Anonymous Referee #2

We thank the reviewer for all his/her questions and suggestions, which will help to improve the manuscript substantially. Please, find attached below the one-to-one reply to the comments.

Comment 1:

1) The FLEXPART analysis, to my understanding, is largely underutilized here. Is it only to justify the location of the wall line? I think the wall line location is fairly intuitive and I don't believe the authors would find much sensitivity to its location (within reasonable limits). As a minimum, I would encourage the authors to include the FLEXPART-derived moisture source regions for each case study in Supplemental Material.

We appreciate the comment and the figure of moisture sources for each case study will be added to the supplementary material. Answering the question, the lagrangian Flexpart model was used to objectively justify the position of the wall. Fig. RC2.1 (in this document) shows the 75th percentile the sources of moisture (E - P > 0) for the 6 cases of study. The purple line shows the position of the wall of moisture labelling. The vectors refer to the wind for each case study and are plotted at surface level (aprox. 500m). As it is observed, moisture enters the Great Plains in a channelized way through the wall from the Gulf of Mexico. In the Fig. RC2.1a (no-LLJ day) the vectors do not show the flow of the South. Therefore, the transport of moisture from the Gulf of Mexico will be weakened as is the case with simulation 0. In the remaining simulations we can observe a structure of LLJ with a maximum of moisture transport intensified to the south of the Great Plains responsible for advection of atmospheric moisture from the Gulf of Mexico.

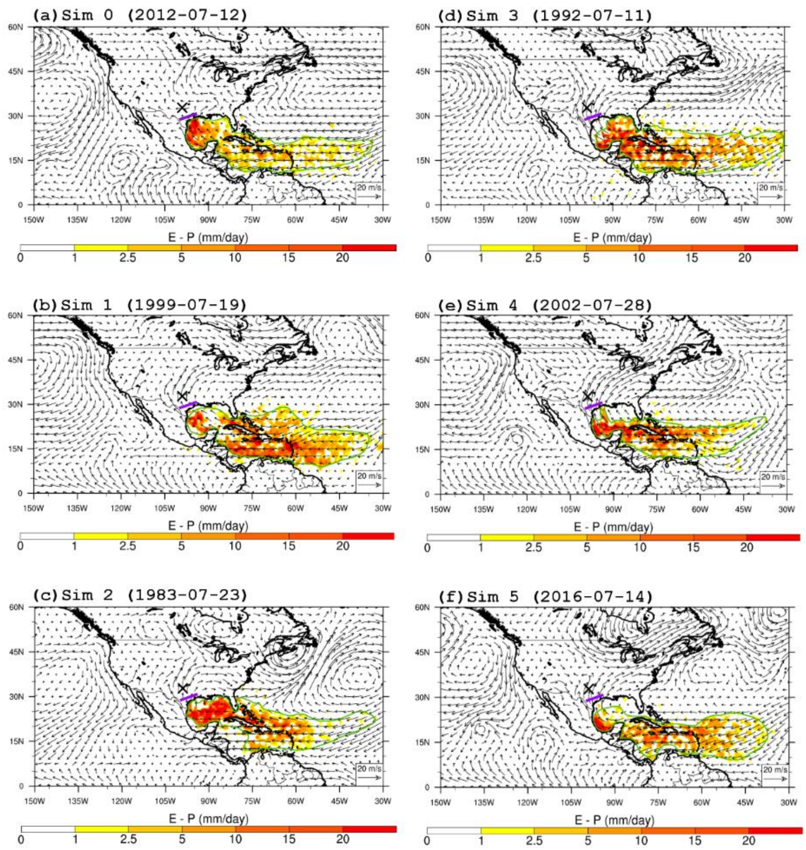


Figure RC2.1. Moisture sources for the 6 study cases analysed. The vectors show the wind direction and intensity for each case study at surface level (aprox 500m). The purple line shows the position of the moisture labelling wall used in the WRF simulation.

