Geophysical Research Abstracts
Vol. 17, EGU2015-2262, 2015
EGU General Assembly 2015

Inversion to estimate ocean wave directional spectrum from high-frequency radar

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An high-frequency (HF) radar observes ocean surface currents and waves by radiating HF radio waves to the sea surface and analyzing the backscattered signals. Ocean wave spectrum is estimated from the first- and the second-order scattering of Doppler spectra by the inversion. The estimation of ocean surface currents is robust, because the surface currents can be derived from the peak Doppler frequency of the first-order scattering in the Doppler spectrum. The method to estimate ocean wave spectra is complicated and the second-order scattering in the Doppler spectrum is fragile, which is affected by the noise in the Doppler spectrum. A new method to estimate ocean wave spectra from HF radar is developed. This method is the extension of Hisaki (1996, 2005, 2006, 2009, 2014). The new method can be applied to both the single radar and dual radar array case, while the previous methods can be applied only the single radar case (Hisaki, 2005, 2006, 2009, 2014) or dual radar case (Hisaki, 1996). Ocean wave spectra are estimated in the regular grid cells, while wave spectra are estimated on the polar grids points with the origin of the radar position in the previous method for single radar case. The governing equations for wave estimation are the integral equations which relate the wave spectrum to the Doppler spectrum, and the energy balance equation under the assumption of stationarity. The regularization constraints in the horizontal space and the wave frequency-direction space are also used for the estimation. The unknowns, which are spectral values, surface wind speeds and directions, are estimated by seeking the minimum of the objective function, which is defined as the sum of weighted squares of the equations. The signal to noise ratio in the Doppler spectrum for wave estimation must be high. We selected the Doppler spectra using the SOM (Self organization map) analysis method. The method will be demonstrated by comparing with in-situ observed data, in which only the Doppler spectrum from the single radar can be available.