Diffusivities as barriers to mixing: Control Vectors give glimpse into mixed layer dynamics

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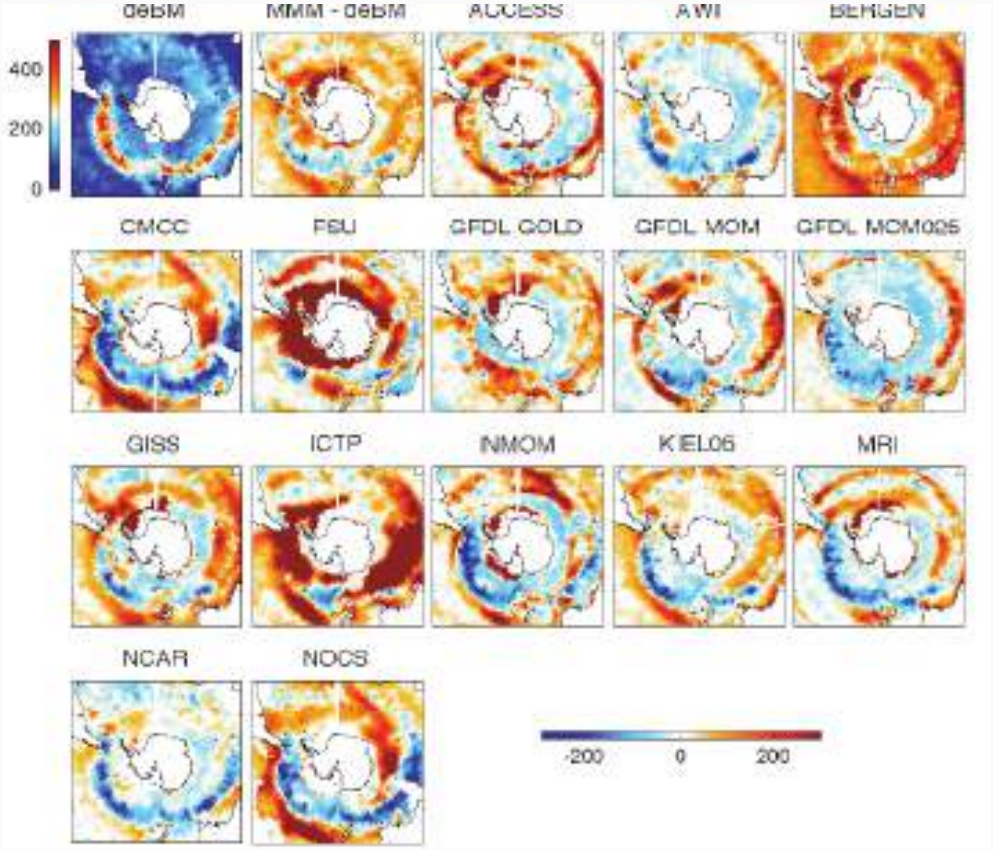
Oct, 2018

[1]MIT, [2]Harvard & [3]JPL

Does ECCOv4r3 (llc90) do a good job in the surface?



Downes *et al.*, 2015

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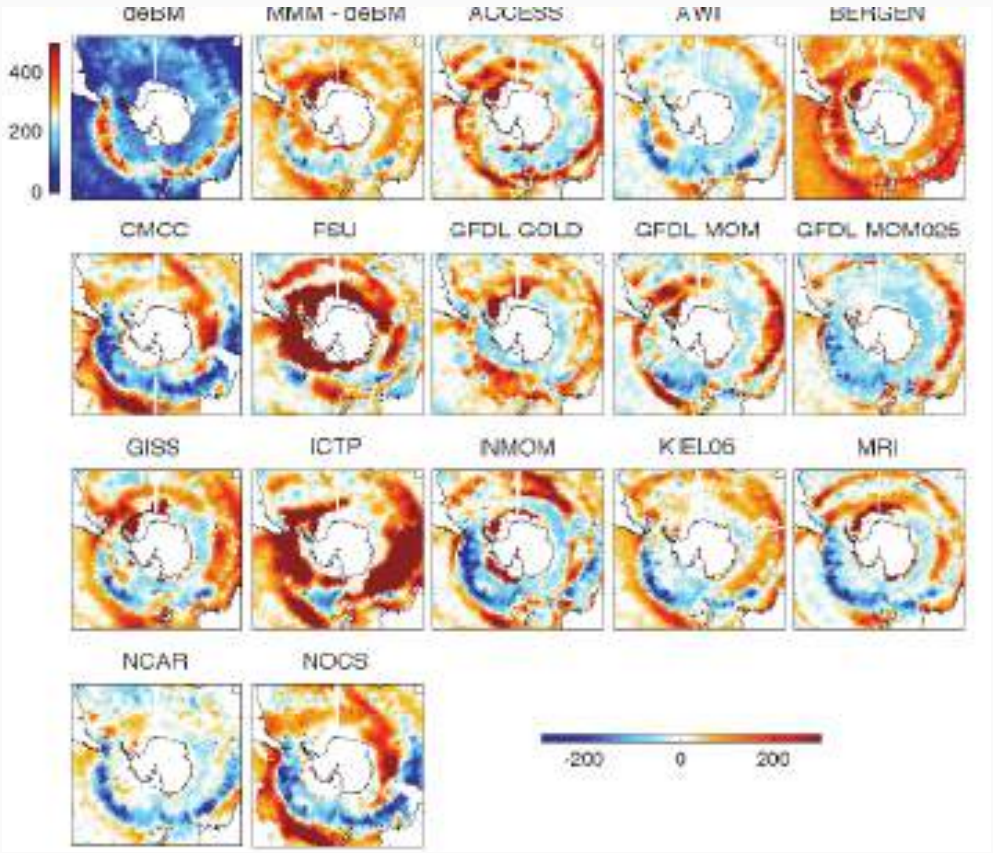
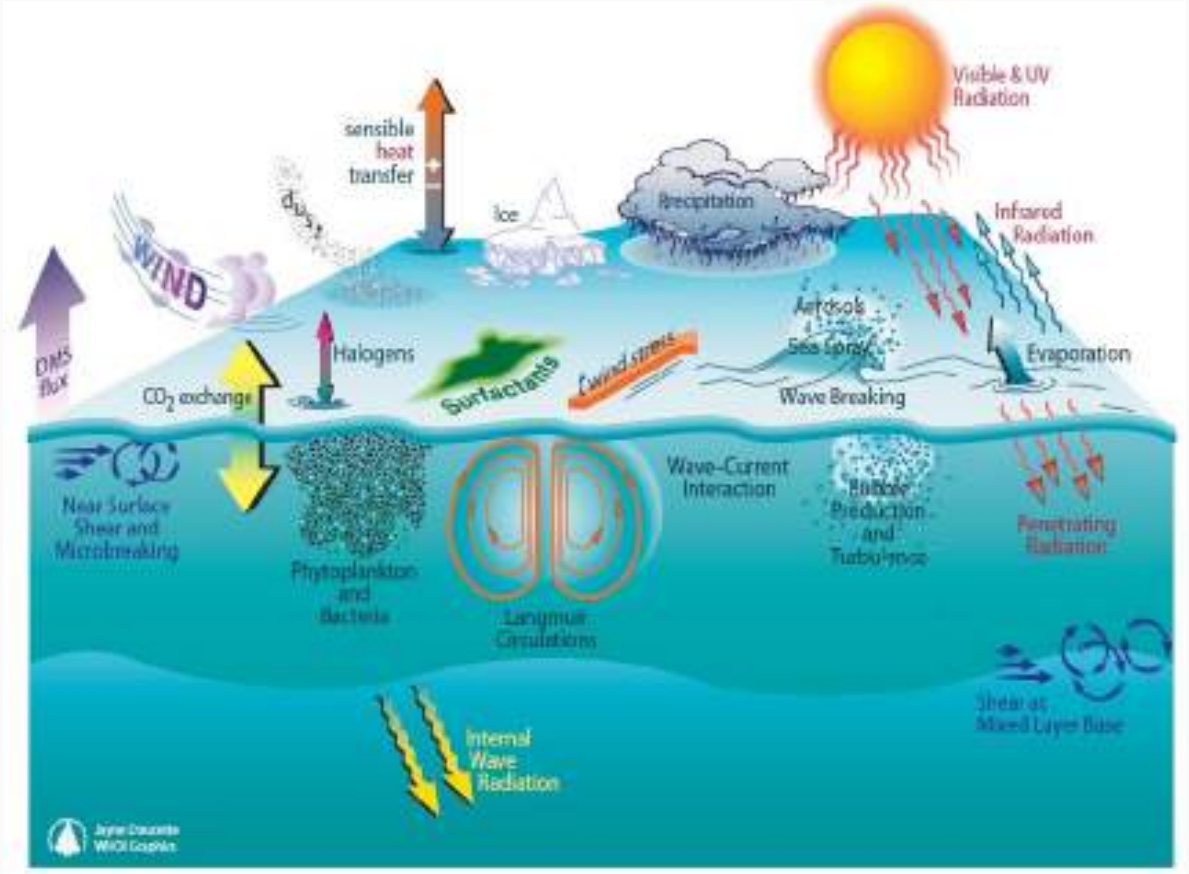


Downes *et al.*, 2015

ECCO itterations towards State Estimate are reasonable ensemble members

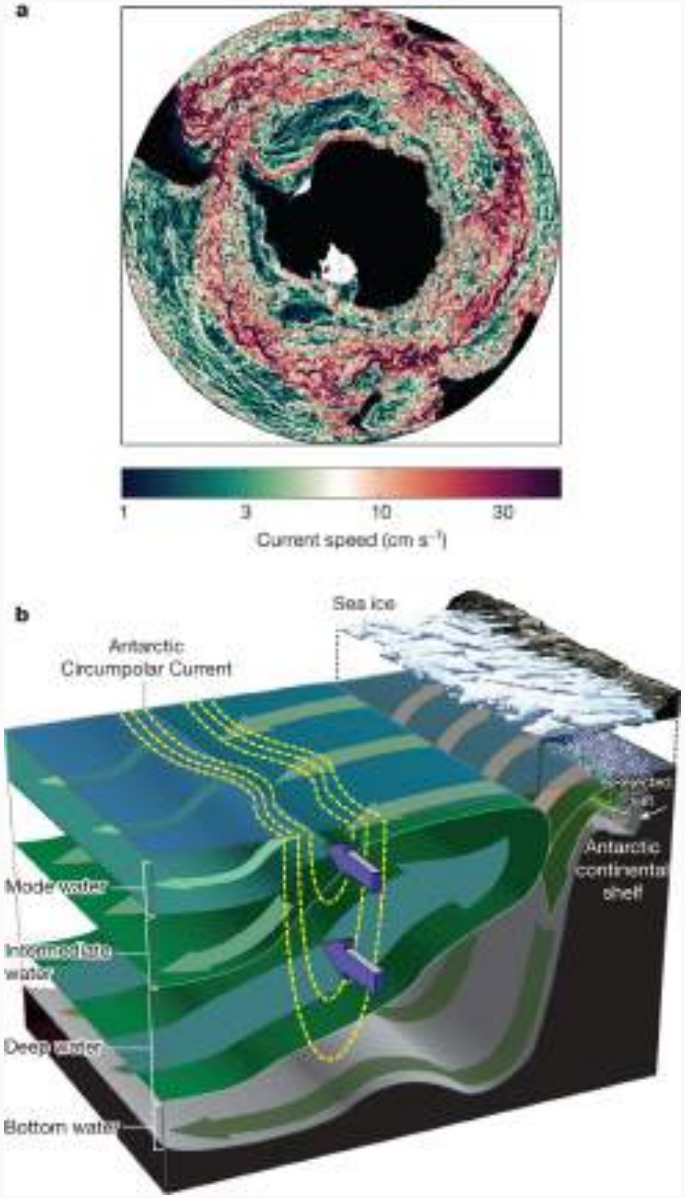
Introducing: Surface "mesoscale zoo"



Details in parameters etc.

