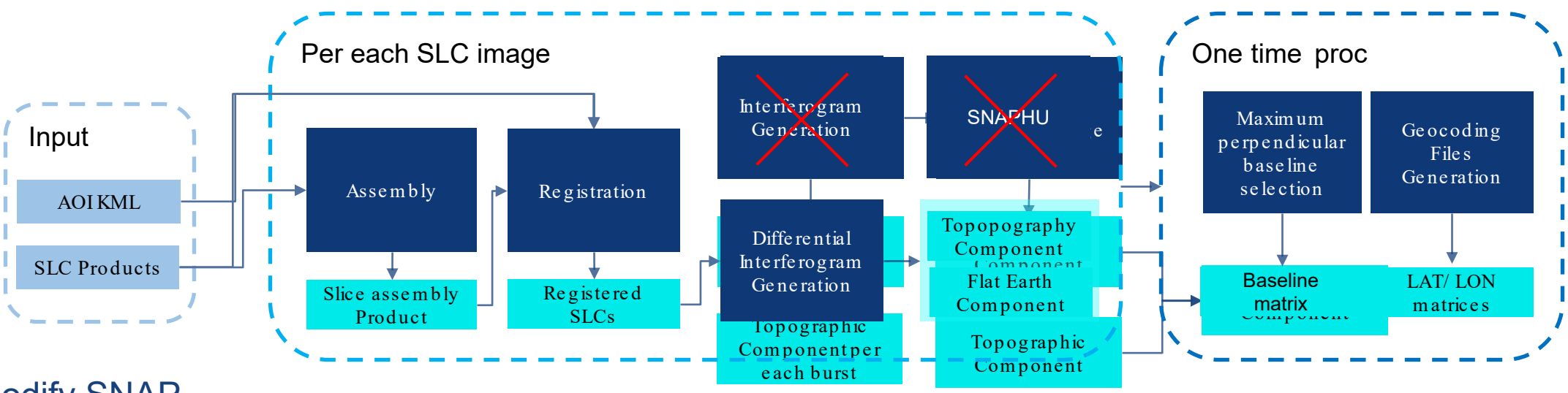
In DInSAR it is required to remove topographical and flat earth components .
Computed exploiting the perpendicular baseline defined between each secondary image and the reference one

Georeferencing grid

The SLC data is defined in sensor geometry slant-range plane .
The transformation from the sensor's domain to a more useful perspective, as a geographical coordinate system, it is required to include additional information to the Datacube



Pre-processing based on SNAP



Modify SNAP

- Include save Output phase component in Code
- Rebuild SNAP Sentinel-1 toolbox with changes
- More information at

SAR2Cube
Data Indexing

DARES

Six L0 datacubes , pre-processed with SAR2Cube, indexed with OpenDatacube , and available through openEO:

- Doñana: track 147 (ASC), 2017/ 2019, 181 samples
- Doñana: track 154 (DSC), 2017/ 2019, 178 samples
- South Tyrol: track 117 (ASC), 2016/ 2022, 311 samples
- South Tyrol: track 168 (DSC), 2016/ 2022, 305 samples
- Finland AOI1: track 80, Nov 2017/ Nov 2018, 64 samples
- Finland AOI2: track 80, Nov 2017/ Nov 2018, 64 samples

OPEN DATA CUBE

xarray.Dataset

- Dimensions: (**time**: 228, **x**: 44250, **y**: 7751)
- Coordinates:

time	(time)	datetime64[ns]	2016-09-08T23:59:59 ... 2020-11-...
y	(y)	float64	5.099e+06 5.099e+06 ... 5.091e+06
x	(x)	float64	5.44e+05 5.44e+05 ... 5.882e+05
spatial_ref	()	int32	32632

