Response to RC1

The revised manuscript reads well, and I thank the authors for addressing the reviewer comments in detail.

The addition of the kinetic energy and vertical velocity spectra enhanced the discussion regarding the model's capabilities in representing turbulence across scales. Doing additional post-processing and including new supporting figures is much appreciated. The manuscript is acceptable for publication. I have a few minor comments/suggestions listed below.

Thank you for your careful reading, especially on the careful check on the moisture flux distribution, and your insightful suggestions! In response to your comments, we have revised Figs. 9, 10 and 14, videos A1 and A2. The associated main text has been updated. Please see the detailed responses for each specific comment as follows.

When I suggested doing ensemble runs in the initial review, I meant more in terms of changing the choice of physics/dynamic parameterizations/options. Nevertheless, adding perturbations to the initial conditions does address the model's robustness. I have 2 suggestions: 1) quantify what % of perturbations are used in the ensembles (for example: +-X% of the initial value), and 2) remove the error bars in skill score figures (Figs. 10 and 14). As the ensemble spread is small (too small for some variables at select stations), it is enough to state it in the text. Having it for only one of the bars could confuse readers who focus more on figures.

Thanks for your explanation and the helpful suggestions! We used “pertlim = {1-10} e-14” in the user_nl_eam, which specifies the maximum amplitude of temperature perturbation used to randomly perturb the initial temperature field. An initial perturbation of order 1e-14 is the suggested magnitude for ensemble members (e.g., https://noresm-docs.readthedocs.io/en/noresm2.3/configurations/ensemble_runs.html, https://sites.uci.edu/fowler/2017/02/22/random-temperature-perturbations-in-cesm/, https://bb.cgd.ucar.edu/cesm/threads/how-does-pertlim-work.2728/).

We have added the magnitude of initial temperature perturbations in the main text and updated Figs. 10 and 14 by removing the ensemble spread:

> “Ensembles were generated by adding random perturbations of order 1^{-14} to the initial temperature profiles at all grid points.”

