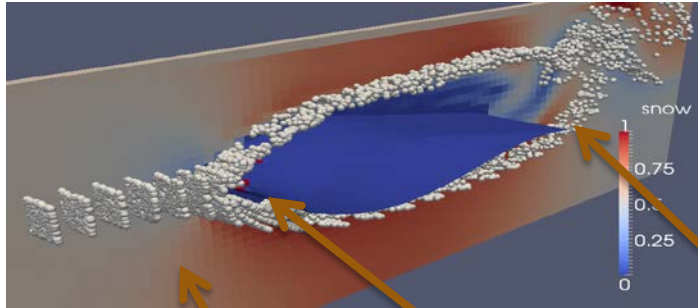


Numerical prediction of ice accretion based on LES and LPT

R. SZASZ, L. FUCHS, LUND UNIVERSITY, SWEDEN

WINTERWIND2013, ÖSTERSUND, 2013.02.12-13



Flow: LES + Im.Bound.

Accretion: Impacting droplets freeze instantaneously

Droplets: LPT

Goals

- Develop tool to model simultaneously flow and ice accretion
 - Efficient
 - Flexible
- Validate
- Check sensitivity

Strategies

Ice shape → Flow

Flow → Ice shape

Flow & Ice shape



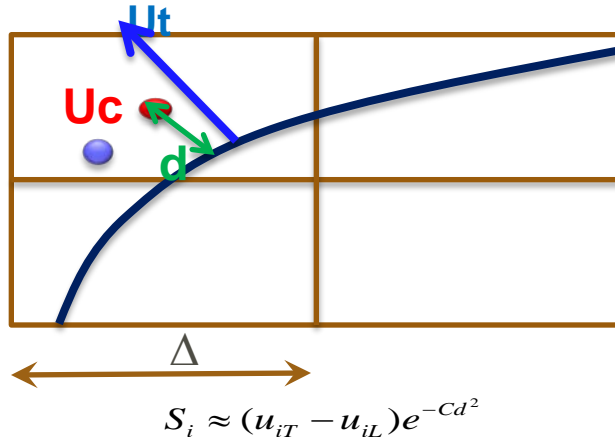
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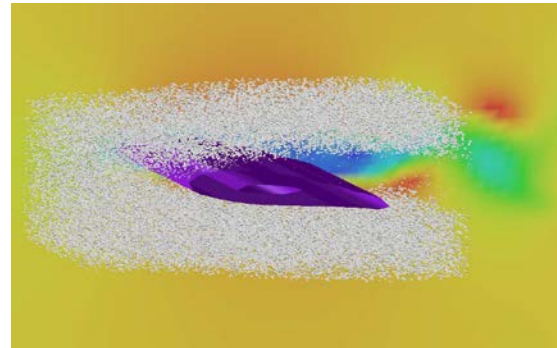
Flow

- Incompressible Navier Stokes
- Finite Differences (3rd, 4th)
- 3D, time resolved
 - LES (implicit)
- Efficient solver
 - Equidistant Cartesian grid
- Complex geometries
 - Immersed Boundary



Droplet transport

- Lagrangian Particle Tracking
- Typically low LWC
- Only drag force
- No collision
- No break-up
- Release: rectangular area, random distribution
- Removal: accretion or max streamwise position
- Impact parameters logged



Ice accretion

- All droplets impacting on the surface freeze instantaneously
 - Rime-ice conditions
 - For other conditions heat transfer must be included
- Distance from distance function used for IBM
 - Efficient but slightly lower accuracy
- Critical distance
 - $d_{cr} = f\Delta$

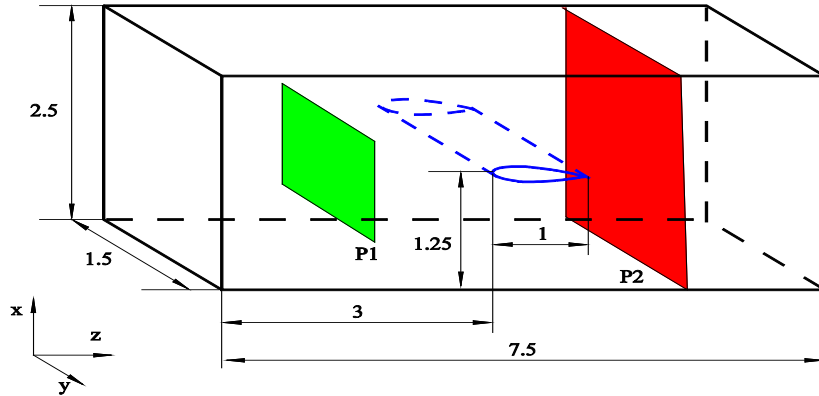


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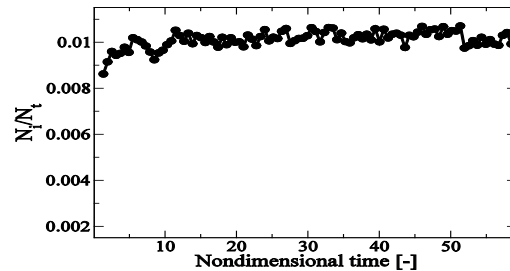
Problem set-up



- 'In-fog icing event 2' [Hochart2008]

Parameter	Value
Profile	NACA 63415
Angle of attack	3°
LWC	0.37g/m ³
MVD	27.6 μm
Vrel	18.7 m/s
Re	2.49e5
Time	10.6 min
Mass of accreted ice	24±1.75 g