2) The article focuses entirely on July GPLLJs with the logic that southerly GPLLJ frequency is highest for this month. Firstly, have the authors found this to be the case? In my own work, I have found May to be the month of highest frequency. The authors should include a figure or table of the ERA-INT-derived monthly GPLLJ climatology. Secondly, are July GPLLJs representative of the springtime LLJs that are predicted to increase in frequency and intensity (lns 6-10, ph 3)? The authors could have designed their study to be better aligned with their motivations/stated best projections of a future GPLLJ.

We use the data from ERA-Interim and temporal period of 37 years (from 1980 to 2016). Examining the monthly variability, we find that July is the highest frequency month of GPLLJ. Understood the frequency as the largest number of days of GPLLJ (Fig. RC2.2, in this document). For the 37 years, we detected that the frequency increases during the months of May to October, with more than half of the days of GPLLJ. Nevertheless, we detected a peak in the month of July, with a frequency greater than 80%. Other authors, such as Rife et al. 2010 reported a frequency of GPLLJ of 78% also for the month of July. Despite this author used another dataset and a different time period than the one we use in our work.

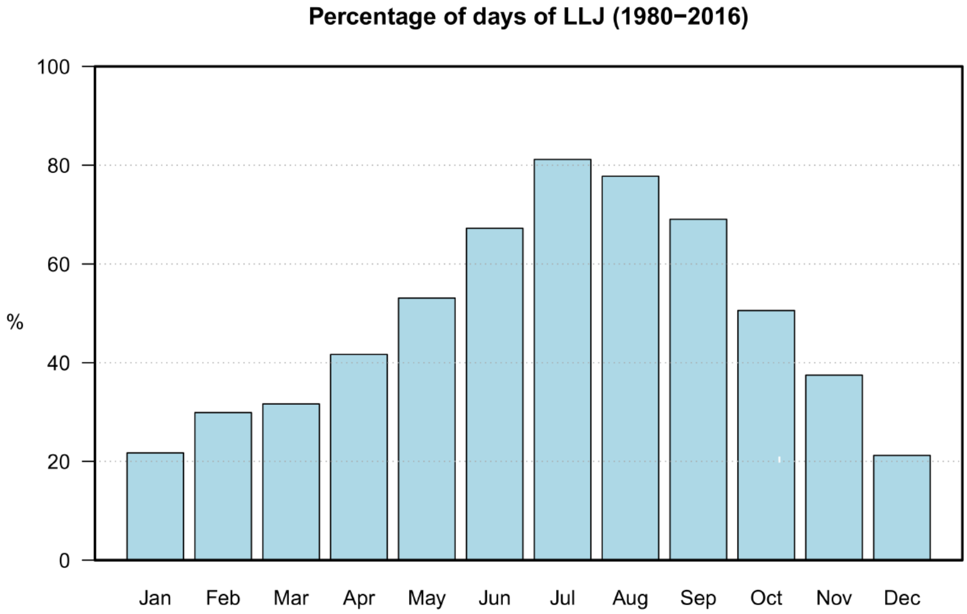


Figure RC2.2 Monthly variability of the percentage of GPLLJ days.

Regarding the second question, the current literature foresees an increase both in the intensity and frequency of GPLLJ in spring. Nevertheless, the main goal of this work is to provide a first quantitative approach to moisture transported by the GPLLJ. Despite the numerous works related with GPLLJ, no work has objectively quantified the moisture associated with this structure. In the introduction we want to highlight the importance of studying these structures related to moisture transport. Changes in frequency and intensity will affect the sink regions and extreme events (droughts and floods). Therefore, it is of great interest to objectively estimate the moisture transported by the GPLLJ. However, in this paper we want to offer a first approximation in terms of average moisture transport. For this reason, we have objectively chosen objectively 5 cases of study based on the Gaussian distribution with the aim to quantify the average transport of moisture in a general perspective of the GPLLJ's behaviour.

