



The Dendrite Generator: Innovation to Produce Quality Snow

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

Nachhaltigkeit in der Tourismusplanung,



15. Jänner, 2013



Universität für
Bodenkultur Wien
Department für
Bautechnik und
Naturgefahren





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



Innovators



Fred Best, GB

Michael Bacher, AT

Sergey Sokratov, RU

Meinhard Breiling, AT



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





Environmental Aspects: Resource Savings





Water Saving for Snow Making



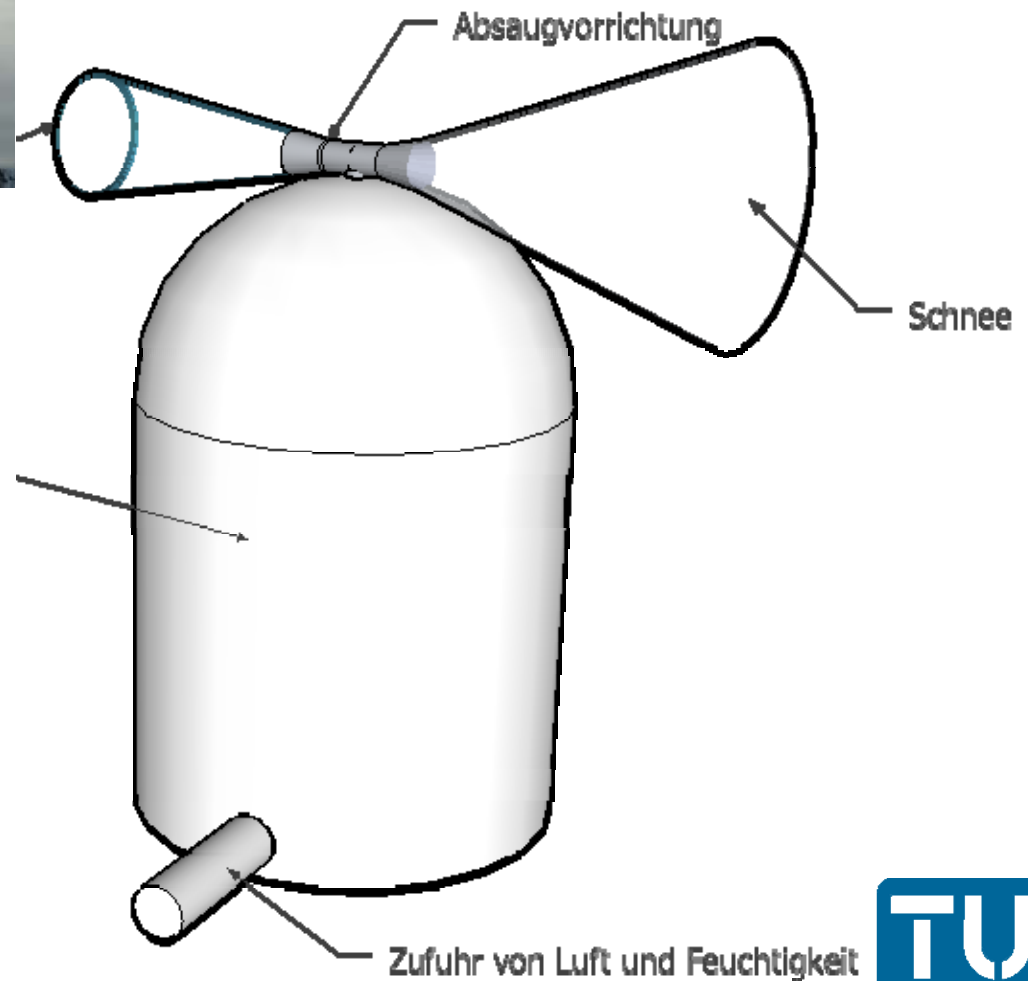
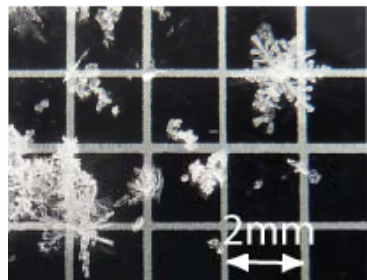


And Accompanied Energy Savings





Principle of the Artificial Cloud





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 continuous)
 - Time in chamber defines the snow properties
- Transport of produced snow into the environment





Output of the artificial cloud

- Snowdensity $< 250\text{kg/m}^3$ (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 ($-1^\circ\text{C} > T > -5^\circ\text{C}$)





