Atmospheric science using PanCam, ISEM and FAST on the ExoMars 2020 Rover and Surface Platform

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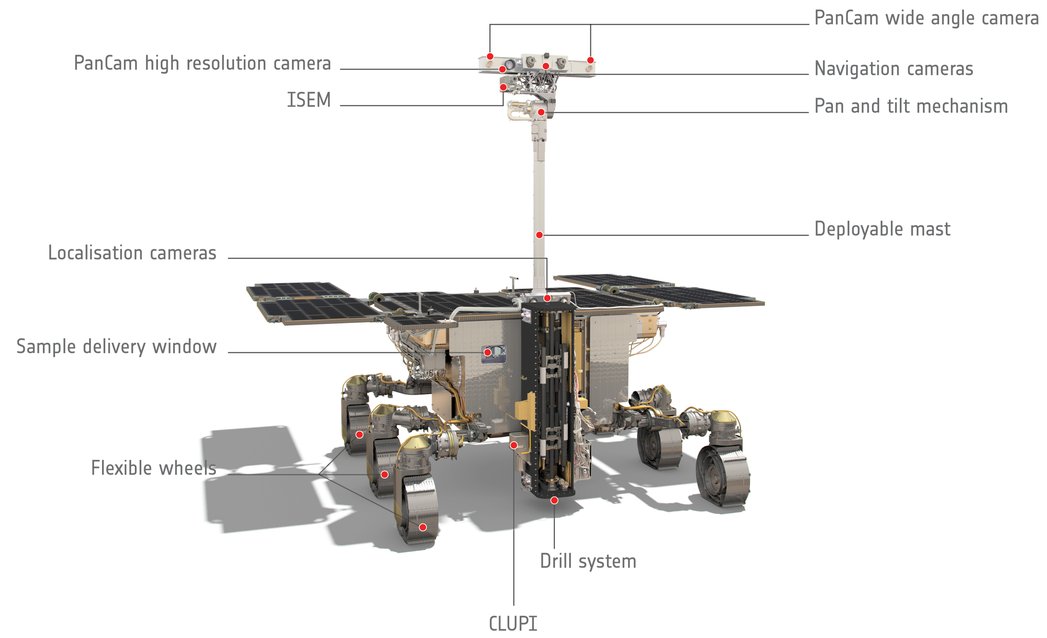
Abstract

The ExoMars 2020 mission, launching in July 2020 and landing in March 2021, comprises two science elements: a rover and a surface platform. We have performed radiative transfer analyses using the NEMESIS code for PanCam, ISEM (rover) and FAST (surface platform) instruments, focussing on their ability to characterize atmospheric dust, temperature, and water vapour.

The ExoMars 2020 Rover has no dedicated instrument to characterise the environmental conditions. Therefore, any information available by other means is of particular value. PanCam's observations of the Sun using the filters at 925 and 935 nm allow the characterisation of atmospheric water vapour. In addition, PanCam's wide field-of-view allows the characterisation of particle distributions through their scattering properties. PanCam's spectral range will be extended using ISEM, which covers several bands of CO_2 and H_2O.

FAST will be situated on the ExoMars 2020 Surface Platform, and will carry out a role similar to the mini-TES instrument on the Spirit and Opportunity Rovers, measuring the diurnal cycles of the temperature field near the surface. Using observations of the Sun, it will also allow the characterisation and detection of minor species.

