Systèmes de réchauffement du sol & écosystème + manipulation des précipitations

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CNRS FR3098 ECCOREV

AMU-IMBE UMR CNRS 7263 / IRD 237

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ECOSYSTEMES CONTINENTAUX ECCOREV FR 3098 ET RISQUES ENVIRONNEMENTAUX

imbe

OHP

Institut Pythéas
Observatoire des Sciences de l'Univers
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Soil cable warming experiment at Harvard Forest, Petersham, Massachusetts, USA (Melillo et al. 2017). Photo credit: A. Barker-Plotkin.

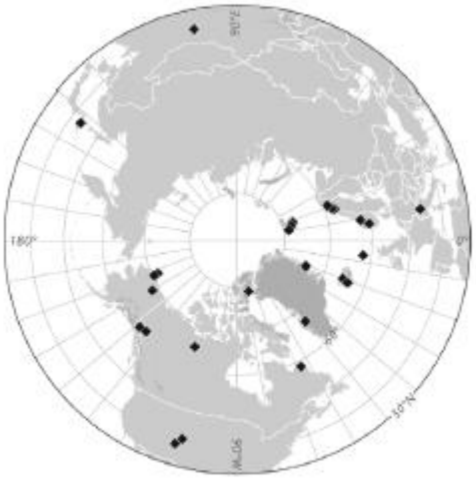
Infrared warming experiment in Pennsylvania, USA (exp09, Rollinson *et al.*, 2012). Photo credit: C. Rollinson.

from harvardforest.fas.harvard.edu

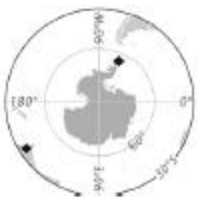
Infrared warming experiment in Montpelier, France (exp02, Morin *et al.*, 2010). Photo credit: I. Chuine.

From Ettinger et al. (2019) How do climate change experiments alter plot-scale climate? Ecology Letters

ITEX – International Tundra experiment



Sarah C. Elmendorf, Gregory H. R. Henry, Robert D. Hollister, Robert G. Björk, Anne D. Bjorkman, Terry V. Callaghan, Laura Siegwart Collier, Elisabeth J. Cooper, Johannes H. C. Cornelissen, Thomas A. Day, Anna Maria Fosaa, William A. Gould, Járngerður Grétarsdóttir, John Harte, Luise Hermanutz, David S. Hik, Annika Hofgaard, Frith Jarrad, Ingibjörg Svala Jónsdóttir, Frida Keuper, Kari Klanderud, Julia A. Klein, Saewan Koh, Gaku Kudo, Simone I. Lang, Val Loewen, Jeremy L. May, Joel Mercado, Anders Michelsen, Ulf Molau, Isla H. et al. (2011) Global assessment of experimental climate warming on tundra vegetation: heterogeneity over space and time. Ecology Letter 15(2):164-175

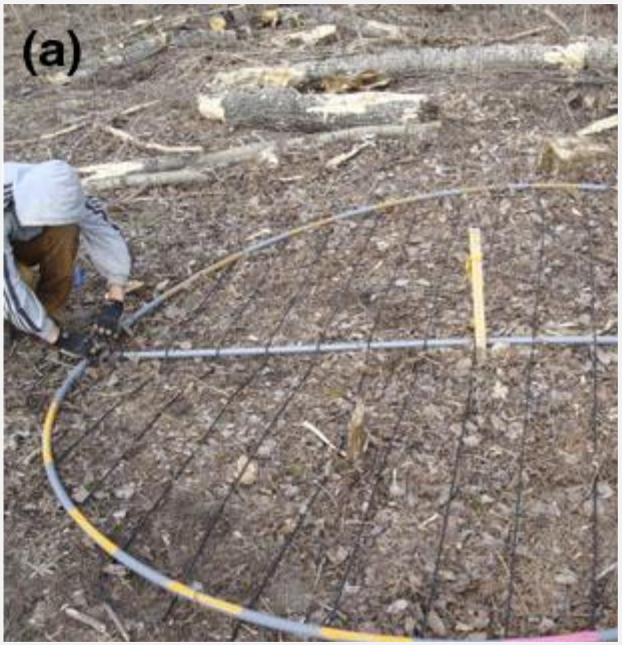


Swiss ITEX experiment in the Val Bercla at Mulegns

from www.wsl.ch

Latnjajaure Lake in Lappland, Sweden. Latnjajaure Field Station

from Nasko, own work, Creative Commons Attribution-Share Alike 3.0 Unported, https://upload.wikimedia.org/wikipedia/commons/5/5d/Open-top_chamber_vid_Latnjajaure_F%C3%A4ltstation_3.jpg



R.L. Rich, A. Stefanski, R.A. Montgomery, S.E. Hobbie, B. A. Kimball, P. B. Reich (2015) *Design and performance of combined infrared canopy and belowground warming in the B4WarmED (BorealForest Warming at an Ecotone in Danger) experiment. Global Change Biology 21, 2334–2348.*

