The sensitivity of ginkgo leaf unfolding to the temperature and photoperiod decreases with increasing elevation

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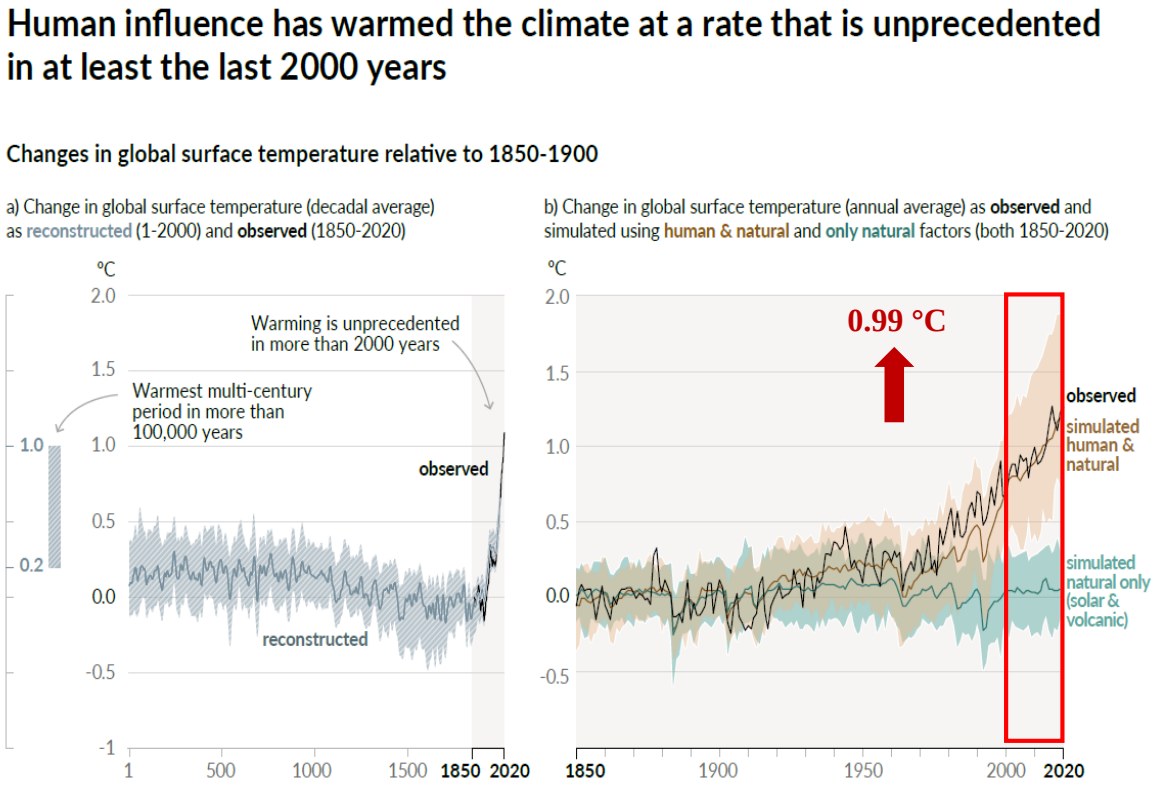
Background

