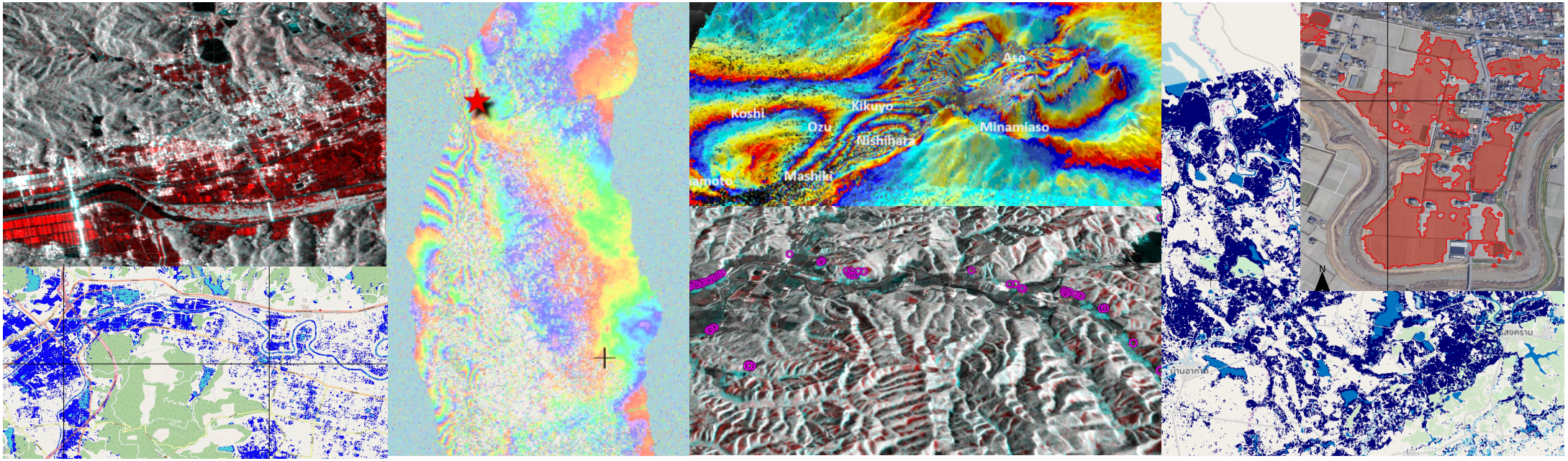


How to better understand SAR, interpret SAR products and realize the limitations

Nopphawan Tamkuan and Masahiko Nagai

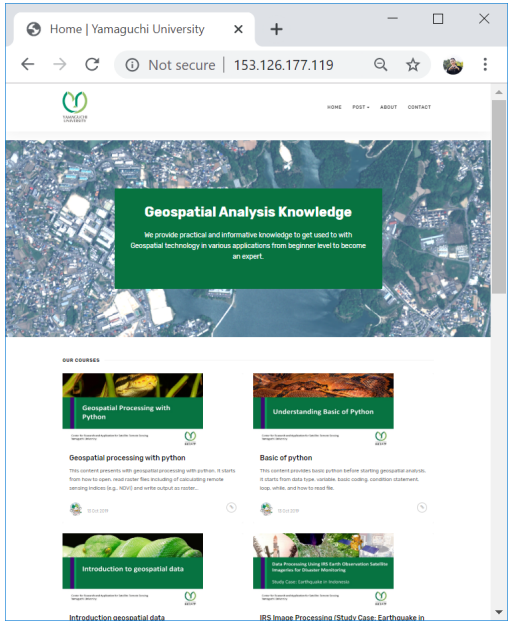
Graduate School of Sciences and Technology of Innovation
Yamaguchi University, Japan

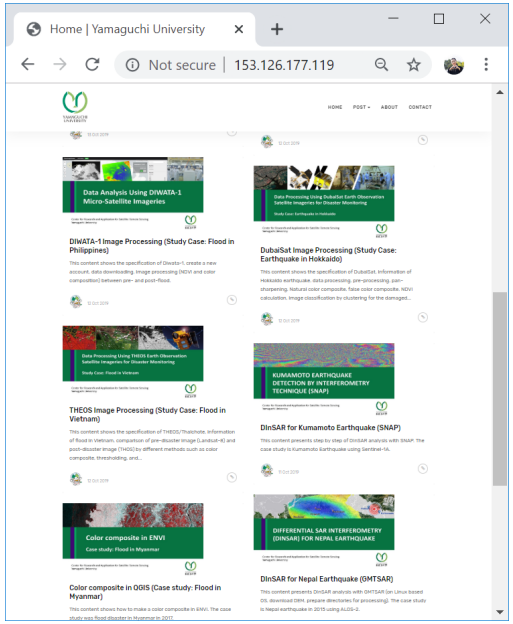
Sentinel Asia

YAMAGUCHI UNIVERSITY 山口大学

Yamaguchi University Resource (website)

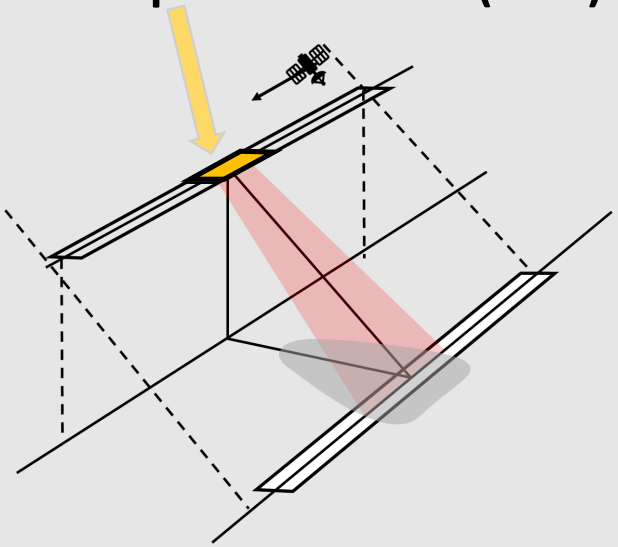
- Collect materials and procedure how to analysis geospatial data especially for disaster application
- Implement to our students and university network to be able to join data analysis activity for emergency case



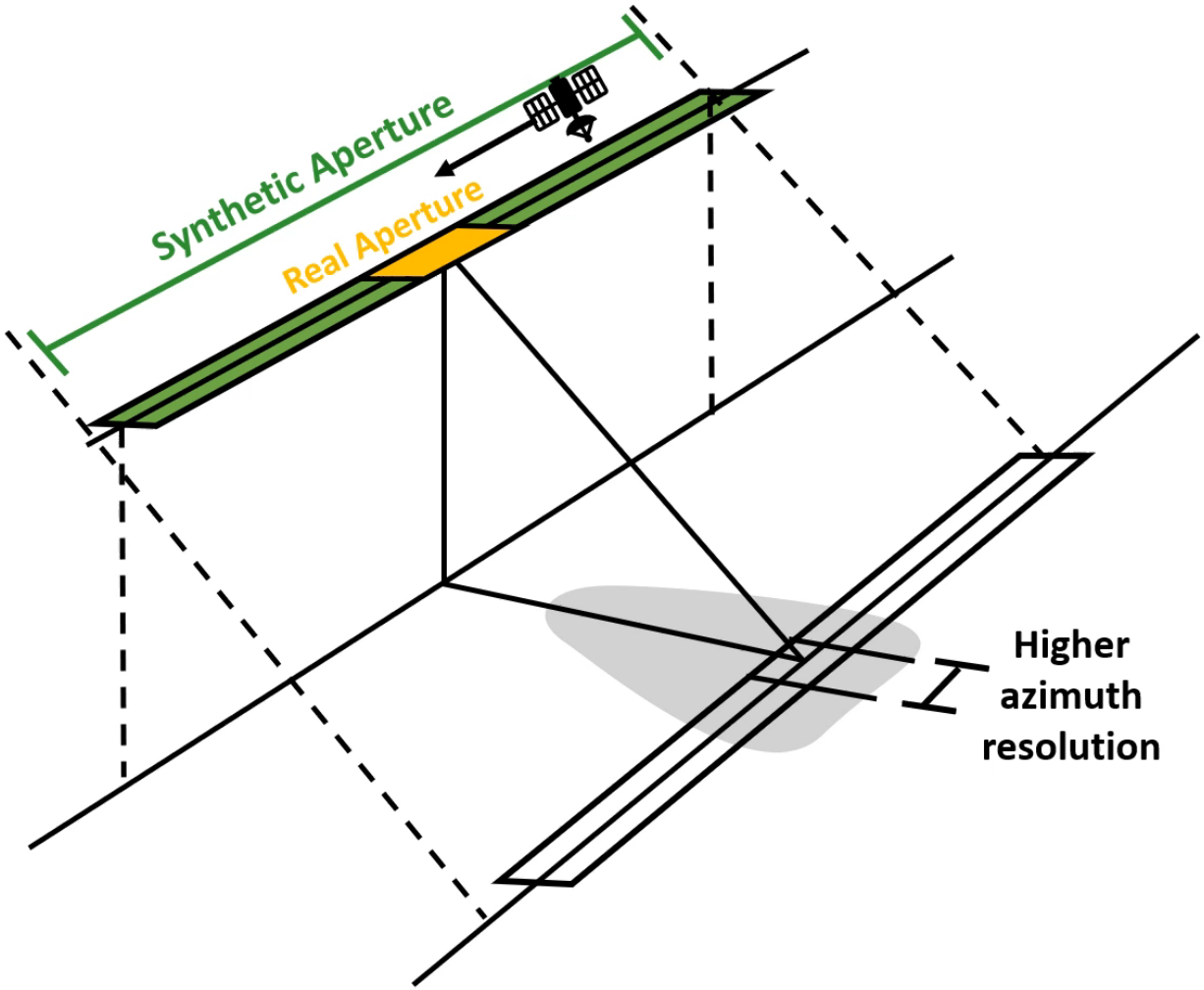


http://bit.do/eduweb

Real Aperture Radar (RAR)



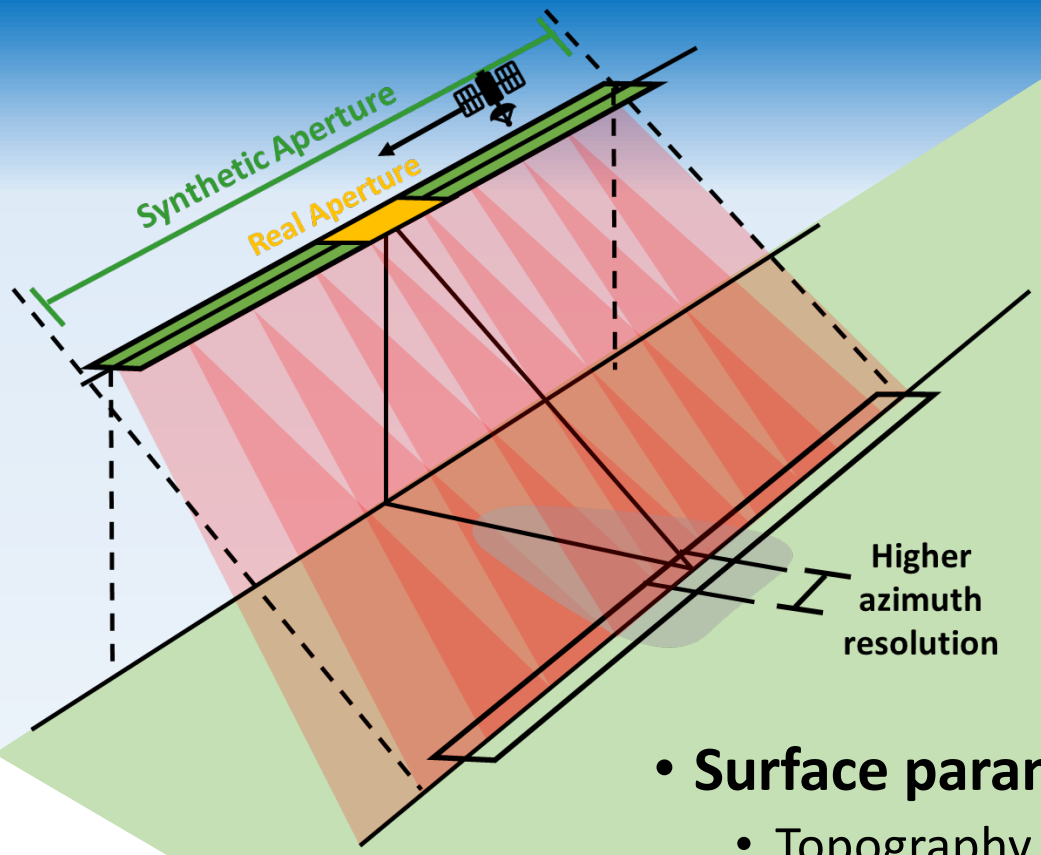
Synthetic Aperture Radar (SAR)



Synthetic Aperture Radar (SAR) is side looking radar which utilizes fight path to increase the antenna's size (aperture) and resolution in azimuth direction.

This system uses complicated data processing of multi-temporal signals and phase receiving from targets to generate high resolution image.

- **Sensor parameters**
  - Band
  - Polarization
  - Incidence angle
  - Location of sensor
    - Azimuth
    - Look direction



- **Surface parameter**
  - Topography
  - Surface roughness
  - Object geometry
  - Dielectric constant

Scattering mechanisms

- Specular Reflection
- Surface scattering
- Double bounce
- Volume scattering

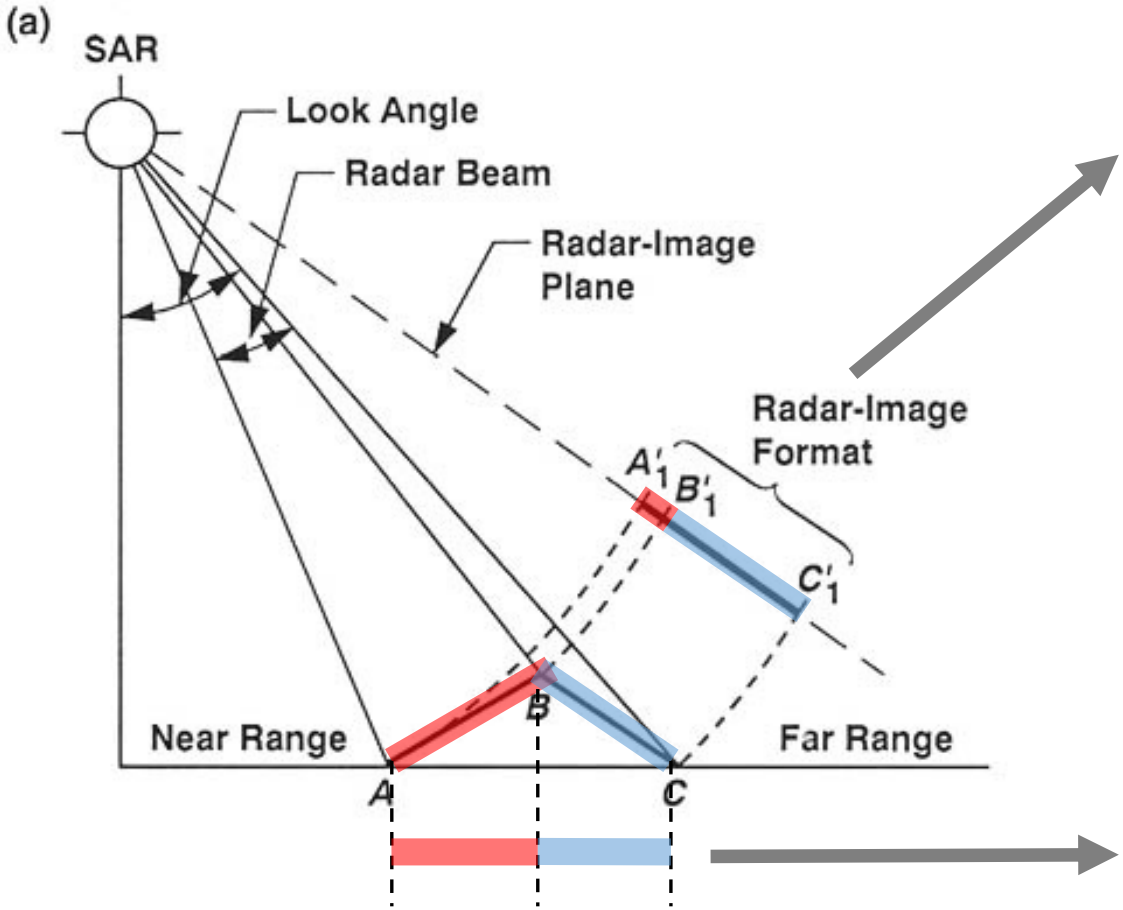
- Sensor parameters
  - Band
  - Polarization

Understand and Interpret SAR

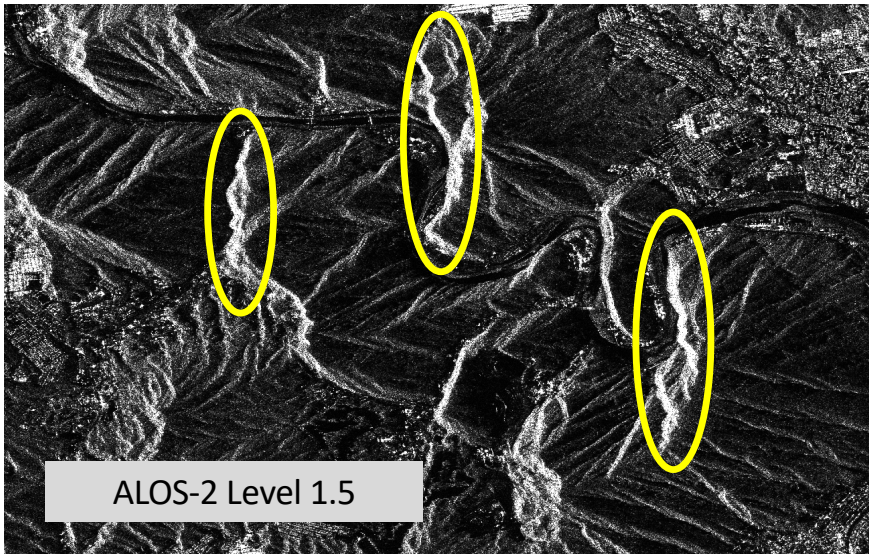
Variety of SAR mechanism
at the same area