- Data variables:

i_VH	(time, y, x)	float32	dask.array<chunksize=(1, 3000, 3000), meta=np.nd...
q_VH	(time, y, x)	float32	dask.array<chunksize=(1, 3000, 3000), meta=np.nd...
i_VV	(time, y, x)	float32	dask.array<chunksize=(1, 3000, 3000), meta=np.nd...
q_VV	(time, y, x)	float32	dask.array<chunksize=(1, 3000, 3000), meta=np.nd...
grid_lon	(time, y, x)	float32	dask.array<chunksize=(1, 3000, 3000), meta=np.nd...
grid_lat	(time, y, x)	float32	dask.array<chunksize=(1, 3000, 3000), meta=np.nd...
phase_unwrap	(time, y, x)	float32	dask.array<chunksize=(1, 3000, 3000), meta=np.nd...
LIA	(time, y, x)	float32	dask.array<chunksize=(1, 3000, 3000), meta=np.nd...
DEM	(time, y, x)	float32	dask.array<chunksize=(1, 3000, 3000), meta=np.nd...

- Attributes:

crs :	EPSG:32632
grid_mapping :	spatial_ref

SAR2Cube_L0_117_ASC_ST_2016_2020_IFG_LIA_DEM

SAR2Cube Level-0 data, Track 117

SENTINEL-1 SAR2CUBE SAR

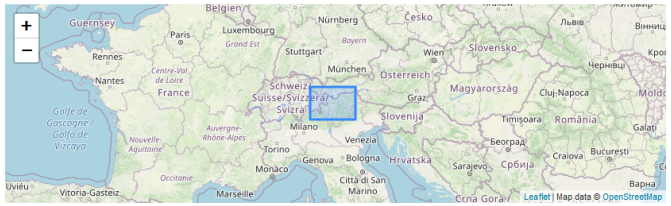
Description

Sentinel-1 SLC data pre-processed using the SAR2Cube pipeline. The pre-processing code can be found here https://github.com/SARScripts/preprocess

License

CC-BY-4.0

Spatial Extent



Temporal Extent

9/8/2016, 11:59:59 PM UTC - 11/10/2020, 11:59:59 PM UTC

Providers

1. Eurac EO ODC PRODUCER

Data Cube Dimensions

DATE TEMPORAL

Labels:
9/8/2016, 11:59:59 PM UTC - 11/10/2020, 11:59:59 PM UTC

X SPATIAL

Axis:
x

Labels:
9.5288352966 – 12.0209131241

Reference System:
4326

Y SPATIAL

Axis:
y

Labels:
45.9815177917 – 47.211139679

Reference System:
4326

bands BANDS

Labels:
DEM, LIA, i_VH, i_VV, q_VH, q_VV, grid_lat, grid_lon, phase_unwrap

SAR2Cube

Introduction to OpenEO processing

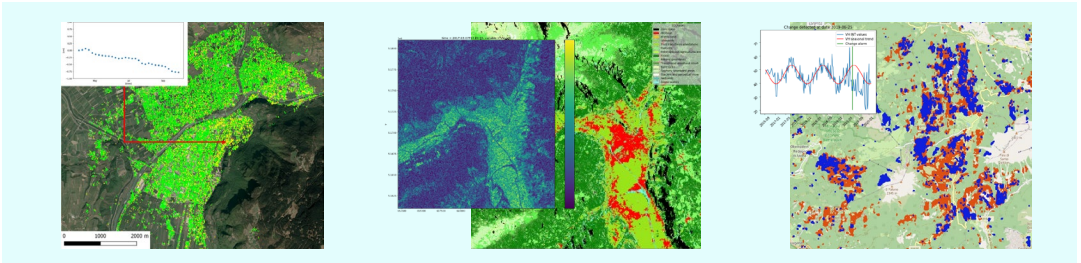
Clients

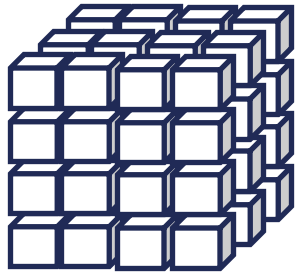
Data Selection | Data Analysis | Result Access

