

CANADIAN R&D ACTIVITIES ON WIND ENERGY PRODUCTION IN COLD CLIMATE AND IN COMPLEX TERRAIN

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Development
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Canada

Québec

PRESENTATION OUTLINE

- Nordic climate
- Major issues
- Canadian R&D Activities on Wind Energy Production in Cold Climate

NORDIC CLIMATE

Definition :

Regions where T is lower than standard operational limits (-20°C) and/or with atmospheric icing

Atmospheric icing

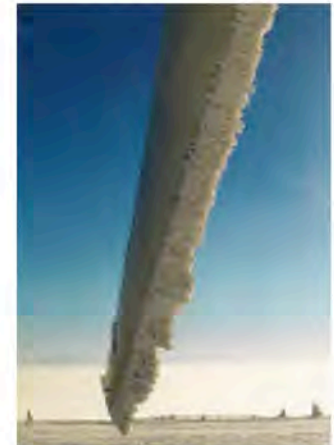
- Glaze ice (freezing rain or drizzle)
 - Usually dense & transparent ice
- Rime ice (in-cloud icing or freezing fog)
 - White & feathery accumulations of variable density
- Wet snow
 - Heavy & wet adhering snow



Source : Tammelin 2005

MAJOR ISSUES

- *Temperatures*
 - Adapted technologies
- *Storms & avalanches*
 - Site access
- *Atmospheric icing*
 - Production losses
 - Vibration
 - Security
 - Noise
 - Measure & control



Source : Tammelin 2003



Source : Maissan 2005



Source : Tammelin 2005



Source : Tammelin 2003

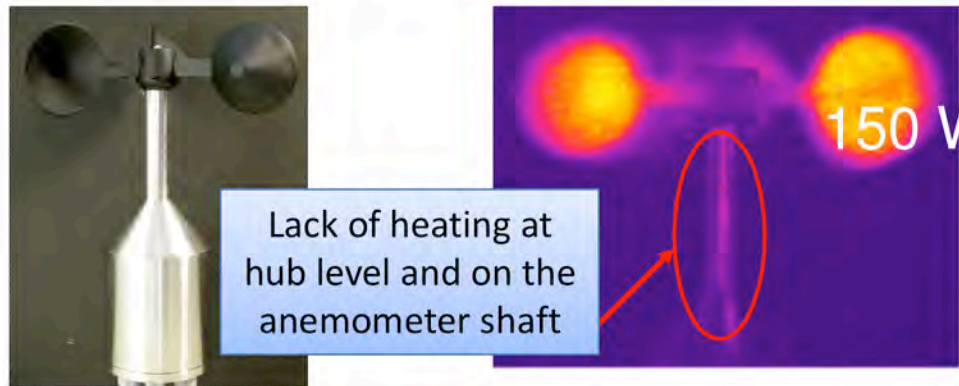
RESEARCH PROGRAM OF CANADIAN WIND ENERGY STRATEGY NETWORK (WESNET)

Focus on 7 projects with cold weather issues:

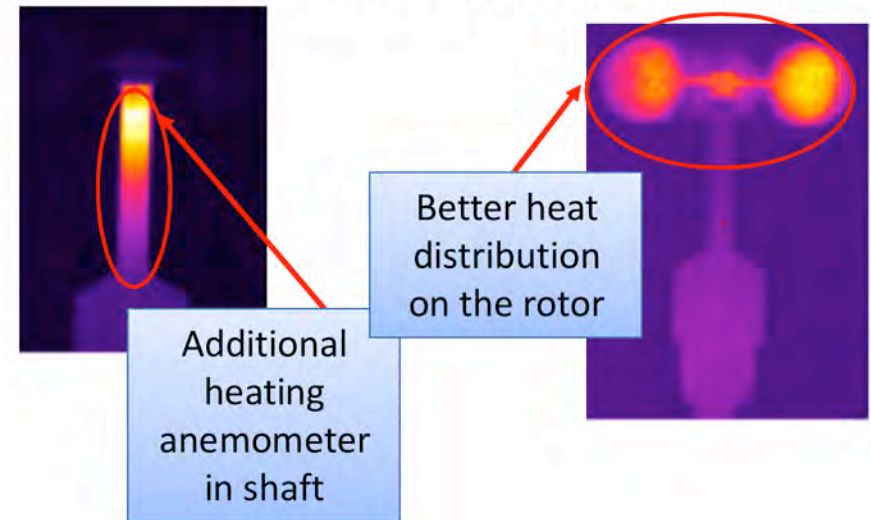
- Design of ice-free anemometers
- Wind turbine composite materials for the Canadian context
- Ice accretion modelling
- Wind tunnel investigations of icing impact on wind turbine blade profiles
- Forecasting icing events
- Icing event monitoring
- Atlas of icing events at high resolution

