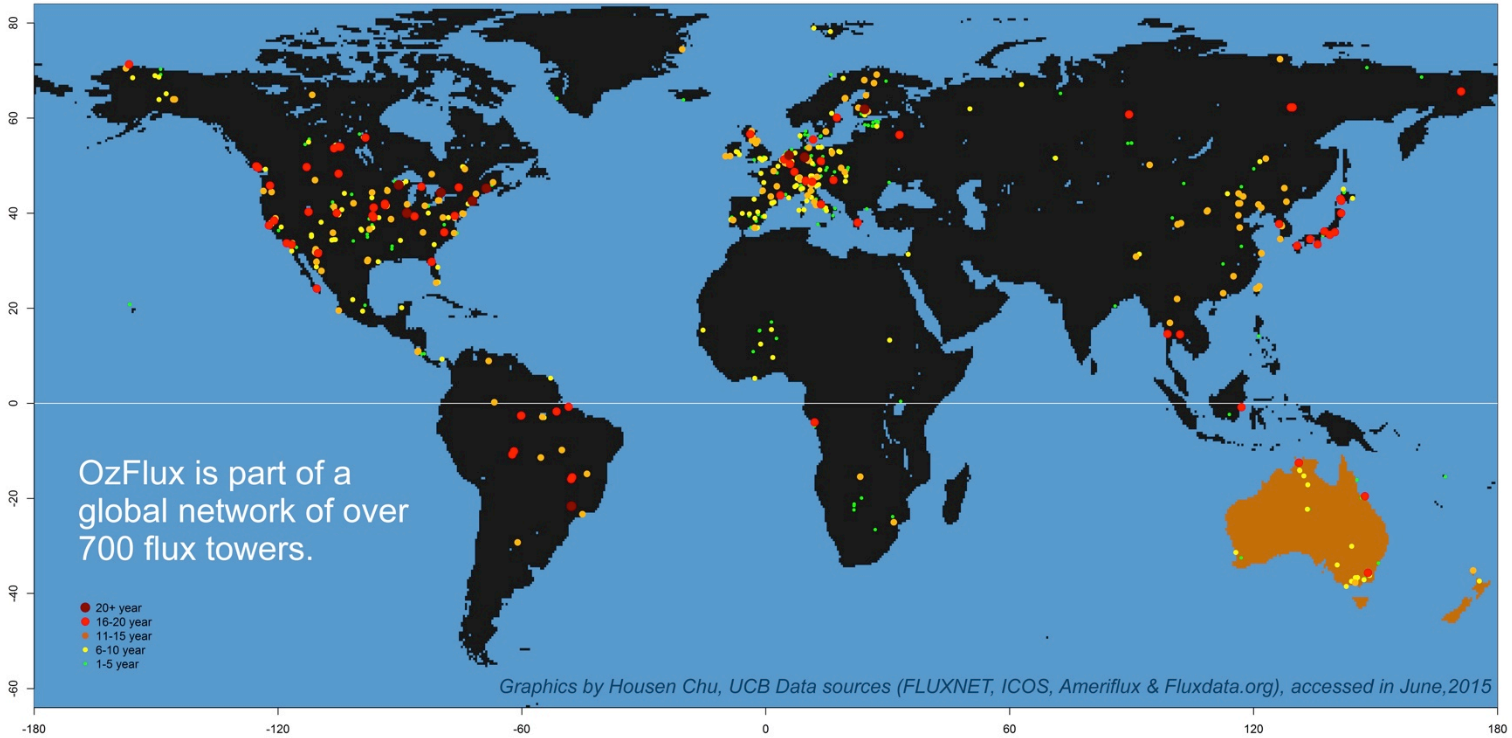
Research Highlights from OzFlux – the Australian and New Zealand Flux Research and Monitoring Network

OzFlux community through SI

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

OzFlux

measures how the land and the atmosphere interact so that we can better understand and manage the environment of which we are part