Abstract workflow definition

Job Management | Graph Parsing | Execution Engine

openEO back-end infrastructure



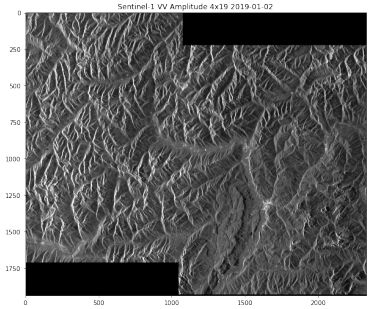


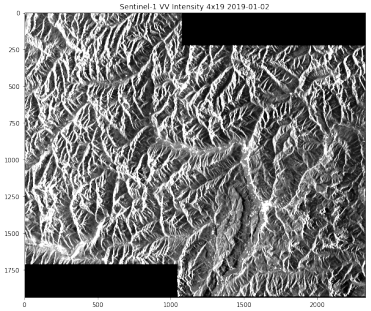
Feature 1
…
Feature N

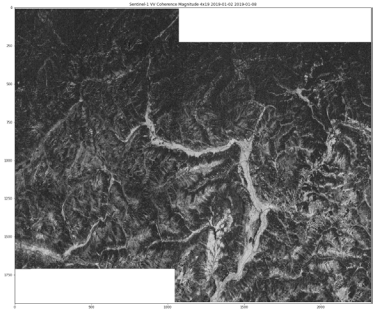
SAR2Cube
OTF Operators

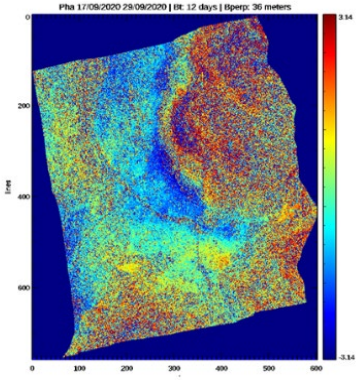
The following OTF operators have been implemented and can be parallelized:

- Temporal subset
- Spatial subset
- Intensity/Amplitude
- Multilook
- Box-car filter
- Interferometry
- Pixel Selection for PSI
- Geocoding







