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Forecasting single-variable weather windows with extremely high certainty

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Weather window decision criteria

- Focus on significant wave height (H) maximized over time period
- DNV-OS-H101:
 - *“The α -factor should be calibrated to ensure that the probability of exceeding the operational environmental limiting criteria (OP_{LIM}) with more than 50% is less than 10^{-4} .”*
- Weather window if
 - $Prob(H > 1.5 * H_{limit} \mid \text{wave model forecast}) < 10^{-4}$
- Alternatively, the 0.9999 conditional quantile (as a function of wave model forecast) should be less than $1.5 * H_{limit}$

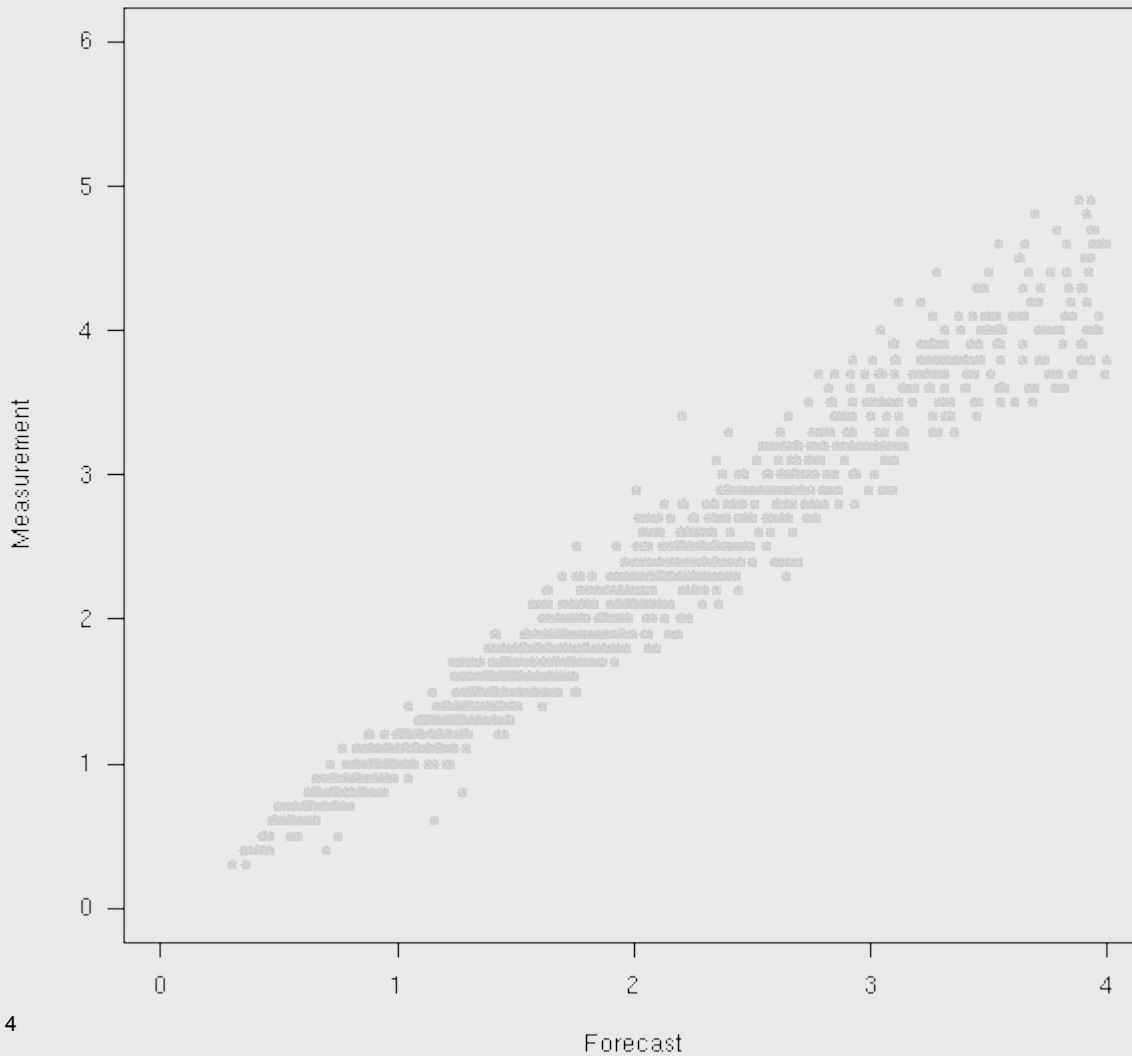


Forecast of the 0.9999 quantile is needed

Objectives

- Evaluate new quantile extrapolation method
- Are ensembles better than single forecasts?

