PolarRES
Exploring future polar climates

Arctic sea ice drift and changing response to wind forcing

17.5.2022 AGCI Workshop

Cecilia Äijälä, Chengfei Jiang, Petteri Uotila, Timo Vihma, Gunnar Spreen, Annette Rinke

@PolarRES_EU

www.PolarRES.eu

Outline

- PolarRES
    - Task 4.4
- Wind factor and turning angle
    - Region
    - Data
    - Results
- Future Plans

PolarRES (Polar Regions in the Earth System)

PolarRES

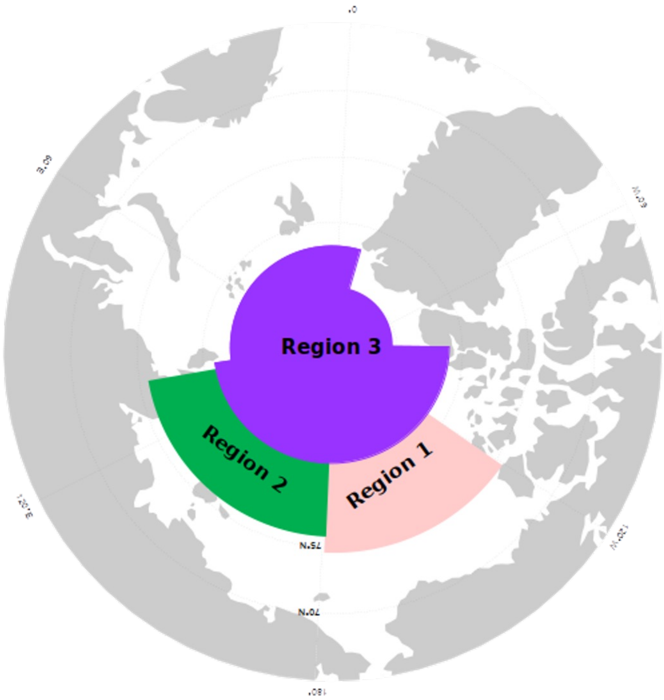
- Funded by the European Union's Horizon 2020 Programme (9/2021-8/2025)
- Aims to make climate projections in the polar regions more reliable by improving our understanding of the polar climate system and its role/position in the global climate system.

Task 4.4

- Study inter-annual and decadal changes in sea ice dynamics
  - Response of ice drift to wind forcing
  - Time series analyses will cover ice drift speed, wind speed wind factor (ratio of drift speed to wind speed) and turning angle

Wind factor and turning angle - Regions

- The Arctic was divided into 3 regions:
  - Region 1 - Chukchi and Beaufort sea
  - Region 2 - Laptev and East Siberian seas
  - Region 3 - Arctic Ocean
- Regions chosen to be same as in Maeda et. al. 2020



Wind factor and turning angle - Data

PolarRES

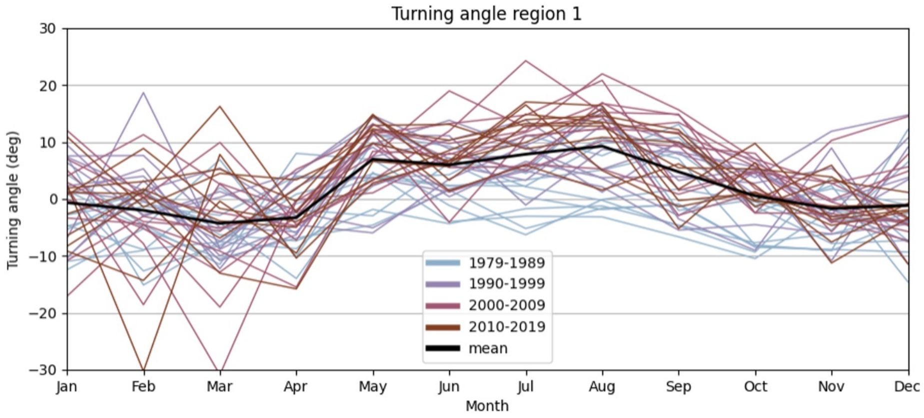
- **Sea ice** velocity:
  - **Polar Pathfinder** Daily 25 km EASE-Grid **Sea Ice Motion Vectors**, Version 4
  - Preprocessing:
    - Convert Pathfinder horizontal and vertical components to east and north components
    - Convert to EASE-Grid 2.0 North (EPSG:6931) 25*25km
- **Wind** Velocity
  - **ERA-Interim** reanalysis data, **mean sea level pressure** 0.75°x0.75
  - Preprocessing:
    - **Calculate geostrophic wind velocity**
    - Convert to EASE-Grid 2.0 North (EPSG:6931) 25*25km

