# The Dendrite Generator: Innovation to Produce Quality Snow

Project „Snow Crystal Growth in the Artificial Cloud“
Austrian Climate Research Project: SNOW ACRP N. 829757,

Presented at the World Snow Forum in Novosibirsk Russia

January 17th-20th, 2013

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WORLD SNOW FORUM 2013
www.worldsnowforum.org

# Overview of Presentation

a) Innovation: „nature identical snow“

b) Explanation of difference to conventional man made snow

c) Application in ski areas

d) Application in ski domes

e) The Austrian market

f) The world market

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# Innovators

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# International and interdisciplinary research team: more than 30 people worked on the development within the last 3 years

Naturgefahren

# Environmental Aspects: Resource Savings

# Water Saving for Snow Making

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# And Accompanied Energy Savings

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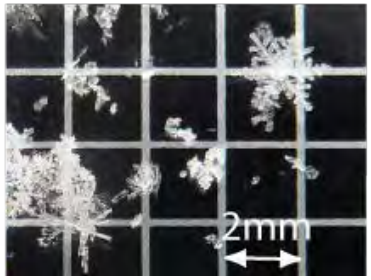
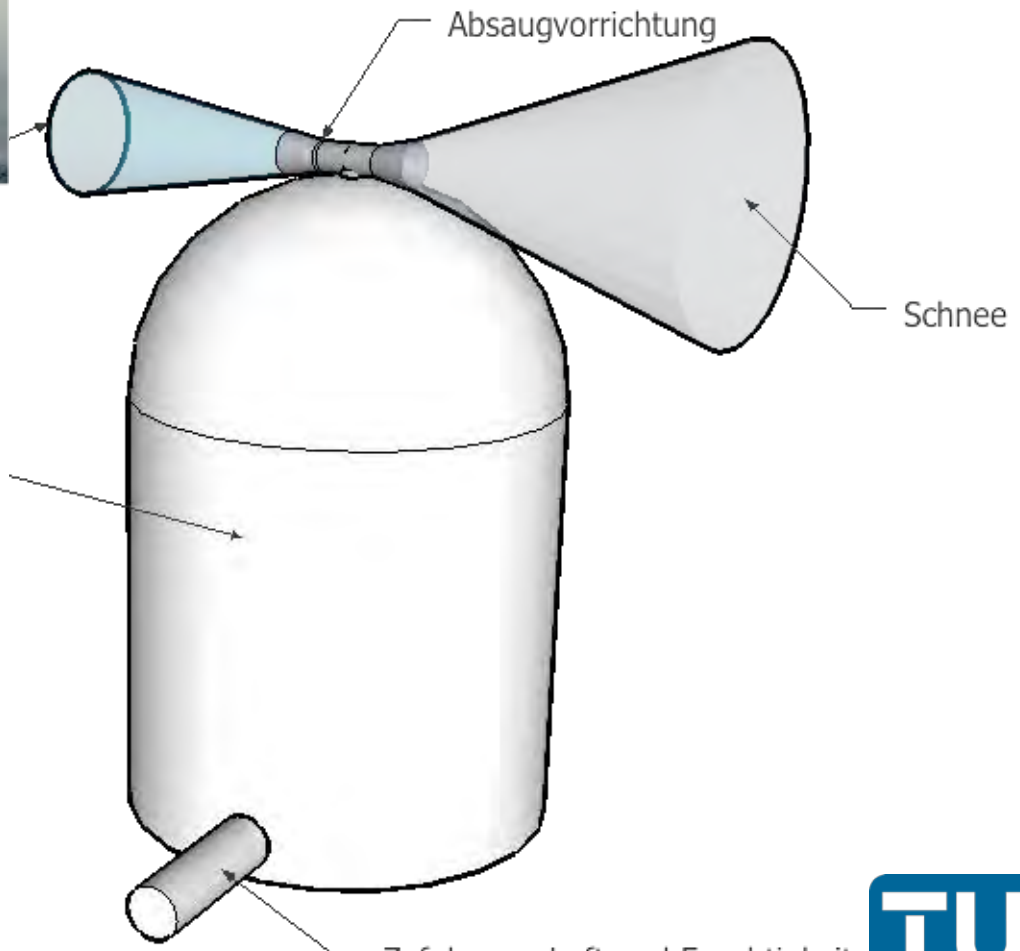
# Principle of the Artificial Cloud

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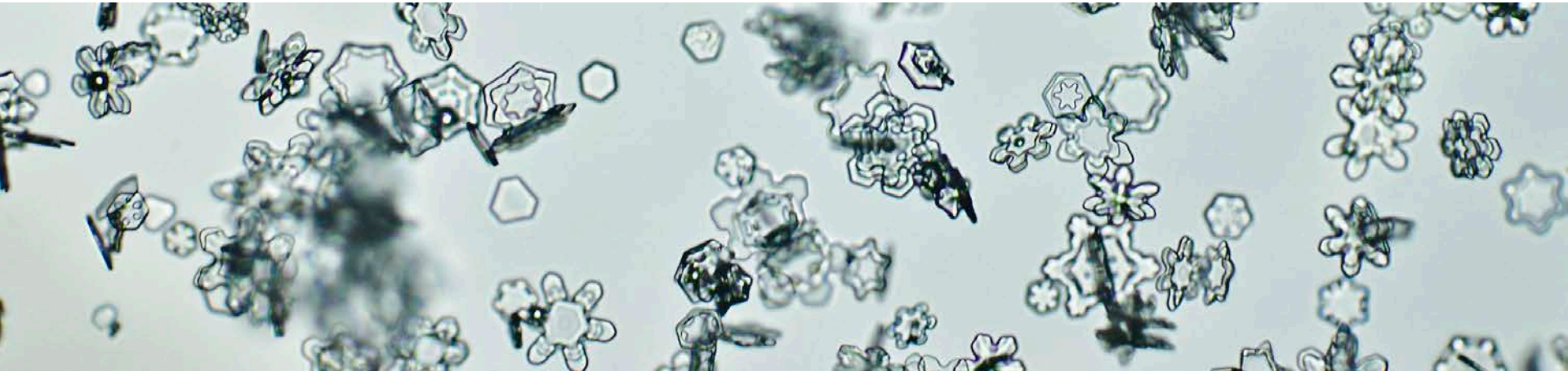
# Principle of Artificial Cloud

