

Supporting Information for "Simulated response of South Atlantic Subtropical Mode Water to air-sea processes"

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Introduction

The supporting information presented here in this document refers to the extra details of the model configuration used to identify the South Atlantic Subtropical Mode Water (Text 1) and the volume identified throughout the model's time series (Figure S4). We also present the tests of the possible criteria used for this identification (Text S2), the table of the tested criteria (Table S1) and the result of these variations on the observed volume (Figure S3).

The configuration of the developed sensitivity experiments and the basis for changing the short wave flux for the experiments were presented in two figures (Figure S1 and S2).

The results of the experiments by type of SASTMW are shown between Figure S5 and S22.

Finally, the calculation of the subtropical modal water intensity (STMW) was presented (Text S3). This is a important parameter used for the evaluation of the experiments.

Text S1.

The Community Earth System Model version 1.2.2 create simulations using up to seven geophysical models: atmosphere, sea-ice, land, river-runoff, ocean, land-ice and ocean-wave. These systems presents different versions: "active" (geophysical model), "data", "dead" (invalid information) or "stub" (interface data) and the information are transmitted from one system to another through a coupler that also synchronizes the step of the models for the same time (Vertenstein et al., 2013).

Text S2.

The identification sensitivity test of the South Atlantic Subtropical Mode Water (SASTMW) was developed to identify which criteria were more or less restrictive for this process. The important variables for the selection of SASTMW are: temperature, salinity, potential density, potential vorticity and vertical temperature gradient.

Therefore 14 variations of the criteria used by Bernardo and Sato (2020) were created (Table S1). The limits of the criteria for the aforementioned variables have been enlarged or reduced and the result on the volume of SASTMW observed on the surface and sub-surface can be seen in the Figure S3. The volume referring to the application of criterion N°.0 (Table S1) was subtracted from each time series of the volume of the different cases.

Text S3.

The STMW intensity (I) is defined by the vertical integral of the potential vorticity (PV) anomaly (Qiu et al., 2006). The anomaly is calculated using a reference PV value (Q_a) relative to the threshold $1.5 \times 10^{-10} \text{ m}^{-1} \text{ s}^{-1}$, used in the identification of the SASTMW. The equation of the STMW intensity is:

$$I = \int_{z_2}^{z_1} [Q_a - Q(z)] dz, \quad (1)$$

where z_1 is the depth of the 16°C isotherm, z_2 is the depth of the 13°C isotherm and $Q(z)$ is the PV value of each vertical layer.

References

- Bernardo, P. S., & Sato, O. T. (2020). Volumetric Characterization of the South Atlantic Subtropical Mode Water Types. *Geophysical Research Letters*, 47(8), e2019GL086653.
- Qiu, B., Hacker, P., Chen, S., Donohue, K. A., Watts, D. R., Mitsudera, H., . . . Jayne, S. R. (2006). Observations of the subtropical mode water evolution from the Kuroshio Extension System Study. *Journal of Physical Oceanography*, 36(3), 457–473.
- Vertenstein, M., Bertini, A., Craig, T., Edwards, J., Levy, M., Mai, A., & Schollenberger, J. (2013). CESM user’s guide (CESM1. 2 release series user’s guide). *NCAR Tech. Note*.

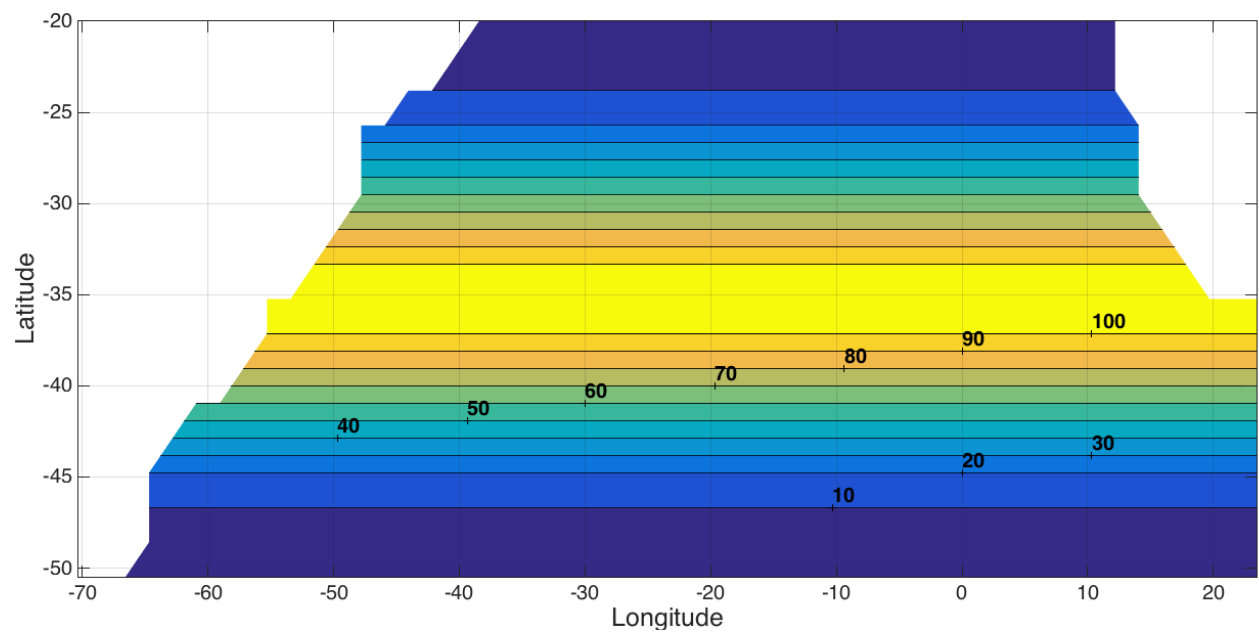


Figure S1. Scheme used to create the SASTMW formation sensitivity experiments over a year using the CESM model. The central band (100) represents the total application of the changes created in each experiment scenario. All the number (from 100 to 10) represent the percentage of the change applied per area.

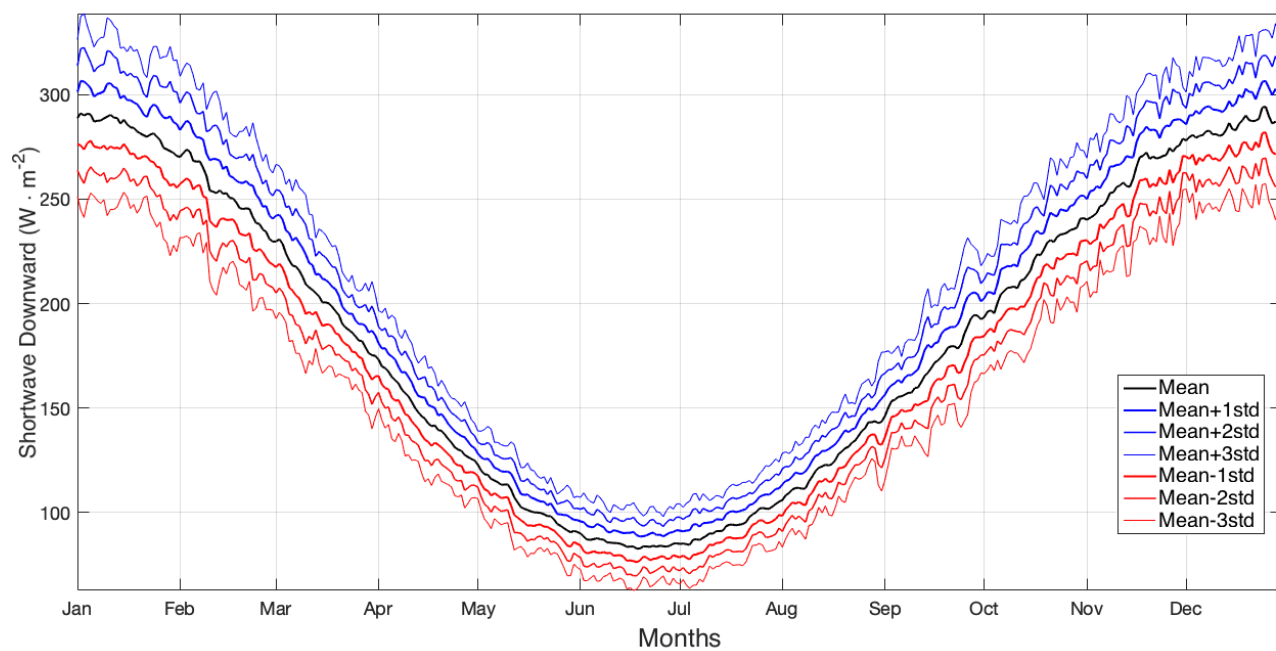


Figure S2. Climatological time series of the shortwave downward flux component mean and mean plus/minus n times the standard deviation for the period of 1971 to 2009, region of 25°S to 45°S, 60°W to 20°E.

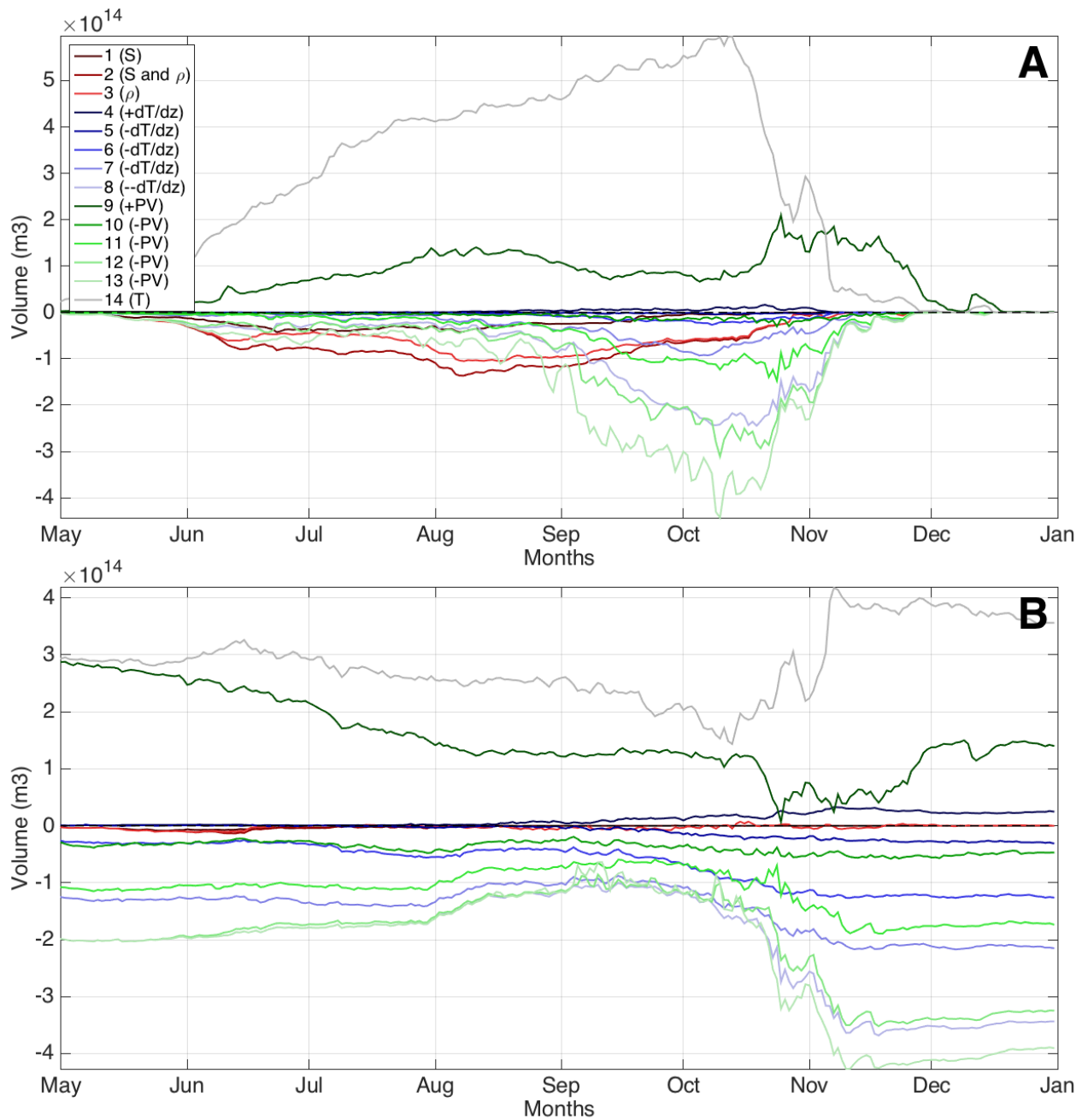


Figure S3. Comparison between the difference of the volume resulting from the use of different criteria for the identification of SASTMW, in relation to the criterion determined by Bernardo and Sato (2020) and applied in the article (No.0 in Table S1). The values for each criterion are specified in Table S1. Diagram A: Surface; B: Subsurface.

