# Ice research enables cost-efficient offshore wind turbine foundations

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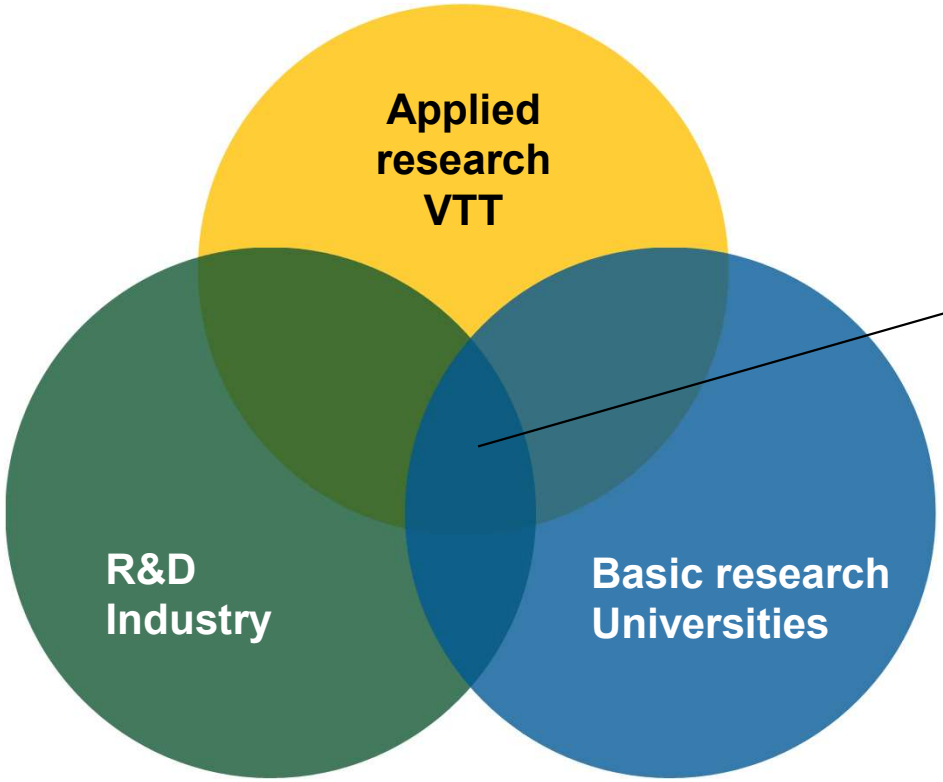
# We turn science into practical innovations through applied research



