Quantification of Constrained Scales with an Ensemble Ocean Analysis

Environment and Climate Change Canada | Environnement et Changement climatique Canada

Drew Peterson
Environmental Numerical Prediction Research Section

Atmosphere and Ocean Dynamics,
Celebrating Richard Greatbatch's
Scientific Achievements
12 April, 2024, Kiel, Germany

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In Collaboration with

Environment and Climate Change Canada

Environnement et Changement climatique Canada

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Honoured to be Here in Kiel

Jurgen Goos
b. 1864 in Owschlag

Honoured to be Celebrating Richard's Science

1994

Importance of having initial spread in Observations

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RESEARCH ARTICLE

Understanding sources of Northern Hemisphere uncertainty and forecast error in a medium-range coupled ensemble sea-ice prediction system

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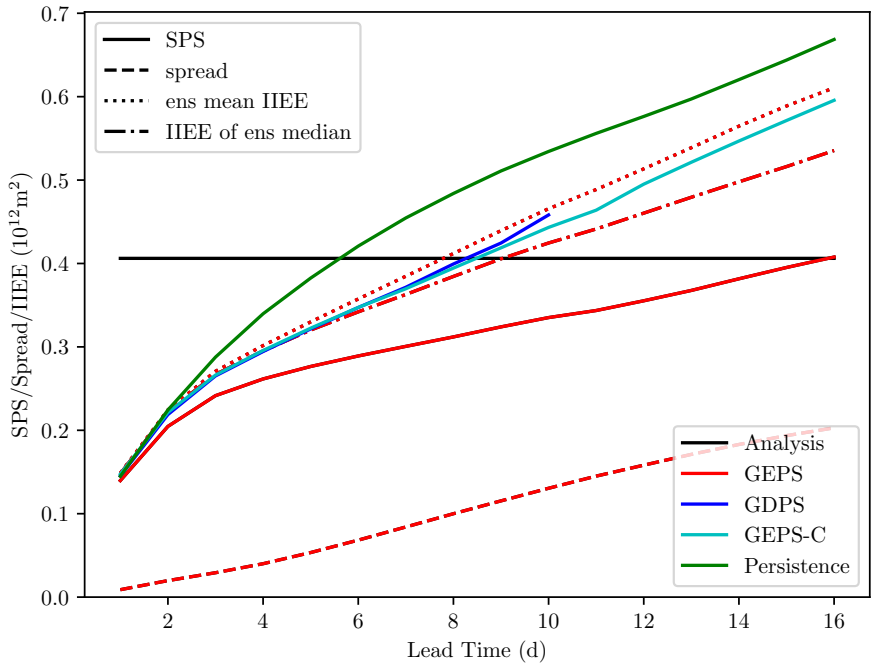

Ensemble GIOPS

- Start with GIOPS.
- replace GDPS forcing with GEPS Ensemble Atmospheric Forcing (21 members)
  - From 12-36h forecast

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    - Results in instabilities.
    - Increases spread in quiescent (gyre) areas with small errros.

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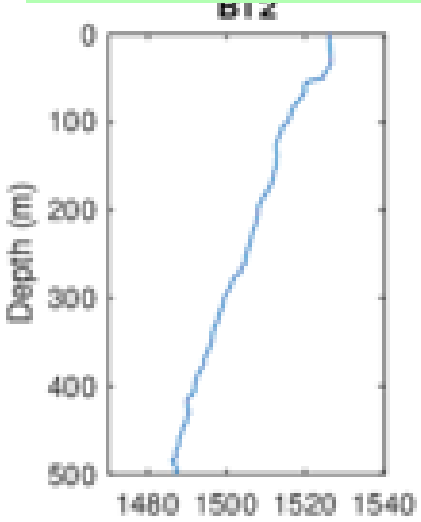
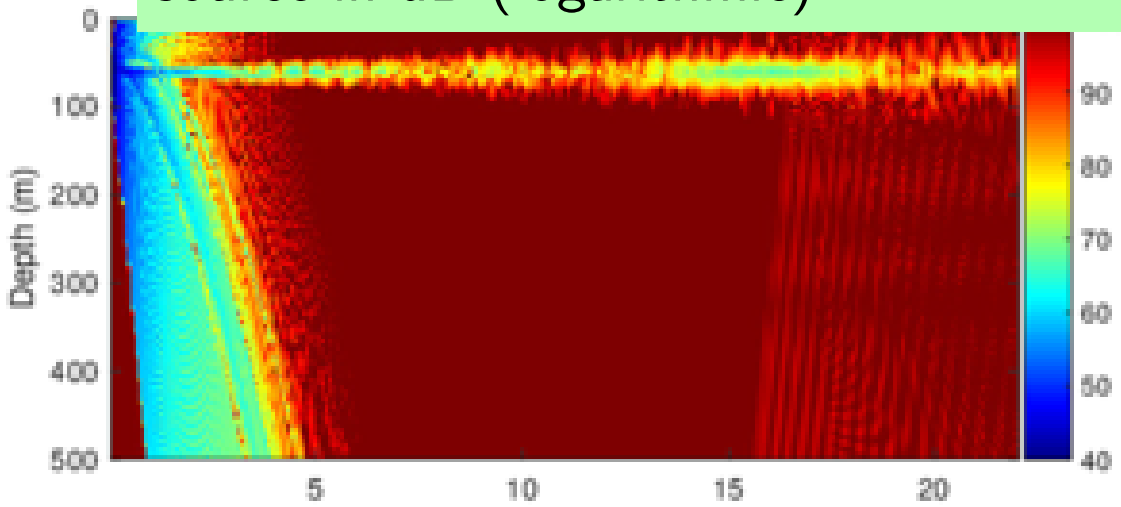
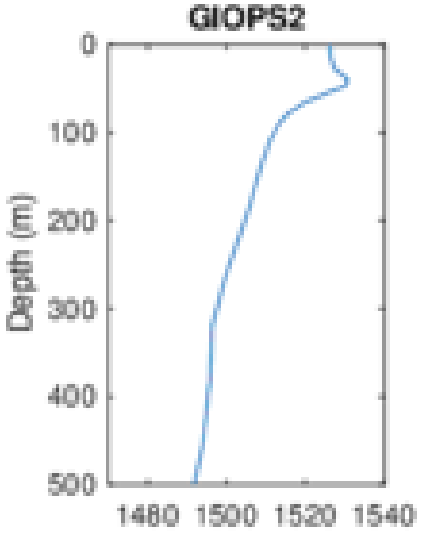
Possible Use: Probability of Sound Duct

