

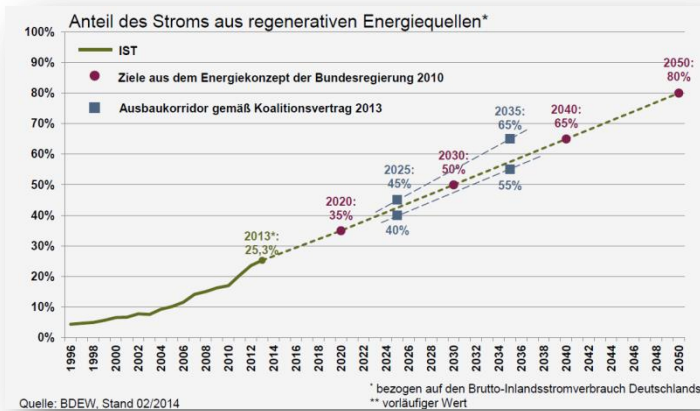
The Renewable Energy Research Projects EWeLiNE and ORKA

A scenic landscape featuring rolling green hills and a dense forest of evergreen trees in the foreground. In the distance, several white wind turbines are visible on the hillsides under a clear blue sky. The overall scene is bright and sunny.

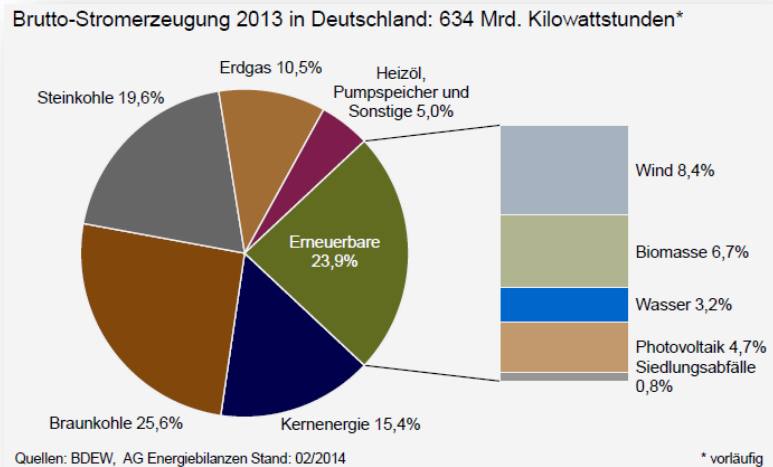
Kristina Lundgren
EWeLiNE & ORKA-Team
Deutscher Wetterdienst, DWD

The German Electricity Supply

→ Increased share of renewables

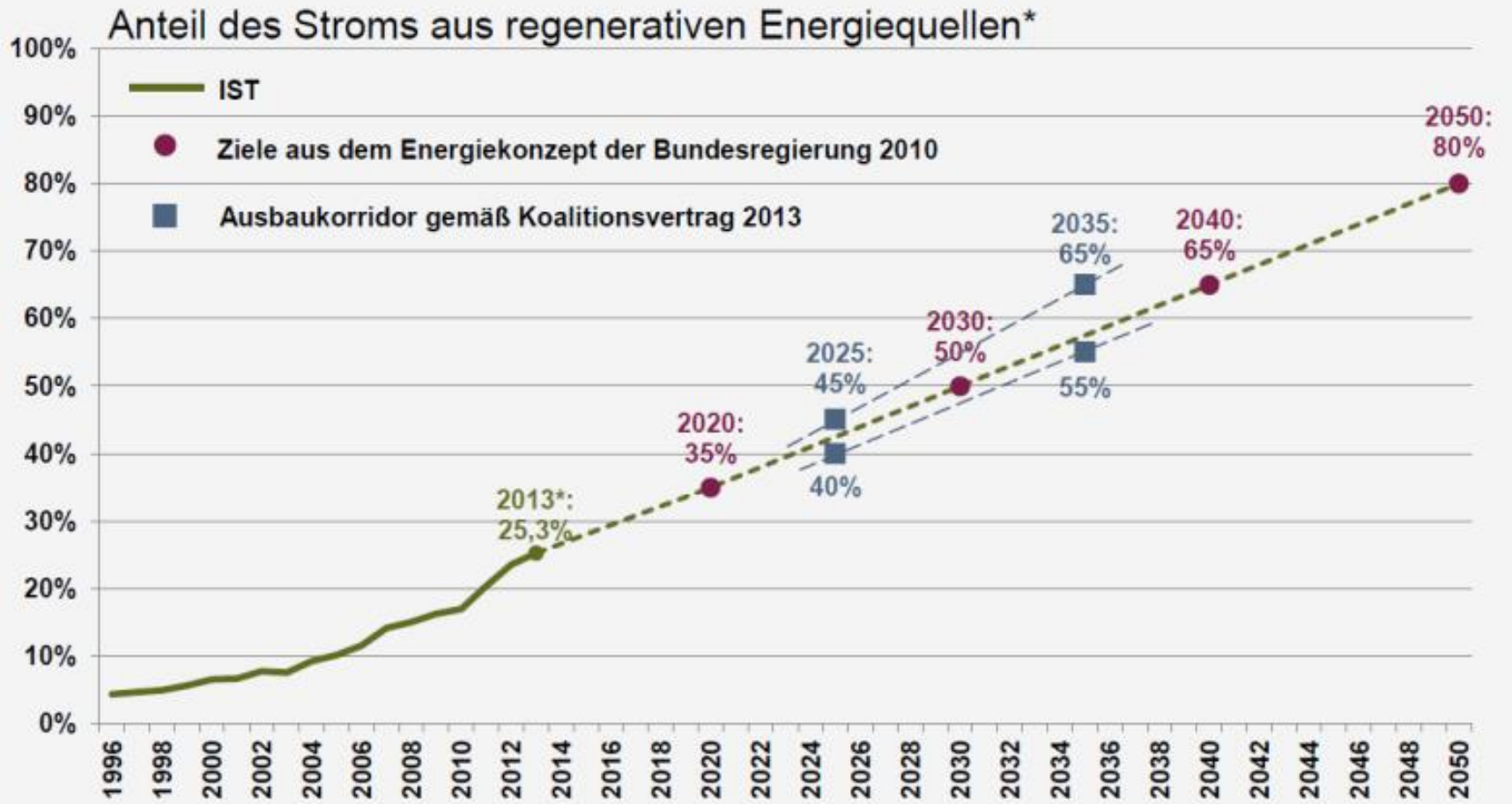


→ Electricity generation in 2013



The German Electricity Supply

→ Increased share of renewables



Quelle: BDEW, Stand 02/2014

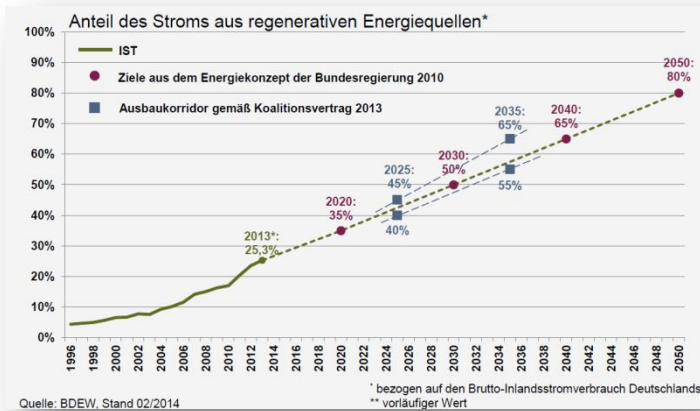
* bezogen auf den Brutto-Inlandsstromverbrauch Deutschlands