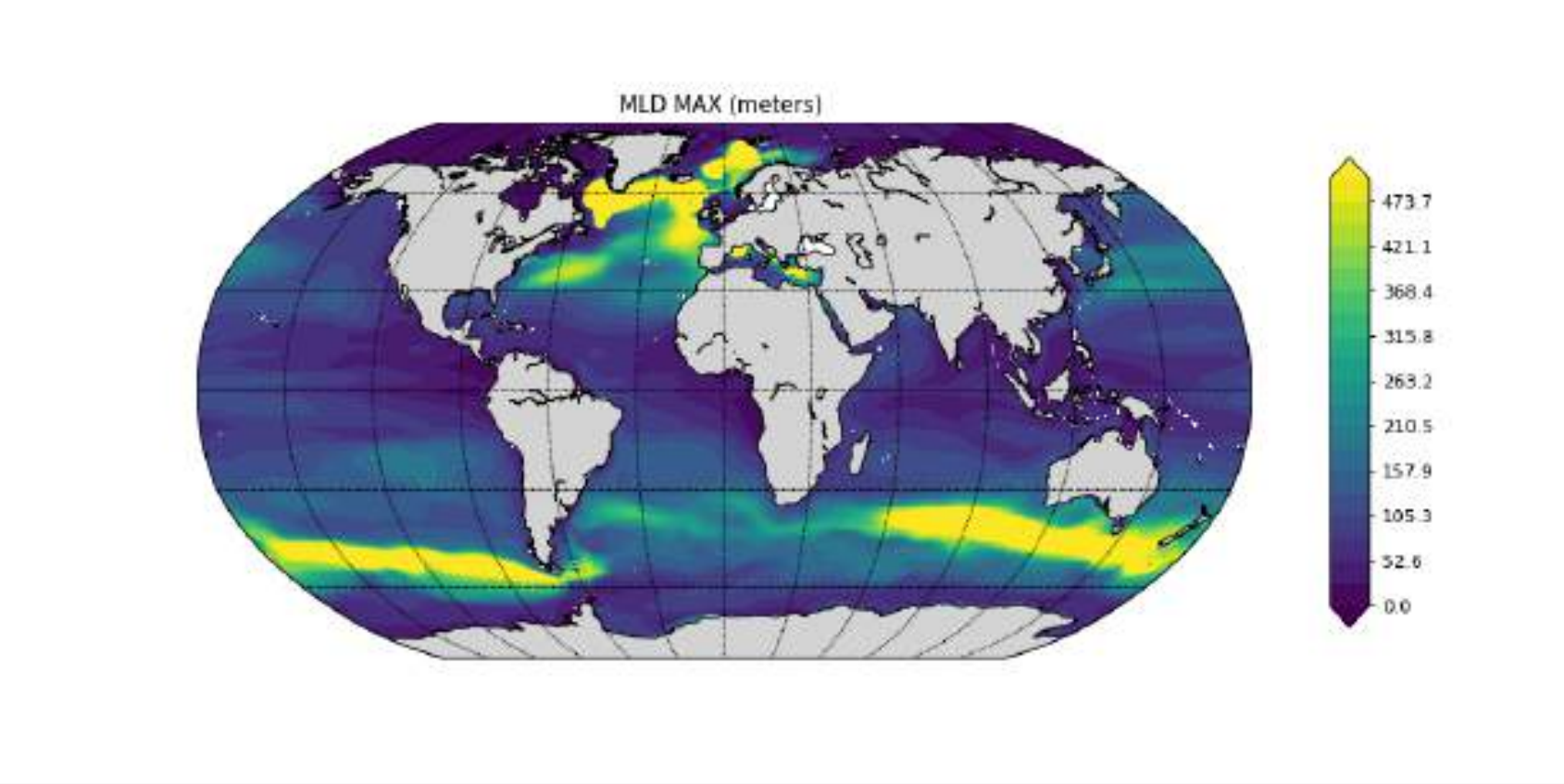
Here: Diffkr, Kapgm, Kapredi

MLD importance: Winter export



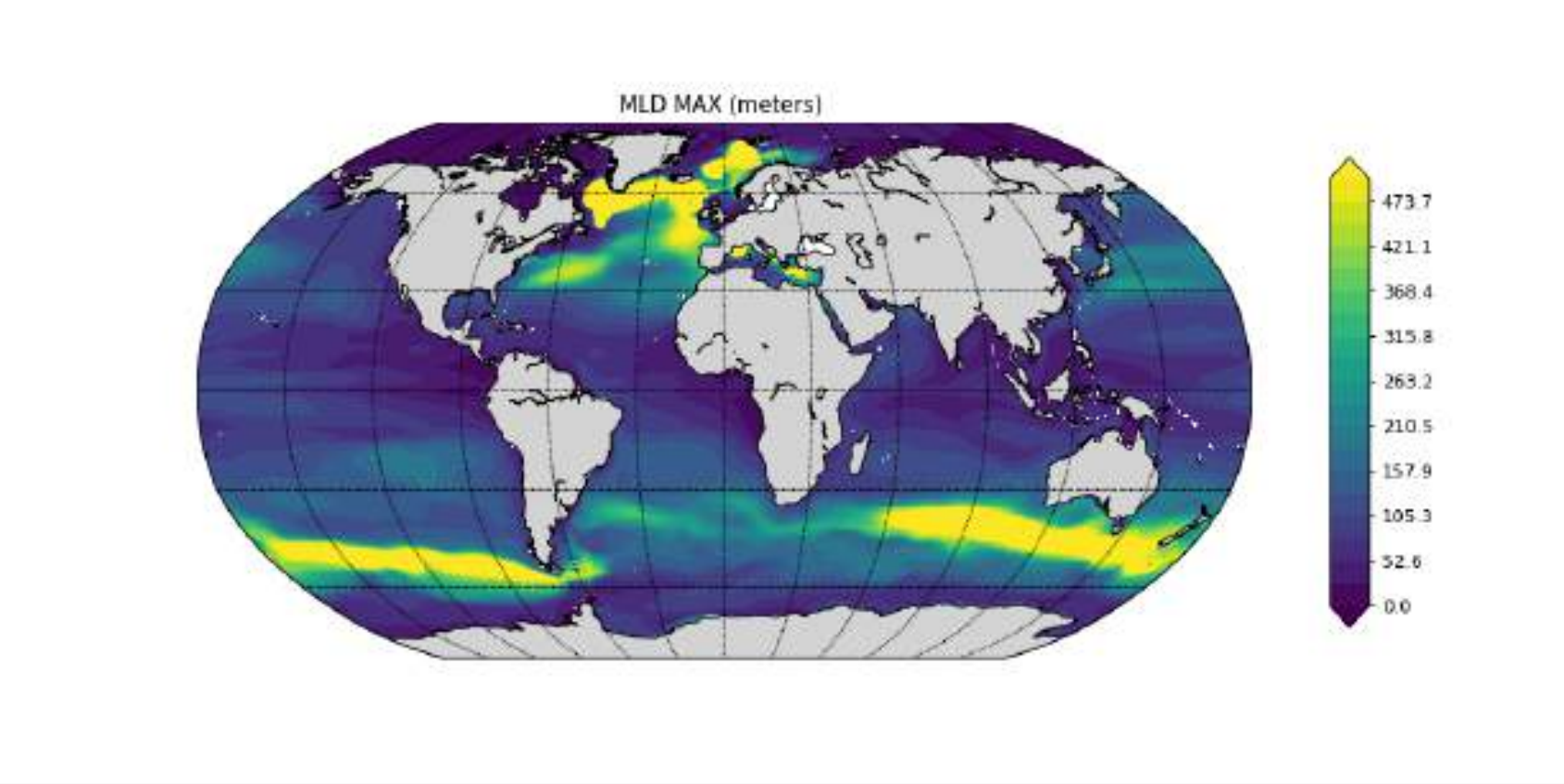
Rintoul, 2018

Motivation



The winter max is what we care about for climate/ventilation

Motivation

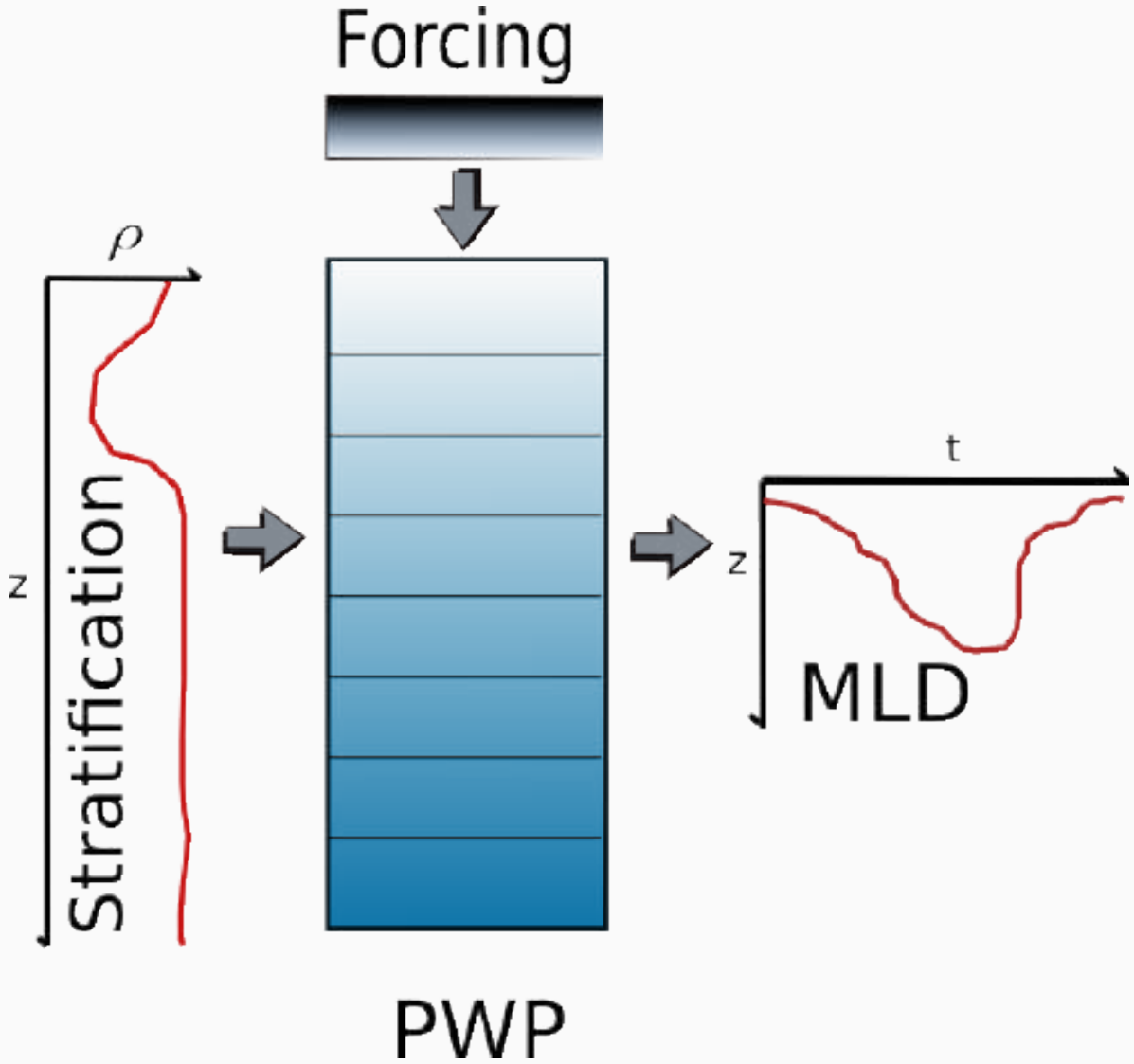


The winter max is what we care about for climate/ventilation

Motivation

What parameters adjustments encourage/inhibit MLD deepening?

Simple exploration: Price Weller Pinkel



Simple exploration: Price Weller Pinkel

The PWP model is based on mixing based on three stability criteria:

Static stability

$$\frac{\partial \rho}{\partial z} \geq 0,$$

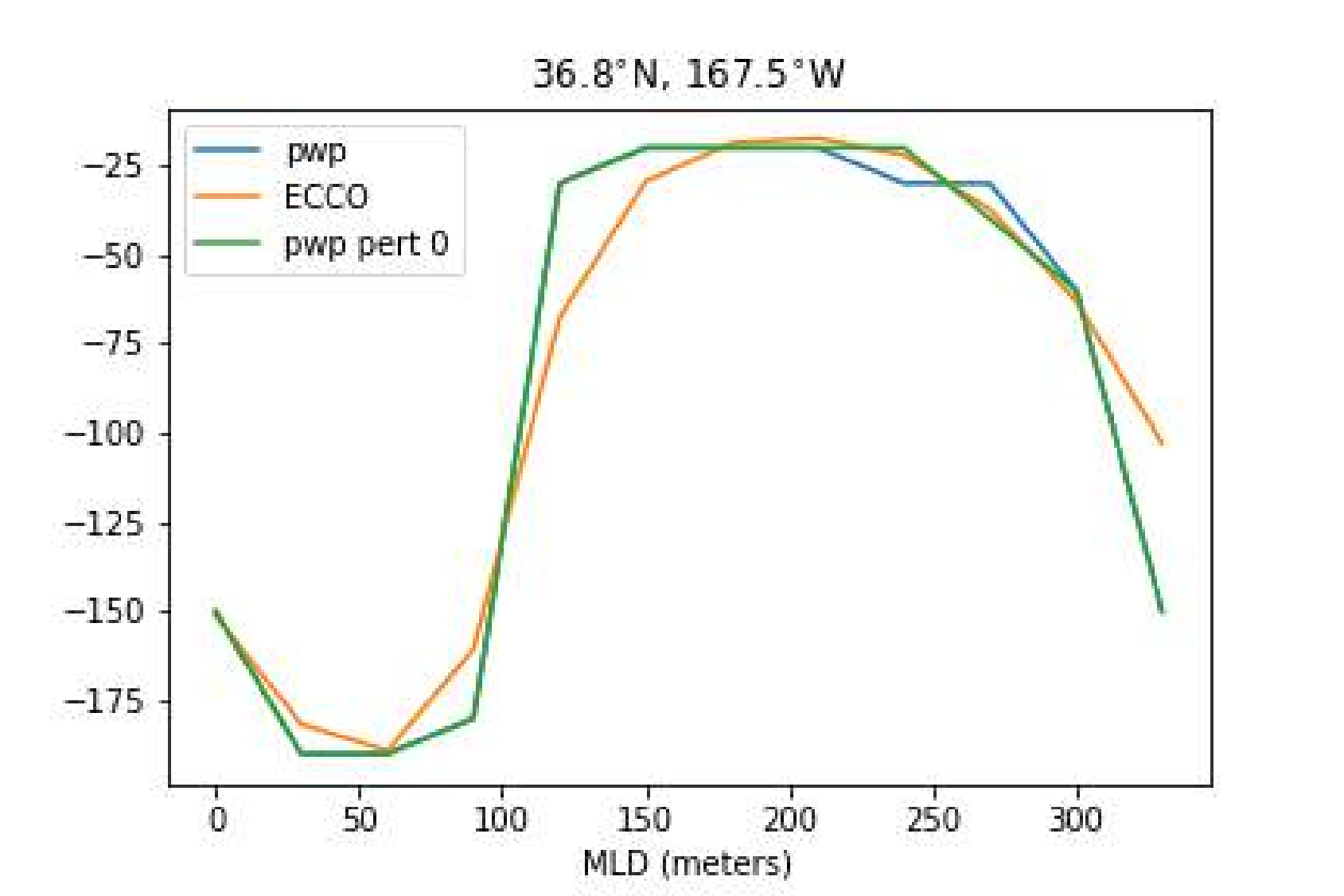
mixed layer stability

$$R_b = \frac{g \Delta \rho h}{\rho_0 (\Delta V)^2} \geq 0.65,$$

and shear flow stability below the mixed layer

$$R_g = \frac{g \partial \rho / \partial z}{\rho_0 (\partial V / \partial z)^2} \geq 0.25.$$

PWP vs ECCO MLD



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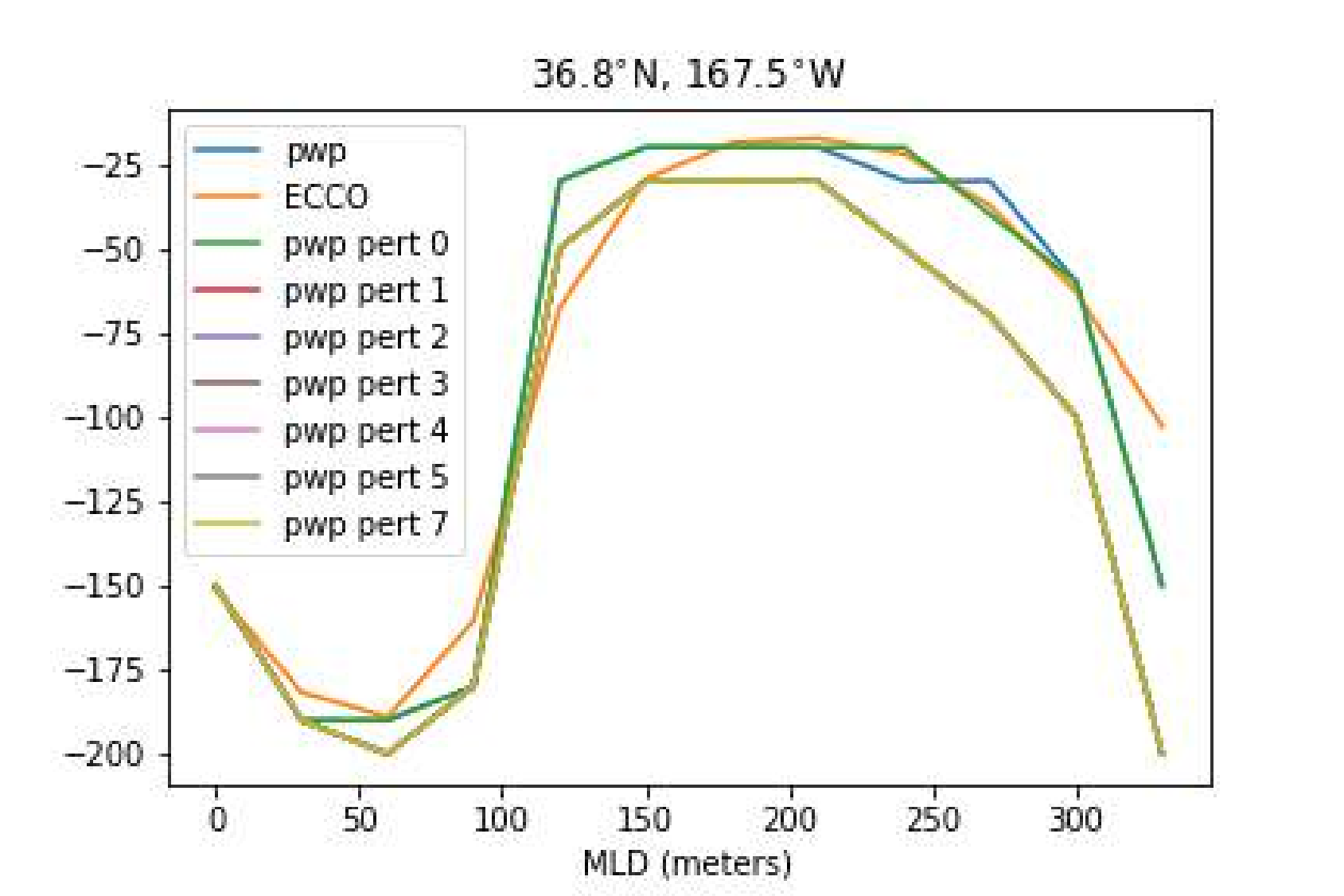

