5th Intercontinental Geoinformation Days

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Analysis of three hydro-meteorological parameters for the East Mediterranean Basin with GLDAS data

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Keywords
GLDAS
East Mediterranean
Trend
Spatial analysis
Remote sensing

Abstract

In this study, precipitation, actual evapotranspiration and potential evapotranspiration in the East Mediterranean Basin were investigated temporally and spatially. The data of this study, in which January 2000-July 2022 was determined as the study period, was obtained from the Global Land Data Assimilation System (GLDAS). According to the results obtained, it was determined that precipitation has a decreasing slope and evapotranspiration parameters have an increasing slope during the study period. In addition, it has been determined that the basin has spatial variability in terms of the investigated hydro-meteorological parameters.

1. Introduction

Hydro-climatological difficulties that occur with global warming cause many disasters all over the world (IPCC 2021). However, some regions are more affected by this phenomenon than others regions. The Mediterranean Basin comes first among these regions (Talu and Özüt 2011). In addition to its socio-economic importance, its historical background is one of the reasons why it has been preferred by many people as a settlement for years. Along with drought, deteriorating ecosystems damage biodiversity, leading to the gradual loss of natural riches. In geographies with a sensitive hydrological balance, precipitation is one of the important water inputs of the basin. In addition, evaluation together with evapotranspiration is frequently used in the comprehensive examination of precipitation.

Depending on the development of remote sensing and land cover models, global observations can be made with the data provided by many data sets. The Global Land Data Assimilation System (GLDAS) is one of these data sets (Rodell et al. 2004). There are many studies in the literature using these data sets (Awange et al. 2014; Lv et al. 2017; Mo et al. 2016). Studies are using hydro-meteorological analysis tools related to the East Mediterranean Basin, which is located within the borders of Turkey, which is determined as the study area. Oğuz et al. (2017) conducted a drought analysis for the East Mediterranean Basin using ERA-Interim data. It was stated that there was variation in precipitation in the results obtained. They also reported that drought had the most negative impact on crop production. Özfidaner et al. (2015) calculated the streamflow drought index from the streamflow data of the flow observation station no 1712 in the East Mediterranean Basin. According to the results obtained, they determined that the drought had an effect during the 1967-2007 periods. Koçyiğit et al. (2021) performed a flood risk analysis for the East Mediterranean Basin based on the river morphology. According to the results obtained, it was stated that the flood risk is located along the basin, with variability depending on the size of the sub-basin. There are other studies in which drought analysis is done for the East Mediterranean Basin (Altin and Altin 2021; Simsek 2021).

According to the information obtained from the literature review, no study was found in which the GLDAS dataset was used in the analysis of hydrological parameters for the East Mediterranean Basin. From this point of view, it is aimed to examine the three hydro-meteorological parameters (precipitation, actual evapotranspiration and potential evapotranspiration) obtained from the GLDAS dataset for the East Mediterranean Basin. Spatial and temporal averages of the basin were obtained from the raw data obtained from GLDAS. In addition, a linear trend is applied spatially.

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Cite this study

Koycegiz C & Buyukyildiz M (2022). Analysis of three hydro-meteorological parameters for the East Mediterranean Basin with GLDAS data. 5th Intercontinental Geoinformation Days (IGD), 141-144, Netra, India

2. Material and Method

2.1. Study area and data

The East Mediterranean Basin, determined as the study area, is one of Turkey's 25 main basins with a surface area of 21800 km^2. It constitutes 3% of Turkey's surface area. The East Mediterranean Basin is located between the coordinates 36°00′-37°28′N and 32°06′-35°09′E (Fig. 1). The altitude of the basin mainly varies between 0-2000 m. However, the altitude of the basin rises above 3000 m on the ridges of the Taurus Mountains (Altin and Altin 2021). The drainage area is bounded by the Sedir River on the west and the Tarsus River on the east. The study area, which has a typical Mediterranean climate, is a flood-risk basin with sharp slopes. The summers are hot and the winters are experienced as the months when precipitation occurs predominantly. In the mountainous parts of the basin, the climate is shifting from the Mediterranean climate to the continental climate. Annual average precipitation is 745 mm (Altin and Altin 2021). Agricultural areas of the basin are evaluated in the crop production class with 63%. Other areas consist of areas used for vegetable and fruit production, especially olive groves (Koçyiğit et al. 2021).