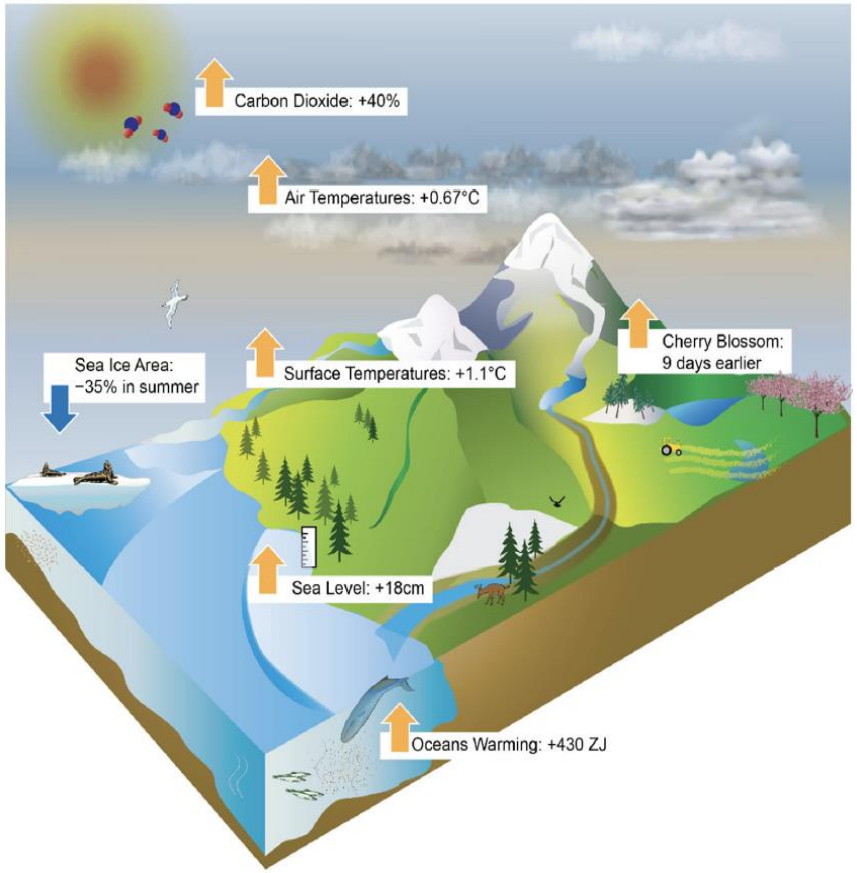
- **Climate change**

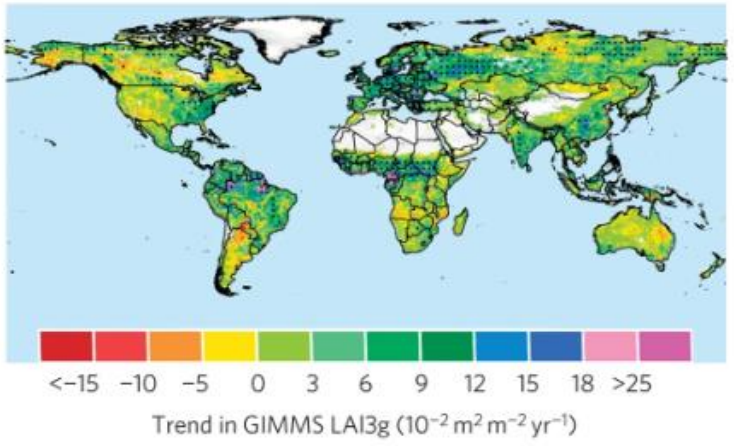


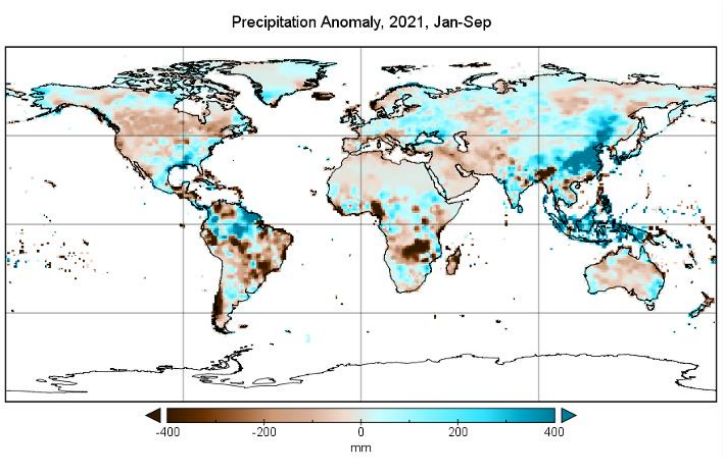
IPCC AR6, 2021

Background

- **Effects of climate change**



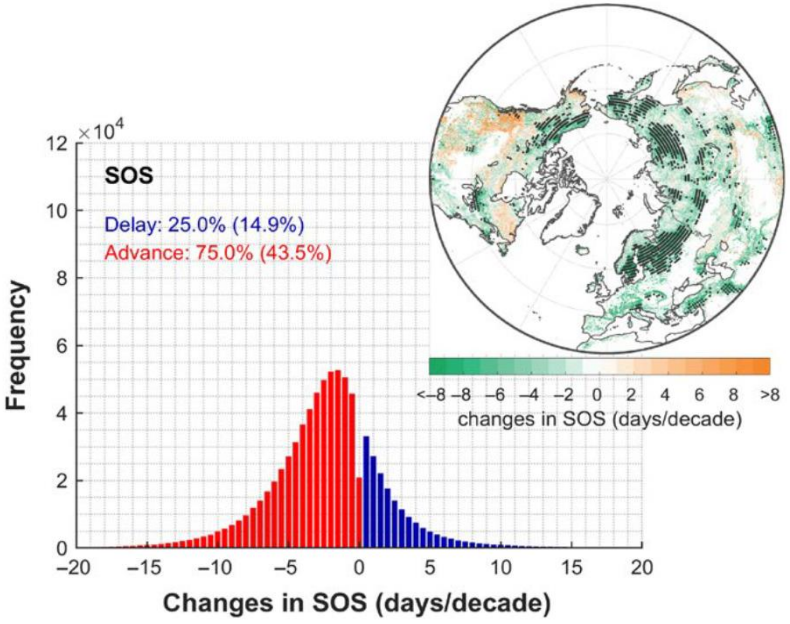




IPCC AR6 2021; WMO, 2021; Zhu et al., 2016

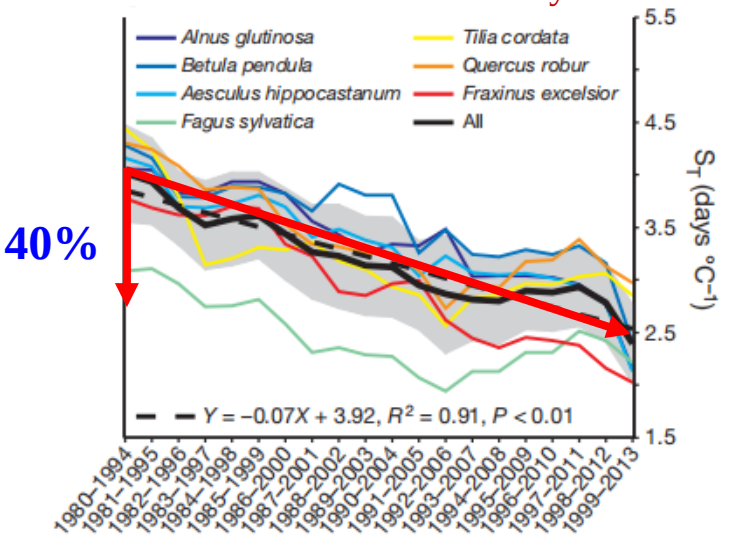
Background

- **Phenology responses**
  - Global warming largely **advanced** spring leaf unfolding over the past decades.
  - The temperature sensitivity of leaf unfolding (S_T, expressed in days advance of leaf unfolding per degree warming) significantly **decreased** from 1980 to 2013.



