Evaluation of 3 mainstream weather forecast models with IJmuiden observations at the North Sea

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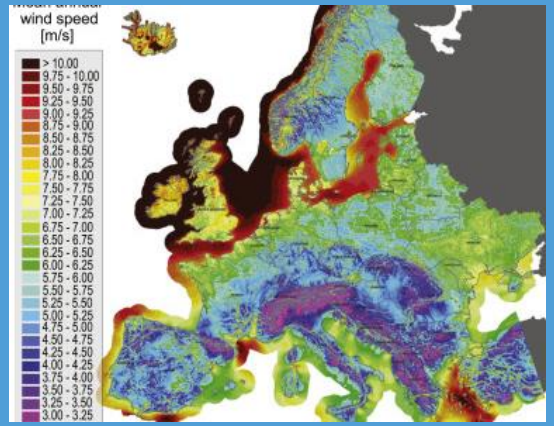
Presentation at Seminar National Doctoral College in Offshore Renewable Energy,
TU Delft, March 2, 2018

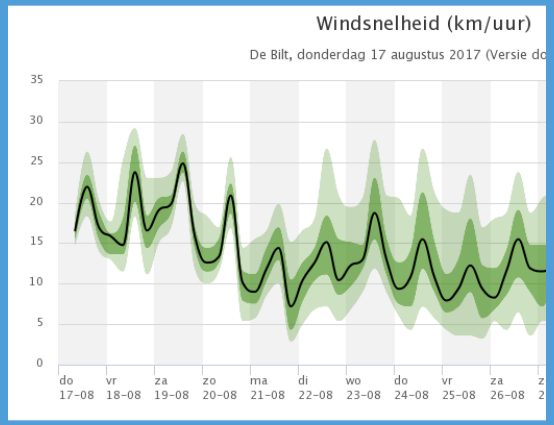
Use of (mesoscale) weather forecast models

Among others:



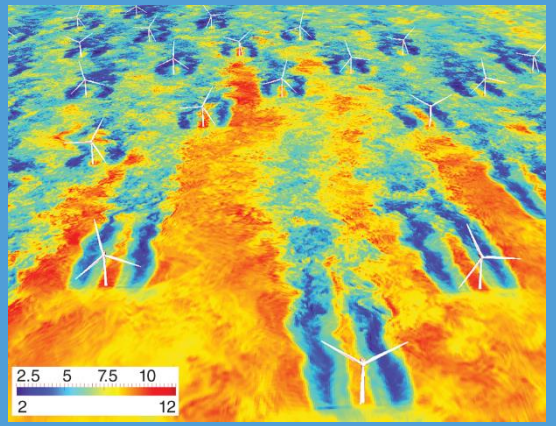
Resource assessment

Rodrigues et al., 2015



(Power) forecasting

e.g. Foley et al., 2012



Realistic inflow fields

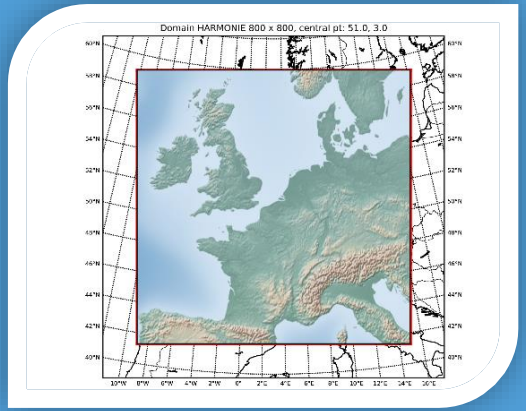
Sanz Rodrigo et al., 2017

Research questions

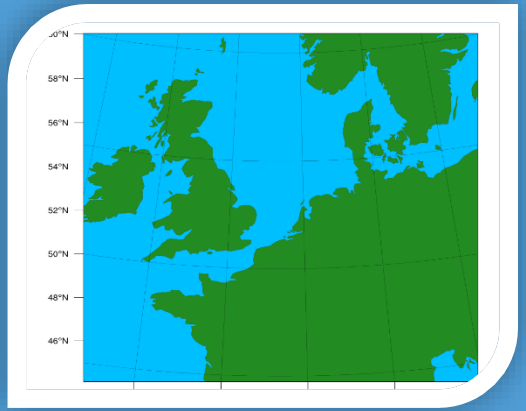
- What is the typical performance of each model for +36h forecasts?
- How much does model performance depend on weather type?
- Does more resolution help to improve results?

ECMWF-IFS (16km)

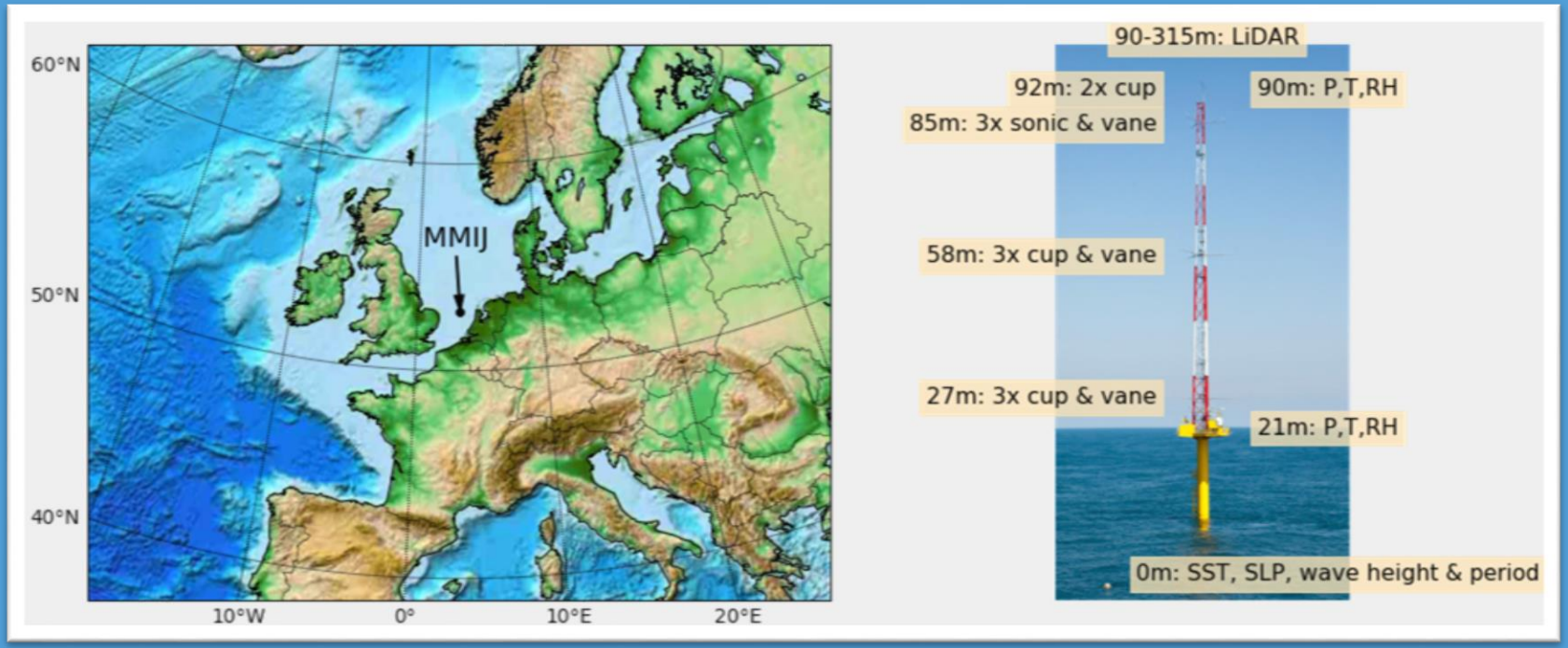
Harmonie (2.5 km)



WRF (3 km)



