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Impact of climate change on the vegetation cycle over France and the associated uncertainties

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Climate is traditionally characterized by atmospheric variables such as air temperature. In the context of climate change it is important to consider, also, terrestrial variables more directly linked to life, such as the above-ground biomass of vegetation or soil moisture. The ISBA (Interactions between Soil, Biosphere and Atmosphere) model is developed by Meteo-France and is used in the CNRM APREGE climate model through the SURFEX surface modelling platform. ISBA is also used in many European atmospheric and hydrological models to simulate the water and energy fluxes on a sub-hourly basis. This model is able to simulate photosynthesis, plant growth, and carbon storage into soils. ISBA is a generic model able to represent the main vegetation types using a limited number of parameters. In this study, ISBA was forced by the atmospheric variables produced by different climate models. An ensemble of eleven downscaled climatic simulations was used to characterize consistent future trends over France. The simulations covered 150 years from 1950 to 2099. Two time horizons 2020-2049 (near future) and 2070-2099 (distant future) were compared to the 1970-1999 period. Four vegetation types (rainfed straw cereals and grasslands, broadleaf and coniferous forests) were considered. The leaf area index simulations were used to determine phenology variables (leaf onset, leaf offset). A statistical analysis permitted quantifying the impact of climate change and to show whether the future trends were significant or not. The uncertainties related to these trends were characterized. A spatial classification method was developed in order to map the spatial variability of the impact of climate change. An earlier leaf onset was simulated for all the vegetation types, everywhere in France. The CO_2 effect triggered a slight increase in the productivity of grasslands (first cut) and of straw cereals. On the other hand, the forest productivity displayed high uncertainties as it was very sensitive to the use of a given climate model. Other trends presented regional characteristics. In the Brittany-Normandy-Picardy area, ISBA simulated a much earlier leaf offset than today for all the vegetation types, in relation to a more pronounced summer drought. In the Poitou region, forest defoliation occurred much earlier than today. Conversely, the model simulated a slightly later leaf offset of broadleaf forests in the Vosges, Jura, and Dauphiné mountainous areas. A much earlier leaf onset was simulated for low vegetation in the Mediterranean area. Finally, leaf offset correlated better to drought duration than to air temperature. This shows that developing in situ soil moisture networks could help monitoring the long-term impacts of climate change.