European Research on Icing of Structures

Lasse Makkonen, VTT Technical Research Centre of Finland

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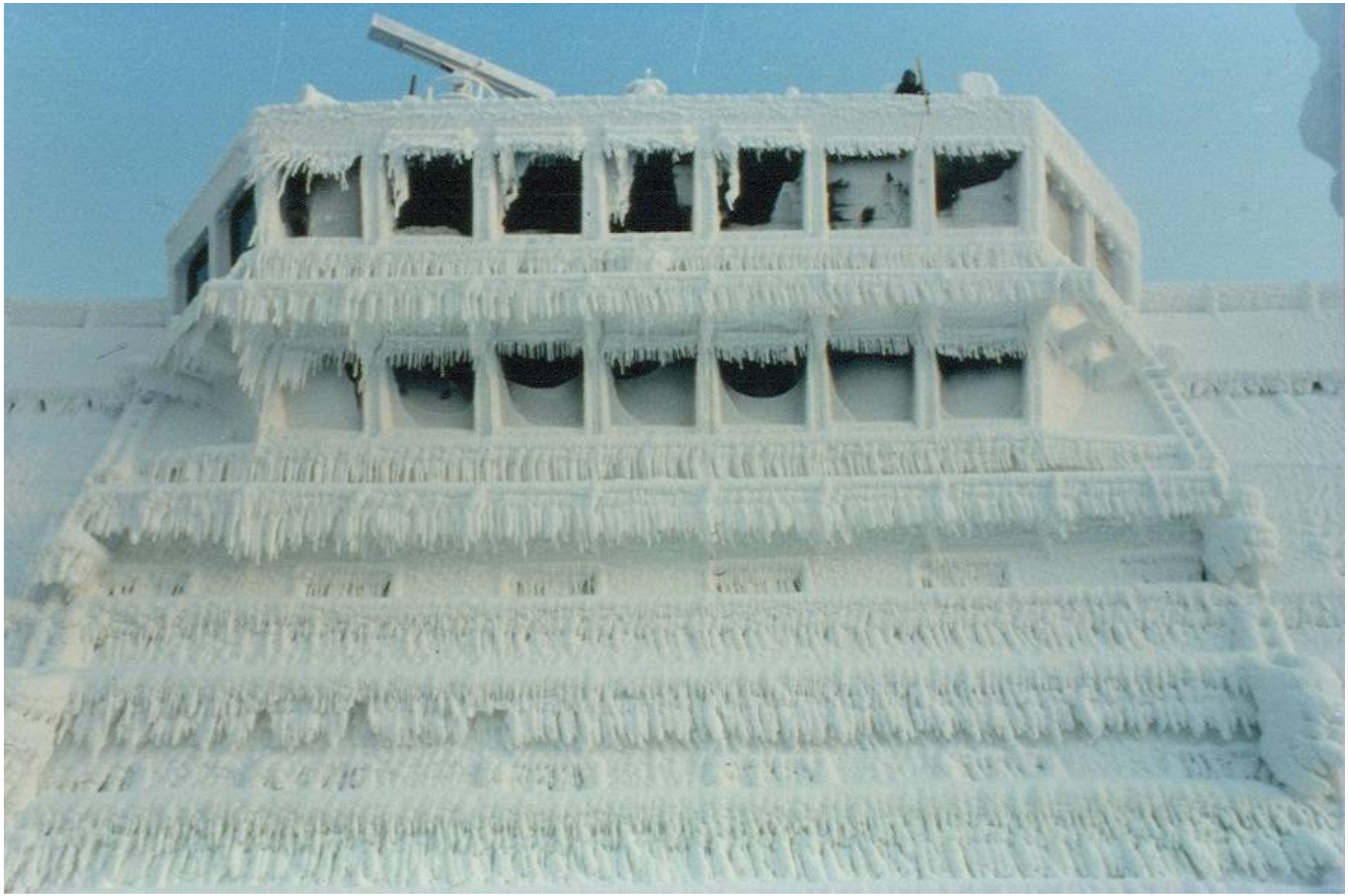

