EPSC Abstracts
Vol. 18, EPSC-DPS2025-295, 2025
EPSC-DPS Joint Meeting 2025

Cloud Morphologies on Mars: A Closer Look through the HRSC Cloud Atlas

Daniela Tirsch[1], Jorge Hernández-Bernal[2], Agustín Sánchez- Lavega[3], Pedro Machado[4,5], Francisco Brasil[4,5], Ashwathy Nair[1], and Mariana Da Silva Encarnacao[1,6]

[1]German Aerospace Center (DLR), Institute of Planetary Research, Berlin, Germany (daniela.tirsch@dlr.de)

[2]Laboratoire de Météorologie Dynamique, Sorbonne Université, Paris, France

[3]Universidad del País Vasco UPV/EHU, Bilbao, Spain

[4]Instituto de Astrofísica e Ciências do Espaço, Lisboa, Portugal

[5]Faculdade de Ciências da Universidade de Lisboa, Portugal

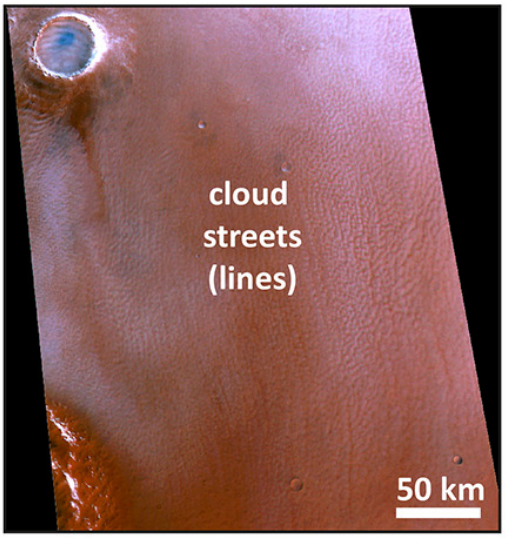
[6]Universidade de Coimbra, Coimbra, Portugal

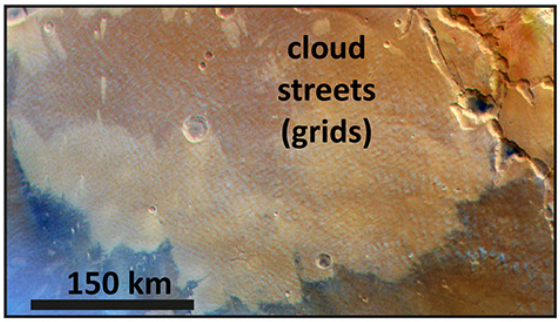
Thanks to a long-term atmospheric monitoring campaign, the High Resolution Stereo Camera (HRSC) onboard Mars Express provides an exceptionally detailed view of atmospheric phenomena on Mars. These observations have been compiled into a comprehensive database - the HRSC Cloud Atlas [1, 2] - which offers in-depth information on the types, distributions, characteristics, and morphologies of various clouds and storm systems across different Martian seasons. Covering data from 2017 to the present, this catalog provides fundamental knowledge about when and where specific cloud and storm types occur on Mars. This in turn allows conclusions on the underlying atmospheric conditions and surface-atmosphere interactions, as each of these phenomena forms under specific boundary conditions constrained by factors such as temperature, pressure, dust and aerosol content, circulation patterns, seasonal cycle, topography, and altitude [e.g., 3, 4, 5].

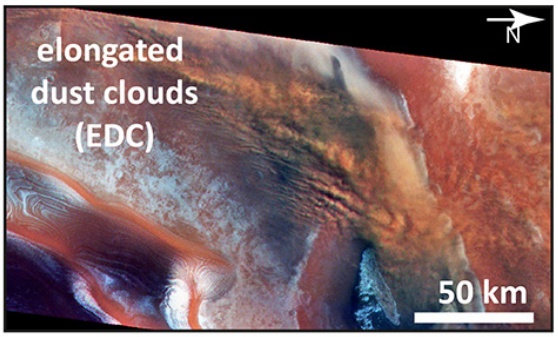
We will present a comprehensive overview of the cloud type classes identified in our study, the classification scheme developed for their categorization, and detailed close-up views to illustrate the remarkable variability and visual elegance of Martian clouds. Due to space and time constraints, this presentation focuses exclusively on cloud phenomena.