Traitements multifactoriel - prairie

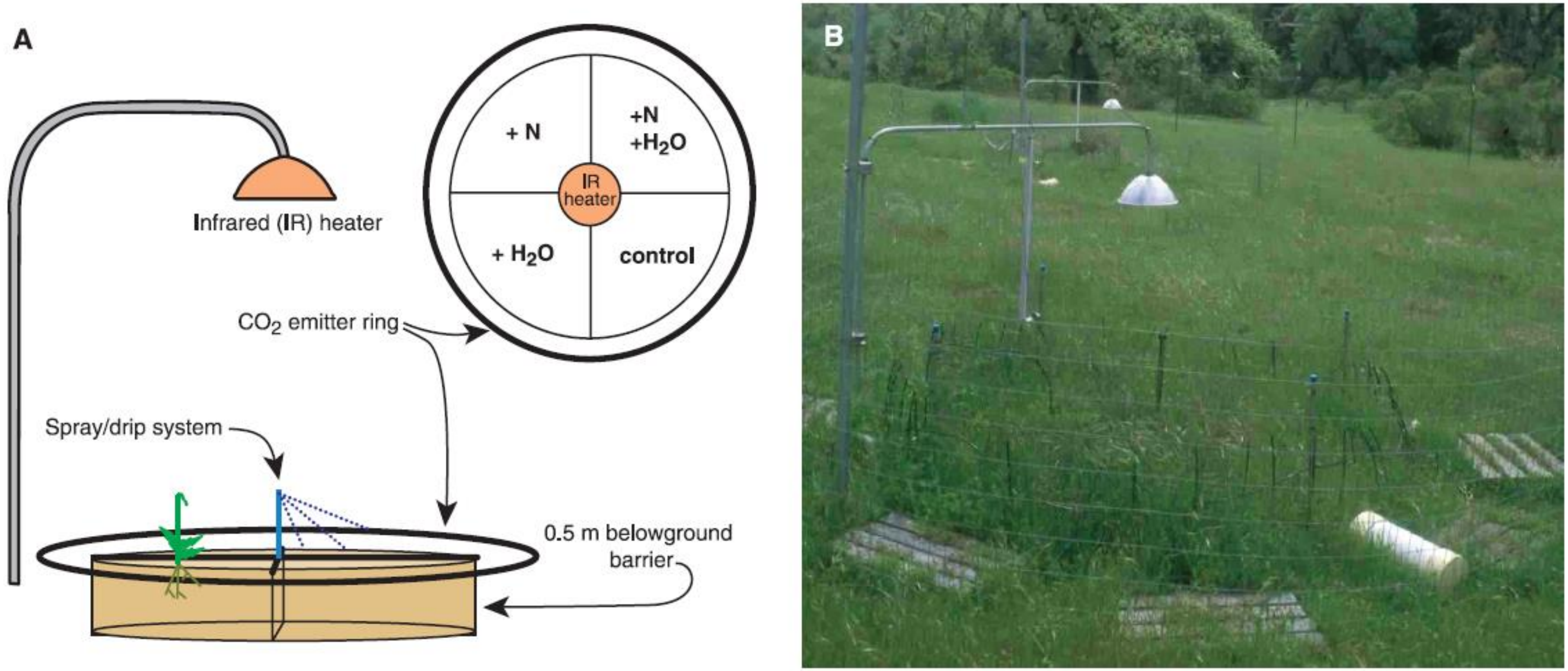
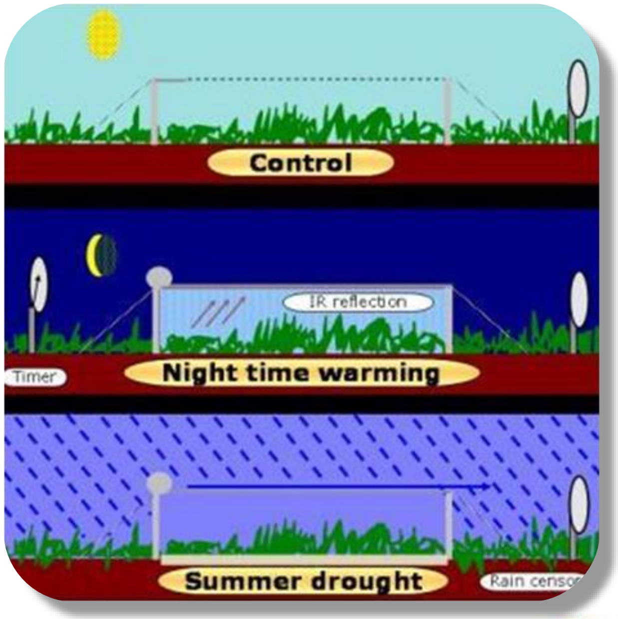


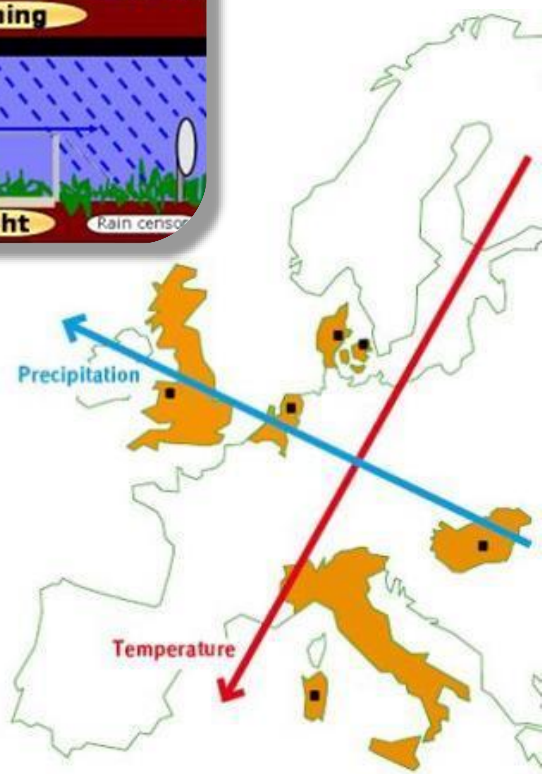
Fig. 1. (**A**) Schematic drawing of the study plots, side view (left) and top view (right). The plot is 2 m in diameter. (**B**) Photograph of a study plot.

→ Réponses aux traitements est très différents entre des facteurs combinés et des facteurs simples

M. Rebecca Shaw,Erika S. Zavaleta,Nona R. Chiariello,Elsa E. Cleland,Harold A. Mooney, Christopher B. Field (2002) Grassland Responses to Global Environmental Changes Suppressed by Elevated CO_2. Science 298(5600): 1987-1990

arbustres (shrubland)

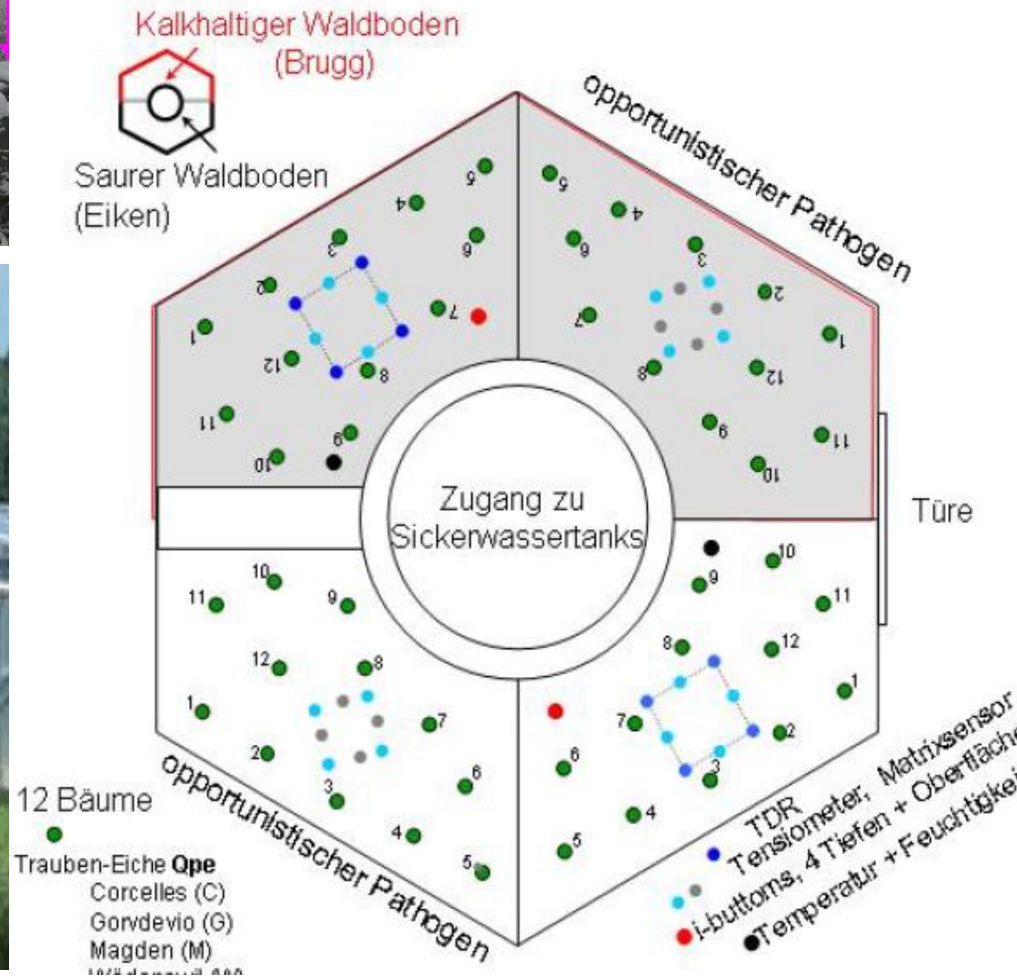




VULCAN → INCREASE

see increase.ku.dk

Jeunes arbres - projet « Querco »



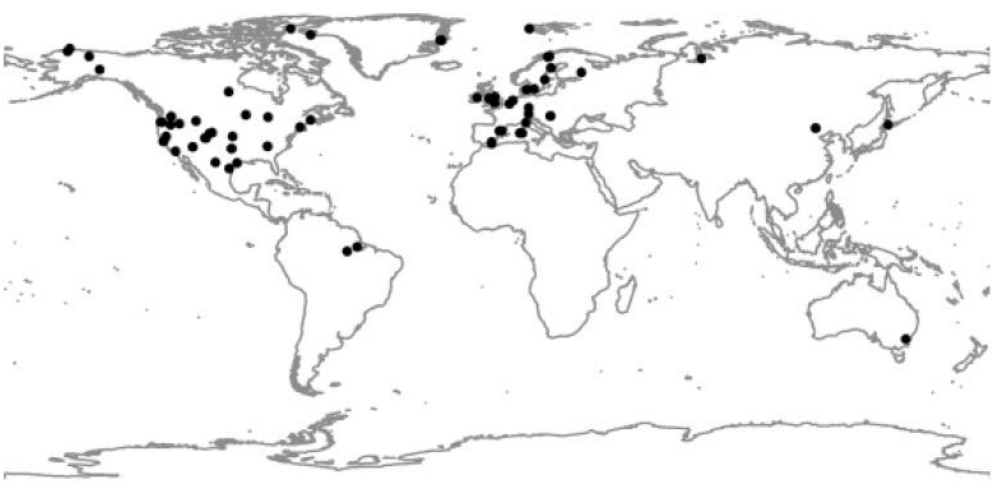
Traitements : temoin , rechauffement d'air, secheresse, rechauffement x secheresse

from http://www.wsl.ch/fe/walddynamik/projekte/querco/index_DE

Temperature and precipitation response – meta-analyses

(1) Measure total and belowground biomass and productivity in addition to aboveground biomass and productivity. Aboveground biomass and productivity are commonly used to estimate responses of plant growth to climate change. However, belowground biomass and productivity play an important role in such responses, with which total biomass and productivity can be calculated to quantify ecosystem level responses to climate change.

(2) Conduct more experiments manipulating precipitation. Because of the variability and unpredictability of future precipitation projections, more precipitation manipulation experiments are needed to elucidate the impacts of wide range of possible scenarios. These experiments should manipulate not only precipitation quantity, but also alter precipitation timing, frequency, intensity as well as seasonality.