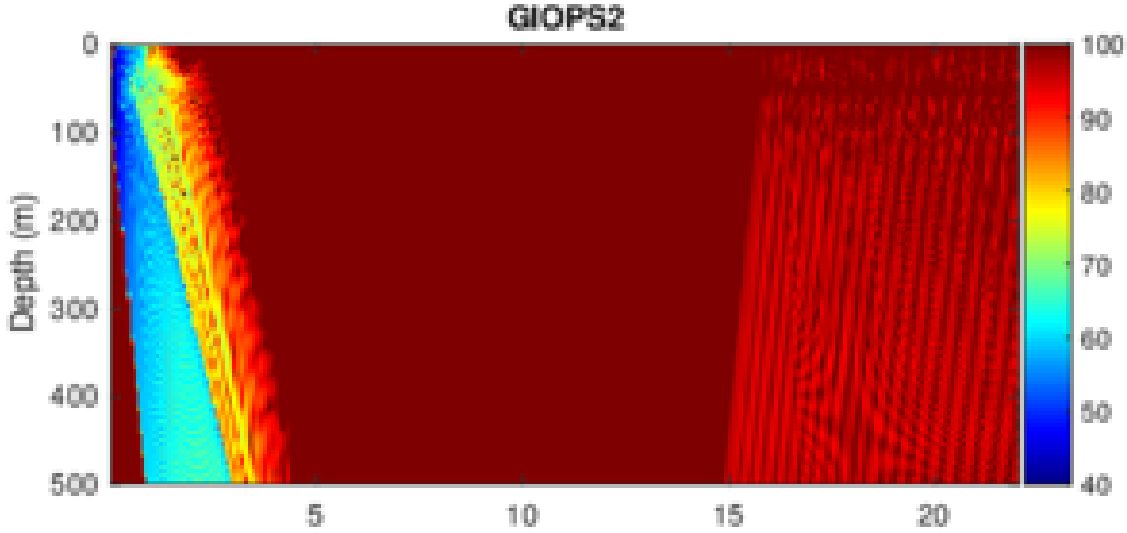
Sound Speed Profile

Transmission Loss at distance (km) from source in dB (logarithmic)









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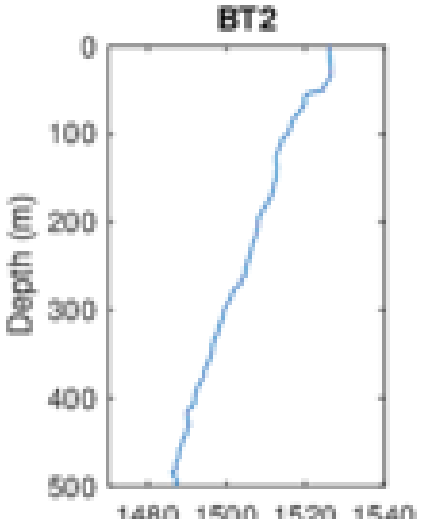

