



Meteorologisk
institutt

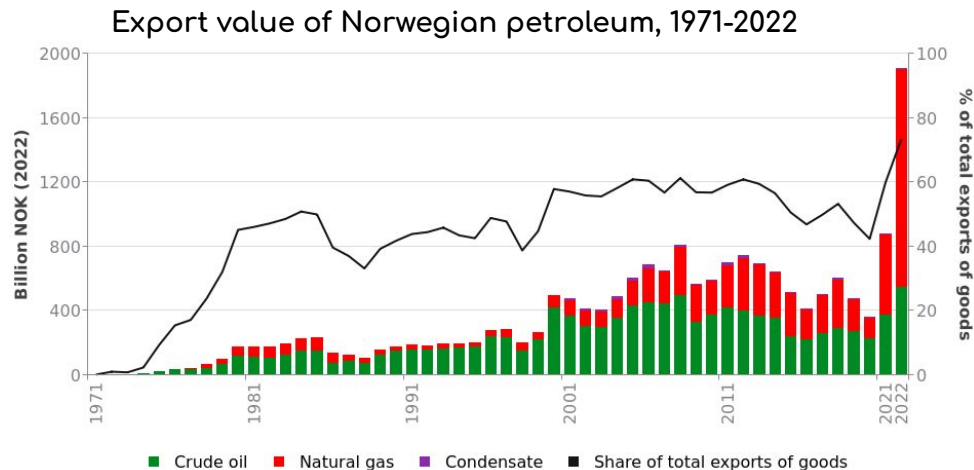
The 3-km Norwegian reanalysis - NORA3

Birgitte Rugaard Furevik, Konstantinos Christakos, Clio Michel,
Hilde Haakenstad, Ana Carasco, Øyvind Breivik, Magnar Reistad

IEA Wind TEM#111 REANALYSES FOR WIND ENERGY at DTU Lyngby 25.04.2024

Offshore forecast and hindcast in Norway

- Closely connected to fisheries, offshore oil & gas and offshore wind
- Including waves - important factor for offshore design and operations



From <https://www.norskipetroleum.no/>

Hywind Tampen



The Hywind Tampen floating wind farm in the North Sea.
(Photo: Karoline Rivero Bernacki / Equinor ASA)

Hindcast and reanalysis in Norway

NOWAMO

MET Norway develops a hybrid wave model which combines swell components with wind sea parameter evolution

