

How much data is good data ?...

RAVE International Workshop 2023

11 May 2023

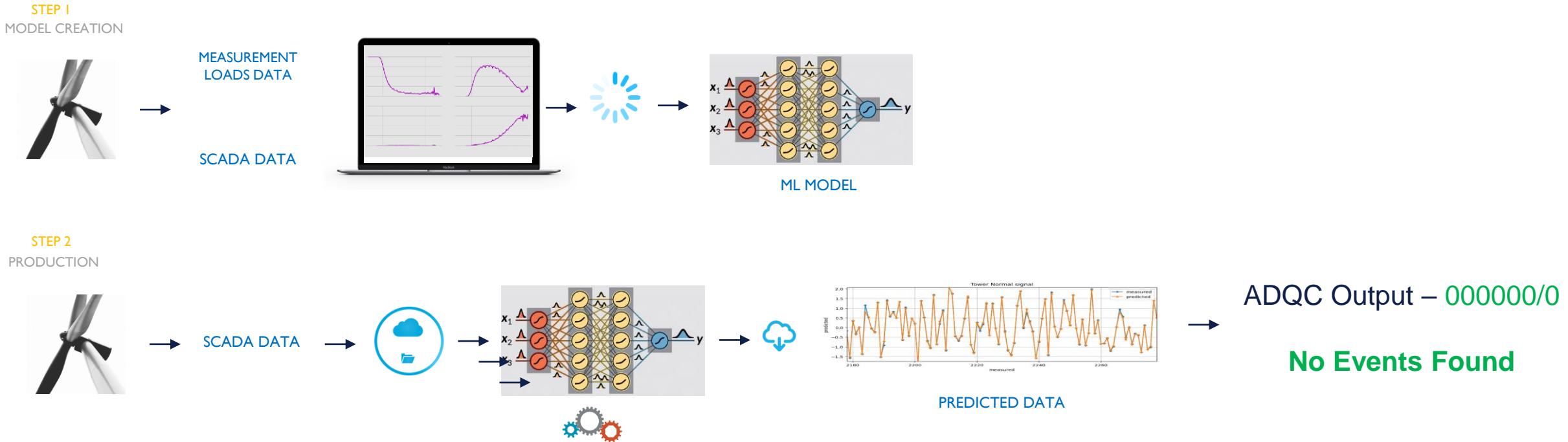
Anish Venu (28)

- Senior Data Science and Domain Expert
- Digitalization & Research
- 4 years with DNV

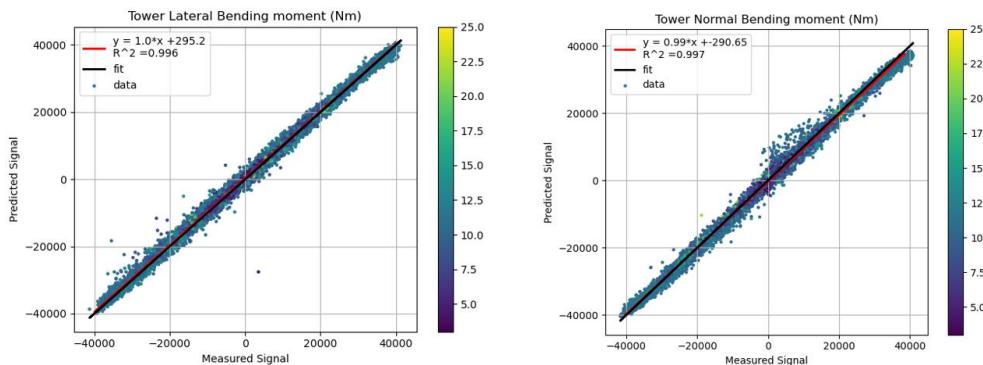
Agenda

- Introduction
- General Background
- Project Data – Research at Alpha Ventus (RAVE)
- Experiments & Results
- Future Works

General Background – Automatic Data Quality Control (AQCC)



Performance/Results



Questions

- What are the minimum needed inputs & how is the model influenced with additional inputs ?
- How much data we need ? More data more accuracy ?

Project Data – Research at Alpha Ventus (RAVE)

- The research Initiative RAVE carries out research and development work on the offshore test field alpha Ventus.
- RAVE is funded by the Federal Ministry for Economic Affairs and Climatic Actions (BMWK) and coordinated by the Fraunhofer Institute for Wind Energy Systems (IWES).
- In more than 30 research projects, more than 60 partners from science and industry have been working on a wide range of research questions since 2008.
- The financial support from the BMWK so far amounted to more than 50 million euros.

Wind Farm Outlook

- 45 Km North von Borkum
- 30 m water depth
- 12 Wind turbines
 - 6 AREVA WIND M5000
 - 6 Senvion 5M
- CAPEX : 250 Million Euros
- More than 10 years of measurement data



Experiments/Results

What are the minimum needed inputs & how is the model influenced with additional inputs ?



