AERODYNAMIC EROSION DAMAGE MODELLING ON WIND TURBINE BLADES

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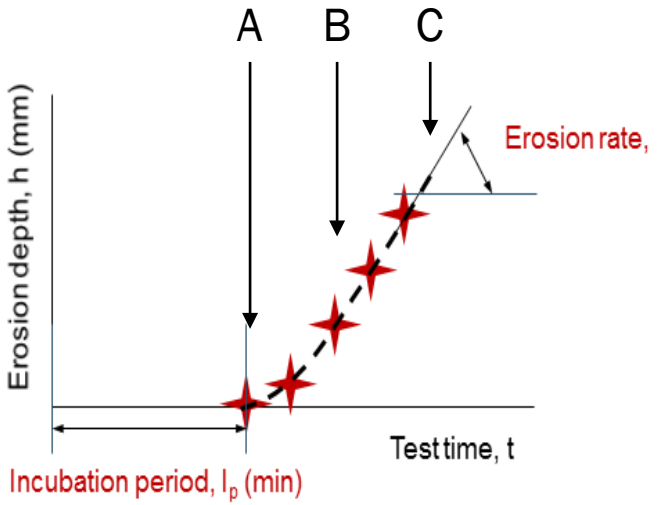
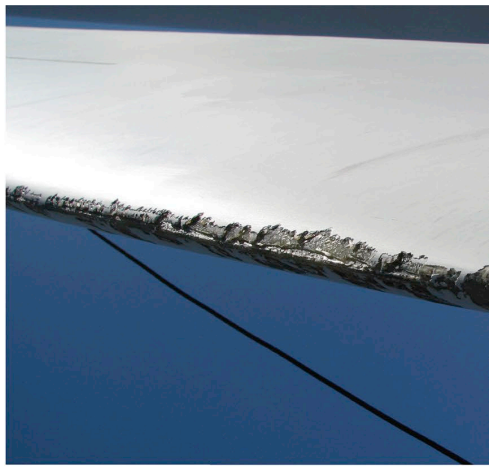
LEADING EDGE EROSION (LEE)
THE PROCESS

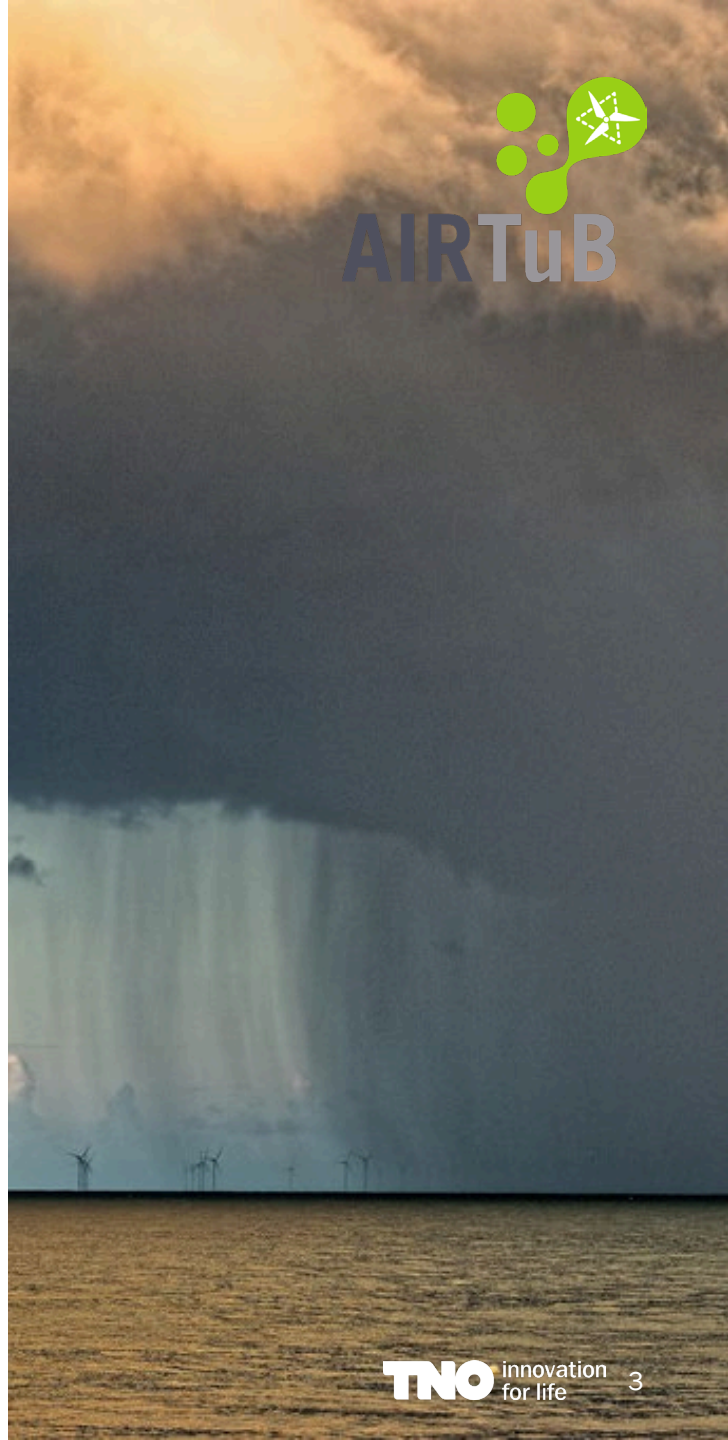
- The process LEE 'water droplet impact erosion'
  - Problem with the high tip speeds (up to 90m/s)
  - Fatigue related, brittle cracking related or a combination
- LEE damage of wind turbine blades results in
  - High O&M costs, downtime, reduction AEP





