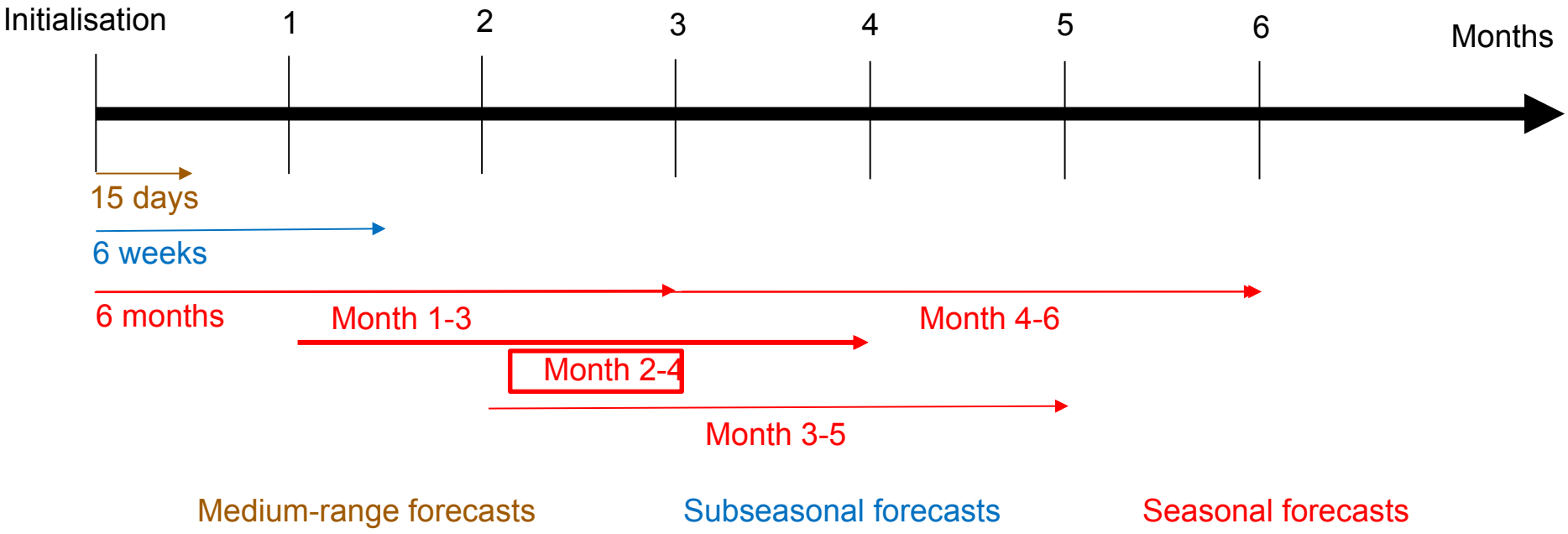
Seasonal forecasts of 100m wind and solar radiation for Germany

1 Deutscher Wetterdienst
Wetter und Klima aus einer Hand

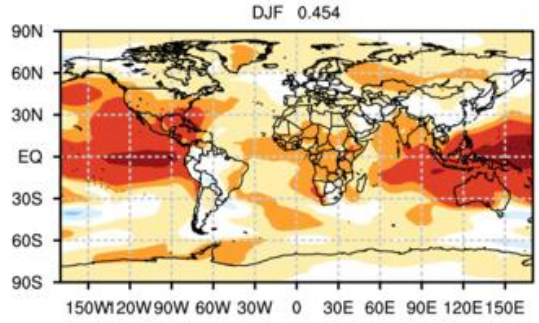
2 Fraunhofer IEE

J. Wandel[1], A. Paxian[1], C. Dalelane[1], A. Tyagi[2], A. Happ[2], M. Siefert[2]

Seasonal forecasts

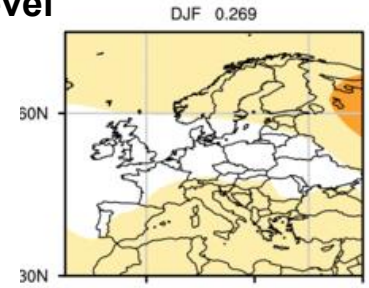


Seasonal forecast skill



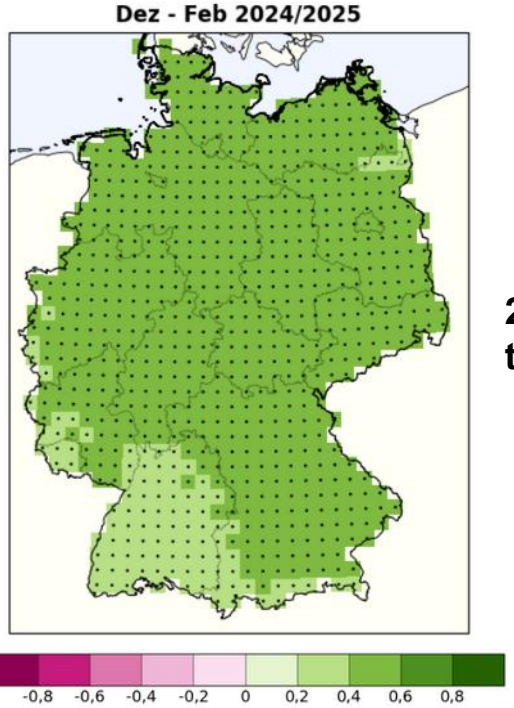
Mean Sea Level Pressure (MSLP)

1993-2009



Source: WMO

Anomaly correlation coefficient (ACC) for DWD hindcasts started in November (DJF; leadtime 2-4 months)

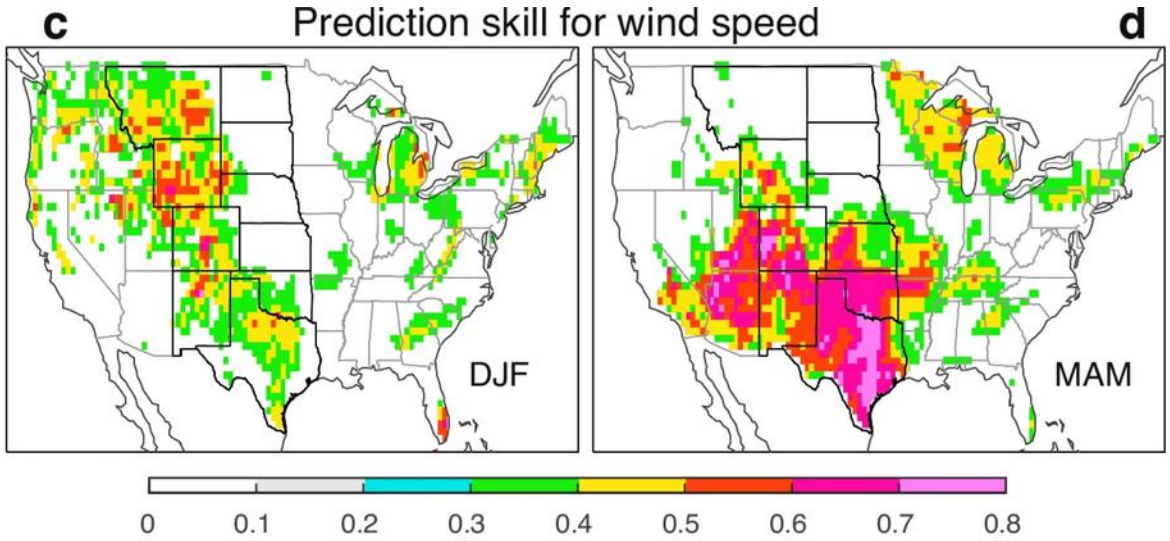


2m temperature

1991-2020

Source: DWD

Seasonal forecast skill



Anomaly correlation coefficient (ACC) for SPEAR's Seasonal Retrospective Forecasts (SRF) (1991-2022) started in c) November (DJF; leadtime 2-4 months) and d) January (MAM; leadtime 2-4 months)

Xiasong Yang et al. 2024

Data

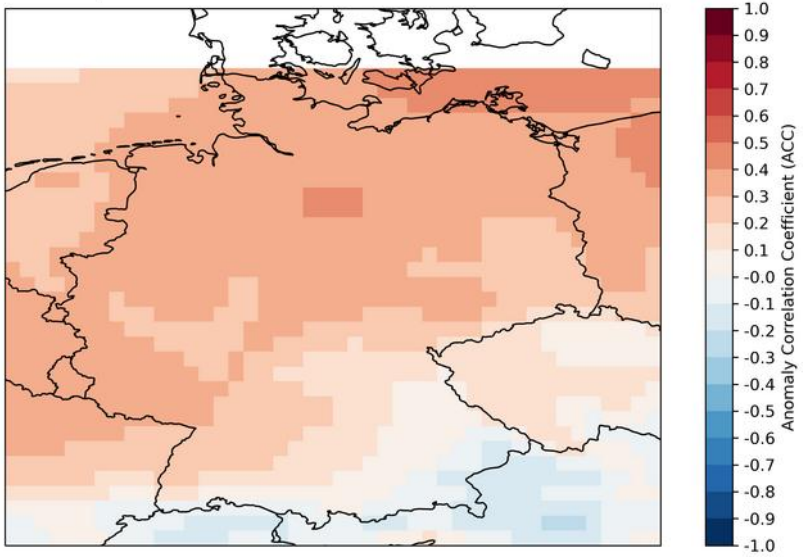
- **DWD (GCFS2.1) Hindcasts** (1990-2020) with empirical-statistical downscaling **EPISODES** for **solar radiation** and **100m wind**
- **ECMWF** and **Meteo France Hindcasts** (1993-2016) downscaled with **EPISODES**
- „**Subsampling**“ to create a smaller subensemble based on SSTs and the large-scale circulation (Dalelane et al. 2020 and Dalelane et al. 2025, in review)
- **HYRAS** (High-resolution gridded analyses) (**solar radiation**: daily, 5 km, 1951-2020)
- **ERA5 reanalysis** (**100m Wind**: hourly, 28 km, 1940-today)

