GPU-based simulation of Radar sea clutter

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The paper will describe the status of a work currently in progress under DGA/MRIS foundings, involving Alyotech Technologies, IFREMER Brest and Telecom Bretagne: the development of a new fast radar sea clutter simulator, running on GPU (Graphical Processing Units).

Most radar sea clutter models provide statistical descriptions of backscattered signals, for given wave spectrum, viewing geometry and radar wavelength. The “composite model” is a widely used approach consisting of summing back-scattered local contributions from small-scale capillary waves (Bragg scatterers), conveyed and modulated in amplitude by surface motions induced by gravity waves of all larger scales. Averaging local radar cross-section (RCS) over geometrical and hydrodynamic modulations in the assumption of an homogeneous/stationary sea surface is at the origin of most statistical sea clutter descriptions (e.g. K-ditributed clutter).

In contrast to the classical approach, the future GPU simulator will provide a description of the clutter resolved in space, time and Doppler shift, by summing the locally backscattered amplitudes at each time step and in the radar resolution element, over an animated 3D sea-surface model. As the model perimeter includes surface radar systems operating at low grazing angles (from less than 1° to 20°), non-Bragg basckattering processes have to be accounted for, in order to reproduce the main features of radar returns in such conditions, i.e. strong individualized echoes (“spikes”), transitory large HH/VV polarization ratio and enhanced upwind/downwind asymmetry. This requirements, together with typical radar systems spatial coverage and resolution, leads to very large amounts of computations, since hundreds of thousands to millions of Bragg scatterers have to be modeled in a single resolution cell. As, fortunately, this problem is essentially “embarrassingly parallel”, it can fully benefit from the huge computational capabilities offered by the GPU.

As the project is currently entering its development phase, the paper will emphasize the underlying choices in terms of sea surface and EM backscattering models, and the corresponding constraints on software architecture.