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Influences of climate change on agri-forestry systems

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The physiological development of most plants is largely controlled by atmospheric parameters, such as air temperature, precipitation, moisture, radiation and wind, among others. Furthermore, many environmental conditions (e.g. soil moisture) are considerably influenced by atmospheric parameters, thus underling indirect plant-atmosphere relationships. These relationships are far from being linear, as the plant response to a given atmospheric perturbation is a function of optimal growing conditions and limiting thresholds, which are also variety-dependent. Overall, agri-forestry systems tend to be highly sensitive to both climate (long-term changes in atmospheric parameters) and weather (short-term changes in atmospheric parameters), including their extremes. The most sensitive systems may also be more vulnerable to climate change, whereas the less sensitive may be more resilient. For each location, plants are gradually selected either by natural processes or by human-decisions, often based on the suitability of local conditions to their growth, also envisioning economic revenue and sustainability. Bioclimatic indices are commonly-used tools to assess plant-relevant climatic features, as they take into account specific climatic measures that have been related to plant physiological development, phenology, yields and quality attributes. The spatial patterns of these indices can thereby be relevant variables in explaining the current distribution of different plant species. Under future climates, these patterns are projected to undergo shifts. These shifts may help assessing the impacts of climate change on agri-forestry systems, promoting the development of guidelines and measures to adapt and mitigate detrimental impacts, e.g. by alleviating biotic and abiotic stress or through the selection of more suitable crops/varieties for future conditions.

For the specific case of Portugal, a ‘hot spot’ of climate change in Europe, significant warming and drying trends are projected under different greenhouse gas emission scenarios. As an illustration, some examples of bioclimatic assessments under present and future conditions in Portugal will be presented, giving particular emphasis to economically-relevant crops, such as grapevines, fruit trees (e.g. olives, almonds, citrus fruits, pears, apples and cherries) and forest species (e.g. cork oak, eucalyptus and pine trees). State-of-the-art observational datasets (E-OBS and WorldClim) and regional climate model ensembles (CMIP5 Euro-CORDEX), with experiments for both past and future periods, are used for this purpose. Model runs for future periods are forced by two Intergovernmental Panel on Climate Change (IPCC) representative concentration pathways – RCP4.5 and RCP8.5, which provide greenhouse gas emission scenarios until the end of the 21st century.

Bioclimatic indices at very high spatial resolution (~1 km grid spacing), using a combination of dynamical and statistical downscaling strategies (spatial interpolation techniques and pattern downscaling), will be presented. An overview of the likely climatic shifts will be provided and some potential impacts for different agri-forestry systems will be discussed. In fact, these shifts may trigger biotic and abiotic stresses that need to be timely and adequately tackled. Amongst the different abiotic stresses driven by climate change in Portugal, water stress is expected to become the most prominent, urging e.g. for improvements in water use efficiency, irrigation re-scheduling, use of cover crops, changes in soil management, adaptation of agricultural practices and selection of more drought-resistant varieties. Furthermore, there is a rather complex interplay between plant growth, water stress, nutrient stress and fertilization. As such, in order to assess potential climate change impacts on specific plants and to test different adaptation measures, process-based (dynamic) crop models (INRA-STICS and FAO-AquaCrop), already calibrated and validated for some Portuguese crop-variety pairs, are used. These models are indeed important decision support systems for agri-forestry sectors. Preliminary modelling results regarding climate-induced abiotic stresses on some crops in Portugal will be presented. However, further and sustained research, including model and field experiments, is critical for a better understanding of the climate-plant relationships and of the mechanisms underlying climate change, as there are still considerable uncertainties in the climate change impacts. Lowering uncertainties is essential for decision-making.