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Measurement of ocean surface wind by using airborne dual-frequency polarimetric synthetic aperture radar

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To analyze the coastal environment, the ocean surface wind field with high spatial resolution is important. The special resolution of spaceborne synthetic aperture radar (SAR) is enough fine to this purpose. However, the spaceborne SARs were designed to make observation using one polarization (VV or HH). Because the winds have two components (speed and direction), the external data of one component of winds is needed to measure the ocean surface wind using the SAR. The coarse spatial resolution of these external data leads the measurement error of wind measurement using SAR. Recent years, many spaceborne polarimetric SARs become operational, and the polarimetric analysis becomes applicable for the earth surface observation including the ocean. However, the knowledge of polarimetric feature of normalized radar cross section (NRCS) is little on the ocean surface. In this paper, the NRCS of ocean surface are measured using an airborne SAR and the dependency of NRCS of ocean surface on ocean surface winds is compared between radar polarizations and frequencies.

The NICT and the JAXA has been developed an airborne dual-frequency polarimetric SAR (Pi-SAR) with L- and X-band. The range of incidence angle is enough wide to acquire the dependency of NRCS on incident angle from one observation, because the swath is more than 10km. Moreover, the time interval of observation of one target is able in less than several minutes. The NRCS of ocean surface depends strongly on the wind over the ocean. The airborne SAR is able to observe same area in enough short time to be ignore the change of wind.

The NRCS for parallel polarizations (VV, HH) is much stronger than that for cross polarizations. The large difference represents the ability of Pi-SAR to measure the NRCS for parallel polarizations. The dependency of NRCS on incident angle is different between the radar frequencies and the polarizations. The NRCSs for X-band parallel polarization decrease more rapidly than those for L-band components with the increasing of incidence angle. There is not so large difference between the decreasing of NRCS for L-band parallel polarizations and the polarization rate is almost constant for observed incidence angle. On the other hand, the decreasing of NRCS for X-band HH component is more rapid than that for VV component, and the polarization rate increases with the incidence angle.

The dependency of NRCS of ocean surface on wind direction is analyzed using multiple SAR observations of same ocean area in short time by using the model function as $NRCS = a0 + a1 \cos(INC) + a2 \cos(2INC)$, where *NRCS* and *INC* is the NRCS and the relative direction of wind to the radar beam, respectively. For X-band HH polarization, the magnitude of a1 is much larger than that of X-band VV component. As a result, the difference of NRCS between upwind and downwind conditions becomes larger in case of X-band HH polarization than other components. This peculiarity of X-band HH polarization suggests the possibility of measurement of ocean surface wind only using X-band polarimetric SAR data. The polarimetric rate of X-band also changes with the relative wind direction. On the other hand, the NRCSs of L-band parallel components change almost same with the wind direction.

As a result of this study, the possibility of measurement of the ocean surface winds with high spatial resolution by using the X-band polarimetric SAR is shown. Though the ocean surface wind measurement using L-band polarimetric SAR is difficult, L-band SAR is able to measure wind speed. The analysis for C-band SAR is left. The measurement of ocean wind field with high spatial resolution is quite important to analyze the coastal environment. The polarimetric SAR using C-band or higher frequency will be one of powerful tools in near future.