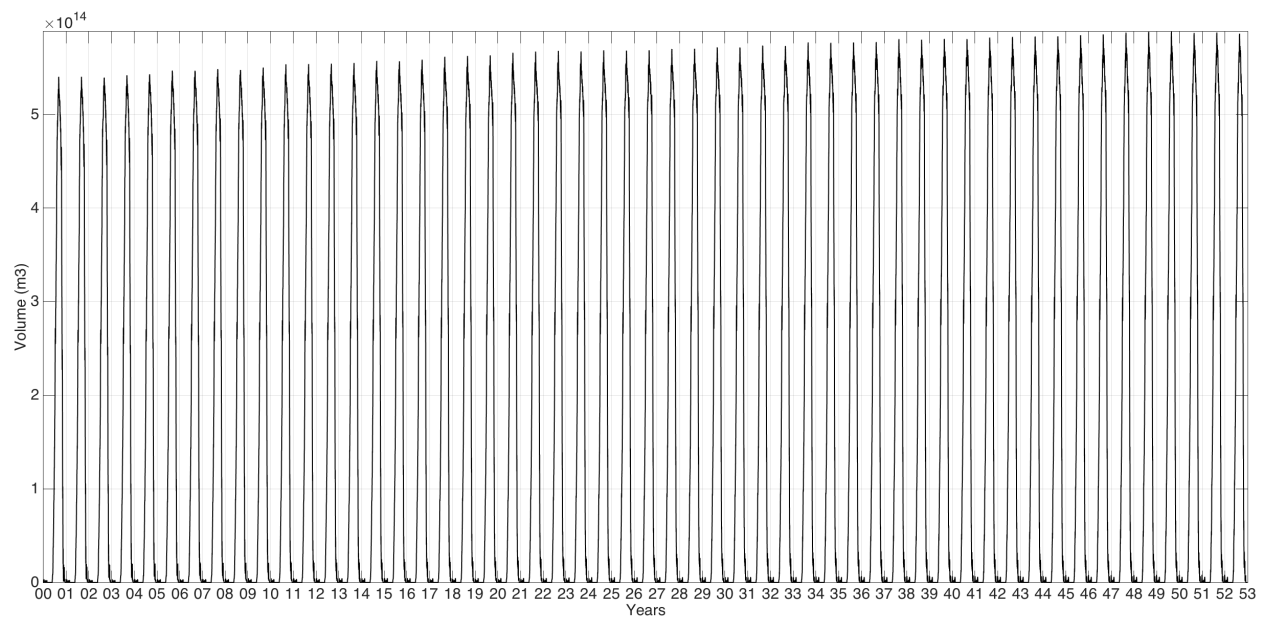


Figure S4. Times series of volume of the SASTMW in the surface of the 52-years CESM - Normal Year Forcing control run.

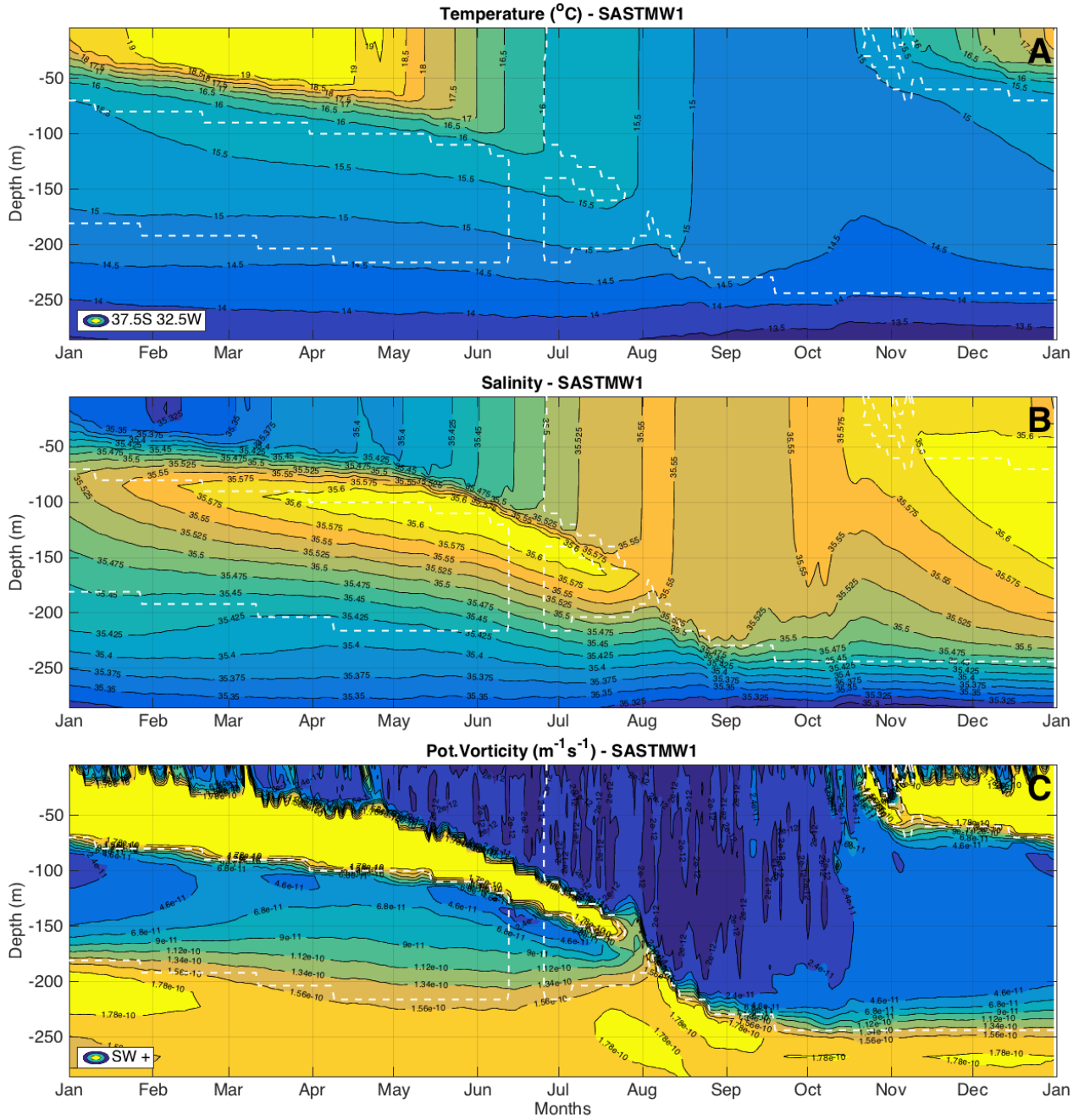


Figure S5. Temperature, shortwave radiation, salinity, precipitation, potential vorticity, and wind speed variation over one year at 37.5°S, 32.5°W in the CESM SW+ experiment. The white contour represents the SASTMW 1 identified throughout the cycle. All the PV values greater than $1.5 \times 10^{-10} \text{ m}^{-1} \text{ s}^{-1}$ were included in the maximum value contour.

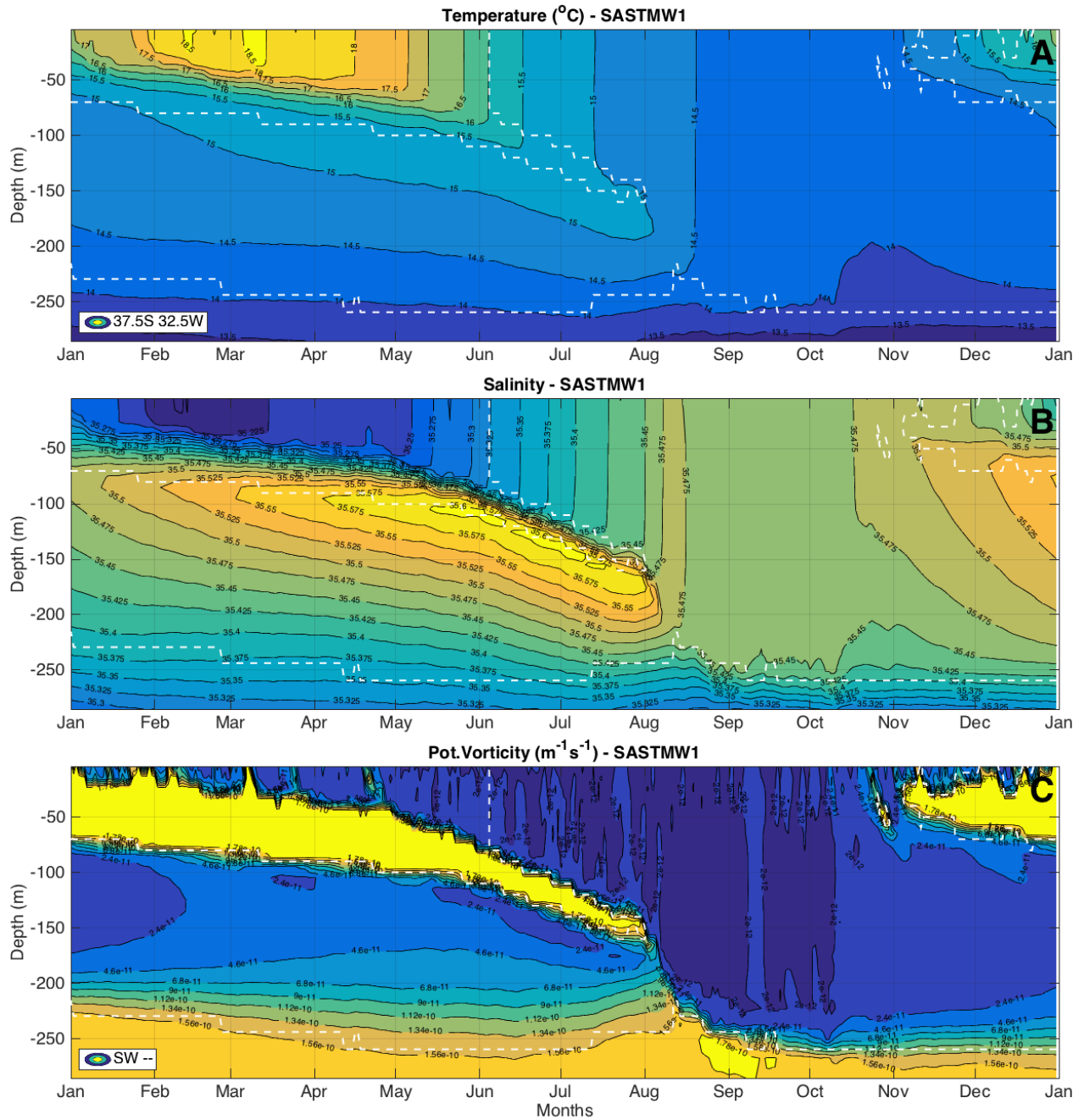


Figure S6. Temperature, shortwave radiation, salinity, precipitation, potential vorticity, and wind speed variation over one year at 37.5°S, 32.5°W in the CESM SW- experiment. The white contour represents the SASTMW 1 identified throughout the cycle. All the PV values greater than $1.5 \times 10^{-10} \text{ m}^{-1} \text{ s}^{-1}$ were included in the maximum value contour.

