The Equatorial OH Airglow Analysis by ISUAL Instrument on Board the FORMOSAT 2 Satellite

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Abstract

Airglow is a phenomenon caused by chemical reactions in the mesosphere and thermosphere, which emit visible light at specific wavelengths. Airglow can act as a tracer for certain chemical species, and can be used to infer temperature and wind velocity. As preparation for long term ground-based airglow observations in Taiwan, OH airglow near the mesopause (630 nm wavelength) observed by the ISUAL (Imager of the Sprites and Upper Atmospheric Lightning) instrument on board FORMOSAT 2 is analyzed. The satellite is sun-synchronous and ISUAL CCD camera is limb view scan, so we can use these properties to study the vertical structure of the upper atmosphere in detail. In order to avoid noise from sunlight, the scanning region must avoid the summer hemisphere. Due to this reason, the observations in the middle and low latitudes are much better than the regions approaching the pole. OH airglow is at about 80–90 km altitude, so we can study the phenomenon in mesosphere and lower thermosphere (MLT) region via OH airglow research. In this report, I choose the images in 2007 of 630 nm filter channel on ISUAL CCD camera to discuss the variation of OH airglow in the low latitude region.

Introduction

Airglow is a kind of Chemiluminescence due to the transition between different energy levels in the upper atmosphere. Figure 1 and Table 1 show the different emission layers in the mesosphere and thermosphere regions. OH airglow (Meinel band) is at about 80–90 km and the main chemical reaction for Meinel band (9,1)(630 nm) is : 

\[ H + O_2 \rightarrow OH \quad \text{with} \quad \text{V}_\text{rot} = 0 \quad \text{and} \quad \text{V}_\text{trans} = 0.9 \]

FORMOSAT-2 is a sun synchronous satellite, so that ISUAL is able to study the airglow continuously and repeatedly everyday at the same local time. Figure 2 shows the orbit of FORMOSAT-2 in 2007.

Results and Discussion

Table 1. The information of different airglows

<table>
<thead>
<tr>
<th>Transition Process</th>
<th>Type</th>
<th>Wavelength (nm)</th>
<th>Peak Altitude (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>O (2P → 1D)</td>
<td>OH Red Line</td>
<td>630</td>
<td>~250</td>
</tr>
<tr>
<td>O (2S → 1D)</td>
<td>OH Green Line</td>
<td>557.7</td>
<td>~97</td>
</tr>
<tr>
<td>Na (2P → 3S)</td>
<td>D lines</td>
<td>589, 6, 589</td>
<td>~90</td>
</tr>
<tr>
<td>OH(X)</td>
<td>Meinel bands</td>
<td>600–2000</td>
<td>~87</td>
</tr>
</tbody>
</table>

Data processing

1. Take the range of longitude about 70°E–180°E (East Asia)
2. Scale the mean brightness of the right CCD to match that of the left CCD:
   - There are two CCD sensors in the ISUAL camera (figure 3). We must make background balance in each CCD sensor.
3. Locate the OH airglow on ISUAL images.
4. Compute the mean vertical profile of the OH airglow layer using the central 100 columns (figure 3 black region).
5. Continue this process for all images along the orbit to get vertical profiles across multiple latitudes.

Summary

1. As preparation for long term ground-based photometer in Taiwan, OH airglow is observed by FORMOSAT-2 by using CCD camera at 630nm.
2. To avoid the noise from sunlight, the observing region is focus on winter hemisphere region.
3. The peak intensity region may transfer to the winter hemisphere. (Figure 4)
4. The ground-based observation is helpful to analysis the peak intensity transfer.

Future Direction

- The figure in right hand side is the goal of the ground-based photometer system. It contains telescope, filter wheel, motor, and photomultiplier (PMT). Because of the long term observation, we also need the cooling system.
- We can study the circulation between mesosphere and thermosphere (figure 5) via doing a long term airglow observation.

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Reference

2. Fazhul I. Laskar and Duggirala Pallamraju (2014)

Fig. 1. The emission layers in upper atmosphere

Fig. 2. The sun synchronous orbit of FORMOSAT-2. Left hand side is in the northern hemisphere summer, right hand side is in the northern hemisphere winter. Because of the noise from the sun, ISUAL avoids measuring the summer hemisphere.

Fig. 3. The limb view image of OH airglow on 6 January 2007. The intensity is different in left hand side and right hand side because there are two CCD chips joined together in the camera. The black region is centered 100 columns OH airglow region.

Fig. 4. The OH airglow intensity integrate with height.

Fig. 5. The circulation in mesosphere. The temperature in winter hemisphere is higher than in the summer hemisphere.