# GEOS 639 – InSAR and Its Applications

[Applications of Geodetic Imaging]

Lab 1 / Assignment 1: Interpreting Optical vs SAR Images (20 points)

**Instructor:** FJ Meyer

**Due Date:** February 13, 2024

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## 1 General Instructions:

While it is not required, some questions in this assignment may be easier to answer when images are analyzed in a GIS system such as QGIS. QGIS is a freely available geographic information system and can be downloaded from here. Versions are available for several operation systems:

https://www.qgis.org/en/site/forusers/download.html

I like the QuickMapService plugin to visualize data in a map context. If that's your thing, you can find instructions on how to install that plugin here.

Please **submit** the completed homework via the GEOS 639 **Canvas** page.

## 2 Comparing Information Content of Optical & SAR Images

### 2.1 Springtime at the Yukon River (10 points)

The optical/SAR image set we will be looking at is from May 2023, covering an area of the Yukon River. The optical image was acquired May 5$^{th}$ and the SAR image on May 2$^{nd}$ of 2023. The optical image is a Landsat-8 RGB product and the SAR image is a dual-pol (VV and VH) Sentinel-1 C-band data product processed into an RTC image. Both images are sampled at 30-m pixel spacing.

#### 2.1.1 Data to be used for this problem:

The GeoTIFF data for this exercise are available here:

- YukonOpticalAndSAR.zip

The Landsat-8 data are provided as RGB composite. The SAR RTC data are provided as VV- and VH-polarized bands.

#### 2.1.2 Answer the following image interpretation questions:

**Water surfaces**: Look at the lakes and rivers in the scene and compare the optical and SAR images. Focus roughly on the area marked "WS" in Figure 1.

a. In the VH SAR data, can you discriminate the frozen parts of the river from the open water regions? Feel free to rescale the image to help with answering this question. **—1.5 points**

b. In the VV SAR data, can you discriminate the frozen parts of the river from the open water regions? Feel free to rescale the image to help with answering this question. **—1.5 points**

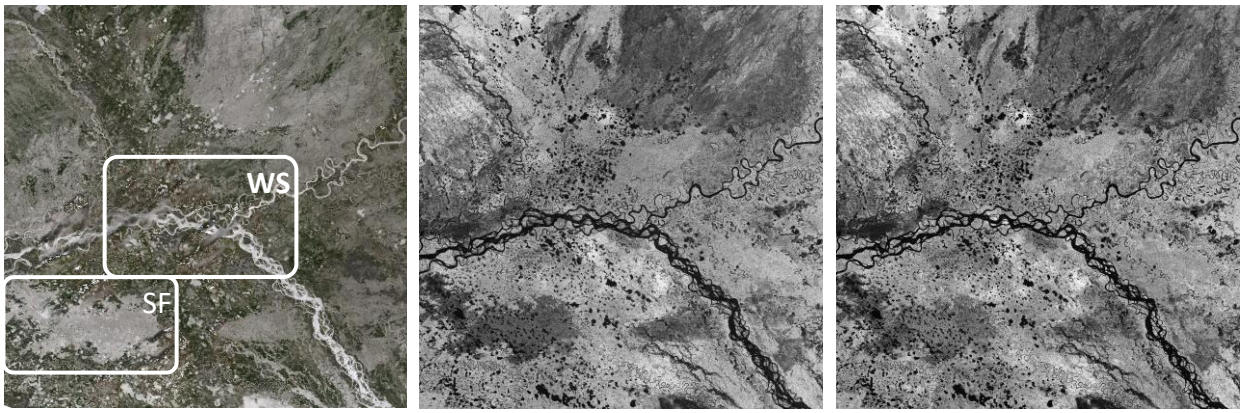
c. Explain your findings from questions a) and b). What may the properties of the ice be like to create the observed SAR response? **—2 points**

**Residual Snow Fields**: Look at the areas of residual snow (regions marked as "SF" in Figure 1) and compare the optical and SAR images.

d. In the VH band, describe the radar brightness patterns you see within this snow field. In your answer, also address whether or not the radar brightness is roughly uniform across this area. **—1.5 points**

e. In the VV band, describe the radar brightness patterns you see within this snow field. In your answer, also address whether or not the radar brightness is roughly uniform across this area. **—1.5 points**

f. Based on your answers to a) & b), what might the properties of the snow in this area be? **—2 points**




(a) (b) (c)

***Figure 1**: Satellite images over the Yukon River (a) Landsat RGB image acquired on May 5, 2023; (b) VV-polarized C-band Sentinel-1 SAR image acquired on May 2, 2023; (c) VH-polarized C-band Sentinel-1 SAR image acquired on May 2, 2023*

