Earth Observation on mountain areas using SNAP

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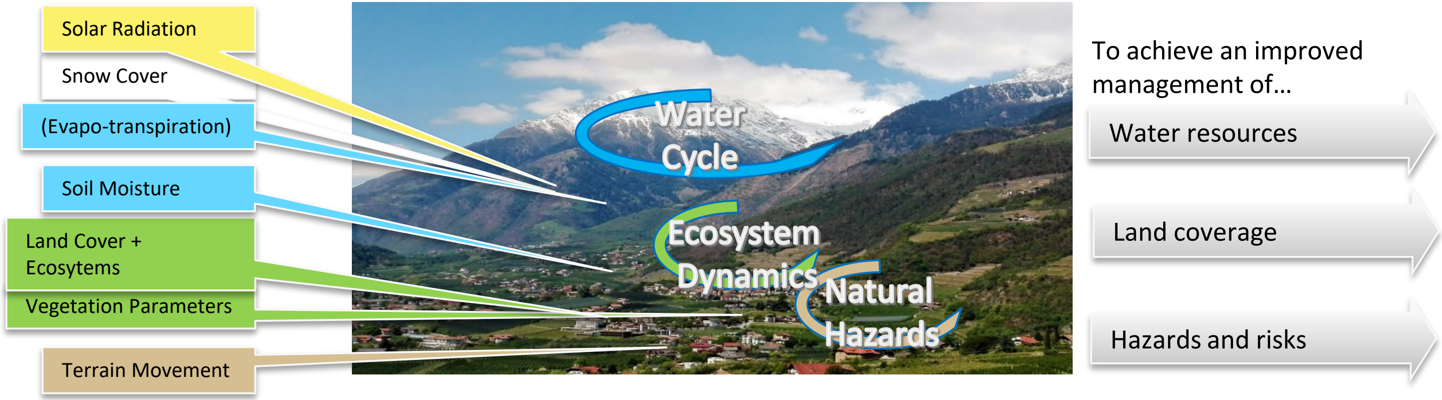
- Private research center (12 institutes)
- Based in Bolzano/Bozen (South Tyrol/ Italy)
- 300 people

Institute for Earth Observation

- Earth Observation for Environmental Monitoring
- Climate and Disaster Risk

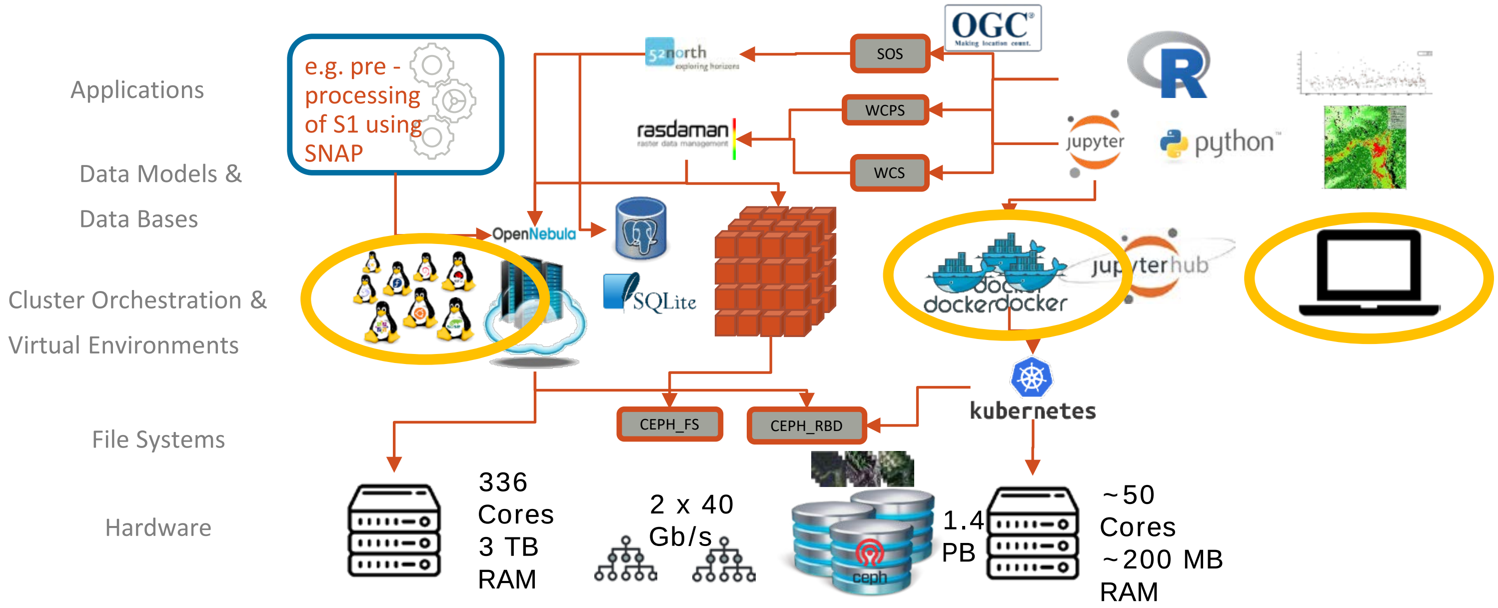
Main aim:
…to integrate remote sensing techniques with interdisciplinary approaches
…to monitor and understand key environmental dynamics and related risks
…by focusing on mountainous areas



