UiT The Arctic University of Norway

Field spray flux measurements to improve icing models for fish farms

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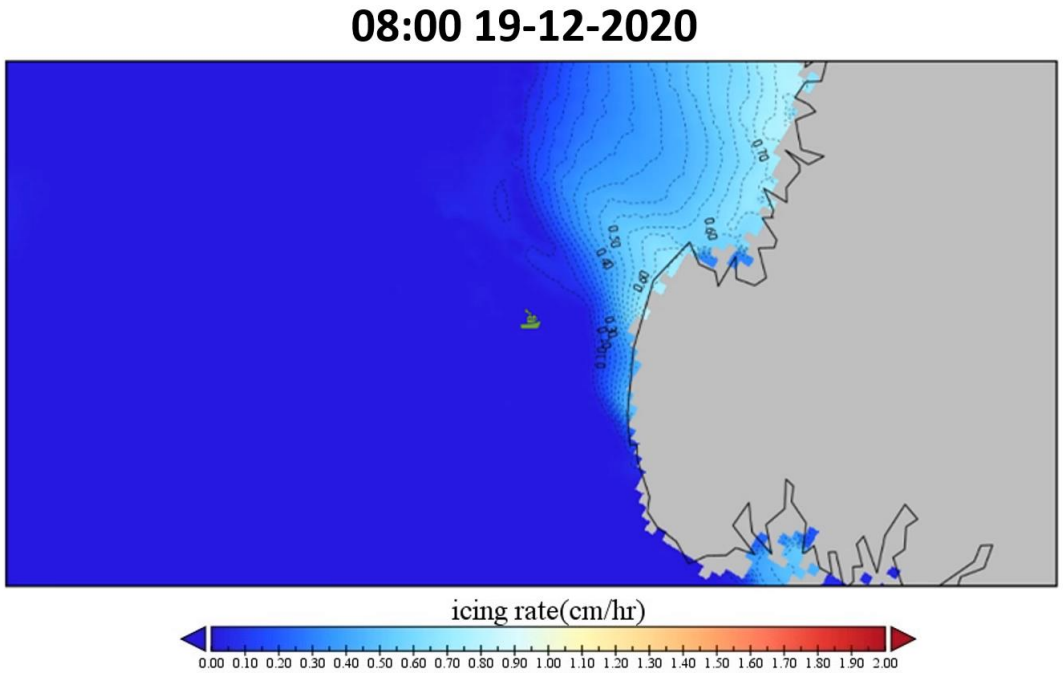
Multidisciplinary approach for spray icing modeling and decision support in the Norwegian maritime sector (SPRICE)

https://en.uit.no/project/sprice

UiT The Arctic University of Norway · HERMES · KYSTVERKET Norwegian Coastal Administration · SINTEF · Gratanglaks · Norwegian Meteorological Institute · The Research Council of Norway

The sinking of the fishing vessel ONEGA, which led to the loss of 17 lives on 28 December 2020 while fishing west of Novaya Zemlya.

Dhar et al., 2022



ONEGA and icing rate MINCOG

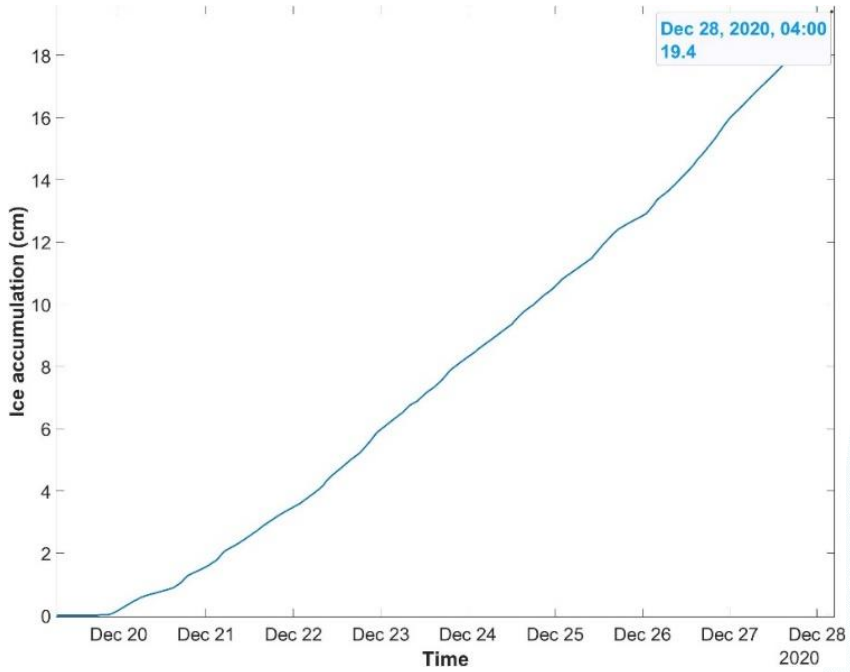
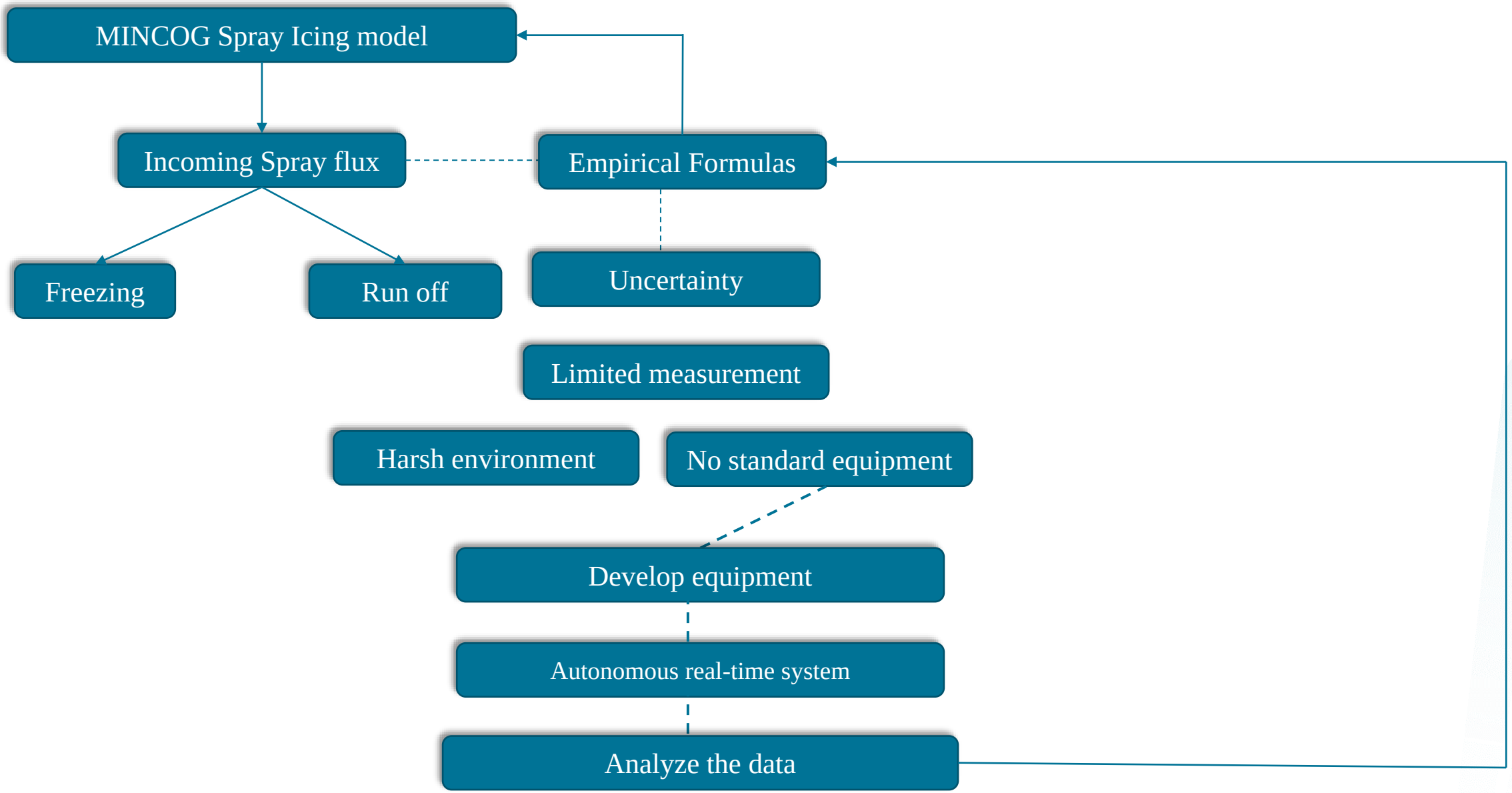


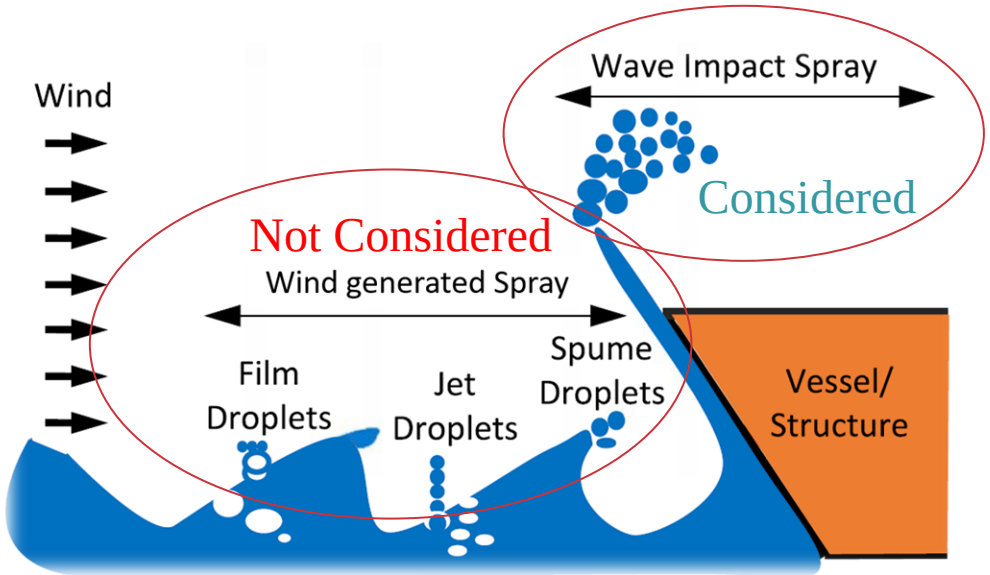
Fig. Ice accumulation during voyage of ONEGA from modified MINCOG

