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Comment

Multilayer coupled mechanism Comment on "Impacts of climate change on vegetation pattern: Mathematical modeling and data analysis" by G.Q. Sun et al.

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Over the past few hundred years, the global climate system is experiencing significant changes characterized by global warming. Apart from the Arctic, the semi-arid region of the world is the one that has experienced the greatest warming [1]. It is concerning because if the average world temperature rises by 2 °C, the arid and semi-arid regions will see increases of 3.2-4 °C, making it possible to trigger severe climatic disasters and very likely to result in irreparable ecological damage [2].

In the atmospheric, ocean, and land spheres, the vegetation system plays a crucial role. The vegetation and climate system interact in a variety of ways, both directly and indirectly. On the one hand, changes in temperature, illumination, precipitation, and dust particles influence the degree of opening or closing of stomata on plant leaves, further impacting the three physiological processes that are the foundation of vegetation growth: respiration, transpiration, and photosynthesis. On the other hand, vegetation has a significant impact on the atmosphere's feedback loop. Increasing the vegetation coverage can successfully lower the air temperature, regulate the carbon-oxygen balance, and offer scientific solutions for the earliest possible attainment of carbon neutrality [3]. Nevertheless, the ecological environment is fragile and infrequently populated in northwest China's arid and semi-arid regions. Currently, the drought in the semi-arid region of northwest China has intensified due to the frequent occurrence of sand dust weather in the summer [2]. This has eventually resulted in the emergence of a significant number of vegetation self-organization structures, namely vegetation patterns.

We firmly believe that combining mathematical modeling and data analysis to study impacts of climate change on vegetation system by G. Q. Sun et al. [4], is a very novel and fascinating framework, which could contribute to design and decision making of ecological environmental protection strategies. In this review article, the author comprehensively and specifically accounts a variety distribution structure of vegetation patterns in arid and semi-arid areas, such as, Spots, Tiger bush (Stripes or Banded), Labyrinth, Gaps, Fairy circles (FCs) and so on, as well as the formation mechanisms underlying the vegetation pattern including scale-dependent feedback, phase separation principle and nonlocal effects. Except for this, the systemic review article explicitly reveals the key climatic factors

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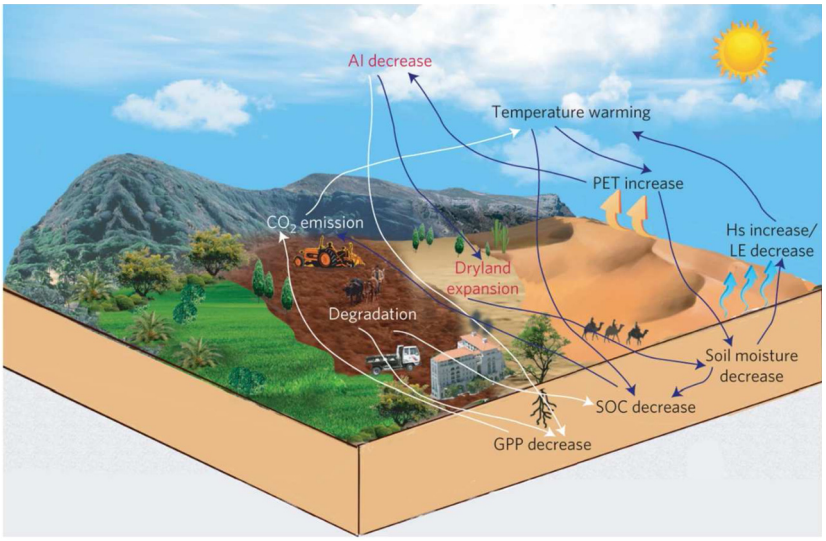

Fig. 1. Global regional land-atmosphere feedback schematic diagram (figure source [5]).

affecting vegetation growth and distribution, combined with meteorological data analysis from regional to global scale. As previously indicated, vegetation growth will be impacted by diverse climate parameters including precipitation, temperature, solar radiation and CO_2 concentrations, which can be taken into account in the vegetation dynamical modeling.

Unlike earlier research on the formation mechanism, structure and function of vegetation patterns, this paper primarily focuses on the combination of dynamical modeling and meteorological data. By establishing a coupled dynamical model of climate-vegetation system, the authors further investigated the characteristics of vegetation pattern evolution in Altay Prefecture under current climate change. Apart from these, the coupled dynamical model would be conducive to predict the vegetation distribution structure and density change status under four Shared Socioeconomic Pathways (SSPs) of the Sixth Coupled Model Intercomparison Project (CMIP6) datasets. In terms of vegetation patterns robustness, various scientific recommendations regarding the ecological protection of Altay and California are mentioned in this article.

Undoubtedly, this review paper promotes the integration of data analysis and the ecological dynamical model, as well as the blending of theory and actual application. Despite all this, we want to mention that it is really challenging to consider climate-vegetation system in global scale. The vegetation ecological environment is inseparable from the regulation of ocean circulation on climate system. Using the Ensemble Empirical Mode Decomposition method, Zhang et al. explored the impacts of El Niño-Southern Oscillation (ENSO) on variability of semi-arid ecosystems [6]. The Earth system models (ESMs) that couple atmosphere, ocean and vegetation system, interpreted either bistability between a vegetated and a desert state or oscillatory behavior [7]. Further, we still want to highlight the feedback from terrestrial vegetation to the atmosphere that might be interesting to investigate in the coming days [8]. The feedback mechanism of land-atmosphere interaction and drought proposed by Huang et al., found that an increase in surface temperature and the destruction of subterranean vegetation would inhibit soil carbon storage, cause more CO_2 to be released into the atmosphere, and intensify the greenhouse effect [5] (Fig. 1). On the contrary, the presence of a large number of vegetation can affect the global atmosphere and ocean circulation, thereby impacting regional precipitation, temperature, cloud layer and surface wind patterns [9]. Nowadays, the oxygen flux in large cities is seriously unbalanced, and the health threat is approaching. As a result, increasing urban vegetation covering will be a key measure in addressing this issue [10,11].

To sum up, we consider that data analysis combined by Sun et al. is prominent for the practical application of ecological dynamical modeling. It has a potential to inspire further studies regarding the effects of climate change on dryland ecosystems. The Authors illustrate the response of vegetation distribution to regional climate change, but they have ignored the impact of global air-ocean circulation on partial climate and the feedback effect of the vegetation system. We sincerely hope that our brief comments can complement these shortcomings in the review.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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