Spatial evaluation of high-resolution wind fields from empirical and dynamical modeling in hilly and mountainous terrain

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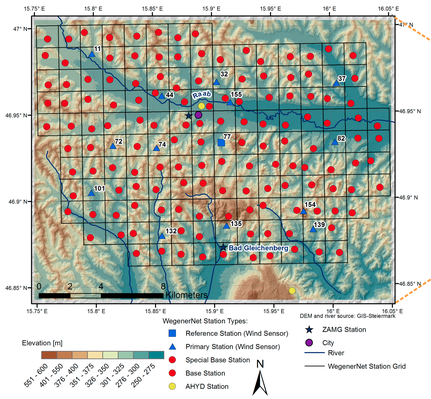
Photography encouraged

EGU 2019 - X5.115

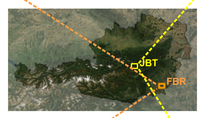
Study regions

WegenerNet Feldbach Region (FBR) - hilly terrain

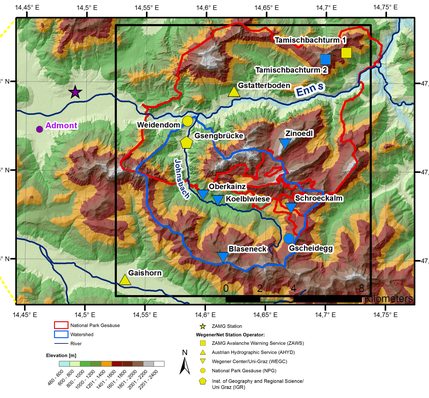
- 155 meteorological stations (including 13 wind stations; blue symbols) within 22 km x 16 km area (1 station / ~2 km^2)
- Hilly terrain, altitudes from 250 m to 600 m
- Main parameters: air temperature, relative humidity, precipitation, and wind
- 5 min sampling, data available since 2007
- Automatic processing system (data transfer, quality control, generation of weather and climate data products)
- Wind fields generated at 100 m x 100 m resolution
- Interpolated gridded data for T, q, precip (200 m x 200 m UTM)
- Processed data provided at data portal (www.wegenernet.org)



Location of study areas in Austria



WegenerNet Johnsbachtal (JBT) - mountainous terrain



- 11 meteorological stations (plus 1 hydrographic station) within 16 km x 17 km area
- Mountainous terrain, altitudes ranging from below 700 m to over 2100 m
- Main parameters: air temperature, relative humidity, precipitation, wind, radiation, and snow depth
- Wind measured at 7 stations (blue symbols)
- 10 minute sampling
- Automatic processing system
- Wind fields generated at 100 m x 100 m resolution
- Quality controlled data provided at data portal (www.wegenernet.org)
- Data available partly since October 2010, partly since January 2007

Evaluation of models

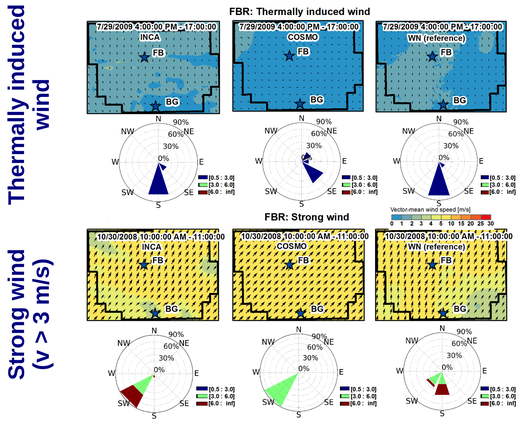
CALMET / WPG (100 m x 100 m, 30 min) :
WegenerNet Wind Product Generator (WPG, also WN in some plots) using diagnostic CALMET model, WegenerNet station data (see study regions, left panel), and auxiliary data.
(Schlager et al. 2017, 2018a, 2018b)

INCA: (1 km x 1 km, 1 h):
Wind field analyses, using NWP (ALARO) model as first guess + ZAMG wind station data.
(Haiden et al., 2011)

COSMO CLM: (3 km x 3 km, 1 h):
Regional climate model data, available from 2008 - 2010, using COSMO CLM version 5.0.
(Schättler et al., 2016)

Case studies

FBR wind field results and examples

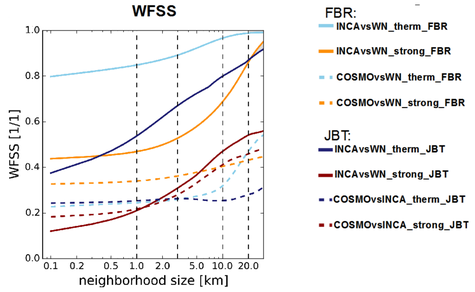


Wind Fractions Skill Score (WSFF)