MINCOG (Samuelsen et al., 2017)

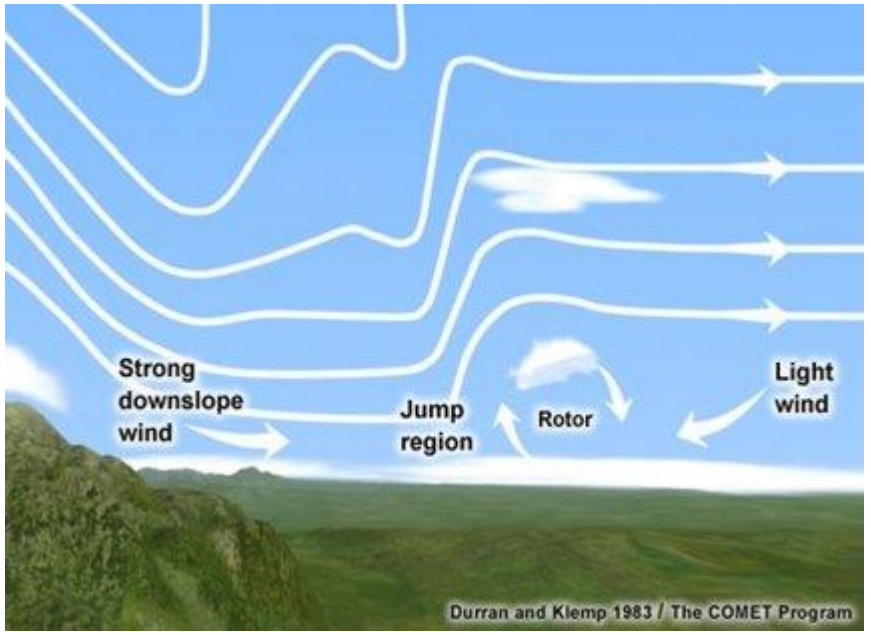
My work


MINCOG Spray Icing model
Incoming Spray flux
Empirical Formulas
Freezing
Run off
Uncertainty
Limited measurement
Harsh environment
No standard equipment
Develop equipment
Autonomous real-time system
Analyze the data

Fish Farms data collection



Wind flow near complex mountain terrain

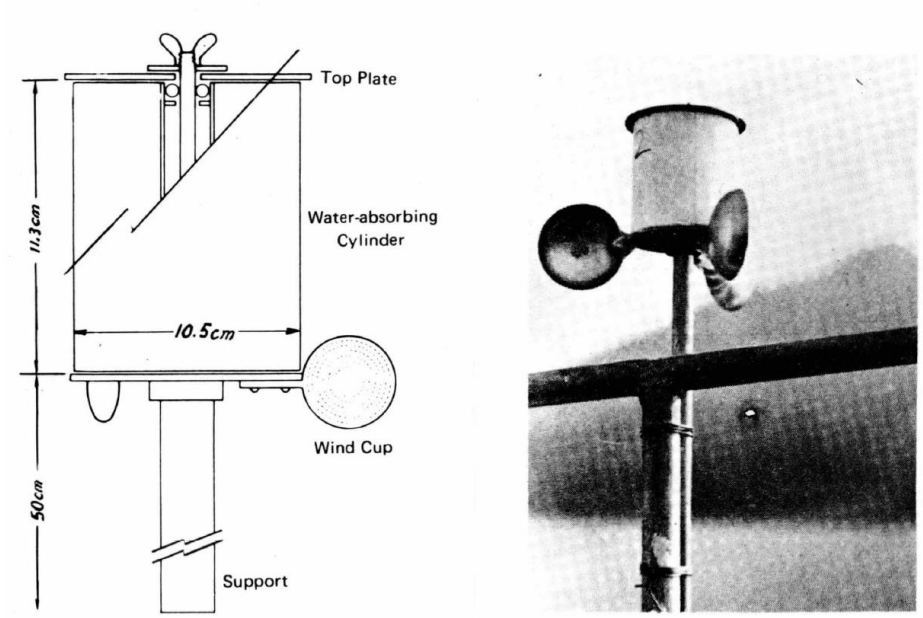


Sea-spray generated during a downslope windstorm in Lofoten (Northern Norway)

Review and analysis of past sea-spray measurements

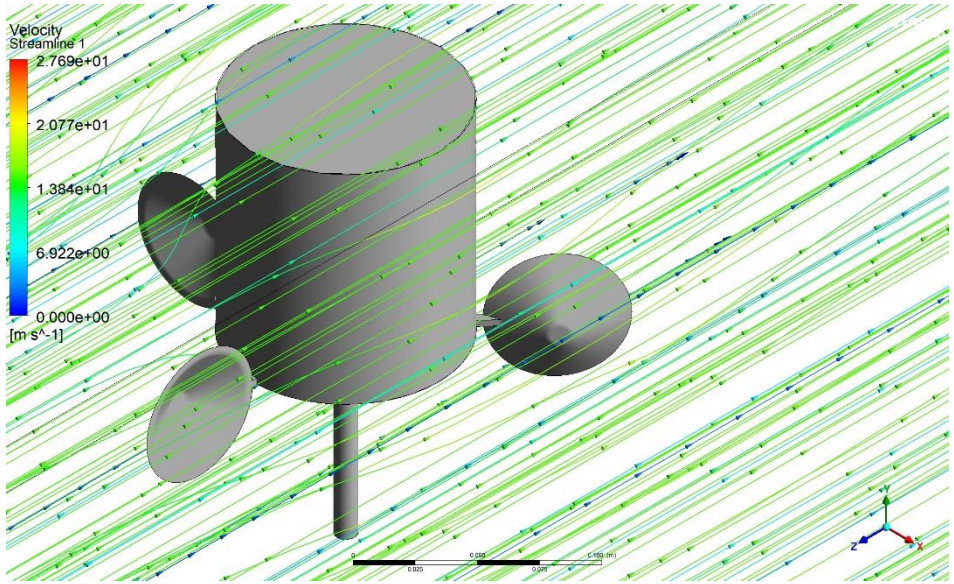
Spray measurement onboard Japanese patrol boats between 1963-1967

Toilet paper rolls



igure 10. Sea spray collector. (Tabata 1969) (Copyright, T. Tabata; reprinted by permission.)

Tabata, 1969



CFD, RANS K-ω SST

- sea spray droplet size: 0.01μm – 7.7 mm,

  smaller droplets stokes number <<1

Spray measurements on medium-sized fishing vessels by Soviet researchers in 1960s and 1970s

Medium-sized fishing vessels (~ 39 m length)

- Special Traps designed by Leningrad Polytechnic Institute - Liquid water content (Lwc) 50 samples
- High-speed camera – spray propagation
- Droplet size – sticky film technique

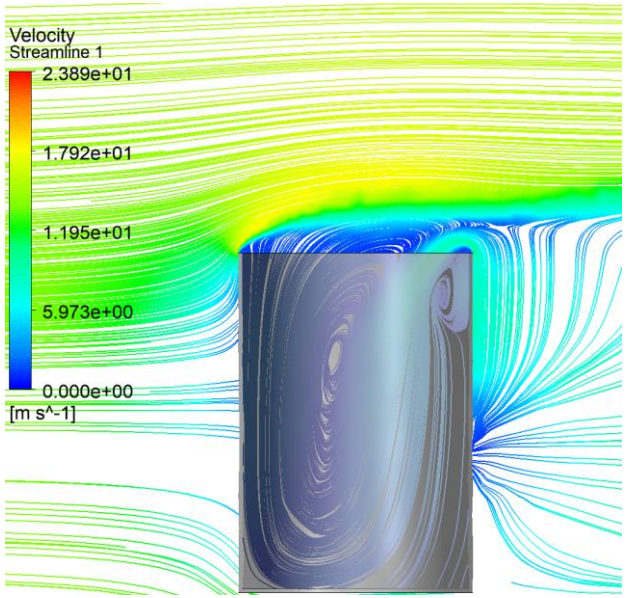
MINCOG
(Samuelsen et al., 2017)

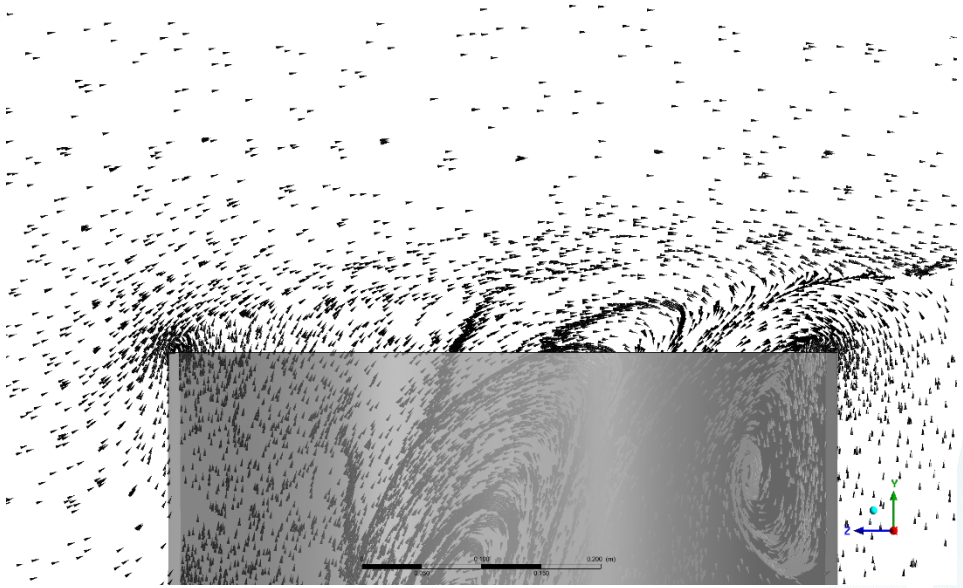
MFV "lceberg" (Gashin's work published in Borisenkov, 1972; Borisenkov & Panov, 1972) and on MFV "Narva" (Borisenkov et al., 1975)