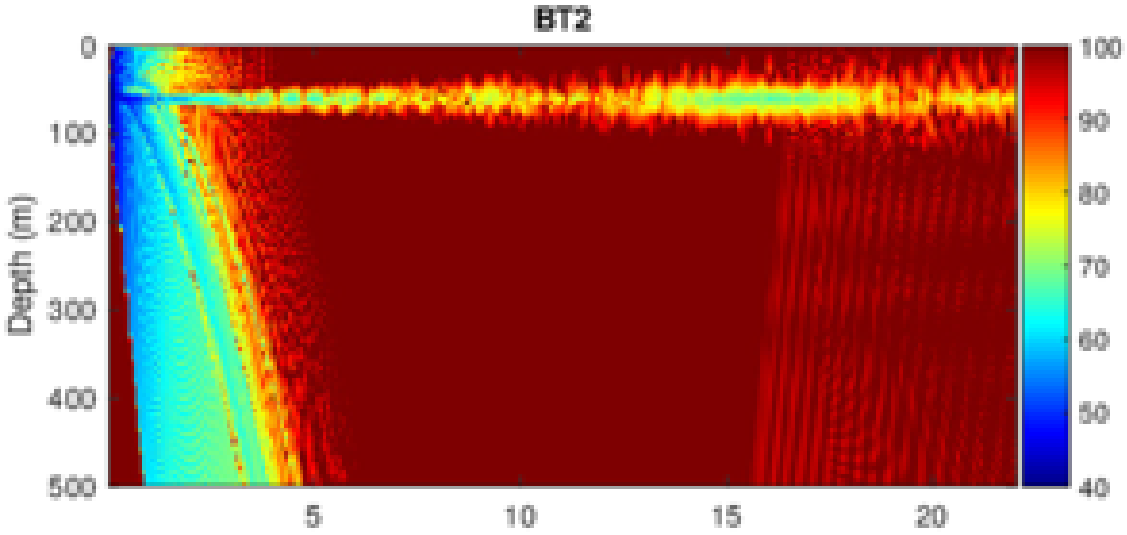

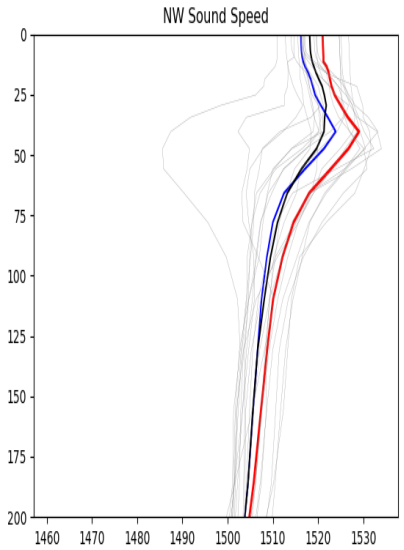

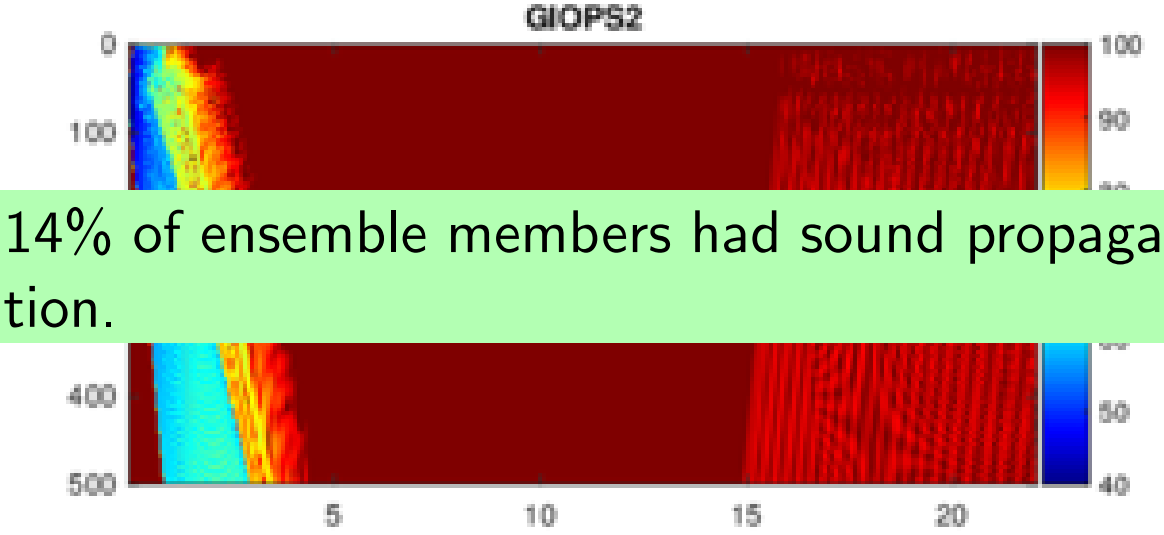

14% of ensemble members had sound propagation.

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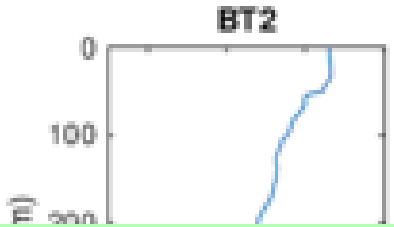
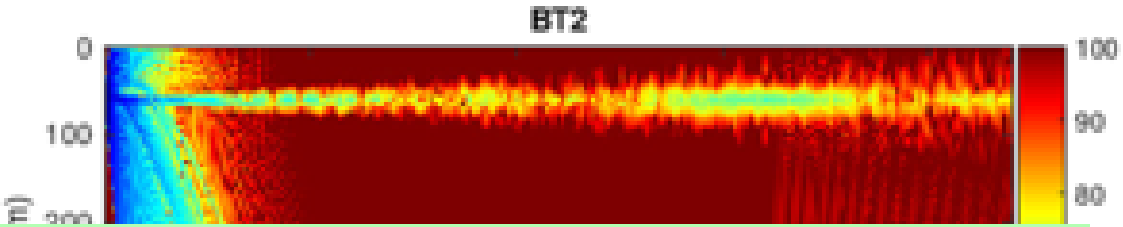
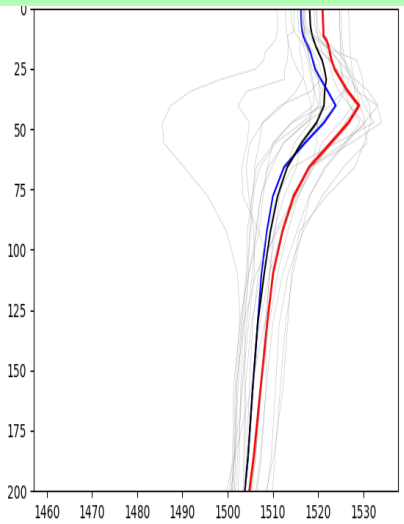
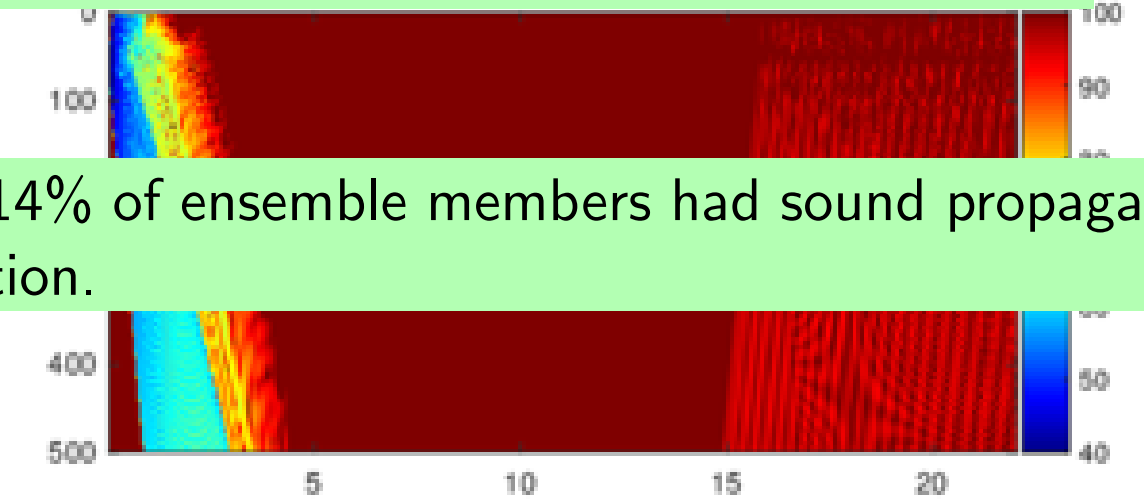




https://www.dropbox.com/scl/fi/5nqjitt14zyhbdsutjmdi/EnGIOPS_CONCEPTS_20Nov2023.pdf