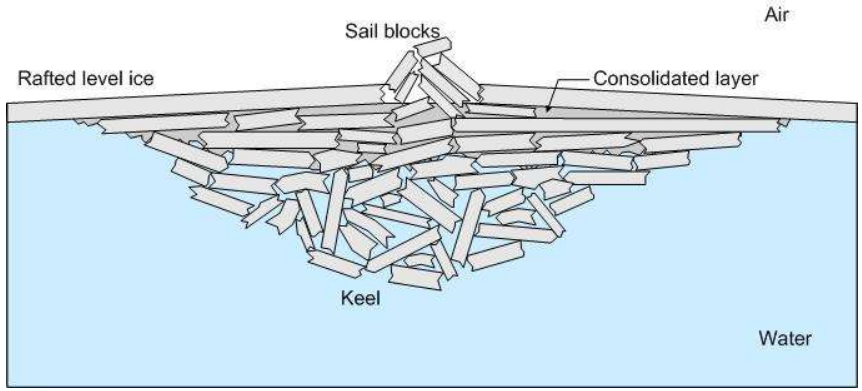

**The sweet spot where innovations are born**

# State-of-the-art methods for ice load design

NASA, Terra MODIS satellite image 25.2.2023

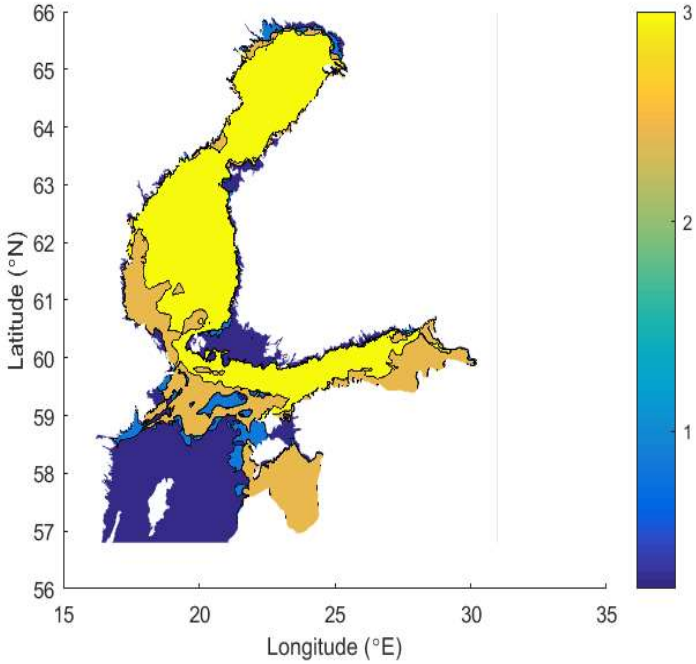
# Extensive research on ice conditions is needed

- Ice field consists of level ice and deformed ice types such as ice ridges
- Annual and spatial variations are large:
  - In some years, almost the entire Baltic Sea has frozen
  - And in some years, not even the entire Bay of Bothnia has froze over
  - With a long design period, the probability of severe ice winter increases
  - Local conditions need to be studied
- Climate change is also affecting the ice conditions
- Extensive research on ice conditions is needed for realistic estimates with 50-year recurrence period



# Realistic estimation of ice conditions saves costs and decreases risks

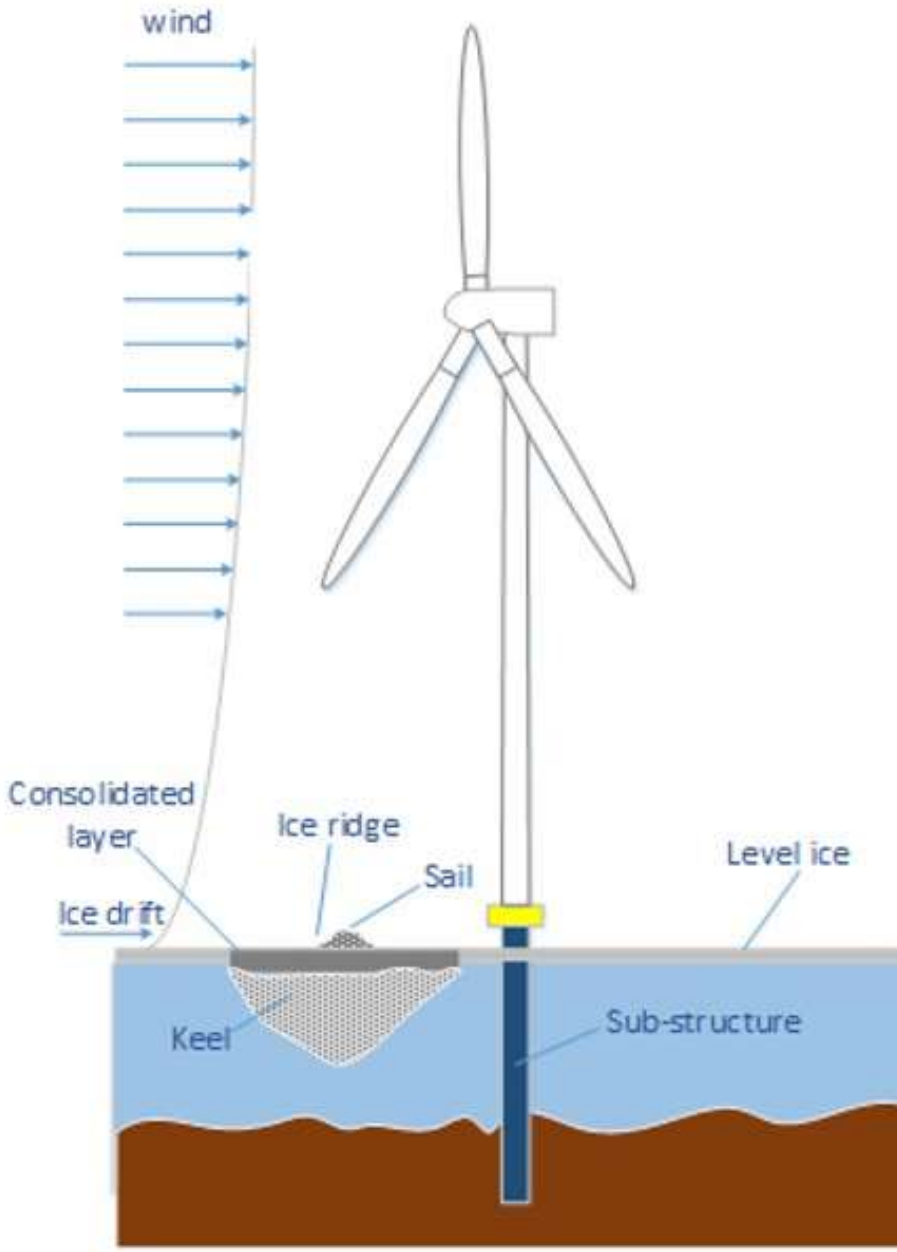
- Ice condition database
  - Based on FMI's digital and digitized ice chart data from 1980-2022
- Site-specific design parameters calculated from the GIS data
  - 50-year maximum level ice thickness
  - Amount of days of ice in each thickness class
  - Ice type: drifting or landfast ice, ridges etc.
- Unique database for design
- Other information from different sources also can be utilized




