Sentinel-1 Toolbox

Offset Tracking Tutorial

Issued August 2016

Jun Lu
Luis Veci

Offset Tracking Tutorial

The goal of this tutorial is to provide novice and experienced remote sensing users with step-by-step instructions on the use of Offset Tracking tools in generating glacier velocity maps with Sentinel-1 Level-1 Ground Range Detected (GRD) products.

What is Offset Tracking?

Offset Tracking is a technique that measures feature motion between two images using patch intensity cross-correlation optimization. It is widely used in glacier motion estimation.

Sentinel-1 Level-1 GRD Products

Level-1 focused data are the generally available products intended for most data users. Level-1 products can be either Single Look Complex (SLC) or Ground Range Detected (GRD). Each acquisition mode can potentially generate Level-1 SLC and GRD products. GRD resolutions will depend on the mode and the level of multi-looking.

Level-1 Ground Range Detected (GRD) products consist of focused SAR data that has been detected, multi-looked and projected to ground range using an Earth ellipsoid model such as WGS84. The ellipsoid projection of the GRD products is corrected using the terrain height specified in the product general annotation. The terrain height used varies in azimuth but is constant in range.

Rink Glacier

This tutorial will examine the movement of the Rink glacier. Rink glacier is a large glacier located on the west coast of Greenland. It drains an area of 30,182 km2 (11,653 sq mi) of the Greenland ice sheet with a flux (quantity of ice moved from the land to the sea) of 12.1 km3 (2.9 cu mi) per year, as measured for 1996. It is also the swiftest moving and highest surface ice in the world.

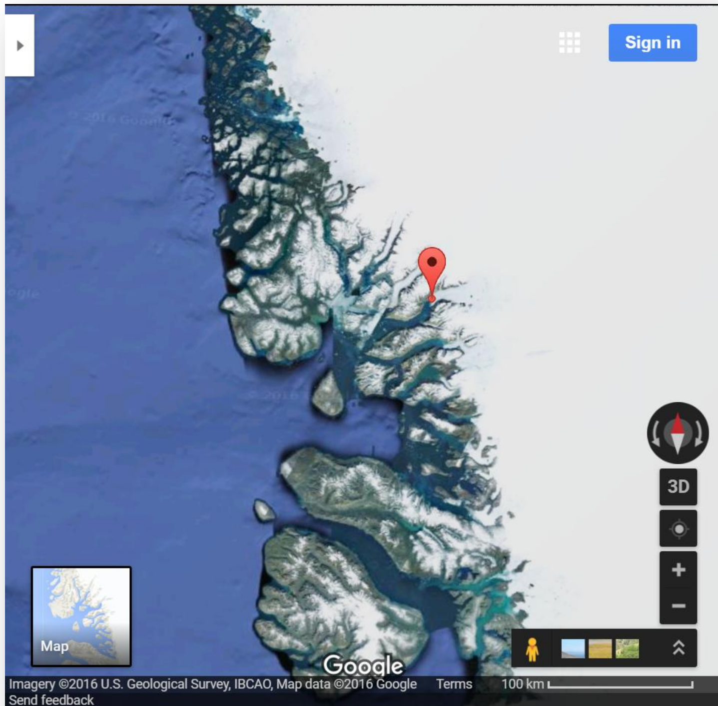


Figure 1 Google map of Rink Glacier

Figure 2 Photograph of Rink Glacier from Wikipedia

Opening a Pair of GRD Products

In this tutorial, we will process two Sentinel-1 IW GRD products acquired in July 2016 over the Rink Glacier.

In order to generate glacier velocity map using the Offset Tracking tool, the input products should be two GRD products over the same area acquired at different times. The time interval should be as short as possible. In this tutorial, we will use the following two GRD products acquired 12 days apart:

S1A_IW_GRDH_1SSH_20160708T204736_20160708T204801_012062_012A6D_D116
S1A_IW_GRDH_1SSH_20160720T204737_20160720T204802_012237_013014_9C25

Step 1 - Open the products: Use the **Open Product** button in the top toolbar and brows for the location of the two GRD products.

Select the **manifest.safe** file from each Sentinel-1 product folder and press **Open Product**. Press and hold the Ctrl button on the keyboard to select multiple products at a time.

If the product is zipped, you may also select the zip file.