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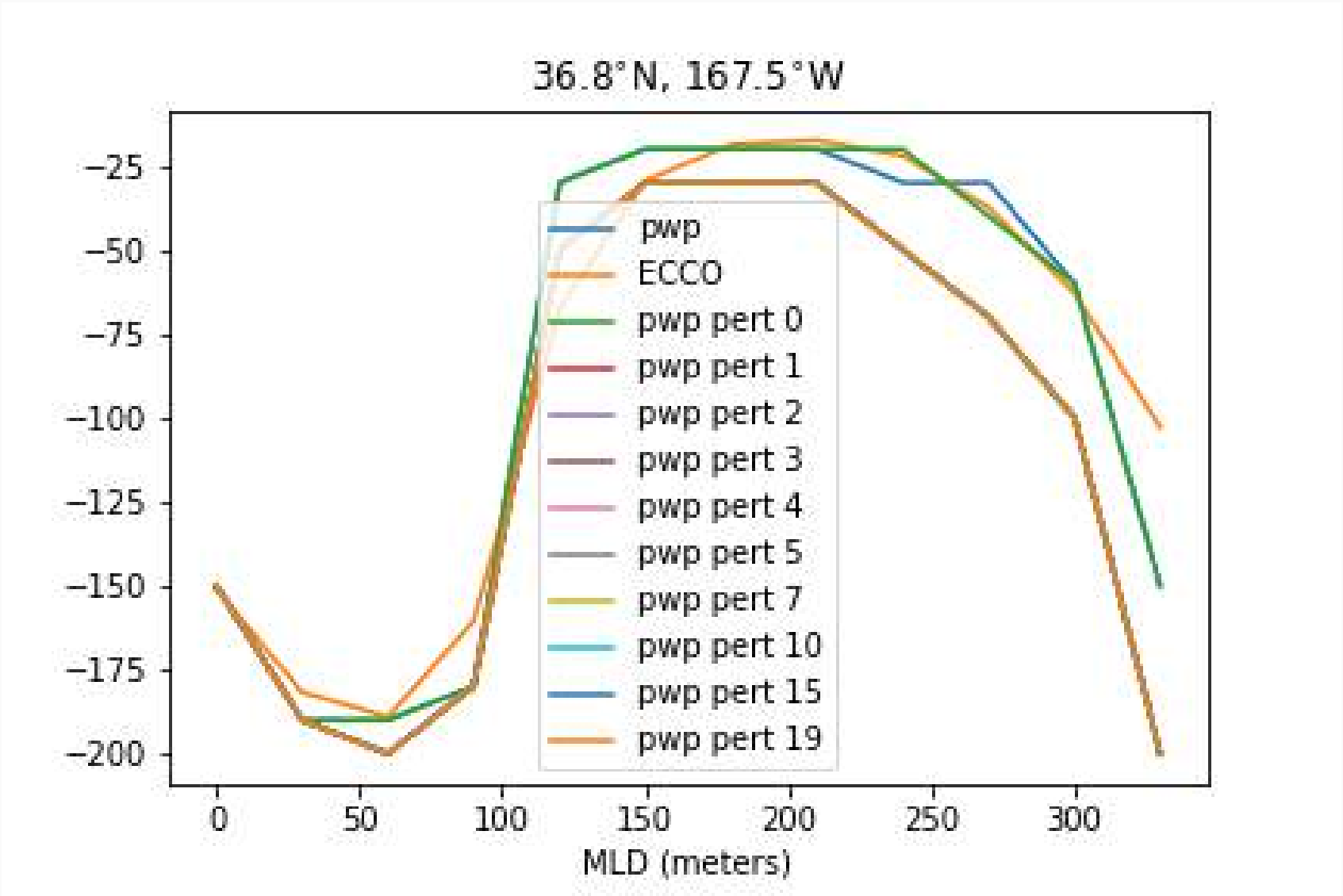
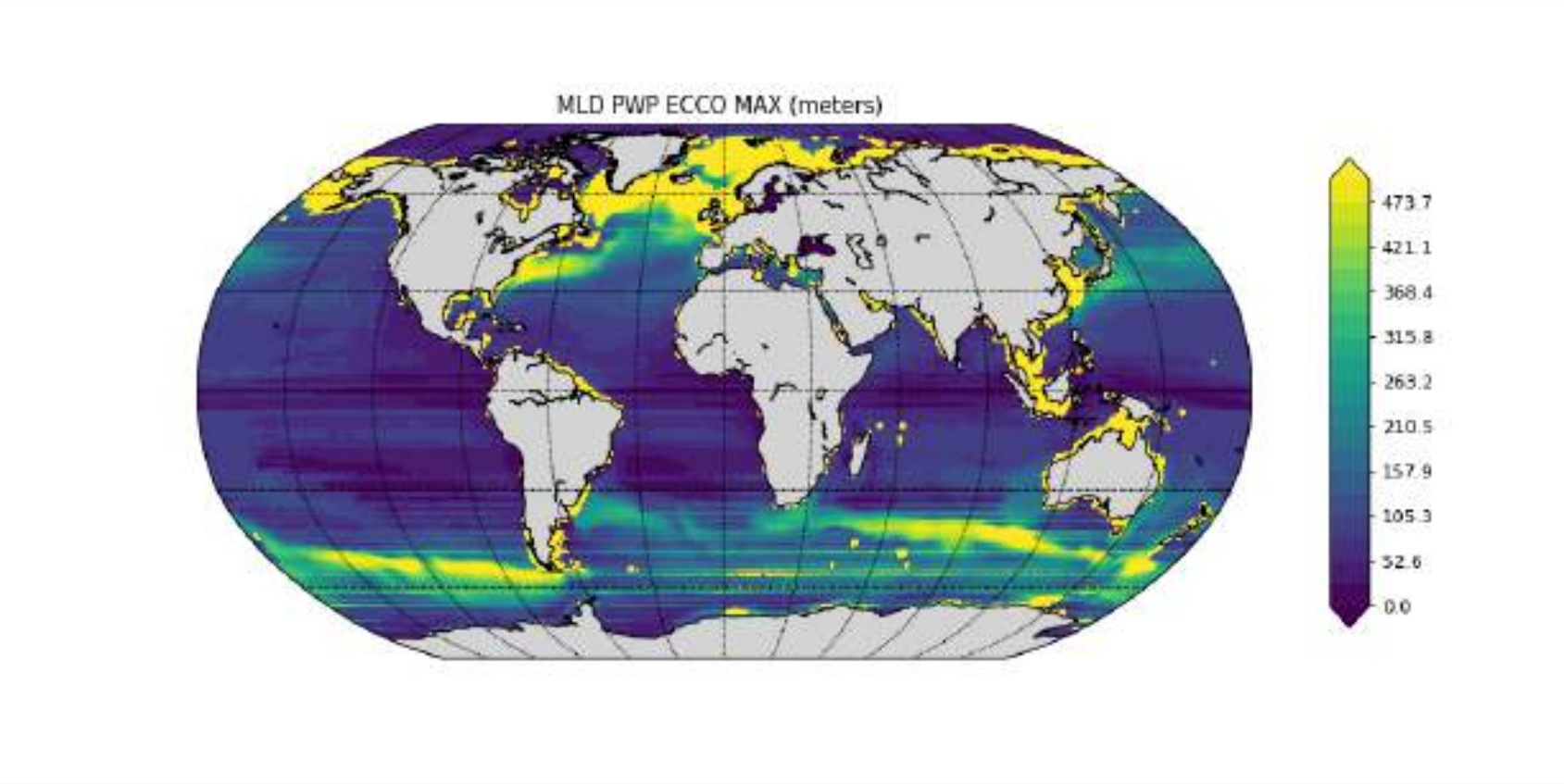
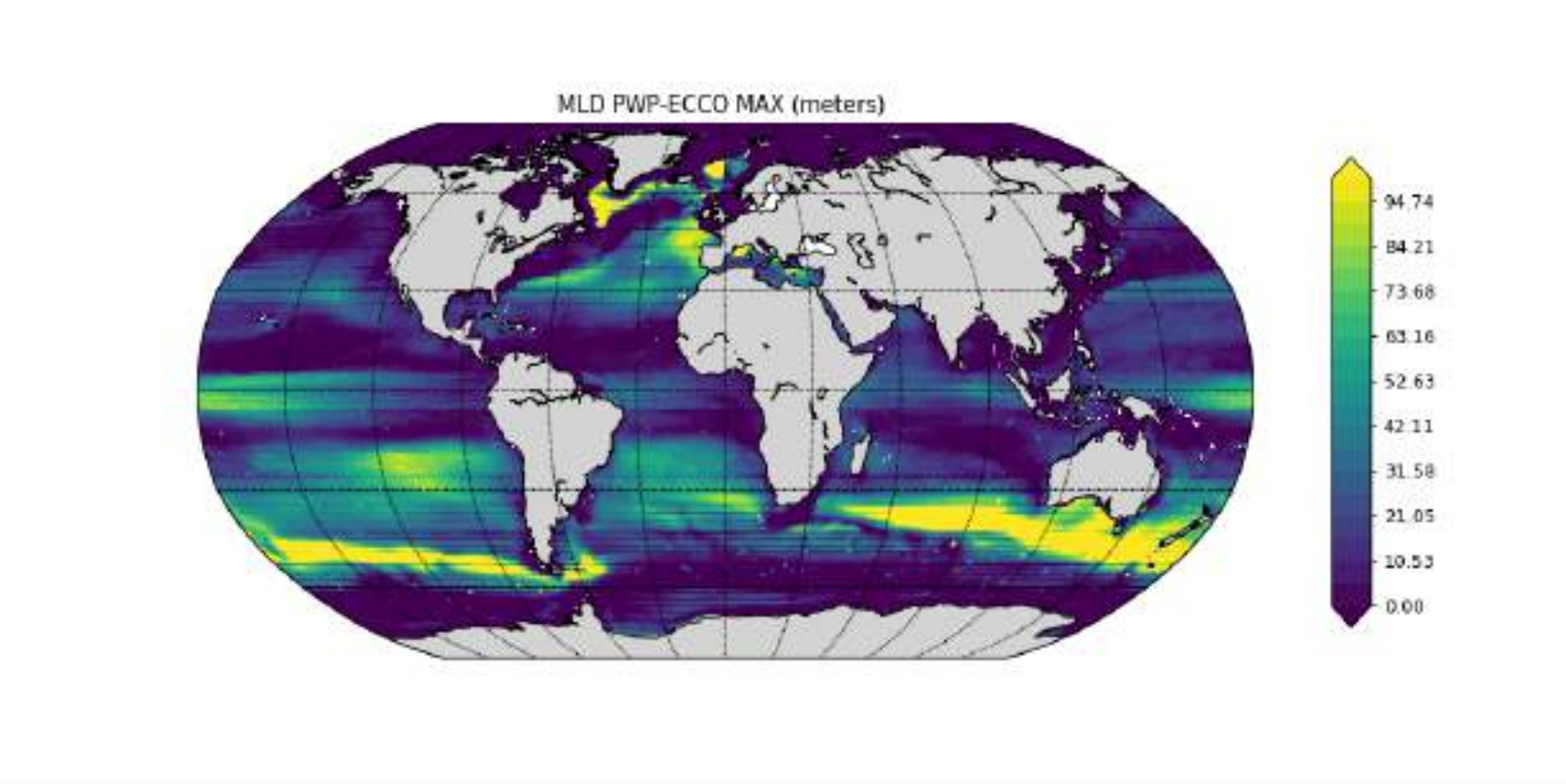