Spray measurements on Tarsiut Island between July-September 1982

Tarsiut Island

45-gallon drums



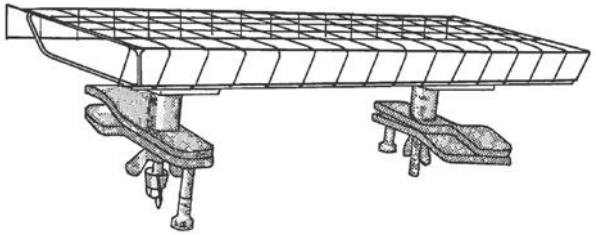


CFD simulation

RIGICE model

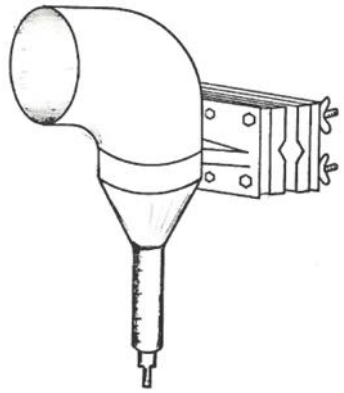
Muzik & Kirby (1992)

Spray measurements on offshore platforms (Jorgensen,1984, 1985, 1986)

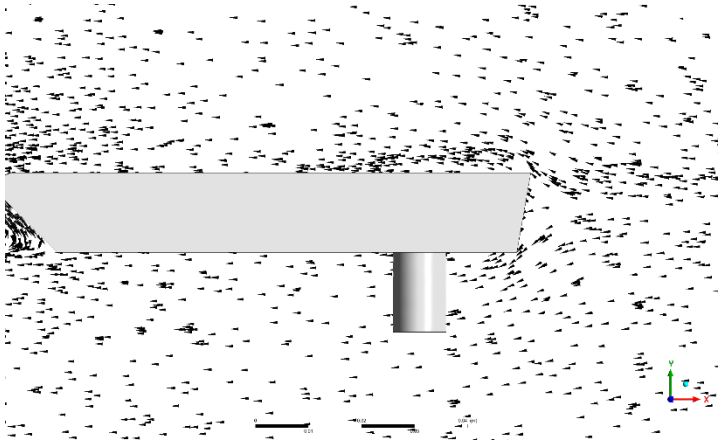


Baby diapers

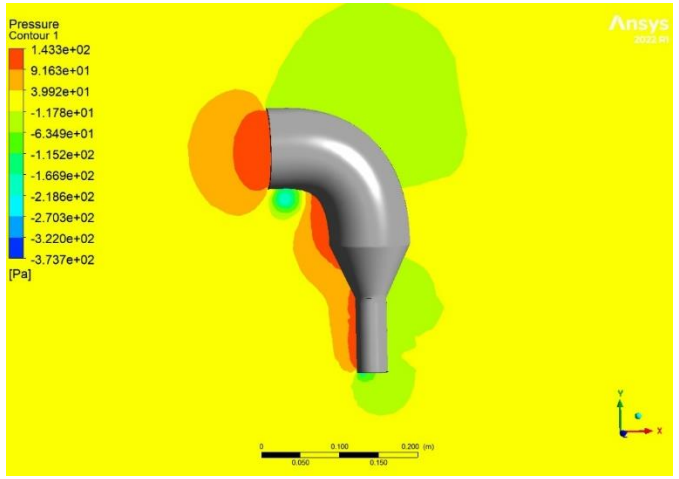
Spray measurements on vessels Horjen et al. (1986)

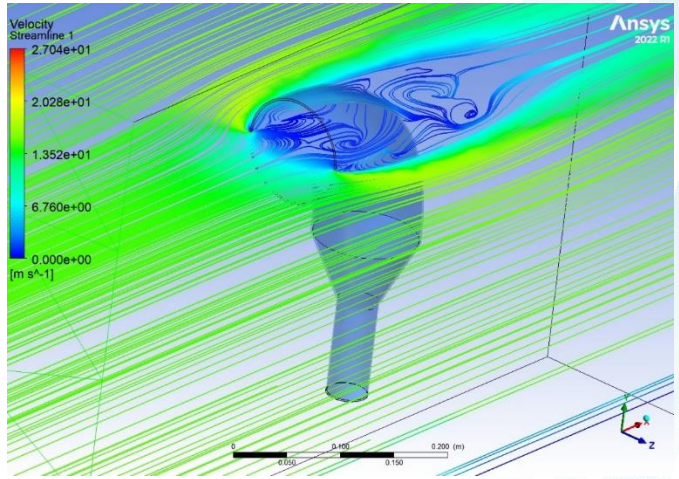


Bend pipe collector

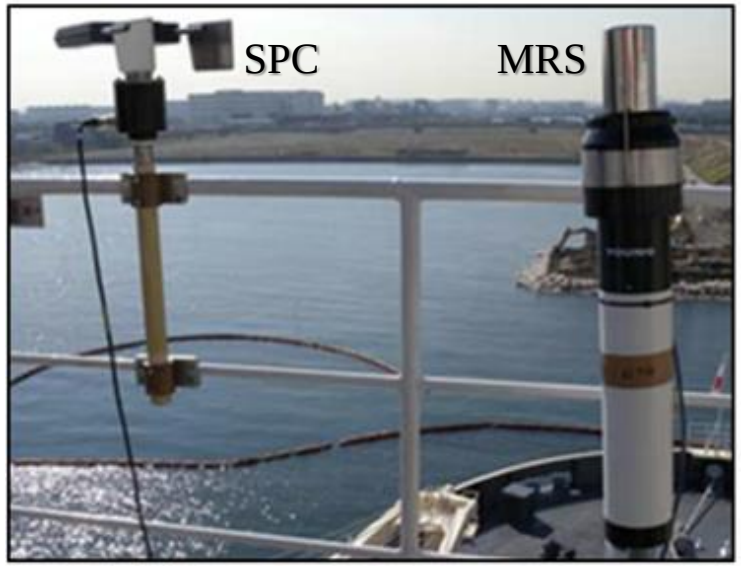


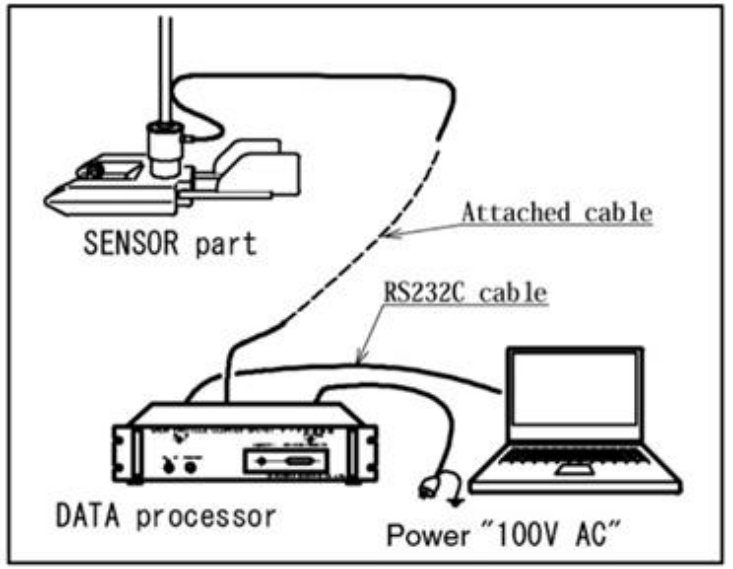
ICEMOD (Horjen et al.)



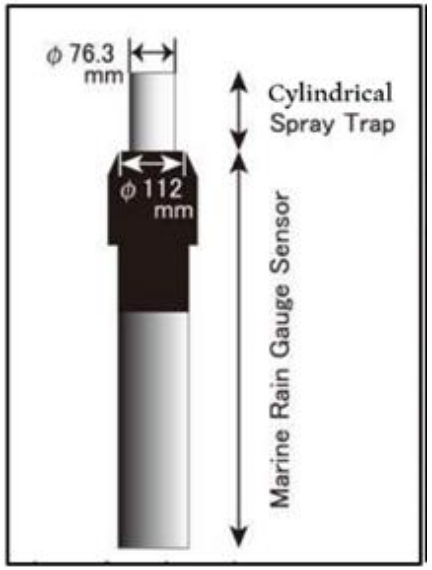


Measurements on large vessels using Spray Particle Counter (SPC) and Marine Rain gauge type Spray gauge (MRS) between 2012-2021



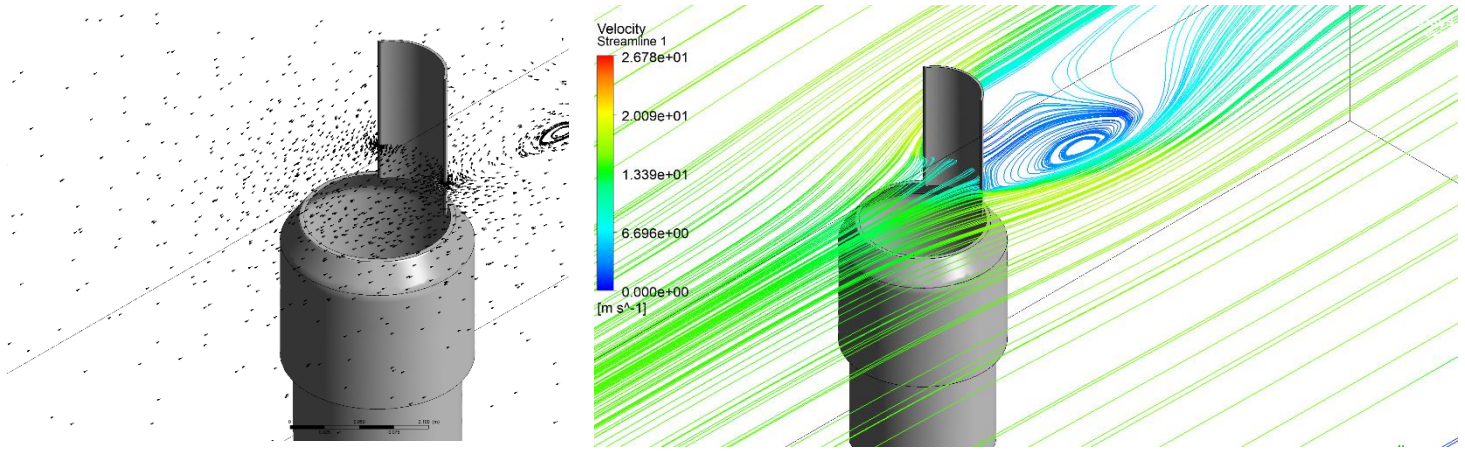


Spray Particle Counter (SPC)

