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UN-SPIDER / DLR / GloFAS / ZFL
International Training Workshop
Space Technologies for Flood Management

Martin Hilljegerdes

UNOOSA/UN-SPIDER Bonn Office

21 February 2023

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UN-SPIDER
Recommended Practice on Flood Mapping using Sentinel 1 (SAR) Imagery and Google Earth Engine

Martin Hilljegerdes
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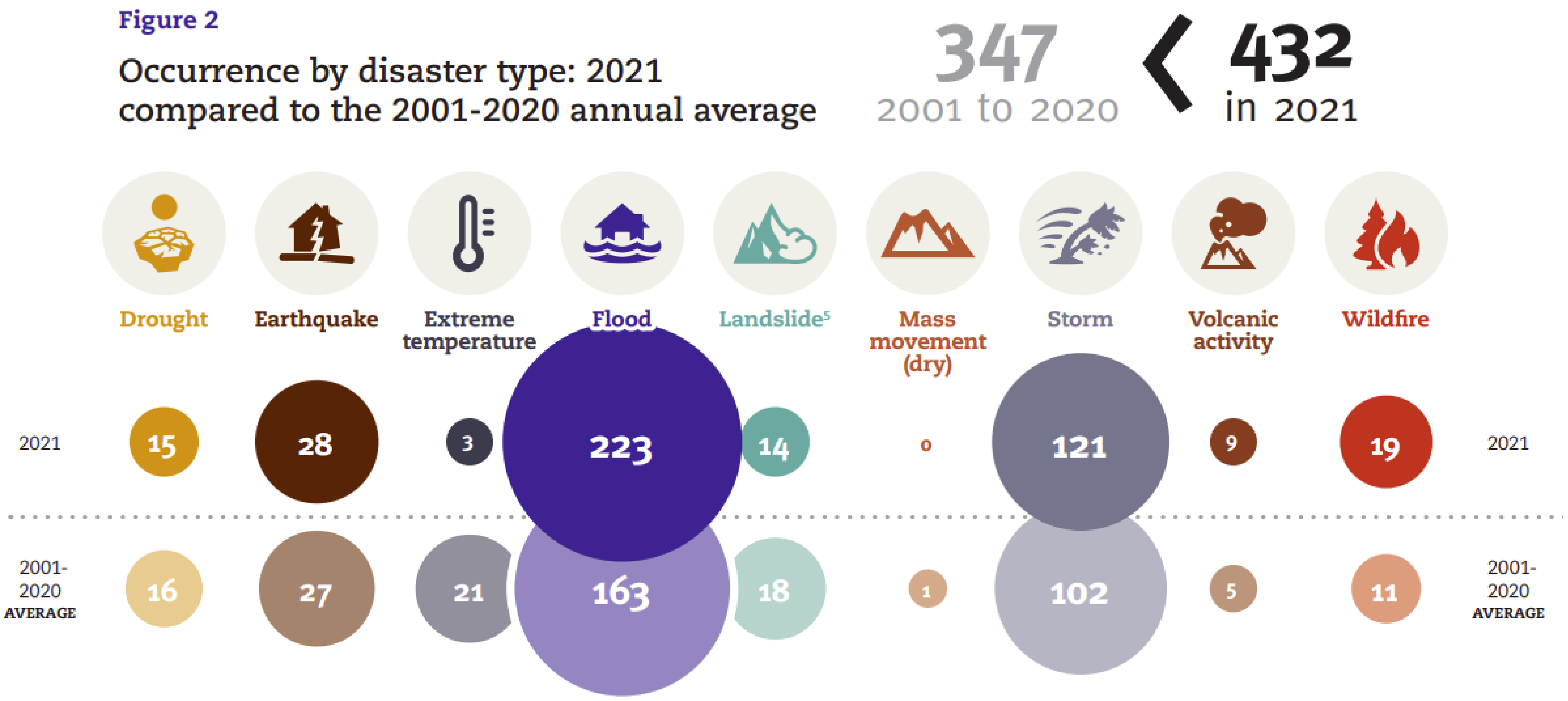
Outline

1. Flood information products for the entire disaster management cycle
2. Radar remote sensing basics
3. Hands On:

   UN-SPIDER Recommended Practices on SAR-based flood mapping using Google Earth Engine
4. Further learning opportunities
5. Q&A and discussion

Flood trends



Centre for Research on the Epidemiology of Disasters (CRED). Disasters in Numbers 2021, p.4. Brussels: CRED; 2022.

Flood information for the entire disaster management cycle

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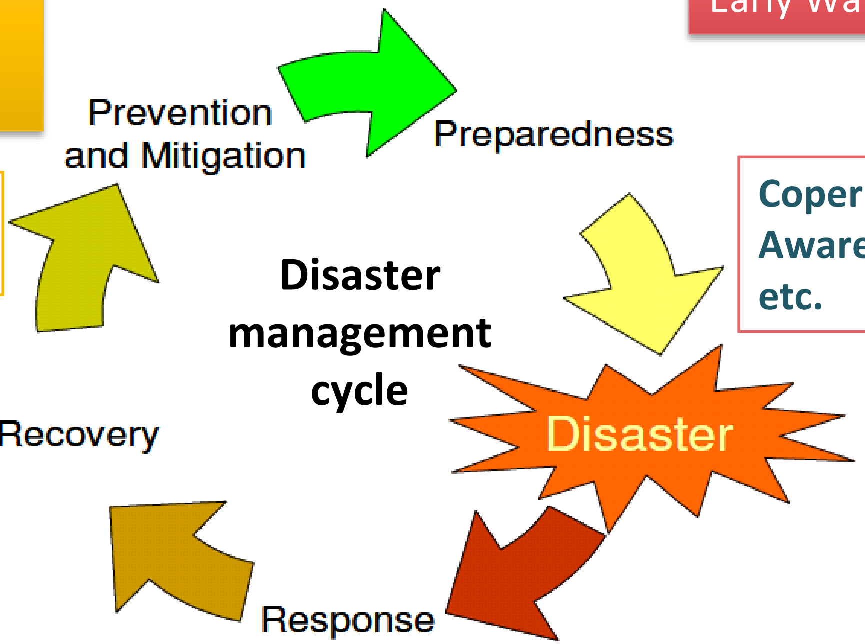
Geoinformation for
Hazard, exposure, vulnerability, and risk assessment

Recommended Practice on Flood Hazard Mapping

Geoinformation for
Early Warning systems

Copernicus Global Flood Awareness System, FANFAR, etc.



Geoinformation for
Post Disaster Needs Assessment (PDNA)/ Damage and Loss Assessment (DaLA)

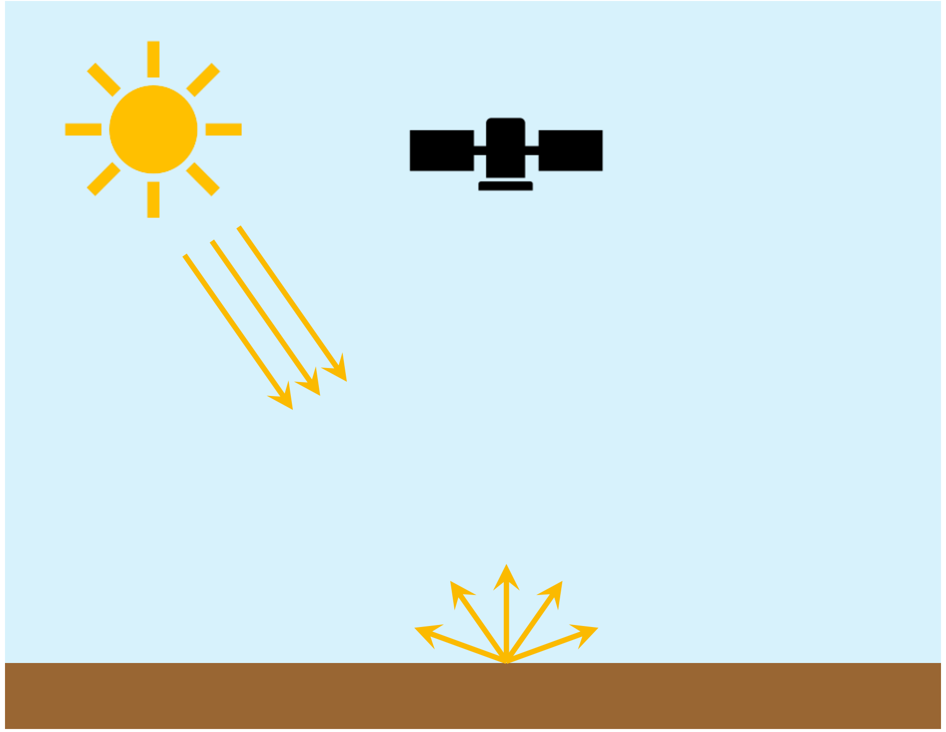
Recommended Practices on Flood Mapping and Damage Assessment (GEE)

Geoinformation for
Rapid mapping: Extent and impact

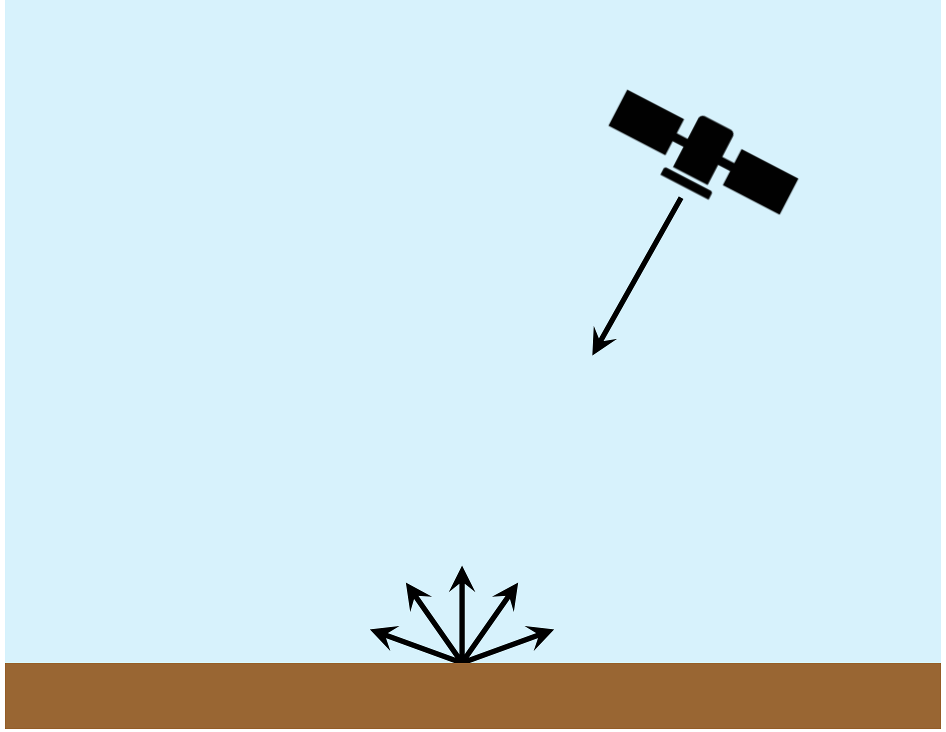
Recommended Practices on Flood Mapping (SNAP, Python), NOAA global flood map products, Dartmouth Flood Observatory

Satellite remote sensing sensors

- **Passive Sensors**
  Sensors detect only what is emitted from the landscape, or reflected from another source (e.g. reflected sunlight).



