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Next Generation Forecasting Solutions for Wind Energy – Results from the Smart4RES Project

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Next Generation Forecasting Solutions for Wind Energy

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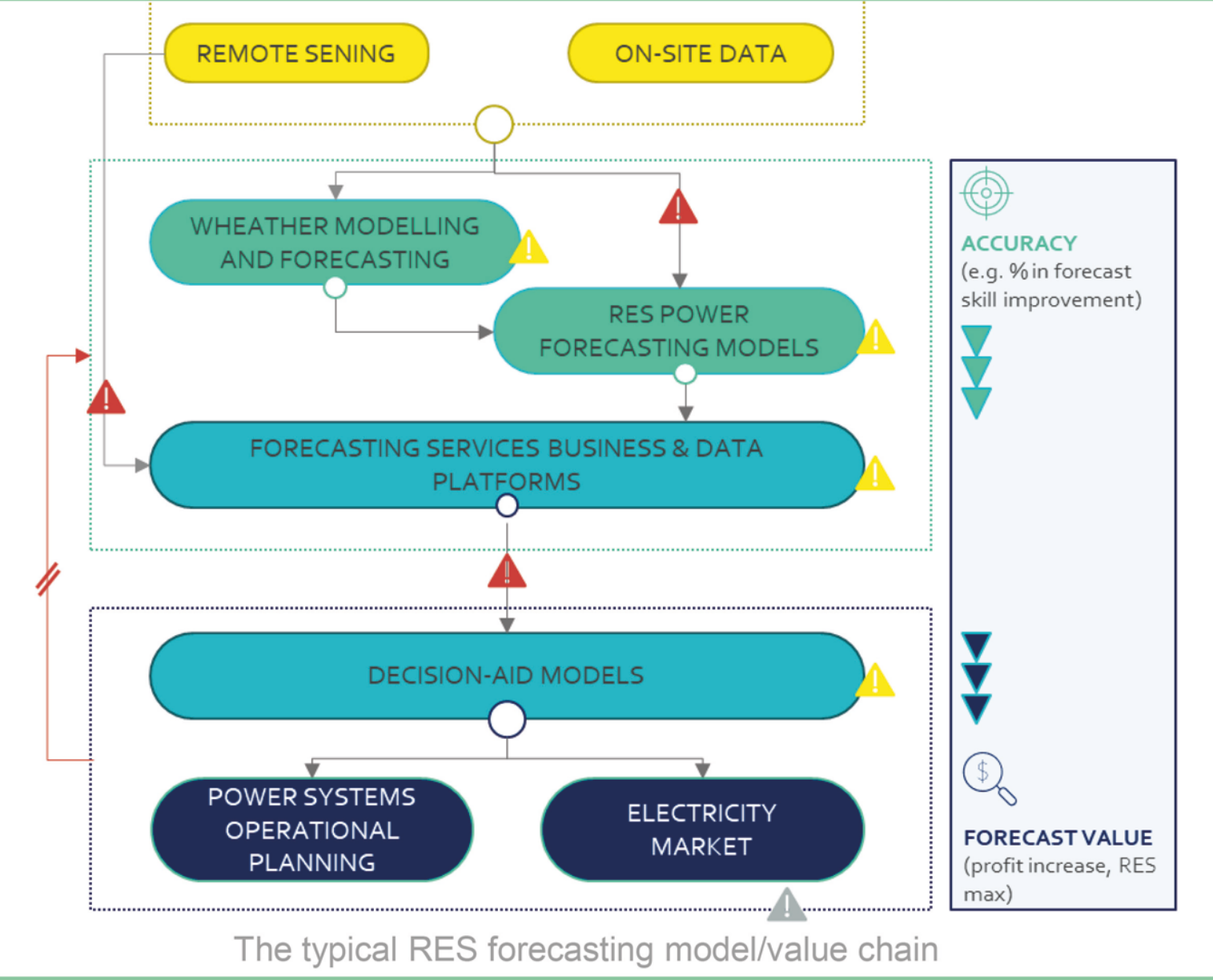
- Results from the Smart4RES Project.

