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Simulating cropping periods to parametrize varieties′ phenology at the global scale

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Phenology is a fundamental trait characterizing crop varieties, and it largely determines the selection of these in different environments. To simulate phenological development is a key feature of most crop models at any scale. There is a general lack of information on how crop varieties are distributed globally, and therefore on how to parametrize phenological traits in global-scale vegetation models.
We address this issue by developing a model (routine) to simulate global cropping periods of six major grain crops. The sowing dates are estimated as proposed by Waha et al. (2012). With a consistent rule-based approach, we simulate the most suitable harvest dates. We derive from the literature some physiological traits of the crops, such as temperature thresholds for growth and development, and the time allocated to different phenophases. The occurrence of suitable periods for critical stages of the crop cycle is then used to classify the climate in each location and to identify the most suitable growing season for each crop.
The simulated cropping periods are on average in agreement with the two most applied global datasets (MIRCA2000 and SAGE) in the modelling community. Our model highlights the central role of climate and crop physiology in the agronomic decision making process. The results show that a single set of rules (with crop-specific parameters) is valid for simulating the growing season of any of the grain crops. To set the sowing time and the reproductive phase in non-stressful periods are both strategies to optimize crop productivity. The species studied here have similar optimum temperature for the reproductive phase, while they differ more in the base temperature for sowing, as well as in the duration of the flowering to physiological maturity period. These aspects together largely influence the selection of the best growing period of the different grain crops.
Due its simplicity, the model cannot capture the entire variability of the observed calendars, certainly because other factors play a role in the choice of cropping periods. Nonetheless, the model introduces a new way for simulating the decision making process in agricultural management for the crop variety choice. This is strongly needed for a realistic representation of global agricultural systems, and for their dynamic simulation under climate change. Finally it represents the first step toward an improved crop phenology, which would lead to enhanced crop modelling performances, but could also improve simulated land-surface dynamics in earth system and terrestrial ecosystem models.