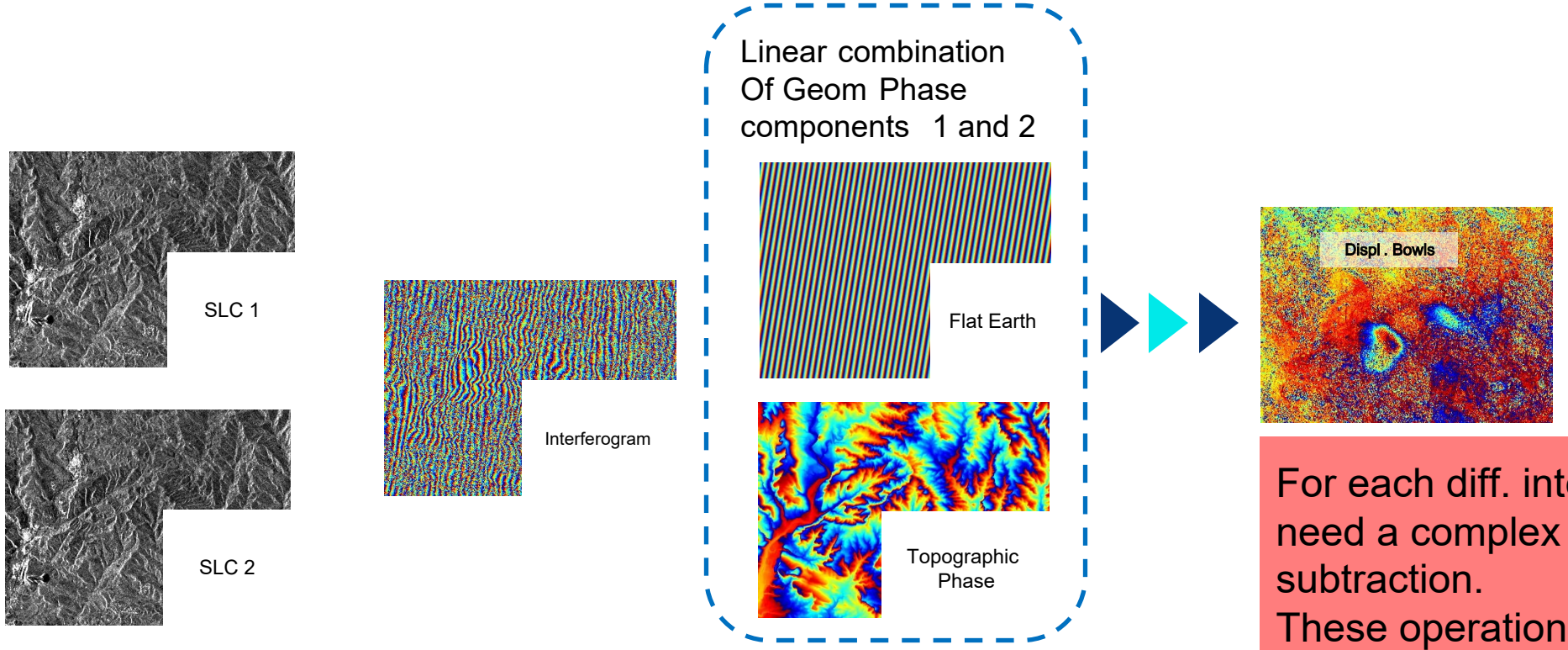


SAR2Cube

OTF: Interferogram generation

Main aspects of the operator:

- Extract a filtered interferogram list from the full list according to a limitation of temporal and spatial baselines.
- Generation of the differential interferograms over a temporal and spatial subset
- Generation of mean coherence map for the full interferogram dataset
- Selection of pixels based on coherence and setup for PSI processing



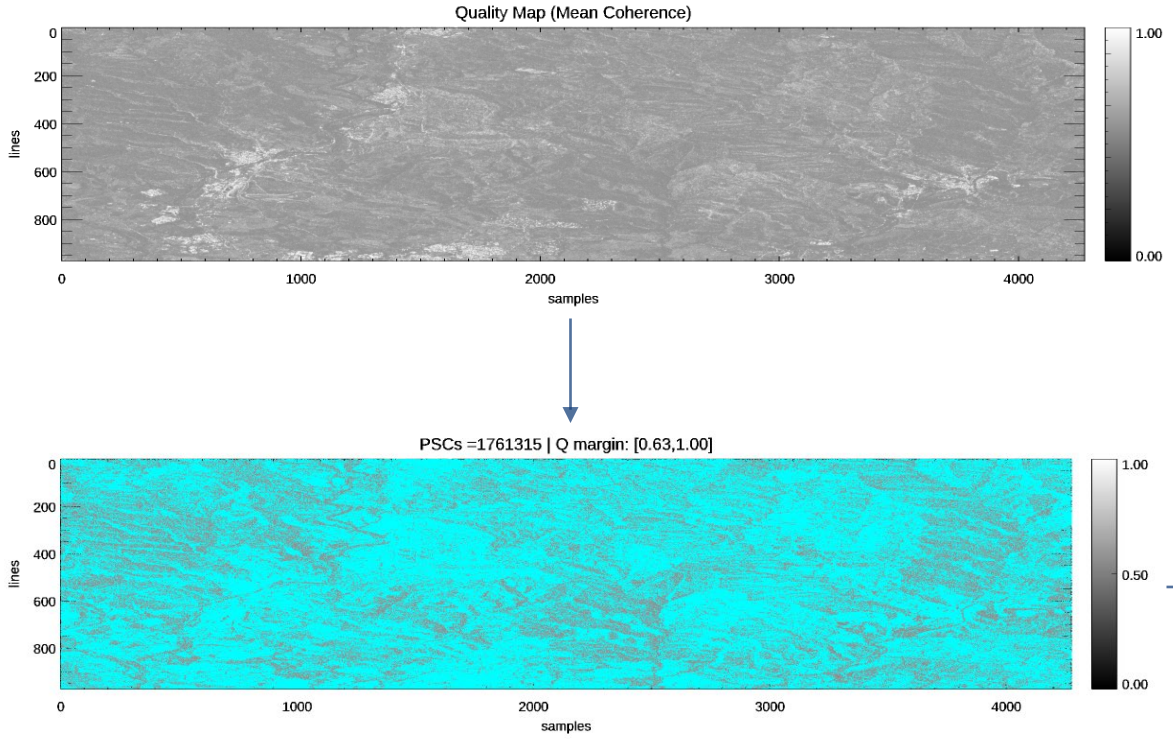
For each diff. interferogram we need a complex product and a subtraction.
These operations can be easily parallelized