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Abstract

Forecasting renewable energy (RES) production, a few minutes to days ahead, is a quite mature technology. The majority of actors (grid operators, aggregators, traders...) use today operational forecasting tools and services to optimize their decisions related to wind power integration in power systems and electricity markets. Despite that maturity, uncertainty in forecasts remains high and end users continuously request higher accuracy. The H2020 Smart4RES project was initiated in 2019 to develop next generation forecasting solutions with increased forecasting performance and also innovative approaches to leverage the value (technical or economic) of forecasts by considering the whole model chain from weather forecasting to end-use applications. Here we present a selection of highlight final results both regarding forecasting and also the optimal use of forecasts.



Objective – A transformation of the forecasting technology

Gaps & bottlenecks

- REDUCED KNOWLEDGE OF THE PHYSICAL SYSTEM**
 - Weather forecasting is an essential input but not always tailored to energy applications.
- VULNERABILITY**
 - Not 100% reliable data (i.e. communication faults).
 - Possible corruption of data and models from cyberattacks or other malicious factors.
- COMPLEXITY**
 - High dependability of RES prediction models on specific data sources.
 - Due to multiple modelling steps, the resulting decisions lack interpretability especially in situations with high uncertainties/extremes
- UNCERTAINTIES**
 - High uncertainties not always understood by operators
 - Optimisation tools remain deterministic in business practices
- SUBOPTIMALITY**
 - Potential value of the available data not fully extracted. Data not shared due to confidentiality or privacy constraints. Forecasting models are seen as stand alone without considering the application they are used and the value they bring.

Developed solutions & Impacts

- Ultra/high resolution modeling of weather conditions
 - Weather forecasts adapted to the energy sector
 - Modelling based on multiple sources of data
 - Solutions that permit operators to take optimal decisions under situations with lacking information
 - Convergence of the technology through seamless solutions
 - Joint forecasting and optimisation prescriptive approach
 - Reduce information for human operators
 - Reduce uncertainties through better predictions
 - Optimisation tools to manage uncertainties
 - Value-oriented vs accuracy-oriented forecasting
 - Privacy/confidentiality preserving data sharing & optimisation
 - Prescriptive analytics
- HIGHER MODELLING ACCURACY**
- RESILIENCE**
- SIMPLICITY**
- ROBUSTNESS**
- VALUE MAXIMISATION**