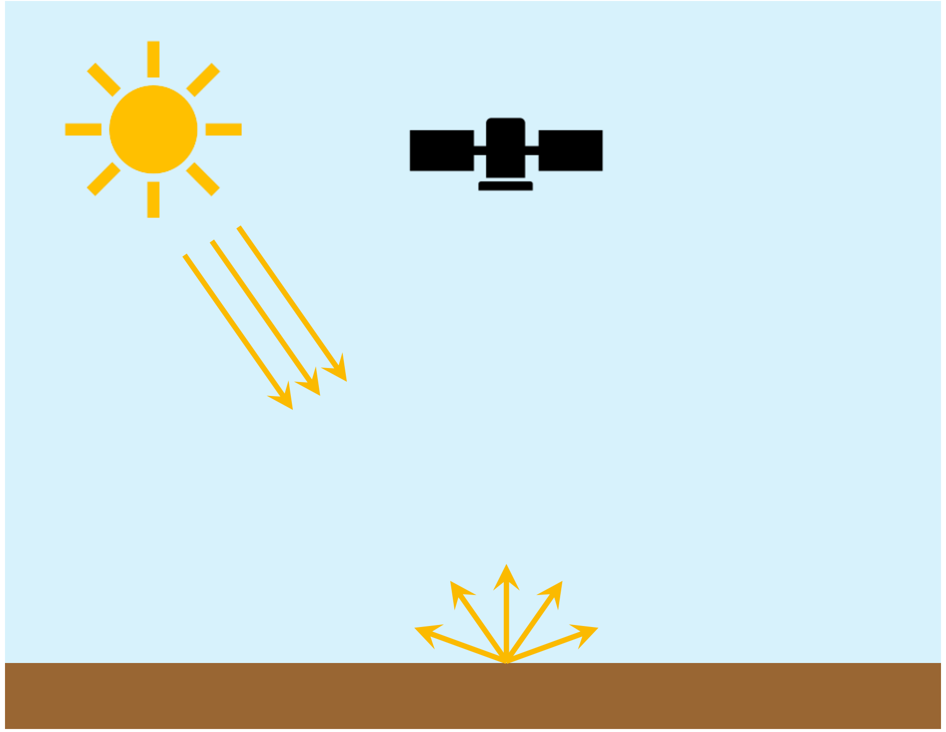
- **Active Sensors**
  Instruments emit their own signal and the sensor measures what is reflected back to the sensor (e.g. Synthetic Aperture Radar, SAR).



Satellite remote sensing sensors

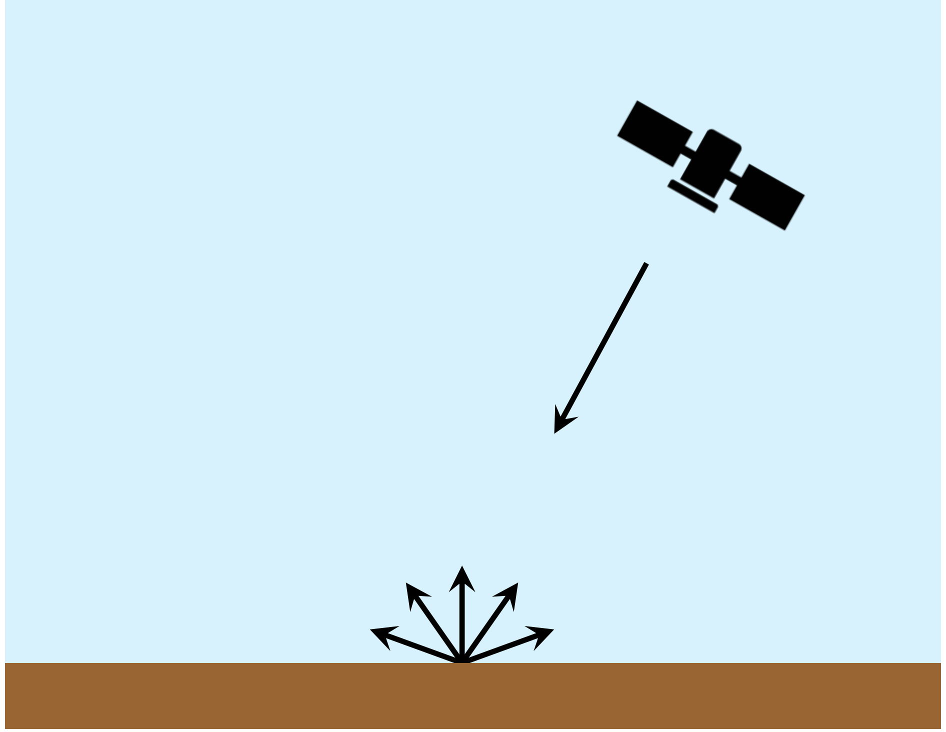
❑ Passive Sensors

+ Easy interpretation
- Depends on weather and lighting conditions



❑ Active Sensors (e.g. Synthetic Aperture Radar, SAR)

+ Independent of weather and lighting conditions
- Requires pre-processing



Flood information for the entire disaster management cycle

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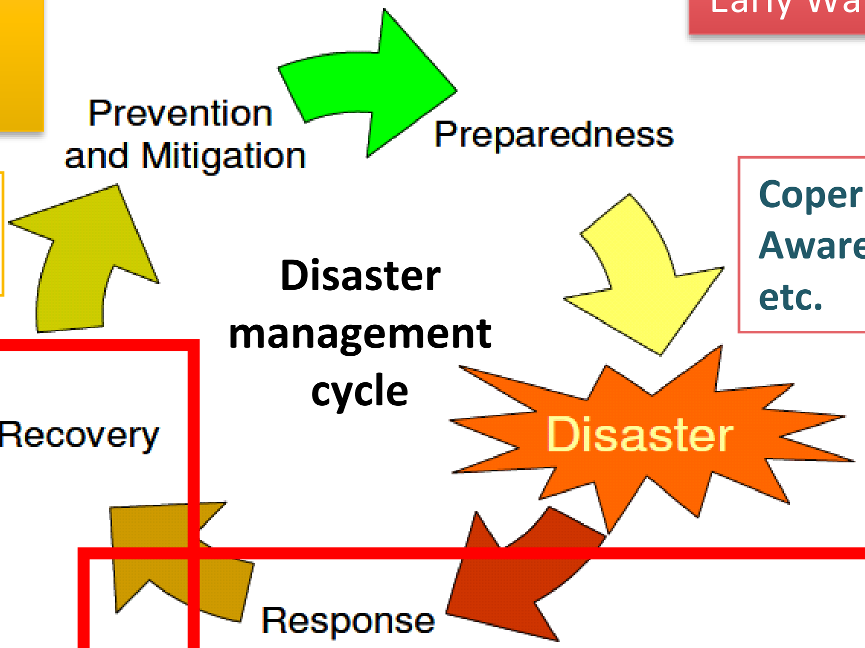

Geoinformation for
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Rapid mapping: Extent and impact

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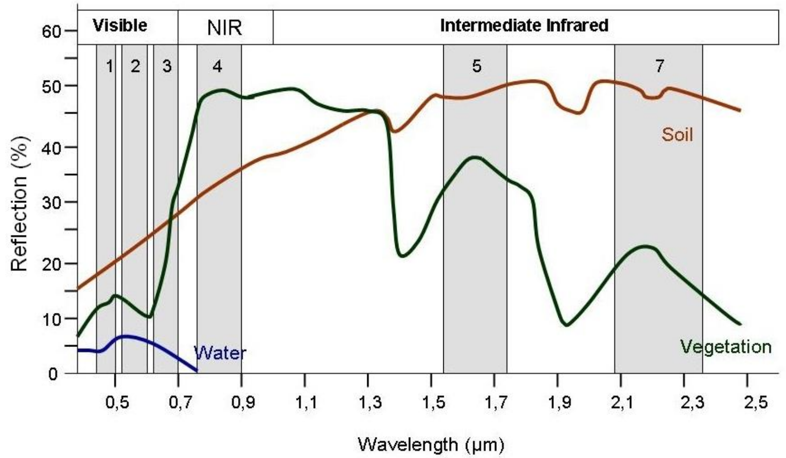
Flood mapping using optical imagery

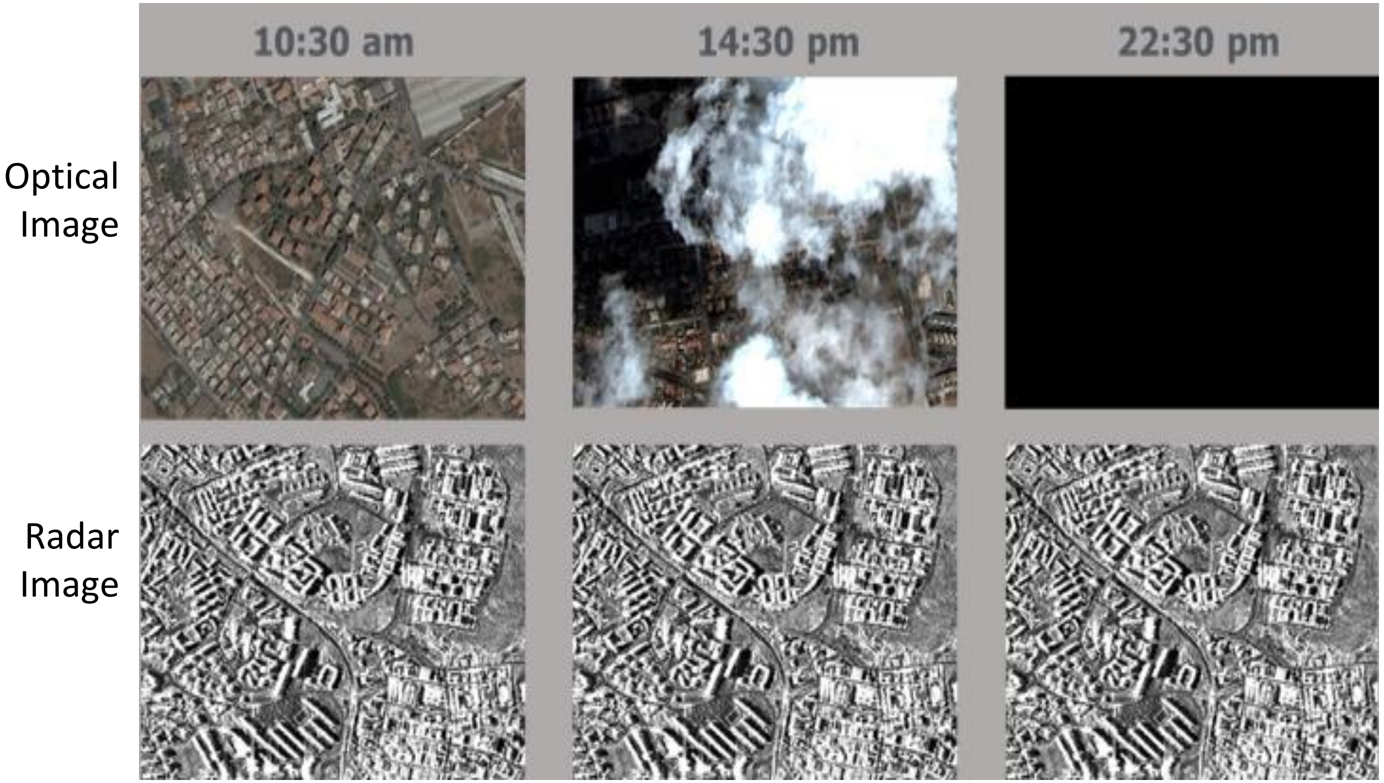
- Landcover classification or
- Calculation of indices that make use of spectral reflectance of water
  - Reflectance higher in visible than in NIR and SWIR channels
  - Using the Normalized Difference Water Index (NDWI)
    - Near-infrared (NIR) and short-wave infrared (SWIR)
    - Or green and NIR
- NOAA global flood map products (https://floods.ssec.wisc.edu/?products=RIVER-FLDglobal.75&center=0,0&zoom=2&basemap=satellite&labels=-&timestep=1d)



