PICES-2019 Annual Meeting

Effects of the non-breaking surface wave induced vertical mixing on winter MLD

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CONTENTS

1 Background

2 Models

3 Results

4 Conclusion & Discussions

1 Background

1.1 Significance

1.2 Actuality of the Simulation of MLD

1.3 Actuality of Bv

1.4 Research Problems

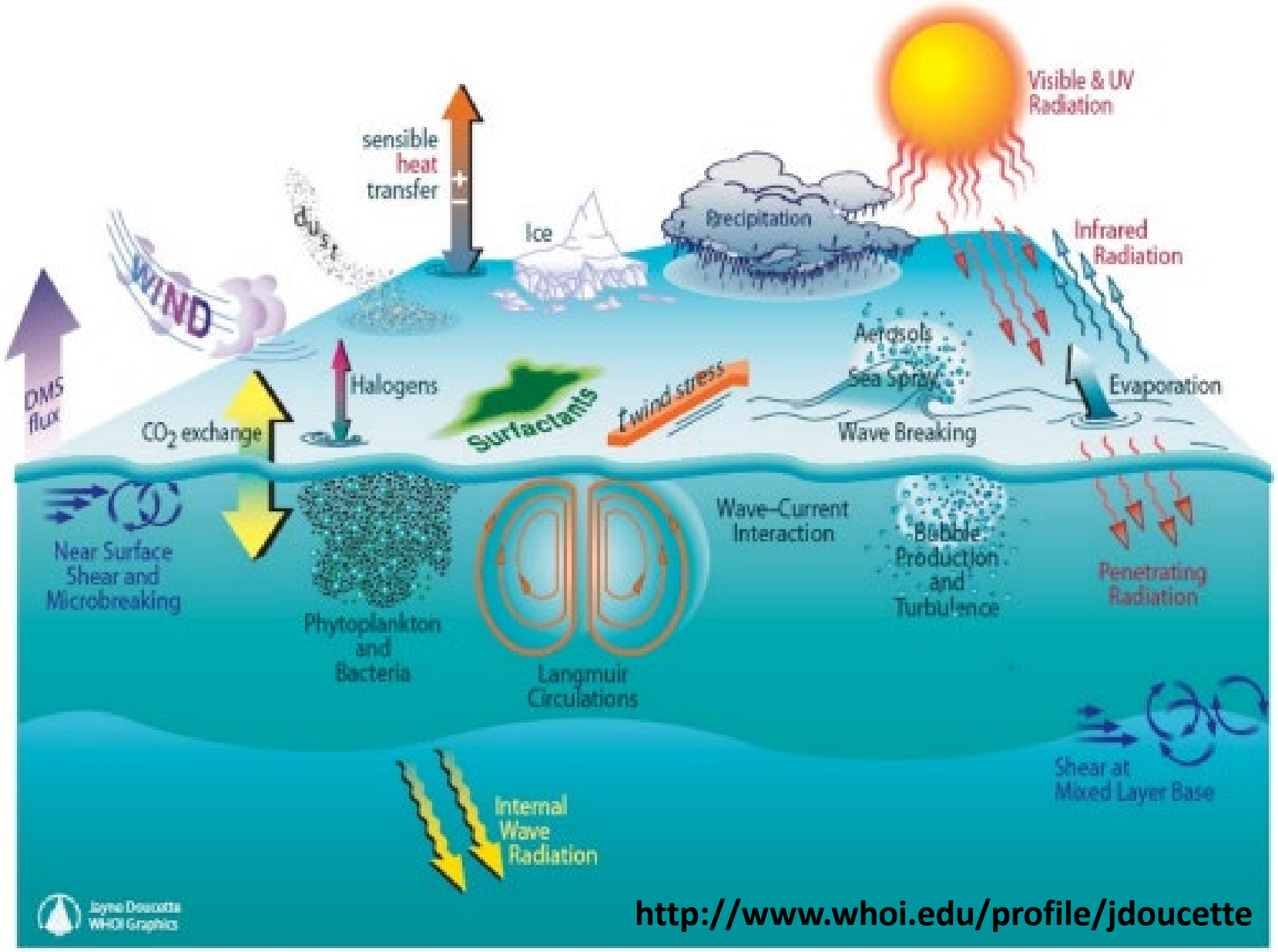
1.1 Significance

Background

Models

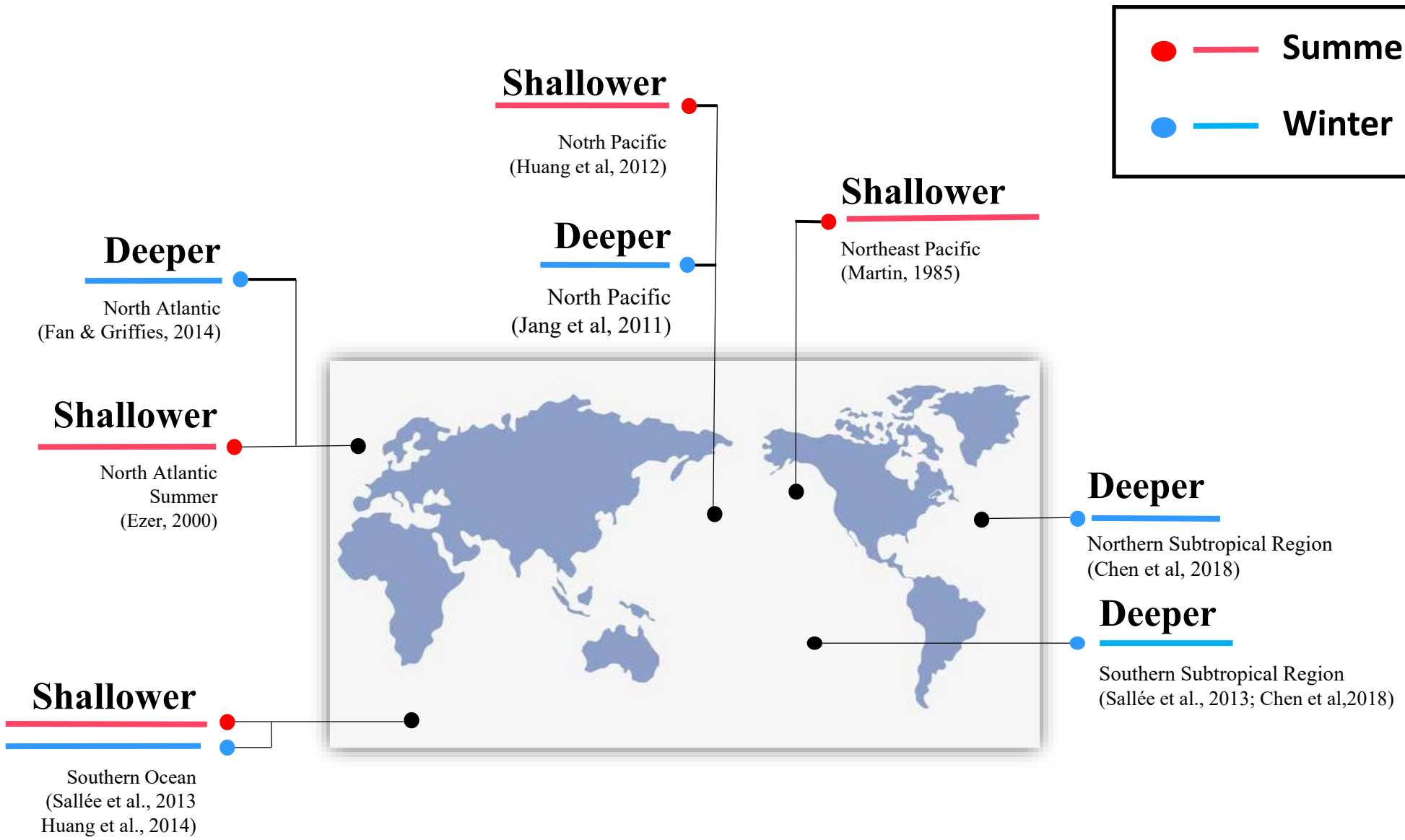
Results

Conclusions
& Discussions



