DTU Danmarks Tekniske Universitet

MINES ParisTech

RSE Ricerca Sistema Energetico

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«WIRE» COST Action, benchmark results

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Objectives & Motivation

In the frame of WG1 of WIRE a benchmarking exercise was organised:


cost

WIRE
Weather Intelligence for Renewable Energies

COST Action ES1002

BENCHMARKING EXERCISE ON SHORT-TERM FORECASTING MODELS FOR RENEWABLE GENERATION

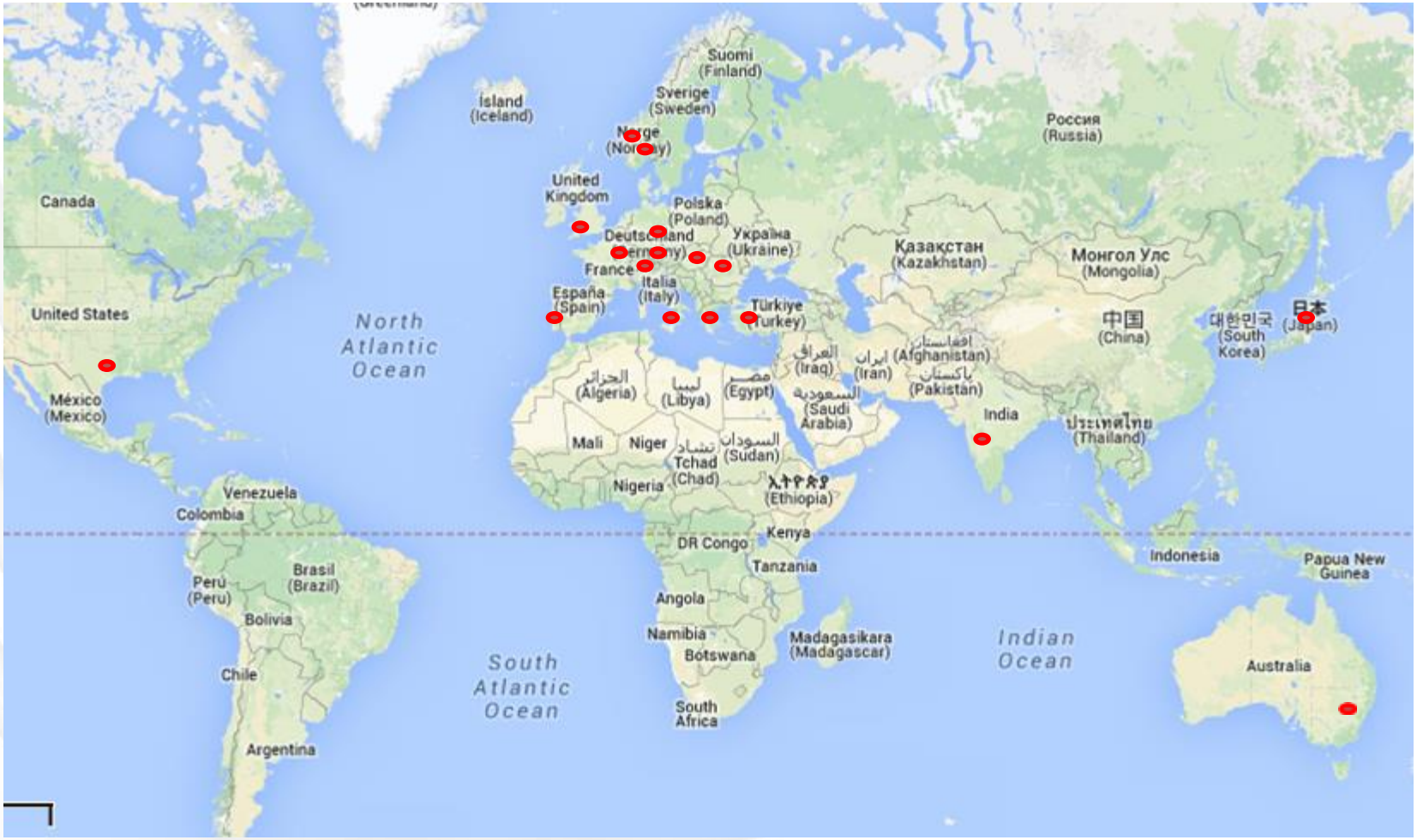
ANNOUNCEMENT

The **main objective** is to evaluate the performance of state-of-the-art models on the problems of short-term forecasting of:

- the power output of a wind farm,
- the power output of a photovoltaic power (PV) plant.

- ❑ The exercise evaluates the merits of forecasts based on different modelling approaches and input data (data from 2 wind farms and 2 PV plants considered).
- ❑ It contributes to a better knowledge of the state of the art, and its evolution through time (comparison with results from past exercises).
- ❑ It permits to identify challenges in the field and areas for improving accuracy in the future.

