

Offshore Renewables Accessibility for Crew transfer, Loss Estimation & Safety (ORACLES)



Dr David McMillan
SUPERGEN Wind Hub
General Assembly

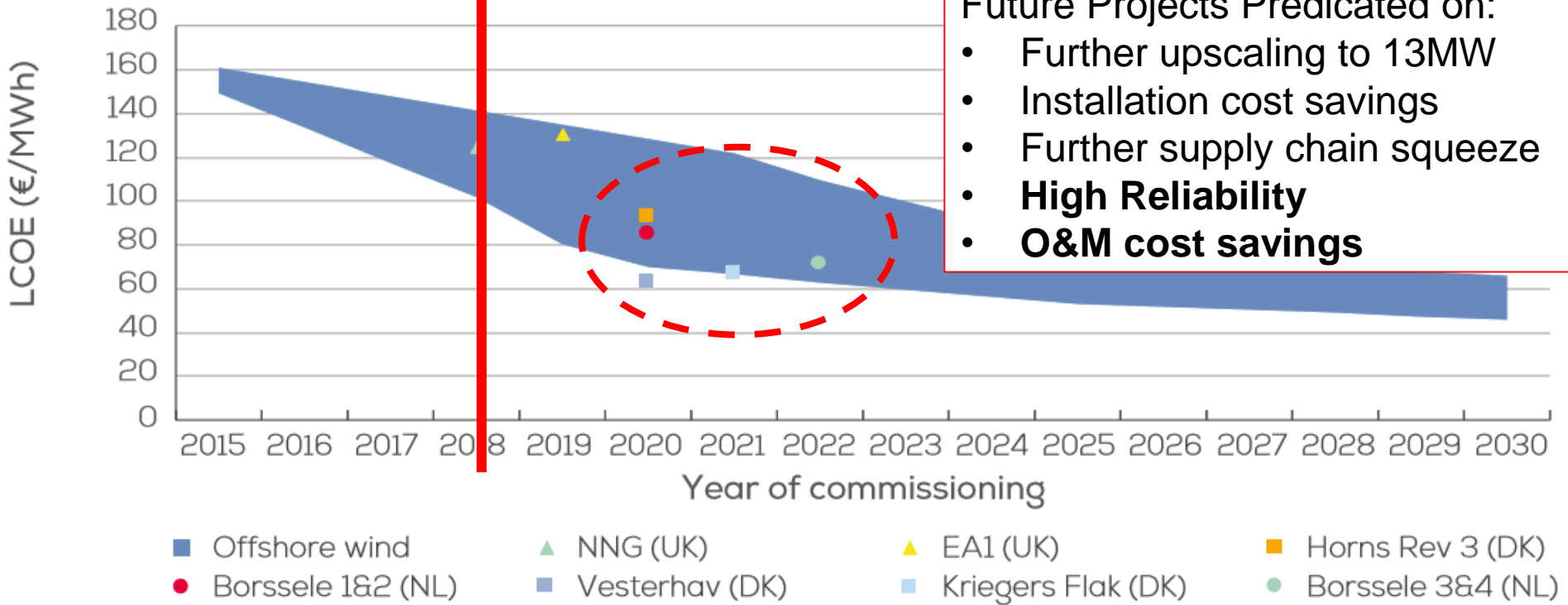
8th November 2018

Agenda

- Context: Why is access important?
- ORACLES objectives
- Engagement
- Early results
- The future

Good News/ Caveats

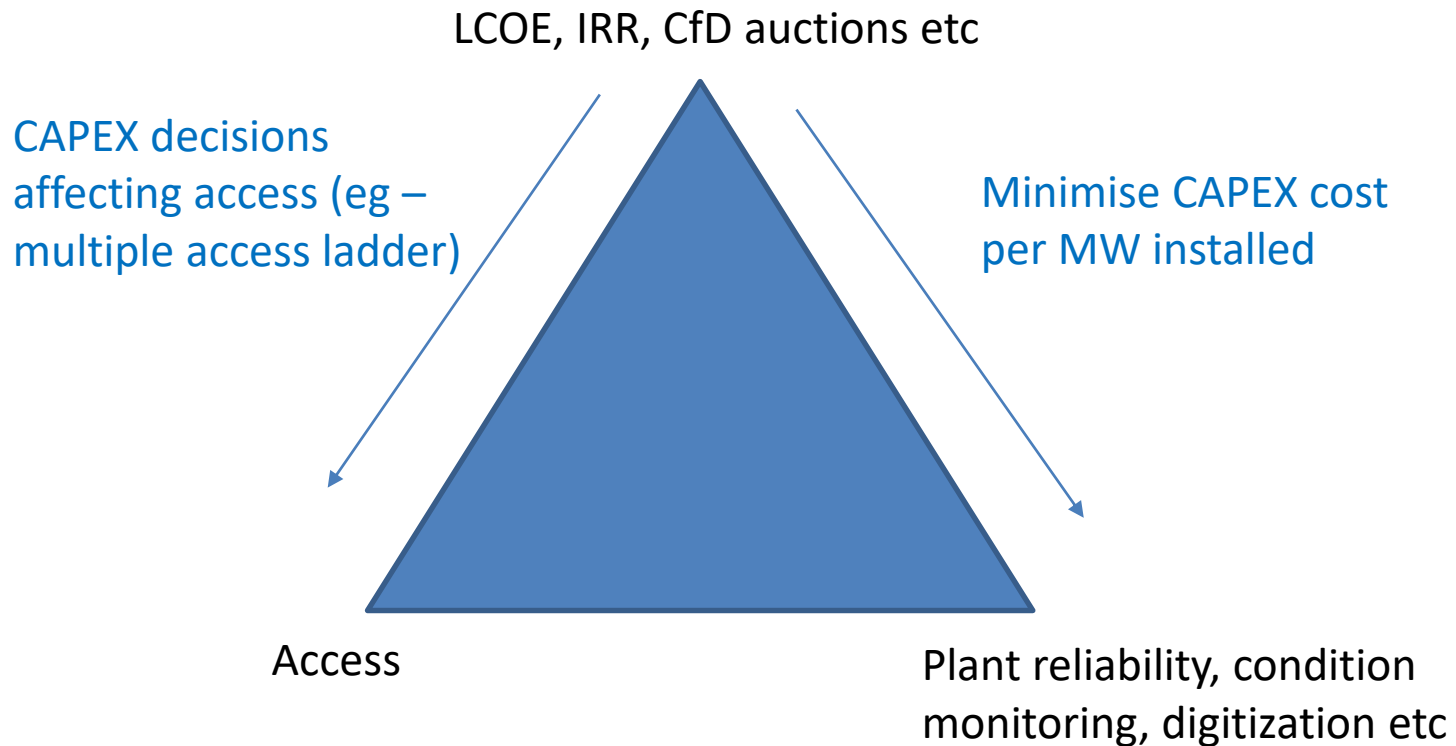
Offshore wind LCOE range and trajectory from 2015 to 2030, including estimated LCOE



Source: BVG Associates for WindEurope

Offshore Access and Money (1)

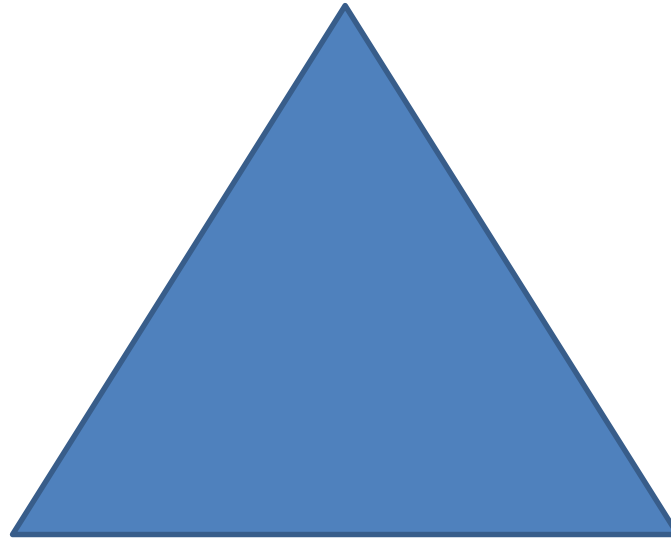
At FID



Offshore Access and Money (2)

