

Interactive comment on “The perfect pattern of moisture transport for precipitation for Arctic sea ice melting” by Luis Gimeno-Sotelo et al.

Anonymous Referee #2

Received and published: 6 March 2018

Review of the manuscript "The perfect pattern of moisture transport for precipitation for Arctic sea ice melting" by Gimeno-Sotelo, Nieto, Vazquez and Gimeno submitted to ESD.

The manuscript addresses an important question about the potential role of poleward moisture transport and associated changes precipitation in the recently accelerating Arctic sea ice decline. In order to identify the tipping points in the Arctic sea ice extent, the authors apply a statistical approach of computing the so called "change points" and focus on the year 2003 as the most important change point further analyzing changes in the moisture transport and atmospheric circulation patterns before and after this point. The moisture transport patterns are identified first by a Lagrangian approach estimating E-P along 10-day forward trajectories initiated from four sub-Arctic regions

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- and integrated over different Arctic regions. The authors use the moisture source region identified in a previous study as primary climatological moisture source regions. Particularly, the detected changes since the 2003 tipping point include a decrease in the (E-P) in summer and increase in fall and early winter (except for October).

I believe that combining these different methodologies can give new insights into the processes behind the observed sea ice extent changes. However, I find that conceptually the manuscript in its present stage misses to convey its message and needs major revisions before it can be considered for publication in ESD.

First, I find the title confusing and even misleading. Which perfect pattern is meant? Also, the statement "moisture transport for precipitation for Arctic sea ice melting" sounds rather awkward. I suggest to modify the title.

The authors present a detailed analysis with clear graphical representations, however methodology description is unfortunately too vague to appreciate and understand the results. I invite the authors to explain the concept of the change points in relationship to its application to the Arctic sea ice extent data. Further, it is not clear how the results shown in Fig 6 have been obtained and how these results can be interpreted. Section 3.2 text is very descriptive and lacks interpretation.

The methodology of the E-P analysis along the trajectories also needs to be better described. The moisture source regions are predefined from another study without any explanation - I invite the authors to explain the method in more details. The wording itself "moisture transport for precipitation" sounds confusing and has to be rephrased and better defined. The sentence explaining the methodology ("Then, we selected all particles losing moisture, $(e - p) < 0$, at the sinks (whole Arctic or any of the sub-regions), and by adding $e - p$ for all of these particles, we estimated moisture transport for precipitation from the source to the sink $(E - P) < 0$ at daily, monthly or yearly scales.") needs more clarification with an extended explanation. This approach also doesn't imply that precipitation results exclusively from the moisture transport and local

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moisture re-circulation can also contribute.

I find a lot of similarities of this manuscript with another article by a coauthor of the present article Vasquez et al 2017 (www.mdpi.com/2073-4433/8/2/32/pdf), which is not somehow in the reference list. Can the authors put this manuscript in context of Vasquez et al 2017 explaining the novelty of the results?

"We grouped individual days into four circulation types using the methodology developed by Fettweis et al. (2011) and explained in the Data and Methods sections." - in the Methods section the authors mention five (not four) circulation types and give no further explanations (which types, how they were defined...). Abbreviations used for the circulation types are not explained. What does it mean "the positive phase of the East Atlantic pattern" or "the negative phase of the East Atlantic/western Russia"?

I find that many statements in the Conclusions are not supported by the results. A major change seems to occur in 2003 - however unclear how this was obtained and what does it mean exactly (from the conclusions one can deduce that it means a drastic sea ice decline - I suppose the "change point" technique allows to detect that the mean SIE over the period after 2003 is significantly smaller than before). And the "perfect pattern of MTP for Arctic sea ice melting consists of a general decrease in moisture transport in summer and an increase in fall and early winter", as stated in the Conclusions section, refers to this year as I understand (no longer mentioned in the Conclusions). "This pattern is not only statistically significant but also consistent with Eulerian flux diagnosis, changes in circulation type frequency, and known mechanisms affecting snowfall or rainfall on ice in the Arctic." - which other known mechanisms affecting precipitation the authors refer to? "it is clear beyond doubt that an increment in moisture transport during this month favours ice melting, regardless of the source of moisture." - how is that clear? September's increase in MTP according to the methodology used here (if I understood correctly) means increased local precipitation vs evaporation (not necessarily increased moisture transport), and its impact to the SIE has not been established in this study. There are previous studies showing that the linkage can be the other way

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around - that precipitation has increased because of the decreased sea ice extent (eg, Bintanja, R. & Selten, F. M. Future increases in Arctic precipitation linked to local evaporation and sea ice retreat. *Nature* 509, 479–482 (2014).).

"Snowfall is the dominant (almost unique) form of precipitation during most of the year, with the exception of late summer." - there is frequent rain during summer (and not only later summer), especially in the peripheral Arctic regions. Even in the central Arctic rain can occur in the very beginning of the melt period (like during SHEBA, eg Perovich et al 2002).

"when precipitation is produced in the form of snowfall on sea ice, it enhances thermal insulation, and reduces sea ice growth in winter (Leppäranta, 1993), but increases the surface albedo, and thus reduces melt in spring and summer (Cheng et al., 2008). These phenomena justify the opposite change in moisture transport for fall and winter versus spring." - how can these phenomena justify any changes in moisture transport?

The manuscript has to be checked for language and consistency - there are many vague, incomplete phrases.

Interactive comment on Earth Syst. Dynam. Discuss., <https://doi.org/10.5194/esd-2017-122>, 2017.

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