EGU General Assembly 2022
Vienna, Austria & Online
23–27 May 2022

Highlight results of the Smart4RES project on weather modelling and forecasting dedicated to renewable energy applications

Georges Kariniotakis & Simon Camal for the Smart4RES team*

MINES Paris - PSL, Centre PERSEE

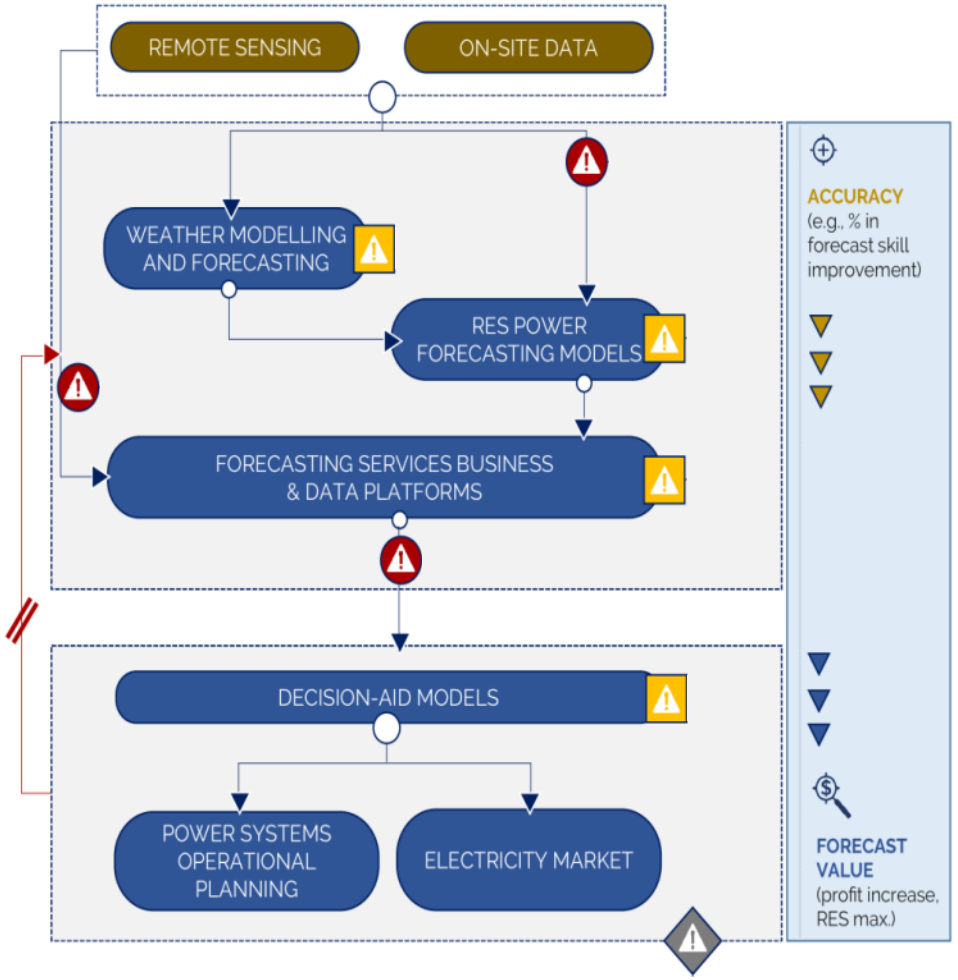
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 864337

Outline

1. The Smart4RES project
2. High-resolution weather forecasting
3. Seamless weather and RES forecasting
4. Integrated forecasting and optimization for RES applications
5. Conclusions

Some highlight results

1. The Smart4RES project



The typical RES forecasting model/value chain

Project vision: Achieve outstanding improvement in RES predictability through a holistic approach, that covers the whole model and value chain related to RES forecasting

Objectives:

1. Requirements for forecasting solutions to enable 100% RES penetration
2. RES-dedicated weather forecasting with 10-15% improvement using various sources of data and very high resolution approaches.
3. New generation of RES production forecasting tools enabling 15% improvement in performance.
4. Streamline the process of getting optimal value through new forecasting products, data market places, and novel business models
5. New data-driven optimisation and decision aid tools for power system management and market participation
6. Validation of new models in living labs and assessment of forecasting value vs remedies.