** vorläufiger Wert

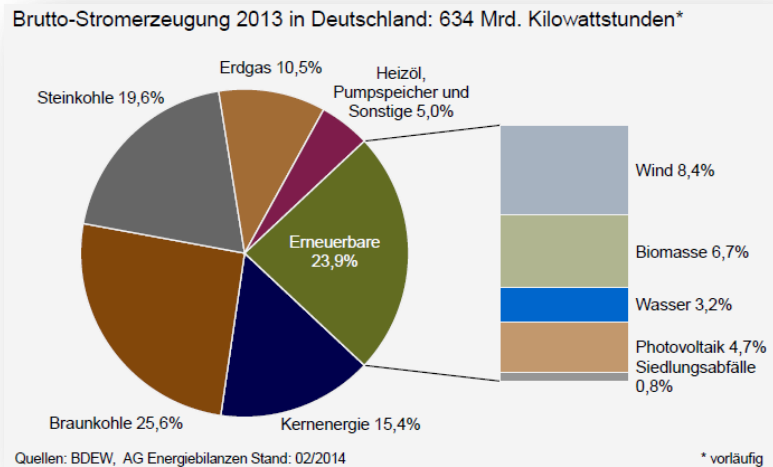


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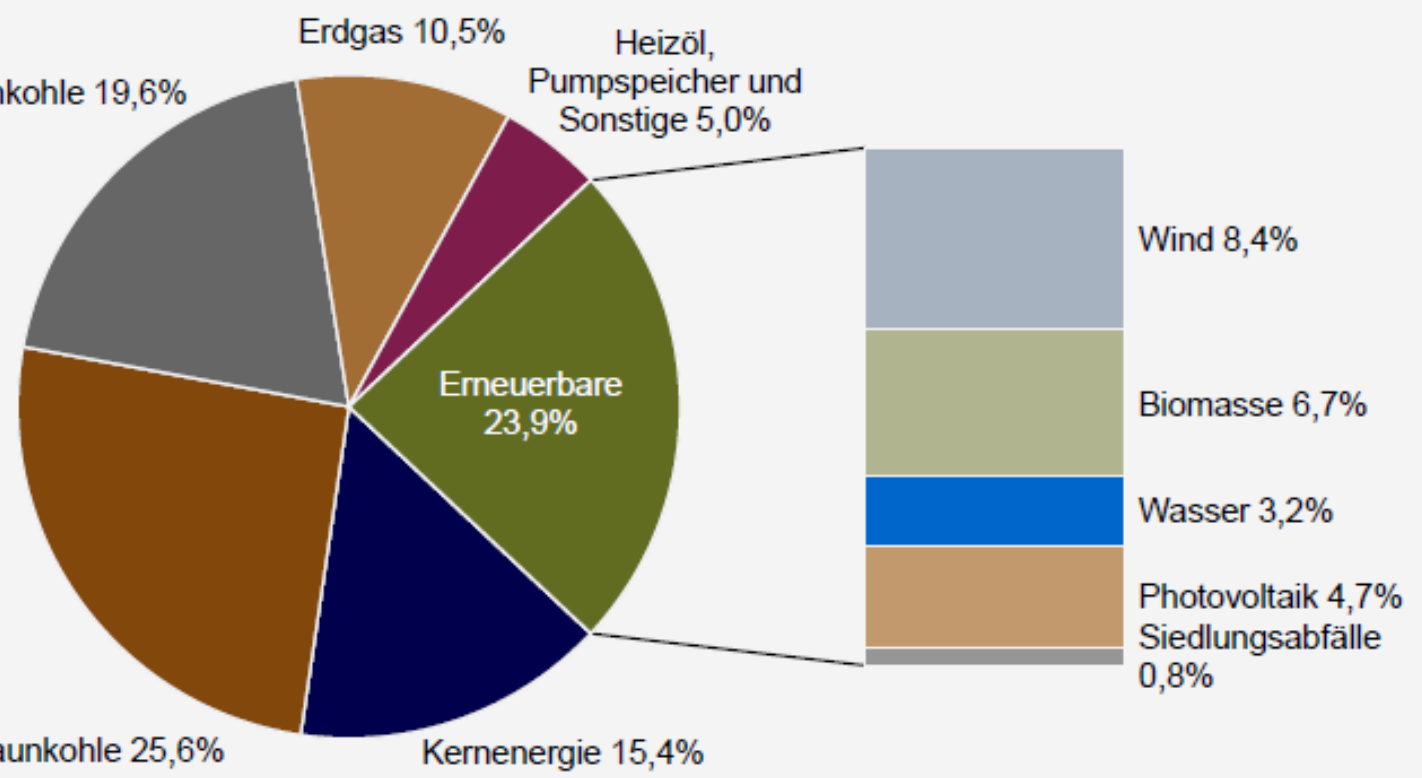
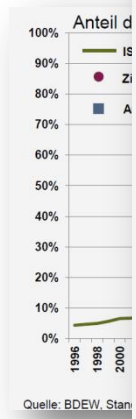
→ Electricity generation in 2013



The German Electricity Supply

→ **Increase**

Brutto-Stromerzeugung 2013 in Deutschland: 634 Mrd. Kilowattstunden*



→ **Electric**

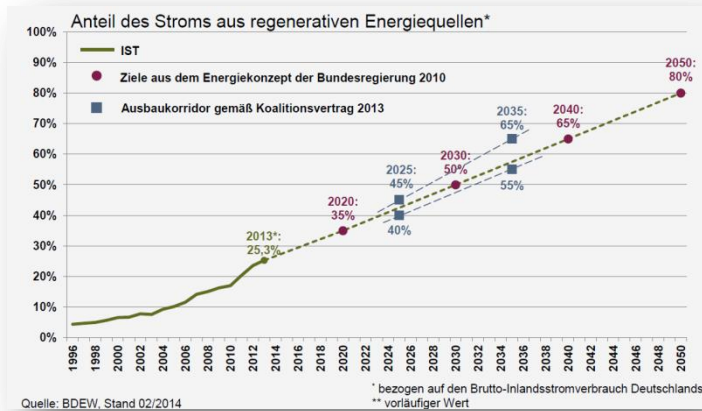
Quellen: BDEW, AG Energiebilanzen Stand: 02/2014

* vorläufig



The German Electricity Supply

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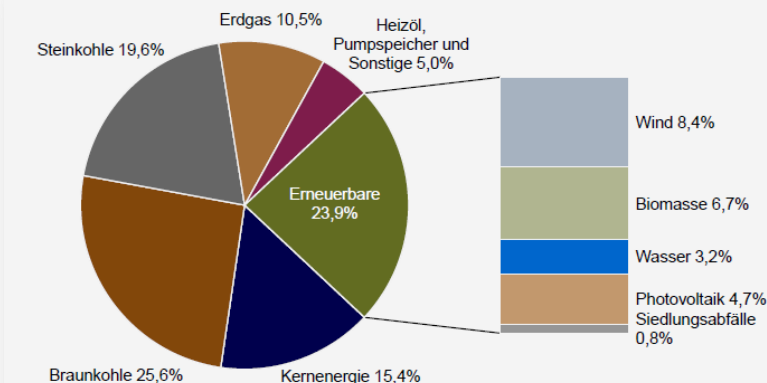


