# Phenological diversity is linked to the diversity of functional traits in alpine grasslands

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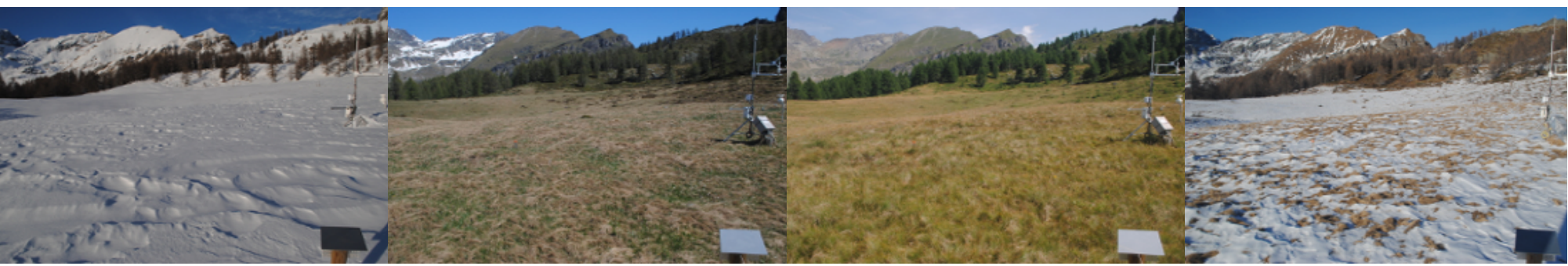

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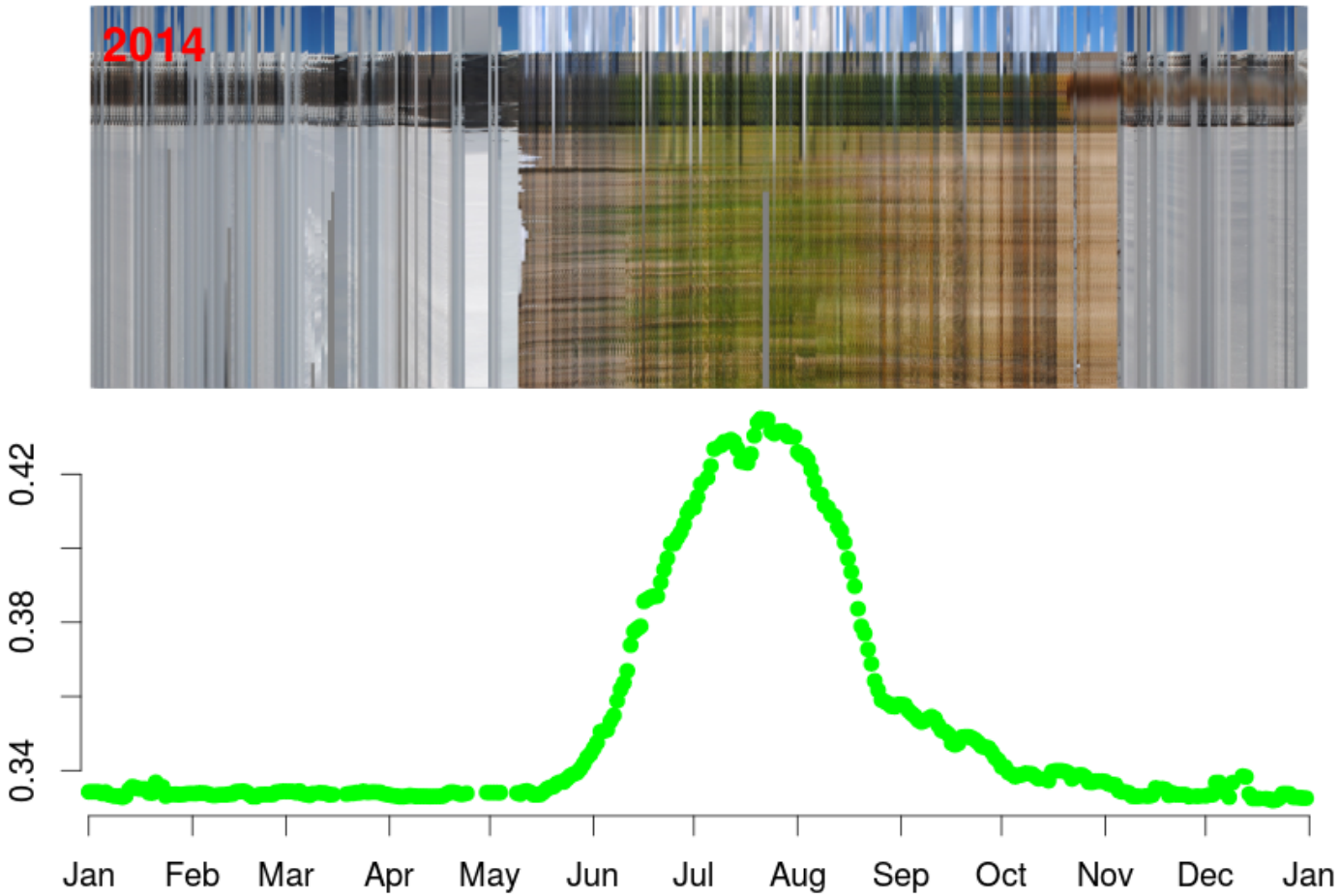
## Motivation

