Dear Editor,

Please find enclosed the revised version of the manuscript entitled “Changes in the simulation of atmospheric instability over the Iberian Peninsula due to the use of 3DVAR data assimilation” by S. J. González-Rojí, S. Carreno-Madinabeitia, J. Sáenz and G. Ibarra-Berastegi, that we resubmit to the journal Hydrology and Earth System Sciences.

In this version, all the points raised by the reviewer have been addressed. To do so, we have updated figures 9 and 10 (also Figure 8 for consistency with the new ones), and we have added some new text in the results section. Additionally, we have also corrected some minor inaccuracies included in the manuscript that we submitted last time. These corrections do not modify the final outcomes from the paper. Apart from that, with the aim of reducing the length of the main manuscript, we decided to move the figures included in the annexes to the Supplementary Materials online. Finally, we have also modified the affiliations of most of the authors in order to be consistent with the new names given recently to the Departments by the University of the Basque Country (UPV/EHU).

As always, attached to this cover letter you will find the new version of the manuscript, the version with the changes tracked where all the modifications are highlighted, and a detailed response to the reviewer's points. We consider that we have successfully addressed all the points raised by the reviewer and, as such, we hope that the manuscript can be accepted this time.

Yours faithfully,
Santos J. González-Rojí

Reply to the review made by the Anonymous Referee #2
Received on: 30 April 2021

The authors have done a great job. I think that the paper has improved considerably. Therefore, I suggest to accept the paper, but to please consider the few points below.
>> Thanks for taking into consideration all the effort that we made to improve the paper according to your comments.

1. L107: “precipitation can be developed” --> “precipitation may occur”
>> We have corrected it as suggested.

2. Sentence L107-109: There’s something missing in this sentence (verb?)
>> The reviewer is right and something was missing in the sentence. We have rephrased it to:
“As shown before, atmospheric instability is a highly demanding feature in model simulations and a topic with great importance nowadays due to the large damage that extreme convective events can cause to society, and which frequency will be increased in the future. Thus, it is of great interest to diagnose the ability of particular configurations of a model to properly simulate the structure of temperature and moisture at low levels, which lead to unstable atmospheric instability“

3. L224: a extremely --> an extremely
>> We have corrected that typo.

4. L552: in the pressure levels --> at the pressure levels
>> We changed it as suggested in the new version of the manuscript.

5. 574-576: Be careful with that statement about CAPE/CIN as their calculation is highly sensitive to the low-level values even though when considering mixed values. This is not the case for TT. Or what do you mean by “reliable”?
>> We meant with “reliable” that because of employing more pressure levels during its calculation, the information provided by CAPE and CIN should be more physically meaningful than the information obtained by TT, as this index is only calculated from two pressure levels (500 and 850 hPa). In order to make this clear, we have changed the sentence to: “Thus, since the calculation of CAPE and CIN takes into consideration the vertical profile of the atmosphere until the Level of Neutral Buoyancy, these two variables should be considered first to evaluate atmospheric conditions and not TT, as this index only takes into account two pressure levels (500 and 850 hPa).”

6. My point 8: This is a general misunderstanding. You say that your main objective is to evaluate the WRF results during unstable conditions. Absolutely understood. But CIN against to CAPE and TT is not a measure of instability. For example, during a very stable situation, CAPE is = 0, but CIN could be in the convective range of ~50-200 J/kg K. So if you consider CIN on all days, your focus is not on convective conditions as stated several times. That's the point.

With the relation between CAPE and CIN in my comment I didn't refer to their correlation, but to consider CIN only during unstable conditions, i.e. when CAPE is > 0 J / kg K.

>> We see the point made by the reviewer now. We didn't understand it the previous time. We do not dispute (never did) that evaluating CIN only during unstable conditions is interesting for weather forecasting. However, we believe that if we want to evaluate the performance of the model at reproducing the observed atmospheric conditions with TT, CAPE and CIN, we need to evaluate the entire period (2010-2014) and not restrict the evaluation to only the days when CAPE is above a given threshold.

>> However, it is true that when we comment on the maps that show the regions with larger values of TT, CAPE and CIN, we talk about the most unstable regions over the IP, and to do so, we say that we need to evaluate CAPE and CIN in combination. So, in order to ease the interpretation of that for the reader and to answer this point by reviewer, we have calculated the mean maps for CAPE and CIN only for the days in which CAPE is above the 75th percentile (calculated for each point, season and time - 00 or 12 UTC). We decided not to apply a fixed threshold such as 0 or 50 J/Kg as suggested by the reviewer in previous comments to each point of the domain since each of them presents a different behaviour, and consequently, the number of data computed in the mean would not be the same in each point depending on that threshold. By using the 75th percentile, the amount of data employed for the calculation of the mean at each point would be the same, and the evaluation will be fair for all the points of the domain. Besides that, the third quartile will always be representative of conditions at the unstable range of the distribution for every grid point.

