Report of Activity

Visiting Scientist Mario Papa
University of Rome "La Sapienza", Italy

The goal of the visiting scientist activity is to perform a preliminary assessment in support of the development of ICI Cal/Val geolocation validation algorithms.

The first part of the activity was devoted to search for targets on the surface that are visible at the high frequencies of ICI. The activity was performed using data provided by the SSMIS instrument at 183±6.6 GHz used as a proxy of ICI channel 1. The 183.3 GHz channels are characterized by high water vapour absorption, so the research was focused on geographic area with low water vapour in winter seasons or target with high altitude to reduce the absorption of the atmosphere. In particular, target areas are on Polar Regions. Additional site that was investigated is Lake Titicaca. The second part was devoted to develop an algorithm to calculate the geolocation error, considering the targets found in the first phase.

1. Antarctic region

On Antarctic region, the ice shelfs represent promising targets for ICI geolocation. They are thick suspended platform of ice with a Tb contrast sufficient to extract the contour of the ice coastline. In particular, we focused on Ross, Ronne and Amery ice shelfs, as shown in Figure 1.

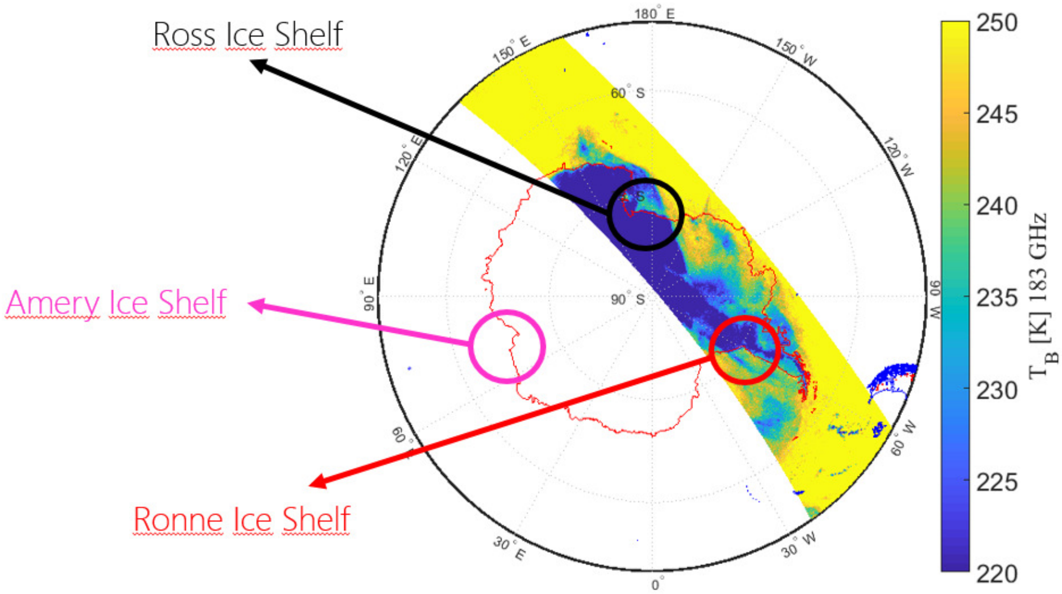


Figure 1: F17 SSMIS at 183±7 GHz H-Pol

The shelfs are in movements along seasons. As such, as a reference we use Sentinel 1 SAR imagery with their high special resolution. The method that has been developed to compute the geolocation error consists in the following steps:

1. Resampling of radiometric image in a regular grid in a polar stereographic projection;
2. Performing an Edge Detection, using Canny method, for both radiometric and SAR images (see Figure 2).

