Minute-scale wind forecasting introduction

IEA Workshop: Forecasting for the Weather Driven Energy System
April 10-11, 2024
Roskilde, Denmark

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6 years ago, in this very spot..

iea wind

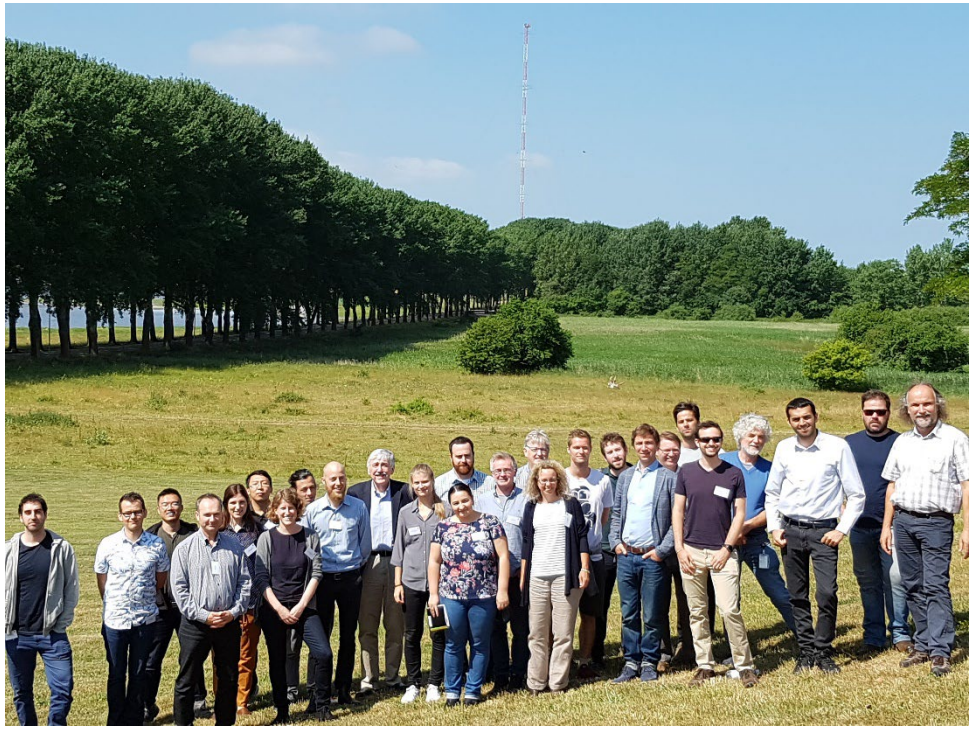
task 32 lidar

IEA WIND TASK 36

June 2018

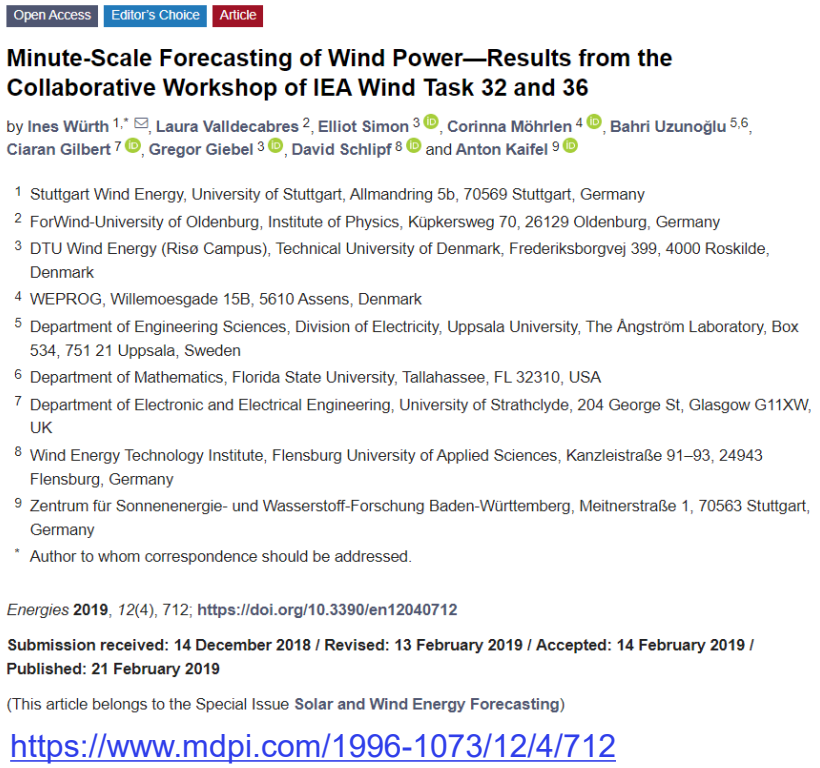
Final Programme of the
Joint IEA Wind Task 32 and Task 36 Workshop on
Very short-term forecasting of wind power

