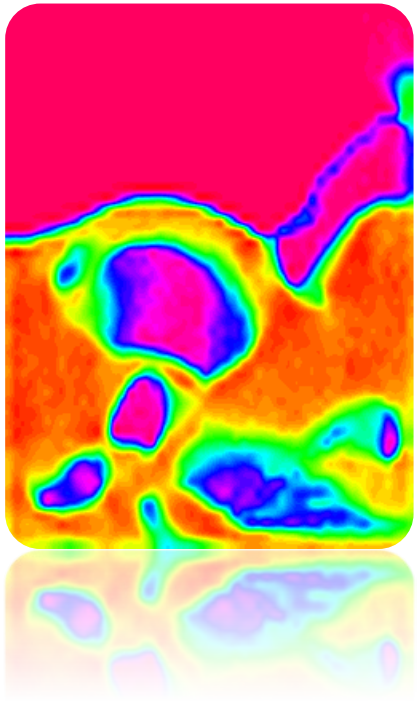
MULTIPHYSICS PERSPECTIVE OF MICROSPRAY



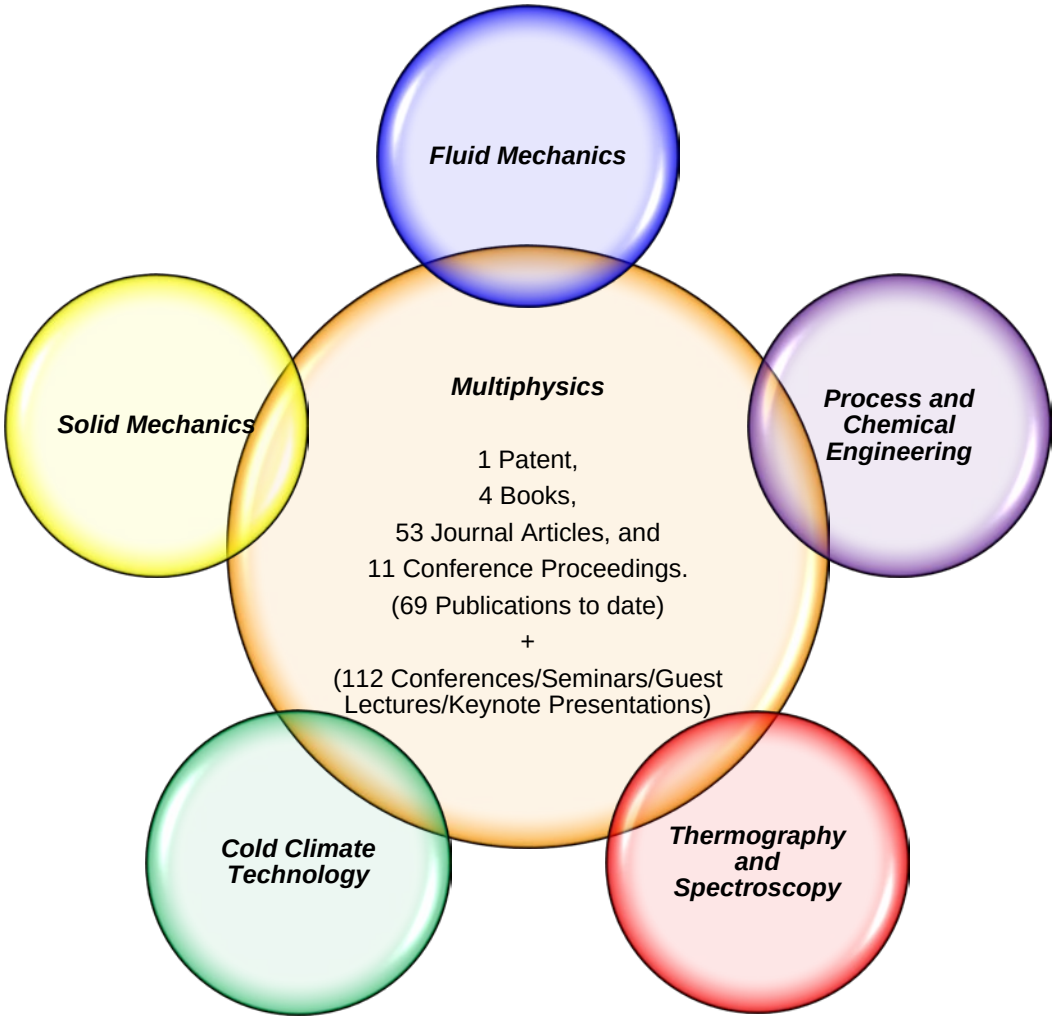
PRESENTATION OVERVIEW

- INTRODUCTION
  - Presenter's Bio
- PRESPECTIVE
  - Multiphysics
  - Words of Caution
  - Fluid-Particulate Systems
  - Stokes Number
- PROJECT EXAMPLES
  - Stokes number ≈ 1
    - Particle Spray and Deposition Model
    - Fluidized Bed
  - Stokes number << 1
    - Exhaust Emissions – Tromsø Harbour
    - Tunnel Ventilation – Lærsdaltunnelen
  - Icing/De-icing/Anti-icing/Adhesion

