Solar PV power forecasting in Australia using GFS and ECMWF

Henrik Aalborg Nielsen & Torben Skov Nielsen, ENFOR A/S, Denmark

Hans-Peter (Igor) Waldl, Overspeed GmbH & Co. KG, Germany

Peter Coppin, CSIRO, Australia

Outline

- Operational system
- Physical model
- Combined physical and statistical model
- Data & methods used in the comparison
- Results
- Conclusions

Prediction system

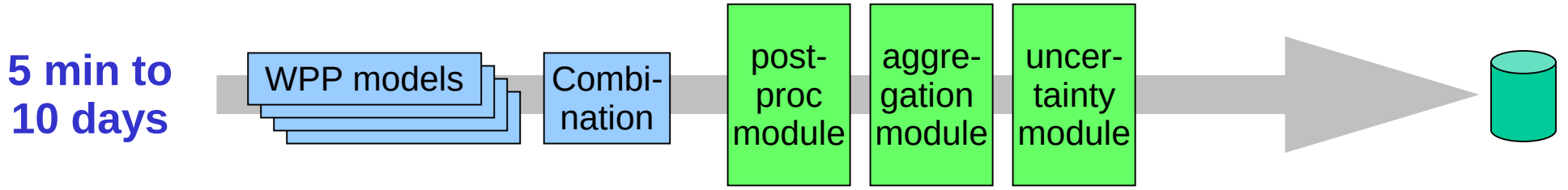
Basis: Anemos prediction platform

Fully integrated in Australian market system

„Market-system-proof“

24/7 operation

100% availability (AWEFS/ASEFS,5 years)



Physical base model

Principle: Physical modelling

NWP Irradiation → local tilted irradiation by physical direct/diffuse modelling

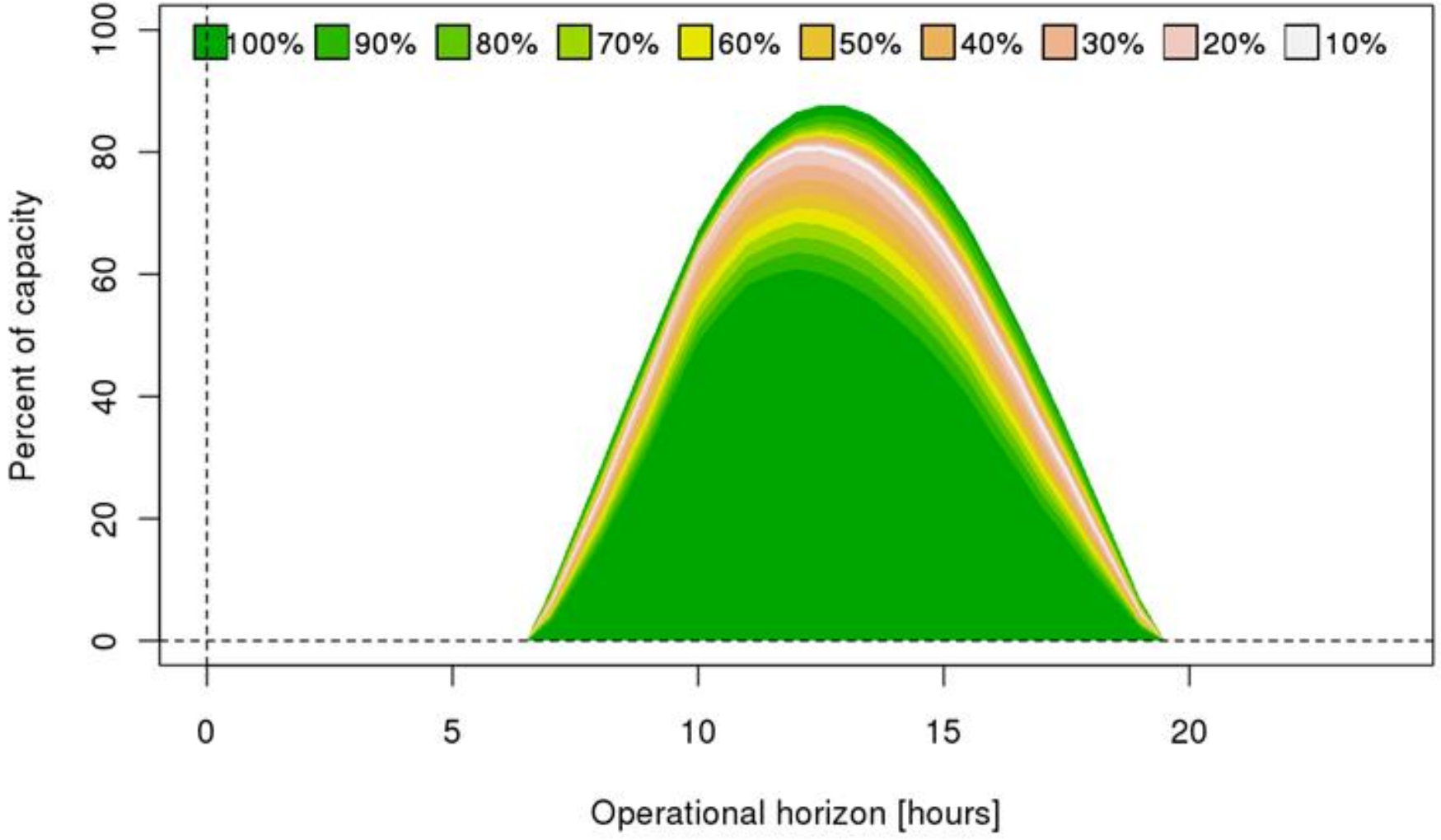
Physical parametric model of PV (wafer material) and inverter behaviour

