Estimating the Offshore Wind Resources off Nova Scotia

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Outline

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3. Dynamical Downscaling
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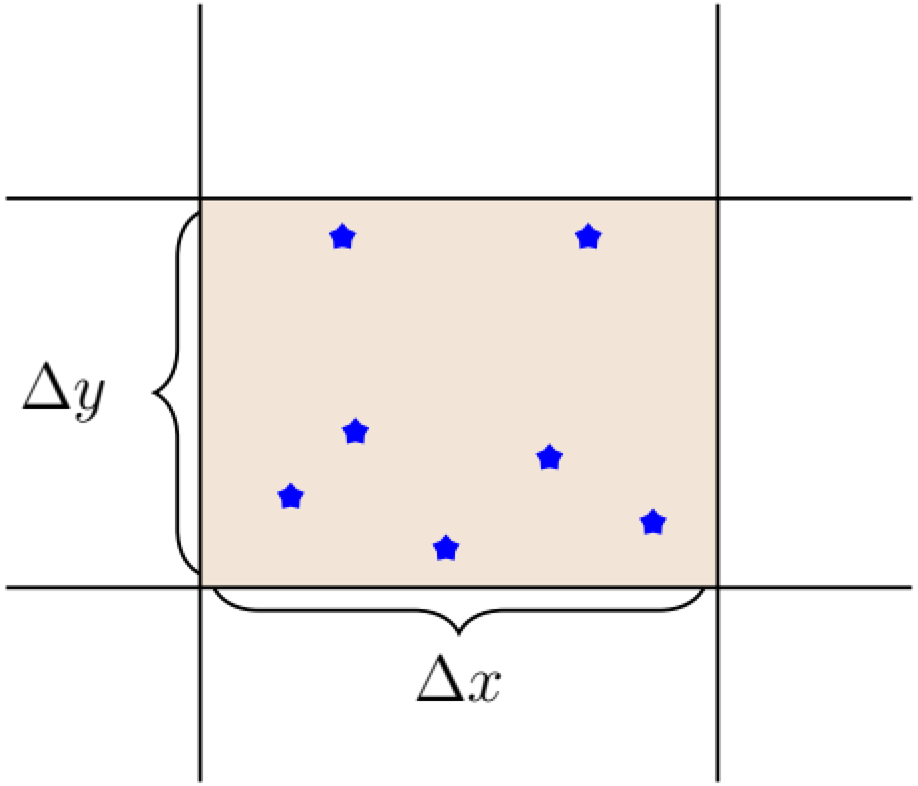
5. Wind speed on northern Scotian Shelf
6. Wind speed on southern Scotian Shelf
7. Concluding summary

1. Introduction: How to estimate the wind resource? Resolution matters…

1. Previous estimates of global onshore wind energy potential (WEP) is from 64 to 690 PWh /yr
2. Different estimates come from various wind resource data, wind turbines etc.
3. Horizontal resolution of wind speed data also affects wind potential estimates.



Example: Global Wind Speed Model (GloWiSMo) at 250 m horizontal resolution vs ERA5* at 0.25°
- Global WEP decreases from 404 PWh/yr to 339 PWh/yr (16.1%).

*ECMWF Reanalysis v5

Jung, C. and Schindler, D., 2022. On the influence of wind speed model resolution… wind energy potential. Renewable and Sustainable Energy Reviews, doi.org/10.1016/j.rser.2021.112001