1. The Smart4RES project

- A multi-disciplinary consortium

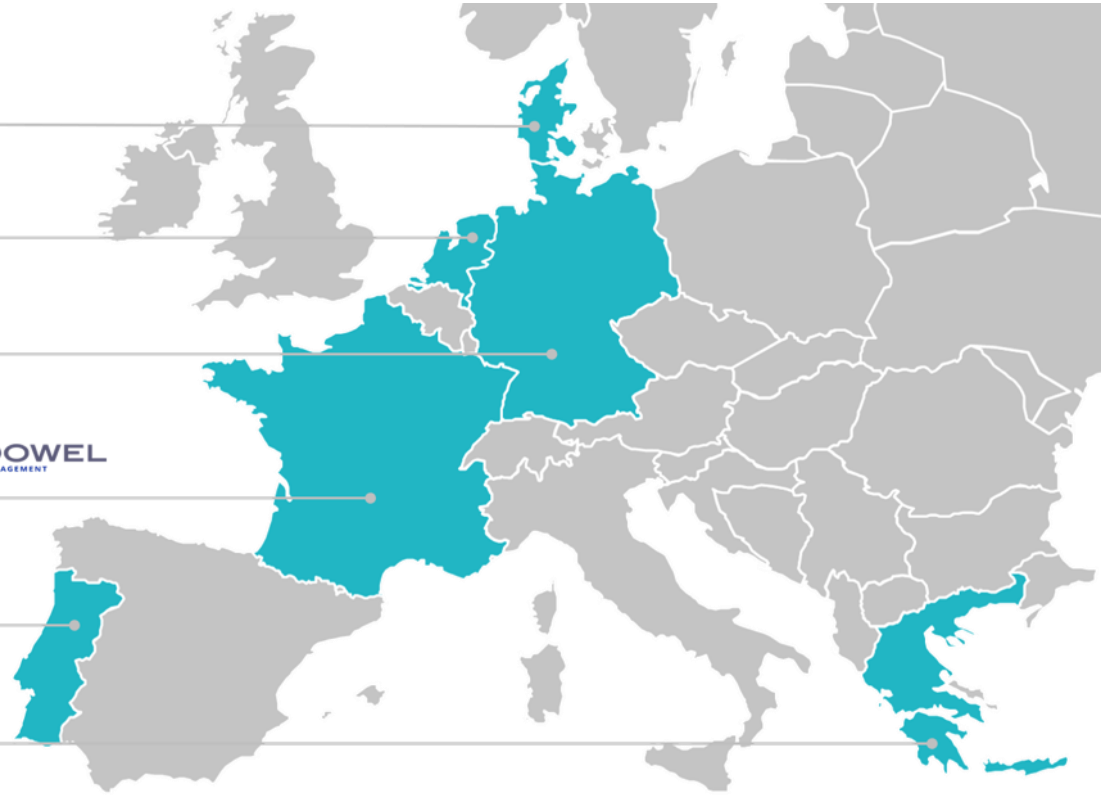
6 countries
12 partners

End-users
Industry
Research
Universities
Meteorologists

Funds: H2020 programme
Budget: 4 Mio€
Duration: 3.5 years

11/2019-4/2023

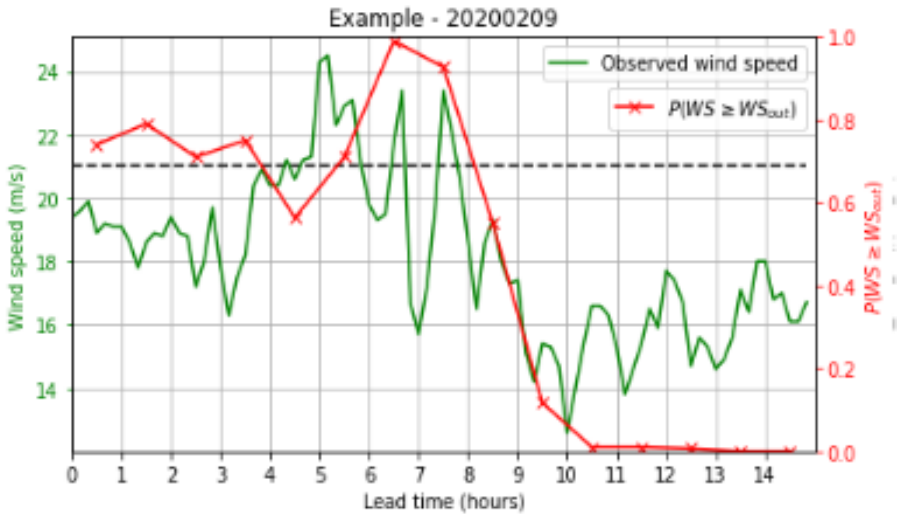
Denmark: DTU
Netherlands: WHIFFLE, DNV·GL
Germany: DLR, energy & meteo systems
France: ARMINES, MINES ParisTech, METEO FRANCE, DOWEL MANAGEMENT
Portugal: INESCTEC, NEW ENERGY WORLD
Greece: HEDNO, ICCS



