Weather dependency of European wind and photovoltaic power production for present and future installations

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EGU abstract

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1. Overview

Motivation

- Higher share of wind and photovoltaic (PV) power in Europe in 2050 to meet the climate-neutral target
- The ratio of PV to wind power installation can also change in the future

⇒ Weather patterns associated with extremes in renewable energy can be different compared to present

Research question

- Which pairs of weather pattern—extremes in power production are sensitive to the installed capacity?
- Seasonal differences and the duration dependency of these association?

2. Method

- Reanalysis data COSMO-REA6 hourly with 6 km horizontal resolution 1995—2017 [1]
- Simulation PV [2] and wind power capacity factor
- Future installation (2050) from CLIMIX [3]: 870 GW of PV power, 440 GW of wind power
- Present-day installation using scaling factor: 120 GW of PV power, 167 GW of wind power [4]

⇒ Hourly power production of PV and wind power

⇒ Paired with classification of daily weather patterns of 29 types [5]

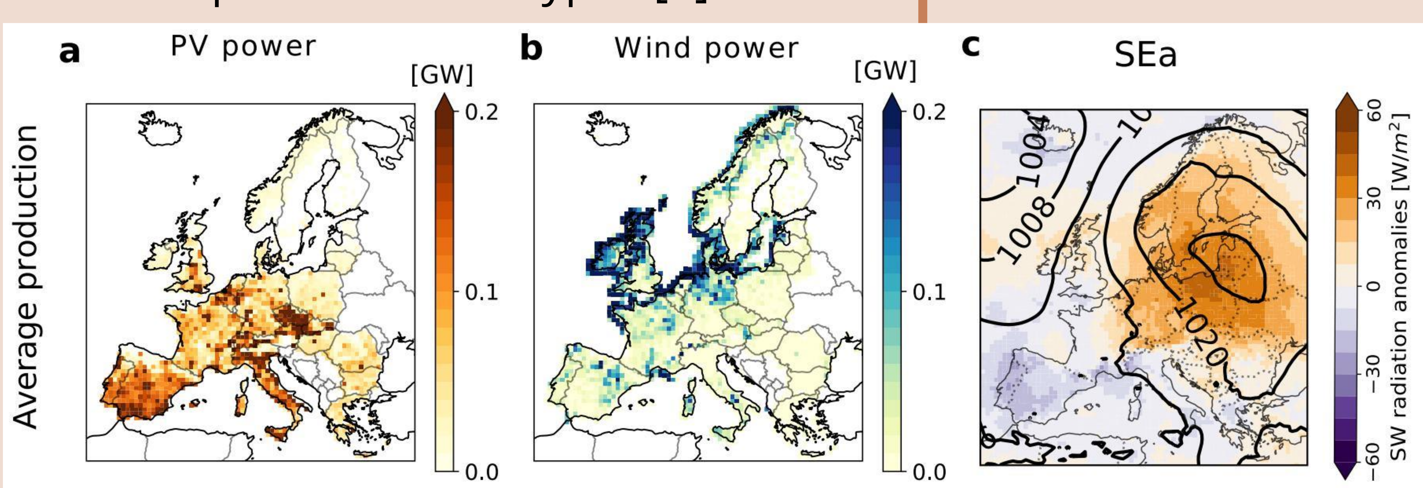

Fig 1. (a,b) Hourly average of power production of PV and wind power 1995—2017; (c) Climatological mean of Anticyclonic Southeasterly (Sea), showing radiation anomaly (shading) and mean sea level pressure (contour).

3. Weather pattern differences

- Compared to present-day installation, total production anomalies in the future installation have similar sign but smaller magnitude
- Highest total production associated with patterns with westerly wind
- Patterns associated with lowest total production depend on the installed capacity
- Dark doldrum (low in both PV and wind power production), e.g., Ws, associated with the lowest total production in the future installation

