GENERAL COMMENT

We have changed the tittle by removing SHORT COMMUNICATION in the beginning so that the manuscript will be labelled so by the journal.

REFEREE 3

1) The abstract needs major revision. For example: a) The abstract, in its current form, does not present the main results of the study. It presents a great deal of background material and the methods used. However, I do not believe it states in a clear and concise fashion the problem being addressed nor the main conclusions of the paper. The background information should be shortened to make room for the authors to more clearly state the previous results, what is still "disconnecting" in those results, and what the authors find in their study. b) Page 1034 Line 2: The first sentence is confusing: "could affect the global climate in similarly asymmetric way with respect to other regions" c) Page 1034 Line 5: This line seems to suggest that the "atmospheric branch of the hydrological cycle" is the only thing linking the Arctic system and the global climate. d) Page 1034 Line 20: The main results of the paper should be here rather than a listing of mechanisms that contribute to sea-ice loss.

Shortened and rewritten. The first two sentences were deleted and main results were added in the last sentence (Strikethrough text shows what is old and removed and text in red shows what is new and added)

~~" If we could choose a region where the effects of global warming are likely to be pronounced and considerable, and at the same time one where the changes could affect the global climate in similarly asymmetric way with respect to other regions, this would unequivocally be the Arctic. The atmospheric branch of the hydrological cycle lies behind the linkages between the Arctic system and the global climate.~~ Changes in the atmospheric moisture transport have been proposed as a vehicle for interpreting any of the most significant changes in the Arctic region. The increasing moisture over the Arctic during last decades it is not strongly associated with the evaporation that takes place within the Arctic area itself, despite the fact that the sea-ice cover is decreasing. Such increment is consistent is more dependent on ~~but to the fact that~~ the transport of moisture from the extratropical regions to the Arctic that has increased in recent decades, and is expected to increase within a warming climate. This increase could be due either to changes in circulation patterns which have altered the moisture sources, or to changes in the intensity of the moisture sources because of enhanced evaporation, or a combination of these two mechanisms. In this short communication we focus on the assessing more objectively the strong link between ocean evaporation trends and Arctic Sea ice melting. We will critically analyze several recent results suggesting links between moisture transport and the extent of sea-ice in the Arctic, this being one of the most distinct indicators of continuous climate change both in the Arctic and on a global scale. To do this we will use a sophisticated Lagrangian approach to develop a more robust framework on some of these previous disconnecting results, using new information and insights. Results reached in this study seems to stress the connection between two climate change indicators, namely an increase in evaporation over source regions (mainly the Mediterranean Sea, the North Atlantic Ocean and the North Pacific Ocean in the paths of the global western boundary currents and their extensions) and Arctic ice melting precursors. ~~Among the many mechanisms that could be involved are hydrological (increased Arctic river discharges), radiative (increase of cloud cover and water vapour) and meteorological (increase in summer storms crossing the Arctic, or increments in precipitation)"~~

2) The first paragraph of the introduction (Page 1034 Line 25 through Page 1035 Line 14) makes a strong case that the "hiatus" does not actually exist. However, to me, this discussion seems somewhat tangential and distracting (due to the controversy surrounding it) to the rest of the paper. I suggest the possibility of using this space to expand the discussion on Arctic climate change and/or possible mechanisms that are contributing to Arctic amplification.

We partially agree with the reviewer in this issue. Before tackling the main topic of our work we tried to provide a convincing link between global warming and the Arctic amplification. In this context, it is important to realize that both phenomena are not abating, despite the strong inter-annual or inter-decadal variability superimposed.

It is now known that 2014 was the warmest year on record according to NOAA (BAMS, Vol 96, Nº7, 2015, "State of the climate in 2014", a fact that was not clear when we submitted the manuscript). Furthermore, there is a good chance that 2015 will be even warmest than 2014 (partially due to the ENSO phase). According to NOAA (http://www.ncdc.noaa.gov/sotc/): "During January–June, the globally-averaged land surface temperature was 2.52°F (1.40°C) above the 20th century average. This was the highest for January–June in the 1880–2015 record, surpassing the previous record of 2007 by 0.23°F (0.13°C)."