Geostrophic wind

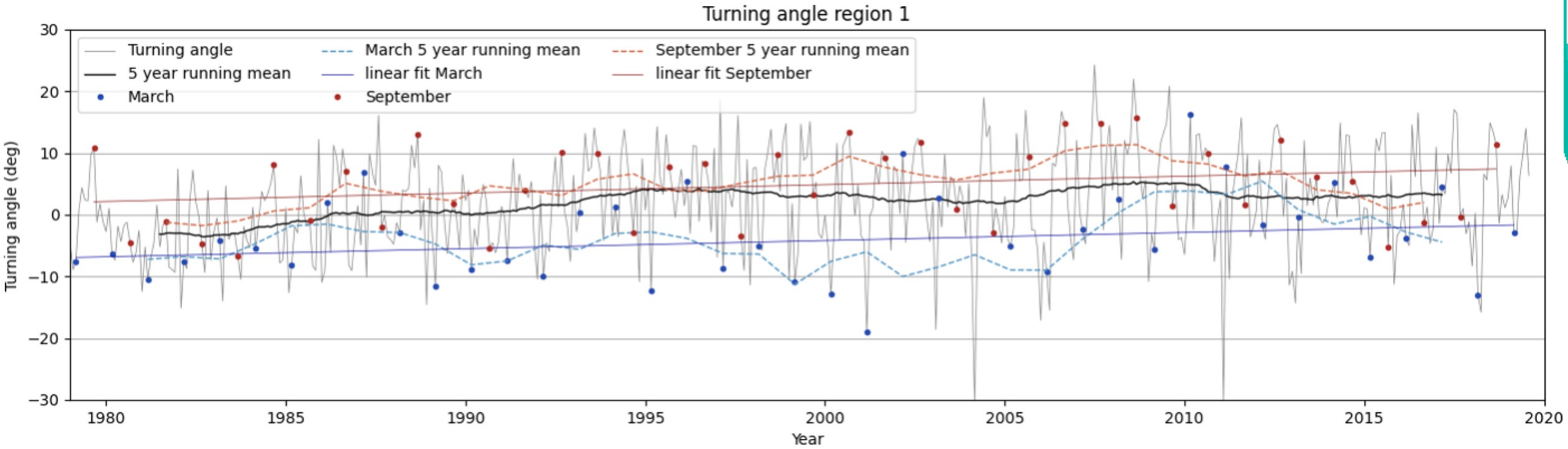
$$\begin{cases} U_g = -\dfrac{1}{\rho f}\dfrac{\partial P}{\partial y}, \\ V_g = \dfrac{1}{\rho f}\dfrac{\partial P}{\partial x} \end{cases}$$

P = pressure, f = coriolis parameter, ρ = air density (1.301 kg/m³)

