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Simulations of Sulfur Oxide Profiles in Venus' Mesosphere

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Abstract

Preliminary results using a 1-dimensional model with a simplified photochemical scheme suggest the inclusion of both $ClSO_2$ and SO_2Cl_2 in the model and adjustment of selected reaction rate coefficients within their standard uncertainties can produce at least a factor of two upper mesosphere inversion for SO_2. The results from simulations using a more comprehensive photochemical model will be presented.

1. Introduction

The primary sulfur species in Venus' atmosphere, sulfur dioxide (SO_2), is a precursor for the sulfuric acid that condenses to form Venus' global cloud layers and may be a precursor for the unidentified UV absorber(s), which, along with CO_2 near the tops of the clouds, appears to be responsible for absorbing about half of the solar energy deposited in Venus' atmosphere [1]. Published simulations using standard photochemistry [2,3] indicate the mixing ratio of SO_2 should decrease roughly monotonically with increasing altitude as the source for SO_2 is the troposphere, although a small inversion is evident in one set of simulations [3]. Observations, however, despite disagreeing on the magnitude of the phenomenon, have consistently found an inversion layer in the upper mesosphere (above about 85 km altitude) where the mixing ratio of SO_2 increases with increasing altitude [4,5,6]. Simulations using H_2SO_4 as the medium for transporting sulfur from the lower mesosphere to the upper mesosphere that replicated the upper mesosphere SO_2 inversion layer [2,7] either required assumptions that stretch the boundaries of known laboratory data or had a calculated H_2SO_4 abundance that exceeds the observational upper limit on upper mesospheric gaseous H_2SO_4 [8]. S_8 remains as a viable alternative medium by which sulfur can be transported from the lower mesosphere to the upper mesosphere but there are significant uncertainties due to lack of laboratory data [7]. Another possible alternative is transport via a combination of sulfur-chlorine-oxides [9].

2. Photochemical Model

The Caltech/JPL photochemical model [10] was used for the numerical simulations. It applies a common core of atmospheric physics to all planets, drawing planet-specific information from custom databases, and converges to a steady-state solution via a finite-difference iterative algorithm. For these simulations, the 1-d continuity equation is solved simultaneously for all species over 58–110 km altitude. Vertical transport via eddy diffusion is set based on observations, as are the lower boundary conditions for HCl, CO, and OCS.

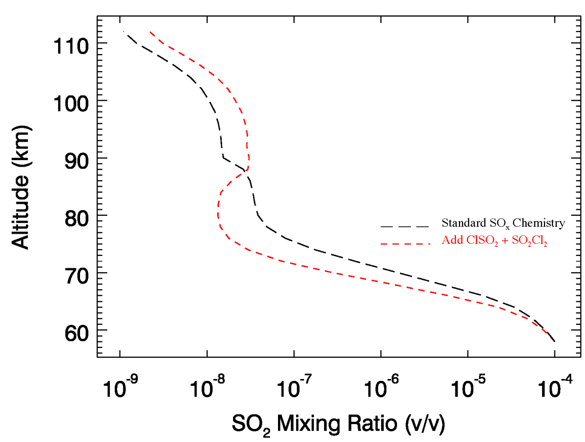

Figure 1: Simulated SO_2 mixing ratio using a modified version of the Zhang et al [2] model with SO_2Cl_2 and $ClSO_2$ (red short-dashed) and without (black long-dashed) [after 9].

3. Summary and Conclusions

Preliminary results using a modified version of the Zhang et al [2] model suggest the inclusion of both $ClSO_2$ and SO_2Cl_2 in the model and adjustment of selected reaction rate coefficients within their standard uncertainties can produce at least a factor of two upper mesosphere inversion for SO_2, Figure 1. The results from simulations using a more comprehensive photochemical model will be presented.

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