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Editorial

Land–Atmosphere Interactions and Effects on the Climate of the Tibetan Plateau and Surrounding Regions II

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1. Introduction

As the world's highest and largest plateau, the Tibetan Plateau (TP) is referred to as 'the Asian Water Tower' and 'the Third Pole of the World' [1]. A better understanding of the water and energy cycles in the TP is not only critical for revealing the mechanisms of regional land–atmosphere interactions, but also essential for assessing the causes of changes in the cryosphere and hydrosphere in relation to changes in the plateau atmosphere in the Asian monsoon system [2]. Since the TP is an ecologically fragile region that is sensitive to climate change [3], the systematic evaluation of land–atmosphere interactions in this region also contributes to the quantitative understanding of climate change.

To this end, the aim of this Special Issue was to present recent advances in quantifying (1) processes in the atmospheric boundary layer, (2) soil properties, drought, and freezing–thawing processes, (3) lake and glacier monitoring, (4) hydrological processes, and (5) data assimilation and validation by applying in situ measurements, remote sensing or numerical modelling approaches to the TP region.

Eighteen papers (sixteen articles, one communication, and one technical note) are published in this Special Issue, covering the quantitative assessments of land surface temperature, sensible heat flux, soil moisture, vegetation and drought indices, groundwater storage, runoff, condensation, and desublimation, as well as the distinct surface processes over lakes and glaciers driven by climate warming. The MODIS and GIMMS datasets are validated, and a new high-resolution assimilated dataset is released. In addition, the application of coherent Doppler wind LiDARs is analysed. Additionally, the formation and climatic–environmental significance of the yardangs surrounding the Suoyang city ruins are also discussed.

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2. Overview

The surface air temperature difference and sensible heat flux are critical variables in the atmospheric boundary layer, both of which have undergone significant changes due to climate change. Wang et al. [4] reported that although the entire TP was found to be dominated by a positive surface air temperature difference both annually and seasonally, from 1950 to 2021 the TP experienced a significant decreasing trend in the annual surface air temperature difference at a rate of -0.07 K/decade. Additionally, a decreasing trend in sensible heat flux from the mid-1980s to the beginning of the 21st century was also reported by Wang et al. [5] via Noah-MP simulations. The decrease in sensible heat flux was found to be linked to the decrease in both the surface air temperature difference and wind speed [5].

Using the Community Land Model version 4.5, Fu et al. [6] demonstrated that the TP has become warmer and wetter from 1981 to 2016, with increases in both regional average temperature and precipitation. In addition, soil temperature and moisture in most areas of the TP were affected by air temperature and precipitation in turn, and both showed an upwards trend. Consequently, the duration of the freeze–thaw process over the TP has shortened. Despite the increase in the northwest TP, the freeze–thaw duration decreased in the rest of the whole plateau [6]. Additionally, Fang et al. [7] also found that an area of 0.60×106 km^2 of permafrost in the TP degraded to seasonally frozen ground in the 1960s–2000s, and the primary shrinkage period occurred in the 2000s. However, the seasonal and diurnal variation characteristics of soil moisture are diverse in different in situ stations. According to Li et al. [8], the soil moisture at depths of 5 and 10 cm for the Lhari, Biru, Nyainrong, Amdo, Nagqu, Baingoin, and Seng-ge Kambab stations was measured to be 0.55, 0.4, 0.34, 0.3, 0.25, 0.14, and 0.1 cm^3/cm^3, respectively. These large differences also indicated that it was unreasonable to use only the soil moisture of several stations to represent the overall soil moisture of one region [8].

Drought is a major disaster across the TP, and drought indices that can describe drought evolution at a fine temporal scale are still scarce. Cheng et al. [9] constructed daily drought indices based on multisource remote sensing and reanalysis data using four machine learning methods, and a new daily drought index, the standardized integrated drought index (SIDI), was developed via the extreme gradient boosting regression model, which showed the best performance for monitoring agricultural drought. In addition, to analyse the mechanism of drought in Southwest China, Ye et al. [10] constructed a binary linear regression forecast model, which successfully relates precipitation to the anomaly of 500 hPa relative vorticity and relative divergence. Additionally, the spatiotemporal variation characteristics of drought on the TP from 2016 to 2099 were predicted by Liu et al. [11], showing that the overall future climate of the TP will still develop towards warm and humid conditions. However, as the concentration of carbon dioxide emissions increases in the future, the proportion of extremely significant aridification and humidification areas in the TP will significantly increase, and the possibility of extreme disasters will also increase [11].