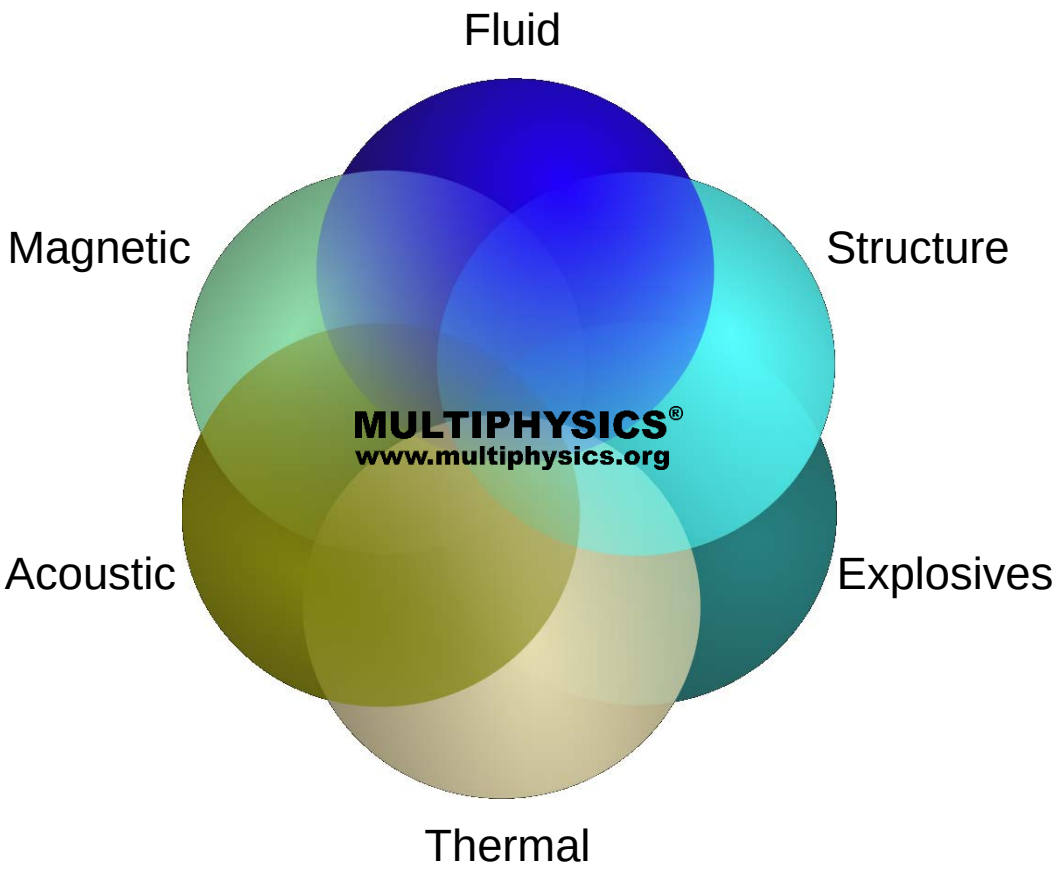
PRESENTER'S BIO

PRESENTER'S BIO

PRESENTER'S BIO



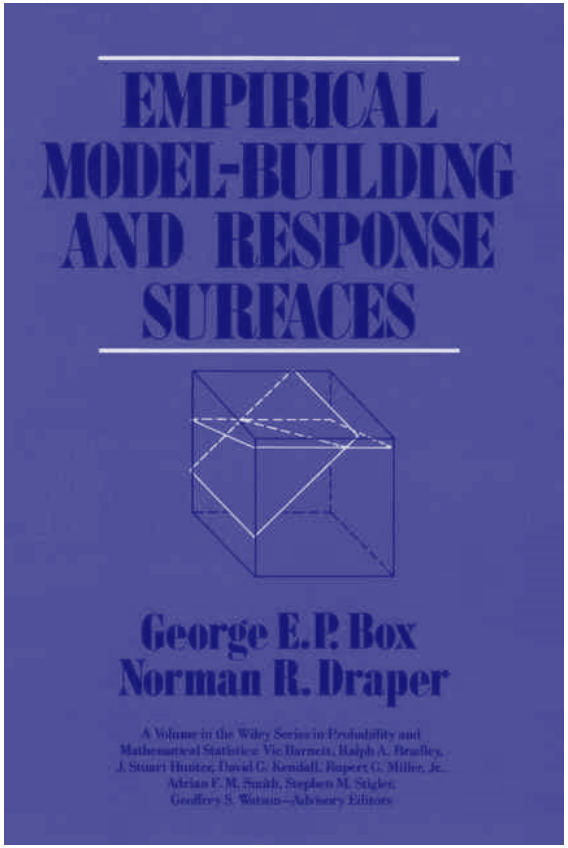
MULTIPHYSICS



WORDS OF CAUTION - MODELS (1987)

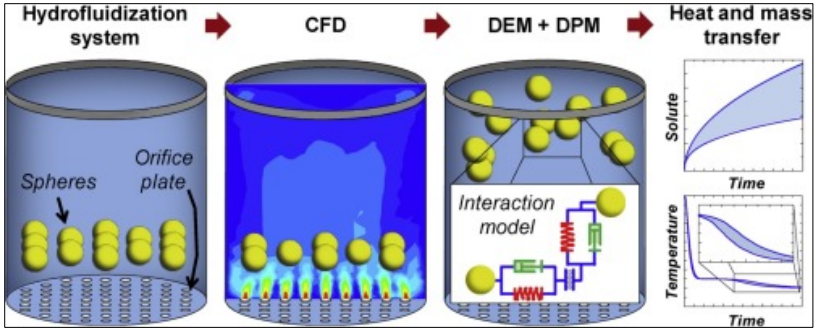
"Essentially, all models are wrong, but some are useful,"

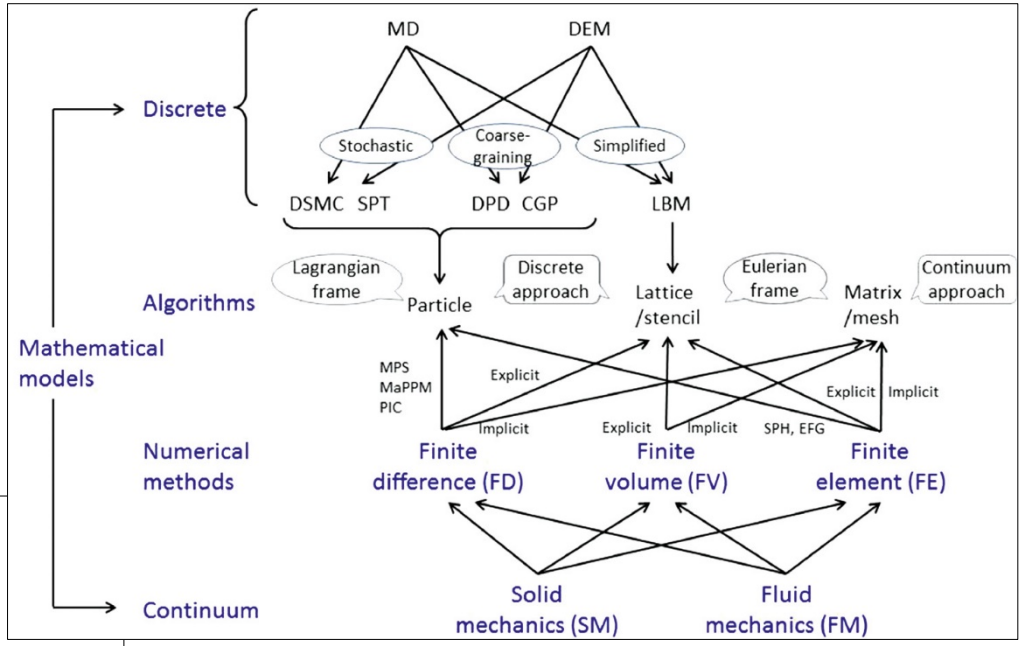
"Remember that all models are wrong; the practical question is how wrong do they have to be to not be useful."

