Reconstructing the vertical velocities in the global thermocline from observations

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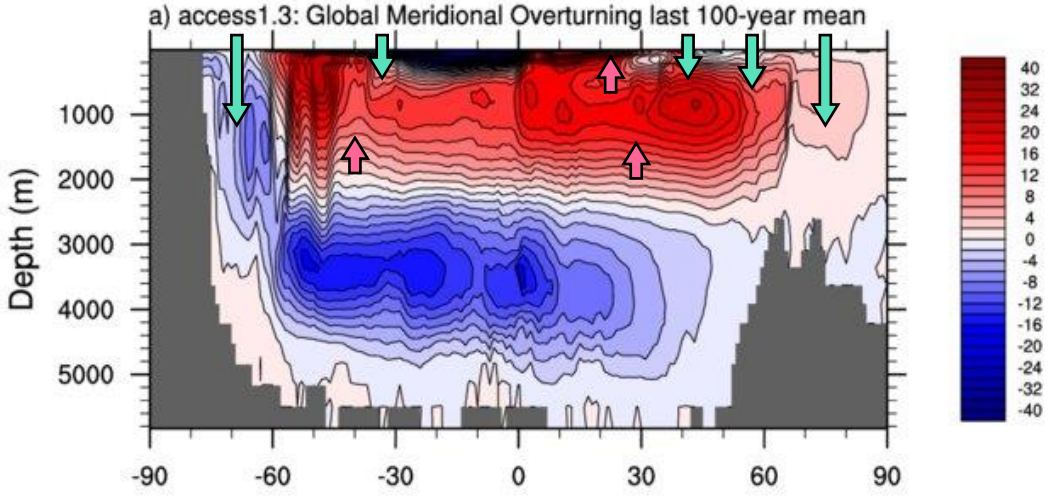
An overlooked key quantity of the ocean

Vertical velocities (***w***) drive the distribution of essential ocean properties but retrieving them is a challenge to be yet accomplished.

w too small to be directly observable (10^{-6} m/s)

↓

Link with more easily measured variables.



Law et al. 2015

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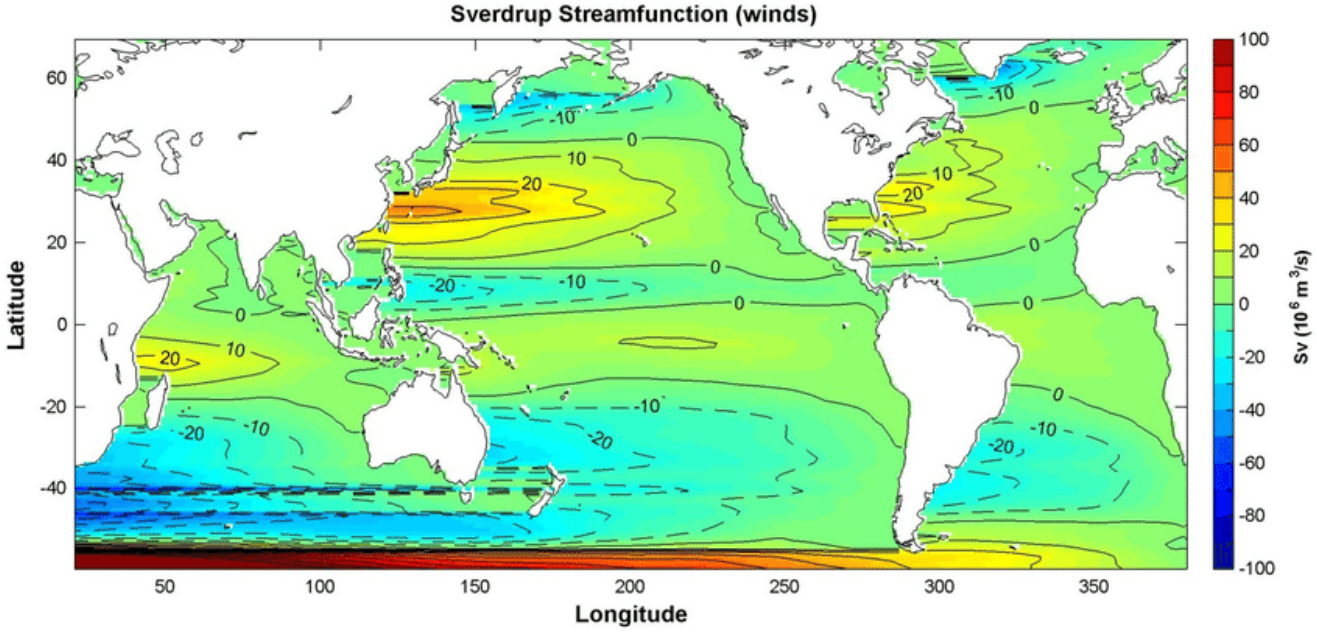
Sverdrup Balance:

$$\beta V_g = f w_{Ek} = \hat{\boldsymbol{k}} \cdot \nabla \times \boldsymbol{\tau}/\rho_0$$



Chu, 2016

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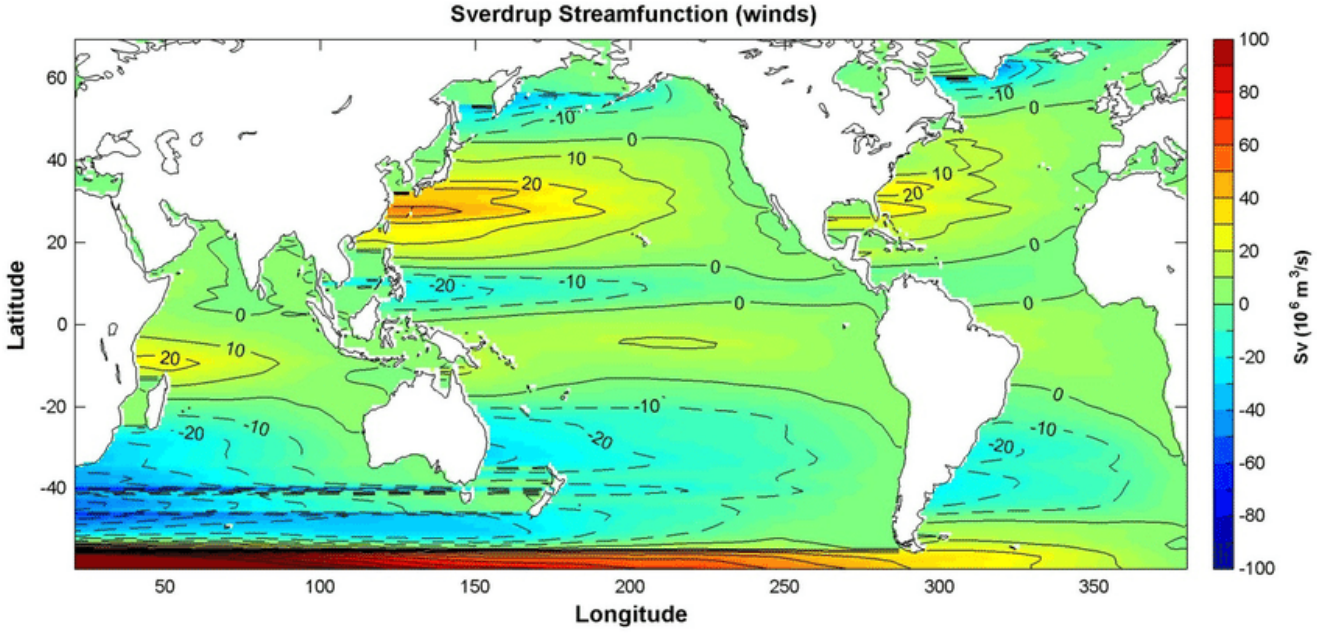
Baroclinic case

