Wind Energy Production Backcasts Using a High-Resolution Reanalysis Dataset

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Presentation Overview

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2. Wind Energy Forecasting – Why?
3. Data Sources
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5. Methods
6. Results – Wind Energy Forecasts
7. Corrections
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Background to the Study

ClimAtt project at UCC: Tools for Climate Change Attribution of Extreme Weather Events

Examine the probability of specified extreme weather events in the ‘natural’ world and the ‘counterfactual’ world

Infer the influence of climate change on event probabilities

MÉRA is a useful validation dataset for the ‘natural’ world

Wind Forecasting – Why?

The usual reasons…

- Renewables are unpredictable therefore:
- Help system operators schedule generators to balance supply and demand
- Help energy traders predict supply and prices
- Help wind farm owners to schedule maintenance

Some new reasons…

- New “ancillary services” are required to keep the grid stable in the face of rapidly-changing wind generation output
- Market reforms – penalties for over- or under-production
- Wind-storage hybrid power plants – when to store and when to release?
    - Elimination of payments for curtailed energy

Aims of this study

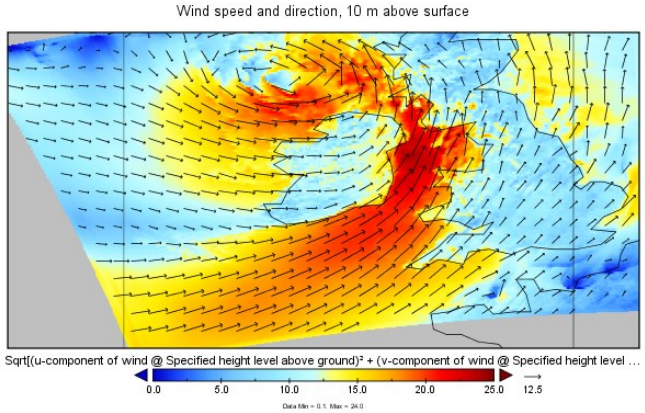
- Examine accuracy of a 2.5km horizontal resolution product for wind energy forecasting
- Identify appropriate forecast corrections to remove bias and improve quality
- Wind-battery system: how much storage is needed?

Samuel Liu MEngSc minor thesis topic, 2018

Data Sources and Preprocessing

Wind speeds from MÉRA : u and v surface wind components combined to give wind speed.
33h forecast is useful for day-ahead bidding

dataDate	dataTime	validityDate	validityTime
20140101	0	20140101	100
20140101	0	20140101	200
20140101	0	20140101	300
20140101	300	20140101	400
20140101	300	20140101	500
20140101	300	20140101	600



"Nearest neighbour" to wind farm target location was extracted using ECMWF's grib_tools utility

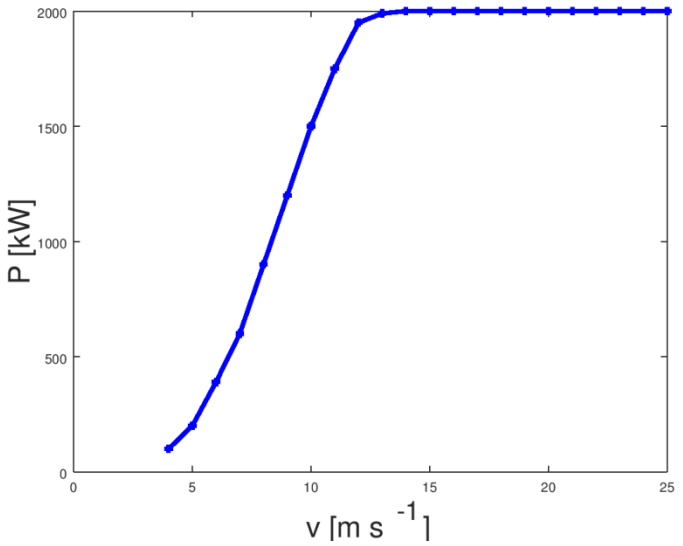
No wind speed measurements from site!
- Bias cannot be directly calculated.
Wind farm generation data obtained from the Single Electricity Market Operator
More details can be found at http://eel.ucc.ie/

