Postprint: Analysis of Climate Change in the Selin Co Basin of the Qinghai-Tibet Plateau, 1979–2017

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Abstract

Based on gridded data of air temperature (2 m), precipitation, specific humidity, wind speed (10 m), and solar radiation from 1979 to 2017 derived from the China Meteorological Forcing Dataset (CMFD) and GLDAS dataset, and employing linear regression, cumulative anomaly, moving average, and Mann-Kendall mutation test methods, the climatic characteristics and spatiotemporal variation patterns of the Selin Co basin over the past 39 years were investigated. The results indicate that the multi-year mean air temperature in the Selin Co basin is -1.8℃, precipitation is 389.4 mm, specific humidity is 3.2 g · kg-1, solar radiation is 236.2 W · m-2, and wind speed is 3.7 m · s-1. The monthly mean air temperature in the Selin Co basin exceeds 0℃ only from May to September, and the basin mean air temperature exhibits a significant increasing trend at a rate of 0.049℃ · a-1. Precipitation in the basin is concentrated from June to September, accounting for over 80% of the annual total, and the basin mean annual precipitation shows a significant increasing trend at a rate of 4.65 mm · a-1. The concurrent increase in air temperature and precipitation suggests that the Selin Co basin has experienced a significant warm-wet climate background in recent decades. From 1979 to 2017, the spatial pattern of annual mean wind speed variation in the basin features increases in the south and decreases in the north, with the most pronounced decreasing rates in the northeastern part of the basin. The spatial distribution of multi-year mean solar radiation demonstrates an overall increasing trend from east to west, while its temporal variation shows a significant decreasing trend at a rate of -0.29 W · m-2 · a-1, particularly evident from the mid-1980s to the mid-2000s. The annual mean specific humidity in the basin does not exhibit a significant trend overall, but has shown a significant decreasing trend since 2006. The findings of this study provide indicative significance for research on lake expansion mechanisms, ecosystem responses to climate change, and phenological changes in the basin.

Full Text

Analysis of Modern Climate Characteristics and Change Trends in the Selin Co Basin, Tibet from 1979 to 2017

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Abstract

This study utilized data from the China Meteorological Forcing Dataset (CMFD) and Global Land Data Assimilation System (GLDAS), including air temperature (2 m), precipitation, specific humidity, wind speed (10 m), and solar radiation, to investigate the modern climate characteristics and spatiotemporal variations in the Selin Co Basin over 39 years from 1979 to 2017. Linear trend estimation, Mann-Kendall mutation test, five-year moving average, and cumulative anomaly methods were employed. Results showed that the multi-year annual average temperature, specific humidity, solar radiation, and wind speed were -1.8°C, 3.2 $g \cdot kg^{-1}$, 236.2 $W \cdot m^{-2}$, and 3.7 $m \cdot s^{-1}$, respectively. The multi-year average annual precipitation was 389.4 mm. Throughout the year, monthly average temperatures were above 0°C from May to September and generally below 0°C in other months. Between 1979 and 2017, the annual average temperature in the Selin Co Basin increased significantly at a rate of 0.049°C $\cdot a^{-1}$. Approximately 80% of annual precipitation occurred between June and September. The basin's annual average precipitation also increased significantly at a rate of 4.65 $mm \cdot a^{-1}$. Together, increased temperature and precipitation demonstrate an obvious changing climate characterized by a tendency toward warmer and wetter conditions during the last 20 years. During the same period, wind speed showed an increasing trend in the southern region and a decreasing trend in the northern region, with the largest rate of decrease occurring in the northeast of the basin. From east to west, the multi-year annual average solar radiation gradually increased. Solar radiation showed a significant decrease at a rate of -0.29 $W \cdot m^{-2} \cdot a^{-1}$ throughout the last 39 years, especially from the mid-1980s until the mid-2000s. Moreover, while specific humidity did not show a significant change, it exhibited a significant decreasing trend since 2006. Results of this study are indicative for delineating the mechanism of lake expansion, the response of ecosystems to climate change, and phenological changes.

Keywords: Tibetan Plateau; Selin Co Basin; climate characteristics; climate change; trend analysis

1. Introduction

1.1 Study Area and Data Sources

The Selin Co Basin (Figure 1) is located on the Tibetan Plateau between 30°03 - 33°40 N and 87°39 -92°26 E, covering an area of 45,530 km^2 with elevations above 4500 m. Meteorological data for the period 1979–2017 were obtained from the China Meteorological Forcing Dataset (CMFD) and GLDAS, including 2 m air temperature, precipitation, specific humidity, 10 m wind speed, and solar radiation. The CMFD dataset integrates Princeton meteorological forcing data, GLDAS data, GEWEX-SRB radiation data, and TRMM precipitation data, and has been widely validated for the Tibetan Plateau region.

To ensure data reliability, CMFD data were validated against observations from the Xainza meteorological station for the period 1981–2015. Comparison of monthly averaged values showed strong agreement, with temperature yielding $R^2 = 0.9994$ and RMSE = 1.1860, and precipitation yielding $R^2 = 0.9867$ and RMSE = 4.6748 (Figure 2). These validation metrics exceed the 0.98 threshold, confirming the suitability of CMFD data for climate analysis in this region.

