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# HDO and $SO_2$ thermal mapping on Venus : Statistical analysis of the $SO_2$ plumes

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Since January 2012, we have been monitoring the behavior of sulfur dioxide and water on Venus, using the TEXES (Texas Echelon Cross-Echelle Spectrograph) imaging spectrometer at the NASA InfraRed Telescope Facility (IRTF, Mauna Kea Observatory). We present here the observations obtained in January 2016, December 2016, January 2017, July 2017, July 2018 and September 2018. As in the case of our previous observations (Encrenaz et al. 2012, 2013, 2016), data have been recorded in two spectral ranges around 1345 cm-1 (7.4 $\mu$m) and 530 cm-1 (18.9 $\mu$m). At 7 $\mu$m, $SO_2$, $CO_2$ and HDO (used as a proxy for $H_2O$) are observed, and the cloudtop of Venus is probed at an altitude of about 64 km. We concentrate here on the 7.4 $\mu$m data. The volume mixing ratio of $SO_2$ is estimated using the $SO_2/CO_2$ line depth ratios of weak transitions; the $H_2O$ volume mixing ratio is derived from the $HDO/CO_2$ line depth ratio, assuming a D/H ratio of 200 times the Vienna Standard Mean Ocean Water (SMOW) value. As reported in our previous analyses, the $SO_2$ mixing ratio shows strong variations with time and also over the disk, which is an indication of the formation of $SO_2$ plumes with a lifetime of a few hours. In contrast, the $H_2O$ abundance is remarkably uniform over the disk and shows moderate variations as a function of time. We have performed a statistical analysis of the behavior of the $SO_2$ plumes, using all TEXES data between 2012 and 2017. They appear to be located largely around the equator. Their distribution as a function of local time seems to show a depletion around noon. The distribution of $SO_2$ plumes as a function of longitude shows no clear pattern, apart from a possible depletion around 100E-150E and around 300E-360E. We see no clear correlation or anti-correlation between the $SO_2$ and $H_2O$ abundances at the cloudtop, neither in the individual maps nor over the long term. Finally, there is a good agreement between the TEXES results and those obtained in the UV range (SPICAV/Venus Express and UVI/Akatsuki), which shows that $SO_2$ observations obtained in the thermal infrared can be used to extend the local time coverage of the $SO_2$ measurements obtained in the UV range.