Reply to Reviewer 2

This article presents extensive work on comparing the performance of different datasets on the closure degree of the water budget and demonstrates the acceleration in the hydrological cycle over Czechia. Overall, the paper is well written and readable and provides direct evidence of the performance on evaluation from different datasets. However, the title of the article could probably be rephrased, as it looks like a new method for demonstrating water cycle acceleration, but the actual story of the article is more about comparing the performance of different datasets using a novel method. Here are several issues needed to be addressed or clarified, which are listed as follows.

We thank the reviewer for their encouraging feedback and detailed comments. The empirical ranking framework we propose is our original approach. However, the focus of our work is to assess how different data sets portray different stories. While often there are similarities between data sets specially at coarser scales, in reality, each data sets depicts a different scenario. We will change the manuscript title from: "Water Cycle Acceleration in Czechia: A Water Budget Approach"

To: "Water Cycle Changes in Czechia: A Multi-Source Water Budget Perspective"

In the following, we provide detailed replies to all comments and discuss changes to the main manuscript.

Major comments:

Line 12: What does the median space pattern mean here? Why only mention spring and summer here?

To add further detail and clarity the text will be rephrased from: "Interestingly, the most significant temporal changes in Czechia take place during spring, while median spatial patterns stem from summer changes in the water cycle."

To: "Interestingly, the most significant temporal changes in Czechia occur during spring, while the spatial pattern of the change in median values stems from summer changes in the water cycle, which are the seasons within the months with statistically significant changes."

Line 17-21: A more logical organization is needed, perhaps adding a sentence in front of "on the one hand" to introduce the relationship between the water cycle and water fluxes you have chosen here (precipitation, evapotranspiration. . .). The information behind "on the one hand" and "on the other hand" are not parallel associations, and these two aspects are less relevant to the focus of this article.

For clarity and brevity the text will be rephrased from: "On the one hand, small changes in total precipitation suggest a shift in precipitation towards more intense and less frequent events [Trenberth, 2011]. On the other hand, it was hypothesized that an increased vertical gradient of atmospheric water vapor would offset atmospheric wind convergence in the tropics making wet regions wetter and dry regions drier [Held and Soden, 2006]."

To: ”It was hypothesized that an increased vertical gradient of atmospheric water vapor would offset atmospheric wind convergence in the tropics making wet regions wetter and dry regions drier [Held and Soden, 2006].”

Line 36-43: The information in parentheses may be summarized in a supplementary table and moved the table to supplementary materials for detailed clarification. In addition, please add the datasets categories (which ones belong to satellites or ground-based measurements, or climate models) in the table.

As suggested the information will be added as supplementary tables (Table S1, S2, S3, S4, and S5) in a formatting compatible with revised Table 1.

Table S1. Compiled from Sahoo et al. [2011]. P is precipitation, E is evapotranspiration, Q is runoff, and Δ TWS is changes in total water storage.

Name	Variable	Spatial Resolution	Temporal Resolution	Record Length	Data Type	Reference(s)
GPCP	P	1°	Daily	1997-2006	Satellite-based	Adler et al. [2003]
TMPA 3B42RT	P	0.25°	3h	1997-2019	Satellite-based	Huffman et al. [2007]
CMORPH	P	8km	30min	2003-2006	Satellite-based	Joyce et al. [2004]
PERSIANN	P	0.25°	3h	2000-2006	Satellite-based	Hong et al. [2004]
CPC PRECL	P	2.5°	Monthly	1950-Present	Gauge-based	Chen et al. [2002]
CRU TS3.0	P	0.5°	Monthly	1901-2006	Gauge-based	Mitchell and Jones [2005]
WM v2.01	P	0.5°	Monthly	1900-2008	Gauge-based	Willmott and Matsuura [2001]
GPCC	P	0.5°	Monthly	1900-2007	Gauge-based	Schneider et al. [2011]
PM (ISCCP)	E	2.5°	3h	1984-2005	Satellite-based	Sheffield et al. [2010]
PM (EOS)	E	5km	Daily	2003-2006	Satellite-based	Vinukollu et al. [2011]
PT (EOS)	E	5km	Daily	2003-2006	Satellite-based	Vinukollu et al. [2011]
SEBS (EOS)	E	5km	Daily	2003-2006	Satellite-based	Vinukollu et al. [2011]
VIC	E	1.0°	3h	1948-2006	Model	Sheffield and Wood [2007]
ERA-interim	E	T255	12h	1989-2006	Reanalysis	Simmons [2006]
GRACE	Δ TWS	Basin	~Monthly	2002-2006	Satellite-based	Swenson and Wahr [2006]
GRDC	Q	Basin	Monthly	1900-2006	Station	`www.bafg.de/GRDC`

