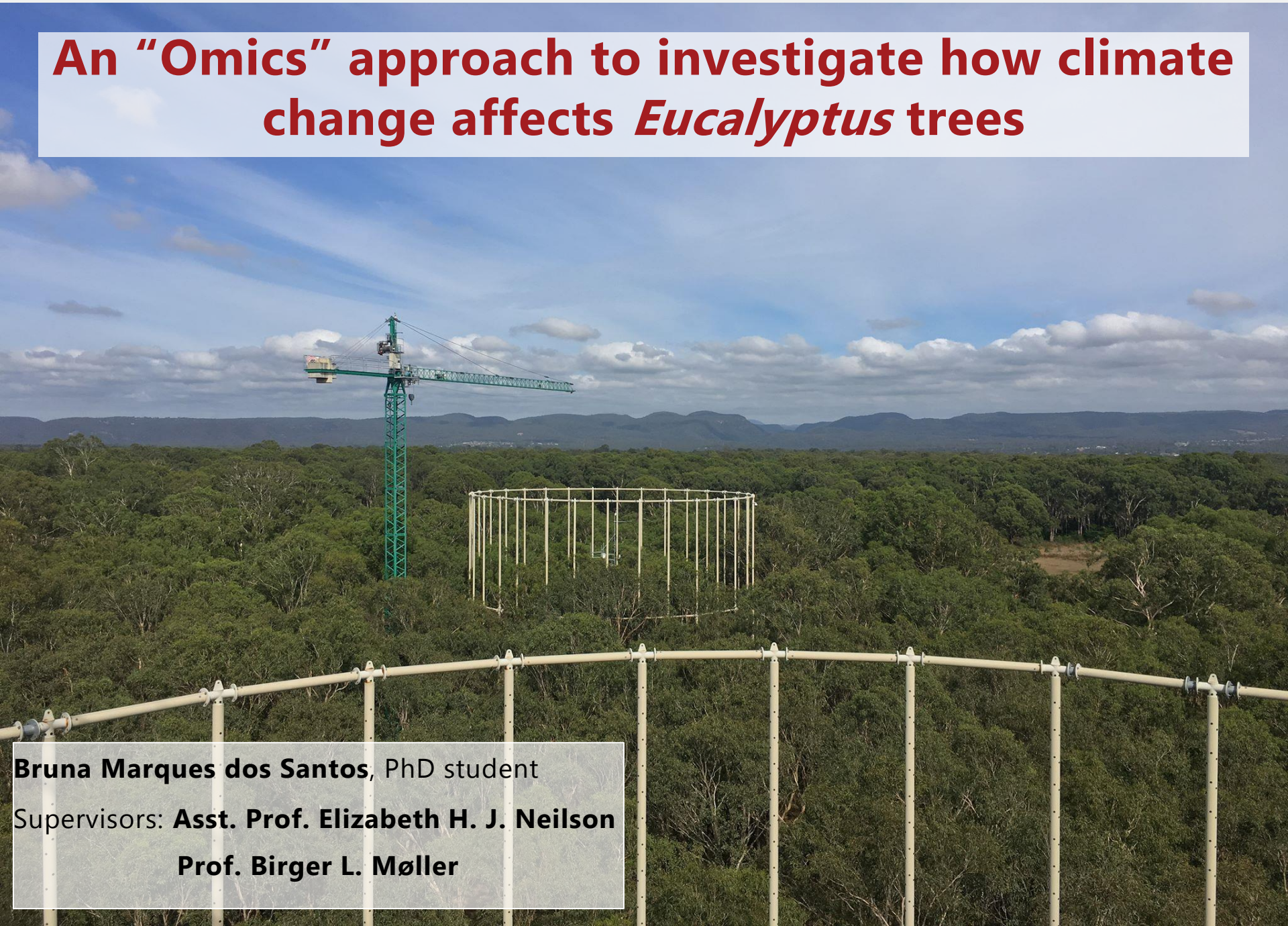
An "Omics" approach to investigate how climate change affects *Eucalyptus* trees