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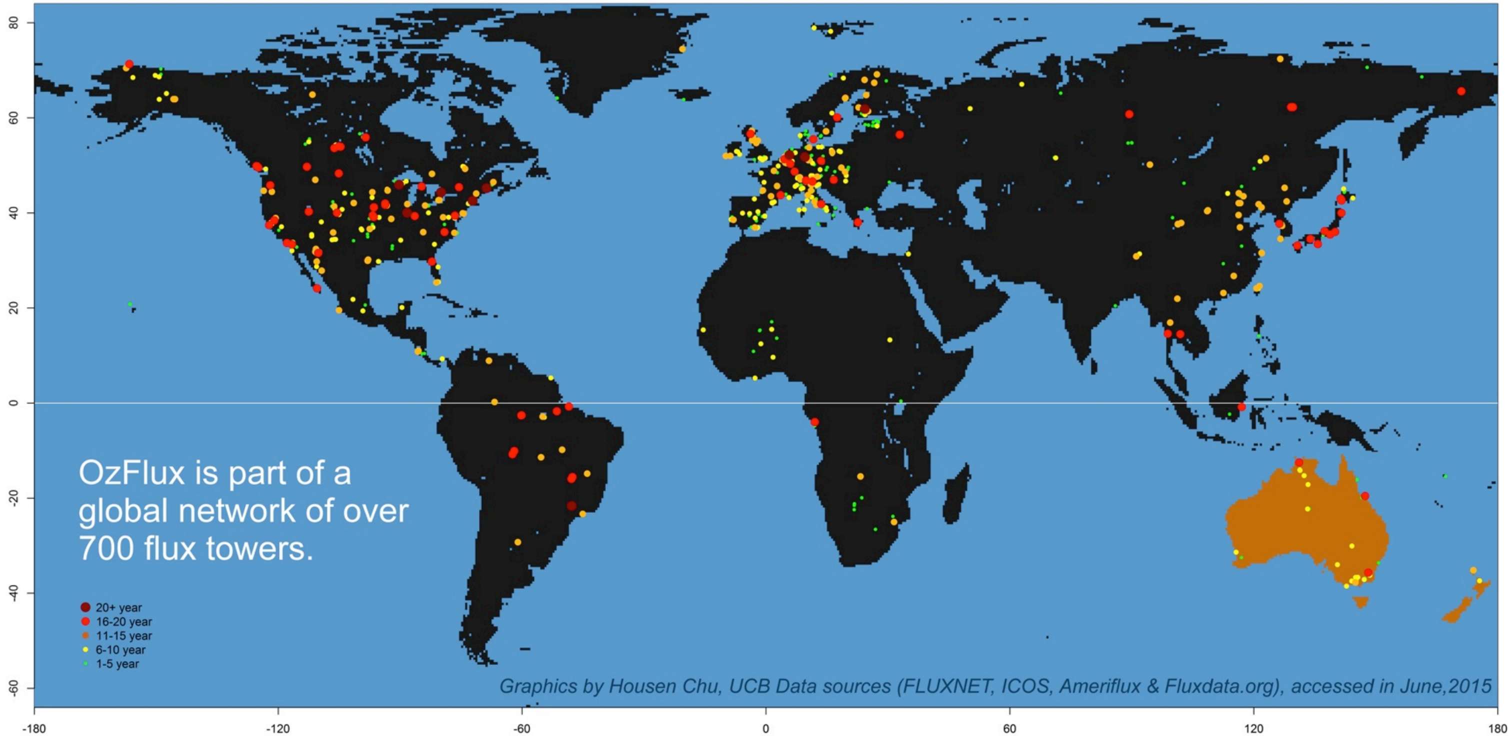
OzFlux

is a network of towers to provide the global earth system science and ecosystem modeling communities with consistent observations of energy water and carbon exchange between key Australian ecosystems and the atmosphere.



