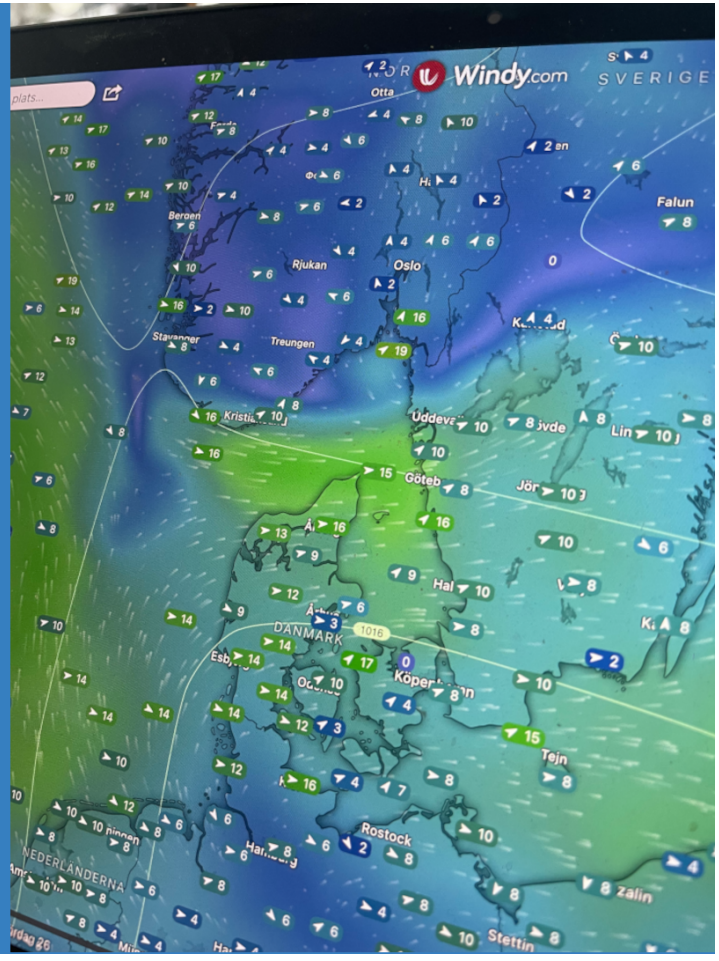
# CAN WE IMPROVE WIND FORECASTING USING CONFORMAL PREDICTIONS?

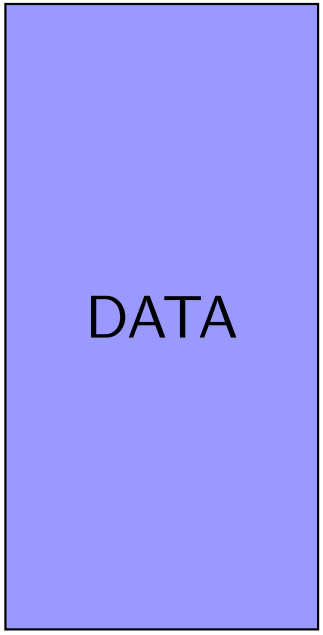


# Conform with the wind

Simon Althoff
Johan Hallberg Szabadváry
Jonathan Anderson
Lars Carlsson

September 13, 2023

# Ensemble forecast



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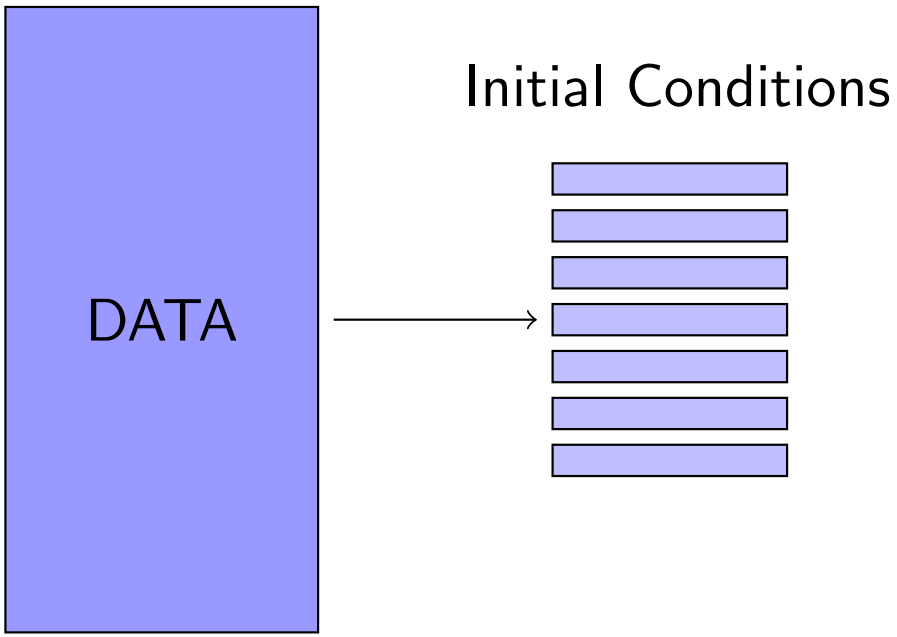

