Section: Physical and Mathematical Sciences

DOI 10.70286/EOSS-26.01.2026.006.179-183

TEMPERATURE REGIME AND THE INFLUENCE OF VOLCANISM ON THE COMPOSITION OF THE MARTIAN ATMOSPHERE

Vidmachenko Anatoliy Petrovych
Doctor Phys.-Math. Sci., Professor
Professor of Department of Physics
National University of Life and Environmental Sciences of Ukraine

Abstract. The current extremely thin Martian atmosphere is mainly composed of carbon dioxide. The current average temperature near the surface of Mars is 210 K. At the equator, the surface temperature reaches +30°C at noon in summer and drops to -153°C at the poles in winter. Diurnal variations in the mid-latitudes exceed 100°C. Currently, the Martian climate is characterized by global dust storms. Seasonal fluctuations are also observed in methane concentrations. The current state of the atmosphere is the result of a continuous process of atmospheric loss over geological time. This emphasizes the dramatic climatic and atmospheric evolution. At an altitude of about 40 km, an ozone layer up to 7 km thick has been found in the atmosphere.

Keywords: Mars, atmospheric evolution, diurnal variations, chemical composition.

Mars is currently a very cold world [4, 14, 20, 21]. The average surface temperature is about 210 K, which is much colder than the harshest conditions in Antarctica on Earth. Temperatures on Mars vary widely. According to the "Curiosity" rover, in the warmest conditions, the surface temperature at the equator in summer at noon can temporarily rise above 0°C, reaching +20°C, or even +30°C. However, the extreme lows are much lower: at the poles during the polar night the temperature can drop to -143°C, or even -153°C. The very thin atmosphere of Mars now does not retain heat well. This leads to huge daily temperature fluctuations. Even at the equator, the temperature can drop from +20°C during the day to -80°C the next night. That is, daily differences in mid-latitudes can exceed 100°C. Observations by the “Perseverance” spacecraft in the Jezero crater recorded a rapid drop in temperature of 5°C (from -20°C to -25°C) in just half an hour; this indicates very sharp changes even in local conditions. Temperature also varies significantly depending on the season, elevation [1, 16, 19, 24], and latitude. Polar regions are the coldest, especially in winter; while equatorial regions receive more solar heat. A significant amount of CO_2 is currently not participating in seasonal changes, since it does not have time to evaporate from one polar cap, while the rest of it is adsorbed in the regolith.

On Mars, aerosol particles in the atmosphere [8, 9] have a significant influence on the formation of the general climate [10]. When Mars passes near perihelion, this influence is significantly enhanced. And then global dust storms begin to arise [6, 2], transporting significant amounts of dust across the planet [26, 27]. Therefore, dust storms are now a characteristic feature of the Martian climate (Fig. 1, left). They can range from small local vortices, known as “dust devils” (Fig. 2, right), to gigantic global storms that can cover the entire planet and last for months [26, 27].

Fig. 1. Left – local type of dust storm that formed on the edge of the southern polar region (http://photojournal.jpl.nasa.gov/). Right – the “Perseverance” rover recorded the collision of two dust vortices on the surface of Mars (https://benchmark.rs/wp-content/uploads/2025/04/Pustinjski-davoli-na-Marsu.webp).

These storms lift vast quantities of fine reddish dust into the atmosphere, which can also significantly affect surface and atmospheric temperatures by blocking sunlight, as well as atmospheric pressure. During powerful dust storms, the dust rises to heights of up to 20 km. The atmosphere then becomes noticeably dusty, containing particles about 1.5 microns in diameter. Their presence gives the Martian sky a reddish or pinkish hue [3, 17, 22] when viewed from the surface due to iron oxide particles suspended in the atmosphere. Seasonal fluctuations are also observed in methane concentrations, which vary from about 0.24 ppb in the northern winter to about 0.65 ppb in the summer and may be associated with the presence of certain life forms [12, 13, 15]. The current Martian atmosphere is mostly carbon dioxide and is extremely thin. This low pressure, combined with low temperatures, makes liquid water unstable on the planet's surface. However, extensive geological evidence, such as ancient river valleys and lake beds, strongly suggests that liquid water was widespread on Mars in its past. This poses a significant paradox: how could liquid water have existed under such conditions? The logical conclusion is that the early atmosphere of Mars must have been much denser, likely supported by significant and prolonged volcanic outgassing [23] due to the absence of plate tectonics [2, 5].