- ✓ **Phenology** is a primary indicator of climate change impacts on the biosphere and is a major regulator of ecosystem processes and biogeochemical cycles
- ✓ Recent studies proposed that **plant traits** have a high potential in explaining phenological variations (Bucher *et al.* 2017, Koenig *et al.* 2017)

**Digital cameras** (i.e. phenocams) can be used to track canopy phenology (Richardson *et al.* Oecologia, 2007)

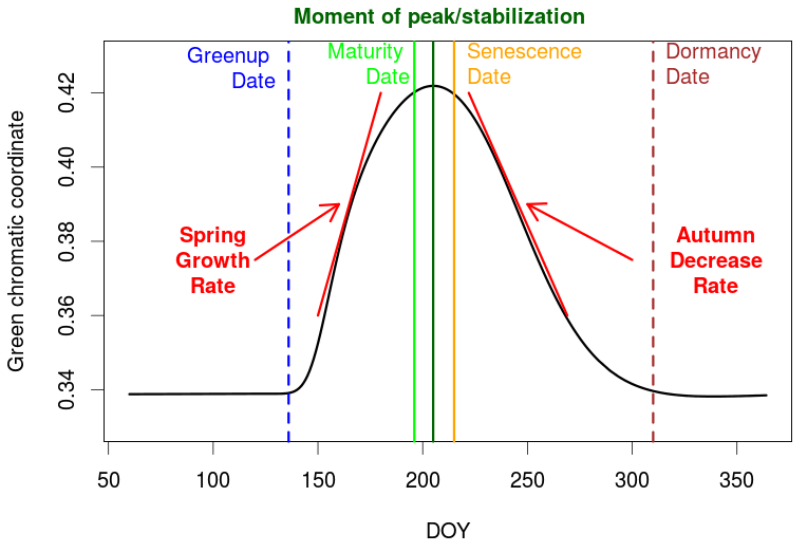
## Motivation




**Green Chromatic Coordinate** (GCC = G/R+G+B) is used to track canopy phenology over a wide range of ecosystems

## Motivation: phenocam processing, applications and networks

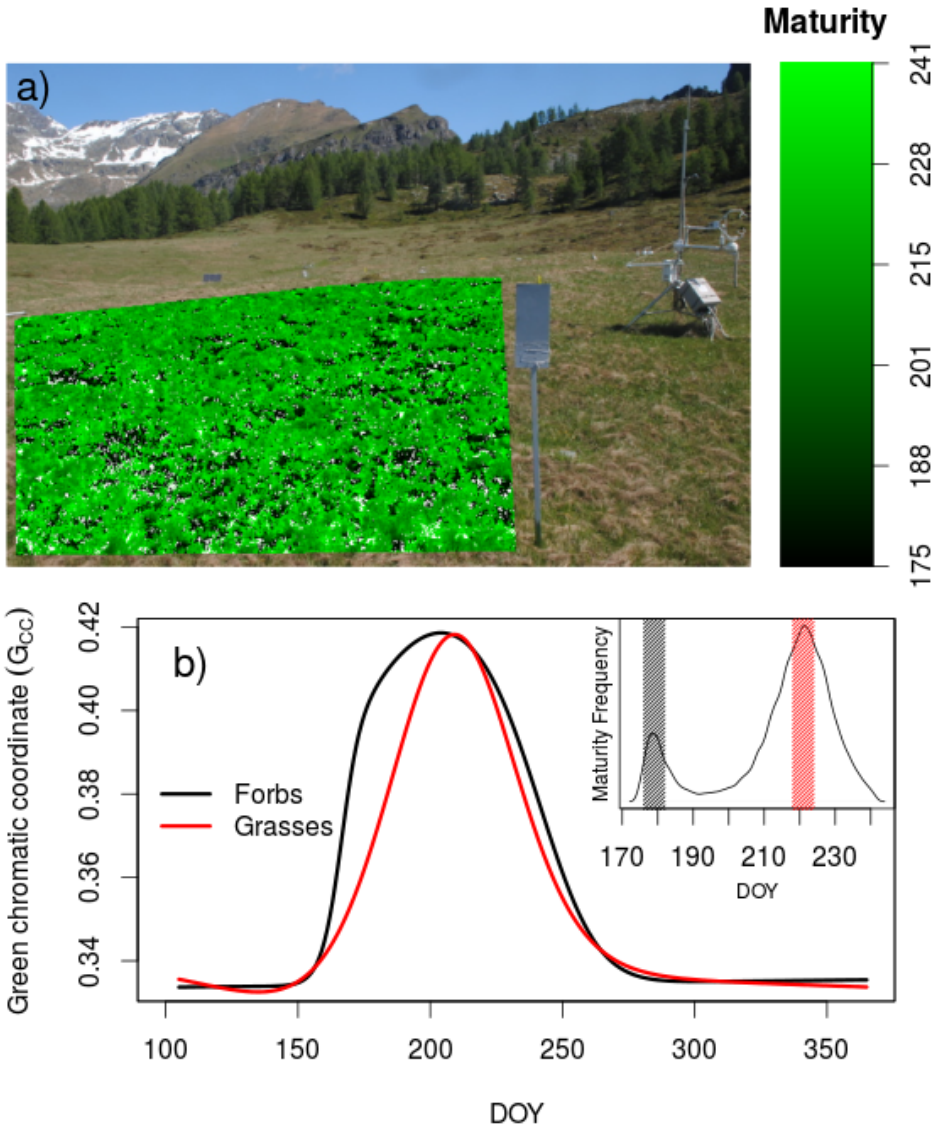
Phenocam common processing workflow and applications