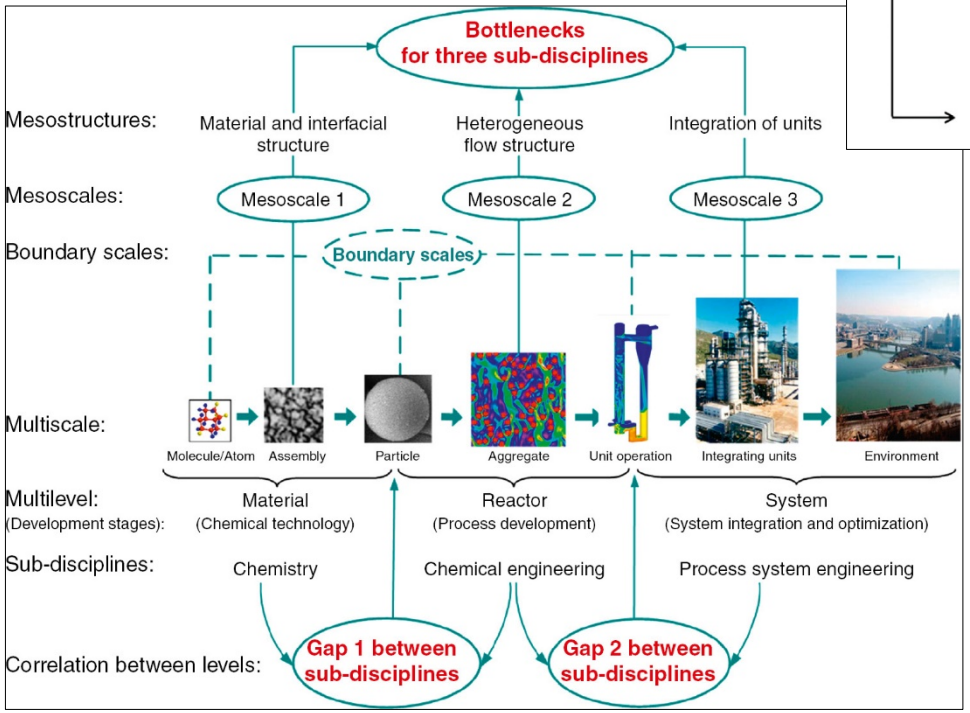


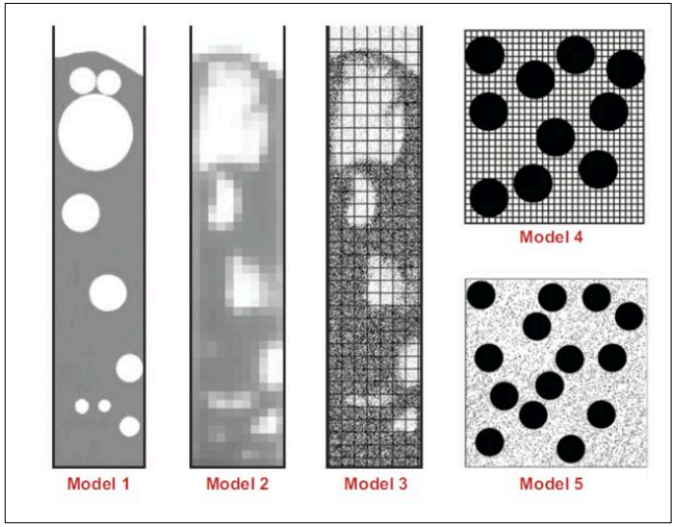
George E. P. Box
(1919 – 2013)