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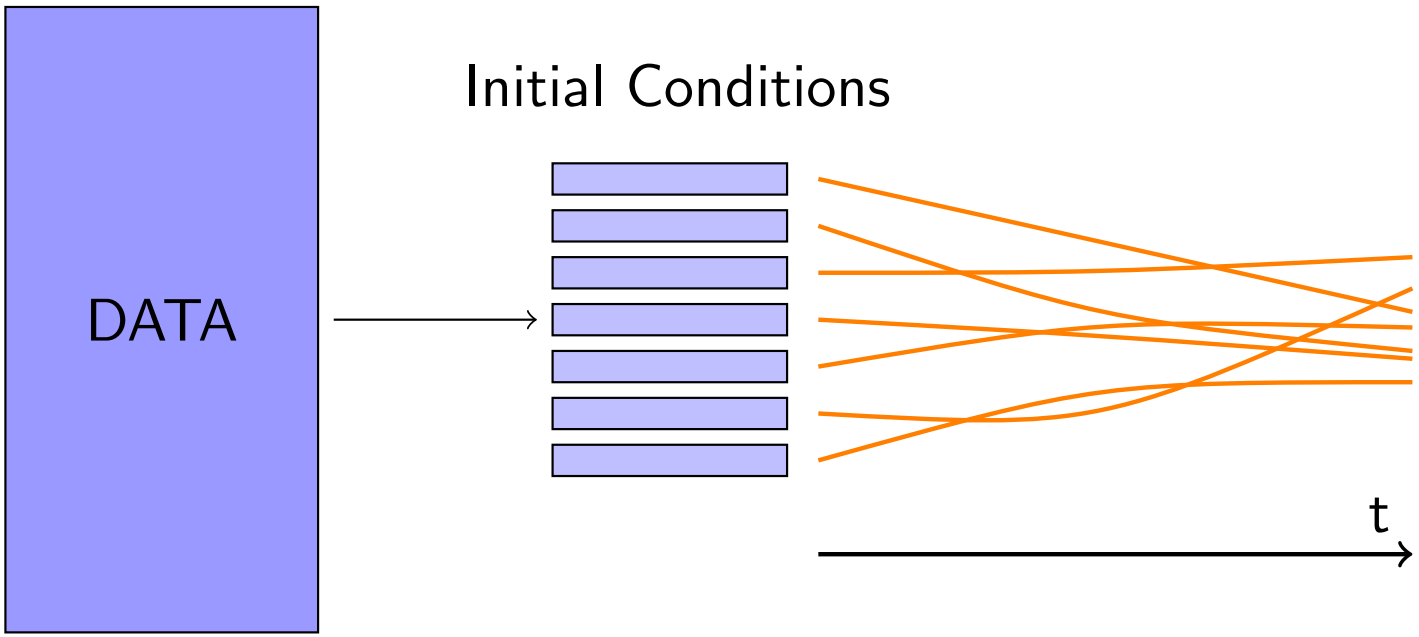

