Weather Intelligence
for Wind Energy
WILL4WIND

Weather Intelligence for Wind Energy - WILL4WIND project -

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and DHMZ team

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What means to manage energy?

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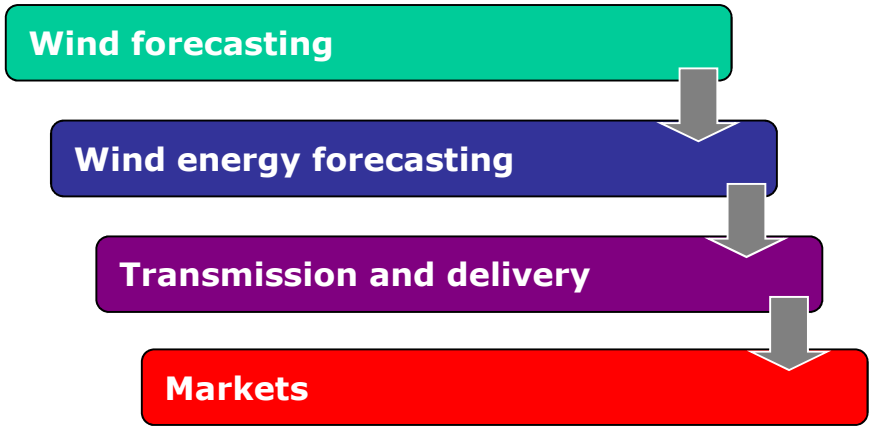
Wind energy management is

- Knowing what to do with produced energy
- How frequent is balance of production and consumption?
- Includes issues of planning (transmission, scheduling, maintenance, trading, ..)
- Thus predictions are required for efficient energy management
- Near-surface wind variability and predictability are key words here

Predictions

- Required forecast horizons from seconds to weeks
- Required realistic treatment of uncertainty



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Wind energy in Croatia

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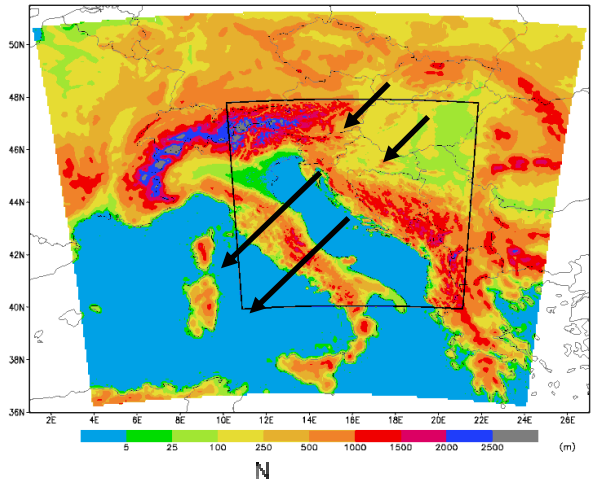
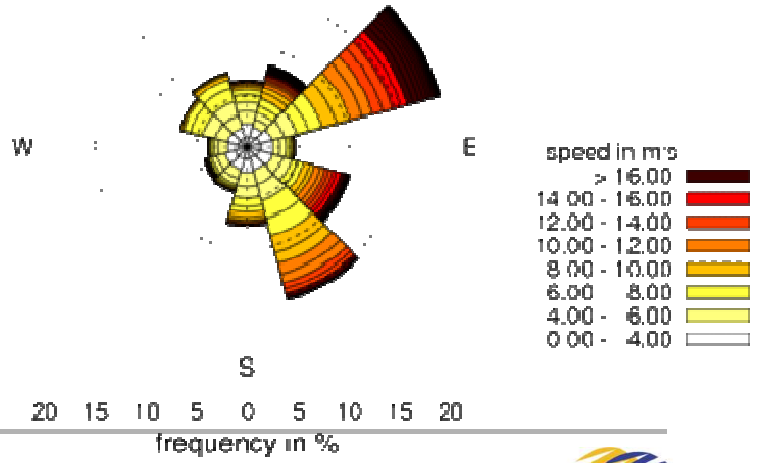
Wind energy in Croatia

- Wind energy is an accelerating business in the coastal part of Croatia (currently ~10% of installed total national energy production capacity)
- Plans for 3x by 2020

Challenges

- The coastal area of Croatia has a specific wind climate
- Complex coastal terrain prone to strong winds, esp. severe, turbulent NE bora windstorms
- May reach wind speeds of 40 m/s, gusts of 70 m/s and TKE of 65 J/kg





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Wind energy in Croatia

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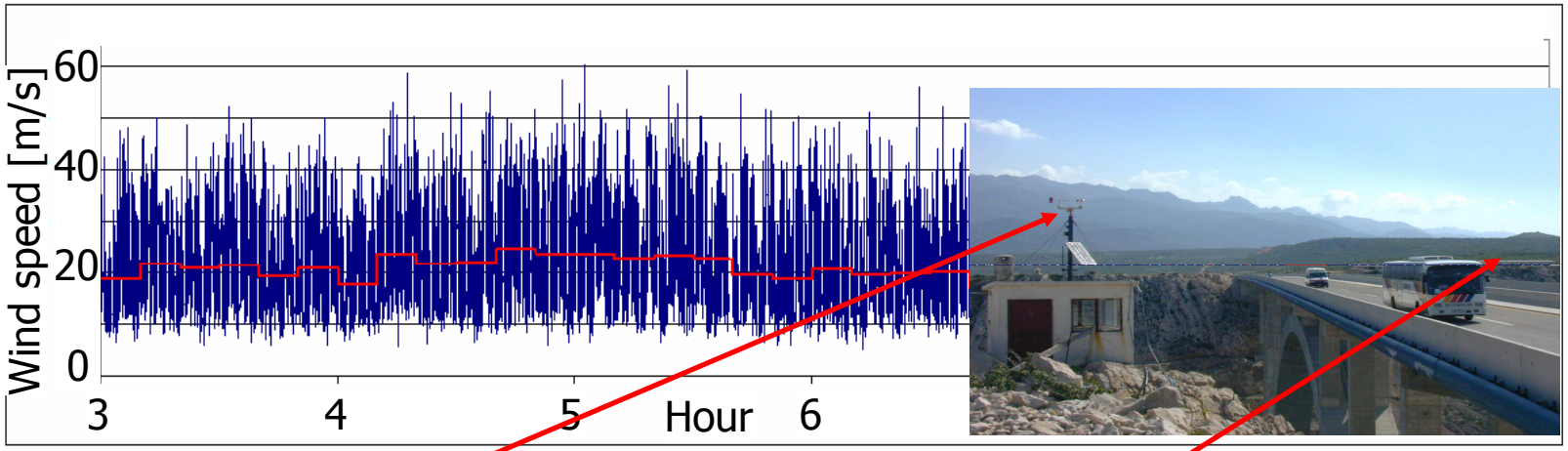
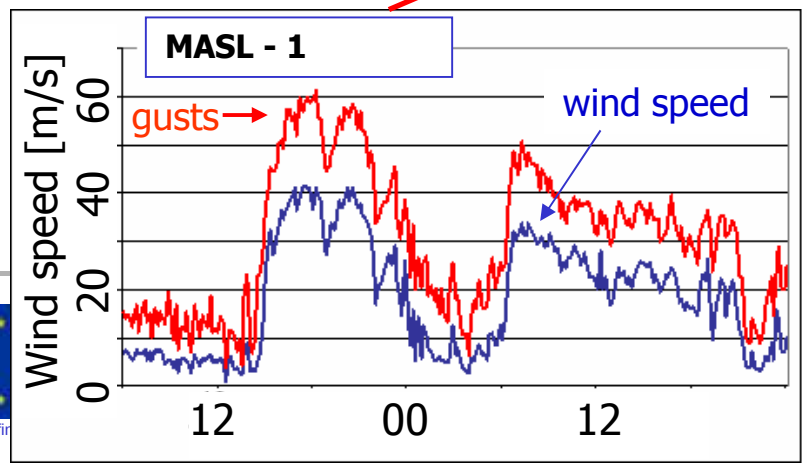
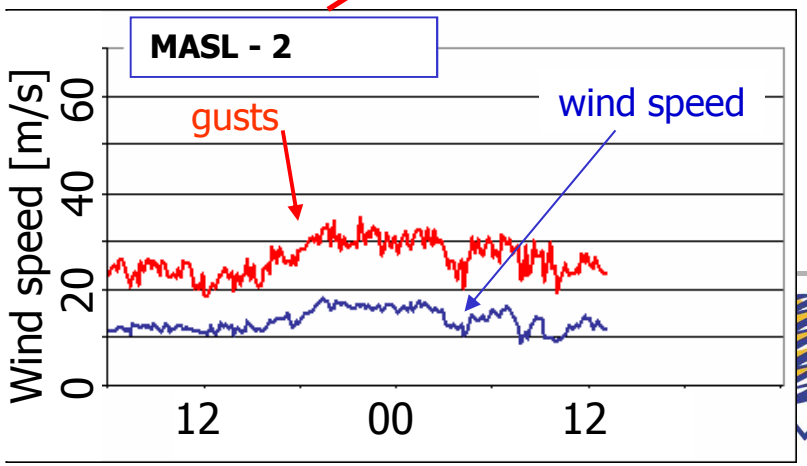
Bora flows