AERODYNAMIC EROSION DAMAGE MODELLING ON WIND TURBINE BLADES

- Goal
  - Erosion modelled on blade section level corresponding loss in AEP through a standard BEM code
- First part "LEE damaged surfaces"
  - Aerodynamic performance of scanned eroded wind turbine blade sections using RANS CFD
  - Focused on modelling the actual shape change (10 – 20 mm) at the blade leading edge due to erosion
- Second part: "roughened surfaces"
  - Development and calibration of transport equation based boundary layer transition model for surfaces with distributed roughness
  - Focused on modelling the textural differences (0.10 - 0.20 mm) at the leading edge due to blade erosion or contamination



PERFORMANCE MODELLING OF DAMAGED LE USING CFD

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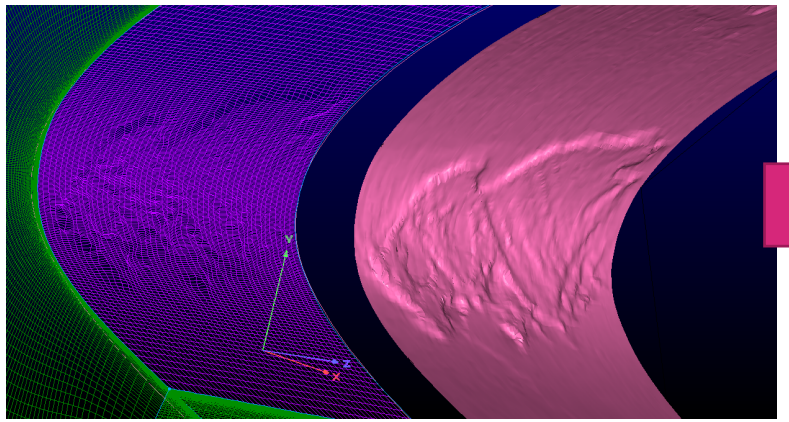
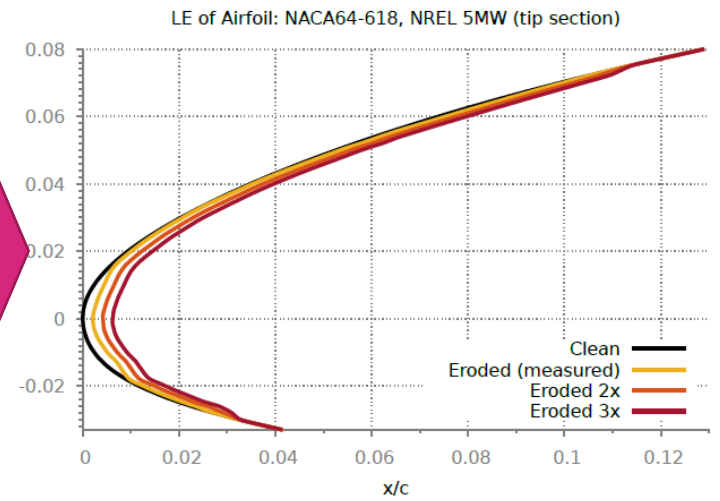
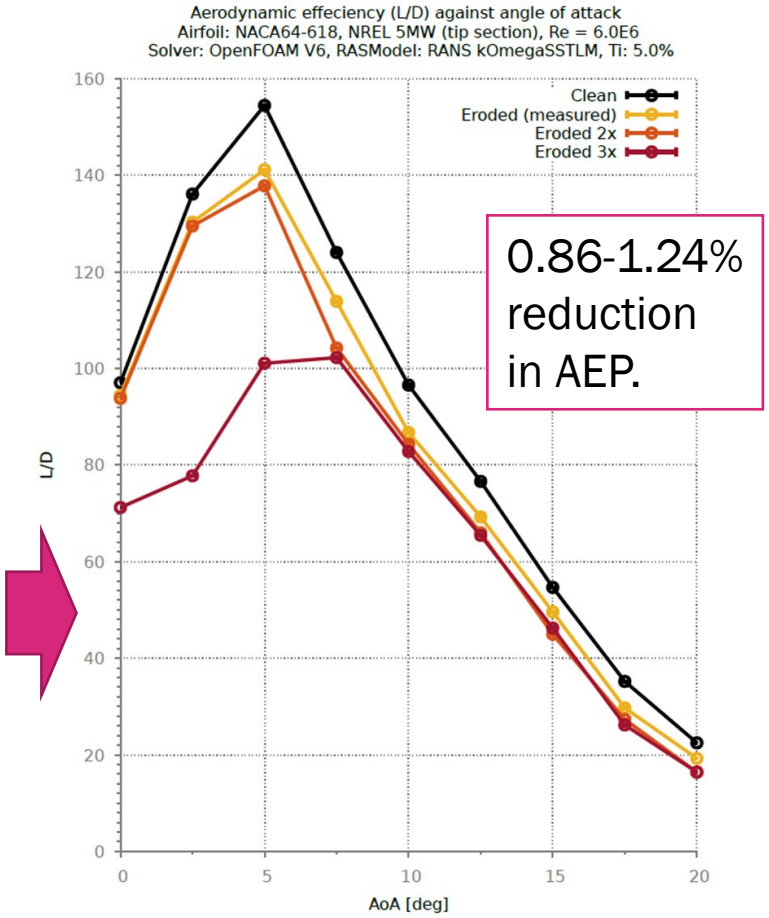
- 3D scanned LE into watertight mesh model
- Performance modelling of damaged blade profile
- CFD modelling at moderate Reynold numbers Re no ~3 million