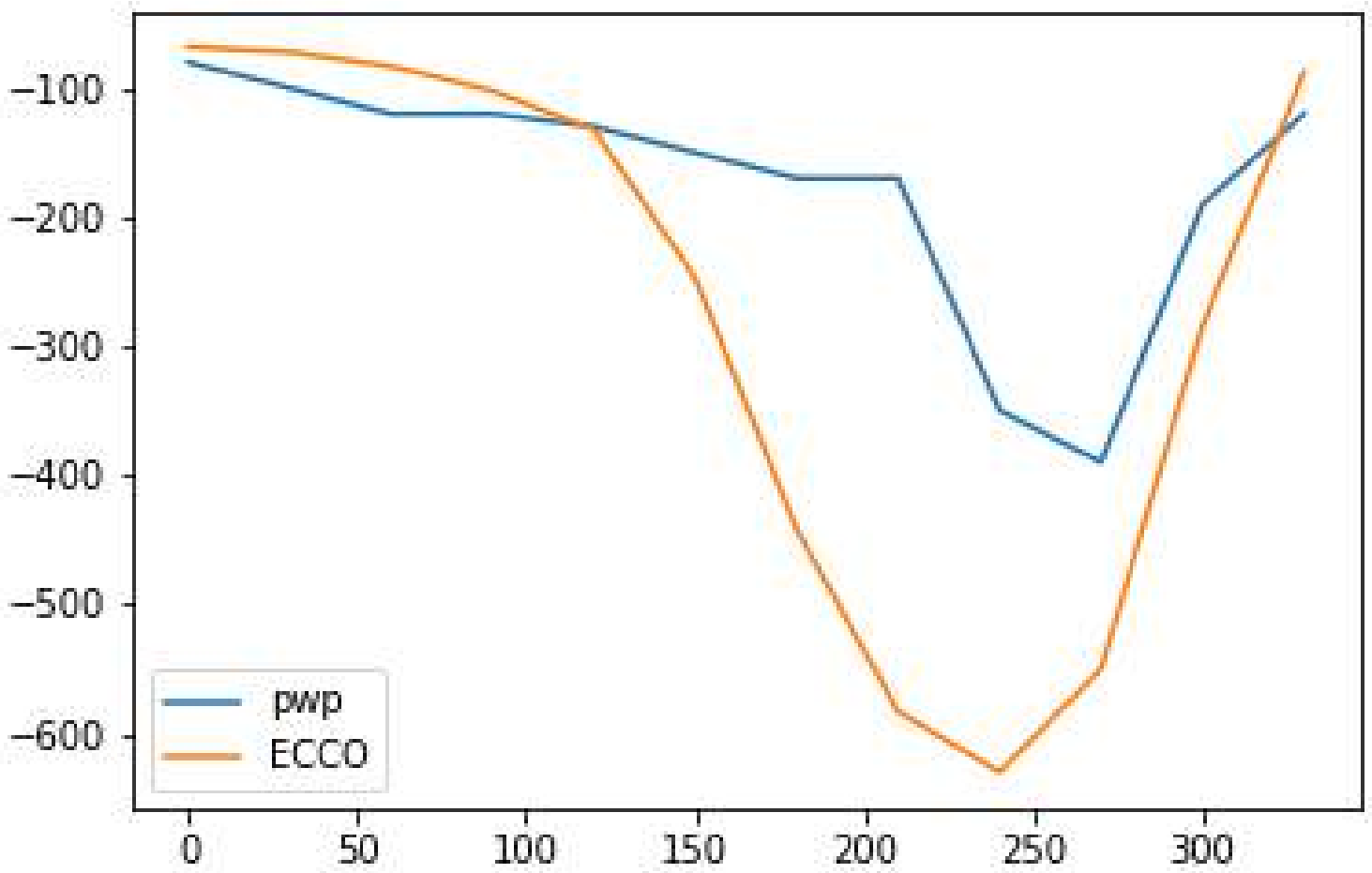
PWP with ECCO forcing



PWP with ECCO forcing, BIAS



PWP vs ECCO MLD: Deep Southern Ocean



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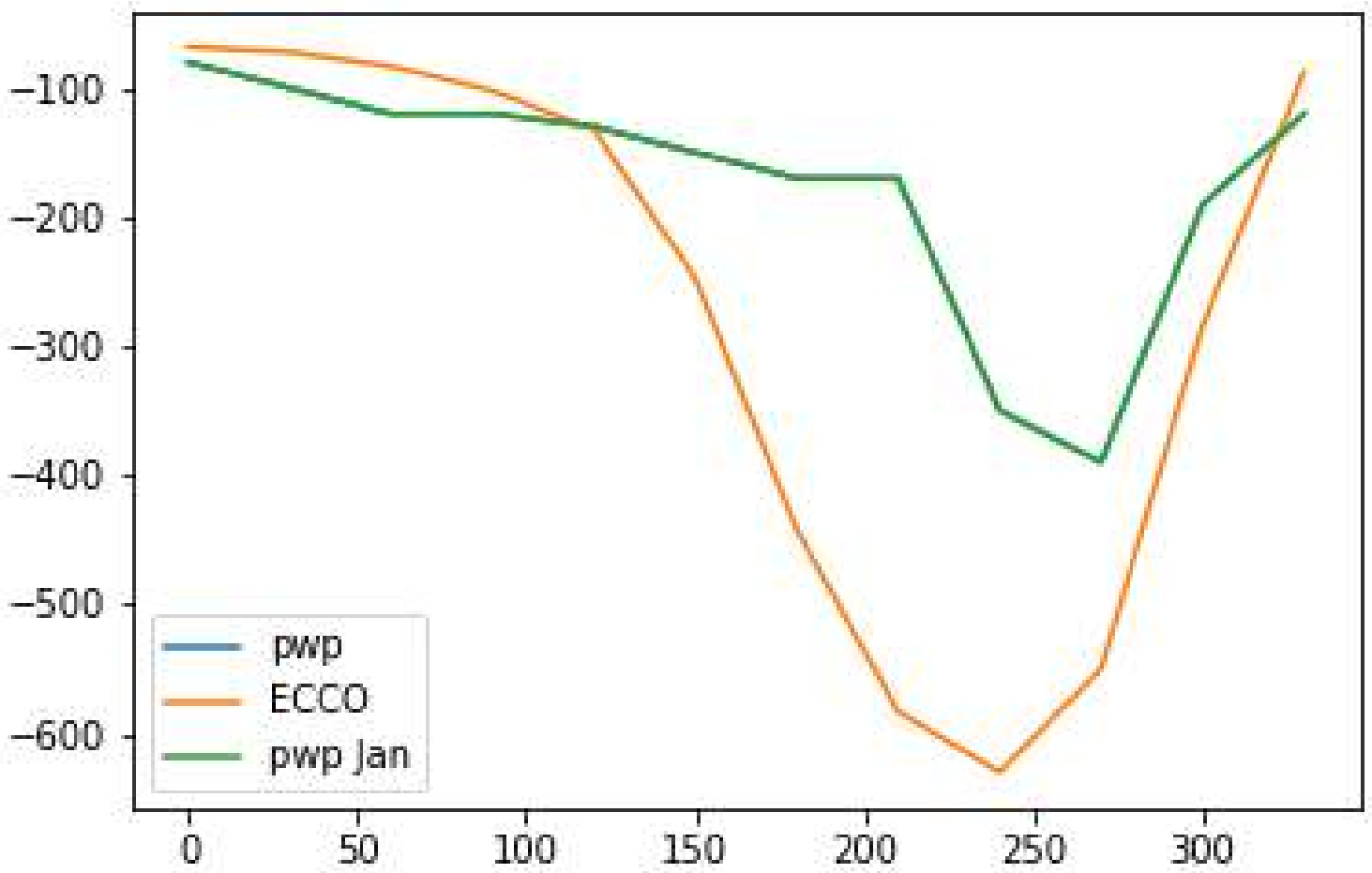

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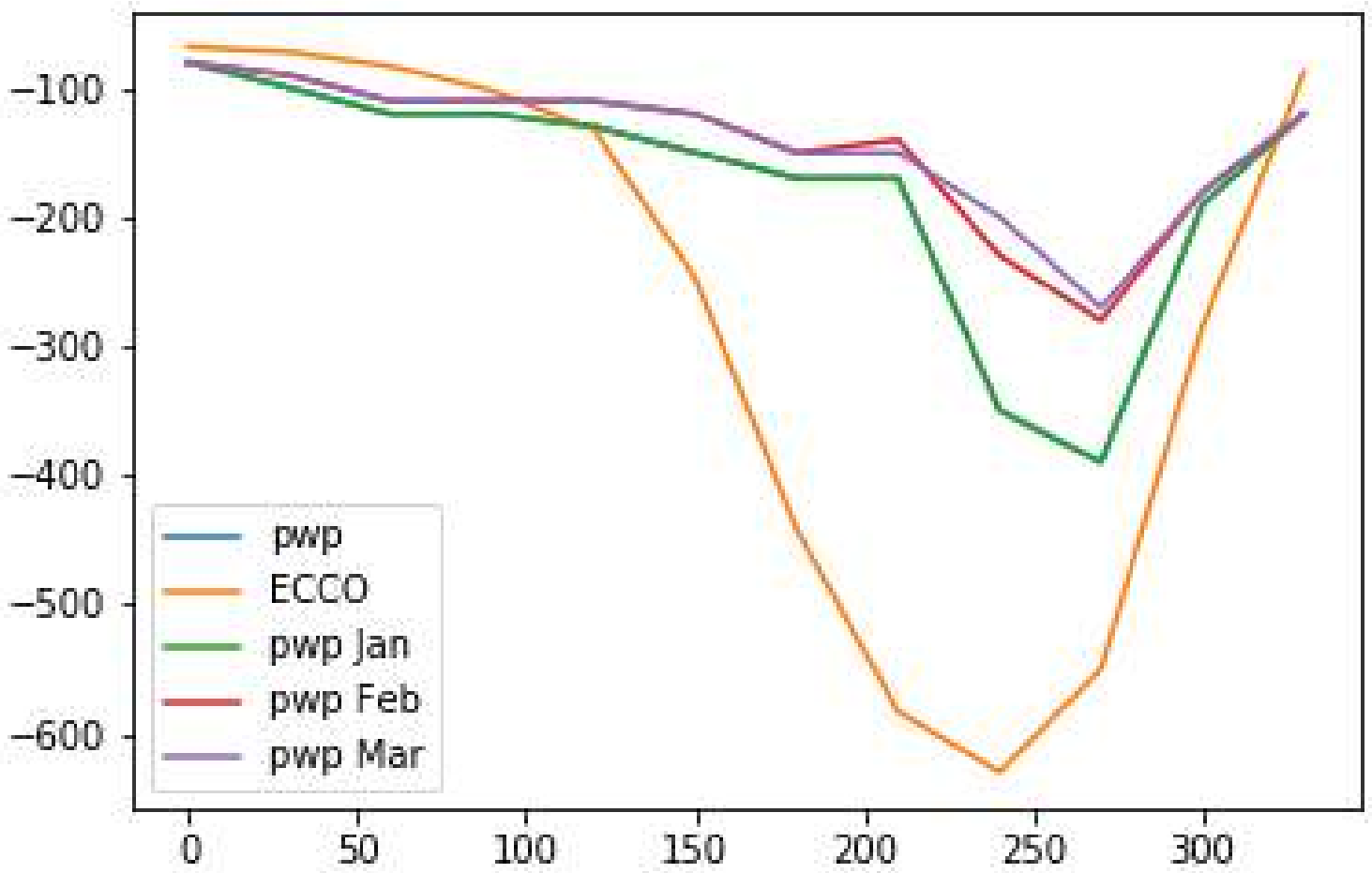

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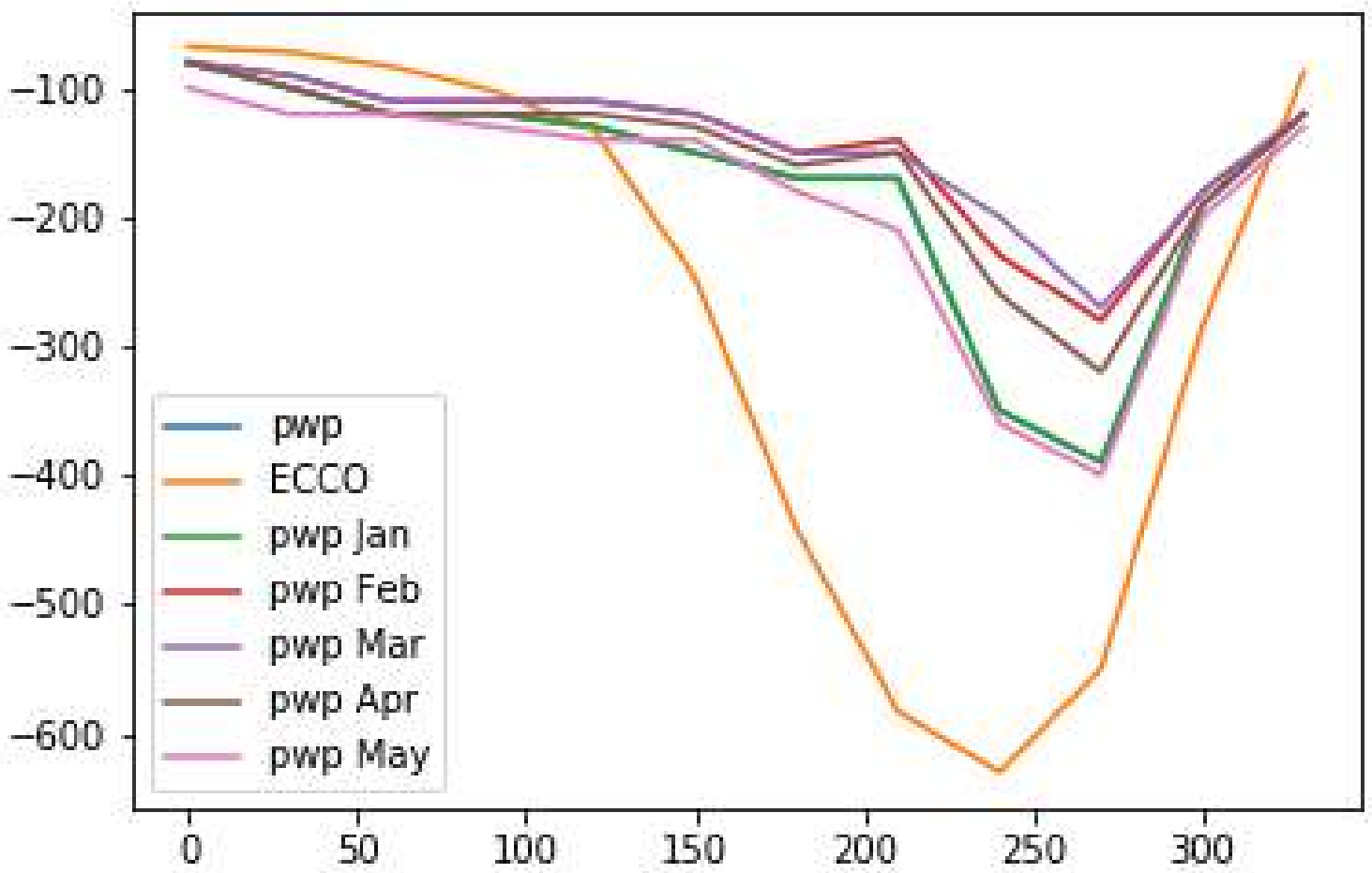

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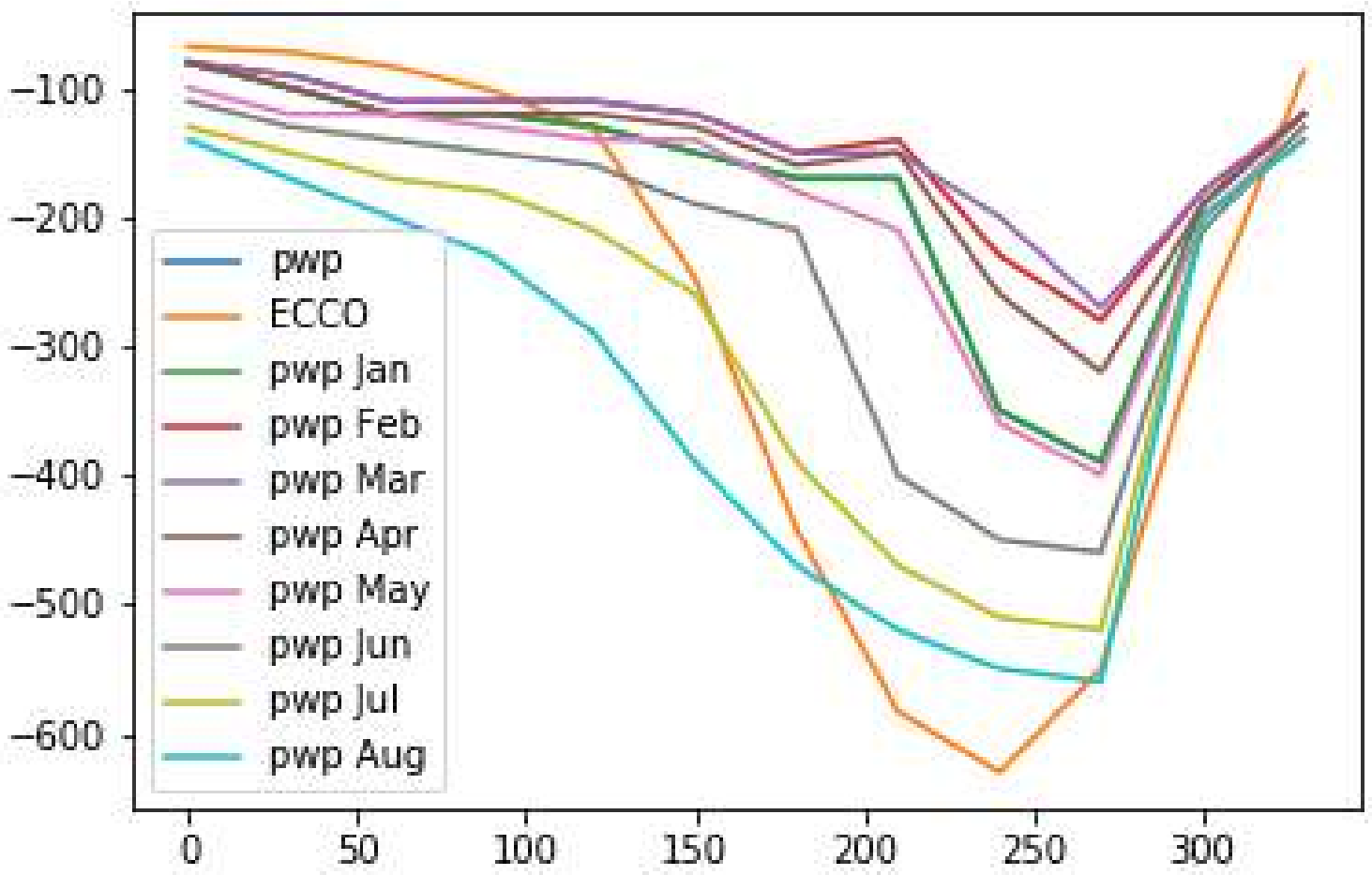