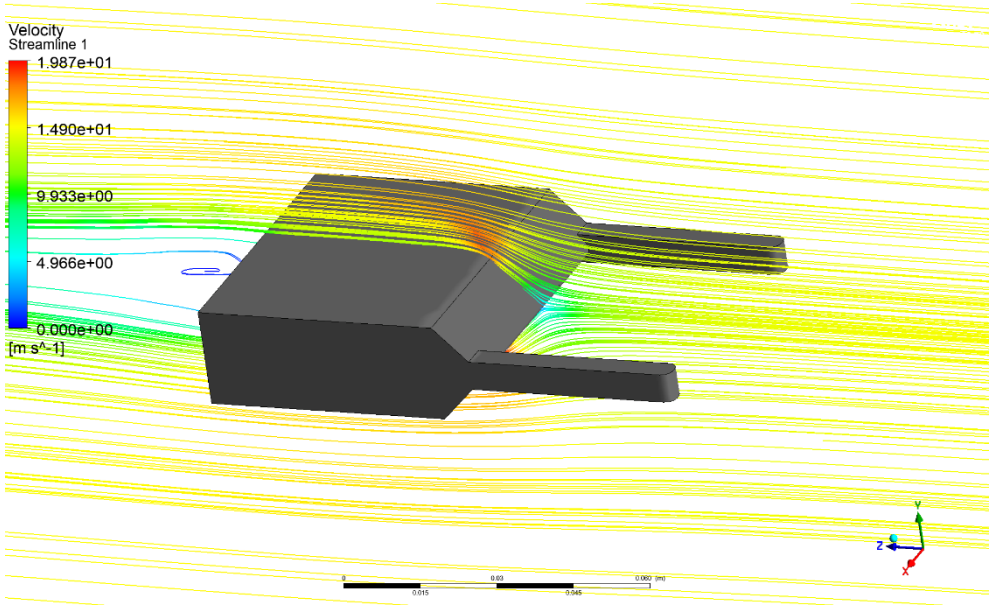


Marine Rain gauge type Spray gauge (MRS)

Ozeki et al.



Marine Rain gauge type Spray gauge (MRS)



Spray Particle Counter (SPC)

Measurement range -

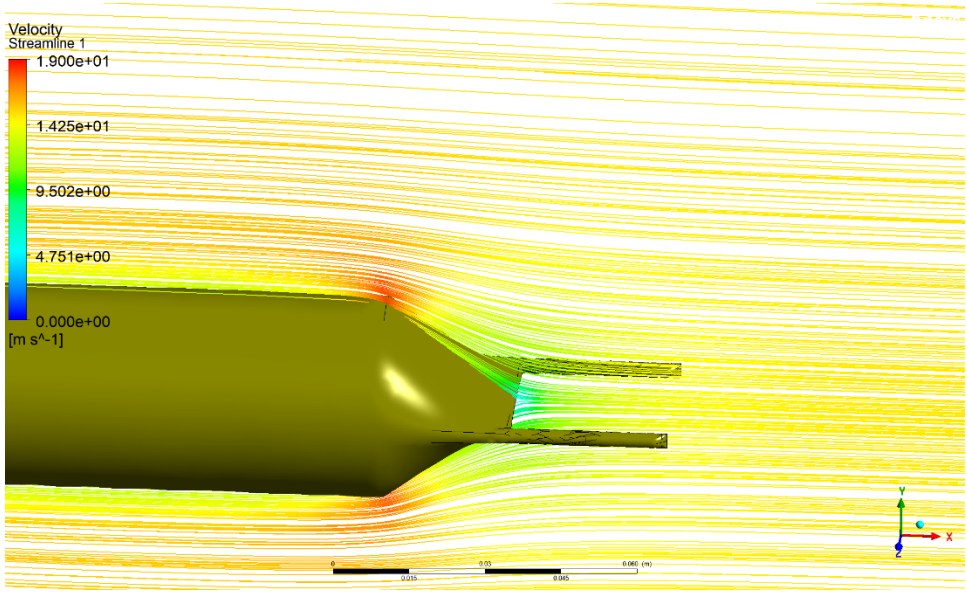
100 to 1,000 μm in diameter,

But sea-spray 0.01 to 7700 μm

Ozeki et al.

Spray measurements at Mt. Desert Rock between 2012 – 2014

FIG. 2. The DMT CIP and the Gill sonic anemometer/thermometer mounted on the foghorn platform on Mount Desert Rock.



Cloud Imaging Probe (CIP)

Count droplets with radii up to 775 μm.

Accuracy decreases for the larger droplets

Quotation: 226,390.00 USD

(Andreas, 2016)

RigSpray - Norne FPSO between 2017 – 2019

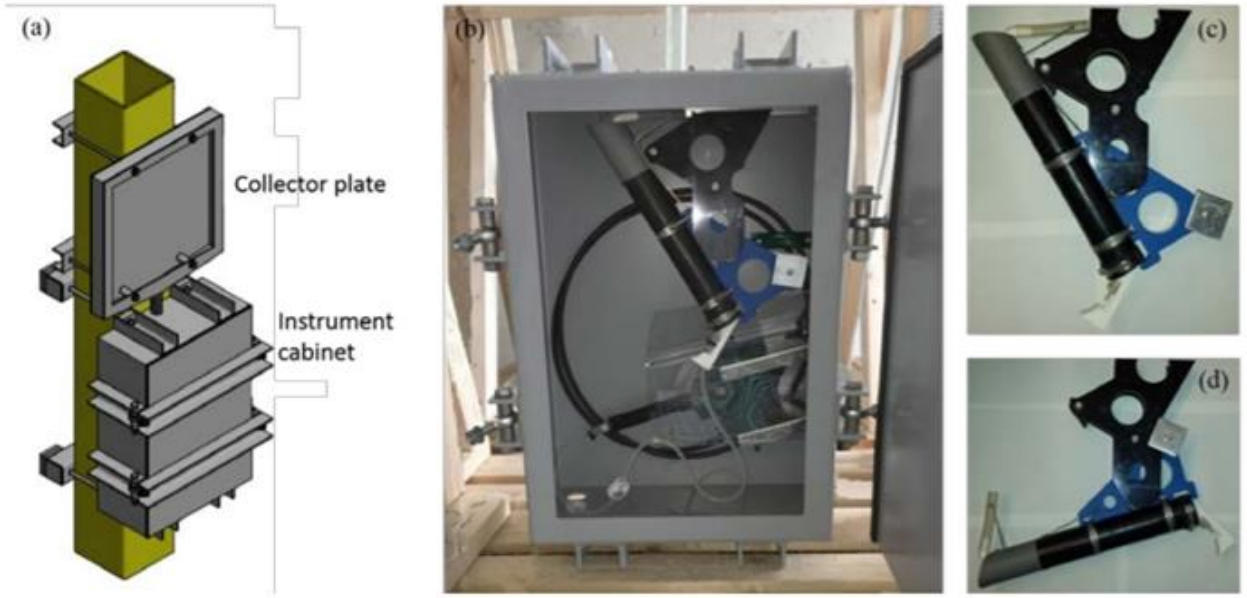
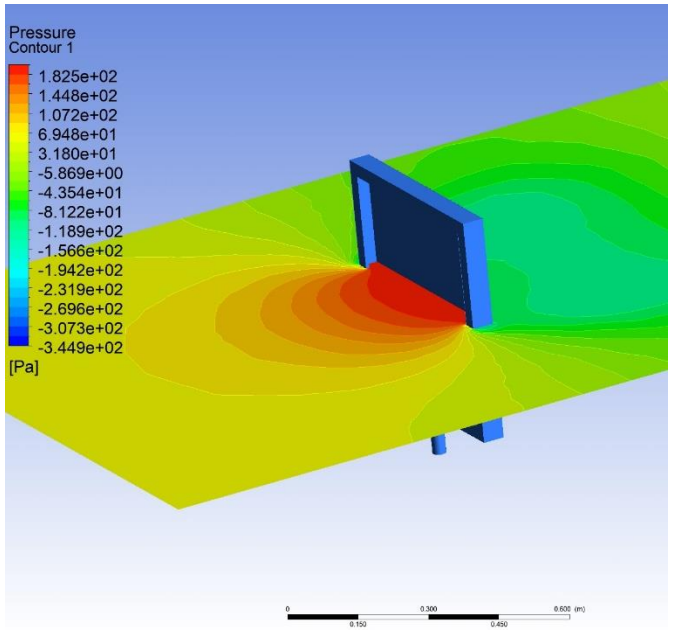


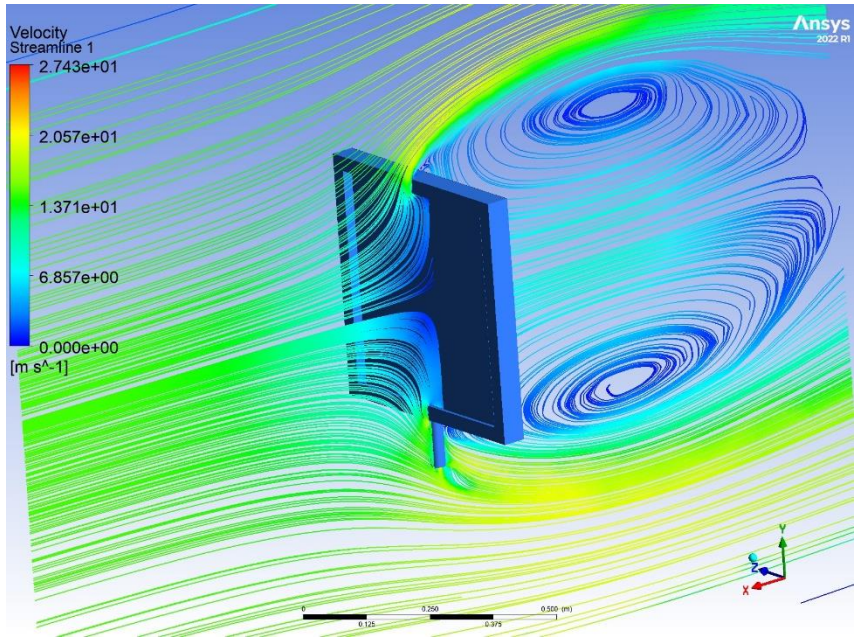
Figure 3. (a) Technical drawing of the collector plate and instrument cabinet assembly mounted on a vertical column, (b) Internal view of the instrument cabinet, (c) Close-up of tipping bucket in upright position, (d) Close-up of tipping bucket in tilted position.

