High Altitude Observatory

Early Morning Upward Ion Drifts at the Geomagnetic Equator

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Abstract:

Observations from Jicamarca Incoherent Scatter Radar show a tendency for ion drifts in the early morning period on some days to be upward, instead of the downward direction that empirical models predict. Potential relationships with certain geophysical parameters and conditions are examined using drift data gathered from the CEDAR database, and geophysical data taken from OMNIweb. It is found that there is no discernible relationship with season. Relative occurrences appear to be higher as kp-values increase and occurrences drop sharply with increasing F10.7 values. The north-south component of the magnetic field (Bz) appears to have the strongest correlation with the drift behavior out of the examined geophysical parameters, and a pattern emerges in which the vertical drifts sometimes mimic the behavior of Bz, but not in all cases. This may be suggestive of an electric field penetration, or another complex relationship involving Bz, which is influencing the drifts.

Data:

Vertical ion drift data was extracted from Jicamarca ISR data files from the CEDAR database. Select geophysical data taken from OMNIweb data files included kp, F10.7, solar wind speed, proton density, Bz, and By. Data were plotted using Matlab to observe any patterns between drift and geophysical parameters, and basic statistics were examined to discern any dependence on certain conditions, such as kp, F10.7, and season. Jicamarca is costly to operate and there is not continuous data available. In all, there are 224 useful days of data spanning 1984 to 2008.

Average Daily Ion Drifts 1984-2008

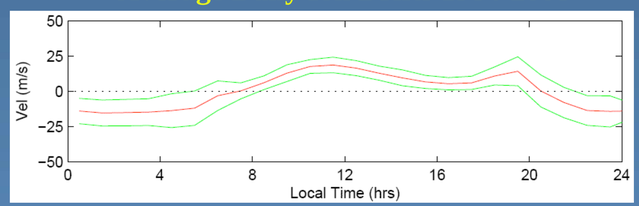

Fig 1. Daily ionospheric drift at Jicamarca, averaged from 1984 to 2008 (red line). ±0.5 σ (green lines).

"Events" versus "Non Events"

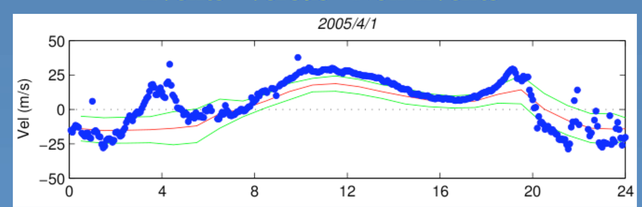

Fig 2(a). Example of early morning upward drifts, referred to as an "Event" for the purposes of this correlation study.

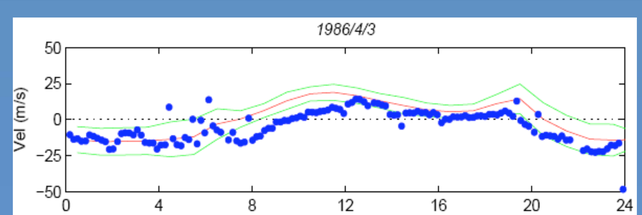

Fig 2(b). Drift data which falls within ±0.5 σ is considered normal variation, and is counted as a Non-Event. Drift data that is not positive also constitutes a Non-Event

Examples:

While this study did find some distinct correlations with some of the geophysical parameters considered, particularly the behavior of the north-south magnetic field, they are not absolute. Bz appears to be correlated with the drift behaviors on most days, however on some days there appears to be no link between Bz and the drift behaviors, and it should be considered that a complex relationship is behind the upward early morning drifts.

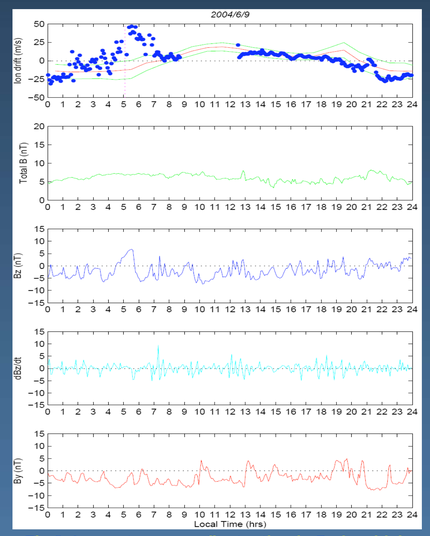

Fig 3. In most cases, a fluctuation in Bz in which polarity swtiches from negative to positive with a stronger relative magnitude is correlated with a strong upward ion drift.