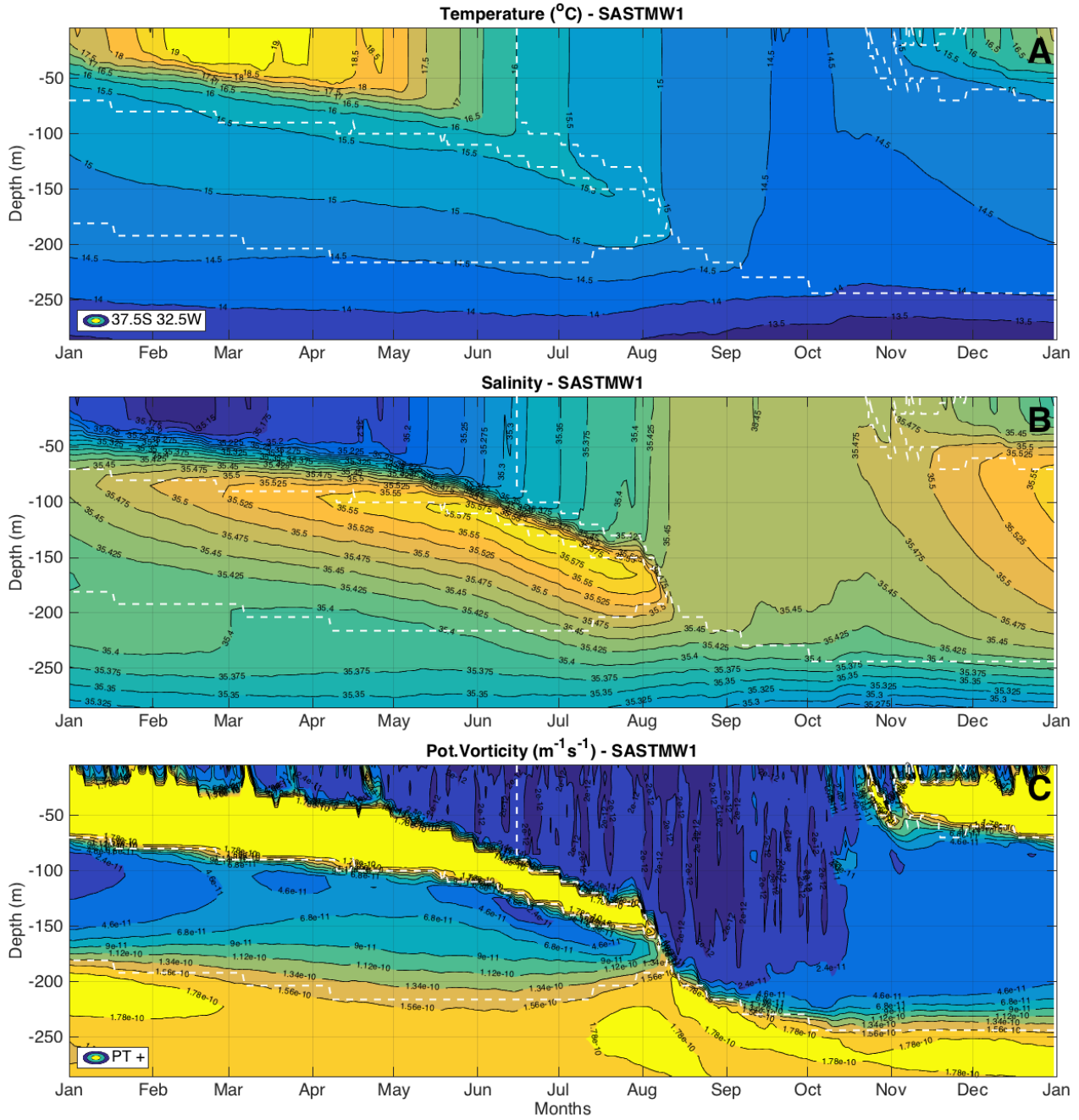


Figure S7. Temperature, shortwave radiation, salinity, precipitation, potential vorticity, and wind speed variation over one year at 37.5°S, 32.5°W in the CESM PT+ experiment. The white contour represents the SASTMW 1 identified throughout the cycle. All the PV values greater than $1.5 \times 10^{-10} \text{ m}^{-1} \text{ s}^{-1}$ were included in the maximum value contour.

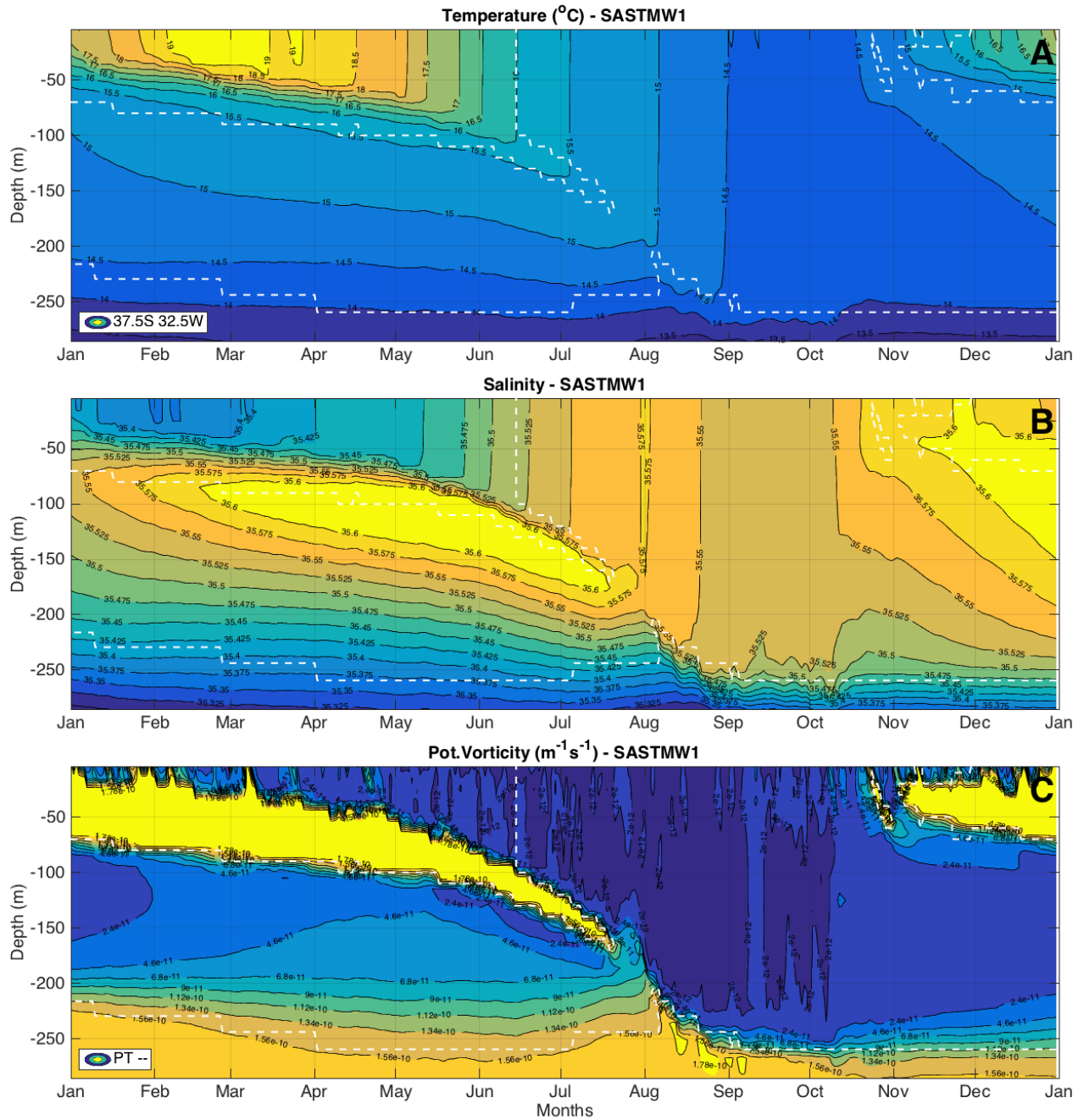


Figure S8. Temperature, shortwave radiation, salinity, precipitation, potential vorticity, and wind speed variation over one year at 37.5°S, 32.5°W in the CESM PT- experiment. The white contour represents the SASTMW 1 identified throughout the cycle. All the PV values greater than $1.5 \times 10^{-10} \text{ m}^{-1} \text{ s}^{-1}$ were included in the maximum value contour.

