North Atlantic Response to the stochastic mesoscale wind

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NATURAL ENVIRONMENT RESEARCH COUNCIL

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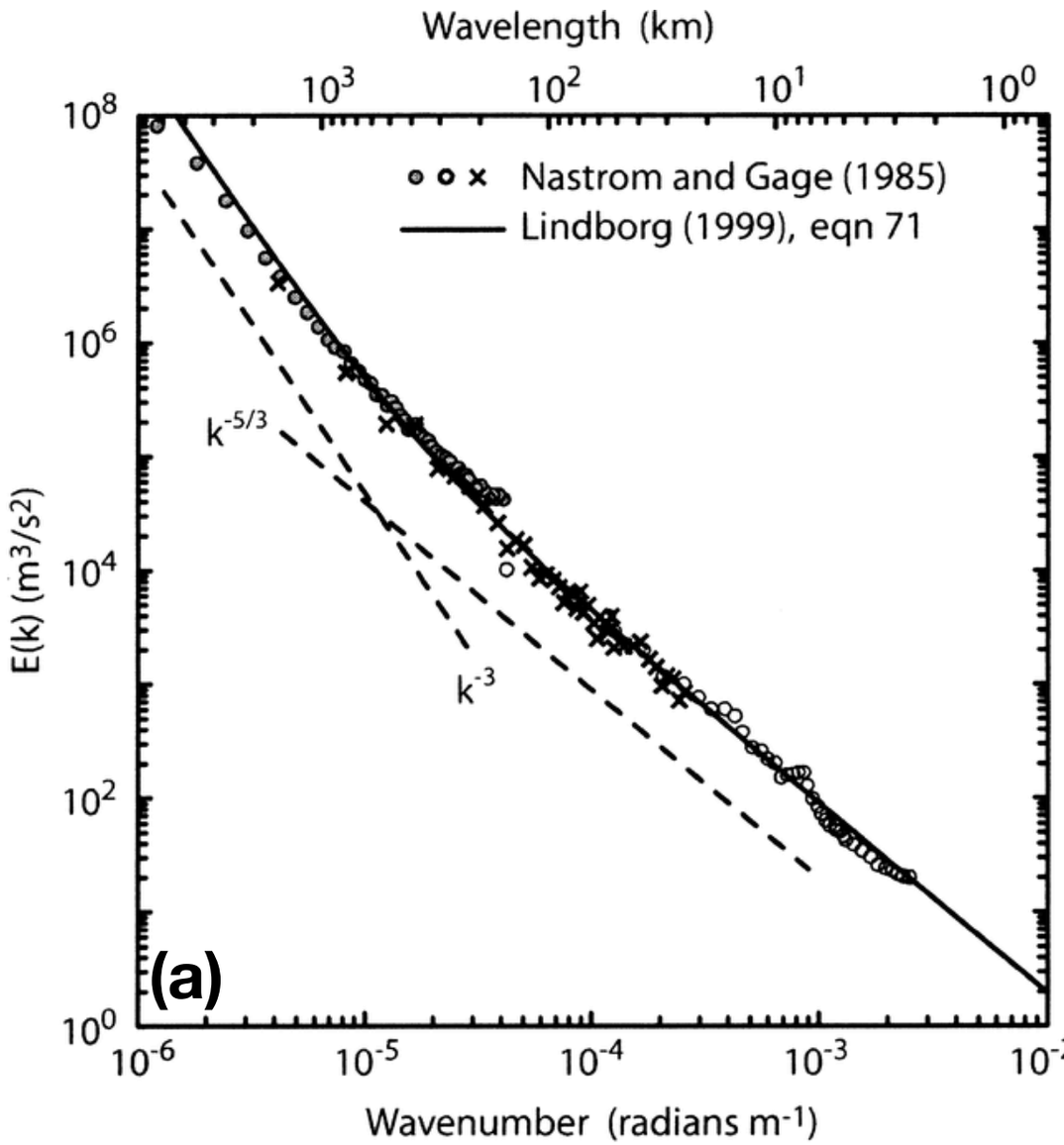
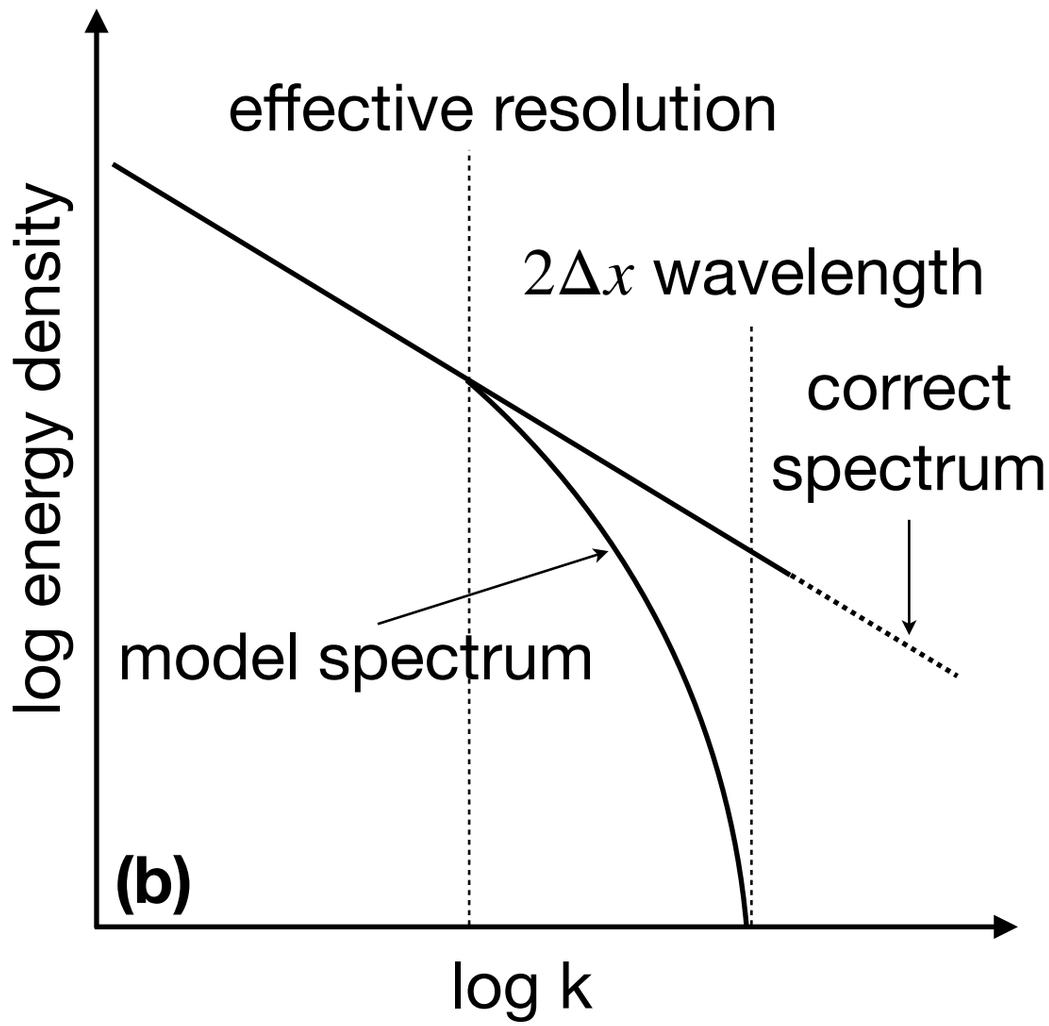
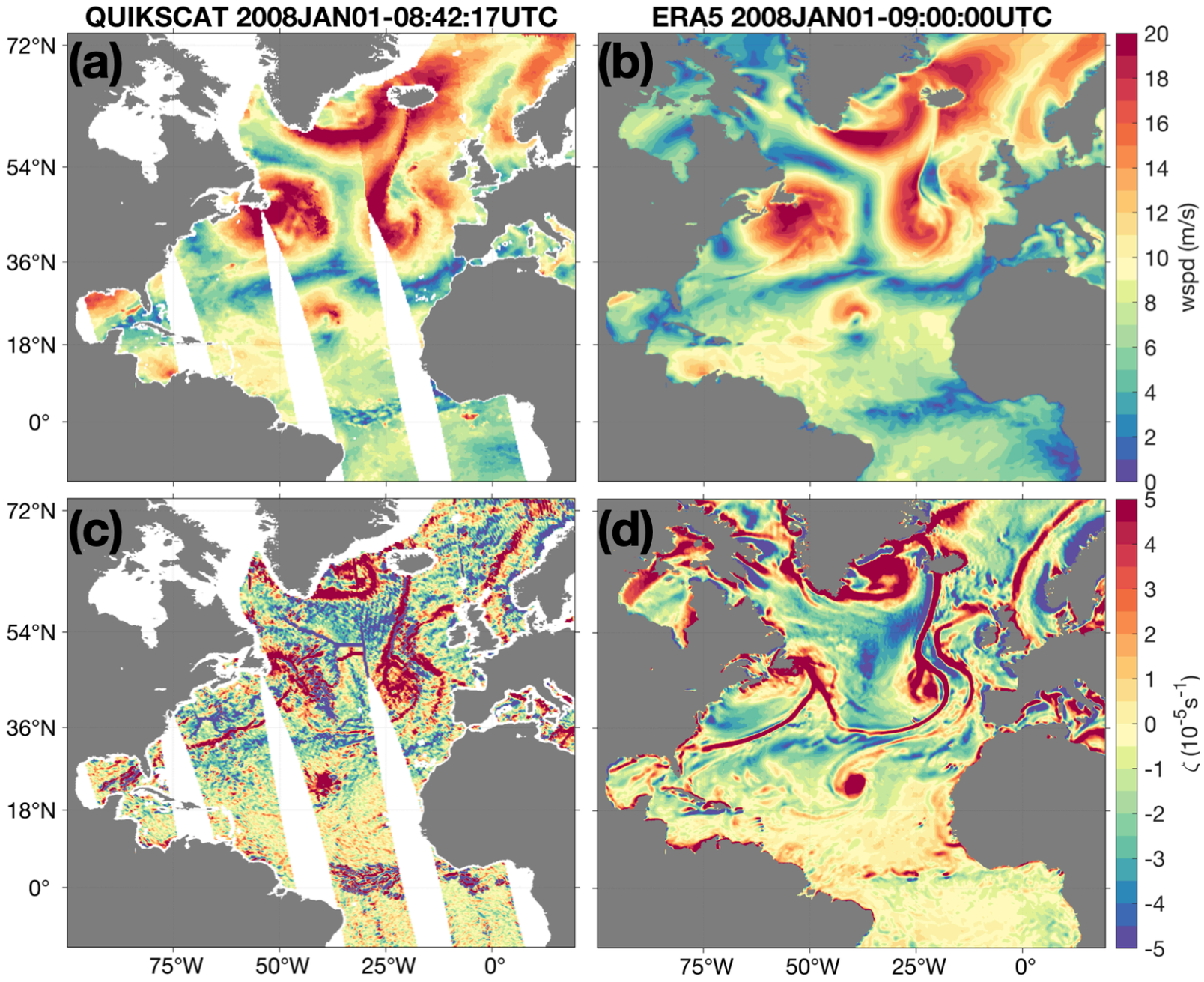
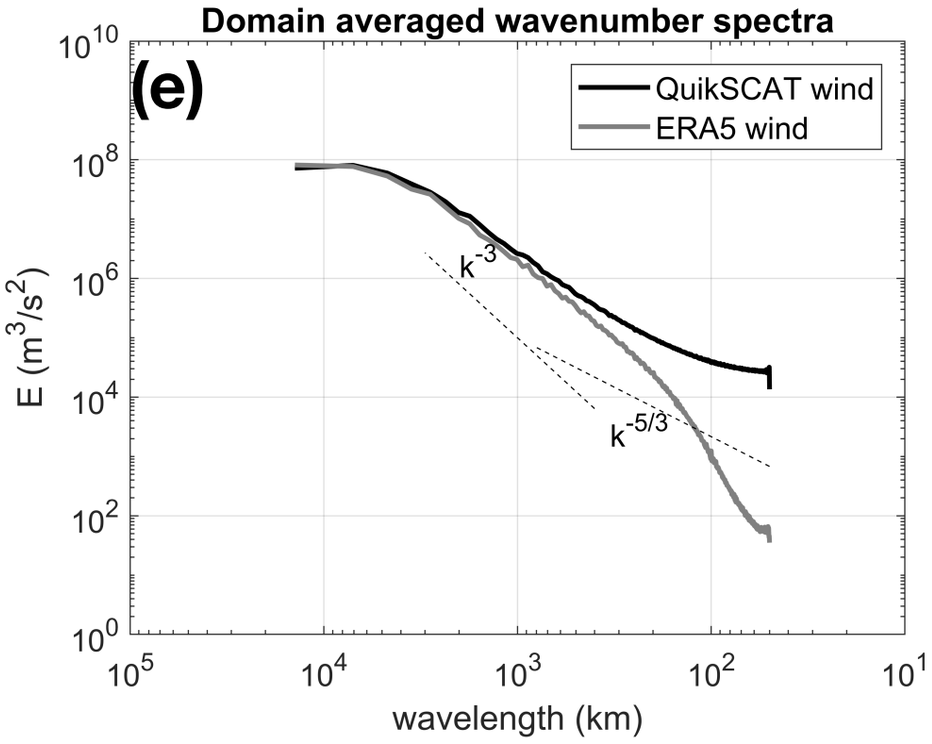