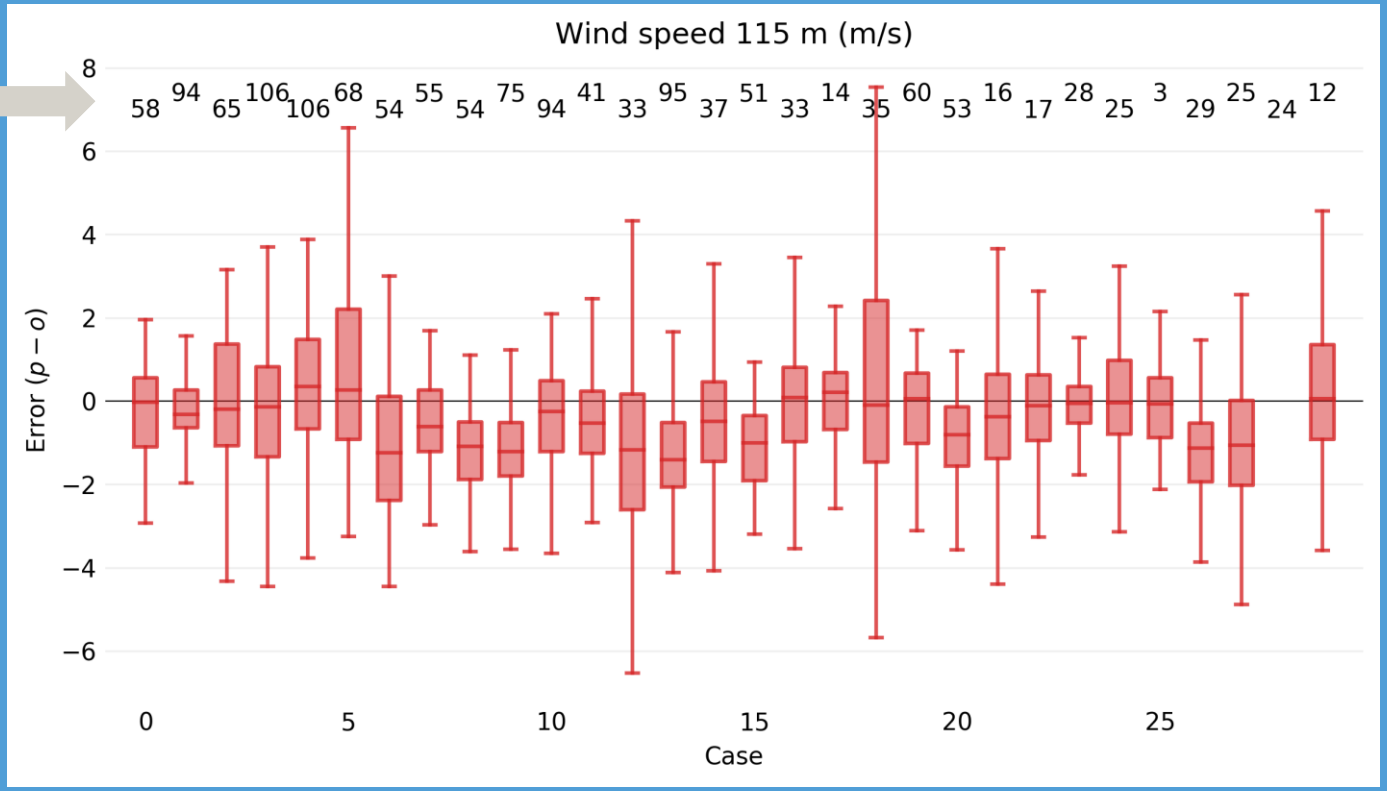
Four years of high quality data for validation (2012-2015)



Kalverla et al., 2017, JWEIA – An observational climatology of anomalous wind events ...

WRF results for wind speed at 115 m

Number of cases in cluster



30 clusters of weather types represent climatology

Results for +36 h forecasts (case weighted numbers)

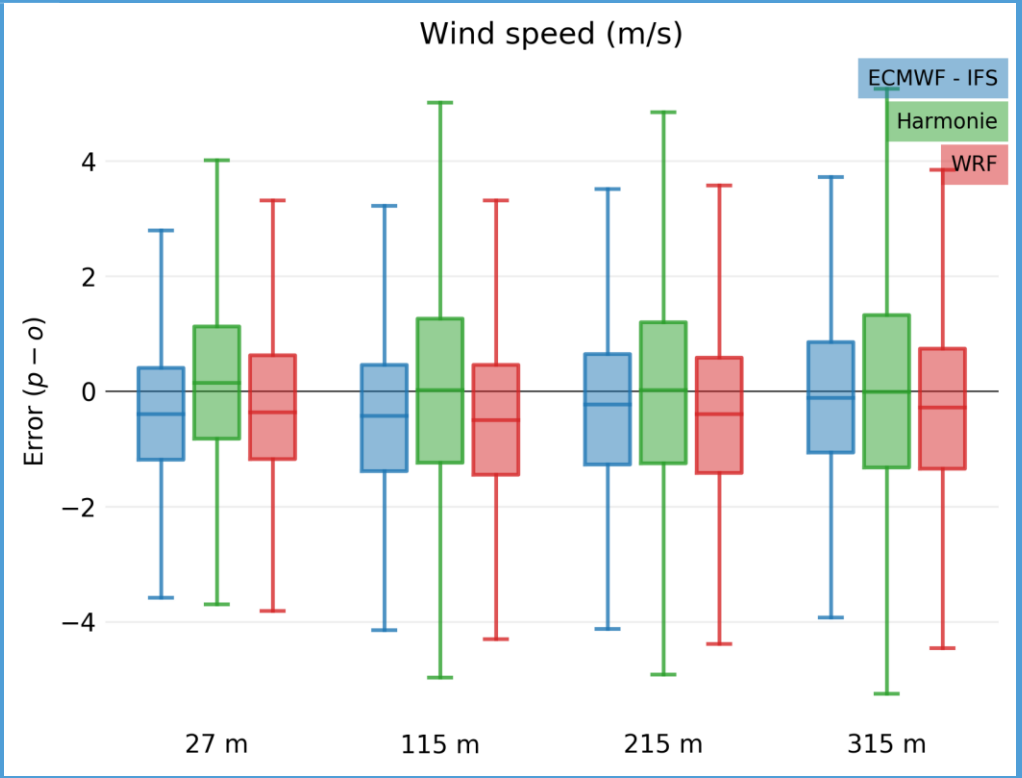
All bias: < 0.5 m/s

Typical spread: < 2m/s

Harmonie:

Smallest bias, largest spread

Impact of more refined data assimilation?

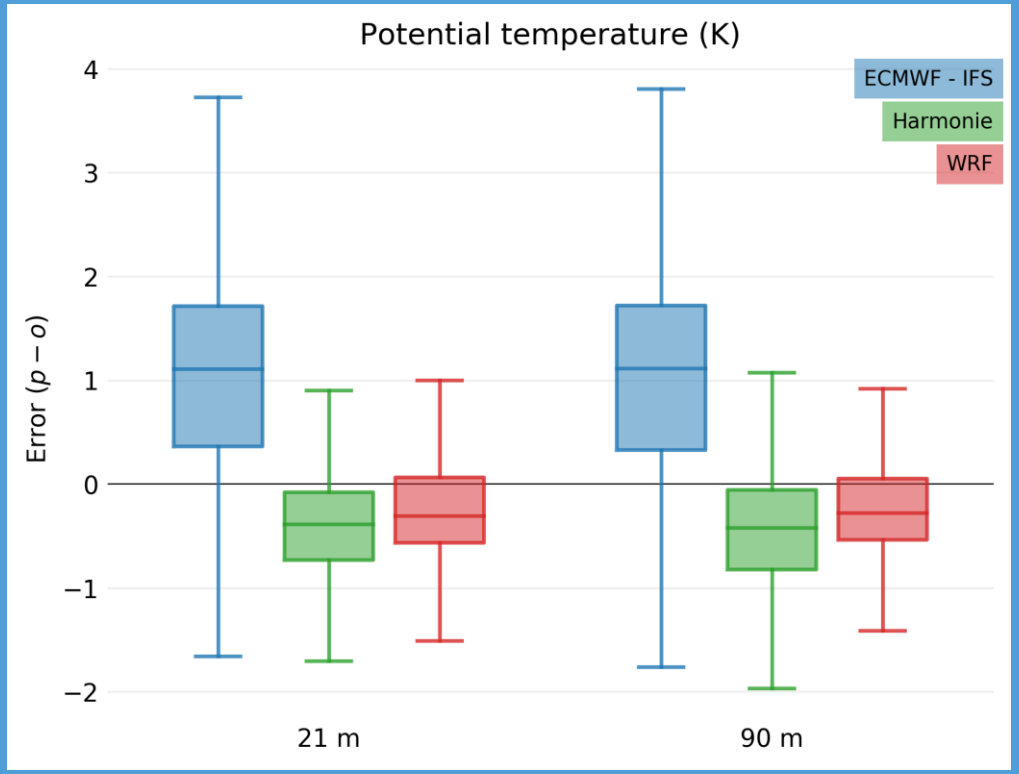


Results for +36 h forecasts (case weighted numbers)