In fact most recent literature on the issue has reinforced the idea that there is no hiatus at all, taking into account the level of heat incorporated by the Pacific (Kosaka and Xie, 2013) or the Atlantic (Chen and Tung, 2014) Oceans. Furthermore, the evolution of major external forcing factors in the last 20 years (solar, volcanic and aerosols) have dampened observed warming trends since 1992 (Schmidt, Shindell and Tsingaridis, 2014. Nature Geoscience).

Nevertheless, we agree we the reviewer that this is a bit lateral to the main focus of the paper, therefore, we have shortened this paragraph. Additionally, when answering some of the other issues raised by all the reviewers implied to incorporate some additional material concerning Arctic climate change mechanisms, as when answering questions 4, 8, 11 of reviewer #3.

3) Page 1035 Lines 20-26: The authors should discuss the seasonality of sea-ice loss and snow cover extent here, as I believe it is relevant to their study. With respect to SCE, there are clearly strong downward trends during spring and summer, but the trends actually reverse and are positive in fall and early winter (http://climate.rutgers.edu/snowcover/). Considering J. Cohen's identification of increasing Eurasian snow cover build-up during the fall, I think these positive trends have ramifications with respect to enhanced river discharge during the following melt season.

Clarification included in the text with respect to the summer and autumn sea-ice-extent (SIE) and the spring and summer snow-cover extent (SCE). The positive trend in fall and early winter is addressed in Q11.

"….the evolution of the climate in the Arctic region is often associated to two important indicators; the summer and autumn sea-ice-extent (SIE) and the spring and summer snow-cover extent (SCE), both characterized by a very significant decline since the 1970s and widely recognized as some of the most undeniable indicators of continuous climate change affecting the climate system (Tang et al., 2014; IPCC 2013)."

4) Page 1036 Line 15: Baggett and Lee (2015) find the existence of a planetary-scale wave life cycle that is highly amplified (blocking) despite a reduced meridional temperature gradient (consistent with Francis et al. 2012). Furthermore, the life cycle is preceded by enhanced warm pool tropical convection (consistent with the hypothesis presented in Palmer (2014)).

We have added the suggested comment in the text

"According to some authors, the recent rise on the incidence of summer extreme weather events over northern hemisphere continental land masses (Coumou and Rahmstorf, 2012; Seneviratne et al., 2014) is probably driven by the accelerated decline of summer SIE and SCE observed in recent decades (Francis and Vavrus, 2012; Tang et al., 2014). According to this hypothesis, the observed weakening of poleward temperature gradient triggered changes in atmospheric circulation namely slower progression of Rossby waves (Francis and Vavrus, 2012) and the existence of a planetary-scale wave life cycle (Bagget and Lee, 2015) that is highly amplified (blocking) despite a reduced meridional temperature gradient (consistent with Francis and Vavrus, 2012).These mechanisms have favored more persistent weather conditions that are often associated to extreme weather events, such as …"

5) Page 1036 Line 26: The confusing sentence from the abstract is more or less repeated here.

Rewritten

~~"For all the above mention reasons if we could choose a region where the effects of global warming are likely to be particularly noticeable, and on the other hand, one where the changes could affect the global climate in a similarly asymmetric way with respect to other regions, this would unequivocally be the Arctic (Screen and Simmonds, 2010; Tang et al., 2014, Cohen et al, 2014)."~~

"Considering all the above reasons the Arctic sector emerges as the most sensitive region of the climate system to the effects of global warming but it also represents an area where current and future changes are bound to affect the climate at a much larger scale (Screen and Simmonds, 2010; Tang et al., 2014, Cohen et al, 2014)."

6) Page 1037 Lines 5-14: Woods et al. (2013) and Liu and Barnes (2015) may be good references here, as they have done some work with respect to the atmospheric branch of the hydrological cycle. They discuss extreme atmospheric moisture transport into the Arctic through Rossby wave breaking and atmospheric rivers.

We have added the following comment in the text and the corresponding references:

"Some works try to explain extreme events of atmospheric moisture transport to the Arctic throughout the occurrence of atmospheric rivers (Woods et al., 2013) and Rossby wave breaking events (Liu and Barnes, 2015)."

