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Two decades of OzFlux

Measuring Australia's breathing biosphere

Prof Jason Beringer (The University of Western Australia), Dr Helen Cleugh, Dr James Cleverly, Dr Peter Issac, Prof David Campbell, Prof Elise Pendall and Ozfluxers

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Context

Terrestrial ecosystems play a key role in:

- Ecosystem services: carbon sequestration, water availability, biodiversity etc
- Land surface properties: regional weather and climate
- Carbon-climate feedbacks: future climate trends and variability

What are the combined effects of land use change, disturbance and climate?

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OzFlux - A continental-scale “observatory” to monitor and assess trends, and improve predictions, of Australia’s terrestrial biosphere and climate

- Continuous measurements of greenhouse gas sources and sinks, and water use, in terrestrial ecosystems
- Quantify the effects of land management, disturbance, plant function, and climate variability (incl. extremes) on ecosystem productivity and water use
- In situ data for calibrating and validating remotely-sensed satellite observations
- Test and improve terrestrial ecosystem/land surface models

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1. A short history of OzFlux

Australian flux research and monitoring in mid 1990s (OASIS: 1994 and 1995).

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1. A short history of OzFlux

Charles Darwin, UTS, then Monash Universities and ARC funds: Howard Springs (1997) adhoc funding

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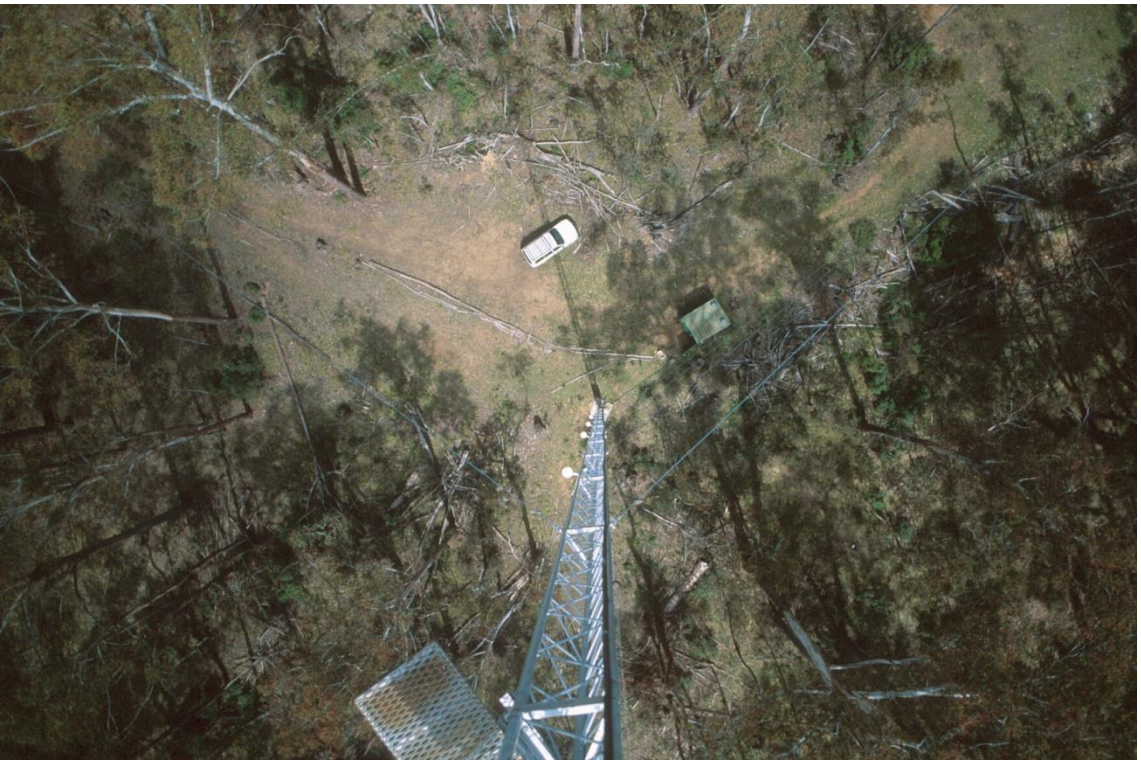
1. A short history of OzFlux



CSIRO: Tumbarumba site in 2000

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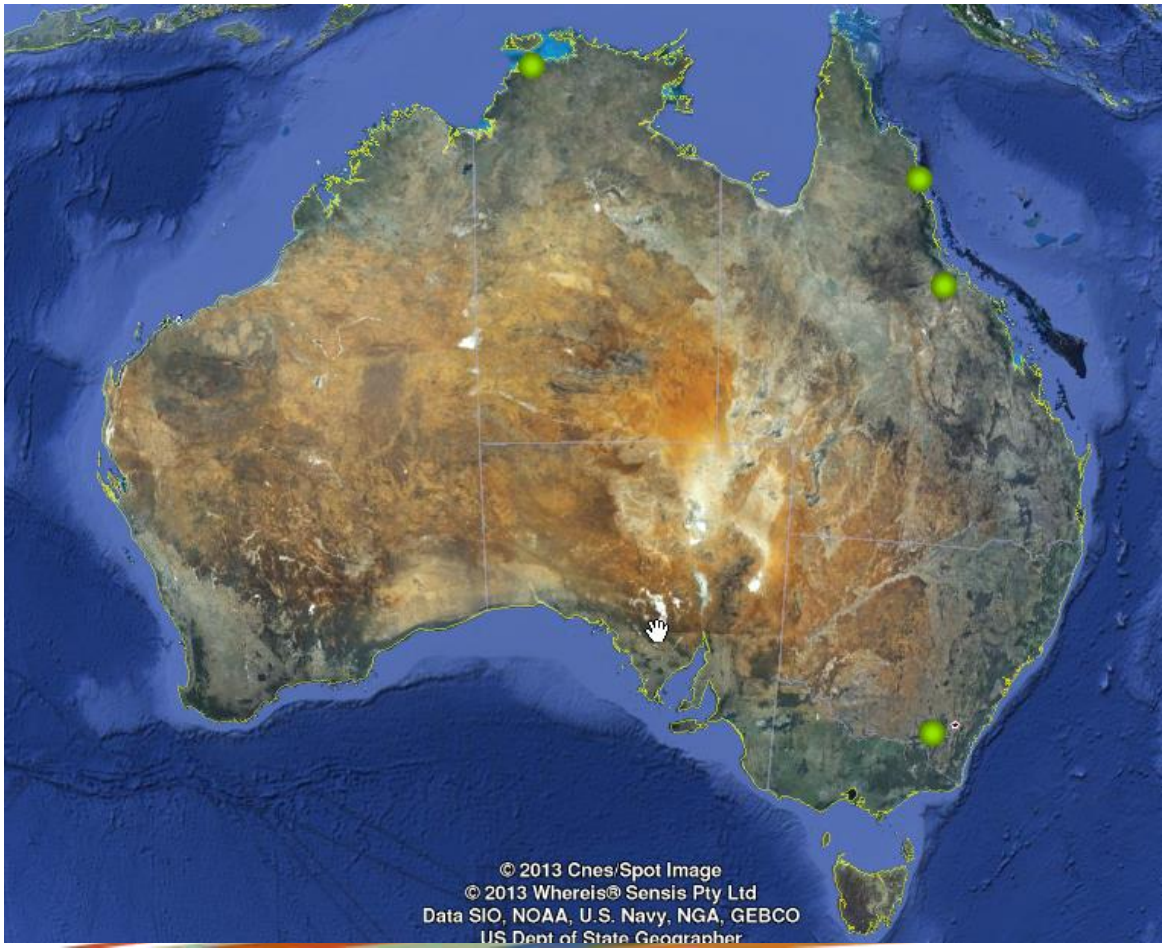
1. A short history of OzFlux

By 2001, OzFlux was a vision shared across CSIRO, Monash, UTS, ANU, and Charles Darwin Universities....
but really a network in search of some flux towers

just 4 flux towers and 3 agencies in 2003 ...

