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Preparing Martian Atmospheric Observations with MIRS, the MMX Imaging Spectrometer

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MIRS (MMX InfraRed Spectrometer) is the imaging spectrometer (0.9-3.6 μm) [1] of the JAXA MMX (Martian Moon eXploration) mission [2]. The mission will be launched in the autumn 2026 to the Martian system, with an arrival around Mars planned in autumn 2027. The main objective of the mission is to study the two Martian moons, Phobos and Deimos, to collect samples of Phobos and bring them back to Earth in 2031. Another major objective of the mission [3] and the MIRS instrument [1] is to answer key science questions regarding the transport processes of dust and water in the Martian atmosphere [3], such as: how do local and regional dust storms form, grow and evolve? What is the diurnal behaviour of water ice clouds (formation, transport, dynamics)?

The MMX probe will be injected into a quasi-circular equatorial orbit around Mars at an altitude of about 6000 km from the surface. From this particular orbit, three different observation modes of MIRS are expected for Mars observations (see Figure 1) in addition to the limb mode: the so-called nominal mode whose purpose is to monitor up to low-medium latitudes, global mapping mode that covers most of the lighted Martian disk up to high latitudes ($\pm 60^\circ$), and region of interest mode that provides temporal resolution (down to 15 minutes) above a chosen area. Each mode will be used to study the spatial and temporal variations of the aerosols (atmospheric dust, water and CO_2 ice), and their fine diurnal variations. Indeed, the particular orbit of MMX (the second probe after Hope from EMM [4] to be in equatorial orbit) will allow MIRS to provide high-resolution spectral images in near-infrared and at very different local times, which will certainly contribute to answer to the questions addressed above.

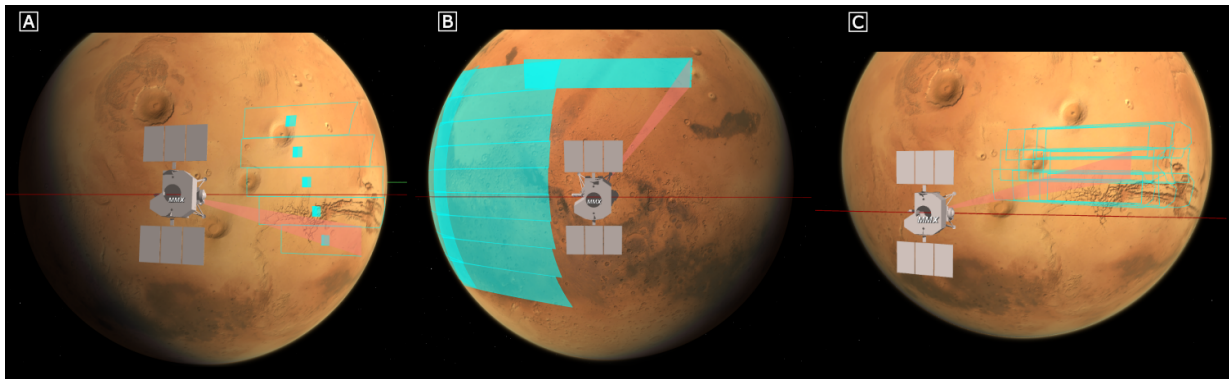


Figure 1: Illustration of the three expected observation modes of MIRS in addition to the limb mode: [A] nominal mode, [B] global mapping mode and [C] region of interest mode. Credits: CNES.

The retrieval pipeline for the MIRS observations is being prepared in coordination between the instrument team and the Mars Sub Science Team of the MMX mission. The two retrieval modules for trace gas and aerosols with nadir and limb observations are currently under development and will be validated by testing them on existing OMEGA/Mars Express data (e.g., [5], [6], [7]). In this study, focused on the aerosol retrievals, we use the DISORT (DIScrete-Ordinate-method Radiative Transfer) code [8, 9] through the *pyRT_DISORT* Python module [10] to simulate the expected radiance of the Martian atmosphere that MIRS will measure. First, we will present the parameter space exploration (estimated at up to 10 dimensions) of the radiative transfer model done to quantify the impact of each physical parameter (e.g., observation angles, surface albedo) on the generated spectra. Then, we will discuss the look-up table created by using different algorithms to explore the parameter space and their sampling in order to optimise the size of the look-up table (estimated at almost 75 million spectra), the computation time to create it, and to search in it. This table will be used to retrieve the aerosol properties in the flight data, which allows a faster retrieval than spectrum-to-spectrum inversion (given the large quantity of data that will be returned by MIRS). Finally, we will present MIRS images simulated with DISORT in real conditions during Phase 0 (orbit insertion and phasing), corresponding to the arrival of the MMX probe around Mars in 2027, for the different MIRS observation modes. These simulated data will be used to test the retrievals with the look-up table for future observations of Mars, get an understanding of the reachable performances, and help in defining the Phase 0 Mars set of observations.

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