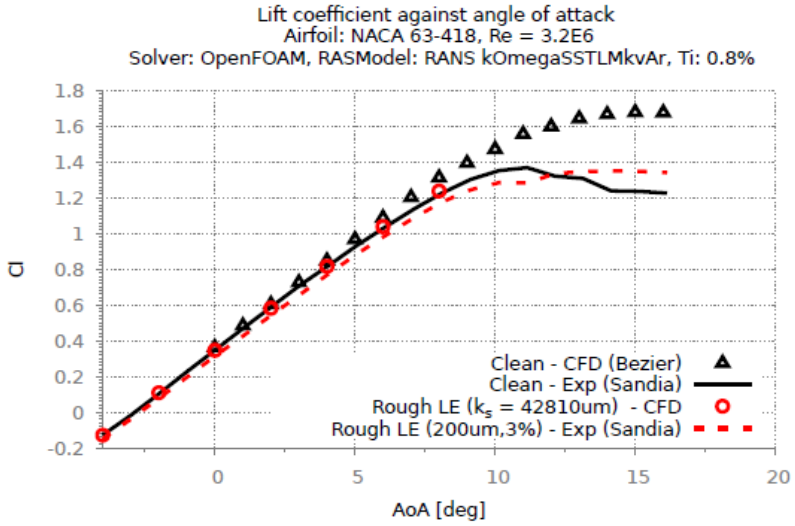


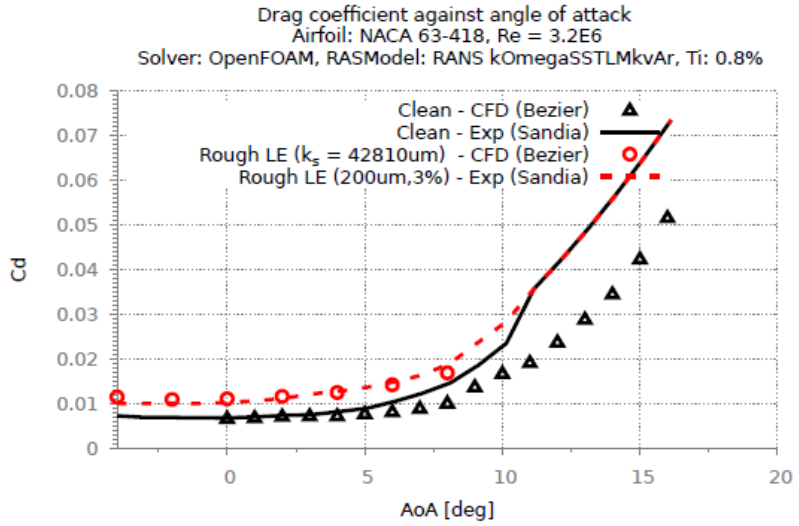


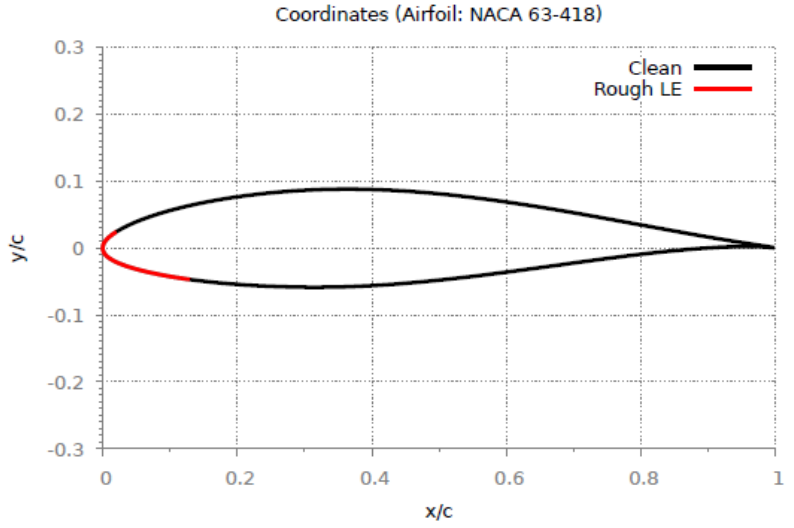


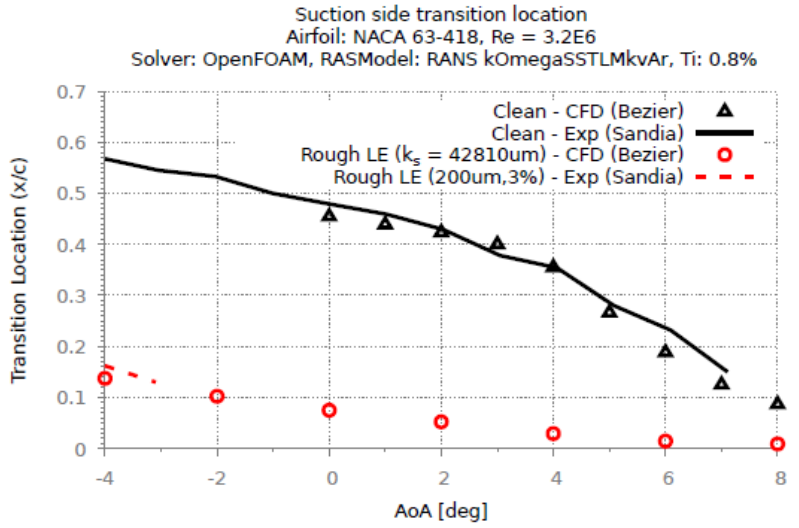
0.86-1.24% reduction in AEP.

