Comenius University Bratislava, Slovak Republic
Faculty of Mathematics, Physics and Informatics
Damborská Ingrid
e-mail: damborska@fmph.uniba.sk
http://www.dmc.fmph.uniba.sk

EVAPOTRANSPIRATION AND CLIMATIC IRRIGATION INDEX IN SLOVAKIA IN 1951–2021

The changes in air temperature and precipitation in Slovakia, mainly in the first two decades of the 21st century, influence evapotranspiration (E), which is integral to meteorological, hydrological, and biological processes. Evapotranspiration shapes climate variability, trends, and extremes and connects the land with the atmosphere. The evapotranspiration depends only on external meteorological factors, which means it equals the potential evapotranspiration E_0 (maximum possible evapotranspiration in the given meteorological conditions at a sufficiently irrigated surface layer of the soil) with sufficient water content in the soil and with snow cover in winter. At soil moisture lower than its critical value, evapotranspiration decreases proportionally with the decrease in soil moisture. Using potential evapotranspiration, the climatic irrigation index K can be determined for analyzing irrigation conditions and drought risk. This index reflects the relationship between the amount of water that can potentially evaporate from sufficiently humidified soil and vegetation and the precipitation received.

We focused on the spatial and time distribution of evapotranspiration in 1951–2021 calculated by modified Budyko-Tomlain method for selected meteorological stations SHMI, which characterize the development throughout Slovakia. This method comes from a joint solution of the energy and water balance equations of the soil surface and the experimentally determined dependence of the evapotranspiration intensity on soil moisture. The input data were air temperature and humidity, cloudiness, number of days with snow cover, and precipitation. The climatic indicator of irrigation, which shows the water's necessity to cover maximum evapotranspiration demands, was evaluated from 1951 to 2021 as $K = E_0 - P$ (differences between potential evapotranspiration and precipitation total for the same season). It is a climatological index used for regionalization of the climate in terms of humidification.

The results confirmed an increase in potential evapotranspiration (E_0) from 1951 to 2021. The annual sums of E_0 calculated by the Budyko-Tomlain method indicate that an increase in potential evapotranspiration can be seen much more in the south than in the north of Slovakia. This increase is caused mainly by global warming impacts (temperature rise) and partly by decreased relative humidity, especially in the south. Potential evapotranspiration increased at all stations from 1991 to 2020 compared to 1961 to 1990 and 1981 to 2010.

Actual evapotranspiration (E), which depends on soil moisture, mainly showed a decrease in the observed period. However, there is a significant increase in the mountains where potential evapotranspiration increased, and there is also enough precipitation to evaporate.