100m Wind (Skill: ACC)

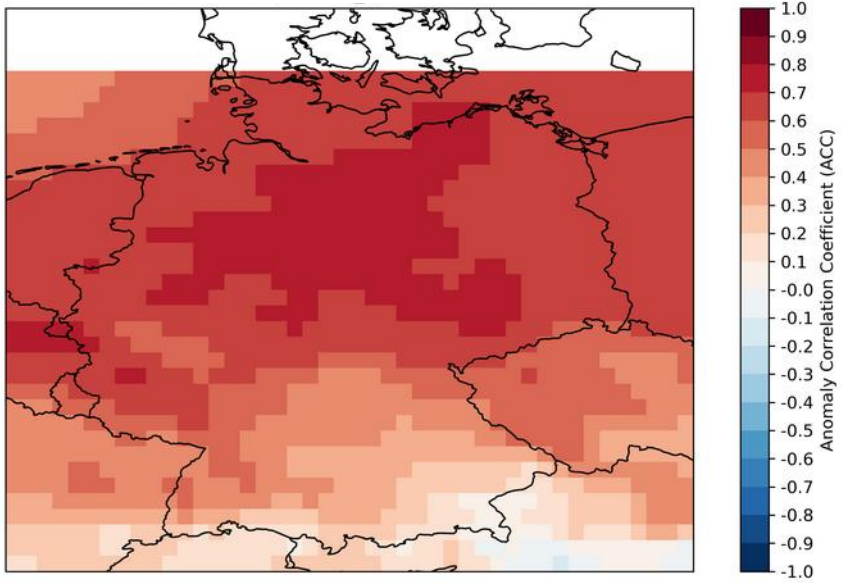
Fraunhofer IEE

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Full Ensemble (30 Ensemble Members)

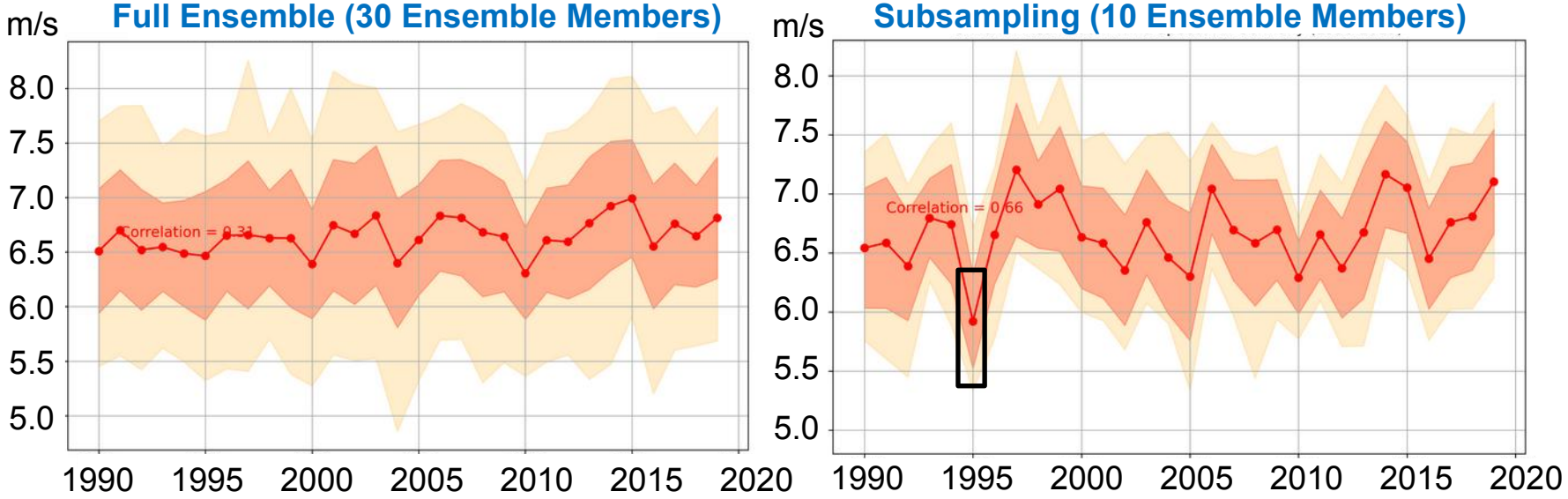


Subsampling (10 Ensemble Members)



DWD Hindcasts (1990-2019)
Initial time: November
Leadtime: Month 2-4 (winter; DJF)

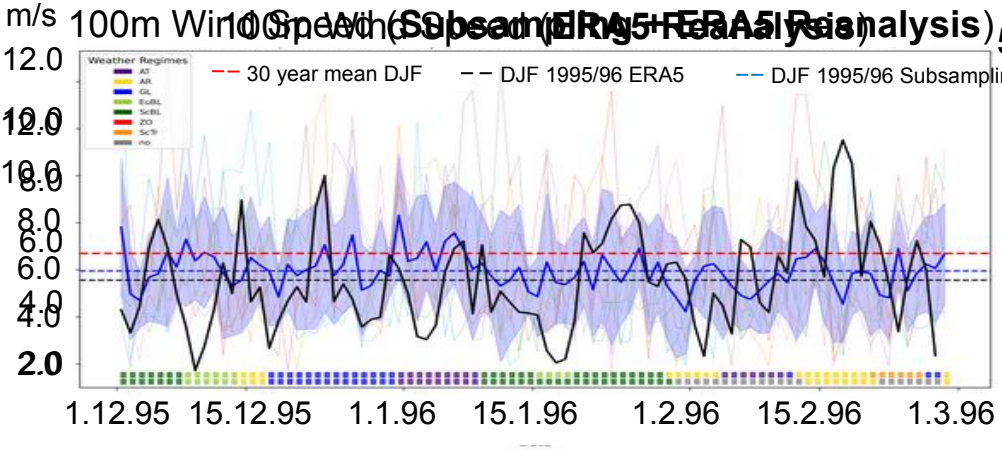
100m Wind (Timeseries)



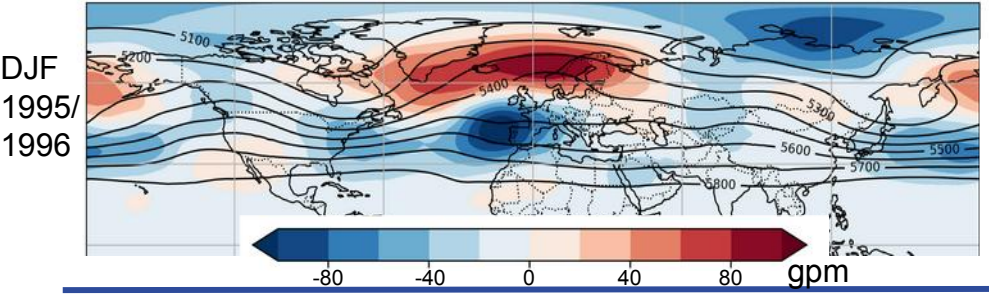
- Ensemble Mean
- 66 % of ensemble members
- Full Ensemble spread
- ERA5 Reanalysis

DWD Hindcasts (1990-2019)
Initial time: November
Leadtime: Month 2-4 (winter; DJF)

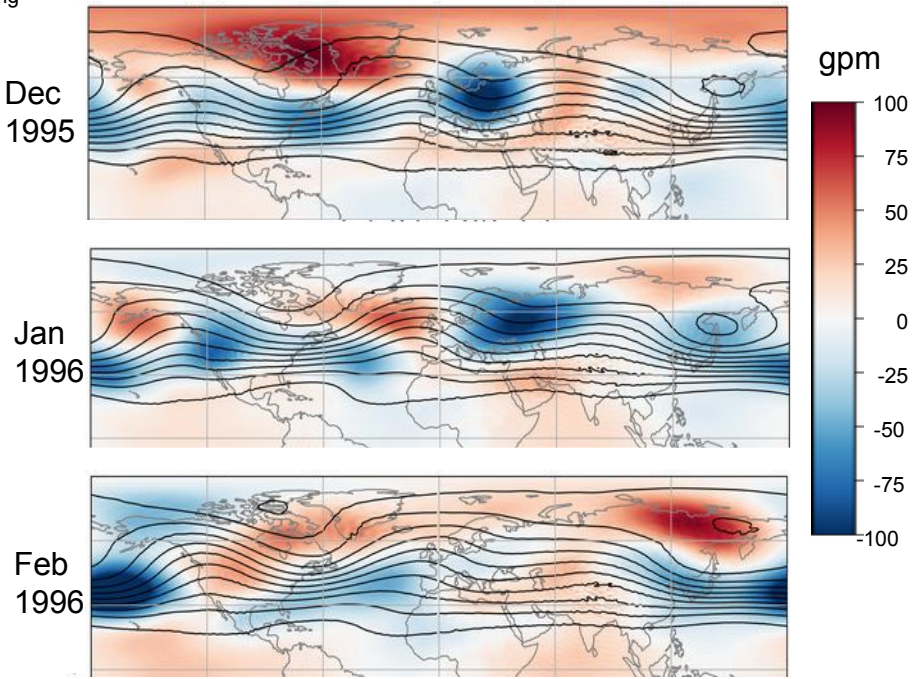
100m Wind (DJF 1995/96)