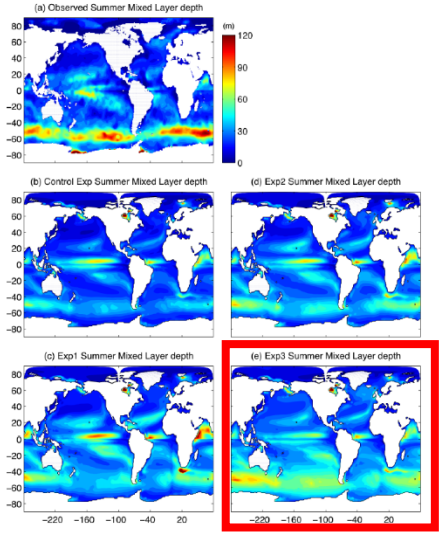
http://www.whoi.edu/profile/jdoucette

1.2 Actuality of the Simulation of MLD

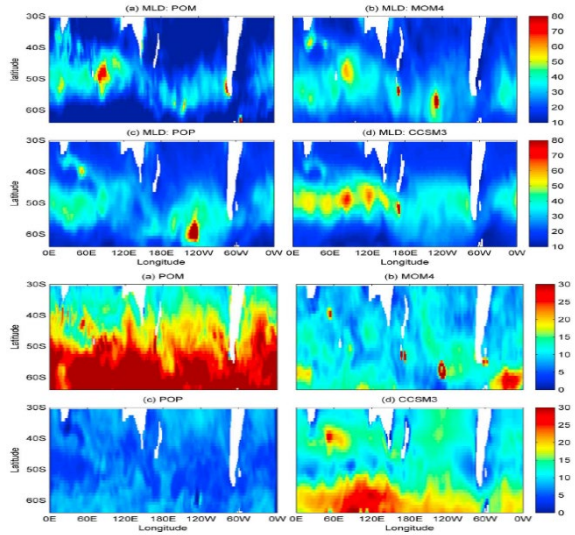


1.3 Actuality of Bv

Effect of Bv on the Simulation of Summer MLD

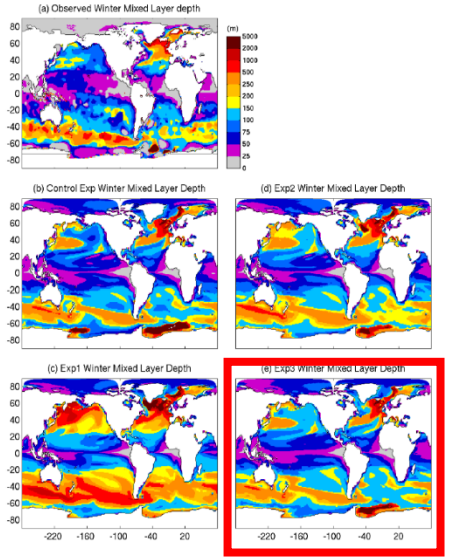


(Fan & Griffies, 2014, JC)

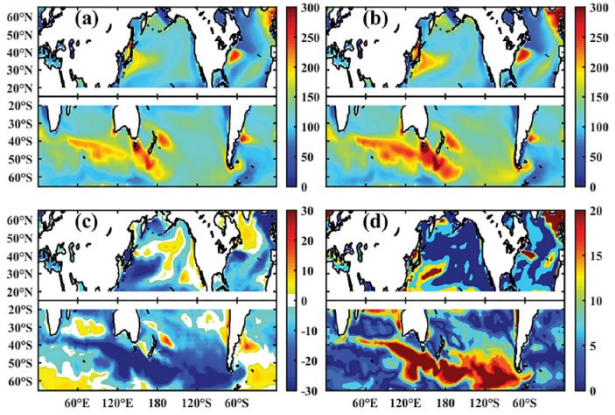


(Huang et al, 2012, JGR)

Effect of Bv on the Simulation of Winter MLD



(Fan & Griffies, 2014, JC)



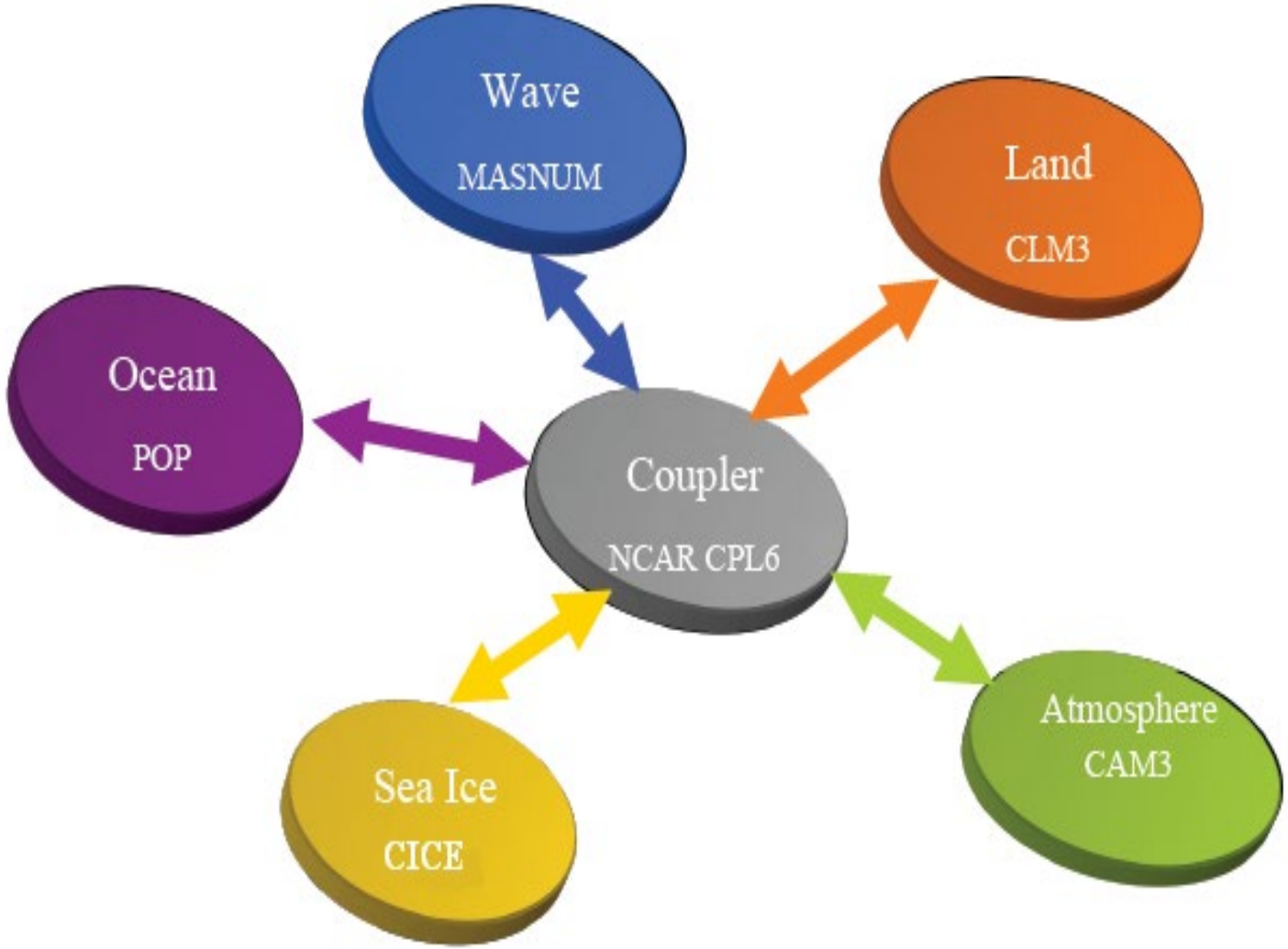
(Chen et al, 2018, JGR: Ocean)

