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Impact of upstream moisture structure on a back-building convective precipitation system in south-eastern France during HyMeX IOP13

Introduction

This piece of work investigates how the simulated accumulation, duration and extent of rainfall in an observed convective event respond to variations of the moisture content in the upstream air (in two different layers: the marine boundary layer below 1 km ASL; and the free atmosphere between 1 and 2 km ASL). The general finding is that higher moisture availability leads to increased rainfall (in terms of either duration or amount). Some subtle deviations to this general pattern are documented, but are not explained in great detail.

Recommendation

The manuscript is written in good English and figures are very well made. The authors do a good job in justifying the design of the sensitivity study and in documenting the findings. However, they could do better in the interpretation and critical examination of the results. I have the feeling that there could be a bit more of physically- and dynamically-based reasoning in the explanation of the observed sensitivities (see for instance comment 1 below).
Even if the study is well designed and there is no major flaw in the arguments, I honestly have doubts about the degree of novelty and significance of the results. Here we have a sensitivity study that demonstrates that rainfall rates depend on the upstream moisture, mostly in fairly obvious ways. Is this really new enough to justify publication?
I recommend requesting major revisions before accepting the manuscript.

Major comments

1. While the sensitivity to moisture variations in the MBL seems rather obvious, that to moisture variations in the 1-2 km layer doesn't seem to be. Unfortunately, the authors don't do much to explain it.
   To clarify: Simulations show that moistening the 1-2 km layer enhances precipitation, in terms of duration and extent. Conversely, drying that layer reduces both precipitation duration and amount.
   I find it hard to reconcile this finding with the ideas, suggested by the authors themselves, that: (1) the moisture supply for the convective system comes from the marine boundary layer, below 1 km ASL; (2) air in the cold-air-pool mostly descends from the 1-2 km layer; (3) the precipitation rate is mostly governed by the cold-air-pool dynamics.
   Cold-air-pools are generated by the latent heat uptake due to evaporating precipitation in the convective downdraft. Evaporation should be enhanced if it occurs in a drier air mass, so drier mid-level air should imply greater evaporative cooling and a stronger cold pool. But the manuscript documents just the opposite, so this is not a good explanation.
   What is then the causal relationship between the moisture variations in the 1-2 km layer and the observed sensitivity? Can the authors clarify them?
2. The initialization of the sensitivity runs with dry or moist bubbles, and the related consequences, could be described better. Even if they can be guessed by the reader, several aspects are not thoroughly explained. (A) How far do the bubbles travel, between the model initialization and the initiation of convection? (B) How is their shape deformed? (C) Most importantly, do bubbles follow exactly the same trajectories for all sensitivity runs? How much do the trajectories differ between runs? (D) Most of the initial profiles in Figure 5

differ by constant amounts in either the lower or upper layer, but this is not always the case. For instance, the *5P profiles deviate from this pattern. Why?

3. Naming the two experiment series MST* and DRY* is confusing, because runs 1-2-5M are dry in both series, while 1-2-5P are moist in both series. I suggest renaming to MBL* (for "marine boundary layer"; e.g. MBL5M) and FA* (for "free atmosphere" – or something similar).

