TERN

Terrestrial Ecosystem Research Network

OzFlux and OzEWEX: continental-scale monitoring of Australia's ecosystems, their ecohydrology, and the productivity of their unique flora

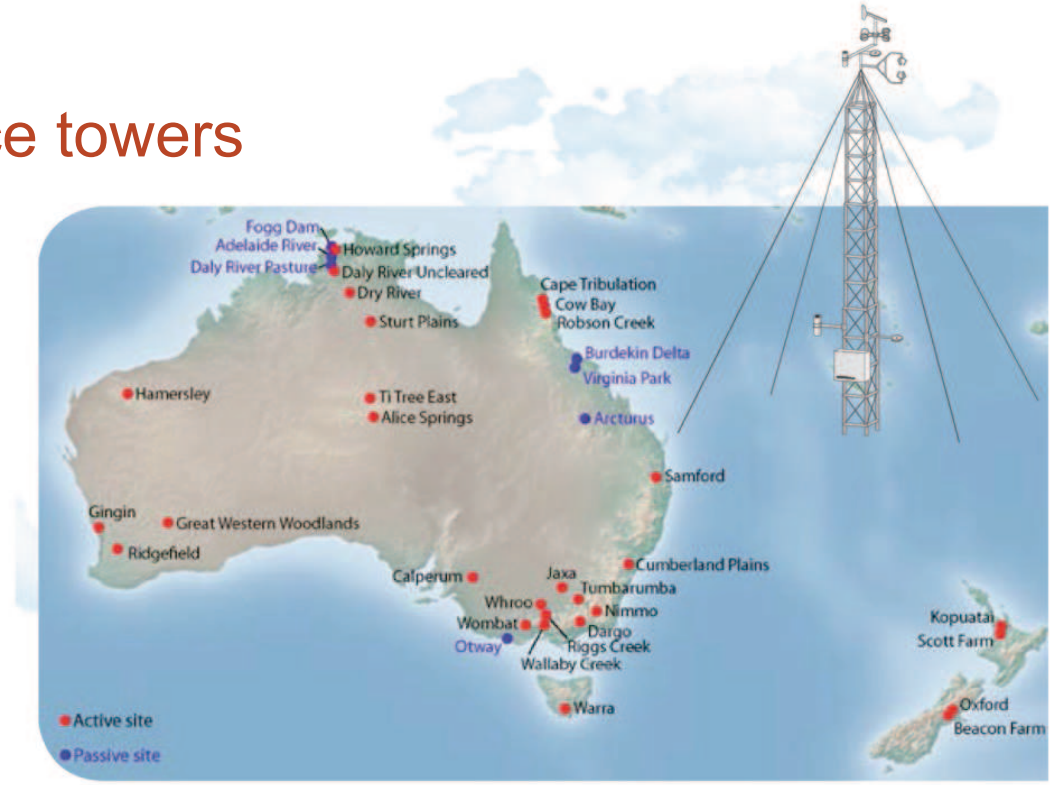
OzFlux

Australian and New Zealand Flux Research and Monitoring

TERN is supported by the Australian Government through the National Collaborative Research Infrastructure Strategy and the Super Science Initiative.

What is OzFlux?

- A network of eddy covariance towers
- Australia and New Zealand
- Surface exchange of
  - energy
  - water
  - carbon
- Soil moisture
  - Calibration varies
- Groundwater
- Eucalypt forests
- North Australian Tropical Transect



Groundtruthing

We are busy measuring soil respiration, biomass, leaf area index for determination of the basal soil respiration (Rh) and net primary production (NPP).

Thankyou

THE UNIVERSITY of ADELAIDE

Wet extreme...

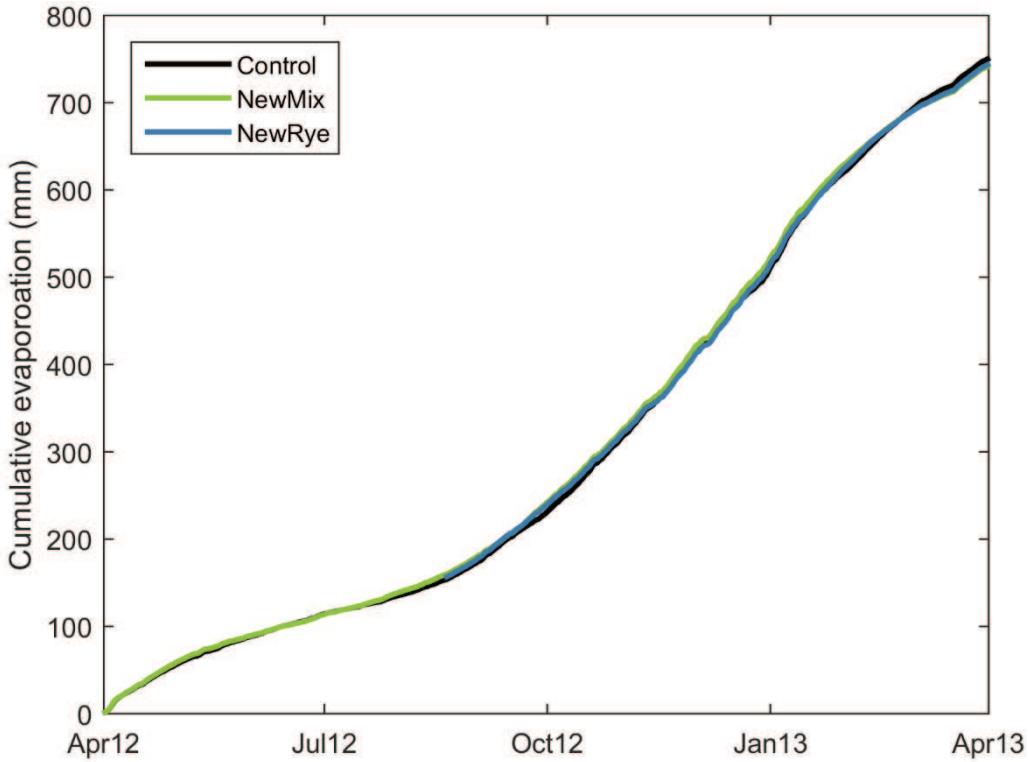
Daintree OzFlux Sites

- Pristine lowland rainforest at both stations.
- Complex Type 1A mesophyll vine forest
- Canopy height 25-35m
- Leaf area index ≈ 4
- Elevation: 65m
- Rainfall: 4250mm (COW)
  5179mm (CTR)
- T_{mean} °C: 24.2 (COW)
  24.4 (CTR)

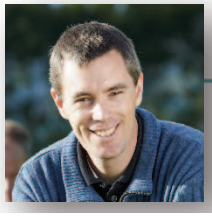
$T_{min - max}$ °C

- COW
  11.2 – 39.9
- CTR
  10.6 – 38.6

Evaporation – main findings so far



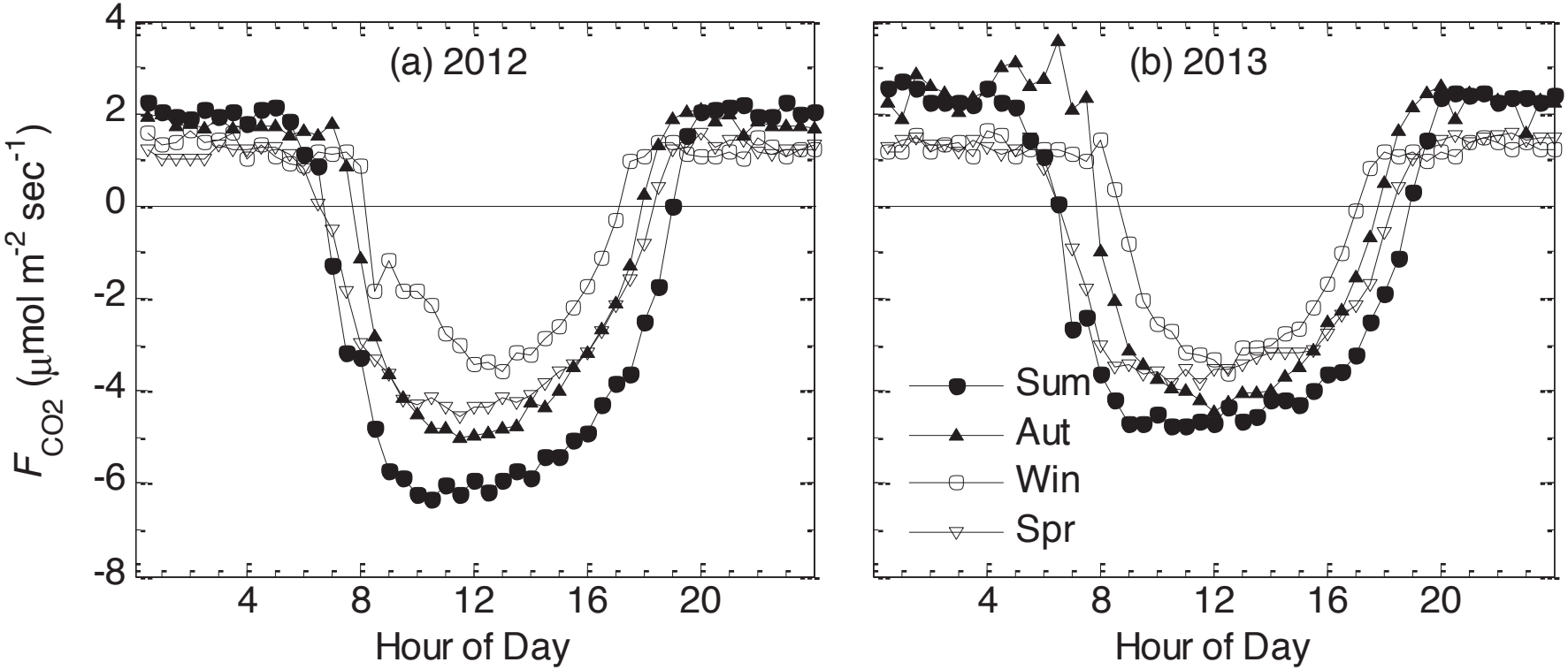
- E driven by radiation and soil moisture
  - Low spatial variability during calibration period
  - Low inter-annual variability of control site over 3 years
- No effect of grazing on E (probably due to soil compensation)



Jack Pronger et al, in prep. Low spatial and inter-annual variability in evaporation from a year round intensively grazed temperate pasture system in New Zealand

Mild winters...

Ensemble mean diel NEE at Kopuatai



Summer 2013 was the severe drought and this resulted in less negative daytime NEE, as well as higher nighttime NEE (ecosystem respiration).

Northern and central Australia...

Motivation

- Vegetation dynamics of global savanna systems , which exhibit enormous spatio-temporal variability in woody and herbaceous biomass, structure and plant functional forms are poorly understood. “A single model cannot adequately represent savanna woody biomass across these regions” (Lehmann et al. 2014)*.
  - Accurate C-allocation and phenology for the main elements of savanna systems (trees and grasses) may be a key to understanding variations in tree/grass partitioning in time and space in the savanna biome worldwide.
- No existing vegetation model allows phenology to emerge as a result of allocation of assimilated carbon.
- New approach: links phenology and allocation, accounting for a temporal shift between assimilation and growth, mediated by plant carbohydrate storage

*Lehmann, C. E., Anderson, T. M., Sankaran, M., Higgins, S. I., Archibald, S., Hoffmann, W. A., Hanan, N. P., Williams, R. J., Fensham, R. J., and Felfili, J.: Savanna vegetation-fire-climate relationships differ among continents, Science, 343, 548-552, 2014.

HAVANA (Hydrology, Allocation and Vegetation-dynamics Algorithm for Northern Australia) land surface model

Key Features

- Root/shoot C-allocation optimises NPP based on resource limitation
- Growth decoupled from production
- Storage to buffer stress
- Tree-grass competition
- Emergent leaf and root phenology

Structure➔Function feedbacks

- Mortality ➔ biomass turnover
- Sapwood area ➔ leaf/wood C-allocation (pipe model)
- Sapwood biomass ➔autotrophic respiration
- Clumping index ➔light interception