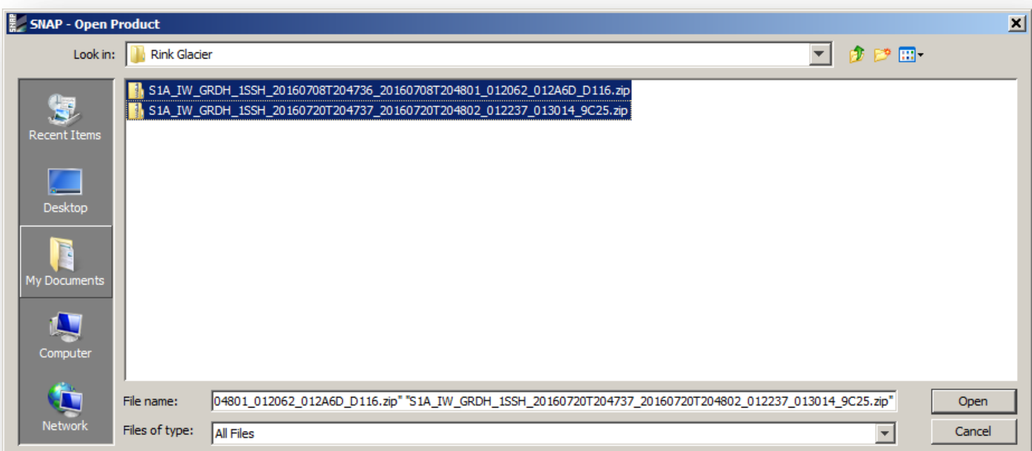


Figure 3 Opening a Product

Step 2 - View the product: In the **Products View** you will see the opened products. Within the product bands, you will find two bands: an amplitude band which is a band that is actually in the product, and a virtual intensity band which is there to assist you in working with the GRD data.

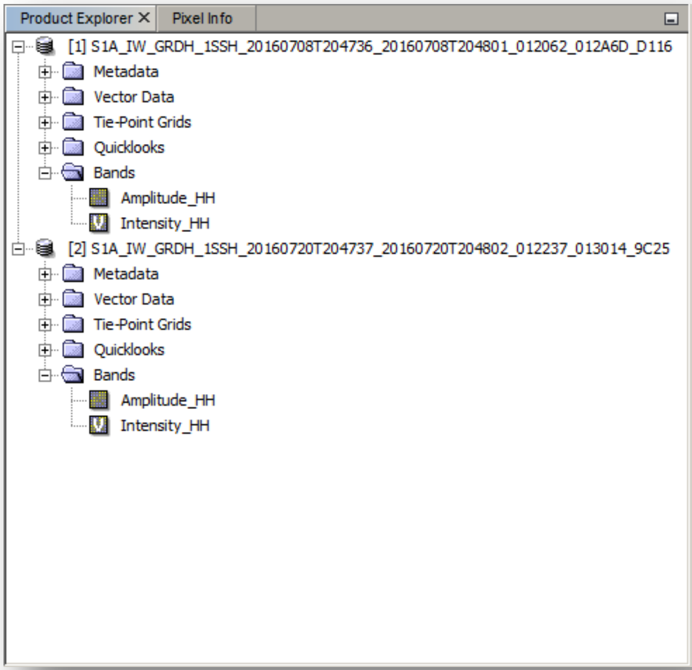


Figure 4 Products View

The image area can be seen in the **World View** window:

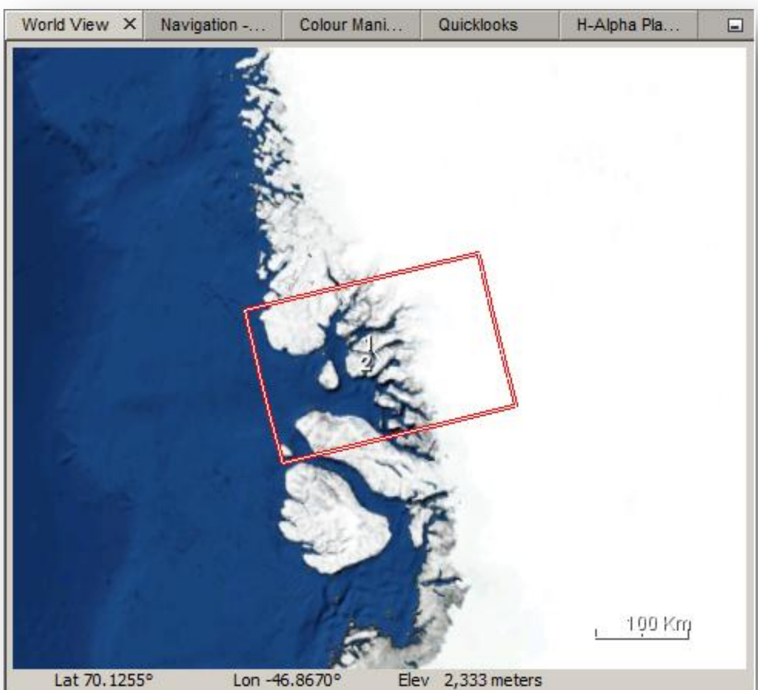


Figure 5 Image Area

Step 3 - View a band: To view the data, double-click on the Amplitude_HH band. Zoom in using the mouse wheel and pan by clicking and dragging the left mouse button.

