

Description of federally-supported project requiring this application

This license is being sought in pursuit of the research project AGS-1342895 being carried out by Cornell University and the University of Alaska, Anchorage, with support from the National Science Foundation of the U.S. The work uses a small research radar system on Diamond Ridge to support experiments using the Poker Flat Incoherent Scatter Radar in Fairbanks, Alaska. Research of this kind was performed for many years under the experimental license WE2XDT. The abstract for the NSF proposal behind this project is given below.

This is a proposal to investigate Farley-Buneman waves and turbulence in the auroral electrojet, their internal wave mechanics, their effects on the background ionospheric state, and the interpretation of coherent radar backscatter that can be received from them. The investigation has experimental, theoretical, and modeling aspects as well as strong educational underpinnings. The broad goal of the research is to elucidate the processes involved in generating ionospheric structure by magnetospheric forcing (from above), one of the two main themes highlighted by the 2013 Decadal Survey for Solar and Space Physics. Its emphasis on the multiscale connections between the background forcing available during disturbed conditions, the auroral instability and turbulence it creates, and the feedback on the mean ionospheric state supports the systems theme of the CEDAR Strategic Plan. The proposed study will be carried out by faculty and students at Cornell University and the University of Alaska, Anchorage, and will involve experimental field work in Alaska.

Overview The experimental component of this research will be conducted in Alaska and focus on a 30 MHz coherent scatter radar imager fielded by the team in Homer. The Homer radar will be supported by the Poker Flat Incoherent Scatter Radar (PFISR) with which it shares a common volume along with optical and ancillary instruments deployed by the Geophysical Institute at and around the Poker Flat Rocket Range. Campaigns will provide coincident, collocated measurements of Farley Buneman waves, the background conditions (convection electric field, electron and ion temperature) under which they occur, and variations in the background due to subsequent wave heating.

Experimental data will be interpreted in the context of results from the theoretical investigation. One component of that investigation involves the construction of a 3D hybrid fluid-kinetic model of Farley-Buneman waves capable of simulating the wave mechanics at small and intermediate scales. The second component involves the development of a mathematical model of Farley-Buneman waves and turbulence, including saturation effects, based on the formalism of stochastic differential equations (SDEs). Whereas the former approach is essentially reductionist, the latter follows the principles of systems science and may be regarded as a prototype for CEDAR.

Intellectual merit The intellectual merit of this proposal stems from the fundamental science questions being investigated, which are keystones for understanding how the auroral ionosphere behaves under geomagnetically active conditions and how the ionospheric boundary as viewed by the magnetosphere is consequently, dynamically altered. Although ionospheric irregularities were discovered in the auroral zone more than 75 years ago, fundamental questions about the way that the waves propagate and saturate in a turbulent state persist. The experimental and computational machinery finally exists to make definitive progress in this area of research. One successful outcome of this study will be a recipe for using coherent scatter from the radio aurora as an incisive and inexpensive diagnostic of ionospheric convection and heating.

Broader impact The broader impact of this investigation is associated with the novelty of the tools we will develop, which have applications outside research in the radar aurora. Radar imaging has tremendous potential as a means of performing discovery research in geospace but is computationally demanding and will see little application outside the current effort until it can be simplified and accelerated. Hybrid kinetic-fluid simulations have received little attention within the CEDAR science community but could resolve some practical limitations of existing particle-in-cell (PIC) approaches. The SDE formalism could one day offer an alternative to costly ensemble forecast methods but will require the kind of exploration and development we propose here. Additional broader impact will come from undergraduate and graduate education in geospace and CEDAR science at Cornell and UAA.