Lobbied for capability



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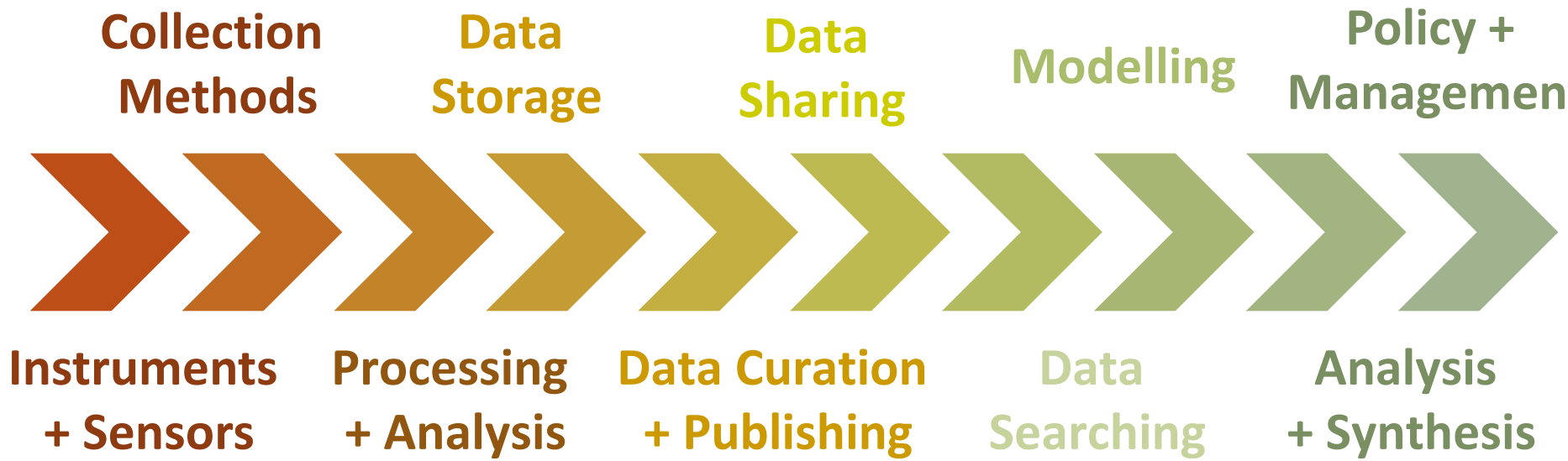
TERN Terrestrial Ecosystem Research Network

Infrastructure for a sustainable network of **people** and **data collection**, **data discovery** and **data sharing** systems to advance ecosystem science and management in Australia



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2. Achievements

NCRIS investment in 2009 established OzFlux as a national facility or observatory as part or TERN:

- A continental network: hardware and software
- Common set of core measurements and methods
- "Hub and Spoke model": Central node plus sites
- OzFlux community: Workshops & training
- Data Management System: QC/QA and curation
- OzFlux Data Portal: data discovery and distribution

All play a key role in realising the value of OzFlux

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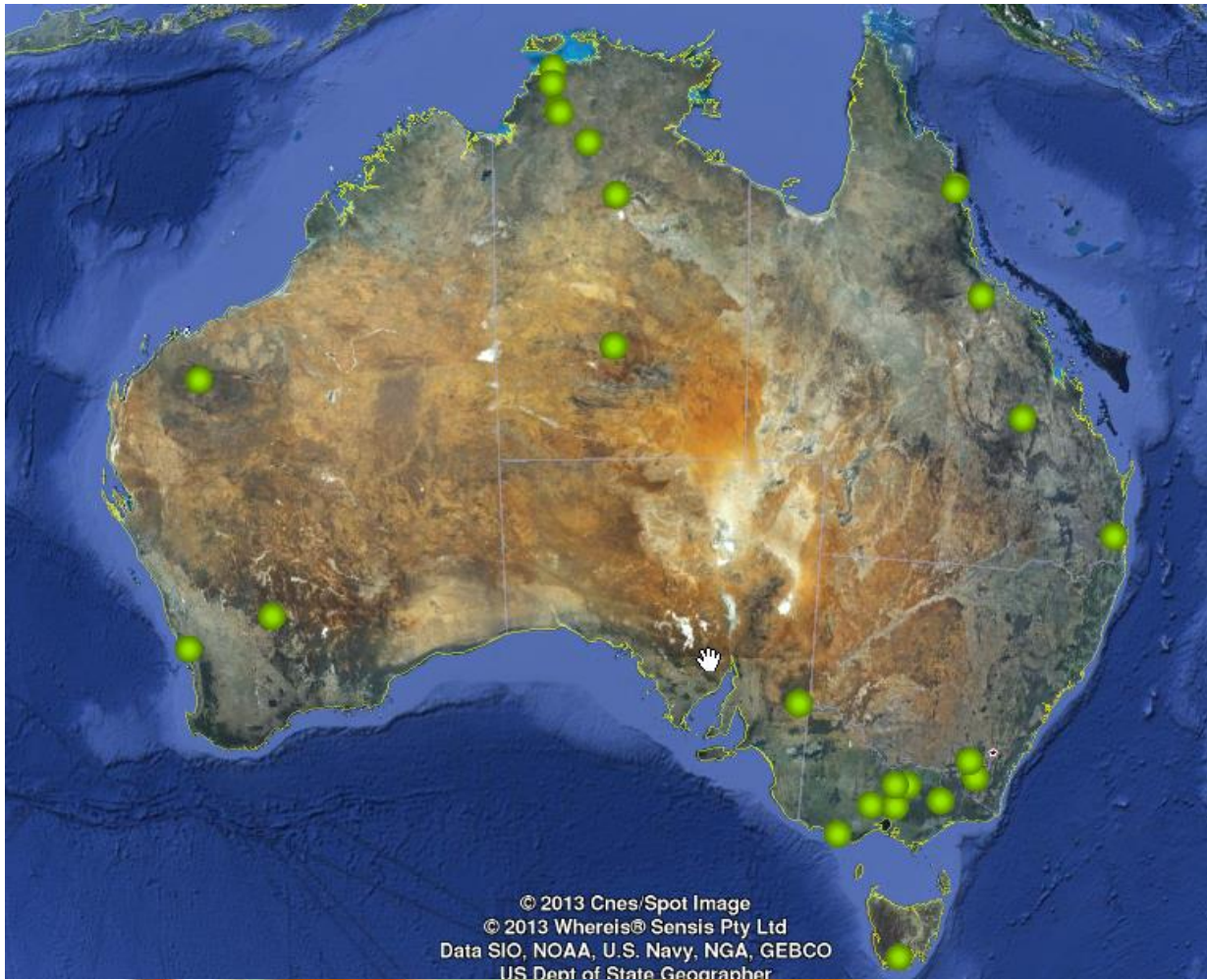
2. Achievements

A network of **flux towers**

...now 23 long term active flux towers across Australia (+4 in NZ) in 2017

Operated by 10 agencies (+2 in NZ)