Benchmark Participants



18 Total participants

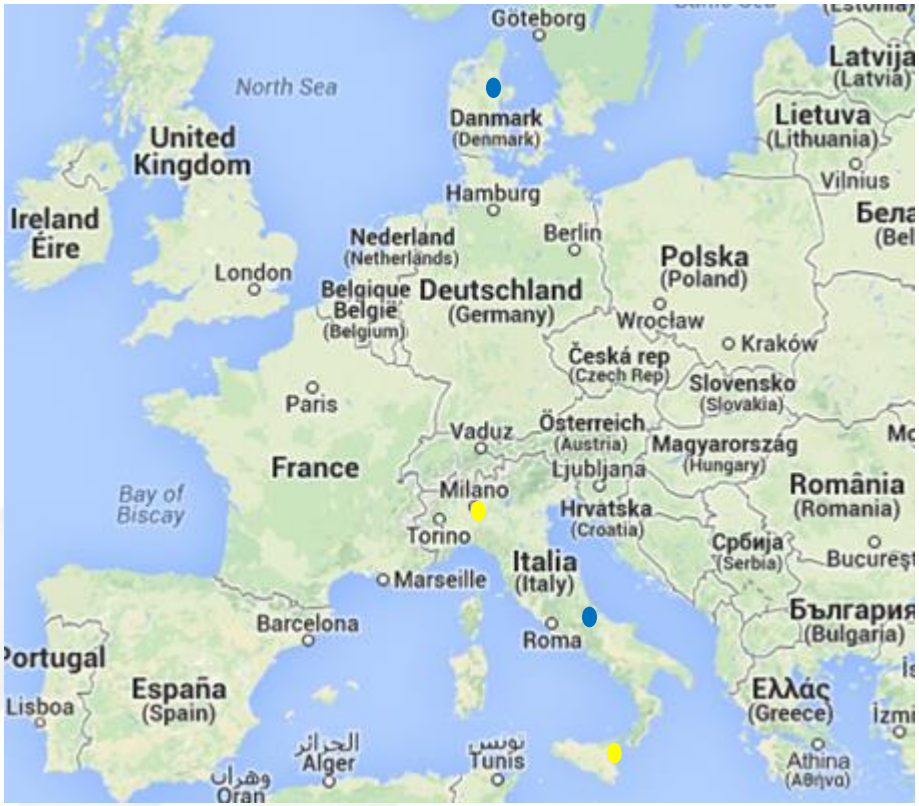
General Data Description

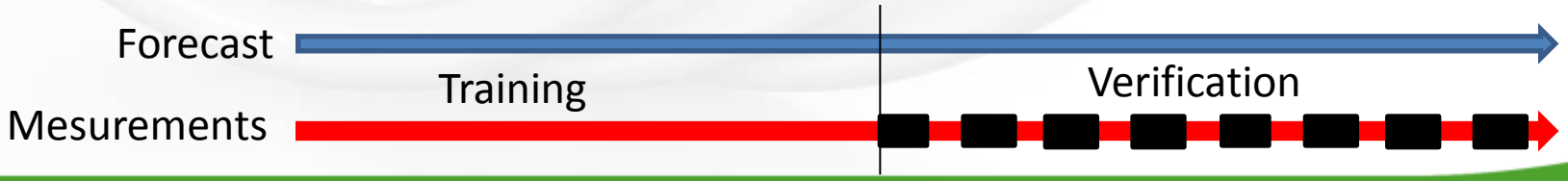
2 solar PV farms (Italy)

- **Catania** (5.21 kW, 01/01/2010 - 31/12/2011, hourly power data)
- **Milano** (5.21 kW, 01/07/2010 - 31/12/2011, hourly power data)

2 wind farms (Italy, Denmark)

- **Abruzzo** (104 MW, complex terrain, 01/01/2010-31/12/2011 hourly power data)
- **Klim** (21 MW, flat terrain, 01/01/2001-31/12/2002 hourly power data)





Abruzzo case (Wind)

ECMWF deterministic runs (12 UTC, 0.125°)

↓

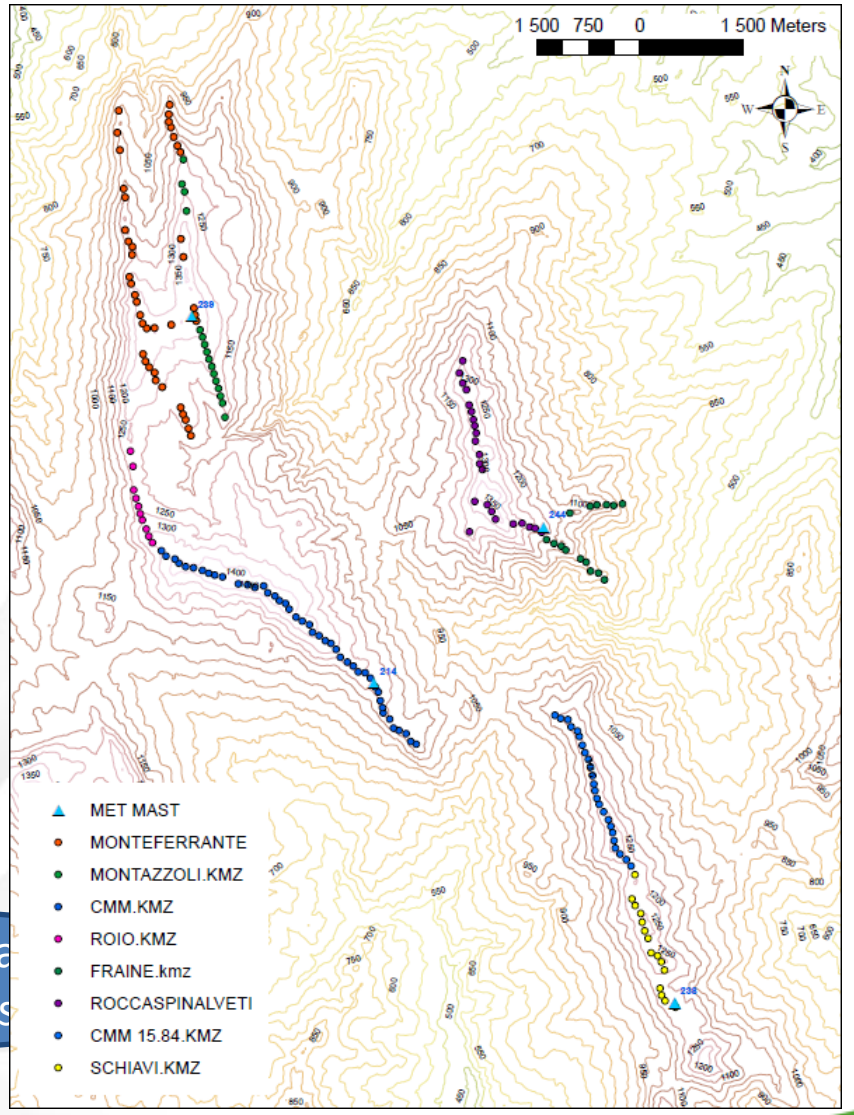
0-72, 3 hourly Meteo forecast 1 point

↓

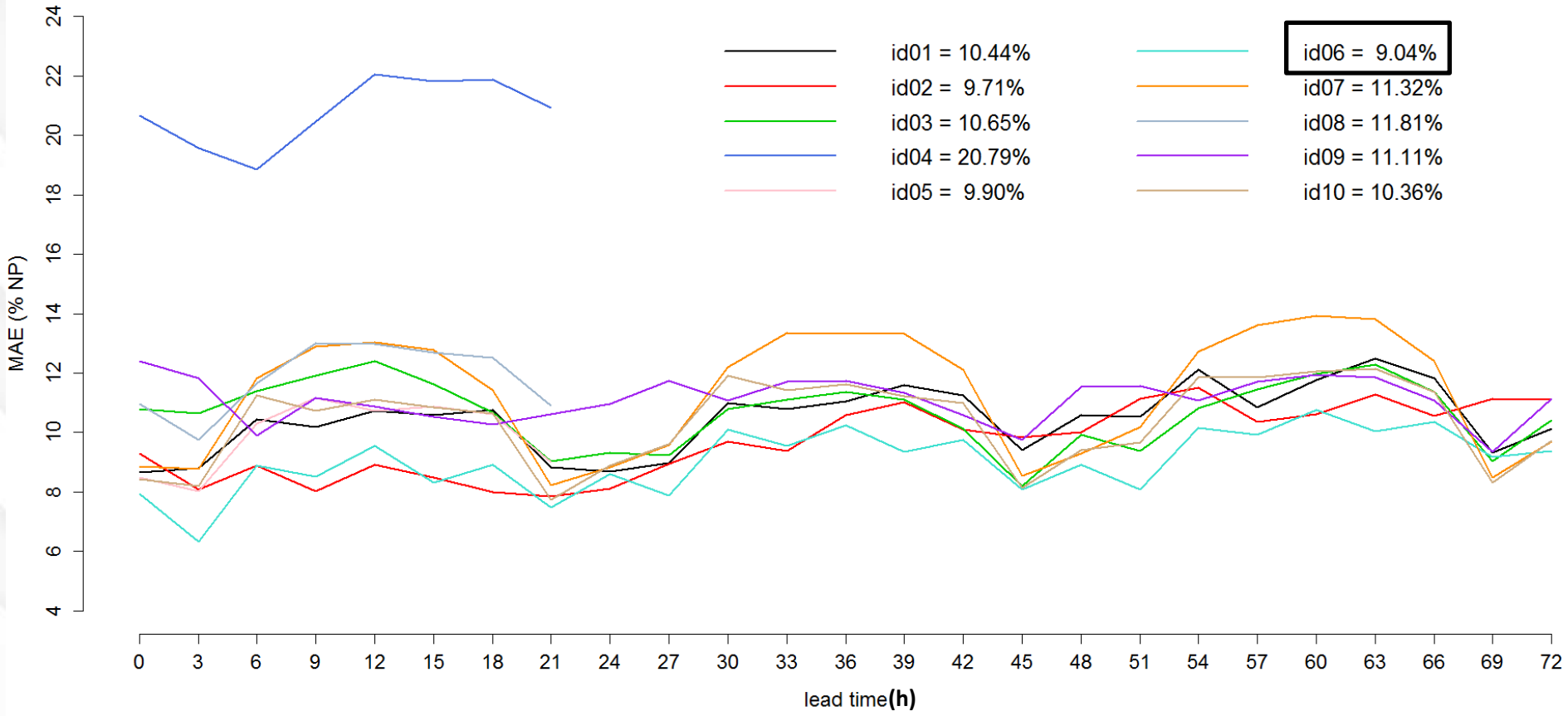
- Wind speed (10m)
- Wind direction (10m)
- Temp. 2m
- HPBL
- MSLP