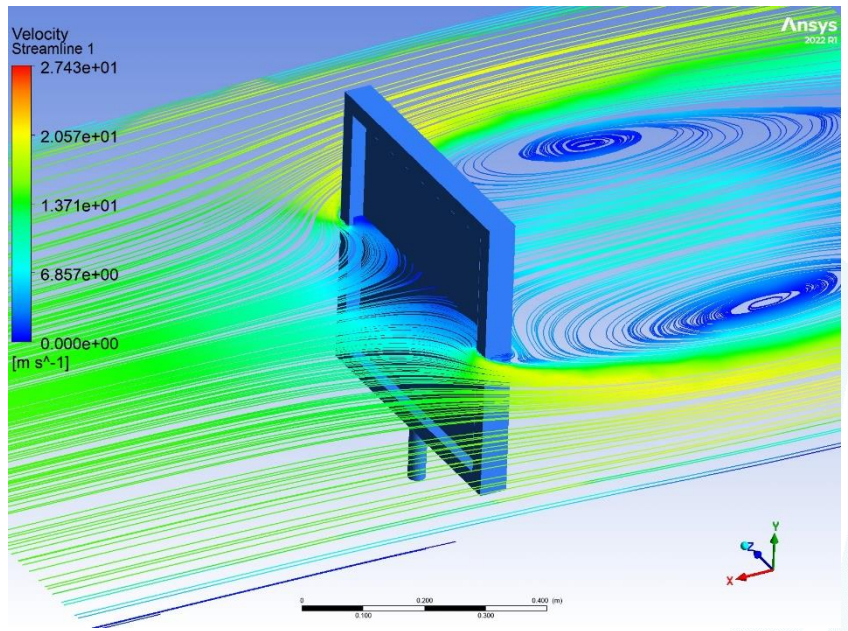
Fluxmeter

(Teigen et al., 2019)

RigSpray design (Teigen et al., 2019)

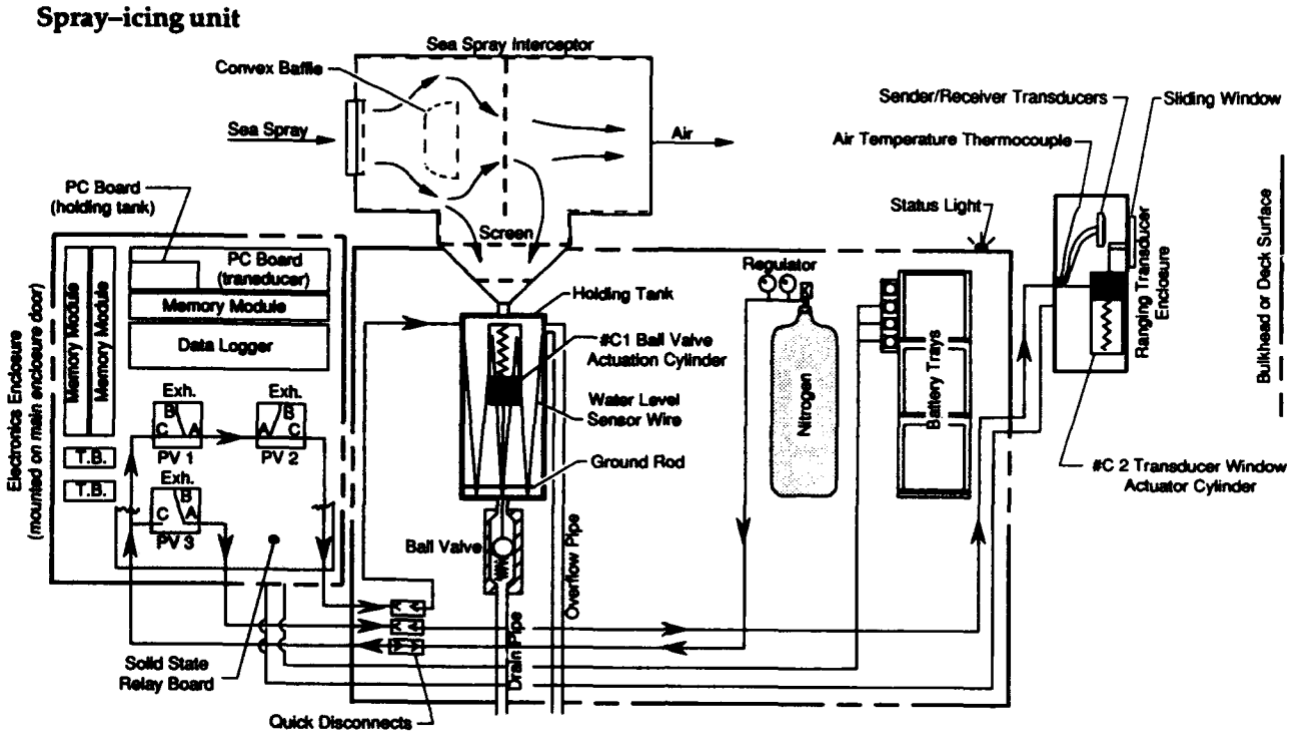






CFD simulation

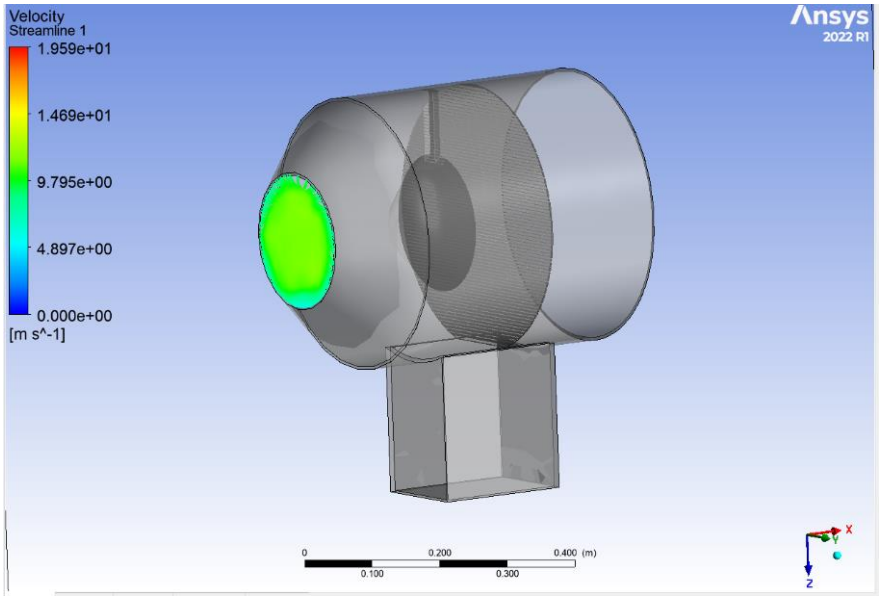
CREL design horizontal spray interceptor

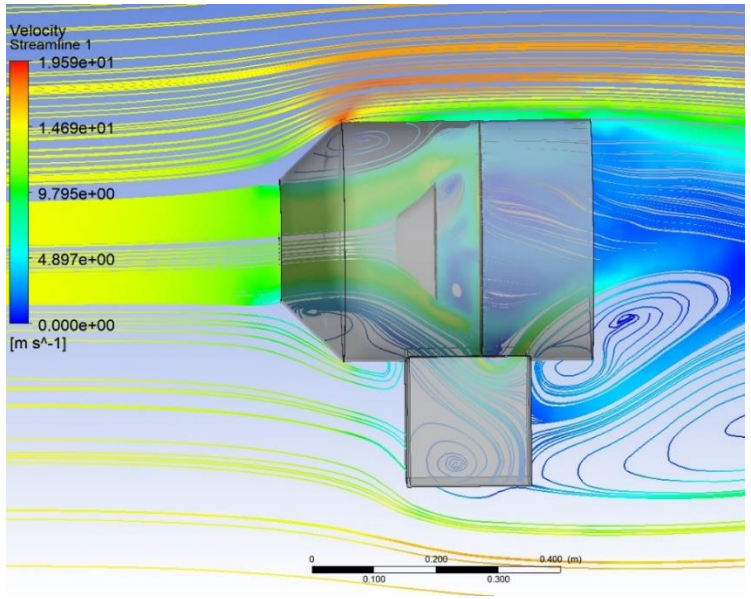


Ryerson (1992)

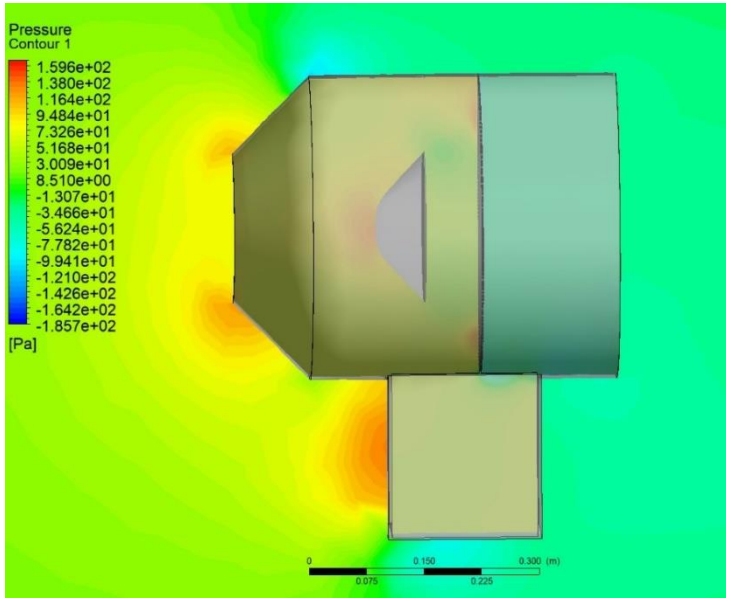
U.S. Coast Guard Midgett Research Cruise between February – March 1990