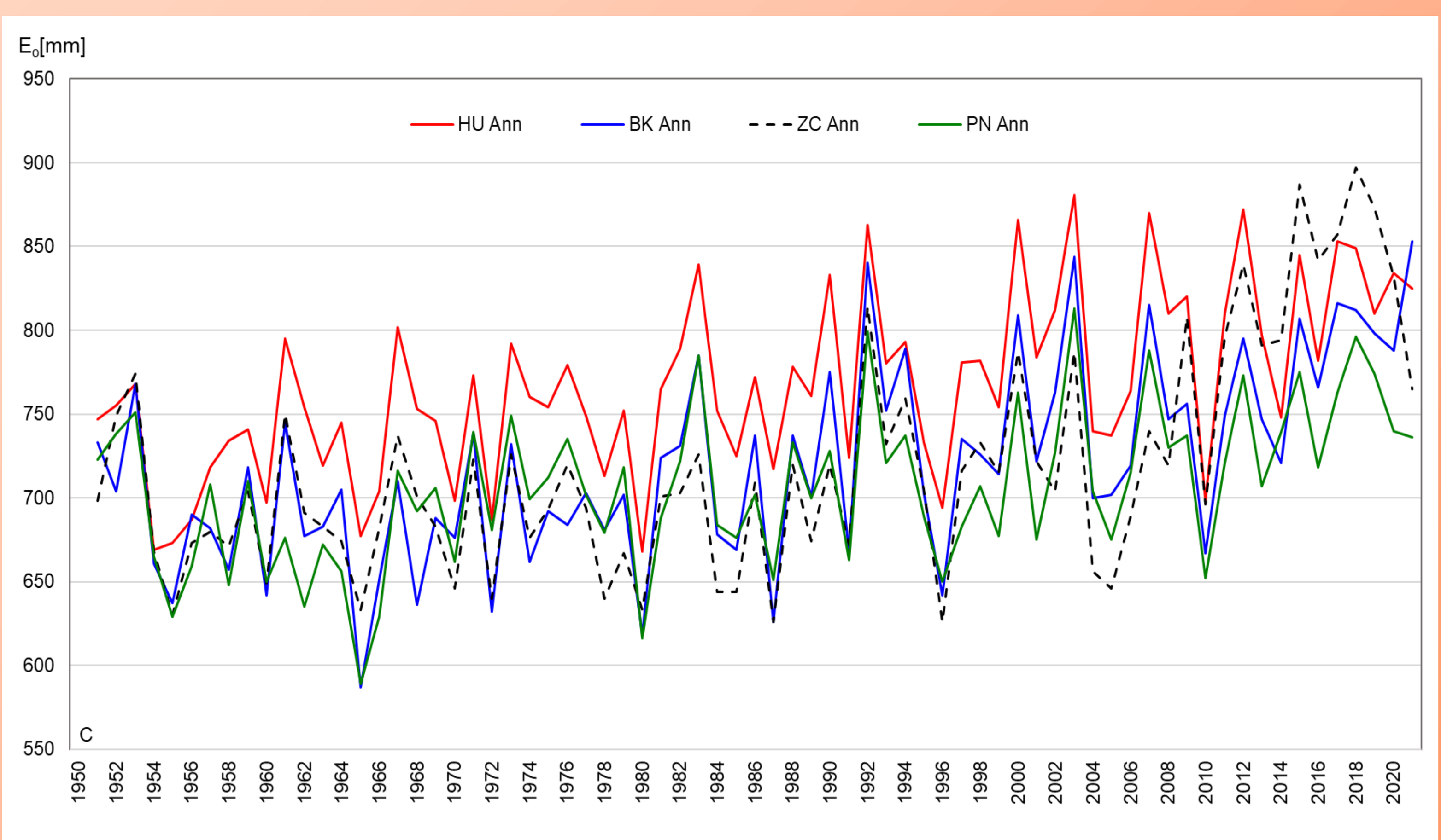

Fig. 1. Annual sums of potential evapotranspiration calculated by Budyko-Tomlain method for stations in SW Slovakia (Hurbanovo (HU), Bratislava-Koliba (BK), Ziharec (ZC), Piestany (PN)) in 1951–2021.

