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A theory and data based model of wheat yield

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Climate is an essential influence on crop development and grain harvest. But despite considerable efforts to model climate change impacts, there is still considerable uncertainty over the consequences of environmental change for the yields of major crops. This may in part be because the existing crop models are too complex and too much reliant on specific assumptions about processes. There are good reasons to seek simpler models with a strong theoretical and empirical basis. In this study, we developed a parsimonious, theory- and data-based model of wheat yield in China. We first predicted gross primary production (GPP) using a generic light-use efficiency model driven by climate, CO_2 and foliage cover. This model is built on ecological first principles and well supported by eddy covariance flux observations in all biomes. Modelled GPP agrees very well with observations at a research site (R2 = 0.89). We then established a relationship between grain yield and aboveground biomass based on the data at six sites. We found that yield follows a saturation function with aboveground biomass. Non-linear mixed-effects regression showed that aboveground biomass and nitrogen application amount accounted for more than 60% of yield variation while differences in wheat varieties explained about 13%. In the end, we were able to estimate wheat yield from GPP assuming that GPP is proportional to accumulated aboveground biomass. We were then able to successfully track the interannual variation and trends in yield, and to perform sensitivity analyses providing a first “new look” at the impacts of global change scenarios on wheat production in different regions.