Table S2. Compiled from Pan et al. [2012]. P is precipitation, E is evapotranspiration, Q is runoff, and Δ TWS is changes in total water storage.

Name	Variable	Spatial Resolution	Temporal Resolution	Record Length	Data Type	Reference(s)
GPCP v2.2	P	2.5°	Monthly	1950-Present	Gauge-based	Adler et al. [2003]
CRU TS3.0	P	0.5°	Monthly	1901-2006	Gauge-based	Mitchell and Jones [2005]
WM v2.01	P	0.5°	Monthly	1900-2008	Gauge-based	Willmott and Matsuura [2001]
GPCC	P	0.5°	Monthly	1900-2007	Gauge-based	Schneider et al. [2011]
MPI	E	0.5°	Monthly	1982–2008	Flux tower-based	Jung et al. [2010]
SEBS (EOS)	E	5km	Daily	2003-2006	Satellite-based	Vinukollu et al. [2011]
GRACE	Δ TWS	Basin	~Monthly	2002-2006	Satellite-based	Swenson and Wahr [2006]
GRDC	Q	Basin	Monthly	1900-2006	Station	`www.bafg.de/GRDC`

Table S3. Compiled from Rodell et al. [2015]. P is precipitation, E is evapotranspiration, Q is runoff, and Δ TWS is changes in total water storage.

Name	Variable	Spatial Resolution	Temporal Resolution	Record Length	Data Type	Reference(s)
GPCP v2.2	P	1°	Daily	1997-2006	Satellite-based	Adler et al. [2003]; Huffman et al. [2009]
Princeton ET	E	5km	Daily	2003-2006	Satellite-based	Vinukollu et al. [2011]
MERRA and MERRA-Land	E	0.5°x0.667°	Hourly	1980-2016	Reanalysis	Rienecker et al. [2011]; Bosilovich et al. [2011]; Reichle
GLDAS	E	0.25°	3h	1948-2014	Model	Roderick et al. [2014]
University of Washington runoff	Q	2°	Monthly	1998–2008	Model	Jung et al. [2010]
GRACE	Δ TWS	Basin	~Monthly	2002-2006	Satellite-based	Swenson and Wahr [2006]

Table S4. Compiled from Zhang et al. [2016]. P is precipitation, E is evapotranspiration, Q is runoff, and Δ TWS is changes in total water storage.