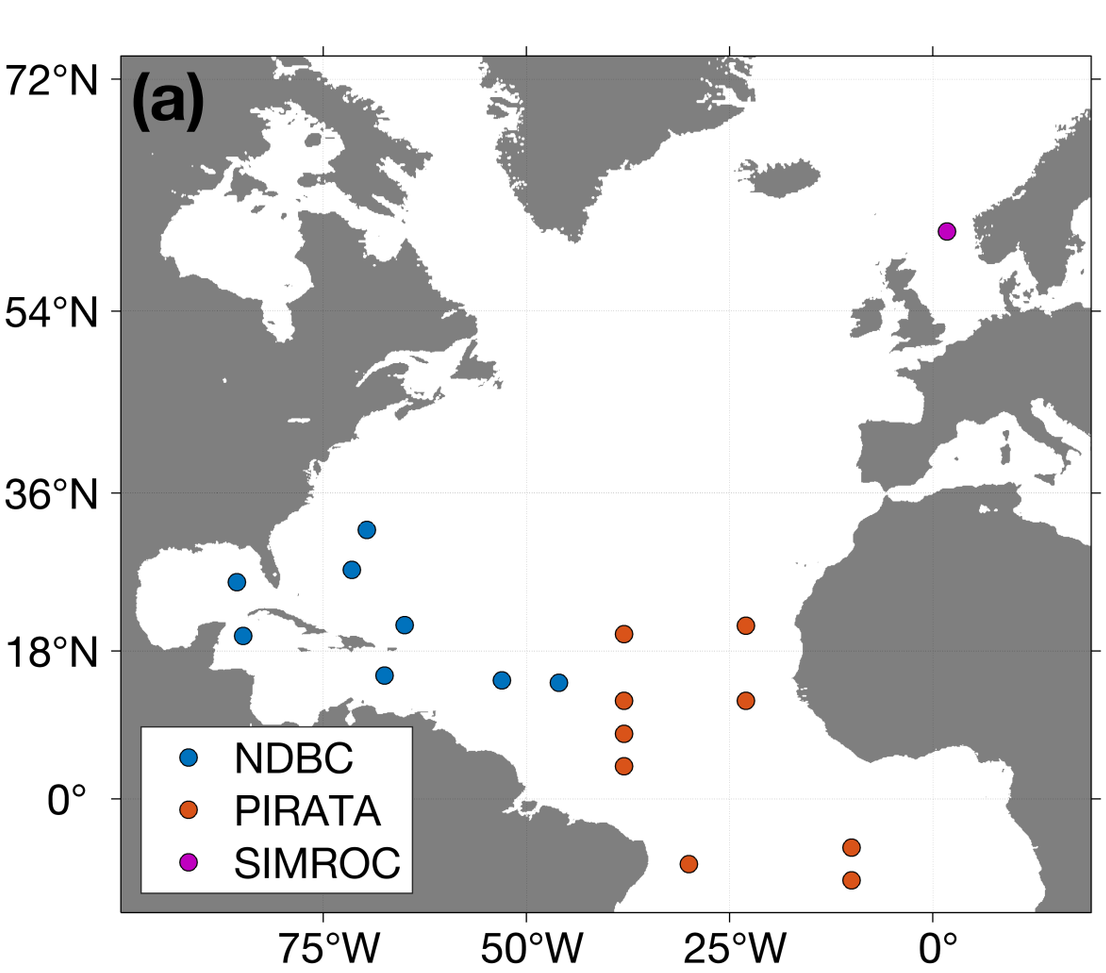


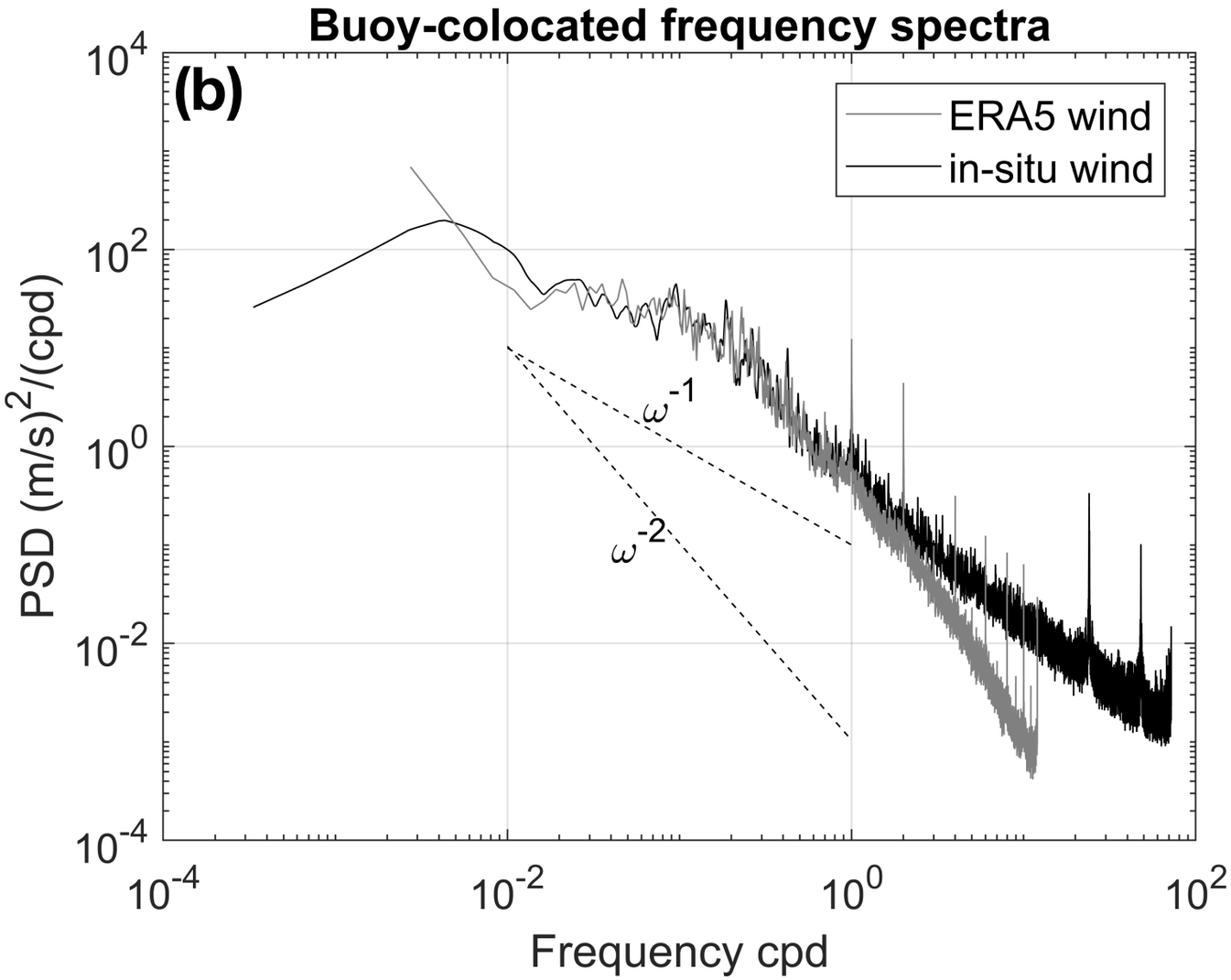
Effective resolution in numerical models prevents the model from resolving fine scale variability approaching to the model resolution.





- Similar effective resolution is found in the most recent atmospheric reanalyses wind data.
- Rich small-scale variability stands out in relative vorticity field between obs and reanalyses.
- ERA5 wind effective resolution at ~450 km.