Piao et al., 2019 GCB

Decreased from 4.0 to 2.3 days °C^{-1}

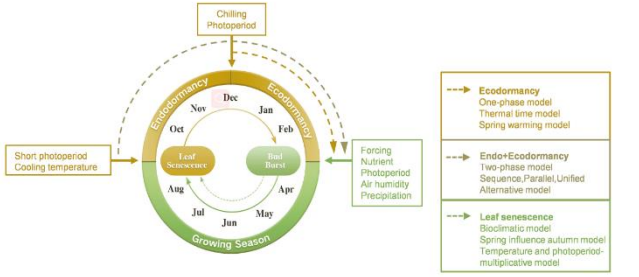


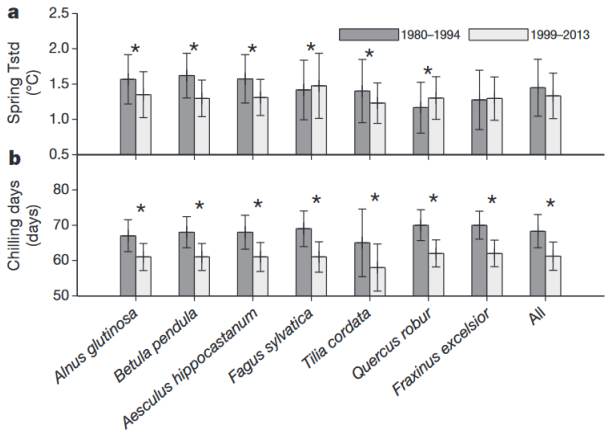
Fu et al., 2015 Nature

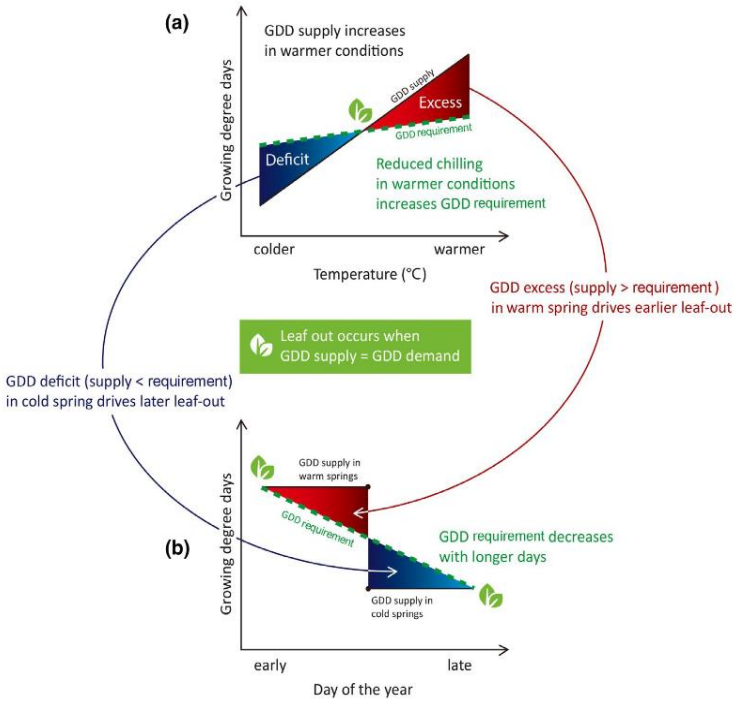
Background

- **Chilling and photoperiod limitation**

The reduction in S_T is likely to be partly attributable to reduced **chilling** and/or **photoperiod limitation** mechanisms.





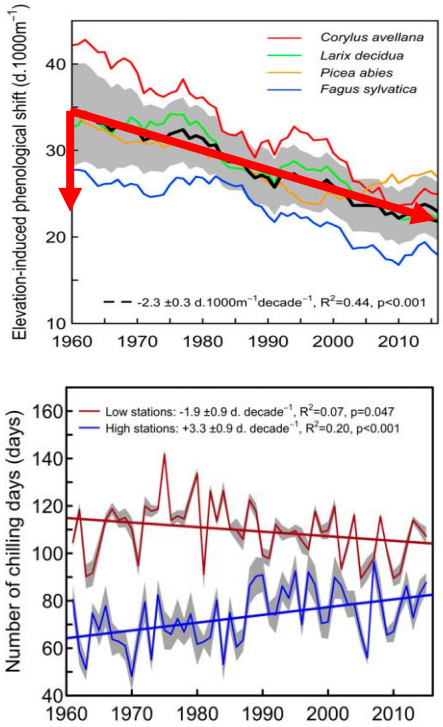


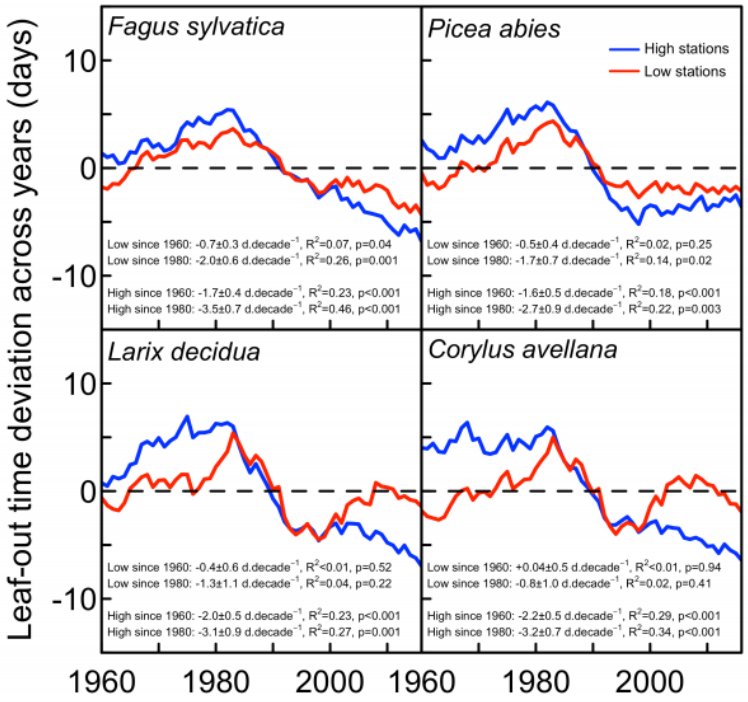
Fu et al., 2015 Nature, 2019 GCB

Background

- **Response differences among elevations**
  - The **elevation-induced phenological shift (EPS)** has significantly **declined** from 34 d km^{-1} in 1960 to 22 d km^{-1} in 2016.
  - **Stronger** phenological advance was found at **higher elevations**.

35%





Vitasse et al., 2018 PNAS

Background

- **Dioecious species**

  - There were more than 15,000 species of **dioecious plants** on the earth, i.e. Ginkgo.
  - The spring phenology of **male** gingko trees are usually 3-5 days **earlier** than **female** ginkgo trees.

