

November 22<sup>nd</sup> 2021

To Whom It May Concern,

In this file, we provide details of needed changes on the proofs of our manuscript. There are four components to this:

- (1) Response to remarks from the copy-editor
- (2) Requested changes to main text on part of authors
- (3) Requested changes to supplementary text on part of authors
- (4) Description of file replacement needed for Fig. 2 and Fig. 4

Sincerely, and in behalf of all of all of the coauthors as well,

Keith Rodgers

krodgers@pusan.ac.kr // keithbrodgers@gmail.com

## **(1) Responses to Questions/Edits of Proof-team**

CE1: Please confirm the addition of a state abbreviation here

Yes, the abbreviation is correct.

CE2: Please confirm the insertion of “and”

Yes, thank you for finding and fixing this.

TS1: Please provide department

There is no departmental affiliation at Pusan National University.

TS2: The composition of all figures has been adjusted to our standards

Thank you for doing this.

TS3: Please provide last access date

November 19<sup>th</sup> 2021.

TS4: Please provide last access date

November 19<sup>th</sup> 2021.

TS5: Please provide last access date

November 19<sup>th</sup> 2021.

TS6: Please provide last access date

November 19<sup>th</sup> 2021.

TS7: Please confirm change

Yes, we can confirm this change.

TS8: Please provide a reference list entry including creators, title, and date of last access

FIG\_CODE\_GENERAL: Figure code for Rodgers et al., 2021, available at <https://github.com/kj-stein/CESM2-LE> [code], last access: November 19<sup>th</sup> 2021.

TS9: Please provide a reference list entry including creators, title, and date of last access

FIG\_CODE\_WAVELET: Figure code Fig. 3 wavelet analysis in Rodgers et al., 2021, available at <https://atoc.colorado.edu/research/wavelets/> [code], last access: November 19<sup>th</sup>, 2021.

TS10: Please provide a reference list entry including creators, title, and date of last access

CESM2\_LE\_OUTPUT: Model output for CESM2-LE presented in Rodgers et al., 2021, available at: <https://www.cesm.ucar.edu/projects/community-projects/LENS2/data-sets.html> [data set], last access: November 19<sup>th</sup>, 2021.

TS11: Please check DOI number

doi:10.5065/D6RX99HX

TS12: Please ensure that any data sets and software codes used in this work are properly cited in the text and included in this reference list. Thereby, please keep our reference style in mind, including creators, titles, publisher/repository, persistent identifier, and publication year. Regarding the publisher/repository, please add “[data set]” or “[code]” to the entry (e.g. Zenodo [code]).

We have addressed this for TS8, TS9, and TS10 above.

TS13: please provide page range or article number.

The full reference here, as provided by AGU, is:

Chung, E.-S., Ha, K.-J., Timmermann, A., Stuecker, M. F., Bodai, T., & Lee, S.-K. (2021). Cold-season Arctic amplification driven by Arctic Ocean-mediated seasonal energy transfer. *Earth's Future*, 9, e2020EF001898. <https://doi.org/10.1029/2020EF001898>.

(the article itself spans 17 pages in the journal, and they are numbered 1-17)

TS14: Please provide place of publication.

In a recent publication in *The Cryosphere* (Parera-Portell et al., 2021) this was referenced as : Fetterer, F., Knowles, K., Meier, W., Savoie, M., and Wind- nagel, A.: Sea Ice Index, Version 3, NSIDC: National Snow and Ice

TS15: Please provide place of publication.

A fuller reference for this study of Ghil indicates that the place of publication is London: Ghil, Michael. “A mathematical theory of climate sensitivity or, How to deal with both anthropogenic forcing and natural variability?” In *Climate Change: Multidecadal and Beyond*, edited by C. P. Chang, Michael Ghil, Mojib Latif, and J. M. Wallace, 31–51. World Scientific Publ. Co./Imperial College Press, London, 2015.

TS16: Please provide page range or article number.

The fuller reference of this paper totaling 13 pages is:

Goosse, H., Kay, J.E., Armour, K.C. *et al.* Quantifying climate feedbacks in polar regions. *Nat Commun* 9, 1919 (2018). <https://doi.org/10.1038/s41467-018-04173-0>

TS17: Please provide page range or article number.