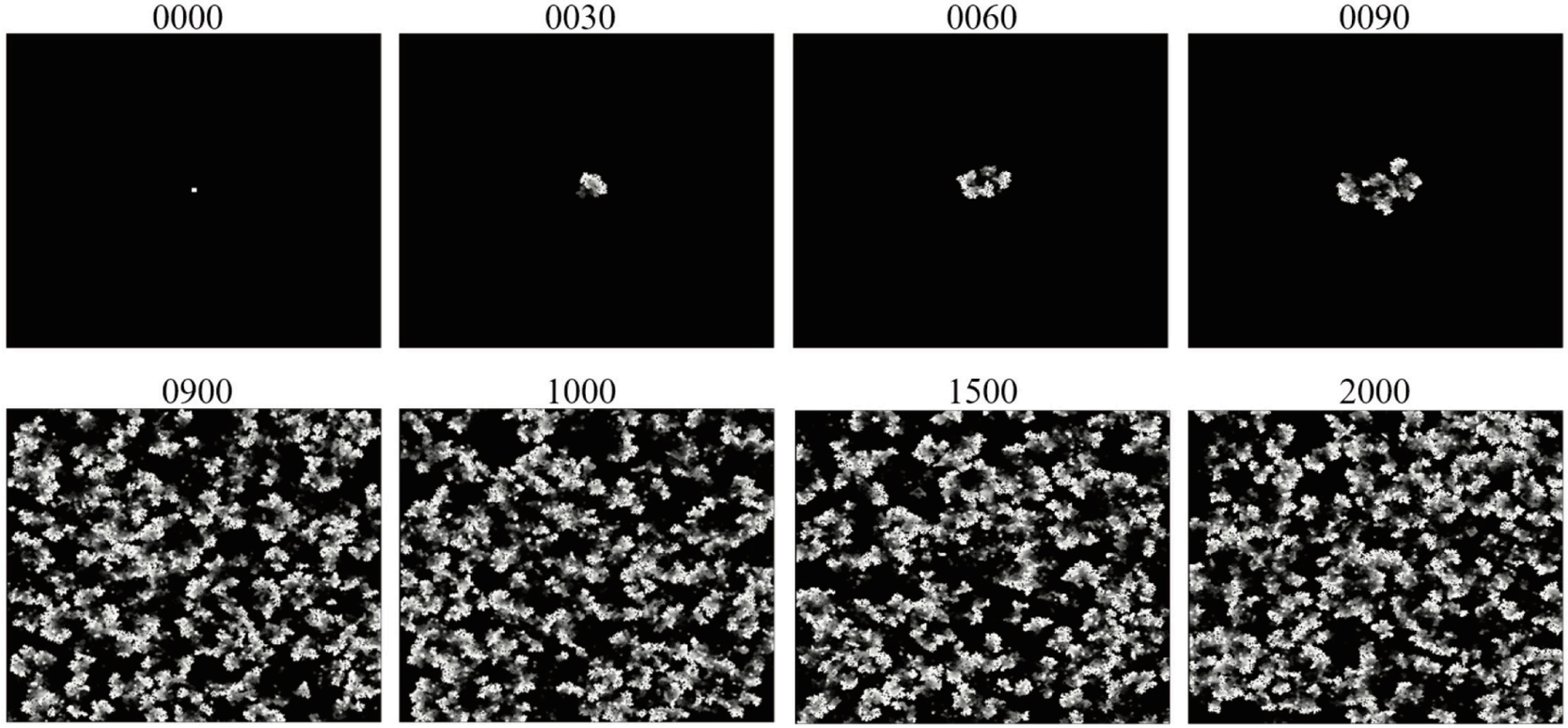


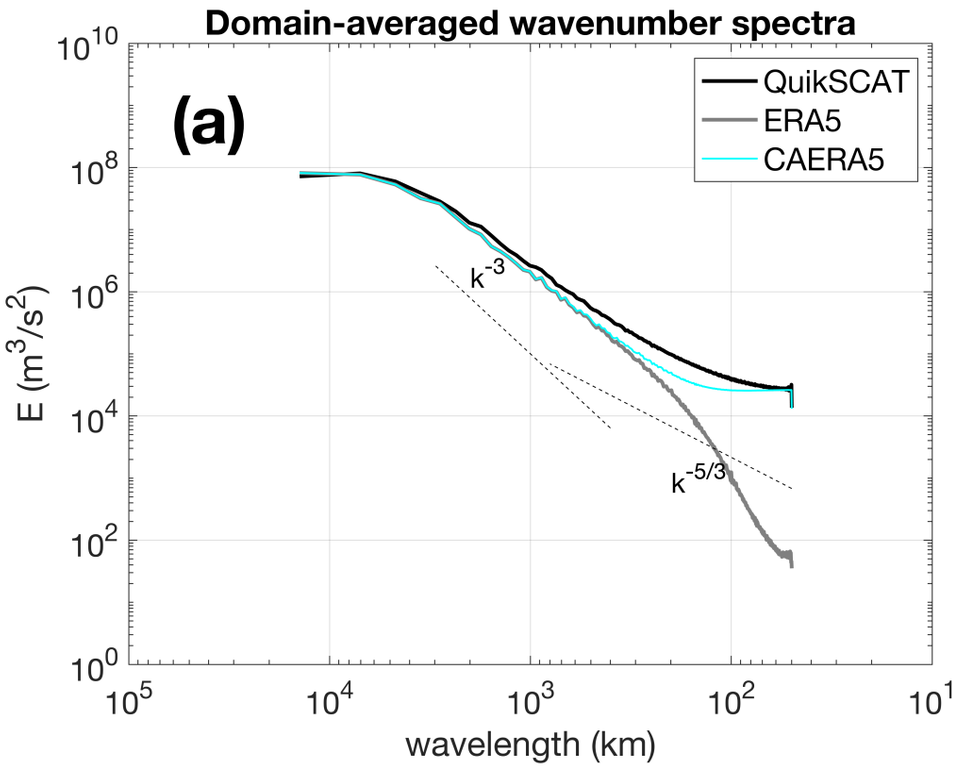


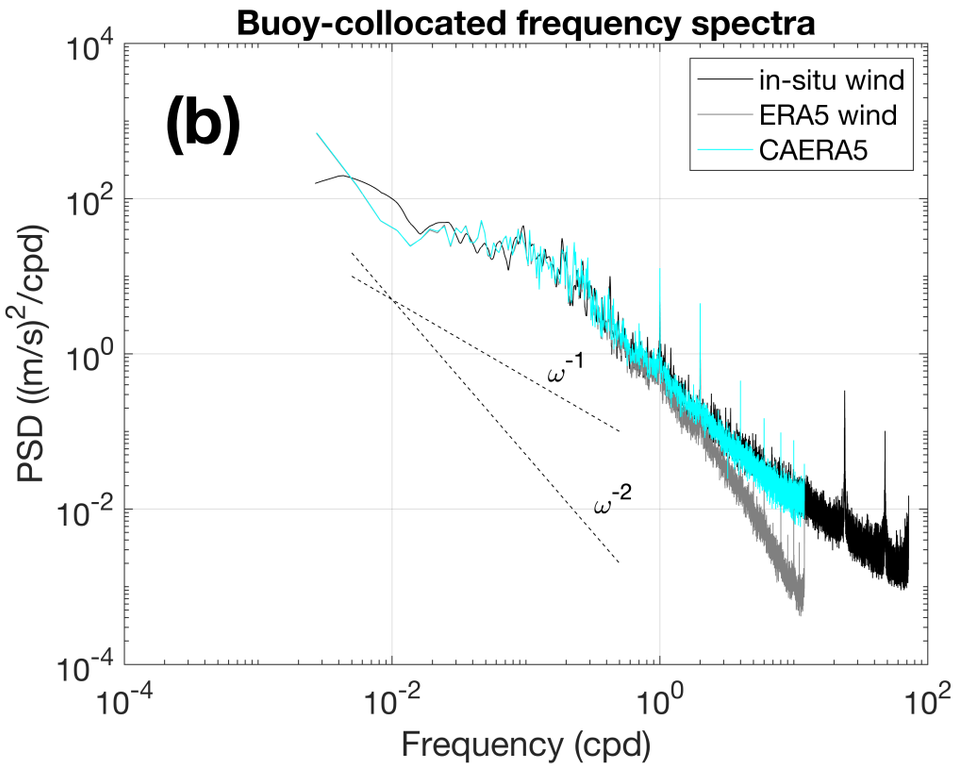
Comparison with in-situ met buoy wind, ERA5 also demonstrates weaker sub-daily variabilities.