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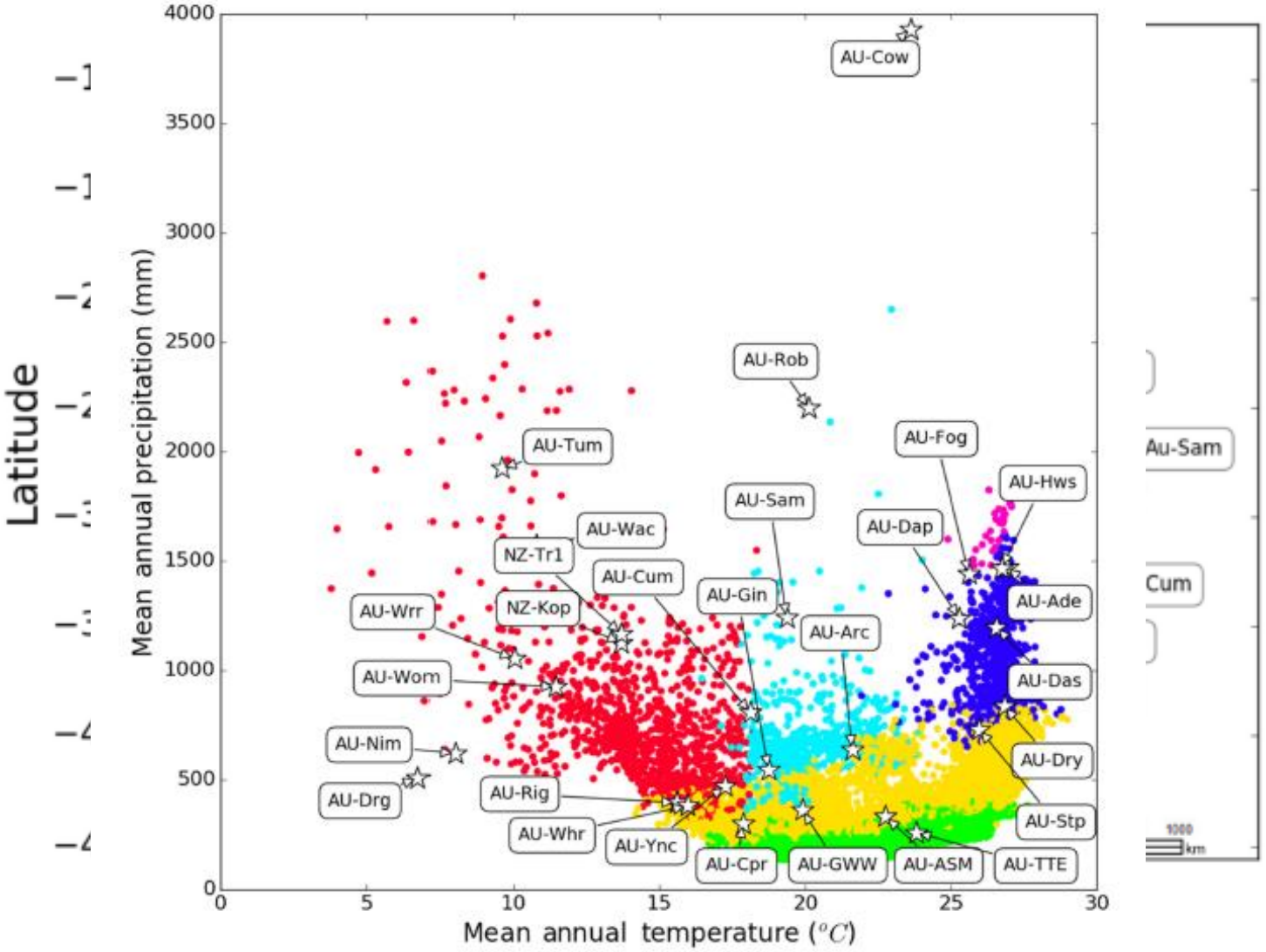
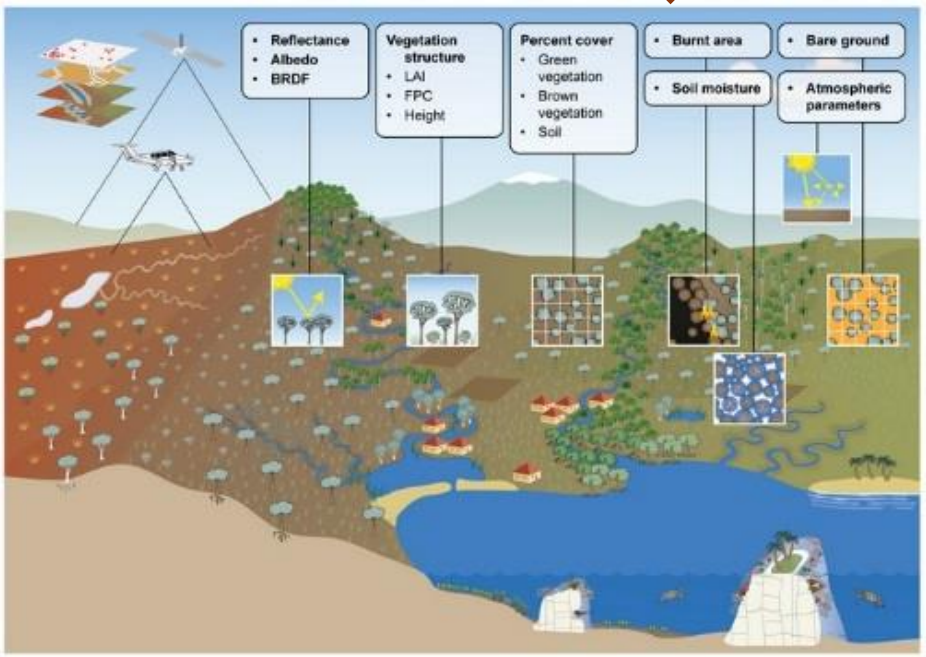


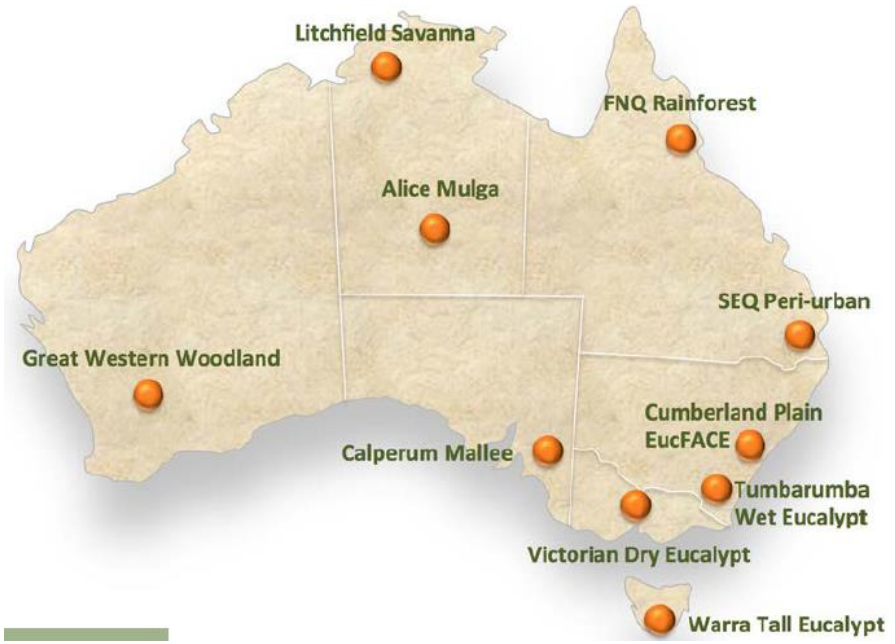
Biomes not equally represented by OzFlux – only 8% of sites are located in arid/semi-arid biomes

Beringer et al. (2016)

2. Achievements

A network of flux towers **plus Australian SuperSite Network and AusCover**





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2. Achievements

A network of flux towers **and people!**

- Annual Workshops
- Training Days
- More than just TERN

OzFlux Workshop Site Visit 2009:
Howard Springs Flux Tower Site

3. Future Improvements and Challenges OzFlux

Measurements and data – continuous improvements

- Techniques that enhance data quality; national and global consistency; and efficiency
- Data discovery, access and utility

Site and network improvements – enhancing the observatory

- Greater representation across ecosystems, e.g. agricultural and urban systems
- Building a more comprehensive suite of observations (incl. atmospheric composition?)