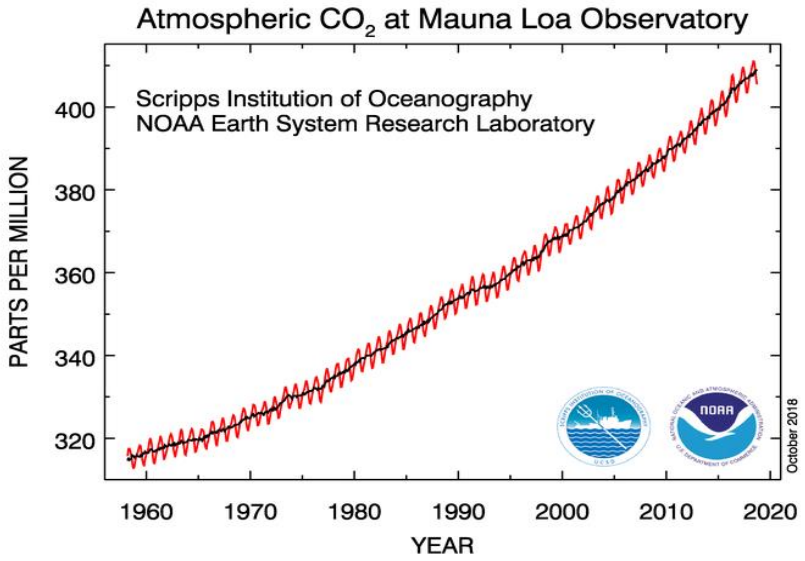


Bruna Marques dos Santos, PhD student

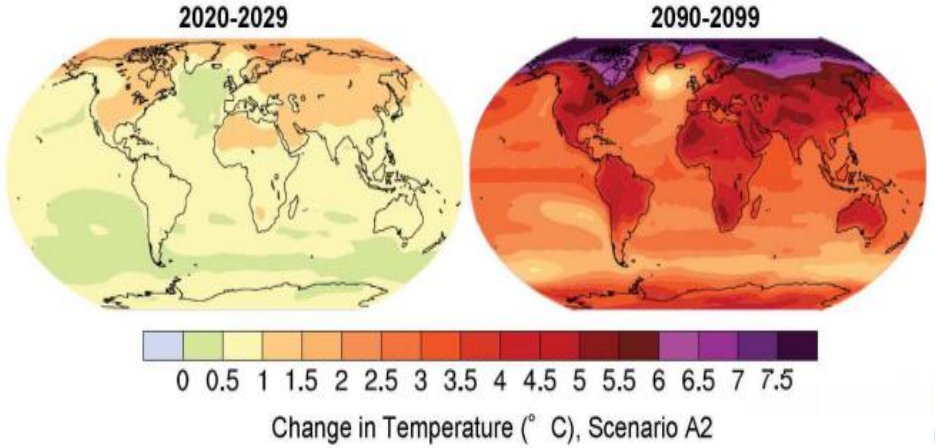
Supervisors: **Asst. Prof. Elizabeth H. J. Neilson**