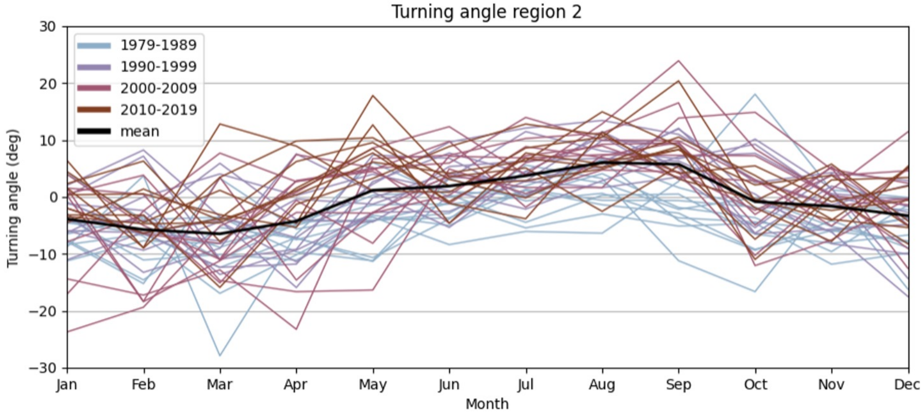
Results - Turning angle region 1



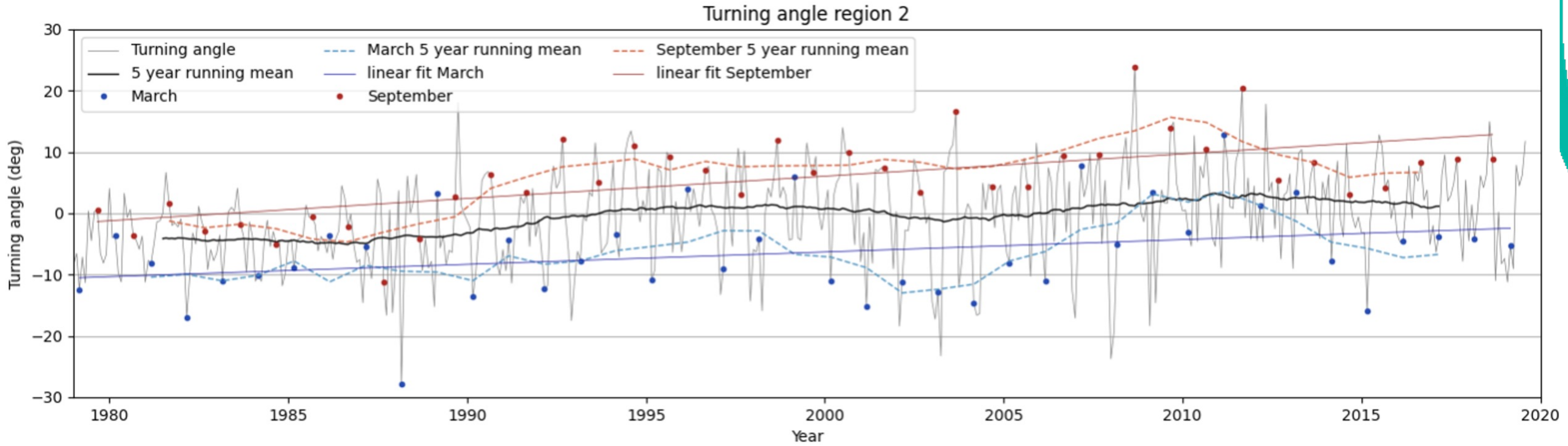
	March	September
Linear trend (°/y)	0.132	0.136
95% confidence interval (°/y)	-0.091 - 0.354	-0.047 - 0.320
R^2	0.035	0.057
p_value	0.238	0.140



