Numerical Study on Polarimetric SAR Imaging Response to Ocean Current

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Abstract – Ocean surface current (OSC) is one of the key marine dynamic elements which dominates the global circulation of carbon and heat. Measurements of the OSC are of particular significance for the studies and applications of marine environment monitoring, global climate change forecasting, marine search and emergency response, etc. [1-3]. By modulating ocean surface topography and roughness, the ocean currents could be characterized on synthetic aperture radar (SAR) images [4]. By far, two main-stream technical routines for OSC measurement based on SAR have been proposed, i.e., along-track interferometric SAR (along-track INSAR, ATI) [5, 6] and Doppler centroid anomaly (DCA) technique [7, 8]. Essentially, these techniques utilize the surface Doppler information to retrieve the corresponding velocity which are confronted with the challenge of separating the contributions from waves and currents. This requires a physical modeling of radar scattering from ocean current surface. Thus, in this study, we aim to numerically investigate the polarimetric SAR imaging responses to two-dimensional ocean surfaces with currents and waves. The well-developed radar imaging model (RIM) proposed by Kudryavtsev et al. [4] is employed to conduct the numerical simulations under various frequencies, incidence angles, wind speeds and full polarizations. The current surface with a typical internal wave phenomenon generated by the MITgcm numerical mode is used, which has resolution of about 1/200° in longitude direction and 1/60° in latitude direction. The current modulation of wave spectrum is considered in the KHCC03 spectrum. Experimental results indicate that current modulation on ocean scattering is more significant at lower wind speeds. It is also noted that the current modulation of ocean scattering performs most remarkable at cross-polarization, while has least effects at VV-polarization. The current modulation effect is nonlinear to current velocity. At large current velocity, the current modulation effect could be saturated, particularly for co-polarizations. More detailed numerical results will be given in the presentation.

极化 SAR 成像对海流响应的数值仿真研究

摘要 - 海洋表面流场是主导全球碳和热循环的关键海洋动力要素之一。海流的测量对海洋环境监测、全球气候变化预测、海洋救援搜索和应急响应等研究和应用都具有特别重要的科学意义。海面流场通过海面的形态和粗糙度分布，可以在合成孔径雷达（SAR）图像呈现出显著的特征。到目前为止，主流基于 SAR 的海流反演和监测技术手段主要有顺轨干涉 SAR（ATI）和基于多普勒中心频移异常（DCA）原理等两大类。本质上，这些技术利用海面多普勒信息来反演相应的粗糙海面相对于雷达的速度，但其目前面临的最大挑战是

如何将波浪和海流的运动贡献相分离。这需要我们对包含流场的海面雷达散射进行准确的物理建模。因此，在本文中，我们的希望基于数值仿真研究极化 SAR 成像对二维海面波浪和海流的响应。通过采用 Kudryavtsev 等提出的先进理论模型，即雷达成像模型（RIM），对不同频段、雷达入射角、风速和极化条件下的流场海面进行成像仿真，来研究海面流场在 SAR 图像上的成像特征。仿真所采用的流场数据为由 MITgcm 数值模式仿真生成的典型内波现象流场，其在经度方向上的分辨率约为 1/200°，在纬度方向上的约约为 1/60°，并采用成熟的 KHCC03 谱来描述受流场调制的粗糙海面。数值仿真结果表明：流场对海面散射的调制在第风速下更为显著，且随着风速增大而减小。对于不同极化，流场对海面雷达散射的调制在交叉极化下表现最显著，其次为 HH 极化，而在 VV 极化影响最小。海面雷达散射的流场调制作用与流速呈非线性关系，海面流场速度较大时，流场的调制效应可能饱和，特别是在同极化条件下。

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