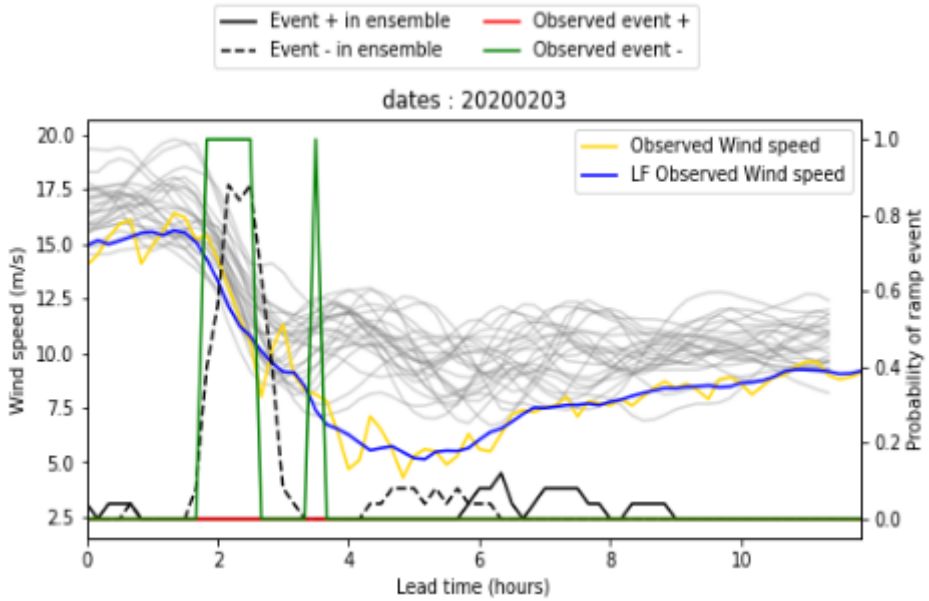
2. High-resolution weather forecasting

- Generation of high resolution ensembles (1km - 5min, MeteoFrance)

  Derive different types of products, i.e.:
  - Pseudo-deterministic Numerical Weather Predictions
  - Forecasts for extreme situations (cut-out, ramps…).
  - Applied to wind speed and direction at hub height (121 wind farms)