7) Page 1037 Line 23: Do the authors mean "these methods" or "Lagrangian techniques"?

The authors refer to the Lagrangian techniques

8) Page 1038 Lines 15-26: Zhang et al. (2012) makes a nice connection between atmospheric moisture transport and increased river discharge, but, in my opinion, they do not provide a strong link between an increase in discharge and an increase in sea ice melt. They rely on the 2007 melt season as an example of a high discharge/high melt relationship. To me, the high discharge/high melt relationship is intuitive. However (and it may be outside the scope of this paper), it would be beneficial if there were quantitative evidence to support the relationship.

We agree with the reviewer in both stances, i.e. in what concerns to the comment and also in relation to the fact that this specific issue could be out of the scope of the article. However we would like to add additional examples of works done over Canadian Arctic region that support these results. These two references were added concerning this comment.

"The increase in Arctic river discharge is a possible cause of melting sea-ice in agreement with several studies realized over the Canadian Arctic region support these results (e.g. Dean et al., 1994; Nghiem et al., 2014)."

Dean, K. G., Stringer, W. J., Ahlnas, K., Searcy, C. and Weingartner, T.: The influence of river discharge on the thawing of sea ice, Mackenzie River Delta: albedo and temperature analyses. Polar Research, 13: 83–94, doi: 10.1111/j.1751-8369.1994.tb00439.x, 1994.

Nghiem, S. V., Hall, D. K., Rigor, I. G., Li, P. and Neumann, G.: Effects of Mackenzie River discharge and bathymetry on sea ice in the Beaufort Sea, Geophys. Res. Lett., 41, 873–879, doi:10.1002/2013GL058956, 2014.

9) Page 1039 Lines 20-27: The description of the method provided by the authors is sufficient, but I needed to read Stohl et al. (2004) to fully understand. Perhaps the authors should emphasize that Stohl et al. (2004) is a good reference near Page 1040 Line 5-7.

Done.

"For further information on FLEXPART model see Stohl el al. (2004)."

10) Page 1039 Line 19: It is not clear to me what constitutes the 3-D wind field. The authors state that October-March trajectories are calculated to test Zhang et al. (2012)'s results. Is the climatological October-March wind field used or are daily wind fields used to calculate the trajectories? I.e., are backward trajectories calculated for each day during October through March for the entire 1979-2013 dataset (initialization on ~ 6300 individual days)?

The trajectories are tracked every 6 hours for all the period (October-March), and then added day by day. So the 3D wind field data was used every 6 h in the model for the period October-March (initialization on ~6300x4 = 25300 individual time steps).

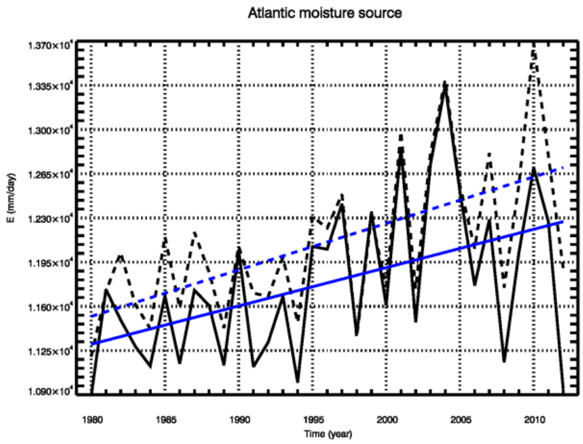
11) Page 1040 Lines 9-21: This may be a good area of the paper to discuss the increasing trend in SCE over Eurasia during fall and winter. Although, I am admittedly unsure if an increasing trend in SCE actually corresponds to an increasing trend in snow-liquid-water content found in the Eurasian Arctic river basins.