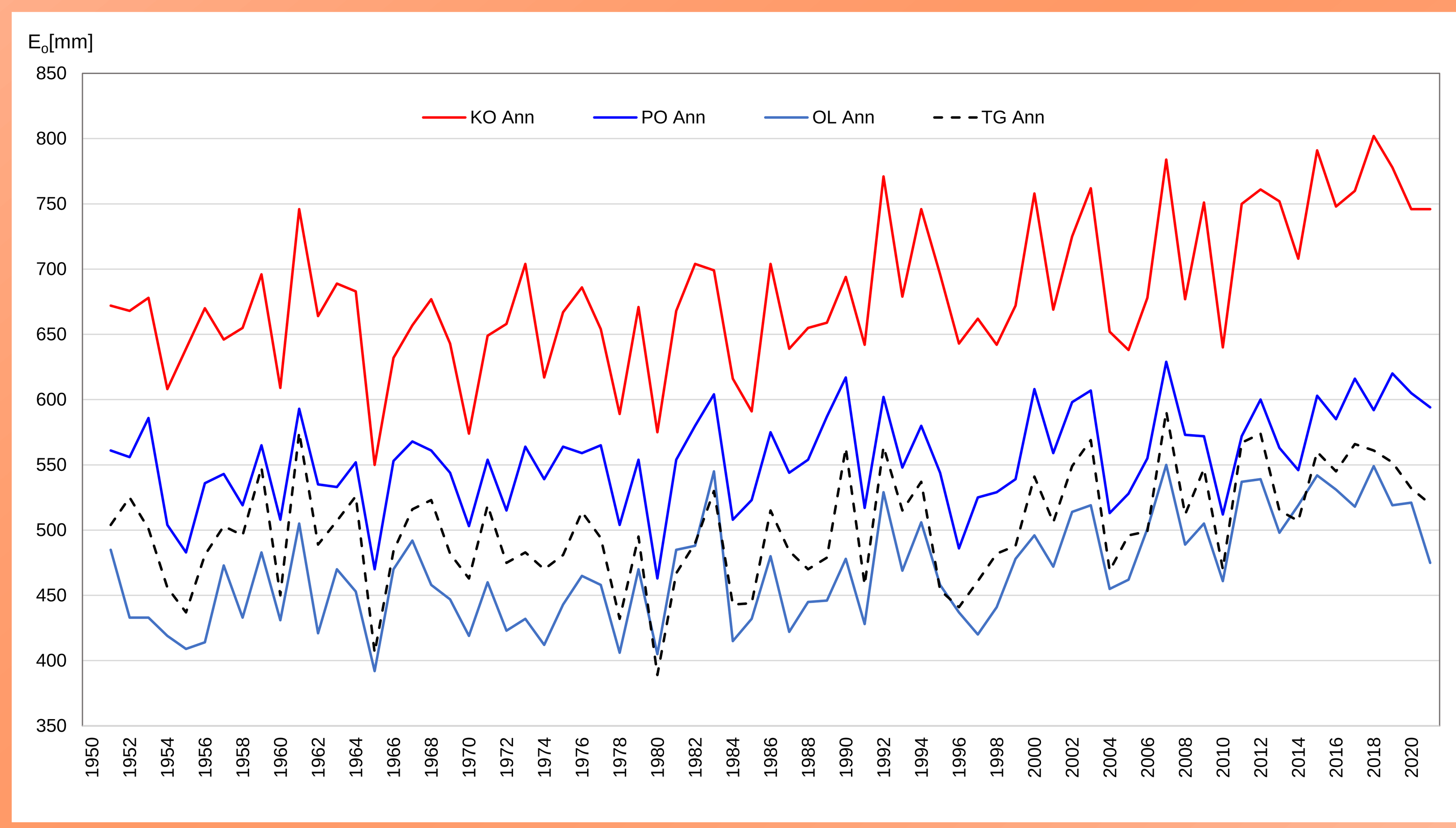

Fig. 2. Annual sums of potential evapotranspiration calculated by Budyko-Tomlain method for stations in SE, N and C Slovakia (Kosice (KO), Poprad (PO), Oravska Lesna (OL), Telgart (TG)) in 1951–2021.