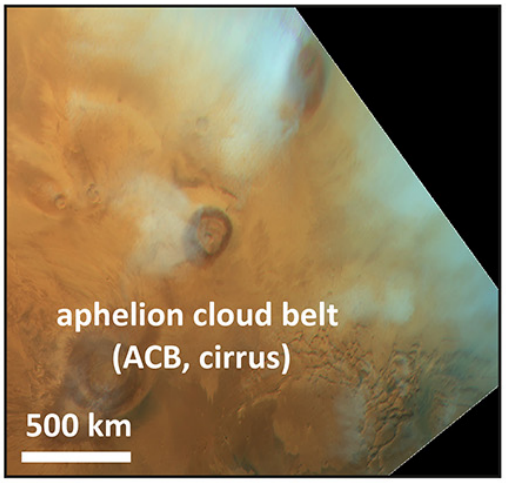
Our analysis reveals that cloud types on Mars are significantly more diverse than previously reported in studies based on lower-resolution imaging instruments [e.g., 3, 6, 7], which nonetheless serve as the foundation of our classification scheme. The higher resolution of HRSC has allowed us to refine and extend existing classification systems, propose updated definitions, and introduce previously unidentified cloud types.

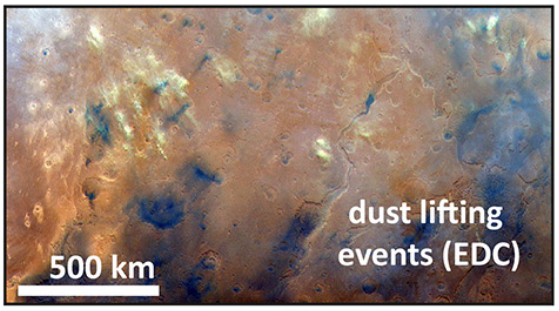
One such discovery is a new class of Elongated Dust Clouds (EDCs) - enigmatic features that occur during a narrow seasonal window and within a specific southern latitude band. While they resemble trough clouds likely formed by katabatic jumps [8], EDCs appear farther from the South Pole and are not always associated with topographic troughs. Another notable finding is that the Aphelion Cloud Belt (ACB, [e.g., 2, 8]), does not only contain diffuse cirrus-type clouds, also forms as gravity wave fields as well as structured cloud street fields made up of small cumulus cloud cells arranged in linear or grid-like patterns - features previously observed only at high northern latitudes. Furthermore, it was possible to observe the daily cycle of the Arsia Mons Elongated Cloud (AMEC, [10]) in high resolution and at multiple local solar times, allowing us to visualize its development phases in great visual detail.

