ISSN: 2642-9020

Short Article | Journal of Marine Science Research and Oceanography

On the Issue of Doppler Centroid When Operating SAR Over the Ocean

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Submitted: 2024, Sep 18; **Accepted**: 2024, Oct 09; **Published**: 2024, Oct 21

Citation: Kanevsky, M. B. (2024). On the Issue of Doppler Centroid When Operating SAR Over the Ocean. *J Mari Scie Res Ocean, 7*(4), 01-02.

Abstract
Another approach to the problem of determining the Doppler centroid for space borne SAR operating over the ocean is being considered.

The random location of the Doppler centroid is determined by the ratio of the components of the random spectrum estimate. Therefore, we believed it was appropriate to first derive a formula for the Doppler spectrum itself - the mean that the random spectral components fluctuate around [1].

It turned out that the spectrum has the shape factor

$$\hat{S}(\omega) = \exp\left[-\frac{2\Delta_{SAR}^2}{\pi^2 V^2}(\omega - 2k\bar{v}_{rad})^2\right] \qquad (1)$$

Here, $V \approx 8\ km/s$ is the SAR carrier speed, Δ_{SAR} is the nominal azimuthal (i.e., along way) resolution, and $\bar{v}_{rad}$ is the regular part of the radial component of velocity on the ocean surface. Formula (1) describes the mean level around which random spectral components fluctuate and is in good agreement with the simulation results [2].

We introduce the confidence interval and present its upper $\hat{S}_+(\omega)$ and lower $\hat{S}_-(\omega)$ boundaries:

$$\hat{S}_\pm(\omega) = (1 \pm \alpha)\exp\left[-\frac{2\Delta_{SAR}^2}{\pi^2 V^2}(\omega - 2k\bar{v}_{rad})^2\right] \qquad (2)$$

Figure.1 schematically shows a fragment of a random spectral estimate and the indicated boundaries. It also shows the frequencies ω_1 and ω_2 that limit the effective spectral interval that can be limited to when finding the centroid [1].

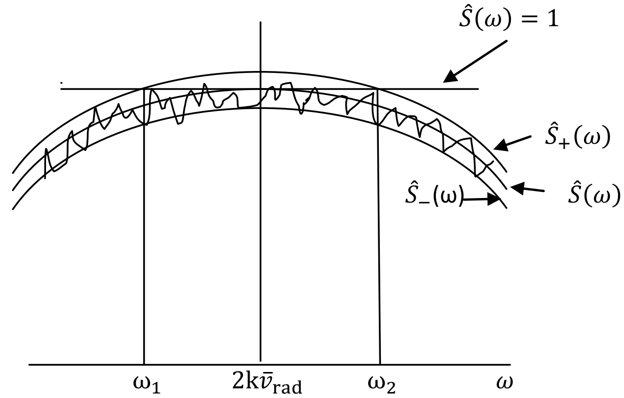

Figure 1: Section of random realization of spectral estimate (the scheme).

The width of the effective spectral interval is determined by the technical parameters V and Δ_{SAR}, as well as the parameter α, through which (when specifying the probability) the width of the confidence interval is determined.

The effective spectral interval is determined by the formula [1]:

$$\Delta f_{eff}[Hz] \cong \sqrt{\alpha/2}\,\frac{V}{\Delta_{SAR}} \qquad (3)$$

We will assume that the components of the Doppler spectrum, fluctuating around the mean level $\hat{S}(\omega)$, obey a normal distribution with dispersion σ_2. In this case, having specified the probability for the confidence interval, it is not difficult to find its boundaries. In particular, the values of the fluctuation part of the components with a probability close to 0.9 are concentrated in the interval $\mp 1.6\ \sigma$ around the mean.

The question remains: how are σ and the mean related? We need to know this in order to indicate the value of α in formula (2). A reliable answer can only be obtained experimentally for each specific experiment, since this is determined by the state of the ocean surface. Unfortunately, we do not have experimental material, so we focus on the modeling results [2] and, based on the graphical material in this article, we accept α = 0.08, which will provide a confidence interval with a probability parameter close to 0.9. If the nominal azimuthal resolution is taken to be close to the actual resolution (i.e., about 100 m), then the width of the effective interval will be close to twice the standard deviation of the centroid found in [2] by simulation. If a higher nominal resolution is chosen and therefore a wider effective interval is obtained, there is nothing to prevent further processing of Δf_{eff} to find the Doppler centroid using existing algorithms [2, 3].

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