SCADA

- Yaw angle
- Generator speed
- Pitch angle
- Electrical power
- Wind speed
- Rotor position

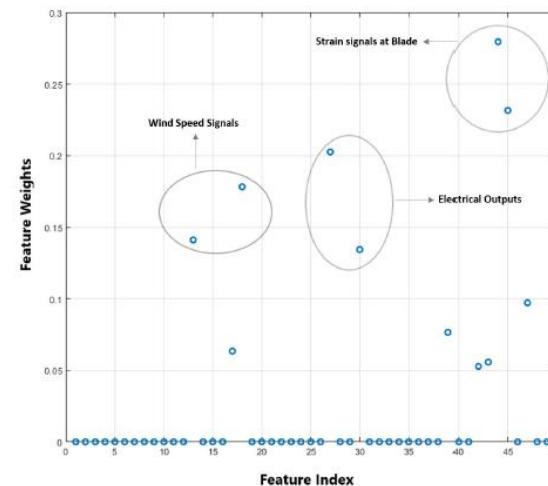
Tower bottom acceleration

- Acceleration X direction
- Acceleration Y direction

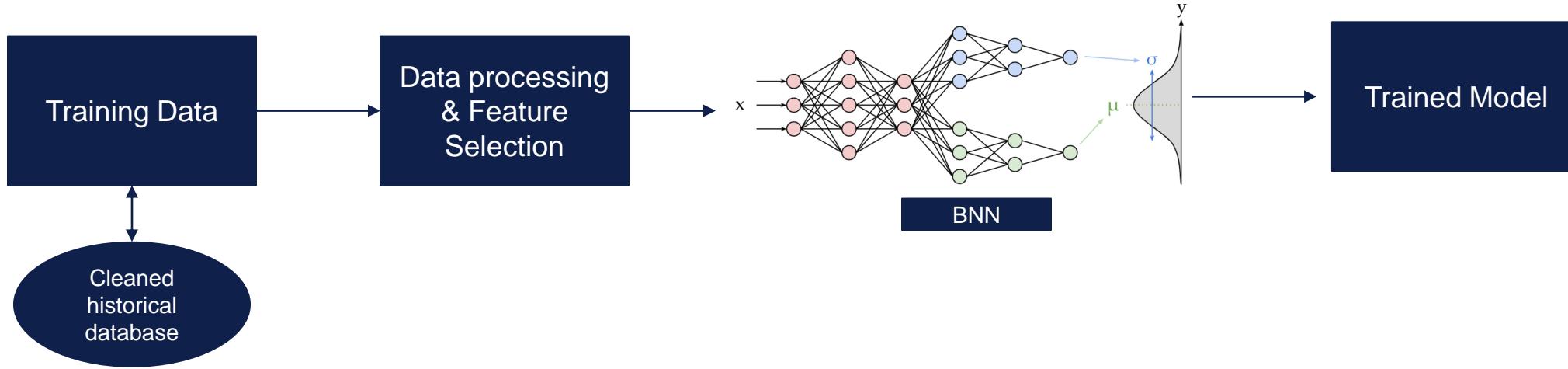
Temperature

- Temp – blade root
- Temp – tower sections
- Temp – nacelle cooling

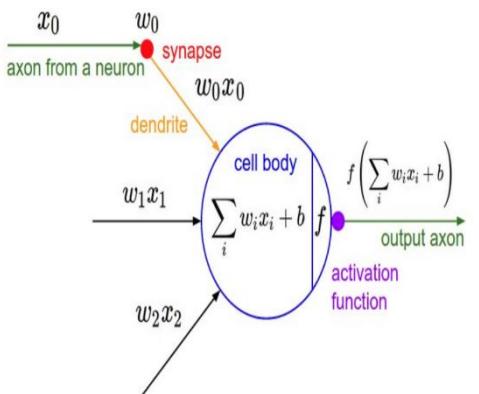
- Neighbourhood component analysis was performed to select potential inputs
- Approx. 4 years of cleaned database was used
- No status filters are applied