>> The results show that the spatial distribution of CAPE is rather similar to that obtained for the mean of the entire period, and only the values are larger (Figure 1 in this response). However, some differences can be observed for CIN, particularly at night during both winter and summer (Figure 2 in this response). During winter, it can be seen that the highest values of CIN appear at night at the Mediterranean coast. This area is usually where nocturnal radiation cooling is large because of a lower cloud cover, although this result is highly dependent on the dataset used for the analysis (Calbo and Sanchez-Lorenzo, 2009), and consequently, it should be further analysed for our simulations in the future. During summer, large areas of the southern IP are affected by the stabilizing effect due to radiational surface cooling during the frequent clear nights beyond the Mediterranean regions which were also apparent in the average summer night (00 UTC) map. In addition,

the same differences between both WRF experiments are observed in these new maps as in the case of the mean maps for the entire period 2010-2014. Consequently, N shows larger CIN values than D during winter, but this is reversed in summer when larger values are shown by D.

>> In order to include in the manuscript the most relevant results, we have decided to include only the maps for CAPE and CIN above the 75th percentile of CAPE for the D experiment in a new column in Figures 9 and 10 (CAPE and CIN maps respectively in the manuscript). Moreover, we have included some new text in section 2.3.2 (Analysis) explaining how these maps were calculated, in the results section explaining and interpreting these new maps, and finally also in the conclusions. These new paragraphs are highlighted as changed in the uploaded version with changes marked.

Calbó, J. and Sanchez-Lorenzo, A.: Cloudiness climatology in the Iberian Peninsula from three global gridded datasets (ISCCP, CRU TS 2.1, ERA-40), Theoretical and Applied Climatology, 96, 105–115, https://doi.org/10.1007/s00704-008-0039-z, 2009.