Linear Vorticity Balance (LVB)

$$\beta v_g = f \frac{\partial w}{\partial z}$$



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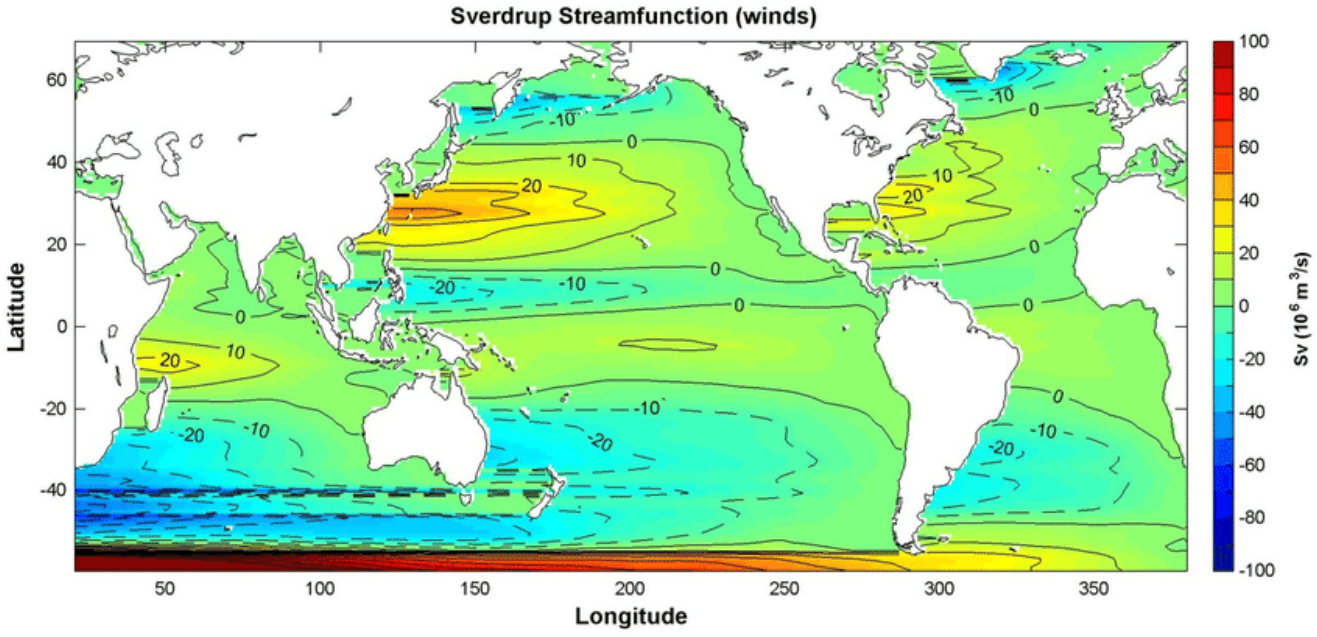
$$\beta v_g = f \frac{\partial w}{\partial z}$$

Vertical integral from surface

$$w(z') = w_{Ek} - \int_{z'}^{0} \frac{\beta v_g}{f} dz$$



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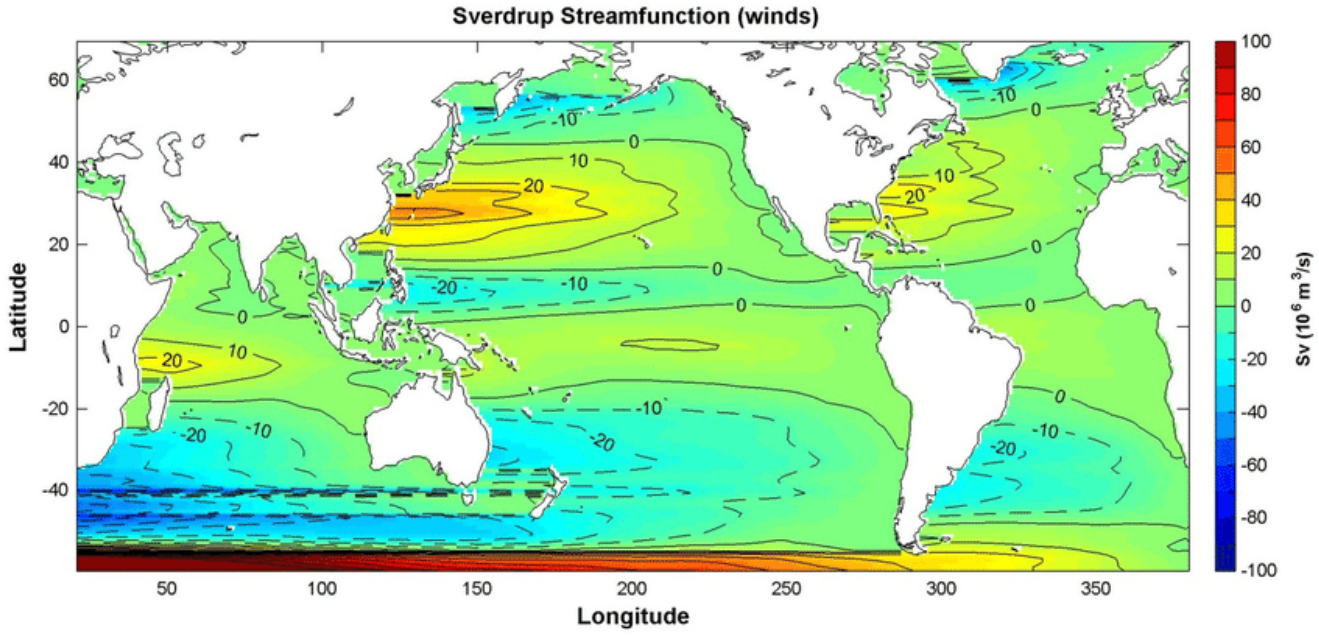
LVB-W



Chu, 2016

- Validation **NEMO OGCM LVB-W**
- Observation-based [Argo-based **ARMOR3D** v_g] **LVB-W**
- Obs. **LVB-W** comparison with other ***w***

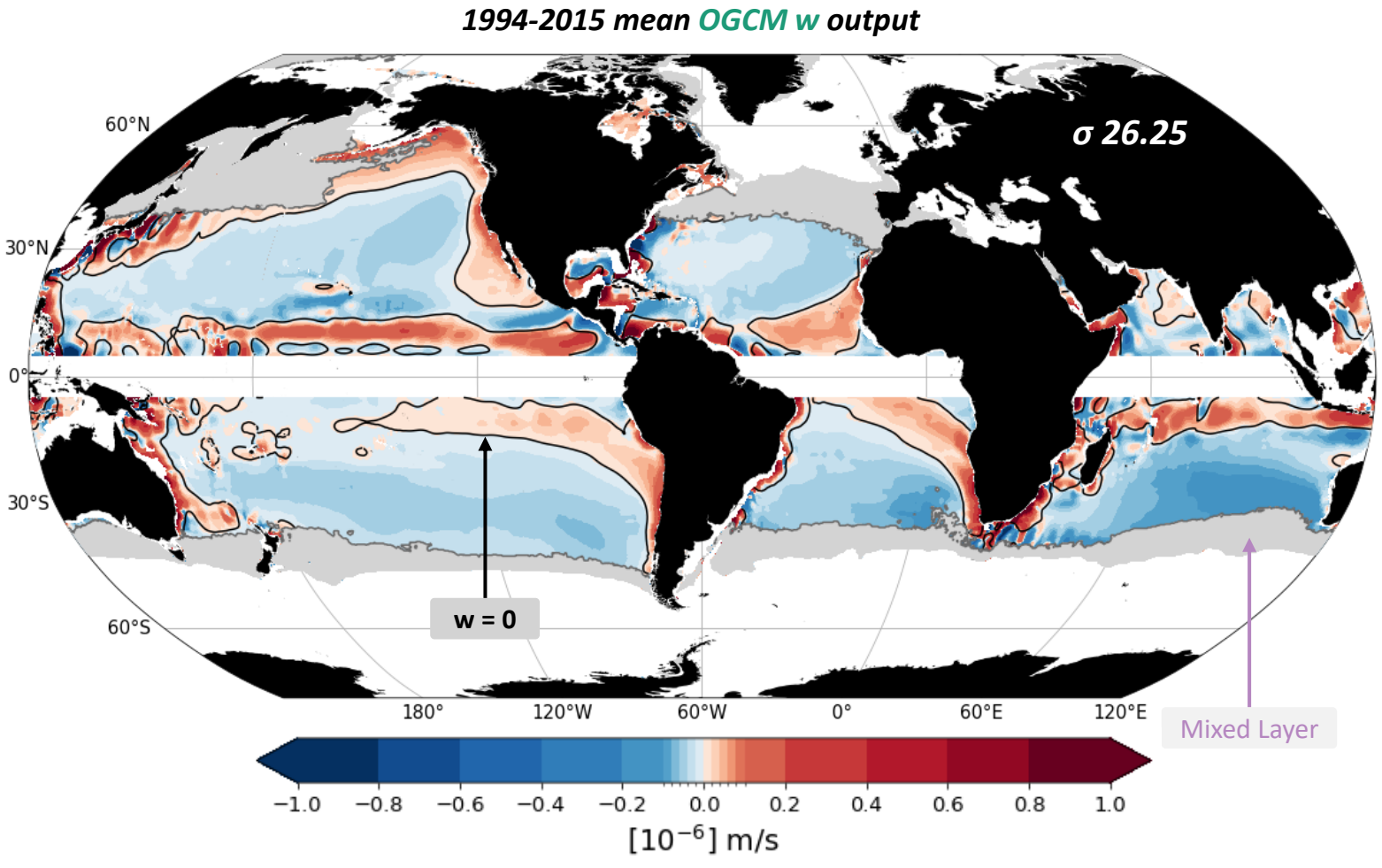
NEMO OCGM simulation: Bessières et al., 2017

