Uncertainties in estimating budburst heat requirement when using local or gridded temperature compared to bud tissue temperature

Marc Peaucelle[1], Cinta Sabate Gil[2], Josep Peñuelas[2,3], Hans Verbeeck[4], Jonas Gisler[5] and Yann Vitasse[5]

PHENO 2022 – Avignon, France – June 2022

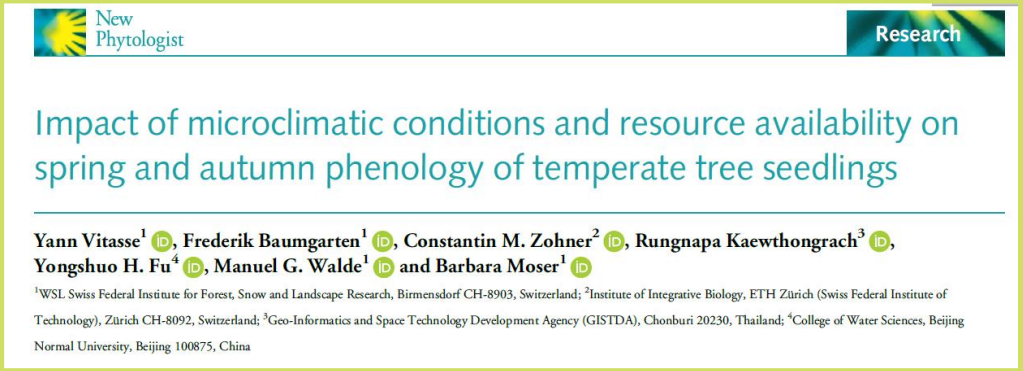
Temperature drives phenology in extra-tropical ecosystems

We know:

→Important role of preseason temperature

→Temperature is sensed locally within each bud

→Bud albedo and sun exposure affect budburst date



New Phytologist — Research

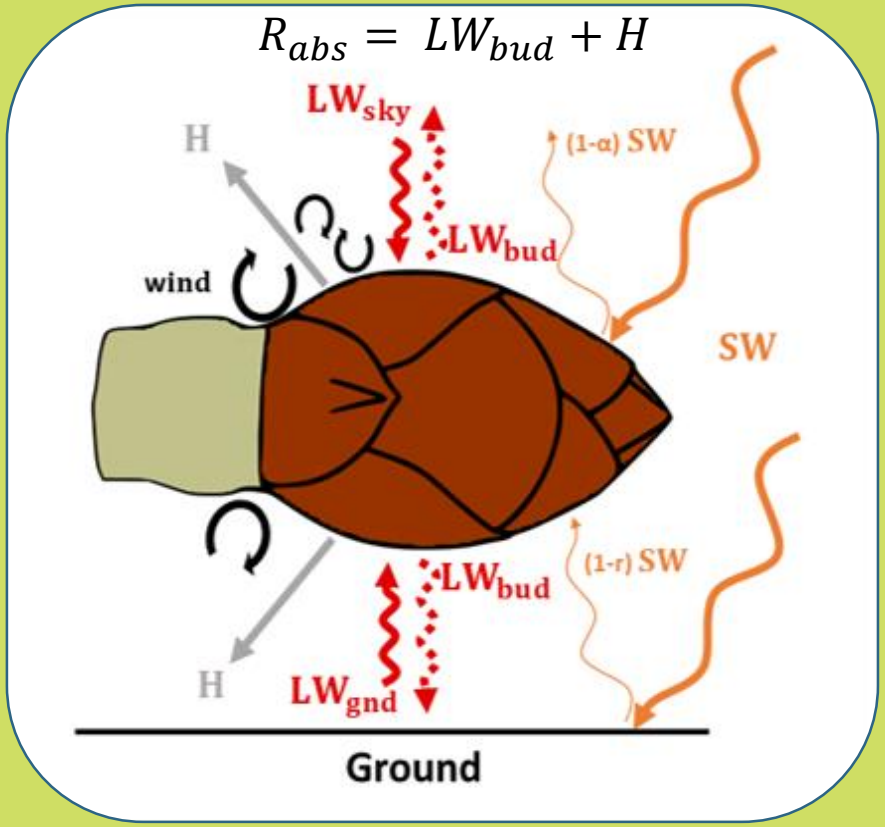
Impact of microclimatic conditions and resource availability on spring and autumn phenology of temperate tree seedlings

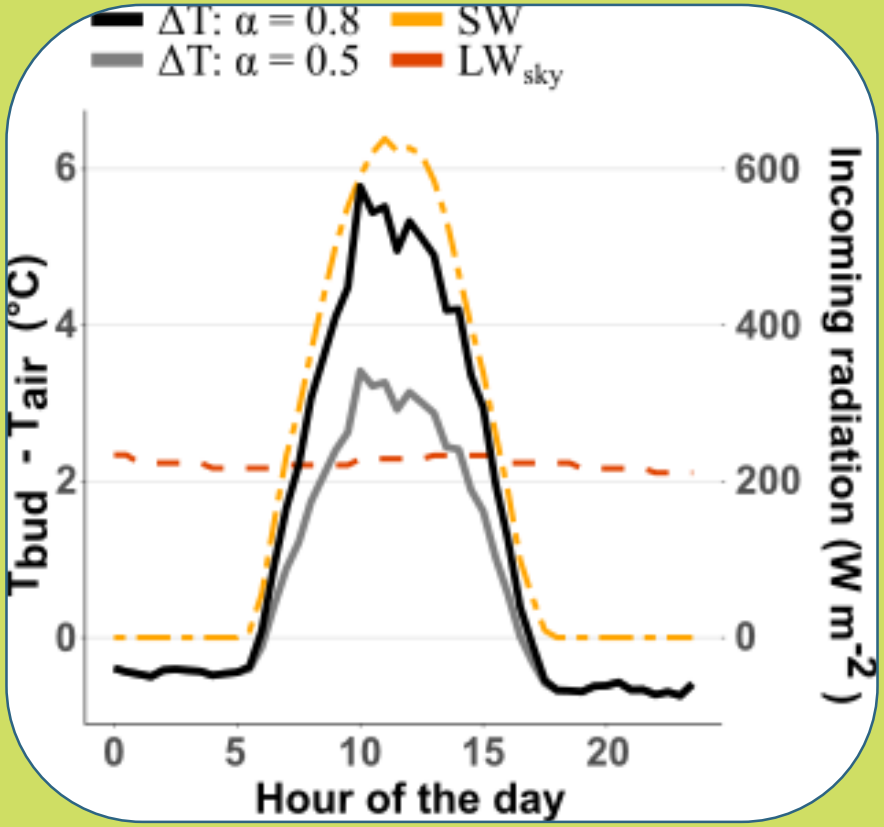
Yann Vitasse[1], Frederik Baumgarten[1], Constantin M. Zohner[2], Rungnapa Kaewthongrach[3], Yongshuo H. Fu[4], Manuel G. Walde[1] and Barbara Moser[1]

[1]WSL Swiss Federal Institute for Forest, Snow and Landscape Research, Birmensdorf CH-8903, Switzerland; [2]Institute of Integrative Biology, ETH Zürich (Swiss Federal Institute of Technology), Zürich CH-8092, Switzerland; [3]Geo-Informatics and Space Technology Development Agency (GISTDA), Chonburi 20230, Thailand; [4]College of Water Sciences, Beijing Normal University, Beijing 100875, China

Temperature is sensed by organs, still we « always » use air temperature in phenology studies

The forgotten effect of microclimate and bud traits





SW = shortwave radiation
LW = longwave radiation
H = Sensible heat
α = solar absorptivity of bud

→ Direct effect on tissue temperature

Do bud and air temperature differs to such extent as to bias phenology studies ?