↘

11 participa
(3 probabilis



Abruzzo results (MAE)



Abruzzo results (deterministic)

Ranking

1. **id06** (9.04 % MAE)
2. id02 (9.71 % MAE)

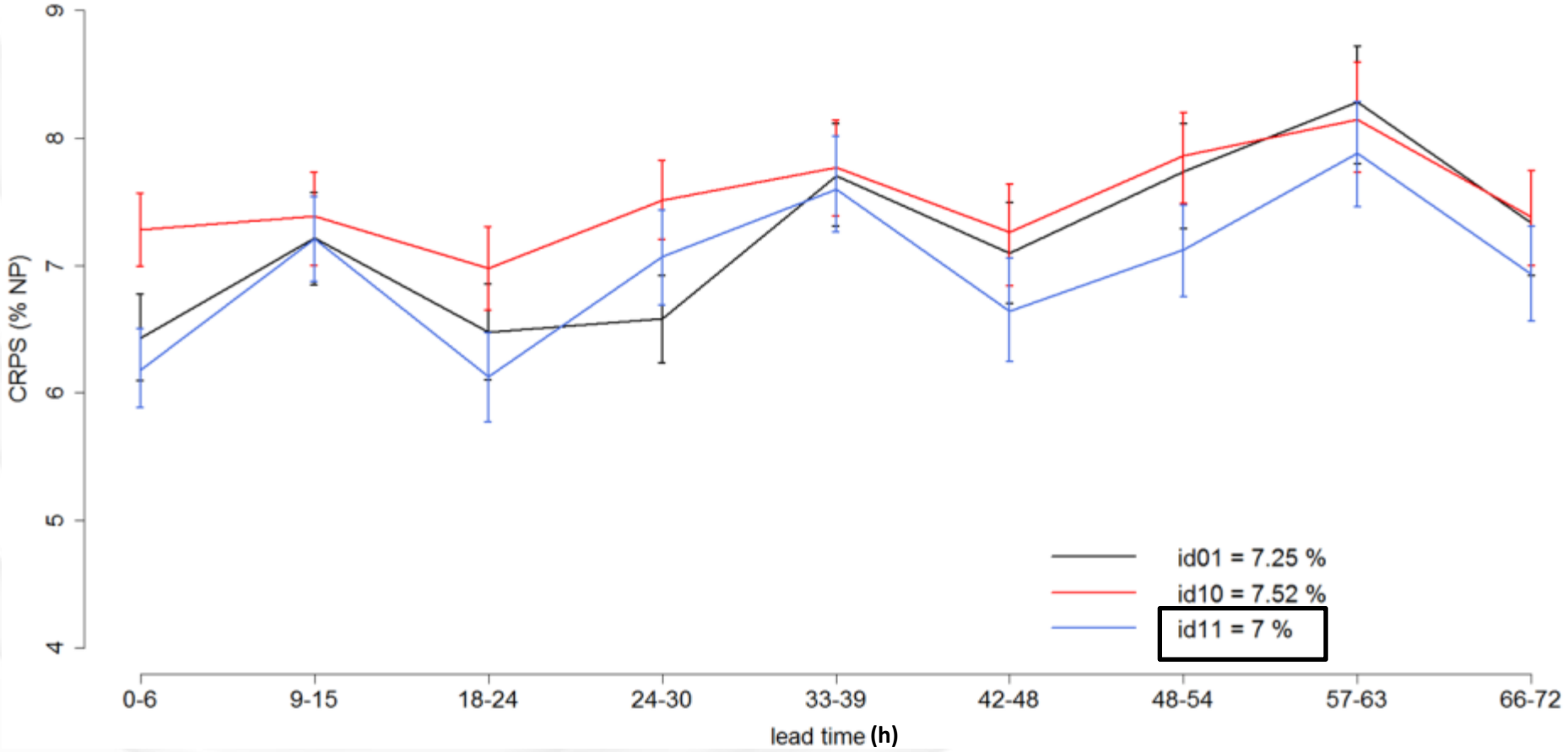
Diebold-Mariano statistic

- H0: the two models have the same forecast accuracy
- H1: 2nd model is less accurate than the 1st one
- p-value=**$3.91*10^{-6}$**

Method used by id06

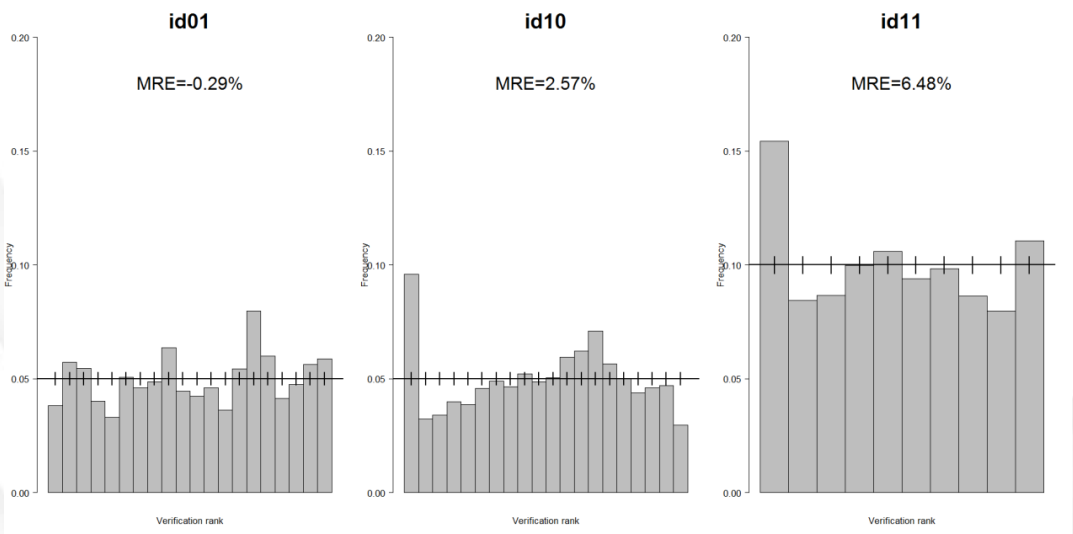
- Meteorological model: ECMWF provided by COST
- Post-processing with an Artificial Neural Network

