Hans-Ertel-Zentrum
für Wetterforschung

„Climate Monitoring and Diagnostics (Cologne/Bonn)"

Estimating the benefit of assimilating remote sensing profilers for sustainable energy applications

subproject A02

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Motivation

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- Renewable energy requires skillful short-term forecast
- Assimilation of new observation types could help
- Ground-based observations are potentially valuable for data assimilation

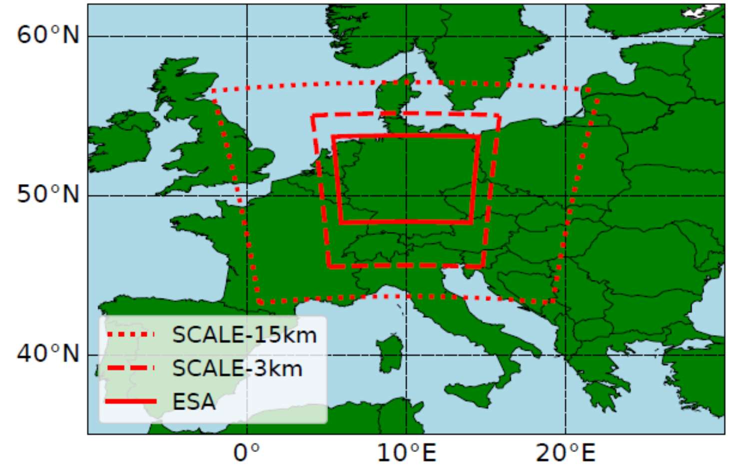
Research questions

- How much can specific ground-based remote sensing instruments improve short-term forecast (e.g. cloudiness and low level wind)?
- How dense should the station network be to get an optimal improvements of short-term forecasts?

Method: Estimate a variance reduction based on ensemble sensitivity analysis

Model data

- SCALE-RM output over Germany
- Convective-scale 1000-member ensemble (Necker et al, 2020) (focus over Germany, 3 km)



Necker et al., 2020

Simulated observations:

- Wind profiles from hypothetical observations of Doppler lidar

https://w3.windfair.net/wind-energy/product/403-windcube-v2

- MWR brightness temperatures

Calculate variance reduction:

$$\delta\sigma^2 = \delta\mathbf{J} * [\delta\mathbf{x}]^T * \mathbf{B}^{+} * (\mathbf{B}' - \mathbf{B}) * \mathbf{B}^{+} * \delta\mathbf{x} * [\delta\mathbf{J}]^T ,$$

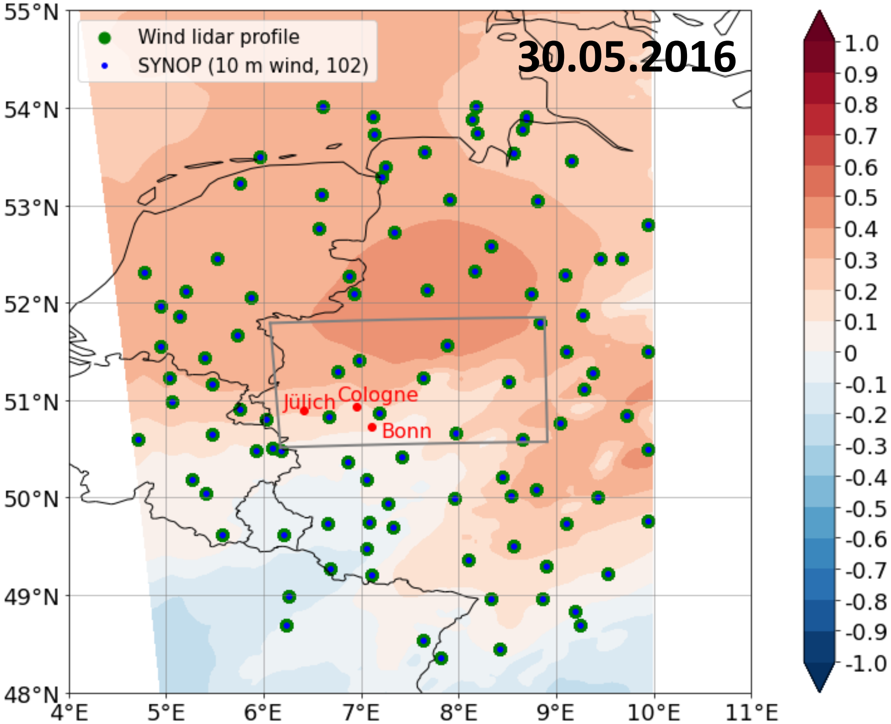
where $\mathbf{J}$ – forecast metric, $\mathbf{x}$ - state vector of initial conditions,
$\mathbf{B}$ - state covariance matrix, **+** denotes pseudoinverse matrix,
$\mathbf{B}'$ - covariance matrix updated using hypothetical observations

Experimental setup based on SCALE-RM 1000 ensemble

Potential wind lidar network to improve 3-hour forecasted low-level wind:

$$\delta\sigma^2 = \delta\mathbf{J} * [\delta\mathbf{x}]^T * \mathbf{B}^{+} * (\mathbf{B}' - \mathbf{B}) * \mathbf{B}^{+} * \delta\mathbf{x} * [\delta\mathbf{J}]^T$$