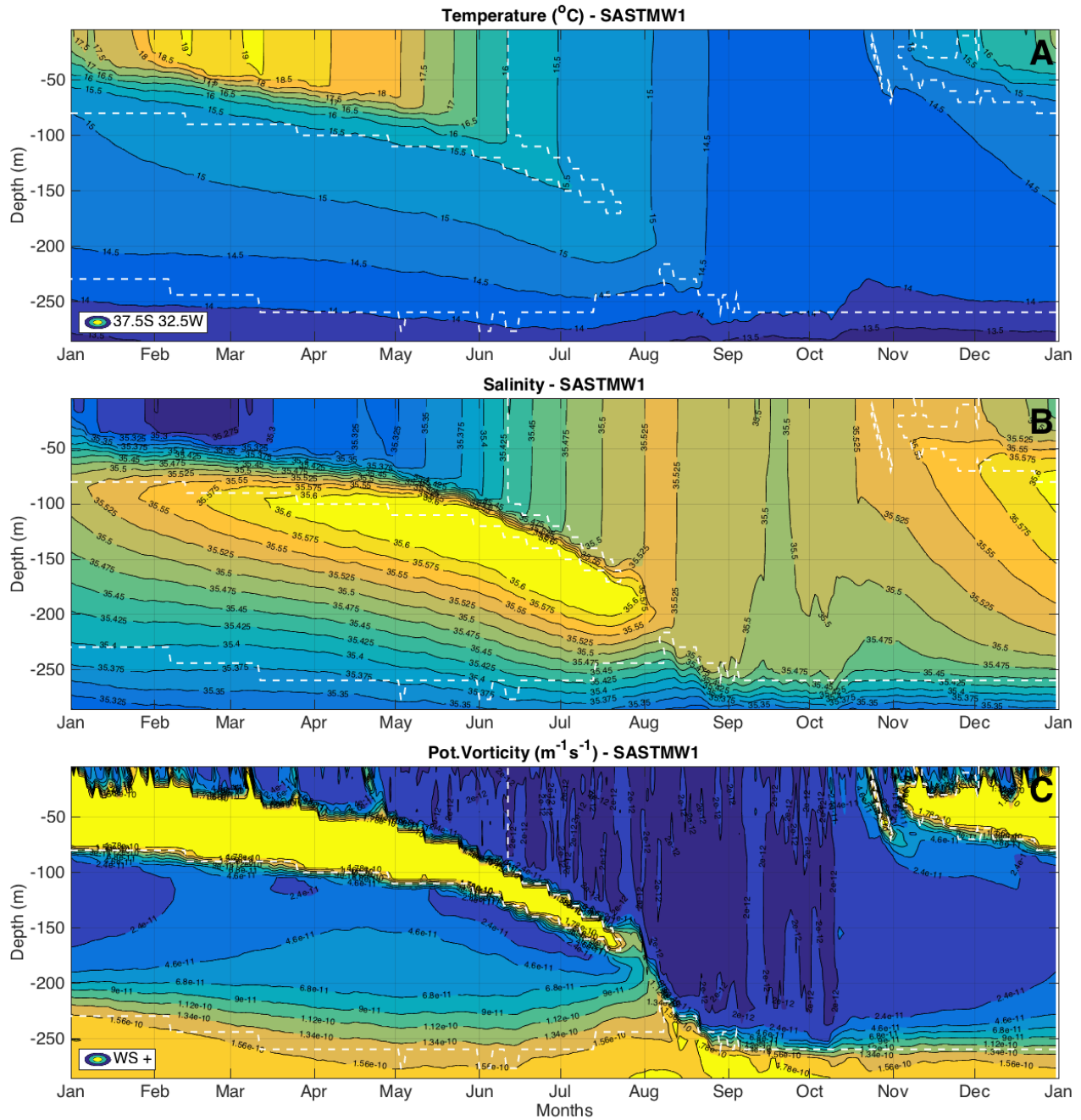


Figure S9. Temperature, shortwave radiation, salinity, precipitation, potential vorticity, and wind speed variation over one year at 37.5°S, 32.5°W in the CESM WS+ experiment. The white contour represents the SASTMW 1 identified throughout the cycle. All the PV values greater than $1.5 \times 10^{-10} \text{ m}^{-1} \text{ s}^{-1}$ were included in the maximum value contour.

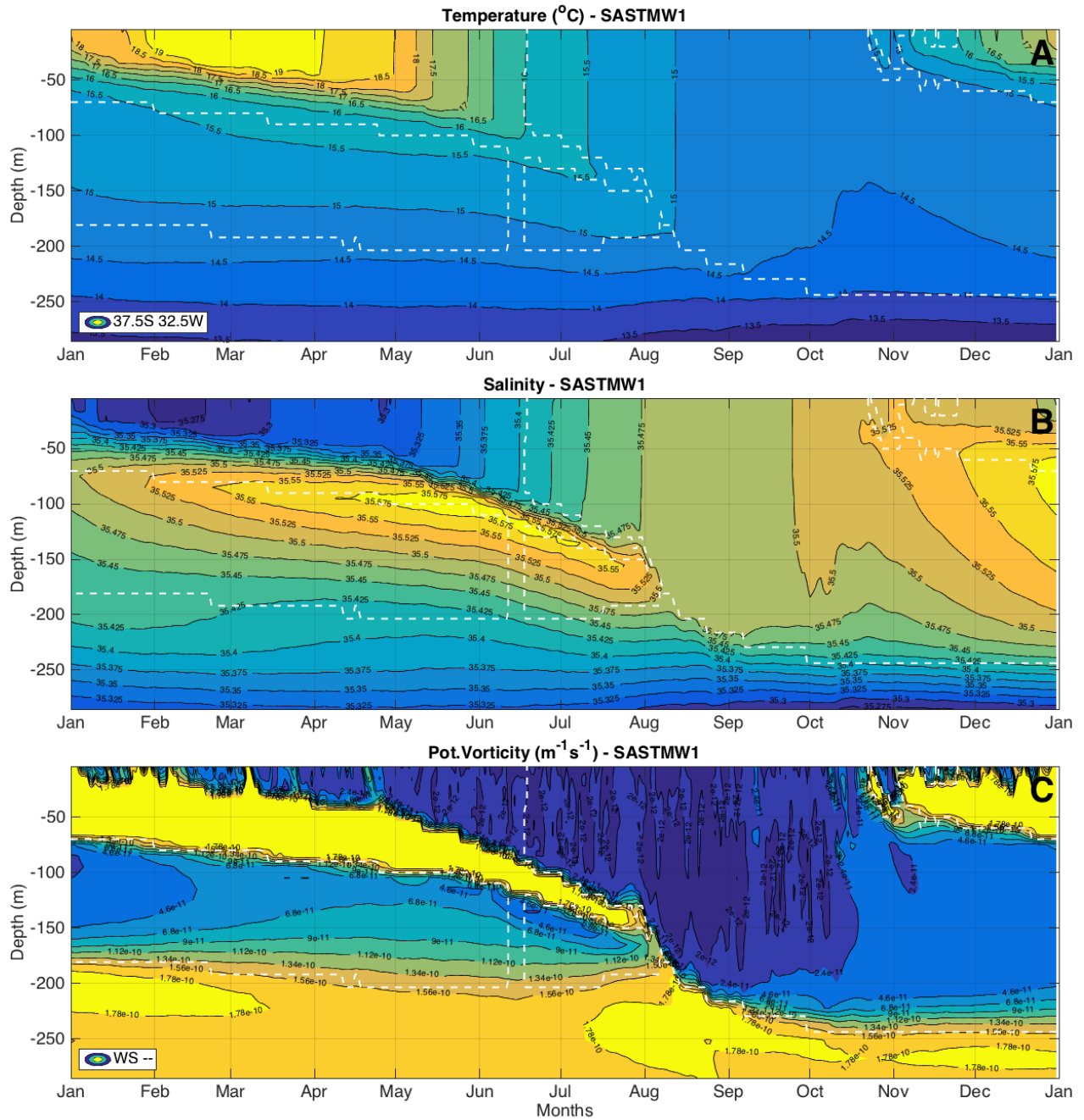


Figure S10. Temperature, shortwave radiation, salinity, precipitation, potential vorticity, and wind speed variation over one year at 37.5°S, 32.5°W in the CESM WS- experiment. The white contour represents the SASTMW 1 identified throughout the cycle. All the PV values greater than $1.5 \times 10^{-10} \text{ m}^{-1} \text{ s}^{-1}$ were included in the maximum value contour.

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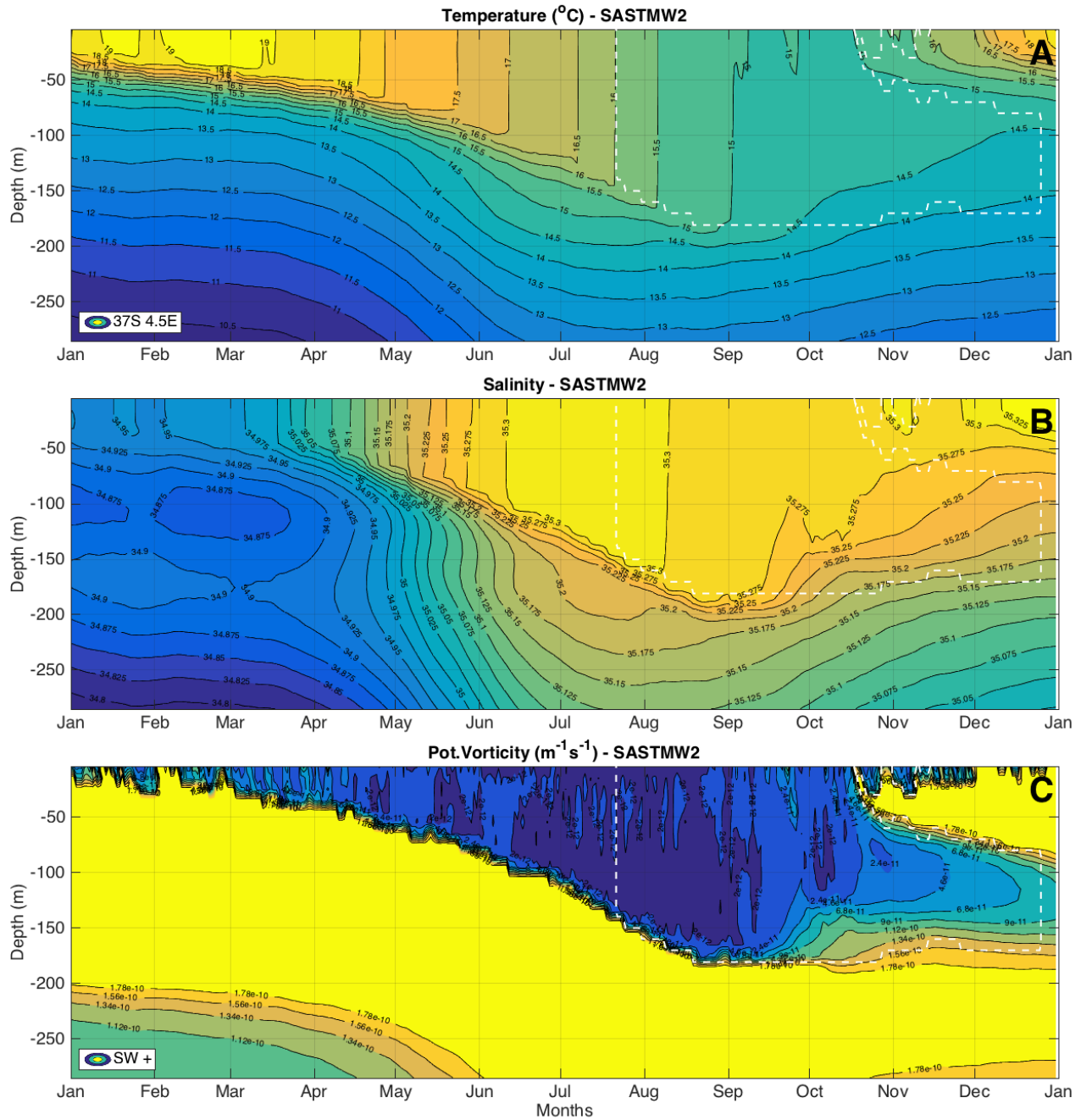


Figure S11. Temperature, shortwave radiation, salinity, precipitation, potential vorticity, and wind speed variation over one year at 37°S, 4.5°E in the CESM SW+ experiment. The white contour represents the SASTMW 2 identified throughout the cycle. All the PV values greater than $1.5 \times 10^{-10} \text{ m}^{-1} \text{ s}^{-1}$ were included in the maximum value contour.