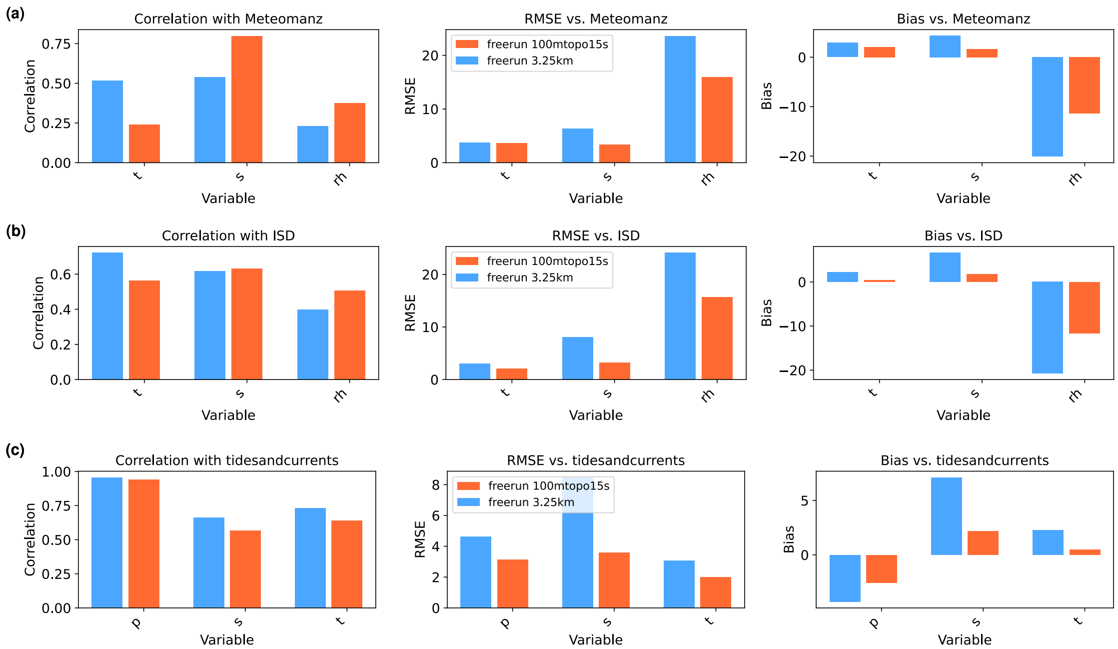

Figure 10. Skill scores for the Storm2008 event are shown for near-surface temperature (t), wind speed (s), relative humidity (rh), and surface pressure (p). These are compared against observations from (a) Meteomanz, (b) ISD, and (c) Tides and Currents, and presented as three overall metrics: Pearson correlation coefficient (left), root-mean-square error (RMSE, middle), and bias (right). The blue and orangered bars indicate simulation results from the 3.25 km California SCREAM-RRM and the 100 m Bay Area SCREAM-RRM, respectively.

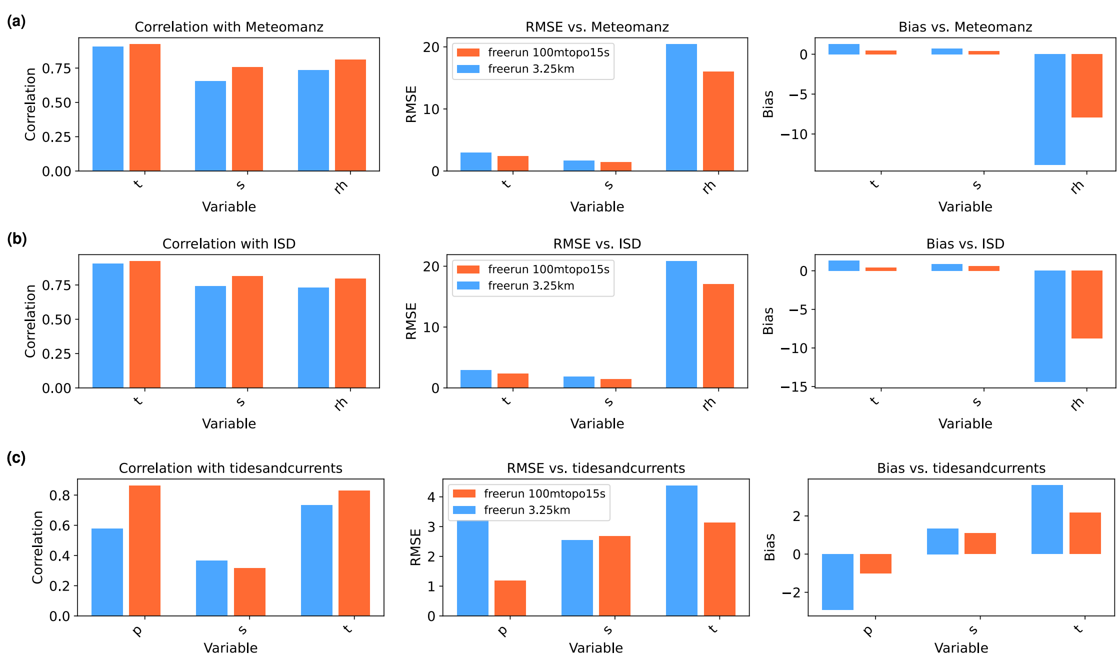

Figure 14. Same as Fig. 10 but for the Stratocumulus2023 event.