Changes in lake water volume and glacier mass are sensitive indicators of regional environmental change. Ma et al. [12] systematically analysed the interannual changes from 1970 to 2021 in three typical inland lake basins using multisource remote sensing and water level observations. The results showed that lakes in the monsoon-dominated region showed a significant trend of expansion from 2000 to 2014, but the trend slowed down and stabilized after 2014; lakes in the westerlies-dominated region showed a small expansion trend, while lakes in the region affected by both westerlies and the monsoon showed an overall shrinking trend [12]. On the other hand, Yao et al. [13] reported that the Yala Glacier and the Qiyi Glacier were shrinking, with change rates of -736 mm w.e./a and -567 mm w.e./a, respectively, both undergoing a state of intensive and accelerating mass loss [13].

Condensation, desublimation, runoff, and groundwater storage are all important processes in land–atmosphere interactions. Li et al. [14] evaluated the spatiotemporal variations in condensation and desublimation from 1950 to 2020 on the TP using hourly ERA5-Land and ERA5 reanalysis datasets. The annual mean condensation was estimated to be 8.45 mm, with an increasing trend of 0.24 mm/10a, and the annual mean desublimation was 11.45 mm, with a decreasing trend of −0.26 mm/10a, with the total annual mean condensation and desublimation reaching 19.89 mm, with a weak decreasing trend on the TP overall. Wei et al. [15] investigated the relationships between fourteen landscape patterns and four hydrological indices for ten watersheds in the TP and found that runoff increases when a watershed is dominated by a small patch of landscape. Regarding the variability in groundwater storage, Ren et al. [16] reported that the groundwater storage of the TP decreased at an average rate of −0.89 mm/a from January 2003 to December 2021. However, since January 2016, it has gradually recovered at a rate of 1.47 mm/a. It was found that the rising temperature may result in an increase in groundwater storage in regions where glaciers are distributed [16].

Several articles have evaluated the current products or released new datasets via data assimilation. Lazhu et al. [17] validated the MODIS lake surface water temperature dataset over the TP region. The MODIS LSWT agrees well with the in situ measurements, with a root mean square error < 1 K at nighttime and <2 K in the daytime, indicating a high accuracy of the MODIS LSWT data. However, the MODIS lake surface water temperature data were questionable in the monsoon-controlled region [17]. In addition, Wang et al. [18] applied the MODIS and GIMMS datasets to analyse the annual and seasonal trends in vegetation responses and feedback to temperature on the TP. The results showed that both MODIS and GIMMS data showed a common increase in the normalized difference vegetation index on the TP for all timescales, while the former has had a larger greening area since 2000 [18]. In addition, Wen et al. [19] utilized the weather research and forecasting (WRF) model and a three-dimensional variational assimilation method to create a high-resolution assimilated dataset (HRAD) with a spatial resolution of 0.05° × 0.05° and a temporal resolution of 1 h. The correlation coefficients of the 2 m temperature, surface temperature and surface pressure were relatively high, all above 0.9, and those of relative humidity and wind speed were approximately 0.7 and 0.5, respectively [19].

Moreover, Song et al. [20] evaluated the observations of the wind field and boundary layer height from coherent Doppler wind LiDARs located at the northern edge of the TP from 1 May to 30 August 2021, showing that coherent Doppler wind LiDAR has good applicability in reproducing wind fields in dust, precipitation, and clear-sky conditions. Fan et al. [21] analysed the formation of yardangs surrounding the Suoyang City ruins in the Hexi Corridor of northwestern China. According to ^{14}C dating and historical records of local human activities, the formation of yardangs in the Suoyang City oasis has been suggested to start in the mid-Yuan Dynasty of China, around AD 1291 [21].

3. Summary

In summary, this Special Issue mainly presents up-to-date advances in the quantitative assessments of land surface temperature, sensible heat flux, soil moisture, vegetation and drought indices, groundwater storage, runoff, condensation, and desublimation, as well as the distinct surface processes over lakes and glaciers on the TP. These selected papers are novel and timely in informing the knowledge on land–atmosphere interactions driven by climate warming.

We trust that the collation of these papers will provide quantitative references for the better assessment and prediction of the land–atmosphere interactions in the "Third Pole".

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