The full reference for this paper spanning five pages (numbered 1 to 5) as provided by AGU is: Jin, F.-F., L. Lin, A. Timmermann, and J. Zhao (2007), Ensemble-mean dynamics of the ENSO recharge oscillator under state-dependent stochastic forcing, *Geophys. Res. Lett.*, 34, L03807, doi:10.1029/2006GL027372.

TS18: Please provide the publishing journal or institution.

This appeared in an AGU monograph entitled “El Niño Southern Oscillation in a Changing Climate”, edited by Michael J. McPhaden, Agus, Santoso, and Wenju Cai. AGU refers to this book series as “Geophysical Monograph Series”.

TS19: Please provide journal name, volume, and page range (or article number) or publisher and place of publication.

This paper was accepted on November 15<sup>th</sup> 2021 for publication by AGU's Journal of Advances in Modeling Earth Systems (JAMES), with DOI number:  
<https://doi.org/10.1029/2021MS002647>

TS20: Please provide publisher and place of publication.

This documentation (CVDLP-LE) has not been published or peer-reviewed, but is rather served as documentation via: <https://opensky.ucar.edu/islandora/object/manuscripts:1001>

TS21: Please provide page range or article number.

The article number is 036410

TS22: Please provide page range or alternatively article number.

The page range is 1489-1503.

TS23: Please provide publisher and place of publication.

As with TS20, this documentation has not been published or peer-reviewed, and is served via:  
<https://opensky.ucar.edu/islandora/object/manuscripts:825>

TS24: Please provide publisher and place of publication.

Cambridge University Press, Cambridge England.

TS25: Please provide full page range.

Pages 124-129.

TS26: Please provide full page range.

Pages 427-433.

TS27: Please provide full page range.

Pages 414-421.

TS28: Please provide the publisher and place of publication.

This appeared in an AGU monograph entitled "El Niño Southern Oscillation in a Changing Climate", edited by Michael J. McPhaden, Agus, Santoso, and Wenju Cai. AGU refers to this book series as "Geophysical Monograph Series".

TS29: Please provide page range or article number.

The full reference for this paper as given by AGU is:

Vissio, G., Lembo, V., Lucarini, V., and Ghil, M. (2020). Evaluating the performance of climate models based on Wasserstein distance. Geophysical Research Letters, 47, e2020GL089385.  
<https://doi.org/10.1029/2020GL089385>

TS30: Please provide page range or article number.

AGU provides the full reference for this paper as:

Weijer, W., Cheng, W., Garuba, O. A., Hu, A., & Nadiga, B. T. (2020). CMIP6 models predict significant 21st century decline of the Atlantic Meridional Overturning Circulation. *Geophysical Research Letters*, 47, e2019GL086075. <https://doi.org/10.1029/2019GL086075>

## (2) Author-requested changes to Proofs of main text

### MAIN TEXT

Blue text indicates specific changes

List of authors: (Tamás Bódai has affiliations with both “1” and “2”, and his name requires proper accents which we accessed through adding the Hungarian keyboard on MacOS)

Tamas Bodai<sup>2</sup> -> Tamás Bódai<sup>1,2</sup>

Affiliation #4: (Hawaii should not be written with an apostrophe, but rather an Okina <https://en.wikipedia.org/wiki/ʻOkina>; this was accessed by downloading a Hawaiian keyboard on MacOS, where the Okina can be referenced by the conventional apostrophe key)

Hawai'i -> Hawaiʻi

Line 9 of abstract: (get rid of comma)

probability, distribution -> probability distribution

Page 2, line 8 (get rid of word Climate)

Coupled Model Intercomparison Project

Page 2, lines 84-85 (get rid of “referred to here as CESM2-LE”)

...(Danabasoglu et al., 2020). The simulations cover...

Page 3, line 2

layers -> levels

Page 3, line 63 (the year “1381” is wrong)

1251, 1281, and 1301

Page 3, line 70 (the year “1091” is wrong)

1091 -> 1191

Page 3, line 71 (the year 1091 is wrong)

Intervals over 1001-1191

Page 3, line 71 (need to remove sentence that says “It warrants mention...control simulation”)

Intervals over 1001-1191

Page 3, line 105 (the year “1091” is wrong)

1031, 1051, ...1191} have greatly

Page 6, line 8 (the word “data” is wrong, should be replaced by “observational”)

For both the model and the observational product.

Page 6, line 32 (“ensemble-aggregated” is wrong)

Fig. 2 illustrates the ensemble- and gridpoint-aggregated Fourier...