Facilities

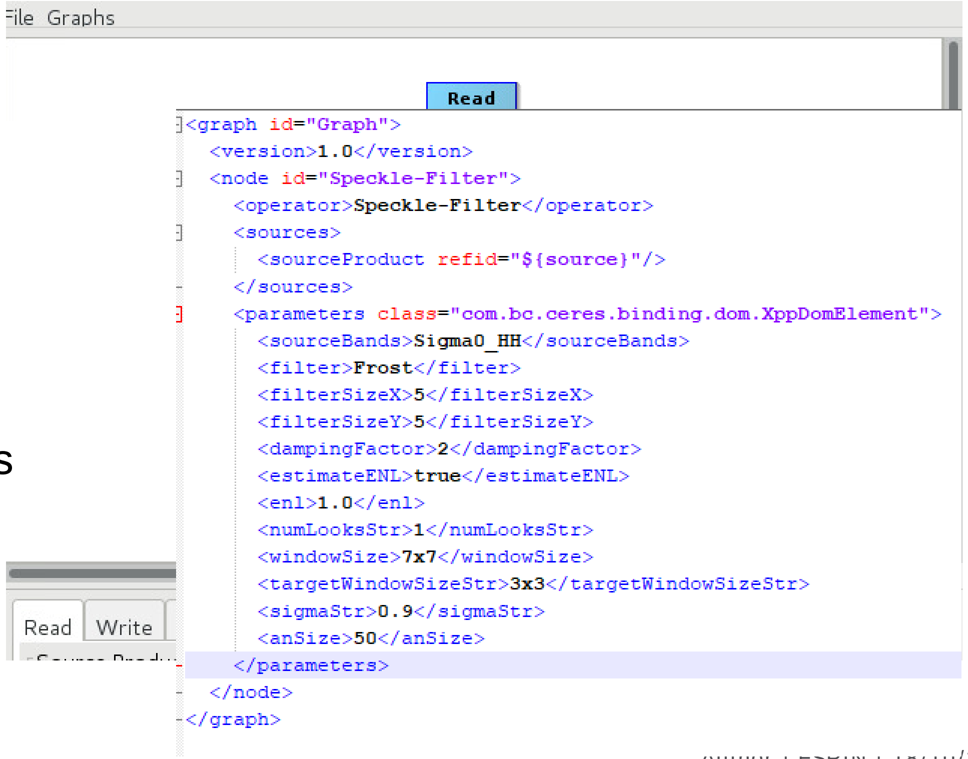
- Processing software and routines developed ‘in house’ related to soil, snow and vegetation monitoring (see http://sao.eurac.edu for more information)
- Hyperspectral and thermal instrumentation on board a UAV platform
- Moreover, Eurac is equipped with a Big Data processing and archiving infrastructure (1.4 PB archive data) and a computation cluster equipped with 340 nodes and 3 TB RAM with a direct access to the national scientific network (GARR)