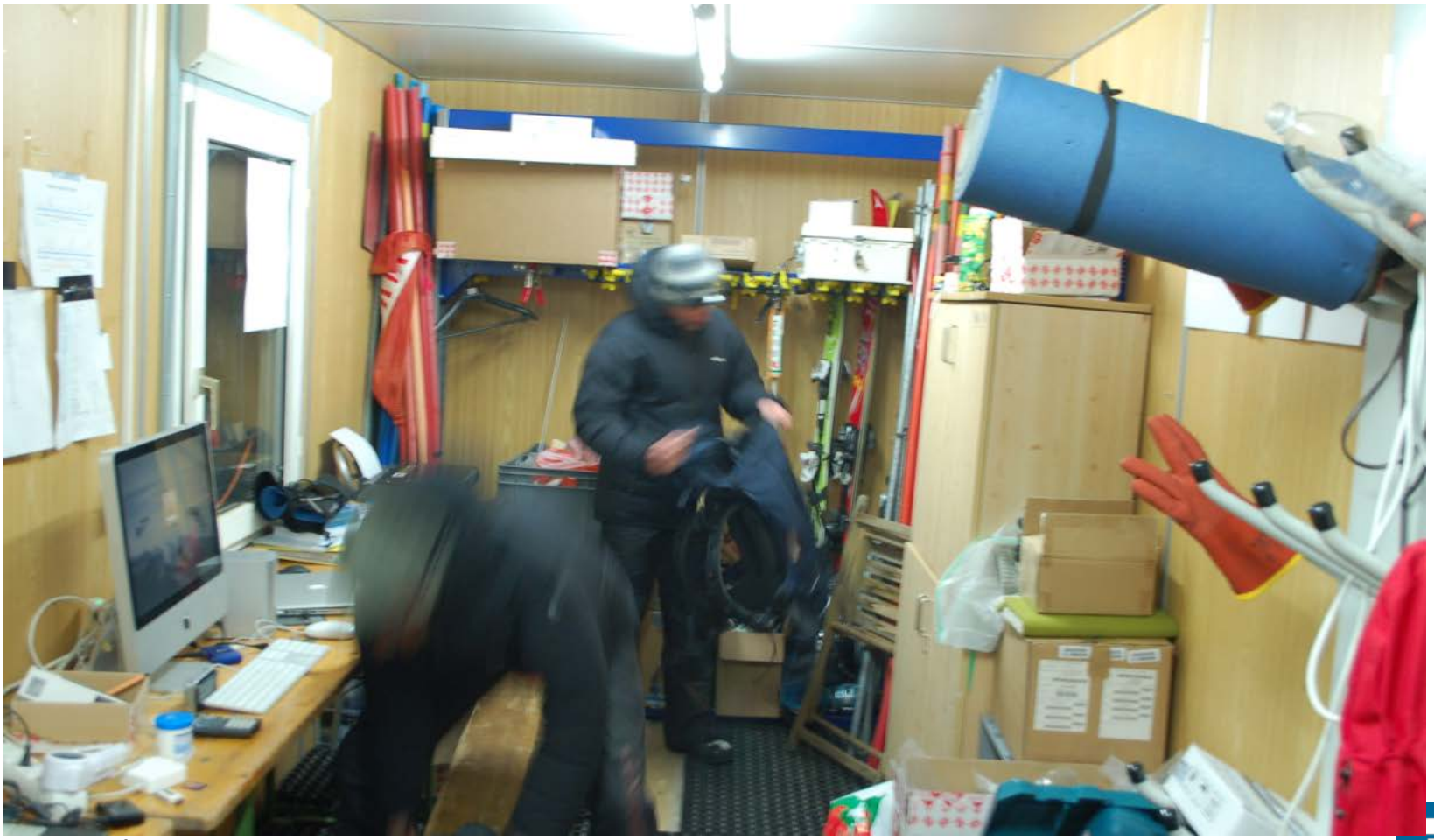
- Provision of ice nuclei
- Feeding the ice nuclei with humidity
  - Growth depends mainly on temperature and available water vapor (cyclic or continous)
  - Time in chamber defines the snow properties
- Transport of produced snow into the environment



# Output of the artificial cloud

- Snowdensity < 250kg/m$^3$ (in our trials between 90 and 210kg/m$^3$)
  - Decisive for kind of application
- We can save water
  - The production method in a container is fundamentally different from the method we find today
  - Up to 30% of water savings are theoretically possible
- We can reduce energy usage
  - Equivalent to % in water saving
  - Plus energy savings due to less pressure to transport water
- Without cooling
  - we can snow at higher temperatures than conventional machines (-1°C > T > -5°C)

# Laboratory Experiments



# A Cool Job for Researchers

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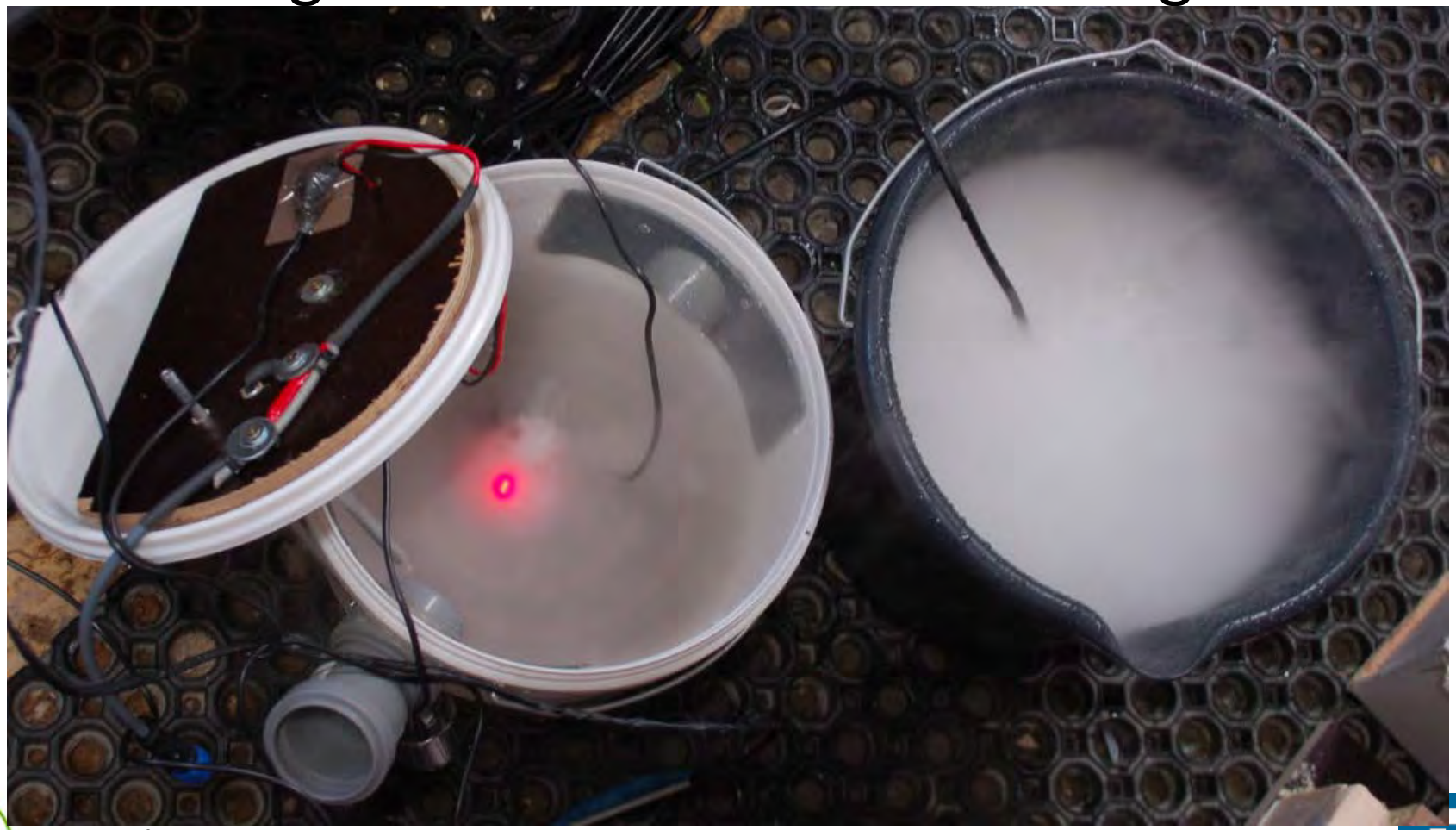
# Team of Experts Undertaking Field Experiments

