# Laboratory studies into the fragmentation of ice particles due to collision

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## Laboratory studies into the fragmentation of ice particles due to collision **SECONDARY ICE PRODUCTION (SIP) / ICE MULTIPLICATION**

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### MOTIVATION

Fragmentation due to collisions of

particles with dendritic crystals



### THEORETICAL FRAMEWORK

Collision kinetic energy (CKE, K<sub>0</sub>)

$$K_0 = \frac{1}{2} \frac{m_1 m_2}{m_1 + m_2} (v_2 - v_1)^2$$

• Number of new fragments per collision

$$N = \alpha \cdot A \left[ 1 - exp\left( - \left[ \frac{C \cdot K_0}{\alpha \cdot A} \right]^{\gamma} \right) \right]$$

lpha - equivalent spherical area of the smaller particle

Phillips et al., JAS, 2017

- A number density of breakable asperities
- *C* asperity-fragility coefficient
- γ shape function



IGIL

#### Graupel generator



Temperture: -7°C to -15 °C Air speed: 2.8 m/s

### **INVESTIGATED PARTICLES**

GRAUPEL W/ DENDRITES

BARE GRAUPEL

ICE PELLETS

JGU



2.12 mm	2.5 mm	2.45 mm	5.0 mm
0.21 g/cm <sup>3</sup>	0.334 g/cm <sup>3</sup>	0.558 g/cm <sup>3</sup>	0.89 g/cm <sup>3</sup>
-15 °C	-15 °C	-7 °C	-15 °C; -5°C

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#### **GRAUPEL-GRAUPEL COLLISION**



#### **GRAUPEL – GRAUPEL COLLISION RESULTS**



### **GRAUPEL-GRAUPEL COLLISION RESULTS (DENDRITIC)**



- Same distribution shape
- Maximum at 75 µm
- Similar to Takahashi (1993) observation of 60/100 µm crystals
- Distribution shape is independent of CKE

- Distribution peak depends on CKE
- Mean area depends on CKE
- Same distribution shape

Note: detection limit is 25 to 30  $\mu$ m

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#### **GRAUPEL-SNOWFLAKE COLLISIONS**



Side collision

JGU

### **GRAUPEL-SNOWFLAKE COLLISIONS - RESULTS**



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Number of fragments depends on

- CKE
- Impact position



Variability likely due to manual production

Sum of 16 distributions

### **SUMMARY AND OUTLOOK**

- Density, i.e. structural dependence of the number of fragments generated in graupel-graupel/ice pellet collisions
- We could derive size distributions for the fragments for low-density graupels with dendritic crystals on their surface and for snowflakes

...still to be answered/done

- Is there any difference if a graupel has other crystal type on its surface?
- Is there a temperature dependency on the number of fragments generated?
- Snowflake-snowflake collisions

Results published in: Grzegorczyk et al., ACP, 23, 13505-13521, 2023; Yadav et al., EGUsphere-2024-3222

#### **THANK YOU FOR YOUR ATTENTION!**



#### **SIP HAPPENS!**

(A. Korolev)

IGU

Results published in: Grzegorczyk et al., ACP, 23, 13505-13521, 2023; Yadav et al., EGUsphere-2024-3222

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#### THANK YOU FOR YOUR ATTENTION



Dendrite



Dendrite with sectors



Dendrite with plates



Plates with dendrites



Assemblage of crossed plates



Skeletal plate



Needles





Dendrite with columns



Skeletal column with Bun scrolls



GIL

#### HONESTLY... (CONSTRAINS OF THE EXPERIMENTS)

- artificial graupel and snowflakes
- whether dendritic crystals on the surface represent natural conditions, is debatable
- one fixed temperature (-15 °C) and one fixed relative humidity (120% wrt ice)
- Iarge snowflakes (~ 1 cm)
- relatively low number of experiments

### **GRAUPEL-SNOWFLAKE COLLISIONS**



#### Holographic instrument

#### Launch system



Snowflake position

Collision tube

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#### Reconstructed holographic image