Date: June 12-13, 2018
Venue: Niels Bohr Auditorium, DTU Risø Campus, Roskilde, Denmark
Workshop leaders: Ines Würth (Uni Stuttgart), Laura Valldecabres (Uni Oldenburg),
Elliot Simon (DTU Wind Energy), Mike Courtney (DTU Wind Energy)



What we achieved

- Gathering of 40+ forecast users, providers, and researchers
- Abandoned the term “very-short-term” and adopted “minute-scale”
- Published field review article covering:
  - Minute-scale wind and power variability
  - Applications of minute-scale wind forecasts
  - Status quo and state-of-the-art forecast methods
  - Implementation challenges and recommendations



Open Access Editor's Choice Article

Minute-Scale Forecasting of Wind Power—Results from the Collaborative Workshop of IEA Wind Task 32 and 36

by **Ines Würth** [1,*], **Laura Valldecabres** [2], **Elliot Simon** [3], **Corinna Möhrlen** [4], **Bahri Uzunoğlu** [5,6], **Ciaran Gilbert** [7], **Gregor Giebel** [3], **David Schlipf** [8] and **Anton Kaifel** [9]

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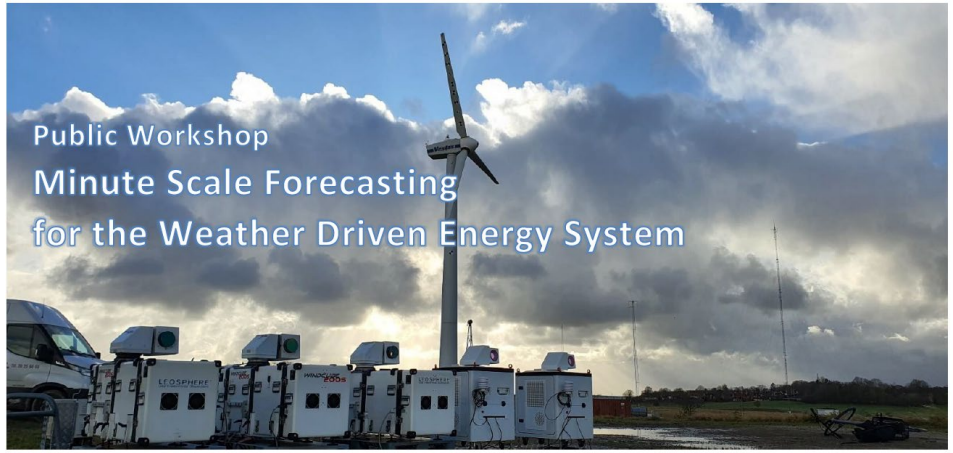
https://www.mdpi.com/1996-1073/12/4/712

Today

- Many early ideas have developed into working tools and methods
- Cooperation has grown to unite with solar, storage, and hybrid systems
- 70+ attendees at this workshop ☺

- New regulations and markets are bringing focus to the field
- EU commission guideline on electricity balancing (2021):
  "…all TSOs shall apply the imbalance settlement period of 15 minutes in all scheduling areas…"



Motivations

1. Operation and decision horizons are shortening due to increase in share of variable renewables
   – Power system imbalances → financial costs and inefficient resource use, potentially grid failures
   – Early movers: Australia (5-min), Nordics, Germany (15-min), UK (30-mins)

2. Predictive control of wind turbines can improve production and extend lifetime
   – Feedforward control: yaw/pitch regulation, extreme load and erosion avoidance

