INCORPORATING PLANETARY-SCALE WAVES INTO THE VTGCM: UNDERSTANDING THE WAVES' IMPACT ON THE UPPER ATMOSPHERE OF VENUS. A. S. Brecht[1], S. W. Bougher[2], D. Shields[3], H. Liu[4], [1]NASA Ames Research Center, M/S 245-3, Moffett Field, CA, 94035, USA (Amanda.S.Brecht@nasa.gov), [2]CLaSP, 2418C Space Research Building, University of Michigan, Ann Arbor, MI, 48109, USA, [3]NCAR/HAO, Boulder, CO, 80301, USA.

Introduction: Venus has proven to have a very dynamic upper atmosphere. The upper atmosphere of Venus has been observed for many decades by multiple means of observation (e.g. ground-based, orbiters, probes, fly-by missions going to other planets). As of late, the European Space Agency Venus Express (VEX) orbiter has been a main observer of the Venusian atmosphere. Specifically, observations of Venus' O_2 IR nightglow emission have been presented to show its variability (e.g. [1], [2], [3], [4]). Nightglow emission is directly connected to Venus' circulation and is utilized as a tracer for the atmospheric global wind system. More recent observations are adding and augmenting temperature and density (e.g. CO, CO2, SO_2) datasets (e.g. [5], [6], [7], [8]). These additional datasets provide a means to begin analyzing the variability and study the potential drivers of the variability. A commonly discussed driver of variability is wave deposition. Evidence of waves has been observed, but these waves have not been completely analyzed to understand how and where they are important. A way to interpret the observations and test potential drivers is by utilizing numerical models.

Results and Discussion: For the presented work, the 3-D Venus Thermospheric General Circulation Model (VTGCM) will be utilized in understanding the impact implementing planetary-scale waves at the VTGCM lower boundary (near the top of the cloud deck) will have on the thermospheric structure and variability (~70 – 200 km). Currently, the VTGCM utilizes Rayleigh friction (RF) to help simulate mean thermospheric conditions observed by VEX. Two RF scenarios are utilized: one is symmetric to provide a constant deceleration to the winds (RF-sym) and the second is asymmetric to simulate the retrograde superrotation zonal wind (RSZ) [9]. The purpose of RF is to obtain a 1st order approximation of the necessary wave deposition to reproduce observations. Therefore, the RF provides guidelines for the implementation and adjustment of wave momentum deposition schemes.

Kelvin waves have been incorporated within the VTGCM, but most importantly the Kelvin wave implementation has also been tested with a self-consistent moving lower boundary (winds are not equal to zero and temperature is not constant). The moving lower boundary is composed of non-uniform zonally averaged temperature, zonal wind, meridional wind, and geopotential height at the lower boundary of the VTGCM as provided by the Oxford Venus GCM [10], [11].

Figure 1 represents initial tests with Kelvin waves within the VTGCM and its impact on the O_2 IR nightglow peak integrated intensity with respect to time (days) of simulation. The last 8 days of a 51 day simulation are shown. There are four cases shown: (1)[KW] this is a simulation with RF-sym and Kelvin waves, (2) [NoKW] is a simulation with only RF-sym, (3) [KW+OXVGCM] is a simulation with RF-sym, Kelvin waves, and moving lower boundary, (4) [NoKW+OXVGCM] is a simulation with RF-sym and the moving lower boundary. It can be concluded that the Kelvin waves do provided a small amount of variability, about 0.3 MR. However, the combination of the moving lower boundary and Kelvin waves induces an intensity range from 1.4 MR to 2.8 MR. Moreover, of those four cases, the combination of the moving lower boundary and Kelvin wave is the only case to provide temporal shifts for the nightglow peak local time; 23:00 to 1:00 local time (figure not shown).

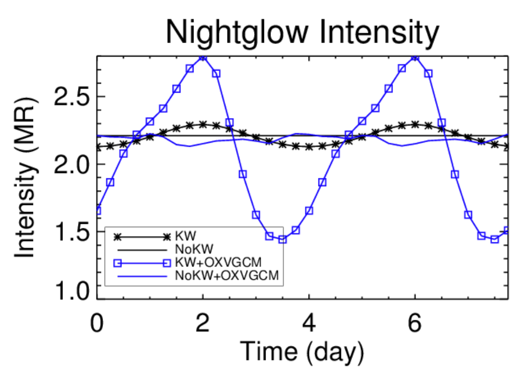

Figure 1: O_2 IR nightglow peak integrated intensity with respect to time of simulation. MR = Mega-Rayleigh (10^{12} photons cm^{-2} s^{-1} in 4π sr). The time is the last 8 days of a 51 day simulation. The four cases shown are: (1)[KW] a simulation with RF-sym and Kelvin waves, (2) [NoKW] a simulation with only RF-sym, (3) [KW+OXVGCM] a simulation with RF-sym, Kelvin waves, and moving lower boundary, (4) [NoKW+OXVGCM] a simulation with RF-sym and the moving lower boundary.

For an initial comparison, [12] employed a simple Venus GCM and implemented Kelvin waves. Their GCM has RF-sym and a non-moving lower boundary. With Kelvin waves the O_2 IR nightglow peak integrated intensity varies from 1.11 MR to 1.32 MR. The local time variation is 23:50 to 00:20. The VTGCM produces similar intensity variations when Kelvin waves are employed without the moving lower boundary. The VTGCM local time variation is comparable too, with just Kelvin waves.

Both model results can be compared to the 3-D statistical map of the O_2 IR nightglow from VEX VIRTIS limb and nadir observations in [4]. The statistical peak intensity is 1.58 MR. However, it can range from ~0.79 MR to 1.58 MR and in local time it ranges from 22:30 to 1:30. The VTGCM intensity variation (Kelvin wave with the moving lower boundary) is too large, while [12] intensity variation is too small compared to the observations. However, the VTGCM does a better job capturing the local time variation (Kelvin wave with the moving lower boundary) compared to the [12] results with respect to the observations.

Conclusion: In conclusion, it has been shown that Kelvin waves can contribute to the variability to O_2 IR nightglow. However, the work to be presented will be to show more sensitivity tests with the Kelvin waves, implementation of Rossby waves, Rossby wave sensitivity tests, and the impacts these waves have on the upper atmosphere of Venus.

The characterization of waves (e.g. planetary-scale and gravity waves) with observations (current and future) and models is important in understanding the variability within Venus' upper atmosphere. The current parameter space for modeling waves (e.g. wavelengths, amplitudes) is very wide and largely uses Earth parameters. Furthermore, testing the boundary conditions (lower and upper) of the VTGCM will be important due to the impact it has on propagating waves through the thermosphere. Lastly, these wave studies are imperative to knowing if they contribute to RF within Venus' upper atmosphere.

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