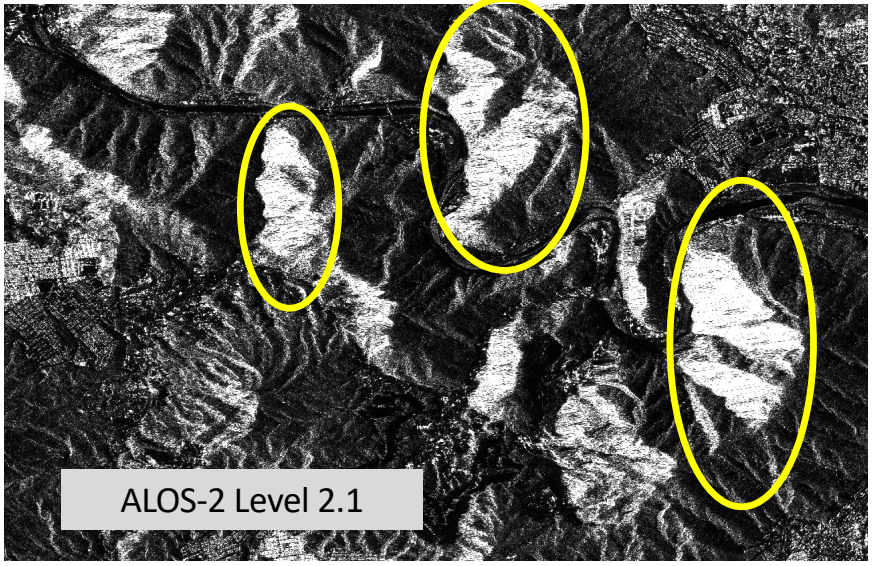
- Dielectric constant

Radar image foreshortening

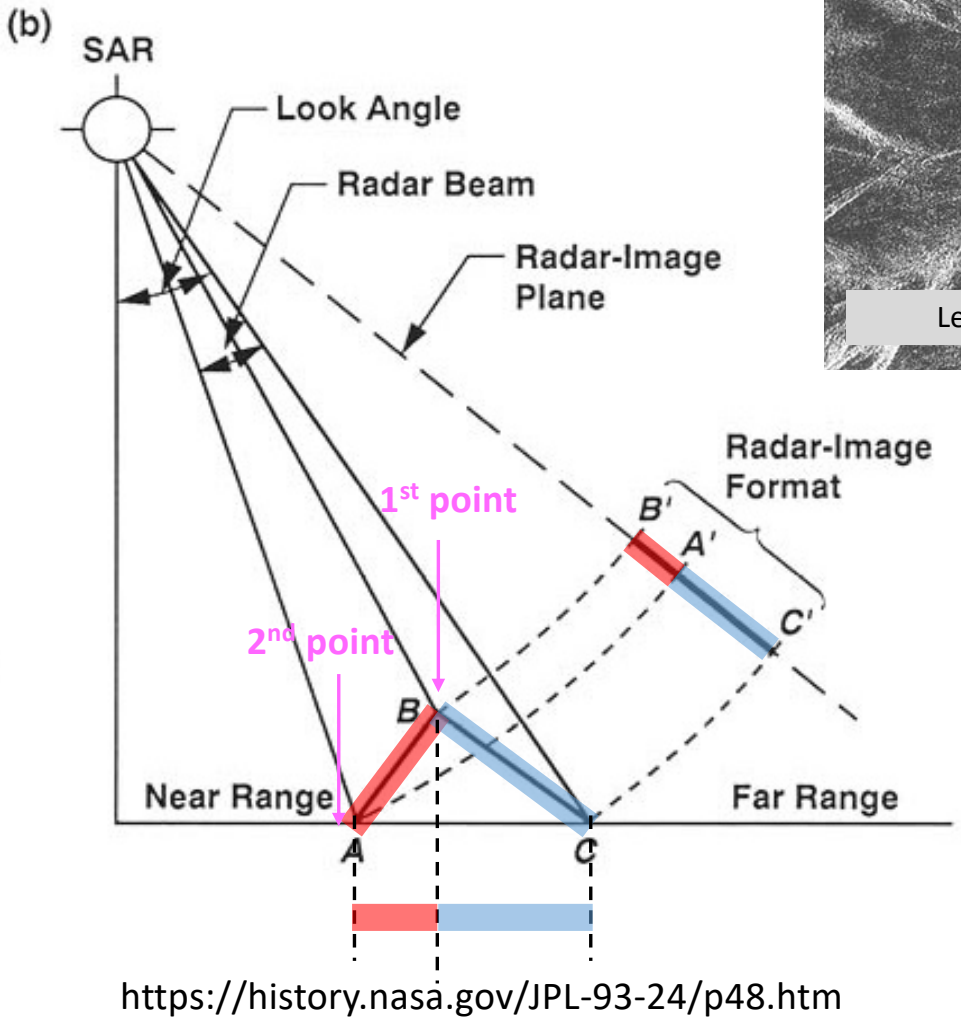


https://history.nasa.gov/JPL-93-24/p48.htm

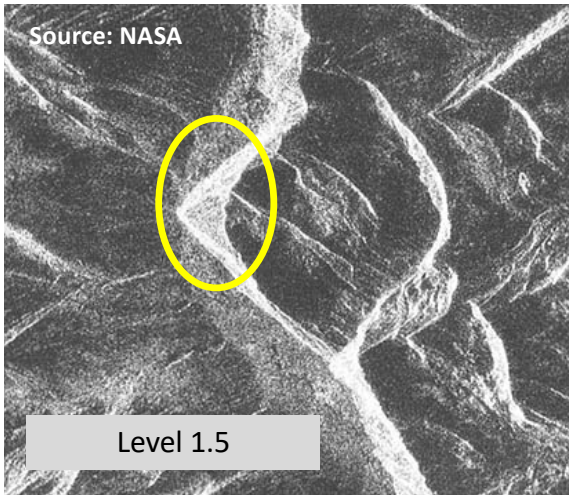


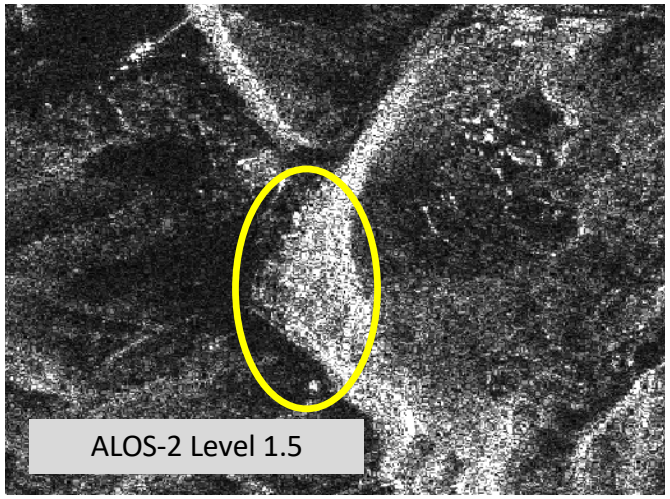


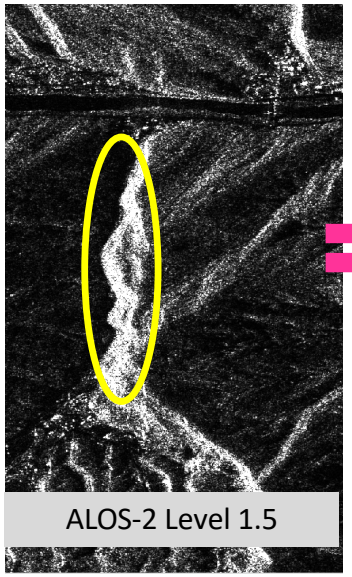
Radar layover

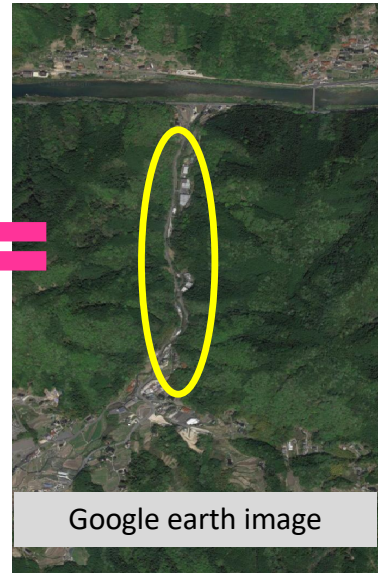


https://history.nasa.gov/JPL-93-24/p48.htm

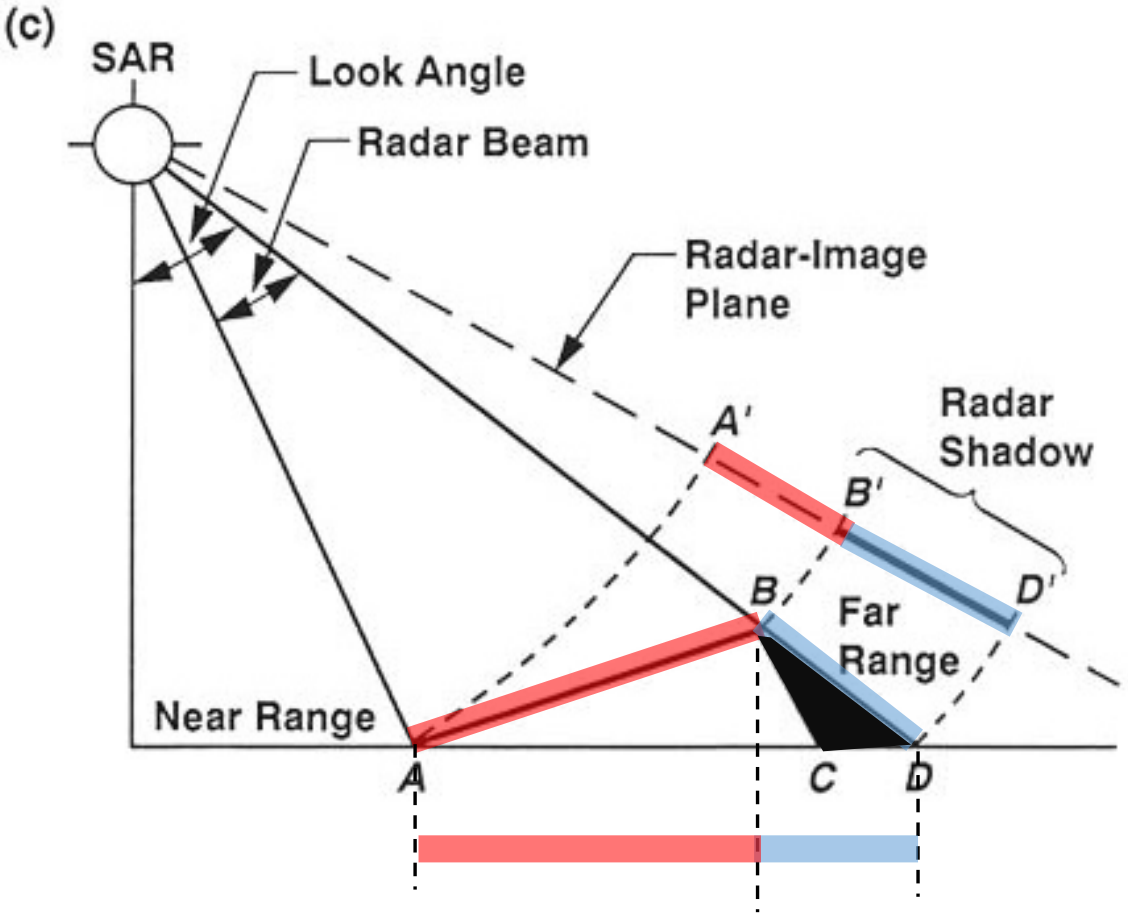




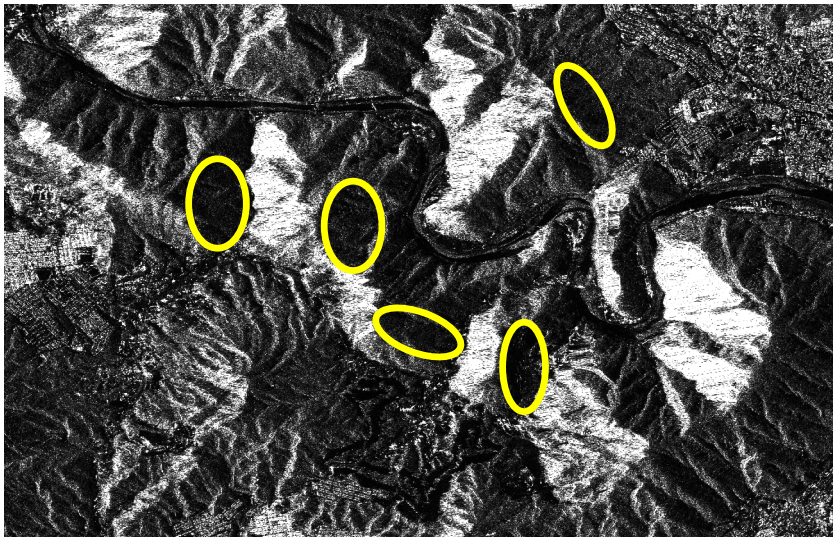


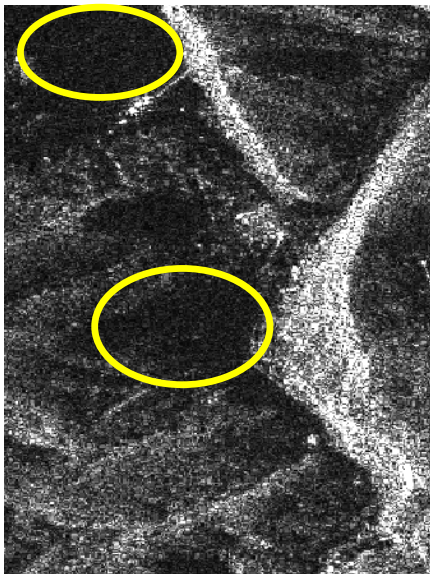


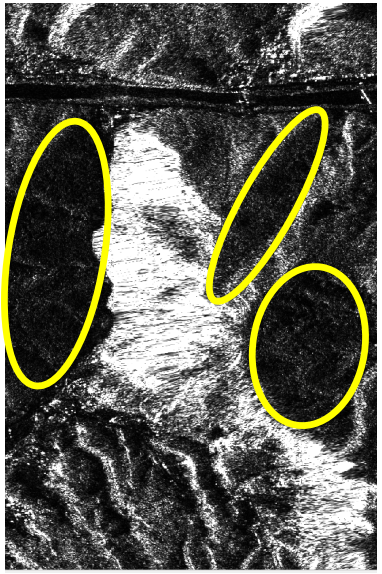
Radar shadowing

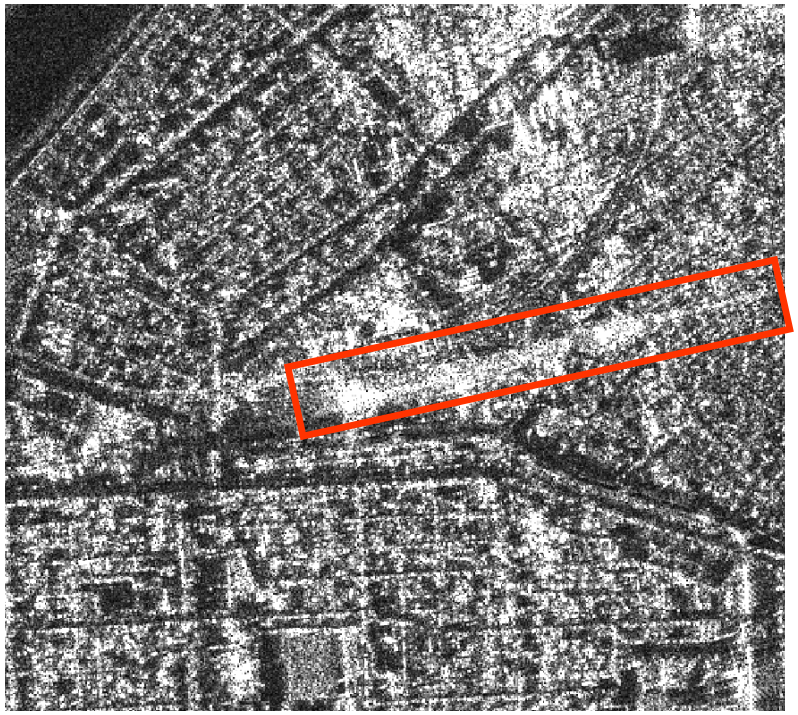


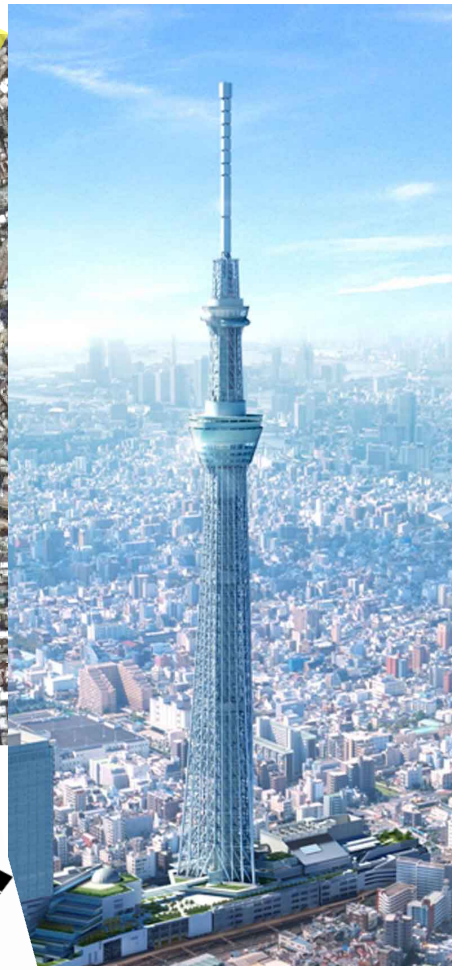
https://history.nasa.gov/JPL-93-24/p48.htm