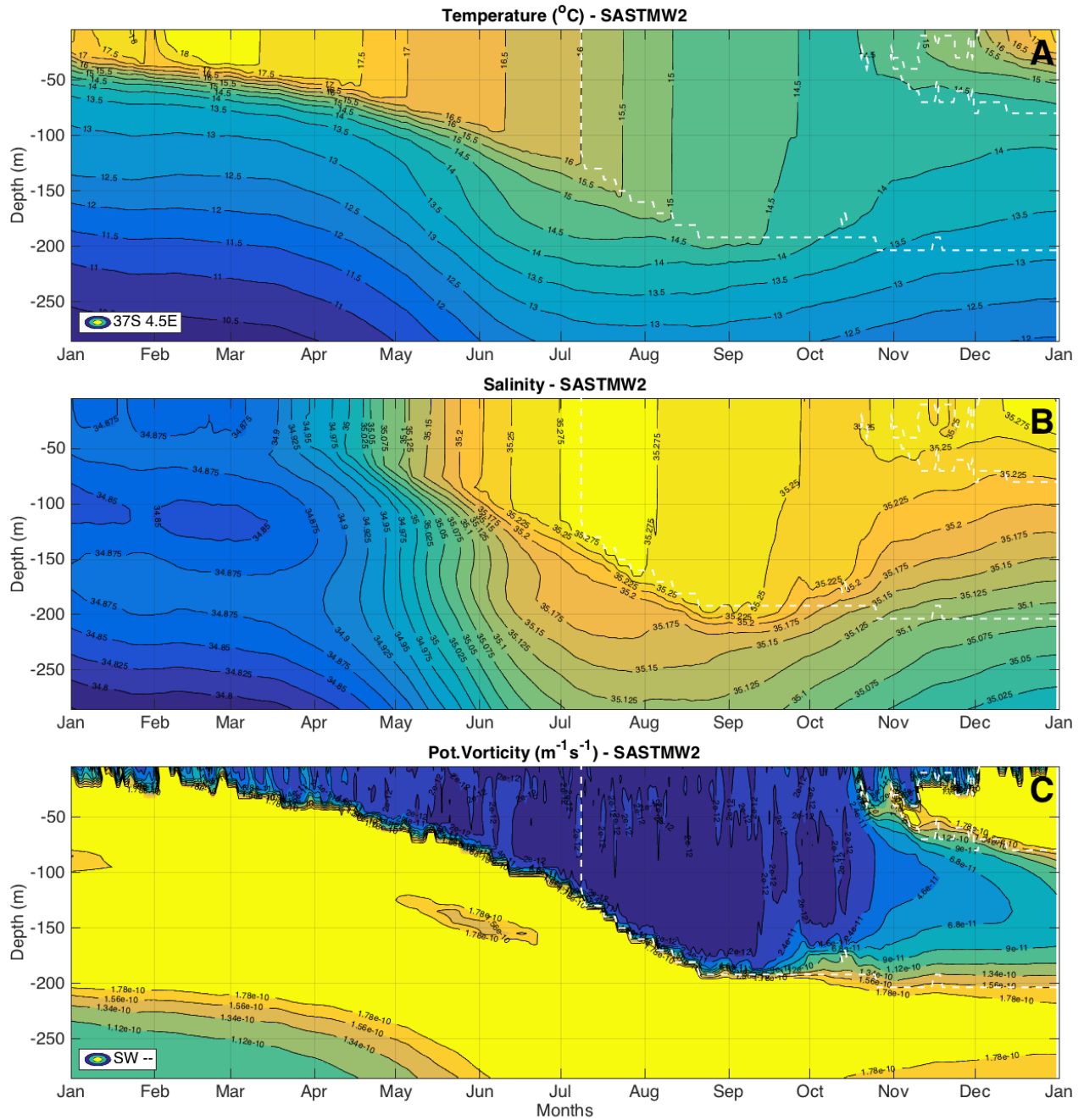


Figure S12. Temperature, shortwave radiation, salinity, precipitation, potential vorticity, and wind speed variation over one year at 37°S, 4.5°E in the CESM SW- experiment. The white contour represents the SASTMW 2 identified throughout the cycle. All the PV values greater than $1.5 \times 10^{-10} \text{ m}^{-1} \text{ s}^{-1}$ were included in the maximum value contour.

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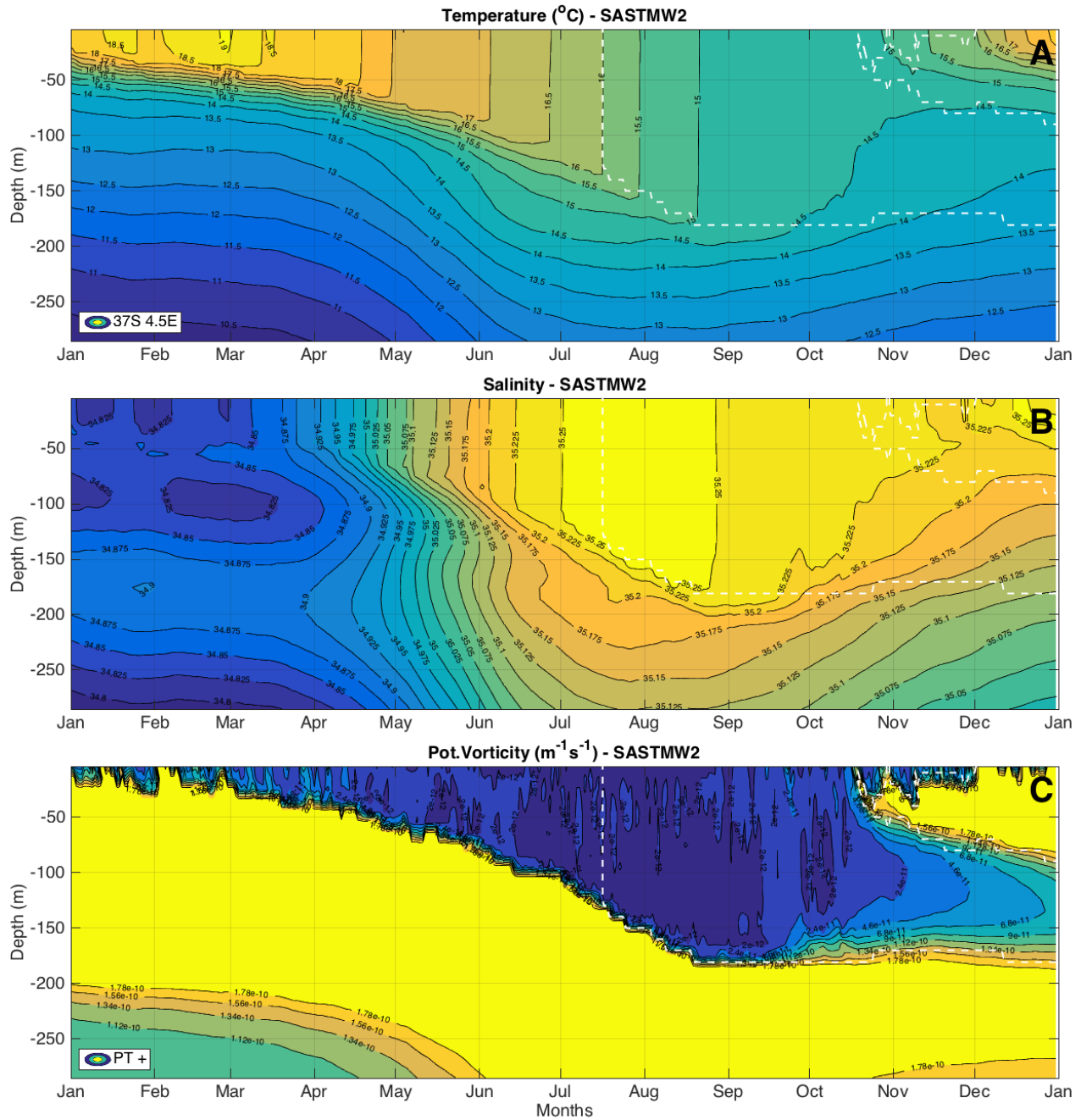


Figure S13. Temperature, shortwave radiation, salinity, precipitation, potential vorticity, and wind speed variation over one year at 37°S, 4.5°E in the CESM PT+ experiment. The white contour represents the SASTMW 2 identified throughout the cycle. All the PV values greater than $1.5 \times 10^{-10} \text{ m}^{-1} \text{ s}^{-1}$ were included in the maximum value contour.

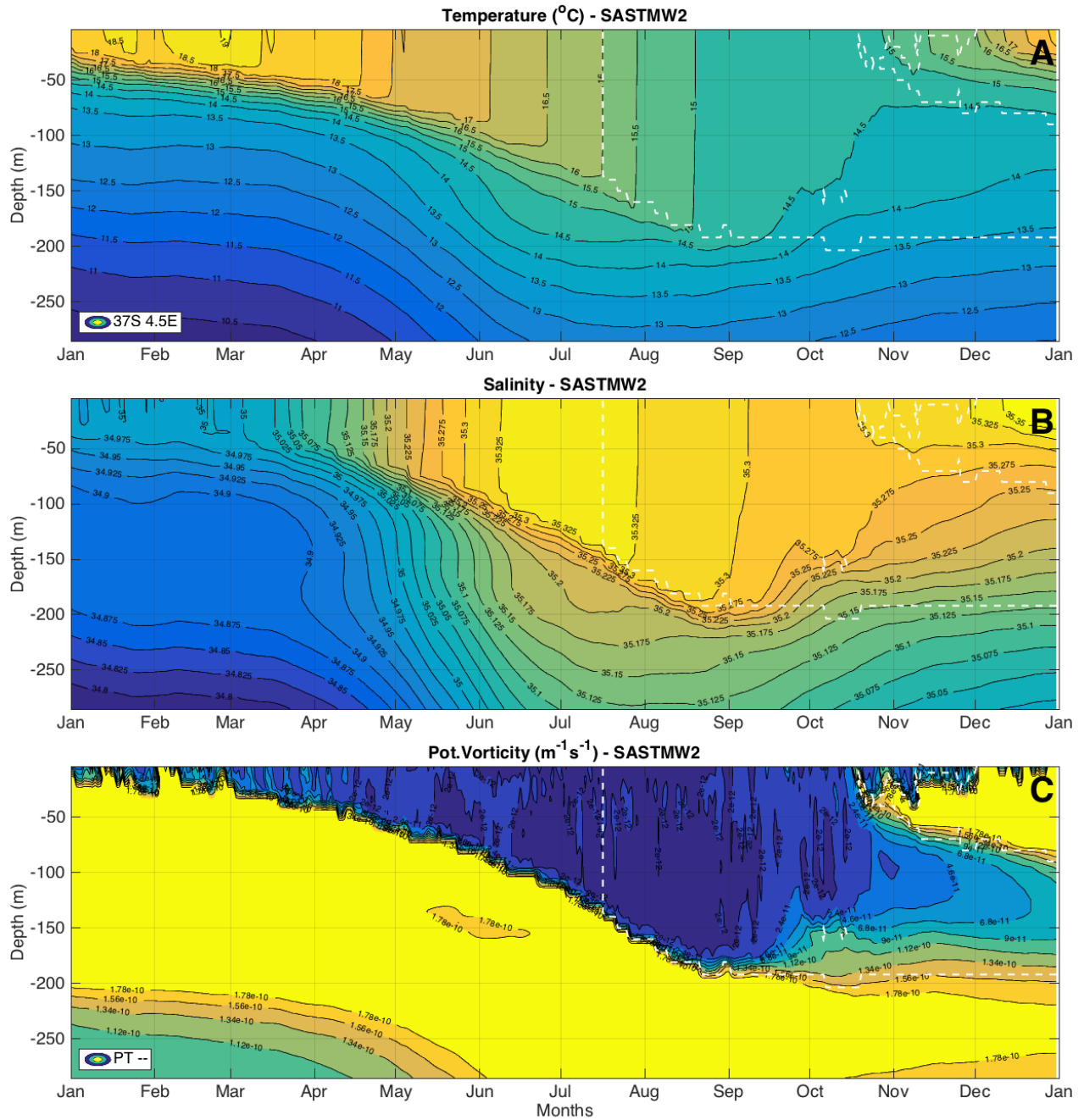


Figure S14. Temperature, shortwave radiation, salinity, precipitation, potential vorticity, and wind speed variation over one year at 37°S, 4.5°E in the CESM PT- experiment. The white contour represents the SASTMW 2 identified throughout the cycle. All the PV values greater than $1.5 \times 10^{-10} \text{ m}^{-1} \text{ s}^{-1}$ were included in the maximum value contour.