Sabina chinensis

Ginkgo biloba

Purposes

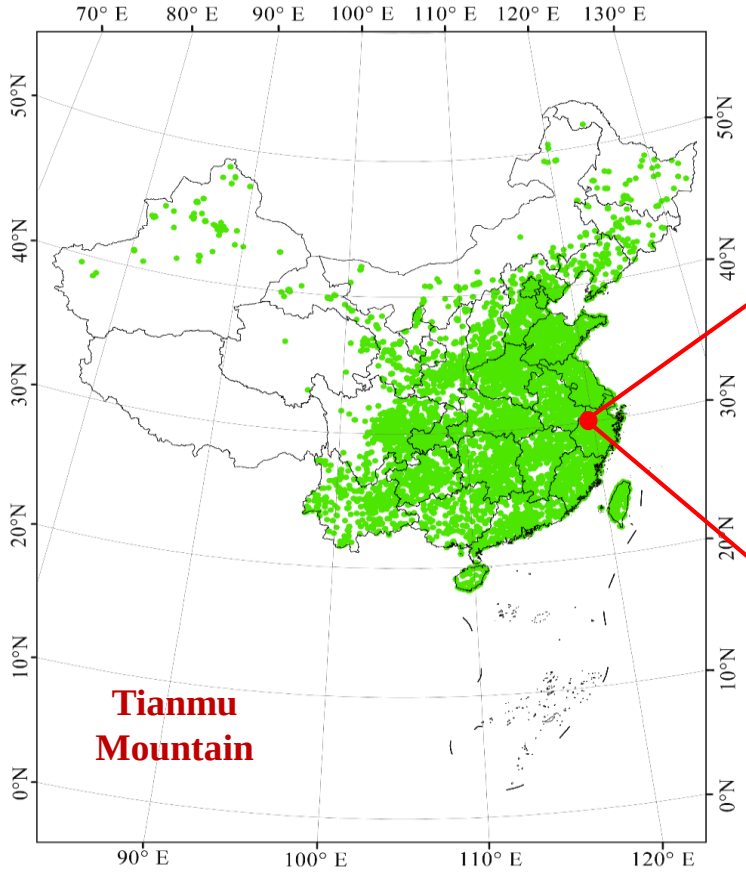
- whether leaf unfolding time and its temperature sensitivity are similar between male and female individuals?

- how the responses of leaf unfolding to temperature and photoperiod differ among populations growing in different elevations?

Material & methods

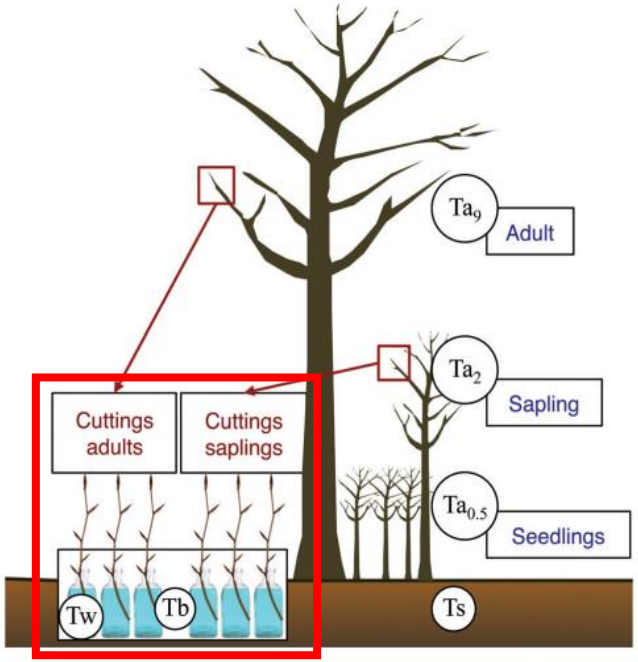
- **Study site**

The dominant vegetation type on Tianmu Mountain is a subtropical evergreen and deciduous broad-leaved mixed forest at an elevation of **300-1506 m**.



Material & methods

- **Twig cutting experiment**
  - **Larger uncertainty** in field investigation as the intricate environmental condition.
  - Twig cuttings have been proven to be **a viable alternative to donor trees** for phenological studies.




Tree Physiology 00, 1–10
doi:10.1093/treephys/tpt116

Research paper

Is the use of cuttings a good proxy to explore phenological responses of temperate forests in warming and photoperiod experiments?

Yann Vitasse[1] and David Basler

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frontiers in Plant Science

EDITORIAL
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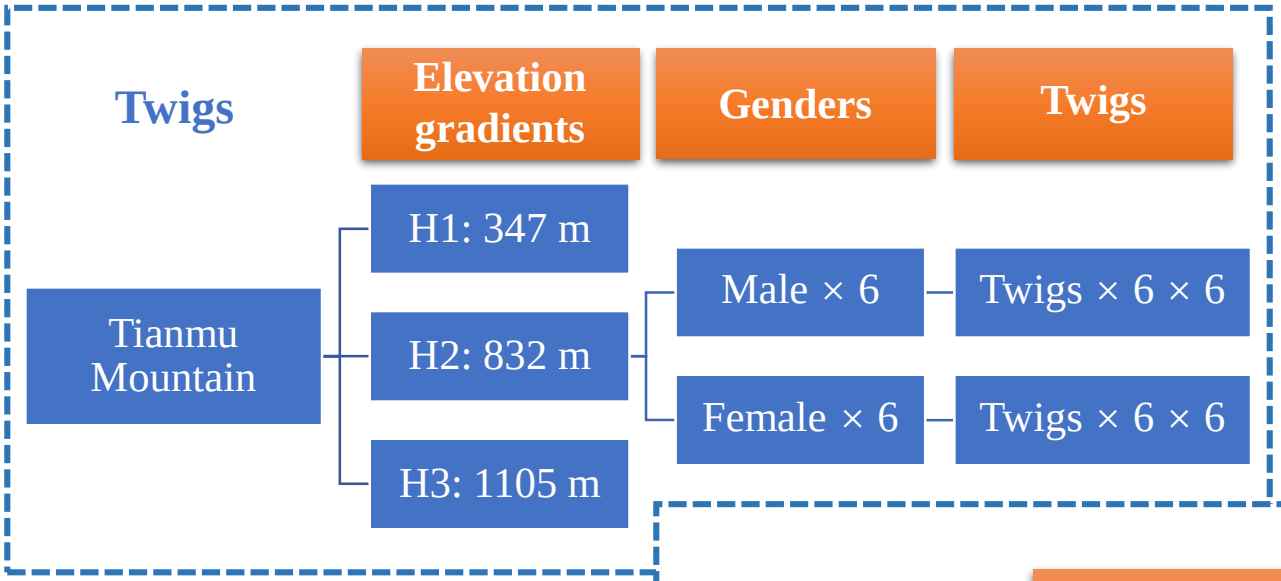
Editorial: Experimental Manipulations to Predict Future Plant Phenology