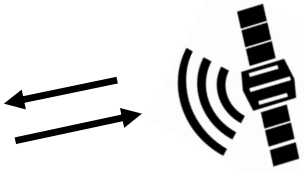


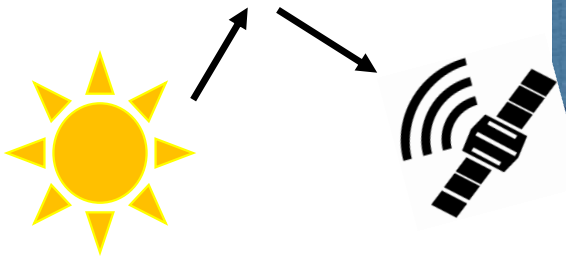




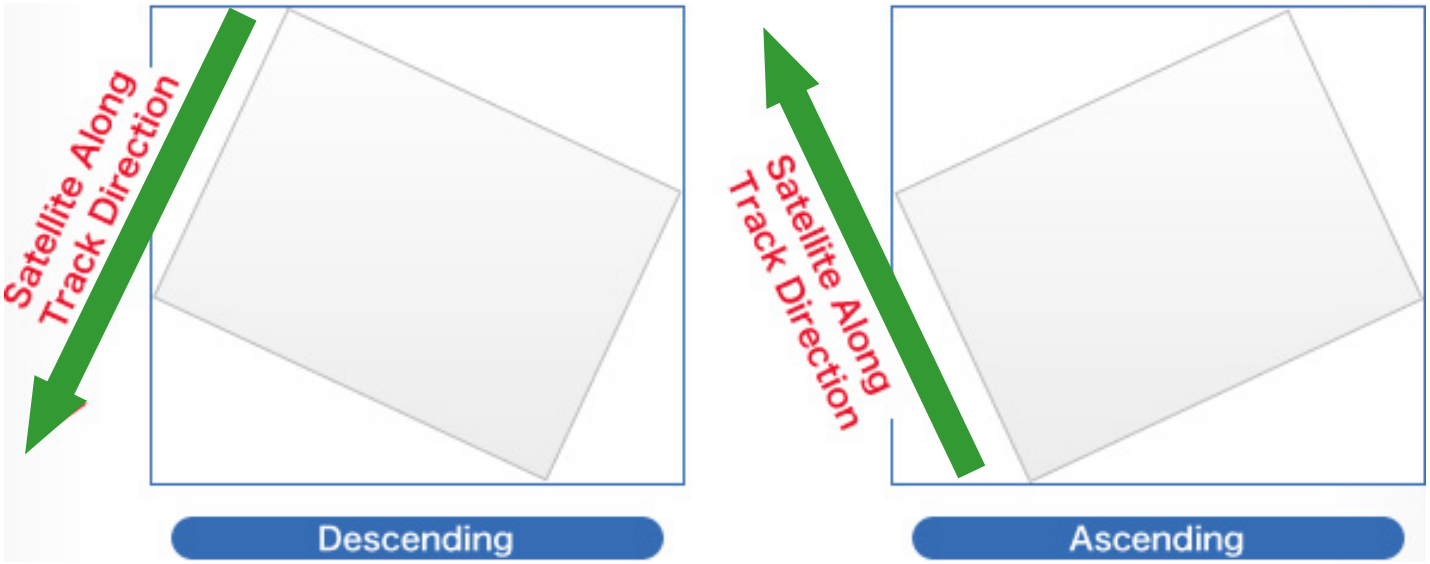






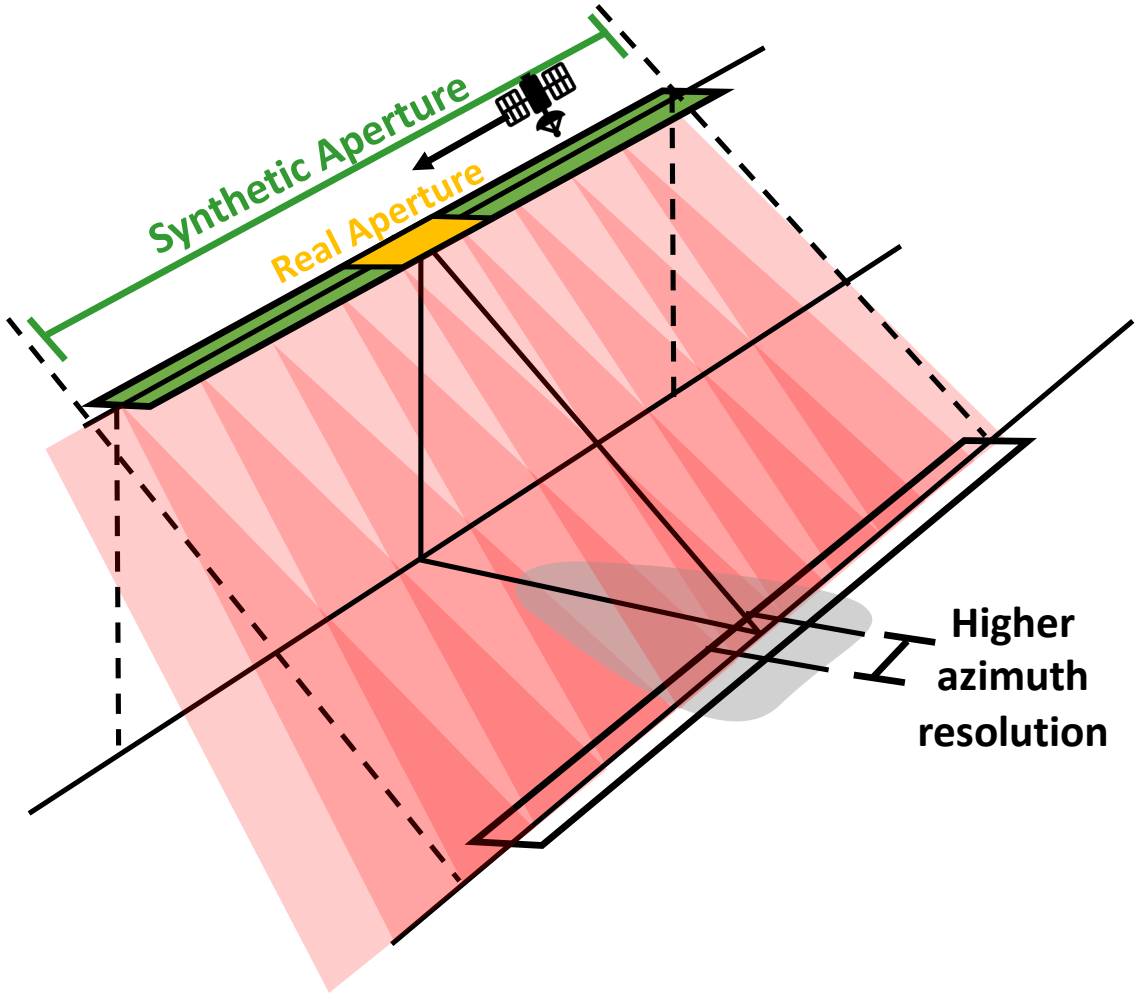


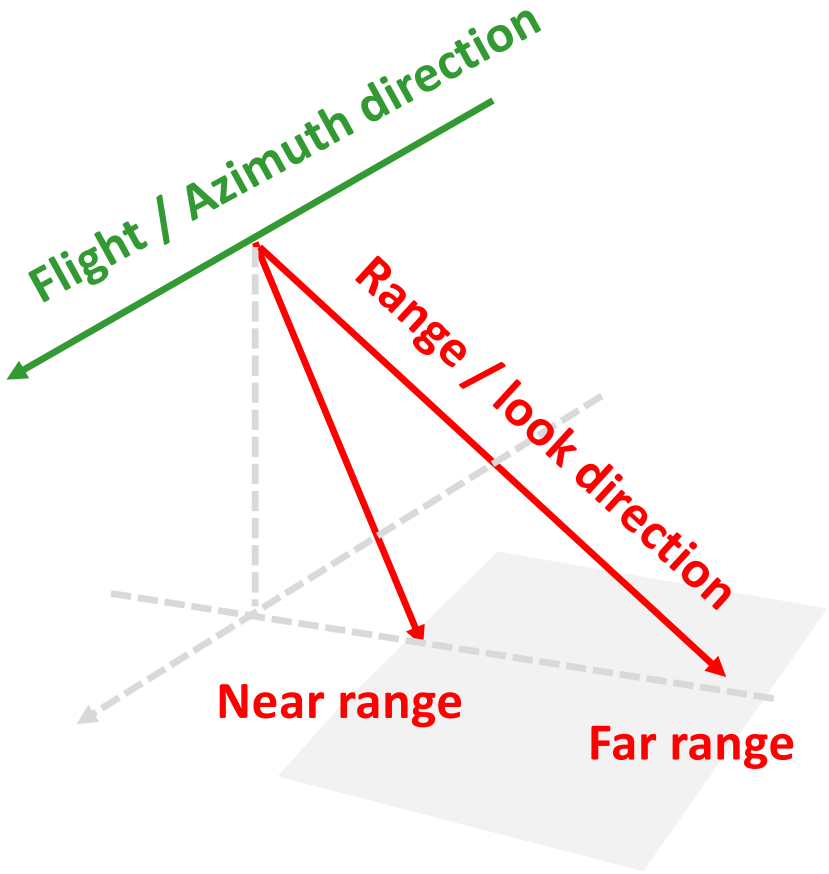
Azimuth and range directions

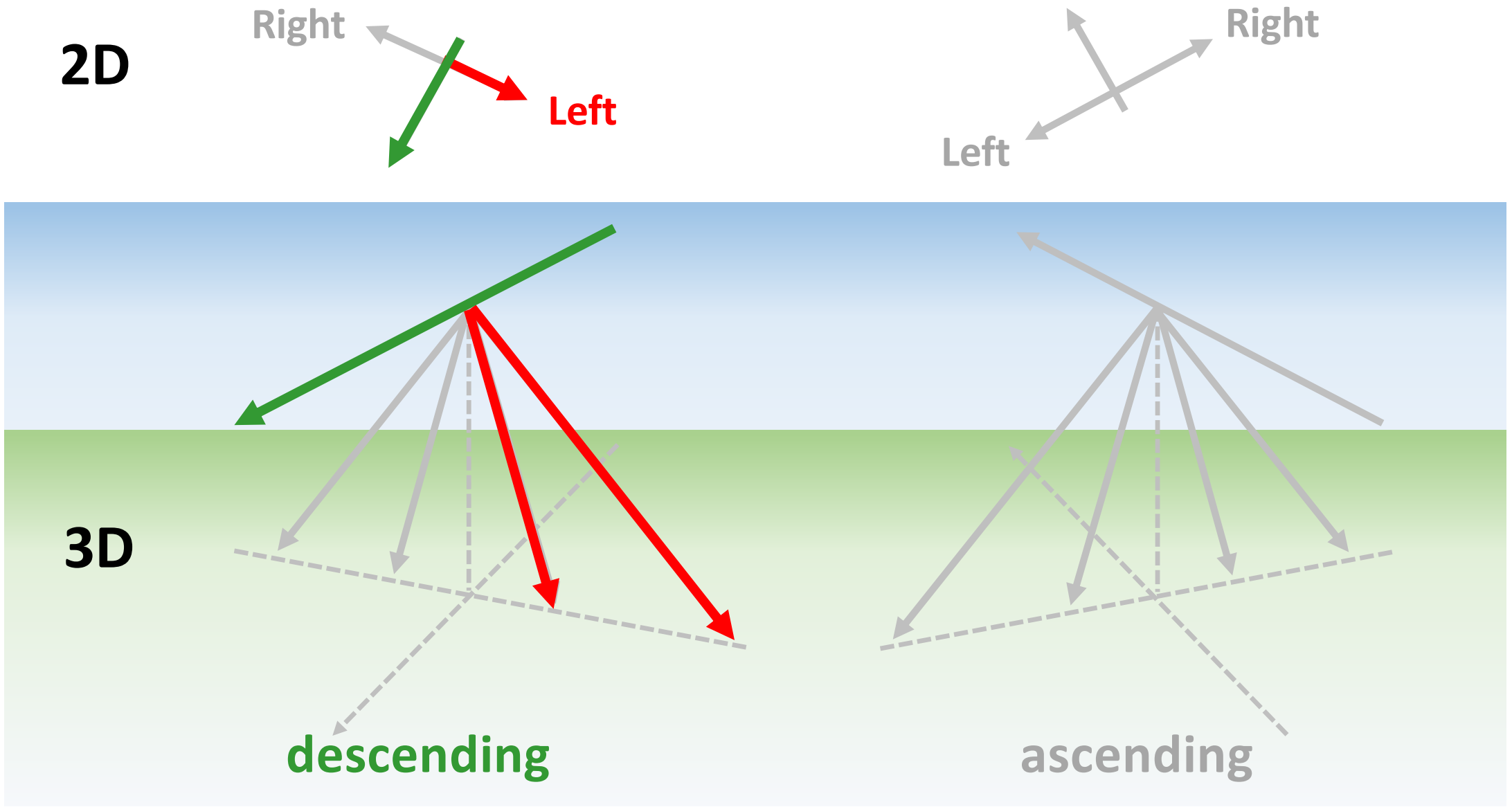


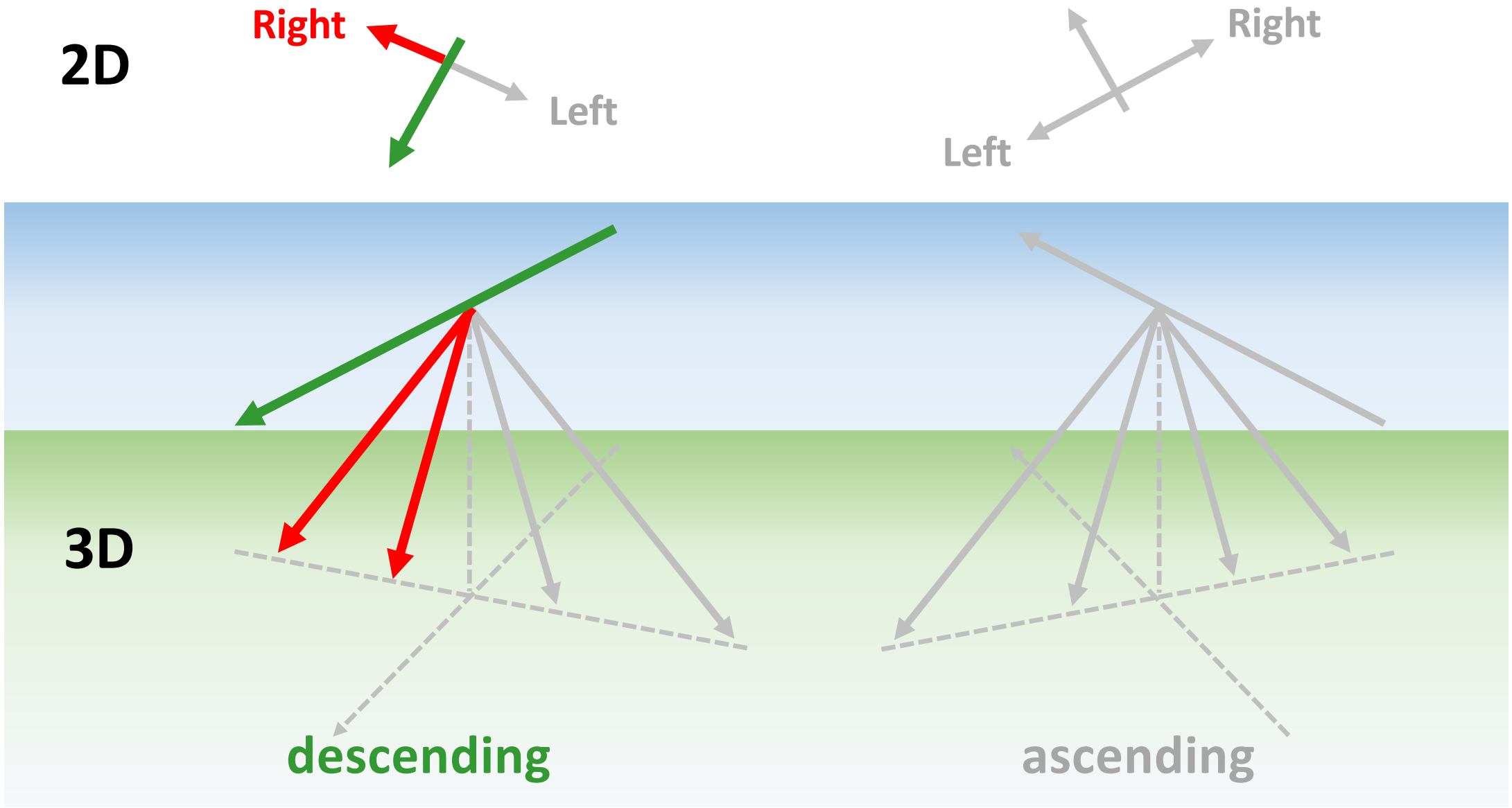
Ref: http://en.alos-pasco.com/alos-2/palsar-2/

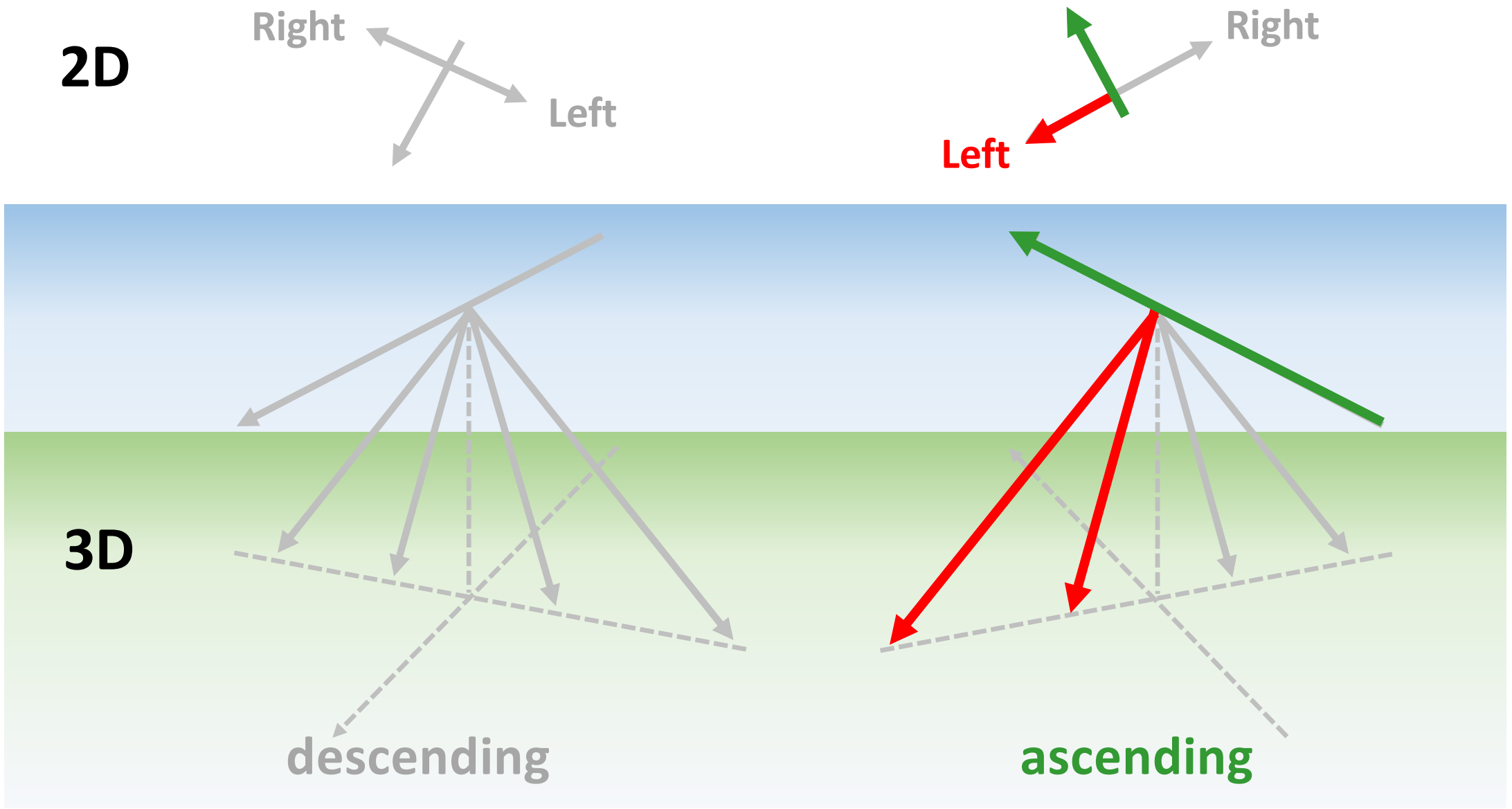
Synthetic Aperture Radar (SAR)