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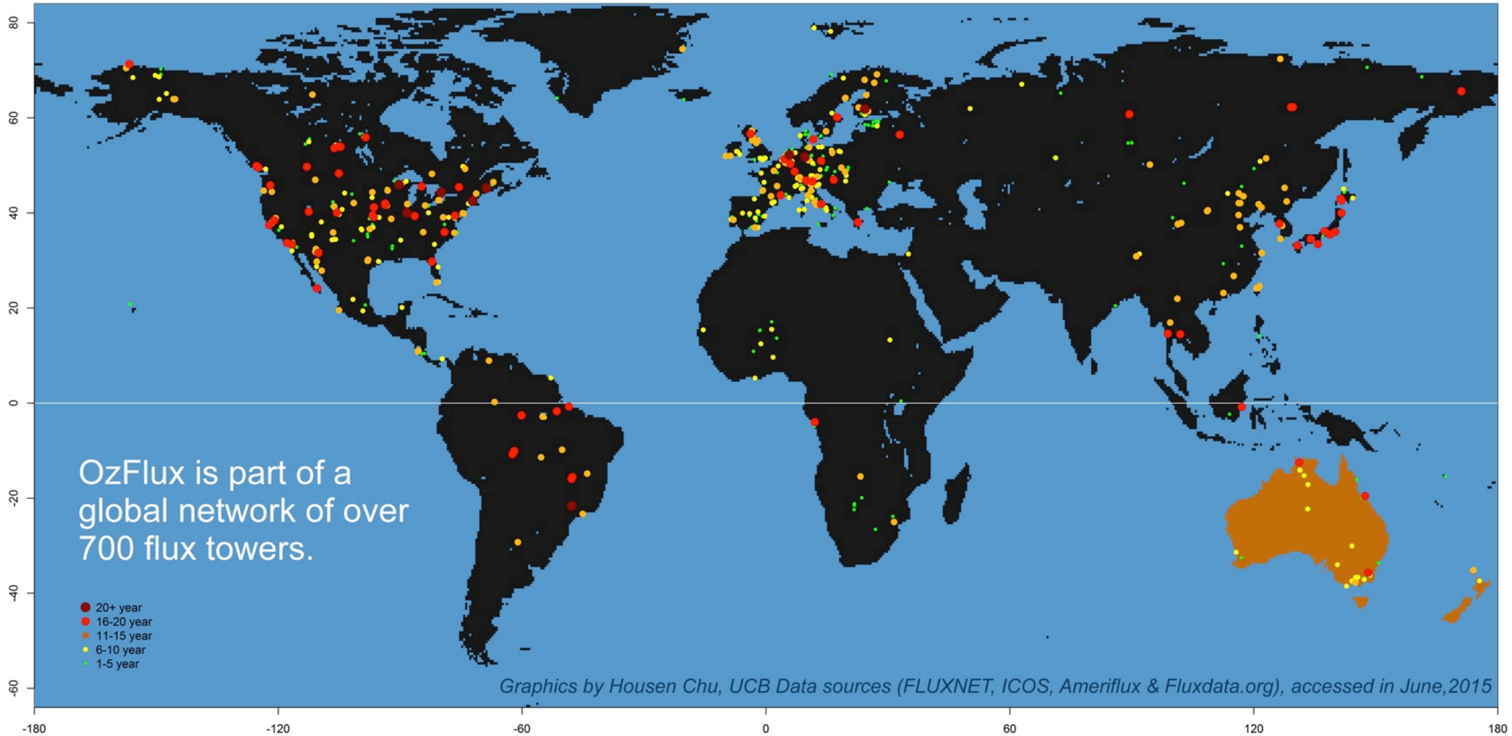
OzFlux SI

discuss the biogeochemical cycling of carbon, water and nutrients of Australian and NZ ecosystems. Using flux measurements, models and remote sensing to explore ecosystems within the context of climate fluctuations, meteorological drivers, phenology and management activities..



Questions OzFlux is helping to answer:

- *How much carbon is taken up by vegetation on the Australian continent? How much water is used? How, when and why does this vary? What is the impact on a continental to global scale?*
- *How stable are land-based carbon sinks and what are the implications for our future climate?*

Questions OzFlux is helping to answer:

- *How much carbon is taken up by vegetation on the Australian continent? How much water is used? How, when and why does this vary? What is the global impact?*
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This SI shows how OzFlux:

- *Delivers consistent and continuous data*
- *Is used to better understand underlying processes in the soil plant atmosphere continuum*
- *Is used to upscale fluxes from ecosystem to region, continent and globe*

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Delivers consistent and continuous data

1) Dynamic INtegrated Gap-filling and partitioning for OzFlux (DINGO)
   Jason Beringer
2) OzFlux Data: Network integration from collection to curation
   Peter Isaac

Delivers consistent and continuous data

DINGO and OzFluxQC a research grade and an operational data processing tool

L1 – ingests the flux tower data, writes data and metadata to a netCDF file.