500 hPa geopotential height anomalies (**ERA5 reanalysis**)



500 hPa geopotential height anomalies (**Subsampling**)



100m Wind (Monthly)

Fraunhofer IEE

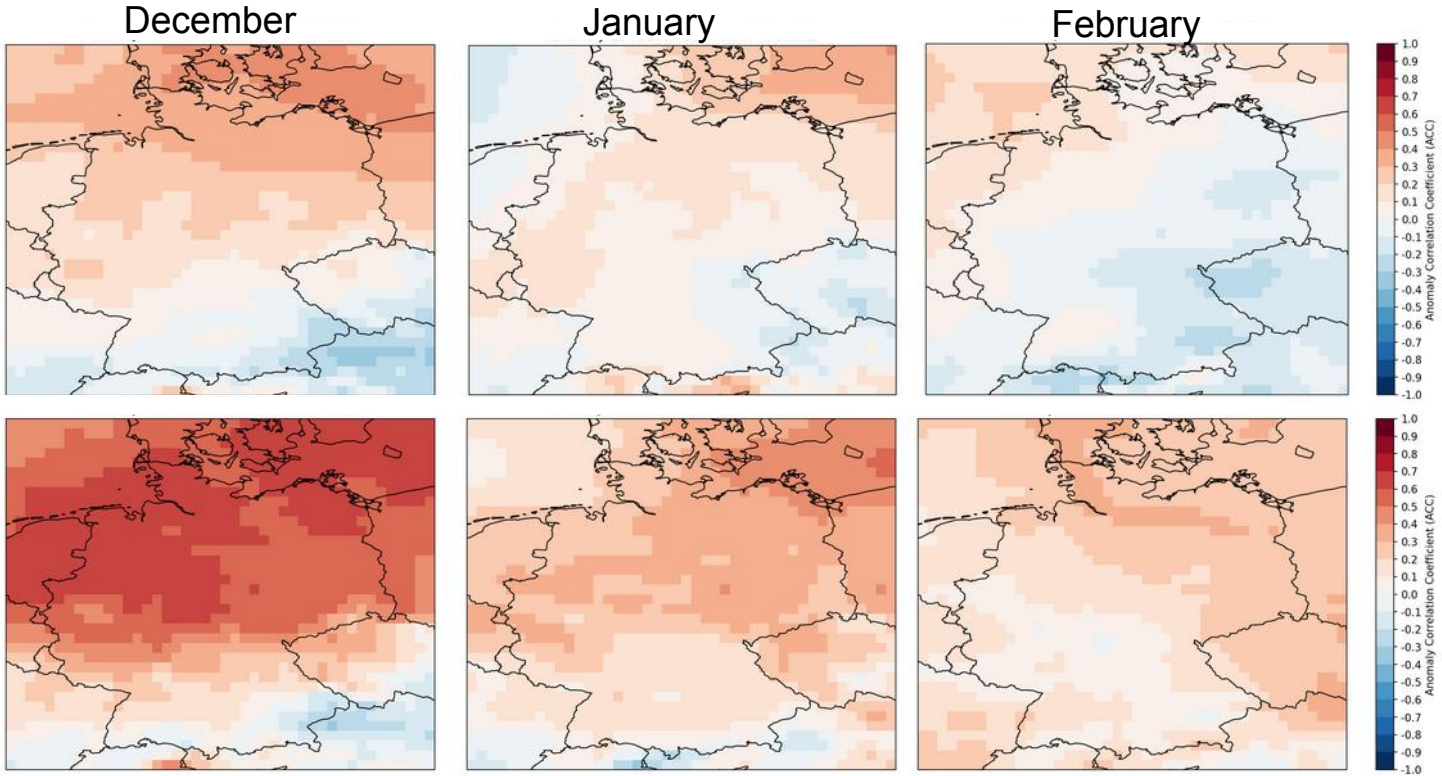
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

DWD

Full Ensemble

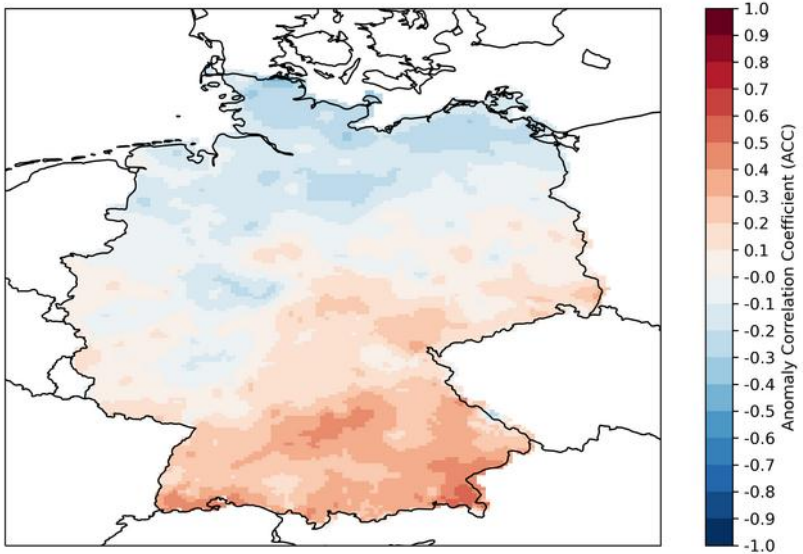
DWD Hindcasts (1990-2019)
Initial time: November
Leadtime:
Month 2 (Dec)
Month 3 (Jan)
Month 4 (Feb)

Sub-sampling

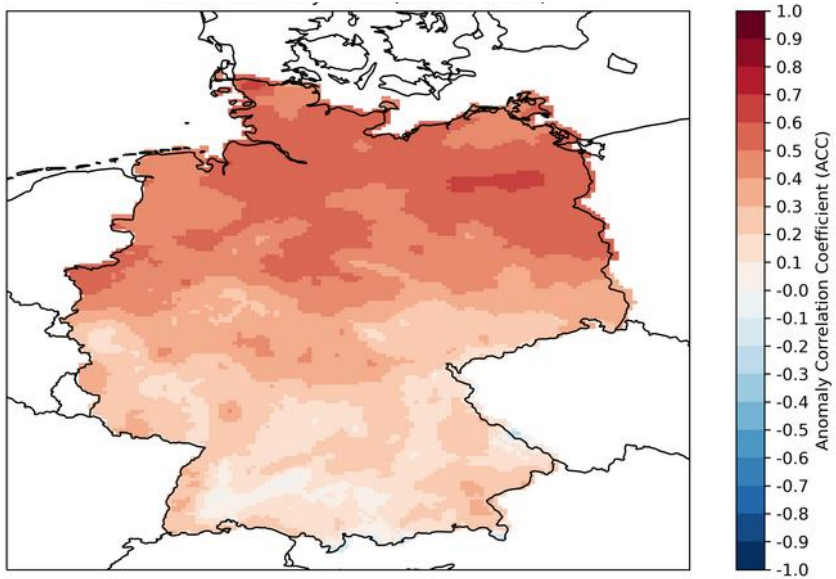


Solar radiation (Skill: ACC)

Full Ensemble (30 Ensemble Members)

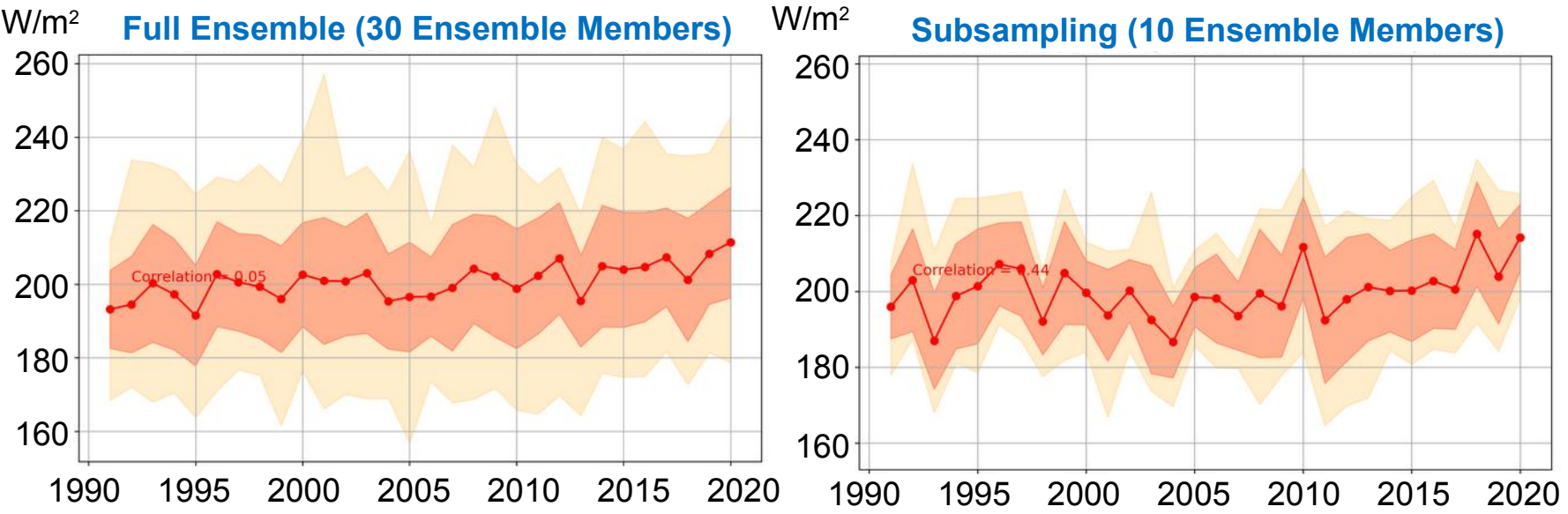


Subsampling (10 Ensemble Members)



