General Comments from Reviewer #1:

The authors developed 40-year (1980-2019) Taiwan reanalysis downscaling data with a 2-km grid from the ERA5' s hourly data using the WRF model. They also validated their results with observ ations from CWA stations, 1-km TCCIP data and the shortwave radiation data derived from Hima wari-8 satellite by CWA. The TReAD data is freely available for climate related studies and would be a very valuable data set for Taiwan. However, the reviewer has comments on procedures, data s ources, and analyses used for validation for the authors to consider. Plausible explanations on error s statistics would be very useful.

Specific comments

1. Since TCCIP is one of the major data sources for validation. This data set should be properl y described in Section 2.3, including variables, time intervals, resolution, accuracies, and perio ds each variable is available. The only information on this data set is given in Weng and Yang (2018). In the reference list, Weng and Yang (2018) is on daily grided rainfall data during 196 0-2015 in Taiwan. Furthermore, this is a gray paper and may not be readily available to reader s.

Thank you for pointing out the insufficient but important information about the TCCIP observation al data set used for validation. In addition to Weng and Yang (2018) in which the methodology wa s established and described therein, three more reference papers have been added along with a con cise description of the TCCIP observational data set. Furthermore, a climate change-related impact study of applying the TCCIP data set has been added to support the applicability. We have introdu ced a new paragraph to describe the required information of the TCCIP data set itself and the subse quent application as below.

TReAD provides high-resolution spatial data that is highly demanded in climate change application s, thus the observation-based gridded data set from the Taiwan Climate Change Projection Informa tion and Adaptation Knowledge Platform project (denoted TCCIP hereafter) has been used to evalu ate the results. "Using the methodology developed by Weng and Yang (2018), the TCCIP collect ed, digitized, and homogenized source-varying observational data sets before providing a long-ter m, applicable, gridded daily temperature and precipitation data sets for the period from 1960 to 20 23 (details of ground stations used please refer to Hung, 2012; Tung et al., 2022, climate change-re lated impact studies such as Kono et al., 2025). In addition, 1-km resolution temperature and preci pitation data were used in this study for validation."

2. In Section 2.1, in addition to model domains, physical parameterization schemes, the author s described the 1-km terrain data and land use data used. There is no information on soil type d ata used. The soil type is an important parameter for lower boundary conditions over land. Als o, there is no mention of SST data used. Did the authors use SST data from ERA5?

Thank you for pointing this out. We have added two clarifying descriptions in the revised manuscr ipt (at the end of Section 2.1) to address the soil type and SST data sources:

- *Soil type data: Although the land-use data was updated, the soil type dataset used in our si mulations remains the WRF default FAO (Food and Agriculture Organization of the Unite d Nations) 5-minute, 16-category global dataset.*
- *SST Data: The Sea Surface Temperature (SST) data is adopteddirectly from the 6-hourly E RA5 reanalysis dataset to provide the initial and boundary conditions for simulations (inclu ding 30-level pressure field variables, surface fields, skin/soil temperature, and soil moistur e).*

3. In Section 2.2, the authors describe the time integration procedures using the WRF model, i nitialized by the ERA5 data. The authors cited Lynch and Huang (1992) for the digital filter in itialization method used. Lynch and Huang (1992) is not cited in alphabetical order in the refer ence list. A brief description of this initialization technique and blending procedures should be given. In addition to initialization of atmospheric parameters, were any initializations being ma de for the lower boundary conditions over land?

Thank you for your comments on the order of Lynch and Huang (1992) in the reference list. We h ave reordered and double checked the entire order of the reference. Regarding the initialization, the applied digital filter initialization, dfi_opt=3 and dfi_nfilter=7 (default Dolph filter in WRF), simul ated backward for 30 mins and then forward for 45 min for the outer domain only. Regarding the b lending approaches, a new reference (Hsiao et al., 2015) has been added.
Procedure details are listed and added to the revised section 2.2 with a renewed flowchart (Figure 4).