Laboratory Experiments





A Cool Job for Researchers





Team of Experts Undertaking Field Experiments



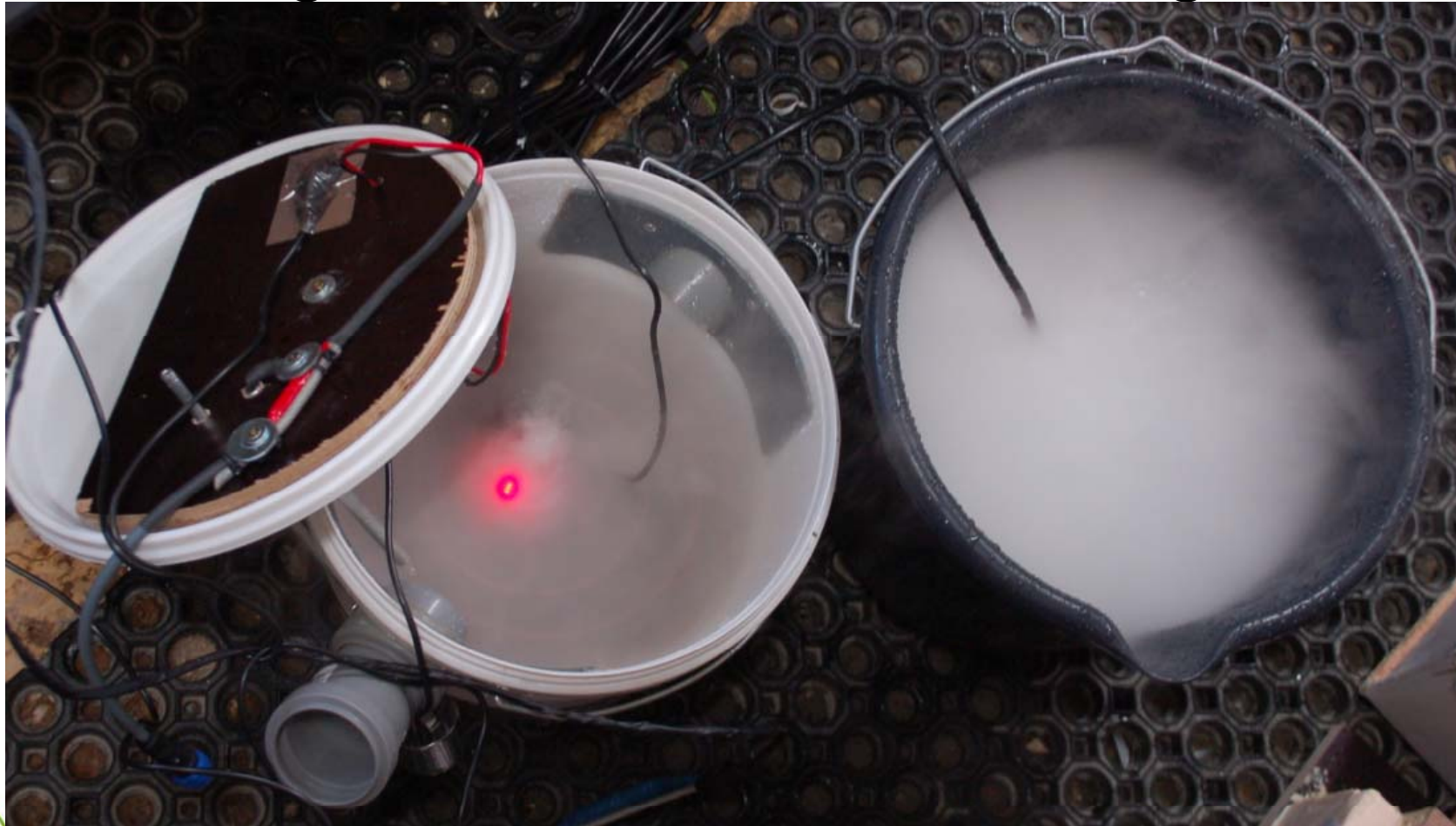


..sometimes fingers get stiff





High Tech For Better Water Usage





Water Tube in Outdoor Laboratory





Measurement instruments & data collection



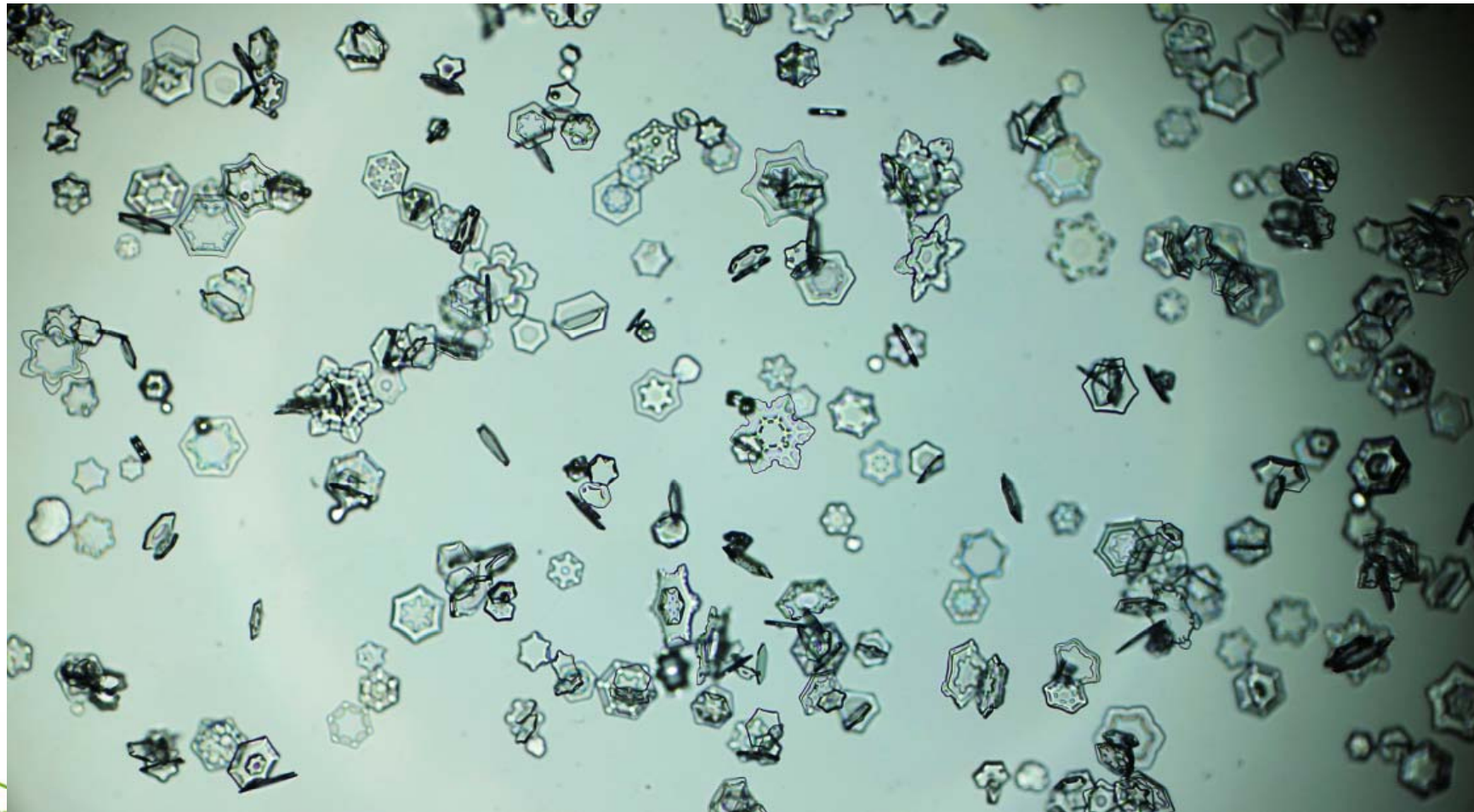


Quality Control of Produced Snow under Microscope





Snow Crystals



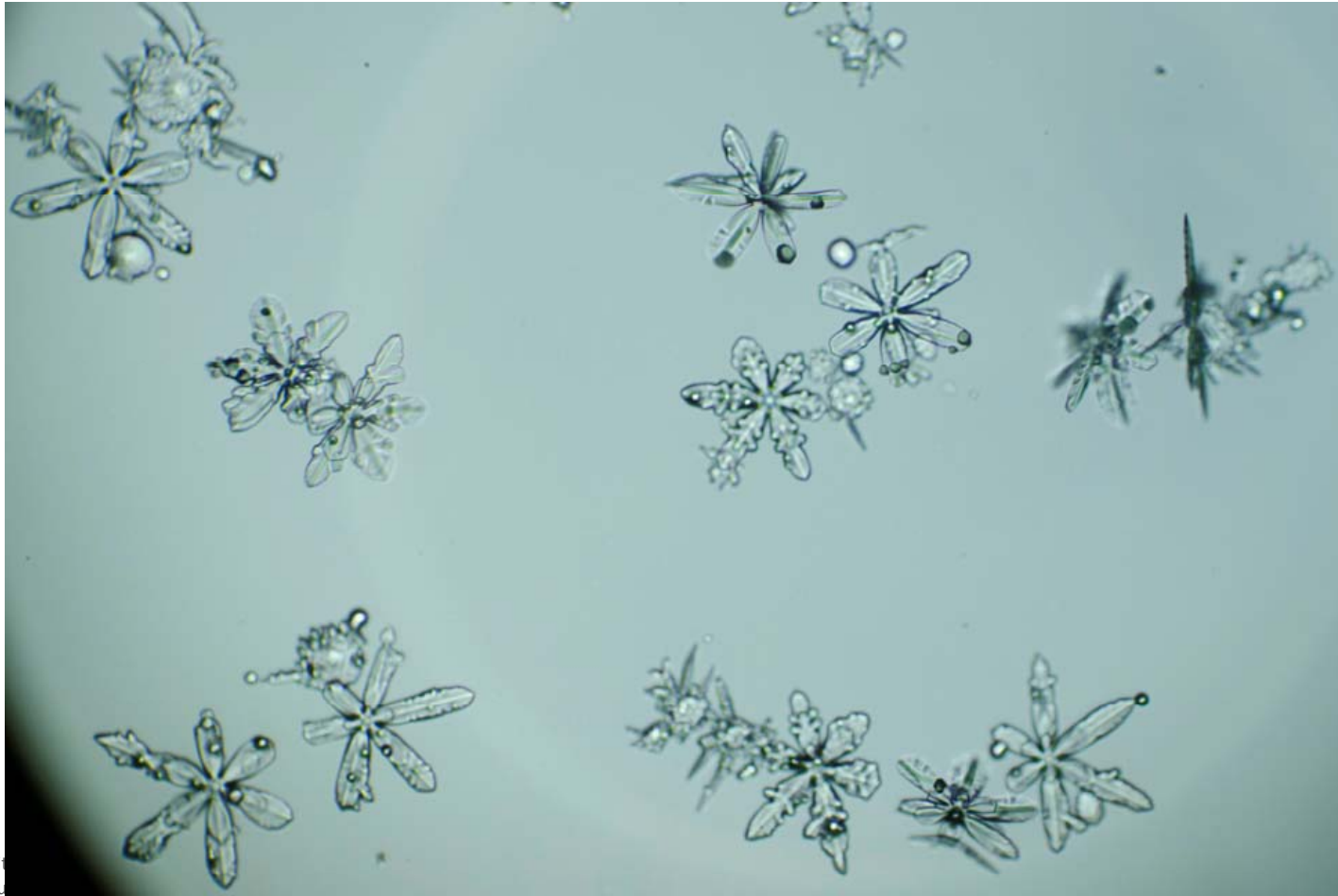


Snow Crystals (1)



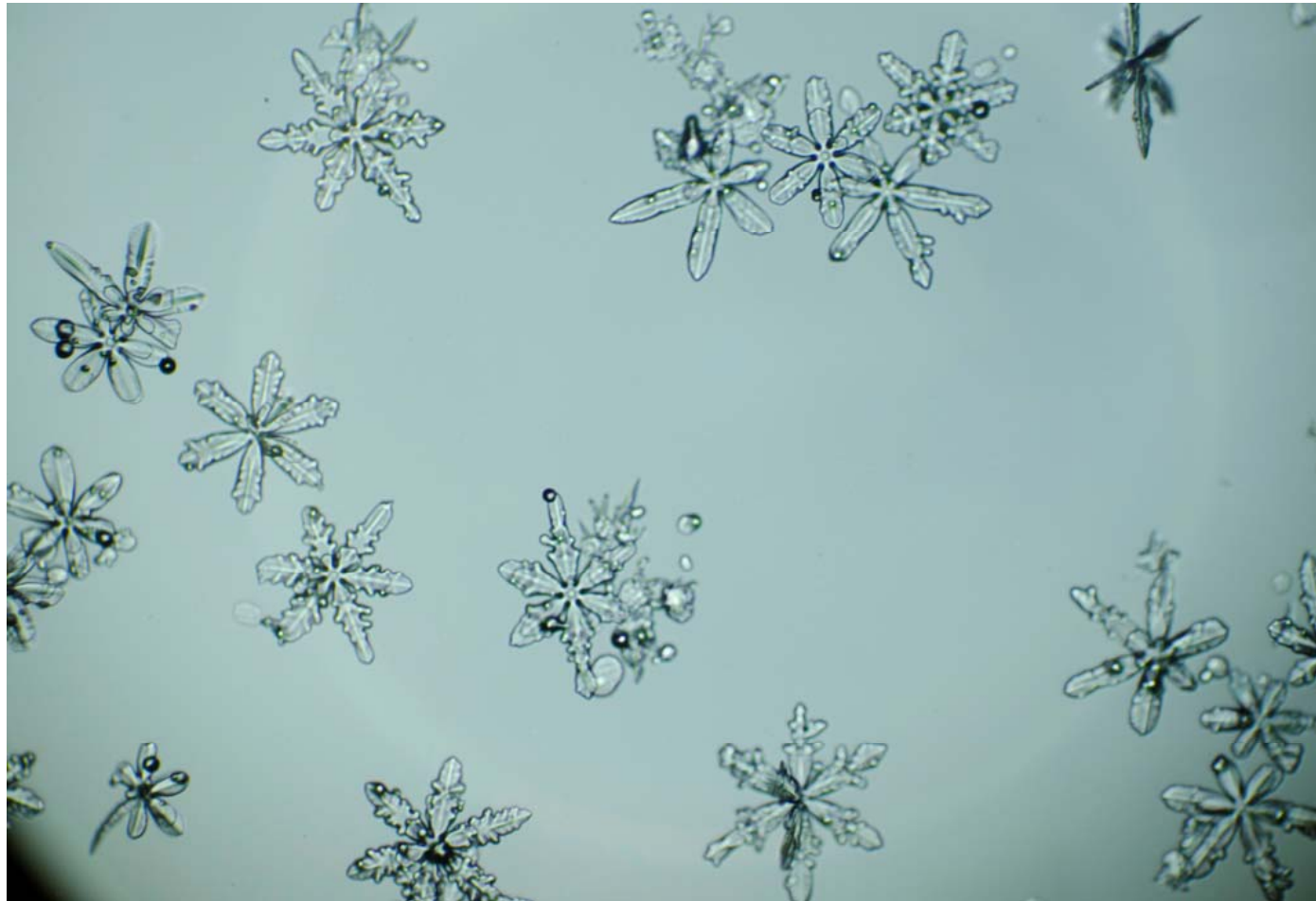


Snow Crystals (2)





Snow Crystals (3)



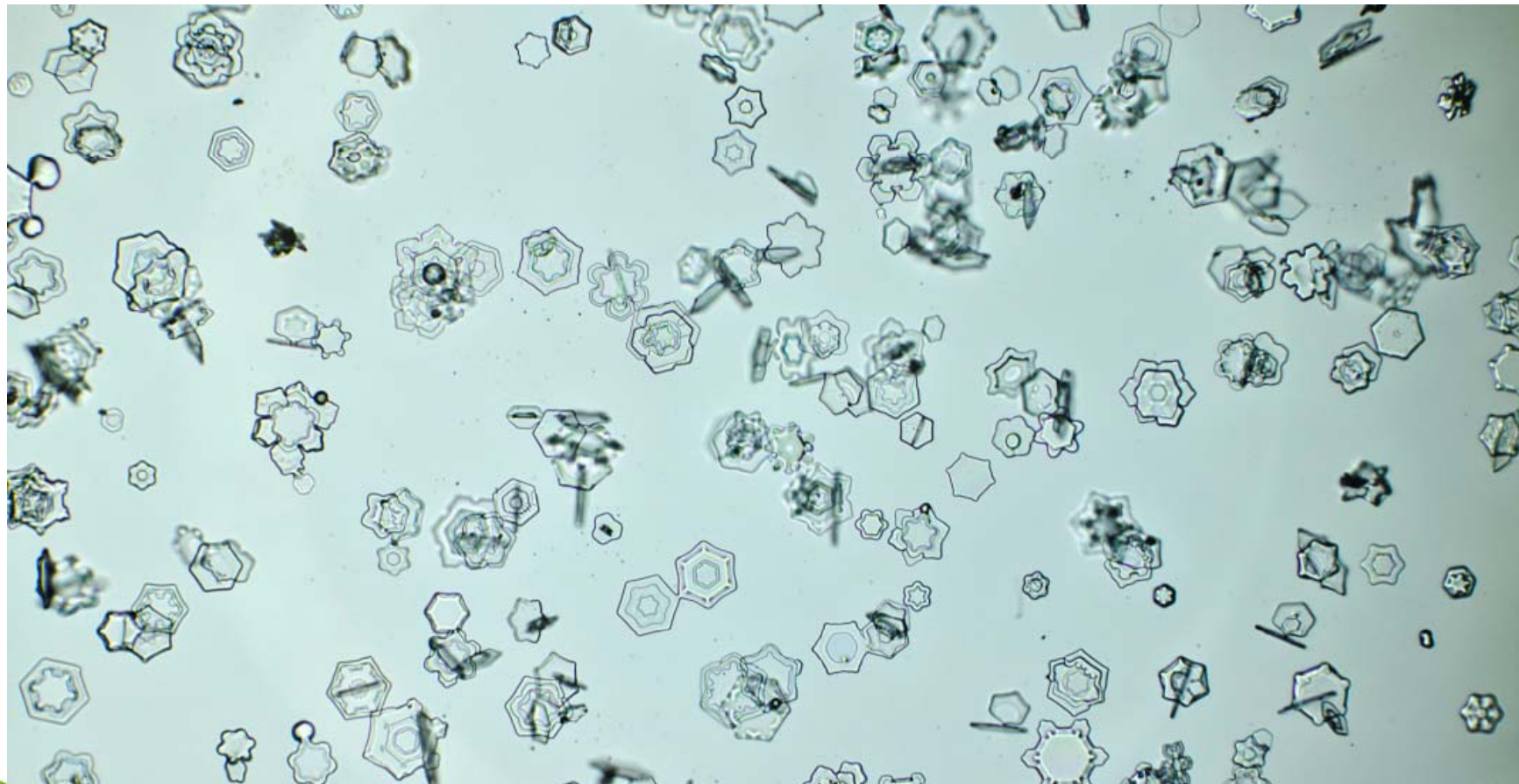


Snow Crystals (4)





