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HF Propagation and Scattering in the Marginal Ice Zone

Stuart J. Anderson
Physics Dept., University of Adelaide, Adelaide, Australia
stuart.anderson@adelaide.edu.au

One of the most pronounced effects of climate change is the reduction of the polar ice fields, especially in the Arctic. A consequence of this change is the rapidly increasing intensity of human activities in this domain, most notably shipping but extending to offshore resource exploitation and operations relating to national sovereignty. Central to the successful conduct of many of these activities is a requirement for knowledge of the prevailing large-scale distribution of sea ice, its structure, its thickness (in the case of sheet ice) and its mechanical properties.

Space-borne sensors offer some useful remote sensing capabilities related to the mapping of ice distribution and even thickness, but not the physical properties of the ice. Moreover, the evolution of the ice field can occur on a time scale much shorter than the revisit time of existing remote sensing satellites, so the information may not be helpful in real-time operations.

Some recent studies [1,2] have led to the development of a theory of HF radio wave scattering that enables one to infer some of these properties from the dynamic response of the ice to waves penetrating the ice field from the open sea. It has been shown by *in situ* measurements that the perturbations can be appreciable at substantial distances into the ice field, sometimes exceeding 100 km, so there is some prospect for employing HF radars to provide persistent monitoring of ice fields. In the case of HF skywave radar, the illuminating signals are incident directly on the zones of interest, so considerations relating to radio wave propagation are those common to other applications of this technology, namely, the vagaries of the ionosphere. For HF surface wave radars, though, the situation is novel. Instead of the wave propagating across the usual ocean surface, it must now travel, for at least part of its trajectory, across the ice-covered surface. This introduces several complications: (i) the electrical properties of the surface are no longer well modelled as PEC, (ii) the surface motions that impose a modulation on transiting radio waves are now governed by a modified dispersion relation, and (iii) multiple scattering now occurs from a surface whose geometry is far removed from that of a free sea surface.

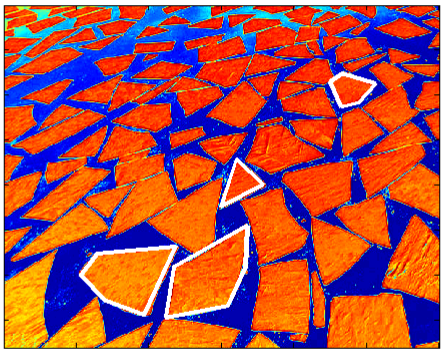

Figure 1. A field of ice floes, with superimposed polygons illustrating the automatic recognition of individual floes from airborne imagery. This is one step in the procedure for parameterizing the multiple scattering problem.

In this paper we will present an update on our progress towards the goal of demonstrating that HF radar can provide a viable real-time, persistent ice monitoring capability, including the inversion techniques required to extract the desired ice parameters from the radar echoes.

Reference

1. S. J. Anderson, “Monitoring the marginal ice zone with HF radar”. Proceedings of the IEEE Radar Conference, Seattle, USA, May 2017.
2. S. J. Anderson, “Prospects for the inversion of HF radar echoes from sea ice to recover structural and viscoelasticity parameters”, Paper presented at the 3rd Australasian Conference on Wave Science, Auckland, New Zealand, February 2018.