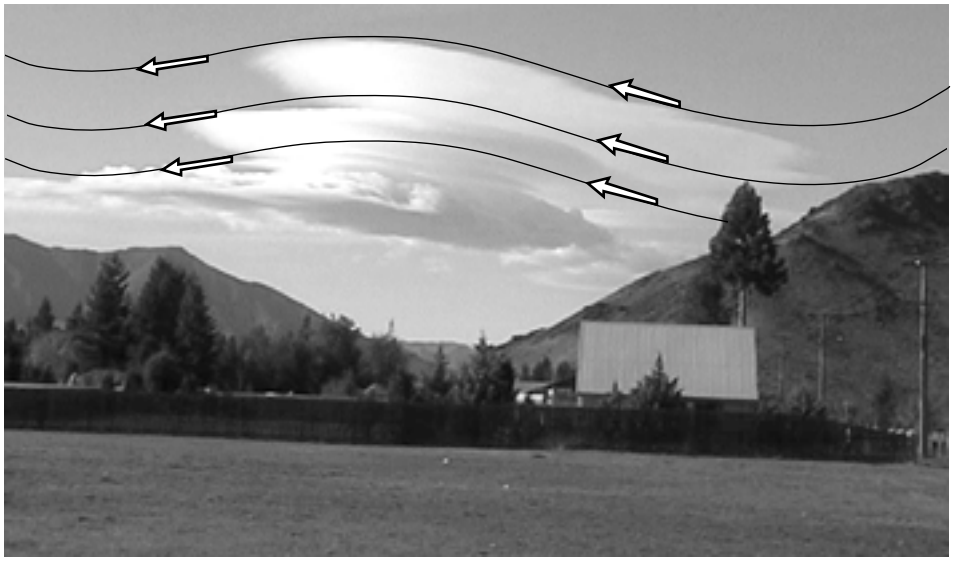


Lenticular cloud indicating the position of the crests of standing waves.

These lenticular clouds were formed after a moist westerly airstream passed over the high mountain ranges of New Zealand's south island.
The actual mountain range is out of the picture to the right and the stationary clouds illustrate the undulating motion of the atmosphere after it has crossed the range.

New Zealand's south island is a popular venue for gliding. Glider pilots find the rising air currents by exploring the region at the upwind side of the clouds. Once established in the rising side of the wave, the glider can rise to heights much greater than the mountain range which triggered it.

AIRFRAME ICE

Supercooled water droplets. When you make ice cubes in your refrigerator, the liquid water freezes when its temperature drops to or below 0°C. To allow water to freeze, latent heat must be released from the water to the environment [see Section 3].

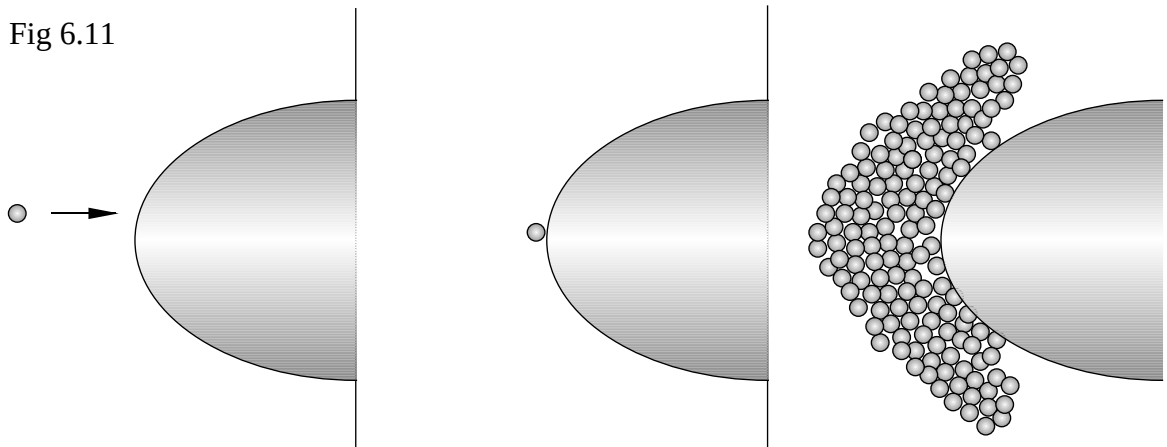
When water exists as tiny droplets suspended in the atmosphere, the exchange of latent heat is much less efficient and freezing does not occur until temperatures well below zero are achieved. Depending on their size, water droplets suspended in a cloud can remain liquid at temperatures as low as -40°C. The smaller the droplet, the lower the temperature required to cause it to freeze. Water in its liquid form at temperatures below freezing is called *supercooled* water.

