Integrating Approaches to Estimating Surface Fluxes at Regional Scales Over Tropical Savanna

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Introduction

Re-visit the project objectives

A possible framework

Results to date

Future directions

ARC Discovery Project Title

"Patterns and processes of carbon and water budgets across northern Australian landscapes: From point to region"

Project Research Questions

What is the spatial variability in H_2O and CO_2 fluxes and what drives the variability?

Can data from flux towers, aircraft and satellites be integrated to constrain estimates of the H_2O and CO_2 budgets?

Can a coupled mesoscale and land-surface model replicate the observations?

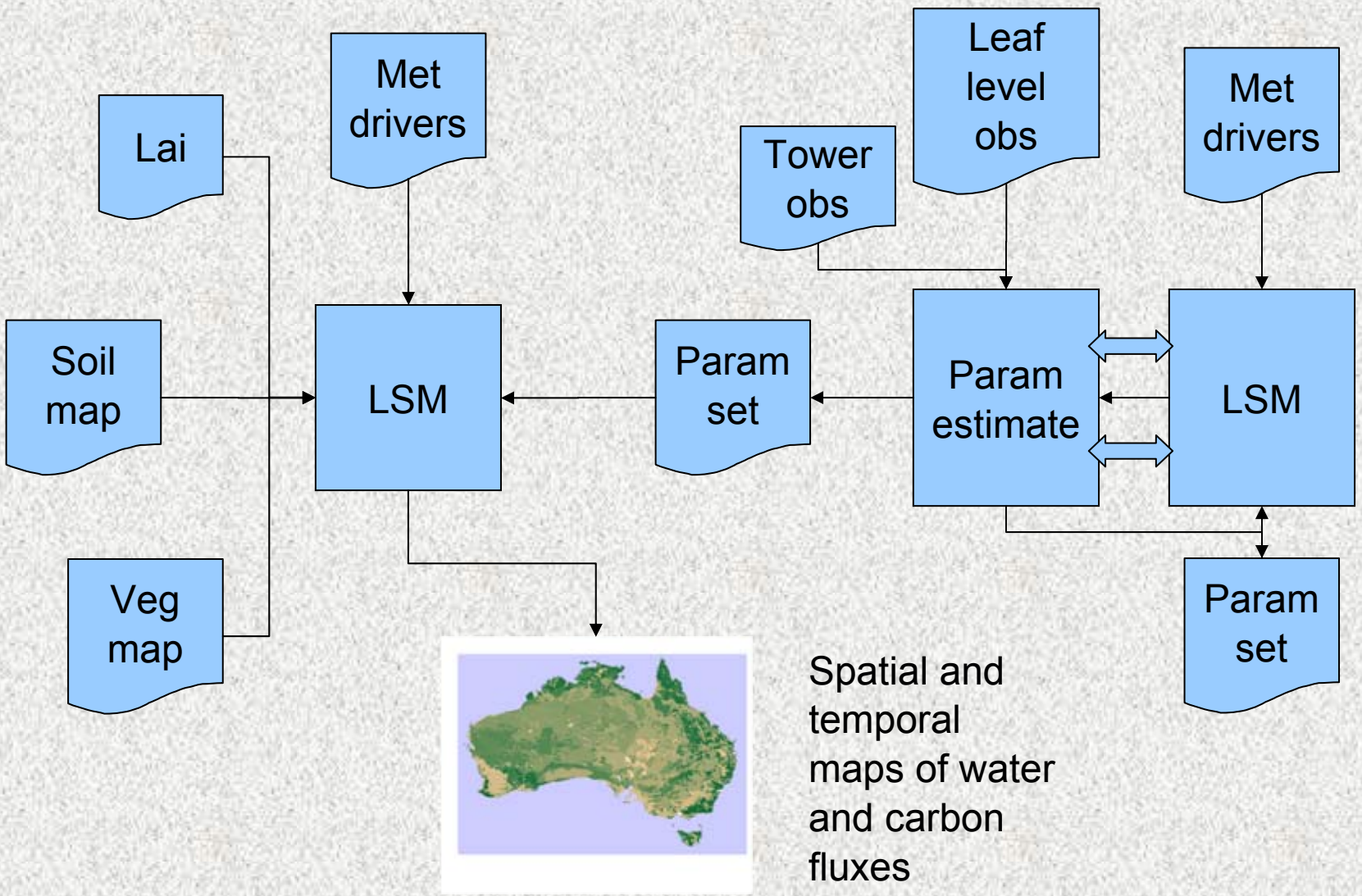
What Does This Mean?