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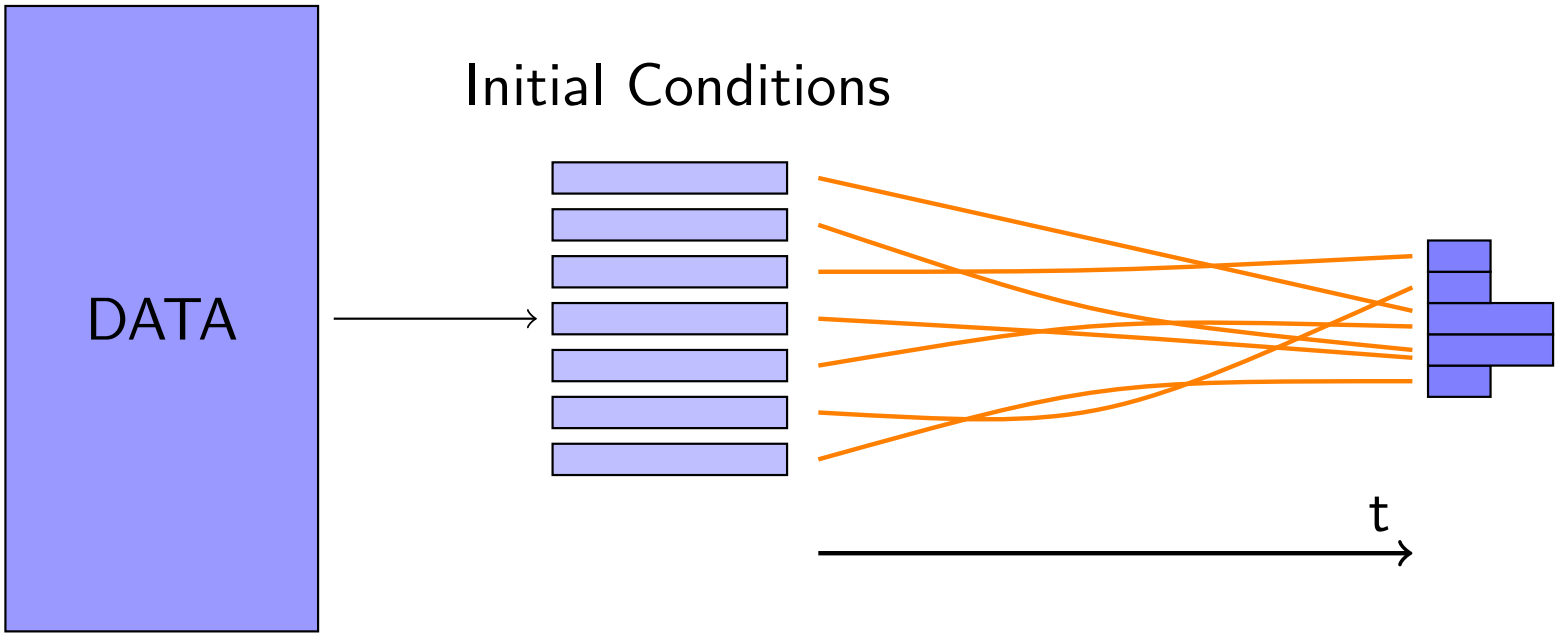
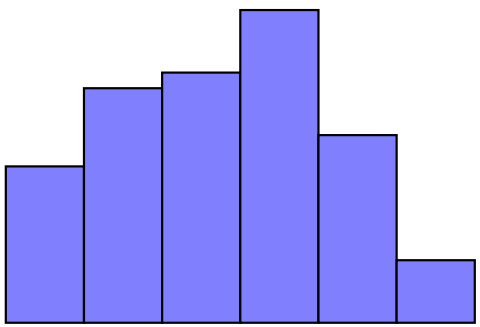


# Ensemble post processing



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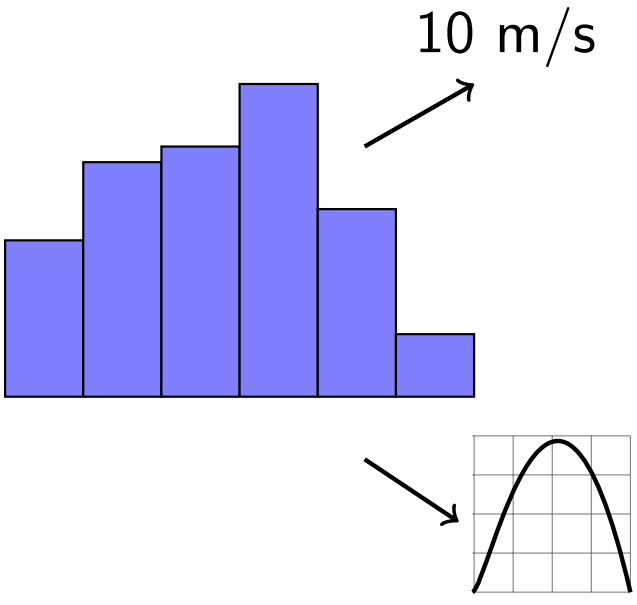

