



International Conference on Phenology
5 - 8 October 2015, Kusadasi (Turkey)



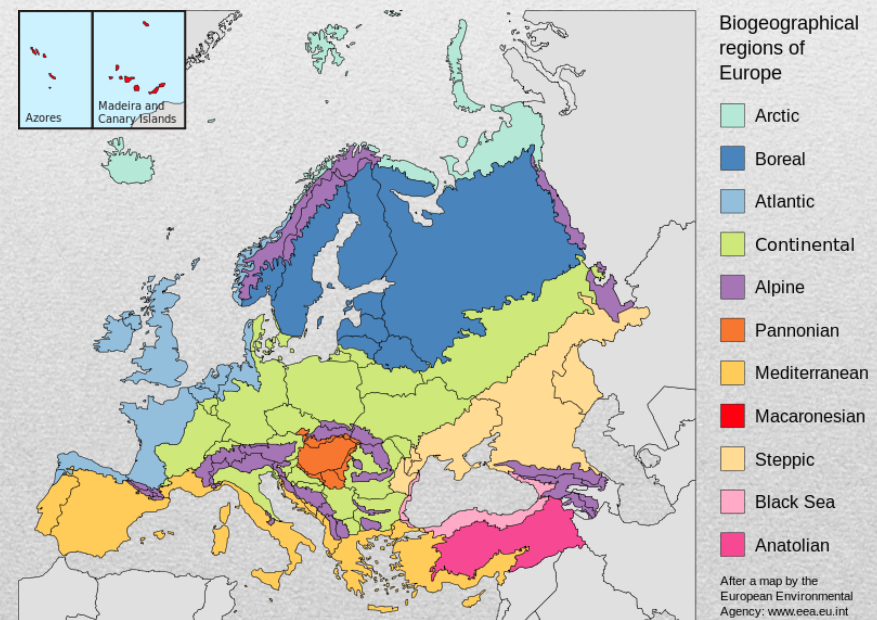
Biogeographical regions and their flowering phenological patterns across Europe

Barbara Szabó¹, M. Templ, P. Filzmoser, A. Lehoczky, R. Pongrácz, G. Kalvane, E. Baksiene, A. Briede, H. Gregow, S. Hodzic, K. Jatczak, E. Kubin, P. Nejedlik, T. Niedźwiedźz, V. Palm, T. Popovic, D. Romanovskaja, Z. Snopkova, S. Stevkova, J. Terhivuo†, V. Vucetic, A. Zust

¹ Eötvös Loránd University and Centre for Ecological Research, Hungary

- climate change is evident across Europe causing a wide range of impacts on the environment (EEA, 2012)
- from the Northern (Schwartz et al. 2006) to the Southern Hemisphere (Chambers et al. 2013) shifts in timing of particular stages of plant development observed
- these responses are species- and phenophase- specific, geographical differences in their main drivers

- Biogeographical regions “are useful geographical reference units for describing habitat types and species which live under similar conditions in different countries” (Roekaerts, 2002).



Introduction

Arctic

Temperature rise much larger than global average
Decrease in Arctic sea ice coverage
Decrease in Greenland ice sheet
Decrease in permafrost areas
Increasing risk of biodiversity loss
Intensified shipping and exploitation of oil and gas resources

North-western Europe

Increase in winter precipitation
Increase in river flow
Northward movement of species
Decrease in energy demand for heating
Increasing risk of river and coastal flooding

Coastal zones and regional seas

Sea-level rise
Increase in sea surface temperatures
Increase in ocean acidity
Northward expansion of fish and plankton species
Changes in phytoplankton communities
Increasing risk for fish stocks

Mediterranean region

Temperature rise larger than European average
Decrease in annual precipitation
Decrease in annual river flow
Increasing risk of biodiversity loss
Increasing risk of desertification

Increasing water demand for agriculture
Decrease in crop yields
Increasing risk of forest fire
Increase in mortality from heat waves