Yang et al. (2003) JGR, 10.1029/2002JD003149 shows good agreement between SCE and Eurasian rivers streamflow. However it is difficult to include this discussion in this section because of possible discrepancies between moisture source regions for Arctic rivers basin and areas of SCE positive trends, so we have preferred to include a reference in the third paragraph of the introduction as show below:

"In recent years a number of mechanisms have been put forward relating the strength of moisture transport and Arctic SIE. These mechanisms vary significantly in the nature of their main driver, including; i) hydrological, such as increments in Arctic river discharges (Zhang et al., 2012) or increments in precipitation due to enhanced local evaporation due to less SIE (Bintanja and Selten, 2014), ii) radiative, particularly through rises in cloud cover and water vapour (Kapsch et al., 2013), iii) dynamical, namely more summer storms with unusual characteristics crossing the Arctic, (Simmonds and Rudeva, 2012). Most likely these different mechanisms coexist to a certain extent and are not necessarily mutually exclusive (for instance the autumn and early positive trend is SCE (Estilow et al., 2015) can be closely related to positive trends in Eurasian rivers (Yang et al., 2007)…"

12) Page 1040 Line 23: The authors use OAFlux data to calculate trends in evaporation over the oceans. The authors use the wind field and q data from ERA-Interim to calculate E-P along the Lagrangian trajectories. Since q is clearly related to evaporation, it would be nice if the authors linked the two datasets to show that they are consistent with each other. I suggest recalculating the trend lines as seen in Figure 1 using ERA-Interim evaporation data to see how well they match the OAFlux results.

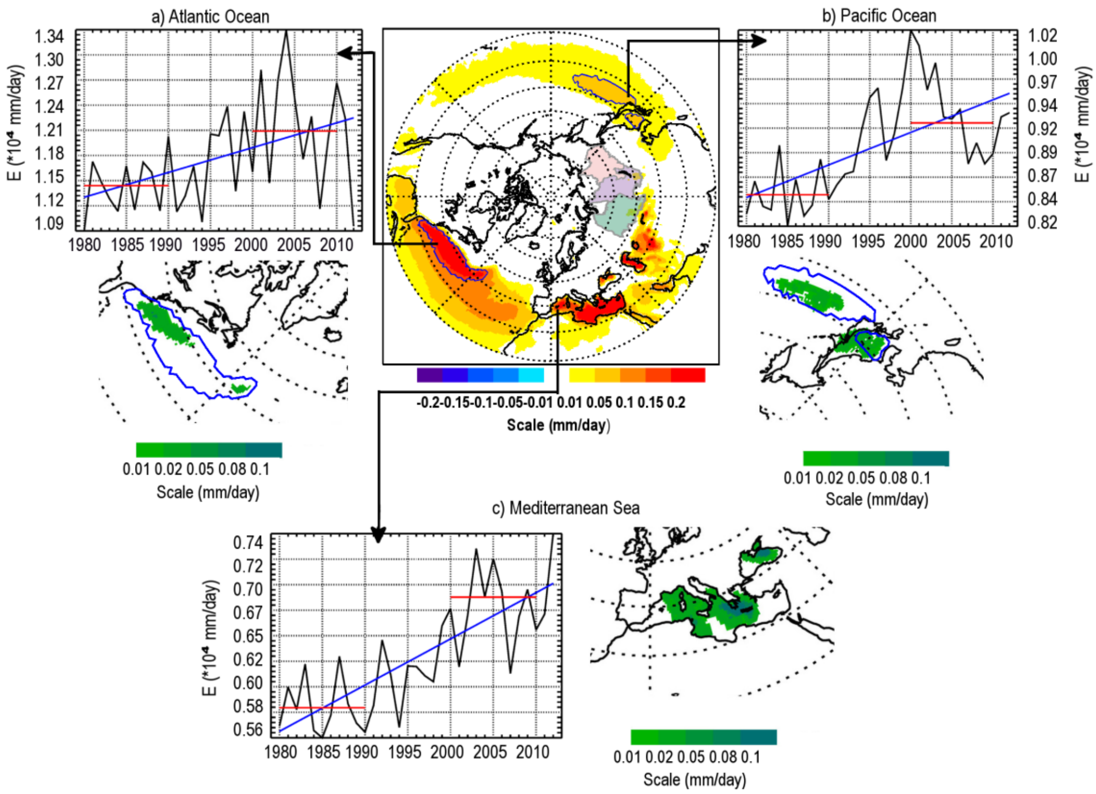
Done, they match pretty well. Figures are not included in the text, nevertheless a comment explaining that both dataset were used with similar results was included in the manuscript. We are including in this comment to reviewers the figure for the Atlantic comparing evaporation for both set of data (ERA-Interim data in dotted line).