SAO Infrastructure

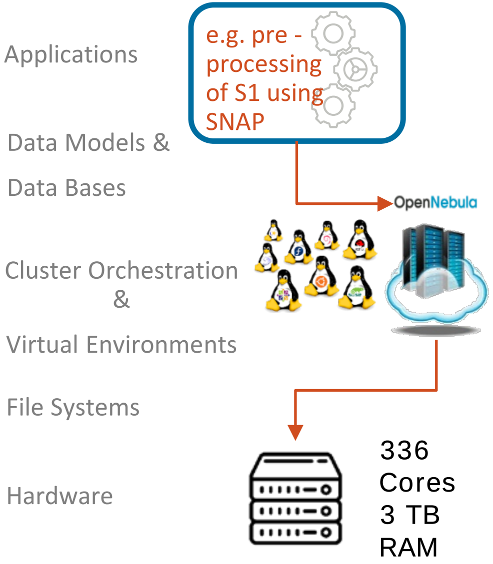


Typical SAR pre-processing workflow

- Define your graph in SNAP Desktop
- Define parameters of each node on the graph
- Execute in order to verify graph
- Save your graph nodes as XML files



Typical operational workflow




```
# define input and output directories
base_input_path=/mnt/INPUT_DATA
base_output_path=/mnt/OUTPUT_DATA

# loop over all images in input directory
for image in $(ls $base_input_path/);do
    echo "currently working on date: "$image
    date
    path_img=$(echo $base_input_path/$image/*/*.h5)
    echo "located in: "$path_img

    # create temporary target directory
    mkdir "/mnt/RAM_DISK/$image/"

    # define path to all intermediate results in RAM disk
    target1="/mnt/RAM_DISK/$image/read.dim"
    target2="/mnt/RAM_DISK/$image/calibration.dim"
    target3="/mnt/RAM_DISK/$image/multilook.dim"
    target4="/mnt/RAM_DISK/$image/speckle.dim"
    target5="/mnt/RAM_DISK/$image/terrain.dim"

    # launch processing of all intermediate results sequentially per image
    /opt/snap/bin/gpt /mnt/xml/read.xml -Psource="$path_img" -t "$target1"
    /opt/snap/bin/gpt /mnt/xml/calibration.xml -Ssource="$target1" -t "$target2"
    /opt/snap/bin/gpt /mnt/xml/multilook.xml -Ssource="$target2" -t "$target3"
    /opt/snap/bin/gpt /mnt/xml/speckle.xml -Ssource="$target3" -t "$target4"
    /opt/snap/bin/gpt /mnt/xml/terrain.xml -Ssource="$target4" -t "$target5"

    # copy final result to persistent location
    rsync -avhr /mnt/RAM_DISK/$image/terrain* $base_output_path/$image
    echo "finished processing off date: "$image
    date
    # remove all intermediate results
    rm -rf "/mnt/RAM_DISK/$image/"
done
```

Pre-Processing of Sentinel-1 data

- The Eurac Research Sentinel-1 backscatter data pre-processing encompasses a number of standard SAR pre-processing steps in order to derive geo-coded intensity backscattering images.
- The pre-processing starts from ground range detected (GRD) data provided by ESA.
- These operations are performed using the tools included in SNAP (Sentinel Application Platform) version 6.0 but also some custom tools developed in Python by Eurac researchers:

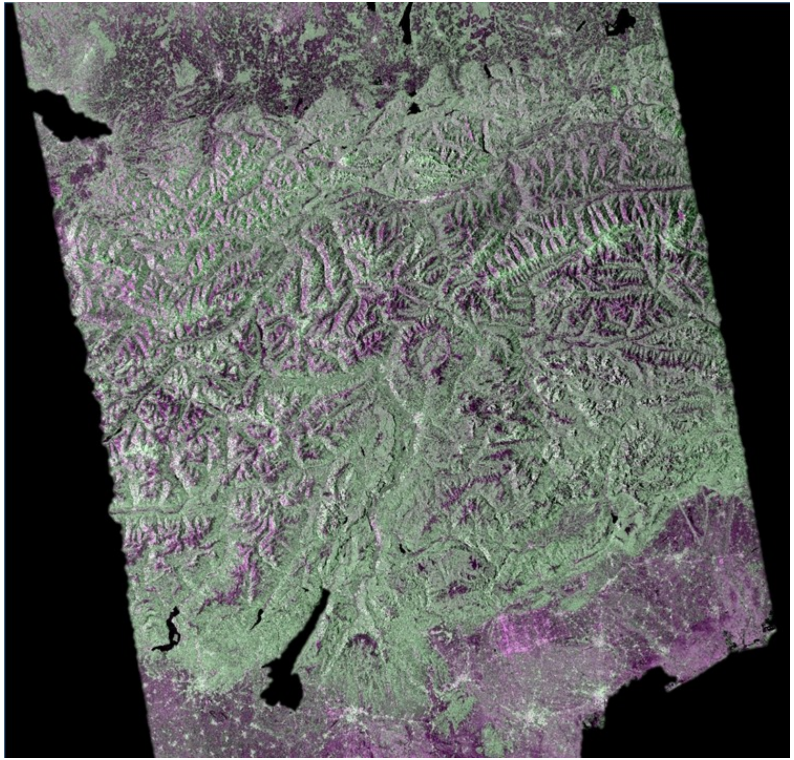
Pre-Processing of Sentinel-1 data

- Application of the precise Sentinel orbit to the data (S);
- Removal of the thermal noise present in the images (S);
- Beta nought calibration (S);
- Assembly of the S1-tiles coming from the same track (S);
- Co-registration of the multi-temporal images (S);
- Application of the multi-temporal filtering (C) [1];
- Application of the gamma-MAP spatial filtering (S);
- Geocoding and sigma nought calibration (S);
- Masking of the layover and shadow (C).

(S indicates SNAP tool, C indicates custom tool)

[1] Quegan, T. L. Toan, J. J. Yu, F. Ribbes and N. Floury, “Multitemporal ERS SAR Analysis Applied to Forest Mapping”, IEEE Transactions on Geoscience and Remote Sensing, vol. 38, no. 2, March 2000.

Pre-Processing of Sentinel-1 data

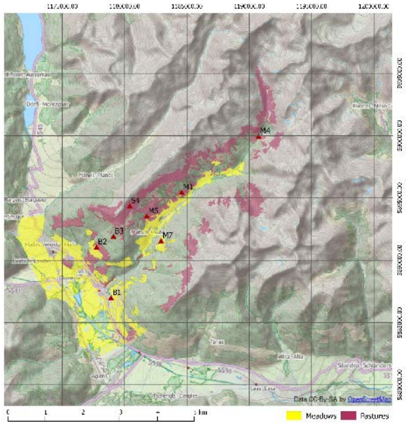


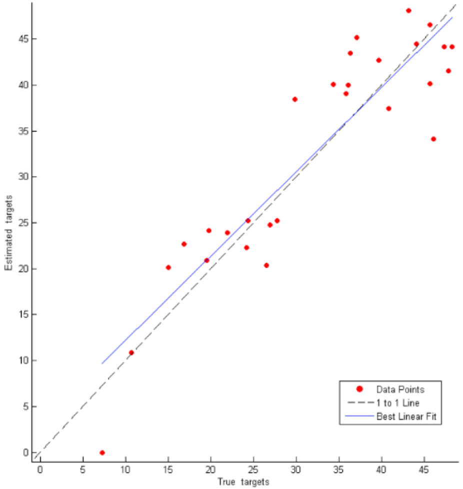
RGB composition of preprocessed Sentinel-1 backscatter data (Red: VV; Green: VH Blue: VV) from Track 117 on 24 January 2016.