FLUID PARTICULATE SYSTEMS

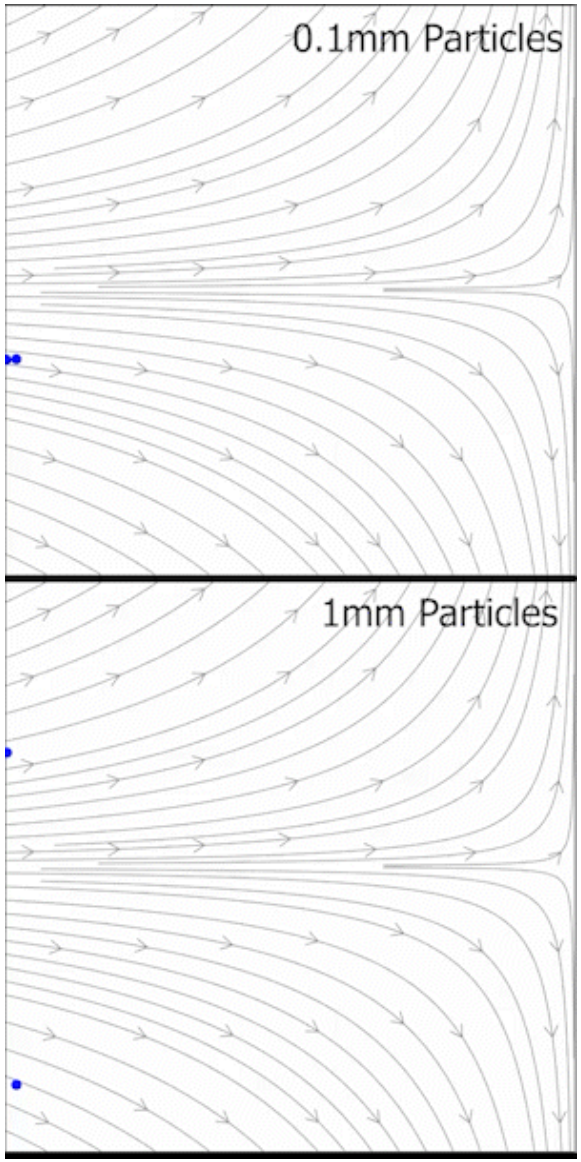








STOKES NUMBER



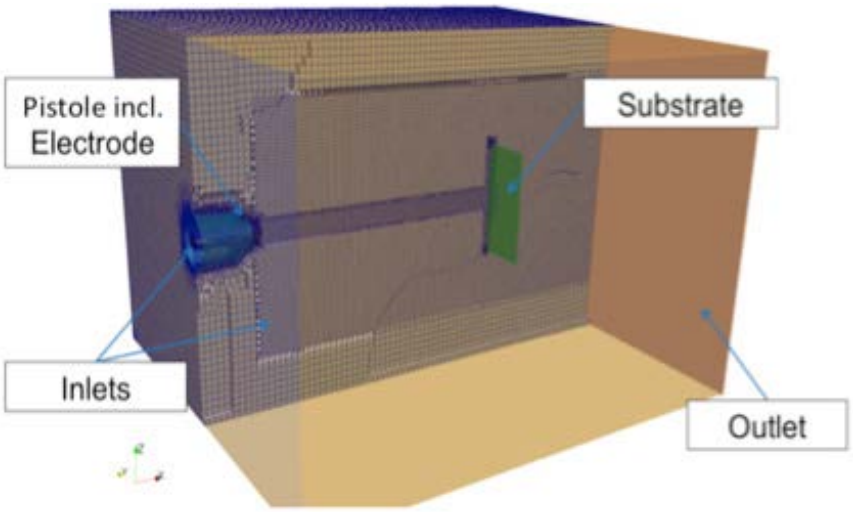
$$Stk = \frac{t_0 u_o}{l_o},\ t_0 = \frac{\rho_0 d_p^2}{18\mu_g}$$

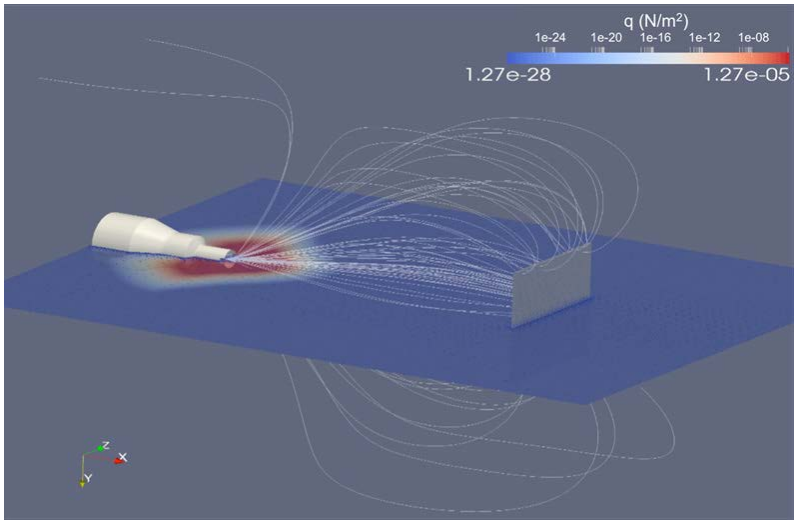
t_0 is particle relaxation time
u_0 is fluid velocity
l_0 is characteristics length
ρ_0 is fluid density
d_p is particle diameter
μ_0 is fluid dynamic viscosity

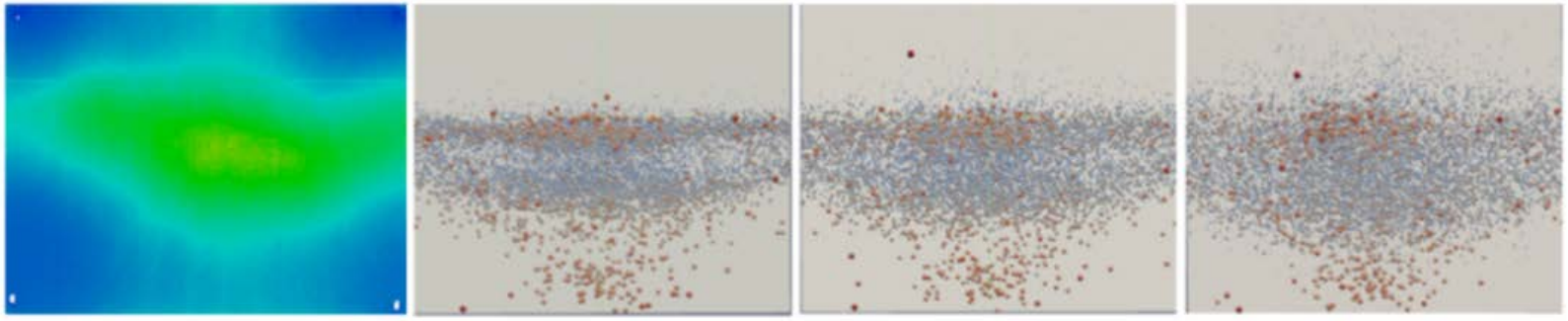
Figure (shown): Comparison between two different particles sizes for tracking accuracy for PIV. Simulated particles (blue dots) of Propyleneglycol advecting in a stagnation point flow field (gray streamlines). Note the 1 mm particles crash onto the stagnation plate whereas the 0.1 mm particles follow the streamlines.