# ..sometimes fingers get stiff

# High Tech For Better Water Usage



# Water Tube in Outdoor Laboratory

# Measurement instruments & data collection

# Quality Control of Produced Snow under Microscope

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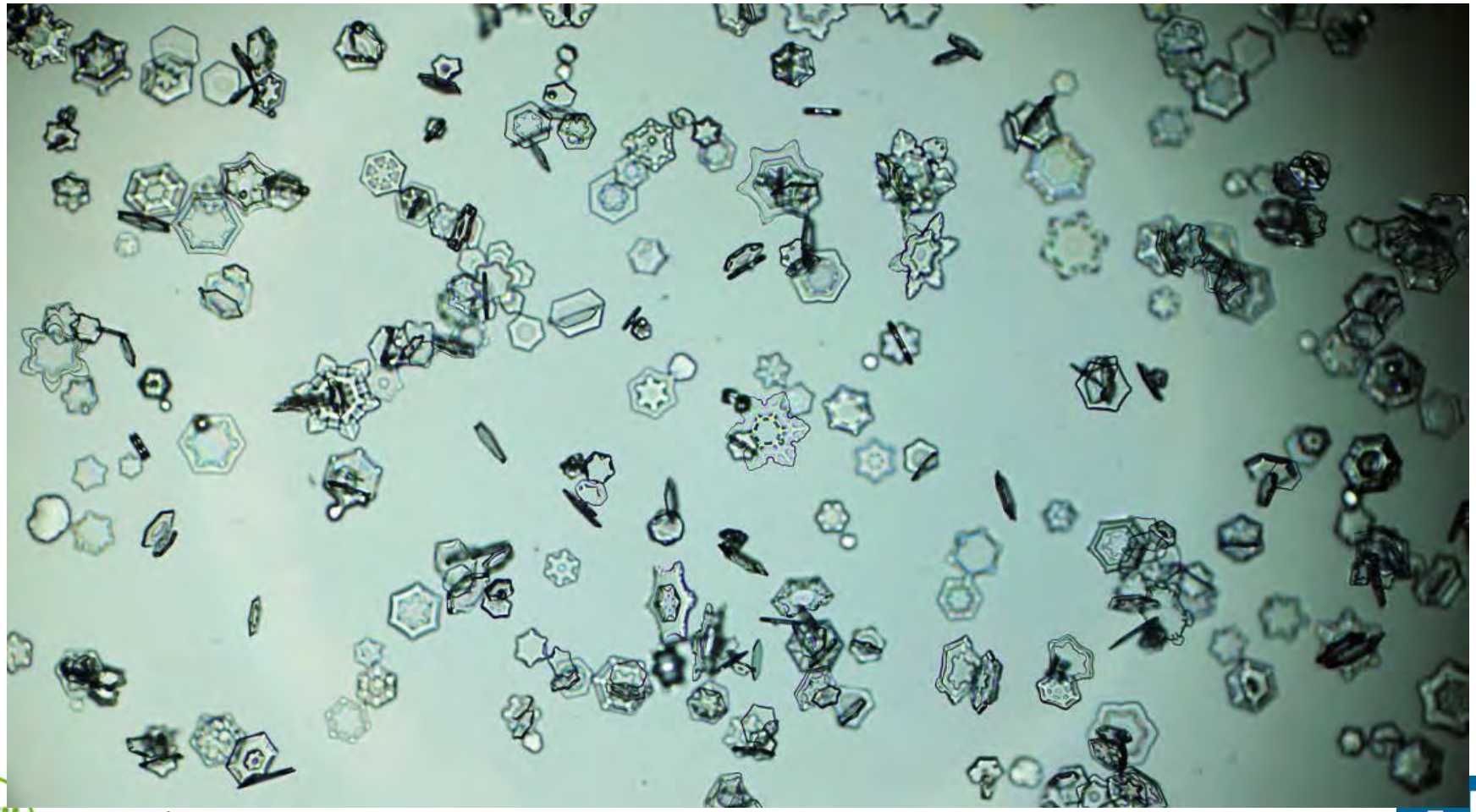
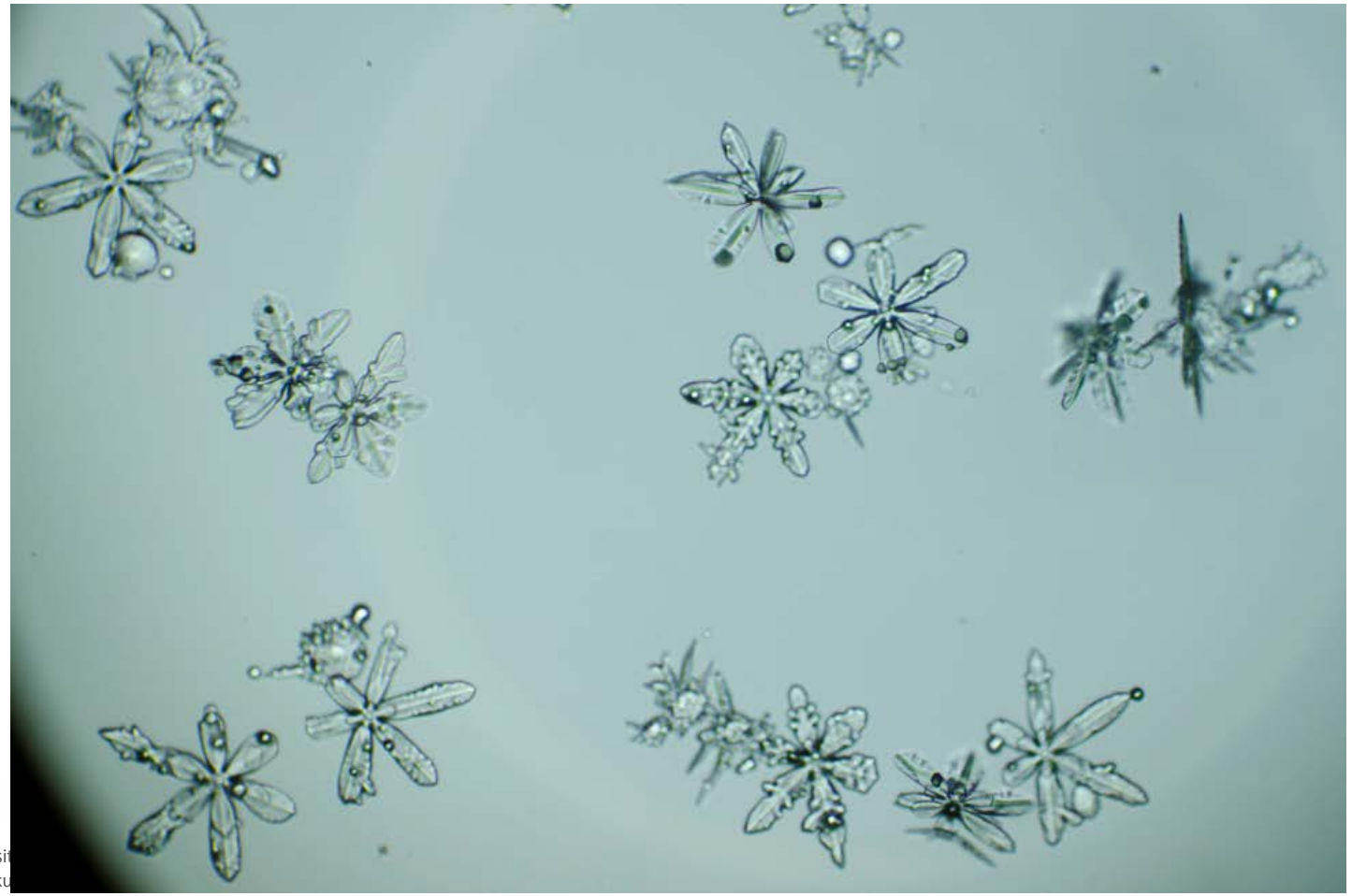
# Snow Crystals