2 Model

2.1 FIO-ESM

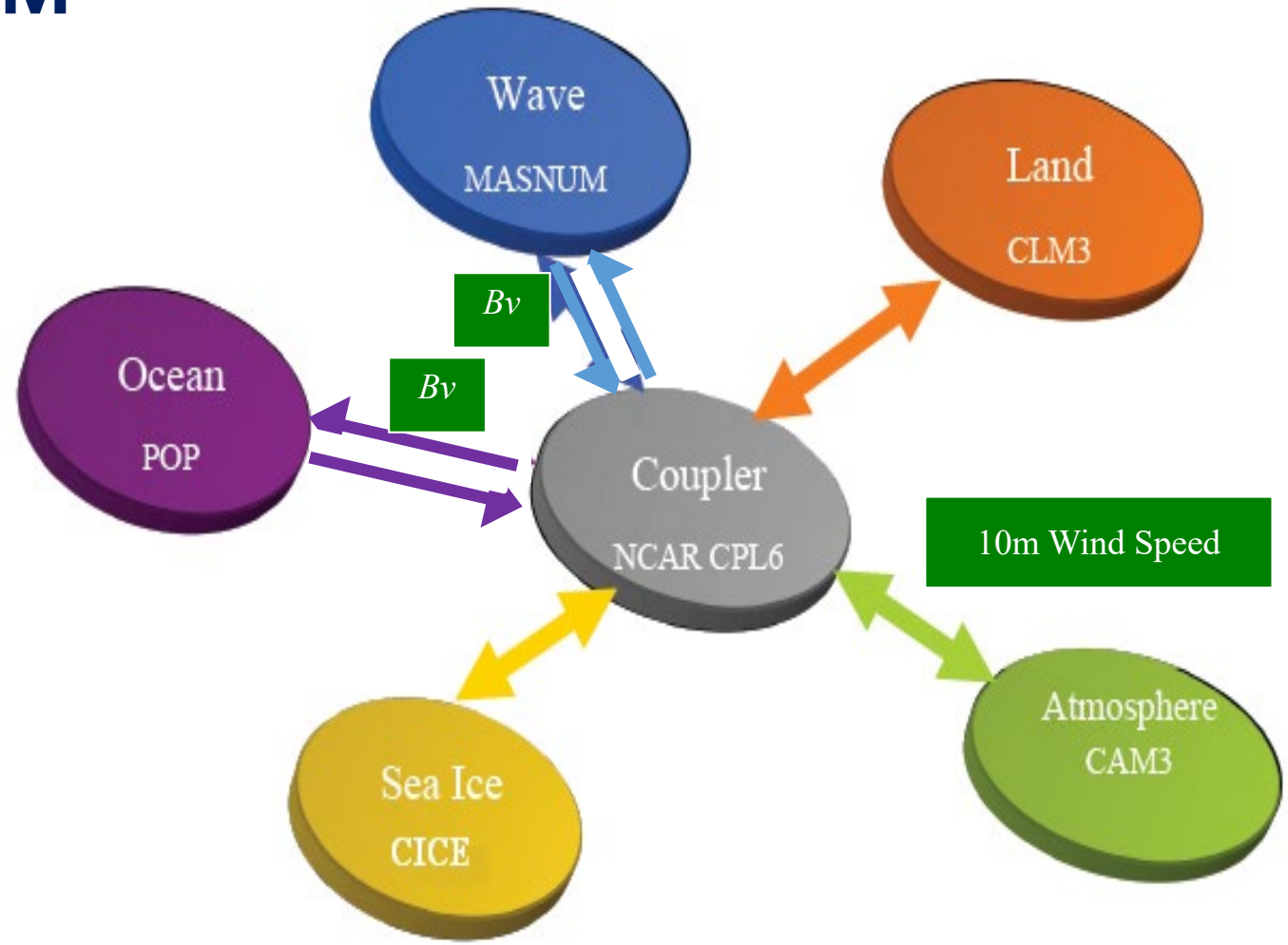
2.2 Design of Numerical Experiment

2.1 FIO-ESM



(Qiao et al., 2013, J. Geophys. Res.)

2.1 FIO-ESM

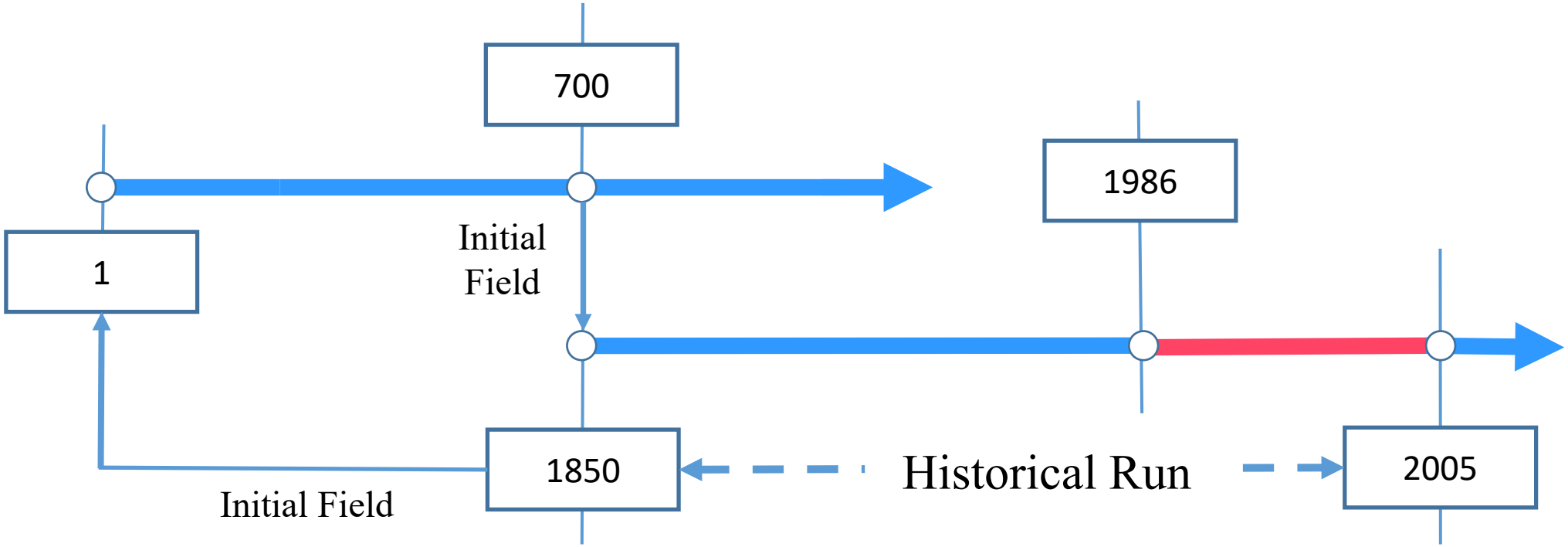


$$Bv = \alpha \iint_{\vec{k}} E(\vec{k}) \exp(2kz) d\vec{k} \frac{\partial}{\partial z} \left[\iint_{\vec{k}} \omega^2 E(\vec{k}) \exp(2kz) d\vec{k} \right]^{1/2}$$

$$K_m = K_{m0} + Bv$$

$$K_h = K_{h0} + Bv$$

2.2 Design of Numerical Experiments



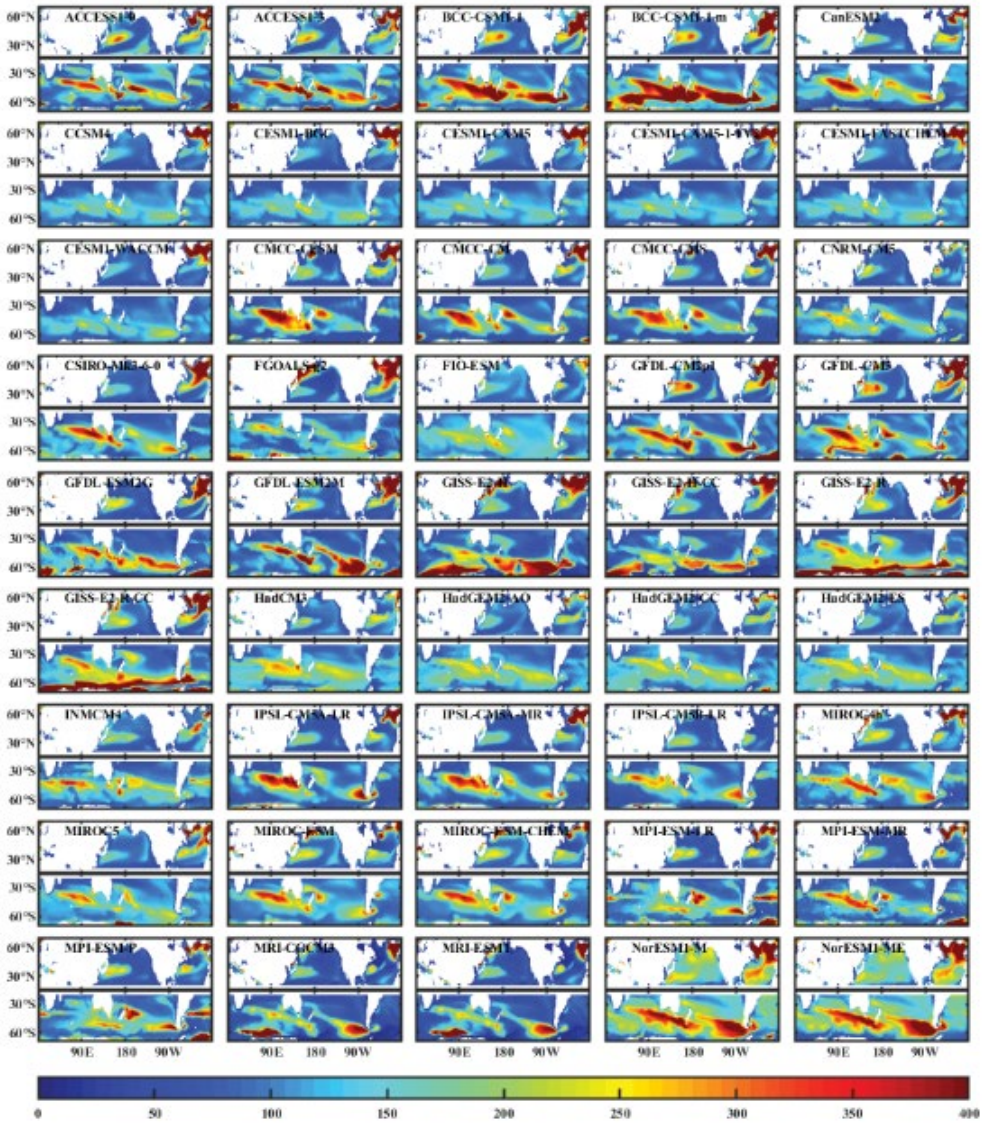
Numerical Experiment	Time	Bv
Effect of Bv	1986-2005	√
		×