- Spatial and temporal variability in H_2O and CO_2 fluxes
- Spatial scales from 10^2 m^2 to 10^{10} m^2
- Temporal scales from 10^3 to 10^5 seconds
- Combination of methods required
  - Leaf-level measurement
  - Flux observations
  - Modelling
  - Remote sensing

Soapbox Time

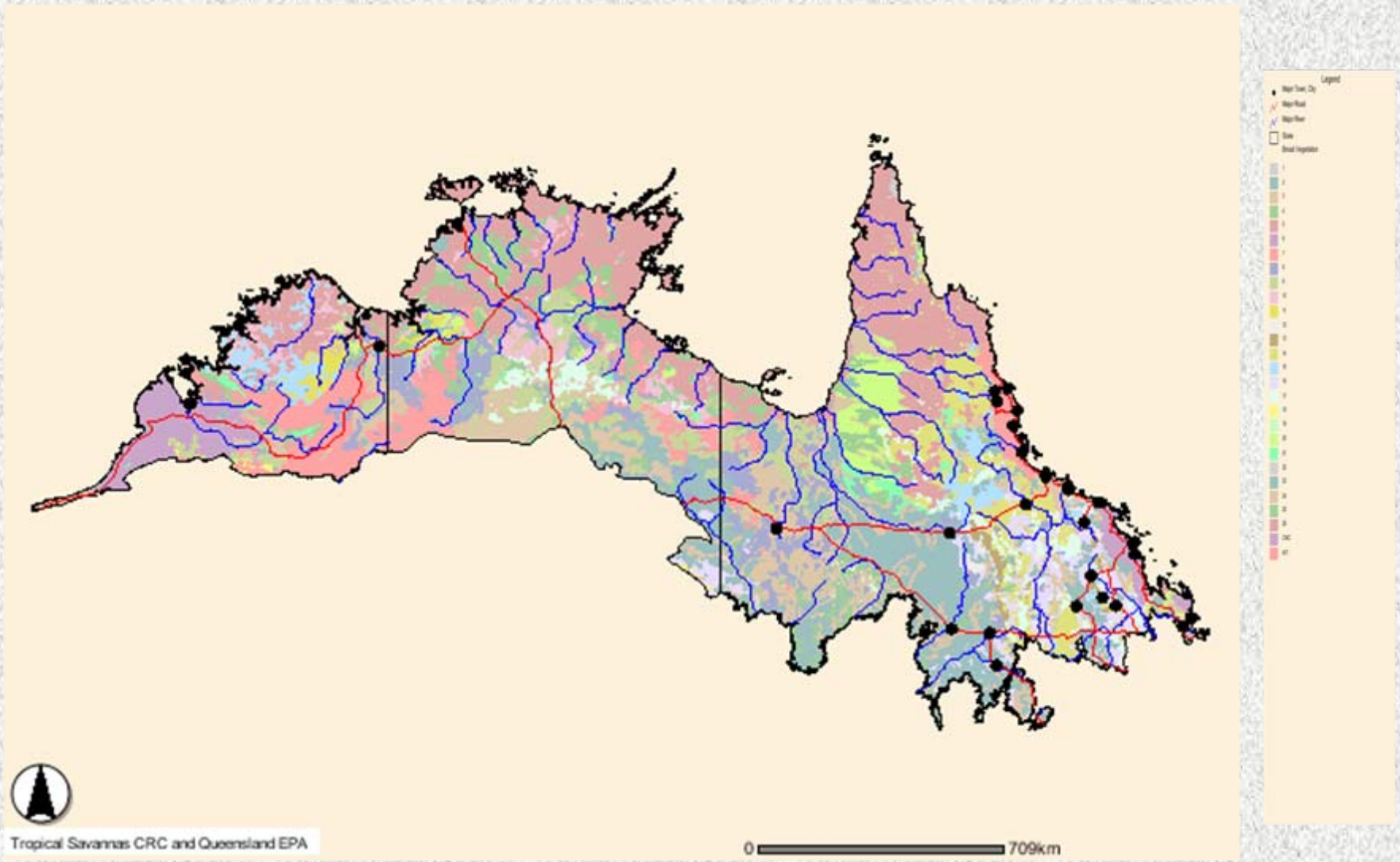
- “Northern Australian landscapes” and “point to region”
  - Landscape or regional scale fluxes
  - Resolving patterns in large spatial-scale fluxes
  - Not necessary to resolve canopy scale processes
  - Broad strokes with a big brush
- What magnitude of variability do we want to resolve?
  - Can the chosen method achieve this?

