Reviewer 1

We would like to thank the reviewer for their helpful comments and feedback on our manuscript. Below are the reviewer comments in bold text followed by our response.

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1. Yucatan transport: You estimated a Yucatan transport of 20.6 Sv. It is important to include that value in Table 4 and compare with more recent estimated for the region. Although you cited a couple of studies that seems to be in good agreement with your model result (Sheinbaum et al. [2002] and Candela et al. [2003] with 23.08 and 23.06 Sv, respectively), a more recent study by Candela et al. (2019; DOI: 10.1175/JPO-D-18-0189.1) using an extended time series reported a Yucatan transport of about 27.6 Sv. The observed value is somewhat below the transport you can derive from GLORYS, which is about 29 Sv. This implies that CARIB12 underestimated the Yucatan transport by 25% or more. You should recognize that model bias, and maybe provide some discussion about what could be the reason of this underestimation.

We thank the reviewer for sharing an updated reference for the transport across the Yucatan channel. We have included the Yucatan transport on Table 4 (shown below) along with the updated reference. We also expanded our discussion in response to this comment (Lines 351-356 in the original manuscript) as follows:

"The net mean inflow to the Caribbean Sea is 20.94 Sv which is 0.31 Sv more than the mean flow out of the Caribbean Sea via the Yucatan Channel (20.63 Sv) (Figure 1a). The mean flow through the Yucatan Channel in CARIB12 is ~3 Sv less than that estimated from observations by Sheinbaum et al. (2002) and Candela et al. (2003) (23.8 and 23.06 SV, respectively); it is also ~7 Sv below GLORYS12 and the most recent estimate of 27.6 Sv by Candela et al. 2019. The difference in mean transport across observational estimates collected in different years may indicate low frequency variability that is not well-captured in CARIB12 and is partially captured in GLORYS12. Also, the estimates by Sheinbaum et al. (2002) and Candela et al. (2003) are based on observations between September 1999 and June 2001, whereas the estimate in Candela et al. 2019 is based on observations between September 2012 and August 2016. We note that the section defining the Yucatan Channel in CARIB12 is not completely bounded by land which may result in a lower mean outflow there."

Table 4. Mean ocean transports (Sv) across passages in the Caribbean Sea: estimates from CARIB12 and the GLORYS12 reanalysis are for the period 2000-2020; estimates from observations are for the date ranges indicated in the table and are included together with relevant references. The location of each passage is shown in Figure 1. Negative transports correspond to a westward or southward flow, and positive transports to eastward or northward flows.

Passage	CARIB12	GLORYS	Observations [date range]	Observations reference
Windward Passage	-1.91	-2.8	-3.8/-3.6 [Oct '03–Feb '05]	Smith et al. (2007)
Mona Passage	-0.38	+1.22	-3.0 [Mar '96, Jul '96]	Johns et al. (2002)
Anegada Passage	-1.53	+0.14	-2.5 ± 1.4 [spread across the 1990's]	Johns et al. (2002)
			-4.8± 0.32 [Oct '20, Jul '21, Sep '21, Mar '22]	Gradone et al. (2023)
Antigua Passage	-2.11	-4.06	-3.1 ± 1.5 [spread across the 1990's]	Johns et al. (2002)
Guadeloupe Passage	-0.74	-0.10	-1.1 ± 1.1 [spread across the 1990's]	Johns et al. (2002)
Dominica Passage	-2.79	-3.02	-1.6 ± 1.2 [spread across the 1990's]	Johns et al. (2002)
St. Lucia Passage	-1.97	-4.92	-1.5 ± 2.4 [spread across the 1990's]	Johns et al. (2002)
St. Lucia - Trinidad	-9.51	-16.62	-8.6 [spread across the 1990's]	Johns et al. (2002)
Yucatan Passage	+20.63	+27.08	23.8 [Sept '99 - Jun '00]	Sheinbaum et al. (2002)
			+23.06 [Aug '99 - Jun '01]	Candela et al. (2003)
			+27.6 [Sept '12 - Aug '16]	Candela et al. (2019)

Updated version of Table 4 to include the Yucatan Passage transports including the most recent estimate by Candela et al. (2019) .

- Candela, J., Tanahara, S., Crepon, M., Barnier, B., and Sheinbaum, J.: Yucatan Channel flow: Observations versus CLIPPER ATL6 and MERCATOR PAM models, Journal of Geophysical Research: Oceans, 108, 2003.
- Candela, J., Ochoa, J., Sheinbaum, J., Lopez, M., Perez-Brunius, P., Tenreiro, M., Pallàs-Sanz, E., Athié, G., and Arriaza-Oliveros, L.: The flow through the Gulf of Mexico, Journal of Physical Oceanography, 49, 1381–1401, 2019

