Review of Galewsky and Los 2025

February 6, 2026

I was disappointed by the brevity of the response to reviewers. For my comments there is just one page (twice shorter than my initial comments!) with just a few selected points and vague responses of a few lines. I would have expected a more detailed point-by-point review to better assess the improvement on the manuscript and better understand the choices made by the authors.

The article has been improved with the inclusion of an enriching effect of liquid-vapor exchanges as an increasing function of mesoscale ascent. Now the analytical model is able to reproduce the larger sensitivity to mesoscale ascent of δD relative to q. However, from a physical point of view, considering liquid-vapor exchanges with no moistening rather than rain evaporation brings some inconsistencies. In addition, the theoretical model deserved to be better explained and justified.

1 Major comments

1.1 Better highlight the role of rain evaporation

- The addition of rain evaporation in the model is a key component of the model and of the interpretation. It should be explained in the abstract.
- l 36: add the key role of rain evaporation.
- I don't understand how diffusive exchanges can enrich the water vapor. Hydrometeors come from the cloud layer, so they come from the condensation of a vapor that is more depleted than the SCL. So **diffusive exchanges alone would deplete the vapor**. The only process that can enrich the water vapor is total or **near-total evaporation of rain drops**, e.g. [Tremoy et al., 2014, Graf et al., 2019]. So the process to incorporate in the model is not just diffusive exchange, it is rain evaporation. This could easily be incorporated as an input of water with the isotopic composition of hydrometeors.
- It's awkward to argue that rain evaporation impacts more δD than q using a model in which the impact of rain evaporation on q is neglected. It is a **circular rationale**. So I recommend to explicitly account for the role of rain evaporation on both q and δD.
  l 394: "net vapor mass changes may be small": this deserves to be shown, otherwise the rationale showing small impact on q is circular.
- Be more explicit by correctly naming physical processes:
  - l 260-263: these are very vague sentences. Be more explicit on the physical processes: rain evaporation?
  - l 271-273: "additional dynamical modulation of this process": if it was just a modulation of surface evaporation and mixing, q and δD would keep the same slope with or without W. So you have to incorporate additional processes: name rain evaporation?
  - l 284: "cannot be treated as a simple two-endmember system" be more explicit: how should it be treated? As a 3 endmember system, with surface evaporation, entrainement and rain evaporation?
  - l 313: "where mesoscale circulation most strongly influence": directly, or through rain evaporation?

1.2 Clarify the model

- The **model equations should be in the main text**. They are necessary to understand what are the key physical ingredients of the model. Otherwise, the model looks like something magical, and we discover only at the end that there were tricks that artificially made things work. Also, each model equation, hypotheses, approximations should be made explicit. The inclusion of arbitrary choices and tunable parameters should be highlighted, and whenever possible, justified by previous studies.
- A schematic illustrating the reservoirs, fluxes and processes taken into account in the model could be useful.
- Clarify the role of parameter tuning in the model:
  - l 219-221: this needs much more explanations: what tunable parameters are incorporated? What is the sensitivity to these tunable parameters? What are the risks of overtuning?
  - l 320: "without ad-hoc tuning": the representation of evaporation includes ad-hoc functions and tunable parameters. This should be acknowledged.
- more comments on the model formulation in the detailed comments

1.3 Deepen the discussion

- Here the model assumes a relationship between W and rain-vapor exchanges. Is this relationship expected to be universal or case-specific? Should it depend on the cloud organization? On aerosols? On thermodynamical conditions? To what extend could these results be generalized to other regions or cloud organizations? What could be done to address these questions? -> This could be discussed in the "Discussion" section.
- l 253-254: what mechanisms are responsible for the localization of the correlation maximum? Is it due to the shape of the W profile? Does it correspond to the rain evaporation maximum just below cloud base?
- Better discuss and more precisely name physical processes. In absence of a deeper discussion on physical mechanisms, the sentence "... sharpens the physical picture ... " seems exaggerated. What are the physical mechanisms revealed by your study?

