

Comment on acp-2021-609

Anonymous Referee #3

General comments:

The paper by Viceto et al. 2021 analyses three atmospheric river events which took place during the ACLOUD/PASCAL campaigns near Svalbard. They compare model simulations, with a wide variety of reanalysis datasets and observations. In addition, they use two different detection methods for Atmospheric rivers, besides looking at the synoptic situation and vertical profiles. This paper provides an in-depth analysis of those events and provides extra insights of moisture intrusions to this specific region of the Arctic. I found the analysis well done and results well described. In my opinion, the paper could improve in readability by reducing the length of the abstract and summary/conclusions, and by stating more clearly the research questions and uniqueness of the study. By doing so the paper will be easier to read and the main message will appear more clearly. I explain those comments below, together with some minor comments on the paper.

The authors thank the referee for taking the time to carefully review the manuscript. We believe the manuscript will benefit from these revisions. Below we addressed all the questions raised by the referee. Comments from the referee are in **black** and the responses from the authors are in **blue**.

Abstract

Is it needed to mention the dates of the field campaign in sentence 17, for me it would be enough to indicate the dates of the events which fall within the field campaign.

The complete information with the dates of the ACLOUD campaign was removed from the abstract. We included information about the year of the events since it was not included in the previous version of the manuscript. The updated version of these sentences is shown below:

“During the two concerted intensive measurement campaigns, Arctic Cloud Observations Using airborne measurements during polar Day (ACLOUD) and the Physical feedbacks of Arctic planetary boundary layer, Sea ice, Cloud and Aerosol (PASCAL), which took place at and near Svalbard, three high water vapour transport events were identified as ARs, based on two tracking algorithms: on 30 May, 6 and 9 June 2017.”

Can you indicate the research question/objective more clearly in the abstract? And as well in the introduction?

The authors thank the suggestion from the referee. The research question/objectives of the manuscript were explained with more detail by including the following sentence to the Abstract:

“The objective of this manuscript was to build knowledge from detailed AR case studies, with the purpose to perform long-term analysis. Thus, we adapted a regional AR detection algorithm to the Arctic and analysed how well does it identify ARs; used different datasets (observational, reanalyses and model) and identified the most suitable dataset; and analysed the evolution of the ARs and their impacts in terms of precipitation.”

The objectives of the manuscript were already included in the Introduction, in the last paragraph of this section:

“Further, we apply these various observational and modelling products for investigating the ARs development and evolution, their role in the poleward moisture transport (reaching and affecting Svalbard and Greenland), and associated precipitation characteristics. Another purpose of this study is to adapt the AR tracking algorithm by Gorodetskaya et al. (2020), developed originally for Antarctica, to the Arctic region, to evaluate how well does it identify ARs and to identify the most suitable reanalysis dataset to analyse this type of events. Building on this detailed case studies analysis, it will be possible to extend this work to longer time periods from the recent past (using reanalyses) and into the future.”

Line 21-25; is all this information needed in the abstract or can you reduce the text here?

The authors tried to shorten these sentences, by removing specific information about the spatial (“ranging from 0.25 to 1.25 degree”) and temporal resolution (“ranging from 1 hour to 6 hours”). Also, the sentence “Despite being consecutive, these events showed different synoptic evolution and precipitation characteristics” was removed, since the following sentences in the manuscript already mention the differences in the synoptic conditions and precipitation amounts and phase.

The upgraded version of these sentences is shown below:

“Results show that the tracking algorithms detected the events differently partly due to differences in spatial and temporal resolution, and in the criteria used in the tracking algorithms.”

Line 33: there was an increase **of values** with height. This 'of values' is not really clear. Can you improve this sentence?

The authors changed and shortened the sentence, in order to be more readable. The updated version is shown below:

"There was an increase of wind speed with height during the first and last events, while during the second event there were no major changes in the wind speed."

Line 35: ..during spring **and** beginning of summer ..

The authors thank the referee. The new version of the manuscript includes this correction.

Minor comments

Line 53: reasons

Thank you for the comment. In our opinion the sentence is correct since *"Gimeno et al. (2019) reason in their review (...)"* is a study performed by multiple authors, and that is why reason is in plural form.

Line 55: Here it's indicated that a typical duration of an AR is 2 to 4 days, but in your study you have two separate ARs within 3 days (6 and 9 of June). Can you comment on this? It shows up as different AR events from the figures but it would be good to emphasize that these are separate events

The information about the typical duration is not directly related with ARs. The study that mentions the 2 to 4 days duration is about moisture intrusions (Woods et al., 2013), which are not exactly the same phenomena as an AR.

In our study, we did not mention the typical duration of ARs, because it depends on the region, and there are not many studies about ARs in the Arctic. In the case of these consecutive ARs detected in a 3-day period (June 6 and 9), they were short duration events. Based on Figure 5, one can notice that the IWV and/or IVT peaks had a short duration, associated with these short events. Additionally, these two events were detected by different algorithms: the 6 June pAR was identified by Gorodetskaya et al. (2020) and the 9 June AR by Guan et al. (2018), based on different variables, namely IWV and IVT. Furthermore, both events had different pathways: the first AR moved from Western Siberia and the second from Greenland.