L2 – applies a suite of quality control checks to the L1 data.

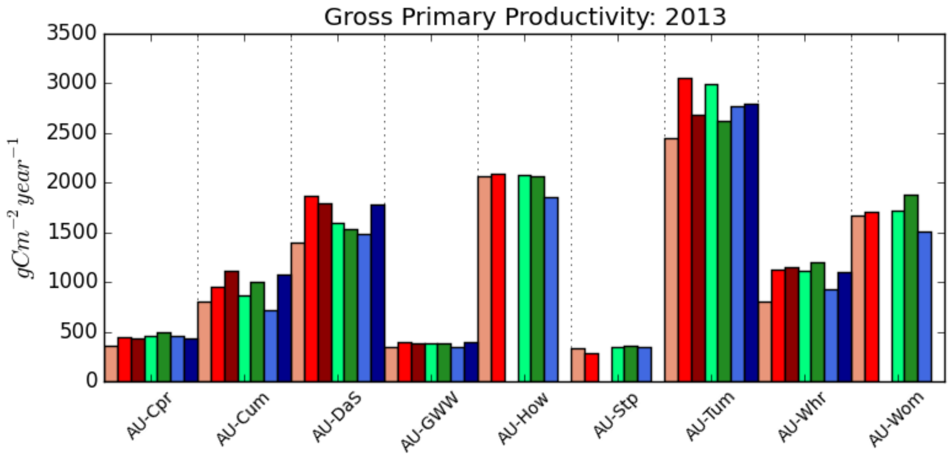
L3 – applies a range of corrections to the L2 data.

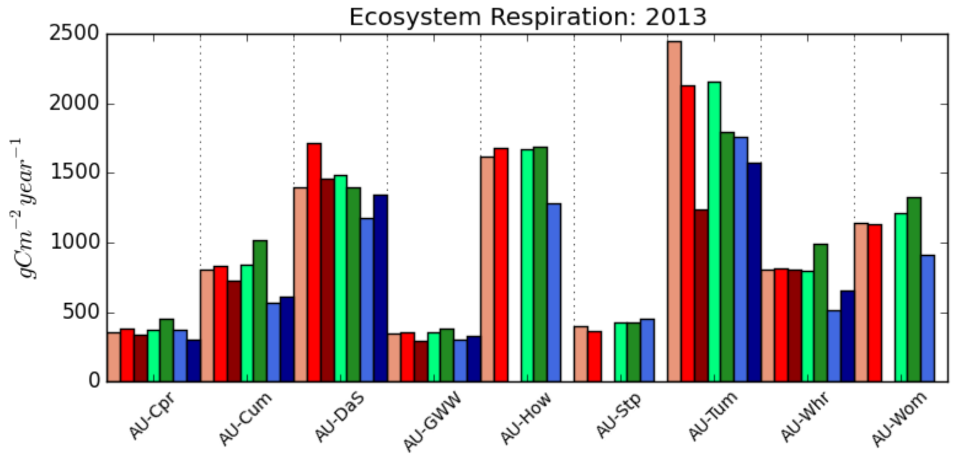
L4 – fills gaps in the radiation, meteorological and soil quantities.

L5 – fills gaps in the flux data.

L6 – partitions the gap filled NEE into GPP and ER

Delivers consistent and continuous data





Lloyd-Taylor (OzFluxQC, ReddyProc, FluxNet)

Nocturnal ANN (OzFluxQC, DINGO)

Daytime light response (OzFluxQC, FluxNet)

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LUC and Agriculture

1) Quantifying the relative importance of greenhouse gas emissions from current and future savanna land use change across northern Australia
   Mila Bristow
2) Carbon budgets for an irrigated intensively grazed dairy pasture and an unirrigated winter-grazed pasture
   John Hunt
3) Combining two complementary micrometeorological methods to measure CH_4 and N_2O fluxes over pasture
   Johannes Laubach

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Quantifying the relative importance of greenhouse gas emissions from current and future savanna land use change across northern Australia

Mila Bristow

- Paired approach (uncleared – before, during, after clearing)

- At current rates of deforestation, savanna burning is as significant a source of GHG emissions as deforestation.
- However, expanded deforestation could exceed fire emissions and a clearing scenario was examined which suggested that clearing over and above current rates could add up to 5% to Australia's national GHG account for the duration of the clearing activities.