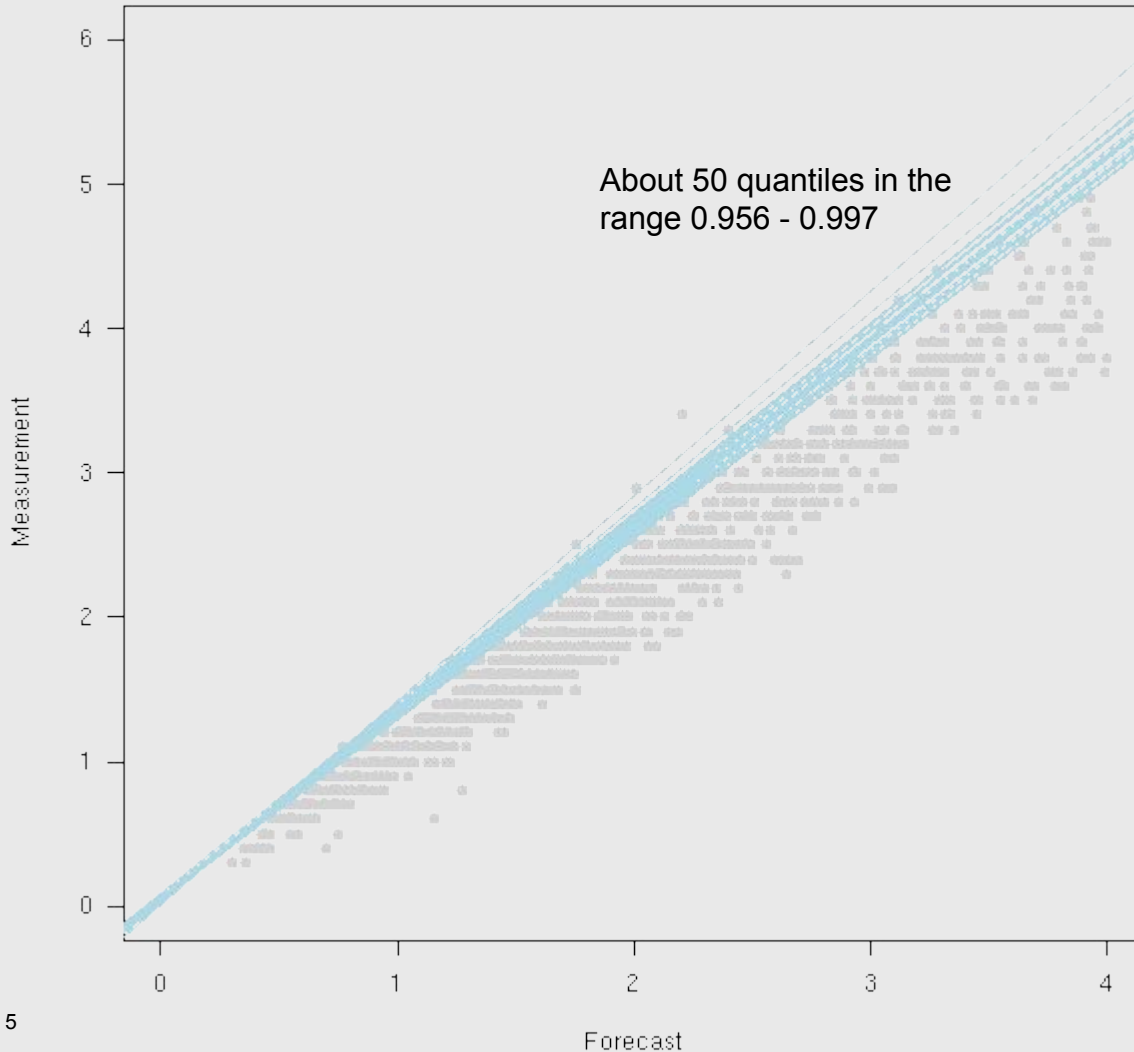
Methodology



1. Organize training data

Methodology

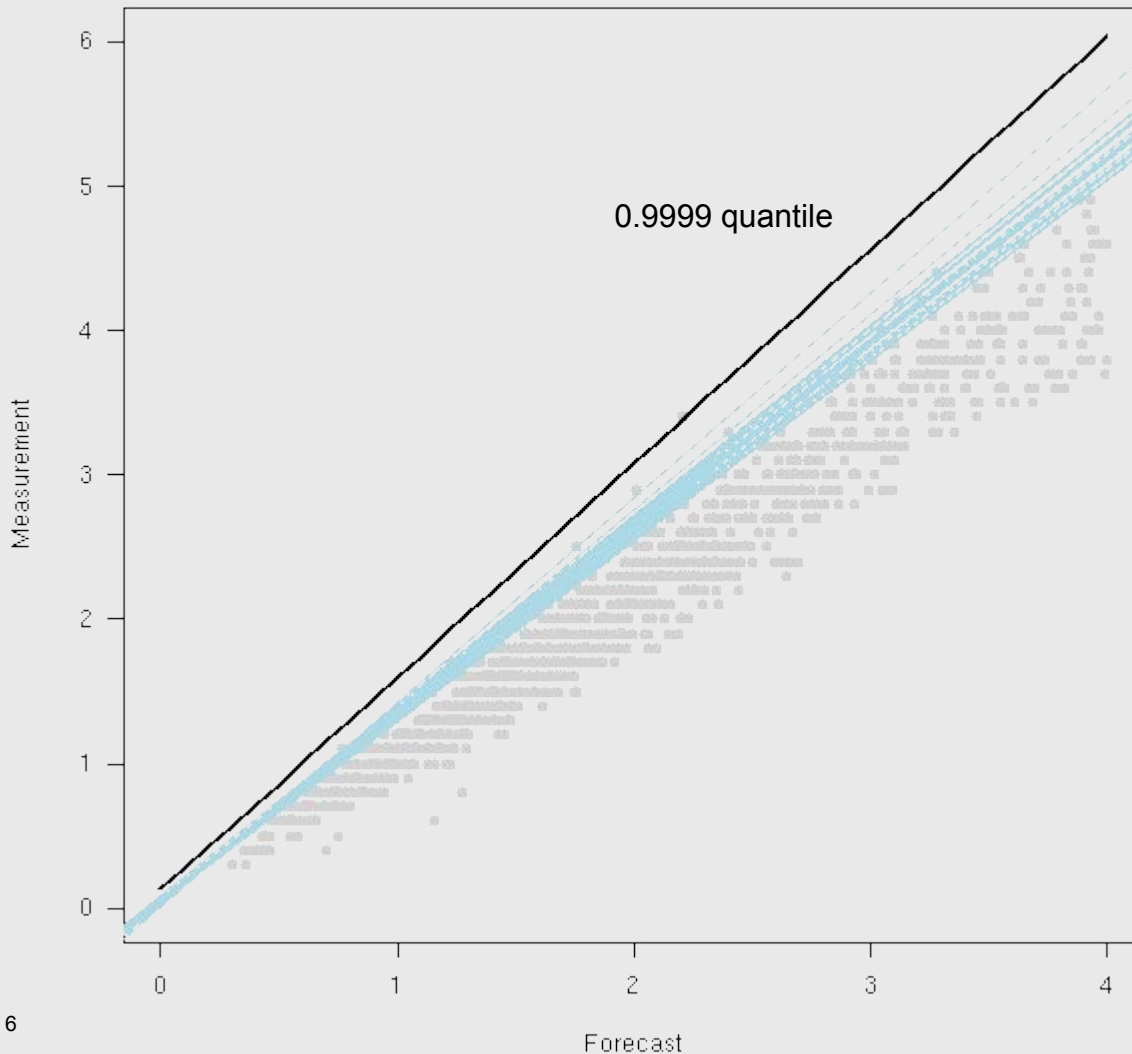
Wang et. al. (2012) Journal of American Statistical Association



