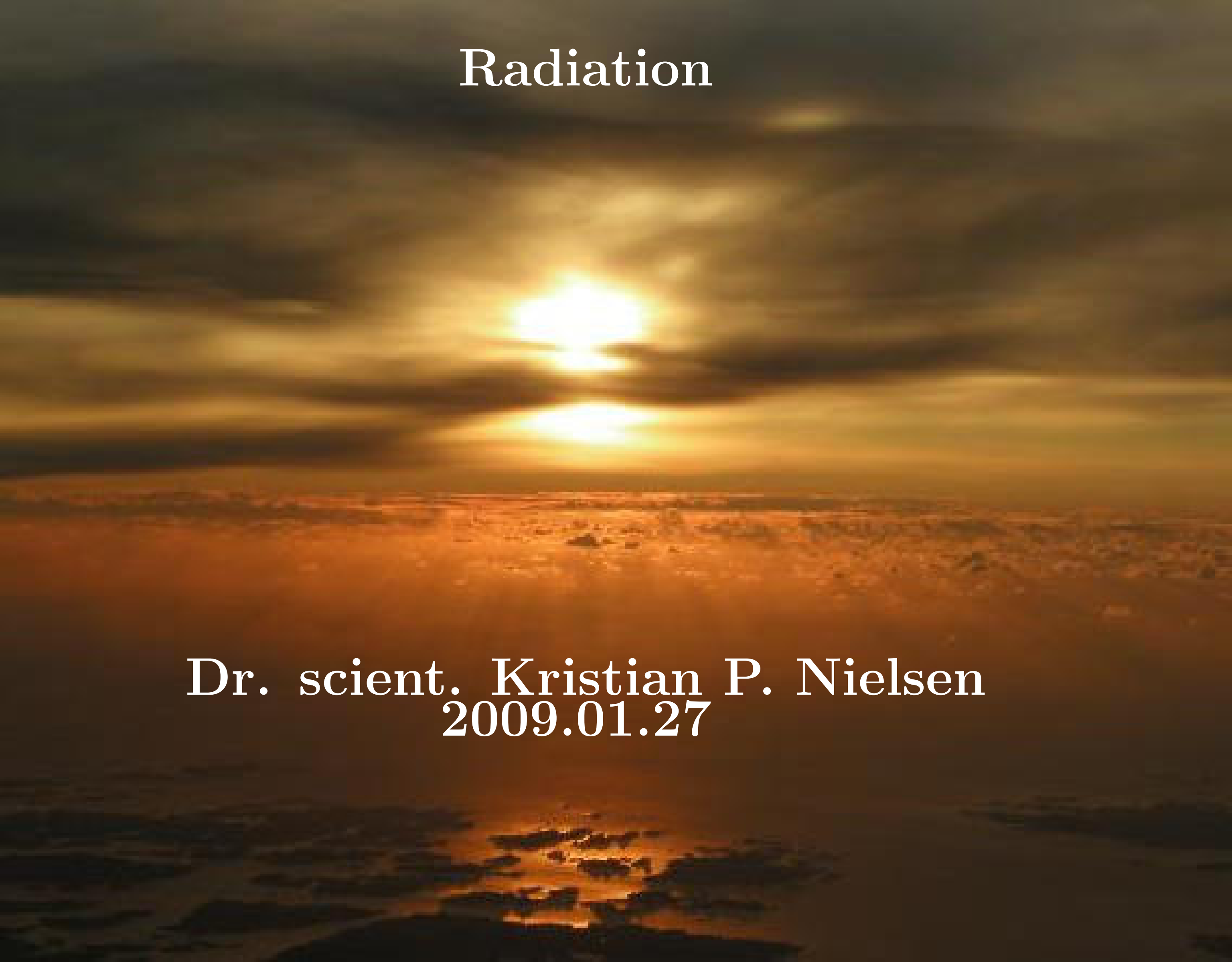
Radiation



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Key trade-off

Accuracy vs speed.

Introduction

$$c_p \frac{DT}{dt} - \alpha \frac{Dp}{Dt} = J \tag{1}$$

Eq. (2.42) from Holton (1992).

$$J_{\mathrm{rad}} = \frac{\partial F}{\partial z} \approx 2\pi\sigma_a[I^+(\tau) + I^-(\tau)] - 4\pi\sigma_a B \tag{2}$$

Shuster-Swarzschild (1905, 1906) approximative heating rate.