13) Page 1041 Line 2: Rather than referring to the panels as "lateral", I suggest giving the panels letters to designate them clearly.

We have redone the Figure 1 and we added "Letters" [a, b and c] to each "lateral panel", and we modified the figure according with the other reviewer's comments. The text were modified.

"The a), b) and c) ~~three lateral~~ panels in Figure 1 also show the evolution of the average evaporation …"



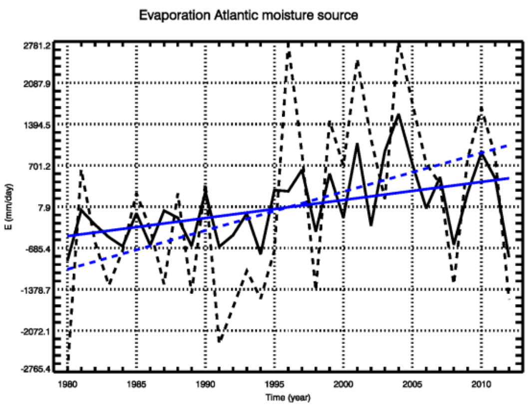
14) Page 1041 Line 4: How is the blue contour chosen? It appears that it is chosen via a specific contour line for each basin, but it also appears the value of the contour line is different for each basin. Also, there is no blue line for the Mediterranean. Is the whole Mediterranean basin used? If so, the blue line in that basin would not follow a particular contour. Is the OAFlux trend sensitive to the choice of the blue contour?

As the reviewer noticed the entire Mediterranean Sea basin was chosen as source. We have added this comment in the text and in the caption of the figure 1.

The blue contour in figure, as the review noticed, has a different value between the Atlantic source and the Pacific one. Our intention was not to compare the influence among sources but to take into account for each basin the main area of influence. So, we selected the 0.1 mm/day contour for the Pacific (the higher E-P value over this ocean) and the 0.2mm/day contour for the Atlantic (the higher in this case)

Trends were significant for both 0.1 mm/day (dotted line) and 0.2 mm/day (figure not included in the text but added to this comment of reviewers)

"Although superimposed to a pronounced decadal-scale variability ~~The~~ trends are significant in most of the grid points encircled, and are especially clear for the Atlantic, Pacific and Mediterranean sources. Similar results were reached when evaporation taken form ERA-Interim was used (not shown)."



15) Page 1041 Line 13: Which months are used for spring trajectories? Also, referring to my question (10), are trajectories calculated for every spring day?

We have specified in the text the month used: April and May.

See response to Q10. The trajectories were calculated every 6h.

16) Page 1041 Lines 13-21: The discussion concerning the results of Kapsch et al. (2013) seem quite rushed (although the authors state the figure is similar, it may still be nice to show it). The net result of the short discussion and lack of figure is to seemingly emphasize the results of Zhang et al. 2012 when perhaps that is not the intention of the authors.

We have included the figure for Kapsch et al. (2013) in the text in a similar way to that for Zhang et al. (2012) commenting the dominant role of the Pacific source.