DWD Hindcasts (1991-2020)
Initial time: May
Leadtime: Month 2-4 (sommer; JJA)

Solar radiation (Timeseries)

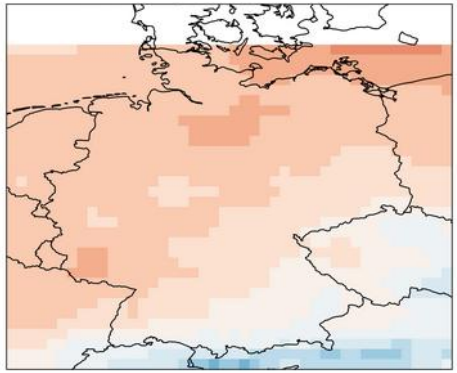


Ensemble Mean
66 % of ensemble members
Full Ensemble spread
HYRAS

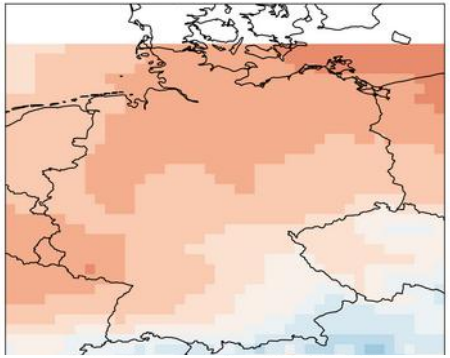
DWD Hindcasts (1991-2020)
Initial time: May
Leadtime: Month 2-4 (summer; JJA)

100m Wind (ACC: Multimodel)

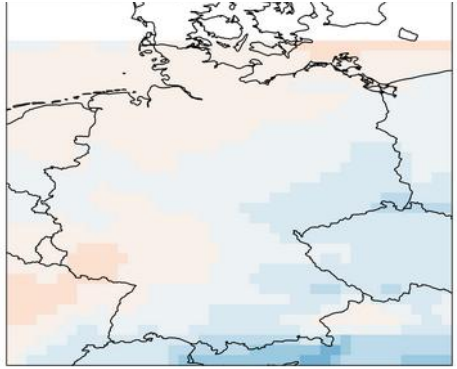
Multimodel
80 Ensemble Member



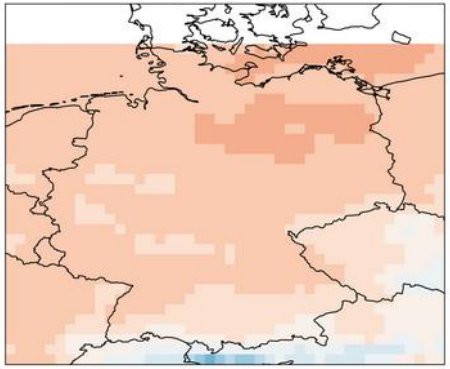
DWD
30 Ensemble Member

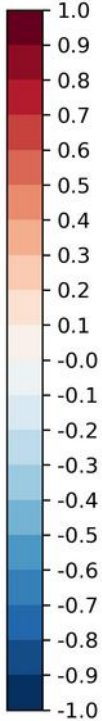


ECMWF
25 Ensemble Member



Meteo France
25 Ensemble Member

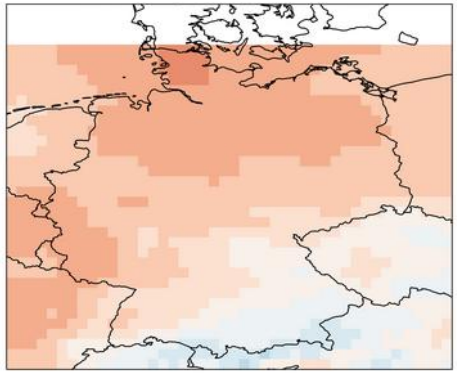




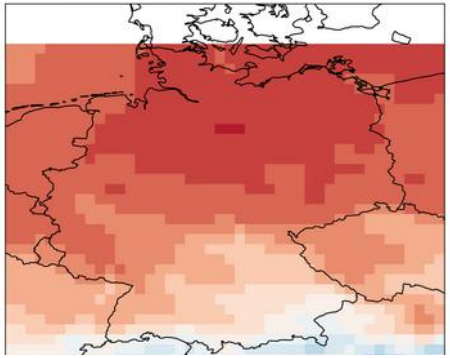
Hindcasts (1993-2016)
Initial time: November
Leadtime: **Month 2-4**
(winter; DJF)

100m Wind (ACC: Subsampling)

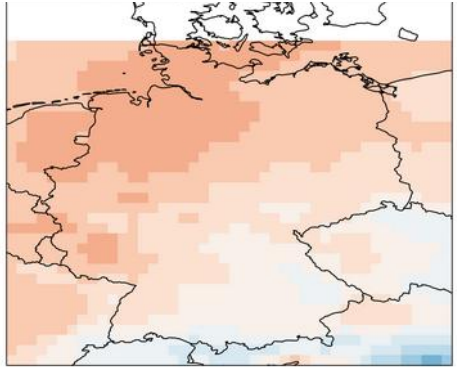
Multimodel
10 Ensemble Member



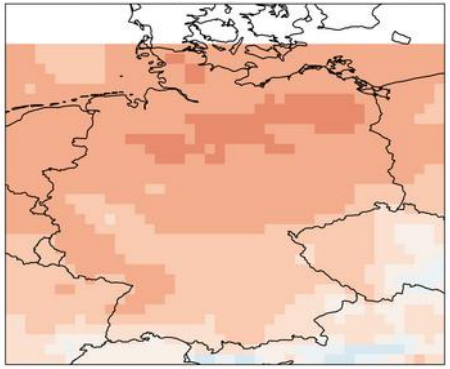
DWD
10 Ensemble Member

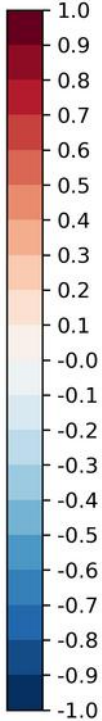


ECMWF
10 Ensemble Member



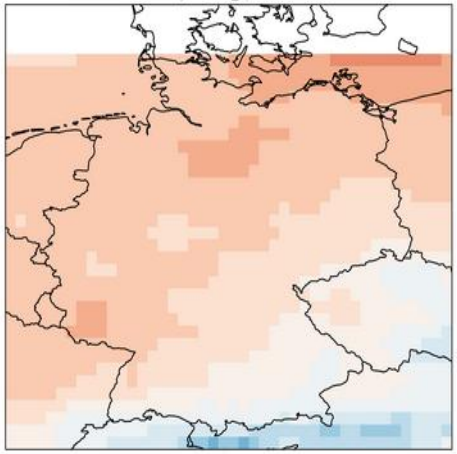
Meteo France
10 Ensemble Member



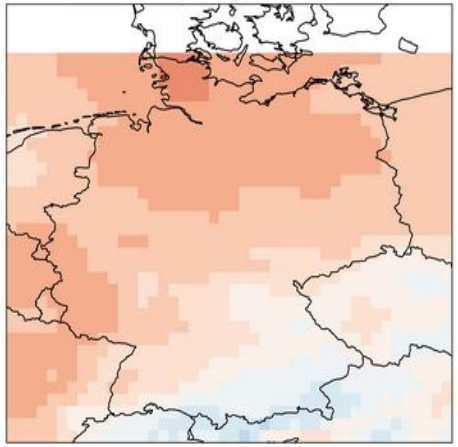


Hindcast
Subsampling (1993-2016)
Initial time: November
Leadtime: Month 2-4 (winter; DJF)

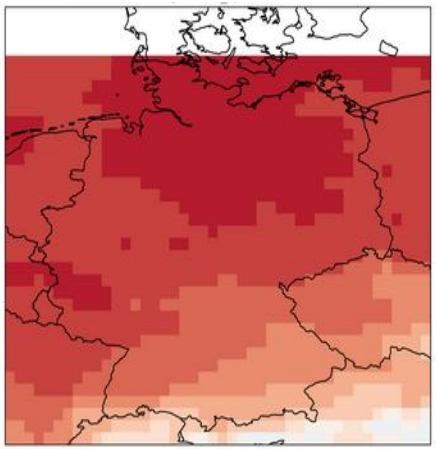
100m Wind (ACC: Multimodel)