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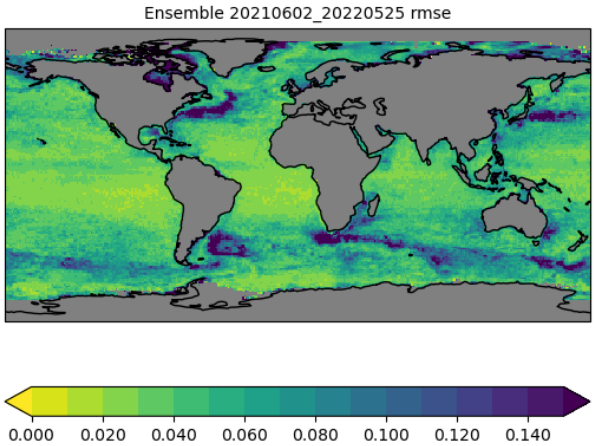
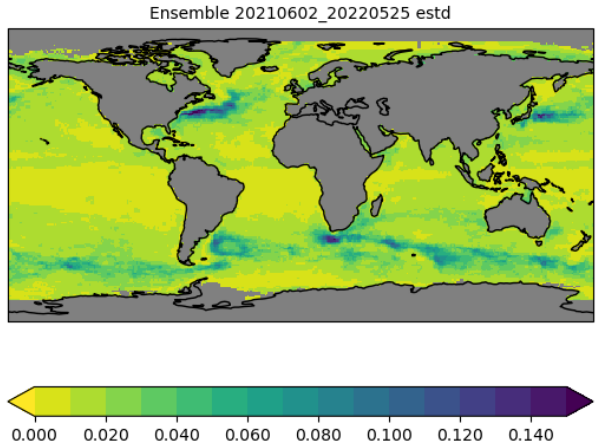
SSH RMSE/SPREAD Relationship

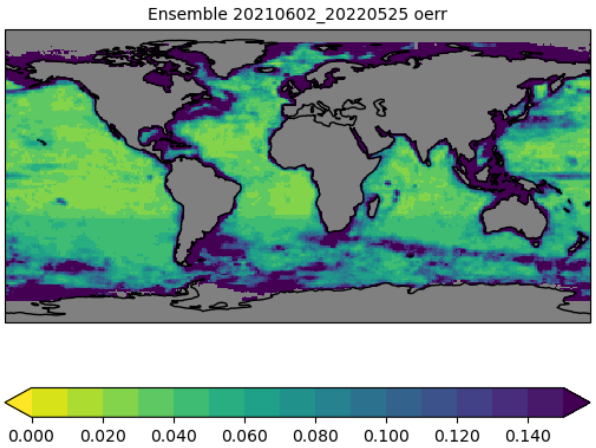
RMSE



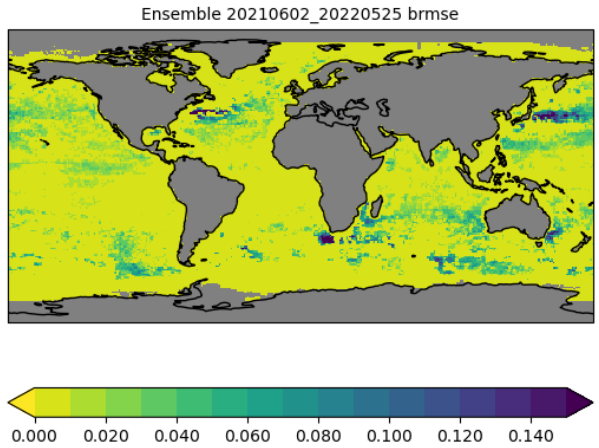
SPREAD



Obs Error



$$\sqrt{(\mathrm{RMSE})^2 - \mathrm{bias}^2 - (\mathrm{Obs\ Error})^2}$$



Constained and Unconstained Scales

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Observation and model resolution implications to ocean prediction

