A.D. 1308 unipg
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Assessment of factors controlling the runoff coefficient in the Mediterranean context: a case study in central Italy

Arash Rahi (1) , Mehdi Rahmati (2,3), Jacopo Dari (1,4), Carla Saltalippi (1) and Renato Morbidelli (1)

1. Introduction & aims

Global warming is affecting hydroclimatic parameters determining changes in temperature and precipitation patterns. In addition, human-induced activities act on the land use and land cover (LULC) features of catchments.

Runoff generation can be affected by changing hydroclimatic and LULC parameters. Runoff coefficient (Rc) is frequently used in hydrologic designs as a key input parameter and diagnostic variable to reflect runoff generation in a catchment and it is also useful to understand runoff dynamics and available streamflow.

The **aim** of this study is to investigate the relationship between the Rc, computed by exploiting long-term rainfall and streamflow records, and several features that can potentially affect it, namely meteorological parameters and LULC changes.

For this purpose:

1) The wavelet coherence analysis (WCA) is utilized to evaluate the coherency and phase shift between Rc and Temperature (T), Precipitation (P) and LULC changes.

2) To better understand the catchment condition, a trend analysis has been performed using the Mann-Kendall (MK) test.

2. Study area

Analysis has been done over the **Upper Tiber basin at Ponte Nuovo outlet** that underlies an area of 4,147 km^2 with an average altitude of 523 m asl.

