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Assessing the CO2 fertilization effect on cereal yield in Morocco using the CARAIB dynamic vegetation model driven by Med-CORDEX projections

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In Morocco, the economic weight of agriculture is so high that any temporal trend or seasonality change in the climate will immediately affect the country economy, particularly that involving crops used as the basis of food security like cereals. It is therefore necessary to develop knowledge about CO2 fertilization effect on cereal crops and strengthen forecasting systems for predicting the impacts of climate change.

Dynamic Vegetation Models can be used to investigate and interpret vegetation trends related to increasing levels of atmospheric CO2. In fact, an increase in CO2 concentration causes an elevated photosynthesis rate, resulting in more energy and thus a quicker development of the plant. On the other hand, it reduces the amount of water needed to produce an equivalent amount of biomass. Hence in dry areas like Morocco, it may significantly alter future crop production and reduce the negative effects of climate change on agricultural yields.

CARAIB (CARbon Assimilation In the Biosphere) is a dynamic vegetation model developed to study the role of vegetation in the global carbon cycle and to study vegetation distribution in the past, the present, and in the future. The model is composed of several modules dealing with soil hydrology, photosynthesis and stomatal regulation, carbon allocation and biomass growth, soil and litter carbon dynamics, and natural vegetation fires. CARAIB was improved by the addition of the crop module. In fact, crop growth is driven by photosynthetic activity but differs on the use of phenological stages. Two stages are defined (from sowing to emergence, and from emergence to harvesting). These stages are completed when a prescribed level of heat is reached based on the growing degree days. The yield is then estimated from net primary productivity using a harvest index.

The simulations are performed across all Morocco. The three main cereal crops simulated include soft wheat, durum wheat, and barley, they are grown in all agro-ecological zones. The simulation of the recent period was dedicated to the validation of the crop module over Morocco. For temporal and spatial validation, we used yearly yield data collected between 1997 and 2017 at the scale of the smallest territorial unit which is the municipality. To assess the impact of CO2

concentration on cereal yield, we are using interpolated and bias-corrected fields from a regional climate model (ALADIN-Climate) from the Med-CORDEX initiative run at a spatial resolution of 12 km driven by two Representative Concentration Pathway scenarios (RCP4.5 and RCP8.5) and three horizons (2020-2040, 2041–2060 and 2081–2100). Modeling is conducted twice, one with an annually adapted concentration according to the RCPs, and another one with fixed concentration to separate the influence of CO2 from that of the other input variables.