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Does elevation impact local level climate change? An analysis based on fifteen years of daily diurnal data and time series forecasts

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ABSTRACT

The impact of elevation on climate change is a well-established research agenda. In the present era of climate change, it is necessary to understand the local impacts of such relationships. In this study, we attempted to portray local climate change using its altitudinal factor and fifteen years (2000–2014) of daily diurnal data from 20 stations in West Bengal, India that experienced increasing summer temperatures over the last several years. The study region is a combined zone of the plateau and plain region where there are variations in altitude. The study used the ARMA model to forecast future climatic conditions of the region. The results demonstrate that climate change is playing an active role in the region, although there was not a convincing relationship between elevation and climate change. The low-lying counterparts of the study area were influenced by climate change. Per the forecast, the gap between the daily maximum and minimum temperatures will generally remain similar to or slightly less than the present conditions, while there is a high possibility of a more prominent decrease in the diurnal temperature range (DTR) over time.

1. Introduction

The daily average temperature is generally used as a global measurement to indicate climate change (CC) [1]. However, the average temperature is not sufficient to identify complex variations of climate [1]. In fact, trends in average surface temperature are often due to changes in daily maximum and minimum temperatures [2]. Therefore, diurnal temperature range (DTR) is also an important indicator for climate change [3]. One of the aspects of climate change that has received limited attention is the potential difference between changes in daily maximum and minimum temperatures and the resulting changes in the diurnal temperature range (DTR) [37]. DTR has steadily increased in the elevated zones of the study area, which leads to an increase in the gap between the maximum and minimum temperatures compared to low lying areas.

Generally, climatic conditions become colder as the elevation increases. However, several studies have strongly suggested that elevated regions have warmed at a faster rate than their low elevation counterparts and often with a greater increase in the daily minimum temperatures than the daily maximum temperatures [4–9]. According to Beniston et al., the tendency for greater warming rates at higher altitude may be more prominent in the tropics [5]. Many mechanisms can accelerate the enhanced warming rates at certain elevation bands because they significantly contribute to differential changes in climate drivers, such as water vapour and soil moisture. Therefore, evaluating climatic habits in elevated areas is an optimal approach to understanding climate change at local levels. Q4

In this study, we try to portray the local climate change using its altitudinal factor and fifteen years (2000–2014) of daily diurnal data. Karl et al. studied the impact of clear and cloudy sky conditions on the diurnal temperature range [10]. The outcomes revealed that there was a significant decrease in the DTR over time during cloudy days. Many other studies also investigated the effect of DTR through additional factors such as irrigation [11], land use-landcover transformation [12], desertification, station moves, and other climatic events [13] and urbanization [14,15]. All these factors showed an important contribution to changing the character of the DTR. However, only a few studies show the relationship between elevation and DTR. Apart from these parameters influencing DTR, a

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Table 1
Literature showing elevation sensitive warming within mountainous regions.

Author	Region	Elevation range (m)	Time	Observations
Rangwala and Miller, 2010 [32]	Southern Colorado Rockies	1763–3536	1895–2005	58
Bhutiyani et al., 2007 [22]	Indian Himalayas	1200–3800	1901–1989	10
Jungo and Beniston, 2001 [29]	Swiss Alps	271–3572	1901–1999	19
Kothawale et al., 2010 [23]	Indian Himalayas	not available	1901–2007	12
Vuille and Bradley, 2000 [25]	Tropical Andes	0–5000	1939–1998	268
Pepinand Lundquist, 2008 [19]	Global Mountains	500–4700	1948–2002	1084
Pepin and Seidel, 2005 [20]	Global Mountains	500–4700	1948–2002	1084
Vuille et al., 2003 [26]	Tropical Andes	0–5000	1950–1994	277
Pepin and Losleben, 2002 [31]	Colorado Front Range	1059–3749	1952–1998	3
Ceppi et al., 2010 [28]	Swiss Alps	200–3500	1959–2008	2 km gridded data
Seidel and Free, 2003 [21]	Global Mountains	2–3649	1960–2000	52; incl. radiosonde data
Lu et al., 2010 [27]	Tibetan Plateau	1000–5000	1960–2005	140
Shrestha et al., 1999 [24]	Nepal Himalayas	72–3705	1971–1994	49
Clow, 2010 [30]	Colorado Rockies	2560–3536	1986–2007	70
Qin et al., 2009 [8]	Tibetan Plateau	2000–5000	2000–2006	71; incl. satellite data
Diaz and Bradley, 1997 [4]	Global Mountains	1055–3310	20th Century	126

wide variety of data and methodologies have been used. Most studies utilized station observations and analysed the trends in diurnal temperature range on a global level [3,16,17]. Karl et al. studied the decreasing trend of diurnal temperature at the country level in the United States and Canada [18]. Another significant study used satellite measurements to understand the DTR [2]. All these studies analysed the diurnal temperature range at a global or country level and covered a limited amount of historical climatic data. In the present research, we focused on local level climatic changes using fifteen years of daily diurnal datasets.

