



## Applied Remote Sensing Training (ARSET) Program

### An Introduction to Synthetic Aperture Radar (SAR) and its Applications (2024)

## Homework Questions

### Question 1

What are the advantages of radar over optical sensors?

Answers: (bold correct)

- a. They can "see" through clouds
- b. They can "see" the surface of the Earth day and night
- c. They can penetrate through a medium (vegetation, snow, soil)
- d. All of the above**

Feedback:

Radar sensors can 'see' through clouds, most weather conditions, and operate day or night. They can also penetrate various mediums (e.g. vegetation, snow, soil).

### Question 2

True or false: the spatial resolution of radar sensors varies between the along-track and across-track directions.

Answers: (bold correct)

- a. True**
- b. False

Feedback:

The spatial resolution of radar sensors varies between the along-track and across-track directions. The along-track direction refers to the direction in which the radar platform moves, which is usually along the satellite path. This resolution is determined by the antenna length.

The across-track resolution refers to the perpendicular direction, across the swath (the area covered by the radar's beam), which is determined by the pulse length.

### Question 3

True or false: wavelength is inversely related to frequency.

Answers: (bold correct)

- a. **True**
- b. False

Feedback:

Wavelength is equal to the speed of light divided by frequency.

### Question 4

What are the three radar parameters that need to be considered for any study?

Answers: (bold correct)

- a. Wavelength, Polarization, and Dielectric
- b. Wavelength, Incidence Angle, and Structure
- c. **Wavelength, Polarization, Incidence Angle**
- d. Incidence Angle, Dielectric, and Structure

Feedback:

Wavelength, polarization, and incidence angle are indeed three important radar parameters to consider in radar-based remote sensing studies. These parameters are often chosen based on the specific objectives of the study.

### Question 5

What is the relationship between wavelength and penetration depth?

Answers: (bold correct)

- a. The longer the wavelength, the lesser the penetration depth.
- b. The shorter the wavelength, the greater the penetration depth.
- c. **The longer the wavelength, the greater the penetration depth.**
- d. None of the above

Feedback:

The longer the radar wavelength, the greater the penetration depth.

Longer wavelengths (e.g., L-band, P-band) can penetrate deeper into certain materials, like soil, vegetation, or even snow, because they are less affected by small particles and surface roughness.

### Question 6

The information content in radar images is related to:

Answers: (bold correct)

- a. Moisture and Wind Speed
- b. Moisture and Temperature
- c. Structure and Moisture**
- d. Structure and Barometric Pressure

Feedback:

The information content in radar images is fundamentally shaped by the moisture and structural characteristics of the observed surface or material. Moisture impacts how radar waves are absorbed or reflected by surfaces, while structural properties like roughness, density, and texture affect the radar signal scattering.

## Question 7

What types of polarizations are commonly used in radar?

Answers: (bold correct)

- a. Horizontal and Trihedral
- b. Horizontal and Vertical**
- c. Triangular and Vertical
- d. Vertical and Trihedral

Feedback:

The most commonly used radar polarizations are:

- Single-polarization: HH and VV
- Dual-polarization: HH and HV, VV and VH
- Quad-polarization: HH, HV, VH, VV

## Question 8

What are the main radar backscattering mechanisms?

Answers: (bold correct)

- a. Specular Reflection, Triple-Bounce, Double-Bounce
- b. Volume Scattering, Triple-Bounce, Roof Scattering
- c. Roof Scattering, Double-Bounce, Specular Reflection
- d. Specular Reflection, Rough Surface Scattering, Volume Scattering, and Double-Bounce**

Feedback:

Radar backscattering refers to the reflection of radar waves from a surface or object back to the sensor. This backscattered signal provides valuable information about the properties of the surface or medium. The main radar backscattering mechanisms are specular reflection, volume scattering, rough surface scattering, and double bounce.

## Question 9

What is speckle?

Answers: (bold correct)

- a. Triangular features in the radar image
- b. "Salt and pepper" texture in the radar image**
- c. Circular features in the radar image
- d. None of the above

Feedback:

Speckle is a granular noise pattern that appears in radar images due to the interference of multiple scattered signals from the surface being observed.

## Question 10

How can speckle be reduced?

Answers: (bold correct)

- a. Multilooking
- b. Temporal Filtering
- c. Spatial Filtering
- d. All of the Above**

Feedback:

Speckle can be reduced in radar images using several methods that aim to either smooth out the noise without losing important surface details or enhance the signal in a way that diminishes the randomness caused by interference. Multilooking and spatial filtering reduces speckle but also reduces the spatial resolution of the image. Temporal filtering does not reduce the spatial resolution.

## Question 11

Which band does Sentinel-1 use?

Answers: (bold correct)

- a. L-band
- b. S-band
- c. Ku-band
- d. C-band**

Feedback:

Sentinel-1 SAR's operate at C-band.

## Question 12

True or false: in general, the radar signal interacts with objects on the surface that are roughly the same size as the radar wavelength.

Answers: (bold correct)

- a. **True**
- b. False

Feedback:

The radar signal interacts with objects on the surface that are approximately the same wavelength of the radar signal.

## Question 13

Which band is the most suitable for crop mapping and monitoring?