(3) Design multifactorial experiments in a wide range of ecosystems. Temperature and precipitation effects could be additive, so single-factor experiments can be very informative and provide the basic mechanisms for ecosystem responses. However, complex interactions do exist and may not be consistent among ecosystems or treatments. In this sense, a single factor experiment is not adequate to illustrate the responses of ecosystem under interactive climate change effects.

(4) Establish experiments in underrepresented biomes and environments. Multiple-factor experiments have been limited to herbaceous ecosystems. Yet, given the greater biomass, soil microbial biomass, soil C pools, and high C fluxes in woody communities, it is crucial to include more woody systems in multifactor manipulation experiments. However, the technological and cost constrains make mature forest ecosystem warming experiments very difficult. In addition, most manipulation experiments have been in mid-to-high latitudes in northern hemisphere, and new experiments are needed in low latitude and tropical systems to identify a systematic variation of responses across ecosystems.

Zhuoting Wu, Paul Dijkstra, George W. Koch, Josep Peñuelas, Bruce A. Hungate (2011) Responses of terrestrial ecosystems to temperature and precipitation change: a meta-analysis of experimental manipulation. Global Change Biology 17, 927–942

Projet IMBE : rechauffemt du sol + exclusion des pluies

- Chauffer la litière & le sol, pas l'écosystème (pour l'instant)
- Exclusion dynamique des pluies
- surface 3-4 m²
- 3 répliqua par traitement
- Comment :
  - +2° (biblio), profondeur 5 cm
  - Ou bilan radiatif GIEC
  - Respecter la pose naturelle de la litière, pas perturber le sol,
  - pas d'arbustres
  - Traitement croisé : exclusion x chaleur, important
  - Traitements : 3 exclusions, 3 température+, 3 exclusions x température+, 3 contrôles → 12 parcelles
- Prévoir des traitements similaire et réalisable pour O_3HP, Puechabon, Fontblanche
- Eviter de perturber des traitements (parcelles) déjà en cours
  → nouvelles parcelles spécifiques
  → systèmes d'exclusion de pluie *et* chauffage indépendantes des structures existantes
  → adopter protocoles d'exclusion de pluie

Prototype prévu pour ANR ‘SOCADYM’ (projet soumis)

panneaux radiants x volets, parcelles de 3-4 m^2

Bruce A. Kimball, A.M. Alonso-Rodríguez, M.A. Cavaleri, S.C. Reed, G. González, T.E. Wood (2018) Infrared heater system for warming tropical forest understory plants and soils. Ecology and Evolution 8:1932–1944

- Panneaux radiantes (électriques), méthode non-invasive
  Produits ‘WATLOW’, standard, avec adaptations specifiques pour ce manip
  Consommation environ 100 W m^{-2} °C^{-1}
- + Volets du type INCREASE ou Station IRSTEA ‘Col de Lautaret’

Bruce A. Kimball, A.M. Alonso-Rodríguez, M.A. Cavaleri, S.C Reed, G. González, T.E. Wood (2018) Infrared heater system for warming tropical forest understory plants and soils. Ecology and Evolution 8:1932–1944

