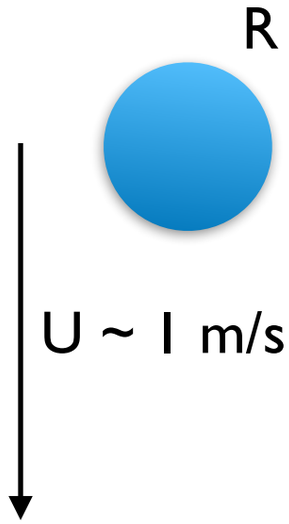
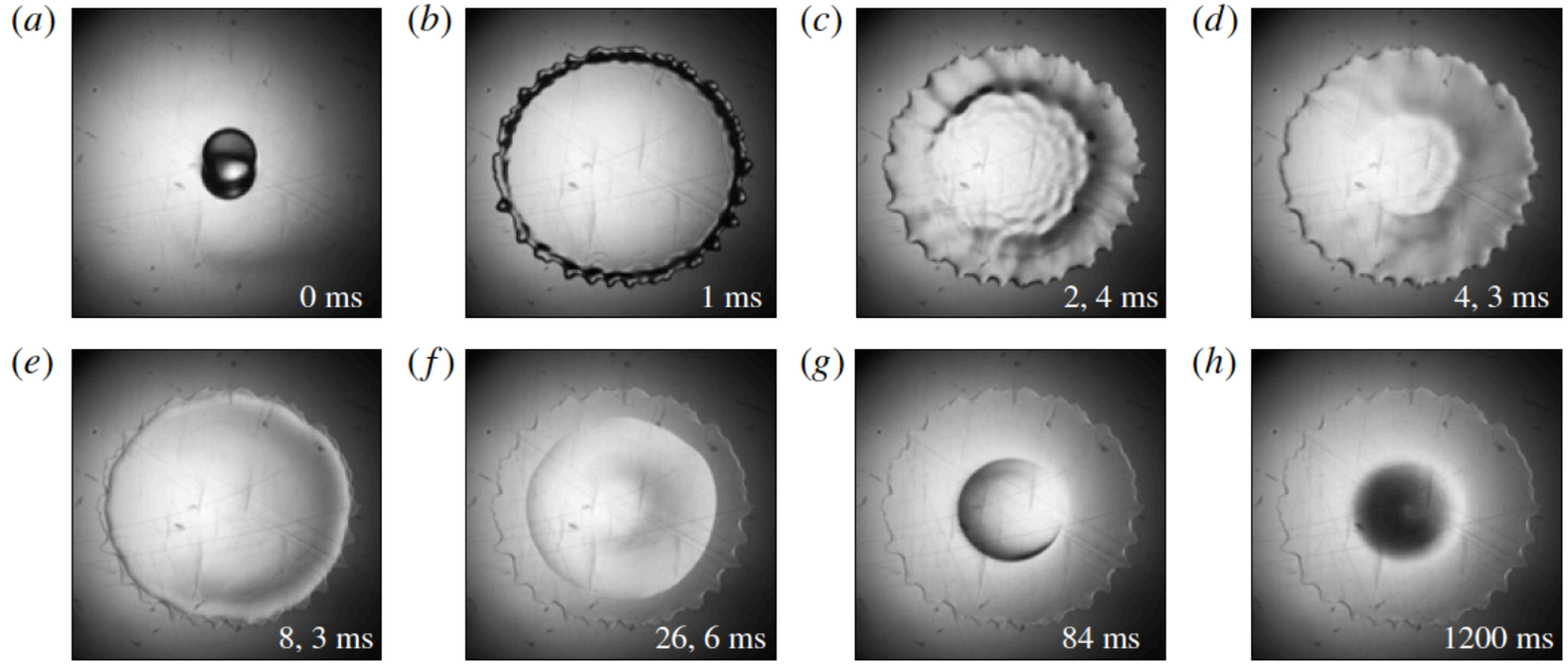
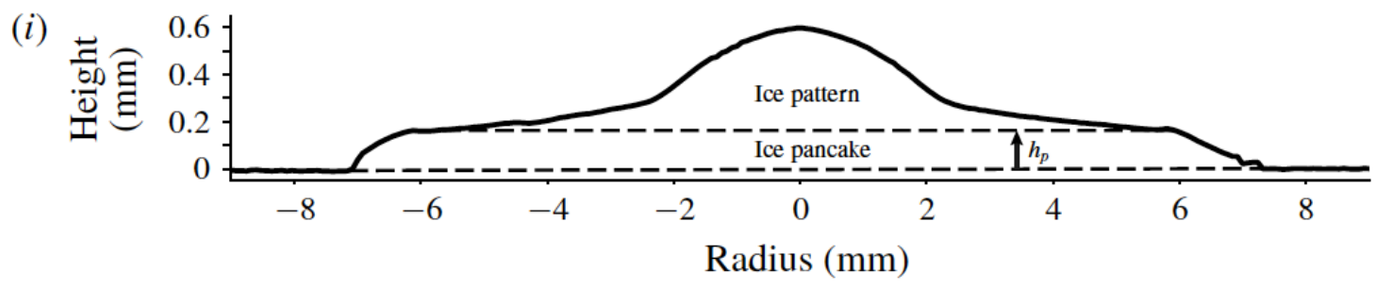
The freezing rain problem