Tuning of physical parameters with historical data

SolarFor

- Combined physical / statistical model for each NWP provider (here GFS-HD / ECMWF).
- Optimal combination of PV power forecasts based on tracking the individual model performance.
- Short-term correction of NWP based forecasts based on tracking the temporal correlation of errors, together with shadow detection.
- Reliable uncertainty information based on modelling quantiles of forecast errors.

Probabilistic (quantile) forecast (example)



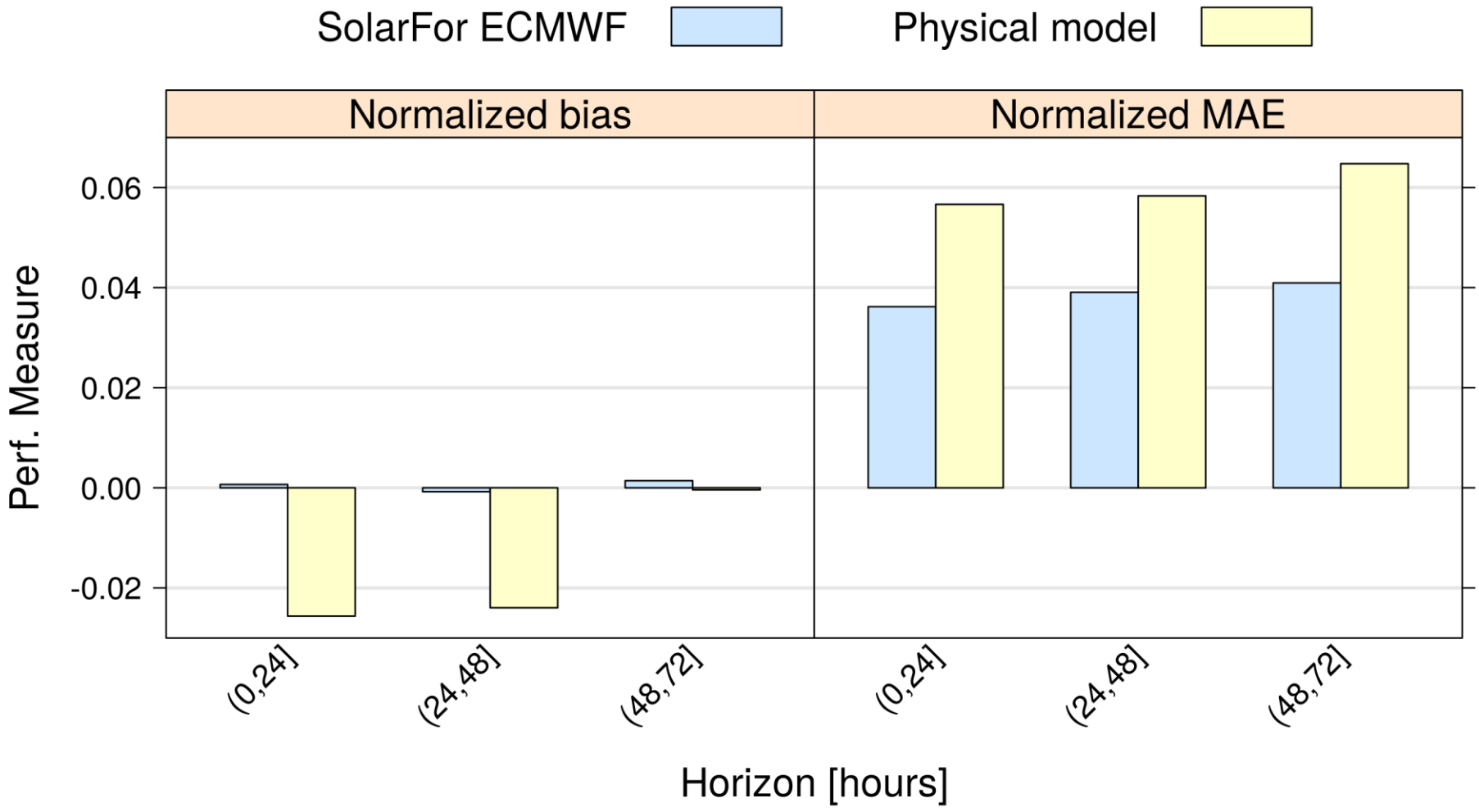
SolarFor – combined phys./stat. model

- Core of model based on physical principles (direct/diffuse irradiation, panel efficiency, …).
- Model characteristics estimated from NWP data and actual PV power production.
- An number of secondary NWP variables (e.g. atmospheric water content) used in order to detect systematic NWP errors via data mining / machine learning methods.
- Continuous re-calibration of models.