→ Increased share of weather dependent energy sources

- Highly fluctuating energy production
- Electricity is **no more** generated **where** and **when** it is **needed**

→ Electricity generation in 2013

Brutto-Stromerzeugung 2013 in Deutschland: 634 Mrd. Kilowattstunden*



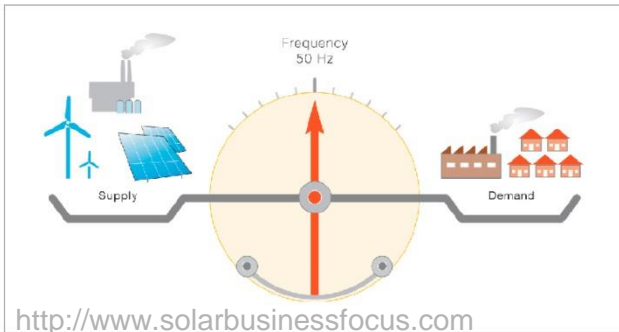
Quellen: BDEW, AG Energiebilanzen Stand: 02/2014

* vorläufig



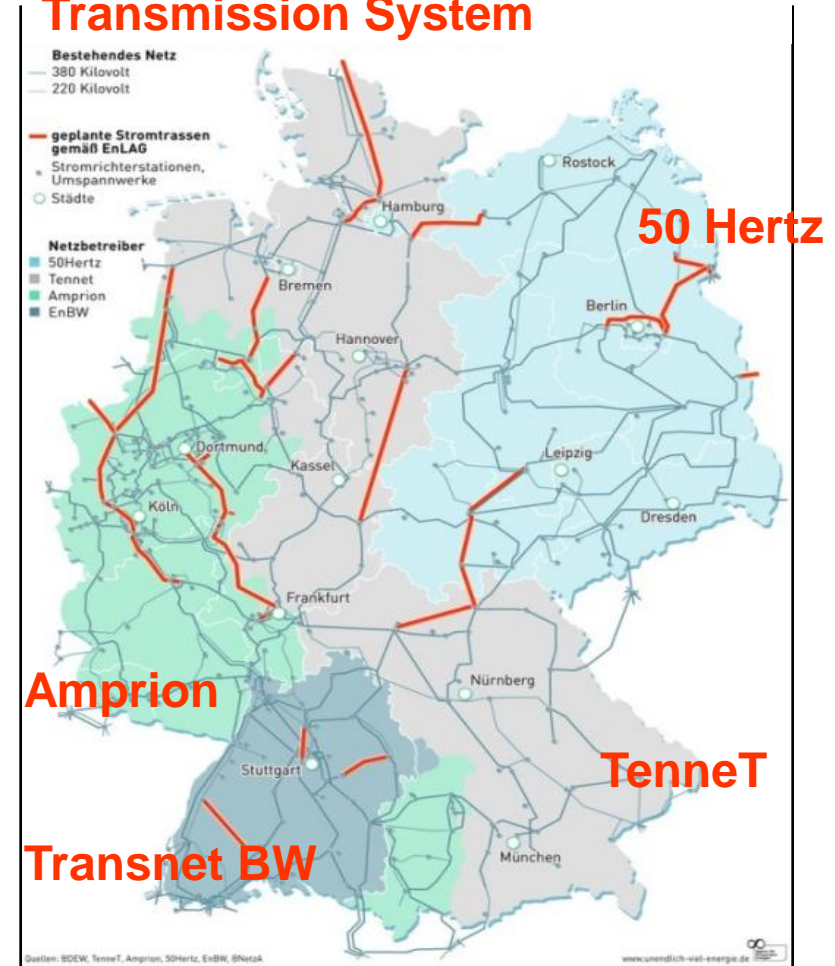
Role of TSOs

- **Transport** of energy using fixed infrastructure
- Manage the **security** and **reliability** of the power system
 - balance between production and consumption at any time
 - stable frequency (50 Hz) and voltage (380/220 kV)



- **Trading** on the power exchange market
- EPEX SPOT**
EUROPEAN POWER EXCHANGE

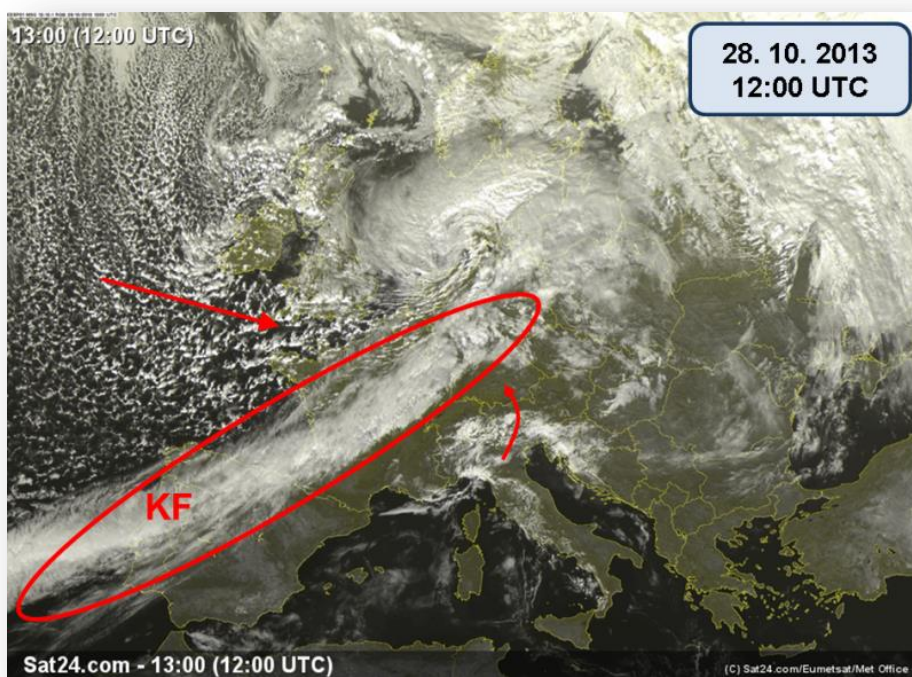
German High-Voltage Transmission System



New Challenges for the TSOs

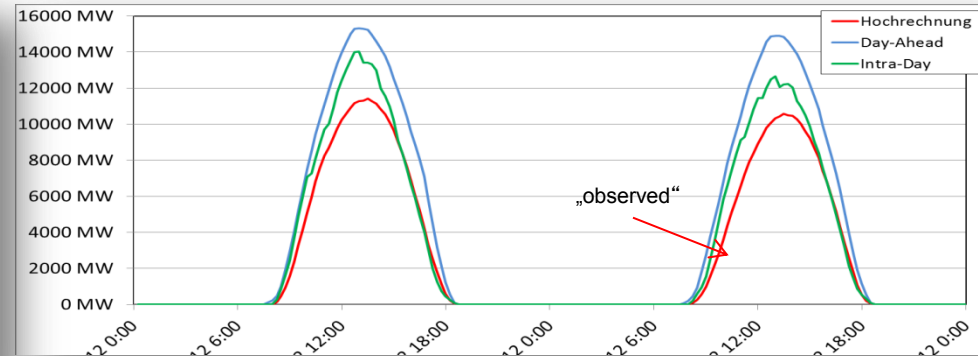
→ Forecast **errors close** to the amount of **control energy** (± 4.5 GW)