Prof. Birger L. Møller

Introduction: climate change impact on plants

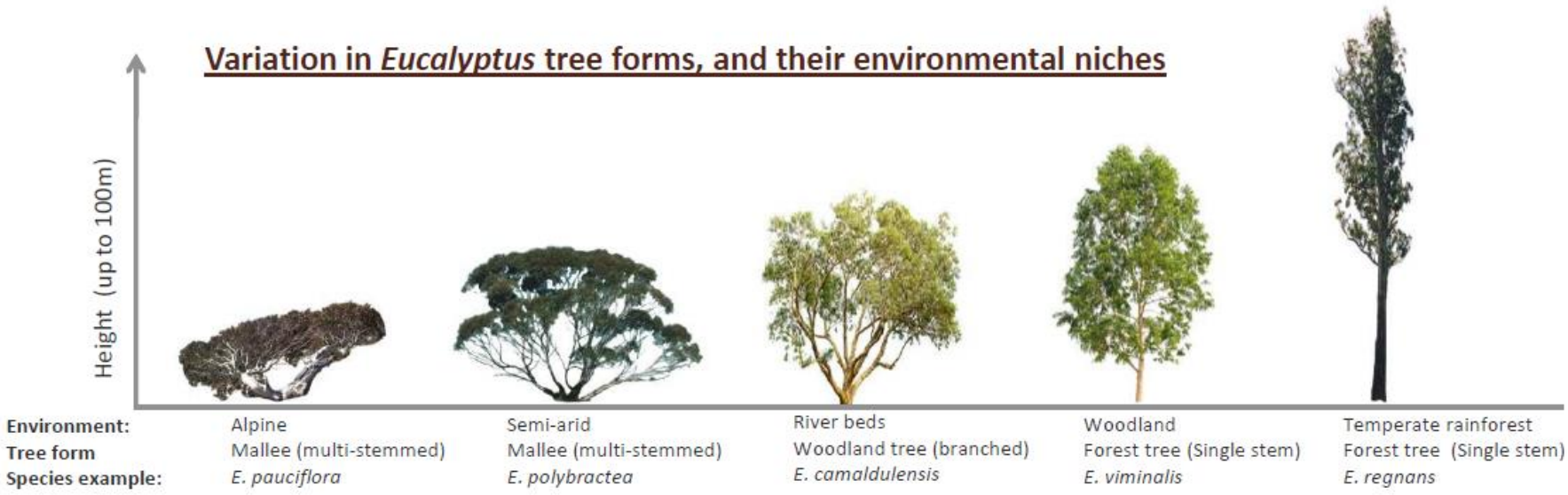


NOAA, 2018.



IPCC, 2014.

Eucalyptus as a model to study climate change



General metabolites VS **Specialized metabolites**

Essential for growth/development

e.g. hormones, proteins, sugars

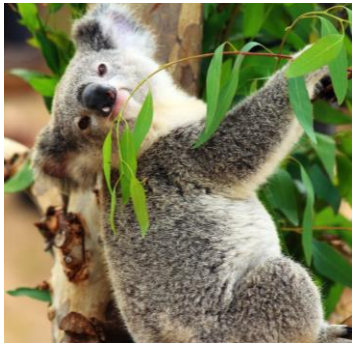
NUTRITIONAL VALUE ↓

Climate change

Essential for biotic/abiotic interactions

e.g. phenolics, terpenes, cyanogenic glucosides

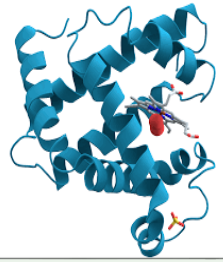
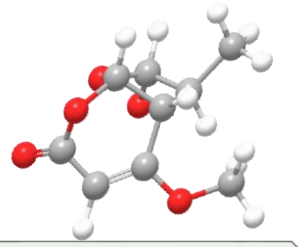
TOXICITY ↑



Phascolarctos cinereus, the koala
Specialist herbivore, iconic species, vulnerable

The omics approach




Genomics → **Transcriptomics** → **Proteomics** → **Metabolomics** → **Phenomics**

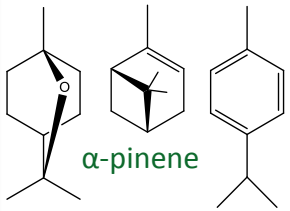
Myburg et al., 2014

Pathway regulation and elucidation
Hansen et al., Plant Physiology
2018 *in press*

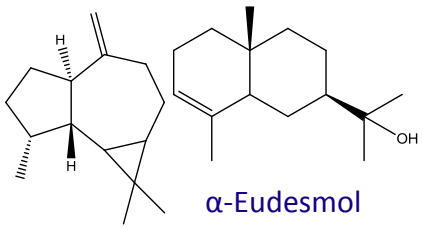
Toxicity
- VOCs
- FPCs
- Terpenoids

Nutritional value
- Biomass/growth
- Photosynthesis
- Cell wall content

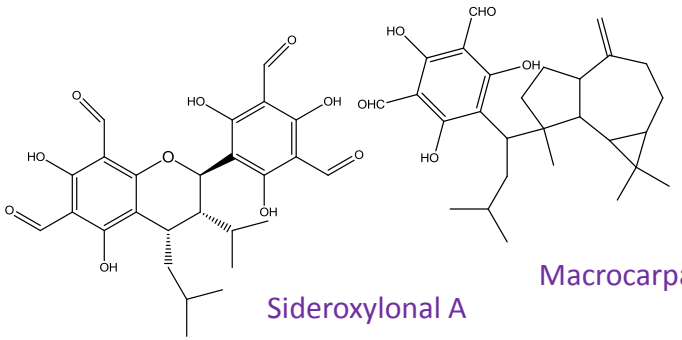
Monoterpenes:



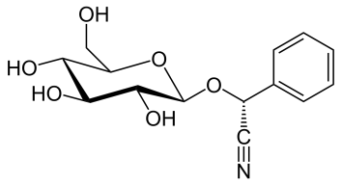
Sesquiterpenes:



Formylated Phloroglucinol Compounds (FPCs):



Cyanogenic glucosides:



Are VOC emissions affected by environmental change?

