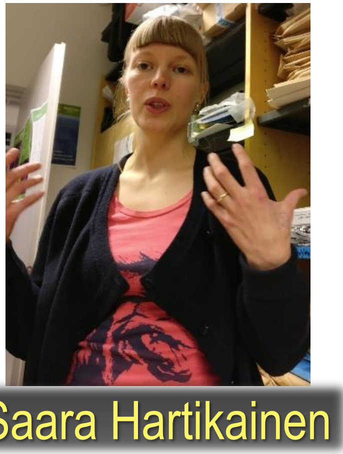

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Canopy Spectral Ecology & Ecophysiology Group

Light Cues for Plants in Forest Canopies and Beyond

eLTER H2020
Integrated European Long-Term Ecosystem & socio-ecological Research Infrastructure

ViPS
Viikki Plant Science Centre

ACADEMY OF FINLAND

UNIVERSITY OF HELSINKI
FACULTY OF BIOLOGICAL AND ENVIRONMENTAL SCIENCES

UNEP
United Nations Environment Programme

Light Cues for Plants in Forest Canopies and Beyond

- 1. Measuring sun and shade in canopies
- 2. Changes in spectral composition across the environment
- 3. Climate change alters exposure of plants to light because of snowmelt
- 4. Potential plants responses to this change in exposure.
- 5. Snowmelt and phenology shift in the alpine zone.
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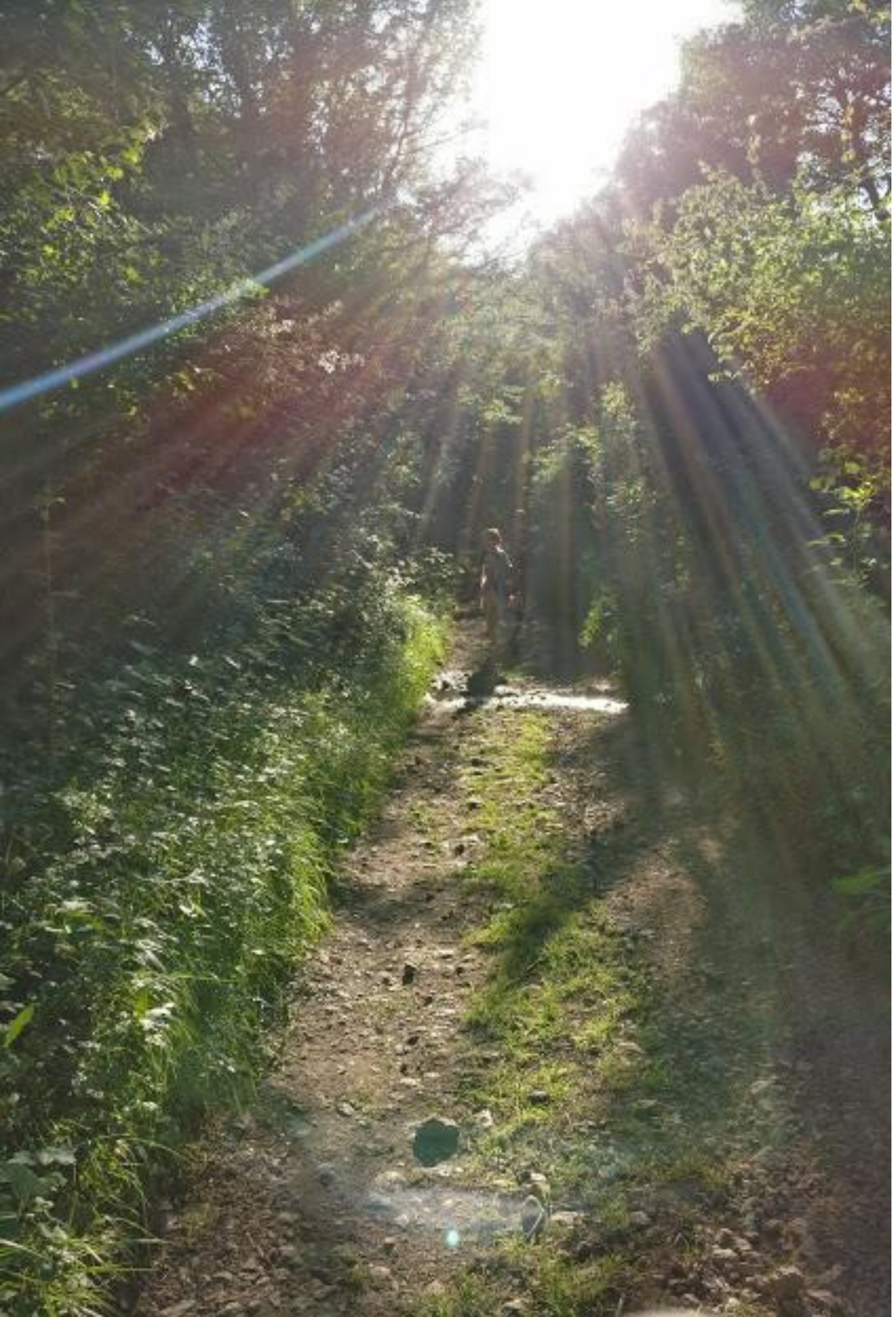
- 7. Geoengineering and its effects on sunlight.



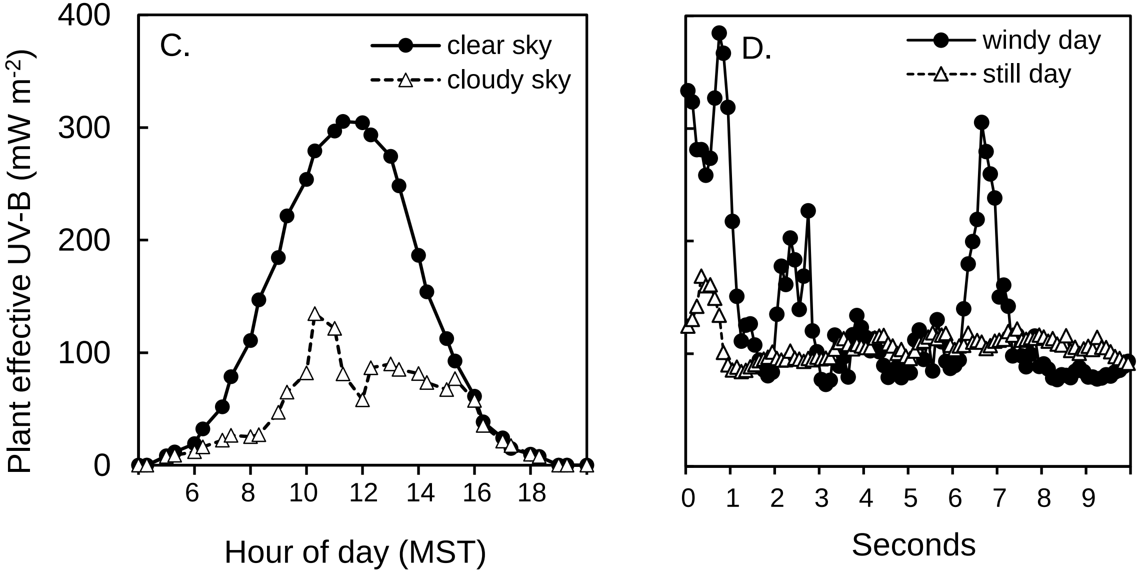
Sunlight changes in predictable and unpredictable patterns

- Sunlight is fundamental for plants and their form is adapted for light capture.
- Many adaptations in plant form and function result from the nature of changes in the light environment.
- Plants must be able to withstand predictable and unpredictable changes.

Sunlight changes in predictable and unpredictable patterns

Unpredictable Changes in Sunlight

- Fast dynamic changes in irradiance and spectral composition because of clouds, sunflecks, and atmospheric features.
- Potentially longer-term filtering of radiation by snow-cover, water, canopy shade, and topography.



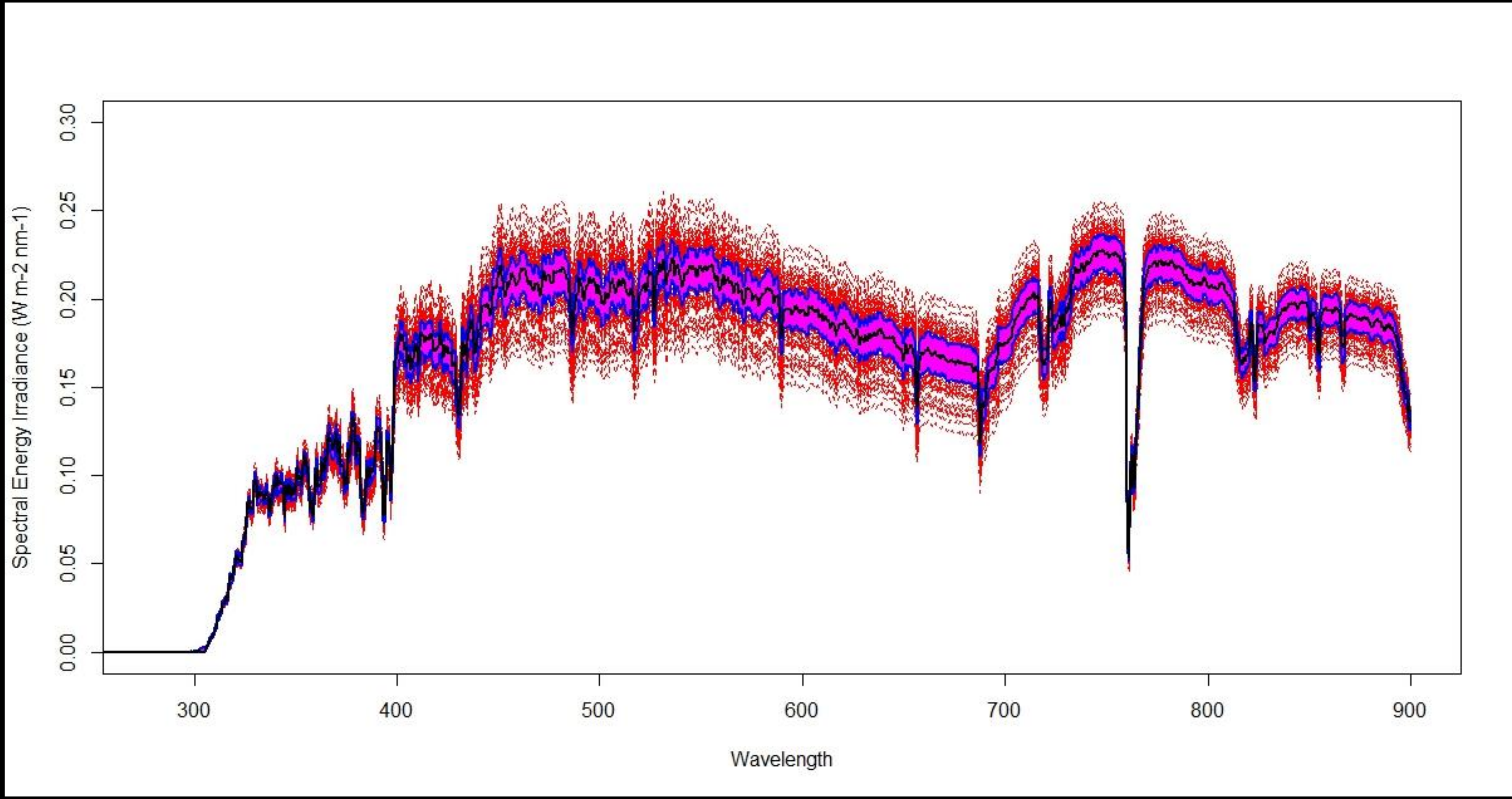
Barnes PW, Robson TM, Tobler MA, Bottger IN, Flint SD. (2017) Plant responses to fluctuating UV environments. Chapter 6 in B. Jordan. Plant UV Biology, CABI publishers, p 72-89.

Phenology of *Anemone nemorosa, Oxalis acetosella* and *Hepatica nobilis* as they past through sun flecks on the forest floor.