In Early Operation

LCOE, IRR, CfD auctions etc



Access



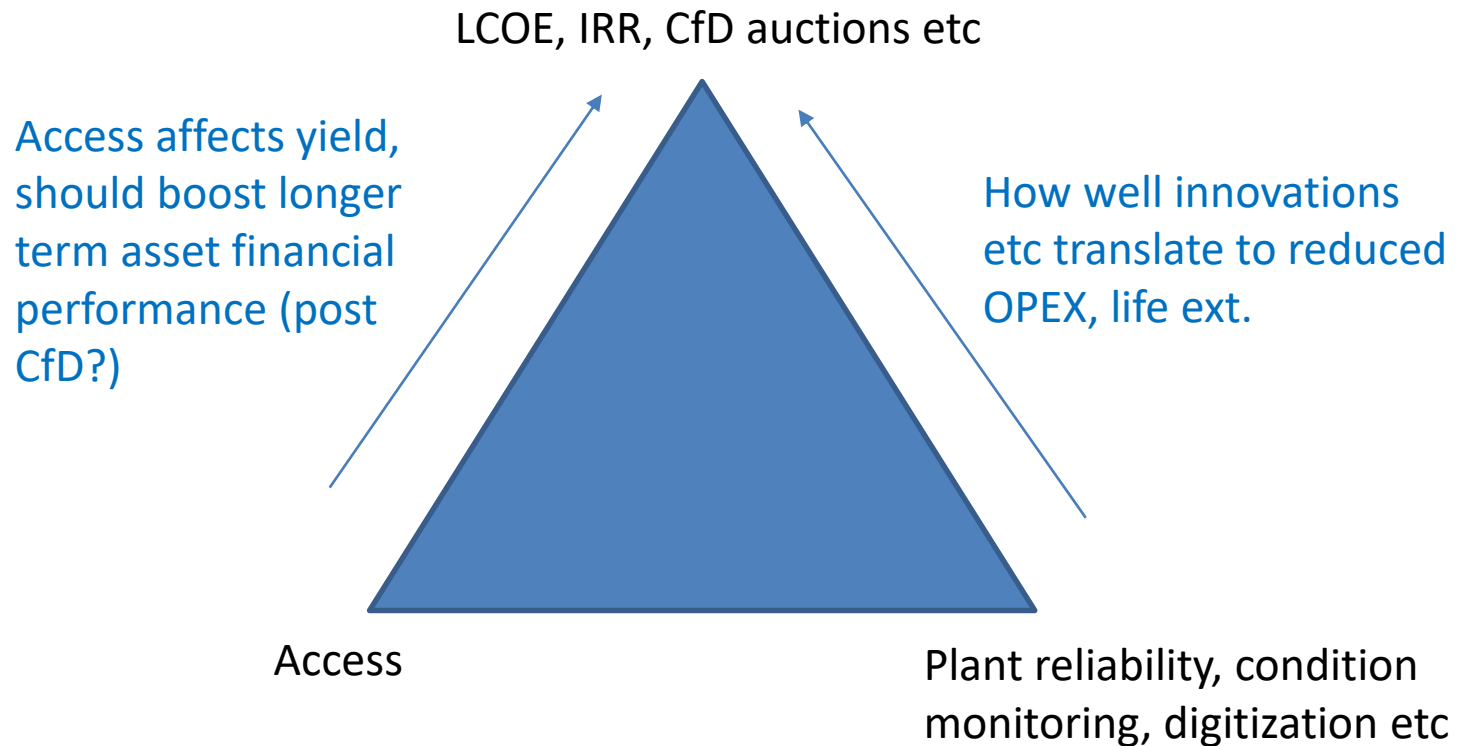
Plant reliability, condition
monitoring, digitization etc

Better use of
information should
increase accessibility

Better access should
increase reliability

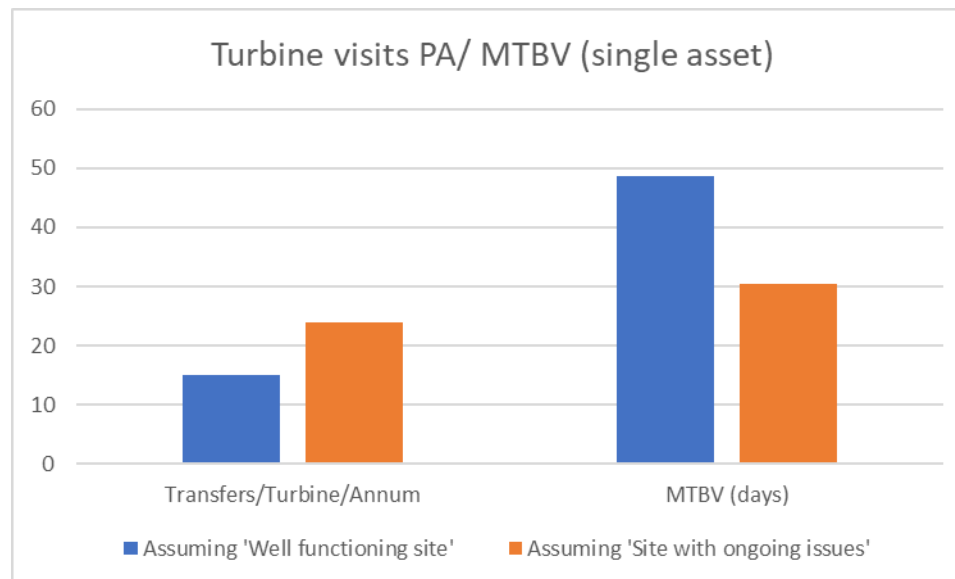
Offshore Access and Money (3)