PERFORMANCE MODELLING OF ROUGHENED LE USING SSTLM METHOD









- Result:
  - Roughness heights of 140um and 200um : very good agreement between the modelled and the experimented drag for the large
  - Roughness height 100 um roughness no correlation

CONCLUSION

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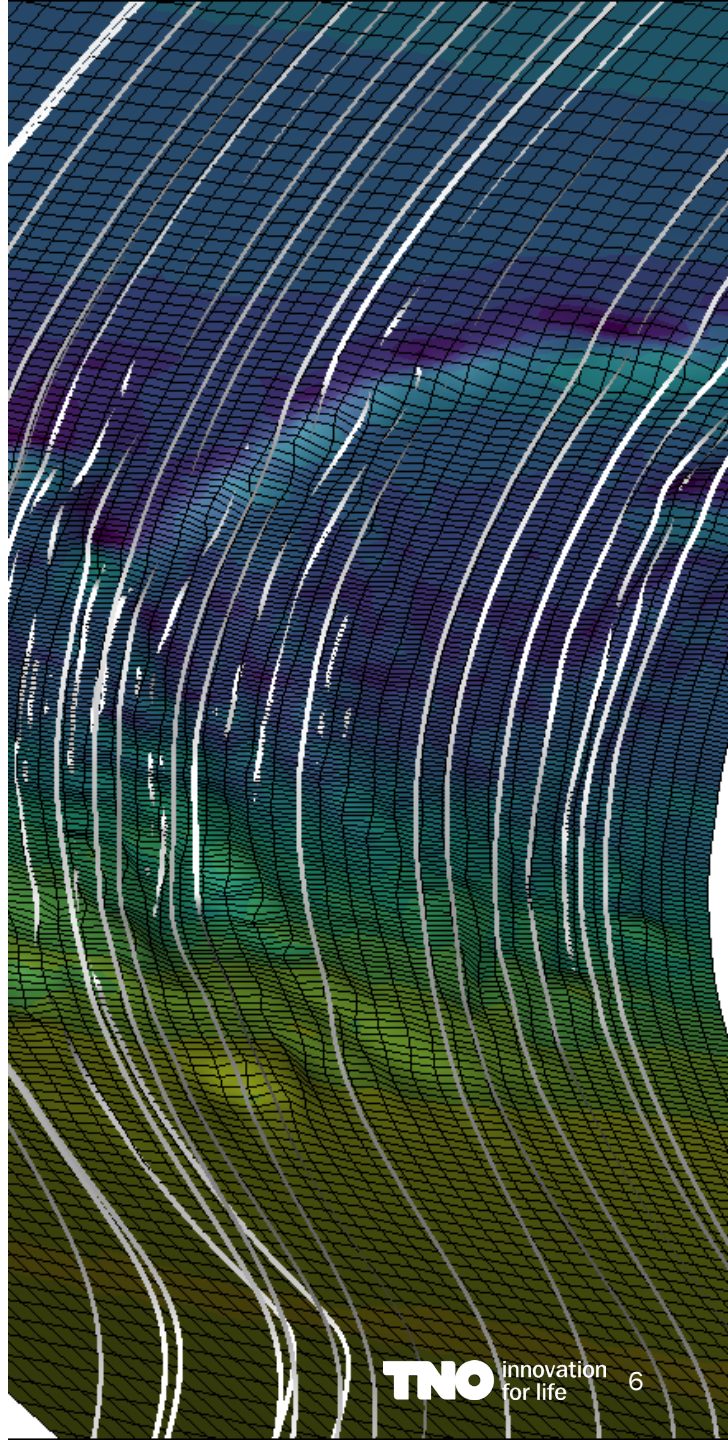
- Shape change due to erosion damage
  - Significant damage at the tip section
  - AEP reduction in the range of 0.86-1.24% is realised when the LE shape is eroded by >0.8% of the chord length
- Modelling transition for rough blade surfaces
  - Very good agreement with the measurement for leading-edge roughness heights in the order of 140-200um
  - For smaller roughness height of 100um, the model fails to accurately predict the measured drag forces



PUBLICATION
WIND ENERGY SCIENCE

- Please see our publication for more discussion and details on the results

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  - Many thanks to Sandia (Experimental data)

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THANK YOU FOR YOUR TIME!

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