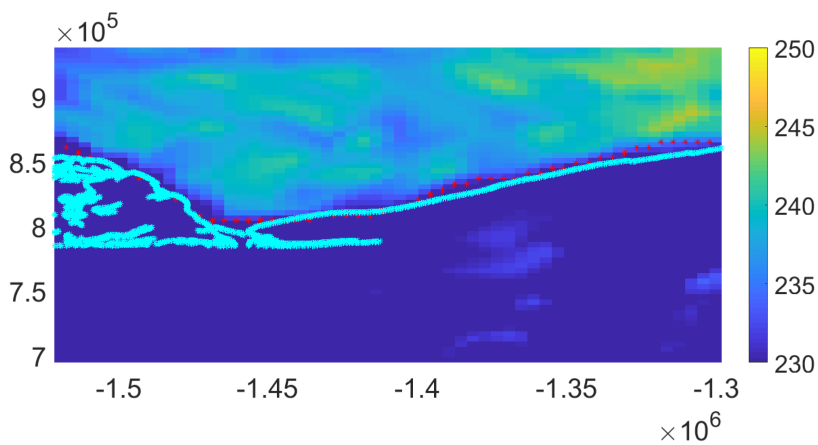


Figure 2: Red markers are the points of radiometric contour and cyan markers are the points of SAR contour.

3. Projection of SAR contour in the same grid of radiometric contour (*Figure* 3);

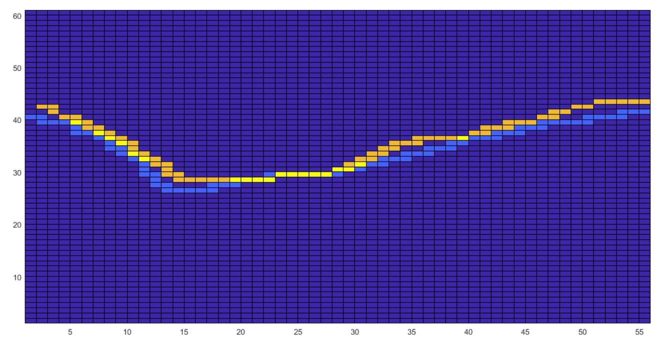


Figure 3: light blue line is the radiometric edge, orange line is the SAR edge and yellow pixels are the overlap of two edges.

4. Performing a cross-correlation between the two edges;
5. Calculation of displacement in pixels and, finally, the geolocation error, expressed in km.

Applying the methods in the period from May to September 2016, we obtained the preliminary results shown in Table 1.

Table 1: Preliminary result for Antarctic ice shelfs

Shelf	*Mean shifts (km)*	*σ mean (κμ)*	*n° of samples*
Ross	4.2	2.3	255
Ronne	5.9	2.2	95
Amery	6.5	2.2	88

2. Titicaca Lake

Titicaca is a large, deep lake in the Andes on the border of Bolivia and Peru with a surface elevation of 3,812 metres. For this target is it possible to use the same method for Antarctic ice shelfs, described in paragraph 1. However, for Titicaca Lake, the coastlines do not change along seasons, so it is possible to use a shorelines database as reference in the cross-correlation. In particular, we adopted the *Global Self-consistent, Hierarchical, High-resolution Geography Database* (GSHHG database). It is important to note, that the coordinates of satellite (in this case SSMIS) are provided on satellite coordinates are projected on WGS84 (ellipsoid), but it is necessary to introduce a correction with digital elevation model (DEM), especially for such target with high altitude.

Figure 4: Titicaca Lake

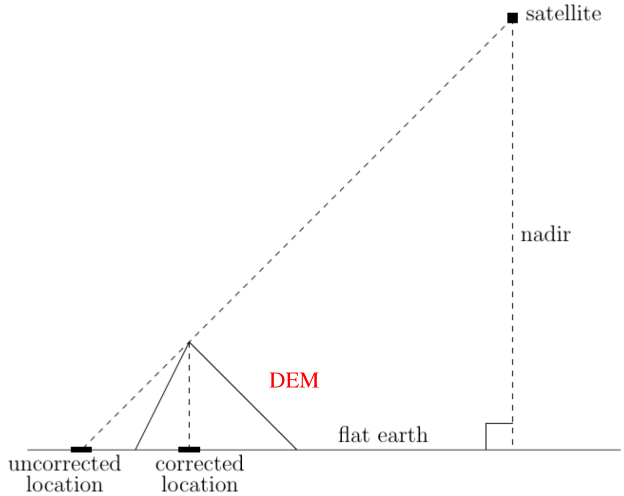


Figure 5: Correction with digital elevation model.