Abruzzo results (CRPS)



Abruzzo results (probabilistic)

Rank histogram



Ranking (probabilistic)

1. **<u>id11</u>** (7.0 % CRPS)
2. id01 (7.25 % CRPS)

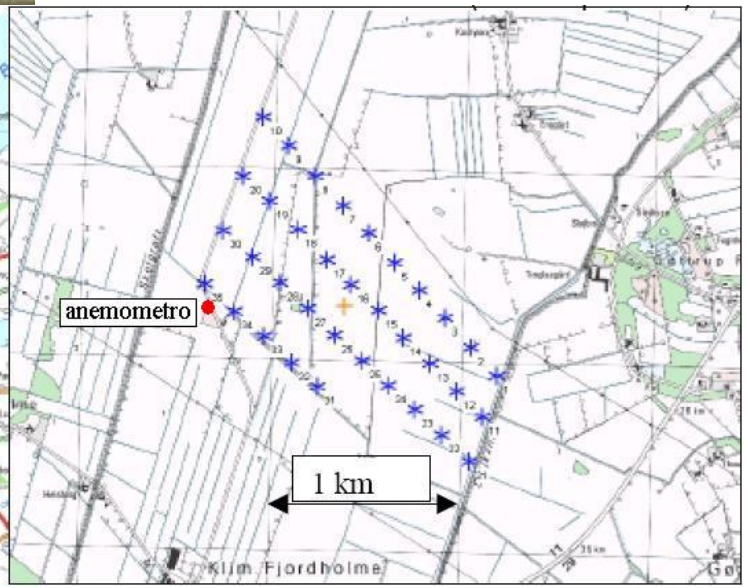
Method used by id11

- Local quantile regression with wind speed and wind direction as predictors.

KLIM case (Wind)

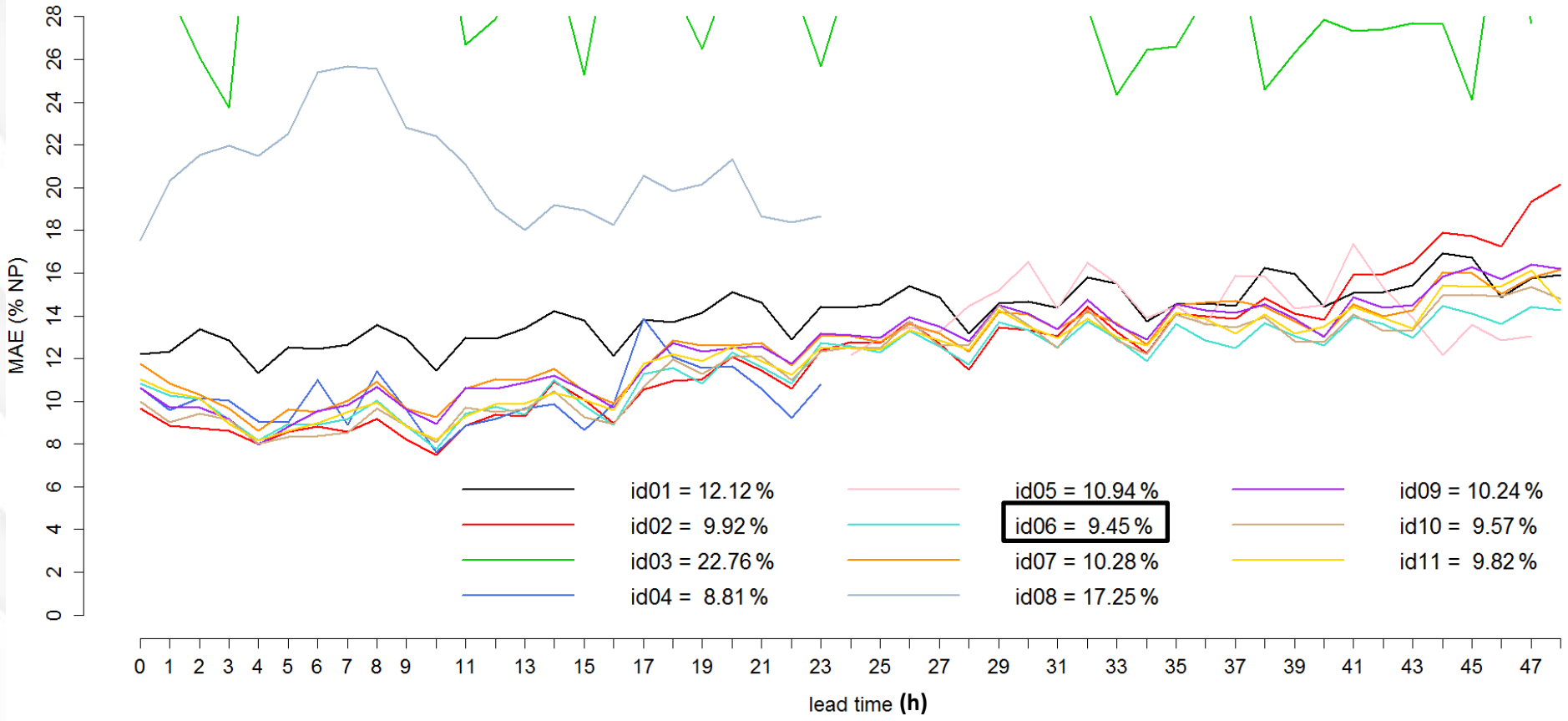
Boundary Conditions from ECMWF

- Wind speed (20m
- Wind direction (2
- Temp 2m



11 participants
(2 probabilistic)

Klim results (MAE)



Klim results (deterministic)

Ranking

1. **id06** (9.45 % MAE)
2. id10 (9.57 % MAE)