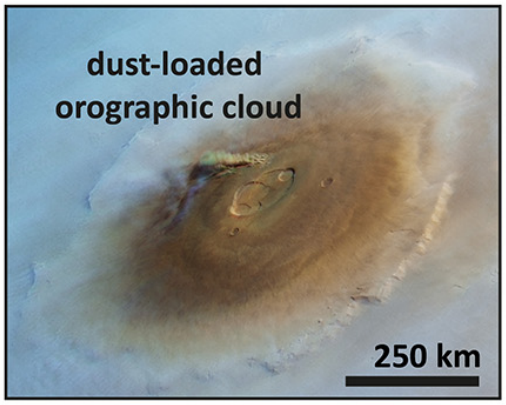

cloud
streets
(lines)
50 km

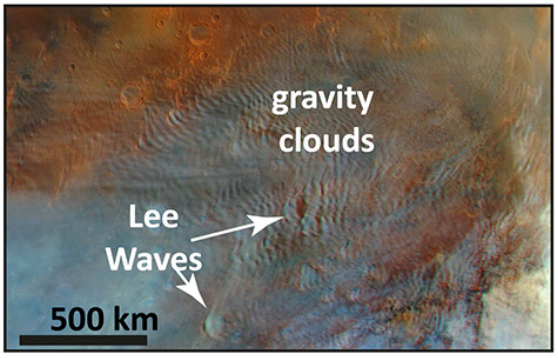

cloud
streets
(grids)
150 km

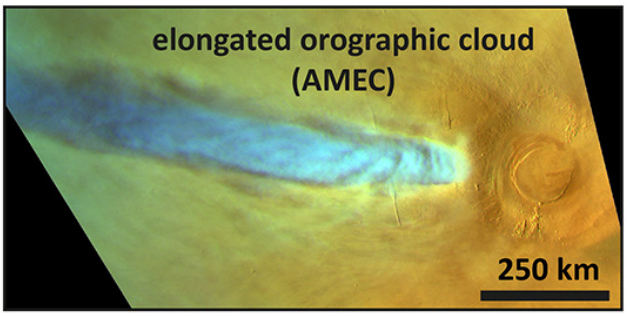

N
elongated
dust clouds
(EDC)
50 km


aphelion cloud belt
(ACB, cirrus)
500 km


dust lifting
events (EDC)
500 km


dust-loaded
orographic cloud
250 km


gravity
clouds
Lee
Waves
500 km


elongated orographic cloud
(AMEC)
250 km

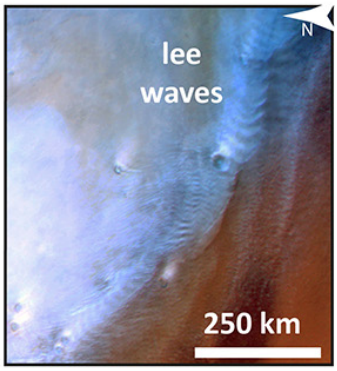

N
lee
waves
250 km

Fig. 1: Selection of close-up example images of cloud types identified in HRSC data.

References:

[1] Tirsch, D., Machado, P., Brasil, F., Hernández-Bernal, J., Sánchez-Lavega, A., Carter, J., Montmessin, F., Hauber, E., Matz, K.-D., Nair, A., 2024, Clouds and Storms as seen by HRSC - A catalogue of atmospheric phenomena on Mars, European Planetary Science Congress, Berlin, Germany, EPSC2024-2044.

[2] HRSC team site; data products node: https://hrscteam.dlr.de/public/data.php

[3] Clancy, R.T., Montmessin, F., Benson, J., Daerden, F., Colaprete, A., Wolff, M.J., 2017. Mars Clouds, in: Haberle, R.M., Clancy, R.T., Forget, F., Smith, M.D., Zurek, R.W. (Eds.), The Atmosphere and Climate of Mars. Cambridge University Press, Cambridge, pp. 76-105.

[4] Cantor, B., Malin, M., Edgett, K.S., 2002. Multiyear Mars Orbiter Camera (MOC) observations of repeated Martian weather phenomena during the northern summer season. Journal of Geophysical Research: Planets 107, 3-1-3-8,https://doi.org/10.1029/2001JE001588.

[5] Sánchez-Lavega, A., del Río-Gaztelurrutia, T., Spiga, A., Hernández-Bernal, J., Larsen, E., Tirsch, D., Cardesin-Moinelo, A., Machado, P., 2024. Dynamical Phenomena in the Martian Atmosphere Through Mars Express Imaging. Space Science Reviews 220, 16,10.1007/s11214-024-01047-4.

[6] French, R.G., Gierasch, P.J., Popp, B.D., Yerdon, R.J., 1981. Global patterns in cloud forms on Mars. Icarus 45, 468-493,https://doi.org/10.1016/0019-1035(81)90047-6.

[7] Wang, H., Ingersoll, A.P., 2002. Martian clouds observed by Mars Global Surveyor Mars Orbiter Camera. Journal of Geophysical Research 107, 8-1-8-16,https://doi.org/10.1029/2001JE001815.

[8] Smith, I.B., Holt, J.W., Spiga, A., Howard, A.D., Parker, G., 2013. The spiral troughs of Mars as cyclic steps. Journal of Geophysical Research (Planets) 118, 1835-1857

[9] Pearl, J.C., Smith, M.D., Conrath, B.J., Bandfield, J.L., Christensen, P.R., 2001. Observations of Martian ice clouds by the Mars Global Surveyor Thermal Emission Spectrometer: The first Martian year. Journal of Geophysical Research: Planets 106, 12325-12338,https://doi.org/10.1029/1999JE001233.

[10] Hernández-Bernal, J., Sánchez-Lavega, A., del Río-Gaztelurrutia, T., Ravanis, E., Cardesín-Moinelo, A., Connour, K., Tirsch, D., Ordóñez-Etxeberria, I., Gondet, B., Wood, S., Titov, D., Schneider, N.M., Hueso, R., Jaumann, R., Hauber, E., 2021. An Extremely Elongated Cloud Over Arsia Mons Volcano on Mars: I. Life Cycle. Journal of Geophysical Research: Planets 126, e06517,doi: 10.1029/2020je006517.