Line 73-75: The majority of ... --> this sentence feels unlogic here as you have been talking about ARs before but in that particular section you discuss the influence on the Arctic. I would move the sentence to line 65 or remove it from the text

The authors decided to remove the sentence. Also, the reference Zhu and Newell (1998), was removed from the manuscript since it only was referenced in this sentence.

Line 84-89: The information provided here is already very specific and would better suit in the method or discussion section

The authors understand that the information provided in lines 84-89 is too technical to be included in the Introduction (Section 1). Thus, we thank the suggestion from the referee, and moved the paragraph to the beginning of Section 3.2, where we explain in detail the algorithms used to detect atmospheric rivers. This paragraph is suitable to give a short introduction about the topic of AR tracking algorithms.

Line 90: Shields et al. (2018) study aimed to understand

The authors removed the adverb “Furthermore” from the beginning of the paragraph. The following paragraph was updated in the new version of the manuscript:

“Shields et al. (2018) study aimed to understand...”

However, the authors are not sure if this was the suggestion made by the referee.

Line 146: from 1000 hPa to 300 hPa. What are the vertical steps?

The vertical resolution of the reanalyses depends on the dataset. For ERA-Interim, ERA5, CFSv2 and JRA-55, we downloaded 20 pressure levels. From 1000 to 750 hPa the vertical steps were 25 hPa and from 700 to 300 hPa the vertical steps were 50 hPa. In the case of MERRA-2, we downloaded 21 pressure levels. From 1000 to 700 hPa the vertical steps were 25 hPa, while from 650 to 300 hPa, the vertical steps were 50 hPa.

Some information about the number of pressure levels and vertical steps was included in the updated version of the manuscript:

“To detect the ARs, specific humidity, temperature and meridional and zonal components of the wind were acquired from 1000 hPa to 300 hPa. Except for MERRA-2, all reanalyses were downloaded from 20 pressure levels, with vertical steps of 25 hPa, from 1000 to 750 hPa, and vertical steps of 50 hPa onwards. In the case of MERRA-2, the variables were downloaded for 21 pressure levels, from 1000 to 700 hPa, with vertical steps of 25 hPa, and from 650 hPa onwards, with vertical steps of 50 hPa.”

Section 3.3 Air mass trajectories: For the air mass trajectories the NCEP dataset is used, which is not used for the rest of the analysis of detections of ARs, which is a bit inconsistent. Can you motivate your choice in the text, and did you analyse the performance of simulating the ARs in the NCEP dataset?

The authors thank the comment from the referee. Although the choice of NCEP dataset might seem a bit inconsistent, the reason why we chose this dataset is because, concerning the available datasets, this was the most suitable for our study. In the HYSPLIT online platform (<https://www.ready.noaa.gov/hypub-bin/trajasrc.pl>) the datasets available for the archive trajectory model are the following:

1. GDAS (1 degree, global, 2006-present)
2. GFS (0.25 degree, global, 06/2019-present)
3. GDAS (0.5 degree, global, 09/2007-06/2019)
4. NAM 12km (pressure, U.S., 05/2007-present)
5. HRRR 3km (sigma, U.S, 06/2019-present)
6. HRRRV1 3km (sigma, U.S, 06/2015-07/2019)
7. NAM 12km (hybrid sigma-pressure, U.S, 03/2010-present)
8. NARR 32km (N.A., 1979-2019)
9. EDAS 40km (U.S., 2004-present)
10. EDAS 80 km (U.S., 1997-2004)
11. NGM (N.A., 1991-1997)
12. REANALYSIS (global, 1948-present)
13. WRF 27 km (U.S., 1980-present)

Several datasets do not cover the period analysed in our study (May – June 2017), such as 2, 5, 10 and 11. At the same time, some datasets are focused on some regions, such as the U.S (4, 6, 7, 9 and 13) or North America (8). The datasets that cover the period and location of this study are 1, 3 and 12. Both datasets 1 and 3 are from the NCEP Global Data Assimilation System, and dataset 12 is from the NCEP/NCAR Reanalysis. We chose the dataset 3 (GDAS – 0.5 degree), since datasets 1 and 12 have both lower horizontal resolutions, respectively 1 degree and 2.5 degree.

The performance of NCEP to simulate ARs was not analysed in this study. All the datasets used to identify ARs were shown in the manuscript.

A short explanation about the choice of this dataset was included in the updated version of the manuscript:

“For this study we used NCEP’s Global Data Assimilation System (GDAS) model, with a horizontal resolution of 0.5 degree. Amongst the datasets available in the online platform, this was the most suitable to our study, due to its finer spatial resolution.”

