Phenology studies need to account for tissue temperature, not (only) air temperature

Marc Peaucelle, Josep Peñuelas, Hans Verbeeck

CL 2.8 28 April 2021

EGU General Assembly 2021

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CREAF

Temperature drives phenology in extra-tropical ecosystems

→ Important role of Chilling and Forcing over the preseason
→ Strong shift in phenophase induced by climate warming
→ Extension of growing season length

But
→ Heterogeneity in response between species and regions
→ Phenology might be co-limited by several other factors (light, water, nutrients…)

Light in phenology studies = Photoperiod

The effect of light is often considered by photoperiod and mainly daylength

- Direct sensing of the quantity and quality of light? (phytohormones?)
- Spectral composition?
- More sporadically, insolation sum as forcing.

→ Still debated, but recent studies suggest complex interactions between light and temperature

Context

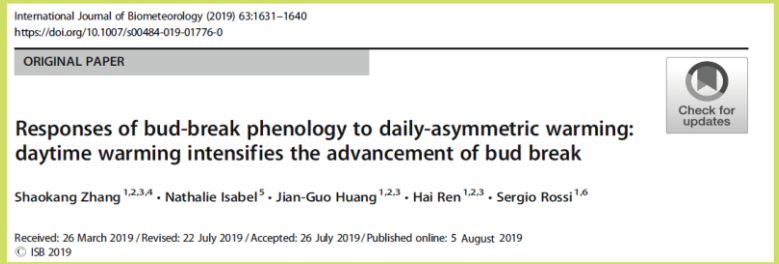

frontiers in Plant Science

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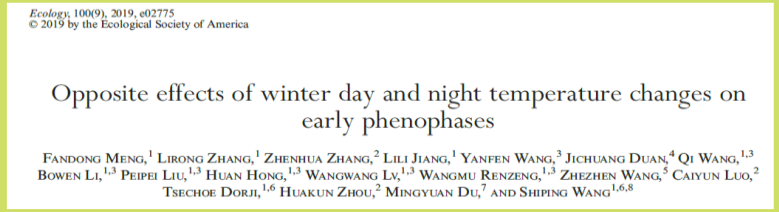
Ecology, 100(9), 2019, e02775
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Opposite effects of winter day and night temperature changes on early phenophases

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,[5] Caiyun Luo,[2] Tsechoe Dorji,[1,6] Huakun Zhou,[2] Mingyuan Du,[7] and Shiping Wang[1,6,8]

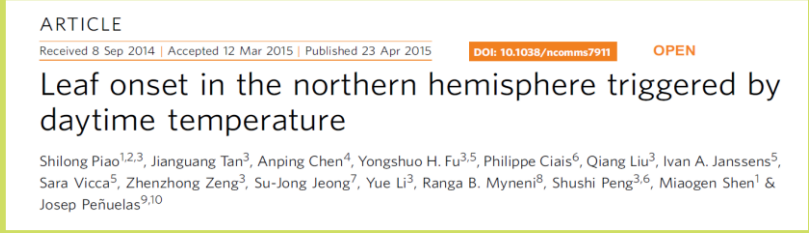

Contents lists available at ScienceDirect

Ecological Indicators

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,*]