Post CfD Operation/ Life ext

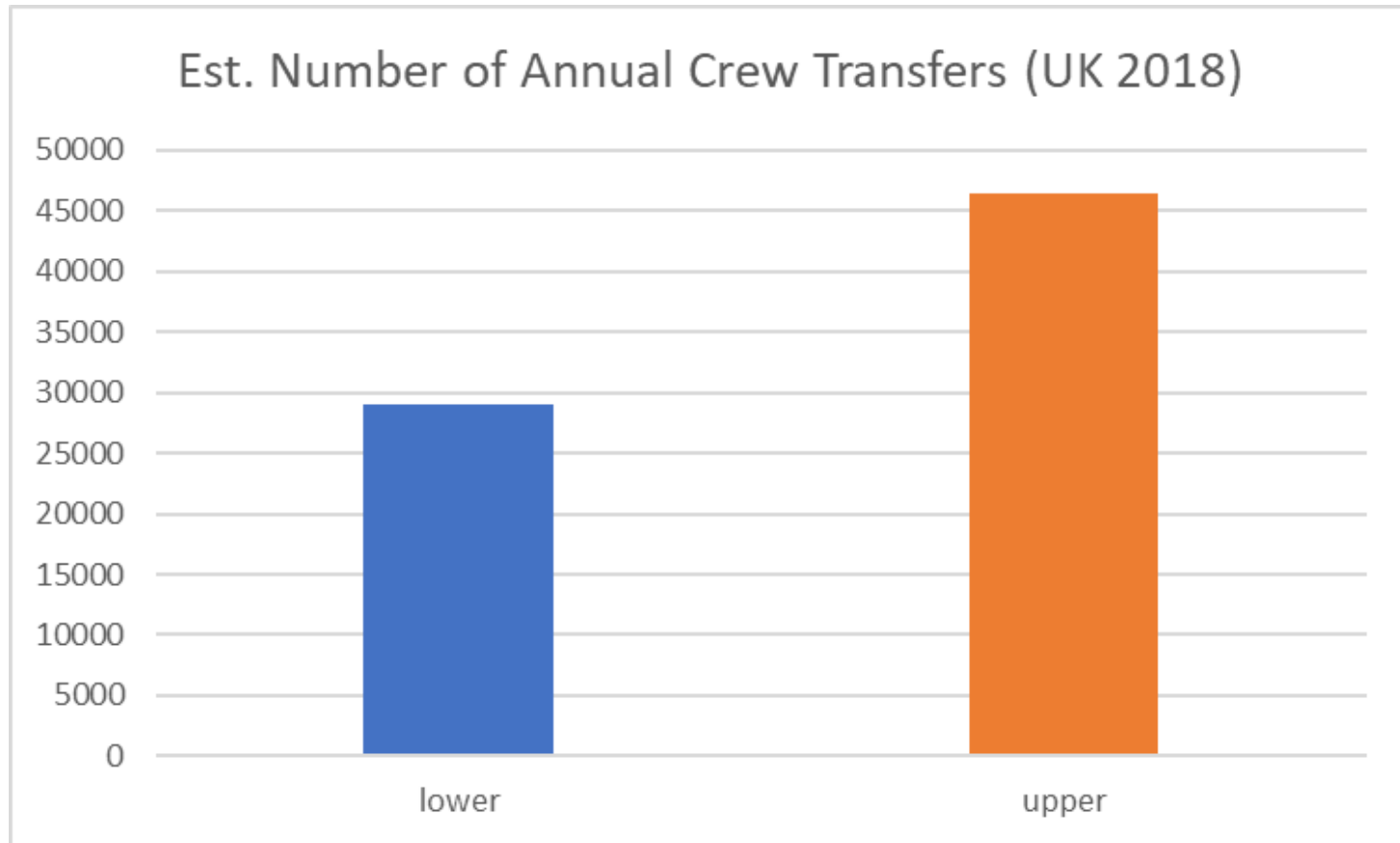


How many visits/ transfers?

- Published figures put this at 7-8 visits per turbine per annum (14-16 transfers) **ON AVERAGE**
- Known to be higher for some sites~ 10-12 visits pt/pa (up to 24 transfers)
- Implies waiting time -> lost production -> opportunity cost
- ~2000 operational offshore machines in the UK



Visits/ Crew transfers per annum



Interfaces/ **KPIs**

OEM

Contracted KPI
OEM Share Price

Owner/ operator

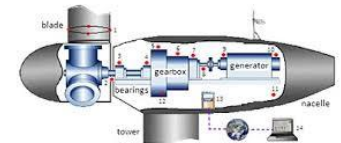
Production/ OPEX
Utility Share Price

Marine co-ordinator



Safety
Availability
Production Target/ Yield
OPEX

3RD Party CMS



1 --- fibre optic transducers; 2, 8 --- speed transducers; 3, 4, 5, 6, 7, 9, 10, 11 --- accelerometers; 12 --- oil debris counter; 13 --- online CMS; 14 --- PC at control center.

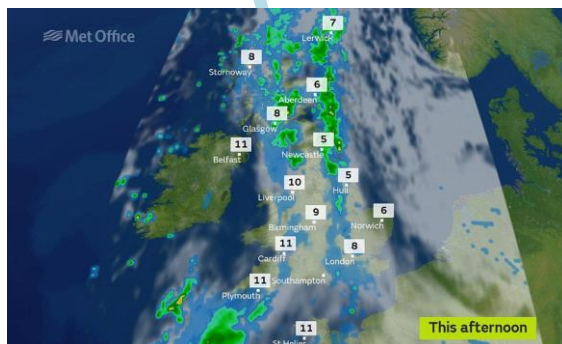
Fault detection accuracy
Downtime

Offshore technicians



Safety
Number of turbines restored

Weather/ MetOcean forecast



Accuracy metric

CTV/ SOV skipper



Safety

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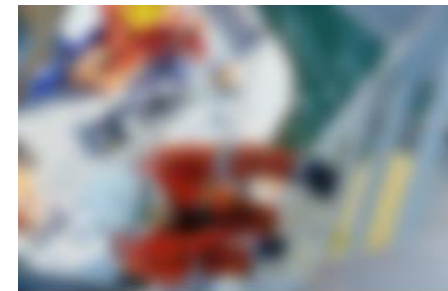
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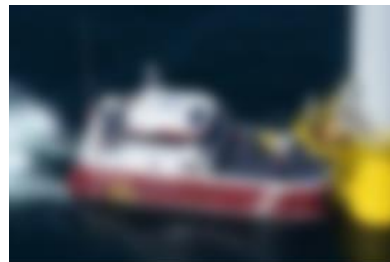
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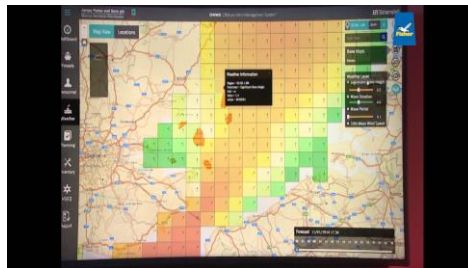
Interfaces/ **KPIs**



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Safety
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Fault detection accuracy
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Accuracy metric

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Safety

Overview of ORACLES

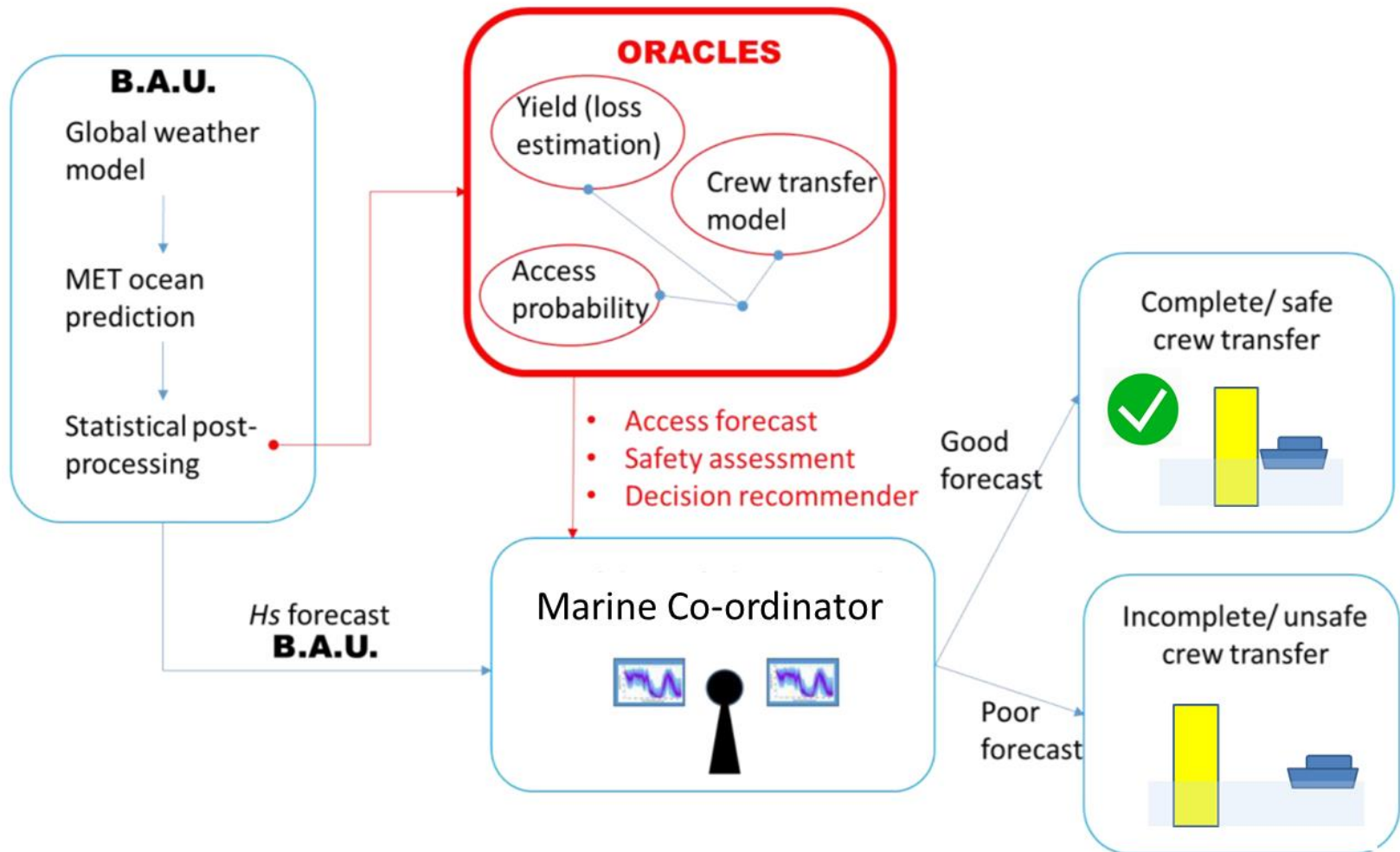
The pressure to achieve increased access to turbines implies a greater number of marginal-weather transfers, which carry a greater safety risk.