DESIGN OF ICE-FREE ANEMOMETERS

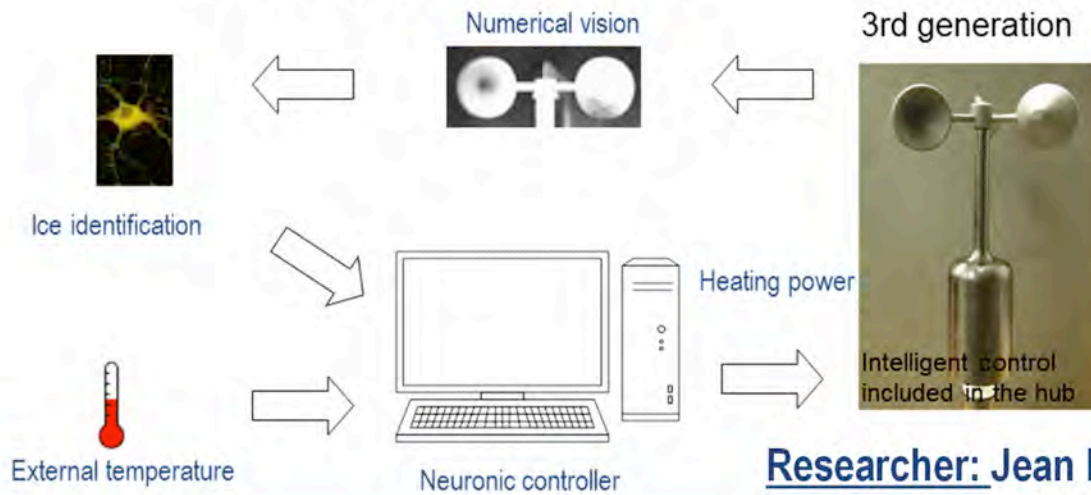
Anemometer design (1st generation)



Anemometer design (2nd generation)



Heating power control



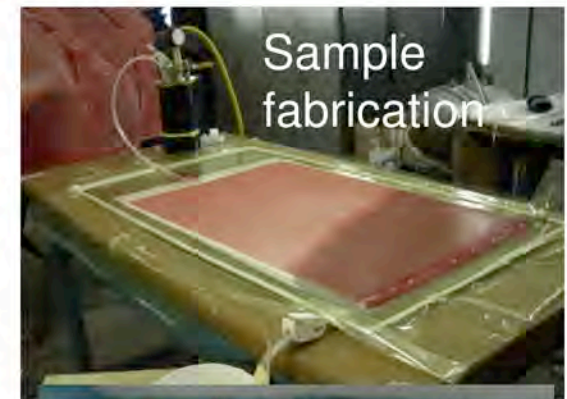
Project goals and motivations:
 Simple, robust, low-consumption and reliable instrument for wind velocity measurement

Researcher: Jean Ruel, André Bégin-Drolet, Université Laval

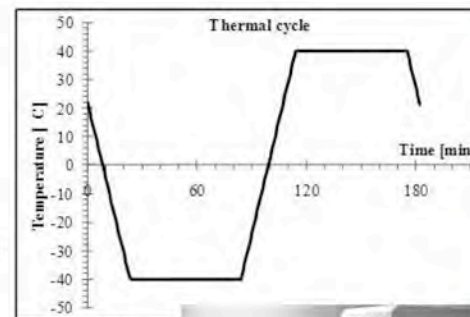
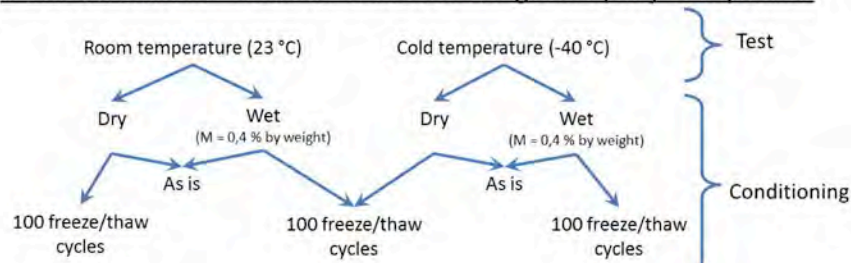
WIND TURBINE COMPOSITE MATERIALS FOR THE CANADIAN CONTEXT

Objectives:

- Investigate possible limitations of current blade designs when used in cold climate.
- **ETS** - Material characterisation in extreme conditions:
 - Static and dynamic mechanical properties at low temperature.
 - Failure modes analysis.
 - Effect of freeze-thaw cycles.
- **UVic** - Finite element (FE) modelling of blade structure relying on cold temperature material data.



