Validation of space based equatorial plasma bubble measurements using ground based observations

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Abstract

Observations of the nighttime 135.6-nm emission made by the Special Sensor Ultraviolet Spectrographic Imager (SSUSI) on board the Defense Meteorological Satellite Program (DMSP) F18 satellite are used to detect and study postsunset ionosphere irregularities called equatorial plasma bubbles (EPBs). These structures tend to occur after local sunset, have widths on the order of 100 km, and can extend in latitude into the tropical ionosphere. Small-scale irregularities associated with the EPBs can cause scintillations on trans-ionospheric radio waves. Observations from a space-borne platform, such as SSUSI allow for the generation of global statistics of the occurrence and morphology of EPBs. However, these observations need to be validated to understand the limitations caused by viewing geometry and resolution considerations and how they affect the ability of SSUSI to detect EPBs. An algorithm has been developed that compares the detection, location and width of the EPBs observed by SSUSI on DMSP and the ground-based Cornell Narrow Field Imager (CNFI) located on the Haleakala Volcano on Maui, Hawaii. The results of this comparison provide useful information of the ability of SSUSI to accurately detect EPBs as well as their spatial characteristics. It also demonstrates the importance of validating space based measurements using ground based observations.

EPB detection algorithm

- Northern hemisphere SSUSI data and CNFI data are projected along IGRF field lines to magnetic equatorial plane to get a direct visual comparison
- SSUSI and CNFI images are passed through median filtering
- The algorithm runs for the north hemisphere and takes latitude cuts from 5° to 17° for each night
- For each latitude cut, the width and center of all located bubbles are calculated by finding the local minima and maxima, and by creating a unique max-min-max combination for each bubble
- Process is repeated for all 53 nights that bubbles are observed

Data selection

- DMSP orbit is selected around 15N,203E to correspond to the center of the CNFI imager
- Data were selected for the period spanning 2011-2014 from Equinoxes and June solstice where there is an increased EBP occurrence between 1830 and 2100LT
- Dataset consists of 220 nights; 53 had visually observable bubbles in CNFI data
- SSUSI data were binned onto a uniform 0.5 x 0.5 degree grid

Results

- For all 53 nights, bubble detection is performed for both SSUSI and CNFI
- Results are categorized into 4 cases

- Bubble missed detections are mainly due to:
  1. the viewing geometry
  2. low signal-to-noise ratio due to low background emissions
  3. bubbles having a width smaller than the spatial resolution of SSUSI

Conclusions

- Ground based measurements can help identify misdetections and validate bubble detection from space measurements
- Limitations of space instruments (i.e., resolution) can be determined
- Algorithm successfully detects 96% for CNFI and 68% for SSUSI, of the 53 visually identified EPBs in CNFI

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References