ISSN: 2642-9020

Short Communication

Journal of Marine Science Research and Oceanography

Another Method for Surveying the Ocean Surface with A Radar Altimeter

Mikhail B. Kanevsky

Independent researcher, Canada

***Corresponding author**
Mikhail B. Kanevsky, Independent researcher, Canada

Submitted: 11 Feb 2022; **Accepted**: 22 Feb 2022 **Published**: 18 Mar 2022

Citation: *Mikhail B. Kanevsky (2022) Another Method for Surveying the Ocean Surface with A Radar Altimeter. J Mari Scie Res Ocean, 5(1):55-57.*

Among the many problems of oceanography solved with the help of a radar altimeter, the measurement of the significant wave height (SWH) occupies one of important places. Recall that the radar altimeter operates in vertical sensing mode, sending electromagnetic pulses, whose arrival time and shape carry information about the state of the surface.

Obviously, the more intense the ocean waves, the more the returned pulse is stretched in time, and traditionally the SWH is estimated by the slope of its leading edge.

The slope of the leading edge of the returned pulse gives an idea of the thickness of the layer of roughness, but does not say anything about its internal structure. In contrast to the convenient surveying method, we are going to propose a method that allows, along with possible improvement of SWH estimate, to obtain some information about the structure of the roughness layer.

The essence of this method is that a radar altimeter is used as an imaging radar, creating a vertical "swath" about 10 m wide with a given vertical resolution.

A traditional imaging radar operating at long range generates range resolution by passing the reflected chirp pulse through a matched filter. The ground range resolution δ_{gr} is determined by the chirp pulse bandwidth, whereas the slant range R_{sl} of the resolution cell and, consequently, the distance between two selected cells (see Figure1) are determined by the filter adjusting.

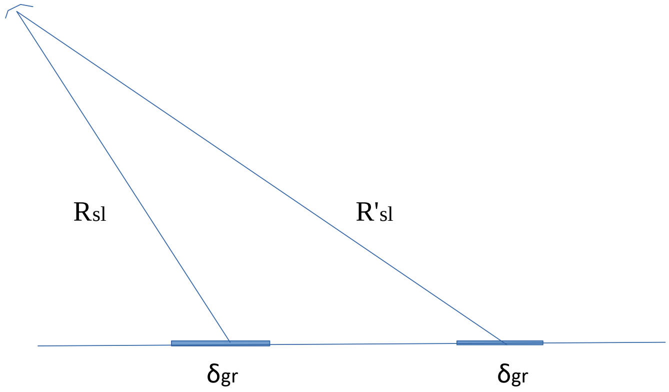

Figure 1: Traditional survey scheme using imaging radar

We propose, using the imaging radar technique, to construct the scheme of survey shown in Figure 2. In this case, having formed the discrete 'lattice' of cells or the continuous 'swath' of several meters wide, one can receive the echo from different levels. Evidently, strong reflections from the selected level indicate that horizontal and near-horizontal surface elements dominate at this level, while weak reflections indicate relatively large slopes, and the complete absence of reflections means that the selected level is outside the roughness layer. This is schematically illustrated in Figure 3, where the dependence of the intensity of reflections as a function of the deviation of the surface from its mean level h=0 describes the distribution of horizontal and near-horizontal elements over the height within the layer of roughness. The clarity of this picture allows us to hope for an increase in the accuracy of SWH determination in comparison with the traditional method (see above).

