General comments

This paper shows that a 6-year oscillation is visible in the time-varying gravity recorded by 6 Superconducting Gravimeters (SGs). The origin of this 6-year oscillation also seen in other geophysical and geodetic time-series is still debated today. A core origin has been suggested but surficial climatic events could also be responsible for that periodic oscillation. This paper completes the catalog of observables containing a 6-year oscillation. It confirms that it is a global effect. They then try to prove that it is of internal origin, but as discussed here after, it is not so clear, and hydrology still prevails. The methods they employed are not new either, and one of their method (AR-z spectrum) could even raise some criticism. There are also a few scientific flaws and worries that need to be considered and corrected, in particular with respect to the published literature.

Response: We are grateful for your comments and corrections on some of the interpretations that we made as well as some of the technical errors that we made, which will assist to improve the work. Our replies to your comments can be found below.

Specific comments (individual scientific questions/issues)

This paper is a follower of a series of studies by Pr. Hao Ding and co-workers who support a core origin for the 6-year oscillation observed in geodetic and gravimetric data, despite some evidence for a more probable surficial origin by Rosat et al. (2021). The criticism can be reproduced here, since hydrological loading does also contain a 6-yr oscillation contrary to what the authors claim (Fig. S5 is not at the same scale as Fig.3 so it is misleading). If you do plot the FFT spectra of ERAin or ERA5 (or ERA5_land) hydrological loading products, as I did, you will see a non-negligible contribution around 6-year. You can also plot the time-series of SG gravity residuals with respect to hydrological loading, band-pass filtered them around 6-yr, and you will see a good correlation between both time-series, for most worldwide SG stations of sufficient data length, but with a time-shift for some stations. You have to consider cautiously the sign of the local contribution of hydrological loading for underground stations like Moxa, Membach and Strasbourg. Indeed, another group of researchers has shown that the continental hydrology as well as other climatic time-series exhibit a 6-year oscillation e.g. Pfeffer et al. (2022, https://doi.org/10.5194/egusphere-2022-1032), Cazenave et al. (2023, https://doi.org/10.5194/egusphere-2023-312) and Pfeffer et al. (2023, http://ssrn.com/abstract=4388237). This hydrological signal contributes to the observed 6-yr gravity change and would mask any potential signal originating from the core. Consequently, as long as you do not correctly deconvolve gravity data from this hydrological signal, you cannot interpret the 6-yr oscillation as a signal of core-origin.

Response: We appreciate your comments and the references that you supplied. Here the main question of controversy is whether or not the hydrological loading contains the 5.9-year oscillation (SYO) (alternatively, whether or not the hydrological effects contribute to the observed SYO gravity change). In addition, you brought to my attention that previous research found that the other climatic time series indicate a 6-year oscillation. In response to these two issues, the following will give detailed verifications using publicly accessible data from four perspectives.

(1) Verification using hydrological loading models at IGEST sites

We collected the hydrological loading data at six SG stations selected in this study from 6 different global hydrological models (Fig. 1), including ERA5, ERAin, ERA5-land, GRACE, GLDAS2, and MERRA2, provided by the EOST Loading Service (http://loading.u-strasbg.fr/sg_hydro.php). We use Fourier and Morlet wavelet spectra to verify whether the modeled hydrological loading data contain the SYO signals.

Fig. 2 shows the Fourier amplitude spectra of the modeled hydrological time series at six SG stations. The spectral analysis findings indicate that none of the hydrological models exhibit any noteworthy peaks that align precisely with the SYO frequency (1/5.9years=0.1695cpy, as denoted by the horizontal red lines). Nonetheless, there exist proximate peaks within the period band around 5.9 years, such as the peaks of ~5.4 years at the CB station and ~6.4 years at the CA station. Moreover, we plot the Morlet wavelet spectra of the hydrological data obtained from the ERA5 model and GRACE iterated global mascons in Figs. 3 and 4, respectively. The ERA5 hydrological data at all SG stations exhibit a deficiency in power at the ~5.9-year intradecadal variability. The GRACE hydrologic data at the CB, MO, MB, and ST stations exhibit some degree of power during certain time intervals. However, these signals do not demonstrate significant and consistent SYO patterns in the studied time spans.

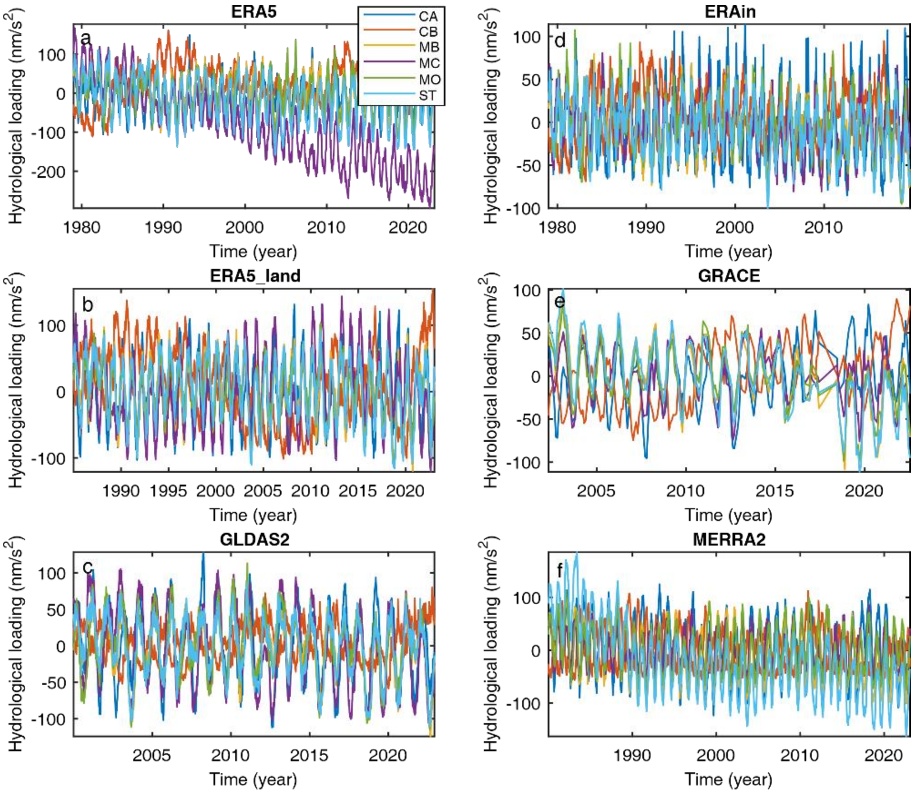

Figure 1. Modeled hydrological loading data series at six SG stations: (a) ERA5, 1979-2023; (b) ERAin, 1979-2019; (c) ERA5-land, 1985-2023; (d) GRACE, 2002-2022; (e) GLDAS2, 2000-2022; (f) MERRA2, 1980-2023.

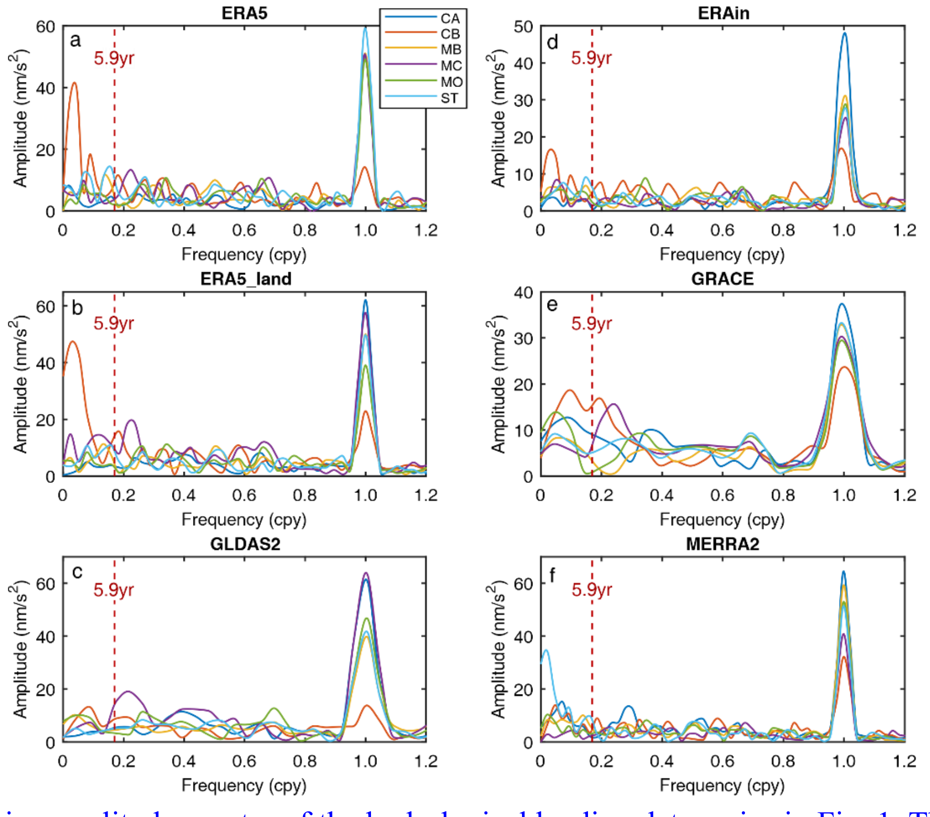

Figure 2. Fourier amplitude spectra of the hydrological loading data series in Fig. 1. The vertical red dashed lines denote the reference period 5.9 years of the SYO signal.

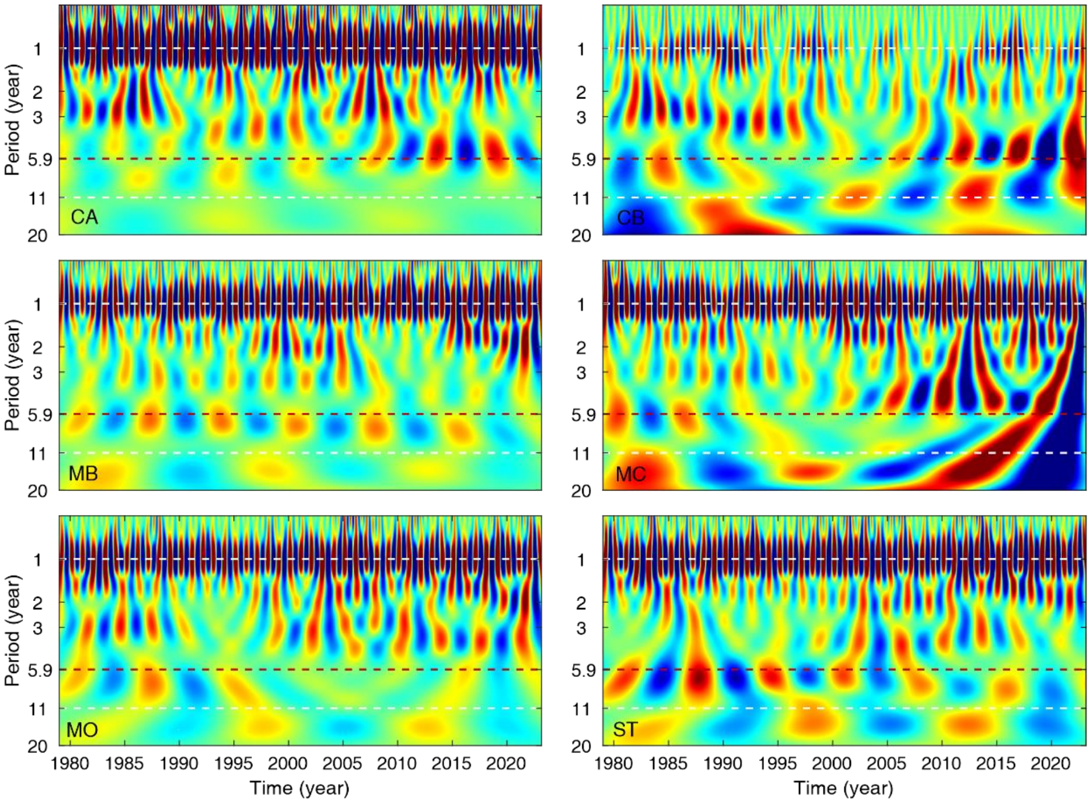

Figure 3. Morlet wavelet spectra of the hydrological data series estimated from ERA5 model.

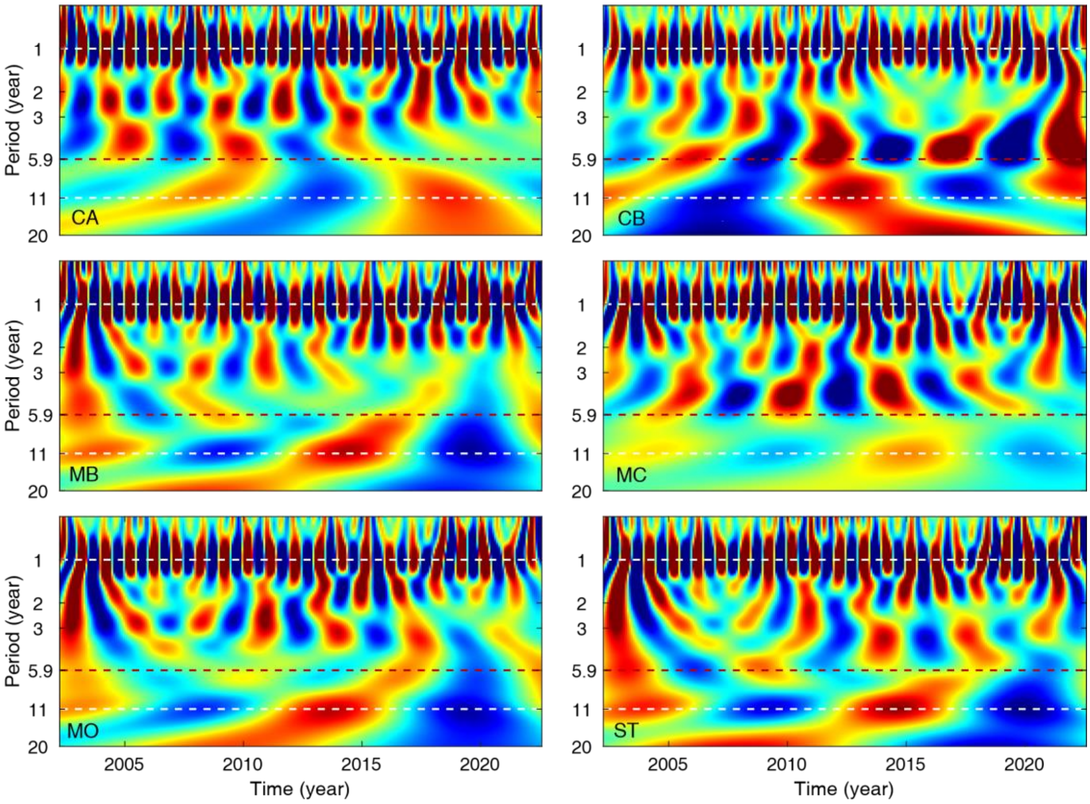

Figure 4. Morlet wavelet spectra of the hydrological data series estimated from GRACE iterated global mascons.

(2) Verification using global gridded precipitation data

According to Pfeffer et al. (2022, 2023), the 6-year oscillation could potentially originate from either precipitation or terrestrial water storage (TWS). Pfeffer et al. (2023) applied a band-pass filter to isolate the frequency band around the 6-year signal from the time series of precipitation or TWS anomalies, derived from satellite gravity observations, in-situ and satellite-based precipitation records, and predictions from global hydrological models. Here we employ the Fourier and wavelet spectra to examine the monthly precipitation data series obtained from the ERA5-Land global gridded precipitation model (https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-land-monthly-means) and GPCC global gridded precipitation dataset (https://psl.noaa.gov/data/gridded/data.gpcc.html). With the exception of the entirety of the Earth's land surface, our attention is directed towards specific regions (R1, R2, R3) that encompass the used SG stations in order to involve the precipitation effects on both global and regional scales (see Fig. 5).

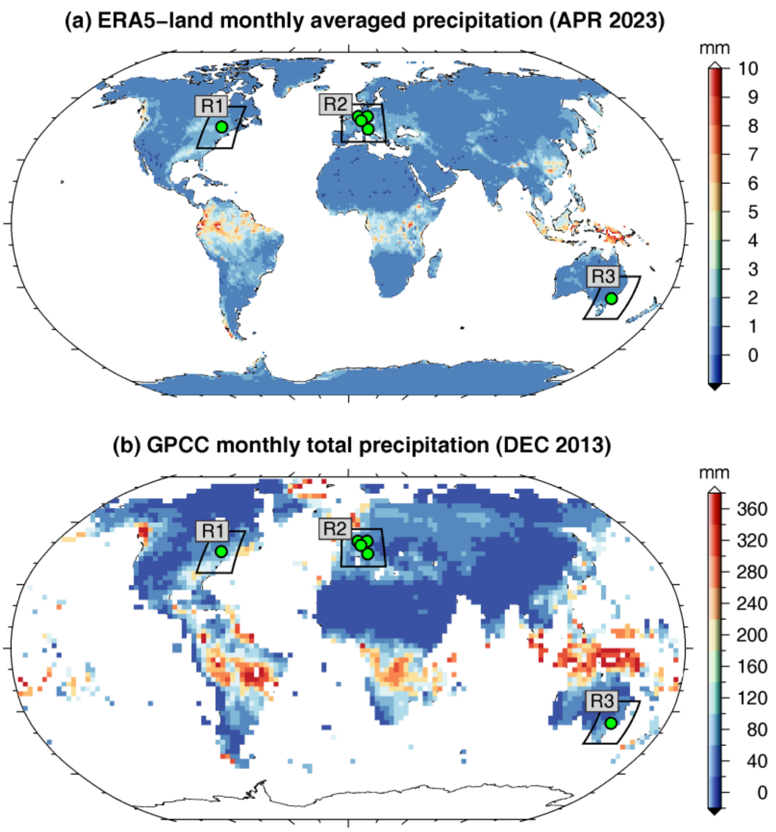

Figure 5. Global gridded precipitation data: (a) The ERA5-Land monthly averaged precipitation model resampled at a 1°×1° grid, in Apr. 2023; (b) The GPCC monthly total precipitation observations sampled at a 2.5°×2.5° grid, in Dec. 2013. The black frames labeled by R1, R2, and R3 indicate the regions covering the used SG stations, respectively CA, MB/MC/MO/ST, CB (green circles).

In Fig. 6 the Fourier and wavelet spectra of the ERA5-Land precipitation data in the global, R1, R2, and R3 regions indicate no oscillation signal at the 5.9-year period. Within the period band around 5.9 years, a peak of approximately 5.0 years is observed, with a low signal-to-noise ratio (SNR) and the amplitude lower than the 95% confidence level (CL) in the frequency band under investigation (Fig. 6e-h). It is worth noting that the wavelet spectra for the global region exhibit evident annual signal, 11-year fluctuation, and 18.6-year lunar tide on annual-to-decadal timescales (Fig. 6a, e). In Fig. 7 an analogous examination is conducted for GPCC precipitation observations based global station data. The Fourier spectra exhibit peaks of ~5.2 years in the vicinity of a 5.9-year period (Fig. 7e-h); however, these peaks do not manifest as consistent oscillatory signals in the wavelet spectra (Fig. 7a-d). Despite the presence of consistent power levels lasting ~5.9 years in narrow time intervals (Fig. 7a), we think that these occurrences may be attributed to errors in modeling or reanalysis.

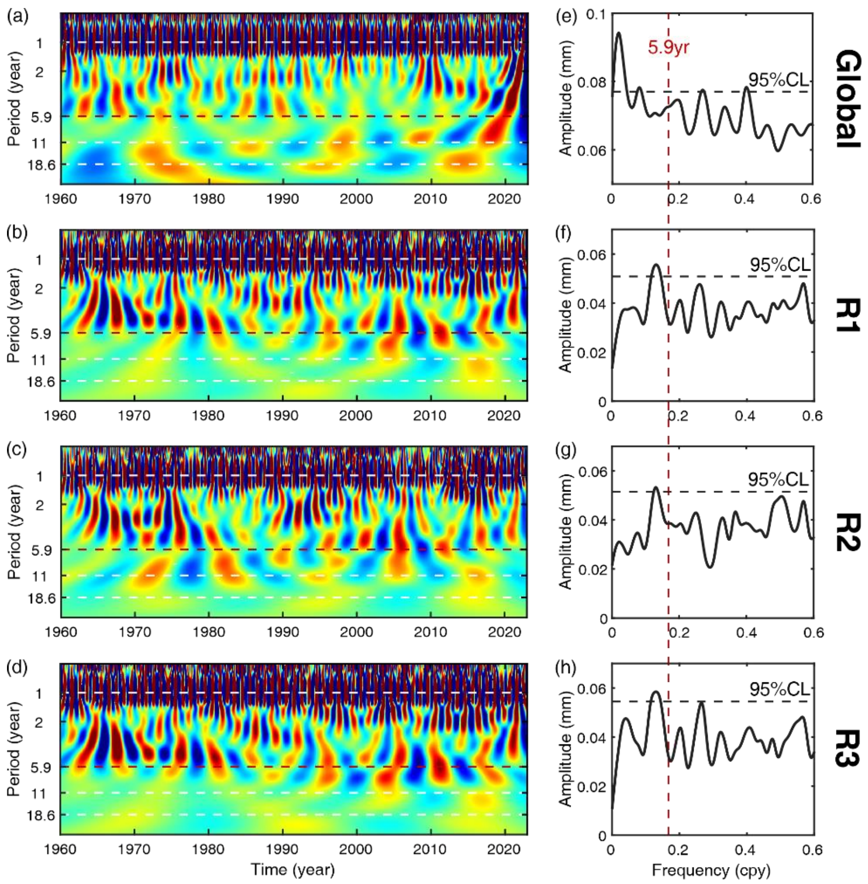

Figure 6. ERA5-Land precipitation model: (a-d) The Morlet wavelet spectra of the average series of the detrended precipitation data in the global, R1, R2, and R3 regions. (e-h) The mean Fourier amplitude spectra of the detrended precipitation data series in the global, R1, R2, and R3 regions. The precipitation time series span from Jan. 1960 to Apr. 2023. The horizontal and vertical red dashed lines denote the reference period 5.9 years of the SYO signal, and the horizontal black dashed lines in (e-h) show the 95% confidence level (CL).

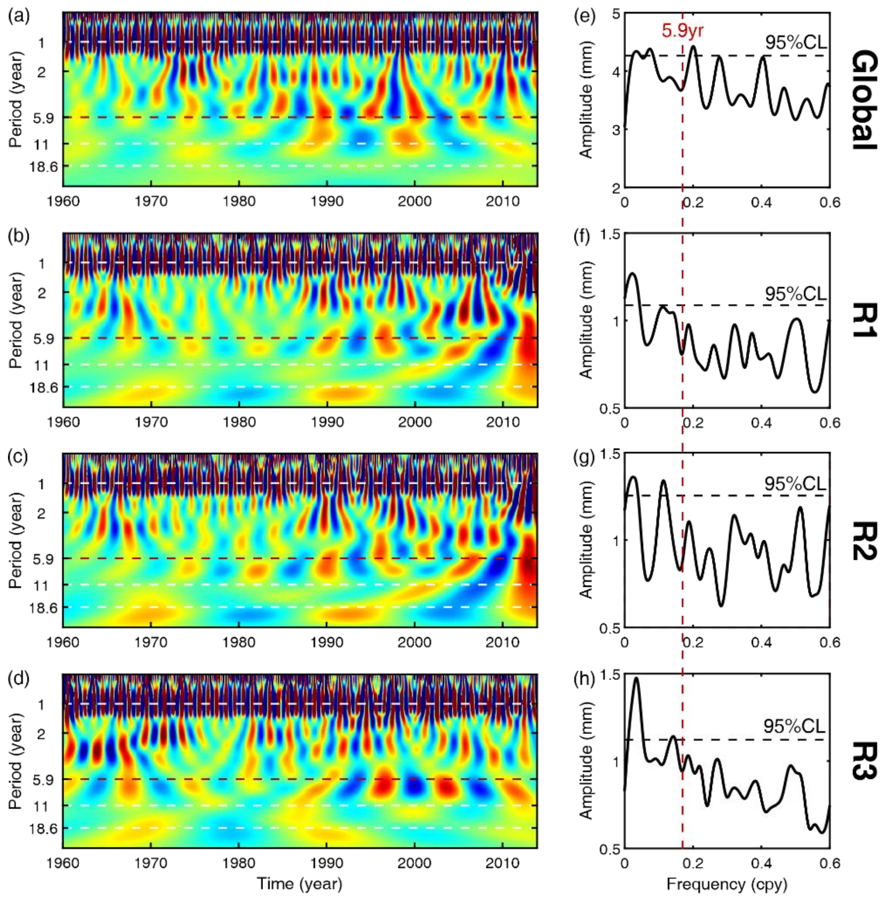

Figure 7. GPCC precipitation observations: (a-d) The Morlet wavelet spectra of the average series of the detrended precipitation data series in the global, R1, R2, and R3 regions. (e-h) The mean Fourier amplitude spectra of the detrended precipitation data series in the global, R1, R2, and R3 regions. The precipitation time series span from JAN 1960 to DEC 2013.

To sum up, we do not find any significant and consistent ~5.9-year oscillation in the hydrological loading model data and global gridded precipitation data. From previous studies of ΔLOD, geomagnetic fields, and SLR, it has been observed that the SYO behaves a relatively stable fluctuation with `(e.g., Liao and Greiner-Mai, 1999; Gillet et al., 2010; Ding & Chao, 2018, EPSL; Ding, 2019; Duan & Huang, 2020; Chao & Yu, 2021; Ding et al., 2021). Besides, the hydrology-excited LOD time series does not contain the ~5.9-year signal and the overall influences of the hydrology on ΔLOD are very small, but the atmosphere-excited LOD time series contains a ~5-year signal (Zotov et al., 2020; Ding et al., 2021). Based on the aforementioned verifications and analysis, we preliminarily consider that the hydrological loading does not contain the SYO signal. However, the accuracy of the used reanalysis models or datasets cannot be ascertained with certainty, thus further demonstration is required to determine whether there is a SYO signal in continental hydrology. The optimal and persuasive approach entails showcasing in-situ surface observation data, such as precipitation, soil water, and groundwater level.

(3) Verification using climate indices, GMST, and GMSL

The research conducted by Moreira et al. (2019) and Pfeffer et al. (2023) is what we will be referring to in the present verification. Moreira et al. (2019) focused on the interannual variabilities in global mean sea level (GMSL) over 1993-2019, which were linked to various climate modes or indices. Pfeffer et al. (2023) employed a bandpass filter to examine the time series of the global mean sea temperature (GMST) and GMSL over 1993-2002. Here we collected more abundant climate indices from NOAA Physical Sciences Laboratory (NOAA PSL, https://psl.noaa.gov/data/climateindices/), and GMST and GMSL data series from various institutions or workgroups. The classical Fourier and wavelet spectra are still employed to analyze the data to mitigate potential methodological errors.

Fig. 8 displays the Morlet wavelet and Fourier spectra of the monthly climate index series, encompassing PDO, AO, NAO, SOI, AMO, NINO3, AAO, ESPI, and MEI, from 1951 to the present. Just looking at the period band around 5.9 years in the Fourier spectra (Fig. 8j-r), it is evident that, except for AMO, there are peaks of ~5-5.6 years with the amplitudes surpassing the 95% CLs for the majority of climate modes. Upon further observing the wavelet spectra (Fig. 8a-i), no substantial or stable oscillation signal with a period of ~5.9 years was detected. The 5.9-year periodicity continues to exhibit a degree of power in narrow time intervals, particularly in relation to PDO, NINO3, ESPI and MEI over 2000-2020. Additionally, the NAO over 1951-1990 and SOI over 1990-2010 also demonstrate this periodicity. However, as previously stated, the wavelet spectra is still incapable of resolving a stable oscillation of ~5.9 years. It can be seen that the classical Fourier spectrum, which is restricted to frequency resolution, occasionally exhibits unreliable low-frequency signals, which may arise from the superposition of near-periodic signals in different time spans. Hence, in order to acquire precise information pertaining to a long-period signal, it is more efficacious to scrutinize its instantaneous fluctuations.

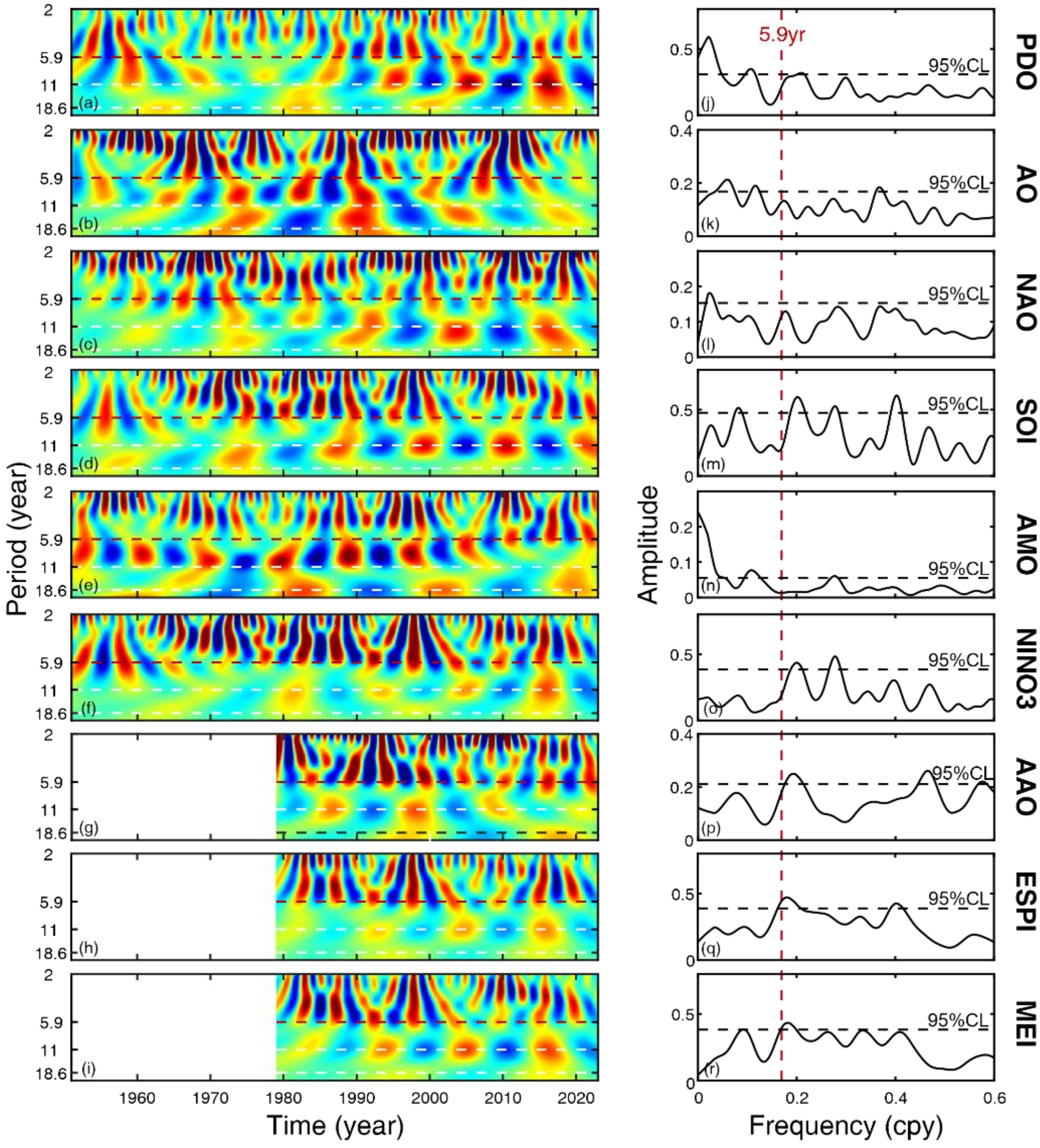

Figure 8. NOAA Climate Indices: The Morlet wavelet (left) and Fourier (right) spectra of the climate monthly index data series since 1951 to present. From top to bottom: Pacific Decadal Oscillation (PDO), Arctic Oscillation (AO), North Atlantic Oscillation (NAO), Southern Oscillation Index (SOI), Atlantic Multi-decadal Oscillation (AMO), Eastern Tropical Pacific SST (NINO3), Antarctic Oscillation (AAO), ENSO Precipitation Index (ESPI), and Multivariate ENSO Index (MEI).

Fig. 9 provides evident indication that there are no discernible peaks present at ~5.9 years in either the Fourier or Morlet wavelet spectra of the GMST anomaly data series. The horizontal white lines in the wavelet spectra show the resolved 18.6-year lunar tide signals (Fig. 9c-f), which are also identified in the Fourier spectra (Fig. 9b). The Fourier spectra also reveal the presence of notable peaks at the periods of ~10 years, which are in proximity to the 11-year oscillation albeit indiscernible in Fig. 9c-f. It is noteworthy that there exist peaks of ~6.3 years in the Fourier spectra, which align with the findings of Pfeffer et al. (2023) as depicted in their Fig. 8. However, these peaks have been confirmed to be fake signals in the wavelet spectra.

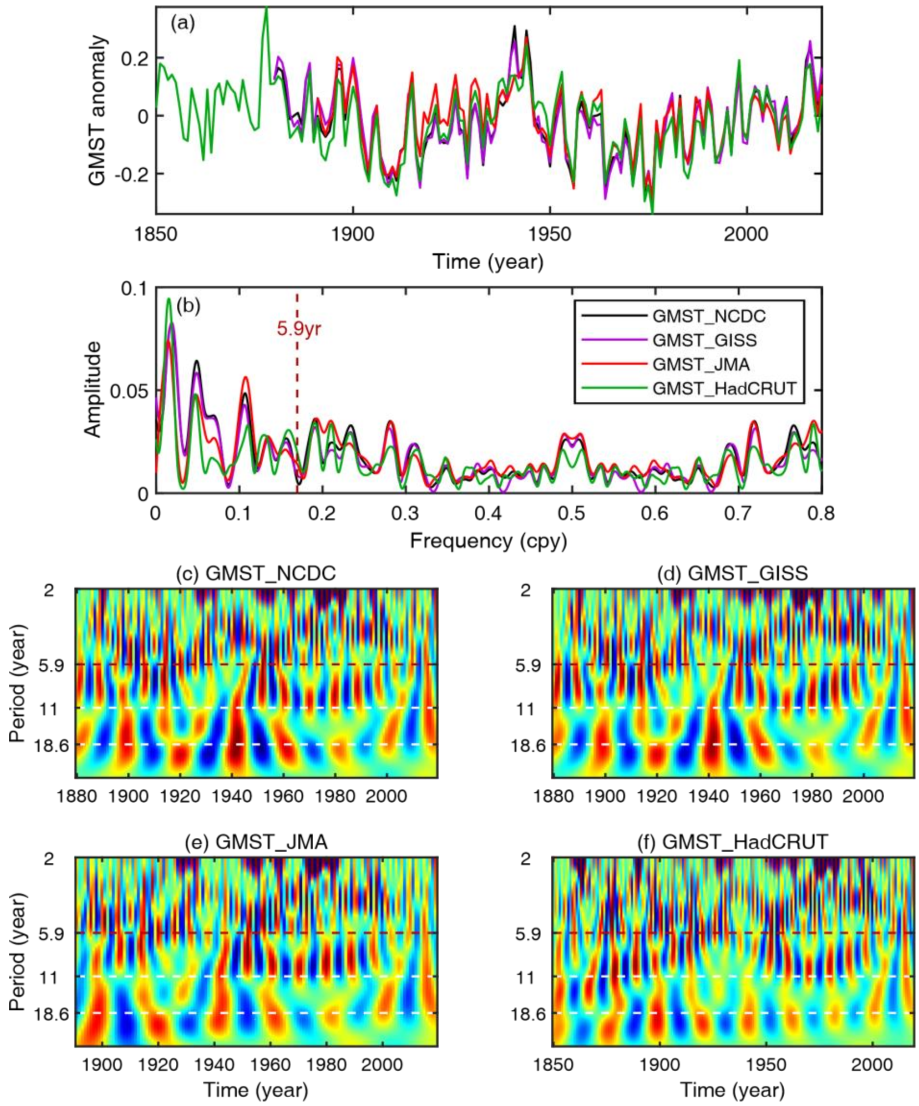

Figure 9. **Global mean sea temperature (GMST):** The Fourier amplitude spectra (b) of the detrended annual GMST anomaly data series (a). Data source: GMST_NCDC (from NOAA/NCDC), GMST_GISS (from NASA/GISS), GMST_JMA (from Japan Meteorological Agency), GMST_HadCRUT5 (from Met Office Hadley Centre observations datasets).

Fig. 10 depicts the Fourier and Morlet wavelet spectra of the GMSL data series obtained from various sources, including CSIRO, JPL, AVISO, NOAA, Colorado, and NASA. In the analyzed data sets, specifically in the monthly reconstructed data from CSIRO and JPL and 10-day sampling data from AVISO with seasonal signals removed, no discernible peaks were observed around the 5.9 years (Fig. 10c-e). In the time series from NOAA, Colorado, and NASA spanning from 1993 to present, with seasonal signals retained, the very weak peaks around 5.9 years are detected in the Fourier spectra (Fig. 10f-h). These peaks are significantly lower than the 95% CLs. Furthermore, we do not find any statistically significant signals exceeding the 95% CL around 6-7 years, especially 6.3 years, which were exhibited by Moreira et al. (2019) and Pfeffer et al. (2023) in the power spectra density periodogram.

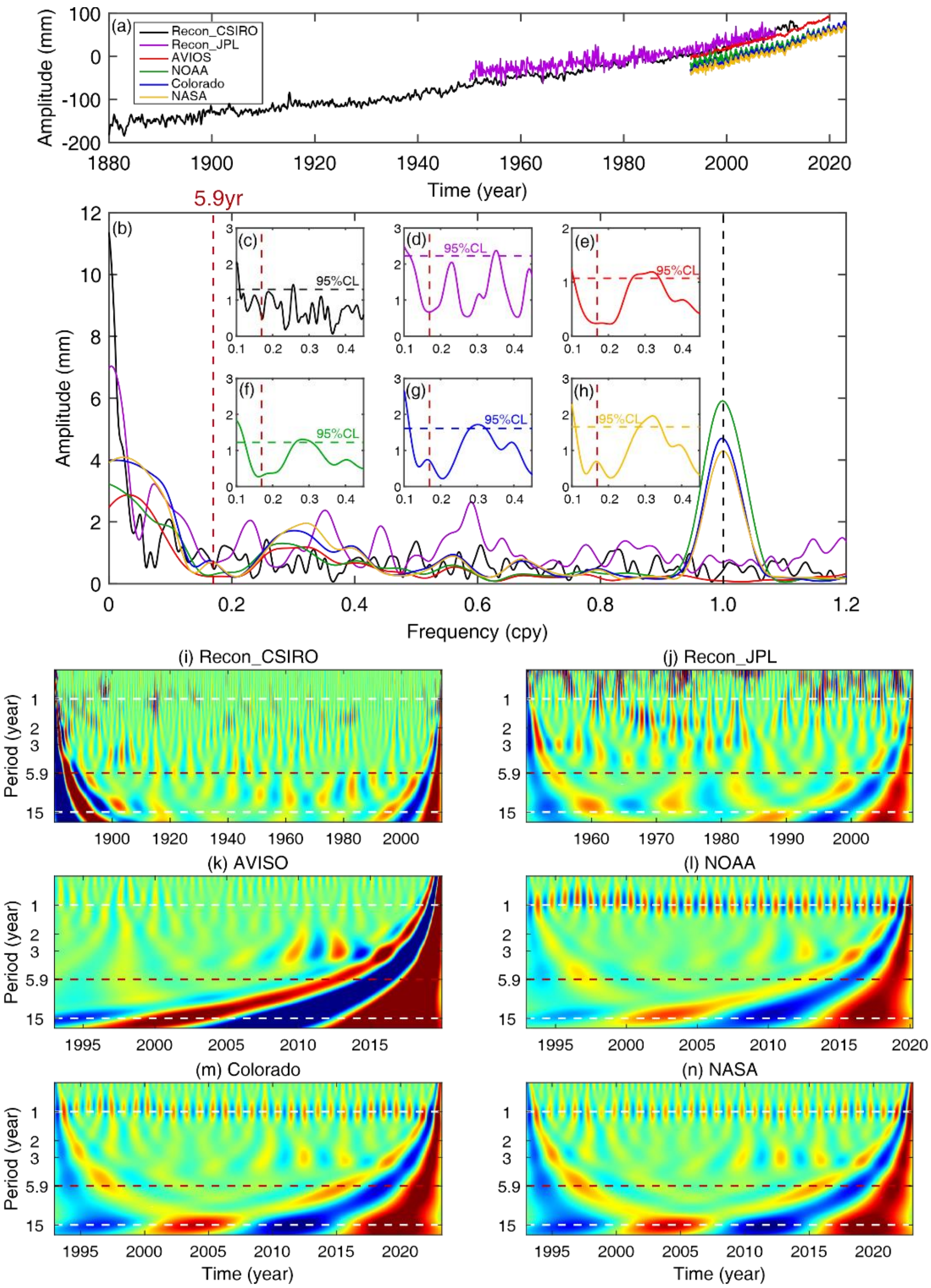

Figure 10. **Global mean sea levels (GMSL):** The Fourier (b-h) and Morlet wavelet (i-n) spectra of the GMSL data series (a). (c, i) Monthly reconstructed data from CSIRO (Common-wealth Scientific and Industrial Research Organization), 1880-2014; (d, j) Monthly reconstructed data from JPL (Jet Propulsion Laboratory), 1950-2009; (e, k) 10-day interval data from AVISO of CNSE (Centre National d'Etudes Spatiales), 1993-2020; (f, l) 10-day interval data from NOAA Climate.gov, 1993-2020; (g, m) Monthly data from Sea Level Research Group of University of Colorado, 1993-2023; (h, n) 10-day interval data of TPJAOS v5.1 (Integrated Multi-Mission Ocean Altimeter Data) from the NASA Sea Level Change program, 1993-2023.

(4) Verification using the oblateness ΔJ_2

The terrestrial water storage variations can result in Earth's mass redistribution, potentially causing the change of the Earth's shape (via private communication with Benjamin F. Chao). As per this perspective, the J_2 variations (ΔJ_2), which serve as indicators of alterations in the oblateness of the Earth, have the potential to reflect the global hydrological changes. Therefore, we use the Fourier and wavelet spectra to analyze the ΔJ_2 time series spanning from 1975 to 2023 (https://filedrop.csr.utexas.edu/pub/slr/degree_2/). Fig. 11 demonstrates notable signals on interannual-to-decadal timescales., i.e., the 18.6-year lunar tide and 11-year variation, which highly coincide with the results of Chao et al. (2020). These signals are also found in the spectra analysis of the ERA5-Land global precipitation model (see Fig. 6). Additionally, the Fourier spectrum reveals the presence of a weak and spurious signal of a ~5 years period, which is consistent with the findings in Fig. 6. This exemplary correlation serves to illustrate that the oblateness ΔJ_2 has the capacity to depict certain overarching hydrological information on a global scale. The absence of a SYO signal in ΔJ_2 suggests a lower probability of the hydrological effects being the source of the SYO signal.

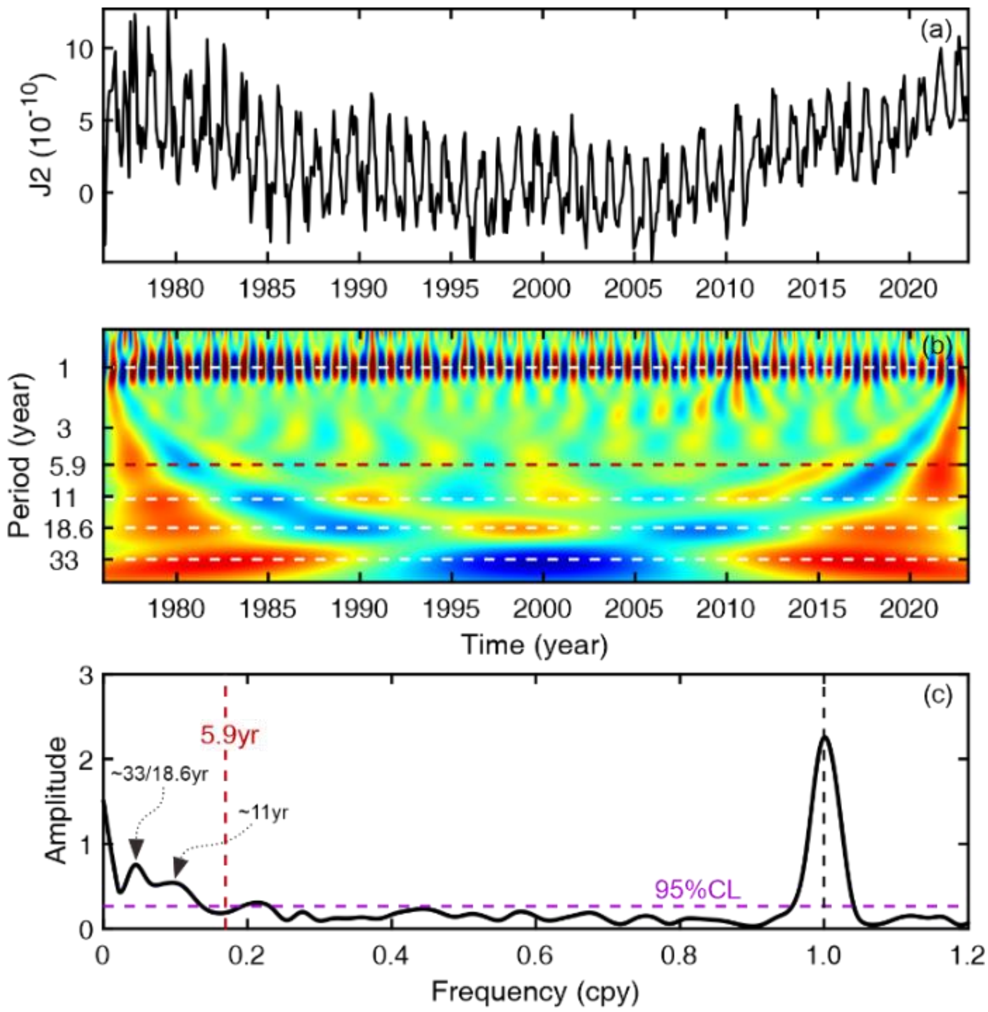

Figure 11. ΔJ_2: The Morlet wavelet (b) and Fourier (c) spectra of the Δ$J_2(t)$ data series (a) in 1975-2023. The oblateness J_2 is the Earth's lowest-degree gravitational component that measures the (normalized) difference between the polar and equatorial moments of inertia. The J_2 time series is concatenated from satellite laser ranging data (Cheng et al., 2004). The 18.6-year lunar tide, 11-year and 33-year fluctuations are prominent, but no appreciable presence of SYO is detected, ruling out a degree-2 order-0 mass change (a redistribution in the net meridional sense) for causing the SYO in hydrological effects (Ding et al., 2018, EPSL, Supplementary Materials).

Besides, the authors still employ the AR-z spectrum. This method has been used in many papers now, but the code is still not made publicly available. If it is so much better than the FFT, why you do not share it? This AR-z spectrum always displays additional peaks with respect to the FFT. How do you explain the additional peaks that are visible on Fig. 3 but not visible in FFT?

Response: Ding et al. (2018, JGR) have provided the test code of the AR-z spectrum in their Supporting Information (https://agupubs.onlinelibrary.wiley.com/doi/10.1029/ 2018JB015890). A Matlab code for the AR-z spectrum, which includes a function code ‘arz_spec.m’ and a test code ‘test.m’ accompanied by a detailed description, was recently made available to the public on ResearchGate (https://www.researchgate.net/publication/370231571_The_simply_Matlab_code_for_the_ARz_spectrum). The methodology was executed and assessed by Hsu et al. (2021, JoG, https://doi.org/10.1007/s00190-021-01503-x). The present study employed the stabilized AR-z spectrum technique, which incorporated a Monte Carlo noise-assisted bootstrap scheme to yield more robust spectral estimates for a single record. It should be noted that the shared codes and the one verified by Hsu et al. (2021) are consistent as the core code to implement the AR-z method, without considering the noise-adding process; whereas this noise-adding process for the stabilized AR-z spectrum can be easily implemented (refer to Ding et al., 2018, JGR for details).

The AR-z spectrum exhibits several peaks with high SNRs, which are notably distinct from those observed in the FFT spectrum. However, it is imperative to underscore that the power of the peaks in the AR-z spectrum directly correlates with their stability rather than their actual amplitude. Please refer to Ding et al. (2018, JGR)’s supporting information for the conclusion. In other words, the spectral peak in the AR-z spectrum may appear strong even if the signal is weak, provided that it is relatively stable. As seen in Fig. 3 of the manuscript, the atmospheric/oceanic/hydrological (AOH) signals in the 3-5 years frequency band are representative instances. The AR-z spectra of the CA, MO, and ST stations exhibit insignificant spectral peaks, suggesting that the AOH signals are quite erratic during the analysed time spans. This is also discernible in the wavelet spectra, as illustrated in Fig. 4 of the manuscript.

P. 11, section 4.2: the argument of the ratio δ/h is not sufficient to propose an internal origin for the 6-yr oscillation. This ratio for surface loading is also very different from the tidal one (see for instance de Linage et al. 2007, doi: 10.1111/j.1365-246X.2007.03613.x and de Linage et al. 2009, doi: 10.1111/j.1365-246X.2007.03613.x, who have estimated this ratio for various loading and have shown some variability). Local hydrology would also affect this ratio, particularly at underground stations like Moxa, Membach, Strasbourg (e.g. Rosat et al. 2020, https://doi.org/10.1007/1345_2020_117). This argument is hence not sufficient to justify your interpretation of the 6-yr oscillation as the signature of an internal process.

Response: We first appreciate your valuable comments and providing us with significant references. The degree-2 tidal Love numbers were exclusively taken into account to derive the ratio of δ/h, which was determined to be approximately 1.9, while the surface loading ones were disregarded. This is an important oversight in the manuscript.

The actions of surface gravity variations resulting from a surface load comprise of the load's direct attraction and elastic deformation, and the latter also encompasses mass redistribution and free-air effect (de Linage et al., 2007). According to de Linage et al. (2009), the average ratio for hydrological loading (which includes soil moisture and snow) over the continents is -0.87 μGal mm^{-1}, but this ratio tends to increase as the size of river basins decreases; The atmospheric loading, assuming an inverted-barometer response of the ocean, exhibits larger values for high latitudes, with a positive ratio of 0.49 μGal mm^{-1} (because the atmospheric masses are located above the measurement point); In the case of ocean tidal loading, the mean ratio for diurnal tidal waves over the continents is -0.26 μGal mm^{-1}. The relationship between vertical deformation and surface gravity, as expressed by $\Delta g = -\frac{2g}{R}\frac{\delta}{h}\Delta V$, allows for the approximate determinations of the ratios δ/h associated with the hydrological, atmospheric, and ocean tidal loadings. Specifically, the ratios corresponding to these loadings are approximately 2.84, 1.60, and 0.85, respectively. In contrast with our calculated values of 2.0 to 4.1, the atmospheric and oceanic tidal loadings as the external sources of the SYO can be excluded, whereas the hydrological loading's contribution to the SYO still needs intensive discussions. However, as demonstrated in the above responses, we have confirmed that the hydrological loading has a negligible impact on the surface gravity variation linked to the SYO.

Hence, it can be concluded that we can rule out that the SYO originates from external sources, but attribute it to some internal dynamical processes, such as the MAC wave we suggested; the 6-year related gravity changes, which may include core motions and some unknown 6-year changes due to strong coupling interactions between the mantle and core. Namely, the 6-year related surface gravity changes may be the result of a superposition of multiple internal motions in the Earth's coupling layers. In fact, we have stated this opinion in the 2nd paragraph (lines 265-267) in Section 5, i.e., "we assume that the Earth's core processes may also be coupled to the motions of other regions in the Earth, and thus form secondary effects; And the magnitudes of which are not necessarily smaller than the direct effects." Except excluding the external loads, our conclusions are similar to the conclusions of Cazenave et al. (2023) and Pfeffer et al. (2023), who suggested the SYO affects the Earth system as a whole. These new discussions and references will be added to the revised manuscript.

Lines 270-272: the statement here is wrong. In Gillet et al. (2020) they used pressure Love numbers exactly as in Greff-Lefftz et al. (2004). You can check the values for the Love numbers h in their respective Table 1 and see that they are the same. The mistakes are in Fang et al. (1996) who have considered the pressure flow as a surface load but they have ignored the deformation of the equipotential surfaces in the core. They only considered the deformation of the mantle, while in Greff-Lefftz et al. (2004) and in Gillet et al. (2020), they both considered the deformation of the mantle and of the equipotential surfaces in the core. The Love numbers and surface deformation estimates by Gillet et al. (2020) are hence correct.

Response: We have carefully re-read the articles by Gillet et al. (2020), Greff-Lefftz et al. (2004) and Fang et al. (1996). Indeed, as you say, we have made a nonnegligible mistake. We will remove these wrong discussions in the revised manuscript.

Technical corrections

Lines 51, 59, 64 etc… satellite laser ranging should be abbreviated as SLR not SRL

Response: Thank you for your correction for our clerical error, and we will revise the manuscript.

Line 73: the GGP project does not exist anymore, it has been replaced by the IGETS.

Response: We appreciate your corrections regarding the incorrect description in our manuscript, and we will proceed to make the necessary revisions accordingly.

Lines 86-87: you say that you used level-2 products that mean that major disturbances have already been corrected from the data. Else, please precise what you are referring to as "h2" corrections since official IGETS products are called Level 1, Level 2 and Level 3 products.

Response: We must explain that the Code "h2" dataset, which is collected in the Level 2 data products, includes hourly gravity and pressure data corrected for instrumental perturbations and ready for tidal analysis (see Boy et al., 2020), was adopted for the used records (see Supplement Table S1 for the detailed information). We will modify the manuscript to avoid unnecessary misunderstanding.

Line 154: in the processing of data, a tidal analysis was performed with ETERNA software to remove tides. So why is there still the 18.6-yr tide? You did not include it in the groups of waves to be analyzed? Why?

Response: We must declare that the long-period tide constituents, ranging from SA to MQM tides, have been considered in our tidal analysis. However, as analyzed by many scholars, the harmonic analysis results of long-period tides are not very ideal, i.e., exhibiting significant amplitude and phase errors. This is attributed to that the time length is not enough for extracting precise information of long-period tide through iterative least-squares. Therefore, we employed a simple approach by substituting the long-period tide constituents with the 'long' wave, which operates within the frequency range of 0.004709-0.501369 cpd, and exhibits an amplitude and phase of 1.15000 and 0, respectively, as recommended by Tsoft. This method includes the 18.6-year tide and also leaves the intradecadal fluctuation unaffected.

Line 160: some spurious or unexplained peaks are visible in the AR-z spectrum (between annual and QBO, and at 2.6-yr). Why you do not discuss them? Are they artefacts of the AR-z spectrum? How confident are you on the AR-z spectral peaks? You should provide some confidence levels with this method, since many spurious peaks seem to appear…

Response: The present study focuses on the analysis of interannual-to-decadal signals, as detailed in Section 3. The signals within the frequency band of 1-2 years were not discussed, as they were considered as background noise. The peaks in this frequency band were amplified to an observable level because of the usage of an analytical continuation distinct from that employed in the interannual-to-decadal band. Certain peaks may possess practical significance or could potentially arise from background noise. Evidently, our unreasonable handling led to your misunderstanding. In the revised manuscript, we will conduct a more meticulous analytic continuation of this frequency band to align with the Fourier spectrum. Alternatively, we will employ a more straightforward method of low-pass filtering during data preprocessing to eliminate the frequency band above 2 cpy and minimize the influences of unidentified signals. Besides, it should be noted that during the implementation of nonlinear fitting for the recovery of the ~5.9-year oscillation, the frequency band of 1-2 years was not considered due to its negligible impact on the retrieval process. Finally, we appreciate your reminder, and the confidence levels for the AR-z spectra will be added in the revised manuscript.

References

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