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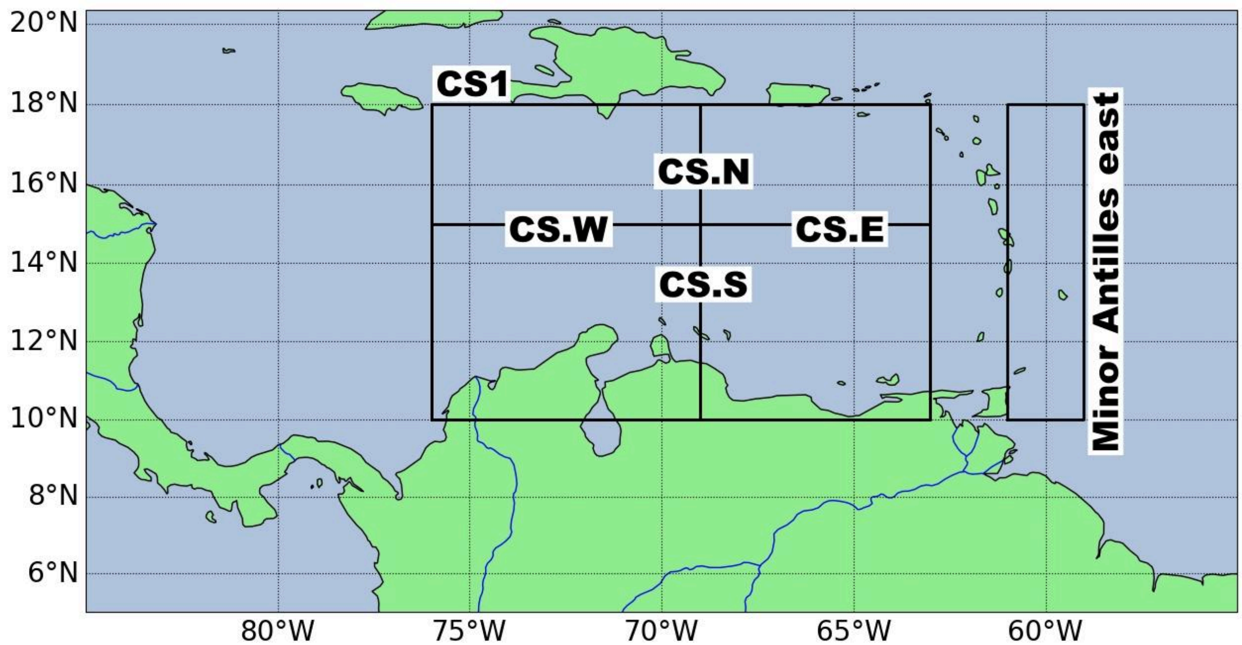
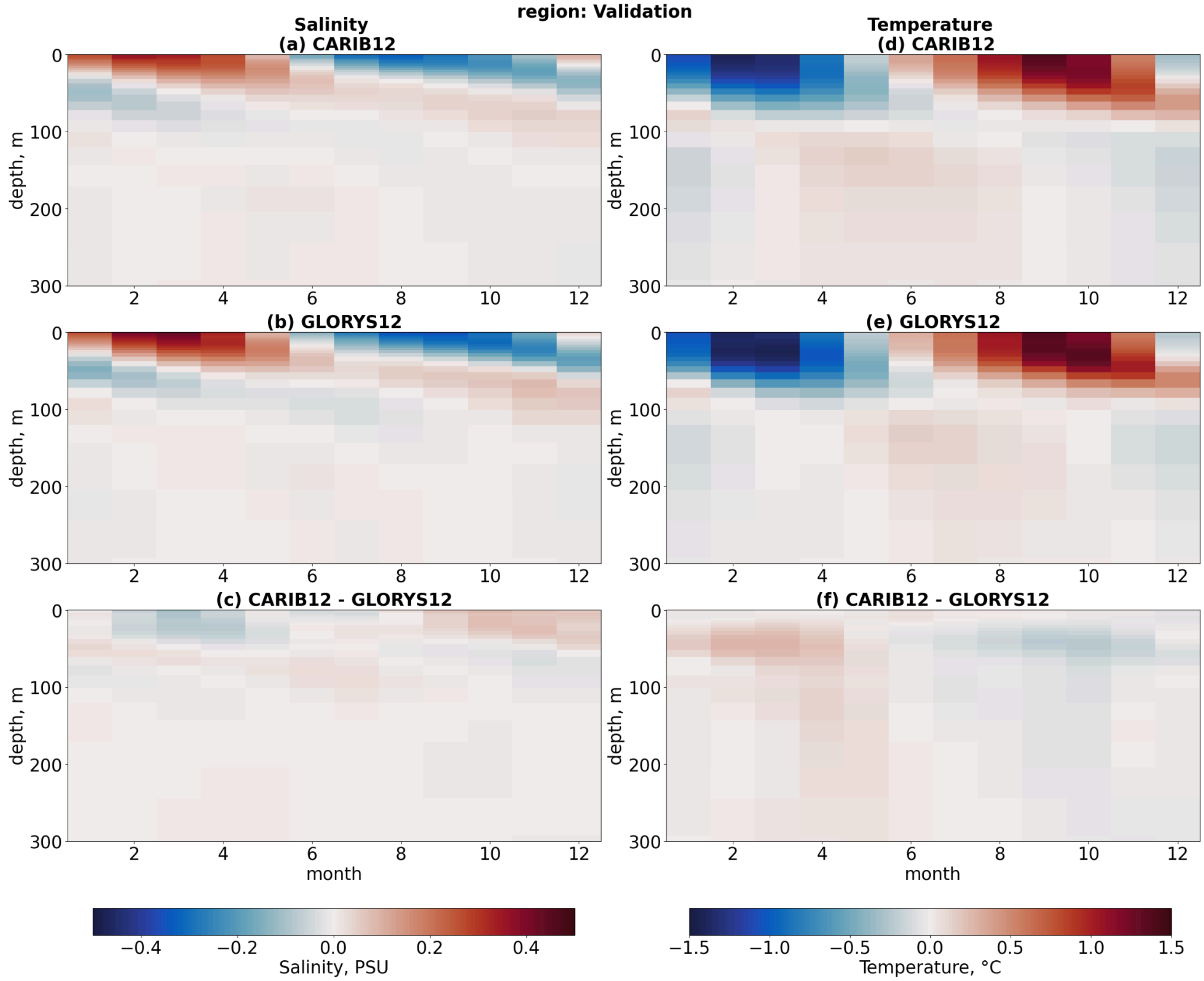
2. Monthly climatologies for specific subregions: It could be interesting to compare monthly climatological patterns of salinity and temperature in specific subregions (either surface fields or vertical profiles). You calculated a monthly climatology in Figure 13, but that is an average for the entire interest region, which I think is not the right approach. Averaging over this large area could mask subregional biases, and you are also not discriminating important spatial variability that can be worth to describe for the region.

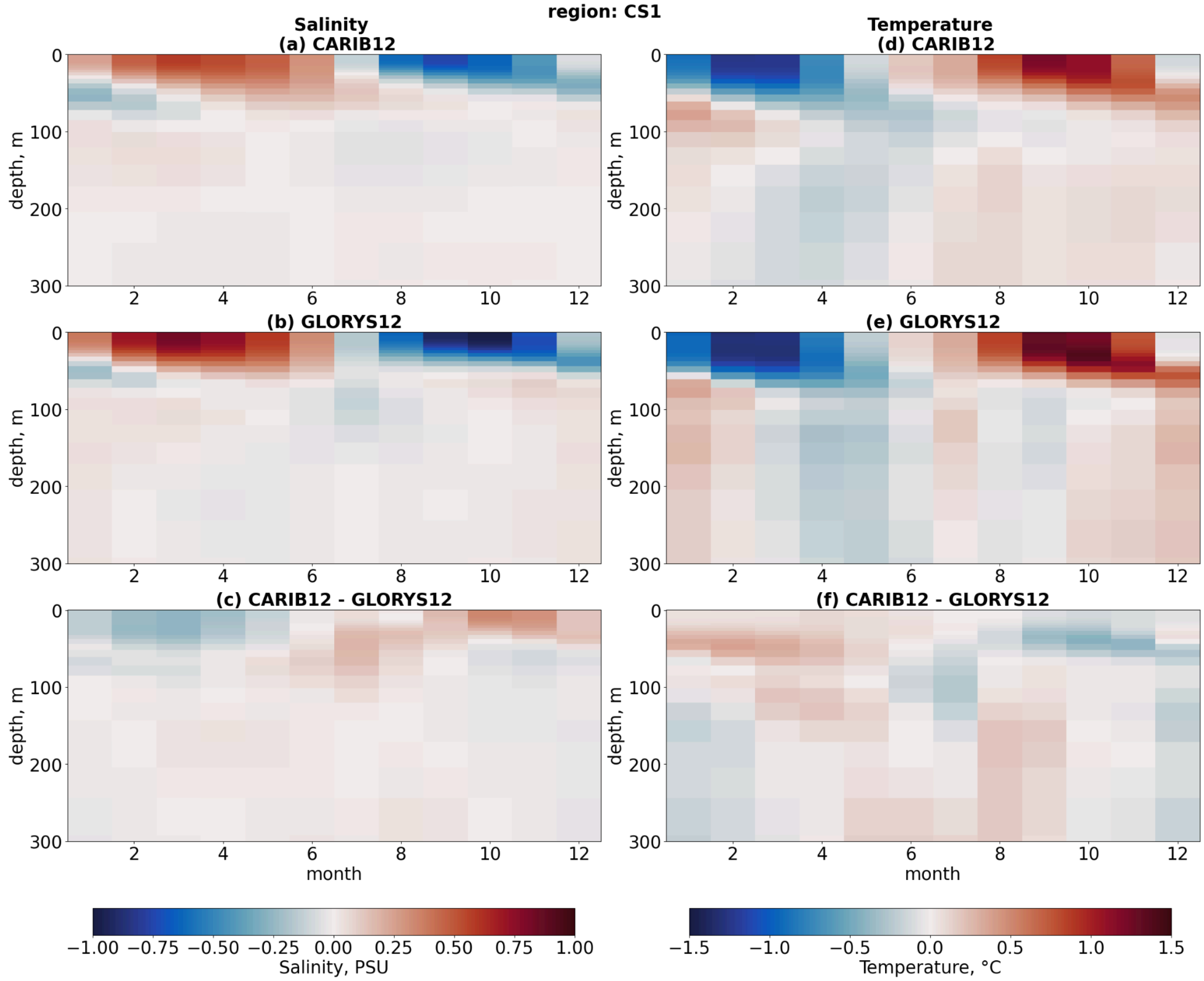
Thank you for the suggestion. We have created the monthly climatology for different sub-regions (Figures included below). We have also included a revised map showing these new subregions for reference. The figures show overall similar biases in temperature across the different sub-regions. In the case of salinity, the biases are slightly larger in the eastern subregion inside the Caribbean Sea than the western subregion, similar to the biases shown for the surface in Figures 3 and 4 of the manuscript. The meridional biases of salinity within the Caribbean Sea are similar, which also agrees with the surface biases in salinity shown in Figures 3 and 4 of the manuscript. Outside the Caribbean Sea, along the eastern side of the minor Antilles, the near-surface biases in salinity are somewhat larger during June, but otherwise similar to what we see in the surface maps. We have included in the revised manuscript the figures for the eastern CS (CS.E) and the Minor Antilles east subregions as they show biases within the Caribbean Sea are smaller than east of the Minor Antilles. The description in Section 3.3 has been extended to include a discussion regarding these two new figures.