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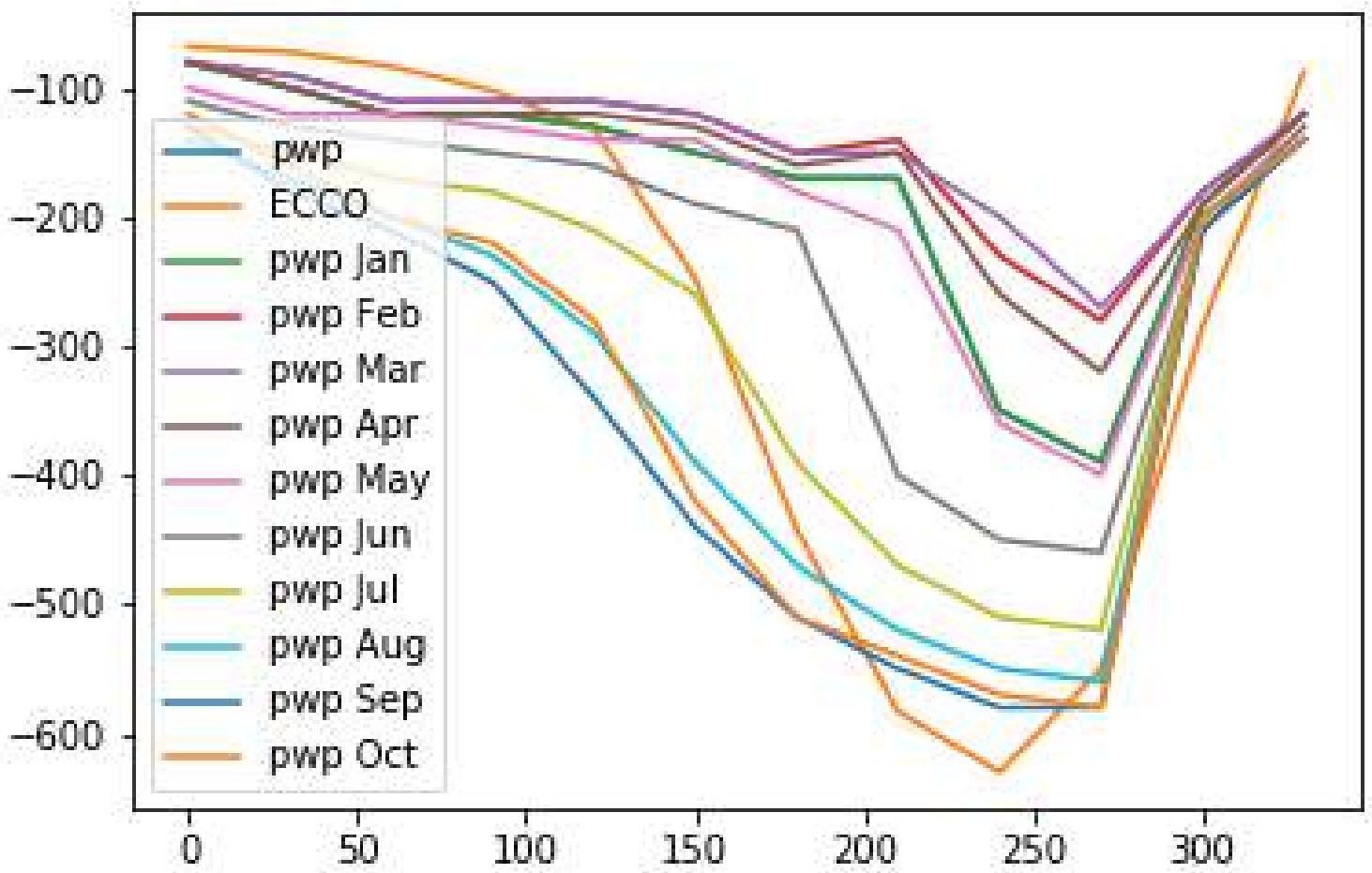
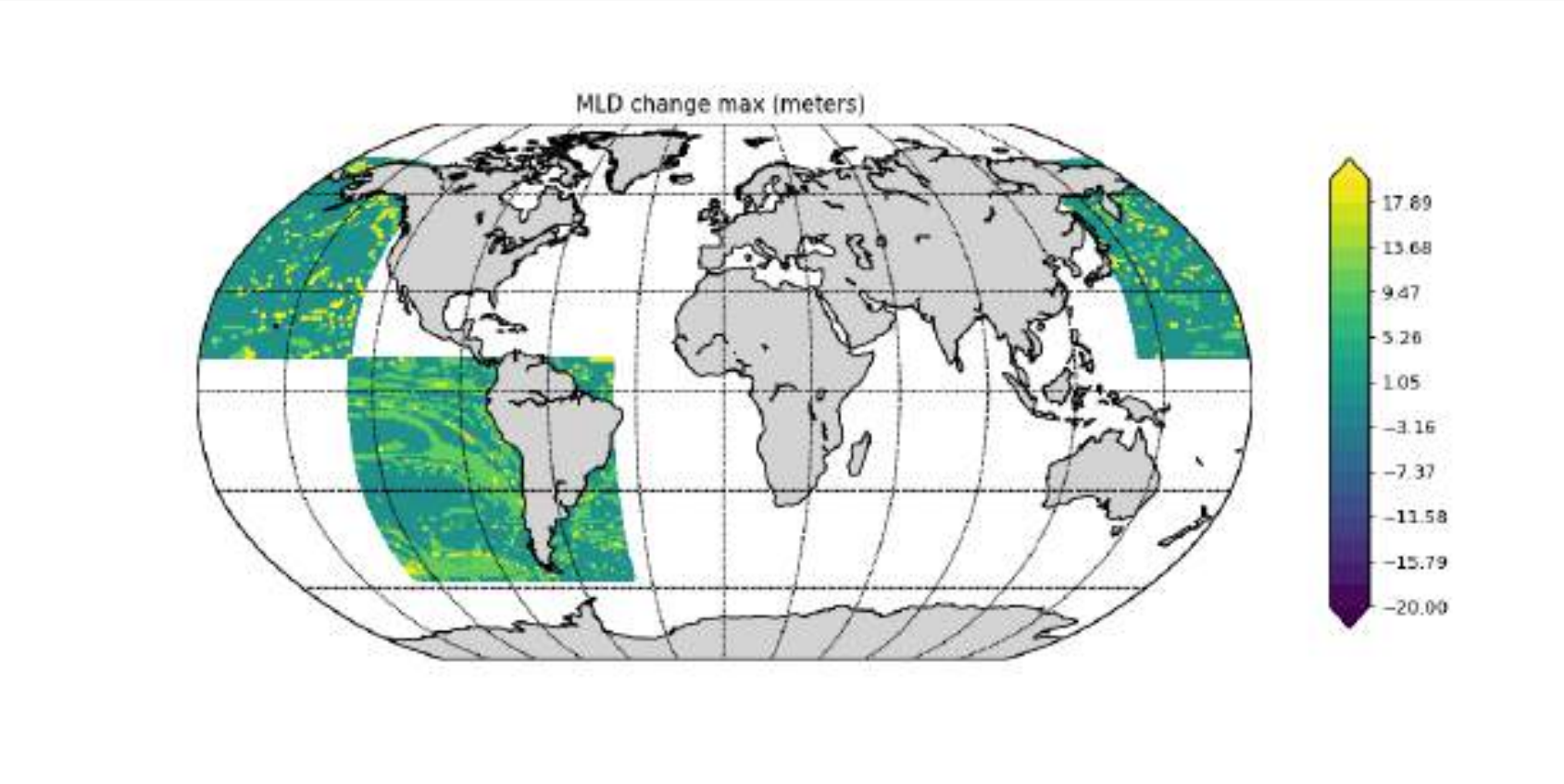


Winter MLD: Difference to State Estimate



Max difference from State Estimate $\rightarrow$ Improved considering advection!

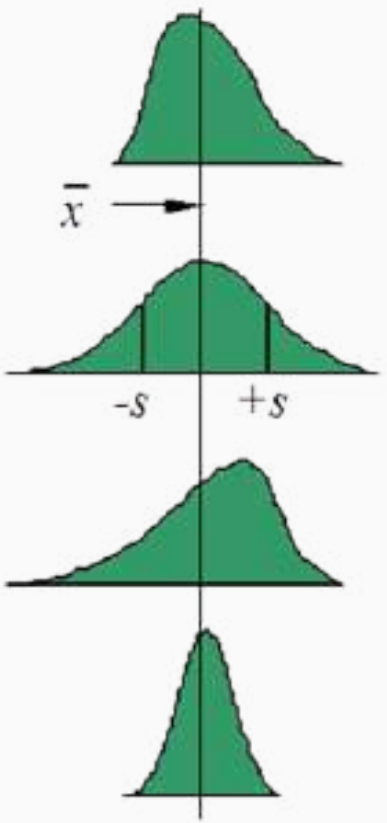
Moments

First Moment:
mean - measure of location

Second Moment:
Standard deviation - measure of spread

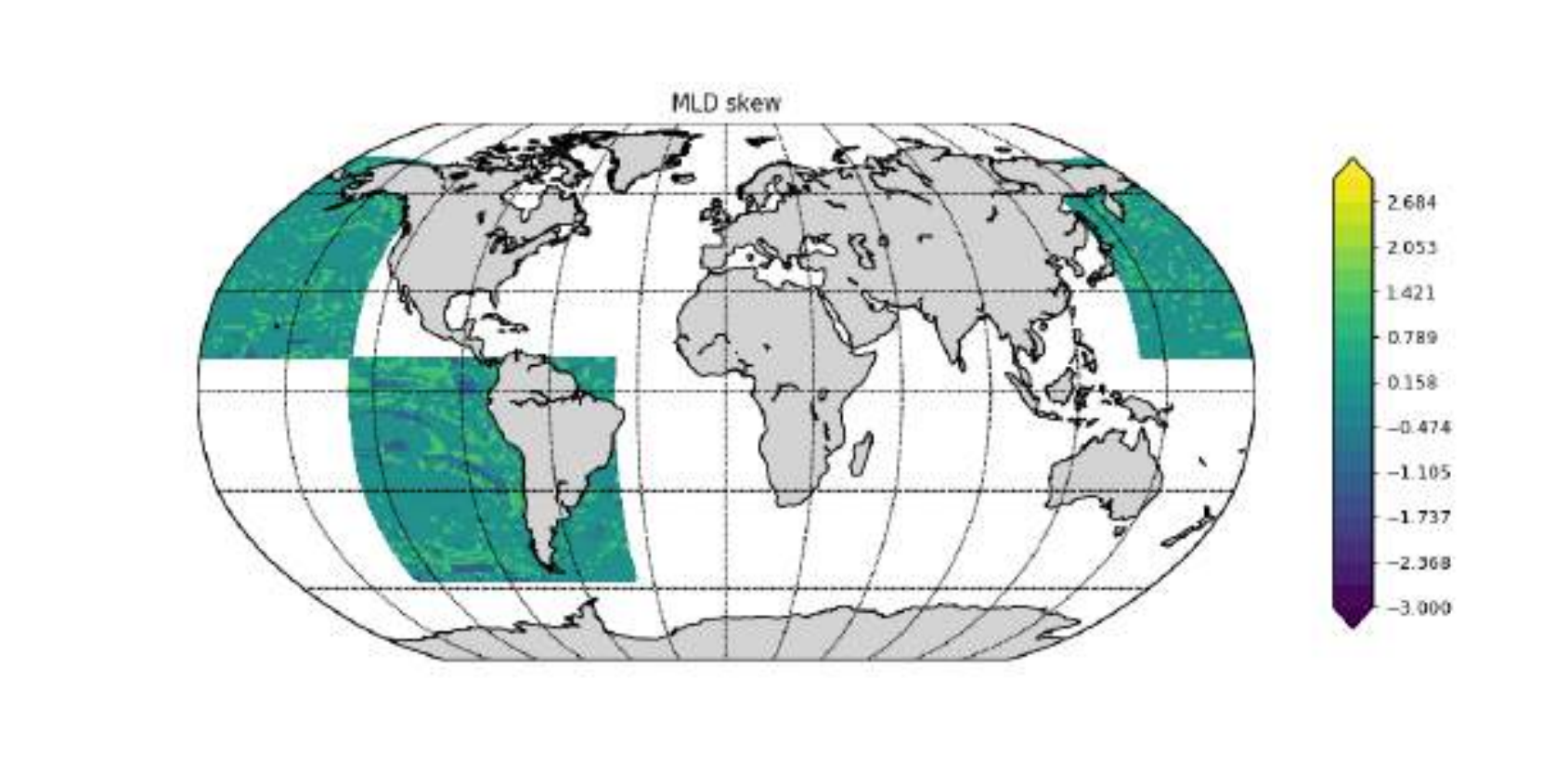
Third Moment:
skewness - measure of symmetry

