

Title: Meteorological Evaluation of the MERRA-2 Reanalysis Dataset: Insights for the Indian Subcontinent

Manuscript ID: egusphere-2025-4229

Review of the manuscript titled “Meteorological Evaluation of the MERRA-2 Reanalysis Dataset: Insights for the Indian Subcontinent by Malasani et al.,

This manuscript presents a comprehensive and well-executed evaluation of MERRA-2 meteorological fields over the Indian region using multiple independent observational datasets. The analysis is thorough and covers a wide range of key variables across seasons and pressure levels, which significantly strengthens the credibility of the results. The identification of variable- and region-specific biases, particularly in the lower troposphere and over complex terrain, is especially valuable given the widespread use of MERRA-2 data in climate and chemical transport modeling (CTMs) studies over India.

I would like to mention that the authors have done a huge amount of work by using datasets from the different platforms as its is not really easy to deal with bulk datasets from various platforms. Also the authors used the datasets for validation that has already assimilated in MERRA2, so this is also very interesting to see how the final assimilated MERRA2 is varying from the original observation data from satellites and observations.

Overall, this is a well-written and informative study that provides useful guidance for the appropriate use of MERRA-2 data over the Indian region, and it represents a valuable contribution to regional reanalysis evaluation efforts. Thus, I would like to recommend it for publication with minor corrections.

We sincerely thank Reviewer 2 for the thorough and constructive evaluation of our manuscript, and for the kind and encouraging comments regarding the scope and quality of the work. We are pleased that the reviewer found the analysis comprehensive and the identification of variable- and region-specific biases valuable. We also appreciate the reviewer's acknowledgement of the complexity involved in handling multi-platform datasets and the scientific interest of comparing MERRA-2 against its own assimilated observation. We believe that these revisions adequately address the reviewers' comments and have improved the overall quality and clarity of our manuscript. Comments by the reviewer are given in **black**, our response to the comments are shown in **blue**.

To improve readability, we numbered each reviewer comment in the style R.C. 2.1 for Reviewer 2 Comment 1 and A.R. 2.1 as author's response to reviewer 1 comment 1, respectively. Please find below our point-by-point response to all comments.

Minor Corrections;

R.C.2.1. The presentation could be further improved by slightly streamlining the description of results to enhance readability, particularly in sections where multiple statistics (MB, RMSE, correlation) are discussed together. Additionally, a brief summary table highlighting the main strengths and limitations of MERRA-2 across variables and regions could help readers quickly grasp the key findings.

A.R.2.1: We thank the reviewer for this suggestion. Regarding the streamlining of statistical descriptions, the Results section has been revised to consolidate the discussion of MB, RMSE, and correlation where appropriate, improving readability by presenting the statistical metrics in a more integrated manner.

Regarding the summary table, we respectfully note that the findings vary substantially across variables, seasons, pressure levels, and regions, making a simplified tabular summary potentially misleading. Instead, the concluding paragraph has been substantially revised to provide a concise quantitative summary of the key findings for each variable, including specific bias values and correlation ranges.

R.C.2.2. When discussing warm and cold biases in temperature and moisture fields, a brief physical explanation (e.g., boundary-layer processes, terrain representation, or data assimilation influences) would enhance the interpretability of the results.

A.R.2.2: The physical explanations for the warm and cold biases in temperature and moisture fields are already provided in the revised manuscript. The larger RMSE values and lower correlations in the lower troposphere are attributed to complex boundary layer processes, land-atmosphere interactions, and topographic influences, together with the reduced sensitivity of AIRS temperature retrievals near the surface. The reduced agreement during the monsoon season is attributed to enhanced spatial and temporal variability in atmospheric moisture arising from active monsoon circulation and deep convective processes. These explanations are consistent with the reviewer's suggestion and are discussed in detail in Sect. 3.2 of the revised manuscript.

R.C.2.3. The overestimation of monsoon rainfall over complex terrain is an important finding. Indicating whether this bias is spatially localized or widespread within mountainous regions would add clarity.

A.R.2.3: This has been partially addressed in response to R.C.1.130 and R.C.1.131. To further clarify, the overestimation of monsoon rainfall in MERRA-2 over complex terrain is not uniformly widespread but rather spatially localized to specific orographic features. The largest positive biases are concentrated along the windward slopes of the Western Ghats and the Himalayan foothills, where orographic lifting of moisture-laden monsoon winds is most

intense. Over the interior of the Tibetan Plateau and the leeward slopes, MERRA-2 tends to underestimate precipitation, consistent with the rain shadow effect. This spatial heterogeneity of the bias has been clarified in the revised manuscript.

R.C.2.4. Please ensure consistent formatting of units (e.g., m s^{-1} , mm d^{-1}) and statistical symbols σ throughout the manuscript.

A.R.2.4: Thank you for this observation. The formatting of all units and statistical symbols has been reviewed and standardised throughout the manuscript.

R.C.2.5. The larger discrepancies with radiosonde-derived tropopause pressure compared to AIRS are interesting. A short discussion on potential causes (e.g., vertical resolution differences or detection methods) could strengthen this section.

A.R.2.5: Following the reviewer's suggestion, a brief discussion of the potential causes of the larger discrepancies between MERRA-2 and radiosonde-derived tropopause pressure compared to AIRS has been added to the manuscript.