MORE
leaves
tree cover
LESS
stress mortality

MORE
roots
grass cover
stress mortality

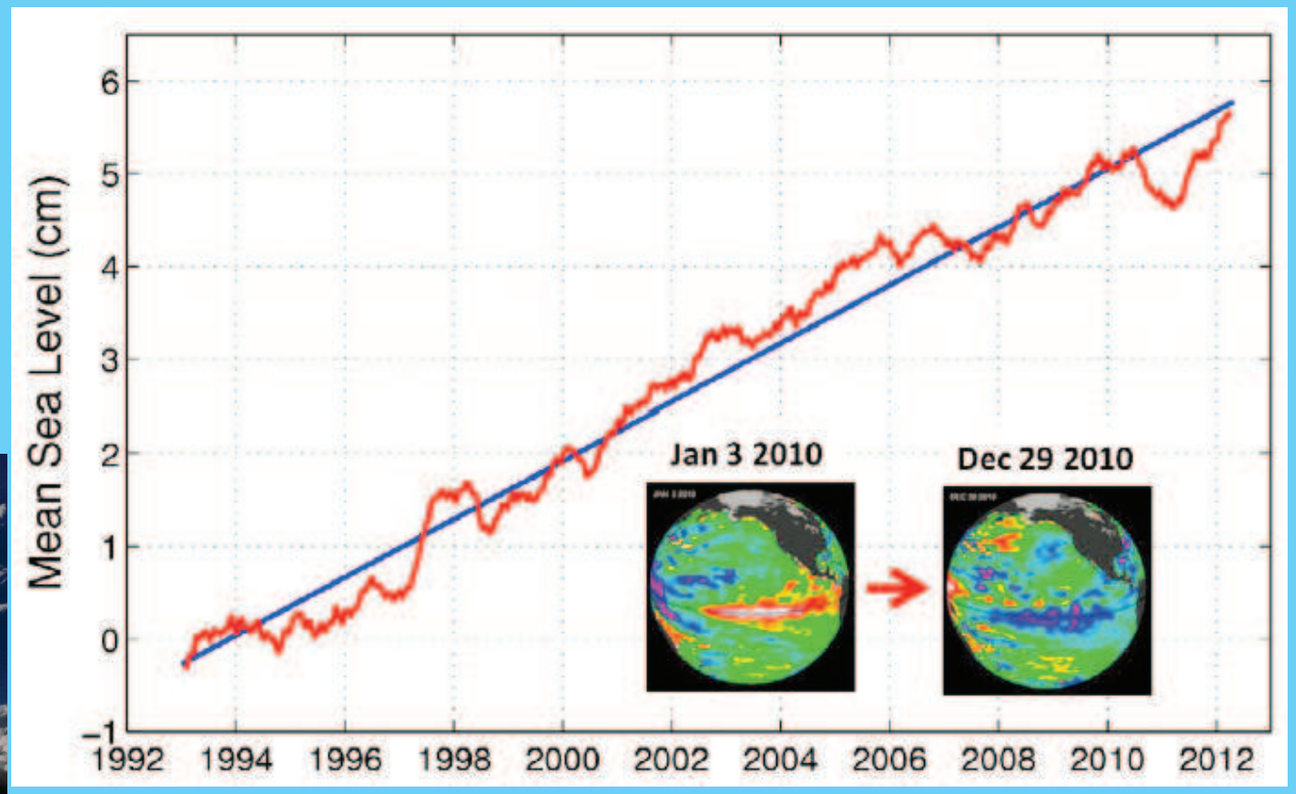
Haverd, V. *et al.* Coupling carbon allocation with leaf and root phenology predicts tree-grass partitioning along a savanna rainfall gradient. *Biogeosciences Discuss.* **12**, 16313-16357, (2015)

Variability in precipitation...

Global anomalies: ocean level decline
2010–2011

Strongest sustained La Niña in over 90 years (since 1917) [Boening et al. 2012]
5 mm drop in ocean level [Boening et al. 2012]
Increase in total continental water mass through 2012 [Fasullo et al. 2013]

Runoff returned additonal water to the ocean from other continents



[Boening et al. 2012]

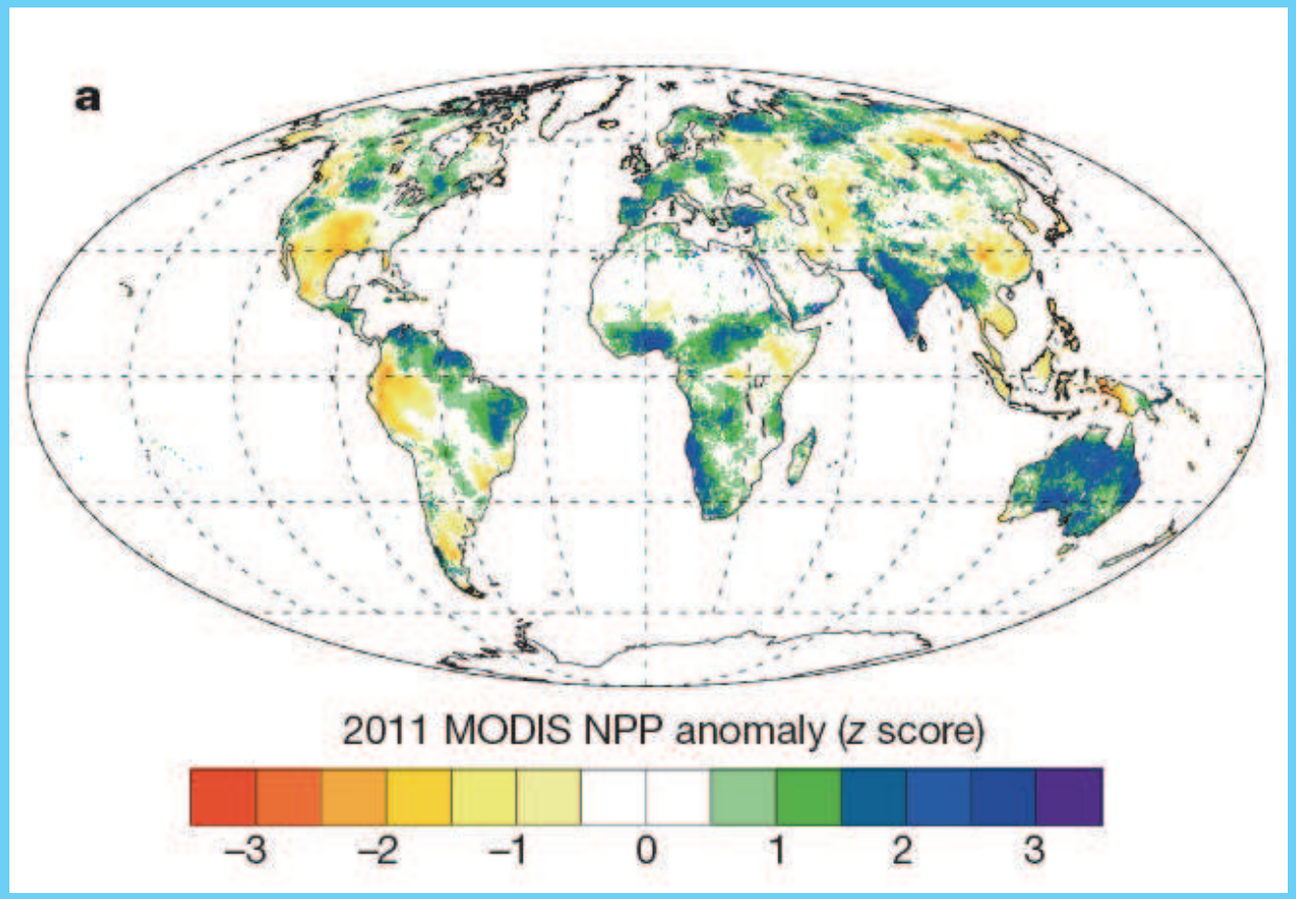
2011 global land C sink anomaly

Extraordinary C sink identified in semi-arid regions of the Southern Hemisphere attributed to La Niña [Poulter et al. 2014]