Specific Comments:

Abstract: mention of ERA-INT and "southerly" GPLLJ needs to be made. - The word *southerly* was added and we mention the ERA-Interim reanalysis data used in the work.

Introduction: the work of Claudia Walters and Julie Winkler on GPLLJ (northerly and southerly) climatologies needs to be referenced here. There are several works from which to choose between 2001-present. - The work of Walters and Winkler, 2008 and other recent works have been added to the introduction.

Pg2,ln12 insert "southerly". – The word "southerly" has been included in the latest version of the manuscript.

Pg2,ln21 specify whether Higgins et al (1997b) analysis was conditioned on GPLLJ occurrence -

Pg2,ln23 unclear meaning of "compared with the diurnal one"

Pg2,ln24 unclear if "this work" refers to Higgins or Mo reference

We consider the last three comments and the paragraph now read as follows:

Nevertheless, a large number of studies have documented the relationship between the major moisture transport and the GPLLJ. Higgins et al. (1996) studied the moisture budget over the central US in May employing NASA/DAO and NCEP/NCAR datasets, together with station observations, to evaluate the limitations of these products. Although both reanalyses overestimate daily mean precipitation rates, they accurately capture the basic temporal and structural characteristics of the GPLLJ. From the data, these authors calculated an increase in atmospheric moisture transport from the Gulf of Mexico during night-time of more than 50%. In a later work, Higgins et al. (1997) observed a well-defined nocturnal maximum of precipitation over the Great Plains in spring and summer by analysing station data. Particularly and linked to LLJ events this research found in this region an excess of 25% in nocturnal rainfall during summer when compared with the diurnal precipitation, associated with a rainfall decrease over the Gulf of Mexico. Additionally, Higgins et al. (1997) reported significant differences in precipitation pattern in coincidence (or not) with LLJ events. When a LLJ event occurs, the observations show an enhanced precipitation over the north-central United States and the Great Plains region, together with a decrease along the Gulf of Mexico and the western Atlantic. On the other hand, Mo and Juang (2003) found regional correlation at a distance between evaporation and precipitation, reflected in evaporation anomalies over the Great Plains along the trajectory of the GPLLJ, which are associated with downstream precipitation anomalies.

Pg2,ln27 suggest "found regional correlation at a distance between…" or similar – The text has been updated following the reviewer's suggestion.

Pg2,lns30-32- one example of a "floating sentence" that needs to be grouped with another paragraph – Following the reviewer's suggestion, the paragraph now reads as follows:

Otherwise, extreme rainfall events in the central US are related to an increase in moisture convergence downwind of the GPLLJ (Mo et al., 1997). A decisive factor that triggers heavy rains and floods is the presence of moisture advected by the GPLLJ from Gulf of Mexico and the Caribbean Sea. Moore et al. (2012) reported the physical processes related to the floods in May, 2010. A persistent southerly low-level jet associated with an atmospheric river (AR) enhanced the transport of moisture from the Gulf of Mexico into the heavy rainfall region. Thus, important socioeconomic impacts follow enhanced GPLLJ events, which modulate a large percentage of the local extreme precipitation events and flooding in warmer months (Mo et al., 1995, 1997; Beljaars et al., 1996; Trenberth and Guillemot, 1996; Arritt et al., 1997; Nakamura et al., 2013;

Nayak et al., 2016). All these results are consistent with the large-scale atmospheric moisture transport and support the marked influence of the GPLLJ over the central-eastern US, which has been shown to trigger more than 60% of the spring local precipitation there (Wang and Chen, 2009).

Pg2ln31 meaning of "local" is unclear. Define local as opposed to non-local in this context. - The sentence has been rewritten as follow: *All these results are consistent with the large-scale atmospheric moisture transport and support the marked influence of the GPLLJ over the central-eastern US, which has been shown to trigger more than 60% of the spring precipitation over the Great Plains region (Wang and Chen, 2009).*

Pg3,ln4 suggest replacing "common" with "frequent" – "common" has been replaced by "frequent".

