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Sea Surface Wind Field Retrieval from X-band SAR and Its Applications To Coastal Areas

Li, XiaoMing[1]; Lehner, Susanne[1]; Ren, YongZheng[2]
[1]German Aerospace Center (DLR); [2]Center for Earth Observation and Digital Earth, CAS

Progress of the active spaceborne microwave scatterometer and Synthetic Aperture Radar (SAR) in these decades have provided us with important marine-meteo parameters in the air-sea interface, particularly the sea surface wind speed and direction in high spatial resolution and global coverage. The spaceborne SAR has the unique advantage to derive sea surface wind field in high spatial resolution up to 500 m, which is around 50 times compared with the operational sea surface wind field products of scatterometers, e.g., QuikSCAT and ASCAT. The general methodology to derive the sea surface wind speed from SAR is to apply the Geophysical Model Function (GMF) on the calibrated SAR image by resolving the 180º ambiguity of wind direction. The GMF was originally developed for scatterometer to derive sea surface wind field, e.g., the widely used CMOD4 and CMOD5. As the ERS/SAR and ENVISAT/ASAR are also operated in C-band, the CMOD functions are therefore adopted to the C-band SAR sensors. Besides the C-band spaceborne SARs, other sensors such as the ALOS PALSAR operated in the L-band (1.27 GHz), TerraSAR-X/Tandem-X and the Cosmo-Skymed operated in the X-band (9.6 GHz) are also available to provide us with the sea surface wind field.

A preliminary X-band GMF, denoted as XMOD1, is developed for retrieving sea surface wind from the X-band SAR data based on a linear approach. Here we propose a new non-linear GMF, i.e. the XMOD2, to retrieve sea surface wind field from the TerraSAR-X (TS-X) data. Coefficients in the XMOD2 are determined by using nearly 300 data pairs of TS-X data and collocated in situ buoy measurements.

Comparison of the sea surface wind speed derived from the TS-X data to in situ measurements obtained in the South China Sea Campaign is also presented. During this campaign, we also obtained a TS-X image acquired over typhoon Mina, though in situ measurements were far from the TS-X acquisition due to the R/V had to avoid the extreme weather.

Applications of deriving high resolution sea surface wind field from the TS-X data to coastal area, particularly over the offshore wind farm sites in China Sea and North Sea are presented.

Dragon project id
08 COASTAL ZONES (ID. 5338)

X波段合成孔径雷达海面风场反演及其在海岸带地区的应用

李晓明1, Susanne Lehner1, 任永政2
1 德国空间宇航中心遥感技术研究所　　2中科院对地观测与数字地球中心海气实验室

摘要

几十年来，星载主动微波传感器散射计和合成孔径雷达的发展和进步，使得我们获取了在海气界面上重要的海气参数，尤其是具有高空间分辨率和全球覆盖的海面风速和风向。星载合成孔径雷达具有独特的观测海面风场的能力。从合成孔径雷达可以获取空间分辨率达到500米的海面风场，其约为散射计，如QuikSCAT和ASCAT，业务化海面风场产品分辨率的50倍。从合成孔径雷达反演海面风速的方法是应用地球物理模式函数（简称为GMF）。模式函数的输入为经过辐射校正后的合成孔径雷达强度数据，和消除180°方向模糊的海面风向。GMF函数，例如广泛应用的CMOD4和CMOD5，起初是开发应用于工作在C波段的散射计。由于ERS/SAR以及ENVISAT/ASAR都是工作于C波段的微波传感器，因此，CMOD函数也被扩展应用于C波段的合成孔径雷达以反演海面风速。除了C波段的合成孔径雷达，还有工作于其他波段的合成孔径雷达传感器，比如L波段（1.27GHz）的ALOS-PALSAR，和X波段的TerraSAR-X/Tandem-X，Cosmo-Skymed。因此我们需要开发设计新的模式函数用于从不同波段的合成孔径雷达反演海面风速。

XMOD1是我们最先开发的应用于TS-X反演海面风速的模式函数。它是一个基于线性组合的模式函数。本研究中，我们介绍非线性的模式函数XMOD2。通过与海洋浮标匹配的近300幅TS-X数据，确定了XMOD2模式函数中的系数。

在2011年8月，我们在中国南海开展了现场观测与TS-X观测的同步实验。获取了重要的海洋现场观测资料和卫星数据。TS-X反演的海气参数与现场测量结果进行了详细的对比。在这次现场实验中，很偶然地获取了经过台风Mina的TS-X数据。虽然调查船为了避开恶劣的台风天气，而使得现场观测点距离TS-X数据点非常远，但是这是一个非常难得的印证高风速条件下XMOD2反演海面风场准确性的个例。

此外，我们还展示了利用高分辨率合成孔径雷达TS-X在中国东海和欧洲北海的近海海洋风能场反演海面风场的个例研究。