IFS 1 K too warm

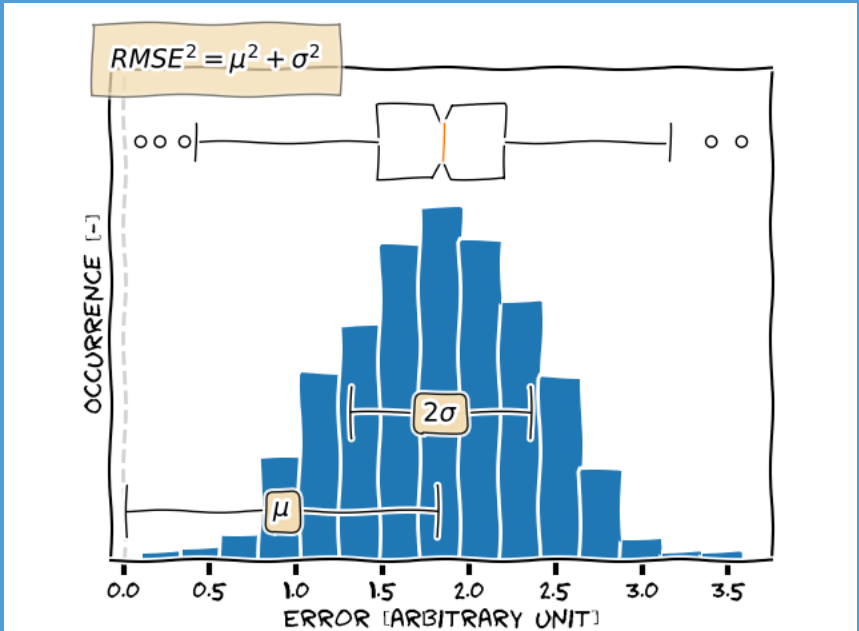
Others too cold

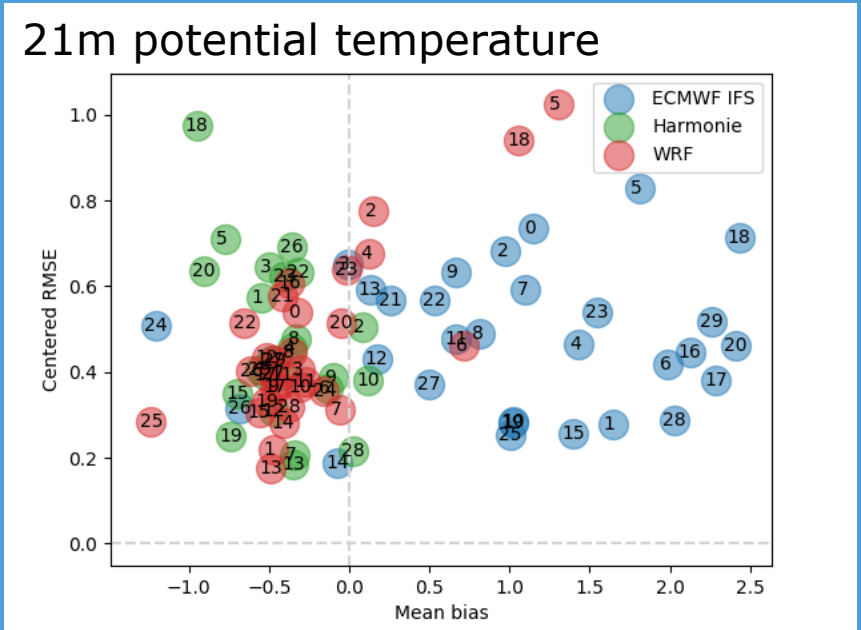
IFS much larger spread



Introducing error diagrams

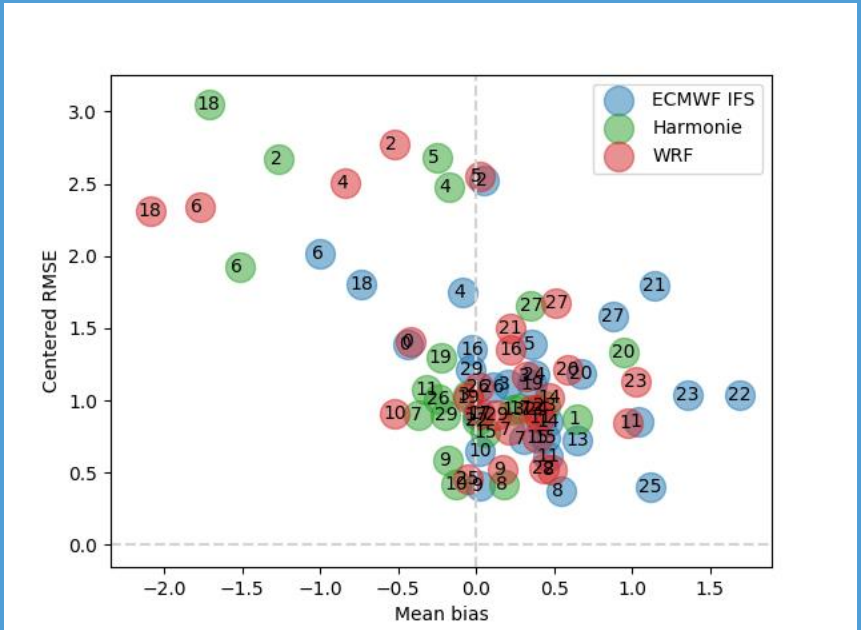
For quick comparison of 1st and 2nd moments of error distributions



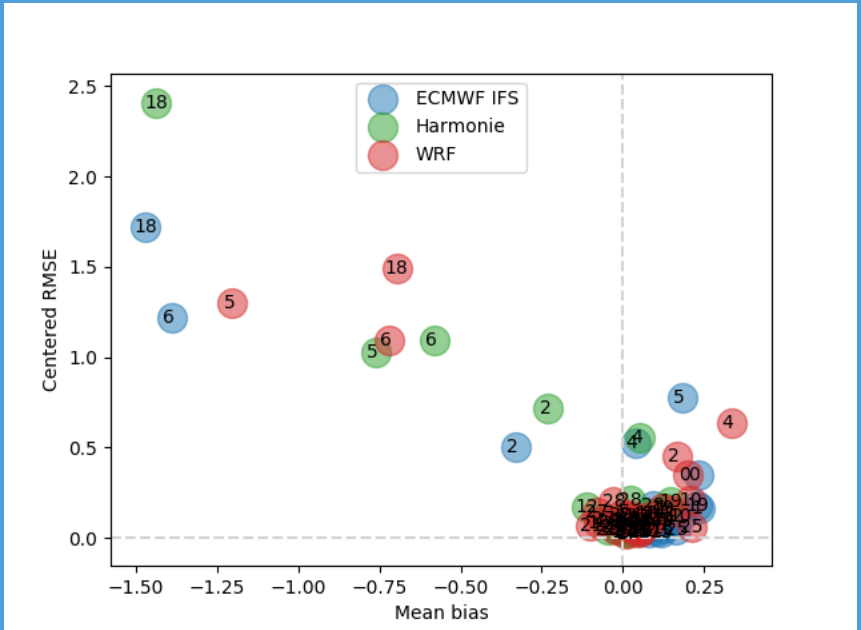


Models struggle to represent stable conditions (cluster 18)

315m – 27m wind speed difference



90m – 21m virtual potential temp. diff.



Take home

Wind speed bias < 0.5 m/s

Wind speed error std < 2 m/s

ECMWF temperature bias 1K

Stable conditions most challenging

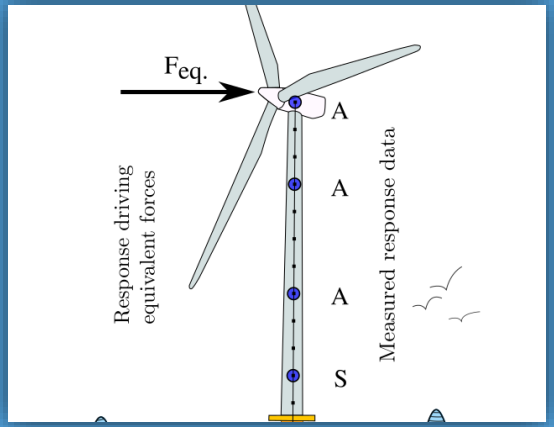
Not much impact of higher resolution in this study

See also poster!

More info: peter.kalverla@wur.nl

EUROS: uncertainty reductions in ...

External Conditions



Loads & Damage

Logistics & Design

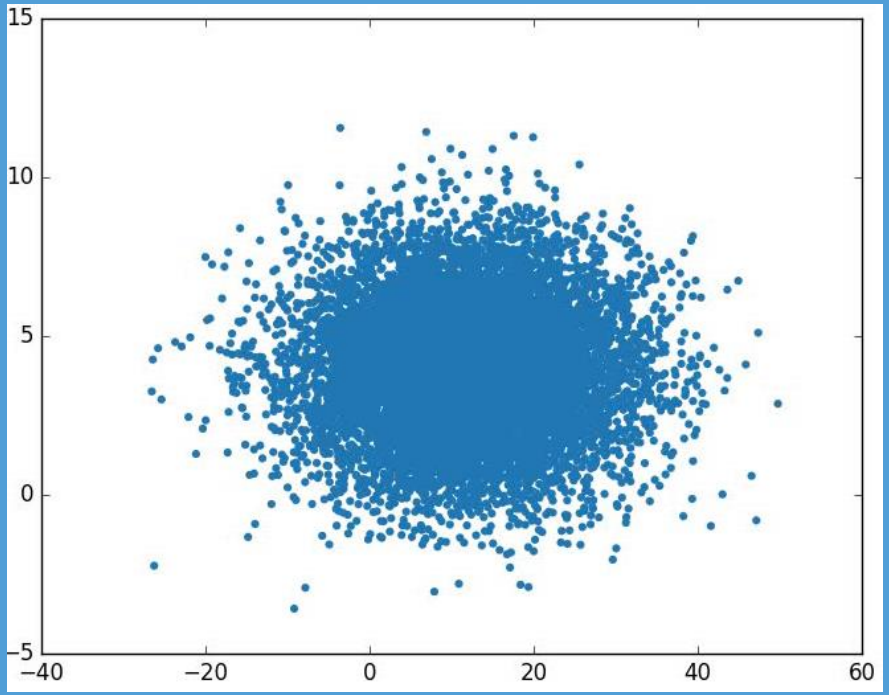
www.offshorewindenergy.org/EUROS/

Back-up information

Case selection strategy: "UVS•t_2" clustering

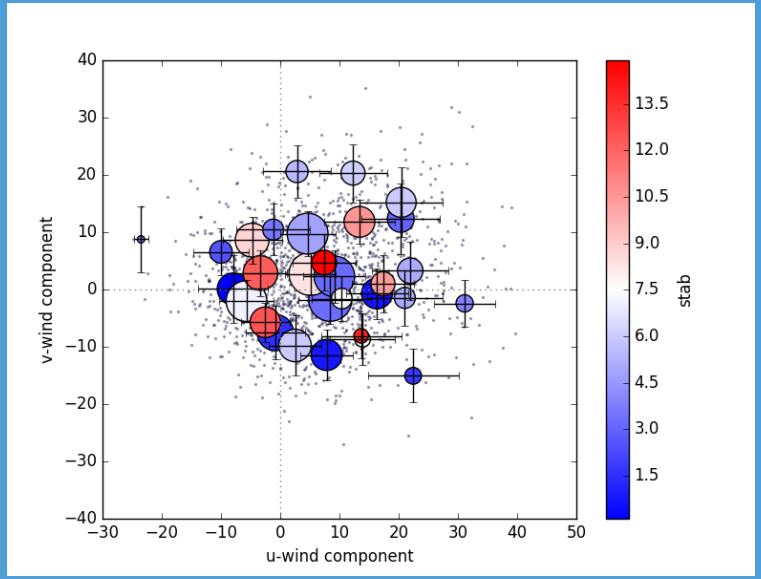
principle component analysis in 6 dimensions (illustrated here for 2 dimensions)