The Chosen Method



Spatial and temporal maps of water and carbon fluxes

Savanna Vegetation



Top End Vegetation Types

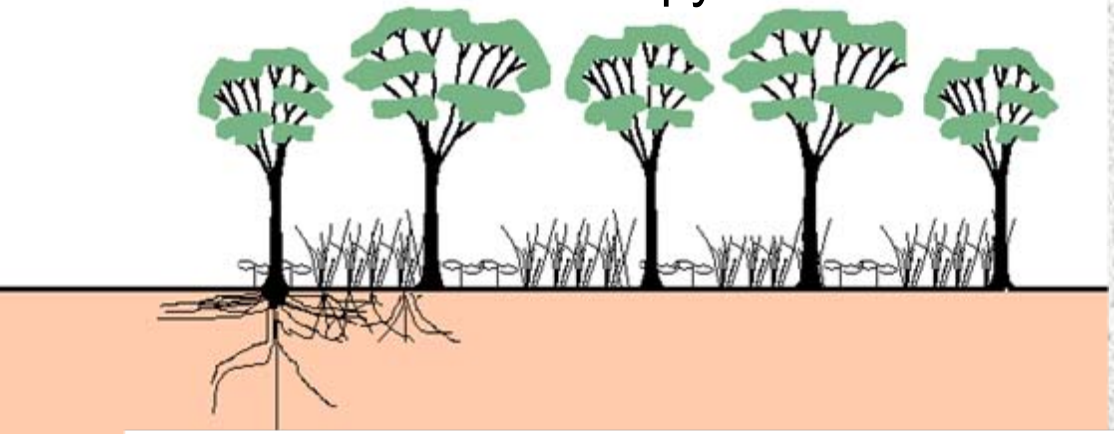
Type	Area	Description	Location
23	17.4%	Tussock grassland	Sturt Plains
5	13.2%	E. tetradonta, E. miniata	Howard Springs Daly Uncleared
10	8.2%	C. capricornia	Dry River
14	6.5%	Northern box, ironbark	No communities within reach
4	5.4%	E. tectifica	Adelaide River
7	5.1%	E. brevifolia, E. leucophloia	No communities within reach
16	4.9%	Acacia spp	No communities within reach

Land-surface Model: CABLE

- Kowalczyk et al. (2006), CMAR Paper 013
  - coupled assimilation/transpiration
  - one sunlit leaf, one shaded
  - mixed C3/C4 canopy by specifying C4 fraction
  - seasonally varying Lai and C4 fraction
  - 13 vegetation types, 9 soil types, 6 soil layers
  - destined to be the LSM in ACCESS
  - 7 parameters for photosynthesis/evapotranspiration model

Reality vs Model

Savanna canopy



ACASA

C3 overstorey
L_{ai} 0.6 - 1.0
h_c 16 m

C4 understorey
L_{ai} 0.08 - 1.4
h_c 0.1 - 2 m

C4 roots shallow

C3 roots deep

Parameter Estimation: The Big Four

- Wang et al (2001) in GCB
  - Vcmax – maximum Rubisco carboxylation capacity
  - D0 - response of stomatal conductance to vapour pressure deficit
  - β – response of soil evaporation to soil moisture
  - a1 – slope of stomatal conductance as a function of assimilation
- These are probably the most we can derive from measurements

