

Physical processes causing the formation of penitentes

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Penitentes are natural patterns made of compact snow or ice. They are typically found in mountains at high altitudes where humidity and temperature are low and solar radiation is intense. In these conditions, solid water sublimates when heated, and tall thin spikes oriented toward the main direction of the sun emerge by differential ablation. They have been reproduced at a centimeter scale in laboratory experiments (Bergeron et al., 2006).

Here we have investigated the physical processes at the initial stage of penitente growth and performed the linear stability analysis of a flat surface submitted to the solar heat flux. We have shown that these patterns do not simply result from the self-illumination of the surface –a scale-free process– but are primarily controlled by vapor diffusion and heat conduction. The wavelength at which snow penitentes emerge is derived and discussed. We found that it is controlled by aerodynamic mixing of vapor above the ice surface.

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