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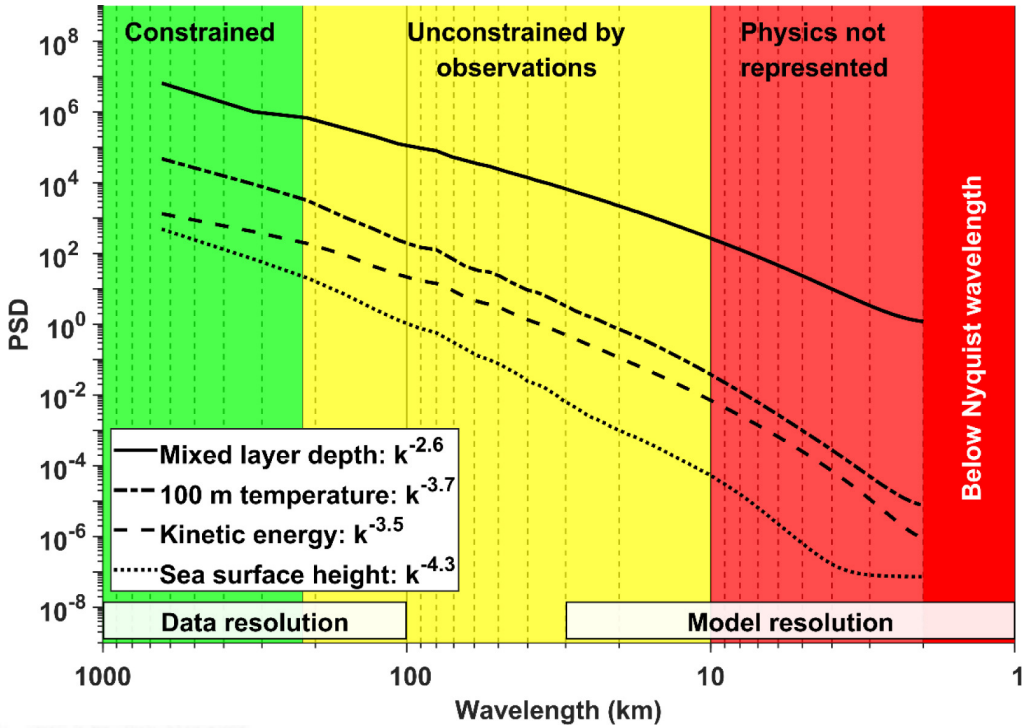
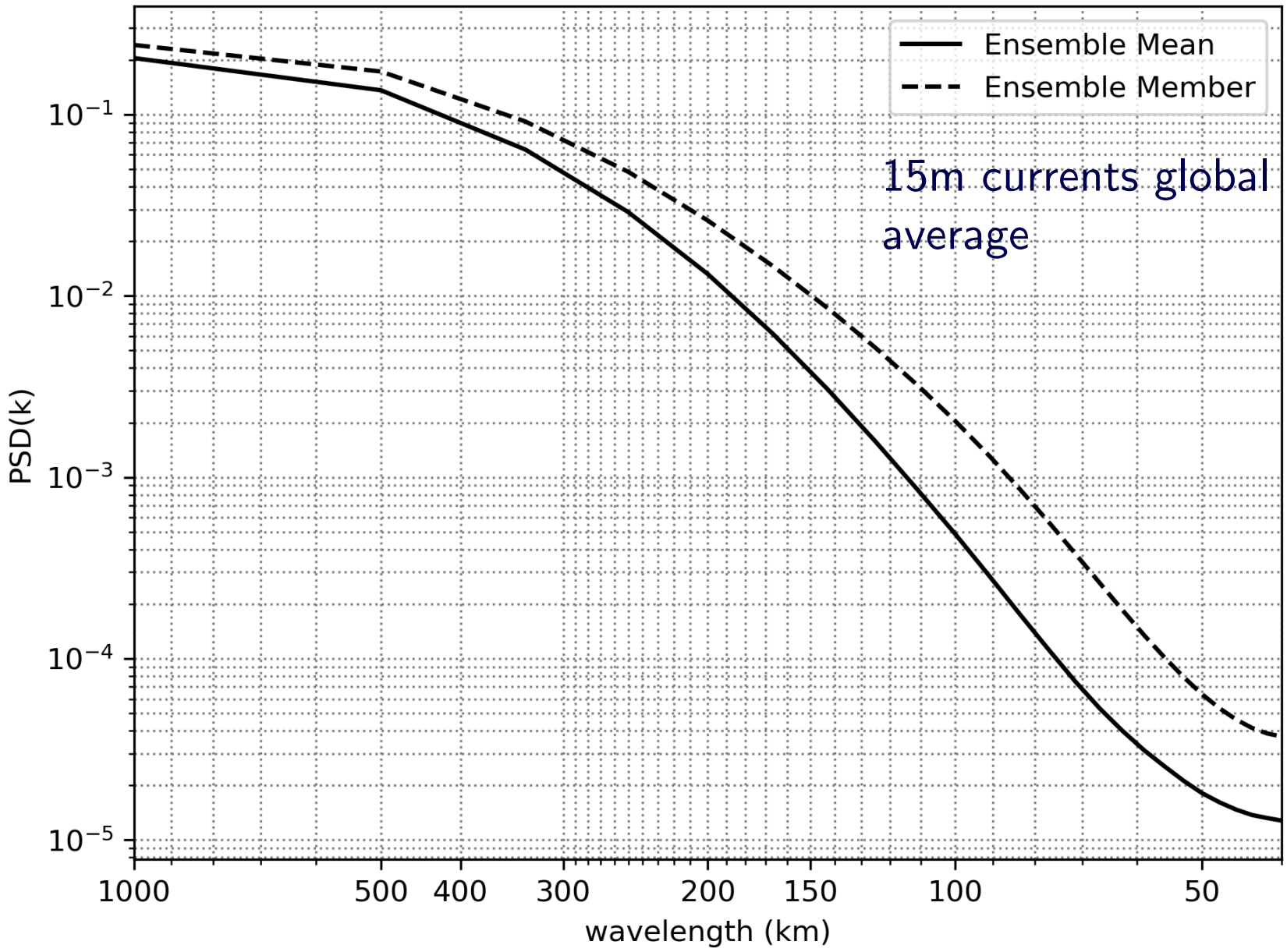
[b] University of New Orleans, Department of Physics, LA, USA