Experiments/Results - Bayesian Neural Network



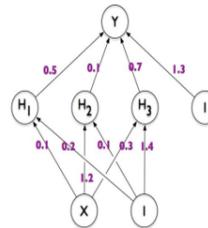
Neural network state of Art



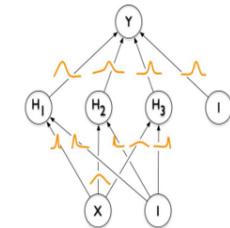
Conditional Probability : Bayes Theorem

$$P(A|B) = \frac{P(B|A) P(A)}{P(B)}$$

Standard Neural Net



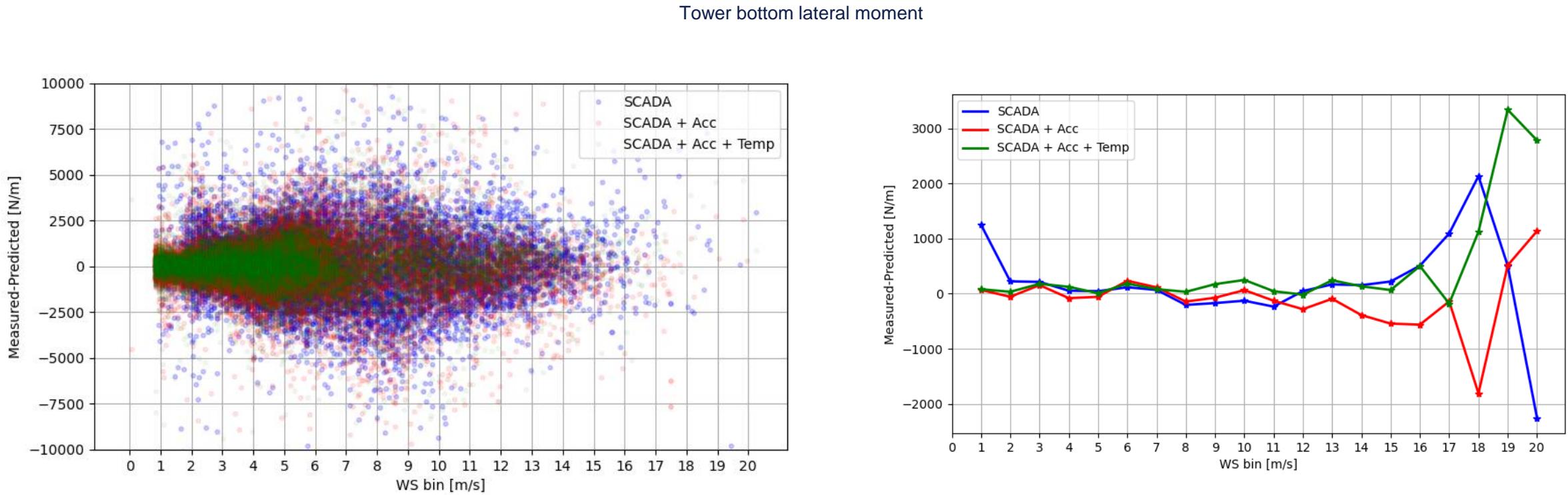
Bayesian Neural Net



- Parameters represented by *single, fixed values (point estimates)*
- Conventional approaches to training NNs can be interpreted as *approximations* to the full Bayesian method (equivalent to MLE or MAP estimation)
- *Regularization* arises naturally through the prior $P(w)$
- Enables principled *model comparison*