Figure 6 Amplitude_HH Band of product [1]

Comparing this image to the world map in Figure 5, you will find that the image is flipped upside-down. This is because the image was acquired with an ascending pass and right-pointing antenna. Therefore, the bottom part of the image area was first sensed and in SNAP the first sensed line is always displayed on top of the image.

Coregistering the Data

For Offset Tracking processing, two images must be coregistered into a stack. The image that was acquired earlier is selected as the master and the other image is selected as the slave. The pixels in slave image will be moved to align with the master image with the help of the orbital data and a reference DEM.

Coregistration ensures that each ground target from stationary scene contributes to the same (range, azimuth) pixel in both the master and the slave image.

For Offset Tracking application, **DEM Assisted Coregistration** should be used. It coregisters the products strictly based on the geometry using a DEM, orbit positions and times. This avoids possibly warping the image incorrectly due to the movement in the scene.

Before image coregistration, the orbit state vectors in the original GRD product should be updated with the more accurate orbit data provided in the available orbit file. This can be done with **Apply Orbit File** operator.

Step 4 - Apply orbit file: Select **Apply Orbit File** in **Radar** menu.

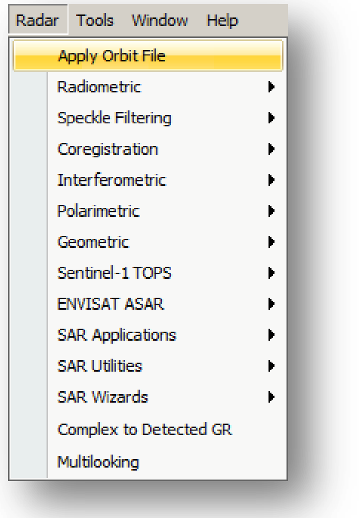


Figure 7 Select Apply Orbit File

In the Apply-Orbit-File window, select **Sentinel Precise Orbits**. Orbit auxiliary data contain information about the position of the satellite during the acquisition of SAR data.

The Precise Orbit Determination (POD) service for SENTINEL-1 provides Restituted orbit files and Precise Orbit Ephemerides (POE) orbit files. POE files cover approximately 28 hours and contain orbit state vectors at fixed time steps of 10 seconds intervals. Files are generated one file per day and are delivered within 20 days after data acquisition.

If Precise orbits are not yet available for your product, you may select the Restituted orbits which may not be as accurate as the Precise orbits but will be better than the predicted orbits available within the product. Orbit files for Sentinel-1 are automatically downloaded by the Toolbox.

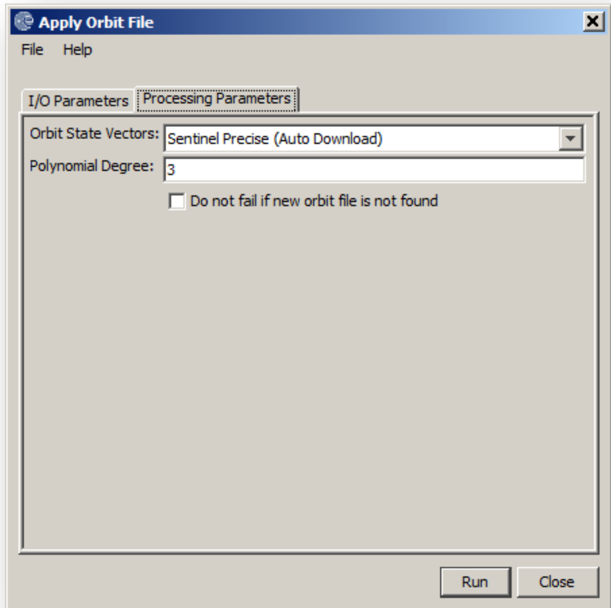


Figure 8 Apply-Orbit-File Dialog

Step 5 - Coregister the images into a stack: Select **DEM Assisted Coregistration** in **Radar** menu.