3 Results

3.1 Simulations Biases

3.2 Effect of Bv

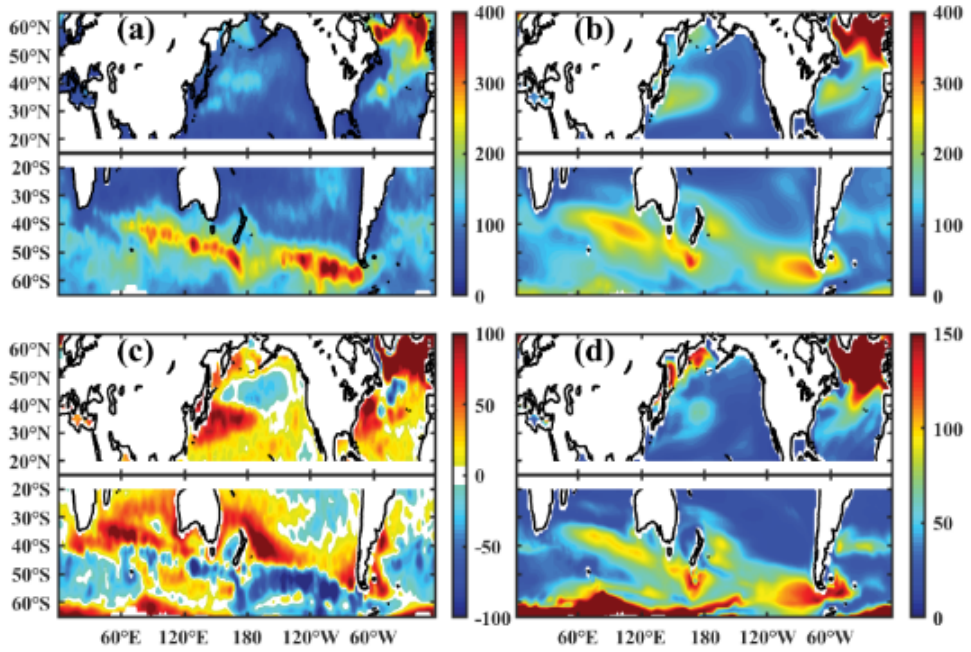
3.1 Simulations Biases

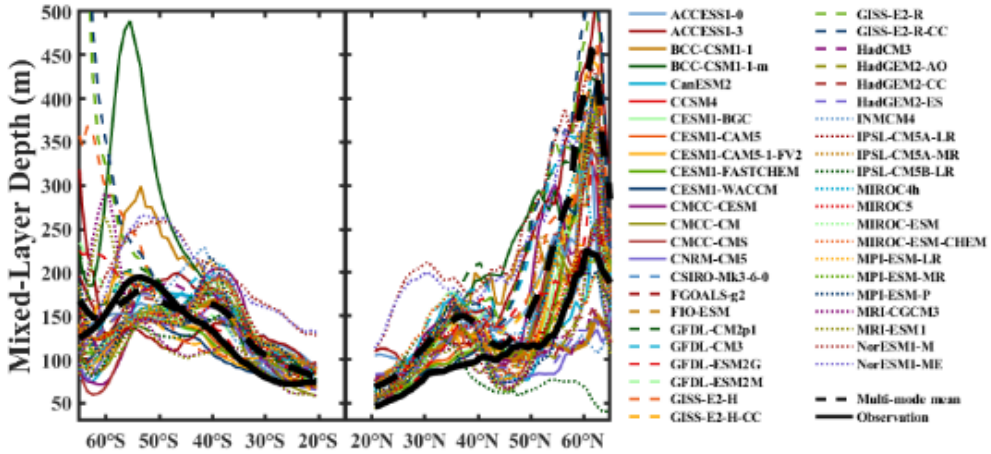


Winter

Subtropical : Deeper

Southern Ocean : Shallower

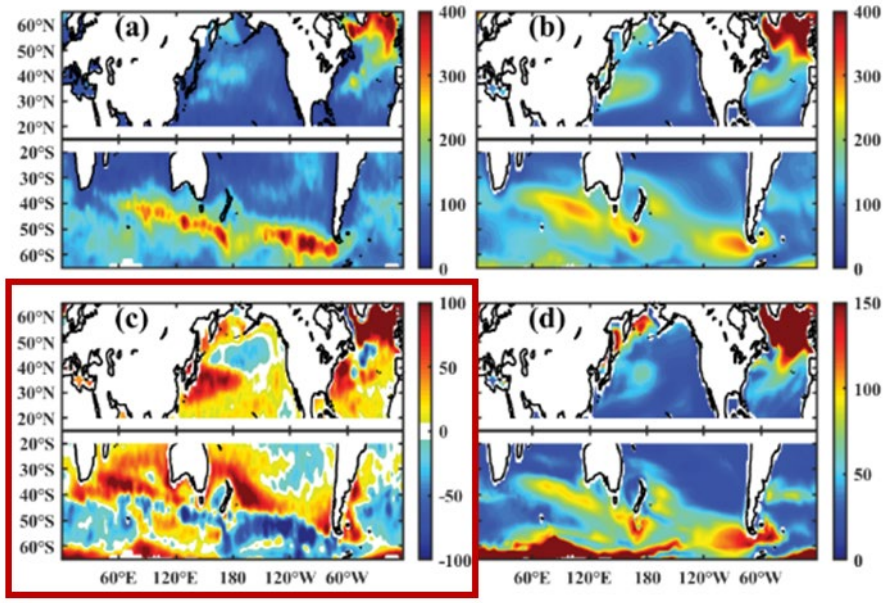




3.2 Effect of Bv

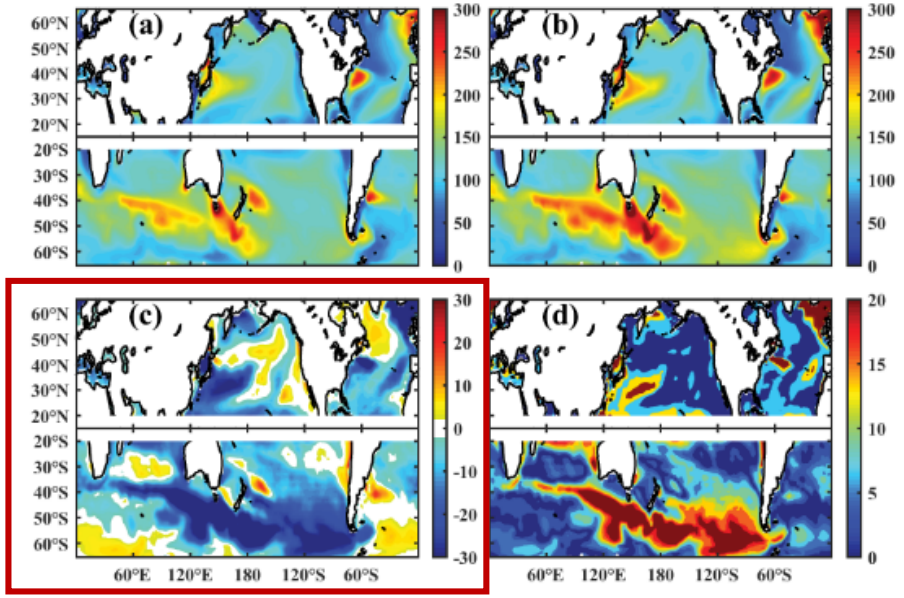
Winter

Simulation Bias



Multi-Model Mean – Observation

Effect of Bv

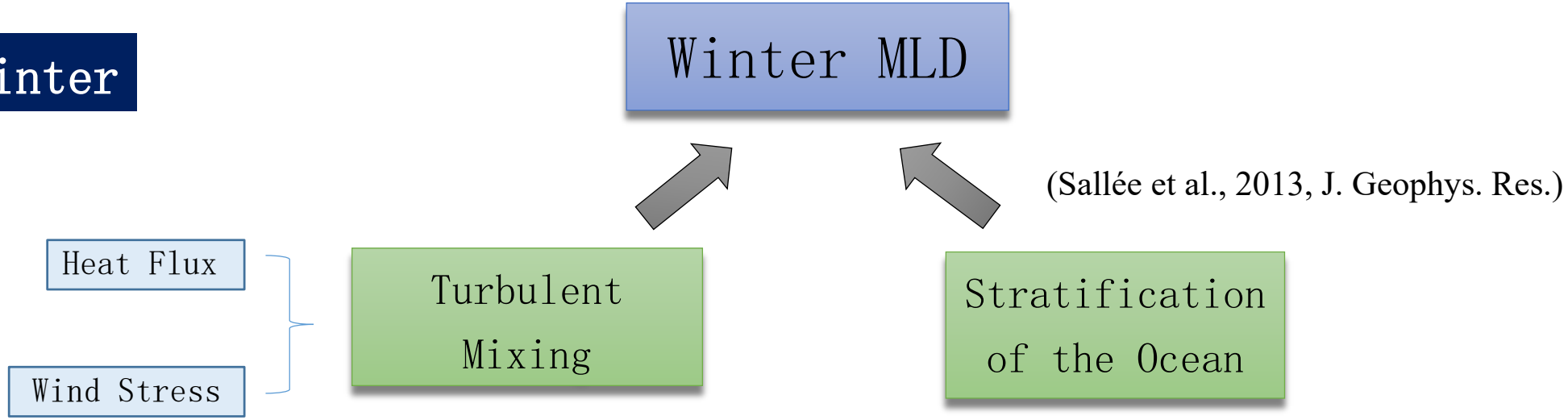


With Bv – Without Bv