# Snow Crystals (1)

# Snow Crystals (2)



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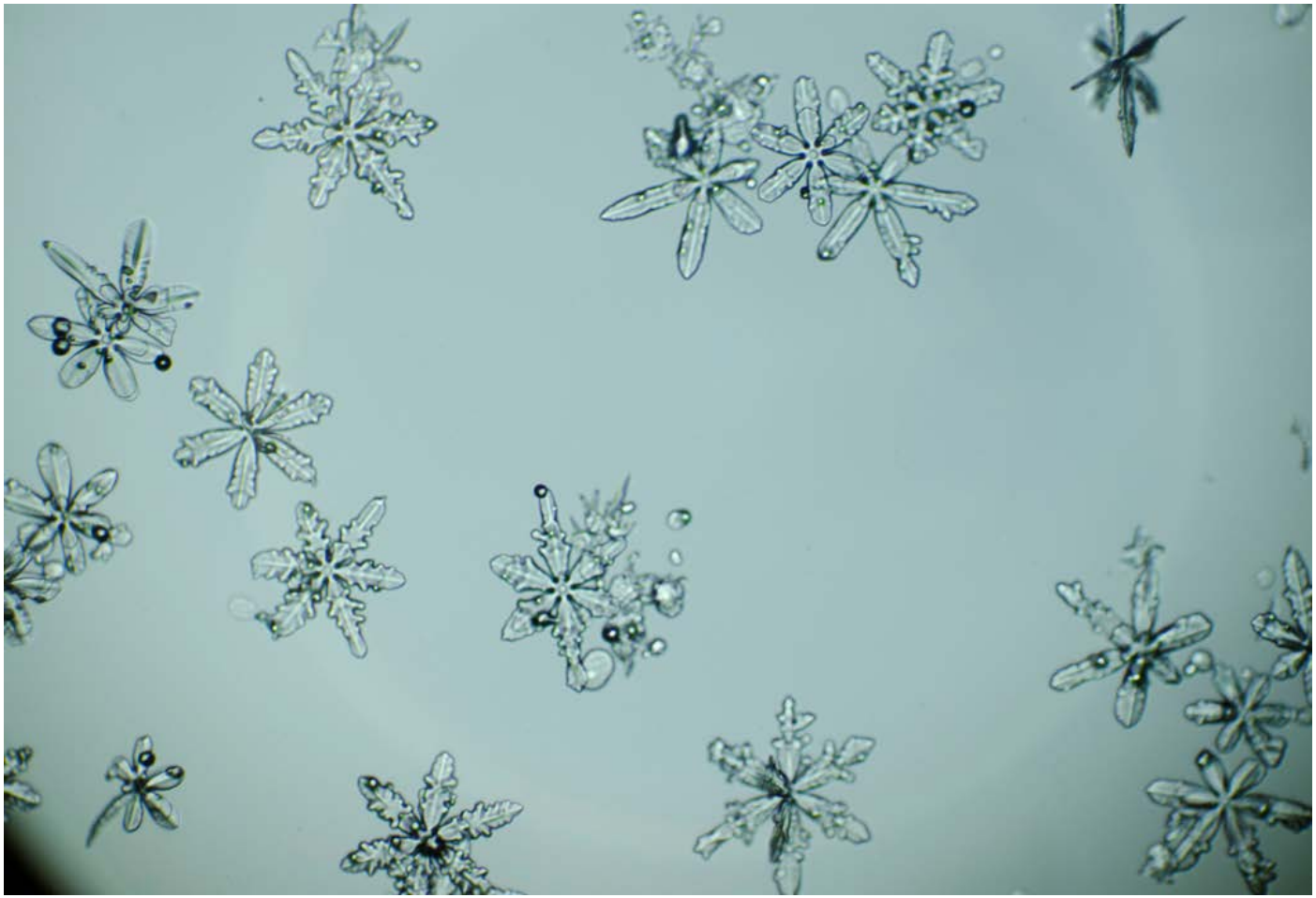
# Snow Crystals (3)



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# Snow Crystals (4)