ARMOR3D: Mulet et al.,2012

Time-mean *w* output from OGCM

Upwelling

Downwelling



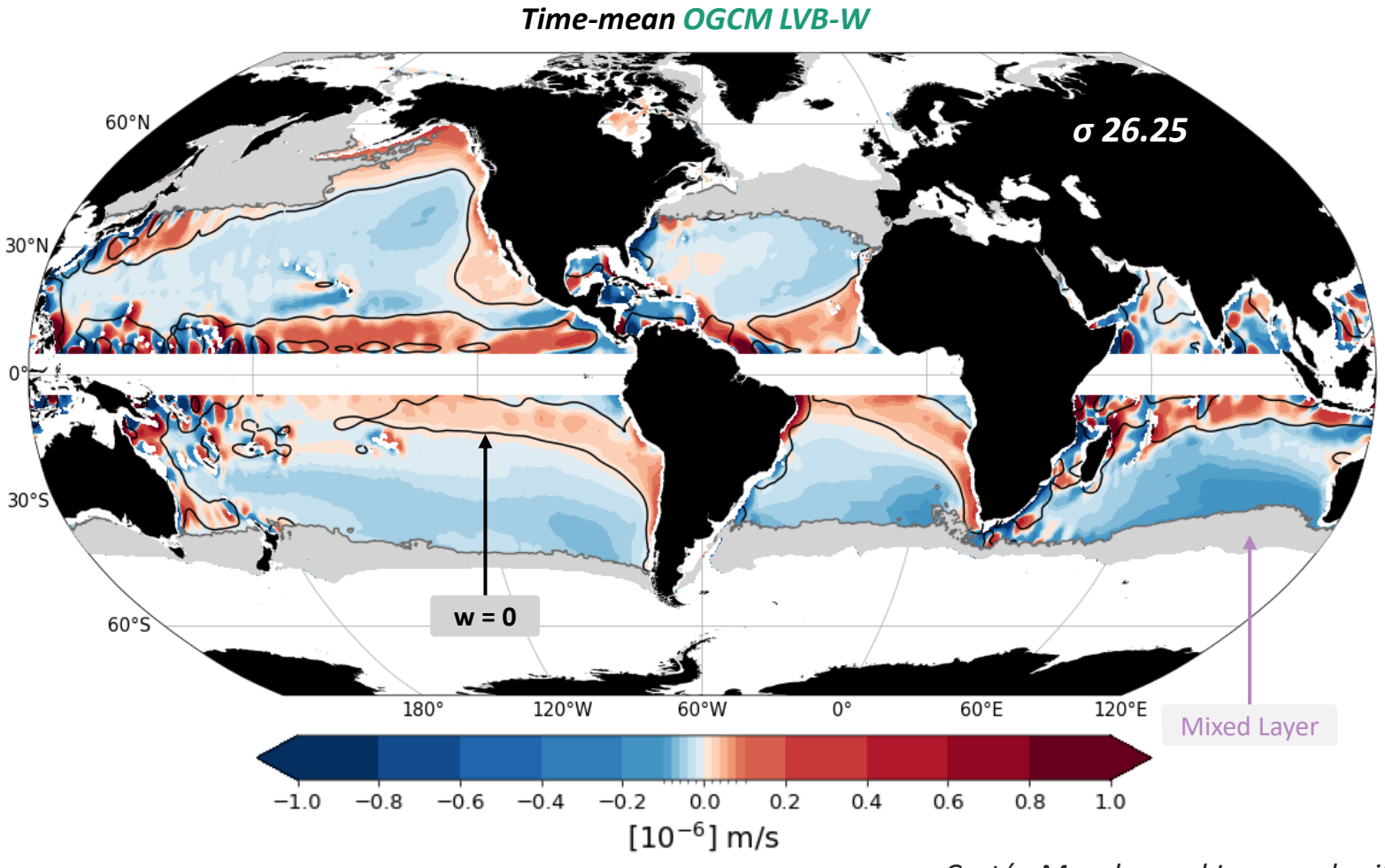
NEMO OCGM simulation: Bessières et al., 2017

Time-mean *w* estimate (LVB-W) from OGCM v_g

LVB vertical integral from surface:

$$LVB\text{-}W(z') = w_{Ek} - \int_{z'}^{0} \frac{\beta v_g}{f} dz$$

The **upwelling** and **dowelling** regions are well reconstructed.



Cortés-Morales and Lazar, submitted

NEMO OCGM simulation: Bessières et al., 2017

Time-mean *w* estimate (LVB-W) from OGCM v_g

The **upwelling** and **dowelling** regions are well reconstructed.

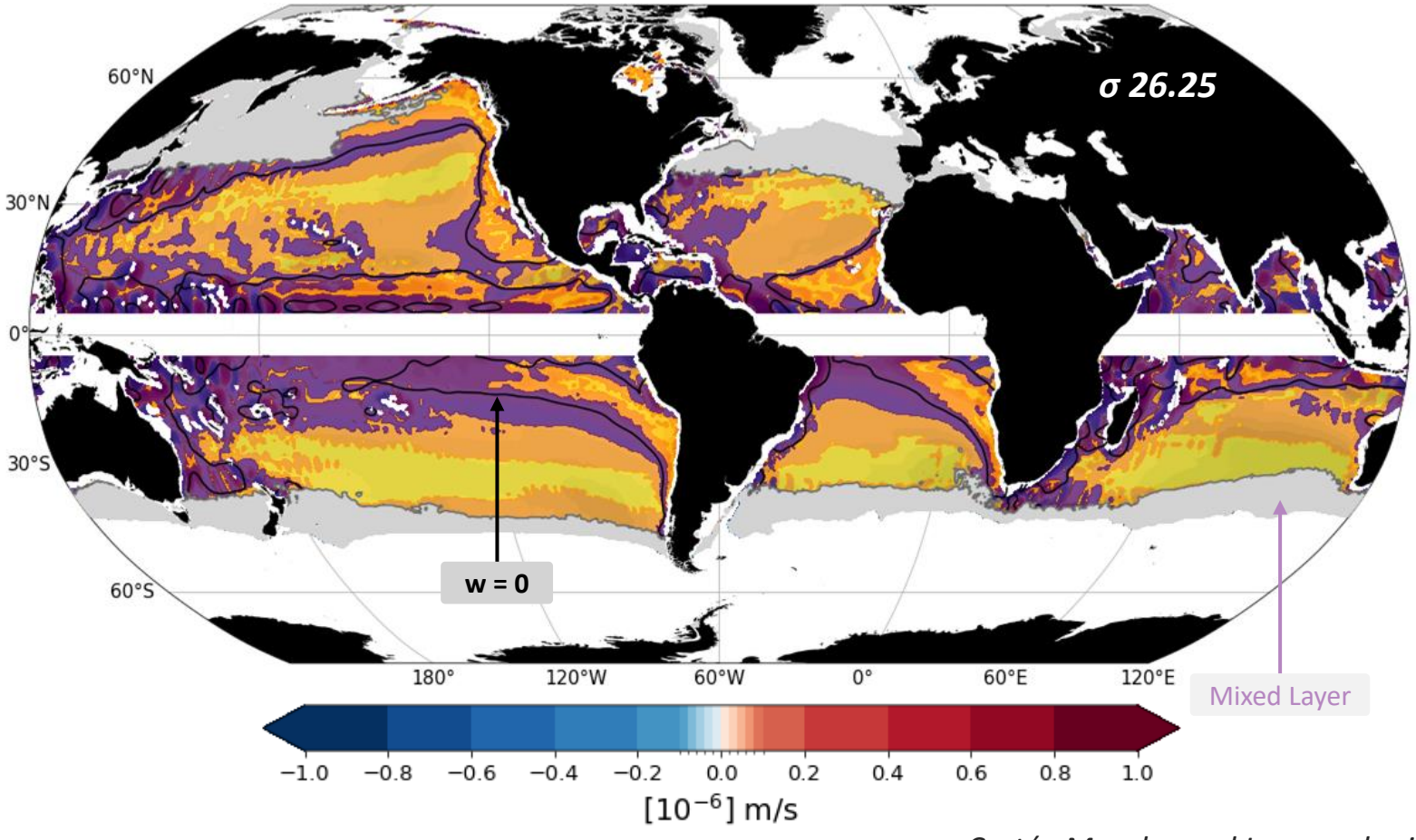
Good mean relative error (<10%)

Acceptable mean relative error (10-50%)

Poor mean relative error (>50%)

Most of vertical circulation in the Gyres has a relative error below 50%.