Figures 18 and 19: While the magnitudes of SGS moisture flux reduced drastically from 3.25km to 100-m grid resolution, the finer mesh run has the maximum near the surface, which in itself could be a significant result. Without the total moisture flux profile (resolved + SGS), it is difficult to comment on the vertical mixing of moisture between the two grid resolutions. As seen from the SGS moisture flux profiles for the 3.25-km mesh, the maximum is located above the surface, indicating that most of the flux is parameterized or handled by the turbulence scheme, which could result in bulk-like mixing of the moisture in the PBL. On the other hand, the 100-m run has the maximum location near the surface, hinting that most of the flux is resolved and the surface gradient is handled at the sub-grid level. This can also be seen from the 100-m energy spectra results for the Storm2008 case, where the spectral peak was maintained across different scales before its roll-off. Looking at the 500- and 200-hPa level vertical velocity spectra, the 100-m run is allowing a lot more convective action to reach deep into the atmosphere (also seen from Fig. 7). Connecting all these dots across Figs. 7, 9, 18, and 20 tell a coherent story of how the 100-m run could more or less realistically distribute moisture within the atmosphere in the Storm2008 case, affecting the total precip amounts simulated. This is an important result worthy of a brief discussion in the manuscript, as it highlights the model's capability in simulating turbulent motions at finer scales. I suggest adding the cross-section of the 3.25-km run total hydrometeors. Also, there is a typo in the units for the total cloud hydrometeors in the Fig. 9 subplot title. Please correct it. Describe each sub-figure (a and b) in the Fig. 9 caption; currently, it only lists the Storm2008 case.

Thank you for your thorough and insightful analysis! We have incorporated the following additions in "Sub-grid-scale flux" Section based on your comments, and have revised Fig. 9 accordingly (adding the corresponding 3.25 km panel, correcting the units of hydrometeors, removing redundant variables, and updating the caption to include a description of the Stratocumulus2023 case):

> "Beyond the overall reduction in SGS fluxes at finer resolution, the vertical structure of moisture transport differs markedly between the two resolutions. Although the resolved moisture flux was not archived and therefore the total flux cannot be evaluated directly, the contrasting SGS-flux maxima provide insight into the nature of vertical mixing.
>
> In the 3.25 km simulation, the maximum SGS moisture flux is located above the surface, indicating that most of the vertical moisture transport is handled by the turbulence parameterization and likely reflects bulk-like mixing in the PBL. In contrast, the 100 m simulation has the SGS moisture-flux maximum near the

surface, hinting that most of the flux is resolved while the surface gradient is handled by the subgrid scheme. This interpretation is consistent with the enhanced small-scale energy in the 100 m vertical velocity spectra (Figs.~\ref{spectraStorm2008} and \ref{spectraStratocumulus2023}; see Section ``Energy spectra''), where the spectral peak is maintained across a broader range of scales before its roll-off. The stronger resolved vertical motions in the 100 m run also reach more deeply into the troposphere (also seen from the horizontal distribution in Fig.~\ref{horizStorm2008} and the cross section of \emph{w} in Fig.~\ref{cross1}a).

Taken together, Figs.~\ref{horizStorm2008}, \ref{cross1}a, \ref{SHOCtimeplevStorm2008}, and \ref{spectraStorm2008} tell a coherent story of how the 100 m run could more realistically distributes moisture within the atmosphere in the Storm2008 case, affecting the total precipitation amounts simulated. This highlights the model's capability in simulating turbulent motions at finer scales."

