



Norwegian  
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*Ice Service*

## Recognition of fast and drift ice using SAR

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### Purpose:

Operational ice services provide routine information to support activities working in and around ice covered areas. This lesson will present an overview on how they efficiently make use of Synthetic Aperture Radar (SAR) data, in addition to other satellite data sources, to monitor landfast and drift ice. It will also help to familiarize participants with the challenges involved in clearly identifying sea ice conditions during the Spring and Summer seasons.

### Scope and Applicability:

This practical exercise will:

- Present how free and open-source software (FOSS) such as the ESA Sentinel Application Platform (SNAP) and Quantum Geographical Information System (QGIS) can be used in sea ice operations.
- Provide hands-on training working with several areas of landfast and drift ice in the Arctic relevant to sea ice operations.
- Assess how to identify different sea ice types using SAR, optical imagery, and webcams.
- Demonstrate a simple approach on how to integrate satellite data processing toolboxes with a user-friendly geospatial viewing tool to provide necessary sea ice information for specific users.

Table 1. Table of resources required for practical lesson

Resources			
<b>Software</b>	<b>ESA Sentinel Application Platform (SNAP):</b>	Install using .sh script at: <a href="http://step.esa.int/main/download/">http://step.esa.int/main/download/</a>	
	<b>Quantum Geographic Information System (QGIS):</b>	Download package and install at: <a href="https://qgis.org/en/site/forusers/download.html">https://qgis.org/en/site/forusers/download.html</a>	
<b>Data</b>	<b>Danmarkshavn, Greenland (July 20, 2017):</b>	<b>Sentinel 1A:</b> S1A_EW_GRDM_1SDH_20170720T075429_20170720T075529_017552_01D5AE_41A1	
		<b>Sentinel 1B:</b> S1B_EW_GRDM_1SDH_20170720T084230_20170720T084330_006569_00B8D6_E9C1	
		<b>Sentinel 2B:</b> S2B_MSIL1C_20170720T141009_N0205_R053_T28XDL_20170720T141004.tile_28XDL	
	<b>Isfjorden, Svalbard (March 9, 2018)</b>	<b>Sentinel 1A:</b> S1A_EW_GRDM_1SDH_20180309T054249_20180309T054337_020934_023EC0_10B5	
		<b>Sentinel 1B:</b> S1B_EW_GRDM_1SDH_20180309T063105_20180309T063205_009951_012072_3476	
		<b>VIIRS:</b> VIIRS-I-bands-mosaic_vis-ch4_20180309024205-20180309010232	
	<b>Bay of Bothnia (March 17, 2018)</b>	<b>Sentinel 2A:</b> S2A_MSIL1C_20180317T100021_N0206_R122_T34WFT_20180317T120747.tile_34WFTt	
		<b>Sentinel 1A:</b> S1A_IW_GRDH_1SDV_20180317T155811_20180317T155836_021057_0242AD_BDF3 S1A_IW_GRDH_1SDV_20180317T155746_20180317T155811_021057_0242AD_7AE9	
	<b>Weather History</b>	Pdf's from Weather Underground Weather statistics for Isfjord Radio observation site	

**References:**

- 1) **Meteorological Service of Canada (2005), MANICE:** Manual of standard procedures for observing and reporting ice conditions, 9th ed., Environ. Can., Ottawa, <https://goo.gl/CqjzL7>
- 2) **SNAP - ESA Sentinel Application Platform v2.0.2,** <http://step.esa.int>
- 3) **QGIS Development Team (2018).** QGIS Geographic Information System. Open Source Geospatial Foundation Project. <http://qgis.osgeo.org>