57% attributed to Australian aridlands

Remainder attributed to southern African aridlands and temperate S America

Direct measurements of enhanced C sink and productivity [Cleverly et al. 2013, Eamus et al. 2013]



[Poulter et al. 2014]

Exceptional resilience

JAMES CLEVERLY

JAMES CLEVERLY

Figure 1 | Hummock grassland during dry and wet growth seasons. Some ecosystems, such as hummock grasslands in southeastern Australia, compensate for poor growth during dry periods by increasing growth during wet periods. Ma *et al.*[5] report that such ecosystems have until now been less vulnerable to drought than are croplands or pasture.

Rammig and Mahecha 2015, *Nature*

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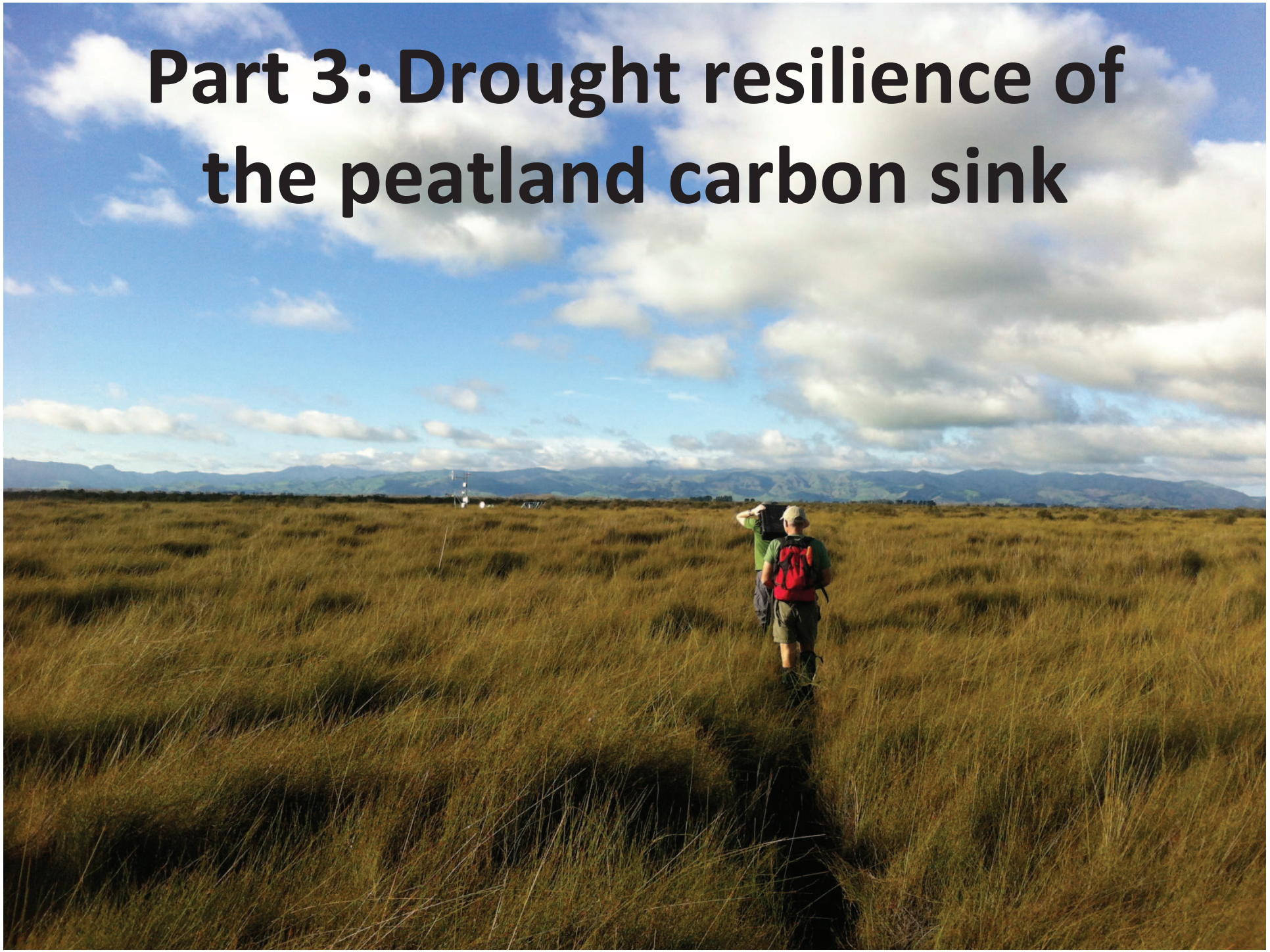
OzFlux