1. Organize training data
2. Estimate high intermediate quantiles (blue) using quantile regression

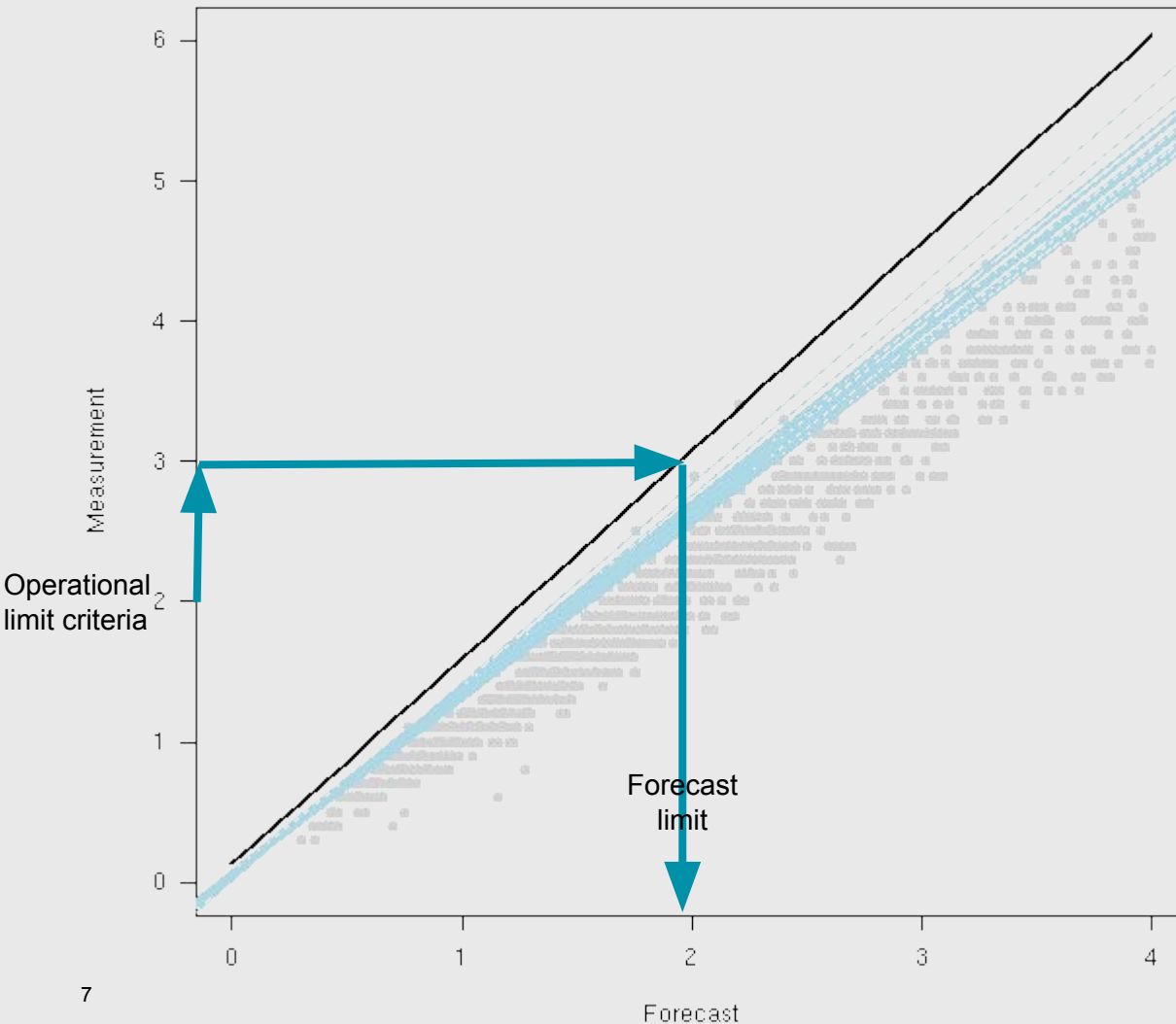
Methodology

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1. Organize training data
2. Estimate high intermediate quantiles (blue) using quantile regression
3. Extrapolate intermediate quantiles using extreme value theory