## 2.2 Look at them Bridges – Fun with SAR Geometry (2 points)

Look at the pair of optical and SAR images over a Bridge in Germany shown in the top row of Figure 2. Answer the following questions:

a. Given what you see in the image. Which direction did the sensor look? Is it more likely that the sensor looked left to right or from bottom up? Provide a justification for your answer. **—1 point**

b. Due to the imaging geometry, the SAR image of this bridge looks a bit weird. You may see that there are three main bright responses in the image that are labeled 1, 2, and 3, in the top right figure. The images on the bottom row shows scattering mechanisms that created the bright responses in the SAR image. Please answer which scattering mechanism corresponds to which of the bright lines. **—1 point**

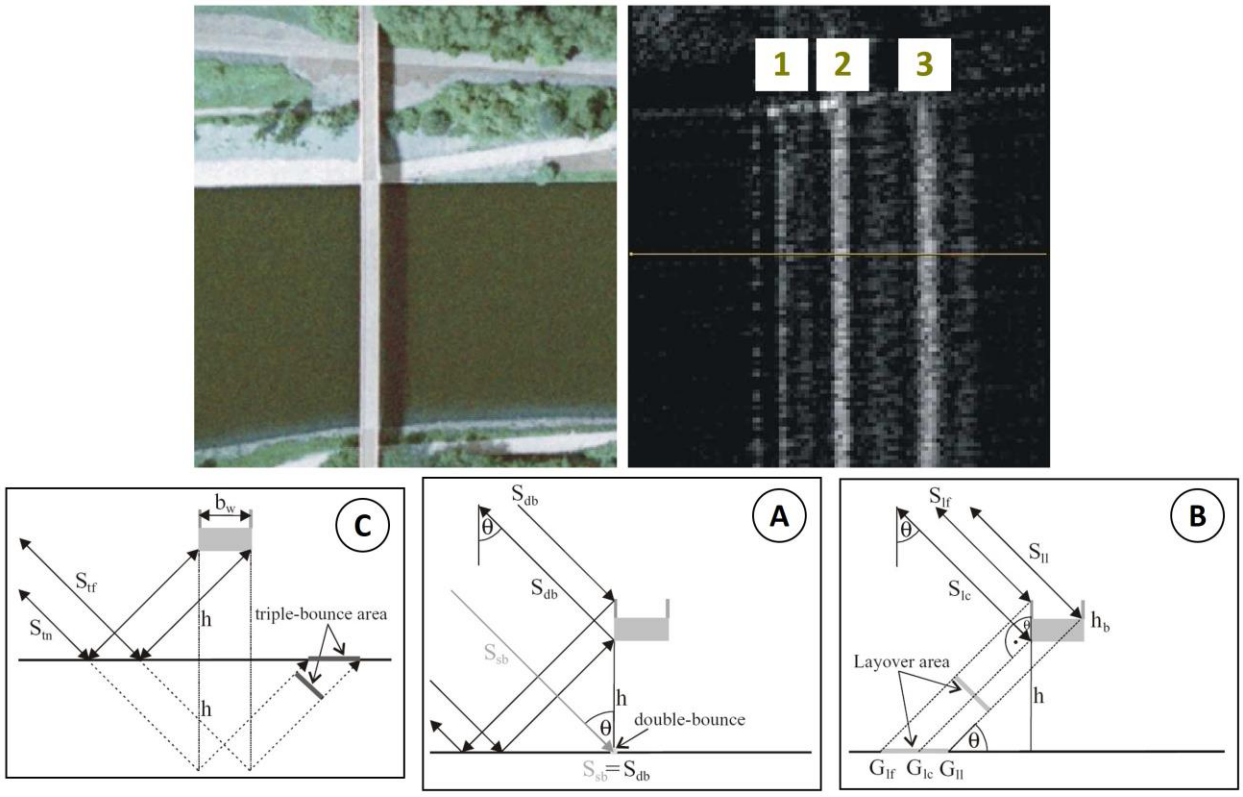



***Figure 2**: (top row) optical image and SAR image of a bridge in Germany; (bottom row) three different scattering mechanisms that gave rise to the SAR response for that bridge.*

# 3 Optical and SAR Images for Geodesy (8 points)

## 3.1 Exploring Jakobshavn Glacier, Greenland

Jakobshavn is the fastest glacier in the world, moving ice from the interior of Greenland to the coast at a breakneck speed of up to 45 meters per day near its calving front. Velocities vary extensively in space and time but are fasted near the terminus and during the summer months. We will be exploring repeated optical and SAR images to evaluate their information content and attempt a rough velocity estimation of this glacier for a time in early August 2023. The SAR images were acquired by Sentinel-1 on Aug 4 and Aug 21, 2023. The optical data are from Landsat-8 and were acquired Aug 5 and Aug 21, 2023. The images can be downloaded following the information below and are visualized in Figure 3.

### 3.1.1 Data to be used for problem:

For Section 3.1.2, please use the following data:

- GreenlandImageInterpretation_SARandOptical.zip

To answer the question in Section 3.1.3, please use the following data:

- GreenlandVelocity_SARandOptical.zip

Consider loading these images into QGIS for visualization and analysis.