A) **Cold front** and **convection**



$\Delta(\text{day-ahead}) \approx 3.3$ GW
 $\Delta(\text{intra-day}) \approx 1.0$ GW

B) **Low stratus clouds**: observed but not predicted



$\Delta(\text{day-ahead}) \approx 4.8$ GW
 $\Delta(\text{intra-day}) \approx 0.5$ GW

New Challenges for the TSOs

→ Forecast **errors close** to the amount of **control energy** (± 4.5 GW)

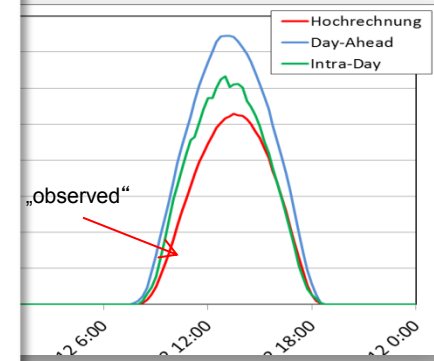
A) **Cold front** and **convection**

B) **Low stratus clouds**: observed but

Improved power predictions are required..

.. These **depend** crucially on the **quality** of the **underlying weather forecasts!**

→ The **research projects EWeLiNE & ORKA**



4.8 GW
0.5 GW

$\Delta(\text{day-ahead}) \approx 3.3$ GW
 $\Delta(\text{intra-day}) \approx 1.0$ GW

Energy Meteorology Projects at DWD



Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety



EWeLiNE 12/2012-11/2016



23 Researchers (10 IWES + 13 DWD)

→ **Focus: improved day ahead forecasts** for renewable energies

→ **Research topics:**

- **Improved initial conditions** by applying new data types (data assimilation)
- More accurate forecasts by **optimizing the model physics**
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- **Optimized Model Output Statistics**

→ **Integration of new products in decision making processes!**



ORKA 8/2012-7/2015



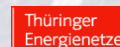
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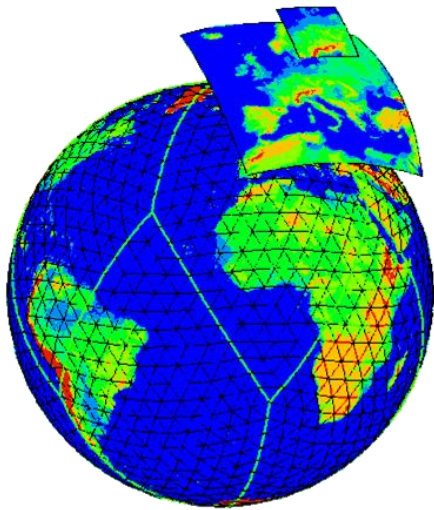
- **Optimized ensemble forecasts** for renewable energies
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→ **Iterative cycle of evaluation and test results**

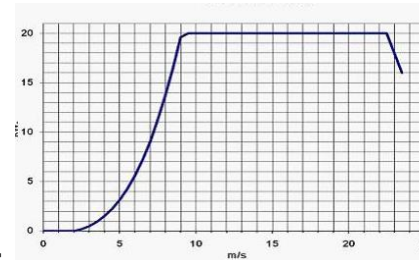
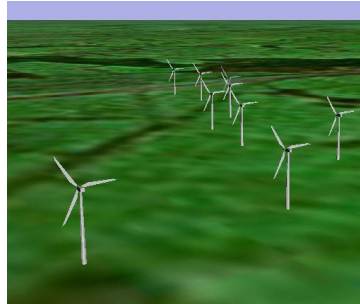


The research project EWeLiNE

Weather forecasts
(wind, radiation fluxes,...)

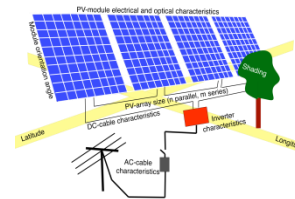


Post-processing Transformation in power

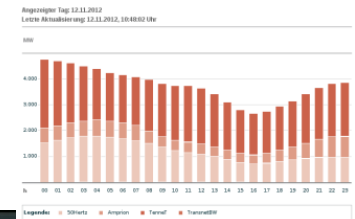


Taking into account effects of e.g.:

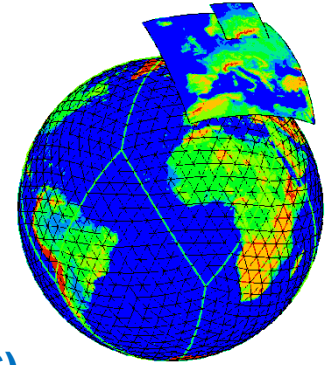
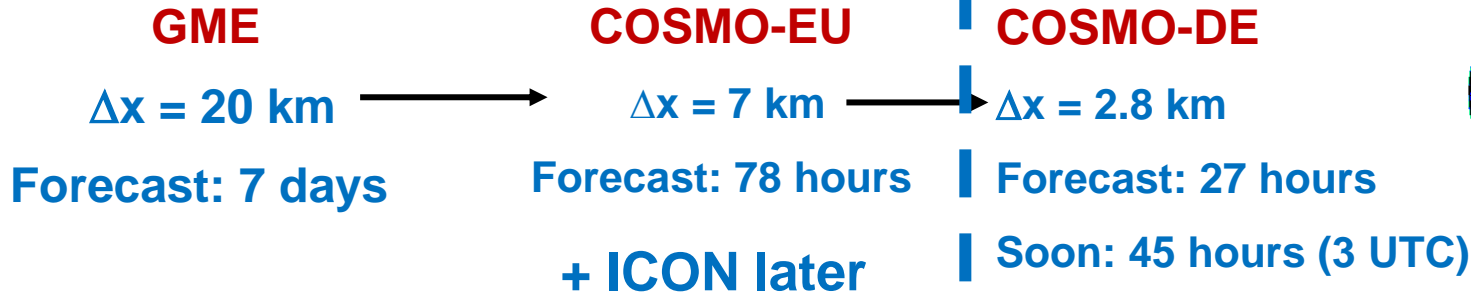
- atmospheric stability
 - orography
 - wakes



Power forecasts for decision making processes

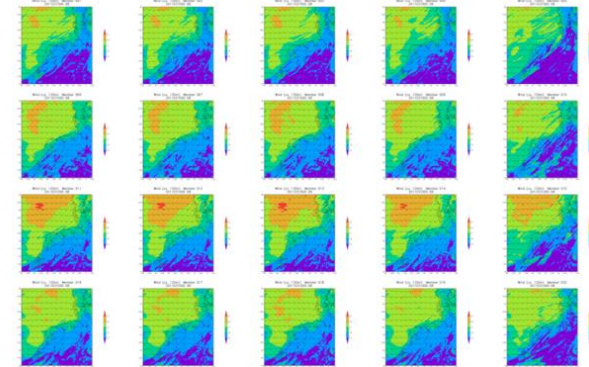
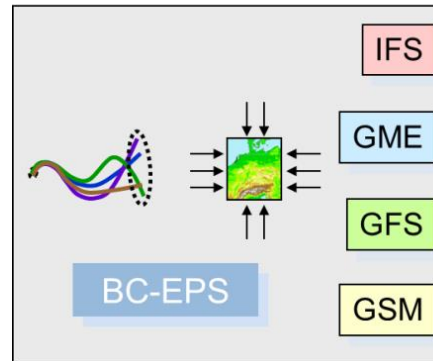