Wind energy forecast calculation

Wind speeds were extrapolated to 95m hub height using log law
Manufacturer's power curve was used to transform wind speed to wind power

Assumptions:

- Neutral atmospheric stability at all times
- Mean wind speeds -> mean wind power over model timestep
- All turbines have identical production
- No turbine wake interactions
- All turbines have 100% availability
- No other site losses (electrical etc.)
- No microscale effects



Lisheen Windfarm Case Study

Relatively flat terrain in midlands
Site mean wind speed 7.7 ms^{-1}
(SEAI wind atlas, 100m)

Phase I commissioned in 2009
18 Vestas V90/2000kW turbines
Hub heights 95 m
Operated by Brookfield Renewable Power

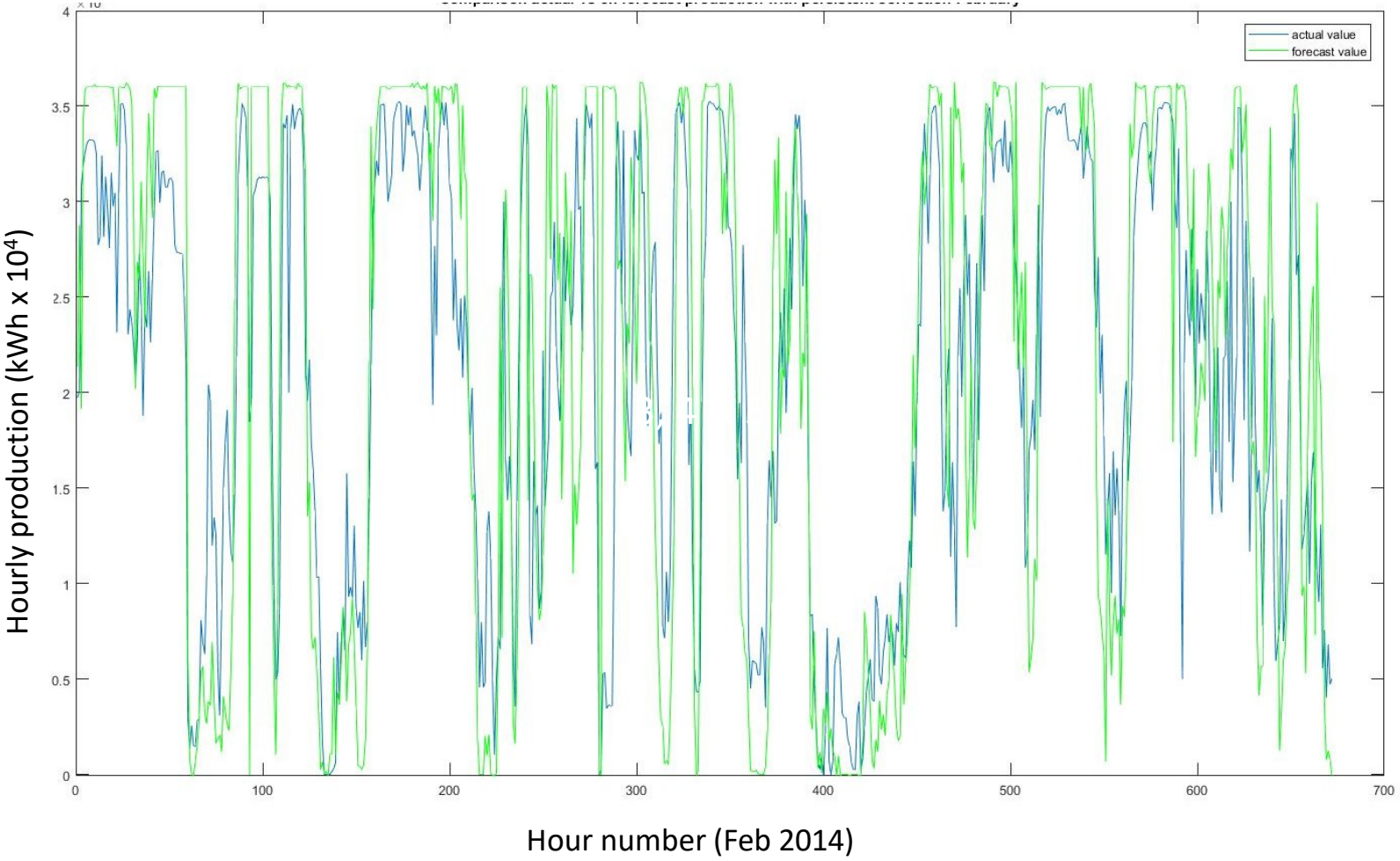
Phase II was commissioned in 2013
12 Vestas V90/2000kW turbines