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Carbon budgets for an irrigated intensively grazed dairy pasture and an unirrigated winter-grazed pasture

John Hunt

- Paired approach (net ecosystem carbon budget over irrigated, fertilised and rotationally grazed dairy pasture – neighbouring unirrigated, unfertilised winter grazed pasture)

- The intensively managed (IFR) dairy pasture retained significantly more C than it lost, despite multiple grazing events, while the only weakly managed pasture was C-neutral.
- The combined management effects of the IFR pasture increased both the biomass production (GPP) and respiration (ER) significantly and the increase in GPP outpaced the increase in ER.

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Combining two complementary micrometeorological methods to measure CH_4 and N_2O fluxes over pasture

Johannes Laubach

- Paired approach (CH_4 and N_2O over irrigated, fertilised and rotationally grazed dairy pasture – neighbouring unirrigated, unfertilised winter grazed pasture)

continuous methane (CH_4) and nitrous oxide (N_2O) measurements are still comparably sparse at the ecosystem scale despite importance for full GHG budgets especially in agroecosystems

- continuous methane (CH_4) and nitrous oxide (N_2O) through flux gradient and concentration accumulation method.
- Both methods indicated both sites as net sources of CH_4 and N_2O, the fertilization leading to stronger N_2O emissions.

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Savanna –Tree/Grass Phenology and contribution to GPP

1) Tree-grass phenology information improves light use efficiency modelling of gross primary productivity for an Australian tropical savanna
2) The contribution of trees and grasses to productivity of an Australian tropical savanna
   Caitlin Moore
3) Coupling carbon allocation with leaf and root phenology predicts tree–grass partitioning along a savanna rainfall gradient
   Vanessa Haverd

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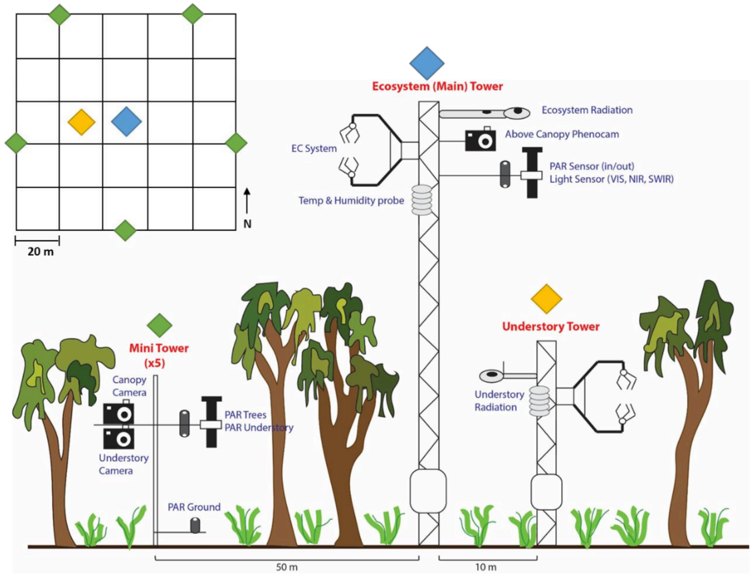
Tree-grass phenology information improves light use efficiency modelling of gross primary productivity for an Australian tropical savanna

Caitlin Moore

- Productivity, estimated from overstory (tree) and understory (grass) eddy covariance flux tower estimates of gross primary productivity (GPP), was compared against two years of repeat time-lapse digital photography (phenocams).



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Tree-grass phenology information improves light use efficiency modelling of gross primary productivity for an Australian tropical savanna

Caitlin Moore

- Productivity, estimated from overstory (tree) and understory (grass) eddy covariance flux tower estimates of gross primary productivity (GPP), was compared against two years of repeat time-lapse digital photography (phenocams).

- Indices (GCC, ExG) derived from photography captured the temporal dynamics of the understory (grass) and overstory (trees) phenology. They were mostly well correlated with tower GPP.
- The MODIS enhanced vegetation index (EVI) correlated well with GPP at the ecosystem scale.
- GCC and EVI were used to parameterise a light use efficiency (LUE) model leading to improved estimates of GPP for the overstory, understory and ecosystem.