Correlation between domain-averaged wind speed at 80 m (17 UTC) and wind at 2845 m (14 UTC)



1) **How much can we reduce the uncertainty of short-term wind forecast inside the rectangle by adding wind profile observations?**

2)Goal: 80 m wind speed over RRA **(typical hub-height of wind turbines)**
Forecast 3 hour (17 UTC)

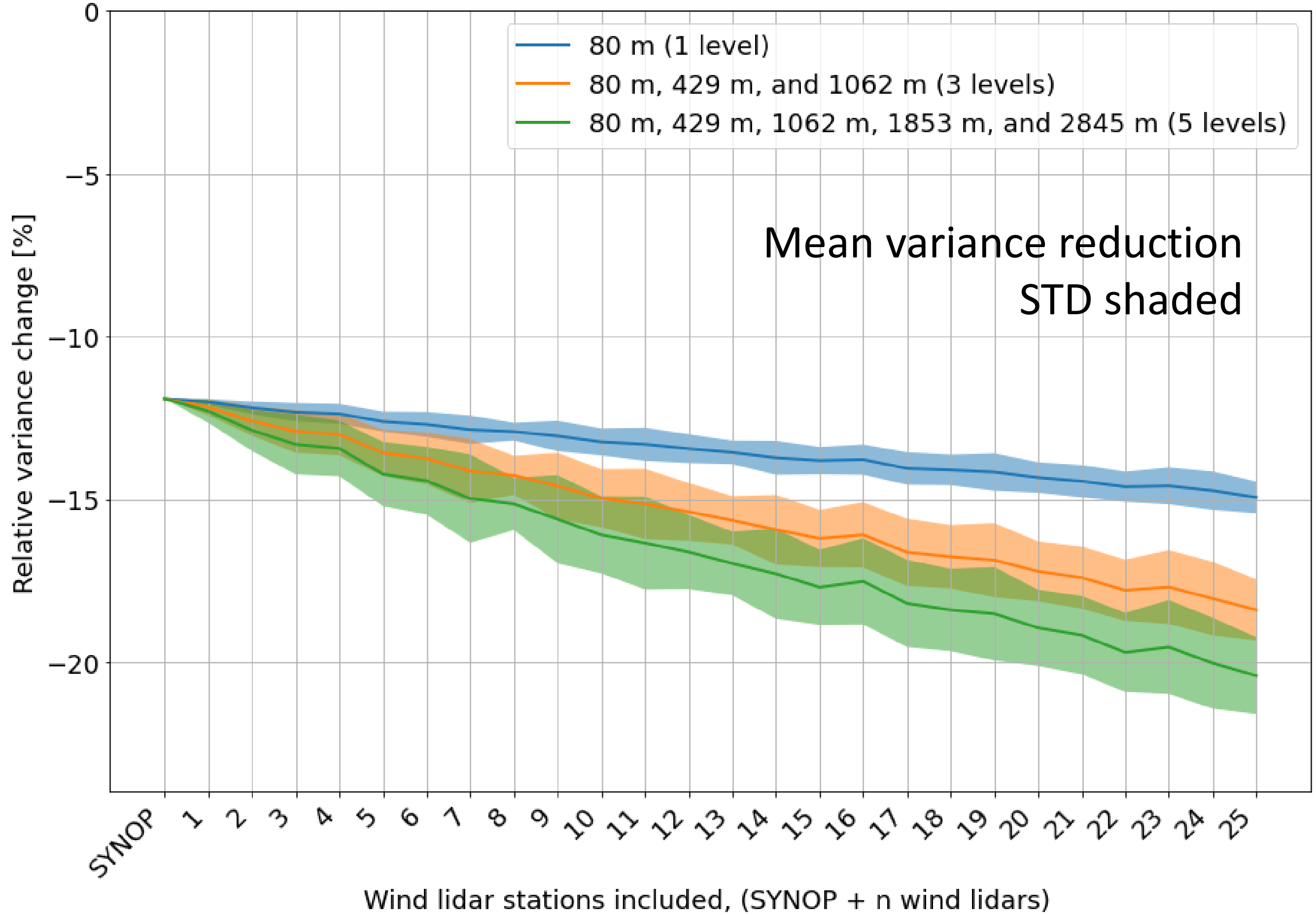
3) Incorporated observations:

- **wind speed at 10 m** (**102** SYNOP stations)
- **wind speed profiles** (up to **25 random stations** assimilated)
- **1 to 5 levels** included: **80, 429, 1062, 1853, 2845 m**
- **50 repetitions** (random choice of stations)

Preliminary results

Potential wind lidar observations:

25 stations assimilated randomly,
50 repetitions (random choice of stations)



- SYNOP 102 stations (10 m wind) reduce wind forecast variance by **12%**
- SYNOP + 25 additional wind lidars up to **22%**
- An additional relative change in variance reduction due to the incorporated wind lidar profiles ranges from **2%** to **10%** depending on different wind lidar ranges, influenced by ABL conditions