ARTICLE

Received 8 Sep 2014 | Accepted 12 Mar 2015 | Published 23 Apr 2015

DOI: 10.1038/ncomms7911 OPEN

Leaf onset in the northern hemisphere triggered by daytime temperature

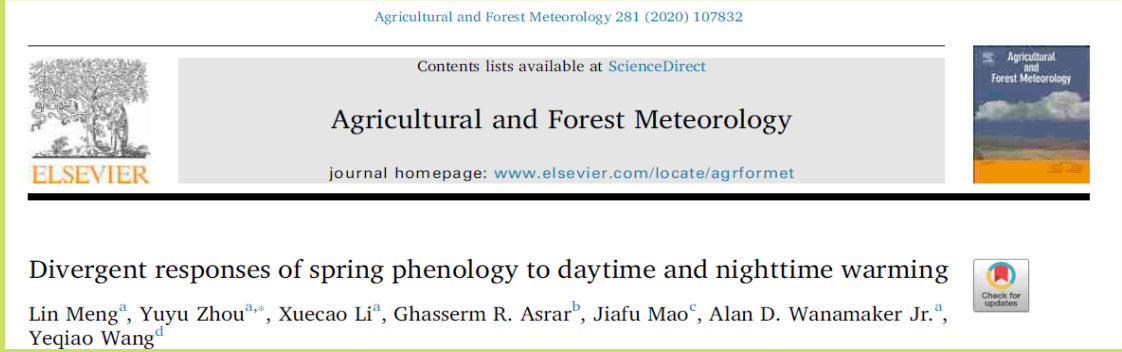
Shilong Piao[1,2,3], Jianguang Tan[3], Anping Chen[4], Yongshuo H. Fu[3,5], Philippe Ciais[6], Qiang Liu[3], Ivan A. Janssens[5], Sara Vicca[5], Zhenzhong Zeng[3], Su-Jong Jeong[7], Yue Li[3], Ranga B. Myneni[8], Shushi Peng[3,6], Miaogen Shen[1] & Josep Peñuelas[9,10]


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

Contents lists available at ScienceDirect

Agricultural and Forest Meteorology

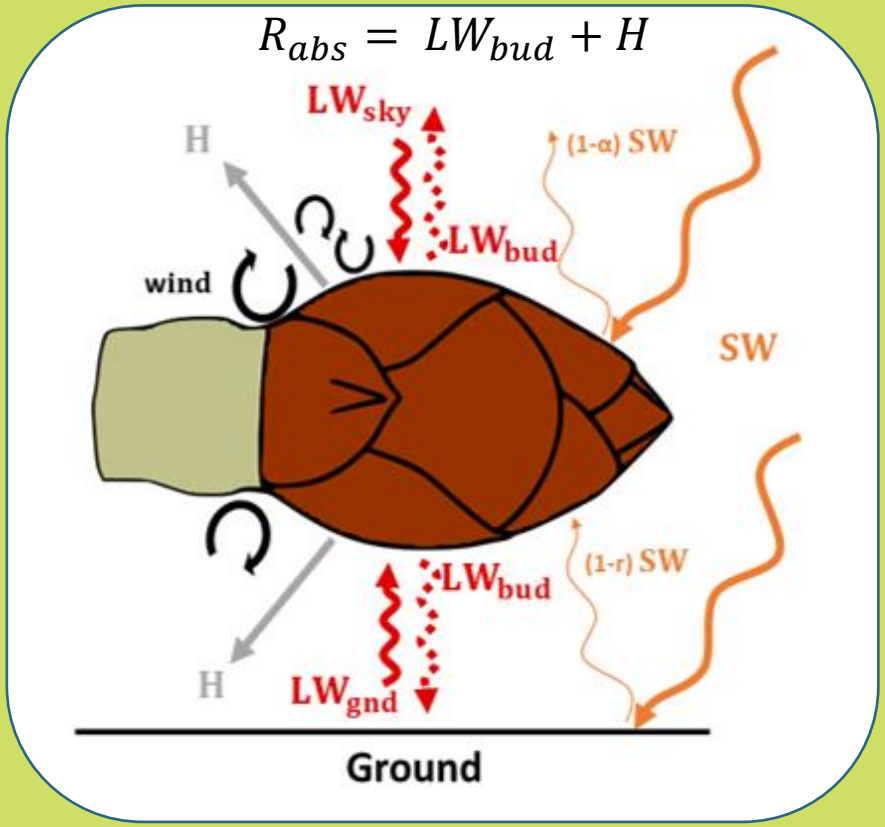
journal homepage: www.elsevier.com/locate/agrformet