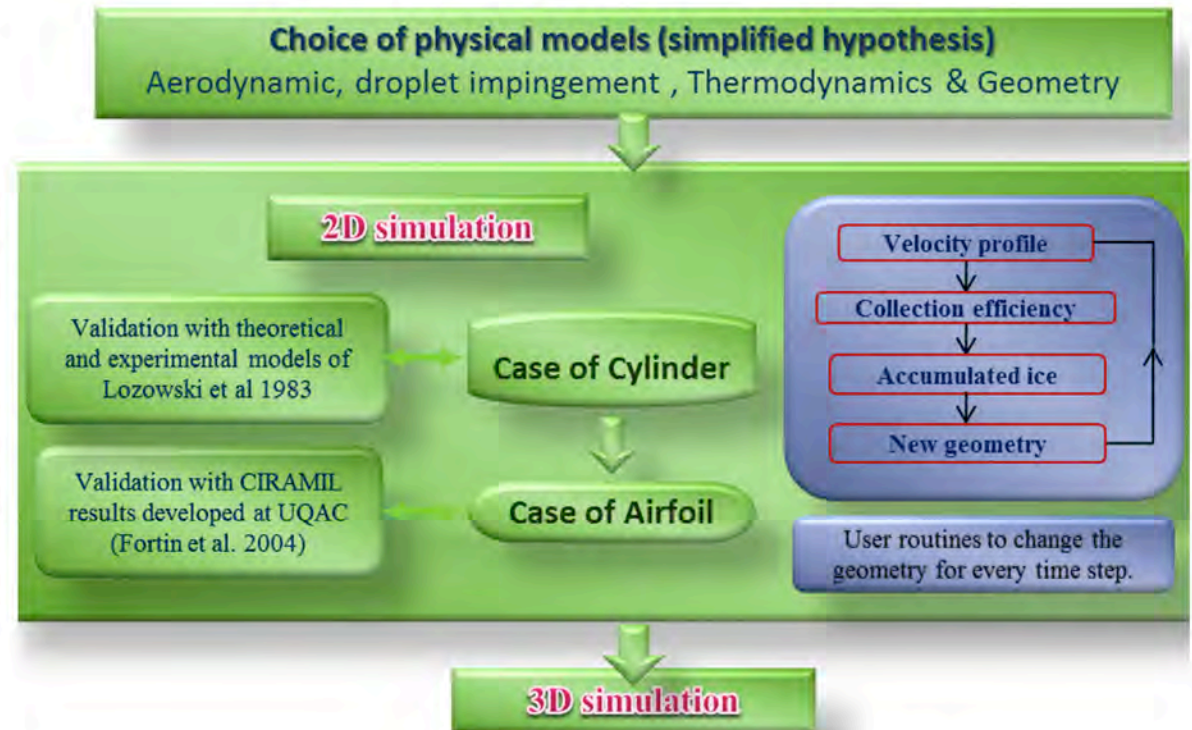
8 test conditions – tests on unidirectional glass-epoxy composites



Researchers: Simon Joncas (ETS), Curran Crawford (UVic)

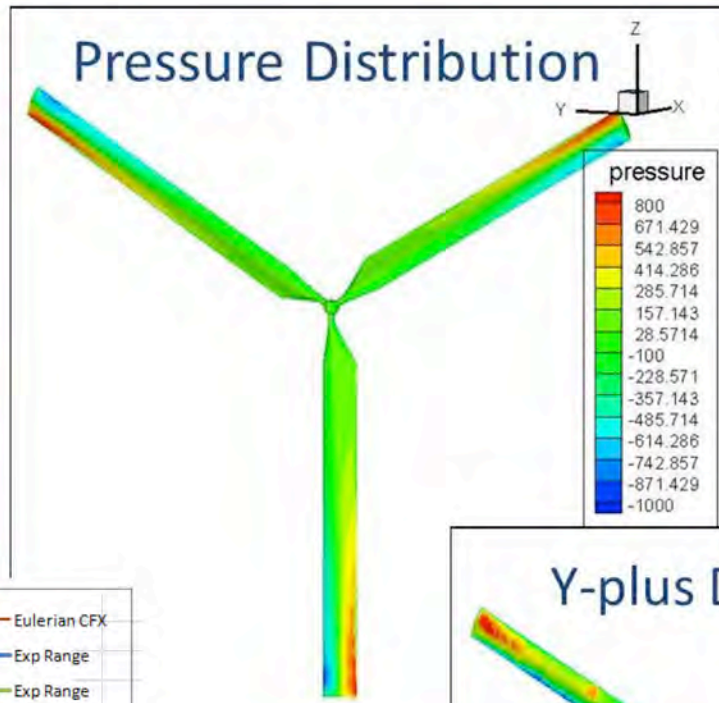
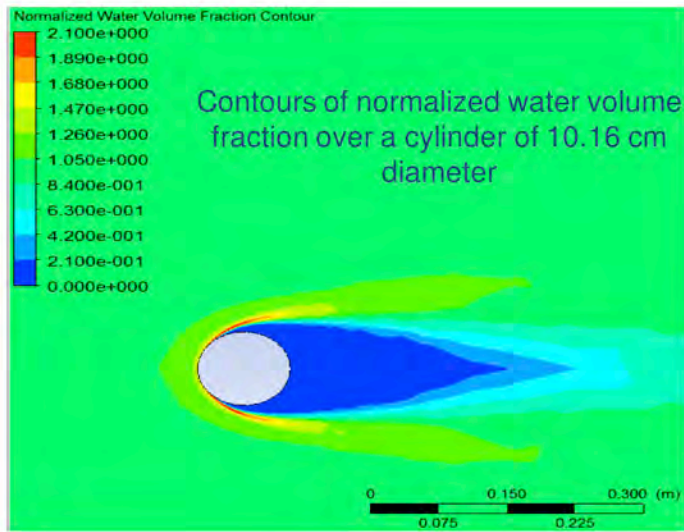
ICE ACCRETION MODELLING