2. Climate change?

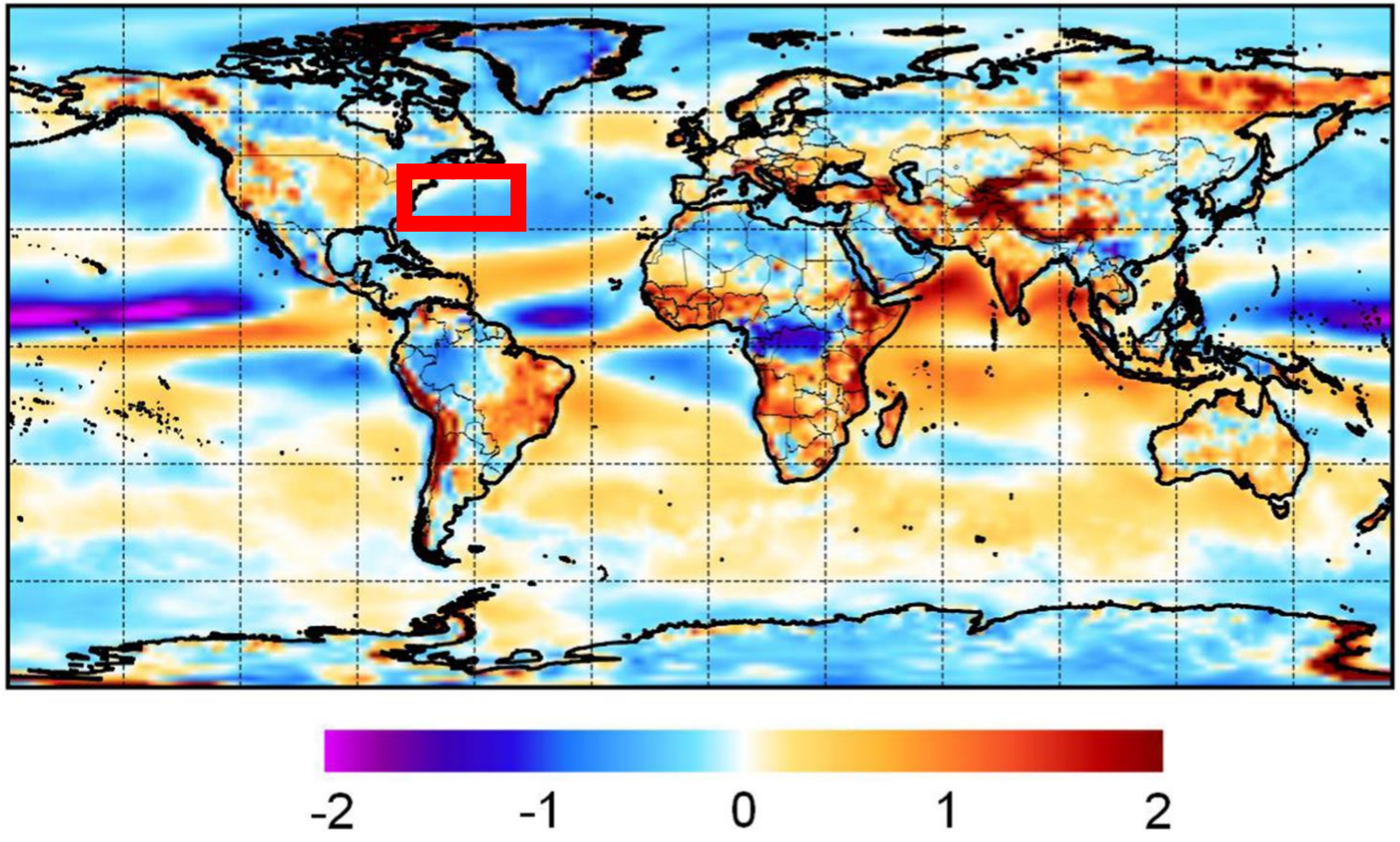
1. Significant decline in wind resources predicted in Northern Hemisphere.
2. Why? Arctic amplification of climate change

→smaller meridional temperature gradients

→ weakened jet stream

→ *declining* midlatitude wind power

3. Changes to spatial variability of wind resources → need regional-scale analyses to estimate future wind energy potential.



Bias in historical (2005–2014), surface wind of the multi-model ensemble (MME) against ERA5
- normalized against the standard deviation (σ/μ).

Martinez & Iglesias, 2024. Global wind energy resources decline under climate change. Energy, doi.org/10.1016/j.energy.2023.129765.

2. Climate change?

SSP2-4.5: middle of the road, CO2 emissions about current levels till 2050

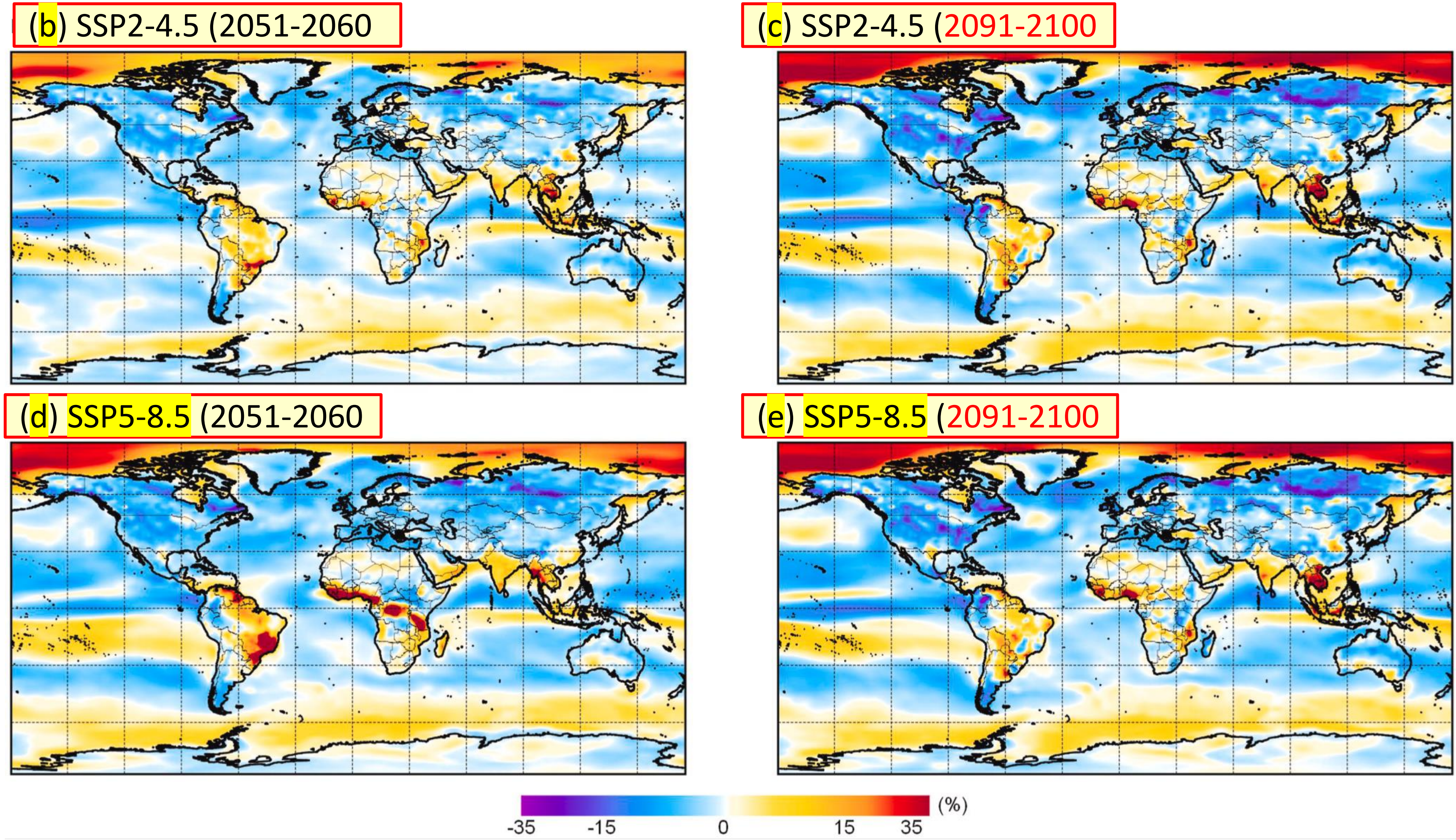
SSP5-8.5: CO2 emissions 3X by 2075, temperatures up by 5°C by century-end

