

Research motivation and aim

- **Southern Europe** is a **climate change hot spot** and affected by disproportionately large phenological changes compared to other world regions
- How did **phenological phases shift** in southern Europe over the last decades for different **plant functional types**?
- Which are the **main climatological drivers** of phenological patterns?

Methods

- **Linear (mixed effect) model** based on 2586 time series
- Predictors: Normalized, 30-day anomalies of mean temperature and precipitation sum
- BBCH scale aggregated into four categories (**leaf unfolding, flowering, fruiting, senescence**)

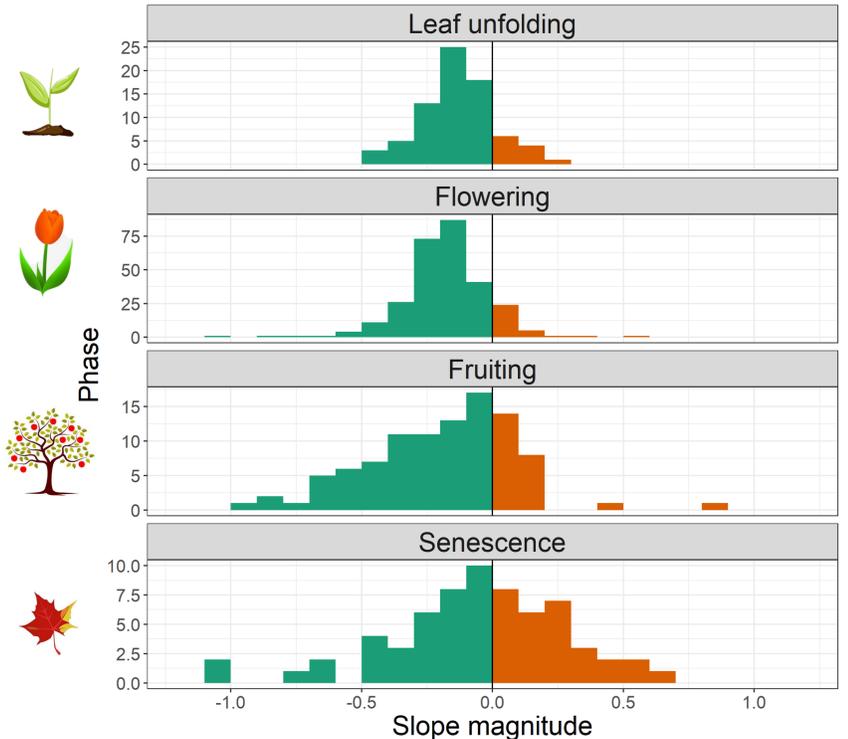


Fig. 1: Magnitude of regression slope of phenological trends (days per year) for all species for leaf unfolding, flowering, fruiting and senescence

Data



| Data set | Type | Time span | Extent |
|--------------------|----------------|-----------|--------|
| E-OBS | Climatological | 1950-2020 | Europe |
| PEP725 | Phenological | 1946-2020 | Europe |
| Tempo / Perpheclim | Phenological | 1954-2020 | France |
| AEMET | Phenological | 1984-2020 | Spain |

Plant functional type

- Deciduous broadleaf tree
- Evergreen needleleaf tree
- Evergreen broadleaf tree
- Deciduous shrub
- Evergreen shrub
- Crop
- Perennial herb