Case	f	Δ
B	1.0	7.81e-3
G1	1.0	1.25e-2
G2	1.0	2.08e-2
F1	0.75	7.81e-3
F2	0.50	7.81e-3



- Nondimensional
 - Chord length 0.2 m
- Slightly smaller domain
 - 1.5x2.5 vs 2.5x3.0
- Shorter time
- Extrapolated in time and space
- Top-hat velocity profile
- Uniform droplet diameter
- At least 20+10 TU



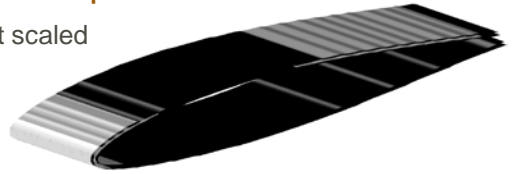
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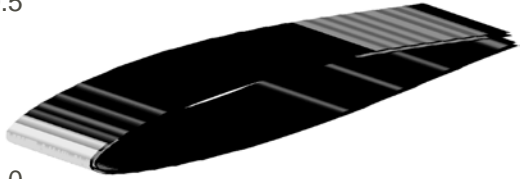
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Sample results

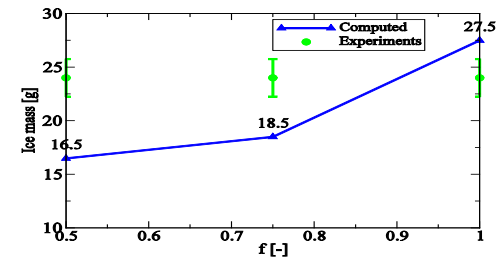
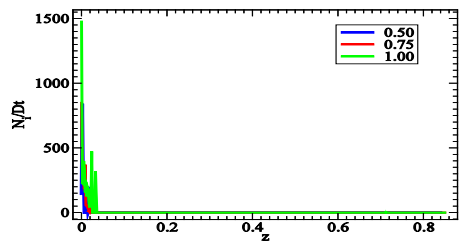
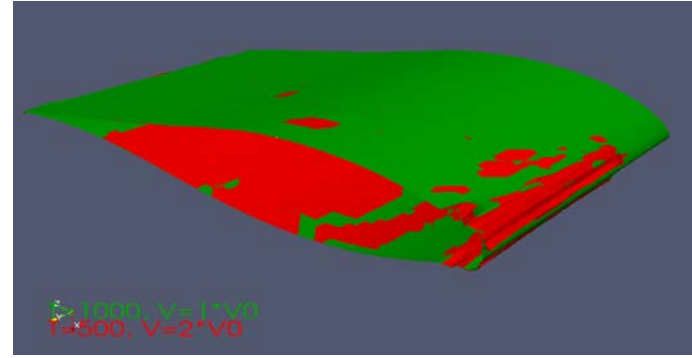
Not scaled



f=0.5



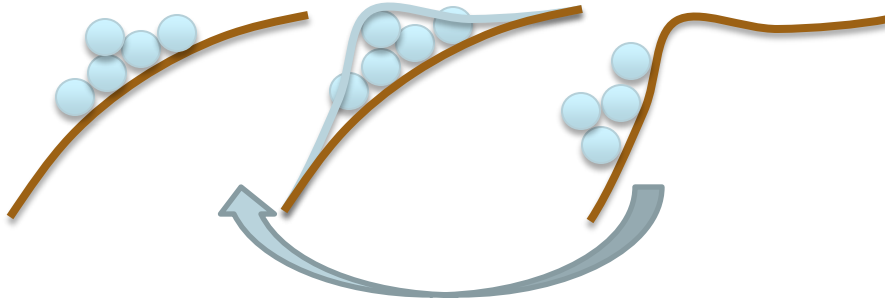
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Numerical prediction of ice accretion based on LES and LPT

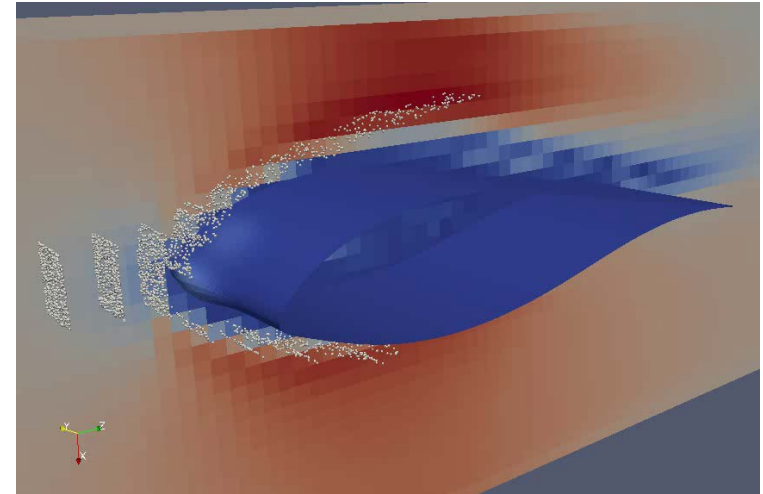
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Future work

- Other icing regimes
 - Heat transfer
- Combine with other existing models
 - FSI
 - Noise



- Exaggerated testcase
 - Coarse grid
 - Huge droplets
- Goal
 - Illustrate methodology
 - Test robustness