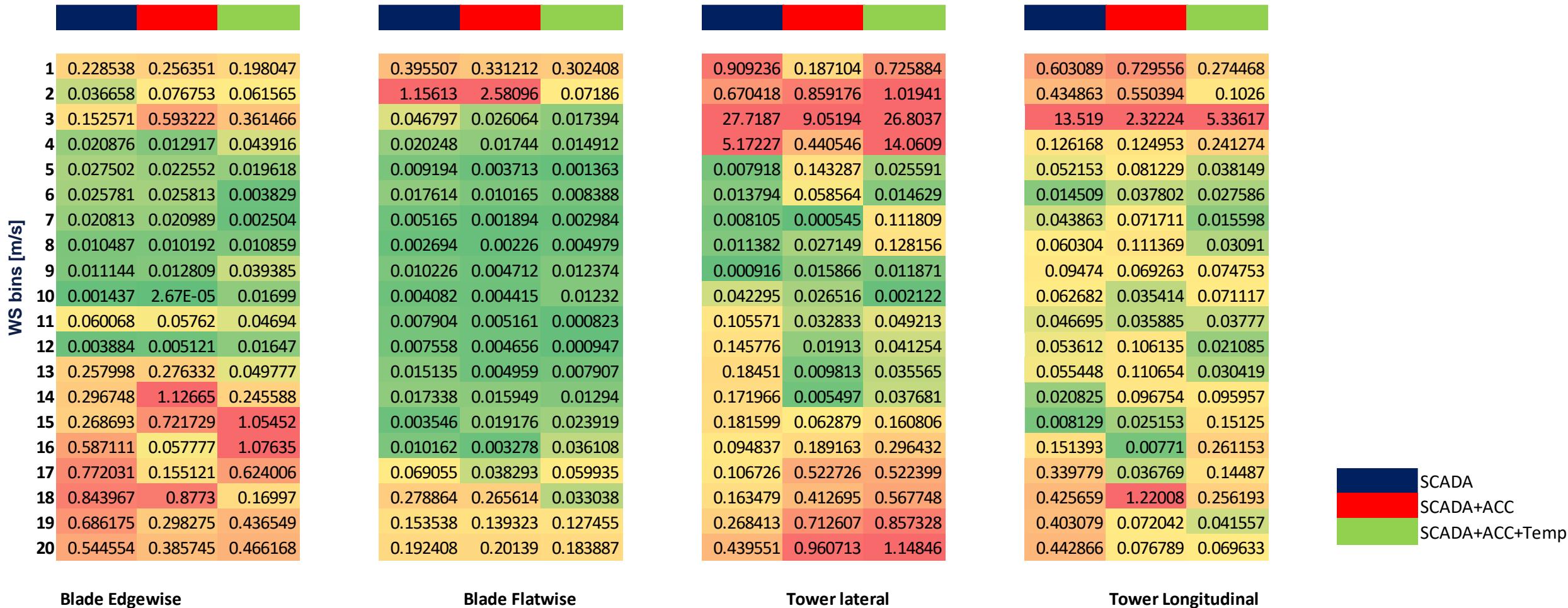
Experiments/Results

What are the minimum needed inputs & how is the model influenced with additional inputs ?



Experiments/Results

What are the minimum needed inputs & how is the model influenced with additional inputs ?