From the glass house to the field

Growth Chamber Experiment

- ***E. tereticornis***
- *E. camaldulensis*
- *E. cladocalyx*
- *E. grandis*

Elevated temperature (+4°C)
Elevated CO_2 (+150 ppm)

Field Exeriment - EucFACE

- ***E. tereticornis***

Elevated CO_2 (+150 ppm)
Summer and fall 2018

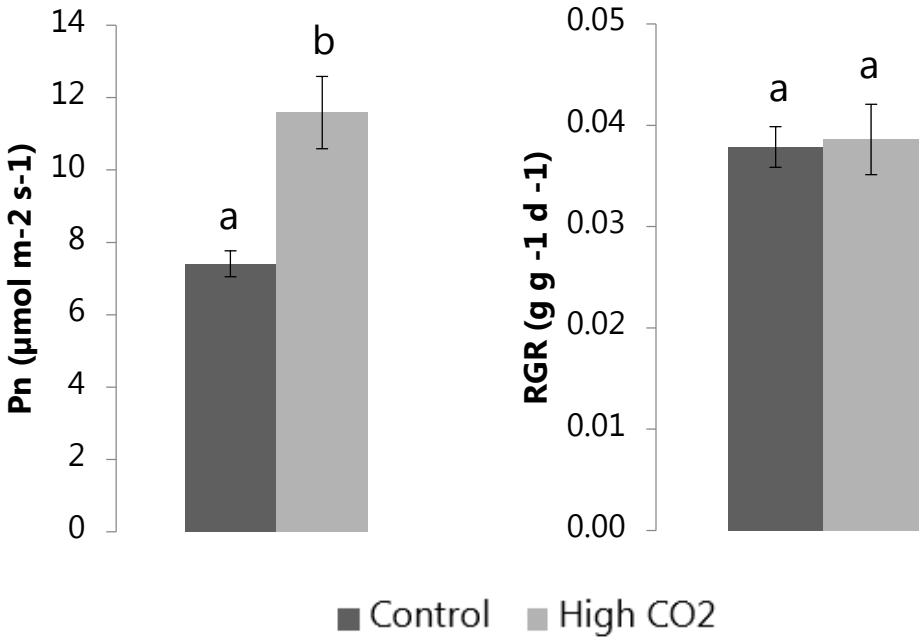
Experiment 1: seedlings in the growth chamber

Eucalyptus tereticornis

Control

High CO_2

Scale bar = 50 cm
2 months under 550 ppm CO_2



Mean ± standard error of n=4.
T-test p value < 0.05.

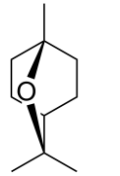
We hypothesize that the assimilated carbon is allocated to specialized metabolites such as **VOCs**.

Volatile organic compounds (VOCs)

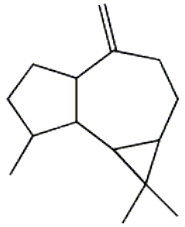
Overview:

41 VOCs identified, 20 standards

Monoterpenes: 1,8-cineole



Sesquiterpenes: aromadendrene

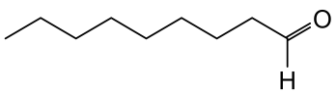


Benzenoids: benzaldehyde

Aldehydes: nonanal

Nitrile: isobutyronitrile

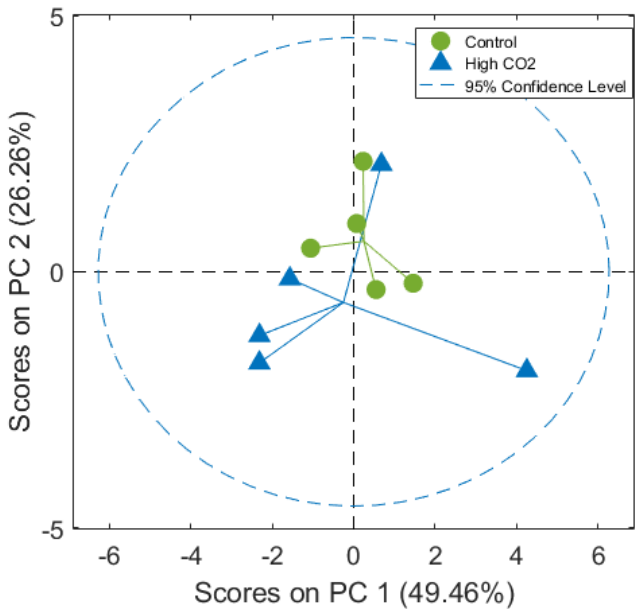
Ketones: 2-Butanone

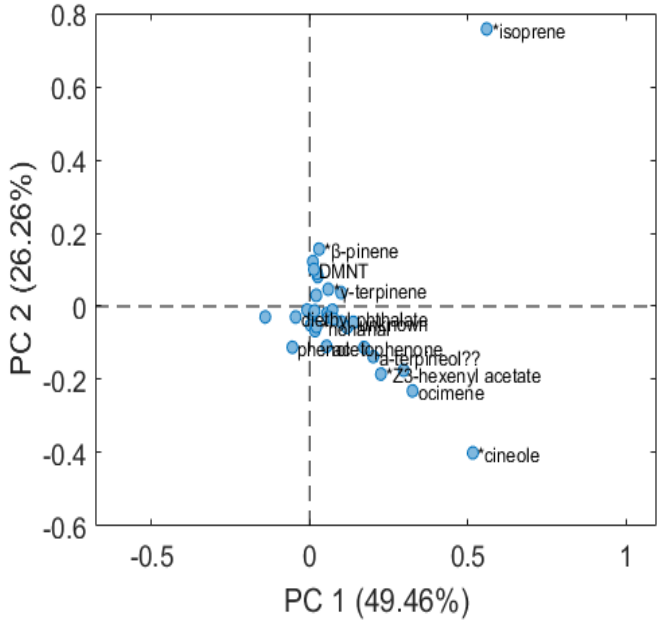


Alkanes: 1,3-pentadiene

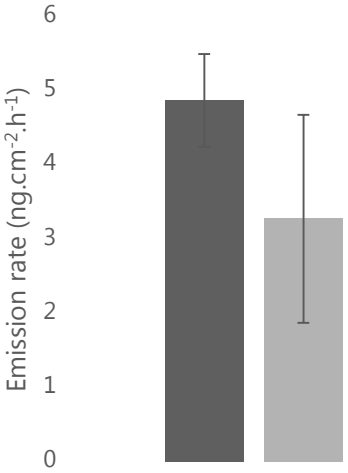
Prof. Riikka Rinnan, Dr. Tao Li Dept. of Biology – University of Copenhagen