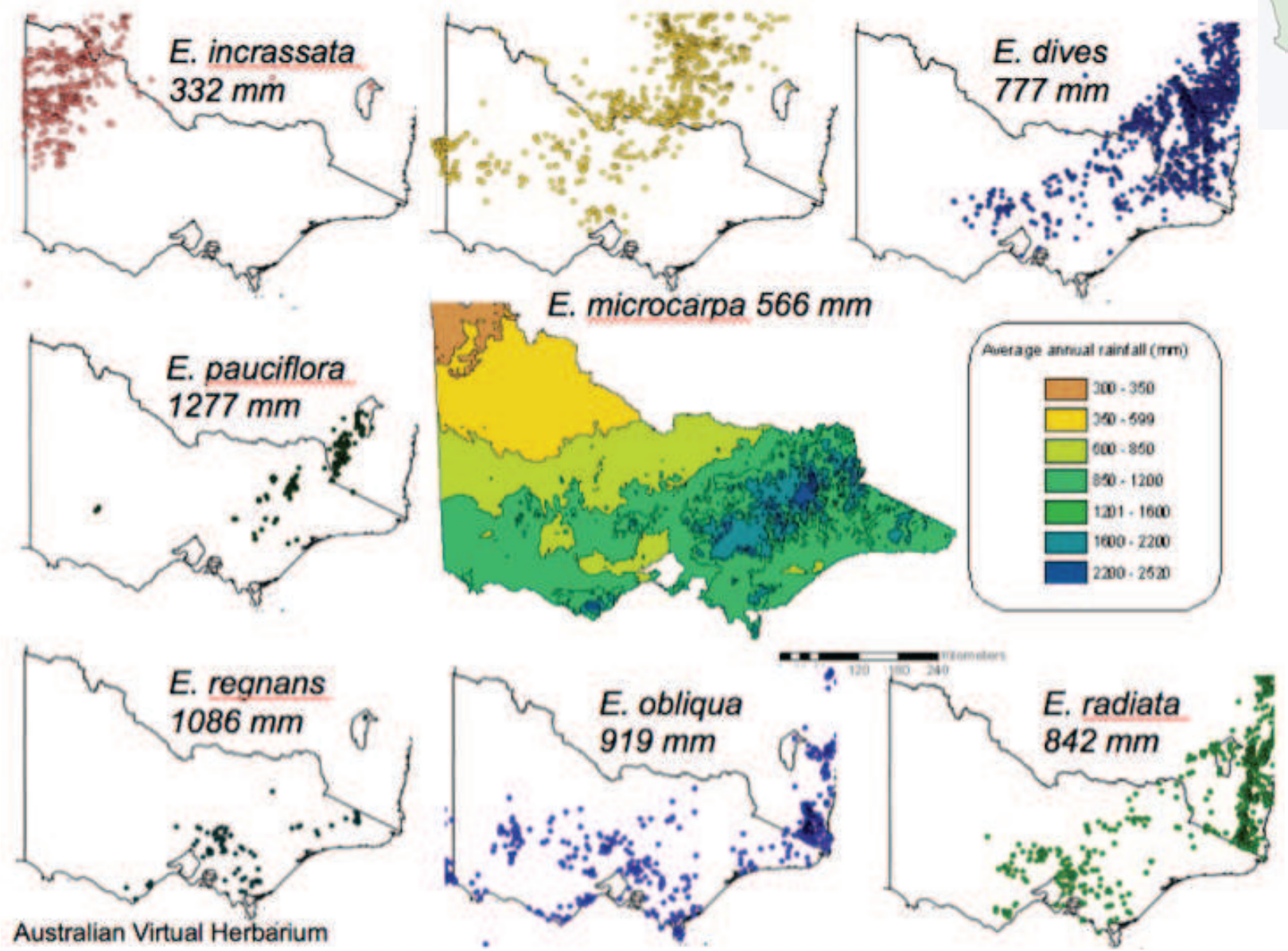
Part 3: Drought resilience of the peatland carbon sink



Vegetation and climate...

Eucalypts and climate

Many eucalypts have *very narrow* climatic ranges
Over 140 eucalypt species in Victoria (SE Australia)



Australian Virtual Herbarium

Objectives

What are the water relation strategies within one genus (*Eucalyptus*)?

Does expression of water relation traits depend on climate?

- How important are water relation traits for the distribution of eucalypts?
- Are these traits expressed inherently?
- How plastic are these traits?
- Do we observe adjustment of traits?

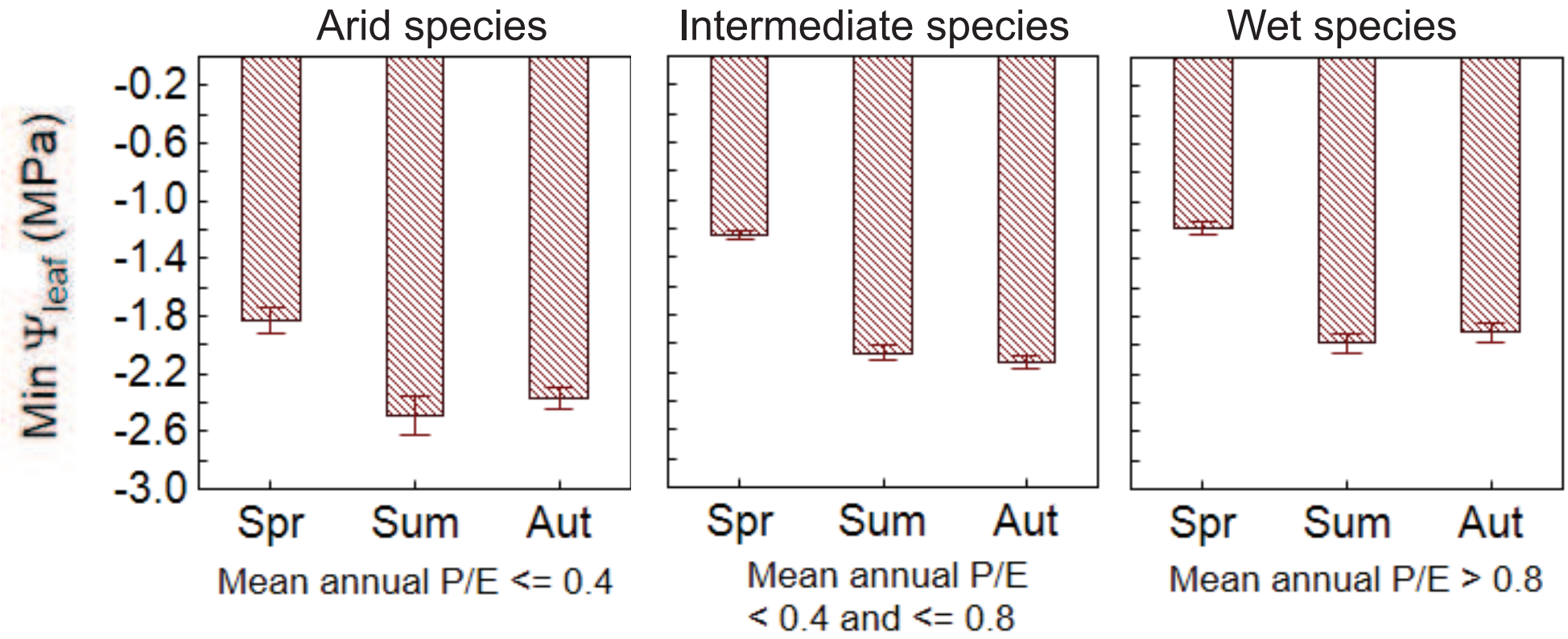
Semi arid

Ironbark woodlands

Dry sclerophyll

Temp rainforest

Are wet eucalypts isohydric and arid ones anisohydric?