Source: https://en.wikipedia.org/wiki/Stokes_number

PARTICLE SPRAY AND DEPOSITION MODEL

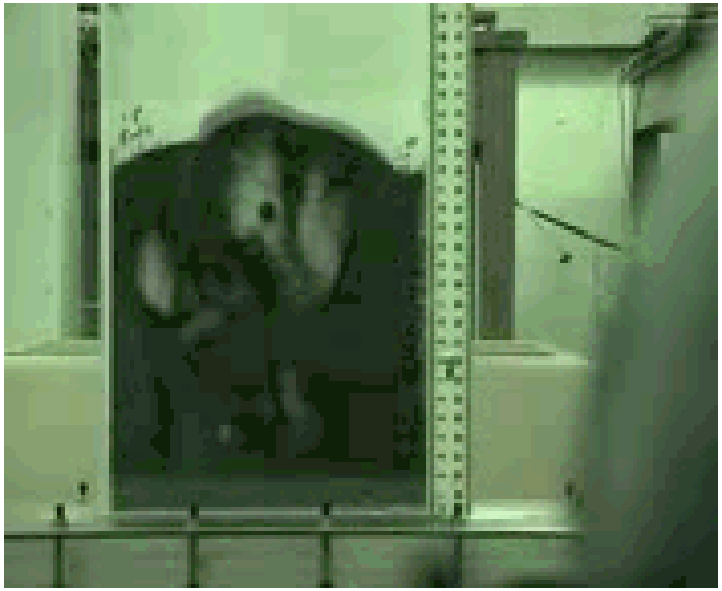


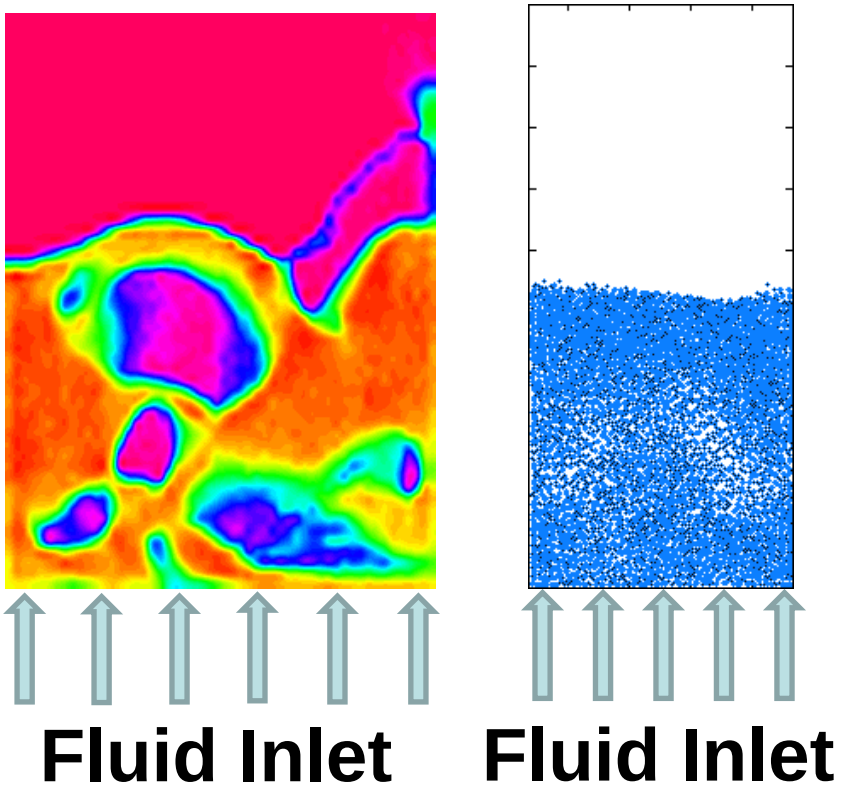




Gernot Boiger, Marlon Boldrini, Viktor Lienhard, Bercan Siyahhan, Hassan Khawaja, Mojtaba Moatamedi. Multiphysics Eulerian-Lagrangian Electrostatic Particle Spray Model for OpenFOAM® and KaleidoSim® Cloud-Platform. The International Journal of Multiphysics, 2020, 14(1): pp.1-16. http://dx.doi.org/10.21152/1750-9548.14.1.1