Elevated atmospheric CO_2 effect on VOCs

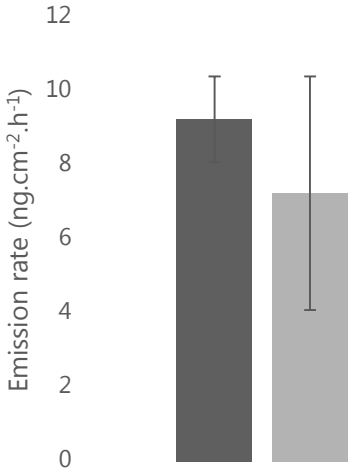




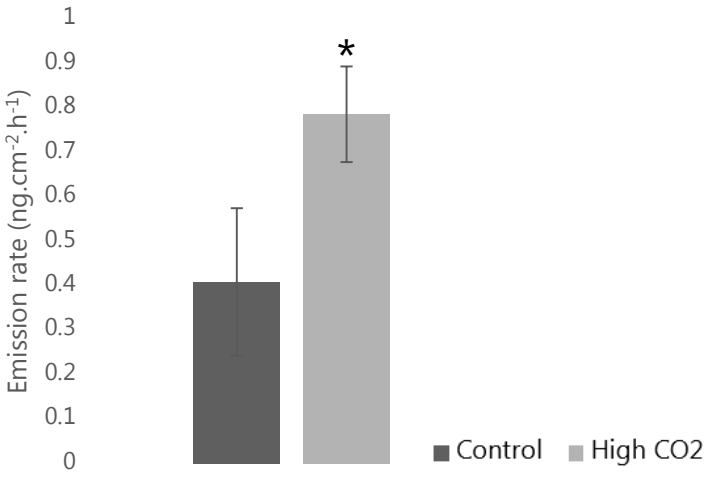
Isoprene



Total terpene emission

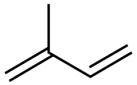


Total benzenoid emission

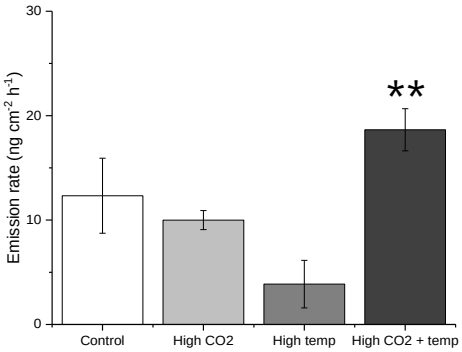


VOC differences in other species

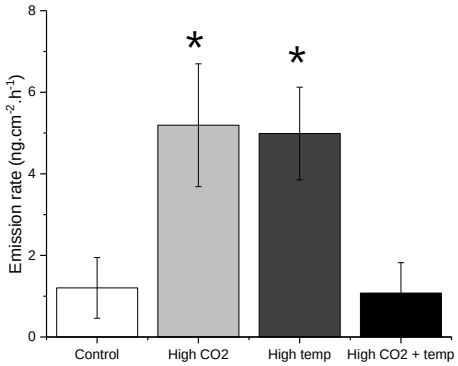
E. grandis



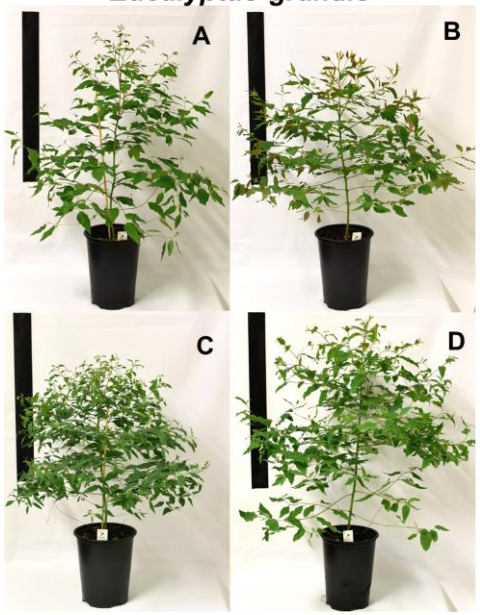
Isoprene



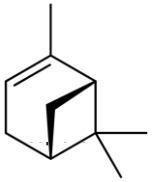
α-pinene



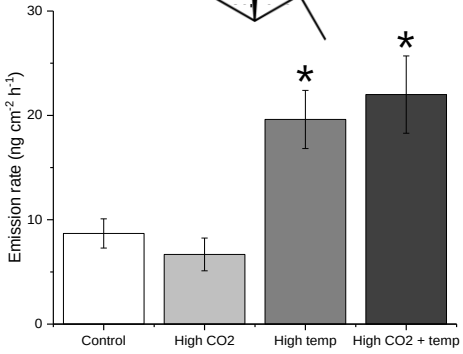
Eucalyptus grandis



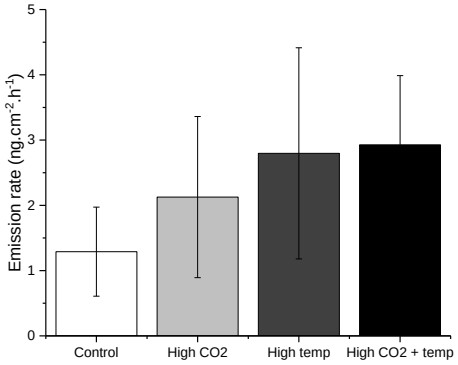
E. cladocalyx



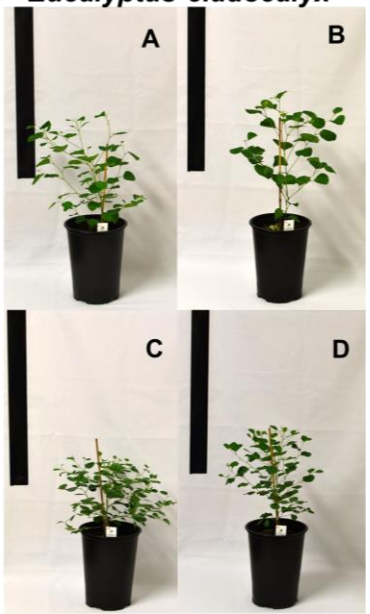
Isoprene



α-pinene

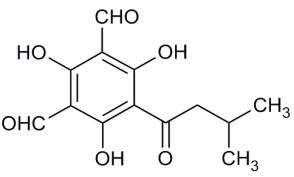


Eucalyptus cladocalyx

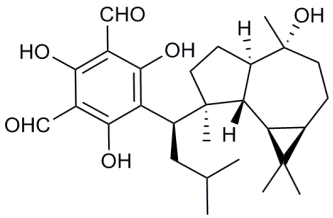


An improved method to detect and quantify FPCs

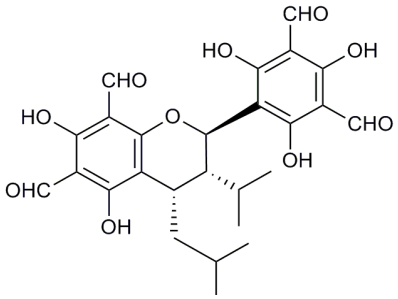
Formylated phloroglucinol compounds - FPCs
Active against bateria, fungi, malaria, HIV and tumors.
Role *in planta* : defense against herbivory.