Cut-out probability



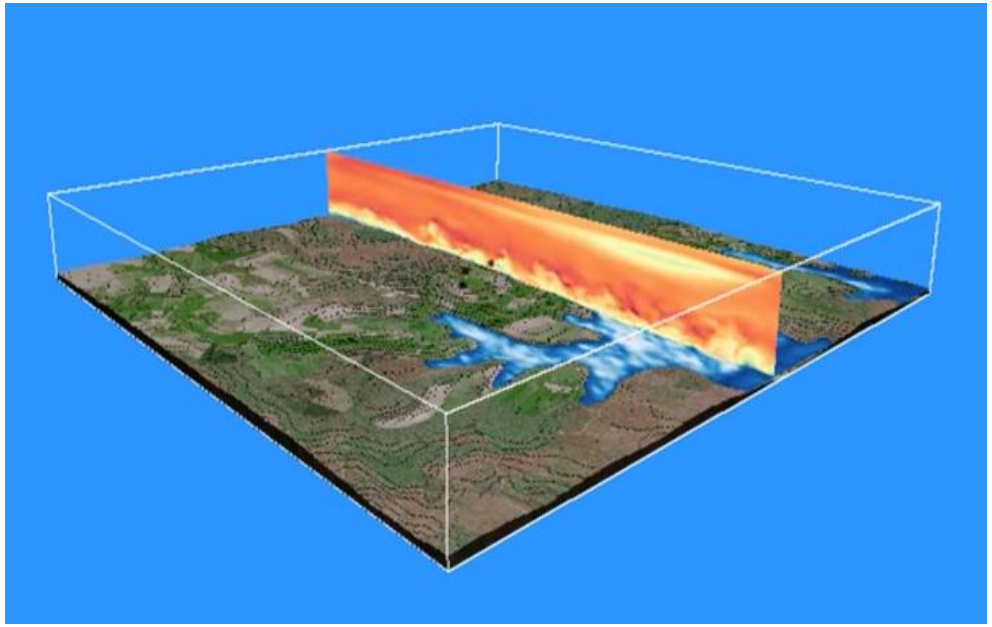
Ramp probability

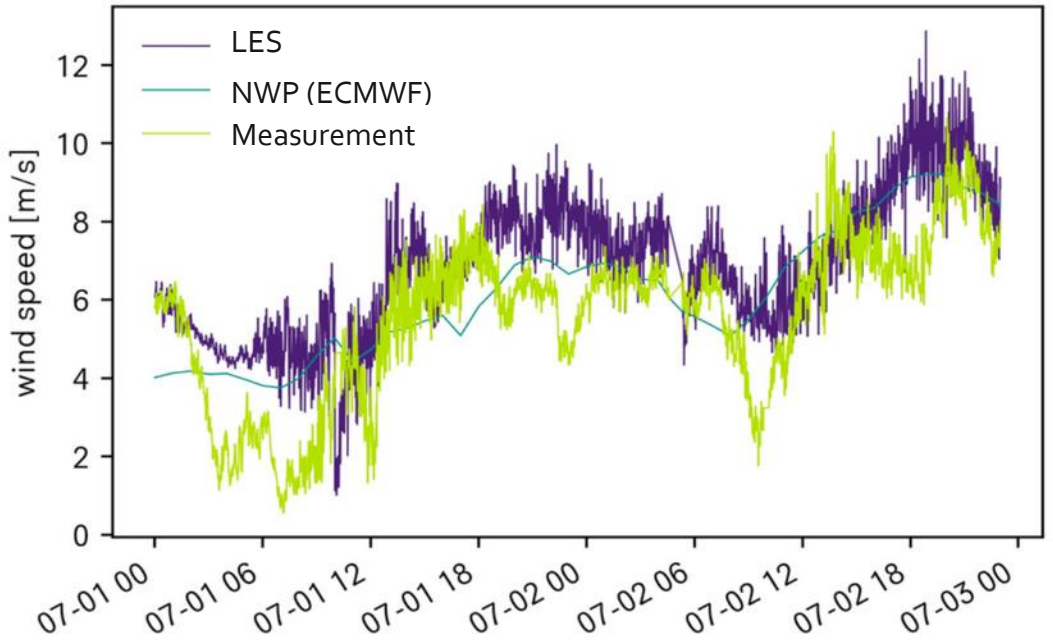
- **15%** improvement of RMSE compared to standard NWP model
- Forecasting products for specific situations, eg extremes or ramps

2. High-resolution weather forecasting

- Large Eddy Simulation provides local forecasts of wind speed and power (Whiffle)

  Resolves turbulence, clouds/fog and effect of surface on local weather conditions, by numerical simulation over a much finer grid than conventional NWP (50m - 30sec resolution)



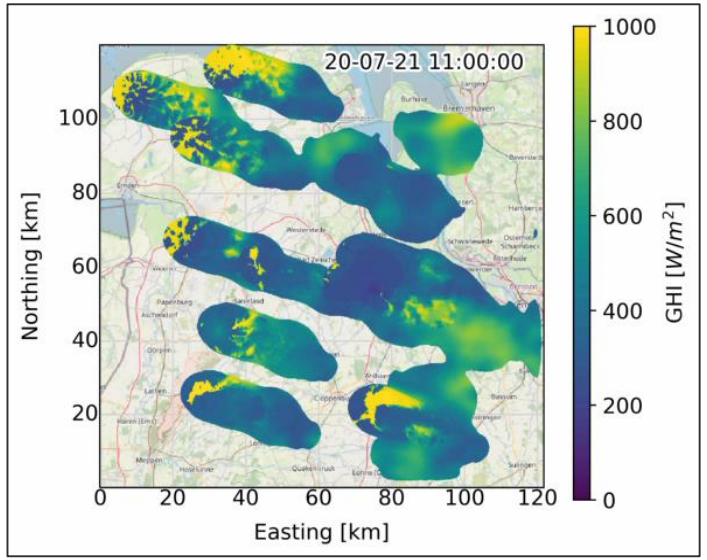


- Accurate modelling of turbulent fluctuations at timescales below 15 min
- New forecasting product for grid management and flexibility provision