R=1.9 mm
U = 2.6 m/s
Ts = -9° C



$T_s < T_f$

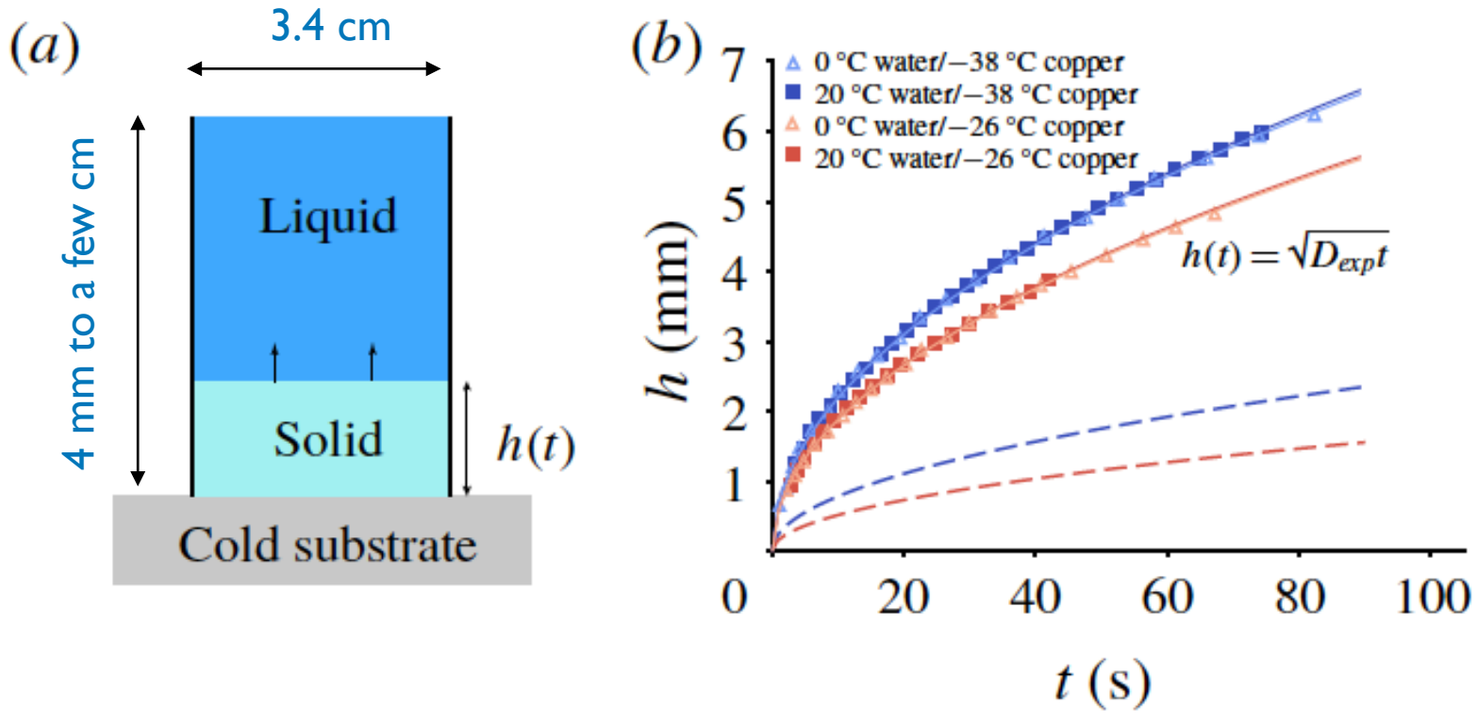




Final profile of frozen drop

Thiévenaz et al.,Solidification dynamics of an impacted drop, *J. Fluid Mech.* **874**, 756 (2019)

The freezing rain problem: a simpler 1D geometry



Write the heat transport equations in the substrate and solid phases
(assume isothermal liquid phase).

Write the boundary conditions at the substrate/solid [$z=0$] and solid/liquid [$z=h(t)$] interfaces

Rewrite the equations with a rescaled space variable

Find the self-similar solutions of the heat equation

Thiévenaz et al., *J. Fluid Mech.* **874**, 756 (2019)

The freezing rain problem: physical parameters

Liquid water (at 0°C) :

thermal conductivity λ_w = 0.6 W/m.K

heat capacity C_w = 4.2 10^3 J/kg.K

heat diffusivity κ_w= 1.2 10^{-7} m^2/s

Latent heat of freezing : L = 3 10^5 J/kg

Ice:

thermal conductivity λ_i = 2 W/m.K

heat capacity C_i = 2.0 10^3 J/kg.K

heat diffusivity κ_i= 1.12 10^{-6} m^2/s

Substrate (copper):

thermal conductivity λ_s = 400 W/m.K

heat capacity C_s = 385 J/kg.K

heat diffusivity κ_s= 1.2 10^{-4} m^2/s