→Quantify the potential error in heat requirement estimated from ***in situ*** **bud temperature and air temperature** from different sources

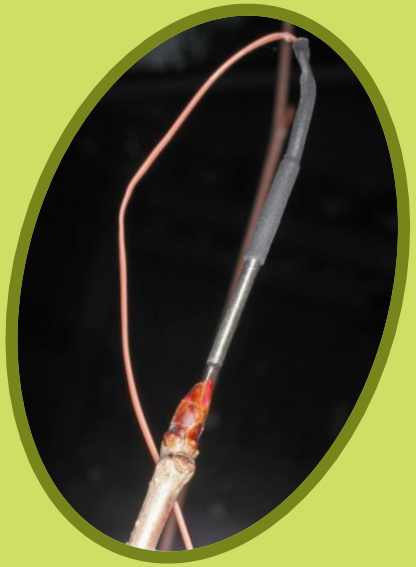
→Identify environmental variables that are responsible for observed discrepancy using a simple **energy budget model** adapted for buds

Bud temperature and microclimate

→ Data from Vitasse et al. (2021) experiment in north-eastern Switzerland

- *in situ* bud temperature from T-type thermocouples (10 min)
- local microclimate (Tair, radiation, wind – 10 min)

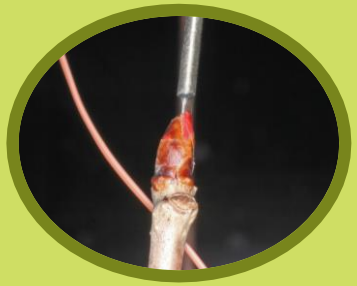
- 4 species (Quercus robur, Prunus avium, Fagus sylvatica, Fraxinus excelsior)
- 2 light regime (sun / 70% shade)
- 2 albedo treatment (bud painted in black / white)



GDH error propagation

Heat requirement = Growing Degree Hours

GDH definition : Sum of hourly temperature > 5°C from 1st January to leaf unfolding



Bud temperature

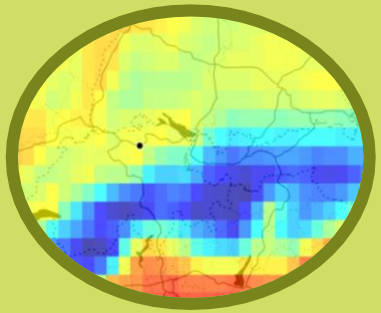
GDH_{bud}

Microclimate

GDH_{mic}

Nearby station

GDH_{sta}



ERA-5

GDH_{era}

Environmental control

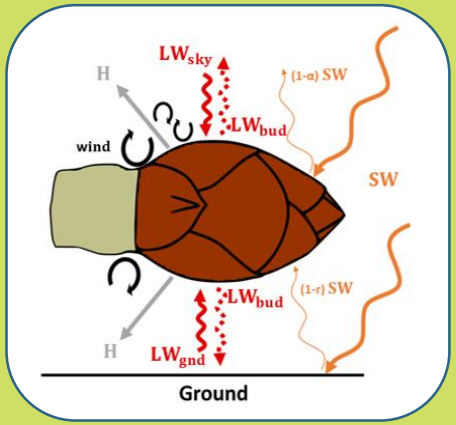
→ From data:

- Partial correlation between Tdif (Tbud-Tair) and climate

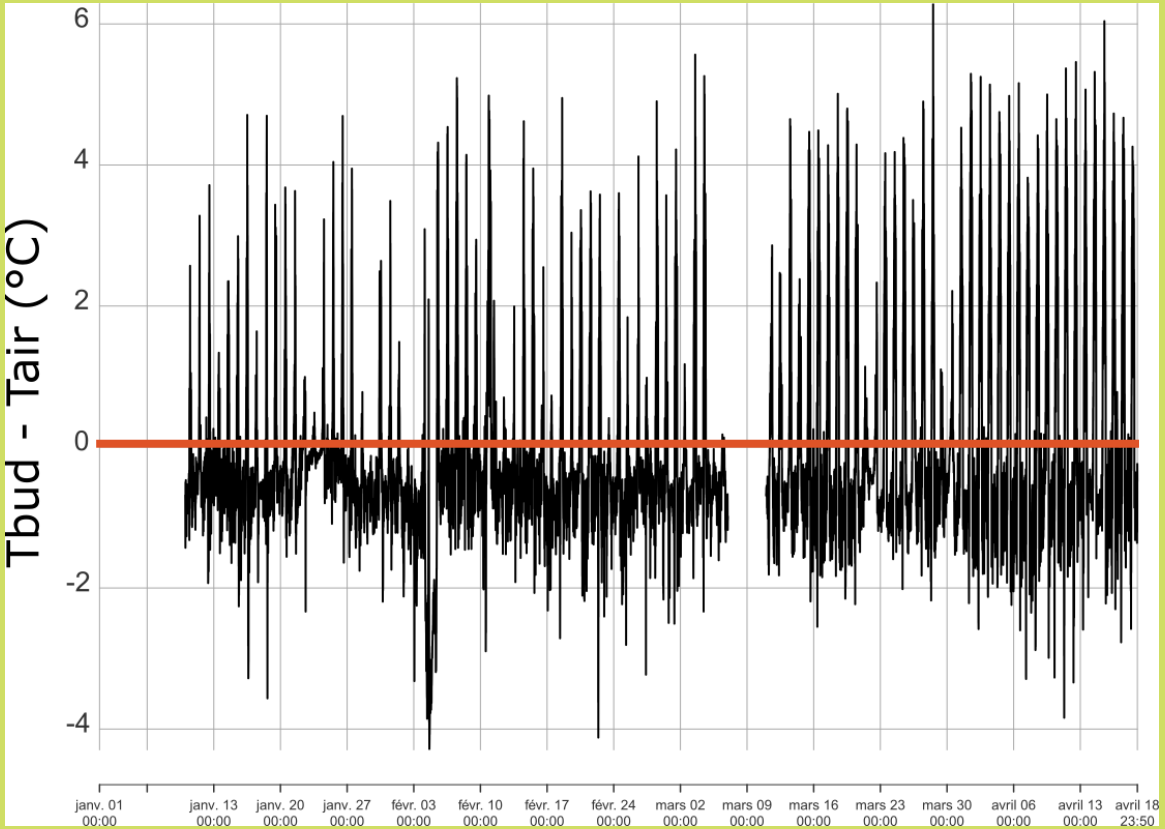
→ From model:

- Energy budget computed for an isolated bud (“big-bud model”)
- **Estimate Tbud at equilibrium**

