RESULTS FROM THE EMIRATES MARS MISSION (EMM) - HOPE PROBE.
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Introduction: The Emirates Mars Mission (EMM) is the United Arab Emirates' (UAE) first mission to Mars and is the first Arab mission to another planet. It launched an unmanned observatory called "Hope" into an elliptical orbit around Mars on July 20, 2020 carrying three scientific instruments to study the Martian atmosphere in visible, ultraviolet, and infrared wavelengths. EMM is a strategic initiative that was announced by the UAE government in 2014 to disrupt and accelerate the development of the UAE's science and technologies sectors.

Hope Probe reached Mars on February 9th, 2021 and commenced its science phase on May 23rd, 2021. The mission aims to provide the first comprehensive picture of Mars' atmosphere with global coverage examining the diurnal and seasonal variations throughout one full Martian year. This submission highlights the scientific objectives of the mission, the instruments suite, as well as the status and key results from the mission since its arrival to Mars.

Orbit insertion on Feb 9, 2021.

Science Objectives: Hope's scientific mission is focused on studying the atmospheric circulation and dynamics from a highly elliptical orbit (20,000 km periapse and 43,000 km apoapse) that provides unprecedented local and seasonal time coverage over most of the planet. The three scientific objectives are to (A) characterize the state of the Martian lower atmosphere on global scales and its geographic, diurnal and seasonal variability, (B) correlate rates of thermal and photochemical atmospheric escape with conditions in the collisional Martian atmosphere, and (C) characterize the spatial structure and variability of key constituents in the Martian exosphere.

Science Instruments: EMM has three science instruments on the Hope Probe that are described below.

The Emirates Mars InfraRed Spectrometer (EMIRS) is a Fourier transform infrared spectrometer that captures synoptic views of the Martian disk. EMIRS measures the infrared spectrum from 1666 to 100 cm^{-1} (6-100 μm) in 10 and 5 cm^{-1} spectral sampling. EMIRS is designed to determine the column integrated abundance of water vapor, the column integrated dust and water ice opacities, and the atmospheric and surface temperatures.

The Emirates eXploration Imager (EXI) is a dual-telescope imaging system that provides full disk views of Mars using six band-passes (220, 260, 320, 437, 546, 635 nm) with single pixel footprints of 2-4 km on the Martian surface when observing from periapsis to apoapsis of the EMM orbit. EXI is designed to characterize the distribution of atmospheric constituents in the lower atmosphere such as water ice particles and ozone.

The Emirates Ultraviolet Spectrometer (EMUS) is a far-ultraviolet (FUV) imaging spectrograph that obtains views of the disk of Mars and the tenuous extended atmosphere surrounding it in the wavelength range of 100–170 nm. EMUS is designed to study two broad regions of the Mars upper atmosphere: 1) the thermosphere (100–200 km altitude), observing UV dayglow emissions from hydrogen, oxygen, and carbon monoxide, and 2) the exosphere (above 200 km altitude), observing bound and escaping hydrogen and oxygen.

Science Results: Hope is continuously collecting scientific data on the Martian atmosphere since its arrival to Mars on February 9th 2021. The data returned from the mission is enabling us to improve our understanding of the weather circulation in the lower atmosphere, the mechanisms behind the upward transport of energy and particles, and the subsequent escape of atmospheric particles from the gravity of Mars.

While the seasonal coverage objectives of the EMM mission will require more time to achieve, the data being returned is already beginning to push at the boundaries of knowledge about the Martian atmosphere. Due to the spacecraft's vantage point, EMIRS is able to measure the diurnal thermal cycle across the planet in a way not possible since the Viking mission. Preliminary atmospheric retrievals of temperature and water vapor allow for an unprecedented holistic comparison with predictions from a global circulation model (GCM). Even before the nominal mission began, the EMUS instrument serendipitously imaged displays of discrete aurora on the night side of the planet at wavelengths not previously observed. Its more routine measurements of the upper atmosphere are now showing large variations in atomic oxygen and carbon monoxide the upper atmosphere, likely due to diurnal transport and planetary waves. The EXI instrument is now returning frequent images of the cloud patterns across Mars at all times of day, much like the weather satellites orbiting Earth. It has also demonstrated the ability to track the distribution of ozone in the atmosphere, which is much less abundant than on Earth and anti-correlated with the abundance of water vapor. Figure 1 shows images captured by the three instruments at different times of the day for water ice in the lower atmosphere and hydrogen in the upper atmosphere showcasing how the water cycle can be studied using the EMM data.

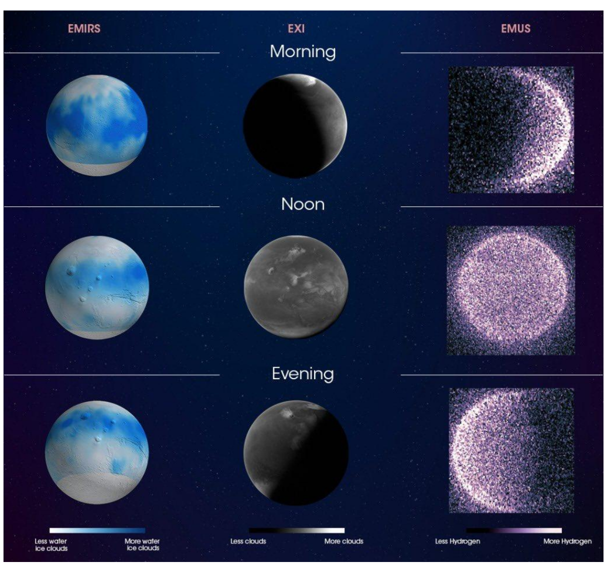

Figure 1: Three images from each EMM instrument are shown at morning, noon, and evening. EXI images show the diurnal cycle of water ice clouds in the lower atmosphere, while EMIRS images are showing the water ice optical depth with high abundance around the cloud belt near the equator. Complementary EMUS observations illustrate thin clouds of atomic hydrogen in the upper atmosphere of Mars.

While the types of observations made to date by the EMM mission have precedence in some aspects, the comprehensive coverage and the fact that coordinated observations in the infrared, visible, and ultraviolet are occurring from the same spacecraft with a coordinated purpose is novel. The science return possible from these fully integrated views of the atmosphere is only just starting to be realized.