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SHORT PAPER

Data Analysis and Forecasting to Mitigate Climate Change in Drylands Areas*

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ABSTRACT

Drylands are zones covering over 40% of the planet's earth surface. Here, rainfall is balanced by processes involving water evaporation and by plants, which transpire. This short review looks at two key areas where drylands are increasing—the Sahara-Sahel-Arabian Peninsula (SSAP) zone and the Qinghai-Tibet Plateau in China—and shows ways that data analysis and forecasting in both geoengineering and in genomics techniques may help in understanding and progressing climate change mitigation.

KEYWORDS

climate modelling, omics, genetics, Arabia, Sahel, flowering, *Thlaspi arvense*

1 INTRODUCTION

Drylands are zones covering over 40% of the planet earth's surface. Here, rainfall is balanced by processes involving water evaporation and by plants, which transpire. Almost 100% of all hyper-arid lands are in the Global South. These arid regions have undergone highly significant temperature increases in the past century, and have contributed 44% to previous warming of the land [1]. This short review looks at two key areas, the Sahara-Sahel-Arabian Peninsula (SSAP) zone and the Qinghai-Tibet Plateau in China, and shows ways that data analysis and forecasting in both geoengineering and in genomics techniques may help in understanding and progressing climate change mitigation.

In recent times, the western part of the SSAP zone has produced humid conditions, while the eastern area has tended towards drought [2]. Cold temperature extremes have decreased, and warm temperature extremes increased in the Arabian Peninsula (AP) from 1986–2008 [3]. Drylands in China expanded by 8.3% from 1980–2015, as measured by an aridity index; expansion was in the NE region and the SW Qinghai–Tibet Plateau [4].

Geoengineering has been described as a deliberate large-scale intervention in natural systems of our planet in order to counteract the effects of climate change.

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It involves either carbon dioxide removal (CDR) or solar radiation management (SRM). Marine cloud brightening (MCB) has been proposed to help in cooling climate by increasing cloud reflectivity (albedo) in order to reflect some of the solar radiation into space. Cloud condensation nuclei, for example, sea salt, can be introduced into the marine boundary layer. This enables an increase in cloud droplet number concentration, reduces size of droplets, and so ultimately leads to an increase of the cloud reflectivity.

2 MARINE CLOUD BRIGHTENING IN THE SSAP ZONE

Using the Hadley Centre Global Environmental Model (version 2-Earth System) simulations of MCB [5, 6], six climatic extreme indices [i.e., hottest days (TXx), coolest nights (TNn), warm spell duration (WSDI), cold spell duration (CSDI), consecutive dry days (CDD) wettest consecutive five days (RX5day)] have been employed. Analysis of spatiotemporal development of climate extreme events in the SSAP zone, with and without MCB, has been studied. Compared with a representative concentration pathways (RCP) 4.5 scenario, from years 2030 to 2059, use of MCB was predicted to decrease the mean annual TXx and TNn indices by 0.4–1.7 and 0.3–2.1°C, respectively, for most of the SSAP zone. MCB would also decrease mean annual WSDI index by 118–183 days and mean annual CSDI index by 1–3 days. MCB could also lower mean annual CDD index by 5–25 days throughout the Sahara and Sahel belt and increase mean annual RX5day index by approximately 10 mm in the east part of the Sahel belt over 2030–2059. Overall, application of MCB could reduce both the frequency and intensity of heat waves and reduce drought over the SSAP.

3 THE GENETICS OF EARLY FLOWERING ON THE QINHAI-TIBET PLATEAU

Global warming and carbon emission from soils are related to land degradation and dryland expansion. Deforestation and overgrazing results in degradation of soil's biological, physical, and chemical properties. Overall, increased heat and drought, together with more extreme rains, are expected to intensify. These are predicted to expand the drylands, with consequent desiccation and degradation. Population growth, together with rising water and food demands as global climate changes continue, is expected to further expand drylands in China and elsewhere.

Understanding how organisms evolve and adapt to extreme habitats is of crucial importance in evolutionary ecology and in climate mitigation. There are distinct climate conditions at different altitudes, and height gradients are an important determinant of both distribution patterns and ranges of organisms Extreme environments at high altitudes include low temperature and oxygen concentration, poor soil, and high levels of UV radiation. This leads to few plant species populating heights greater than 4000 m. Field pennycress (*Thlaspi arvense*) can grow at such altitudes. It is a crop rich in oilseed, and it is also an emerging model plant found over a height range of nearly 4500 m. Modern hi-throughput DNA sequencing generates large amounts of data that can then be analysed and interpreted to show how organisms can themselves adapt and evolve in extreme climate situations [8]. Such analysis can detect naturally selected genes in the Qinghai-Tibet Plateau (QTP) populations. Some of these genes are involved in the ubiquitin system and in DNA repair and are potential candidate genes important in adaptation to high–altitudes [8].

Flowering early gives a competitive advantage to plants on the QTP. Alpine plants living on the QTP usually have to cope with a short growing and vegetation season, so that flowing time, which involves the life cycle and reproductive success of the plants, is critical [9]. Interestingly, high-altitude populations of field pennycress exhibited a single base mutation in the FLOWERING LOCUS C (FLC) [8]. This mutation may facilitate a rapid adaptation to the shorter growing season on the QTP.

4 DISCUSSION

Data analysis and forecasting with regard to climate change depends now and in the future on Big Data; which includes not only climate modelling but also Big Data in – omics studies, e.g., genomics, transcriptomics and metabolomics, in biology.

It is interesting that the SSAP zone is predicted to be drier and hotter with the G4cdnc scenario from 2030–2059 than it was from 1975–2004. This finding suggests that a 50% increase in the marine cloud CDNCs is not enough to reverse any warming trends in the future.

Large-scale genomics studies can identify several physiological processes and related genes implicated for adaptation to environments with extreme elevation and climate differences. Such studies providing a genome view of how organisms adapt to extreme and challenging environments may be useful in understanding how organisms can adapt in times of climate change.

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