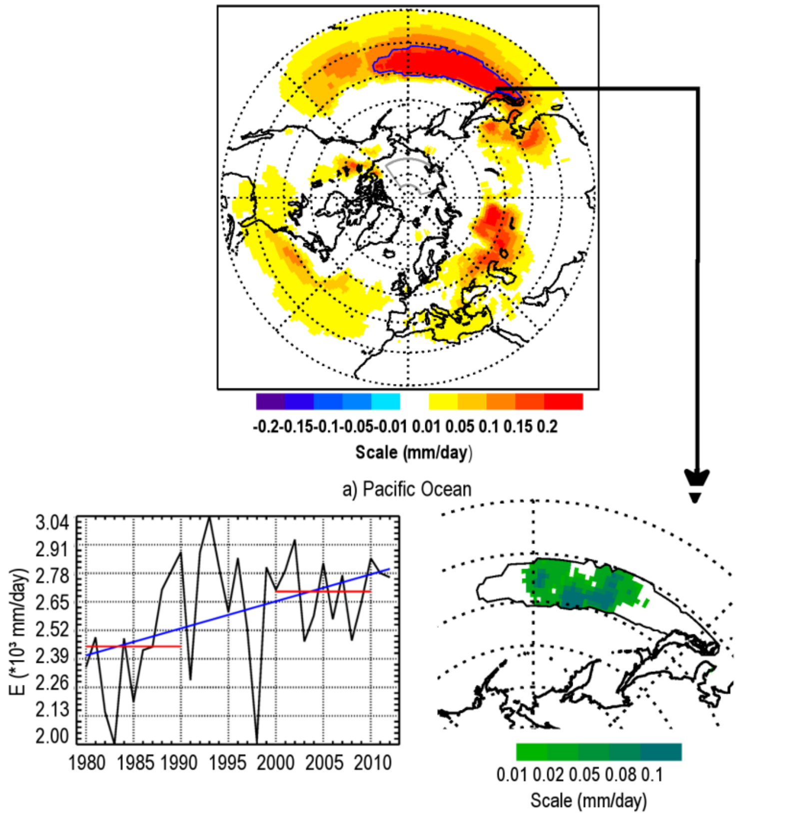


Figure 2. As Fig.1 but for the Kapsch area (115º-215º E ; 75º-85º N), denoted with the grey contour in the bottom panel.

New TEXT: "We have repeated the procedure considering the region analyzed by Kapsch et al. (2013), i.e. in this case, the late spring (April and May) moisture sources detected are related to the area where the September sea-ice anomaly is encountered. Overall results (Figure 2) are quite similar to those presented for the Arctic river basins, ~~in Figure 1 (figure not shown),~~ and the main moisture sources are also placed in the paths of the global western boundary currents in both the North Atlantic and the North Pacific Oceans (the main one in this case), and in the Mediterranean basins (more moderated in this case)."

17) Page 1042 Lines 1-5: These lines should be incorporated in some fashion into the abstract.

The abstract has been rewritten. See Q1

18) Page 1045 Caption: a) Rather than say "reddish colours" maybe use "warm colours" or "contours only show positive moisture sources"

Modified in the text

b) What are the units for the green shading?

The units used in the green shading of the figure are mm/day. Now all the units in the figure are the same.

c) The period 2000-2010 does not appear to be the highest period of evaporation for all source regions. For example, it appears the Pacific source regions peaked between 1995-2005. Perhaps the authors are just being consistent by using the same period for all three sources, but, regardless, I think something needs to be corrected here.

The referee is right. The sentence could get confuse. We selected the same period for all the analyzed sources. We have re-written the sentence in the text and in the caption of the figure.

Text: "The differences in the composites of the moisture sources of the Arctic river basins between the decade 2001-10 ~~(the highest evaporation)~~ and the decade 1981-90 ~~(the lowest)~~ are also shown in Figure 1, …"

Caption: "Figure 1. (Central panel) Climatological October-March 10-day integrated (E-P) values observed for the period 1979 – 2012, for all the particles bound for the Ob, Yenisei and Lena rivers basins (green, purple and pink areas respectively ~~grey contour line~~ indicate the basin area), determined from backward tracking. Warm ~~Reddish~~ colours represent regions acting as moisture sources for the tracked particles. Plots in green show the significant positive differences at the 95% level after bootstrap test (1000 interactions) in the composites of the moisture sources of the Arctic river basins between the decades 2001-10 ~~(the highest evaporation)~~ and 1981-90 ~~(the lowest)~~. Temporal series show the evolution of the average evaporation derived from OAFLUX dataset for the main moisture sources for the Arctic river basins (the Atlantic and Pacific sources, those circled with a blue line in the central figure, and for the whole Mediterranean Sea basin). ~~And plots in green show the significant positive differences at the 95% level after bootstrap test (1000 interactions) in the composites of the moisture sources of the Arctic river basins between the decade 2000-10 (the highest evaporation) and the decade 1980-90 (the lowest).~~ The blue lines are the linear trend and the red ones denoted the 10-year periods used on composites."