Only Phase I considered in this presentation

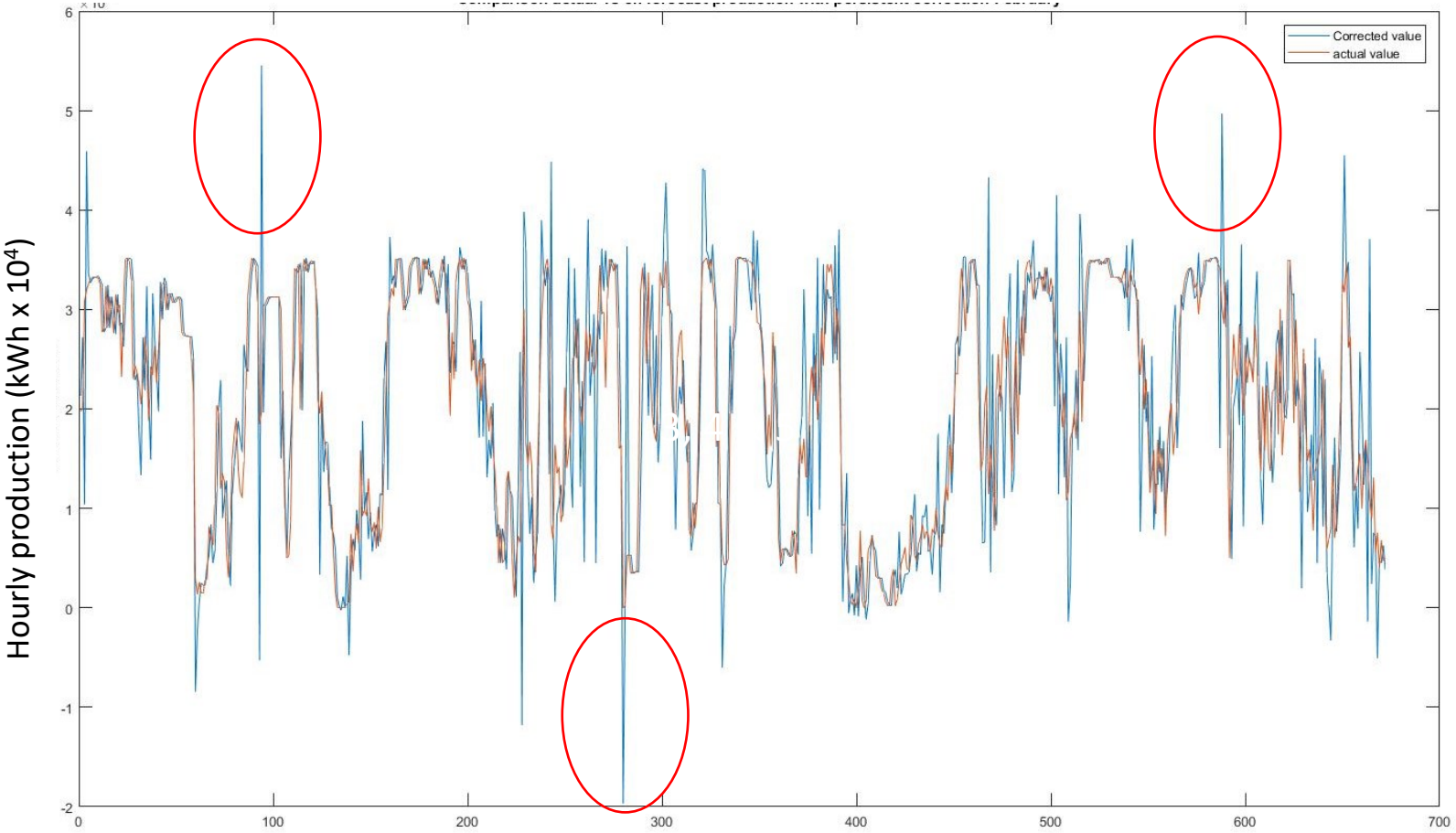
- data from thewindpower.net

Lisheen Windfarm (images: Google & irishsilicon.com)

