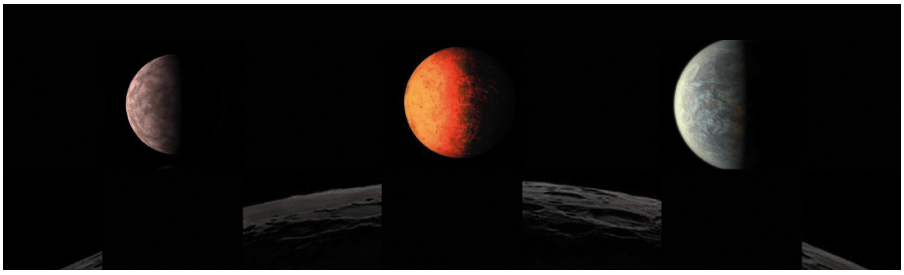

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Toward the first tree on Mars: energy balance simulations of growth conditions

Friday 24 October 2025 18:00 (1 hour)

We developed a high-resolution surface energy balance model for Mars using a 4002-cell Goldberg polyhedron. The model accounted for radiation, heat diffusion between cells, CO_2 phase changes, subsurface exchange, and atmospheric heat transport. We calibrated parameters against Viking lander data and Mars GCMs, and then applied the model to assess the combined effects of elevated CO_2 pressure and artificial greenhouse forcing on surface temperatures.

The atmospheric conditions existing on Mars today make the existence of life impossible. Sustained tree growth demands growing seasons of 110 sols, with daily temperatures ranging from >−6℃ (minimum) to < 40℃ (maximum), and mean values >6℃. The requirements for plant growth on Mars have been considered in the context of terraforming and for low-pressure greenhouses. The total pressure must be above ~10 kPa, and while a high percentage of CO_2 is acceptable, O_2 is needed for respiration at a level of ~ 0.1 kPa. Water must be available, and the temperatures must be in the range required for growth. Here, we focus on temperature as this is the fundamental environmental variable that changes during terraforming, and it controls the CO_2 cycle and the formation of liquid water. O2 levels in a thick warmer atmosphere remain an important separate concern. Focusing on the temperature, it must be several tens of degrees higher, while its diurnal fluctuations should be much lower.

We present results for an assumed CO_2 surface pressure of 10 kPa, which is known to support plant growth. We find that temperatures suitable for trees to grow occur when the added, artificial, greenhouse thermal infrared gray opacity is ~0.27 optical depths. Surprisingly, the conditions that allow plant growth do not occur first within the tropics (±25°) but in the Hellas Basin region. A further increase in the greenhouse effect expands the area suitable for plant growth in the southern hemisphere.

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