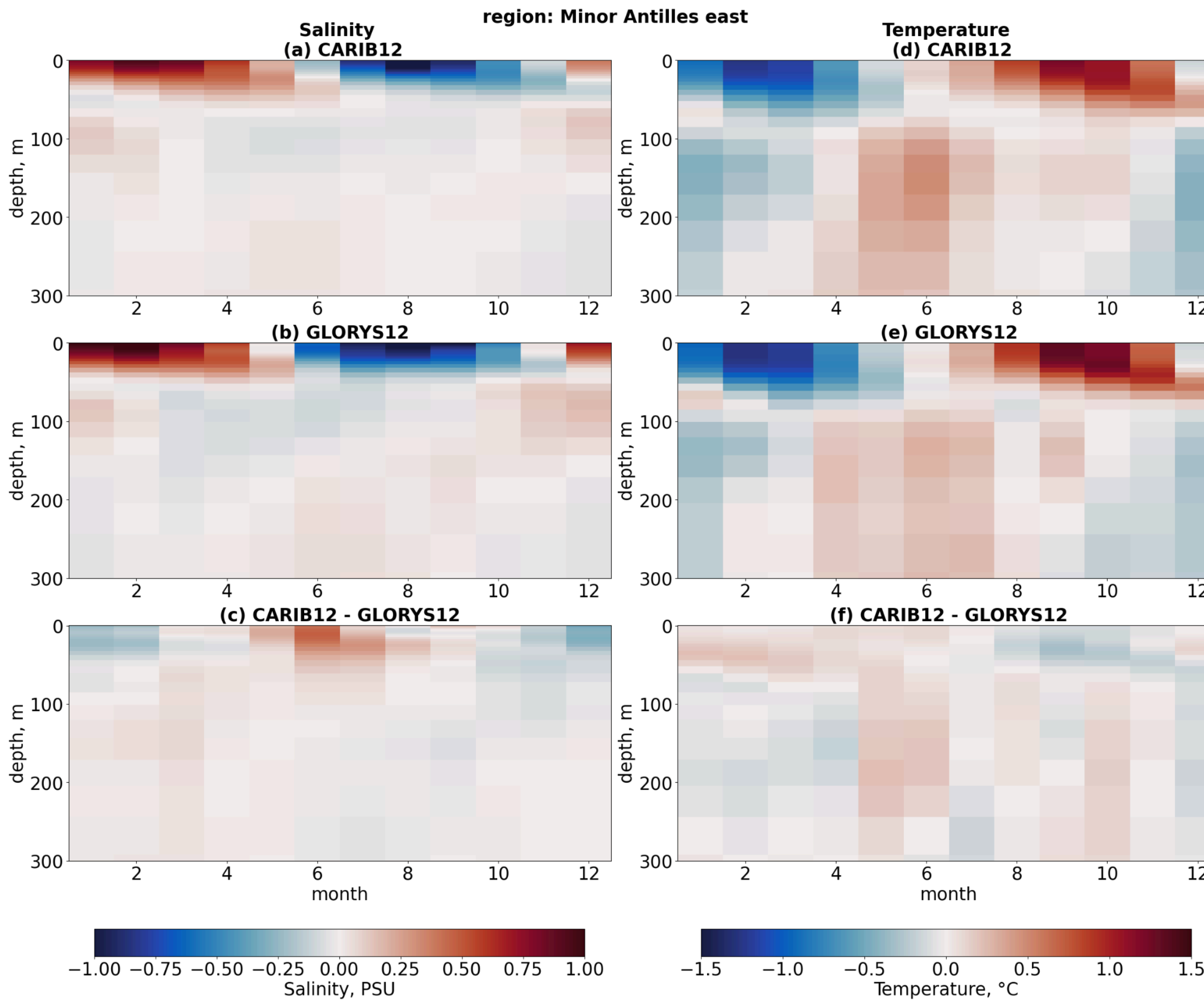
Subregions for the climatologies added to the analysis and shown in figures below. This figure will be added to the Appendix.



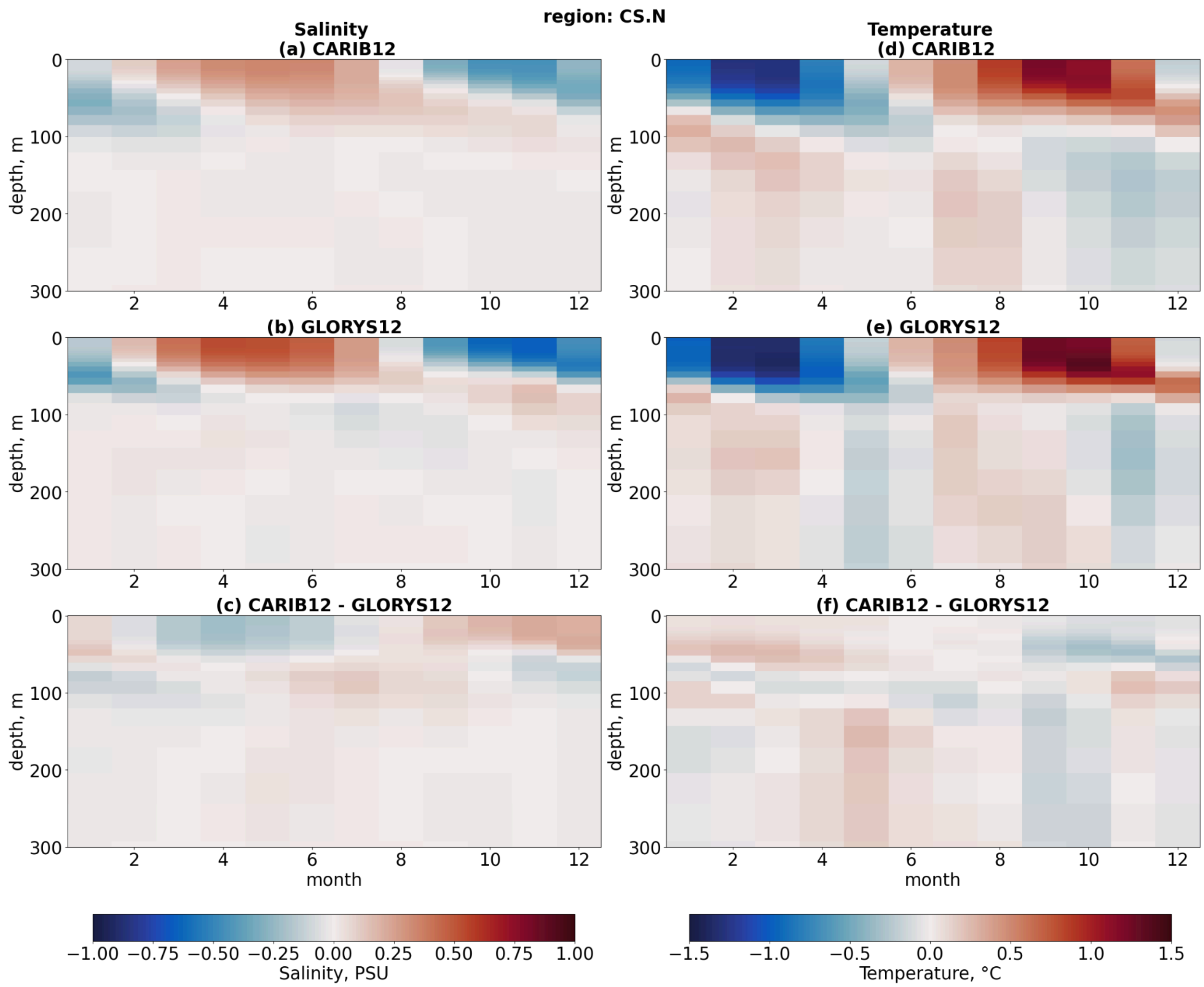
Revised version of Figure 13 in the manuscript for the validation region.



