Senti-water

Kickoff

Internship objectives

- Teach you how big organizations organize work in software engineering projects
- Teach basic principles of Agile methodology
- Introduce you to career building in IT
- Create real-world PoC that can be developed after internship (and can be added to portfolio)
- Develop skills in problem solving, programming, teamwork, learning advanced concepts in software engineering and science

IBM SkillsBuild

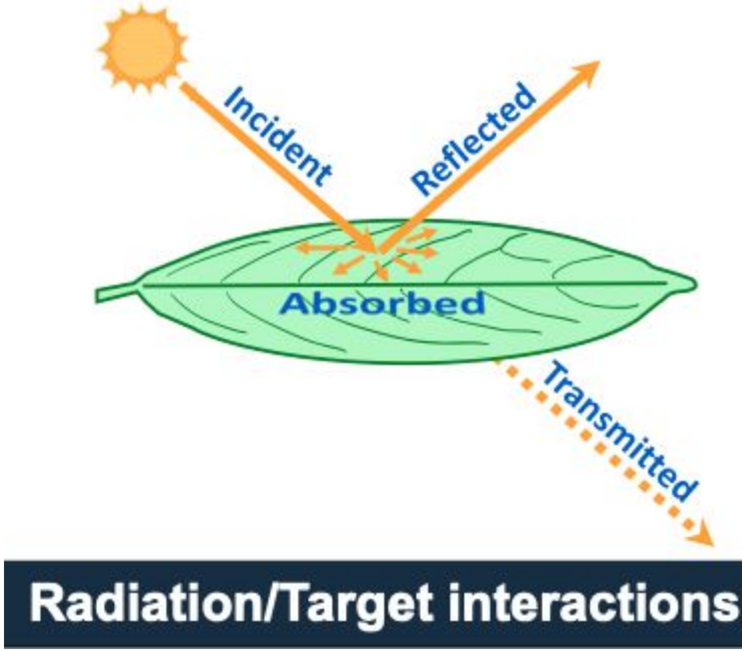
https://students.yourlearning.ibm.com

What we will do?

- We will analyze satellite data!
- Create data processing pipeline from Sentinel data to Database of big water reservoirs in Poland

Basics

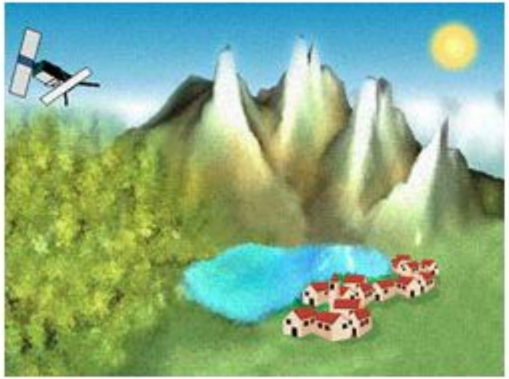
- Humans see world based on light reflecting off objects in the visible range of EM spectrum
- Satellite sensors see world in same way but we don't limit ourselves to visible light…
- Resolutions:
  - spatial resolution
  - temporal resolution
  - radiometric resolution
  - spectral resolution



Sentinel-1

- Imaging radar mission providing continuous all-weather, 24-hour imagery at C band
- SENTINEL-1 potentially images all global landmasses, coastal zones and shipping routes in European waters in high resolution and covers the global oceans at regular intervals
- One satellite still working (Sentinel 1A), Sentinel 1B lost in 2022

SAR imaging

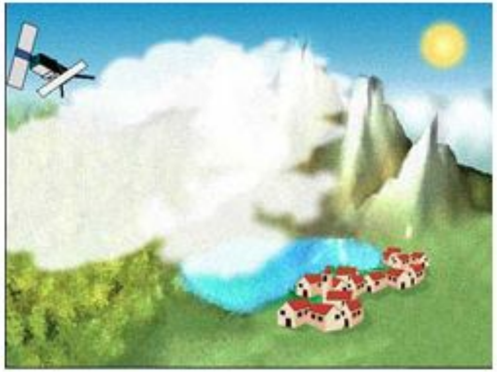


SAR is an active system.

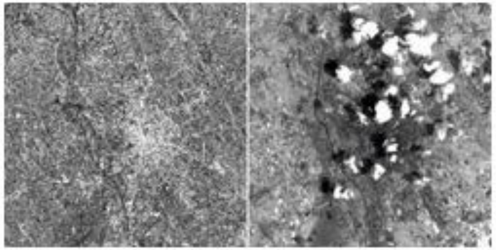
It illuminates the Earth surface and measures the reflected signal. Therefore, images can be acquired day and night, completely independent of solar illumination, which is particularly important in high latitudes (polar night).