- large temporal and spatial variability beyond NWP capabilities







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Project consortium: "handling all aspects"

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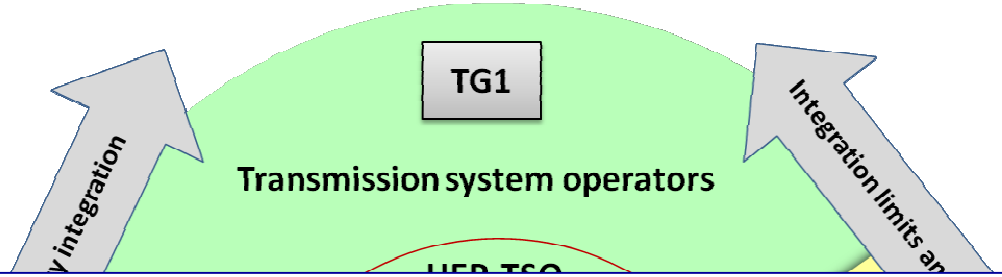
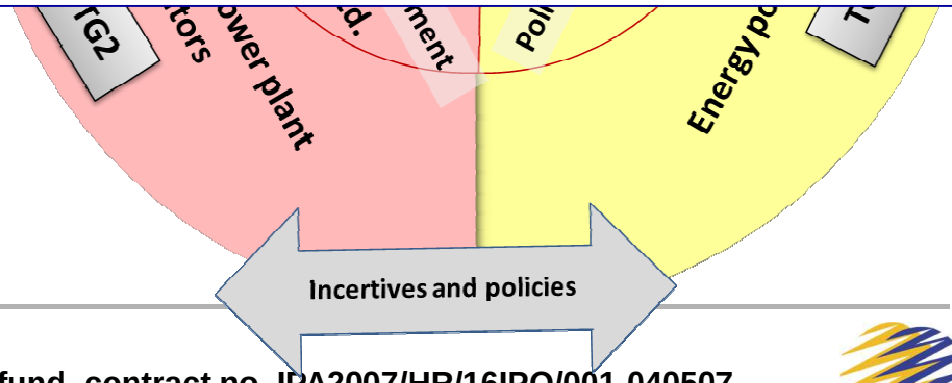
- Starting date: 10 Apr 2013
- Duration: 2 years



Energy systems are local-oriented – needs for local interactions

Croatian consortium = Solutions for specifics of the wind climate

- TSO (Croatian)
- Energy Inst. Hrvoje Požar
- SME (RPGP)
- (Wind turbine producer Končar)



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ALADIN model chain

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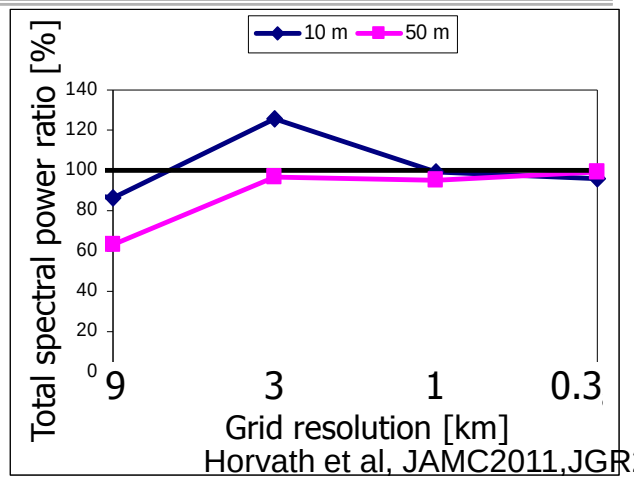
- Meteorological aspects
  - NWP modelling
  - Statistical modelling
- Period 2010-2012

GLOBAL MODEL(S)
ARPEGE/IFS (&IFS)

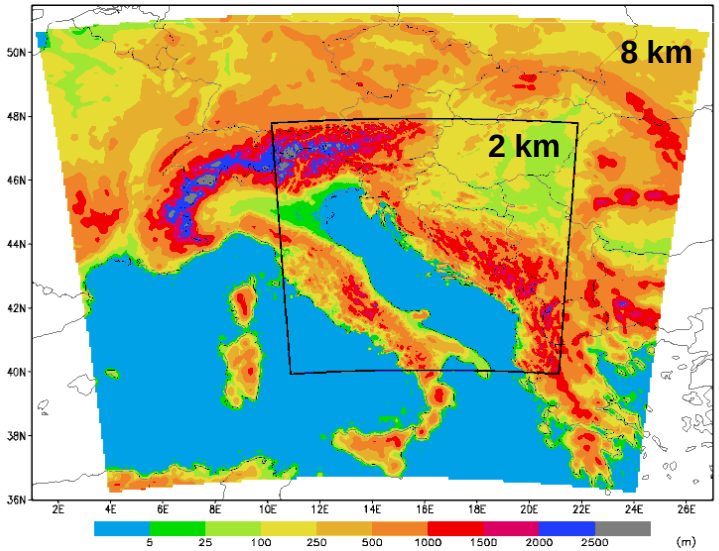
ALARO32T3+3DVar
Grid spacing ~ 8 km, +72h
(MPS-Catry et al., 2007; Geleyn et al.,2008
CPS-Gerard et al., 2009; PBL-Geleyn et al. 2006)
(national poster!)

