Journal of Geoscience and Environment Protection, 2026, 14(9), 81-95
https://www.scirp.org/journal/gep
ISSN Online: 2327-4344
ISSN Print: 2327-4336

Satellite-Based Monitoring of Drought Characteristics and Meteorological-Hydrological Drought Propagation in Shijiu Lake, China

Shanshan Chen[1], Jing Li[2], Yu Yang[2], Kai Wang[1], Chenkai Tang[1], Feiran Luo[1]

[1]Nanjing Lishui District Meteorological Bureau, Nanjing, China
[2]Nanjing Meteorological Bureau, Nanjing, China
Email: css7860@163.com

How to cite this paper: Chen, S. S., Li, J., Yang, Y., Wang, K., Tang, C. K., & Luo, F. R. (2026). Satellite-Based Monitoring of Drought Characteristics and Meteorological-Hydrological Drought Propagation in Shijiu Lake, China. *Journal of Geoscience and Environment Protection, 14,* 81-95.
https://doi.org/10.4236/gep.2026.149006

Received: August 26, 2026
Accepted: September 18, 2026
Published: September 21, 2026

Abstract

Objective: In recent years, with ongoing climate change and the increasing frequency of extreme weather events, drought disasters have become increasingly prominent. By utilizing existing precipitation observation data from meteorological stations, investigating the propagation patterns between meteorological and hydrological droughts in the Shijiu Lake area can help scientifically formulate hydrological drought response strategies, improve water resource dispatch efficiency within the lake region, and enhance disaster prevention and mitigation capabilities. **Methods:** This study focuses on Shijiu Lake as the research subject. Based on the Global Surface Water Mapping Layers V1.4 product (hereafter referred to as GSWE), monthly lake water surface areas of Shijiu Lake from 1990 to 2021 were extracted to identify the hydrological drought characteristics within the lake region. Combined with monthly precipitation observation data from the surrounding Lishui China National Basic Meteorological Station (Station ID: 58340) and the Gaochun China National Basic Meteorological Station (Station ID: 58339), the meteorological drought characteristics of the area where the lake is located were identified. An event-based drought propagation analysis method was applied to reveal the lag time of hydrological drought formation following the occurrence of meteorological drought in the Shijiu Lake basin. **Conclusion:** 1) Between 1990 and 2021, hydrological and meteorological droughts occurred most frequently in winter and spring within the Shijiu Lake area, requiring particular attention. 2) The direct impact of precipitation reduction on lake water surface area in the Shijiu Lake area lasts approximately 3 months, with the most pronounced effect occurring at around 2 months. 3) The average propagation time from meteorological to hydrological drought in this region is 1.6 months. When it is predicted that meteorological drought of moderate intensity or above (SPI < −1.0) will occur in this region at the 9-month SPI time scale, attention should be paid to the potential occurrence of hydrological drought, and relevant water resource dispatch plans should be prepared in advance.

Keywords

Drought Monitoring, Meteorological Drought, Hydrological Drought, Drought Propagation, Water Resources Regulation and Operation

1. Introduction

In recent years, with the increasing frequency of extreme weather events, drought occurrences have also become more frequent. In China, the average annual area affected by drought reaches 2.16×10^5 km^2, accounting for over 60% of the total area impacted by meteorological disasters, with resulting grain losses exceeding 10 billion kg per year (Lai et al., 2020).

Meteorological drought typically serves as the starting point of drought evolution. Precipitation deficits propagate progressively through the hydrological cycle into soil moisture, surface runoff, and groundwater systems, ultimately evolving into hydrological drought (Van Loon & Laaha, 2015). Using satellite-based dynamic monitoring of water surface area as a hydrological drought indicator and characterizing the meteorological-hydrological drought propagation patterns has emerged as a burgeoning research hotspot in domestic and international drought studies in recent years. Internationally, Pekel et al. (2016) constructed a 30 m resolution global surface water dataset (JRC GSWE) based on approximately 3 million Landsat scenes, revealing a net loss of approximately 9×10^4 km^2 in global permanent surface water during 1984-2015, with over 70% concentrated in the Middle East and Central Asia, thereby establishing a data foundation for water-area-based drought monitoring. Li et al. (2025a) fused MODIS and Landsat data through deep learning to produce monthly 30 m resolution water area maps for approximately 1.4 million lakes globally during 2001-2023, finding that seasonal dynamics dominate 66% of global lake areas, and that seasonal extreme events can double the shrinkage of contracting lakes within short periods or fully offset the expansion of growing lakes, underscoring the significant impact of extreme climate on lake hydrological processes. Domestic studies have predominantly focused on Poyang Lake as a representative study area: for instance, Zheng et al. (2025) reconstructed monthly water surface areas for 2000-2023 based on Landsat-MODIS data, proposed using a Standardized Water Index (SWI) to identify hydrological drought, and revealed a lag of approximately 2 months in the propagation from meteorological drought in the inflow catchments (Xiushui, Xinjiang, and Raohe rivers) to hydrological drought in the lake region; Xiong et al. (2025)

developed a Dynamic Water Drought Index (DWI) based on the GLAD-GSWD dynamic water product, finding that DWI was significantly and positively correlated with SPI in 88.2% of sub-basins in the middle reaches of the Yangtze River during 1999-2020, with a median meteorological-hydrological propagation lag of 6 months; Ye et al. (2025) proposed a Standardized Hydrological Drought Index based on inundation area, demonstrating that station-based water level indices involve considerable uncertainty in characterizing the overall hydrological drought of Poyang Lake, whereas inundation area indices offer greater reliability; Yuan et al. (2025) traced the inundation area of Poyang Lake during 1994-2023 using Landsat imagery, finding that the annual minimum inundation area decreased significantly at a rate of −21.51 km^2/a, indicating increasingly severe hydrological drought; Qi et al. (2025) developed a seasonal Surface Water Area (SWA) product for the middle and lower reaches of the Yangtze River, confirming that SWA exhibited the strongest correlation with precipitation and drought indices in most sub-basins. In summary, domestic and international studies collectively demonstrate that changes in water surface area monitored via remote sensing can intuitively reflect the hydrological drought conditions of a region. By investigating the propagation patterns between hydrological and meteorological drought, meteorological drought can be leveraged to provide early warning of hydrological drought, thereby substantially extending the lead time for hydrological drought warning, which is of significant indicative value for the early warning and monitoring of regional drought conditions.