Future changes in mean wind power density:

(a) Base (2005–14) mean wind power density

(b,d) Relative change to mid-century(2051–60) for winds in SSP2-4.5 & SSP5-8.5

(c,e) etc., to end-of-century (2091–2100).



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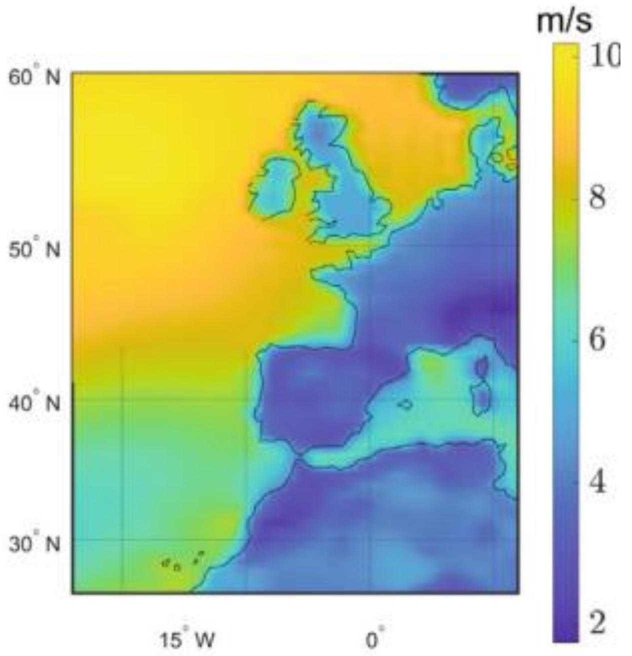
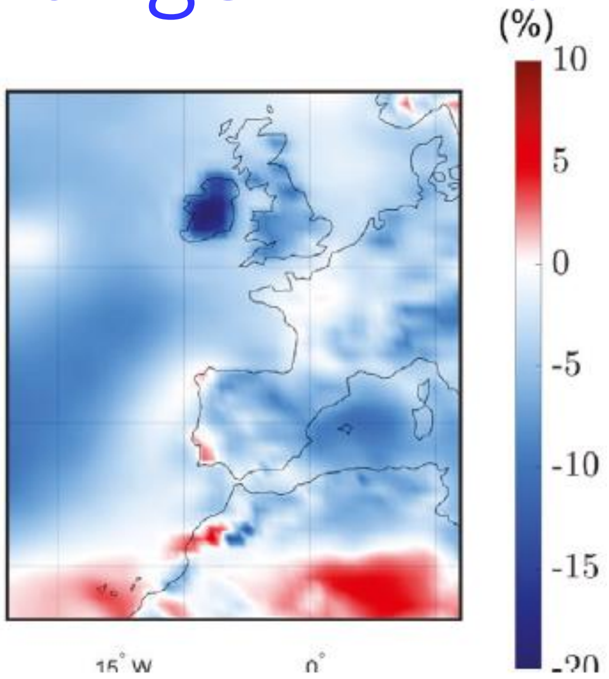
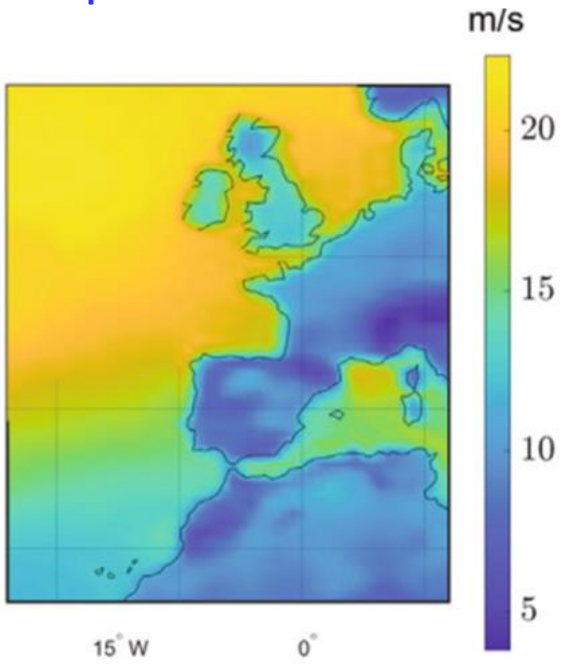
2. Climate change? … the European offshore.