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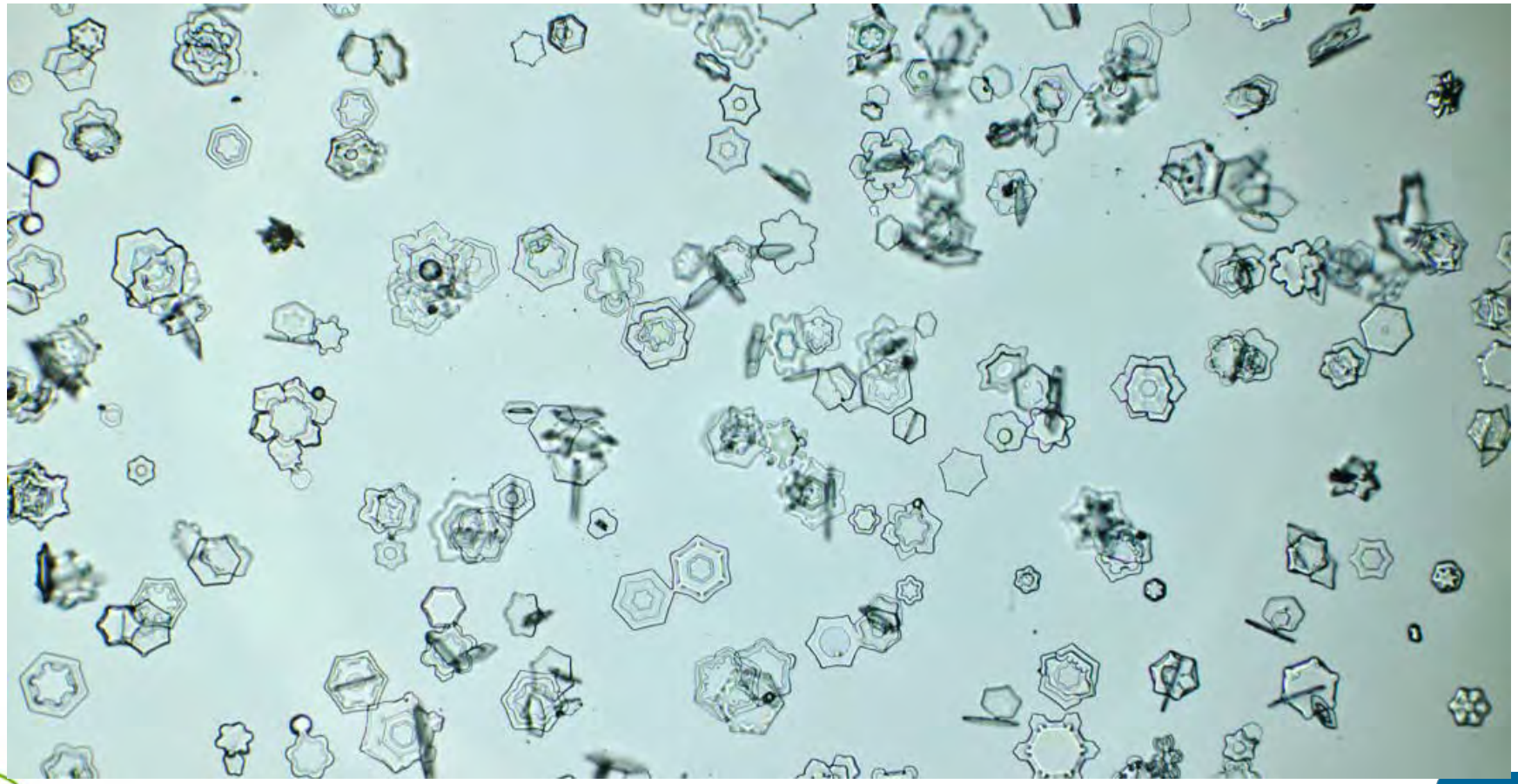
# Relation Between Shapes of Snow Crystals



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# Measurement of Snow Properties

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# Snow at the Bottom

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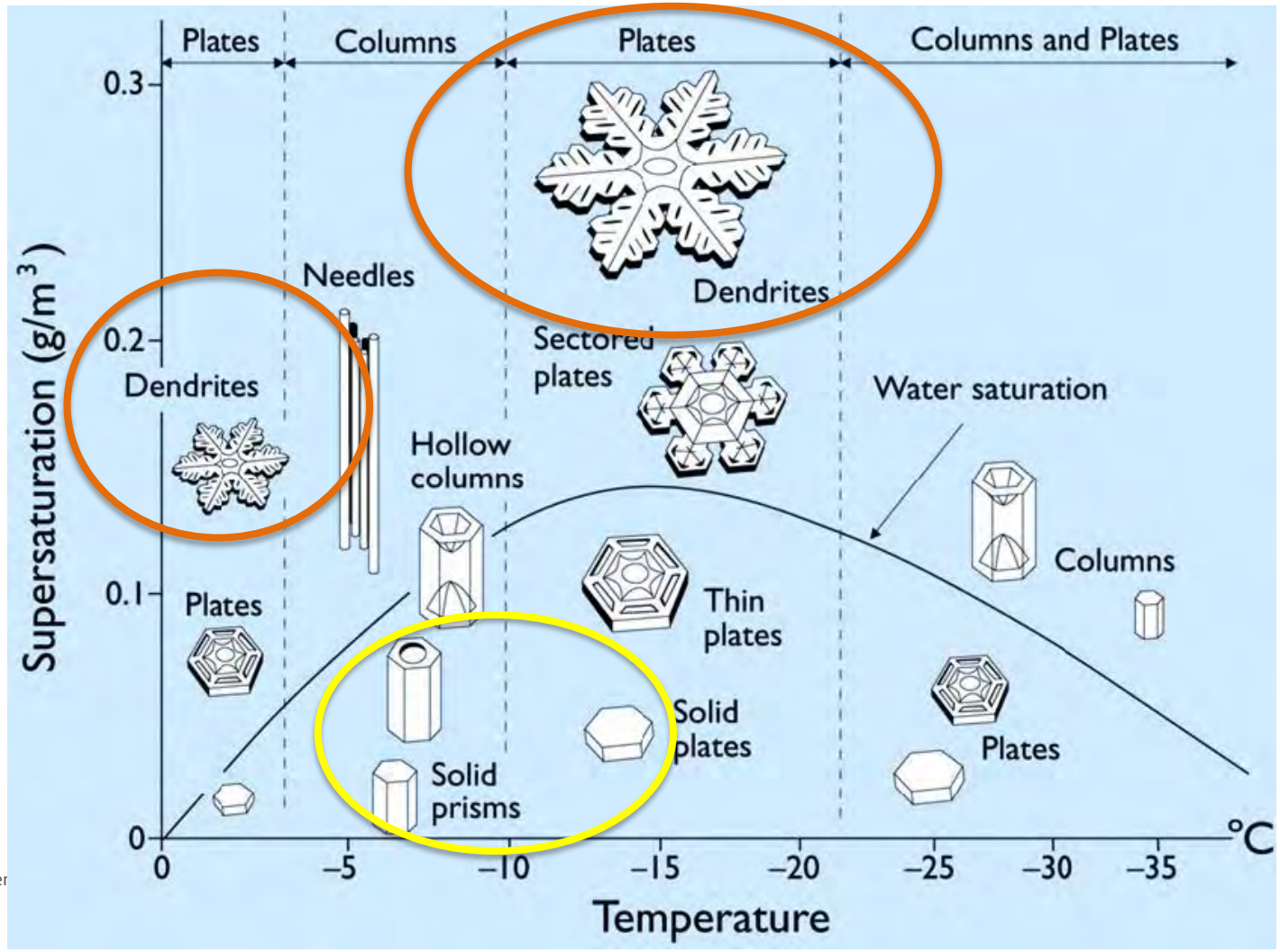
# Snow genesis: Nakaya Diagram