Janet S. Prevéy[1]*, Yann Vitasse[2] and Yongshuo Fu[3]

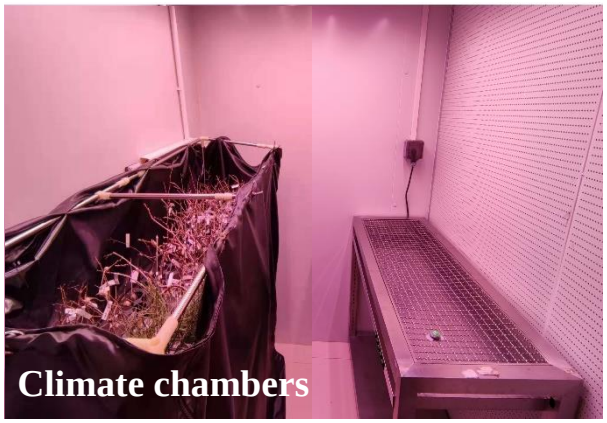
[1] U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO, United States, [2] Swiss Federal Institute for Forest, Snow and Landscape Research, Forest Dynamics, Birmensdorf, Switzerland, [3] Beijing Normal University, Beijing, China

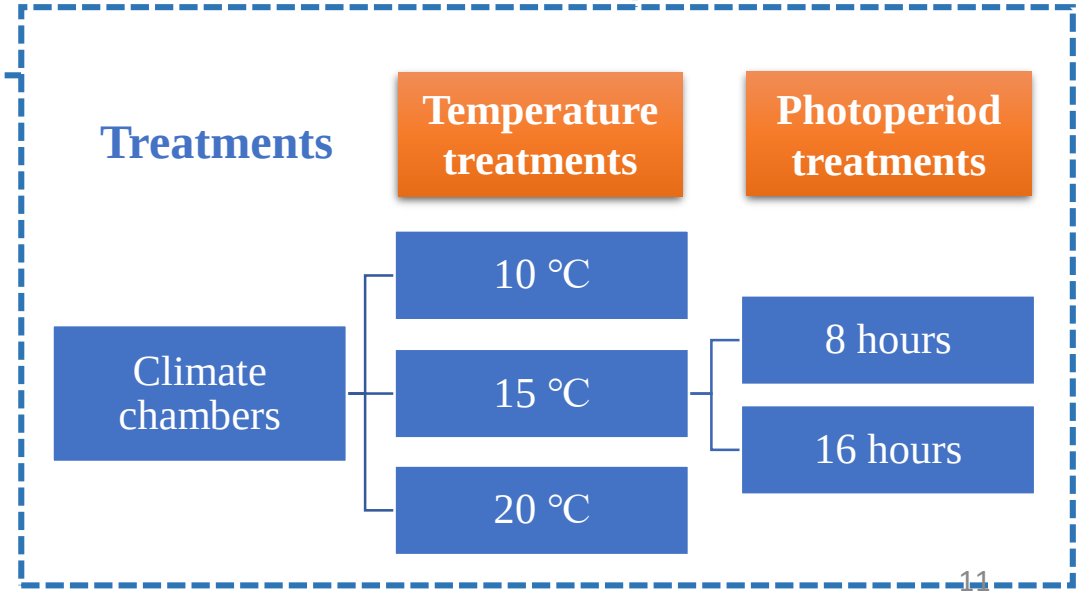
Material & methods

- **Environmental treatments**



January 17-19, 2021





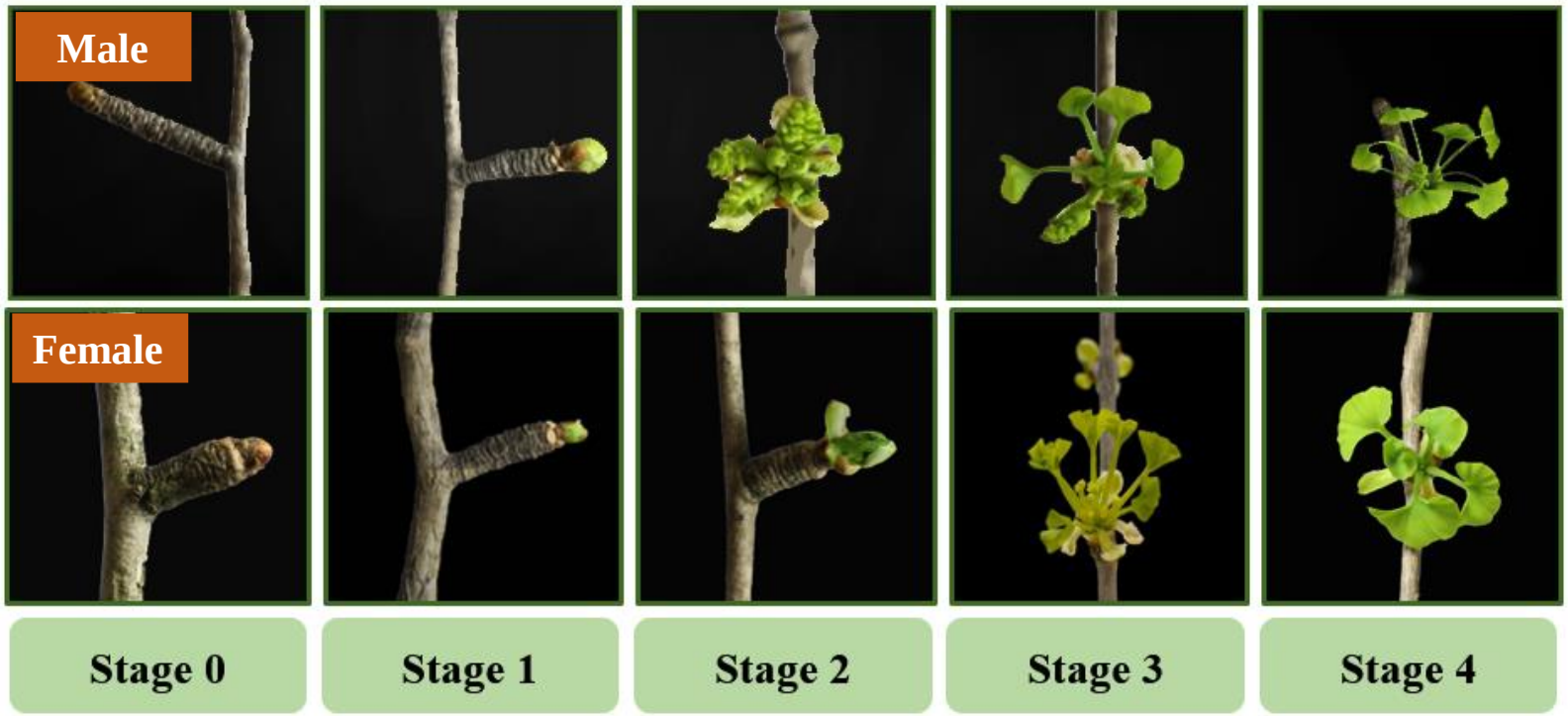