Name	Variable	Spatial Resolution	Temporal Resolution	Record Length	Data Type	Reference(s)
CSU	P	0.25°	3h	1998–2010	Satellite-based	Bytheway and Kummerow [2013]
PGF	P	0.25°	3h	1948–2010	Satellite-based	Sheffield et al. [2006]
CHIRPS	P	0.5°	Monthly	1981–present	Satellite-based	Funk et al. [2014]
GPCC(v6)	P	0.5°	Monthly	1901–2010	Gauge-based	Schneider et al. [2014]
TMPA-RT	P	0.25°	Monthly	2001-2019	Satellite-based	Huffman et al. [2007, 2010]
SRB–PGF–PM	E	0.5°	3h	1984–2007	Satellite-based	Vinukollu et al. [2011]
VIC	E	0.25°	3h	1948-2010	Model	Sheffield and Wood [2007]
ERA-interim	E	T255	12h	1989-2006	Reanalysis	Simmons [2006]
MERRA	E	0.5°x0.667°	Hourly	1980-2016	Reanalysis	Rienecker et al. [2011]
GLEAM	E	0.5°	3h	1984-2017	Satellite-based	Gonzalez Miralles et al. [2011]
SRB-CFSR-SEBS	E	0.5°	Daily	1984–2007	Satellite-based	Vinukollu et al. [2011]
SRB-CFSR-PM	E	0.5°	Daily	1984–2007	Satellite-based	Vinukollu et al. [2011]
SRB-CFSR-PT	E	0.5°	Daily	1984–2007	Satellite-based	Vinukollu et al. [2011]
VIC	Q	0.25°	3h	1948-2010	Model	Sheffield and Wood [2007]
VIC	Δ TWS	0.25°	3h	1948-2010	Model	Sheffield and Wood [2007]
GRACE	Δ TWS	1°	Monthly	2002-present	Satellite-based	Landerer and Swenson [2012]

Table S5. Compiled from Munier and Aires [2018]. P is precipitation, E is evapotranspiration, Q is runoff, and Δ TWS is changes in total water storage.

Name	Variable	Spatial Resolution	Temporal Resolution	Record Length	Data Type	Reference(s)
TMPA	P	0.25°	Monthly	1998-2019	Satellite-based	Huffman et al. [2007]
CMORPH	P	0.25°	Daily	1998–present	Satellite-based	Sheffield et al. [2006]
NRL	P	0.25°	12h	2003–2010	Satellite-based	Turk et al. [2010]
GPCP	P	2.5°	Monthly	1979–present	Satellite-based	Schneider et al. [2014]
GLEAM	E	0.25°	3h	1980–2011	Satellite-based	Gonzalez Miralles et al. [2011]
MOD16	E	1km	8-day	2000–2012	Satellite-based	Mu et al. [2007]
NTSG	E	8km	Daily	1983–2006	Satellite-based	Zhang et al. [2010]
CSR	Δ TWS	Basin	Monthly	2002-present	Satellite-based	`http://grace.jpl.nasa.gov/data/`
GFZ	Δ TWS	Basin	Monthly	2002-present	Satellite-based	`http://grace.jpl.nasa.gov/data/`
JPL	Δ TWS	Basin	Monthly	2002-present	Satellite-based	`http://grace.jpl.nasa.gov/data/`
GRGS	Δ TWS	Basin	Monthly	2002-present	Satellite-based	`http://grgs.obs-mip.fr/grace/`
GRDC	Q	Basin	Monthly	1900-present	Station	`http://www.grdc.sr.unh.edu/`

Table 1: Add the datasets categories (which ones belong to satellites or ground-based measurements or climate models) in table 1.

Table 1 will be revised as follows:

Table 1. Data set description. P is precipitation, E is evapotranspiration, and Q is runoff.

Name	Variable(s)	Spatial Resolution	Temporal Resolution	Record Length	Data Type	Reference
CHMI	P	Point	Daily	1961-2020	Stations	`http://portal.chmi.cz`
CRU TS v4.06	P	1°	Monthly	1901-2020	Gauge-based	Harris et al. [2020]
E-OBS	P	0.125°	Daily	1950-2020	Gauge-based	Cornes et al. [2018]
ERA5-Land	P, E, Q	0.1°	Monthly	1950-2020	Reanalysis	Muñoz-Sabater et al. [2021]
GRDC	Q	Point	Daily	1921-2017	Stations	`www.bafg.de/GRDC`
mHM	E, Q	0.125°	Daily	1950-2020	Model	Samaniego et al. [2010]
NCEP/NCAR R1	P, E, Q	T62	Monthly	1948-2020	Reanalysis	Kalnay et al. [1996]
PREC/L	P	0.5°	Monthly	1948-2020	Gauge-based	Chen et al. [2002]
TerraClimate	P, E, Q	4 km	Monthly	1958-2020	Model	Abatzoglou et al. [2018]

Line 173: Are there any supporting references to this similar approach? If yes, please provide the citations.