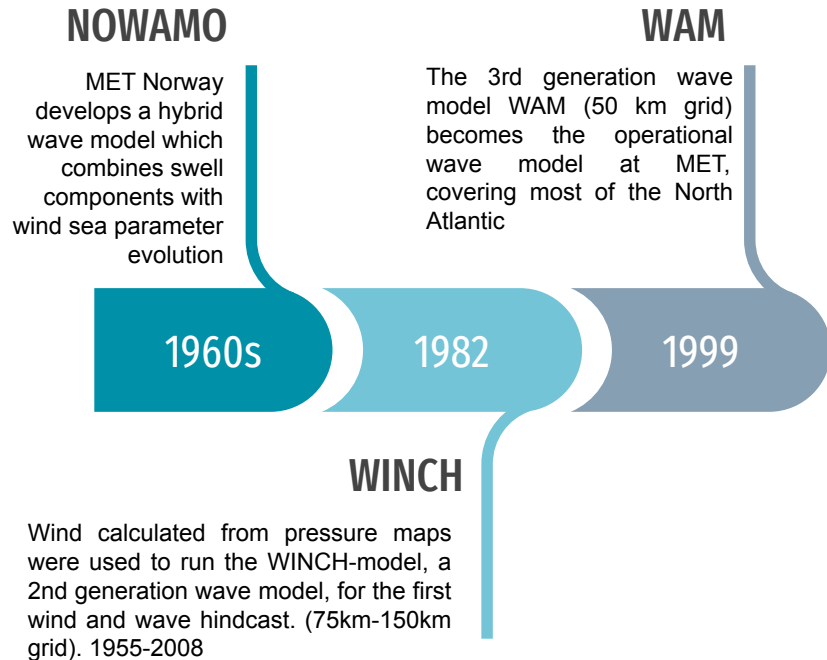
1960s

1982

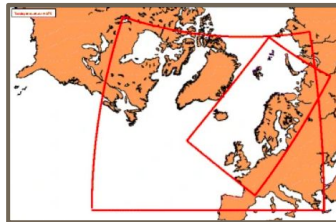
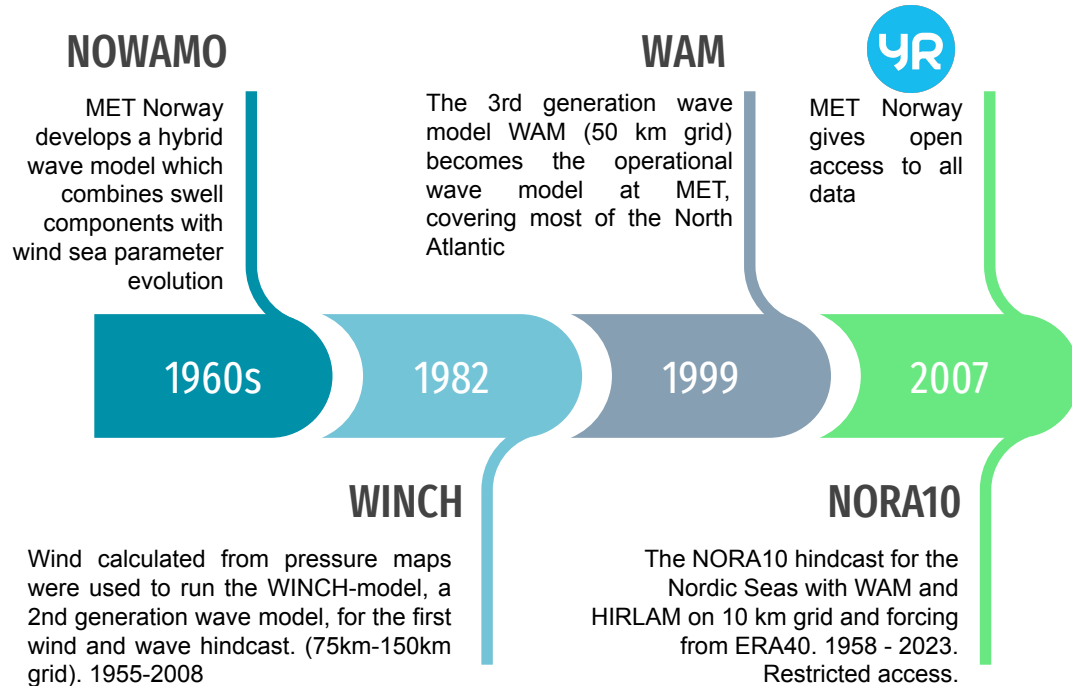
WINCH

Wind calculated from pressure maps were used to run the WINCH-model, a 2nd generation wave model, for the first wind and wave hindcast. (75km-150km grid). 1955-2008