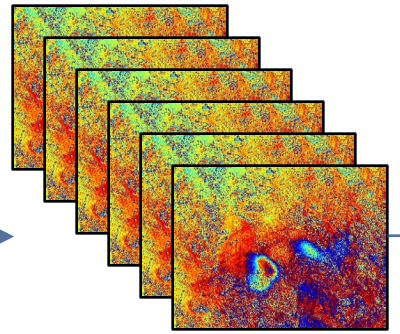
SAR2Cube

OTF: Interferogram generation for PSI

Main aspects of the operator:

- Extract a filtered interferogram list from the full list according to a limitation of temporal and spatial baselines.
- Generation of the differential interferograms over a temporal and spatial subset
- Generation of mean coherence map for the full interferogram dataset
- Selection of pixels based on coherence and setup for PSI processing



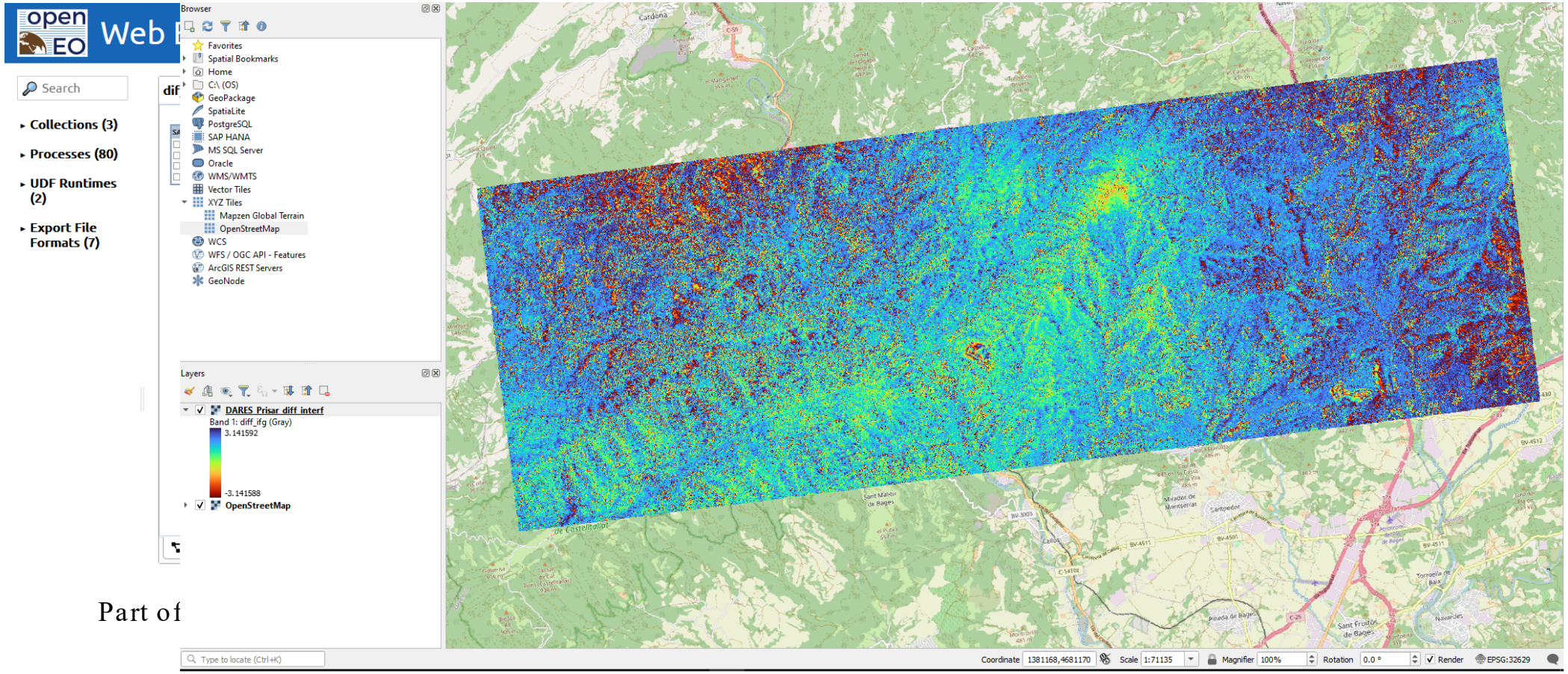


Interfs
X
PS

Save on disk just the minimum information of the full interferogram dataset

Main aspects of the operator:

- Extract a filtered interferogram list from the full list according to a limitation of temporal and spatial baselines.
- Generation of the differential interferograms over a temporal and spatial subset



Part of

SAR2Cube

Scalability and performance tests

Computation of 253 differential interferograms with different Dask LocalCluster setups:

- LocalCluster(n_workers=4, threads_per_worker=1, processes=True, memory_limit='64GB')