The total available water resources of the Shijiu Lake area account for approximately 52% of the total available water resources of Lishui District. When the water level of Gucheng Lake in Gaochun District falls below 7.00 m, water is diverted from Shijiu Lake for replenishment. Currently, Shijiu Lake is replenished by Gucheng Lake and surrounding small and medium-sized reservoirs such as Zhongshan and Fangbian (Li et al., 2025b), and its water resources play a vital role in agricultural production and the characteristic crab aquaculture in the surrounding lake region. Therefore, by utilizing measured meteorological data combined with lake surface area data retrieved through satellite remote sensing, this study conducts an in-depth investigation of the propagation relationship between hydrological drought and meteorological drought within this region, aiming to provide early warning of impending hydrological drought based on variations in measured precipitation and to offer scientific reference for regional water resource allocation, striving to substantially reduce drought-induced economic losses related to agricultural production.

2. Study Area and Data Sources

2.1. Study Area Overview

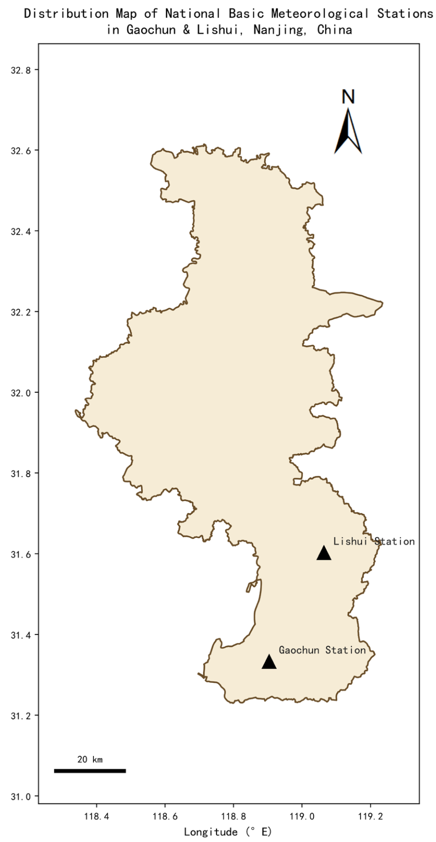
Shijiu Lake (118˚46'E - 118˚56'E, 31˚23'N - 31˚33'N) is situated at the junction of Lishui District and Gaochun District of Nanjing City, Jiangsu Province, and Ma’anshan City, Anhui Province. It receives inflows from the Shuiyang River, Qingyi River, and Zhanghe River, draining the mountainous regions of southern Anhui, as well as the Xinqiao River and Natural Bridge within Lishui District, and ultimately discharges into the Yangtze River via the Guxi River and Qingshui River (Yu et al., 2010), belonging to the Yangtze River basin. The highest water level occurs from July to August, whereas the lowest water level occurs from December to March of the following year. The total water surface area of Shijiu Lake is 212.22 km^2, and the elevation of the deepest lake bottom ranges from 4.43 to 4.93 m. The lake region is rich in aquatic products, among which the "Three Delicacies"—icefish, crabs, and wild ducks—are the most renowned.

2.2. Data

2.2.1. Global Surface Water Mapping Layers

The primary dataset used in this study to extract the water surface area of Shijiu Lake during 1990-2021 is the Global Surface Water Mapping Layers V1.4 product (hereafter referred to as GSWE) provided by the Joint Research Centre (JRC) of the European Commission.

2.2.2. Precipitation Data



Note: Administrative boundary of Nanjing: derived from the basic geographic information data of the Second National Land Survey of China, provided by the National Geomatics Center of China (NGCC); Locations of the two national basic meteorological stations: plotted using the official longitude/latitude coordinates of the stations, obtained from the China Meteorological Administration/National Meteorological Information Center (CMA /NMIC).

Figure 1. Distribution map of national basic and regional meteorological stations in Nanjing, China.

The precipitation data for 1990-2021 are obtained from the measured monthly precipitation records of the Lishui China National Basic Meteorological Station (Station ID: 58340) and the Gaochun China National Basic Meteorological Station (Station ID: 58339) (their specific locations are shown in **Figure 1**). This study employed monthly precipitation data, all derived from in-situ observations at meteorological stations. In accordance with the observation specifications of the China Meteorological Administration (CMA), these data underwent a rigorous quality-control (QC) procedure and exhibit both completeness and representativeness. As Shijiu Lake is situated at the junction of Lishui District and Gaochun District of Nanjing City, Jiangsu Province, and Ma'anshan City, Anhui Province, the Lishui China National Basic Meteorological Station (Station ID: 58340) and the Gaochun China National Basic Meteorological Station (Station ID: 58339) were adopted in this study (**Figure 1**). The measured monthly precipitation data can truly reflect the variations of meteorological elements within the study area.

2.2.3. Watershed Boundary Data

The watershed boundary mask used for Lake Shijiu water-area extraction was derived from the fundamental geographic information dataset of the Second National Land Survey (2007-2009), administered by the former Ministry of Land and Resources (now the Ministry of Natural Resources) of China. The mask is a vector polygon delineating the lake's basin/lake boundary, digitized from the hydrography and administrative-boundary layers at a scale of (1:50,000) and referenced to the CGCS2000 coordinate system. The source dataset was quality-controlled through integrated interpretation and field verification, map-sheet edge-matching, topological and attribute checks, and national-level accuracy assessment per the Technical Regulations for the Second National Land Survey (TD/T 1014-2007).

3. Data Processing

3.1. Water Surface Area Data Extraction

Surface-water detection in the JRC Global Surface Water (GSW) Monthly History product was performed with an expert-system classifier that assigns each Landsat pixel to water, non-water, or invalid observations (e.g., clouds, shadows, snow, ice) and generates monthly water-history maps by temporally collating these pixel classifications (water band encoding: 0 = no data, 1 = non-water, 2 = water; Pekel et al., 2016). To reconstruct a consistent Surface Water Inundation (SWI) time series for Shijiu Lake, dynamic water boundaries were first constrained using long-term water occurrence (>5%) to isolate seasonally inundated zones, while narrow connected river channels and tributaries were decoupled by morphological opening combined with seed-point connected-component labeling. To further mitigate contamination from invalid observations (clouds, shadows, and SLC-off gaps), monthly scenes with a valid-observation fraction below 70% were discarded, and the raw surface water extent in retained scenes was normalized by the valid-observation ratio.

Throughout the above procedure, all monthly water-history maps and the resulting water extents were strictly clipped to and aggregated within the Lake Shijiu watershed boundary mask described in Section 2.2.3. This polygon—delineating the lake basin from the Second National Land Survey dataset—constitutes the fixed spatial domain for the monthly water-area calculation: only pixels falling inside the basin are retained for area summation, so that connected rivers, seasonally inundated peripheral wetlands, and terrain outside the basin are explicitly excluded, and any invalid observations occurring within the domain are handled as specified above.