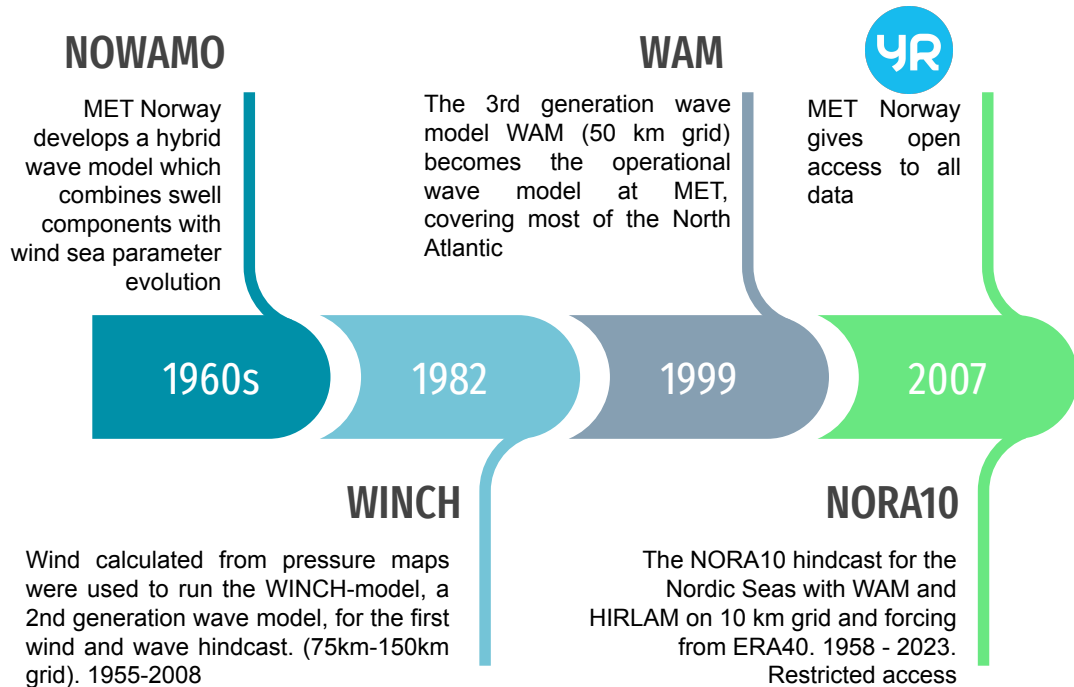
Hindcast and reanalysis in Norway



Hindcast and reanalysis in Norway



Hindcast and reanalysis in Norway



NORA10: Recommended dataset in the NORSOK standard N-003



Hindcast and reanalysis in Norway

NOWAMO

MET Norway develops a hybrid wave model which combines swell components with wind sea parameter evolution

1960s

WAM

The 3rd generation wave model WAM (50 km grid) becomes the operational wave model at MET, covering most of the North Atlantic

1999

4R

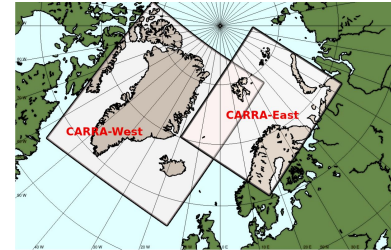
MET Norway gives open access to all data

2007

CARRA

Copernicus Arctic Regional Reanalysis (2.5km grid). 1990 - 2023
open access

2017



PROGRAMME OF THE EUROPEAN UNION

COPERNICUS

ECMWF

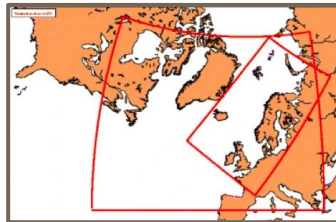
Other partners

WINCH

Wind calculated from pressure maps were used to run the WINCH-model, a 2nd generation wave model, for the first wind and wave hindcast. (75km-150km grid). 1955-2008

NORA10

The NORA10 hindcast for the Nordic Seas with WAM and HIRLAM on 10 km grid and forcing from ERA40. 1958 - 2023.
Restricted access



Hindcast and reanalysis in Norway

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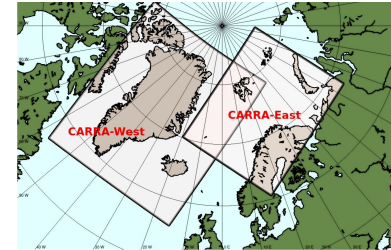
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Copernicus Arctic Regional Reanalysis (2.5km grid). 1990 - 2023
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EUROPEAN UNION

COPERNICUS

ECMWF

NOAA

2020

NORA3

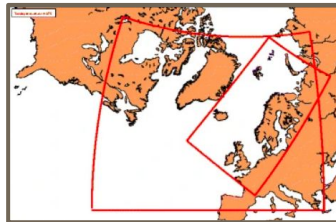
A pan-Arctic wave hindcast with **open access** and 3 km grid with winds from AROME and ERA5. 1970 - 2023