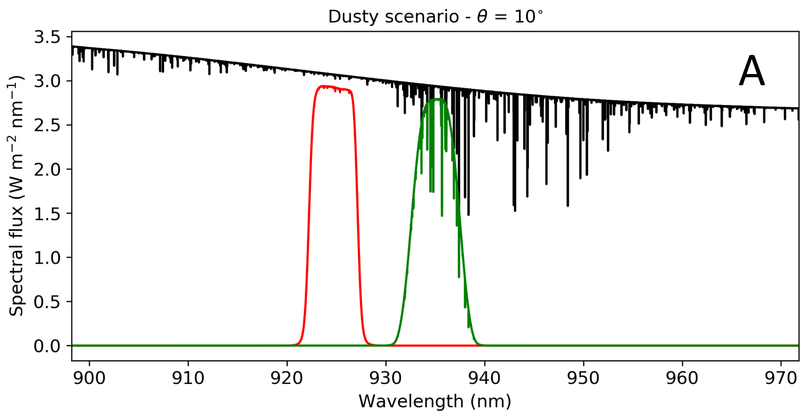


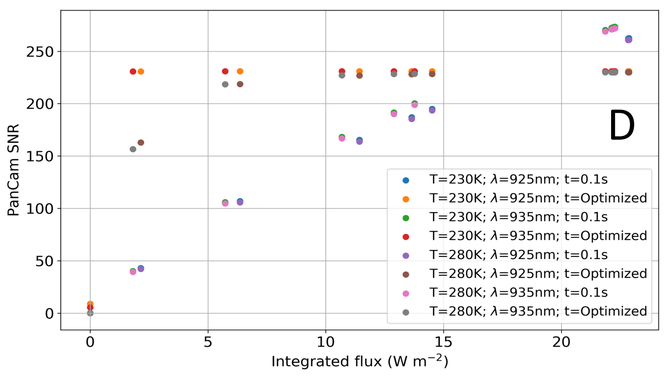
PanCam

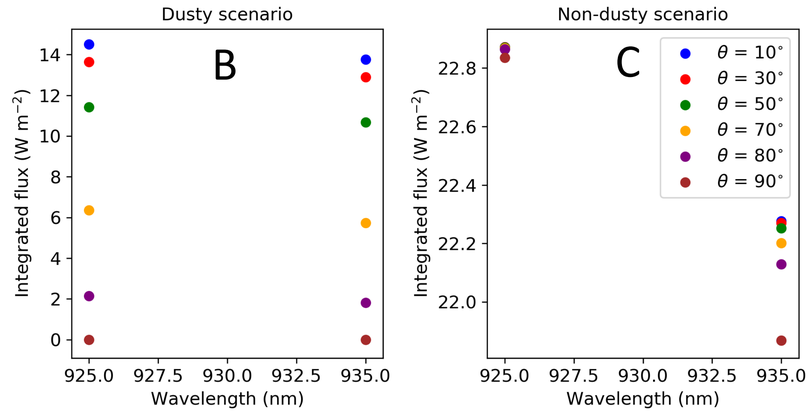
PanCam is a panoramic camera mounted on the rover mast. Observations of the Sun using filters at 925 (L10) and 935 (L11) nm allow the characterisation of atmospheric water vapour.

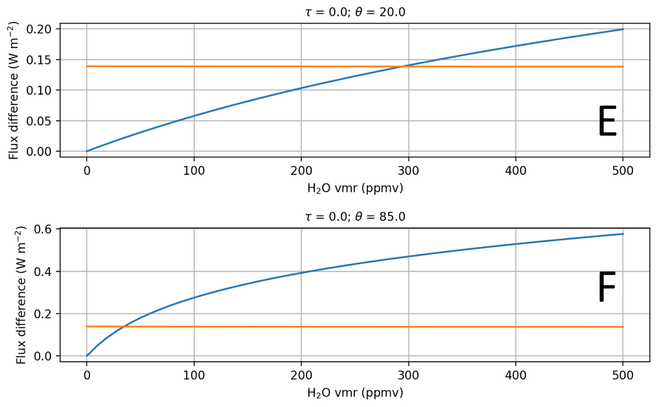
The spectral range filtered by L11 lies within a water vapour absorption band, while the observed flux within L10 is only affected by aerosol extinction (A). The difference between the flux observed by both filters allows the retrieval of water vapour column density in the atmosphere.

Observations near the horizon increase the line-of-sight H_2O column density, but also the aerosol opacity (B and C).