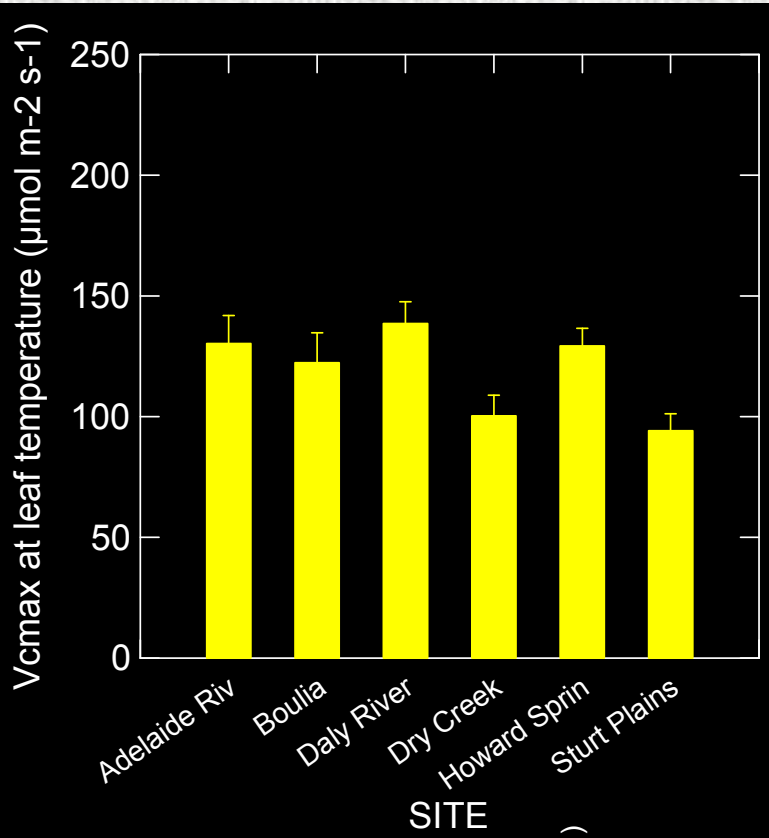
The Other Three

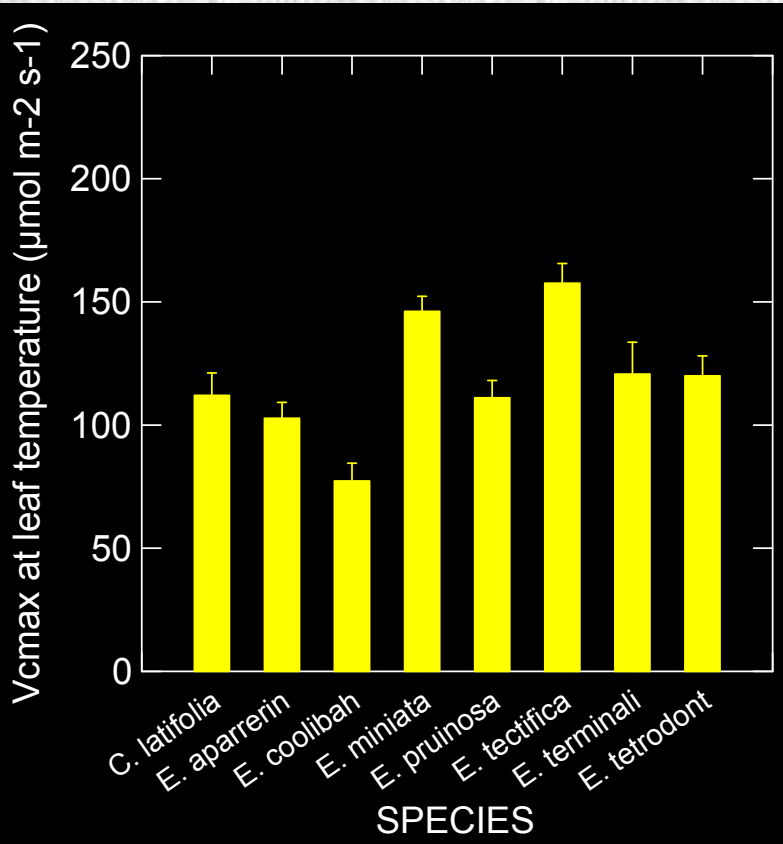
- Θ – convexity of light response
- r_p – non-leaf respiration rate
  - previous work at Howard Springs?
- r_s – soil respiration rate
  - chamber measurements?

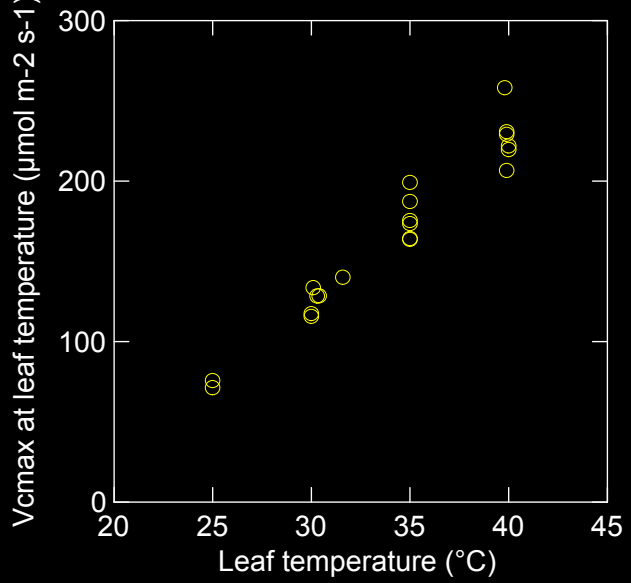
Constraints on Parameter Estimation

- We would like a scheme to interpolate parameters derived at a few sites across a heterogeneous landscape
  - Traditionally done via vegetation type, can we use hyperspectral information?
- Can we constrain canopy-scale parameters with leaf-level measurements?
  - Spatial patterns in parameters derived at canopy scale should match parameters measured at leaf scale