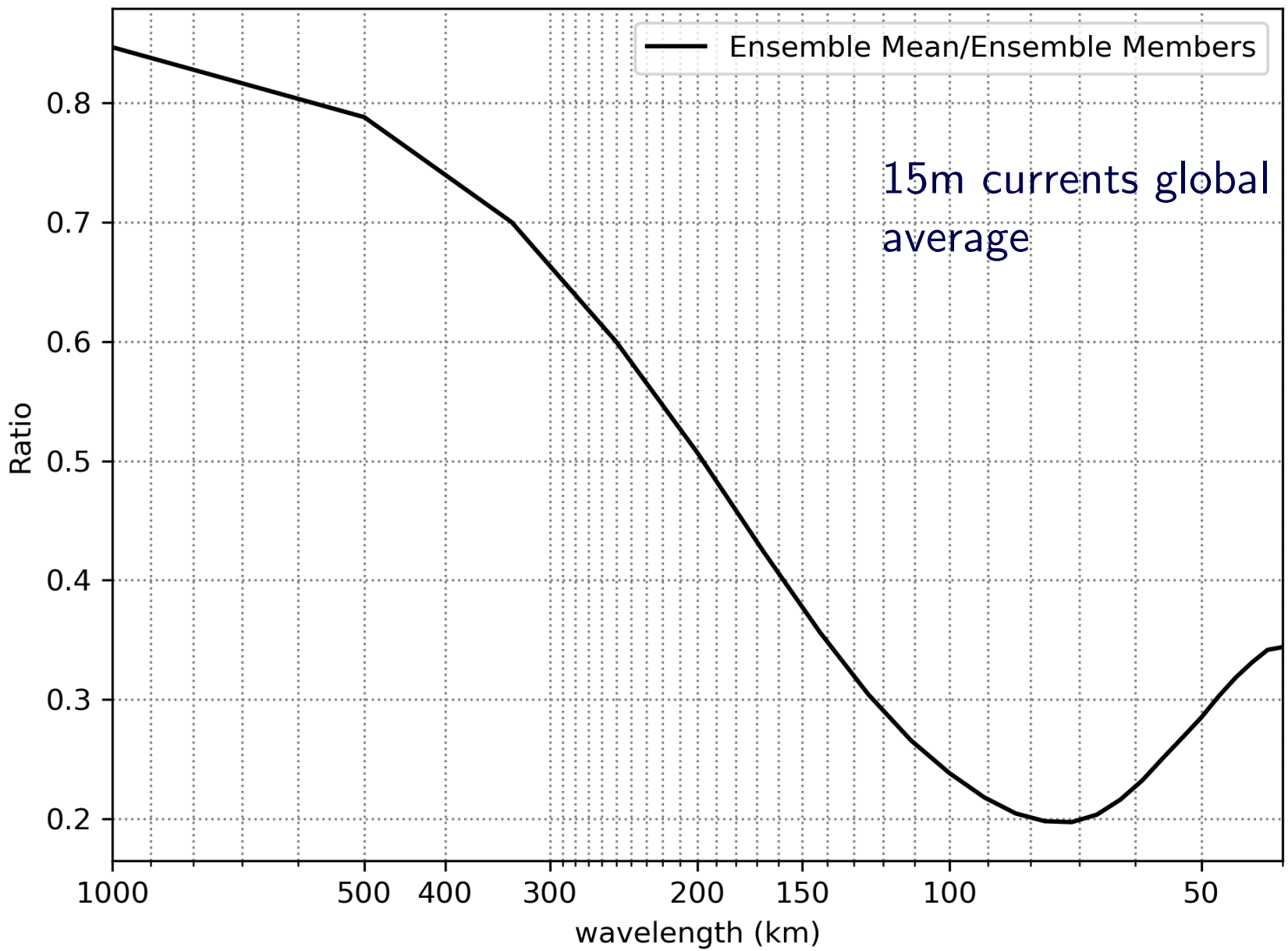
Power Spectrum Analysis

- Performed a power spectrum analysis on 10-20m velocities in 247 1000km$\times$1000km boxes
  - Boxes will be shown later
  - Fields interpolated onto 20km cartesian grid in box.
- Performed power spectrum on ensemble mean and on ensemble members over 2021-06-09 through 2022-06-01 (every 7th analysis day only!).
  - 53 dates
- Contrasted – and took ratio – of power lost in ensemble mean.

PSD Ensemble Mean & Ensemble Members

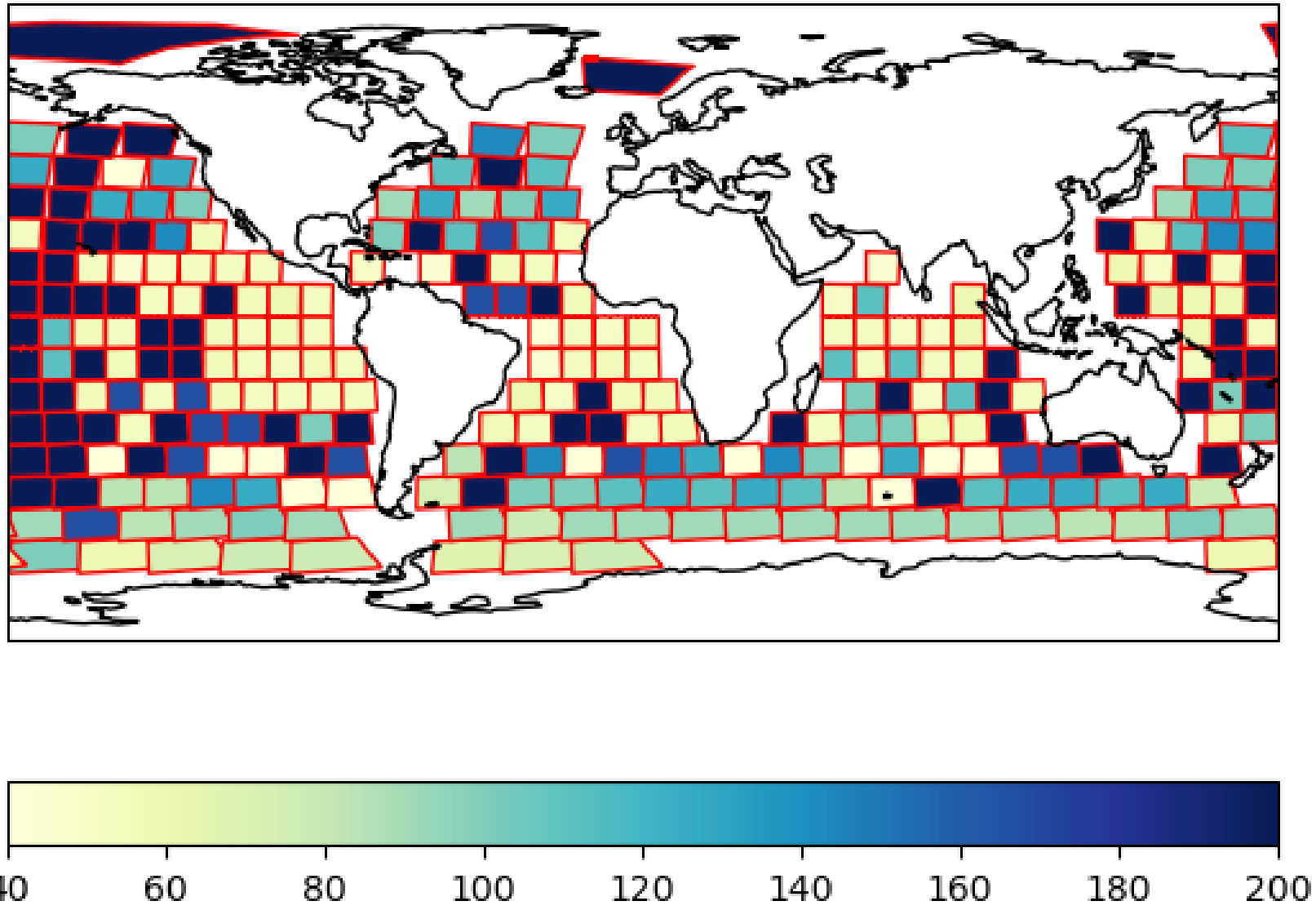


PSD ratio Ensemble Mean / Ensemble Members



Power Spectrum lengthscale of minimum ratio.