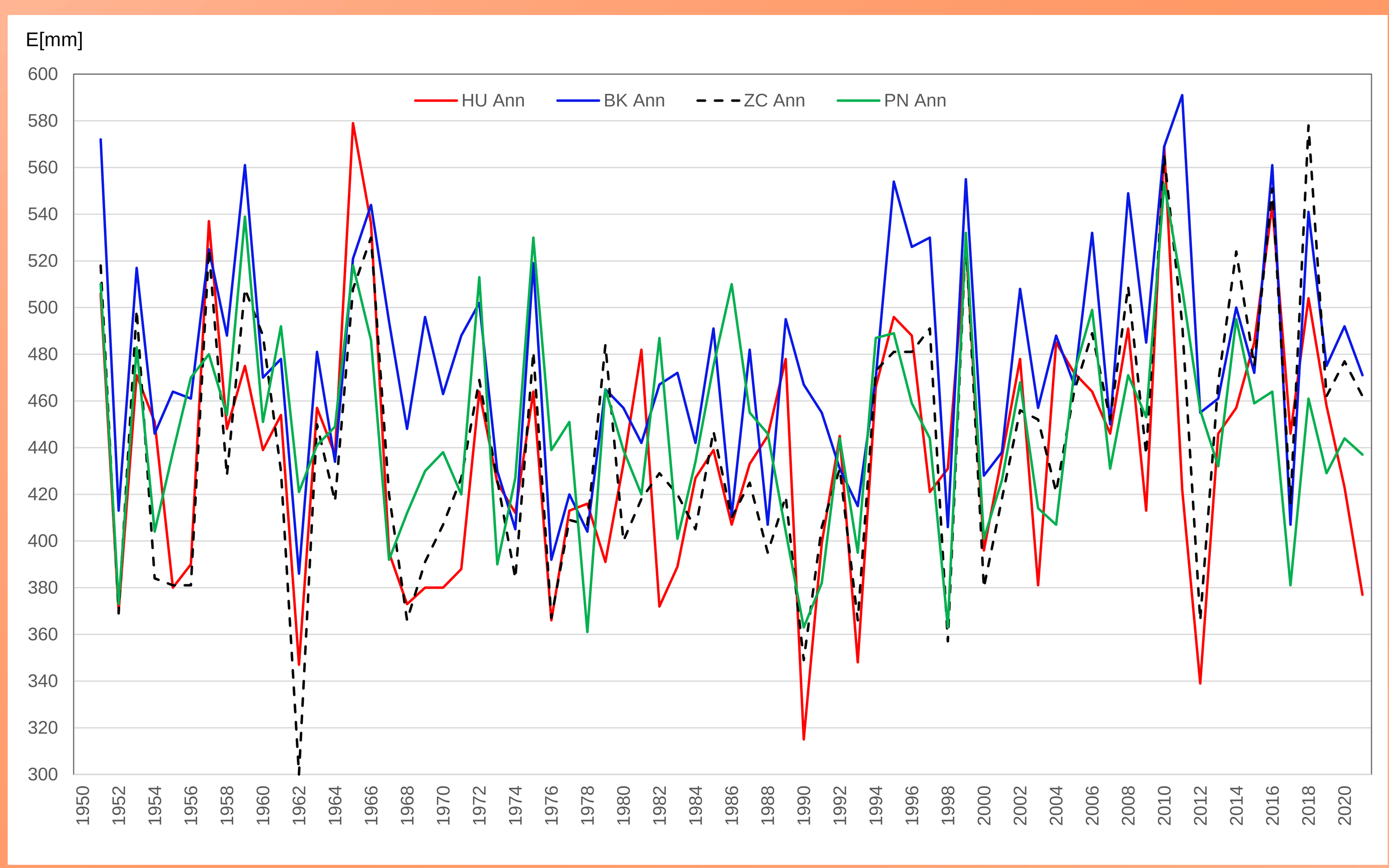

Fig. 3. Annual sums of actual evapotranspiration calculated by Budyko-Tomlain method for stations in SW Slovakia (Hurbanovo (HU), Bratislava-Koliba (BK), Ziharec (ZC), Piestany (PN)) in 1951–2021.

