Second Peer review of
"Understanding the diurnal cycle of land-atmospheric interactions from flux-site observations"
By: Raquel González Armas and Jordi Vilà-Guerau de Arellano

We thank the authors for their responses and the changes. In our opinion, the manuscript has improved.

Below our reaction to their responses and the changes in the manuscript (in blue). If there is no reaction, we are satisfied with their answers and the revised manuscript.

Major comments

1.- Although the processes of entrainment and boundary layer growth is acknowledged throughout the paper, we have the feeling that is played down in the research. We realized that with a surface data set is difficult to quantify, although the mixed-layer diagrams proposed by Santanello et al. (2009) could be an adequate tool to further quantify the relevance of entrainment of warm and dry air at the different sites. Could the authors elaborate and quantify more regarding the role of entrainment?

Could they be more precise on the projects dominant after midday when entrainment becomes less relevant? The word obscure is vague in the revised manuscript.

We also think that they are missing here a great opportunity in elaborating a bit more in the relevance of the processes at the sub-diurnal scales. Our recommendation is that based on their analysis and metrics they performed a more deep analysis on which processes are relevant or differ under the water and energy regimes.

Please rephrase and elaborate more (in red there is typo):

"Although the effect of atmospheric entrainment continues until continues until dissipation of the daytime boundary layer around sunset, it is obscured by the other contributions after noon."

5.- Along the results section in part *4.2 Diurnal mixing diagrams* and *4.3 Climate regime dependence,* hysteresis of the thermal process chain versus the moist process chain is discussed. Regarding the discussion of hysteresis, we have three comments:

1. We highly encourage to define in this context the term hysteresis. Hysteresis is a word originally coined in science to describe systems which state depends on their history. The typical scientific example is the magnetic hysteresis. This refers to a magnet that is able to experience different magnetic moments when subject to the same magnetic field. Those magnetic moments depend on the previous states of the magnet. To us, using hysteresis in land atmospheric context may be misleading since the state of the system may be different between morning and afternoon because the external factors are also different. For instance, soil water content and vapor pressure deficit are generally different between morning and afternoon. Therefore, the sub-diurnal asymmetry may be attributed to it not because an inherent change on the interactions due to the previous history. Nonetheless, we acknowledge that hysteresis term is generally used in land-atmospheric interactions context. We recommend defining the term in this context. We already find a definition in conclusions section, line 417, the

fact that “the evening path through the water-energy phase does not retrace the morning path”. We would move or repeat the definition to results because there is where the hysteresis is widely discussed. In addition, we think it would be valuable to specify in which way we consider it a hysteresis. In essence, which system is subject to its previous history? Is it the vegetation, is it a vegetation-soil system? What are considered the external factors? Another simpler solution is to coin another term such as temporal asymmetry which does not imply previous history relations.

What do you mean by a kind of hysteresis? Is it not more appropriate to call it asymmetry? Please formulate with precision

2. We highly recommend discussing the hysteresis’ possible causes both on the land and the atmospheric coupling. We argue that due to many processes that peak at different times (e.g., radiation peaks around noon, sensible heat flux peaks in the early afternoon and latent heat flux which with peaks later in the afternoon), morning-afternoon asymmetry can be expected. It is not clear to us what is the added value of assessing the asymmetry or if the aim of the research is simply to characterize it. We recommend clarifying either if the paper aims to characterize them as a general characteristic observed or if the asymmetry is seen as a possible option to evaluate land atmosphere interactions.

   It is a pity that the authors do not develop and elaborate a bit more on the physics of this asymmetry based on the observational analysis

   Other Comments

- *In line 109,* the lifting condensation level is used as the variable to understand the coupling of the land with the atmosphere. We think the reader would appreciate a short sentence in which it is stated why this variable is an important indicator of the coupling to the atmosphere (e.g., because its strong relation with cloud initiation or its importance in convection schemes in atmospheric models).

  Perhaps here it is convenient to be more rigorous and stress that the condition h > LCL is a rough approximation. Majority of the situations in which shallow cumulus form are characterized by an opposite situation (h < LCL) (see for instance figure 7a at https://journals.ametsoc.org/view/journals/atsc/71/3/jas-d-13-0192.1.xml) . Could they please elaborate a bit more here?

- *3.3 Mixing diagrams* section. Along this section mixing diagrams are introduced. It is stated that for computing them, 2-m temperature and humidity or vapor pressure deficit are used. In the last paragraph of the section, some shortcomings of this approach are addressed. For instance, it is mentioned that embedded in this method it lies one hypothesis. The hypothesis that 2-m measurements reflect mixed-layer values. We find this hypothesis to be dubious for certain ecosystems. For instance, in vegetated areas whose trees are taller than 2-m, the measurements fall into the in-canopy range. Many forests have trees that surpasses this height. Therefore, unlike many of the observations in other land types, observations in forests lie inside the canopy. In the research 102 from 230 sites (approx., 44 %) are classified as forests. Consequently, for forests sites, we wonder how much sensitive the land and surface couplings are to the height in which the surface heat fluxes, temperature and humidity

are measured. We would expect that using measurements located right above the canopy would reflect different land and atmospheric coupling. We do acknowledge the challenge of comparing the diverse land-types considered in the study within the same methodological framework. Nonetheless, we would appreciate a justification of using the 2-m height measurements for forests or at least addressing the special advantages and shortcomings of such approach for forests. In addition, we wonder how the inclusion of these observations affect the general conclusions for the land-atmospheric interactions. For instance, are patterns more easily generalizable (in figures 2, 3, 4 and 5) when forests are excluded?

In the new manuscript it has been written that the observations of FLUXNET2015 data have been assumed to be taken at 2 m above the canopy. We do not fully understand what does "assume" means here. Does it mean that it is unknown the convention of height of FLUXNET2015? For instance, is it unknown if the documentation means 2m height from the surface or 2m height above the canopy? We would like some clarification or contacting FLUXNET for further details about the height of measurements with respect to height of the trees.

New comments connected to the revised manuscript

Regarding the addition of figure 6 and section "4.4. Canopy effects", we think it adds value to the manuscript. We think figure 6(b) could be omitted because the processes explained in the section can be visualized from figure 6(a), so we do not think it adds value to the analysis. In addition, it is a new way of visualization that has not been used before in the manuscript so it may disorientate the reader.

Section 5 is called "Conclusions" whereas section 6 is called "Discussion". We think it must be the other way around.