Methodology



1. Organize training data
2. Estimate high intermediate quantiles (blue) using quantile regression
3. Extrapolate intermediate quantiles based on extreme value theory
4. Determine the forecast limit for weather windows

Data

Significant wave height at Ekofisk

- Years 2011 - 2014 used for estimation/training
- 2015 for evaluation

Wave model forecast data

- ECMWF ENS 00 UTC up to 10 days ahead
- 51 ensemble members/forecasts
 - member number 0 is used as single deterministic forecast
 - maximum is used as ensemble forecast

Measurement data

- NORA10 hindcast

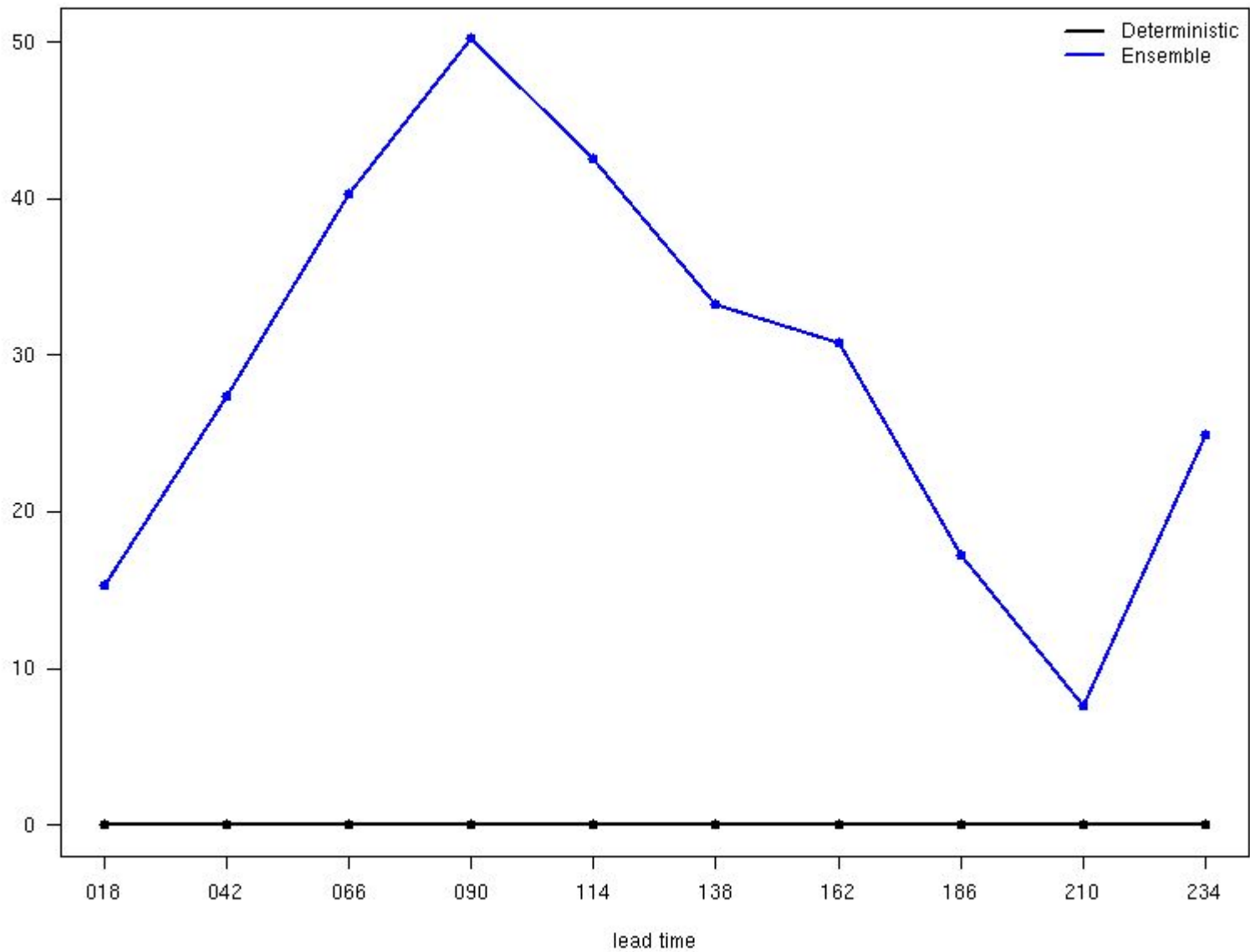
12h-weather windows

- Significant wave height data are maximized over 12-hour periods

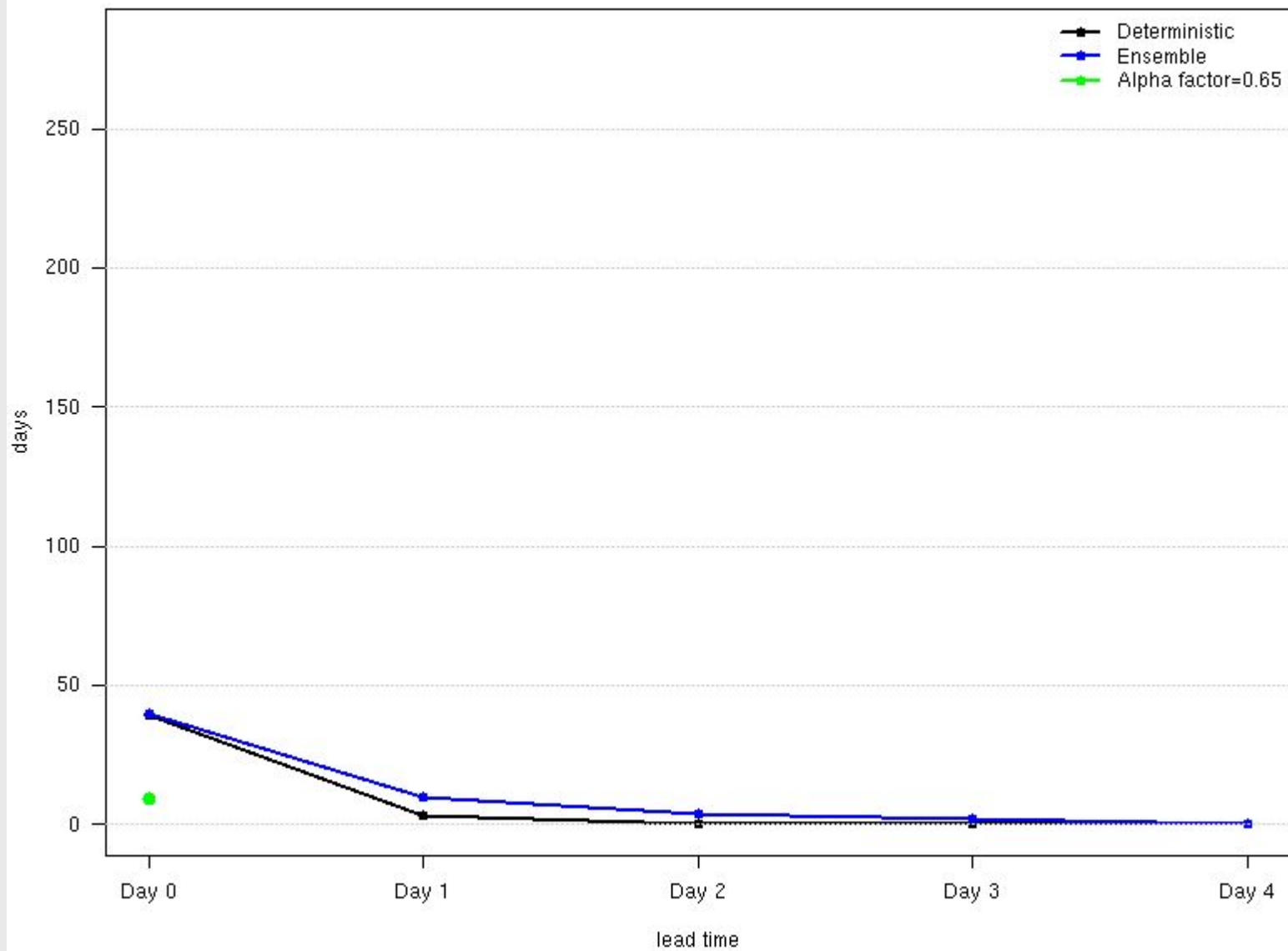
Results

preliminary

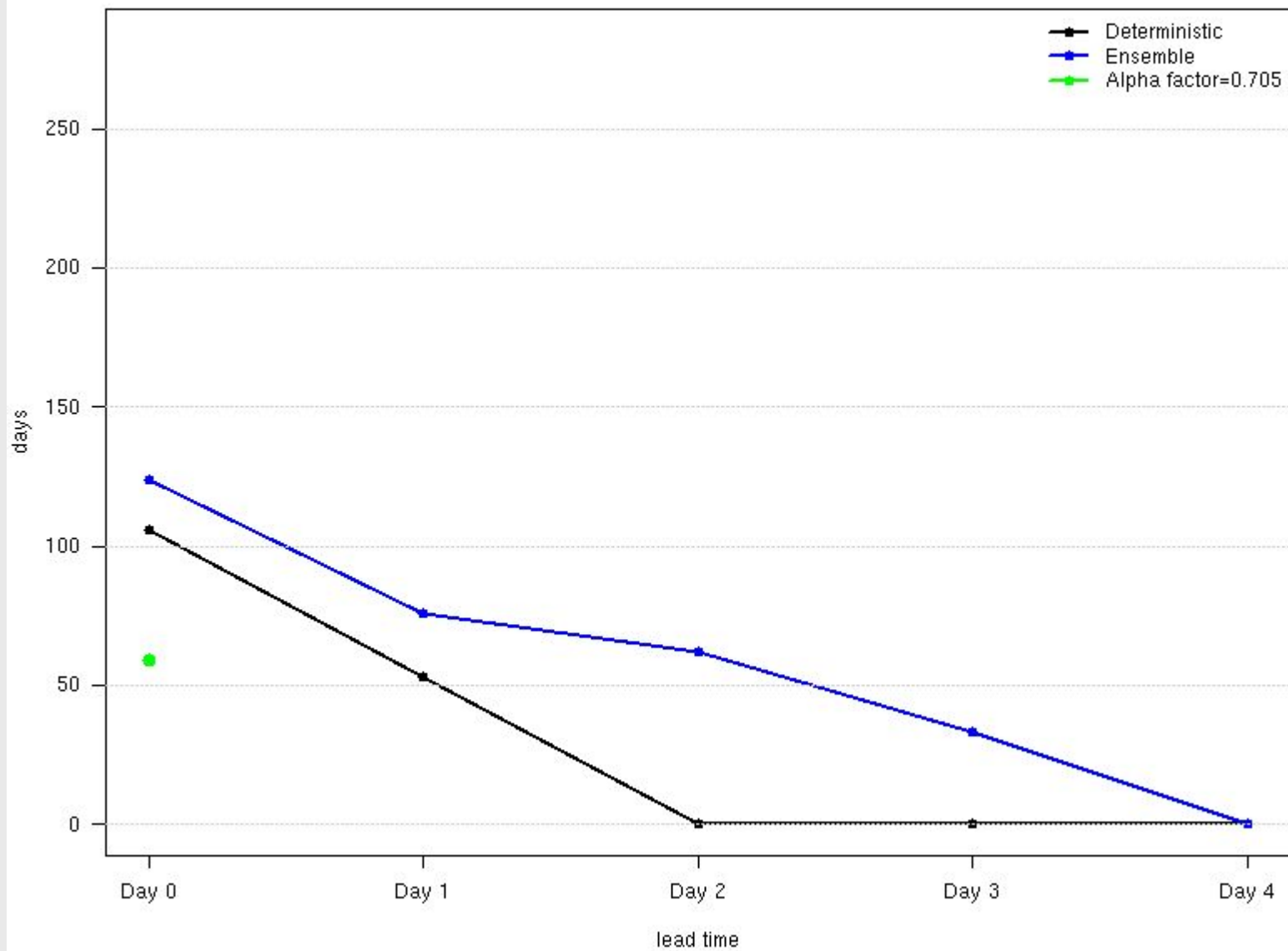
Quantile skill score (%)
0.9999 quantile