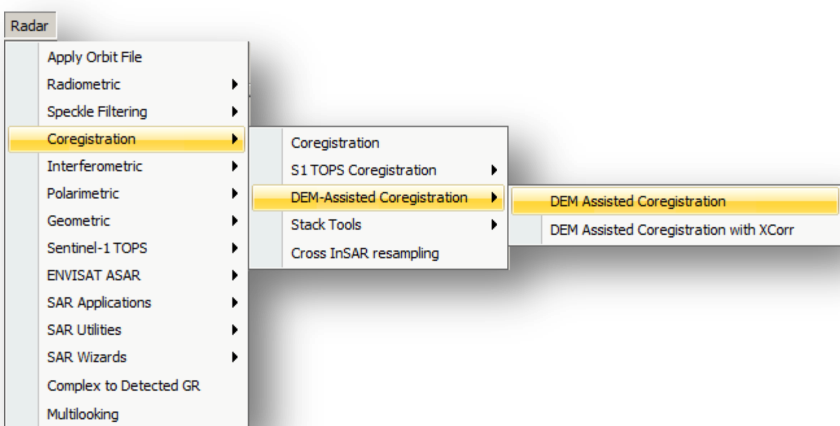


Figure 9 Select DEM Assisted Coregistration

In the first Read operator, select the first product [1]. This will be your **master** image. In Read(2) select the other product. This will be your **slave** image.

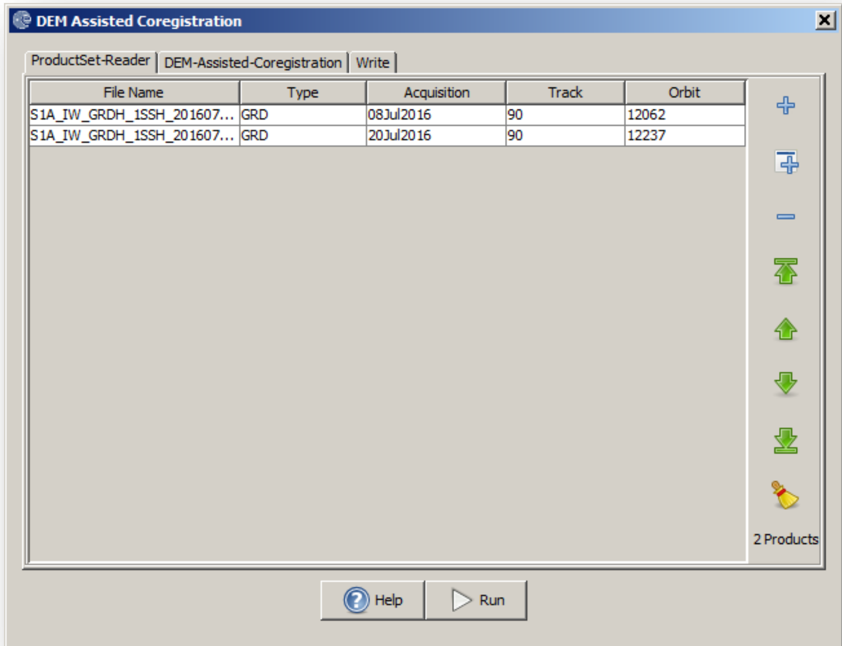


Figure 10 Select master and slave products

In the DEM-Assisted-Coregistration tab, select the Digital Elevation Model (DEM) to use, the DEM resampling method, and image resampling method.

The default DEM, which is SRTM 3 Sec, covers most area of the earth's surface between –60 degree latitude and +60 degree latitude. However, it does not cover the high latitude area where Rink Glacier is located. Therefore, ASTER GDEM, GETASSE30 or ACE30 DEM could be selected.

Areas outside the DEM or in the sea may be optionally masked out.

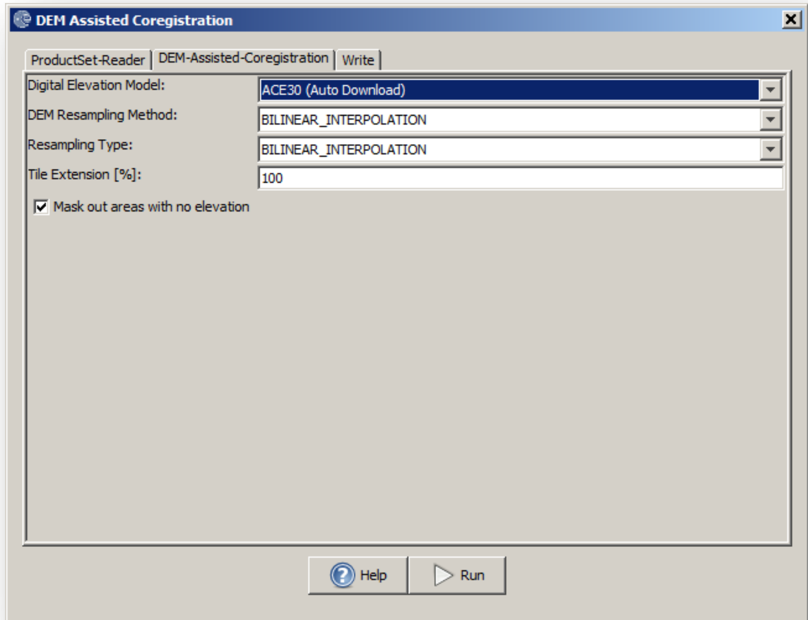


Figure 11 DEM-Assisted-Coregistration Parameters

In the **Write** tab, specify the output folder and the target product name.