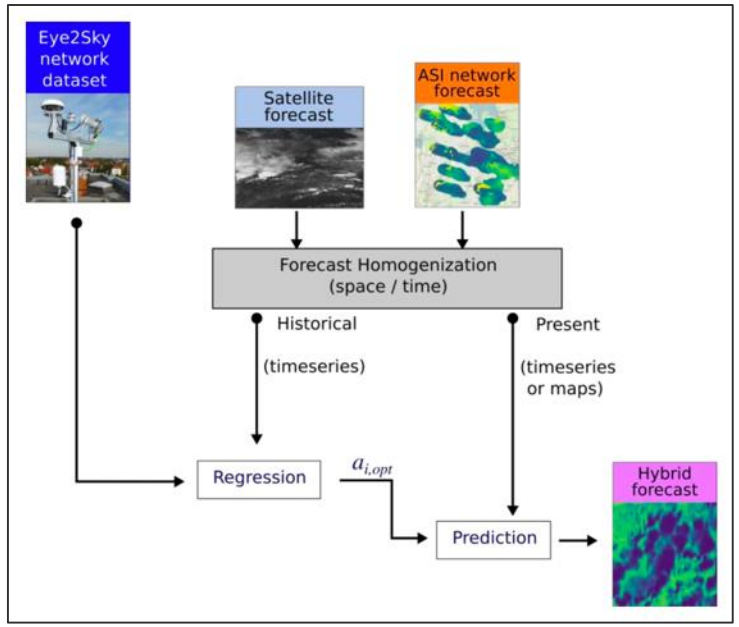
3. Seamless weather forecasting

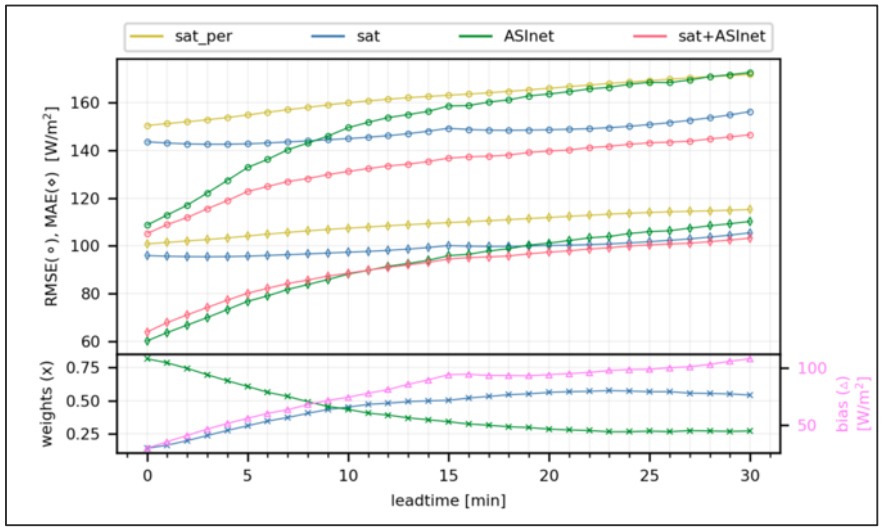
- Regional high-resolution seamless solar irradiance forecasts up to 6 hours ahead

Irradiance maps from a network of All Sky Imagers (ASI)



