#19 Received 12/15/2014

Jackson-Booth, Natasha[1]; Selzer, Luke[1]; Reid, Joseph[1]; Penney, Richard[1]; Pedersen, Todd[2]; Caton, Ronald[2]; Cannon, Paul[3]; Groves, Keith[4]; Angling, Matthew[3]; Parris, Richard[2]; Su, Yi-Jiun[2]; Attrill, Gemma[5].
1. QinetiQ
2. U.S. Air Force Research Laboratory
3. University of Birmingham
4. Boston College
5. U.K. Defence Science and Technology Laboratory

Recreating the effects of Artificial Ionospheric Modification observed in the HF environment; an application of numerical ray-tracing

Abstract:
Artificial Ionospheric Modification (AIM) can occur through deliberate or incidental injections of aerosols, chemicals or radio (RF) signals into the ionosphere. The Metal Oxide Space Clouds (MOSC) experiment was undertaken in April/May 2013 to investigate chemical AIM. Two sounding rockets were launched from Kwajalein Atoll (part of the Marshall Islands) and each released a cloud of vaporized samarium (Sm). The samarium created a localized plasma cloud that formed an additional ionospheric layer.

The effects were measured by a wide range of ground based instrumentation dispersed in several locations across the Marshall Islands. The collected data included HF measurements, optical observations, trans-ionospheric beacon measurements, and incoherent scatter measurements using the ALTAIR radar. A subset of the HF measurements included a 17 channel direction finding chirp receiver, which was used to observe and track the cloud. The recorded ionograms showed that the new layer was visible for approximately 25 minutes after release: the maximum frequency of the new trace decays with time, indicating a decrease in cloud density. The ionograms also revealed the existence of ‘ghost traces’ above the F-layer.

Extending this work, a highly accurate parametric cloud model was developed by AFRL using optical data. The cloud model was added to simulated ionospheric electron density grids to understand the impact on radio propagation in the cloud’s vicinity. A 3D numerical ray trace was undertaken to find the paths through the simulated electron density grid for a given fan of elevation and azimuth ray angles. Using the ray tracer it was possible to demonstrate that significant off-great circle propagation occurred, and that the broad characteristics of the recorded ionograms can be synthesised. Synthetic oblique ionograms from 2 to 30 MHz were derived to investigate the potential cause of the “ghost traces”.

This paper will present results from ray-tracing simulations conducted to investigate the effects of the Samarium release. The results include providing a possible cause of the “ghost traces” whereby the ray path is deflected from the cloud to the F layer and down to the receiver. In certain geometries this small deviation adds enough delay to represent it as a distinct layer. The consistency of the results with the angle of arrival information obtained from the deployed HF system will also be highlighted.