Advantages	Limitations
No backscatter, double bounce or overlay issues	No cloud penetration
Easily separates water from soil and vegetation	NDWI cannot separate well water from built-up areas

Synthetic Aperture Radar (SAR) principles

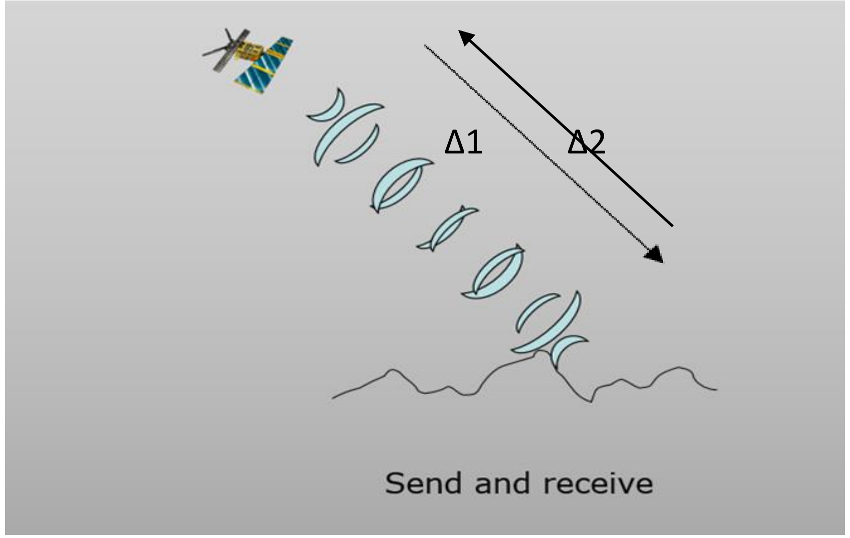
Interpretation: Advantages and Limitations

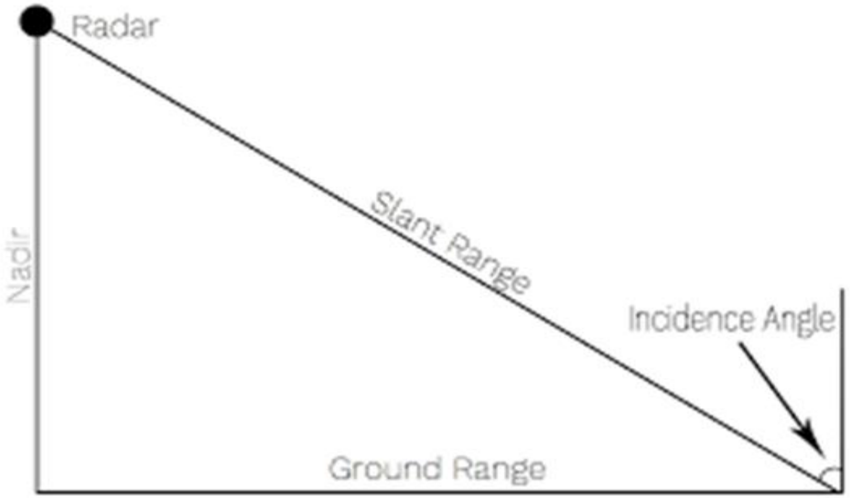


e-Geos
COSMO-SkyMed

SAR principles

How does a radar image work?

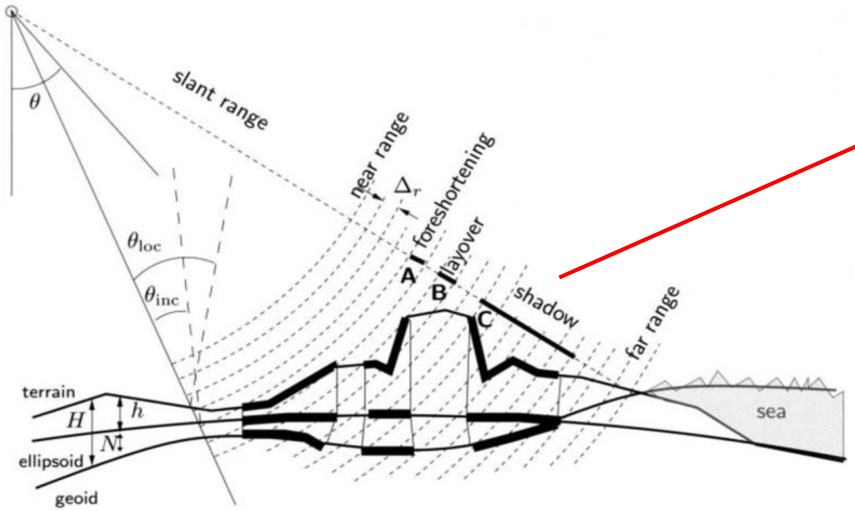


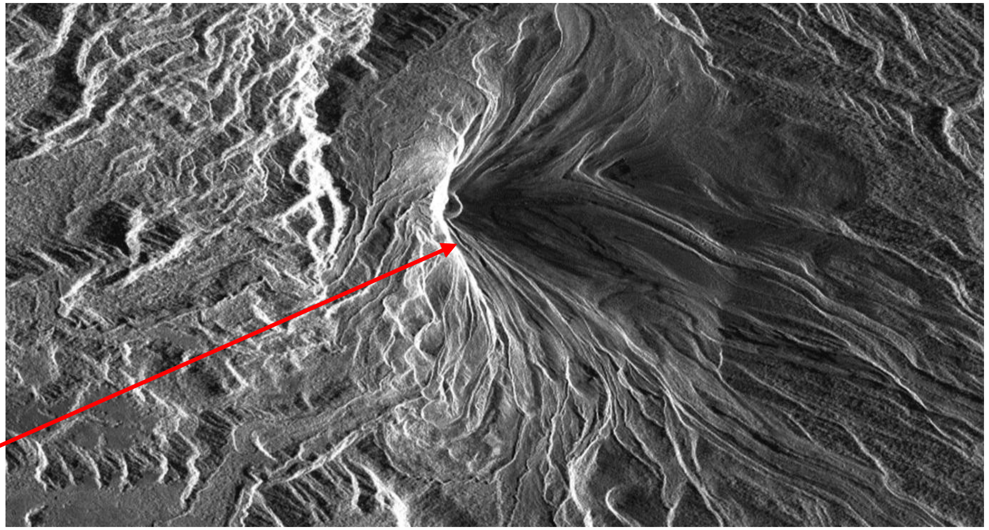


SAR principles

Ground parameters (variable)

1. Topography
2. Surface roughness
3. Object geometry
4. Object orientation
5. Dielectric constant (water content dependant)