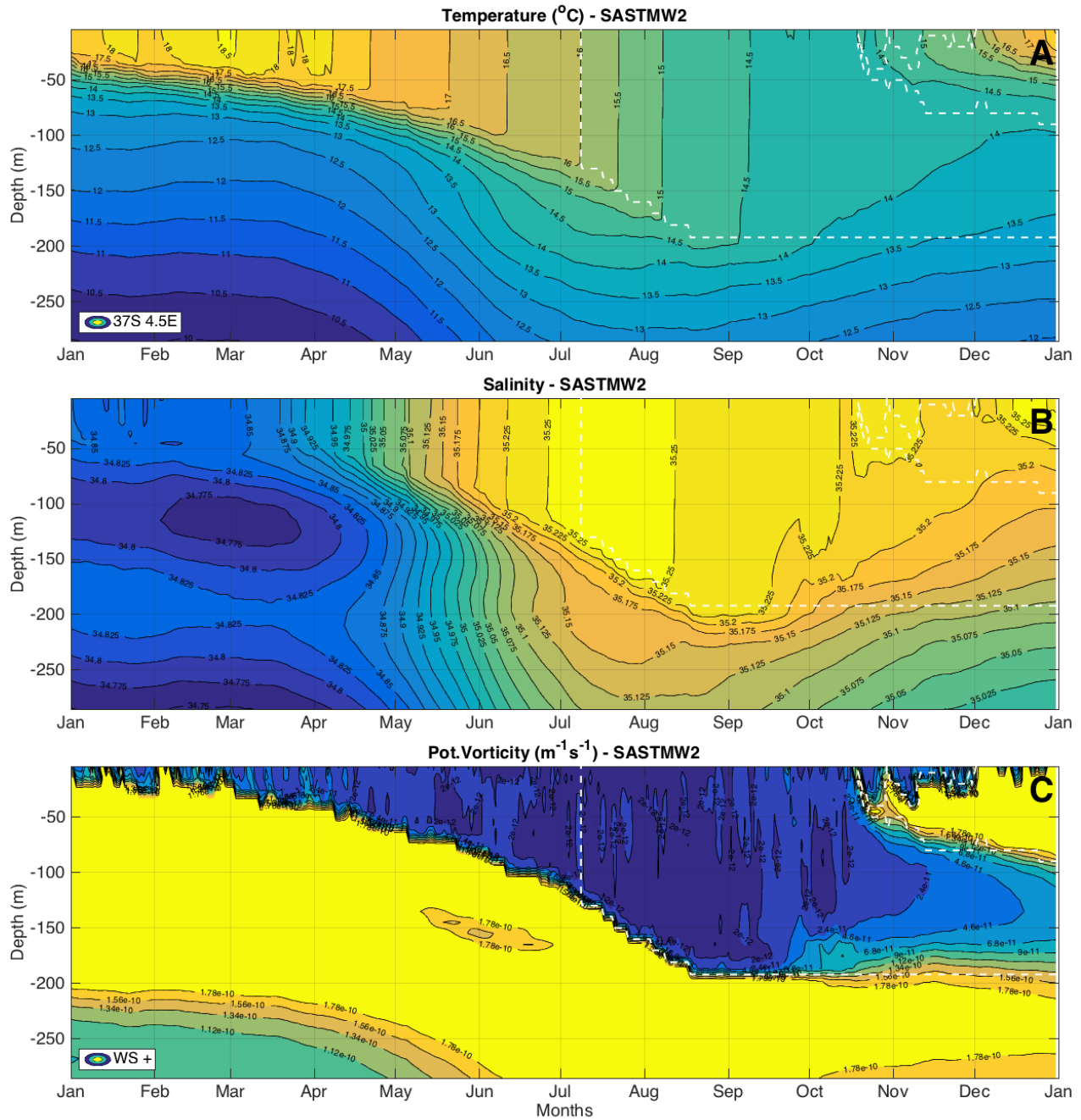


Figure S15. Temperature, shortwave radiation, salinity, precipitation, potential vorticity, and wind speed variation over one year at 37°S, 4.5°E in the CESM WS+ experiment. The white contour represents the SASTMW 2 identified throughout the cycle. All the PV values greater than $1.5 \times 10^{-10} \text{ m}^{-1} \text{ s}^{-1}$ were included in the maximum value contour.

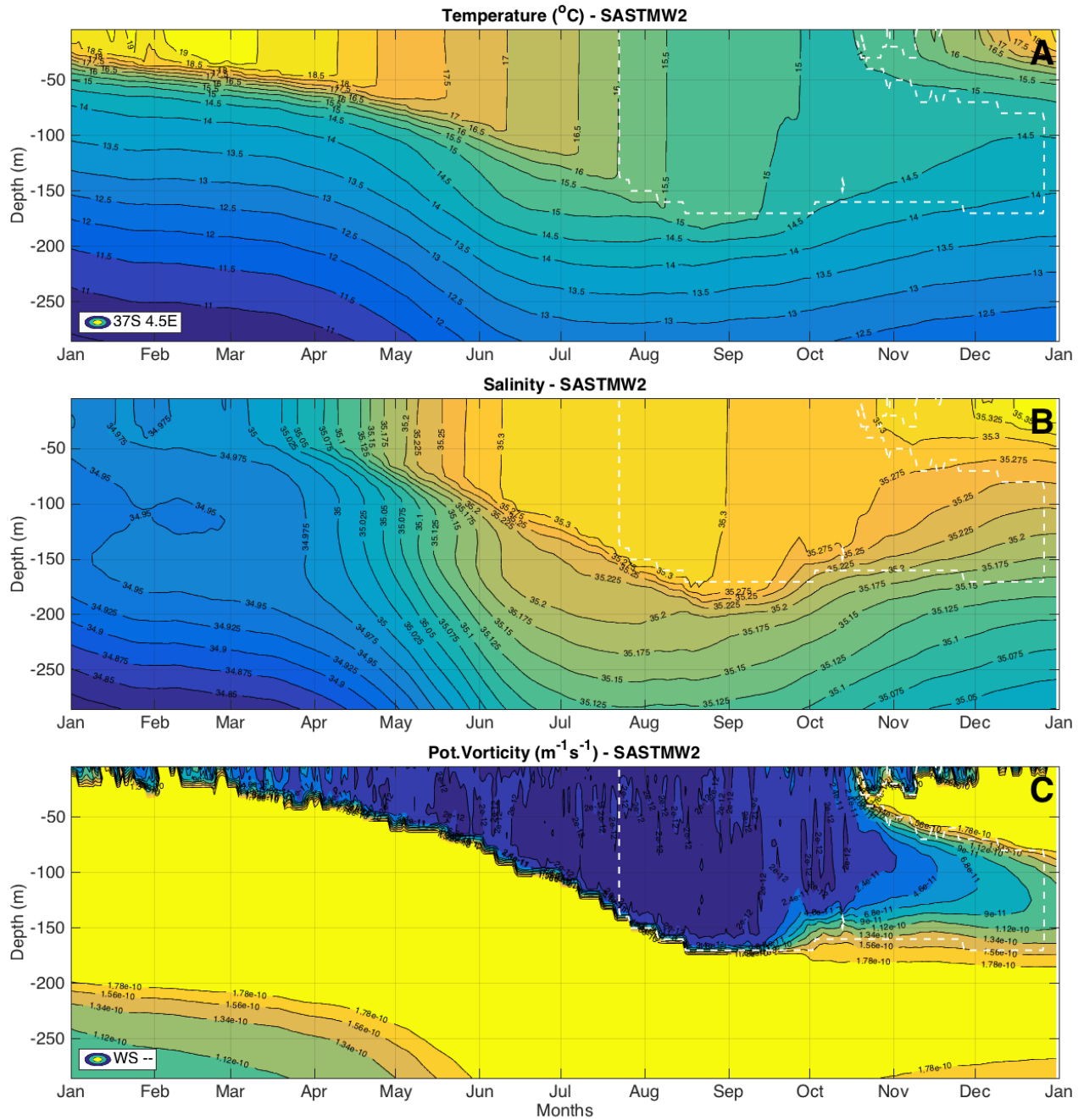


Figure S16. Temperature, shortwave radiation, salinity, precipitation, potential vorticity, and wind speed variation over one year at 37°S, 4.5°E in the CESM WS- experiment. The white contour represents the SASTMW 2 identified throughout the cycle. All the PV values greater than $1.5 \times 10^{-10} \text{ m}^{-1} \text{ s}^{-1}$ were included in the maximum value contour.

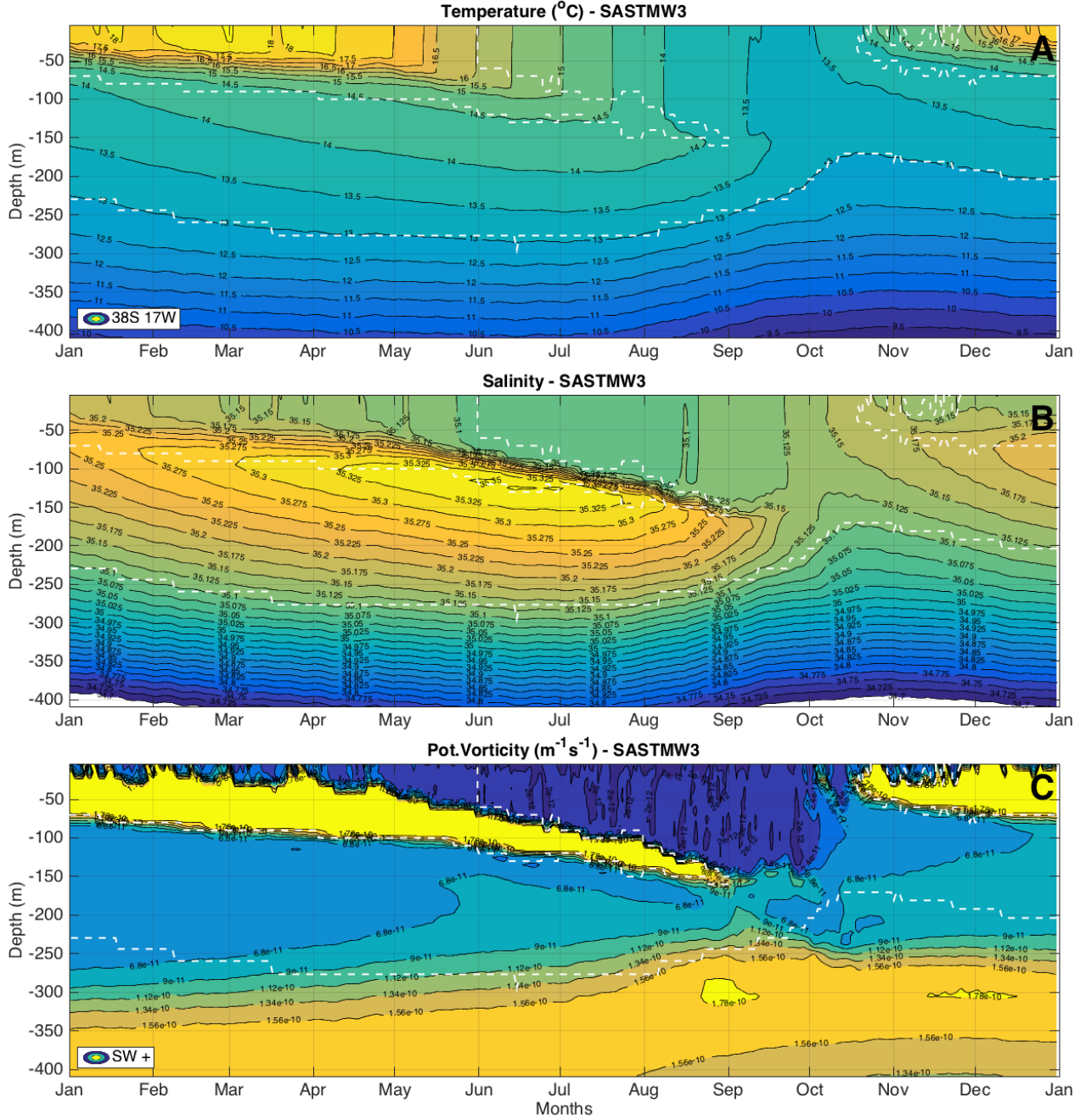


Figure S17. Temperature, shortwave radiation, salinity, precipitation, potential vorticity, and wind speed variation over one year at 38°S, 17°W in the CESM SW+ experiment. The white contour represents the SASTMW 3 identified throughout the cycle. All the PV values greater than $1.5 \times 10^{-10} \text{ m}^{-1} \text{ s}^{-1}$ were included in the maximum value contour.