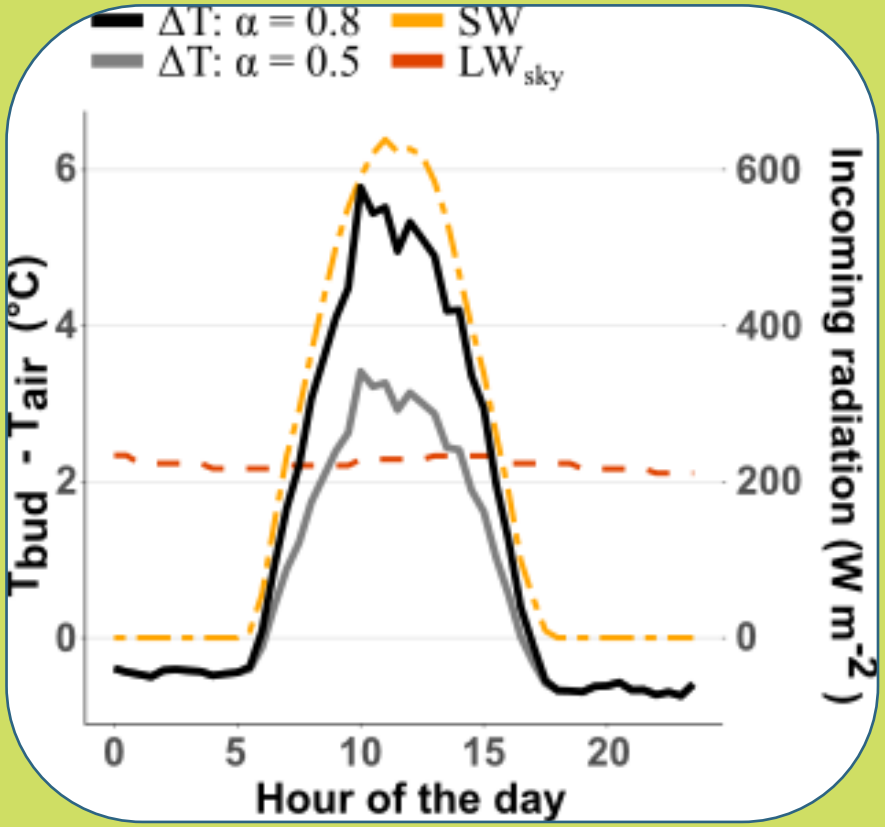
Divergent responses of spring phenology to daytime and nighttime warming