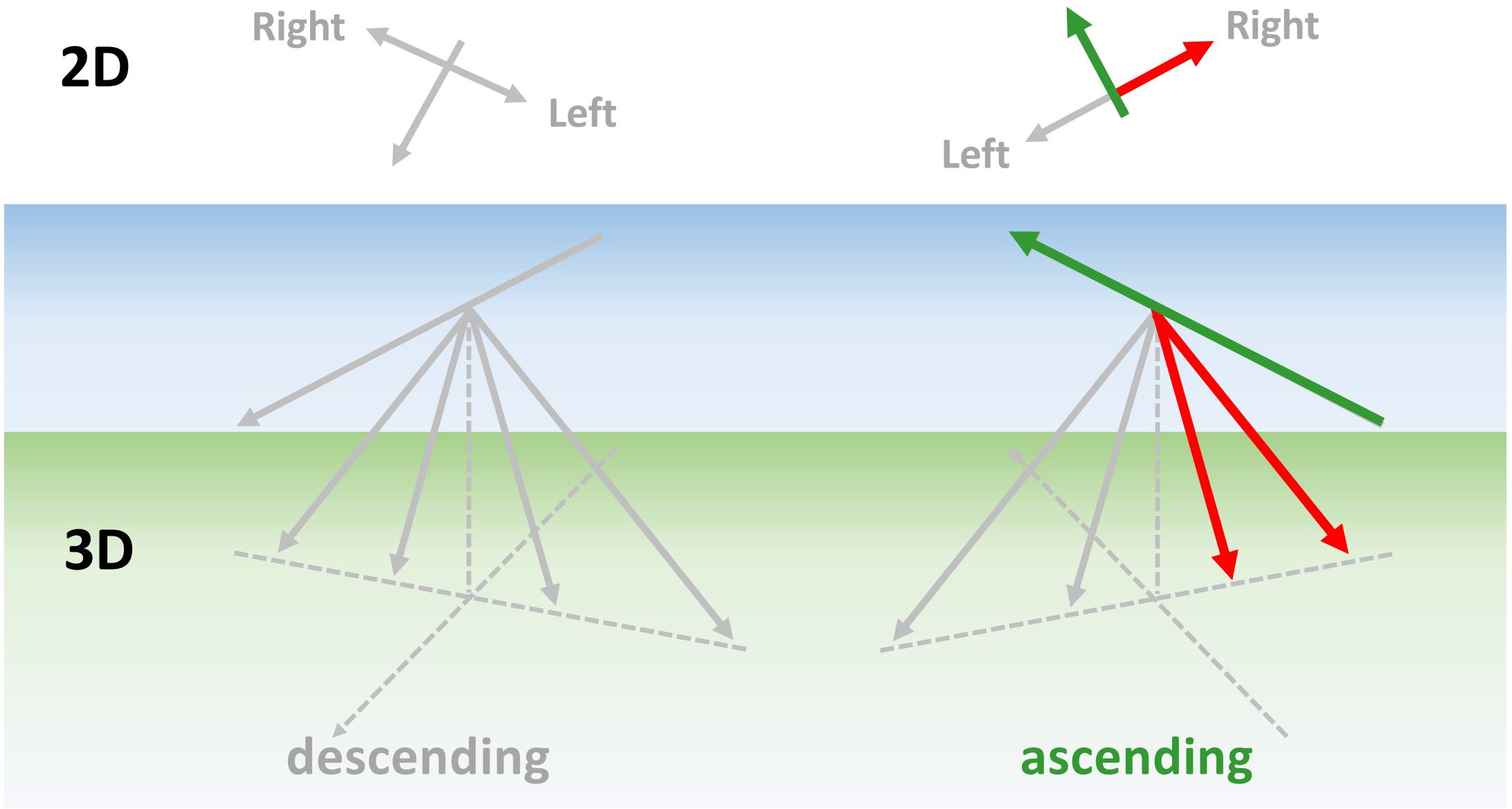


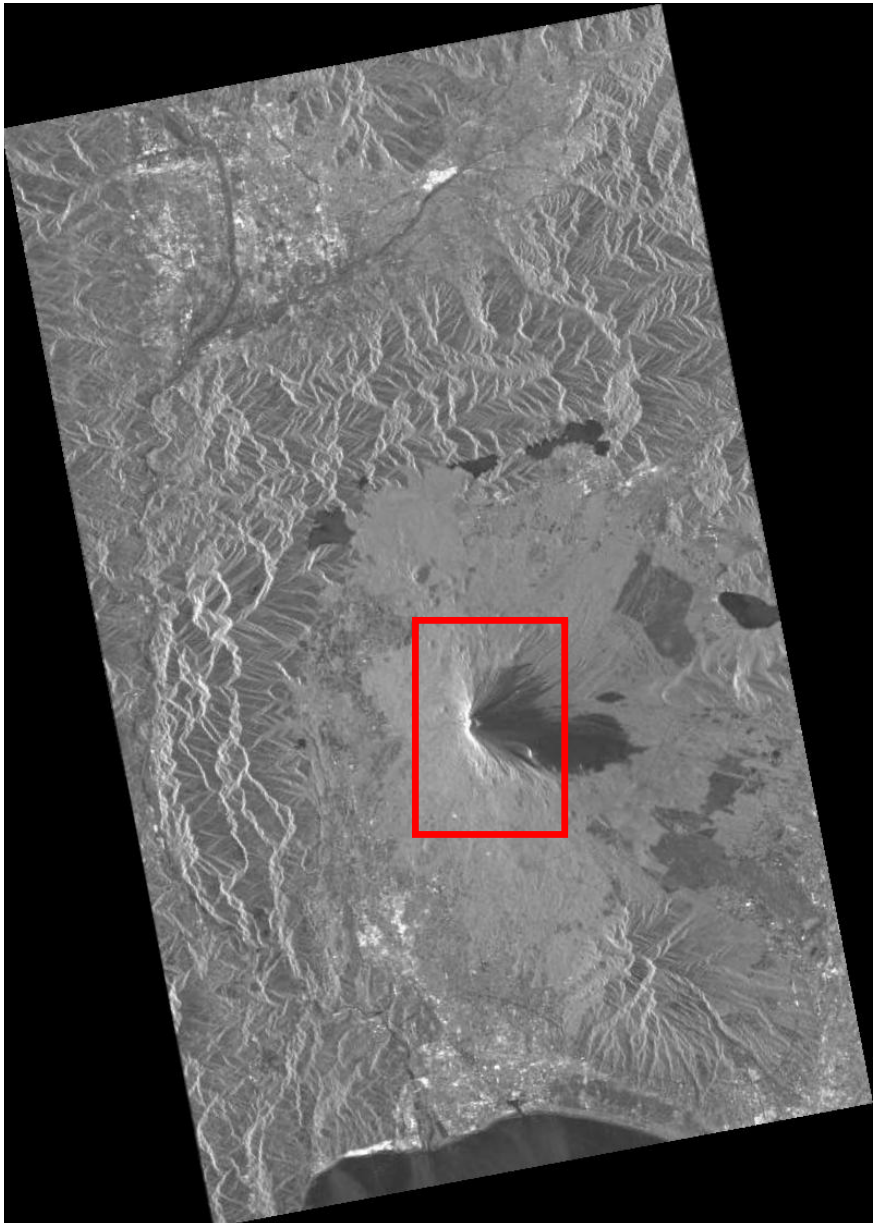



2D
Right
Left
Right
Left
3D
descending
ascending

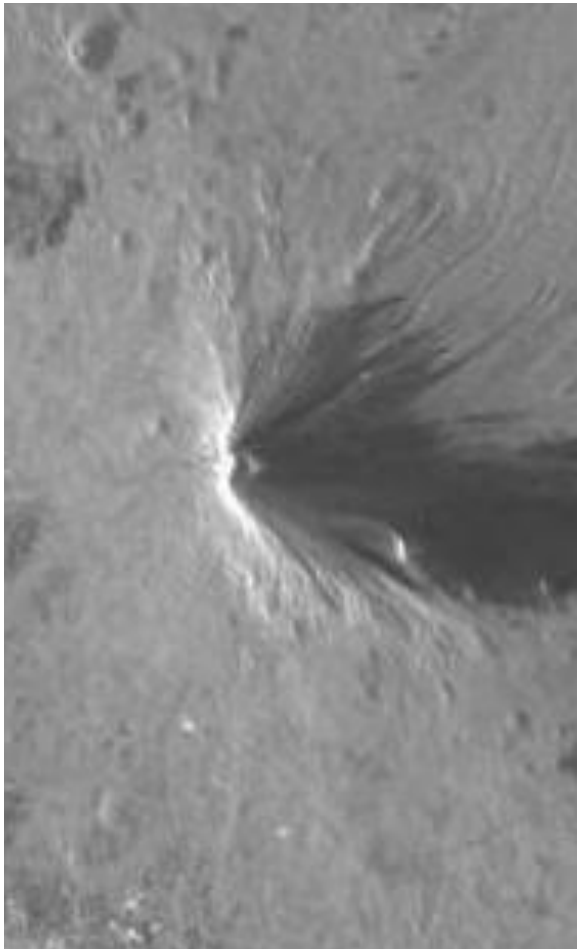

2D
Right
Left
Right
Left
3D
descending
ascending


2D
Right
Left
Right
Left
3D
descending
ascending


2D
Right
Left
Right
Left
3D
descending
ascending

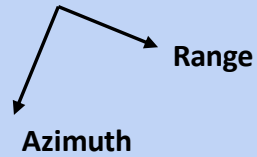


- azimuth and range direction of the image?

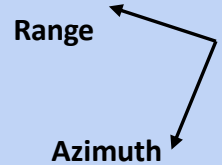


Level 1.5

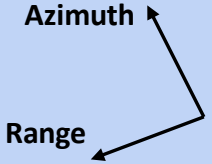
A



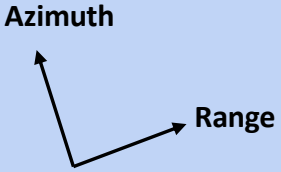
B

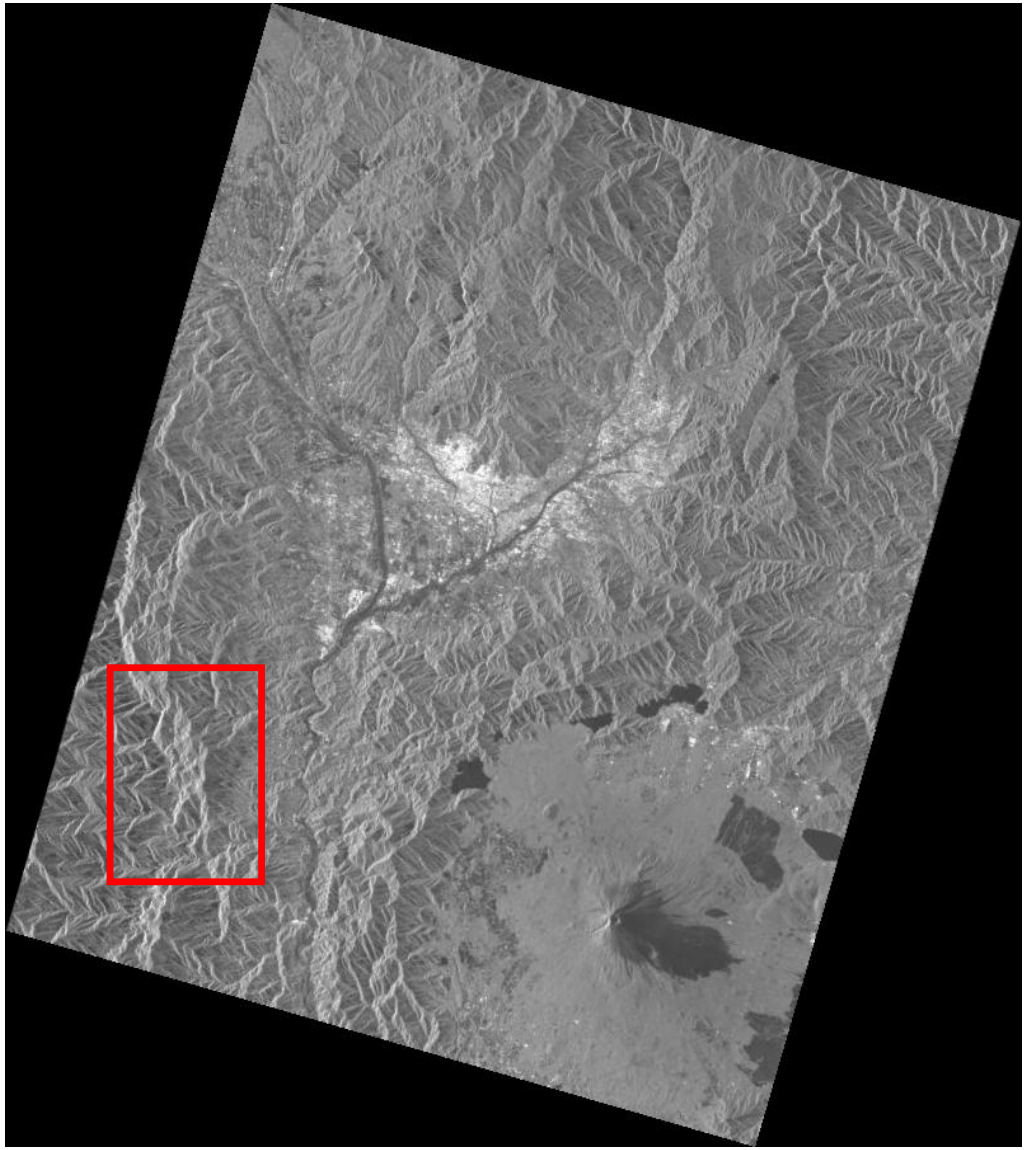


C

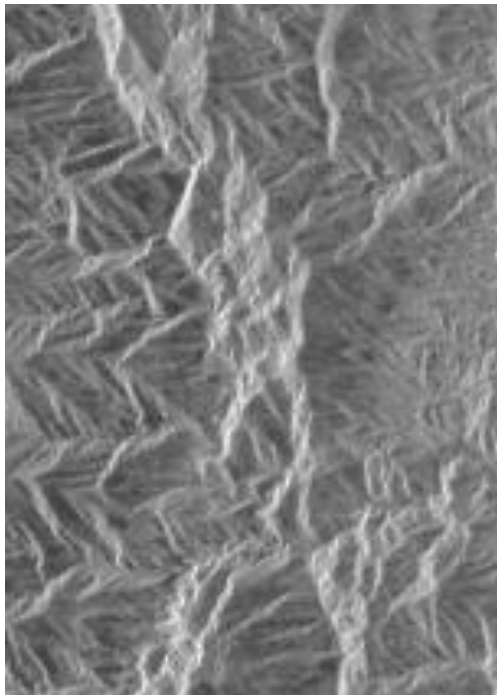


D



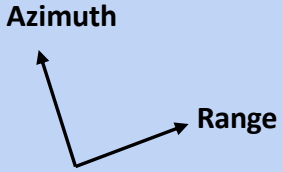


- azimuth and range direction of the image?

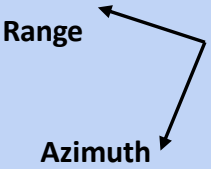


Level 1.5

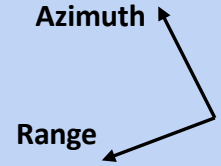
A



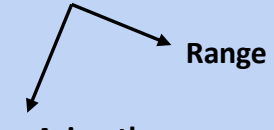
B

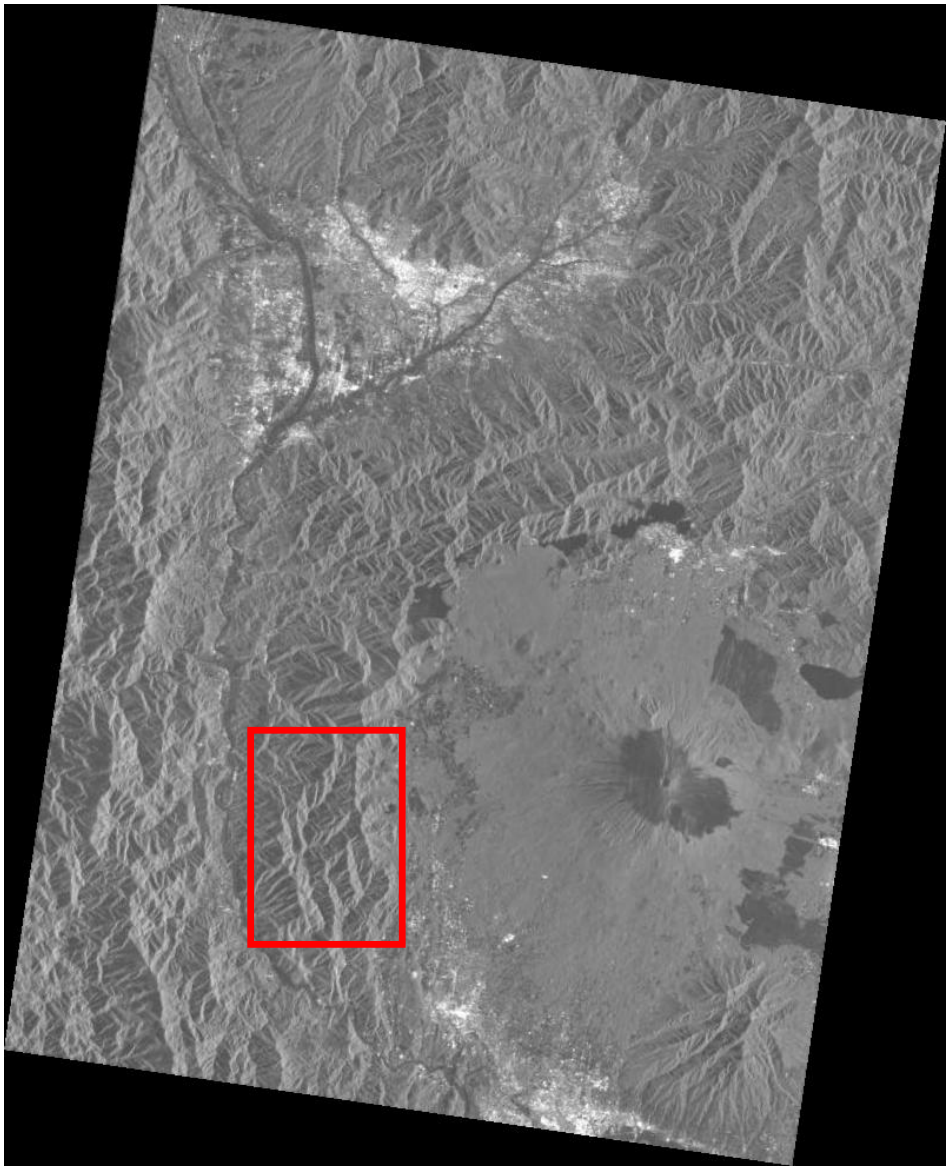


C

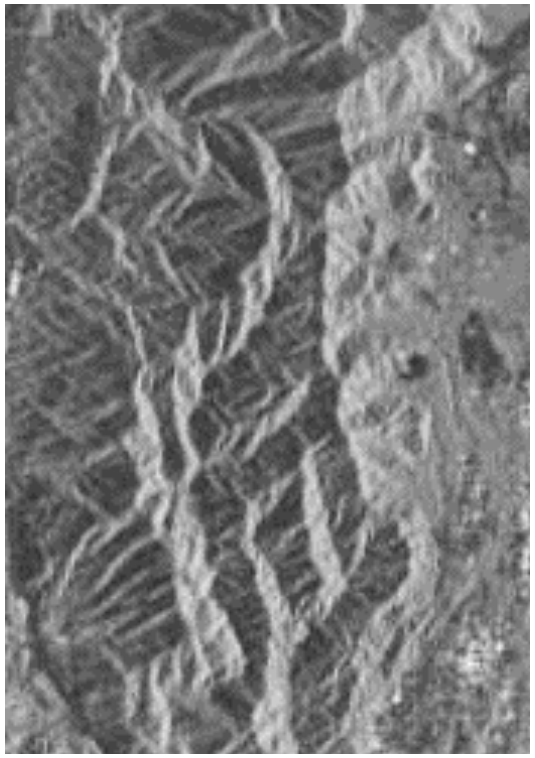


D

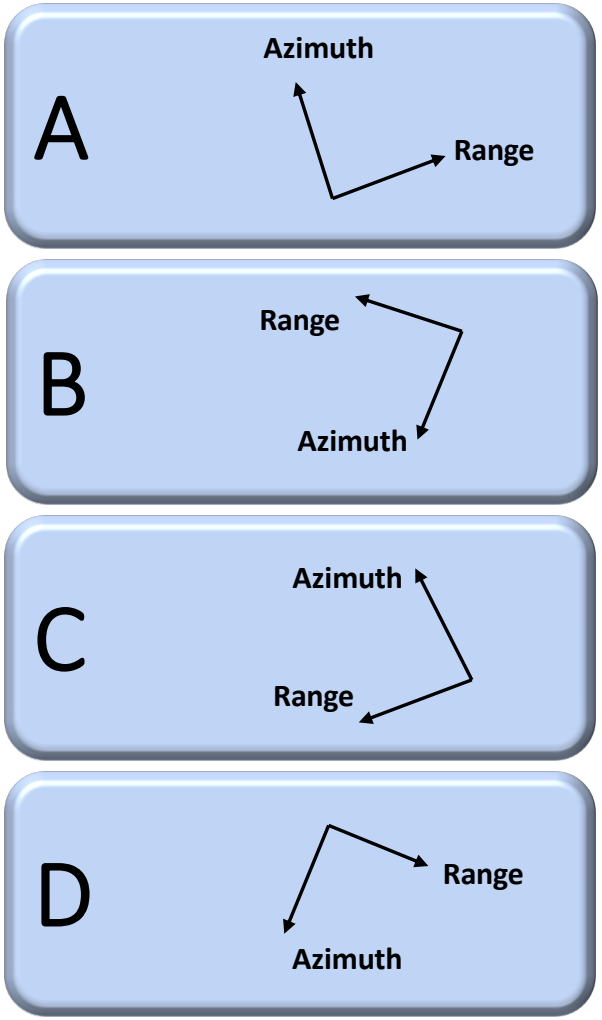




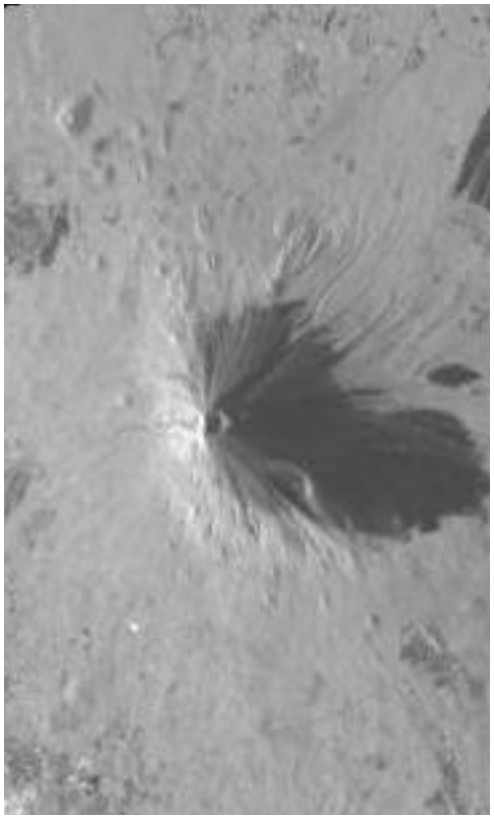
- azimuth and range direction of the image?



Level 1.5

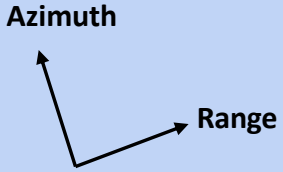


- azimuth and range direction of the image?

