MASS OF INDIVIDUAL SNOW PARTICLES RETRIEVED FROM MEASURED FALL SPEED FOR VARIOUS SHAPES

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Sharing is encouraged

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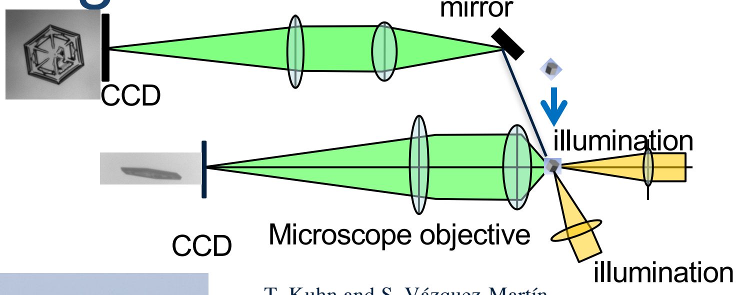
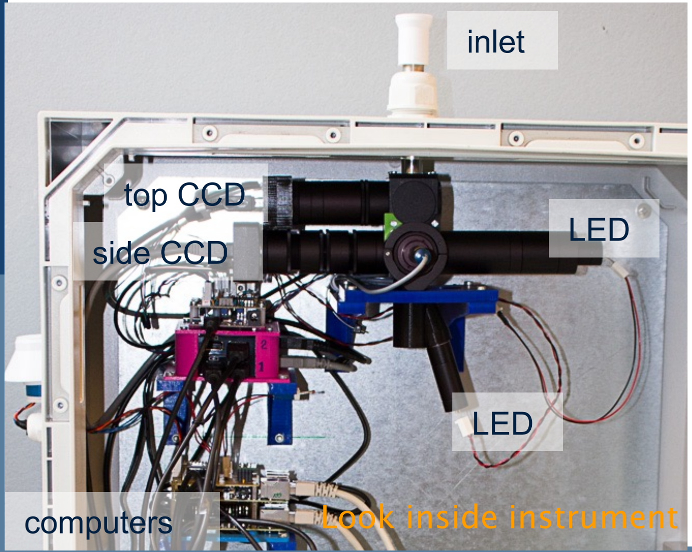
Snow ice particle in-situ imaging

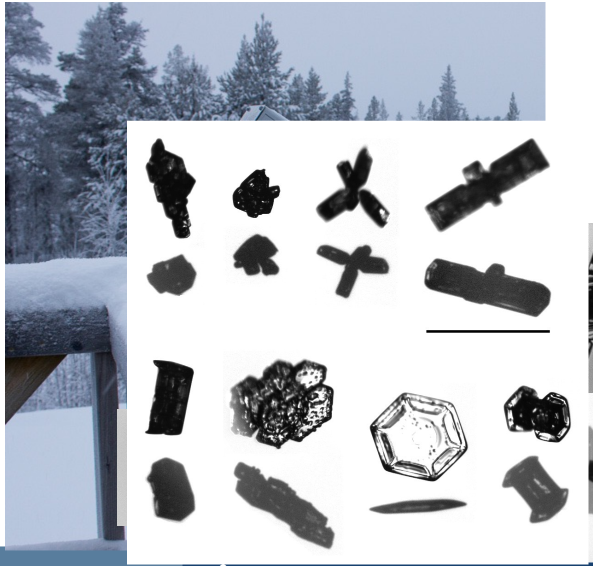
Dual-Ice Crystal Imager: D-ICI

- Two images of the same particle:
  - side view
  - top view
- Better 3D shape
- Fall speed (side view) and other properties (top)



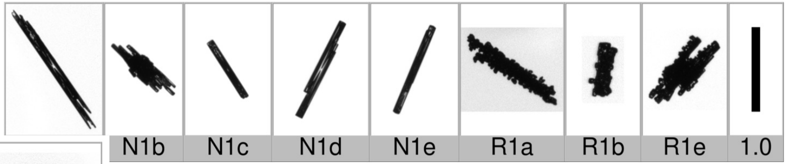
T. Kuhn and S. Vázquez-Martín (2020), Atmos. Meas. Tech., 13, 1273-1285, doi: 10.5194/amt-13-1273-2020