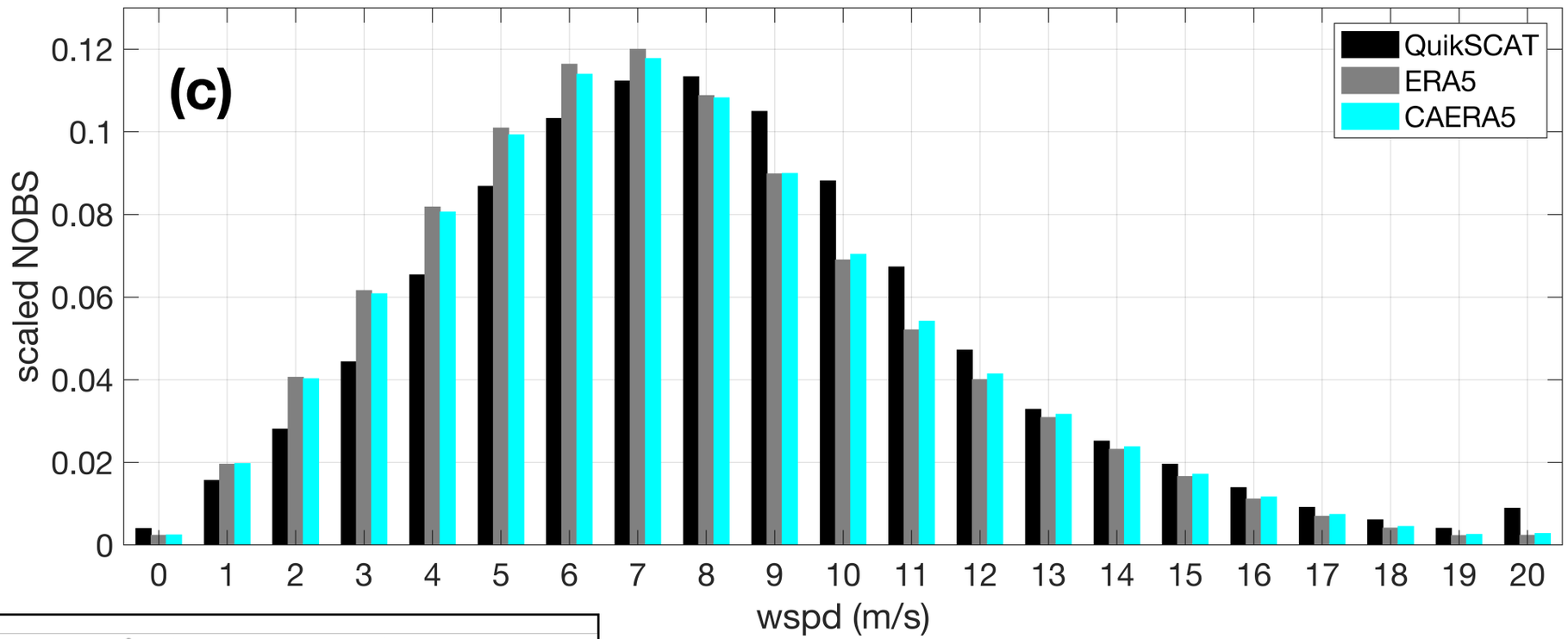
Cellular Automata

- Cell status - to ‘live’ or not to ‘live’ (probabilistic rule, stochasticity)
- Coherent spatial patterns
- N, resT and resS controlling the spatial and temporal characteristics
- Potential to fix the wavenumber/ frequency spectra simultaneously







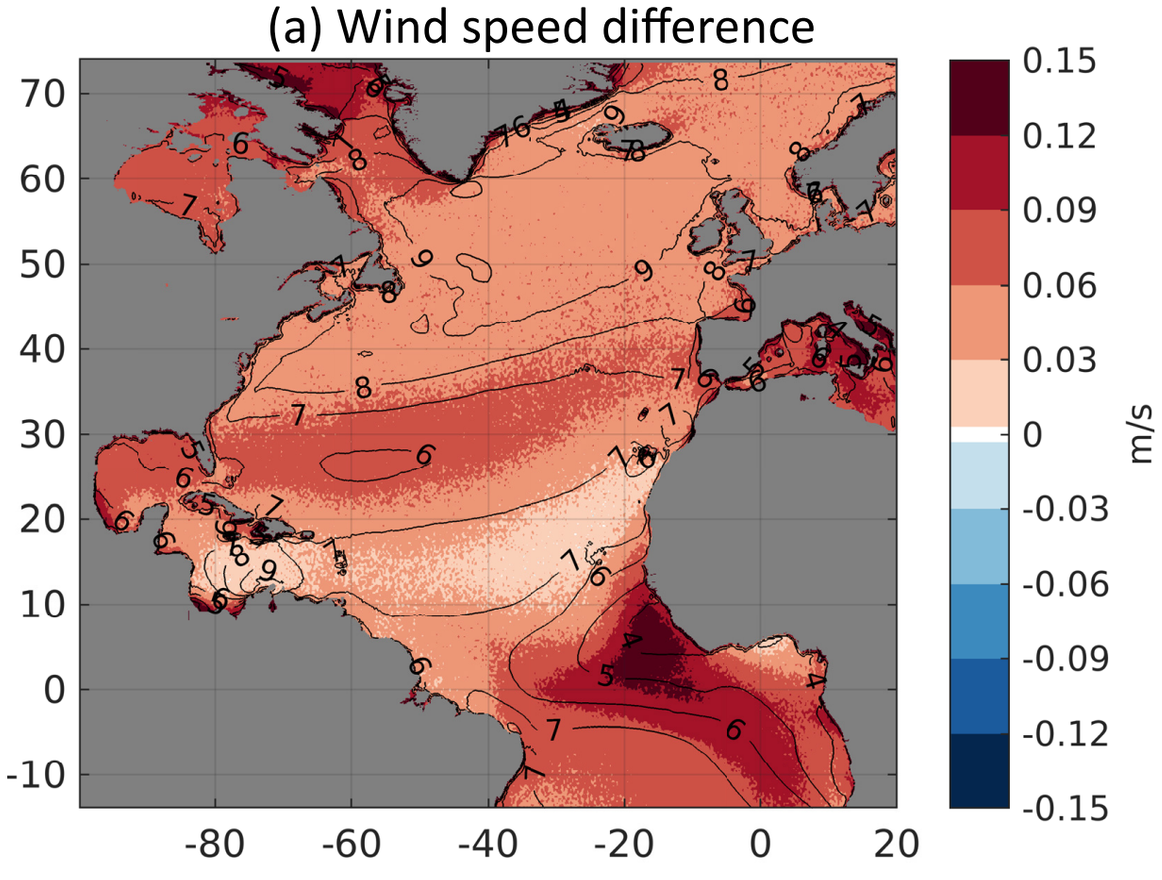


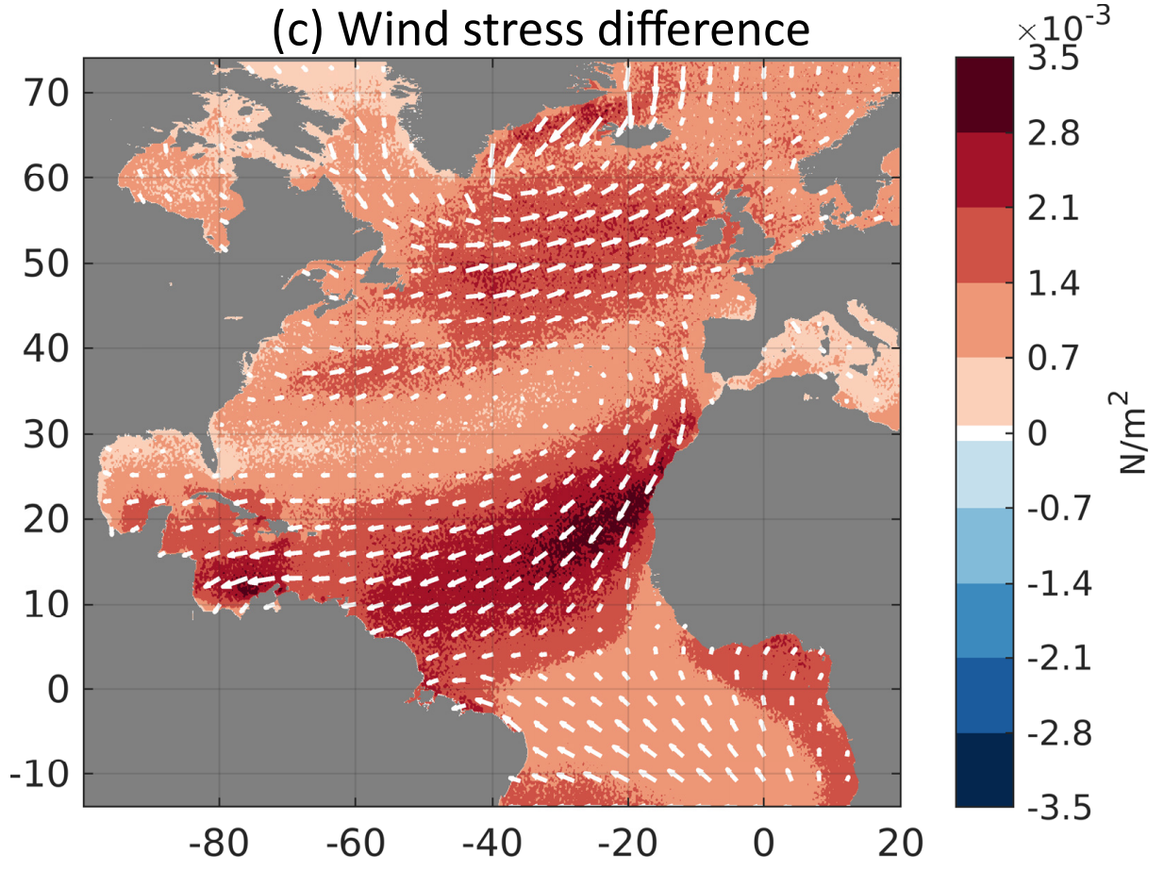
NOL = 1 , ΔL = 25/3 km, Δt = 1 hour.