Fourth Moment:
kurtosis - measure of peakedness

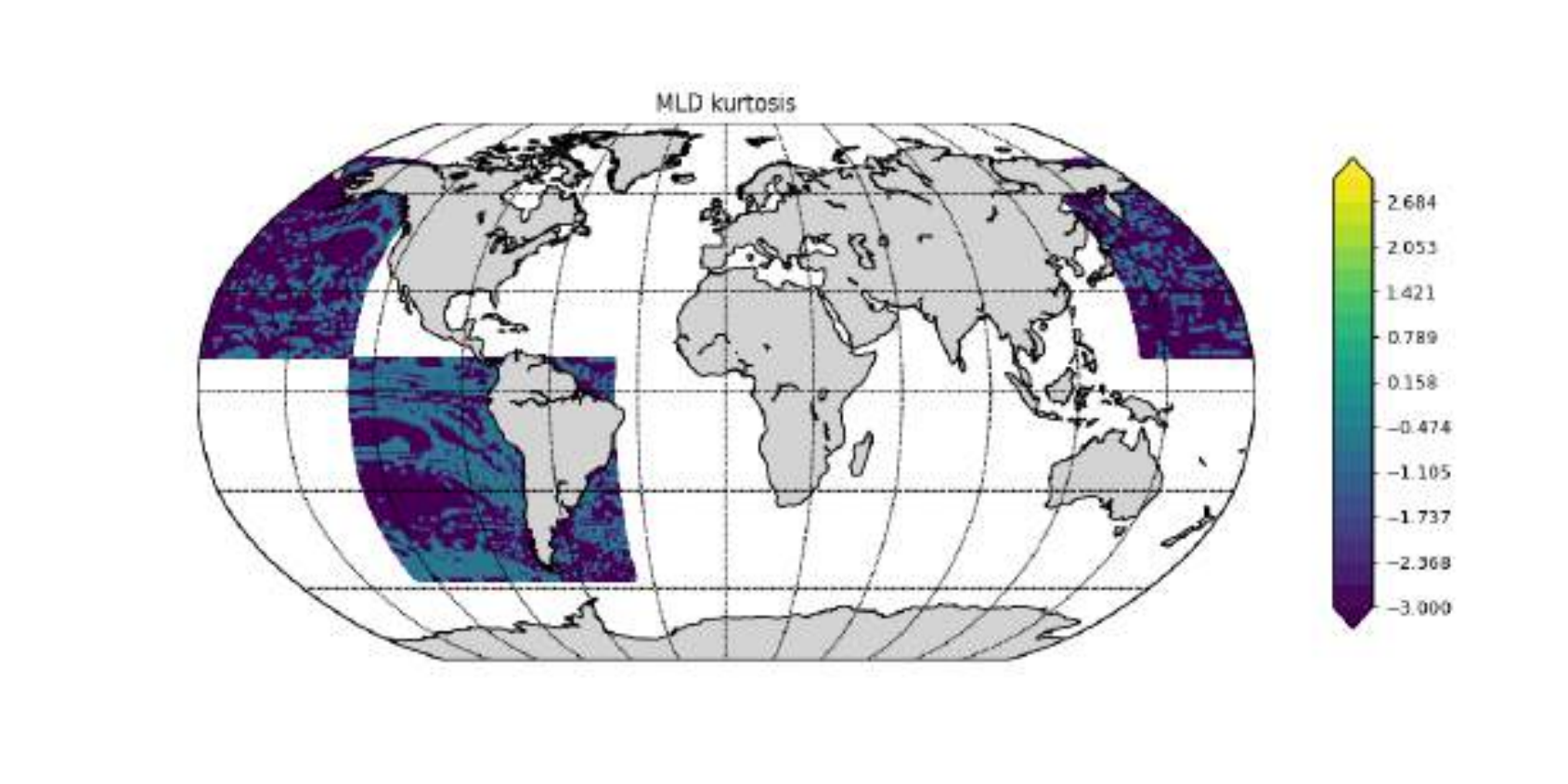


Looking at *change*
from State Estimate

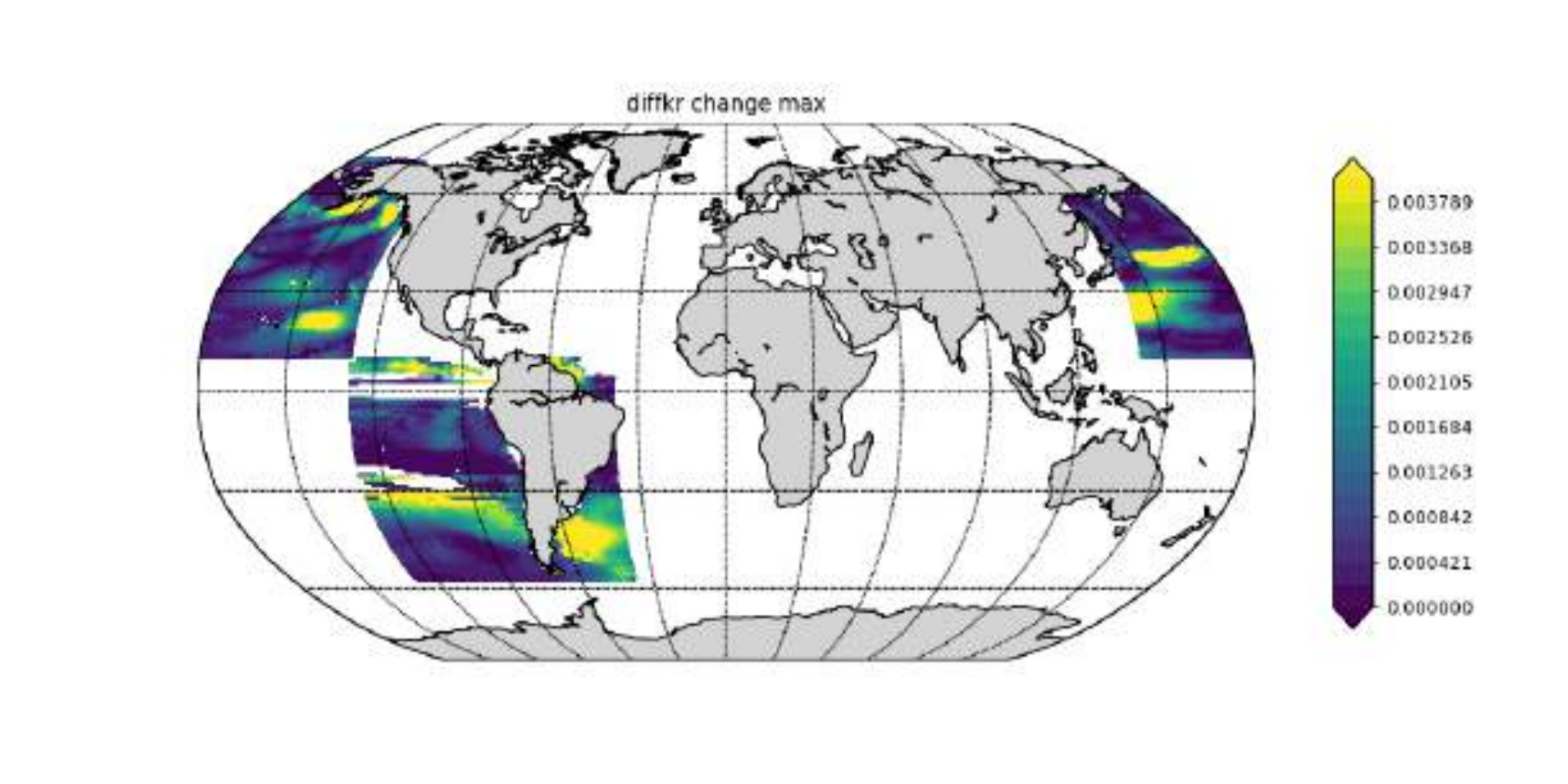
Winter MLD: Skew



Winter MLD: Kurtosis



Winter diffkr: Difference from State Estimate



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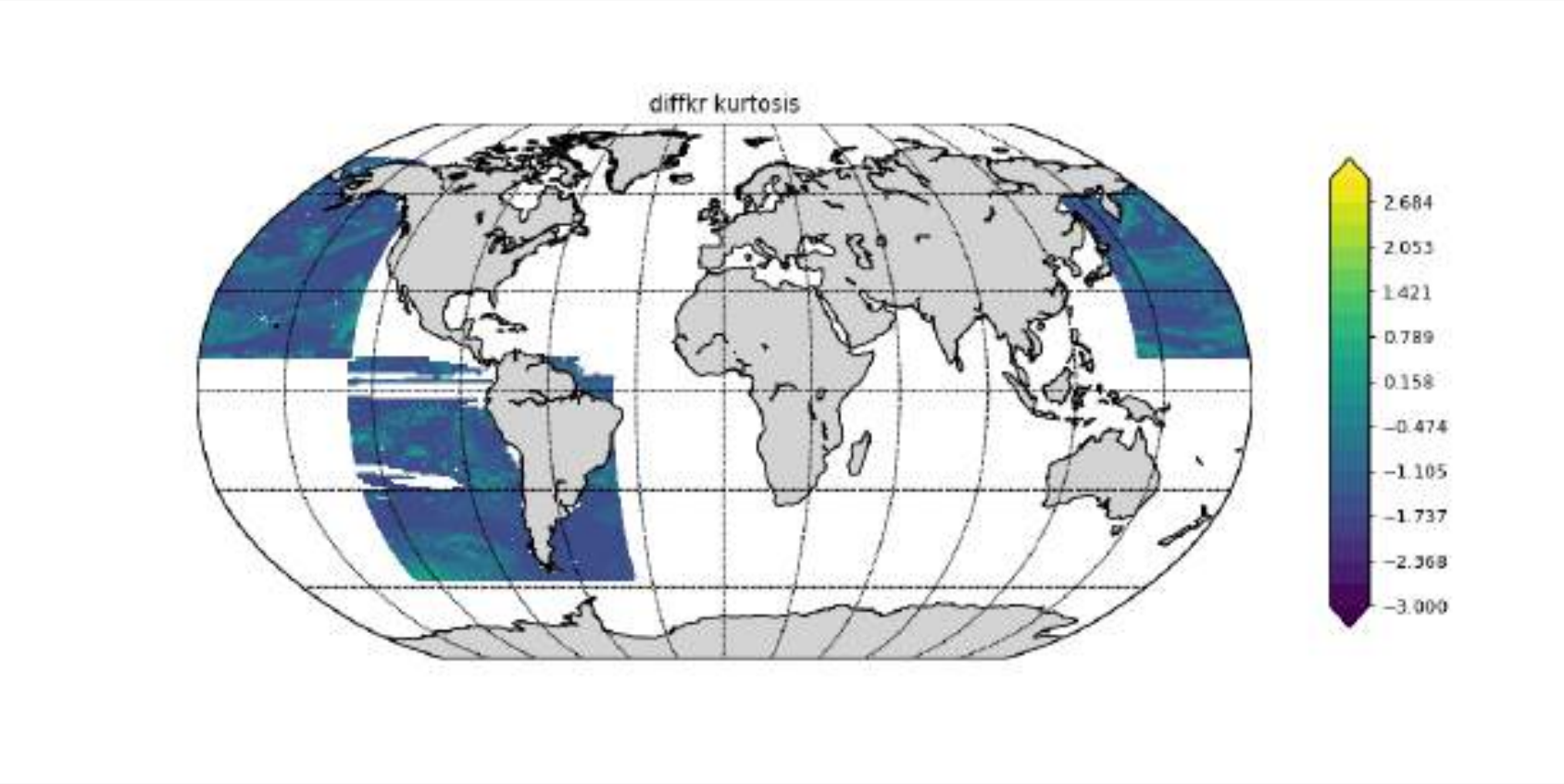