Figure 5 shows the location error without DEM correction. In our tests, we adopted SRTM30 DEM, with a resolution of 30 arc second (about 900 m), as shown in figure 6.

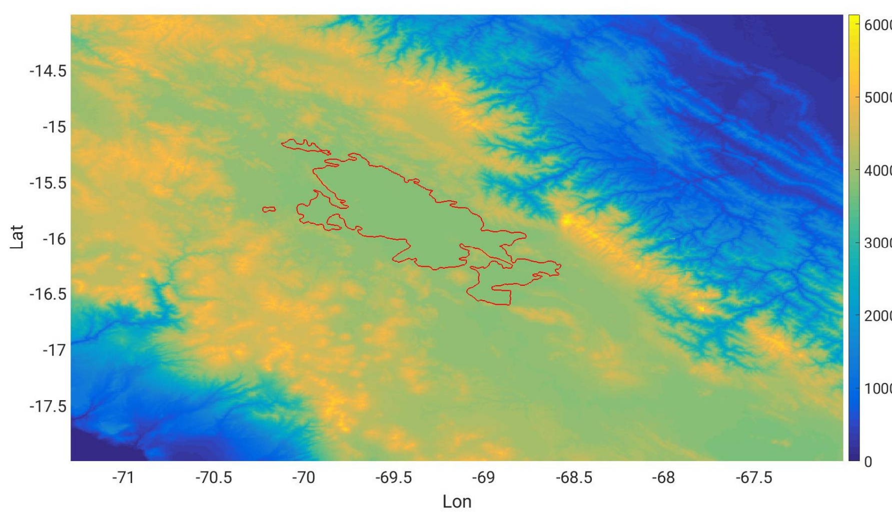


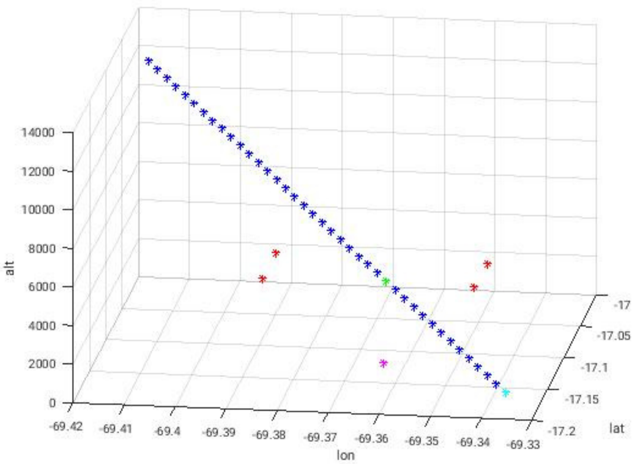
Figure 6: Altitude of DEM (meters) with special resolution of about 900 m.

To correct the coordinates of radiometric image, we developed a method with the following steps:

1. Find the line of sight, linking the spacecraft position with the coordinates of pixel on WGS84;
2. Discretize the line of sight with chosen step, for example 500 m;
3. Find the point along line of site that cross the DEM. The algorithm controls, for each step along line of sight, if the four nearest DEM points have an altitude lower than it. The line of sight cross DEM in the case in with not all four nearest DEM points have lower altitude.

4. Find the nearest point between line of sight and the surface generated from the four DEM points.

5. Coordinates correction according the intersection found in step 4



- Line of sight
- 4 nearest points of DEM
- First point of the line of sight that has an altitude lower than DEM
- Intersection between line of sight and earth ellipsoid (WGS84)
- Corrected coordinates of surface

Figure 7: DEM correction algorithm

After DEM correction is it possible to correlate the extracted contour from radiometric image (corrected) with the reference contour from GSHHG shoreline database. Table 2 reports same results for Titicaca before and after DEM correction for four selected test cases in which the lake is well visible with SSMIS.

Table 2: Results for four tests cases on Titicaca Lake with DEM averaged at 9 km of spatial resolution

DATE	SHIFT (KM) WITHOUT DEM	SHIFT (KM) WITH DEM
01/05/2016	4.45	2.08
31/05/2016	4.45	1.63
01/06/2016	7.23	3.44
31/07/2016	5.02	4.71
MEAN VALUE	5.29	2.97