- *General objectives*
 - To evaluate icing impact on wind turbine performance
 - Optimize de-icing
- *Specific objectives*
 - Use commercial CFD codes to simulate ice accretion on objects and wind turbine blades;
 - Validate the 2D methods and extend to three-dimensional simulations of ice accretion around rotating blades;
 - Use CFD and heat transfer analysis to optimize electro-thermal de-icing

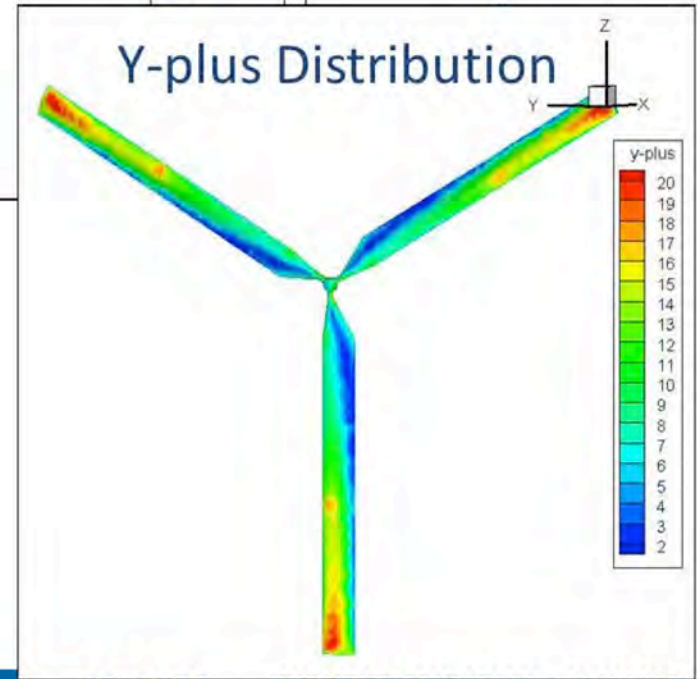
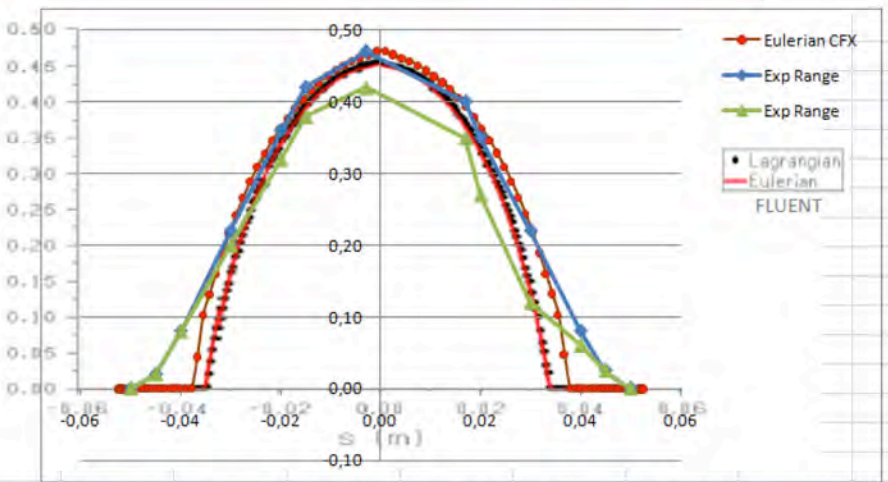


Researchers: Adrian Ilinca, UQAR; Guy Fortin, Jean Perron UQAC; Marcelo Reggio – École Polytechnique