Combination of multiple data sources for seamless forecasting





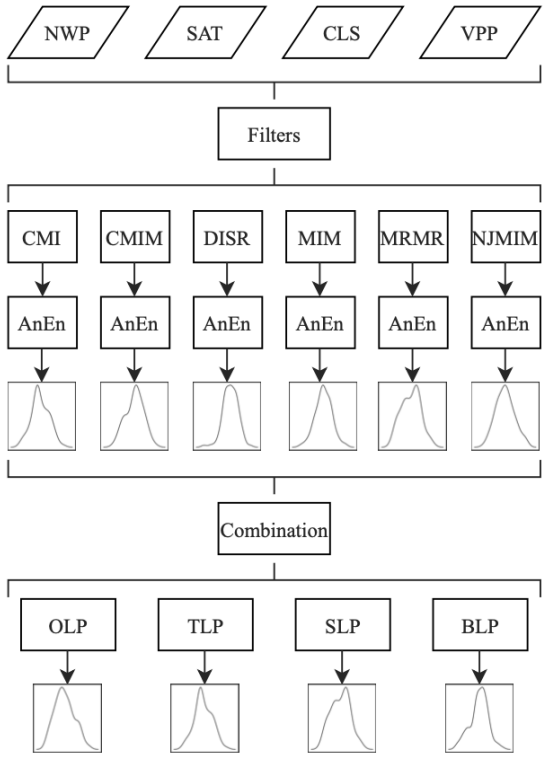
RMSE improvement of **10% - 12%** at 15min-ahead and 6h-ahead respectively compared to single data source

3. Seamless weather forecasting

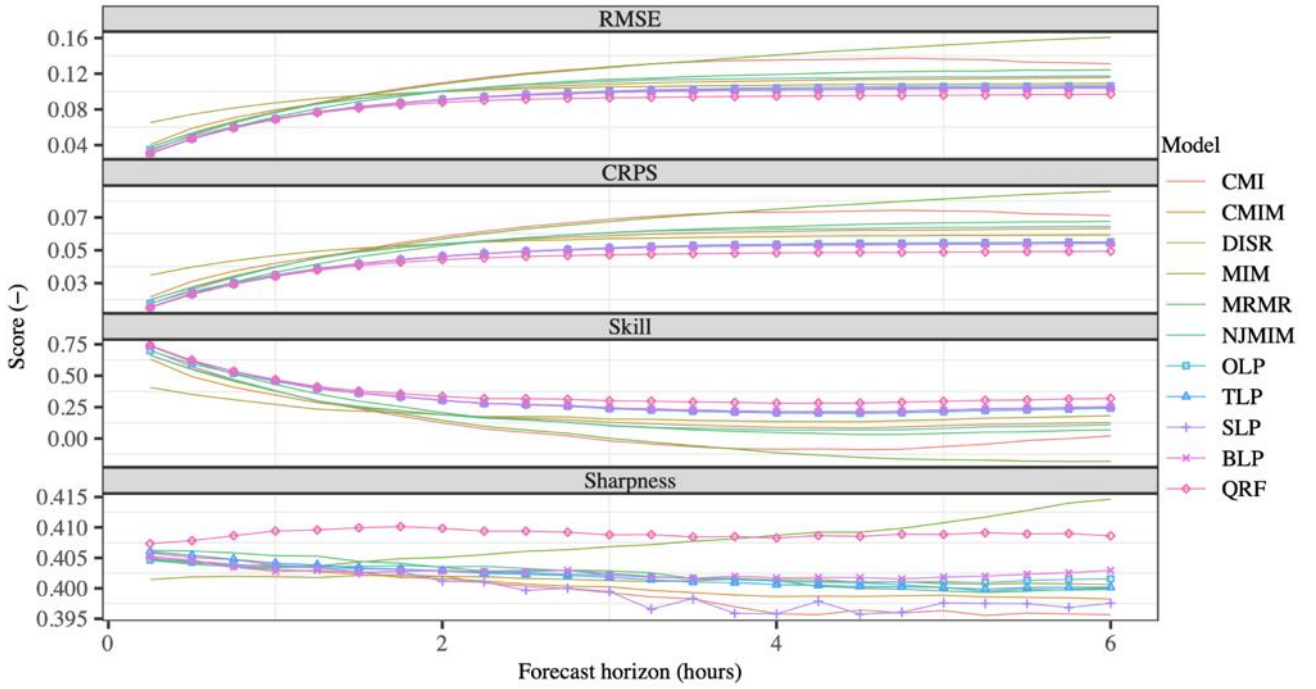
- Combination of multiple data source for seamless RES forecasting