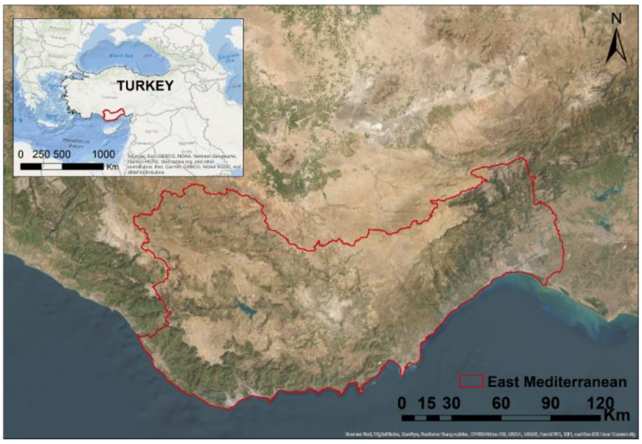

Figure 1. Location map of the East Mediterranean Basin

GLDAS, a project that aims to bring together the information obtained as a result of integrating satellite and observations with advanced land surface modeling techniques, provides data with 0.25^0 spatial resolution (Beaudoing et al. 2021; Rodell et al. 2004). Aiming to provide high-resolution data, GLDAS supports water resources, climate and weather research and global land surface analysis studies with the data it provides. GLDAS brings together the results of Noah, Variable Infiltration Capacity (VIC), Mosaic, Common Land Model (CLM) and Catchment land surface models. Many hydro-meteorological parameters are available from the GLDAS dataset. Within the scope of this study, data were obtained from GLDAS for precipitation, actual evapotranspiration and potential evapotranspiration parameters for the 2000 January-2022 July period.

2.2. Simple Linear Regression Model (SLRM)

Within the scope of the study, Simple Linear Regression Model (SLRM) was used to determine the monotonic trends of spatially distributed hydro-meteorological parameters. This model, which is frequently used in hydrological studies, provides a general view of the entire time series. In addition, it gives insight into the general behavior of the determined study area in terms of ease of application. SLRM is applied by determining the slope and constant coefficients of the linear equation including the dependent and independent variables. The slope of the equation contains trend information about the overall behavior of the data set. Accordingly, depending on the studied parameter and period, if the slope value of the SLRM is close to zero, it is stated that the parameter has a constant slope, if it is positive, it has an increasing slope, and if it is negative, it has a decreasing slope. Within the scope of the study, SLRM was applied not only to the time series of the determined parameters but also to the spatially distributed maps. Each grid (0.25^0x0.25^0) contains a time series of that area. When SLRM is applied for all grids in the study area and the slopes obtained are mapped, spatially scattered trend information is obtained. There are many studies in the literature in which SLRM is used in spatial and temporal analyzes of hydro-meteorological parameters (Zhang et al. 2017; Patel et al. 2016; Sriram and Rashmi 2014; Dimitriadou and Nikolakopoulos 2022; Mogaji and Lim 2020; Zhang et al. 2018).

3. Results

For the period January 2000-July 2022, the spatial average of the precipitation (P), actual evapotranspiration (aET) and potential evapotranspiration (PET) parameters for the East Mediterranean Basin obtained from GLDAS was obtained, and the time series was obtained. The obtained time series is given in Fig. 2. Accordingly, it is observed that precipitation has a negative slope and evapotranspiration parameters have a positive slope. In addition, precipitation in winter and evapotranspiration reach peak values in summer.

