To anonymous Referee #1, 23 May 2022

General comments for the authors' reference:

This manuscript is about the temporal downscaling of satellite based terrestrial water storage anomalies (TWSA) using data-based methods with in-situ meteorological data and assimilated soil moisture data as inputs. In addition, a new index is proposed incorporating downscaled TWSA estimates and daily precipitation to monitor flood events. The concepts are applied to four (sub-)basins of the Yangtze River Basin (YRB) in China.

Overall, the paper is well structured and written, and presents an interesting approach to temporally downscale GRACE/ GRACE-FO data to obtain daily TWSA estimates and its subsequent use in a daily normalized flood index. The authors generally use informative figures to illustrate their results. However, several issues need attention such as the concept and method to remove trends from the TWSA time series (see specific comment 7), the assumption that the data-based relationships between TWSA and hydro-meteorological variables are time scale invariant (see specific comment 16) and the advantages of the proposed method and possible operationalisation (see specific comment 21). These and other specific and technical comments can be found below.

Response: Thanks for your valuable suggestions. We have tried our best to improve the manuscript both in the language and contents based on your comments and suggestions. We sincerely appreciate your valuable inputs and we hope that the changes implemented are sufficient for acceptance of our paper for publication.

Specific comments

(1) L23: Only damage to structures and agriculture? No other types of flood damage and/ or casualties? See also line 38, where only a monetary value is mentioned without non-monetary damage and casualties/victims.

Response: As described in Line 23 and Line 64, we have rewritten these sentences to provide more information about the effects of extreme floods based on your suggestions.

"Extreme floods, as one of the most destructive natural hazards, not only cause lots of casualties in China and around the world, but also have considerably wider and adverse economic consequences (Dottori et al., 2018)."

"For example, in Year 2020, the YRB has experienced one of the most extreme flood events on record. According to the data from the Ministry of Emergency Management of the People's Republic of China, a total of 38.173 million people were affected and 27,000 houses collapsed due to the 2020 flood, with 56 deaths or disappearances and a great economic loss of $27.68 billion (USD) (Jia et al., 2021)."

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(2) L31: Why does this study use the YRB as case study? How representative is the YRB for other basins in the world? To what extent can the methods and/ or results be generalized to other basins? This needs more attention in the manuscript, both in the introduction and discussion sections. The introduction of the YRB might be moved to the end of the introduction section (after objective) to emphasize the role of the YRB being a case study to show the concepts and methods of this paper.

Response: Thanks for your valuable suggestions. More attentions have been paid to explain the reasons why we use the YRB as case study in the manuscript, both in the introduction and discussion sections based on your suggestions. As described in the **Section of Introduction**, the reasons why we use the YRB as case study can be explained by the flowing two aspects. On one hand, **as described in Line 57 to Line 58**, the YRB is one of the most important basins in China, because it can provide hundreds of millions of people with drinking water, food, hydropower, and other ecosystem services. On the other hand, **as described in Line 58 to Line 67**, the YRB has been regarded as one of the most sensitive and vulnerable regions that suffered from severe extreme floods. During the past decades, extreme floods have caused catastrophic damage to human beings in this basin, such as the 1998 Yangtze River Flood. Meanwhile, it has been found that both the frequency and severity of extreme flood events generally showed an upward trend in the YRB in the recent decades (Huang et al., 2015; Liu et al., 2019; Yang et al., 2021; Zhang et al., 2008). Therefore, there is a great need to provide more deep insights into the monitoring of extreme floods in the YRB.

Furthermore, we also added some sentences to explain the reasons why we use the YRB as case study in the **Section of Discussion**. **As described in Line 544 to Line 556**, the present study shows the great potential of temporally downscaled GRACE/GRACE-FO satellite data in monitoring the extreme flood events. Meanwhile, the study provides an effective means for the temporal downscaling of original TWSA estimates from GRACE/GRACE-FO satellite data, which can help develop monitoring and early warning systems for severe flood events over large-scale basins. Therefore, the methods and/ or results shown in this study can also provide important implications of flood hazard prevention and water resource management for other similar basins that are prone to suffer from severe extreme floods.

Furthermore, the introduction of the YRB has been moved to **the end of the introduction section** (after objective) to emphasize the role of the YRB being a case study to show the concepts and methods of this paper as you suggested (Line 57 to Line 67).

"The YRB is one of the most important basins in China, because it can provide freshwater, hydropower, food, and other ecosystem services for hundreds of millions of people. Meanwhile, the YRB has been regarded as one of the most sensitive and vulnerable regions that suffered from severe floods due to its highly uneven rainfall pattern (Zhang et al., 2021). During the past decades, the increasingly intensified human activities and climate change have substantially changed the hydrological cycle in the YRB and thus accelerated the variation of flood characteristics in this region (Fang et al., 2012; Wang et al., 2011). It has been found that both the frequency and severity of extreme flood events generally showed an upward trend in the YRB in recent decades owing to substantial changes in climate, infrastructure and land use (Huang et al., 2015; Liu et al., 2019; Yang et al., 2021; Zhang et al., 2008). For example, in Year 2020, the YRB has experienced one of the most extreme flood events on record. According to the data from the Ministry of Emergency Management of the People's Republic of China, a total of 38.173 million people were affected and 27,000 houses collapsed due to the 2020 flood, with 56 deaths or disappearances and a great economic loss of $27.68 billion (USD) (Jia et al., 2021)."

(3) L86-88: Which ranges are meant here? Ranges in space or in time (i.e. interannual variability)? Both temperature and precipitation ranges seem a bit narrow for a large river basin like YRB.

Response: As described in Line 89 to Line 91, the results shown in this study refer to ranges in time, which are derived from the interannual variability of the precipitation and temperature during the study period. As stated in this study, precipitation and temperature from 2003-2020 are provided by the China Meteorological Administration (CMA) (http://data.cma.cn/) with a total of 150 National Meteorological Observatory stations distributed in the YRB (shown in Fig. 1). The reason why both temperature and precipitation ranges seem a bit narrow for a large river basin like YRB might be that the study period spanning from 2003 to 2020 is relatively limited in this study and the ranges are basin-averaged values. For example, according to the statistics from the Water Resources Bulletin of the Yangtze River (http://cjw.gov.cn/zwzc/bmgb/), mean annual precipitation in the YRB shows a narrow range from 931 mm to 1282 mm from 2006 to 2020, which is highly consistent with the results shown in this study.

"According to the observations from meteorological stations, the mean annual air temperature of this basin ranges from 14.4 ℃ to 15.4 ℃ and mean annual precipitation ranges from 1049 mm to 1424 mm during the study period 2003-2020."

(4) L104-106: Why did the authors use the average of three types of GRACE and GRACE-FO solutions? Do these three types show equal performance in estimating TWSA? If not, wouldn't it be better to use weights depending on individual product performance when averaging the three products?

Response: Many studies (Ali et al., 2021; Liu et al., 2020; Liu et al., 2021) indicate that these GRACE and GRACE-FO solutions show equal performance in estimating TWSA and also directly use the average of these GRACE and GRACE-FO solutions to estimate the variation of regional TWSA, which is consistent with the method applied in this study. For example, the study of Seyoum (2018) clearly indicates that basin-wide TWSA could be calculated by averaging multiple GRACE and GRACE-FO solutions over the basin in order to reduce uncertainty. Furthermore, no other in-situ observations are available for deriving the weights depending on individual product performance. Therefore, we use the average of three types of GRACE and GRACE-FO solutions to characterize the variations of TWSA in the YRB in this study.

References

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(5) L119-120: Is the Thiessen method the most suitable method for spatial averaging given for instance elevation differences in (sub-)basins?

Response: In this study, the classic Thiessen polygon method is applied to calculate the basin-average precipitation based on the observations from different meteorological stations. In fact, many studies (Chao et al., 2021; Spencer et al, 2019; Strauch et al., 2012) have calculated the catchment-averaged precipitation in different basins including the Yangtze River Basin. For example, Chen et al., (2014) calculated the basin-average precipitation for the Yangtze River Basin and its sub-catchments using the Thiessen polygon method to spatially distribute the single point records of raingauges. Wang et al., (2019) calculated basin-wide precipitation for the upper Yangtze River basin and its sub-catchments where obvious elevation differences can be found using the Thiessen polygon method. Li et al., (2018) also calculated basin-wide precipitation and temperature the upper Yangtze River basin and its sub-catchments using the Thiessen polygon method. This method is a classical method used for calculating basin precipitation. In our future study, other methods can be investigated to consider the elevation differences, in particular in the upper part of the YRB.

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(6) L143: Shouldn’t the 3-hourly SMS data be summed instead of multiplied with 8? The SMS values for each 3-hourly time step are not necessarily the same, so multiplication with 8 will result in errors.

Response: Thanks for your valuable suggestions. As described Line 141 to Line 150, we have carefully checked and rewritten this section to better present the process of collecting SMS data. According to Table 2, the temporal resolution of SMS derived from GLDAS Noah land surface model is three hours. That is, there are eight SMS outputs for a specific day using the GLDAS Noah land surface model. Therefore, daily SMS estimates can be obtained by estimating the average of eight SMS outputs included in one day, because soil moisture storage is a state variable.

“Therefore, in this study we adopt the SMS (kg/m^2) with a spatial resolution of $0.25^\circ \times 0.25^\circ$ from the Global Land Data Assimilation System version 2.1 (GLDAS 2.1) Noah land surface model to estimate their correlations with regional TWSA derived from the GRACE and GRACE-FO satellite data. This product can provide the simulations of SMS at four different depths of soil layers from 0 to 200 cm, that is, 0 - 10 cm, 10 - 40 cm, 40 - 100 cm and 100 - 200 cm depths per three hours. To keep consistent with TWSA, the original value of SMS should be transferred into soil moisture storage anomaly values (SMSA) after subtracting the time-mean baseline during the period of 2004-2009. Furthermore, the temporal resolution of original SMS derived from GLDAS 2.1 Noah land surface model can be decreased from 3-hours to 1-day and 1-month composite respectively, which is consistent with the methods applied in previous studies (Mohanasundaram et al., 2021; Mulder et al., 2015; Syed et al., 2008).

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(7) L175-177: It is not completely clear which trends are considered here. As the authors indicate, long-term trends due to human activities should be removed in order to analyse the relation between ‘natural’ TWSA and hydroclimatic variables. The question is whether one can remove the human induced trend without removing part of a possible hydroclimatic (natural) induced trend. Did the authors analyse trends in precipitation and evapotranspiration (or temperature) to see whether climatic trends also could have been partly responsible for trends in TWSA? Should SMSA also be detrended similarly to TWSA? And did all relevant human activities cause a trend in TWSA or also abrupt changes in TWSA? Finally, it is doubtful whether the trend is always linear and hence linear methods can be used to remove the trends.

Response: On one hand, the effects of human activities on changes in TWSA cannot be neglected considering that the YRB is strongly influenced by various human activities, such as the construction of Three Gorges Reservoir and intense human water consumption (Huang et al., 2015; Yao et al., 2021). On the other hand, detailed statistics related to human use such as water consumption, reservoir operation and inter-basin water diversion projects are not available in this region. Therefore, we have removed the linear trends from the original time series of TWSA in training and calibration periods assuming that all these linear trends arise from the joint effects of various human activities, such as the water withdrawals and reservoir operation over the study region. This application is consistent with many previous studies when reconstructing TWSA estimates (Bai et al., 2022; Liu et al., 2021; Rodell et al., 2018; Yang et al., 2021).

Furthermore, we also analyzed monthly times series of precipitation and evapotranspiration (shown in Figure R1) to investigate whether climatic trends also could have been partly responsible for trends in TWSA based on your suggestions. To accurately characterize the monthly variations in ET in the YRB, one high-resolution ET product is applied in this study, namely the Global Land Evaporation Amsterdam Model Version 3.5a (GLEAM v3.5a) product with a 0.25 °×0.25 °resolution (Miralles et al. 2011; Martens et al. 2017) (https://www.gleam.eu/). This ET product has been widely used in many studies (Baik et al., 2018; Khan et al., 2018; Liu et al., 2022; Rehana et al., 2021) due to its high accuracy and resolution. As shown in Figure R1, it seems that no significant trends can be found in monthly precipitation during the study period for the YRB. Meanwhile, a slight increase trend can be found in monthly evapotranspiration but this trend is not significant. The variable of SMSA is simulated by Noah land surface model by compiling ground and satellite-based observations while no data reflecting human activities are incorporated or assimilated in this model for the YRB (Rodell et al., 2004). That is, SMSA can be viewed as the outputs from the land surface model under the sole effects of climatic variability. Therefore, we do not have to remove the linear trends of SMSA when reconstructing TWSA estimates. Nevertheless, considering that this method might be further applied in other regions where substantial changes in climate occurred, we also added some sentences in Section 6.3, showing the possible uncertainties and limitations of this method applied in this study as you suggested.

"By using the method of linear detrending, long-term trends in series of TWSA estimates have been removed during the reconstruction of TWSA, because they are generally driven by various human activities such as irrigation and reservoir operation and water withdrawals, all of which cannot be well reconstructed by hydro-climatic factors (Humphrey and Gudmundsson, 2019). Although the detrending method can reduce the impacts of human activities on reconstructing TWSA to some degree, it could still result in some discrepancies between the results of detrended TWSA and natural TWSA under climatic variability particularly in some regions where intense human activities existed. In future, more attentions should be paid to reconstruct the series of regional TWSA under climatic variability when more detailed statistics related to human use such as water consumption, reservoir operation and inter-basin water diversion projects are available."

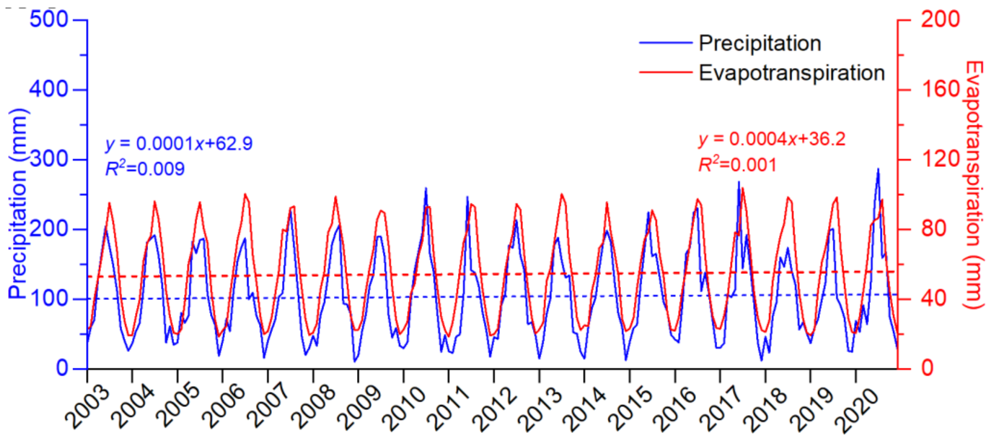

Figure R1. Monthly times series of precipitation and evapotranspiration in the YRB during 2003-2020.

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(8) L191: The number of hidden neurons of the MLP model has been set to five using a trial-and-error method. How has this been done and are the results reproducible? And did the authors obtain the same optimal number of hidden neurons for each of the four basins?

Response: Thanks for your kind reminder. For a MLP model, the number of neurons in the input layer and that in the output layer are determined by the number of inputs (i.e. three) and outputs (i.e. one), respectively. The number of neurons in the hidden layer determines the structure of MLP model and needs to be optimized through model calibration. Trial-and-error has been a widely used method for selecting the best network structure (Adamowski et al., 2012; Maroufpoor et al., 2020; Patault et al., 2021; Rahman et al., 2020; Sahoo et al., 2008; Sattari et al., 2021; Xie et al., 2019; Xie et al., 2021; Zhou et al., 2020; Zhu et al., 2022;) and is therefore applied in this study to determine the optimum number of neuros in the hidden layer. Furthermore, a rule-of-thumb suggests that the number of hidden neurons should be more than half the number of inputs but never be more than twice as large when developing a MLP model (Berry and Linoff, 2004; Long et al., 2014). Therefore, the optimum number of neurons in the hidden layer can be obtained by testing different alternative values ranging from two to six and selecting the value with a corresponding ANN model that shows the best performance in the validation set after being trained in the training set using the available data. According to the above procedures, we can eventually set the number of hidden neurons to five via a classic trial-and-error process in the YRB. Similarly, the MLP models in other basins are also tested on a ‘‘trial and error’’ basis in order to determine the optimum number of neurons in the hidden layer. Theoretically the optimal number of hidden neurons for each of the four basins may vary from region to region. After further comparing the performance of the MLP model with different hidden neurons in other three subbains, there are no obvious improvements in reconstructing TWSA compared to the MLP model with five hidden neuros. For convenience, the most optimal number of hidden neurons is therefore set to five in four basins in this study.

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(9) L210-229: Are these formulas new or have these formulas already been described in the literature? In the latter case, this part can be removed from the manuscript.

Response: To better introduce the LSTM model, these formulas were presented in this study. Given that these formulas are described in the related literature cited by this study, they have been removed from the manuscript as you suggested.

(10) L234-240: Why is the regression equation linear? Shouldn't any non-linear transformations be considered or is it reasonable to assume linear relations between the three inputs and TWSA?

Response: The reason why we applied the method of multiple linear regression in this study can be explained as follows. As shown in previous studies, the multiple linear regression model can be an alternative way to derive the relationships between the GRACE/GRACE-FO derived TWSA and its predictors (e.g., in situ river gauging data, air temperature, precipitation, soil moisture, climate indices, and other climate variables) (de Linage et al., 2014; Sun et al., 2020; Humphrey et al., 2017; Humphrey and Gudmundsson, 2019; Jing et al., 2020; Li et al., 2020; Nie et al., 2015; Sohoulande et al., 2020; Yang et al., 2021; Zhang et al., 2022). For example, Sun et al., (2020) used a multiple linear regression model to learn the relationship between the GRACE TWSA and climate drivers or the past and the present TWSA over the 60 basins. Therefore, the method of multiple linear regression was applied as an alternative way (or benchmark model) to analyze the relationships between the GRACE/GRACE-FO derived TWSA and its predictors in this study. It should be noted that although these multiple linear regression models are relatively simple and easy to implement, they are typically reliable and useful only in some specific regions where linear relationships between TWSA and independent variables existed (Yang et al., 2021). As shown in previous studies, changes in TWSA can also be affected by climate through a nonlinear relationship for most regions (de Linage et al., 2014; Sun et al., 2020; Humphrey et al., 2017; Humphrey and Gudmundsson, 2019; Jing et al., 2020). Therefore, another two models, namely the MLP model and the LSTM model, were applied in this study to further analyze the nonlinear relationships between GRACE/GRACE-FO derived TWSA and other climatic variables in the YRB and its sub-basins. After comparing the performances of each model, the specific model which shows the best performance in simulating TWSA can be identified.

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(11) L243-253: Several issues regarding the flood event selection are not clear. Why were five-day windows selected (step 1)? I can imagine that different windows need to be used for basins of different sizes. What is the background of the factor 1.11 (step 2)? How were the runoff events identified, i.e. how reproducible are the results (step 4)?

Response: Thanks for the valuable comments. As documented in previous studies (Fischer et al., 2021; Giani et al., 2022; Lu et al., 2020; Tarasova et al., 2018; Winter et al., 2021, 2022), this method to select flood event has been widely applied in many different basins over the world because of its advantages in capturing flood events. For example, Lu et al. (2020) applied this nonparametric algorithm to identify runoff events occurred in the Southeastern Coastal Region of China, whose event characteristics are similar to the YRB, with the approach of Tarasova et al. (2018). Considering that it has been successfully applied in many basins over the world including some basins whose event characteristics are similar to the YRB, this nonparametric algorithm suggested by Tarasova et al. (2018) is therefore adopted to identify runoff events in the YRB. The main procedure of this algorithm has been introduced in Section 4.4. Furthermore, as described in Line 228 to Line 230, we also added some necessary sentences in order to explain the reason why we choose the method of flood event selection in this study. According to the study of Tarasova et al. (2018), five-day windows and the factor of 1.11 are selected based on the findings shown in Institute of Hydrology (1980) and World Meteorological Organization (2008) because it proved to be superior in identifying the starting point of potential runoff events (i.e., troughs) and performed consistently in a wide range of catchments, which is beyond the main topic of this study. Nevertheless, much more efforts will be made to analyze the effects of different windows on identify runoff events for basins of different sizes in our future work. Before we start the Step 4, digital filters are previously used to separate the base flow from the total streamflow due to its applicability to large data sets. In Step 4, streamflow time series are screened to identify runoff events after the separation of base flow, which are characterized by their peak, beginning, and end points. As described in Section 4.4, a typical runoff event can be characterized by three main components, namely peak, beginning, and end points. A peak refers to the maximum of streamflow for a specific period. The beginning point refers to the closest point in time when total runoff is equal to base flow before the peak. Similarly, the end point denotes the closest point in time when total runoff is equal to base flow after the peak. More detailed information about this step can also refer to the study of Tarasova et al. (2018).

“A nonparametric algorithm suggested by Tarasova et al. (2018) is adopted to identify runoff events in this study, which has been widely applied in many different basins over the world because of its advantages in identifying flood events (Fischer et al., 2021; Giani et al., 2022; Lu et al., 2020; Winter et al., 2022).”

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(12) L276: It would be good to also describe the spatial characteristics (e.g. different basins, averaging) of the analyses.

Response: Thanks for your valuable suggestions. As described in Line 262 to Line 266, we have added some sentences to describe the spatial characteristics (e.g. different basins, averaging) of the analyses based on your suggestions.

"Monthly TWSA estimates during the extreme flood events occurred in the YRB can be reconstructed at regional scales based on the above three different learning-based models, namely the MLP model, the LSTM model and the MLR model. Meanwhile, these three models are further validated in four different basins covering from the upstream to downstream of the Yangtze River in order to better evaluate their applications. More detailed information about all these four different basins can also refer to Table S1."

Table S1. Long-term hydro-meteorological characteristics of different basin during 2003-2020.

Catchment	Gauge station	Area (10^4 km^2)	Precipitation (mm/yr)	Temperature (°C/yr)	Streamflow (10 m^8/yr)	Elevation (m)
SYRB	Shigu	20.8	525	-0.6	437	4526
UYRB	Yichang	99.3	843	8.1	4186	2676
UMYRB	Hankou	140.6	973	11.3	6929	1911
YRB	Datong	181.1	1094	12.3	8781	1621

Note: SYRB = Source regions of the Yangtze River Basin; UYRB = Upper regions of the Yangtze River Basin; UMYRB = Upper and the Middle regions of the Yangtze River Basin; YRB = Yangtze River Basin.

(13) L308-309: Why is TWSA consistent with temperature? What is the physical mechanism causing a high (positive) correlation between these variables?

Response: The physical mechanism causing a high (positive) correlation between the temperature and TWSA can be explained as follows. Temperature, representing the available energy over regions, is an important proxy for evapotranspiration (ET) because it can indirectly reflect evaporation from water bodies and soil layers in the humid region and therefore be linked to surface water and groundwater, both of which are essential components of TWSA. In other words, temperature plays a critical role in variation of ET while the latter is closely correlated with changes in TWSA (i.e. TWSC) according to the water balance method (Long, et al., 2014; Lv et al., 2017; Xie et al., 2019) (Eq. (1)).

$$TWSC = P - R - ET \quad (1)$$

where TWSC represents changes in TWSA for regions, P represents precipitation, R and ET represents the outflow and evapotranspiration for a specific region of interest.

Therefore, temperature has been viewed as one of the most important factors that can influence the variation of TWSA and shows a high correlation with TWSA in many studies (Humphrey et al., 2017; Long, et al., 2014; Li et al., 2020; Trautmann et al., 2018). For example, de Linage et al., (2014) examined how sea surface temperature anomalies influence interannual variability of TWSA in different regions within the Amazon Basin and found that interannual TWSA in tropical South America was significantly influenced by variations in sea surface temperature anomalies. Deng et al., (2017) investigated the effects of climate change on TWSA in the Central Asia and found that there was a significant positive correlation between TWSA and temperature in the southwestern and southeastern regions of the Central Asia.

In addition, changes in temperature can also influence the variation of glaciers or snow in the upper stream of the study area, which are components of regional TWSA. Given that the above reasons, temperature has been usually selected as an essential variable when reconstructing the time series of TWSA for regions.

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(14) L362-363: Are the relationships between TWSA and hydroclimatic factors indeed complicated? Figure 4 suggests that these relations are rather straightforward as also confirmed by the authors when using linear correlations for the relations.

Response: As shown in Figure 4, regional TWSA indeed shows a close correlation with precipitation and temperature because precipitation is the main input flux of terrestrial water while temperature represents available energy over regions, both of which play key roles in the regional hydrological cycles. Ignoring anthropogenic influences, all these hydro-climatic factors theoretically dominate changes in TWSA for regions, which is in line with previous studies (Bai et al., 2022; Humphrey et al., 2019; Syed et al., 2008; Xie et al., 2019; Yang et al., 2021; Zhang et al., 2019).

In addition, all of these variables present significantly seasonal variations as shown in Figure 4, which can also explain the close correlation between regional TWSA with precipitation and temperature to some degree. Nevertheless, the results shown in Figure 5 indicate that the MLP model can simulate TWSA better than the multiple linear regression (MLR) model for all basins, indicating that the relationships between TWSA and hydro-climatic factors might not be simple linear correlations. Therefore, two another learning-based models, namely MLP model and the LSTM model, are applied to analyze the relationships between TWSA and hydro-climatic factors besides the MLR model considering its further applications in other basins. The reason why we apply the method of MLR to reconstruct TWSA and more explanations about the relationships between TWSA and hydro-climatic factors can also be found in our responses to comment #10 and comment #13.

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(15) L368-369: Is the limited availability of training data the main reason for the moderate performance of the LSTM model? In this study, it seems that sufficient data are available for training and validation. Another factor which might (partly) explain the moderate performance of this model compared to the MLP model is the possibly limited role of the memory function in the LSTM model, since relations between inputs and the output are quite direct without much memory effects.

Response: Thanks for your valuable suggestions. As described in Line 356 to Line 359, we have added some sentences and references to better explain the moderate performance of the LSTM model in reconstructing TWSA based on your suggestions. Furthermore, we mainly focus on the relationships between TWSA and hydro-climatic factors in this study due to the limitation of data available. Therefore, the LSTM method for temporally downscaling monthly TWSA derived from GRACE/GRACE-FO satellite data should be further assessed by incorporating with more related factors in the future. More detailed exaltations about the relationships between TWSA and hydro-climatic factors can also be found in our response to Comment #14.

"In addition, the moderate performance of LSTM model in reconstructing TWSA compared to the MLP model can be partly attributed to the possibly limited role of the memory function in the LSTM model (Wei et al., 2021; Yin et al., 2022), since relations between inputs and the output of this model (shown in Figure 4) are pretty direct without much memory effects."

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(16) L374-378: An important assumption in this study is the independency of the input-output relations as determined by the data-based models on time scales, i.e. the relations found from monthly data are also assumed to be valid for daily data. The authors use as argument that 'the same scaling properties have been commonly assumed for baseline and future periods in temporal downscaling'. However, the situation/ conditions mentioned in this argument (translation from one period to another) is different from the situation relevant in this study (translation from one (coarse) time scale to another (fine) time scale). Relations between (hydro)climatic variables and (other) hydrological variables are very different at different time scales. For instance, rainfall-runoff relations at hourly or daily time steps usually are highly non-linear, where relations at monthly or annual time scales are more or almost linear. Hence, it is doubtful whether the input-output relations at monthly time scales established by the three data driven models (in particular the MLP model) can be used for daily time steps as well. The authors should try to use some independent data sources (e.g. groundwater level measurements) at sub-monthly (preferably daily) scales to test the downscaled relations. Without such a validation/ testing it will be hard to assess the reliability of the results.

Response: Thanks for your valuable suggestions. We greatly agree with you that it is meaningful to use more independent data sources (e.g. groundwater level measurements) at sub-monthly (preferably daily) scales to test the downscaled relations. Therefore, we further compare the temporally downscaled TWSA estimates with the daily TWSA estimates derived from the ITSG-GRACE2018, which is a daily TWSA dataset, considering that other independent data sources (e.g. groundwater level measurements) are not available indeed in this study. ITSG-GRACE2018 is derived from GRACE Level-1B data and generated at the Institute of Geodesy of Graz University of Technology (ITSG) (Kvas et al., 2019), which has been proved to be effective in tracking TWSA variation at a daily scale (Bai et al., 2022; Eicker et al., 2020; Xiong et al., 2022; Gouweleeuw et al., 2018; Gürr et al.,2018). For further detailed descriptions about ITSG-GRACE2018, the reader is referred to the website of https://www.tugraz.at/institute/ifg/downloads/gravity-field-models/itsg-grace2018/. As shown in Figure R2, daily TWSA estimates based on the MLP model are significantly consistent with that derived from the ITSG-GRACE2018 particularly in the YRB. The highest coefficient of determination between daily TWSA (mm) derived from ITSG-GRACE 2018 and that simulated by the MLP model is observed in the YRB with $R^2 = 0.72$ ($p < 0.01$), indicating that the method applied in this study is effective and acceptable in obtaining a daily time series of TWSA when independent data sources such as groundwater level measurements are not available. Furthermore, some sentences are also added in Section 6.3, emphasizing that more efforts should be made to validate the reliability of downscaled relations in our next study when more independent data sources are available based on your suggestions.

"Additionally, more efforts should be made to further validate the reliability of temporally downscaled relations proposed in this study when more independent data sources (e.g. groundwater level measurements) are available in YRB."

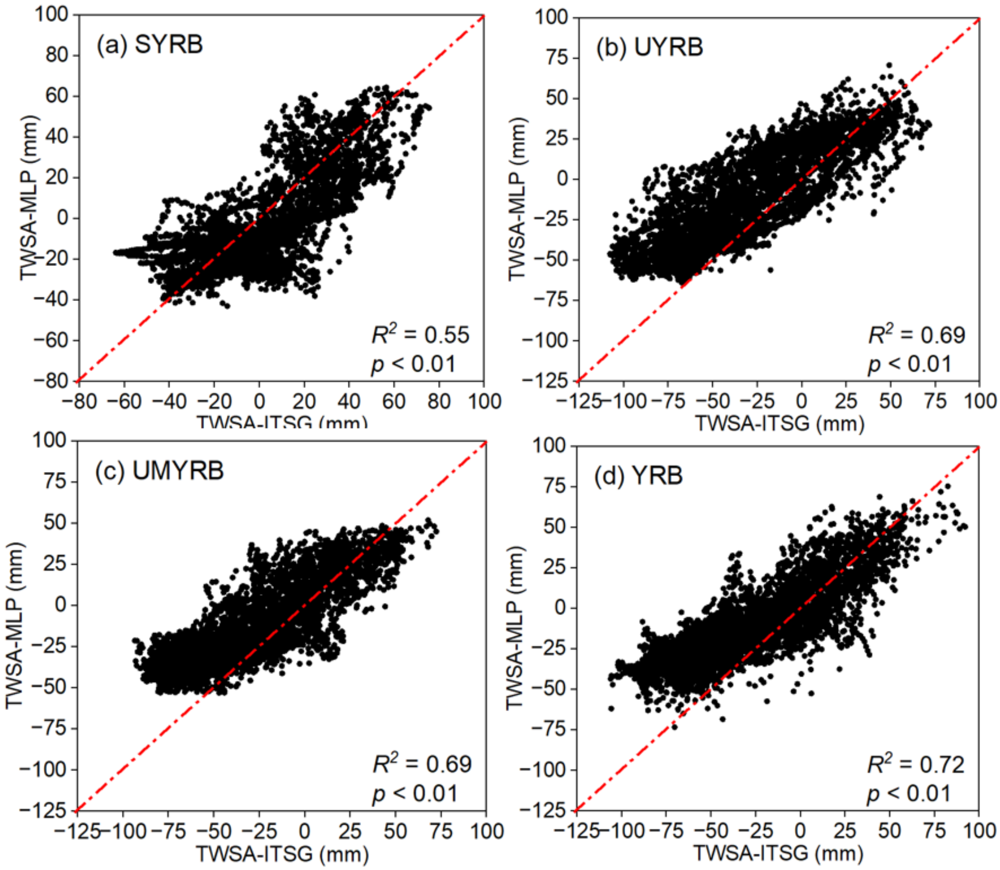

Figure R2: Comparison between daily TWSA (mm) derived from ITSG-GRACE 2018 and that simulated by the MLP model for (a) the SYRB, (b) the UYRB, (c) the UMYRB and (d) the YRB respectively. TWSA= Terrestrial water storage anomaly; ITSG = Institute of Geodesy of Graz University of Technology; GRACE = Gravity Recovery and Climate Experiment; MLP = Multi-layer perceptron; SYRB = Source regions of Yangtze River Basin; UYRB = Upper regions of Yangtze River Basin; UMYRB = Upper and middle regions of Yangtze River Basin; YRB = Yangtze River Basin. Note that the TWSA data derived from ITSG-GRACE2018 only covered the period between 2003 and 2016.

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(17) L379-381: The relations determined at a monthly scale are used with daily inputs as well. I would not call this downscaling as the same relations are used for different time steps.

Response: Thanks for your valuable suggestions. We have further validated the reliability of temporally downscaled TWSA by comparing with the results derived from another dataset as described in detail in our response to Comment #17. Meanwhile, some sentences are also added in Section 6.3, emphasizing that more efforts should be made to validate the reliability of downscaled relations in our next study when more independent data sources are available. Furthermore, we have revised the title of this manuscript with “Monitoring the extreme flood events in the Yangtze River Basin based on GRACE/GRACE-FO satellite data” based on your suggestions.

“Additionally, more efforts should be made to further validate the reliability of temporally downscaled relations proposed in this study when more independent data sources (e.g. groundwater level measurements) are available in YRB.”

(18) L385-387: The results in Figure 6 show that the daily TWSA estimates do not capture the minimum monthly TWSA observations in all basins for several years. That is opposite to what the authors mention in this sentence. It would be good to also compare daily and monthly TWSA estimates in addition to the comparison between daily TWSA estimates and monthly TWSA observations. This might partly explain this behavior.

Response: Thanks for your valuable suggestions. We have revised Figure 6 and further added the monthly TWSA estimates estimated by the MLP model based on your suggestions. As shown in Figure 6, daily and monthly TWSA estimates estimated by the MLP model and monthly estimates derived from GRACE/GRACE-FO satellite data are presented in this figure.

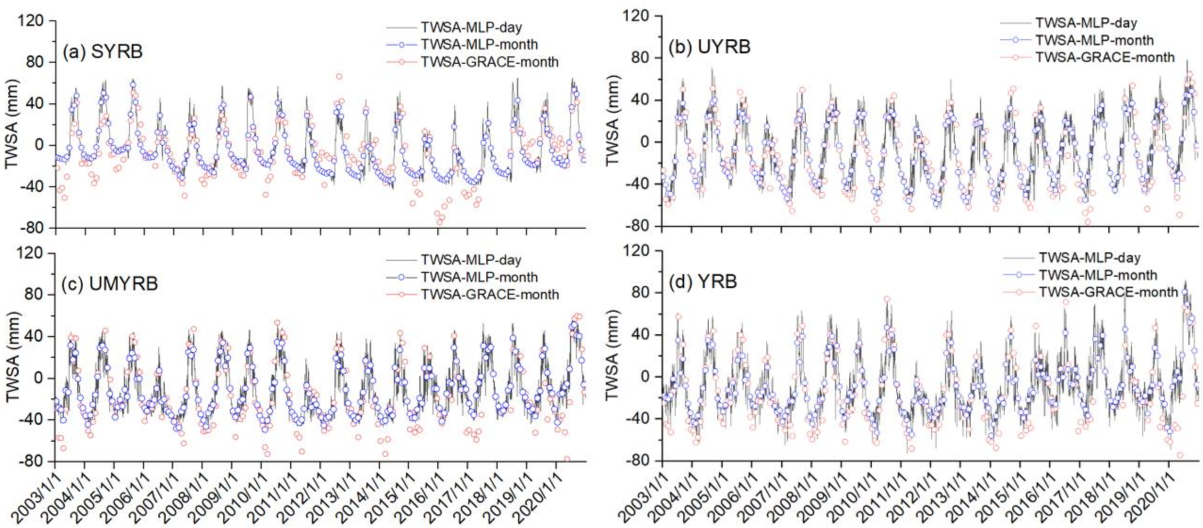

Figure 6: Daily (TWSA-MLP-day) and monthly (TWSA-MLP-month) time series of TWSA simulated by the MLP model for (a) the SYRB, (b) the UYRB, (c) the UMYRB and (d) the YRB respectively during 2003-2020. Note that monthly TWSA estimates derived from GRACE/GRACE-FO satellite data (TWSA-GRACE-month) shown in this figure are detrended because hydro-climatic factors may not fully simulate their long-term trends. TWSA = Terrestrial water storage anomaly; MLP = Multi-layer perceptron neural network; SYRB = Source regions of Yangtze River Basin; UYRB = Upper regions of Yangtze River Basin; UMYRB = Upper and middle regions of Yangtze River Basin; YRB = Yangtze River Basin.

(19) L401-402: It is doubtful whether soil moisture is the dominant component of TWSA. Most water is stored as (saturated) groundwater or surface water and the soil moisture storage is limited compared to these two storage components. Also changes in groundwater and surface water storage can generally be much larger than changes in soil moisture storage.

Response: Thanks for your valuable suggestions. As described in Line 401 to Line 403, we have carefully checked and revised this sentence to avoid ambiguity. In addition, we also added some necessary references to make the explanation clear.

"This is partly because high antecedent soil moisture, which is a component of TWSA, has been identified as an important driver of flood events for regions (Fatolazadeh et al., 2022; Jing et al., 2020; Reager et al., 2014; Wasko et al., 2019)."

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(20) L444-446: Do the lag times vary with the size of the basins? I can imagine that larger basins (e.g. the entire YRB) will have larger lag times than smaller basins.

Response: Yes. The lag times may vary with the size of the basins as you mentioned. More specific, larger basins (e.g. the entire YRB) generally have larger lag times than smaller basins for extreme flood events. Above all, the comparison analysis indicates that the flood events can be monitored by the proposed NDFPI earlier than traditional streamflow observations for all basins, which is very vital for flood forecasts and warning across this region.

(21) L478-485: The advantages of the proposed method and possible operationalisation need some nuance. Besides the considerations mentioned under specific comment 16, it should be emphasized that operationalisation would mean application of the MLP model at a daily scale using daily temperature, precipitation and soil moisture storage as inputs. In fact, the TWSA observations are not directly used for early flood detection, but only indirectly for establishing relations at a monthly scale which are used at a daily scale. As such, the early flood detection is still mainly based on in situ data and will be hardly applicable to poorly or ungauged areas. Hence, the authors are encouraged to investigate whether observed TWSA estimates at a monthly time scale can be downscaled to a daily time scale without using in situ data or at least without using these data in an operational context.

Response: We agree with the reviewer that it is very meaningful to investigate whether observed TWSA estimates at a monthly time scale can be downscaled to a daily time scale without using in situ data. Although the flood potential index proposed in this study is estimated by jointly using the GRACE satellite data and meteorological data, it can provide a simple but useful framework for monitoring the flood events and its hydrological impacts at finer temporal scales for study regions. Furthermore, the methods and conclusions shown in this study can provide broader implications for flood monitoring in ungauged or poorly gauged basins. For example, advances in satellite remote sensing have made remote sensing a promising approach to capture various hydrological variables (e.g. precipitation, temperature and soil moisture), since they can substantially reduce the limitations of traditional ground-based observations. This is extremely useful and important in hydrological research and applications particularly in ungauged or poorly gauged basins. Recent studies (Chen et al., 2017; Famiglietti et al., 2015; Gao et al., 2017; Li et al., 2019; Samain et al., 2012) revealed that remote sensing data could be used as a valuable alternative to in situ observations as forcing data particularly over ungauged or poorly gauged basins where ground-based observations are extremely limited, because their resolutions and availability were not significantly influenced by climatic conditions or terrain. Therefore, we can calculate the flood potential index proposed in this study (i.e. NDFPI) by jointly using remote sensing-based precipitation, temperature and soil moisture estimates combined with GRACE/GRACE-FO satellite data, which can further provide the potential for flooding in ungauged or poorly gauged basins during the study period. More detailed description about multiple remote sensing data except for GRACE/GRACE-FO satellite data can also refer to Table R2. In brief, much further work, including monitoring and predictions of extreme floods using pure remotely sensed data products, is urgently needed as you stated in this question. As described in Line 543 to Line 556, we have added some sentences to better show the important implications provided by this study.

Table R2. Detailed description about multiple remote sensing data.

Data types	Data sources	Spatial Resolution	Temporal Resolution	Period
Temperature	MODIS	day	1 km	2000-2022
Precipitation	TRMM-3B42	day	0.25°	1998-2020
	GPM	day	0.25°	2000-2022
	CMORPH_CDR	day	0.25°	1998-2021
Soil moisture	SMAP	day	1 km	2015-2022
	SMOS	day	25 km	2010-2022

Note: MODIS = Moderate-resolution Imaging Spectroradiometer; SMOS = Soil Moisture and Ocean Salinity; SMAP = Soil Moisture Active and Passive; TRMM = Tropical Rainfall Measuring Mission; CMORPH-CDR = Climate Prediction Center morphing method Climate Data Record; GPM = Global Precipitation Measurement.

"Furthermore, this study can also provide broader implications for flood monitoring in ungauged or poorly gauged basins. For example, advances in satellite remote sensing have made remote sensing a promising approach to capture various hydrological variables (e.g. precipitation, temperature and soil moisture), since they can substantially reduce the limitations of traditional ground - based observations. This is extremely useful and important in hydrological research and applications particularly in ungauged or poorly gauged basins. Therefore, we can calculate the flood potential index proposed in this study (i.e. NDFPI) by jointly using remote sensing-based precipitation, temperature and soil moisture estimates combined with GRACE/GRACE-FO satellite data, which can further provide the potential of remote sensing data for flooding in ungauged or poorly gauged basins."

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(22) L517-518: Only water consumption data or also for instance data on reservoir operation?

Response: Thanks for your kind reminder. In addition to water consumption, more detailed statistics related to human use such as reservoir operation and inter-basin water diversion projects should be further considered in our next study when reconstructing the series of regional TWSA across the YRB. Therefore, we have rewritten this sentence to show all factors that should be taken into consideration as you suggested (Line 513 to Line 515).

"In future, more attentions should be paid to reconstruct the series of regional TWSA under climatic variability when more detailed statistics related to human use such as water consumption, reservoir operation and inter-basin water diversion projects are available."

Technical corrections

L8: 'monitor flood' instead of 'monitor the floods'.

Response: As described in Line 8, we have changed "monitor the floods" with "monitor flood" after carefully checking this sentence.

"Gravity Recovery and Climate Experiment (GRACE) and its successor GRACE Follow-on (GRACE-FO) satellite provide terrestrial water storage anomaly (TWSA) estimates globally that can be used to **monitor flood** in various regions at monthly intervals."

L20: 'satellite data' instead of 'satellites data'.

Response: As described in Line 20, we have changed "satellites data" with "satellite data". In addition, we have carefully checked the other related terms through this manuscript and made proper changes.

"All these findings can provide new opportunities for applying GRACE/GRACE-FO **satellite data** to investigations of sub-monthly signals and have important implications for flood hazard prevention and mitigation in the study region."

L25: 'floods' instead of 'flood'.

Response: As described in Line 25, we have changed "flood" with "floods".

"According to the report published by the United Nations Office for Disaster Risk Reduction (UNDRR), the total economic loss induced by **floods** is up to $651 billion (USD) worldwide from 2000 to 2019 (https://www.undrr.org/publication/human-cost-disasters-overview-last-20-years-2000-2019)."

L33: 'cycle' instead of 'cycles'.

Response: As described in Line 60, we have changed "cycles" with "cycle".

"During the past decades, the increasingly intensified human activities and climate change have substantially changed the hydrological **cycle** in the YRB and thus accelerated the variation of flood characteristics in this region (Fang et al., 2012; Wang et al., 2011)."

L35: ‘in recent decades’ instead of ‘in the recent decades’.

Response: As described in Line 62, we have changed “in the recent decades” with “in recent decades” based on your suggestions.

“It has been found that both the frequency and severity of extreme flood events generally showed an upward trend in the YRB **in recent decades** owing to substantial changes in climate, infrastructure and land use (Huang et al., 2015; Liu et al., 2019; Yang et al., 2021; Zhang et al., 2008).”

L48: ‘based on a copula function’ instead of ‘based on the copula function’.

Response: As described in Line 39, we have changed “based on the copula function” with “based on a copula function” based on your suggestions.

“Xiong et al. (2021) developed a novel integrated flood potential index by linking the flood potential index derived from six GRACE products **based on a copula function**, which was further used to identify and characterize the floods with different intensities over the study region.”

L57: ‘few attention’ instead of ‘few attentions’.

Response: As described in Line 49, we have changed “attentions” with “attention” based on your suggestions.

“To date, **very few studies have paid attention** to monitor flood events at sub-monthly time scales using GRACE data.”

L59: ‘using temporally downscaled GRACE data’ instead of ‘using the temporally downscaled GRACE data’.

Response: As described in Line 51, we have deleted the phrase “using the temporally downscaled GRACE data” based on the suggestions from Reviewer Abhishek Abhi.

L62: ‘to monitor extreme flood events’ instead of ‘to monitor the extreme flood events’. Similar corrections should be made in the remainder of the manuscript. Preferably, a native English speaking person should check and correct the document.

Response: As described in Line 53, we have changed “to monitor the extreme flood events” with “to monitor extreme flood events” based on your suggestions. Furthermore, we have carefully checked the other terms through this manuscript and tried our best to improve the manuscript both in the language and contents based on your comments and suggestions.

“Therefore, we aim to downscale the TWSA estimates derived from GRACE/GRACE-FO satellite data into daily values and demonstrate its application to **monitor extreme flood events** at sub-monthly time scales for the YRB.”

L80: What do the authors mean with ‘three-step ladder distribution’? Why three steps and not e.g. two, four or five steps?

Response: To avoid ambiguity, we have deleted the expression of “three-step ladder distribution” shown in this sentence as described in Line 82 to Line 83.

“The terrain of the YRB generally decreases from west to east with altitudes ranging from -142 m to 7143 m above the sea level (shown in Fig. 1).”

L100: ‘can be found in Fig 1’ instead of ‘can refer to Fig. 1’.

Response: As described in Line 103, we have changed “can refer to Fig. 1” with “can be found in Fig 1” based on your suggestions.

“More information about the location and topography of the YRB **can be found** in Fig. 1.”

L118: 150 stations for both precipitation and temperature?

Response: Yes. As stated in Section 3.2, daily time series of precipitation and temperature from 2003-2020 can be acquired from all these 150 stations distributed in the YRB (shown in Figure 1).

L142: ‘to daily and monthly estimates’ instead ‘o daily and monthly estimates’.

Response: Thanks for your reminder. As described in Line 148, we have rewritten this sentence based on your Comment #6.

“Furthermore, the temporal resolution of original SMS derived from GLDAS 2.1 Noah land surface model can be decreased from 3-hours to 1-day and 1-month composite respectively, which is consistent with the methods applied in previous studies (Mulder et al., 2015; Mohanasundaram et al., 2021; Syed et al., 2008).”

L153: ‘which consists of four steps’ instead of ‘which is made of four steps’.

Response: As described in Line 155, we have changed “which is made of four steps” with “which consists of four steps” based on your suggestions.

“A detailed flow diagram of our study is given in Fig. 2, **which consists of four steps.**”

L158: The role of scenarios is not clear yet.

Response: As described in Line 160 to Line 164, we have rewritten this sentence when describing the role of scenarios in order to make it clear in the manuscript. In addition, we also described in detail the role of three scenarios in Line 266 to Line 269 as you suggested.

“Given that different periods of data used for training and validation might influence the performances of each model in simulating TWSA, a total of three scenarios are therefore designed according to the way of dividing training periods and validation periods for each model. After comparing the performances of each model in simulating monthly TWSA estimates under all three scenarios, the calibrated parameter sets of the model with a specific scenario that shows the best performance in simulating monthly TWSA estimates are identified and retained.”

“According to previous findings in Liu et al. (2021), different periods of data used for training (i.e. identification of model parameter sets) and validation can eventually influence the corresponding performances of a specific model when simulating TWSA. Therefore, we design a total of three scenarios according to the way of dividing training periods and validation periods for a specific model.”

L159: What is meant with ‘scaling properties’? This is not clear here.

Response: Thanks for your valuable suggestions. As described in Line 162 to Line 164, we have written this sentence to better explain the specific details of Step 2.

“After comparing the performances of each model in simulating monthly TWSA estimates under all three scenarios, the calibrated parameter sets of the model with a specific scenario that shows the best performance in simulating monthly TWSA estimates are identified and retained.”

L161: ‘Step 2’ instead of ‘Step 3’?

Response: As described in Line 166, we have changed “Step 3” with “Step 2” based on your suggestions.

L200: ‘existing’ instead of ‘existed’.

Response: As described in Line 204, we have changed "existed" with "existing" based on your suggestions.

"Long short-term memory network (LSTM) is one of the most representative RNNs as it has the fabulous memory ability and can effectively avoid the vanishing gradient problem **existing** in other RNNs (Hochreiter, 1997; Guo et al., 2021)."

L240-242: Shouldn't this sentence be moved to section 4.6?

Response: As described in Line 262 to Line 263, this sentence has been moved to section 4.6 based on your suggestions.

"Monthly TWSA estimates during the extreme flood events occurred in the YRB can be reconstructed at regional scales based on the above three different learning-based models, namely the MLP model, the LSTM model and the MLR model."

L252-253: Reformulate this sentence.

Response: Thanks for your reminder. As described in Line 237, we have rewritten this sentence as you suggested. More detailed information about the method of identifying runoff events can also refer to our response to Comment #11.

"Similarly, the end point denotes the closest point in time when total runoff is equal to base flow after the peak."

L270-271: 'the typical difference between the storage change and precipitation'; what do the authors mean with this?

Response: We apologize for such confusion because of the wording. As described in Line 254 to Line 260, we have written this sentence to avoid ambiguity.

"Finally, we can calculate the normalized daily flood potential index (NDFPI) from the DFPA with the goal of removing the effects of hydrological heterogeneity varying from region to region (Reager et al., 2009), which can be described as follows:

$$NDFPI(t) = \frac{DFPA(t) - DFPA_{min}}{DFPA_{max} - DFPA_{min}}, \quad (4)$$

where $DFPA_{max}$ and $DFPA_{min}$ represent the maximum DFPA and minimum DFPA during the study period respectively. The NDFPI indicates the corresponding probability of flood occurrence with a range from 0 to 1. More flood is likely to occur when the NDFPI is closer to 1 for a specific region."

References:

Reager, J.T., Famiglietti, J.S., 2009. Global terrestrial water storage capacity and flood potential using GRACE. Geophys. Res. Lett. 36, L23402.

L280: Remove 'generally'.

Response: As described in Line 268, we have deleted this word based on your suggestions.

"Therefore, we design a total of three scenarios according to the way of dividing training periods and validation periods for a specific model."

L290-295: The subscripts in the formulas are not clear. Subscripts are used for both the time step and observed values, simulated values do not have an additional subscript. For average values an unclear subscript is used as well without having a clear meaning or role. The authors are advised to use subscripts for observed and simulated values (i.e. 'o' and 's') and put the time step between brackets.

Response: Thanks for your valuable suggestions. As described in Line 274 to Line 281, we have revised the subscripts in the formulas based on your suggestions.

"Furthermore, three kinds of statistical measures including root mean square error (RMSE), correlation coefficient (r), and Nash-Sutcliffe efficiency coefficient (NSE) are used in this study as they can jointly measure the matching quality in terms of both magnitude and phase between the simulated and the observed time series. These statistical measures are defined as:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N}(x_{s,i}-x_{o,i})^2}{N}} \quad (5)$$

$$r = \frac{\sum_{i=1}^{N}(x_{s,i}-\bar{x}_{s,i})(x_{o,i}-\bar{x}_{o,i})}{\sqrt{\sum_{i=1}^{N}(x_{s,i}-\bar{x}_{s,i})^2 \times \sum_{i=1}^{N}(x_{o,i}-\bar{x}_{o,i})^2}} \quad (6)$$

$$NSE = 1 - \frac{\sum_{i=1}^{N}(x_{s,i}-x_{o,i})^2}{\sum_{i=1}^{N}(x_{o,i}-\bar{x}_{o,i})^2} \quad (7)$$

where $x_{s,i}$ and $x_{o,i}$ represent simulated and observed TWSA in month i, respectively; $\bar{x}_{s,i}$ and $\bar{x}_{o,i}$ represent the average of simulated and observed TWSA series; N is the total months of observed (or simulated) TWSA available."

L302-303: This sentence includes quite some repetition.

Response: Thanks for your reminder. As described in Line 302, we have deleted this sentence to avoid repetition based on your suggestions.

L306: Is the maximum TWSA value 130.9 mm (this line) or 130.1 mm (line 300)?

Response: Thanks for your reminder. The maximum TWSA value is 130.9 mm after we carefully checking the results shown in Figure 4. Therefore, we have rewritten the sentence shown in Line 286 to keep consistent with the results shown in Line 292.

Line 286: "The results show that monthly TWSA over the YRB has a wide range from -58.0 mm to 130.9 mm during the study period."

Line 292: "Accordingly, TWSA reaches its maximum in July 2020 with an estimate of 130.9 mm during 2003-2020, reflecting the evolution of TWSA in response to heavy rainfall during this period."

L312: 'resulting' instead of 'resulted'.

Response: As described in Line 298, we have changed "resulted" with "resulting" based on your suggestions.

"This phenomenon can be explained by the discrepancies **resulting** from the components of SMSA and TWSA."

L349: 'difference' instead of 'decrease' (two times).

Response: As described in Line 335, we have changed "decrease" with "difference" based on your suggestions.

"…, which is lower than that of 15.1 mm/month for the LSTM-derived TWSA estimates (~39% **difference**) and that of 13.3 mm/month for the MLR-derived TWSA estimates (~22% **difference**)."

L361: 'of' instead of 'higher than' and 'of' instead of 'lower than'?

Response: As described in Line 347, we have changed “higher than” with “of” and changed “lower than” with “of” based on your suggestions.

“Overall, Fig. 5 clearly suggests the MLP model’s superior performances in simulating TWSA with an average value of NSE **of** 0.81 and an average value of RMSE **of** 12.8 mm/month during the validation periods for all regions, …”

L368: ‘ANN models’ instead of ‘ANNs models’.

Response: As described in Line 355, we have changed “ANNs models” with “ANN models” based on your suggestions.

“…, which indicates that the LSTM model may not show better performances in simulating time series data than other traditional **ANN models** in some cases especially when limited trained data are available.”

L371: ‘satellite data’ instead of ‘satellites data’.

Response: As described in Line 362, we have changed “satellites data” with “satellite data”. In addition, we have carefully checked the other related terms through this manuscript and made proper changes.

“5.3 Temporal downscaling of GRACE/GRACE-FO **satellite data**”

L454: ‘Discussion’ instead of ‘Discussions’.

Response: As described in Line 453, we have changed “Discussions” with “Discussion”.

L460: Is hysteresis the right term here?

Response: As described in Line 457 to Line 459, we have rewritten this sentence to avoid ambiguity based on your suggestions.

“This is consistent with the results found at the Missouri River basin by Reager et al. (2014). Reager et al. (2014) indicated that regional TWSA may lead river discharge slightly before the flood season, which can provide useful information on the signal of high streamflow in the coming flood season.”

L461: What do the authors mean with the term ‘predisposition’?

Response: We apologize for such confusion because of the wording. As described in Line 457 to Line 459 we have written this sentence to make the explanation clear.

"This is consistent with the results found at the Missouri River basin by Reager et al. (2014). Reager et al. (2014) indicated that regional TWSA may lead river discharge slightly before the flood season, which can provide useful information on the signal of high streamflow in the coming flood season."

L504: What is 'deficit' here?

Response: We apologize for such confusion because of the wording. As described in Line 502, we have changed "deficit" with "difference" to make the explanation clear.

"The highest difference in the temporally downscaled TWSA and the daily precipitation during the wet season, as revealed by the NDFPI, can indicate the early signs of the region's transition from normal state to a flood-prone situation."

L511: 'activities' instead of 'activates'.

Response: Thanks for your reminder. This sentence has been removed from this manuscript to avoid repetition based on the suggestions of anonymous Referee #2. More detailed information about this change can also be found in the response to anonymous Referee #2.

L513: What kind of surface conditions are meant here?

Response: As described in Line 508 to Line 510, we have revised this sentence to make the explanation clear.

"By using the method of linear detrending, long-term trends in series of TWSA estimates have been removed during the reconstruction of TWSA, because they are generally driven by various human activities such as irrigation, reservoir operation and water withdrawals (Humphrey and Gudmundsson, 2019)."

References:

Humphrey, V., Gudmundsson, L., 2019. GRACE-REC: a reconstruction of climate-driven water storage changes over the last century. Earth Syst. Sci. Data 11 (3), 1153-1170.

L533-534: It is not clear what is meant with 'spatially correlated features'.

Response: We apologize for such confusion because of the wording. As described in Line 534 to Line 537, we have revised this sentence to make the explanation clear.

"The latest study has made some initial attempts to learn the spatio-temporal patterns of difference between TWSA derived from GRACE data and those simulated by land surface models based on the convolutional neural network (CNN) models with the goal of providing more accurate TWSA estimates (Mo et al., 2022; Sun et al., 2019)."

References

Mo, S., Zhong, Y., Forootan, E., Mehrnegar, N., Yin, X., Wu, J., Feng, W., Shi, X., 2022. Bayesian convolutional neural networks for predicting the terrestrial water storage anomalies during GRACE and GRACE-FO gap. J. Hydrol. 604, 127244.

Sun, A.Y., Scanlon, B.R., Zhang, Z., Walling, D., Bhanja, S.N., Mukherjee, A., Zhong, Z., 2019. Combining physically based modeling and deep learning for fusing GRACE satellite data: can we learn from mismatch? Water Resour. Res. 55 (2), 1179-1195.

L755: What is 'Now'? 2022?

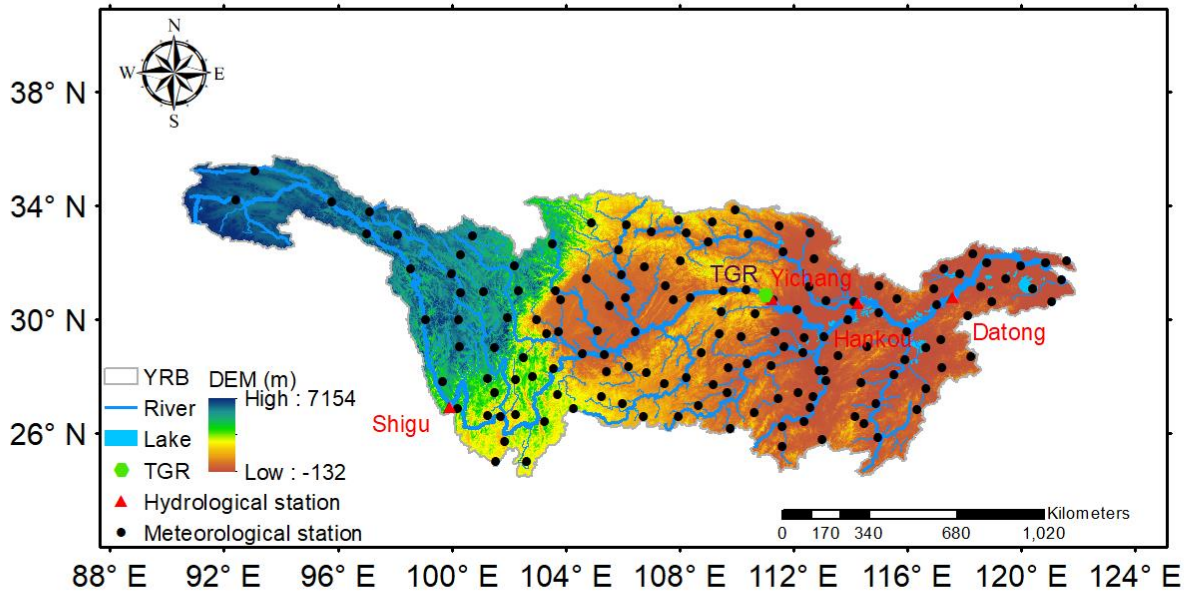
Response: To make it clear, we have changed "Now" with "2020" shown in Table 2 because this table mainly introduces all datasets used in this study.

L760: Is it meaningful to show the overall performance mixing training and validation periods?

Response: Thanks for your reminder. We have deleted the overall performance mixing training and validation periods based on your suggestions.

L768: The Three Gorges Reservoir is difficult to identify on the map.

Response: To make it easy to identify on the map, we have changed the symbol and color of the Three Gorges Reservoir as shown in Figure 1 (denoted as a green hexagon).



980 **Figure 1: Location of the Yangtze River Basin (YRB) in China and its topography. Distribution of meteorological stations and hydrological stations are also shown in this figure. TGR = Three Gorges Reservoir; DEM = Digital Elevation Model.**