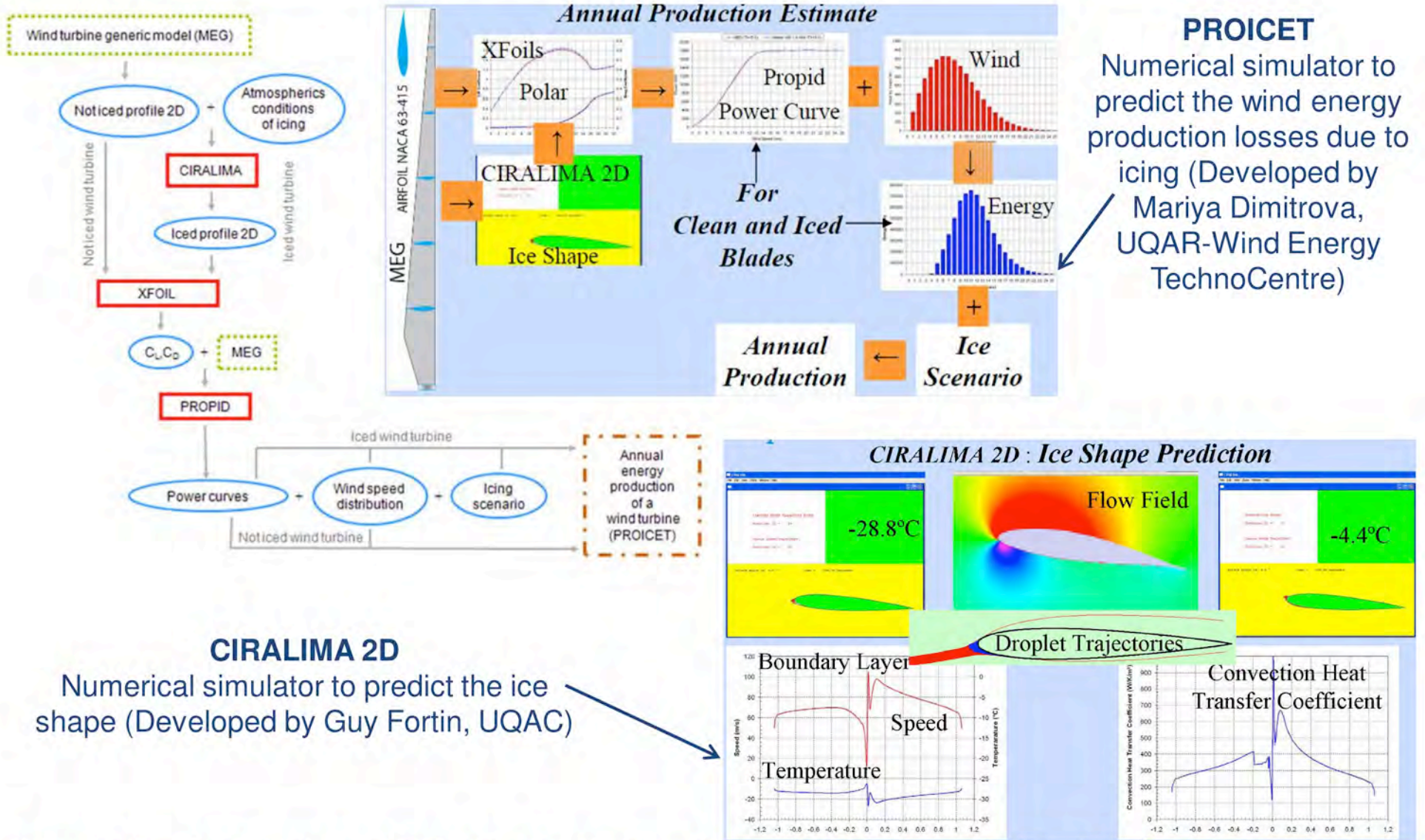
ICE ACCRETION MODELLING : RESULTS



3D results – Aerodynamics
- NREL case



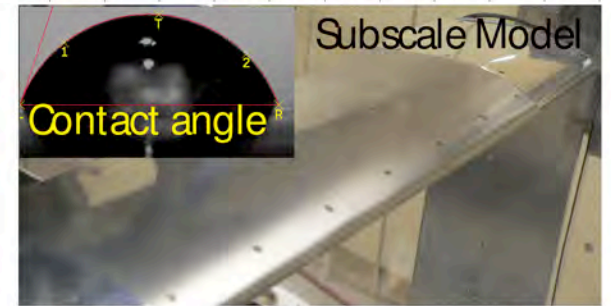
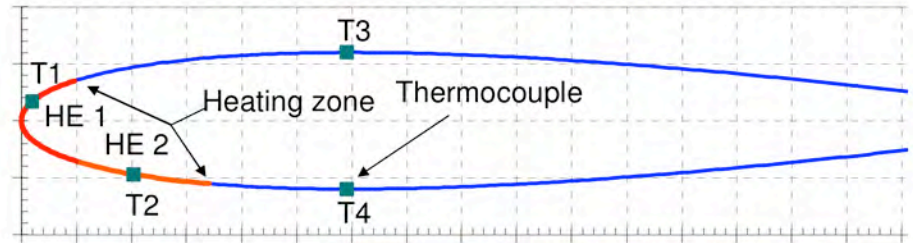
ICE ACCRETION MODELLING : RESULTS