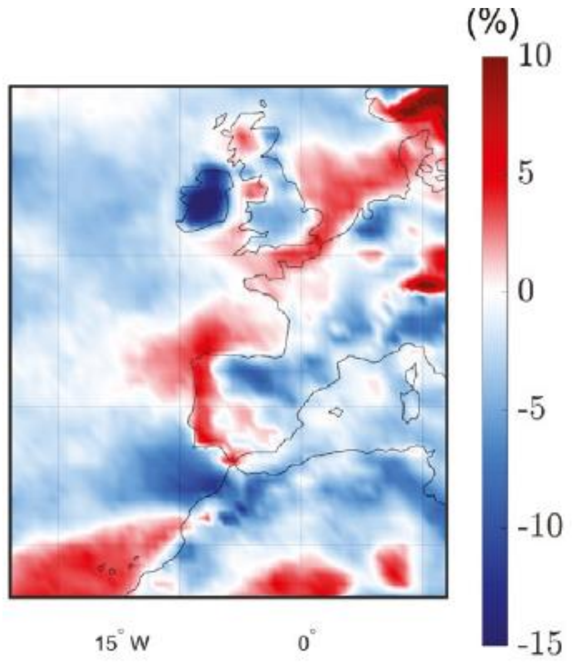
Historical mean U_{10}



Long-term forecast mean U_{10} SSP5-8.5 (relative to Historical)



Historical extreme U_{10}



Long-term extremes U_{10} SSP5-8.5 (relative to Historical)

•Climate change → lower mean winds + **more intense** extremes (in SSP5-8.5).

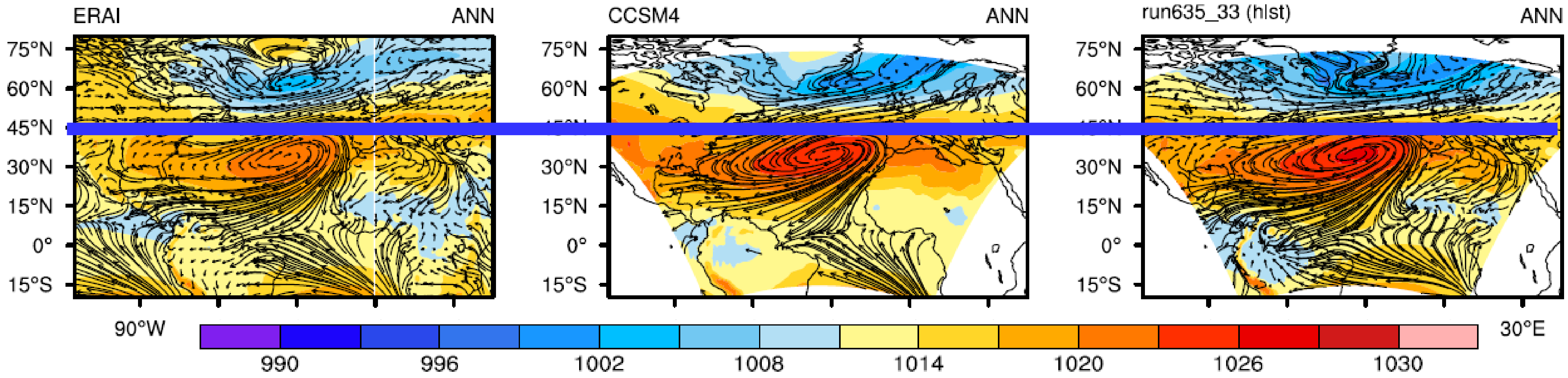
→ Implies higher standards for **survivability** and **lower** energy production.
→ Need **downscaled wind data** to get local geographical characteristics.

