Dynamics, Airglow, and Chemistry of the Venus Upper Atmosphere: Interpretation of Venus Express Datasets Using the VTGCM

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One of the major goals of the Venus Express (VEX) mission has focused upon increasing our understanding of the global circulation and dynamical processes impacting the Venus mesosphere-thermosphere (~80 – 200 km). Several VEX instruments (e.g. SPICAV and VIRTIS) and ground based observations have provided measurements that characterize the upper atmosphere structure and dynamics during the solar minimum period of the solar cycle and for variable lower atmosphere conditions. An expanded climatology of these structural features is being constructed that combines VEX, Pioneer Venus and ground based observations over several decades. In particular, selected night airglow emissions (NO- UV, O_2-IR and OH-IR), temperature distributions (especially on the nightside), and distributions of tracer species are being used to infer the characteristics of the global circulation patterns (and their variations) above the Venus cloud tops (e.g. Gerard et al., 2008, 2009, 2010; Piccioni et al., 2008, 2009; Bertaux et al. 2007; Bailey et al., 2008; Clancy et al. 2008). We review the key VEX and recent ground-based measurements that provide constraints on these changing global circulation patterns and dynamical processes.

Proper interpretation of these upper atmosphere measurements (i.e. variability and climatology) requires the progressive application of detailed 1-D chemical and 3-D chemical-dynamical models. Our approach has been to first exercise the CalTech 1-D KINETICS model (Yung and DeMore, 1982) and subsequently the Venus Thermospheric General Circulation Model (VTGCM) to address the combined chemical, dynamical and energetic processes that impact the airglow, tracer species, and temperature distributions of the Venus mesosphere-thermosphere. A later paper will focus upon the 1-D KINETICS model and its results (Parkinson et al, 2010).

Here we describe the capabilities/limitations, processes and primary applications of the extended VTGCM code. The modern VTGCM domain has been extended upwards and downwards (now ~80 to 200 km) to capture the entire dynamical and chemical region impacting these key night airglow emissions (NO, O_2, OH) and the nightside temperature distributions near ~100 km. A simplified chemical scheme and corresponding reaction rates for the mesosphere region are adapted from Yung and DeMore (1982), Mills (1988) and Pernice et al., (2004). Short-lived chemical trace species are specified from offline 1-D KINETICS model simulations for similar input conditions. NLTE CO_2 15-micron cooling and near IR heating rates are taken from Roldan et al. (2000). Our immediate goal (addressed in the later paper of Brecht et al, 2010) is to explain the observed lack of correlation between the NO and O_2 nightglow emissions in the presence of strong horizontal winds in the mesosphere-thermosphere transition region (Gerard et al., 2009).