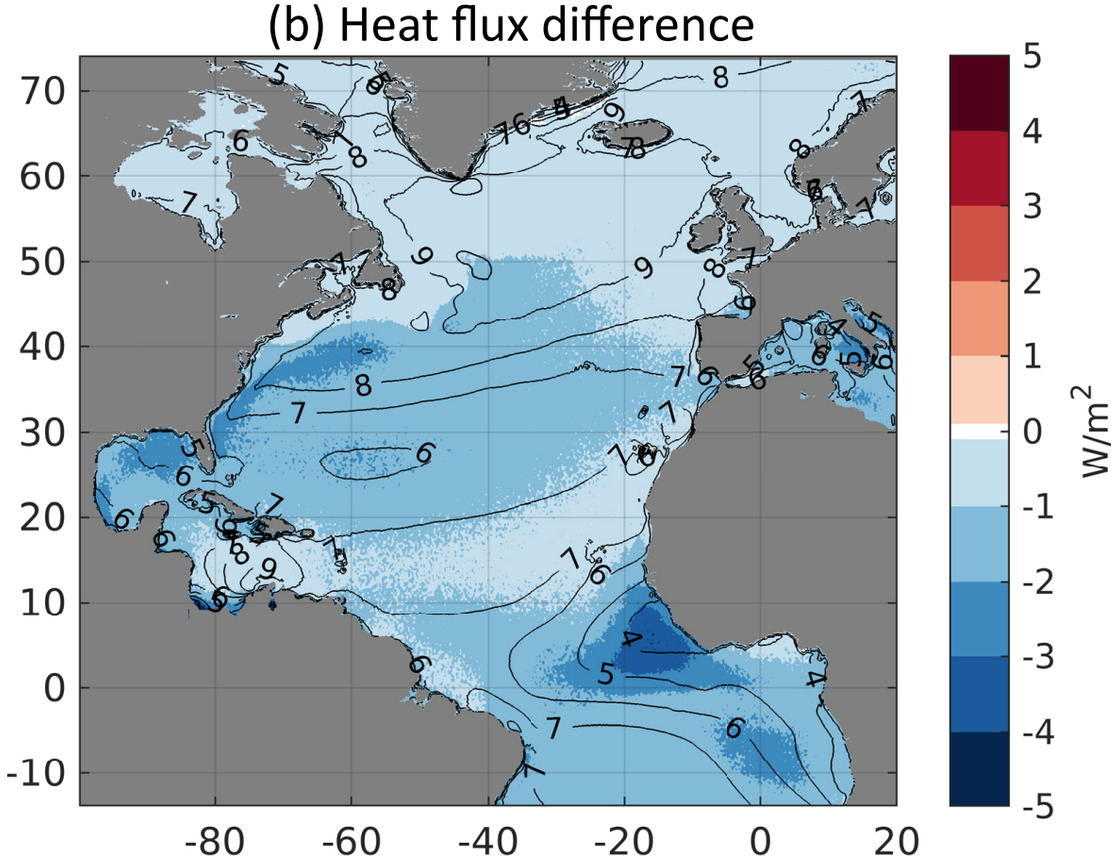
Perturbation scheme:

$$\begin{cases} u_{ca} = u_{era} + std(wspd_{era}) \times CA \times \alpha \\ v_{ca} = v_{era} + std(wspd_{era}) \times CA \times \alpha \end{cases}$$

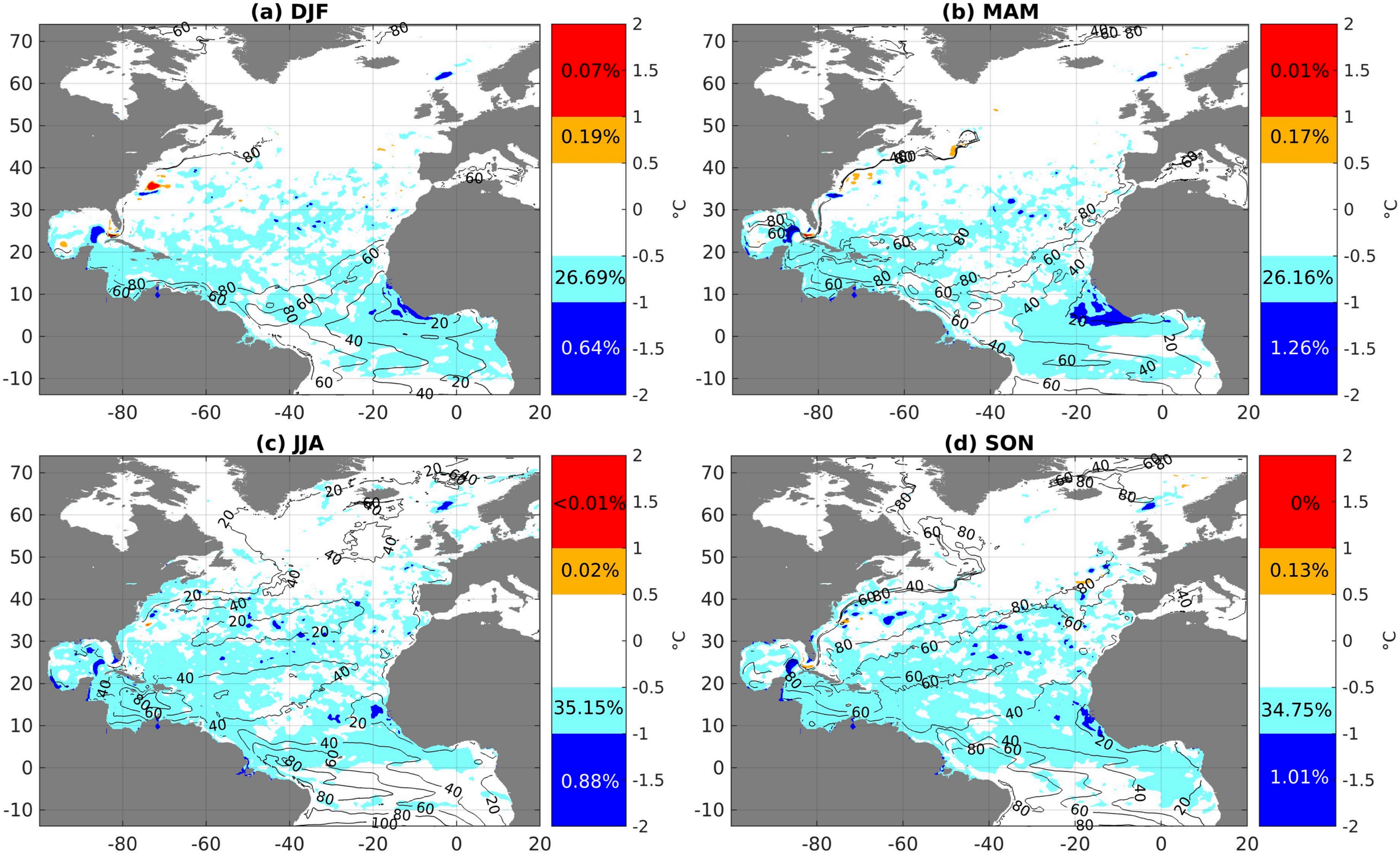
- Improved spatial and temporal variabilities
- Improved high-wind events fraction (>9m/s).