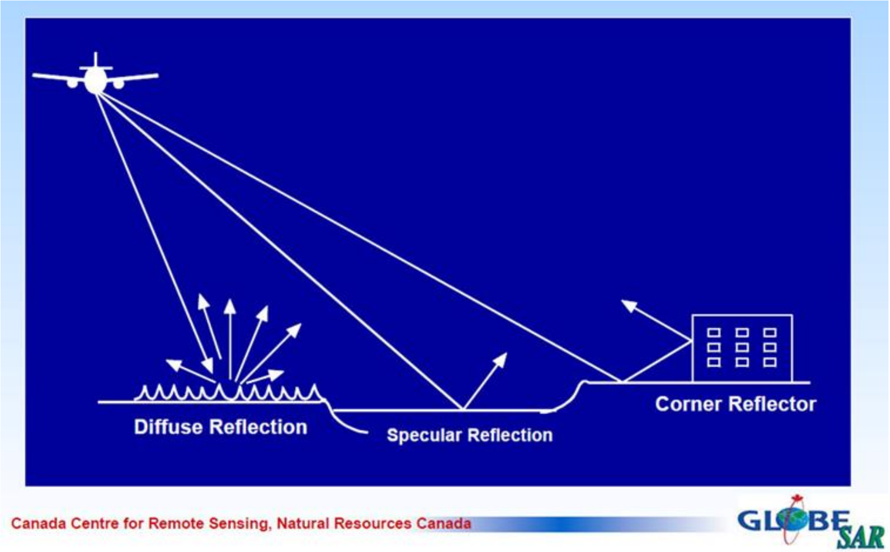


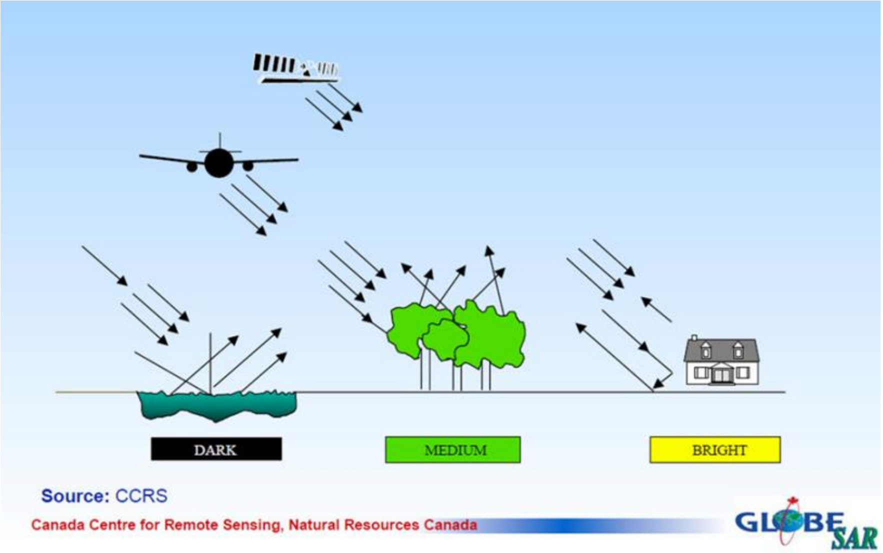


Colima Volcano- México TerraSAR-X, band C, view angle: 33°

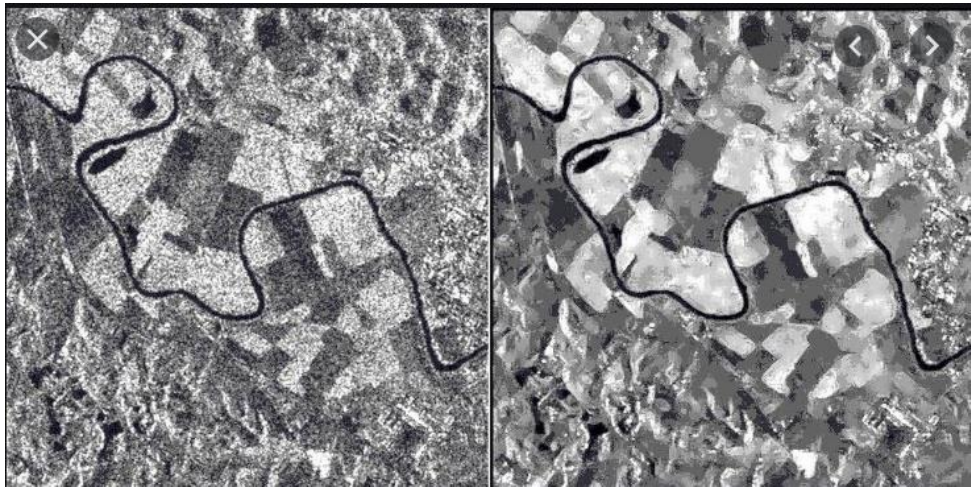
SAR principles

Backscattering





Speckle



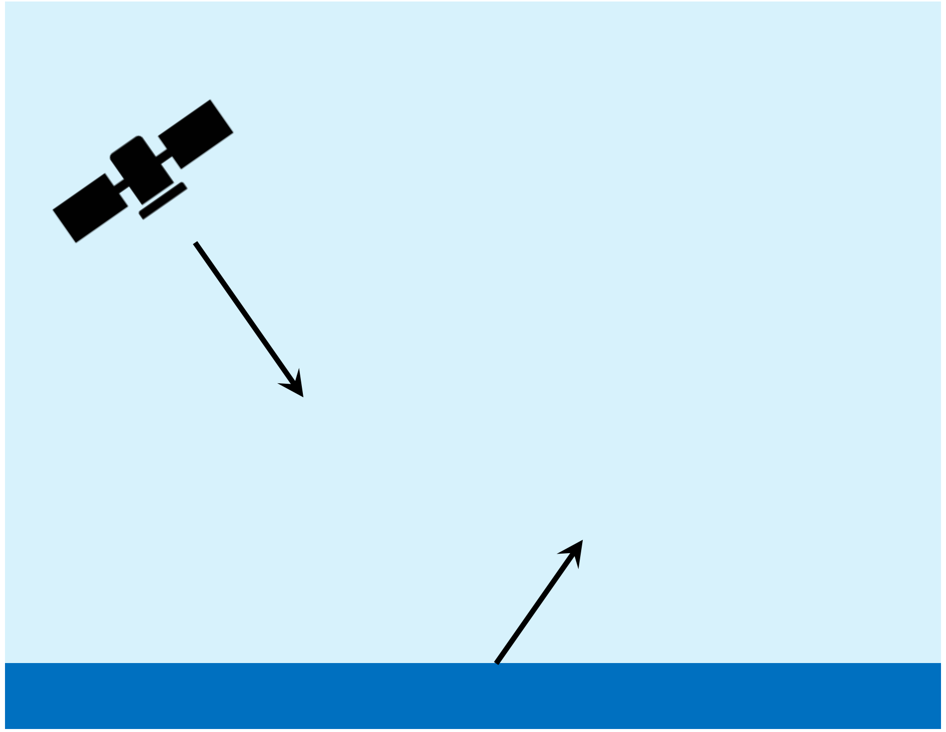
(Globe –SAR 2006)

SAR Reflection Types

❑ Specular Reflection

Occurs on smooth surfaces (e.g. water)

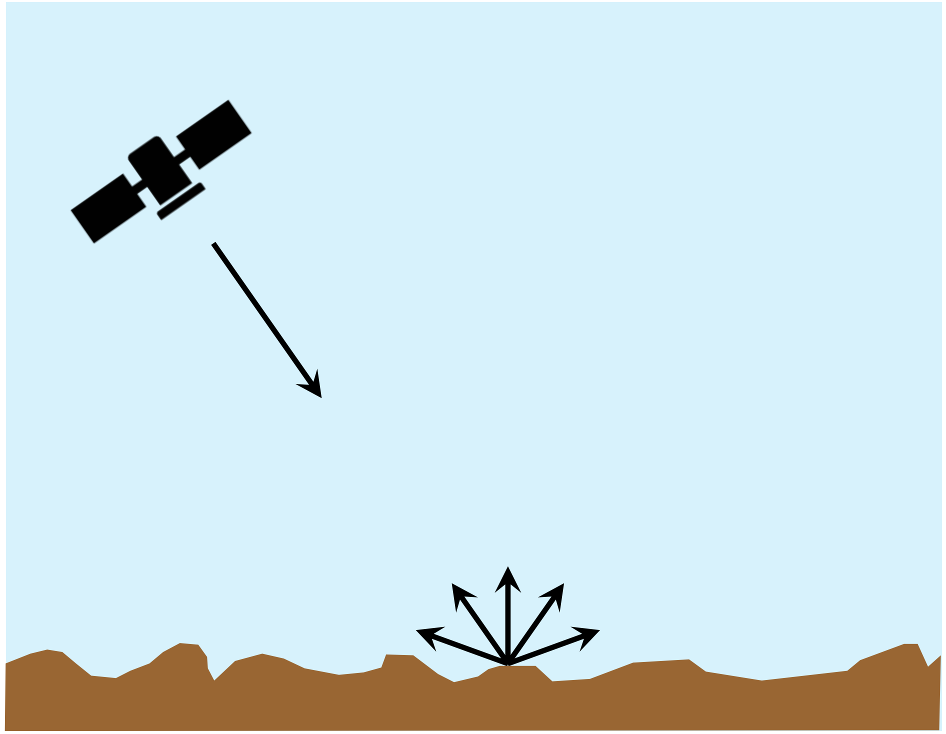
 Appears **dark** due to low backscatter intensity



❑ Diffuse Reflection

Occurs on rough surfaces (e.g. soil)

 Appears **bright** due to high backscatter intensity

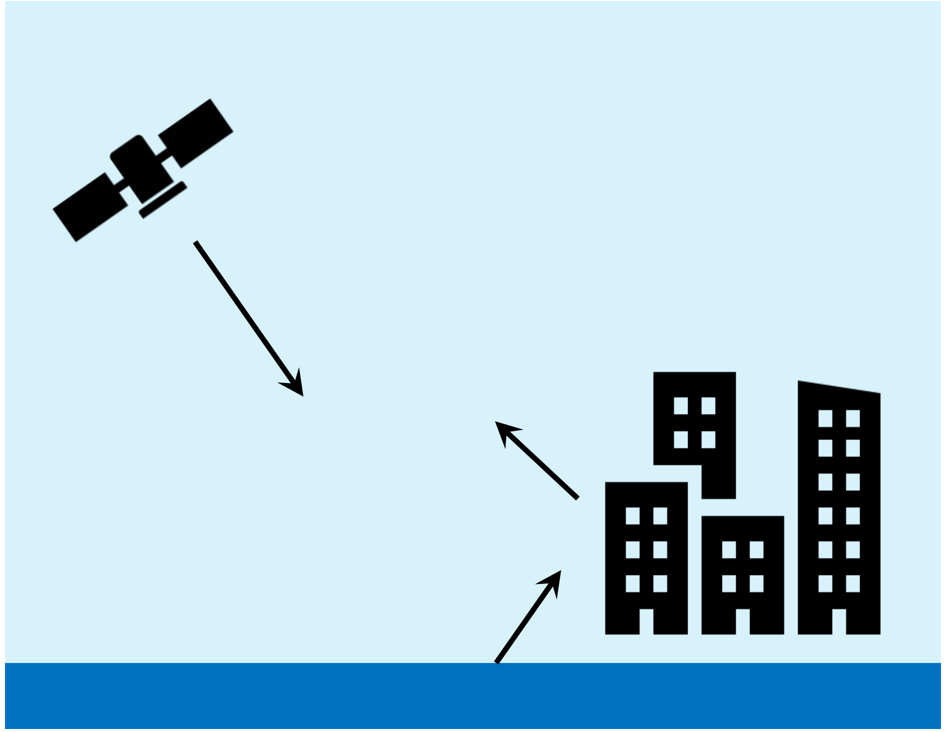


Limitation: Double bounce backscatter

❑ Urban Areas

Multiple reflections at urban geometries

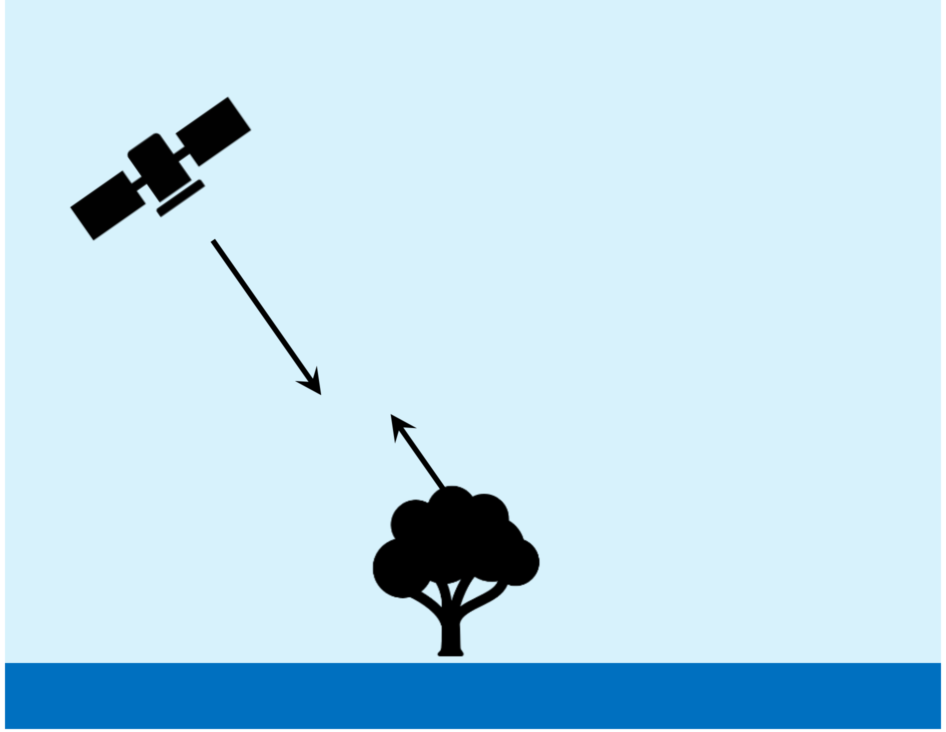
 Appears **bright** due to high backscatter intensity