Time-mean OGCM w/ OGCM LVB-W relative



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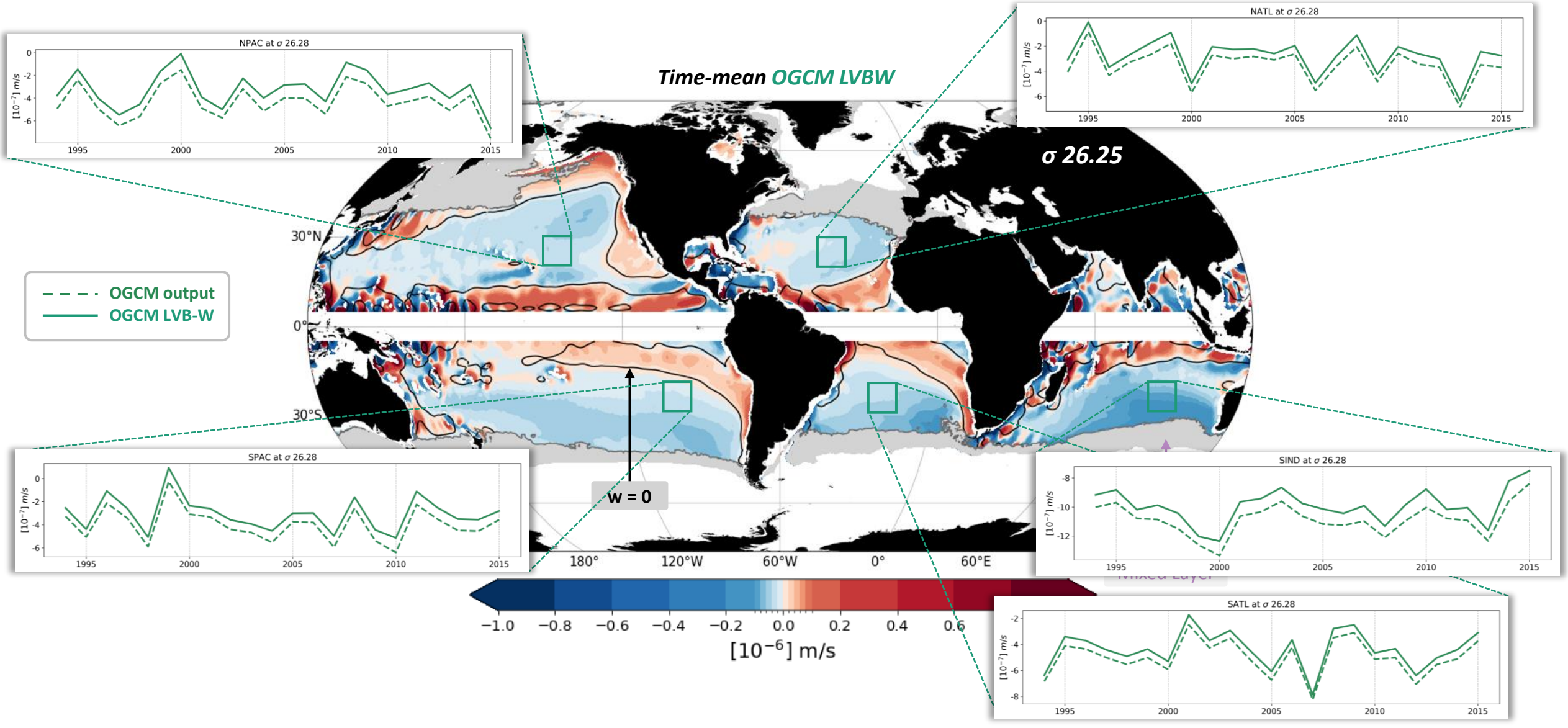

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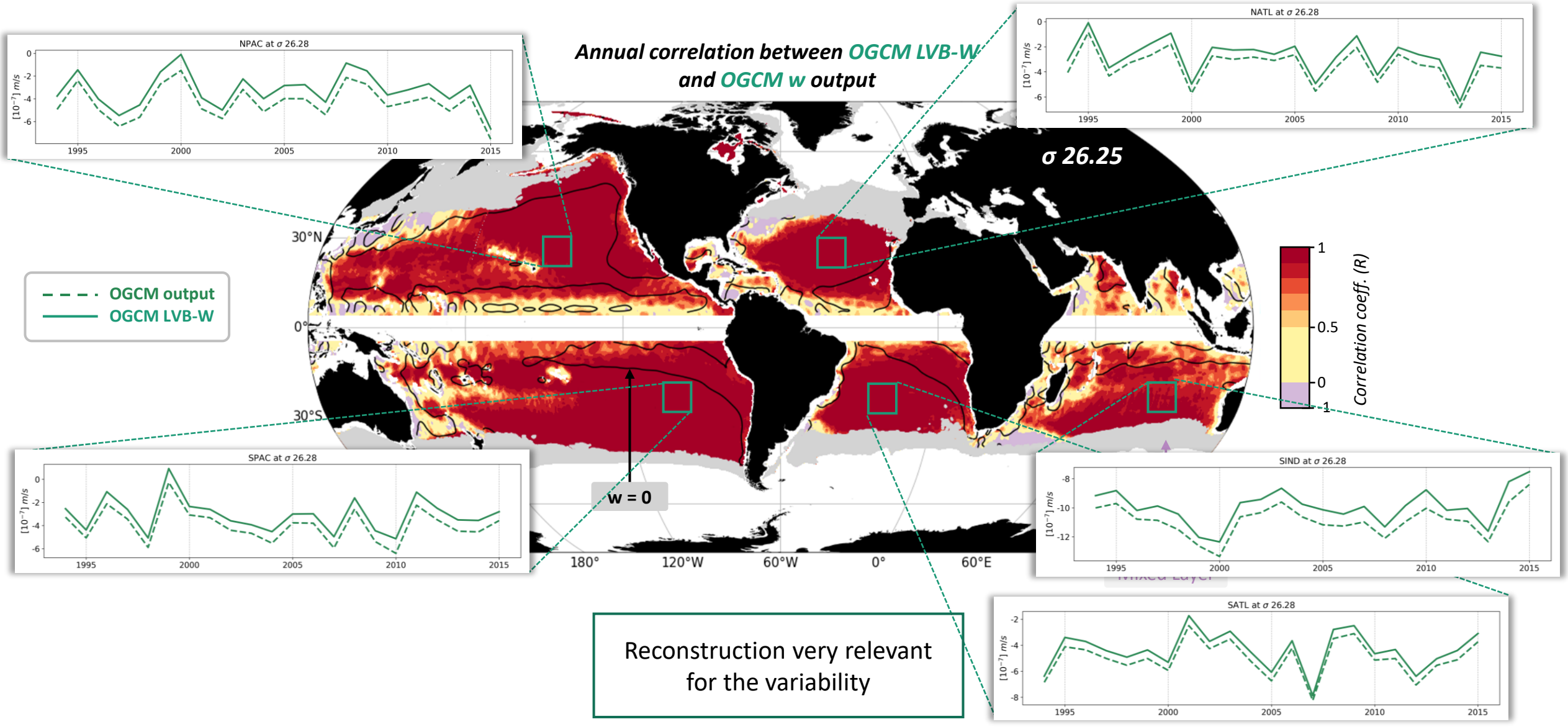