Wind Stress from Atmosphere Ensemble



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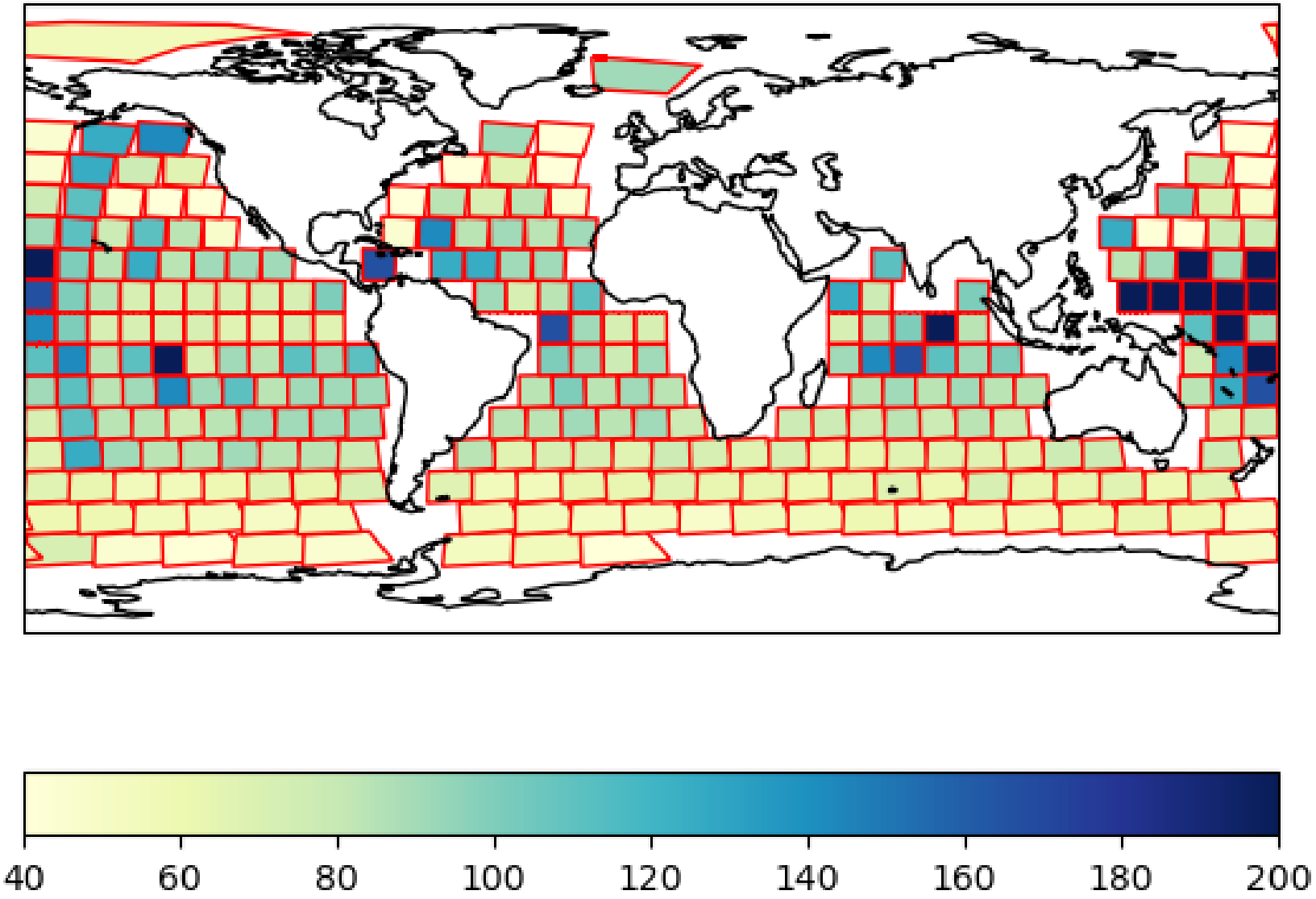
Ensemble Ocean Currents – 10-20m KE



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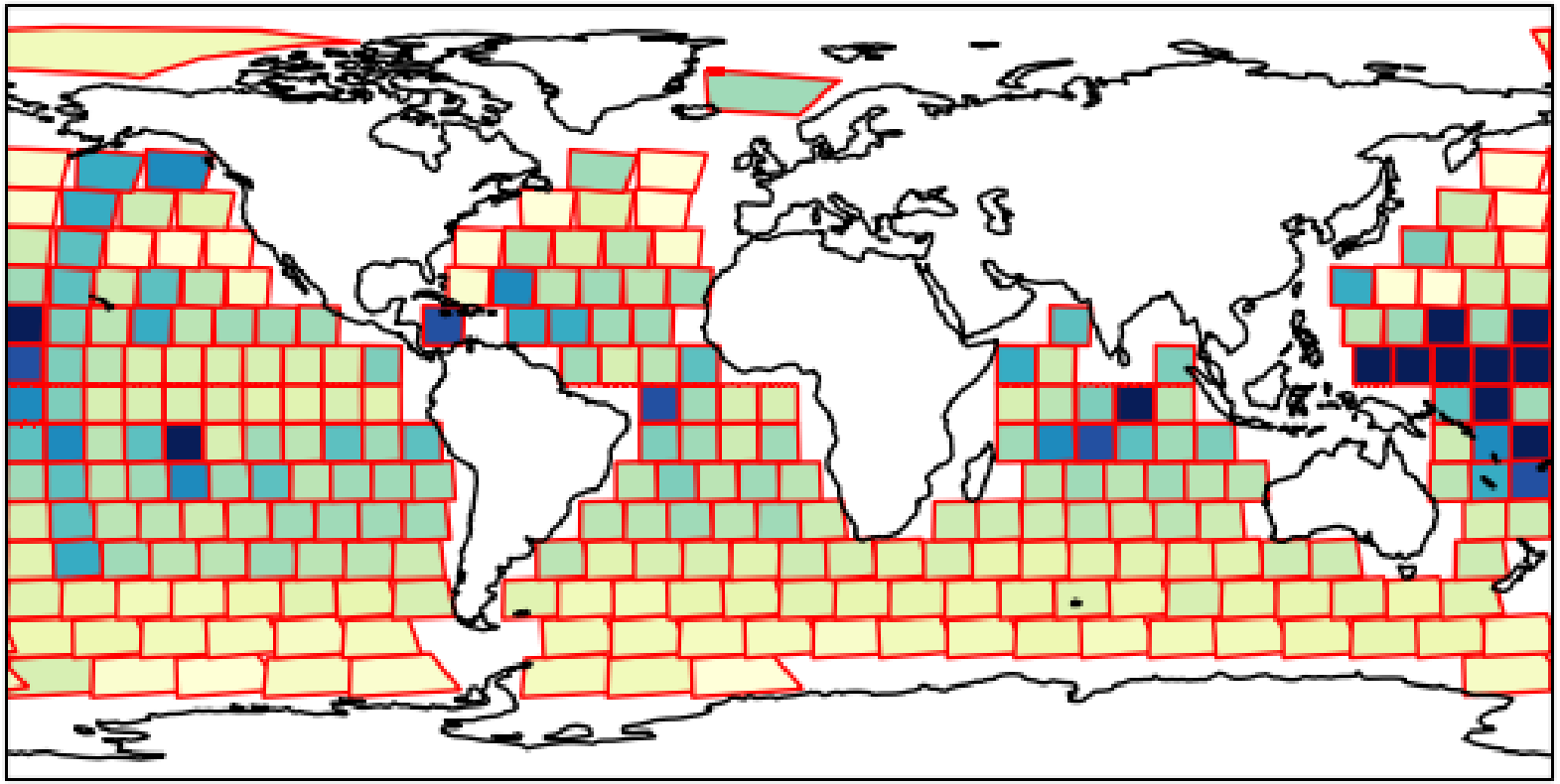
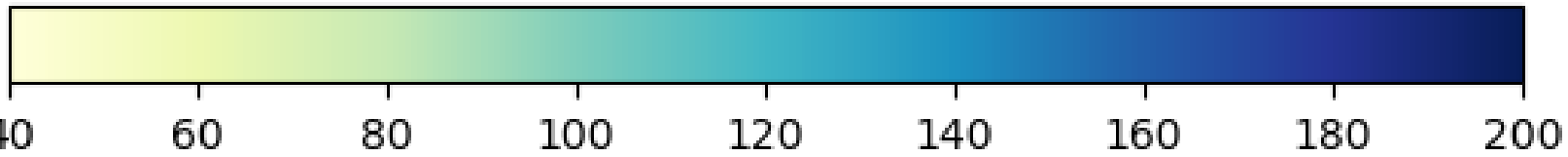