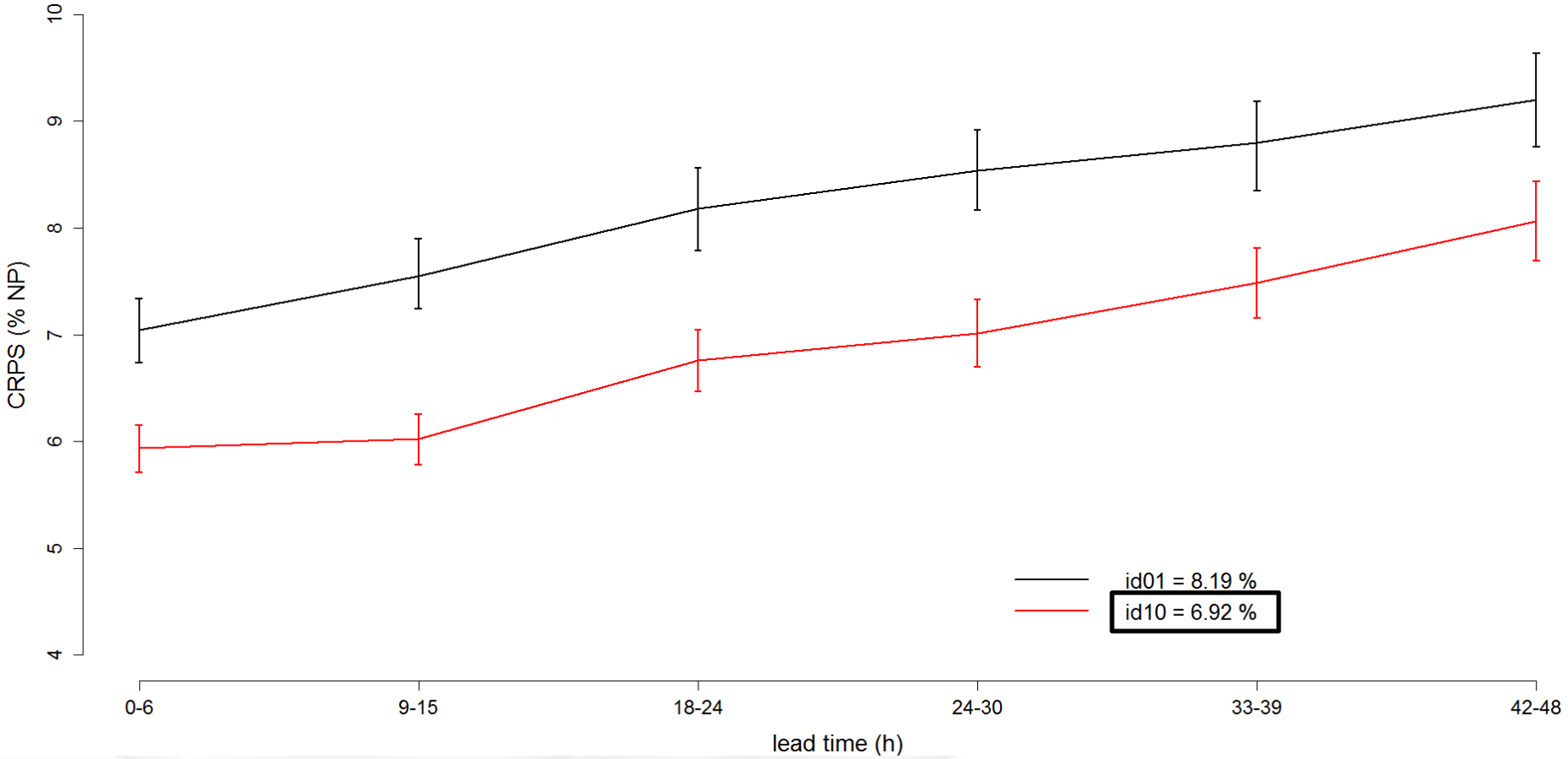
Diebold-Mariano statistic

- H0: the two models have the same forecast accuracy
- H1: 2nd model is less accurate than the 1st one
- p-value=**$4.68*10^{-73}$**

Method used by id06

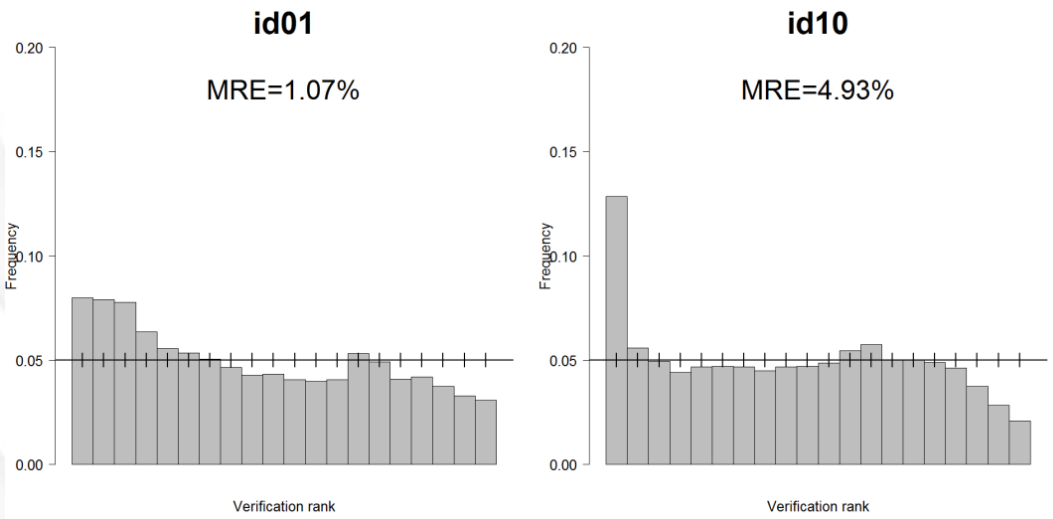
- Meteorological model: ECMWF provided by COST
- Post-processing with an Artificial Neural Network

Klim results (CRPS)



Klim results (probabilistic)

Rank histogram



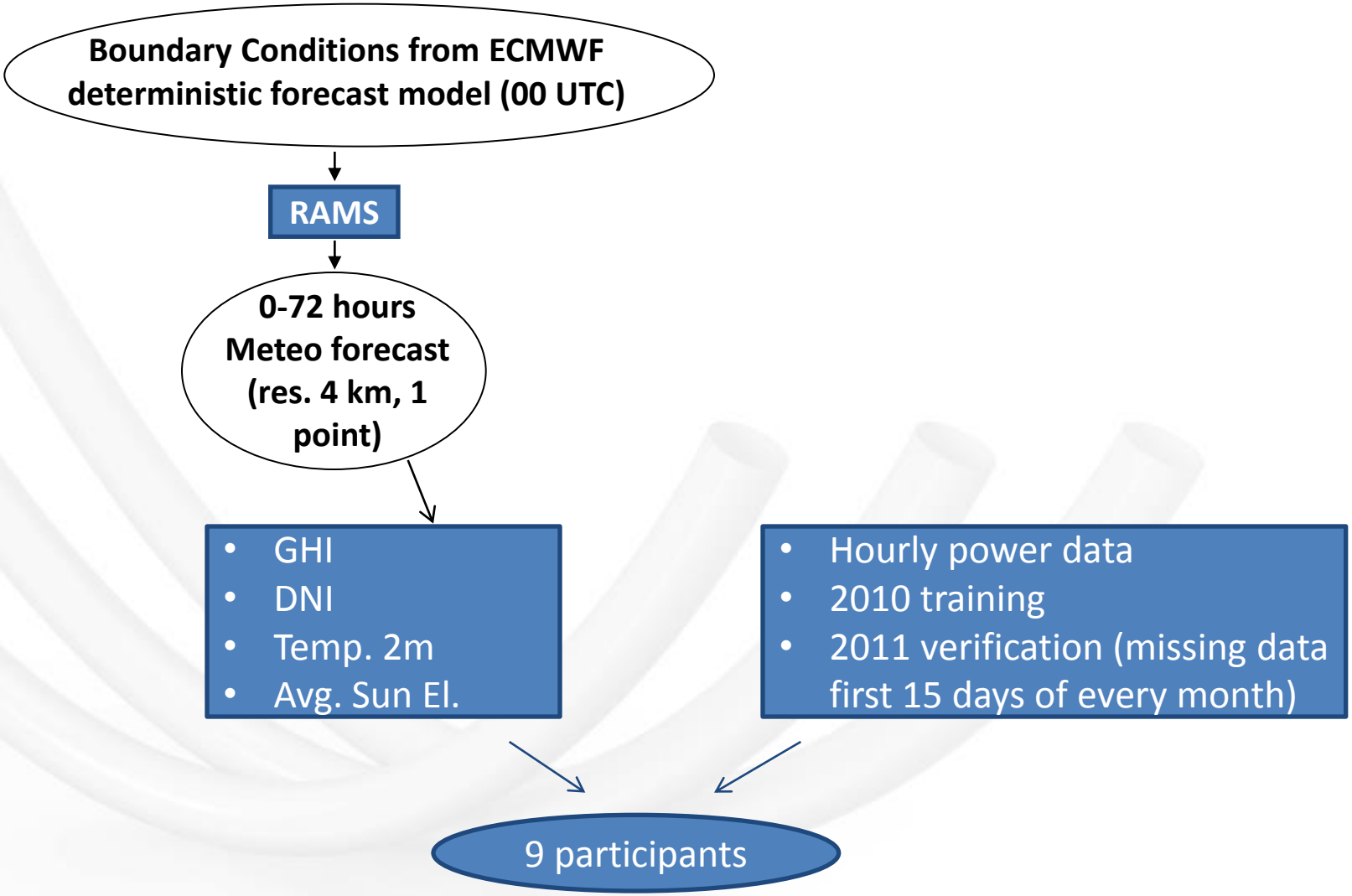
Ranking (probabilistic)