CREL design horizontal spray interceptor

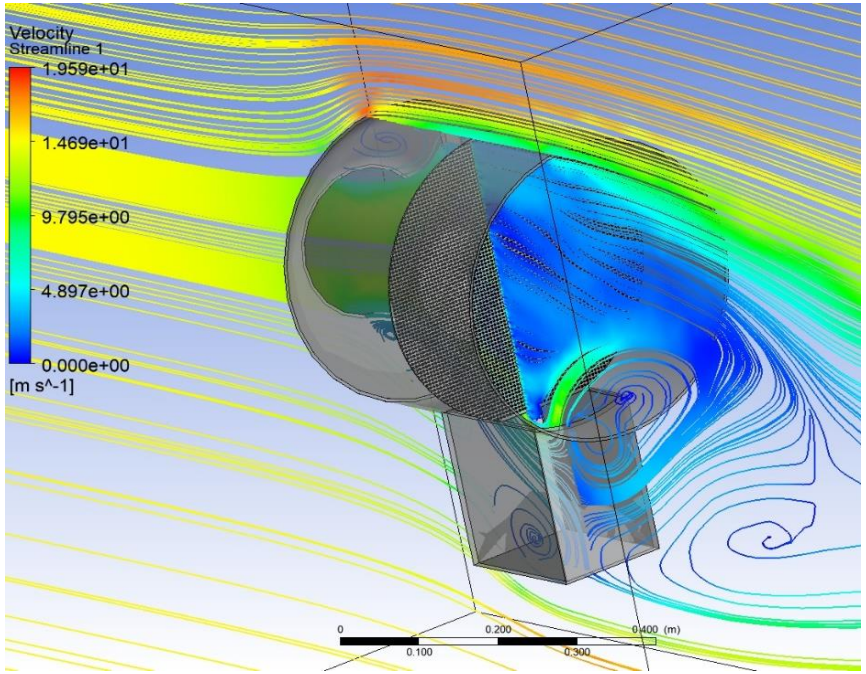




CFD simulation



CREL design horizontal spray interceptor



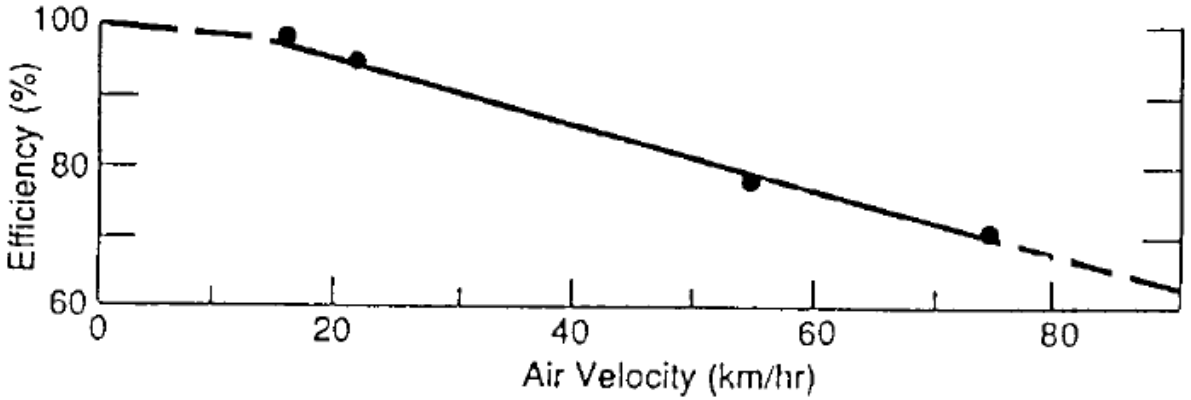
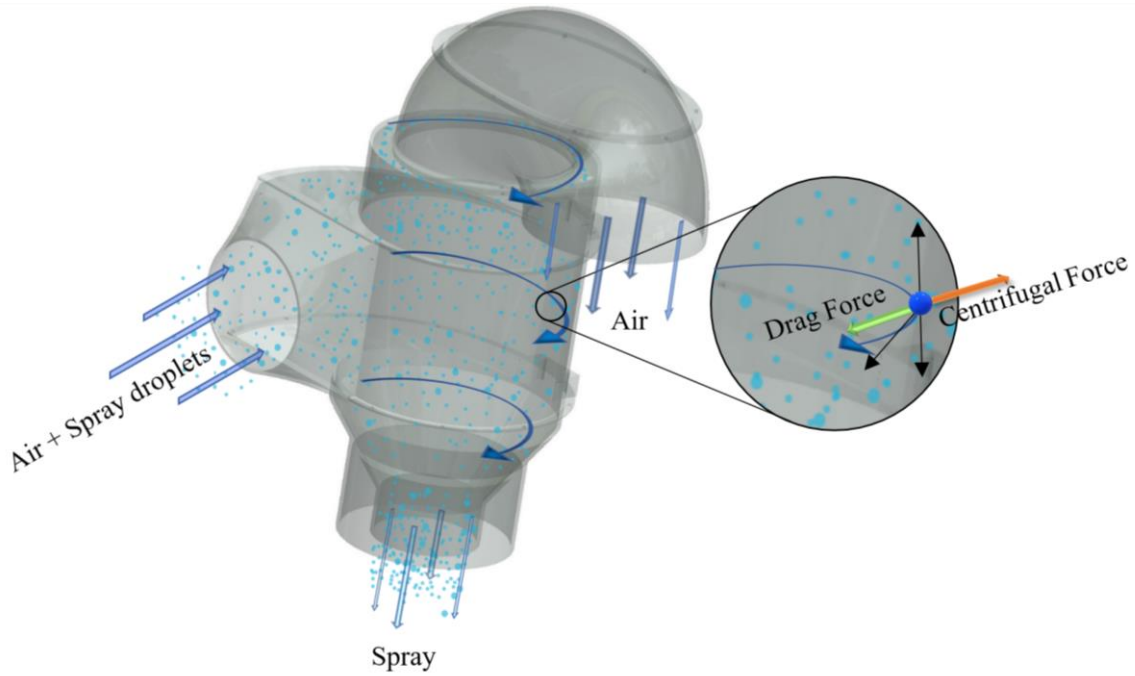
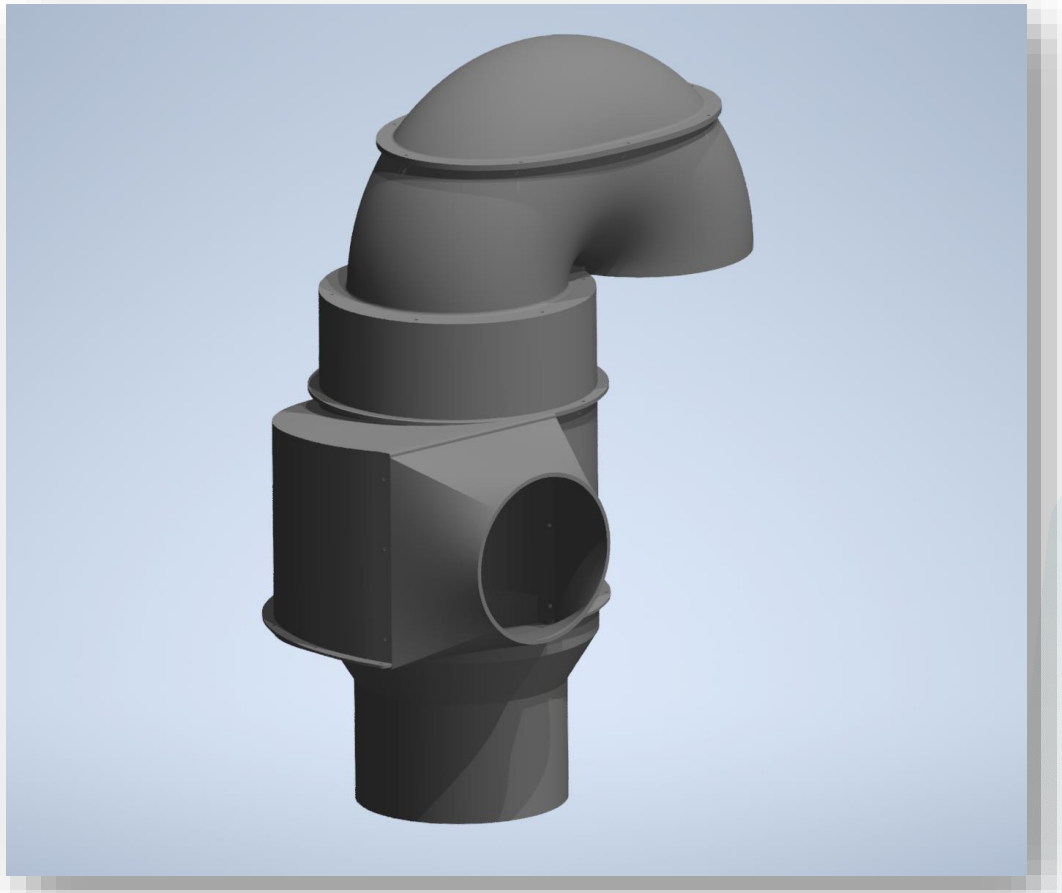


Figure 25. Efficiency curve for horizontal collector droplet interception (from Walsh et al. 1992).