1. ALADIN (DADA)
Dx~2 km, +72h

2. ALARO36T1-NH
Dx~2 km, +30h



Horvath et al, JAMC2011,JGR2012



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ALADIN model chain

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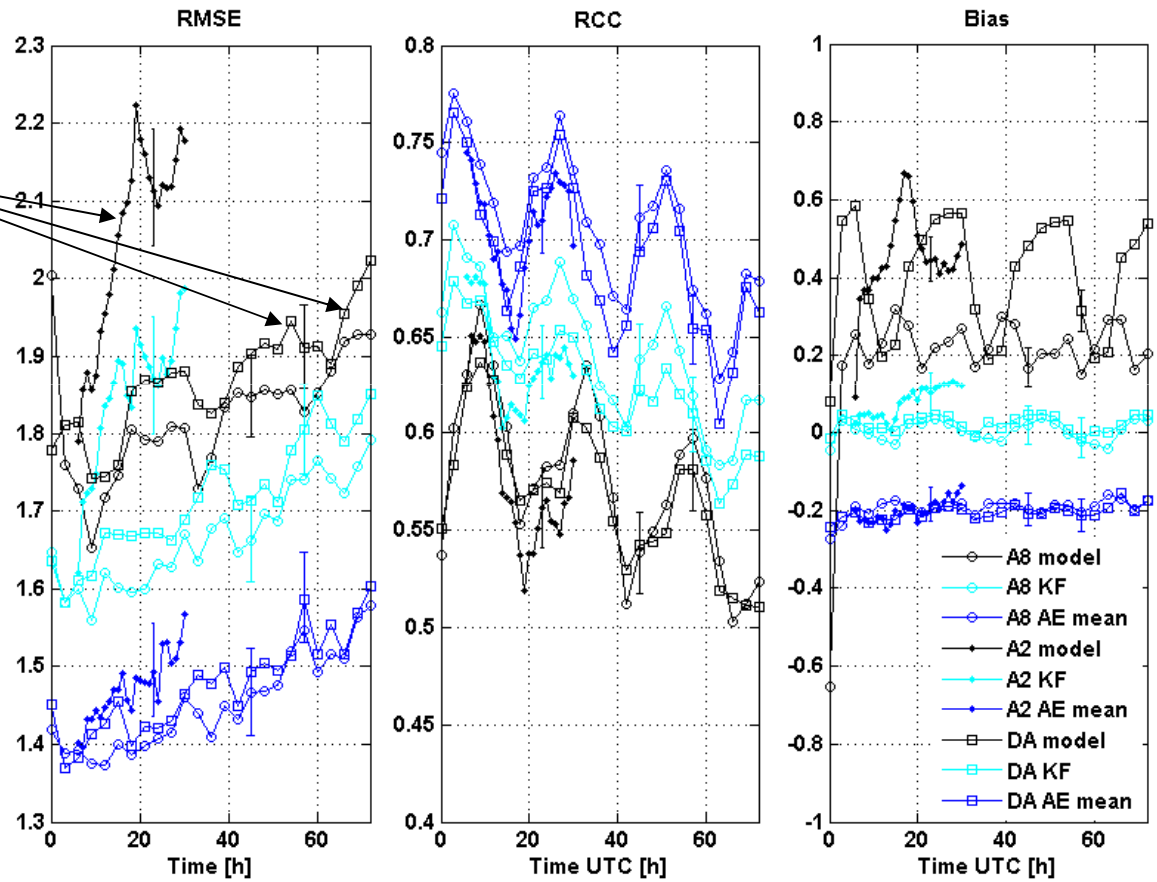
- Statistical verification: generally similar results

ALARO deterministic models



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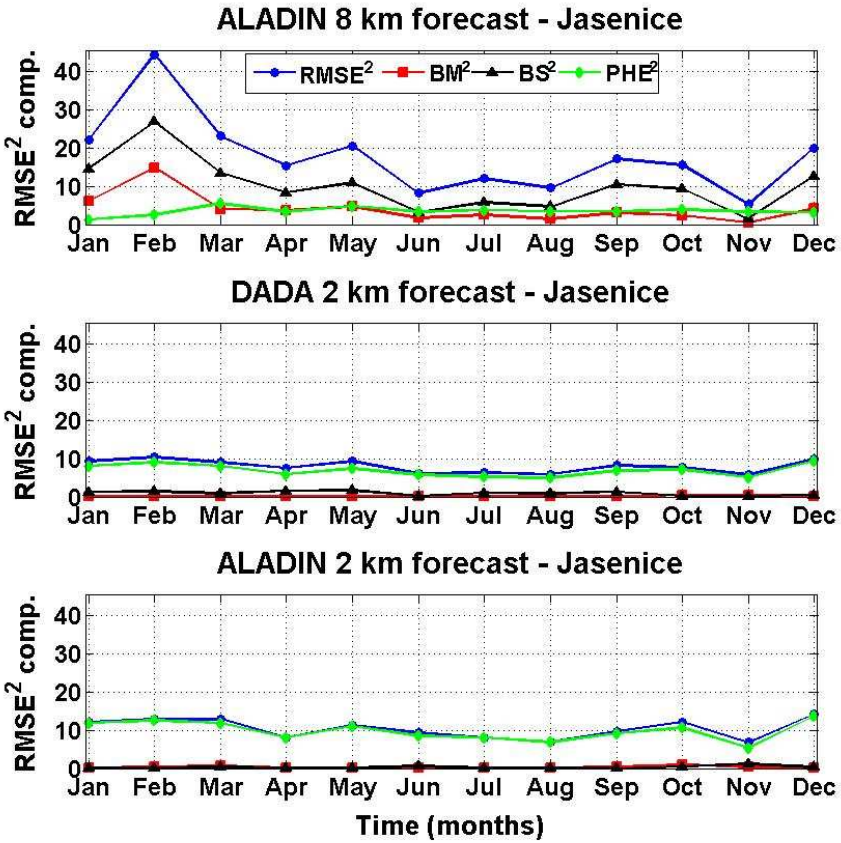
- However, large differences in coastal areas prone to bora flows
- RMSE decomposition (e.g. Murphy, MWR1988)