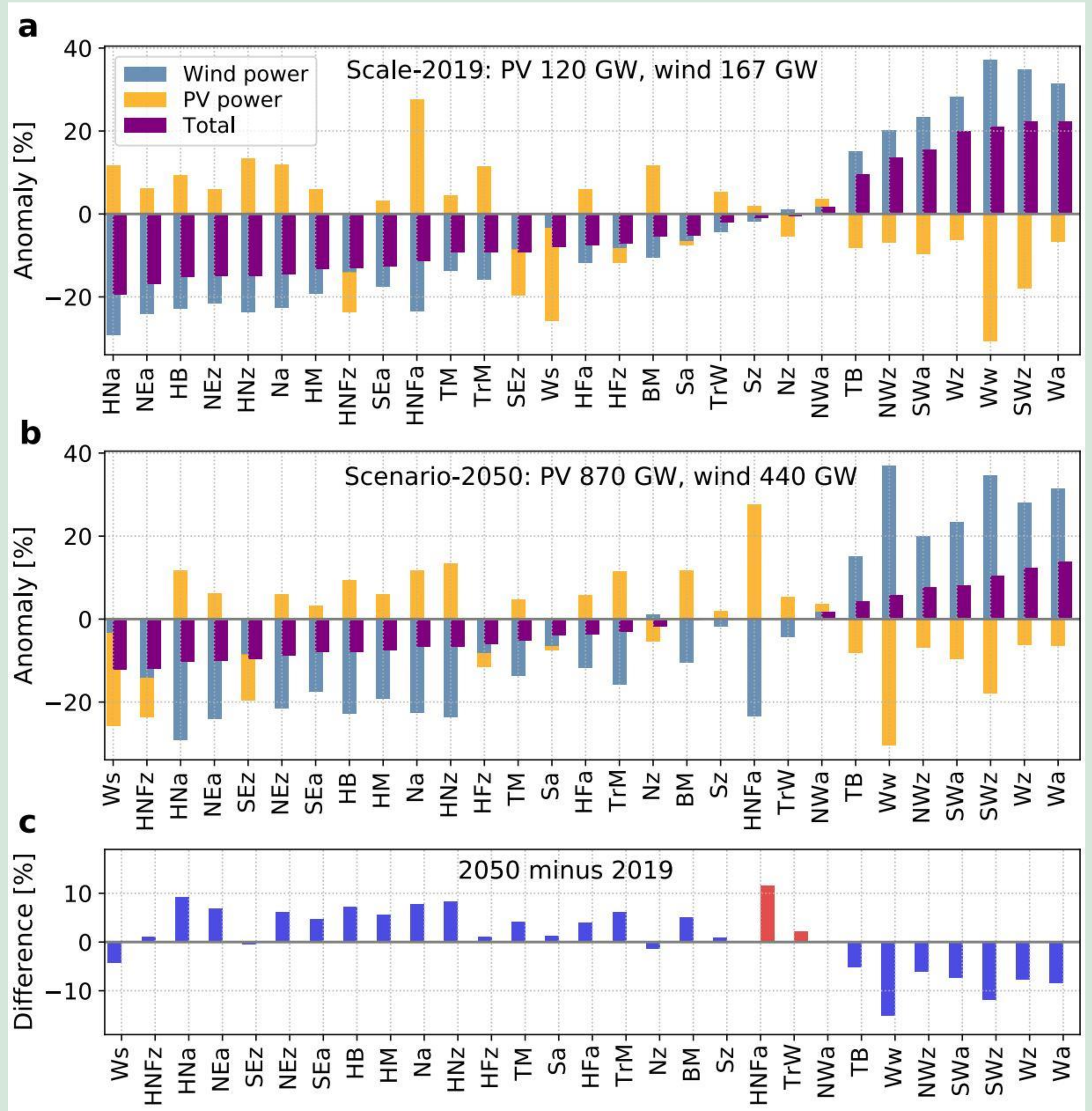

Fig 2. Anomalies of PV, wind power and their total production for Europe by weather patterns with (a) present-day and (b) scenario-2050 installation, (c) their difference of total production anomalies, changed signs in red.

4. Seasonal differences

For both lowest and highest power production:

- More events occur in the winter
- High frequency of 1-day events in October, of 14-day events in December
- Increase of events occur in the summer in the future installation

For highest production: less seasonal difference, less dependency on installation

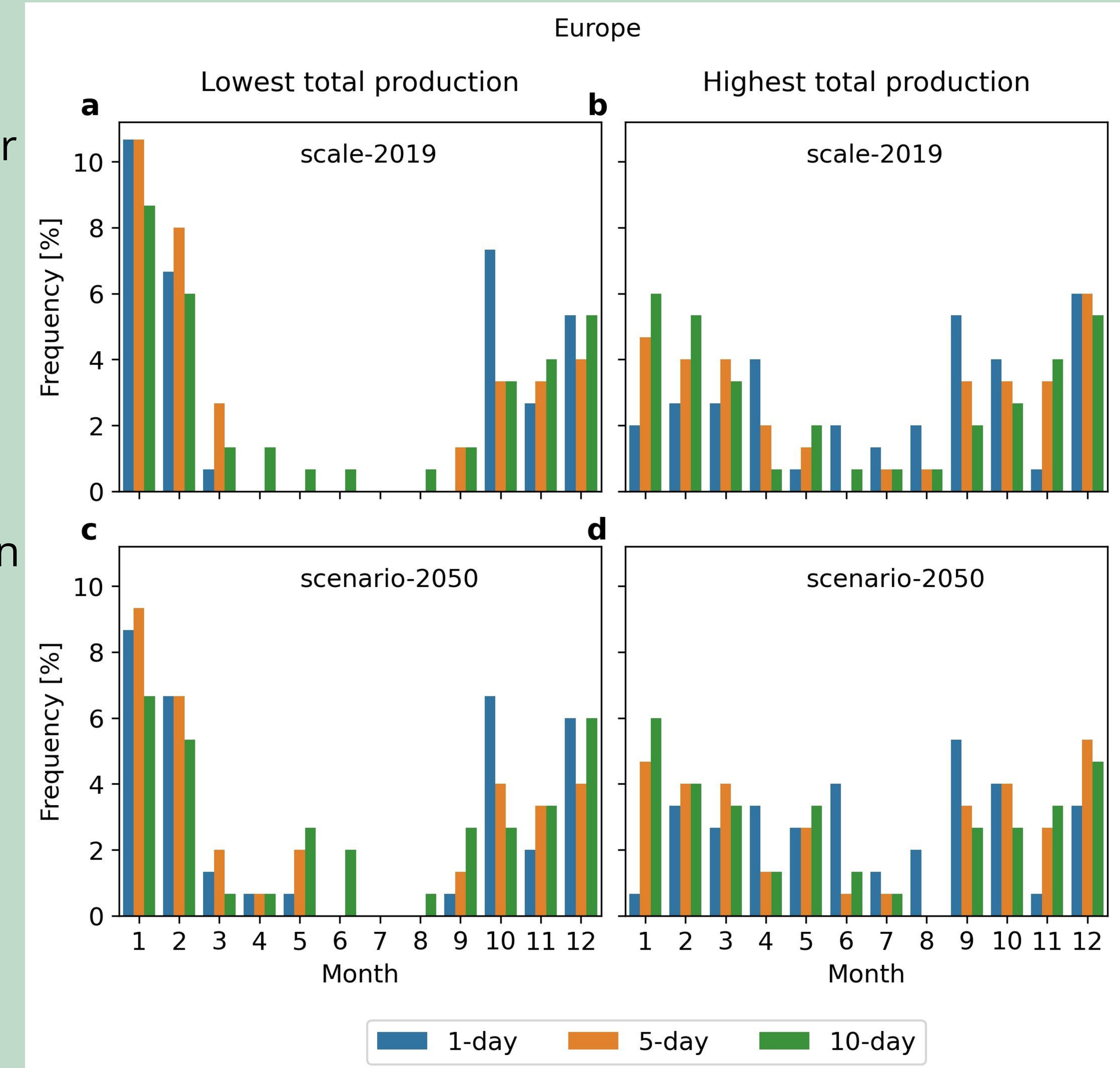

Fig 3. Frequency of occurrence of 50 lowest and highest total production events for Europe by month of year, colour denotes the duration of the event (1, 5, 10 days), for two installations.

5. Duration differences

- In the future installation, patterns associated with the lowest total production change more than with the highest production
- Events with duration 1 and 5 days similar to events for hourly production
- SEa (Anticyclonic Southeasterly) associated with 10-day lowest total production for both installations
- In region C and D, the anomalous production events depend on the installation more than region A and B

		1-day average [TWh/day]	Lowest production event 1-day	Lowest production event 5-day	Lowest production event 10-day	Highest production event 1-day	Highest production event 5-day	Highest production event 10-day
Total 2019	Europe	1.81	HNa	HB	SEa	Wa	Wa	Wz
	A	0.09	TB	TB	Ws	HB	HM	HM
	B	0.54	HM	HM	BM	SWz	SWz	Wz
	C	0.18	Wa	Wa	Wa	TB	TB	Ws
	D	0.04	SWz	SWa	SEa	TM	TM	Ws
Total 2050	Europe	6.74	*Ws*	*SEz*	SEa	Wa	Wa	*NWz*
	A	0.26	TB	*Ws*	Ws	HB	HM	HM
	B	1.73	HM	HM	BM	*Wa*	SWz	Wz
	C	0.95	Wa	*Ww*	*SEa*	*TM*	*TM*	Ws
	D	0.22	*Ww*	*NEa*	*BM*	*HNz*	TM	Ws

−100 −75 −50 −25 0 25 50 75 100

Anomalies [%]

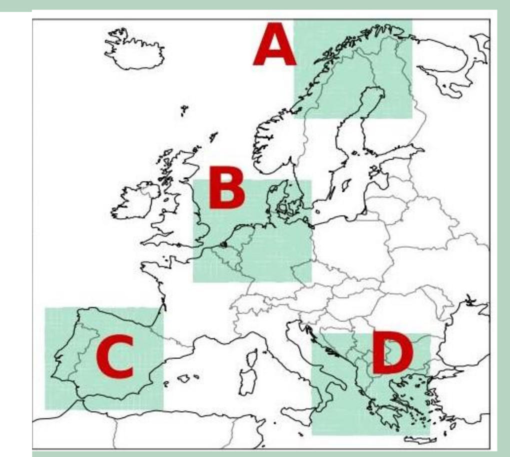

Fig 4. Weather patterns associated with events that have the same pattern for 1, 5, and 10 days, for Europe and four selected regions (above)

6. Conclusion

- Weather patterns with prevailing westerly wind are associated with high total production, regardless of the installed capacity and duration
- Dark doldrum (simultaneously low PV and wind power production) are associated with the lowest hourly total production in the future installation
- Patterns associated with the lowest total production strongly depend on the event duration, except for Anticyclonic Southeasterly (SEa) with 10-day events
- In the future, more extreme events in renewable energy occur in the summer

Insights into weather-driven extremes in Europe's resources for renewable energy

(Ho-Tran and Fiedler, 2023, in review)

Names of weather patterns

Wa Anticyclonic Westerly, **Wz** Cyclonic Westerly, **Ws** South-Shifted Westerly, **Ww** Maritime Westerly (Block Eastern Europe), **SWa** Anticyclonic South-Westerly, **SWz** Cyclonic South-Westerly, **NWa** Anticyclonic North-Westerly, **NWz** Cyclonic North-Westerly, **HM** High over CE, **BM** Zonal Ridge across CE, **TM** Low (Cut-Off) over CE, **Na** Anticyclonic Northerly, **Nz** Cyclonic Northerly, **HNa** Icelandic High, Ridge CE, **HNz** Icelandic High, Trough CE, **HB** High over the British Isles, **TrM** Trough over CE, **NEa** Anticyclonic North-Easterly, **NEz** Cyclonic North-Easterly, **HFa** Scandinavian High, Ridge CE, **HFz** Scandinavian High, Trough CE, **HNFa** High Scandinavia-Iceland, Ridge CE, **HNFz** High Scandinavia-Iceland, Trough CE, **SEa** Anticyclonic South-Easterly, **SEz** Cyclonic South-Easterly, **Sa** Anticyclonic Southerly, **Sz** Cyclonic Southerly, **TB** Low over the British Isles, **TrW** Trough over Western Europe (CE: Central Europe).

References and Acknowledgement

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This study has been conducted in the framework of the Hans-Ertel-Centre for Weather Research funded by the German Federal Ministry for Transportation and Digital Infrastructure (grant number BMVI/DWD 4818DWDP5A).