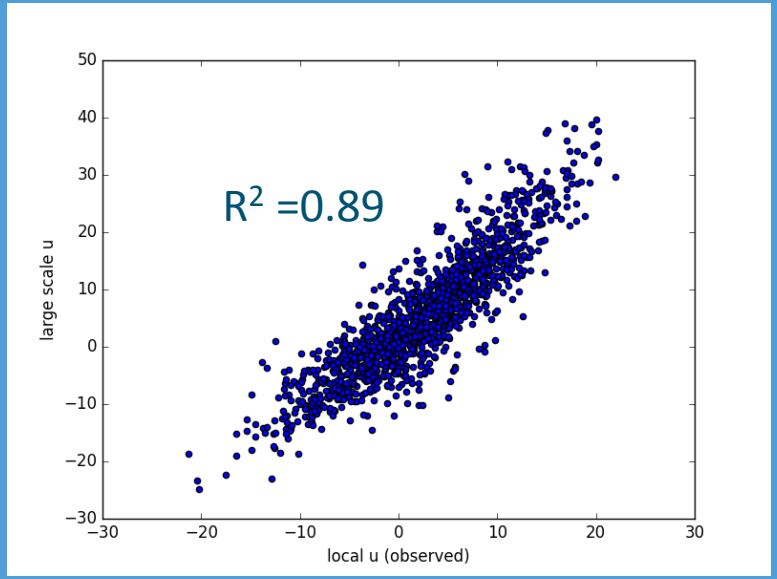
- **U** 10° N-S pressure difference
- **V** 10° E-W pressure difference
- **S** Stability (850 hPa pot. temp. minus SST)
- **t** Every day and day-1 (History)



Select 30 weather type cases representative for climatology

Results of clustering algorithm





Cases representative for climatology

Good correlation with local observations

Additional info: cases

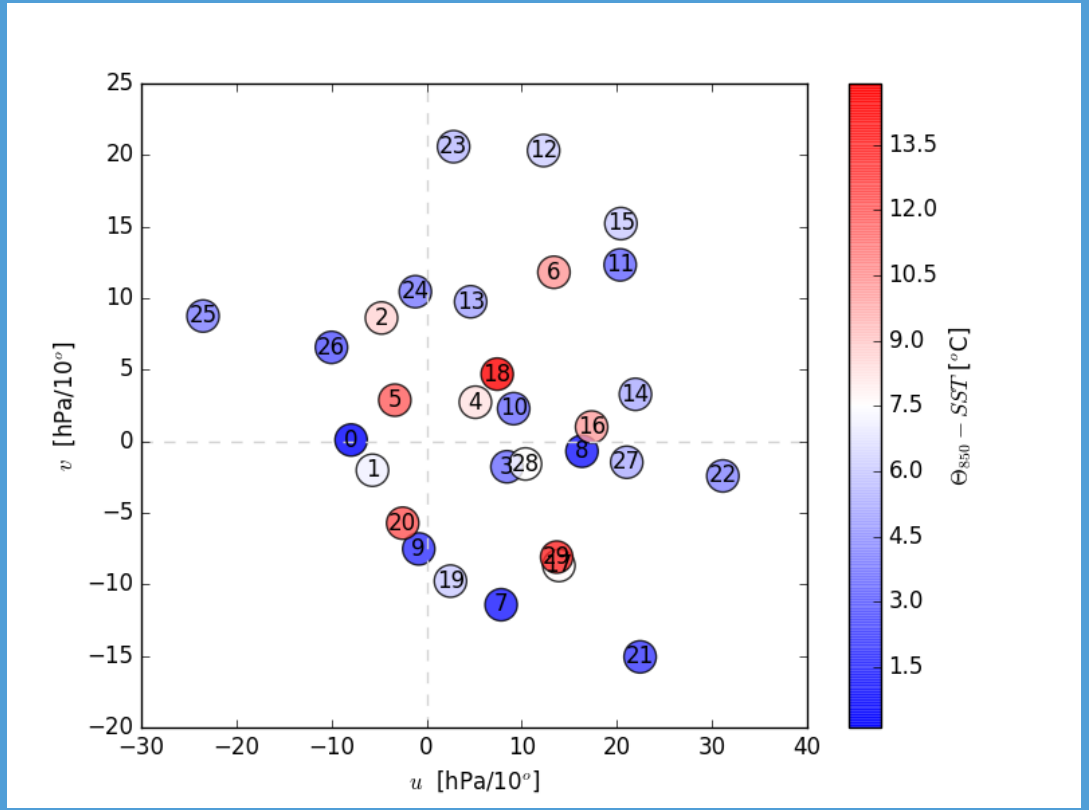
Case 18 most stable

Worst performance

Case 4,5,6 also stable

4,5 weak wind

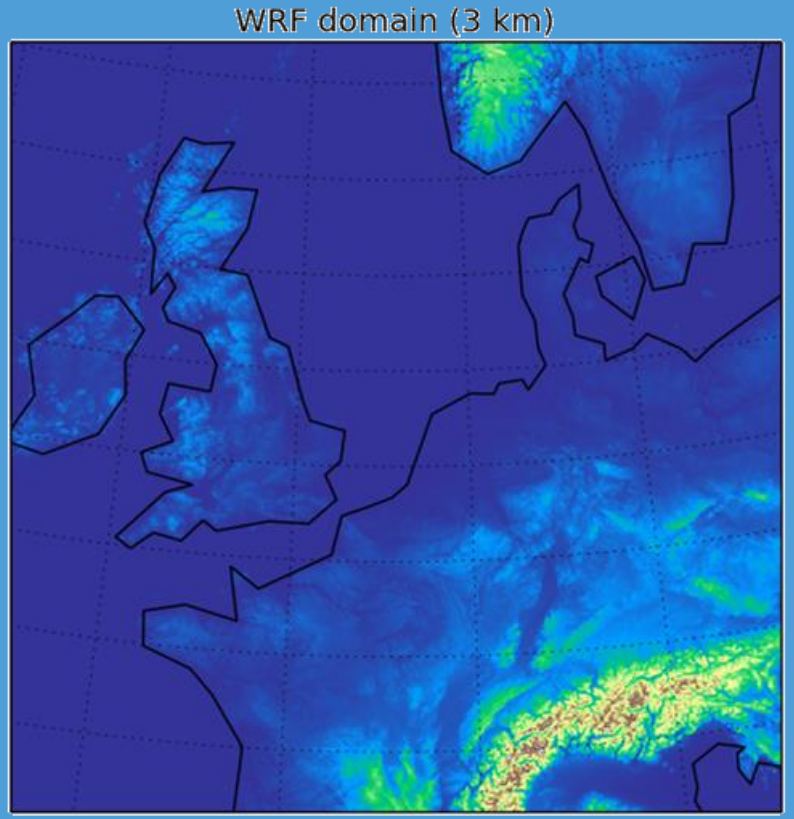
6: stronger wind



Additional info: WRF set-up

- WRFV3.9
- 600*600*91 points; 3 km hor. spacing
- Driven by ECMWF OA (~ 16 km)
- Noah land surface
- New Thompson microphysics
- RRTMG radiation
- Grell-Freitas scale-adaptive cumulus
- MYNN2.5 PBL and SL with mass-flux

- Based on 3km HRRR, CONUS/NCAR ensemble and active development



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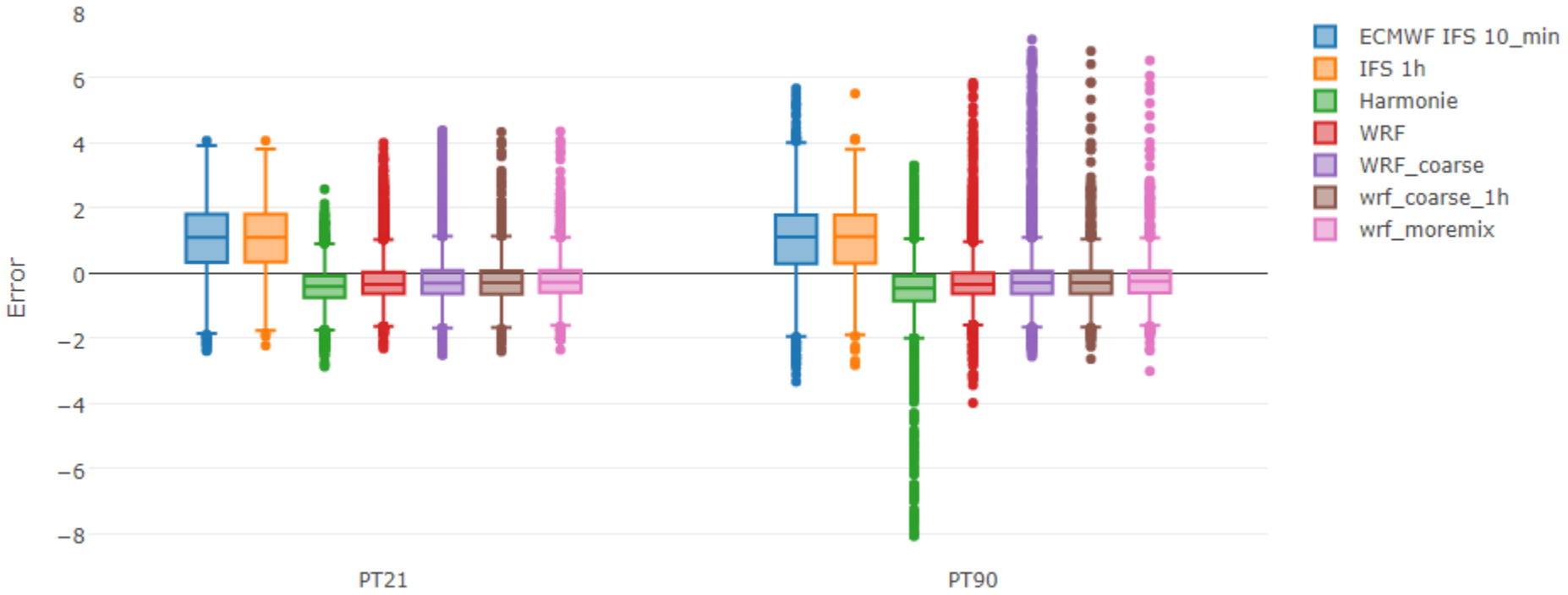
Additional info: additional simulations