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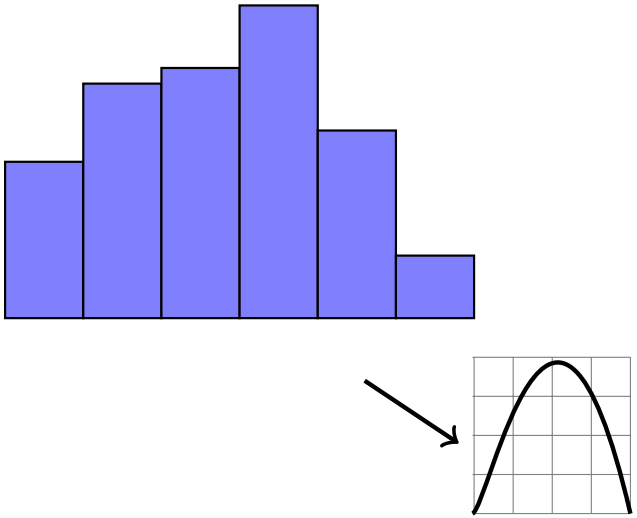

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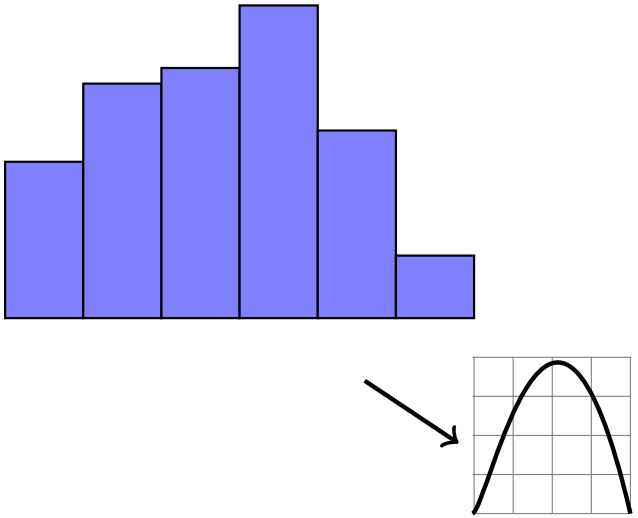

- Parametric method (EMOS)
- Neural networks
- Quantile regression (forest)
- Conformal?

# Use cases

- Predictive maintenance and safety of wind turbines
- Electricity pricing
- etc.

# Forecast Data

Forecasts from MET Norway

Ensemble variables

- x-wind-10m, y-wind-10m

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# Measurement Data

## Measurements from SMHI[1]


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[1]Swedish Meteorological and Hydrological Institute

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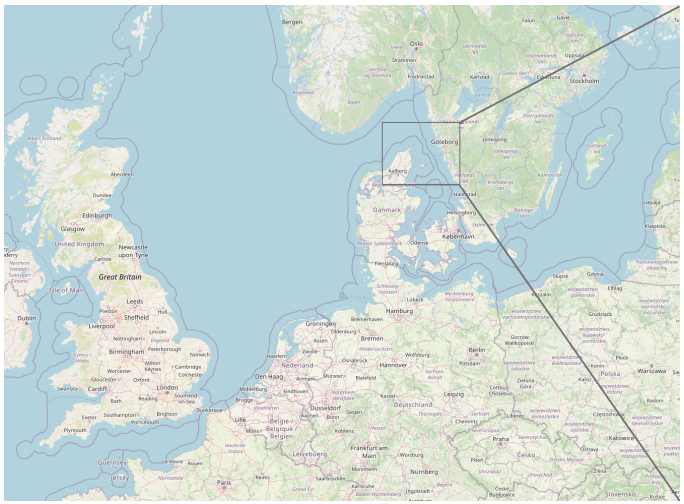