Chen, S., Qiao, F., Huang, C., & Song, Z. (2018). Effects of the non-breaking surface wave-induced vertical mixing on winter mixed layer depth in subtropical regions. *J. Geophysical Res.*

3.2 Effect of Bv

Winter

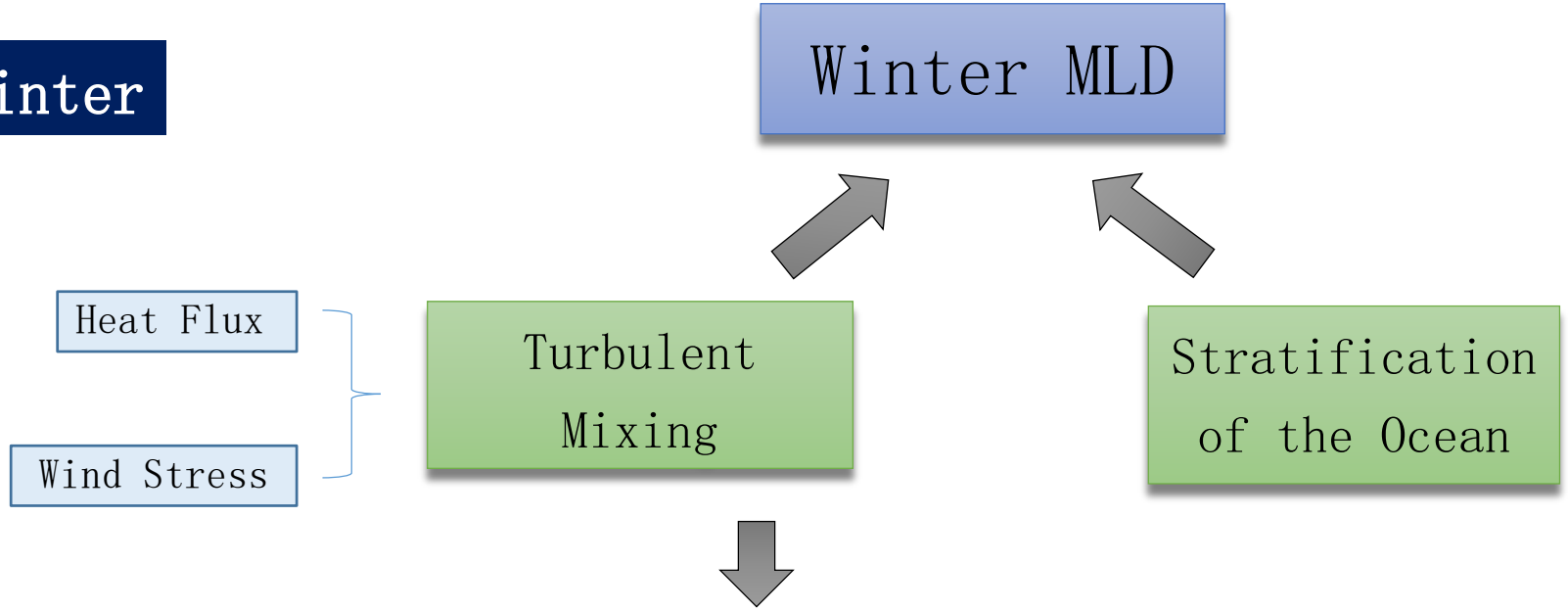


(Sallée et al., 2013, J. Geophys. Res.)

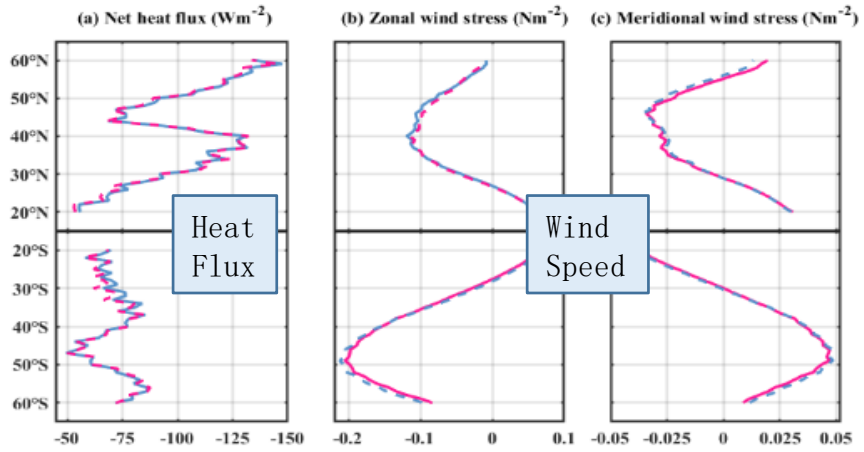
$$K_\rho = \frac{R_f}{1-R_f}\frac{\varepsilon}{N^2} = \Gamma\frac{\varepsilon}{N^2}$$

3.2 Effect of Bv

Winter



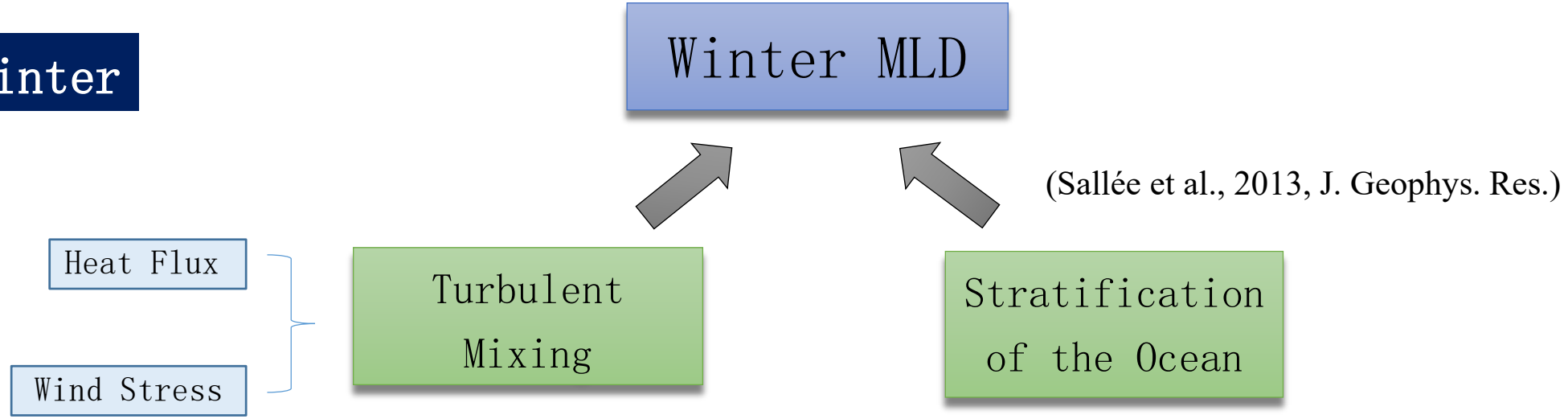
$$K_\rho = \frac{R_f}{1-R_f}\frac{\varepsilon}{N^2} = \Gamma\frac{\varepsilon}{N^2}$$