- ✓ consolidated setup (camera models, installation instructions, ...) and processing procedures (**ROI averaging**, filtering, fitting and **phenophases estimation**)
- ✓ **common applications**: comparison with ground observations, evaluation of remote sensing phenology products, productivity modelling, relation with canopy properties
- ✓ phenocam **networks** deployment worldwide (USA, EU, AUS, JP)

## Motivation: phenocam spatial analysis

- ✓ Phenocam images can be analysed at pixel level to obtain phenophase maps
- ✓ We define **phenological diversity** as the variability of phenophase maps
- ✓ The spatial distribution of phases reflects the spatial distribution of plant species or functional groups, having different phenology (Julitta *et al.* 2014)



## Motivation: Biodiversity effect on phenology

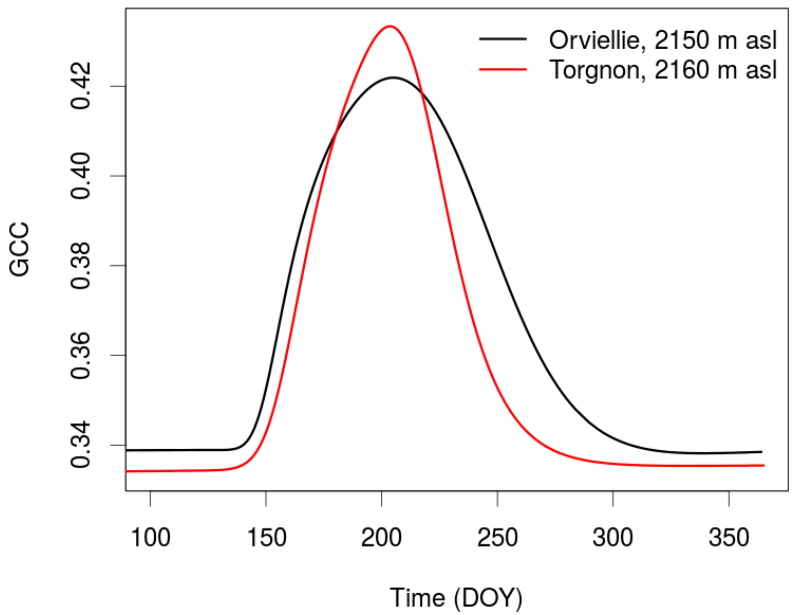
same climate, different species composition $\rightarrow$ phenological diversity