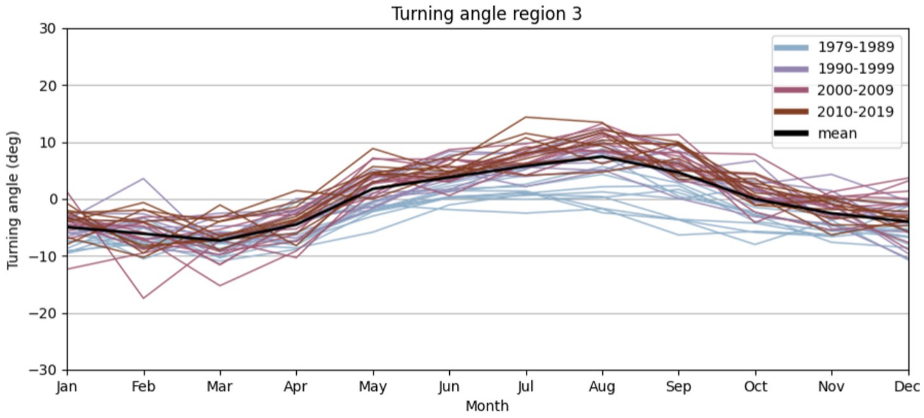
Results - Turning angle region 2



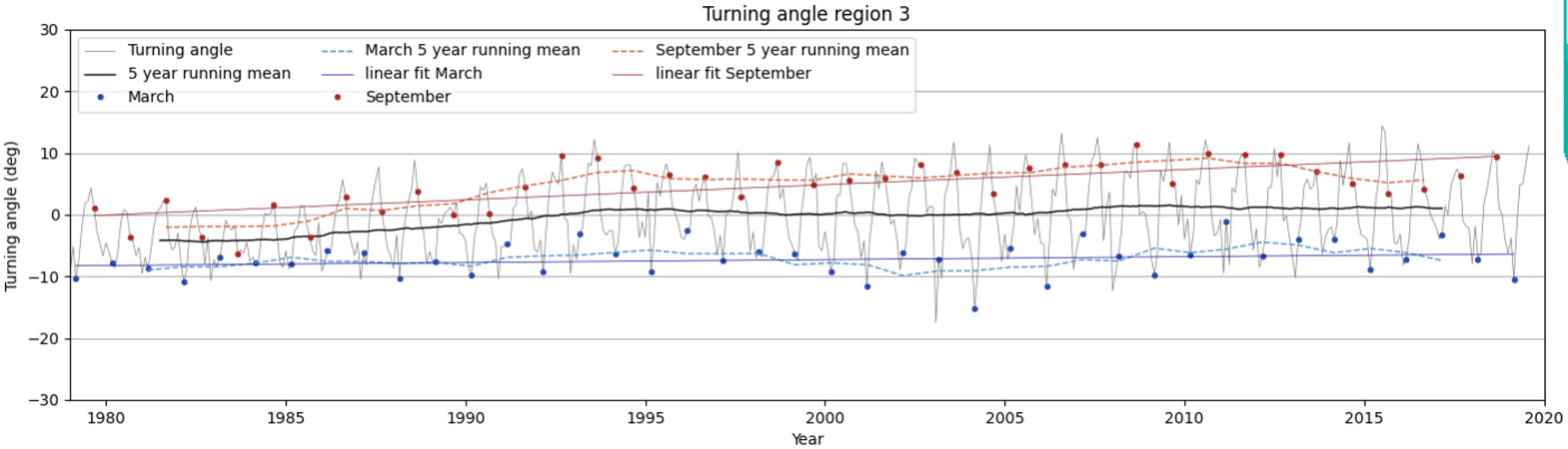
	March	September
Linear trend (°/y)	0.202	0.364
95% confidence interval (°/y)	0.005 - 0.399	-0.211 - 0.517
R^2	0.099	0.378
p_value	0.045	0.000



Results - Turning angle region 3

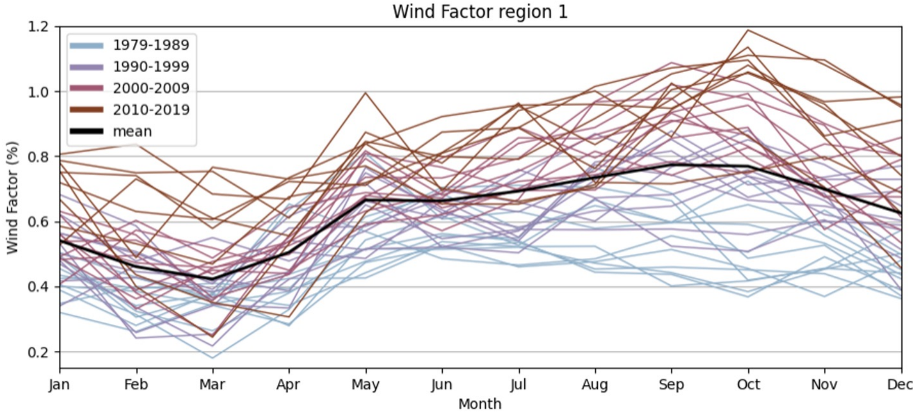


	March	September
Linear trend (°/y)	0.048	0.246
95% confidence interval (°/y)	-0.028 - 0.123	0.159 - 0.333
R^2	0.040	0.464
p_value	0.211	0.000