The current state of the atmosphere is thus the result of a profound and continuous process of atmospheric loss over geological time, underscoring dramatic climatic and atmospheric evolution [11, 18, 25]. At an altitude of about 40 km, even an ozone layer, nearly 7 km thick, has been found in the atmosphere. At an altitude of □300 km, atomic oxygen becomes the main constituent of the atmosphere. Its presence can be explained by the processes of photodissociation of carbon dioxide.

This conclusion follows from the fact that the density of its other product, carbon C, decreases with altitude faster than the density of oxygen. Starting from an altitude of 400 km, the predominant component of the atmosphere on Mars is atomic hydrogen with a concentration of 10^4 atoms in 1 cm^3. It is expected that almost the same amount of helium is retained at the same altitude. At an altitude of several thousand kilometers, the atmosphere should consist of almost pure hydrogen. And such an outer atmosphere of Mars from pure hydrogen extends to an altitude of 20,000 km, forming a kind of hydrogen “corona” of the planet.

It was studied by various spacecraft [11, 12] that used special receivers sensitive to radiation in the hydrogen Lyman-□ resonance line. Such radiation occurs when solar ultraviolet radiation is scattered by hydrogen atoms located in the upper part of the Martian atmosphere. Hydrogen atoms in the upper parts of the planet's atmosphere should dissipate into interplanetary space. But since they are present in the modern atmosphere of Mars, there must be a constant source of their replenishment at present. It is clear that one of the main such sources could be the dissociation of water vapor from the upper layers of the atmosphere of Mars. Thus, even a very small amount of water vapor H_2O, which is currently present there, is sufficient for this purpose.

References

1. Bertka C.M., Fei Y. (1998) A profile of Martian mineralogy and density up to core-mantle boundary. LPSC. V. 27. P. 107-108.
2. Bi H., Sun D., Sun N., et al. (2025) Seismic detection of a 600-km solid inner core in Mars. Nature. 645, p. 67–72.
3. Bibring J.-P., Langevin Y., MustardJohn Y. F., et al (2006) Global mineralogical and aqueous mars history derived from OMEGA/Mars express data. Science. 312, p. 400-404.
4. Carr M.H. (1999) Retention of an atmosphere on early Mars. Journal of Geophysical Research: Planets. 104(E9), p. 21897-21909.
5. Clinton J.F. (2017) Preparing for InSight: An Invitation to Participate in a Blind Test for Martian Seismicity. Seismological Research Letters. 88(5), p. 1290-1302.
6. de Beule C., Wurm G., Kelling T., et al. (2015) An insolation activated dust layer on Mars. Icarus. 260, p. 23-28.
7. Fisher J.A., Richardson M.I., Newman C.E., et al. (2005) A survey of Martian dust devil activity using Mars Global Surveyor Mars Orbiter Camera images. J. Geophys. Res. 110(E3), p. 3-4.
8. Morozhenko A.V., Vidmachenko A.P. (2017) Optical Parameters of Martian Dust and Its Influence on the Exploration of Mars. Dust in the Atmosphere of Mars and Its Impact on Human Exploration, Proceedings of the conference held 13-15 June 2017 in Houston, Texas. LPICo No. 1966, id.6010.
9. Morozhenko A.V., Vidmachenko A.P. (2020) Dust can affect on the mastering of