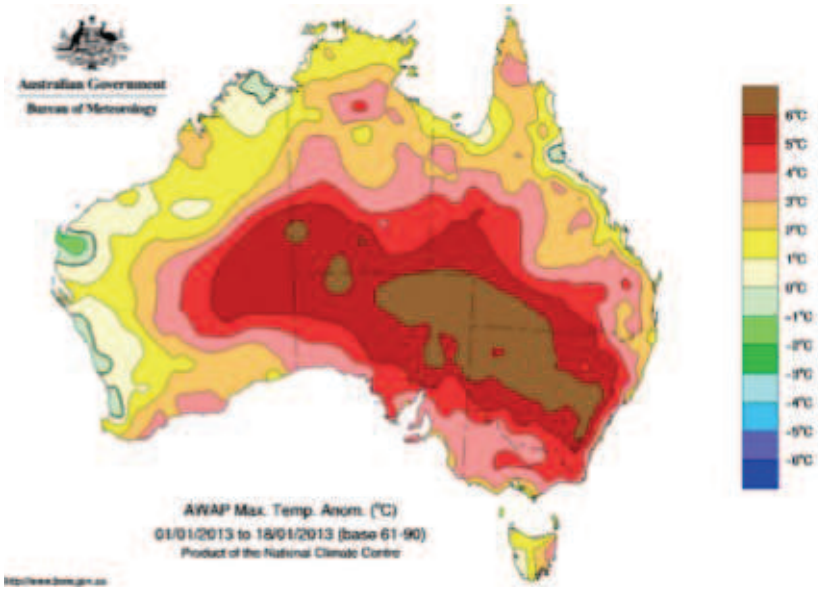
Midday water potential (Ψ_{leaf}) was more negative in summer & autumn than in spring

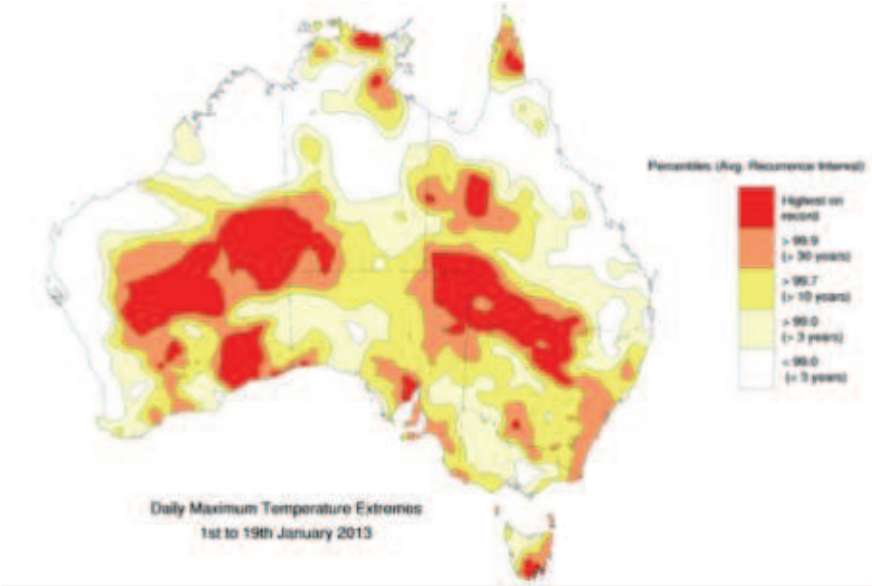
Species from drier and wetter climates showed similar change from wet to dry seasons

→ all species are anisohydric

heatwaves...