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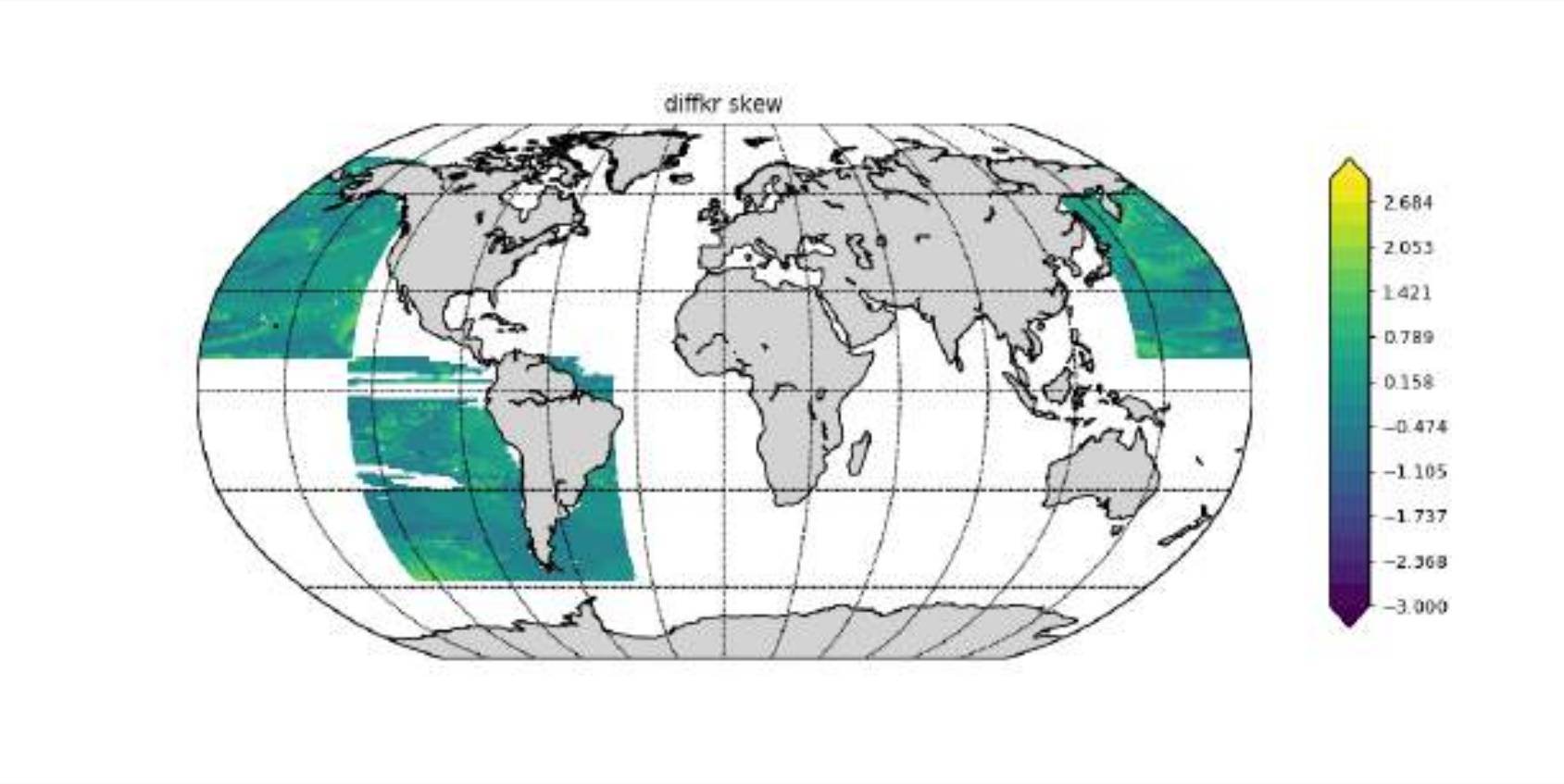
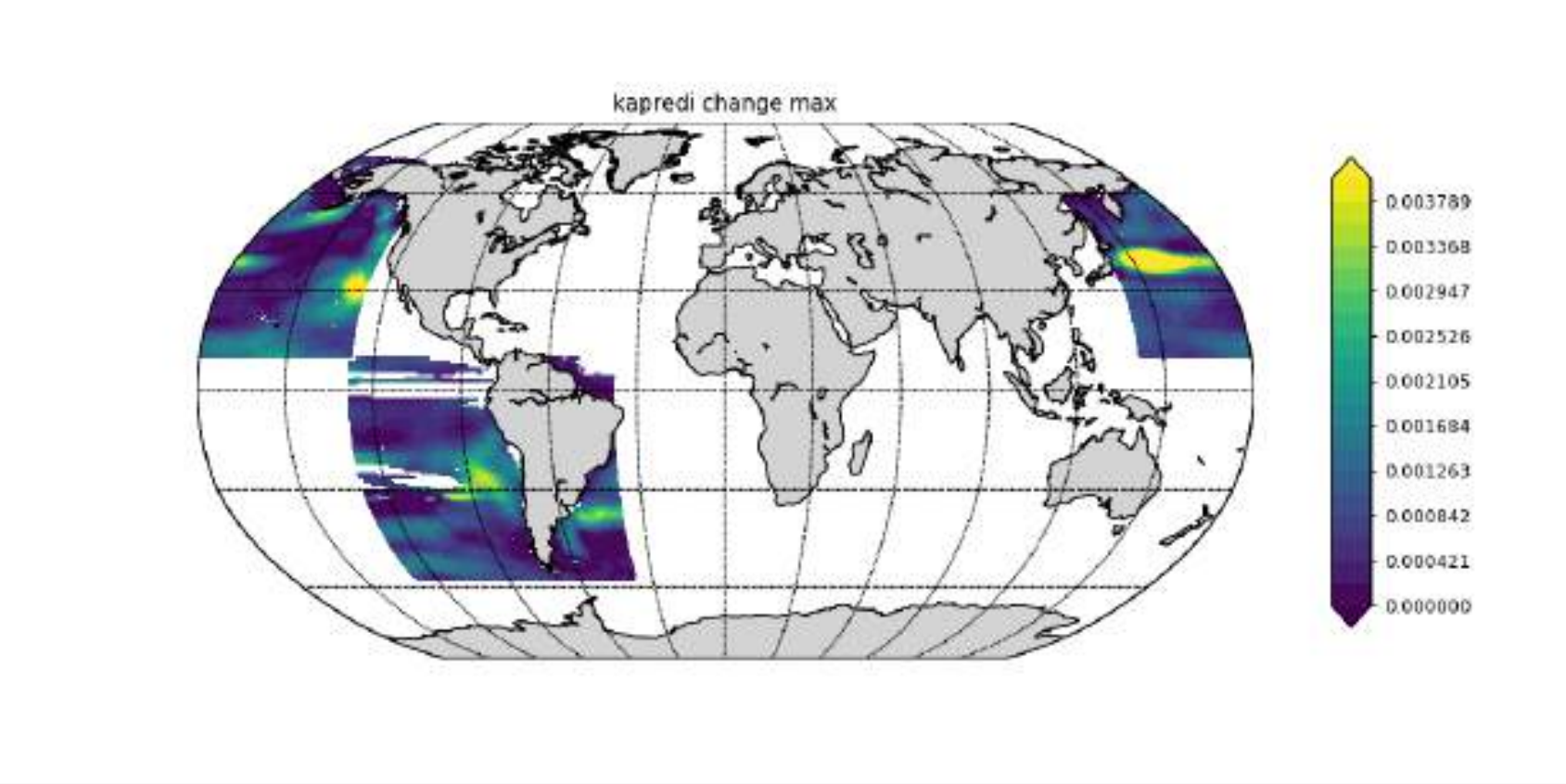
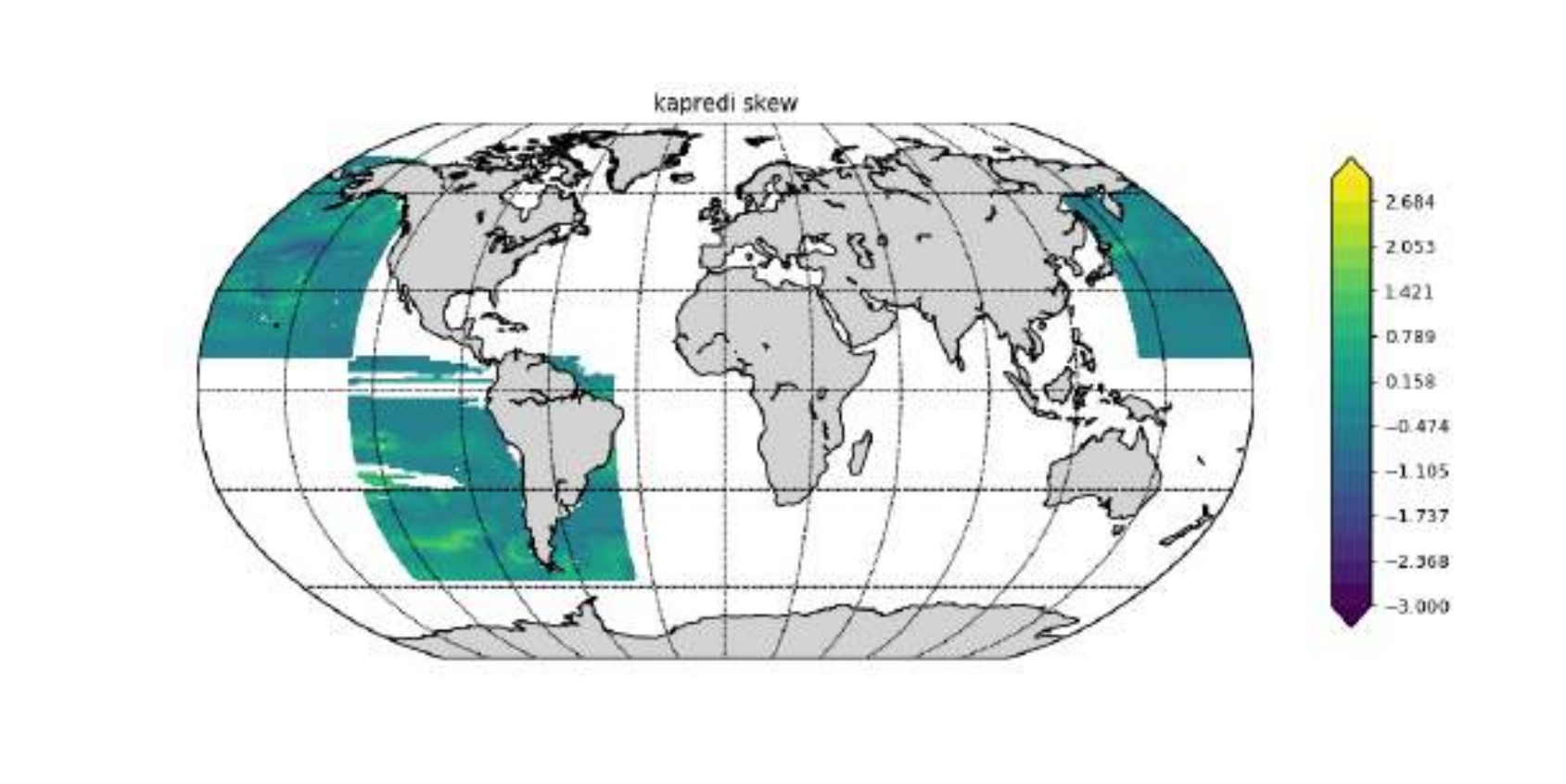


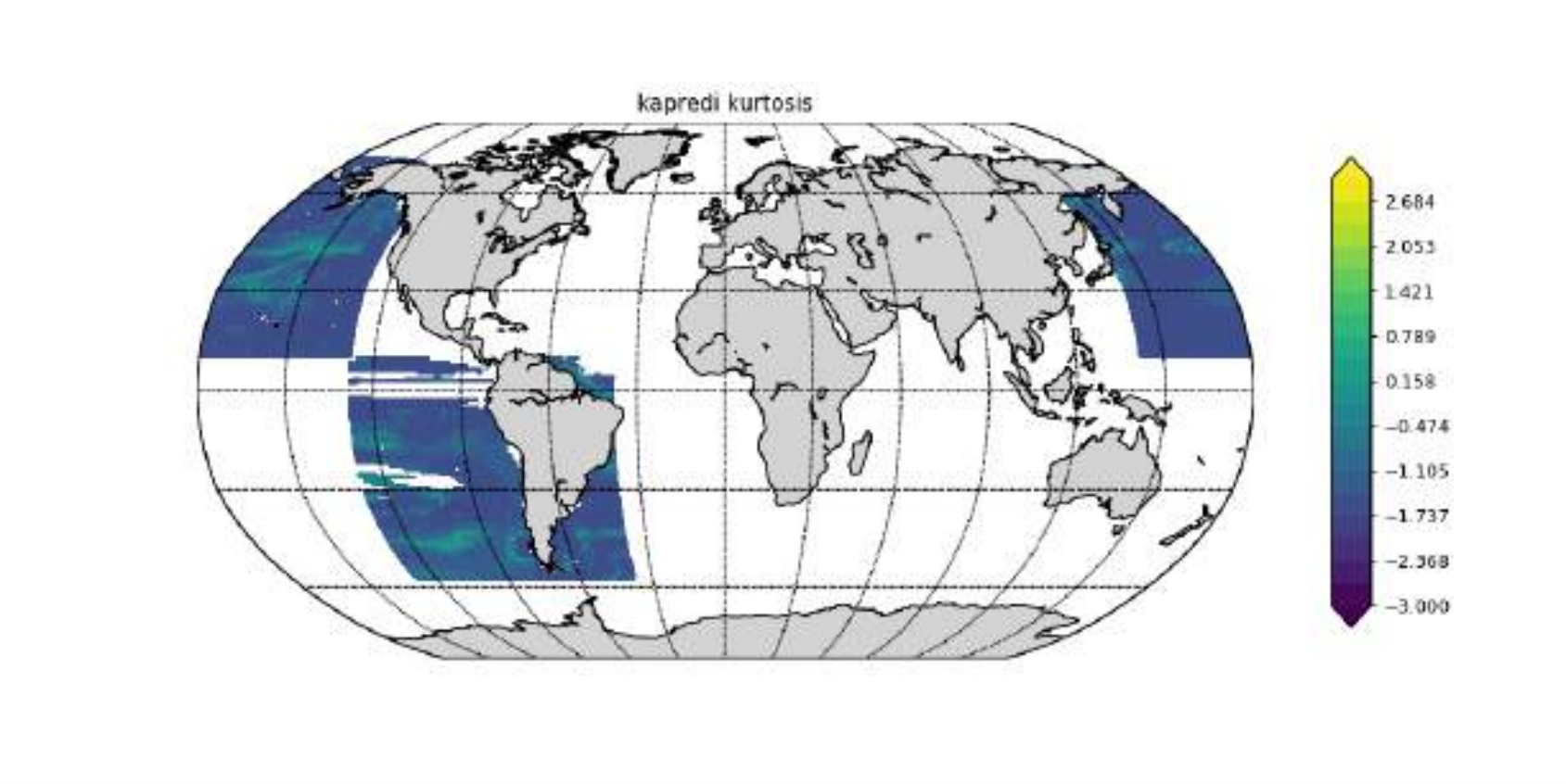
Winter kapredi: Difference from State Estimate