3.2. Standardized Drought Indices

The Standardized Precipitation Index (SPI) and the Standardized Water Index (SWI, archived in this study as the Drought Water Index) were both derived by fitting a two-parameter Gamma distribution to their respective time series (McKee et al., 1993; WMO, 2012; Nalbantis & Tsakiris, 2009). For a variable $x > 0$, the Gamma probability density function is

$$f\left(x\right)=\frac{1}{\beta^{\alpha}\Gamma\left(a\right)}x^{a-1}\mathrm{e}^{-x/\beta}$$

where $a > 0$ and $\beta > 0$ are the shape and scale parameters, estimated by the method of moments independently for each calendar month (McKee et al., 1993; WMO, 2012). For SPI, monthly precipitation was first accumulated over each considered time scale (1, 3, 6, and 9 months); the probability mass at zero precipitation was then accounted for by setting

$$G\left(x\right)=q+\left(1-q\right)F\left(x\right)$$

where q is the probability of zero precipitation and $F(x)$ is the Gamma cumulative distribution function (McKee et al., 1993). For SWI, the monthly lake surface area—extracted from the JRC Global Surface Water dataset (Pekel et al., 2016)—was used directly, so no zero-value correction was required (Nalbantis & Tsakiris, 2009). The resulting cumulative probability was transformed to the standard normal distribution via the probit (inverse normal CDF) function,

$$\mathrm{SPI}\left(\text{or SWI}\right)=\Phi^{-1}\left(G\left(x\right)\right)$$

so that both indices have zero mean and unit variance and are standardized separately for each calendar month (McKee et al., 1993; Nalbantis & Tsakiris, 2009). A hydrological drought event was defined as a continuous period during which SWI remained below −0.5 for at least two consecutive months, with the −1.0 level denoting moderate or stronger hydrological drought (McKee et al., 1993; Nalbantis & Tsakiris, 2009).

4. Results and Discussion

4.1. Monthly Water Surface Area Data of Shijiu Lake

Analysis of the water surface area data of Shijiu Lake retrieved from satellite remote sensing reveals that Shijiu Lake is a distinctly seasonal lake (Figure 2): December to March of the following year constitutes the dry season, while April to October constitutes the wet season. Meanwhile, the largest standard deviation occurs in November (Figure 3), indicating drastic fluctuations in the lake water surface area during November. Analysis of the intra-annual variation coefficients of the lake water surface area over the years (Figure 4) shows that the extreme ratio (Amax/Amin) ranges from 1.3 to 3.19, with the largest intra-annual fluctuation occurring in 1995 (3.19).

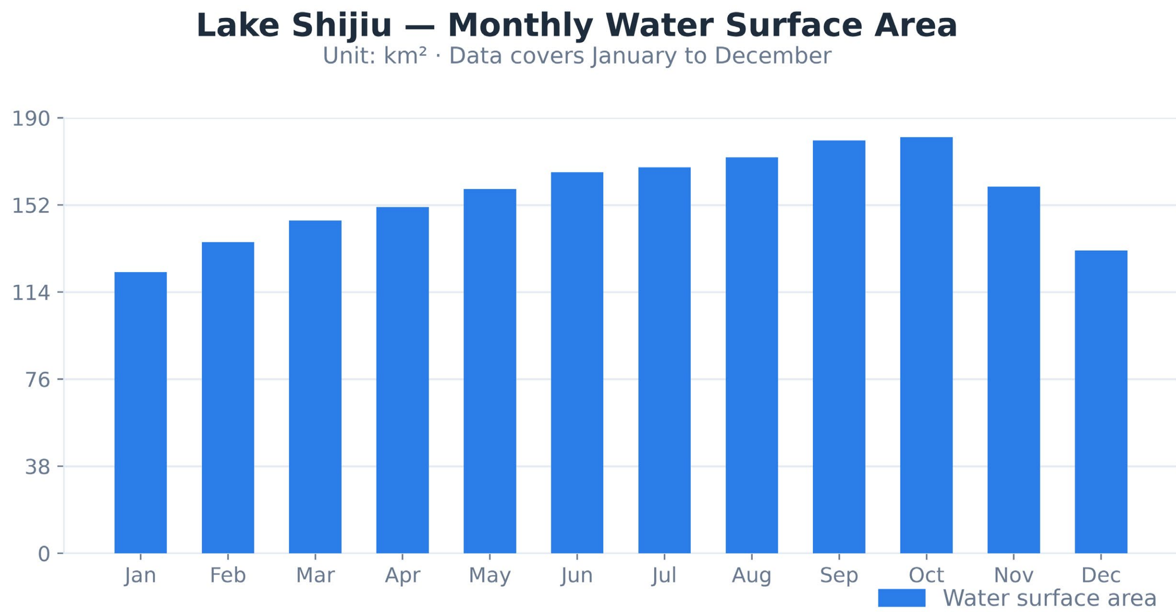


Figure 2. Shijiu Lake—monthly water surface area.

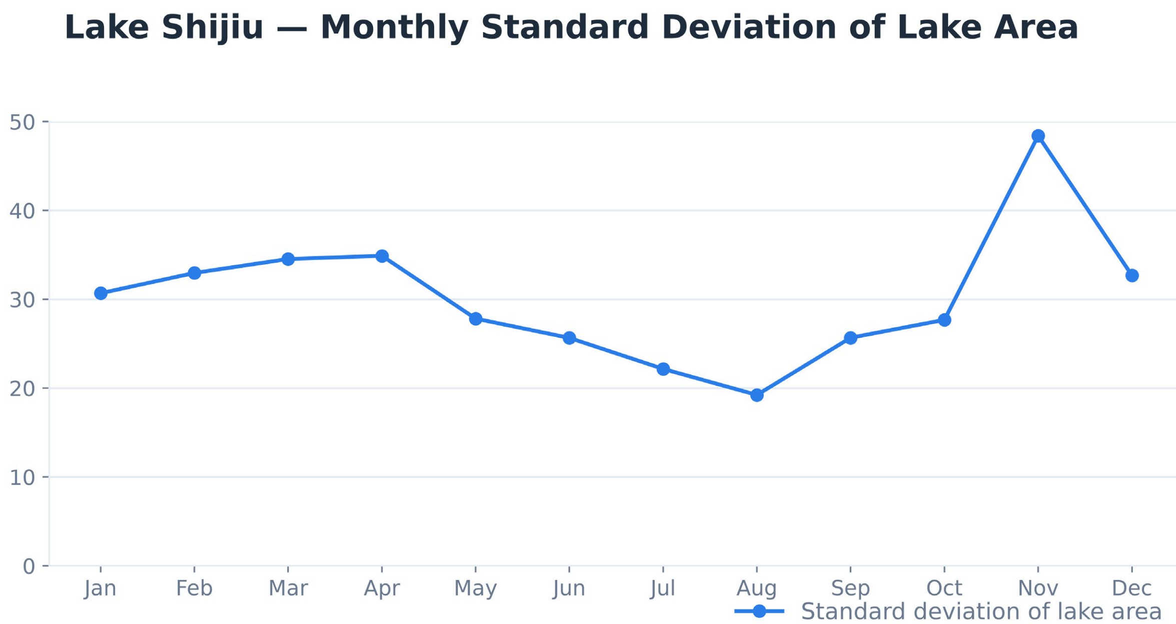


Figure 3. Shijiu Lake—monthly standard deviation of lake area.