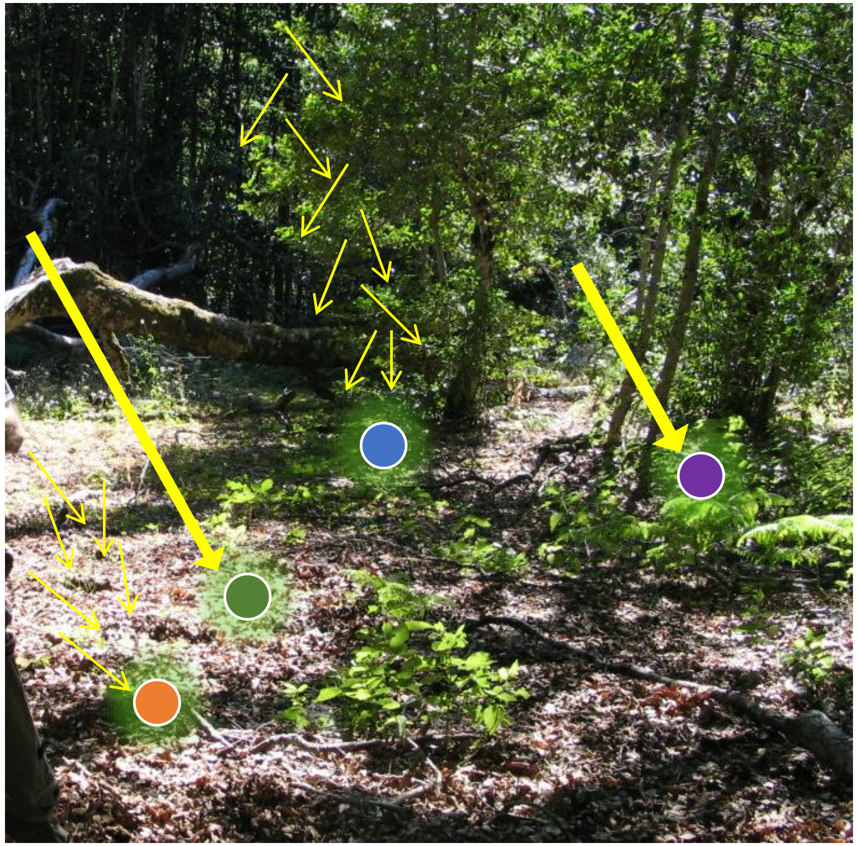
Measurements of changing light in forest understoreys with an array spectrometer (Maya 2000Pro, Ocean Optics)

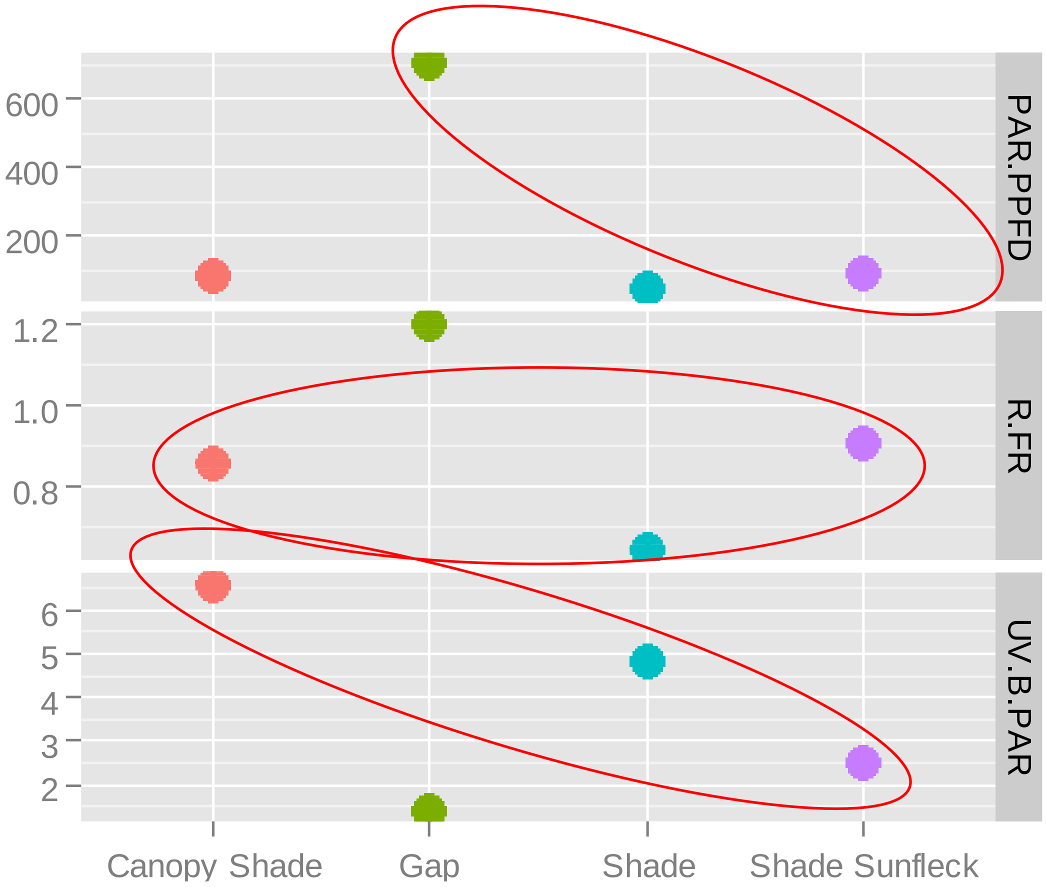
Measured light environment in the understorey

Time course of 100 spectroradiometer spectra during 5 seconds from semi-shade (*leaf shade*) in a the understorey of a forest stand.
Black line showing the deepest curve (as calculated by functional data analysis)



Heterogeneous light environment in the forest understorey

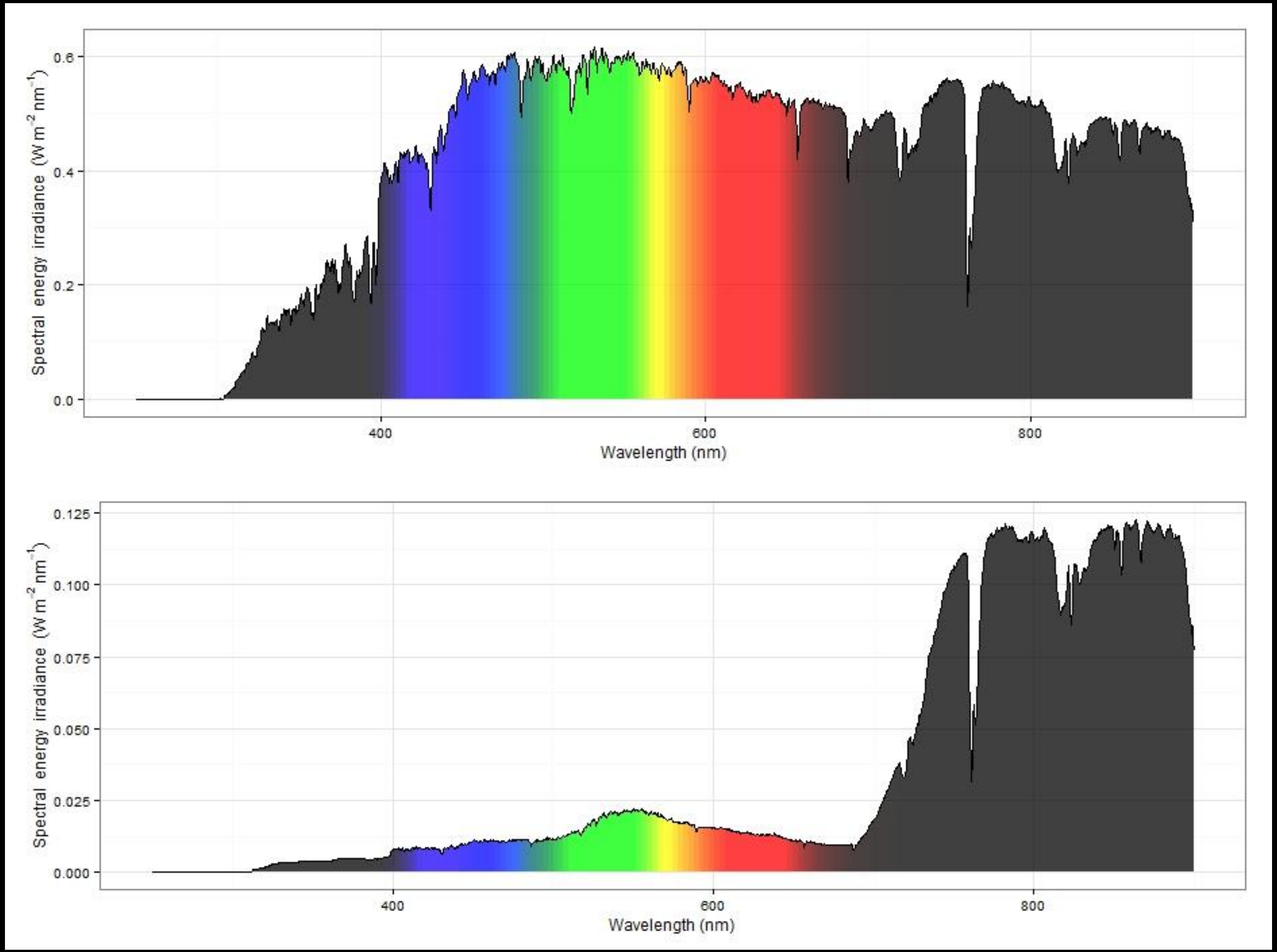




The size of gaps and shade from different height trees affect the spectra of light

Measured light environment in the understorey

Spectroradiometer arrays from a sunfleck and leaf shade at the same location.