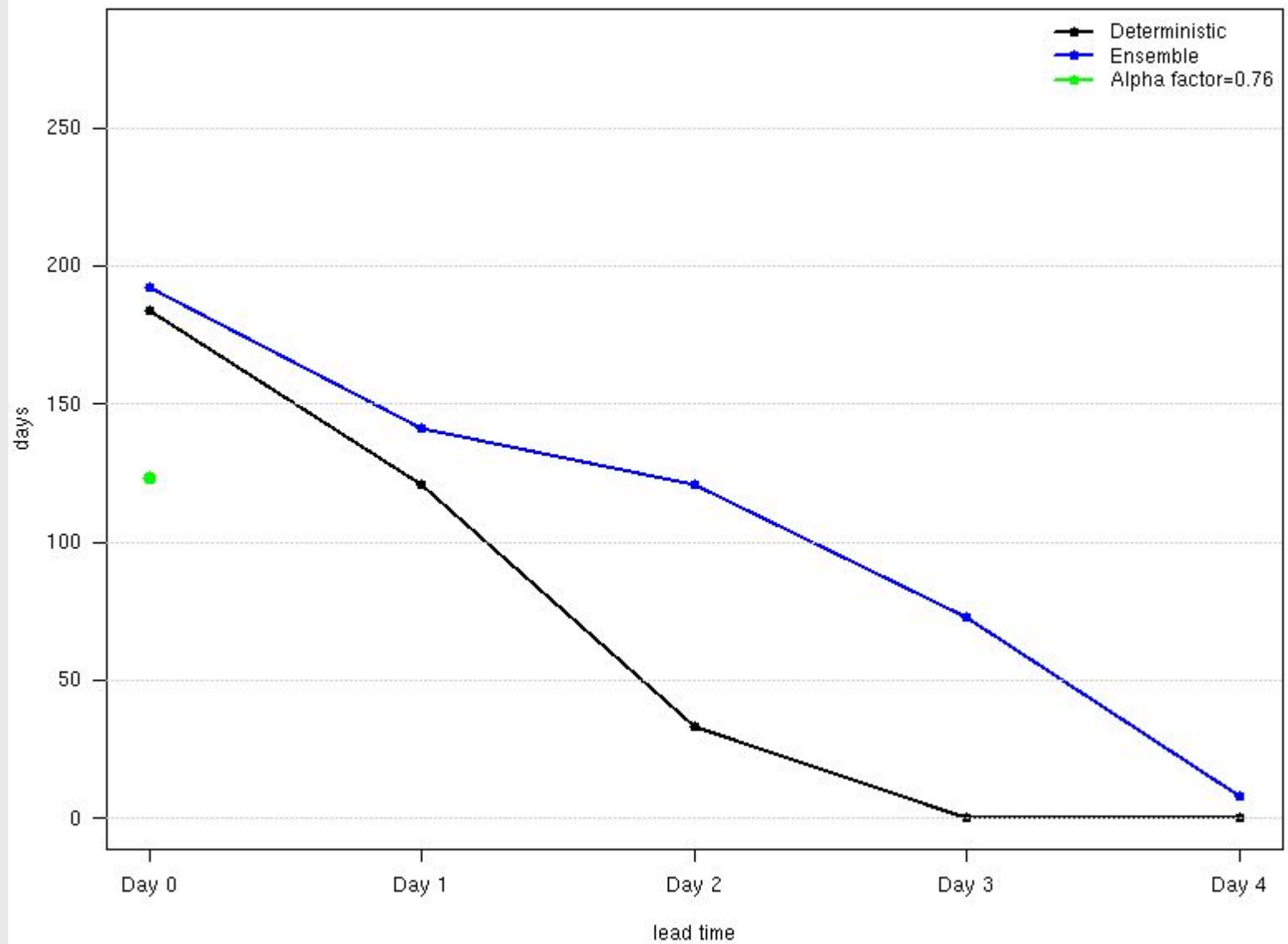
Number of predicted weather windows in 2015 Operational limit = 1 m