Line 180: where g is the acceleration due to the gravity

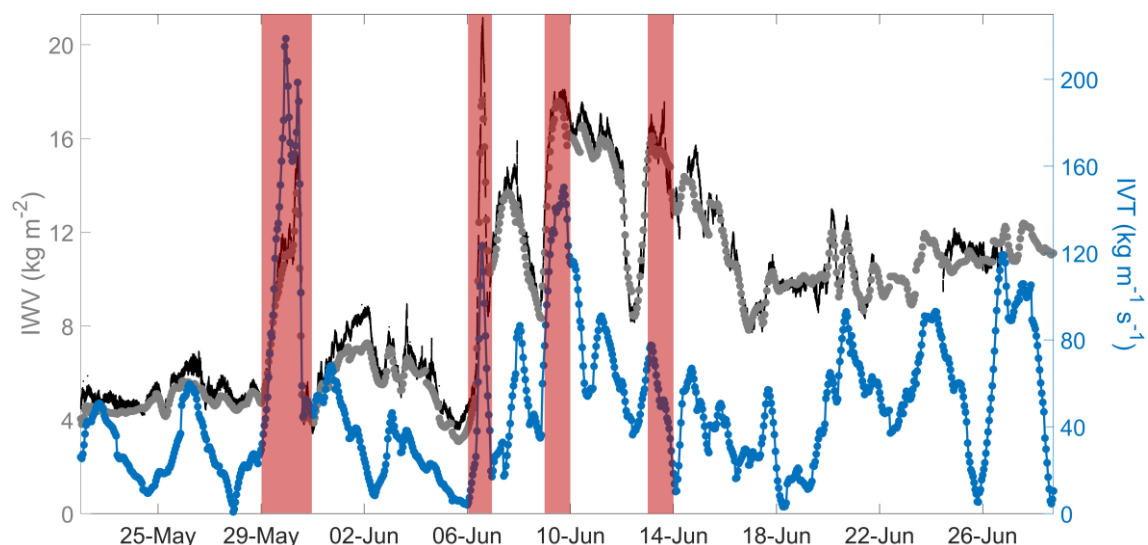
The beginning of the line was changed to lowercase letter, in order to be a continuation of the equation. The sentence was updated to the following:

“where g is the acceleration due to the gravity.”

However, the authors are not sure if this was the suggestion made by the referee.

Line 225: here you explicitly mention ERA-Interim, but why don't you compare with ERA5?

The authors thank the comment from the referee, and we agree that ERA5 is a more suitable dataset to use in the manuscript. Besides having a higher temporal and horizontal resolution when compared with ERA-Interim, this reanalysis has been widely used over the Arctic region and it has shown better results when compared to other datasets (Graham et al., 2019). Thus, we updated Figure 1 by replacing IWV and IVT time series based on ERA-Interim by ERA5 data. The updated version of the figure is shown below.



References:

Graham, R. M., S. R. Hudson, and M. Maturilli, 2019: Improved Performance of ERA5 in Arctic Gateway Relative to Four Global Atmospheric Reanalyses, *Geophys. Res. Lett.*, 46, 6138-6147, doi:10.1029/2019GL082781.

Line 297: First and second line of this section have a lot of overlap, combine them?

The authors thank the suggestion from the referee and agree that the content of the sentences is overlapping. The paragraph below was removed from the manuscript:

“To understand which meteorological conditions triggered the detected events, their synoptic situation was analysed. For this purpose, we performed a detailed analysis of the synoptic conditions focusing only in the days when the pARs/ARs reached Ny-Ålesund, using ERA5 reanalysis, due to its high temporal and spatial resolution.”

An improved version of this paragraph, shown below, was included in the new version of the manuscript:

“To understand which meteorological conditions triggered the detected events (pARs and ARs), we performed a detailed analysis of the synoptic conditions, using ERA5 reanalysis, due to its high temporal and spatial resolution.”

Line 304: ..used to study the atmospheric blocking

The adverb *“usually”* was removed from the sentence. The new version of the sentence, shown below, was included in the updated version of the manuscript:

“The combination of these variables is used to study the atmospheric blocking...”

However, the authors are not sure if this change comprises the suggestion proposed by the referee.

Line 354: After the landfall.. --> I believe here you mean the timing after the landfall while it could be interpret as location. This could be stated more clearly.

The following sentence was improved in order to be clearer to the readers:

“After the time of landfall, IVT and IWV decreased sharply, which was properly represented by all datasets.”

Line 378: Are you talking about the RMSE for IWV?