Develop a novel methodology to produce access forecasts:

1. The upside of a marginal-weather crew transfers in terms of cost and other KPIs
2. Safety/risk factors of the crew transfer itself
3. Develop the methodology in a way which better connects across site interfaces & KPIs

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Business as usual & ORACLES



ORACLES Team



David McMillan (PI), Jethro Browell, Ciaran Gilbert



Lars Johanning (CI), Giovanni Rinaldi



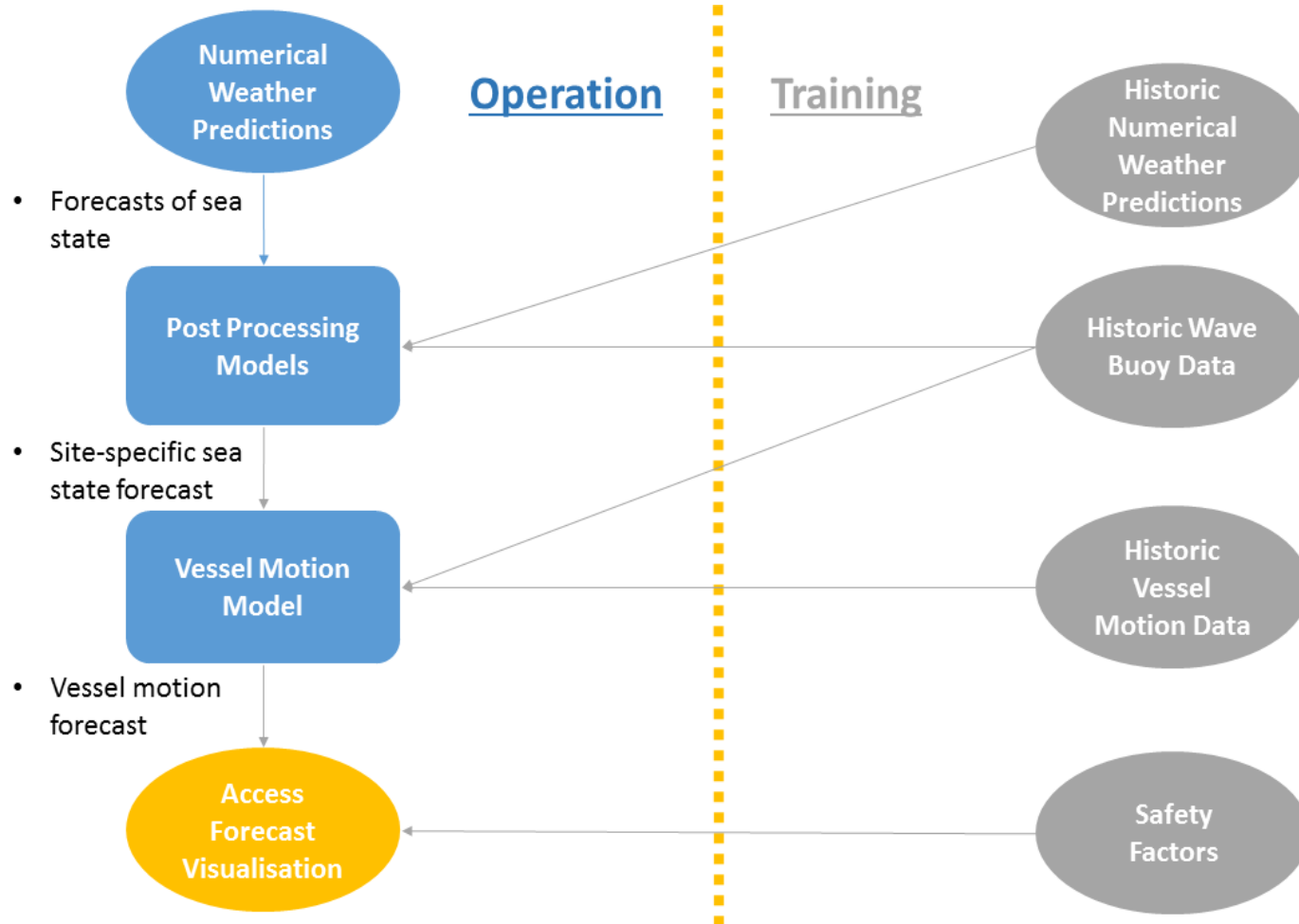
Pete Leach (Marine expert), Amine Hadjer (systems engineer), John Best (special projects)



Sally Shenton (CTO, 11 years of offshore ops experience)

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Inputs & Outputs



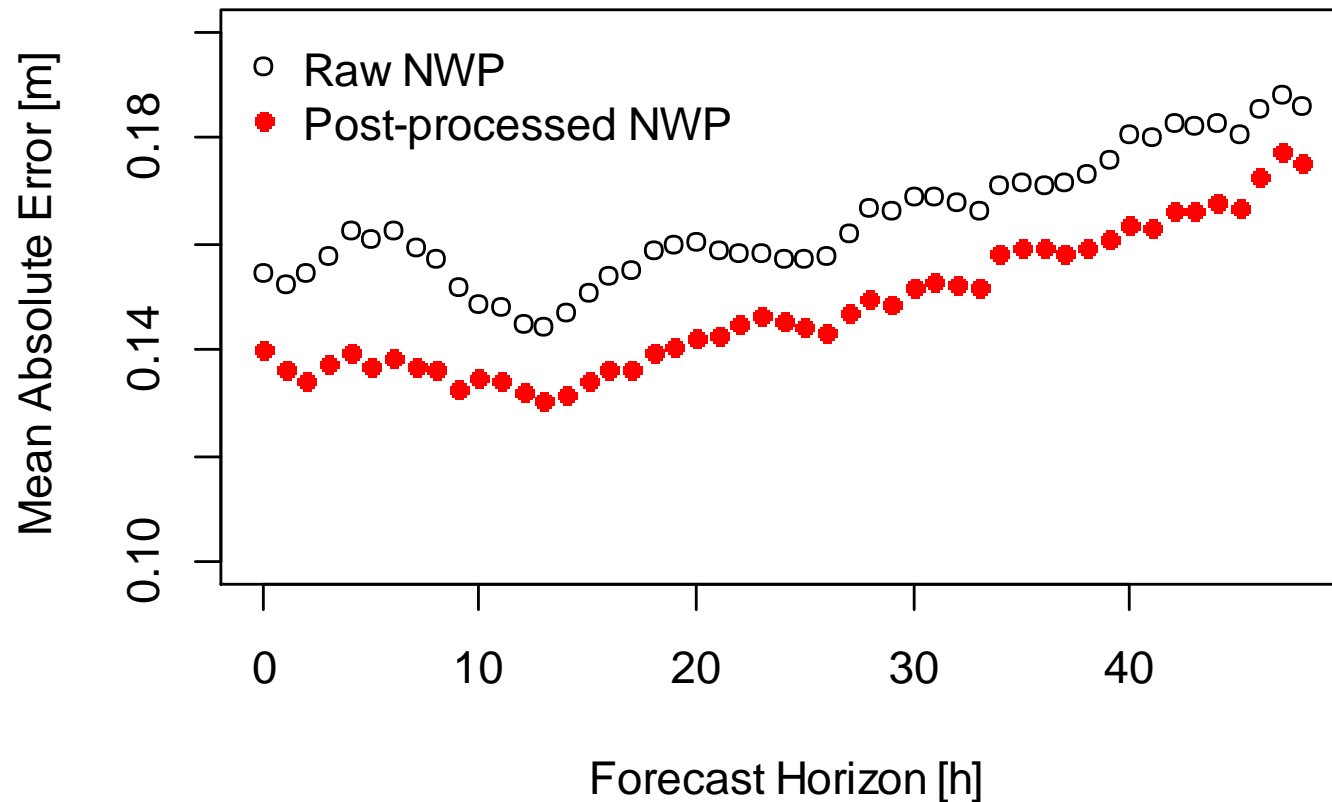
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Summary