  - ✓ CPU times: user 30.1 s, sys: 4.46 s, total: 34.6 s
  - ✓ Wall time: 5min 55s
- LocalCluster(n_workers=1, threads_per_worker=1, processes=True, memory_limit='64GB')
  - ✓ CPU times: user 3min 36s, sys: 1min 29s, total: 5min 6s
  - ✓ Wall time: 21min 13s

[37]: xarray.Dataset

- Dimensions: (**time**: 23, **y**: 1000, **x**: 4000)
- Coordinates:

time	(time)	datetime64[ns]	2022-11-24 ... 2023-08-15
y	(y)	float64	-1.842e+03 ... -2.842e+03
x	(x)	float64	4.998e+03 5e+03 ... 8.998e+03
spatial_ref	()	int32	32632

- Data variables:

i_VV	(time, y, x)	float64	dask.array<chunksize=(1, 1000, 2), meta=np.ndarr...
q_VV	(time, y, x)	float64	dask.array<chunksize=(1, 1000, 2), meta=np.ndarr...
phase	(time, y, x)	float64	dask.array<chunksize=(1, 1000, 2), meta=np.ndarr...
grid_lon	(time, y, x)	float64	dask.array<chunksize=(1, 1000, 2), meta=np.ndarr...
grid_lat	(time, y, x)	float64	dask.array<chunksize=(1, 1000, 2), meta=np.ndarr...

- Indexes: (3)
- Attributes:

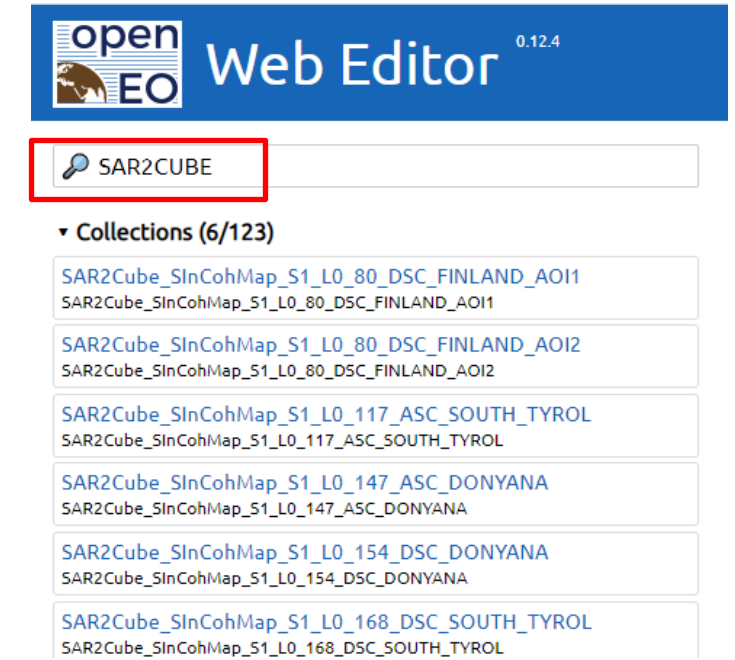
crs :	EPSG:32632
grid_mapping :	spatial_ref