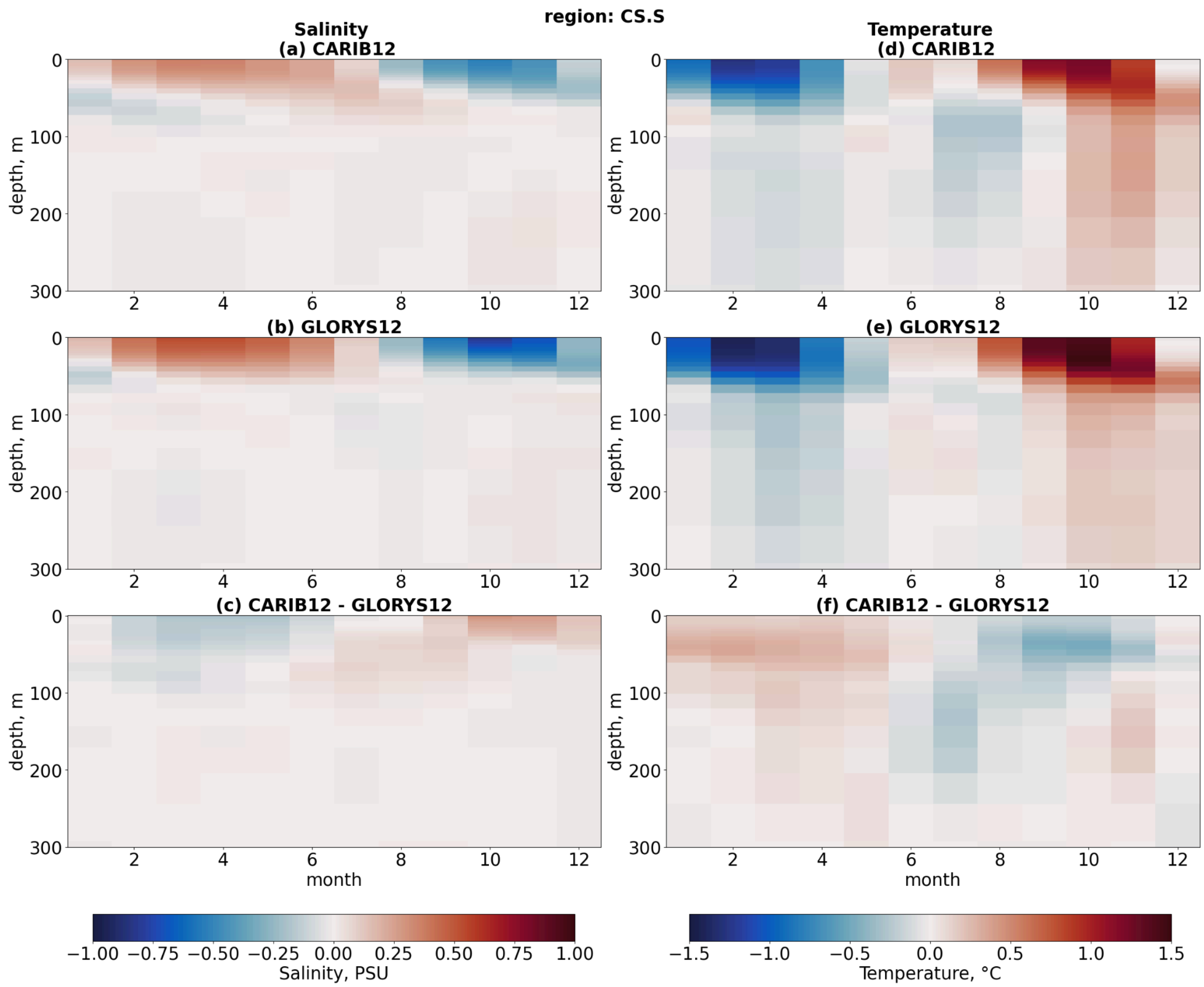
Monthly climatology anomaly of salinity and temperature in the top 300m of the water column. The average is over the Caribbean Sea box identified as CS1 in the map above. This figure will be included in the manuscript.