Relation Between Shapes of Snow Crystals





Measurement of Snow Properties



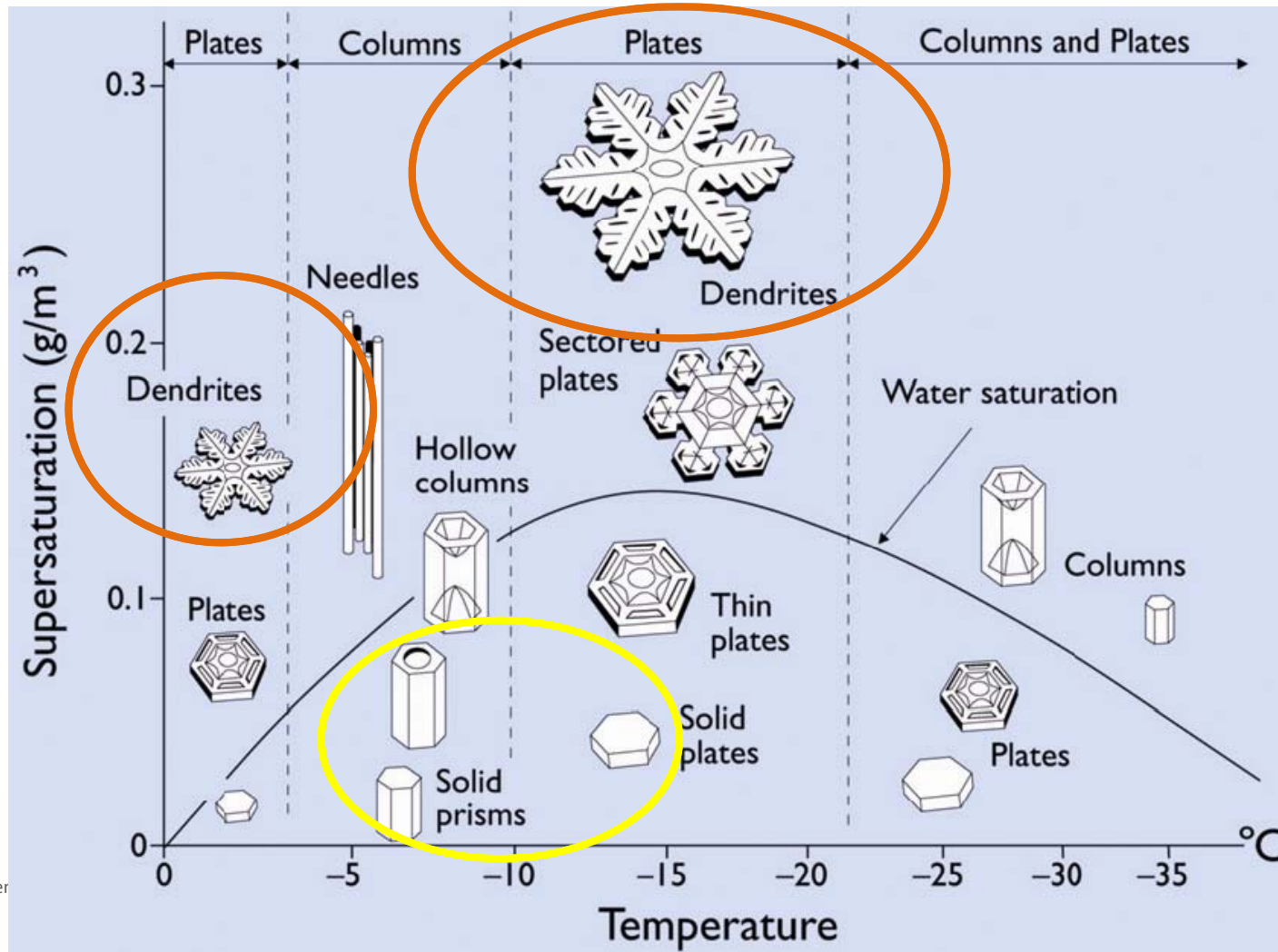


Snow at the Bottom





Snow genesis: Nakaya Diagram



Source: Libbrecht (2005) after Nakaya (1954)