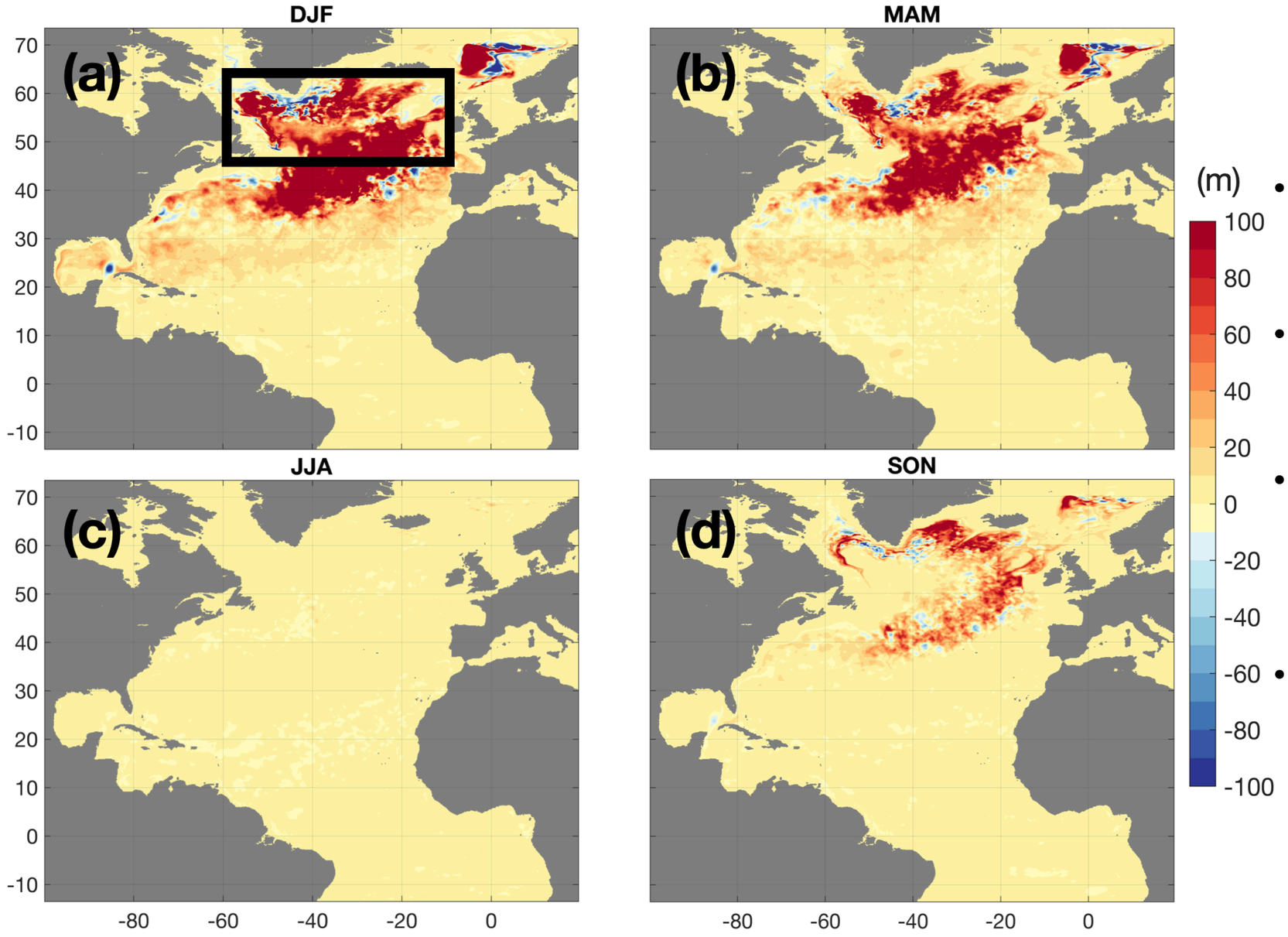


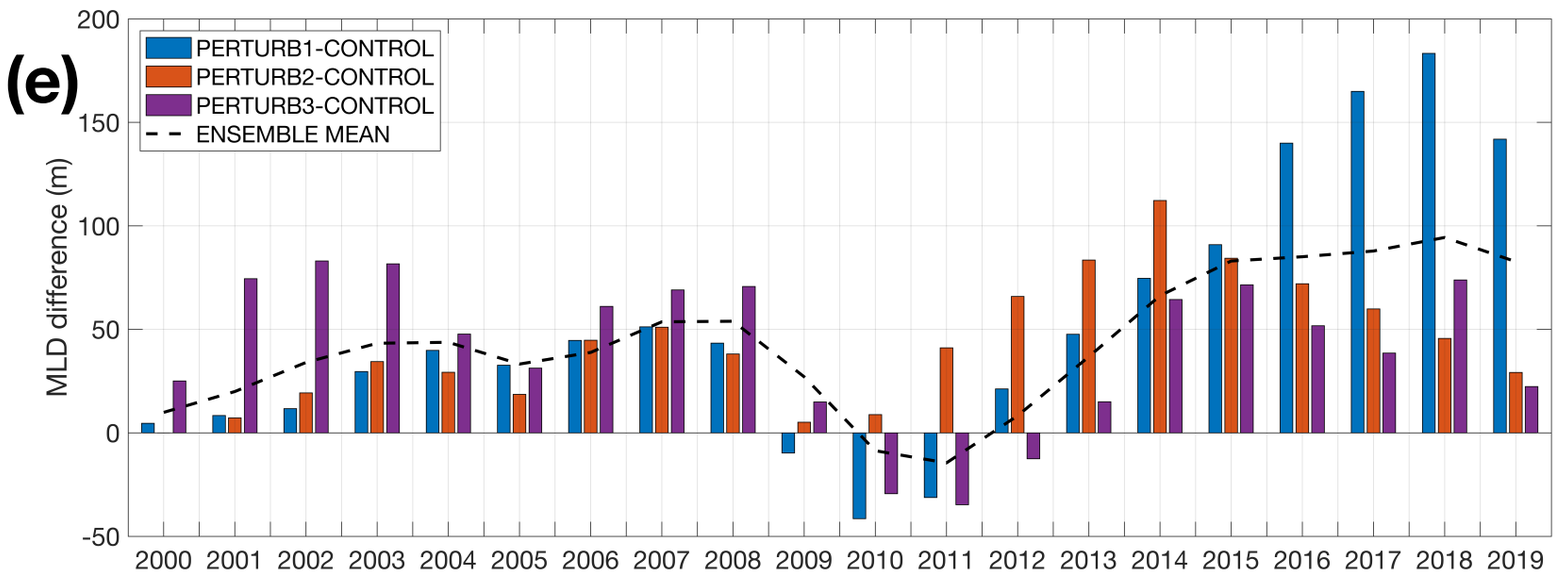


- Wind perturbation is isotopic everywhere in the domain
- Wind speed difference is however organised into large scale pattern, pronounced in weak wind region
- Similarly, excessive heat loss over weak wind region.
- Stronger wind stress in strong wind region.