Blade Edgewise

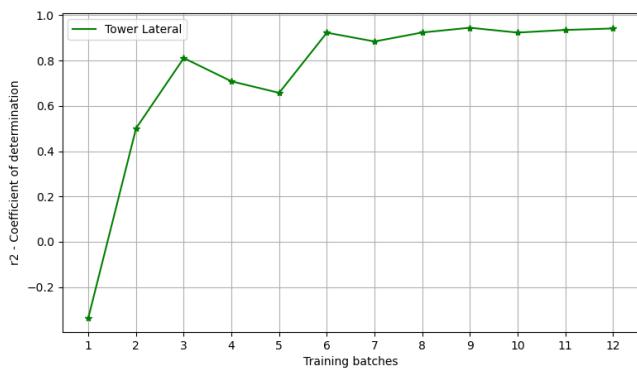
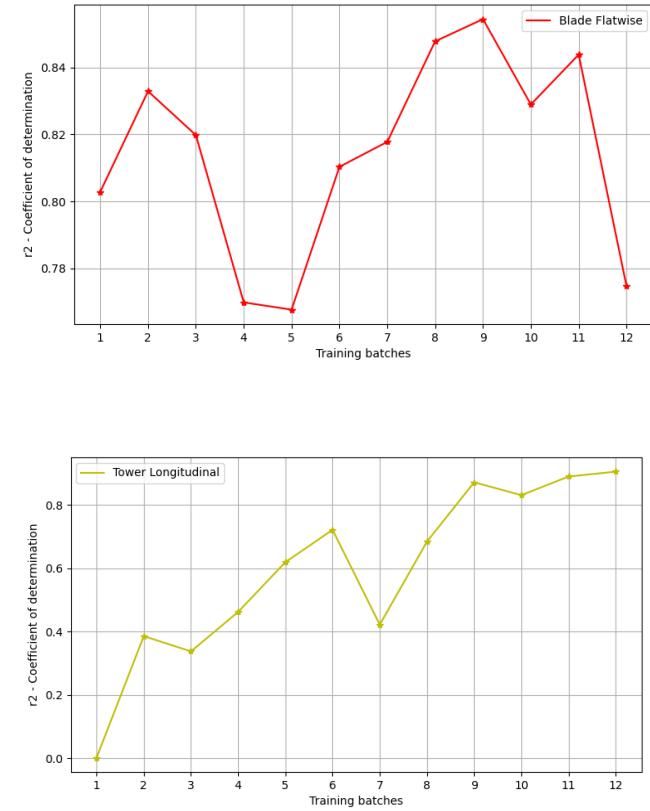
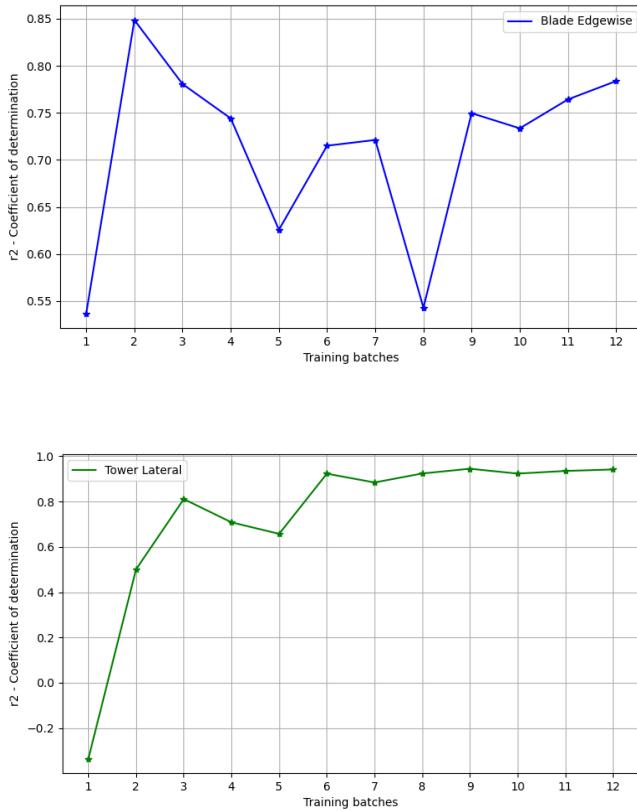
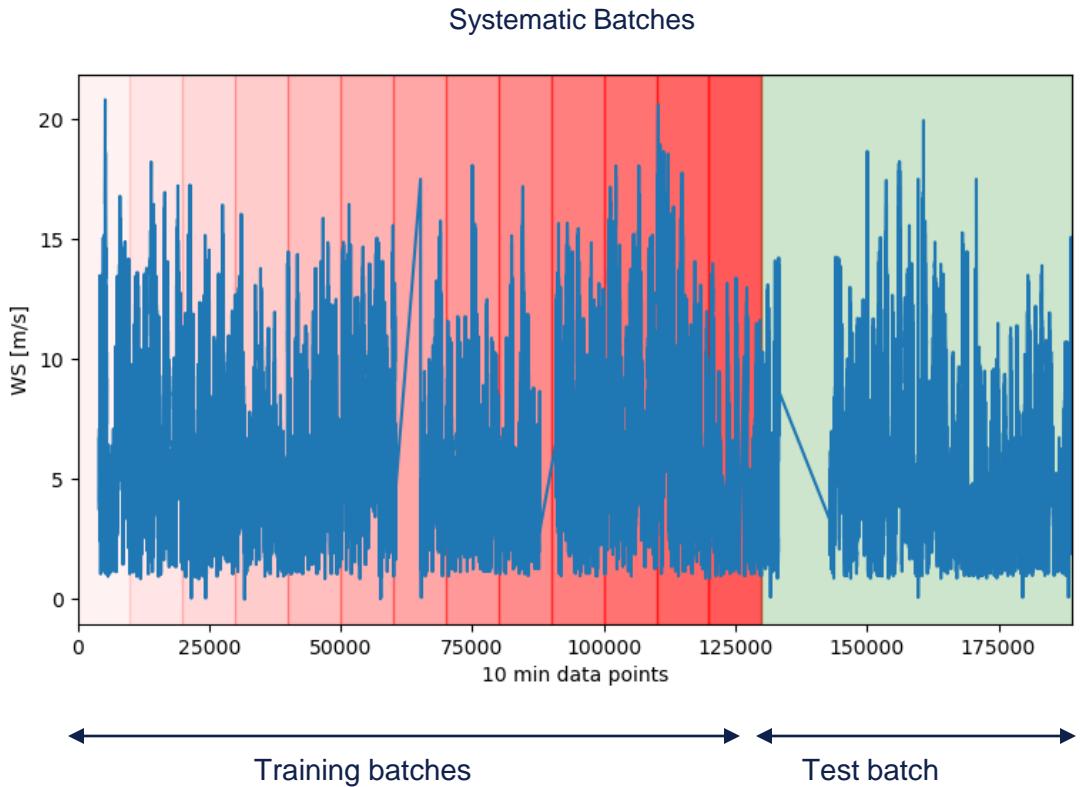
Blade Flatwise