$$R_{abs} = LW_{bud} + H\ (+L)$$



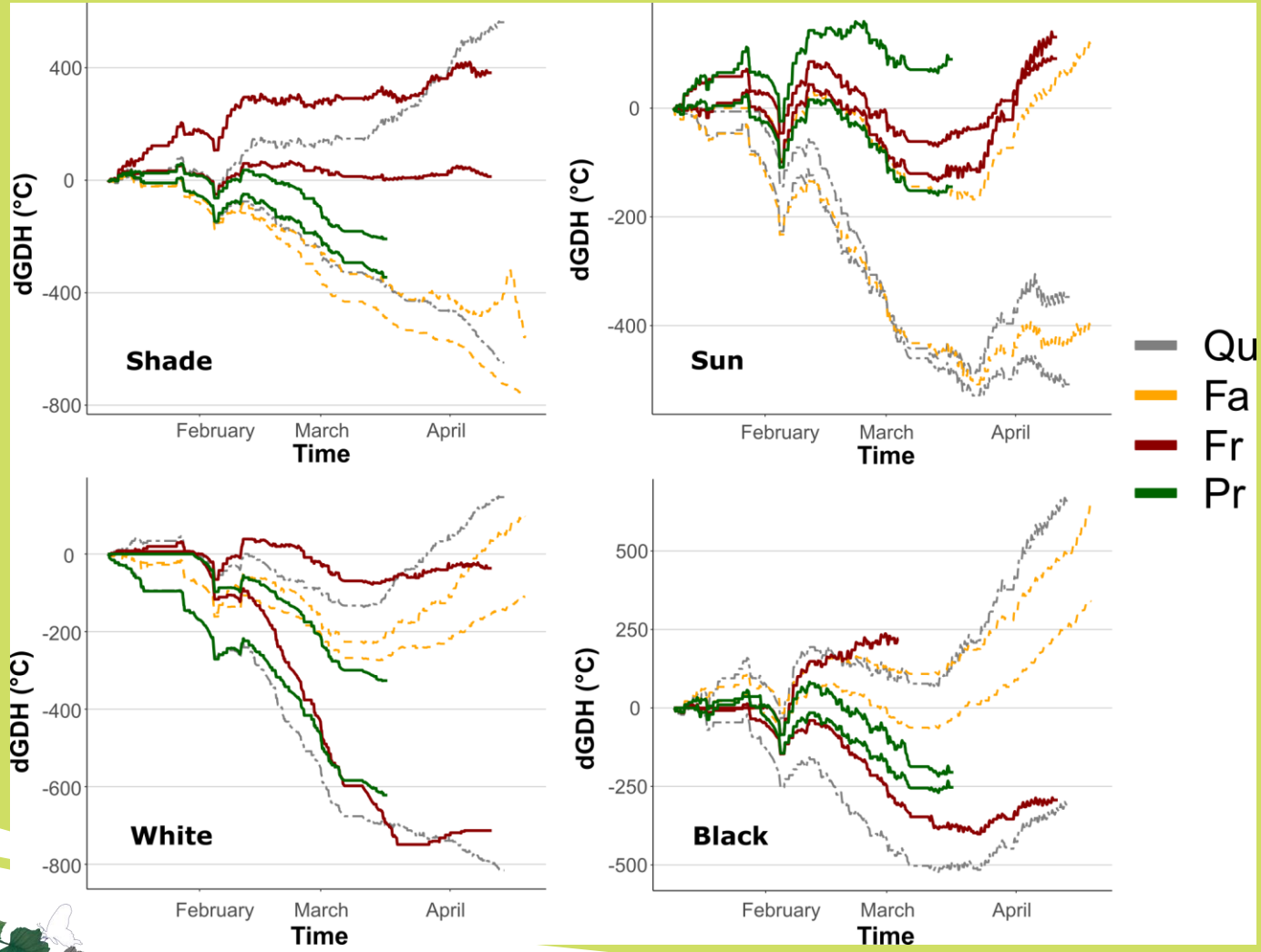
Overview of bud temperature data



Fagus, average January → April

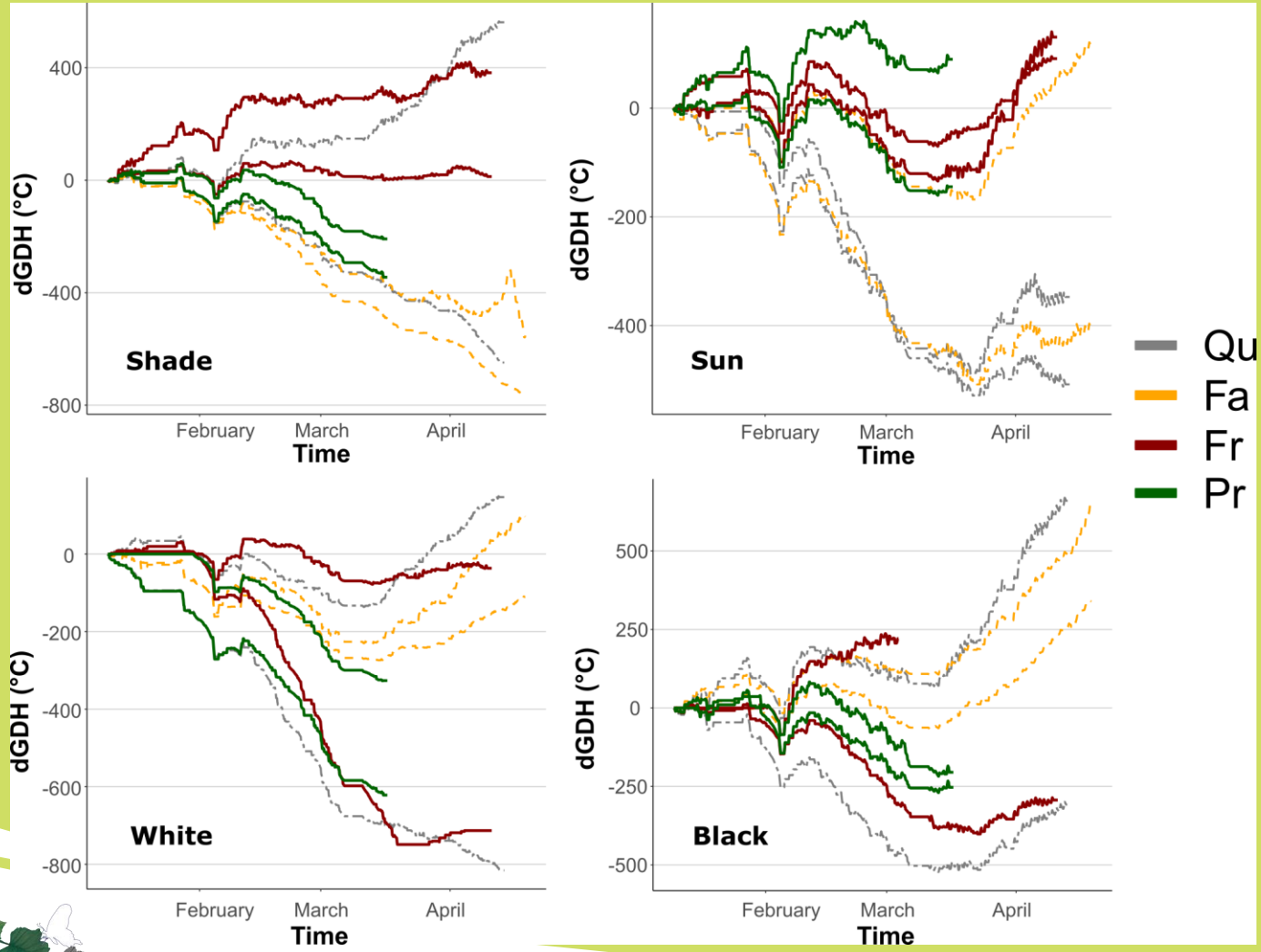
- **5.6 ± 2.1 hours** at **1.46 ± 0.79 °C**
- **18.5 ± 2.2 hours** at **– 0.77 ± 0.28 °C**