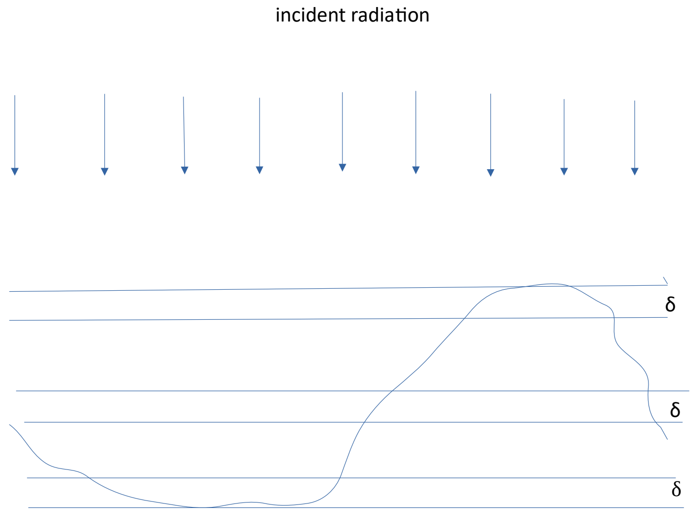

Figure 2: Proposed survey scheme using a radar altimeter

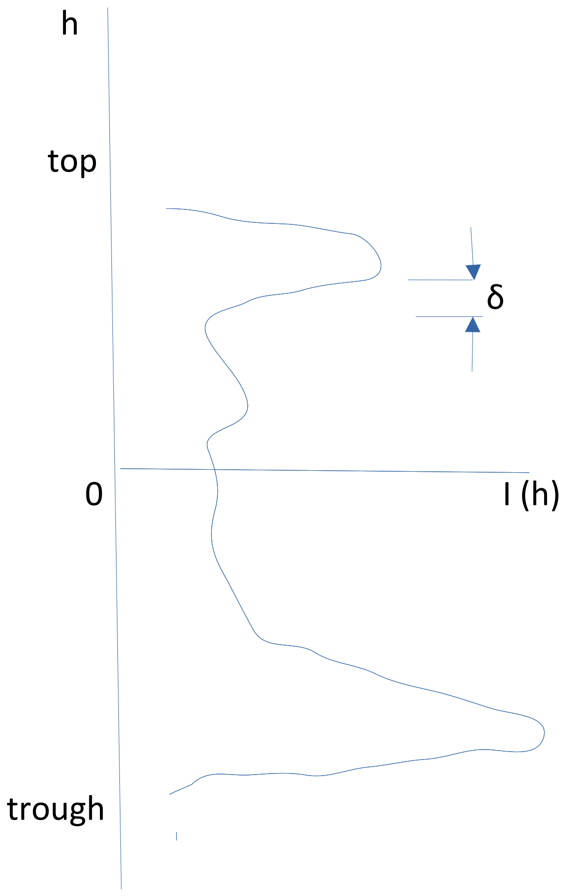

Figure 3: Intensity of reflections as a function of surface elevations relative to the mean level (schematic representation).

Let us find the chirp pulse bandwidth B, which is needed to provide the required vertical resolution. The change of angular frequency inside the probing chirp pulse:

$$\omega(t) = \omega_0 + 2\pi\gamma t \qquad -\tau_p/2 \le t \le \tau_p/2 \tag{1}$$

where γ is the chirp rate and τ_p is the pulse duration, i.e. $B = \gamma\tau_p$. The intensity of the compressed pulse obtained after the reflected chirp pulse passes through the matched filter

$$I(t) \propto \left|\frac{\sin[2\pi\gamma(t-2R/c)\tau_p]}{2\pi\gamma(t-2R/c)\tau_p}\right|^2 \tag{2}$$

where *R* is given vertical range and c is the light speed. The compressed pulse duration determined by the level of amplitude decrease two times (i. e., of intensity four times)

$$\tau'_p = \frac{1.2\pi}{2\pi\gamma\tau_p} = \frac{0.6}{B} \tag{3}$$

and for the vertical resolution we obtain: $\delta = c\tau'_p / 2 = 0.3c / B$. Inversely

$$B = \frac{0{,}3c}{\delta} \tag{4}$$

whence for δ =20 cm follows B=450 *MHz*. One can see that this value about in half exceeds the chirp pulse bandwidth 320 *MHz* of Envisat RA-2 and CryoSat , and practically coincides with that of SARAL/AltiKa (480 *MHz*) [1-3].

In order to avoid losing vertical resolution because of sphericity of the wave front of radiation as well of sphericity of the Earth, it is needed to have sufficiently narrow antenna pattern, that is, the probing radiation should be concentrated in a sufficiently narrow cone near the nadir. From geometric considerations it follows that the angular half-width of the cone φ must satisfy the condition:

$$\varphi \le \varphi^* = \left[\frac{2\delta}{H(1+H/a)}\right]^{½} \tag{5}$$

where H is the altitude of altimeter carrier flight, and a=6371 km is the Earth radius. This formula follows from the requirement that the difference in heights above the mean sea level of two points of the wavefront, lying on the rays directed to the nadir and along φ , should not be more than δ (see Figure 4). From here, it is possible to estimate the linear size D of the antenna providing the required vertical resolution:

$$D = \frac{\lambda}{2\varphi^*} \tag{6}$$

where λ is the working wavelength of the altimeter. In particular, for λ = 0.8 cm and δ = 20 cm we get D≈ 6 m (H=800 km), D ≈ 4 m (H=400 km), and D≈0.6 m (H=10 km).

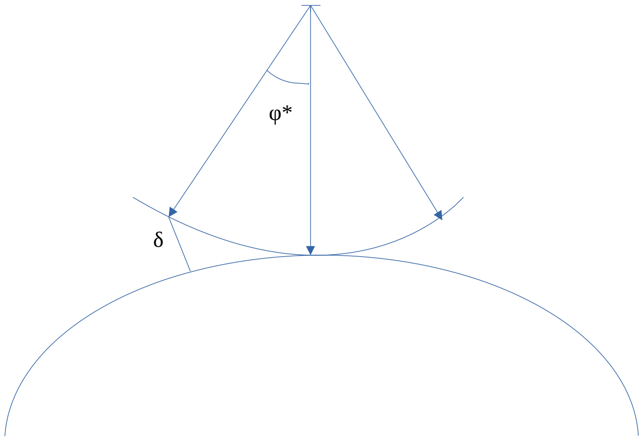

Figure 4: Probing geometry

Obviously, in the case of a space altimeter, the required linear size of the antenna turned out to be large enough, but this only concerns the dimension transverse to the flight direction, since in the along-track direction the equivalent narrow antenna pattern can be acquired using the aperture synthesis technique [2, 4].

Thus, the Ka-band is the most suitable for this method, and in the case of an airborne altimeter, unlike a space one, there are no special requirements for the antenna pattern. Obviously, it is aircraft experiments that will make it possible to establish how real the benefits of the proposed method are.

References

1. Resti, A., Benveniste, J., Roca, M., Levrini, G., & Johannessen, J. (1999). The Envisat radar altimeter system (RA-2). ESA bulletin, 98(8), 94-101.
2. Emery, B., & Camps, A. (2017). Introduction to satellite remote sensing: atmosphere, ocean, land and cryosphere applications. Elsevier.
3. Vernon, J., Sengenes, P., Lambin, J., Noubel, J., Steunou, N., Guillot, A., ... & Gupta, P. K. (2015). The SARAL/AltiKa altimetry satellite mission. Marine Geodesy, 38(sup1), 2-21.
4. Sentinel-3 Altimetry Technical Guide: https://sentinels.copernicus.eu/technical-guides/sentinel-3-altimetry/ .