Weather Clim. Dynam. Discuss., referee comment RC2
https://doi.org/10.5194/wcd-2021-85-RC2, 2022

Comment on wcd-2021-85

Anonymous Referee #2

Referee comment on "Meridional-energy-transport extremes and the general circulation of Northern Hemisphere mid-latitudes: dominant weather regimes and preferred zonal wavenumbers" by Valerio Lembo et al., Weather Clim. Dynam. Discuss., https://doi.org/10.5194/wcd-2021-85-RC2, 2022

This study investigates the characteristics of the extreme meridional energy transport associated with various zonal scales, using the reanalysis data. Using Extreme Value Theory, extreme events of the meridional energy transports are identified, and their associated zonal wavenumbers and meteorological patterns are analyzed. They found that extreme energy transports are, in general, associated with planetary (synoptic) scale wave during boreal winter (summer). Further, they connect those extreme energy transport events with commonly known teleconnection patterns. The topic and the results of this paper generally fits the aim of the WCD and would improve the scientific community's knowledge about the meridional energy transport.

However, I found that the manuscript's writing and the scientific results are vague. I think the Introduction needs more strong motivation and hypothesis, and the Methodology section should be written with more details as readers with meteorological background might not be familiar with advanced statistical method such as EVT. More importantly, I found it very difficult to digest the meteorological and dynamical interpretations of the extreme events presented in the Result and Discussion sections. My specific comments are presented below.

Introduction

First three paragraphs introduce general information of the meridional energy transport, and L48-51 only mentions the plan of this paper. Yet, I think the introduction can be improved by adding more motivations and hypothesis. Here are some suggestions.

- Why do we need to pay attention to the energy transport extremes at different length scales? I think L33-35 touches this issue, but it is not so clear to me how planetary waves can oppose the total transport. I think it just depends on the structure and the phase of the wave itself, and thus one cannot make a general statement about it. Can you provide some more references or more explanations?
- What is the main hypothesis? What do authors expect to find out by analyzing the different component of the meridional transport, for different seasons?

Method:

- L92: Authors have defined the planetary scale to be k=1 to 5, while some previous researches have defined waves with zonal wave number 1 to 3 as planetary scale waves and wavenumber 4 or higher as synoptic scale waves (cf. Baggett and Lee 2015; Shaw 2014 https://doi.org/10.1175/JAS-D-13-0137.1). Therefore, some discussion to justify the author's choice of the threshold between planetary and synoptic scale wave number would be helpful. Also, in L276, authors refer k=5 as a synoptic scale wave which is not consistent with the definition of the synoptic scale used in this paper.
- L124-126: I think this is a serious issue. If authors decided to remove the trend, then they should remove it from the entire grid point. Removing trend only at certain latitudinal band may result a physical unrealistic field and further analysis based on these data would make the readers to suspect the results. So, I suggest either do not remove the trend or remove the trend from the entire grid point. Or at least, authors should provide some information (perhaps as a supplementary figures) that qualitative results don't change regardless of the de-trending method (Even if the results may qualitatively remain same, authors would need to justify their choice anyway).
- L150-157: Authors argue that Figure 1 justifies the choice specific threshold values. However, even after looking at Figure 1, I cannot understand how authors have chose these specific threshold value (ex: 86% percentile for DJF poleward). So more detailed explain regarding this step would be helpful.
- L170: Can you explain why do you first apply EOF analysis before K-means clustering? Can't you just apply K-means clustering to the raw data, or just use the PC timeseries of the first 4 EOFs?
- I question the purpose of finding the weather regimes using a clustering algorithm. It makes more sense to me to directly diagnose the dynamical characteristics of energy transport extremes using the composite map of z500 pattern. My interpretation is that authors are hypothesizing that energy transport extremes should be associated with the identified teleconnection patterns, but that is not

  necessarily guaranteed. It is possible that each event may have their own circulation structure that may not resemble the known teleconnection patterns. Therefore, some discussion on why authors use clustering algorithm instead of directly diagnosing the circulation composite structures would be helpful.

Result

- L221: If the JJA PDF shows positive skewness, are you refereeing more colored contours toward left side of the yellow (mean) line? At least to me, the difference between high and low latitude are not so clear in Figure 4a.
- Can you add some scientific/meteorological interpretations of what it means to have positive skewness, and why positive skewness is an important finding?
- L251-253: Can you explain how PT regime (Fig. 2c) can be characterized as lower latitude negative anomalies and high latitude blocking? I think this pattern is rather zonally oriented without a prominent high latitude blocking-like structure or lower latitude signals.
- It is somewhat difficult to interpret the results presented in Figs 5 and 6, along with circulation structure presented in Fig. 2. For example, JJA NHC3 is similar to winter AO, and yet they show opposite results in Figs. 5e and 6e. Besides the seasonal difference, can you comment what makes such a difference in the poleward transport even when two circulation fields are dynamically similar? In addition, EATC3 shows increasing frequency in the 30-42°N degree band (Fig. 6b), while its strong circulation patterns are rather located at higher latitude near Greenland and Scandinavia (Fig. 2b). Can you explain how this circulation pattern can be related to the equatorward transport occurring near 30-40°N latitude?