Barkanov *et al.*, (2024). Evolution of European offshore renewable energy … climate change scenarios etc. Energy Conversion and Management, doi.org/10.1016/j.enconman.2023.118058

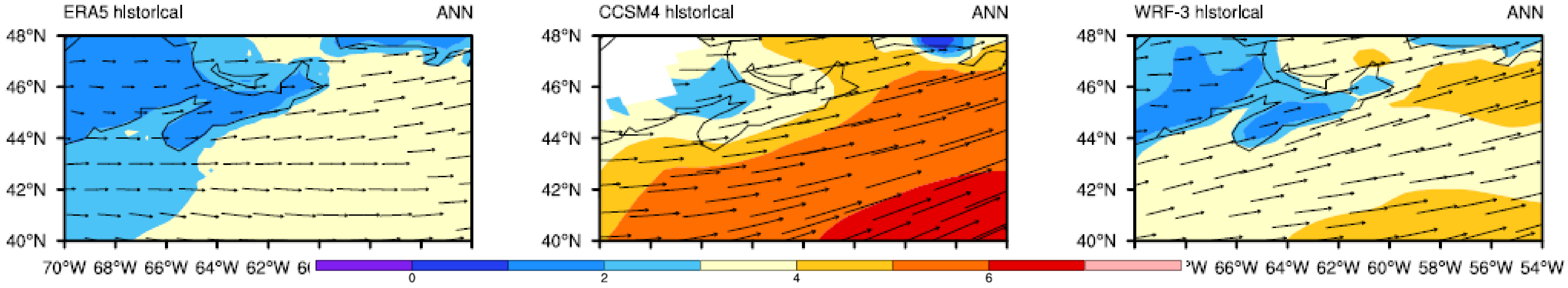
3. Dynamical downscaling: →choose good models…

