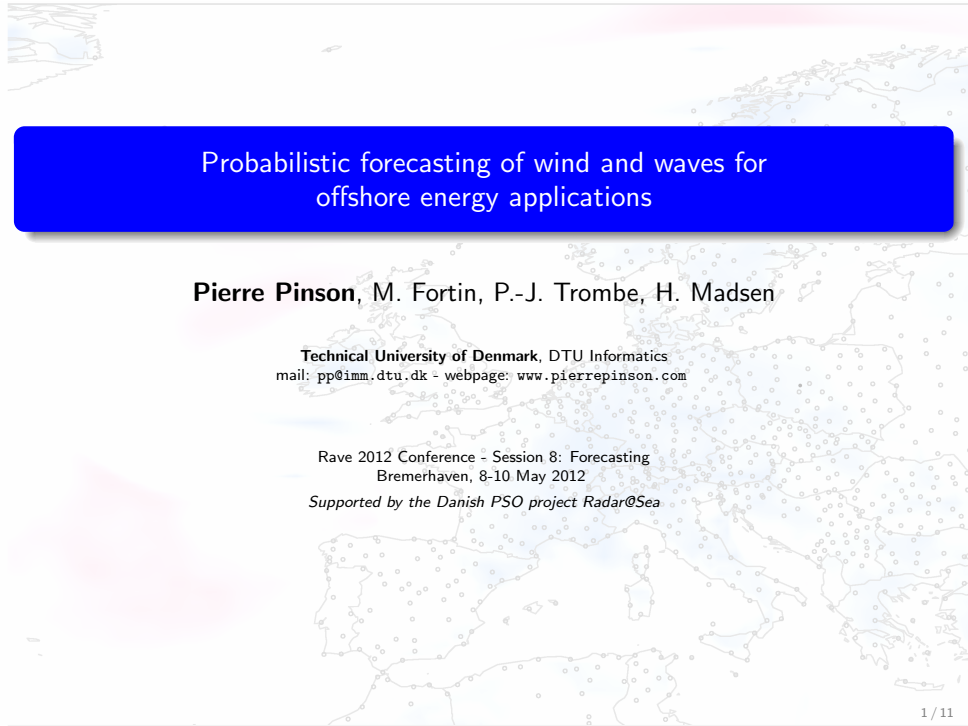




Probabilistic forecasting of wind and waves for offshore energy applications

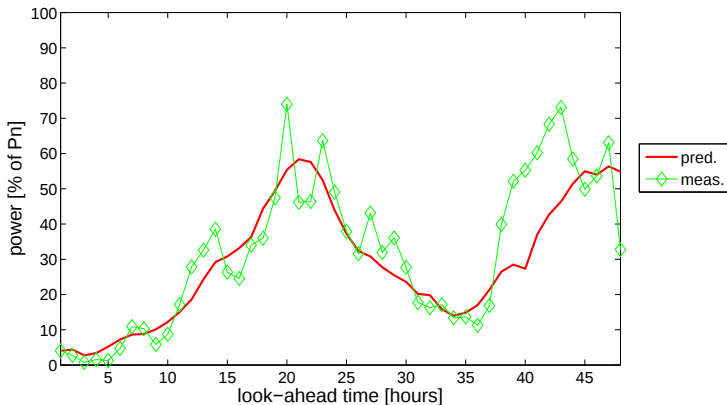
Pierre Pinson, M. Fortin, P.-J. Trombe, H. Madsen

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Rave 2012 Conference - Session 8: Forecasting
Bremerhaven, 8-10 May 2012

Supported by the Danish PSO project Radar@Sea

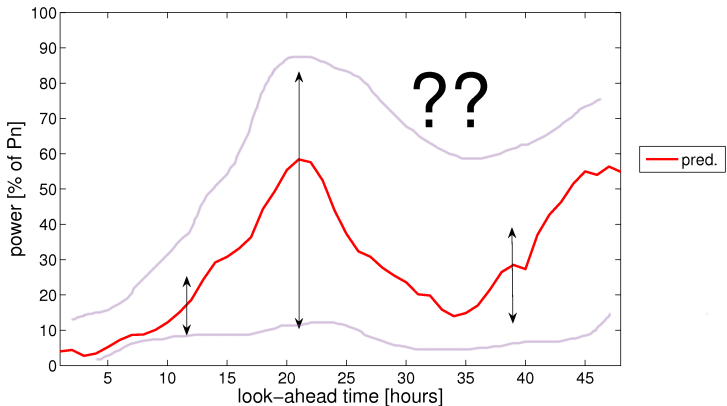
- Forecasts (weather, energy production, etc.) are commonly provided in the form of point forecasts (i.e. the conditional expectation for each look-ahead time)



- Different methodologies have been introduced and evaluated for wind, solar and wave power forecasting
- Their level of accuracy is highly variable and depending upon external factors

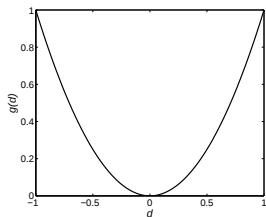
Background: uncertainty !?!

