Progress in modeling global dynamics of Venus' mesosphere and thermosphere

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One of the striking characteristics of Venus' atmosphere is its retrograde super-rotation which has been observed as a persistent feature of the top cloud layer and, with considerable variability, in the upper mesosphere and lower thermosphere near 95-120 km altitude. Additionally, a sub-solar to anti-solar wind flow, driven by day-night pressure gradients, has been detected in the lower thermosphere. A key scientific question is how strongly the mesosphere and thermosphere are dynamically coupled on Venus, and by which physical mechanisms. Related to this is the question of the validity of cyclostrophic balance between 60 and 120 km altitude, which is often assumed to infer dynamics in that region from thermal measurements.

We have developed a General Circulation Model (GCM) of the coupled mesosphere and thermosphere on Venus (~60-250 km) in order to investigate the above questions and obtain a deeper understanding of the dynamics above the cloud top on Venus. Since our focus is initially on the dynamics, we have decoupled the dynamical core from the energy equation and assume a constant background atmosphere in the form of a 3-D thermal and gas density profile. To-date, neither of the two key empirical models available for Venus (VIRA and VTS3) offer a realistic and continuous profile ranging from around 60 km into the thermosphere, but instead contain a boundary at 100 km where hydrostatic balance is violated. One part of our model development work has therefore consisted in constructing a background atmosphere by hydrostatically linking two initially disparate empirical atmosphere model, thus creating a single continuous 3-D atmosphere profile above the cloud top.

This talk will present key results from this ongoing project. We will present comparisons between temperatures and dynamics from the model and recent observations by Venus Express and ground based telescopes. This allows us to investigate the flow of momentum from the cloud top into the upper atmosphere, to determine the momentum balance and characterise dynamics of the middle and upper thermosphere. We investigate the roles of turbulent viscosity and Rayleigh friction, two mechanisms that can profoundly affect the wind structures, but are generally poorly constrained. This work illustrates the importance of using GCM's in tandem with the observations for maximising the scientific information we can extract from both.