**Source:** Libbrecht (2005) after Nakaya (1954)

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# Snow metamorphosis

- Cold environment temperature
  - Snow flakes fall on frozen ground
  - Snow flakes cumulate to a snow layer
  - The first snow layer get a second snow layer with next precipitation
  - A snow cover blanket accumulates to tens or even hundreds of snow layers
- Mixed cold and warm environment temperature
  - In particular the top of the snow cover melts and freezes
  - The volume of air reduces in snow cover
  - The more often this process is going on, the less air we find in the snow cover blanket
  - Finally the snow cover can become ice
- The specific weight per cubic meter changes
  - Starting from as light as 40kg/m³
  - Ending up with 900kg/m³ and in form of ice
  - Ending up with 1000kg/m³ and in form of water

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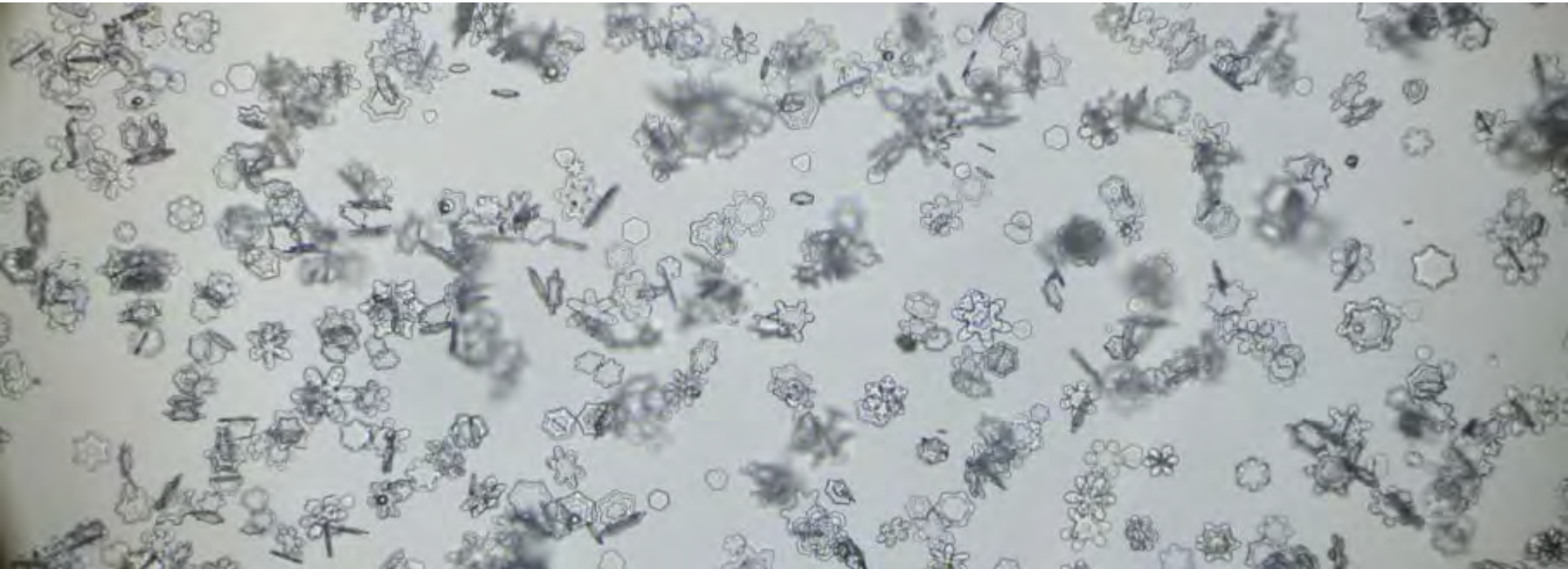
# DG snow is nature identical snow

- Snow is a mixture of different states of water:
  - ice, water and air
- DG snow has considerably more air included
  - Just as if fallen from the sky
- Temperature, humidity, wind speed
  - define the shape of the snow flakes

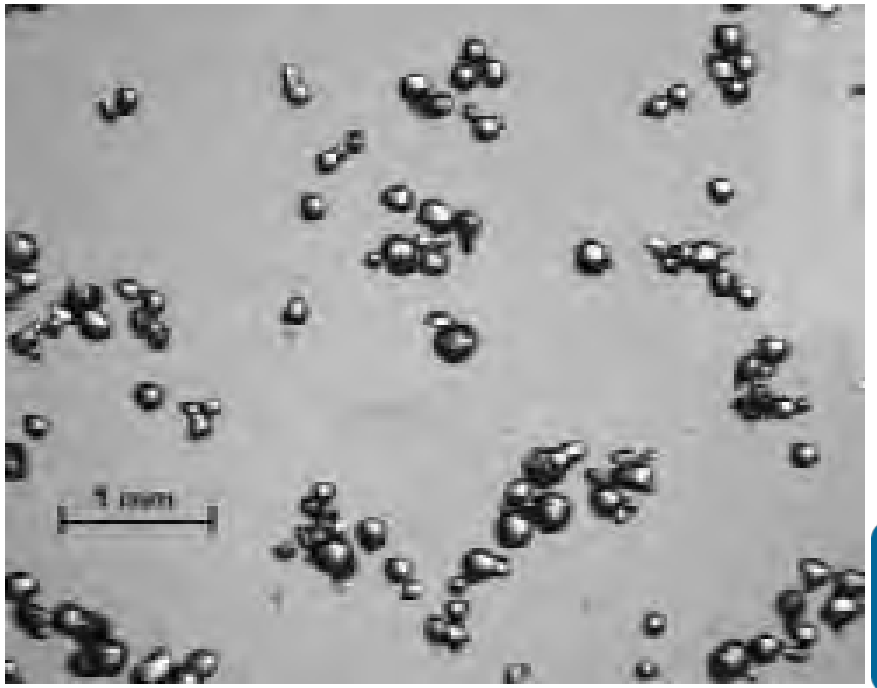


# The product: nature identical snow

- Natural snow crystals are unique and grow on hexagonal basis to needles, prismas and dendrites.
- Dry snow with hexagonal dendrites = Powder snow (light fluffy snow)
  - Can also vary from 40kg to 150kg/m³ depending on crystals forming it
- Stands at the beginning of the snow metamorphosis

