ESTIMATION OF ICE THICKNESS OF TUNDRA LAKES USING ERS – ENVISAT CROSS-INTERFEROMETRY

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In 2002 ESA launched the ENVISAT satellite with the Advanced SAR (ASAR). ENVISAT is operated in the same orbits as the ERS-2, preceding ERS-2 by approximately 28 minutes. One of the ASAR modes, namely IS2 at VV-polarization corresponds closely to the ERS SAR mode, except for the slightly different sensor frequency used. A unique opportunity offered by these two similar SAR instruments operated in the same orbital configuration is ERS – ENVISAT cross-interferometry (CInSAR). At perpendicular baselines of approximately 2 kilometers the look-angle effect on the reflectivity spectrum compensates for the carrier frequency difference effect. As was shown with examples over Germany, the Netherlands, Italy, and Switzerland [1] CInSAR has a good potential to generate accurate DEMs over relatively flat terrain. One special focus of ESAs ERS - ENVISAT Tandem (EET) Campaigns were high northern latitudes.

As demonstrated in [2] C-band SAR has a good potential to identify and map frozen Tundra lakes. Furthermore, the backscattering indicates very clearly if the lake is completely frozen to the bottom or if it is only partially frozen with liquid water being still present below the ice. Attempts to estimate the ice thickness based on bathymetry done in summer and getting the position of the boundary between the completely frozen and partially frozen area of such lakes showed some potential but did not prove to be sufficiently reliable and accurate. As discussed in [2] this information is of high interest to protect the survival of fishes when withdrawing water from the lakes as done for the preparation of ice roads.

Over frozen Tundra lakes high coherence, backscattering and a constant interferometric phase were observed (Figure 1). Based on the backscattering change from a ring of low backscattering to high backscattering the completely and partially frozen parts of Tundra lakes can be delineated. The phase difference between the phase over the ground outside the lake and the phase over the partially frozen surface can be used to estimate the thickness of the frozen layer.

The microwave propagation model used to convert the interferometric phase difference to ice thickness takes into account the influence of the ice on the radar wavelength and the refraction and the air – ice interface. At a 2km baseline of the phase to height sensitivity of an EET interferogram is very high with an ambiguity height of 4.7m per phase cycle. Consequently, dm accuracies are possible with the proposed method.

In our contribution we will present the methodology applied and results obtained over Northern Canada and Russia.

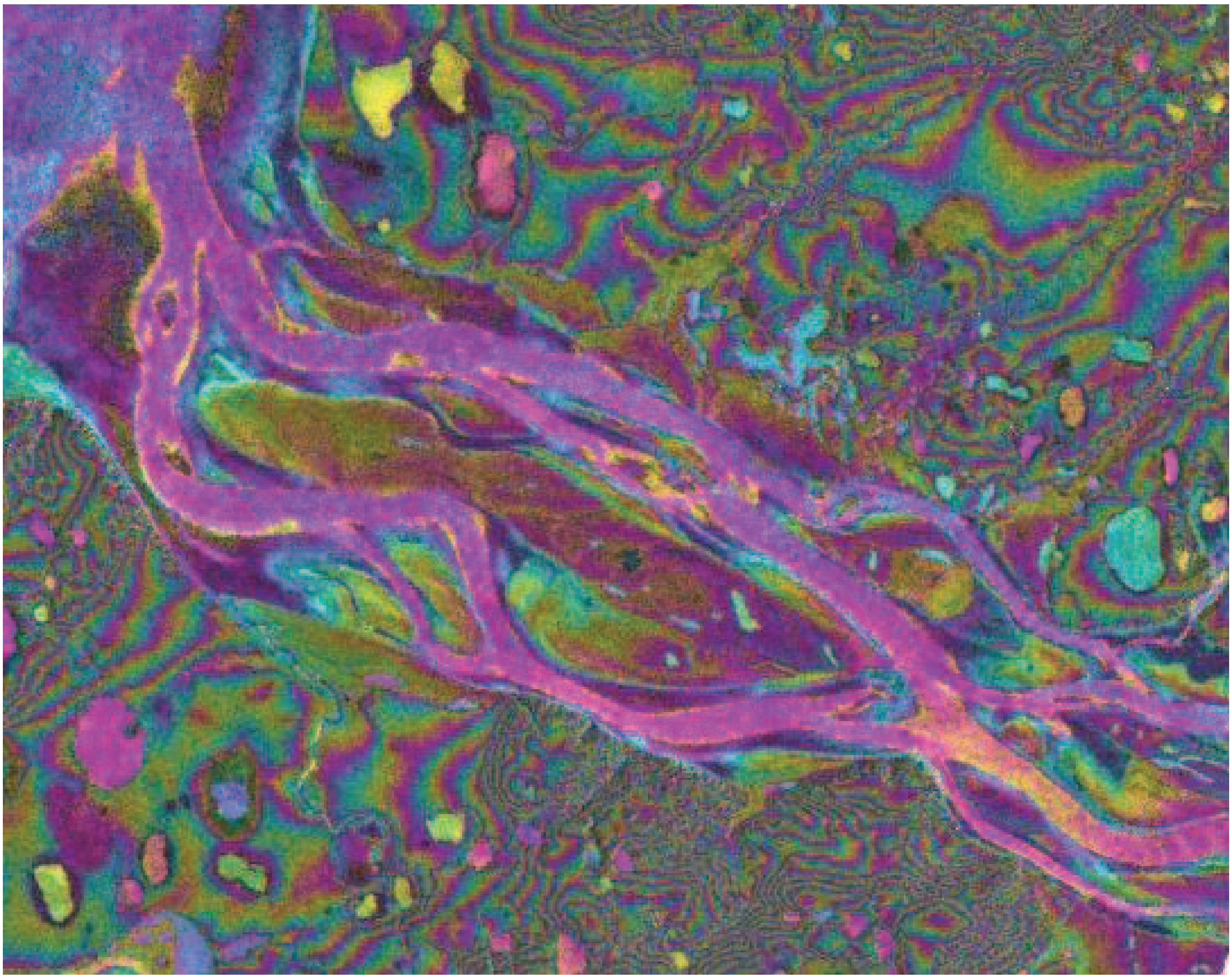

Figure 1 EET CInSAR (17-Feb-2009, *dt*= 28minutes, $B_{\perp}$= 2150m, *dDC*= 624Hz) differential interferometric phase relative to constant height over Khatanga Delta. Color cycle corresponds to phase cycle.

[1] Wegmüller U., M. Santoro, C. Werner, T. Strozzi, A. Wiesmann, and W. Lengert, "DEM generation using ERS–ENVISAT interferometry", Journal of Applied Geophysics Vol. 69, pp 51–58, 2009, doi:10.1016/j.jappgeo.2009.04.002.

[2] Hirose T., M. Kapfer, J. Bennet, P. Cott, G. Manson, and S. Salomon, "Bottemfast ice mapping and the measurement of ice thickness on tundra lakes using C-band Synthetic Aperture Radar, " Journal of the American Water Resources Association, Vol. 44, No. 2, pp. 285-292, 2008.