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WIND TUNNEL INVESTIGATIONS OF ICING IMPACT ON WIND TURBINE BLADE PROFILES

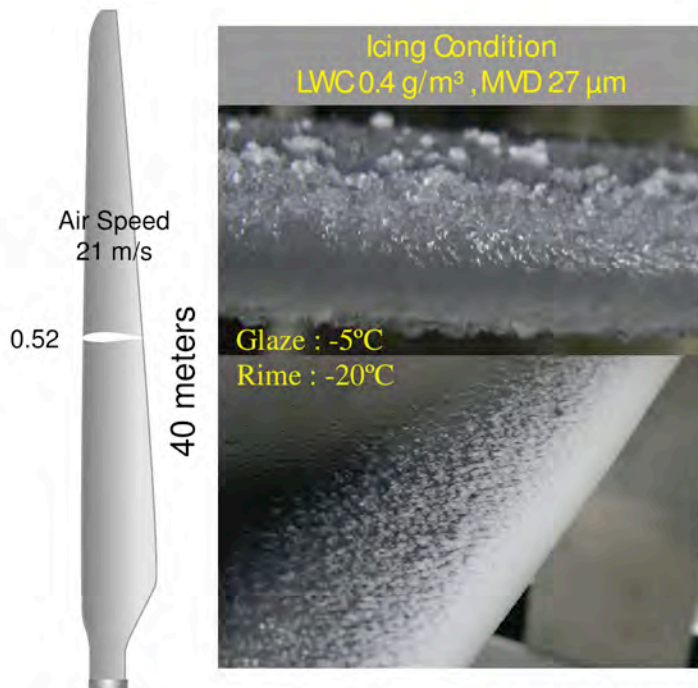
Experimental Study of Hybrid Anti-icing Systems combining Thermoelectric and Hydrophobic Coatings.



Aluminium sheet covered by 3M™ High Performance Protective Film

EXPERIMENTS

Hydrophobic and Superhydrophobic Coatings Tested under Icing Condition

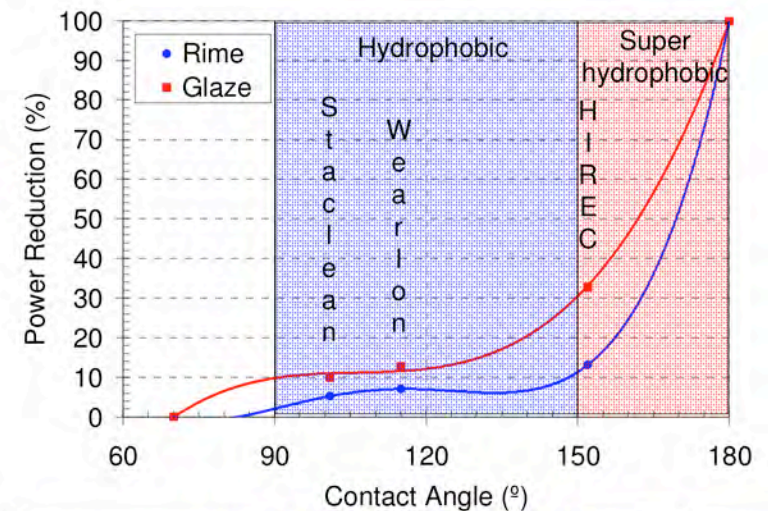
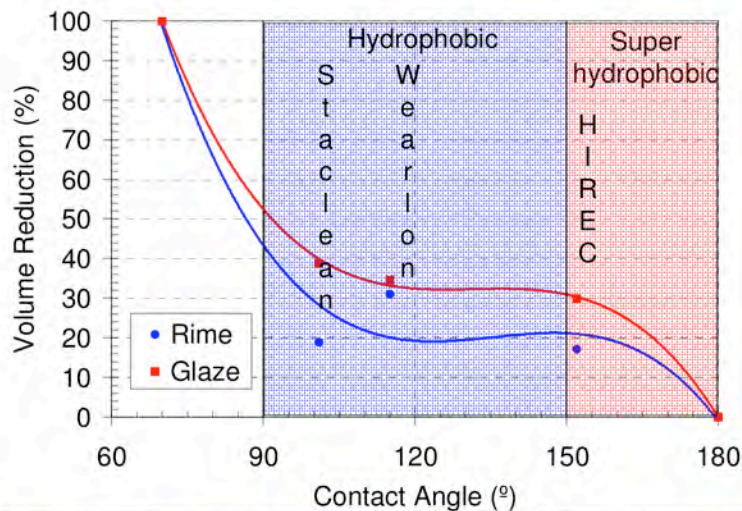


Researchers: Jean Perron & Guy Fortin, AMIL at UQAC

WIND TUNNEL INVESTIGATIONS OF ICING IMPACT ON WIND TURBINE BLADE PROFILES

Experimental Study of Hybrid Anti-icing Systems combining Thermoelectric and Hydrophobic Coatings.