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**

The forgotten effect of radiation and wind





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

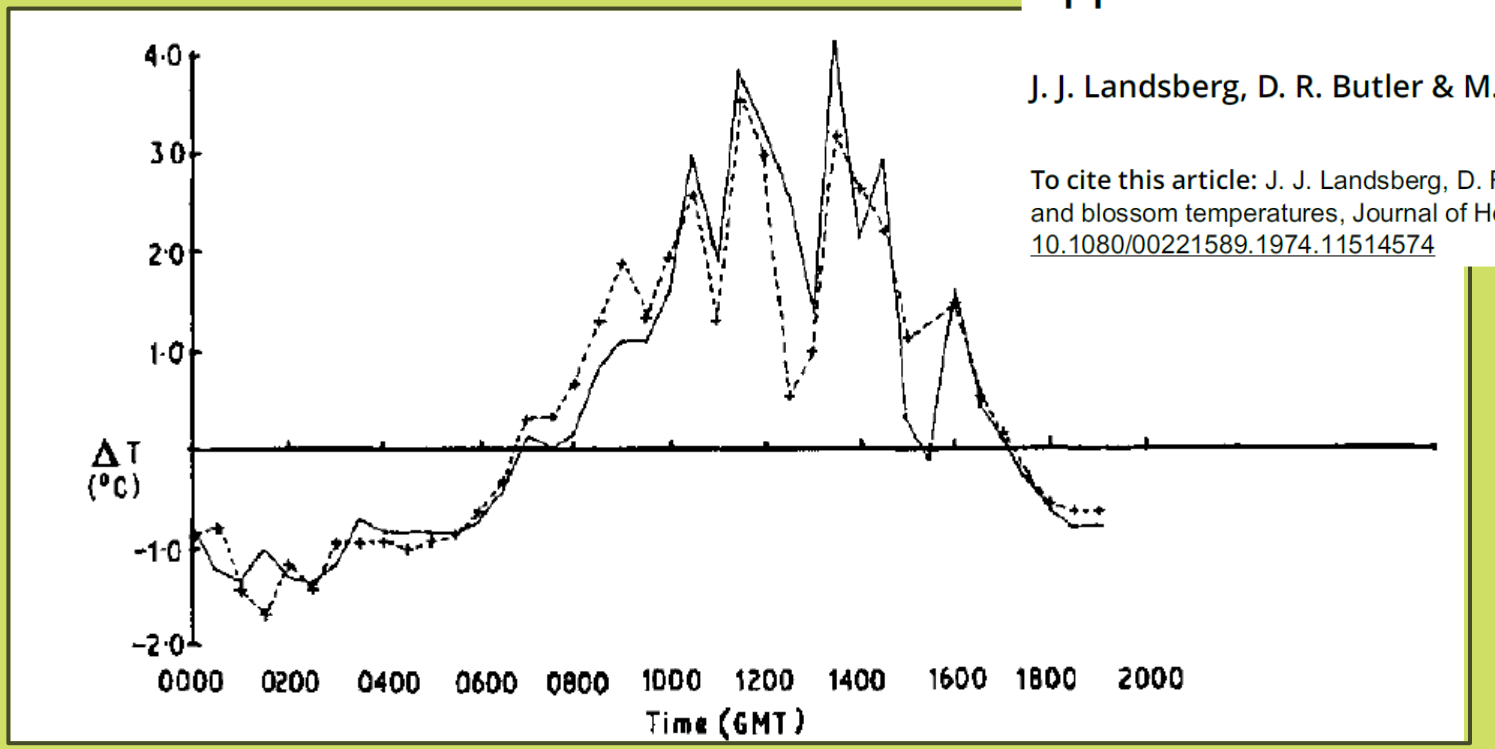
→ Direct effect on tissue temperature

The forgotten effect of radiation and wind

Effect known for a long time

——— Obs

– – – Model



Apple bud and blossom temperatures

J. J. Landsberg, D. R. Butler & M. R. Thorpe

To cite this article: J. J. Landsberg, D. R. Butler & M. R. Thorpe (1974) Apple bud and blossom temperatures, Journal of Horticultural Science, 49:3, 227-239, DOI: 10.1080/00221589.1974.11514574

→ Direct effect on tissue temperature

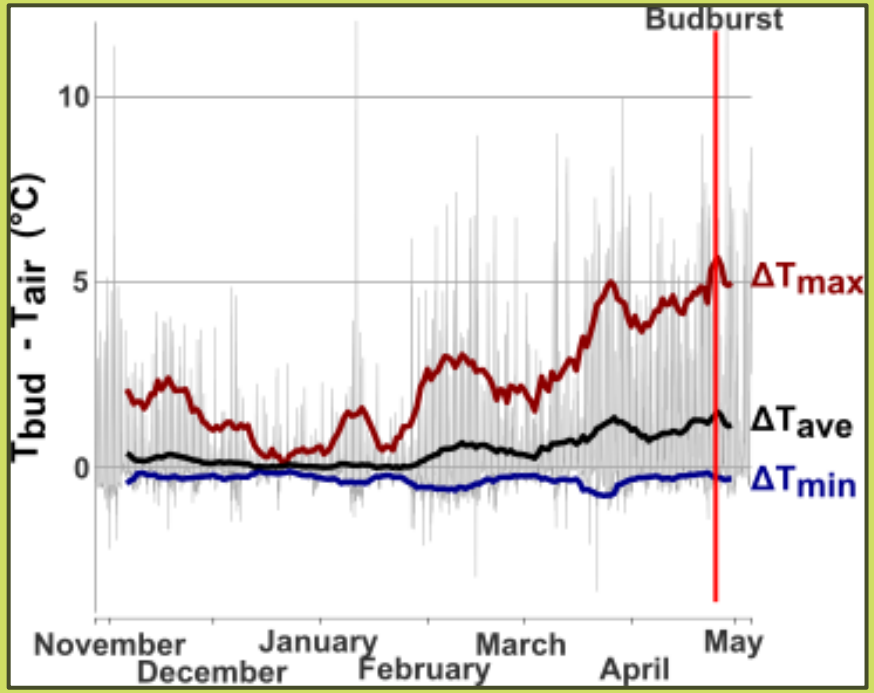
What can we expect if we account for bud temperature in phenology studies?