❑ Flooded Vegetation

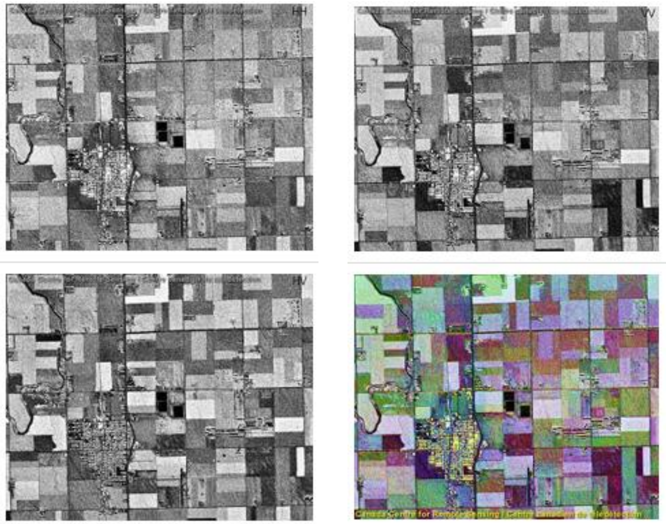
Multiple reflections in vegetation

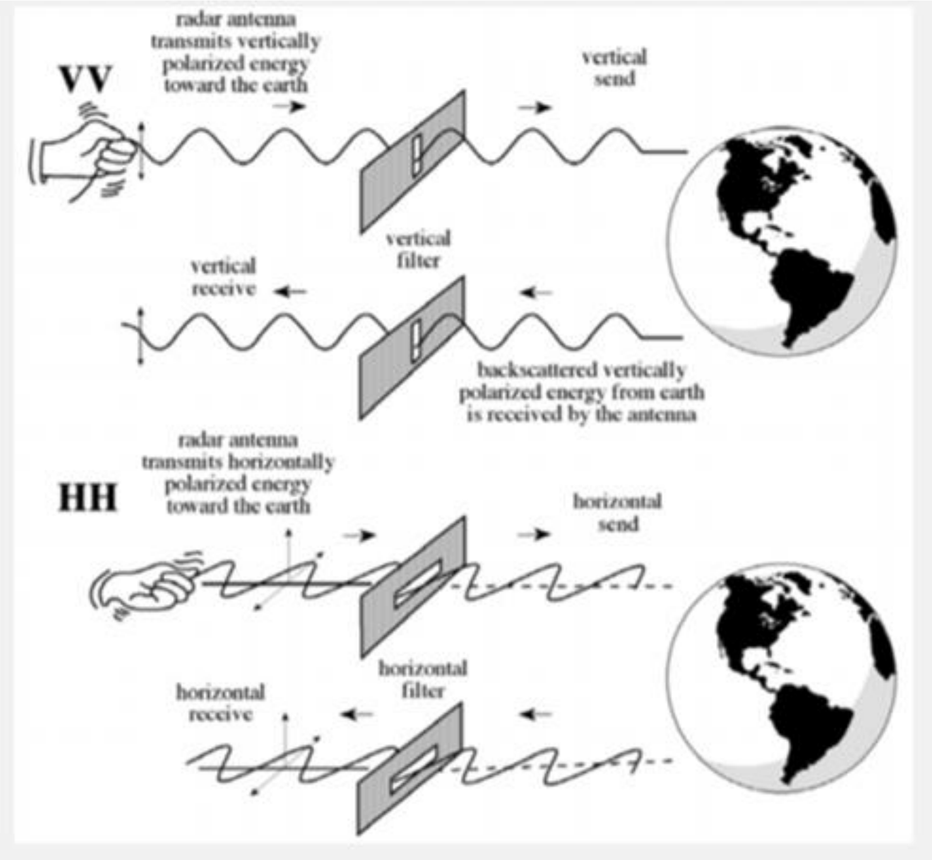
 Appears **bright** due to high backscatter intensity



SAR principles

- Radar Parameters: Polarizations
  - HH: Horizontal Transmit, Horizontal Receive
  - HV: Horizontal Transmit, Vertical Receive
  - VH: Vertical Transmit, Horizontal Receive
  - VV: Vertical Transmit, Vertical Receive
  - Quad-Pol: all polarizations are measured
- *For the UN-SPIDER Recommended Practice we use VV…*





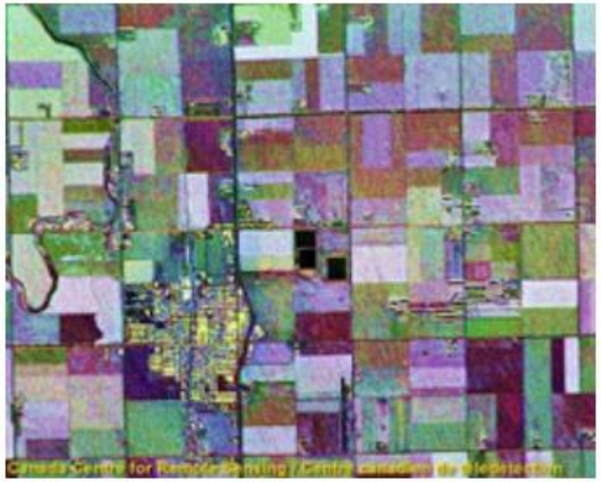
(Applied Remote Sensing Training Program- NASA)

SAR principles

HH

VV

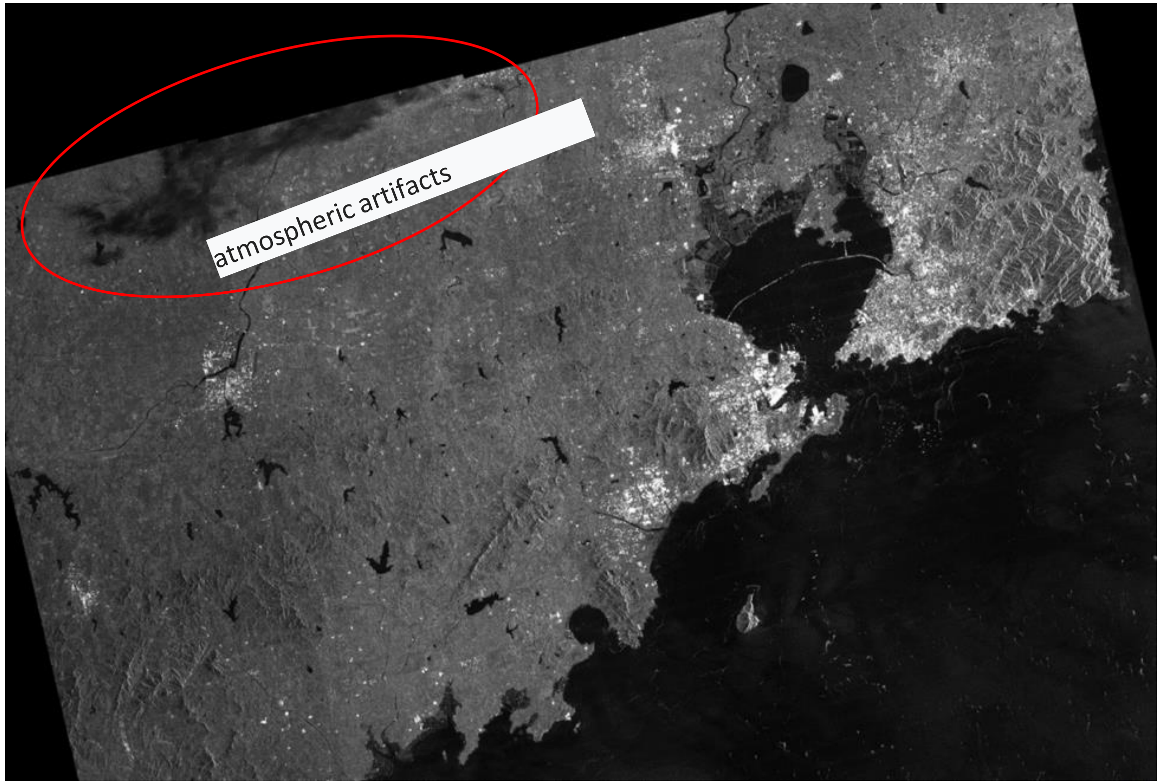
VH



Composite

Interpretation

Atmospheric artifacts



Advantages/Limitations

Advantages	Limitations
Cloud penetration	Backscatter signal of rough water surfaces
Daylight independence	Geometric distortions
Open data & free access to archive	Double-bounce effect in vegetated or urban areas
Dielectric constant alteration	Radar shadow

Methods for flood identification

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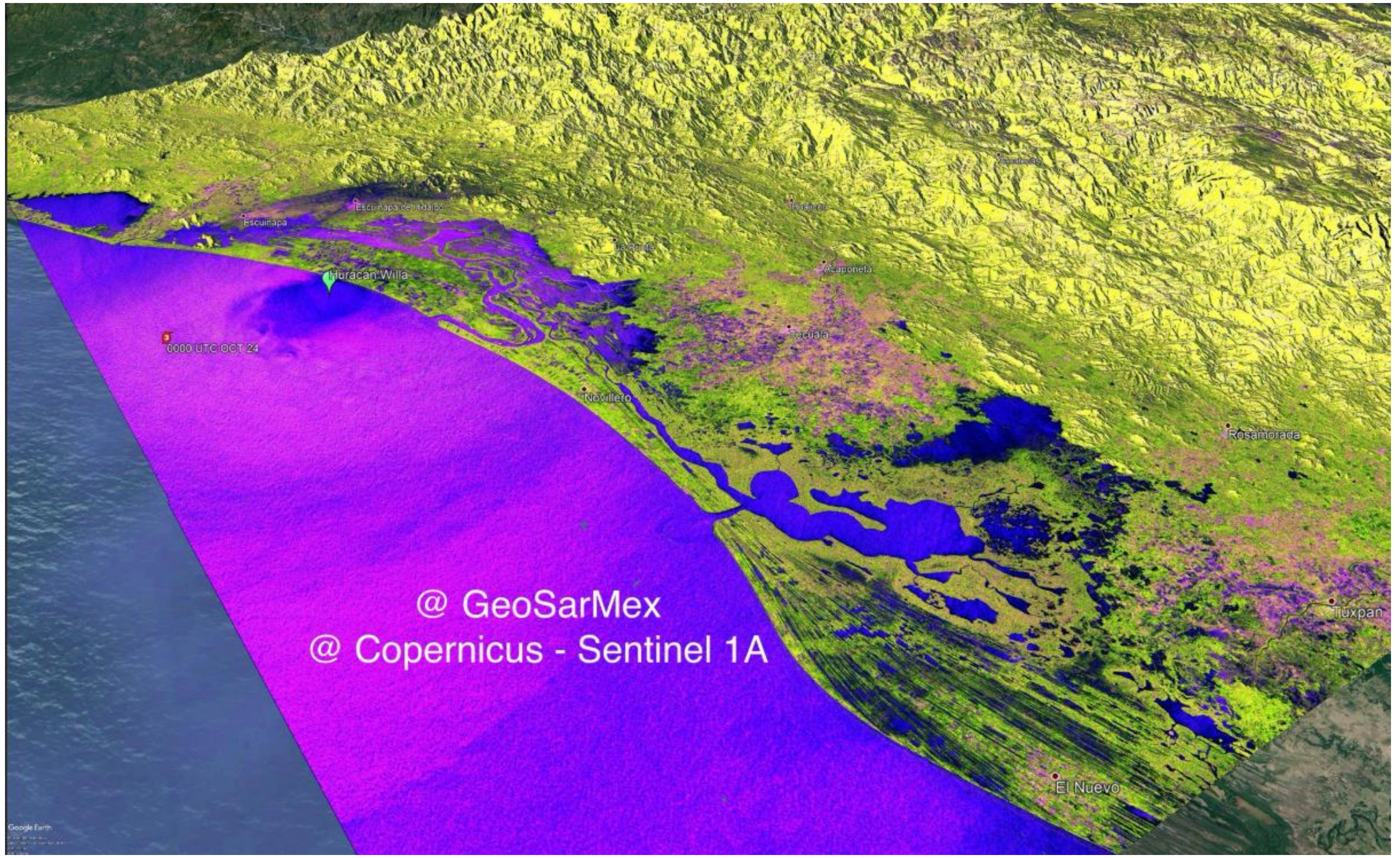
Principal methods for flood mapping:

1. **Thresholding** - Radiometric correction and setting of db limit **on after-event image**

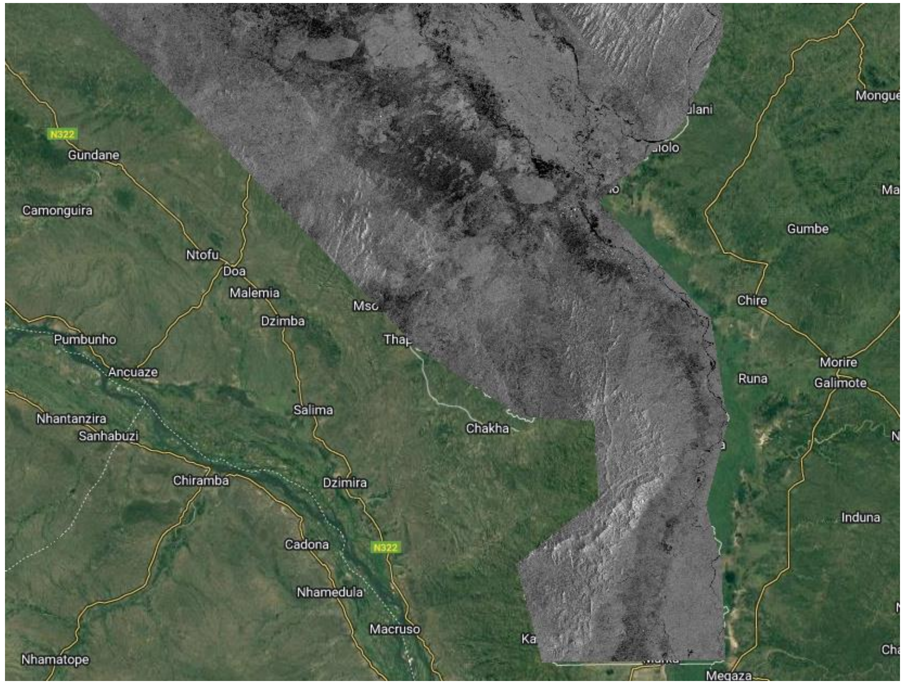


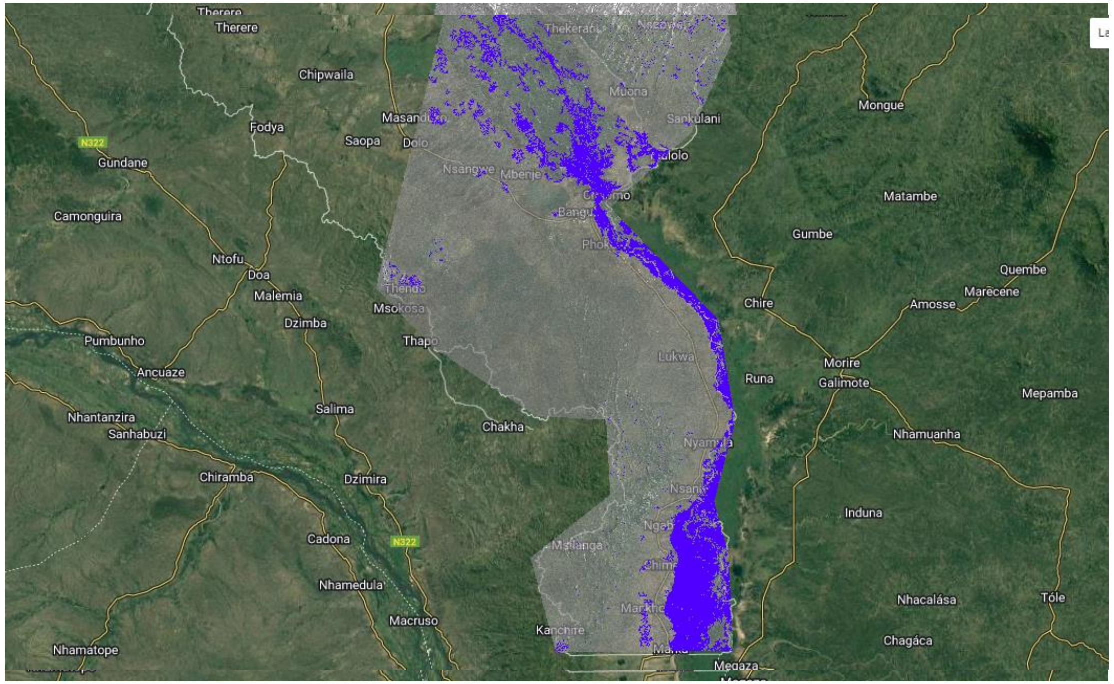
Mazatlán- México West coast

Methods for flood mapping

Principal methods for flood mapping:

2. **Ratios and change detection** (using **before and after-event SAR images**)





Veracruz-Mexico (2018)

UN-SPIDER Recommended Practices

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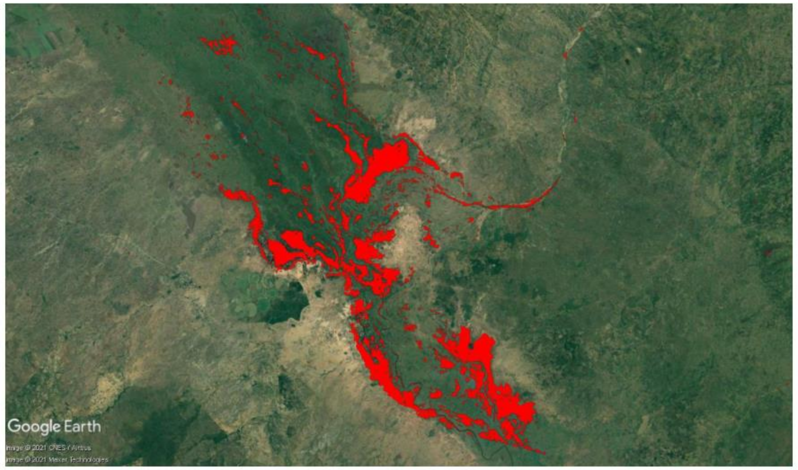
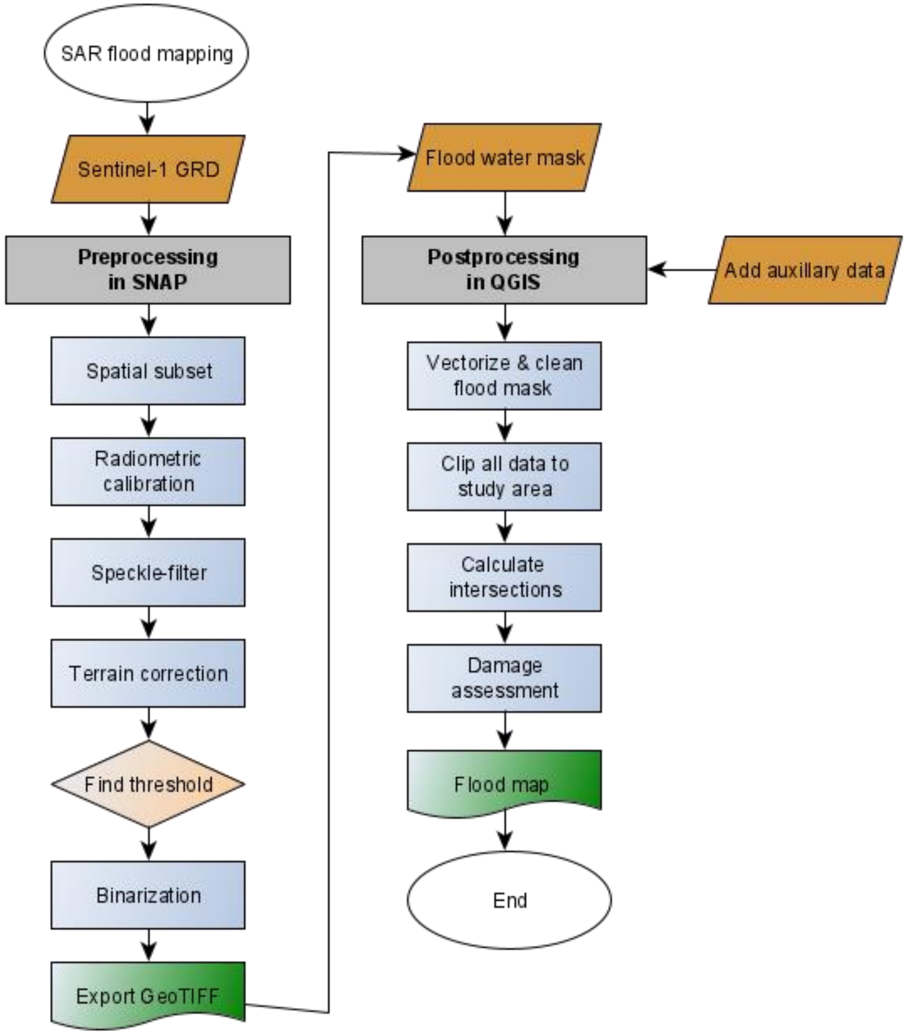
- Radar-based Flood Mapping
  - https://www.un-spider.org/advisory-support/recommended-practices/recommended-practice-radar-based-flood-mapping
  - Uses Sentinel-1 SAR data obtained from Open Access Hub
  - SNAP (free desktop software) or Python (Jupyter Notebook online)
  - Result can be imported into QGIS / Google Earth