# Difference to current state of the art

- Conventional manmade snow is in between: very little air and 380kg to 500kg/m³,
  - Higher shares in ice and water
  - Lower share in air
  - Equivalent to old and settled snow cover
  - Intermediate state between powder snow and ice




Source: M. Fauve, H. Rhyner, und M. Schneebeli. 2002

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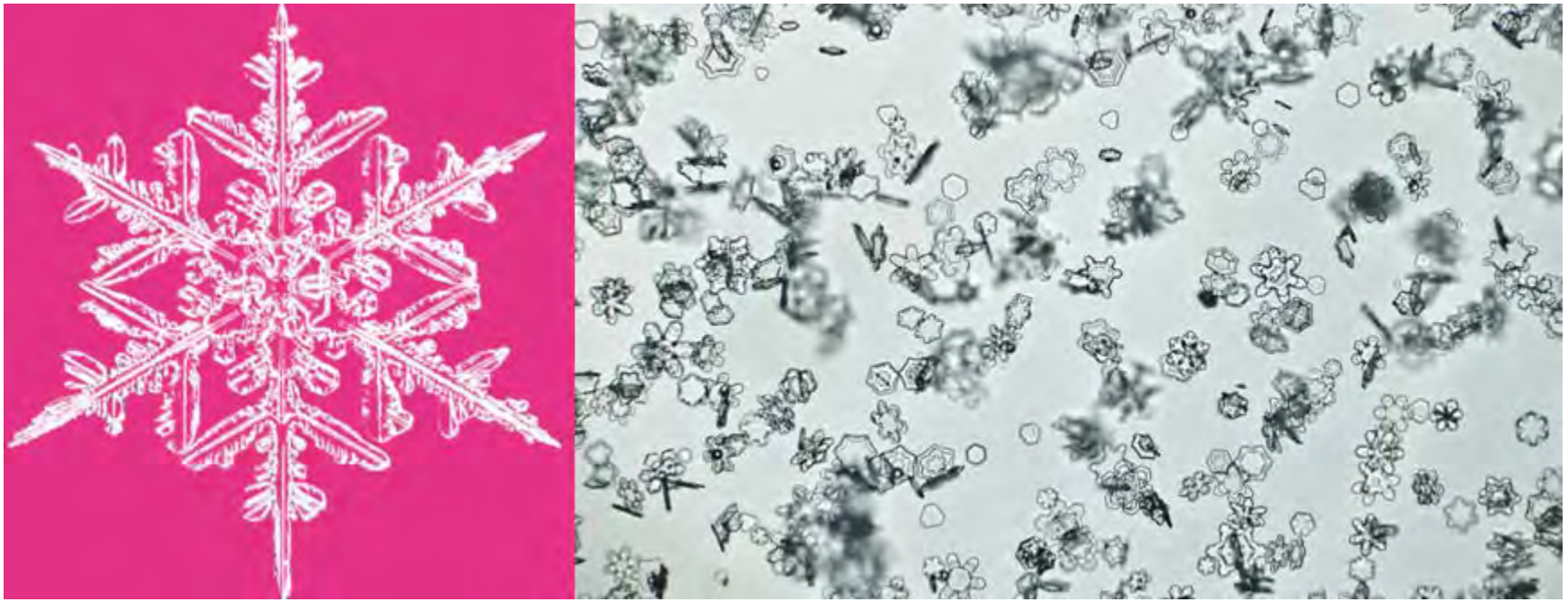
# The UNESCO SNOW Classification

- Physical Properties
  - Microstructure
  - Cornform
  - Size of corn
  - Snow density
  - Snow hardness
  - Water content of snow
  - Snow temperature
  - Impurifications in snow
  - Snow cover depth

Source: http://unesdoc.unesco.org/images/0018/001864/186462e.pdf

# A different product



- Different densities: in lab from 90kg to 210kg/m³
- Deep snow ski runs can be planned independently from weather
- More safety on ski runs

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New touristic products become feasible for ski areas

# Powder Snow Tracks

Foto: M. Breiling, Nov. 2011

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# Free Style Snow Park

Foto: M. Breiling, March 2012

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# Less accidents on ski slopes

Foto: M. Breiling, March 2012

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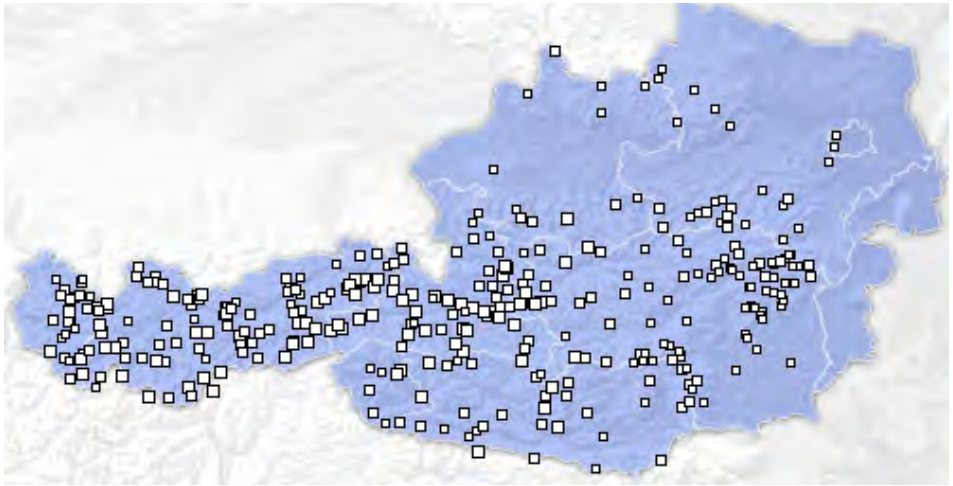
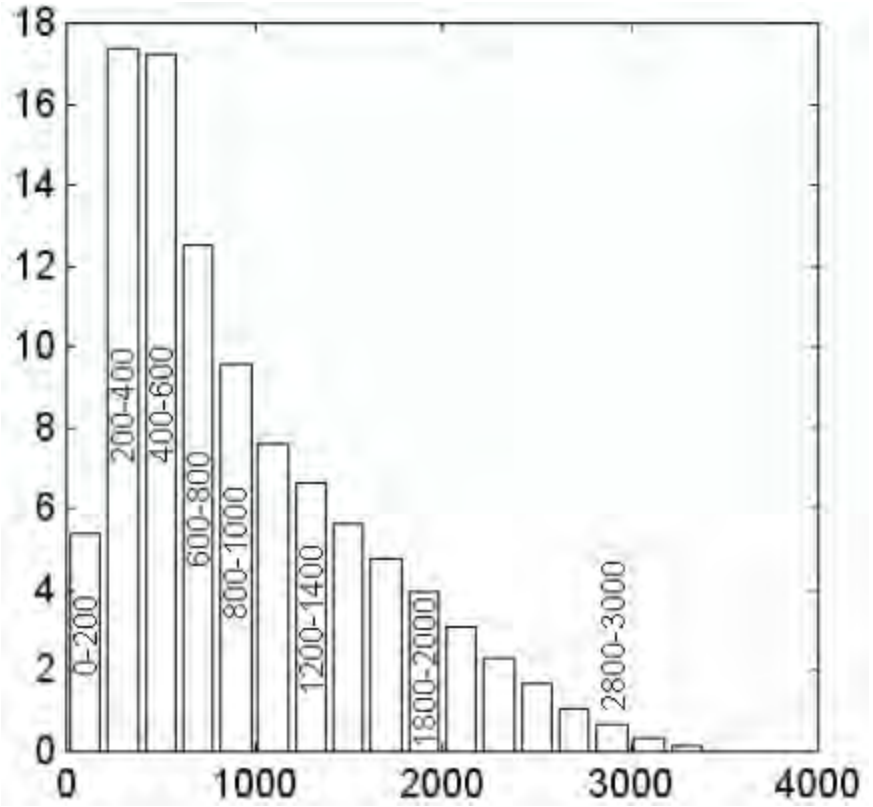
# Tests in laboratory have to verified in diversified environment situations

