Warning Electricity Grid Operators about Large Photovoltaic Forecast Errors

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overview

- motivation
- data
- methods
- results
- conclusions

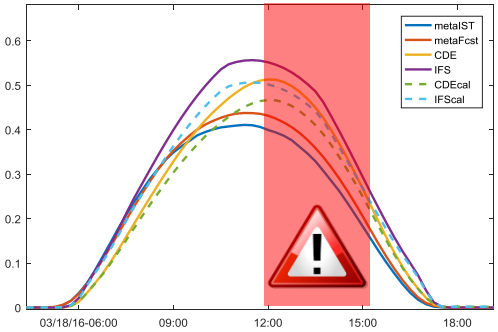
motivation
PV in Germany

- high penetration of photovoltaic (PV) systems in German electricity system
  - ~1.5 million PV plants sum up to ~39GWp (2016)
  - yearly energy production 38.5 TWh (2015)
    7.5% of net electricity demand
  - maximum share power consumption <50% on weekends (<35% else)

- most of PV within EEG-marketing
  - EEG = German renewable energy act
  - 31GW of 39GW ~ 80%
  - responsibility of Transmission System Operators

motivation

- Transmission System Operators (TSOs)
  - need high quality PV forecasts for
    - secure grid operation (reserve ~4GW / 10% of PV)
    - economic trading following EEG
  - → horizon starting several days before delivery time t
  - build optimized/weighted mix of forecasts
- requirements
  - 15 minute timesteps
  - point-forecast (a single value per timestep)
- additional information is welcome !



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data

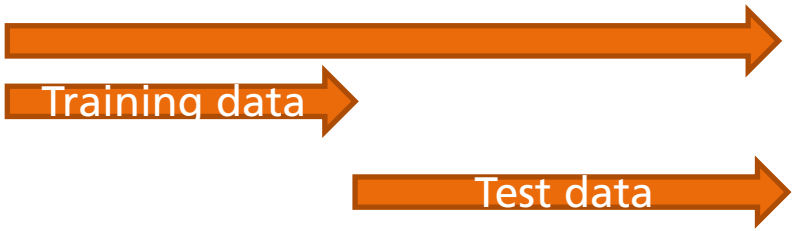
- own PV capacity database

- reference timeseries of regional PV actual value
  - transparency data from individual TSO web pages

- NWP
  - DWD COSMO-DE +21h… +45h 2015/01 - 2016/08
  - DWD CDE-EPS +21h… +45h „

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

20 member ensemble



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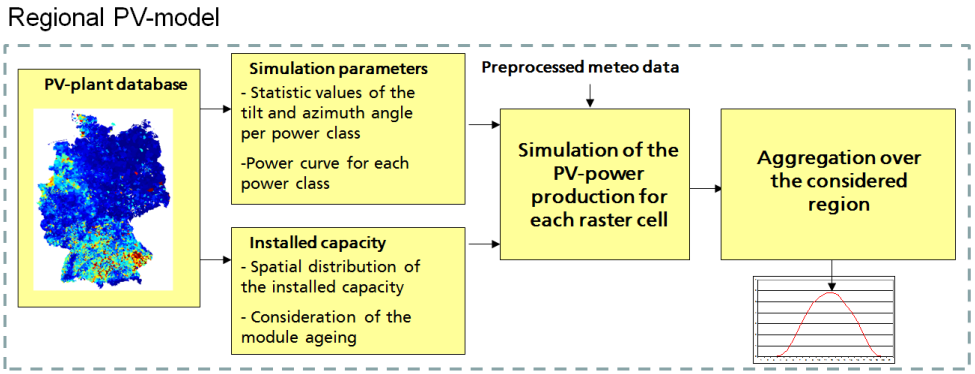
step I
transformation of NWP to PV power

- our solar prediction system IWES.sps
  - operational EWeLiNE demonstrator
  - NWP variables → regional PV production (here: Germany)

N input sets of NWP variables rad + T2m +…



N raw scenarios of PV power

- our assumption:
  - ensemble spread is related to forecast skill → make use of correlation

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step II
calibration of PV power timeseries

- N ensemble member → K quantiles
  - similar to ECC approach, but no back-ordering

- calibration of PV power scenarios to reference timeseries via
  - spline quantile regression
  - optimization of CRPS