This SAR image was acquired by ERS-1 on 2 August 1991 over the Netherlands, local time 23:40.

2. Independence of cloud coverage



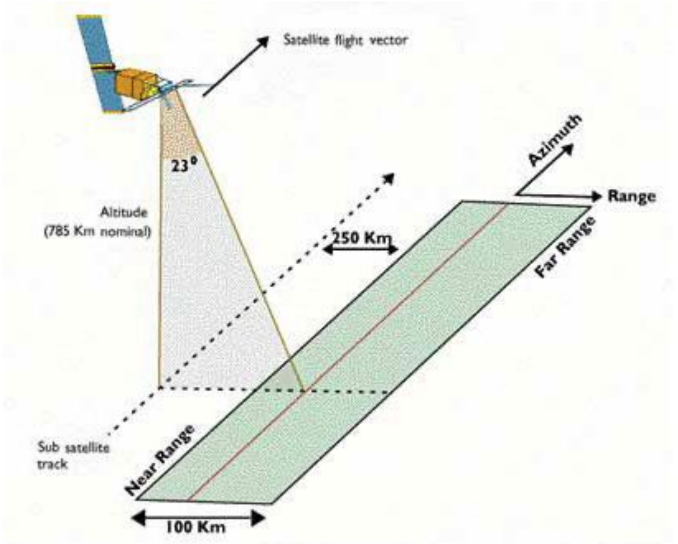
The microwaves emitted and received by ERS SAR are at much longer wavelengths (5.6 cm) than optical or infrared waves. Therefore, microwaves easily penetrate clouds, and images can be acquired independently of the current weather conditions.



Udine

These images were acquired over the city of Udine (I), by ERS-1 on 4 July 1993 at 09:59 (GMT) and Landsat-5 on the same date at 09:14 (GMT) respectively. The clouds that are clearly visible in the optical image, do not appear in the SAR image.

3. ERS SAR geometric configuration



SAR sensor

The spacecraft flew in its orbit and carried a SAR sensor which pointed perpendicular to the flight direction.

The projection of the orbit down to Earth is known as the ground track or subsatellite track. The area continuously imaged from the radar beam is called radar swath. Due to the look angle of about 23 degrees in the case of ERS, the imaged area is located some 250 km to the right of the subsatellite track. The radar swath itself is divided in a near range - the part closer to the ground track - and a far range.

In the SAR image, the direction of the satellite's movement is called azimuth direction, while the imaging direction is called range direction.

4. Image geometry

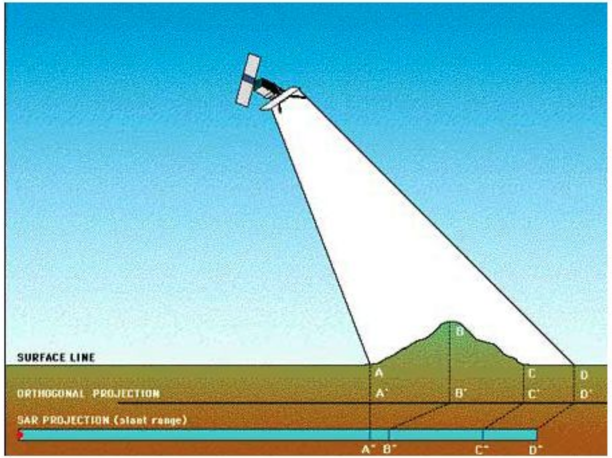
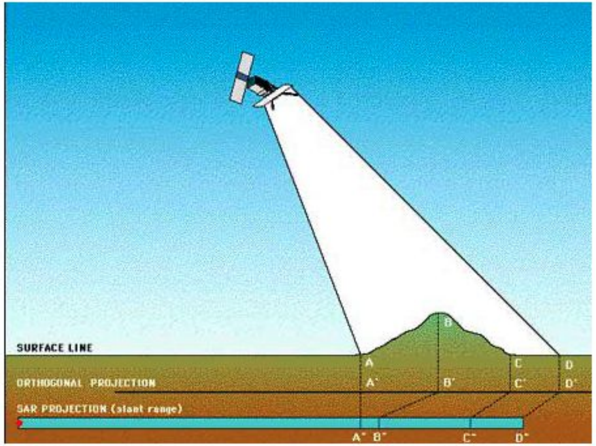


Illustration - Image geometry

SAR image geometry

The most striking feature in SAR images is the "strange" geometry in range direction. This effect is caused by the SAR imaging principle: measuring signal travel time and not angles as optical systems do.