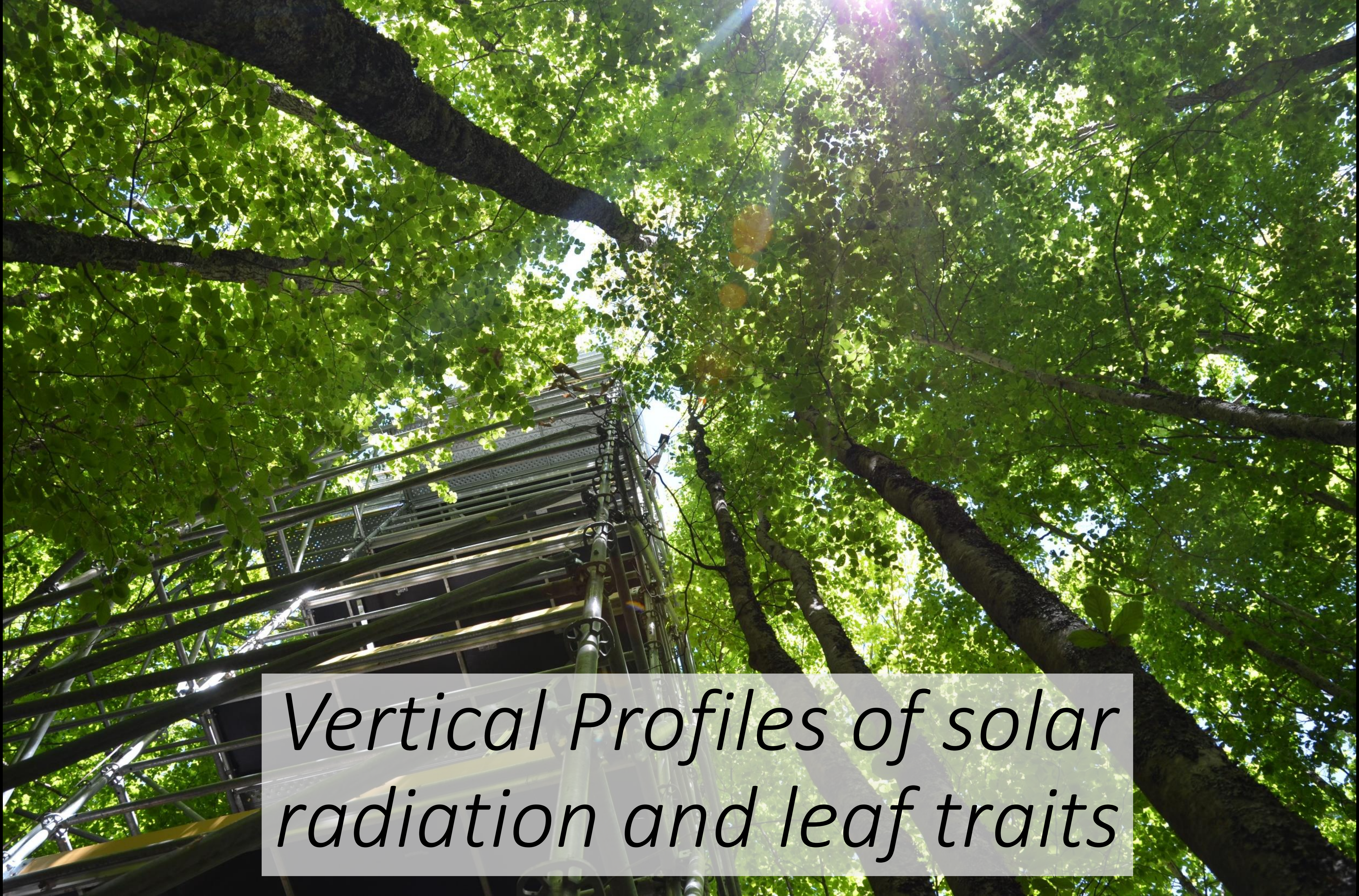


Visible

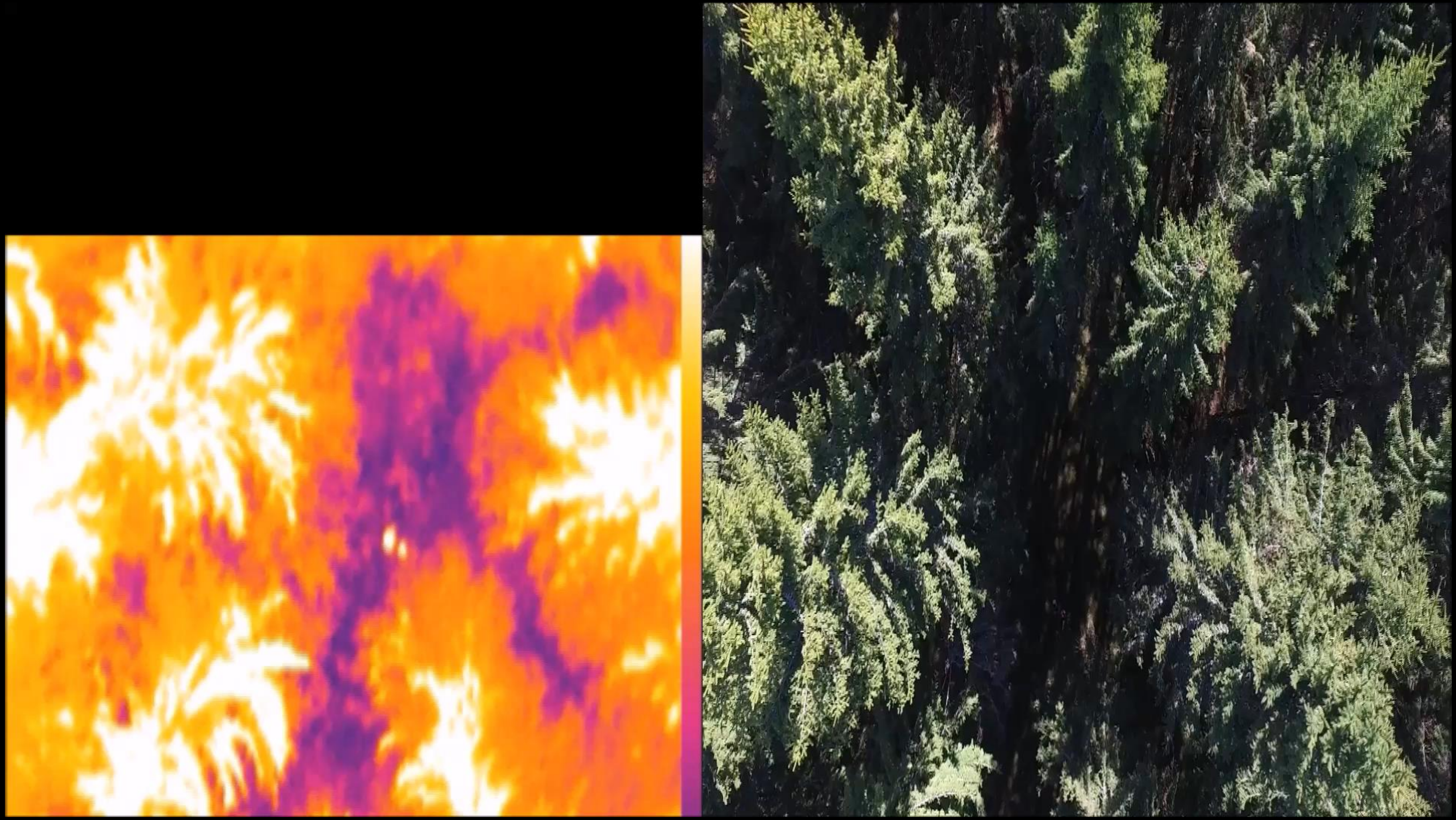
UV

Unfiltered

Far Red


Vertical Profiles of solar
radiation and leaf traits

Drone video showing sun flecks on the forest floor of a spruce stand



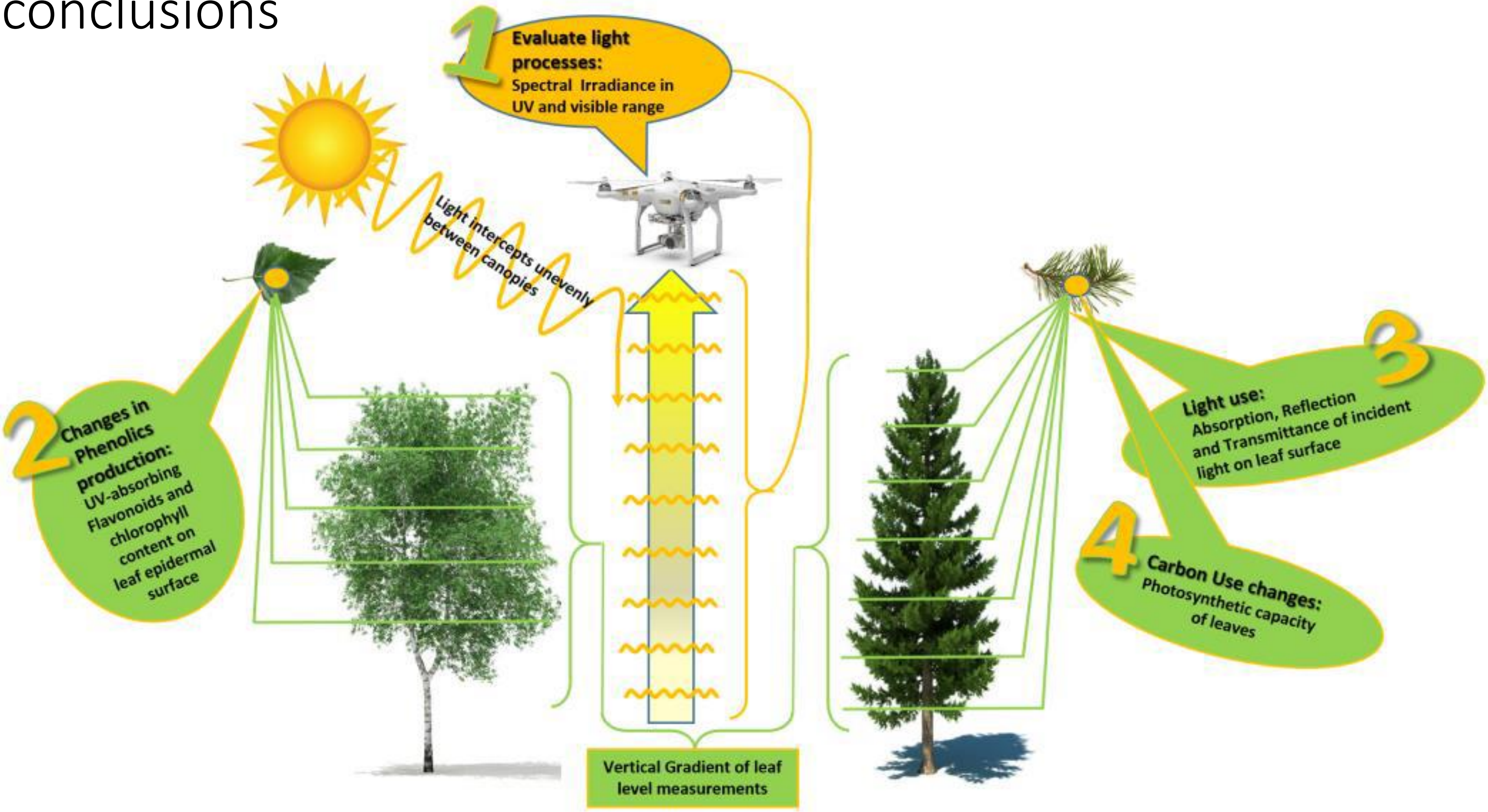
Marta Pieriste & John Loehr
CanSEE group - Univ. Helsinki

Flying a drone through the canopy to take spherical images for leaf area index

Properties of sunflecks in forest and crop canopies

- We can now measure highly dynamic changes in solar spectral radiation – on the ground and through vertical profiles.
- We can also determine how plants are able to react both quickly and efficiently to these rapid changes.
- Chlorophyll fluorescence measurements allow us to assess the speed of response, the photosynthetic capacity, and recovery from transient bright light by leaves.

Measurements of sun and shade in forest canopies – conclusions

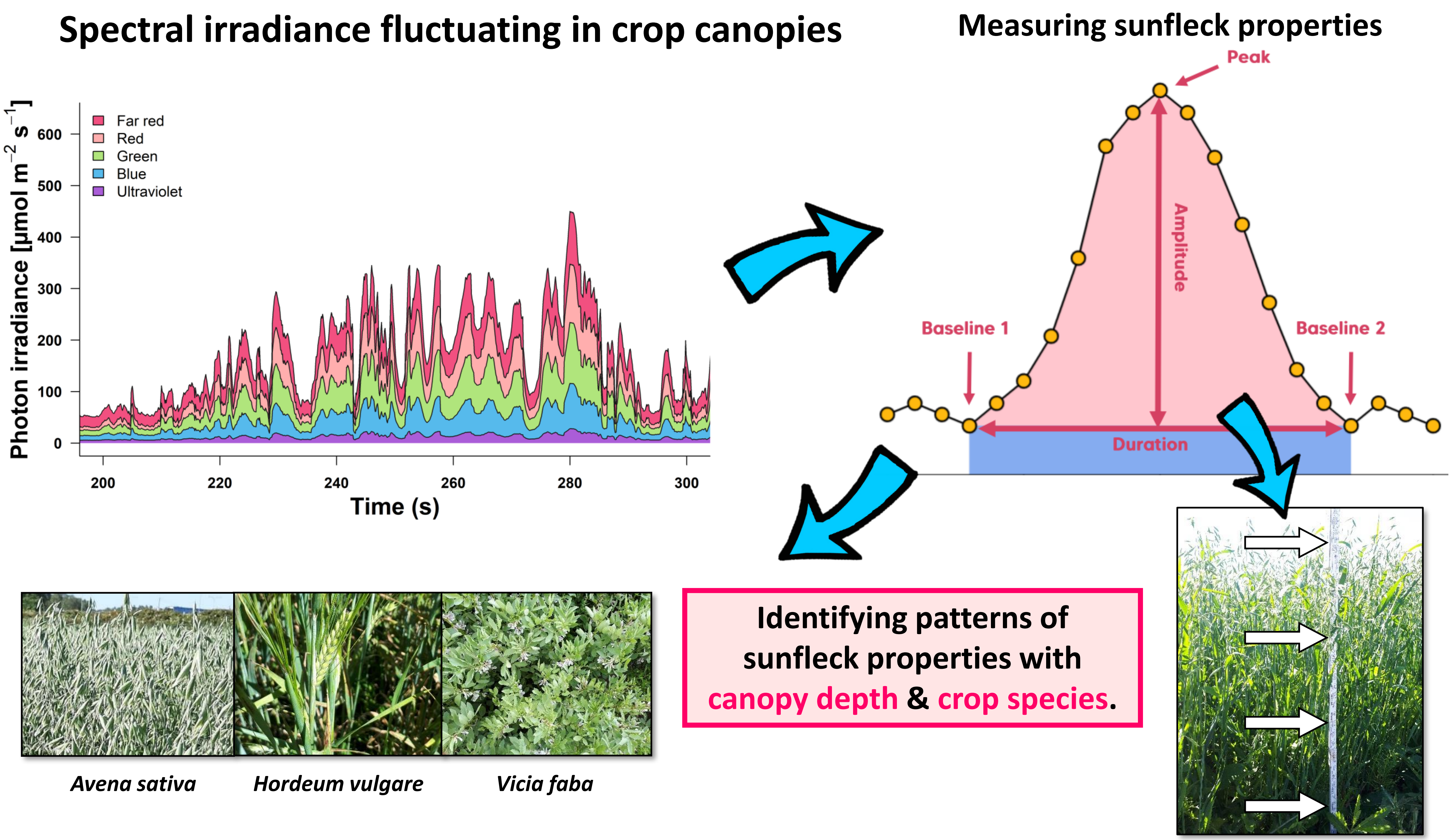


Extension from forests to crop canopies – 3D radiative transfer models of cereal crops for cultivar selection

This should allow for better light use efficiency over the growing season of plants in the field.