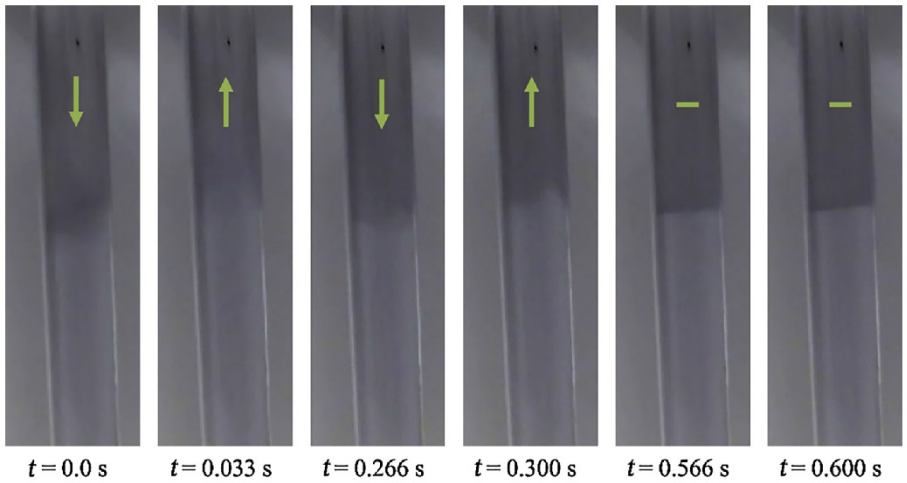
FLUIDIZED BED - BUBBLES

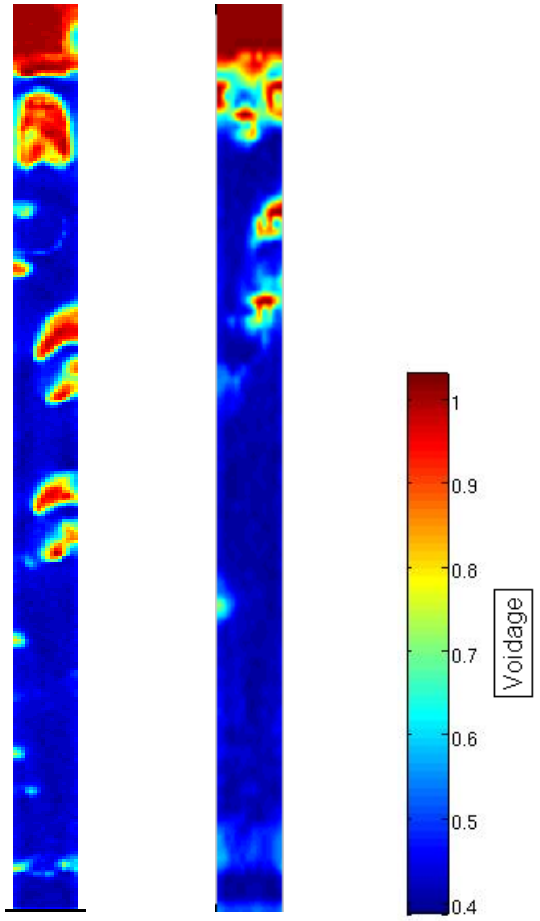




H Khawaja, M Moatamedi. Multiphysics Modelling of Fluid-Particulate Systems. Academic Press, 2020, ISBN 978-0-1281-8345-8.
https://doi.org/10.1016/C2018-0-02737-1

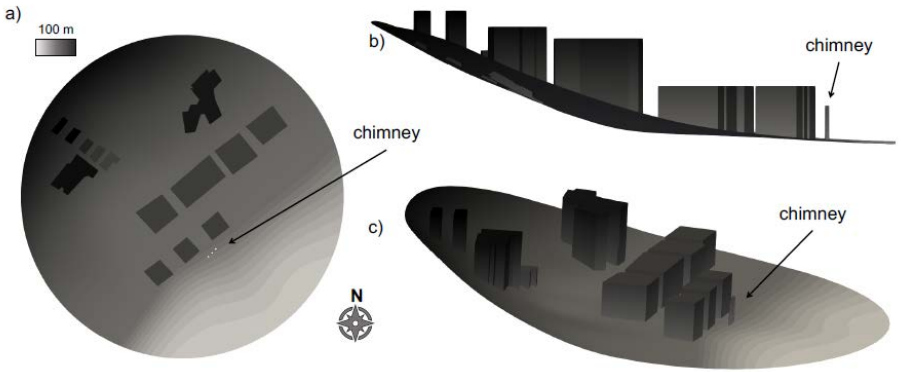
FLUIDIZED BED – SOUND WAVES

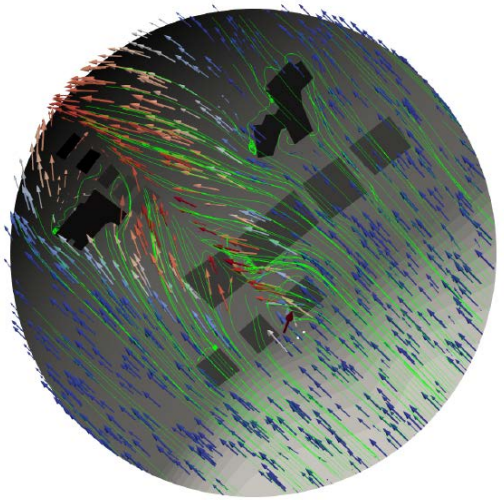


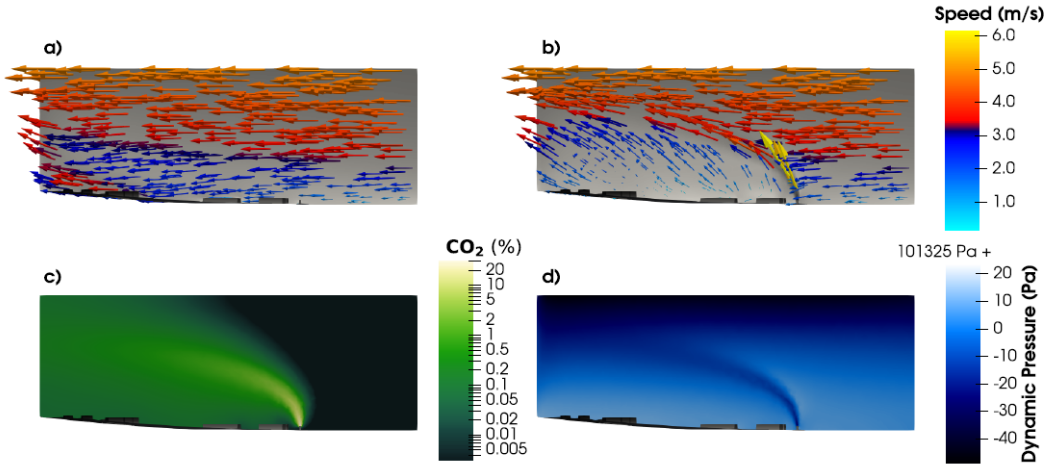


H Khawaja. Study of Sound Waves in Fluidized Bed using CFD-DEM Simulations. Particuology, 2017, 38: pp.126 - 133. https://doi.org/j.partic.2017.07.002