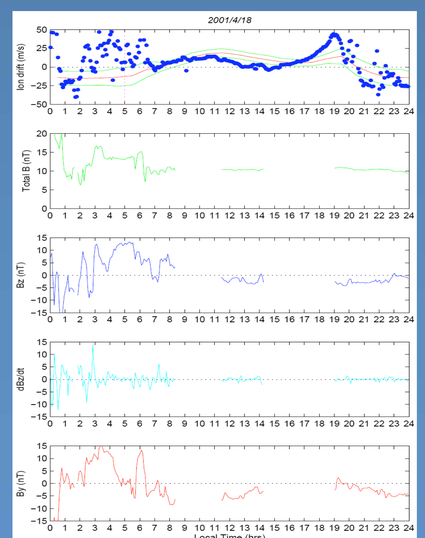

Fig 5. Strong fluctuations in Bz in which polarity switches several times in a short time span seem to correspond to the appearances of "bubbles" in the drift data.

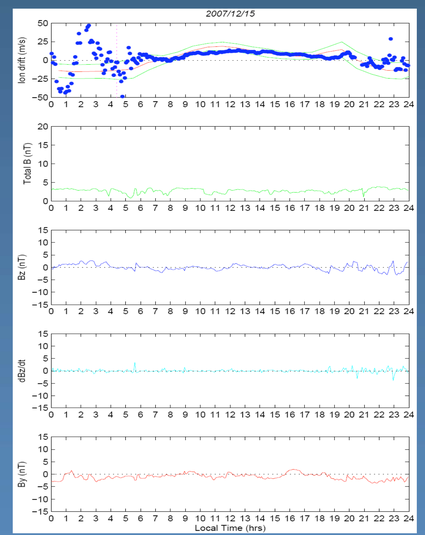

Fig 4. In some cases, this correlation seems to not exist when looking at 5-minute data instead of the hourly data. There is no strong relative fluctuation in Bz apparent in the 5-minute data, but a significant upward ion drift still occurs.

Statistical Results:

The events were divided by season, kp-value, and F10.7 to determine if there was any correlation between these geophysical parameters and the behavior of the early morning drifts. The behavior of Bz and By were then considered and compared to the drift behavior to note any correlations.

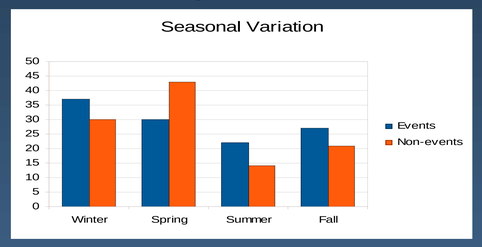

Fig 4. Events and Non-Events separated by season. Both Events and Non-Events occur at all times of the year and appear unrelated to season.

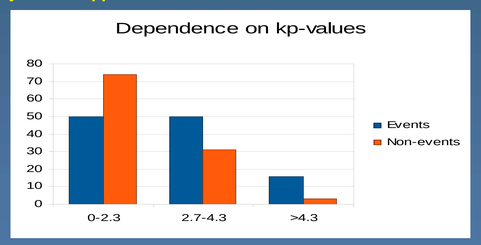

Fig 5. Events and non-Events binned by kp-values. Events appear to occur in greater numbers relative to Non-Events with increasing kp-values.

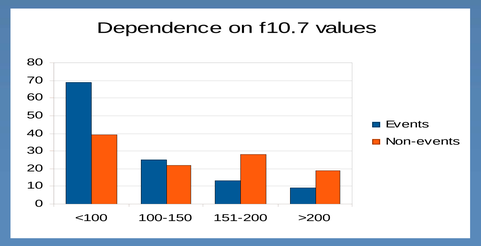

Fig 6. Events and Non-Events binned by f10.7 values. Non-Events seem to stay at comparable relative numbers regardless of f10.7 values, but there are significantly more Events at f10.7 values less than 100, and these drop off sharply as f10.7 increases.

Conclusion:

The events occur at all times of year, and are most likely not influenced by season. There are more events occuring relative to non-events with higher kp-values. There are significantly higher events at low F10.7 values, and the occurrence of events drops significantly as F10.7 values increase. By does not show any significant correlation with the drift behaviors, but in the most prominent upward drift events, a strong (5-10 nT) change in Bz involving a polarity switch almost always also occurs.