Climate change threatens the viability of temperate fruit orchards in the Mediterranean region

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1. Introduction

- Temperate fruit trees undergo winter dormancy. To flower in spring, buds need a combination of cold (chill) and warm (heat) temperatures
- Effect of warming winters on flowering is uncertain, as it accelerates heat accumulation but slows chill accumulation → Climate change can lead to earlier, unchanged and even delayed flowering
- Consequences are increased frost risk during bloom, physiological anomalies and bloom failure in the worst case
- **Information on future bloom and potential failure rates help to identify climate change-adapted cultivars**

Main goal

Project shifts in **bloom date** and potential **failure rates** under **future climate conditions** for major **temperate fruit tree** species in the **Mediterranean region**.

Study region

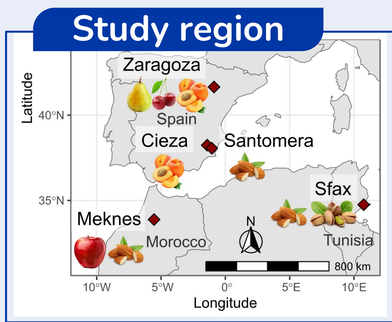

Fig. 1: Phenology and temperature data from five locations in three countries including six species (cherry, pistachio, almond, apricot, apple) and 99 cultivars in total.

2. Methodology

- Subset of long-term phenology database of cultivars with ≥ 20 observations
- Calibrate PhenoFlex model with phenology and temperature data (75%)
- Evaluate model by withheld phenology data (25%)
- Repeat calibration and validation for ten data splits, combine predictions as a validation-weighted mean
- Project bloom dates and potential bloom failure rates using calibrated models for 4 climate change scenarios and 2 scenario periods (2035 – 2065, 2070 – 2100) and 14 – 18 global circulation models from CMIP6

Key Finding

Almond and pistachio in Tunisia, apricot in southern Spain and apple production in Morocco threatened by reduced chill, northern Spain unchanged.

3. Results

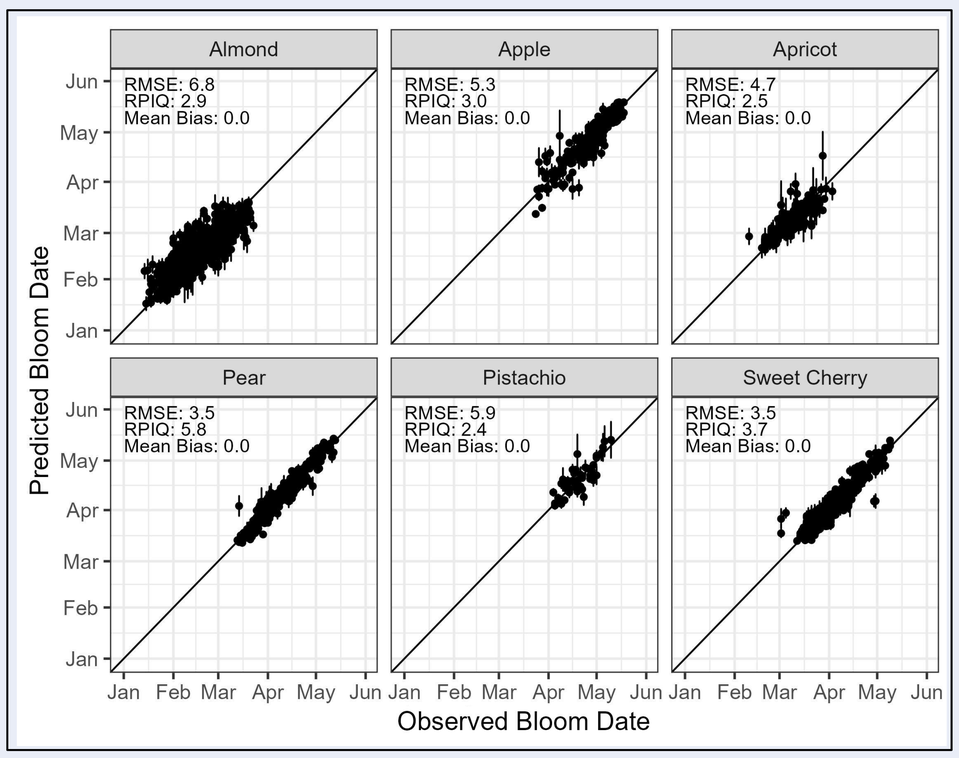

Fig. 2: Predicted and observed bloom dates using the validation-RPIQ-weighted predictions of the 10 repetitions of fitted models within a cultivar (ensemble model) for each species. Performance is summarized at species level; predictions are made at cultivar level. Error bars show the standard deviation of the ensemble member predictions.