Reconstruction very relevant for the variability

Cortés-Morales and Lazar, submitted

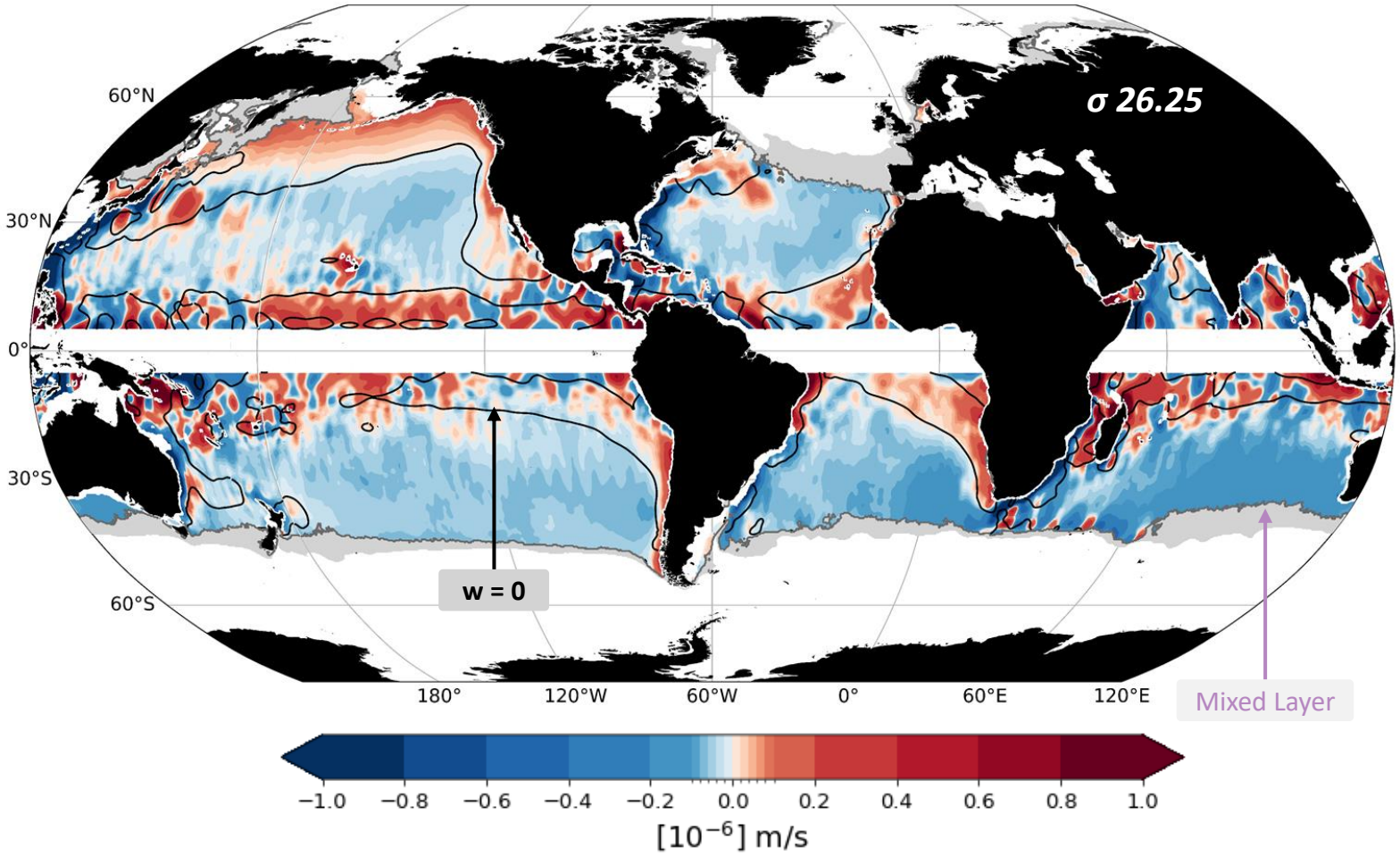
Time-mean *w* estimate (LVB-W) from observations

ARMOR3D

$$\textit{obs. LVB-W}(z') = w_{Ek}^{ERA5} - \int_{z'}^{0} \frac{\beta v_g}{f} dz$$

obs. LVB-W
with similar **large scale** structures and amplitude as **OGCM** simulation

Time-mean obs. LVB-W



ARMOR3D: Mulet et al.,2012

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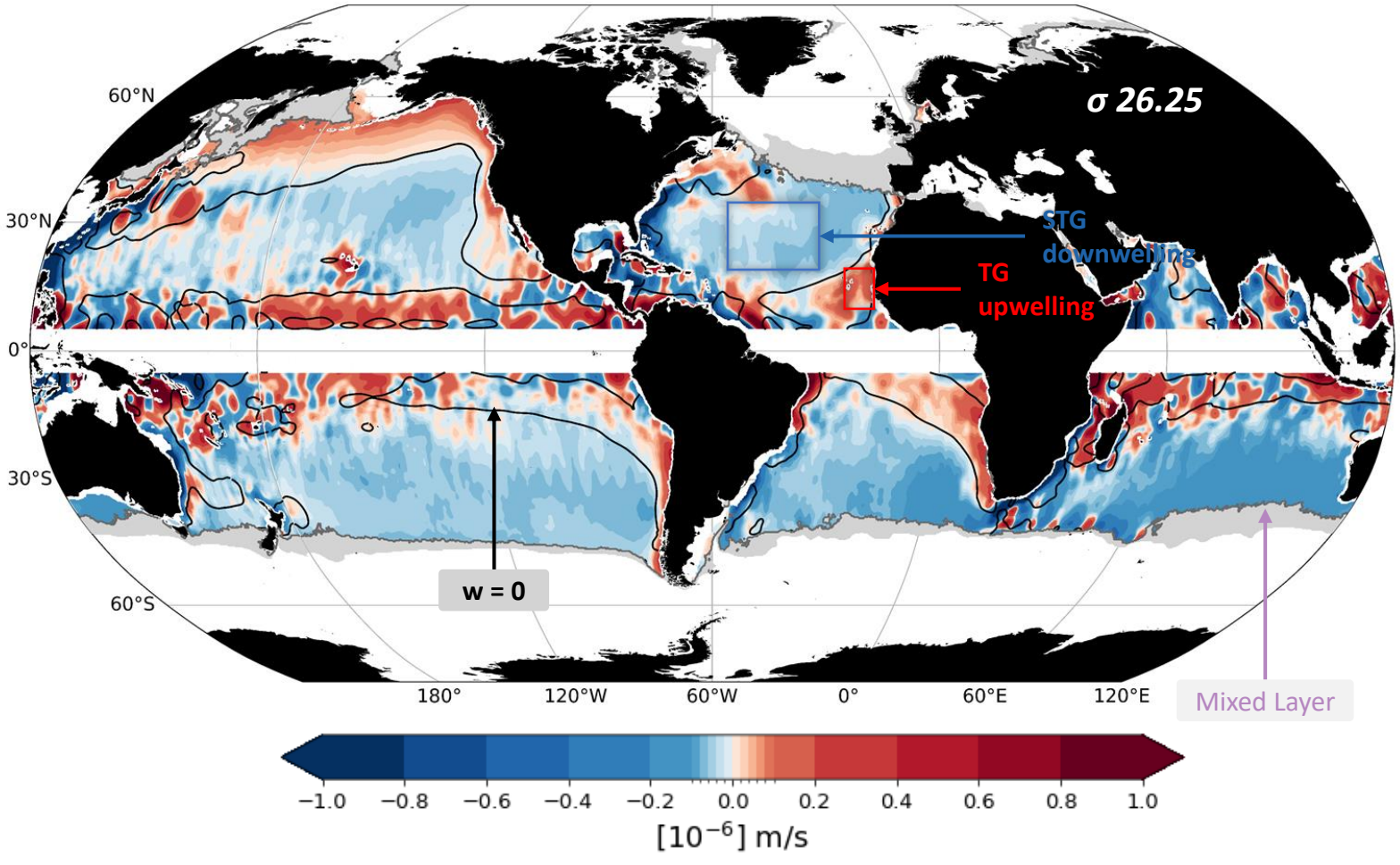
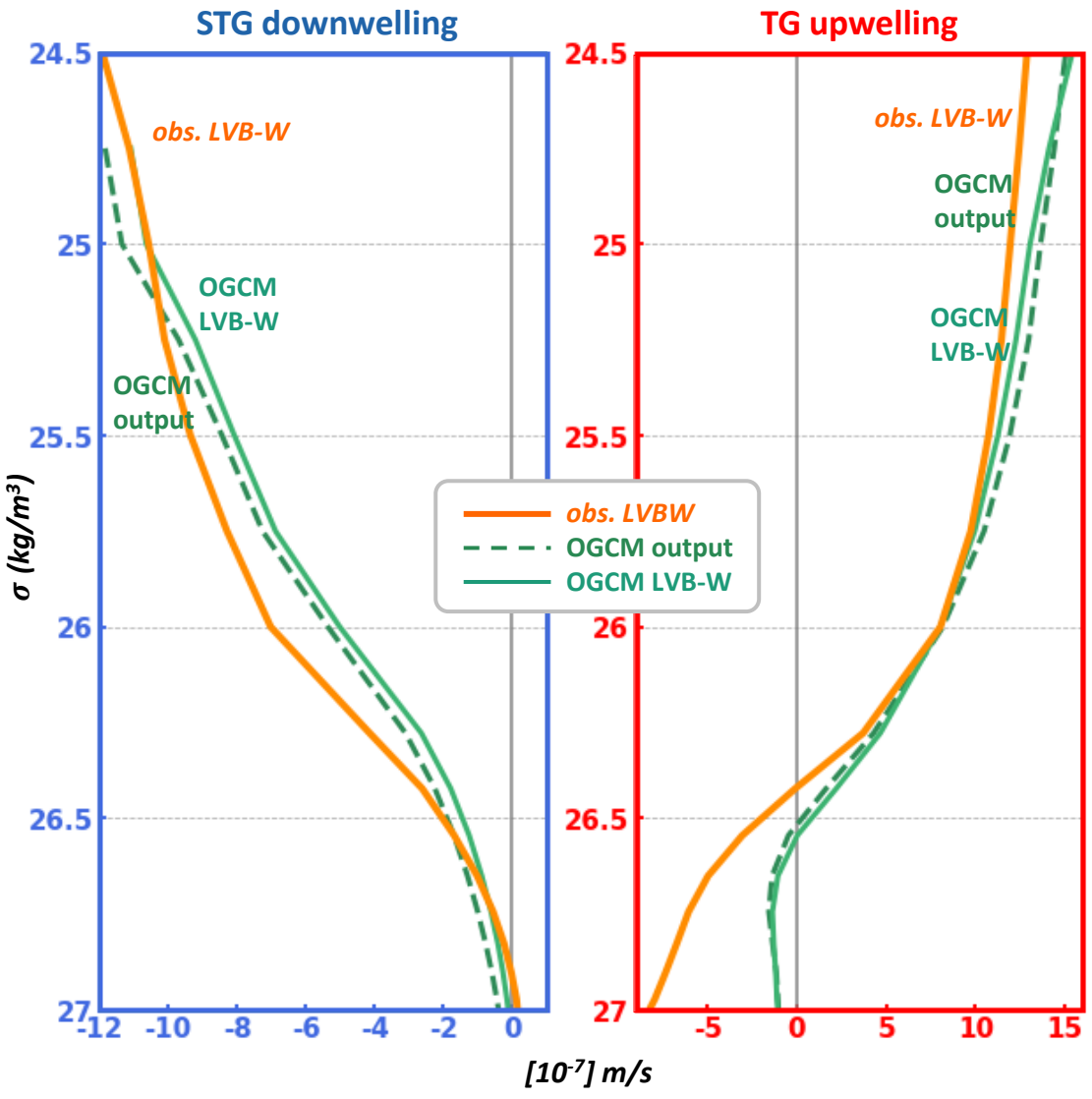


