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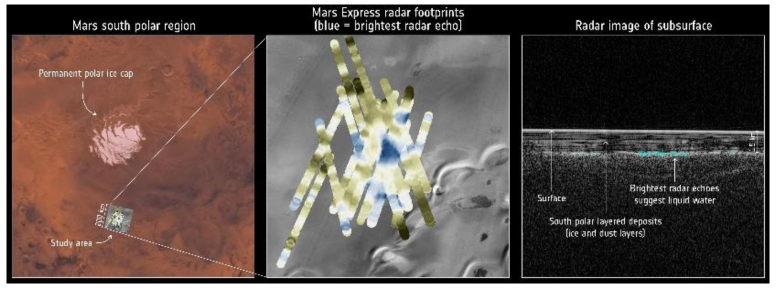
# Modelling the water cycle on Mars …

## … and how it affects one location – Lyot Crater

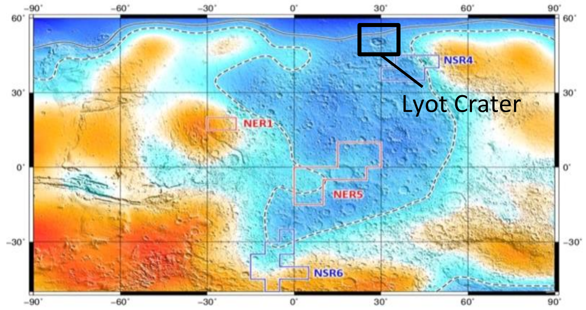
### Water on Mars

- We know there is water on Mars and water is essential for life.
- But we still need to understand where water is, in what form and how it behaves.
- So I am studying the water cycle – how water moves around the planet: in the air, on the ground and under the ground, and how it affects the geology.
- Water ice can be found at the poles, in the soil, and in glaciers and other icy deposits on the surface.




An underground lake has been found at the South Pole by the Mars Express orbiter: (left) the study area; (centre) the surface radar image, where the blue dots indicate subsurface water; (right) a subsurface radar image showing a water lake below the ice. [1]

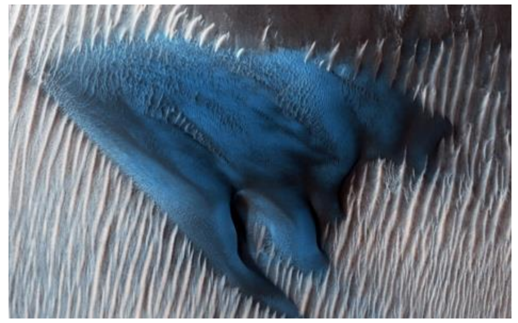
Korolev Crater, 80 km in diameter, is filled with water ice.[2]



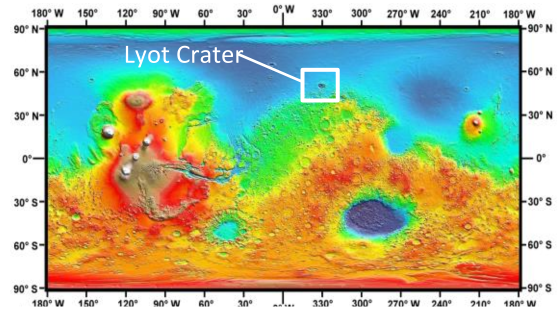

The FREND instrument on the ExoMars orbiter is studying the location and history of subsurface water ice[3] – on this map blue areas have more water ice than red and yellow areas. Lyot Crater, which I am studying, is in a relatively icy area.

### Lyot Crater

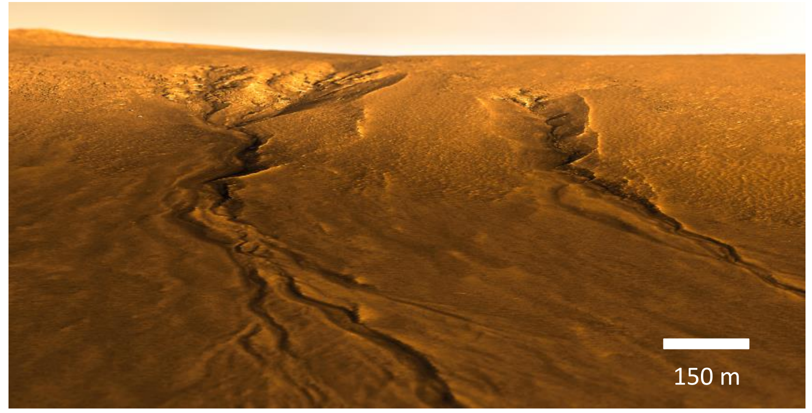
- Lyot Crater is ~220 km wide and it is 3 km deep, making it one of the lowest points in the northern hemisphere.
- It has the highest surface pressure in the northern hemisphere, at >10 mb; surface pressure, together with temperature, affects whether water is a gas, liquid or solid.
- Being a wide, deep hole in the ground with a high surface pressure, Lyot Crater is likely to have a microclimate which allows it to have ice-rich deposits and possibly liquid water.
- Its features will have been affected by climate changes over the millennia.