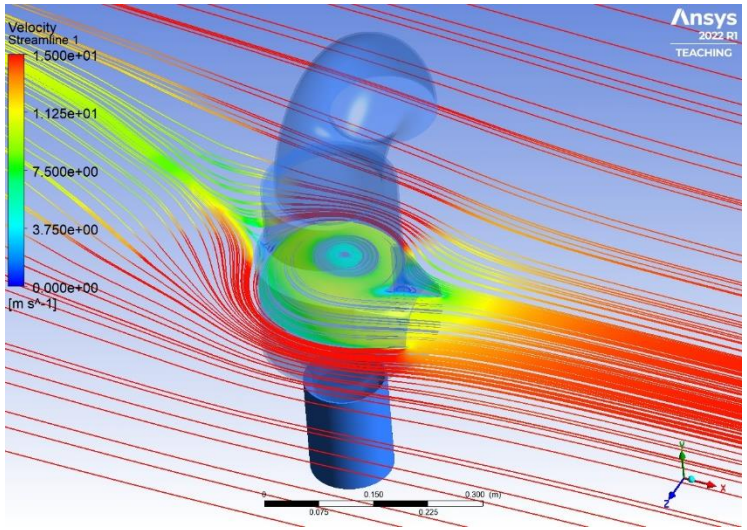
SPRICE Spray Collector

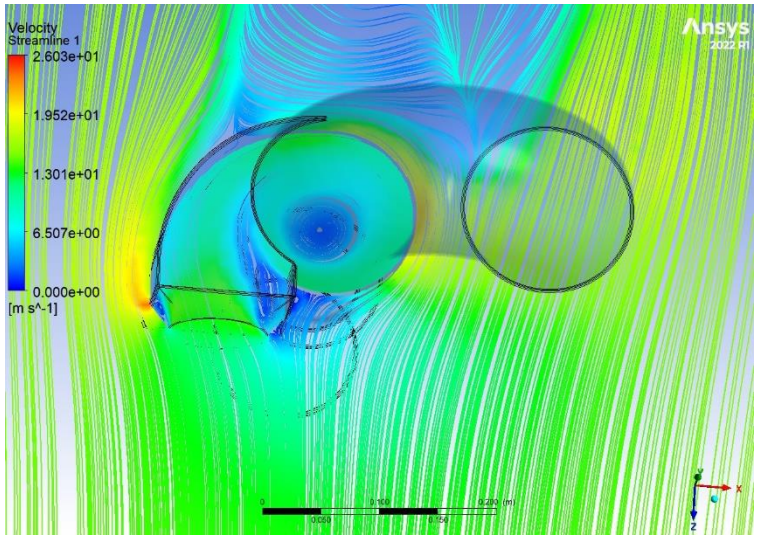


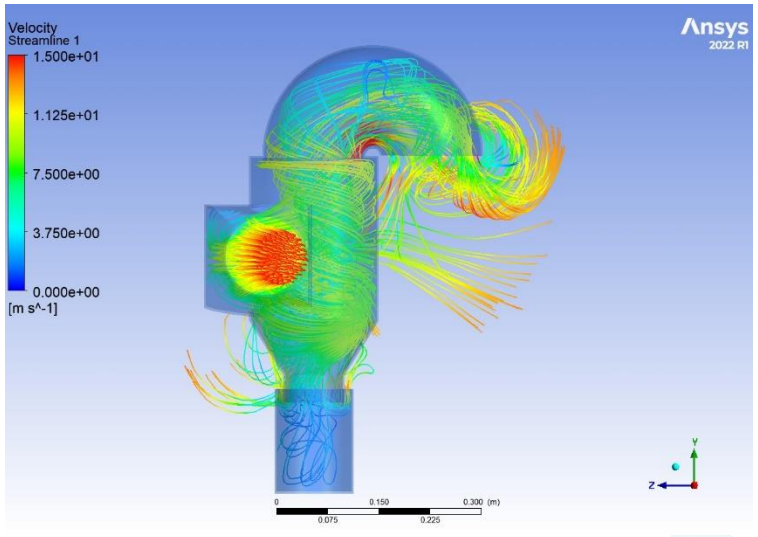


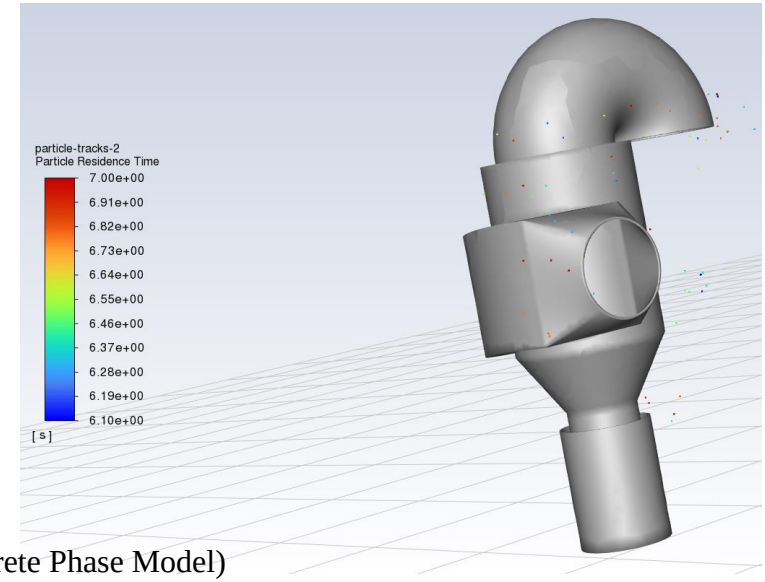
Based on the principles of cyclone separators

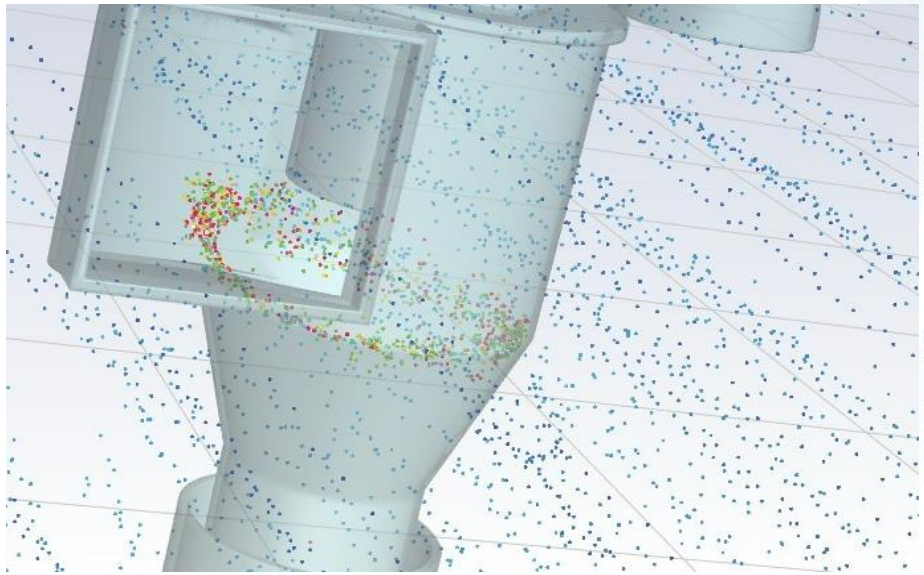
CFD simulation





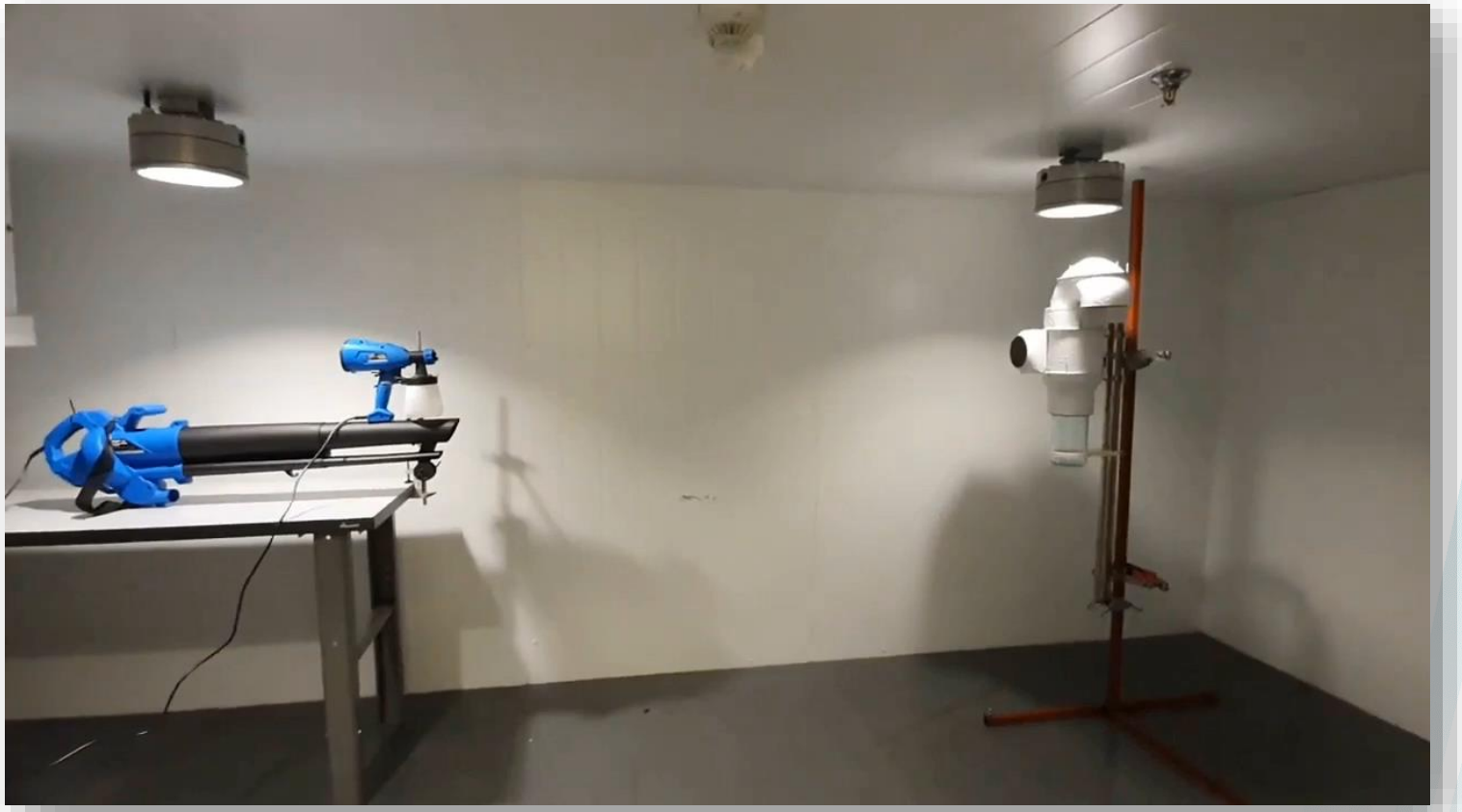






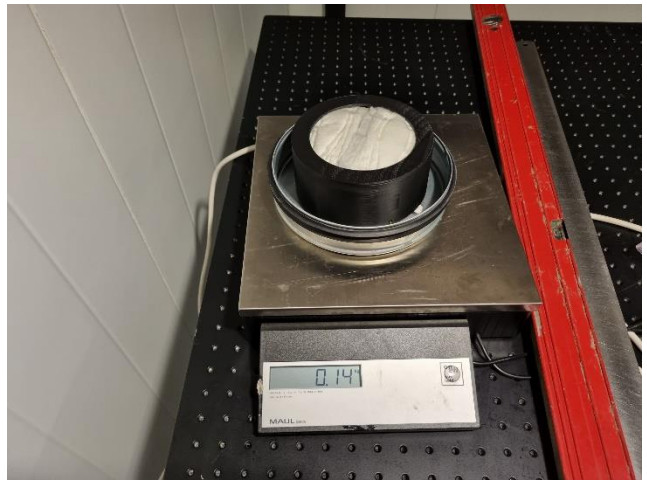
DPM (Discrete Phase Model)

