Hope: The UAE Mars mission will study the mysteries of the red planet
Becky Nevin

The United Arab Emirates is a desert nation that's considering life after oil. And as part of that effort, they are retooling to study another desert on a different planet: Mars.

Just 50 years after it became a country, the UAE is teaming up with the University of Colorado, Arizona State University, and University of California Berkeley, to send the first ever space mission from an Arab nation 300 million miles to Mars.

"The UAE is shifting from just building the tangible things like technology and buildings. It's changing into building the future," says Noora Alsaeed, a student of planetary astronomy at the American University in Sharjah. "It kickstarted the Hope Mars mission."

The aptly named Hope mission will serve a dual purpose of propelling young Arabs like Alsaeed onto the world stage as scientists, while also unveiling the dual mysteries of Mars' missing atmosphere and liquid water.

Why is studying the atmosphere of Mars so important? As we struggle to understand our own fragile and ever-changing climate here on Earth, our neighboring planet offers a unique opportunity to learn about how an atmosphere affects a planet and changes over millions and billions of years.

"This will help us to model Earth's atmosphere and how it will evolve with time over millions of years," says Sarah Amiri, Deputy Project Manger of the Hope mission and science lead.

After decades of successful Mars orbiters and missions, the Hope mission is not just another face in the crowd.

The Hope mission will literally go above and beyond what other Mars climate orbiters have achieved in the past. It will collect data over the entire Martian year at higher altitudes than previous missions, and over a range of latitudes and longitudes.

"Our science mission is to produce the first ever truly global picture of the Mars atmosphere. This is the first holistic study of the Martian climate and how the layers of the climate fit together," says Omran Sharaf, Project Manager of the Hope Mission.

Past missions have focused on specific altitudes, longitudes, latitudes, and times of day, among a number of particular factors. For example, the MAVEN mission, run out of the University of Colorado, is designed to characterize just the lower atmosphere of Mars. This is important because it determined that solar radiation is responsible for stripping away particles in the atmosphere of Mars, but MAVEN alone cannot provide a complete picture of the entire atmosphere.

"Mars is a very complex environmental system," says Bruce Jakosky, MAVEN Principal Investigator and Hope Mission Co-Investigator at CU Boulder. "No one spacecraft mission can measure all of these things at one time. Each one plays a role in the broader scheme of putting together a picture of Mars."

From its higher vantage point, the Hope mission will stitch together the findings of MAVEN and other missions to create an overall picture of Mars' atmosphere. It will extend these findings even further to characterize how the Martian weather affects the atmosphere, how particles and energy travel between different layers of the atmosphere, and how particles escape from the upper atmosphere.

Step one for Hope is creating a weather channel for Mars.

“For the first time we'll be able to understand the seasonal changes that are occurring on Mars, the changes in the weather,” says Amiri.

Yes, Mars does have weather, even with an atmosphere that is 100 times thinner than our own. Among the weather phenomenon on the Red Planet are dry ice clouds, meaning they are made of carbon dioxide; and global dust storms that can last for weeks on end.

Understanding how seasonal changes can affect the energy and particles in the upper atmosphere will shed light on the big mystery of Mars’ missing atmosphere and water.

Today Mars is a desert world. Temperatures vary from a frigid -225°F during polar winter to a sweaty 95°F during equatorial summer. But unlike deserts here on Earth, intense study of the surface of Mars by rovers and orbiters over the last couple of decades has revealed that there is no liquid water on the surface of Mars.[1]

This wasn’t always the case. Hints of river deltas, glacial runoff, and other surface features point towards the presence of liquid water on Mars billions of years ago. Why was there flowing water in the past, and where did it go?

“The most compelling hypothesis is that there was a thicker atmosphere earlier on, probably carbon dioxide, and that provided greenhouse warming,” Jakosky says. “That greenhouse warming warmed the atmosphere and allowed liquid water to exist.”