Page 6, lines 77, 81, and 83 (“C modes” is wrong, needs replacing by “C-modes”)

C modes -> C-modes

Line 13 of Caption for Fig. 2 (“C modes” is wrong, needs to be “C-modes”)

C modes -> C-modes

Page 7, line 17 (need to add new words “of the forced change”)

To demonstrate the significance of the forced change for the spectra considered

Page 8, caption for Fig. 3, line 4 (cut text that says “The y-axis shows the equivalent Fourier period in years”)

Compo, 1998). The hatching indicates...

Page 8, line 6 (need to add the word “standard”)

The ensemble-wise (or across-ensemble) standard error using the 100...

Page 9, lines 3-7 (need to remove this text stating “It is worth noting.....significant in their difference”)

Remove final sentence of paragraph.

Page 9, line 11 (need to add reference to Torrence and Compo, 1998)

For the wavelet analysis (Torrence and Compo, 1998) in Fig. 3, we apply a Morlet.....

Page 9, lines 14-30

(these lines 14-30 are all in the wrong place describing Fig. 3, they in fact need to be moved to describe Fig. 4, and thereby place in what is now Page 10 at the end of line 36, with the new text modified so as to say as follows), but standing as an independent paragraph:

To calculate statistical significance of the changes, the general approach is to first calculate the equivalent sample size  $\hat{n}$ , to account for potential serial correlations of the time series. This is then used to calculate the degrees of freedom for the Welch’s  $t$ -test, which is an adjusted version of the Student’s  $t$ -test that allows for the two samples to have unequal variance (i.e., heteroskedasticity). First, the decorrelation timescale  $T_e$  was calculated at each grid point, and for each period, based on the e-folding timescale of the autocorrelation function  $r(\tau)$ , defined as the smallest lag  $\tau$  for which  $r(\tau) < e^{-1}$ . Then the equivalent sample size  $\hat{n}$  was defined as  $\hat{n} = \frac{N}{T_e}$ , where  $N = 30$  is the total sample size in our case. The equivalent sample size was then used to calculate the degrees of freedom of the standard Welch’s  $t$ -test. Note that this test may still be liberal if the equivalent sample sizes are small, i.e., in areas of high serial correlation.

Page 10, line 2 (need to replace “n” with “in”)

...becomes the dominant minimum in the across-ensemble SD....

Page 10, line 21 (need to replace “ (top) annual-mean ensemble SDs” with “seasonal mean.....”)  
calculations of seasonal mean SDs and Pearson correlation coefficients, respectively (bottom)

Page 10, line 22 (need to add “or correlation coefficient”)

...calculating the SD or correlation coefficients across all ensemble....

Page 10, line 24 (“sequence” => “sequence of steps”)

This sequence of steps was chosen....

Page 10, line 27 (Replace text stating “For the case of...all years spanning 1960-1989” with the following...)

To examine peak ENSO variance, surface temperature (Fig. 4a and 4c) and precipitation (Fig. 4b and 4d) were averaged over December-January-February (DJF), and then the across-ensemble SDs and correlation coefficients were calculated separately over all years spanning 1960-1989

Page 10, lines 28-29 (get rid of comma, such that “Fig. 4a),” becomes “Fig. 4a)”, and also get rid of “for DJF” on line 29)

Over December-January-February (DJF) (Fig. 4a) and precipitation (Fig. 4b)

Page 10, line 37 (“interannual variance” should be changed to “interannual to decadal variance”)

We begin by considering interannual to decadal variance changes in....

Page 10, line 42 (add to the end of the sentence “and their respective future changes are shown in circles”)

...is shown in shading (Fig. 4a and b) and their respective future changes are shown in circles.  
Surface temperature....

Page 11, caption for Fig. 4, second line (get rid of the word “absolute”)

...shading shows the time-averaged across-ensemble SD....

Page 11, caption for Fig. 4, fifth line (“p values” is wrong, change to “p-values”)



Determined based on the  $p$ -values

Page 11, caption for Fig. 4, fifth line (“ $t$  tests” is wrong, change to “ $t$ -tests”)  
...two-sample Welch’s  $t$ -tests...

Page 11, caption for Fig. 4, sixth line (“(Methods)” should say rather “(Section 3.3)”)   
...to account for serial correlations (Section 3.3). In the bottom row...

Page 11, caption for Fig. 4, sixth line (“ensemble wise” => “across-ensemble”)   
...color shading shows across-ensemble correlations ...