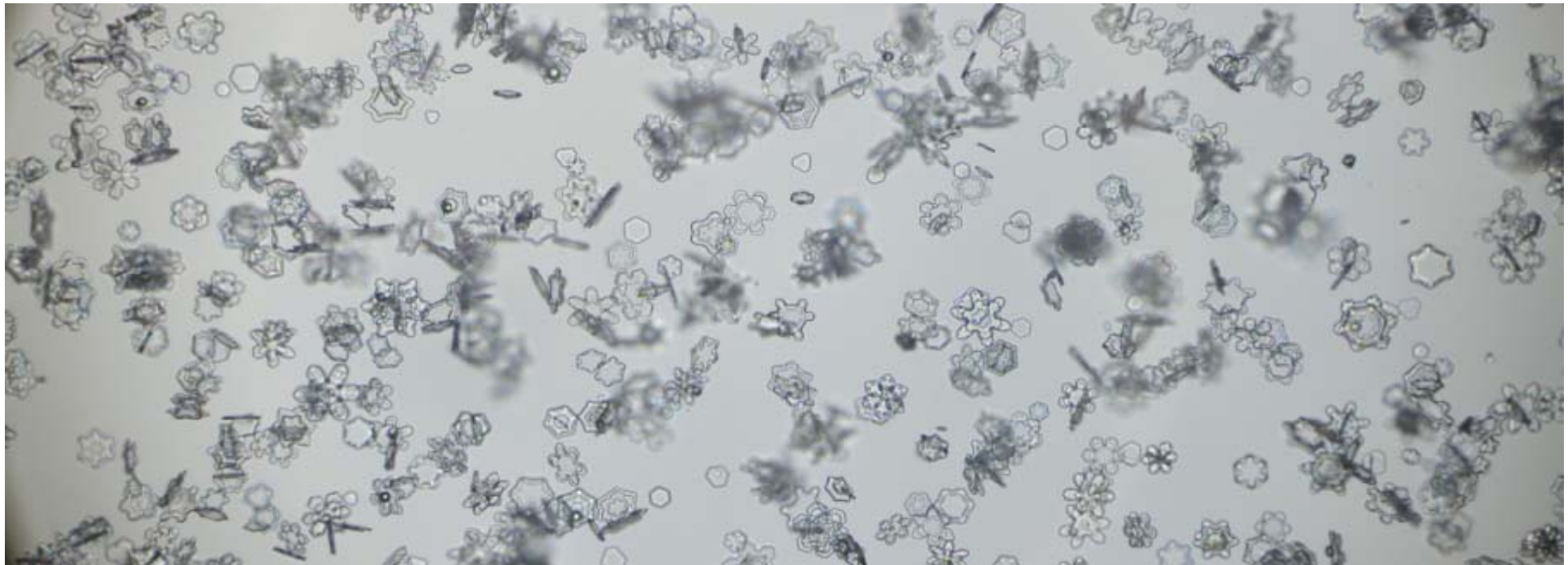
Snow metamorphosis

- 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/m^3
 - Ending up with 900kg/m^3 and in form of ice
 - Ending up with 1000kg/m^3 and in form of water



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

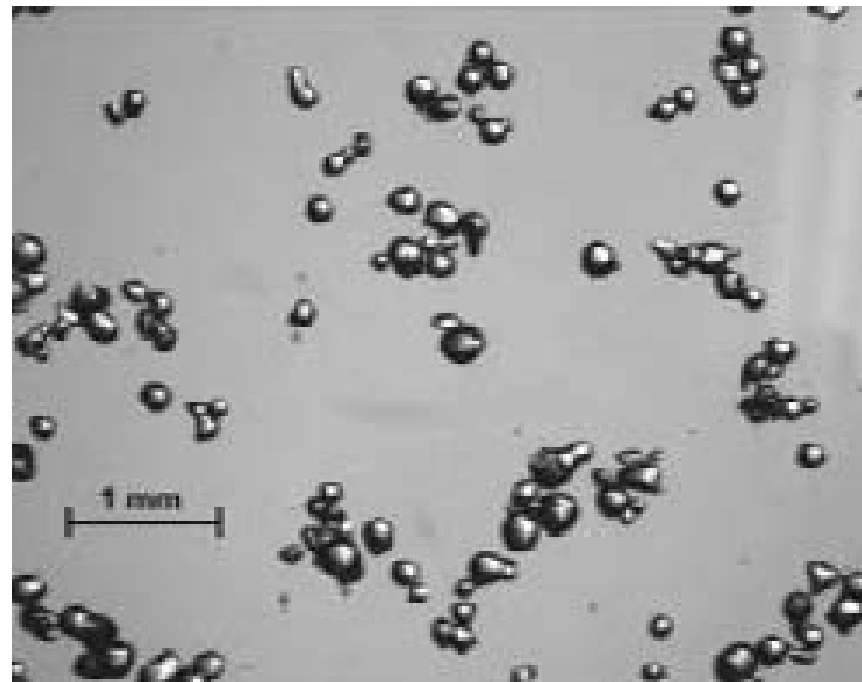
- Natural snow crystals are unique and grow on hexagonal basis to needles, prisms and dendrites.
- Dry snow with hexagonal dendrites = Powder snow (light fluffy snow)
 - Can also vary from 40kg to 150kg/m³ depending on crystals forming it
- Stands at the beginning of the snow metamorphosis

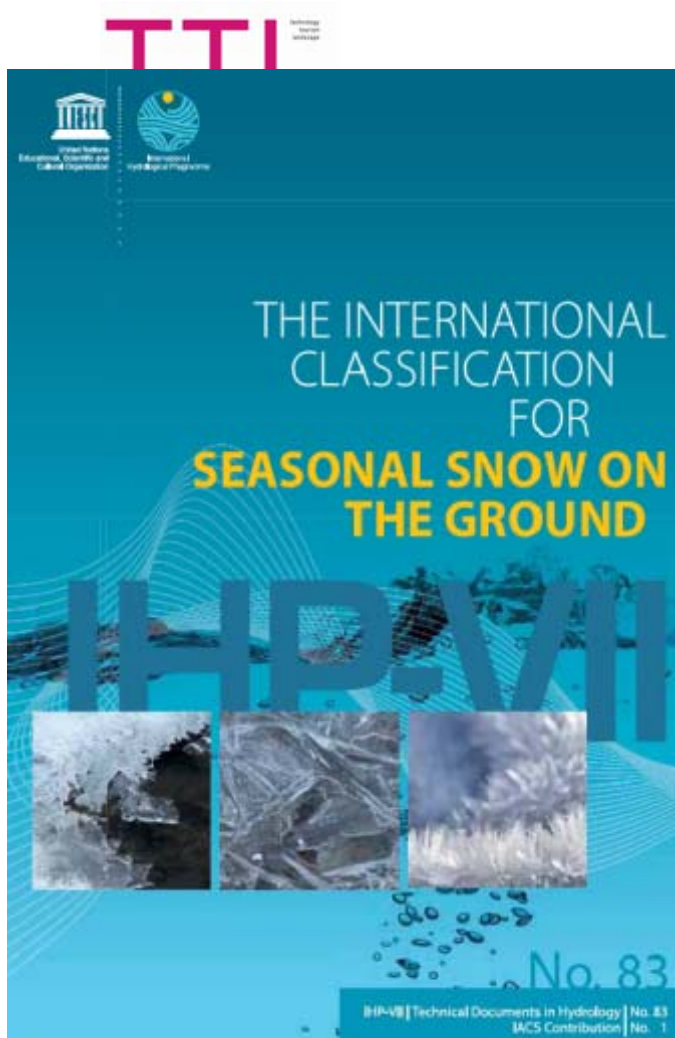




Difference to current state of the art

- 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: <http://unesdoc.unesco.org/images/0018/001864/186462e.pdf>



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

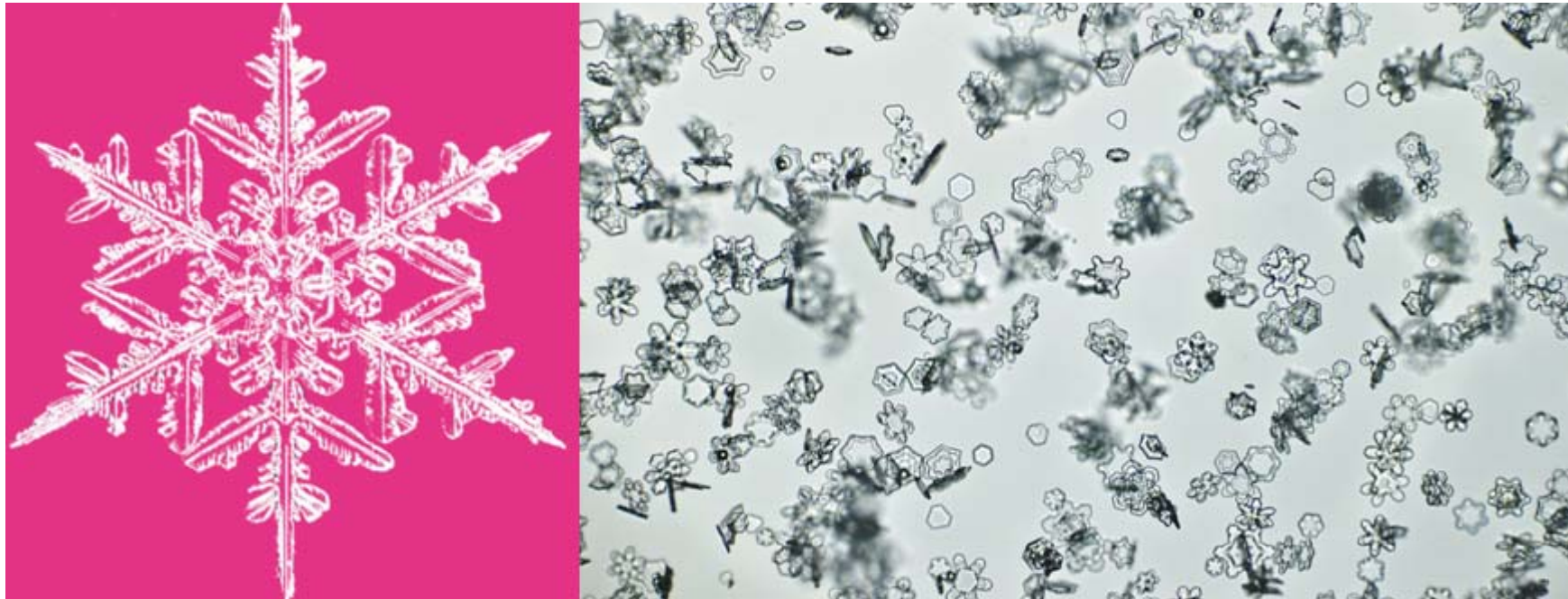


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A different product



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



New touristic products become
feasible for ski areas



Powder Snow Tracks



Foto: M. Breiling, Nov. 2011



Free Style Snow Park





Less accidents on ski slopes

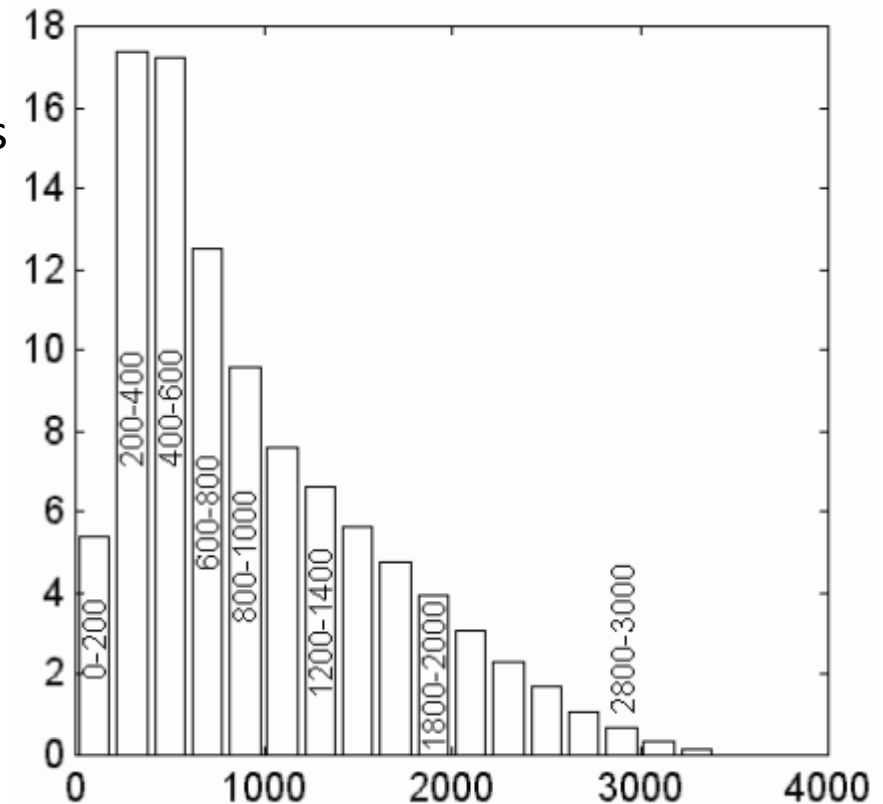
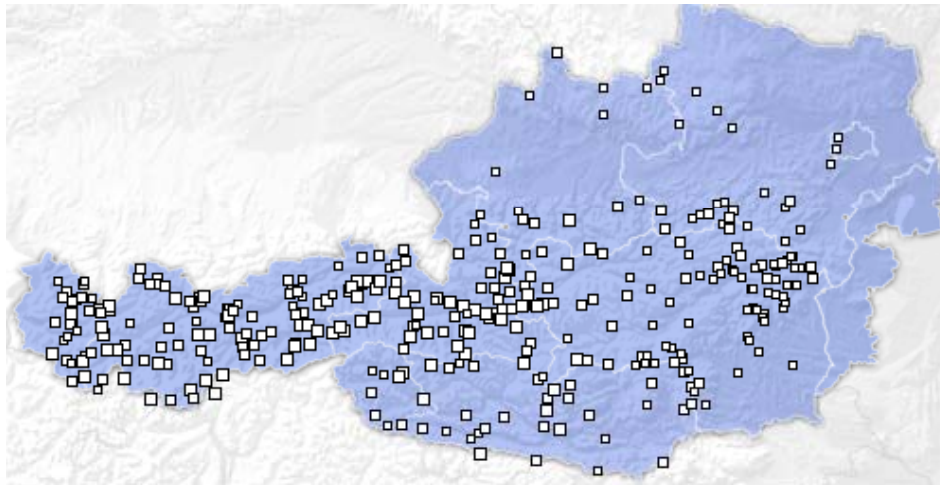


Foto: M. Breiling, March 2012



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



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



New ice hotel for the season



Foto: M. Breiling, Dez. 2007



The ice hotel in Jukkasjärvi





Method to quickly construct snow houses



Foto: H. Gelter, Jan. 2005



An organ built of snow and ice



Foto: H. Gelter, 2004



Quality of ice instruments can increase



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



Glenn Eden ski resort near Toronto



Foto: M. Breiling, Feb. 2012



Chikopee ski area near Toronto





Ski domes: another market for urban regions



Foto: M. Breiling, Nov. 2011



Ski dome in Shenzhen China



Foto: M. Breiling, Nov. 2011



Sculptures from snow and ice

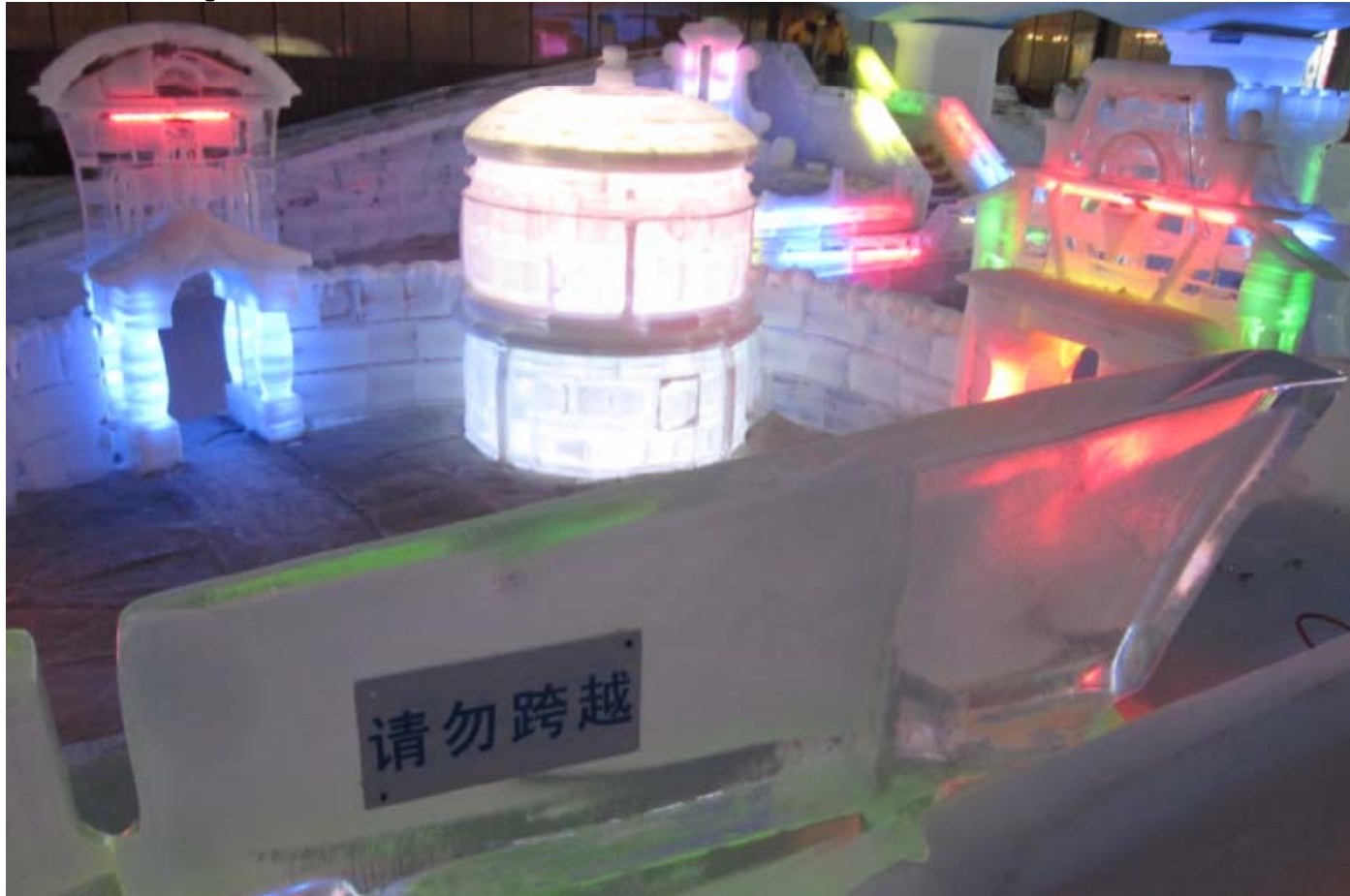


Foto: M. Breiling, Nov. 2011



Artwork produced of snow





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





Thanks

To You for listening

and

Austrian Climate Research Program to support the SNOW project



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