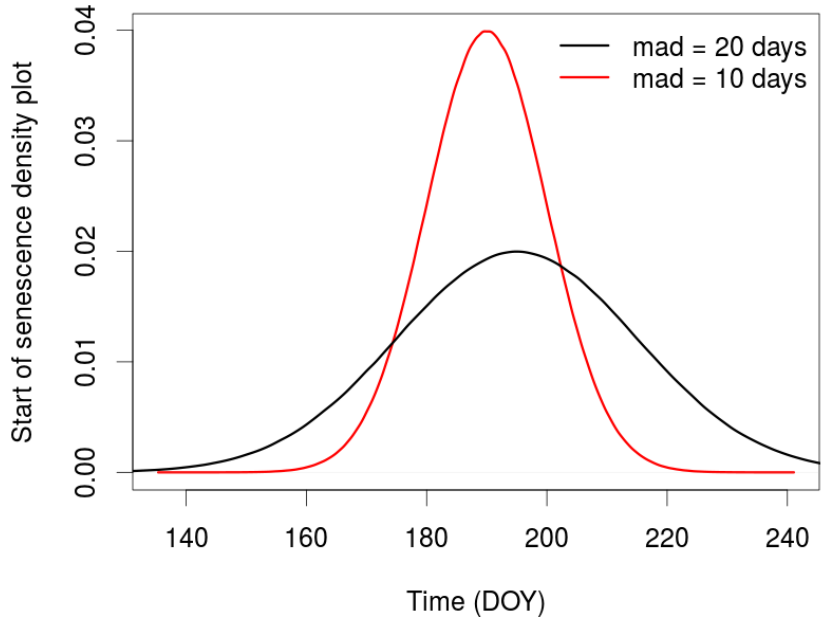
low taxonomic diversity

high taxonomic diversity

## Motivation: Biodiversity effect on phenology

Same Climate, Different Species Composition → Phenological Diversity

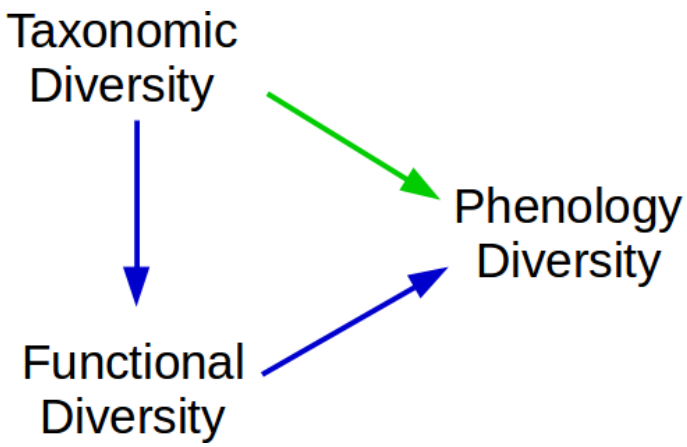



**GCC seasonal trajectories**: differences in sites with different taxonomic diversity

**Start of senescence**: higher doy variability in sites with higher taxonomic diversity

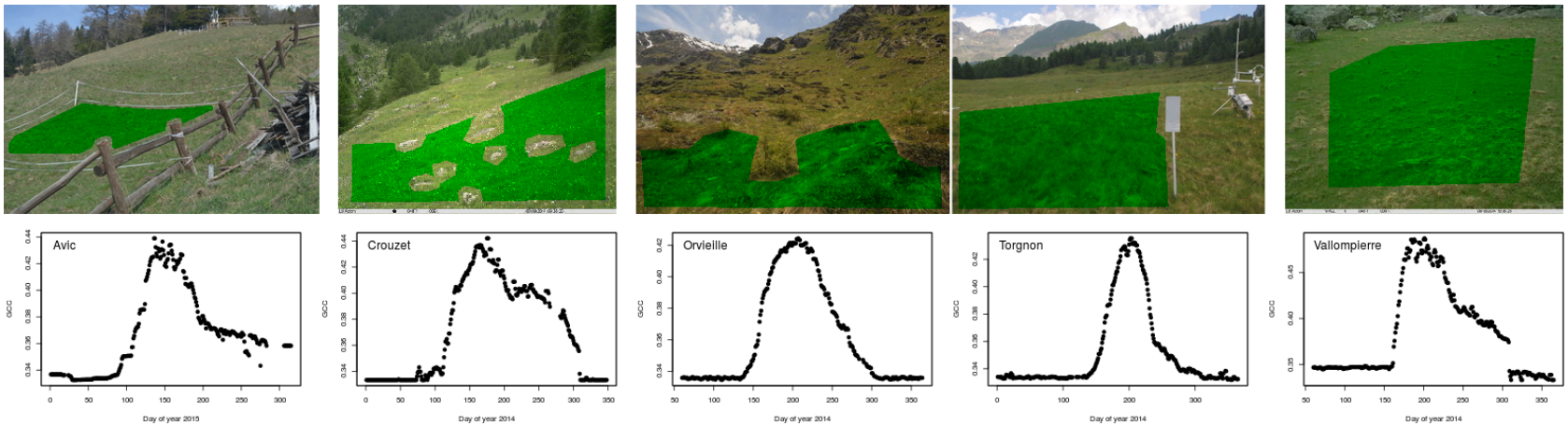
## Objectives




Question:

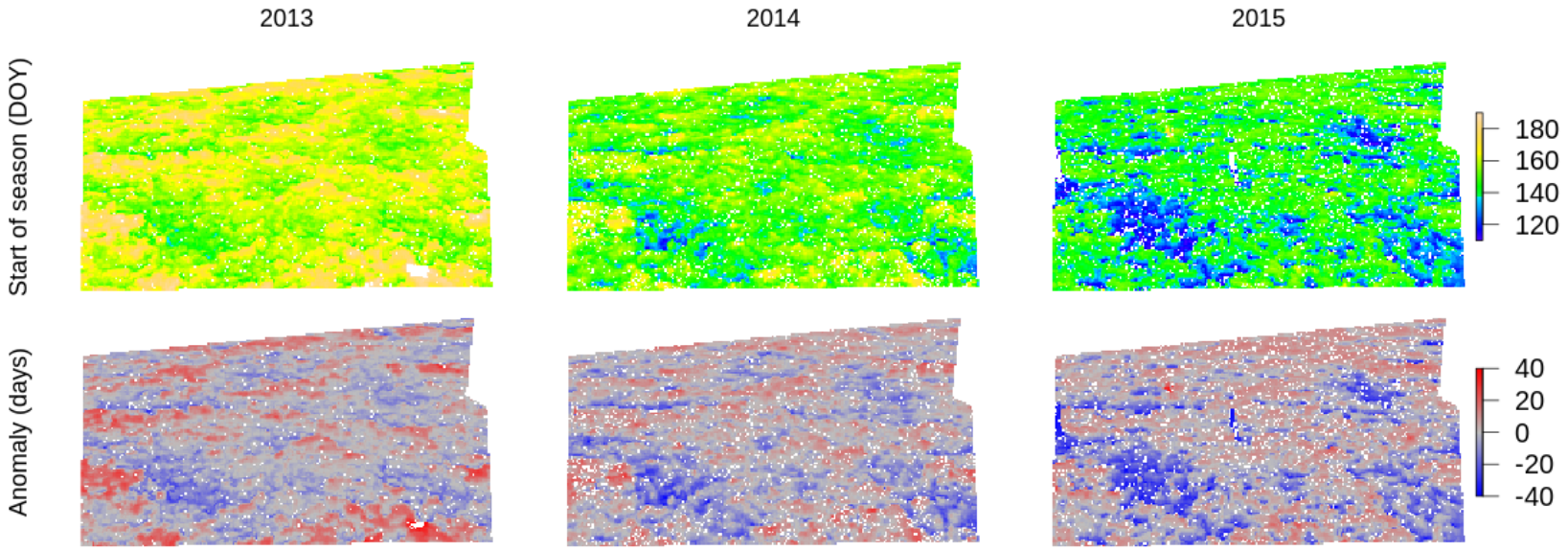
Is **phenological diversity** directly linked to **taxonomic diversity** or is it mediated by **functional traits diversity**?