1. **id10** (6.92 % CRPS)
2. id01 (8.19 % CRPS)

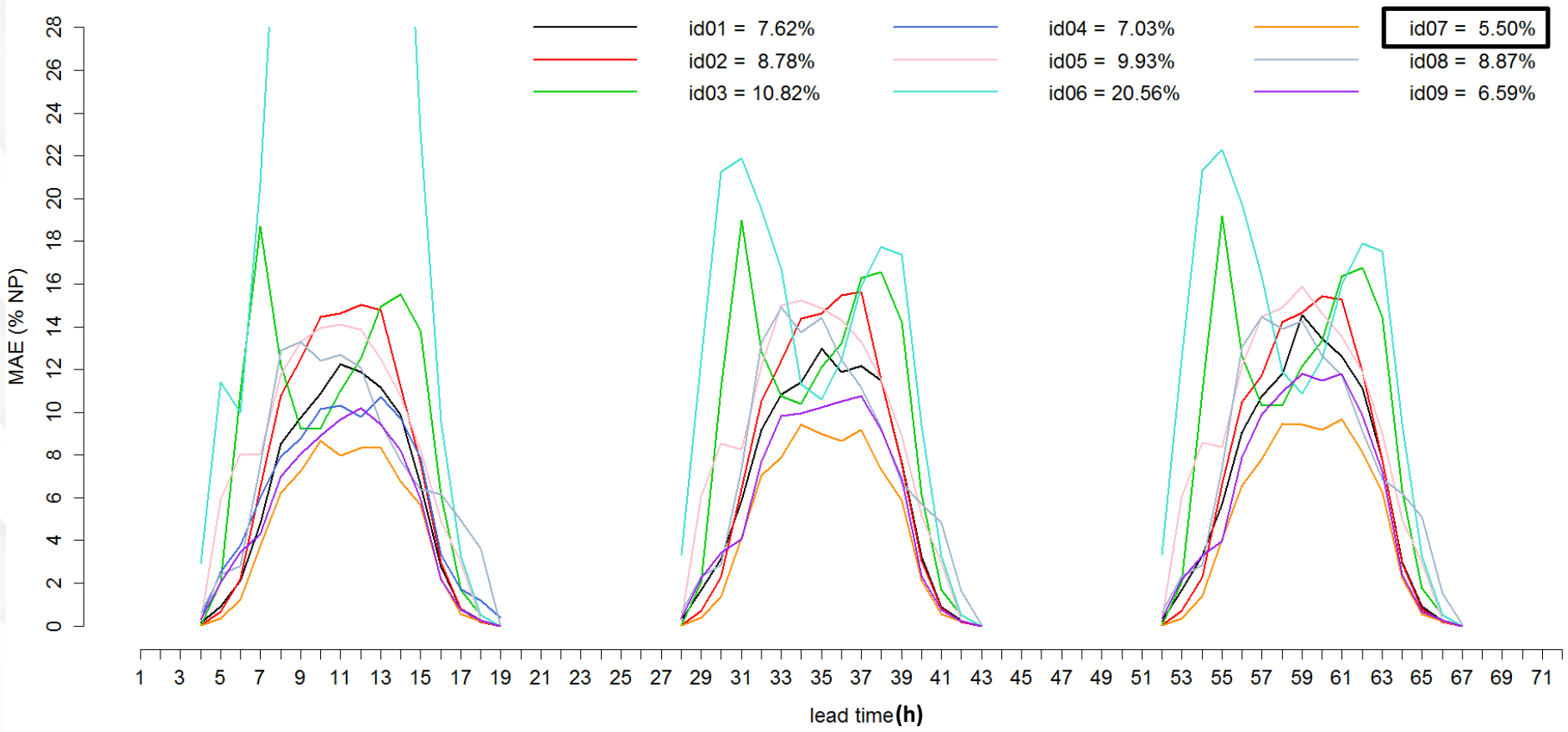
Method used by id10

- Conditional kernel density estimation with a quantile-copula estimator.
- Inputs: forecasted wind speed and direction (level 30), hour of the day and lead-time. 5% and 95% quantiles were computed from the forecasted PDF using numerical integration.

Catania case (PV)



Catania results (MAE)



Catania results (conclusions)

Ranking

1. **id07** (5.50 % MAE)
2. id09 (6.59 % MAE)