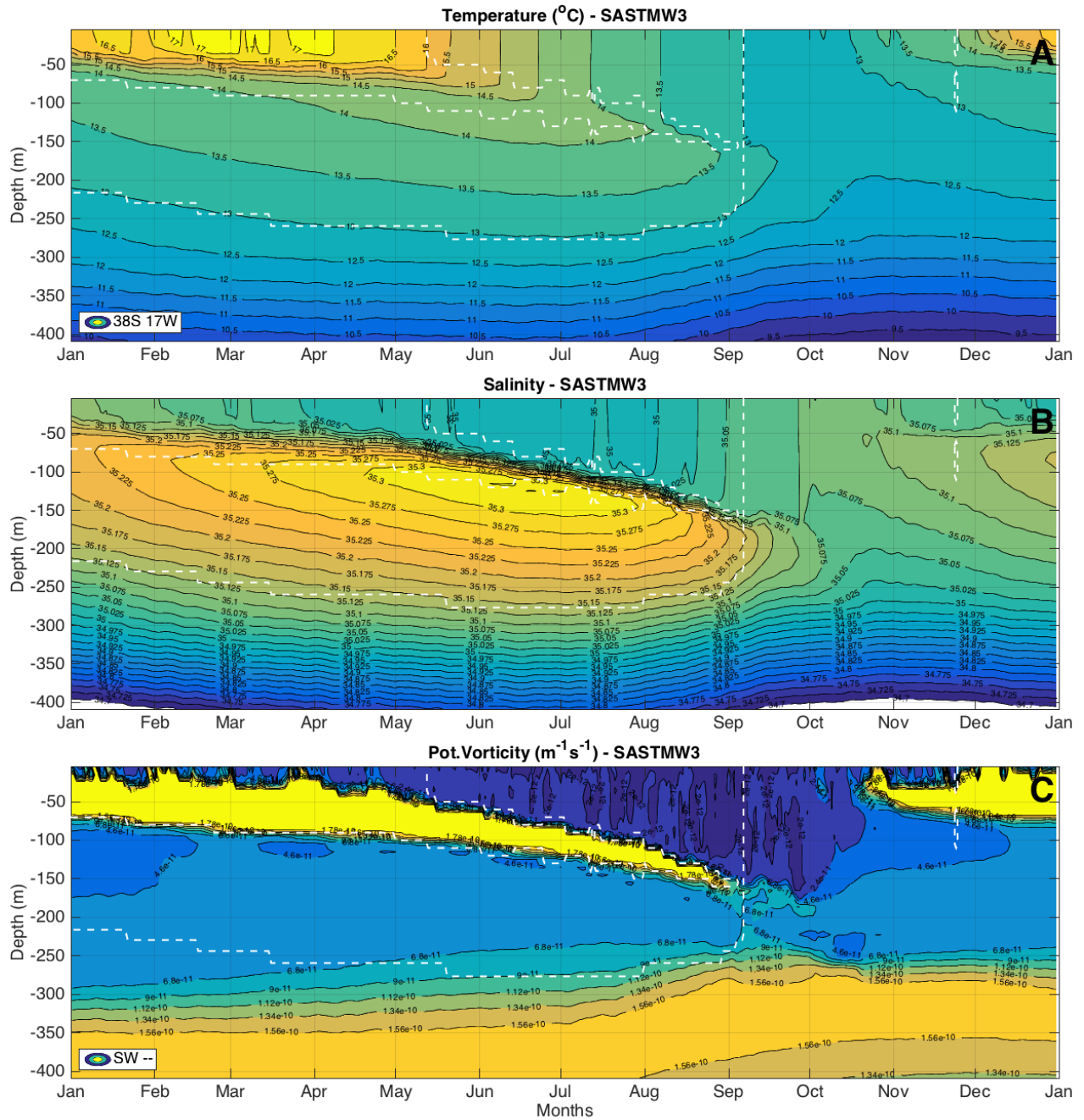


Figure S18. Temperature, shortwave radiation, salinity, precipitation, potential vorticity, and wind speed variation over one year at 38°S, 17°W in the CESM SW- experiment. The white contour represents the SASTMW 3 identified throughout the cycle. All the PV values greater than $1.5 \times 10^{-10} \text{ m}^{-1} \text{ s}^{-1}$ were included in the maximum value contour.

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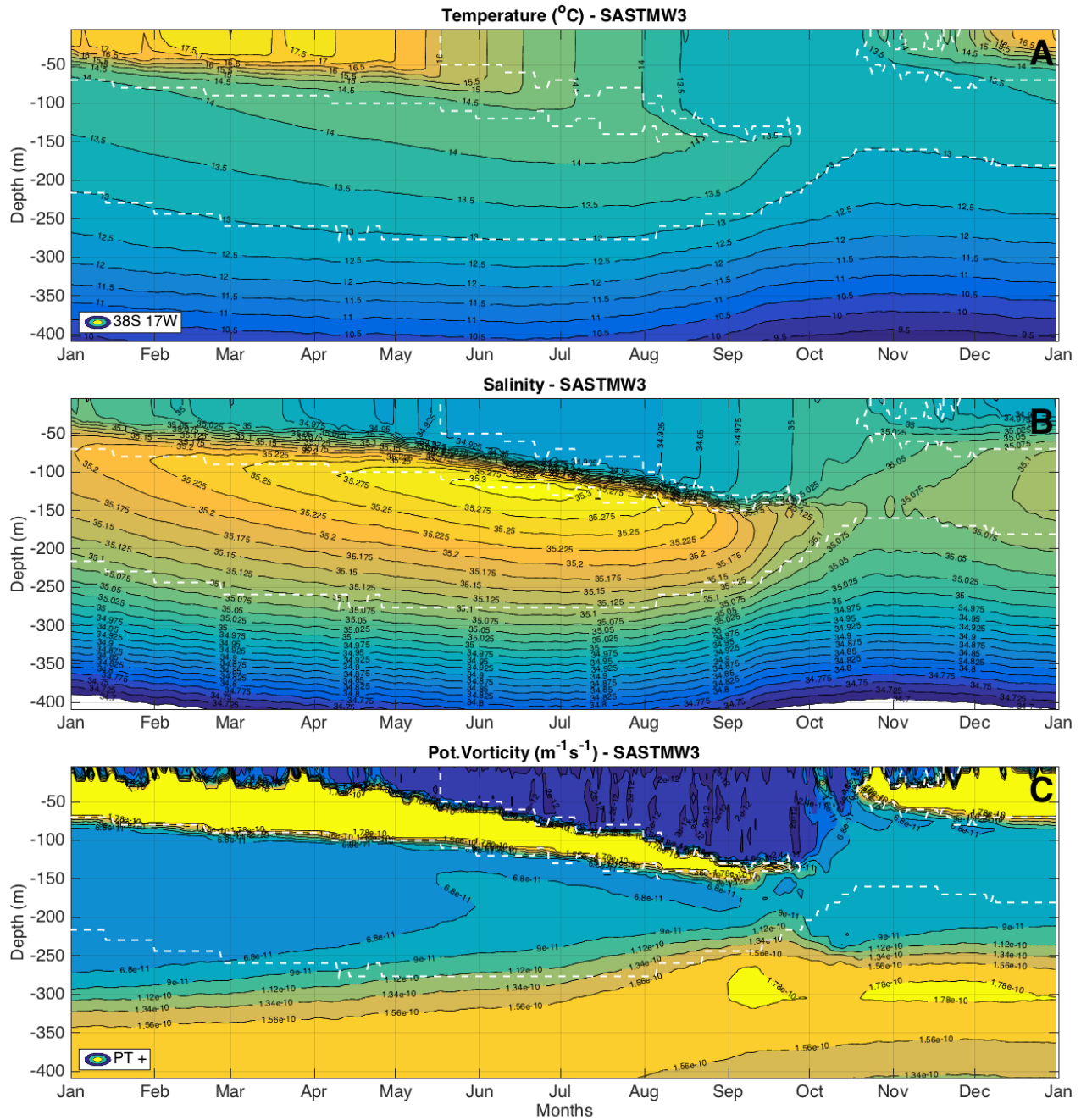


Figure S19. Temperature, shortwave radiation, salinity, precipitation, potential vorticity, and wind speed variation over one year at 38°S, 17°W in the CESM PT+ experiment. The white contour represents the SASTMW 3 identified throughout the cycle. All the PV values greater than $1.5 \times 10^{-10} \text{ m}^{-1} \text{ s}^{-1}$ were included in the maximum value contour.

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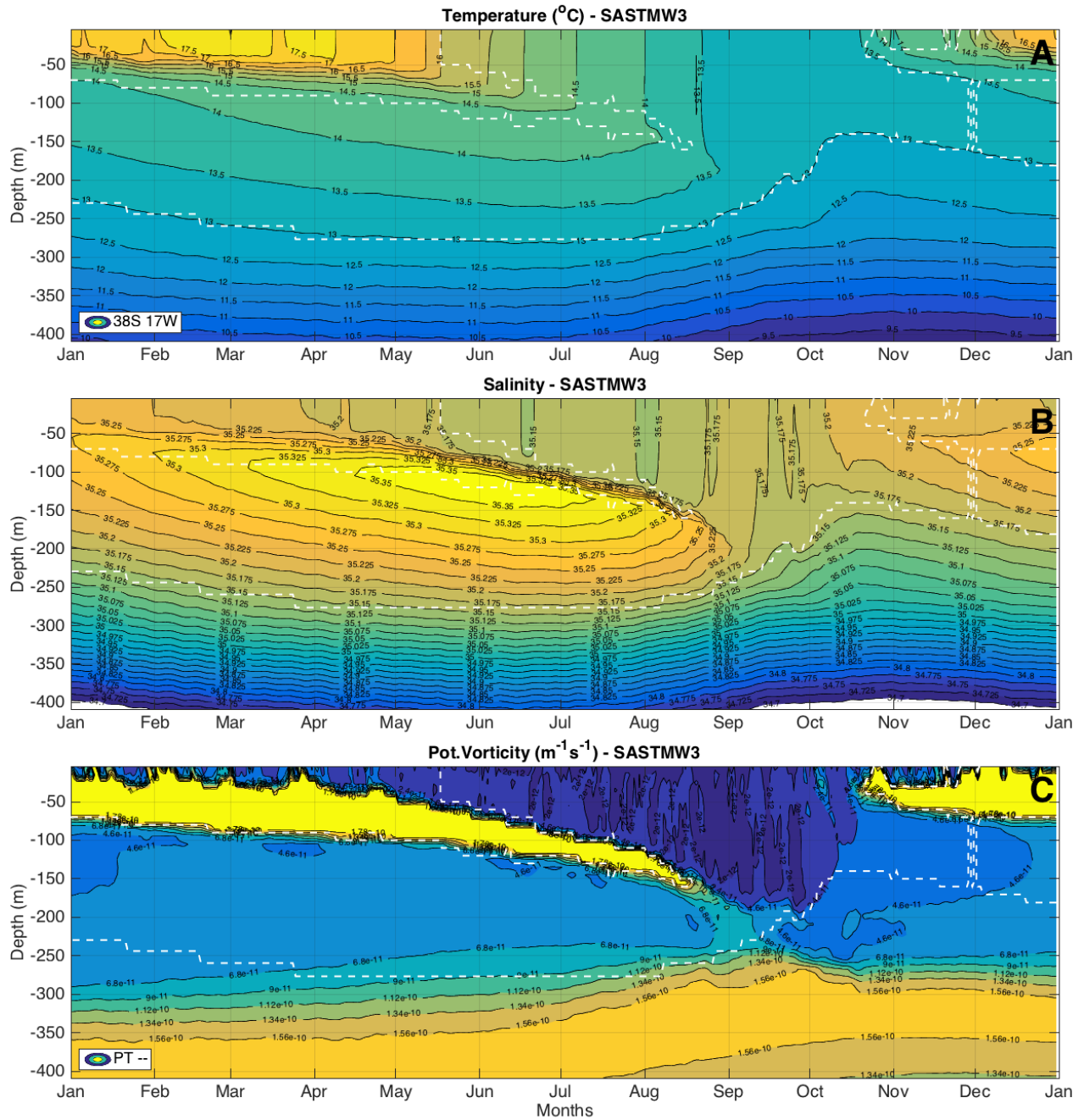