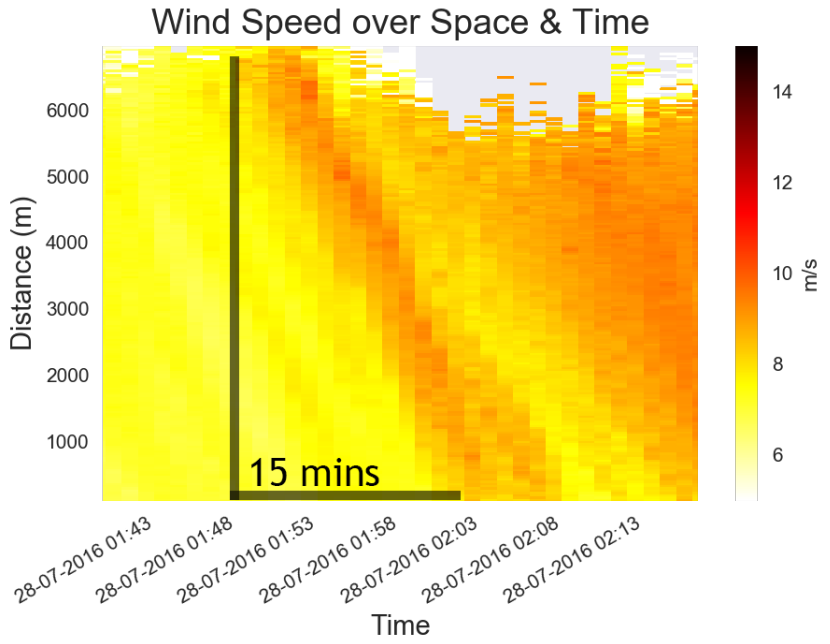
Data driven methods

- Physical models (i.e. NWP) are very useful but fall short on resolution and runtime
- Historical data can be used to identify patterns and attempt to predict the future
- The atmosphere is complex and statistical approaches using only past data can lead to large (costly) errors

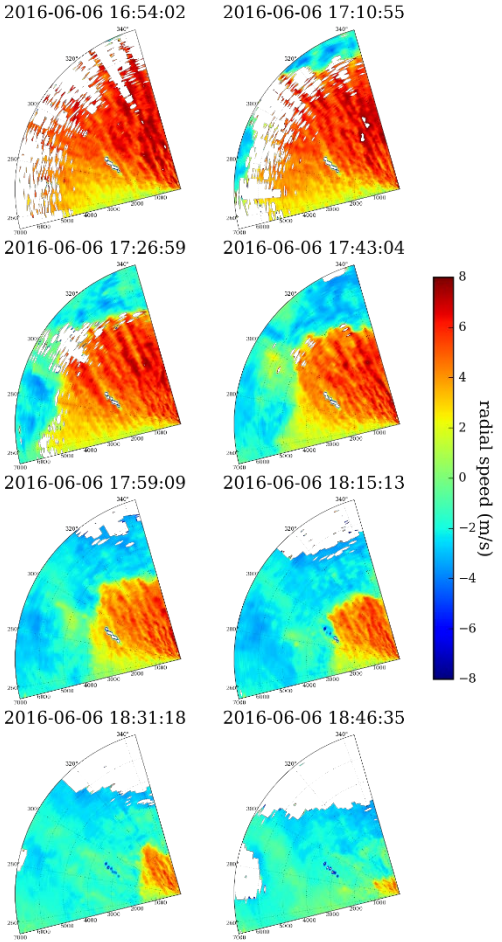
- Site measurements can provide immense value to improving forecast accuracy
- For wind, this includes e.g.:
  - Wind speed and direction, and variability
  - Boundary layer height, atmospheric stability, turbulence intensity
  - Local and surface effects: terrain, vegetation and flow patterns
- These measurements are expensive and require experts to set up and operate!