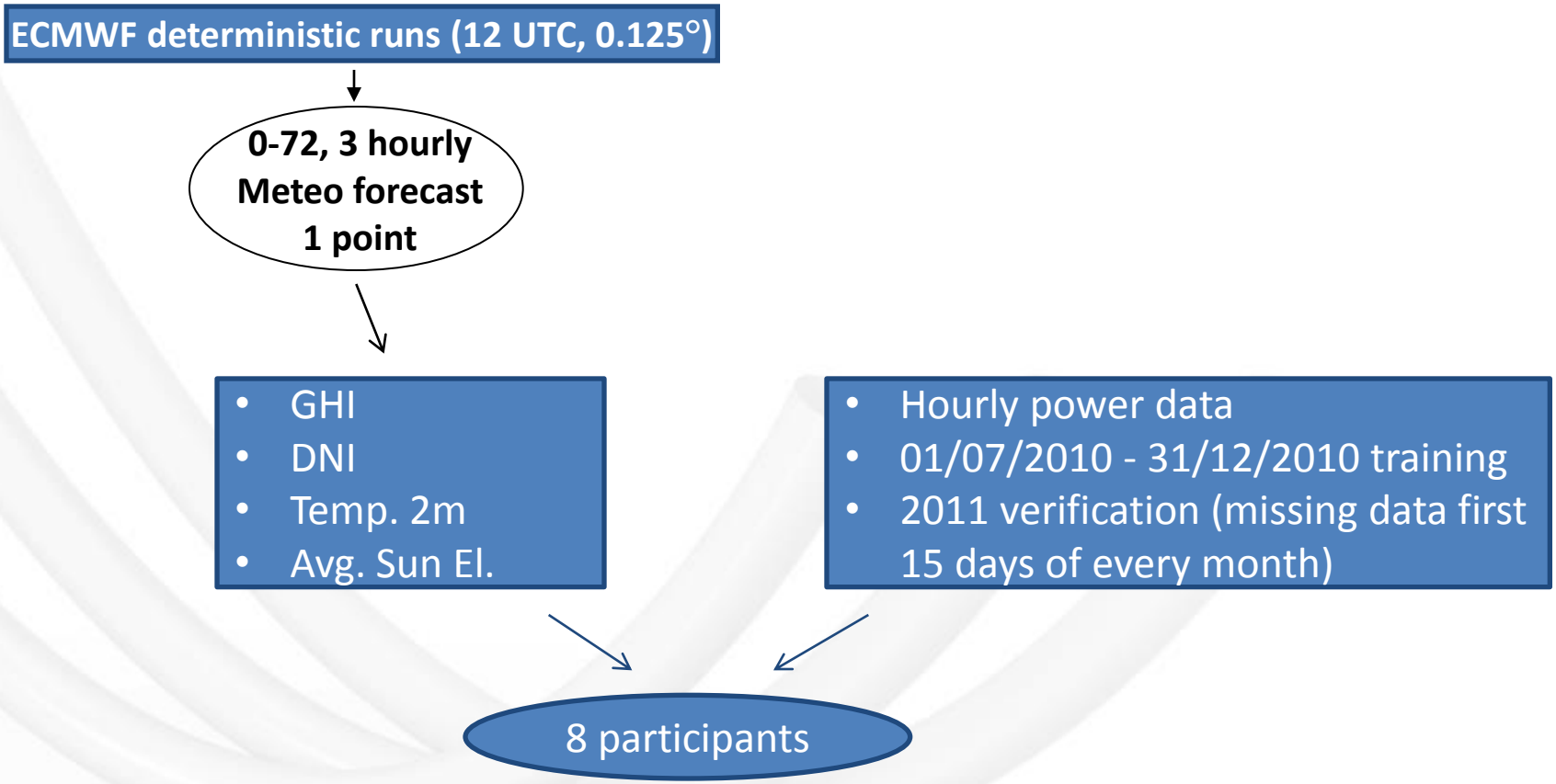
Diebold-Mariano statistic

- H0: the two models have the same forecast accuracy
- H1: 2nd model is less accurate than the 1st one
- p-value=**0.998**

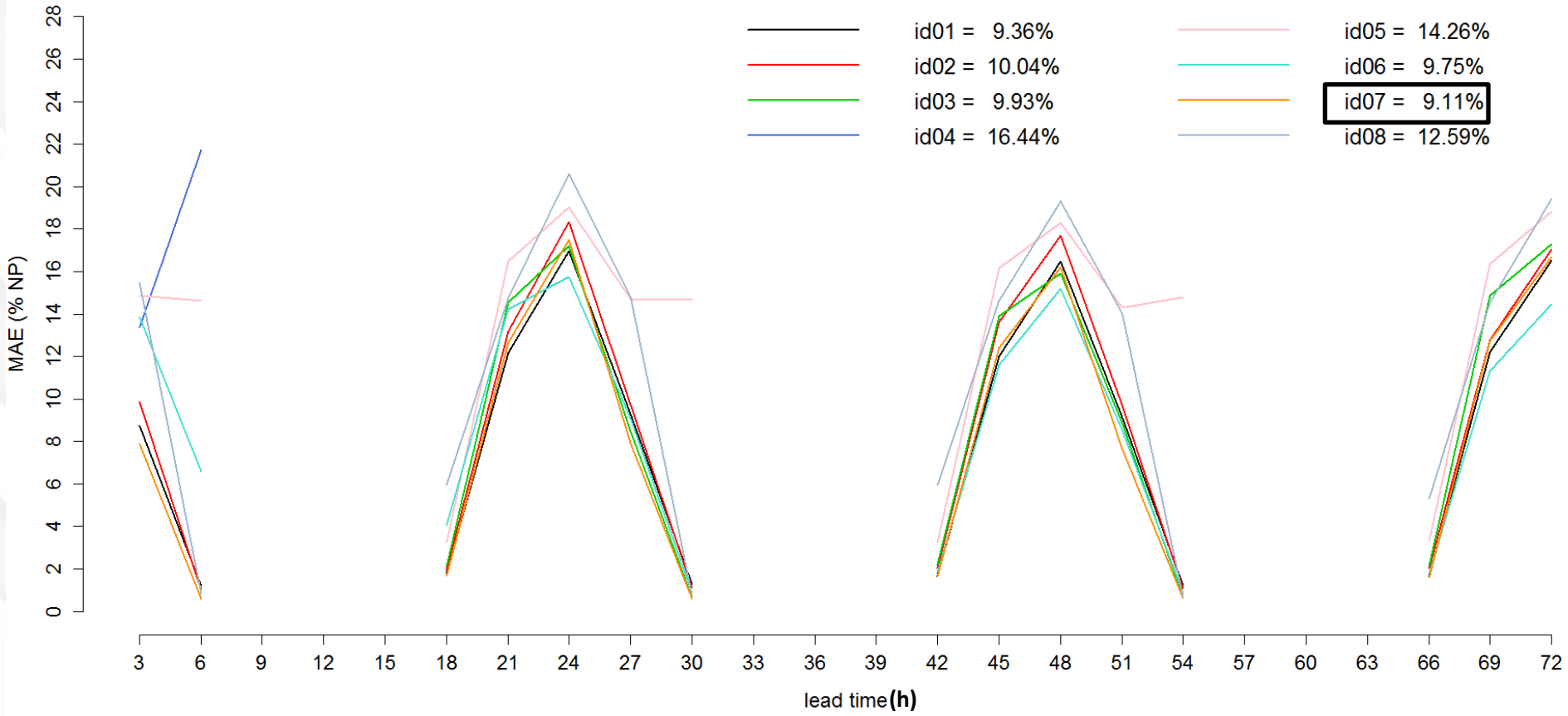
Method used by id07

- Meteorological model: RAMS provided by COST
- Quantile regression in order to estimate a clear sky production, a clear sky irradiation and a medium temperature.
- Linear regression to explain the rate of clear sky production observed.
- Bias correction depending on time and the power forecasted using although a quantile regression.

