Characteristics of ripple structures revealed from long-term OH airglow images

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Abstract
Using the dataset observed in the mesopause region by an OH all-sky imager at Yucca Ridge Field Station, Colorado (40.7° N, 104.9° W) from 2003 to 2005, we study the characteristics and seasonal variations of ripple structures. Analyzing simultaneous observations of background wind and temperature by a nearby sodium temperature/wind lidar at Fort Collins, Colorado (40.8° N, 105° W) and a Medium Frequency (MF) radar at Platteville, Colorado (40.2° N, 105.8° W), we are able to statistically study the possible relation between ripples and the background atmosphere conditions. Characteristics and seasonal variations of ripples have been presented in detail in this study. In addition, more than half of observed ripples do not advect with background flow, which have higher Richardson number than other ripples advect with background flow. The former ripples are possibly not instability features, but wave structures that are hard to distinguished from the real instability features.

1. Introduction
1.1 What is ripple structures?
Waves crests: typically 3-10 number lifetime: less than 45 min (5-20 min)
λ h: 5-15 km

1.2 Sources:
Small-scale ripple structures, observed in OH airglow images, are believed to be induced by either dynamic instability due to large wind shear or convective instability due to super-adiabatic lapse rate.

2. Data and Methods
2.1 Data

<table>
<thead>
<tr>
<th>Data</th>
<th>Station</th>
<th>Altitude</th>
<th>Temporal resolution</th>
<th>Vertical resolution</th>
<th>Space range</th>
</tr>
</thead>
<tbody>
<tr>
<td>All-sky OH imager</td>
<td>Yucca Ridge Field Station</td>
<td>40.7°N, 104.9°W</td>
<td>2 min</td>
<td>2 km</td>
<td>500 km x 500 km</td>
</tr>
<tr>
<td>CSU Sodium lidar</td>
<td>Fort Collins, CO</td>
<td>40.6°N, 105°W</td>
<td>15 min</td>
<td>2 km</td>
<td></td>
</tr>
<tr>
<td>MF Radar</td>
<td>Platteville, CO</td>
<td>40.2°N, 105.8°W</td>
<td>1 hr</td>
<td>3 km</td>
<td></td>
</tr>
</tbody>
</table>

2.2 Methods
(1) The OH image data is preprocessed, a method of time differencing images to find the possible ripples and calculate the parameters of ripples.
(2) Select days of ripples appear when lidar also works.
(3) Calculating the Squared Brunt-Vaisala frequency (N²) and Richardson number (Ri) to estimate the instabilities when ripples appear.
(4) Comparison of ripples moving directions and background wind directions.

3. Results and Discussion
3.1 Seasonal Variations and Features

3.2 Correlation between ripples and Instabilities

4. Conclusion

3.3 Relation between ripples and background winds

Figures shows that more than half of ripples do not actually advect with background winds, which is different from the previous works. Pritts et al., 1997; Hecht, 2004. These ripples not advect with background winds have much larger speed difference with background winds, and have higher Ri than other ripples advect with background flow. We still couldn’t fully understand why more than half of ripples do not advect with the background winds. However, these ripples are possibly not the instability features; rather, they are wave structures that are hard to distinguish from the real instability features.

Reference

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