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Wind Speed Ensemble Predictions with an Analog-based Method in Complex Terrain

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Weather Intelligence for Wind Energy
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Outline

- **Introduction** and AE method basics
- **Results**:
  - Deterministic AE forecasting
    - ✓ General results
    - ✓ Adjustment to complex terrain
    - ✓ Different starting models
  - Probabilistic AE forecasting (current work)
- **Conclusion**

Introduction

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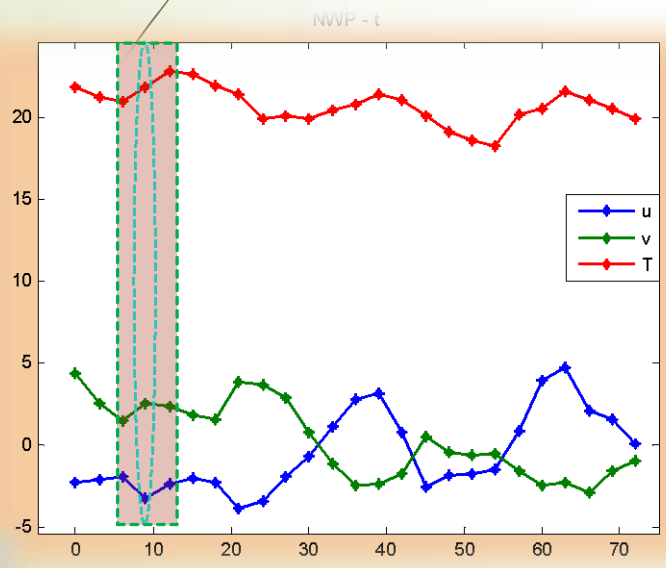
Analog – based method needs:

- Time series of measurements on location of interest
- Historical NWP on the same location and period (training + verification)
- Current NWP



Current NWP

How does this method work?

1. For each lead time of a current prediction it searches the most similar past NWP in training period considering several predictors (variables forcasted) and $\bar{t}$ time steps before/after:

$$\|NWP_t\ A_{t'}\| = \sum_{i=1}^{N_A} \frac{w_i}{\sigma_{fi}} \sqrt{\sum_{j=-\bar{t}}^{\bar{t}} (F_{i,t+j} - A_{i,t'+j})^2}$$

F – NWP
A – analog
t – time (now)
t' - time (in the past)
$\bar{t}, j$ – time frame
N_A, i – predictors

Introduction

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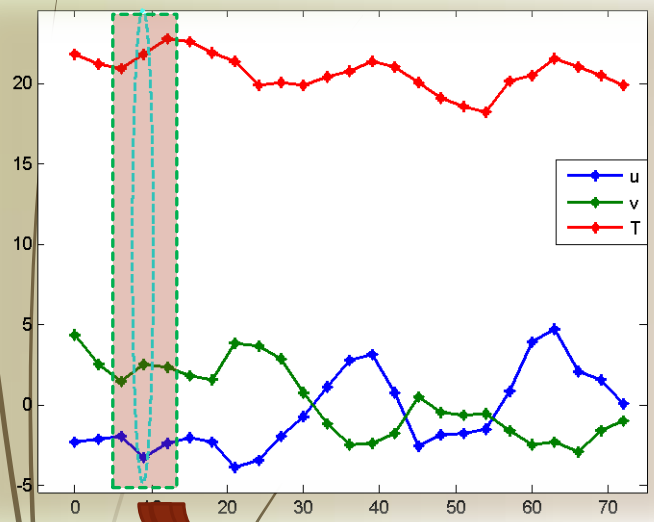
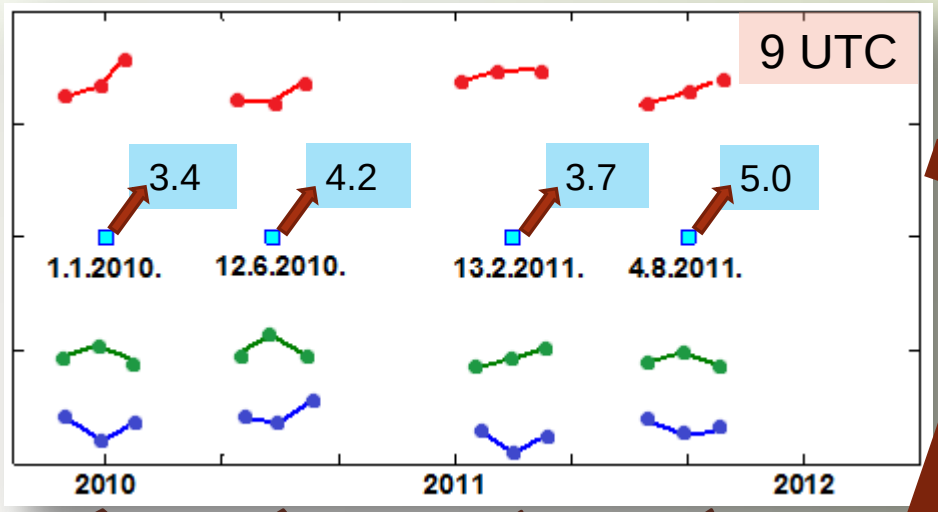
Current NWP