## Example 1: Danmarkshavn, Greenland

### Use of SNAP to processing raw Sentinel 1 (SAR) and comparison with Sentinel 2 (Optical) data

1. Open Virtual Machine and upload raw SAR data files from */shared\_folderESA/Danmarkshavn* into SNAP:
  - a. **Sentinel 1A:**  
*S1A\_EW\_GRDM\_1SDH\_20170720T075429\_20170720T075529\_017552\_01D5AE\_41A1.SAFE*
2. Summary of folders:
  - a. annotation: Calibration and information on noise floor values for backscatter
  - b. measurement: HH and HV geotiff files
  - c. preview: Quicklooks
  - d. support: metadata attributes
  - e. manifest.safe: Index file that pulls information from all the other folders
  - f. pdf: specifications
3. Select manifest.safe. Each product consists of metadata and raster bands and may contain support information such as tie point grids or vector data

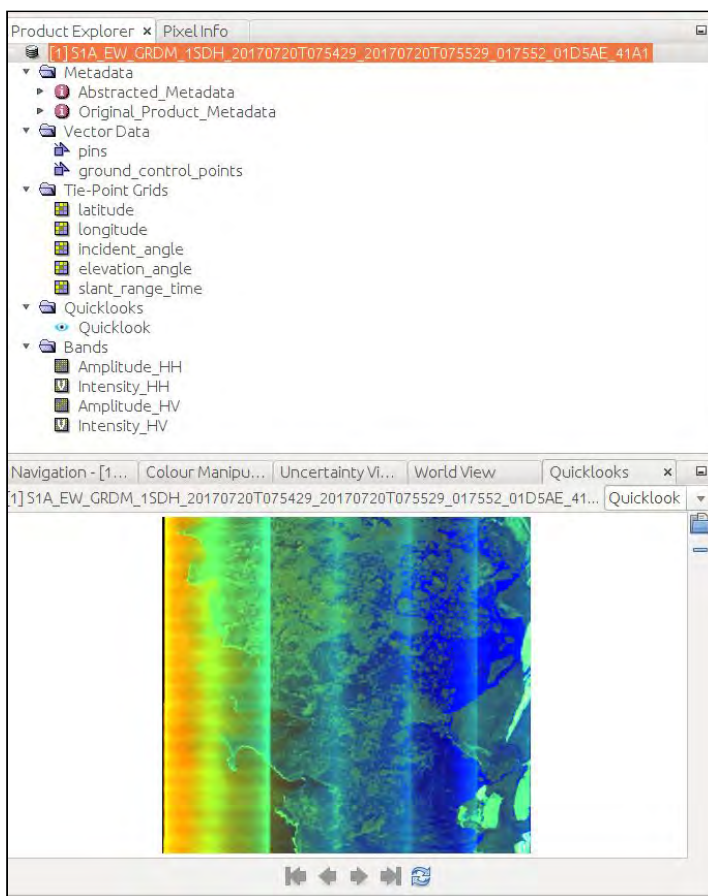


Figure 1. Example of Sentinel-1 SAR data in ESA SNAP software

4. Amplitude and Intensity HH/HV:
  - a. Amplitude: The strength/size of the waveform, think the distance between the crests and troughs
  - b. Intensity: How much energy you get back in the waveform depending on the surface
  - c. **Discussion: What do we know about HH and HV? How does that relate to full polarimetry?**

To properly work with the SAR data, the data should first be calibrated. We use Ground Range Detected - Medium resolution (GRDM) data. This is Level-1 but unlike the Single Look Complex (SLC) data has already been converted and multi-looked. It's easier to work with and takes up less space.

Each process creates a new file below the original file. They're notated with a new number [#] and descriptive label at the end of the filename. For example, the first step will be to apply the orbit file. The original file is labeled:

[1]S1A\_EW\_GRDM\_1SDH\_20170720T075429\_20170720T075529\_017552\_01D5AE\_41A1.SAFE

New file will be:

[2]S1A\_EW\_GRDM\_1SDH\_20170720T075429\_20170720T075529\_017552\_01D5AE\_41A1.Orb

### Use the new file for each subsequent step!

Begin steps:

5. Apply Orbit file: Radar -> Apply Orbit file > run (use default settings)
6. Calibration: Radar -> Radiometric -> Calibrate > run (use default settings)
7. Speckle filtering: Radar -> Speckle Filtering -> Single Product Speckle Filter
  - a. Processing parameters select polarisations and Lee filter 7x7 window
8. Geometric Correction: Radar -> Geometric -> Terrain Correction -> Range Doppler Terrain Correction
  - a. Processing parameters: select DEM (At high latitudes SRTM is not available so CDEM works sometimes, otherwise use GETASSE30), Resampling Bilinear Interpolation , Nearest Neighbour, Pixel Spacing (200), and Map Projection (Stereographic!),
  - b. Custom CRS > Projection Parameters > Latitude of Origin: 90.0
  - c. Deselect "Mask out areas without elevation" because we're looking at sea ice
  - d. Output Bands select: "Selected Source Band" and "DEM"
9. Export to GeoTIFF
10. Try using "Graph Builder" for batch or iterative SAR processing

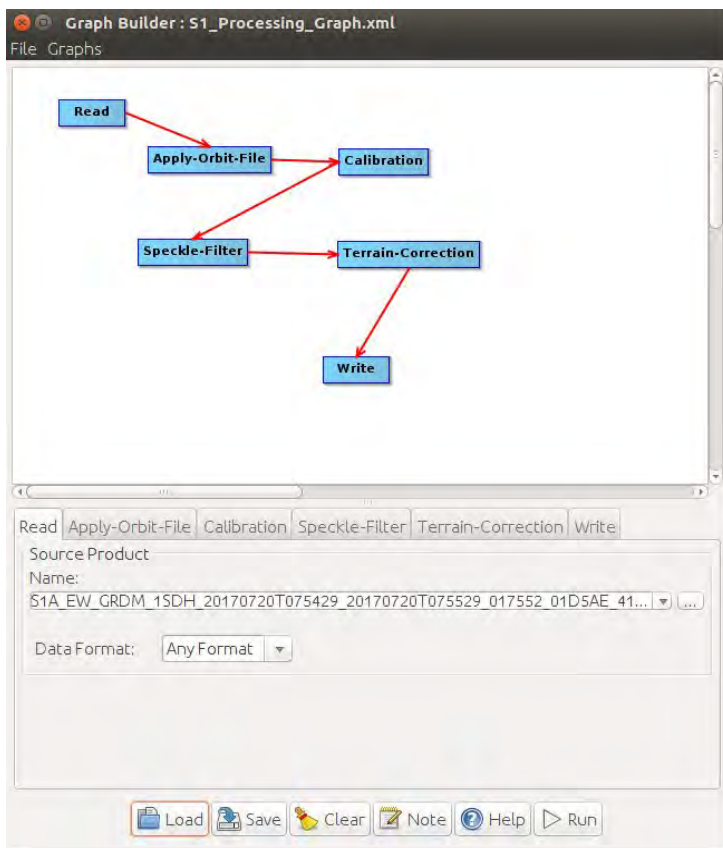


Figure 2. Example of SNAP Graph Builder

11. Can also (but not required for this exercise) process SAR scene **Sentinel 1B**:  
S1B\_EW\_GRDM\_1SDH\_20170720T084230\_20170720T084330\_006569\_00B8D6\_E9C1.SAFE

Ready for spatial visualization!!

## QGIS for geospatial visualization


1. Open QGIS and go to Project > Save As > Practical\_session1.qgs.
2. Add Landmask: Add Layer > Add Vector Layer (or select ) > In /shared\_folderESA/GSHHS\_shp/i/, Select **GSHHS\_i\_L1.shp**.
  - a. Project > Project Properties > CRS > Select "Enable "on the fly" Transformation
  - b. In the search bar put in "polar" and select "WGS 84 / NSIDC Sea Ice Polar Stereographic North (Authority ID EPSG: 3413) > Apply > OK