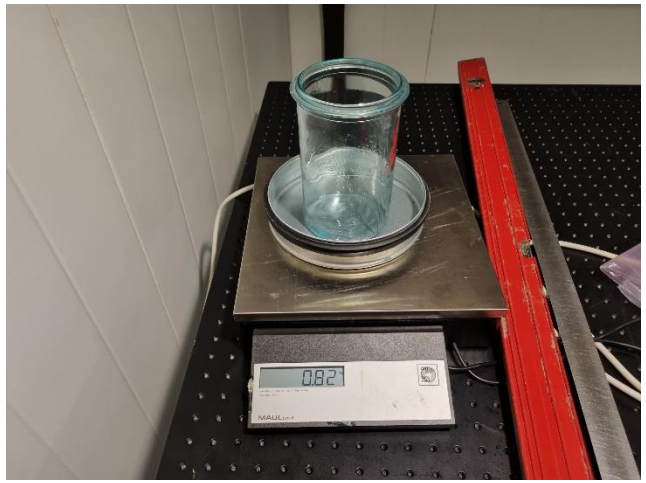
Lab Test



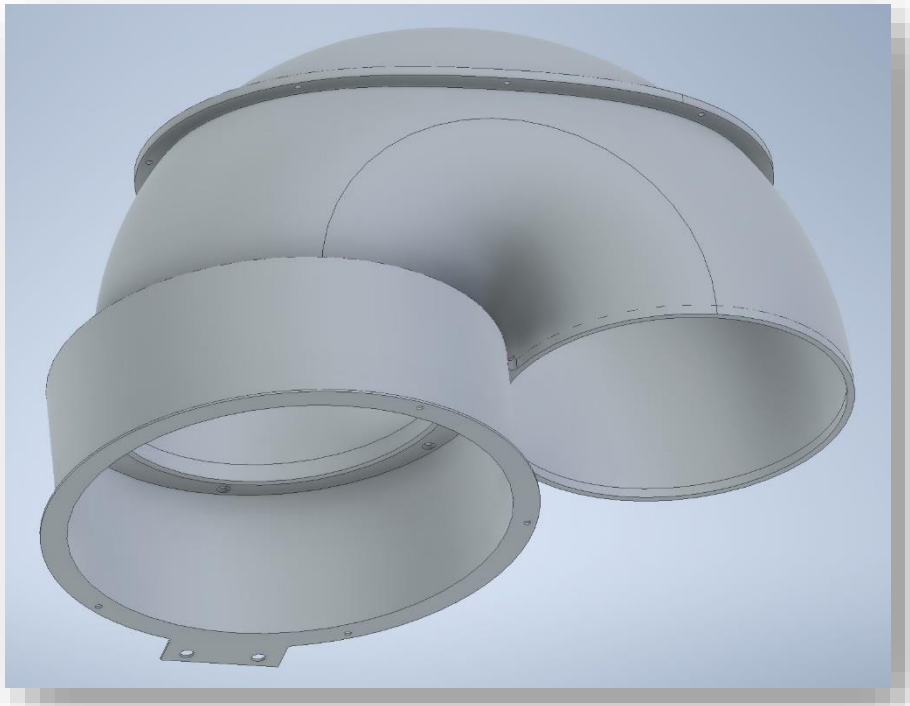
3D printed with Carbon fiber infused nylon filament

Lab Test





Lab Test

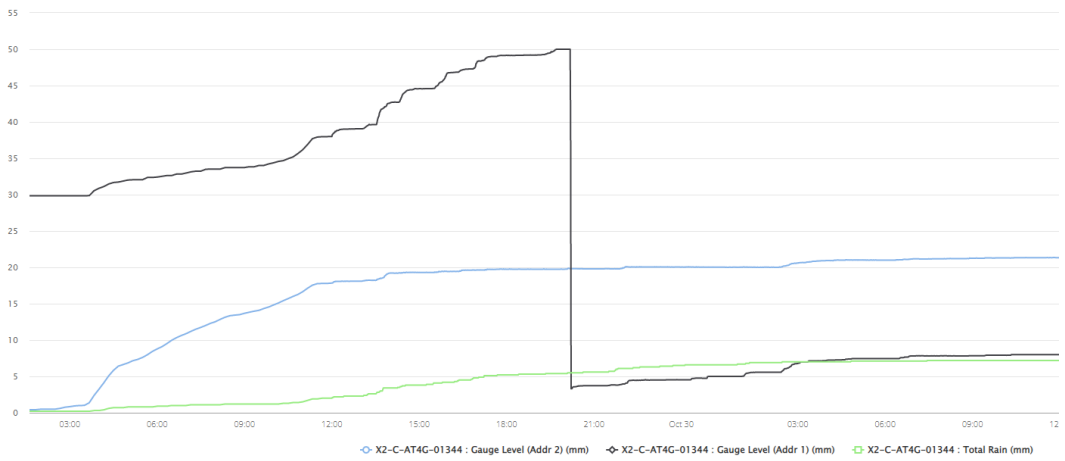


Field deployment

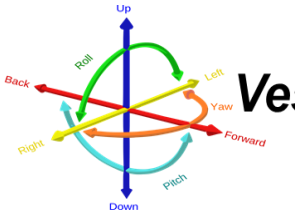
Gratanglaks

Autonomous real-time system

Field deployment, 7th October 2022

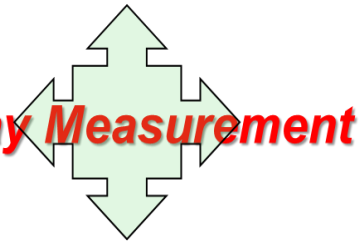


Radiometer



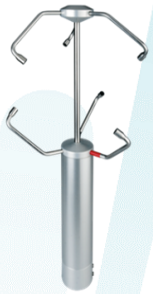
Vessel motion

Temperature, humidity and Precipitation



Spray Measurement

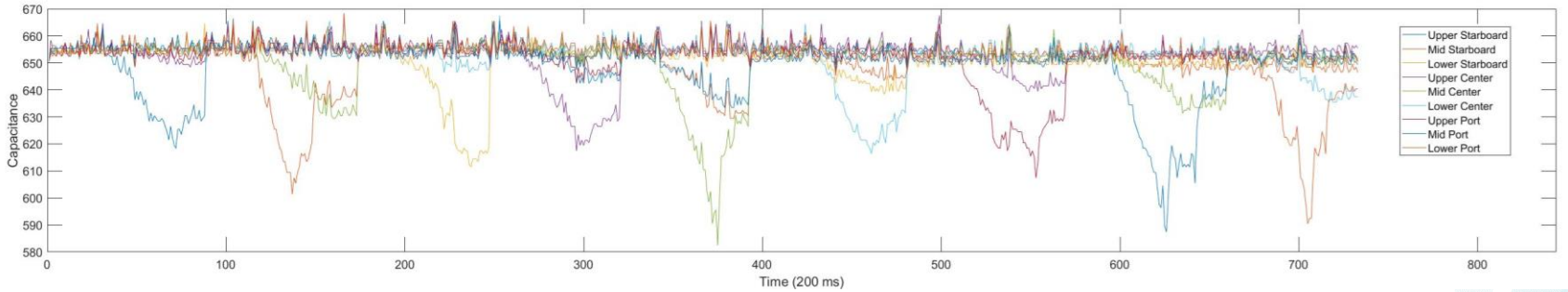
Wave Parameters

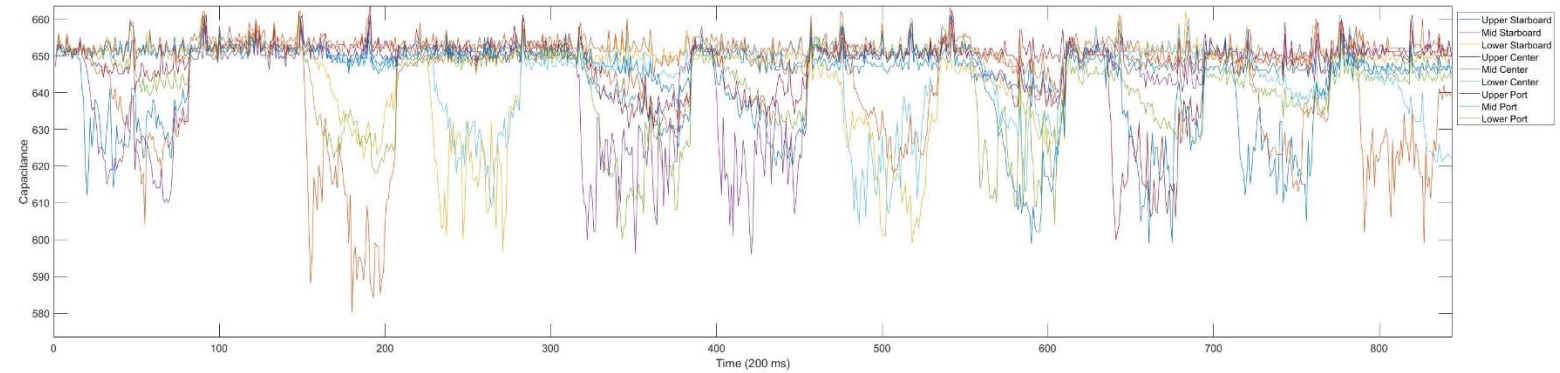


3D Wind

Field deployment, 27th February 2023

Spray distribution measuring equipment prototype





Thanks for listening

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