Material & methods

- **Experimental process**

Illuminance: ~161 μmol m^{-2} s^{-1}; **Concentration of CO_2**: ~442 ppm; **Relative air humidity**: ~40%.

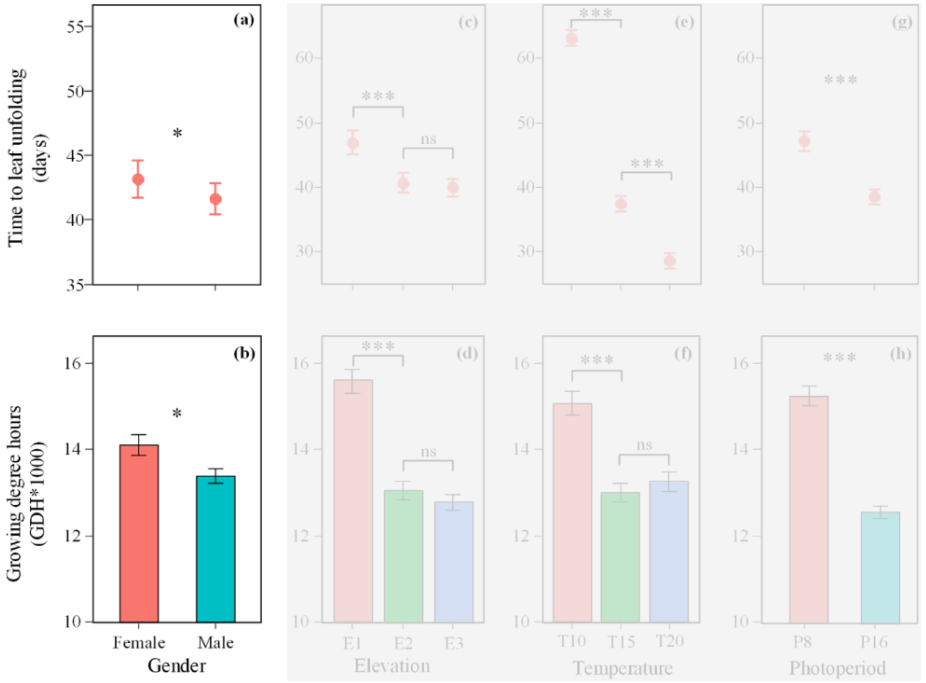
Material & methods

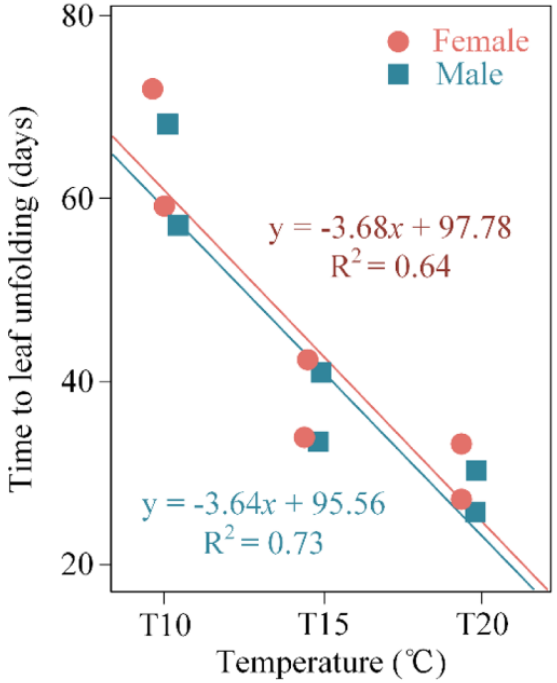
- **Phenological observation**
  - The guideline of phenology monitoring was consistent with **the four-stage categorical scale** provided by Vitasse (2013).
  - We monitored the leaf unfolding of each twig **every 3 days**.



