URSI GASS 2021, Rome, Italy, 28 August - 4 September 2021

Calculation of high frequency land backscatter coefficients across Northern Australia from over-the-horizon backscatter ionograms

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Extended Abstract

Over-the-horizon radar is a class of high frequency (HF) radar used for long range (1000-3000 km) wide area surveillance. As these radars utilize the refractive properties of the ionosphere to illuminate targets beyond the Earth's horizon, their performance is highly dependent on the ionosphere. Typically backscatter sounders (BSS), a type of over-the-horizon environmental radar, measure the returned power from ground backscatter in order to assess the propagation conditions. The main surveillance radar is then tasked accordingly. However, low (high) power noted by a BSS may be due to either poor (good) ionospheric propagation or low (high) ground backscatter. Clearly, accurate models of the radar ground backscatter are required at HF to accurately assess the propagation conditions and thus the expected performance of over-the-horizon radars for operational purposes.

The ground backscatter coefficient is used to characterise the amount of radiation scattered back from a surface towards a receiver per unit area. While the backscatter coefficient of the sea/ocean is well understood and may be calculated from theory if the sea state in known, the backscatter coefficient of land at high frequencies is not well understood and is expected to be highly dependent on the terrain type and moisture content.

To calculate the land backscatter coefficients over Northern Australia, we have developed a methodology which compares observed backscatter ionograms to those synthesized using HF radio wave ray tracing techniques through model ionospheres. The numerical ray tracing toolbox PHaRLAP [1] developed by the Defence Science and Technology Group was used together with a near real time data-driven model of the ionosphere. Propagation losses such focussing/defocussing and ionospheric absorption are accounted appropriately and the transmit and receive antenna gains were modelled by using a method-of-moments electromagnetic (EM) solver (Numerical Electromagnetics Code-4 [2]).

Data from the Jindalee Operation Radar Network (JORN) [3] frequency management system's (FMS) [4] backscatter sounders from September 2015 was analysed and a map of the backscatter coefficients across Northern Australia was developed. The effects of the surface properties, including topography and moisture content, on the backscatter coefficients were investigated. It was found that desert like regions had a much lower backscatter coefficient than mountainous regions. Areas with higher moisture content had higher backscatter coefficients.

References

[1] Cervera, M. A., and Harris, T. J. (2014) Modeling ionospheric disturbance features in quasi-vertically incident ionograms using 3-D magnetoionic ray tracing and atmospheric gravity waves, *J. Geophys. Res. Space Physics, 119,* 431–440, doi:10.1002/2013JA019247

[2] Burke, G., Poggio, A., Logan, J., and Rockway, J. (1979) NEC - Numerical Electromagnetics Code for antennas and scattering. In *Proceedings of the Antennas and Propagation Society International Symposium*, Seattle, WA, June 1979, 147-150

[3] Cameron, A. (1995), The Jindalee Operational Radar Network: Its architecture and surveillance capability, In *Proceedings of the IEEE International Radar Conference*, Alexandria, VA, 1995, 692–697

[4] Earl, G. F., and Ward, B. D. (1987), The frequency management system of the Jindalee over- the-horizon backscatter HF radar, *Radio Science, 22*, 275-291, doi: 10.1029/RS022i002p00275