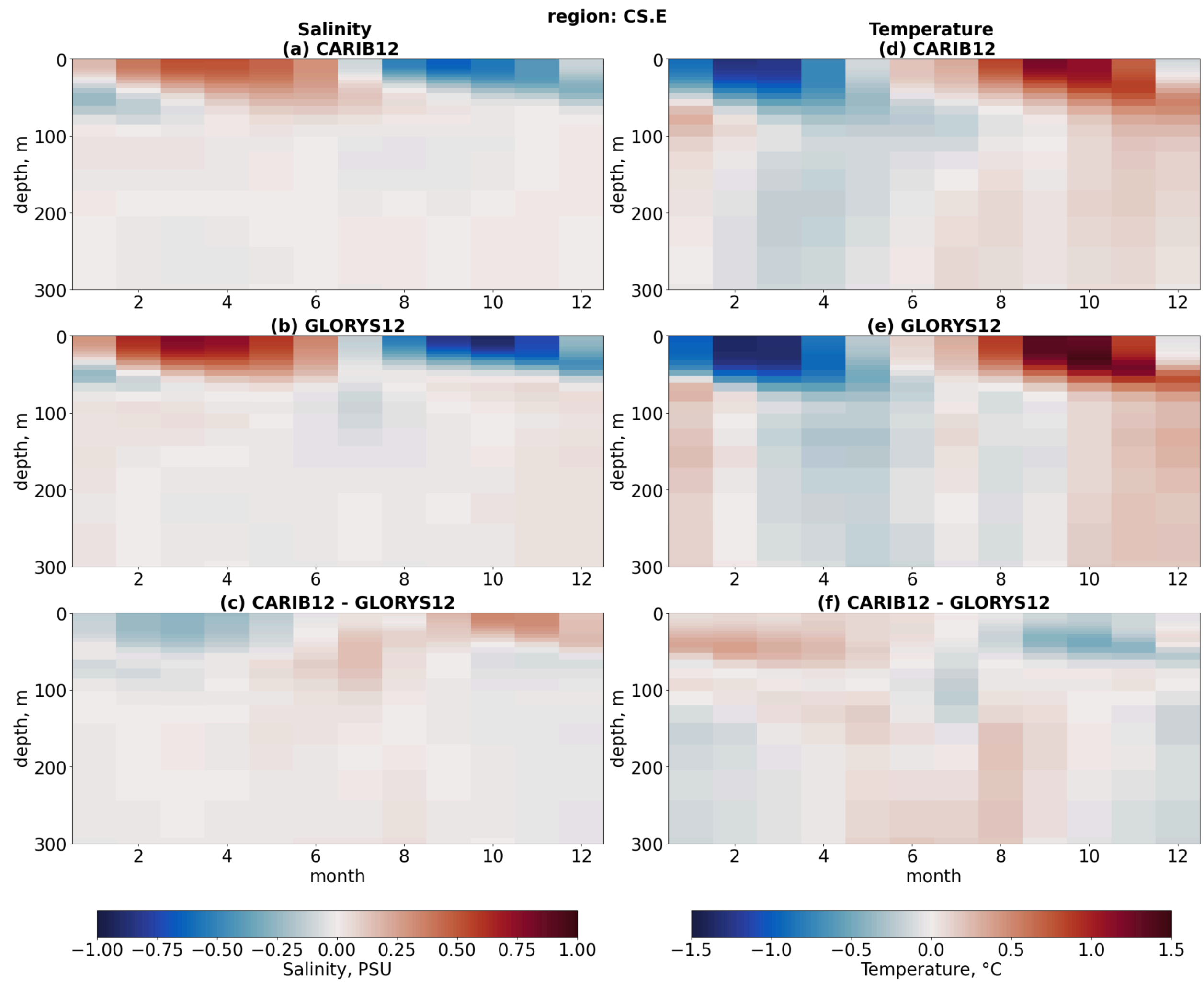
Monthly climatology anomaly of salinity and temperature in the top 300m of the water column. The average is over the eastern side of the minor Antilles as shown in the map above. This figure will be included in the manuscript.



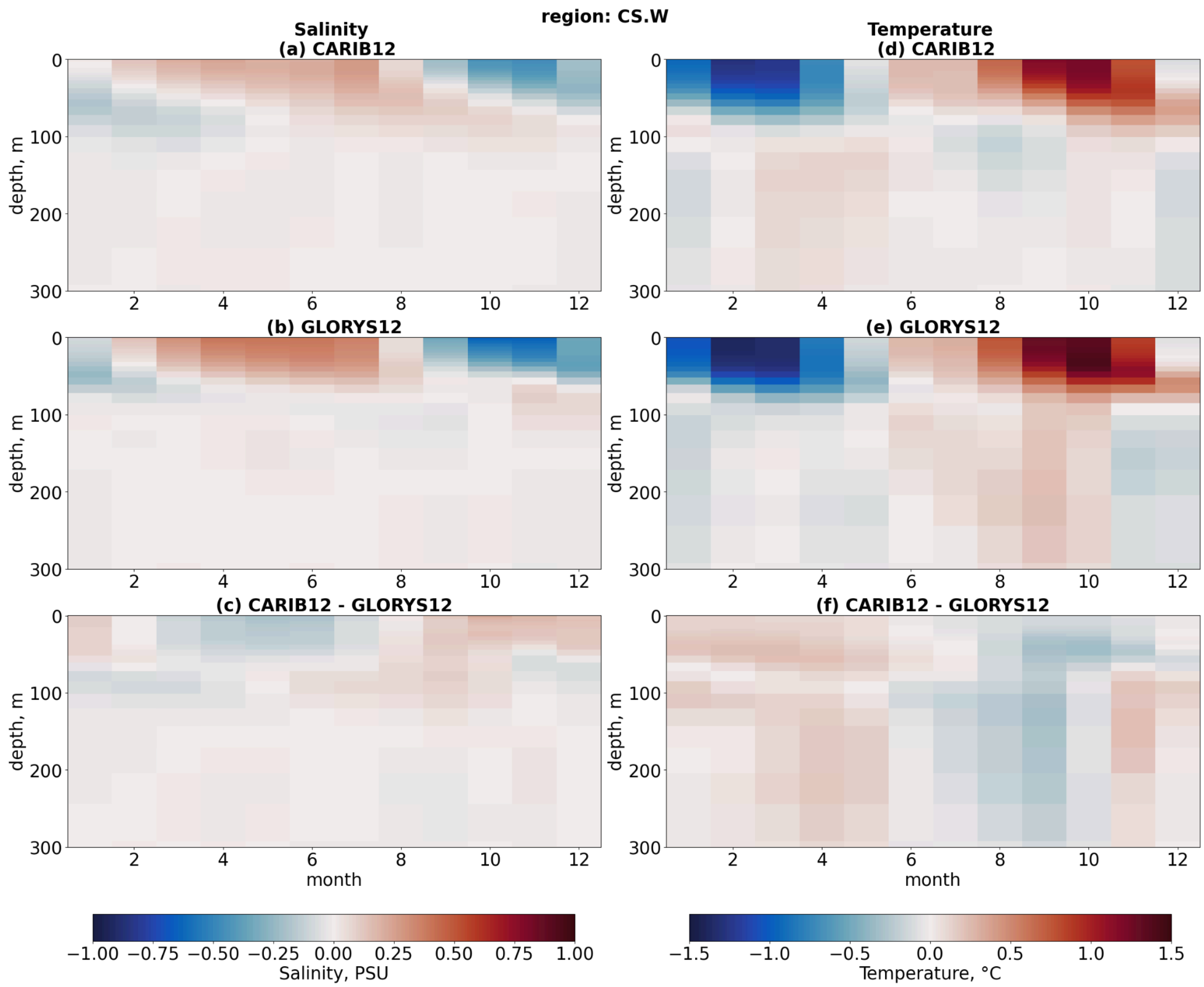
Monthly climatology anomaly of salinity and temperature in the top 300m of the water column. The average is over the northern half of box CS1 in the map above. This figure will be included in the Appendix.



Monthly climatology anomaly of salinity and temperature in the top 300m of the water column. The average is over the southern half of box CS1 in the map above. This figure will be included in the Appendix.



Monthly climatology anomaly of salinity and temperature in the top 300m of the water column: horizontal average in the eastern caribbean. This figure will be included in the Appendix.



Monthly climatology anomaly of salinity and temperature in the top 300m of the water column. The average is over the western half of box CS1 in the map above. This figure will be included in the Appendix.