Results & Discussion

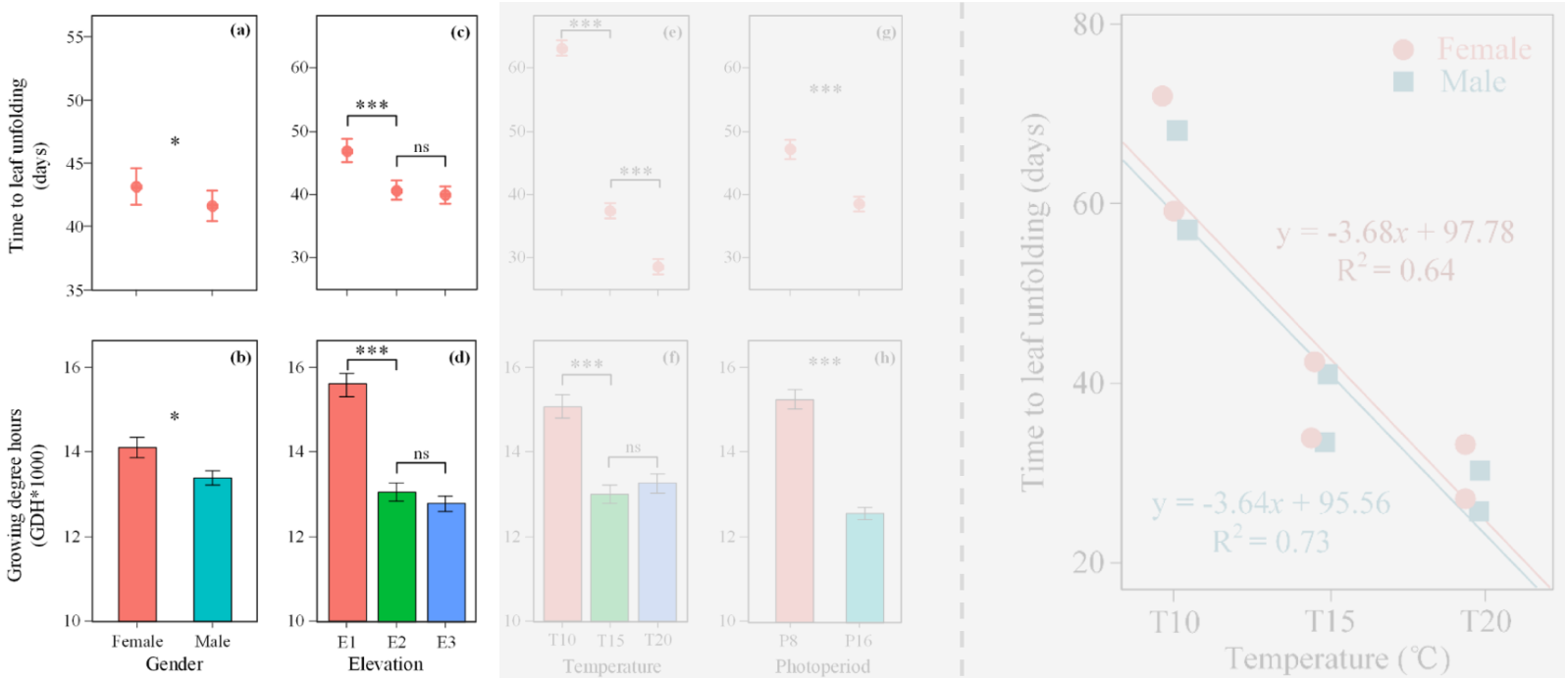
- **Differences in leaf unfolding between genders**
  - There was **no significant difference** in S_T between female and male samples, which are likely related to the reproduction strategy of dioecious plants to **ensure a higher overlap in the male and female** reproductive periods.





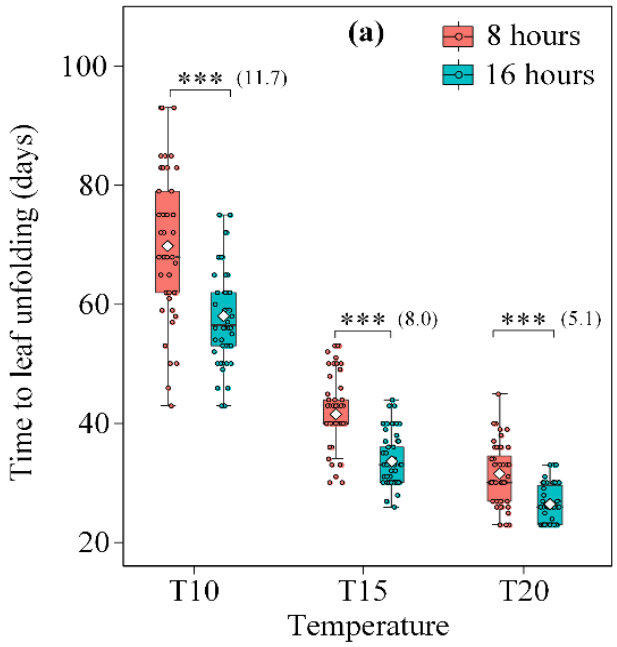
Results & Discussion

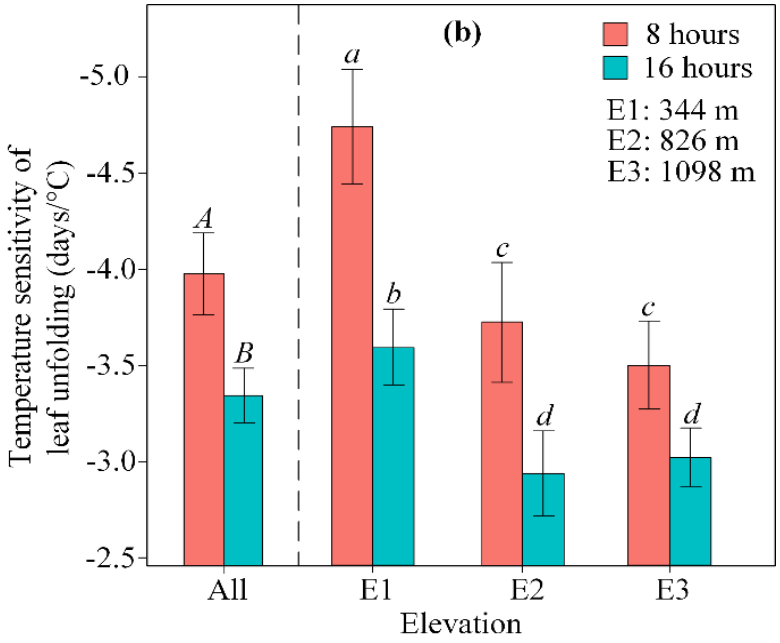
- **Differences in leaf unfolding between provenance elevations**
  - The time required to reach the leaf unfolding stage was **significantly longer** for the twigs collected **at the lowest elevation**.
  - This may be related to the **insufficient chilling** conditions at the lowest elevation when samples were collected.



Results & Discussion

- **Temperature and photoperiod effects on leaf unfolding**
  - **Warming** and **longer photoperiod** significantly accelerated leaf unfolding.
  - The constraining effect of photoperiod **increased as the elevation decreased**.
  - This phenomenon may be related to **environment-induced local adaptations** and **self-protection mechanisms** of trees at high elevations.