Continuing to integrate flux, ecological and satellite observations

Sustaining observations and continuity

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3. Future direction for OzFlux

Increased resolution and integration needed for knowledge and information that is relevant and useful for decision-making

- Across domains, space and time
- Data and information products that can be used by others

Integrated observing system for understanding, monitoring and assessing trends in Australia's terrestrial biosphere and climate

- Assimilating multiple data streams - Data fusion
- Utilising new sensor technologies; e-research infrastructure

Building an environmental modelling capability: current and future assessments and predictions

- Process representation (Australian ecosystems)
- Quantify the way that climate, land-use management and change, disturbance and CO_2 affect ecosystem function and services


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4. Scientific achievements

Australian ecosystem responses to land management and disturbance; climate change and variability including extremes

Testing and parameterising models (e.g. CABLE), the land surface model in Australia's weather and climate model [ACCESS]

First observationally-constrained terrestrial carbon budget

Methods to scale-up using satellite and near-field remote sensing

Biogeosciences, 13, 5895–5916, 2016
www.biogeosciences.net/13/5895/2016/
doi:10.5194/bg-13-5895-2016

Biogeosciences Open Access EGU

An introduction to the Australian and New Zealand flux tower network – OzFlux

Jason Beringer[1], Lindsay B. Hutley[2], Ian McHugh[3], Stefan K. Arndt[4], David Campbell[5], Helen A. Cleugh[6], James Cleverly[7], Víctor Resco de Dios[8], Derek Eamus[7], Bradley Evans[9,10], Cacilia Ewenz[11], Peter Grace[12], Anne Griebel[4], Vanessa Haverd[6], Nina Hinko-Najera[4], Alfredo Huete[13], Peter Isaac[6], Kasturi Kanniah[14,25], Ray Leuning[6,†], Michael J. Liddell[15], Craig Macfarlane[16], Wayne Meyer[17], Caitlin Moore[3], Elise Pendall[18], Alison Phillips[19], Rebecca L. Phillips[20], Suzanne M. Prober[16], Natalia Restrepo-Coupe[13], Susanna Rutledge[6], Ivan Schroder[21], Richard Silberstein[22], Patricia Southall[22], Mei Sun Yee[23], Nigel J. Tapper[3], Eva van Gorsel[6], Camilla Vote[24], Jeff Walker[23], and Tim Wardlaw[19]

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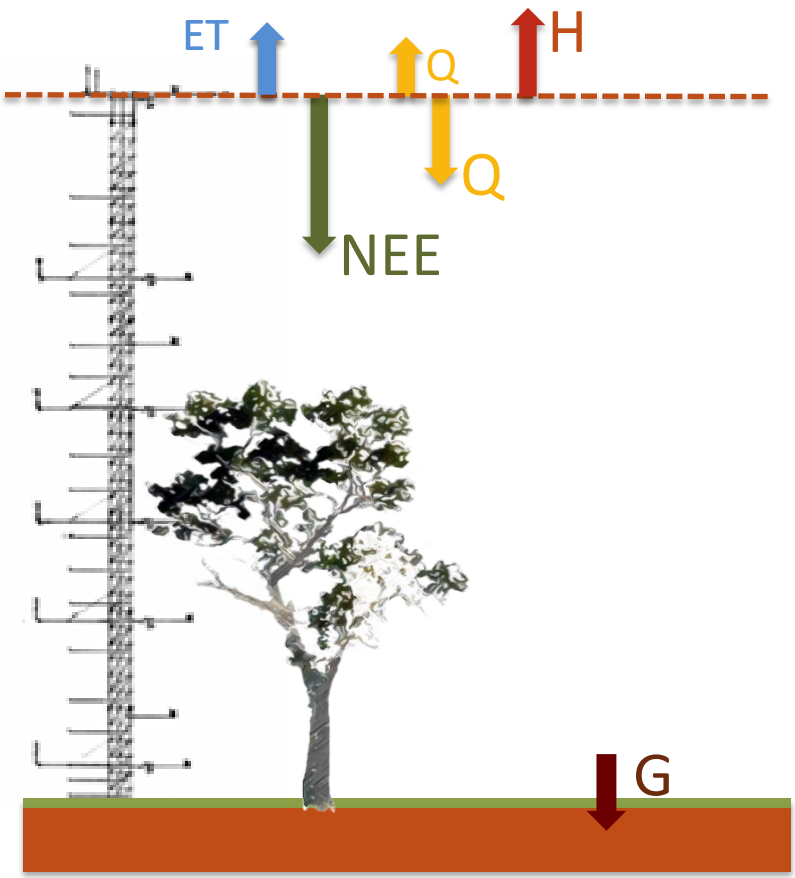
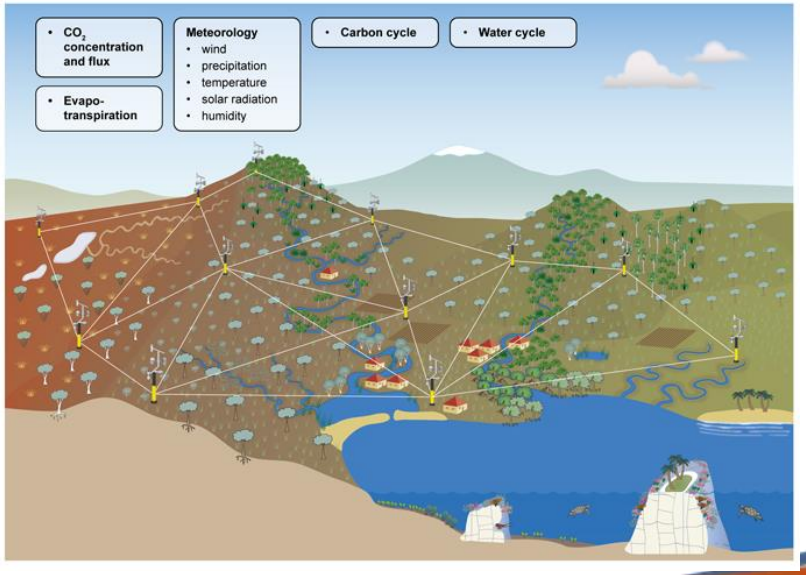
OzFlux: A Land-Atmosphere Observatory



A network of instrumented flux towers measuring:

- Unique Australasian ecosystems
- Continuous: hourly to multi-annual but young network



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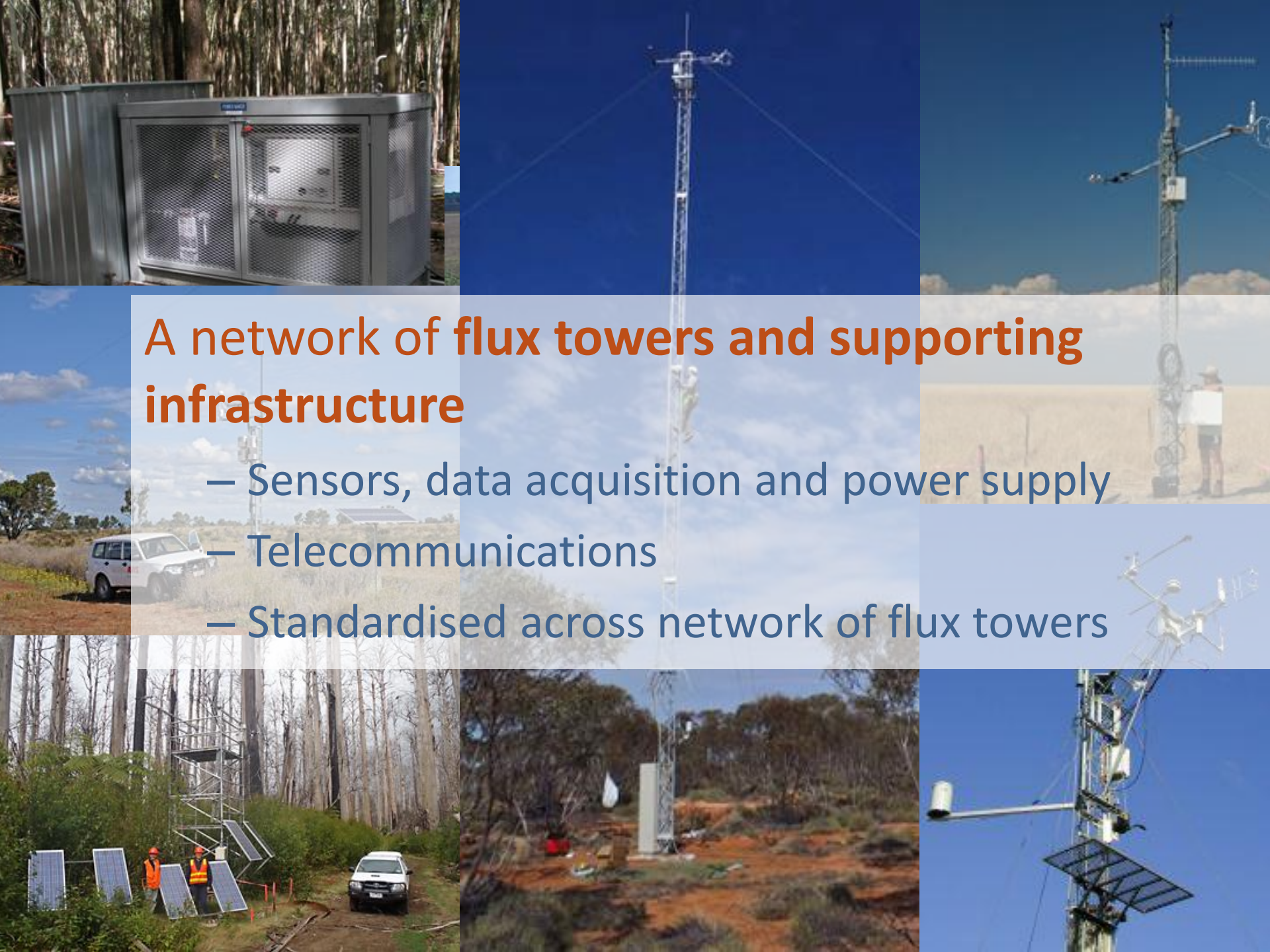