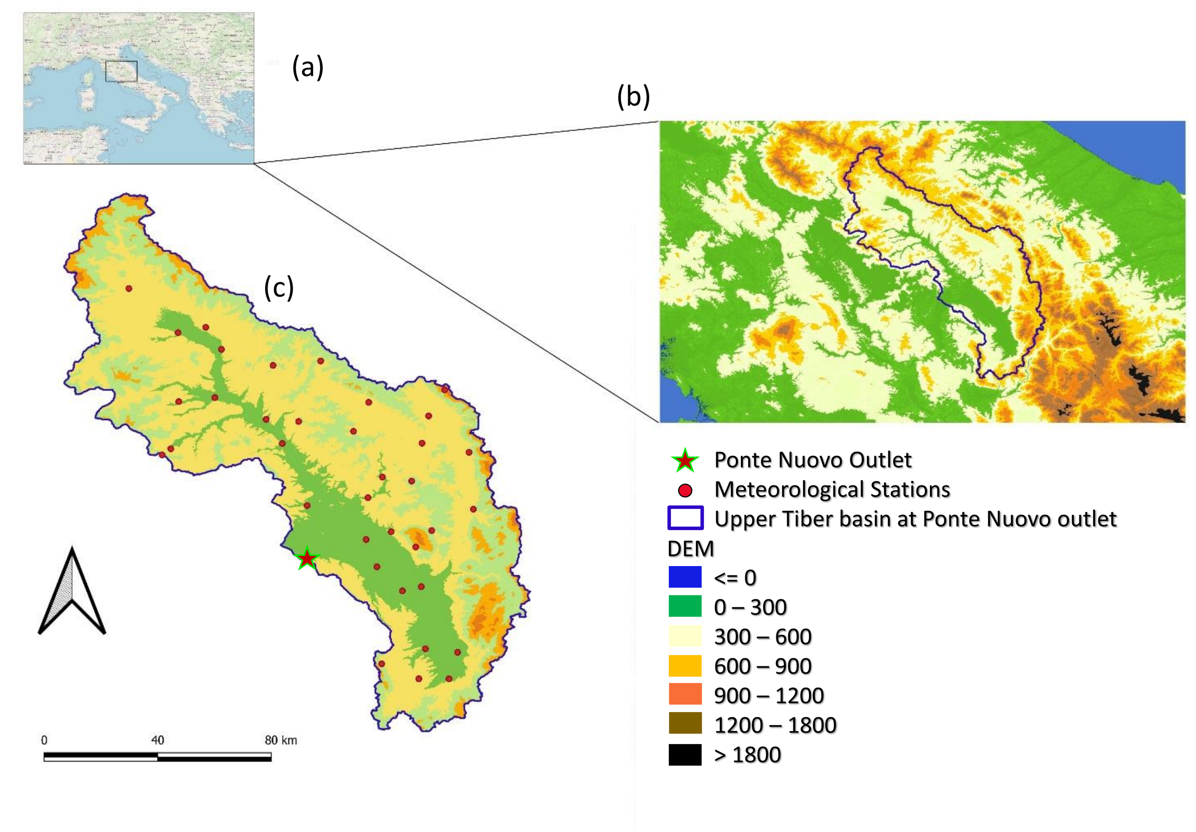

Fig. 1: (a) The Upper Tiber basin at Ponte Nuovo outlet in Umbria (central Italy) (b) DEM map (c) Location of the outlet and 36 hydro-meteorological stations ●.

3. Data

1_ P, Runoff and Rc

- **P** depths during the period 1927-2020, was collected from 36 hydro-meteorological stations (in-situ data)●.

To define the monthly **P** inside the basin during 1927-2020, Thiessen polygons method was used

- The **Runoff** data observed in the closing section of **basin outlet** ★ is in-situ data.
- The **Rc** represents the ratio between the height of runoff and P → $Rc = \frac{Runoff}{P}$

1927.. 1978 | Missing data rate pertaining to **runoff** and **Rc** during 1979-1989 | 1990 2020

2_ SWS and LULC chance

- The average monthly data of **SWS** during 1950-2020 → Copernicus ERA5-Land service (Muñoz-Sabater et al., 2021) The resolution ~ 9 kilometers
- Annual **LULC** data from 1992 to 2020 → Climate Change Initiative (CCI) of the European Space Agency (ESA) Spatial resolution ~ 300 m

4. Methodology

- Trend analyses of the seasonal time series were determined using the MK test as nonparametric method at the confidence levels of 95%.
- To determine distribution of the correlation between two signals, the continuous WCA was applied between Rc and other examined variables (i.e., T, SWS and LULC changes). Rc is considered as first signal and the coherence of the second signal is analyzed in accordance with first signal to assess the significance of coherence in different periodicities. Fig. 2 shows the graphical concept of wavelet analysis. Phase shift, lag and correlation of signals is shown in Fig.3.

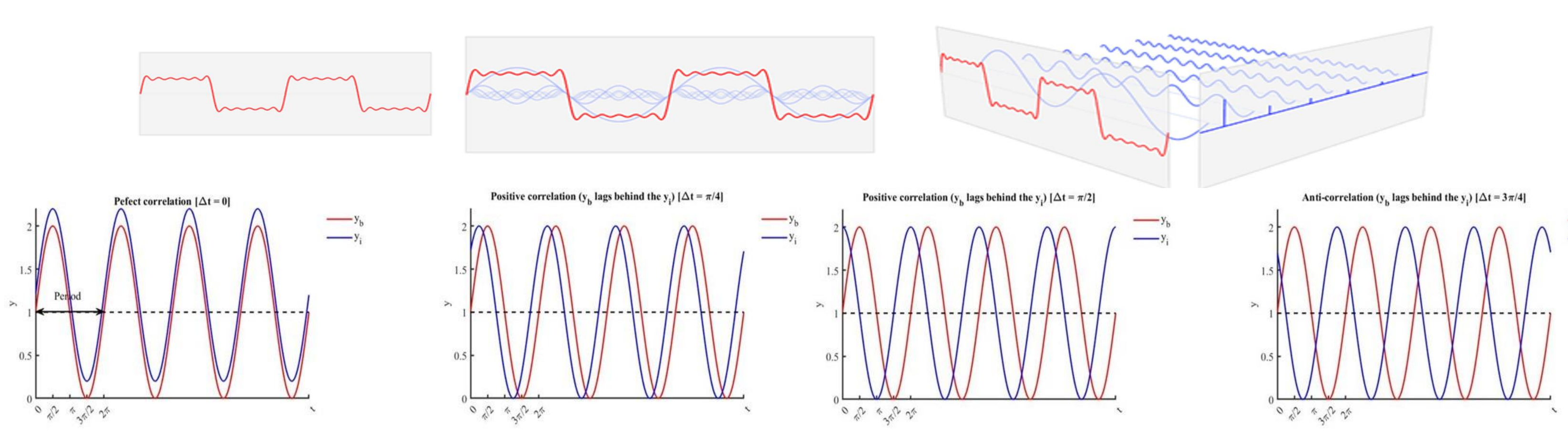

Fig.2 (a) Spectral decomposition of signal (timeseries) with different periodicity (b) Timeseries and lag definition