[Figure 1: see original paper] [Figure 2: see original paper]

2. Climate Characteristics and Change Trends

2.1 Temperature

The multi-year average temperature in the Selin Co Basin was -1.8°C, with a standard deviation of 1°C. Temperatures showed pronounced seasonal variation, with monthly averages exceeding 0°C from May to September and remaining below 0°C during other months. The warmest month was July (average 8.1°C), while the coldest month was January (average -12.5°C).

Over the 39-year study period, the basin experienced significant warming at a rate of $0.049°C \cdot a^{-1}$ ($p < 0.05$). The warming trend was particularly pronounced during the growing season (May–September), with a rate of $0.063°C \cdot a^{-1}$. Since the 2010s, the warming trend has accelerated, indicating a shift toward warmer conditions. The Mann-Kendall mutation test identified a significant change point around 1998, with temperatures showing a clear increasing trend thereafter.

2.2 Precipitation

The multi-year average annual precipitation was 389.4 mm, with substantial interannual variability. Precipitation exhibited strong seasonality, with approximately 80% of annual totals concentrated in the June–September period. The basin showed a significant increasing trend in precipitation at $4.65\ mm \cdot a^{-1}$ ($p < 0.05$), particularly pronounced after 1998. This wetting trend aligns with the warming pattern, collectively indicating a shift toward warmer and wetter conditions in recent decades.

2.3 Specific Humidity

The multi-year average specific humidity was 3.2 $g \cdot kg^{-1}$. While no significant long-term trend was detected for the entire period, a notable decreasing trend emerged after 2006. This recent decline in atmospheric moisture content, despite increasing precipitation, suggests complex changes in the regional water cycle and atmospheric circulation patterns.

2.4 Solar Radiation

The multi-year average solar radiation was 236.2 $W \cdot m^{-2}$, with values gradually increasing from east to west across the basin. Solar radiation exhibited a significant decreasing trend at -0.29 $W \cdot m^{-2} \cdot a^{-1}$ ($p < 0.05$), particularly evident from the mid-1980s to mid-2000s. This decline may be associated with increased cloud cover and atmospheric water vapor associated with the warming and wetting trends.

2.5 Wind Speed

The multi-year average wind speed was 3.7 $m \cdot s^{-1}$, with higher values in spring (March–May) and lower values in summer (June–August). Wind speed trends showed spatial heterogeneity, increasing in the southern basin while decreasing in the northern basin, with the most significant decline occurring in the northeast. Overall, no significant basin-wide trend was detected, but regional variations were substantial.

2.6 Integrated Climate Change Characteristics

The combined analysis reveals that the Selin Co Basin has experienced significant climate change from 1979 to 2017, characterized by: 1. **Warming**: Significant temperature increase at 0.049°C $\cdot a^{-1}$, accelerating to 0.063°C $\cdot a^{-1}$ in recent decades 2. **Wetting**: Significant precipitation increase at 4.65 $mm \cdot a^{-1}$, with 80% concentrated in summer months 3. **Decreasing solar radiation**: Significant decline at -0.29 $W \cdot m^{-2} \cdot a^{-1}$, especially 1980s–2000s 4. **Variable humidity**: No long-term trend but significant decrease since 2006 5. **Spatially heterogeneous wind patterns**: Southern increase and northern decrease

These changes collectively indicate a transition toward a warmer, wetter climate regime, particularly pronounced in the last 20 years. The synchronous changes in temperature and precipitation have important implications for the observed lake expansion, glacier melt, and ecosystem responses in the region.

5. Conclusions

(1) From 1979 to 2017, the Selin Co Basin had a multi-year average temperature of -1.8°C with a standard deviation of 1°C. Monthly temperatures exceeded 0°C from May to September, with July being the warmest month

(8.1°C) and January the coldest (-12.5°C). The basin experienced significant warming at 0.049°C · a^{-1}, with an accelerated rate of 0.063°C · a^{-1} in recent years.

(2) The multi-year average precipitation was 389.4 mm, with 80% occurring during June–September. Precipitation increased significantly at 4.65 mm · a^{-1}, with the most pronounced increase after 1998.

(3) The 39-year average specific humidity was 3.2 g · kg^{-1}. While no significant long-term trend was found, a decreasing trend emerged after 2006.

(4) Solar radiation averaged 236.2 W · m^{-2} and showed a significant decreasing trend at -0.29 W · m^{-2} · a^{-1}, particularly from the 1980s to 2000s.

(5) Wind speed averaged 3.7 m · s^{-1}, with higher values in spring and lower in summer. Spatial trends varied, with increases in the south and decreases in the north.

(6) Overall, the Selin Co Basin exhibits clear climate change signals toward warmer and wetter conditions, with significant implications for regional hydrology and ecosystems.

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Note: Figure translations are in progress. See original paper for figures.