## Study sites



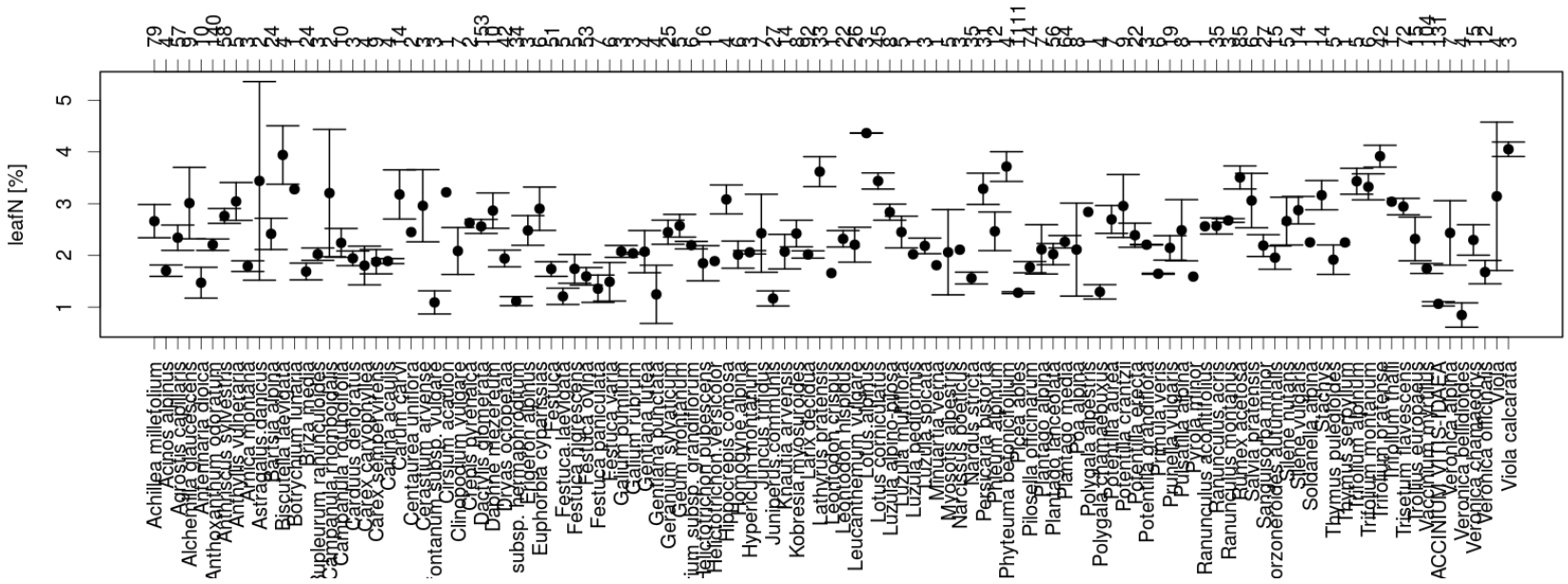

- ✓ Grassland sites in the Western Alps (elevation: 1890-2210 m asl)
- ✓ Species composition and abundance surveys
- ✓ 3-4 years (2014-2017) of phenocam imagery, processed at pixel level → estimation of phenophase maps
  - ✓ → interannual consistency of phenomaps needs to be tested

## Interannual consistency of phenomaps




- ✓ Spatial patterns are consistent over the years (i.e. early vs. late spring growth pixel) reflecting species spatial distribution
- ✓ 60-80% of pixels are always classified in the same classes
- ✓ Climate anomalies can influence spatial patterns