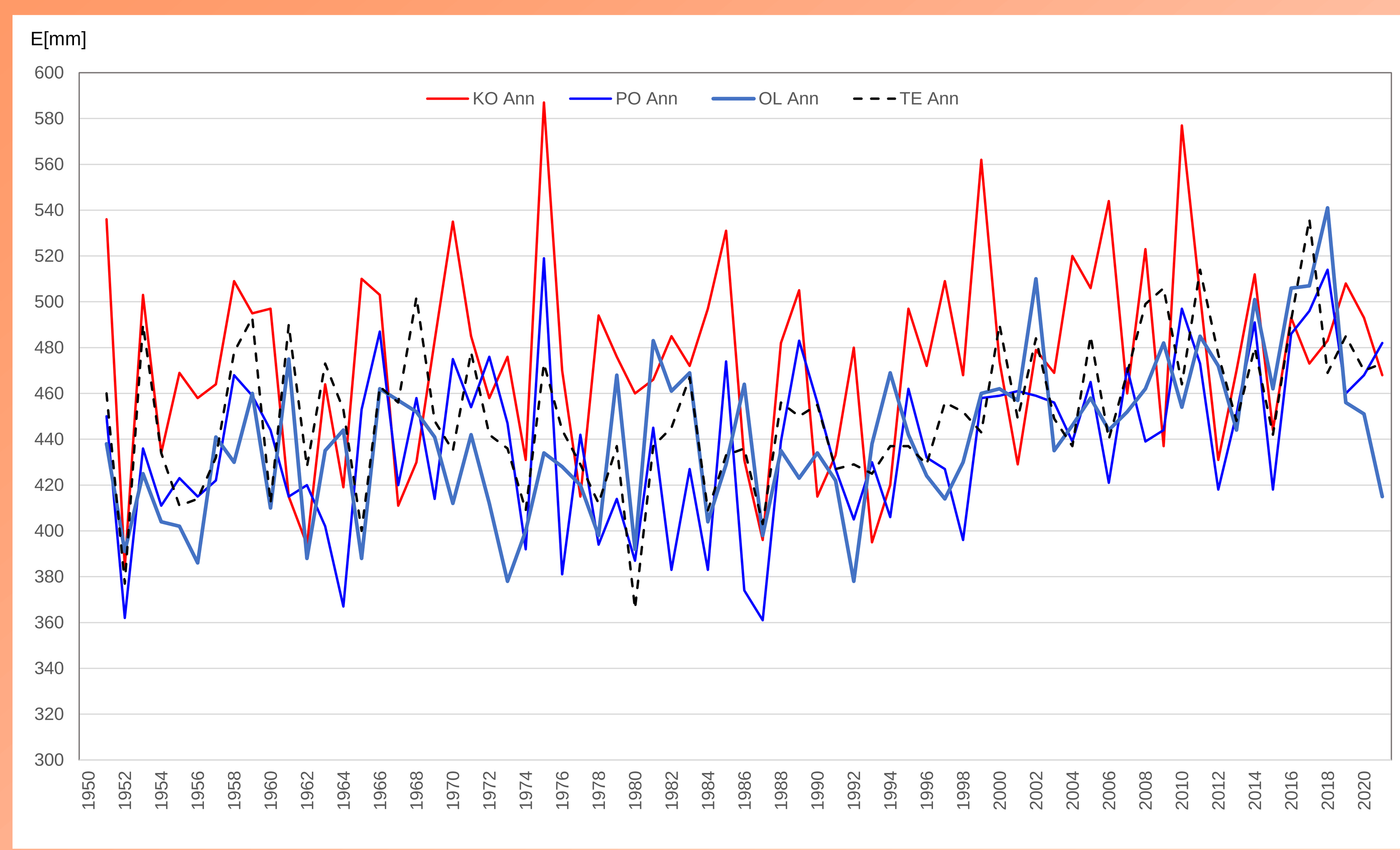

Fig. 4. Annual sums of actual evapotranspiration calculated by Budyko-Tomlain method for stations in SE, N and C Slovakia (Kosice (KO), Poprad (PO), Oravska Lesna (OL), Telgart (TG)) in 1951–2021.

We determined the climatic indicator of irrigation (K) for Slovakia, based on model calculations of potential evapotranspiration. This analysis covers 1951 to 2021 and aims to assess irrigation conditions and drought risk. The index provides measurable values in centimetres, reflecting average humidity conditions for each month of the year. When there is an excess of moisture in the winter months, its values are negative, when there is a lack of moisture in the summer, they are positive. Negative values of K occur throughout the year in the mountainous area and the whole of Slovakia during the winter. In the lowlands, we notice increasingly drier conditions compared to 1961-1990, while the mountainous areas in the north have experienced only minor changes.