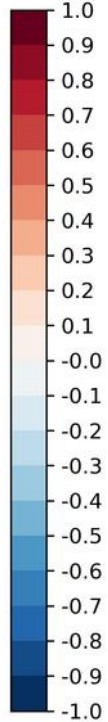
Multimodel
80 Ensemble Member



Multimodel Subsampling
(Targeted teleconnections based on **temperature**)
10 Ensemble Member



Multimodel Subsampling
(Targeted teleconnections based on **100m wind**)
10 Ensemble Member



Hindcasts (1993-2016)
Initial time: November
Leadtime: **Month 2-4**
(winter; DJF)

Summary

➡️ Seasonal forecasts of **100m wind** (Germany, winter, leadtime 2-4 months) have **relatively good skill**

- Full ensemble: large ensemble spread, tendency for low/high 100m wind in 3 month period
- Subsampling: better skill and tendency for low/high 100m wind; smaller ensemble spread, risk of missing reanalysis value

➡️ Seasonal **solar radiation** forecasts for summer **more difficult**

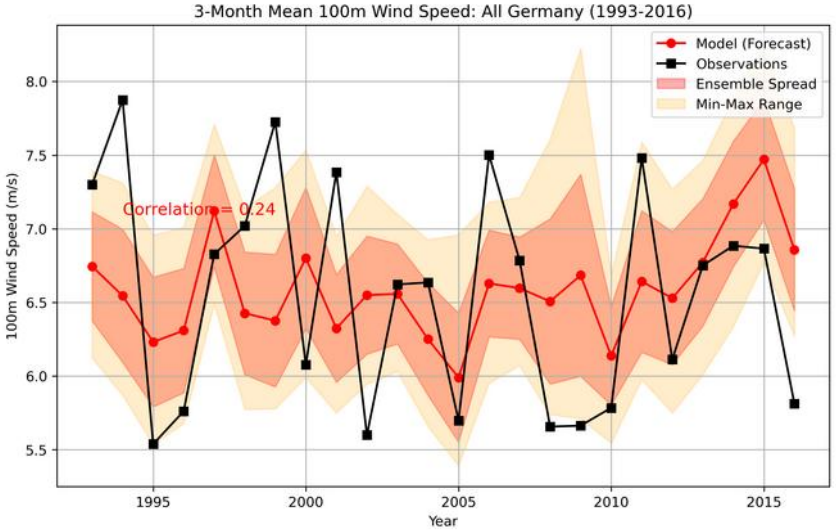
- Full ensemble: no skill for all of Germany (little skill over southern Germany)
- Subsampling: skill increase compared to full ensemble (especially over northern Germany)

➡️ **Multimodel** forecasts with similar skill compared to individual models

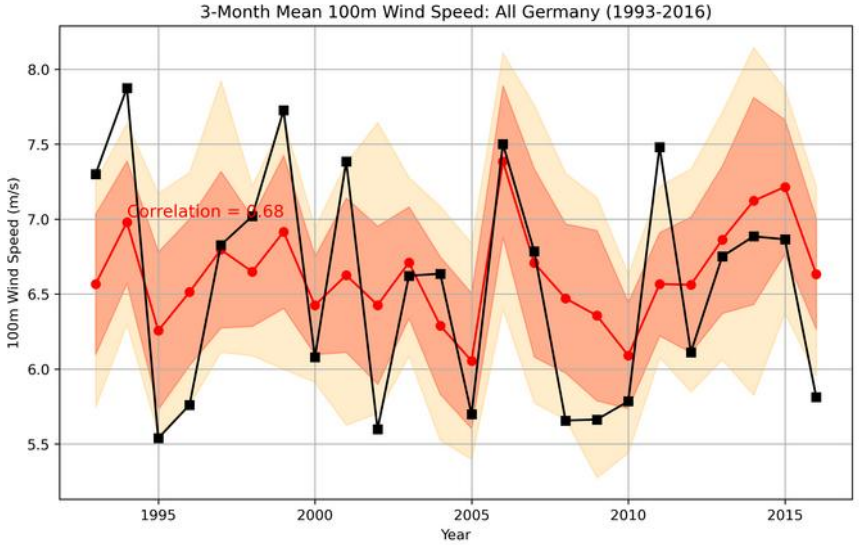
➡️ Outlook: **weather regimes, teleconnections**

Extra Slides

100m Wind (Multimodell)



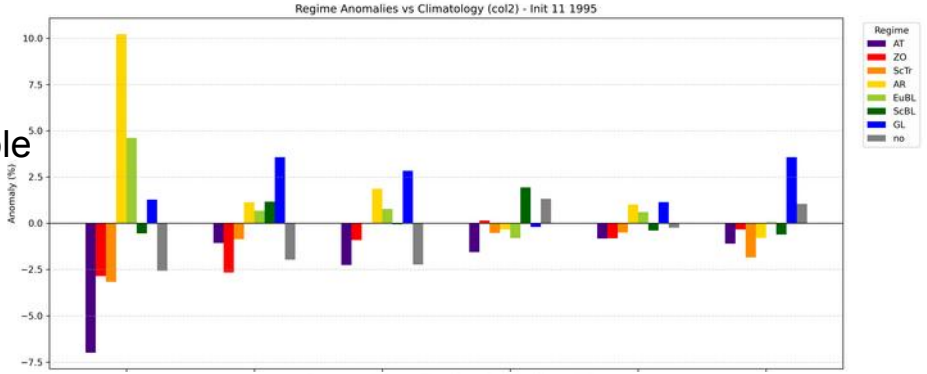
Multimodel Subsampling
(Targeted teleconnections based on **temperature**)
10 Ensemble Member



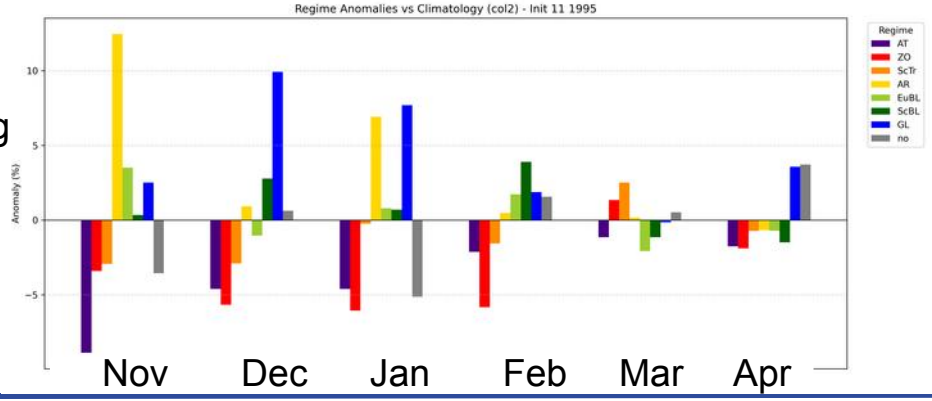
Multimodel Subsampling
(Targeted teleconnections based on **100m wind**)
10 Ensemble Member