WINCH

Wind calculated from pressure maps were used to run the WINCH-model, a 2nd generation wave model, for the first wind and wave hindcast. (75km-150km grid). 1955-2008

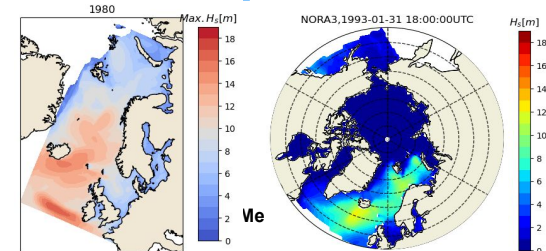
NORA10

The NORA10 hindcast for the Nordic Seas with WAM and HIRLAM on 10 km grid and forcing from ERA40. 1958 - 2023.
Restricted access



NORA10EI

An updated version of NORA10 with **open access** based on ERA-interim. 1979-2017



NORA3

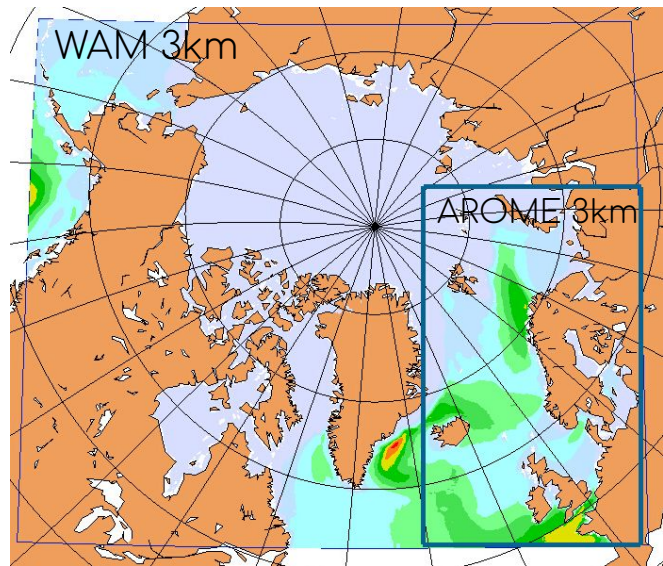
Atmospheric component

- AROME-Harmonie c40h1.2 (operational at MET Norway 2016 - 2020)
- 3 km downscaling of ERA5 as sequence of 9-hour forecast runs
- Adjusted to surface analysis at every forecast cycle, 4 times per day
- Output: Hourly, 3-hourly in model levels

Wave component

- WAM cycle 4.7, with reduced wave growth for high winds
- 3 km pan-Arctic domain (Copernicus)
- Wind from ERA5 and NORA3, boundary spectra from ERA5
- Output: hourly integrated parameters and spectra (30km spacing, 24 by 30 directional/frequency bins)

1970 - 2023

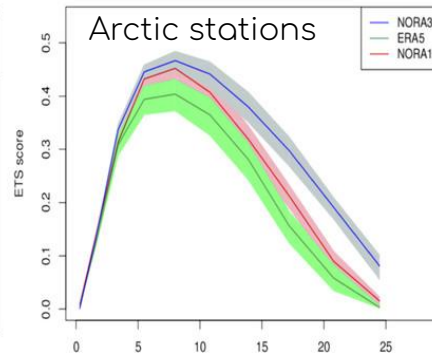
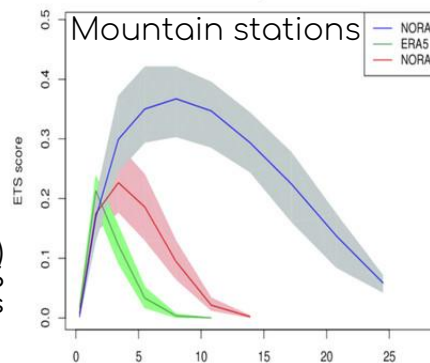
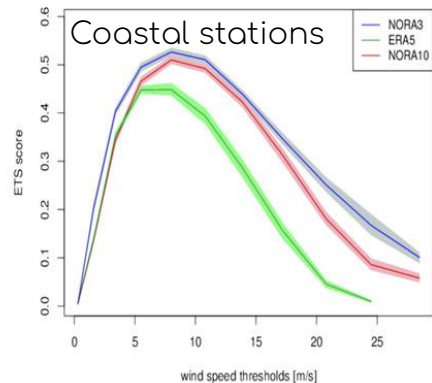
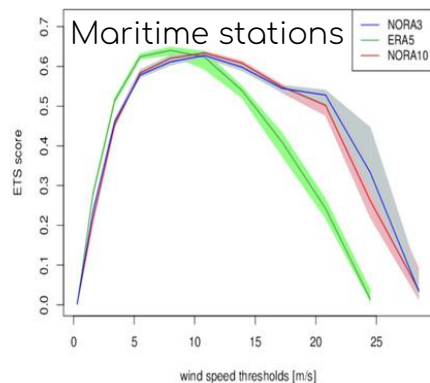


