ERS-ENVISAT TANDEM CROSS-INTERFEROMETRY FOR MONITORING OF SEA ICE

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1. ABSTRACT

The very short temporal separation (about 28 minutes) of the ERS-2 and ENVISAT satellites is very attractive to obtain almost-simultaneous acquisitions, appealing for SAR Interferometric applications both for the very high temporal correlation, for the strong reduction of atmospheric artefacts, and for monitoring fast displacements. The problem of the interferometric combination of such data arises from the difference of 31MHz in the Centre Frequency of the AMI (ERS-2) and ASAR (ENVISAT) instruments. This difference, overcoming the range bandwidths of the instruments (respectively 15.5 and 16Mhz), results in completely uncorrelated range spectra of the two acquisitions, and hence in no possible interferometric combinations, if not for close-to-ideal point targets. The European Space Agency has carried out in the last years a number of ad-hoc EET Campaigns with a specific orbit configuration with a normal baseline between ERS and ENVISAT of around 2.1 Km, tuned according to the principles shown in [1] to compensate the Centre Frequency shift and to allow interferometric combination of the data, at least in areas with moderate slope of the topography.

Data acquired with this configuration is of particular interest for monitoring fast displacement of sea ice in the northern regions. In this case, the very high height sensitivity of this data provided is not exploited, assuming an almost flat elevation of these targets. This assumption allows to easily obtain differential interferograms without the need of very accurate Digital Elevation Models in input of the interferometric processing, and hence to obtain very accurate estimations of the fine displacements of the sea ice occurring during the time interval between the ERS and ASAR acquisitions.

Figure 1 shows the differential phase over an area of the North-west passage obtained from three different pairs, acquired in short time separation on January 4th, 7th and 10th 2009.

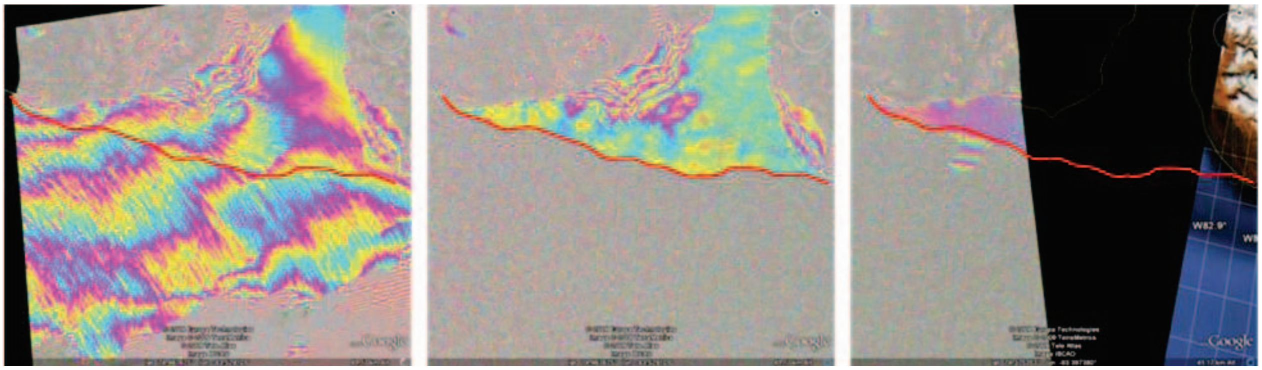

Figure 1. Differential phase on January 4th, 7th and 10th 2009 (from left to right) over the same area of the North-west passage. Every colour cycle corresponds to around 2.8cm of ice displacement. The identified border of the grounded ice is shown as red line.

Here it is possible to distinguish two areas: one close to the land, showing moderate or no displacement, and another area, in the sea, showing different amounts of displacement, up to large enough to destroy the interferometric coherence. The common line that can be identified in the three frames dividing these two regions can be interpreted as the border separating the grounded ice from the sea ice.

The paper will show a number of results obtained in the same areas from EET campaigns carried out in different EET campaigns, allowing a comparison between the results obtained in different years and hence to monitor the evolution of the grounded ice over the years.

The large displacements of the sea ice occurring within the 28 minutes of separation between the ERS and ASAR acquisitions (up to several kilometers per hour) can be estimated in their 2D components by exploiting different techniques.

Offset tracking can be for example exploited, but much better results can be obtained in coherent areas by exploiting Multi-Aperture Interferometry approaches, as proposed originally in [3]. In both cases, coregistration strategies shall be updated to handle large space-varying offsets.

Some results are shown in Figure 2 over the same area covered in Figure 1. Here the left image shows the conventional differential phase (resulting in one 2π cycle for every 2.8 cm of displacement in Line Of Sight), while the right image shows the MAI phase obtained by splitting the original Doppler bandwidths of the ERS and ASAR SLC data in sub-bands and forming differential interferograms between the interferograms generated from the different sub-bands. Here the sensitivity of the differential phase to the azimuth displacements is of around 5m every 2π. Although reduced respect to the accuracy of the LOS displacement estimation, this allows to estimate the full 2D displacement field of the sea ice patches.

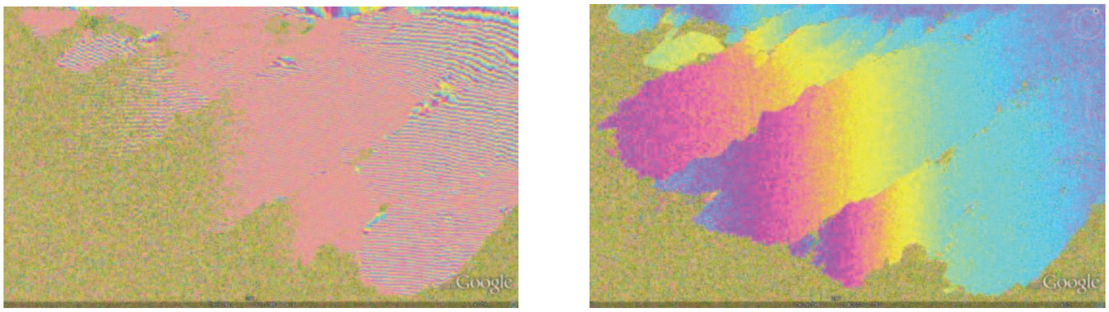

Figure 2. Differential phase over ice showing the Line Of Sight displacement (on the left) and the azimuth displacement (on the right) of sea ice. The system has different sensitivity to the two components.

Due to the large extent of the shifts occurring in the sea ice areas in these regions, to the non homogeneity of the shifts for different ice patches and to the high coherence of the ice patches, the conventional coregistration approaches show some limitations. It Is often possible that the coregistration algorithms converge in some areas of a processed frame but fail to provide correct results in other areas, characterized by shifts significantly different from those in the successful areas. For this reason a new coregistration strategy has been developed to cope with piecewise continuous shifts within a given area. It will be shown in the paper that this approach overcomes the limitation of the maximum shifts measurable with interferometric techniques when conventional approaches are followed for the coregistration.

A number of examples will be shown derived from the different EET campaigns, documenting the usefulness of such unique measurement techniques for the precise monitoring of the sea ice dynamic in Northern latitudes.

2. REFERENCES

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