Mars. 22 ISCo AS YS. December 11-12, 2020. Kyiv, Ukraine. P. 71-73.
10. Pollack J.B., Kasting J.F., Richardson S.M., Poliakoff K. (1987) The case for a wet, warm climate on early Mars. Icarus. 71(2), p. 203-224.
11. Schmidt F., Chassefière E., Tian F., et al. (2016) Early Mars volcanic sulfur storage in the upper cryosphere and formation of transient SO2-rich atmospheres during the Hesperian. Meteoritics & Planetary Science. 51(11), p. 2226-2233.
12. Steklov A.F., Vidmachenko A.P. (2019) In What Places and What Exactly Can be the "Traces" of Life on Mars? 9th ICo on Mars. 2089, 6007.
13. Steklov A.F., Vidmachenko A.P. (2019) Where and What Exactly Can Be the “Traces” of Life on Mars? Mars Extant Life: What's Next? Held 5-8 November 2019, in Carlsbad, New Mexico. LPI Contribution No. 2108, id.5089.
14. Vidmachenko A.P. (2014) Study of Earth-like planets. 16 ISCo Astronomical School of Young Scientists. Kirovohrad, Ukraine. May 29–31, 2014. P. 12-13.
15. Vidmachenko A.P. (2017) What forms of life could have arisen in the ancient conditions of Mars? 19 International Scientific Conference Astronomical School of Young Scientists. May 24–25 2017. Bila Tserkva, Ukraine. P. 16-17.
16. Vidmachenko A.P. (2023) About volcanoes on Mars. Proceedings of 11 All-Ukrainian Scientific Conference “Astronomy and present day”, April 12, 2023. Vinnytsia, Ukraine. LLC "TVORY". ISBN 978-617-552-363-6. P. 76-81.
17. Vidmachenko A.P. (2023) Comparison of features of impact and volcanic craters on the surface of Mars. Proceedings of VIII ISPCo. Progressive research in the modern world (April 27-29). P. 237-246.
18. Vidmachenko A.P. (2023) History of possible climate change on Mars. Proceedings of VII ISPCo Science and innovation of modern world. (23-25.03.2023). Chapter 54. Cognum Publishing House, London, United Kingdom, p. 336-345.
19. Vidmachenko A.P. (2023) Macrorelief of the surface of Mars. Proceedings of XIV ISPCo Prospects for the development of science and the environment. (April 10-12, 2023). Chapter 7. P. 34-39.
20. Vidmachenko A.P. (2023) The atmosphere of Mars. Proceedings of VI International Scientific and Practical Conference. Scientific research in the modern world (April 6-8) P. 283-293.
21. Vidmachenko A.P. (2023) Thermal properties of the surface of Mars. Proceedings of VII International Scientific and Practical Conference. Progressive research in the modern world (March 29-31, 2023). Chapter 42. P. 243-252.
22. Vidmachenko A.P., Klimenko V.M., Morozhenko A.V. (1981) Apparent spectral albedos of the disk of Mars in September-October 1977. Solar System Research. 14(4), p. 157-159.
23. Vidmachenko A.P., Mozghovyi O.V., Steklov O.F. (2023) About volcanoes on Mars. Proceedings of 11 All-Ukrainian Scientific Conference “Astronomy and present day”, April 12, 2023. Vinnytsia, Ukraine. LLC "TVORY". P. 76-81.
24. Vidmachenko A.P., Mozghovyi O.V., Steklov O.F. (2023) Features of the relief on the surface of Mars. Proceedings of 11 All-Ukrainian SCo “Astronomy and present day”, April 12, 2023. Vinnytsia, Ukraine. LLC "TVORY". P. 66-71.

25. Vidmachenko A.P., Mozghovyi O.V., Steklov O.F. (2023) Historical aspects of climate changes on Mars. Proceedings of 11 All-Ukrainian SCo "Astronomy and present day", April 12, 2023. Vinnytsia, Ukraine. LLC "TVORY". P. 56-61.
26. Vidmachenko A.P., Mozghovyi O.V., Steklov O.F. (2023) Peculiarities of dust storms on Mars. Proceedings of 11 All-Ukrainian SCo "Astronomy and present day", April 12, 2023. Vinnytsia, Ukraine. LLC "TVORY". P. 87-92.
27. Wang H. (2017) Major dust storms and westward traveling waves on Mars. Geophysical Research Letters. 44(8), p. 3493-3501.

INVESTIGATING THE RELATIONSHIP BETWEEN POLYMODAL FILLER DISTRIBUTIONS AND MACRO-SCALE THERMAL CONDUCTIVITY IN COMPOSITES

Pysarenko Alexander
c.ph.-m.s., as.prof.
Department of Physics
Odesa State Academy of Civil Engineering and Architecture, Ukraine

Abstract. Polymer-based composites have garnered significant academic and industrial interest in this context, primarily due to their inherent advantages such as ease of manufacturing, environmental sustainability, and overall cost-effectiveness. Despite these benefits, the advancement of high-performance thermally conductive polymer composites is fundamentally challenged by the presence of interfacial thermal resistance. This phenomenon occurs when diverse filler morphologies, encompassing various chemical types, particle sizes, and geometric shapes, are introduced into the polymer matrix. Interfacial thermal resistance acts as a bottleneck for heat flow, significantly restricting the theoretical thermal conductivity values that these materials could otherwise achieve. This article delivers an exhaustive and detailed review of current methodologies designed to minimize the impact of interfacial thermal resistance through the precise optimization of filler parameters. A critical analysis of the literature reveals that the hybridization of two or more distinct filler types demonstrates a remarkable capacity for improving thermal performance. This improvement is driven by a synergistic effect that facilitates the formation of an interconnected three-dimensional conductive network or pathway within the material structure. One of the most significant observations is that the physical size and geometric form of the fillers play a more decisive role in enhancing the thermal conductivity than the specific type of filler material utilized. This is explained by the fact that optimized dimensions and shapes lead to a substantial increase in the contact area between the particles, which in turn drastically reduces the resistance at the interfaces. By addressing these fundamental factors, researchers can more effectively engineer materials that meet the thermal demands of modern electronics.