Thank you for your kind help and arrangement for reviewing our manuscript. All comments are constructive which have been taken into account fully when we prepared our revised manuscript. Point-by-point replies to the comments are addressed as below.

Line 233: The authors investigated the varying impacts of surface air temperature (TAS) and volumetric soil moisture (SM) on photosynthesis (GPP). The GPP was simulated using the Boreal Ecosystem Productivity Simulator model, which utilized meteorological data and evapotranspiration (ET) as inputs. Both of these inputs are closely linked with temperature and soil moisture, respectively. How did you avoid circular effects? Do these effects inflate the correlation coefficients?

I do not think the authors' response answered my question. They still did not explain the possible circular effects in the models.

Reply: Thank you for your comments. This question has been raised twice, so we wonder if there was a misunderstanding. We appreciate the opportunity to clarify further, and here is our additional explanation:

(1) As mentioned in the main text (Section: 2.1 Dataset Used), the BEPS model in this study was driven by satellite-derived LAI and meteorological data (such as temperature, precipitation, and downward solar radiation) to simulate GPP and ET. Therefore, ET is not an input in BEPS model and temperature is a direct driver.

(2) Correlation and regression are widely accepted statistical methods for analyzing the main drivers of GPP/NEP simulations (single model or TRENDY multi-model simulations) on an interannual scale (Zeng et al., 2005; Piao et al., 2013; Ahlstrom et al., 2015; Wang et al., 2016; Jung et al., 2017; Humphrey et al., 2018). Hence, there are no methodological problems.

(3) Regardless of temperature, as it is a direct driving factor, we admit that changes in soil moisture are indeed potentially related to temperature, which seems to be the "circular effect" you mentioned here. However, we prefer to use the terms "direct" and "indirect effect", that is, temperature has a direct effect on vegetation, and it can also affect vegetation by affecting soil moisture (indirect effect). Similarly, Humphrey et al. (2021) used the results of several Earth System Models (ESMs) to discuss the direct

and indirect effects of soil moisture on the inter-annual fluctuations of terrestrial carbon sinks. In response to this problem, we have added a few sentences to the discussion (**4.4 Limitations and Future work**), which are as follows: "*Finally, it is worth noting that climate factors often interact closely with one another. For example, soil moisture can influence changes in surface air temperature, and vice versa. As a result, in addition to direct effects, climate drivers may also impact vegetation through indirect pathways. Humphrey et al. (2021) discussed the direct and indirect effects of soil moisture on variations in terrestrial interannual carbon sinks—specifically, through its influence on temperature and vapor pressure deficit (VPD)—using simulations from four Earth System Models. This area of interaction warrants further investigation in future research*."

Line 240: In Figures 2.4a and 2.4e, please explain why the soil moisture does not align closely with the "pcor" in the east of Guangxi Province, east of Qinghai Province, and west of Sichuan Province. What other variables could affect this?

Regarding this question, I was expecting explanations in the discussion section to address why some regions deviate from the main general pattern, but the authors did not provide this explanation.

Reply: Many thanks for your comments.

(1) In terms of climate factors, temperature and water (precipitation or soil moisture) have long been recognized as the primary climate factors driving the inter-annual fluctuations of GPP/NEP (Zeng et al., 2005; Piao et al., 2013; Ahlstrom et al., 2015; Wang et al., 2016; Jung et al., 2017; Humphrey et al., 2018). Of course, it is undeniable that it is also regulated by other climate factors, such as VPD and radiation. Given that this study includes two climate oscillations (ENSO and IOD) across four seasons, incorporating additional climate factors would complicate the analysis. Therefore, this study focuses on the roles of temperature and soil moisture in driving the inter-annual fluctuations of GPP across different seasons for simplicity.

(2) In Figure 2, we calculate pattern correlations at the national scale to identify the primary driver of GPP variations. We acknowledge possible mismatches between the

pcor patterns of GPP and TAS/SM in specific regions. This mismatch may result from the weak relationship between GPP, TAS/SM, and ENSO in certain areas, as well as the influence of other factors on GPP variation, as previously mentioned.

(3) For this aspect, we have added some discussion in **4.4 Limitations and Future work** as "*Additionally, Temperature and water (precipitation or soil moisture) have long been regarded as the main climate factors driving inter-annual fluctuations of GPP or NEP (Zeng et al., 2005; Piao et al., 2013; Ahlstrom et al., 2015; Wang et al., 2016; Jung et al., 2017; Humphrey et al., 2018). However, other factors, such as VPD and radiation, also play important roles. This may explain the occasional mismatch between GPP patterns and TAS/SM in certain regions in Figs. 2 and 3. Overall, although the dominant driving factors vary seasonally, TAS and SM capture GPP variations more effectively on a national scale.*"

Reference

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