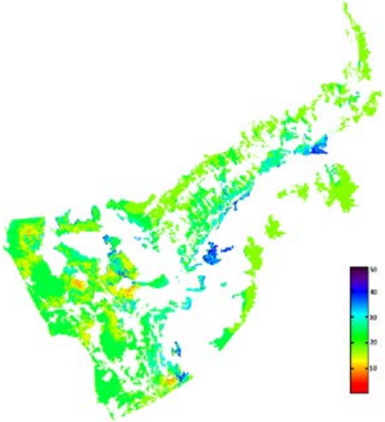
Credit: Contains modified Copernicus Sentinel data [2016]/Eurac Research

Example of application: Soil Moisture Content

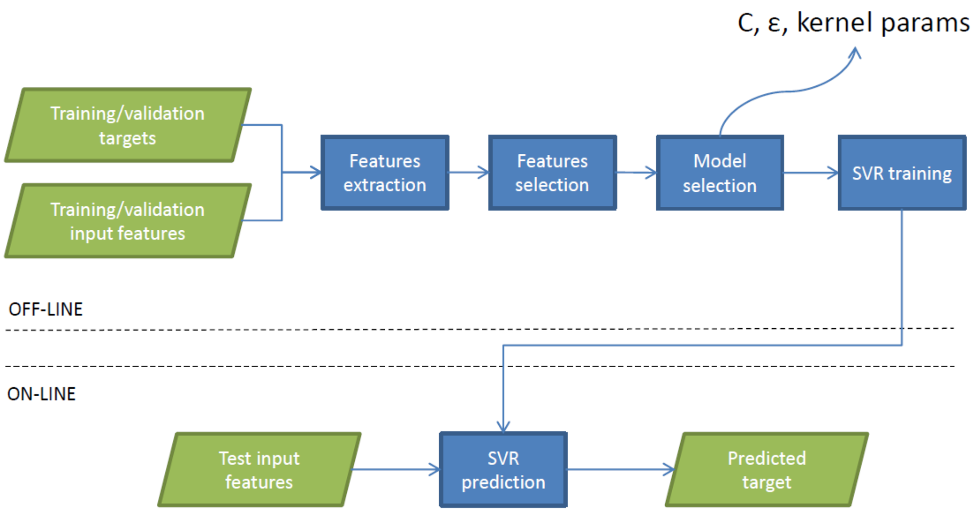
- Test Area in Val Senales monitored with fixed stations and field campaigns
- Sensitivity Analysis: SAR backscattering vs Soil Moisture Content (SMC)
- Support Vector Regression methods (SVR) using different features and data (Backscattering, NDVI, LAI, LIA, landcover maps) to derive SMC maps





