

## Spatiotemporal Variation and Attribution Analysis of Potential Evapotranspiration in the Bosten Lake Basin (Postprint)

**Authors:** Zhong Qiao, Jiao Li, Li Zhi, Jiao Wei, Chen Yaning

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### Abstract

This study utilizes meteorological station data from the Bosten Lake Basin spanning 1970–2014 and the Penman-Monteith formula to calculate potential evapotranspiration (ET<sub>0</sub>), comparatively analyzing the spatiotemporal variations of ET<sub>0</sub> and its differential responses to major meteorological factors between the mountainous and plain regions of the basin. The results reveal that: 1) At the interannual scale, ET<sub>0</sub> in the mountainous region exhibited a fluctuating declining trend from 1970–2000 ( $P < 0.01$ ), followed by a slight increase since 2000; ET<sub>0</sub> in the plain region decreased at a rate of  $-77 \text{ mm}/10\text{a}$  during 1970–1993 ( $P < 0.01$ ), then reversed to an increasing trend at  $83.8 \text{ mm}/10\text{a}$  after 1993 ( $P < 0.01$ ), with changes in the plain region being significantly more pronounced than in the mountainous region. 2) Seasonally, summer exhibits the highest ET<sub>0</sub> in the basin and represents the primary contributor to annual variation; the trend shows that ET<sub>0</sub> in the plain region exceeds that in the mountainous region in spring and summer, while being slightly lower in autumn and winter. 3) ET<sub>0</sub> variation is most sensitive to net radiation and wind speed; concurrently, net radiation and wind speed contribute most significantly to ET<sub>0</sub> variation in the mountainous region, whereas wind speed is the dominant factor affecting ET<sub>0</sub> variation in the plain region, with its contribution rate to ET<sub>0</sub> exceeding 50% in all cases.

### Full Text

#### Preamble

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**Abstract:** Based on meteorological data from nine meteorological stations in the Bosten Lake Basin, Xinjiang, China, from 1970 to 2014, this study calcu-

lated potential evapotranspiration (ET) using the improved Penman-Monteith formula and analyzed its spatiotemporal evolution. The sensitivity of Penman-Monteith potential evapotranspiration to daily maximum temperature, minimum temperature, wind speed, net radiation, relative humidity, and vapor pressure was analyzed, and the contribution rates of major meteorological factors to ET changes were calculated. The results showed: (1) At the interannual scale, ET in the mountainous region showed a significant decreasing trend during 1970–2000 ( $P < 0.01$ ), but a slight increasing trend after 2000. ET in the plain region presented a significant decreasing trend ( $P < 0.01$ ) at a rate of  $-77 \text{ mm} \cdot (10\text{a})^{-1}$  from 1970 to 1993; however, since 1993, the trend reversed to an upward tendency at a rate of  $83.8 \text{ mm} \cdot (10\text{a})^{-1}$  ( $P < 0.01$ ). The variability of ET in the plain oasis region was stronger than that in the mountainous area. (2) At the seasonal scale, ET was highest in summer, followed by spring and autumn, and lowest in winter. At the monthly scale, ET peaked in June and reached its minimum in January, with greater dispersion from May to August, indicating intensive changes during this period. (3) Wind speed and net radiation were the most sensitive variables to ET in the Bosten Lake Basin, though the relative change rate of net radiation was small. (4) The contribution of net radiation and wind speed to ET changes was largest in the mountainous region, while wind speed was the dominant factor in the plain region, contributing more than 50% to ET. This analysis of meteorological factors' contributions to potential evapotranspiration in the Bosten Lake Basin can provide a scientific basis for water resources allocation and downstream ecological restoration.

**Keywords:** Bosten Lake Basin; potential evapotranspiration; sensitivity analysis; contribution rate

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## 1. Study Area

### 1.1 Overview of the Study Area

The Bosten Lake Basin is located between  $41^{\circ}25' - 43^{\circ}34' \text{ N}$  and  $82^{\circ}57' - 88^{\circ}18' \text{ E}$ , in the southern foothills of the Tianshan Mountains. The basin covers an area of  $4.33 \times 10^4 \text{ km}^2$  (Figure 1). The terrain is characterized by mountains in the west, north, and east, with plains in the central and southern parts. Elevations range from 2,400–4,500 m in the mountainous area and 1,000–2,000 m in the plain area. The basin contains nine meteorological stations with complete data records.

[Figure 1: see original paper] Bosten Lake Basin and the spatial distribution of meteorological stations

Data of partial meteorological stations on Bosten Lake Basin

Station	Longitude (E)	Latitude (°N)	Elevation (m)	Annual Precipitation (mm)	Annual Average Temperature (°C)	Annual Sunshine Hours (h)	Annual Average Wind Speed (m/s)
1	86.37	41.78	932.0	79.8	8.2	3,071.3	1.7
2	86.25	41.42	1,099.0	68.1	8.5	3,071.3	1.8
3	86.37	42.23	1,099.0	68.1	8.5	3,071.3	1.8
4	86.37	42.23	1,099.0	68.1	8.5	3,071.3	1.8
5	86.37	42.23	1,099.0	68.1	8.5	3,071.3	1.8
6	86.37	42.23	1,099.0	68.1	8.5	3,071.3	1.8
7	86.37	42.23	1,099.0	68.1	8.5	3,071.3	1.8
8	86.37	42.23	1,099.0	68.1	8.5	3,071.3	1.8
9	86.37	42.23	1,099.0	68.1	8.5	3,071.3	1.8

## 1.2 Data and Methods

Meteorological data from nine stations in the Bosten Lake Basin for the period 1970–2014 were used, including daily maximum temperature, minimum temperature, wind speed, sunshine hours, relative humidity, and precipitation. The Penman-Monteith equation recommended by the Food and Agriculture Organization (FAO) was employed to calculate ET :

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}$$

where  $ET_0$  is potential evapotranspiration ( $\text{mm} \cdot \text{d}^{-1}$ ),  $R_n$  is net radiation ( $\text{MJ} \cdot \text{m}^{-2} \cdot \text{d}^{-1}$ ),  $G$  is soil heat flux density ( $\text{MJ} \cdot \text{m}^{-2} \cdot \text{d}^{-1}$ ),  $T$  is mean daily air temperature ( $^{\circ}\text{C}$ ),  $u_2$  is wind speed at 2 m height ( $\text{m} \cdot \text{s}^{-1}$ ),  $e_s$  is saturation vapor pressure (kPa),  $e_a$  is actual vapor pressure (kPa),  $\Delta$  is the slope of the vapor pressure curve ( $\text{kPa} \cdot ^{\circ}\text{C}^{-1}$ ), and  $\gamma$  is the psychrometric constant ( $\text{kPa} \cdot ^{\circ}\text{C}^{-1}$ ).

Sensitivity analysis was performed to quantify the response of ET to changes in meteorological factors. The contribution rate of each factor to ET variation was calculated to determine the dominant drivers of ET changes in different regions of the basin.

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