In other words, water cannot exist on the surface of Mars without an atmosphere. If a rover were to spill a glass of water on the surface of Mars, it would immediately become water vapor. A lack of atmospheric pressure means that water has a very low boiling temperature. And that is precisely why it is so important scientifically to study the very tenuous atmosphere present today. It might help scientists figure out whether the hypothesis Jakosky sketches out is accurate.

If Mars once did have a thick carbon dioxide (CO_2) atmosphere, where did it go? There are two possibilities. Either the carbon formed carbonate rocks on the surface and the oxygen escaped to space, or the CO_2 escaped to space. Little evidence of carbonates on the surface of Mars has been found, so for planetary scientists like Jakosky, option two currently sounds like the better bet.

And here’s where Hope comes it. It will join MAVEN in investigating the hypothesis of atmospheric escape.

The basic concept of atmospheric escape is that particles in the atmosphere of a planet have some weight and energy. If the planet’s gravity is not strong enough to contain them or if their energy is high enough, they can escape the planet’s gravity. Heavier particles (like CO_2) can also be made lighter if whacked with enough energy to break apart the particle (into carbon and oxygen).

Particles can receive energy in a number of different ways. As MAVEN discovered, the magnetic field of Mars is not strong enough to shield particles from the energy of solar radiation. Likewise, energy can be transferred from the sun-warmed surface of Mars or other layers of the atmosphere through winds or waves into the upper atmosphere. Step two for Hope is investigating this transfer of energy between layers of the atmosphere.

Step three is solving the mystery of where all the water particles that once formed river deltas on the surface of Mars went. MAVEN discovered that the solar radiation is capable of splitting water (H_2O) up into hydrogen and oxygen, but did not study what happens to these lighter particles.

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[1] Scientists have found that there is a tiny amount of an extremely briny substance that exists as a liquid on the surface of Mars.

Michael Chaffin is a postdoctoral fellow at the University of Colorado Boulder who concerns himself with the escape of oxygen and hydrogen from the upper atmosphere. He works with both the MAVEN and Hope missions.

“The escape of oxygen and hydrogen takes place in an extended corona that extends out to many Mars radii,” says Chaffin. “The altitude [of Hope] is much higher than MAVEN and is actually higher than any previous mars spacecraft.”

The altitude of Hope’s orbit will allow it to characterize the escape of the light particles of hydrogen and oxygen that occurs at a distance equivalent to 1/10 the distance from the Earth to the moon. Previous missions have not studied the atmosphere this far away from the surface of Mars. And because of that, they have been missing a significant escape process.

In addition to providing a cohesive picture of the Martian atmosphere, the Hope mission is also critical to introducing the UAE to the global scientific community. The Hope mission was never meant to just be a proof of concept. It will provide open-source data to more than 200 research institutes and universities worldwide.

“I find it incredibly compelling and inspiring on a personal level,” says Jakosky. “They don’t want to just do a mission for the sake of getting hardware there and having it work. They want to be sure that it contributes substantially to our understanding of the planet.”

In addition to the science goals of the mission, the UAE’s strategy for the mission leads to the development of a future generation of scientists.

“We decided to do it ourselves, to build it ourselves, and to learn with our partners along the way. This mission is managed by a 100% Emirati team,” says Amiri.

The UAE is learning from their partner institutes to develop engineering and scientific capabilities, and we also have much to gain by following their lead.

In a field in which about 30% of scientists are women, it is a sharp contrast when the UAE’s science team is 50% female.

“I don’t know if it’s just a cultural thing but I just grew up and we didn’t focus on gender as much on either positive or negative. What you did is what you did and you earned the position that you get,” says Alsaeed of being a student in the UAE.

Amiri recounts visiting planetary conferences elsewhere in the world and being shocked by the lack of women in the field.

When asked how the broader scientific community might go about encouraging more women in science and engineering, she says, “When our country was founded, there were equal opportunities in education from the start. So our country did not inherit a gender gap. Girls were incentivised to go to school.”

The Hope mission is scheduled to arrive at Mars in 2021, on the 50th anniversary of one of the world’s youngest countries. In the meantime, it continues to be a powerful agent of societal and scientific innovation in the UAE and globally.