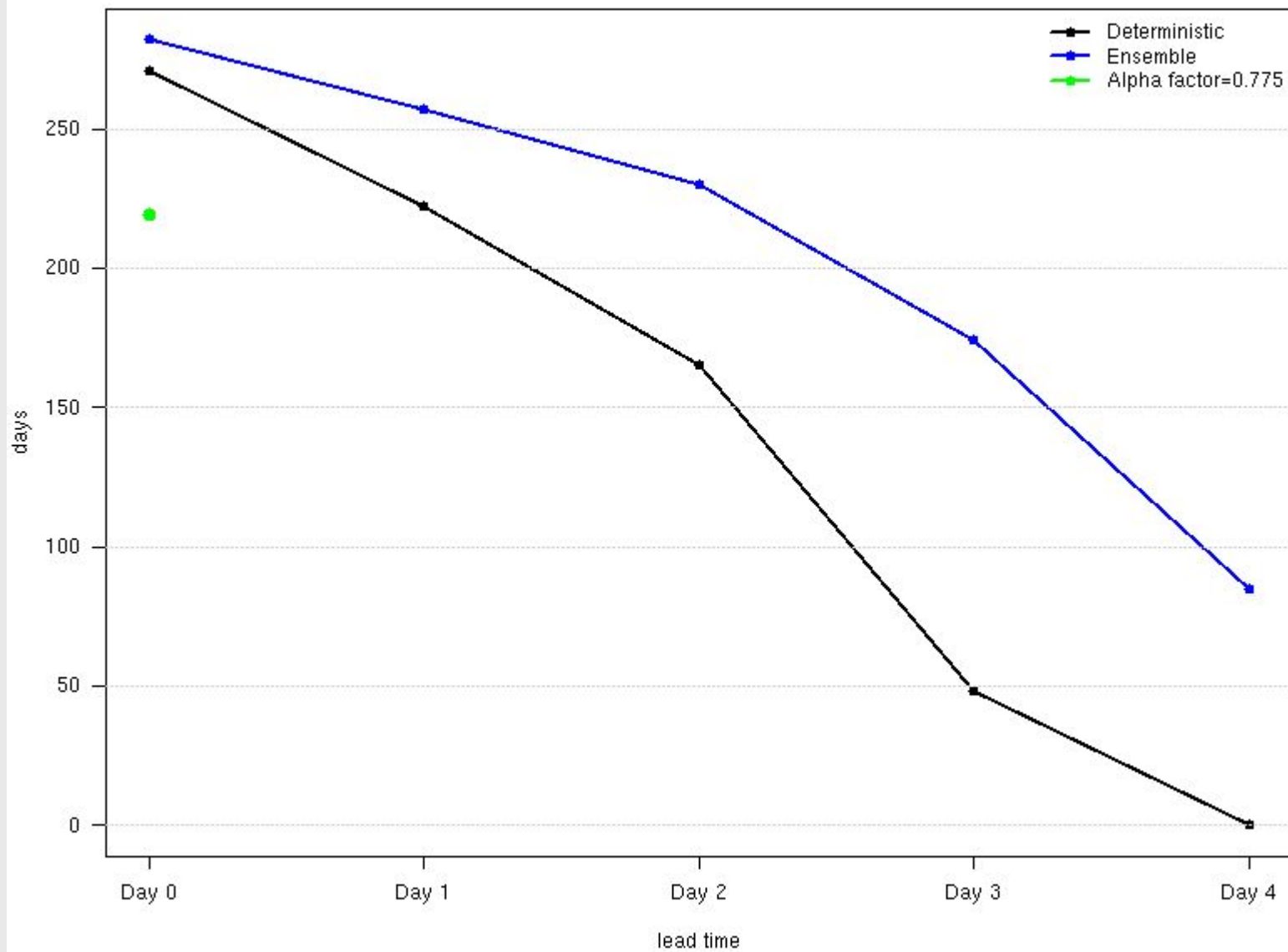
Number of predicted weather windows in 2015 Operational limit = 1.5 m



Number of predicted weather windows in 2015
Operational limit = 2 m



Number of predicted weather windows in 2015 Operational limit = 3 m



α -factors (day 0)