RESULTS



Researchers: Jean Perron & Guy Fortin , AMIL at UQAC



MONITORING ICING EVENTS

Objectives:

- Study the capabilities of icing detectors
- Investigate behaviour of wind measurement instruments in icing conditions
- Construct a database of icing events

Instrumentations:

- Camera
- Goodrich ice detector (0872E3)
- Thies Ultrasonic anemometer
- NRG cup anemometers (#40C & Icefree3)



Researcher: Christian Masson, ETS

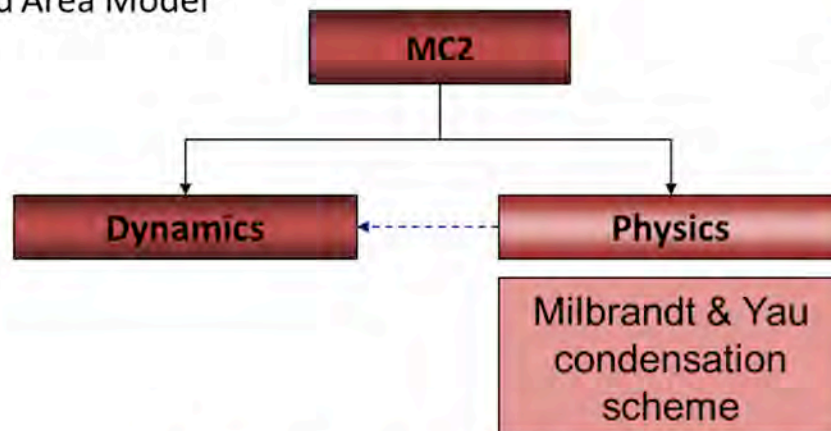
FORECASTING ICING EVENTS

Objectives:

- Managing energy production (fluctuations for network connection)
- Planning turbines shutdown for maintenance operations

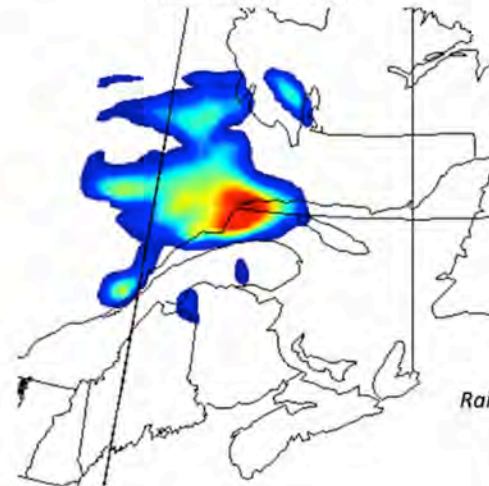
MC2 and M&Y microphysical scheme

- Compressible Community Model (Environment Canada):
 - Mesoscale
 - Semi-implicit, semi-lagrangian
 - Limited Area Model