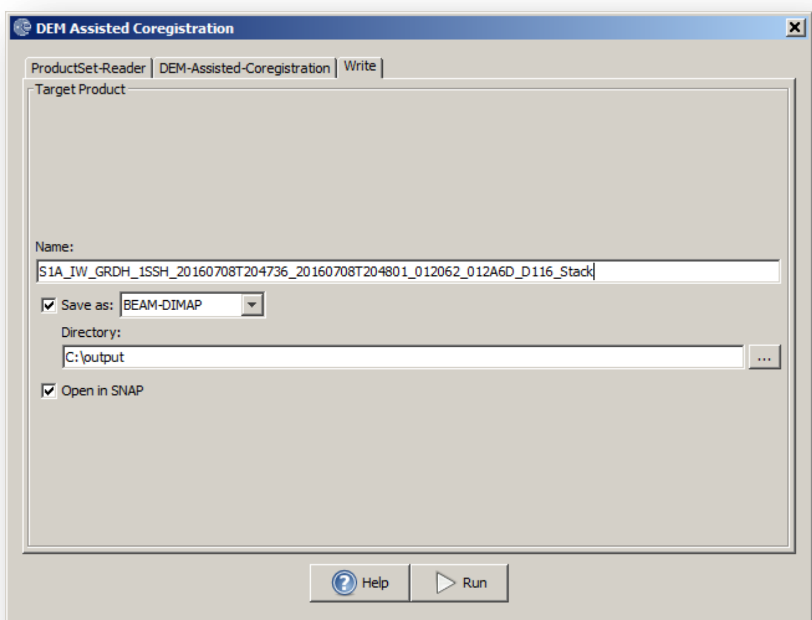


Figure 12 Specify the output name, format and folder

Press **Run** to start the coregistration.

The resulting coregistered stack product will appear in the **Products View**.

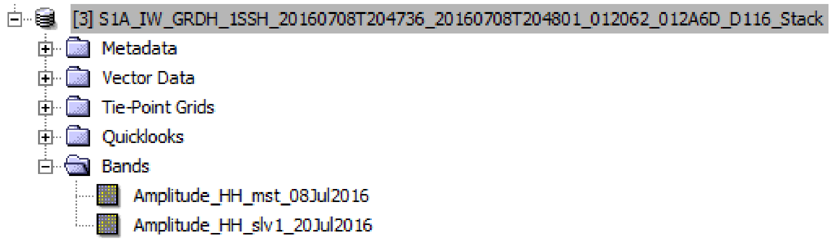


Figure 13 Coregistered Stack Product

Step 6 - Create subset image containing Rink Glacier: Since the image covers a large area of the west coast of Greenland and we are interested only in the Rink Glacier area, we will create a subset of the coregistered stack that contains the Rink Glacier area only.