  Generic in terms of RES: eg. applicable to a Wind + PV Virtual Power Plant

Model workflow



Obtained results

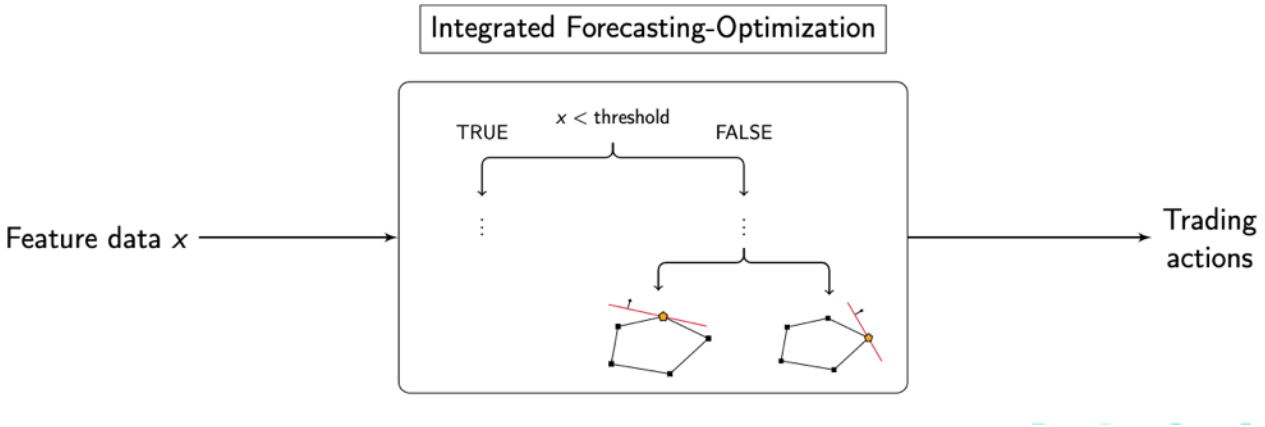


Similar performance to computationally-intensive models (eg QRF)

4. Integrated forecasting and optimization for RES applications

- Closing the loop between forecasting and optimization to improve prescriptive performance

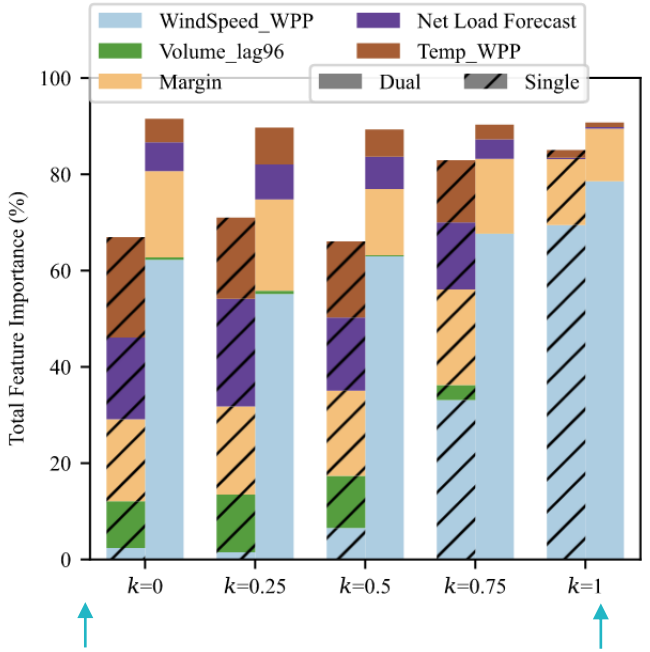
Prescriptive analytics



A. C. Stratigakos, S. Camal, A. Michiorri and G. Kariniotakis, "Prescriptive Trees for Integrated Forecasting and Optimization Applied in Trading of Renewable Energy," in *IEEE Transactions on Power Systems*, doi: 10.1109/TPWRS.2022.3152667.

- Simplification of the decision-making model chain
- Allows explainability of decisions based on feature importance

Application to RES-VPP trading in the energy market



Standard regression (expected RES production)

Optimal trading offer (depends on imbalance pricing)