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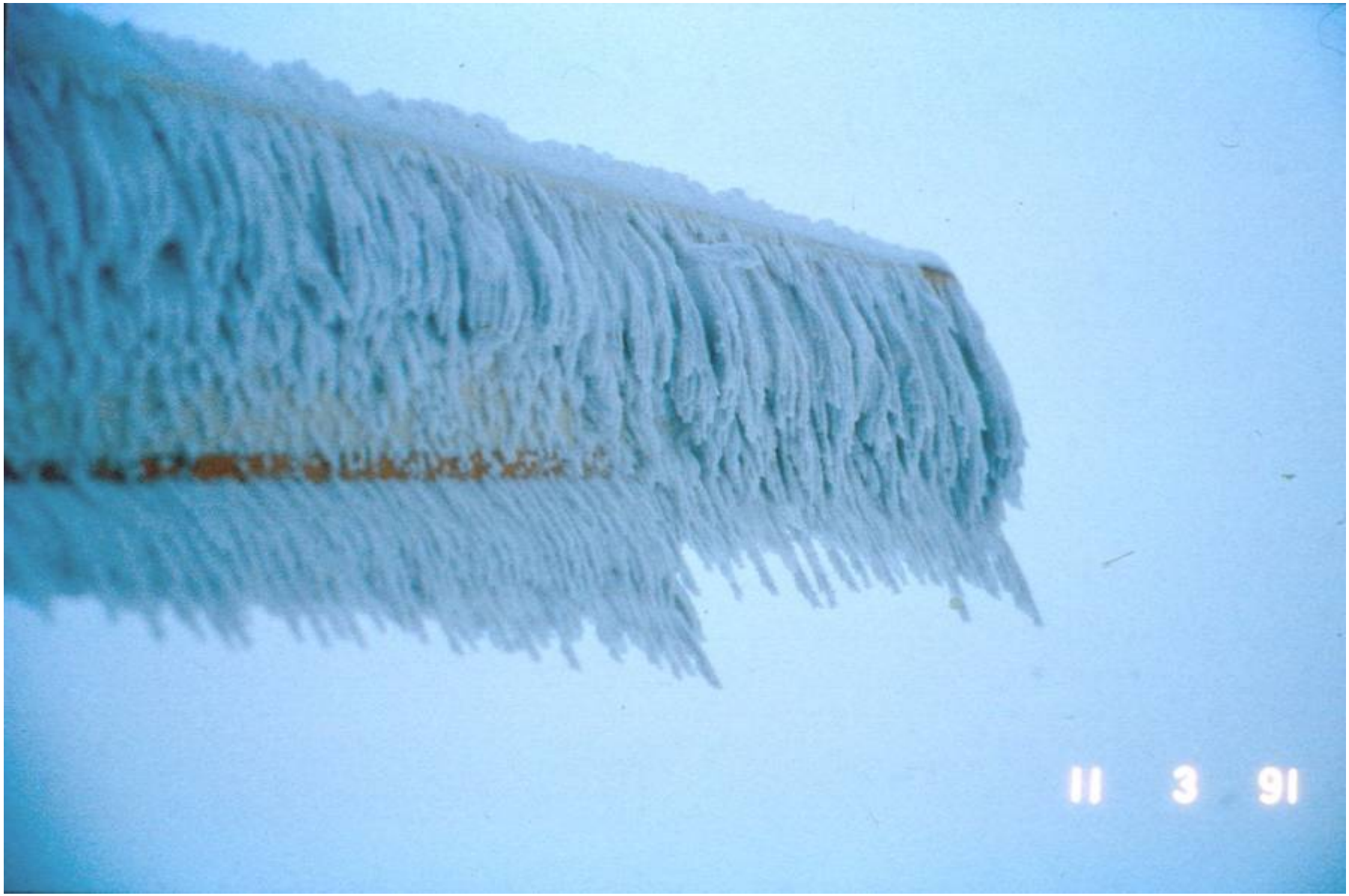

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THE ROYAL SOCIETY

Models for the growth of rime, glaze, icicles and wet snow on structures

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Ice accretion on structures is discussed with an emphasis on estimating structural design iceloads and solving operational icing problems. Basic principles of modelling of icing caused by freezing precipitation, cloud droplets and wet snow, as well as simulation of icicle growth, are presented. Theoretical models of atmospheric ice accretion are critically reviewed, particularly with respect to the simulation of the relevant physical processes. The reasons for the difficulties in simulating some icing phenomena accurately are analysed and proposals for further improvements in the models are made.

Keywords: ice; ice accretion; structures; icing; icicles; modelling

1. Introduction

In January 1998 a devastating icing event took place in southern Quebec and eastern Ontario in Canada. Over two million people were without electricity for weeks as 1300 high voltage power-line towers and 35 000 distribution-line towers were destroyed by excessive iceloads. There were 25 deaths and the total damage costs amounted to billions of dollars. The episode not only showed how vulnerable modern societies are to atmospheric icing, but also how difficult it is to predict its magnitude. Ironically, this unexpectedly severe ice storm took place in the only region of the world where regular icing measurements have been made over a long period of time by a dense observation network (Laflamme & Periard 1996). This demonstrates the limitations of direct icing measurements in determining iceloads for structural design.

Extreme icing events are rare results of complex combinations of various atmospheric and geographic factors, and may not follow an occurrence probability distribution that is readily derivable from measured ice data. Also, such data do not exist in most areas of the world. Furthermore, ice data high above the ground, for example for television- and communication-tower design, cannot usually be collected until the tower has been erected. By then it may be too late, as shown by the 140 ice-induced distribution tower collapses in the last 40 years in the US alone (Mulherin 1998).

All this signifies the importance of modelling ice accretion. The major advantages of modelling are that climatic weather data, much more extensive both in time and space than ice data, can be used, and that using sound theoretical model simulations can be extended outside the range of our limited empirical verifications. The latter advantage is particularly important in structural design because the designer is always interested in extreme events that we may not yet have experienced.

Users of information, data and forecasts of icing

- electric power industry
- wind power industry
- telecommunication sector
- transportation sector
- building sector
- manufacturers of weather sensors
- WMO/CIMO

COST 727: Measuring and forecasting atmospheric icing of structures

COST = European co-operation in the field of scientific and technical research

COST provides funding for Cost Action meetings and short term scientific missions

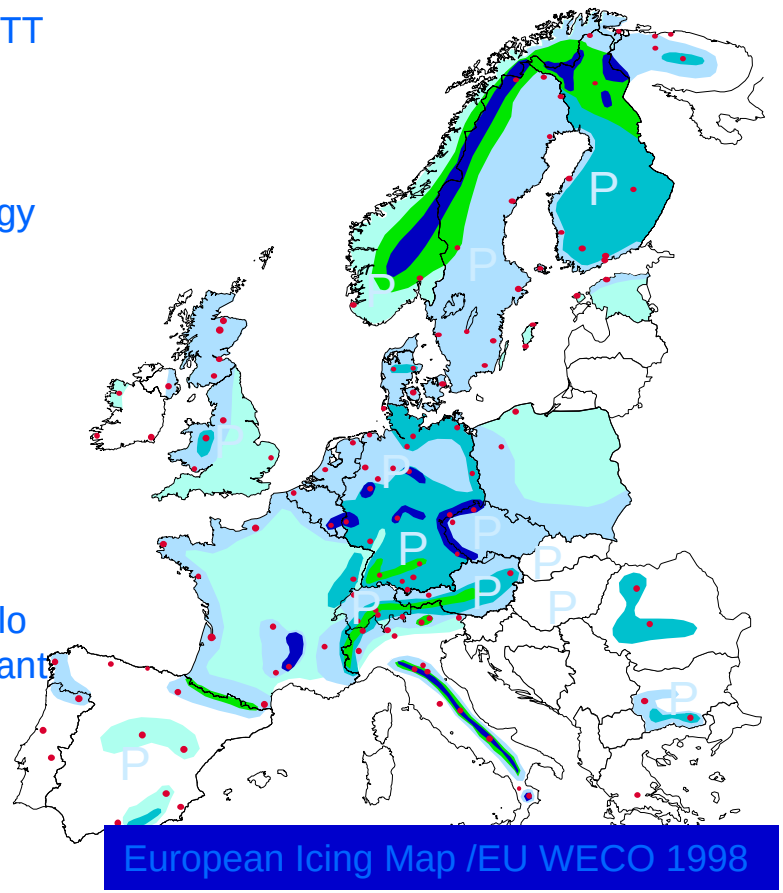
COST does not provide project funding

COST 727 Main Objectives

- Develop understanding of in-cloud icing and icing due to freezing rain in the atmospheric boundary layer
- Produce information on distribution of icing over Europe
- Improve the potential to
    - observe icing
    - monitor icing
    - forecast icing

Signatories and partners

- Finnish Meteorological Institute – FMI
- Technical Research Centre of Finland - VTT
- Zenralanstalt für Meteorologie und Geodynamic - ZAMG
- Bulgarian National Institute of Meteorology and Hydrology
- Institute of Atmospheric Physics
- EGU BRNO a.s.
- German Meteorological Service – DWD
- Hoschule Bremerhaven / Wind Energy
- Hungarian Meteorological Service
- Meteorological Institute, University of Oslo
- Kjeller Vindteknikk AS, S. Fikke - Consultant
- Geophysical Institute
- (Fundacion LEIA C.D.T)
- Swedish Meteorological and Hydrological Institute – SMHI
- Vattenfall, Combitech AB
- MeteoSwiss
- Brian Wareing Tech. Ltd



European Icing Map /EU WECO 1998

Kanagawa Institute of Technology

COST 727 Scientific Programme

Preparatory Phase

- started: April 2004
- finished: December 2006

Research and Development Phase

- started: January 2007
- will be finished: March 2009

Preparatory Phase:

- Establish representative group of signatories
- Gather and assess existing methods to:
  - produce statistics on icing events
  - predict ice loads on structures
  - forecast icing (time, duration, intensity, cumulative load)
  - measure icing and study available data
  - model ice accretion upon structures
- Dissemination of information
- Prepare workplan for the R&D phase

Research and Development Phase:

- Research on icing physics
- Measurement of atmospheric icing
- Modelling of icing processes
- Improved forecasting systems
- Verification of existing icing sensors
- Mapping of icing occurence in Europe

Activities

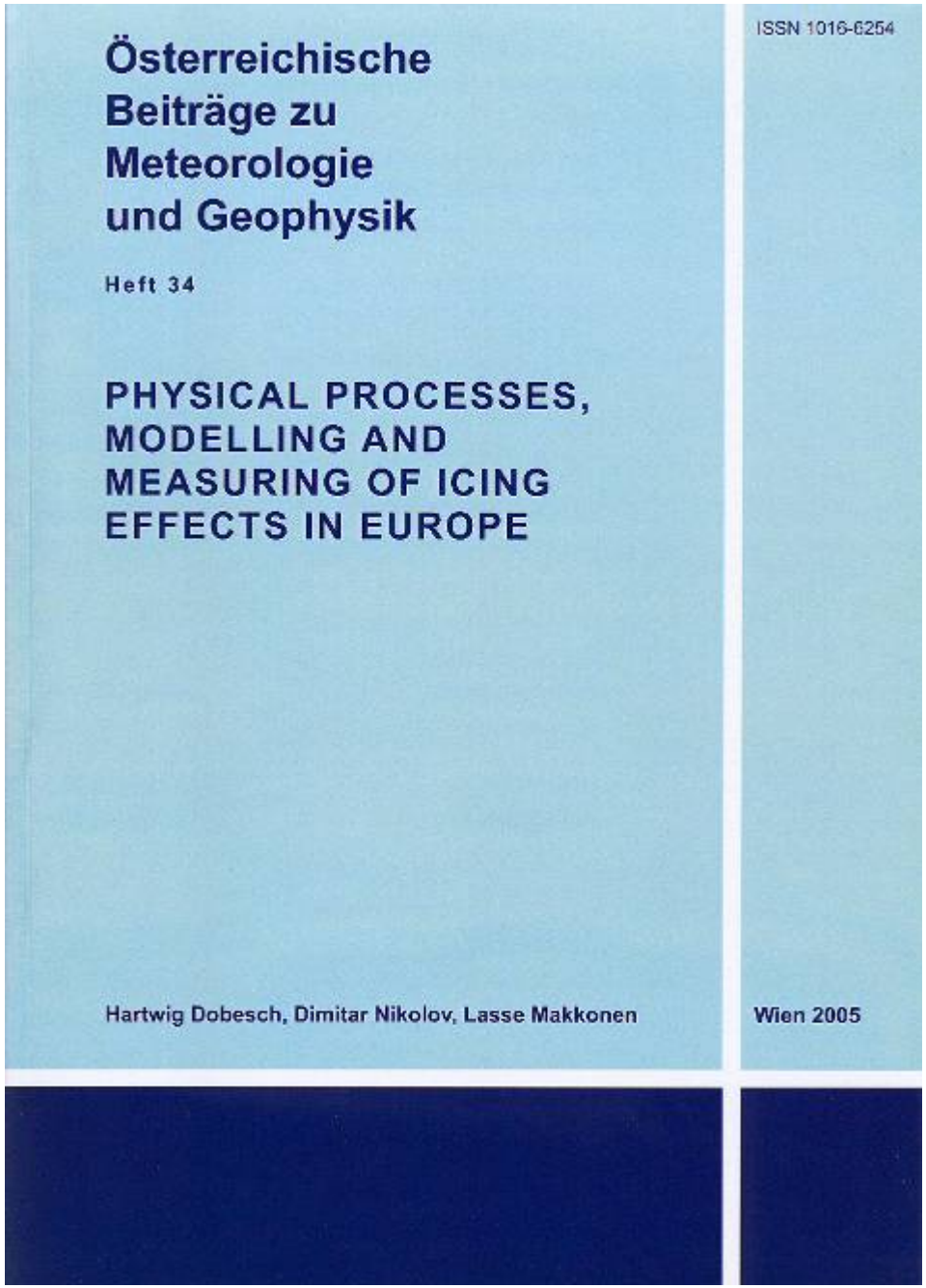
Modelling icing of structures (WG1):

+ theory OK
+ simulation models OK
+ simplified (experimental) models in use

- lack of input data for simulation models
  - Liquid water content
  - Droplet size distribution

- simple modeling based on synoptic observations:
  cloud base, temperature, wind speed etc.

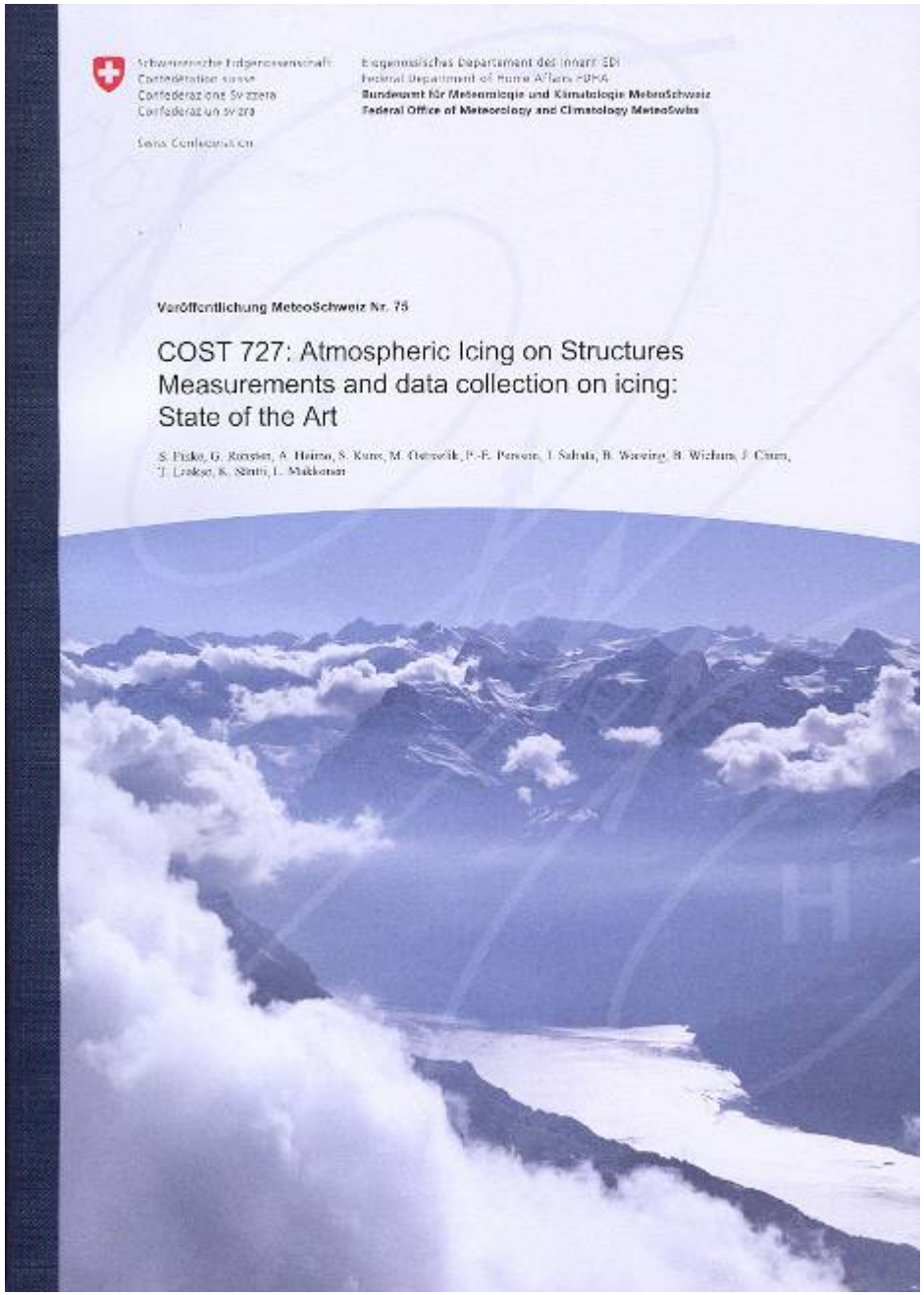
- lack of verification data (loads)
- lack of icing measurements and data


ISSN 1016-6254
Österreichische Beiträge zu Meteorologie und Geophysik
Heft 34
PHYSICAL PROCESSES, MODELLING AND MEASURING OF ICING EFFECTS IN EUROPE
Hartwig Dobesch, Dimitar Nikolov, Lasse Makkonen
Wien 2005

Measurements of icing (WG2):

+ international standard given (ISO 12494)
+ historical data available in many countries
  * oldest data from 1920´s from Czech Republic

- no specification given by WMO
- not included in the measurements done by national weather services
- lack of proper ice sensors
- what should be measured?
- undeveloped market for ice detectors


Schweizerische Eidgenossenschaft
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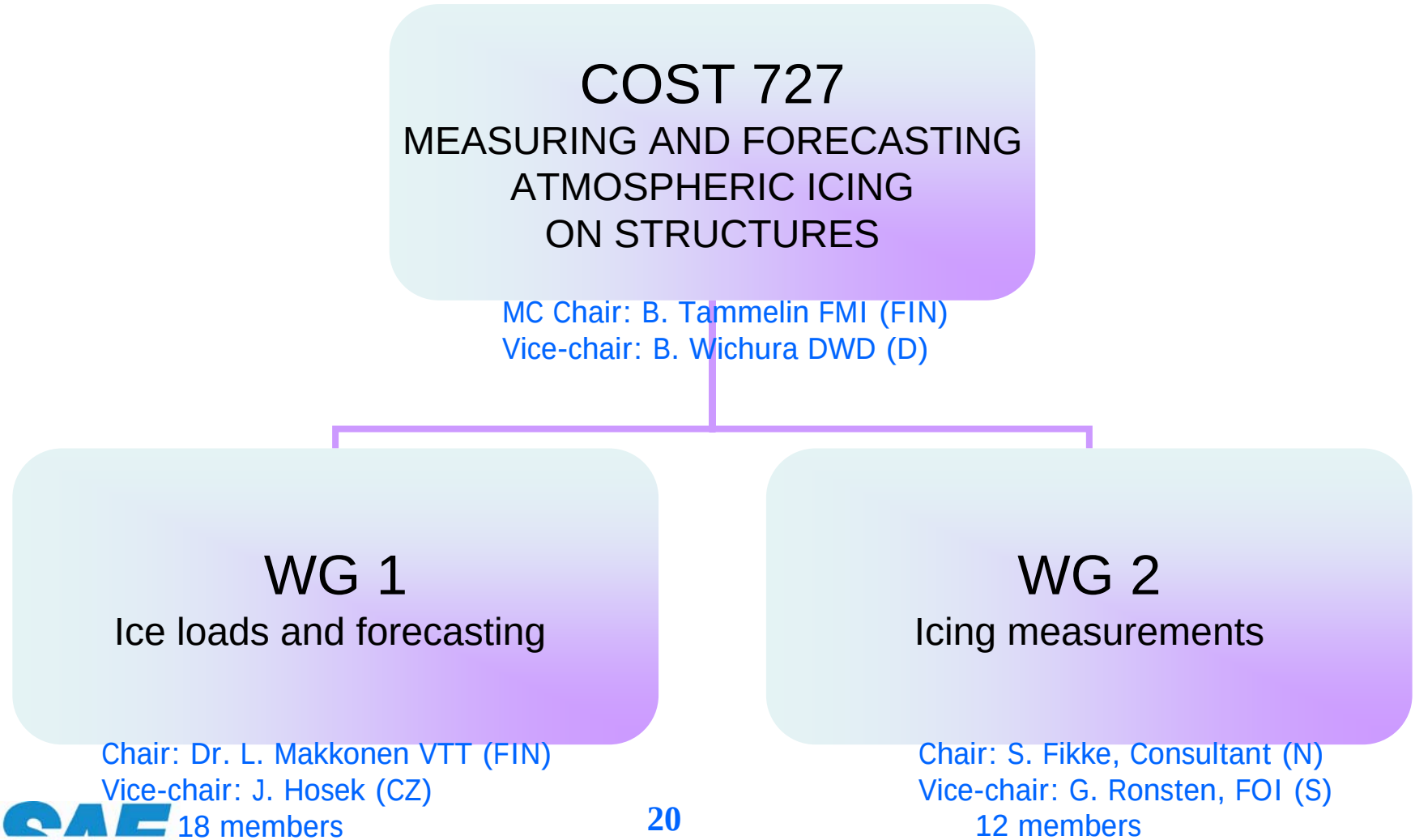
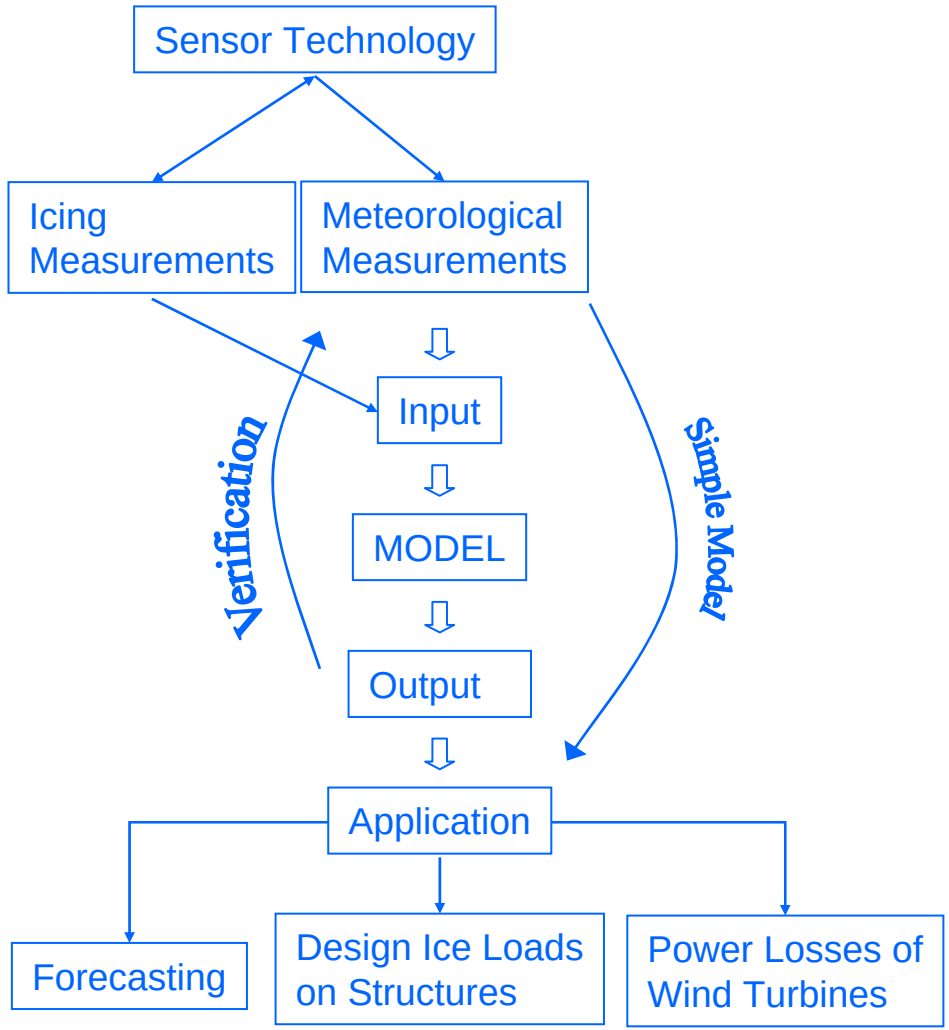
Eidgenössisches Departement des Innern EDI
Federal Department of Home Affairs FDHA
Bundesamt für Meteorologie und Klimatologie MeteoSchweiz
Federal Office of Meteorology and Climatology MeteoSwiss
Veröffentlichung MeteoSchweiz Nr. 75
COST 727: Atmospheric Icing on Structures
Measurements and data collection on icing:
State of the Art
S. Fikke, G. Ronsten, A. Heimo, S. Kunz, M. Ostrozlik, P.-E. Persson, J. Sabata, B. Wareing, B. Wichura, J. Chum,
T. Laakso, K. Säntti, L. Makkonen