1. Haakenstad, H., Breivik, Ø., Furevik, B. R., Reistad, M., Bohlinger, P., & Aarnes, O. J. (2021). NORA3: A Nonhydrostatic High-Resolution Hindcast of the North Sea, the Norwegian Sea, and the Barents Sea. *Journal of Applied Meteorology and Climatology*, 60(10), 1443-1464.
2. Breivik, Ø., Carrasco, A., Haakenstad, H., Aarnes, O. J., Behrens, A., Bidlot, J. R., Björkqvist, J.V., Bohlinger, P., Furevik, B.R., Staneva, J. & Reistad, M. (2022). The Impact of a Reduced High-Wind Charnock Parameter on Wave Growth With Application to the North Sea, the Norwegian Sea, and the Arctic Ocean. *Journal of Geophysical Research: Oceans*, 127(3), e2021JC018196.

Main advances in NORA3 vs NORA10

- ERA5 forcing with wave boundary
- Nonhydrostatic atm model
 - vertical acceleration
- Increased spatial resolution
 - improved coastal winds & waves
 - improved mountain winds
- New wave model physics

Equitable Threat Score (ETS)
for wind speed with 95%
confidence levels



1. Haakenstad, H., Breivik, Ø., Furevik, B. R., Reistad, M., Bohlinger, P., & Aarnes, O. J. (2021). NORA3: A Nonhydrostatic High-Resolution Hindcast of the North Sea, the Norwegian Sea, and the Barents Sea. *Journal of Applied Meteorology and Climatology*, 60(10), 1443-1464.
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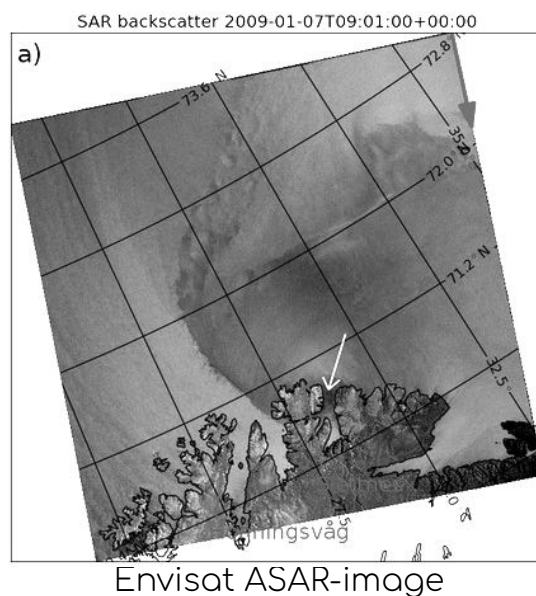
Polar lows