Deterministic:



Probabilistic:

COSMO-DE-EPS
 $\Delta x = 2.8 \text{ km}$
20 ensemble members
Forecast 27 hours
Soon: 45 hours (3 UTC)



Energy Meteorology Projects at DWD

EWeLiNE 12/2012-11/2016



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ORKA 8/2012-7/2015



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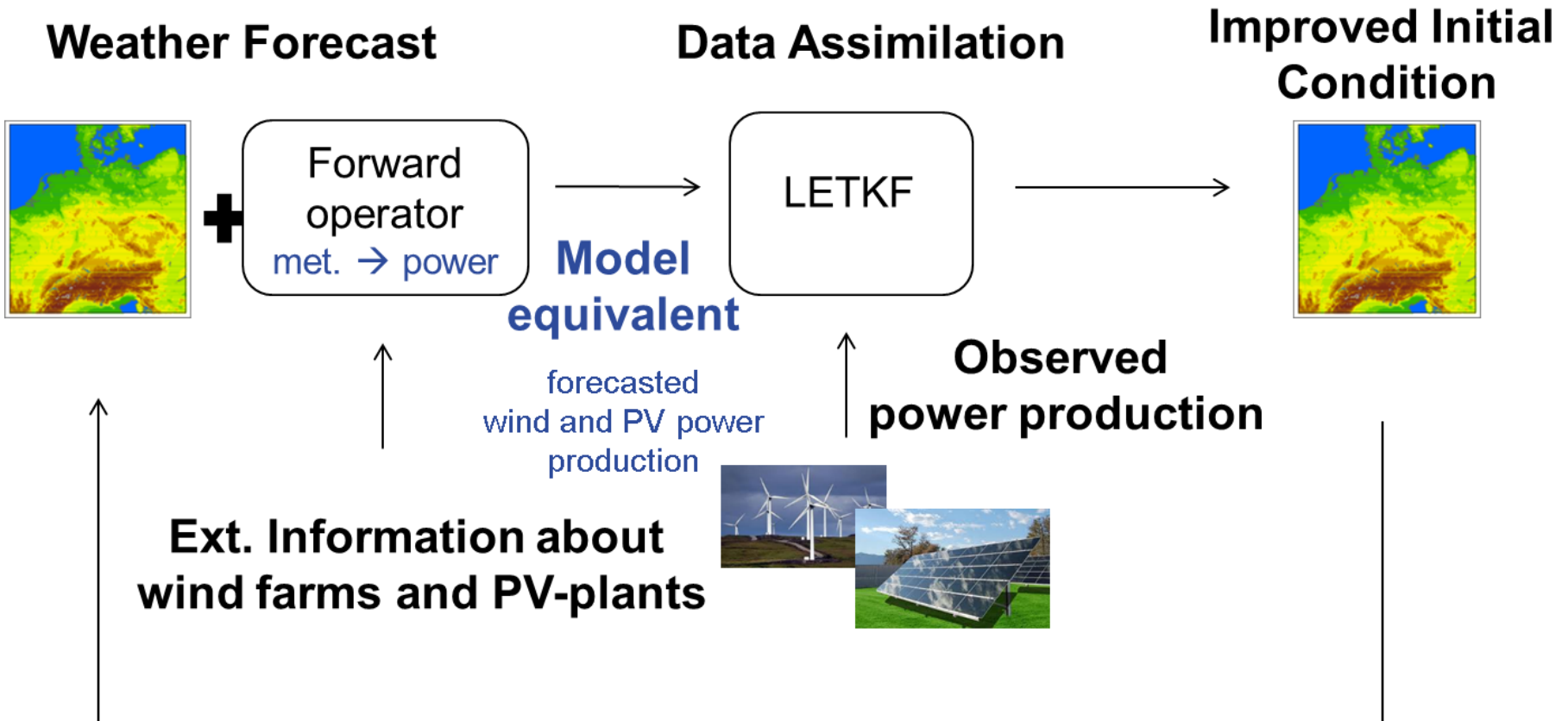
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→ **Iterative cycle of evaluation and test results**



Assimilation of Power Data



*Poster Declair et al.
On Tuesday*

LETKF=Local Ensemble Transform Kalman Filter



Energy Meteorology Projects at DWD

EWeLiNE 12/2012-11/2016



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→ Focus: improved day ahead forecasts for renewable energies

→ Research topics:

- Improved initial conditions by

Next talk in this session



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ORKA 8/2012-7/2015



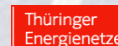
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Energy Meteorology Projects at DWD

EWeLiNE 12/2012-11/2016



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ORKA 8/2012-7/2015



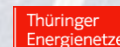
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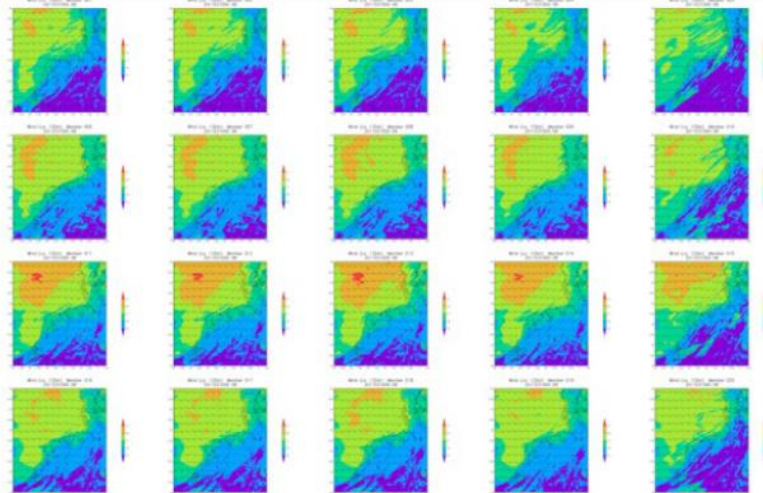
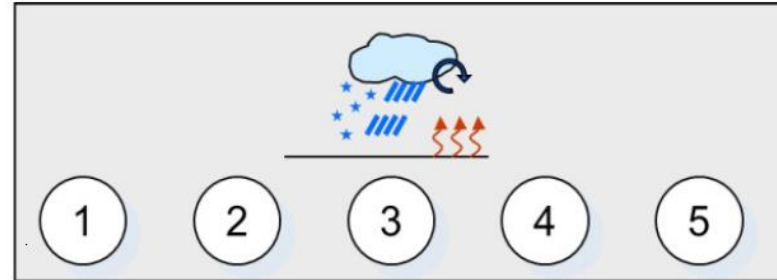
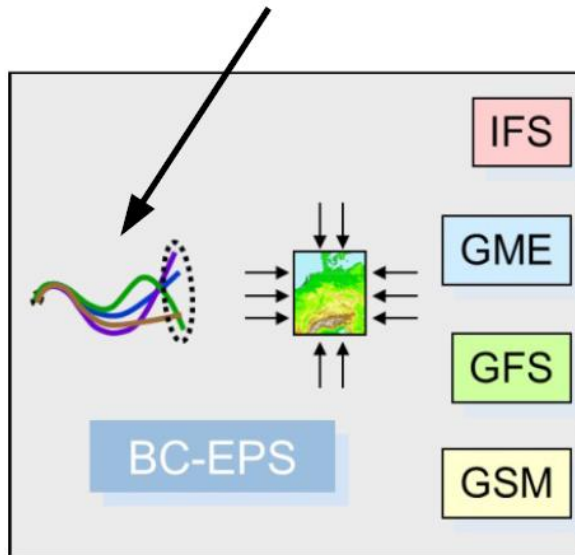
➔ **Iterative cycle of evaluation and test results**



