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Multi-Layer Stochastic Ice Accretion Modelling with Continuous Geometry Representation

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The state-of-the-art in aero-icing simulation has seen great improvement in the last decades with the introduction of partial differential equation (PDE) methods. However, the technology for modelling the ice accretion itself is still limited to algebraic methods applied on a surface mesh. Previously, Pena et al. [1] presented a level-set approach to model the ice accretion, which allowed to handle topological changes in the ice geometry. This method was modified to improve mass conservation and combined with a B-splines geometry representation to handle multi-layer simulations [2]. However, ice accretion is stochastic by nature, as shown by the many ice accretion experiments, and standard computational approaches do not allow stochastic modelling. To overcome this, Szilder and Lozowski [3] presented in various studies the developments of an approach to model ice accretion with a stochastic algorithm. We propose to adapt the stochastic approach [4] by coupling it with the level-set geometry evolution solver [2]. The stochastic accretion is done on a cartesian advancing front grid and the level-set solver is used to detect the contour of the new ice shape on a curvilinear grid. The link between these two grids is done with interpolation algorithms from an overset grids preprocessor already available. The level-set solution is then fitted as a B-spline and a new layer of ice can be computed on this geometry. This combination allows to obtain a stochastic accretion with a continuous geometry representation in a multi-layer process. The results show the capture of complex ice morphologies, such as rime feathers which depends highly on stochastic modelling and local surface curvature. In particular, the results are compared to experimental iced swept wing data and the computational cost of the approach is assessed.

References

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