Figure 3. Landmask with stereographic projection in QGIS

3. Add Layer > Add Raster Layer (or select ) > Select SNAP GeoTiff that was just created

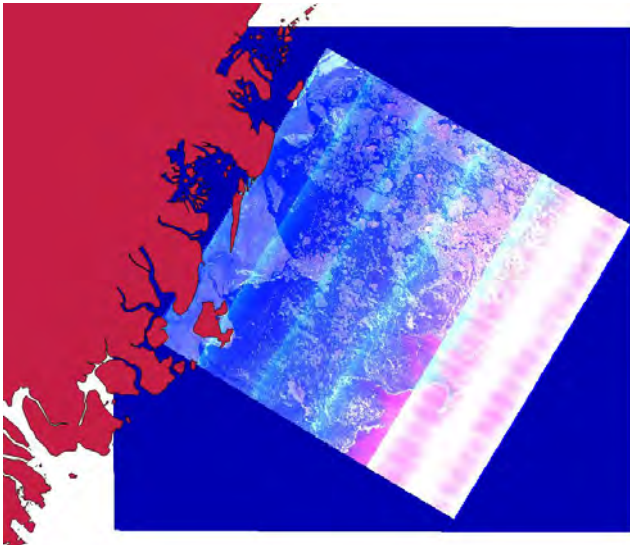


Figure 4. SAR data viewed in QGIS

4. Layer > Properties (or double-click file) > Style (left-side panel)
  - a. Properties: Singleband gray > Stretch to MinMax, > Load min/max values > min/max > Load (should give DN values. For col-pol HH or VV approx. 0-0.15, for cross-pol, HV or VH 0-0.15, if included DEM 0-500) > Apply > OK
  - b. Transparency: Additional no data value: 0 > Apply > OK. Adjustments can be made to the global transparency when overlaying images (refer to exercise 2 and 3)
5. To show the how sea ice in SAR visually differs from Optical, overlay the **Sentinel 2B**:  
S2B\_MSIL1C\_20170720T141009\_N0205\_R053\_T28XDL\_20170720T141004.tile\_28XDL.SAFE

- a. Observe the left side of the S2B optical image. You will see there are two types of landfast ice where one looks like it could potentially be younger first year ice and another area where it appears to be brighter and older.
  - i. [What do you think is holding the northernmost extension of fast ice in place?](#)

Hint: You have to zoom  in

*\*Additional satellite processing software from Nansat is useful and can be found at: <https://goo.gl/N5UQet>  
Download software at github: <https://github.com/nansencenter/nansat>*

## Example 2: Bay of Bothnia

### Comparison of SAR and optical using false color to separate landfast and drift ice

1. Upload (processed) files from \_\_\_\_\_ into QGIS:
  - a. **Sentinel 1A:**
    - S1A\_IW\_GRDH\_1SDV\_20180317T155811\_20180317T155836\_021057\_0242AD\_BDF3
    - S1A\_IW\_GRDH\_1SDV\_20180317T155746\_20180317T155811\_021057\_0242AD\_7AE9
2. Go to Layer > Properties (or double-click file) > Style (left-side panel). Should be set at Singleband gray. Observe the min and max range of DN values.
  - a. [What happens when you adjust the max value to a lower number?](#)
3. Adjust only the following Sentinel1A image:
 

"S1A\_IW\_GRDH\_1SDV\_20180317T155746\_20180317T155811\_021057\_0242AD\_7AE9\_sigma0\_RGB"

 to Multiband color. For settings adjust using the following:
  - a. Contrast Enhancement > Stretch to min/max >
  - b. Load min/max value > min/max > Load > Apply > OK

*Note: Band 1 (VH band), Band 2 (VV), Band 3 (VH/VV)*
4. One SAR scene should be at Singleband gray and the other should be set at the Multiband gray setting. Observe the two SAR images side-by-side.
  - a. [What is the benefit of using the Singleband gray and Multiband gray setting for images?](#)
  - b. [Where is the boundary that separates the fast ice from the drift ice?](#)
5. Overlay optical image
 


"S2A\_MSIL1C\_20180317T100021\_N0206\_R122\_T34WFT\_20180317T120747.tile\_34WFT\_subset"