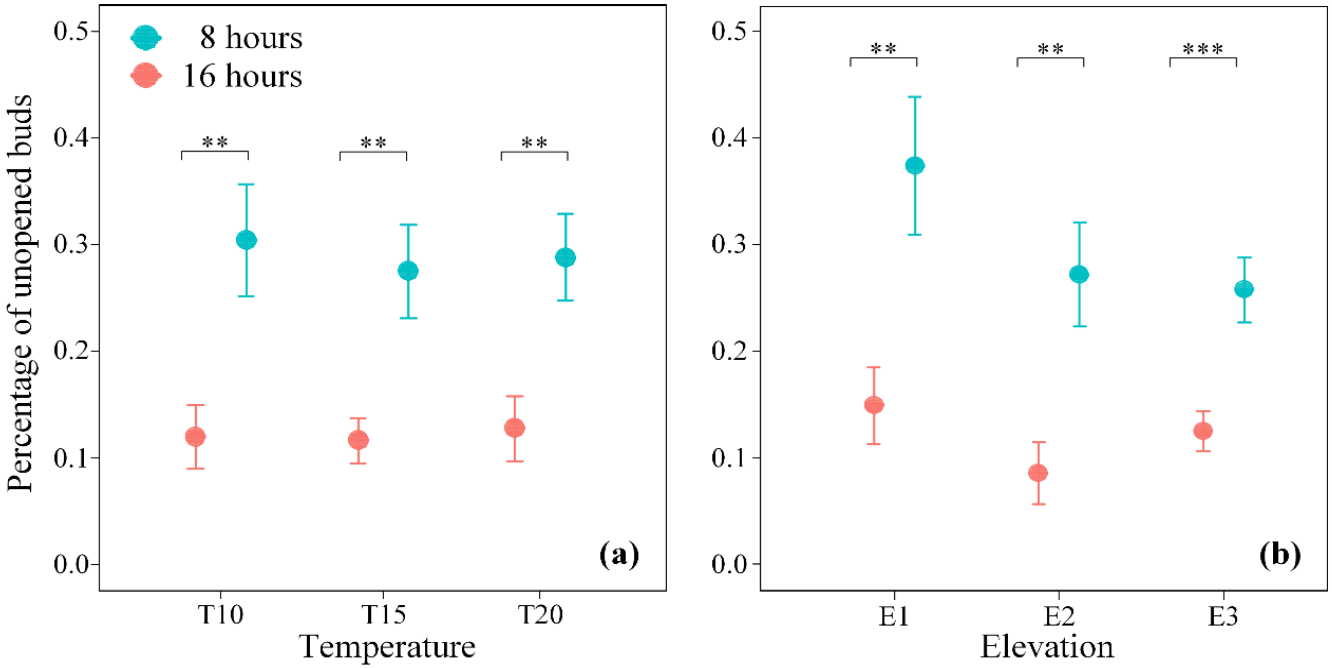




Results & Discussion

- **Effect of the photoperiod on twig vitality**

The percentage of unopened buds per twig was **significantly higher** for the P8 treatment (29%) than for the P16 treatment (12%).



Conclusion

- The sensitivity of gingko leaf unfolding to the temperature and photoperiod decreases as the elevation increases, which may be related to environment-induced local adaptations and self-protection mechanisms of trees at high elevations

- Plants of different genders respond consistently to climate change to ensure a higher overlap in the male and female reproductive periods

- **Limitation**: Only one species was used, and the constant temperature and photoperiod treatments during our experiments do not accurately reflect natural conditions.

Ongoing works

- **Phenology Observatory Network of Chinese University**

Study sites 22 universities

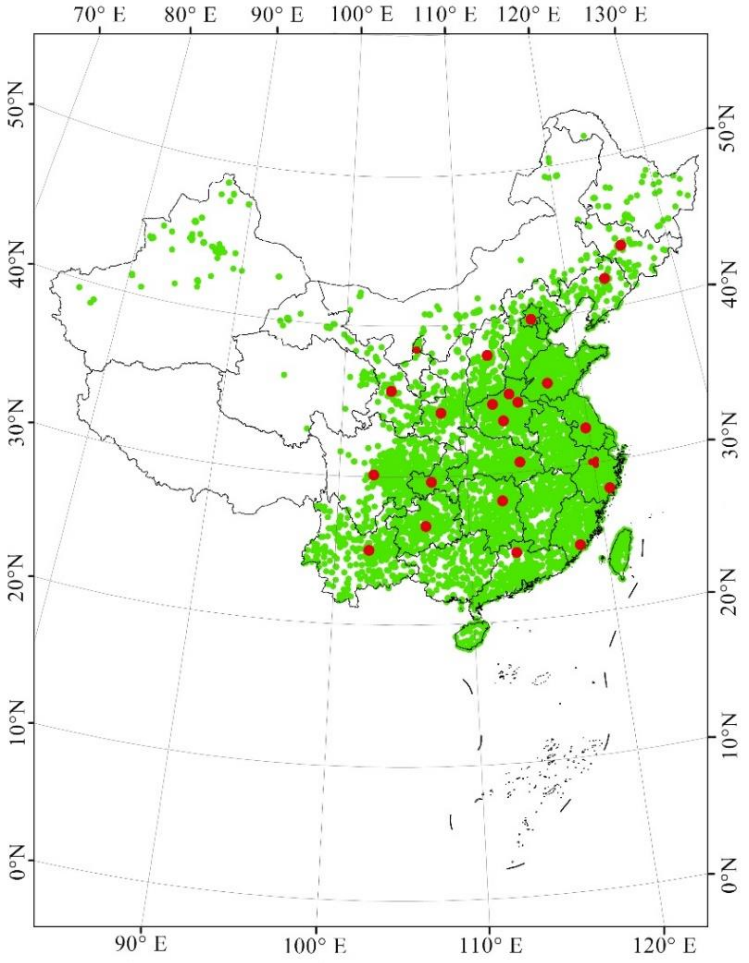
(24.5 - 43.8 ^{0}N, 104.0 - 125.3 ^{0}E)

Materials Twigs of ginkgo (2928)

Treatments Temperature (+0, +2, +5, +10)

Photoperiod (8 & 14 hours)

Chilling (Jan 18 & Feb 27)



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Thank you for your attention!

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