To the best of our knowledge there are no references for a similar approach. This is our proposed equation.

Line 180: It is okay to use the medians for excluding the outliers, but can you provide a supported plot to show the distribution of values as supplementary material?

Instead of adding a supplementary figure, Figure 4 will be revised from a histogram to a box plot. In the revised Figure 5 it can be seen that outliers are present only in the latter period (i.e., 1991-2020).

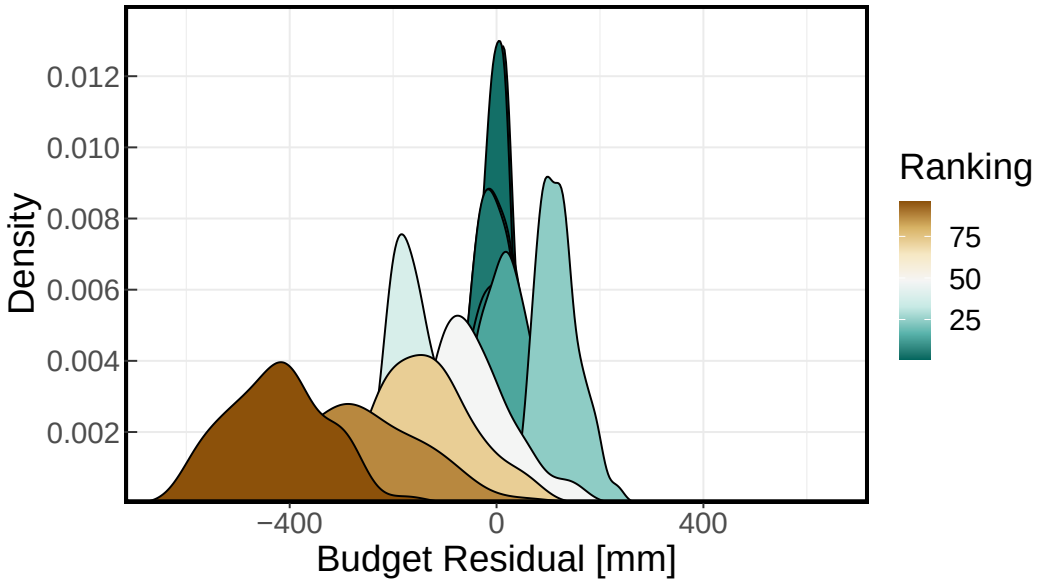

Figure 5. Box plots of spatial weighted average annual water fluxes over Czechia, where P is precipitation, E is evapotranspiration, Q is runoff, and $P - E$ is precipitation minus evapotranspiration. Data are divided into two 30-year periods: 1961-1990 (blue) and 1991-2020 (yellow). Note that outliers are present only in the latter period (i.e., 1991-2020) as expected from the recorded severe drought of 2003.

Line 196-197: The demonstration is on the edge, as it is not all time is overestimated and underestimated, only in some certain period.

It is true that overestimation or underestimation are not present at every single time step. The statements referred to the overall discrepancies as quantified by the 1981-2020 average. The text will be updated to reflect the revised evaluation values (see second major comment from Reviewer 1), also for clarity the text will be rephrased from: "mHM has the highest correlation for runoff, with R-squared circa 0.86 (Figure 2c), falling to the second highest for evapotranspiration (R-squared 0.7; Figure 2c). Interestingly, the values for the 30-year average in mHM underestimates runoff (Figure 2c) but overestimates evapotranspiration (Figure 2b)."

To: "mHM has the highest correlation for runoff, with R-squared circa 0.93 (Figure 2c)."

Figure 4: Can you use the line plot to show the trend as this is a time series for changes in hydrological variables, while a histogram may not be very straightforward?

The intent of the figure is to show the change between two climate normals, not the overall trend. Thus, the figure will revised into a box plot not a line pot (Figure 5 above on reply to comment "Line 180").