2 Minor and detailed comments

- l 5: it's hard to compare a response of δD with a response of q. Reword: e.g. "substantially exceeding the response that would be expected from that of humidity if considering a mixing model."?
- l 5: does this conclusion holds only if the regression slopes are unstandardized? Or is it robust enough to hold whatever the kind of slopes we calculate? The abstract would be stronger of it was robust, in this case remove "unstandardized".
- l 36: "mixing with unsaturated air from below": can you be more precise about this process? Aren't we considering the sub-cloud layer? If so, there is no air below the SCL. And by definition, the SCL is unsaturated itself, so why write "mixing with unsaturated air"?
- I would put Fig 4 before fig 3, because we need to see the time-series of E and W before considering their correlations.
- Fig 4 c: at what altitude are these water vapor measurement made?
- l 144: "()A)" -> "(A)"
- l 174-188: What is the role of the standardisation? Is the result robust whatever the kind of slopes we calculate? I expect so. If so, give both standardized and unstandardized coefficients.
- l 174-175: Are there no units?
- l 187: and for humidity, can you also give the regression lines and the deduce the unstandardized η values? This would be useful to support l 189.

- l 201: “passive reservoir”: what do you mean? This is unclear wording.
- l 211: no, it’s not “orthogonal”, just non-parallel.
  same l 226: it’s not “nearly orthogonal”.
- l 211: why “active processing”? What would be a “passive processing”? Can you name the process: liquid-vapor diffusive exchange, or rain evaporation?
  Same caption fig 8.
  Same l 281: “dynamically modulated rather than passive”: clarify.
- Fig 8: it would be easier to capture the model-observation agreement if adding (a) observations (similar as fig 6a) and (b) model, using same line styles and color codes.
- l 219: “enriched hydrometeor equilibrium”: clarify: do you mean that the composition of the water vapor of the SCL is relaxed toward the composition of a vapor in equilibrium with some hydrometeors, and that this relaxation has an enriching effect? This should be better discussed.
- l 342: “F_{ent} is the net entrainment flux”: I’m not sure, because F_{ent} is negative (eq A1) whereas the net entrainement flux is expected to be positive. As defined in eq A3, F_{ent} is not the entrainement flux but the net specific humidity tendency due to entrainement.
- What is the rationale for formulating ϵ_{eff} this way? Are there any previous studies supporting such a formulation?
- How are variables tuned? Cite previous studies or observations to justify orders of magnitudes?
  - l 410: How is λ tuned?
  - l 412: How is γ tuned?
  - l 411: How is R_{rain} chosen?
  - l 413: “within physically reasonable bounds”: based on what observations or process?
  - l 413: “optimized”: how?
- These comments may become useless if my recommendation to represent rain evaporation, rather than rain-vapor diffusive exchanges, is followed:
  - Eq A12: Why should $F_{iso,ex}$be formulated proportional to q_{BL}?
  - l 392: Why “isotopic re-equilibration” only, in spite of the SCL being unsaturated?
  - Rationale for the formulation of k_{ex}? Any justification based on previous studies?
  - l 411: What does R_{rain} physically represent? If it the vapor in equilibrium with a droplet formed in the cloud layer, it should be more depleted than the vapor in the SCL.

References

[Graf et al., 2019] Graf, P., Wernli, H., Pfahl, S., and Sodemann, H. (2019). A new interpretative framework for below-cloud effects on stable water isotopes in vapour and rain. *Atmospheric Chemistry and Physics*, 19(2):747–765.

[Tremoy et al., 2014] Tremoy, G., Vimeux, F., Soumana, S., Souley, I., Risi, C., Cattani, O., Favreau, G., and Oi, M. (2014). Clustering mesoscale convective systems with laser-based water vapor delta18O monitoring in Niamey (Niger). *J. Geophys. Res.*, 119(9):5079–5103, DOI: 10.1002/2013JD020968.