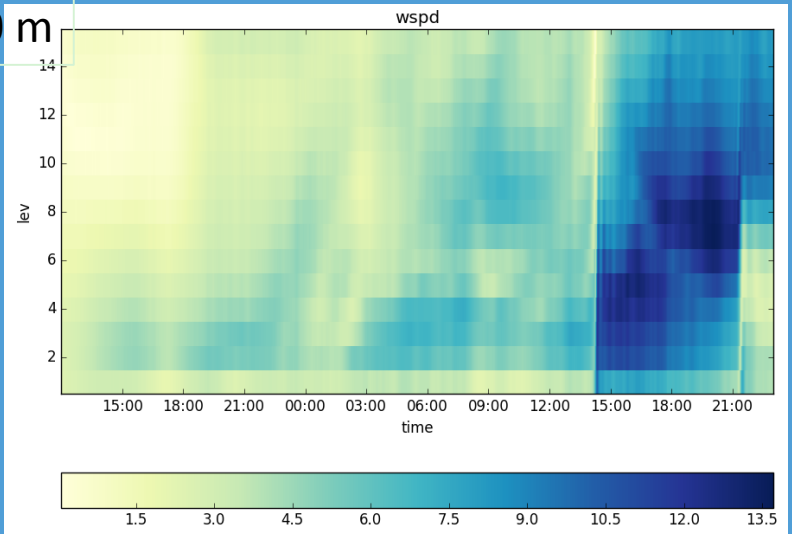


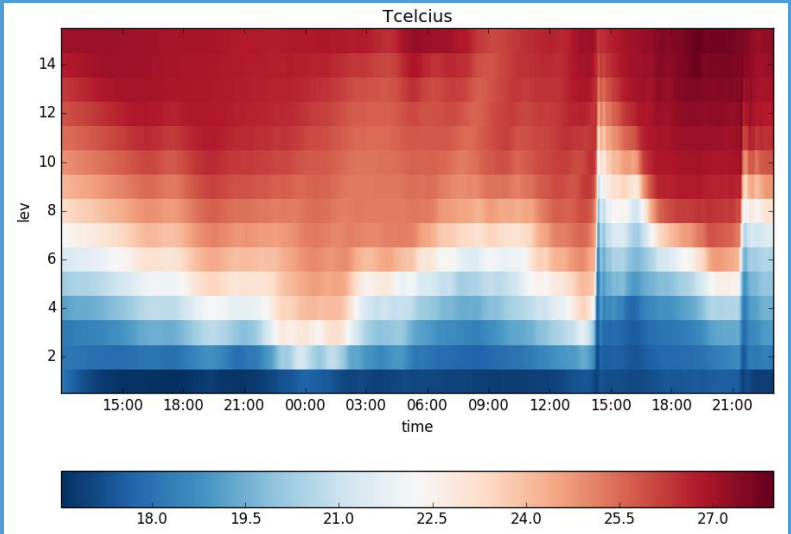
Additional info

- SST is very well represented in all models
- Harmonie is version V36, new cycle V40 includes new mixing length formulation
- Skill scores were calculated but don’t add much to the visual impression
- 10m wind was also evaluated with synops at offshore platforms: similar error patterns