This improves site suitability assessment for crop species and varieties.

This allows for forecasting and modelling of how future changes in weather & climate will affect yield.

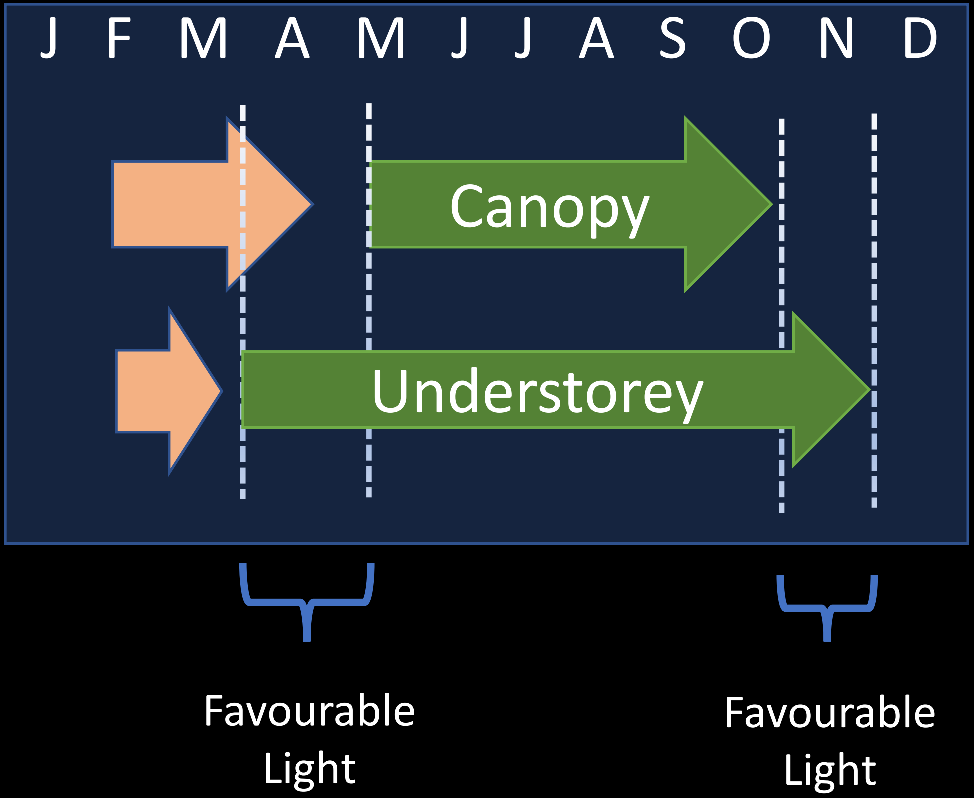

Spectral irradiance fluctuating in crop canopies
Measuring sunfleck properties
Photon irradiance [µmol m−2 s−1]
Far red
Red
Green
Blue
Ultraviolet
0
100
200
300
400
500
600
200
220
240
260
280
300
Time (s)
Peak
Amplitude
Baseline 1
Baseline 2
Duration
Identifying patterns of sunfleck properties with canopy depth & crop species.
Avena sativa
Hordeum vulgare
Vicia faba

The interaction of climate change, snow melt and solar radiation

Changes in snow depth and melt have the potential to change plant photoprotection

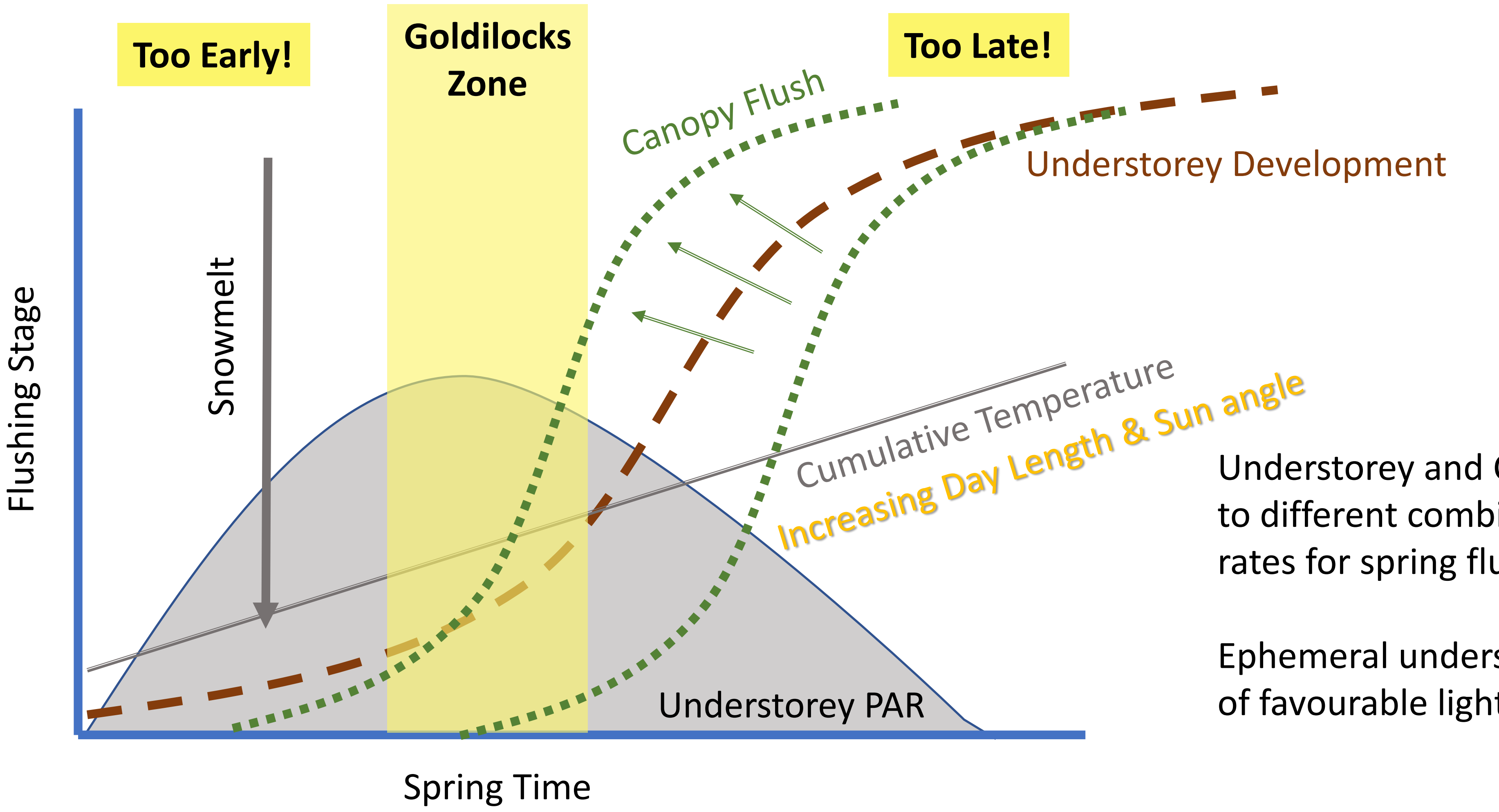
Snow interacts strongly with UV radiation

Ecosystem Processes & Community Ecology




Oxalis acetosella
Hepatica nobilis
Fragaria vesca

Exposure above snow in the understorey affects phenology creating potential mismatches with the canopy



Understorey and Canopy species respond to different combinations of cues at different rates for spring flush.

Ephemeral understorey species require a period of favourable light and temperature to persist.

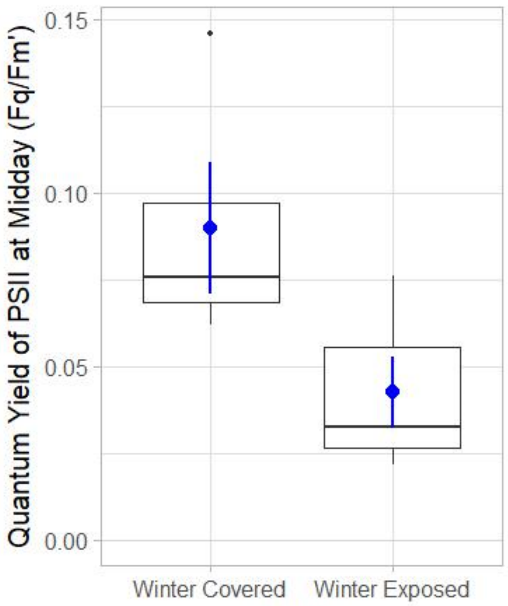
The increased incident of extreme weather events is increasing the likelyhood of mismatching between canopy phenology and understorey phenology: e.g. an extreme late frost event in central Spain) removed the entire canopy

Photo Shows:

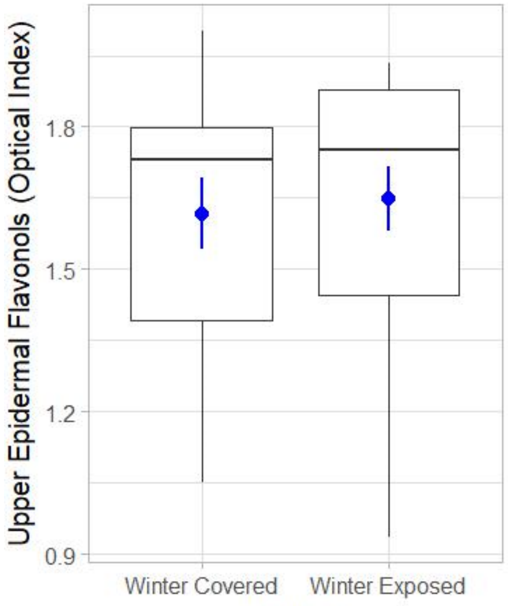
90% elimination of the canopy of a beech *(Fagus sylvatica*) and oak (*Quercus petraea* and *Quercus pyraniaca*) forest in central Spain

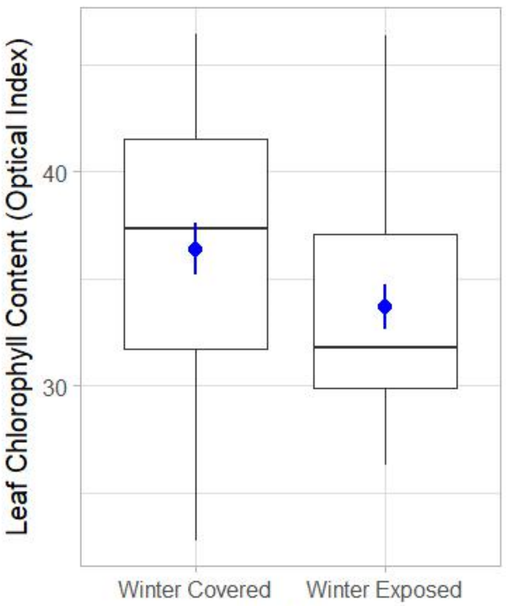
During to a hard frost immediately after leaf flushing in the first week of May 2017.