‘Raw’ 3h forecasts – no correction– February 2014

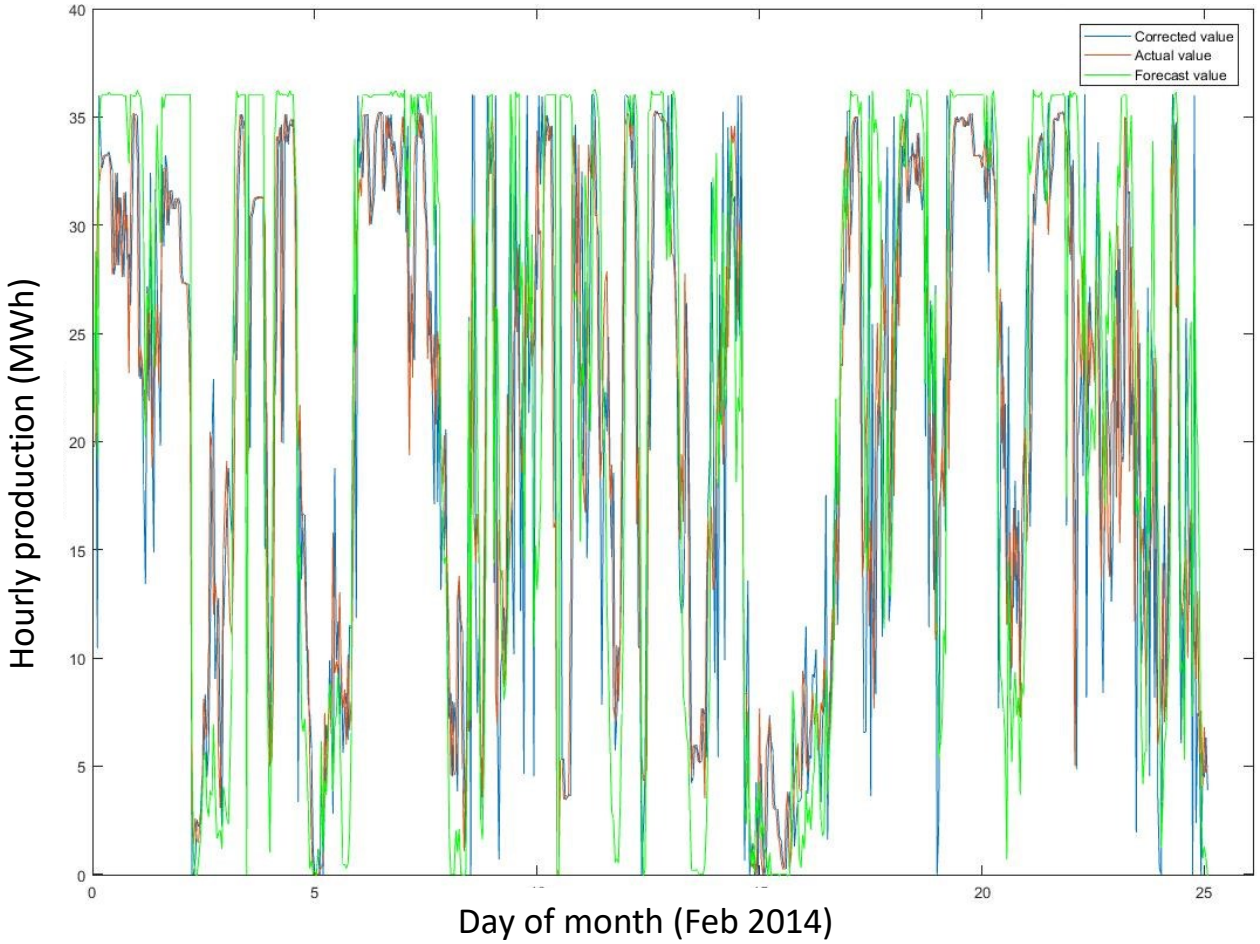


Applying simple persistence correction – February 2014



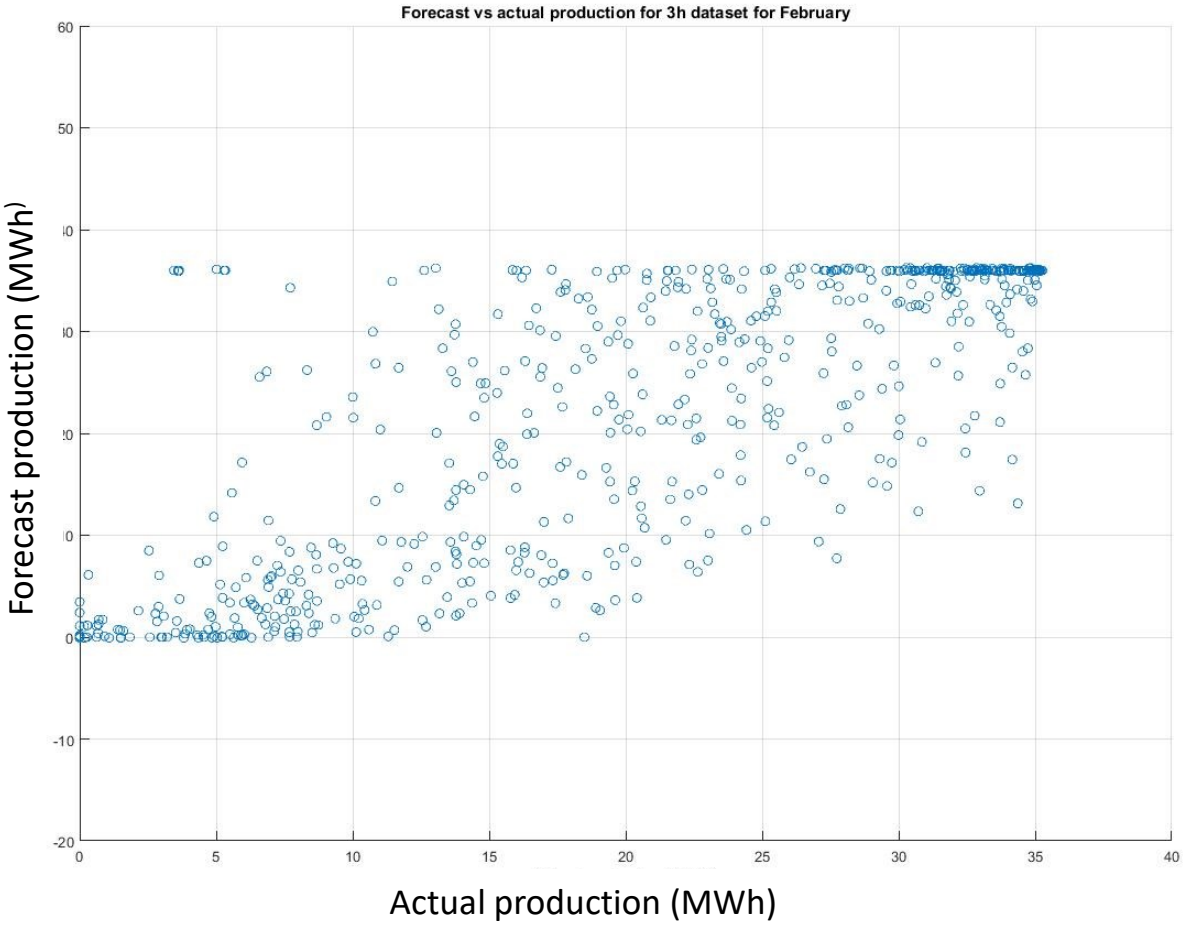
apply persistence to forecast errors: $\hat{P}(t+k|t) = P(t)$