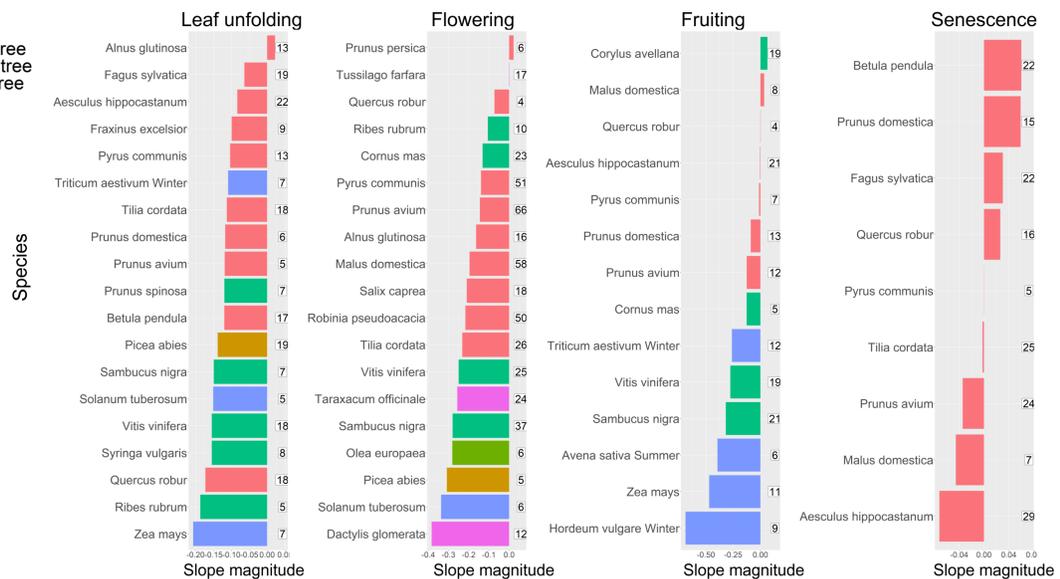


Fig. 2: Mean magnitude of regression slope of phenological trends (days per year) per species and phenophase. The corresponding number of time series is stated on the right side of each bar.

Results

- Temporal development
 - Advancement of leaf unfolding, flowering and fruiting (Fig. 1)
 - No clear pattern for senescence (Fig. 1)
 - **Advancement of phenophases of deciduous broadleaf trees is slower compared to crops and shrubs** (Fig. 2)
- Climatic predictors
 - Temperature of the preceding 2 months determines leaf unfolding and flowering, whereas for fruiting the previous 2-4 months predominate (Fig. 3)
 - Dry conditions advance leaf unfolding and flowering (Fig. 3)

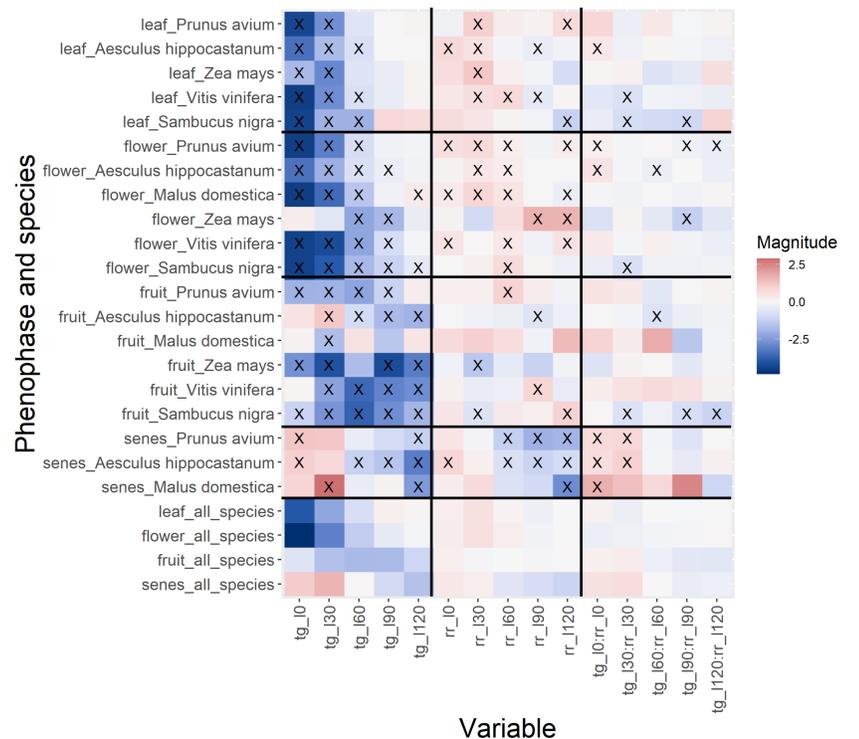


Fig. 3: Regression coefficient of explanatory variables for various species for the phenophases leaf unfolding, flowering, fruiting and senescence. Mean temperature (tg), precipitation sum (rr) and their interaction term (tg:rr) are shown for time lags of 0, 30, 60, 90 and 120 days. Significant coefficients are indicated by black crosses.