- The level of accuracy is highly variable from one prediction to the other. This makes weather and energy-related forecasts somewhat hard to handle...

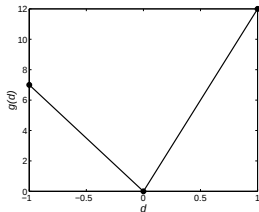


- One cannot make optimal decisions from such predictions — an information on their (non-Gaussian) uncertainty is necessary!! (also accounting for correlation issues)

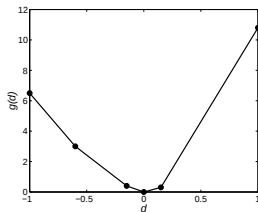
- Forecasts are to be used as input to (potentially complex) decision-making!
- Actually, each forecast user has its own cost function (that he does not necessarily know....!!)



Forecaster

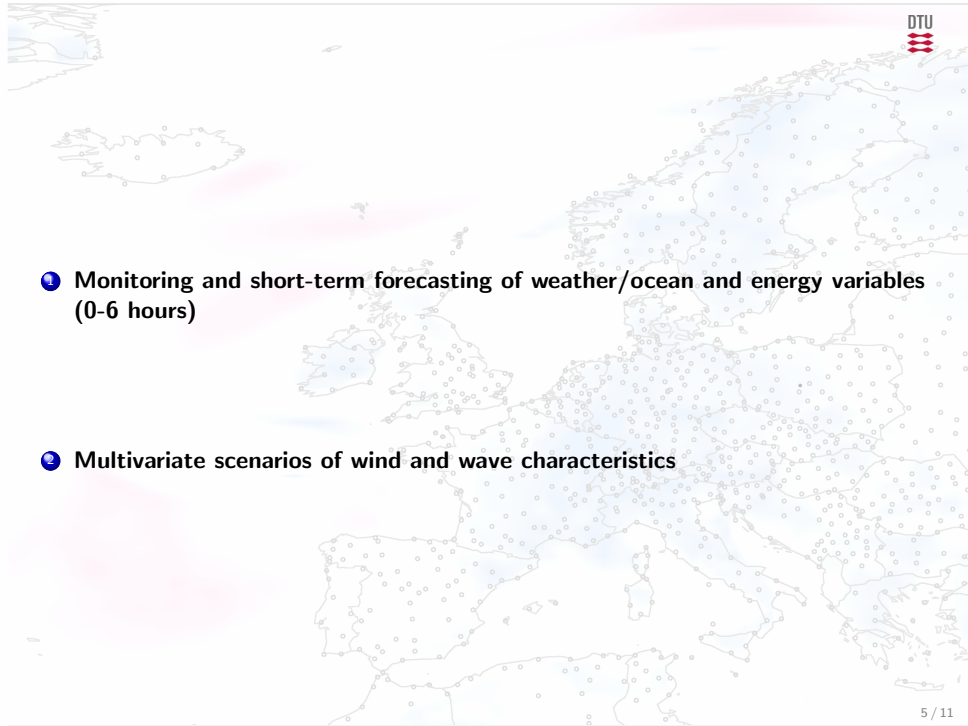


Trader (wind power only)

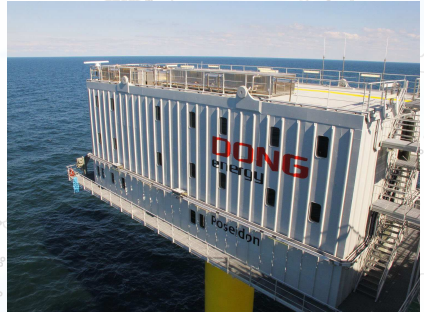


Portfolio manager

- So... What are the best forecasts for offshore energy-related applications??

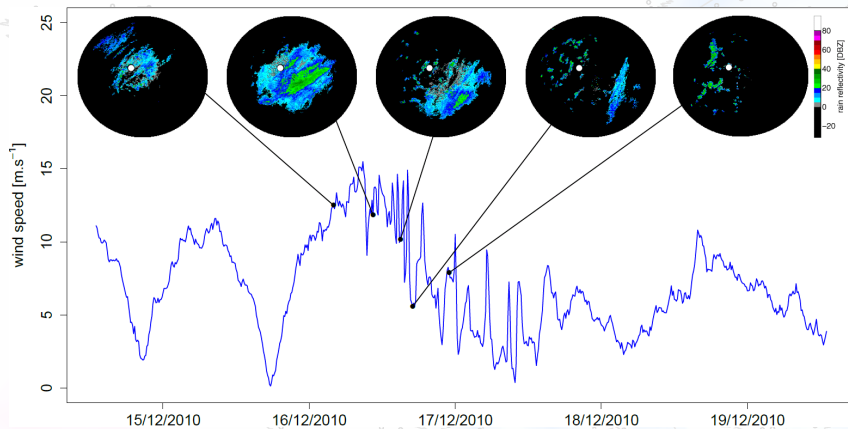
- 
- 1 Monitoring and short-term forecasting of weather/ocean and energy variables (0-6 hours)
 - 2 Multivariate scenarios of wind and wave characteristics