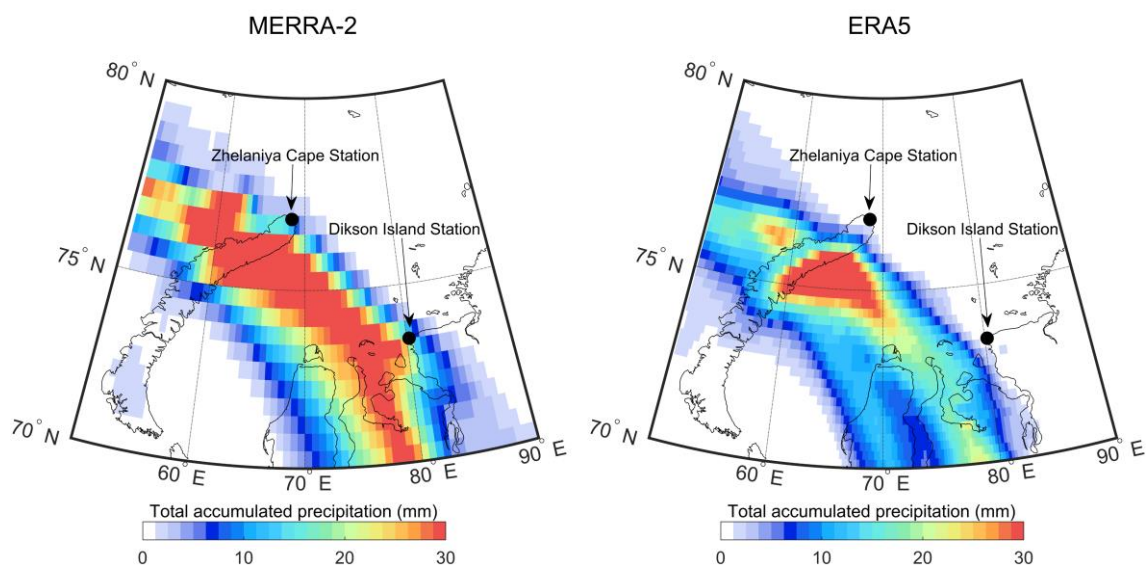
The RMSE value is relative to IWV. More information about the variable being analysed was added to the new version of the manuscript, in the following sentence:

“However, previous studies showed that IWV differences are not significant in Ny-Ålesund with an RMSE lower than 1 kg m^{-2} (Nomokonova, 2020).”

Line 520: Add interpretation to the sentence on low precip in ERA5

When comparing precipitation based on MERRA-2 and ERA5 reanalyses, one can notice that the precipitation amounts have large differences. Furthermore, if we focus on the

surrounding of Zhelaniya Cape and Dikson Island stations (figures below), these differences stand out. First, these stations are in the limits of the enhanced band of precipitation, with MERRA-2 still showing high values of precipitation over both stations, on contrary to ERA5, that already has the stations in the periphery of the precipitation band. Furthermore, even within the band of precipitation there are still substantial differences in the amounts of precipitation. Previous studies have shown that ERA5 and ERA-Interim, which is not shown here but also has similar precipitation patterns to ERA5 (see Figure 8 in the manuscript), simulate lower precipitation amounts when compared to other reanalyses over the Arctic (Boisvert et al., 2018; Barrett et al., 2020). The same studies showed that MERRA-2 reanalysis is one of the datasets with higher precipitation amounts over the entire Arctic.



References:

Barrett, A. P., J. C. Stroeve, and M. C. Serreze, 2020: Arctic Ocean Precipitation From Atmospheric Reanalyses and Comparisons With North Pole Drifting Station Records, *J. Geophys. Res. Oceans*, 125, e2019JC015415, doi: 10.1029/2019JC015415.

Boisvert, L. N, M. A. Webster, A. A. Petty, T. Markus, D. H. Bromwich, and R. I. Cullather, 2018: Intercomparison of Precipitation Estimates over the Arctic Ocean and Its Peripheral Seas from Reanalyses, *J. Clim.*, 31, 8441-8462, doi: 10.1175/JCLI-D-18-0125.1.