Tower lateral

Tower Longitudinal

Experiments/Results

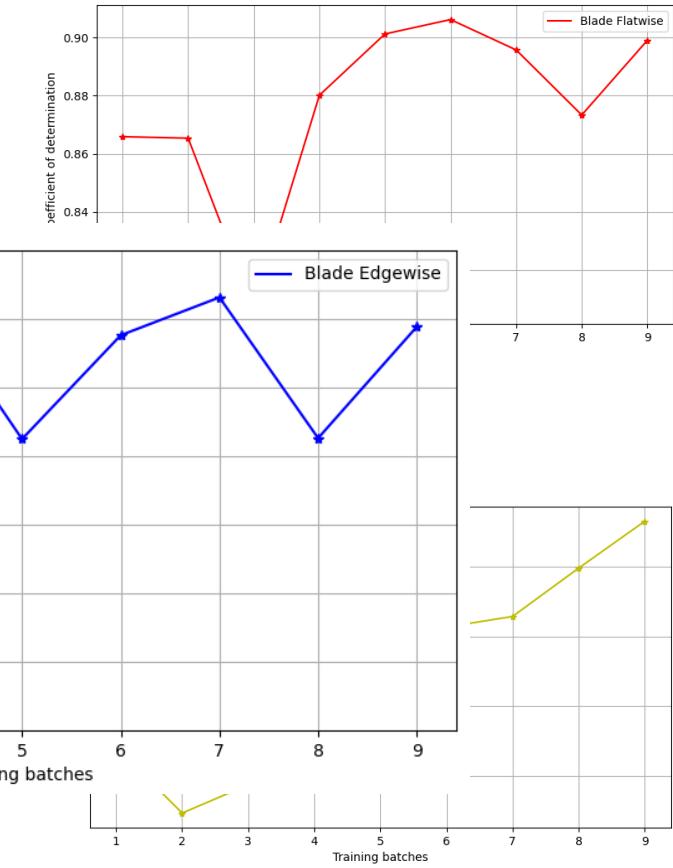
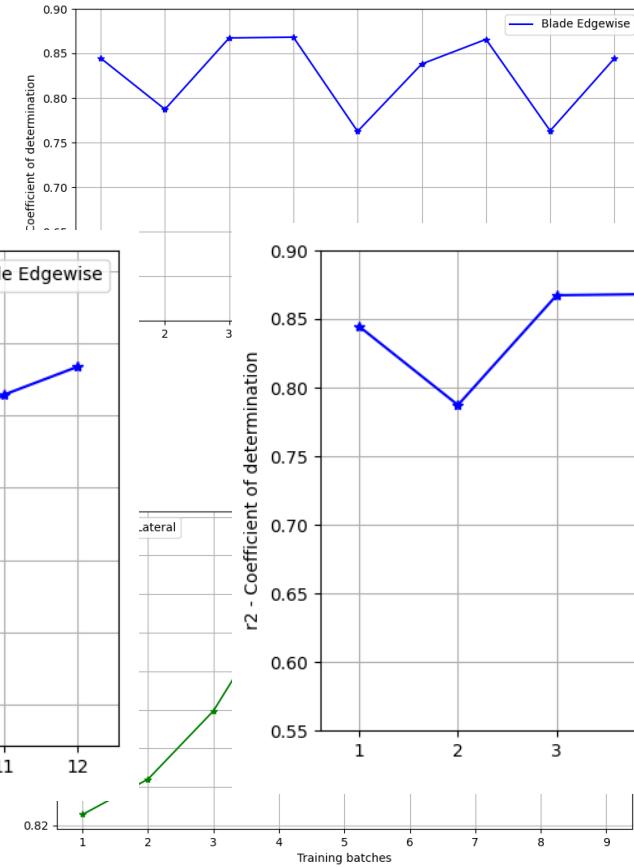
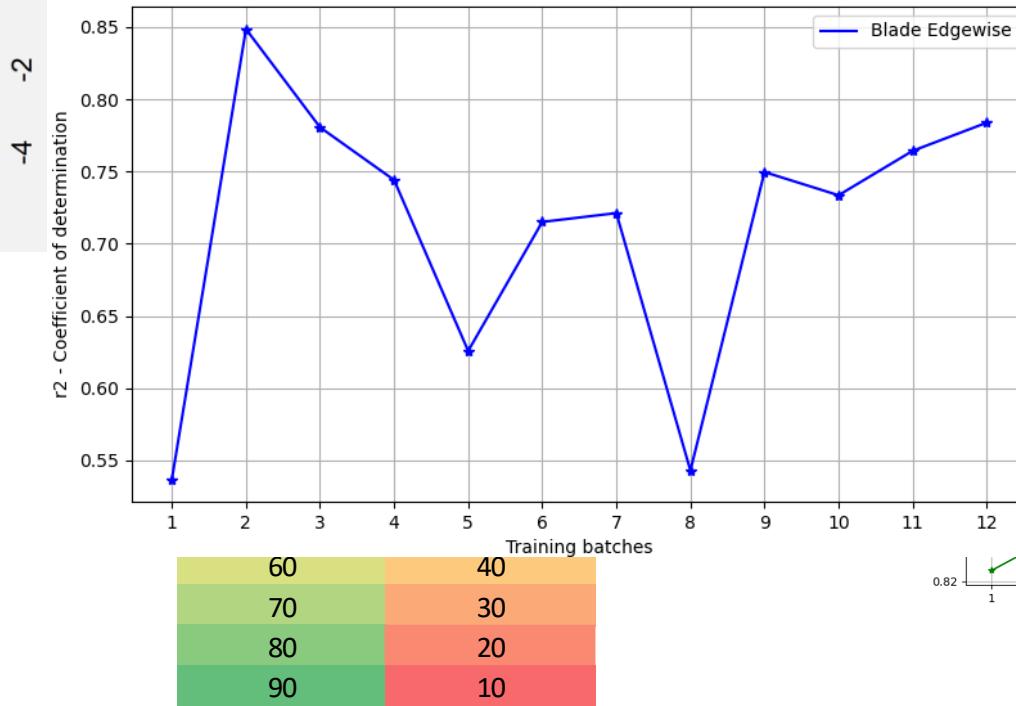
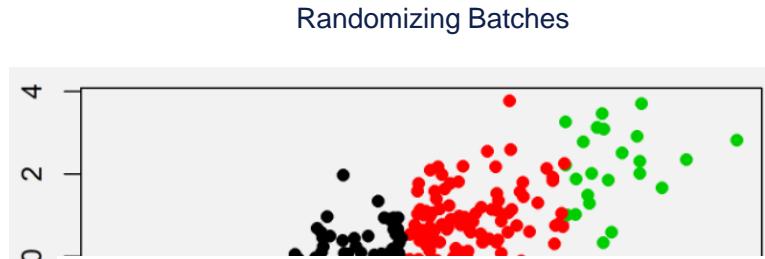
How much data we need ? More data ? More accuracy ?