- Generate **site specific probabilistic forecasts** of wave height/period/direction
- Use these as inputs to a **crew transfer model** which captures the boat motion characteristics during push-ons to generate an access probability
- Capture upside of decisions by **yield/KPI forecasts**
- Dependency Modelling (copulas)
- Decision Support & Safety information

Post-processing of weather FCs

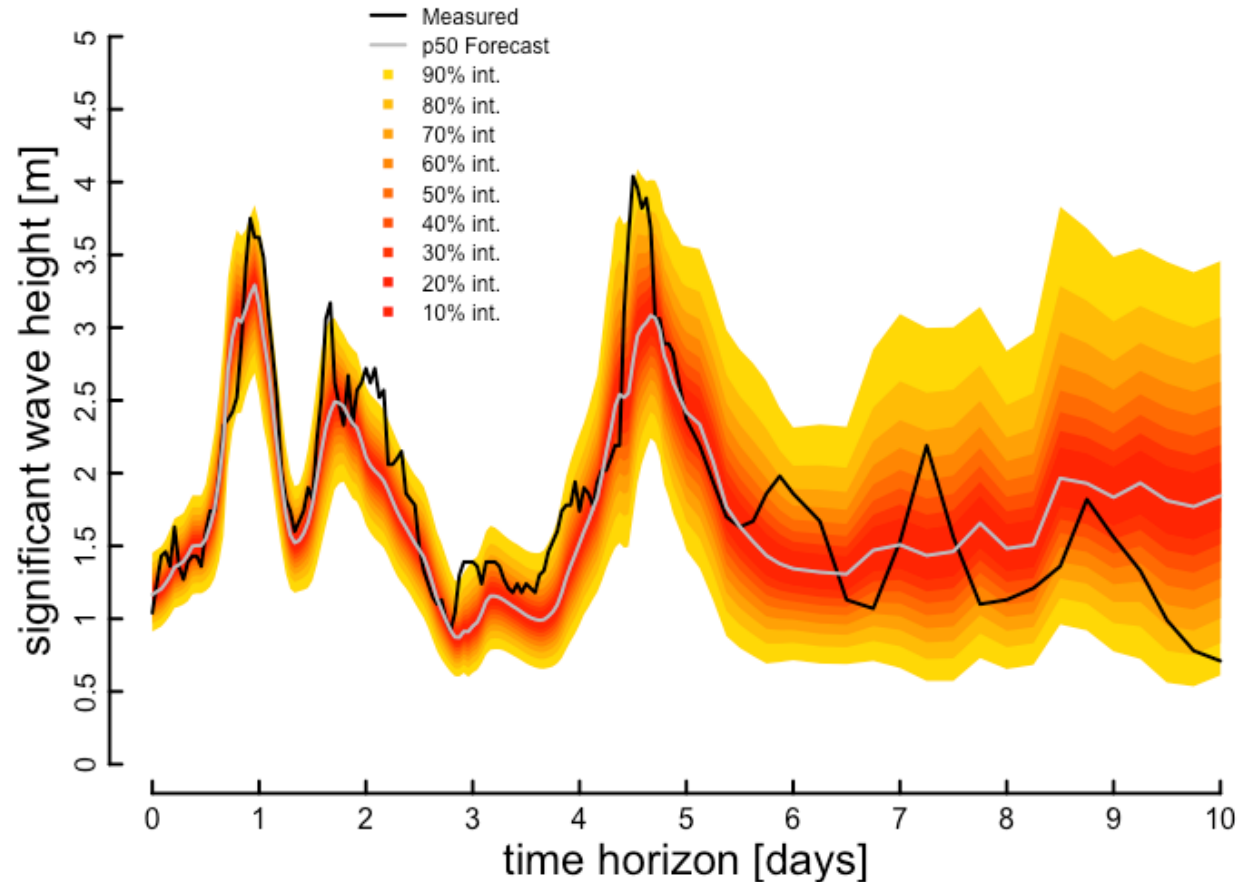
Significant Wave Height Forecast Error



Post-processing of weather FCs

Significant Wave Height: Probabilistic Density Forecast

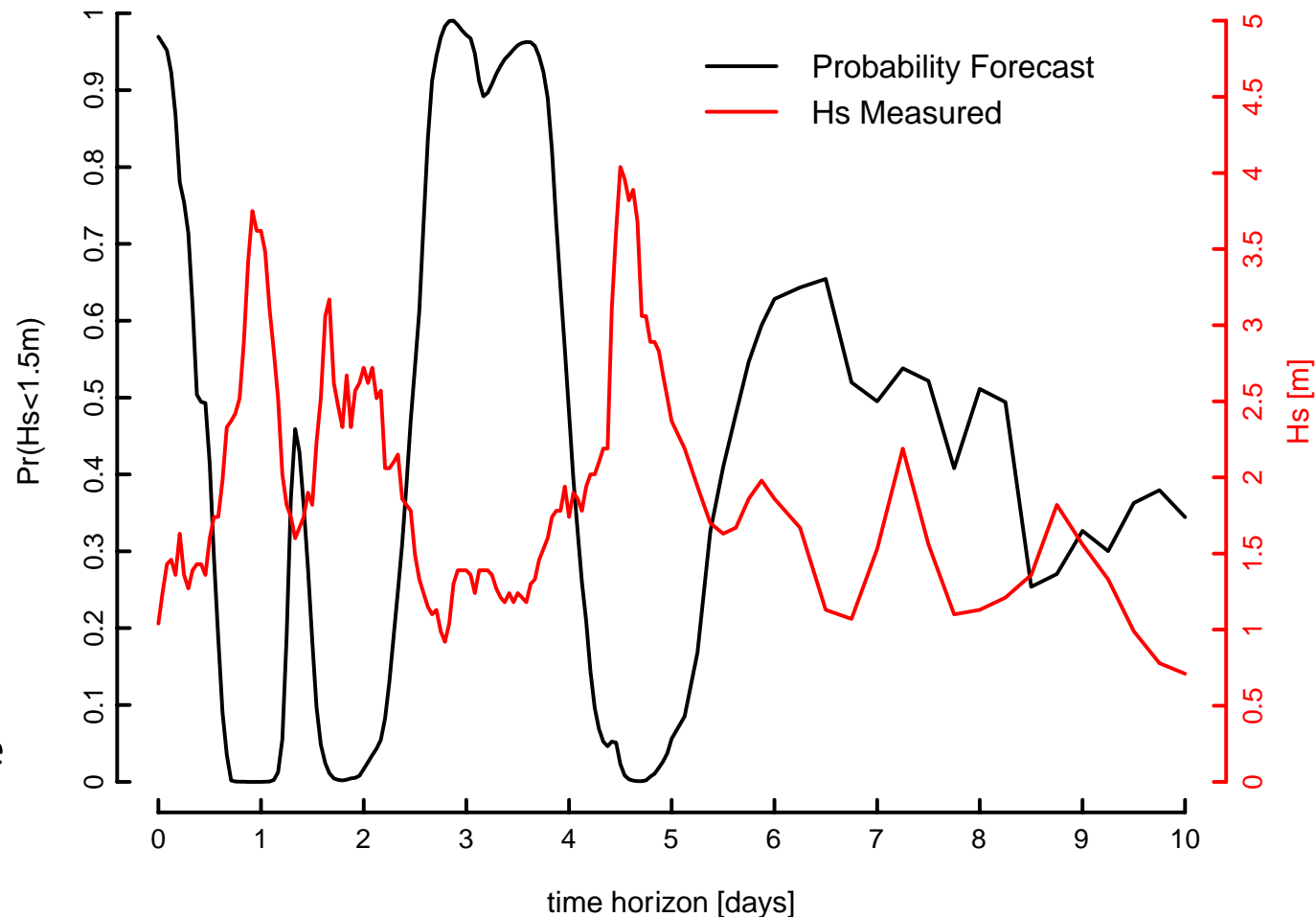
- Each time slice is a predictive distribution
- Each forecast line is a quantile
- 90% chance at each time step of observation falling in widest interval
- Need to ensure robustness for dependency modelling
- Up to 10 days ahead