A network of **flux towers and supporting infrastructure**

- Sensors, data acquisition and power supply
- Telecommunications
- Standardised across network of flux towers

Thank You and Questions

Thanks to:

- Eva van Gorsel
- Suzanne Prober, James Cleverly and Peter Isaac
- OzFlux Steering Committee
- OzFlux PIs and technical staff
- Vanessa Haverd

who have all contributed to this talk and OzFlux in so many ways

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Evaluating CABLE using OzFlux measurements (from Trudinger et al, 2016)

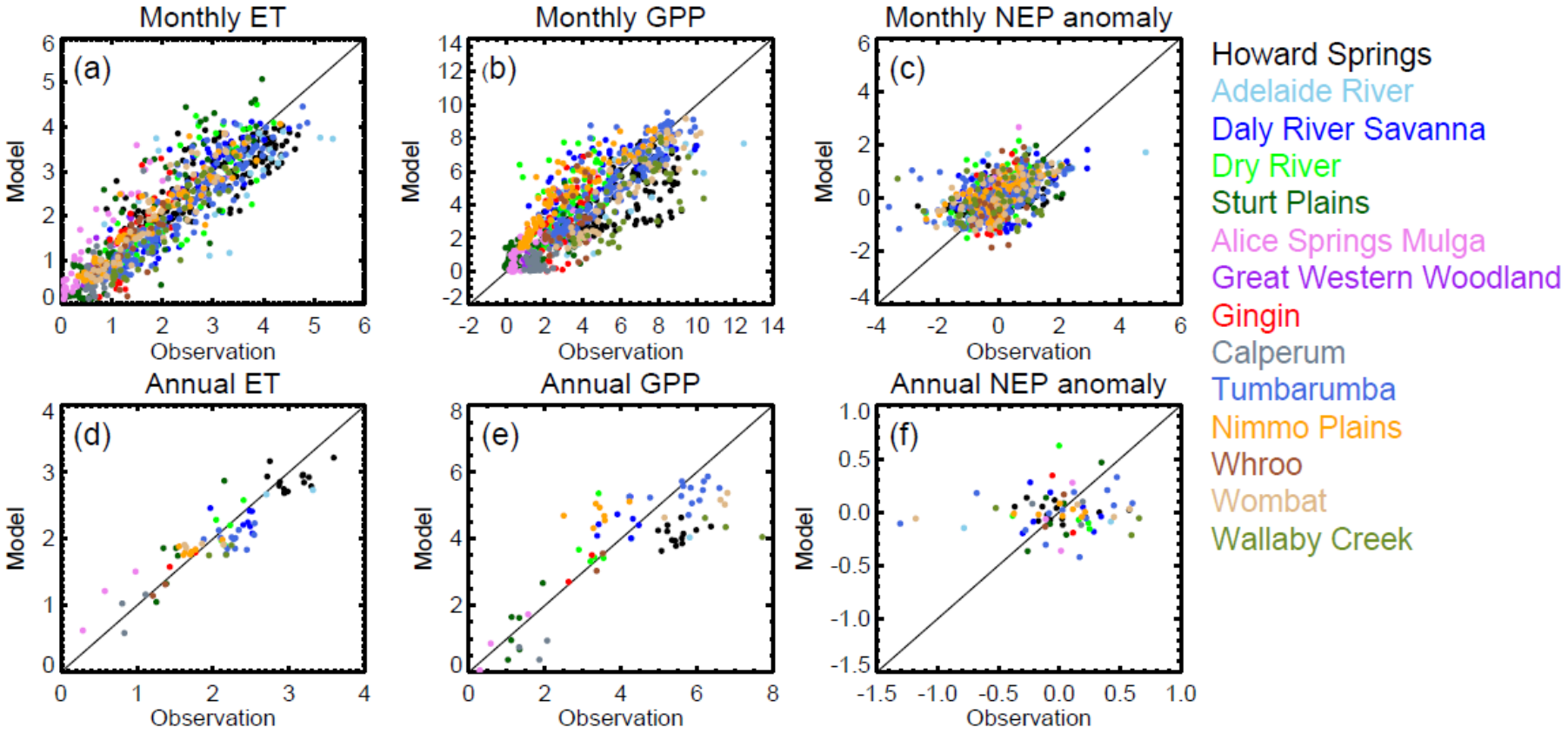


Figure 5. Scatter plots of modelled vs. observed (best case) monthly and annual ET (mm d^{-1}), GPP (gC m^{-2} d^{-1}) and NEP (gC m^{-2} d^{-1}) at 14 OzFlux sites. Symbols are colour-coded according to site.

CABLE-SLI improves land surface evaporation simulations across 18 FluxNet ecosystems – incl. Australia (from Haverd et al, 2016)