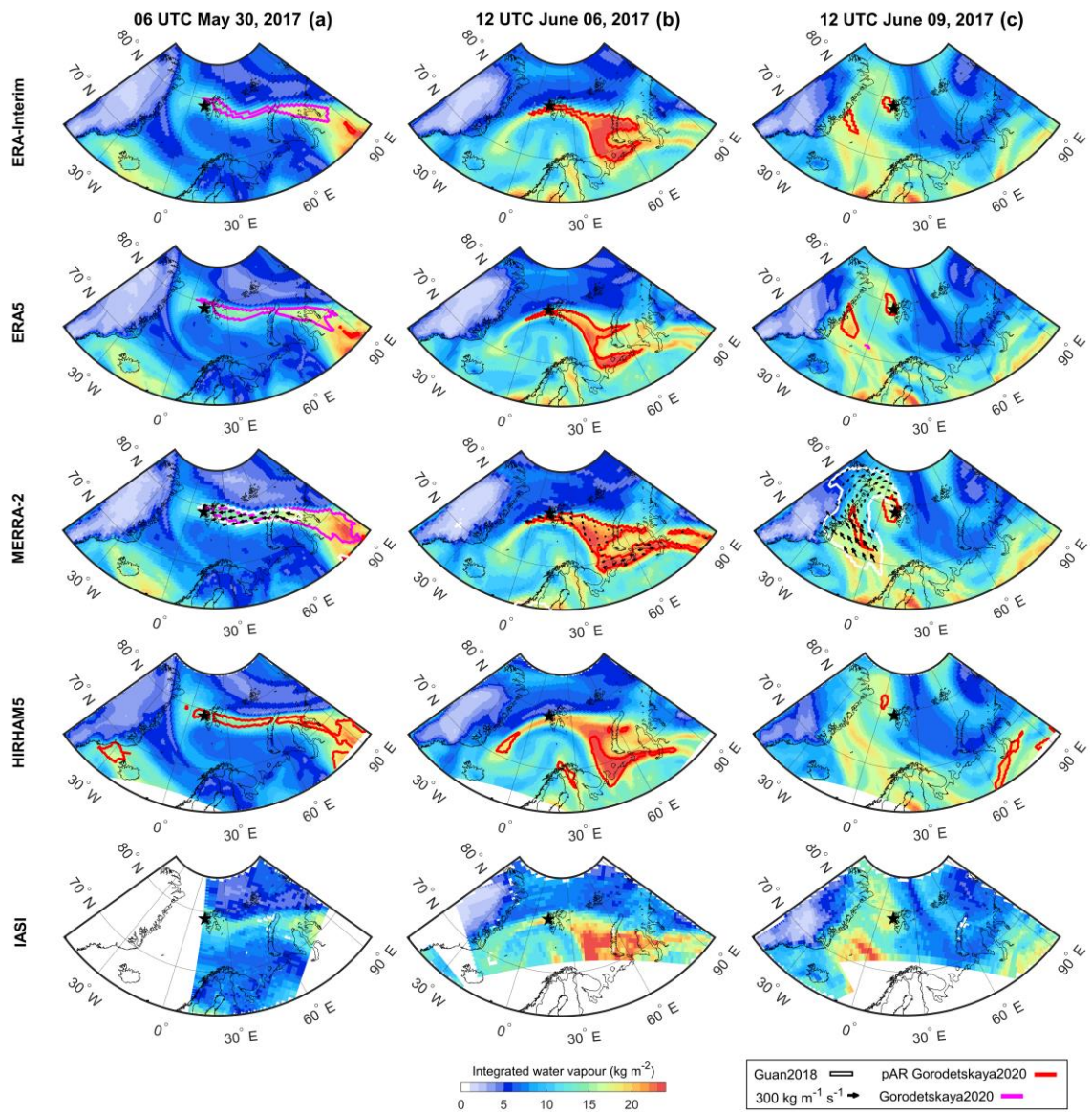
Line 660: In this study we focused **on** understanding

