Ice accretion modelling due to freezing rain using Smoothed Particle Hydrodynamics

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ABSTRACT

Freezing rain consists of raindrops that become supercooled while passing through a sub-freezing layer of air. When these drops impact a surface at a sub-zero temperature, they partially freeze. The resulting ice can accumulate to a thickness of many centimetres during severe freezing rain events called ice storms. Although ice storms are not violent, they often cause power outages and tree damage because of the weight of the ice accretions and wind-on-ice loads. In addition, the shape of ice accretions may alter the aerodynamics of transmission lines and bridge cables, causing large amplitude vibrations called galloping. Finally, pieces of ice falling from structures such as overhead transmission lines, wind turbines and telecommunication masts can cause serious injuries and property damage. Ice accretion is a complex phenomenon involving 3D multi-phase flow, heat transfer, and gravitational, viscous and shear forces. An ability to predict how ice accretes on engineering structures is essential to the prediction and mitigation of its associated aerodynamic penalties.

Over the years a number of numerical models of varying complexity have have developed to simulate ice accretions on surfaces exposed to freezing rain precipitation, Szilder [1] for example. In the present work, the authors have extended the Smoothed Particle Hydrodynamics (SPH) method to simulate water drop freezing as well as the ice accretion process. A weakly compressible SPH is addopted based on Fraser *et al.[2-4]*. Surface tension has been added to the code according to Akinci *et al.* [5]. An advanced particle shifting algorithm and smoothing length update is introduced that is required due to the extensive splashing and subsequent fluid dilatation associated with rain drop impact. The SPH code is developed using CUDA Fortran [6] and allows large numbers of rain drops to be simulated in under 15 minutes of calculation time. Drop freezing is included by considering heat transfer in the liquid coupled with a simple water frezing algorithm. The authors start by validating the code for single rain drop impacts on a dry surface, verify the drop heat transfer, and then carry out multi-drop freeezing rain simulations.

REFERENCES

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