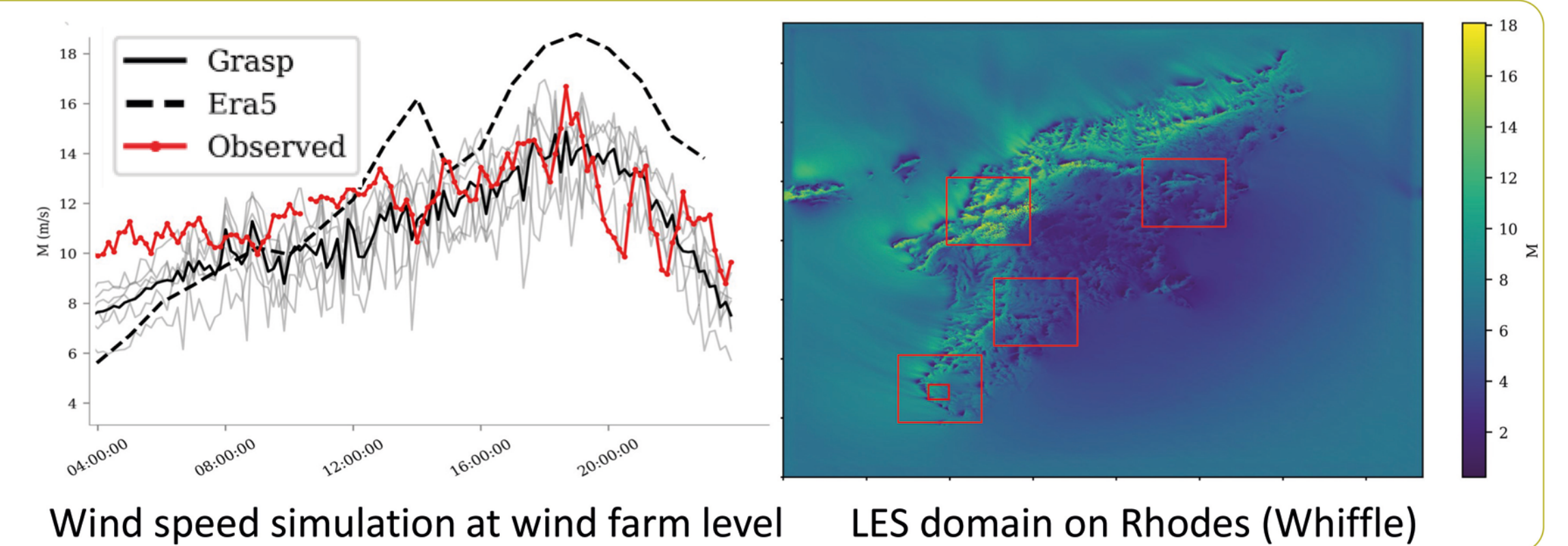
Examples of highlight results

Predicted local wind speeds via Large Eddy Simulation

Method: A Large Eddy Simulation has been developed to predict local wind speeds, reproducing spatio-temporal patterns of variability and modelling complex terrain

A nested LES forecast for islands : Outer domain ~ 200m resolution, 4 inner domains on farms: ~ 40m

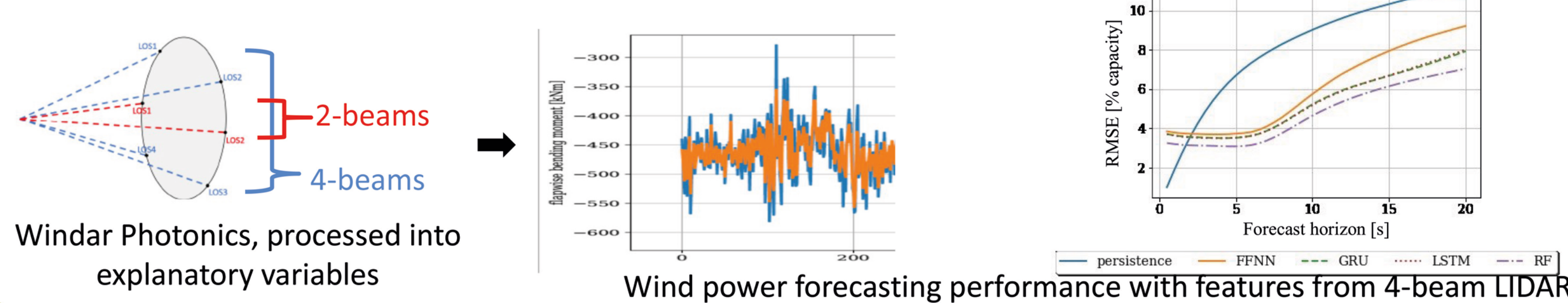
Results: Realistic variability of the LES compared to the smooth signal from NWP (dashed line). The RMSE is at least as good as the underlying NWP model.



Seconds-ahead wind turbine forecasting with LIDAR

Method. Time series from LIDAR serve as explanatory variables of a forecasting tool for wind turbine power and moment forecasting.