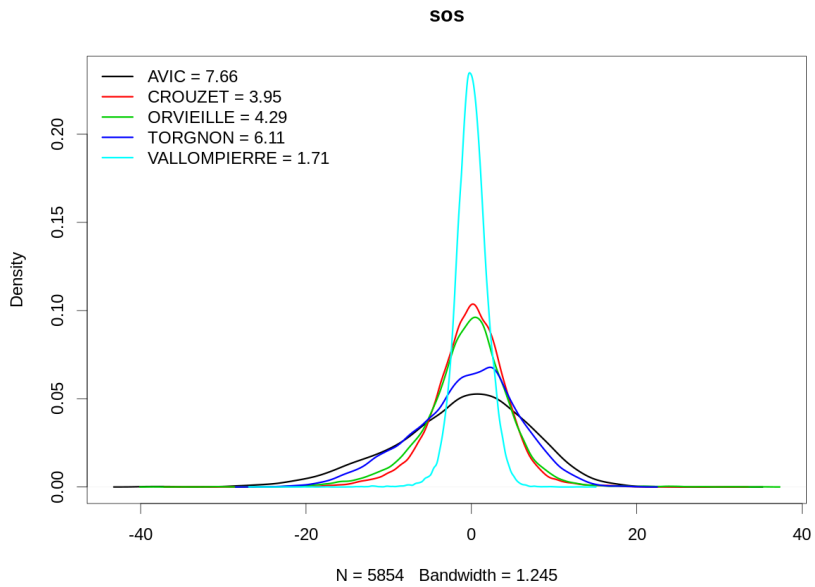
## Functional traits data



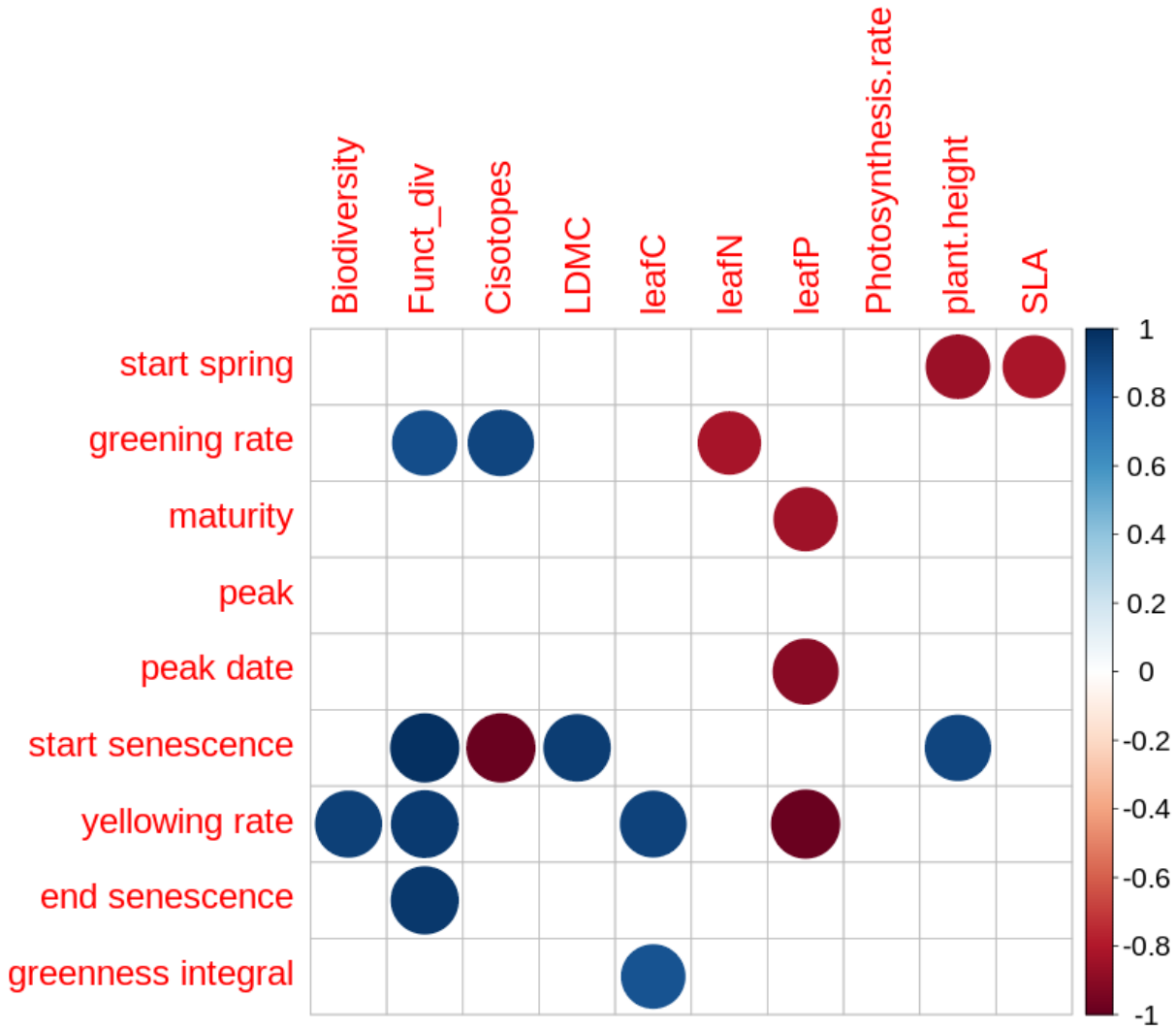

- ✓ Functional traits data were obtained from TRY
- ✓ All traits available for a total of 143 species
- ✓ Phenologically relevant traits (SLA, plant height, LDMC, C-isotopes, leafC, leafN, leafP, photosynthesis rate) were selected based on data availability for each species

## Taxonomic diversity, Functional traits diversity and Phenodiversity

- ✓ **Taxonomic diversity indexes** based on species richness and abundance: Shannon, Simpson, Inverse Simpson and Fisher Alpha ('Vegan' R package)
- ✓ **Functional trait diversity**
  - Functional diversity metrics: functional richness, functional evenness, functional divergence, functional dispersion and Raos quadratic entropy ('FD' R package, Laliberte *et al.* 2014)
  - Community weighted standard deviation of each trait
- ✓ **Phenodiversity**: mean absolute deviation (MAD) of multi-year mean phenophases map of each site