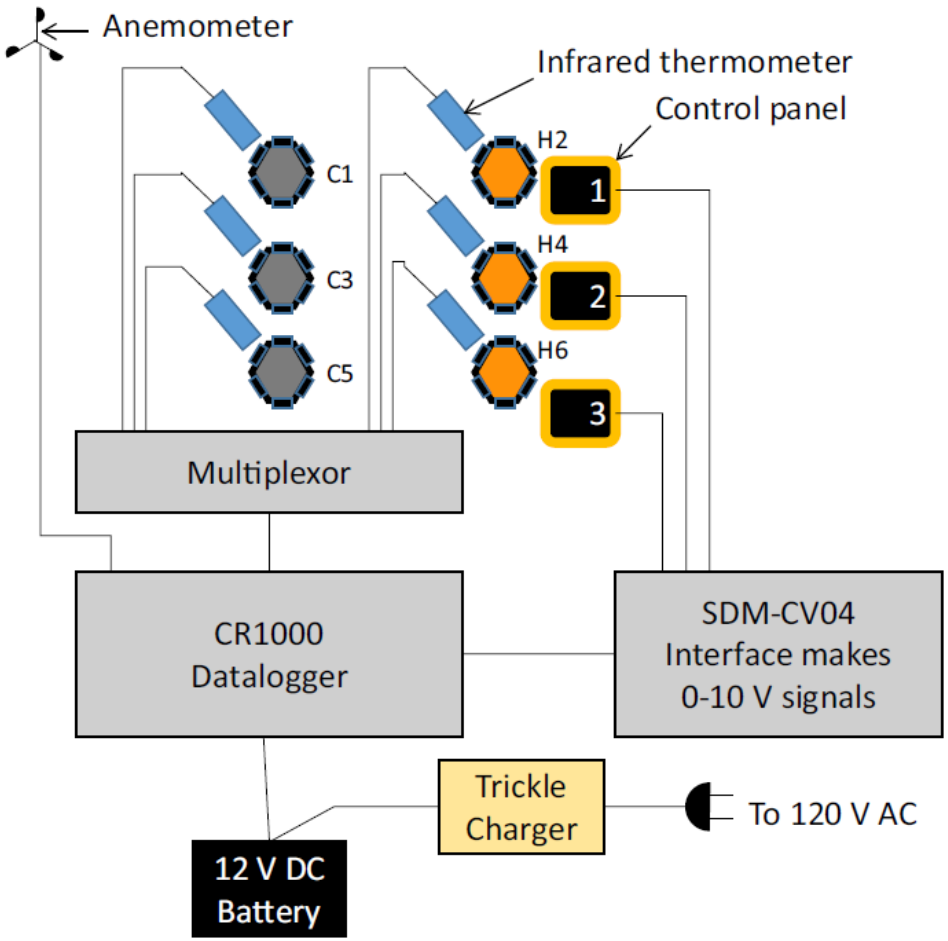
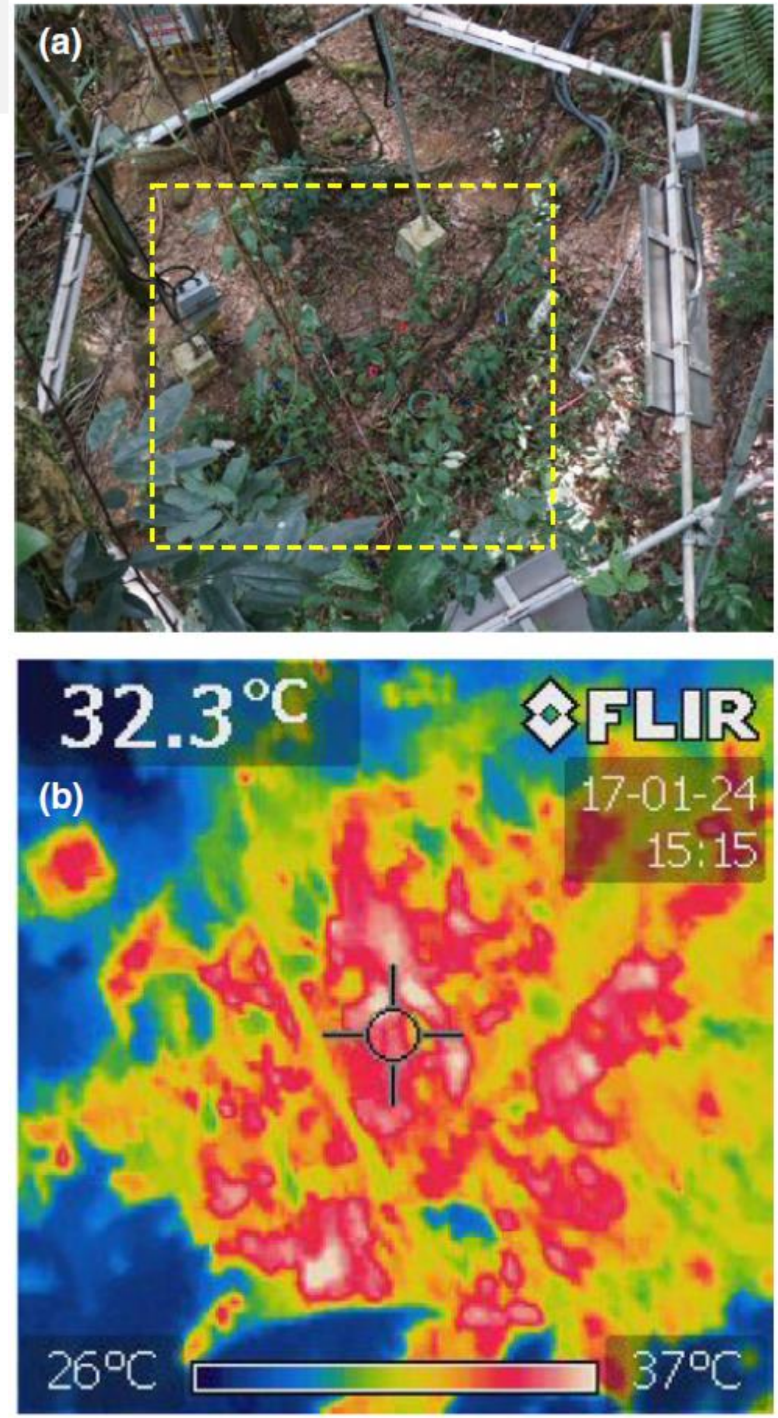


FIGURE 4 Schematic diagram of components to control the temperature rise of heated (orange) hexagonal plots above the temperature of corresponding reference or control (green) plots. Additional weather instruments are also connected to the datalogger