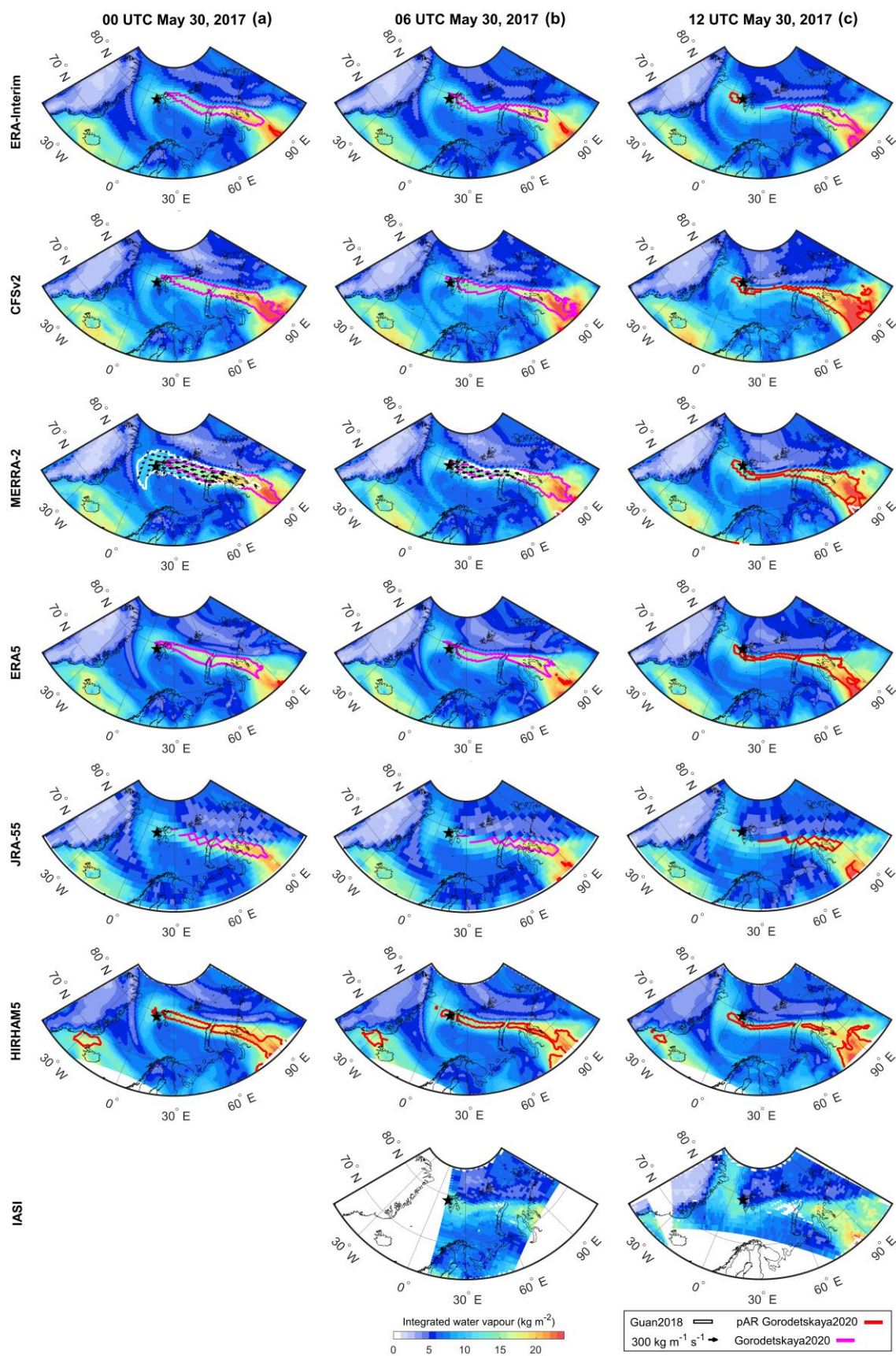
The authors thank the correction. The new version of the manuscript includes this suggestion.