<u>Minor comments</u>

4. Page 1, line 14: "intensive observation period". Please introduce the acronym IOP here.
5. Page 1, lines 18-20. Sentence unclear. The response of what to what?
6. Page 1, lines 27-28. A lifetime can be "shortened", but an amount is "reduced".
7. Page 2, line 3: "At the same time". At the same time of which event?
8. Page 2, line 6: "in lower troposhere" → "in the lower troposhere".
9. Page 3, lines 12-13. Please split this sentence. "...over the sea. These are difficult...".
10. Page 3, line 21: "disturbances" → "disturbance".
11. Page 4, line 1: "moist structure" → "moisture structure".
12. Page 4, line 18: in a bulk one-moment microphysical scheme, the number concentration of cloud concentration nuclei is prescribed. What value was used? Is it appropriate for maritime convection?
13. Page 6, line 12: "French coasts" → "French coast".
14. Page 7, line 6. The meaning of "WVMR" can be easily guessed, but it is better to expand the acronym on its first occurrence.
15. Page 8, lines 3-10. This is a very long sentence. Consider reformulating: "To investigate the WVMR impact on the location, intensity and duration of precipitation, we consider several indicators…".
16. Page 8, lines 10-19. Traditionally, figures are numbered in the same sequence as they are cited. Here, the order of citation is awkward: 6-10-7-13-8-14-9. Please fix.
17. Page 9, line 20: "in the mountainous region of close to Marseille". Confusing. Consider deleting. "West of 6 °E" is easier to understand.
18. Page 9, line 22, Figure 9. How are the CAPE values computed? Are they spatially averaged? What is the initial height of the rising parcels?
19. Page 10, line 3. Does an air mass "weaken"? What you referring to, exactly? Virtual potential temperature? Extent of the cold-air pool?
20. Page 10, line 5: "This combination of decreased CAPE and weakened cold pool can explain the weakened precipitation". The causal link is unclear. Does the cold pool become weaker because of the weaker precipitation, or viceversa?
21. Page 10, line 21: "Instead of CNTL of 435 min" → "Instead of 435 min in CNTL".
22. Page 11, line 11: "in the MST1P" → "in MST1P".
23. Page 11, lines 24-25. "CAPE favours triggering". CAPE doesn't favour triggering. Roughly speaking, CAPE quantifies the "degree of instability". You can have high values of CAPE and no way to overcome convective inhibition. Conditional instability (steep mid-level lapse rate) is one ingredient of deep moist convection; triggering (uplift) is another one.
24. Page 12, line 13: "The duration are" → "The duration is".
25. Page 13, line 4: "Increased over the time" → "Increased over time".
26. Page 13, line 12: "In lower troposphere" → "In the lower troposphere".
27. Page 13, lines 15-19. "However, the duration of precipitation over land (Dland) and the duration of more intense precipitation (DRR15 , ≥ 15 mm in 15 min) are shortened (from 315 min in CNTL to 270 min, 240 min, and 240 min in DRY1P, DRY2P and DRY5P, respectively for Dland, and from 120 min in CNTL to 105 min, 60 min and 30 min, in

DRY1P, DRY2P and DRY5P respectively for DRR15)”. Such lengthy sequences of acronyms and numbers are hard to read and not very informative. What really matters is the sign of the deviation from CNTL – there is probably no need to mention more than that. If you want to include numerical values, you can put them in a table. There are other similar sentences in the manuscript. Removing them would make the paper much better readable.

28. Page 14, lines 6-8: “and less stationary system” → “and a less stationary system”.
29. Page 14, line 15: “topped by dry air mass” → “topped by a dry air mass”.
30. Page 14, lines 27-28: “A small increase of moisture content favours convection triggering”. If the authors are alluding to the effect of moisture in increasing CAPE, then this has nothing to do with triggering (see a previous comment). Incidentally, moisture can also make (orographic) triggering easier by reducing the static stability (buoyancy frequency) of the atmosphere. But I think this is not what the authors mean here.
31. Figure 2, caption: There’s an ellipsoid in panel a. Please explain what it is. Also, please make thicker, so as to make it visible.
32. Figure 6. I am confused by the units of RRacc and RRsum. I am fine with RRacc being in mm; but, if RRsum is a domain wide sum, shouldn’t it be expressed in liters? 1 mm = 1 liter/m^2. Sum up over all grid points accounting for the mesh size should give liters of water.
33. Figure 7. Same as above. Please explain the meaning of the ellipsoids, and make them thicker.
34. Figure 9. Label and units are missing on the y axis.
35. Figre 10. Same as above. Please make the ellipsoids thicker.