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GROUND-BASED INFRARED OBSERVATIONS OF WATER VAPOR AND HYDROGEN PEROXIDE IN THE ATMOSPHERE OF MARS. T. Encrenaz[1], T. K. Greathouse[2], M. Bitner[3], A. Kruger[4], M. J. Richter[4], J. H. Lacy[5], B. Bézard[1], T. Fouchet[1], F. Lefèvre[6], F. Forget[7], S. K. Atreya[8],[1] LESIA, Paris Observatory, F-92190 Meudon, [2] SWRI, San Antonio, TX, USA, [3] STScI, Baltimore, MD, USA [4] University of California Davis, CA, USA, [5] University of Texas at Austin, USA, [6] Service d'Aéronomie, CNRS, France, [7] LMD, CNRS, Paris, France, [8] University of Michigan, Ann Arbor, MI, USA

Introduction: High-resolution ground-based imaging spectroscopy is a powerful technique for monitoring the narrow spectral signatures of trace gases in the low pressure Martian atmosphere. This has been demonstrated particularly for water vapor (H_2O) and hydrogen peroxide (H_2O_2) whose global maps have been made from observations in the thermal infrared with the TEXES instrument (Texas Echelon Cross Echelle Spectrograph, [1]) mounted at the NASA Infrared Telescope facility (IRTF).

The primary objective of the TEXES observation campaign was to search for hydrogen peroxide. Since the time of the Viking observations in 1976, H_2O_2 has been suggested as an oxidizer of the martian regolith, responsible for sterilizing the soil down to a depth of up to a few meters and detroying the surface organics in the process. The presence of H_2O_2 is also expected from photochemical models, where it is formed by self-recombination of two HO_2 radicals resulting from reactions involving H and O_2. The secondary objective of the TEXES campaign was to obtain simultaneous maps of water vapor using the HDO transitions

The observations: Four sets of data have been recorded: (1) February 2001 (Ls = 110°), (2) June 2003 (Ls = 206°), (3) November-December 2005 (Ls = 332°), (4) June 2008 (Ls = 80°). Several spectral intervals of a few cm^{-1} each were recorded in the 1229 – 1245 cm^{-1} range with a resolving power of about 80000. In most of the cases, the 1.1 x 8 arcsec slit of the TEXES instrument was positioned along the N-S celestial axis and moved from west to east in order to map the whole planet. Each individual map was recorded in about 10 minutes. The maps, measured in the continuum, were recentered by superimposing the maximum flux and the limbs. Details about the observations, the data reduction, the atmospheric modelling and the results have been published previously [2-5].

Results:

H_2O_2

Our first attempt to detect H_2O_2 (Feb. 2001) was unsuccessful, and our inferred upper limit was lower than the theoretical predictions [6]. We detected H_2O_2 during our second run (June 2003, Ls = 206°) by measuring half a dozen weak transitions [2]. The H_2O_2 abundance was found to be in agreement with the predictions (Fig. 1a and b). We obtained a map of the H_2O_2 spatial distribution by ratioing the depth of the H_2O_2 transitions to the depth of a nearby CO_2 line of comparable intensity, and found it also in general agreement with the models. The H_2O_2 abundance from TEXES was also in agreement with the disk-averaged H_2O_2 detected in the submillimeter by Clancy et al. 2004 [7].

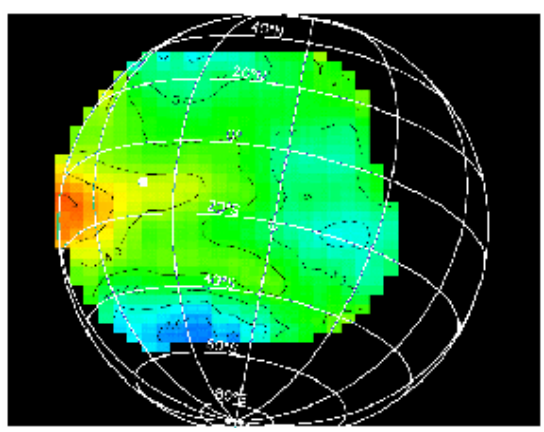

Fig. 1a The spatial distribution of H_2O_2 as observed by TEXES in June 2003 (Ls = 207°)