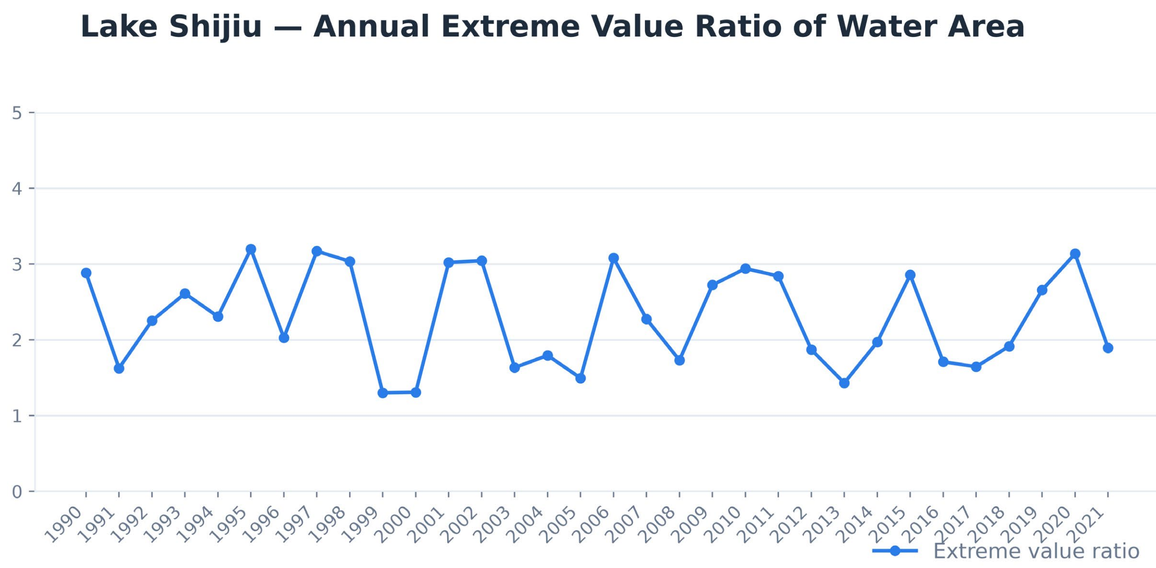


Figure 4. Shijiu Lake—annual extreme value ratio of water area.

4.2. Analysis of Hydrological Drought Characteristics of Shijiu Lake

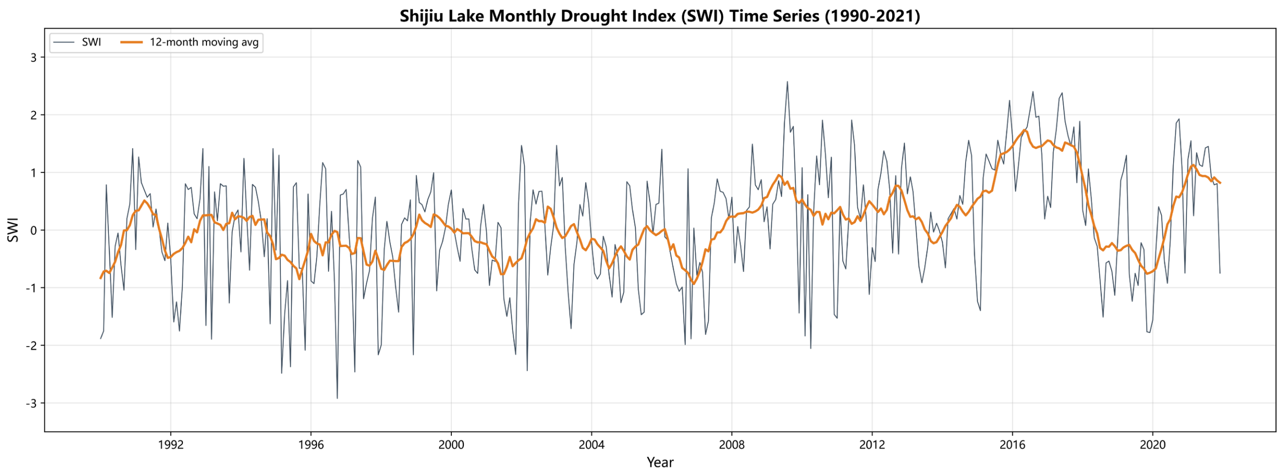


Figure 5. Shijiu Lake monthly drought index (SWI) time series (1990-2021).

Calculation of the water surface area drought index (SWI) for Shijiu Lake during 1990-2021 reveals that drought-prone periods were concentrated in the early 1990s, as well as in 1995, 2001, 2004, and 2018-2019, among which 2001 had as many as 8 drought months. The longest continuous drought occurred from July to December 2018 (spanning late summer to winter and lasting half a year); the most severe event was a two-month consecutive drought in late 1997, with an average SWI as low as −2.08, reaching the extreme drought level (Figure 5). The highest drought frequencies occurred in February, May, and July (34.38%), while the lowest was in October (18.75%). Although the mid-summer period (July-August) exhibits a relatively high mean value, its inter-annual variability is large and droughts may still occur (Figure 6). Seasonal variation analysis shows that the mean SWI in winter and spring is close to 0 and their drought frequencies are the highest, both at 31.25% (Table 1). Therefore, these two seasons constitute the period with the highest hydrological drought risk and warrant particular attention.

