Photochemical Distribution of Venusian Sulfur and Halogen Species

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Recent observations of enhanced amounts of SO_2 at 100 km by Venus Express (Bertaux et al, 2009) suggest that there is a hitherto unknown source of gaseous sulfur species in the upper atmosphere of Venus. The observations of Sandor and Clancy (2010) also show short and longterm variations in mesopause-level (90-100 km) SO and SO_2. Zhang et al (2010) argue that the photolysis of H_2SO_4 vapor derived from evaporation of H_2SO_4 aerosols provides a source of SO_3, which upon photolysis yields SO_2. In this study, the photochemistry of Venus' atmosphere from the cloud tops to 100 km has been modeled using an updated/expanded chemical scheme, with the view to improving our understanding of the vertical distributions of sulfur and halogen species. We mainly follow Yung and DeMore (1982), Mills (1998), Pernice et al. (2004), Krasnopolsky (2010) in our choice of chemical reactions, chemical rate constants, and boundary conditions for 38 species. We will examine a model with an HCl mixing ratio of 10^{-7} corresponding to Venus Express observations made at high northern latitudes. This model agrees satisfactorily with stratospheric observations of key species such as CO, O_2 and SO_2, and we better quantify the implications of the different HCl mixing ratios observed. We also consider a range of eddy diffusion profiles that vary by a factor of 10 and other sensitivity studies. For our cases, $K = K_o (n(z)/n_{ref})^{-a}$, where K_o is the eddy diffusion coefficient at some reference altitude, n is the number density, z is altitude, and a is the variable parameter (<1). Our modeling suggests lower HCl abundances result in greater abundances of SO_2, SO, and SO_3 generally lower O_2 abundances, and greater ClO abundances. Also, the effects on sulfur compounds seems more pronounced for lower mixing ratios of SO_2 at the lower boundary as well as higher up in the atmosphere i.e. above ~58 km. We consider both SO_2 observations of Bertaux et al (2009) and Sandor and Clancy (2010) in our analysis of results. We apply some of the 1-D chemistry tracer species profiles to the Venus Thermospheric General Circulation Model (VTGCM) (Bougher et al, 1997) for comparison to VEX datasets.