Figure 7-9: When you discuss the spatial distributions in different parts of Czechia maybe just focus on the one figure which is most representative as I see the spatial patterns are similar across Figure 7-9 and moved the rest figures to supplementary materials.

Figure 7 (now Figure 8) will be kept in the main manuscript and Figures 8 and 9 will be in the supplementary as Figure S3 and S4, respectively.

Minor comments:

Nine datasets? But in Table 1 there are ten datasets, right?

Nine data sets indeed. Table 1 will be revised and data type will be added (see major comment on Table 1)

Figure 5: Is it possible to zoom in on the y-axis limit because the boxes in the second and third rows are not clear?

The y-axis was modified as suggested:

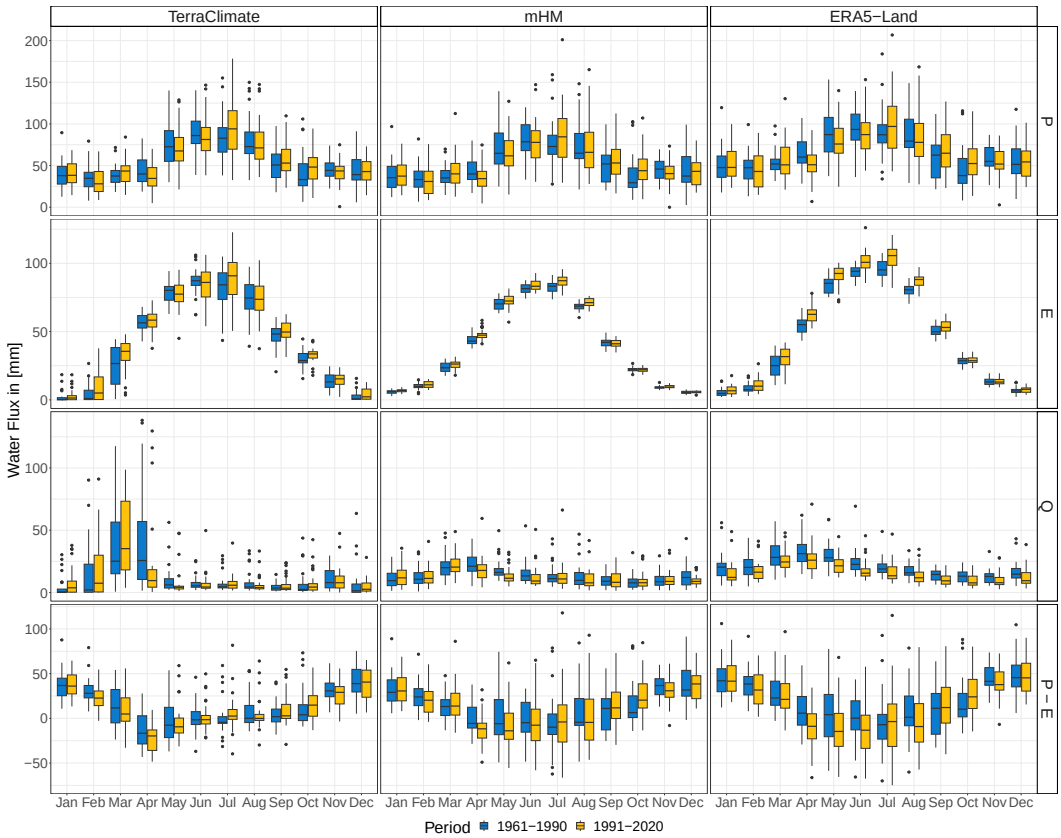

Figure 6. Box plot of spatial weighted average monthly water fluxes over Czechia, where P is precipitation, E is evapotranspiration, Q is runoff, and $P - E$ is precipitation minus evapotranspiration. Data are divided into two 30-year periods: 1961-1990 (blue) and 1991-2020 (yellow). Left column: TerraClimate (P), TerraClimate (E), and TerraClimate (Q). Middle column: mHM(E-OBS) (P), mHM (E), and mHM (Q). Right column: ERA5-Land (P), ERA5-Land (E), and ERA5-Land (Q).

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