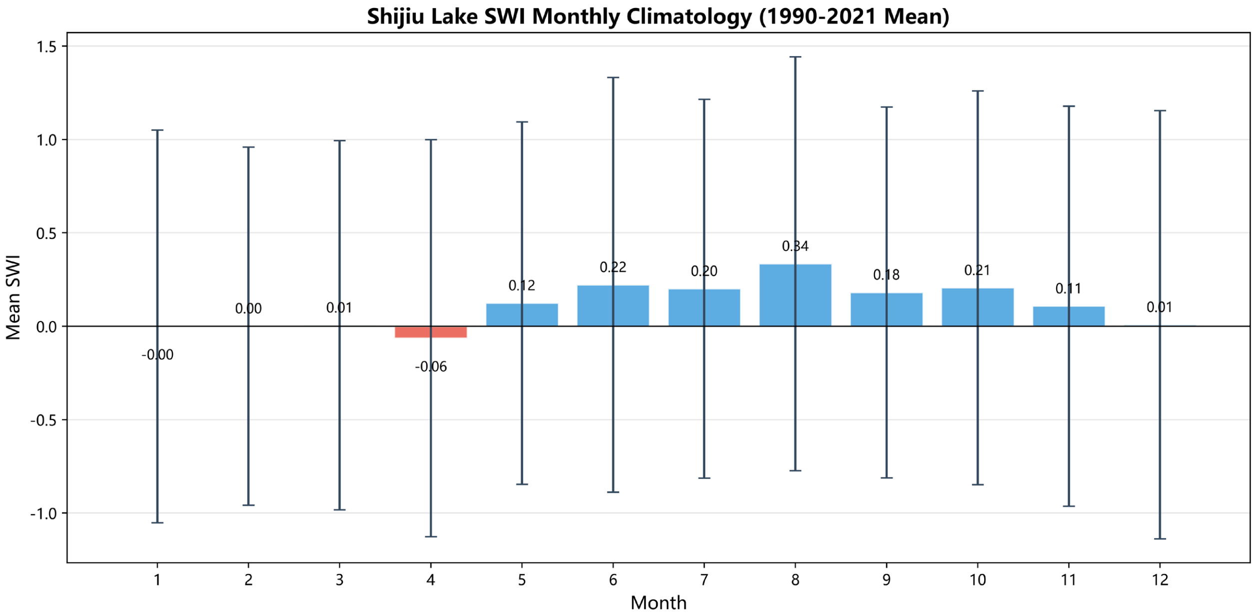


Figure 6. SPI Shijiu Lake SWI monthly climatology (1990-2021).

Table 1. Shijiu Lake SWI seasonal variation.

Season	Mean SWI	Standard Deviation	Drought Months	Drought Frequency
Spring	0.0221	1.0001	30	31.25%
Summer	0.2531	1.0683	27	28.12%
Fall	0.1653	1.0296	23	23.96%
Winter	0.0033	1.0436	30	31.25%

4.3. Analysis of Meteorological Drought Characteristics in the Study Region

Analysis of the four time-scale SPI series (1-month, 3-month, 6-month, and 9-month) at the Gaochun Station (Station ID: 58339) reveals (Figure 7) that 1997 was the most drought-affected year in the medium-to-long term. Three significant drought periods occurred during 1991-1992, 1997, and 2011; in particular, the "successive winter-spring drought" in early 2011 reached an extreme intensity of −2.95 on the SPI-6 scale. Within the 32-year sample, approximately 30% of the months experienced droughts of varying degrees (SPI < −0.5), drought events in Shijiu Lake are dominated by mild drought, with total occurrence ranging from 28.8% (SPI-6) to 32.2% (SPI-9) (Figure 8 and Figure 9). Inter-seasonal differences are relatively small, but the tendency toward long-term winter drought (SPI-9) is the strongest (median = −0.14) (Figure 10).

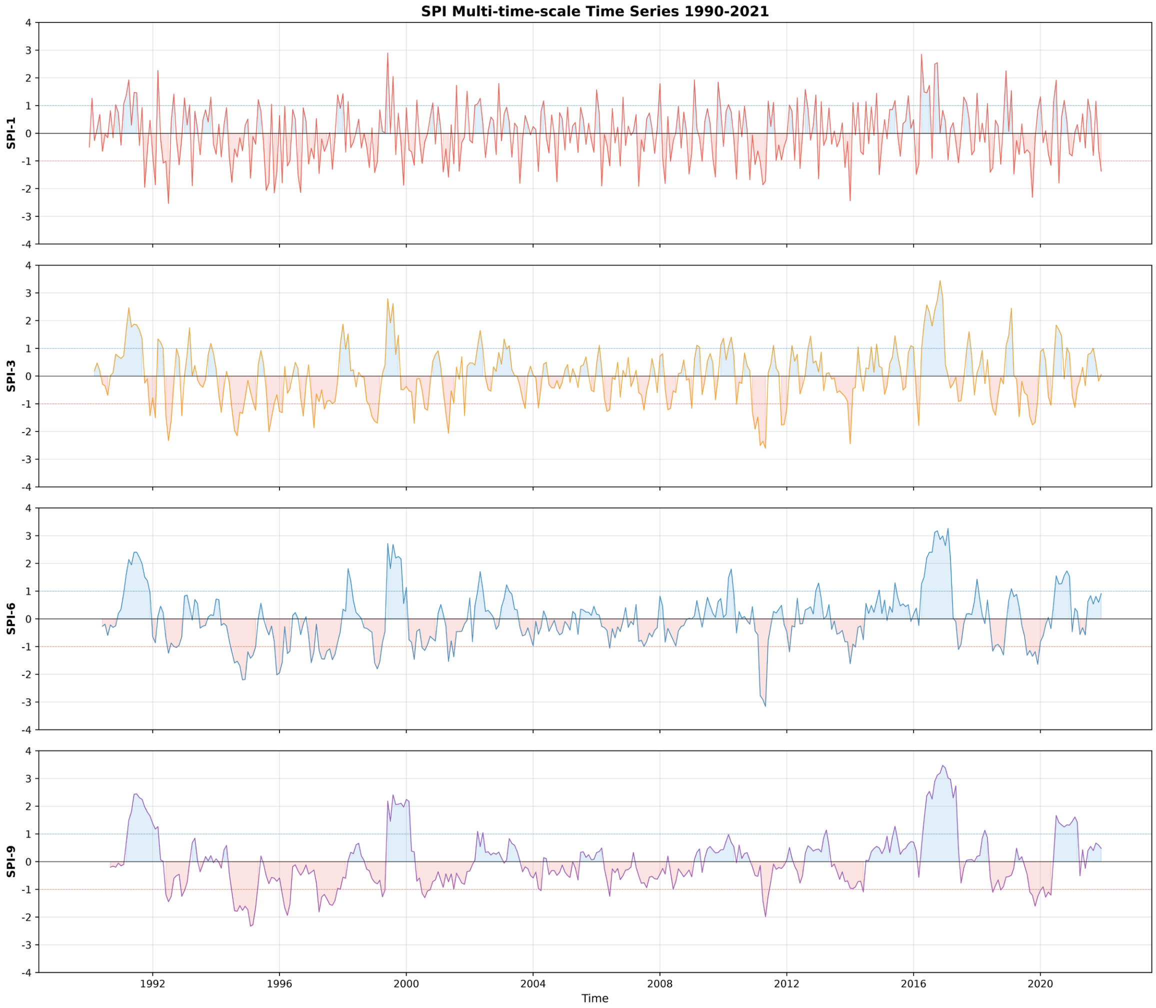


Figure 7. SPI multi-time-scale time series 1990-2021.