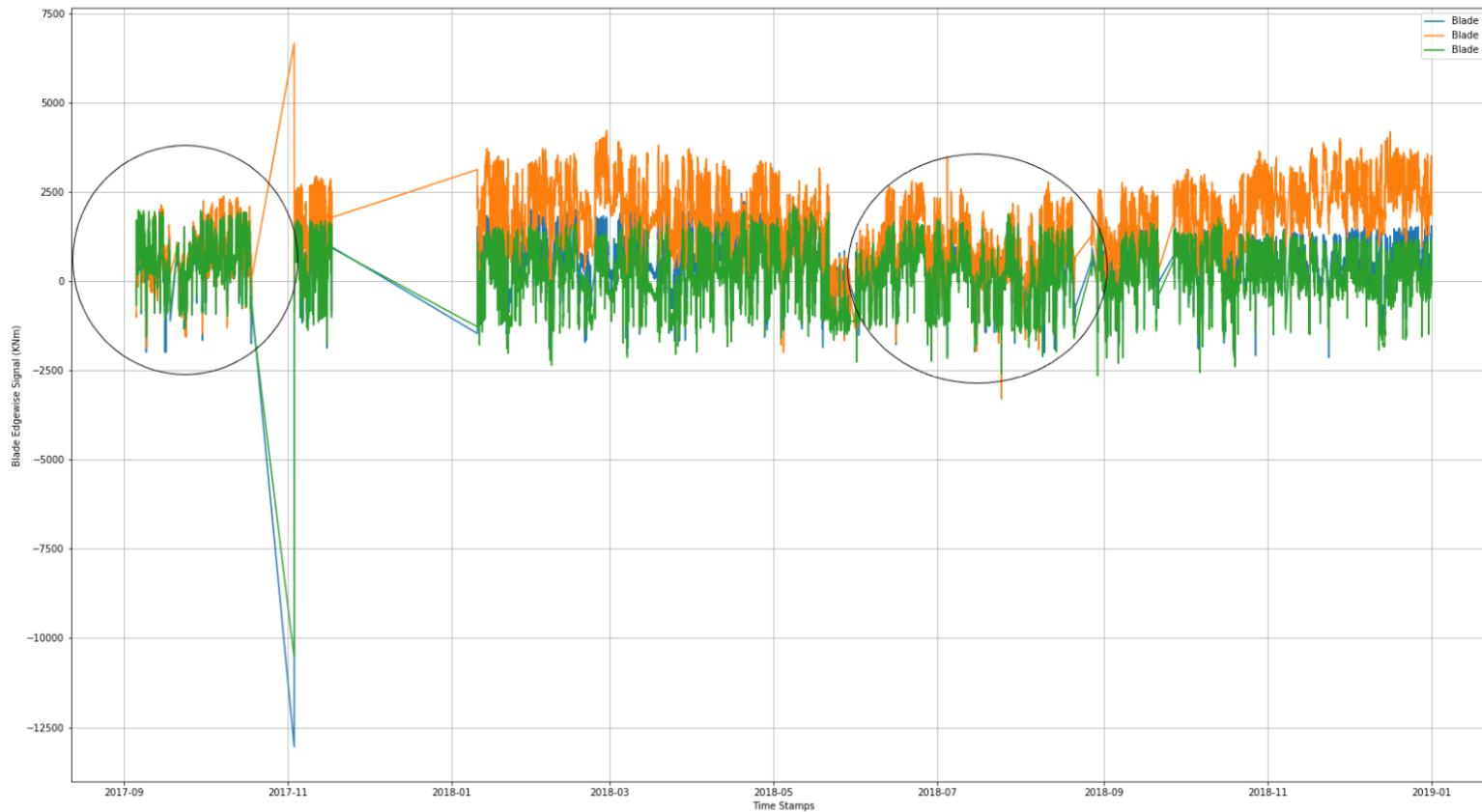
Coefficient of determination (R^2) = $\frac{\sum(\mu_{cup} * \mu_{lid})}{\sqrt{(\sum(\mu_{cup})^2) * (\sum(\mu_{lid})^2)}}$