Maximum degree of ridging (0-3) at the site

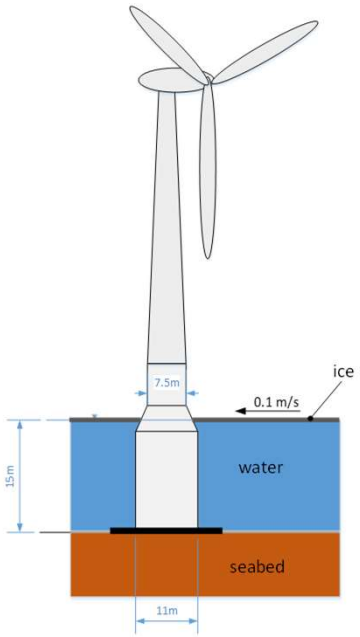
# Ice research aims to reduce the uncertainty of ice loads

- Ice interaction with offshore structures has been studied several decades
  - Standards have been developed for oil and gas industry
  - It is known how to design structures to withstand ice loads
- Wind turbines are different kind of structures: tall and slender → sensitive on dynamic loads
  - The big question is how to design cost-efficient wind turbines in ice conditions
  - We are aiming to reduce the uncertainty

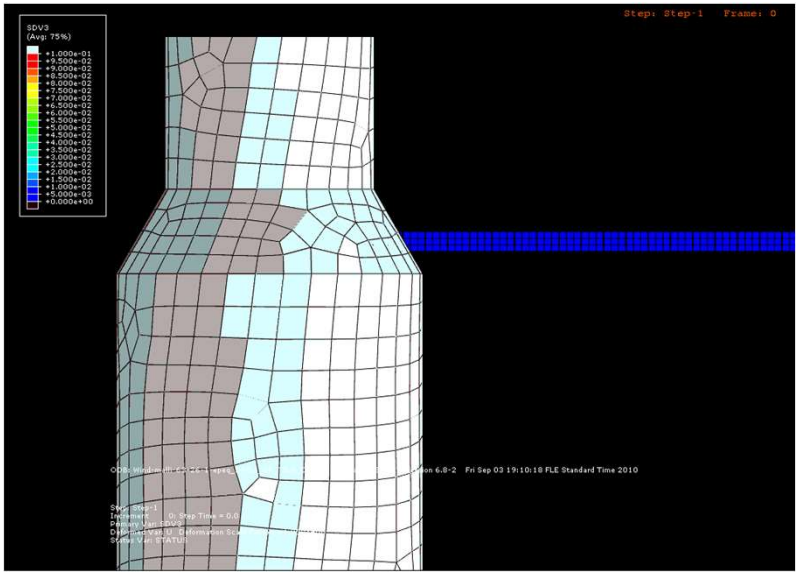


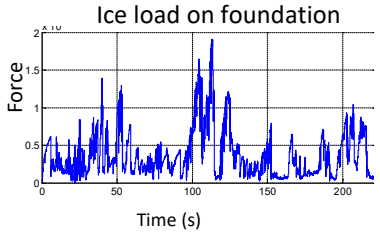
# Ice research creates different methods for ice load design of offshore wind turbines

- Numerical methods for ice load design (standard, semi-empirical and physical depending on the design phase and need)
  - Ultimate and dynamic loads
  - Level ice, ridges
  - Can be used in design and certification
- Model-scale and full-scale experiments