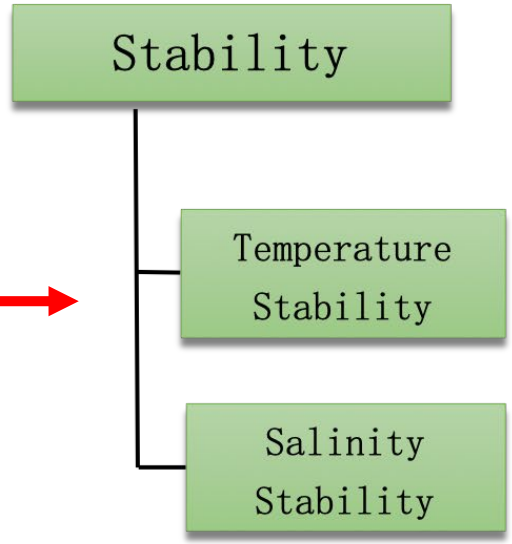
Effect of Bv on Air-sea Buoyancy flux

3.2 Effect of Bv

Winter



$$K_\rho = \frac{R_f}{1-R_f}\frac{\varepsilon}{N^2} = \Gamma\frac{\varepsilon}{N^2}$$



D-values

$$N \equiv \left(-\frac{g}{\rho}\frac{\partial\rho}{\partial z}\right)^{1/2} \Rightarrow D_\rho = \frac{\partial\rho_pp}{\partial z} - \frac{\partial\rho}{\partial z}$$

$$N_T = g\alpha\frac{\partial T}{\partial z} \Rightarrow D_T = \frac{\partial T_pp}{\partial z} - \frac{\partial T}{\partial z}$$

$$N_S = -g\beta\frac{\partial S}{\partial z} \Rightarrow D_S = \frac{\partial S_pp}{\partial z} - \frac{\partial S}{\partial z}$$

3.2 Effect of Bv

Winter

Winter MLD

(Sallée et al., 2013, J. Geophys. Res.)

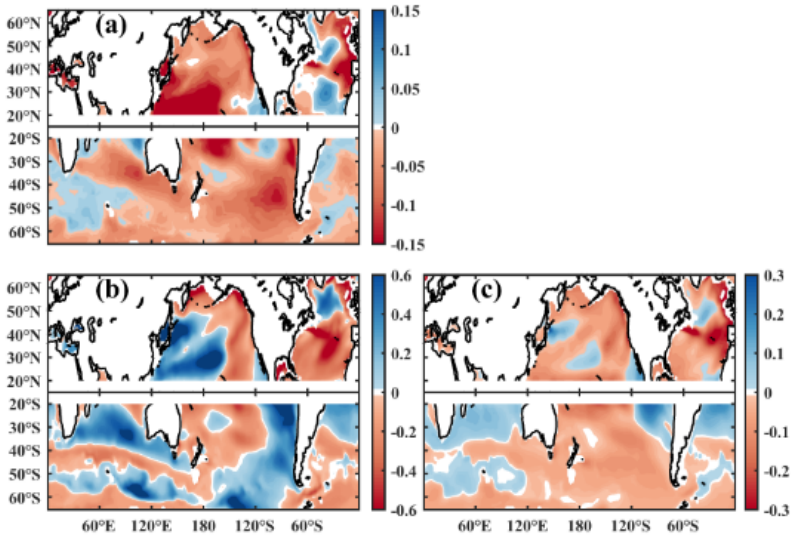
Heat Flux

Wind Stress

Turbulent Mixing

Stratification of the Ocean

$$K_\rho = \frac{R_f}{1-R_f}\frac{\varepsilon}{N^2} = \Gamma\frac{\varepsilon}{N^2}$$