Improved Ensemble Generation

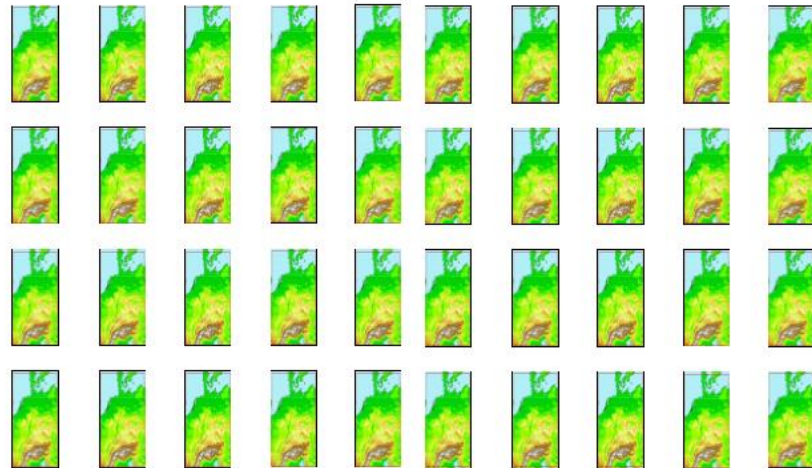
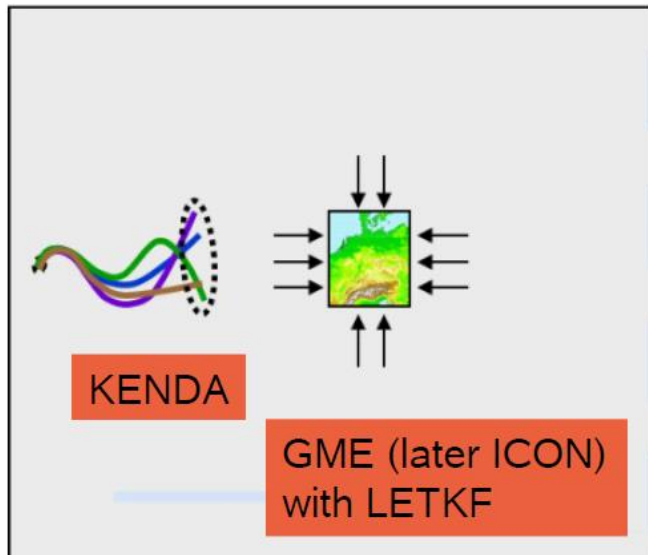
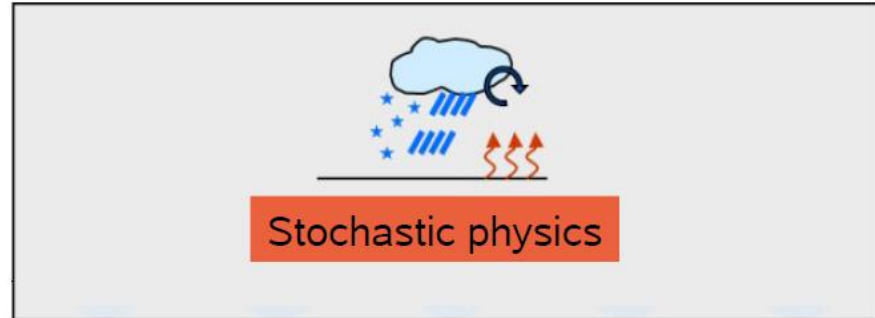
Initial conditions:

$$f_0 = f_{Det.An.} + W(z)(f_{BCEPS} - f_{ref})$$



Improved Ensemble Generation

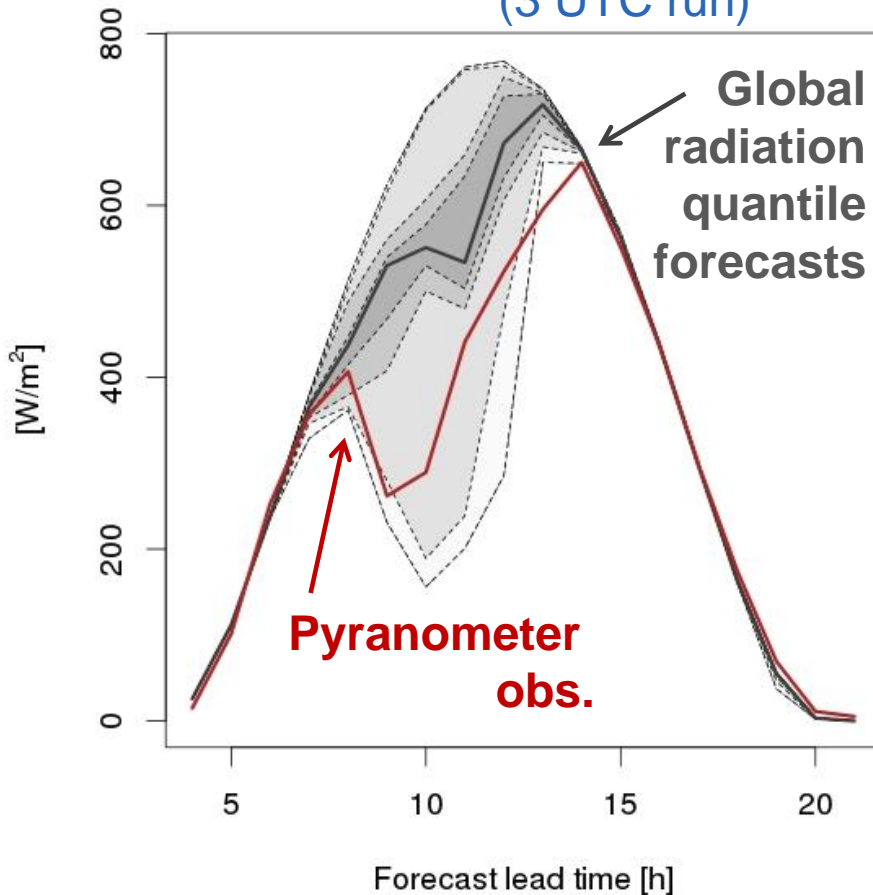
→ These can be combined with the current methods