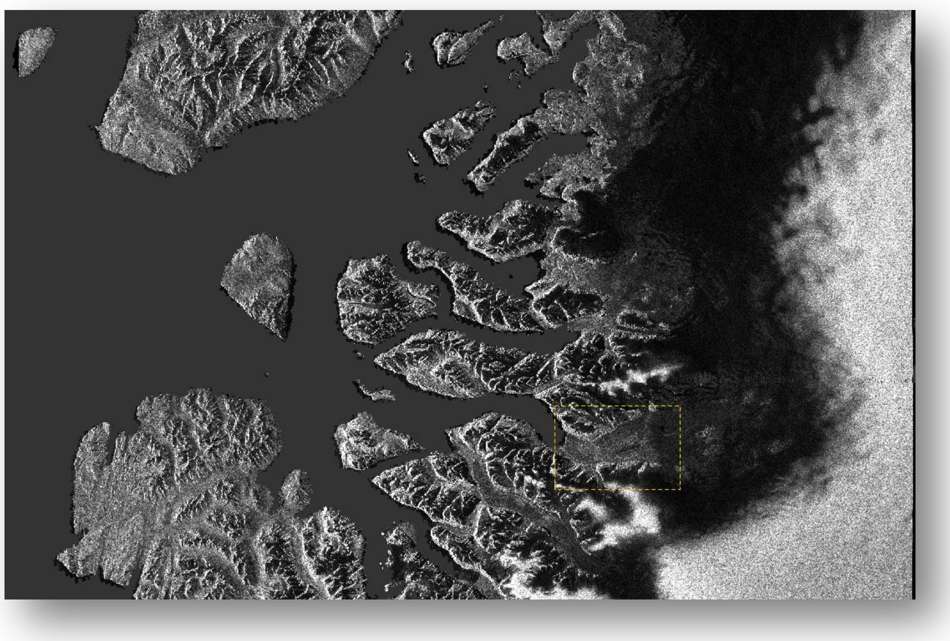


Figure 14 Subset area in the image

The subset image can be created in several different ways. One easy way is to zoom in the image until the image window contains only the area of interest, then right click on the image and select **Spatial Subset from View** from the popup menu.

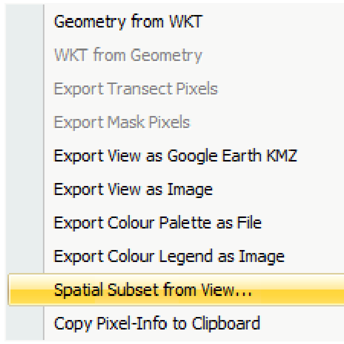


Figure 15 Create subset from view

Then the **Specify Product Subset** window will appear, click on **OK** a subset product is created. Save the newly created subset product, then you can use it for offset tracking.

Figure 16 Subset image that covers Rink Glacier

Offset Tracking

The Offset Tracking operator estimates the movement of glacier surfaces between master and slave images in both slant-range and azimuth direction. It performs cross-correlation on selected Ground Control Point (GCP) in master and slave images. Then the glacier velocities on the selected GCPs are computed based on the offsets estimated by the cross-correlation. Finally the glacier velocity map is generated through interpolation of the velocities computed on the GCP grid.

The Offset Tracking is performed in the following sub-steps:

1. For each point in the user specified GCP grid in master image, compute its corresponding pixel position in slave image using normalized cross-correlation.
2. If the compute offset between master and slave GCP positions exceeds the maximum offset (computed from user specified maximum velocity), then the GCP point is marked as outlier.
3. Perform local average for the offset on valid GCP points.
4. Fill holes caused by the outliers. The offset at hole point will be replaced by a new offset computed by local weighted average.
5. Compute the velocities for all points on GCP grid from their offsets.
6. Finally, compute velocities for all pixels in the master image from the velocities on GCP grid by interpolation.

Step 7 - Generate glacier velocity map: Select **Offset Tracking** in **Radar** menu.

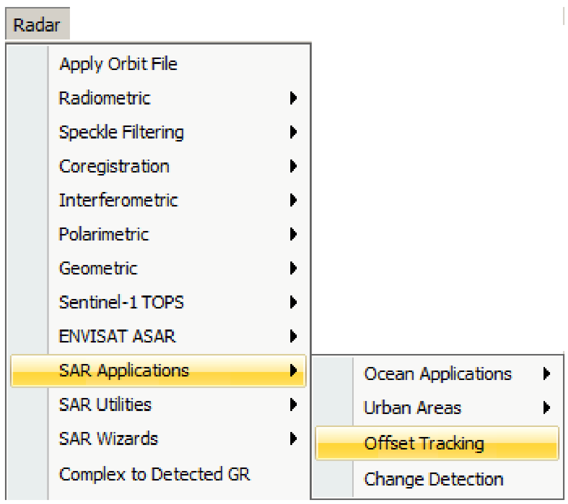


Figure 17 Select Offset Tracking

In the Offset Tracking dialog window, user needs to define a GCP grid by specifying the grid point spacing in range and azimuth directions. The spacing is specified in term of the number of pixels. Then the system will convert the spacing into corresponding spacing in meters and compute the grid dimension.

The user also needs to specify other processing parameters such as Registration Window dimension and Maximum Velocity. Before running the operator, the user is suggested to do some research on the maximum velocity of the glacier under study on the season of acquisition. This will be helpful in guiding the user selecting meaningful processing parameters. For example, the maximum velocity for Rink Glacier is around 10 meters per day. Given that the SAR image acquisition period is 12 days and range and azimuth spacing is 10 meters, we can calculate the maximum shift of a target in the glacier is about 12 pixel. We know that the default Registration Window dimension (128 pixels) is larger enough to cover the target in both master and slave images.

