Introduction

Aside from Earth, Venus is the most studied planet. When learning about exoplanets, Venus is a more typical environment than Earth or Mars. Believed to once have liquid water, but the runaway greenhouse effect dried up the planet.

Models are excellent tools to perform simulations that help teach us more about how planets may have changed over time. This project is presenting the introduction of a new Venus model derived from an existing Earth-based ionosphere-thermosphere model called the Global Ionosphere Thermosphere Model (GITM).

Model Description

GITM is a well-established, physics-based, 3D spherical code that couples the ionosphere and thermosphere of Earth [Ridley and Deng, 2006]. The dynamics and chemistry are solved for the neutrals, ions and electrons. Versions of GITM were developed for Mars, Earth and Titan.

Some unique characteristics of GITM:
- Uses an altitude grid instead of a pressure grid
- Does not assume hydrostatic equilibrium allowing for vertical velocities to be explicitly solved for
- Makes use of FISM fluxes

Simulation Results

In this section, we describe a simulation that illustrates the current state of the Venus Global Ionosphere Thermosphere Model (V-GITM) and how well it computes the thermosphere and ionosphere during solar minimum conditions. (1) Density profiles, (2) winds in the meridional, zonal and vertical directions, (3) temperature profiles, (4) heating rates and (5) the resulting ionosphere are shown.

1. Neutral Density Profile

The neutral densities are plotted for F10.7 = 80 conditions in Figure 1. The resulting ionosphere are shown.

2. Temperature Profile

Figure 2.
- The lower atmosphere temperatures are strongly dictated by balance of the IR heating and CO2 15 micron cooling.
- Gilli et al., 2021 has an updated parameterization for the IR heating that should be used.
- The radiative cooling code originates from the Laboratoire de Meteorologie Dynamique (LMD) group. This cooling was developed for Mars originally and so additional calibration for adapting to Venus may be needed.

3. Ionosphere

V-GITM only has two ions (CO2 and O2) currently calculated due to a simplified set of chemistry applied in the model. Atomic oxygen, NO, and carbon monoxide ions will be added in the future.

- Ionization due to the solar radiation is the primary driver of the ion density.
- Charge exchange has a lower impact on the ion population.
- The densities and ion peak altitudes are reasonable compared to Fox and Sung, 2001 results.

Science questions to answer:
- Once density, winds and temperature structure in V-GITM are closer to satellite measurements, this model can be useful in answering some outstanding questions in the Venus community.

Contact Information

- Brandon M. Ponder: bponder@umich.edu
- Steve W. Bougher: bougher@umich.edu
- Aaron J. Ridley: ridley@umich.edu
- Dave J. Pawlowski: dpawlows@emich.edu

References