Expansion of habitats for southern disease vectors
Decrease in hydropower potential
Decrease in summer tourism and potential increase in other seasons

Northern Europe

Temperature rise much larger than global average
Decrease in snow, lake and river ice cover
Increase in river flows
Northward movement of species
Increase in crop yields
Decrease in energy demand for heating
Increase in hydropower potential
Increasing damage risk from winter storms
Increase in summer tourism

Mountain areas

Temperature rise larger than European average
Decrease in glacier extent and volume
Decrease in mountain permafrost areas
Upward shift of plant and animal species
High risk of species extinction in Alpine regions
Increasing risk of soil erosion
Decrease in ski tourism

Central and eastern Europe

Increase in warm temperature extremes
Decrease in summer precipitation
Increase in water temperature
Increasing risk of forest fire
Decrease in economic value of forests

Observed and projected climate change and impacts for biogeographical regions of Europe (EEA, 2012)

- to compare various biogeographical regions, and test whether the areas experienced advancement in timing of flowering
- to evaluate the possible factors that influence phenological shifts
- to discover phenological patterns along various latitudes and periods

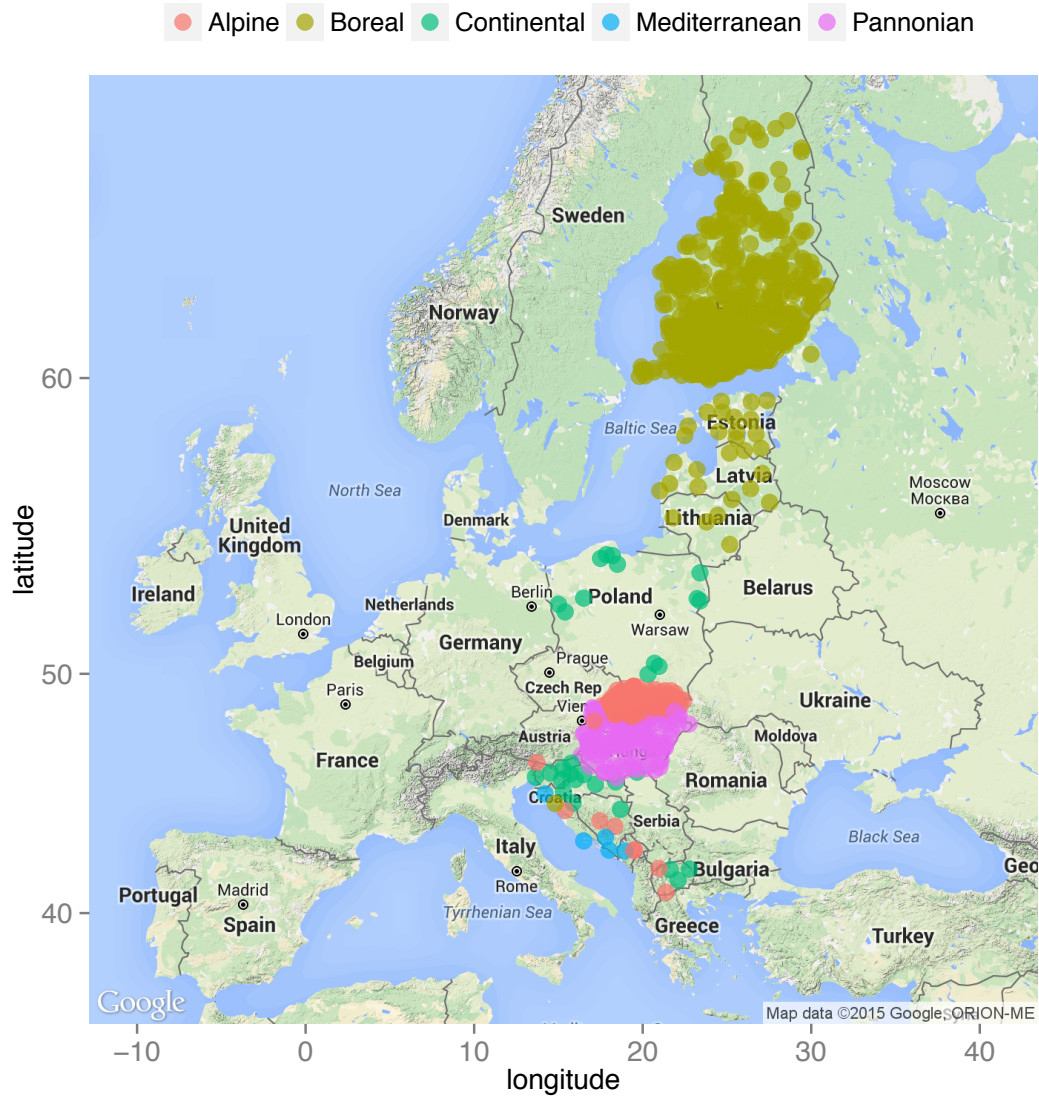
Motivation

Materials and Methods: Phenological datasets



- 6 wild plant species
(*Convallaria majalis*, *Sambucus nigra*, *Syringa vulgaris*, *Taraxacum officinale*, *Tilia cordata*, *Robinia pseudoacacia*)
 - flowering phenological observations from north-south transect in Central-Eastern Europe
 - 12 country (Finland, Estonia, Latvia, Lithuania, Poland, Slovakia, Hungary, Slovenia, Croatia, Bosnia and Herzegovina, Montenegro, Macedonia)
 - metadata: latitude, longitude, altitude
 - 5 biogeographical region (Boreal, Continental, Alpine, Pannonian, Mediterranean) – data from the European Environment Agency (EEA)
 - 40 year: 1970 - 2010
-