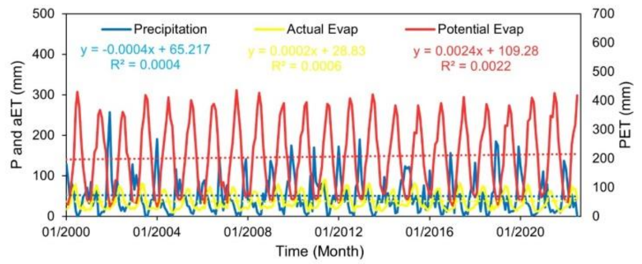

Figure 2. Average time series of P, aET and PET for East Mediterranean Basin

The difference between precipitation and evapotranspiration is frequently used in the interpretation of hydro-meteorological parameters. In practice, it is aimed to interpret the net water entering the basin. In addition, the ratio of the actual evapotranspiration to the potential indicates how close the actual evaporation and transpiration are to the basin potential. P-aET and aET/PET time series were obtained from the time series obtained by taking the spatial averages of the East Mediterranean Basin. These time series are given in Fig. 3. Here, the decreasing slope of the P-aET is an indication that the net water inflow of the basin may be under threat. P-aET reached low values in the last years of the study period. When aET/PET ratios are examined, although an increasing trend is observed in recent years, the slope of the study period is very close to zero.

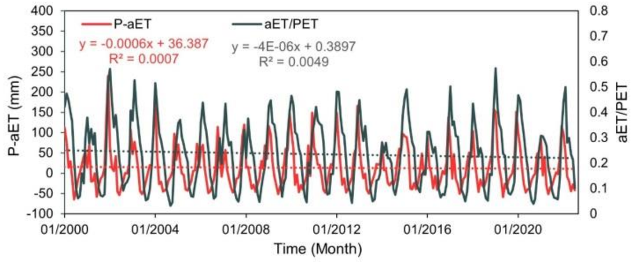

Figure 3. Monthly average P-aET and aET/PET time series for East Mediterranean Basin

In addition to examining the time series, hydro-meteorological analysis of the basin was made with the help of spatially distributed maps. In Fig. 4, temporal averaged maps for the three parameters are given. It is observed that precipitation reaches the highest values (690 mm) in the southwestern parts of the basin. The lowest precipitation (566 mm) was detected on the southeast coast of the basin. When the evapotranspiration parameters were examined, it was determined that there were higher values in the coastline compared to the interior. Maximum values of 572 mm for actual evapotranspiration and about 3000 mm for potential evapotranspiration were observed.

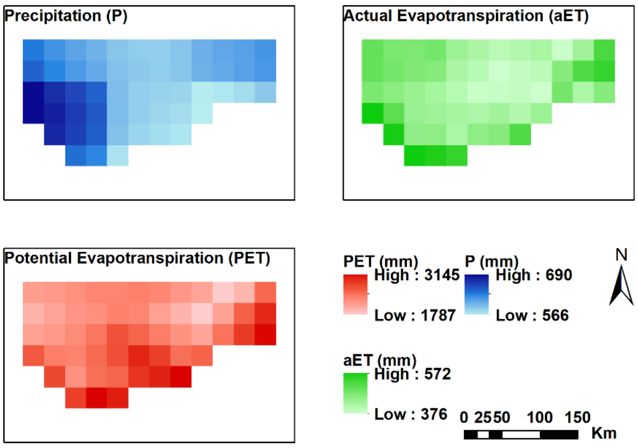

Figure 4. Study period average for P, aET and PET

The temporal averaged maps of P-aET and aET/PET are given in Fig. 5. According to Fig. 5, net precipitation has the highest values in the western parts of the basin. Due to the high evapotranspiration values on the coastline, net precipitation has been relatively low in these areas. Net precipitation decreases from west to east of the basin. When the aET/PET ratio is examined, it is quite interesting that extreme values were observed at the western and eastern borders of the basin. Low rates were determined in the central parts of the basin. The highest rate is 0.24 while the lowest rate is 0.14.