NWPs in training period



measurements

How does this method work?

2. For N most similar past NWPs in training period we choose corresponding measurements called analogs and they make ANALOG ENSEMBLE (AE)

3.4 3.7 4.2 5.0

AE for current 9 UTC

Deterministic forecast

Probabilistic forecast

Methods

2.5	3.2	3.5	3.9	4.2	4.3	5.0	5.4	6.3	7.0

AE for current 9 UTC

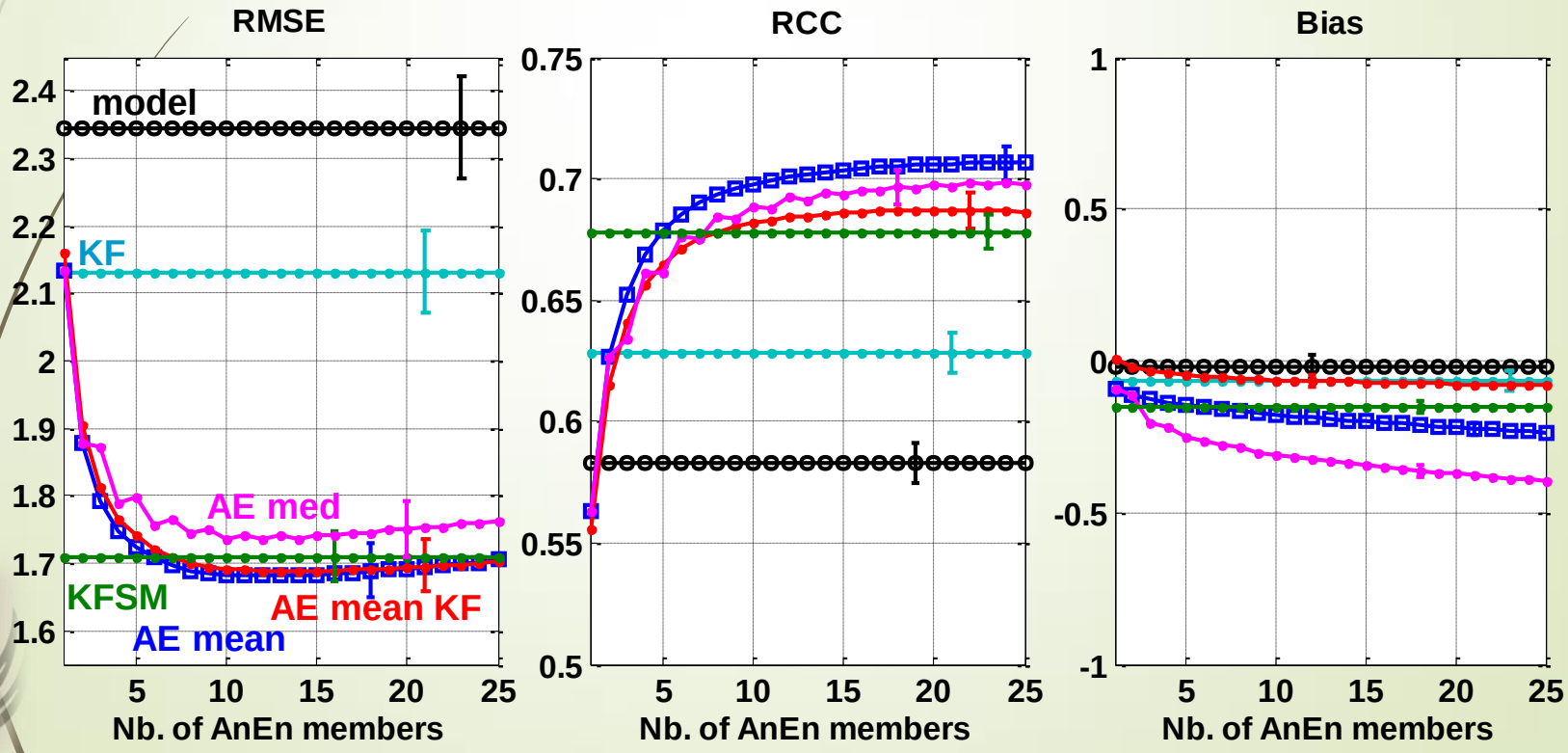
Deterministic forecast:

- AE mean
- Kalman filter of AE mean (AE mean KF)
- AE median (AE med)
- Kalman filter of sorted AE metrics (KFSM)

Probabilistic forecast

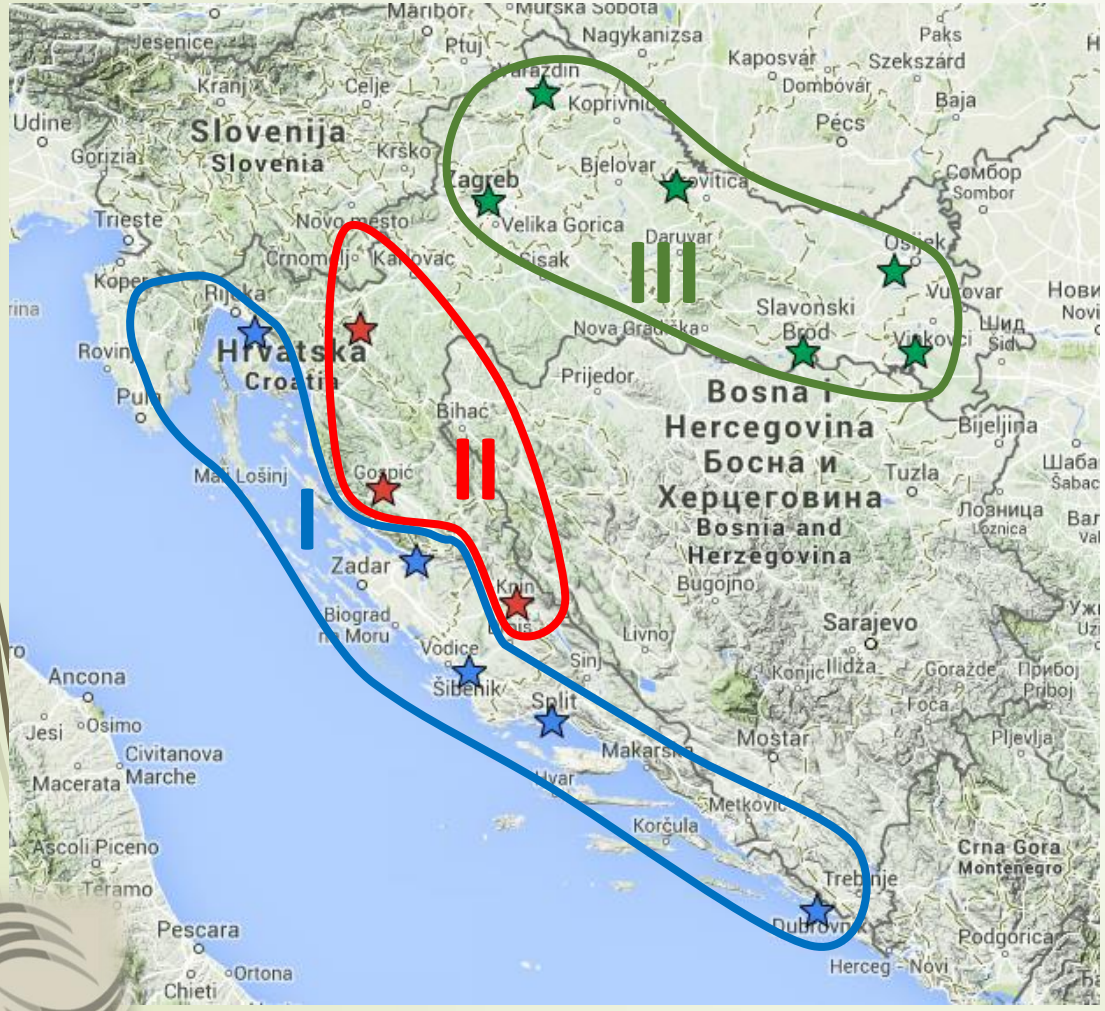
Deterministic AE forecasting

- Trainig period: year 2010 & 2011.
- Verification period: year 2012.
- Starting model: ALADIN regional model with 8 km grid spacing, 3 h lead time step, up to +72 h, starts at 0 UTC