JLG LIFT K16T
DANGER





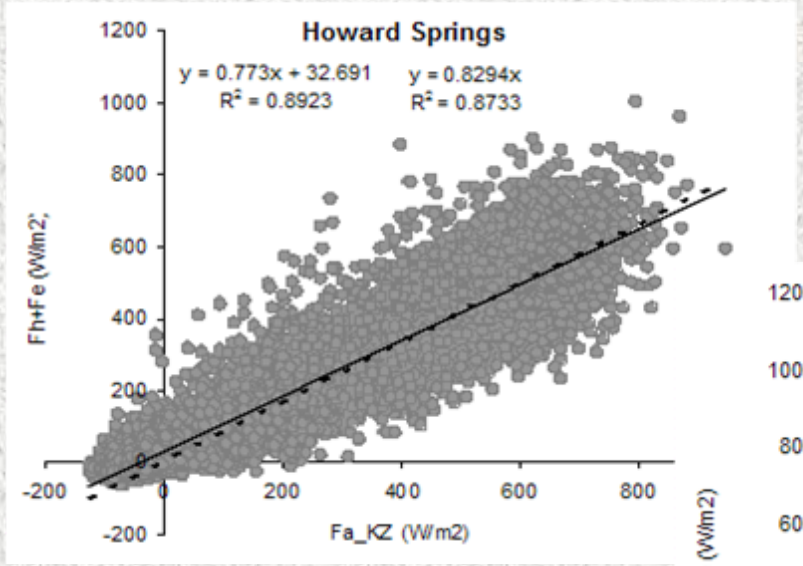


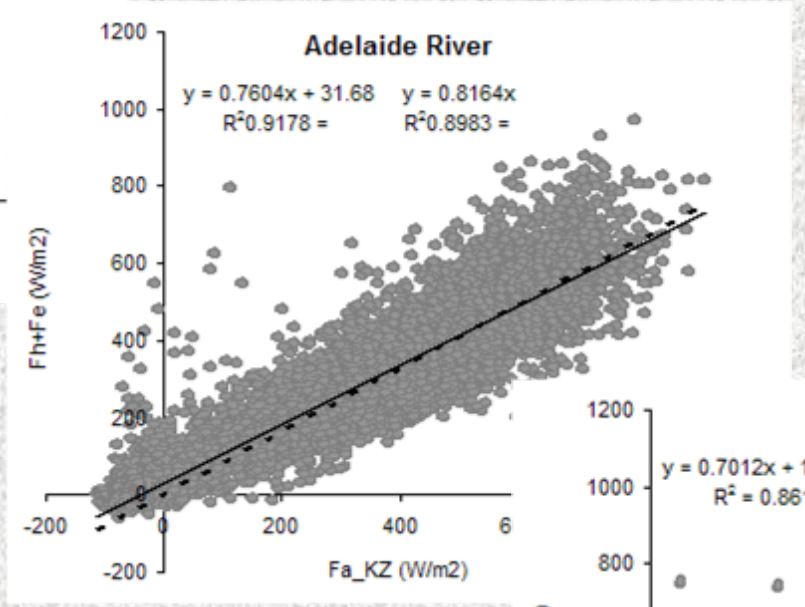
Cernusak et al

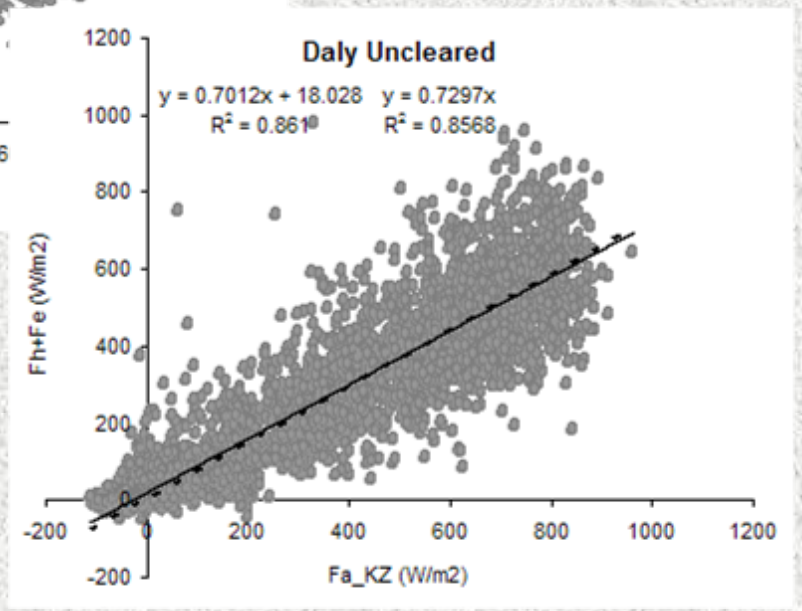
Preliminary Flux Tower Results: 2008

- Howard Springs, Adelaide River, Daly Uncleared, Dry River and Sturt Plains
  - Surface energy balance
  - Net ecosystem exchange