EXHAUST EMISSIONS – TROMSØ HARBOUR

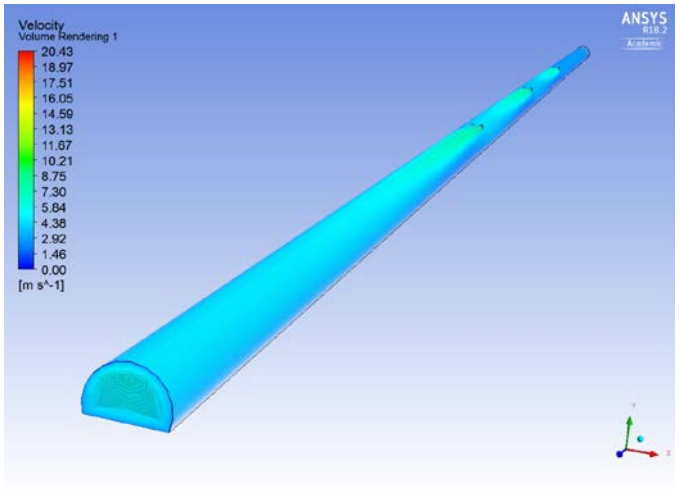


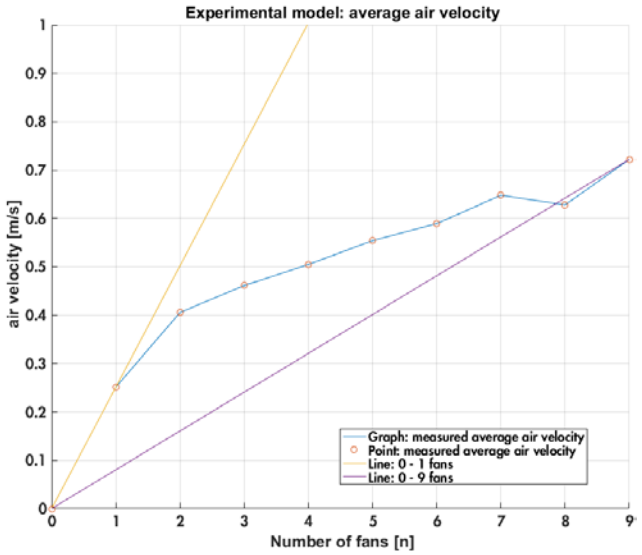


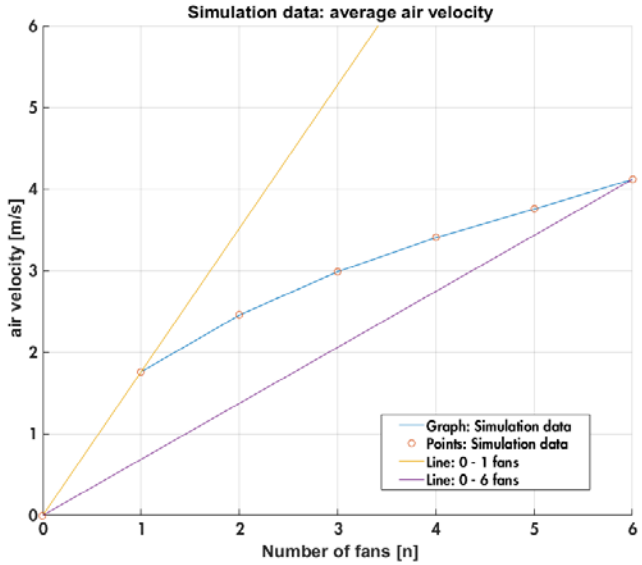


Asier Zubiga, Synne Madsen, Hassan Khawaja, Gernot Boiger. Atmospheric Contamination of Coastal Cities by the Exhaust Emissions of Docked Marine Vessels: the case of Tromsø. Environments, 2021, 8(9), 88. https://doi.org/10.3390/environments8090088

TUNNEL VENTILATION – LÆRDALSTUNNELEN

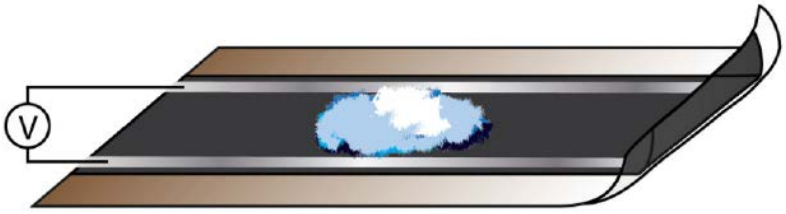


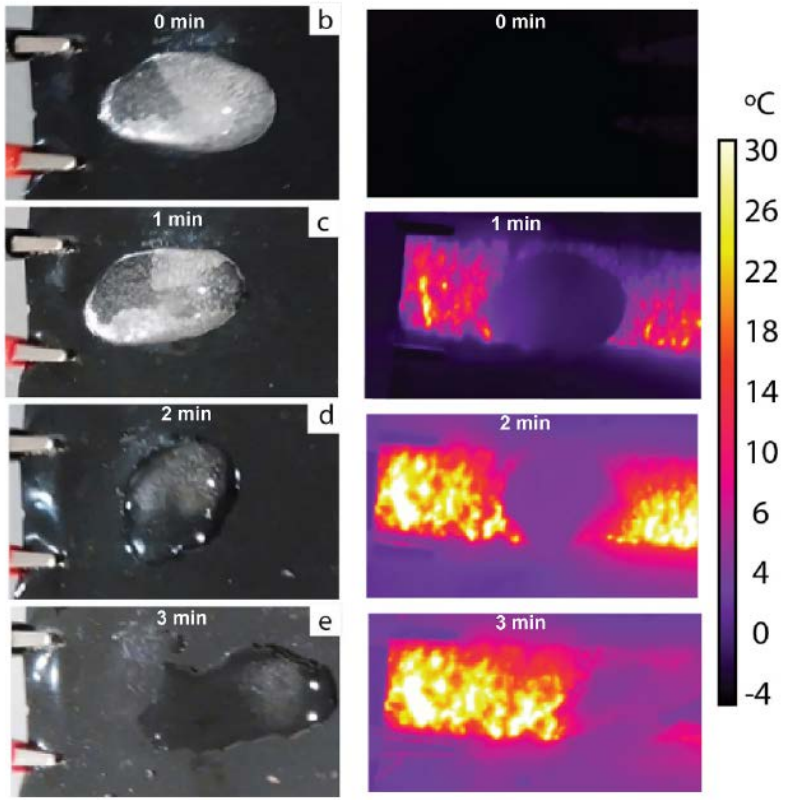




Torgeir Myrvang, Hassan Khawaja, Validation of air ventilation in tunnels, using experiments and computational fluid dynamics. The International Journal of Multiphysics, 2018, 12(3): pp. 295 - 311. http://dx.doi.org/10.21152/1750-9548.12.3.295