The time delay between the radar echoes received from two different points determines their distance in the image. Let us consider the mountain as sketched in the figure. Points A, B and C are equally spaced when vertically projected on the ground (as it is done in conventional cartography).

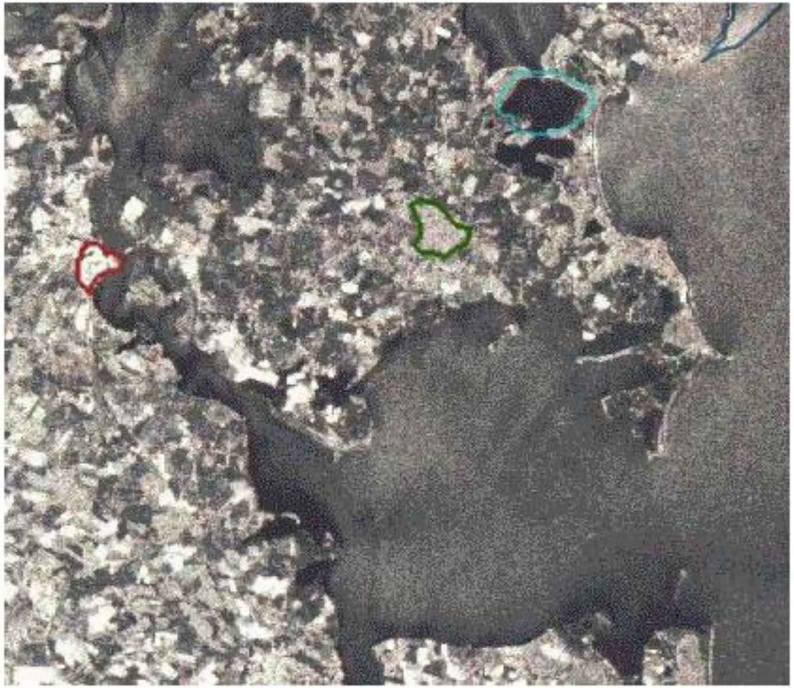
However, the distance between A'' and B'' is considerably shorter compared to B'' - C'', because the top of the mountain is relatively close to the SAR sensor.

This effect is called "foreshortening". It is, among other effects, the most common geometric distortion in SAR images. Foreshortening is obvious in mountaineous areas, where the mountains seem to "lean" towards the sensor as seen in this ERS image.

5. Radiometry

The SAR measures the power of the reflected signal, which determines the brightness of each picture element (pixel) in the image. Different surface features exhibit different scattering characteristics:

- Urban areas: very strong backscatter
- Forest: medium backscatter
- Calm water: smooth surface, low backscatter
- Rough sea: increased backscatter due to wind and current effects



Sentinel-2

- SENTINEL-2 is a wide-swath, high-resolution, multi-spectral imaging mission, supporting Copernicus Land Monitoring studies
- Including the monitoring of vegetation, soil and water cover, as well as observation of inland waterways and coastal areas
- The SENTINEL-2 Multispectral Instrument (MSI) samples 13 spectral bands: four bands at 10 metres, six bands at 20 metres and three bands at 60 metres spatial resolution.

Problem introduction

- Surface water dynamics crucial to societies at regional and global scale
  - Impact on hydrology
  - Agriculture
  - Domestic and industrial water uses
- High-resolution satellite data can provide knowledge of surface water dynamics for scientific and industrial purposes
- Global coverage of Sentinel-1 and Sentinel-2 satellites with high revisit frequency enables creation of huge amount of data about water
- Two-step approach:
  - Sentinel-2 multispectral data and usage of threshold on Spectral Index
  - Sentinel-1 SAR data (histogram thresholding, texture analysis, machine learning and combined methods)

Main Objective

- Create database of big water surfaces in Poland:
  - Processing pipeline from Sentinel-2 images to geometric objects indexed in database
  - [STRETCH 0]: Temporal information (time-series data of each object)
  - [STRETCH 1]: Ability to browse through objects and see their main properties: location, water surface area
  - [STRETCH 2]: Ability to see advanced historical data:
    - changes in water surface area
    - variability of changes, other statistical metrics
    - confidence for given data
    - image shown for given object

Deliverables

- **Data analysis pipeline (in form of a jupyter notebook) that for given satellite data outputs water surfaces objects**
- **Database of big water surfaces with temporal information**
- React application that allows browsing through the objects
- Medium article describing pipeline and usage
- Urania article describing usage of satellite data for flood assessment and environmental monitoring
- Conferences etc.