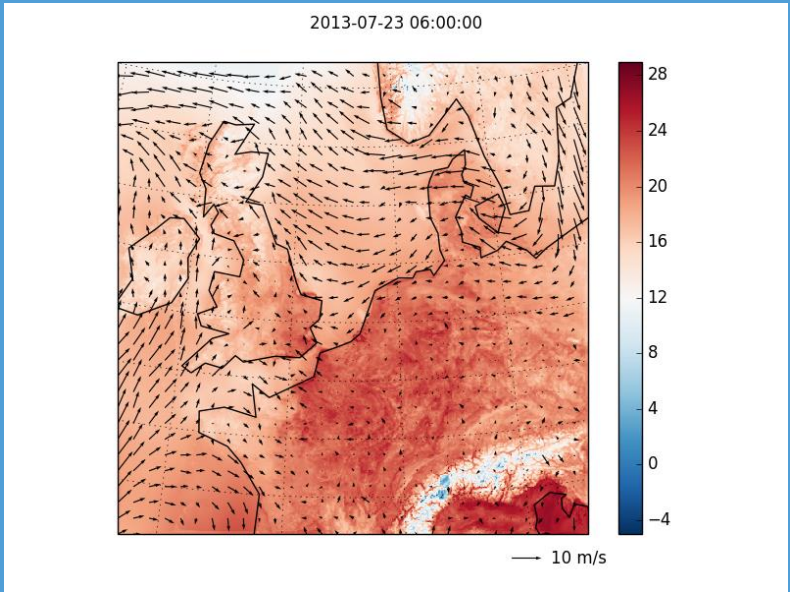
Additional info: case 5 evolution

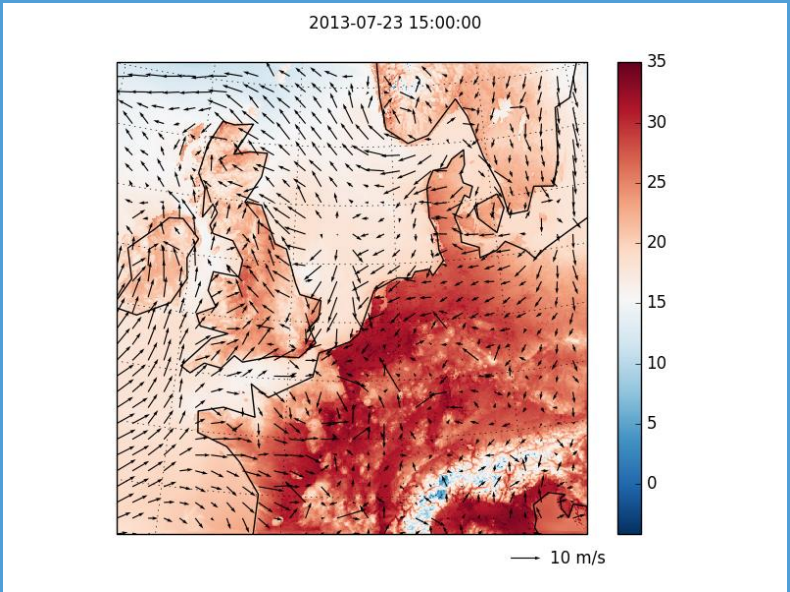
~ 560 m

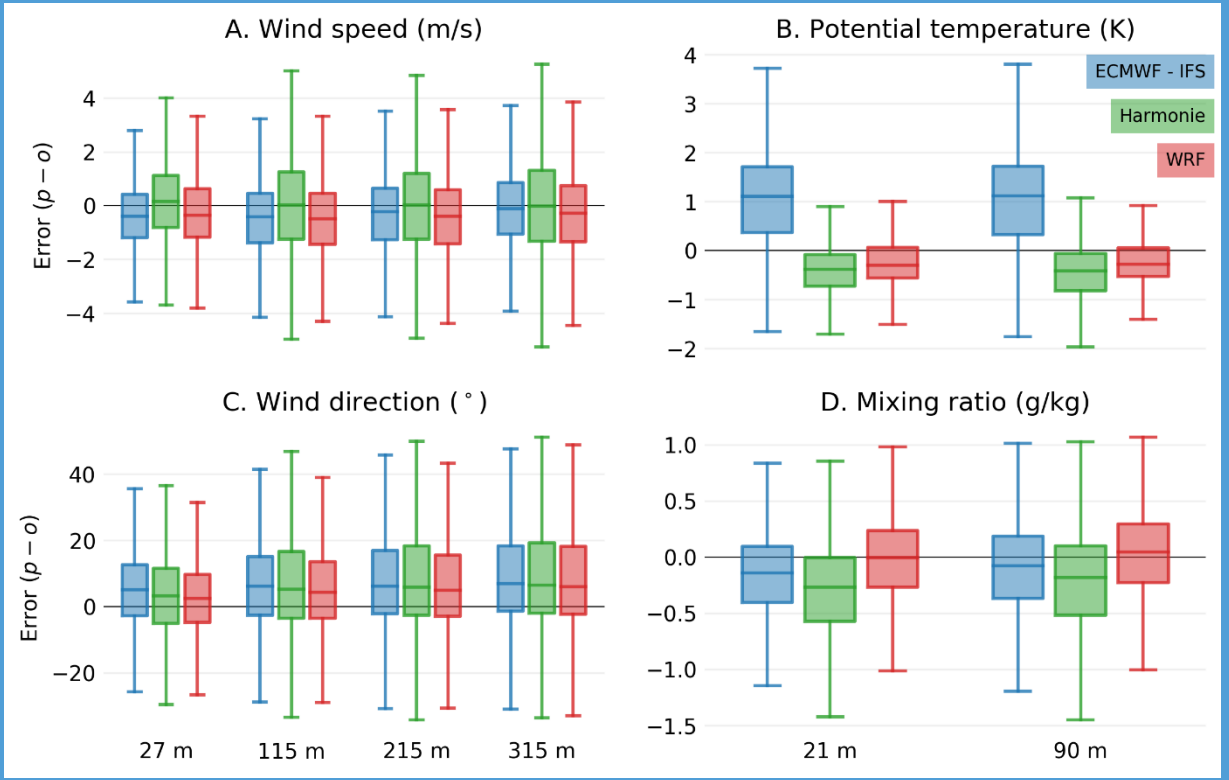


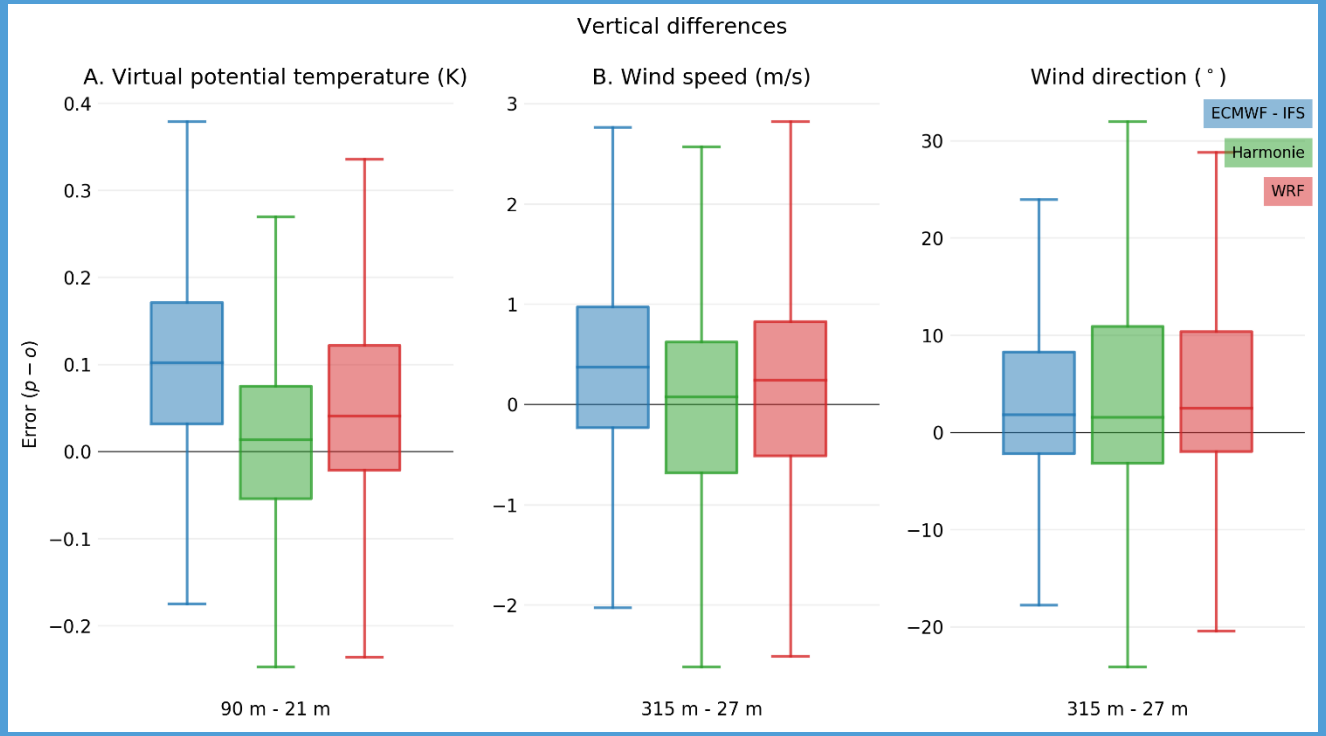


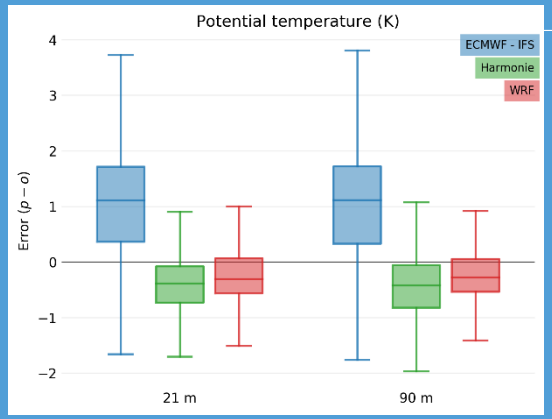
Case 5: surface charts (saddle point)

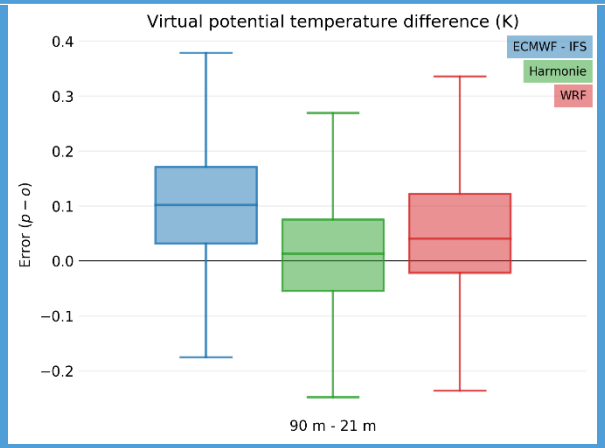


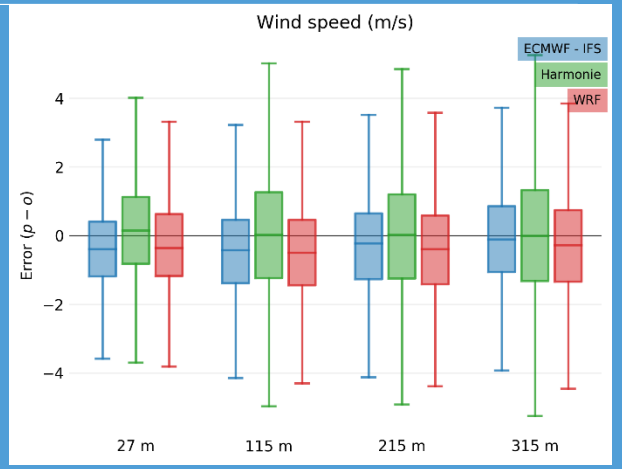


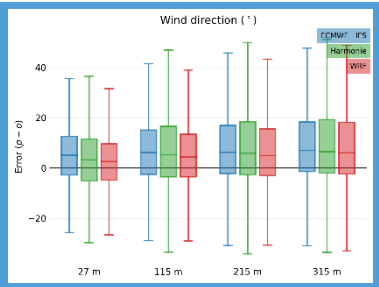

A. Wind speed (m/s)
B. Potential temperature (K)
C. Wind direction (°)
D. Mixing ratio (g/kg)
Error (p − o)
ECMWF - IFS
Harmonie
WRF
27 m
115 m
215 m
315 m
21 m
90 m

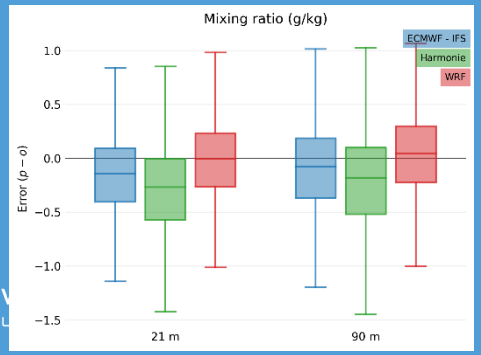

Vertical differences
A. Virtual potential temperature (K)
B. Wind speed (m/s)
Wind direction (°)
Error (p − o)
0.4
0.3
0.2
0.1
0.0
−0.1
−0.2
3
2
1
0
−1
−2
30
20
10
0
−10
−20
ECMWF - IFS
Harmonie
WRF
90 m - 21 m
315 m - 27 m
315 m - 27 m