→ No (or not enough) available data to answer directly this question
→ But we have energy budget models

- application of existing **steady-state** energy model with site level and global meteorological data for **sun-exposed buds**

- exploration of temporal and spatial variability in bud temperature

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

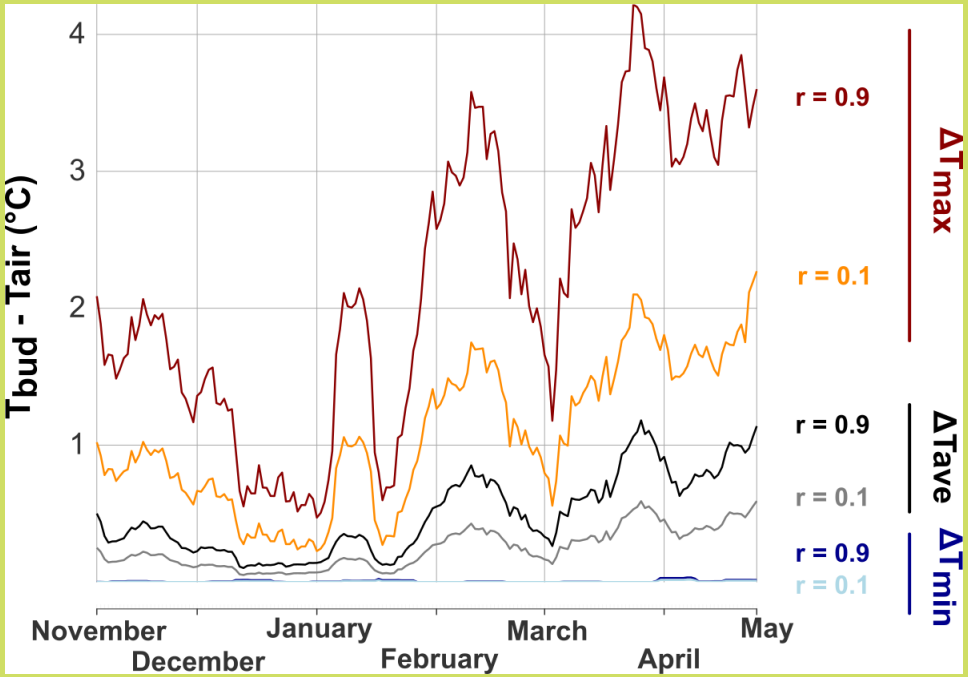


Model forced with 30min FLUXNET data (Hesse, France)
Model with α = 0.8, bud diameter = 5mm

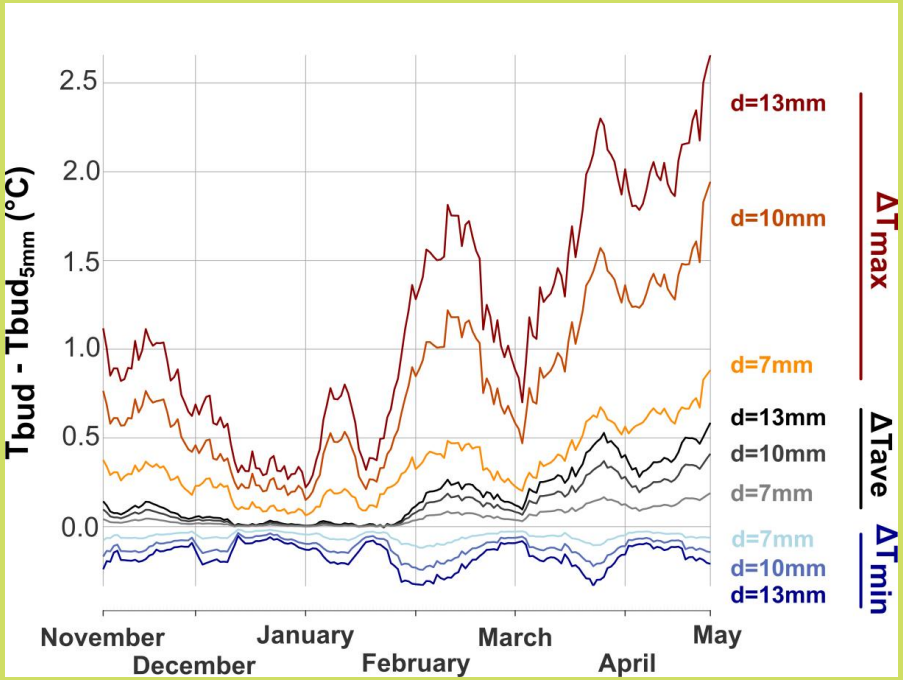
At the site level

→ Non proportional Tbud and Tair trajectories
→ Higher variability in Tbud than Tair
→ Different extremum in Tbud than Tair
→ Depends on bud traits and local environment

