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Cartographic visualization of the Mars terraforming process

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Abstract:

Current atmospheric conditions on Mars make it impossible for life forms known on Earth to exist (Fogg, 1998). In the past, Mars had liquid water and a denser atmosphere. Scientific research indicates that by artificially enhancing the greenhouse effect, it is possible to change the climate of Mars so that it is similar to conditions on Earth (Sagan , 1973, Burns, 1973, Graham, 2004, Beech, 2009). The terraforming process requires that the average temperature on the Red Planet increase by about 60 degrees (Lovelock, 1984). It is also necessary to thicken the atmosphere of Mars (McKay, 1991, Zubrin, 1997, Marinova, 2005, McKay, 2011).

Research conducted using energy balance simulations at high spatial and temporal resolution (Olszewski et al., 2025) indicates that for a CO2 atmosphere with a pressure of 10 kPa, surface temperatures suitable for plant growth occur when the artificial, greenhouse thermal-infrared grey opacity (tau) is ~0.39 optical depths. The region that would then be the first to reach the desired climatic parameters is the Hellas Basin crater (Fig. 1a). The results of the Mars terraforming process for various parameters of the simulation model indicate that for an atmosphere composed of CO2 with a pressure of 50 kPa and a strong greenhouse effect (tau = 0.5), much of Mars would indeed become a “red planet” with a climate too hot for terrestrial life to exist there (Fig. 1b).

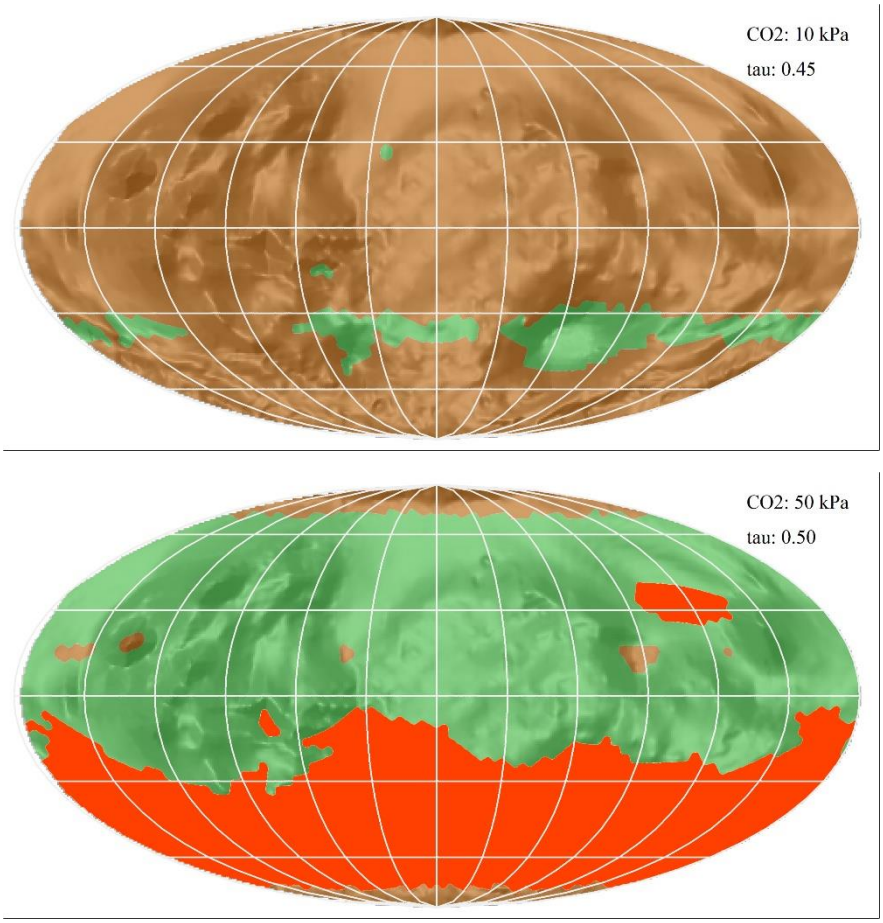

Figure 1. Results of the Mars terraforming process for different parameters of the simulation model.

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The authors of the article, using the results of the modelling of the terraformation process of Mars (Olszewski et al., 2025), developed a methodology for the cartographic presentation of this process that takes into account not only the spatial variation of altitude and climatic conditions on Mars, but also changes over time. Both standard GIS tools and Unreal and Unity game engines were used to present the results in the form of 3D cartographic animation. The use of these technologies made it possible to visualize the process of gradual warming of Mars' atmosphere realistically and in accordance with cartographic methodology. Cartographic animation illustrates the process of melting of polar ice caps on Mars, the formation of zones that allow the growth of plants, as well as the progressive “reddening” of the Red Planet as the greenhouse parameters increase. The developed 3D models can be presented both as static maps and dynamic cartographic presentations.

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