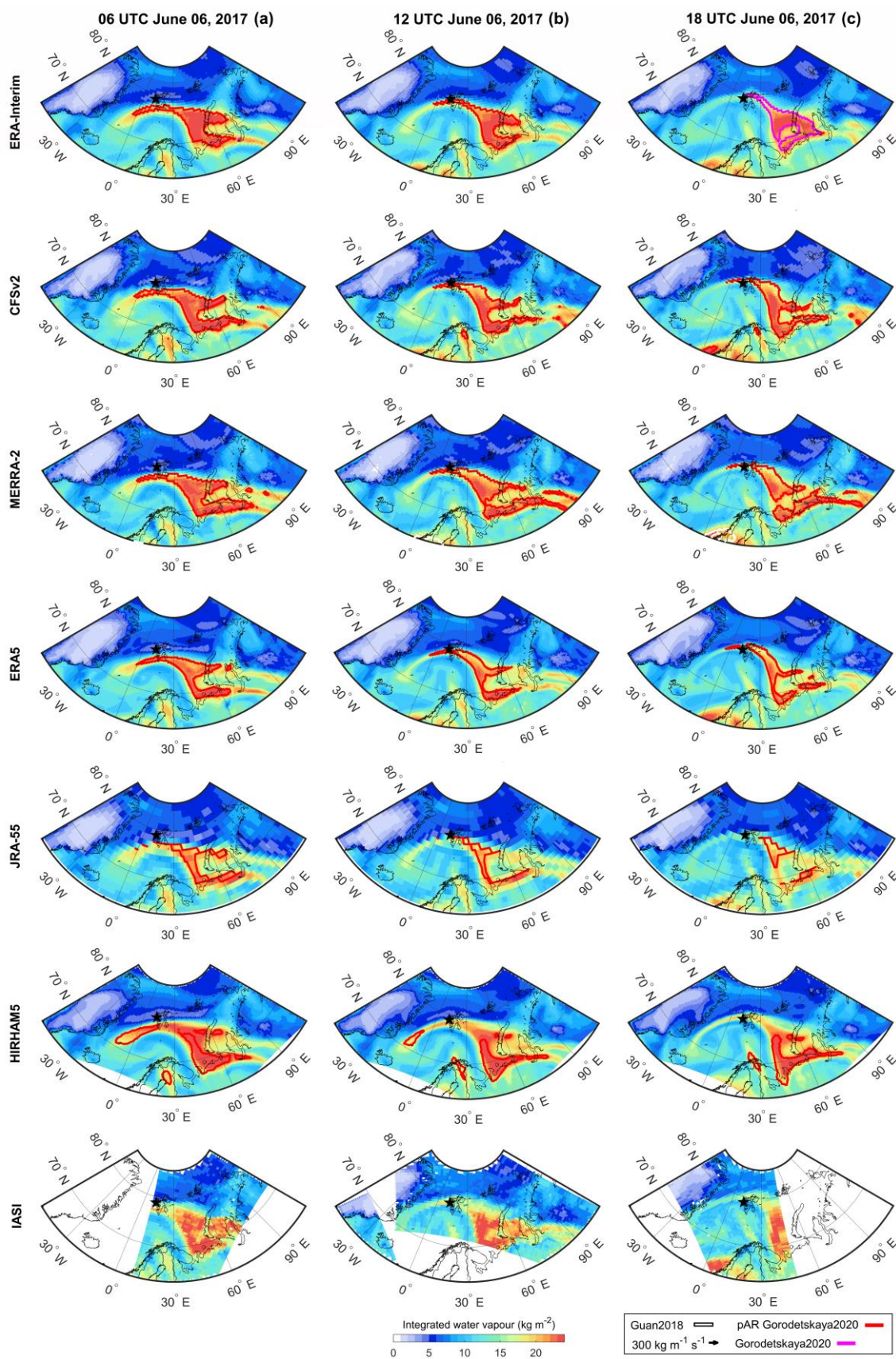
Figures & Tables

Figure 2: It would be nice to see the direction in which the AR is moving for extra insights in the event. You do show the orange arrows above 300, but could you lower it to get the direction for every plot? For the 6 June case you do not know the direction from the plot, which would give extra insights.

The authors thank the comment. The orange arrows (IVT) were only shown within the area of the AR detected by Guan et al. (2018), since IVT is the variable used in this algorithm. Thus, only the plots based on MERRA-2 reanalysis had these arrows, as it is explained in the figure caption (*"... orange arrows show integrated vapour transport (IVT, $\text{kg m}^{-1} \text{s}^{-1}$), both based only on MERRA-2 reanalysis."*). During the June 6 event, since it was not identified as an AR by Guan et al. (2018), the arrows were not shown. In the updated version of the manuscript, we included the IVT arrows in Figure 2 during the June 6 event, within the pAR shape by Gorodetskaya et al. (2020), with the purpose to show the direction of the flow. The colours of the arrows were changed to black to be visible during the June 6 event. Also Figures S1, S2 and S3 were updated to include the IVT arrows in black. The new figures are shown below:







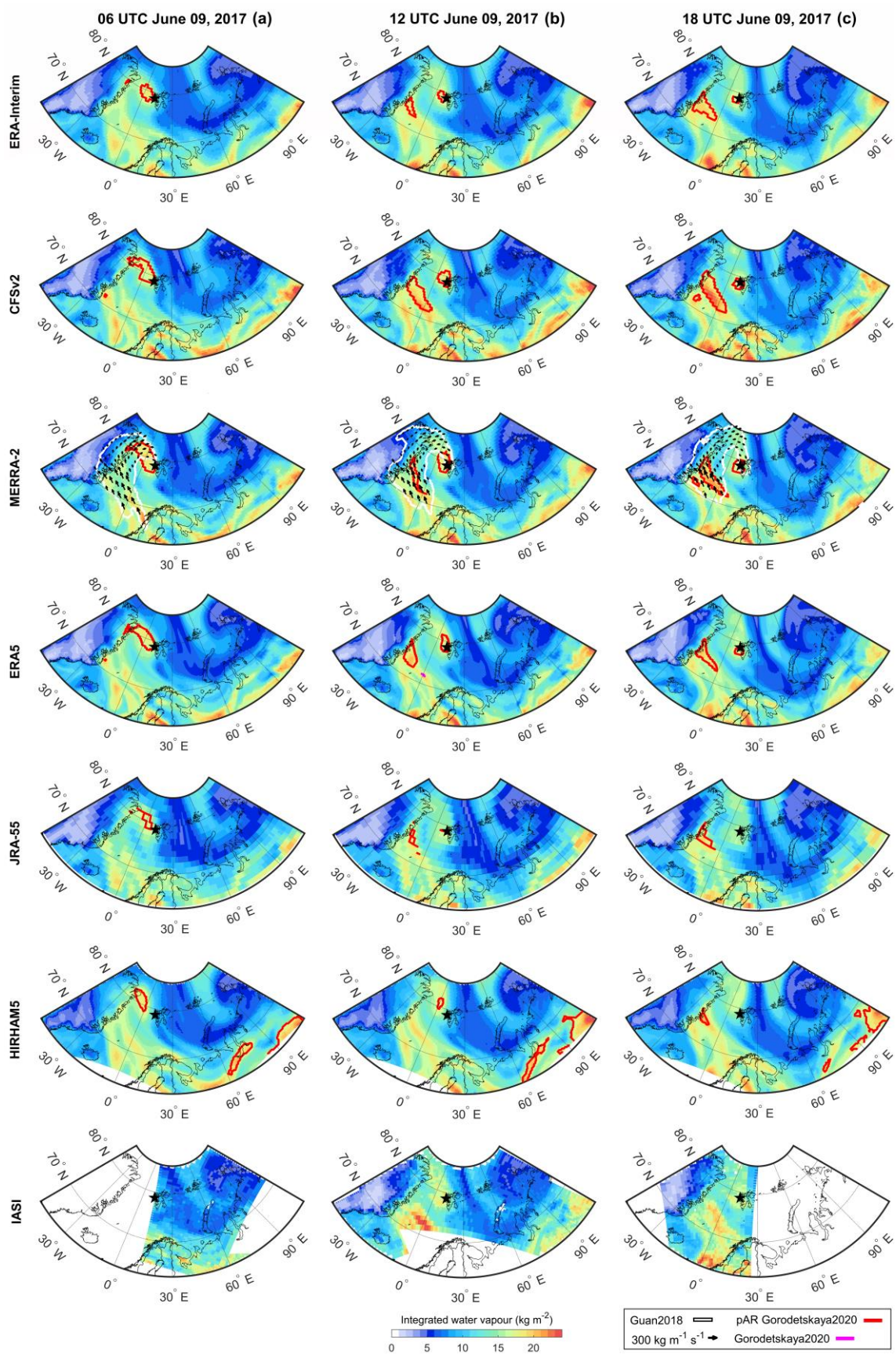


Figure 3: Is there a better way to visualize this data? I found the figure not very attractive.

The authors thank the comment from the referee. An effort was done to make the figure more attractive. The yellow colour, previously representing CFSv2, was changed to blue to be more visible. Furthermore, we plotted each time step closer, to be easier to understand if there was an increase/decrease of the pAR/AR area during the evolution of each event.

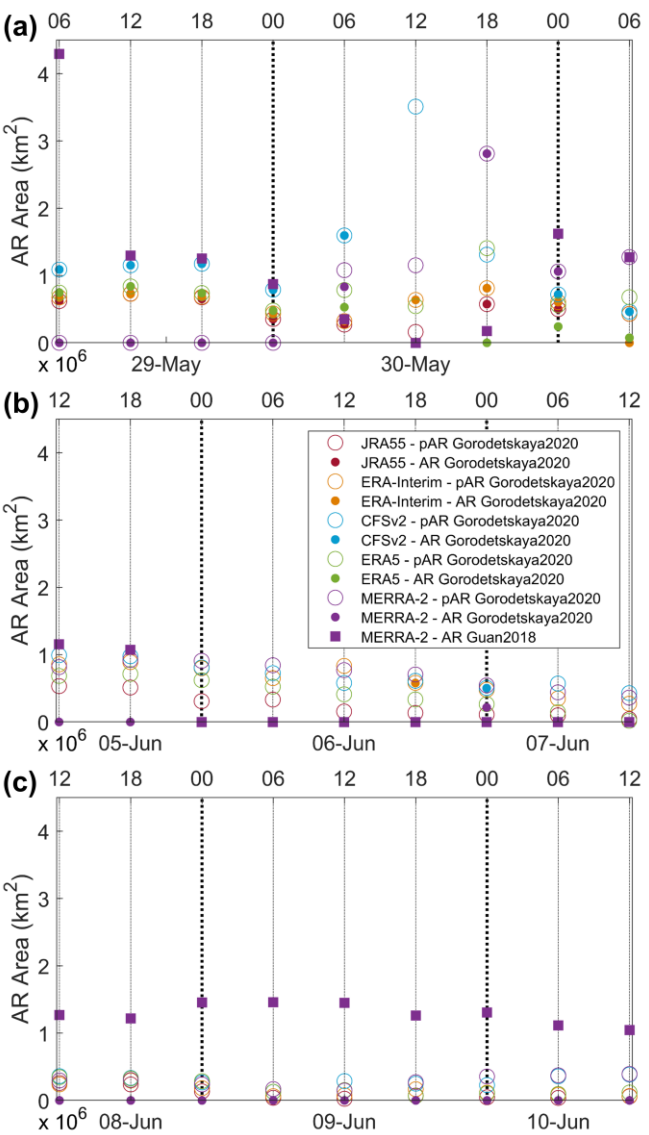


Table 2: I wonder if Table 2 is needed in the main manuscript, as you only refer to it twice in the text and most information can be also found in Figure 5

The authors thank the comment from the referee. Indeed Table 2 is only referred twice in the manuscript. Since this table has important information, that is more easily read in the table than in Figure 5, we moved Table 2 to the Supplementary Material, and in the new version of the manuscript it is named Table S2.

Figure 6: end of caption --> (reference) --> still edits are needed?

The caption from Figure 6 is already completed. The “(reference)” in the end of the caption “... and Figure S9 shows the differences between each reanalysis and model and the radiosondes (reference)” is meant to explain that in Figure S9 the radiosondes are used as reference for the differences. Thus, all the results shown were calculated using the following formulation:

$$Differences = var_{model/reanalyses} - var_{radiosondes}$$

Where *var* corresponds to the vertical profiles of specific humidity and wind speed.

Figure 9: In figure itself it should be accumulated instead of accumulated

The authors thank the correction. The colorbar title in Figure 9 was corrected. Also, the titles in Figures 8, S11, S12 and S13 were corrected.

The figures are shown below:

