Winter teleconnections can predict the ensuing summer European crop productivity

Climate change impact assessment on agricultural crop productivity is becoming an important research arena given the increasing yield losses due to the high frequency of droughts in recent years and the anticipated prevalence of extreme events in future climate scenarios (1–3). It is said that by the middle of the 21st century, climate change probably will result in more frequent wheat crop failures across Europe (1). Most studies examine crop yield and physiology responses to externally forced climate change, particularly variations in temperature, precipitation, or atmospheric CO_2 concentration. The impacts of internal climatic oscillations on crop productivity are often overlooked. Projections of climate change impacts on crop yields are therefore inherently uncertain (2, 3). However, farmers expect the quantification of the impacts and forecasting ability ahead of cropping season to operationally plan potential management options and produce an economically viable yield.

In a recent issue of PNAS, Moore and Lobell (4) present recent climate change impacts on European crop yields based on regression models using subnational growing season temperature and rainfall data. They (4) attribute the recent European temperature trends and its impact on crop yield to anthropogenic forcing. Although attribution of recent climate trends to greenhouse gas emissions is now well established, the European crop yield productivity may be responding more strongly to the changes in the two prominent climatic oscillations on the region, namely, the North Atlantic Oscillation (NAO) and the Scandinavia Pattern (SCA).

For the time period 1980–2012, the winter NAO and SCA show strong potentials on predicting wheat yield and normalized difference vegetation index (NDVI), which indicates physiological fitness of plants (Fig. 1). NAO significantly predicts NDVI for Estonia, Czech Republic, Luxembourg, Latvia, Belgium, Germany, The Netherlands, Poland, Lithuania, and Denmark, and wheat yield for Sweden and Denmark (Fig. 1), whereas SCA significantly predicts NDVI for Slovenia, Belarus, Moldova, Aland Islands, Liechtenstein, Ukraine, Estonia, Czech Republic, Luxembourg, Latvia, Belgium, Germany, The Netherlands, Poland, Lithuania, and Denmark, and wheat yield for Sweden and Denmark (Fig. 1). The discrepancy of oscillation indices performances on predicting NDVI and wheat yield could be explained by different and changing crop management used within each country among annual time series data and the varying quality of crop yield data.

In recent decades, NAO and SCA have remained in one extreme phase, contributing significantly to the recent wintertime warmth across Europe, which is linked to recent dry conditions over southern Europe and wetter-than-normal conditions in northern Europe (5). The nature of climatic oscillations, and changes in their behavior, including predictably of rainfall, snowfall, droughts, heat wave, or temperature patterns with a few months lead time, are central to understand agricultural crop productivity. The winter NAO and SCA patterns provide early warning to farmers to plan and take adaptive measures to minimize yield losses during the growing-season summer months of European countries. Our analysis highlights one of several often-overlooked aspects of agricultural crop yield responses to the anticipated changes in the behavior of climatic oscillations linked to future climate changes.

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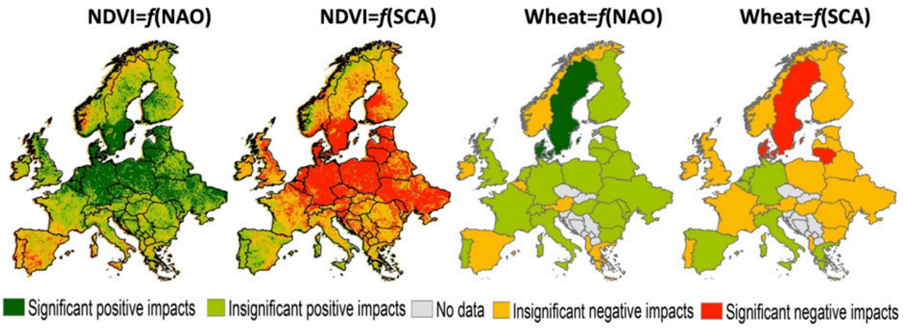

Fig. 1. Impacts of North Atlantic Oscillation (NAO) and Scandinavia Pattern (SCA) on European vegetation productivity and wheat yield. The climatic oscillation anomalies are calculated as a mean value of December of the preceding year and January, February, and March of the normalized difference vegetation index (NDVI) and wheat yield year. All of the climatic oscillation indices, NDVI, and wheat yield data were detrended. The significance level was set at 95% confidence level from a two-tailed Student *t* test. The annually aggregated growing-season 30-y (1982–2011) 8-km satellite NDVI data were obtained from the Global Inventory Modeling and Mapping Studies third-generation (NDVI3g). Climatic oscillation indices were obtained from the National Oceanic and Atmospheric Administration (www.cpc.ncep.noaa.gov). The 33-y (1980–2012) national scale wheat yield (tons per hectare) data were obtained from Food and Agricultural Organization (faostat.fao.org) for European countries.