ARMOR3D: Mulet et al.,2012

Comparison of obs-based *LVB-W* with other datasets

Analysis of the time-mean vertical structure of the North Atlantic gyres



obs. LVB-W vertical structure consistent with:

- **OGCM output** and **OGCM LVB-W**

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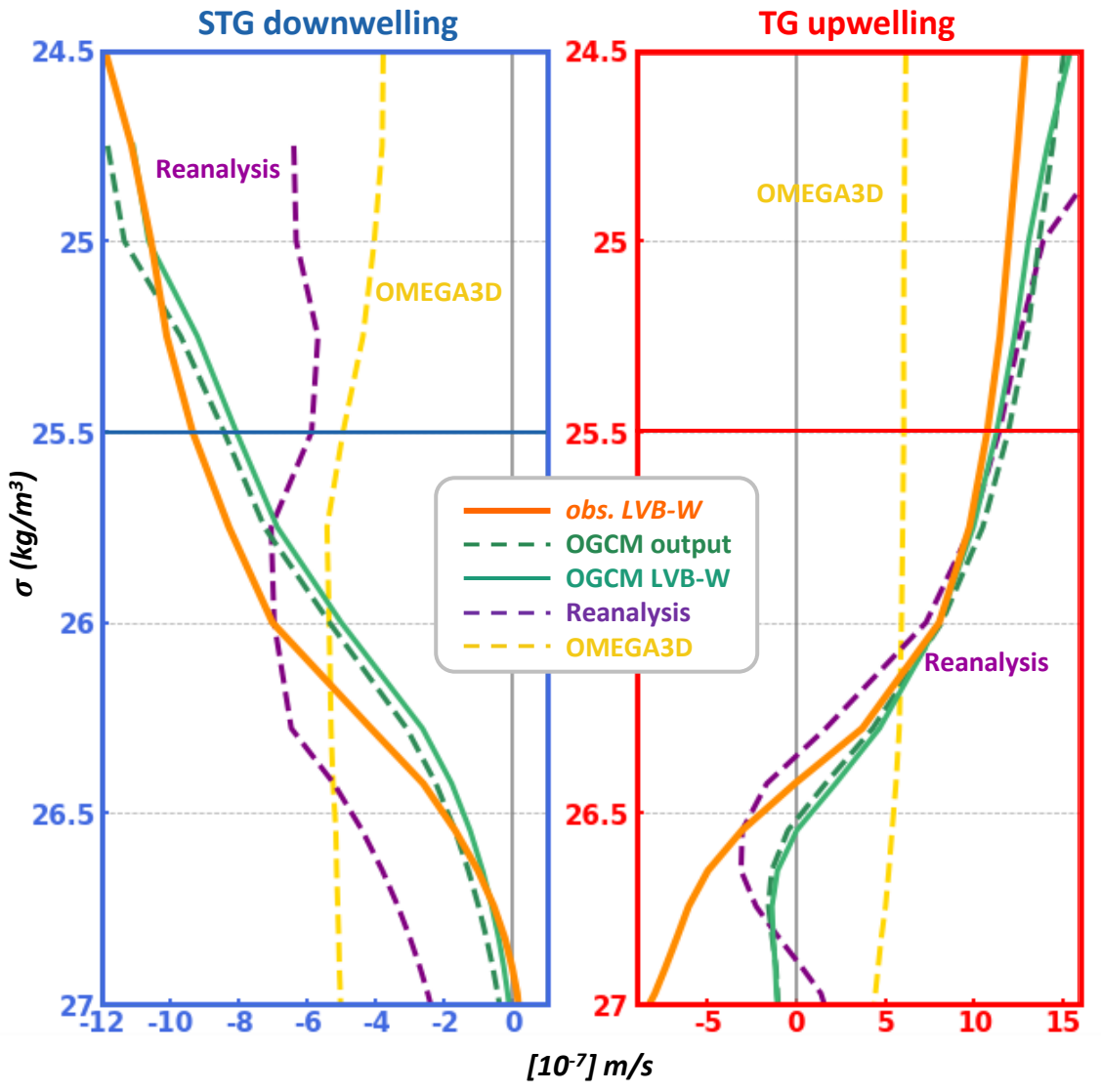


obs. LVB-W vertical structure consistent with:

- **OGCM output** and **OGCM LVB-W**
- **Ocean reanalysis (ECCO)**

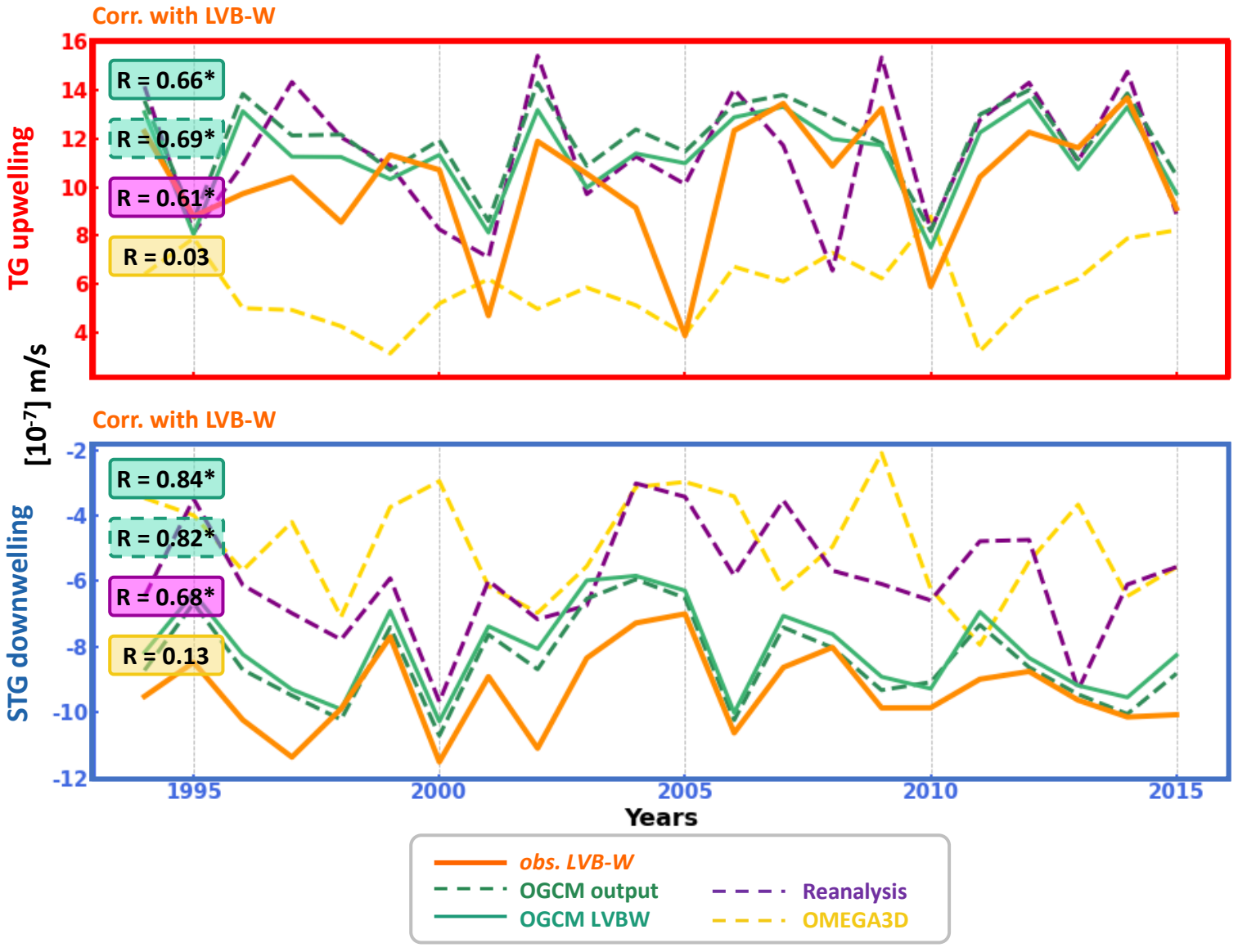
OMEGA3D (Omega Equation derived w) represents a barotropic ocean