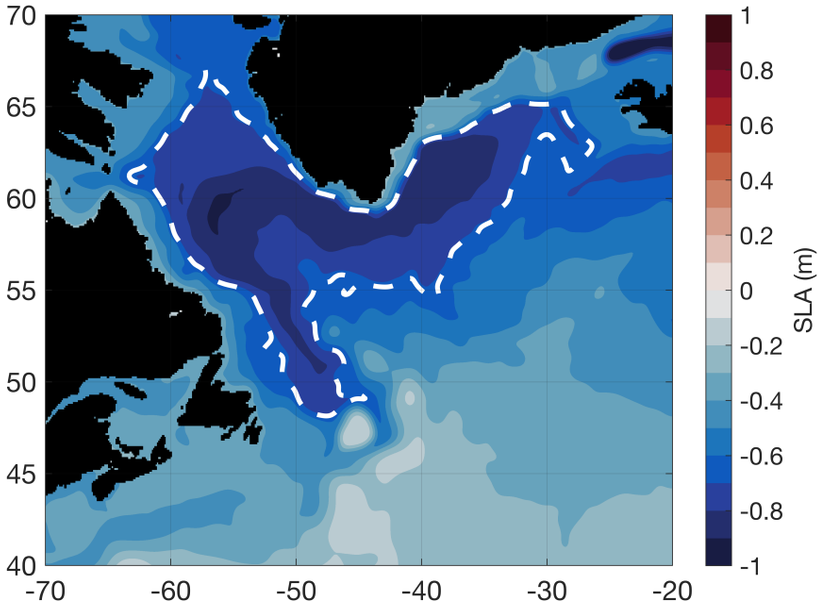


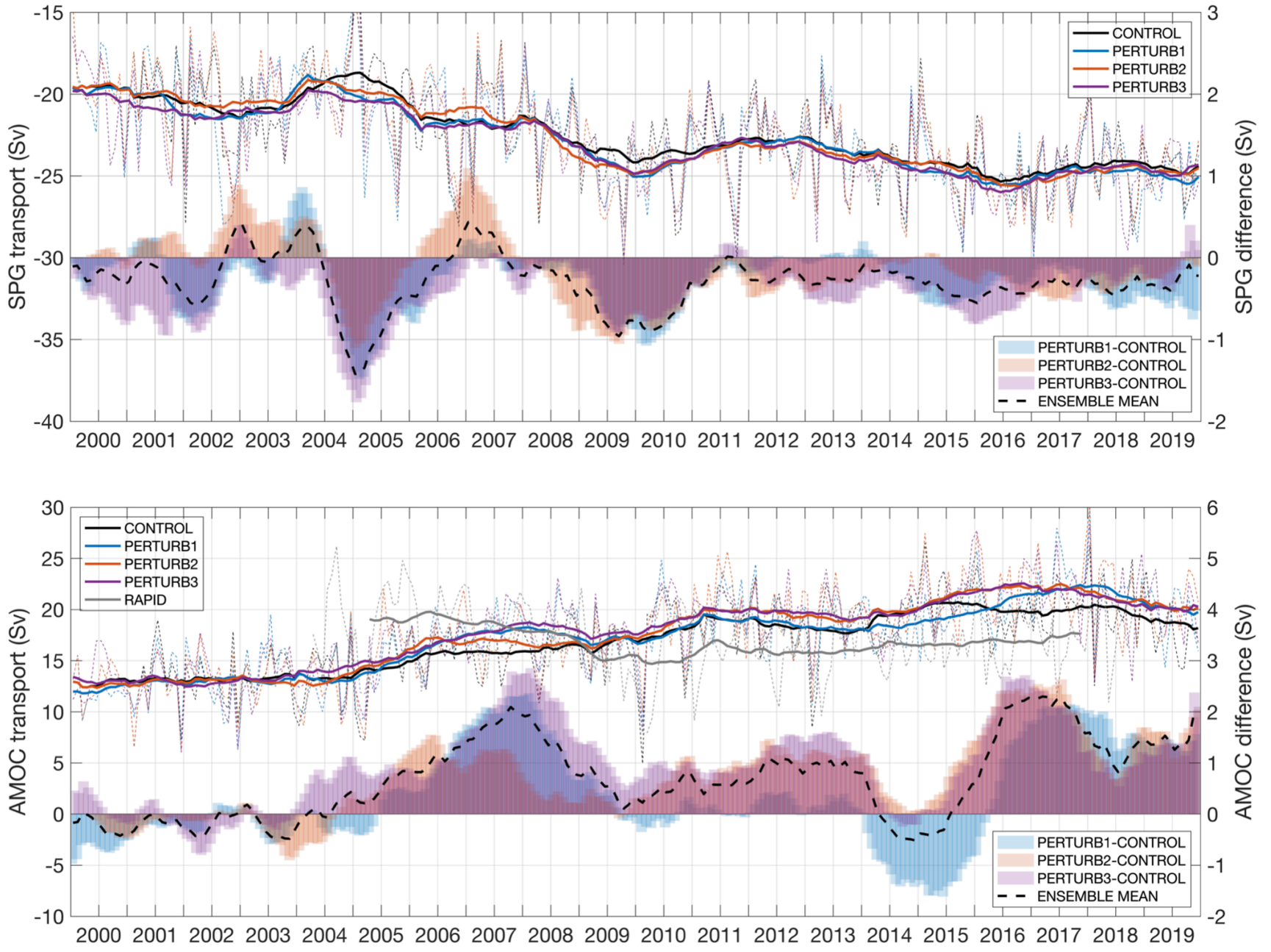
- A systematic SST cooling over (sub-)tropical region corresponding to region with more heat loss
- SST cooling magnitude is associated with the background ML depth, the shallower the stronger.
- Consistent with our 1-D simulation.





- Persistent ML deepening in mid-to-high latitude.
- Overall deeper wintertime mixed layer depth in sub-polar region.
- The SST changes and ML depth response could be explained by the background stratification.
- Weaker stratification in mid-to-high lats leads to vulnerable ML but little changes in ML temperature (SST) in response to surface buoyancy loss and wind stirring.
- Stronger stratification prevents ML being eroded too much by surface cooling and wind forcing but SST or ML temperature is sensitive to the entrainment and surface heat loss.





- Tendency of enhancement in SPG and AMOC in all three ensemble runs, but not always systematic throughout the simulation period.

- Seen response here might not be translated into a definite systematic effect, but rather an addition of variability from the wind perturbation.

Summary

- The CA method has the potential to improve the ERA5 wind kinetic energy spectra over **mesoscale (<450 km)** and **sub-daily scales (<16~24 hr)**

- Perturbed wind field leads to **large-scale organised** difference in surface fluxes that excites changes in ocean

- Systematic **SST cooling** in (sub-)tropical region (strong stratification) and **ML deepening** in mid-to-high latitudes (weak stratification)

- **Mean flows** demonstrates ‘tendency’ of **enhancement** across 3 ensemble simulations but true differences in flow transport **oscillate** over time

➡*Wind perturbation by CA can be regarded as an induced random uncertainty in ERA5 wind, and ocean response to such error has shown some aspects of systematic difference that cannot afford ignorance*

➡*Circulation responses do not completely rule out the possibility of a systematic changes if the simulations continue*

➡*With predicted changes in mesoscale weather systems in this century by eddy-permitting regional climate models, such assessment are of necessity*

Questions?

- I'll be presenting at Friday 30th of Apr, 11:25 CEST (OS1.2) and can take any questions that time or in the breakout room
- I'm also willing to take questions via shezhou@bas.ac.uk :-)