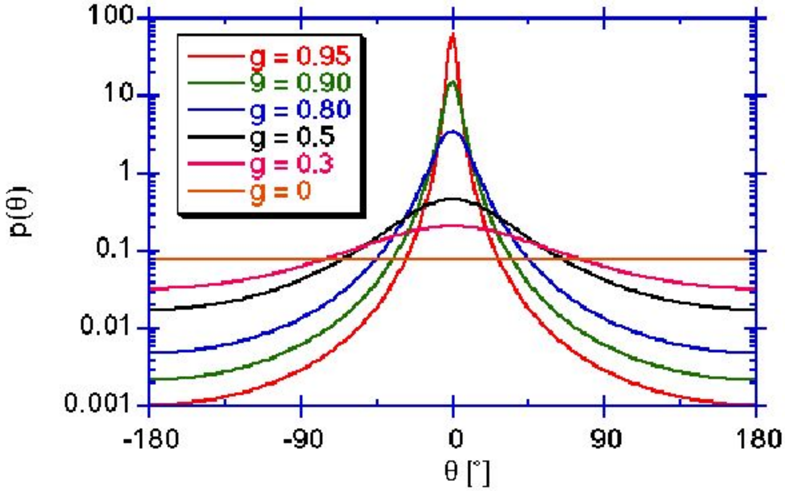
$$I_\lambda = \frac{d^4 E}{dA dt d\lambda d\omega}, \ \ [Wm^{-2}nm^{-1}sr^{-1}] \tag{3}$$

The definition of intensity or radiance.

Inherent optical properties

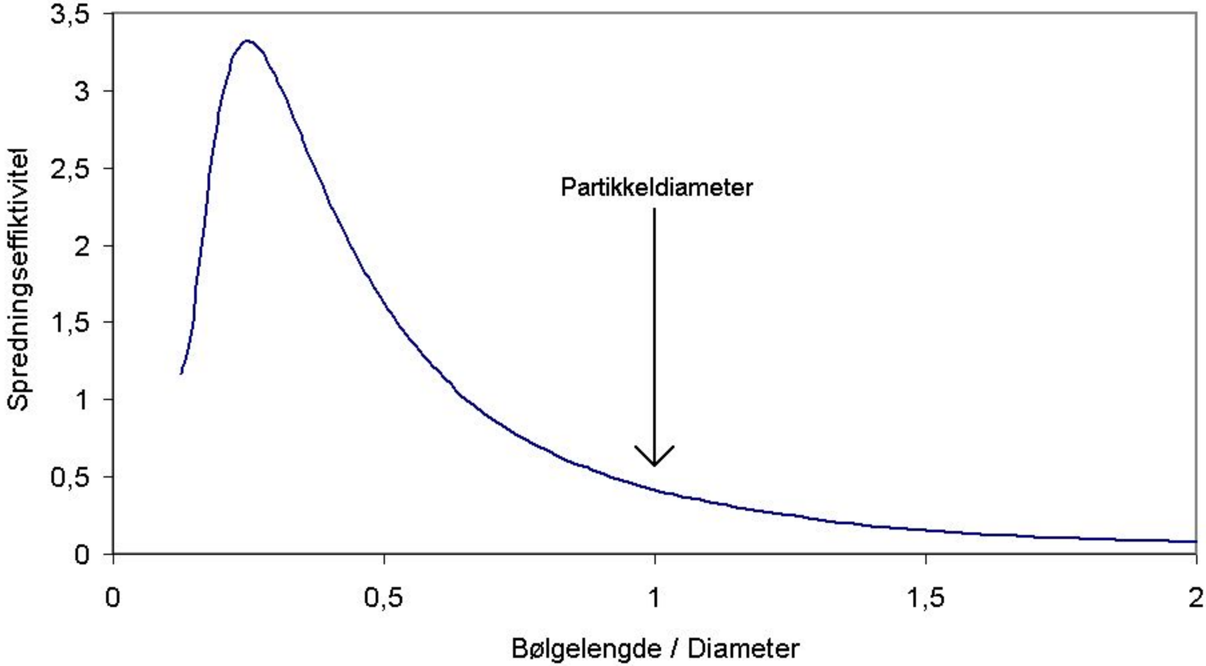
- Extinction [m^{-1}];
- Single scattering albedo
  $=$ 1 - emittance [-];
- Asymmetry factor [-];
- Lower boundary albedo [-].

