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On the derivation of temperature from dayglow emissions on Mars' upper atmosphere

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Abstract

We have used a General Circulation Model able to simulate dayglow emissions on Mars to quantify the accuracy of the temperatures derived from the scale height of the CO_2^+ UV doublet and the Cameron bands on Mars. While the temperature derived from the UV doublet is accurate between about 160 and 200 km and at low solar zenith angles, the temperature derived from the Cameron bands is usually more than 20 K far from the actual temperature. The difference in the temperature derived from both emission system can provide information on CO abundance.

1. Introduction

The analysis of the UV atmospheric emissions arising from Mars' upper atmosphere has been used since the Mariner missions in the 60s to obtain information about this region, very difficult to sound by other means [2, 3, 4, 5]. On the dayside of Mars, two of the most prominent emission systems, the CO Cameron bands and the CO_2^+ UV doublet, are originated by the interaction of the solar radiation with CO_2, the dominant species on Mars. The altitude variation of these emissions has long been used to derive atmospheric temperatures in the thermosphere, under the assumption that all the emission is originated from CO_2. However, this assumption has never been tested and the accuracy of the derived temperature has never been characterized.

2. Methods and results

We have developed the first global model able to simulate the Martian dayglow, which was used to simulate the variability of the dayglow emission during a full Martian year and to compare it with measurements by the SPICAM instrument on board Mars Express [1]. At a set of 10000 randomly distributed locations, seasons and local times, we have then derived temperature profiles from the altitude variation of the simulated emissions and also directly from the CO_2 density profile. We have compared these temperatures with the actual temperature profiles predicted by the model (see Fig. 1). This has allowed us to characterize the errors introduced by the derivation of temperatures from the dayglow emission and to identify the conditions under which this derivation provides good agreement with the actual temperature profile.

We find that the temperature derived from the UV doublet is generally less than 5 to 10 K far from the actual temperature between about 160 and 200 km of altitude from the surface and at relatively low values of the Solar Zenith Angle. On the contrary, the temperature derived from the Cameron bands differs in at least 20 K from the actual temperature. This is because the emission in the Cameron bands has a significant contribution from the CO electron impact excitation [1], which makes the scale height of the emission to depart from that of CO_2. We have also found that the difference of the temperature derived from the CO_2^+ UV doublet and the Cameron bands can provide quantitative information on the abundance of CO in the Martian upper atmosphere.

Finally, we have also derived temperatures from the emission profiles measured by SPICAM, and the conclusions about the accuracy of the derived temperatures have been applied to this dataset.

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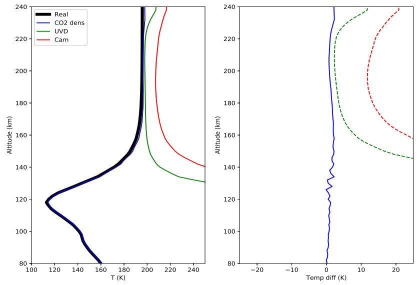

Figure 1: Left: Comparison of the actual temperature profile predicted by the GCM at a given location (black line) with the temperature profiles derived from the CO_2 density profile (blue line), the CO_2^+ UV doublet (green line) and the Cameron bands (red line). Right: Difference with respect to the actual temperature profile

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