Surface Energy Balance

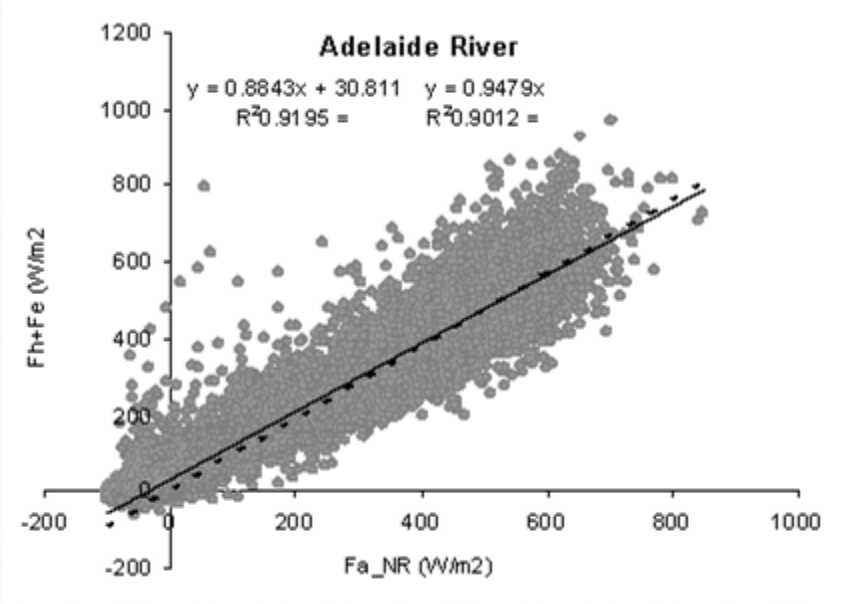




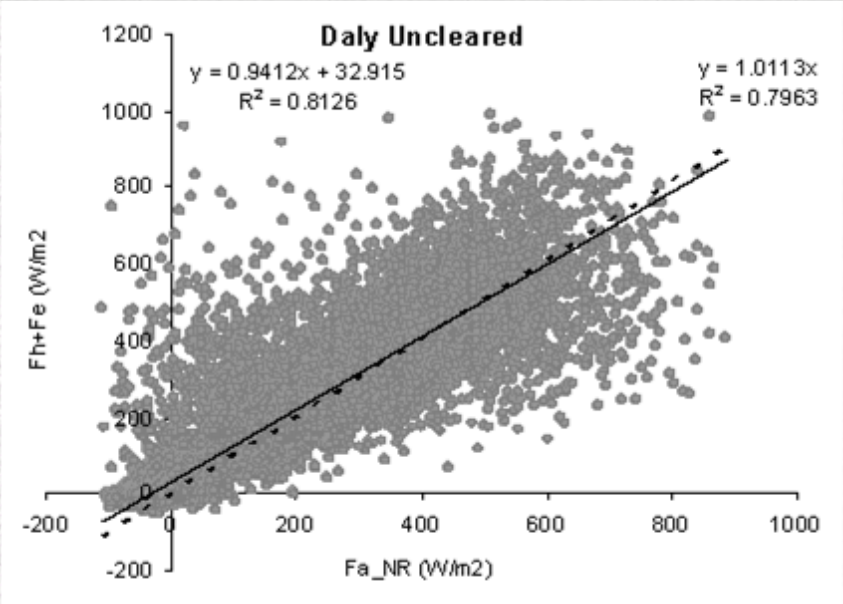


Kipp and Zonen CNR1

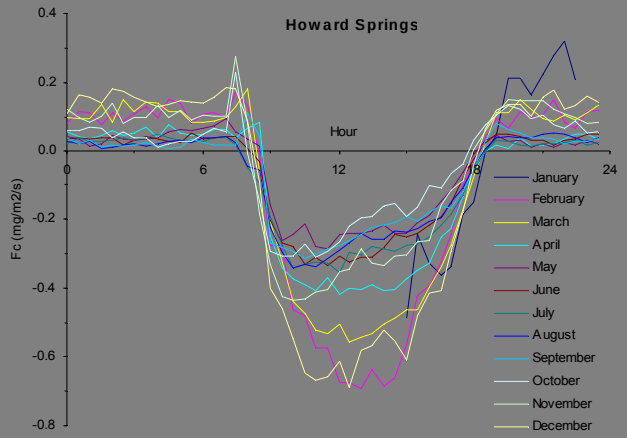
But Wait ...