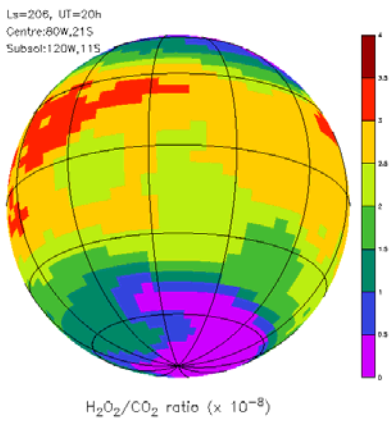

Fig. 1b. The H_2O_2 distribution predicted by the GCM for the conditions of the June 2003 observations

H_2O_2 was also detected in December 2005 (Ls = 332°). However, this time around its abundance was found to be smaller than predicted. A similar result was obtained in June 2008 (Ls = 80°) when H_2O_2 was only marginally detectable, with an abundance even lower than in 2005 and again significantly below model predictions.

H_2O

Weak transitions of HDO also appear in the spectral range of above H_2O_2 observations, i.e. 1229 – 1243 cm^{-1}, and were used to to map the water vapor distribution by ratioing their depth to the depth of weak CO_2 isotopic transitions. The H_2O abundance was inferred from the HDO observations using a constant D/H ratio of 5 times the terrestrial value [8] (we note, however, that this assumption introduces some uncertainty, especially at high latitude). In June 2003 (Ls = 206°), the agreement with the model was satisfactory (Fig. 2). At the time of summer solstice (Ls = 110°, Feb. 2001; Ls = 80°, June 2008), the observed map peaks at high northern latitudes, as expected from previous observations by TES [9] and modeling of the water vapor cycle on Mars [6]. In Nov. 2005 (Ls = 332°), however, the water vapor content was lower than expected and its spatial distribution was different from the models.

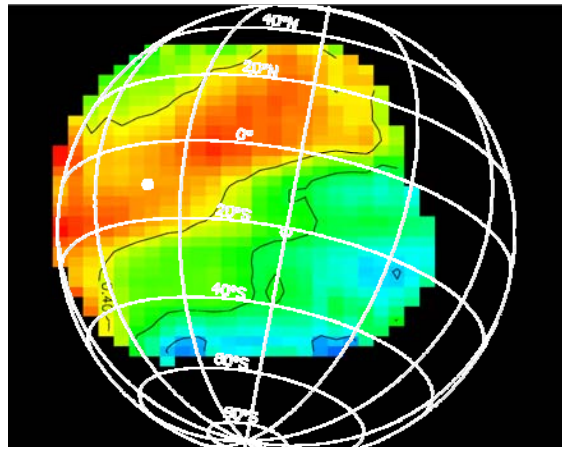

Fig. 2a The spatial distribution of HDO as observed by TEXES in June 2003 (Ls = 207°)

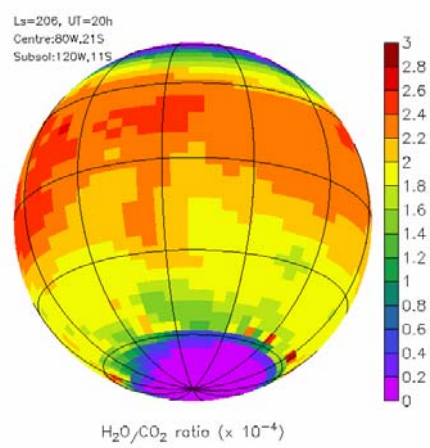

Fig. 2b. The H_2O distribution predicted by the GCM for the condition of the June 2003 observations

Conclusions: We have now obtained measurements of H_2O_2 at 3 different times of the martian seasonal cycle: (1) near summer solstice (Ls = 80° and Ls = 110°); (2) at the beginning of southern spring (Ls =

206°); (3) shortly before northern equinox (Ls = 332°). Our results are the followings:

-Near summer solstice, the H_2O_2 abundance seems to be significantly lower than the predictions; the H_2O distribution, in contrast, seems to be consistent with the models.

-In southern spring, there is a good agreement between our observations and the models, both for the abundances and the spatial distributions of H_2O_2 and H_2O.

-Near equinox, the H_2O_2 observed abundance is again below the predictions, with a spatial distribution which does not fit well the models. The same is actually true for the water vapor distribution.

In summary, the seasonal cycle of hydrogen peroxide on Mars is still not well understood, and requires further investigation.

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