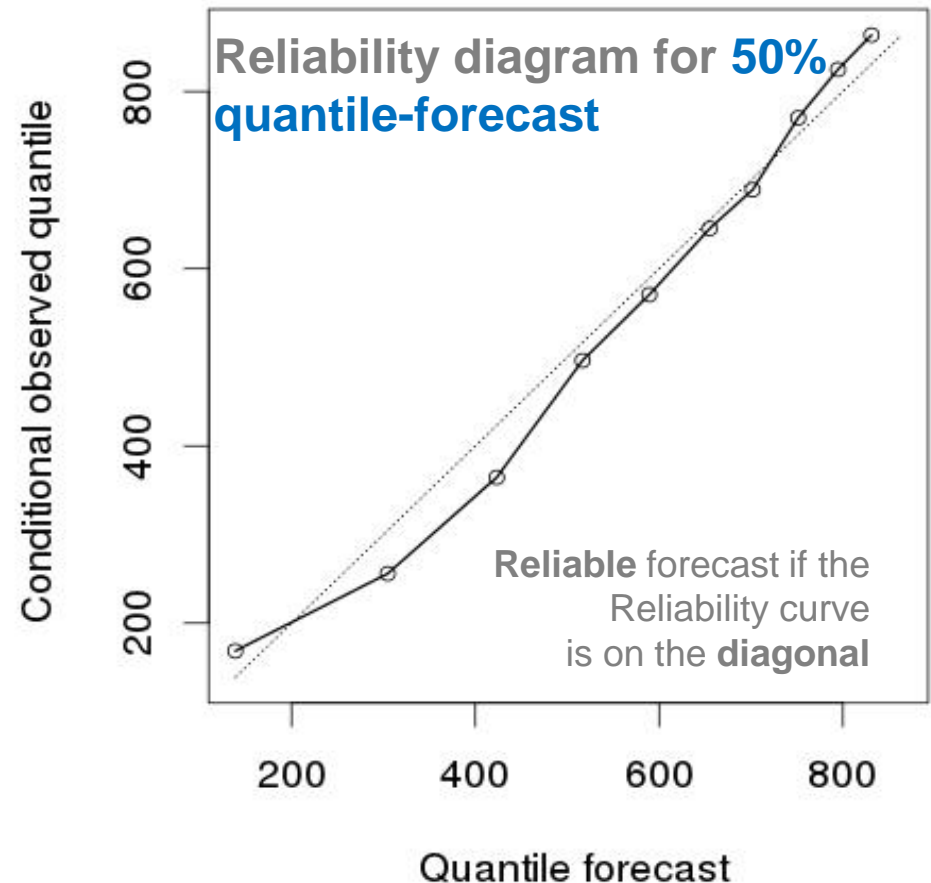
Verification of COSMO-DE-EPS

→ New verification package: CDE-EPS vs. wind tower measurements and pyranometer data

→ Example: “Arkona”, July 2 2013
(3 UTC run)



→ Example: Germany, July to September 2013 (3 UTC run)

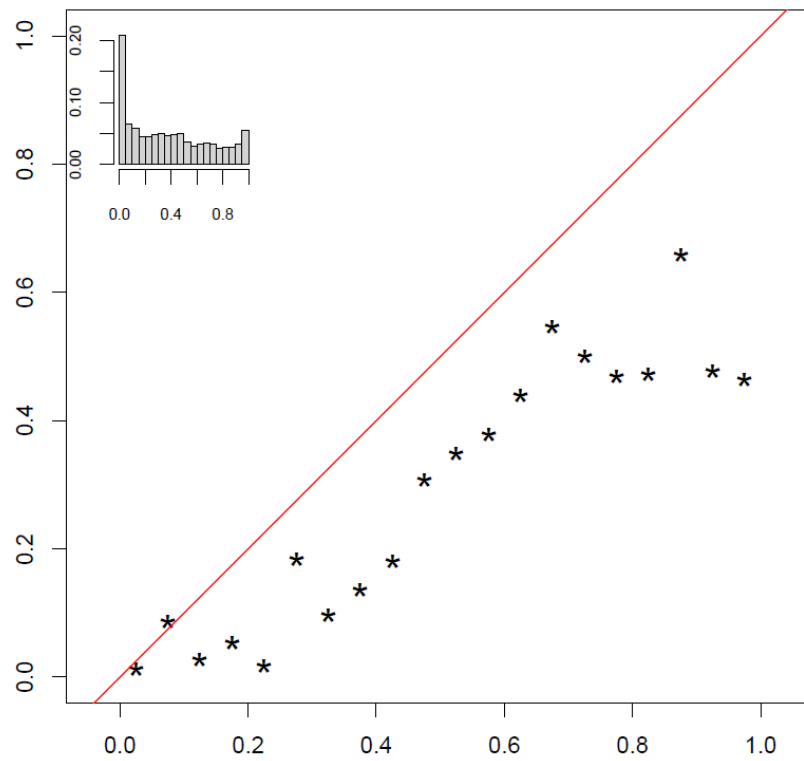


→ Technique: Ensemble Model Output Statistics
for wind vectors (Schuhen et al., 2012)

→ Example: Meridional wind at 100 m, Karlsruhe, 01.05. - 30.06.2013

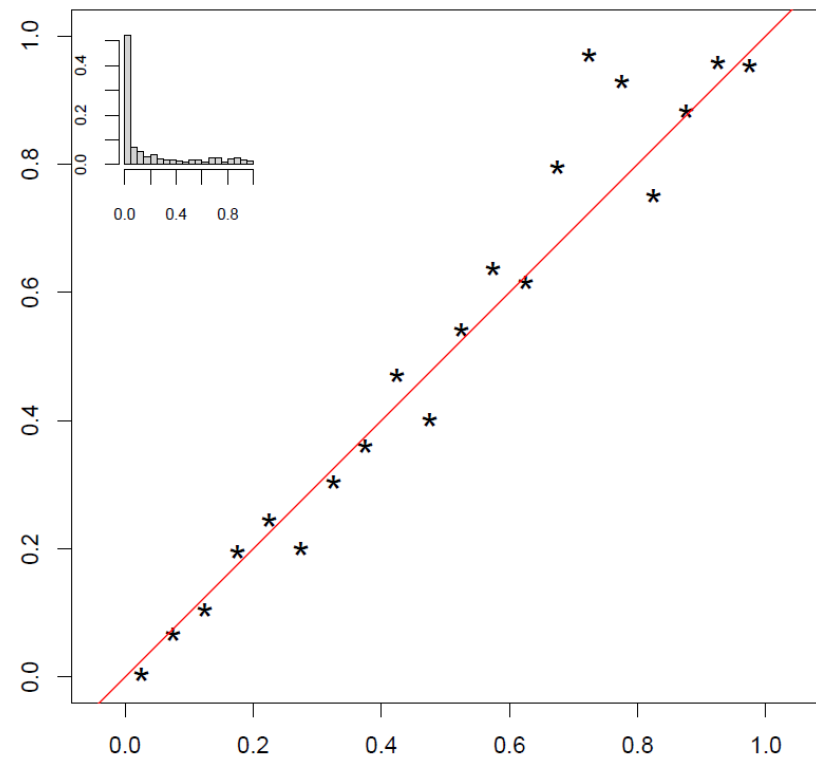
Reliability diagram, vector V, station Karlsruhe

