Retrieval of the vertical profiles of water vapor and other chemical species in the Martian atmosphere using PACS

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PACS observations of Mars

The Herschel Space Observatory is an ESA mission for high spatial resolution observations in the FIR and sub-millimeter regime.

The Photodetector Array Camera & Spectrometer (PACS) is one of the three science instruments of the Herschel observatory.
PACS provides the Herschel Space Telescope with the capabilities for spectroscopy and imaging/photometry in the 55-210 μm range.

- guaranteed time key project "Water and related chemistry in the solar system" includes Mars observations.

- most Mars observations are planned at the beginning and the end of the observation window of March-July 2010, L_s = 67°-116°.

- Mars observations are planned to provide temporal coverage as large as possible.

MOLIERE

MOLIERE is a forward- and inverse- radiative transfer model for planetary atmospheres for millimeter and sub-millimeter wavelength range.

We used it

✓ to calculate synthetic PACS spectra of H_2O, CO and minor species in Martian atmosphere;

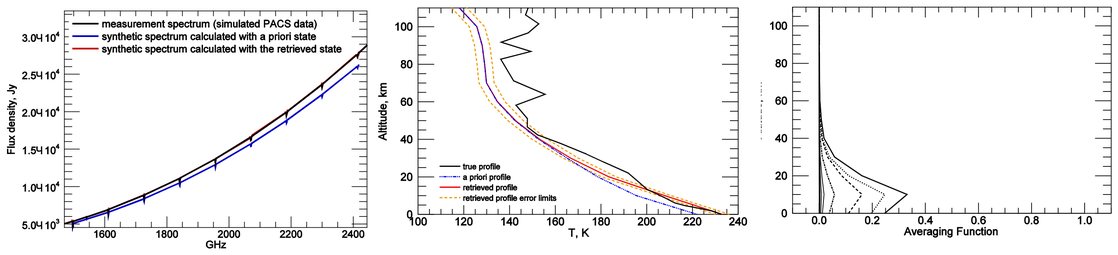
✓ to solve the inverse problem of retrieving H_2O and temperature profiles using these synthetic spectra.

Inputs that had to be adopted to our tasks:

✓ Martian atmospheric conditions;

✓ Herschel observation geometry .

Temperature retrievals using CO-lines



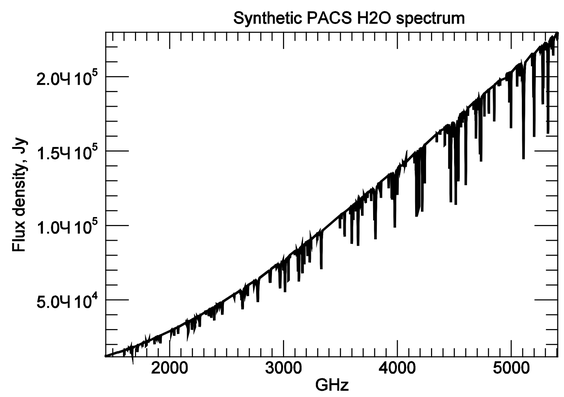
Only few CO absorption lines in PACS range ➡ Retrieval of temperature profile is not reliable

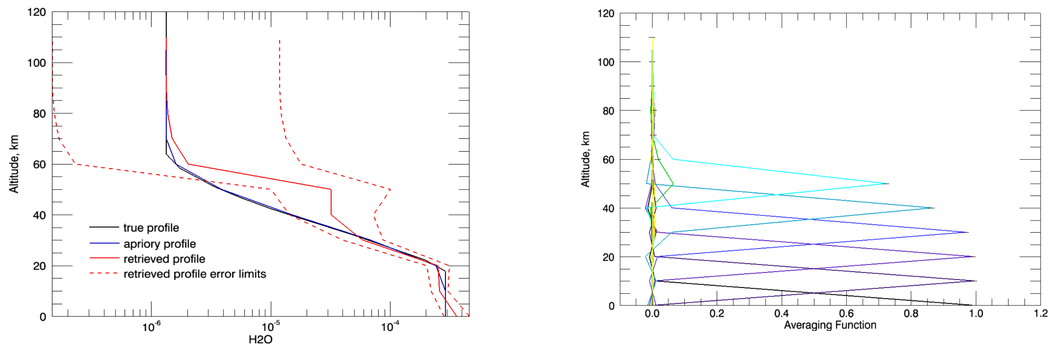
✓PACS spectral range and/or spectral resolution of proposed observation mode is not sufficient for temperature profile retrieval.

✓need external input for temperature profile (GCM? HIFI?)

✓we are also planning joint observations with Mars Climate Sounder on MRO.

Water vapor profile retrievals

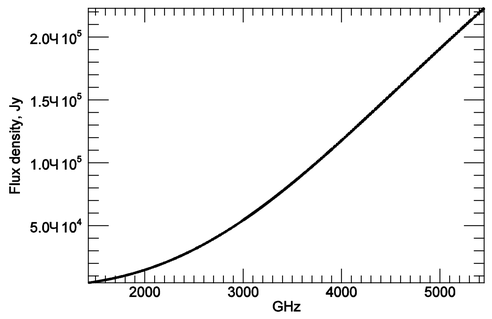


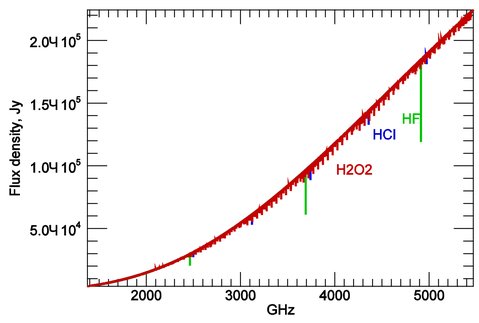


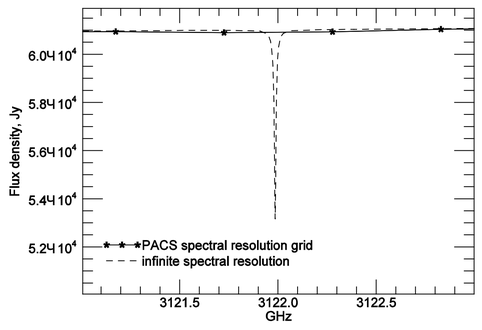
PACS allows to estimate H_2O vapor profile in lower atmospheric layers: up to 40 km.

Minor species detection?

Few gaseous molecular species have been spectroscopically identified in Martian atmosphere: CO_2, CO, H_2O, O_2, O_3, H_2, H_2O_2.
Photochemical models do predict the presence of a number of additional compounds, such as OH, HO_2, NO, etc. (Nair et al., 1994; Lefevre et al., 2004; Sonnemann et al., 2007)







Lines can not be resolved by PACS because of low sampling rate.
Same for: O, O_2, O_3, NO, SO_2, HF, HCl, H_2O_2

Conclusions

- Spectral lines of minor species of Martian atmosphere are too narrow to be detected by PACS in low sampling observation mode.
- Temperature profile can not be obtained from only PACS observations.
- Water profile can be calculated using PACS up to 40 km.

Future plans:

- to simulate D/H ratio retrieval with PACS.
- to get real data ☺