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Ice crystal orientation in both warm and cold ice clouds

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Preferential orientation of ice cloud crystals, which occurs under specific conditions, leads to a variety of optical displays in the atmosphere and might have a radiative impact by increasing cloud albedo and changing sedimentation speed. Moreover, the similar optical signature of oriented ice crystals and cloud droplets can lead to biases in remote-sensing retrievals of cloud properties.

We present two distinct events of ice crystal orientation that were observed during balloon/lidar match experiments in noticeably different temperature and saturation regimes. The balloons carried a frost point hygrometer and a backscatter sonde, while the lidar measured water vapor mixing ratio and particle extinction by Raman effect.

The first event was observed close to water saturation at around -25 °C, which might result from cloud droplet freezing in a temperature and saturation regime favorable for (rather irregular) plate-like crystal formation. The second event was observed close to ice saturation at temperatures as low as
-60 °C, which might result from the presence of pristine, small oriented hexagonal crystals.

We support our physical interpretation and the evidence of ice crystal orientation in both warm and cold ice clouds with cloud optical and microphysical Lagrangian box modeling and with Ray-tracing calculations. This helps to assess the prevailing dynamical conditions and the type of nucleation involved, as well as the number density, size and growth habit of the ice particles, and allows estimating the impact of the oriented ice crystals on the cloud radiative properties.