The contribution of trees and grasses to productivity of an Australian tropical savanna

Caitlin Moore

- evaluation of temporally dynamic partitioning of overstory and under-story CO_2 fluxes in Australian tropical savanna using overstory and understory eddy covariance measurements

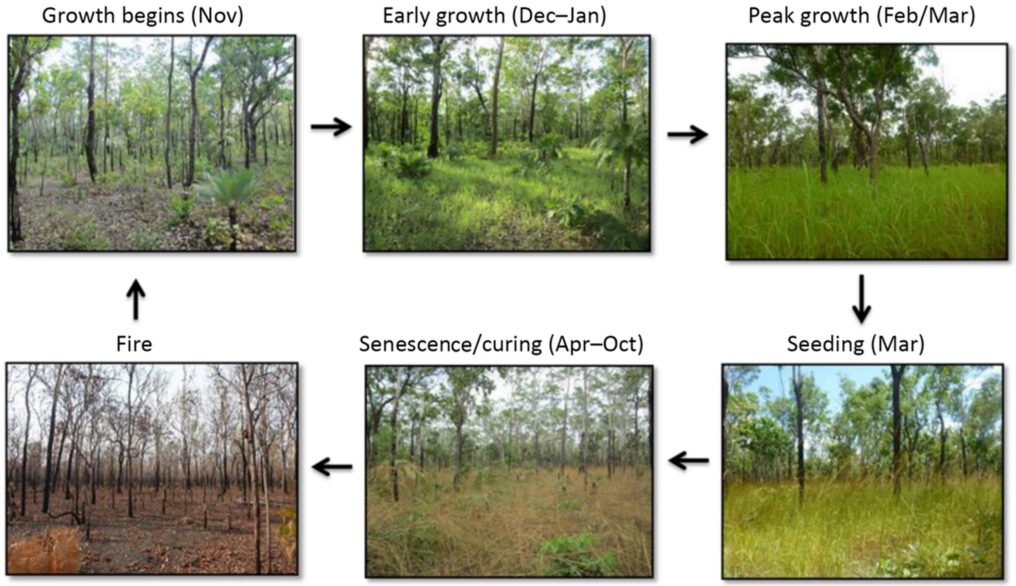


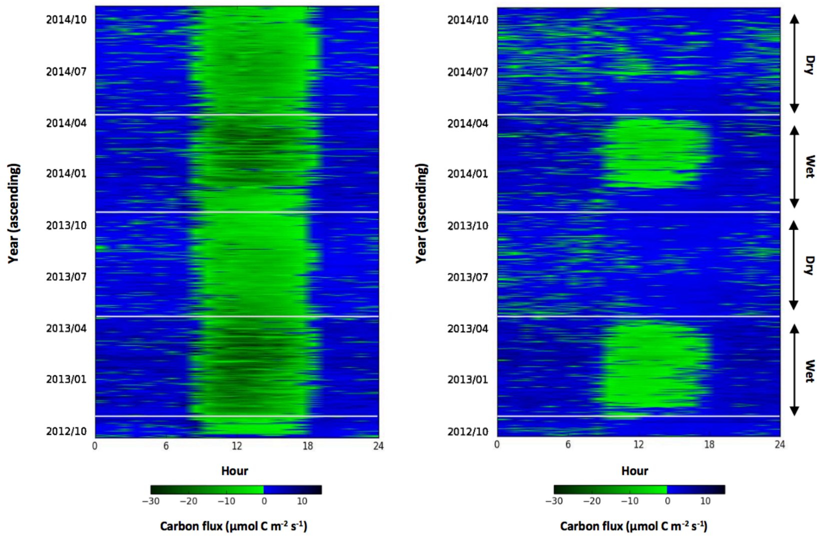
Figure 1. The variability in understory vegetation at Howard Springs OzFlux site, Northern Territory, Australia. The months from late October to early November are when growth in the understory begins, which continues on through the wet season until the end of March and start of April, when the understory grasses senesce and cure. The understory remains dry throughout the dry season months unless fire removes dry biomass.

The contribution of trees and grasses to productivity of an Australian tropical savanna

Caitlin Moore

- evaluation of temporally dynamic partitioning of overstory and under-story CO2 fluxes in Australian tropical savanna using overstory and understory eddy covariance measurements

➢ The understory contributed 32 % to total gross primary productivity.