Effect of Bv on Stratification

3.2 Effect of Bv

Winter

Winter MLD

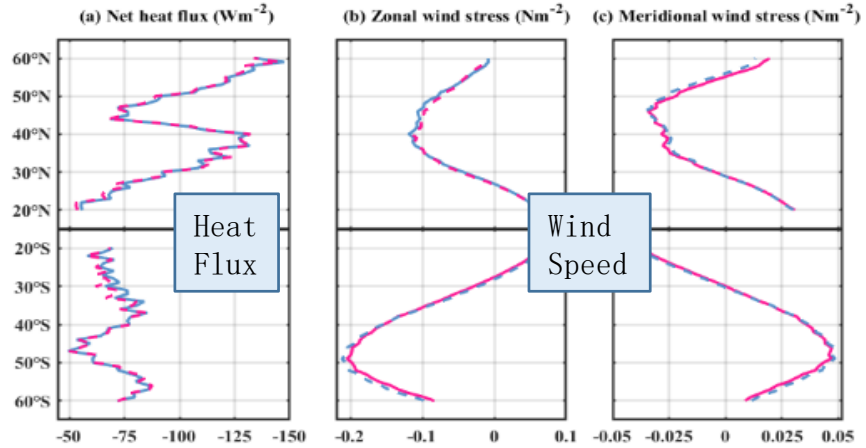
Bv

Heat Flux

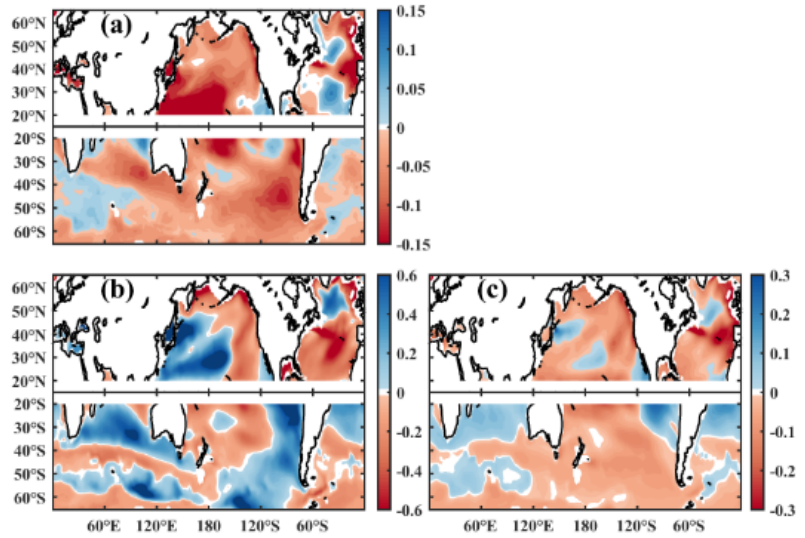
Wind Stress

Turbulent Mixing

Stratification of the Ocean



Effect of Bv on Air-sea Buoyancy flux

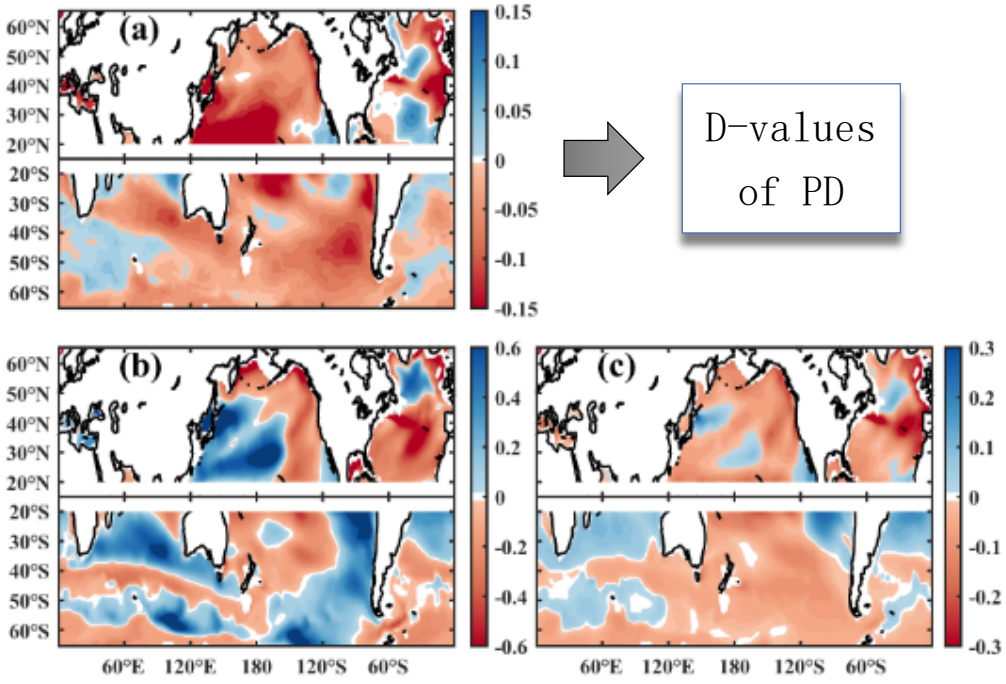


Effect of Bv on Stratification

3.2 Effect of Bv

Winter

Effect of Bv on D-values

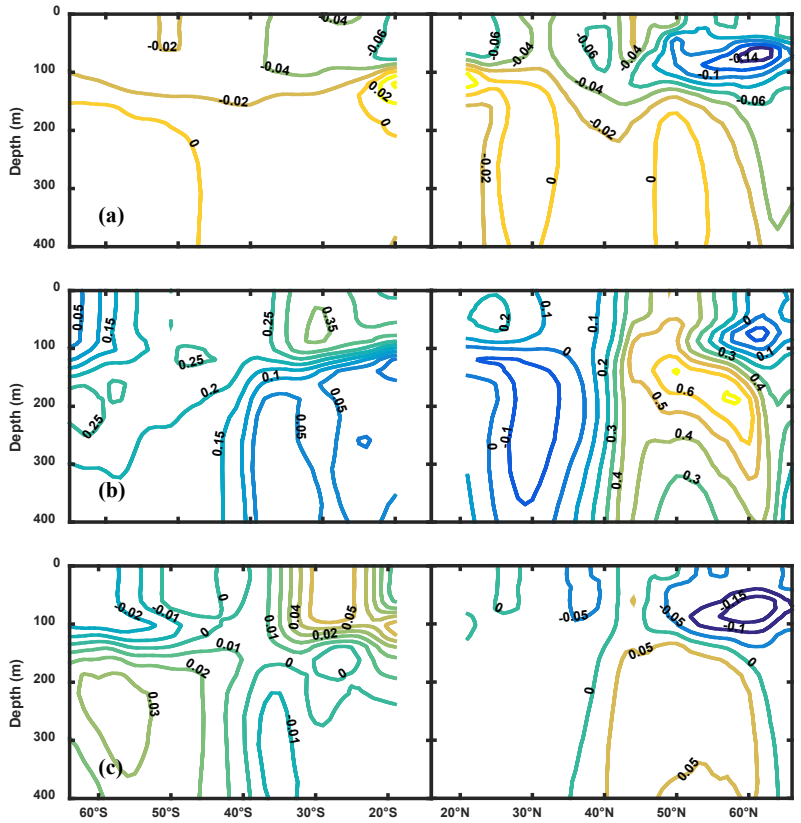


D-values of PD

D-values of Temperature

D-values of Salinity

Effect of Bv on the upper ocean structure



Background

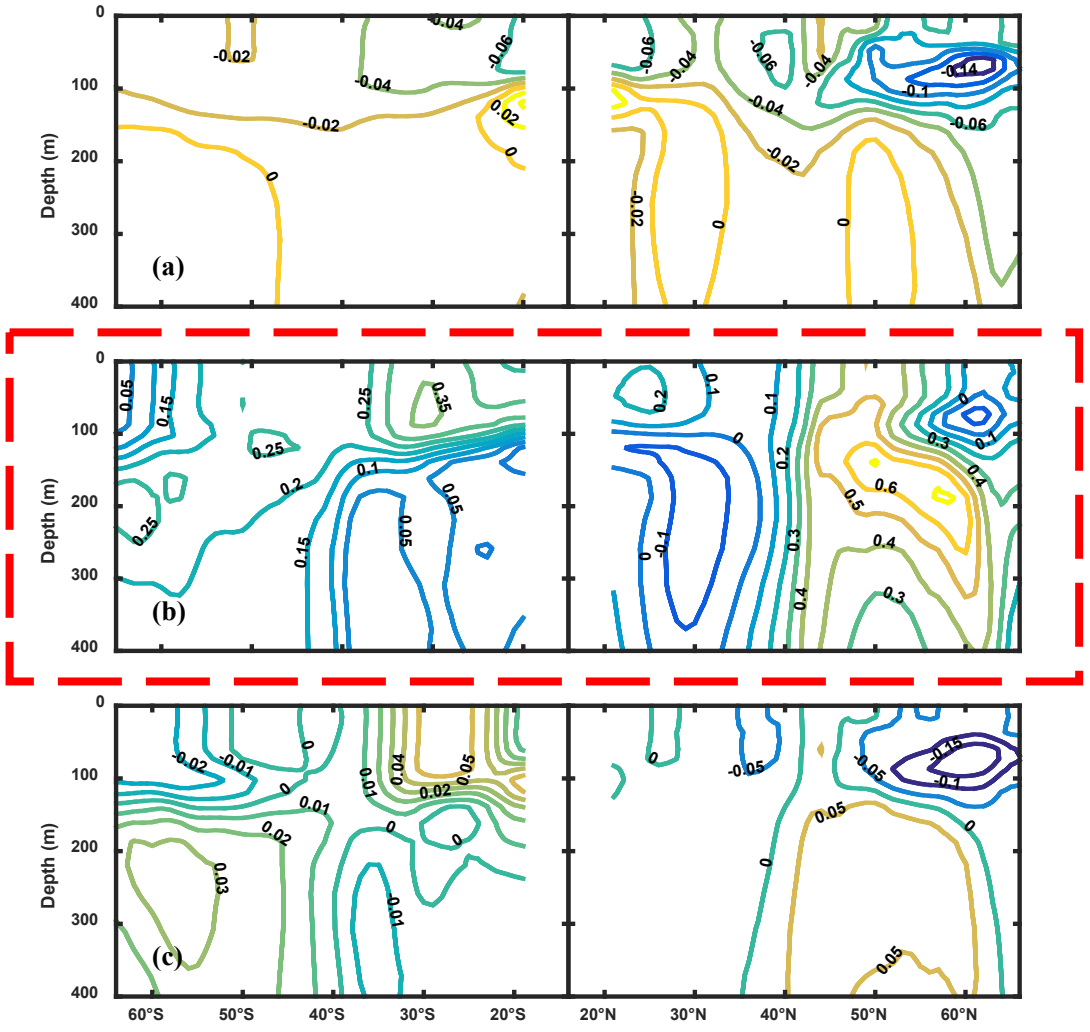
Models

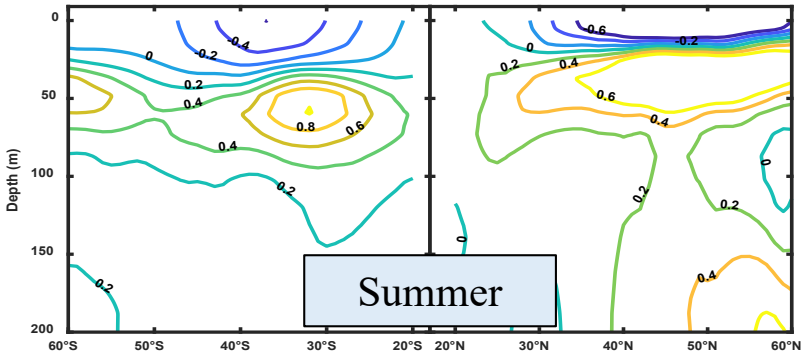
Results

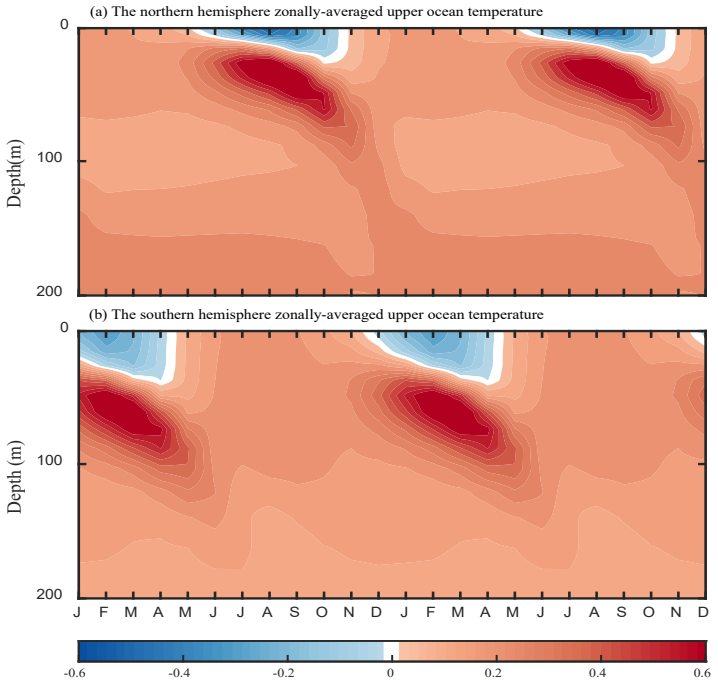