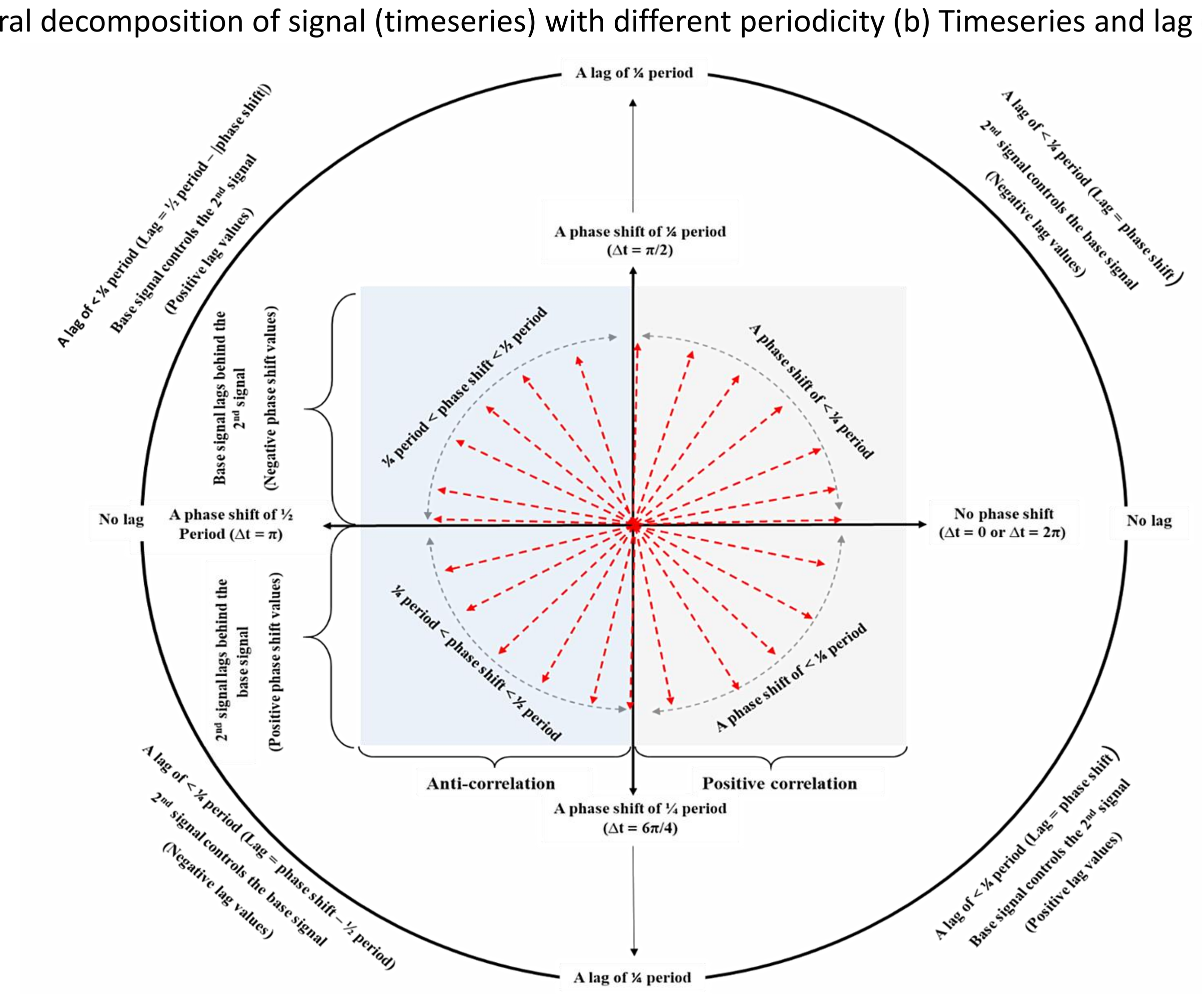

Fig.3 Phase shift, lag, correlations, and arrow directions on wavelet map between base signal and second signal