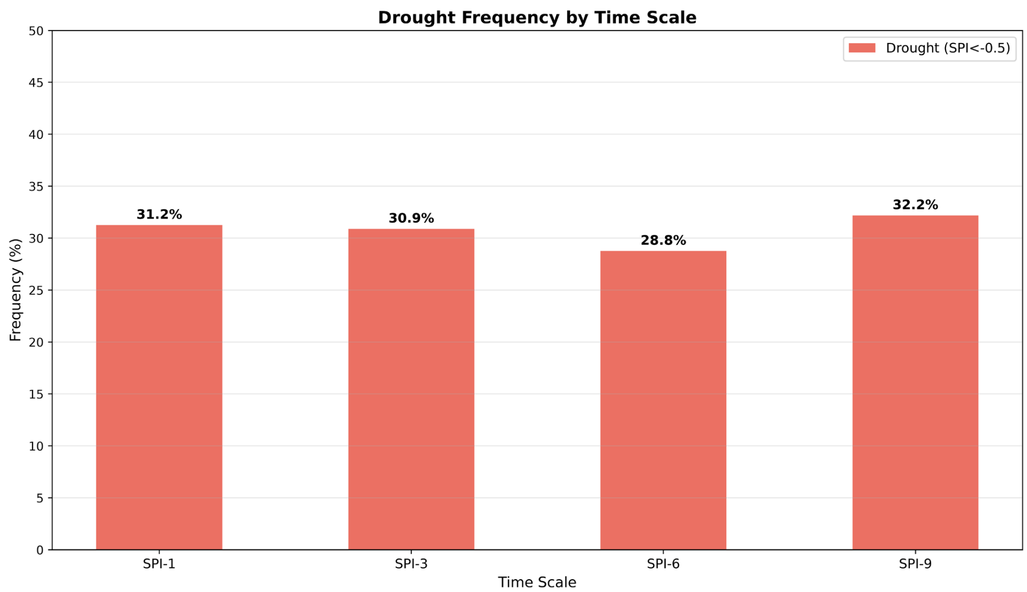


Figure 8. Drought frequency by time scale.

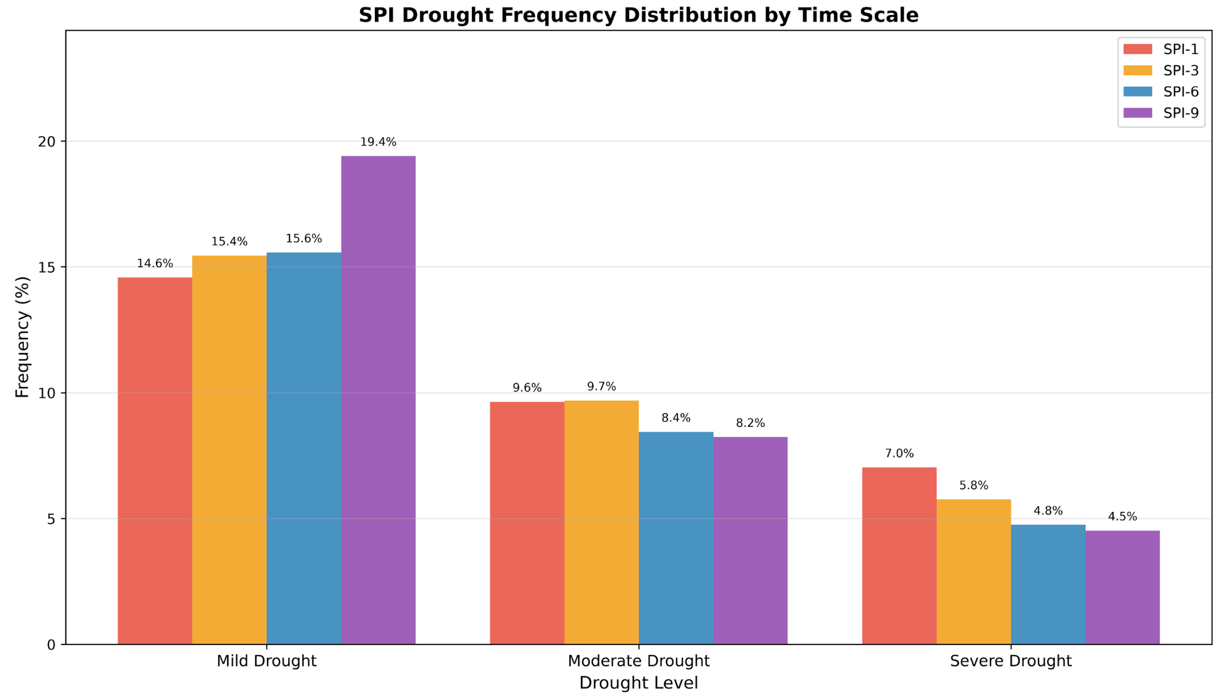


Figure 9. Drought frequency distribution by time scale.