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



Effect of ground albedo (r)

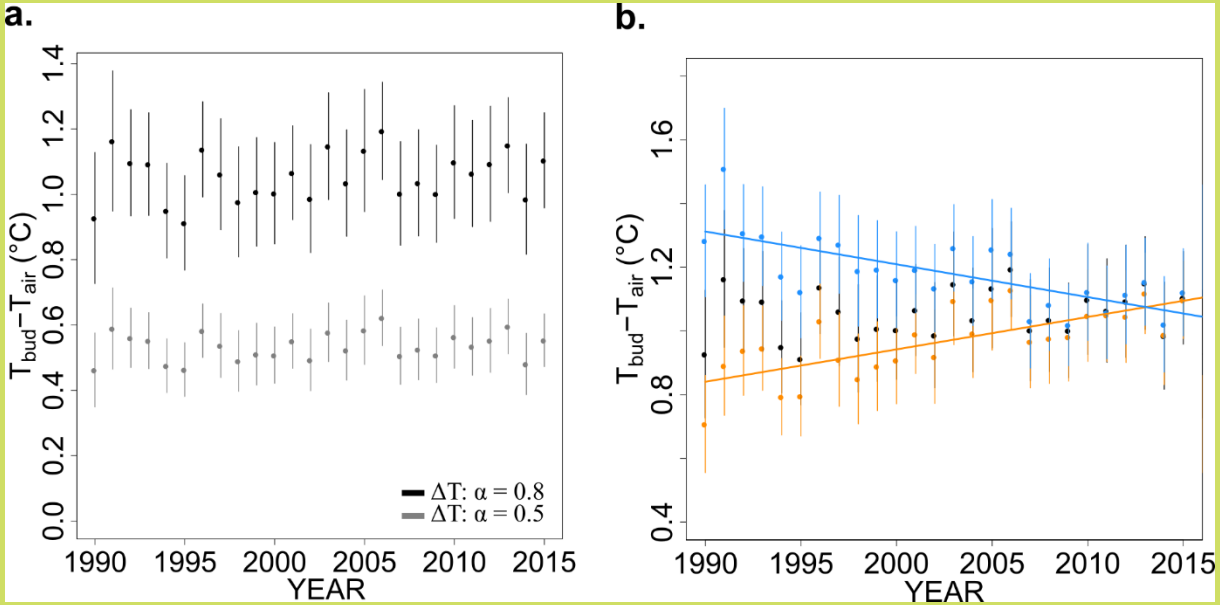


Effect of bud diameter (d)

(!!! Steady-state model !!!)

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

PEP data, 5 species + CRUNCEP, 6h, 0.5°



At the regional level

ΔT is expected to decrease (blue) over the period 1990-2016 for 356 sites*species (7%) and increase (orange) for 902 sites*species (18%) over a total of 5050 sites*species

!!! Steady-state model without species or site calibration !!!

→ Higher variability expected after calibration and the use of a transient model

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

- → Existing models suggest that **air temperature might be an imprecise and biased predictor of bud temperature** (sun-exposed buds)
- → Results from complex combination of biotic and abiotic factors
- → Differences in bud traits could partly explain observed inter-species differences in phenology
- → Differences in local environment could partly explain observed spatial variability in phenology

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- → Use energy balance model to disentangle the effect of photoperiod and temperature?

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- → Use energy balance model to disentangle the effect of photoperiod and temperature?

- → Possible effect on senescence?

Widespread decline in winds delayed autumn foliar senescence over high latitudes

Chaoyang Wu[a,b,1], Jian Wang[c,1], Philippe Ciais[d], Josep Peñuelas[e,f], Xiaoyang Zhang[g], Oliver Sonnentag[h], Feng Tian[i], Xiaoyue Wang[a,b], Huanjiong Wang[a,b], Ronggao Liu[a,b], Yongshuo H. Fu[j], and Quansheng Ge[a,b,1]

Conclusion

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- → Use energy balance model to disentangle the effect of photoperiod and temperature?