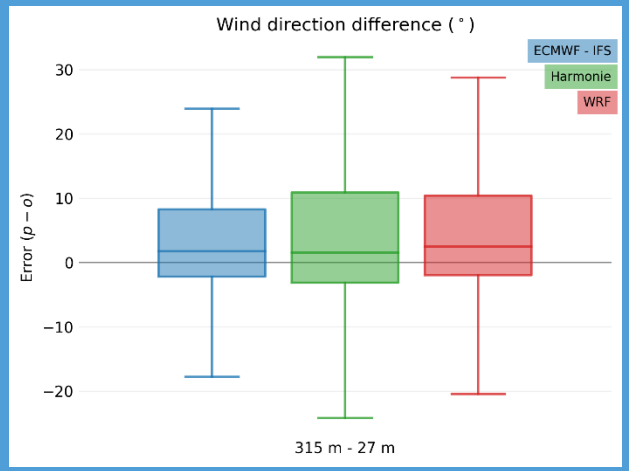

Potential temperature (K)
ECMWF - IFS
Harmonie
WRF
Error (p − o)
21 m
90 m

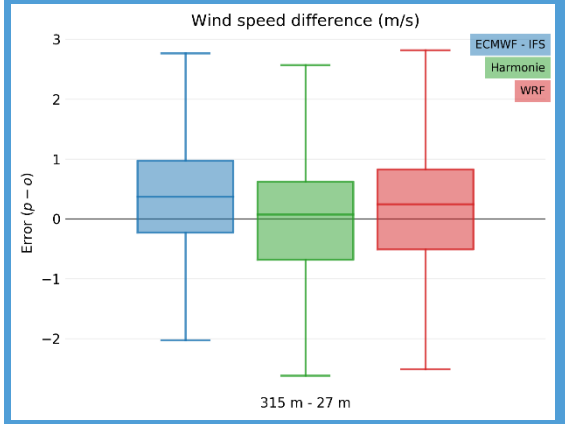

Virtual potential temperature difference (K)
ECMWF - IFS
Harmonie
WRF
Error (p − o)
90 m - 21 m

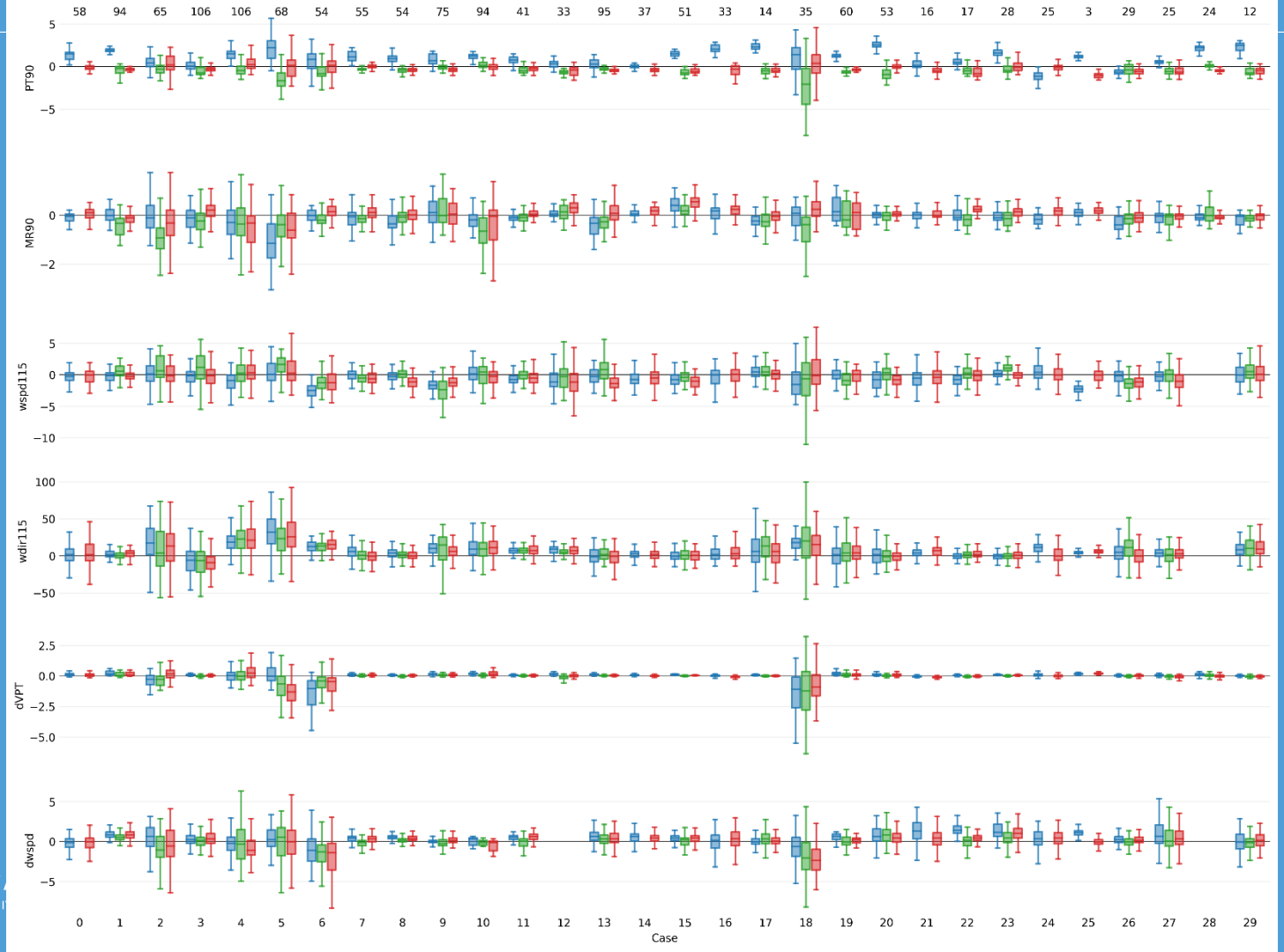

Wind speed (m/s)
ECMWF - IFS
Harmonie
WRF
Error (p − o)
27 m
115 m
215 m
315 m

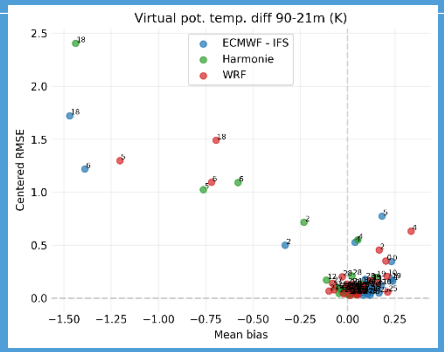

Wind direction (°)
Error (p − o)
27 m
115 m
215 m
315 m

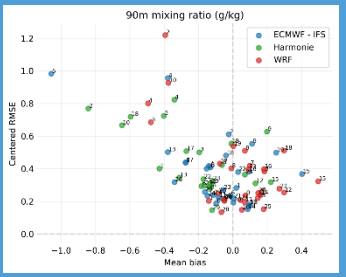

Mixing ratio (g/kg)
ECMWF - IFS
Harmonie
WRF
Error (p − o)
21 m
90 m

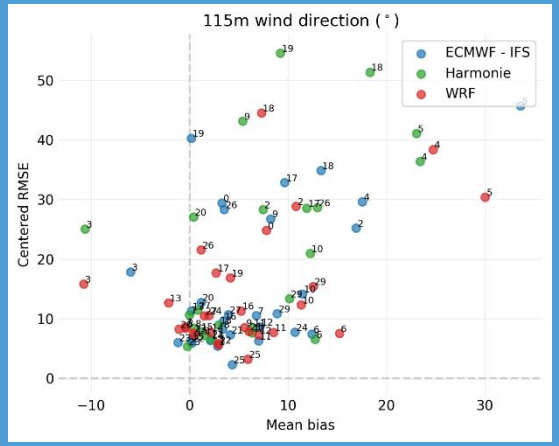

Wind direction difference (°)
ECMWF - IFS
Harmonie
WRF
Error (p − o)
315 m - 27 m

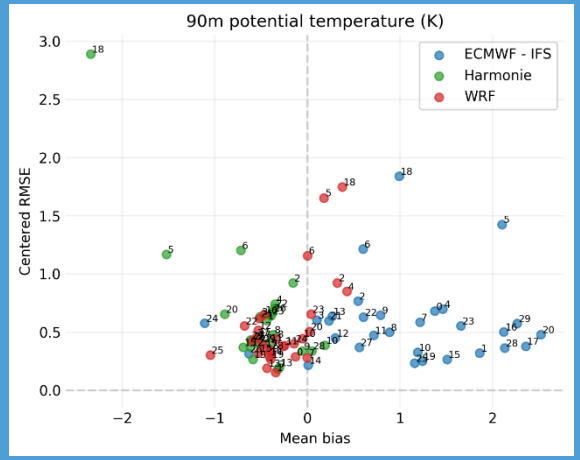

Wind speed difference (m/s)
ECMWF - IFS
Harmonie
WRF
Error (p − o)
315 m - 27 m

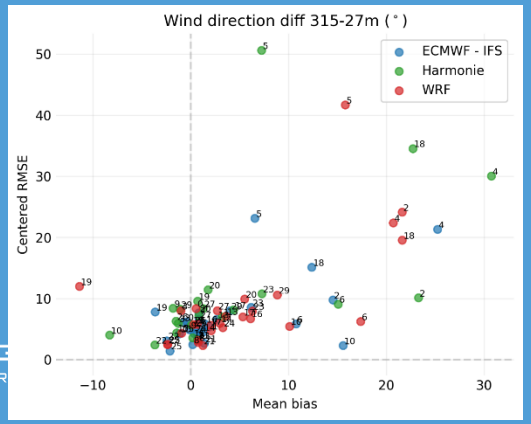

58 94 65 106 106 68 54 55 54 75 94 41 33 95 37 51 33 14 35 60 53 16 17 28 25 3 29 25 24 12
PT90
MP90
wspd115
wdir115
dVPT
dwspd
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
Case

