Meso-Scale Flow Bursts in the High-Latitude Ionospheric Convection Pattern

B.E. Lance† and R.A. Heelis

William B. Hanson Center for Space Sciences, Physics Department, The University of Texas at Dallas

†brandone.lance@utdallas.edu

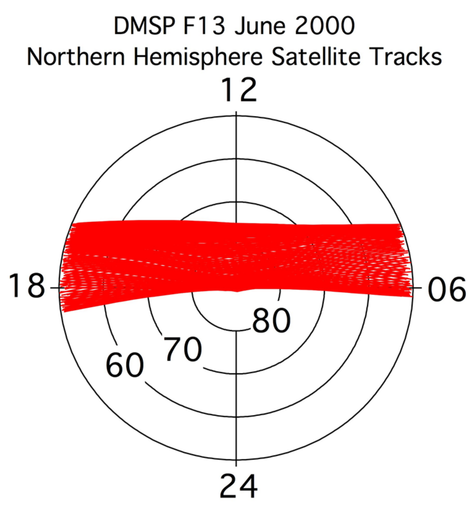
Objective

In this work we undertake a preliminary study to investigate the distribution of spatial scales and plasma flow speeds of features that are embedded within the large-scale convection pattern.

Introduction

- Southward IMF yields a large scale two-cell pattern, with antisunward flows at high latitudes and sunward flows at lower auroral latitudes.
- Northward IMF causes the two-cell pattern to evolve into three- or four-cell patterns, still at the largest of scales.
- Studies of these patterns have produced empirical models dependent on the state of the interplanetary medium. These are used in many models of the coupled ionosphere and thermosphere.
- Recent research suggests substantial EM inputs are deposited into the thermosphere over much smaller scale sizes than these large-scale convection patterns.
- This implies that meso-scale features with spatial scales of several hundred kilometers could be important contributors to the energy/momentum transfer between charged and neutral gases.

In this exploratory study we utilize data from the Defense Meteorological Satellite Program (DMSP) F13 satellite which traverses the ionosphere along the dawn dusk meridian at an approximate altitude of 840 km. The track of the satellite across the northern hemisphere for a typical month may be seen in the figure below.

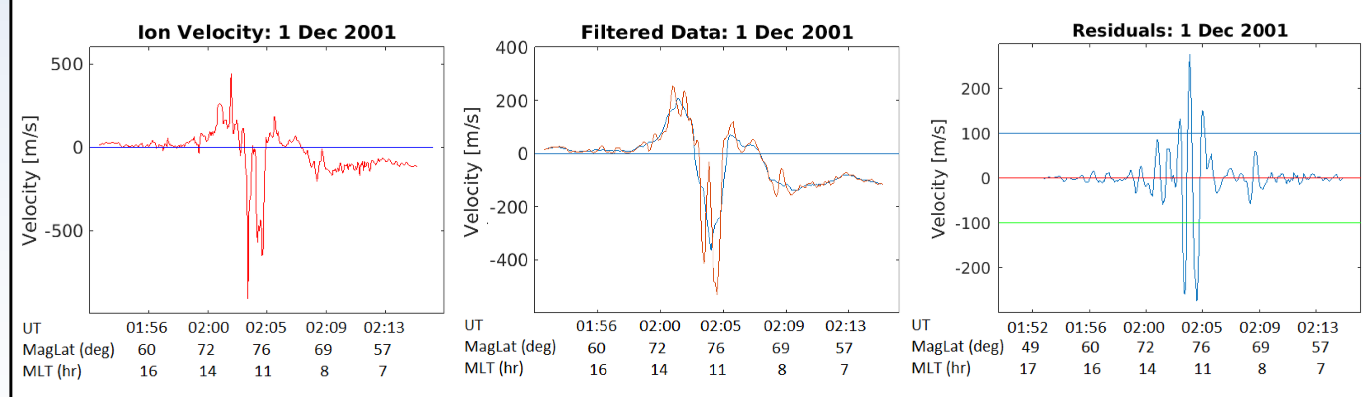


Abstract

Meso-scale convection features are embedded in the larger scale two-cell convection pattern and may contain flow speeds in excess of the background that represent a significant source of heat and momentum to the neutral atmosphere. In order to approach a description of these features it is necessary to describe the spatial scale size of the flow feature, the speed of the flow and the residence time. Here we present a preliminary investigation of the spatial scale of flow bursts at high latitudes observed by the Defense Meteorological Satellite F13 which describes a dawn-dusk orbit across the northern hemisphere. We examine the distribution of scale sizes in flow features in the auroral zones and polar caps, and their relationships to flow cells embedded in the larger scale convection pattern.

