SeawavePy – Sea Surface Simulation

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Surface Module Description

Sea surface eleveations can be calculated as the sum of the harmonics with deterministic amplitudes and random phases

$$\xi(\vec{r},t) = \sum_{n=1}^{N}\sum_{m=1}^{M} A_n \cdot F_{nm} \cos\left(\omega_n t + \vec{\kappa}_{nm}\vec{r} + \psi_{nm}\right), \tag{1}$$

$$A_n(\kappa_n) = \frac{1}{2\pi}\sqrt{\int\limits_{\Delta\kappa_n} S_\xi(\kappa)\mathrm{d}\kappa},$$

$$F_{nm}(\kappa_n,\varphi_m) = \sqrt{\int\limits_{\Delta\varphi_m} \Phi_\xi(\kappa_n,\varphi)\mathrm{d}\varphi},$$

where $A_{nm}(\kappa)$ – wave amplitude calculated from one-dimensional wave spectrum $S_\xi(\kappa)$, $\vec{r}$ – radius measured from zero sea level, ψ – random phases, Φ – azimuthal wave distribution.

Knowing the elevations, we can calculate the slopes of the surface

$$\begin{aligned} \sigma_x(\vec{r},t) &= \frac{\partial\xi}{\partial x} \\ \sigma_y(\vec{r},t) &= \frac{\partial\xi}{\partial y} \\ \sigma_z(\vec{r},t) &= \frac{\partial\xi}{\partial z} = 1 \end{aligned} \tag{2}$$

The function **wind** in module **core.surface** calculates equations (1), (2) on the GPU and returns an array of the NetCDF format with fields:

- **elevations** – elevations of surface with dimensions (x, y, t)
- **slopes** – slopes of surface with dimensions $(3, x, y, t)$
- **velocities** – orbital velocities of surface with dimensions $(3, x, y, t)$
- **spectrum** – Two dimensional wave spectrum

Tilt-modulation

The equation (2) is the normal vector at a point on the surface

$$\vec{n} = \frac{\vec{i} \cdot \sigma_x + \vec{j}\sigma_y + \vec{k} \cdot 1}{\sqrt{\sigma_x^2 + \sigma_y^2 + 1}}$$

$$\vec{u} = (x, y, \xi)$$

Then we can calculate tilt-modulation effect

$$\sigma_{tilt}(x, y, t) = \begin{cases} \vec{n}\vec{u}, & \text{if } \vec{n}\vec{u} > 0 \\ 0, & \text{if } \vec{n}\vec{u} \leq 0 \end{cases}$$

These equations are a complete replacement for equations (3-6) from the article "Research of X-band Radar Sea Clutter Image Simulation Model"