Small intense lows with likeness to tropical hurricanes

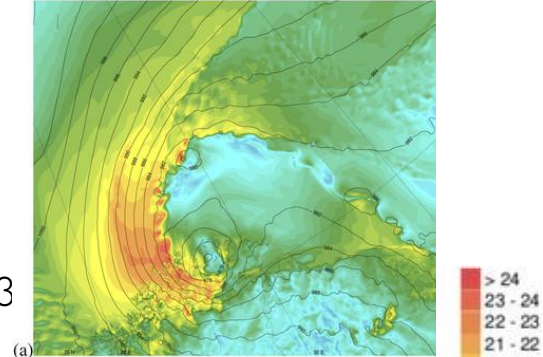
More correct maximum wind speed

Sharp fronts with small-scale details and showers

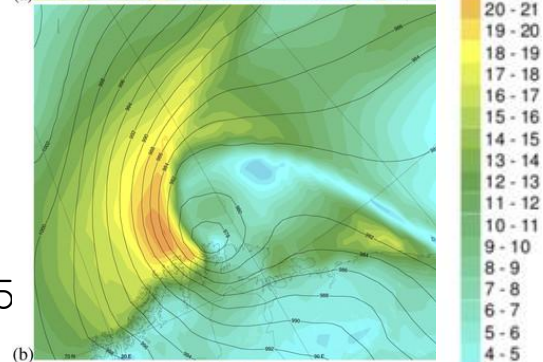
Overall more realistic model activity in wind speed



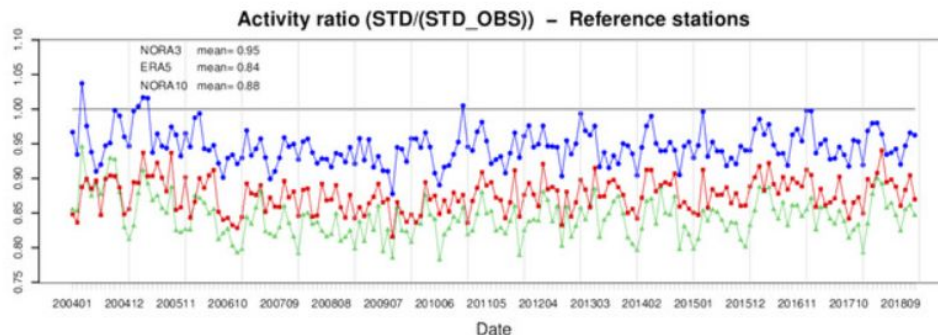
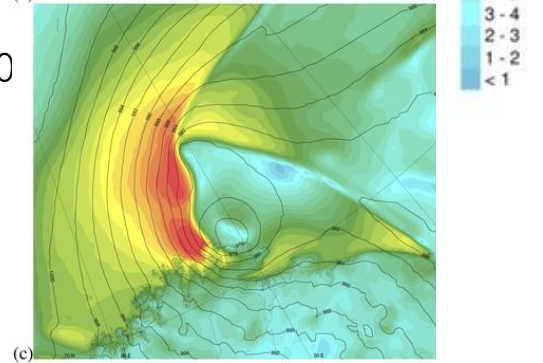
NORA3



ERA5



NORA10



NORA3
NORA10
ERA5

Haakenstad et al. (2021)