Answers: (bold correct)

- a. Ku-band
- b. **C-band**
- c. L-band
- d. P-band

Feedback:

C-band is often considered the most suitable SAR band for mapping and monitoring agriculture. It has a good balance between being able to penetrate through vegetation and retaining enough sensitivity to detect surface features. It can interact with both the surface and the vegetation canopy.

## Question 14

Which band is the most suitable for forest mapping and monitoring?

Answers: (bold correct)

- a. Ku-band
- b. C-band
- c. **L-band**
- d. X-band

Feedback:

L-band provides better penetration into the soil and vegetation than the other bands listed here, making it useful for mapping forests, monitoring forest biomass, and estimating soil moisture.

## Question 15

What is more likely to influence radar backscatter over vegetated areas?

Answers: (bold correct)

- a. Leaf chemistry
- b. The spatial arrangement of trunks, leaves, and branches**
- c. Fluorescence
- d. Nitrogen content

Feedback:

The spatial arrangement of trunks, leaves, twigs, and branches in a vegetation canopy with influence radar backscatter.

## Question 16

What is the basic measurement of SAR interferometry?

Answers: (bold correct)

- a. Radio emissions from ground stations affecting radar images
- b. Polarization of a radar image
- c. Difference in phase between two similar radar images**
- d. Difference in radar wavelength for radar images from different satellites

Feedback:

The basic measurement in Interferometric Synthetic Aperture Radar (InSAR) is the difference in phase between two radar images of the same area taken at different times. This phase difference is used to measure surface displacement (typically ground movement) between the two observation dates.

## Question 17

What are two common measurements from InSAR?

Answers: (bold correct)

- a. Color and Smoothness of the Land Surface
- b. Topography and Color of the Land Surface
- c. Color and Depth of the Ocean
- d. Topography and Deformation of the Land Surface**

Feedback:

Two common measurements obtained from InSAR are displacement (in the Line of Sight - LOS) and topography.

## Question 18

What controls sensitivity of SAR interferometry to topography?

Answers: (bold correct)

- a. **Distance between the radar antennas when the images were acquired**
- b. Color of the leaves covering the surface when images were acquired
- c. Phase of the Moon when radar images were acquired
- d. Height of the Sun when radar images were acquired

## Question 19

What is the sensitivity of SAR interferometry for measuring ground displacements?

Answers: (bold correct)

- a. About 1% of the satellite height above the ground (near 5 km)
- b. Around 100 meters
- c. Roughly the length of the radar antenna (5-10 meters)
- d. **About 10% of the radar wavelength (near 1 cm)**

## Question 20

What does the correlation in SAR interferometry measure?

Answers: (bold correct)

- a. Coherence or similarity of the radar reflection
- b. Changes in the ground surface between radar images
- c. Noise level in the interferogram
- d. **All of the above**

## Part 3 Questions

[This tutorial](#) walks users through the process of searching for OPERA Radiometrically Terrain Corrected -Sentinel-1 (RTC-S1) data products, downloading them, and using them in a GIS-based change detection workflow. For this exercise:

1. Review the information in the [Introduction](#).
2. Follow the instructions in the [Find OPERA RTC-S1 Data: Vertex](#) and the [Download Data](#) sections to search for and download OPERA RTC-S1 products.
3. Read through the [Sentinel-1 RTC On Demand](#) section (you do not need to follow the link to the RTC On Demand! tutorial for this exercise).

## Question 21

When searching for OPERA RTC-S1 data, you find a product with a footprint that covers your area of interest very well.

When searching the Sentinel-1 or S1 Bursts collection, there is a “More Like This” button you can click to restrict your search to the same footprint, but this button is not available when searching for OPERA RTC-S1 products.

What can you do to restrict your search to the footprint of the product you've selected in the results list?

Answers: (bold correct)

- a. Click the Source Data button
- b. Click the gear icon next to Opera Burst IDs and select the option to Add OPERA burst ID to search
- c. Copy the Opera Burst ID value and paste it into the Opera Burst IDs field in the Search Filters window
- d. Either B or C**

Feedback:

B is the easiest way to add the Burst ID to the search filters, but you can also manually populate that search field, as in C.

## Question 22

Select all the reasons that you might want to submit a Sentinel-1 GRD or SLC for On-Demand RTC processing rather than download an OPERA RTC-S1 product.

Answers: (bold correct)

- a. You want an RTC product for a Sentinel-1 acquisition collected before October 4, 2023.**
- b. You want a product that has 20-m pixel spacing rather than the 30-m pixel spacing used in the OPERA RTC-S1 products.**
- c. It is faster to process a Sentinel-1 RTC product on demand than to download an OPERA RTC-S1 product from the archive.
- d. You already have a stack of On-Demand Sentinel-1 RTC products and you want some newer products to extend your time series analysis.**

Feedback:

A. OPERA RTC-S1 products are only available starting October 4, 2023. If you want RTC products from prior to that date, you can submit any Sentinel-1 Level-1 product for on-demand processing.

B. The OPERA RTC-S1 products are output with a pixel spacing of 30 meters. If you want an RTC product that leverages different options for pixel spacing (along with radiometry and scale), you can submit a Sentinel-1 Level-1 product for on-demand processing.

D. Because the OPERA RTC-S1 products and ASF's Sentinel-1 On-Demand RTC products are generated using different software, you will have better results in a time-series analysis if the products are all generated using the same processor.