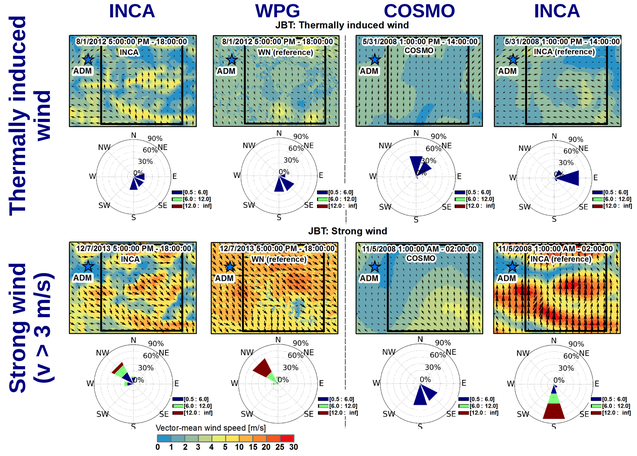
The WFSS takes into account differences in structure, location, amplitude and direction between models in a combined form (highest skill = 1).

$$FSS_{wind} = 1 - \frac{\sum_k \sum_{i,j} [O_k(i,j) - M_k(i,j)]^2}{\sum_k \sum_{i,j} O_k(i,j)^2 + \sum_{i,j} M_k(i,j)^2}$$ (Skok and Hladnik, 2018)

O_k : fraction values for observations for wind class k at location i,j;
M_k : fraction values for forecasts for wind class k at location i,j



JBT wind field results and examples



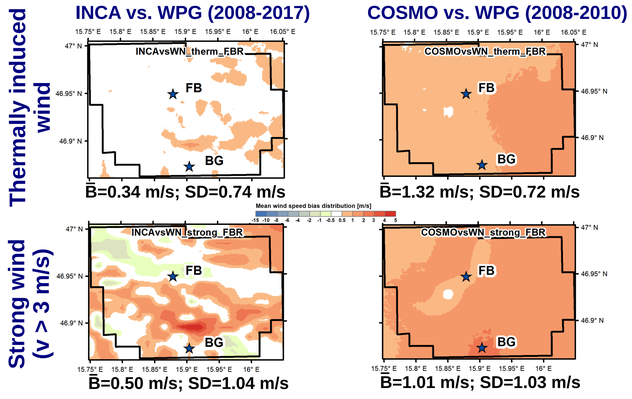
Key results (case studies)

FBR (hilly terrain):
- Reasonably good agreement of INCA and WPG
- Wind direction bias visible in COSMO for thermally induced wind case.
- Strong wind is modeled too homogeneous in COSMO. COSMO generally shows lower skill than INCA.

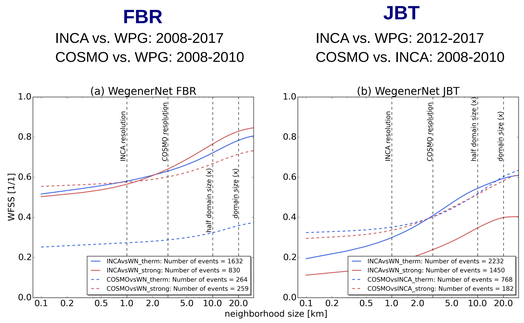
JBT (mountainous terrain):
- COSMO does not resolve orography and therefore has strong biases in direction (for thermally induced wind case) and speed (for strong wind case).
- INCA models too high wind speed at higher elevations for thermally induced wind case.
- Strong wind case shows large differences in valley wind speeds between INCA and WPG, especially in Enns valley where WPG seems to overestimate wind speed. INCA seems to underestimate valley speed due to influence of Admont station.
- Poor skill score for both COSMO and INCA.

Climatological studies

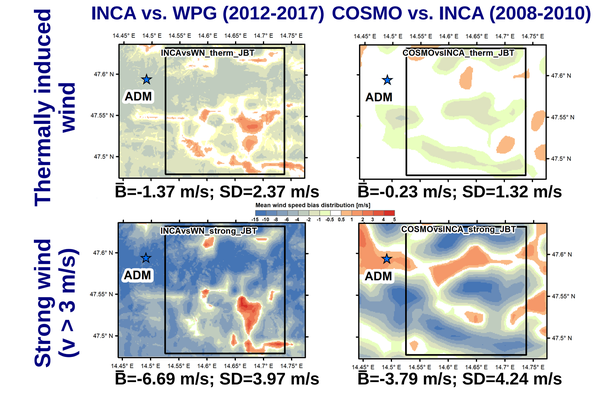
FBR mean wind speed bias distribution



Climatological WFSS



JBT mean wind speed bias distribution



Key results (climatol. studies)

FBR (hilly terrain):
- **BIAS:** Good performance of INCA for thermally induced wind; some bias visible for strong wind. Systematic overestimation (~1 m/s) of COSMO for both thermally induced and strong wind.
- **Skill score:** Moderate skill for INCA and COSMO, except COSMO for thermally induced wind, where skill is low.

JBT (mountainous terrain):
- **BIAS:** Big differences between INCA and WPG for strong wind (mean bias ~6.7 m/s) due to underestimation of INCA and overestimation of WPG in the valleys. Mountaintop speed has some artifacts.
- COSMO shows good performance for thermally induced wind but has large bias and standard deviation for strong wind.
- **Skill score:** Poor skill score for both COSMO and INCA.
- *COSMO CLM should be compared to CALMET / WPG model for further conclusions.*

References:

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Further information, data access and references:
www.wegenernet.org
www.wegcenter.at/wegenernet