Input data with size y:15x15 Km

SAR2Cube
openEO Web Editor

Access to the web editor:

- Access through the link
- Filter the search in collection: SAR2CUBE
- The list of collection already indexed and ready to be used
- Please contact Michele.Claus@eurac.edu or Alexander.Jacob@eurac.edu to get a free access to the collection and test the different OTF tools you can find in gitlab:



SAR2CUBE is an open tool for the scientific community

DARES

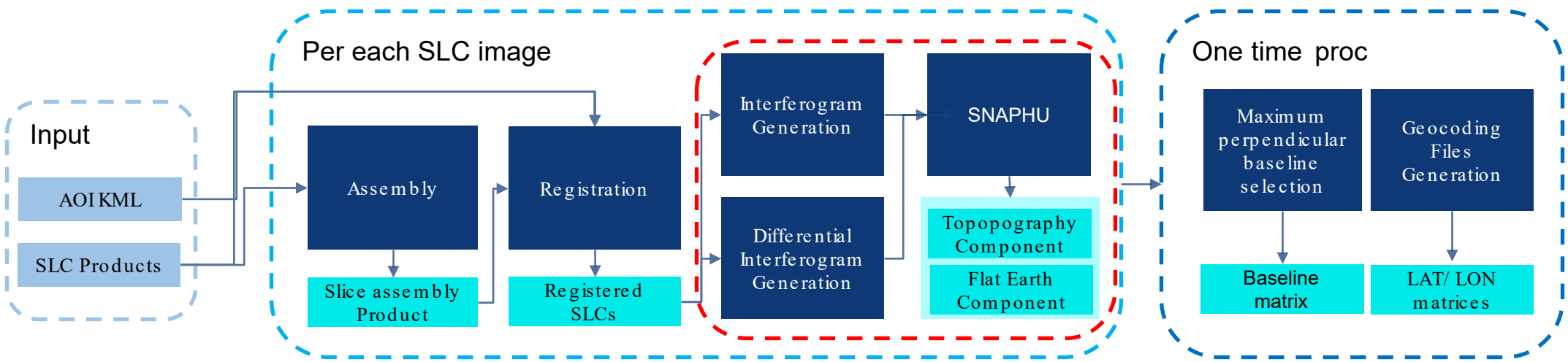
Questions ?

SAR2Cube
Significant Information

List of presentation and other interesting information

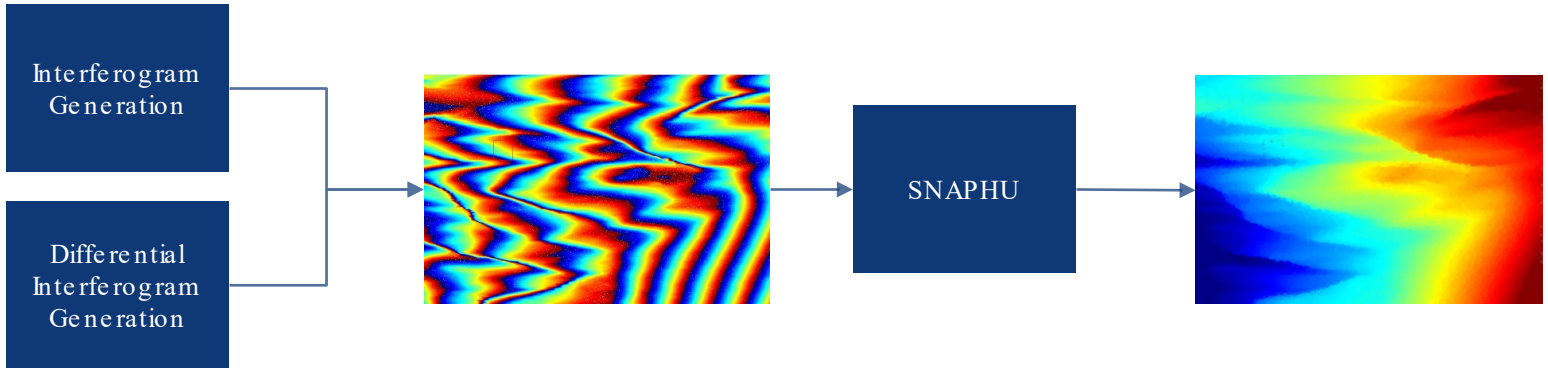
- SAR2CUBE in ESA project: https://eo4society.esa.int/projects/sar2cube/
- SAR2CUBE webpage: https://sar2cube.netlify.app/
- SAR2CUBE preprocess gitlab: https://github.com/SARScripts/preprocess
- Notebook with updated OTF operators: https://gitlab.inf.unibz.it/earth_observation_public/eurac-openeo-examples/-/tree/main/python
- openEO web editor: https://editor.openeo.org/?server=https%3A%2F%2Fopeneo.eurac.edu&discover=1