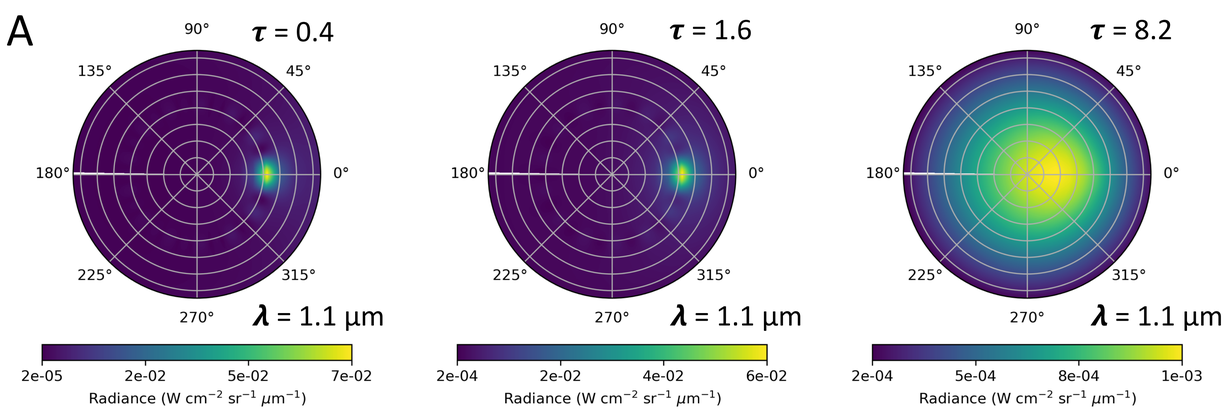
Signal-to-noise ratio (SNR) estimates were provided by the PanCam team, assuming two different instrument temperatures, and two different schemes for the accumulation time (D).

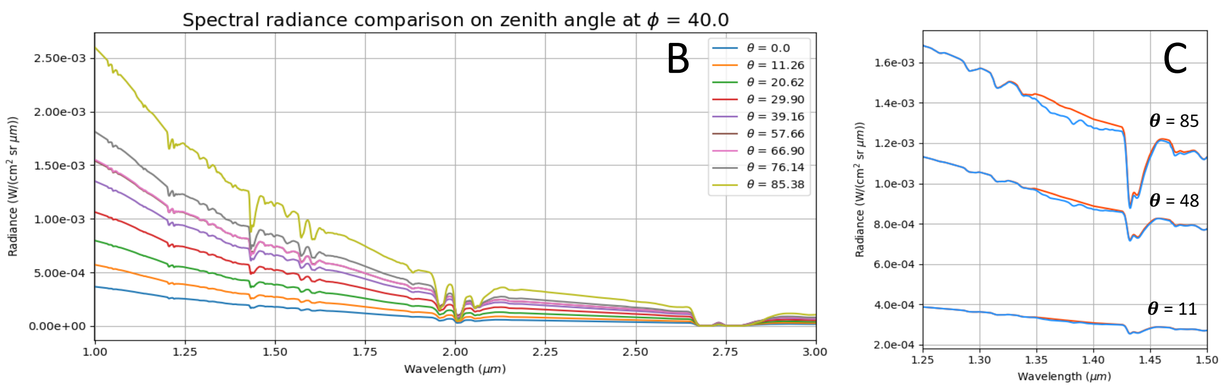
Given a viewing zenith angle and the dust opacity, the water vapour line-of-sight column density can be derived from the difference in observed flux between the L10 and L11 filters. Detection limits can be estimated calculating the lowest amount of water giving rise to a difference equal to the instrumental noise (E and F).

Estimations of PanCam's detection limits to water vapour are still under investigation, due to the complex implications of scattering on the expected instrument's performance.

ISEM

ISEM is an infrared spectrometer mounted on the rover mast, below PanCam, covering a wavelength range between 1.1 and 3.3 µm, with a spectral resolution varying from 3.3 nm at 1.15 µm and 28 nm at 3.3 µm.





We use NEMESIS to simulate the brightness of the Martian sky at all viewing angles within ISEM's spectral range, including multiple-scattering by aerosol particles and gas molecules. The sky brightness is highly dependent on the aerosol opacity, being a trade-off between the absorption and scattering cross sections (A).