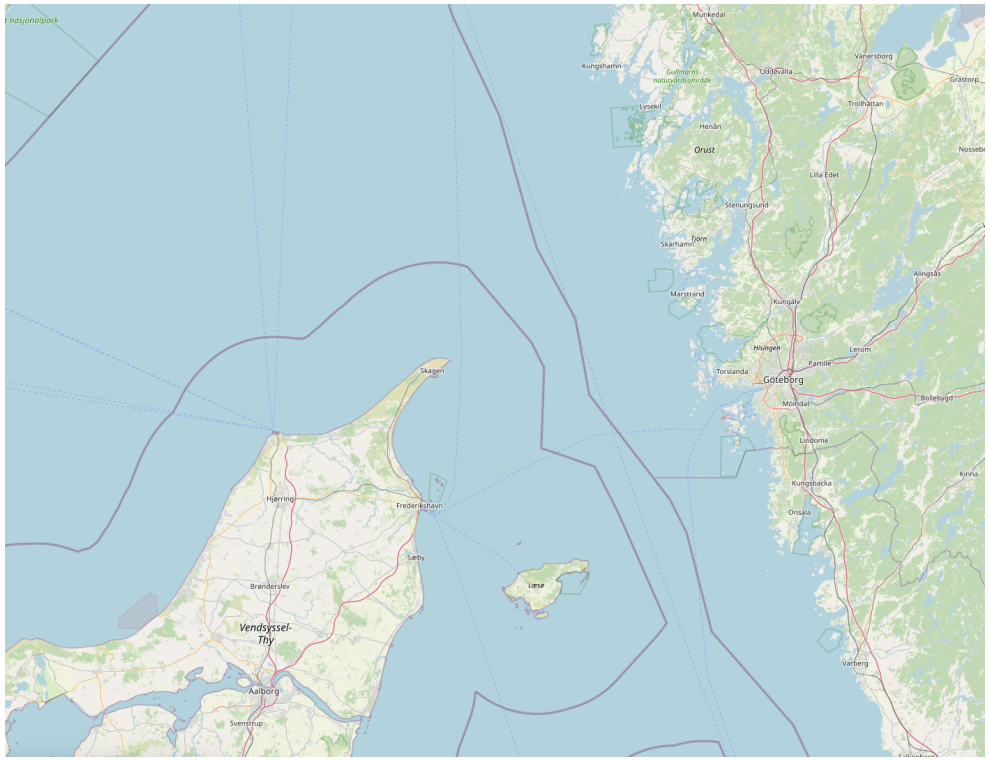


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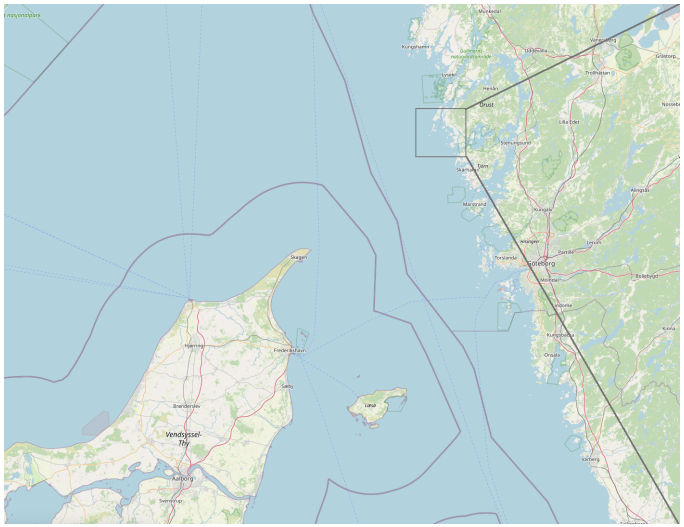