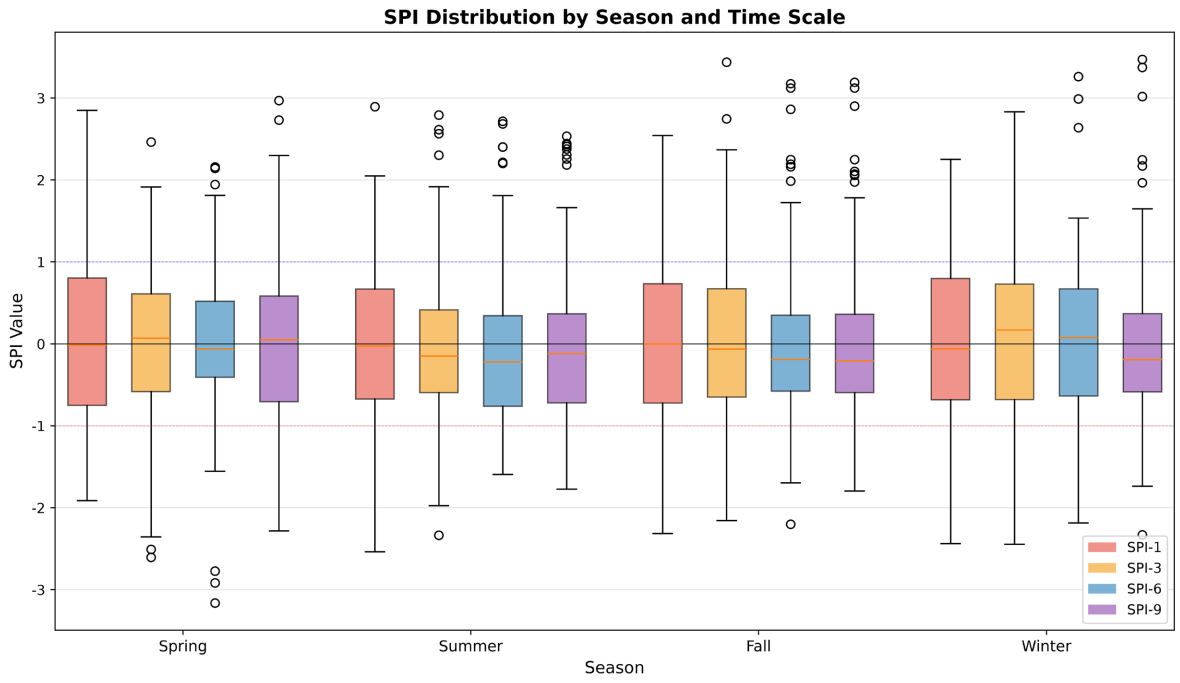


Figure 10. SPI distribution by season and time scale.

4.4. Analysis of the Correspondence between Lake Water Surface Area and Precipitation

Using the measured monthly cumulative rainfall data from the Lishui China National Basic Meteorological Station (Station ID: 58340) and the Gaochun China National Basic Meteorological Station (Station ID: 58339), then lagging the lake water surface area data on a monthly basis (Figures 11(a)-(b)), it was found that a positive correlation exists when the response time ranges from 0 to 4 months, whereas a negative correlation occurs when the response time exceeds 4 months. Furthermore, at a response time of 2 months, the correlation coefficients between the lake water surface area and the precipitation data of both stations reach their maxima, exhibiting a moderate correlation strength. This indicates that the precipitation in the current month exerts the most pronounced promoting effect on the lake water surface area two months later within this region.

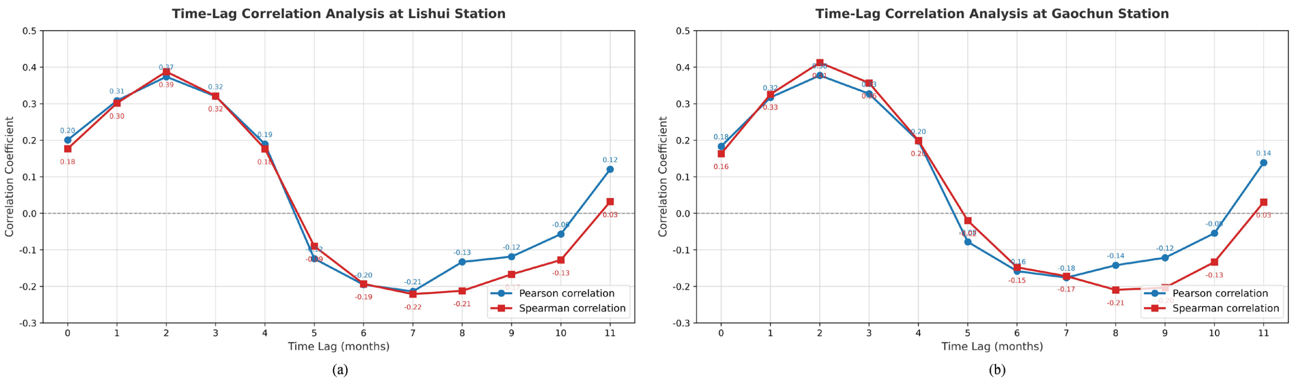


Figure 11. Correlation coefficient of propagation lag between rainfall and Shijiu Lake area.

To distinguish the true lagged response of lake surface area to precipitation from the shared seasonal variation between the two series, we applied a standardized monthly anomaly transformation to both the monthly precipitation and water surface area (SWI) records prior to correlation analysis—i.e., by subtracting the climatological mean of each calendar month and dividing by the corresponding monthly standard deviation—and evaluated statistical significance using the effective-sample-size approach of Pyper and Peterman (1998), which accounts for serial autocorrelation (effective sample size N_eff ≈ 360 - 378; the 95% significance threshold was approximately ±0.10). The results show that after removing the seasonal cycle, both stations exhibit a significant positive lagged response of lake surface area to precipitation. At Lishui station (58340), the response is significant at $p < 0.01$, while at Gaochun station (58339), the strongest response occurs at a lag of 1 month ($p = 0.001$). Taken together, the optimal lag time for meteorological-to-hydrological drought propagation is approximately 1 - 2 months, and the statistical significance of the lagged correlations after deseasonalization confirms that this response is not a spurious correlation driven by shared seasonal variation.

4.5. Analysis of the Propagation Patterns of Meteorological-Hydrological Drought

Using the monthly precipitation data of the Lishui China National Basic Meteorological Station (Station ID: 58340) and the Gaochun China National Basic Meteorological Station (Station ID: 58339), the SPI values at different time scales (1, 3, 6, and 9 months) were calculated. Based on the SPI values, meteorological drought was classified into mild drought (−1.0 < SPI < −0.5), moderate drought (−1.5 < SPI < −1.0), and severe drought (SPI < −1.5). Meanwhile, given that the influence of precipitation on the lake water surface area exhibits a weak-to-moderate positive correlation within a lag of 1 - 3 months in this region, the meteorological-hydrological drought events occurring within the region were defined according to the following criteria (Kwon et al., 2019).

1) The onset of a hydrological drought event cannot precede that of its corresponding meteorological drought event. 2) A hydrological drought event cannot occur more than n = 3 months after the end of the meteorological drought. 3) A hydrological drought event is triggered when SWI ≤ −0.5 and terminated when SWI > −0.5, and each event can be triggered only once. 4) The propagation time is computed only from the first hydrological drought event falling within the meteorological drought's duration.

Based on this analysis (**Figure 12**): 1) The average propagation time from various types of meteorological drought events to hydrological drought is 1.56 months; 2) Based on the average of the two stations, when moderate meteorological drought occurs, the probability of hydrological drought occurrence is the highest, yet the propagation time is the longest, at 1.65 months; whereas when severe meteorological drought occurs, the propagation time is the shortest, at 1.45 months. 3) At both stations, it is clearly evident that when the SPI time scale is 9 months and the meteorological drought intensity is moderate or above, the probability of hydrological drought occurrence is the highest.

Figure 12. Statistical characteristics of meteorological-hydrological drought propagation.