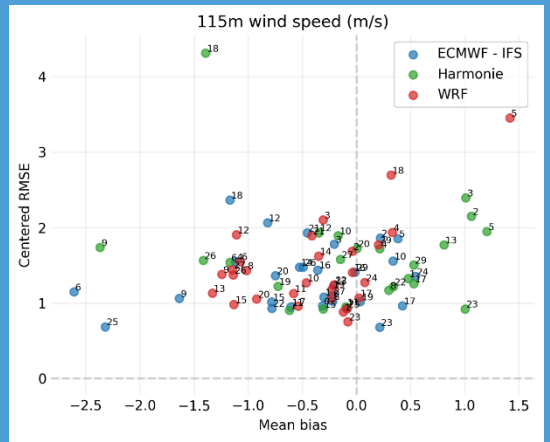

Virtual pot. temp. diff 90-21m (K)
ECMWF - IFS
Harmonie
WRF
Centered RMSE
Mean bias

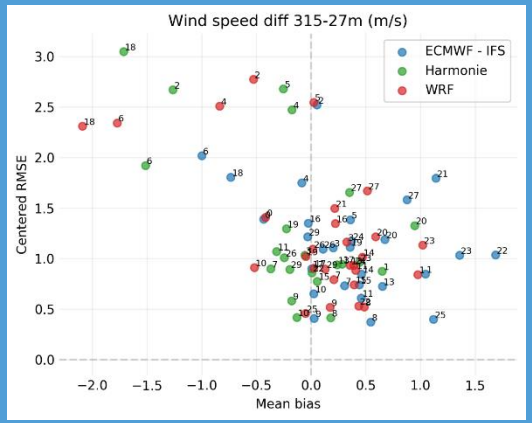

90m mixing ratio (g/kg)
ECMWF - IFS
Harmonie
WRF
Centered RMSE
Mean bias

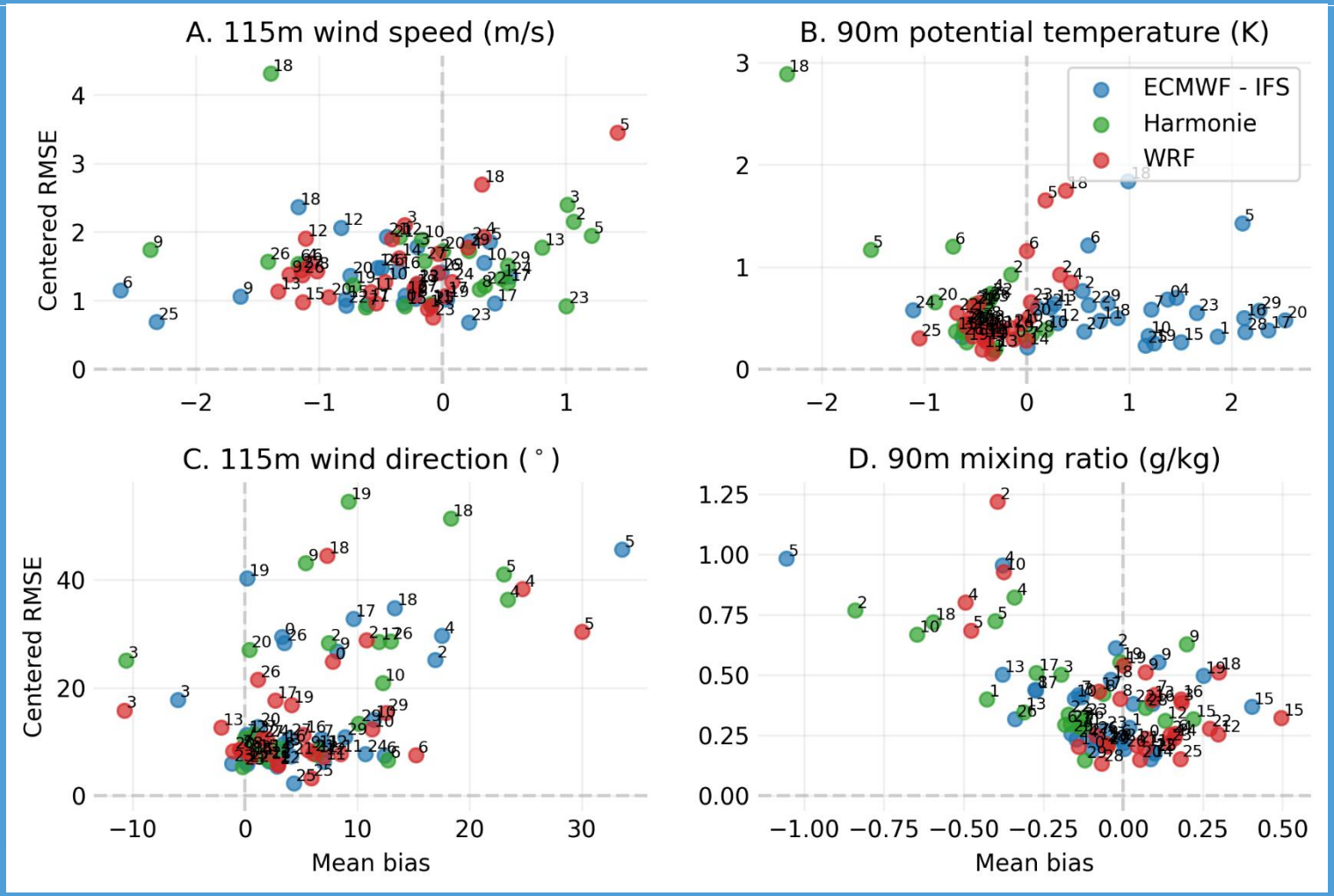

115m wind direction (°)
ECMWF - IFS
Harmonie
WRF
Centered RMSE
Mean bias

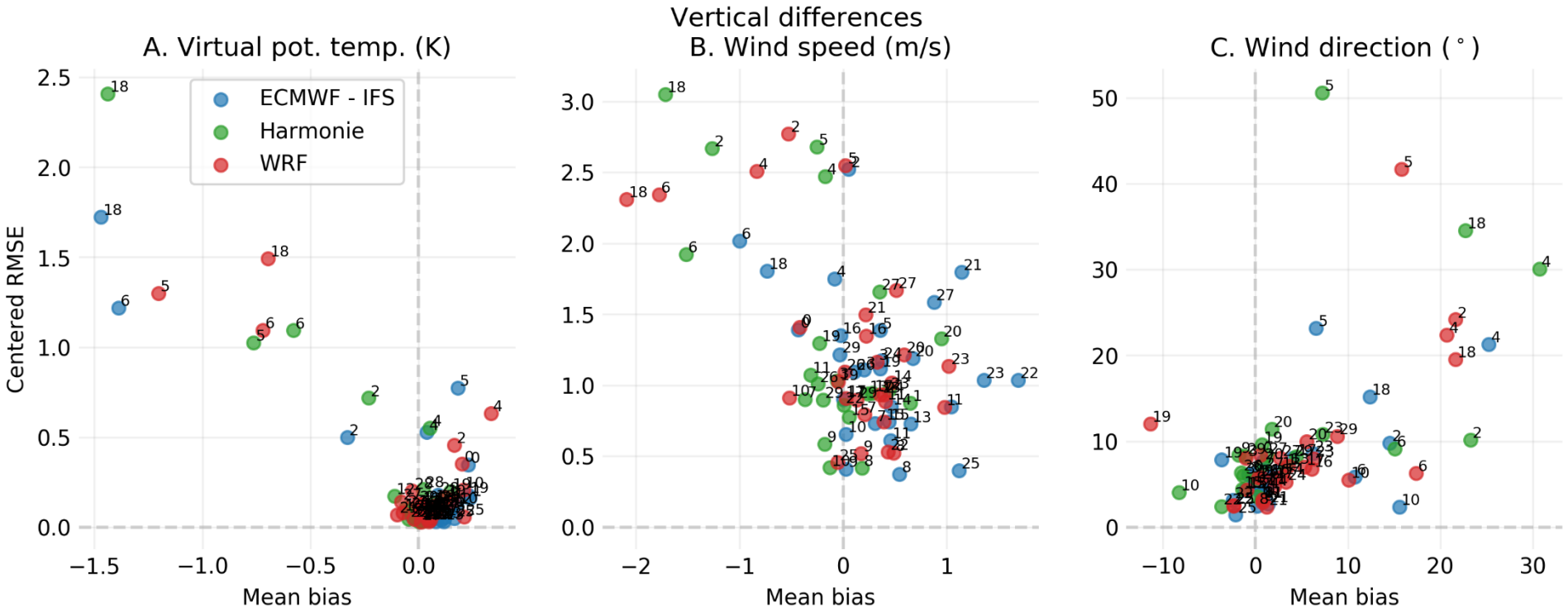

90m potential temperature (K)
ECMWF - IFS
Harmonie
WRF
Centered RMSE
Mean bias


Wind direction diff 315-27m (°)
ECMWF - IFS
Harmonie
WRF
Centered RMSE
Mean bias


115m wind speed (m/s)
ECMWF - IFS
Harmonie
WRF
Centered RMSE
Mean bias


Wind speed diff 315-27m (m/s)
ECMWF - IFS
Harmonie
WRF
Centered RMSE
Mean bias


A. 115m wind speed (m/s)
Centered RMSE
B. 90m potential temperature (K)
ECMWF - IFS
Harmonie
WRF
C. 115m wind direction (°)
Centered RMSE
Mean bias
D. 90m mixing ratio (g/kg)
Mean bias


Vertical differences
A. Virtual pot. temp. (K)
B. Wind speed (m/s)
C. Wind direction (°)
ECMWF - IFS
Harmonie
WRF
Centered RMSE
Mean bias
Mean bias
Mean bias