Pg3,lns3-10 more floating sentences – The cited paragraph now reads as follows:

During the last decades, the GPLLJ has experienced a strengthening, accompanied by a northward migration causing a displacement of rainfall in the same direction. As a result, more frequent droughts have been observed in the southern Great Plains (Barandiaran et al., 2013). Besides, the increase in the number and intensity of GPLLJ events is also forecasted for future projections, which reveal an intensification of the GPLLJ during the spring season associated with global warming (Cook et al., 2008; Tang et al., 2017). As a result, increasing amounts of moisture transport and rainfall are expected, particularly from April to July, over the central US (Harding and Snyder, 2014). The same projections forecast a slight weakening of the GPLLJ from August to December, which could translate into increasing drought conditions.

Pg3,ln17 word "total" may be deleted – The word "total" has been removed from the manuscript.

Pg3,ln19 reword "and the at the point" - The sentence has been reworded as *a 37-year climatology was previously calculated at the point of maximum jet intensity...*

Pg3,ln27 on a monthly basis, I believe the max GPLLJ frequency is in May - We have calculated the monthly frequency for the 1980-2016 study period. As we show in figure RC2.2, we obtain the maximum frequency in the month of July.

Pg3,ln32 the native resolution of ERA-INT is closer to 0.75deg. How was it spatially interpolated (oversampled) to 0.25deg resolution? - The Era-Int data were downloaded directly from the ERA Interim web at a resolution of 0.25º. Although the original resolution is 0.75º, it was interim allowing the download to several horizontal resolutions. In our study, we obtained by downloading them at a resolution of 0.25. More information about the interpolation can be found in the following link: https://confluence.ecmwf.int/display/CKB/ERA-Interim%3A+What+is+the+spatial+reference

Pg5,ln29 delete "30" – The typo has been deleted.

Pg6,ln17 clarify for the reader whether these events were chosen from the NLLJ distribution at 32.75N,99W or for the regional distribution (w/I cyan outline) – The sentence: *The five case-studies were selected based on the Gaussian adjustment applied to the study.* has been included in the new version of the manuscript.

Pg6,ln25 should "LLJ" be "NLLJ"? – This typo has been corrected.

Pg7,ln22 "northeastern" – The typo has been corrected.

Pg8,ln8 clarify that this is done for a specific point (32.75N,99W) - The core (32.75ºN,99ºW) is used only to calculate the 37-yr climatology. We add the following sentence to the text to clarify it: *The target region used in FLEXPART was defined based on the 75th percentile of the index value.*

Pg8,ln16 I do not believe it is true that GPLLJ occurs on more than 16/31 nights in July. Please quantify this using ERA-INT. - We use the ERA-Interim data for the detection of GPLLJ. As we discussed, we obtained a maximum frequency in July. Please, we refer you to the previous comment.

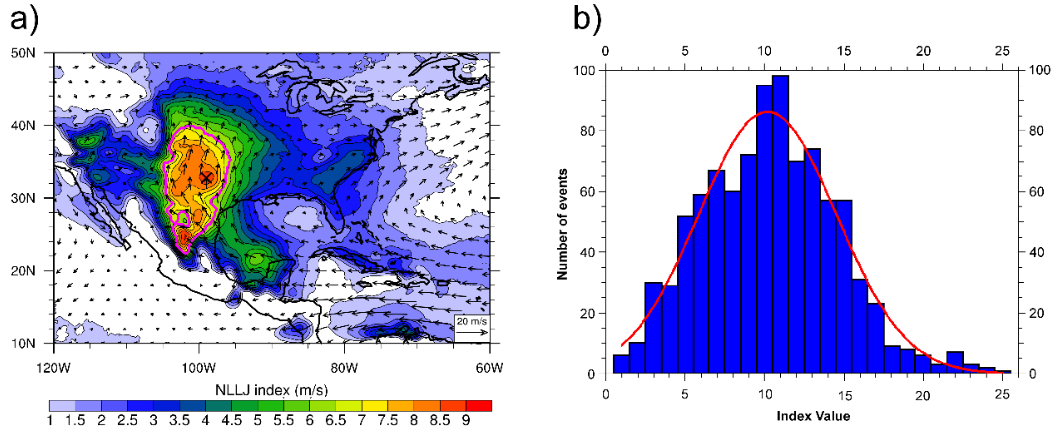
Pg8,ln20 "northeastern" – The typo has been corrected.