ICING/DE-ICING/ANTI-ICING/ADHESION





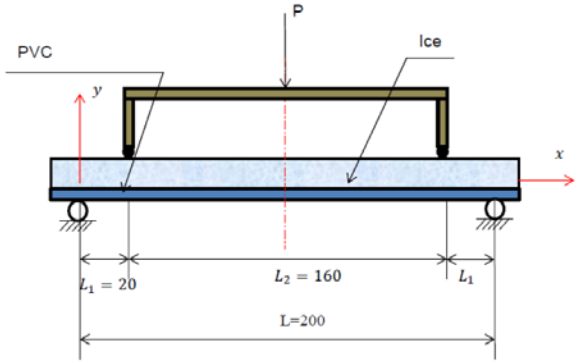


Figure 1: Four-point bending test setup of ice and PVC

Figure 2: ice on polyurethane

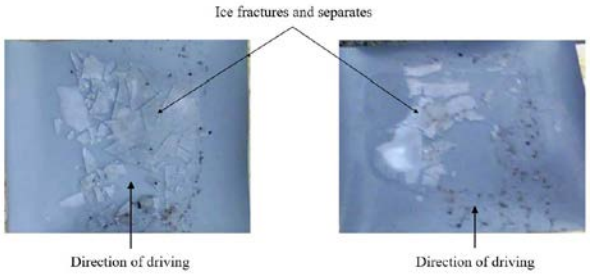


Figure 8: Results from driving. The ice that formed on these surfaces has fractured and separated from the surface, due to the added load from car tyres.

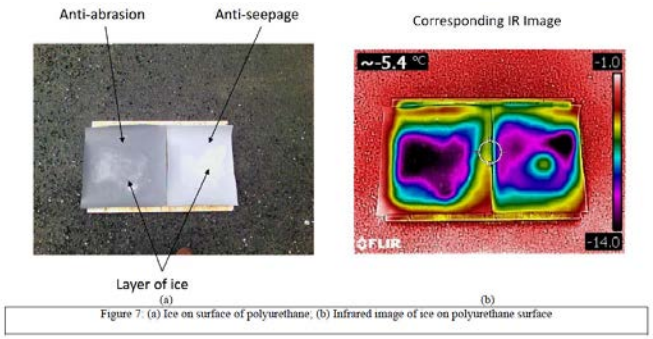
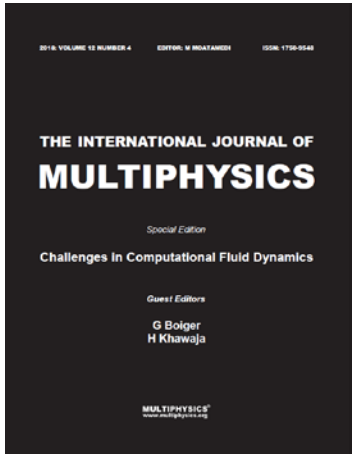


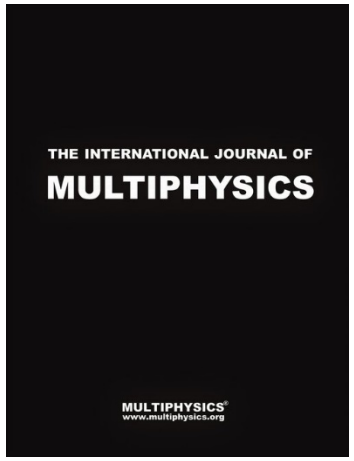
Figure 7: (a) Ice on surface of polyurethane, (b) Infrared image of ice on polyurethane surface

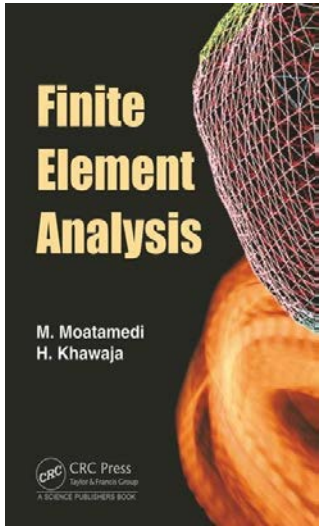
Figure 1: Piece of ice shed from a turbine in Nygårdsfjell wind park, Narvik, Norway [5]

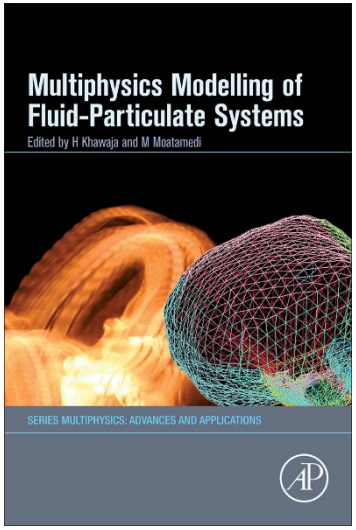
Hui Xue, Hassan Khawaja. Review of the Phenomenon of Ice Shedding from Wind Turbine Blades. The International Journal of Multiphysics, 2016, 10(3): pp. 265 - 276. http://dx.doi.org/10.21152/1750-9548.10.3.265

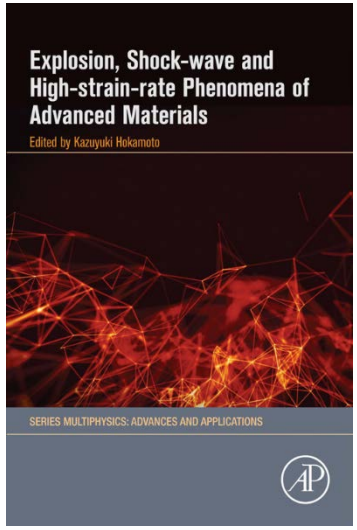
INTERNATIONAL SOCIETY OF MULTIPHYSICS

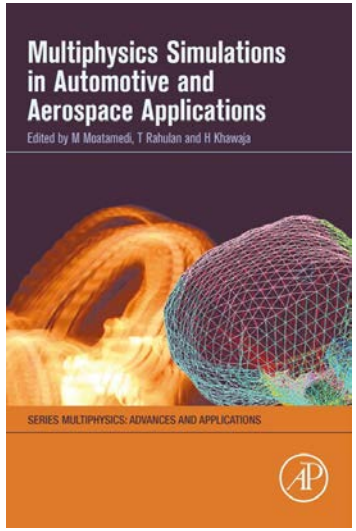












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QUESTIONS/COMMENTS

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