The Spatial Average and Fill Holes processing steps can be optionally turned off by deselecting the corresponding checkboxes in the dialog window.

Click on **Run** to start the processing.

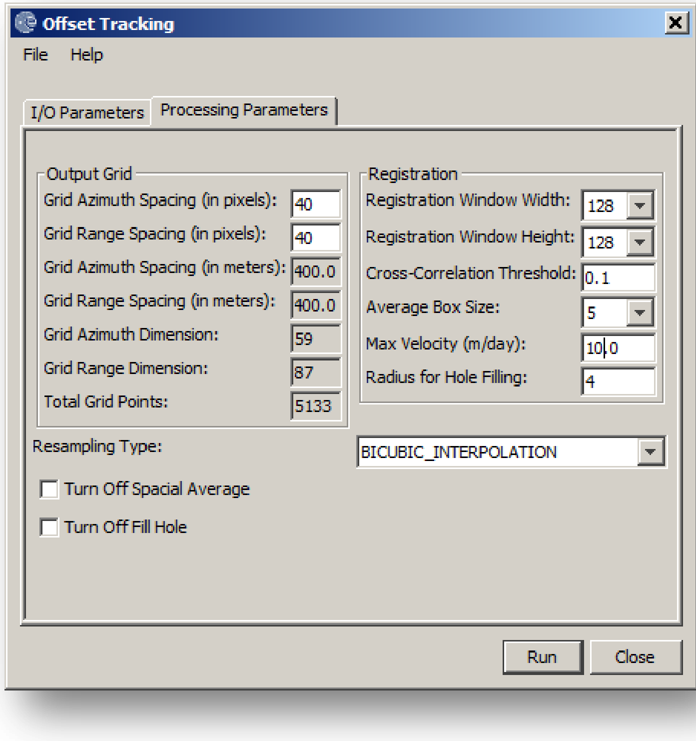


Figure 18 Offset Tracking Dialog

Viewing the Velocity Map

Step 8 - View the glacier velocity map: Double click on velocity band in the resulting product to display the velocity map. Move your mouse cursor across the image, you can see the pixel velocity value in the **Pixel Info** tab.

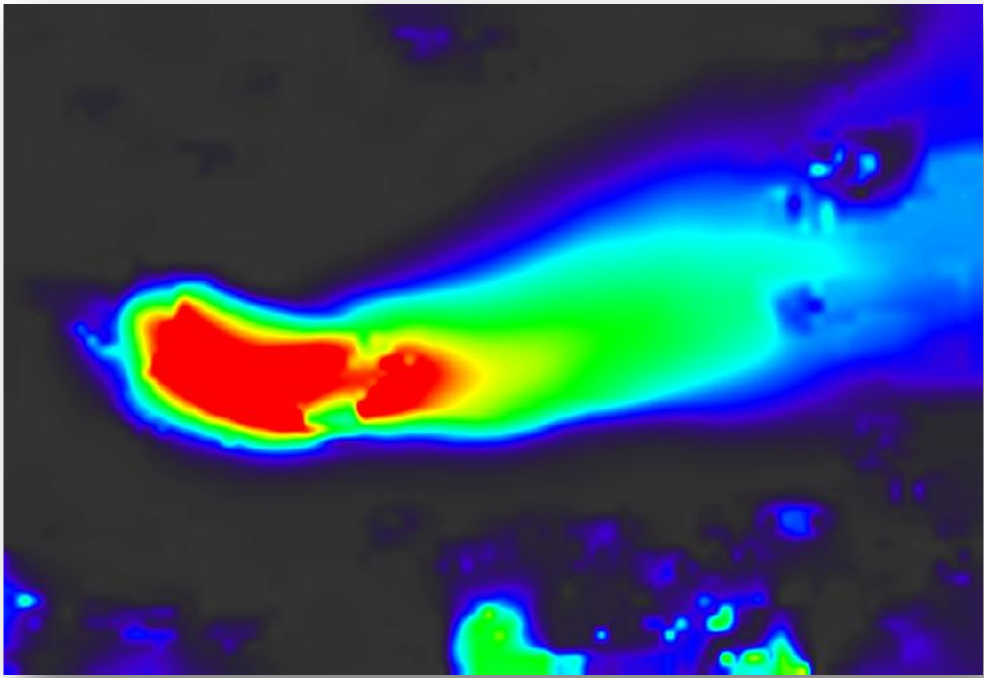


Figure 19 Velocity Map of Rink Glacier

To view the velocity direction, click on **Layer Manager** in the **Layer** menu and click on  button to get the **Add Layer** window.