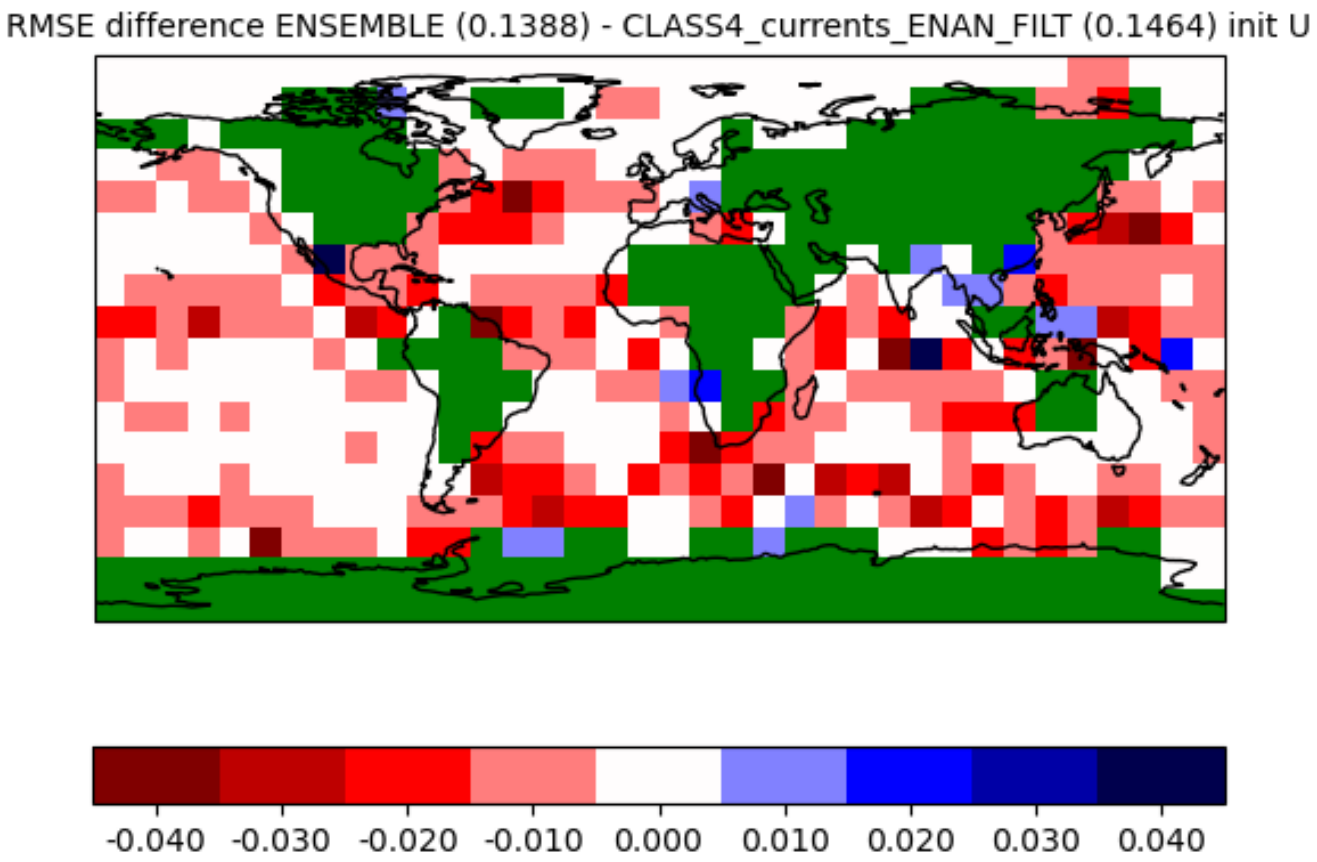
- Rossby Radius Dependent?



Current Statistics with Ensemble Mean

- Calculated (Charly Regnier, MOI) Eulerian Velocity implied by movement of drifting drogued (15m) buoys.
  - Displayed distance for recurring bouys / time.
  - 24h filtering applied / Stokes drift is added to model results.
  - `https://doi.org/10.1016/j.ocemod.2023.102241`
- Showing diffence of RMSE of ensemble mean minus RMSE of control member for East and North components.

Current Statistics with Ensemble Mean



- Ensemble Mean RMSE significantly reduced from control member.
- Particularly in Eddying regions

Future and Current Work

- Probabilistic Detection of Eddies
- Proper ensemble diagnostics (uncertainty) for CLASS4 T/S profile observation/model comparisons.
- Make Ensemble Analysis Operation
- Improve Assimilation Errors Estimates from Ensemble (LETKF)
- Coarse Graining Techniques for Spectral Analysis
  - Storer, B. A., & Aluie, H. (2023). FlowSieve: A coarse-graining utility for geophysical flows on the sphere. Journal of Open Source Software, 8(84), 4277. `https://doi.org/10.21105/joss.04277`