Longitude range: 13.6 - 32.1 degree



Latitude range: 40.9 - 67.9 degree

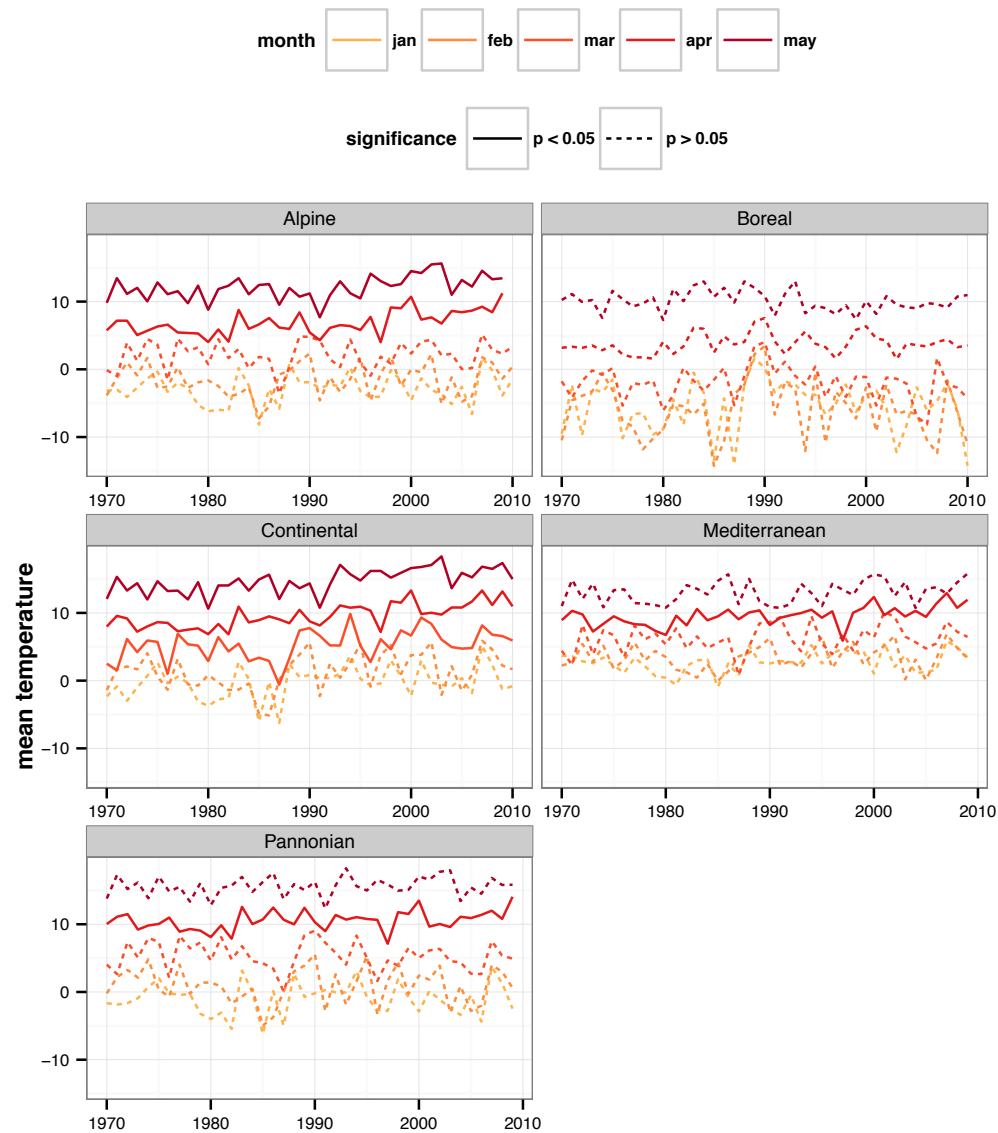
Biogeographical regions

Materials and Methods: Climatological datasets

- daily data of air temperature (mean, minimum, maximum), precipitation and monthly indices of the North Atlantic Oscillation (NAO)
 - data source: E-OBS regular gridded (0.25 degree) datasets developed by the ENSEMBLES EU-FP6 project and Climate Research Unit (CRU) of the University of East Anglia
 - Further data: quartiles at 0.25, 0.5 (median), 0.75 level; skewness of climate data series were also determined
 - 40 year: 1970 - 2010
-