Conclusions

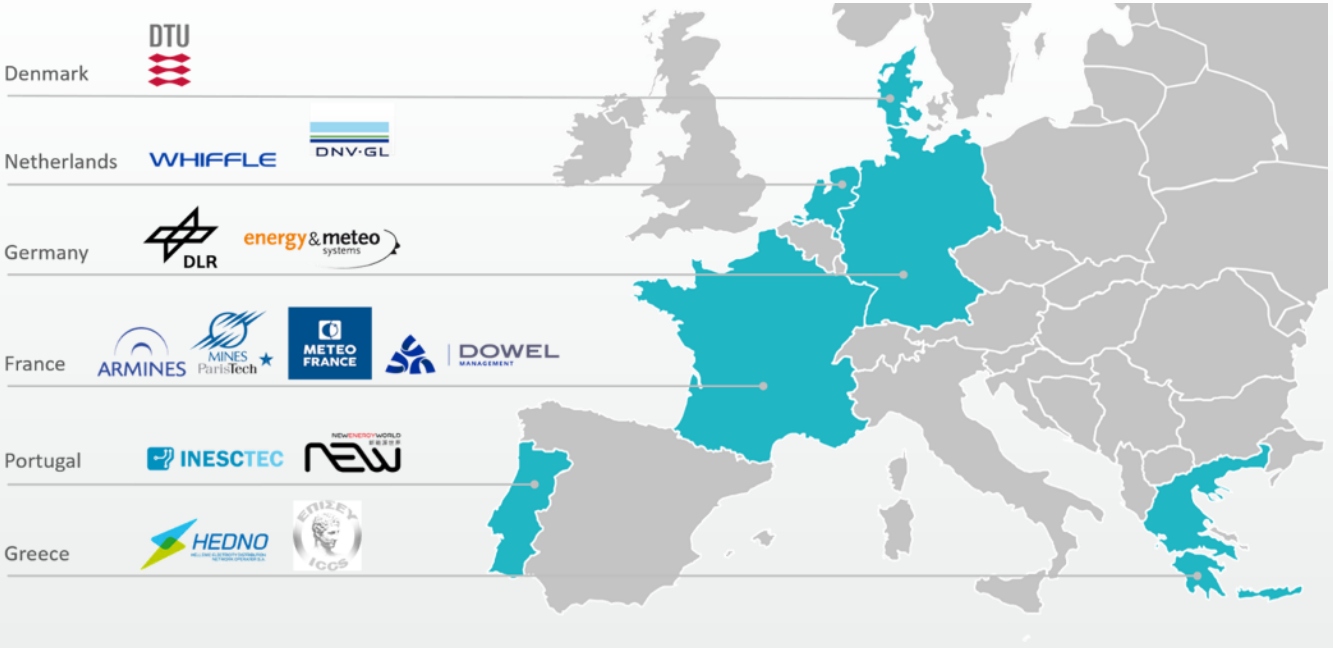
- **Smart4RES:** a multi-disciplinary approach to provide a next generation solutions for renewables forecasting and related decision making
- **High-resolution weather forecasts** provide detailed information about RES production variability at global and local scale
- **Seamless weather and renewable power forecasting** simplifies the forecasting modelling chain
- **Prescriptive analytics** integrate forecasting and optimization to further simplify modelling chains: derive decisions directly from data, robust methods against missing values etc.

To know more, visit www.smart4res.eu : use cases, deliverables, webinars.

Smart4RES-project @Smart4RES Research Gate

Smart4RES

THANK YOU !



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 864337

Smart4RES team:

- Georges Kariniotakis, Simon Camal, Dennis van der Meer, Akylas Stratigakos; **MINES Paris**, PSL, Centre PERSEE, France.
- Gregor Giebel, Tuhfe Göçmen, Pierre Pinson; **DTU**, Denmark.
- Ricardo Bessa; Carla Goncalves, **INESC TEC**, Portugal.
- Ivana Aleksovska, Bastien Alonzo, Marie Cassas, Quentin Libois, Laure Raynaud; **Meteo France**, France.
- Gerrit Deen, Daan Houf, Remco Verzijlbergh; **Whiffle**, The Netherlands.
- Matthias Lange, Björn Witha; **Energy and Meteo Systems**, Germany.
- Jorge Lezaca, Bijan Nouri, Stefan Wilbert; **DLR**, Germany.
- Maria Ines Marques, Manuel Silva; **EDP**, Portugal.
- Wouter De Boer, Marcel Eijgelaar, Ganesh Sauba; **DNV**, The Netherlands.
- John Karakitsios, Theodoros Konstantinou, Dimitrios Lagos, George Sideratos; **NTUA/ICCS**, Greece.
- Theodora Anastopoulou, Efrosini Korka, Christos Vitellas; **HEDNO**, Greece.
- Stephanie Petit; **Dowel Innovation**, France.