5. Results

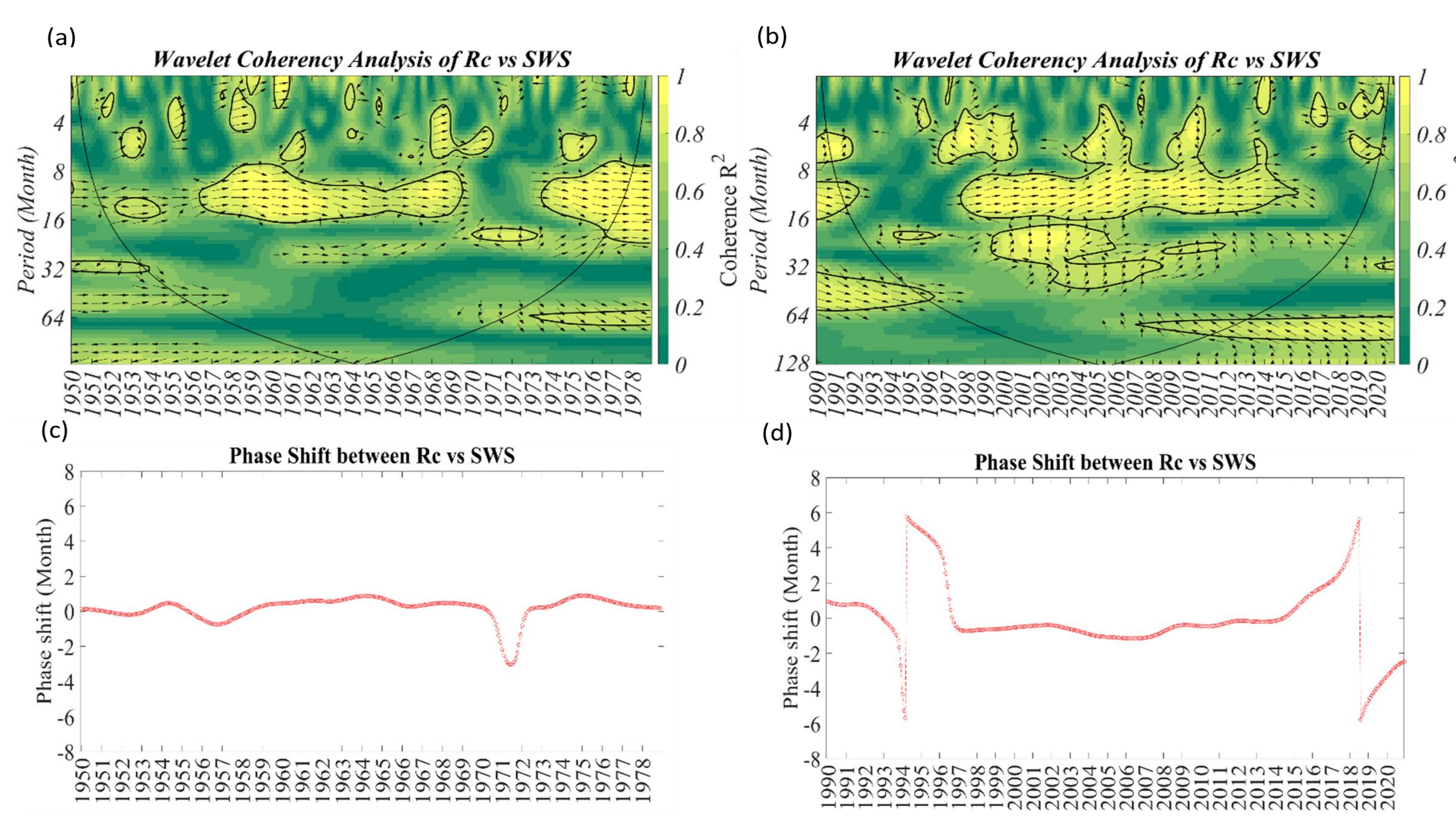

Fig. 4: WCA between Rc and average SWS in the Upper Tiber at Ponte Nuovo outlet (a) 1950-1978 (b) 1990-2020, phase shift during the period of yearly cycle (c) 1950-1978 and (d) 1990-2020.

