Selection of an atmospheric reference model and branching ratios for numerical modeling of gravity wave-airglow interactions

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Introduction

• Because a change in the density of the species reacting in the airglow chemistry will undoubtedly produce changes in the airglow emissions, it is of great interest to investigate and assess the impact of the atmospheric reference model commonly used in modeling studies.

• The simulated wave-induced secular variations and fluctuations of O(1S) greenline and O3(0,0) atmospheric band change when different values are assigned to the branching ratios e and a [Huang and George, 2014].

• There is currently a significant discrepancy in the values used for the branching ratios in the three-body recombination reaction. For instance, Hickey et al. [1993] use e = 0.8 and ε = 0.11, Snively et al. [2010] use e = 0.03, and Huang and George [2014] use e = 0.04 and ε = 7 × 10⁻².

Chemistry Dynamics Model

• Upper boundary: 130 km

• Lateral boundary: periodic, separated by one horizontal wavelength

• Vertical grid spacing: 0.1 km

• Horizontal grid spacing: 1 km

• Time step: 3 sec

• Wave forcing set at 10 km

• Major gases: N₂ and O₂ and temperature at 18°N are obtained from MSIS-90 and NRLMSISE-00

Atmospheric reference model in gravity waves- airglow studies

I. Objective of the study

• Assess the impact of atmospheric reference model in gravity wave-airglow simulations.

II. Importance to the field

• Provides insight for the interpretation of airglow observations and for investigation of energy & momentum transfer in the atmosphere.

III. Methodology

• CMA-ES
  o Bio-inspired algorithm
  o Performs real-valued single-objective optimization
  o Population-based strategy
  o Self-adaptive

Using a numerical optimization approach to find branching ratios

I. Objectives of the study

• Estimate the set of branching ratios e & a involved in the three-body recombination reactions.

II. Importance to the field

• Important for practical applications (i.e. atmospheric models) and to understand fundamental chemistry mechanisms.

III. Methodology

• CMA-ES
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IV. Observations

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IV. Results

• Good agreement between observations and simulation.

• O(1S) altitude diff: 1.86 km

• O3(0,0) altitude diff: 0.45 km

Conclusions

• We present the up-to-date results of our numerical model.

• We show how changes in temperatures and species concentrations indeed have a great impact in the computed airglow intensities.

• Using a numerical optimization approach (CMA-ES), we match the simulated O(1S) and O3(0,0) VERs to VERs from observations to find optimal set of branching ratios.

• We found that the average values for the branching ratios were e = 0.1648 and a = 0.0185.

References

[3] Huang, Y., and J. E. Hickey (2005), Simulations of gravity wave-induced variations of the O(1S), O3(0,0), and O3(1S) airglow emissions in the northern winter, J. Geophys. Res., 110, A10306, doi:10.1029/2004JA010920.
[5] Snively, J. B., V.P. Pasko, and M.J. Taylor (2010), OH and OI airglow layer modulation by ducted short period gravity wave-induced fluctuation in the O2 atmospheric (0,0) altitude diff: 0.55 km

• O3(0,0) altitude diff: 2.49 km

• O(1S) altitude diff: 1.9 km

• Excellent agreement for the peak VER values.

• Average branching ratios values: e = 0.1648 and a = 0.0185

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