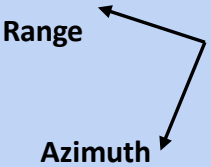


Level 1.5

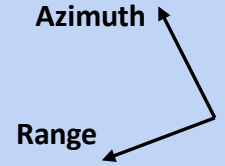
A



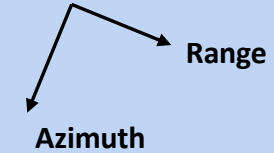
B

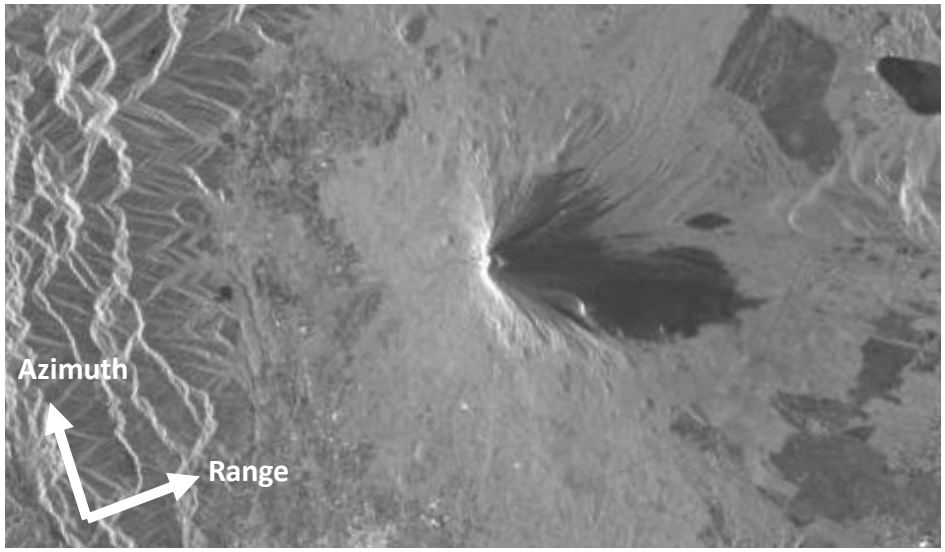


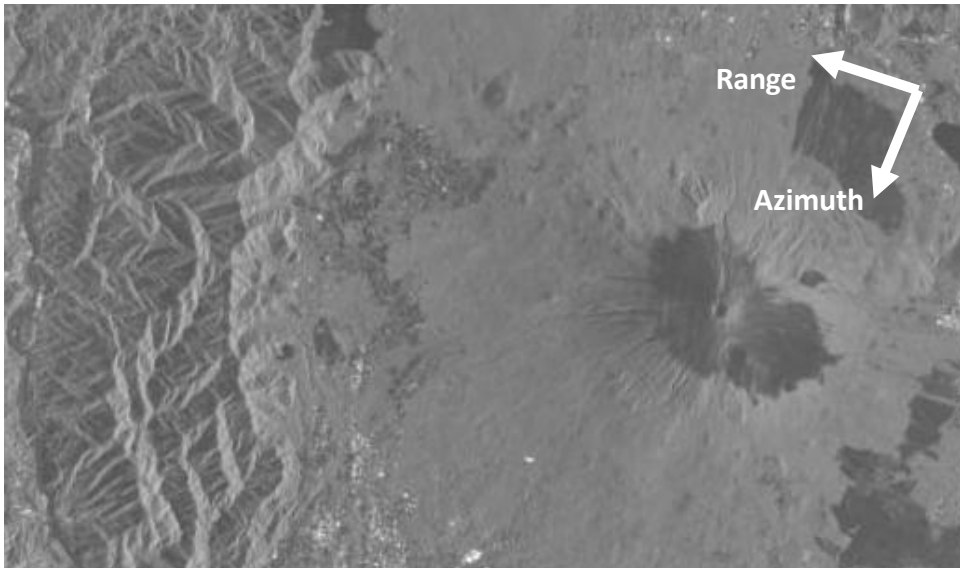
C

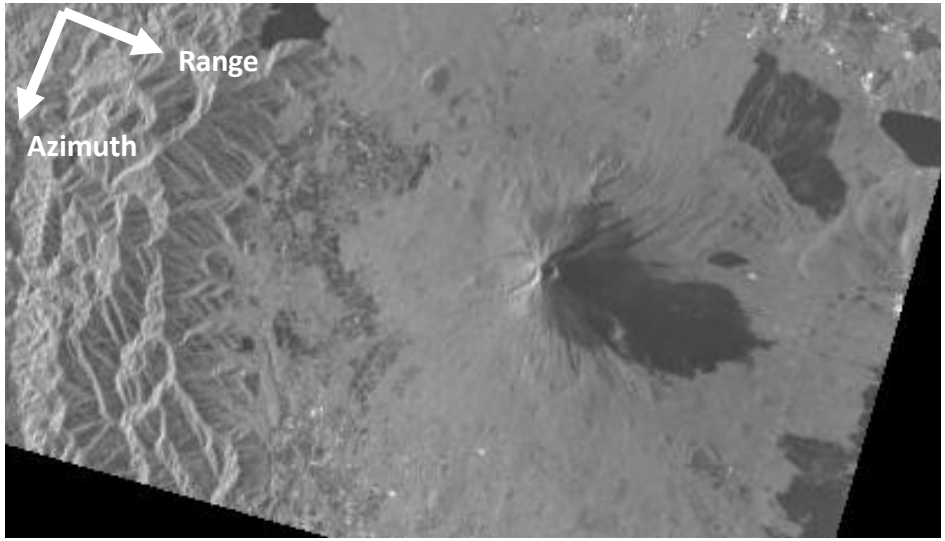


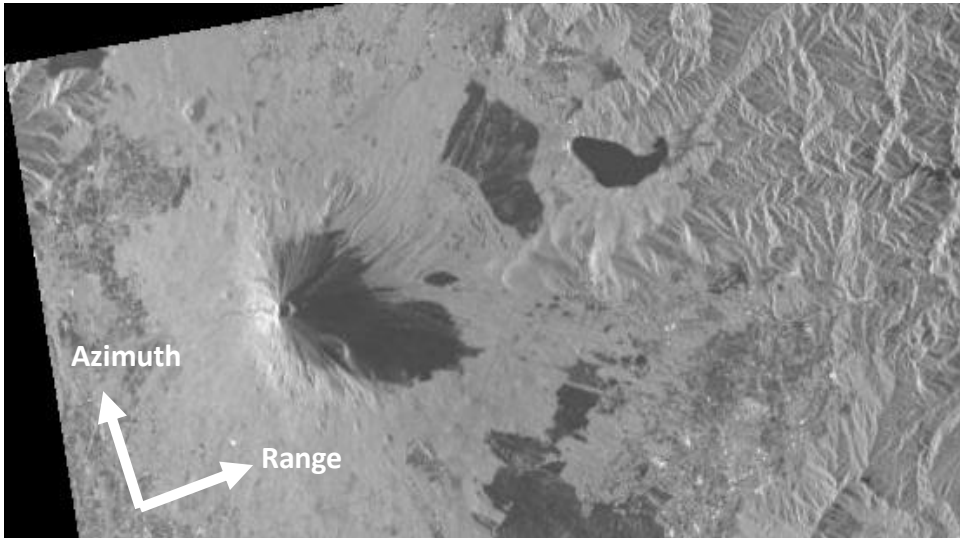
D



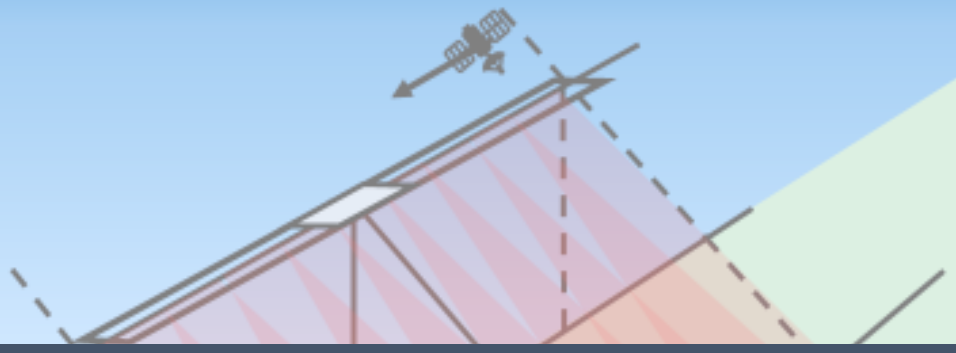

Azimuth
Range


Range
Azimuth


Range
Azimuth


Azimuth
Range

- Sensor parameters
  - Band
  - Polarization
  - Incidence angle
  - Location of sensor



VAPs creation and limitations

Variety of SAR mechanism
at the same area

- Surface roughness
- Object geometry
- Dielectric constant

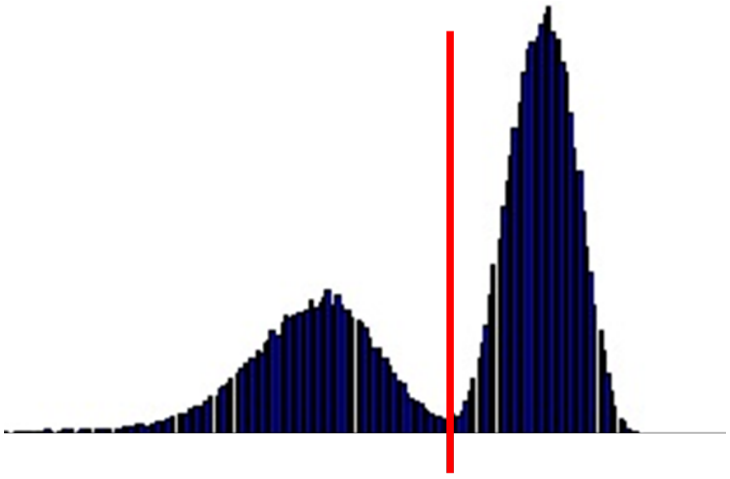
Limitations of SAR utilization for damage mapping

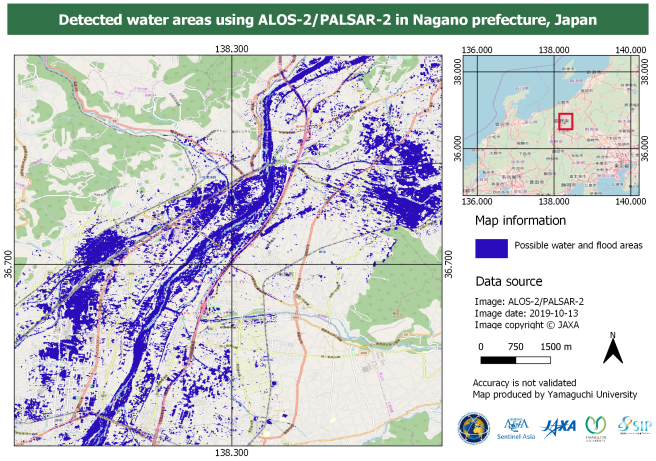
Flood

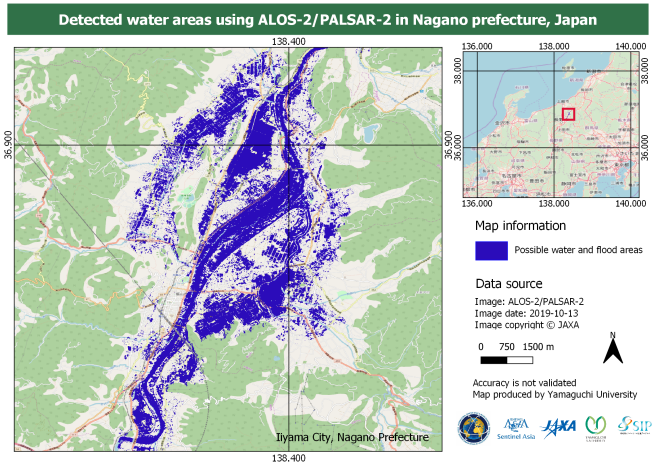
One SAR during flood
(Thresholding)

Discussions

- Include Permanent water
- Difficult for flood under vegetation and urban areas.
- Image change to be discrete value



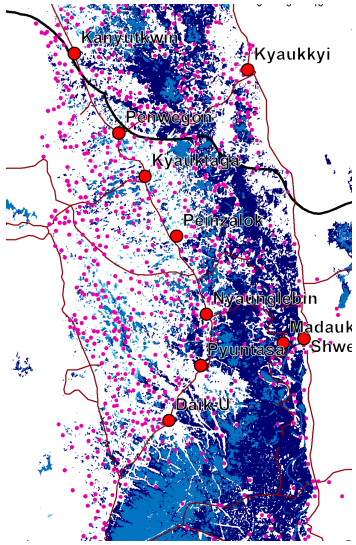




Limitations of SAR utilization for damage mapping

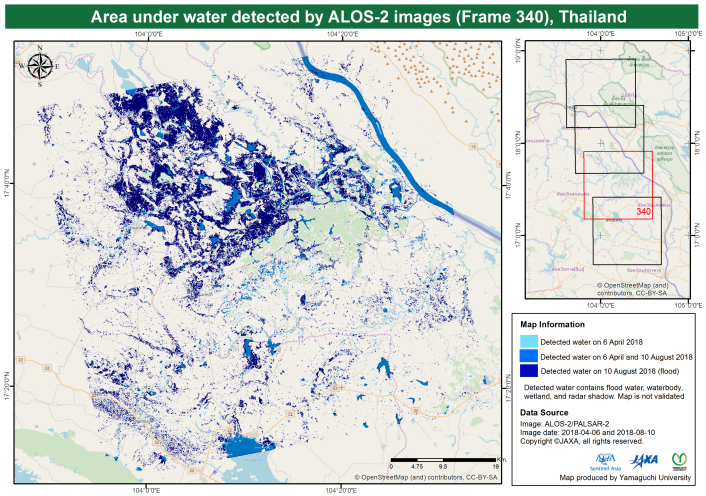
Flood

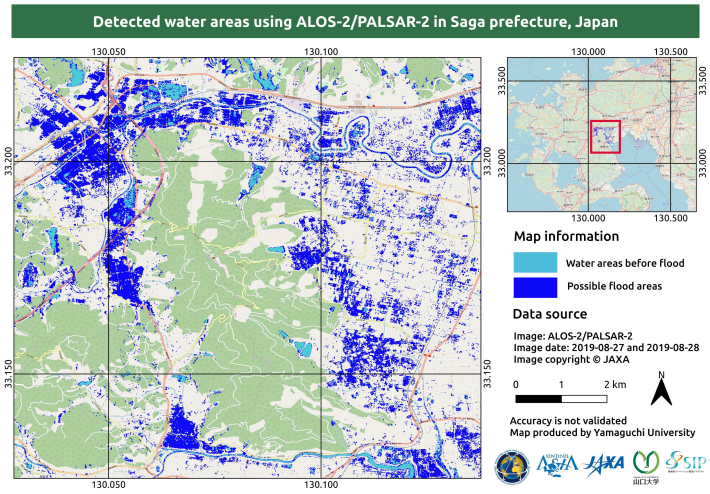
Two image method
(Thresholding)



Discussions

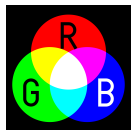
- Better than just one image
- differentiate waterbody and seasonal water from flood
- Seasonal difference → difficult to compare
- Better to use 2 image near time or in the same season



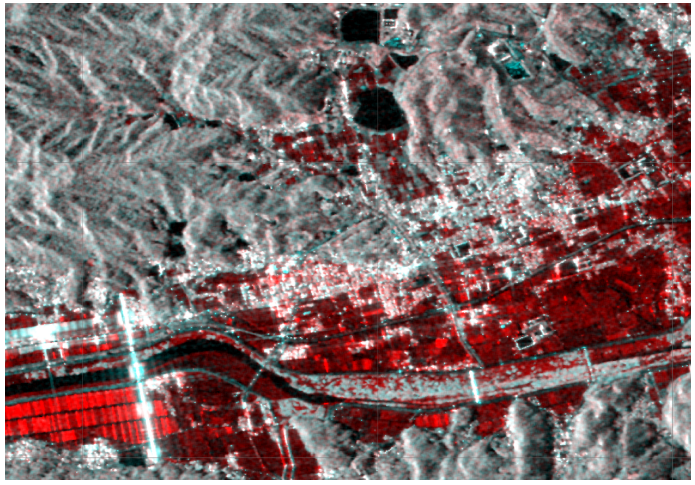


Limitations of SAR utilization for damage mapping

Flood



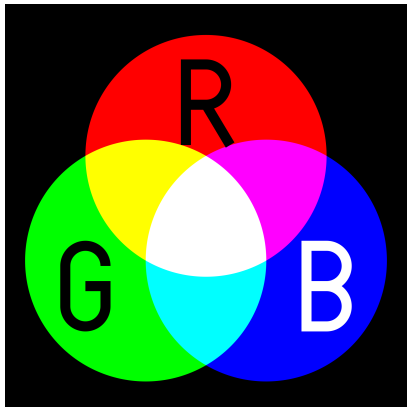
Two image method
(Color composite)



Discussions

- More gradience value → more information
- More difficult for interpretation
- Same SAR limitations
- Should consider seasonal effect of different time acquisition to interpretation

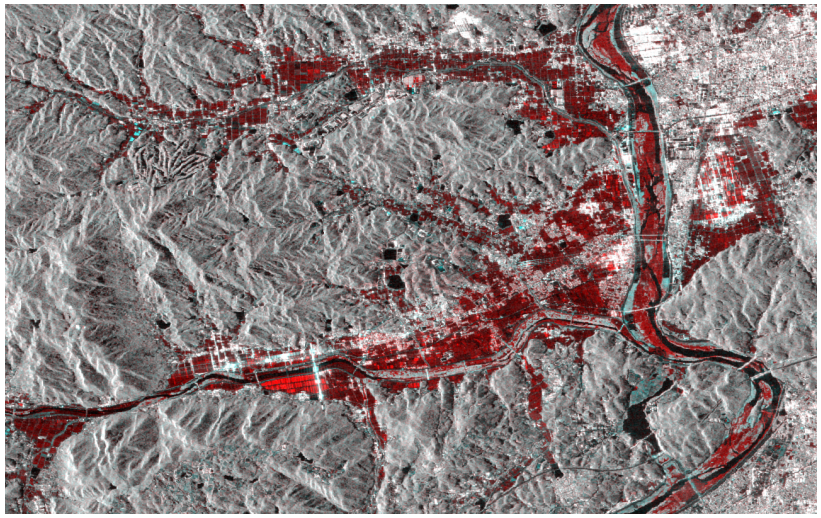
Before flood



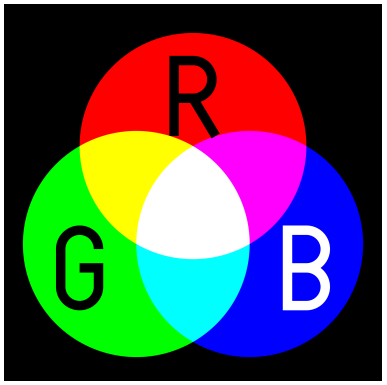
During flood

During flood

Flood is red color



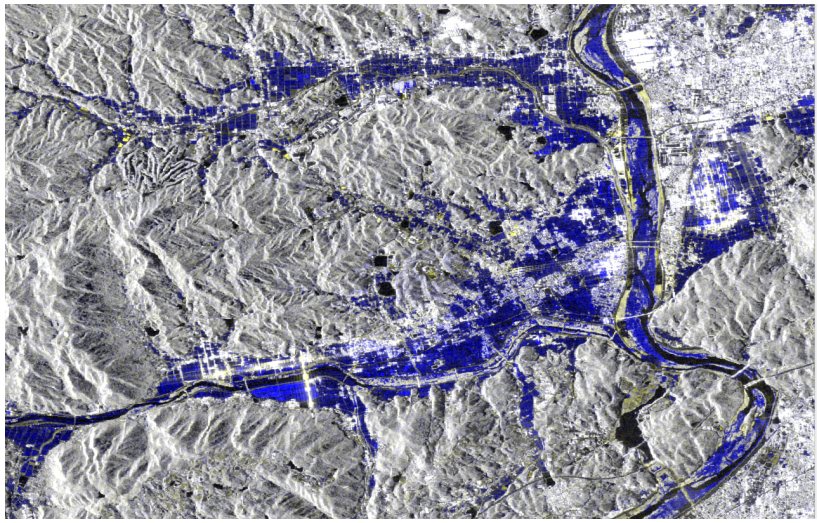
During flood



During flood

Before flood

Flood is dark blue



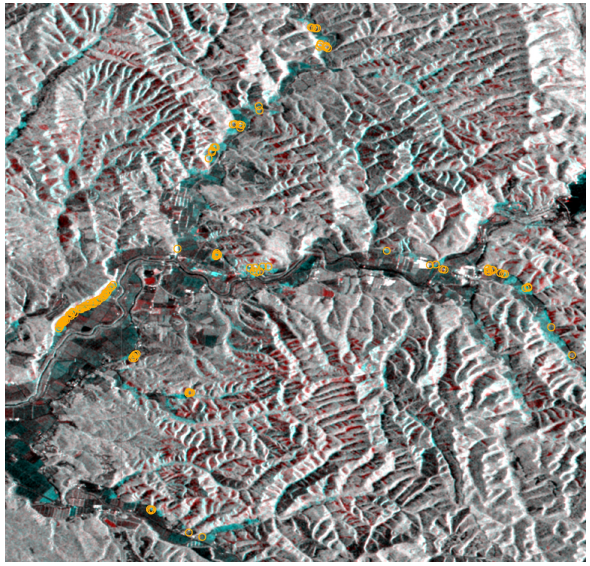
Limitations of SAR utilization for damage mapping