- 14 stations
- How many analogs to choose? ~15



Deterministic AE forecasting

Adjustment to complex terrain



- I:
  - Coastal area
  - Largest wind speeds (bora)
- II:
  - Higher altitude
  - Mountain area
- III:
  - Continental part
  - Smallest wind speeds

Deterministic AE forecasting

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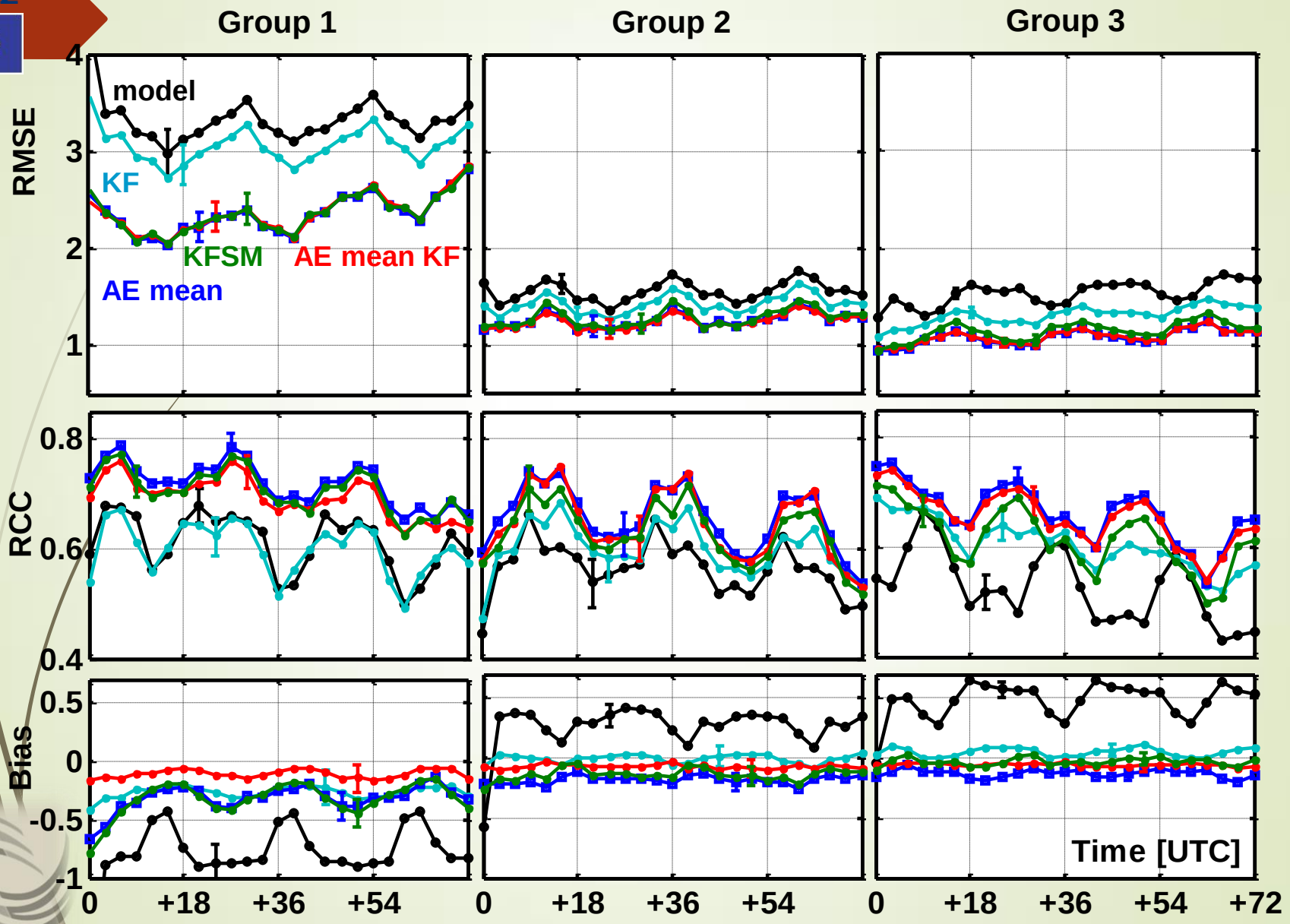

