Titre : Numerical investigation of the melting and growth of an ice sphere in different flow conditions

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Résumé :

We are addressing here the melting or growth of ice objects subjected to different flow conditions, focusing on the coupling between hydrodynamics and shape modification.
The motion of objects made out or covered by ice is of relevance for many environmental and industrial applications. Depending on the flow conditions the contour of the ice interface can evolve under the influence of phase change leading to a modification of the shape of the ice. In the aeronautical or wind energy industry icing can have a significant impact as it can alter the performance of the aircraft or wind turbines. In the meteorological context the growth of ice can have a strong influence on rain formation processes or cloud coverage.
The approach is mainly numerical and relies on the direct numerical simulation of the Navier-Stokes equations coupled to the Level-Set method for the simulation of the ice-fluid interface. The study will be separated in different parts referring to different flow configurations. For each configuration the ice object will be assumed to be initially spherical and the goal of the study will be to characterize the time evolution of the shape of the ice, the evolution of the forces and transfer coefficients as well as the flow structure.
Part of the project will also be dedicated to the numerical implementation of interaction mechanisms as well as the improvement of solver efficiency.

References :

Al-Kebsi, A. (2020), "Multi-step icing modelling in the NSMB solver", PhD Thesis, *University of Strasbourg*

Chouippe A., Krayer M., Uhlmann M., Dušek J., Kiselev A. and Leisner T. (2019) "Heat and water vapor transfer in the wake of a falling ice sphere and its implication for secondary ice formation in clouds". *New J. Phys.*, Vol.21.

Durrenberger D. (2016), "NSIBM: un solveur parallèle de Navier-Stokes avec raffinement automatisé basé sur la méthode des frontières immergées", PhD Thesis, *University of Strasbourg*.

Guo W., Zhan Y., Zhaonan M., Zhan P. and Poncet S. (2020), "Non-uniform melting of a spherical ice particle in free ascending", *Int. J. Heat Mass Transf*. 148:119097.

Hao , Y. L., and Tao, Y. (2002). "Heat Transfer Characteristics of Melting Ice Spheres Under Forced and Mixed Convection ." *ASME. J. Heat Transfer,* 124(5): 891–903.

Kotouč M., Bouchet G., & Dušek J. (2009), "Transition to turbulence in the wake of a fixed sphere in mixed convection", *J. Fluid Mech*., 625, 205-248.

Zhou W. and Dušek J. (2015), "Chaotic states and order in the chaos of the paths of freely falling and ascending spheres", Int. J. Multiphase Flow, 75:205-223.