However, to understand the impact of climate change in elevated areas, many studies have focused on mountainous regions. Table 1 contains a list of studies that assess elevation sensitive warming within mountainous regions.

Most studies focused on mountainous regions to address the impact of climate change in elevated zones; however, there are no such studies that show the climate change sensitivity in the elevated zone, especially considering the locally elevated regions or regionally elevated zones. In this study, we try to show elevation dependent warming scenarios considering locally elevated belts.

2. Study objective and hypothesis

Diurnal temperature range, or DTR, is one of the key indicators of climate change. The primary objective of this study is to analyse the changes in the diurnal temperature range in elevated and low lying regions to understand local climate change scenarios through daily diurnal data station based observations spanning fifteen years. This study also strives to find a significant relationship between elevation and local level climate change. Finally, we have conducted time series forecasting to understand future trends in DTR over the study region (see Figs. 1 and 2). Q5

This study hypothesizes that as the elevation increases, the DTR will increase and that the impact of climate change in the locally elevated zones will be less prominent compared to low lying regions of the study area (See Fig. 3). Therefore, there might be no

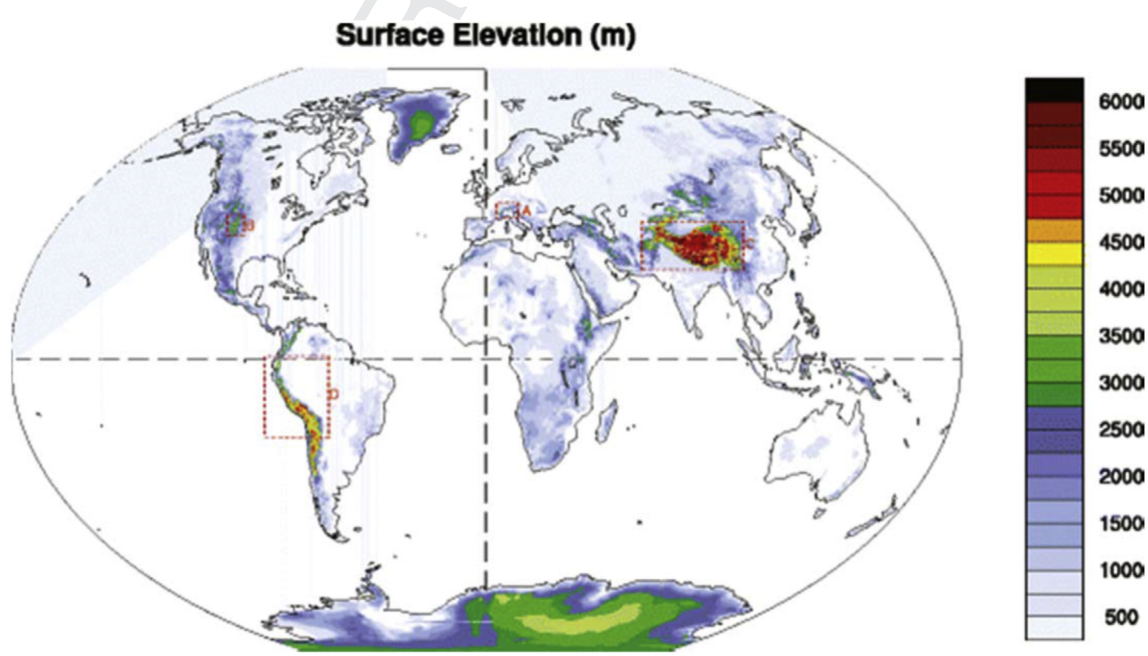

Fig. 1. Global land surface elevation (m). The dashed boxes and letters indicate the four mountain regions considered in this review: (A) the Swiss Alps, (B) the Colorado Rockies, (C) the Tibetan Plateau and the Himalayas, and (D) the Tropical Andes.
Source: Rangwala and James [33].