obs. LVB-W reproduces the baroclinicity of the **OGCM *w*** *unlike* ***OMEGA3D***.

ECCO: Forget et al., 2015
OMEGA3D: Buongiorno Nardelli et al., 2018; 2020

Comparison of interannual *obs-based LVB-W* with other datasets

Analysis of the time variability of the North Atlantic gyres



- Significant correlation between **obs. LVB-W** and model-based ***w*** (**OGCM**; **Reanalysis**)
- No correlation between **obs. LVB-W** and **OMEGA3D**

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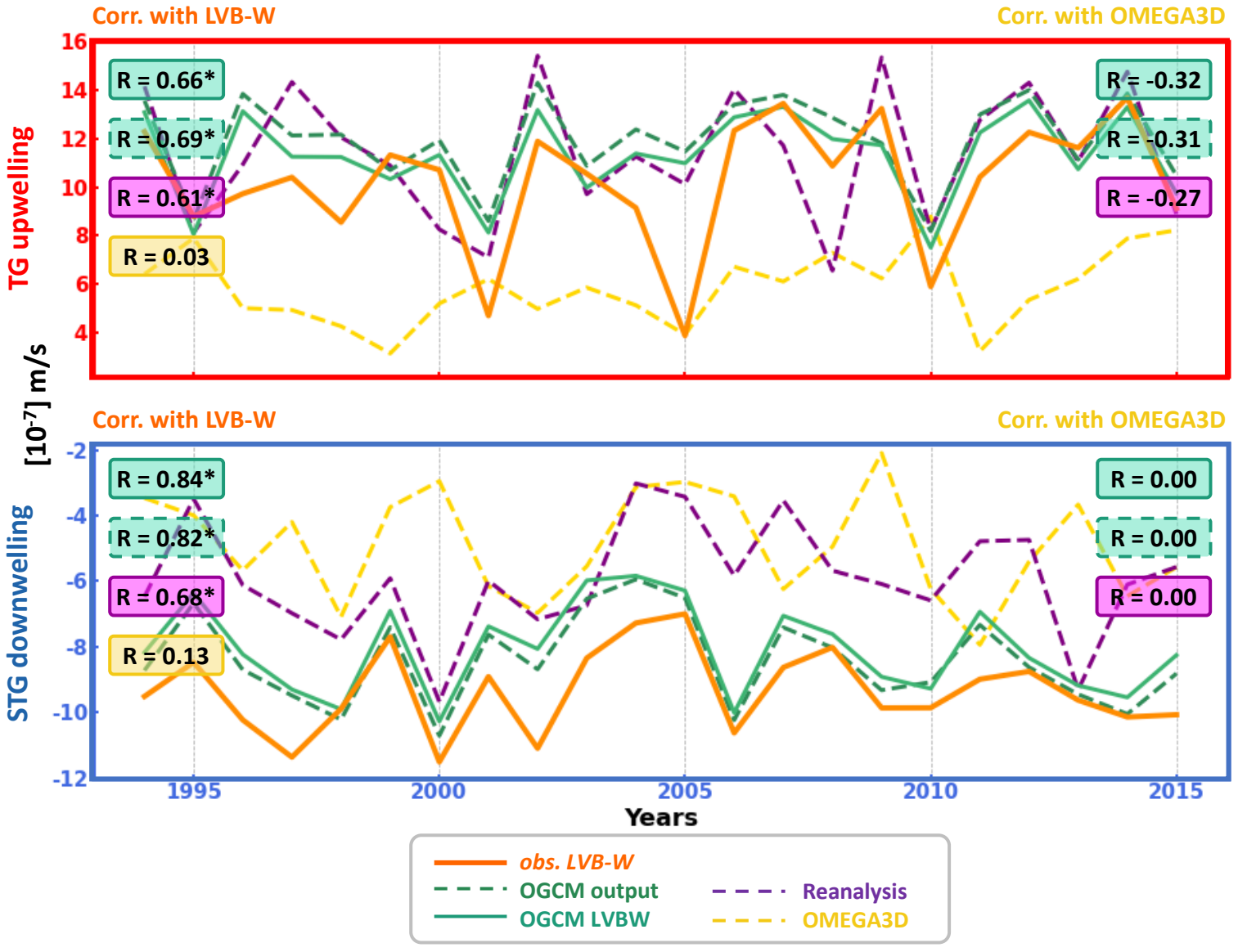
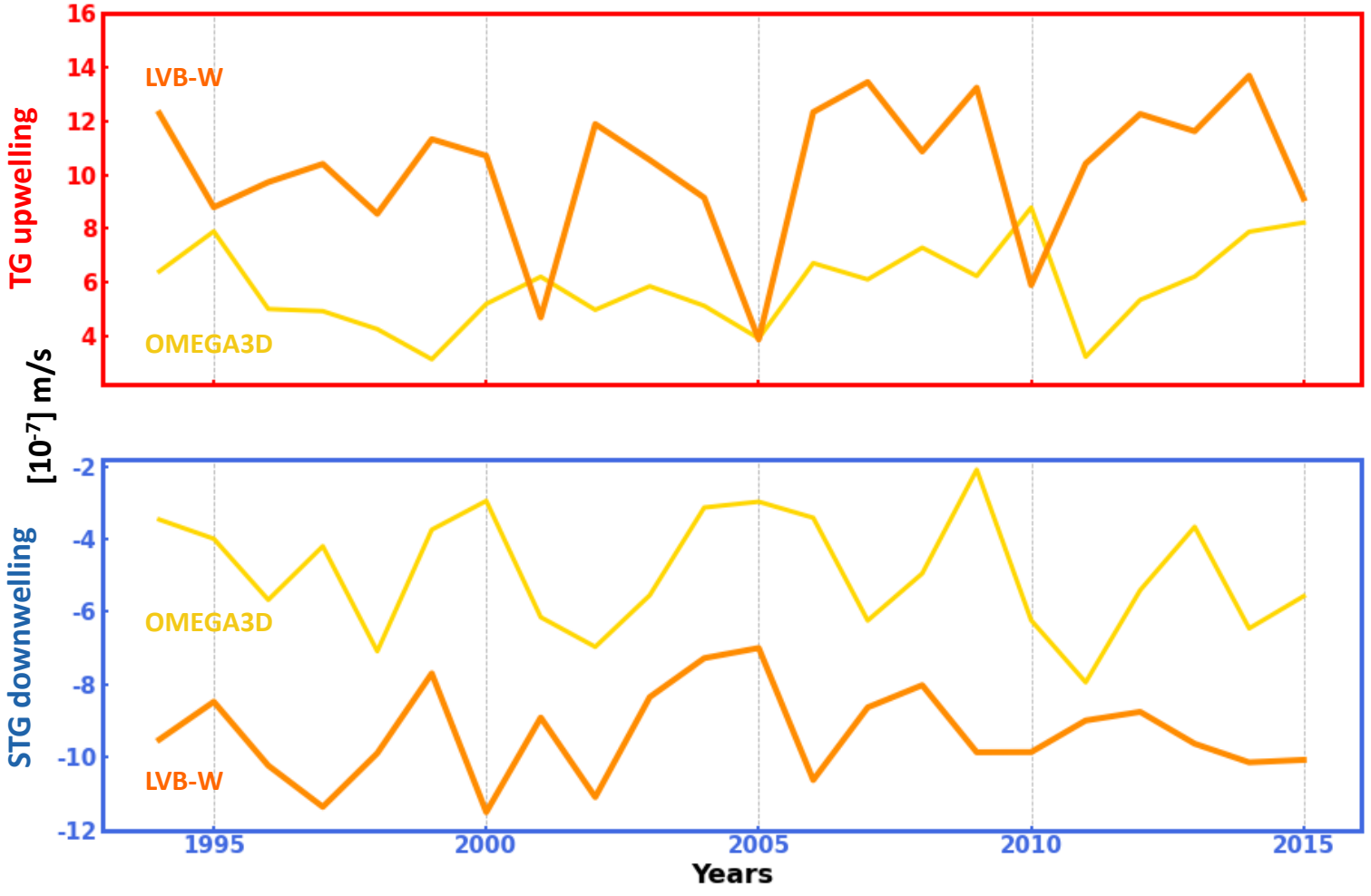
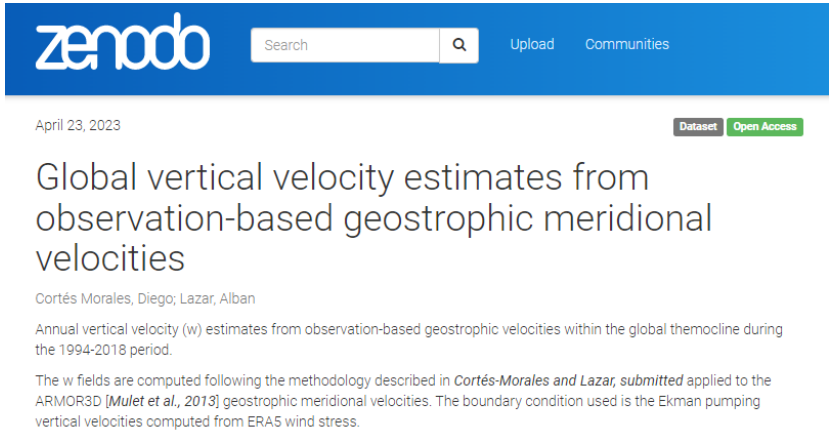


