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Bivariate return periods of temperature and precipitation explain a large fraction of European crop yields

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Crops are vital for human society. Crop yields vary with climate and it is important to understand how climate and crop yields are linked to ensure future food security. Temperature and precipitation are among the key driving factors of crop yield variability. Previous studies have investigated mostly linear relationships between temperature and precipitation, and crop yields variability. Other research has highlighted the adverse impacts of climate extremes such as drought and heat waves on crop yields. Impacts are, however, often non-linearly related to multivariate climate conditions. Here we derive bivariate return periods of climate conditions as indicators for climate variability along different temperature-precipitation gradients. We show that in Europe, linear models based on bivariate return periods of specific climate conditions explain on average significantly more crop yield variability (42%) than models relying directly on temperature and precipitation as predictors (36%). Our results demonstrate that most often crop yields increase along a gradient from hot and dry, to cold and wet conditions with lower yields associated with hot and dry periods. The majority of crops are most sensitive to climate conditions in summer and to maximum temperatures. The use of bivariate return periods allows the integration of nonlinear impacts into climate-crop yield analysis. This offers new avenues to study the link between climate and crop yield variability and suggests that they are possibly more strongly related than what is inferred from conventional linear models.