Approach

- Data is from the Special Sensors—Ions, Electrons, and Scintillations (SSIES). Ion drift velocity perpendicular to the satellite track allows identification of regions of sunward and anti-sunward flow across the high latitude region.
- Time resolution of 4 seconds and satellite velocity of approximately 7500 m/s provides a signature of the high latitude convection patterns, as well as embedded structures, at scale sizes greater than 60 km.

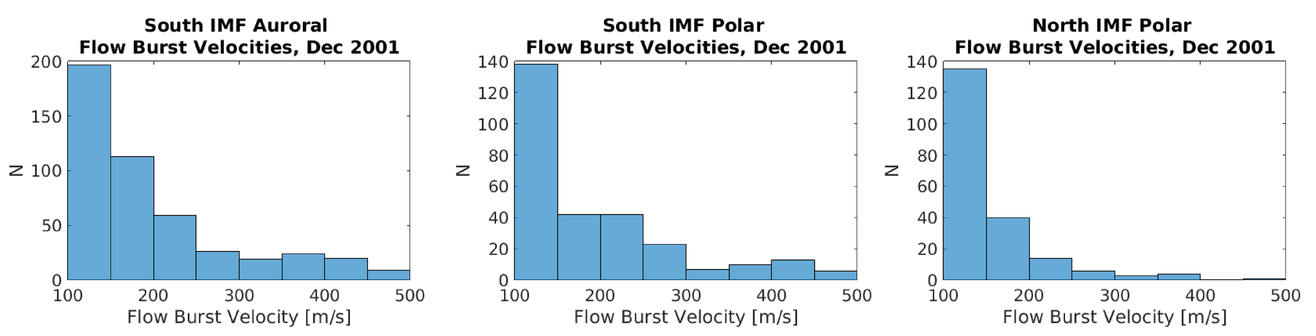


- Convection signatures are filtered to attenuate features with scale sizes less than 90 km.
- Underlying large-scale convection features revealed by filter to attenuate features with scale sizes less than 500 km.

- Meso-scale features with spatial scales between 90 km and 500 km are obtained by removing large-scale background from the initially filtered convection signatures.
- Characterizations of these features include flow burst spatial scale and location; Flow burst direction (sunward/anti-sunward) and Peak Flow Speed

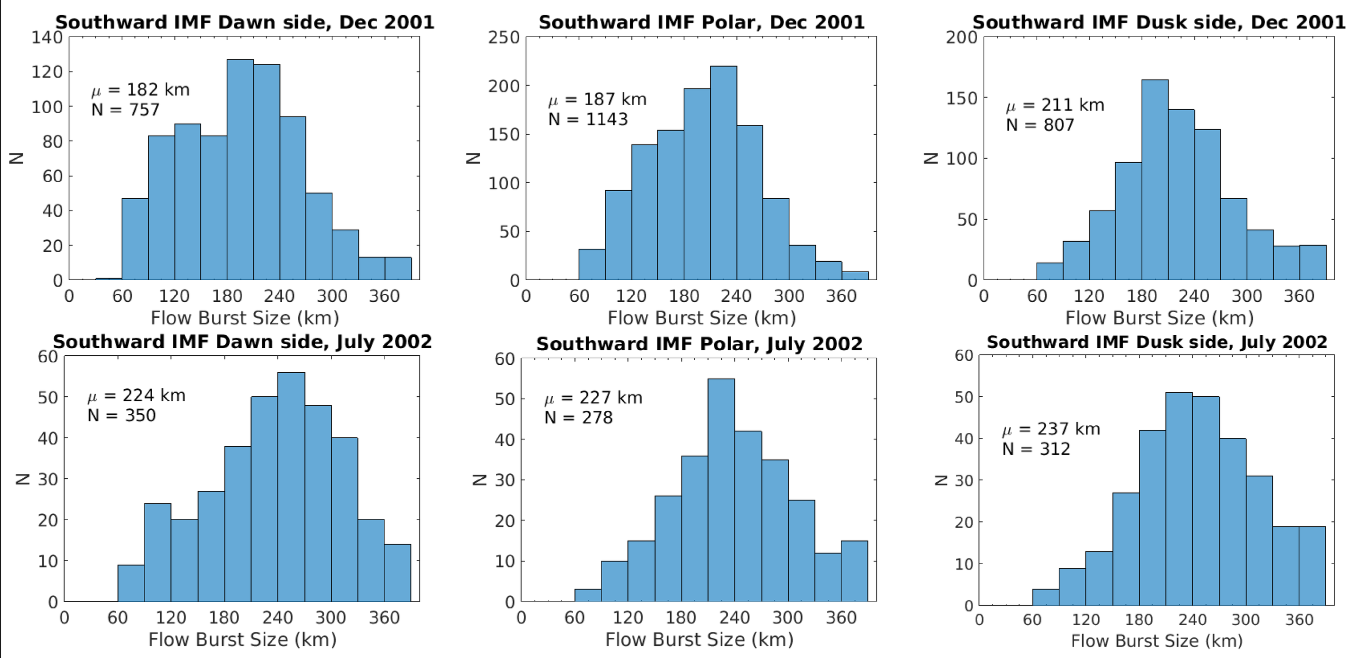
Outcomes & Observations

- We first examine characteristics of flow burst scales based on season, direction of the IMF, and the latitudinal region e.g. auroral zone or polar cap.
- These regions are defined only by latitude.