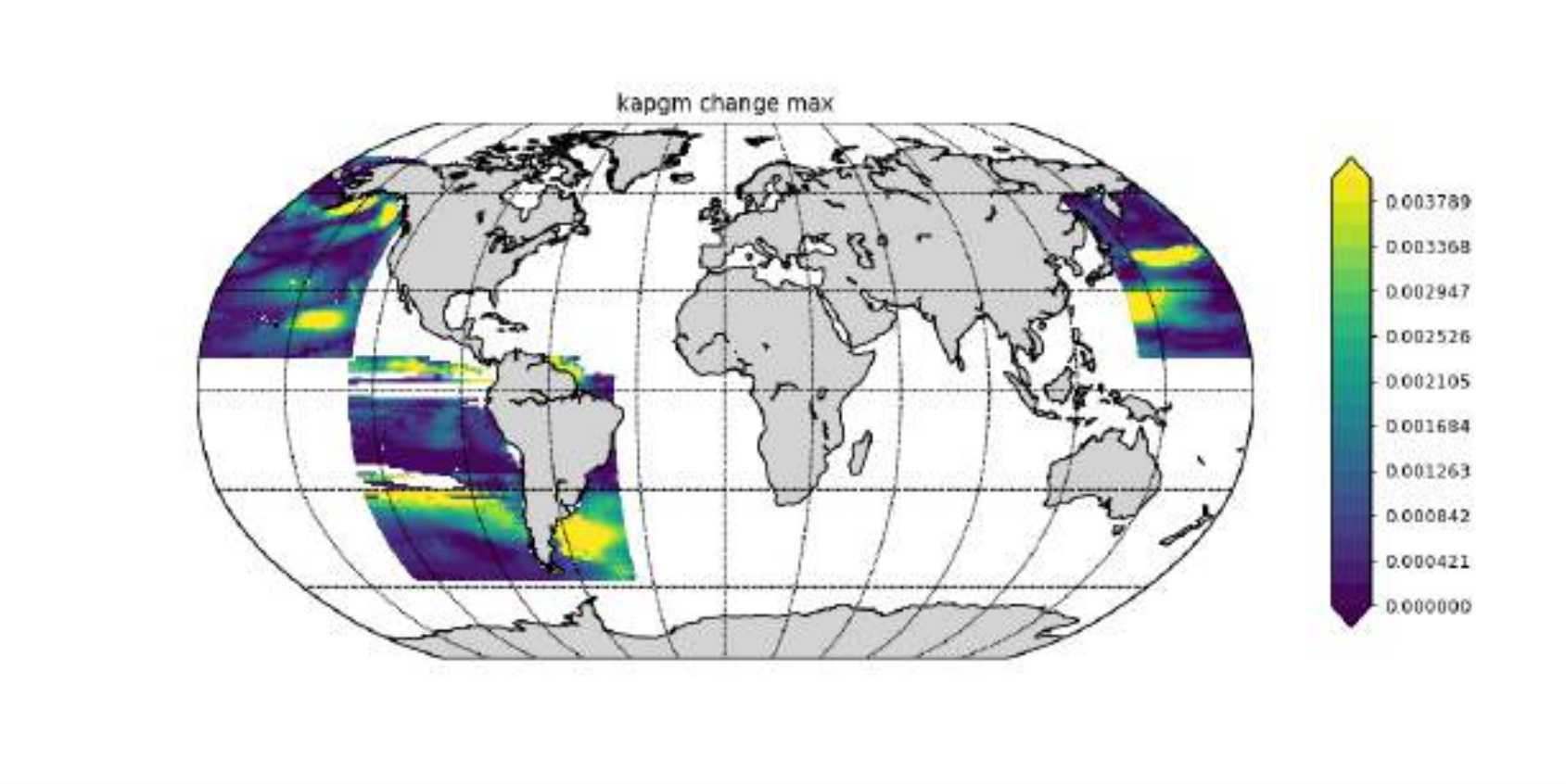
Winter kaprediD: Skew



Winter kapredi: Kurtosis



Winter kapgm: Difference from State Estimate



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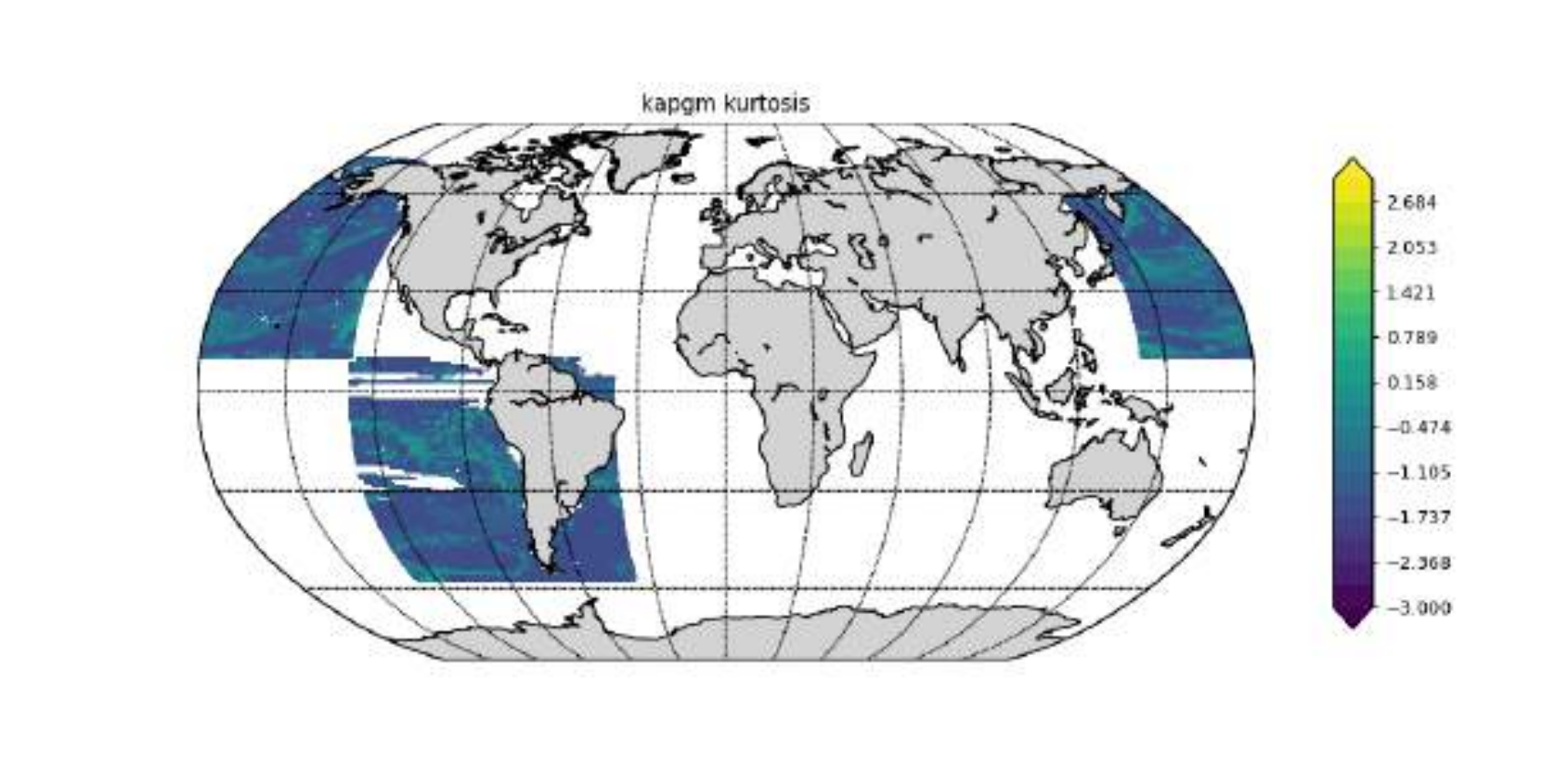

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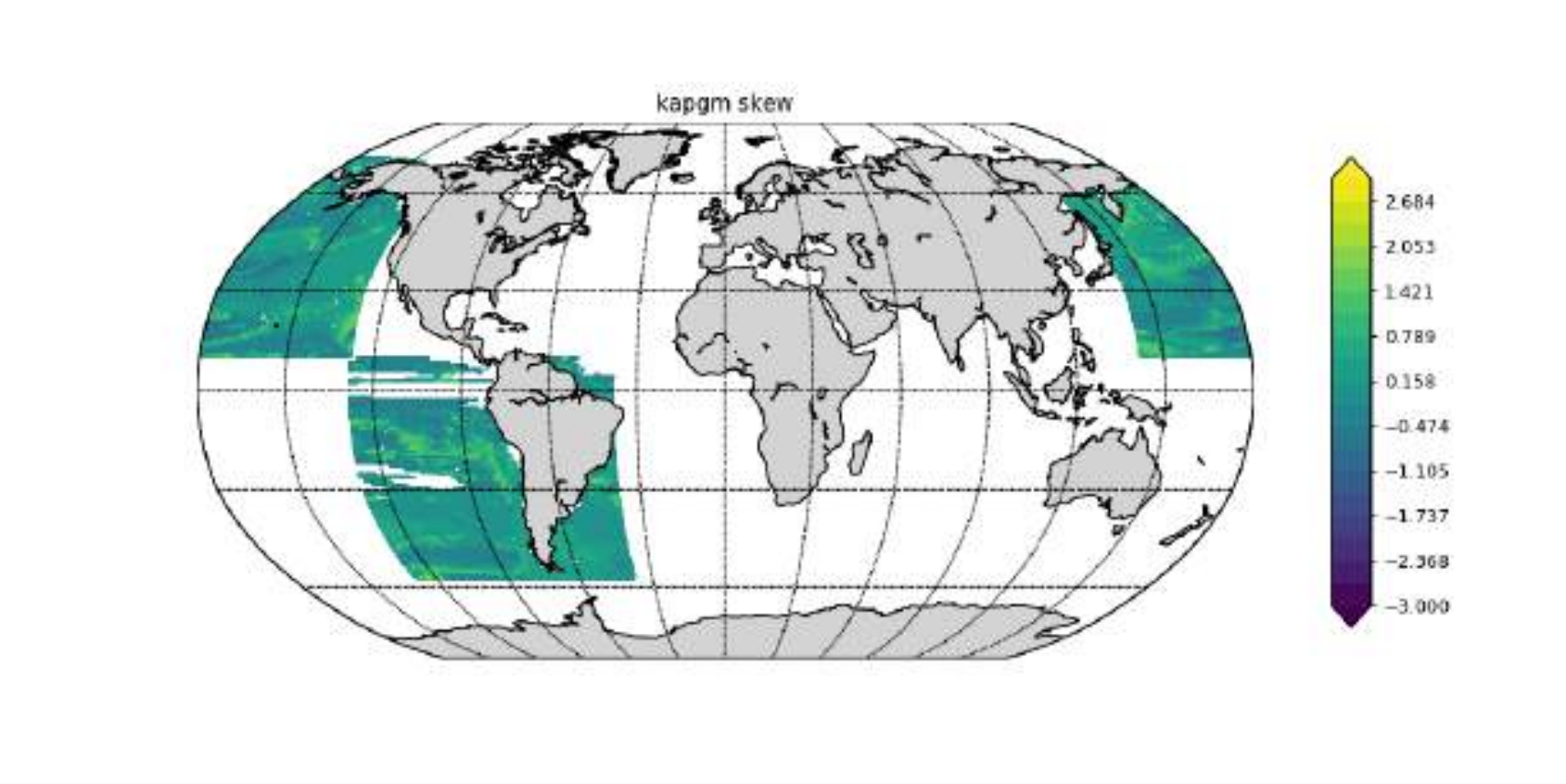
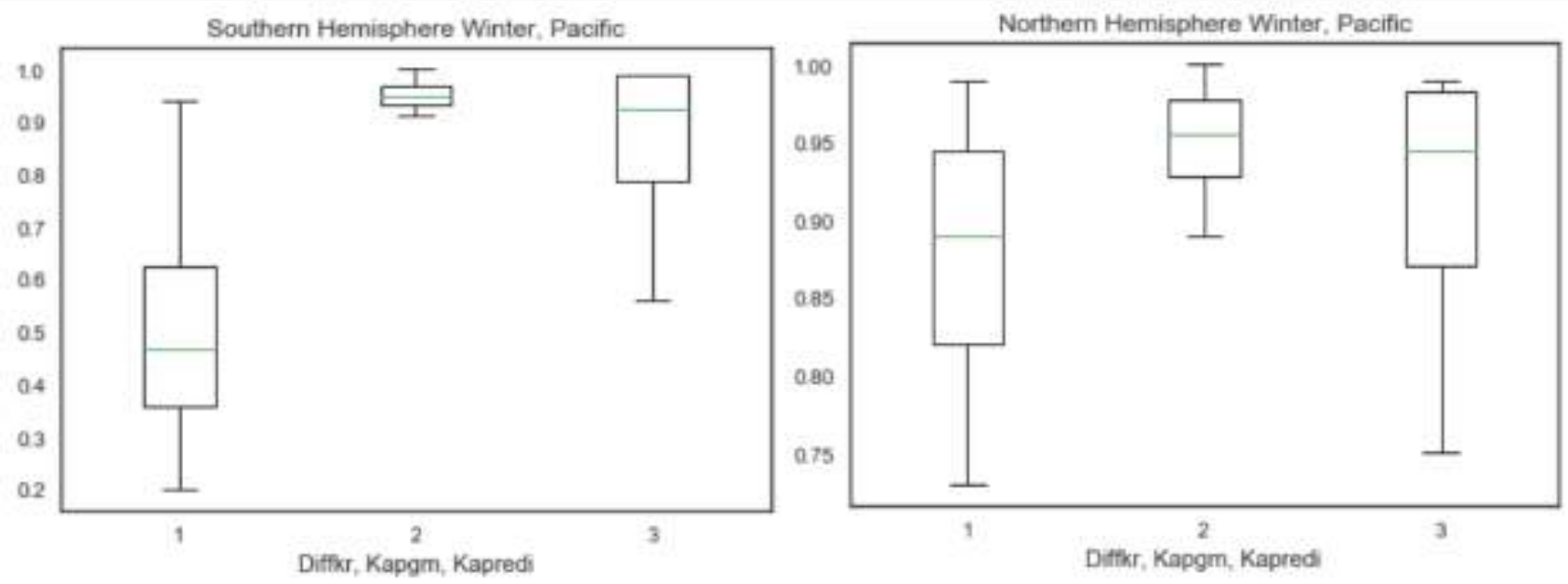


MLD sensitivity: Summary



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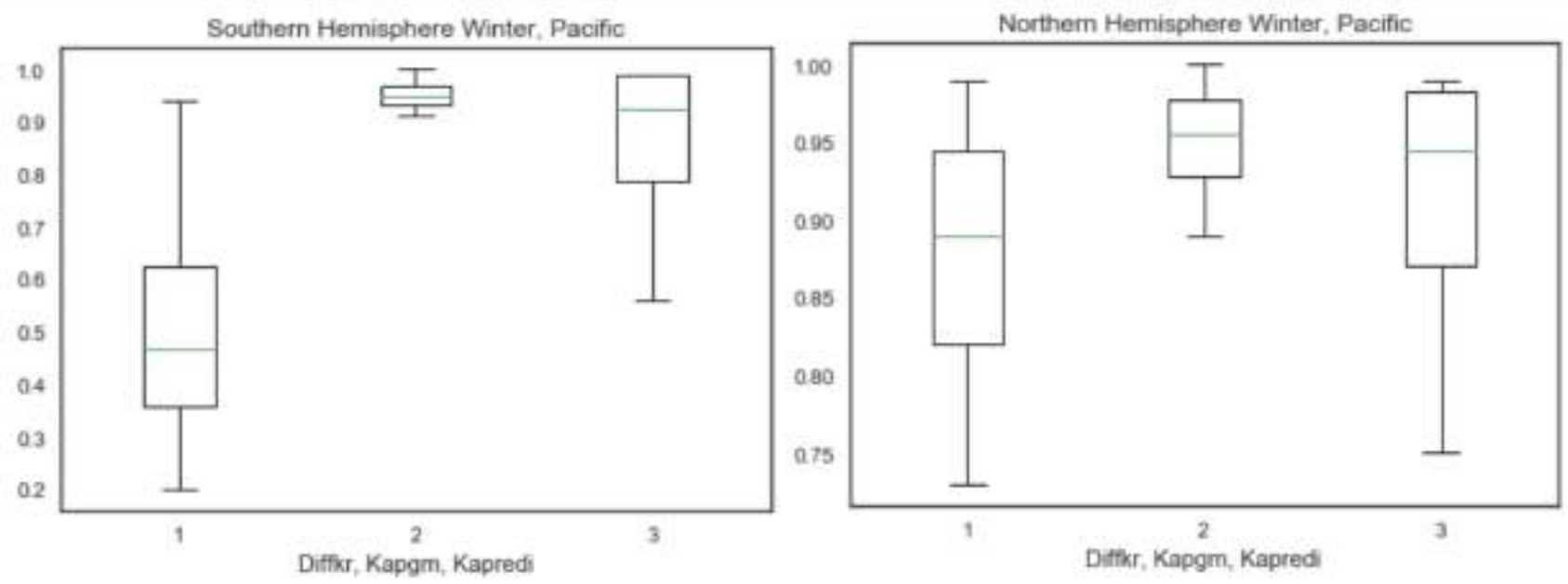

MLD sensitivity: Utility?

ECCO uses TKE (aka GGL)

$$\frac{\partial \overline{e}}{\partial t} = \frac{K_m}{e^2}\left[\frac{\partial u}{\partial z}^2 + \frac{\partial v}{\partial z}^2\right] - K_p N^2 + \frac{1}{e}\frac{\partial}{\partial z}\left[\frac{A^{vm}}{e}\frac{\partial \overline{e}}{\partial z}\right] - C_\epsilon \frac{e^{-3/2}}{l_\epsilon}$$

- Output budget for TKE?

Summary

- ECCOv4r3 does OK!
- Use PWP to assess max winter MLD
- MLD dynamics sensitive to parameters

- Looking for a general narrative of sensitivity? Unclear

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- Clear that SO is highly sensitive to eddy parameterization
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NB: Don't forget the advection!

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Take home:

Highly spatially inhomogeneous sensitivity in winter mixed layers.

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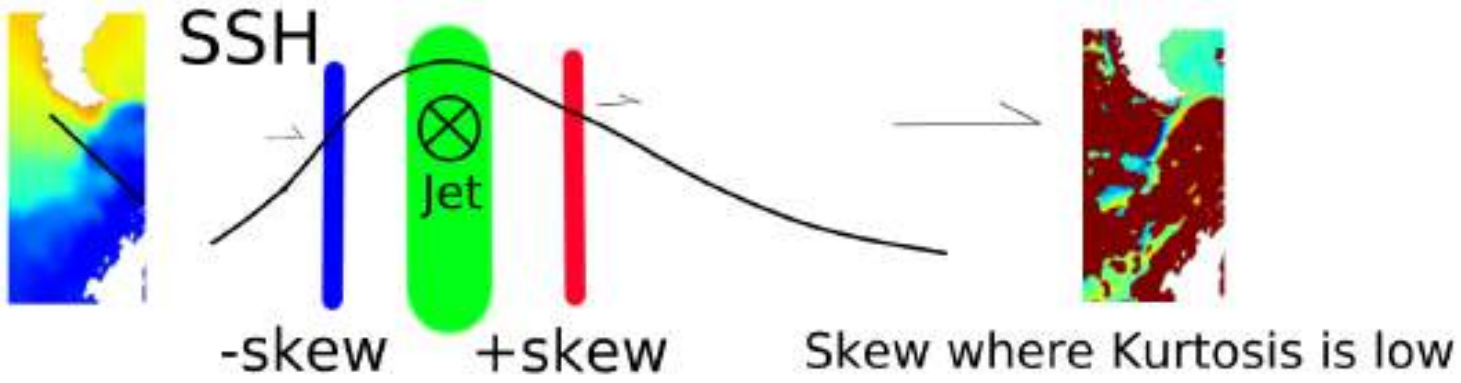
Thank you

Mixing barriers and jets..?



Sharp SSH gradient - high |skew|