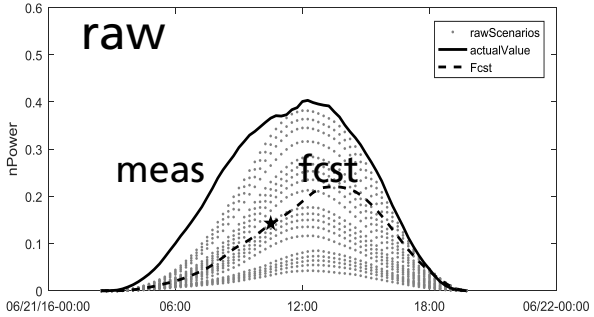
- evaluation score
  - Threat Score / Equitable Threat Score

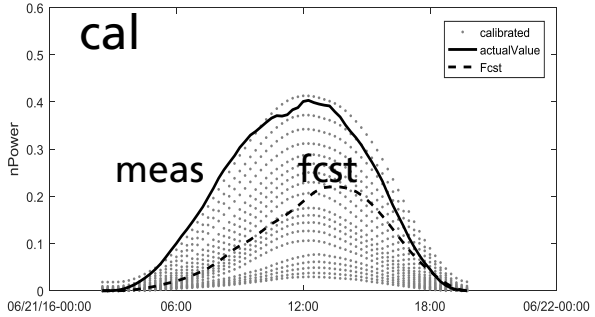
$$\mathrm{TS} = \frac{hits}{hits + false\ alarms + misses}$$

$$\mathrm{ETS} = \frac{hits - hits\ by\ chance}{hits + false\ alarms + misses - hits\ by\ chance}$$

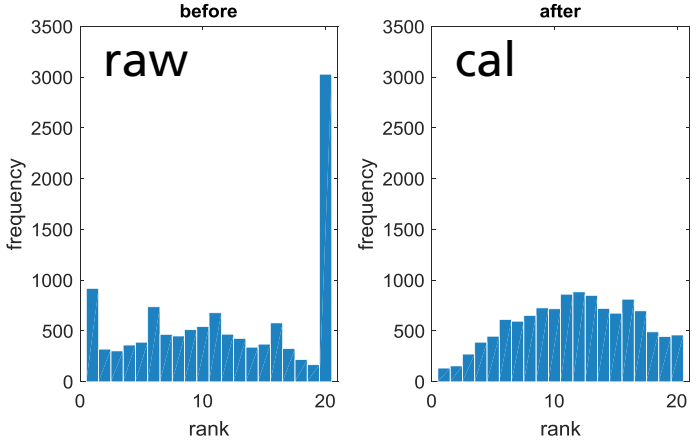
results
calibrated quantiles

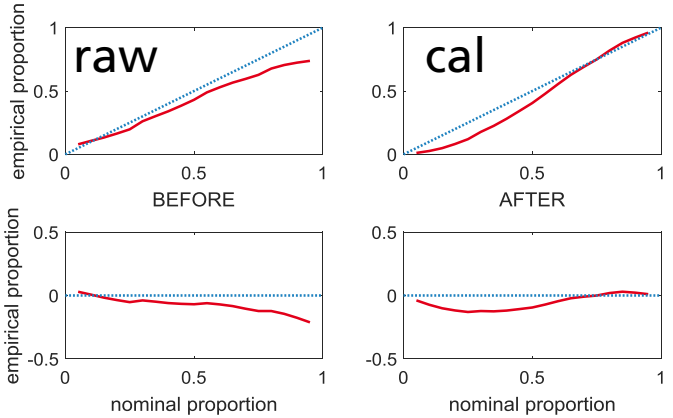
example
21.06.2016





test
period





reliability

difference

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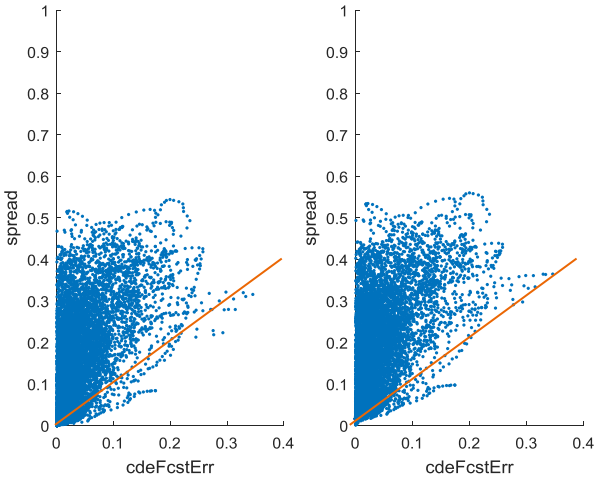
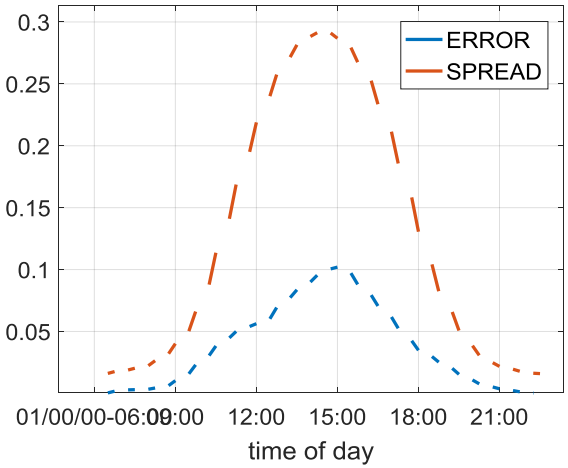
results
spread-error-correlation