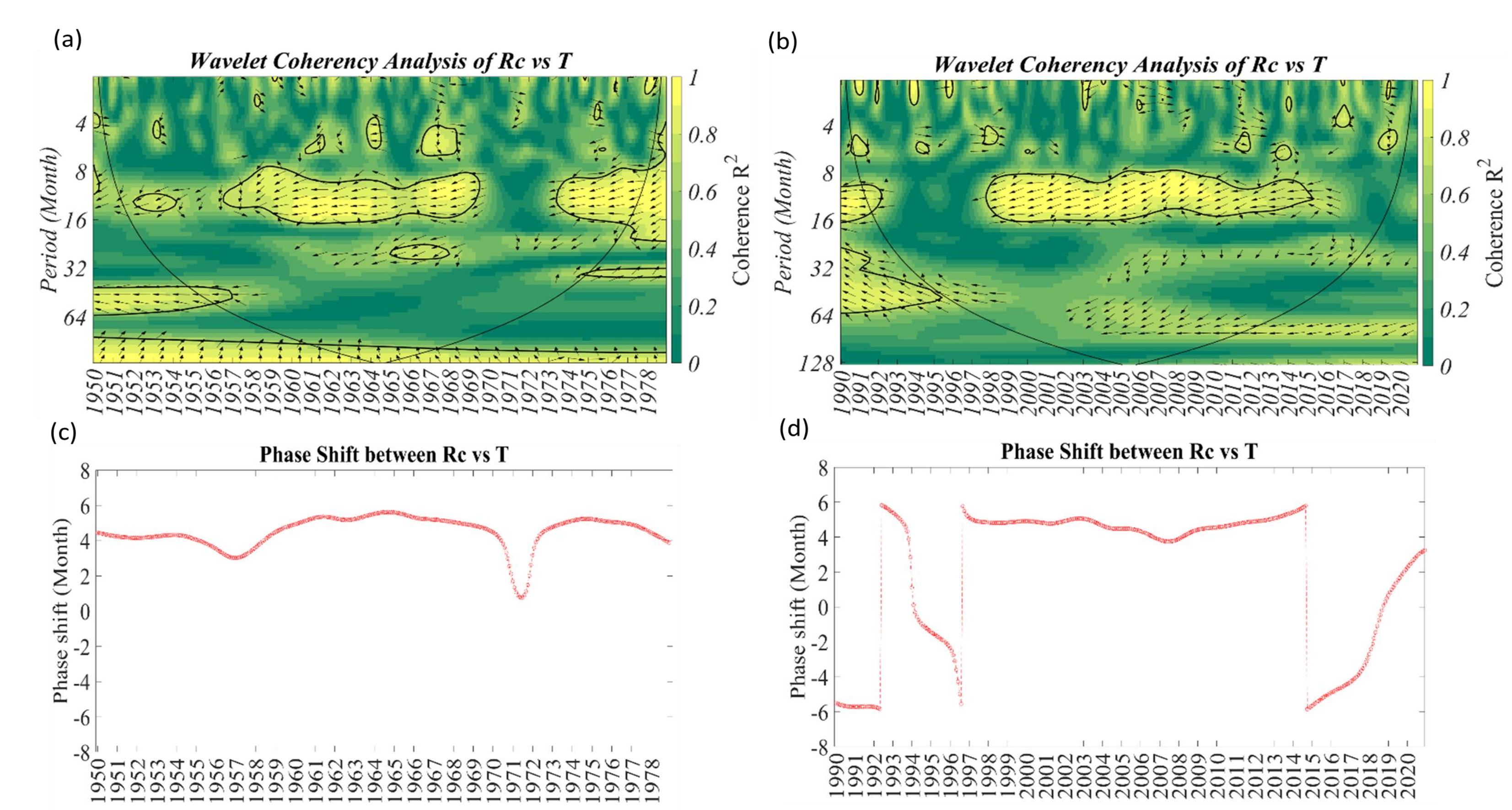

Fig. 5: WCA between Rc and average T in the Upper Tiber at Ponte Nuovo outlet (a) 1950-1978 (b) 1990-2020, phase shift during the period of yearly cycle (c) 1950-1978 and (d) 1990-2020.

- Seasonal Rc and runoff from 1927-2020 show statistically significant declining trends, while SWS displays decreasing trends from 1950 to 2020, except for autumn. Conversely, seasonal T shows significant increasing trends for all seasons from 1950 to 2020, except for winter.
- From 1950 to 1978 and from 1990 to 2020, a strong yearly cycle coherence between Rc and SWS is observed in the study area, as shown in Fig. 4a & b. The arrows' direction is right-aligned and nearly identical, indicating a positive correlation between Rc and SWS during the annual cycle, with either no phase shift or a shift lower than a quarter of the yearly cycle, as represented by the right-aligned horizontal arrows in Fig. 4c & d.
- From 1957 to 1970, a high correlation was observed between Rc and T, while anti-correlation was found in the study area as indicated by identical left-aligned arrows (Fig. 5a). At the yearly cycle from 1998 to 2017, strong coherence was observed between Rc and T, with anti-correlation shown by horizontal left-aligned arrows (Fig. 5b). Furthermore, a phase shift ranging from a quarter to a half of cycle, equivalent to 3-6 months, was observed between Rc and T, represented by left-aligned and almost downward arrows (Fig. 5c & d).
- WCA between Rc and LULC changes showed a weak correlation between agricultural and natural changes and Rc whereas no correlation was found for Ur LULC changes.

6. Conclusions

- ✓ MK test of long-term seasonal Rc from 1927-2020 reveals a decreasing trend for all the seasons.