Milestones

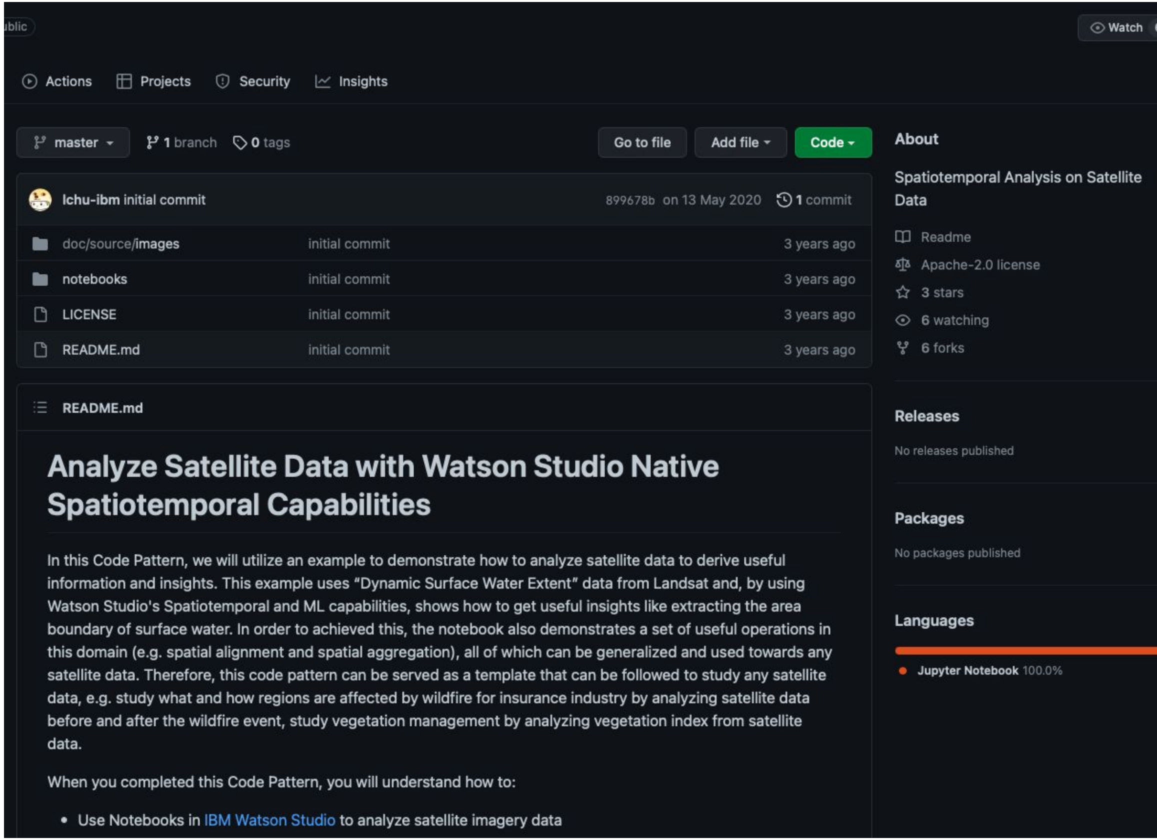
1. Preprocessing timeline that creates dataset for water body extraction algorithm
2. Developing simple water body extraction algorithm (based on optical data)
3. Pipeline that does preprocessing and then applies methods of water body extraction and save it to database using IBM technologies
4. Including temporal dimension for water body data
5. Creating simple React application

How we will organize our work?

- Stand-up Meeting (everyday 9 am)
  - What we completed since previous day?
  - What will we complete today
  - What are the blockers keeping us from completing our tasks?
- Showcase (every Monday)
  - We show our completed work to the key stakeholders and interested people
  - We discuss what is coming next
  - We decide if we need any adjustments
- Planning (every Monday)
  - Our internal meeting when we plan in detail work in the coming Sprint)
- Retrospective (every Friday)
  - We reflect our week
  - We discuss what went well, what didn’t go as planned, what puzzles us?
  - We create few improvement actions

First task (Task 0)

- Run Jupyter notebook for Landsat data on IBM Watson Studio
- Learn more about water surface detection, IBM Watson and other topics that will be required for our project



Sprint 0 (11/04)