IMPROVING A PROBABILISTIC ICING RISK FORECAST SYSTEM FOR WIND FARM OPERATION

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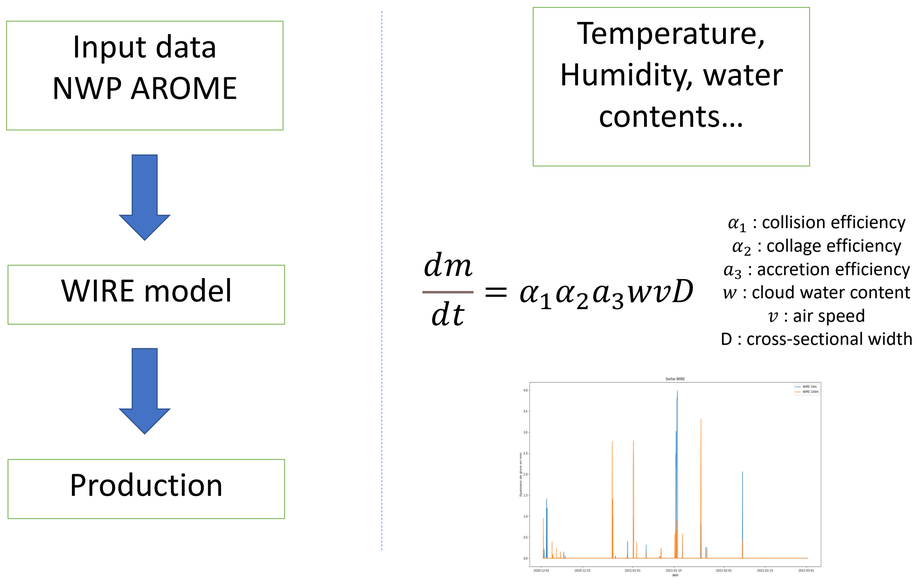
Introduction

Icing problematic is impacting wind farm operators for maintenance activities and for the electricity production valorisation. Production losses due to icing can rise to several thousand MWh per year. Moreover, there are safety issues because if a wind turbine is in operation with ice on blades, some pieces can be ejected and fall hundreds of meters around the machine.
The objective of this thesis is to improve the entire icing risk forecast chain for wind farm operation, by improving:

- The representation of supercooled liquid water in the NWP (Numerical Weather Prediction) model AROME
- The performance of the icing forecast model WIRE (Winter Risks for Energy)
- The uncertainties representation in the icing model via probabilistic forecast

Ejected ice from a wind turbine

WIRE : how does it works ?