GDH differences bud - microclimate



$dGDH = GDH_{bud} - GDH_{mic}$

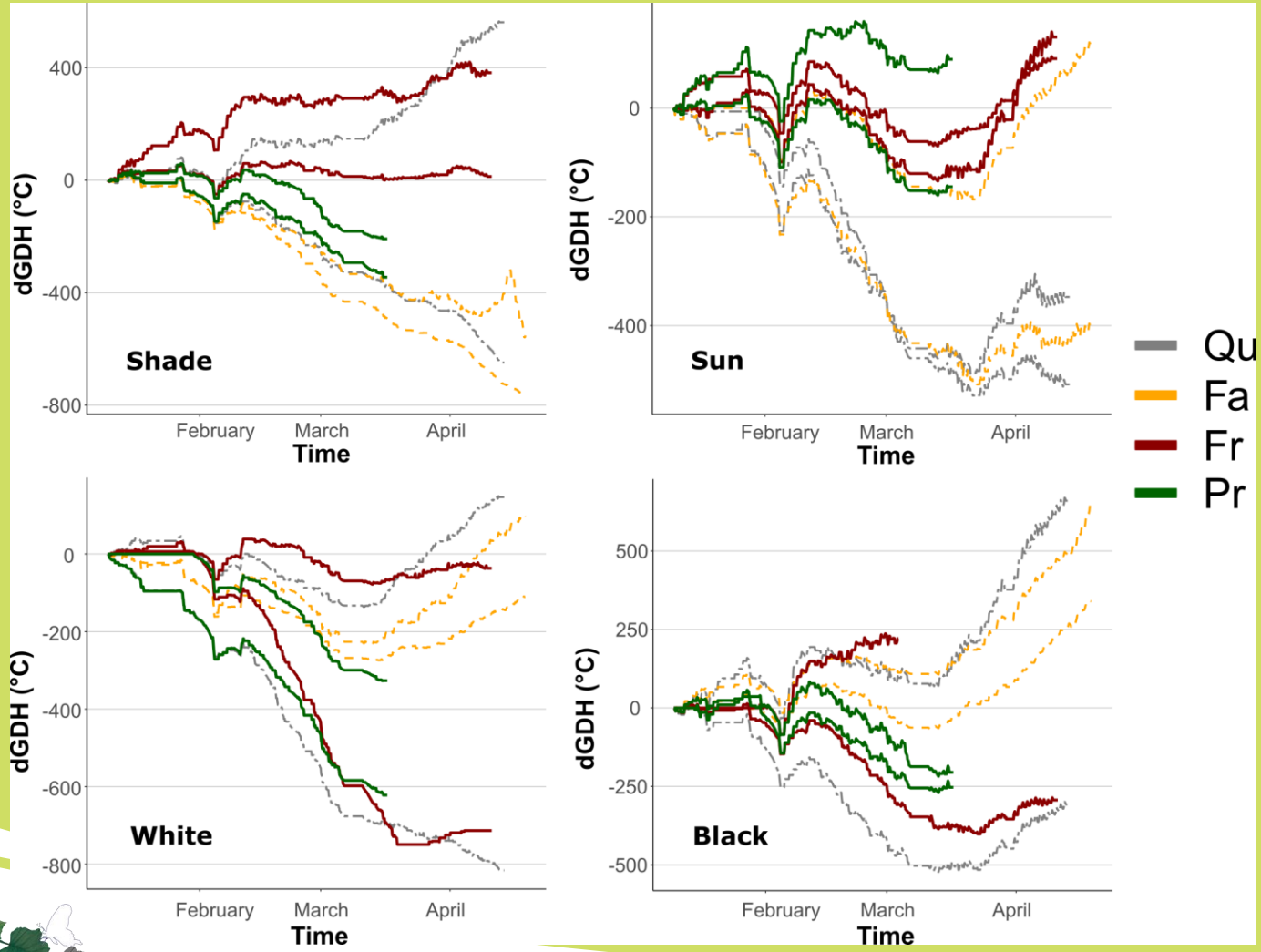
GDH differences bud - microclimate



1) GDH_{bud} and GDH_{mic} are not linear and not proportional

$dGDH = GDH_{bud} - GDH_{mic}$

GDH differences bud - microclimate

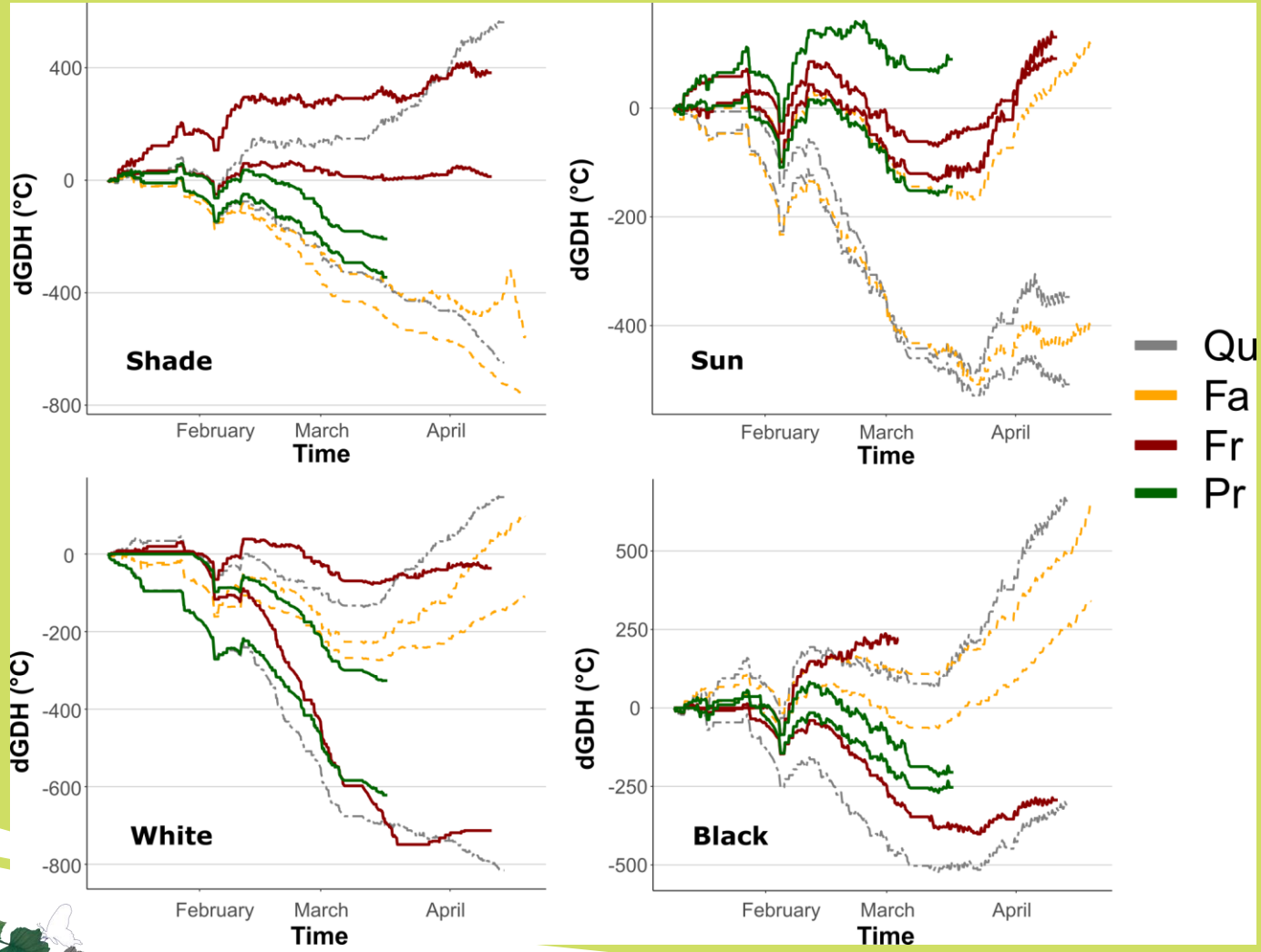


1) GDH_{bud} and GDH_{mic} are not linear and not proportional

2) On average $GDH_{bud} < GDH_{mic}$

$dGDH = GDH_{bud} - GDH_{mic}$

GDH differences bud - microclimate



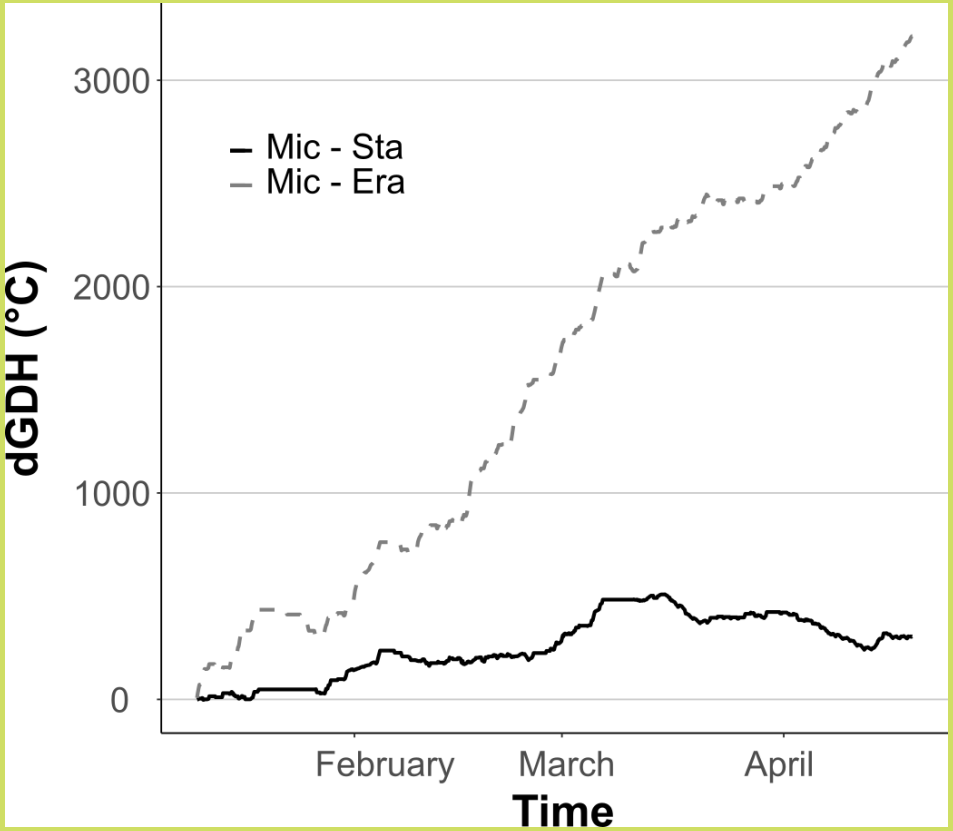
1) GDH_{bud} and GDH_{mic} are not linear and not proportional