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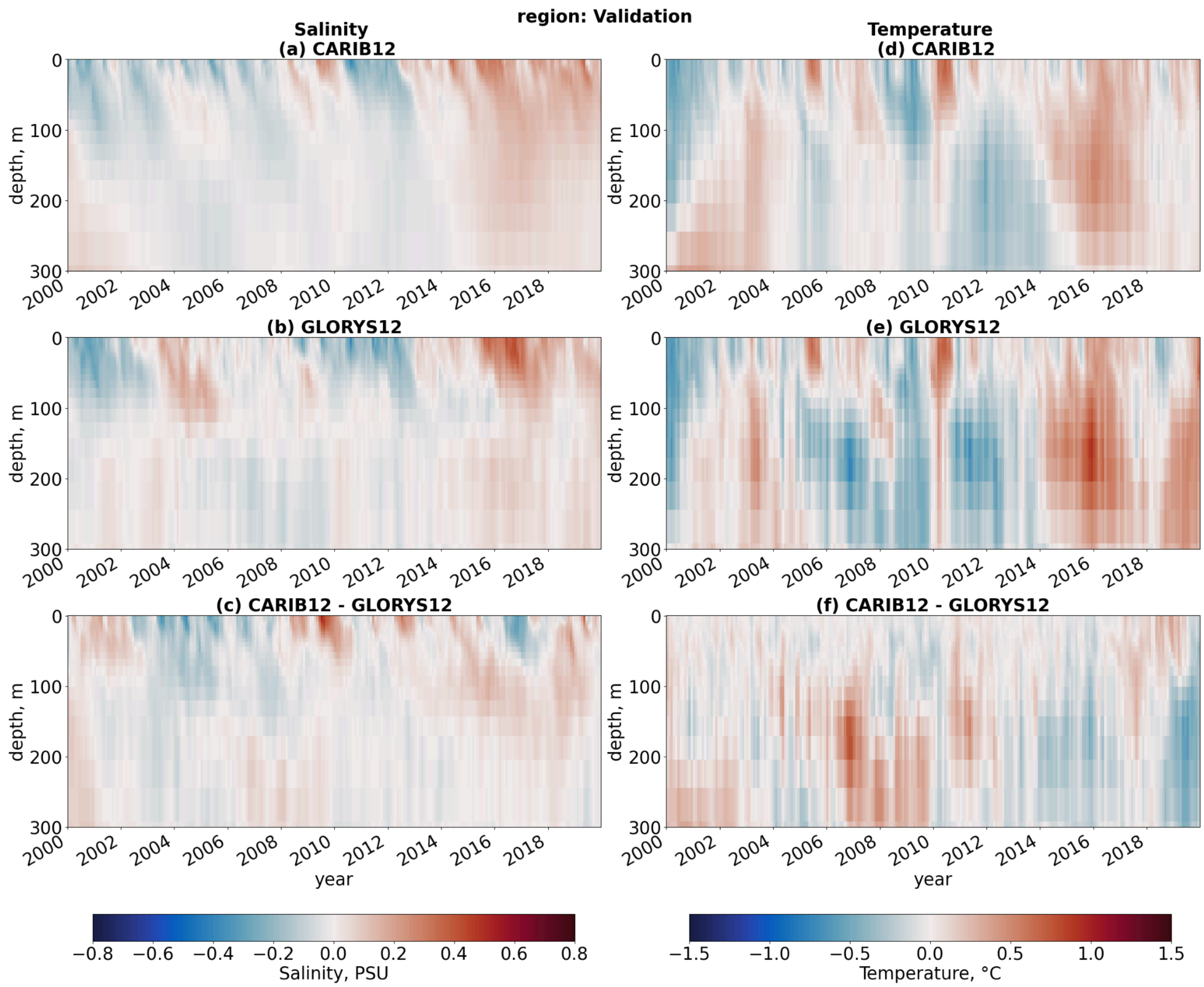
3. Interannual variability. Figures 14 and 15g-l revealed that the interannual transport variability is not well reproduced by the model (I disagree with the statement in lines 365-366 "While the mean inter-annual flows are well represented in CARIB12"). Does the Caribbean Current have a chaotic behavior? This should be further discussed. In addition, since the ability of the model to reproduce interannual variability is critical for the analysis of historical patterns, I wonder to what degree the model was able to simulate realistic interannual variability in temperature and salinity. Is it possible that you generate monthly time series of these variables for specific subregions and compare with observations or GLORYS?

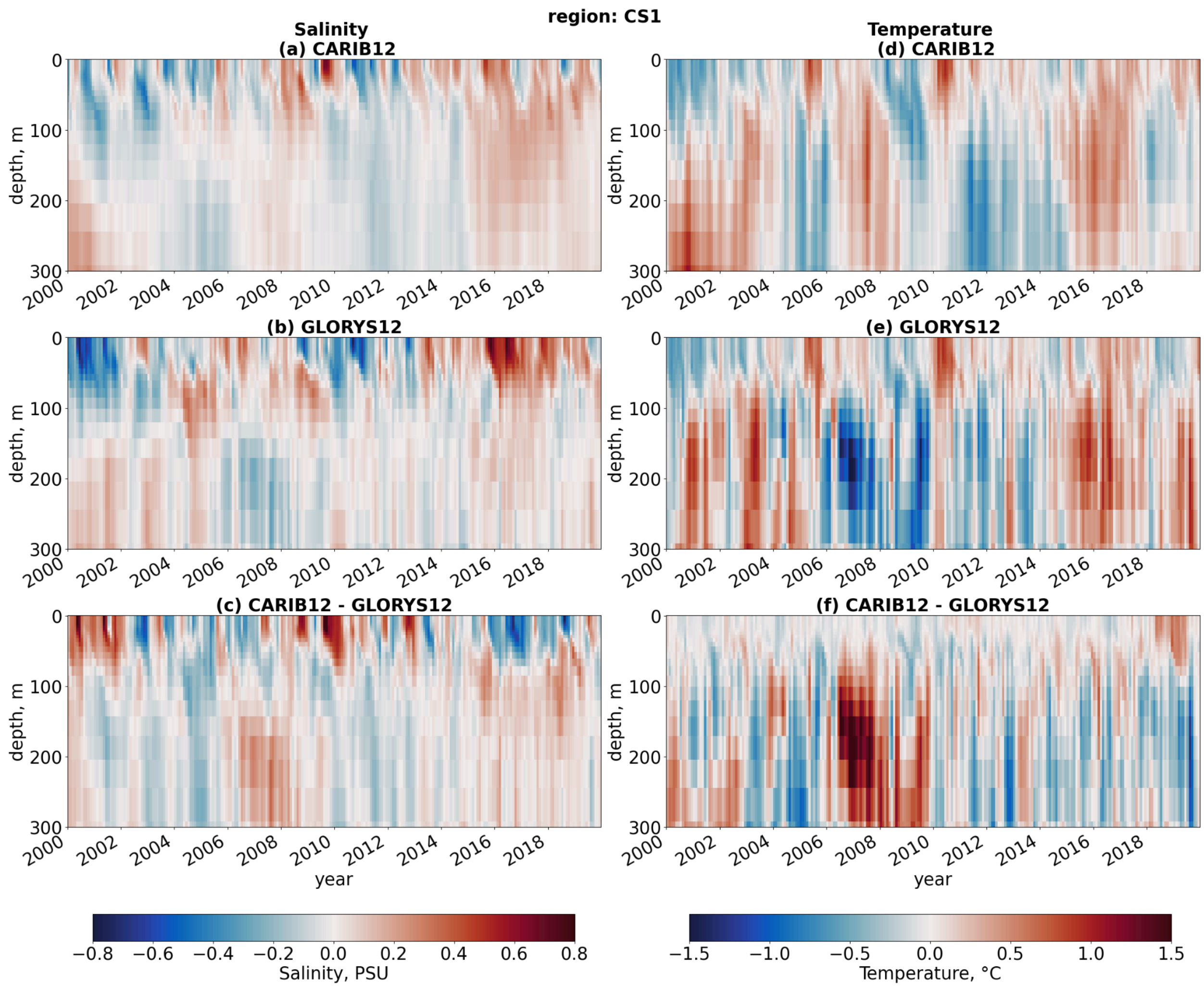
We agree with the reviewer's comment regarding interannual transport variability not being well reproduced by the model in some regions. We have removed the sentence in lines

365-367 of the original manuscript: “While the mean inter-annual flows are well represented in CARIB12, the model does not capture the same amplitude of variability that GLORYS12 suggests exists in some of the passages (Figures 15g-l).”