- correlation of error (CDE-SAT) with spread (CDE_EPS)
  - dominated by diurnal cycle





diagonal as a „guide to the eye“

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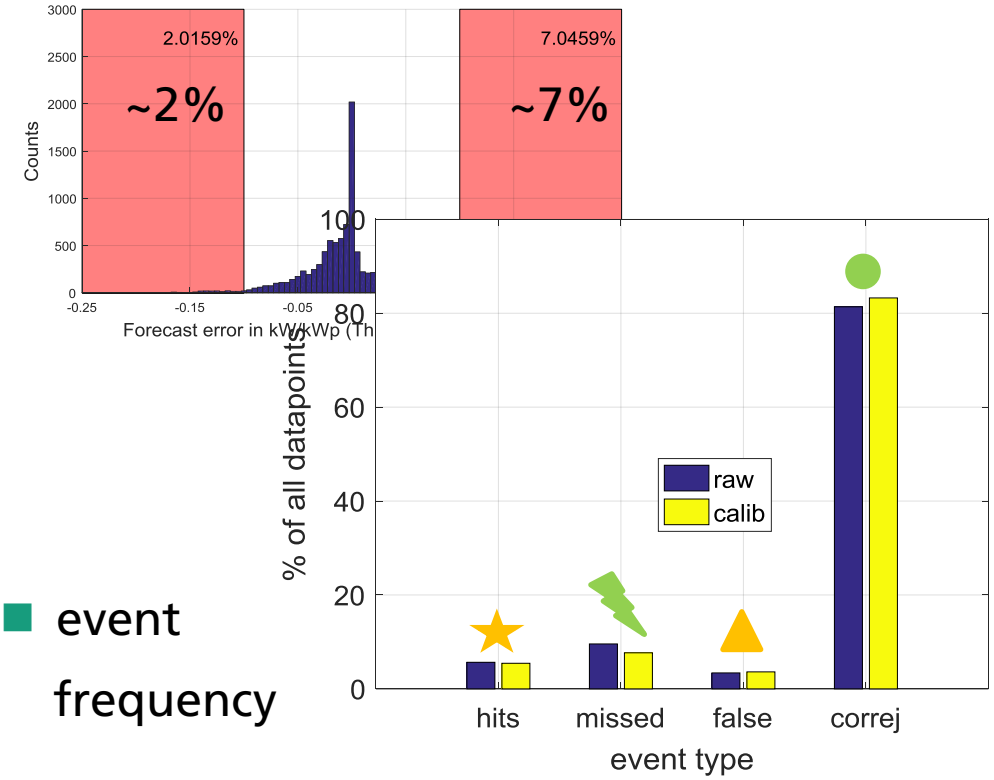
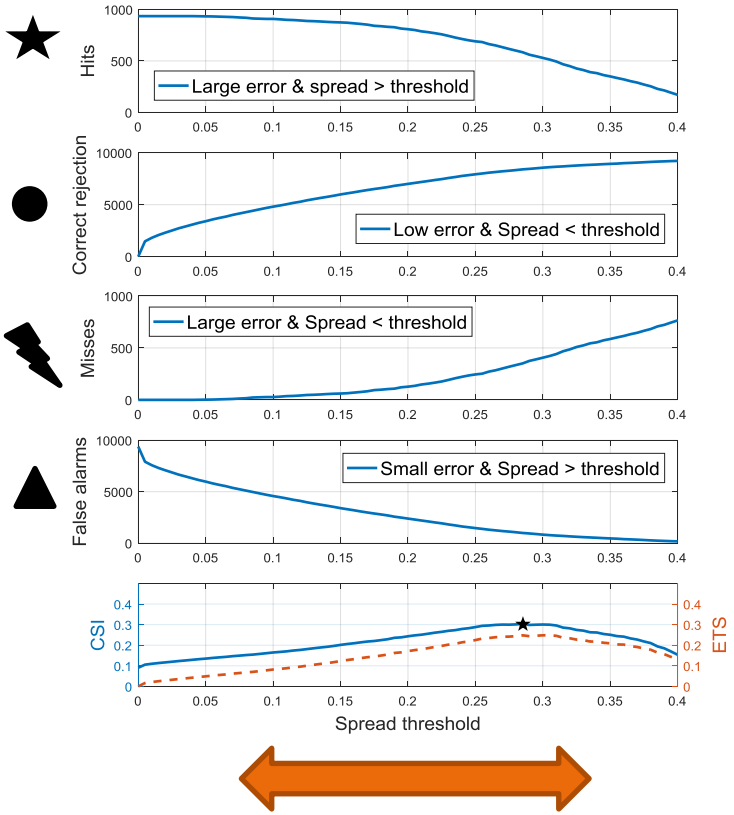
results
optimal warning threshold