2) On average $GDH_{bud} < GDH_{mic}$

3) Strong influence of albedo/species

$dGDH = GDH_{bud} - GDH_{mic}$

GDH differences microclimate/station/gridded dataset

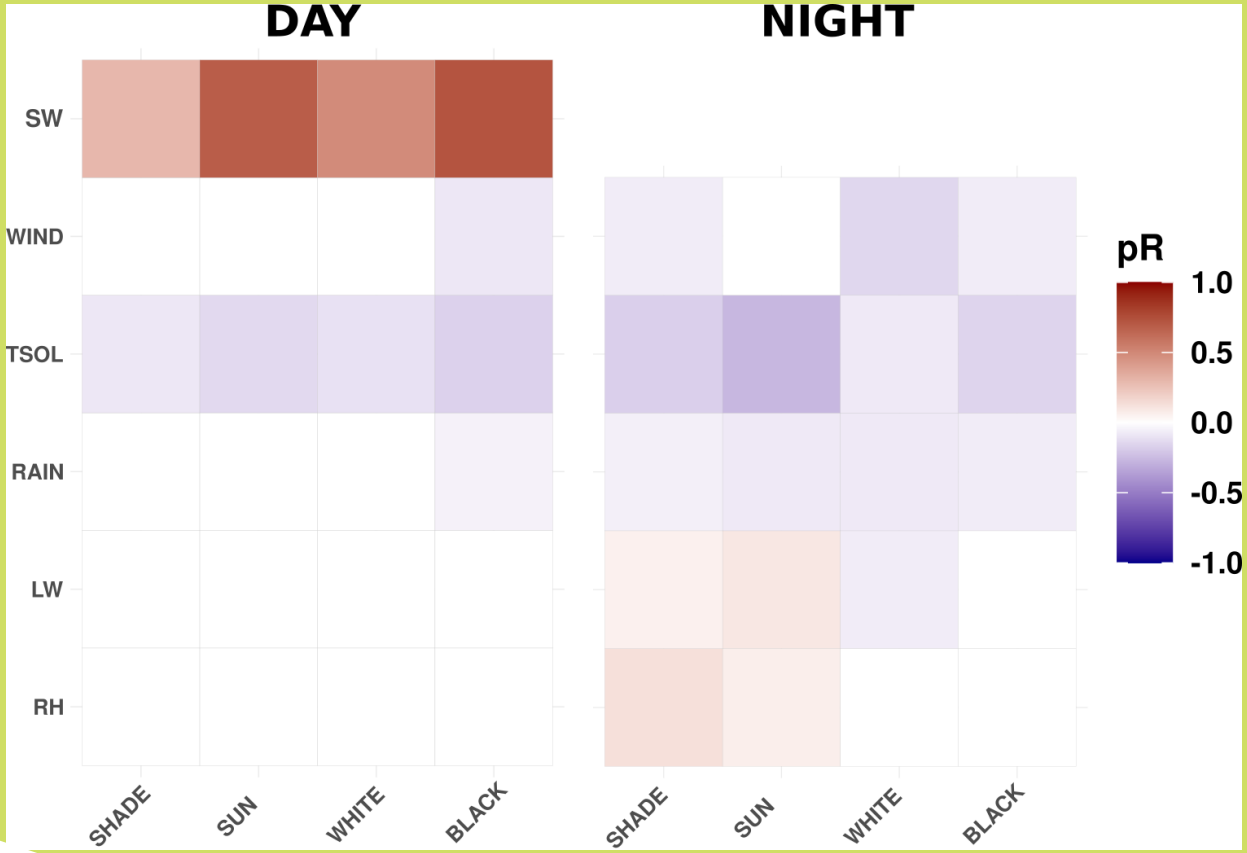


1) Distant temperature data exacerbate the error in GDH

2) Non-linearity between Tair data sources

Preliminary Results (unpublished)