1. *Create intermediate meteorological files by metgrid package, which horizontally interpolat es ERA5 data to WRF grid points.*
2. *Vertically interpolate intermediate meteorological files to sigma level of WRF by real pack age, which create initial condition and lateral boundary condition files.*
3. *Applied analysis blending scheme of Hsiao et al (2015), which blended the 3D wind, poten tial temperature, water vapor mixing ratio, and pressure in the initial condition file with tho se simulated from previous WRF run stored in the restart file for the outer domain. The inn er domain is small and no blending process is needed. The cutoff length is 1200km, the sa me as what was used in Hsiao et al (2015).*
4. *Digital filter initialization, dfi_opt=3 and dfi_nfilter=7 (default Dolph filter), simulate back ward for 30min and then forward for 45 min were exercised for the outer domain to accele rate the spin up.*
5. *For the inner domain, soil temperature and moisture from previous WRF simulation stored i n the restart file were kept to replace the ones in the initial condition file.*

6. *Run WRF for 6 hours to spin up the atmosphere, and the output won't be used.*
7. *Restart WRF runs for the rest of 6 hours and the output will be stored as TReAD data.*

4. The model has a one-month spin up period before 12-h integrations each 6 hours. For each 1 2-h integration, the simulation for first 6-h integration is not used to construct the climate time series of downscaled data. What parameters were spin up during the one-month spin up period? Why?

Thank you for this constructive comment regarding our spin-up strategy. The primary objective of the one-month spin-up period prior to the main simulation cycles is to allow the slow-varying land surface and hydrological state variables—which possess long physical memory—to adjust and rea ch thermal and hydrological equilibrium within our high-resolution (2-km) domain and the Noah L and Surface Model (LSM). Specifically, the key parameters spun up during this one-month period i nclude soil thermal and hydrological variables: Soil temperature across model layers (K), volumetr ic soil moisture content (m3 m-3), soil liquid water (m3 m-3).

5. Section 2.3: With a 2-km grid, the terrain is supposed to be well represented in the model. W hat are the differences in the actual terrain height and model terrain height at the 5 mountainou s CWA stations?

Thank you for the comment on examining the anomaly of the modelled raw terrain height from the actual height of the five mountainous CWA stations. As shown in the Table below, modelled raw h eights of the mountainous stations were mostly underestimated, up to 516.7m. To minimize the eff ect of grid-cell averaged terrain height of the WRF model, particularly on temperature, we adjusted temperatures by applying lapse rate with the differences between modelled raw heights of each gri d and the actual heights of the closest stations. This adjustment, described in revised Section 2.3 is as follows.

"Taking into account the large elevation difference between the point-based CWA observations a nd the grid-cell averages of TReAD (e.g., underestimated elevation at most mountainous locations), TReAD temperatures better be adjusted *before compared with station observation. Temperature ca n be* adjusted *by the height difference and temperature lapse rates, which vary from time to time. T o make it simple, the standard atmospheric lapse rate of 0.65°C per 100 m was used in this study."*

Table. Modelled raw heights, actual heights and the differences of five CWA's mountainous gro und stations and one station on small island

Station name	*Modelled raw height (m)*	*Actual height (m)*	*Difference (m)*
Yushan	*3328.1*	*3844.8*	*-516.7*
Alishan	*2193.8*	*2413.4*	*-219.6*
Anbu	*797.4*	*825.8*	*-28.4*
Zhuzihu	*744.7*	*607.1*	*137.6*
Sunmoonlake	*721.8*	*1017.5*	*-295.7*
Lanyu	*128.4*	*324*	*-195.6*

6. Section 2.3: For shortwave radiation data, for the CWA data derived from satellite for 2011-2018, what is the grid size of this data set? For the shortwave radiation data observed by CWA stations, what are the periods that station observed data are available?

Thank you for your comments. The horizontal resolution of the satellite-derived shortwave radiation data is 0.01° and the period with the observed shortwave radiation data depends on CWA's stations. To clearly describe the above details, we have revised the corresponding paragraph in Section 2.3 as below.

"Another key observational dataset is the shortwave radiation derived from the Himawari-8 satellite (Bessho et al., 2016), which has a horizontal resolution of 0.01°. To evaluate the simulated radiation in TReAD, both CWA station observations (available from 1993 to 2019 for most stations, see Figure S3) and the satellite-derived data (available from 2011 to 2019) were used. Since shortwave radiation was not measured at certain stations during the earlier years, only the TReAD grid points corresponding to valid station observations were selected to ensure a fair comparison."

7. Section 3: The order to present validation of ECVs is personal preference. However, since the surface p, T are affected by the terrain height, and surface winds are affected by the diurnal heating cycle, the reviewer suggests surface p, 2-m T and RH to be presented first followed by surface winds. Localized rainfall distribution and shortwave radiation are affected by locally driven diurnal winds; thus, the reviewer also suggests that these two parameters being discussed after discussion of surface winds.

Thank you for your constructive suggestion regarding the structure of Section 3 Results and Discussion. Our original arrangement placed temperature and precipitation first because these two ECVs are the most frequently requested variables by researchers. However, we fully agree with the reviewer's point of view and have re-organized the evaluation according to physical and dynamical logic—moving from surface pressure, temperature, and moisture to wind fields, followed by precipitation and shortwave radiation—significantly enhances the readability and coherence of the manusc

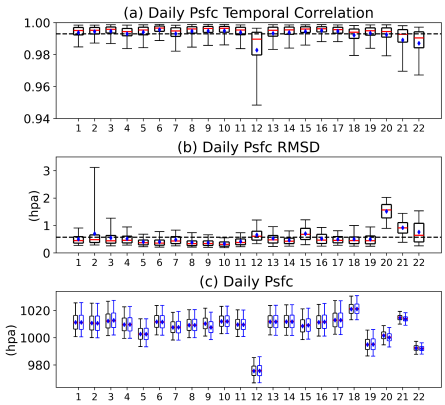
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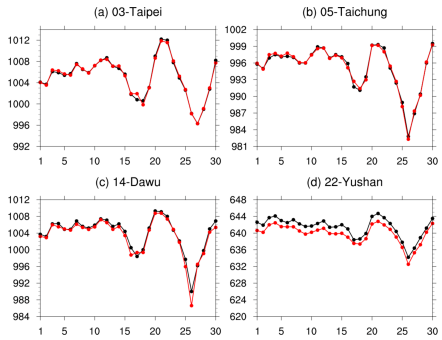
8. Section 3.3, Validation of surface pressure The correlation coefficients for surface pressure are slightly lower for 5 mountain stations (Fig. 13a), the authors suggest that this may be relate d to elevation differences between the model grids and stations even after the former is adjuste d. The elevation differences for these stations are not given. It is not apparent how adjustments to the surface pressure are made. Fig. 13b shows large RMSE values for Yushan (~9 hPa), Alis an (> 2 hPa), Tainan (> 2hPa), Chenggoang (> 6 hPa). These values are large. In addition, a lo wer coefficient with large RMSE (>3 hPa) were reported at Lanyu; the authors speculate that t he model may not catch the exact location of that station due to the fact it is located within a s mall island off the southeastern Taiwan coast (L331-332). The authors should investigate this p ossibility based on the data. During the passage of a TC, unlike the other three stations (Fig. 1 4), the simulated surface pressure at Yushan is persistently lower (more than 12 hPa) than obse rved; the authors suggested that this may be due to the lower intensity of the TC simulated. Th is explanation may not be valid as the surface pressure simulated for the three other stations ag rees well with observations. A few questions for the authors. With a 2-km grid, what are the de ficiencies of terrain height for five mountainous stations (Line 166-167) and Lanyu in the mod el? How would these differences affect the deficiencies in surface pressure at these stations? T he deficiencies at Yushan, Chenggong are relatively large with large RMSE, any reasons for th e relatively large deficiencies? The TC intensity seems to be well predicted for three stations (F igs. 14a,b,c) but why not at Yushan (Fig. 14d)?

Thank you for pointing out these key issues relating to surface pressure validation over mountaino us and remote island stations. We have substantially revised the discussion of surface pressure and Table S1 in the Supplementary Material, which now details the actual elevation, modelled raw terr ain height for all CWA stations. To respectively respond to all the suggestions, we tabulate the co mments and our responses, along with the corresponding revisement.

	Comments and questions	*Responses and revisement*
1	***The correlation coefficients for surface pre ssure are slightly lower for 5 mountain stat ions (Fig. 13a), the authors suggest that thi s may be related to elevation differences b etween the model grids and stations even a fter the former is adjusted. The elevation d ifferences for these stations are not given. Question 1: With a 2-km grid, what are the deficiencies of terrain height for five mou ntainous stations (Line 166-167) and Lany***	*Response 1: The differences of terrain elevati on for five mountainous stations (i.e., Yusha n, Alishan, Sunmoonlake, Anbu, Zhuzihu) an d Lanyu station range between -518m (under estimated) and +137m (overestimated). The modelled raw and actual terrain elevations of 20 CWA stations have been added to Table S 1 in the supplementary material.* *Response 2: Under hydrostatic equilibrium, t he modelled surface pressure varies directly*

	u in the model? *Question 2: How would these differences affect the deficiencies in surface pressure at these stations?*	*with the mass of the atmospheric column above, meaning an underestimated terrain height artificially increases the atmospheric column weight and leads to overestimated unadjusted pressure.*
2	*It is not apparent how adjustments to the surface pressure are made.*	*Thank you for this valuable suggestion. To enhance physical rigor and eliminate empirical assumptions, we have revised the surface pressure height correction in the revised manuscript by adopting the hydrostatic equation ($dz/dP = -\rho g$ and $P_{adjusted} = P_{model} - \rho g(z_{obs} - z_{model})$) where $g = 9.81\ m\ s^{-2}$ is the gravitational acceleration, and ρ is the mean atmospheric column density calculated by averaging the air density derived from the TReAD grid data and the local station observation.* *Advantages of the Revised Method:* 1. *Dynamic Thermodynamic Representation: Unlike simplified hydrostatic adjustment (e.g., a constant air density), this formulation dynamically incorporates real-time temperature and moisture perturbations from both the model and observation.* 2. *Physical Rigor: Taking the arithmetic mean density ($\rho_{mean} = (\rho_{model} + \rho_{obs})/2$) provides a more accurate representative density for the atmospheric layer between the model surface and the station elevation, significantly reducing systematic pressure bias over complex terrain.* *All calculations, figures, and statistical evaluations have been updated accordingly, and detailed methodology has been added to the revised Section 2.3 (see below).* *"To eliminate pressure biases caused by the elevation difference between the TReAD model grid cells and observational stations, simulated surface pressures were adjusted to station elevations using the hydrostatic balance equation: $dz/dP = -\rho g$ and $P_{adjusted} = P_{model}$*

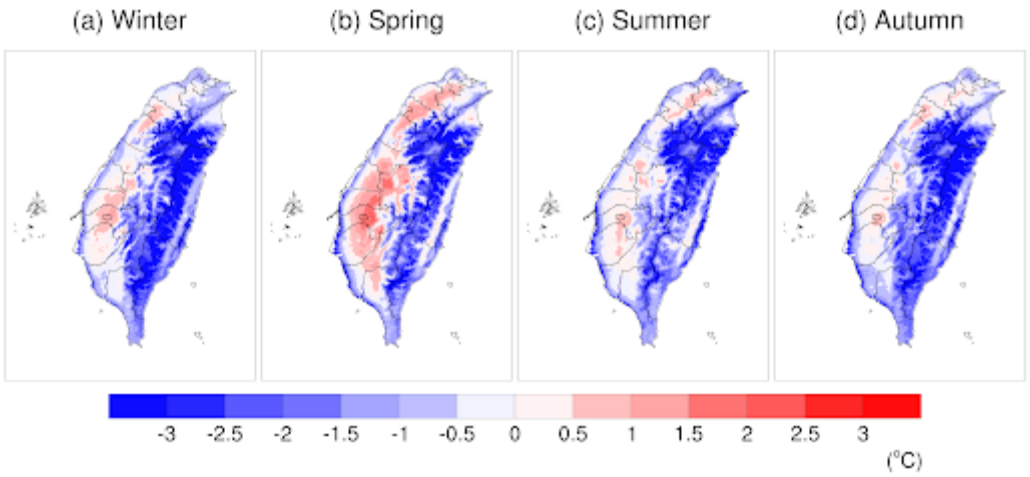
		- ρmean · g(zobs -zmodel), and ρmean is the layer-averaged air density between the model surface and station height: ρmean = (ρmodel + ρobs)/2, where ρobs = Pobs/RTobs). Here, R is the gas constant for dry air, and Tobs represents the virtual temperatures calculated from the station measurements. By integrating real-time temperatures, this approach effectively reduced the pressure biased across Taiwan's complex topography."
3	***In addition, a lower coefficient with large RMSE (>3 hPa) were reported at Lanyu; the authors speculate that the model may not catch the exact location of that station due to the fact it is located within a small island off the southeastern Taiwan coast (L331-332). The authors should investigate this possibility based on the data.*** ***Question 3: The deficiencies at Yushan, Chenggong are relatively large with large RMSE, any reasons for the relatively large deficiencies?***	*Thank you for this critical evaluation and for prompting us to refine the exact spatial representation.* *1. Improvements via the Revised Dynamic Hydrostatic Correction: In the revised manuscript, after applying the upgraded hydrostatic height correction with dynamic layer-averaged air density (ρmean = (ρmodel+ρobs)/2), the statistical verification for Lanyu, Yushan, and Chenggong improved substantially. The correlation coefficients increased, and the root-mean-square differences dropped across all three stations and beyond (see below the figure for station numbers 12, 22, 15 representing Lanyu, Yushan, and Chenggong).*  *Fig. The updated (a) correlation coefficients, (b) RMSDs of atmospheric pressure between (c) the elevation-adjusted TReAD (blue boxes) and the station-based CWA data (black boxes) for the period from 1980 to 2019.* *2. Terminology Clarification (transition from*

		RMSE to RMSD): In the revised manuscript, we have updated our terminology from Root Mean Square Error (RMSE) to Root Mean Square Difference (RMSD) throughout Section 3. This refinement recognizes that grid-based model outputs (2-km area-average) and point-based ground observations inherently represent different spatial scales. Describing the discrepancy as a "difference" (RMSD) rather than an "error" (RMSE) provides a more scientifically accurate representation of spatial scale mismatch and representativeness differences.
4	***During the passage of a TC, unlike the other three stations (Fig. 14), the simulated surface pressure at Yushan is persistently lower (more than 12 hPa) than observed; the authors suggested that this may be due to the lower intensity of the TC simulated. This explanation may not be valid as the surface pressure simulated for the three other stations agrees well with observations. Question: The TC intensity seems to be well predicted for three stations (Figs. 14a,b,c) but why not at Yushan (Fig. 14d)?***	*Thank you for pointing out this logical inconsistency regarding our previous explanation. After replacing the static assumption with our upgraded hydrostatic correction using dynamic layer-averaged air density, the simulated surface pressure at Yushan during the TC passage improved substantially. The systematic pressure underestimation (bias) was markedly reduced, and the simulated pressure trough now closely tracks the observed time series in both magnitude and phase timing (see below the revised figure).*  *Fig. Time series of daily atmospheric pressure (unit: hPa) of TReAD (red lines) and CWA (black lines) in four stations in September 2001. Typhoons Nari and Lekima hit Taiwan between 16-19 and 26-28 September, respectively.* *We have updated the results and figure to reflect the corrected pressure time series in the revised manuscript.*

9. Section 3.1, Validation of 2-m T Anomalies of long-term trend of mean temperature agree w ell with CWA station observations (Fig. 6), the long-term mean daily 2-m T also agrees well w ith TCCIP data (Fig. 8a). However, there are deficiencies. For mean daily 2-m T, there are per sistently warm bias over western plain and northern Taiwan, and cold bias over the mountaino us areas especially on the eastern slopes as compared with TCCIP 1-km data (Fig. 7). These er rors tend to cancel out in the mean temperature. The RMSE errors of 2-m T are relatively large at Yushan (~2 degrees C) even after terrain adjustment and with a lower coefficient (~ 0.7) (Fi g. 5). Also, the daily mean maximum 2-m T is persistently 1.5 degrees colder than TCCIP data (Fig. 8b). The reasons for these deficiencies should be discussed. Would the deficiencies affect the simulated daytime upslope flow? Moreover, the descriptions for TCCIP 1-km 2-m T data a re not properly given (L177-178).

Thank you for this insightful comment. We have re-evaluated the temperature biases as follows:

1. *Lapse Rate Sensitivity: Replacing monthly-varying lapse rates with the standard 0.65°C/10 0m rate yielded negligible statistical differences, confirming that temperature biases stem f rom land-atmosphere boundary layer physics rather than vertical reduction rules.*
2. *Physical Drivers of Spatial Biases: The western warm bias could be partially associated wi th an overestimation of downward shortwave radiation, whereas the mountain cold bias is d riven by overestimated rainfall and subsequent evaporative cooling.*
3. *Spatial Scale & Local Convection: Model outputs (2-km) were spatially interpolated to 1-k m for verification. The model exhibits limited capability of capturing the exact timing, spat ial distribution and intensity of localised convective systems, leading to maximum tempera ture differences in particular over high-mountain peaks like Yushan.*
4. *Impact on Thermal Circulations: Long-term (40-yr) evaluation shows persistent underestim ation of daily Tmax and overestimation of Tmin. The dampened daytime thermal response could weaken the land-sea thermal gradient, thereby moderating the intensity of daytime o nshore sea breezes and upslope winds. While Tmax is underestimated on average across th e 22 stations, the gridded output shows no underestimation—and even a slight overestimati on—over lowland regions (see below the figure of biases of seasonal Tmax). Therefore, th e model can maintain a reasonable land-sea breeze circulation and should not be significan tly affected.*



The discussion of diurnal local circulation and Tmax beyond the scope of this paper. We tend not t o add these discussion materials to the revised manuscript.

10. Section 3.6, Validation of RH (%) The reviewer presumes the authors validate the 2-m RH (%). The long-term trend of simulated 2-m RH (%) anomalies agrees well with those from the CWA station data (Fig.24). Thus, there is a mean warming and drying trend over the island wh ich is interesting. From RMSE errors (Fig. 23b) and daily time series plots during the diurnal c ycle for a few stations (Fig. 25), it is apparent that the major cities over the western plain and n orthern Taiwan (Taichung, Chiayi, Tainan, Hsinchu, Taipei) have a relatively large RMSE erro rs (Fig. 23b) with lower RH (%) especially under the summer monsoon during the daytime (Ta ichung in Fig. 25). With warmer T and drier RH, how would that affect the downscaled surface winds, precipitation and shortwave radiation over the island?

Thank you for your comments. The warm and dry bias over the major cities (temperature overesti mation accompanied by underestimated RH) could reinforce a positive feedback loop: lower RH re duces cloudiness, increasing downward shortwave radiation. Thermodynamically, this warm lowla nd surface can strengthen daytime land-sea thermal contrast, possibly enhancing sea breeze penetra tion (could intensify moisture advection) while suppressing precipitation over the flat plains due to a higher level of free convection. These discussions have been incorporated in the revised manuscr ipt.

11. Section 3.5, Validation of wind velocity. The reviewer presume wind velocity is a vector. However, Figs. 19 and 20 only show wind speeds. No information on wind direction is given. CWA station data shows decreasing wind speed over the island but not in the downscaled TRe AD data (Fig. 20). No explanation is given. Fig. 21 shows the differences in wind vectors betw een the 25-km ERA5 data and the downscaled 2-km TReAD data. The comparison is not infor mative as the ERA-5 data cannot resolve the island induced circulation and winds over the coa stal waters. The ERA5 data represents mesoscale winds over Taiwan. Perhaps, the authors may want to compare the downscale 2-km winds in the afternoon vs before sunrise to show the cap

ability of the TReAD data in simulating the island induced circulation over the island interior a nd coastal waters throughout the year.

Thank you for these constructive comments regarding wind vector evaluation. We agree your opini on about ERA5 cannot do a good job on local circulation induced by island. The reason wind direc tion is not considered as ECVs and compared in this paper is that lots of observation stations build in cities where wind directions are easily affected by nearby buildings. The affected wind direction is less informative and cannot be well simulated by region models.

Regarding the issue of no decreasing trend of wind speed in TReAD, the major reason could be tha t TReAD inherit it from ERA5. Because ERA5 data is the main driver and it also show no decreasi ng trend. After checking the averaged standardized wind speed in Figure S1, it shows that the decr easing trend of observation is smaller and the variation is much closer to observations over the rece nt two decades.

This paper focus on the performance of daily ECVs. Although model did capture good summertim e diurnal local circulation and reasonable distribution of local rainfall, however it won't be presente d in this paper.

These discussions (see below the paragraph) have been incorporated in the revised manuscript.
"velocity" was changed to "speed"
"Discrepancies in 40-year terrestrial wind speed trends may be caused by there is no wind speed decreasing trend in ERA5, which is the major to drive TReAD simulation. Moreover, the decreasin g trends were found and dominated by some stations. Checking the averaged standardized wind sp eed in Figure S1, it shows that the decreasing trend of observation is smaller and the variation is m uch closer to observations over the recent two decades.."

12. Section 3.2, Validation of precipitation. Were the hourly rainfall data or daily rainfall accu mulation from TReAD and TCCIP data used in this section? TCCIP data is available only duri ng 1960-2015 (Weng and Yang 2018), when compare with TCCIP data, did you use the TReA D data for the same period? Correlation coefficients with CWA rainfall data are low compared to other ECVs (Fig. 9a). The RMSE errors from all stations are > 10 mm which is relatively lar ge as compared with the observed daily rainfall accumulation which may be rather typical (Fig. 9b). The anomalous annual precipitation for TReAD and CWA are consistent (Fig. 10) but wit h smaller anomalies for TReAD. Since the authors suggest that rainfall over Taiwan is affected by terrain effects, the authors should discuss how do the terrain effects affect temperature, RH, winds over land and coastal waters and precipitation? Are those effects captured by TReAD 2-km data in some way? In Fig. 11, does the figure show the average daily rainfall accumulation for TReAD and TCCIP during the same 1960-2015 period? The figure caption states the botto m row is the difference between TReAD and CWA data. Can you explain the CWA data used? Do you use the daily rainfall from CWA stations? Could you adjust the color table? What are t

he main deficiencies in daily rainfall accumulation from TReAD? Would that impact the accur acy of the TReAD shortwave radiation data?

Thank you for these valuable and comprehensive comments regarding precipitation verification me trics, observational datasets, color scale improvements, and topographic-radiative interactions. We address each sub-point below:

- *Accumulation interval and time period: All precipitation evaluations and comparisons with the TCCIP dataset were performed using daily accumulation rainfall (mm/day) for the iden tical period from 1980-2019 to ensure consistency.*
- *Clarification on data source of original Fig. 11: the observation field is derived from the T CCIP dataset (which is based on CWA rain gauge stations across Taiwan).*
- *Color table improvement: According to the suggestion, the color scale has been refined and shown clearer gradient contrasts to better distinguish light, moderate and extreme heavy rai nfall distributions.*
- Topographic effects on local precipitation mechanisms: Taiwan's steep terrain governs loca lized precipitation through coupled dynamic and thermodynamic mechanisms. TReAD reas onably captures the primary topographic dynamics, but fine-scale spatial discrepancies exis t. High-resolution precipitation is notoriously difficult to align perfectly in space and time. Discrepancies stem from minor spatial position shifts (displacement errors) of simulated co nvective cells over Taiwan’ s terrain. A slight horizontal shift of a convective rainband le ads to large grid-to-grid biases, so that artificially increasing RMSD despite capturing the o verall rainfall system. To sum up, the main limitation of TReAD precipitation includes loc alized convective displacement and mountain peak intensity overestimation.
- Impact on downward shortwave radiation: In regions where the model overestimates precip itation, simulated convective cloud cover is unrealistically thick and persistent, leading to a localized underestimation of downward shortwave radiation. Conversely, over lowland plai ns where rainband position shifts lead to localized rainfall underestimation, cloudiness is u nderestimated, causing the overestimation of downward shortwave radiation and warm bias es. While excessive precipitation typically increases cloudiness, the concurrent overestimat ion of radiation and precipitation point to other factors including model parameterization. F or example, the simulated convective clouds could be thinner than observed, despite produ cing heavy rainfall, if the cloud optical thickness and cloud fraction were underestimated in microphysical parameterizations. In addition, the satellite-derived radiation could be under estimated if a higher cloud fraction is simulated, particularly over regions with frequent oro graphic clouds.

The refined figure and the expanded discussions have been updated in the revised manuscript. (see below)

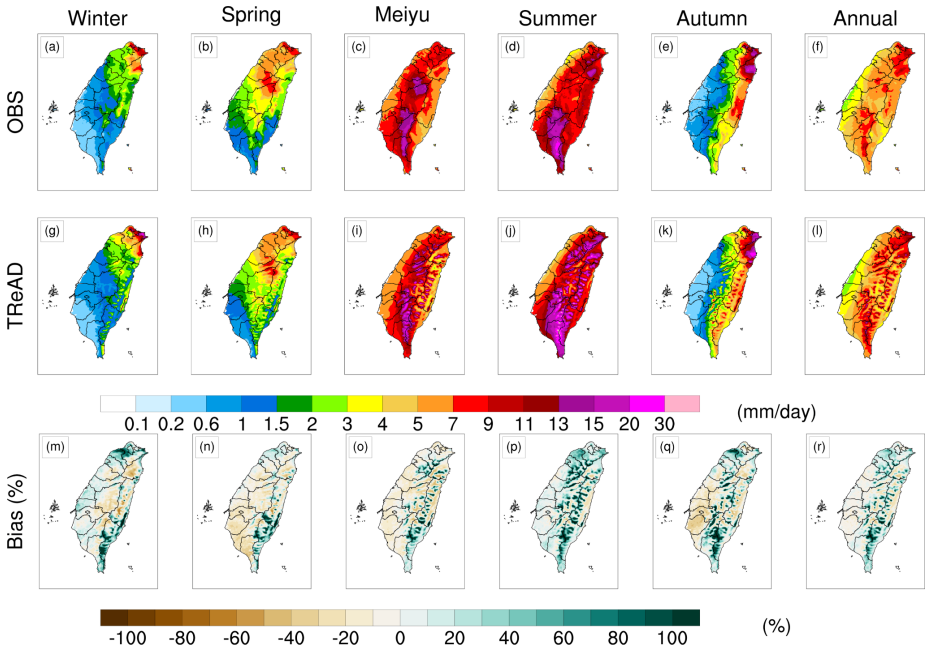


Fig. Spatial comparison of long-term seasonal and annual mean of daily accumulated precipitation for (top row) gridded observations (OBS, interpolated from CWA stations) and (mid row) 2-km T ReAD, (bottom row) TCCIP and the biases (TReAD minus OBS) for the period 1980 to 2019. Sea sons are indicated as the title of each column: Winter, Spring, Meiyu, Summer and Autumn and th e Annual mean (from left to right).

"Taiwan's steep topography governs localized precipitation through coupled dynamic and thermo dynamic mechanisms. While the TReAD dataset reasonably captures the primary macro-scale topo graphic characteristics and rainfall distribution, fine-scale spatial discrepancies remain. These discr epancies could stem primarily from minor horizontal position shifts of simulated convective rainba nds over complex terrain. Since high-resolution precipitation is sensitive to spatial alignment, a slig ht displacement of a convective cell could lead to substantial localized grid-to-grid differences and artificially increase RMSD, despite the overall rainfall system being captured. Consequently, the m ain limitations of TReAD precipitation lie in localized convective displacement and intensity overe stimation over mountain peaks."

13. Section 3.4, Validation of shortwave radiation. The units used in Fig.18 and other figures a re not consistent. Any reasons for the use of different units? Are shortwave radiation data relat ed to rainfall in some way? In compassion of anomalies of annual shortwave radiation data bet ween TReAD and CWA station-based data between 1980-2019, there are differences (Fig. 16). The CWA based data used for comparison should be described.The seasonal means of the shor twave radiation data from CWA, TReAD and ERA5 from 2011-2018 were compared and given in Fig. 17. What is the horizonal spacing for CWA satellite derived data? Information on the d ata set used should be given. It is apparent that the shortwave radiation data from TReAD is no t very useful with significant deficiencies. No explanation is given.

Thank you for these constructive comments regarding unit consistency, observational dataset descr

iptions, precipitation-radiation relationship, and simulated radiation biases. We have addressed eac h point below:
1. Units consistency: All units in the radiation-related figures have been revised to MJ m-2 day-1.
2. Details on observational datasets (CWA Ground Stations & 1-km CWA Satellite Inferences): De tailed descriptions of the radiation observational datasets (see the response of comment No.6) have been added to Section 2.3.
3. Precipitation-radiation relationship: In regions where the model overestimates precipitation, sim ulated convective cloud cover is unrealistically thick and persistent, leading to a localized underest imation of downward shortwave radiation. Conversely, over lowland plains where rainband positio n shifts lead to localized rainfall underestimation, cloudiness is underestimated, causing the overest imation of downward shortwave radiation and warm biases. However, it is worth mentioning that c oncurrent overestimations of both precipitation and shortwave radiation occur possibly due to micr ophysical parameterization—such as underestimations of cloud optical thickness or cloud fraction t hat render heavy rain-producing clouds optically thinner than observed. Additionally, satellite-deri ved radiation observations may exhibit inherent negative biases in regions with frequent orographi c cloud cover, contributing to the perceived radiation overestimation.

The above discussions have been incorporated in the revised manuscript.