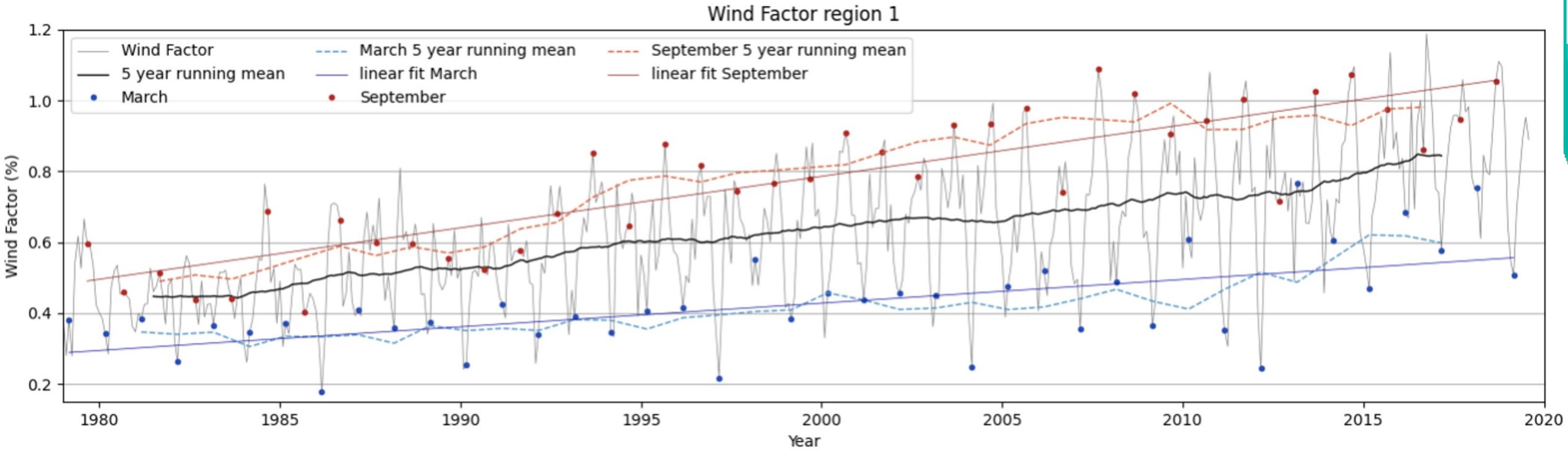


Results - Wind factor region 1

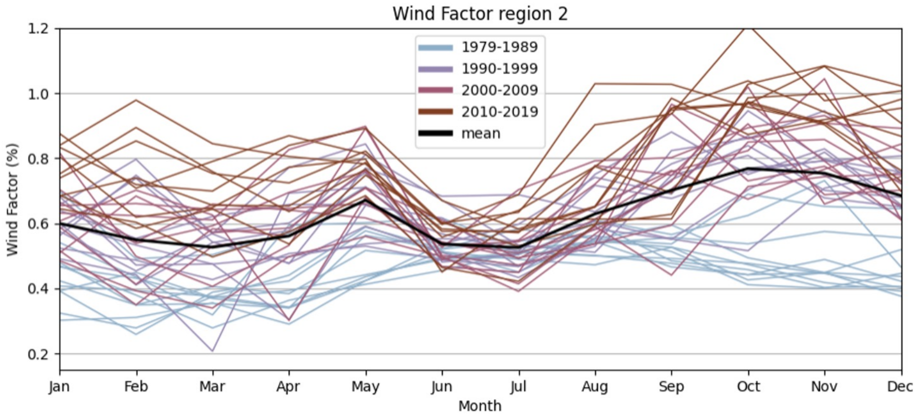
PolarRES



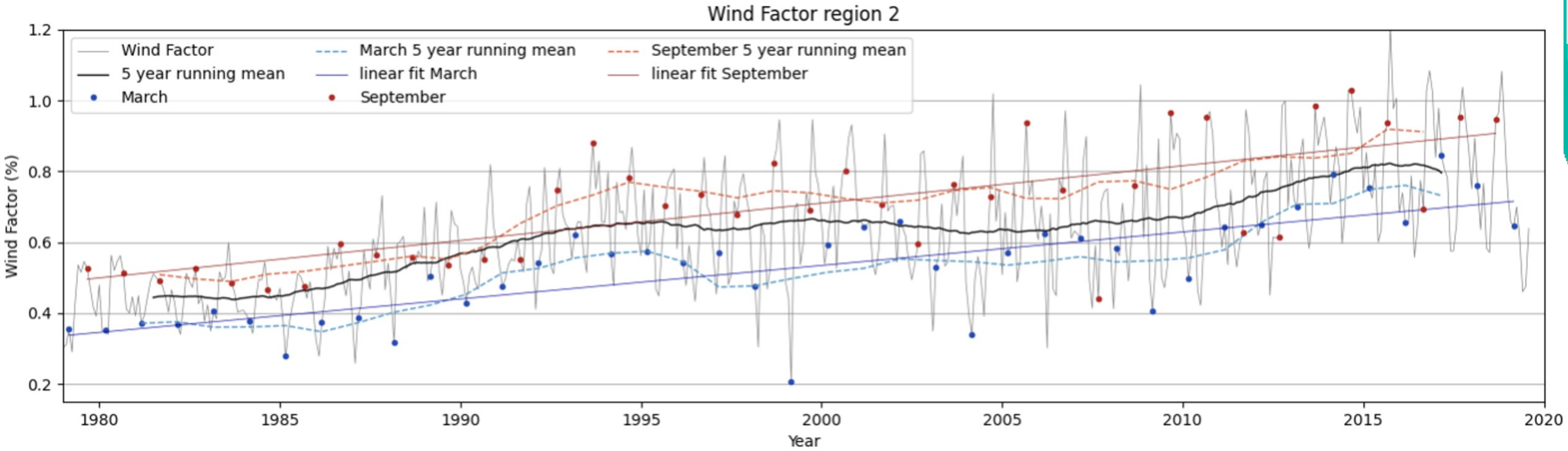
	March	September
Linear trend (%/y)	0.007	0.015
95% confidence interval (%/y)	0.004 - 0.010	0.012 - 0.017
R^2	0.362	0.737
p_value	0.000	0.000