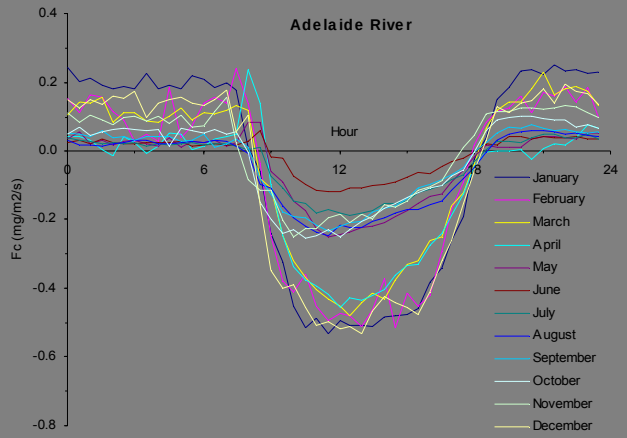


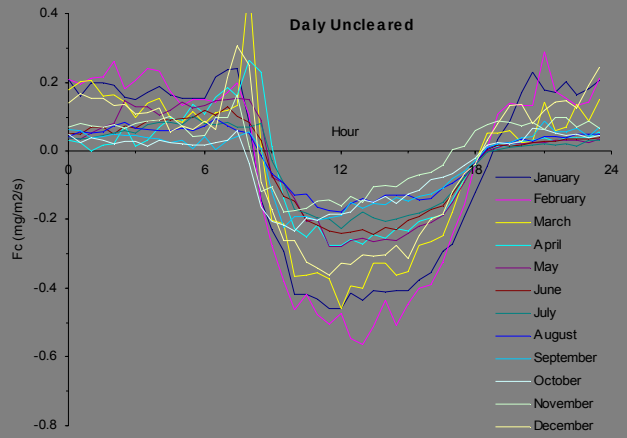
NRlite

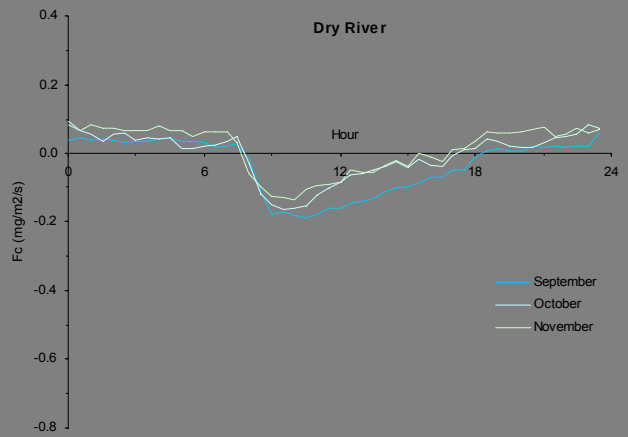


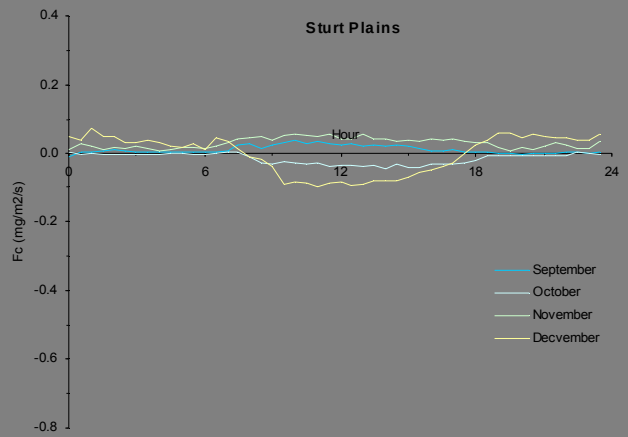
Net Ecosystem Exchange

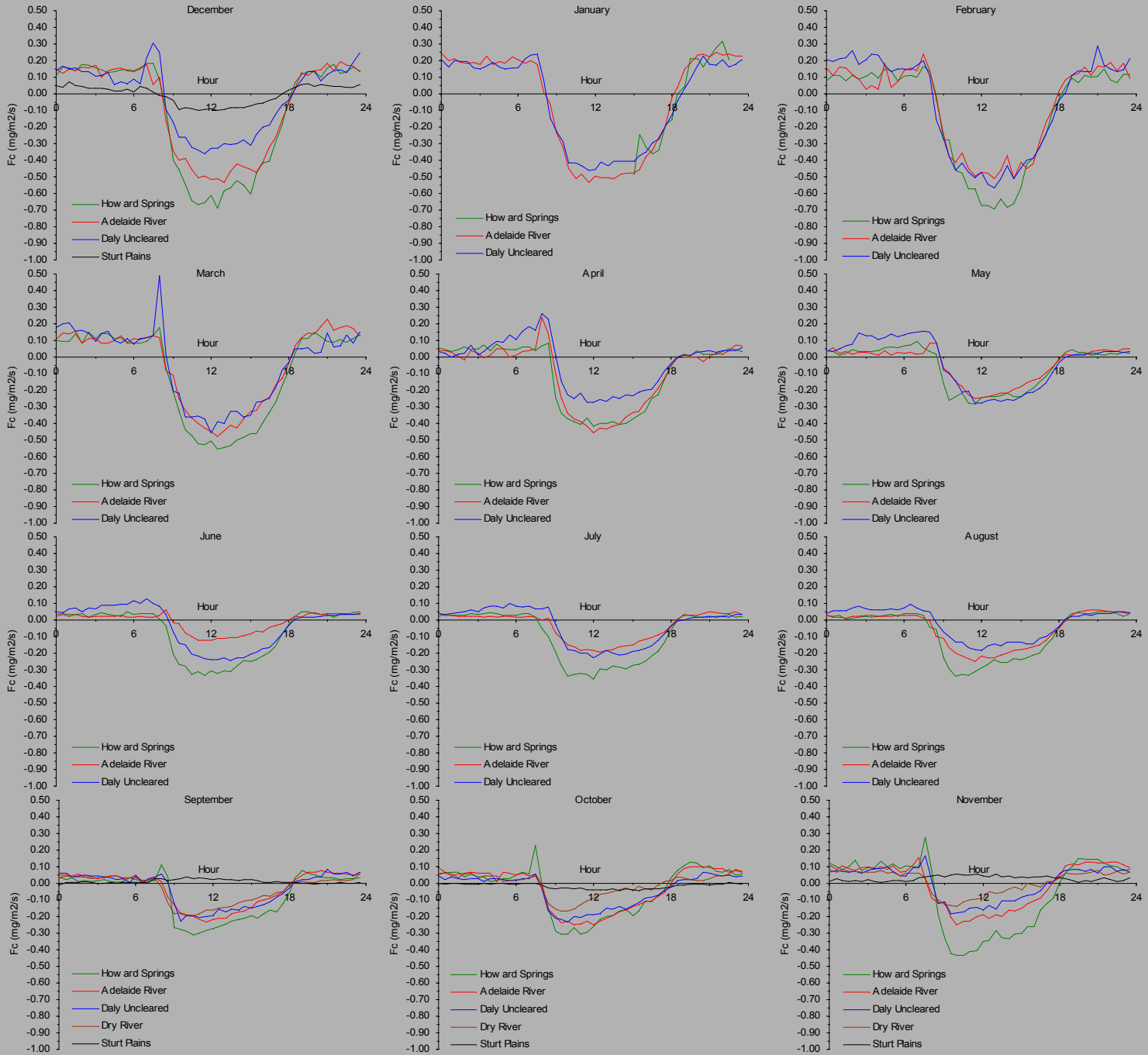