- Significant correlation between **obs. LVB-W** and model-based ***w*** (**OGCM**; **Reanalysis**)
- No correlation between **obs. LVB-W** and **OMEGA3D**

OGCM and **Reanalysis** variability better explained by **obs. LVB-W** than **OMEGA3D**

Comparison of interannual *obs-based LVB-W* with other datasets

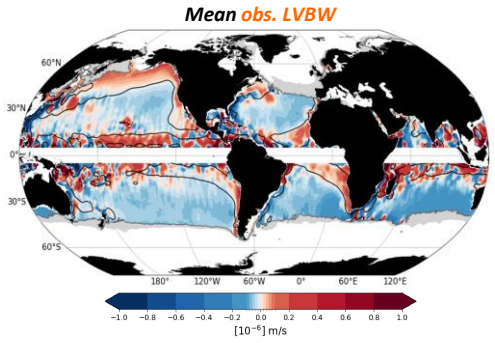
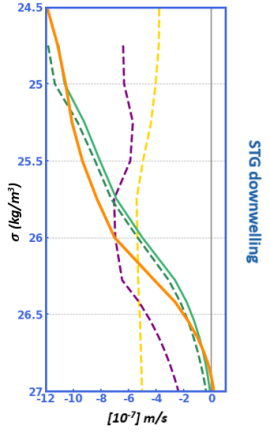
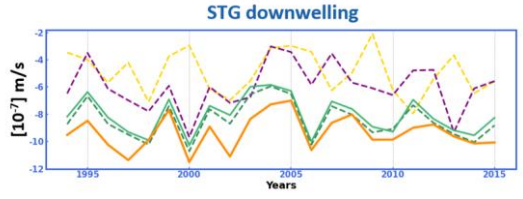




https://zenodo.org/record/7857246#.ZEeVynZBxaQ

Two thermocline *w(x,y,z,t)* estimates derived from observations for the community

Where we are now?

		LVB-W	OMEGA3D
Large scale horizontal structure		✅	✅ NOT SHOWN HERE
Baroclinicity		✅	❌
Time variability		✅	❌

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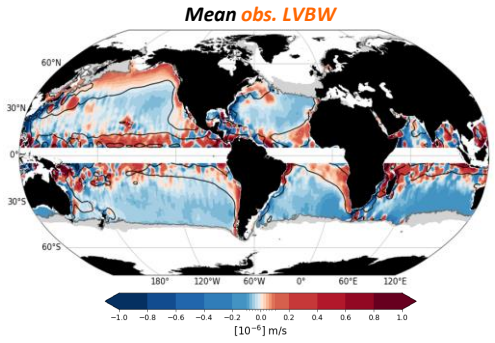
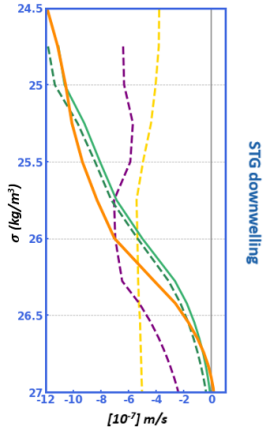
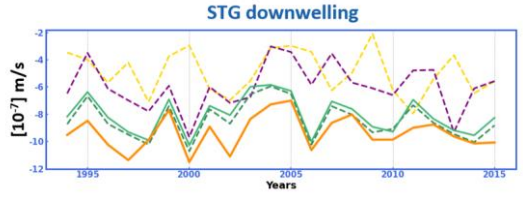
Large scale horizontal structure		✅	✅ NOT SHOWN HERE
Baroclinicity		✅	❌
Time variability		✅	❌

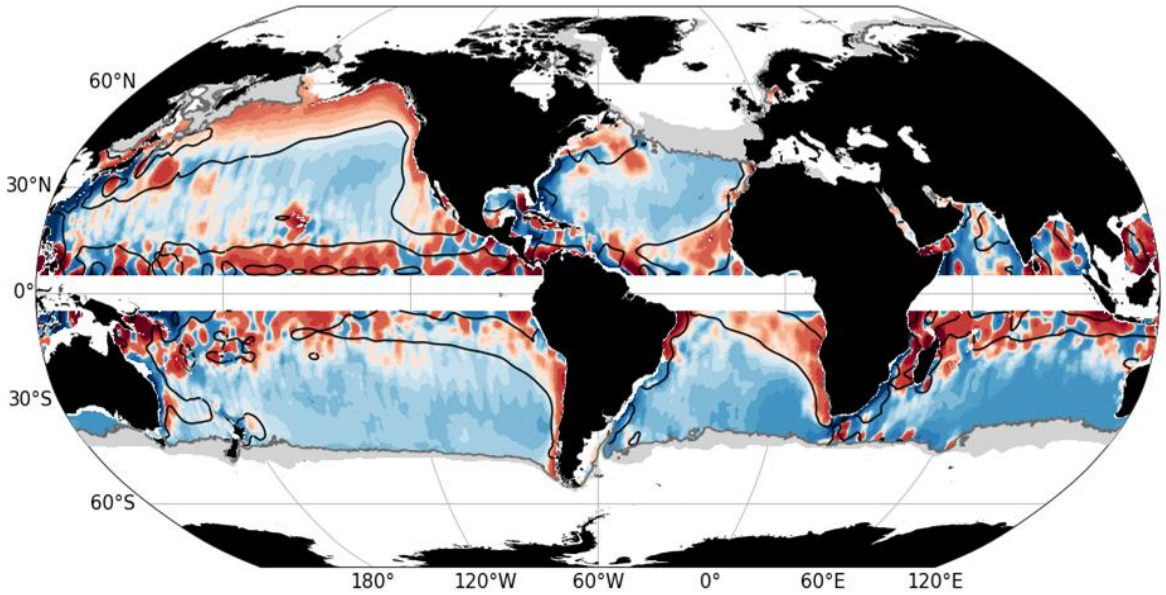
WHY?

Thank you for your attention

Comparison of interannual *obs-based LVBW* with previous datasets

Analysis of the horizontal distribution of the circulation

Mean obs. LVBW



Mean OMEGA3D