The roughly spherical shape of the supercooled water droplets in a cloud has a lot to do with their resistance to freezing. Any disturbance or shock that changes their shape will cause them to lose their latent heat and freeze. An aircraft flying above the freezing level in cloud provides the necessary disturbance and since the airframe is also below zero, the supercooled droplets freeze on impact and a layer of ice builds up on the leading edges.

RIME ICE

When very cold supercooled droplets collide with the leading edges, they freeze so quickly that they don't have time to splash or spread across the skin. They maintain their spherical shape after freezing producing a granular layer of ice with a lot of air trapped between the grains [Fig 6.11]. The ice formed in this manner is white and brittle. It is called *rime ice.*

Fig 6.11



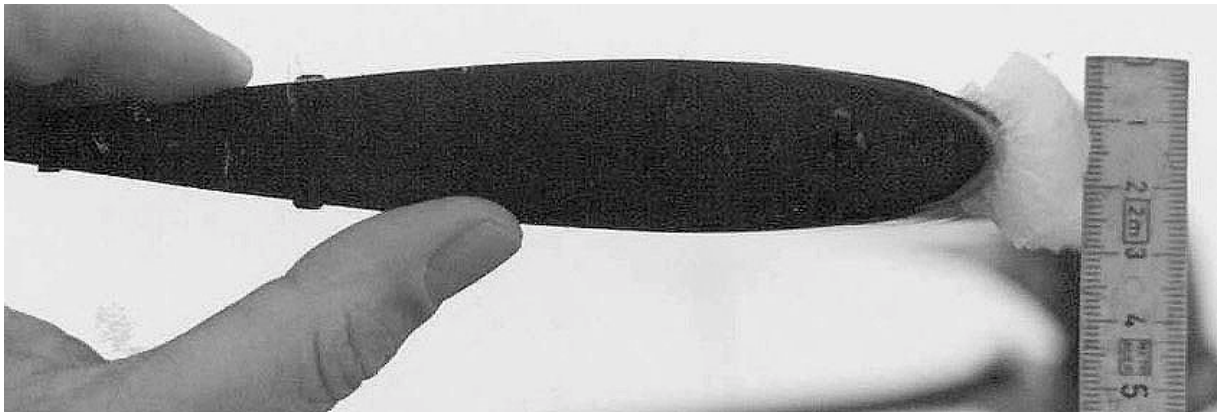
A small supercooled water droplet approaches the wing surface.

Because it is so small, it freezes almost instantly on impact, maintaining its spherical shape.

As other small droplets freeze on impact, a granular deposit of rime ice is built up.

The relative size of the droplets in the figure above has been greatly exaggerated for clarity. The deposit of rime ice grows on the leading edges in a mushroom shape causing disruption to the oncoming airflow. This reduces lift and increases drag, requiring a greater angle of attack to compensate. The aircraft performance can be seriously impaired. Rime ice also forms over pitot tubes, depriving the pilot of airspeed indication.

Rime ice which has formed on the leading edge of a helicopter rotor blade. Note that the ice builds up on the leading edge of the blade leaving the top and bottom surfaces virtually ice free. The ice build-up acts as a spoiler, disrupting the airflow over the aerofoil surface and drastically affecting the lift produced.



Remarkably, this ice build-up occurred during the run-up. The helicopter had not even taken off!

This deposit is typical of rime ice. It is granular, opaque and brittle. The rotor was operating in the presence of small [drizzle-sized] supercooled water droplets in very cold air. Fortunately ice deposits such as this occurring at ground level are extremely rare in Australia. The photos above were taken in Switzerland during a very cold winter. However it should be remembered that conditions favourable for the formation of rime ice may be encountered in Australia when IFR aircraft operate at higher levels in the presence of supercooled droplets.

You may find it surprising that a rapidly rotating helicopter rotor doesn't fling the ice off as it rotates. Not only does it remain firmly attached to the rotor blade, but ice forming on the propeller of a fixed-wing aircraft can build up to such an extent that it produces a significant reduction in thrust or, if the deposit on each blade is not the same, severe propeller vibration.

Aircraft operating in Australia under the VFR are not likely to encounter such conditions.