Review of "Predictive skill of atmospheric rivers in western Iberian Peninsula" by Ramos, A. M., Sousa, P. M., Dutra, E. and Trigo, R. M.

This manuscript quantifies the predictability and forecast skill of winter time atmospheric rivers affecting the Iberian peninsula using ensemble forecasts from ECMWF. Given the impact of precipitation associated with atmospheric rivers in society this is a very worthwhile study. The main results include that integrated water vapour transport is more skilfully predicted than precipitation at longer lead times and that the IFS has a systematic error which results in landfall of the atmospheric rivers being predicted too far north. While most of the manuscript is easy to understand, some parts such as the explanation of the diagnostics and what observations / analysis the forecasts are verified against are hard to understand and lacking critical details. These two major points are further explained in major comments 1-8 and other minor issues and typos which should be addressed are described under minor comments.

Major comments:

1. Section 2.1, lines 111 – 113. Here it is stated that daily values of IVT and precipitation from the IFS are used. Please clarify what is actually done here. I assume for precipitation it is the daily accumulated (so time integrated over 24 hours from 00 UTC - 00 UTC) precipitation but it is not clear what is meant by the daily IVT. Is this also integrated over time (24 hr) at each point?
2. If IVT is integrated over time, does this act to smooth out (or zonally blur) the ARs and how does this impact the skill scores and the predictability. Previous studies for other forecast variables such as clouds and radiation (e.g. Hogan et al, Tuononen et al, 2019) have shown that while 24-hour integrated values are forecast with a large degree of skill, 6 hourly and 1 hourly values have much less skill.
3. Section 2.2, lines 124. Here it is stated that precipitation observations are accumulated into 12 hourly periods whereas the forecast precipitation is 24 hour accumulated values. Is this correct? Please clarify the time accumulations.
4. Section 2.2. Were these precipitation observations, that are used to verify the forecasts, assimilated into these forecasts or are these independent observations?
5. It is hard to follow how the forecasts for IVT are verified. It is said later on in the manuscript that the analysis fields are taken from ECMWF to verify IVT but this should be mentioned much earlier, for example after section 2.2. This is because it is confusing to read how precipitation forecasts will be evaluated but not the IVT forecasts. I am also not sure if the precipitation analysis is used or not, and if not, why not.
6. Section 4. Line 155. How do you verify the precipitation over the boxes which are located over sea where there are no observation stations?
7. Section 4.1, lines 165 – 171. It is very hard to understand these diagnostics and as such this is the biggest weakness of this manuscript. This must be improved. Specific points are
   (a) Landfall distance. As this is described (line 165) this is the scalar distance simply measured between two points which in theory should always have a positive value and no direction. However when this is discussed in the text and shown in Figure 4 this parameter can have negative values and a direction. Is this then the difference in the meridional direction with positive (negative) errors indicating a northward (southward) forecast relative to the analysis? Please clarify.
   (b) How is the landfall location identified? Is this the first point in time when IVT exceeds the threshold value over a land point in any of the boxes? Again please clarify this in the revised manuscript.
   (c) The landfall IVT error is sensitive to both intensity and displacement errors. This should be noted more clearly. It would also be interesting to include a diagnostic which solely measures the intensity error e.g. the difference in the maximum value in the forecast and the analysis regardless of where they occur.

(d) The AR-axis angle error. Two points (or a vector) are always need to calculate an angle e.g. you need to identify the axis of the AR yet this is not done here. I do not fully understand how this angle is calculated in the forecast / analysis and therefore I do not understand how the difference can be calculated. I assume it is the angle of the IVT vector but where and when? Please clarify this. A schematic diagram may be helpful as would adding the IVT vectors to the large panel in Figure 3 to make it clearer to readers that IVT is vector and the shading is the magnitude of that vector.

8. It is not clear how the diagnostics described in section 4.1 are calculated in the cases that no AR is forecast. Are these included as missing data? How does this impact the overall results and conclusions? Please add some information about this.

Minor comments and typos:

1. Title. I'm not 100% sure this title is grammatically correct. Would "Predictive skill of atmospheric rivers in the western Iberian Peninsula" be more correct?
2. Line 75. Should read "These kind of studies..."
3. Lines 77-80. The information presented here about the AR reconnaissance program is somewhat out of place. Either this program needs to be further explain and links made to the research presented in this paper or this should be removed.
4. Line 91. What is meant by this statement "The EFI for IVT became control at ECMWF…."? Please clarify the text here. I think it should read "became operational at..."
5. Line 98 / objective 1. This objective does not make sense. I think what it meant here is to compare the impact of forecast lead time of the forecast values of both IVT and precipitation. Please revise.
6. It would be helpful to add letters to the panels in the figures and refer to the panels using the letters rather than "upper panel" etc.
7. Line 290. There is a typo in the reference here and "to" is missing in the sentence "This is due the…."
8. Line 309. "control context". I think what is meant here is "in an operational context...".

Figure comments:

1. Figure 1, top panel. The colour bar is hard to read since it is an continuum. Can this be changed to have discrete colours and only the number of colours that there are lines on this figure (I think 4 colours). The yellow lines are also hard to see so using darker colours would be better.
2. Figure 1. bottom panel. What is the grey bar above this panel for?
3. Figure 3. The boxes are hard to see in the top panel as they are similar colours to the shading. Furthermore, the panels at the bottom are very small and hard the see. These smaller panels would be clearer if the area boxes were removed and if the titles were shortened as this would allow the images to be made larger.
4. Figure 4 caption. "Solid blue line represents the error in the location of the maximum IVT between observations and each forecast". What observations of IVT is available or should this read "...between the verifying analysis and each forecast". Also see major point 5 above.
5. Figure 5. The shading is not very clear in the top panel and appears to change shade. Can this be improved? Also please add information to the caption about how the "spread" is calculated. For example, is this the maximum and minimum differences or the 25^{th} - 75^{th} percentile that is shaded?
6. Figure 8 is very small and hard to see. The caption is also very long and hard to follow. Could this figure be split into two figures e.g. top panel and then the middle and bottom panels as a separate figure?
7. Figure 9 is also hard to see and could be made large. The colours could be explained briefly in the caption here rather than expecting a reader to return to Figure 2. e.g. The darkest blue bar represent the most northerly box and the yellow bars the most southerly box.

References:

Hogan, R. J., O'Connor, E. J., and Illingworth, A. J.: Verification of cloud–fraction forecasts, Q. J. Roy. Meteorol. Soc., 135, 1494–1511, https://doi.org/10.1002/qj.481, 2009.

Tuononen, M., O'Connor, E. J. and Sinclair, V. A.: "Evaluating solar radiation forecast uncertainty." *Atmospheric Chemistry and Physics* 19.3 (2019): 1985-2000.