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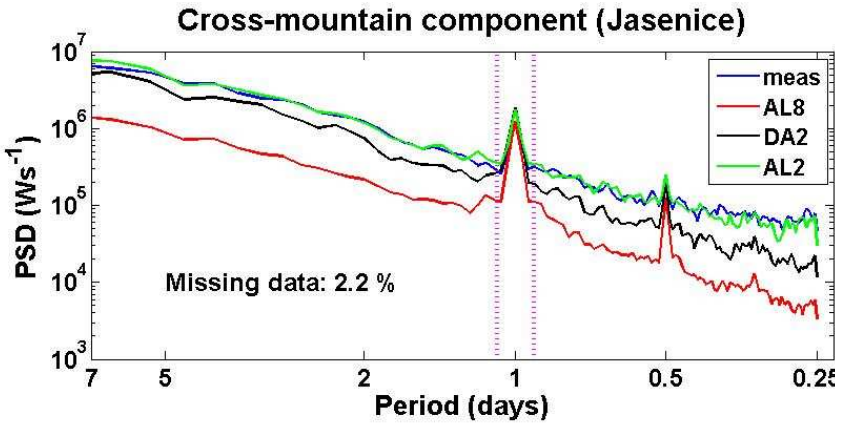
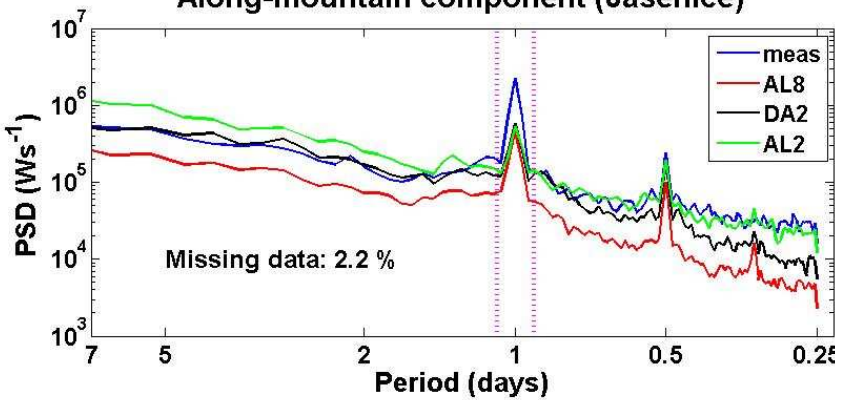
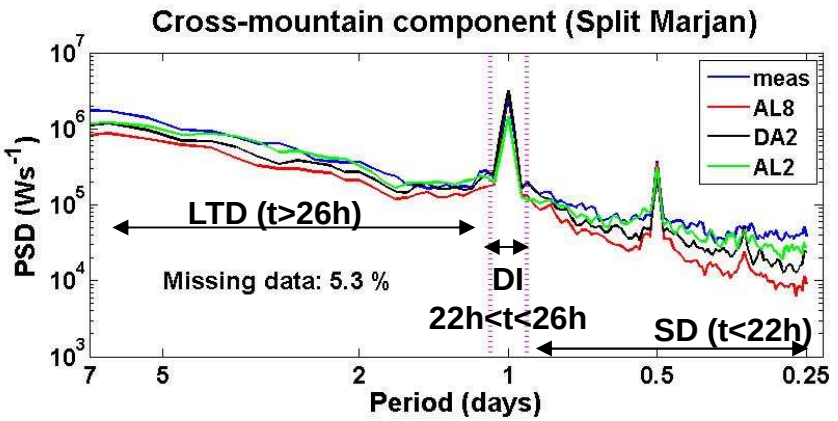
■ Spectral analysis and phase-error tolerant measure in spectral space

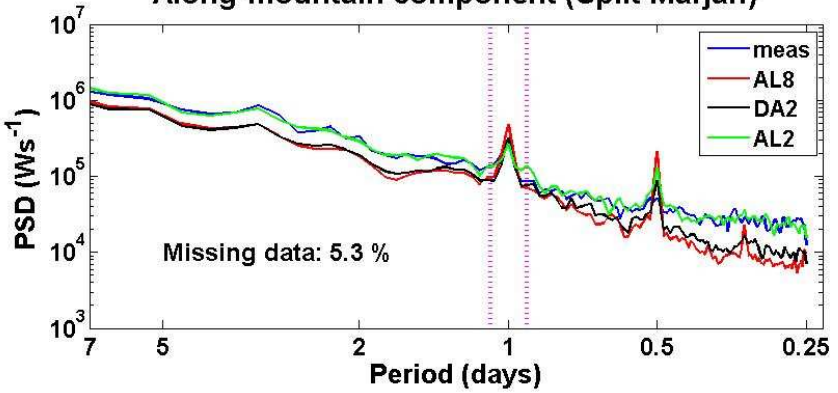
Coastal station with strong bora





Regular coastal station





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ALADIN model chain

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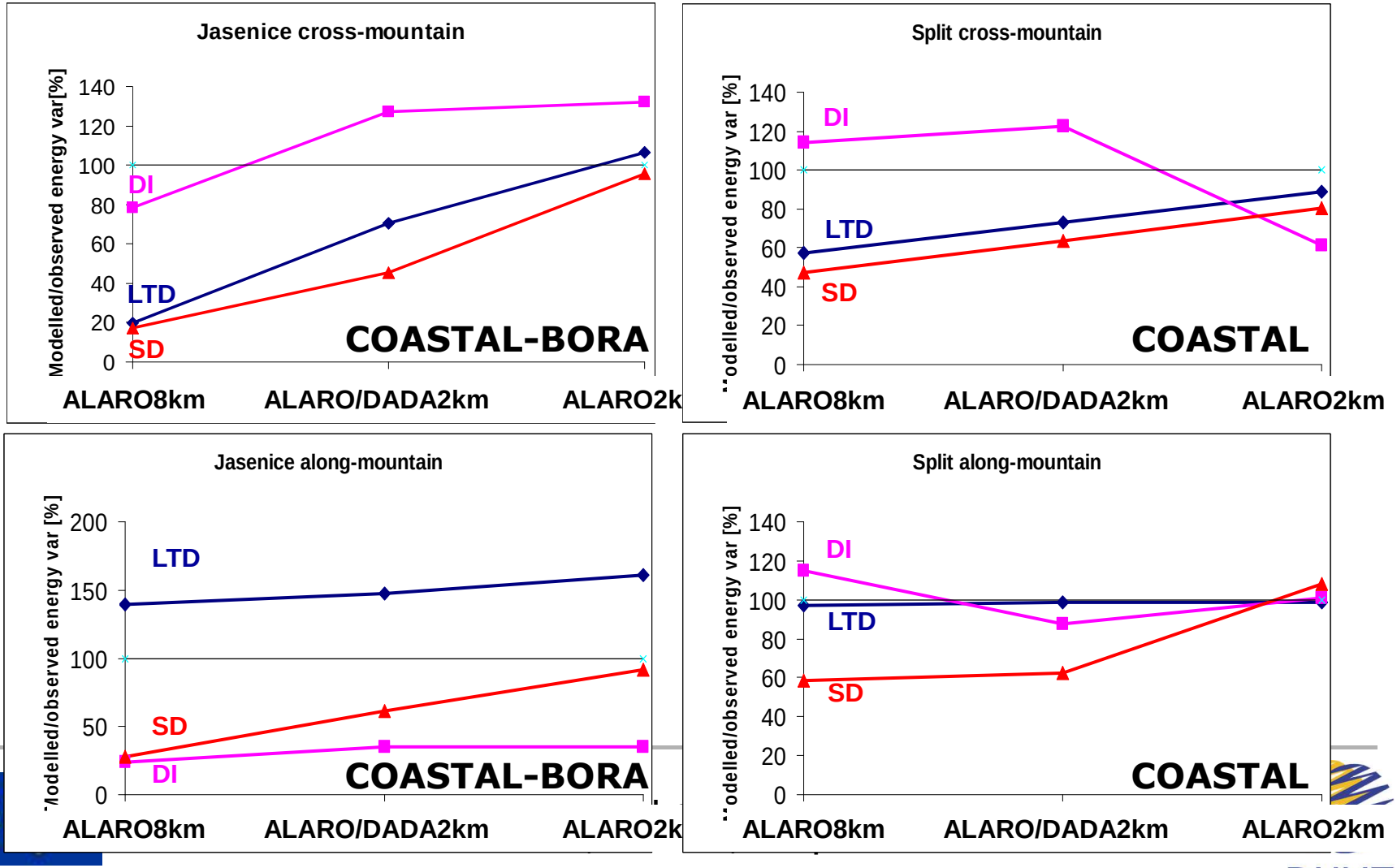
- Spectral measures indicate clear improvement