Pre-processing based on SNAP



Phase unwrapping overview:

- The topographic and geometrical phase is used in linear operators such as sum or difference and the results interferogram difference of the pre-processing gives as result a wrapped phase.
- SNAPHU software works with a reduced size of matrices. The output matrices ingested in datacubes are bigger than this limit.
- Multi block phase unwrapping has been implemented to overcome the dimension of S1 products. The calibration between neighbor blocks is performed through histogram calibration.



Conclusions and Outlook

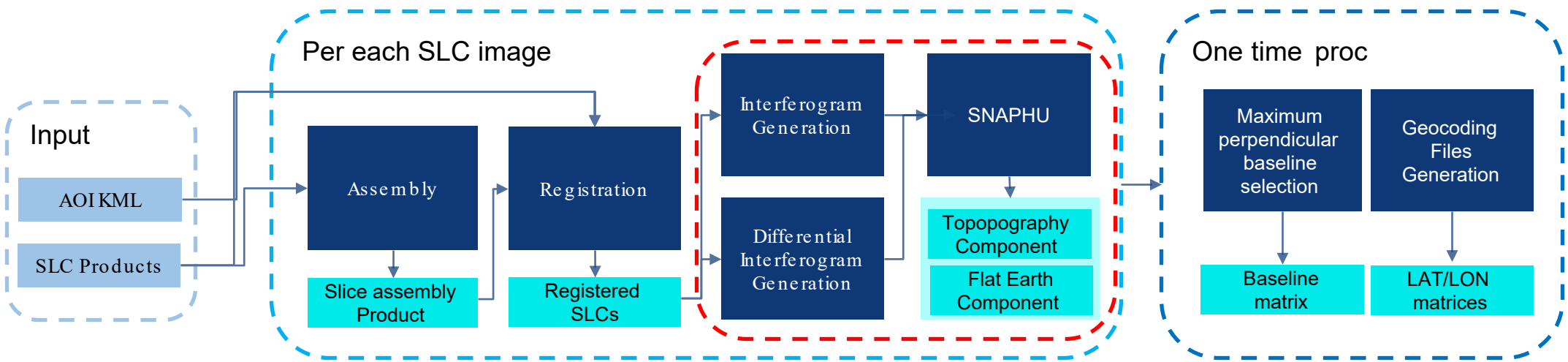
What we have

- Prototype implementation for SLC data cubes
- Fully build and implemented using open source
- Accessible with openEO interfaces
- Scalable processing framework
- Storage efficient
- Improvement of the Interferometric pre-process
- Set of OTF already defined processes in OpenEO
- Useful in real world applications

What we are working on

- Move to a more operational setup
- Upcoming in openEO Platform
  - ✓ Additional SAR OTF operators
  - ✓ E.g. Speckle Filtering
  - ✓ Calibration
- Integrate higher level processing in openEO
  - ✓ PSI?
- On-demand pre-processing
- Integrate other SAR sensors
- Metadata generation

Pre-processing based on SNAP



High computational cost