5. Conclusion

Based on the monthly water surface area data of Shijiu Lake during 1990-2021 extracted from the Global Surface Water Mapping Layers V1.4 product (hereafter referred to as GSWE), and the comparative analysis with the monthly precipitation data of the Lishui China National Basic Meteorological Station (Station ID: 58340) and the Gaochun China National Basic Meteorological Station (Station ID: 58339), this study reveals the correlation between hydrological drought and meteorological drought in the Shijiu Lake area and draws the following conclusions:

1) The frequencies of both hydrological drought and meteorological drought

are the highest in winter and spring within the Shijiu Lake region;

2) The direct influence of reduced precipitation on the lake water surface area in the study region lasts approximately 3 months, being most pronounced at around 2 months. Therefore, when continuously low precipitation occurs in the region for more than or equal to 2 months, special attention should be paid to the changes in the water surface area of Shijiu Lake, and timely warning information can be issued;

3) The average propagation time of meteorological-hydrological drought in this region is 1.6 months. When moderate or more severe meteorological drought ($SPI < -1.0$) at the 9-month SPI time scale is predicted to occur in the region, attention should be paid to the possible occurrence of hydrological drought and relevant water resource allocation should be planned in advance.

The remote-sensing-retrieved water surface area data of Shijiu Lake obtained in this study reflect the variation patterns of the lake water surface area and can effectively identify hydrological drought events. Combined with the meteorological drought indices derived from the measured monthly precipitation data of the Lishui China National Basic Meteorological Station (Station ID: 58340) and the Gaochun China National Basic Meteorological Station (Station ID: 58339), this study objectively reveals the propagation patterns of meteorological-hydrological drought in the Shijiu Lake region, providing important scientific reference and relevant data support for agricultural production, water resource allocation, and disaster prevention and mitigation in the region. In the future, precipitation data from the Anhui region upstream of Shijiu Lake will also be incorporated to further analyze the occurrence and propagation mechanisms, scale effects, and influencing factors of drought in the Shijiu Lake area.

Author Contributions

Shanshan Chen designed the research methodology, performed the GEE-based lake water extraction for Lake Shijiu, conducted the results analysis, produced all figures, and wrote the original draft. Jing Li and Yu Yang organized and processed the SPI datasets. Kai Wang, Chenkai Tang and Feiran Luo collected the relevant reference materials and compiled the DWI datasets. All authors read and approved the submitted manuscript.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Kwon, M., Kwon, H., & Han, D. (2019). Spatio-Temporal Drought Patterns of Multiple Drought Indices Based on Precipitation and Soil Moisture: A Case Study in South Korea. *International Journal of Climatology, 39,* 4669-4687. https://doi.org/10.1002/joc.6094

Lai, P., Zhang, M., Ge, Z., Hao, B., Song, Z., Huang, J. et al. (2020). Responses of Seasonal Indicators to Extreme Droughts in Southwest China. *Remote Sensing, 12,* Article 818.

https://doi.org/10.3390/rs12050818

Li, L. Q., Long, D., Wang, Y. M., & Woolway, R. I. (2025a). Global Dominance of Seasonality in Shaping Lake-Surface-Extent Dynamics. *Nature, 642,* 361-368. https://doi.org/10.1038/s41586-025-09046-3

Li, Y., Miao, D. H., & Guo, L. J. (2025b). Practice and Discussion on Emergency Water Supply for Drought Relief from the Qinhuai River to Shijiu Lake Area in Nanjing City. *China Flood & Drought Management, 35,* 72-76. (In Chinese)

McKee, T. B., Doesken, N. J., & Kleist, J. (1993) The Relationship of Drought Frequency and Duration to Time Scales. In *Proceedings of the 8th Conference on Applied Climatology* (pp. 179-183). American Meteorological Society.

Nalbantis, I., & Tsakiris, G. (2009). Assessment of Hydrological Drought Revisited. *Water Resources Management, 23,* 881-897. https://doi.org/10.1007/s11269-008-9305-1

Pekel, J. F., Cottam, A., Gorelick, N., & Belward, A. S. (2016). High-Resolution Mapping of Global Surface Water and Its Long-Term Changes. *Nature, 540,* 418-422. https://doi.org/10.1038/nature20584

Pyper, B. J., & Peterman, R. M. (1998). Comparison of Methods to Account for Autocorrelation in Correlation Analyses of Fish Data. *Canadian Journal of Fisheries and Aquatic Sciences, 55,* 2127-2140. https://doi.org/10.1139/f98-104

Qi, Z. S., Yao, S. M., Liu, X. G., Ding, B., Wang, H., Jiang, Y. et al. (2025). Monitoring River-Lake Dynamics in the Mid-Lower Reaches of the Yangtze River Using Sentinel-2 Imagery and X-Means Clustering. *Remote Sensing, 17,* Article 3421. https://doi.org/10.3390/rs17203421

Van Loon, A. F., & Laaha, G. (2015) Hydrological Drought Severity Explained by Climate and Catchment Characteristics. *Journal of Hydrology, 526,* 3-14. https://doi.org/10.1016/j.jhydrol.2014.10.059

World Meteorological Organization (WMO) (2012). *Standardized Precipitation Index User Guide.* World Meteorological Organization.

Xiong, X. Q., Zhou, J., Guo, D. L. et al. (2025). Analysis of the Response Relationship between Hydro-Logical Drought and Meteorological Drought from the Perspective of Dynamic Surface Water Area Based on Satellite Observations. *Journal of Remote Sensing, 29,* 958-975. (In Chinese)

Ye, X. C., Yue, E. X., Li, X. H. et al. (2025). Quantification and Variation of Hydrological Drought in the Poyang Lake Based on the Constructed Inundation Area Dataset. *Advances in Water Science, 36,* 320-331. (In Chinese)

Yu, Z. H., Liu, H. B., & Zhang, Z. (2010). Eco-Environmental Driving Factors Analysis and Countermeasures in Jiangsu Section of Shijiu Lake Basin. *Water Resources Protection, 26,* 70-74. (In Chinese)

Yuan, Y., Shang, M. S., Wang, D., Li, G., Liu, M., Wu, L. et al. (2025). Landsat Observations Reveal Lake Poyang Shrinkage over the Past 30 Years: Possible Association with Local Climate Change and Upstream Dam Construction. *Journal of Hydrology: Regional Studies, 62,* Article ID: 102785. https://doi.org/10.1016/j.ejrh.2025.102785

Zheng, S. Q., Chen, Y. Y., Wu, Y. H. et al. (2025). Characterizing Drought and Meteorological-Hydrological Propagation in Poyang Lake Using Satellite-Observed Water Extent. *Journal of Geo-Information Science, 27,* 1011-1023. (In Chinese)