# Project Details

**ROSES ID:** NNH20ZDA001N
**Selection Year:** 2020
**Program Element:** Focused Science Topic

**Topic:** Modeling and Validation of Ionospheric Irregularities and Scintillations

**Project Title:**
Driving the Ionosphere from Below: Effects of Planetary Waves and Ion-Neutral Coupling on Low-latitude Plasma Density Irregularities

**PI Name:** Jeffrey Klenzing
**PI Email:** jeffrey.klenzing@nasa.gov
**Affiliation:** NASA Goddard Space Flight Center
**Project Member(s):**
- McDonald, Sarah E;Co-I;Naval Research Lab
- Smith, Jonathon M;Co-I;Catholic University Of America
- Liu, Guiping;Co-I;Catholic University Of America

**Summary:**
We intend to systematically examine the effect of multi-day planetary waves on the mid- and low-latitude Ionosphere-Thermosphere (IT) system, including the enhancement and suppression of plasma irregularity formation, which have a devastating effect on communication and navigation signals. Because the terrestrial IT system is driven through multiple energy paths (including direct solar EUV forcing, high-latitude geomagnetic inputs, and forcing from the lower atmosphere), forecasting of both the large-scale structure of the ionosphere and smaller-scale irregularities such as scintillation remains a challenge for the space weather community. At low-latitudes, this scintillation is attributed to turbulence around meso-scale plasma depletions formed through a Rayleigh-Taylor Instability (RTI) seeded by waves in the bottomside ionosphere. Two factors are needed to form the depletion: background conditions to sustain a positive growth rate and the existence of a seed. This growth rate varies with longitude as a function of magnetic field line geometry. In certain regions, the seeds occur far more often than the depletions, and yet significant variability within the system is still seen when comparing consecutive days with similar solar or geomagnetic inputs. While coupling with the lower atmosphere is typically invoked as a potential cause of this day-to-day variability, this has not been systematically investigated.

The proposed work will incorporate analysis of the planetary waves using data from TIMED/SABER (Sounding of the Atmosphere using Broadband Emission Radiometry) and the Microwave Limb Sounder (MLS), as well as global ionospheric structure including background density, meso-scale plasma bubbles, and scintillation through data from the Coupled Ion-Neutral Dynamics Investigation (CINDI), the Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC), and ground-based GPS observations. These results will be compared to simulation results from coupled runs of the Whole Atmosphere Community Climate Model with thermosphere and ionosphere extension (WACCM-X) and the SAMI3 ionosphere model. Data comparisons with the model will be performed at every stage of analysis, including validating the WACCM-X planetary waves driving the ionosphere and the background SAMI3 ionospheric plasma distribution. The likelihood of plasma bubbles and scintillation will be determined by calculating the RTI growth rate integrated along the SAMI3 flux tubes as a function of longitude and season throughout long-term runs of the IT models. This study will be the first systematic zonal analysis of the variation and variability of the RTI growth in conjunction with detailed bubble statistics.

This work directly addresses the first and second goals of the Focus Science Topic -- "Identify the mechanisms and structures that are responsible for ionospheric irregularities and scintillations at various latitudes (low, mid, and high latitudes) and longitudes and Determine growth rates, spectral characteristics, the nonlinear evolution associated with specific generation mechanisms and their role in scintillations -- as well as connecting LWS strategic Science Goals SSA-VI Ionospheric Irregularities and SSA-VII Composition and Energetics of the Upper Neutral Atmosphere. As part of the larger Focus Science Topic, this work will contribute simulations of the structure and/or motions of the plasma density at various latitudes, establishing a quiet-time baseline for the variation and variability of the mid- and low-latitude IT system that can enhance or suppress the growth of low-latitude instabilities at various longitudes. The proposal team will work with the full FST team to quantify the relative contributions of other ionospheric drivers on the Rayleigh-Taylor Instability growth rate. This work uses a comprehensive set of publicly available data, including that from NASA (CINDI, GOLD, ICON, TIMED, MLS).

# Publication References:

no references