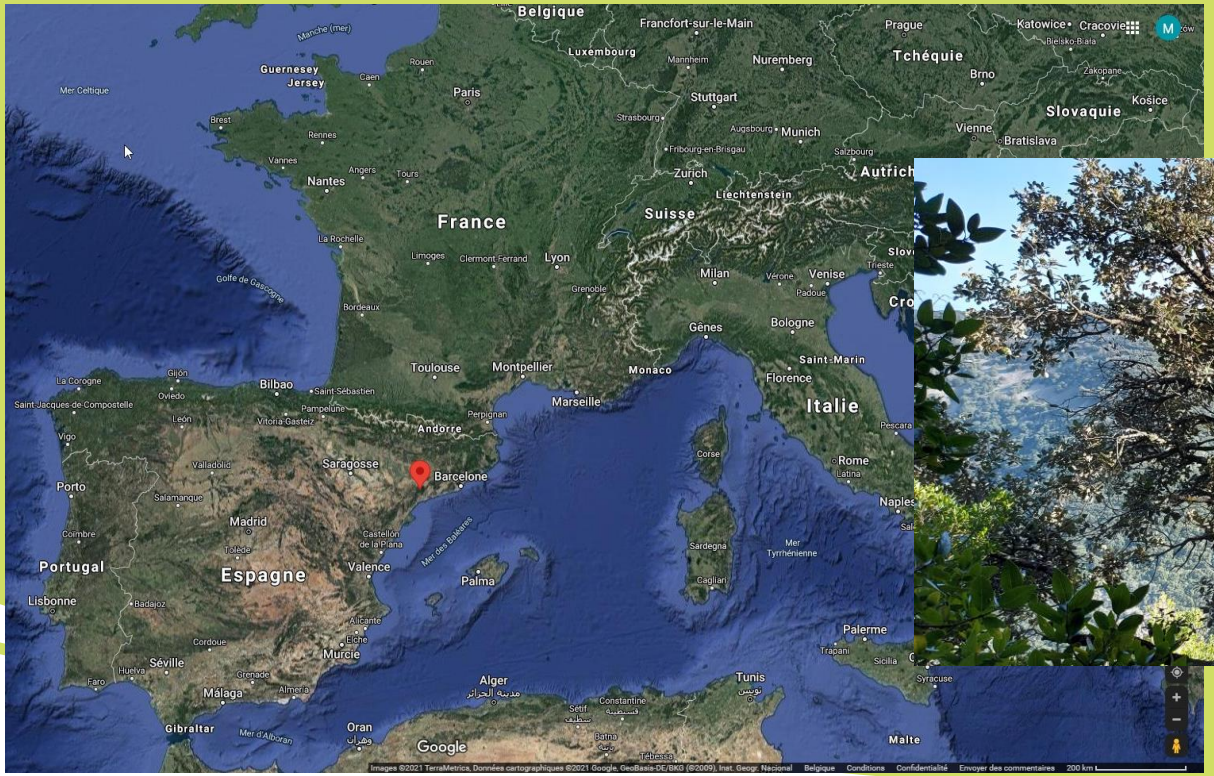
- → Possible effect on senescence?

→ We need bud/leaf temperature, traits, and micrometeorological data to answer these questions

Measurement of bud temperature and microclimate in the field

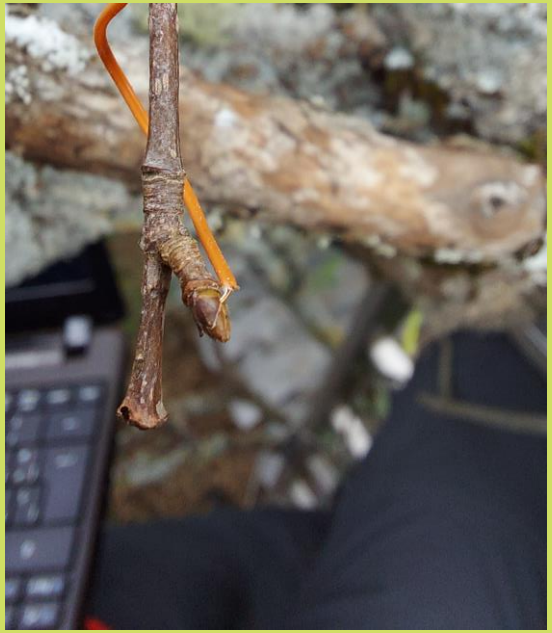
→ Master Thesis of Cinta Sabaté Gil at CREAF

→ Field monitoring of bud temperature and microclimate at Prades Mountains, Catalonia (41°20’38” N, 1°2’0” E, 950 m a.s.l.)