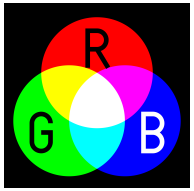
Landslide

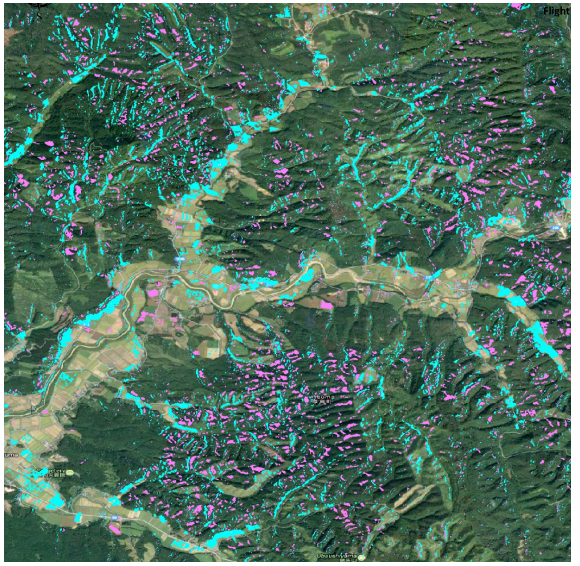
Discussions

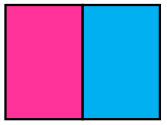
- Same SAR limitations
- More effect for geometry distortion

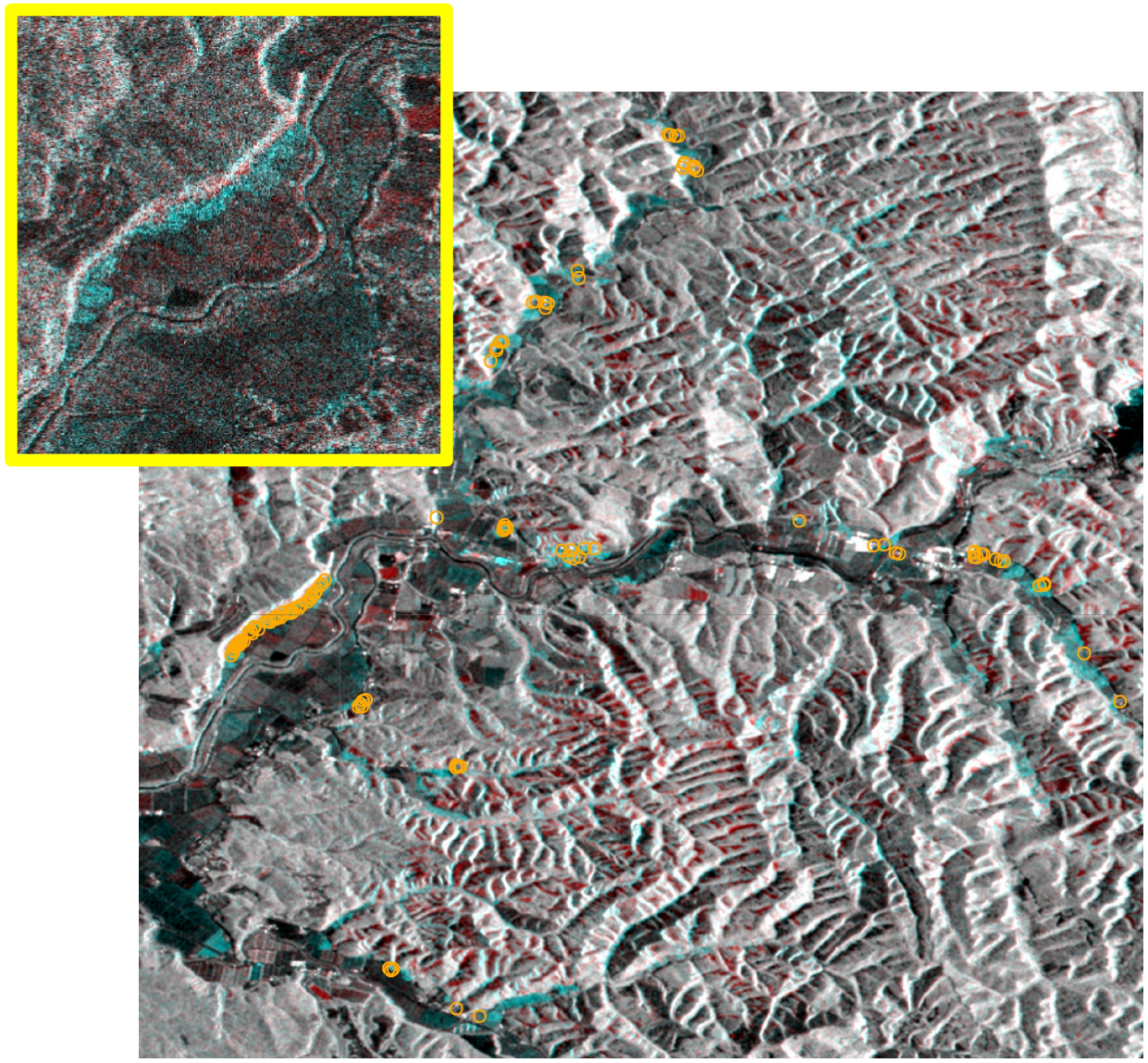
Two image method (needed)



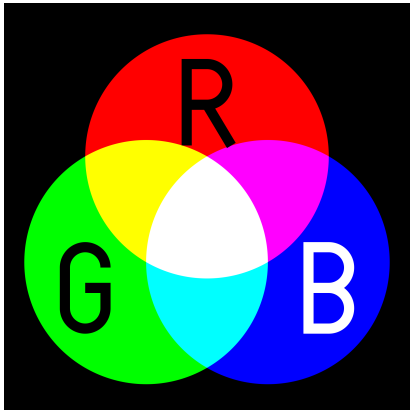






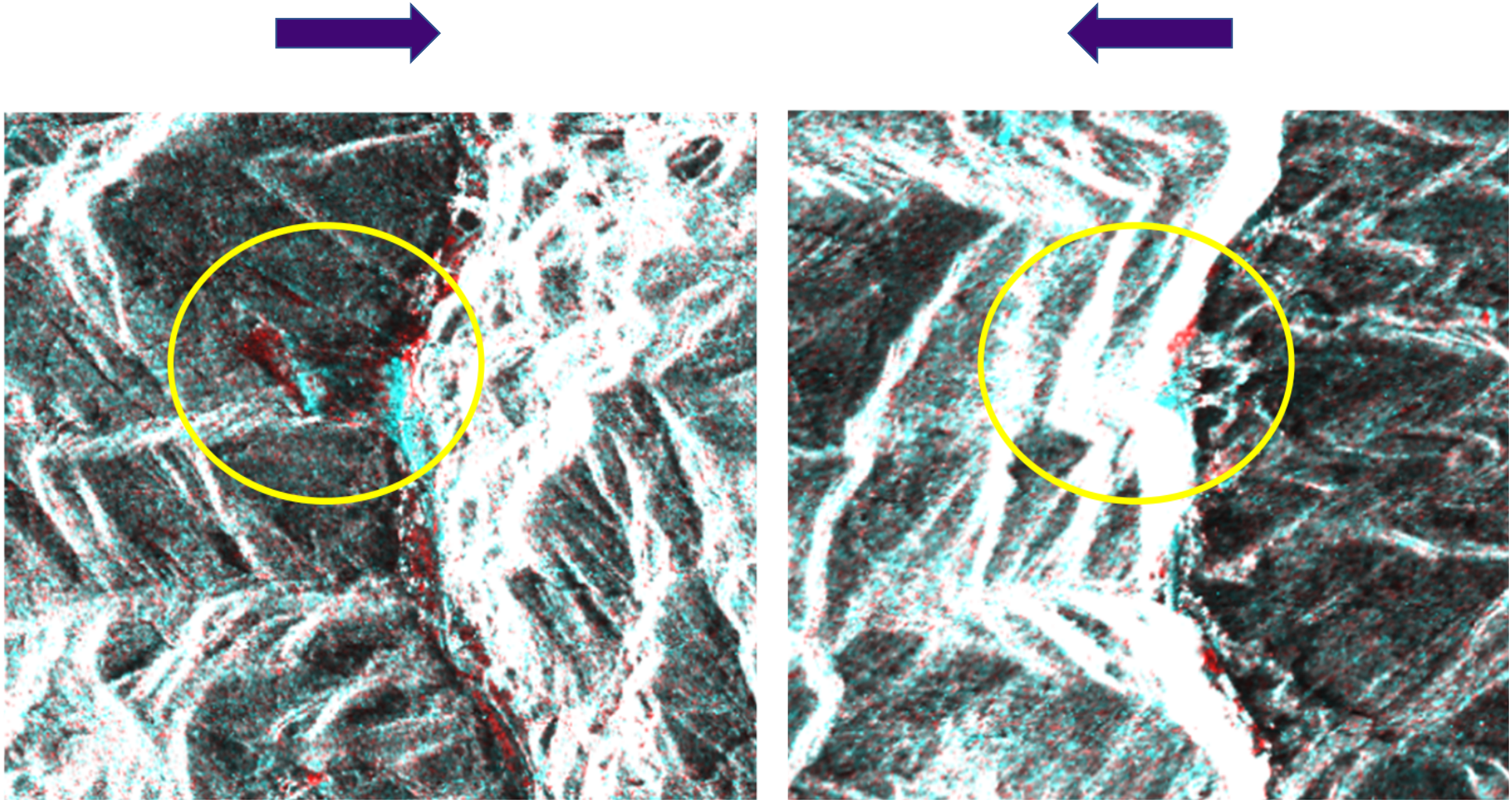


Before landslide



After landslide

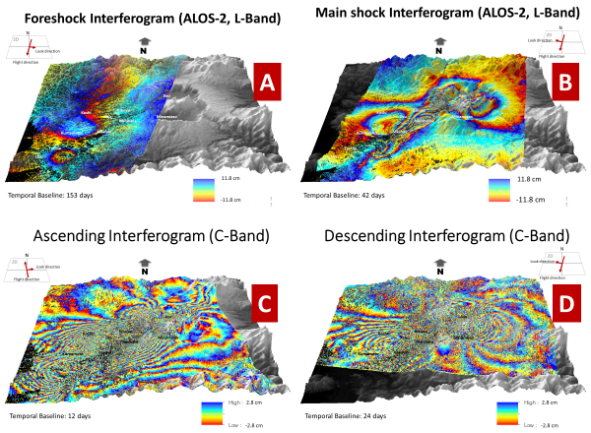
After landslide



Limitations of SAR utilization for damage mapping

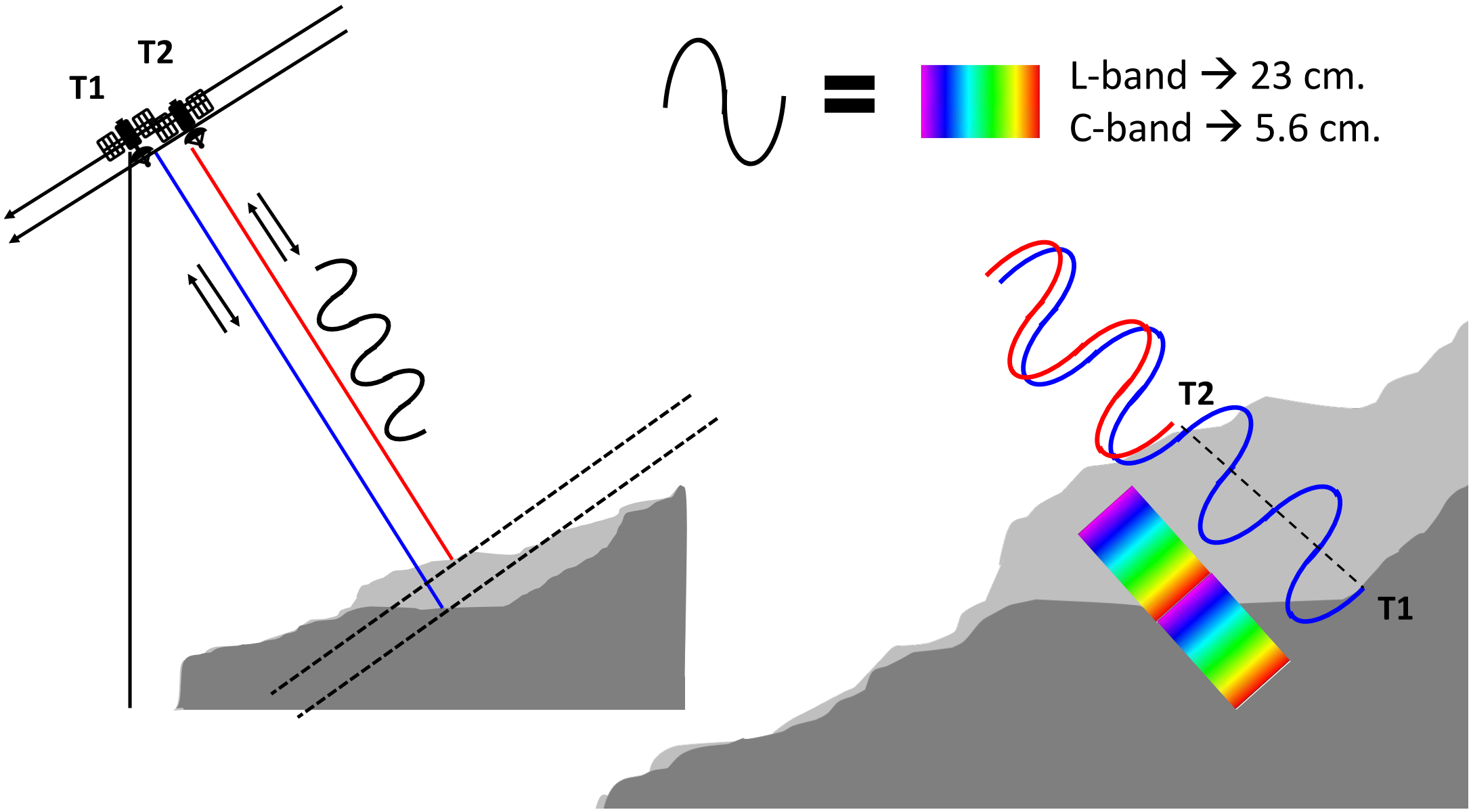
Earthquake

Differential SAR Interferometry (DInSAR)

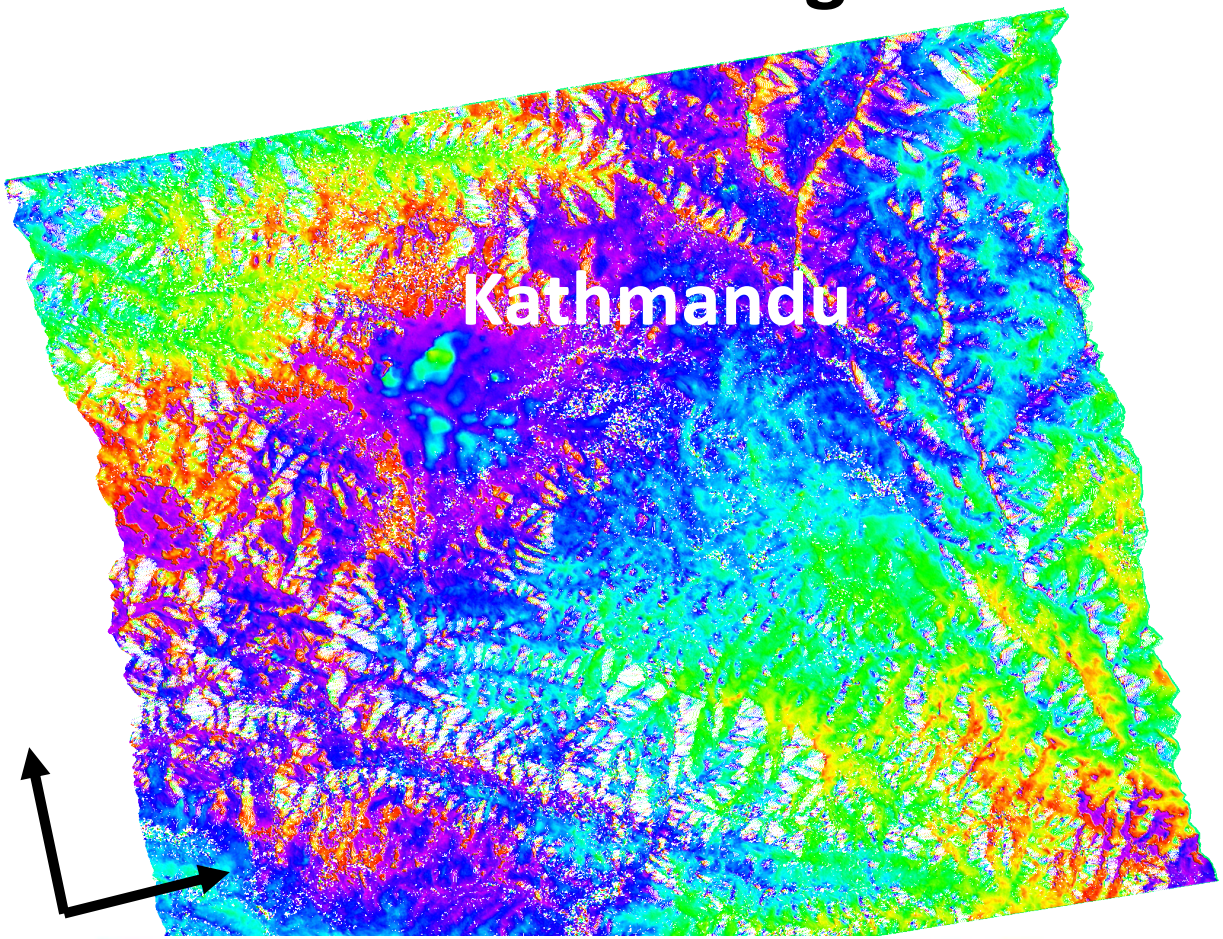


Discussions

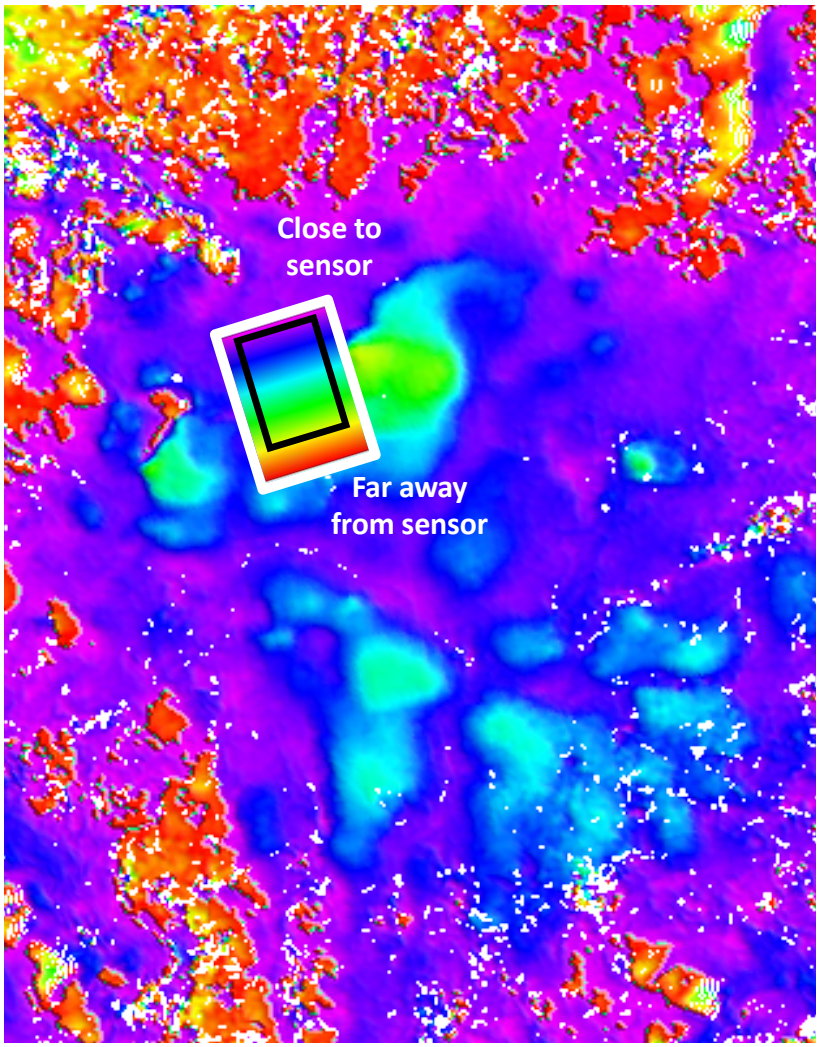
- Fringes → Difficult to understand
- Just relative displacement
- Interferogram has many components. Not only surface deformation but also other effects such as atmospheric delay, topographic phase and noise.