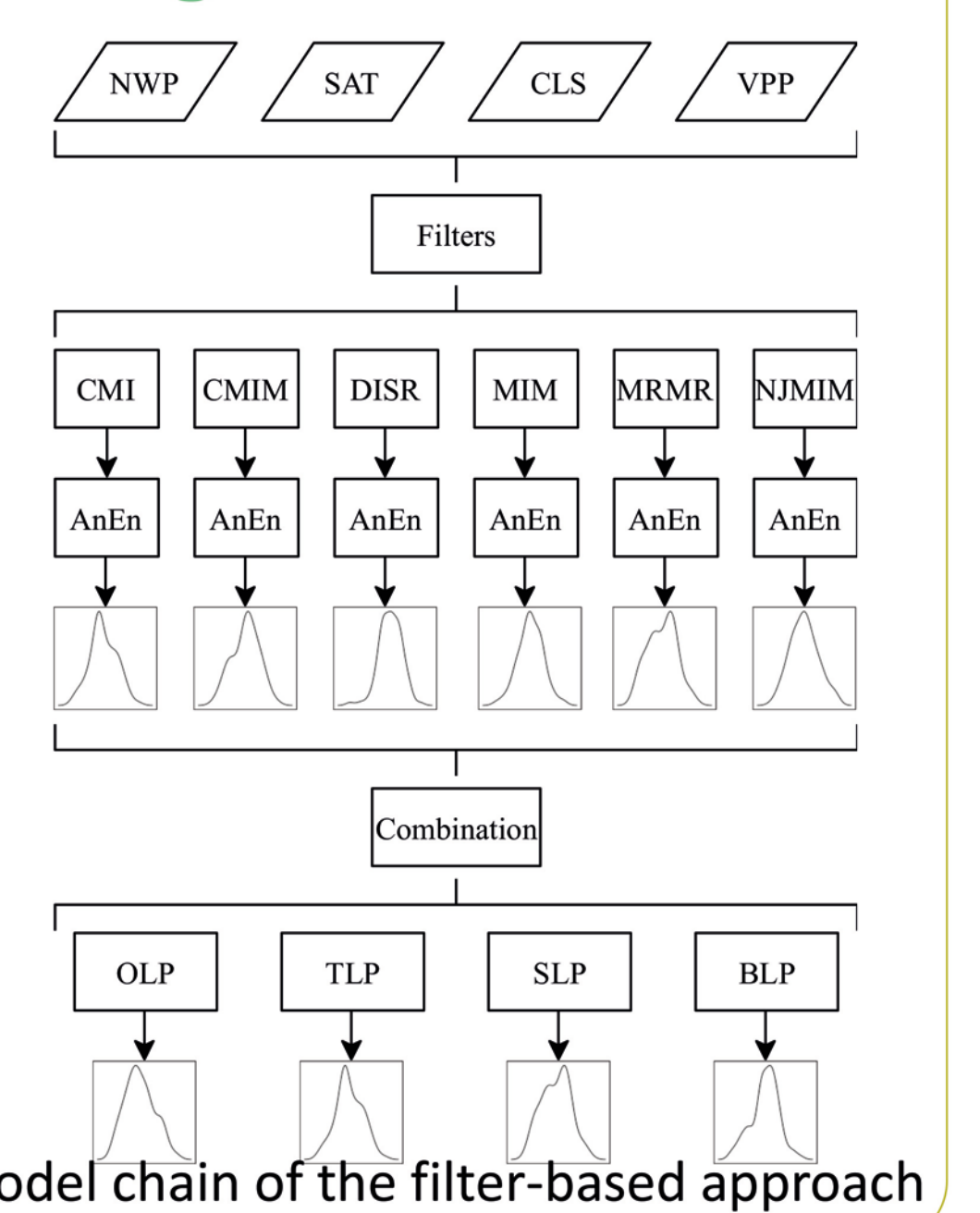
Results. Lidar measurements provide a predictive spatio-temporal information of incoming wind that beats recent past information of the turbine when used in Machine Learning for horizons above 2-4s. 4-beams LIDAR features enable to increase forecasting performance of active power. ML models with good ability to treat highly correlated features work best e.g. here Random Forest (RF).



Filter-based seamless renewable forecasting

Method. Filters automatically select and weigh explanatory variables that are relevant for multiple forecasting horizons. The obtained analog probabilistic forecasts are combined by linear/non-linear methods to mitigate the uncertainty caused by feature selection.

Result. The filters reduce computational effort and decrease CRPS by 16% on average compared to a vanilla analog model, when tested on the 15min to 6h ahead forecasting of Wind+PV production.



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