Winter 1995/96

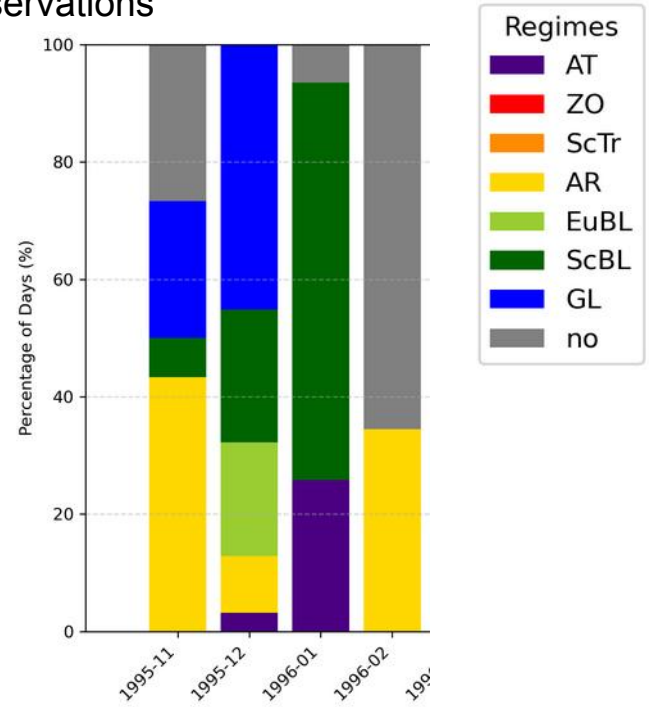
Full Ensemble



Sub-sampling

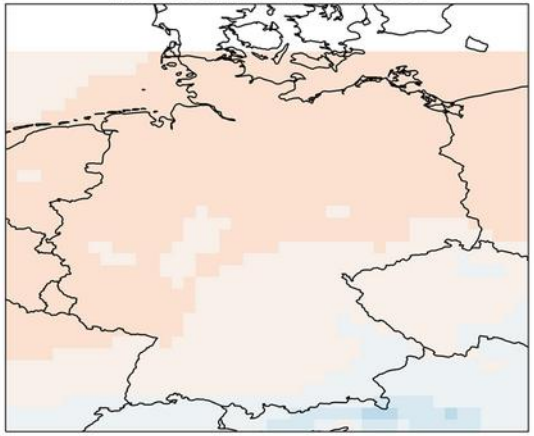


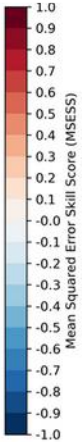
Observations



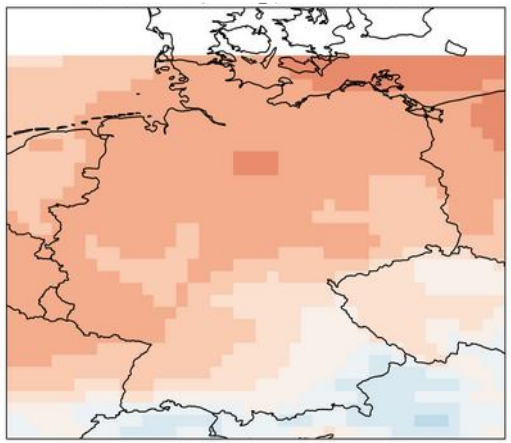
Skill: 100m wind

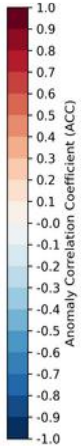
Mean Squared Error Skill Score (MSESS)



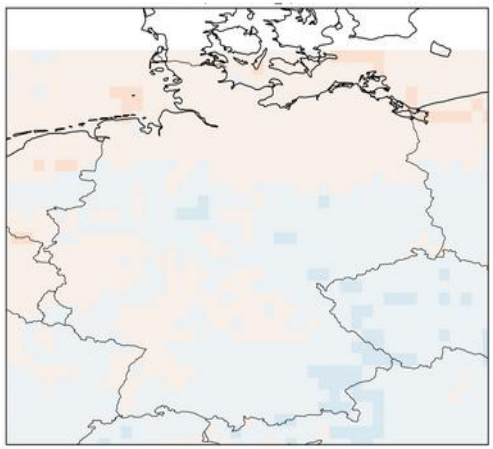


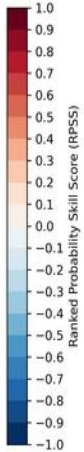
Anomaly Correlation Coefficient (ACC)





Ranked Probability Skill Score (RPSS)



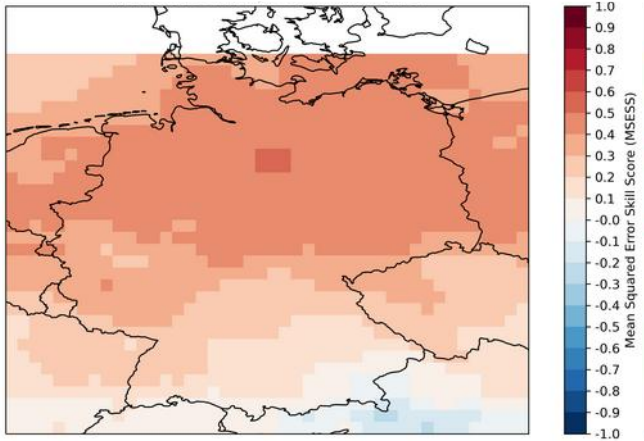


GCFS2.1 Hindcasts
1990-2019
Initial time: November
Leadtime: Month 2-4 (winter; DJF)
Forecasts of 100m wind with EPISODES
Reference: ERA5 reanalysis

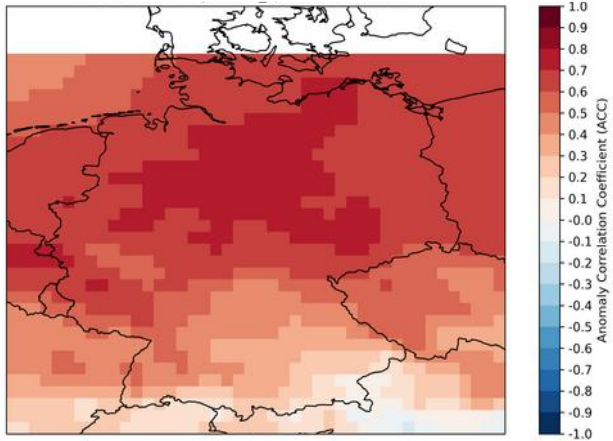
- Full ensemble with skill especially over northern Germany (ACC 0.2-0.4, MSESS 0.1-0.2, RPSS 0-0.1)

Subsampling: 100m wind

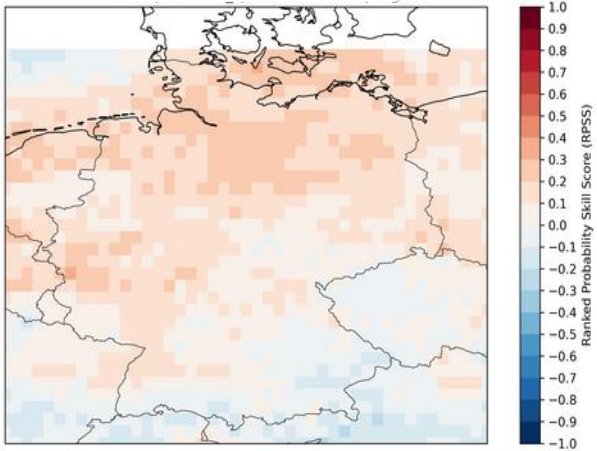
Mean Squared Error Skill Score (MSESS)



Anomaly Correlation Coefficient (ACC)



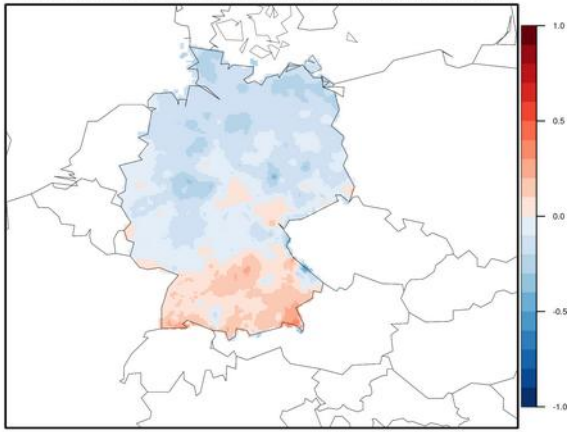
Ranked Probability Skill Score (RPSS)



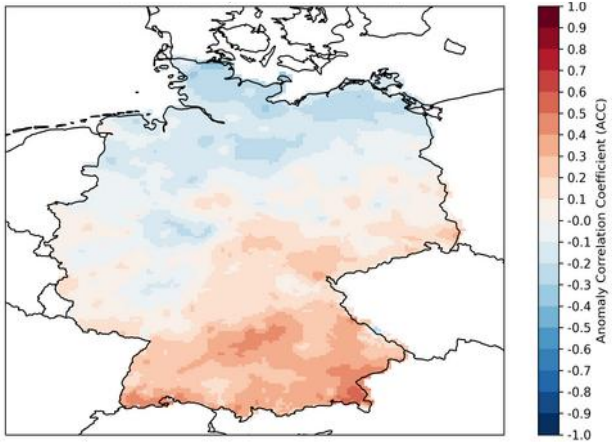
- Strong increase in skill with subsampling
- Northern Germany: ACC 0.5-0.7, MSESS 0.4-0.5, RPSS 0.1-0.3

Skill: solar radiation

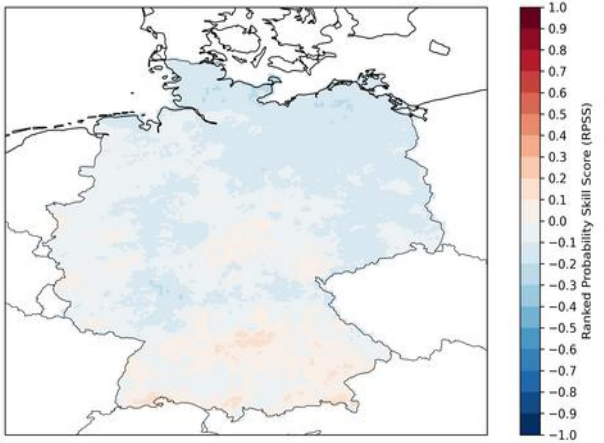
Mean Squared Error Skill Score (MSESS)



Anomaly Correlation Coefficient (ACC)



Ranked Probability Skill Score (RPSS)

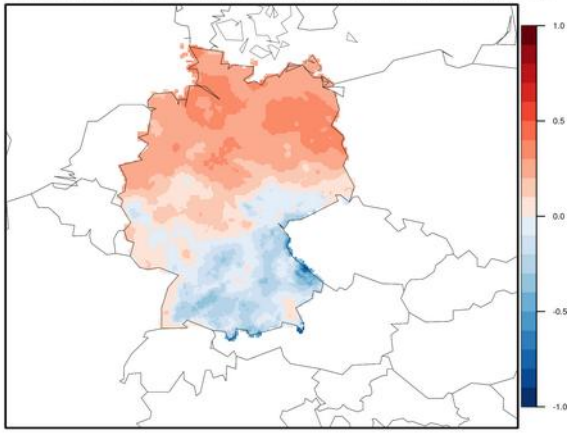


GCFS2.1 Hindcasts
1990-2020
Initial time: Mai
Leadtime 2-4 (Sommer; JJA)
Forecasts of solar radiation with EPISODES
Reference: HYRAS