Experiments/Results

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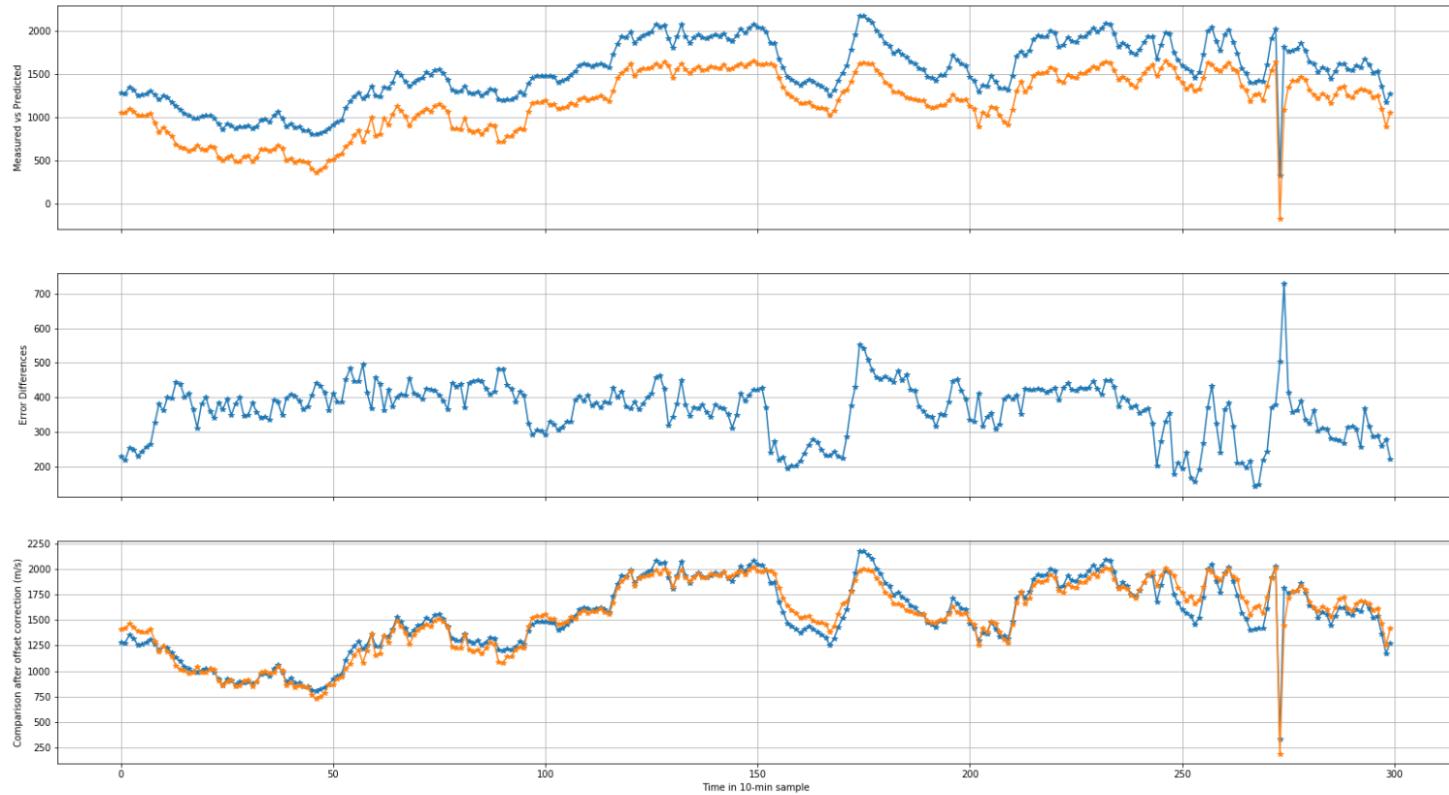
Experiments/Results



- Sensor installed and calibrated in Autumn (Black circles)
- Drifting problem in the other seasons

Experiments/Results

Detection of sensor drift in the blade signals due to temperature change



Measured vs Estimated



Error difference



Correcting the measured signal
based on prediction



BUNDESAMT FÜR
SEESCHIFFFAHRT
UND
HYDROGRAPHIE

Thank You



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