Historical:
1979-2004

SLP – sea level pressure

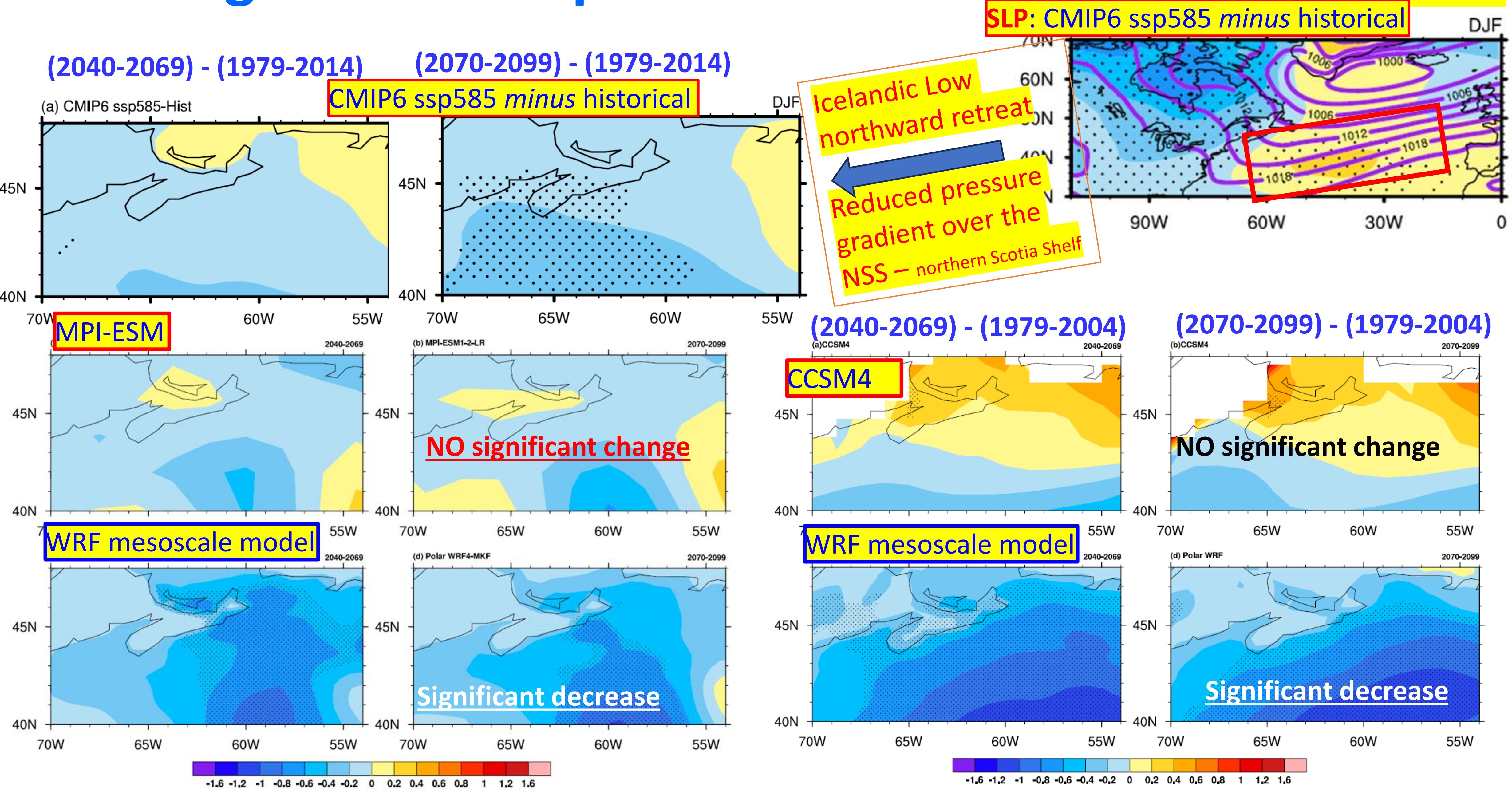


Wind speed

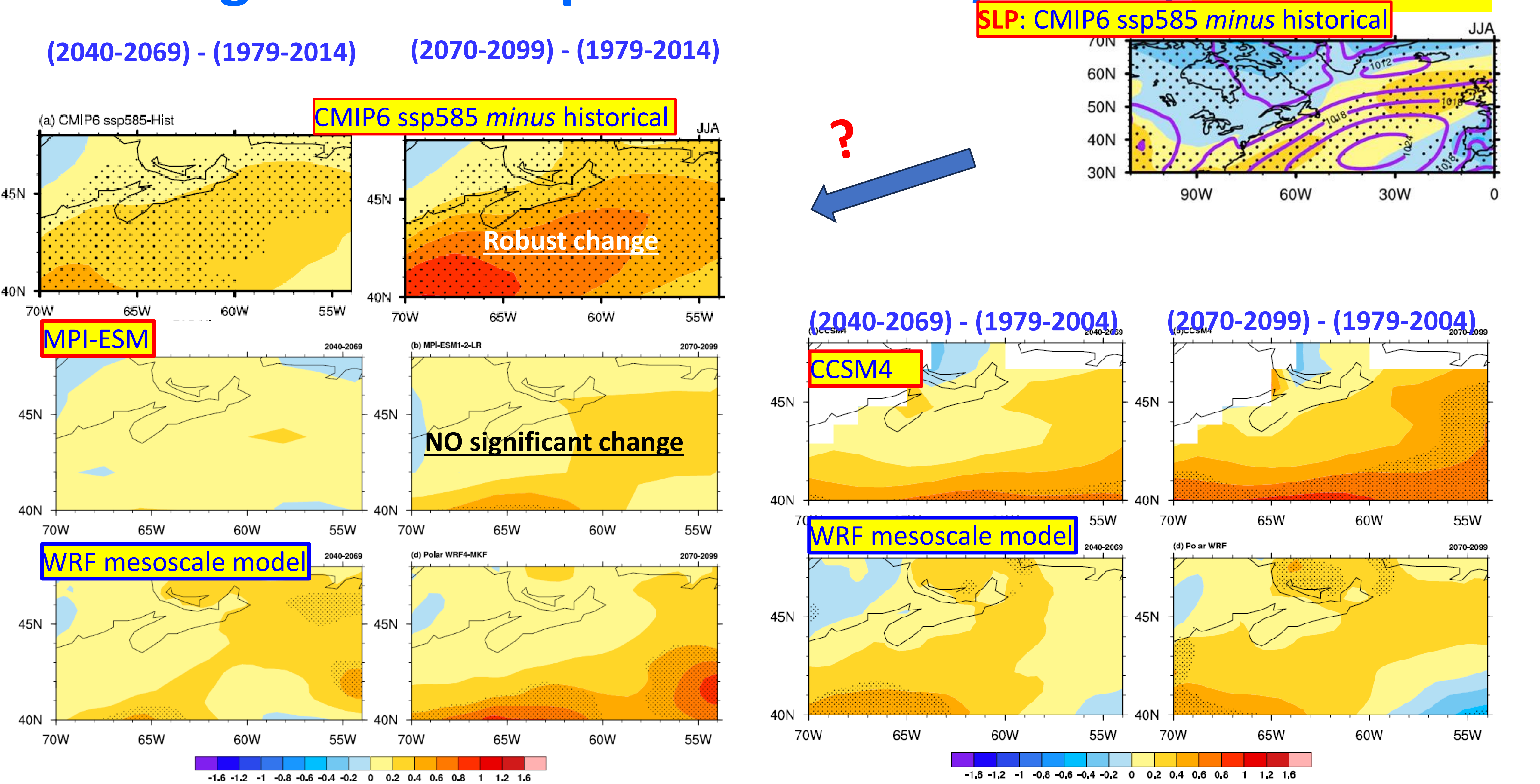


1. Bias in CCSM4 for historical climate: Northward displacement of NA storms → northward shift of Icelandic Low and northward extension of North Atlantic Subtropical High
2. This bias gives northward shift in changes in winds and storms in warming climate scenarios
3. What about variabilities and extremes?