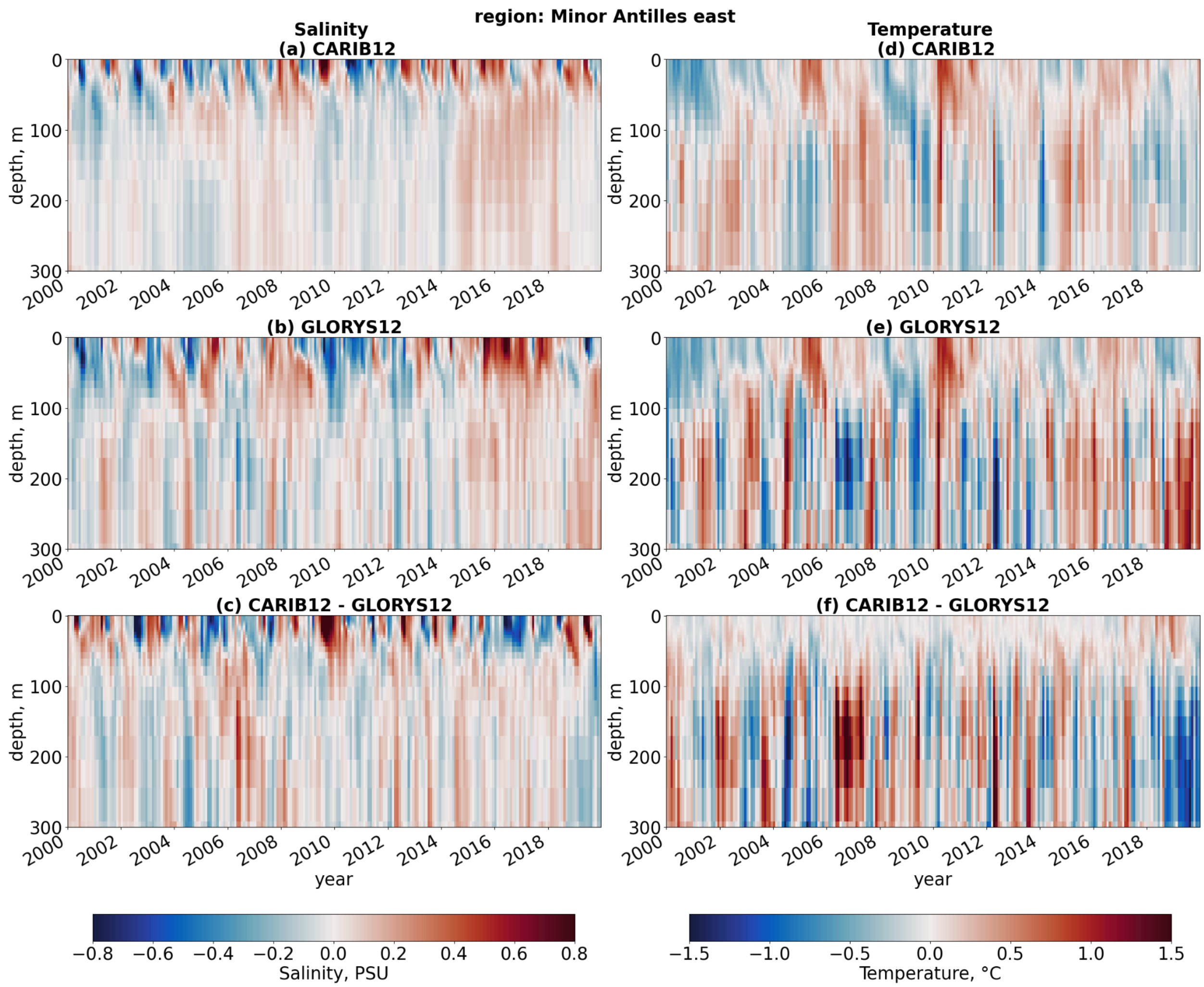
Despite this, internannual temperature and salinity variability is well represented in the model. Figure A7 shows monthly temperature and salinity anomalies in the top 300 meters of the water column. For both fields, the model captures the overall patterns of interannual variability. For example, Figure A7a and A7b show positive salinity anomalies across the last ~5 years of the simulation that are preceded by a 2-3 year negative salinity anomaly. These anomalies correspond well to similar signals in GLORYS12 (shown in Figure A7c). Similar patterns are shown for temperature with biases generally below 10% difference across the top 100 m. We revised Figure A7 (included below) and moved it to the main manuscript instead of the Appendix. We have also generated new figures for the Caribbean Sea (CS1 region in the map included in the answer to the previous comment) and the region east of the minor Antilles. The figures for the subregions show that the temperature and salinity variability is well reproduced across the subregions with differences noted in the magnitude of some of the larger anomalies.



New version of Figure A7. This Figure will be moved from the Appendix to the manuscript.



Interannual salinity and temperature anomalies in the top 300 m for region CS1 (map shown in answer to previous comment by the reviewer).



Interannual salinity and temperature anomalies in the top 300 m for region Minor Antilles east (map shown in answer to previous comment by the reviewer).