UN-SPIDER Recommended Practices

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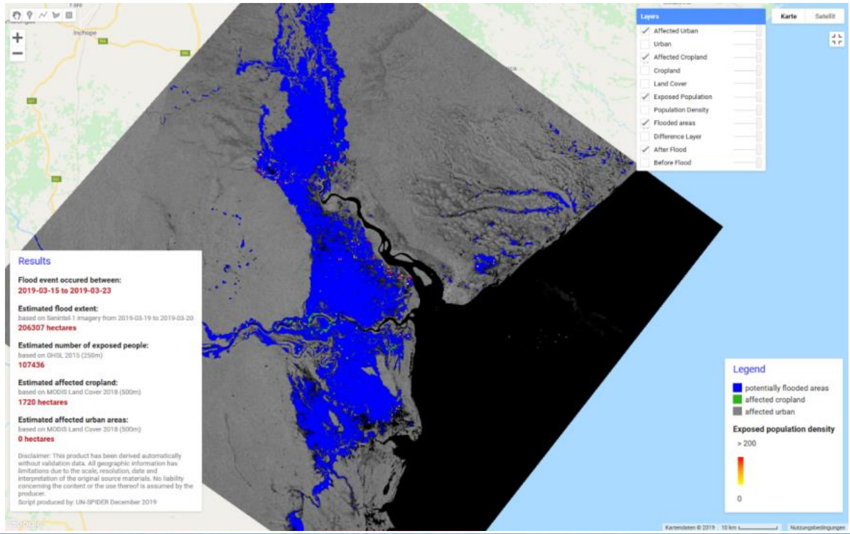
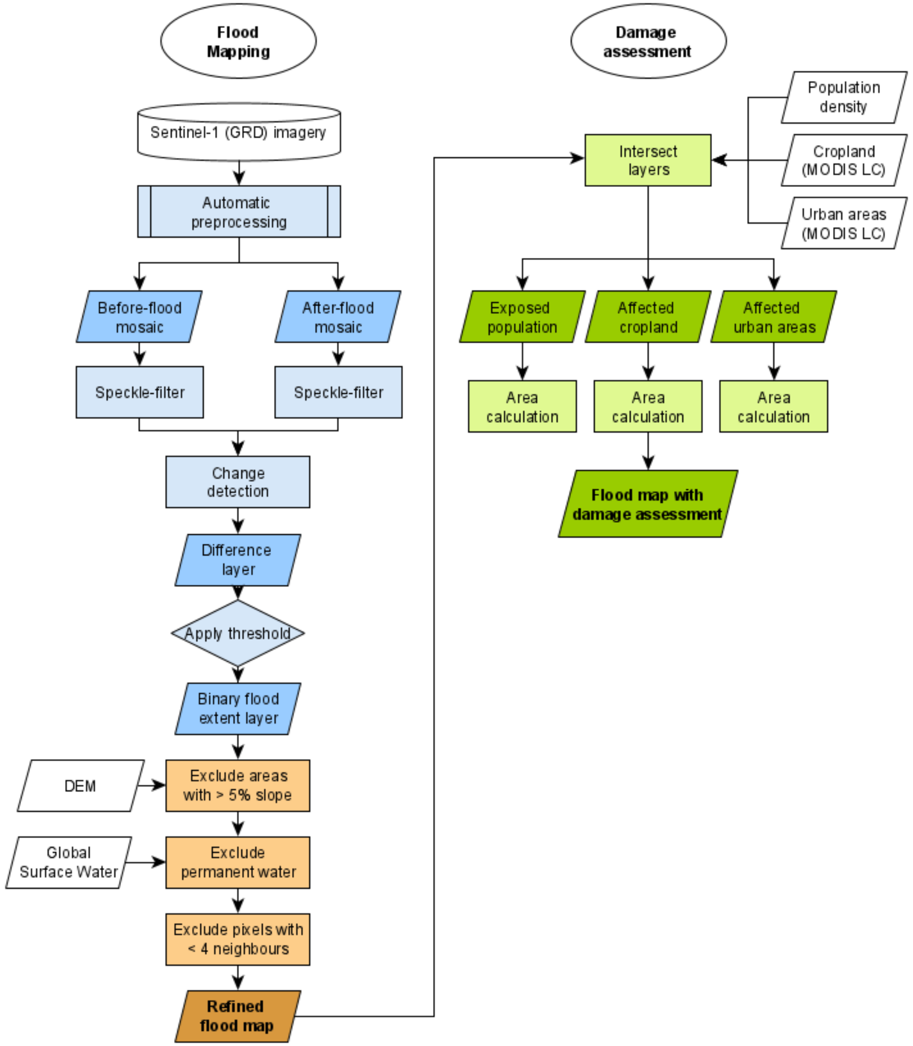
- Flood Mapping and Damage Assessment Using Sentinel-1 SAR Data in Google Earth Engine
  - https://un-spider.org/advisory-support/recommended-practices/recommended-practice-google-earth-engine-flood-mapping
  - Uses Sentinel-1 SAR data obtained from Google Earth Engine (delayed data provision)
  - Result can be imported into QGIS or other software





Hands-on exercise

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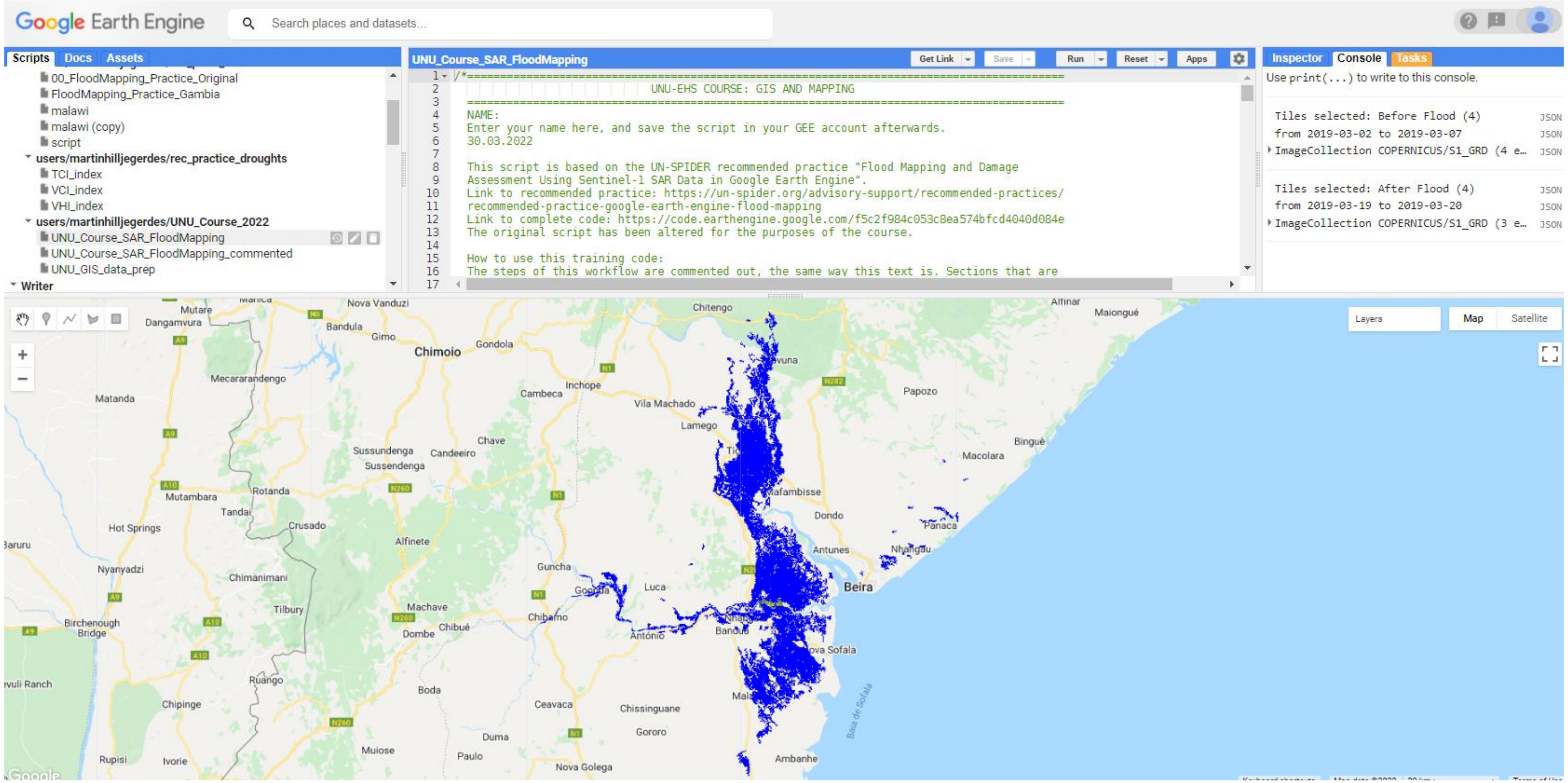
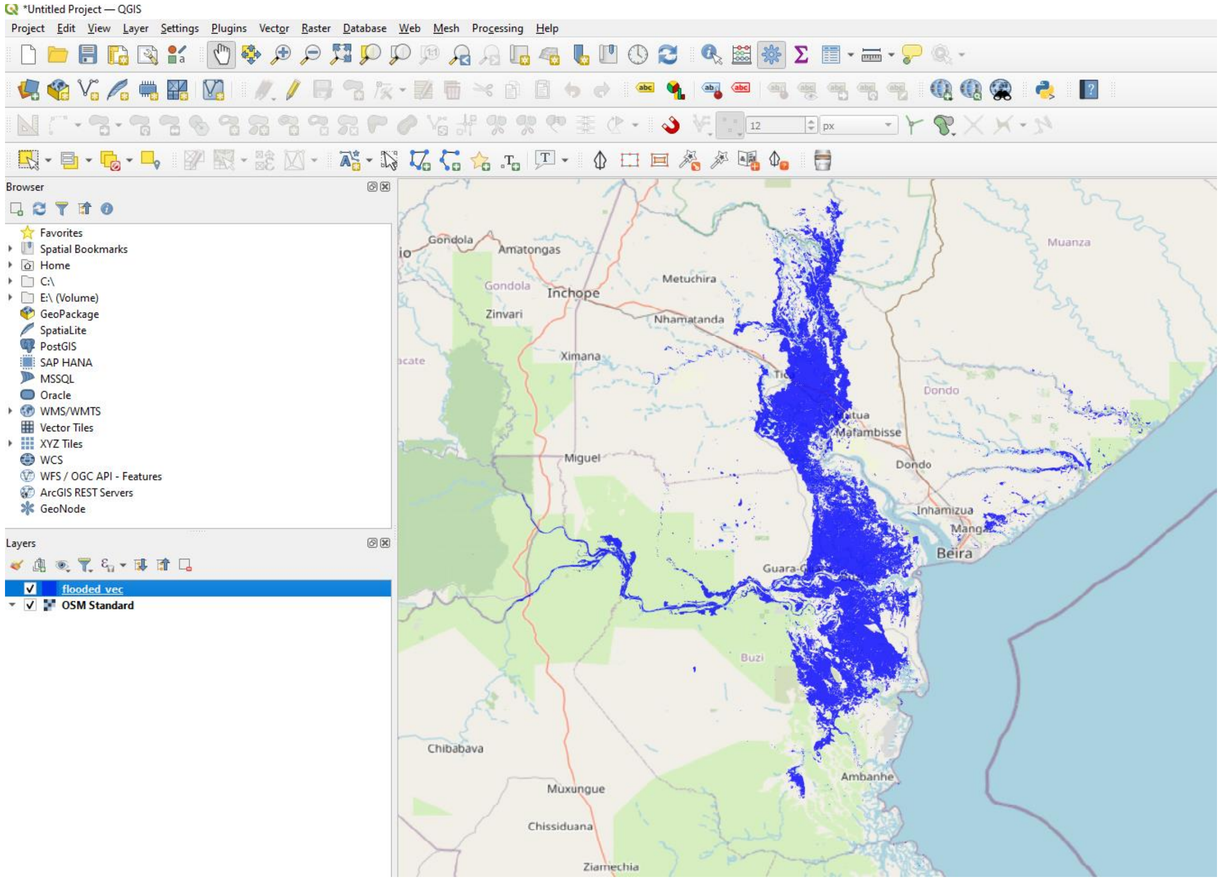
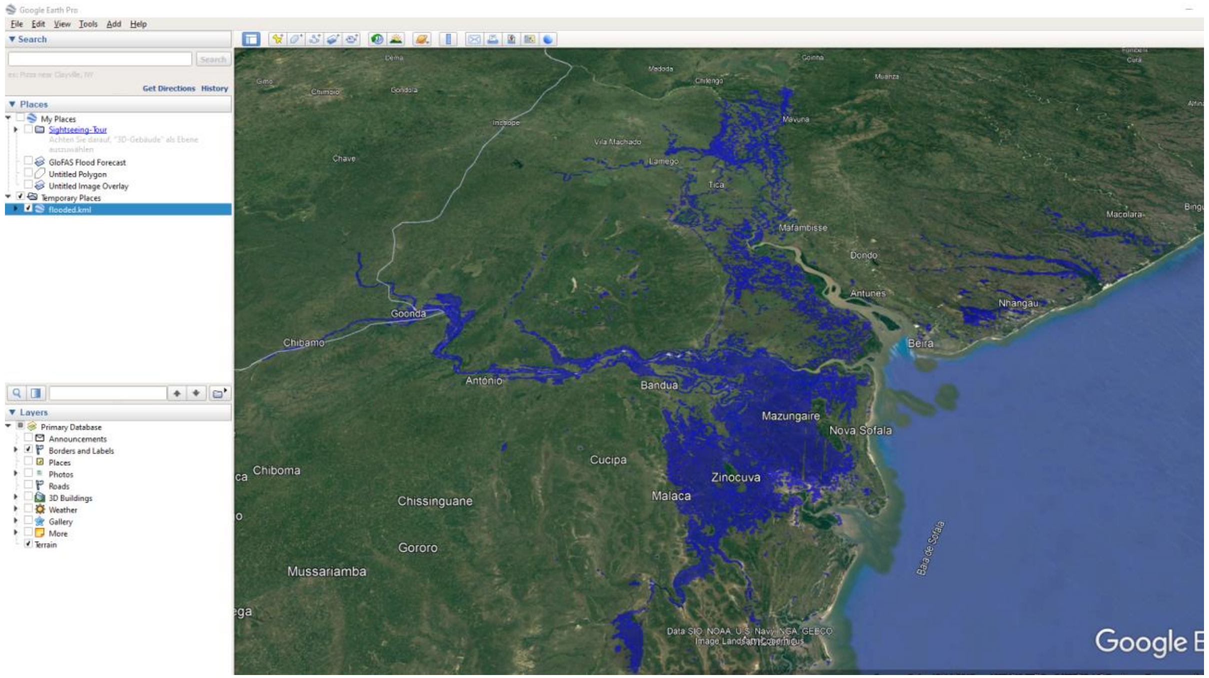
Google Earth Engine training script: https://tinyurl.com/unspider-flood-training2023