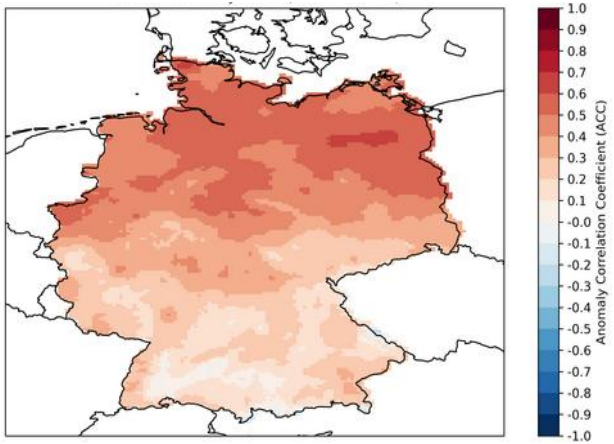
- Full ensemble has some skill only over southern Germany (ACC 0.2-0.4, MSESS 0.1-0.2, RPSS 0-0.1)

Subsampling: solar radiation

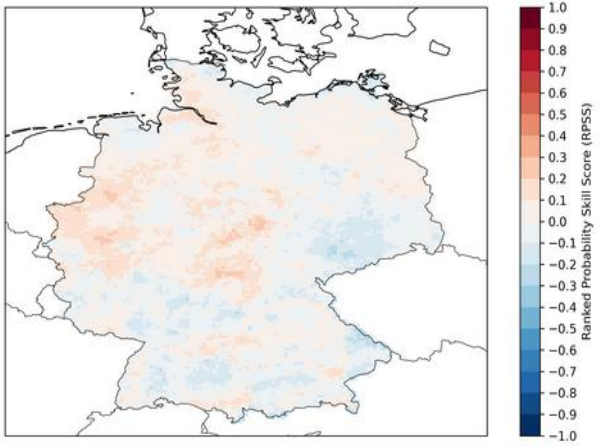
Mean Squared Error Skill Score (MSESS)



Anomaly Correlation Coefficient (ACC)



Ranked Probability Skill Score (RPSS)



- Subsampling improves the forecast skill over northern and central Germany (southern Germany with worse skill compared to full ensemble)
- Northern Germany: ACC 0.5-0.7, MSESS 0.4-0.5, RPSS 0.1-0.3

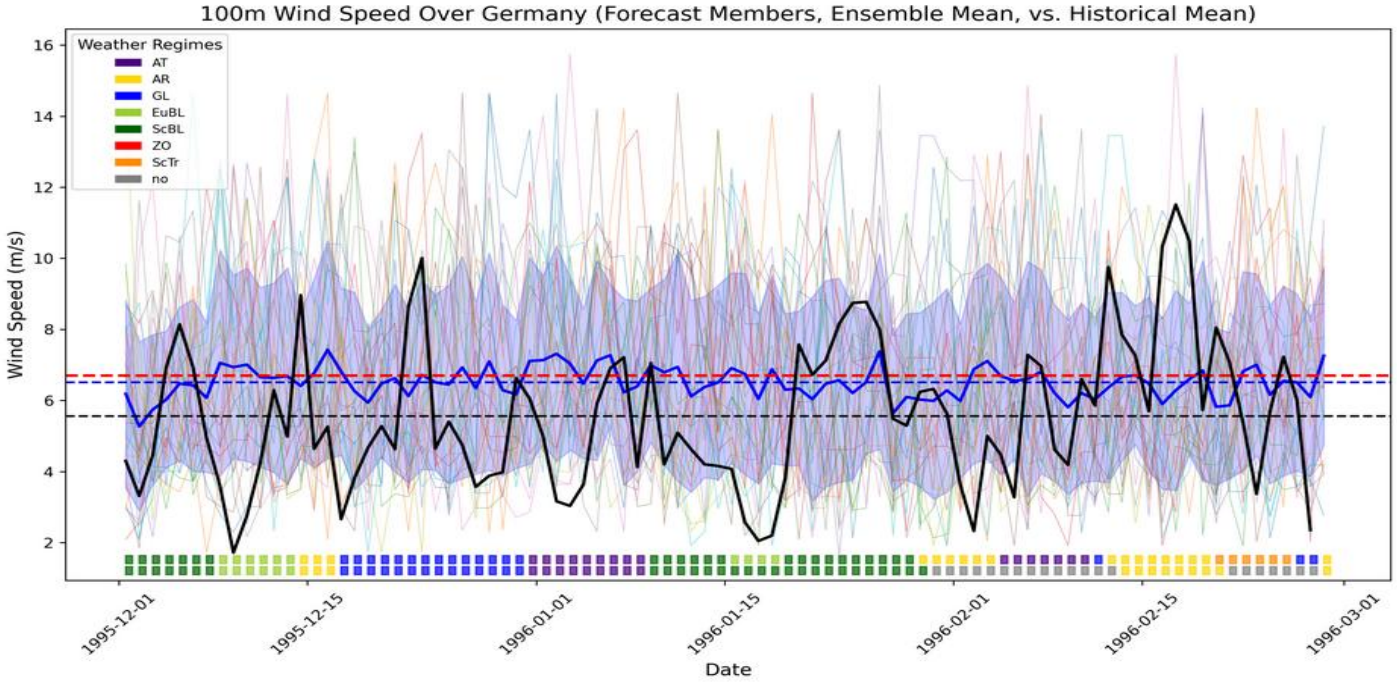
Overview: Skill

		Korrelation	MSESS	RPSS
0	gar kein skill	<0.1	<0.0	<0.0
1	fast kein skill	0.1-0.2	>0.0	>0.0
2	etwas skill	0.2-0.3	>0.1	>0.1
3	mäßig skill	0.3-0.4	>0.2	>0.2
4	guter skill	0.4-0.5	>0.3	>0.3
5	sehr guter skill	>0.6	>0.4	>0.4

100m Wind					Strahlung			
Initial Time	1--3	2--4	3--5	4--6	1--3	2--4	3--5	4--6
Januar								
Februar	0, 0, 0	0, 0, 0	0, 0, 0	1, 1, 1	0, 1, 0	0, 0, 0	0, 0, 0	1, 1, 1
Subsampling_new	*1, 2, 0*	*0, 0, 0*	0, 0, 0	*3, 4, 3*	0, 0, 0	1, 1, 1	1, 1, 1	*3, 4, 2*
März								
April								
Mai	1, 0, 2	1, 0, 2	2, 1, 2	1, 0, 3	2, 2, 2	0, 0, 1	0, 0, 1	1, 1, 2
Subsampling_new	*3, 2, 3*	*3, 3, 3*	*3, 2, 4*	*0, 0, 1*	*3, 4, 2*	*3, 4, 2*	*3, 2, 3*	*0, 0, 0*
Juni								
Juli								
August	0, 0, 0	0, 0, 1	1, 1, 1	1, 1, 1	1, 2, 0	1, 1, 2	2, 1, 2	2, 2, 1
Subsampling_new	0, 1, 0	0, 0, 1	3, 4, 1	*5, 5, 3*	1, 2, 0	2, 2, 3	1, 0, 2	1, 1, 1
September								
Oktober								
November	0, 0, 0	2, 2, 1	0, 0, 0	0, 0, 0	2, 2, 1	0, 1, 0	0, 0, 0	0, 0, 0
Subsampling	*1, 2, 0*	*4, 4, 3*	*1, 1, 1*	*0, 0, 0*	1, 1, 1	1, 2, 0	0, 0, 0	0, 0, 0
Subsampling_new	*3, 4, 1*	*5, 5, 3*	2, 2, 1	1, 0, 1	1, 1, 0	1, 2, 0	0, 0, 0	0, 0, 0
Dezember								

Winter 1995/96: Full Ensemble

Predictions of wind speed (100m) (Full Ensemble) und Observations



Observations (ERA5)