Materials and Methods: Statistics

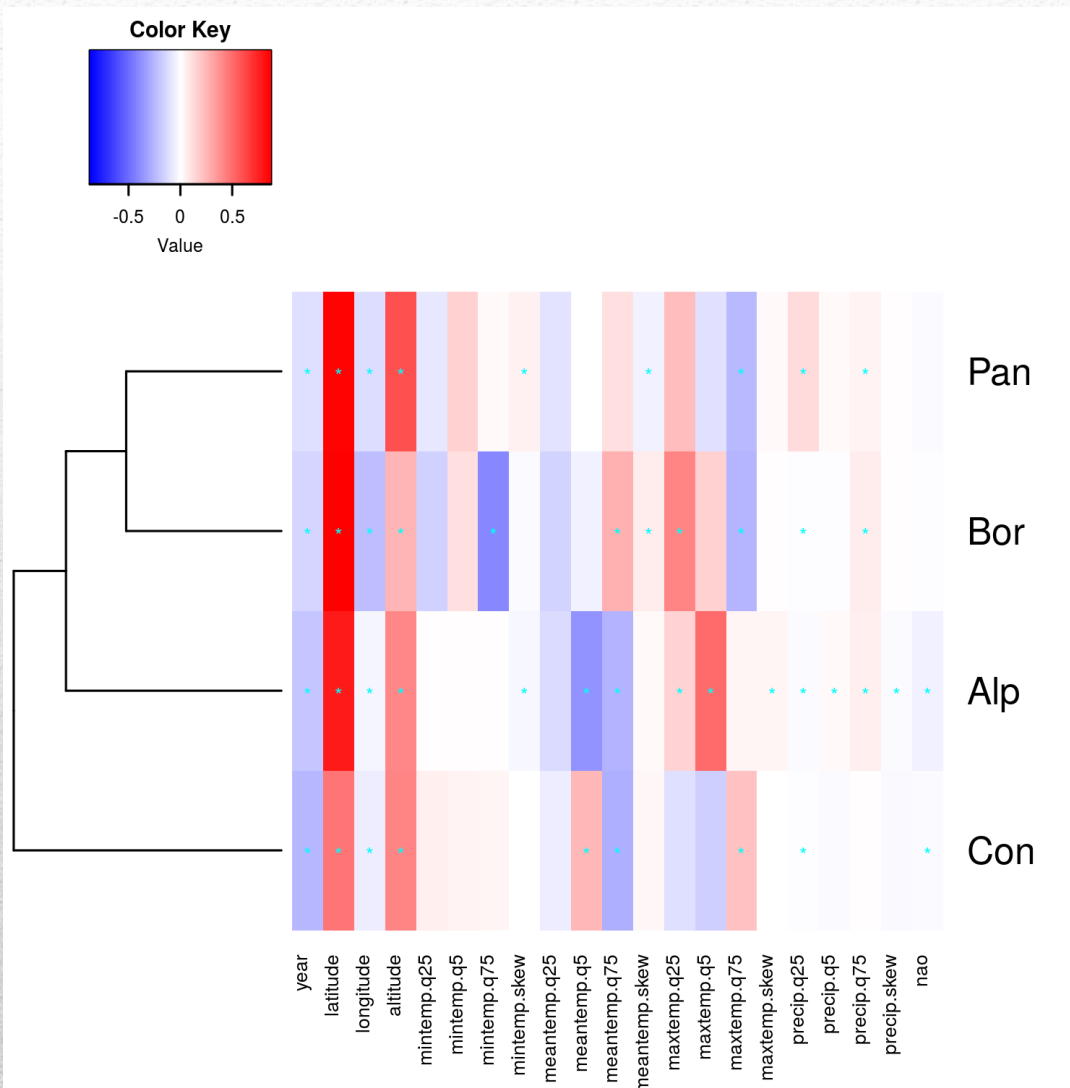
- Two-way linear mixed models – pheno package (*pheno* R package - Schaber&Badeck, 2002)
 - all analyses were carried out on 30 homogenized phenological time series for the 6 species over the 5 biogeographical regions
 - outliers -> robust methods (*robustbase* R package – Rousseeuw&Croux, 2015)
 - Robust linear regressions
 - Heatmap for the visualization of the regression coefficients & hierarchical clustering based on them
-



Results: Annual variation and trends of mean temperature (1970-2010)