### 3.1.2 Answer the following image interpretation questions:

a) Start with the optical images from Aug 5 and Aug 21. Which difference do you see and how would you interpret them? – **2 points**

b) Now look at the SAR images. Using your theory developed from the optical data, how do you explain the differences you see in the SAR images? – **2 points**

### 3.1.3 Answer the following Geodesy question

c) Pick either the optical or SAR image pair and measure the amount of glacier motion that occurred in between the two respective image dates. Pick the region shown in Figure 4 for your assessment. Identify objects you can track and measure the magnitude of the objects motion meters/day units. – **4 points**

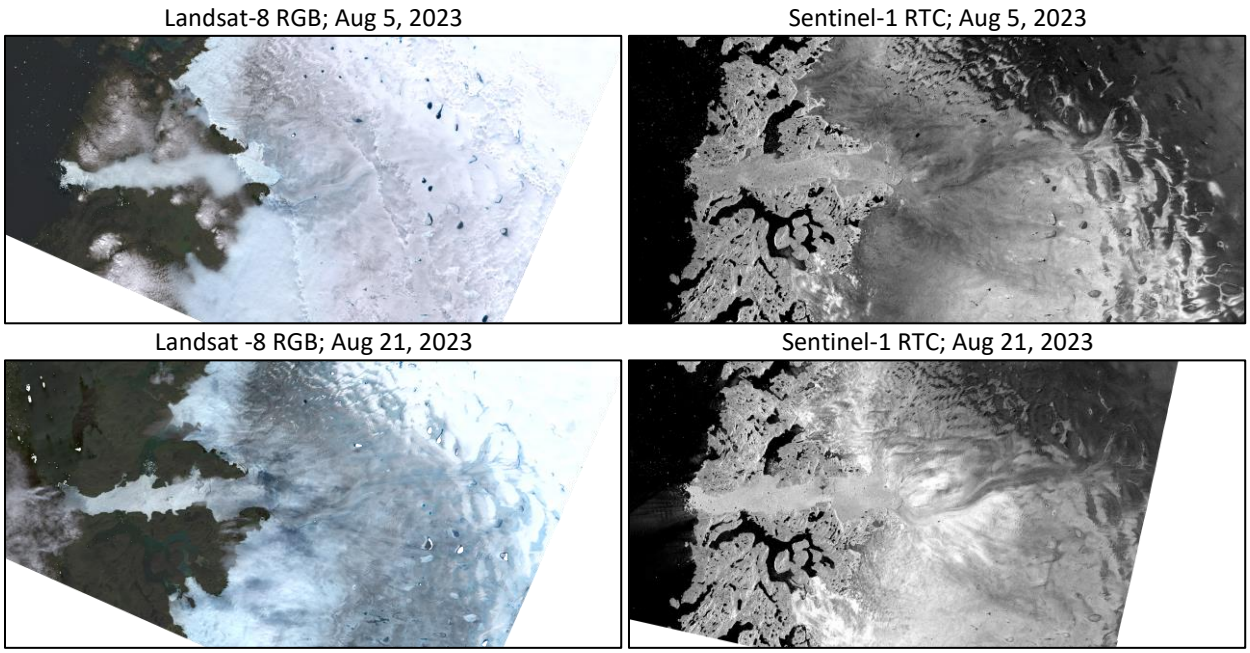



***Figure 3**: Landsat-8 optical and Sentinel-1 SAR image pairs over Jakobshavn glacier in Greenland. The optical image pairs were acquired on Aug 5 and Aug 21, 2023. The SAR images are from Aug 5 and Aug 21, 2023. Optical images are atmospherically corrected RGB data. SAR products are RTC images. The subset in white is shown in Figure 4.*

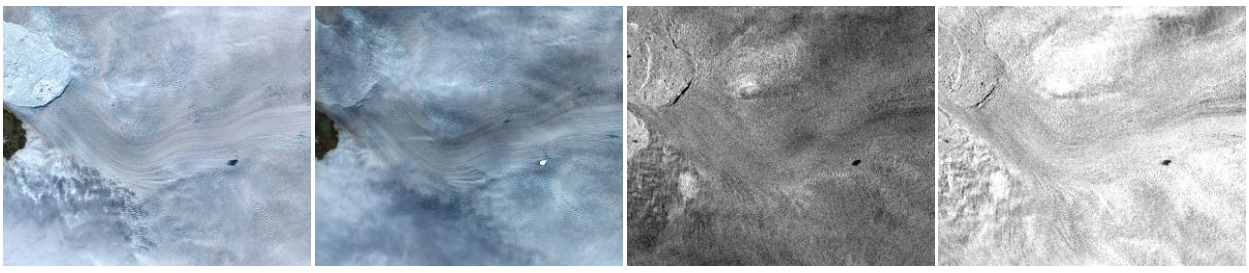



***Figure 4**: Subset of the images in Figure 3. Please use the GeoTIFF versions of these images for glacier velocity estimation.*