High Resolution Tomography and Computer Simulation of an Artificial Ionospheric Cavity

Craig A. Selcher*(1), Paul A. Bernhardt(1), Frank T. Djuth(2), Joe D. Huba(1)
(1) Plasma Physics Division, Naval Research Laboratory, Wash., DC 20375
(2) Geospace Res Inc, El Segundo, CA

Tomographic techniques use line integral measurements to reconstruct local values of the measured parameter. These techniques have been applied to the ionosphere by using radio transmissions to measure the integral of electron density between a satellite and a chain of ground-based receiving stations. The resultant reconstructions form a two-dimensional map of the electron density in the plane of the satellite / receiver chain. Insufficient quantity of receivers and not having a complete range of accessible look angles with the available receivers are responsible for the non-uniqueness in the reconstructions. The limited look angle problem can be alleviated by making use of alternative data sources such as incoherent scatter radars (**ISR**) that provide information on the vertical structure of the electron density. The non-optimal receiver placement problem can be alleviated through the use of sophisticated reconstruction algorithms. The computerized ionospheric tomography (**CIT**) technique has been used to image the artificially modified ionosphere above the Arecibo Observatory (**AO**) HF heating facility. A total of nine radio beacon receivers forming a three by three matrix were deployed across the entire island of Puerto Rico. The arrangement maximizes the likelihood that several of the receiver-to-satellite lines of sight would intersect the heated region of the ionosphere. Several satellite passes associated with such an intersection occurred, and the resultant tomographic inversions indicate the existence of an electron density cavity approximately 45 kilometers in latitudinal extent. The reduction of electron density in this cavity was typically on the order of 20%. The experimental observations were supported by theoretical work using the open-source SAMI2 ionospheric model. Methods were developed to model both the ohmic heating of the electrons and the suprathermal heating caused by nonlinear effects. Modeled ohmic heating values of 941 K/s match the observed heated temperature profiles.