Persistence with threshold limits – Feb 2014

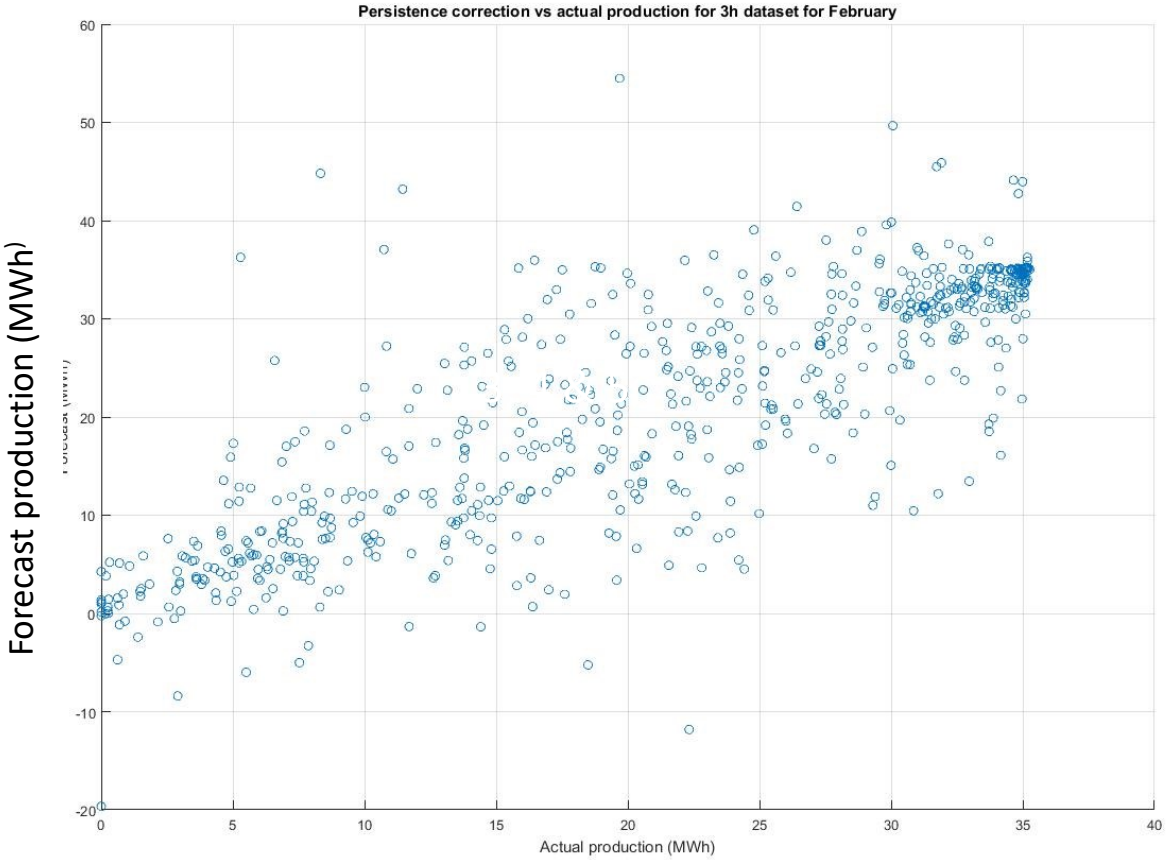


Limit corrected values to [0, 36 MWh]