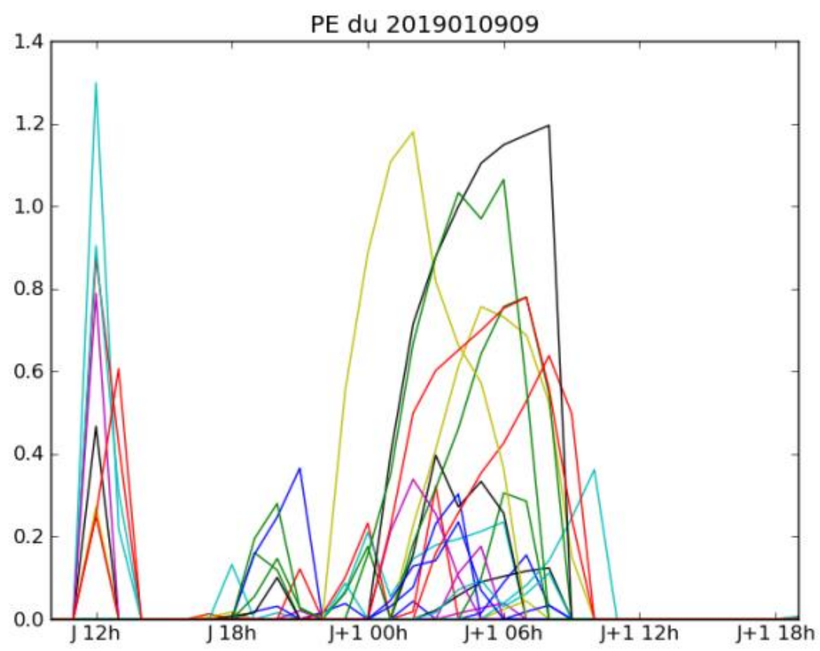


Simplified scheme of the icing forecast system

The icing forecast system WIRE has been developed by Meteo France in 2015.
Firstly, the system goal was to predict ice and snow accretion on power lines (Bouilloud L., 2017). Then, it has been transposed to icing forecast on wind turbine blades (Dupont R., 2020).
The NWP AROME microphysical fields, like the cloud water and graupel contents and some more basic fields such as temperature, wind, pression…, are used as input parameters in WIRE. The icing model is based on the state of the art with regards to the ice accretion modeling, especially on previous work realized in Finland (Makkonen, Modeling of Ice Accretion on Wires, 1984) ; (Makkonen, Models for the growth of rime, glaze, icicles and wet snow on structures, 2020).
Finally, customers get maps and charts where they can visualize the expected accreted ice thickness and mass.

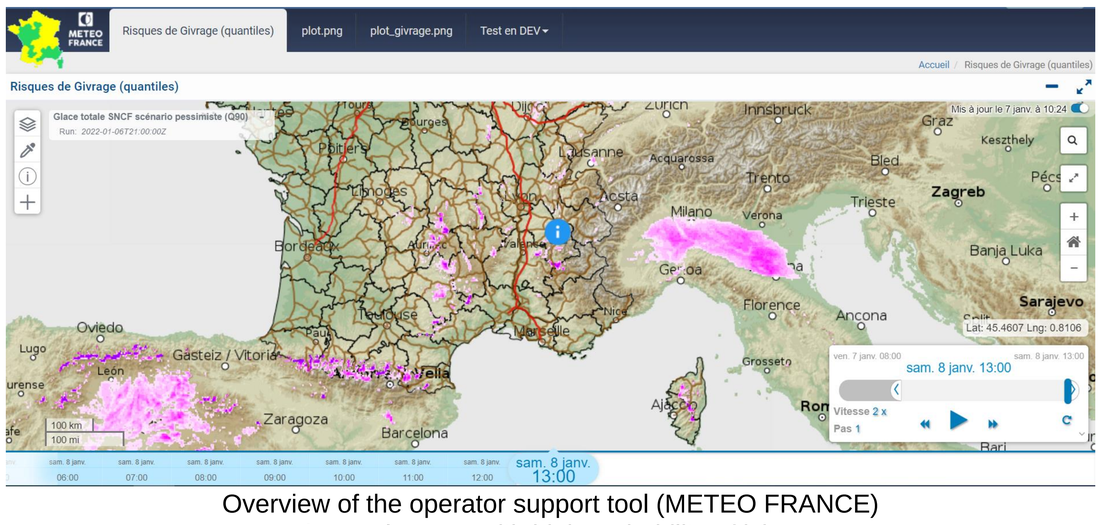
Improve the representation of uncertainties

Currently, WIRE is coupled to the PEAROME model to take into account uncertainties. In PEAROME, model errors are represented by a stochastic method (Boutier F., 2012) which applies perturbations to global trends of different variables. The perturbations are supplied by the Stochastically Perturbed Parametrisation Tendencies scheme (SPPT).
For icing, it could be more interesting to introduce perturbations into the representation of microphysical processes (ice crystals formation, aerosol contents…). Perturbations of some microphysical processes, identified by preliminary study on supercooled liquid water forecast, will be proposed. The PEAROME utilisation will be evaluated for wind farm operations.
Afterward, the possibilities of taking into account model errors into WIRE will be studied with Stochastically Perturbed Parametrisation scheme (SPP) method.



Probabilistic forecast example of ice thickness in mm

Outlook & Applications



Overview of the operator support tool (METEO FRANCE)
In purple, area with high probability of icing

These works will enable VALEMO to:

- Set up a wind farm operation strategy during icing events
- Restart as soon as possible and safely wind turbines to optimize production losses

With this new decision support tool, it would allow to limit icing mechanical loads on wind turbine blades, and, potentially, limit ice accretion on blades. It could be helpful for operators who have to take stop/restart decisions and reduce the associated risks.

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