3-month mean of daily observations in DJF 1995/1996

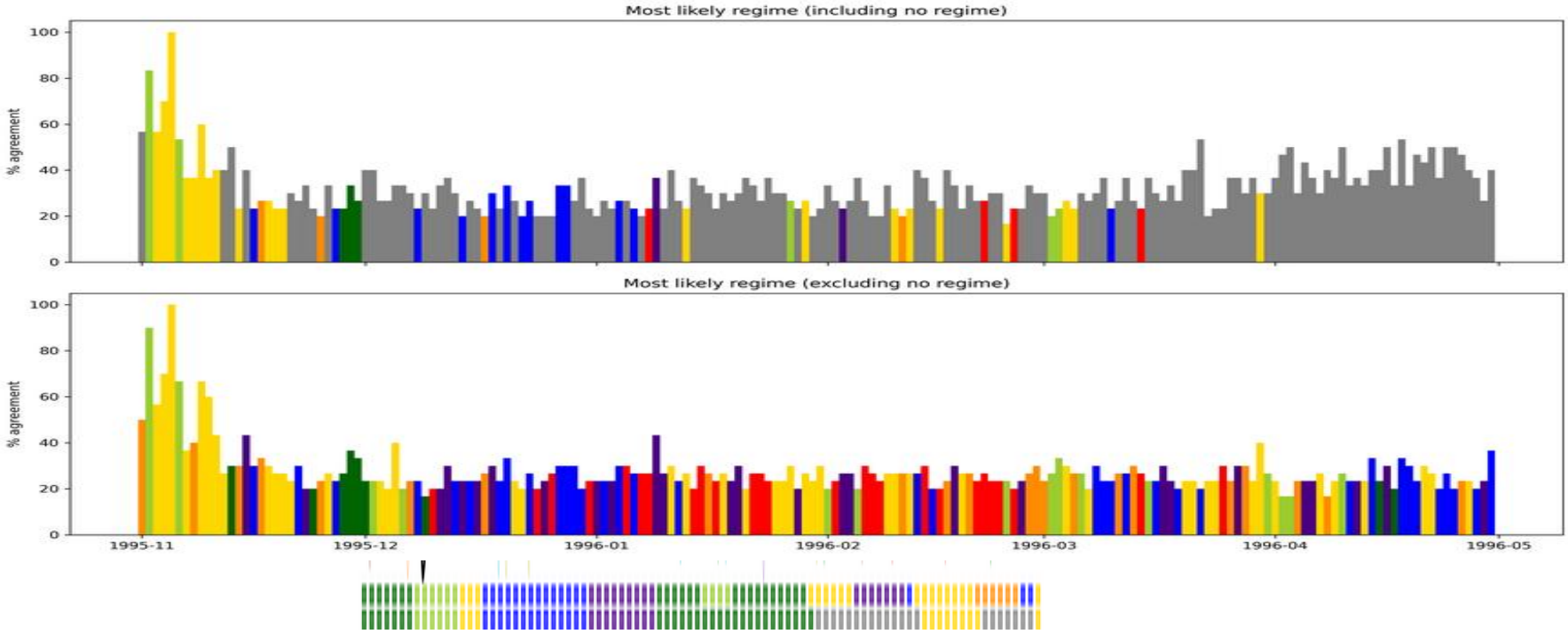
Climatology (DJF; 1990-2020)

Ensemble Mean of forecast (daily)

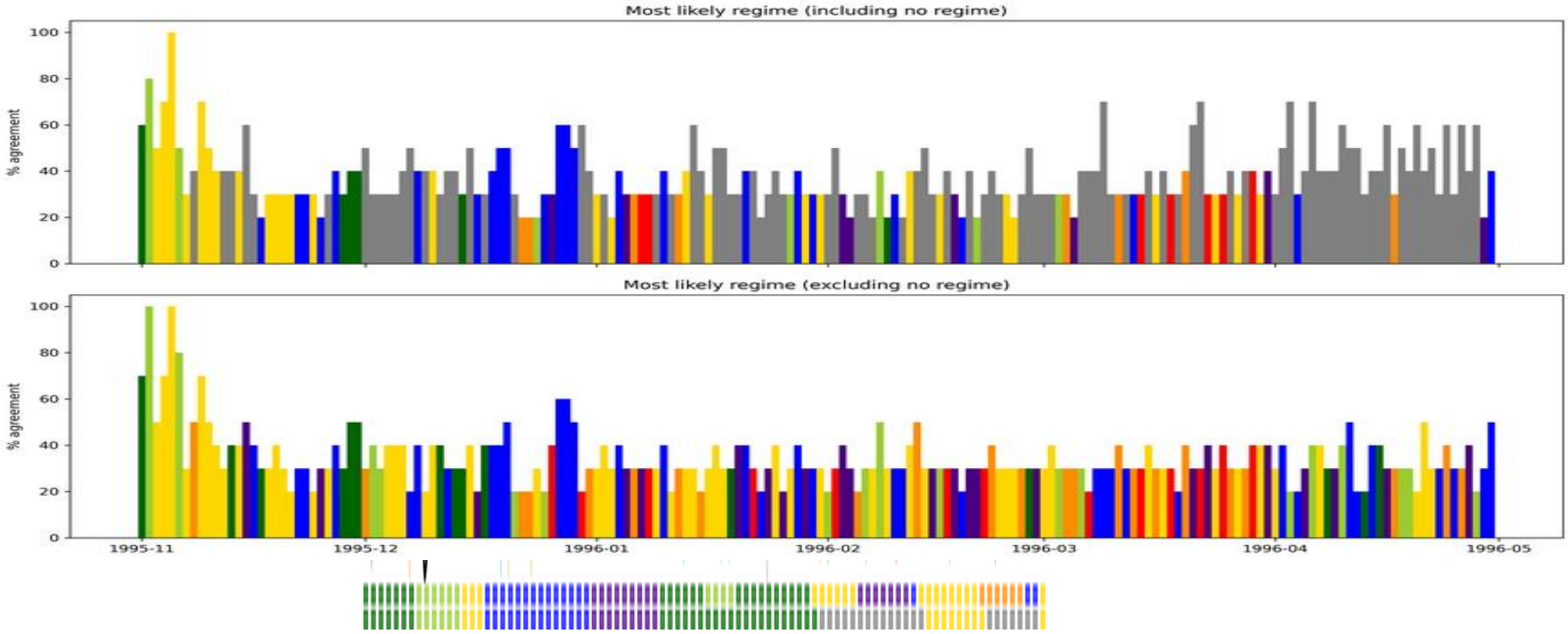
3-month mean of the forecast (DJF 1995/96)

GCFS2.1
November Start
Leadtime 2-4 (Winter; DJF)

Winter 1995/96

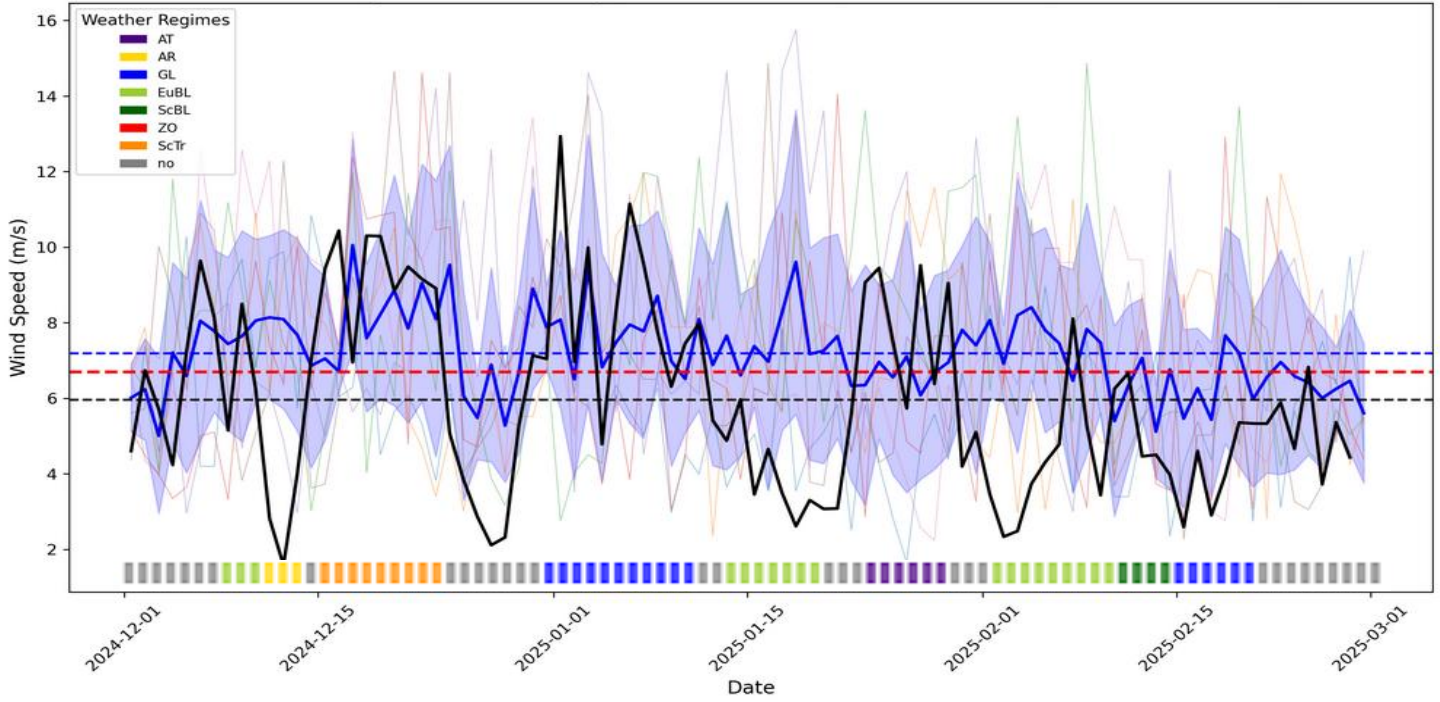


Winter 1995/96



Winter 2024/25: Subsampling

Predictions of wind speed (100m) (Subsampling) und Observations



Observations (ERA5)

3-month mean of daily observations in DJF 2024/25

Climatology (DJF; 1990-2020)

Ensemble Mean of subsampling (daily)

3-month mean of subsampling (DJF 2024/25)

GCFS2.1
November Start
Leadtime 2-4 (Winter; DJF)