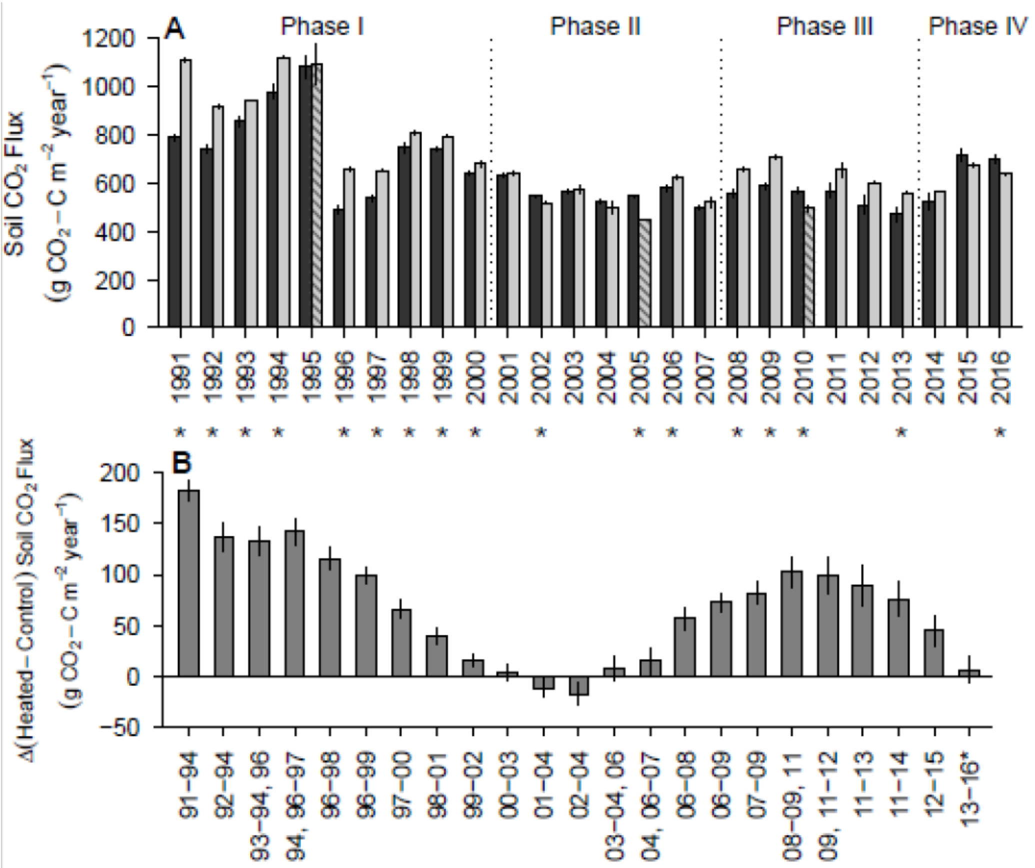
Risque d’incendie

Pilotage, phases et durée

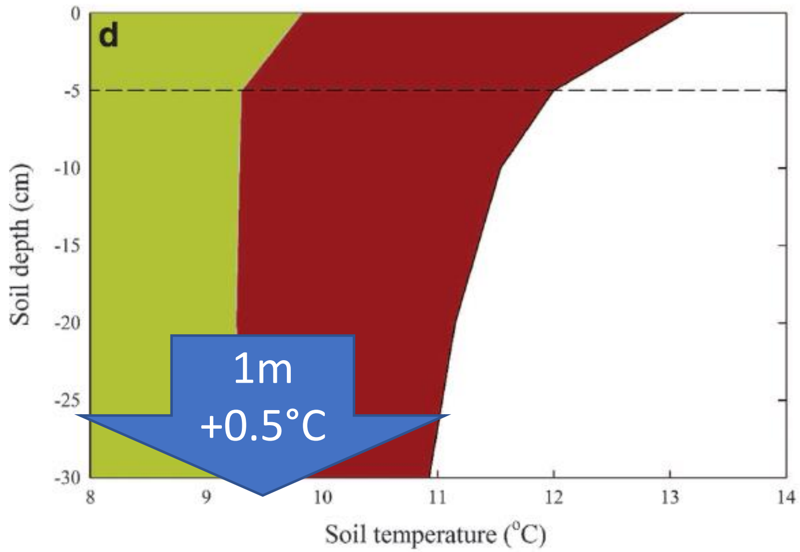
“Responses of **soil biota** to warming were **not explained by the magnitude** of temperature increase, **but** were negatively correlated with **treatment duration**”

“ Effects of altered precipitation were **invariant with MAP**, but **decreased with MAT** and **increased with treatment duration** “

from J.C. Blankinship, P.A. Niklaus, B.A. Hungate (2011) A meta-analysis of responses of soil biota to global change. Oecologia 165:553–565.



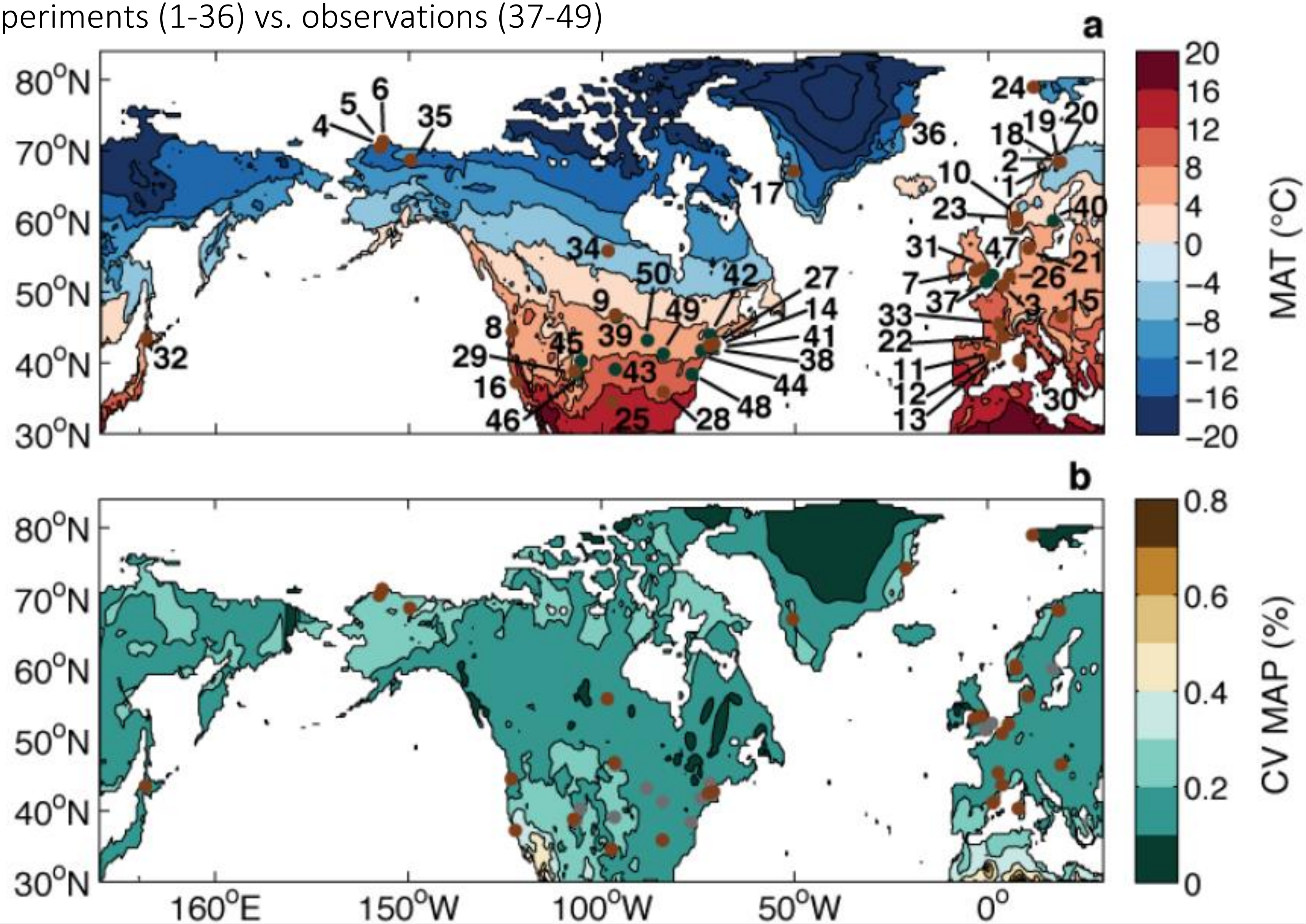
J.M. Melillo, S.D. Frey, K.M. DeAngelis, W.J. Werner, M.J. Bernard, F.P. Bowles, G. Pold, M.A. Knorr, A.S. Grandy (2017) Long-term pattern and magnitude of soil carbon feedback to the climate system in a warming world. Science, 358, 101–105.



JN. Liang, M. Teramoto, M. Takagi, J. Zeng (2017) High resolution data on the impact of warming on soil CO2 efflux from a Asian monsoon forest. Nature-Scientifc Data DOI: 10.1038/sdata.2017.26

Meta-analyses temperature

experiments (1-36) vs. observations (37-49)



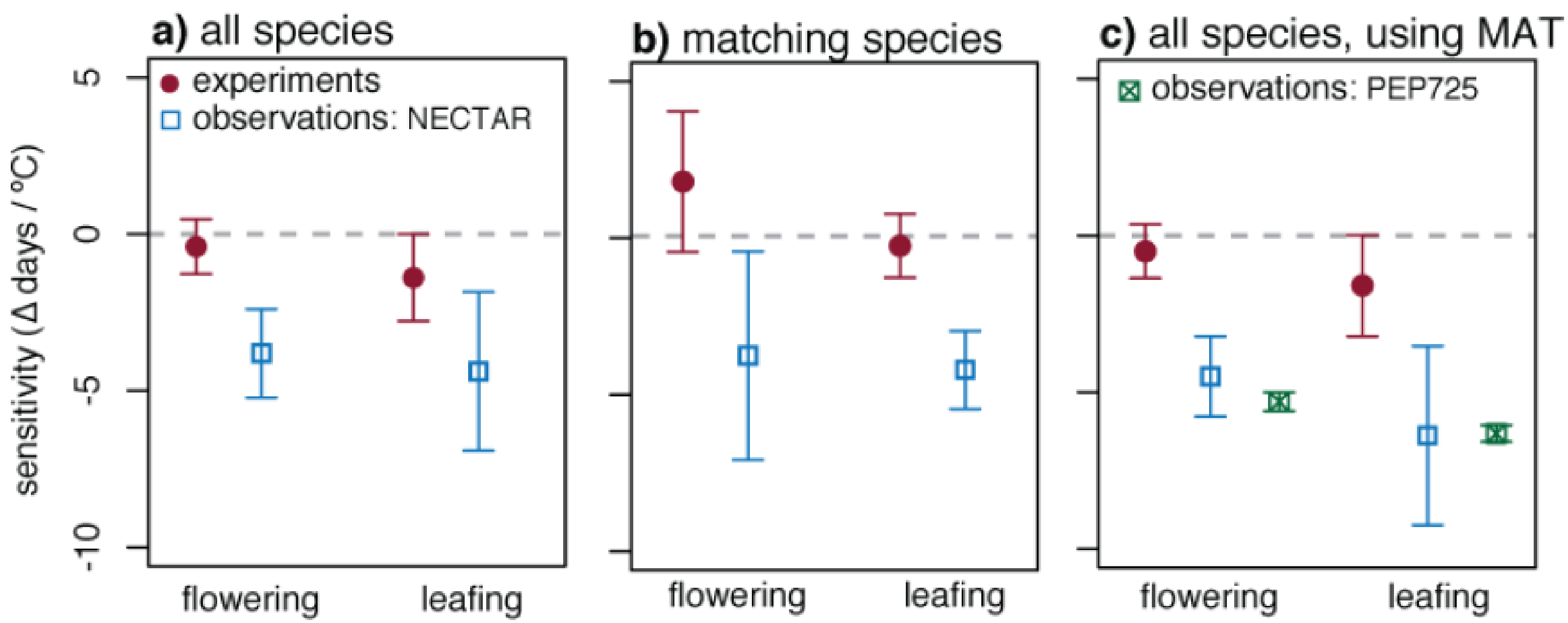
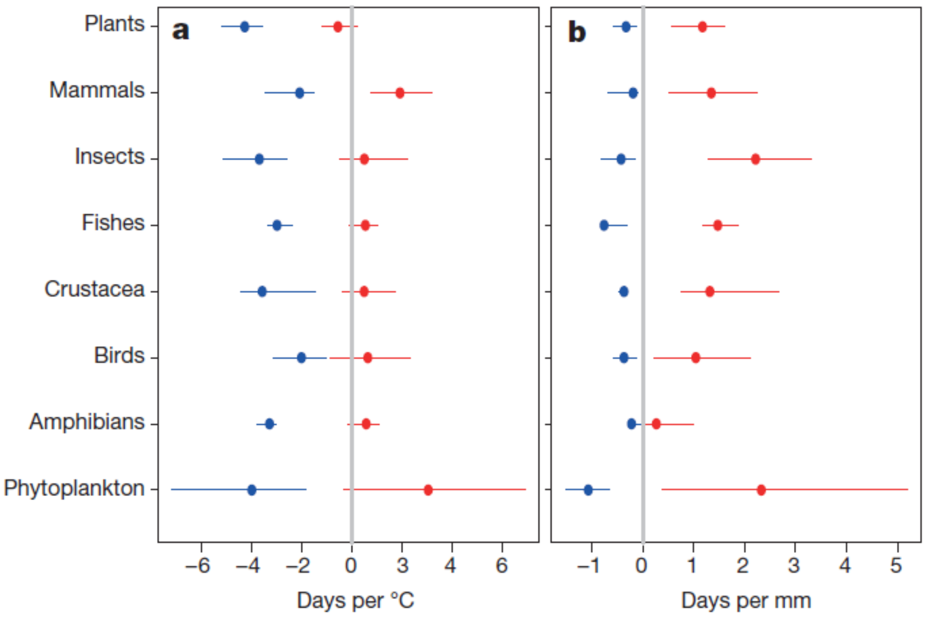