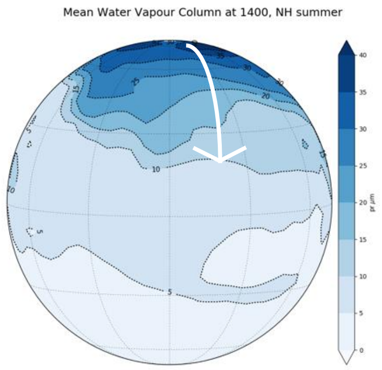
Above: A 400 m-wide dune on top of a field of barchan dunes on the crater floor[4].
Below: Gullies on the central peak of the crater[5].




Lyot Crater is just north of the dichotomy boundary, which divides the mountainous southern hemisphere (red) from the flat northern hemisphere (blue), where there may have been an ocean if Mars had a wet period early in its history[6].

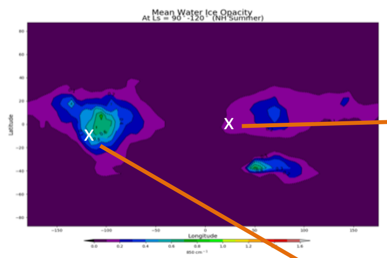


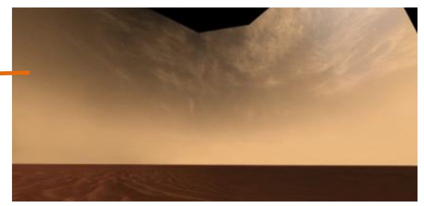

### Modelling the water cycle globally…




- The Mars Global Climate Model simulates the water cycle over the entire planet.
- I am adapting the model to give the best representation of the Martian water cycle, and then I compare the results to observational data to make sure it is reasonably accurate.

My model output shows how water vapour moves from the north polar ice cap, where water ice evaporates into the atmosphere so there is a lot of vapour (dark blue), and travels around the planet towards the south, where there is less vapour (pale blue).

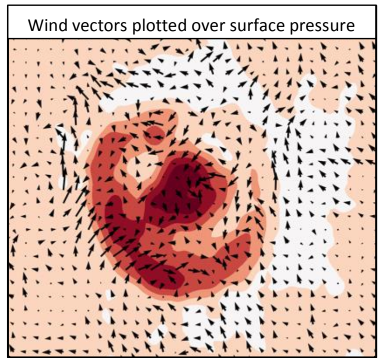


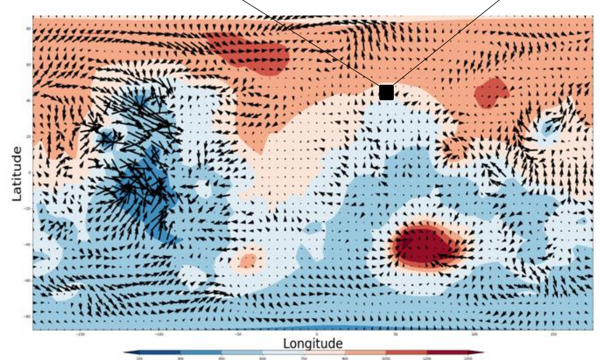



Water ice clouds are seen over the equator. The model (top, left) shows clouds form in the equatorial region. The Opportunity rover took the picture (top, right) of the cirrus-like equatorial clouds[7]; the Mars Express orbiter took the bottom picture of this ~1,500 km-long banner cloud seen near the Arsia Mons volcano[8].

### and at a small scale

- A mesoscale (middle-scale) model provides high resolution simulations which give a realistic depiction of the climate over smaller scales at specific locations.
- Studying the results from this model lets me analyse aspects of the atmosphere and its impact on surface features in Lyot Crater more closely.




My output from the mesoscale model (top) shows a close-up of the winds in and around Lyot Crater in comparison to my global model data (at the bottom), where the winds show only the general flow over the planet as a whole, without any detail of what is happening at specific locations.

### Future work

- Run the global and mesoscale models at different settings to see how the climate changed over time.
- Compare the model results with observations from orbiters.
- Examine how the modelled climate would interact with the water ice in the crater – does it melt and refreeze, when, is there supporting evidence from the geology?
- Compare Lyot Crater with other craters.

**References:** 1. Orosei, R., et al., (2018). Radar evidence of subglacial liquid water on Mars. *Science*, p.eaar7268.; 2. ESA/DLR/FU Berlin, High Resolution Stereo Camera, Mars Express. 3. Mitrofanov, I.G., et al., (2019). Neutron Mapping of Mars with High Spatial Resolution: First Results of FREND experiment of the ExoMars Project. *Proceedings of the Russian Academy of Science*, accepted. 4. NASA/JPL-Caltech/Univ. of Arizona, HiRISE. 5. NASA/JPL-Caltech/Univ. of Arizona, HiRISE, reprocessed by Kevin Gill, USA. 6. Data from the Mars Orbiter Laser Altimeter, NASA. 7. NASA/JPL/Cornell, Opportunity rover. 8. ESA/DLR/FU Berlin, Mars Express.