Correlation of Tbud-Tair with other factors



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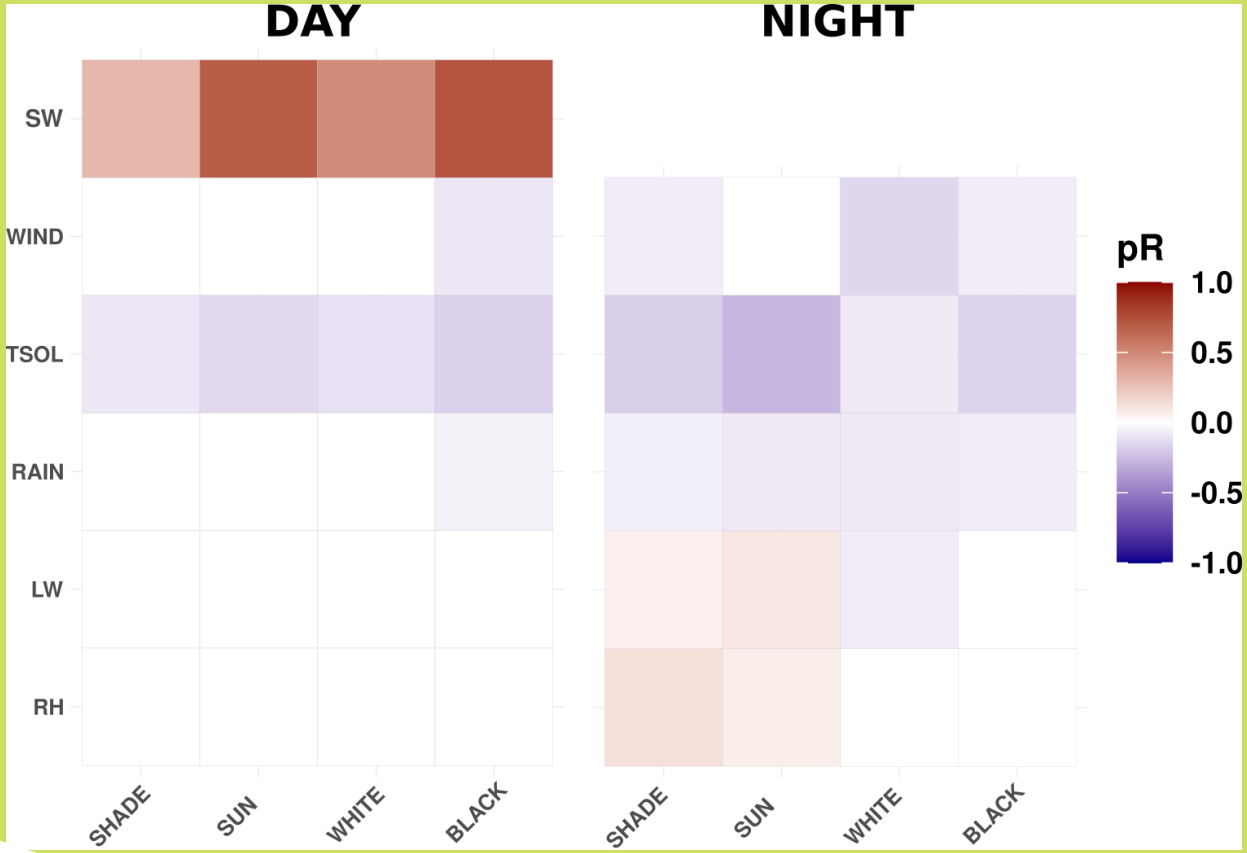
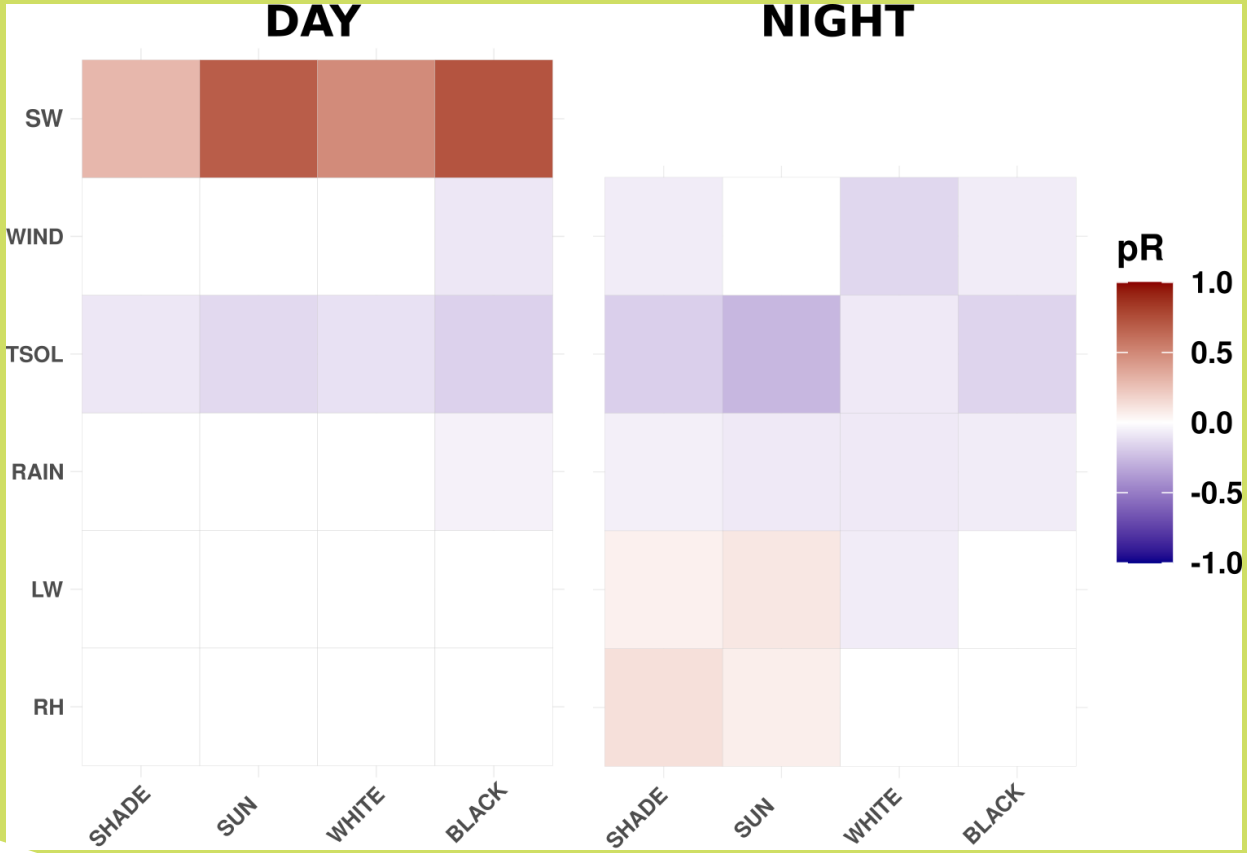