Raw ensemble



Binned Probability
Threshold -1

Calibrated forecast



Binned Probability
Threshold -1

Energy Meteorology Projects at DWD

EWeLiNE 12/2012-11/2016



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ORKA 8/2012-7/2015



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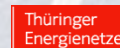
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Improved IC-Perturbations (ORKA)

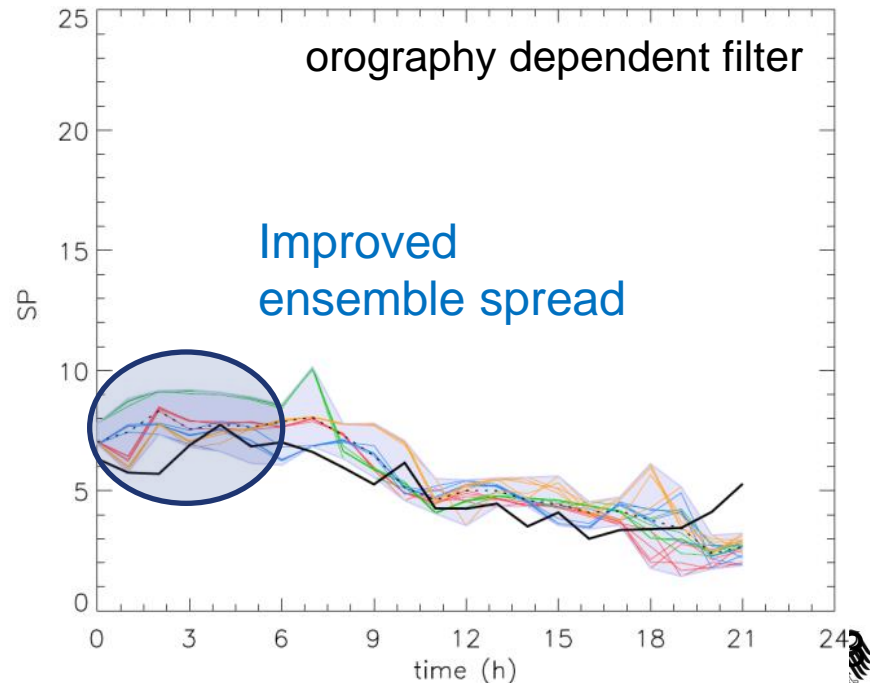
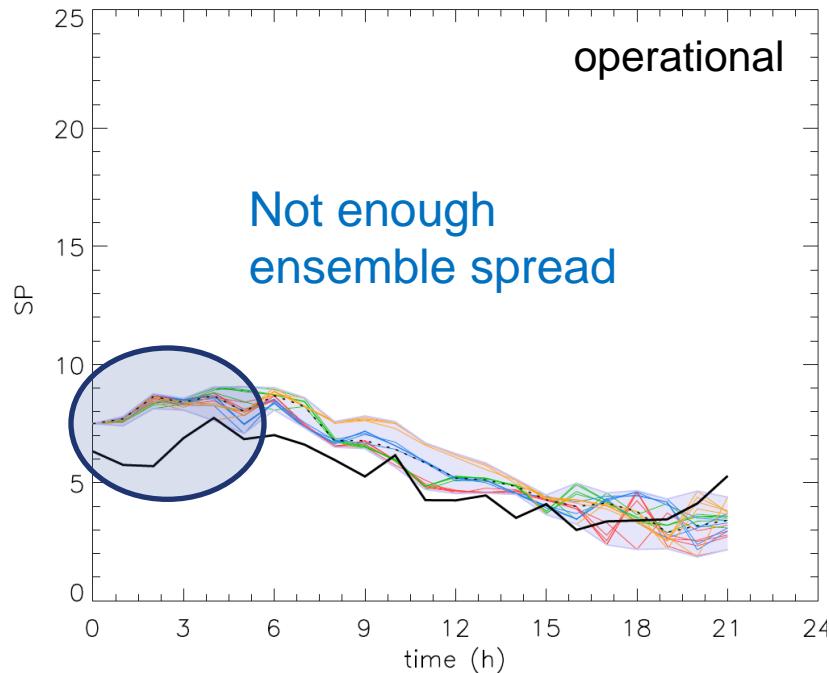
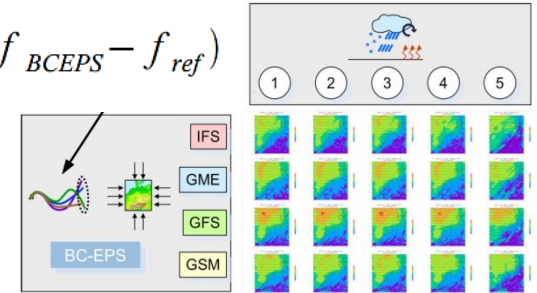
→ **Operational vertical filter:** no perturbations in the Boundary Layer

→ **„Optimized“ vertical filter:** function of the orographic variance

→ **Example:** Wind speed at 98 m, 02.03.2012, Lindenberg

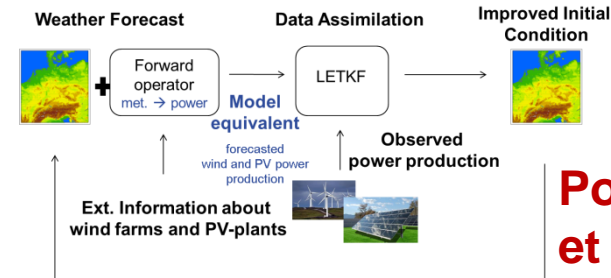
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Improved weather forecasts for energy applications – summary

→ Applying new data types (power production data, satellite data, ...) to improve the **initial conditions**



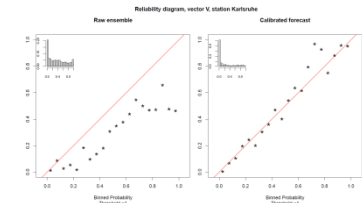
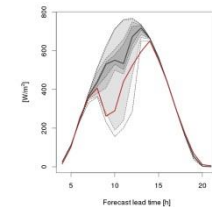
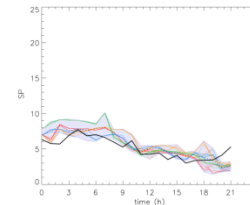
Poster Declair et al. tomorrow

→ Optimize model physics (**next Talk!**)

→ Verification of e.g., global radiation, wind speed at 100m

→ Improved ensemble generation

→ Adapt post-processing methods to user requirements



Strengthen the dialog with users!

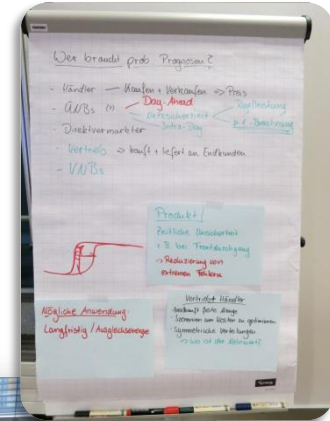
Deutscher Wetterdienst
Wetter und Klima aus einer Hand



→ Understand the user requirements and needs



EWeLiNE "Industrie- und Forschungsplattform Prognose"



EWeLiNE



Thanks for listening!

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



Visit us at www.projekt-eweline.de



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Andrea Steiner

Andreas Röpnack

Gernot Vogt