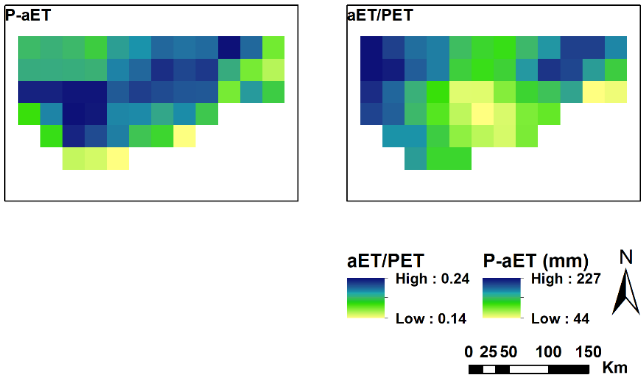

Figure 5. P-aET and aET/PET maps for East Mediterranean Basin

Spatial distributed linear trend maps for the three parameters (P, aET and PET) determined within the scope of the study are given in Fig. 6. It is quite remarkable that precipitation has a high linear trend along a steep grid series from south to north. The highest increasing slope of precipitation in the basin starts from the southernmost grids and progresses to the inner parts. However, the western boundary of the basin has a decreasing slope. When the actual evapotranspiration is examined, there is an increasing slope in the inner parts of the basin in the north. However, the central inner sections have increasing slopes in the potential evapotranspiration parameter. Accordingly, the western and eastern borders of the basin and the middle and coastline sections have different hydro-meteorological characteristics.

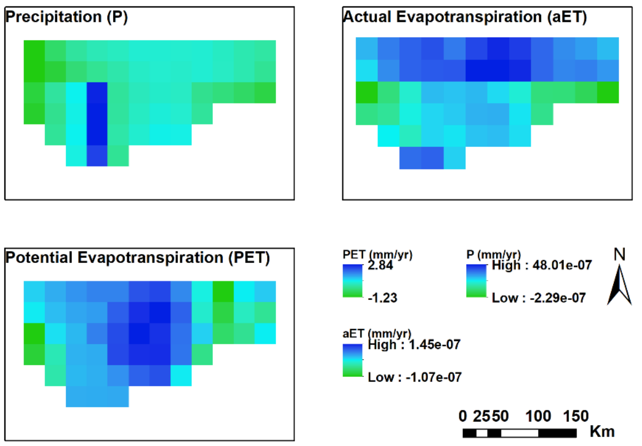

Figure 6. Lineer trend map for P, aET and PET

4. Conclusion

Within the scope of this study, the data obtained from the GLDAS data set for the East Mediterranean Basin were examined. These data are limited by precipitation, actual evapotranspiration and potential evapotranspiration parameters. The period of January 2000-July 2022 has been determined as the study period. The obtained data were analyzed spatially and temporally. In addition, linear slopes were investigated throughout the study period.

In light of the research findings, it was determined that evapotranspiration increased and precipitation decreased during the study period. If this trend continues, it is thought that the significant decrease in net precipitation in the basin may lead to droughts. It has been determined that the hydro-meteorological parameters examined spatially differ in the coastline and inland areas. The increasing continentality as it moves toward the interior reduces evapotranspiration along with precipitation. It is thought that evapotranspiration values on the coastline reach high values with the presence of water depending on the temperature. It is quite remarkable that the potential evapotranspiration has an increasing slope in the middle parts, while the actual evapotranspiration increases in the north of the basin.

It is thought that examining the Eastern Mediterranean Basin by dividing it into temporal sub-periods can provide information that monotonic slopes do not provide, to provide an idea for future studies. In addition, it was considered that it would be very important to examine the spatial variability at higher resolutions by using the station data.

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