- ✓ There is a strong positive correlation between Rc and SWS at both investigated periods (1950-1978 and 1990-2020) during the yearly cycle with a phase shift of less than 1 month.
- ✓ A substantial negative correlation occurred between Rc and T at both investigated periods (1950-1978 and 1990-2020) in yearly circle, with a phase shift of 3-6 months.
- ✓ WCA between Rc and LULC changes showed a weak correlation between agricultural and natural changes and Rc whereas no correlation was found for Ur LULC changes (results referring to LULC are not shown here).

Main Finding: It is clear that Rc is more affected by hydrological and climatic variables than LULC changes in the investigated area. WCA analysis highlighted SWS recognized as a key parameter can affect the Rc with less phase shift in a faster interaction.

HS2.1.1 *- Changes in the Mediterranean hydrology: observation and modeling*
EGU23-6661
Contact: arash.rahi@studenti.unipg.it

(1) Dept. of Civil and Environmental Engineering, University of Perugia, Perugia, Italy
(2) Department of Soil Science and Engineering, Faculty of Agriculture, University of Maragheh, Iran
(3) Institute of Bio and Geosciences (IBG), Forschungszentrum Jülich, Jülich, Germany
(4) National Research Council, Research Institute for Geo-Hydrological Protection, Perugia, Italy

References:
Merz, R., Blöschl, G., & Parajka, J., 2006. Spatio-temporal variability of event runoff coefficients. Journal of Hydrology, 331(3–4), 591–604.
Zhang, Z., Chen, X., Huang, Y., & Zhang, Y., 2014. Effect of catchment properties on runoff coefficient in a karst area of southwest China. Hydrological Processes, 28(11), 3691–3702.
Muñoz-Sabater, J., Dutra, E., Agustí-Panareda, A. et al., 2021. ERA5-Land: A state-of-the-art global reanalysis dataset for land applications, Earth Syst. Sci. Data, 13, 4349-4383.