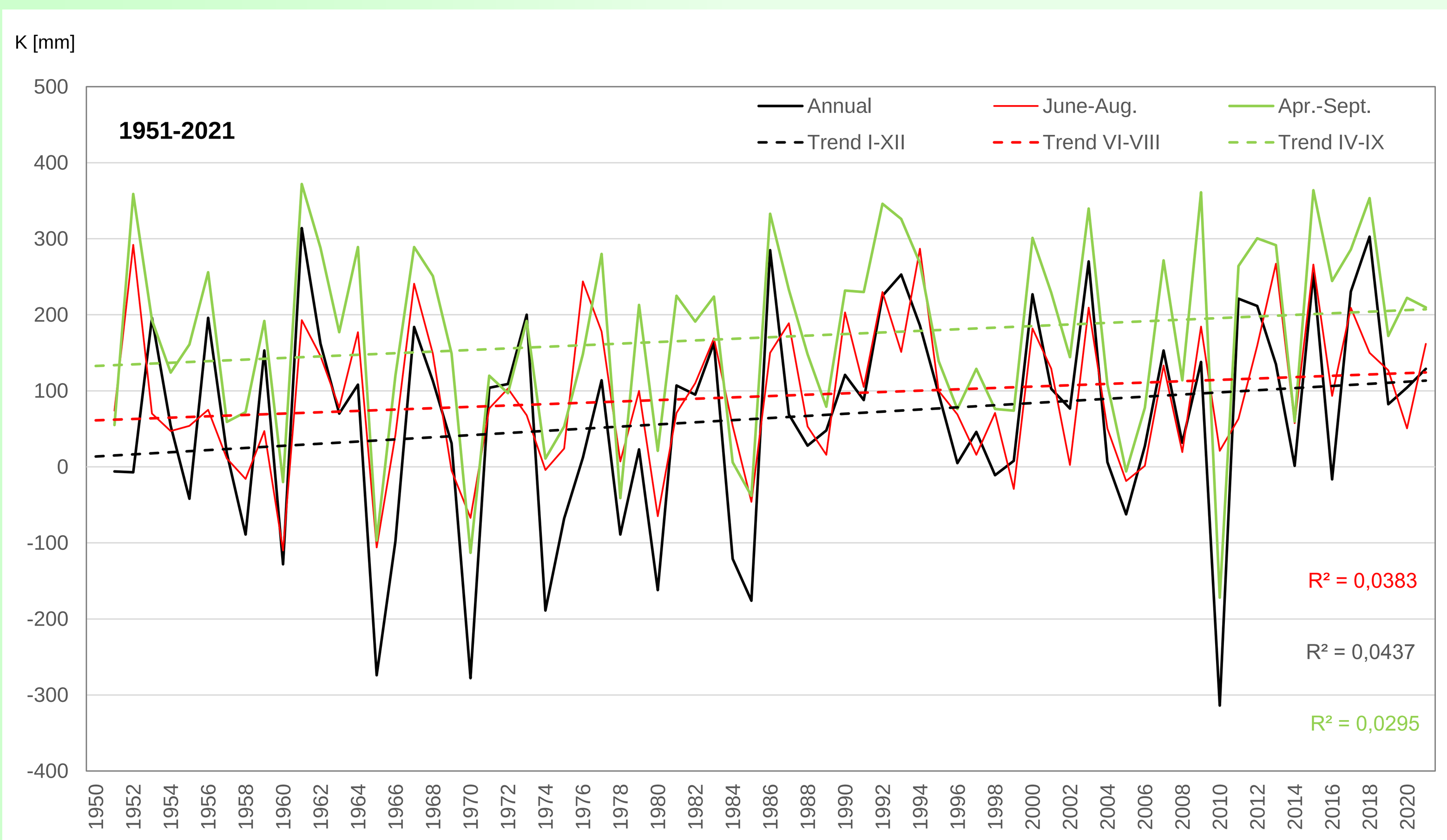

Fig. 5. Irrigation indicator K for Kosice Airport in 1951–2021.

The climatic irrigation index indicates the slightly increasing linear trend in Slovakia from 1951 to 2021. The low determination coefficient suggests that there is no statistically significant linear growth at a constant rate during the monitored period across all stations in Slovakia. This indicator is more reliable when considering long-term averages, so definitive conclusions about the K trend can only be made after several decades of ongoing climate change, such as in 2040.

Conclusion

The evapotranspiration calculated by the Budyko-Tomlain method can be successfully used to prepare studies on the impacts of and the vulnerability to climate change in different sectors. The information about spatial and time distribution of evapotranspiration is of great importance in theoretical and practical problems of agriculture, forest, and water management, or forming and protection of the environment.

The climatic irrigation index is a crucial factor for effective irrigation planning and efficient water resource management.

Acknowledgements: *This study is one of results of solving the Project APVV: DS-FR-22-0017:" Extreme droughts and their impact on agriculture in selected continental climates of Europe" (Multilateral Call for Scientific And Technological Cooperation In the Danube Region - 2022).*

The Slovak Hydrometeorological Institute monthly climatological data have been also used in this study. Author thanks for the support.

SLOVAK RESEARCH AND DEVELOPMENT AGENCY