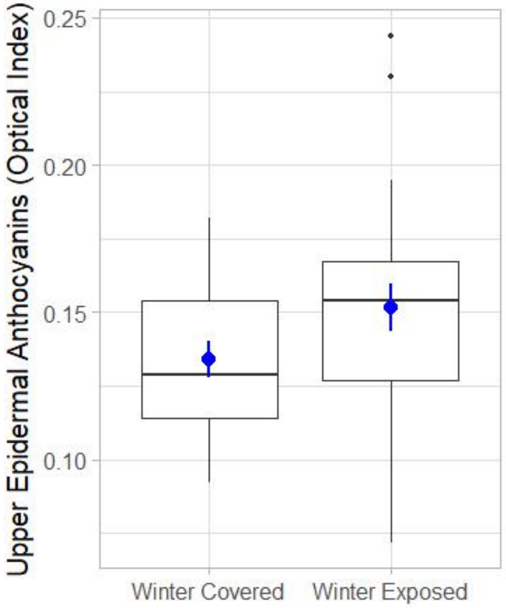
Beech will produce a 2nd flush later in the summer but oak will change the canopy structure to produce shoots directly from the trunk.



Vaccinium vitis-idaea plants from heterogeneous patches in Viikki, Helsinki were monitored during snow melt in late March.





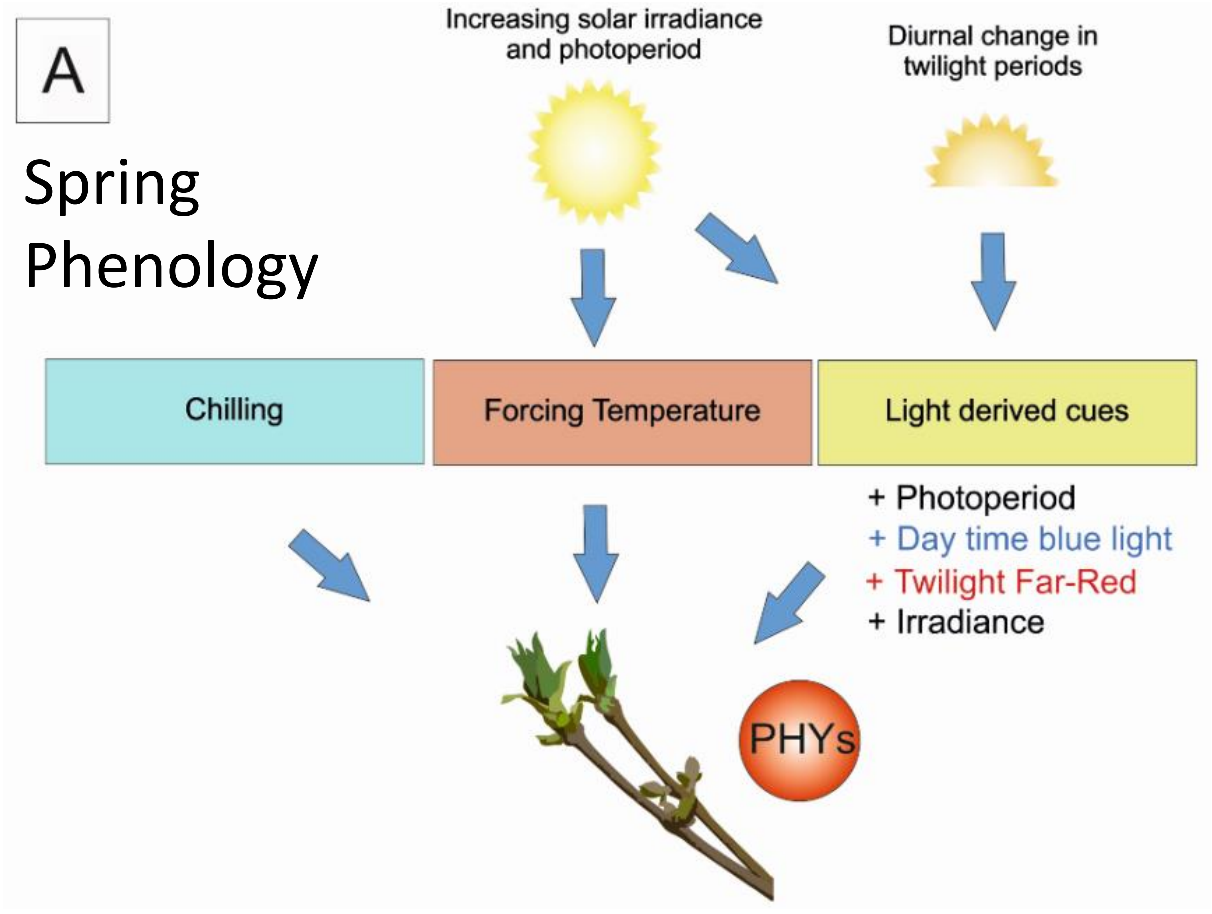


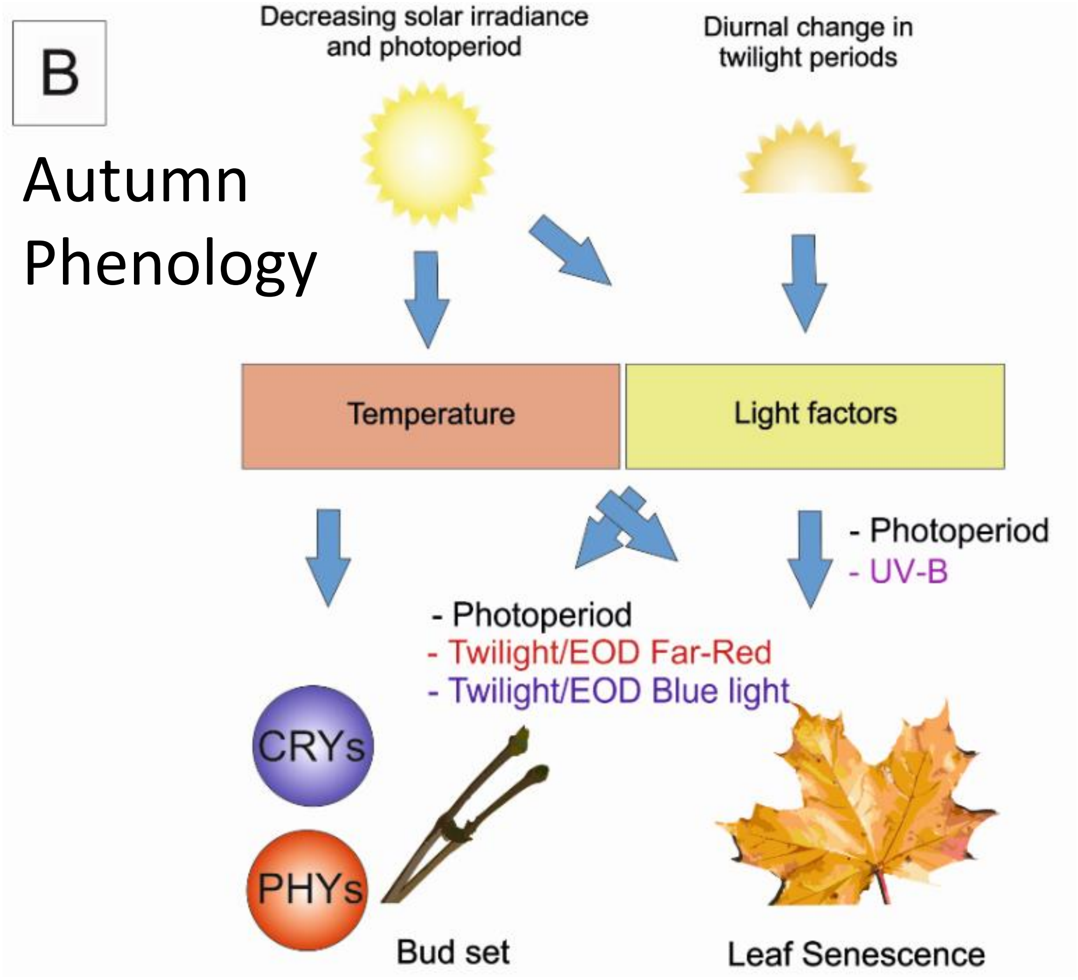
- Photosynthetic yield was higher initially in “winter covered” plants.
- There was no difference in epidermal flavonols, but and anthocyanins were high in “winter exposed” plants.
- Chlorophyll content was lower in exposed plants.

Effect of canopy cover on epidermal UV-screening by ephemeral understorey species and tree seedlings

Long-term filter experiment
at Lammi Biological Station, central Finland

Can plants cope with the novel environmental scenarios presented by shifts in phenology and range?





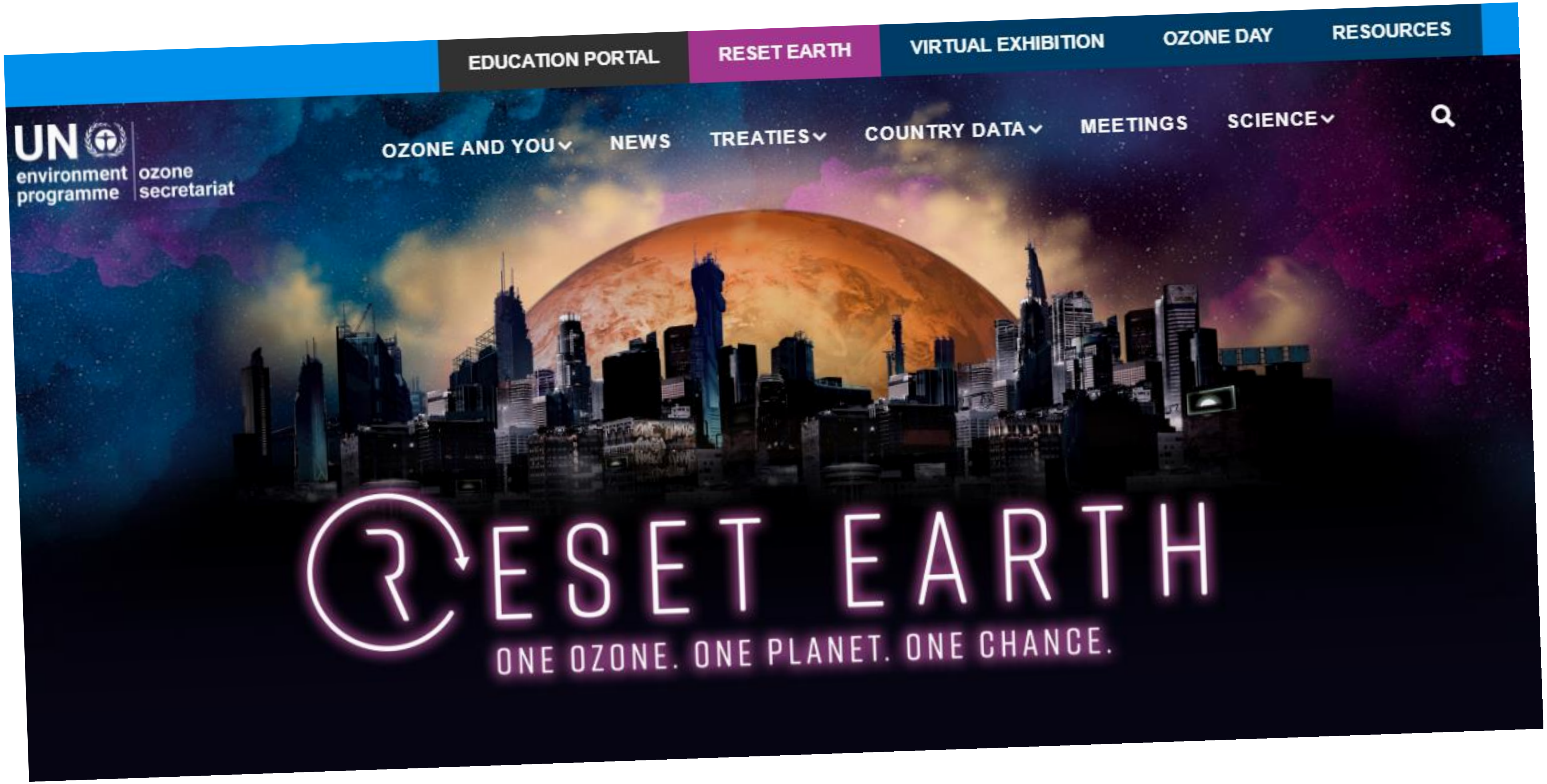
Brelsford, Nybakken, et al., 2019 Tree Physiology

Conclusions – climate change effects on understorey and tree species fitness

- Blue light accelerates sycamore tree seedlings more than understorey plants in their spring phenology.
- Increased canopy leaf retention in winter extends the growing season even if light levels are low.
- Blue light and UV-A radiation increase photoprotection leading to potentially higher photosynthetic efficiency.