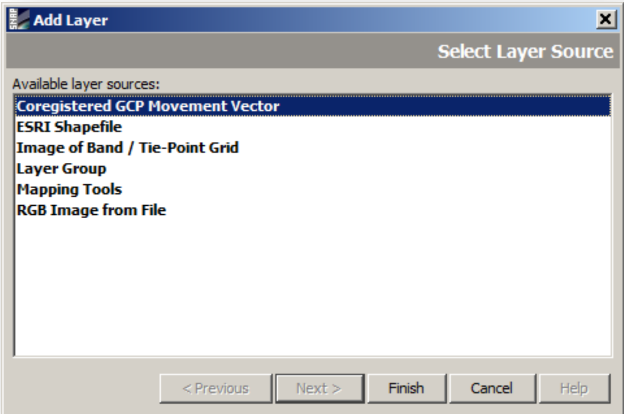


Figure 20 Add Layer Dialog

Select **Coregistered GCP Movement Vector** layer and click on **Finish**. You will see the velocity vectors displayed on the GCP grid showing direction and speed.

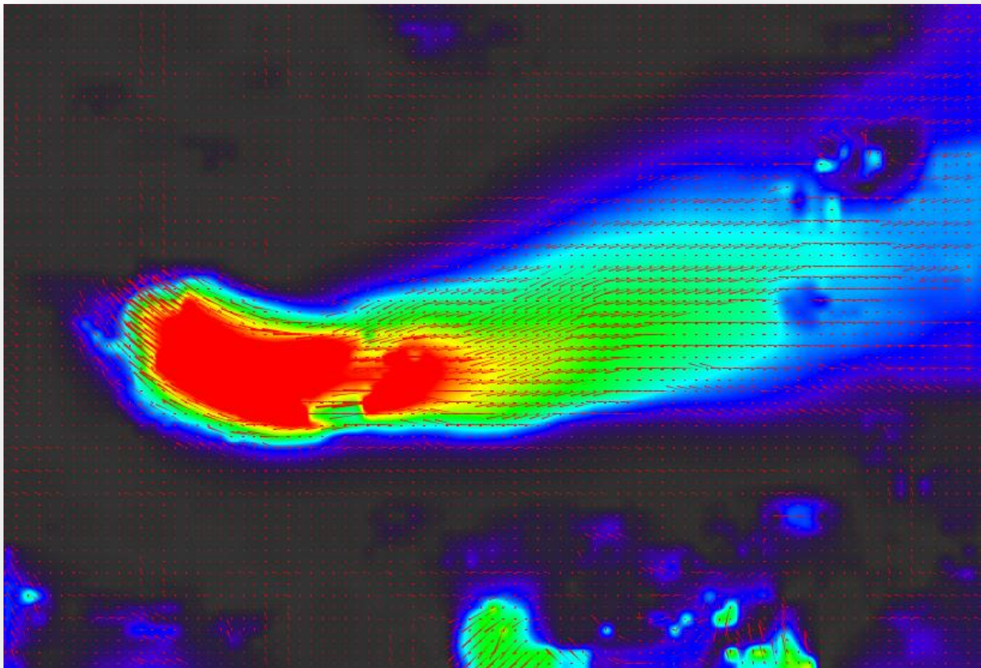
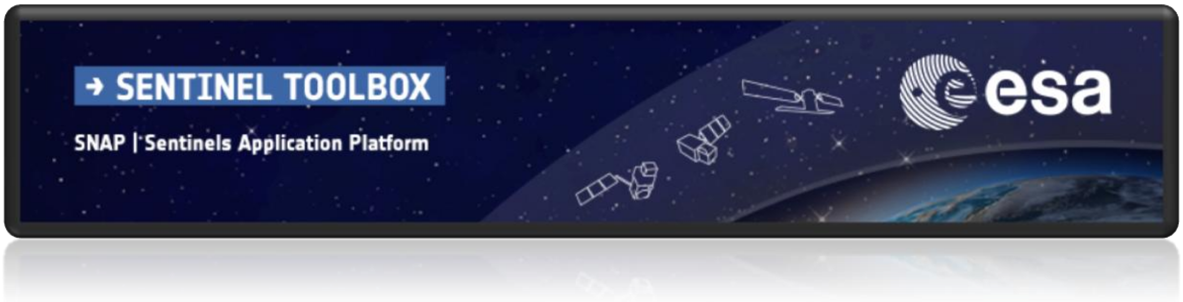


Figure 21 Velocity vectors on GCP grid



For more tutorials visit the Sentinel Toolboxes website

http://step.esa.int/main/doc/tutorials/

Send comments to the SNAP Forum

http://forum.step.esa.int/