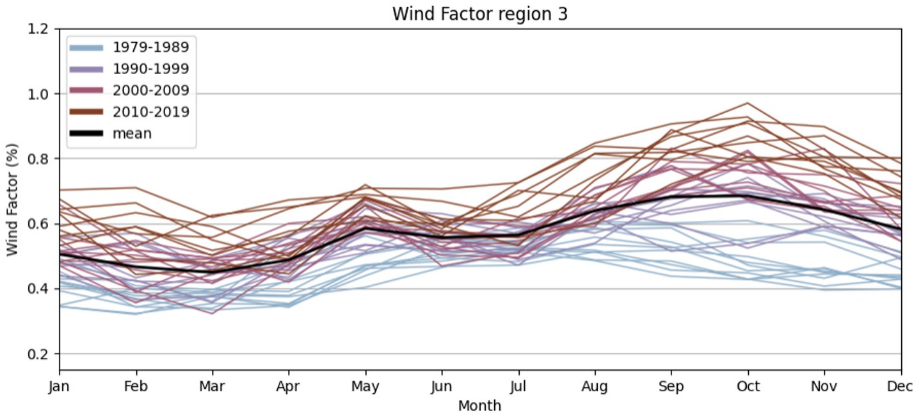
Results - Wind factor region 2



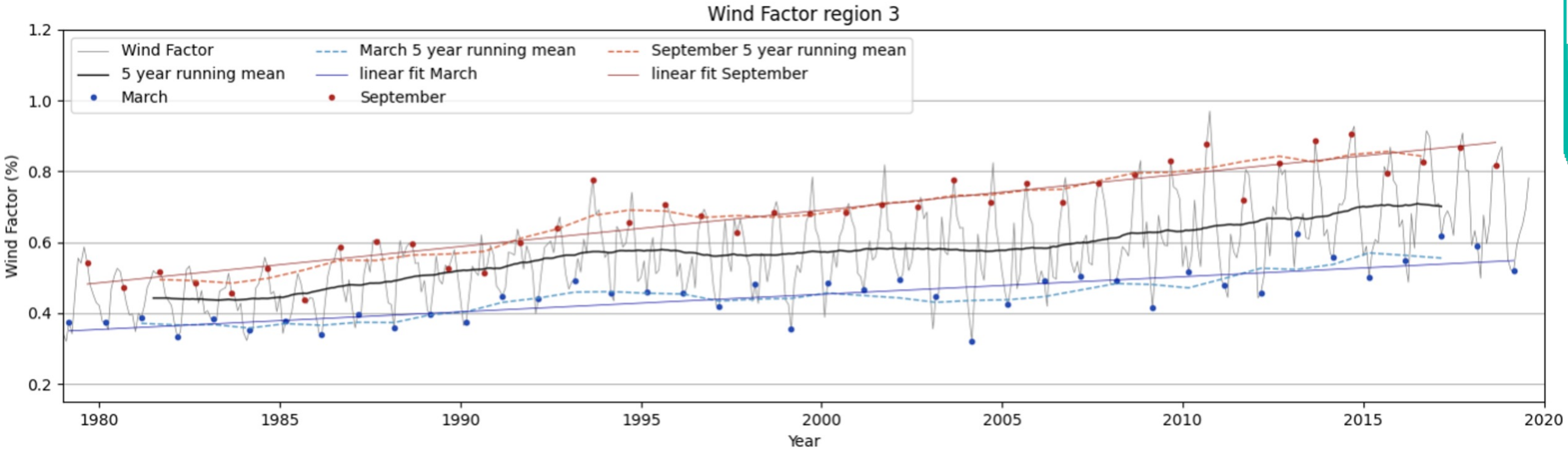
	March	September
Linear trend (%/y)	0.009	0.011
95% confidence interval (%/y)	0.007 - 0.012	0.007 - 0.014
R^2	0.571	0.519
p_value	0.000	0.000