T2
T1
=
L-band → 23 cm.
C-band → 5.6 cm.
T2
T1

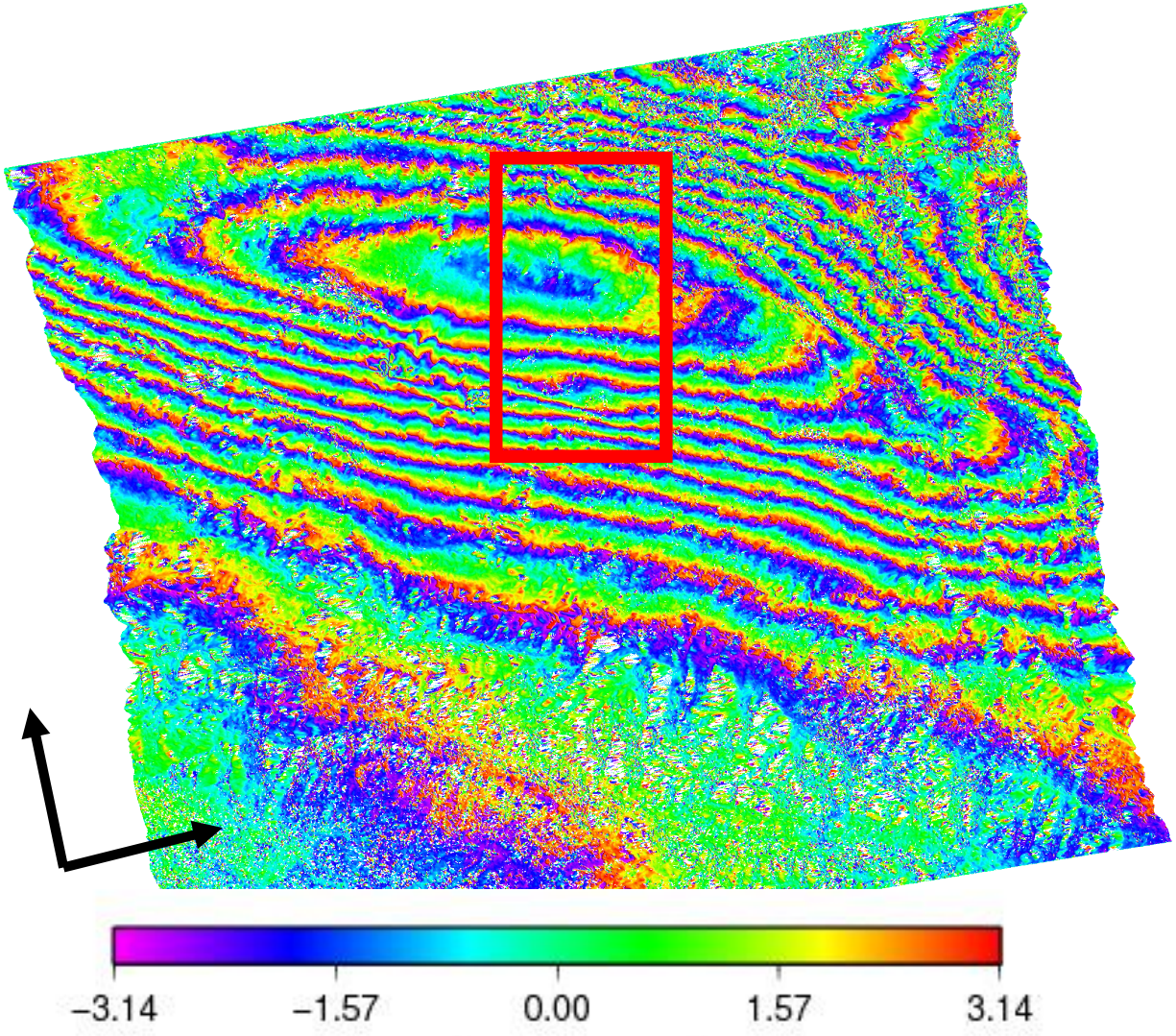
How to read Interferogram



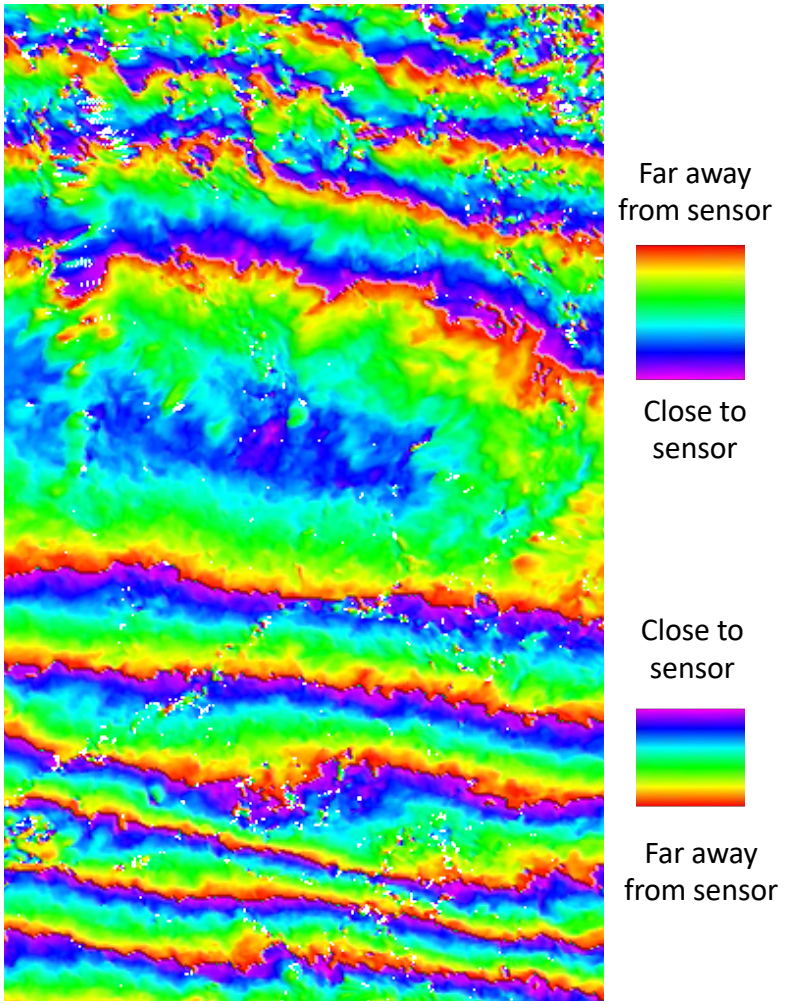
Before earthquake (subsidence)