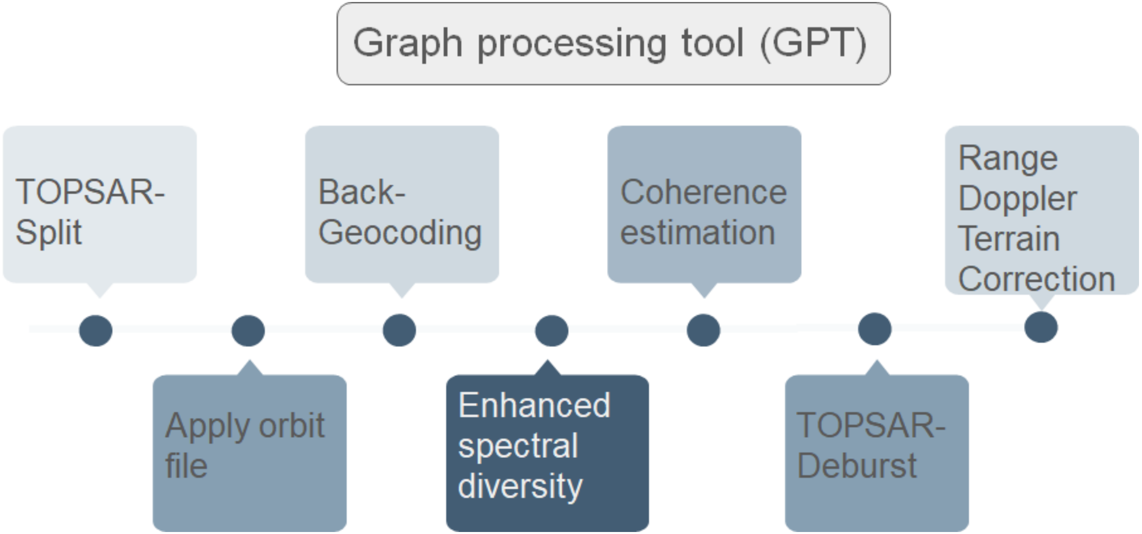


SVR architecture

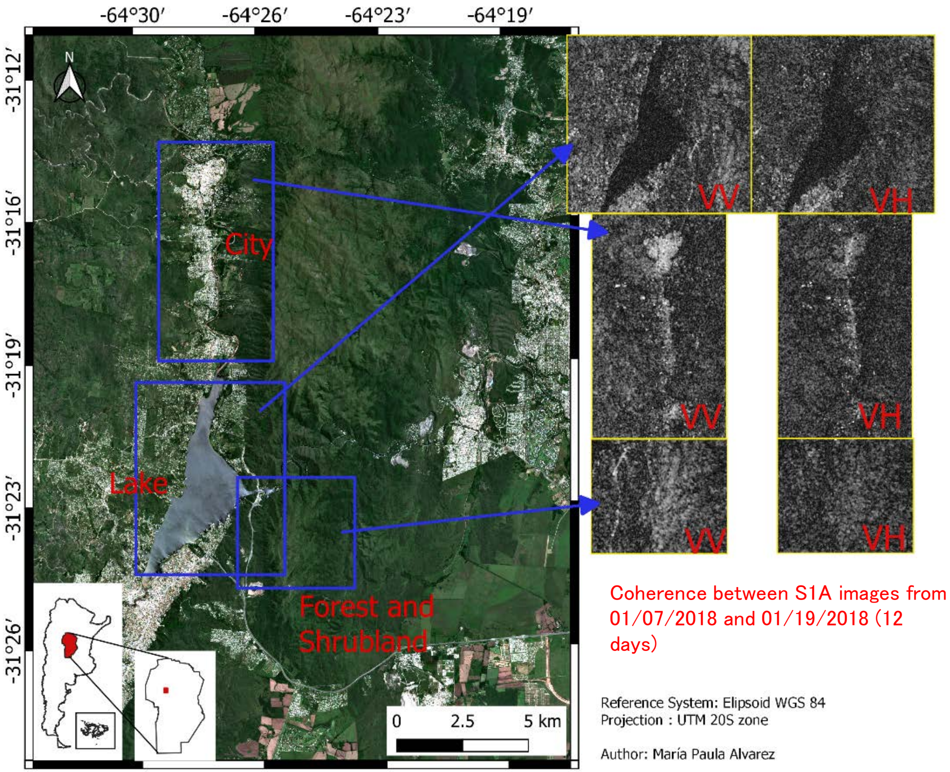


- Notes about SNAP:
  - Local Incidence Angle
  - Different SAR filtering methods available
  - Layover/Shadow masks not directly implemented