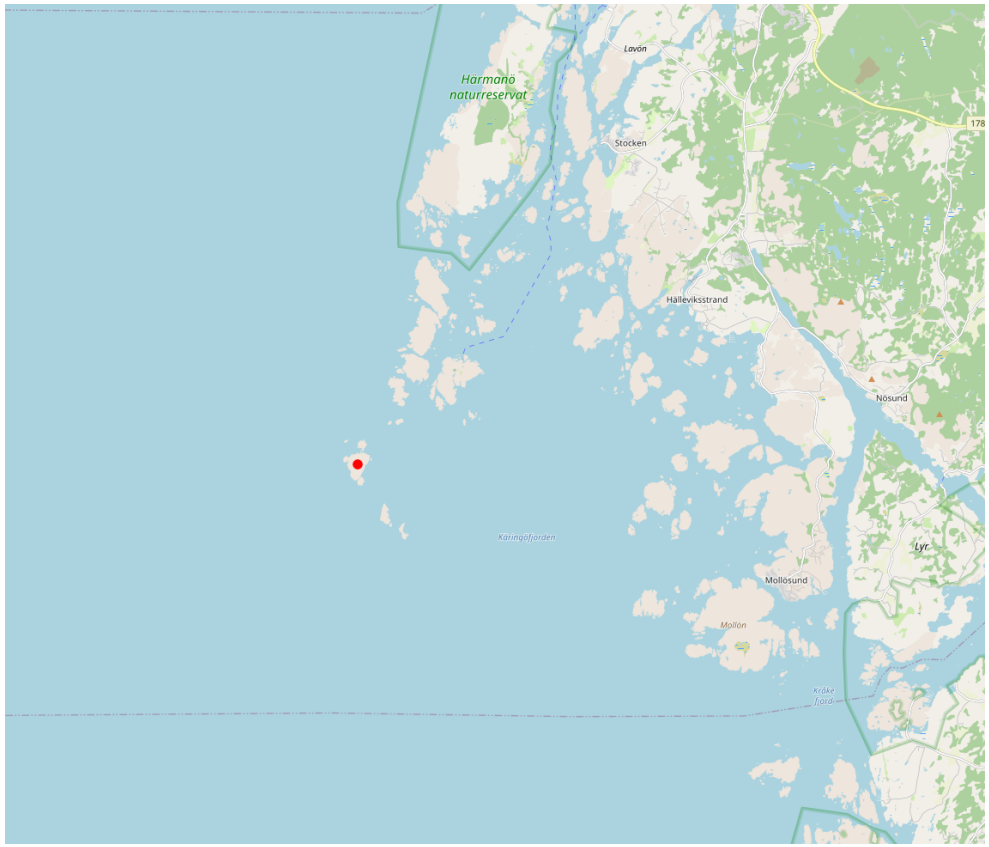


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# Conformal predictive systems

Crepes[2] used for implementation.

Non-conformity score: nearest neighbors

$$\alpha_i = \frac{y_i - \hat{y}_i}{\kappa_i + \gamma}$$

$$\Pi_n = \hat{y}_n + (\kappa_n + \gamma)\vec{\alpha}$$

[2] Developed by Prof. H. Boström

# Non-exchangeable conformal prediction

Based on article from Barber et. al.

Exponential weight decay in time:

$$\omega_i = \lambda^{n-i}, \lambda \in [0, 1]$$

Non-conformity scores as:

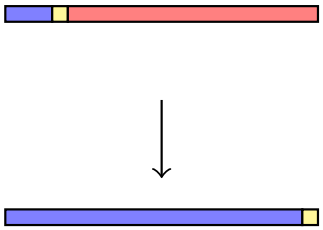
$$\alpha_i = |y_i - \hat{y}_i|(1 + \beta^T \hat{\sigma}[\mathbf{x_i}])$$

Resulting predictive interval:

$$\hat{C}_n = \hat{y}_i \pm \frac{1}{(1 + \beta^T \hat{\sigma}[\mathbf{x_i}])} \left( \mathbf{Q}_{1-\epsilon} \left( \sum_{i=1}^{n-1} \tilde{\omega}_i \cdot \delta_{\alpha_i} + \tilde{\omega}_n \cdot \delta_{+\infty} \right) \right)$$

# Testing through Teaching schedule

Test setting:



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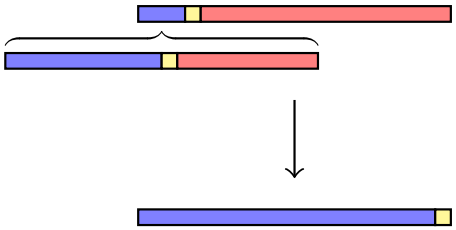

Model selection:
sequential leave one out

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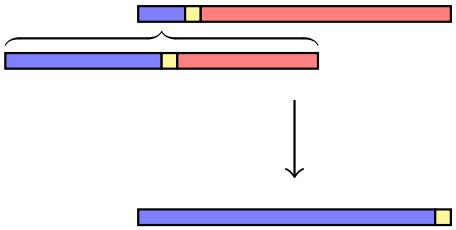