Page 11, caption for Fig. 4, 10<sup>th</sup> line (“ $p$  values” should say “ $p$ -values”)   
...based on the  $p$ -values...

Page 11, caption for Fig. 4, 10<sup>th</sup> line (“ $t$  test” should say “ $t$ -test”)   
 $t$  test ->  $t$ -test

Page 11, caption for Fig. 4, 11<sup>th</sup> line (“ $t$  test” should say “ $t$ -test”)   
 $t$  test ->  $t$ -test

Page 11, caption for Fig. 4, 11<sup>th</sup> line (change “ensemble standard deviations” to “across-ensemble SD”)   
Note that the  $t$ -test treats the across-ensemble SD and correlations...

Page 11, caption for Fig. 4, 12<sup>th</sup> line (“with” is wrong, should say “within”)   
...serially uncorrelated within either of the two periods...

Page 11, line 20 (“1081.010” is wrong, should be replaced by “1181.010”)   
1041.003, ..., 1181.010

Pg 12, caption for Fig. 5, 3<sup>rd</sup> line (“ensemble mean” should be changed to “ensemble-mean”)   
Evolution of the ensemble-mean seasonal cycles

Pg 12, caption for Fig. 5, 4<sup>th</sup> line (“zero crossing” needs to become “zero-crossing”)   
...and the second zero-crossing

Pg 11, caption for Fig. 5, 5<sup>th</sup> line (both instances of “zero crossing” need to be changed to “zero-crossing”)   
...first occurrence of zero-crossing, peak, second zero-crossing...

Pg 11, line 18 (“zero crossing” needs to become “zero-crossing”)   
first zero-crossing...

Pg 11, line 19 (“zero crossing” should be changed to “zero-crossing”)

second zero-crossing...

Pg 13, line 2 (“zero crossings” needs to become “zero-crossings”)  
the transitions (zero-crossings) were first...

Pg 13, line 22 (“oscillation” needs to become “Oscillation”)  
...Madden-Julian Oscillation...

Pg 14, line 59 (“Korean” needs to become “Korea”)  
...of the Korea Polar Research...

### (3) Author-requested changes to Proofs of Supplementary Text

Page 1, List of authors:

Tamas Bodai<sup>2</sup> -> Tamás Bódai<sup>1,2</sup>

Page 1, Affiliation #3: (needs to include CO as abbreviation of Colorado)

Boulder, CO, USA

Page 1, Affiliation #4: (needs to use an Okina rather than an apostrophe)

Hawai'i -> Hawai'i

Page 2, caption for Fig. S1, 2<sup>nd</sup> line:

26°N -> 26.5°N

Page 2, caption for Fig. S1, 2<sup>nd</sup> line: (add abbreviation "PI")

pre-industrial (PI) control run

Page 2, caption for Fig. S1, 4<sup>th</sup> line ("triangles" is wrong)

triangles -> closed circles

Page 3, caption for Fig. S2, 1<sup>st</sup> line at very end ("macro" should be replaced by "micro")

macro- -> micro-

Page 4, caption for Fig. S3, ("macro-" needs to be followed by a space)

...of the macro- and micro-perturbations....

Page 5, caption for Fig. S4, line 1 ("Biomass burning" should say "Biomass burning aerosols")

**Biomass burning.** -> **Biomass burning aerosols.**

Page 9, caption for Fig. S7, line 3 (units need to be cleaned up, with "-1" )

mm day-1 -> mm day<sup>-1</sup>

Page 9, caption for Fig. S7, line 3 ("PF" is wrong, it needs to say "PDF")

PF -> PDF

Page 9, caption for Fig. S7, at end of line 6 ("9red)" is wrong, this should say "(red)"

9red) -> (red)

Page 9, caption for Fig. S7, line 9 ("zonal wind" should say "zonal wind spectra")

zonal wind -> zonal wind spectra

Page 10, caption for Fig. S8, need to add text at end of caption

The confidence interval is based on 100 ensemble members, rather than on individual spatial gridpoints. There are a total of  $2 \times 100 = 200$  degrees of freedom considered here.

#### **(4) Necessary changes for Fig. 2 and Fig. S7**

Unfortunately, the figures we provided for proofs were missing features that were in the accepted version of the manuscript, namely blue stripes corresponding to C-modes. Please see the attached two PDF files for Fig. 2 and Fig. S7 (le\_fig2.pdf and le\_fig7\_supp.pdf)