Heat wave summer 2013





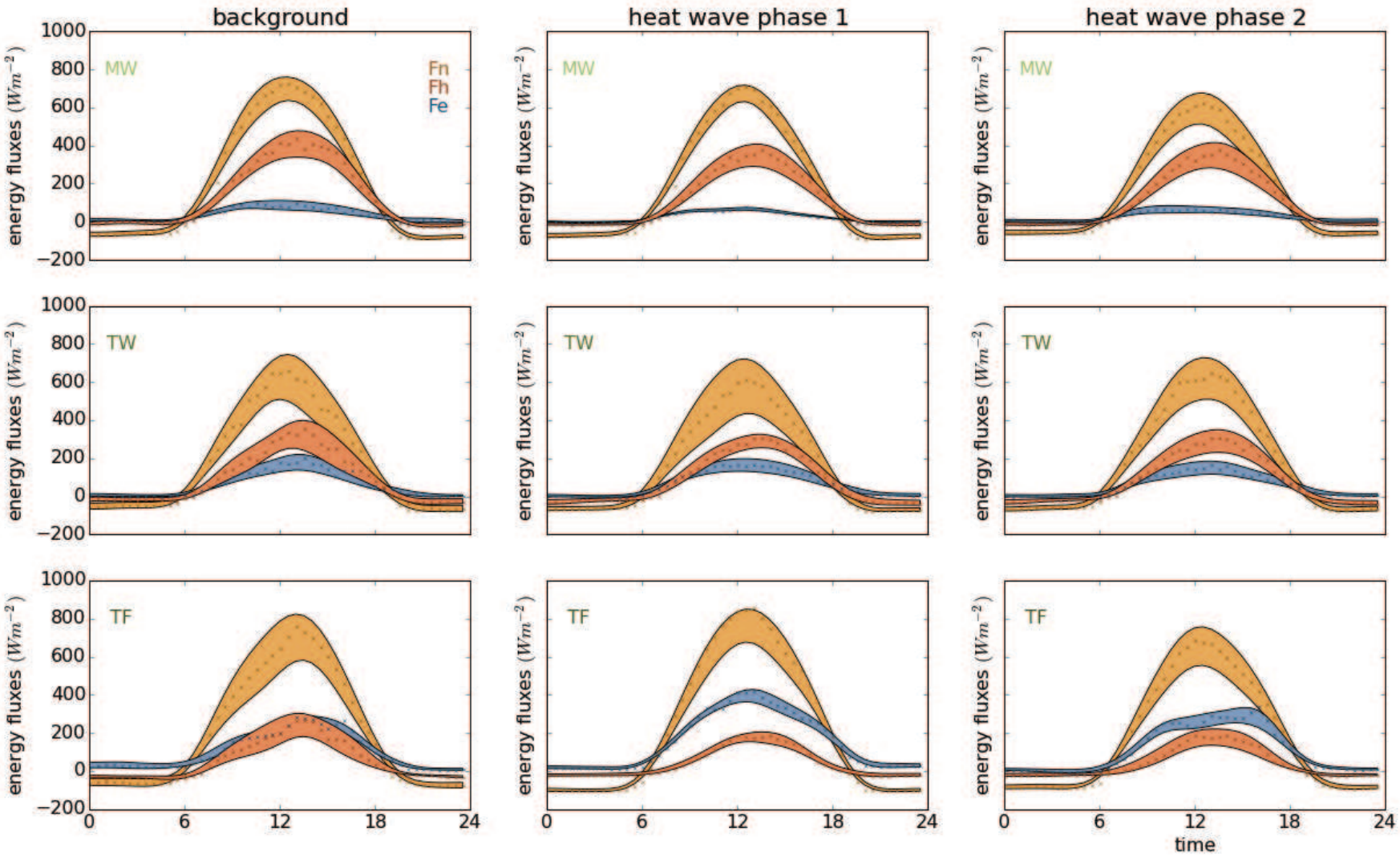
Sites used in Southern Australia - ES

MW - Mediterranean Woodlands
Gingin
Great Western Woodlands
Calperum

TW - Temperate Woodlands
Wombat
Whroo
Cumberland Plains

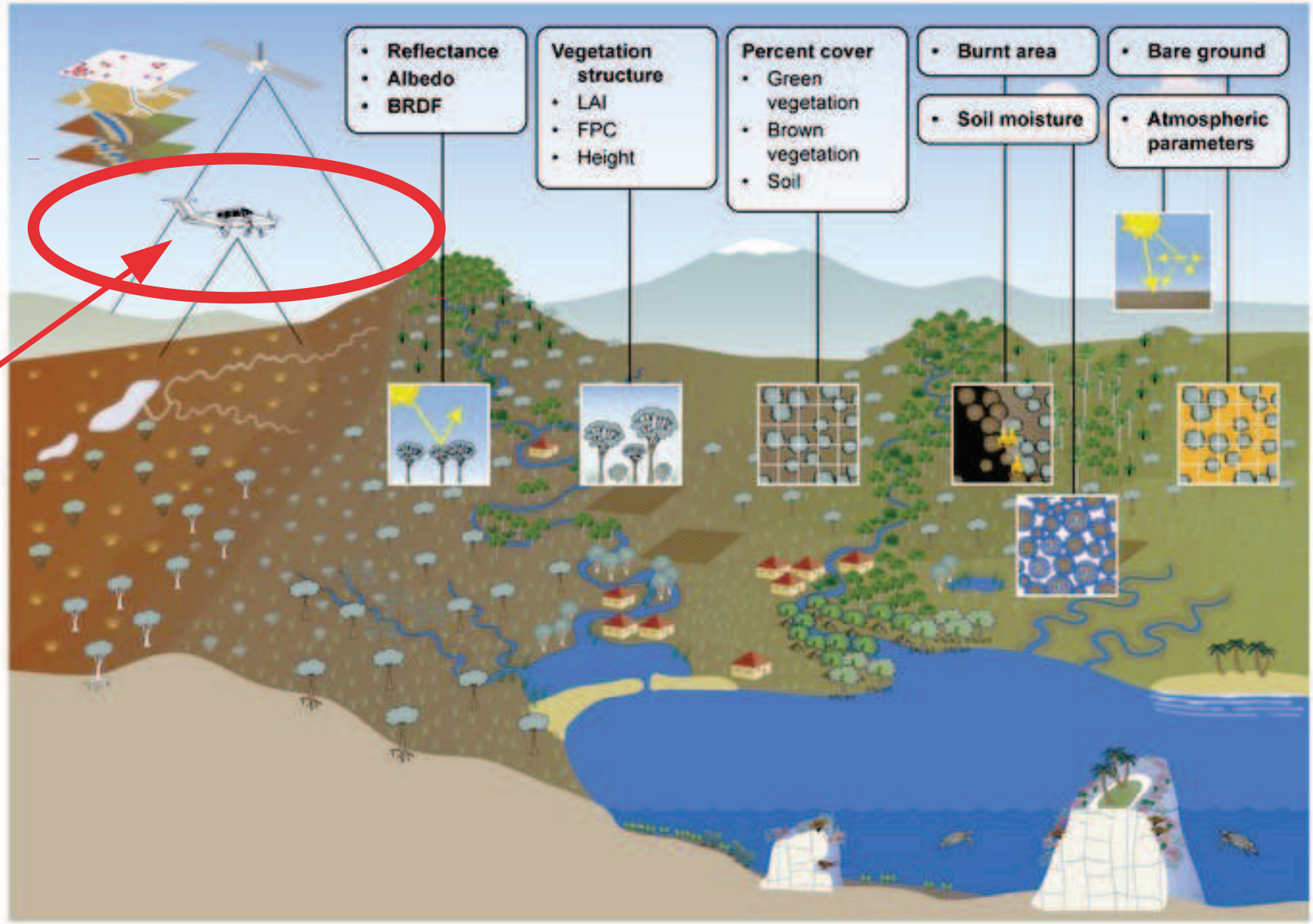
TF - Temperate Forests
Tumbarumba

Energy Fluxes



spatial detail...