1) Surprise! Bud temperature is correlated with radiation during the day

Correlation of Tbud-Tair with other factors

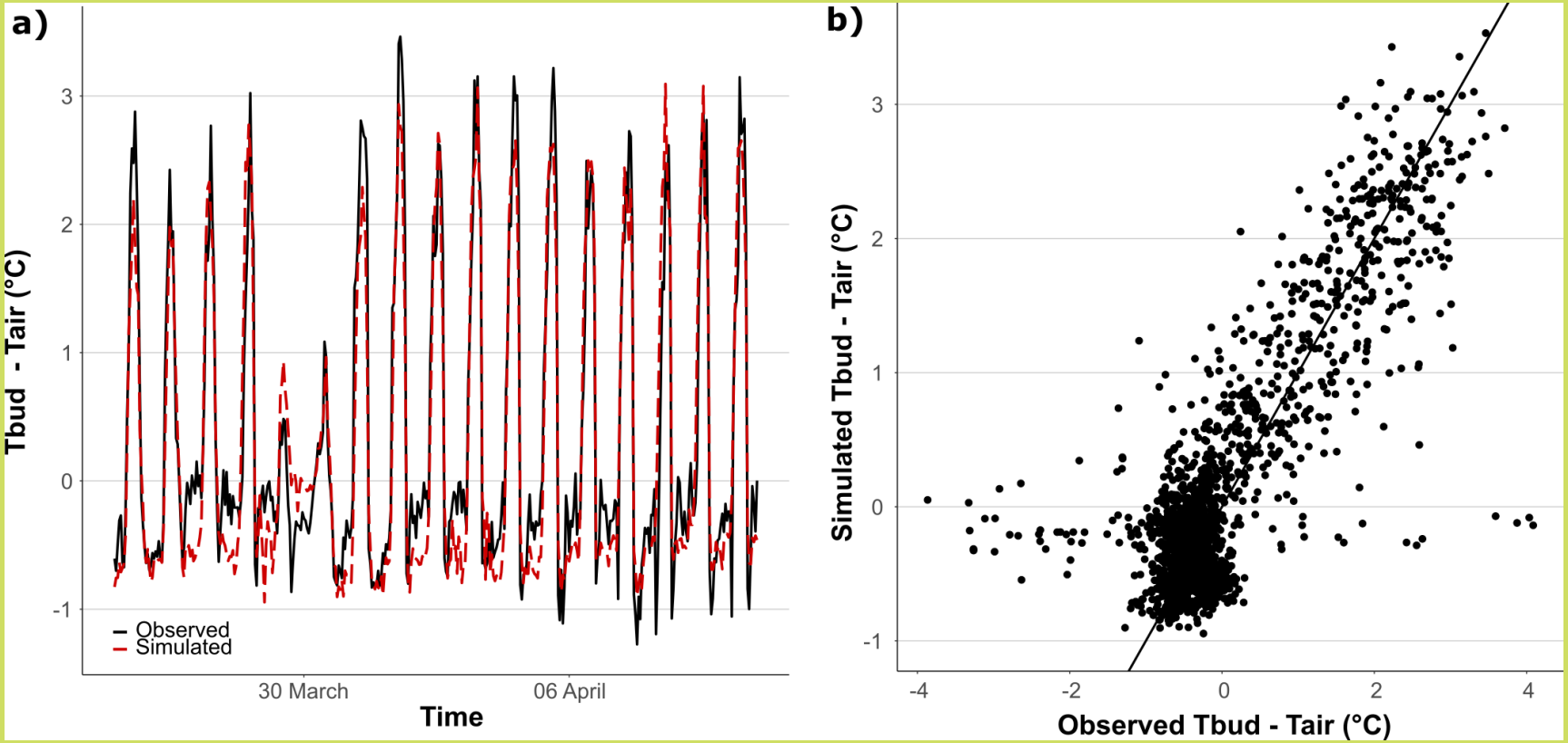


1) Surprise! Bud temperature is correlated with radiation during the day

2) Complex interactions with rain, wind and soil temperature at night

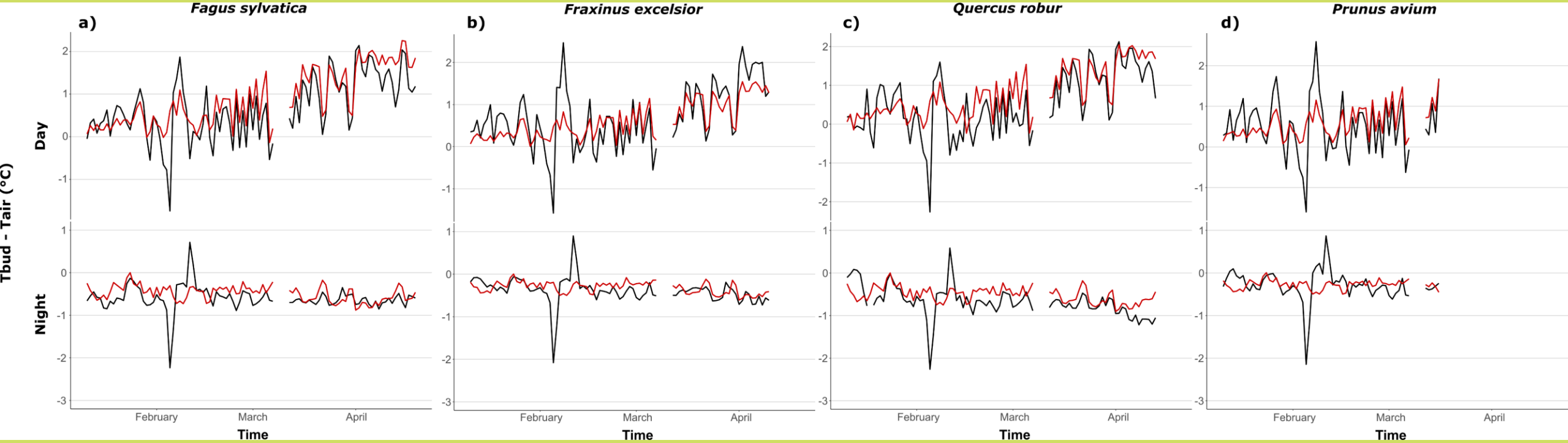
→ **Correlations are in line with energy budget theory**

Model results



→ Well capture the diel variability in Tdif

Model results

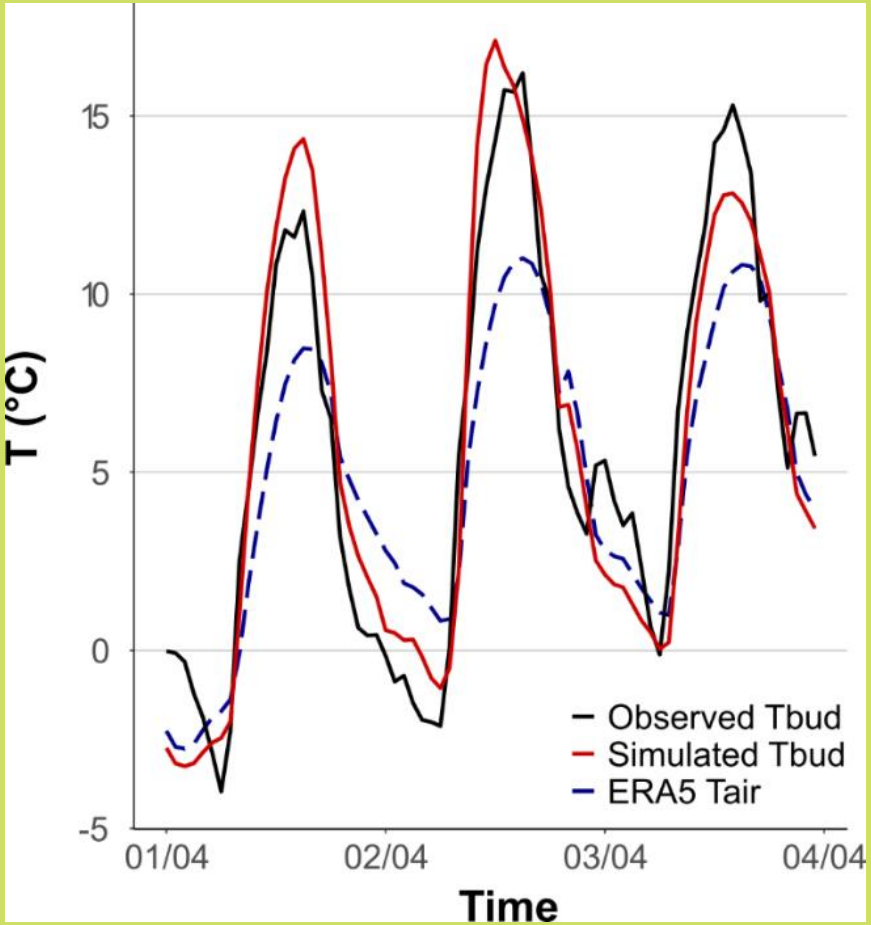


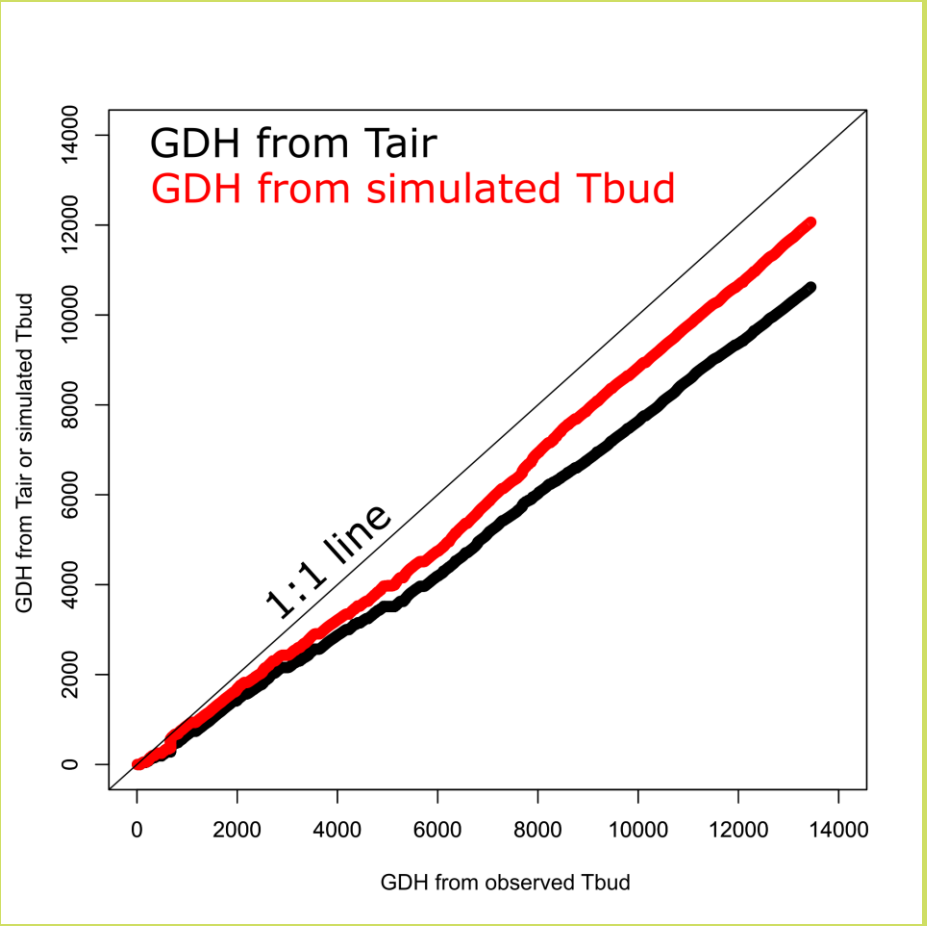
→ Tend to overestimate night temperature
→ Tend to underestimate day temperature

} **Difficulties to capture sensible heat**

Preliminary Results (unpublished)

Model results





→Clear improvement with ERA 5 gridded data

What can we expect if we account for bud temperature in phenology studies?

1) **Air temperature might be an imprecise and biased predictor of bud temperature** (sun-exposed buds)

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2) Clear day/night asymmetry induced by radiation
3) Clear role of bud traits

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1) **Air temperature might be an imprecise and biased predictor of bud temperature** (sun-exposed buds)
2) Clear day/night asymmetry induced by radiation
3) Clear role of bud traits
4) **Energy budget modelling is promising to correct Tair biases**

What can we expect if we account for bud temperature in phenology studies?