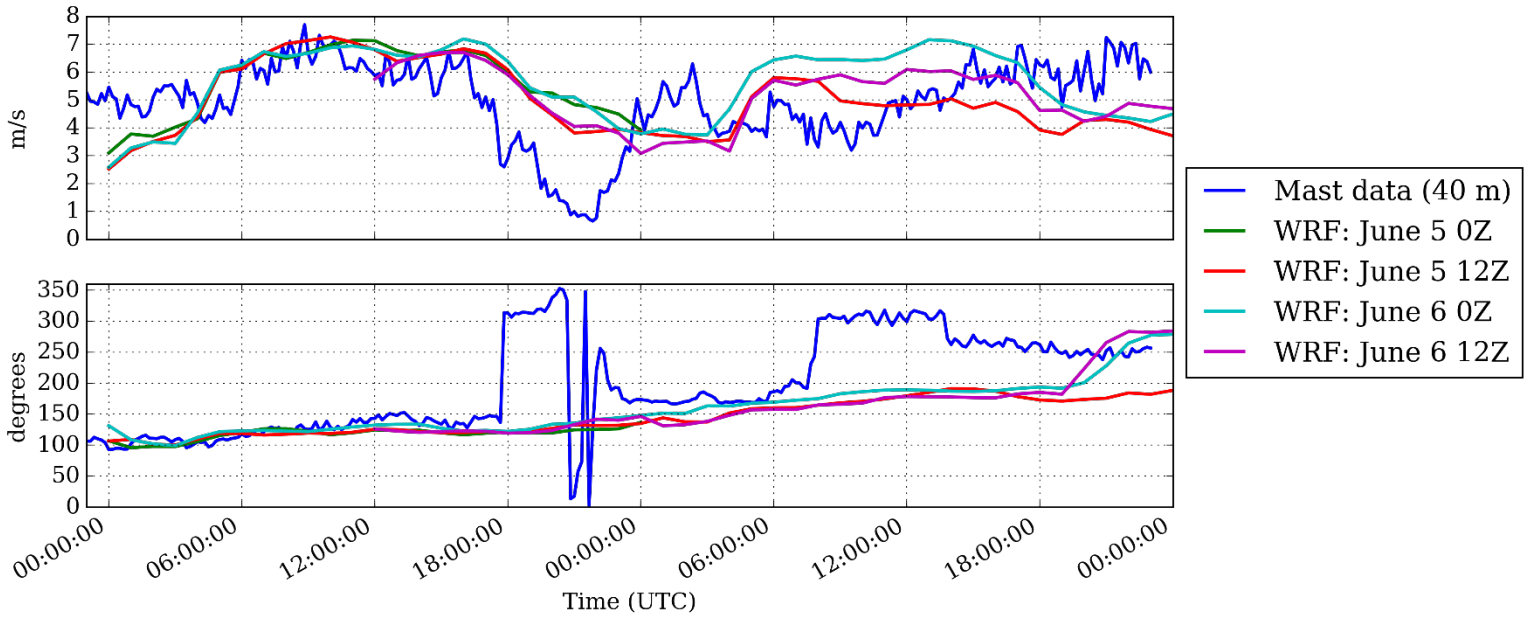
Wind lidars – a tool for minute-scale forecasting

- Pulsed scanning Doppler wind lidars can remotely measure the wind up to ~10 km away
- The lidar's scan head can adapt to any site and measurement configuration



Extreme event witnessed by lidar





E. Simon, 2019. Minute-Scale Wind Forecasting Using Lidar Inflow Measurements. https://doi.org/10.11581/dtu:00000054

Other lidar studies and proofs of concept:

- Magerman, 2014: Short-Term Wind Power Forecasts using Doppler Lidar, https://keep.lib.asu.edu/system/files/c7/124487/Magerman_asu_0010N_14603.pdf
- Valldecabres et. al, 2018: Very short-term forecast of near-coastal flow using scanning lidars, https://doi.org/10.5194/wes-3-313-2018
- Simon, 2019. Minute-Scale Wind Forecasting Using Lidar Inflow Measurements. https://doi.org/10.11581/dtu:00000054
- Pichault et. al, 2021: Short-Term Wind Power Forecasting at the Wind Farm Scale Using Long-Range Doppler LiDAR, https://doi.org/10.3390/en14092663
- Theuer, F et. al, 2022.: Observer-based power forecast of individual and aggregated offshore wind turbines, https://doi.org/10.5194/wes-7-2099-2022

- All above approaches have demonstrated superior forecast skill over statistical methods

Summary

- Minute-scale forecasting of renewables is important today for power system and power plant operation
- Advancements are driven by regulation and commercialization
- Site measurements are essential for improving forecast skill
- Remote sensing instruments like lidars are useful tools for providing real-time atmospheric data used to train/tune/operate the models

- We’re very glad you’re here to contribute to these efforts ☺