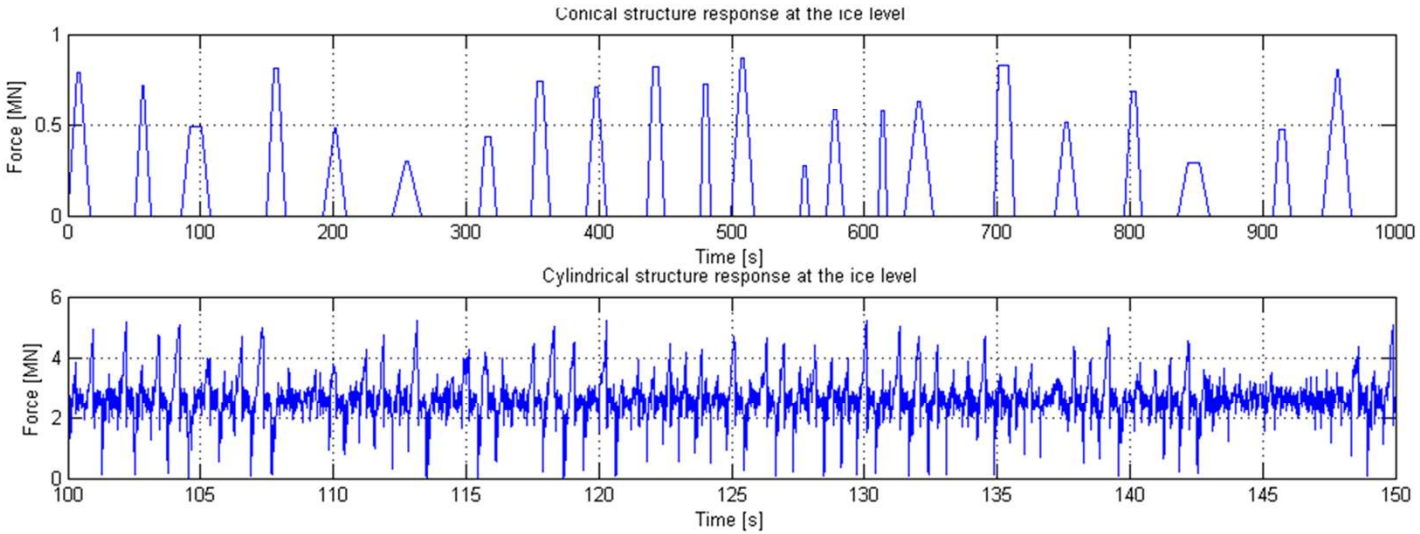


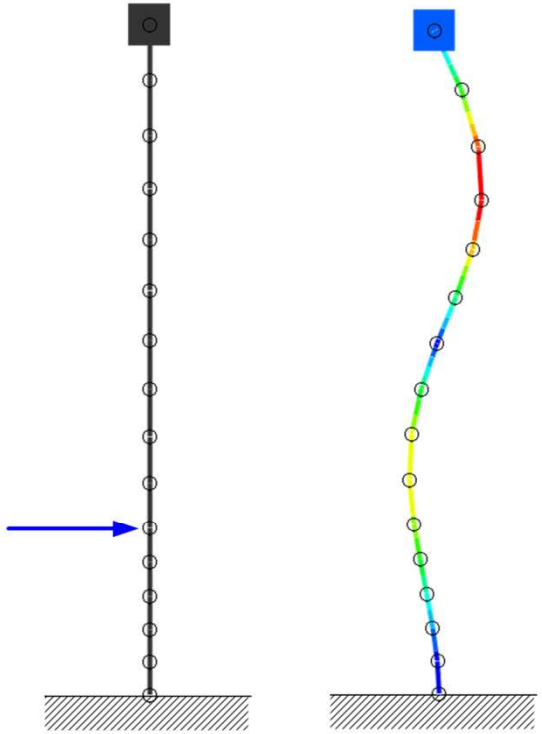

Drifting sea ice interaction with a cone





# Ice cone reduces ice loads and affects the dynamic behaviour



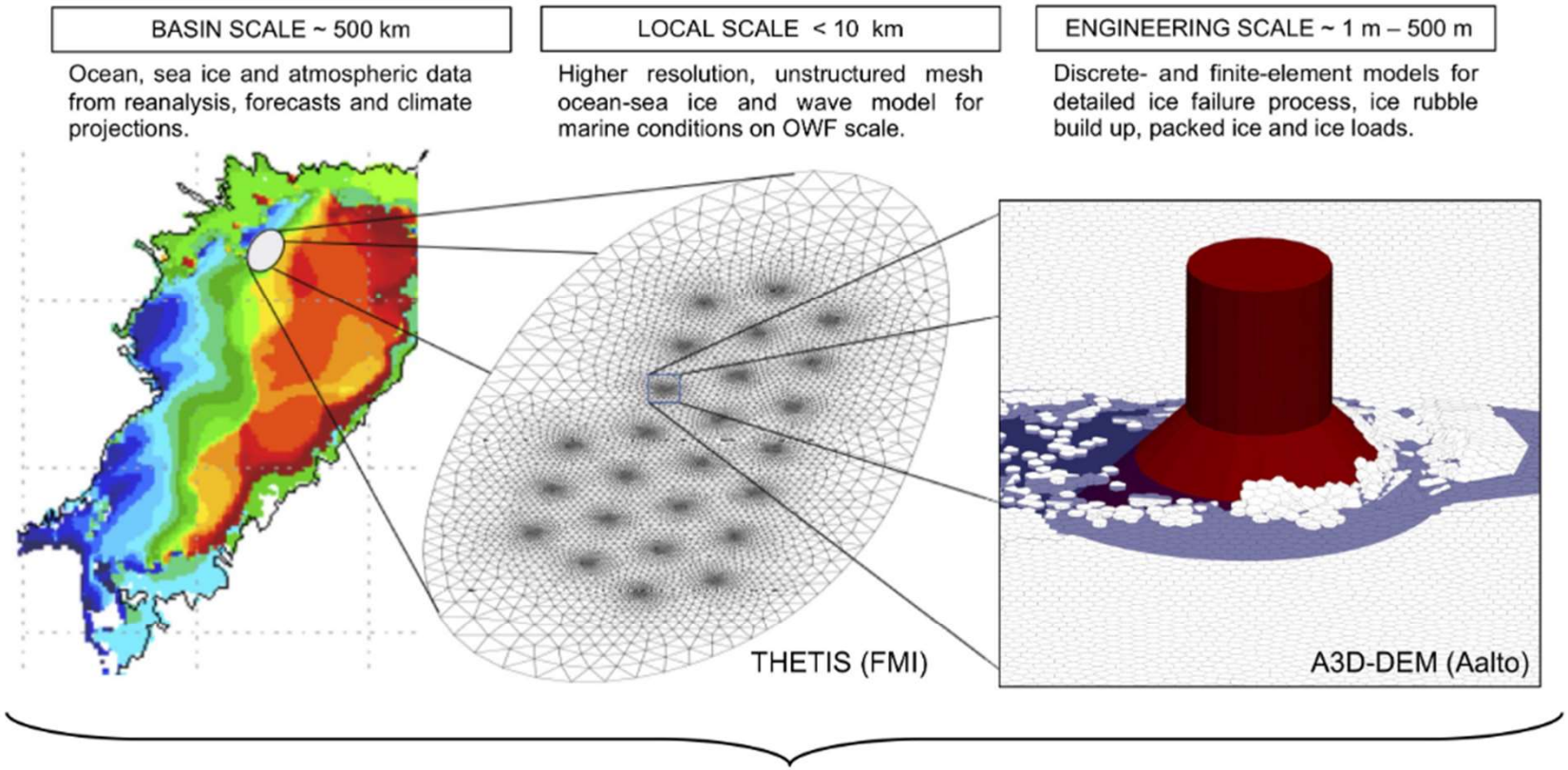



# On-going research projects

# Ice loads on the channel marker at the Bay of Bothnia are measured in Icewind project

- Full-scale ice load measurements on the channel marker in the Bay of Bothnia
  - With ice condition monitoring
- Model-scale measurements of offshore wind turbine foundations in Aalto ice tank
- Full-scale wind turbine blade icing measurements
- Research partners: VTT, Aalto and FMI
- Industry partners: Metsähallitus, OX2, Skyborn Renewables, Labkotec, Skarta, Terramare-Boskalis

# WindySea – modelling ice in different scales




WindySea workshop for stakeholders coming



Aalto University School of Engineering
VTT
FINNISH METEOROLOGICAL INSTITUTE
ACADEMY OF FINLAND
Funded by the European Union
NextGenerationEU

# What next?

- Full-scale ice load measurements on actual wind turbine foundation is crucial for the entire industry to optimize the foundations in ice
- Validated methods for ice loads and conditions to optimize cost-efficient structural designs
- We see this as a valuable next step and are continuosly seeking possibilities for research funding for this topic (especially EU funding)
- Would the stakeholders be interested in joining their forces for this?

# beyond

## the obvious

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