4. Changes in wind speed in SSP5-8.5/RCP8.5, DJF - winter

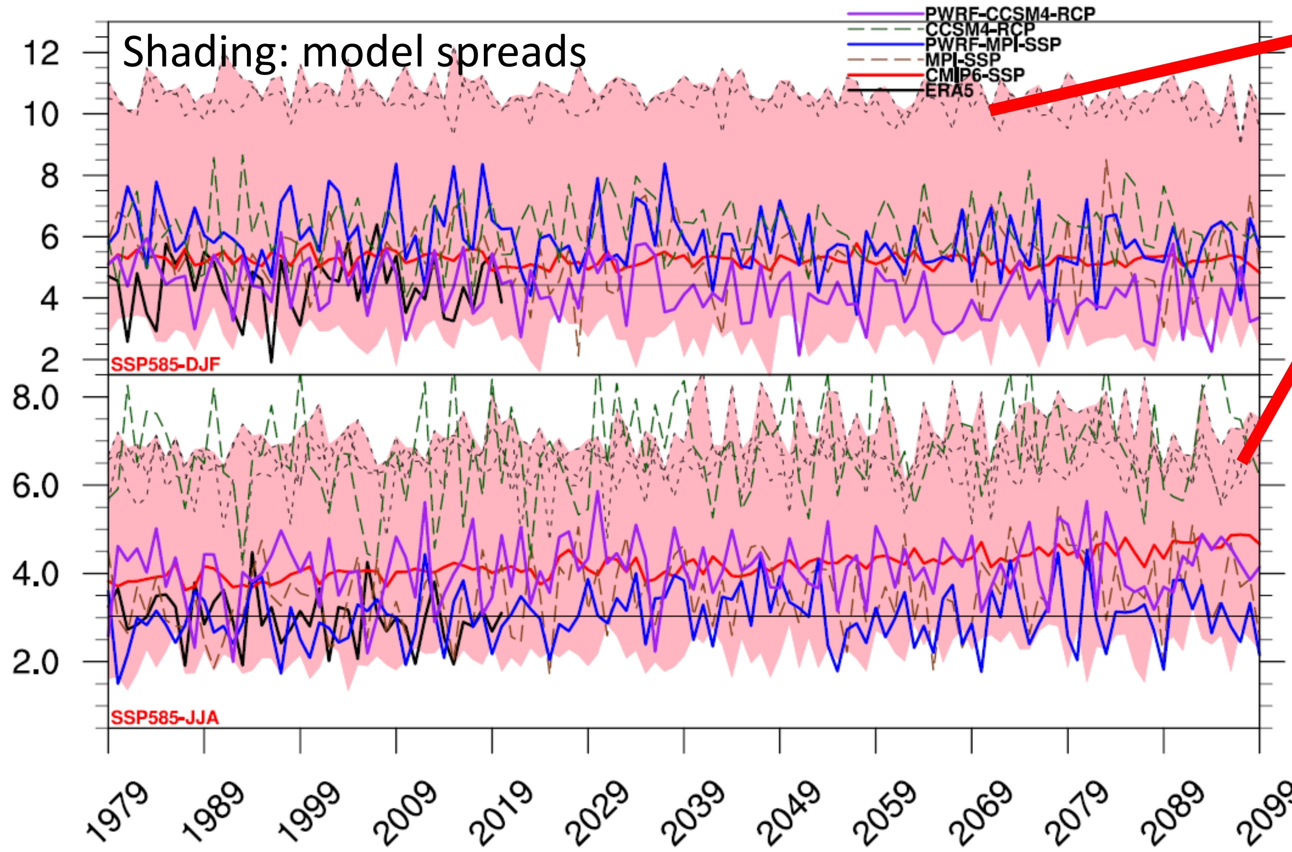


4. Changes in wind speed in SSP5-8.5/RCP8.5, JJA -summer



5. Wind Speed on Northern Scotian Shelf

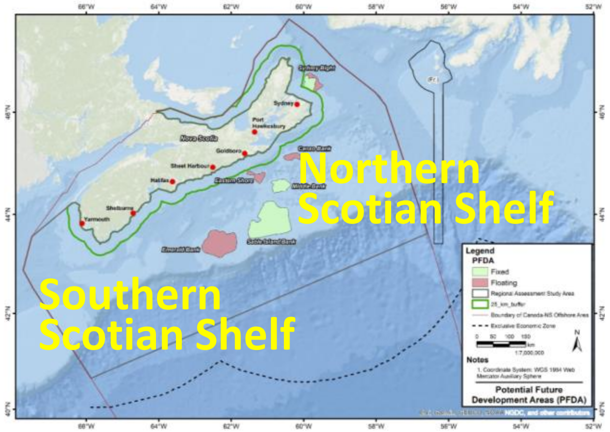
North of NSS:42N-45N, -60W— -57W



Two outliers, CMCC-Italy

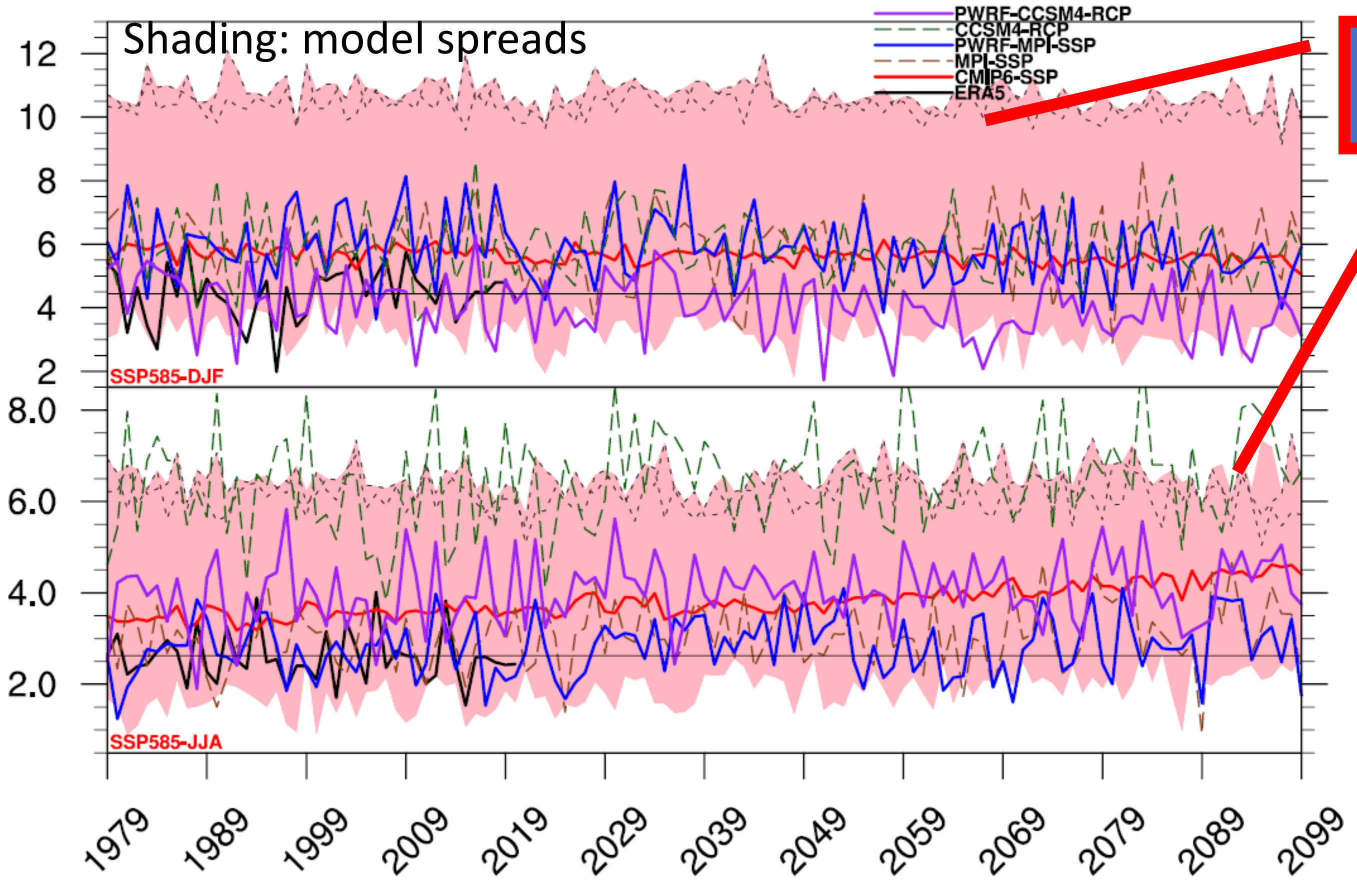
Northern Scotian Shelf from CMIP 6 MME:

1. In Winter, the wind decreases by end-of-century by ~2% (90% significance level)
2. In Summer, wind increases ~ 0.07 m/s per decade, or ~15.8% end-of-century (99.9% significance level).



6. Wind Speed on Southern Scotian Shelf

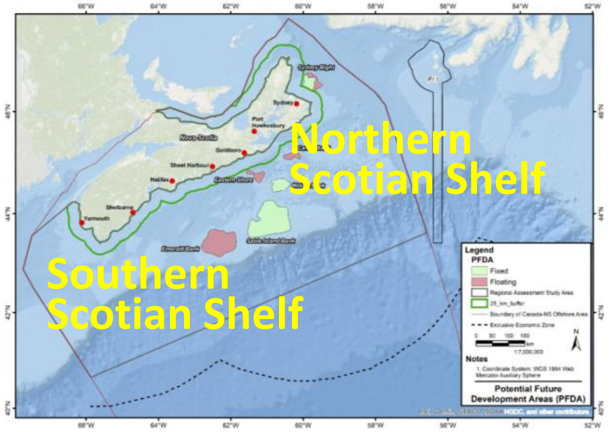
South of NSS:41N-43N, -66W- -63W



Two outliers, CMCC-Italy

Southern Scotian Shelf:

1. In Winter, the wind decreases by ~5% by end-of-century (99.99% significance level).
2. In Summer, the wind increases by ~0.08 m/s per decade, or 21.8% by end-of- century (99.9% significance level).



7. Concluding summary

Under warmest climate scenario, for northern Scotian Shelf (NSS), from CMIP6 MME and WRF results:

- In winter, wind speed tends to decrease, by end-of-century, by about 2%~5%.
- In summer, wind speed of MME tends to increase, by end-of-century, by about 16%~21%.
- BUT this 'summer' result is not significant in fine-spatial resolution WRF mesoscale model results, because of latent heat release from the sub-grid convection processes.

So, maybe little change in mean surface winds in NSS for warming climate scenarios?

Future work

1. Changes in storms alone (so far) cannot account for changes in mean surface winds.
2. We need investigate changes in the extreme winds.
3. The persistence of high-temporal wind data (hourly to 6-hourly)
4. Changes in wind directions
5. Fine-spatial resolution simulations