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The contribution of trees and grasses to productivity of an Australian tropical savanna

Caitlin Moore

- evaluation of temporally dynamic partitioning of overstory and under-story CO_2 fluxes in Australian tropical savanna using overstory and understory eddy covariance measurements

- The understory contributed 32 % to total gross primary productivity.
- Understanding grass productivity is crucial for evaluating fuel loads, as is tree productivity for quantifying the tree carbon sink.
- The strength and duration of the wet season monsoon played a key role in the productivity of these savannas, with the drier (energy richer) year leading to higher understory productivity, and wetter year providing higher soil moisture stores to support overstory productivity for longer during the dry season.
- If the monsoon is to strengthen, the overstory will likely be at a productive advantage over the grasses, which in turn could lead to woody encroachment and a shift in biodiversity.

Coupling carbon allocation with leaf and root phenology predicts tree–grass partitioning along a savanna rainfall gradient

Vanessa Haverd

- new approach for modelling coupled phenology and carbon allocation, applied to competing tree and grass plant functional types
- accounts for a temporal shift between assimilation and growth, mediated by a labile carbohydrate store
- combined with a method to maximize long-term NPP by optimally partitioning plant growth between fine roots and leaves/stem
- calibrated using monthly remotely sensed fraction of absorbed photosynthetically active radiation (fPAR) and EC based estimates of carbon and water fluxes at five tower sites along NATT

➢ model behaviour emerges from complex feedbacks between the plant physiology and vegetation dynamics, mediated by shifting above- versus below-ground resources, and not from imposed hypotheses about the controls on tree–grass coexistence.

➢ Results support the hypothesis that resource limitation is a stronger determinant of tree cover than disturbance in Australian savannas.

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Modelling Savanna ecosystems

1) A model inter-comparison study to examine limiting factors in modelling Australian tropical savanna
2) Challenges and opportunities in modelling savanna ecosystems
   Rhys Whitley

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A model inter-comparison study to examine limiting factors in modelling Australian tropical savanna

Rhys Whittley

- Performance in predicting LE and GPP was measured for 6 TBM using an empirical benchmarking system, which ranks models by their ability to utilise meteorological driving information to predict the fluxes.

- TBMs performed as well as a multi-linear regression of the fluxes against solar radiation, temperature and vapour pressure deficit but were outperformed by a more complicated nonlinear response.
- prescribed tree-rooting depths must be deep enough, enabling the extraction of deep soil-water stores to maintain photosynthesis and transpiration during the dry season
- models must treat grasses as a co-dominant interface for water and carbon exchange rather than a secondary one to trees
- models need a dynamic representation of LAI that encompasses the dynamic phenology of savanna vegetation and its response to rainfall interannual variability

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Challenges and opportunities in modelling savanna ecosystems

Rhys Whittley

highlighting the defining characteristic traits and behaviours of savanna, how these differ across continents, and how this information is (or is not) represented in the structural framework of many TBMs.

- highlight three dynamic processes that we believe directly affect the water-use and productivity of the savanna system, namely: phenology; root-water access; and fire dynamics.
- discuss how these processes are represented in many current generation TBMs and whether they are suitable for simulating savanna dynamics
- such processes must not be static (i.e. prescribed behaviour), but be capable of responding to the changing environmental conditions in order to emulate the dynamic behaviour of savannas.

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Climate and Climate Extremes

1) Describing rainfall in northern Australia using multiple climate indices
   Cassandra Rogers

2) Carbon uptake and water use in woodlands and forests in southern Australia during an extreme heat wave event in the 'Angry Summer' of 2012/2013
   Eva van Gorsel

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Describing rainfall in northern Australia using multiple climate indices

Cassandra Rogers

Vegetation productivity (and hence the carbon balance) is vulnerable to changes in rainfall variability (Kanniah et al., 2011) because savanna structure, composition and function shift in response to short (monsoonal) and long term (ENSO, Inter-decadal Pacific Oscillation, Pacific Decadal Oscillation Index (PDO), etc.) rainfall climatology (Beringer et al., 2011a). Moreover, disturbances, such as fire, cyclones and grazing, are also key drivers of savanna structure and productivity which are in turn driven by rainfall patterns.