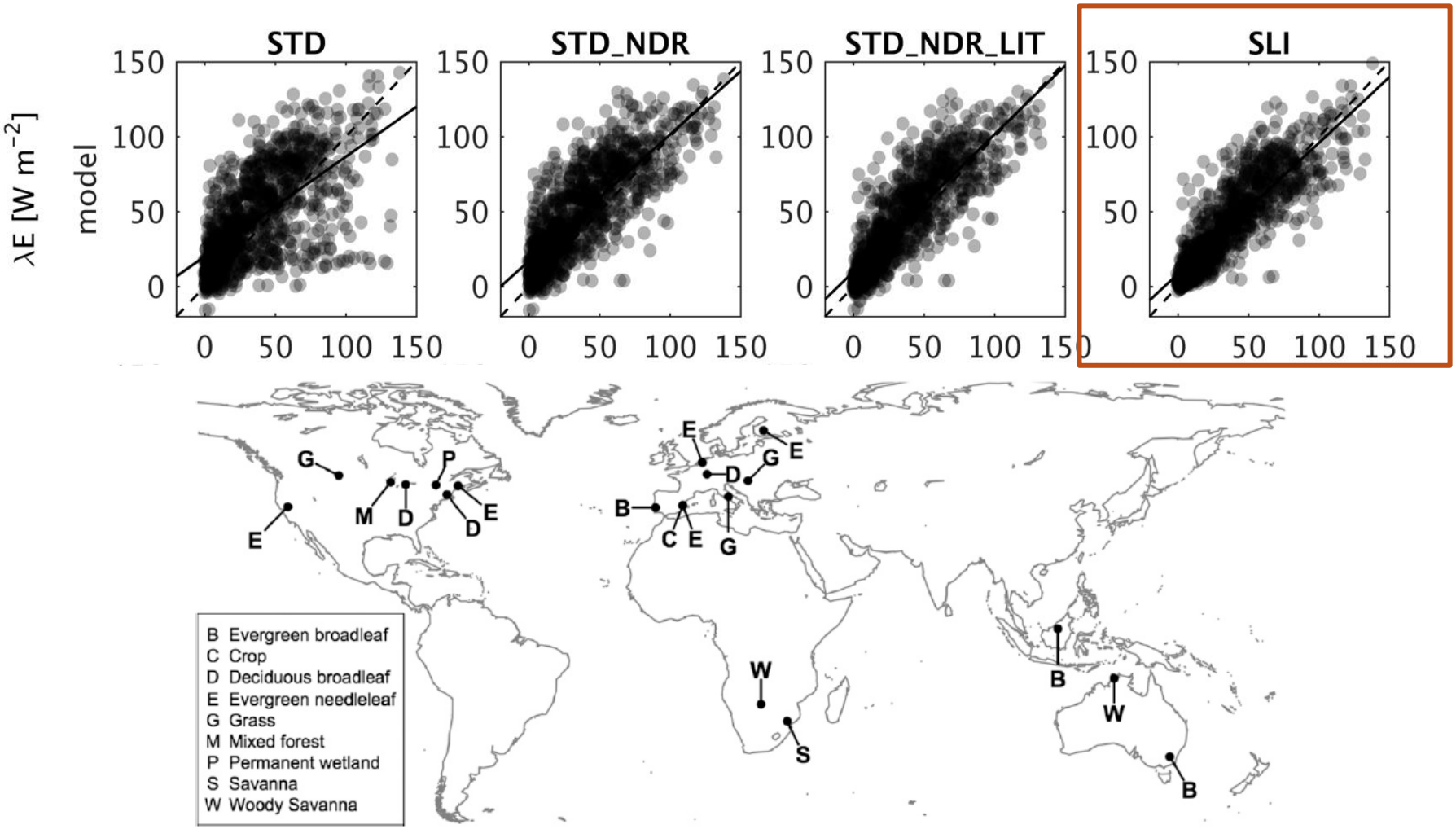
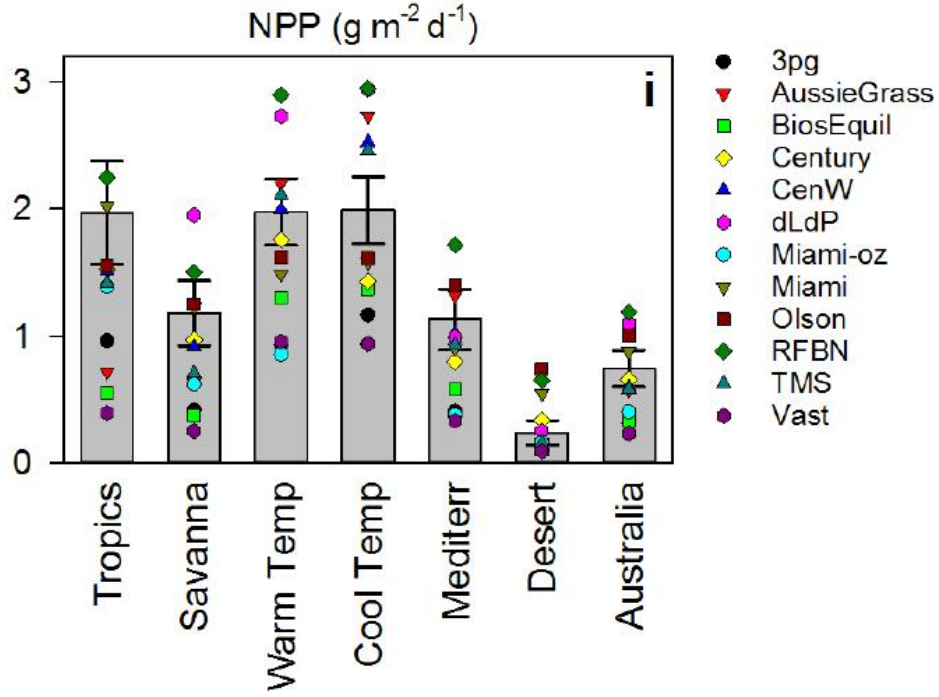
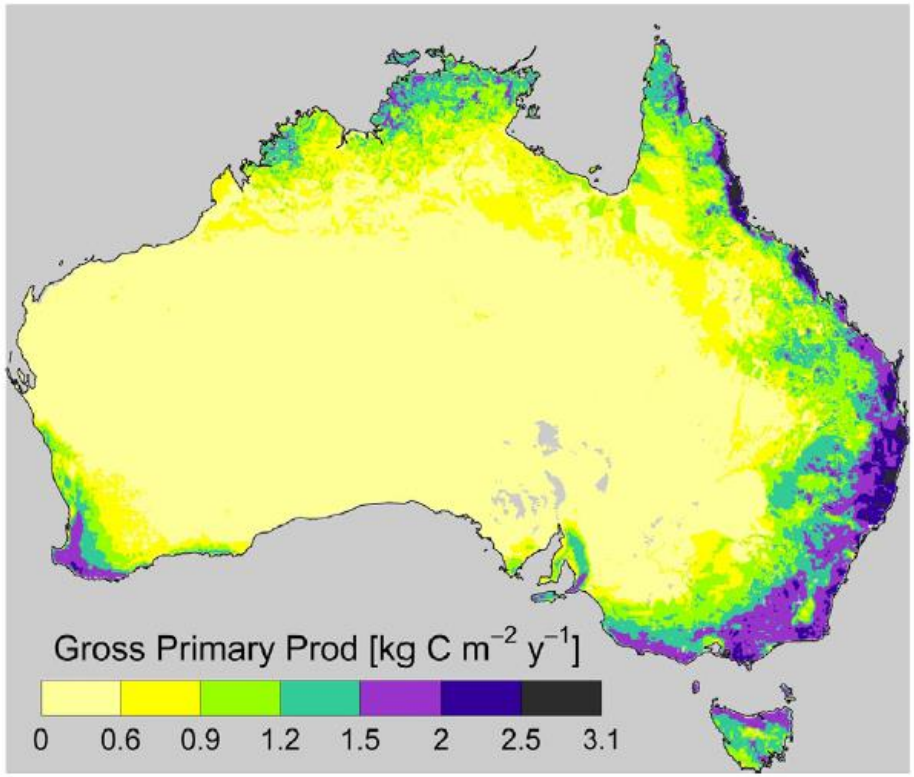


FIG. 2. Locations and biomes of the 20 flux tower sites.

Multiple observational data (incl. OzFlux) reduces uncertainty in Australian NPP and ET





From Haverd et al (2013) and Raupach et al (2013)