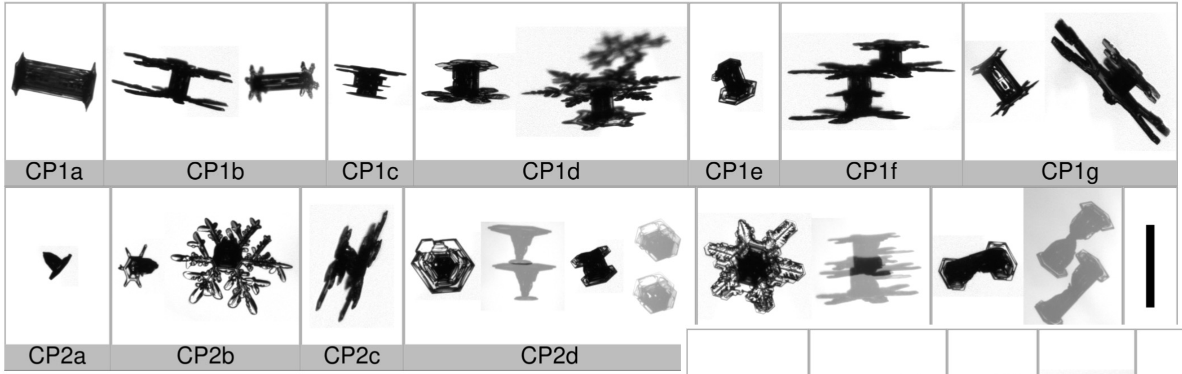


Shapes

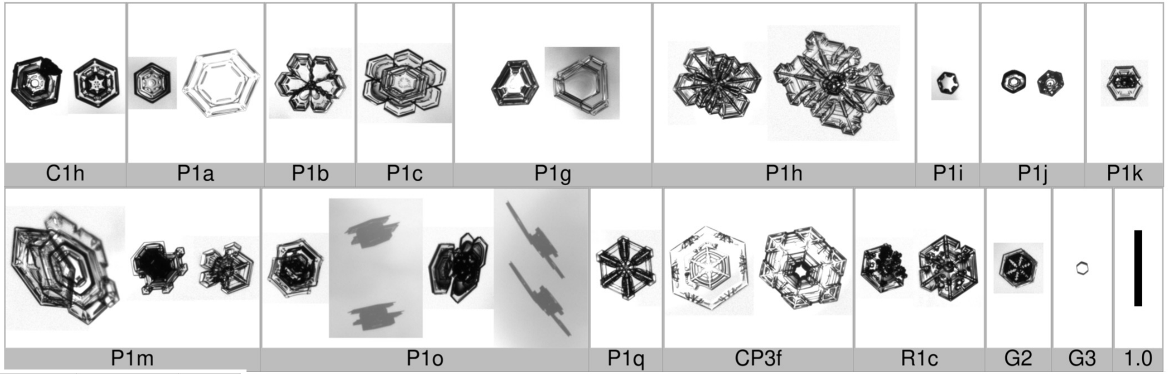
1) Needles



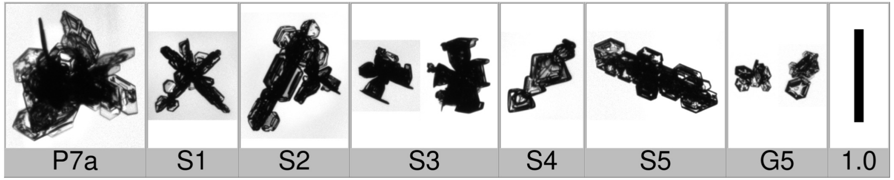
4) Capped columns and bullets



5) Plates



S. Vázquez-Martín, T. Kuhn, and S. Eliasson (2020), Appl. Sci., 10(1163), doi: 10.3390/app10031163.



9) Side planes

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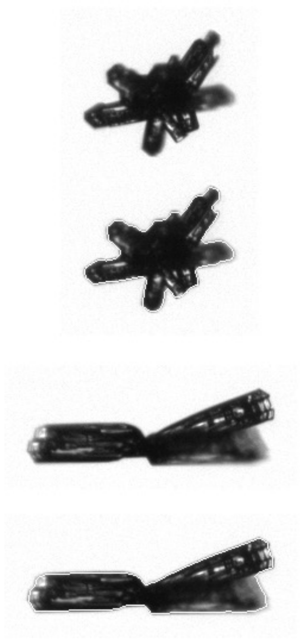
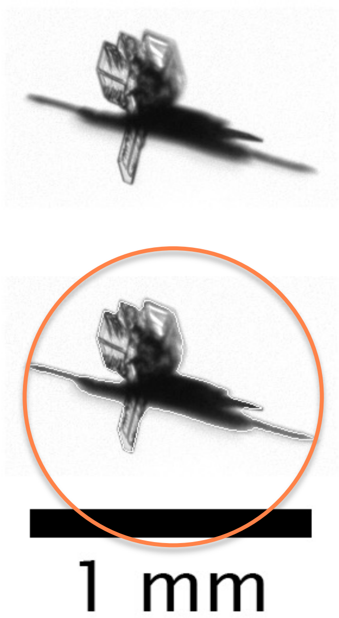
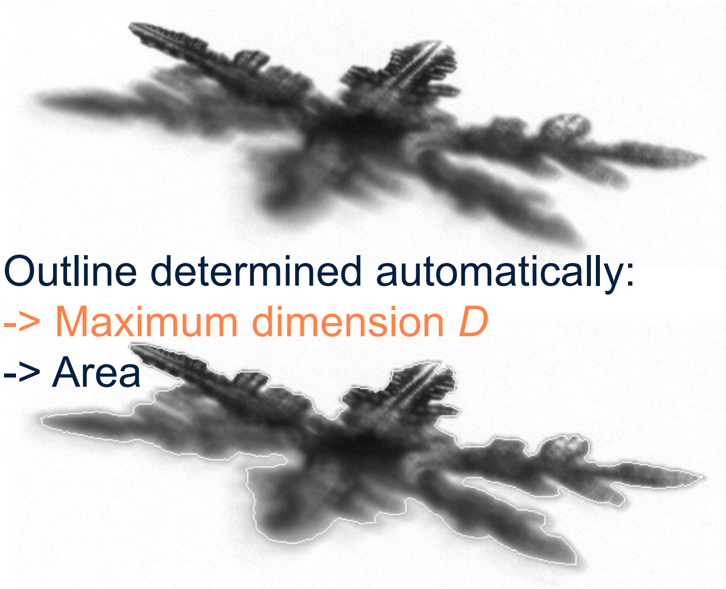
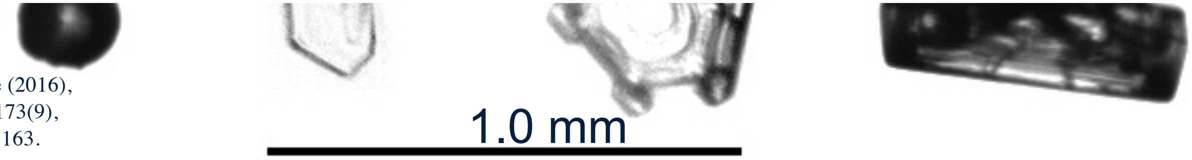


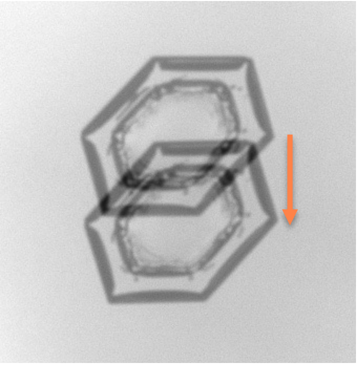




Outline determined automatically:
-> Maximum dimension *D*
-> Area



T. Kuhn and I. Gultepe (2016),
Pure Appl. Geophys., 173(9),
doi: 10.3390/app10031163.



Determine directly
-> Fall speed *v*

S. Vázquez-Martín, T. Kuhn, and
S. Eliasson (2021),
Atmos. Chem. Phys., 21(10),
7545-7565, doi: 10.5194/acp-21-
7545-2021

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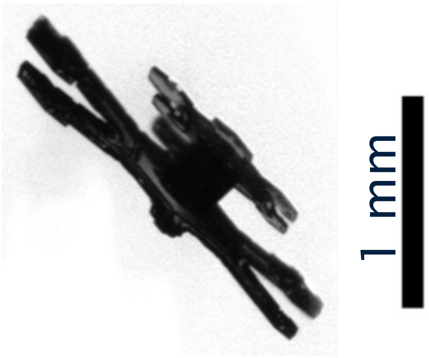
Derive mass

special case: from width and length



in general: from fall speed

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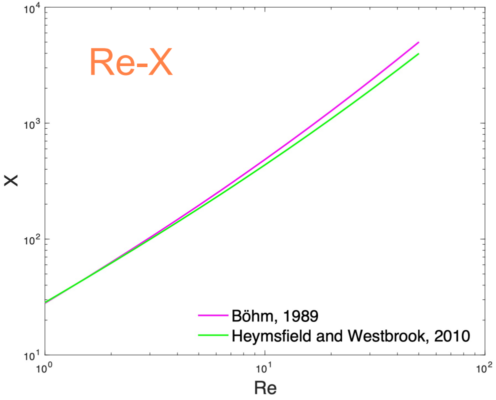
Derive mass from fall speed