Post-processing of weather FCs

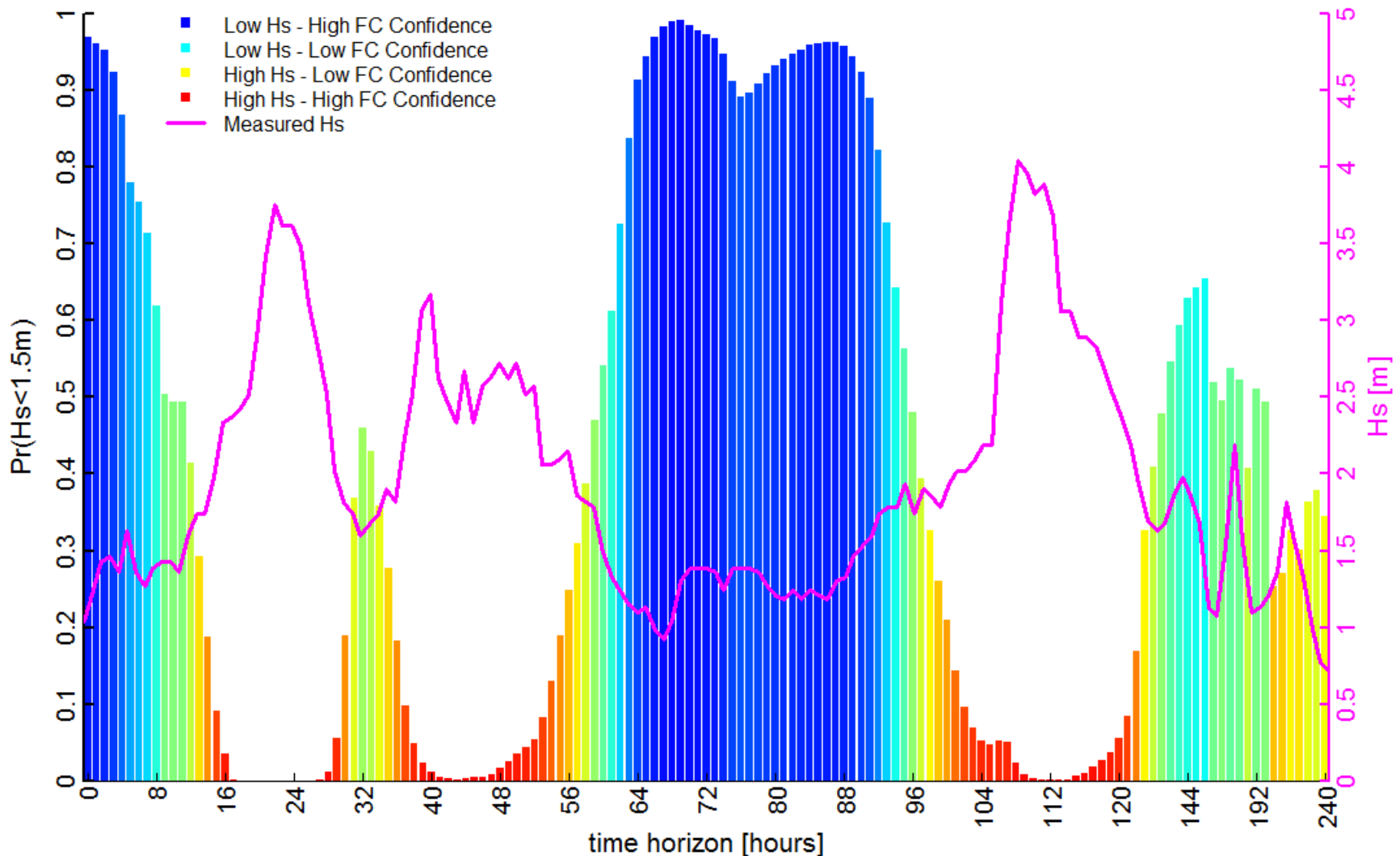
Significant Wave Height: Decision Making Example 1

- Forecast probability that H_s will be less than 1.5m
- Actual outcome of H_s on secondary y-axis
- Very useful forecast for up to 6 day-ahead scheduling
- Operator can define own “appetite” for risk