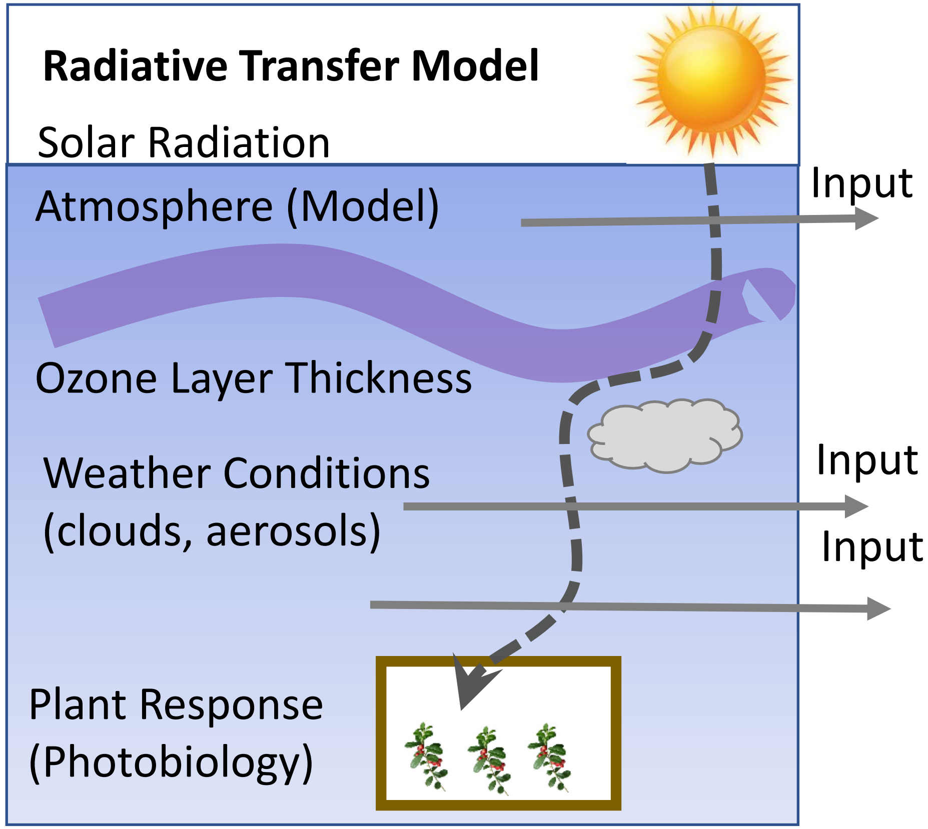
This work can be extended to consider rates of photodegradation and litter decomposition

- Assessing the rate of leaf litter decomposition in a Japanese beech forest.
- The effects of canopy gaps vs continuous understorey can be compared.
- The contribution of photodegradation to the carbon budget of these forest type can be calculated, as well as the contribution of blue, UV-A and UV-B radiation to that photodegradation


EDUCATION PORTAL
RESET EARTH
VIRTUAL EXHIBITION
OZONE DAY
RESOURCES
UN environment programme
ozone secretariat
OZONE AND YOU
NEWS
TREATIES
COUNTRY DATA
MEETINGS
SCIENCE
RESET EARTH
ONE OZONE. ONE PLANET. ONE CHANCE.

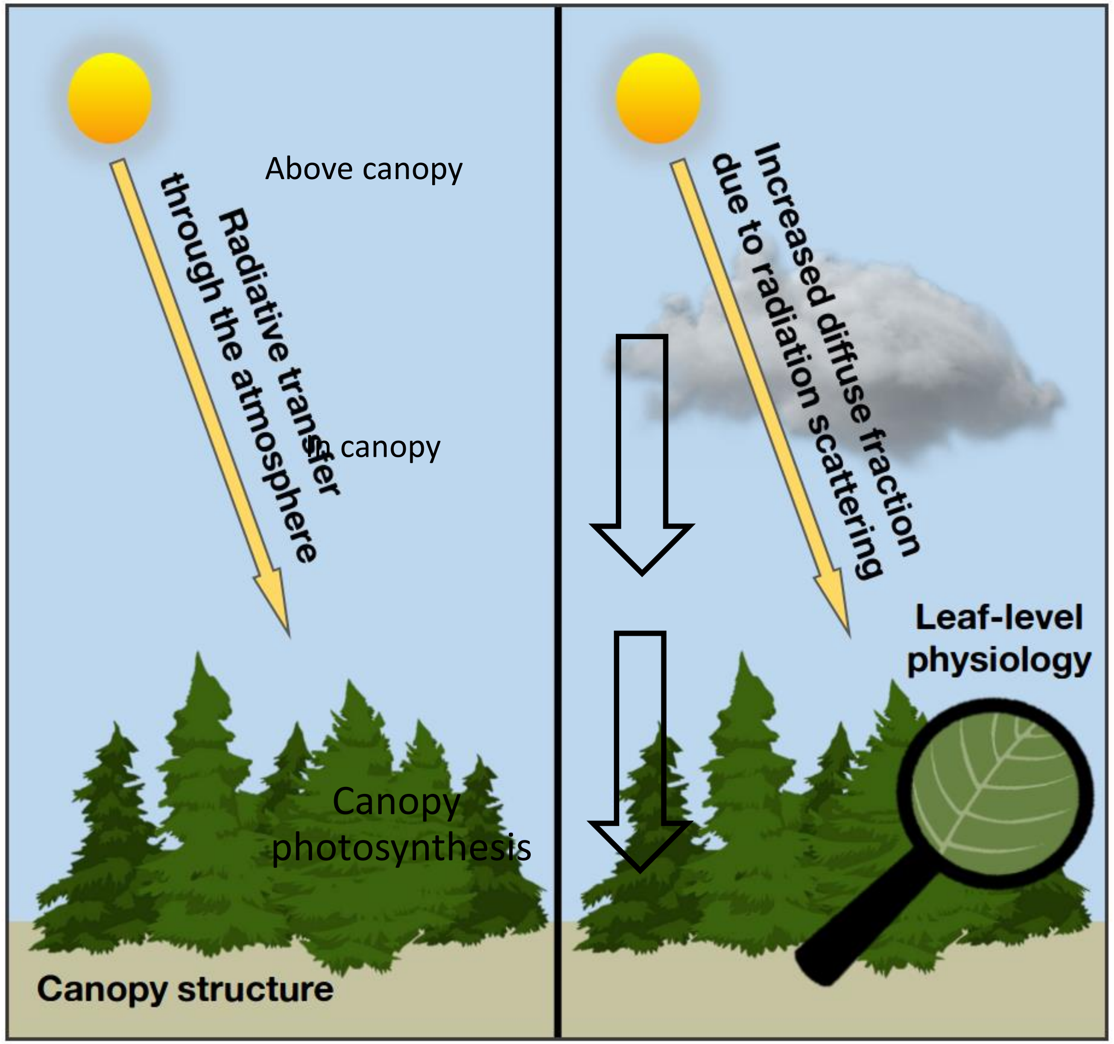
How does the scattering of sunlight in the atmosphere affect solar radiation through the day

<u>Clouds and aerosols</u> both enrich shortwave radiation, UV and blue

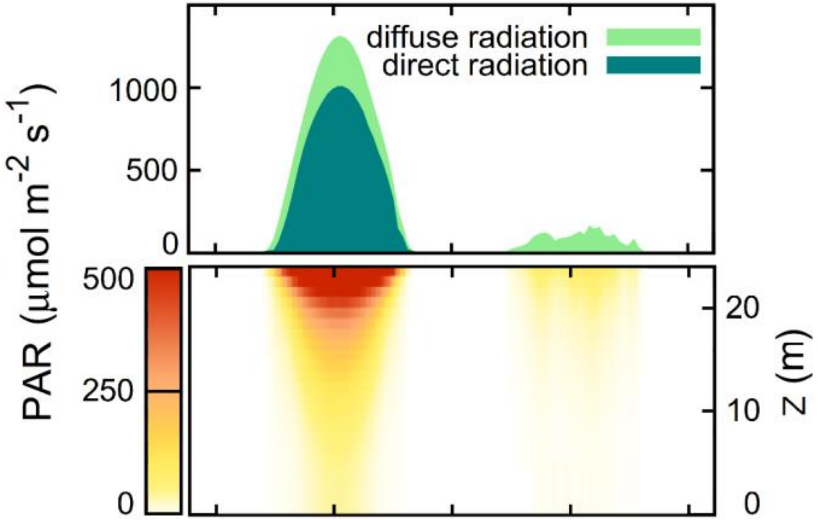


Maxime Durand

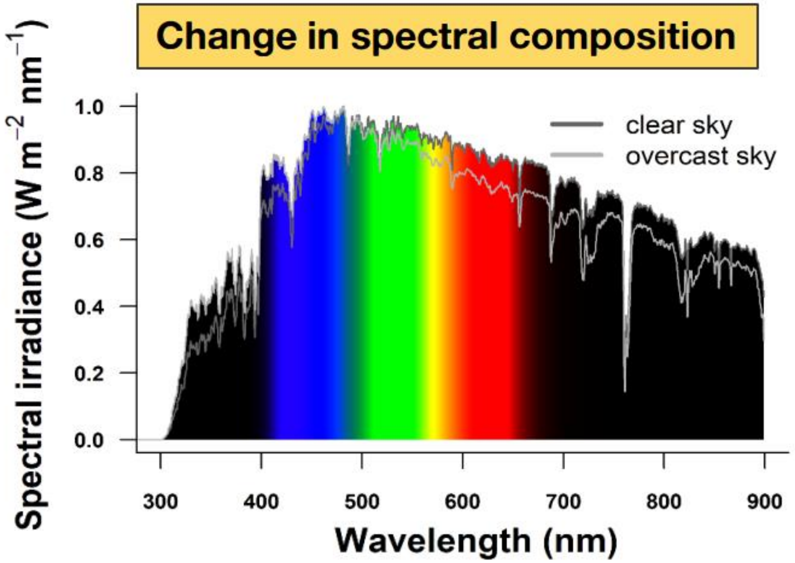
Change in cloud cover and/or
Aerosol loading by geo-engineering