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ALADIN model chain

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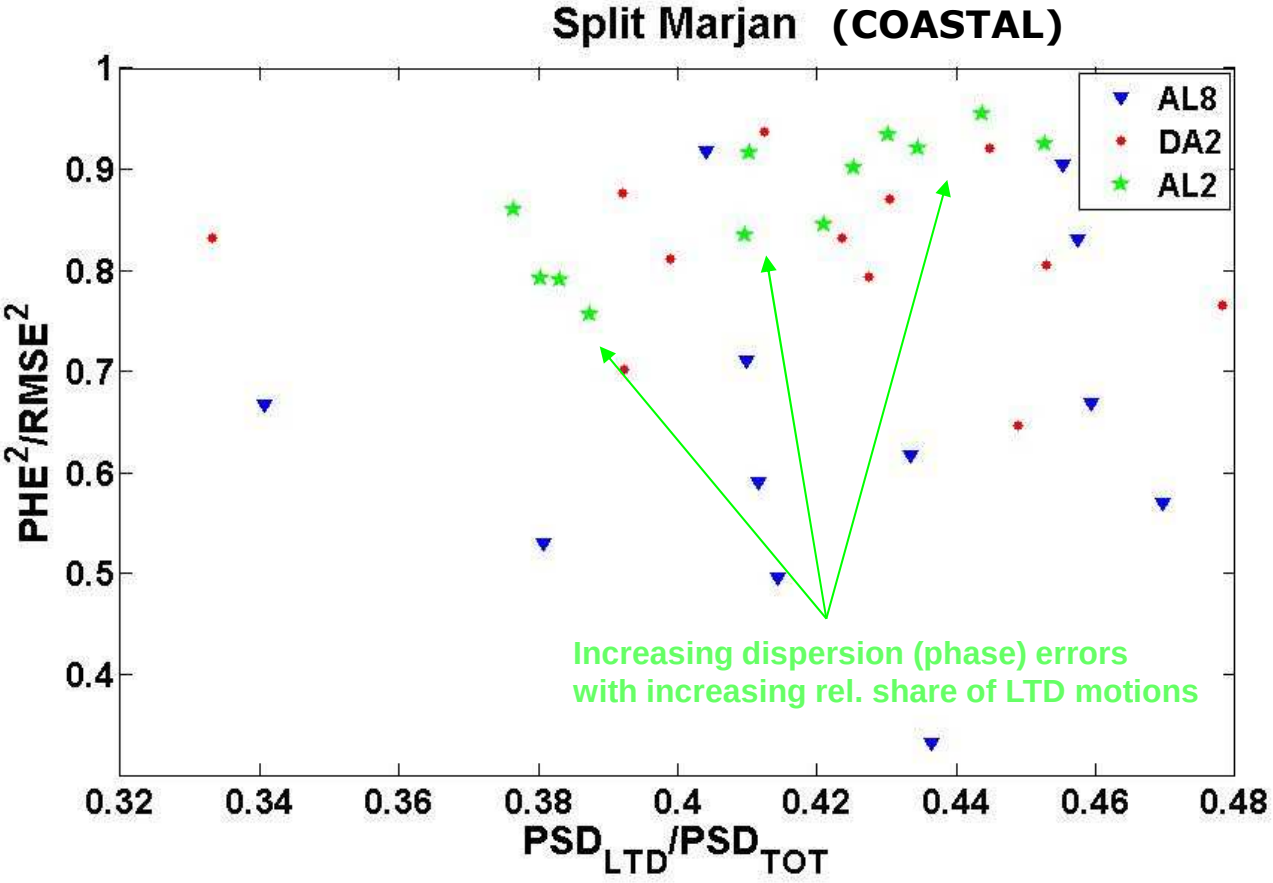
- Relating statistical and spectral verification (monthly averages)



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Statistical modelling

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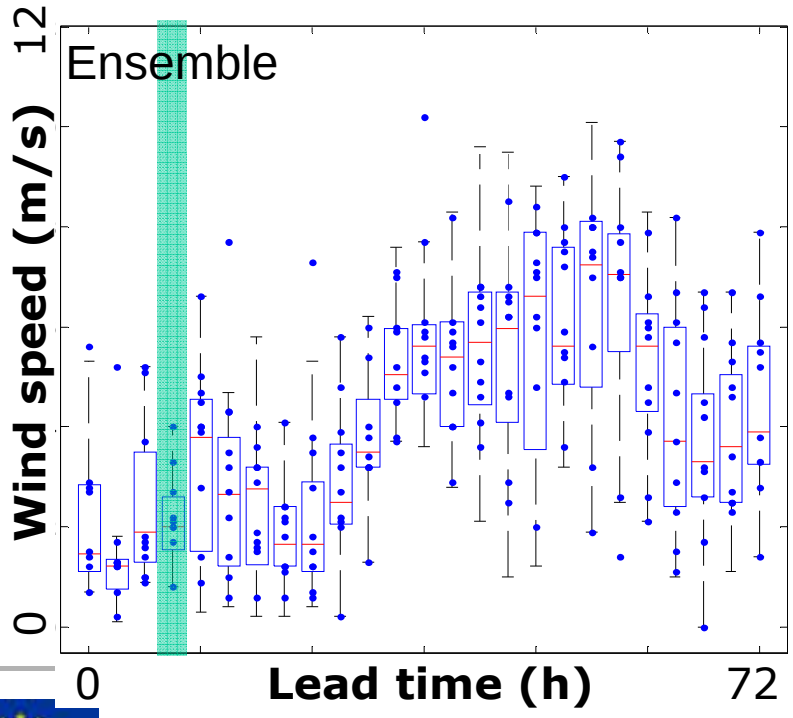
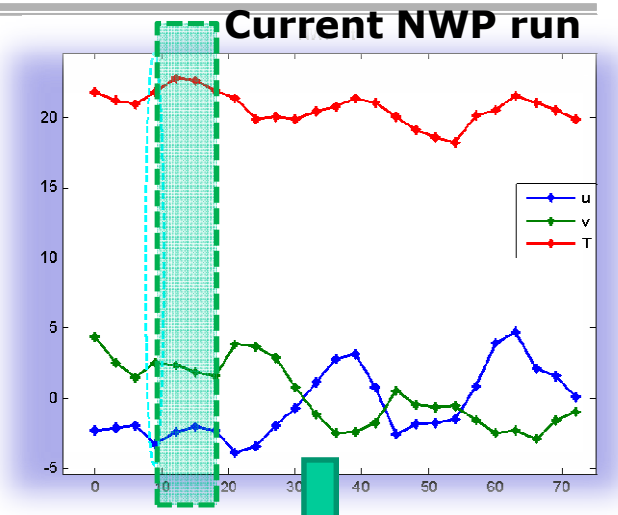
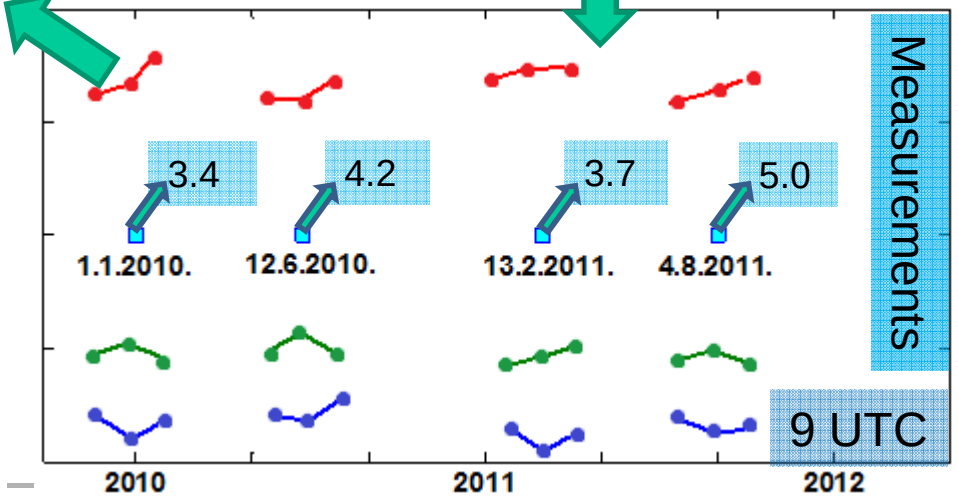
- The "analogue" ensemble method (delle Monache et al., 2011,2014)
- For N the most resembling historical forecasts create an ensemble from corresponding measurements