Milano case (PV)



Milano results (MAE)



Milano results (conclusions)

Ranking

1. **id07** (9.11 % MAE)
2. id01 (9.36 % MAE)

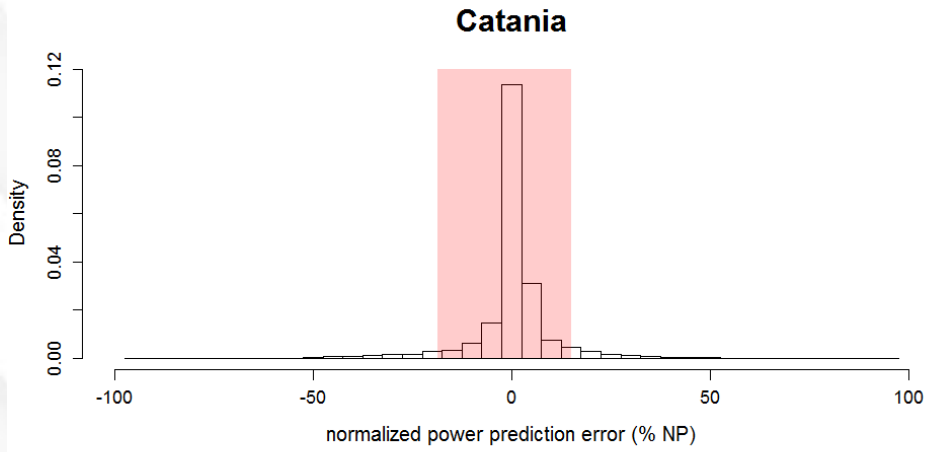
Diebold-Mariano statistic

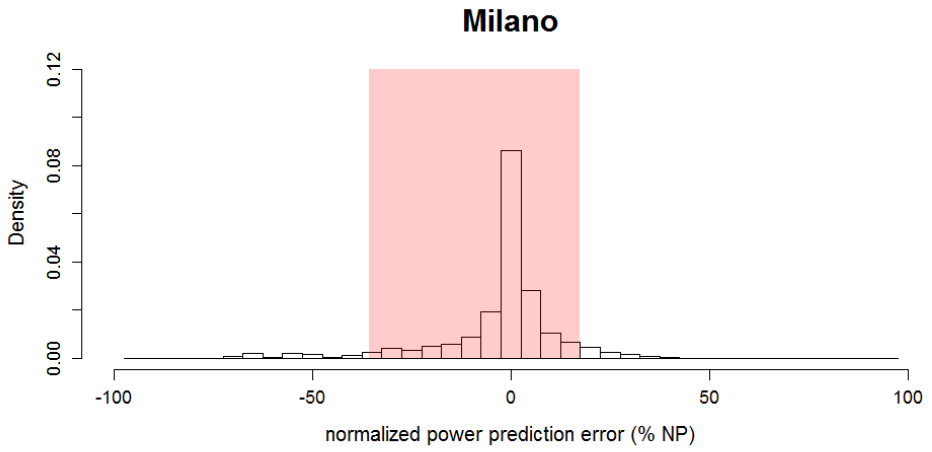
- H0: the two models have the same forecast accuracy
- H1: 2nd model is less accurate than the 1st one
- p-value=**0.961**

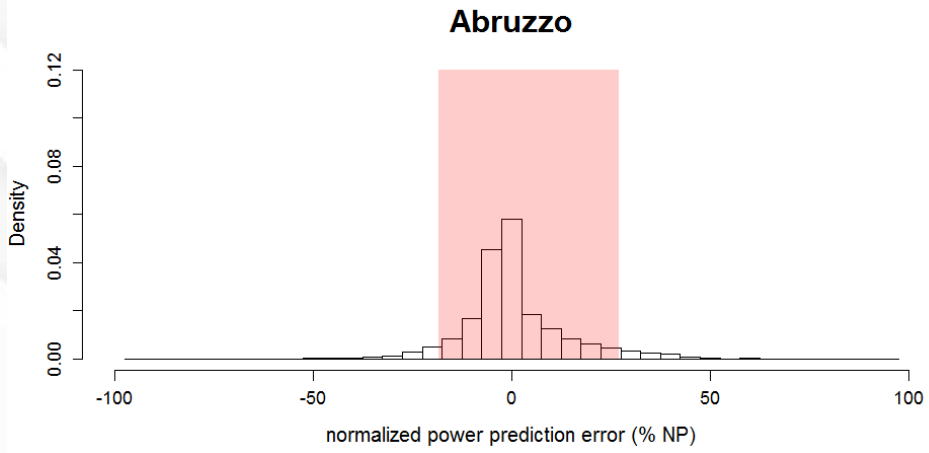
Method used by id07

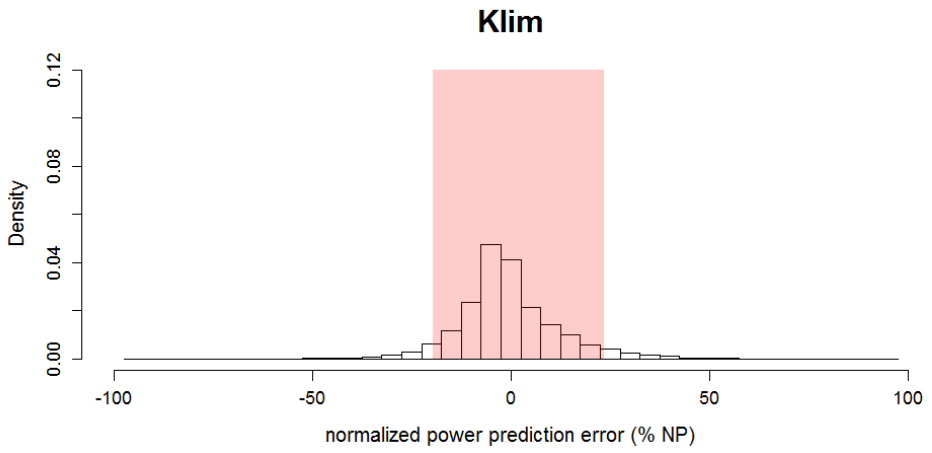
- Meteorological model: RAMS provided by COST
- Quantile regression in order to estimate a clear sky production, a clear sky irradiation and a medium temperature.
- Linear regression to explain the rate of clear sky production observed.
- No bias correction (not enough data)

Solar vs Wind, errors distributions (of best models)









Shaded area: 5%-95% interval

Conclusions

- Wind power prediction, best model performances: complex terrain MAE = 9.04%, flat terrain MAE = 9.45 %
- Using ECMWF global model data (0.125°x 0.125°) of year 2010-2011 (plus post-processing) in a complex site has allowed to obtain the same performance as those obtained by a Limited Area Model of year 2001-2002 in a flat terrain site
- Solar power prediction best model performances: MAE = 5.5% (Catania, less pollution, greater mean irradiation) , MAE = 9.11% (more polluted)
- Solar PV energy seems to be more predictable than wind energy with lower MAE and narrower error distribution only for Catania solar farm
- Same winner for both solar plants (EDF, Christophe Chaussin)
- Same winner for both wind farms deterministic (Fraunhofer Institut, Jan Dobschinski), two for probabilistic (Norwegian Meteorological Institute, John Bremnes and INESC, Ricardo Bessa)