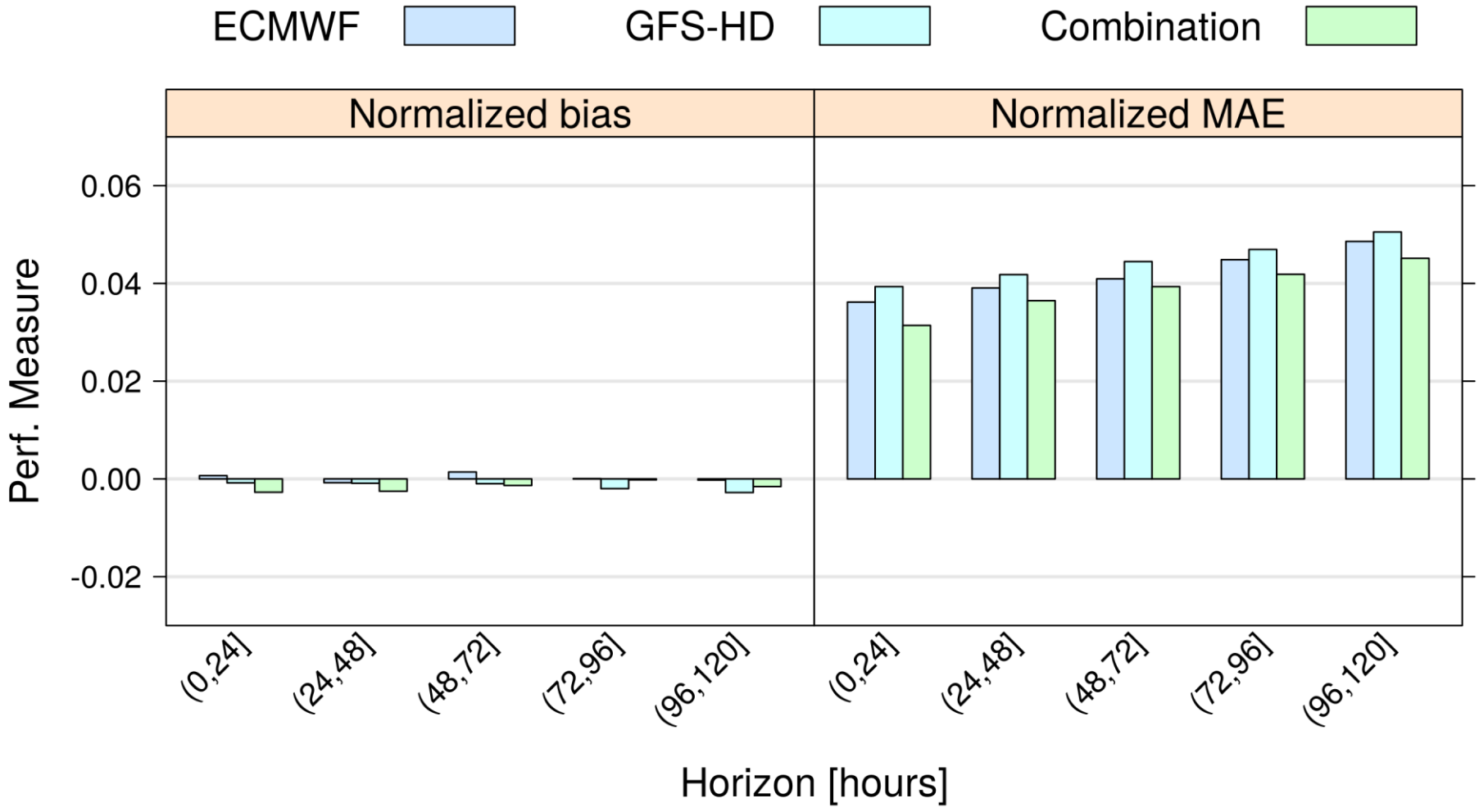
Data and methods

- December, 2013 – September, 2014
- Temporal resolution: 30 minutes.
- Forecasts compared on same data, errors normalized using plant nominal power.
- Consider forecasts available 00z (10 or 11 am Eastern Australian time), i.e. 18z GFS-HD and 12z ECMWF update.
- Normalized bias (average normalized error).
- Normalized mean absolute error.

Comparison of models using ECMWF



SolarFor using GFS-HD and ECMWF



Conclusions

- Optimal combination of forecasts clearly outperforms the best individual forecasts and ensures operational reliability.
- Frequent re-calibration of models in order to estimate the underlying (possibly changing) plant characteristics and systematic NWP errors outperforms a pure physical model.
- Plant characteristics: Module and inverter degradation, system faults (e.g. cabling faults).

THANK YOU FOR YOUR ATTENTION!

Henrik Aalborg Nielsen

han@enfor.dk

www.enfor.dk