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Physics of Impact and Solidification of Supercooled Large Drops

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Abstract

The hydrodynamics and thermodynamics of supercooled large drops (SLD) impacting onto dry solid surfaces will be examined. This is a central topic for ice accretion on aircraft and icing of vehicles and structures. A statistical model describing nucleation is derived, which includes the influence of temperature but also of impact hydrodynamics, as opposed to nucleation in sessile drops. The subsequent solidification of the liquid proceeds in two stages. First, an ice layer forms on the surface, rapidly spreading over the wetted region. In the bulk, dendrites propagate at a slower speed, which is dependent on the degree of supercooling. Once the bulk has warmed up to zero degrees due to the latent heat of solidification of the dendrites, the remaining fluid solidifies according to the one-phase Stefan problem and does so at an even slower rate than the dendrite growth. This process of drop impact, spreading, retraction and solidification is illustrated and analysed using experimental results, theoretical descriptions and numerical simulations.

This contribution is meant to summarize the state of the art in describing SLD impact and solidification. It then addresses the implication of these hydrodynamic-thermodynamic interactions on aircraft icing and its mitigation.

Keywords
Supercooled Large Drops (SLD), Impact, Icing