in general: from fall speed

$$Re = \frac{\rho_a \cdot v \cdot D_{max}}{\eta} \quad 1)$$

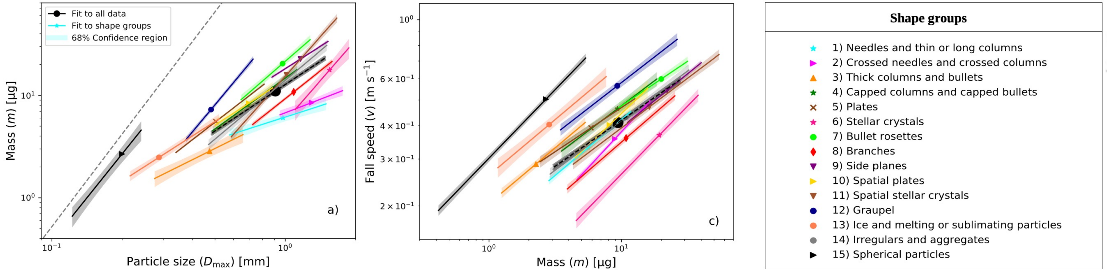
using Reynolds and Best numbers,
Re and X



Böhm (1989), Mitchell (1996), Heymsfield and Westbrook (2010)
determine *v* from *m* using Re-X empirical relationship

We use same Re-X but got the other way, i.e. ***from v to m***

S. Vázquez-Martín, T. Kuhn, and S. Eliasson (2021),
Atmos. Chem. Phys. 21(24), 18,669–18,688, doi: 10.5194/acp-21-18669-2021



$$X = \frac{2 \cdot m \cdot g \cdot \rho_a \cdot D_{max}^2}{A \cdot \eta^2} \quad 3)$$

$$m = \frac{X \cdot A \cdot \eta^2}{2 \cdot g \cdot \rho_a \cdot D_{max}^2}$$

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Derive mass

Problems with certain shapes, e.g. columns/needles

special case: from width and length

using width *W* and length *L* for columns => *m*

$$Re = \frac{\rho_a \cdot v \cdot D_{max}}{\eta}$$

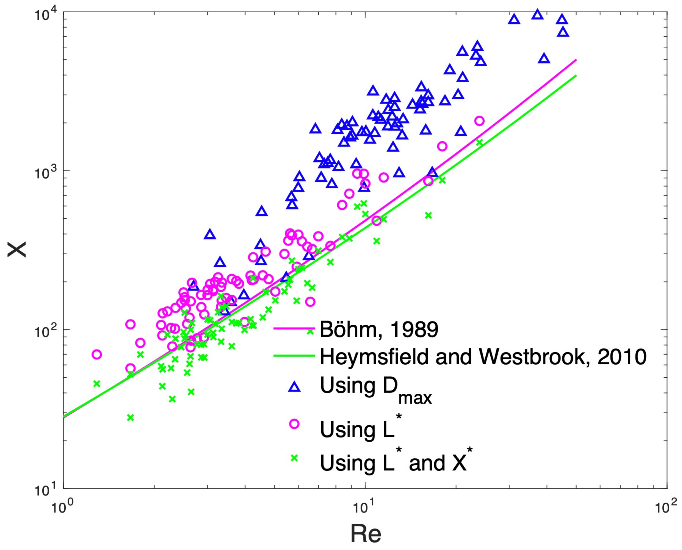
$D_{max} \sim L$

Is D_{max} best size paramter to use for Re and X?
For some shapes yes; not for columns/needles!

Use charactersitic length L^* (Jayaweera, 1971):
$L^* \sim W$

Verify Re-X for special case columns:

- X from *m*
- Re from *v*



Good agreement using L^*
Further improved by using
modified Best number $X^*(Ar)$

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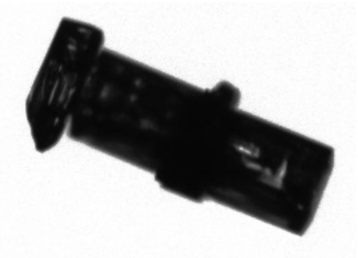
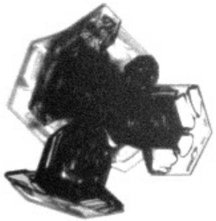
Mass of individual snow particles retrieved from measured fall speed for various shapes

- Dataset of snow images from D-ICI
  - Size, cross-sectional area, fall speed
- Add *m*
  - Use Re-X*
  - Use D_{max} for some shapes
  - Use other size parameter for other shapes





Thank you!

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