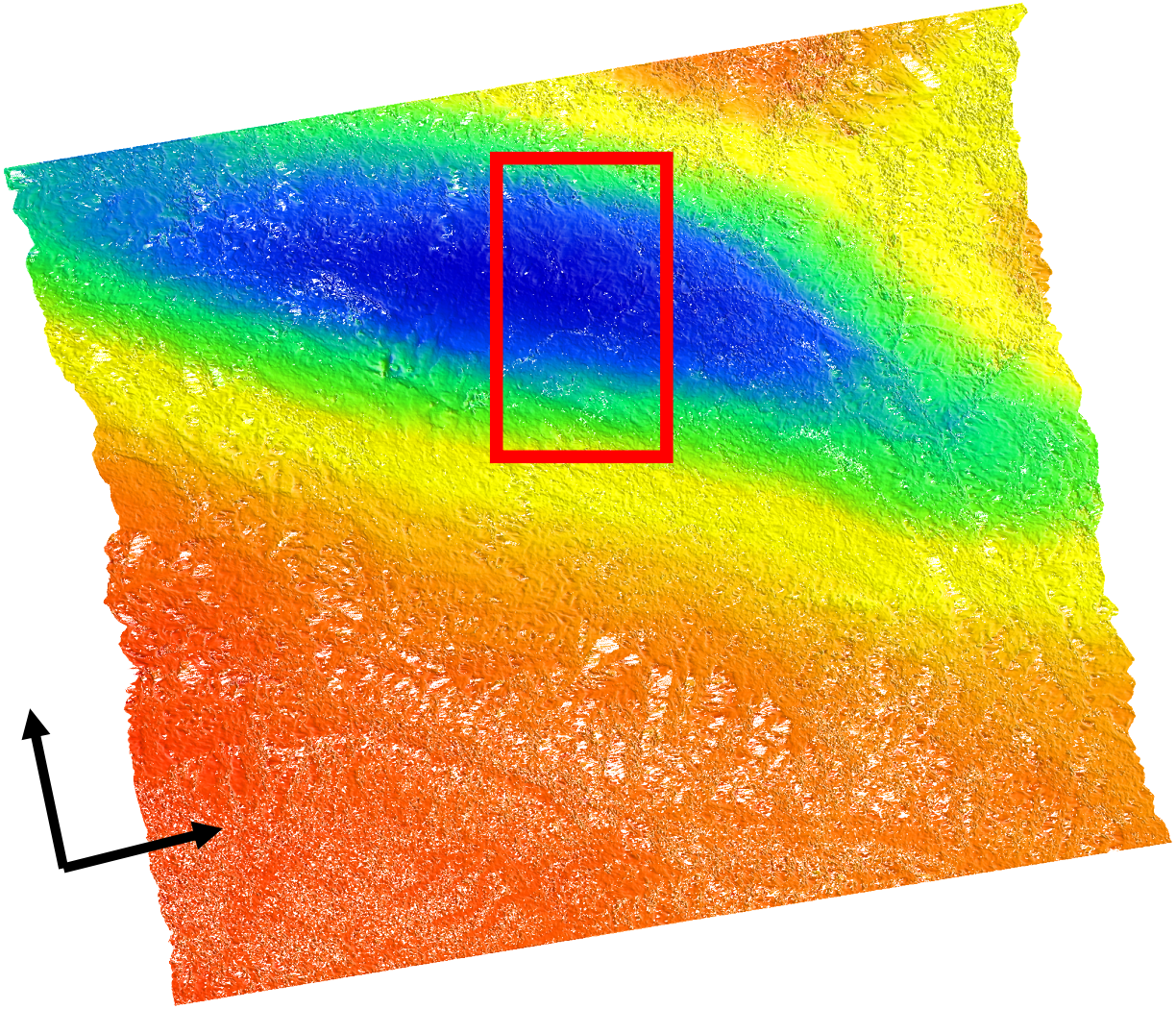
How to read Interferogram



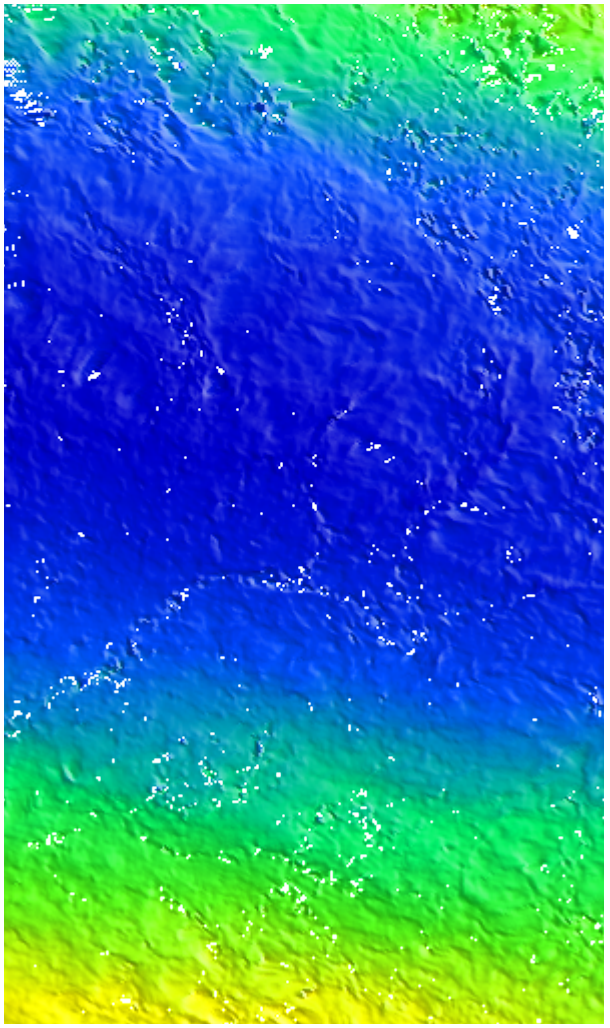
Nepal earthquake



How to read Interferogram

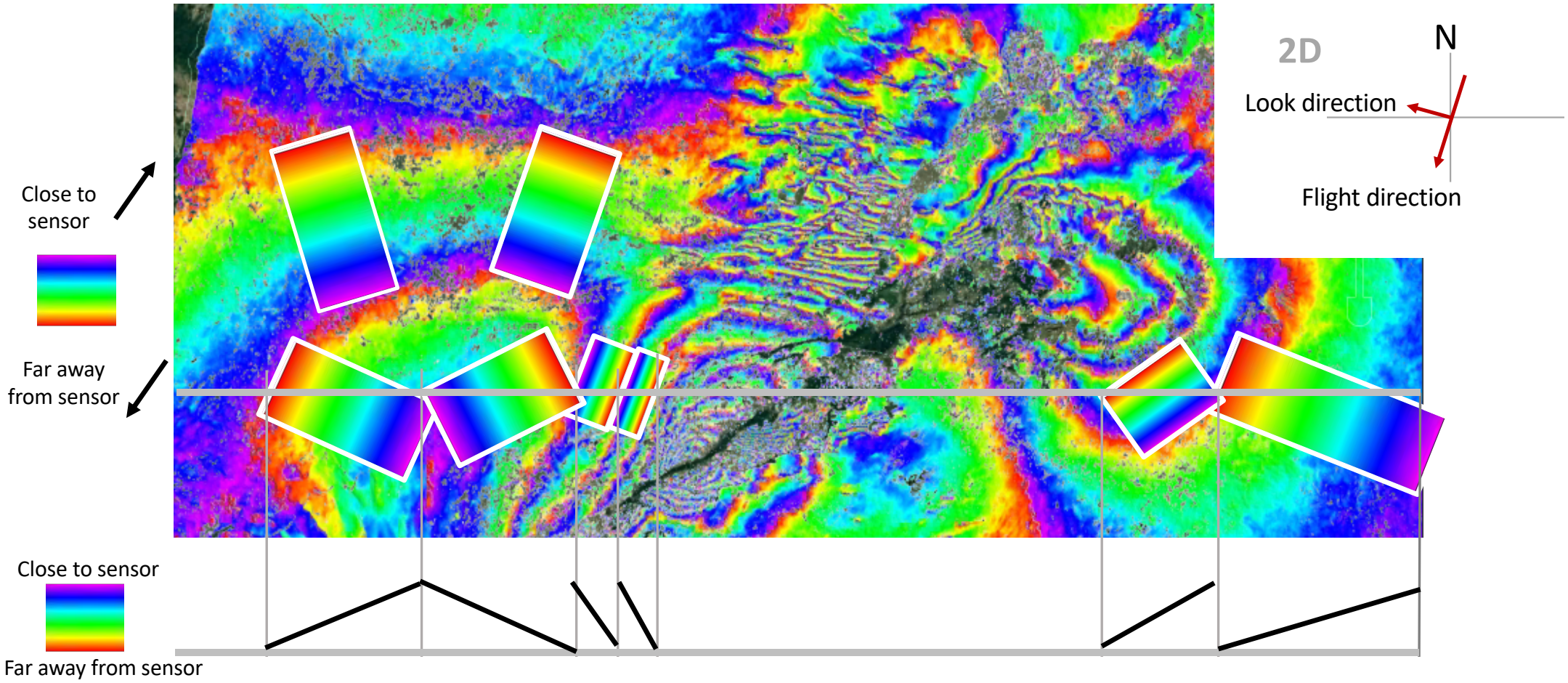


LOS Displacement

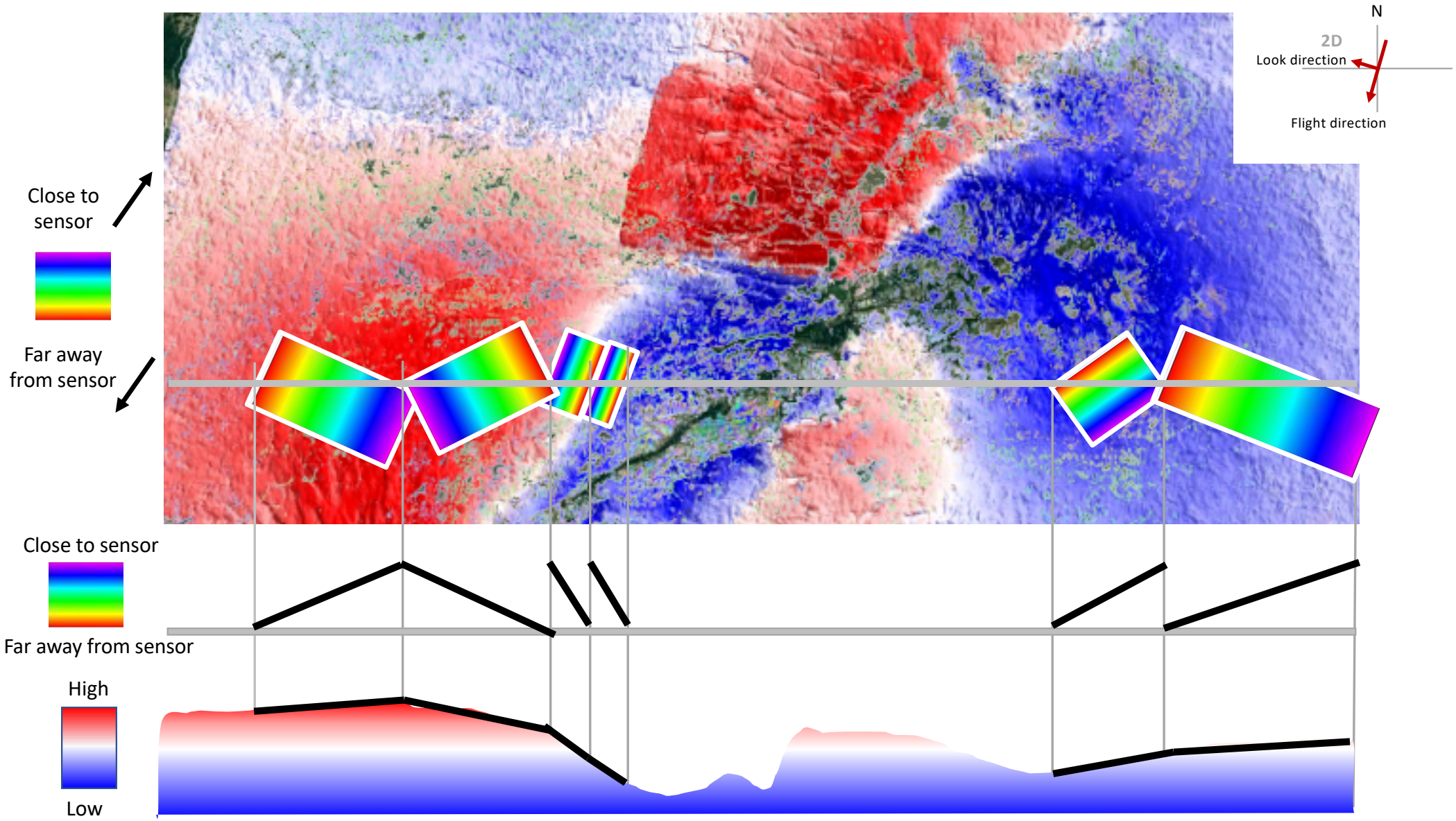


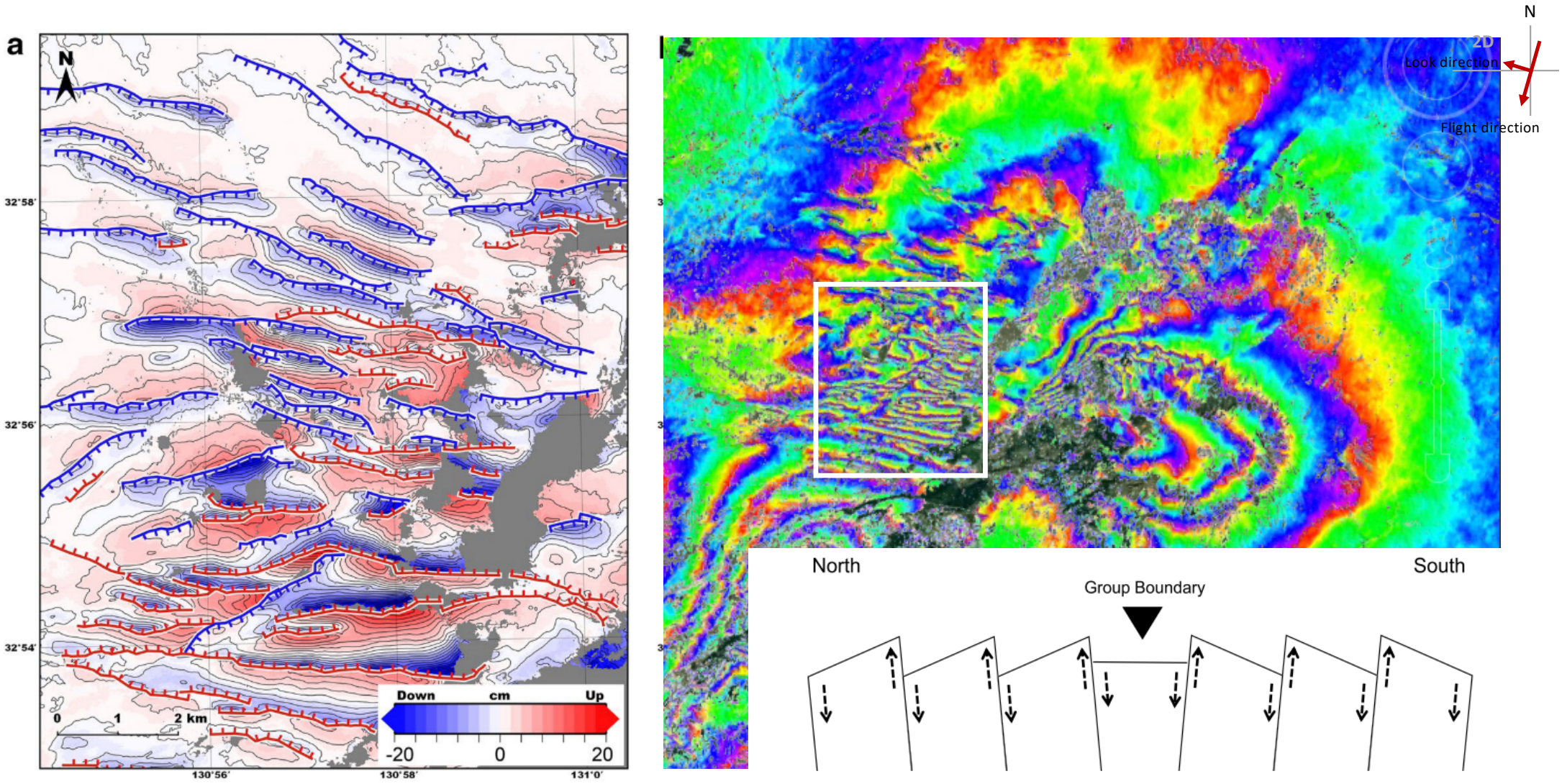
Close to sensor

Far away from sensor



Kumamoto Earthquake In 2016


N
2D
Look direction
Flight direction
Close to sensor
Far away from sensor
Close to sensor
Far away from sensor
High
Low

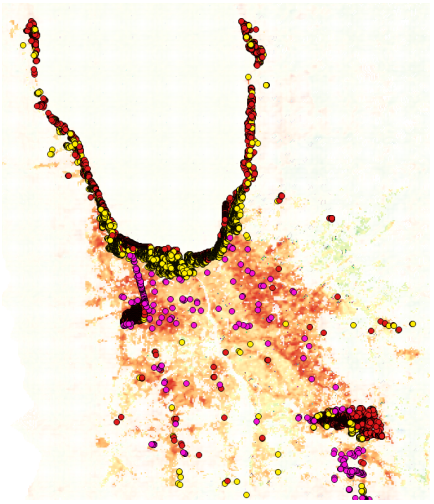


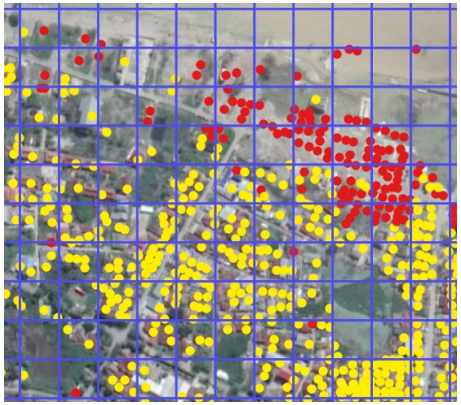
Fujiwara, S., Yarai, H., Kobayashi, T., Morishita, Y., Nakano, T., Miyahara, B., … Une, H. (2016). Small-displacement linear surface ruptures of the 2016 Kumamoto earthquake sequence detected by ALOS-2 SAR interferometry. Earth, Planets and Space, 68(1), 160. https://doi.org/10.1186/s40623-016-0534-x

Limitations of SAR utilization for damage mapping

Earthquake

Interferometric coherence change

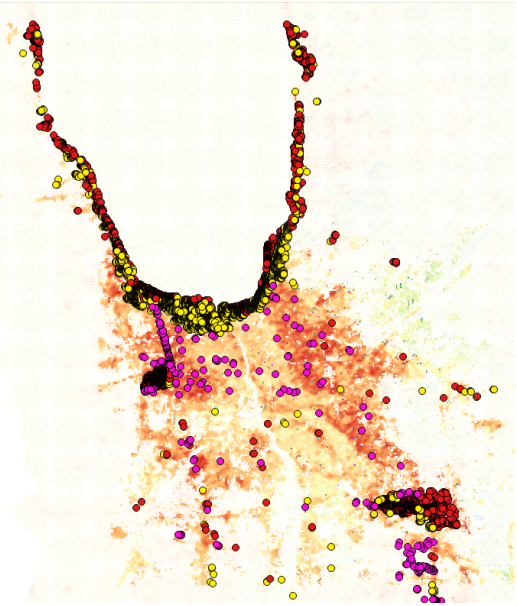




Discussions

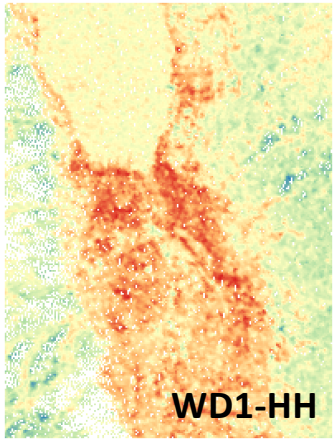
- Need 2 image before and one after earthquake
- Show damage possibility
- Many decorrelation effects
  - Noise in the radar system and processing approach
  - geometric coherence proportional to the perpendicular component of the baseline
  - influence of temporal backscatter change, e.g. from surface cover change or vegetation
- No identify individual building but show as grid result

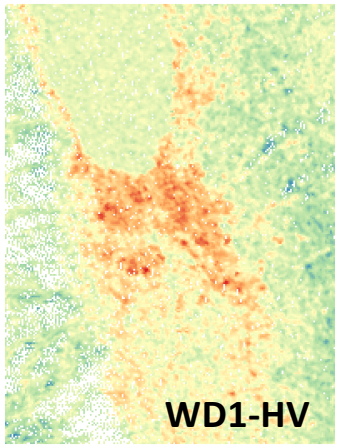
Phase based analysis



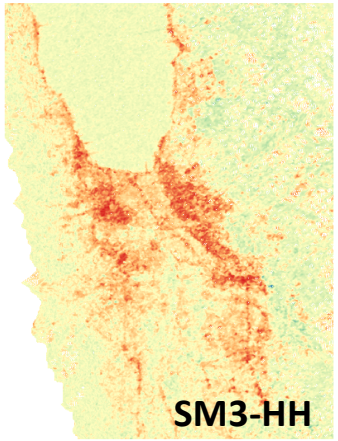
Assigned damage (interpreted by Google earth image)
Damage 5123 (Source: Copernicus EMS)
Destroy 5352 (Source: Copernicus EMS)

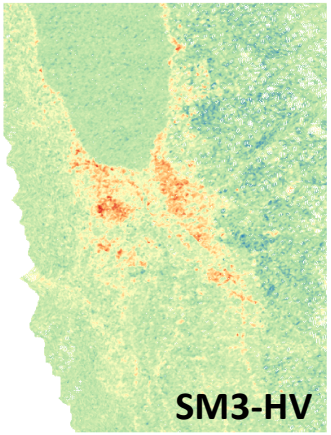
ScanSAR (WD1)



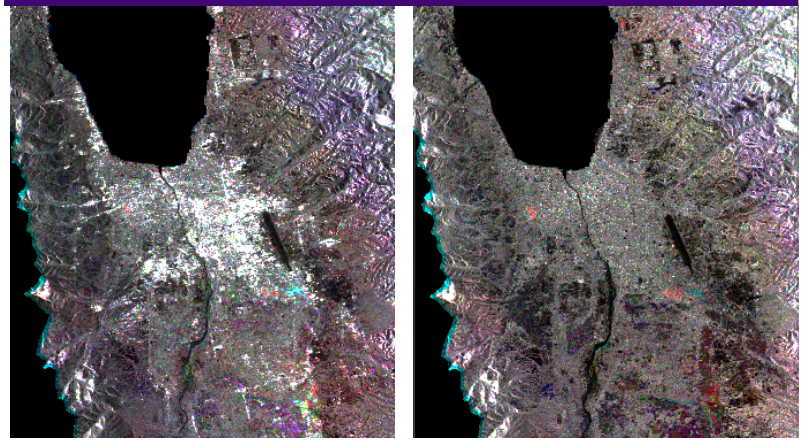


Stripmap (SM3)

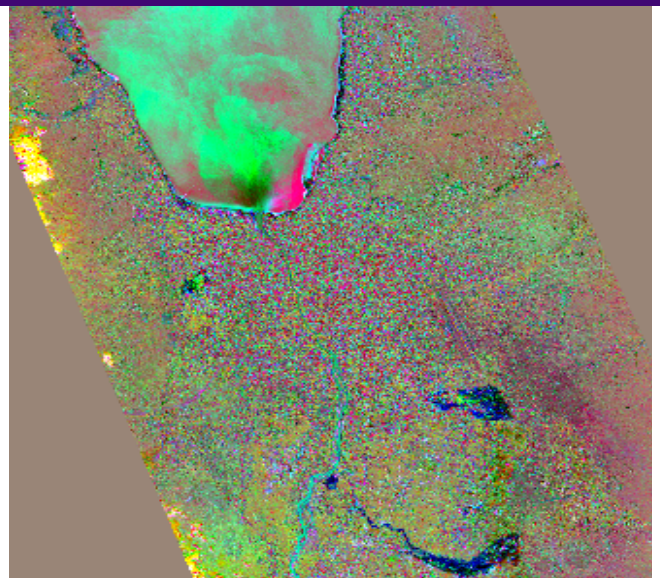




Amplitude base analysis



Optical image - S2 – change detection



ALOS-2

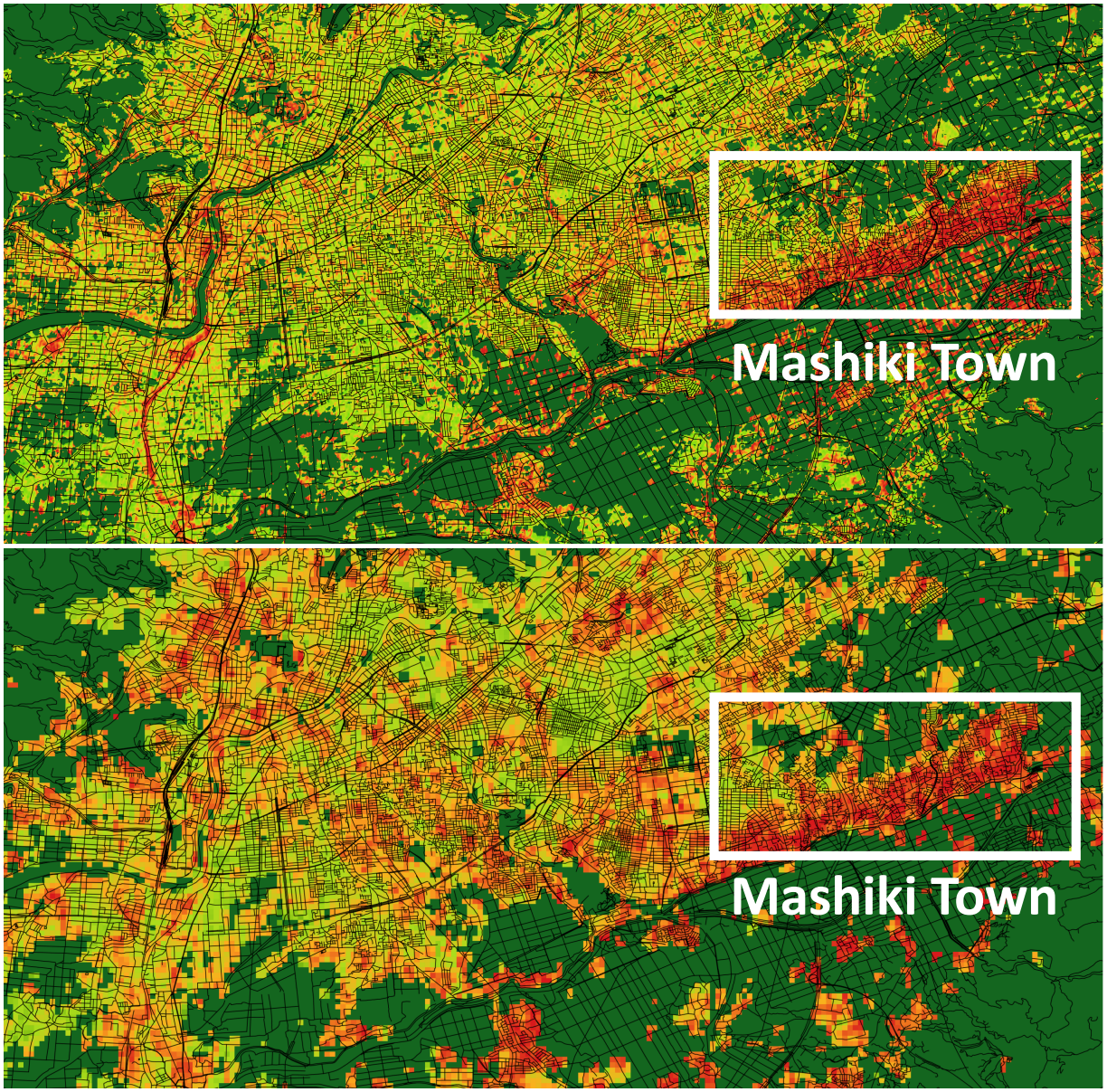
Possibility of damage

High damage

Urban area

None to less damage

Non-urban area



Kumamoto Earthquake In 2016

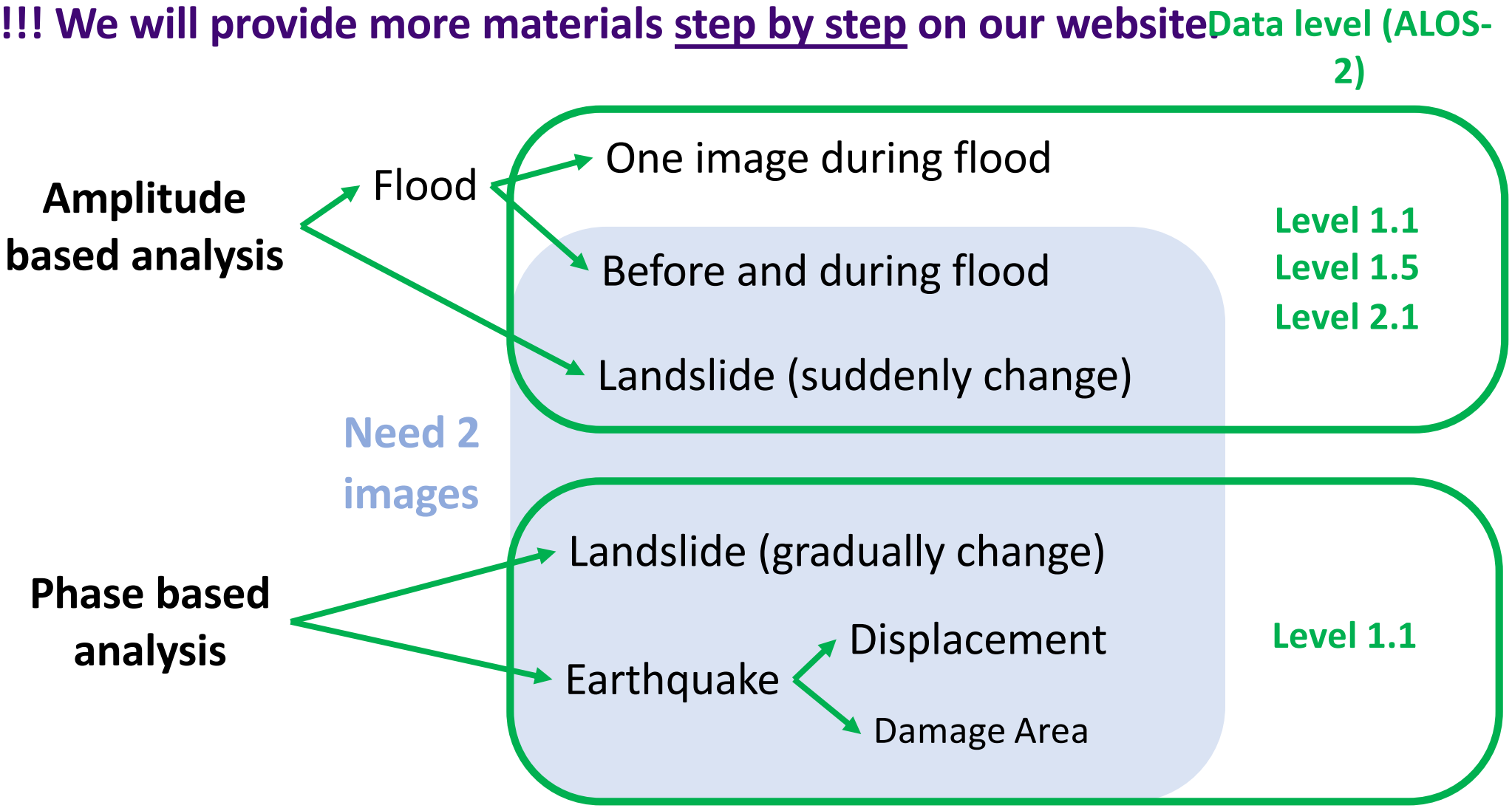
Different band

Different time

Different look

Sentinel-1

!!! We will provide more materials step by step on our website



Upcoming contents

- SAR Application for disasters
  - SAR interpretation
  - Intensity analysis (flood and landslide)
    - QGIS
    - SNAP (from low level)
  - INSAR analysis
    - SNAP
    - GMT5SAR (New version)
- UAV application for disasters
- GNSS application for disasters

Step by step procedure

http://bit.do/eduweb