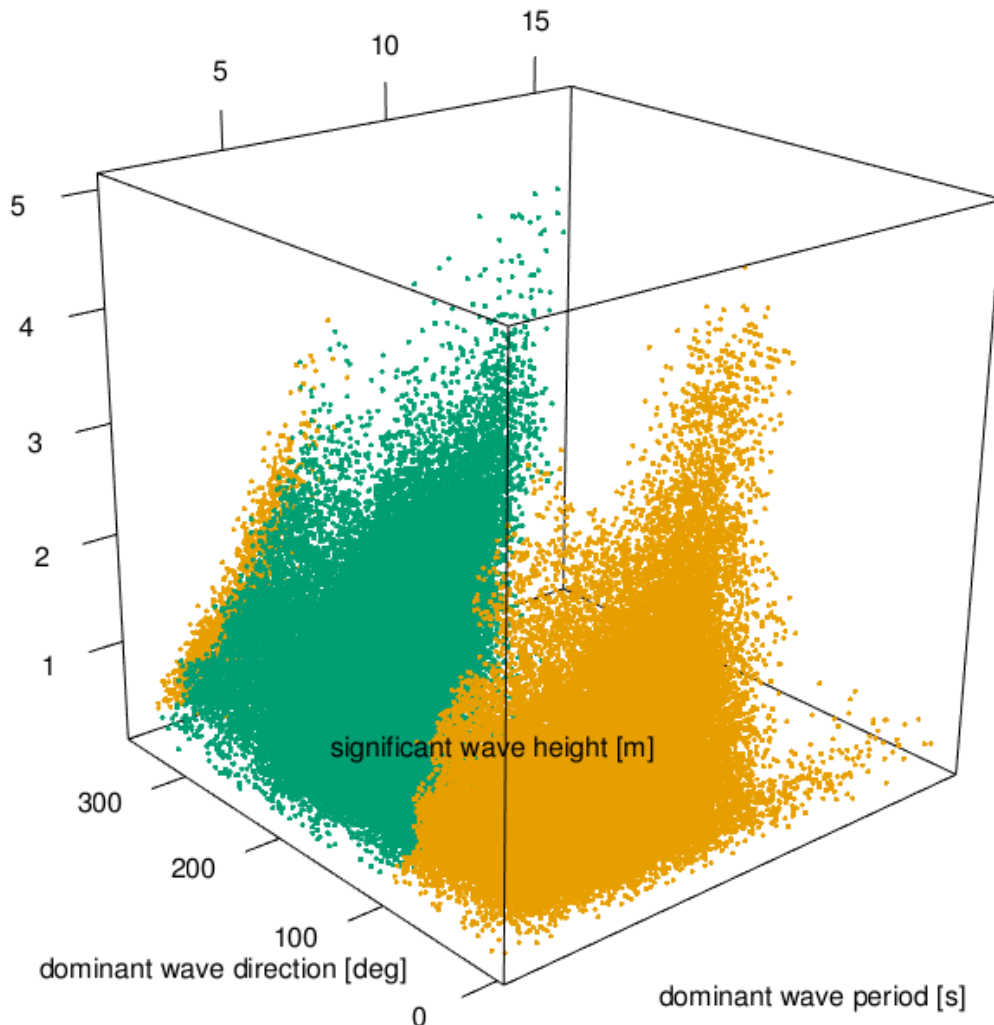
Post-processing of weather FCs

Significant Wave Height: Decision Making Example 2



Post-processing of weather FCs

Sea-state: Clusters

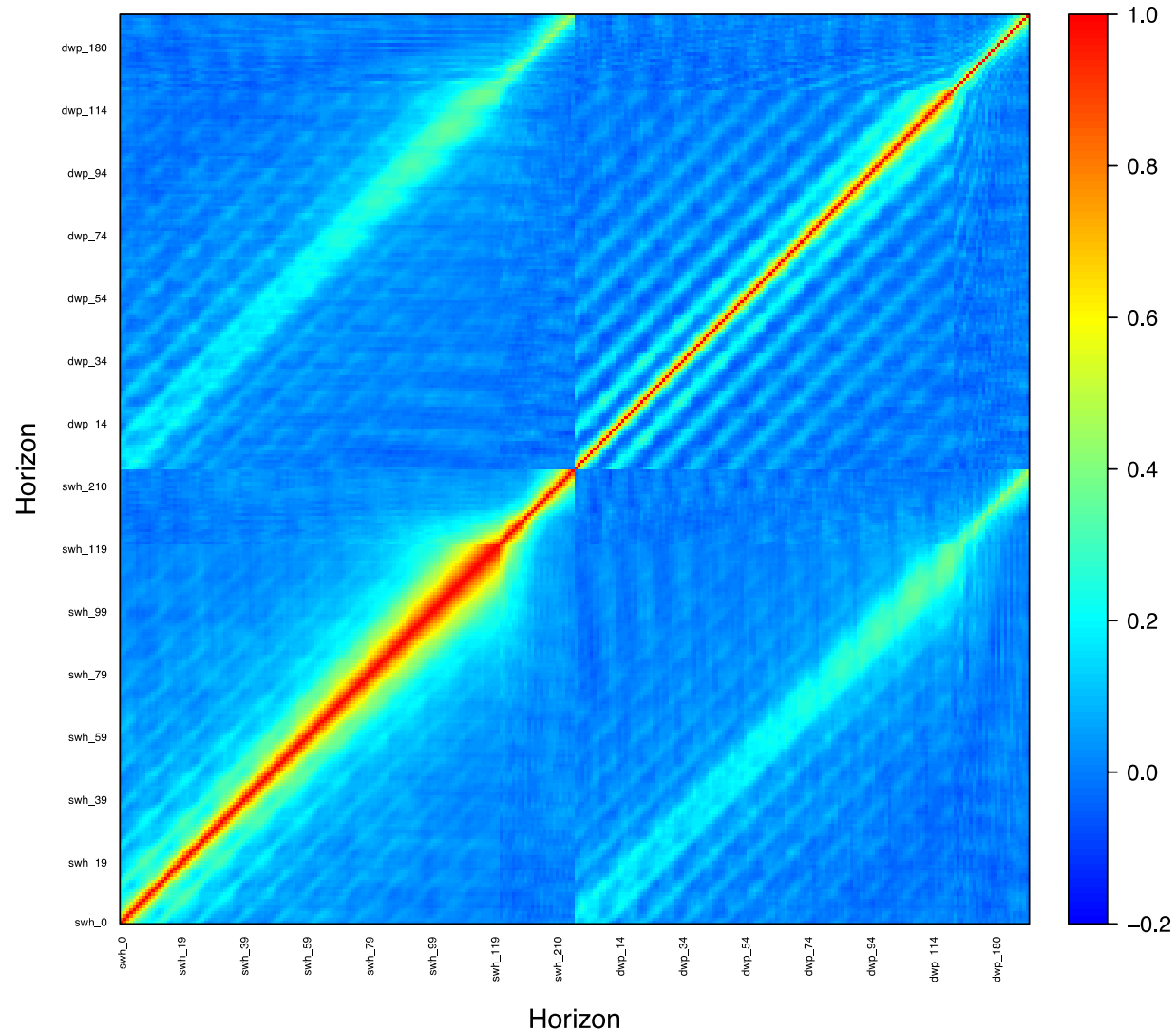


- Use buoy measurements to classify sea-state into two dominant regimes
- Use NWP variables to predict a probability of being in either regime
- Regimes dominated by wave direction
- --> Straightforward way of including wave direction into model
- Physical explanation: regimes by locally wind driven waves from **SW** and swell from **NE**

Post-processing of weather FCs

Dependency modelling: Correlation of forecast errors

- Errors are correlated in time
- Must be accounted for generating scenarios
- Can sample from this matrix to generate temporal scenarios
- Depends on sea-state cluster
- Use this & probability forecasts to feed vessel motion model

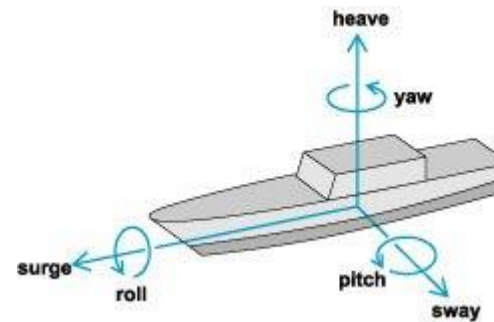


Vessel Motion

Overview

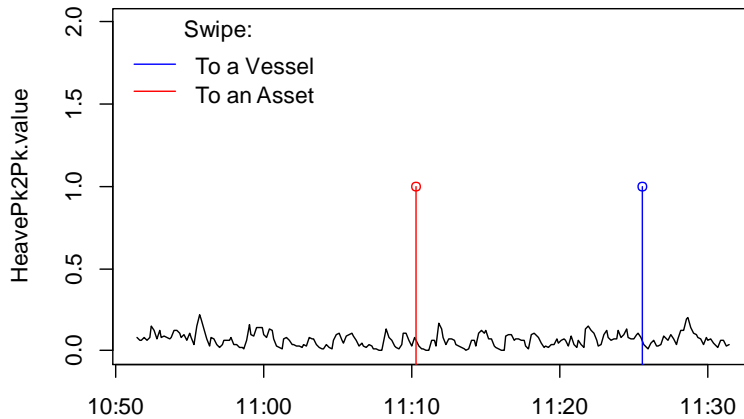
Vessel Motion

- Reygar:
 - Heave peak-to-peak
 - Period
- VMMS:
 - Heave
 - Roll
 - Pitch
 - Accelerations...