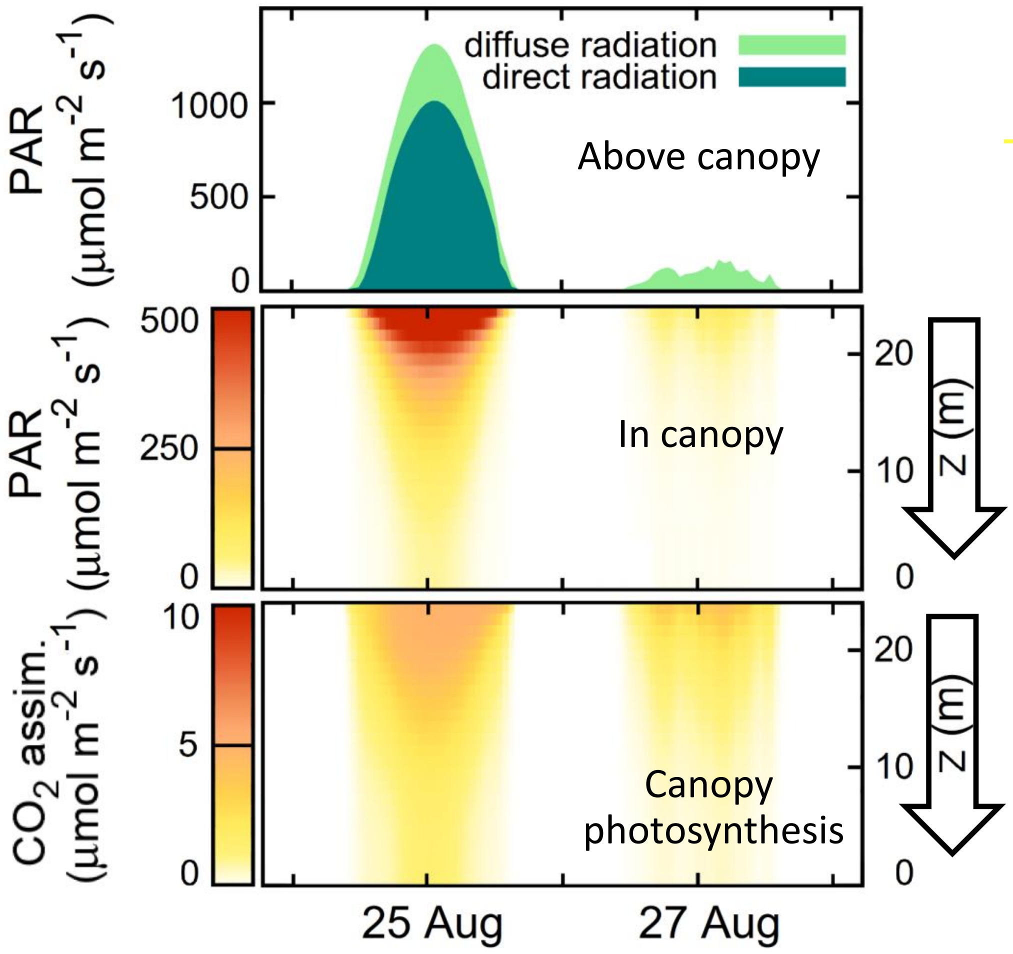


Change in radiation properties and distribution in the canopy



Change in spectral composition





How does the plant canopy respond to diffuse radiation?

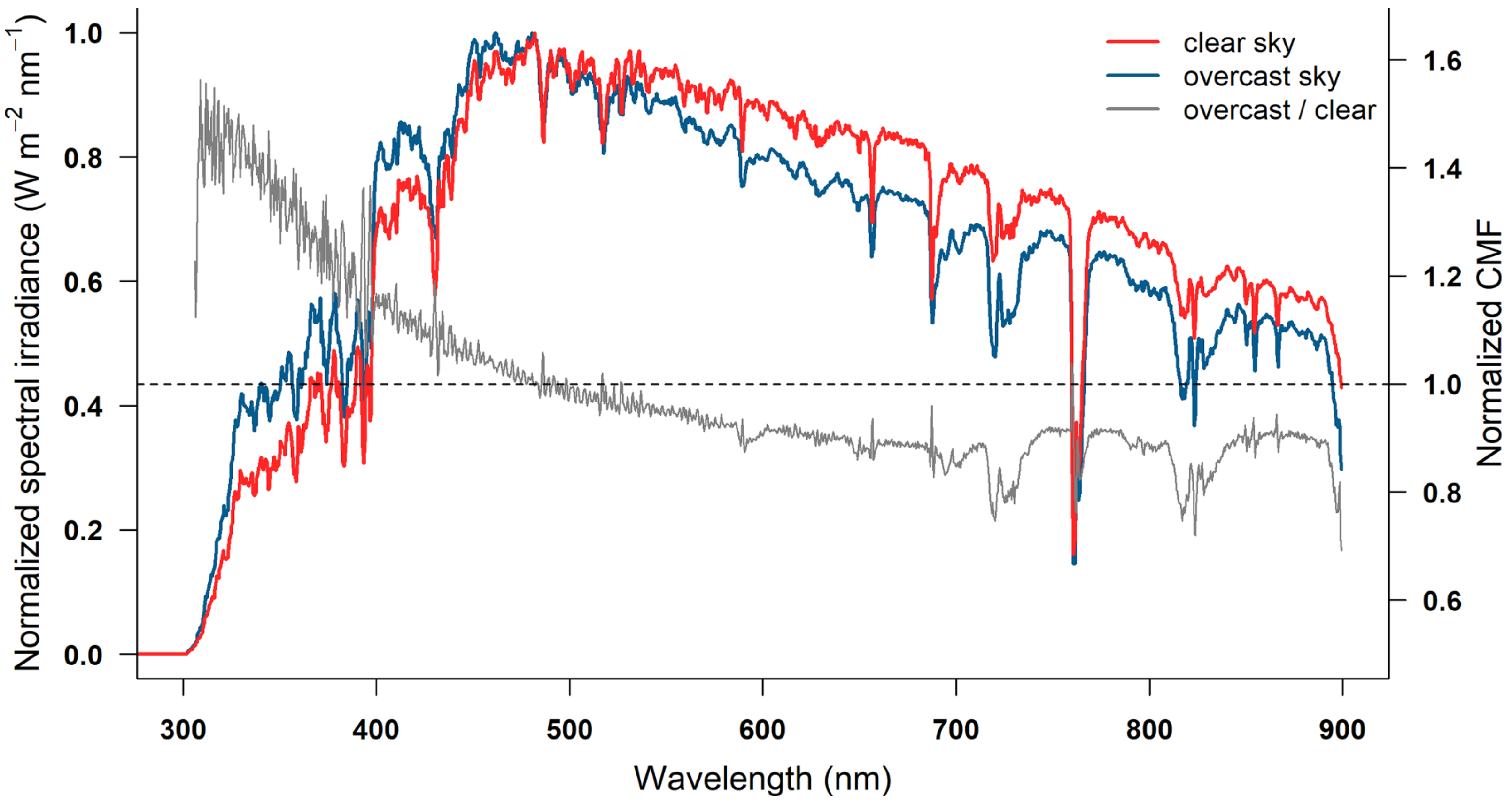
Physiological Responses

- Plant canopies use diffuse radiation more efficiently
- Photosynthesis is not light saturated
- More light reaches lower depths in the canopy.

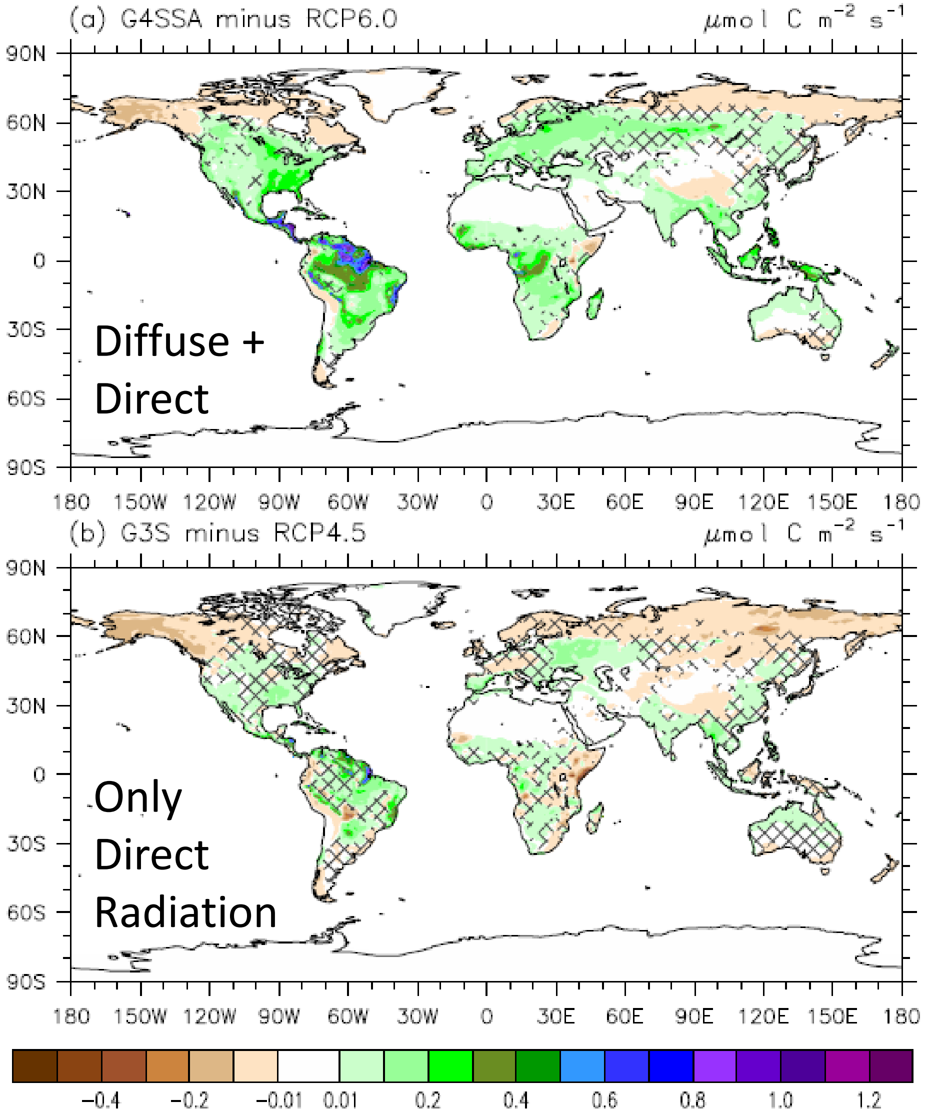
Long term acclimation is not known

- Leaf morphology?
- Canopy architecture?
- Allocation?

On overcast days, Raleigh scattering by the atmosphere means that short wavelength radiation is enhanced relative to longer wavelengths



Scenarios for global effects on photosynthesis of aerosol geoengineering



Projections for change in global net primary productivity 2030-2069 Xia et al., 2016 Atmos. Chem. Phys.

Policy makers are considering geoengineering to reduce climate change effects. 8 Tg/year SO_2 injection into the stratosphere would cool the global atmosphere 1.5-2.0 °C