Post Processing

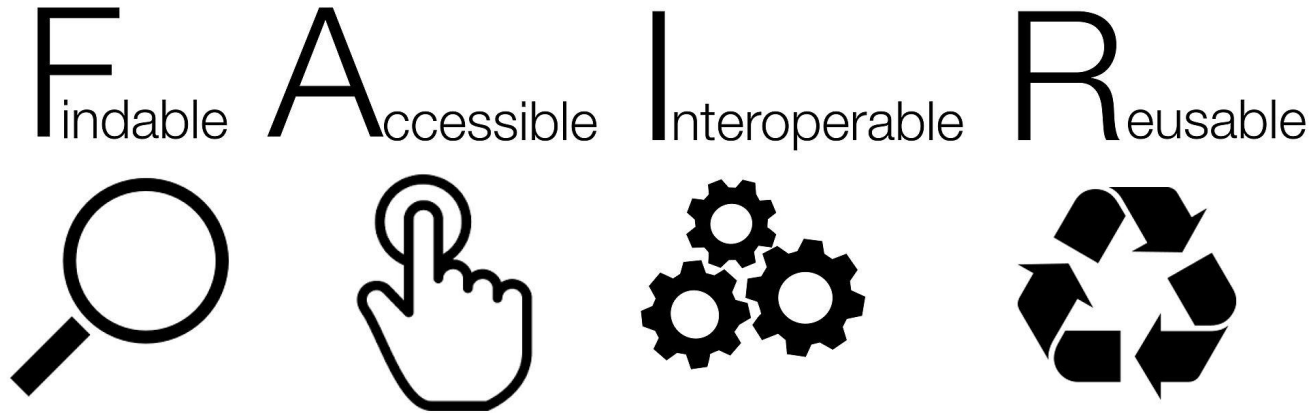
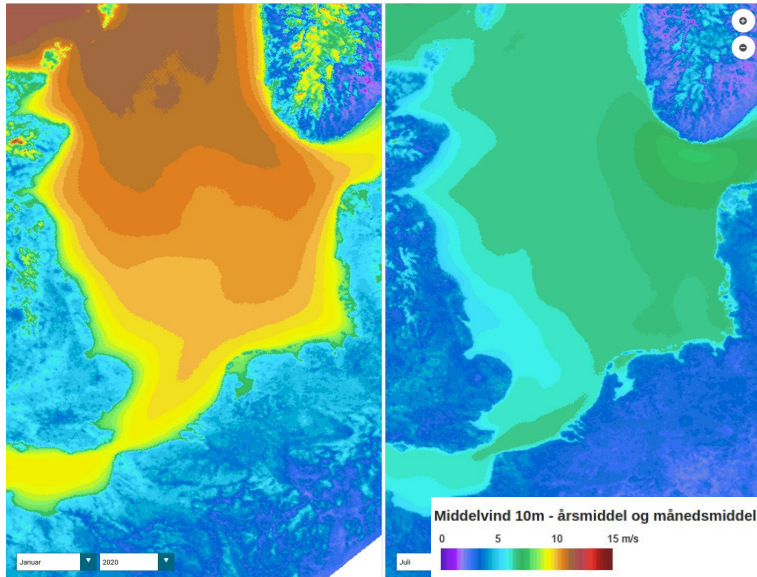


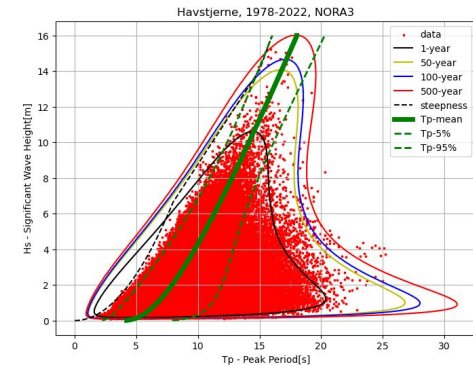
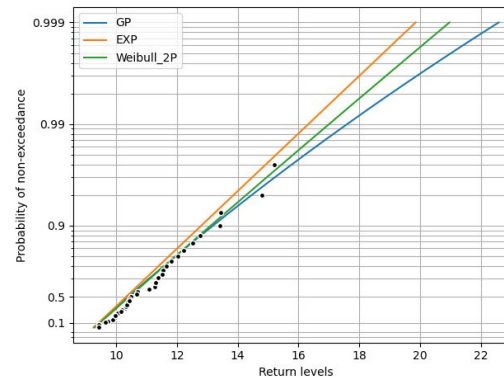
Illustration: SangyaPundir, CC BY-SA 4.0

Extract and analyse data



Comparing mean monthly wind in January and July on barentswatch.no WMS

- Python packages for extraction of time series and point statistics
<https://github.com/MET-OM>



NORA3 open access

- + Increased use, benefit for society and foster collaboration

Using the data

- Citation to papers
- data.met.no (no DOI yet)

Funding through several projects, collaborations & in kind



Funded by
The Research
Council of Norway



Statens vegvesen
Norwegian Public Roads
Administration



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