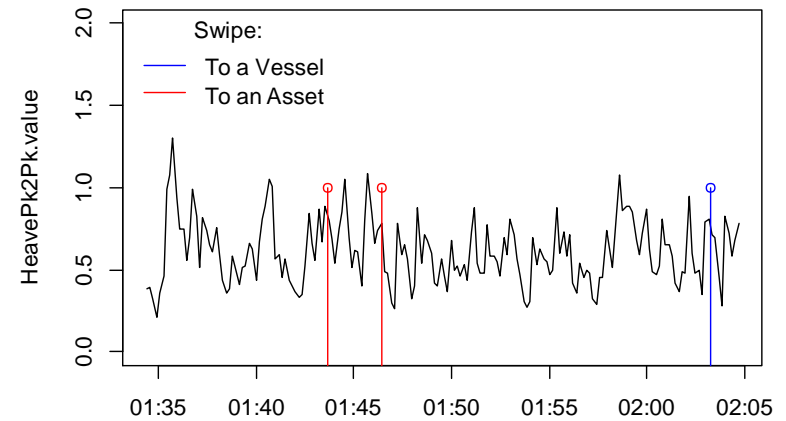


Vessel Motion

Push-Ons & Swipes

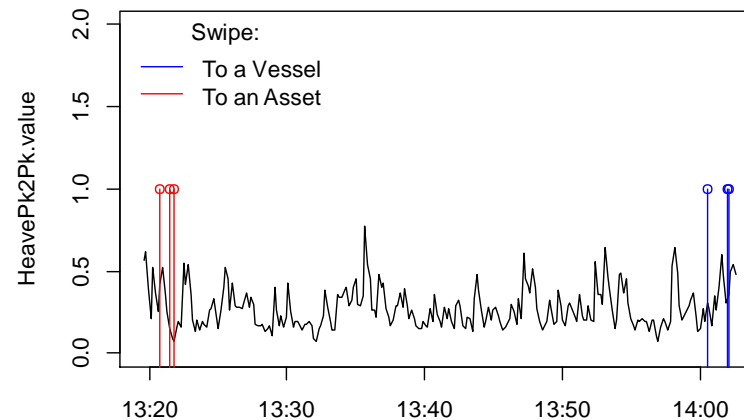


Time on 15/11/2017



Time on 11/12/2017

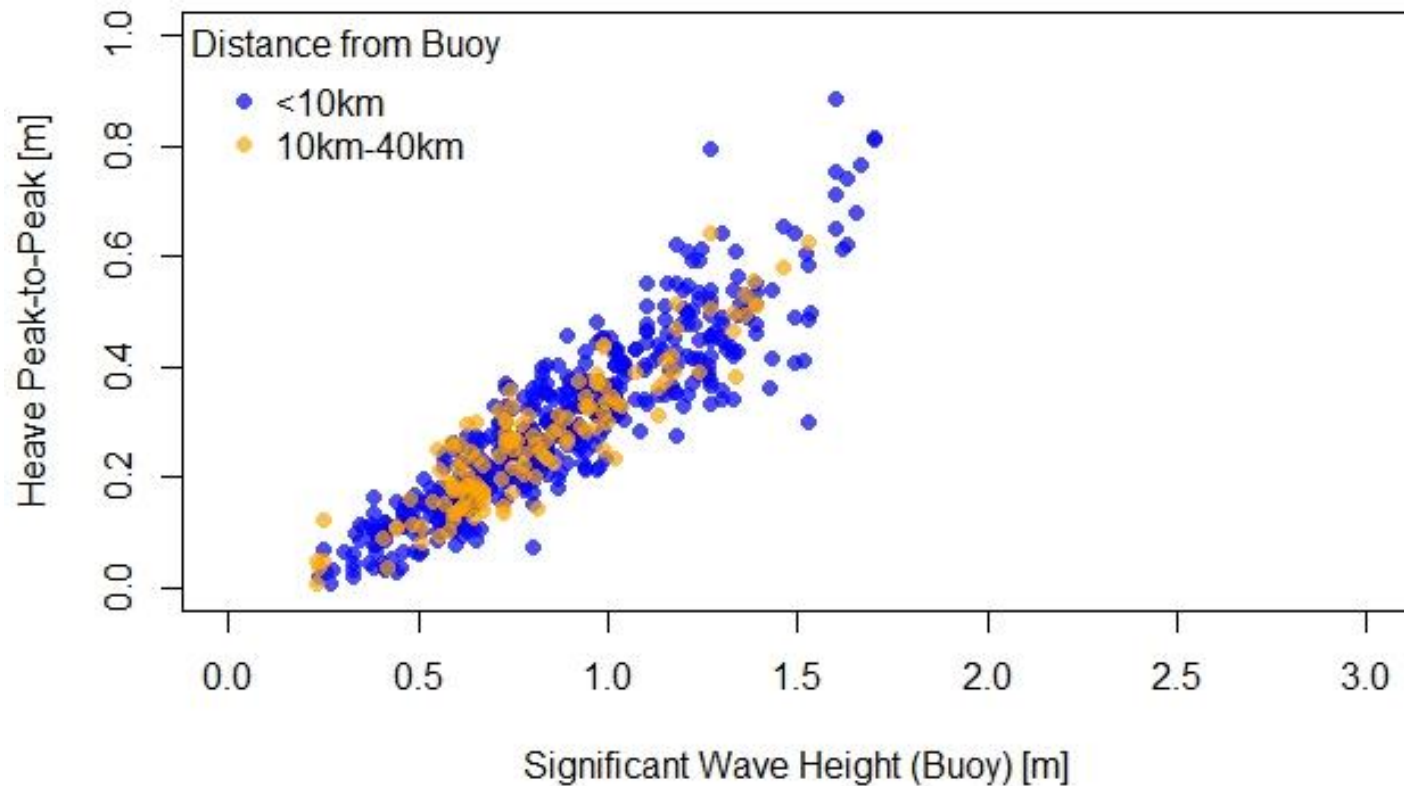
>700 Push-ons
>350 Push-on + at least 1 *Swipe*
>1500 Swipes



Time on 11/11/2017

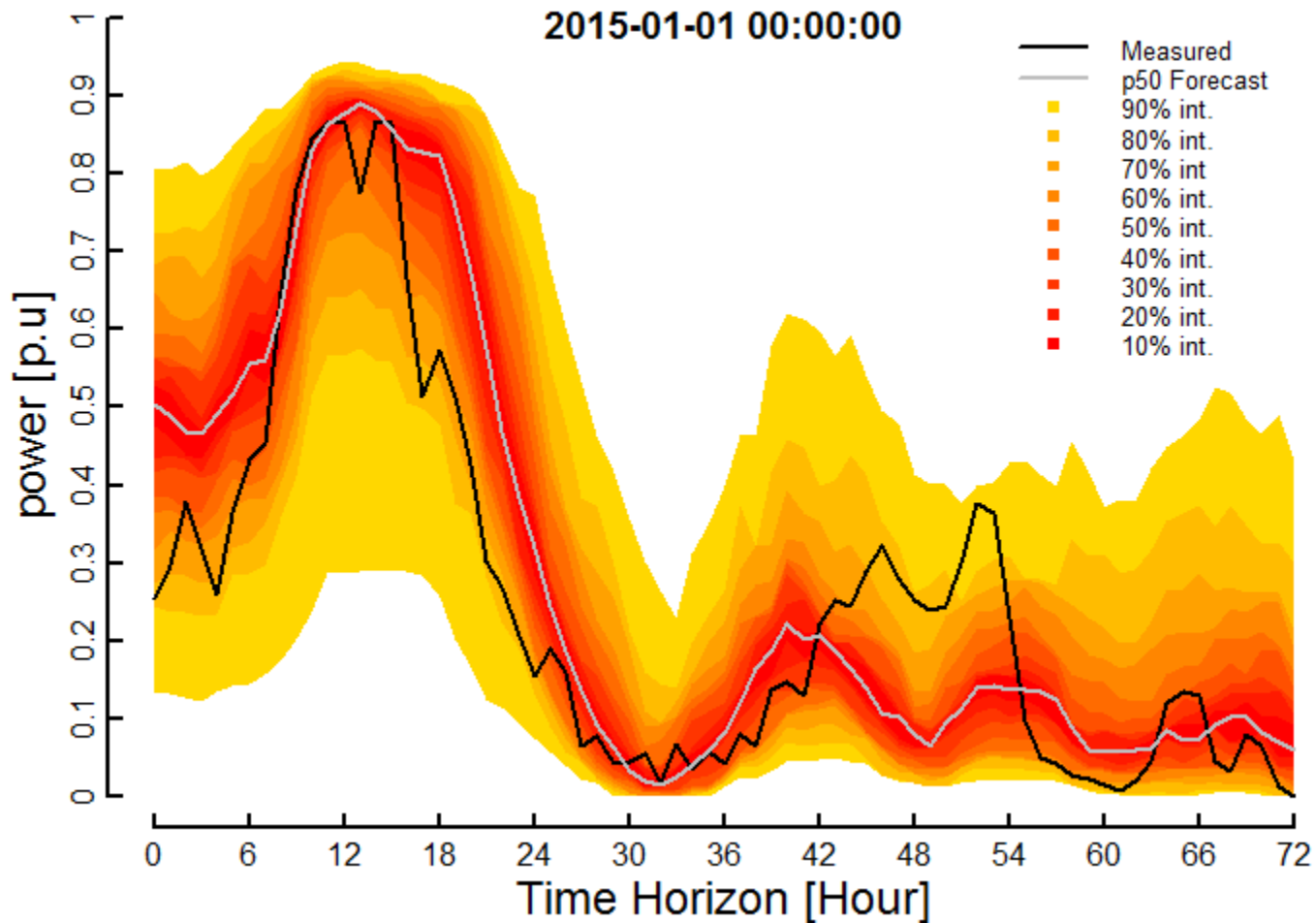
Vessel Motion

Reygar vs Buoy Observations



Post-processing of weather FCs

Yield Forecasting at GG



Engagement



Data & Domain Knowledge

James Fisher
Marine Services



Ops shadowing/ giggle checks



Wd like to talk to



Other projects



Summary & Conclusions

- Vessel motion, met ocean, yield forecast currently analysed in silos & quite bespoke (e.g. VMMS as a contractual lever) – ORACLES joins these up
- “Wouldn’t it be great to have a turbine location-specific access forecast” – Gregg McConnell Site Ops Lead Robin Rigg EOn Q3 2018
- More operations data w/ concurrent SCADA – discussions ongoing/ tips welcome
- Feedback on UI/ visualisation from users (from everyone who is involved in the decision to transfer)
- Validation!



University of
Strathclyde
Glasgow

An Anecdote: OPEX vs CAPEX

(spoiler alert: CAPEX wins)

- Wind farm developer X wants to evaluate impact of multiple boat landings on OPEX (a second access ladder)
- Consultant Y quantifies benefits (improved access, yield uplift) running into 10s of millions over project lifecycle {OPEX wins?}
- Wind farm developer X applies discounted cost to life cycle benefit
- Wind farm developer X goes with a single boat landing {CAPEX wins.}