The asymmetry factor



Normalized volume scattering functions ($p(\Theta)$) plotted as a function of scattering angle (Θ) for different values of the asymmetry factor, g, where $g = 1$ means that all scattering is in the forward direction $\Theta = 0°$.

Mie-Debye scattering efficiency



as a function of $\lambda/2r$.

Cloud ice particles

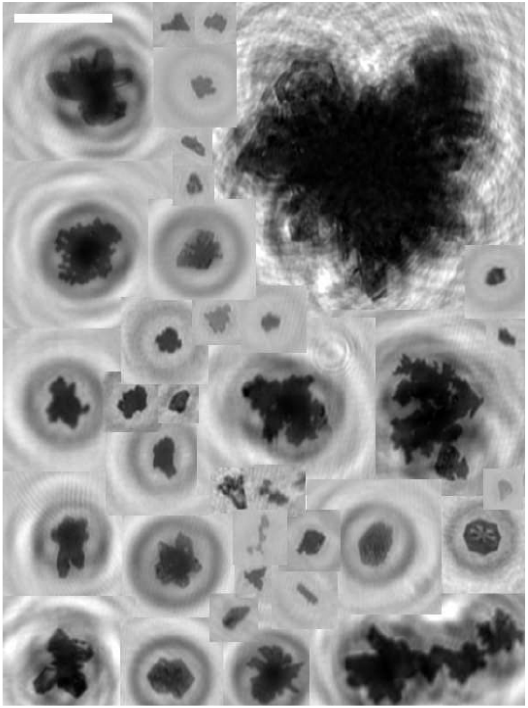


Figure 6: A sample of ice particles taken during Research Flight 2003-09-17. All particles are shown as reconstructed by the automated particle finding algorithm (Fugal et al., 2008) and are only scaled to improve contrast for printing. The white scale bar in the upper left is 0.5 mm in length.

Fugal & Shaw (2008).

Cloud IOPs

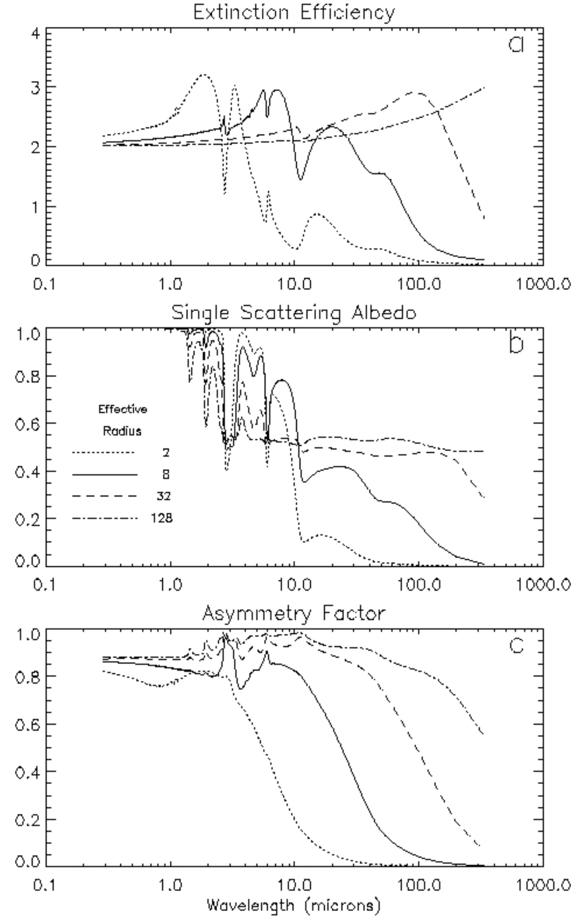


FIG. 1. Extinction efficiency (a), single-scattering albedo (b), and asymmetry factor (c) for cloud droplets of effective radius 2, 8, 32, and 128 μm.

Ricchiazzi *et al.* (1998).

Sketch of radiative transfer