1) **Air temperature might be an imprecise and biased predictor of bud temperature** (sun-exposed buds)
2) Clear day/night asymmetry induced by radiation
3) Clear role of bud traits
4) **Energy budget modelling is promising to correct Tair biases**

→We need more bud/leaf temperature, traits, and microclimate data

Perspective 1

Biophysical and physiological effect of light

frontiers in Plant Science

ORIGINAL RESEARCH
published: 28 March 2019
doi: 10.3389/fpls.2019.00398

Daily Maximum Temperatures Induce Lagged Effects on Leaf Unfolding in Temperate Woody Species Across Large Elevational Gradients

Christof Bigler[1,2] and Yann Vitasse[2,3]*

[1] Forest Ecology, Institute of Terrestrial Ecosystems, Department of Environmental Systems Science, ETH Zürich, Zurich, Switzerland, [2] SwissForestLab, Birmensdorf, Switzerland, [3] Disturbance Ecology, Forest Dynamics, Swiss Federal Research Institute WSL, Birmensdorf, Switzerland

International Journal of Biometeorology (2019) 63:1631–1640
https://doi.org/10.1007/s00484-019-01776-0

ORIGINAL PAPER

Responses of bud-break phenology to daily-asymmetric warming: daytime warming intensifies the advancement of bud break

Shaokang Zhang [1,2,3,4] · Nathalie Isabel [5] · Jian-Guo Huang [1,2,3] · Hai Ren [1,2,3] · Sergio Rossi [1,6]

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journal homepage: www.elsevier.com/locate/ecolind

Effect of preseason diurnal temperature range on the start of vegetation growing season in the Northern Hemisphere

Yan Huang[a,1], Nan Jiang[a,1], Miaogen Shen[a,b,*], Li Guo[c,d,*]

Ecology, 100(9), 2019, e02775
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Opposite effects of winter day and night temperature changes on early phenophases

Fandong Meng,[1] Lirong Zhang,[1] Zhenhua Zhang,[2] Lili Jiang,[1] Yanfen Wang,[3] Jichuang Duan,[4] Qi Wang,[1,3] Bowen Li,[1,3] Peipei Liu,[1,3] Huan Hong,[1,3] Wangwang Lv,[1,3] Wangmu Renzeng,[1,3] Zhezhen Wang,[3] Caiyun Luo,[2] Tsechoe Dorji,[1,6] Huakun Zhou,[2] Mingyuan Du,[7] and Shiping Wang[1,6,8]

ARTICLE

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Leaf onset in the northern hemisphere triggered by daytime temperature

Shilong Piao[1,2,3], Jianguang Tan[3], Anping Chen[4], Yongshuo H. Fu[3,5], Philippe Ciais[6], Qiang Liu[3], Ivan A. Janssens[5], Sara Vicca[5], Zhenzhong Zeng[3], Su-Jong Jeong[7], Yue Li[3], Ranga B. Myneni[8], Shushi Peng[3,6], Miaogen Shen[1] & Josep Peñuelas[9,10]

Research

New Phytologist

Three times greater weight of daytime than of night-time temperature on leaf unfolding phenology in temperate trees

Yongshuo H. Fu[1,2], Yongjie Liu[1], Hans J. De Boeck[1], Annette Menzel[3,4], Ivan Nijs[1], Marc Peaucelle[5], Josep Peñuelas[6,7], Shilong Piao[2,8] and Ivan A. Janssens[1]

Agricultural and Forest Meteorology 281 (2020) 107832

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Agricultural and Forest Meteorology

journal homepage: www.elsevier.com/locate/agrformet

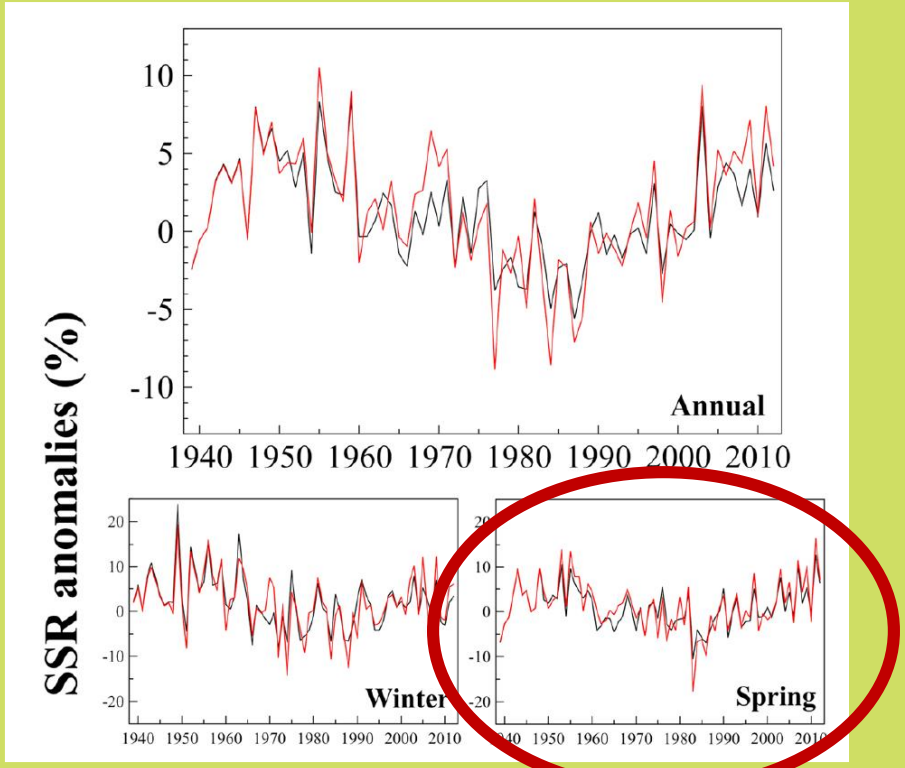
Divergent responses of spring phenology to daytime and nighttime warming

Lin Meng[a], Yuyu Zhou[a,*], Xuecao Li[a], Ghasserm R. Asrar[b], Jiafu Mao[c], Alan D. Wanamaker Jr.[a], Yeqiao Wang[d]

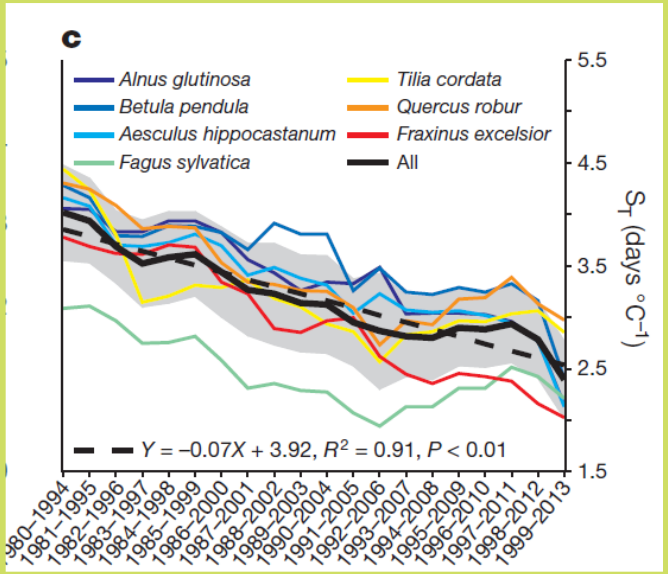
→ **Assymetrical effect of day and night temperature**

Perspective 2

Better quantification of warming sensitivity



Downward Surface Shortwave Radiation (SSR)
Sanchez-Lorenzo et al. 2015 (JGR)



Leaf unfolding sensitivity to warming S_T (days °C-1)
Fu et al. 2015 (Nature)

→Increase in "brightening" since 1980, especially during spring
→Decline in apparent sensitivity of leaf unfolding to warming

Using air temperature potentially leads to wrong interpretation of the sensitivity of phenology to warming

Uncertainties in estimating budburst heat requirement when using local or gridded temperature compared to bud tissue temperature

Marc Peaucelle[1], Cinta Sabate Gil[2], Josep Peñuelas[2,3], Hans Verbeeck[4], Jonas Gisler[5] and Yann Vitasse[5]

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