Spatio-Temporal Dynamics of Global Potential Vegetation Distributions Simulated by CSCS Approach

Qisheng Feng
Lanzhou University, China

Tiangang Liang
Lanzhou University, China

Jiexie Hong
University of Texas at San Antonio

Xiaodong Huang
Lanzhou University, China

Jizhou Ren
Lanzhou University, China

The 22nd International Grassland Congress (Revitalising Grasslands to Sustain Our Communities) took place in Sydney, Australia from September 15 through September 19, 2013.

Proceedings Editors: David L. Michalk, Geoffrey D. Millar, Warwick B. Badgery, and Kim M. Broadfoot

Publisher: New South Wales Department of Primary Industry, Kite St., Orange New South Wales, Australia

Spatio-temporal dynamics of global potential vegetation distributions simulated by CSCS approach

Qisheng Feng [A], *Tiangang Liang* [A], *Hong Jiexie* [B], *Xiaodong Huang* [A] *and Jizhou Ren* [A]

[A] State Key Laboratory of Grassland Agro-ecosystems, College of Pastoral Agriculture Science and Technology, Lanzhou University, Lanzhou 730020, People’s Republic of China, www.lzu.edu.cn
[B] University of Texas at San Antonio, Department of Geological Sciences, Laboratory for Remote Sensing and Geoinformatics, San Antonio, Texas 78249, USA, www.utsa.edu/
Contact email: fengqsh@lzu.edu.cn

Keywords: Potential natural vegetation, spatial distribution, biogeography model.

Introduction

The study of Potential Natural Vegetation (PNV) has been proposed as a way to examine the impact of changes in climate on the distribution of vegetation. This study analyzes the influence of climate change in the potential vegetation distribution at global scale, using the Comprehensive Sequential Classification System (CSCS) approach to explore the changes of area, shift distance and direction for each broad vegetation category.

Methods

The CSCS approach for mapping potential natural vegetation

The CSCS approach is formulated through the grouping or clustering of units with similar moisture and temperature properties. CSCS consists of a three-class level. The class level is the basic unit, and determined by combining the quantitative biological climate indices of Growing Degree Days based on 0°C (GDD0) and humidity (K) (K=MAP/(0.1×GDD0), where MAP is the annual mean precipitation (mm); and 0.1 is a justified coefficient of the model (Fig. 1). The CSCS recognizes 42 vegetation classes which can be merged into 10 broad vegetation categories (Liang *et al.* 2012).

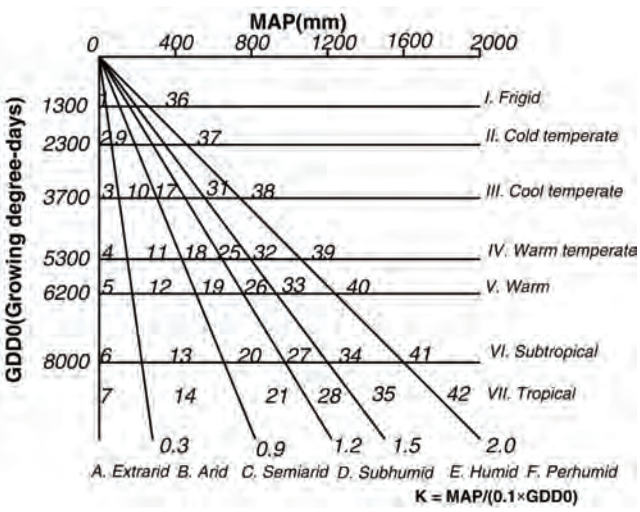

Figure 1. Index chart for potential vegetation class in the CSCS model.

Global potential vegetation maps

The CSCS PNV maps in the periods from 1911 to 1940 (T1), 1941 to 1970 (T2) and 1971 to 2000 (T3) are created by use of the global mean annual climatology data based on the CRU_TS 2.1 dataset in this study. To study the changes of global PNV distribution (*e.g.*, shift distance and direction), the model of the mean centre for each broad vegetation category is formulated using the method of Yue *et al*. (2010).

Results

Change in global PNV distribution from 1911 to 2000

From Figure 2, clear decreasing trends can be seen for the area of tundra & alpine steppe and desert categories. This has amounted to 6.06% and 5.90%, respectively, over the 90 years from 1911–2000. Over the same period, the area of forest and grassland vegetation categories has increased by 2.23% and 4.39%, respectively.

Shift distance and direction of each broad CSCS PNV category

The tundra and alpine steppe and semi-desert shifted towards the east in the northern hemisphere and west in the southern hemisphere (Fig. 3) while the frigid desert and subtropical forest tended eastwards in the northern hemisphere and southwest in the southern hemisphere. The warm desert shifted westerly, and savanna shifted towards the east. Temperate humid grasslands and temperate forest moved west in the northern hemisphere and southwest in the southern hemisphere while tropical forests shifted towards the west in the northern hemisphere and southeast in the southern hemisphere. The steppe trended towards northeast in the northern hemisphere and northwest in the southern hemisphere.