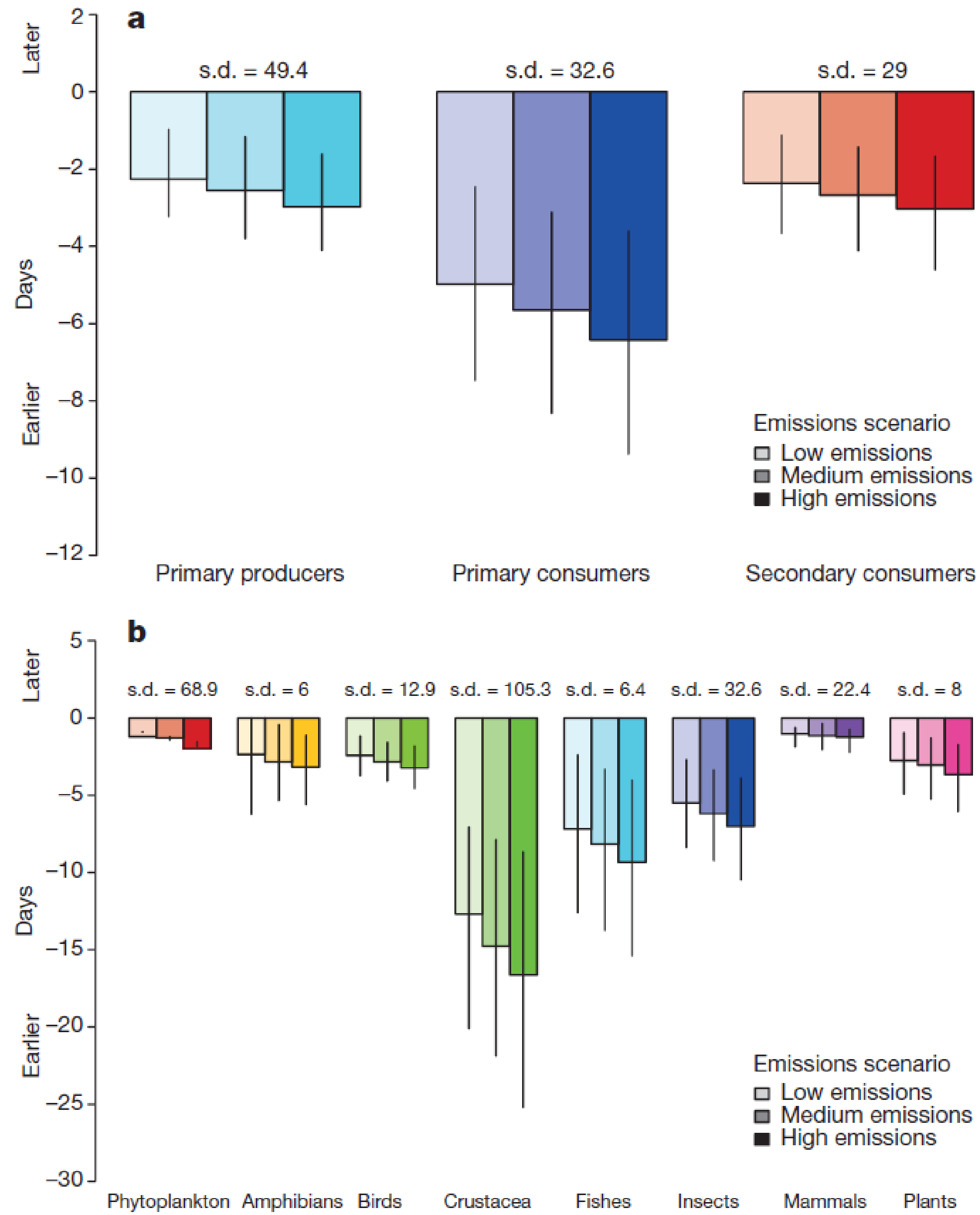
Figure S2: **MAT vs. monthly temperatures & NECTAR vs. PEP725**: Results of comparison of temperature sensitivities based on experiments and observations using a more granular metric than MAT for observational data. Here we show the results using the mean temperature of the 3 months prior to mean flowering date for all species (a) and those we had matching species data (b). Note that results are highly similar to those which used MAT (c). Further, estimates based on MAT using NECTAR were similar to calculations using PEP725 (c).

→… "warming experiments underpredict advances in the timing of flowering and leafing by 8.5-fold and 4.0-fold, respectively, compared with long-term observations."

→ "These significant mismatches seem to be unrelated to the study length or to the degree of manipulated warming in experiments."

UK : Phenological sensitivity to climate across taxa and trophic levels





↑ **Upper and lower limits of phenological climate sensitivity for broad taxonomic groups**. a, b, Lower (blue) and upper (red) limits of the sensitivity of phenological events to seasonal temperature (a) and precipitation (b) change are shown.

→ **Estimated phenological shifts by the 2050s**. a, b, Modelled responses to projected temperature and precipitation change, assuming contemporary climate sensitivity, for trophic levels (a) and taxonomic groups (b).