

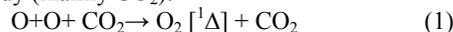
FIRST DETECTION OF O₂ RECOMBINATION NIGHTGLOW EMISSION AT 1.27 μm IN THE ATMOSPHERE OF MARS WITH OMEGA/MEX AND COMPARISON WITH MODEL. B. Gondet¹, J.L. Bertaux², J.P. Bibring¹, F. Montmessin², F. Levrère², ¹*Institut d'Astrophysique Spatiale/CNRS, UniverSud Paris, Orsay, France (brigitte.gondet@ias.u-psud.fr)* ²*LATMOS/IPSL/UVSQ, Université de Versailles Saint-Quentin/CNRS*

Introduction:

In the upper atmospheres of both Venus and Mars, CO₂ and N₂ molecules are photo-dissociated with a production of O and N atoms in the thermosphere ($z > 70-90$ km) on the dayside. The thermospheric circulation of Venus is characterized by a strong flow from the sub solar point to the antisolar point (so called SSAS); in the descending air parcel on the night side, atoms of O and N are recombining, and produce both UV NO emission nightglow [1] and near IR O₂ at 1.27 μm [2]. While the NO emission was already detected in the atmosphere of Mars [3], the O₂ recombination emission had escaped detection up to now. Here we report the first detection of this night side O₂ emission in the atmosphere of Mars, from observations of the OMEGA imaging spectrometer on board Mars Express. Such observations, which trace uniquely a downward advection transport mechanism, are compared with the prediction of the LMD GCM with photochemistry. The main features of the observations are indeed pre-

dicted by the model in which air transport is simulated by advection, with no need of eddy diffusion.

The recombination of O atoms requires a third body (mainly CO₂):



The O₂ molecule is produced in an excited state [¹Δ] which de-excites spontaneously with a time constant of about 1.24 hr: O₂ (*a*¹Δ_g → X₃Σ_g), or may be quenched by collisions.

There is another mechanism which produces the same 1.27 μm emission: photo-dissociation of ozone on the day side, which is monitored from orbiters like Mars Express as a useful mean to quantify ozone. We argue that the observations of OMEGA, performed on the winter polar night, are not due to ozone photo-dissociation but rather to oxygen recombination.

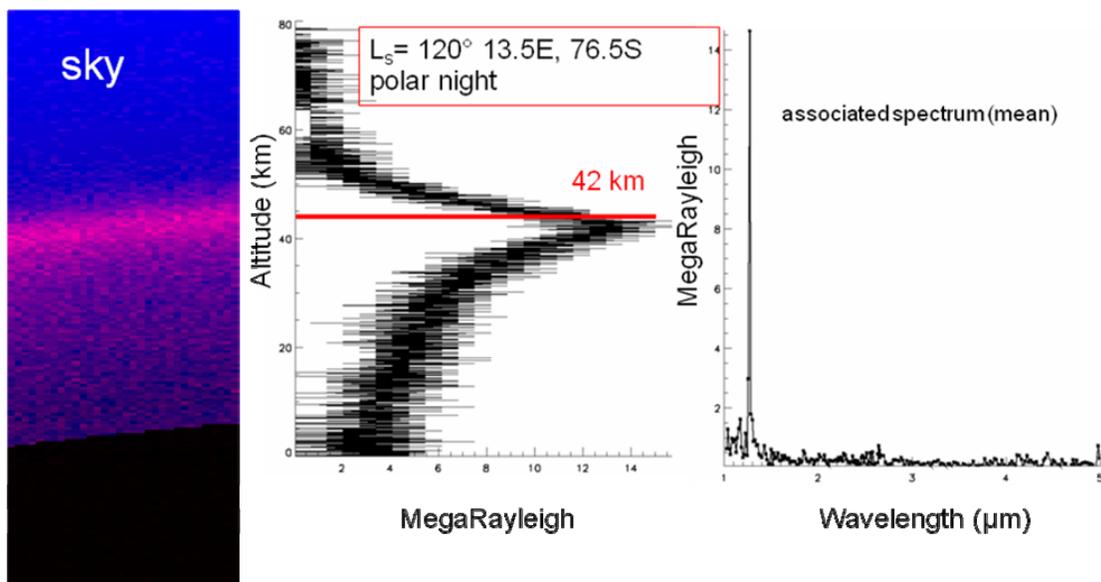


Figure 1. Left: A swath of the observed limb at night by OMEGA, with emission coded in pink. Middle: vertical distribution of the intensity observed in megaRayleigh (integration over azimuth). Right: integrated observed spectrum, showing emission only at 1.27 μm.