Discussion

Rising temperatures and the redistribution of precipitation will potentially play a significant role in plant physiology and lead to major changes in vegetation structure. This, in turn, might provide feedbacks on climate through an effect on meteorological conditions over the land surface. Changes of regional and seasonal climate patterns could strongly influence the diversity and distribution of species

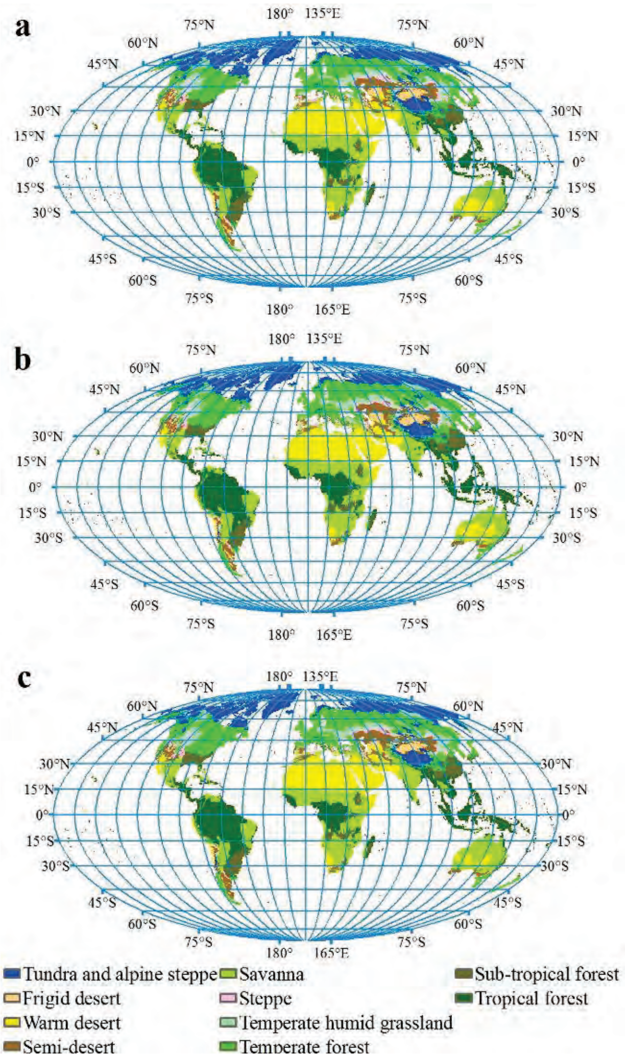

Figure 2. The geographic distribution of broad vegetation categories in the CSCS PNV maps simulated by the CRU TS 2.1 climatic data in the periods T1 (1911–1940) (a), T2 (1941–1970) (b) and T3 (1971–2000) (c)

and thus affect ecosystems and biodiversity. Theoretically, the CSCS model, based on the bioclimatic indicators, has the ability to reflect the generic succession relationships among the PNV classes/broad categories.

Conclusion

At a global scale, the CSCS model classifies the PNV into 42 classes that can be merged into 10 broad vegetation categories. Over the last 90 years from 1911 to 2000, the

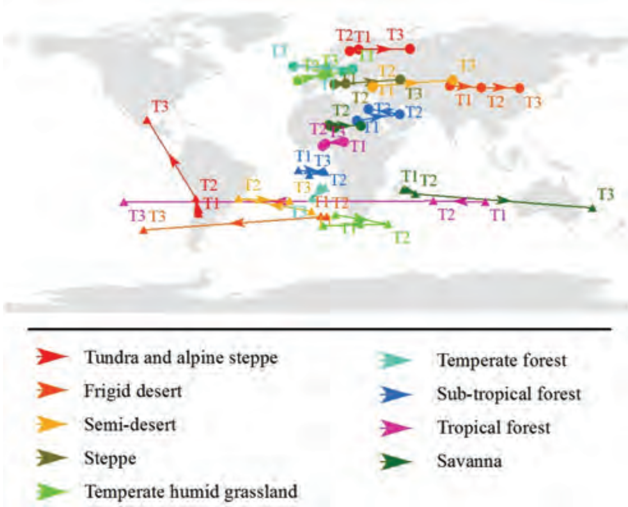

Figure 3. Shift distance and direction for the mean centers of broad vegetation categories in T1, T2 and T3 (The true start position in T1 and shift direction in all periods, with 10 times enlargement in the shift distance)

area of tundra & alpine steppe and desert shows a decrease (by 5.09% and 5.50%), while the area of forest and grassland shows an increase (by 2.31% and 3.76%). However, there was a significant difference in the magnitude of area change between the same vegetation categories in both northern and southern hemispheres. The shift distance of the warm desert in the southern hemisphere was the largest among the 10 broad vegetation categories. Except for tundra and alpine steppe, subtropical forest and temperate humid grassland, the shift distances in the southern hemisphere for the rest of 7 broad PNV categories were larger than that in the northern hemisphere.

Acknowledgments

This work was supported by the Chinese Natural Science Foundation projects (30972135 & 31228021) and the Cultivation Fund of the Key Scientific and Technical Innovation Project, Ministry of Education of China (708089).

References

Liang TG, Feng QS, Cao JJ, Xie HJ, Lin HL, Zhao J, Ren JZ (2012) Changes in global potential vegetation distributions from 1911 to 2000 as simulated by the Comprehensive Sequential Classification System approach. *Chinese Science Bulletin* **57**, 1298-1310.

Yue TX, Fan ZM, Chen CF, Sun XF, Li BL (2010) Surface modelling of global terrestrial ecosystems under three climate change scenarios. *Ecological Modelling* **222**, 2342–2361.