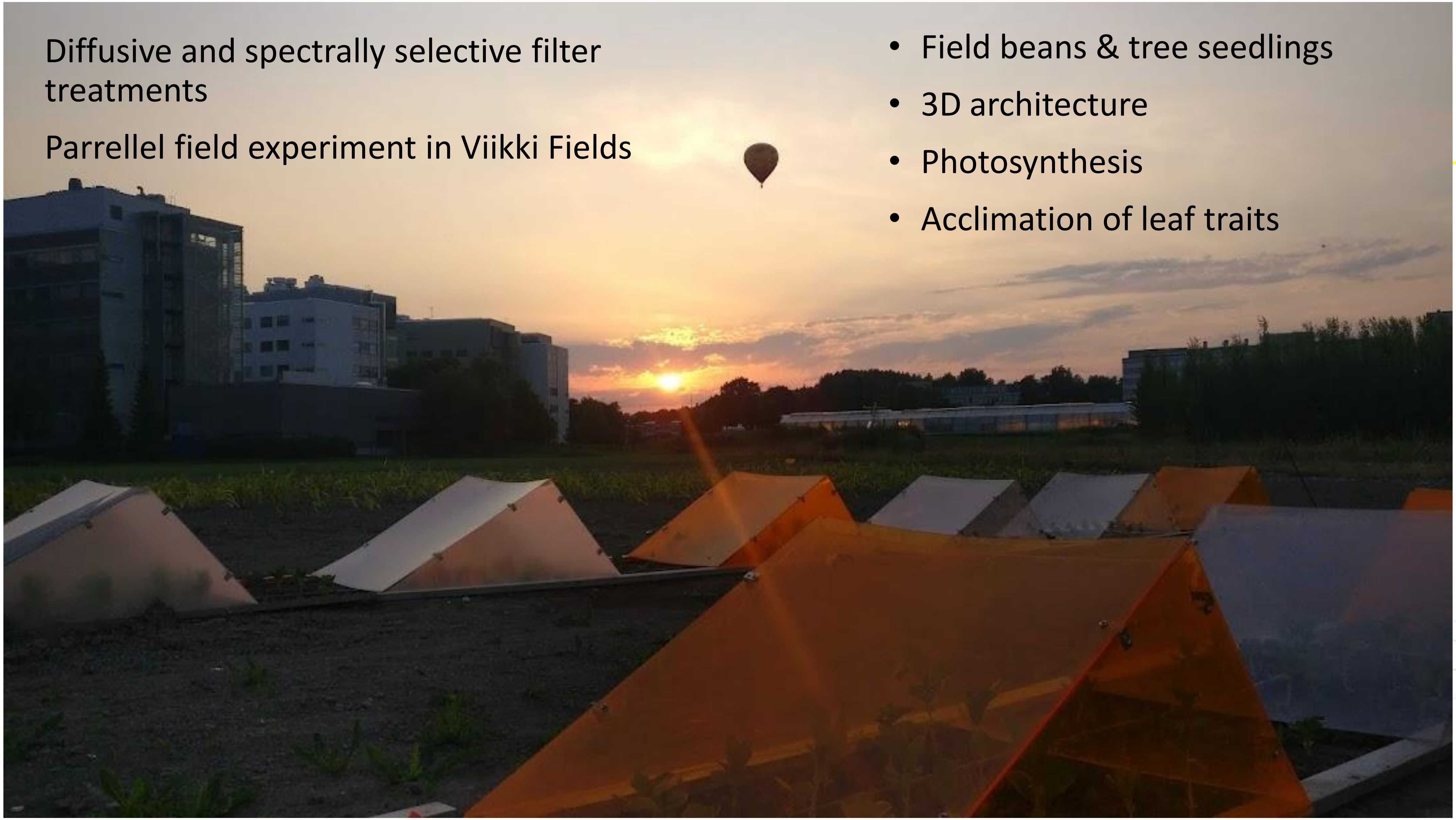
Models forecast an increase in photosynthesis globally 2.5% due to greater penetration of diffuse radiation through canopies despite reduced total irradiance by 11%.

But there are many unknowns involved…

-Stratospheric aerosols will block UV-A and UV-B

-Sulphates (SO2) will destroy ozone.

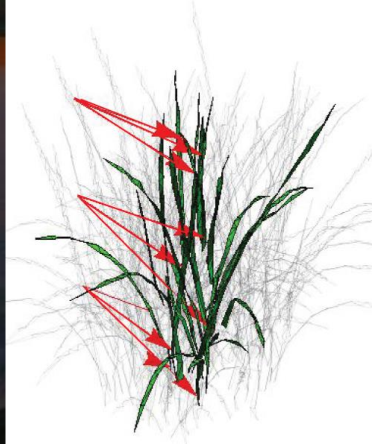
Experiments with filters to study diffuse radiation

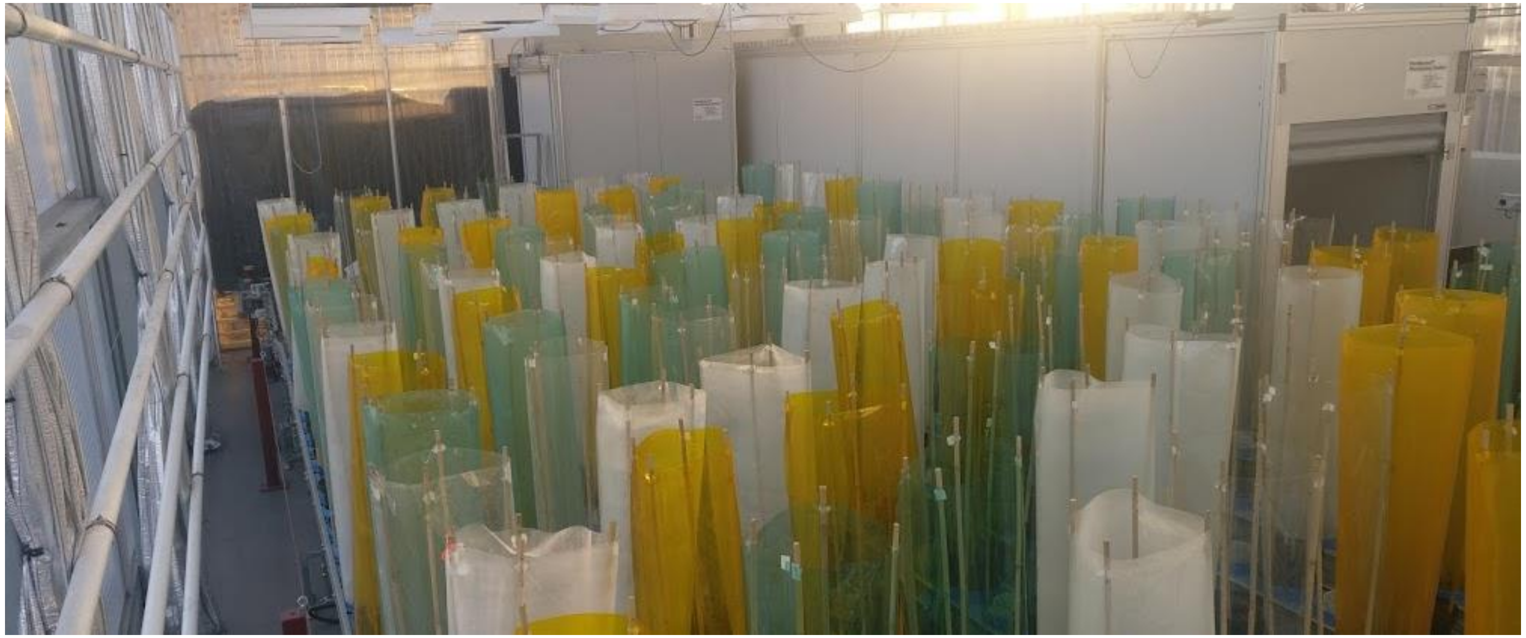


Diffusive and spectrally selective filter treatments

Parrellel field experiment in Viikki Fields

- Field beans & tree seedlings
- 3D architecture
- Photosynthesis
- Acclimation of leaf traits





Comparing spectral and diffusive filter effects on plant canopies in the field and in a phenotyping unit

Light Cues for Plants in Forest Canopies and Beyond

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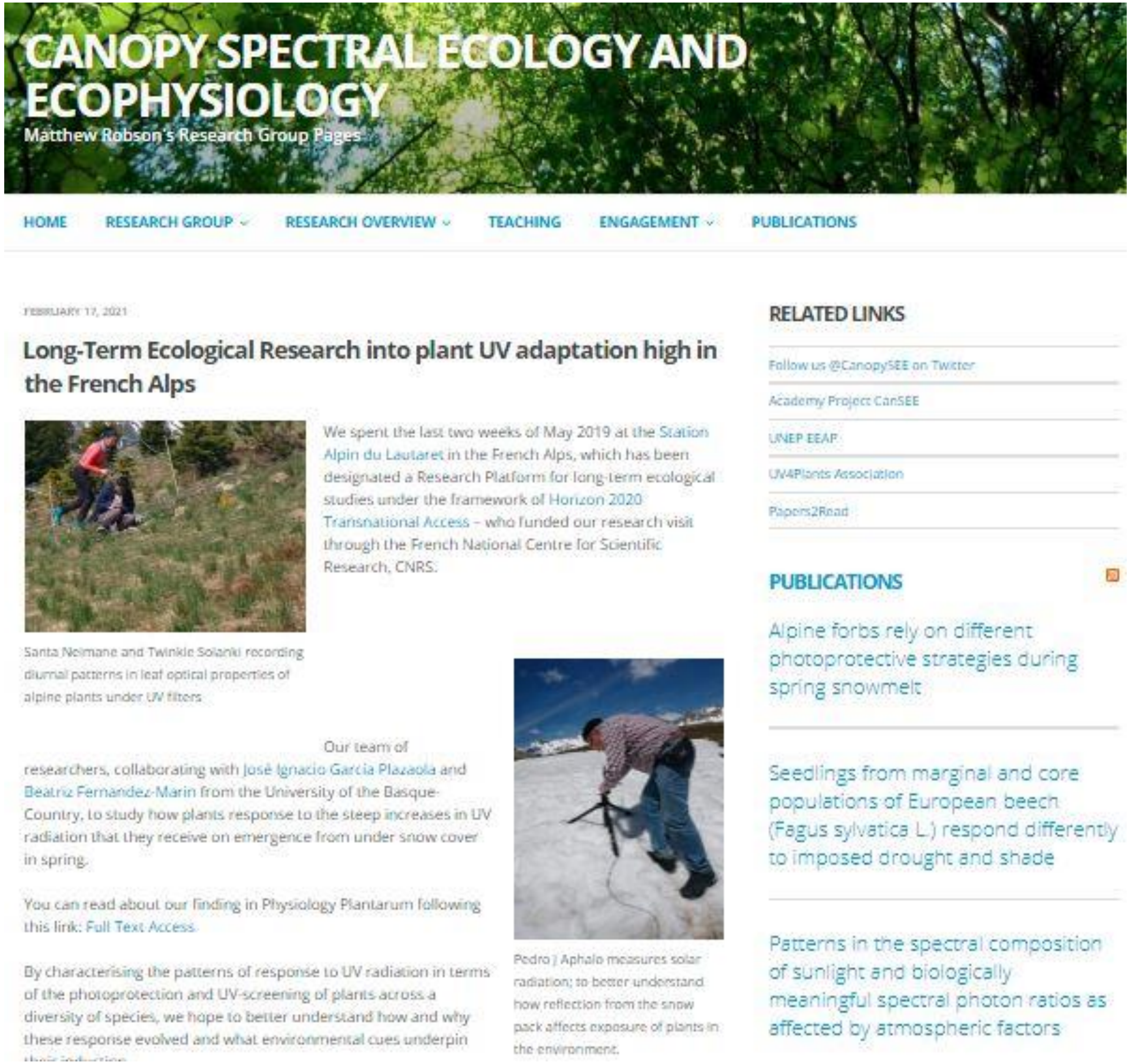

CANOPY SPECTRAL ECOLOGY AND ECOPHYSIOLOGY

Matthew Robson's Research Group Pages

HOME | RESEARCH GROUP | RESEARCH OVERVIEW | TEACHING | ENGAGEMENT | PUBLICATIONS

FEBRUARY 17, 2021

Long-Term Ecological Research into plant UV adaptation high in the French Alps

We spent the last two weeks of May 2019 at the Station Alpin du Lautaret in the French Alps, which has been designated a Research Platform for long-term ecological studies under the framework of Horizon 2020 Transnational Access – who funded our research visit through the French National Centre for Scientific Research, CNRS.

Santa Neimane and Twinkle Solanki recording diurnal patterns in leaf optical properties of alpine plants under UV filters

Our team of researchers, collaborating with José Ignacio García Plazaola and Beatriz Fernández-Marín from the University of the Basque Country, to study how plants response to the steep increases in UV radiation that they receive on emergence from under snow cover in spring.

You can read about our finding in Physiology Plantarum following this link: Full Text Access

By characterising the patterns of response to UV radiation in terms of the photoprotection and UV-screening of plants across a diversity of species, we hope to better understand how and why these response evolved and what environmental cues underpin their induction

Pedro J Aphalo measures solar radiation; to better understand how reflection from the snow pack affects exposure of plants in the environment.

RELATED LINKS

- Follow us @CanopySEE on Twitter
- Academy Project CanSEE
- UNEP EEAP
- UV4Plants Association
- Papers2Read

PUBLICATIONS

Alpine forbs rely on different photoprotective strategies during spring snowmelt

Seedlings from marginal and core populations of European beech (Fagus sylvatica L.) respond differently to imposed drought and shade

Patterns in the spectral composition of sunlight and biologically meaningful spectral photon ratios as affected by atmospheric factors