- L286: Authors said '…JJA and DJF differ in the fact that the higher zonal variability in the latter…'. Shouldn't this be opposite? Figs. 7 and 8 say that JJA is associated with higher zonal variability and higher zonal wavenumber, not DJF.
- L287-288: Authors claim that poleward extremes have more meridionally marked, or zonally uniform, structure compared to the structure of the equatorward extremes. I don't see a clear difference between poleward and equatorward (there are no (a) and (b) in Figs. 9 and 10, so I assume the poleward is the left column and the equatorward is the right column). For example, in Fig.9, both panels of the 45°N-47°N band show zonal wave number 4~5 structure without prominent meridional structure. Also, it is little unclear to me how a relatively zonally uniform circulation structure would favor for a strong meridional energy transport. I would assume meridional wind in a zonally uniform circulation to be small. Providing more detailed reasoning for such an interpretation would be very helpful.
- Also, Figs. 9 and 10 shows the composite mean of z500 anomalies. Please indicate the sample size of the composite, and significance test of this composite sampled is also necessary.
- Regarding Figs. 9 and 10, the composite of z500 anomalies is helpful to diagnose the circulation structure, but it is yet difficult to tell where the energy transport is prominent. I think that plotting the composite of anomalous *vE* would help readers to diagnose the prime location(s) of the meridional energy transport.

Discussion

Comments on QRA and heatwaves:

L302-328: Authors argue that the heat waves are related to the poleward energy transport and present the year 2010 as an example of the extreme poleward energy transport. I found this interpretation is somewhat subjective and lack of dynamical

justifications.

My first concern is the choice of the sample. It looks like the energy transport in JJA, according to Fig. 8, is generally associated with the wavenumber 4 to 6. Accordingly, I would expect to find out energy transport to be associated with wavenumber of 4 to 6, regardless of the year. Therefore, the fact that dominant wavenumbers of the energy transport in 2010 is similar to the preferred zonal wavenumber of the quasi-resonant amplification (QRA) theory does not necessary mean that the energy transport and QRA theory are dynamically connected.

Also, according to the Figure 11, the extremes are computed with respect to 2010 mean, but shouldn't they be computed with respect to the climatology?

The second question is the actual dynamical connection between energy transport, QRA mechanism, and heat waves. If I understand correctly, QRA mechanism requires a zonally oriented enhanced jet stream that can act as a strong waveguide. In line with the comments made earlier, with such a zonally oriented background flow, it is little unclear to me how meridional energy transport can be strong. In addition, heat waves are rather caused by processes such as temperature advection, enhanced solar radiation within an anticyclone, and etc. So, if you can discuss how meridional energy transport can dynamically cause (or be associated with) the heat waves, it will help readers to follow the manuscript.

Other Comments:

- L329: It is confusing how composites based on the 30-33 band and 57-60 band can be characterized by negative NAO. The 30-33 band composite is more zonally oriented without a prominent anticyclonic feature over Greenland, and there are almost no signals in the composite by 57-60 band.
- Decomposing the zonal wavenumber of the energy transport into planetary and synoptic scale is an interesting, and perhaps, an important point, yet their dynamical origin is not discussed well. Therefore, I think the paper can have a broader impact by adding some more discussion on this topic. What are the causes of the planetary vs. synoptic scale meridional energy transports? Is it possible that planetary scale wave and energy transport can be excited by tropical forcing, whereas the synoptic scale waves can be associated with high-frequency transient eddy fluxes? If one can speculate the cause of those energy transport at different zonal scales, it might be beneficial to diagnose the variability and intraseasonal fluctuations of meridional energy transport and perhaps the long-term changes under anthropogenic warming. I will let the authors to decide whether to add a discussion on this topic.

Minor comment

- L179: Here, the patterns are based on the time period of 1979-2013, while L62 says that the analyzed time period is 1979-2012. If this is not a typo, then I think it is better to use the same time period for all analysis.
- L207, L337, and Figure 11 caption: It is better to spell out 'with respect to' instead of just writing wrt.
- L220 and L222: I think it is better to indicate specific latitudinal band instead of expressing as 'edges of the mid-latitudinal channel' or 'high/low latitude'.
- For clarity, it would be good to clearly indicate which figures authors are referring to. For example, L252, "… frequency of NAO-(Fig5a), AO(Fig.5e), and PT (Fig. 5c)" and L253 "In JJA, NHC4(Fig. 6e)/EATC2(Fig.6a) …". Same clarification in other lines will help readers to follow the manuscript better.
- It is somewhat difficult to remember the physical pattern of all the JJA pattern with the current names (for example, L276 and 278 EATC2 and NHC4 / EATC4, PACC4, NHC3). So, I suggest to re-name JJA patterns with more intuitive or commonly known names as in DJF, or explicitly explain in the text. For example, L276 can be re-written as '…EATC2 and NHC4(Scandinavia blocking-like pattern) …'.
- L381-398: In these paragraphs, references are written with out parenthesis. For example, L383 should be written as "… atmospheric features (Galfi et al. (2019); … et al. (2021))".

Figures

- Figures 2 a-d / A1 / A2: I think it might be visually beneficial to use rectangular map instead of circular map if you wish to only plot certain designated domain. This is only a suggestion, so I will let the authors to decide.
- Figures 3b-e and 4b-c: having a same x-axis range for all four panels will make it easier to compare the relative magnitude of the transport for different wave number regimes. Also x-label should be 'Meridional energy transport', not heat transport.
- Figure 9 and 10: (a) and (b) are missing. Also, the unit of color bars in Fig. 9, 10, and 11a are [Pa], which is not [dam].