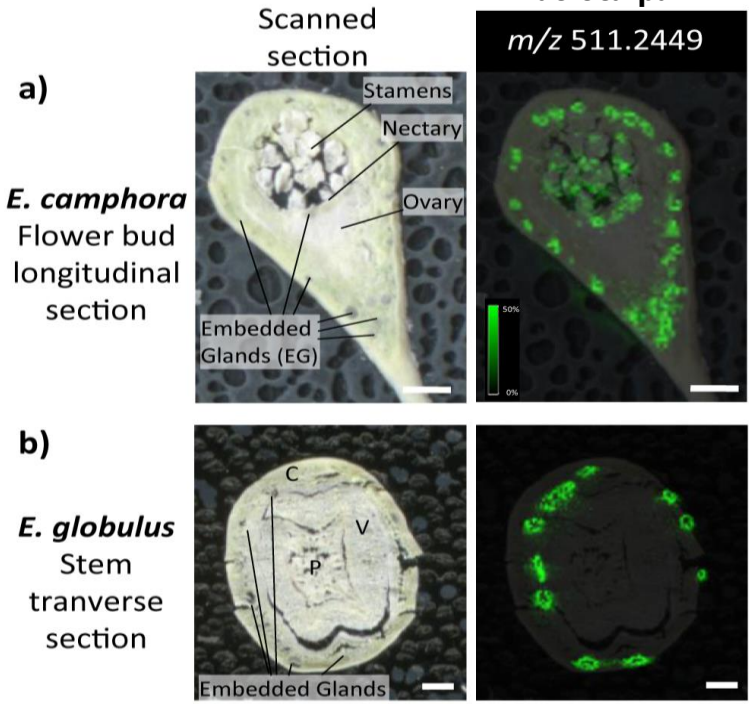
Jensenone

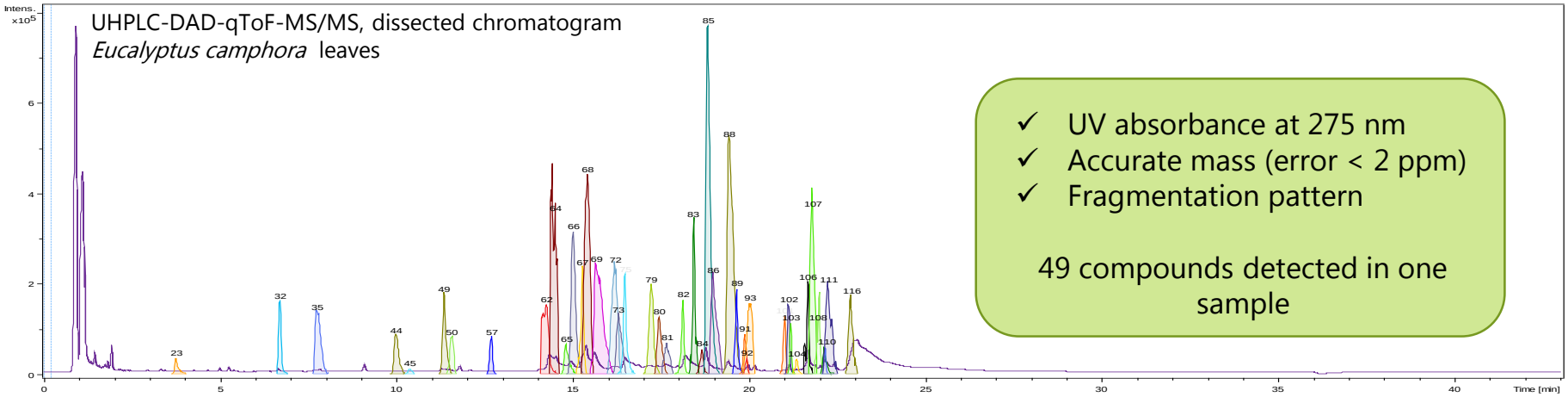


Macrocarpal A



Sideroxylonal A





- ✓ UV absorbance at 275 nm
- ✓ Accurate mass (error < 2 ppm)
- ✓ Fragmentation pattern

49 compounds detected in one sample

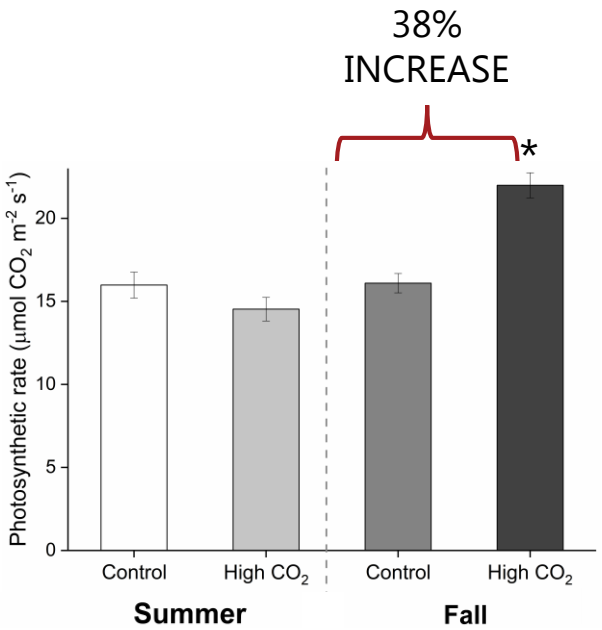
Santos et al (2018) Frontiers in Plant Science *Invited submission*

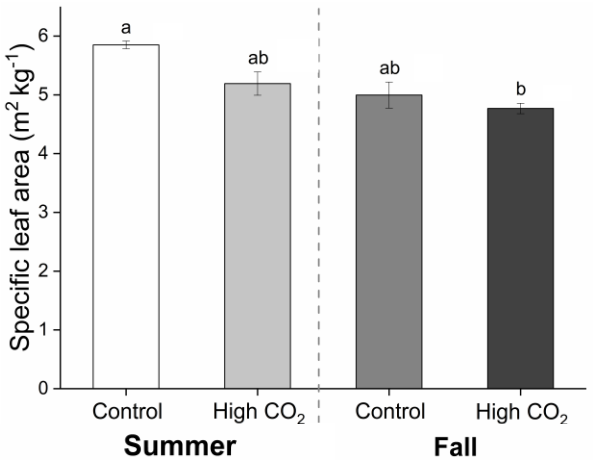
Experiment 2: response of a natural forest to eCO_2

The world's only Free air CO_2 Enrichment experiment in native forest

FACE: Free air CO_2 enrichment
Eucalyptus tereticornis
6 rings with 25m diameter
3 controls and 3 High CO_2
2 seasons: **Summer and Fall**

EucFace preliminary results





Eucalyputs are complex chemists and affected by climate change

In young and adult trees, elevated CO_2 affects specialized metabolism, not biomass

Total VOC emission rates are diven by isoprene
Isoprene emission affected by CO_2 and temperature (season)

Eucalypts are some of the highest isoprene emitters of all plants species tested

Interaction between CO_2 and temperature
Consequences for biotic interactions – food chain

Acknowledgments

- Elizabeth H J Neilson
- Birger L Møller
- Plant Ecophysiology group
- Gustavo Avelar Molina
- Riikka Rinnan
- Tao Li
- Erwin Schoof
- Ben Moore

VILLUM Research Center for Plant Plasticity

Australian Government
Australian Research Council

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UNIVERSITY OF COPENHAGEN

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Technical University of Denmark