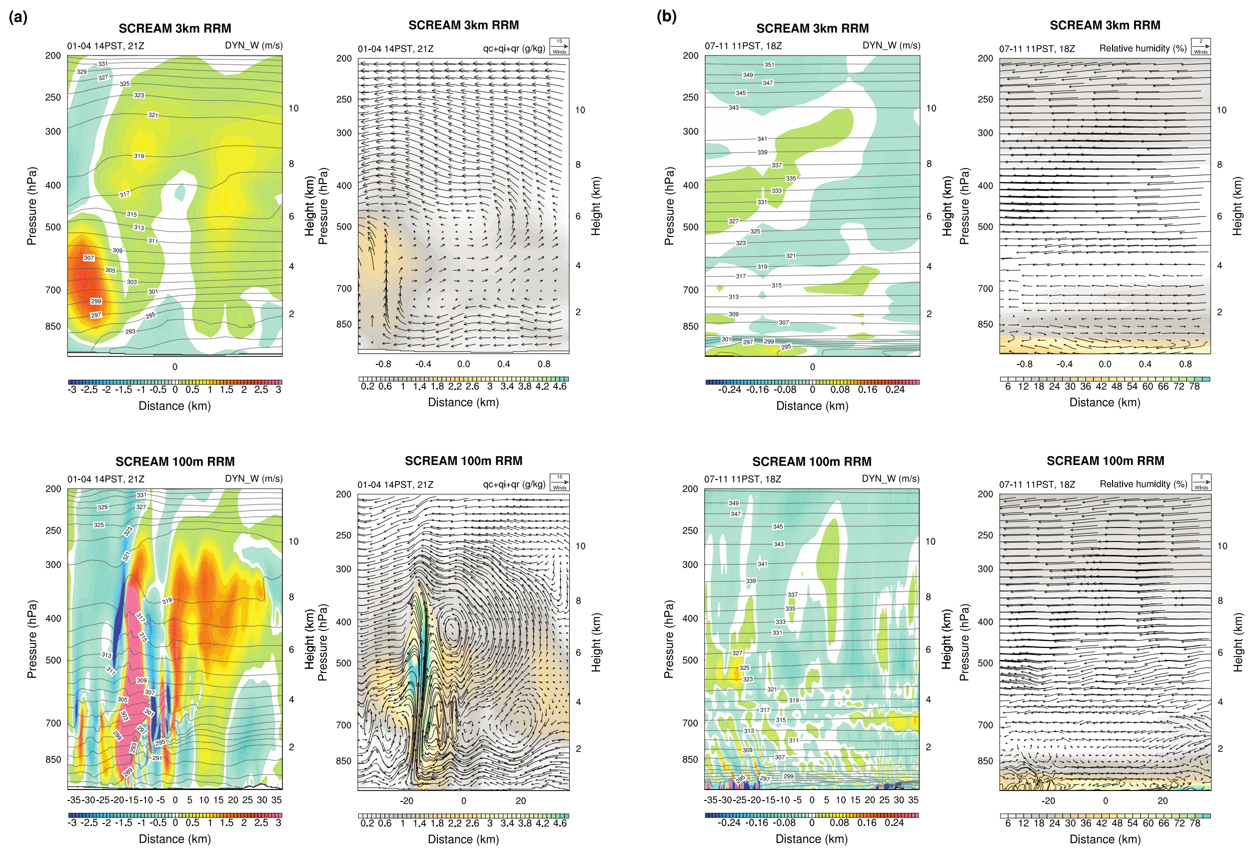

Figure 9. Cross sections (a) the Storm2008 event (2008-01-04 14 PST) and (b) the Stratocumulus2023 event (2023-07-11 11 PST) aligned parallel to the Santa Cruz Mountains extend from the southeast (238E, 37.3N) to the northwest (237.5E, 37.8N), spanning 74 km along the x-axis. The cross-section line is shown in orange-red in Fig. 4 on the IGRA station map. Each panel shows vertical velocity (shading) overlaid with potential temperature (contours) on the left, and total cloud hydrometeors (liquid + ice + rain) overlaid with wind vectors on the right, from the 3.25 km California (top) and the 100 m Bay Area (bottom) SCREAM-RRM simulations. Horizontal winds are adjusted to be parallel to the cross-section, and vertical velocity is amplified by a factor of 10.

Since the authors mentioned posting videos A1 and A2 online following the article's acceptance, I suggest increasing the font size and making the boundary lines more visible. Currently, it is difficult to see the text in the videos, even on a larger monitor.

Thank you for your nice suggestions! These two videos were generated by stitching together the png images saved from ncvis using ffmpeg. When exporting the images with ncvis, we increased the image's dpi to ensure sufficiently high quality, which automatically made the font size smaller in the saved images. Although we cannot modify the original figures directly, we can manually add text to the final mp4 files using ffmpeg. Accordingly, we have added labels for the model, case, variable, and colorbar range. The final results are shown in the updated links in the video supplement, and have been uploaded to Zenodo (https://doi.org/10.5281/zenodo.15390528, last access: 1 December 2025):

https://zenodo.org/records/15390528/files/CA100m_vs_CA3km_Storm2008_2_text.mp4?download=1

https://zenodo.org/records/15390528/files/CA100m_vs_CA3km_Stratocumulus2023_2_text.mp4?download=1

and in the screenshot below: