Review of manuscript "egusphere-2024-3150"

Title: Weather systems associated with synoptic variability in the moist margin

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Summary and recommendation

The study investigates the association of synoptic-scale weather systems with transient structures of enhanced atmospheric water vapor in regions just outside the very moist tropical atmosphere. The authors investigated the role of equatorial waves, monsoon lows, and upper-tropospheric potential vorticity anomalies in modulating the occurrences and characteristics of these moist air perturbations. They found a spatially varying relevance of these weather systems in the occurrence and properties of wet perturbations as can be expected from the different atmospheric circulation regimes from tropical and extratropical origin.

I found the manuscript very well written, clearly structured, presenting very interesting results based on a thorough and solid analysis. The research goals, methods, findings, and conclusions are in line with another. I very much appreciate the clear presentation and description of the results. I recommend publishing the manuscript after the authors considered two general comments and several very minor comments as detailed below.

General comments

1. Relevance of moist margin objects associated with weather systems.
While the overall analysis of the study is very interesting, carefully designed, and informative, my only more general comment is that the information presented in Figures 3 and 4, and the corresponding text in section 3.2, does not account for the spatially varying climatology of the considered weather systems. For example, more than 35% of wet perturbations is associated with active CCTWs (Fig. 3), and around 60% of wet perturbations at 180E, 20N are linked to cyclonic PV anomalies (Fig. 4g). This information doesn't necessarily tell much since these fractions may arise from the matching of wet perturbation and weather system objects by chance. In other words, the fractions may be strongly influenced by the underlying, spatially varying climatology of the wet perturbations and weather systems, as the authors also recognize in lines 231-238. To evaluate the importance/association of the weather systems for/with wet perturbations, the authors may consider to add some form of significance testing (for example, based on a Monte Carlo test) or by computing odds ratios of wet perturbations occurring in association with the weather systems with respect to the matching of these objects if they would occur completely independent of another (for example, by comparing the observed fractions of wet perturbations associated with weather systems to the median fractions of wet perturbations associated with weather systems based on randomized timeseries from a Monte Carlo test).

2. Seasonality.
As mentioned, in my opinion, the analysis is very thorough and leads to interesting and meaningful results. That saying, the study is based on a year-round analysis, and I was wondering if the authors had considered looking into seasonality. For example, are there strong deviations in the relationship between the wet perturbations and weather systems during different seasons of the year? This is merely meant as a suggestion to consider since the study is already rather complete as is.

Specific comments

Line 5. Please, consider writing “upper-level potential vorticity (PV) anomalies” for more accuracy?

Line 8. “equatorial Rossby waves”?

Line 10. To clarify the extratropical nature, perhaps write, “extratropical wave-like signal”?

Line 11. Consider replacing “remotely” by “upstream” (as derived from Fig. 6f)?

Line 11. Specify the text speaks about “moist margin objects”?

Line 30. Perhaps write “derived from the dry shallow water equations”?

Line 96. Would it be useful specifying the focus is on the “lower midlatitudes” instead of the more general “extratropics”?

Line 102. The authors may consider removing the phrase “such as PV streamers” since such streamers can easily exceed the mentioned surface area threshold.

Section 2.3. It may be helpful for readers to add one-two sentences how the tracking of objects in time is realized, for example, based on spatial overlap of the objects in daily mean fields?

Line 118. The phrase “are very nearly normally distributed” reads somewhat odd to me and rephrasing may be considered.

Figure 2a. Would it be possible to add some form of reference of the climatological moist margin, or moist tropical reservoir, for example, by adding a contour(s) where at least 50% of the days of the year the TCWV is larger than 45 kg m-2 or simply the annual or seasonal mean TCWV contour at 45 kg m-2?

Lines 155-156. Given that the text speaks about weather systems as “predictors” of moist margin objects, some form of significance testing or odds ratios in spatial maps may be valuable given that the weather systems objects have a (strong) spatially different climatology and may “by chance” be linked to moist margin objects. Please, see general comment #1.

Lines 184-188. While the description of the results is accurate, some interpretation may be added. For example, does the relatively high wet perturbation frequency in some of regions near the equator tell that mesoscale processes are dominating the occurrences of wet perturbations in these regions? Also, the increasing relevance of cyclonic and anticyclonic PV anomalies towards higher latitudes seems to reflect the latitudinal dependency of the extratropical forcing.

Lines 198-199. A word of caution may be added here. The larger association of wet perturbations with weather systems, and vice versa, may (in part) stem from the higher likelihood of large wet perturbations overlapping by chance with any weather system compared with smaller wet perturbations.

Line 200-202. The described order of different weather systems linked to wet perturbation properties seems to be correct for the precipitation (Fig. 5c) but not for TCWV anomaly (Fig. 5b) where anticyclonic PV anomalies are associated with largest TCWV anomalies, followed by LPS and cyclonic PV anomalies.

Line 206-207. Could this “southern or northern edge of the background state moist margin” be added to Fig. 2a (please, see also one of the previous specific comments). In addition, it may be helpful for readers adding the motivation for the choice removing specific structures.

Figure 6. I would be curious to know how the composites are constructed given the spatially varying distances between grid points across latitudes.

Line 217. The “wave-like pattern” seems to emerge in the moisture, PV, and MSLP fields, but not necessarily in the “precipitation” field?

Line 221. Perhaps add some interpretation on the observed “cyclonic PV anomaly poleward and westward of the object center” implying a poleward and eastward flow transporting moisture of tropical origin into higher latitudes.

Line 241-242. Do the defined odds ratios also account for the spatially varying climatology of the weather systems and wet perturbations? In other words, if let’s say LPS are relatively frequent in a specific part of the world, are the relative changes of nearby wet perturbations considered for these specific regions?

Line 249. Did the authors perhaps mean to say “more zonally confined”?

Lines 275-276. Perhaps some interpretation can be added on the cyclonic and anticyclonic PV anomalies which although independently defined, are in reality closely associated with another, being part of extratropical Rossby wave trains (with embedded trough and ridge structures) propagating into low latitudes (as visible in Fig. 1 weat and east of Australia and over South America).

Lines 280-281. “tend to be the least important”, perhaps specify in terms of surface area, moisture and precipitation properties? In addition, as mentioned before, a word of caution may be added since larger wet perturbations have by definition a larger likelihood to be connected with weather system objects.

Line 306. Likely a typo, “m s-1”.

Figure 8. What surprises me quite a bit is that the zonal velocity of wet perturbations associated with cyclonic and anticyclonic PV anomalies is primarily westward. I would have expected a clear eastward velocity for the larger part of the distribution given the prevalent westward-eastward direction of extratropical Rossby waves and associated PV anomalies. Do the authors have any explanation in this regard? Could it be there are some artefacts or limitations in the tracking of wet perturbations, missing wet perturbations moving fast in time in extratropical latitudes where background winds are typically larger than in (sub)tropical latitudes, potentially leading to a lack in spatial overlap of structures in daily mean fields (assuming this is how the tracking is defined)?

Line 380. The same reference is mentioned twice.

Line 406. “demonstrating the significance of synoptic dynamics”, for what? Please, consider to be more specific.

Line 407. I can’t follow exactly the phrase “which occurs around one quarter of the time”; does it refer to wet perturbations associated with the PV anomalies or to the climatology of the PV anomalies itself? Instead, would a more general interpretation of the role of the extratropical forcing be valuable?