Researcher: Robert Benoit, ETS

Different hydrometeor categories
Snow at 17h00 GMT



Rain at 03h00 GMT



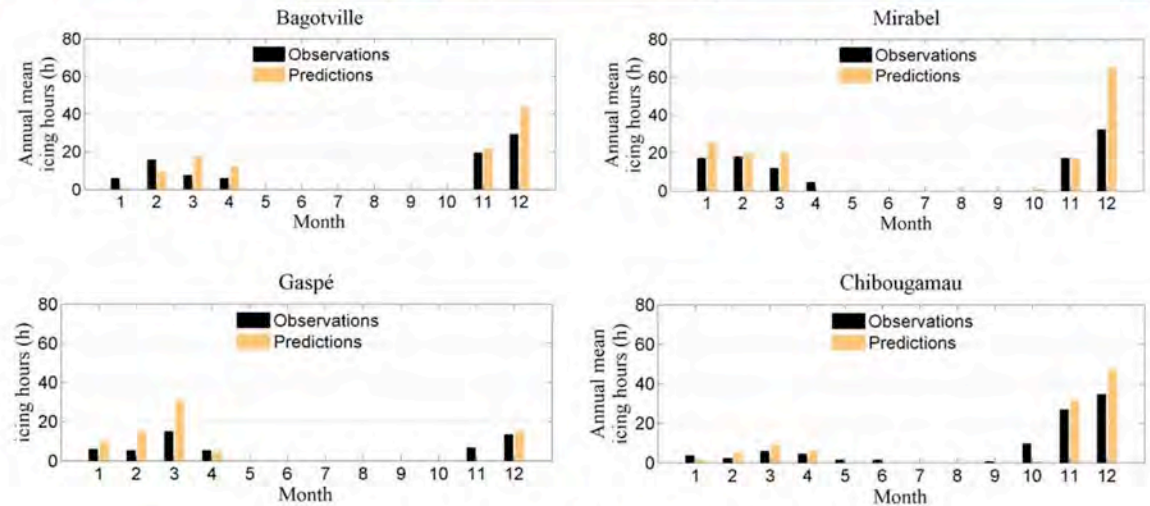
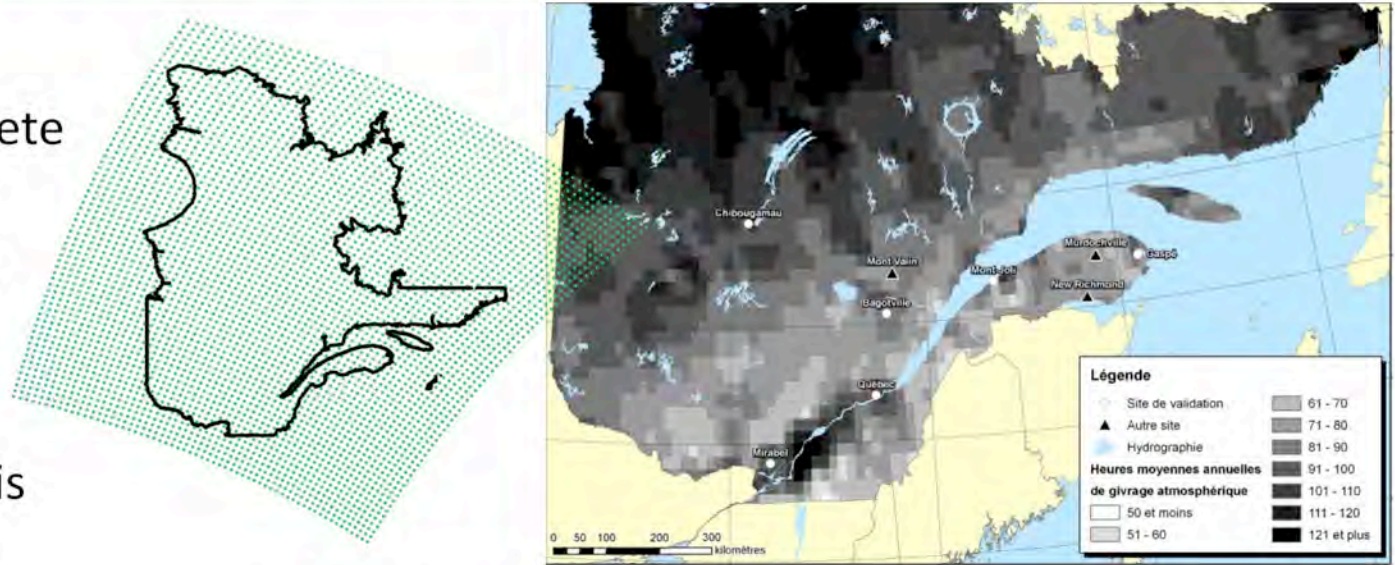
ATLAS OF ATMOSPHERIC ICING EVENTS AT HIGH RESOLUTION

Objective:

- Construct a complete Canadian atlas of atmospheric icing events

Methodology:

- Based on reanalysis data at 32 km resolution (NARR)
- Validated with Airport data



Annual mean icing hours over the four year period

Data :

Temperature
Relative humidity
Liquid water content
Cloud base height
Visibility
Freezing rain forecast

Resolution :

32 km grid
Data every 3 h

Time period :

28 years of data
available

Researchers: Christian Masson & Robert Benoit, ETS; Jean Perron, UQAC

CONCLUSION

- Wind energy development in many countries is faced with cold climate conditions that require adapted technologies and techniques.
- Canada is a prime example for this kind of weather and many research activities focus on the specificities of wind energy in cold climates.
- The most important research initiative regarding the wind energy sector in the country is the Canadian Wind Energy Strategic Network (WESNet), a NSERC funded Strategic Research Network. It regroups highly productive researchers across Canada and is supported by the government, the industry, associations and institutions.
- The projects, financed by WESNet, are carried out by prominent researchers from many universities and involve three major groups (the Canadian research chair on the Nordic Environment Aerodynamics of Wind Turbines (NEAT) at École de Technologie Supérieure (ÉTS), the Anti-icing Materials International Laboratory (AMIL) at Université du Québec à Chicoutimi, and the TechnoCentre éolien, a full-size installation in a Nordic region.
- The research team can find its work on essential resources such as wind turbines farms, meteorological towers, icing monitoring towers, refrigerated wind tunnels, simulation software, super-computers, and excellent laboratories.

Merci!

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