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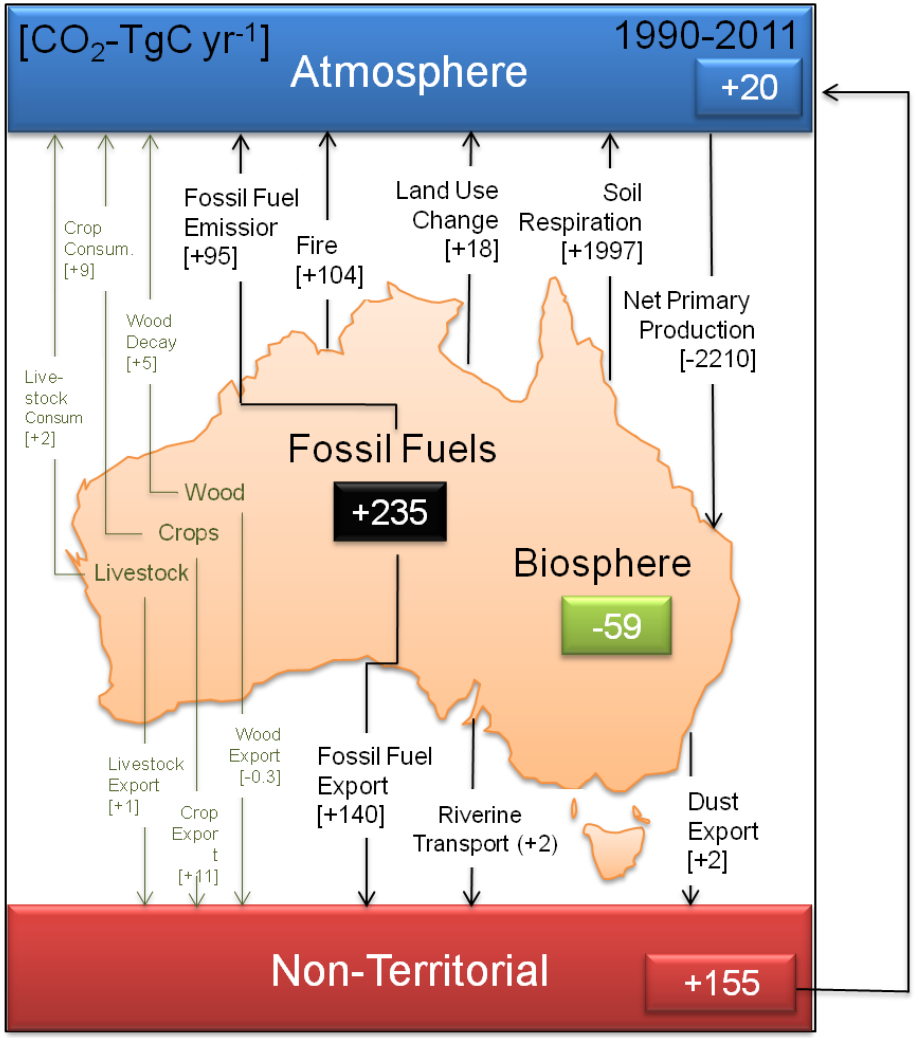
Australian terrestrial carbon budget – constrained by multiple observations



From Haverd et al (2013)

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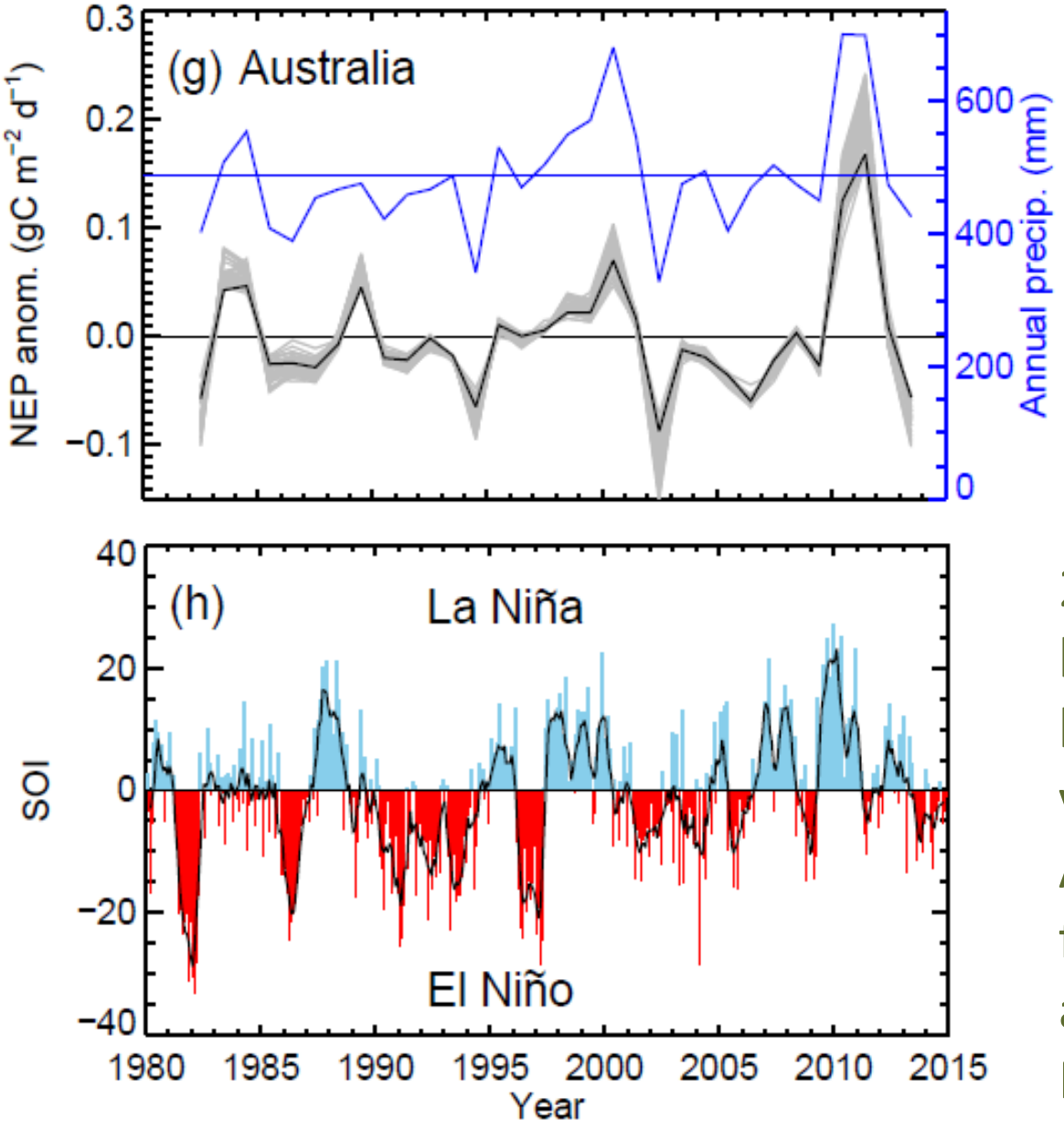

Large interannual variability in NEP - soil moisture a key driver

2011 anomaly in global land carbon sink driven by growth of semi-arid vegetation in SH.
A large contribution from Australia associated with La Niña event following a prolonged drought

from Trudinger et al, 2016

From Beringer et al (2016)

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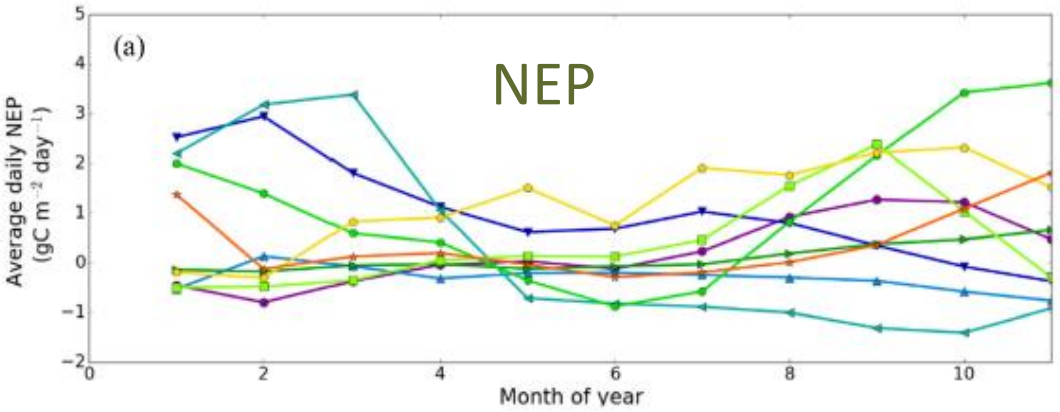
Table 2. Summary of the representation of Australian OzFlux tower sites within each ecoregion compared with the total percentage of the continent comprising this ecoregion (Department of Environment, 2012). The mean carbon fluxes are given for each ecoregion type.