- Calibrated models predict bloom dates well (RMSE 3.5 to 6.8)
- Prediction in locations with sufficient winter chill are more precise than in Tunisia and Morocco
- No shifts in bloom dates in northern Spain (Zaragoza) for most species
- Strong delays coupled with pronounced risk of bloom failure for pistachios in Tunisia (Sfax), apricots in southern Spain (Cieza), almonds in Tunisia (Sfax) and southern Spain (Santomera) and apple in Morocco
- Cultivar-specific responses especially in apricots

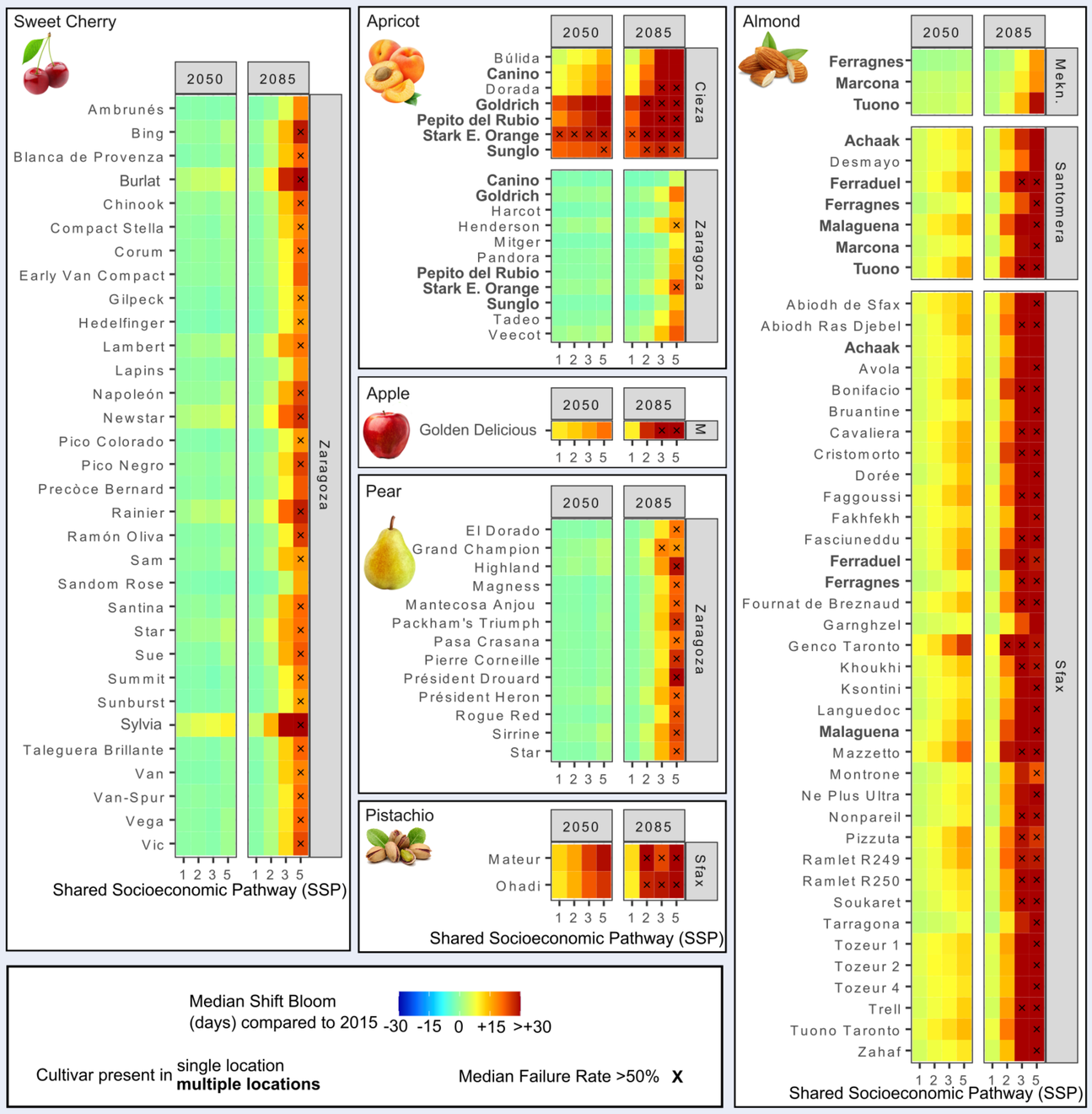

Fig. 3: Heatmap showing changes in median bloom date (days), relative to simulated 2015 conditions, for projected future conditions for four shared socioeconomic pathways (SSP1, SSP2, SSP3, SSP5). Cultivars with observations from several locations are marked in bold font. Cases with rates of more than 50% unfulfilled thermal requirements are marked with an 'x'. The modeled location Meknes is abbreviated as 'Mekn.' and 'M'.

4. Conclusions

- Constant bloom dates and low failure rates for all species in northern Spain and almonds in Morocco
- Long-term production problems due to insufficient future winter chill for apples in northern Morocco (Meknes) and pistachios in Tunisia (Sfax)
- Cultivar-specific responses of apricots and almonds indicate potential for climate change-adapted alternatives

Phenology data

HortiBonn

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