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Application of Envisat ASAR Data on Sea Ice Detection and Classification in Bohai Sea and Comparison to Other Ice Regimes ¡ª Final Report

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The objectives of this project are to analyze the radar backscattering characteristics of different sea ice types in the Bohai Sea using multi-polarization and multi-frequency SAR data, and to extend semi-automatic or automatic sea ice detection and classification methods. In addition, we compared our findings with results of European investigations in particular in the Baltic Sea with comparable environmental conditions and also with results obtained in the Arctic seas. Our research work can be summarized as follows: (1) We used multi-source SAR data, including ENVISAT ASAR, ALOS PALSAR, and Radarsat-2 SAR to analyze the backscattering statistics of different sea ice types found in the Bohai Sea. The goal was to investigate the detection ability of different polarizations and different frequencies. We found that multi-polarization SAR data have a better ability to classify sea ice types than single-polarization SAR data (Wang et al., 2010). Compared with C-band SAR, L band SAR was suitable to distinguish sea ice from open water, rather than to classify the ice types present in the Bohai Sea (Yu, 2009). (2) We analyzed different classification methods, including sea ice classification algorithms based on textural feature detection, hierarchical clustering (Yu et al., 2012), and context analysis; in case of fully polarimetric data, we applied a decision-tree classifier (Zhang et al., 2011). Compared to classification based on intensity thresholds, those methods improved sea ice classification accuracy. (3) A sea ice electromagnetic scattering model is combined with a thermo-dynamic ice growth model of Bohai Sea to study and analyze the influences of different bands, polarization and incidence angles on the SAR capability to retrieve ice thickness (Zhang et al., 2012). Furthermore, we propose using the sea ice types identified by SAR data to define thickness ranges for each ice type (Zhang, 2011). Finally, by virtue of the electromagnetic theory of sea ice, the Freeman decomposition is improved by putting forward a polarization-decomposition-based approach for quantitative ice thickness retrieval using polarimetric SAR. Experimental data are used to examine this method (Zhang, 2011). (4) Results from recent investigations of multi-polarization and multi-frequency radar signatures obtained by Envisat ASAR, ALOS PALSAR, Radarsat-2 and TerraSAR-X from the Baltic Sea (Eriksson et al., 2010, Dierking et al, 2010) are compared with the findings for the Bohai Sea. Also different Arctic ice regimes (Dierking, 2010, Similä 2012, Similä et al., 2012) are considered in this context. In this final result paper, we will give a detailed description on our research works in Dragon-2 project. References Dierking, W. (2010), ¡°Mapping of different sea ice regimes using images from Sentinel-1 and ALOS synthetic aperture radar¡±, IEEE Transactions on Geoscience and Remote Sensing 48(3), 1045-1058, doi: 10.1109/TGRS.2009.2031806 Dierking, W., Ji, Y., Similä, M. (2010), ¡°The Dragon-2 sea ice project: Overview and status after two years¡°, Proceedings of the DRAGON-2 Mid-Term Results Symposium 2010, 17 ¨C 21 May, Guiling, China, ESA SP-684 (on CD-ROM) Eriksson, L. E. B., Borenäs, K., Dierking, et al. (2010), ¡°Evaluation of new space borne SAR sensors for sea-ice monitoring in the Baltic Sea¡°, Canadian Journal of Remote Sensing, 36(1): S56-S73 Similä, M. (2012), ¡°Ice edge detection with dual polarized SAR data¡±, OSI SAF Visiting Scientist Report, Contract OSI-AS11-P01, EUMETSAT Similä, M., Mäkynen M., Cheng B., et al. (2012), ¡°Multisensor and thermodynamic sea ice model based sea ice thickness charts over the Kara and Barents Seas during the winter 2008-2009¡±, in review, submitted to Annals of Glaciology Wang, H., Meng J., Zhang X., et al. (2010), "SAR BACKSCATTERING CHARACTERISTICS OF SEA ICE IN BOHAI SEA", Proceedings of the DRAGON-2 Mid-Term Results Symposium 2010, 17 ¨C 21 May, Guiling, China, ESA SP-684 (on CD-ROM) Yu B. (2009), "Interpretation and Classification Algorithm for Multi-polarization SAR Image of Sea Ice in Liaodong Bay", Ocean University of China [Master thesis] Yu B., Meng J., Zhang X., et al. (2012), "Agglomerative Hierarchical Clustering algorithm based Sea Ice Types Segmentation Method Using Polarimetric SAR Data in Liaodong Bay", to be published, submitted to Journal of Remote Sensing Zhang X. (2011), "Research on Sea Ice Thickness Detection by Polarimetric SAR in Bohai Sea", Ocean University of China [PhD thesis] Zhang X., Zhang J., Meng J., et al. (2012), "Thin Sea Ice Thickness Detection Capability Analysis of Multi-dimensional SAR in the Bohai Sea", in review, submitted to Chinese Journal of Oceanology and Limnology Zhang X., Zhang J., Meng J., et al. (2011), "Polarimetric Scattering Characteristics Based Sea Ice Types Classification by Polarimetric SAR: Take Sea Ice in Bohai Sea for Example", to be published, submitted to ACTA OCEANOLOGICA SINICA.

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本项目的目标是利用多频率多极化SAR数据分析渤海海冰类型的雷达后向散射特征，并且发展半自动或自动的海冰识别和分类方法，并将我们的研究结果与欧方在Baltic海和北极区域的研究结果相比较。主要工作总结如下：

(1)在海冰散射特性分析方面：利用ENVISAT ASAR, ALOS PALSAR和Radarsat-2 SAR等多源SAR数据分析渤海海冰类型的后向散射特征，其目的是研究不同频段、不同极化对海冰类型的探测能力。我们发现多极化SAR数据区分海冰类型的能力优于单极化SAR数据 (Wang et al., 2010)。与C波段SAR相比较，L波段SAR更适合用于区分海冰和海水，但识别渤海海冰类型的能力较C波段SAR弱 (Yu, 2009)。

(2)在海冰分类方法方面：提出了多种海冰分类方法包括，基于纹理特征的海冰分类方法，基于凝聚层次聚类的海冰分类方法(Yu et al., 2012)，基于伴生关系的海冰分类方法和基于极化特征的二叉树海冰分类方法(Zhang et al., 2011)。与基于灰度阈值的分割方法相比较，我们提出的方法可较大的提高海冰分类精度。

(3)在海冰厚度探测方面：首先，结合海冰电磁散射模型和渤海海冰热动力学生长模型，开展了海冰生长过程中，不同波段、极化和入射角等参数对极化SAR海冰厚度探测能力分析(Zhang et al., 2012)。然后，提出根据海冰分类结果估算海冰厚度范围的SAR海冰厚度分级探测方法。最后根据海冰的电磁散射机理，改进Freeman分解的体散射模型，给出了一种基于极化分解的SAR海冰厚度定量反演方法，并利用实测数据验证了本方法(Zhang, 2011)。

(4)利用Baltic海和北极海域的Envisat ASAR, ALOS PALSAR, Radarsat-2和TerraSAR-X海冰SAR数据，研究了上述区域多极化、多波段海冰的雷达后向散射特性(Eriksson et al., 2010, Dierking et al, 2010, Dierking, 2010, Simil? 2012, Simil? et al., 2012) 并与渤海海冰的探测结果相比较。

在本研究结果报告中，我们将给出龙计划-2（ID: 5290）项目的详细进展情况。