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Statistical deterministic modelling

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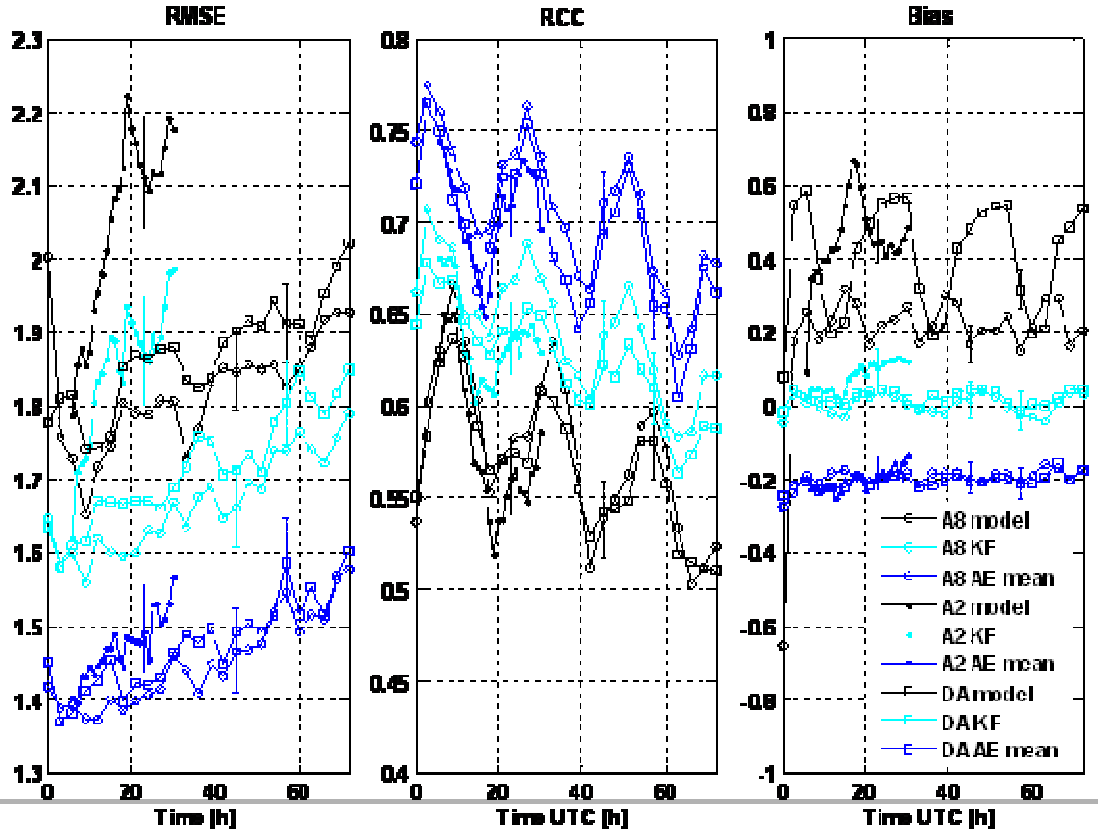
- The performance of deterministic (postprocessing) models
- After applying statistical modelling, the resolution of NWP is not a key issue if analyzed through common measures

ALADIN

KalmanF

AnEn-mean



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Statistical deterministic modelling

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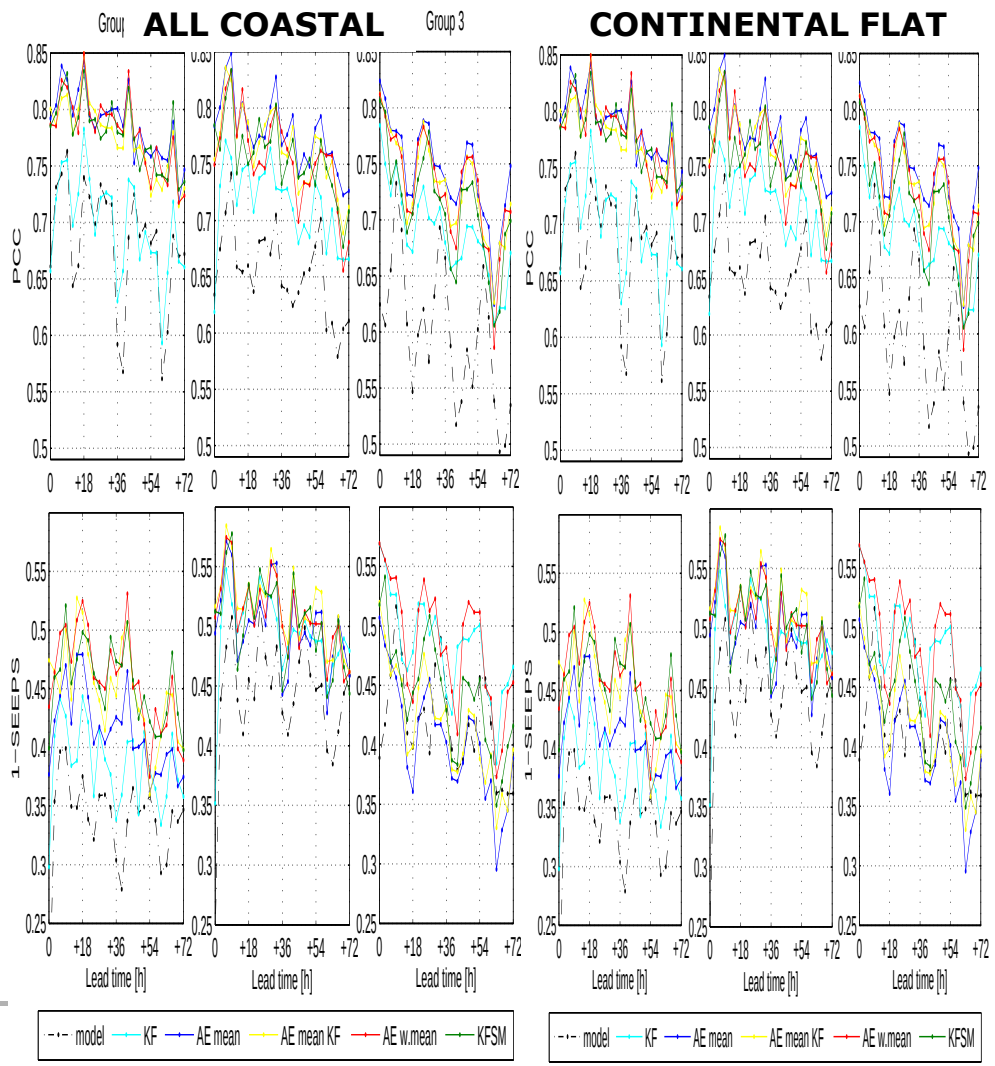
Methods

- Kalman filter
- AE-mean
- AE-w.mean
- KF of AE-mean
- KF of sorted AE metrics
- benefit from AE larger in coastal terrain

Other measures

- PCC – Polyhoric correlation coefficient
- SEEPS – The Stable Equitable Error in Probability Space
- CSI – Critical success index
- FB - Frequency bias



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Statistical probabilistic modelling

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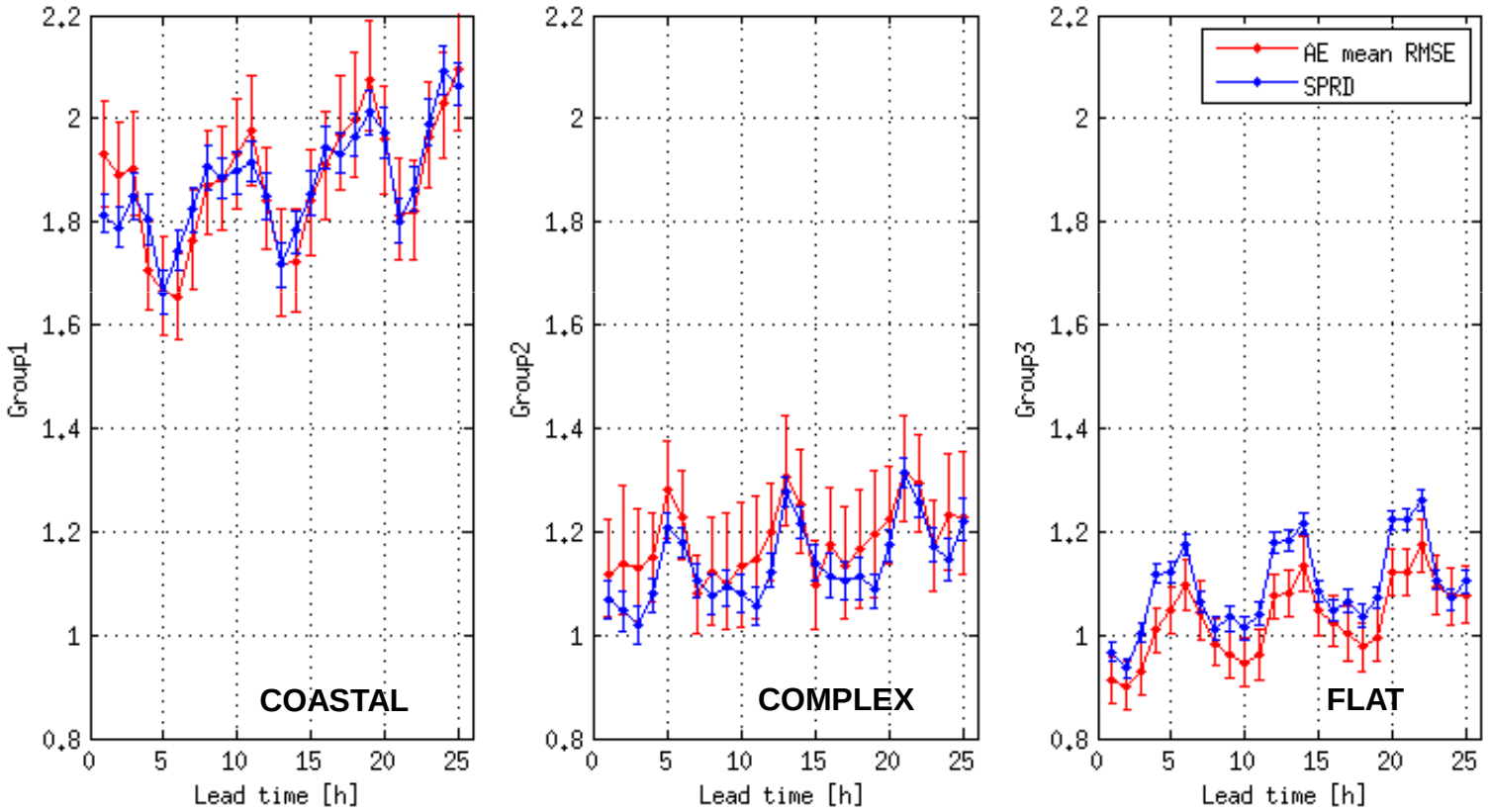
- Comparison of spread and RMSE for AE



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Statistical probabilistic modelling

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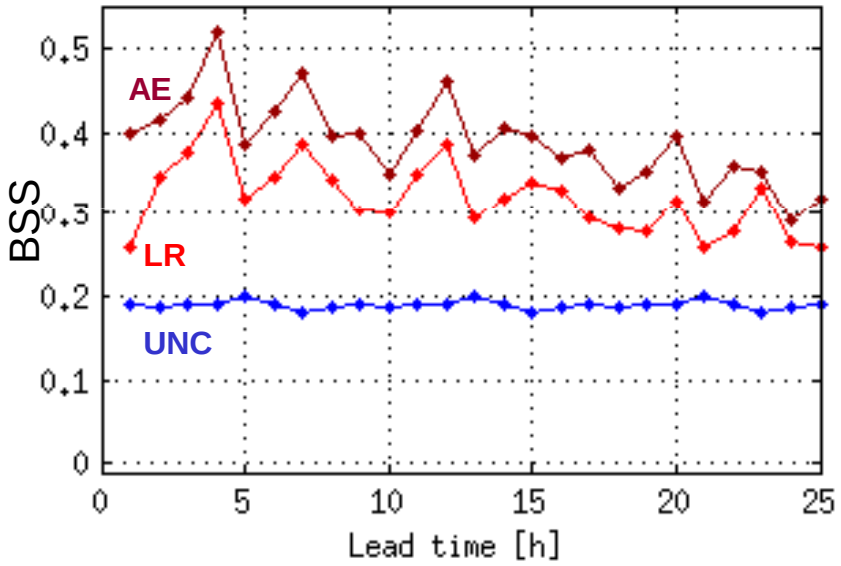
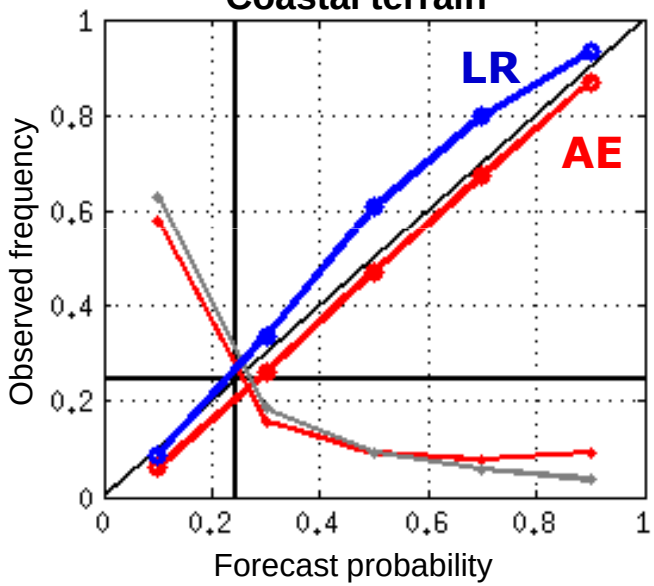
- Comparison of logistic regression and analogue ensemble

Coastal terrain

V>5m/s, 1.1.2012.-31.12.2012.



Coastal terrain



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Nowcasing (0-3h lead time)

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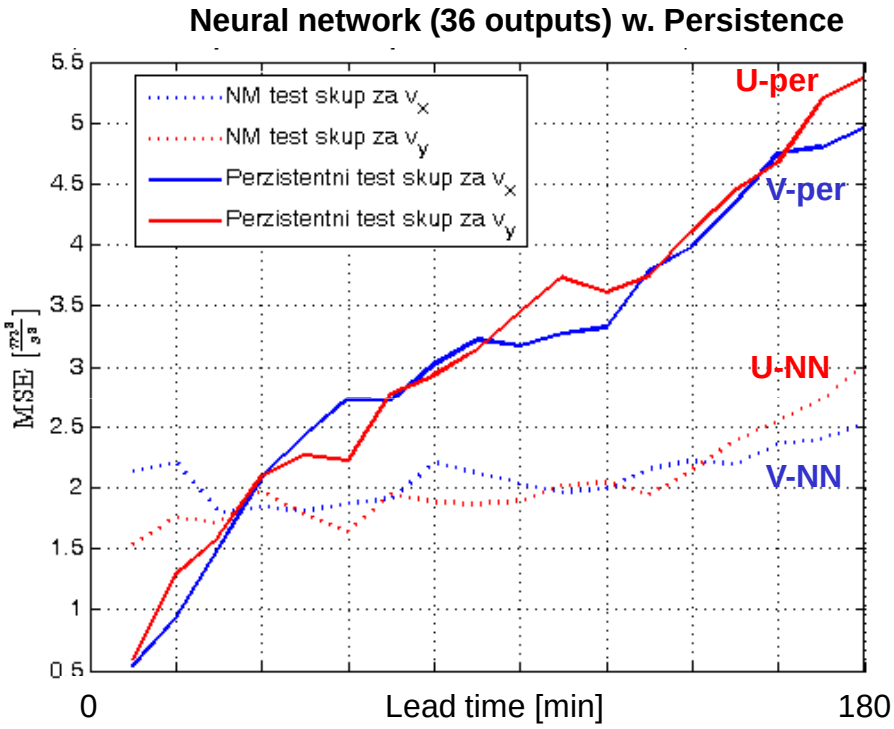
Challenge

- Due to secondary regulation, the greatest technical constraint for TSO is on 10-30min ahead predictions

Methodolody

- Neural network-based approach
- Forecast refreshed every 10 minutes for forecast range 3 hours
- Preliminary results reduce MSE for lead times +2hr by 40% (vs persistence)



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In the end of the day

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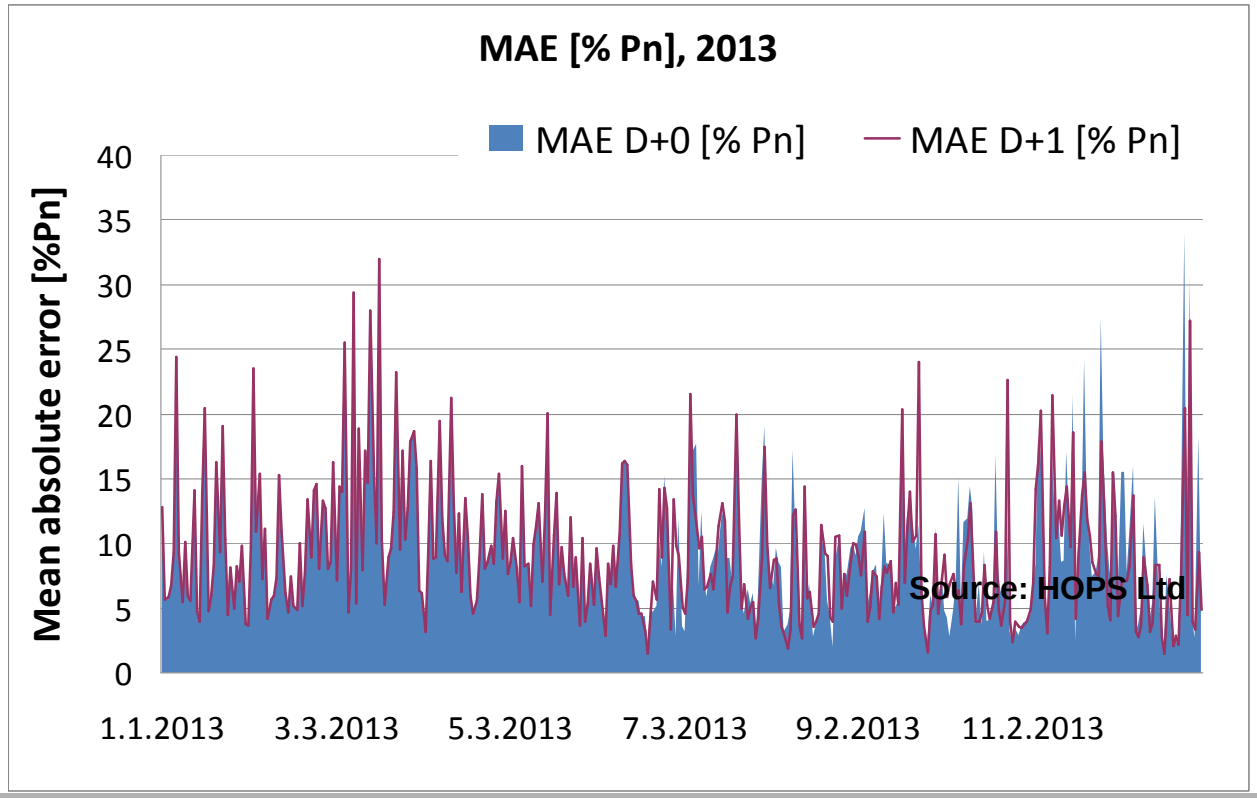
- Croatian TSO uses ALADIN weather forecast in WPPT wind energy production software
- MAE in 2013 was 9% of installed capacity for day-ahead planning



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Instead of conclusions...

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- The uptake of RES is an opportunity to strengthen collaboration between meteorology, ICT and energy sectors

- Meteorological aspects of wind energy are important, but are only one piece of a puzzle

- Meteorologists need to showcase their technologies are useful, and better understand the real needs of the wind energy sector

- Croatian wind climate is a good testbed for:
  - Demonstrating the value of high-resolution modelling
  - Studying different aspects related to severe winds

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