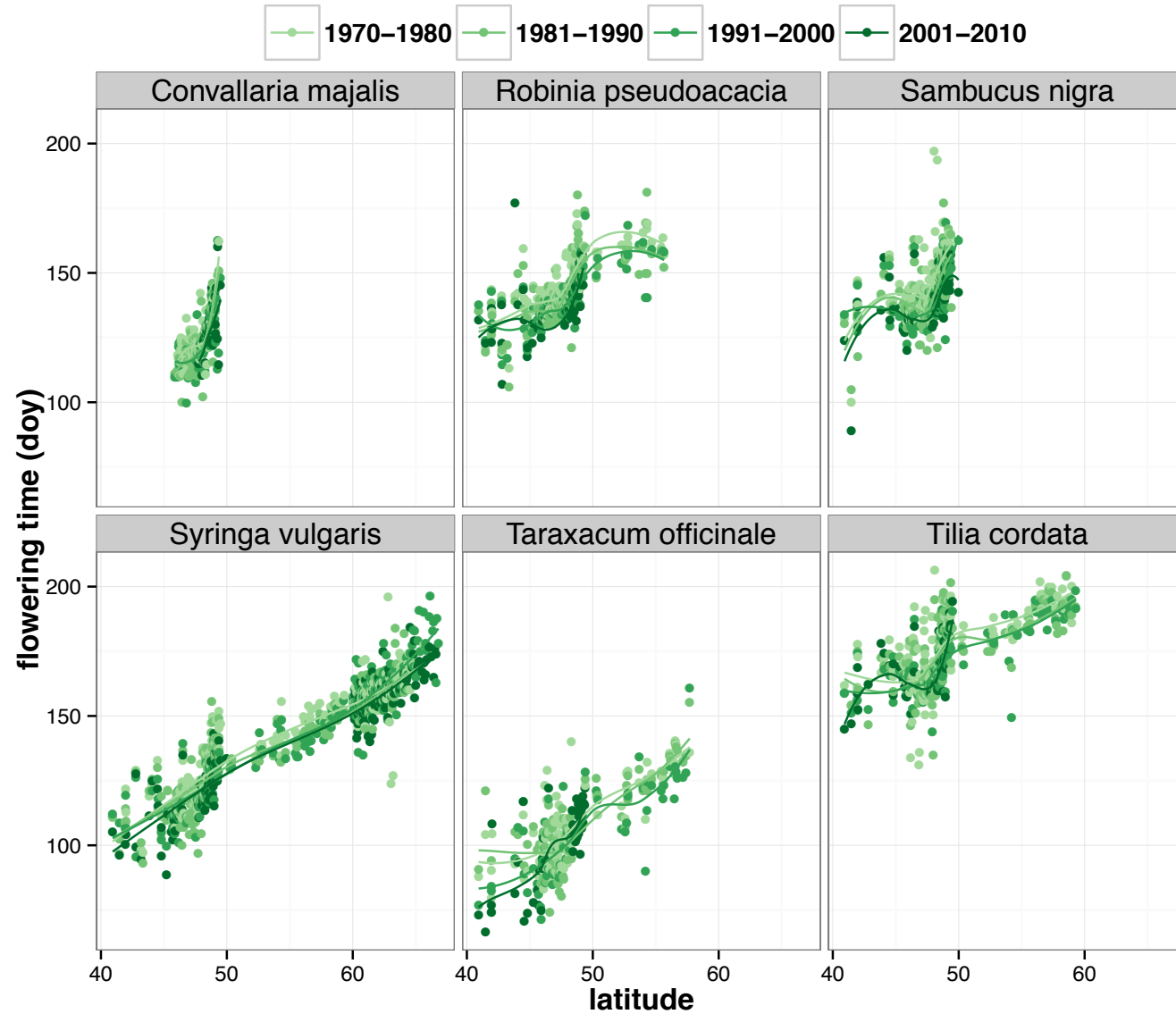


Results: Inter-annual variation of the timing of flowering onset (1970-2010)



As an example:
Tilia cordata

Beta coefficients given for the most influential explanatory variables in different biogeographical zones. (Negative values (blue) indicates their negative effect on phenological response. Significant predictors indicated with dots.)



Results: Flowering onset dates along latitudes over decades (1970-2010)

Flowering onset trends (days/year) in 1970-2010 across biogeographical regions of Europe

	<i>Convallaria</i>	<i>Robinia</i>	<i>Sambucus</i>	<i>Syringa</i>	<i>Taraxacum</i>	<i>Tilia</i>
Alpine	- 0.26	- 0.32	- 0.33	- 0.23	0.01	- 0.24
Boreal	-0.07	- 0.52	-	-	- 0.17	- 0.19
Continental	-	- 0.53	- 0.28	- 0.31	- 0.40	- 0.35
Mediterranean	-	- 0.12	- 0.08	- 0.14	- 0.35	- 0.17
Pannonian	0.06	- 0.12	- 0.11	- 0.03	- 0.05	- 0.03

Empty cells: non-studied cases;
negative bold values: significant
advancing trends

- significant advancement of mean flowering onsets in the Alpine and Continental region
- strongest advancement were given by *Robinia p.*, *Tilia c.*
- species, living in northern or higher latitudes were characterised by later dates of flowering onset
- the flowering started earlier at recent decades (1991-2010)
- significant negative effect of NAO, while positive influence from mean temperature previous to flowering
- the effect of precipitation sum are sporadic

Conclusion



Thanks for your attention!