- Use of Sentinel-1 coherence maps



Example of application: Forest cover type classification

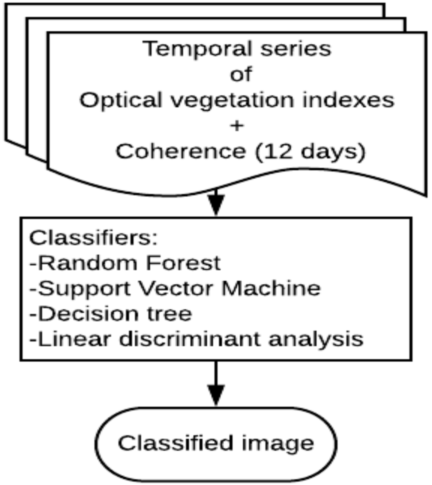


Coherence between S1A images from 01/07/2018 and 01/19/2018 (12 days)

Reference System: Elipsoid WGS 84
Projection : UTM 20S zone

Author: María Paula Alvarez

Forest cover type classification



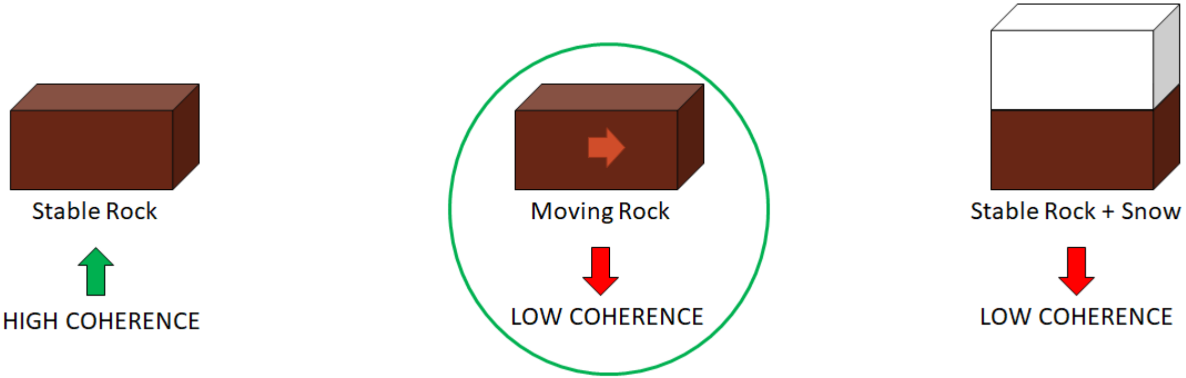
levels of accuracy between 65–95%

Example of application: glacier monitoring

In our research line focused on glacier we developed methods for automatic glacier outlines extraction.

The bare ice part of glacier is mapped using optical data instead the debris covered part is identified exploiting Sentinel-1 data.

In this workflow we use SNAP for coherence computation.



- Since our method is fully automatic, SNAP is used via GPT in a python framework

python

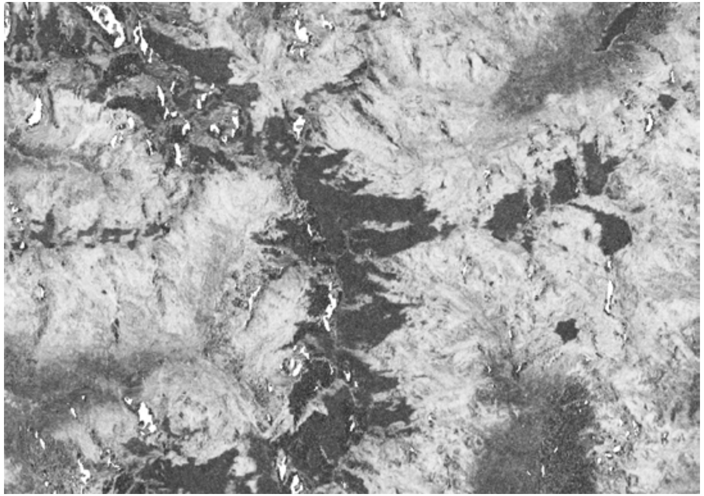
- Scene downloading
- GCP reading for subswath identification
- Processing parameters definition
- Call SNAP from command line