Pg8,ln21 synoptic and land preconditioning will impact ratio of GPLLJ TPW (Fig 3). – This clarification has been included in the text.

Pg8,ln26 replace "leaded" with "preceded" – "leaded" has been replaced by "preceded".

Pg8,ln31 suggest ": : :North America [using WRF-TT. Additional] simulations should…" – "WRF-TT" has been removed from the manuscript.

Fig. 1 the cyan color is hard to distinguish in my color print. Clarify whether these "frequency



distributions" are derived for the region contained in the cyan outline or for a single point (i.e., 32.75N, 99W). - The cyan color is replaced by the magenta. We think it highlights a little better. The frequency of distribution was calculated at the point of maximum intensity. We have been modified the caption of the figure 2 to clarify it.

Figure 1. (a) Mean NLLJ index (shaded) and 500 m winds (arrows, in m s^{-1}) at local midnight in July (boreal summer) for 1980-2016, calculated from ERA-Interim reanalysis. The black cross at 32.75ºN, 99ºW shows the point of maximum NLLJ in the climatology. The cyan contour line surrounds the region containing points above the 75th percentile. (b) Frequency distribution of the GPLLJ for the months of July from 1980 to 2016 (blue bars). The red curve corresponds to the Gaussian fit (see table A2). Noted: The frequency distribution is calculated at the point of maximum intensity of NLLJ (at 32.75ºN, 99ºW, black cross in fig. 1a).

Figs 2-4. Lat/lon labels required on these figures.

Fig 4. Suggest adding state boundaries.

Lat and lon and the states boundaries have been included in the lasted version of the manuscript. An example figure is shown:

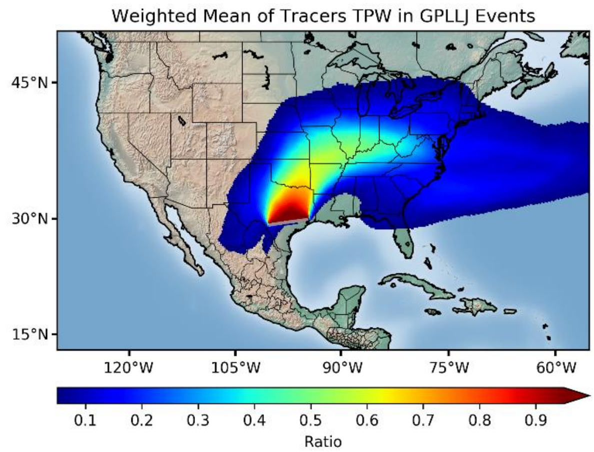


Fig5-6. The order of Fig5 and Fig6 should be switched. Would it also be informative to plot the vertical cross section of relative GPLLJ humidity? E.g., qTR:q; phiTR;phi? – Figure 5 and 6 will be swapped. Additionally, the vertical cross sections will be included and commented in the manuscript.

Table 1. Specify ERA-INT-derived as well as the lat/lon location or domain over which the frequency distribution was composed. - The title of the table has been rewritten as follows:

Table 1: Case-studies objectively selected based in the frequency distribution of the LLJ index to carry out WRF-TT simulations. μ is the mean of the distribution and σ its standard deviation. Noted: The frequency distribution is calculated at the point of maximum intensity of NLLJ at 32.75ºN, 99ºW (black cross in fig. 1a) using the ERA-Interim reanalysis dataset.