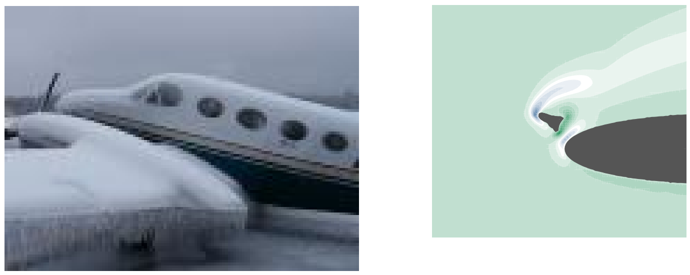
MC2 postdoctoral position - ANR CARPEiNTER

Modeling icing using cartesian grids, penalisation and level sets



(a) Iced aircraft (b) Ice shedding from an airfoil

Ice accretion on aerodynamic bodies is a serious and not yet totally mastered meteorological hazard due to supercooled water droplets (liquid water droplets at a temperature below the dew point) that impact on surfaces. Ice accretions have several negative effects, especially performance degradations. We intend to study icing effects on wind turbines (industrial partnership with Valeol) and aircraft wing sections (industrial partnership with Airbus). For aircraft, sudden performance degradations due to ice accretion cause several incidents and accidents each year. Performance degradations include substantial reduction of engine performance and stability, reduction in aircraft maximum lift and stall angle, and increase of drag. For wind turbine, ice accretion on blades is a major concern in northern climate. When adverse meteorological conditions occur, ice accretes at the outer part of the blade with an approximately linear increase with time. With growing ice accretion, the blade drag increases, diminishing the power output of the turbine and eventually causing a complete loss of production. Other negative consequences include overloading due to delayed stall, increasing fatigue of components due to imbalance in the ice load, and damaging or harm caused by uncontrolled shedding of large ice chunks. A realistic ice accretion simulation is achieved if the three contributing factors: the flow field, the water droplet trajectories, and the thermodynamic ice accretion process, are accurately modeled.

In this postdoctoral position we propose to model icing on moving geometries by an innovative paradigm that is based on cartesian grids, penalization and level sets. The use of cartesian grids bypass the meshing issue in complex geometries and moreover allows extensions to higher order accuracy in

a natural and simple way. Penalization is an efficient alternative to explicitly impose boundary conditions so that the body fitted meshes can be avoided, making multi fluid/multi physics flows easy to set up and simulate. Level sets describe the geometry in a non-parametric way so that geometrical and topological changes due to physics and in particular icing are straight forward to follow. The candidate will start to conceive an accurate approximation of the Spalart-Allmaras turbulence model on cartesian grids. The development will be done in our platform using penalization techniques. To overcome limitations coming from the use of cartesian grids along with high Reynolds number turbulent flows wall law will be studied (1,2).
This work will be done in collaboration with ETS (Ecole de Technologie Supérieure - Université du Québec) from Montreal Canada (3). This university has strong partnership with aeronautic and wind turbine industries. Also, as a CLUMEQ member, ETS will house a tightly coupled cluster of approximate 20,000 processing elements with large storage capabilities.

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Required Knowledge and background:
Scientific computing, Turbulence modelling or Multi-physics modelling.

Keywords : turbulence modelling, wall law for high Reynolds turbulent flows, icing modelling, cartesian grids, penalization, level set.

[1] Georgi Kalitzin and Gianluca Iaccarino, *Turbulence modeling in an immersed-boundary RANS method*, Center for Turbulence Research, 415 Annual Research Briefs 2002.
[2] Rajat Mittal and Gianluca Iaccarino, *Immersed Boundary Methods*, Annu. Rev. Fluid. Mech. 2005 1.
[3] H. Beaugendre, F. Morency, F. Gallizio and S. Laurens, *Computation of ice shedding trajectories using cartesian grids, penalization and level sets*, to appear in MSE Journal.