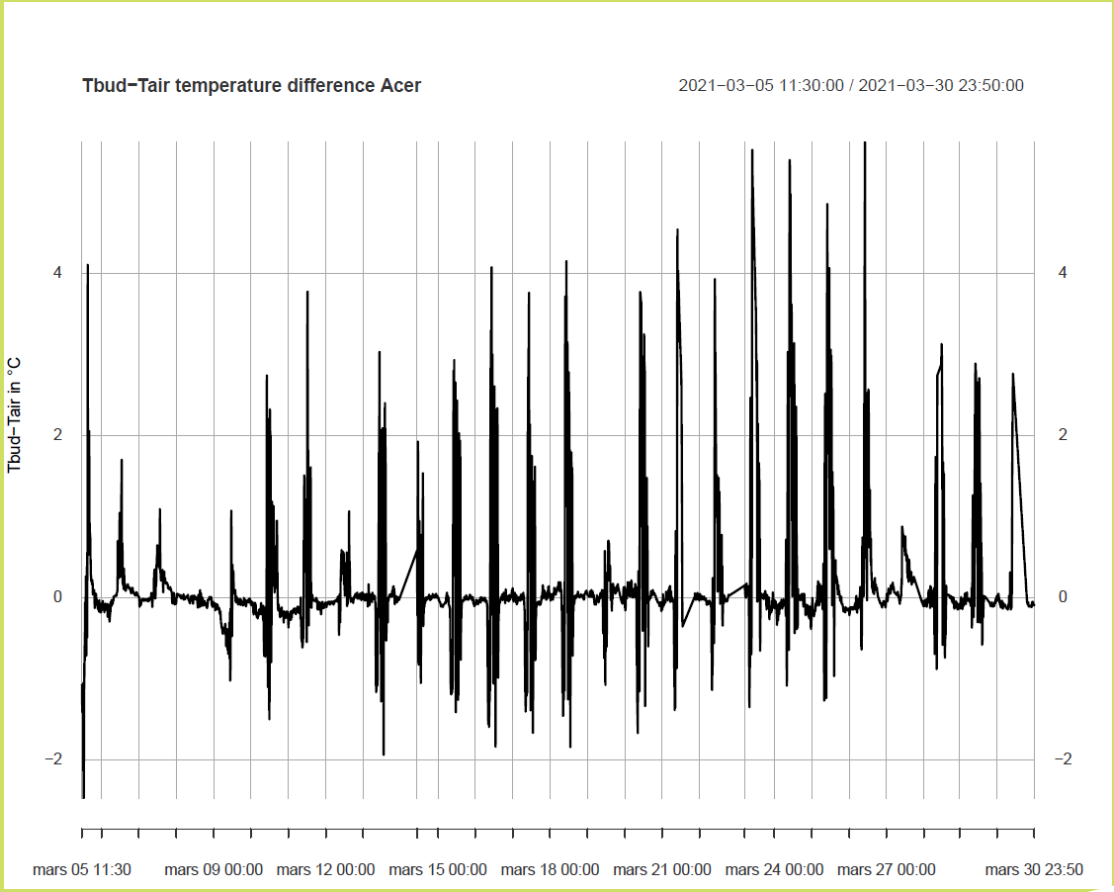


Measurement of bud temperature and microclimate in the field

→ 5 species: *Acer monspessulanum, Sorbus torminalis*, *Quecus Ilex, Phillyrea latifolia* & *Arbutus unedo*



T-type thermocouple



Preliminary results in line with the modeling approach

Measurement of bud temperature and microclimate in the field

→ Collection of buds for traits (spectral properties, size, …)

→ results coming soon ☺

Phenology studies need to account for tissue temperature, not (only) air temperature

Marc Peaucelle, Josep Peñuelas, Hans Verbeeck

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