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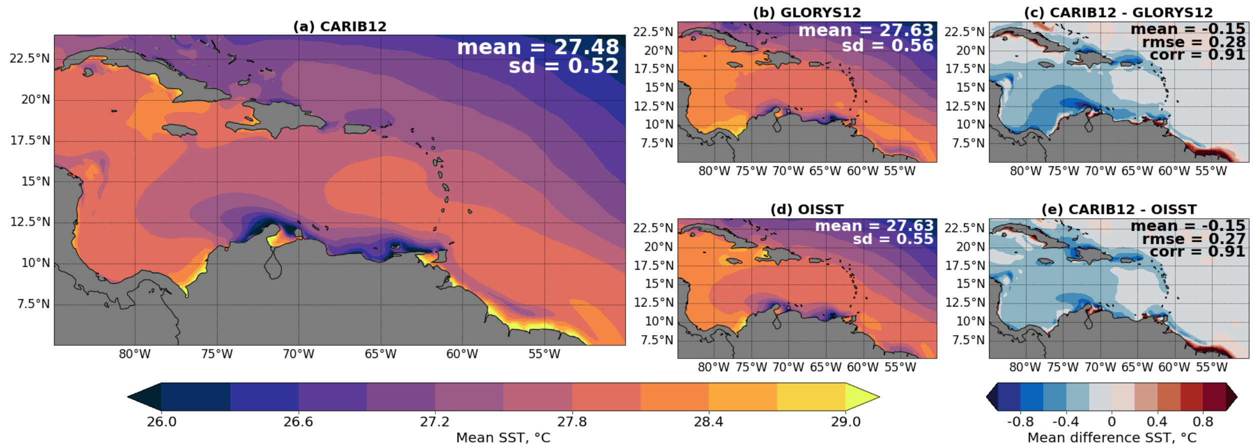
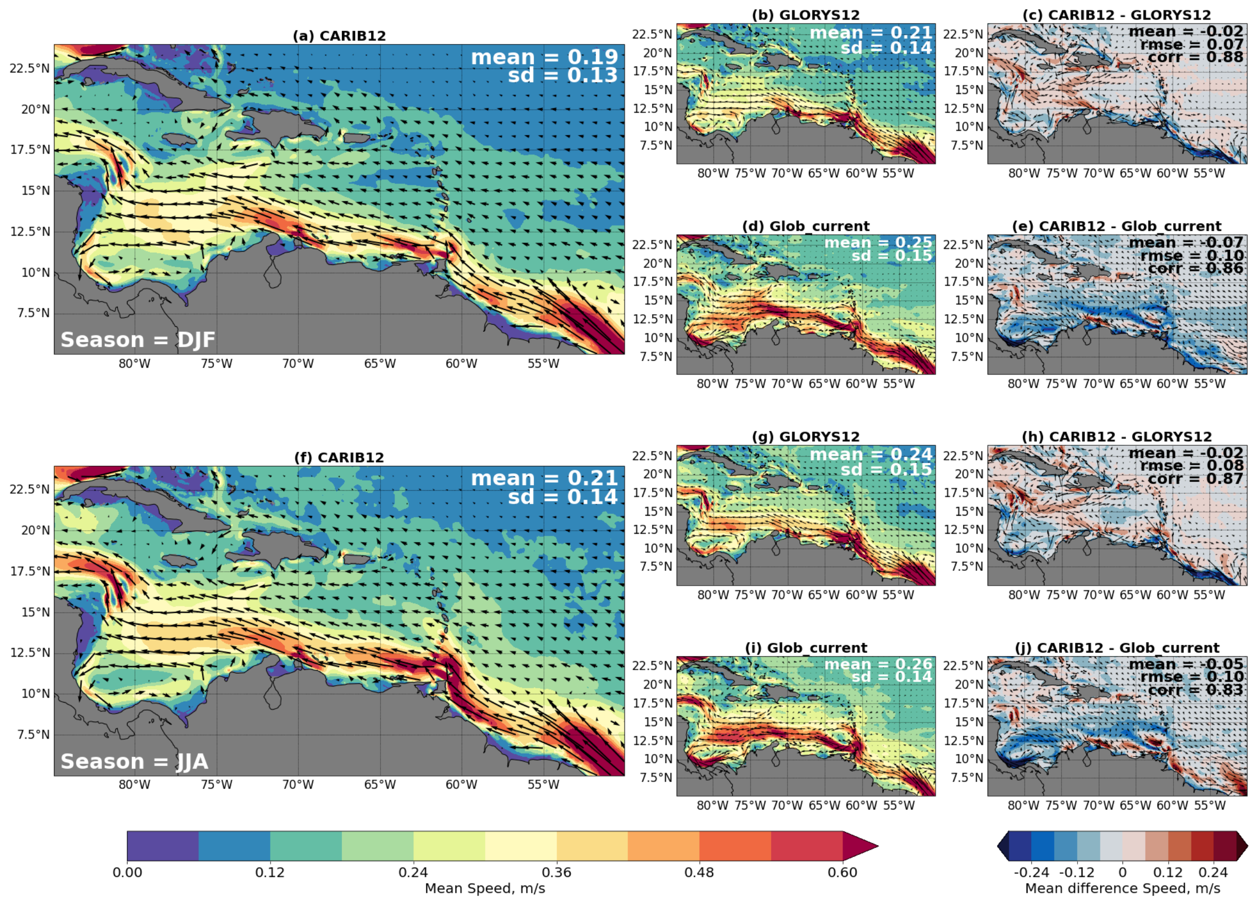
4. Figure quality: The quality of the figure must be improved. You are not using any map projection to display the spatial patterns, and I think you should. I would also consider including some discretization in the colorbar to better discriminate spatial features. You could also evaluate merging several figures, like 3 and 4, 6 and 7, and 9 and 10. That may help to compare better the winter to summer changes in SSS, EKE, and MLD.

We thank the reviewer for the feedback and agree that the surface maps in particular could be improved and in certain cases some figures could be merged. We have modified our surface field validation figures to include map projections and coastlines. We are also now using discrete colormaps instead of continuous colormaps. We also merged the following pairs of figures into single figures: figures 3 and 4, 6 and 7, and 9 and 10. Furthermore, we extended our validation of the surface current speeds to a seasonal comparison rather than the full time mean with speed vectors shown as arrows as suggested by the reviewer in a different comment. New versions of the figures from SST and Speed are shown below. We also included a dataset for the validation of the surface currents as suggested by another reviewer.



New version of Figure 2 in the original manuscript with updates based on feedback by both reviewers.



New version of Figure 5 including feedback by both reviewers. This updated figure also shows an example of how we merged figures 3 and 4, 6 and 7, 9 and 10.

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5. Velocity patterns: In addition to the mean speed, I suggest you compare the mean velocity fields (u,v). That would add further insights about what circulation biases the model has. For example, see Figure 4 in Liu et al. (2015; http://dx.doi.org/10.1016/j.jmarsys.2015.01.007).

Thanks for the suggestion. As shown above, we have included the velocity vectors on top of the colored speed magnitude. We believe that this provides further information on the surface currents and the model performance and the figure will be included as shown in the revision of the manuscript.

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6. Section 3.15. I am not sure if this section is worth to include in the manuscript. This is not model validation and Figure 16 is little bit hard to interpret. Unless you have actual observations to compare the simulated trajectories, I would remove this section.

Thanks for your comment. We agree this section feels somewhat disjointed from the rest of the validation in the manuscript, hence we moved it to the Appendix, together with the description of the method used to generate the relevant figure. We also added text to the main manuscript to clarify the importance to test CARIB12's ability to reproduce known pathways of plume water intrusions into the Virgin Islands basin. While the comparison is not direct (like the validation of the surface fields for example), our results show that indeed CARIB12 is capable of reproducing these pathways. This is important because these pathways are a result of the interactions between the density front of the plume and the topography as the waters approach the eastern Caribbean Sea. Thus, reproducing the pathways indicates that CESM-MOM6 is able to reproduce these processes, with important improvements over coarse resolution climate simulations. In place of this section, we included further analysis of subregions within the Caribbean Sea.

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7. MOM6-NWA12: I wonder what difference in terms of configuration (beyond the model domain extension) has CARIB12 respect to the MOM6-NWA12 configured by Ross et al. (2024). Maybe, it could be worth to mention something about it.

Thanks for the suggestion. We have added the following lines in Section 2.1 below Line 110 of the original manuscript: "The CARIB12 configuration has several key differences with other recent MOM6 configurations that cover a similar region, like the NWA12 configuration of Ross et al. (2023). For instance, the coupling infrastructure used in CESM-MOM6 is the Community Mediator for Earth Prediction Systems (CMEPS), whereas NWA12 uses the Flexible Modeling System (FMS) coupler. In terms of the physical configuration, a few distinctions are worth highlighting. The vertical mixing parameterizations are entirely different. As CARIB12 is a CESM-MOM6 configuration we use KPP for the boundary layer mixing parameterization which is the same scheme used in CESM. On the other hand, NA12 uses the energetics based Planetary Boundary Layer (ePBL) scheme of Reichl et al. (2018). Vertical mixing in CARIB12 is specified via the CvMix library which parametrizes vertical mixing in the interior using schemes that are different to those in NA12. For example, shear-driven mixing in CARIB12 is handled by the parameterization of Large et al. (1994), whereas NA12 applies the Jackson et al. (2008) scheme."

- Reichl, B. G., & Hallberg, R. (2018). A simplified energetics based planetary boundary layer (ePBL) approach for ocean climate simulations. Ocean Modelling, 132, 112-129.
- Large, W. G., McWilliams, J. C., & Doney, S. C. (1994). Oceanic vertical mixing: A review and a model with a nonlocal boundary layer parameterization. Reviews of geophysics, 32(4), 363-403.
- Jackson, L., Hallberg, R., & Legg, S. (2008). A parameterization of shear-driven turbulence for ocean climate models. Journal of Physical Oceanography, 38(5), 1033-1053.