Conclusions & Discussions

3.2 Effect of Bv

Temperature of Upper Ocean

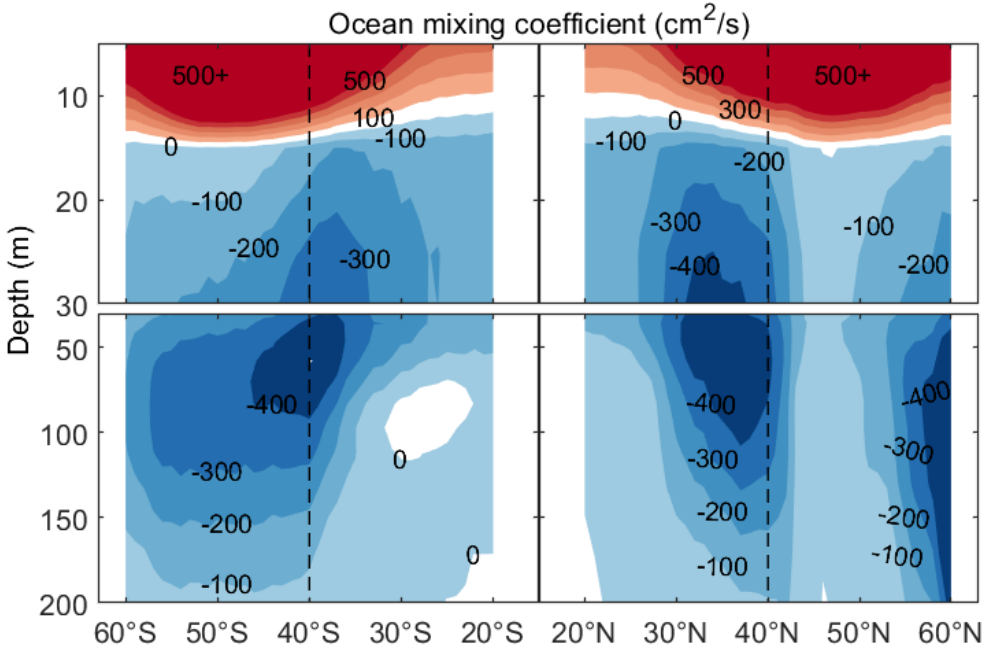


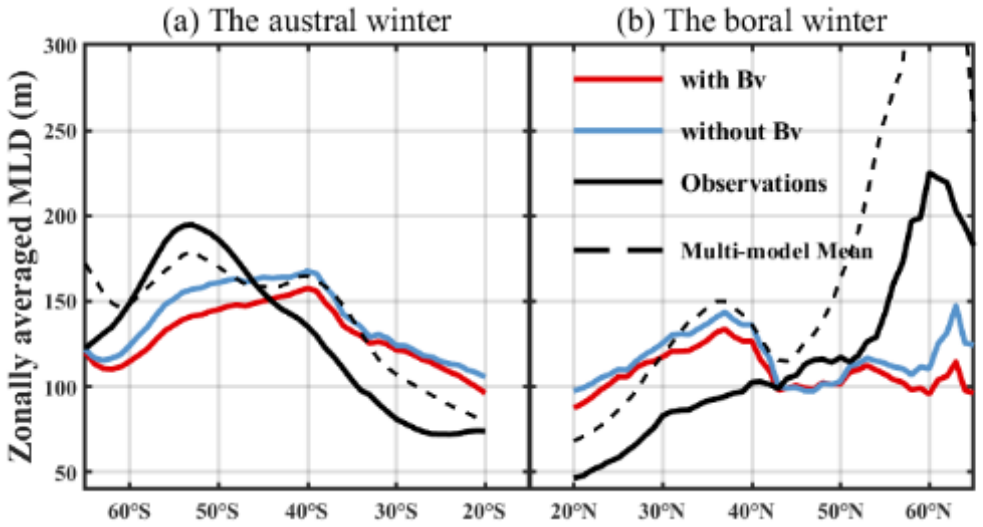




3.2 Effect of Bv

Winter



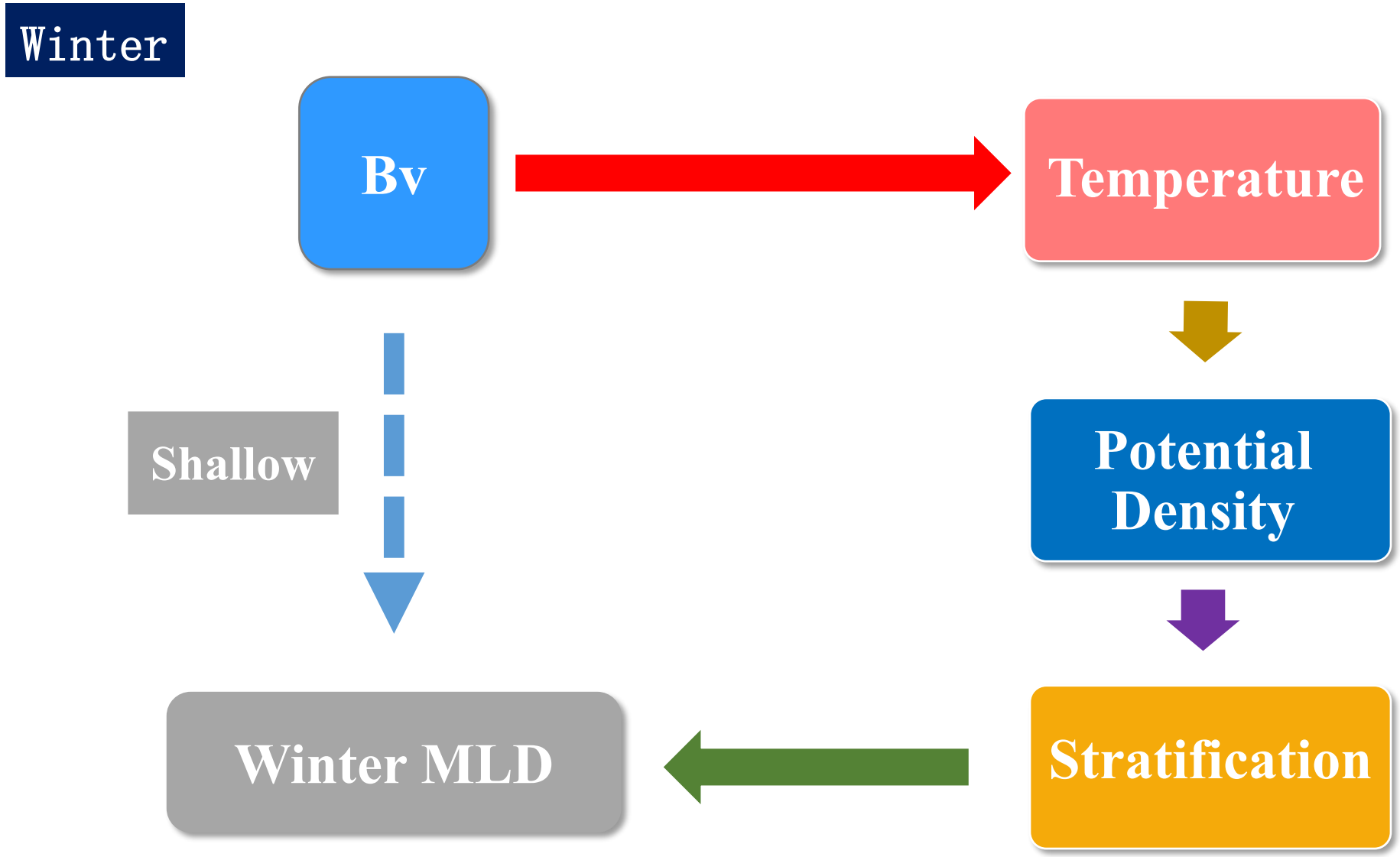


Enhances Stratification

Reduces Mixing

Shallow Winter MLD

3.2 Effect of Bv



4 Conclusion & Discussions

4.1 Conclusion

4.2 Discussions

4.1 Conclusion

- The mechanism via which the Non-breaking Surface Waves affect MLD simulation, especially in Winter;
- The effect of Non-breaking Surface Waves on the upper ocean;

4.2 Discussions

- Some areas;
- Some other physical process;

THANKS

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