Results - Wind factor region 3



	March	September
Linear trend (%/y)	0.005	0.010
95% confidence interval (%/y)	0.004 - 0.006	0.009 - 0.012
R^2	0.608	0.847
p_value	0.000	0.000



Future plans

PolarRES

- Do the analysis with different datasets to confirm robustness of results e.g:
    - ERA5 instead of Era-Interim
    - Coupled reanalysis by CERA-SAT (2008-2016)
    - Centennial simulations
        - PIOMAS-20C (1901-2010)(Based on CERA-20C)
    - AWI's - "HIRHAM-NAOSIM" model
- Do similar analysis with 10 m wind instead of geostrophic wind
- Look into statistics on extreme wind drift events

Thank you!

PolarRES

Sources:

- Copernicus Climate Change Service (C3S) (2017): ERA5: Fifth generation of ECMWF atmospheric reanalyses of the global climate . Copernicus Climate Change Service Climate Data Store (CDS),
- Dee, D.P., Uppala, S.M., Simmons, A.J., Berrisford, P., Poli, P., Kobayashi, S., Andrae, U., Balmaseda, M.A., Balsamo, G., Bauer, P., Bechtold, P., Beljaars, A.C.M., van de Berg, L., Bidlot, J., Bormann, N., Delsol, C., Dragani, R., Fuentes, M., Geer, A.J., Haimberger, L., Healy, S.B., Hersbach, H., Hólm, E.V., Isaksen, L., Kållberg, P., Köhler, M., Matricardi, M., McNally, A.P., Monge-Sanz, B.M., Morcrette, J.J., Park, B.K., Peubey, C., de Rosnay, P., Tavolato, C., Thépaut, J.N., Vitart, F., 2011. The ERAInterim reanalysis: configuration and performance of the data assimilation system. Q. J. R. Meteorolog. Soc. 137 (656), 553–597. doi:10.1002/qj.828.
- Dorn, W., A. Rinke, C. Köberle, K. Dethloff, and R. Gerdes (2019): Evaluation of the sea-ice simulation in the upgraded version of the coupled regional atmosphere-ocean-sea ice model HIRHAM–NAOSIM 2.0, Atmosphere 10, 431, https://doi.org/10.3390/atmos10080431
- Maeda K, Kimura N, Yamaguchi H. Temporal and spatial change in the relationship between sea-ice motion and wind in the Arctic[J]. Polar Research, 2020.
- Schepers, D., de Boisseson, E., Eresmaa, R., Lupu, C., & de Rosnay, P. (2018). CERA-SAT: A coupled satellite-era reanalysis. 32–37. doi:10.21957/sp619ds74g
- Schweiger, A. J., Wood, K. R., & Zhang, J. (2019). Arctic Sea Ice Volume Variability over 1901–2010: A Model-Based Reconstruction, Journal of Climate, 32(15), 4731-4752. Retrieved May 10, 2022, from https://journals.ametsoc.org/view/journals/clim/32/15/jcli-d-19-0008.1.xml
- Tschudi, M., W. N. Meier, J. S. Stewart, C. Fowler, and J. Maslanik. 2019. Polar Pathfinder Daily 25 km EASE-Grid Sea Ice Motion Vectors, Version 4. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. doi: https://doi.org/10.5067/INAWUWO7QH7B. [Accessed 2022].

Arctik
Communication for sustainability

AWI
ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR-
UND MEERESFORSCHUNG

Danmarks
Meteorologiske
Institut

ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI

LUNDS
UNIVERSITET

Norwegian
Meteorological
Institute

NORCE

NIERSC

UNIVERSITY
OF TURKU

British
Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Universiteit Utrecht

UNIVERSITY OF LEEDS

LIÈGE
université

PolarRES @PolarRES_EU www.PolarRES.eu

PolarRES has received funding from the European
Unions Horizon 2020 Research and Innovation
Programme under Grant Agreement No. 101003590