Figure S20. Temperature, shortwave radiation, salinity, precipitation, potential vorticity, and wind speed variation over one year at 38°S, 17°W in the CESM PT- experiment. The white contour represents the SASTMW 3 identified throughout the cycle. All the PV values greater than $1.5 \times 10^{-10} \text{ m}^{-1} \text{ s}^{-1}$ were included in the maximum value contour.

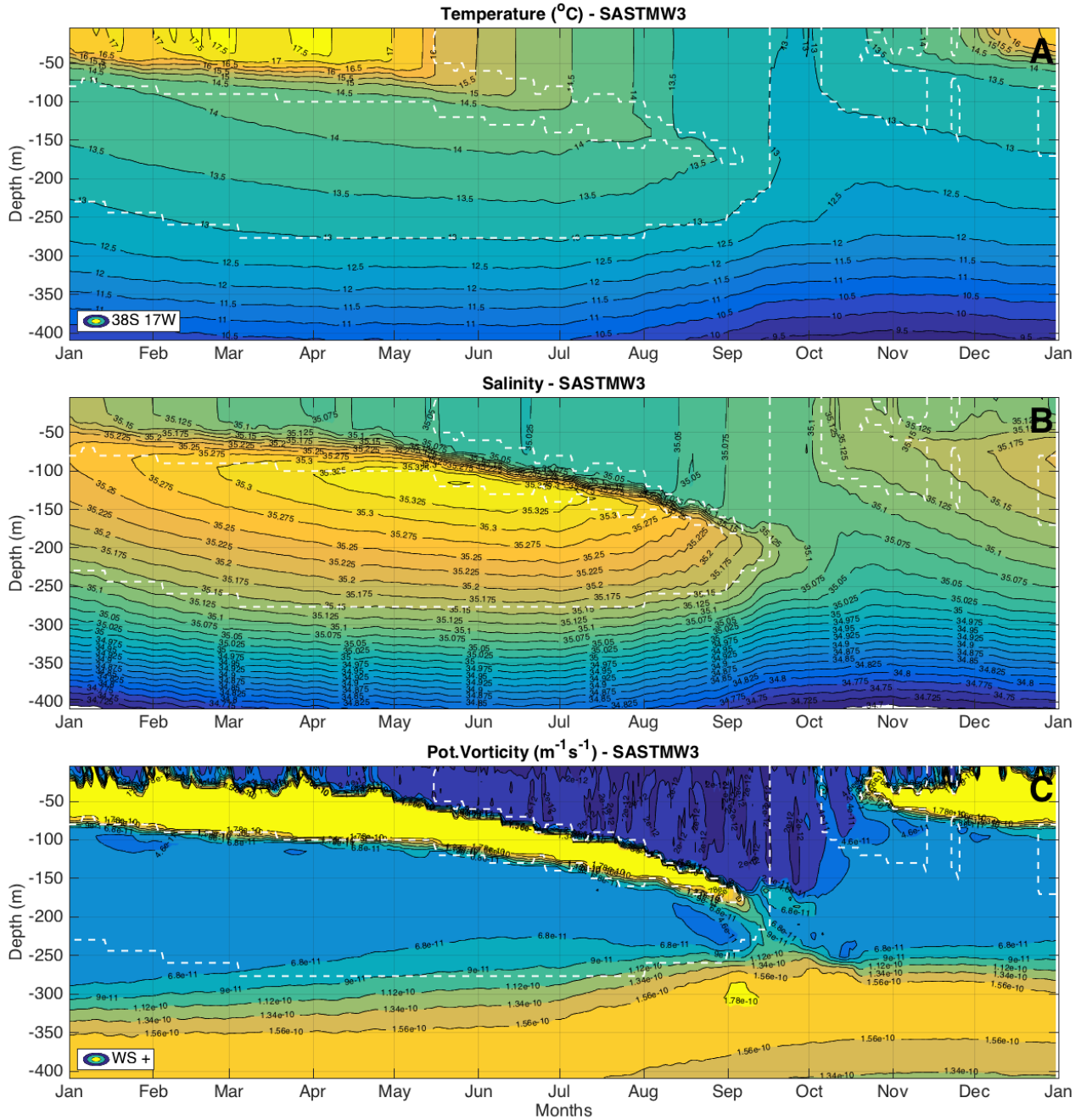


Figure S21. Temperature, shortwave radiation, salinity, precipitation, potential vorticity, and wind speed variation over one year at 38°S, 17°W in the CESM WS+ experiment. The white contour represents the SASTMW 3 identified throughout the cycle. All the PV values greater than $1.5 \times 10^{-10} \text{ m}^{-1} \text{ s}^{-1}$ were included in the maximum value contour.

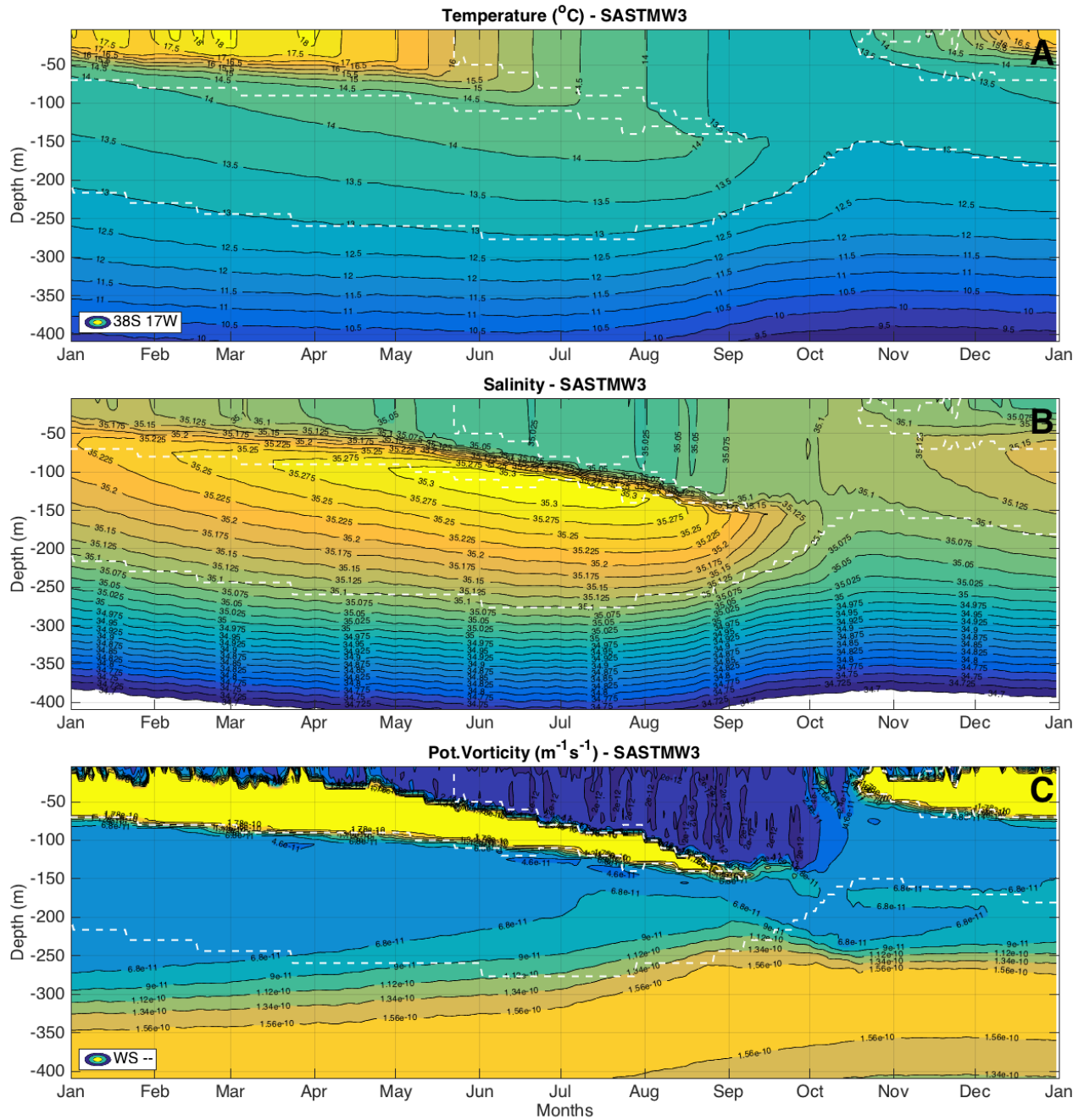


Figure S22. Temperature, shortwave radiation, salinity, precipitation, potential vorticity, and wind speed variation over one year at 38°S, 17°W in the CESM WS- experiment. The white contour represents the SASTMW 3 identified throughout the cycle. All the PV values greater than $1.5 \times 10^{-10} \text{ m}^{-1} \text{ s}^{-1}$ were included in the maximum value contour.

Table S1. Values used for the sensitivity test of the selection of SASTMW related to the application of different criteria. Variables used as criteria: temperature (T); salinity (S); potential density (ρ); potential vorticity (PV) and vertical temperature gradient(dT/dz).

No.	Criteria Ref.	T (°C)	S	ρ (kg·m ⁻³)	PV ^a (m ⁻¹ s ⁻¹)	dT/dz (°C·m ⁻¹)
0	-	13 - 16	-	-	1.5	0.02
1	S	13 - 16	35 - 36	-	1.5	0.02
2	S and ρ	13 - 16	35 - 36	26.0 - 26.6	1.5	0.02
3	ρ	13 - 16	-	26.0 - 26.6	1.5	0.02
4	+dT/dz	13 - 16	-	-	1.5	0.1
5	-dT/dz	13 - 16	-	-	1.5	0.019
6	-dT/dz	13 - 16	-	-	1.5	0.015
7	-dT/dz	13 - 16	-	-	1.5	0.01
8	-dT/dz	13 - 16	-	-	1.5	0.005
9	+PV	13 - 16	-	-	5.0	0.02
10	-PV	13 - 16	-	-	1.4	0.02
11	-PV	13 - 16	-	-	1.0	0.02
12	-PV	13 - 16	-	-	0.5	0.02
13	-PV	13 - 16	-	-	0.2	0.02
14	T	12 - 18	-	-	1.5	0.02

^a $\times 10^{-10}$.