3h forecast comparison – no correction

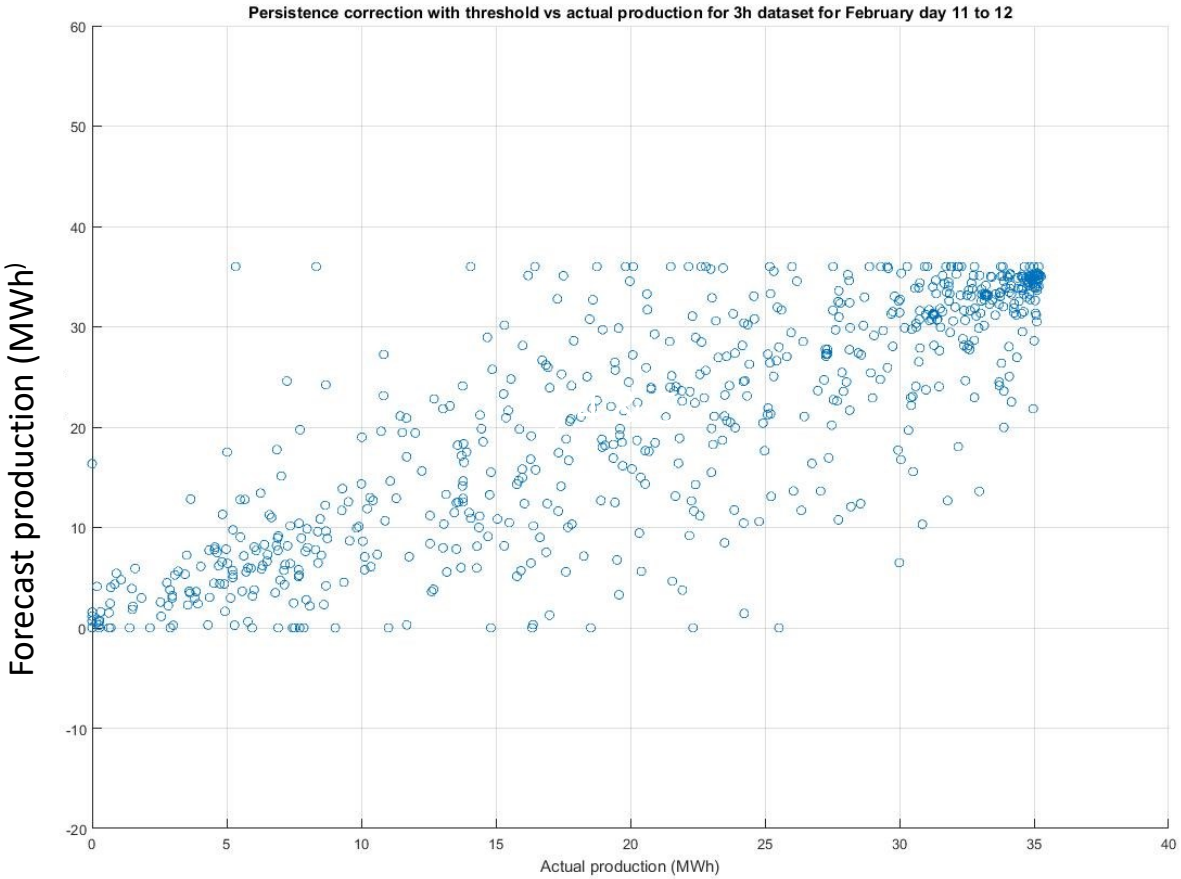


3h forecast comparisons – persistence correction



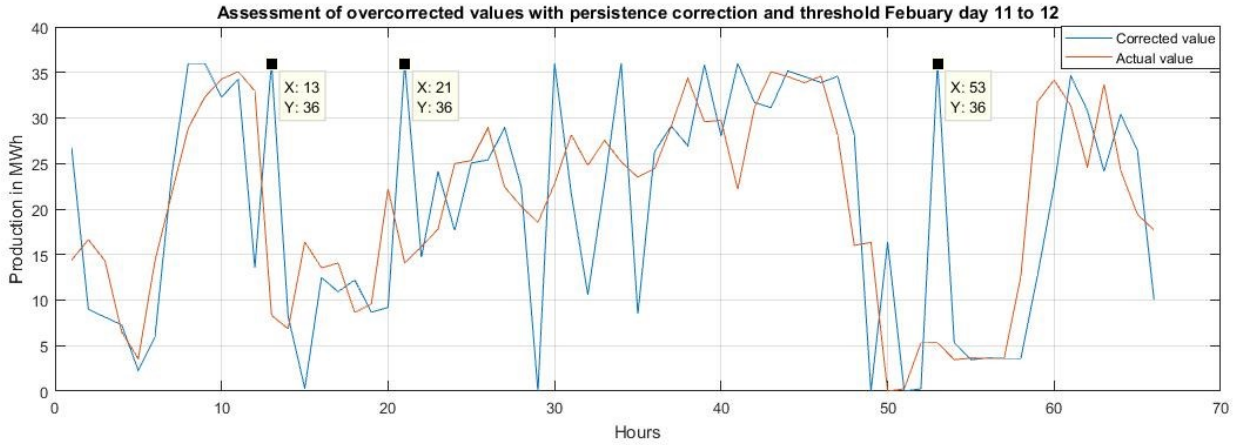
Actual production (MWh)

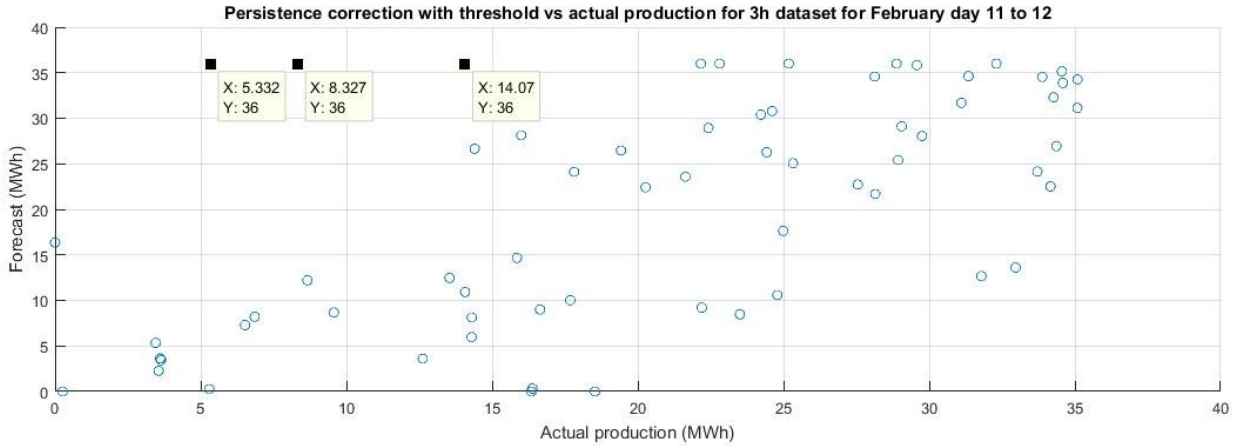
3h forecast comparison – persistence & thresholds



Actual production (MWh)

Errors and wind ramps





Some conclusions

Error performance statistics

	33h raw	33h with persistence	33h with persistence + threshold
ME (kWh)	621.7	-4.7	-141.3
MAPE (%)	17.1	13.4	12.3
RMSE (kWh2)	8277.7	7487.2	6620.2

- Even based on preliminary analysis with simplistic data corrections, MÉRA is showing good forecast accuracy
- Timing of ramp events appears to be good
- 33h forecast performance not significantly worse than 3h
- Lagging forecast correction methods such as persistence reduce ramp forecast accuracy

Next Steps

Compare MÉRA-based predictions with other products (TIGGE-LAM etc)

Apply adaptive bias correction method
Kalman filter is ideal -- the system state (actual wind speeds) are unknown

Investigate correction performance for wind ramps – incorporate spatio-temporal information from adjacent grid cells to improve estimates

Apply the forecasts to determine the optimal size and management of a wind-battery hybrid power plant at Lisheen

Thank you!
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