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Synergistic atmospheric retrievals : Using OMEGA and PFS to retrieve martian CO

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Abstract

Recently, a theoretical study was published showing how science return can benefit from synergistic retrievals [1]. The same approach is here applied to experimental data. OMEGA and PFS instruments, both on Mars Express spacecraft, have collected high-quality data enabling us to retrieve CO volume mixing ratio, among others. The synergy between OMEGA and PFS channels will be presented and the benefits of the synergy will be described by comparing synergistic spectral retrievals and non-synergistic ones.

Introduction

Since 2004, the European mission, Mars Express [2], has delivered a tremendous quantity of data concerning the surface and the atmosphere of Mars. Hopefully so will the ExoMars Trace Gas Orbiter [3] (EMTGO) which was inserted into orbit around Mars in October 2016. The datasets are generally studied separately and that is a necessary first step. However, because each of the spectral regions and geometries has its advantages and disadvantages, the combination of different types of measurements in a synergistic way enables us to better exploit the available data and increase the science return. Tools and methodology have been developed in a previous theoretical study [1]. Simulated spectra based on the characteristics of the two InfraRed instruments onboard EMTGO were used and enabled us to demonstrate the usefulness of synergistic retrievals and to pave the way to more collaborative studies.The expertise built during the theoretical study was used to analyze experimental data in a study associating PFS and OMEGA data, both instruments onboard Mars Express. Carbon monoxide was chosen as test-molecule. CO is a non-condensable gas present in the atmosphere of Mars, varying from 300 to 1500 parts per million in volume mixing ratios, depending on the season [4]. The remote sensing of CO can be performed in different spectral domains and with different geometries of observation.

OMEGA and PFS datasets

We focused on experimental data using the datasets of two infrared instruments on board Mars Express, OMEGA [5] and PFS [6].

Table 1: Characteristics of the instruments' channels. Name of the instrument ; geometry ; type of instrument ; instrumental line shape ; name of the channel ; spectral range and spectral resolution are given.

OMEGA		PFS	
nadir		nadir	
Mapping spectrometer		Fourier transform spectrometer	
Gaussian ILS		PFS ILS	
SWIR-C	SWIR-L	SWC	LWC
0.93-2.69 μm 14 nm	2.52-5.09 μm 20 nm	1.2-5 μm 1.3 cm^{-1}	5-45 μm 1.3 cm^{-1}

We selected datasets in the Hellas Planitia region (30-55°S ; 45-90° E) during Southern winter. These conditions should be advantageous when aiming for a successful retrieval of CO. Therefore, we chose to test the orbits 1186 and 3234, as it was used by Encrenaz et al. [7] and Sindoni et al. [8] and as a high abundance of CO has been retrieved from these orbits in both studies. Two channels of OMEGA and two of PFS were taken into account in order to retrieve surface temperature and CO abundances and if possible,

surface emissivity and surface albedo. The characteristics of the channels are given in Table 1.

Spectral retrievals

We used ASIMUT-ALVL, an home-made Radiative Transfer code [9] which was modified in order to treat OMEGA and PFS data separately and altogether. In the spectral ranges of the considered instruments, two bands of CO can be observed: 1–0 centered at 4.65 μm and the 2–0 band at 2.35 μm. Non-synergistic retrievals were performed in a first step to evaluate the assets of each dataset. For instance, the 2–0 band depth exhibits less than 1% absorption in the SWIR-C channel of OMEGA while the 1–0 band absorption is strong in the SWIR-L OMEGA channel.

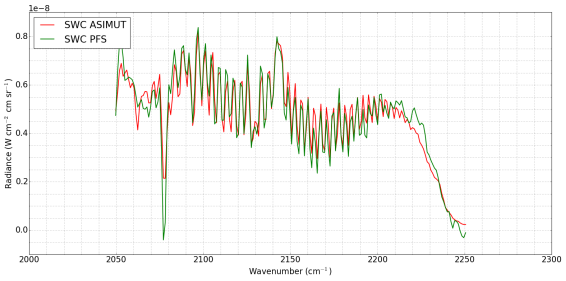

Figure 1: CO 1-0 band fitted with ASIMUT for the orbit 1186 considering PFS instrument. Surface temperature was retrieved using the 400-520 cm^{-1} range. 2550 ppm of CO were retrieved.

CO_2, H_2O and aerosols content were fixed using the results of the BIRA-IASB GCM, GEM-Mars [10]. HITRAN 2012 [11] was used for the spectroscopic parameters and the Sun spectrum was taken from ACE the solar irradiance data were collected from the ACE – FTS data [12] in the IR.

Summary and Conclusions

The previous theoretical study showed how science return can be increased when benefiting from spectral synergies. The demonstration suggested here is made based on experimental data. Considering the quantity of data obtained around Mars, the field of applications of this approach is promising. The retrievals will be presented altogether with the strategy of the synergy and the diagnostic tools developed.

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