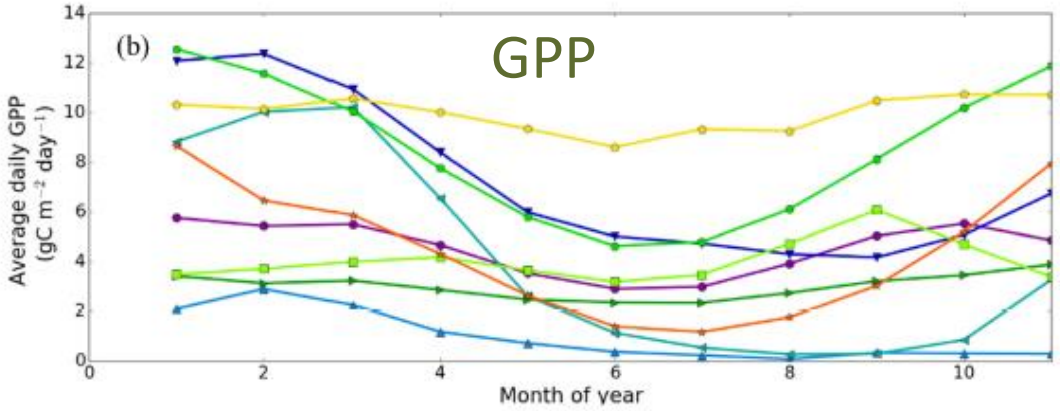
Ecoregion	Percentage of the continent comprising this ecoregion (%)	Percentage of flux towers in that ecoregion (%)	GPP (tC ha^{-1} yr^{-1})	NEP (tC ha^{-1} yr^{-1})	ER (tC ha^{-1} yr^{-1})
Tropical and subtropical moist broadleaf forests	< 1	12	22.1	2.8	19.3
Temperate broadleaf and mixed forest	7	16	21.5	3.9	17.6
Tropical and subtropical grasslands, savannas, and shrublands	30	28	14.1	1.7	12.4
Temperate grasslands, savannas, and shrublands	3	16	14.5	3.4	11.1
Montane grasslands and shrublands	< 1	8	10.6	1.2	9.4
Mediterranean forests, woodlands, and scrub	11	12	6.7	0.2	6.5
Deserts and xeric shrublands	49	8	1.8	−1.1	2.8

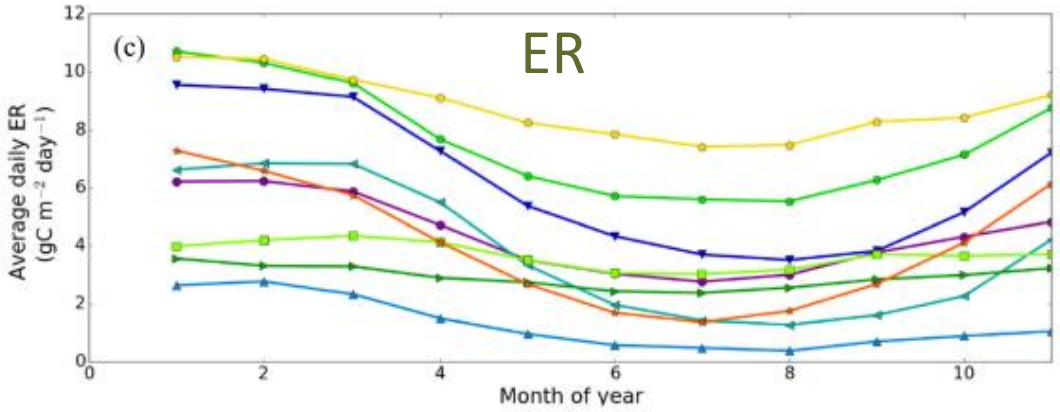
Australia's breathing biosphere

Weekly Ensemble by Biome:

- Temperate Woodlands
- Tropical Savannas
- Desert Shrublands
- Tropical Grasslands
- Mediterranean Woodlands
- Broadleaf Forests:
  - Temperate Broadleaf
  - Tropical Moist Broadleaf
- Pasture
- Montane Grasslands







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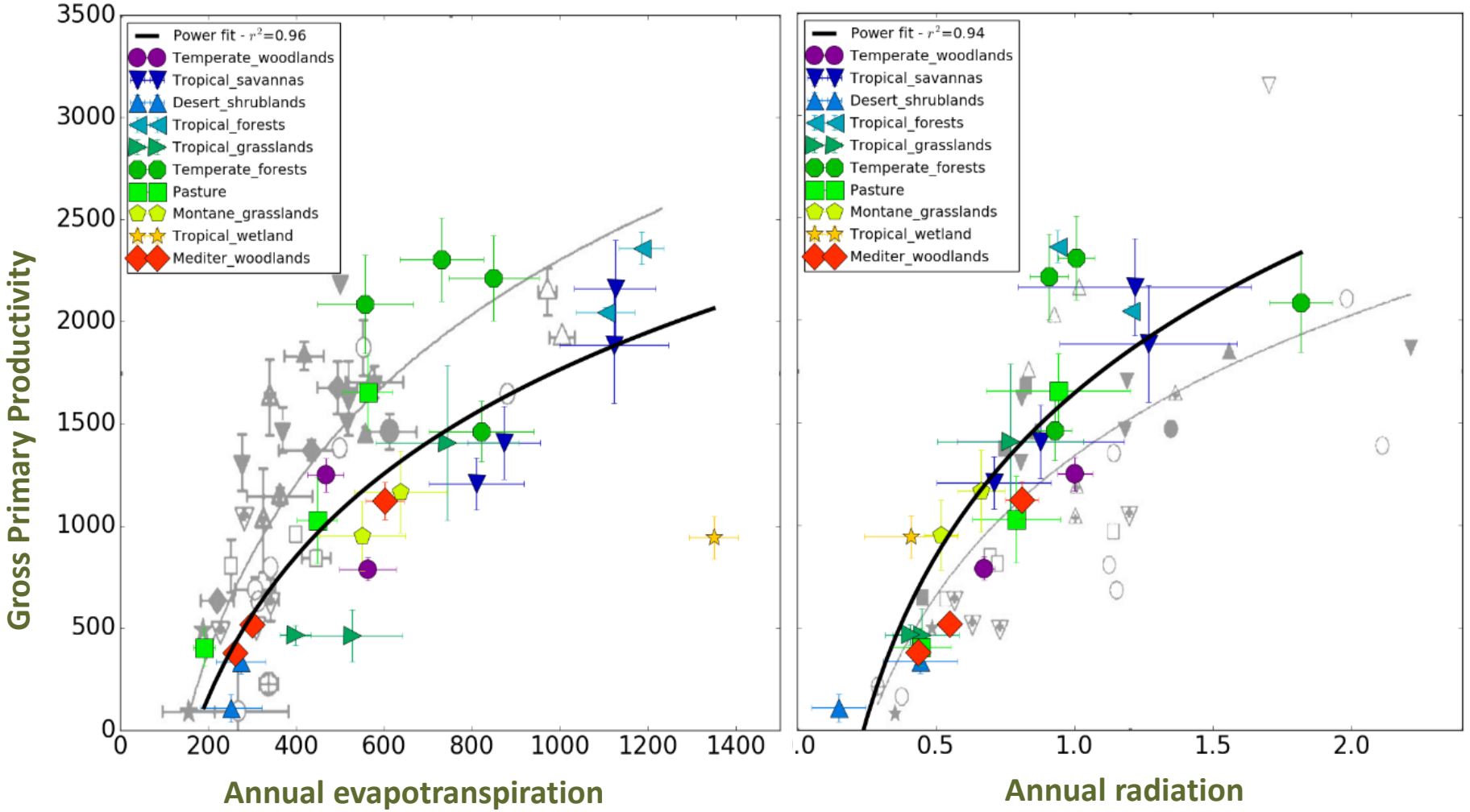
Australian ecosystems compared to global (from Beringer et al, 2016)

Water use efficiency

Light use efficiency



Outline

1. A short history of OzFlux
2. Achievements and Impacts
3. Future opportunities and challenges

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