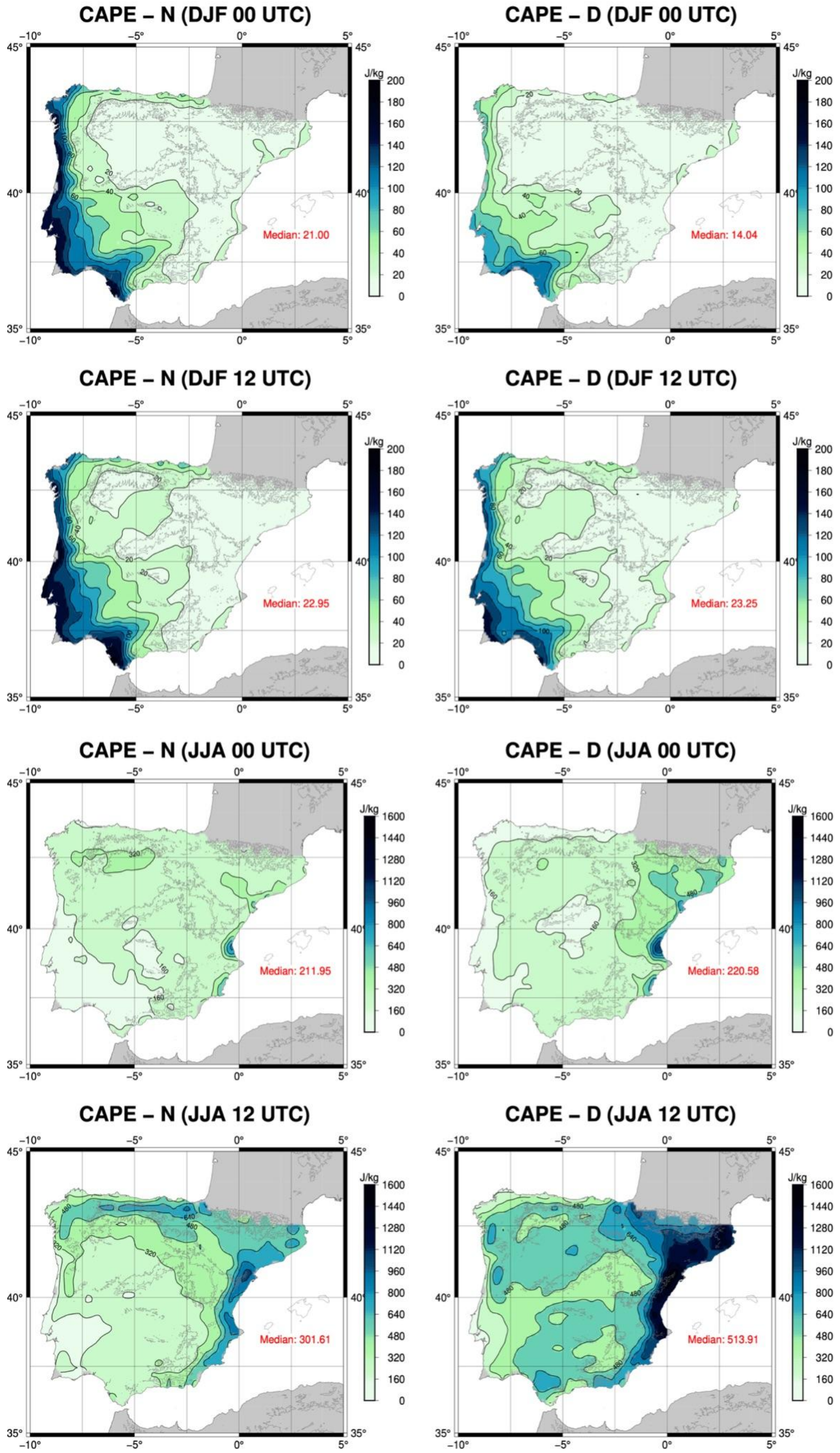

Figure 1: Spatial distribution of mean CAPE for period 2010-2014 over the IP as computed from N (first column) and D (second column) for those days in which CAPE is higher to the third quartile of the sample of CAPE at every grid point. The maps for winter (rows 1 and 2) and summer (rows 3 and 4) at 00 (rows 1 and 3) and 12 UTC (rows 2 and 4) are shown. The median value (J/kg) of each map is presented in the bottom right corner of the plots.

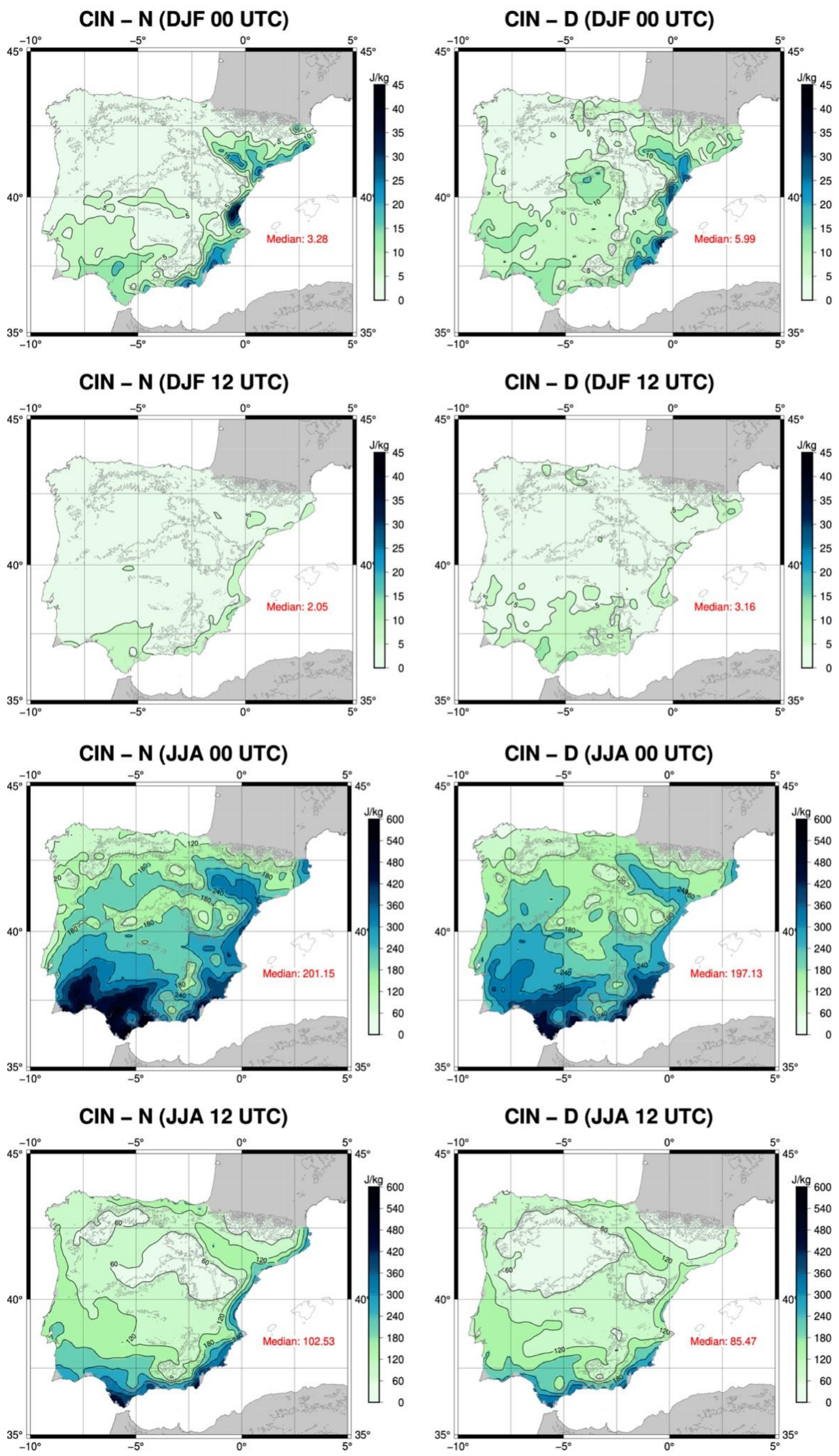

Figure 2: Same ad Figure 1, but for CIN in those days in which CAPE is higher to the third quartile of the sample of CAPE at every grid point.