Research and Development Phase 1/06 – 3/09



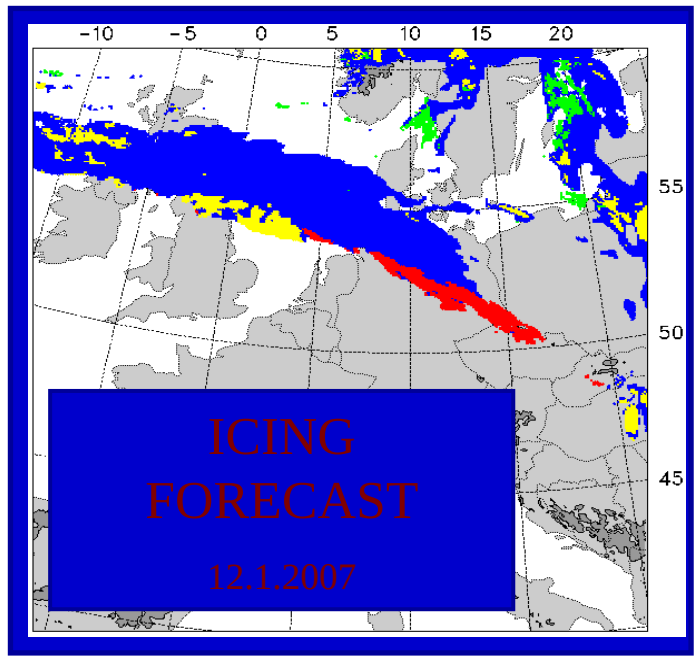
Adjusted targets for the R&D Phase

- Ice measurements as described in standards
- Specifications for ice detection
- Ice observations in meteorological networks
- Permanent forum for ice monitoring in Europe
- Set up improved models and forecast schemes on the basis of available data
- Map icing in Europe
- Recommendation on icing forecast for meteorological offices and WMO



WG1 tasks

- Icing as output from numerical weather prediction models (NWP)
  - HIRLAM, MM5, WRF
- Verification of icing forecasts
- Promote national NWP activities
- Models on icing on structures
- Climatological Icing Map over Europe
- Impacts of Climate Change on icing



WG2 tasks

Fulfill the WMO/CIMO request to provide guidance for performing measurements under harsh icing conditions

Promote the development of robust, rugged icing detectors to be deployed at automatic meteorological stations as well as other sites where icing effects may be critical. Both simple sensors delivering a yes/no information and more sophisticated instruments yielding values of ice thickness/weight, types of ice etc. are needed.

Provide verification data for WG1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In order to increase funding and activities:

- National projects (funding: power industry, aviation, etc.)
  - Icing forecasts
  - Measurement campaigns
- EUMETNET project proposal
  - ice detectors
- EU Research Project Proposal
- EU Network
- Generally: to promote awareness of needs and opportunities related to atmospheric icing.

Dissemination of information:

- scientific articles
- direct contacts with end users
- participation in conferences and seminars

  2007: SAE Aircraft Icing Conference (Spain), 12th IWAIS 2007 (Japan)

- WMO/CIMO/TECO
- BOREAS VIII conference 2008
- 13th IWAIS (Switzerland)
- internet

- FINAL REPORT

Co-operation with the aircraft icing community !

Common interests:

- Icing physics
- Modelling of ice shape
- Modelling of ice roughness
- Icing detection
- Input for the cloud physical parameters
- Use of numerical boundary-layer meteorological models