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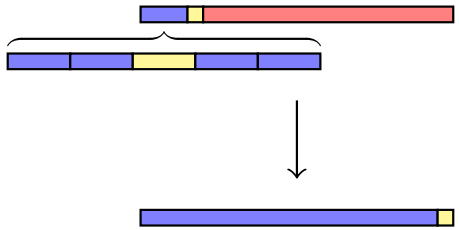


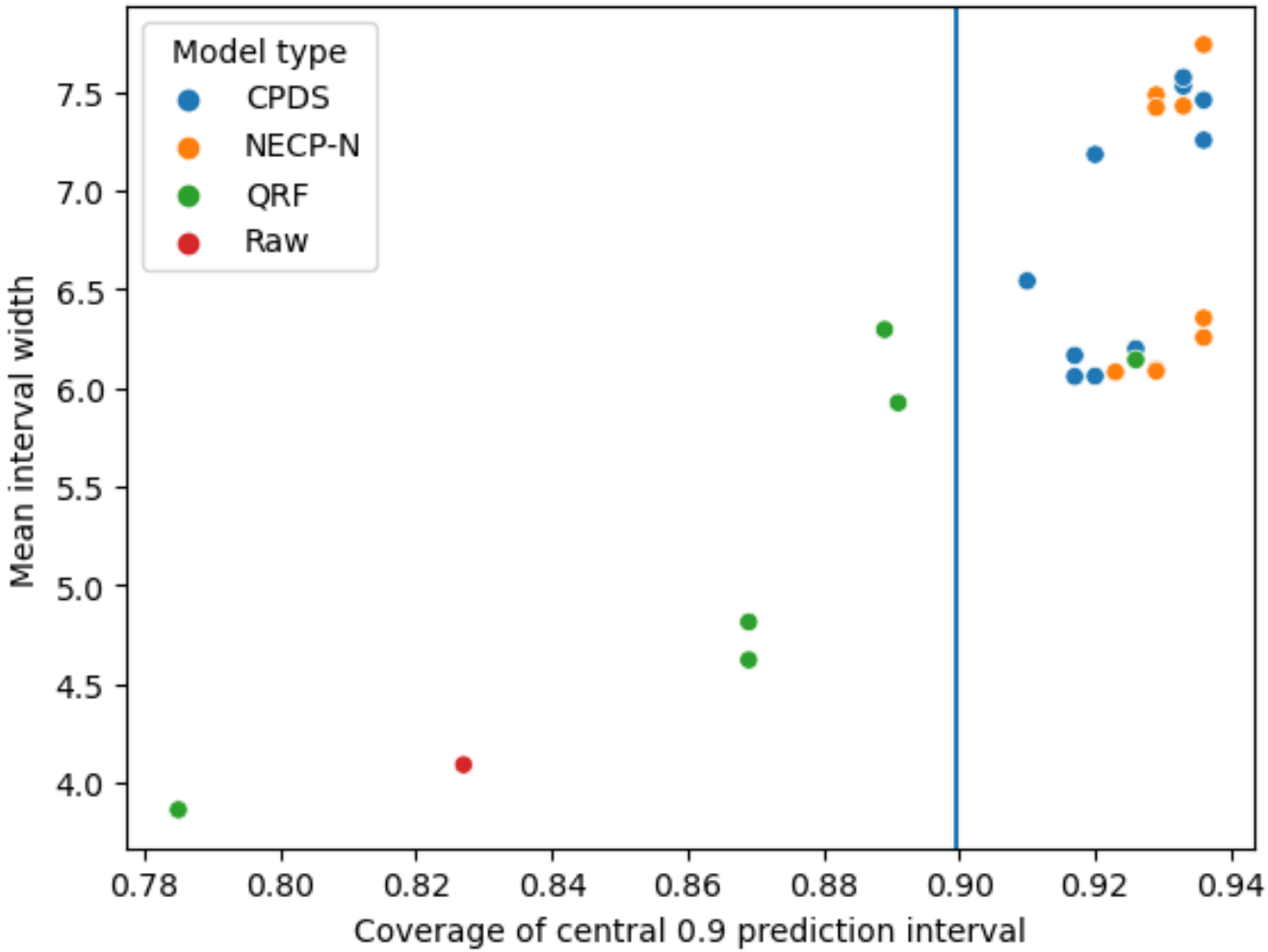
Model selection: block selection

# Model configurations

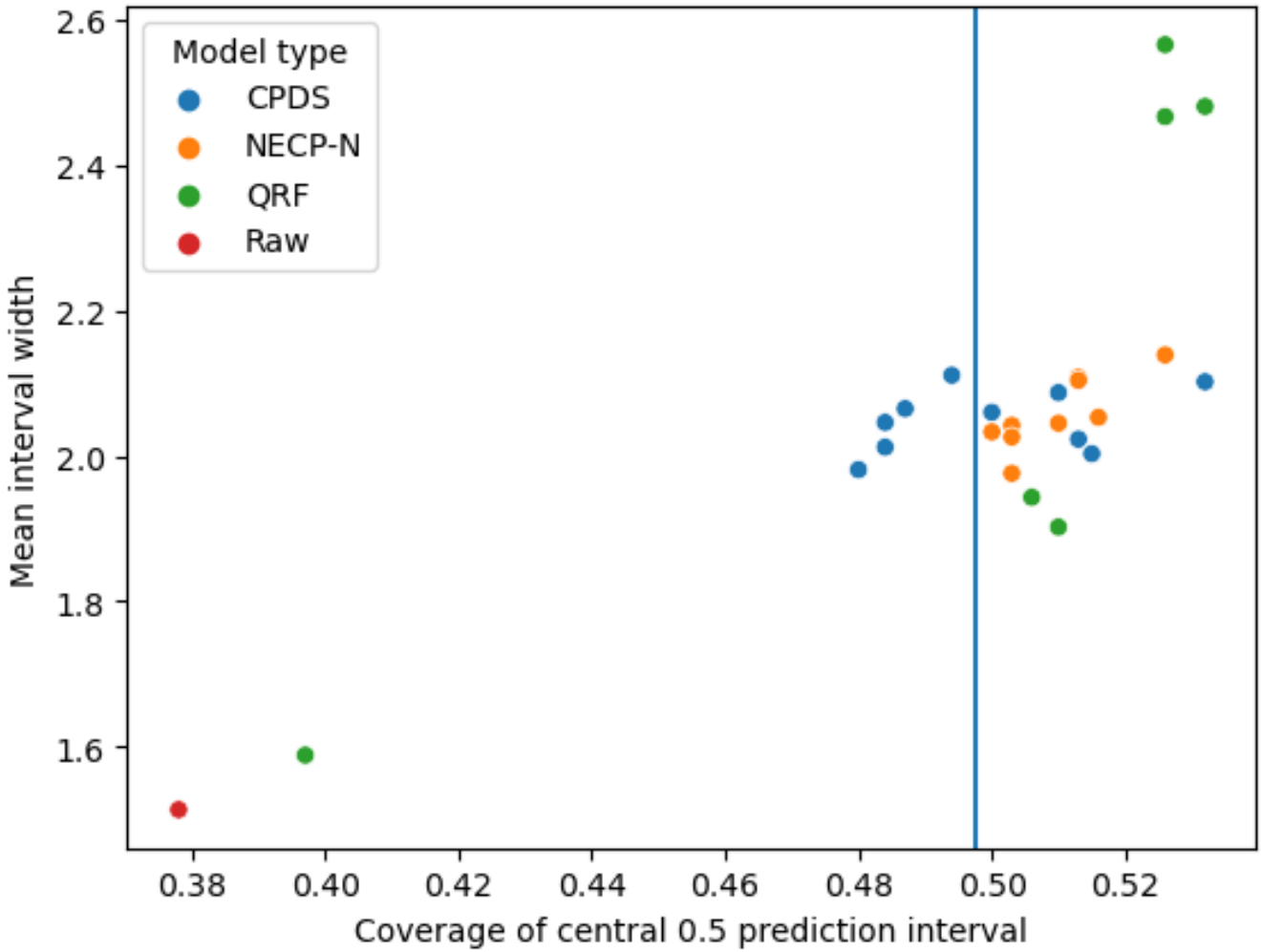
| CPDS | Input Variables | Window length | Used in test |
|---|---|---|---|
| 1 | x-wind<br>y-wind | all | 0.445 |
| | | 200 | 0.131 |
| | | 100 | 0.287 |
| | | 50 | 0.134 |

Table: Parameters and inputs in one model configuration and the ratio of each parameter used in prediction

# Results: Prescribed 0.9 validity



# Results: Prescribed 0.5 validity



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- Seems to do well despite external model.
- Include input variables in model selection.
- More metrics and further comparisons should be made.