2. Observation with OMEGA on Mars Express.

OMEGA is a VIS/NIR hyperspectral imager operating on board of the ESA/Mars Express mission. The instrument is made of two co-aligned channels: a pushbroom "VIS" channel acquires up to 128 spectra (from 0.35 to 1 μm) simultaneously on a CCD matrix; a NIR channel (1 to 5.1 μm) operates in whiskbroom mode (scanning mirror across track), with two linear InSb detectors (128 pixels each), and 13 nm spectral sampling in the range 1 to 2.5 μm . Nadir and limb pointing can be implemented. OMEGA identifies and maps both surface (minerals, ices, frosts) and atmospheric (gas, aerosols, clouds) species, with in particular CO_2 , CO, H_2O and O_3 gaseous detections. The 1.2 mrad IFOV corresponds to a footprint from 0.3 to 4 km (depending on spacecraft altitude or distance to the limb.)

Up to 2010, OMEGA has observed 40 times the atmosphere above the limb at night. In three cases out of 40, an intense emission at 1.27 μm was detected, with a peak emission of 12 megarayleigh at an altitude above the areoid of 42 km (Figure 1) in the whole FOV scanned during the observation. The rest of the spectrum remains void of any detectable emission. At the latitude (76.5° S) and season ($L_s=120^\circ$) of fig.1 observation, the observed air parcel is never illuminated over a diurnal cycle, and therefore, the emission cannot be a remnant of the ozone photo-dissociation process.

3. Comparison with model.

The version of the LMD GCM with coupled photochemistry developed by Lefèvre et al. (2004) [4] was run with the implementation of the calculation of O_2 emission from recombination reaction (1) over a full martian year. The emission rate was integrated vertically, zonally averaged, and plotted as a function of season and latitude on figure 2 in units of megarayleigh (10^{12} photons/cm² s). The emission is present only at high latitudes, is absent during summer, and not perfectly symmetrical between North and South. Two places where OMEGA detected the emission are represented by stars. They are located in the regions/seasons where emission should occur, as predicted by the model.

Comparison of observations to model show great similarities, but also some significant differences (smaller intensity, absence of emission above 50 km). This may be due to day-to-day meteorological variability of the upper atmosphere of Mars, or to some fine-tuning needed in the model. In any case, the O+O emission at 1.27 μm is tracing the descent of air originating in the altitude region of CO_2 photo-dissociation (say, >70 km). Therefore, Figure 2 is a mapping of the mesospheric air descent latitude.

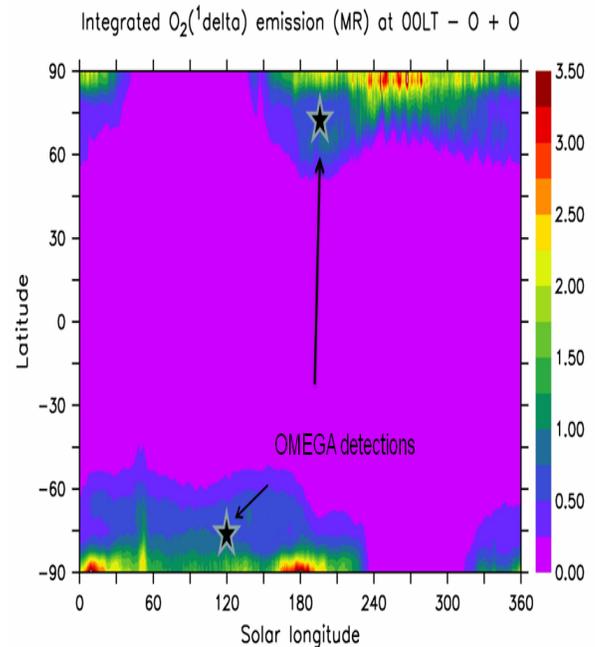


Figure 2. Latitude/season maps of zonally averaged vertical emission rate of O+O recombination in units of megarayleigh. Locations where OMEGA detected an emission (stars) are in the regions predicted by the model. The vertical intensity of OMEGA is computed to be 0.24 Megarayleigh for the South polar observation, smaller than model prediction by a factor 2.

References.

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