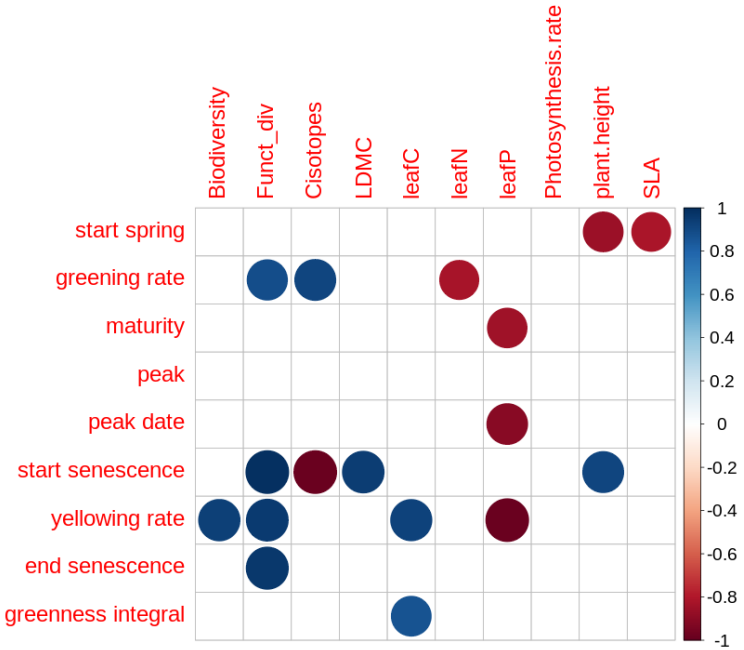


## Phenodiversity relation with taxonomic and functional traits diversity



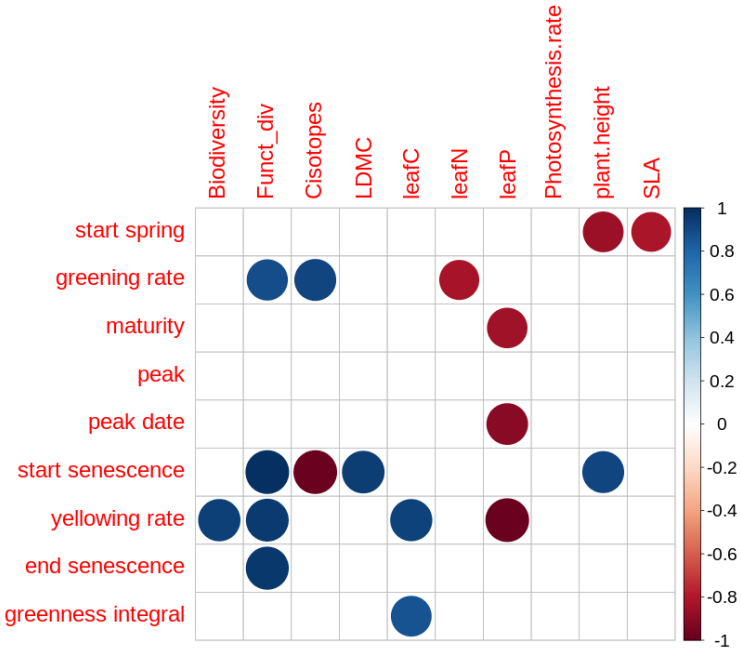

Pearson correlation coefficients, $p < 0.1$

## Phenodiversity relation with taxonomic and functional traits diversity




- ✓ Taxonomic diversity is rarely related to phenodiversity
- ✓ Functional diversity is positively correlated to the variability of several phenological phases, in particular during senescence
- ✓ The variability of senescence phases is more related to functional diversity than spring phases

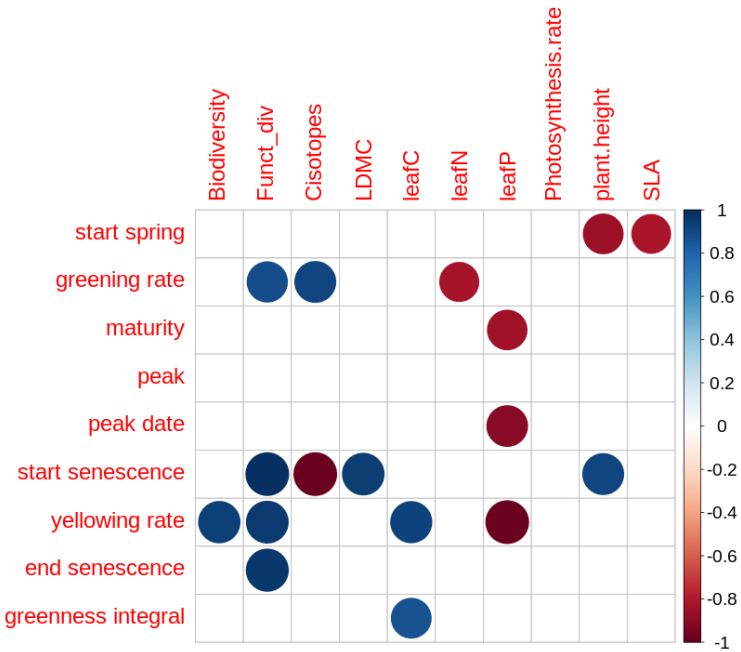
## Phenodiversity relation with taxonomic and functional traits diversity




Considering specific traits:

- ✓ C-isotopes variability (a proxy of WUE variability) positively correlated with variability in spring growth rates
- ✓ Senescence variability increases with increasing variability in traits related to competition, growth and longevity (LDMC, plant height, leafC)

## Phenodiversity relation with taxonomic and functional traits diversity




How can we explain inverse relations?

- ✓ We hypothesize that more homogeneous trait values result in an increase interspecific competition (Kunstler *et al.* 2015) that is expressed in an increased phenodiversity. e.g lower leafN variability (generally related to higher mean leafN values) $\rightarrow$ interspecifc competition is expressed in more variable spring growth rates
- ✓ With caution: inverse relation between start of spring and plant height and SLA can be a indirect effect of snowmelt influence

## Conclusions

- ✓ Taxonomic diversity is less important than functional diversity in explaining phenological diversity
- ✓ Senescence phases are more related to trait variability then spring phases
- ✓ It's difficult to find a common pattern of trait diversity-phenodiversity relation: the variability of specific trait explains specific phases
- ✓ Limitations: few sites and trait data not available for all species
- ✓ Perspectives: increase the number of sites and trait data (any suggestion?), look at climate anomalies, role of functional diversity during climate extremes, ...

# Thank you for the attention

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