ISEM's spectral range includes several absorption bands of CO_2 (1.5, 2.0 and 2.75 µm). Observations at different zenith angles might allow the retrieval of vertical profiles of pressure and temperature, assuming a known CO_2 volume mixing ratio (B). The highest sensitivity to water vapour is found at 1.37 µm (C). Its detectability will be dependent on the instrument's SNR.

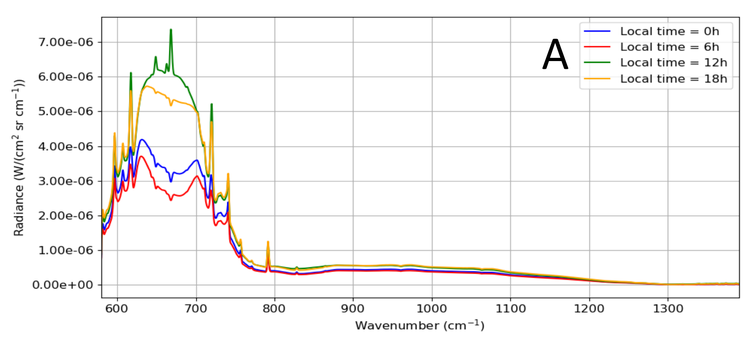
FAST

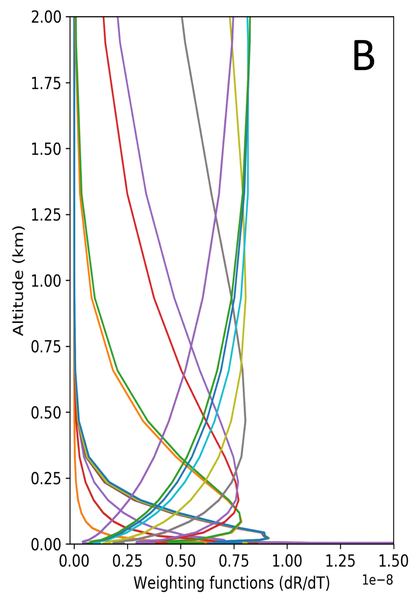
FAST's operation modes:

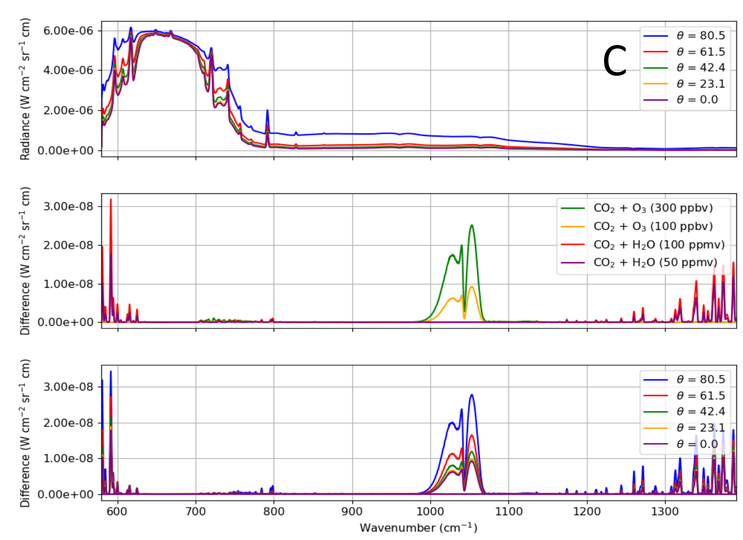
- **Sensitivity mode**: Observations of the Sun at 2-10 µm (spectral resolution 0.05 cm^{-1}).
- **Climatology mode**: Observation of the sky at 2-17 µm (spectral resolution of 2 cm^{-1}).

Temperature in the near-surface atmosphere

Observations of thermal emission within the CO_2 band near 15 µm allow the characterisation of the diurnal temperature field in the near-surface atmosphere (A). The weighting functions in these observations peak within the first two kilometres (B).







Minor species

Thermal emission observations using FAST's climatology mode might allow the characterization of the diurnal cycle of H_2O and O_3, including night observations.

FAST's sensitive mode will allow the characterization of known species (e.g., CH_4, H_2O, CO, O_3, isotopes), as well as the search for undetected species.

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