- error distribution:



- event frequency



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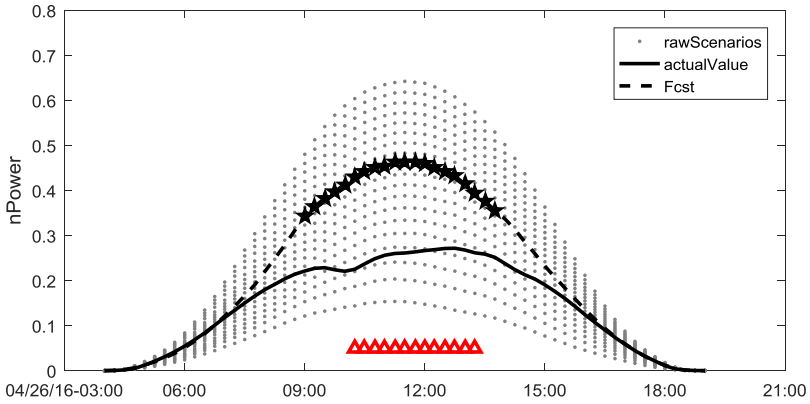
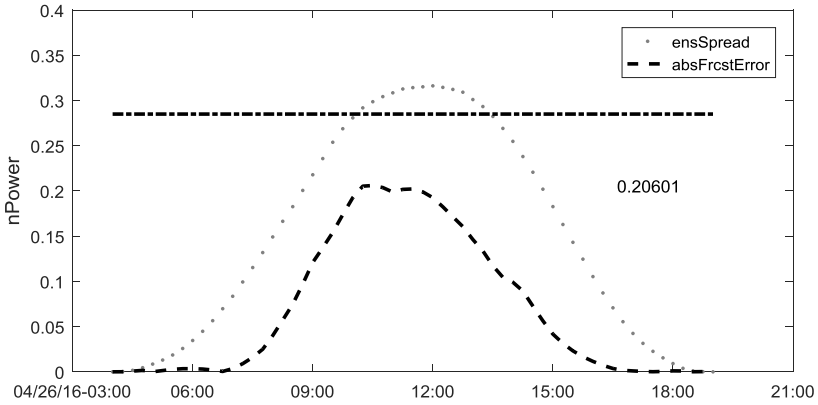
results
example of warning

- example day 26.4.2016
- forecast (- - -) and actual value (---) found within ensemble (. . .)
- warning (spread > threshold) for 10:00-13:30
- final error above limit found in 09:00-13:45





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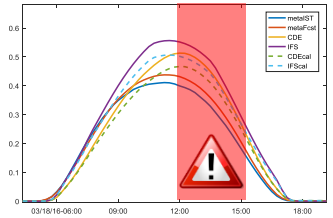
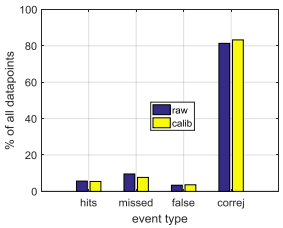
conclusions

- TSOs in need of additional meteorological information
- provided by ensembles like CDE-EPS



- can do straightforward calibration
- classical calibration does not improve event frequencies



- TODOs:
- integration of warning into demo system
- gather more feedback by TSOs

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thank you for your attention

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  - [5] http://www.50hertz.com
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