SNAP SURVEY

- Coherence computation using GPT

Multi-temporal filtering of coherence and data integration

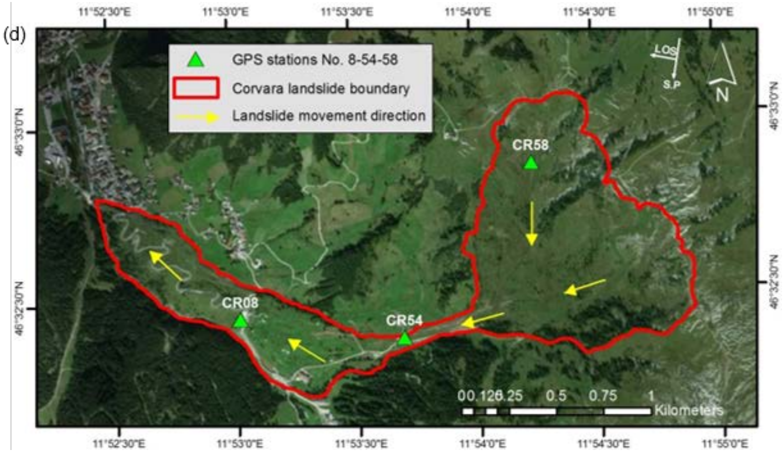
- The coherence is **filtered** selecting the **maximum value for each pixel position** in order to exclude seasonal snow and displacements not related to the presence of debris covered glaciers
- Once the coherence is filtered the information coming from **different tracks** is merged with an **averaging operation**



- This final coherence is used for **debris covered glacier outlines extraction**

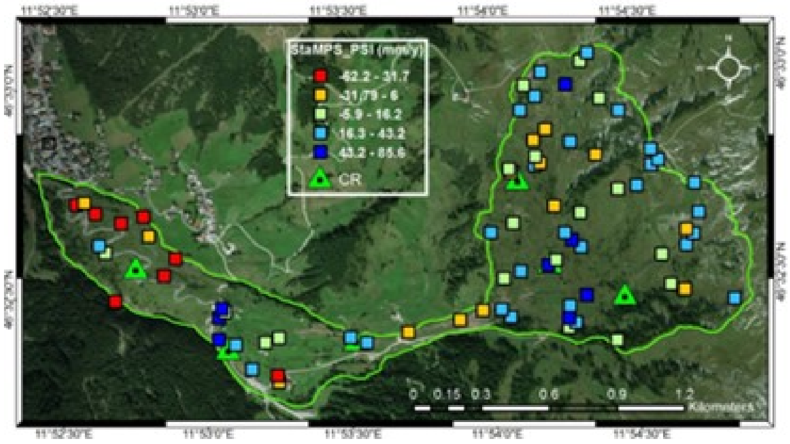
Example of application: landslide deformation monitoring

- Differential SAR interferometry is well recognized tool for monitoring slow slope deformations
- The use of a stack of images could be used to derive the time series deformation by means of algorithms like Persistent Scatterers or Small Baseline Subset
- Multi-temporal interferometry has been applied to the landslide of Corvara



Example of application: landslide deformation monitoring

- Corner reflectors installed
- 3 permanent GPS stations
- Periodic GPS field campaigns
- SAR data selected and processed since SLC level
- Unwrapping using SNAPHU (only Linux)



- Multi-temporal interferometry performed using StaMPS software
- Good software interfacing with PS but not with SBAS

Final considerations

- SNAP is a very flexible and friendly tool for EO data processing
- It could be used in synergy with Python or other scripting languages
- To obtain good performance GPT is often needed to speed up the processing and overcome JVM RAM management issues
- Automatic identification of the sub-swath that contains the area of interest would be an interesting feature to add in SNAP
- It would be interesting if the whole (multi)-interferometric chain were implemented in SNAP (Windows and Linux)
- A good forum is available and very clear and useful tutorials (it would be good to have more on the use of GPT)
- Especially for mountain areas, it could be good to have a tool for estimation of layover/shadowing masks
- Estimation of visibility masks starting from information of data provider without an image already available for data selection tasks

Thank you very much for your attention!

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