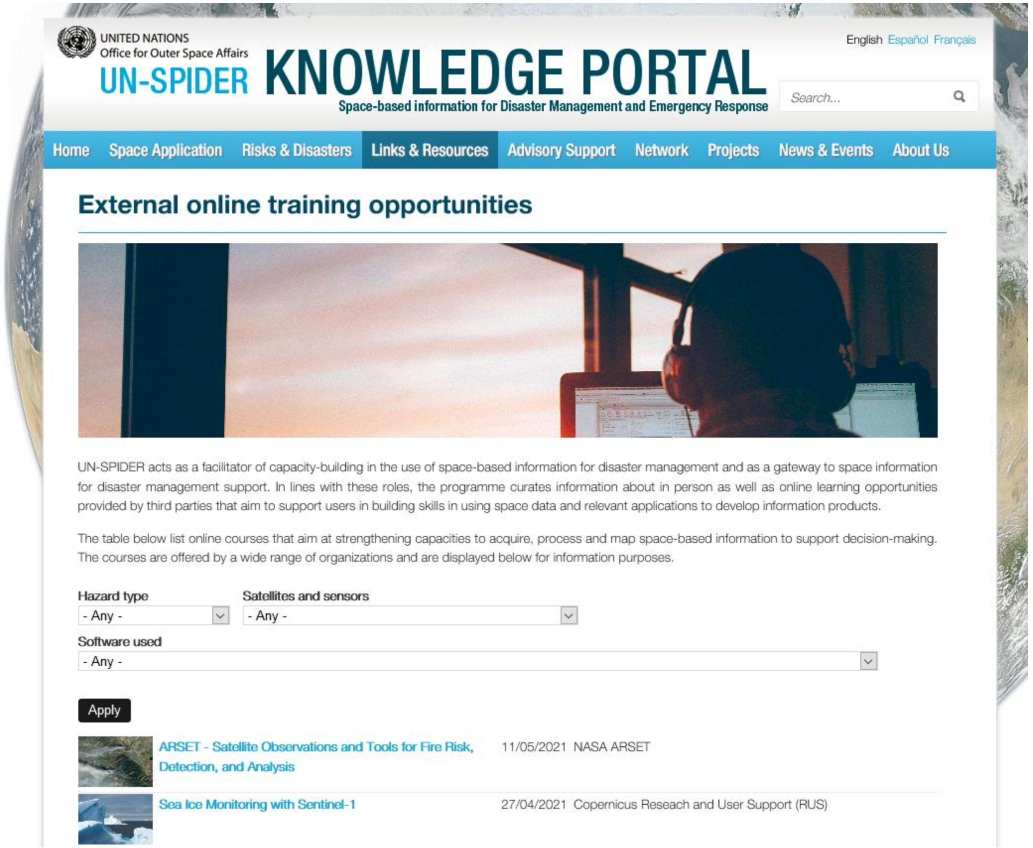
Export and visualize the data in QGIS or Google Earth Pro





Learning resources

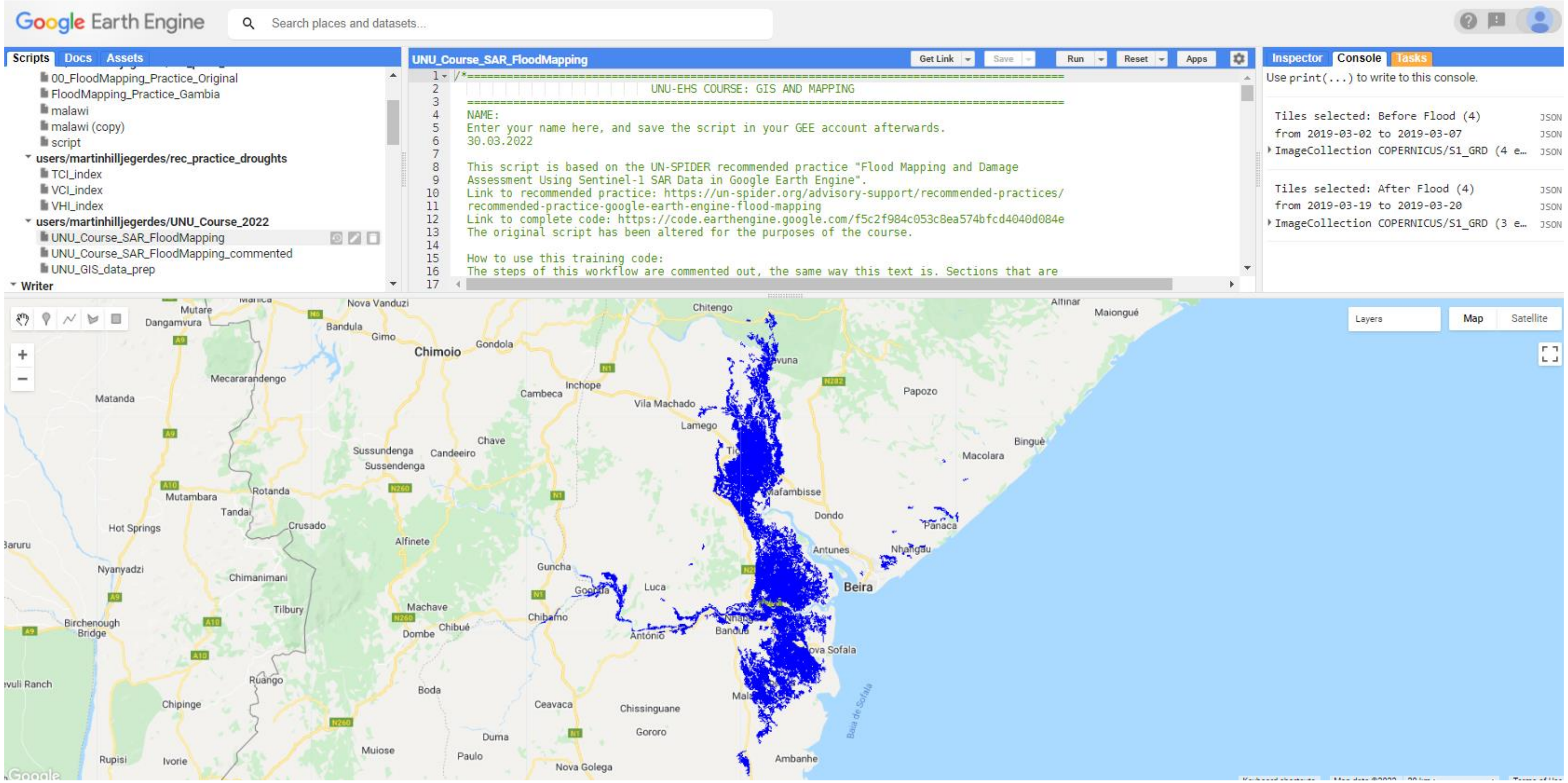
- EO College MOOC Echoes in Space – Introduction to Radar Remote Sensing (https://eo-college.org/courses/)
- University of Alaska Fairbanks – Synthethic Aperture Radar: Hazards (https://www.edx.org/course/sar-hazards)
- NASA ARSET (https://appliedsciences.nasa.gov/what-we-do/capacity-building/arset)
- Copernicus Research and User Support (RUS) (https://rus-copernicus.eu/portal/)
- Regularly updated list of free online training opportunities categorized by hazard at https://un-spider.org/links-and-resources/online-training-opportunities
- UN-SPIDER YouTube channel (https://www.youtube.com/channel/UCTwI1Al7To1f2hlSrLOOzzw)
- Natural Resources Canada (NRCAN) Tutorials (https://www.nrcan.gc.ca/maps-tools-and-publications/satellite-imagery-and-air-photos/tutorial-fundamentals-remote-sensing/9309)



Before we head to coffee break...

- Prepare for Victor’s session...

Google Earth Engine original (full) script: https://tinyurl.com/unspider-flood-full



Thank you

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