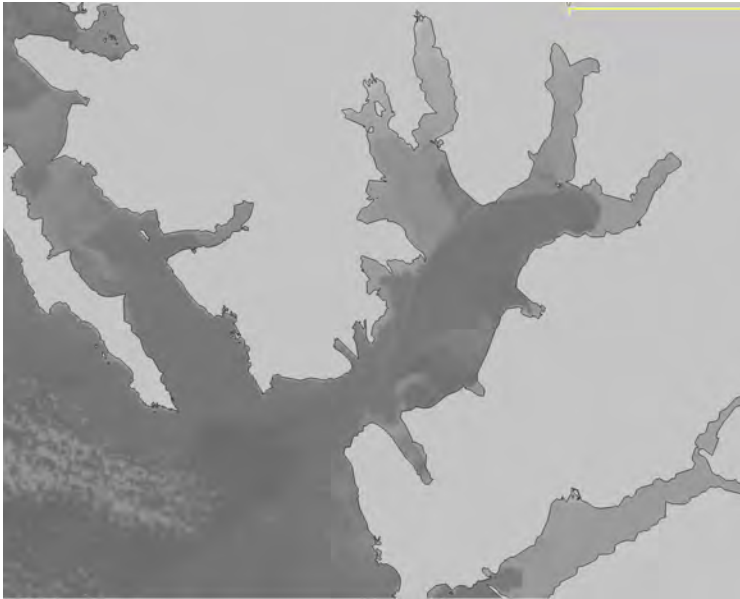
 on top of both SAR images.
  - a. [What area\(s\) and ice type\(s\) are difficult to identify?](#)
  - b. [What can you tell about the surface melt?](#)
  - c. [What other sources of information could be included to confirm the ice conditions?](#)

## Example 3: Isfjorden, Svalbard

### Comparison of SAR and optical for landfast ice detection and drift ice from open water

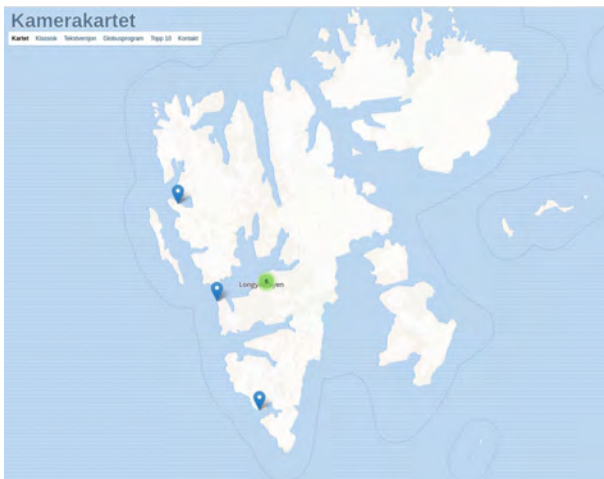
6. Upload the following files from /shared\_folderESA/Svalbard/ into QGIS:
  - a. **Optical:** viirs-l-bands-mosaic\_vis-ch4\_20180309024205-20180309010232

7. Zoom  into Isfjorden and observe the area of fast ice shown as:



**Figure 5. VIIRS image over Isfjorden in Svalbard**

- a. Where is the landfast ice?
  - b. Where is the drift ice? What type of ice types are present?
  - c. Are there clouds?
8. Overlay SAR image  
 "S1B\_EW\_GRDM\_1SDH\_20180309T063105\_20180309T063205\_009951\_012072\_3476.SAFE\_sig  
 ma0\_denoised\_RGB"
- a. How well is the fast ice discriminated from drift ice?
  - b. What area(s) and ice type(s) are difficult to identify?
  - c. What is causing the high backscatter signal in the drift ice area?
  - d. What other sources of information could be included to confirm the ice conditions?
9. On Svalbard the following locations have webcams:
- a. Longyearbyen
  - b. Tempelfjorden
  - c. Isfjord Radio
  - d. Ny-Ålesund
  - e. Hornsund
10. To view webcams in Isfjorden open the following:  
<https://www.kamerakartet.no/>  
<http://longyearbyen.kystnor.no/>



**Figure 6. Locations of webcams in Svalbard**

- a. How can webcams assist with providing additional information on current sea ice conditions?