- quantify the relationship between climate phenomena and historical rainfall variability in Australian savannas, and in particular, how these relationships changed across a strong rainfall gradient, namely the North Australian Tropical Transect (NATT).
- 16 relevant climate indices and correlated against precipitation from 1900 to 2010. Precipitation trends, climate index trends, and wet season characteristics have also been investigated using linear statistical methods.

➢ decreased influence of the Indian-Australian monsoon from the north to the south (IAV increasing), seasonal variation was most strongly correlated with the Australian Monsoon Index, IAV by ENSO, Tasman, Pacific and Indonesian Sea SST

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Carbon uptake and water use in woodlands and forests in southern Australia during an extreme heat wave event in the 'Angry Summer' of 2012/2013

Eva van Gorsel

Warmer temperatures are projected through the 21st century and are already increasing above modelled predictions. Apart from increases in the mean, warm/hot temperature extremes are expected to become more prevalent in the future, along with an increase in the frequency of droughts. It is crucial to better understand the response of terrestrial ecosystems to such temperature extremes for predicting land-surface feedbacks in a changing climate.

- the water-limited woodlands and the energy-limited forest ecosystem responded differently to the heat wave
    - woodlands experienced decreased latent heat flux, an increased Bowen ratio and a reduced carbon uptake while forest ecosystem had increased latent heat flux, reduced Bowen ratio and increased carbon uptake
    - Ecosystem respiration was increased at all sites resulting in reduced net ecosystem productivity in the woodlands and constant net ecosystem productivity in the forest
- all ecosystems remained carbon sinks during the event

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Eddy Covariance and Remote Sensing

1) MODIS vegetation products as proxies of photosynthetic potential: a look across meteorological and biologic driven ecosystem productivity
   Natalia Restrepo-Coupe

2) Australian vegetation phenology: new insights from satellite remote sensing and digital repeat photography
   Caitlin Moore

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MODIS vegetation products as proxies of photosynthetic potential: a look across meteorological and biologic driven ecosystem productivity

Natalia Restrepo-Coupe

A direct relationship between gross ecosystem productivity (GEP) measured by the eddy covariance (EC) method and Moderate Resolution Imaging Spectroradiometer (MODIS) vegetation indices (VIs) has been observed in many temperate and tropical ecosystems. However, in Australian evergreen forests, and particularly sclerophyll woodlands, MODIS VIs do not capture seasonality of GEP.

- satellite derived greenness products constitute a measure of ecosystem structure (e.g. leaf area index – quantity of leaves) and function (e.g. leaf level photosynthetic assimilation capacity – quality of leaves), rather than productivity.
- The relationship between RS products and GEP is only clear when productivity is driven by either: (1) ecosystem phenology and climate, synchronously driving GEP, as was observed at ASP, and similar to many temperate deciduous locations, or (2) solely by the vegetation photosynthetic potential, as observed at the tropical savanna site of Howard Springs (HSP).

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Australian vegetation phenology: new insights from satellite remote sensing and digital repeat photography

Caitlin Moore

- shows how satellite remote sensing and ground-based digital repeat photography (i.e. phenocams) can be used to improve understanding of phenology in Australian ecosystems
- discusses temporal variation in phenology at the continental scale: seasonal dynamics and regularity
- demonstrate how phenology links with ecosystem gross primary productivity (from eddy covariance)

➢ Results support hypothesis that phenocams are not able to discern phenological variability related to carbon exchange at the ecosystem scale in temperate evergreen ecosystems.

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Presenting in the next days…

1) Net ecosystem carbon exchange of a dry temperate eucalypt forest
   Nina Hinko-Najera
2) Under a new light: validation of eddy covariance flux with light response functions of assimilation and estimates of heterotrophic soil respiration. indices
   Georgia Koerber
3) Photodegradation at Ti Tree East
   James Cleverly
4) Interactions between nocturnal turbulent flux, storage and advection at an 'ideal' eucalypt woodland site indices
   Ian McHugh
5) An introduction to the Australian and New Zealand flux tower network – OzFlux indices
   Jason Beringer

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is a network of people. We are passionate about our science because we address environmental questions that are critically important for the wider community.