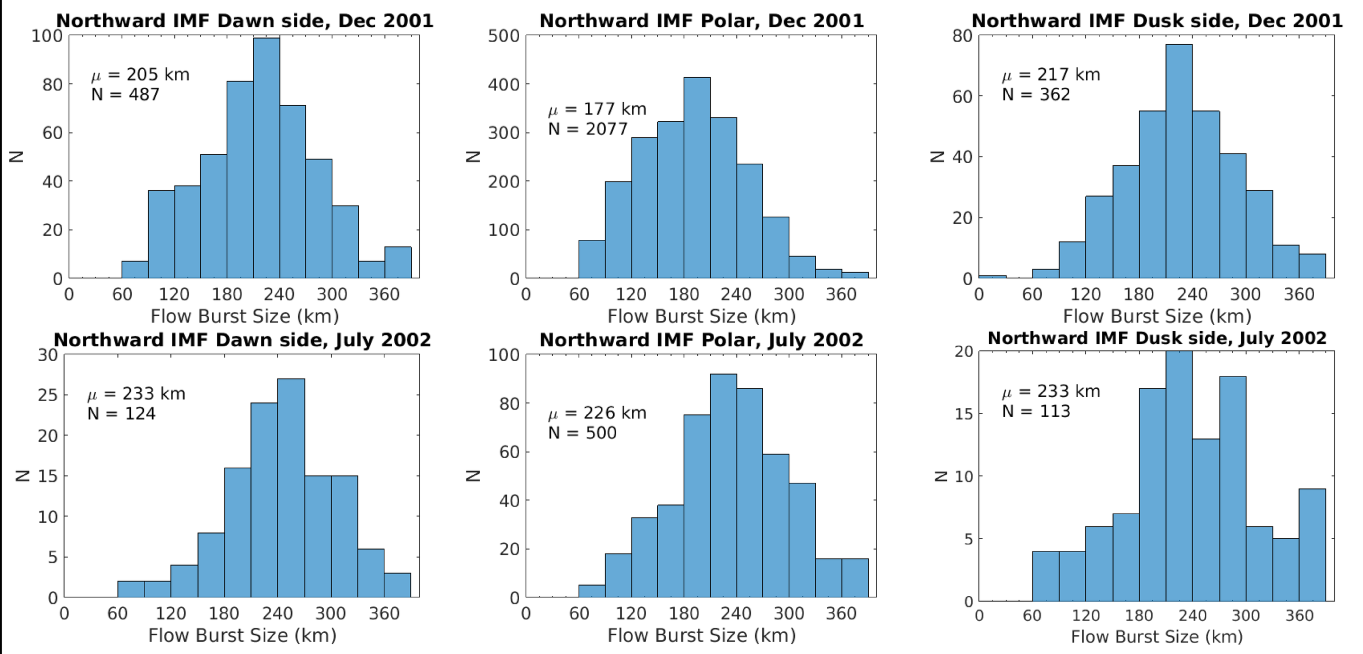
- There are more high speed flow bursts for the southward IMF versus the northward IMF.
- There are more high speed flow bursts for the southward IMF auroral region versus the polar region.

Outcomes & Observations, continued



Southward IMF

- More flow bursts in winter than summer
- Median scale size is smaller in winter (190 km) than in summer (220 km)
- Distribution skewed to smaller scales in dawn side and larger scales in dusk side.



Northward IMF

- Entire convection pattern shrinks to high latitudes.
- Distinction between auroral zone and polar cap by latitude is lost.
- More flow bursts in winter than summer
- Median scale size is smaller in winter (200 km) than in summer (230 km)
- Distribution skewed to smaller scales in winter and larger scales in summer.

Conclusions

- Flow bursts have a characteristic scale size near 200 km.
- Smaller scale sizes preferred within the morning auroral zone for southward IMF
- Larger Magnitude Flow bursts preferred when IMF is southward.

Next Steps

- Examine Flow burst magnitude w.r.t. background flow.
- Examine Prevailing conditions for large flow burst magnitudes.