Deterministic AE forecasting

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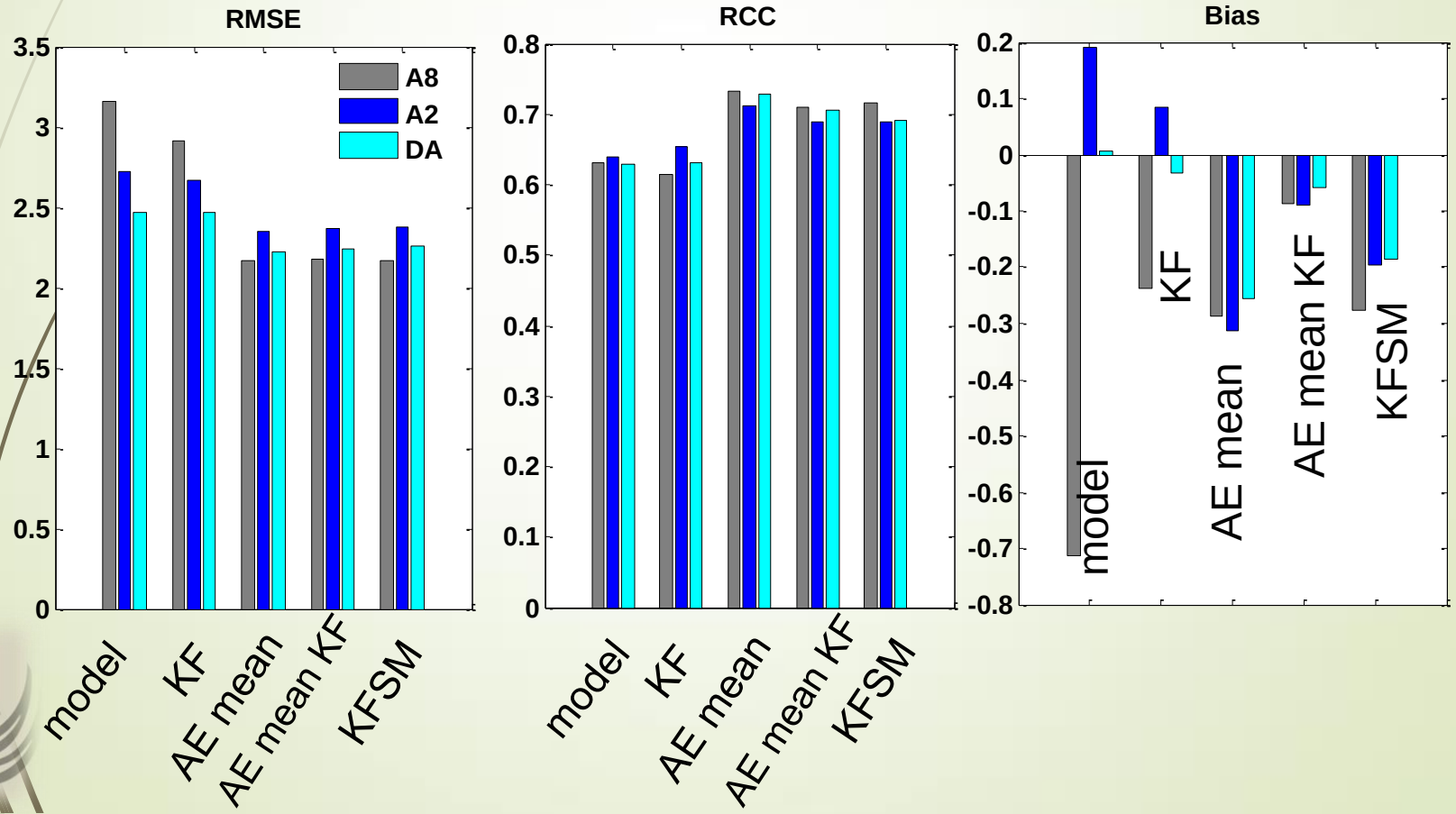
- How does change in horizontal resolution affects AE methods?
  → at Group 1 locations for 09-24h UTC:

ALADIN 8 km: 37 levels; 240 x 216 grid points; 72-hourly forecast, 3 hours output; hydrostatic
ALADIN 2 km: 37 levels; 450 x 450 grid points; 24-hourly forecast; 1 hours output; nonhydrostatic
DADA 2 km: 15 levels; 450 x 450 grid points; 72-hourly forecast; 3 hours output; hydrostatic



Deterministic AE forecasting

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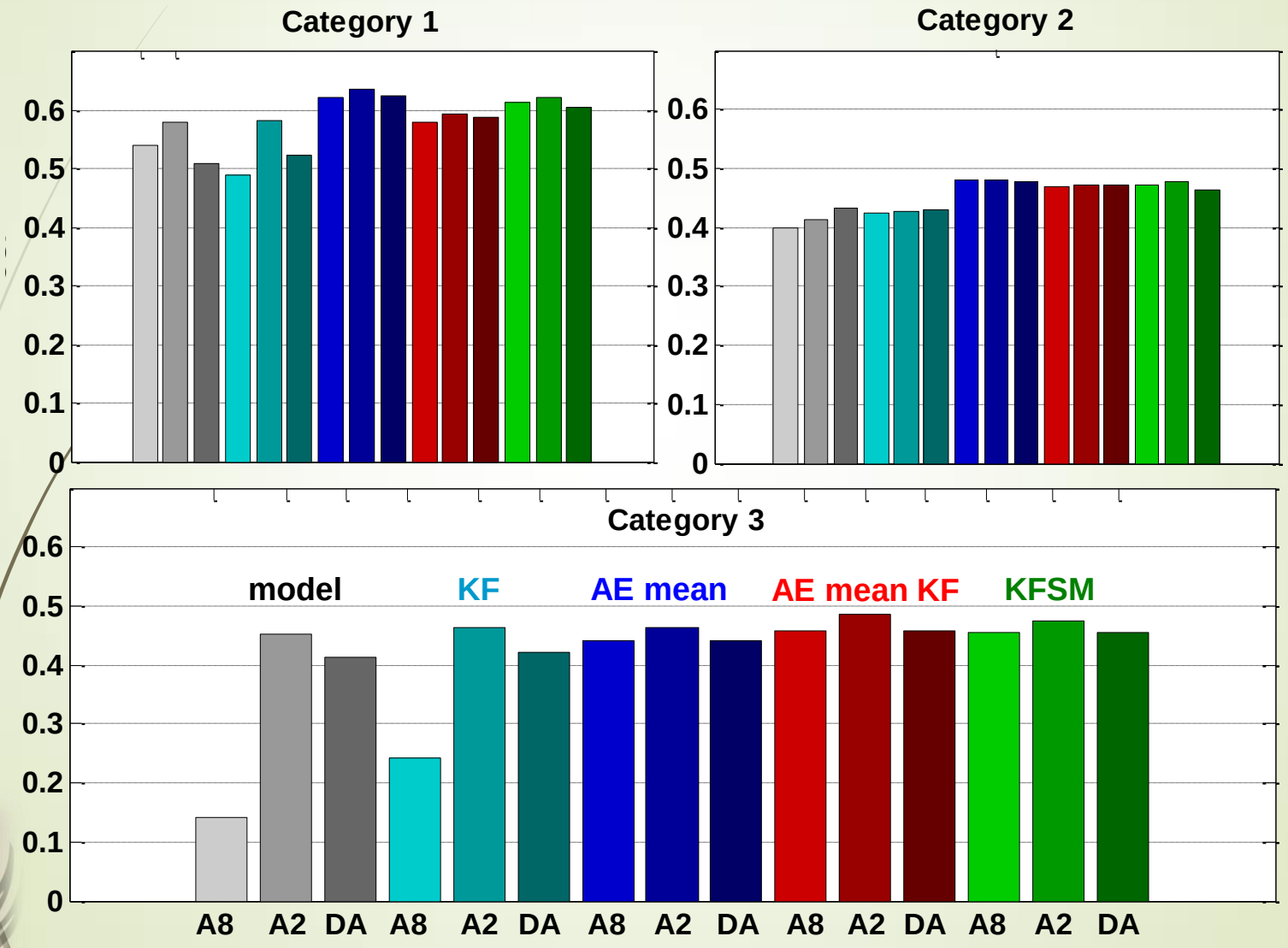
Critical Success Indeks – Group I:



Probabilistic AE forecasting

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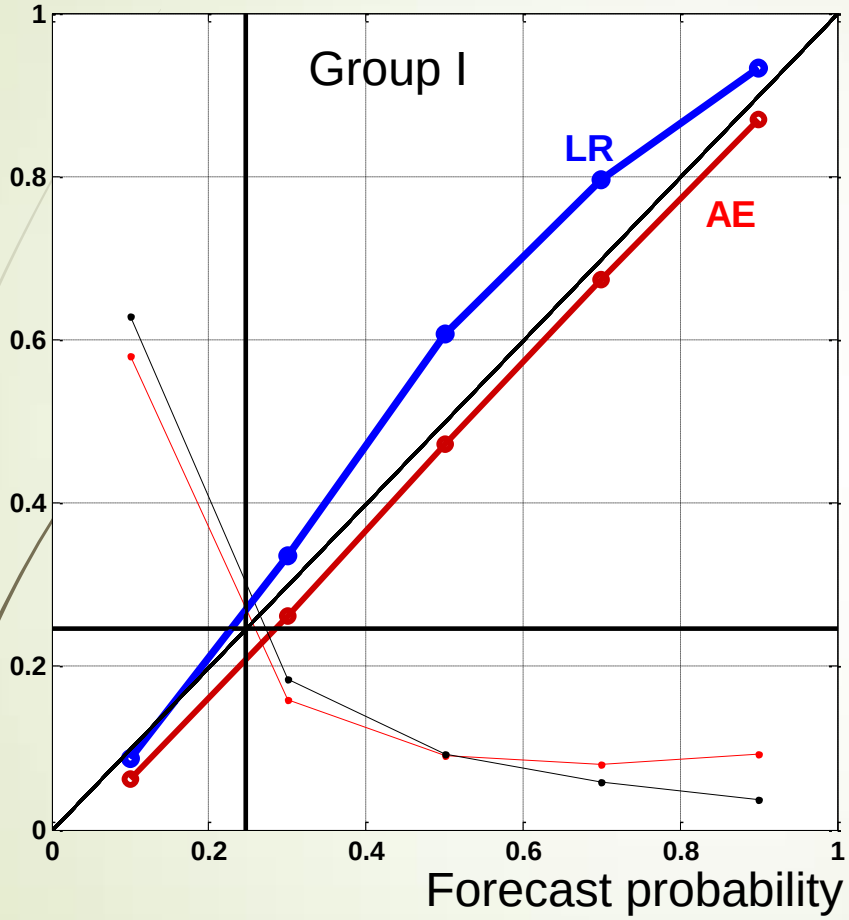
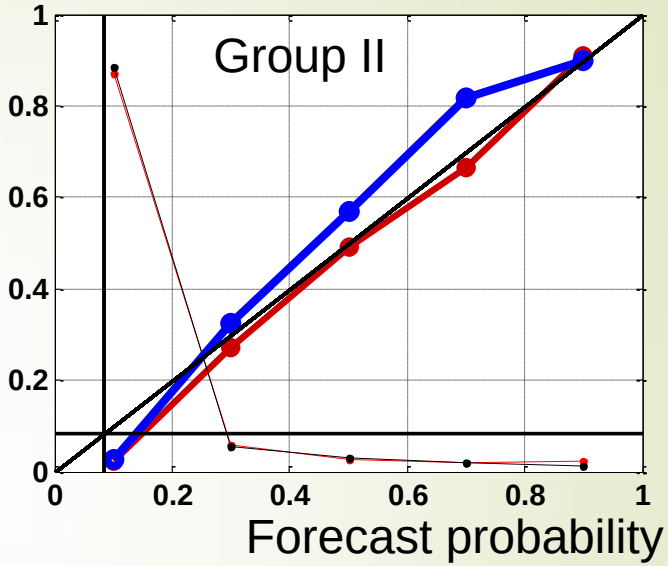
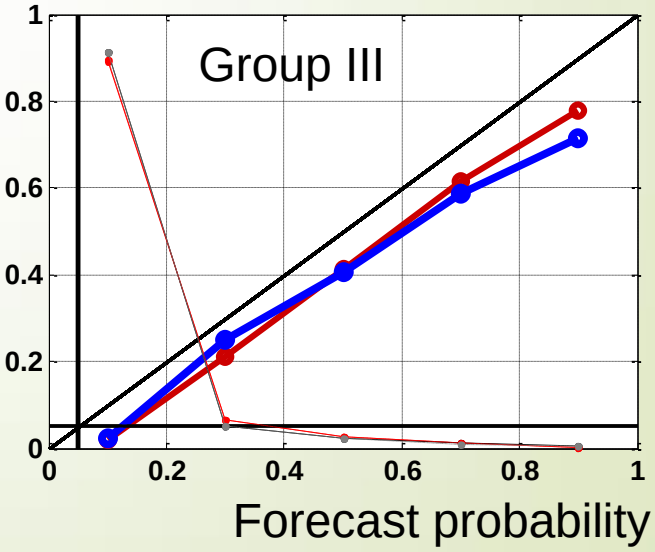
Reliability diagram:







AE Forecast probability
AE Observed relative frequency
LR forecast probability
LR Observed relative frequency

Conclusion

AE methods:

- Well adjusting to all sorts of terrain (especially AE mean)
- Reduce RMSE and bias, while improving RCC
- In most cases starting model with 8-km horizontal resolution produces the best results
- Using higher resolution improves accuracy for high wind speed forecasting
- Reliably quantify uncertainty

THANK YOU!