- Different conditions to produce snow
- Clients are ski areas operators
- Allone in Austria we find 344 ski areas
- Worldwide more than 2000 ski areas






344 Skigebiete www.bergfex.at

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# Other examples outside Austria

- Snow is attractive
- Snow innovations are likely to become more frequent
- The quality of the snow produced by the DG can make more applications feasible

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# New ice hotel for the season

Foto: M. Breiling, Dez. 2007

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# The ice hotel in Jukkasjärvi

Foto: M. Breiling, Dez. 2007

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# Method to quickly construct snow houses

Foto: H. Gelter, Jan. 2005

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# An organ built of snow and ice

Foto: H. Gelter, 2004

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# Quality of ice instruments can increase

http://www.environmentalgraffiti.com/featured/orchestra-made-of-ice/4958

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# Glenn Eden ski resort near Toronto

Foto: M. Breiling, Feb. 2012

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# Chikopee ski area near Toronto

Foto: M. Breiling, Feb. 2012

# Ski domes: another market for urban regions

Foto: M. Breiling, Nov. 2011

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# Ski dome in Shenzhen China

Foto: M. Breiling, Nov. 2011

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# Sculptures from snow and ice

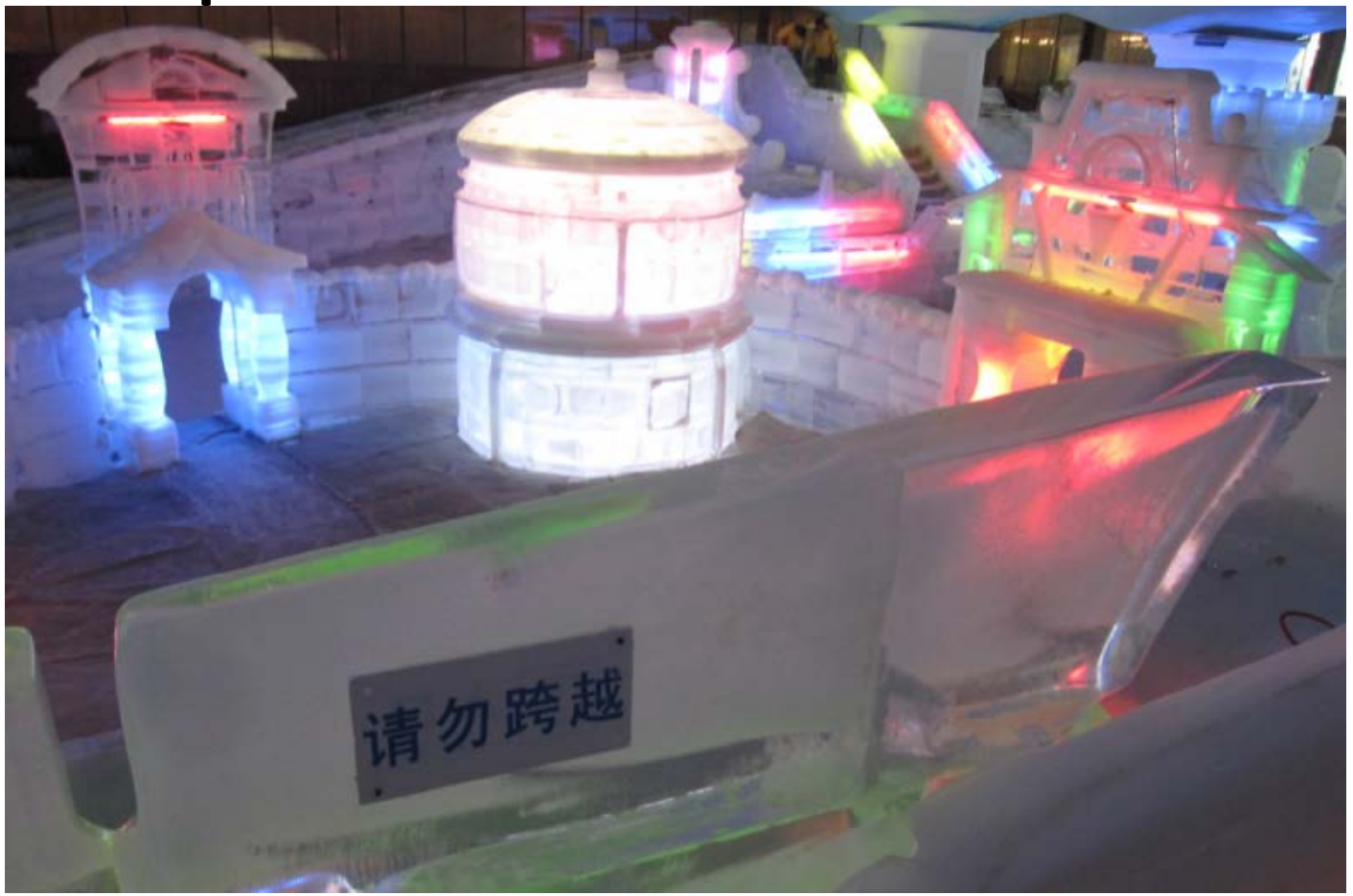


Foto: M. Breiling, Nov. 2011

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# Artwork produced of snow

Foto: M. Breiling, Nov. 2011

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# Fast dissemination of technology

As a research group we search for business partners:

Partners in ski areas worldwide
Partners in industry
Partners providing venture capital

Welcome to Vienna & Austria

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# Thanks

To You for listening

and

Austrian Climate Research Program to support the SNOW project

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