Remote Sensing



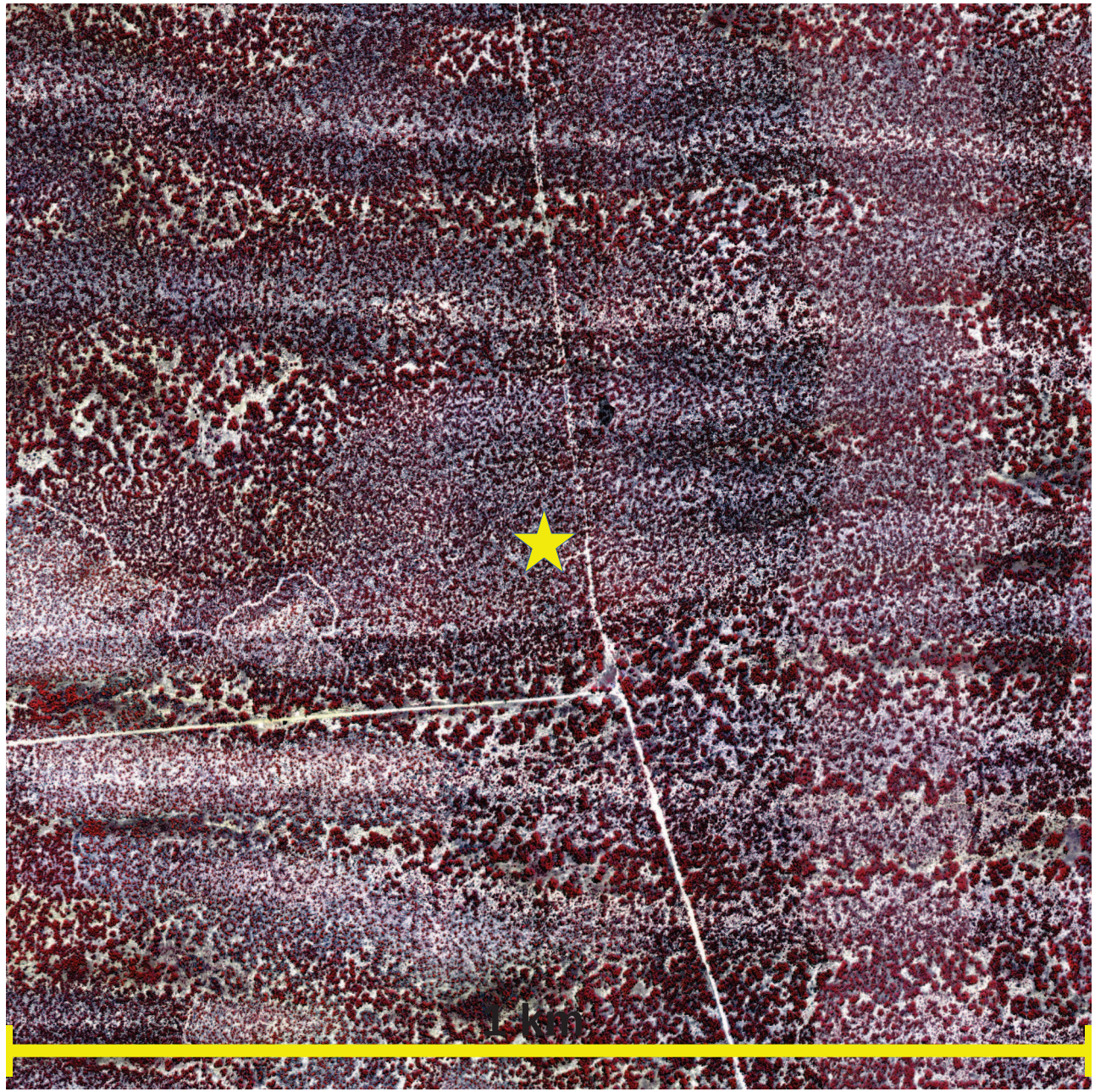
TERN-AusCover (http://www.auscover.org.au/about)


Airborne Research Australia
FLINDERS UNIVERSITY
STRICTED
Riegl Q560

Chowilla

Chowilla

Eagle - CIR

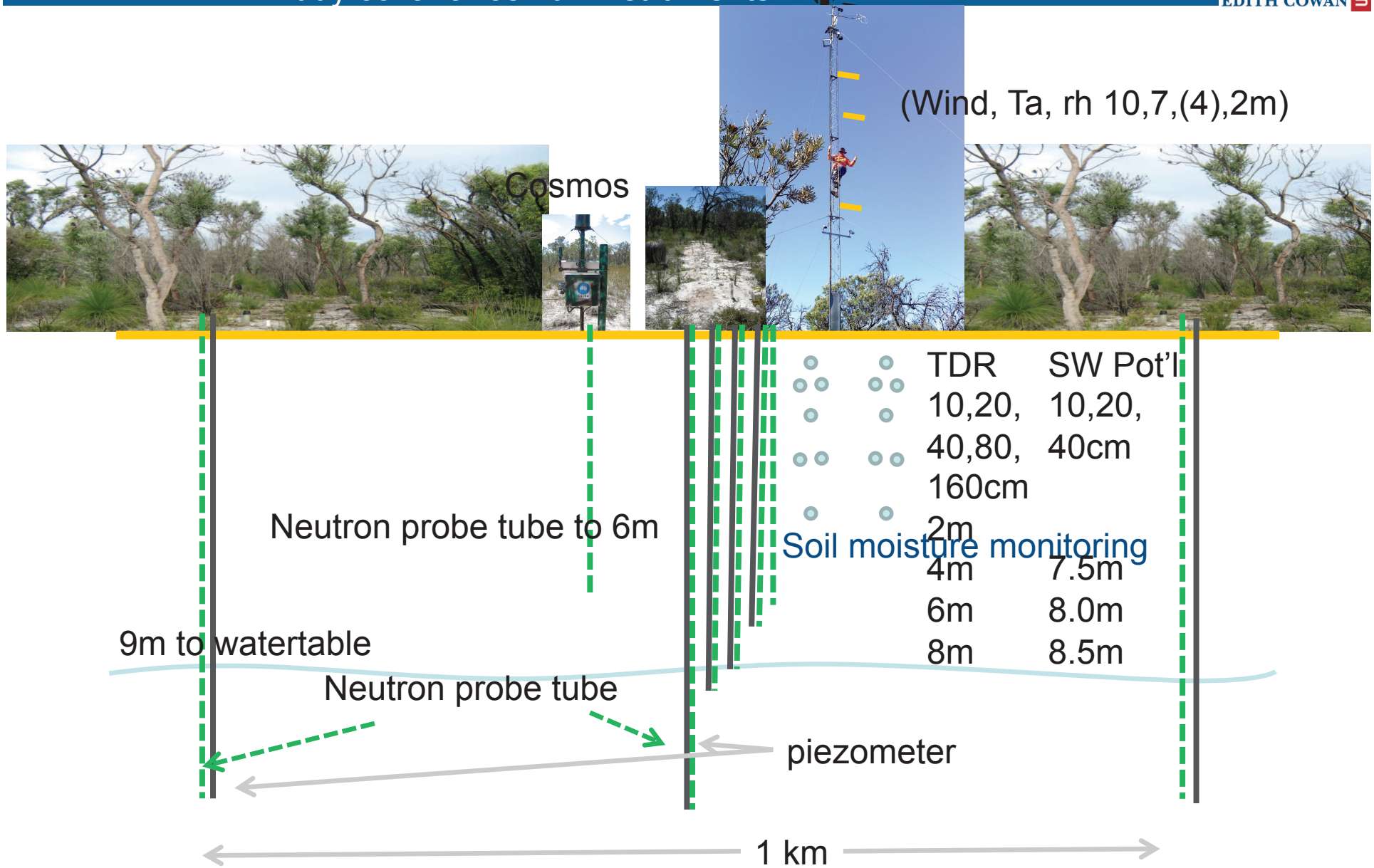


Instruments include

Cosmos - cosmic ray moisture monitoring

and nested piezometers

Eddy covariance flux instruments



Conclusions

- Australia and New Zealand characterised by:
  - mild winters
  - close coupling amongst water, carbon and energy cycles
  - large fluctuations in hydroclimate and productivity
- Opportunities and constraints for vegetation
- OzFlux provides key surface observations and ground truth for regional to global predictions
- Please visit http://ozflux.org.au for original presentations and information on crowd funding

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