$$\alpha = \text{OP}_{\text{forecast_limit}} / \text{OP}_{\text{limit}}$$

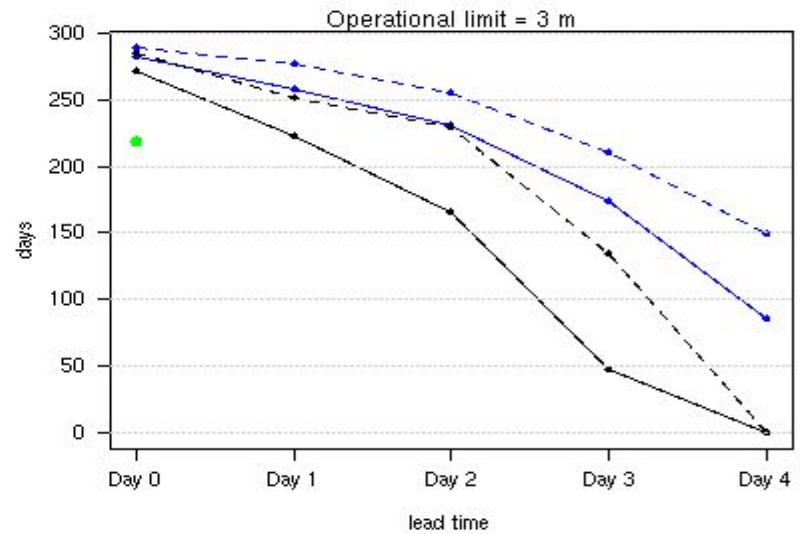
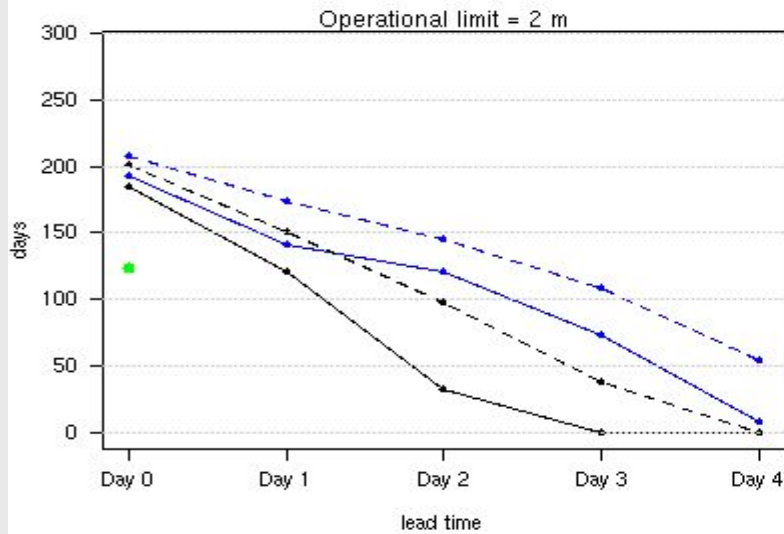
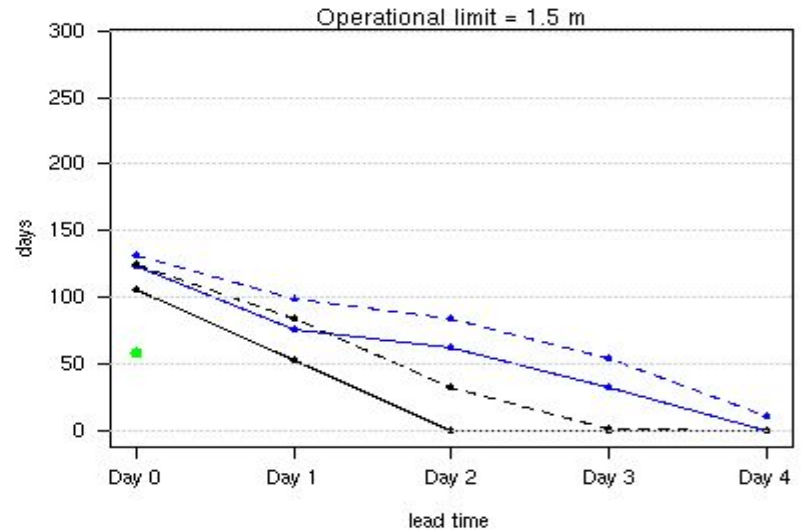
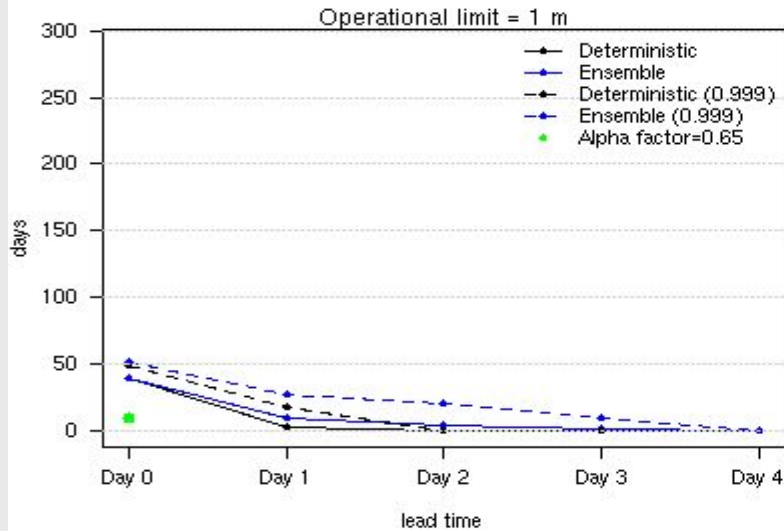
Operational limiting criteria	DNV GL Table 4-1	Quantile extrapolation Deterministic	95% confidence interval
1.0 m	0.650	0.932	0.848 - 0.999
1.5 m	0.705	0.959	0.911 - 1.003
2.0 m	0.760	0.972	0.920 - 1.026
3.0 m	0.775	0.986	0.935 - 1.056

Operational limiting criteria	DNV GL Table 4-2	Quantile extrapolation Ensemble	95% confidence interval
1.0 m	0.680	1.061	0.925 - 1.158
1.5 m	0.740	1.099	1.036 - 1.155
2.0 m	0.800	1.118	1.072 - 1.167
3.0 m	0.815	1.137	1.087 - 1.197

Effect of reducing certainty level

0.9999 \rightarrow 0.999

Number of predicted weather windows in 2015



Concluding remarks

Ensembles better than single forecasts

- further improvement with short range ensemble?
- is the maximum the best predictor?

Quantile extrapolation method probably good

- needs fine tuning
- handling estimation/prediction uncertainty
- inter-comparison with other methods (also DNV method)