- X-band weather radars (range: 60kms) were installed at Horns Rev in 2009/2010 in collaboration with the Radar@Sea project



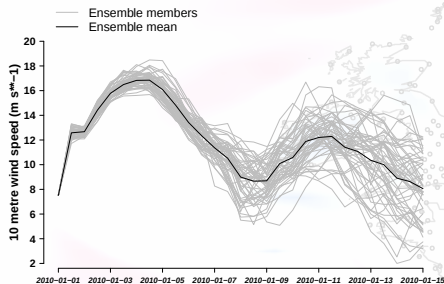
- Supplemented by the DMI C-band radar (range: 240kms) at Rømø, they are used for
 - monitoring of weather conditions (safety)
 - analysis of meteorological episodes (/climatology)
 - improving short-term forecasts
 - better control for episodes with intense fluctuations

Illustrative episode: 15-19.12.2010

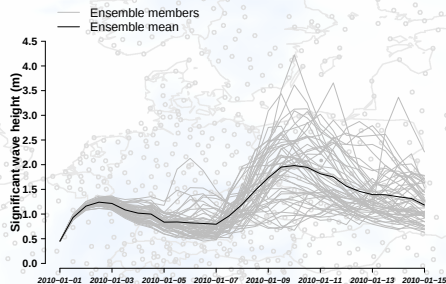


Also see <http://www.youtube.com/watch?v=YShQDCdVyKM>

- Multivariate scenarios of wind and wave characteristics are a **must-have as input to decision-making**
- Example work was performed based on ECMWF ensemble forecasts for FINO-1 over 2010-2011



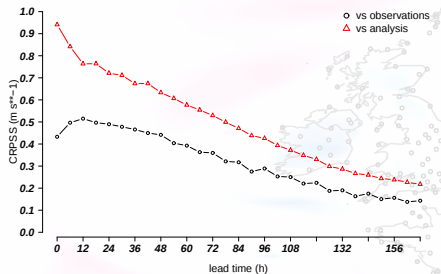
wind speed



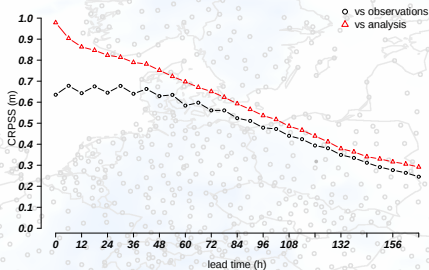
significant wave height

- These scenarios may be
 - *provided* by a number of public and commercial meteorological institutes
 - *calibrated* for the purpose of optimal decision-making
 - *used as input* to complex decision-making problems related to offshore energy applications

- ECMWF ensemble predictions already are extremely good at this kind of job...



wind speed



significant wave height

- and they can be significantly improved through appropriate multivariate calibration procedures

- Producing calibrated **multivariate probabilistic forecasts** of:
 - input meteorological variables (wind and wave characteristics)
 - power generation offshore (wind and wave energy)
- Such forecasts also inform about space-time dependencies
- Toy and real-world **decision-making models** should be set-up and analysed, for:
 - optimal maintenance planning
 - optimal operation of wind-wave offshore energy plant
 - etc.
- Evaluating the **quality and value of probabilistic forecasts (/scenarios)**
 - actual forecast quality
 - (increased) value when used in decision-making

Thanks for your attention!

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Pierre Pinson





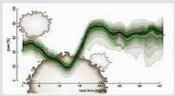
Large-scale integration of renewable energy

Book (coming soon...)



Henrik Madsen and I finally convinced ourselves that we should compile part of our works, ideas and experience with wind power forecasting into a book. It will be published by [Earthscan](#), a publishing house particularly focused and active on topics related to

Wind power forecasting



It is not possible to decide on the level of wind energy to be produced in the coming minutes or days – one relies on nature and the weather. Ways have to be found to optimally assimilate this energy generation in the system. Wind power modeling and forecasting is recognized

A little toy...



If you wonder how future renewable energy forecasting may look, let me invite you to look at this toy forecasting system, which we will make evolve as new features are to become available.