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The Mediterranean viticulture in response to global climate change drivers, the lesson of the past

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Using a statistical emulator of a coupled climate-ecosystem model, this paper proposes a method to link the vine potential productivity and the viticulture extension in the Mediterranean area to global climate drivers, such as orbital parameters, solar and volcanic activities and greenhouse gas concentrations. The emulator was calibrated on several tens of simulations of earth system models in various situations from the PMIP3 past (Last Glacial Maximum, Mid-Holocene, last millennium) and the CMIP5 future simulation up to 2100 under several RCP scenarios. The key climate variables produced by these simulations were introduced in an ecosystem model (BIOME4), so the ecosystem variables can be directly estimated from the global drivers. The large variation of situations used for calibration produces a robust emulator able to extrapolate to a large range of past and future climate states. Applied to the Mediterranean and European area, the emulator has been validated on several key periods of the past where the climate is known to have much changed. Finally, it was used to simulate the viticulture extension not only for these key past periods but also for different scenarios of the future, related to a global warming of 1.5°C, 2°C, 3°C and 5°C. Even if human groups are mainly responsible of viticulture extension, climate is a driver in the way that bad climate conditions may be a limit to extension or even a driver of regression.

The main findings are: (i) If the climate change projected for the future can be attributed to greenhouse gases increase as expected, the variations of the last millennia in the Mediterranean Basin can be attributed to the volcanic activity, the solar activity effect being negligible; (ii) the effects of these volcanic forcing on the climate are not necessarily uniform across the basin and had a large impact on the viticulture as they were sufficiently important to be responsible of extension of viticulture on the whole Gaul during the Roman Climate Optimum; (iii) for the future, it is projected large difficulties for viticulture in Spain and North Africa. They will be particularly important for a global warming of +3°C and more; (iv) there is little hope that an intense volcanic activity could slow down this regression.