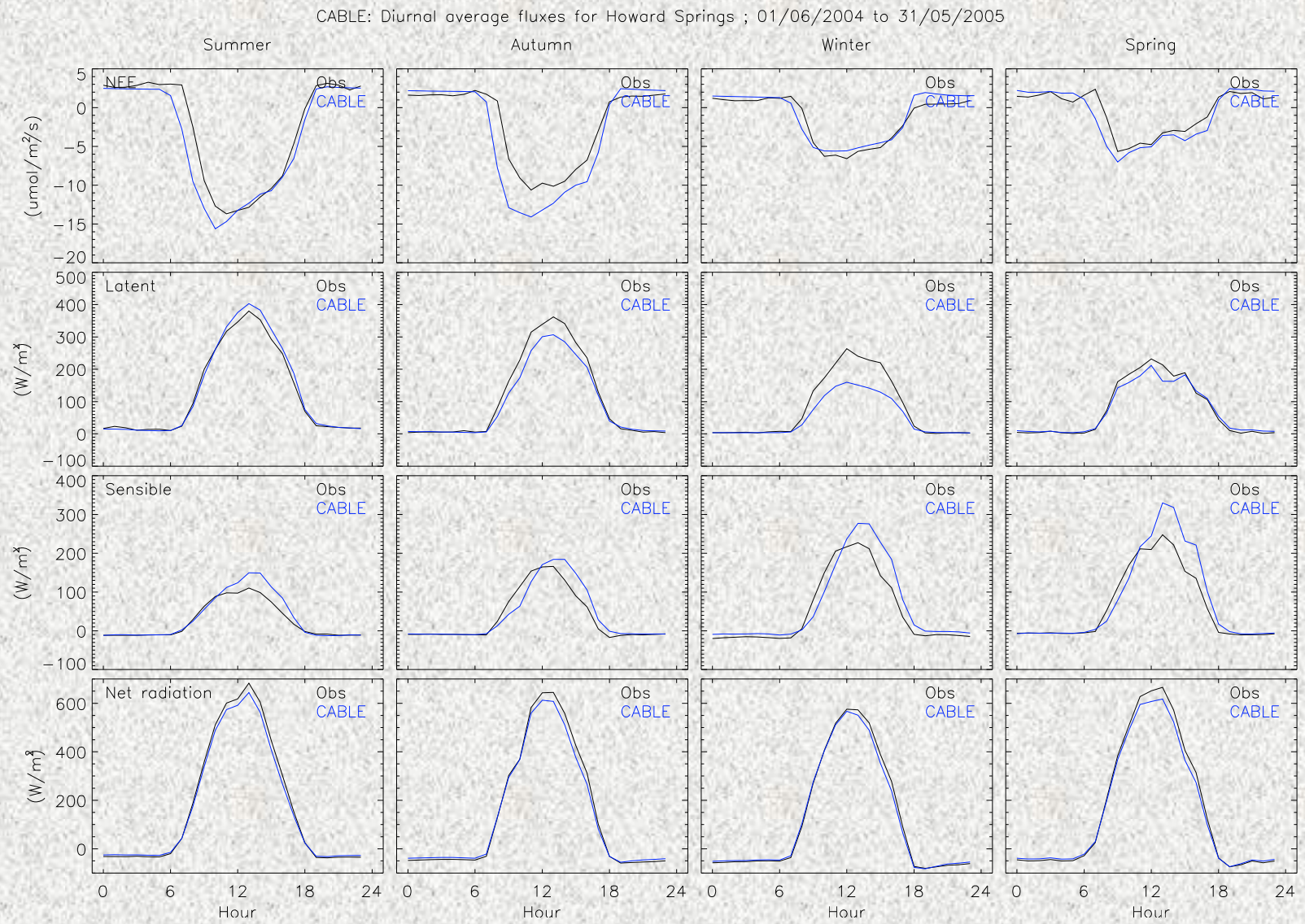



December
January
February
March
April
May
June
July
August
September
October
November
Hour
Fc (mg/m2/s)
How ard Springs
Adelaide River
Daly Uncleared
Dry River
Sturt Plains

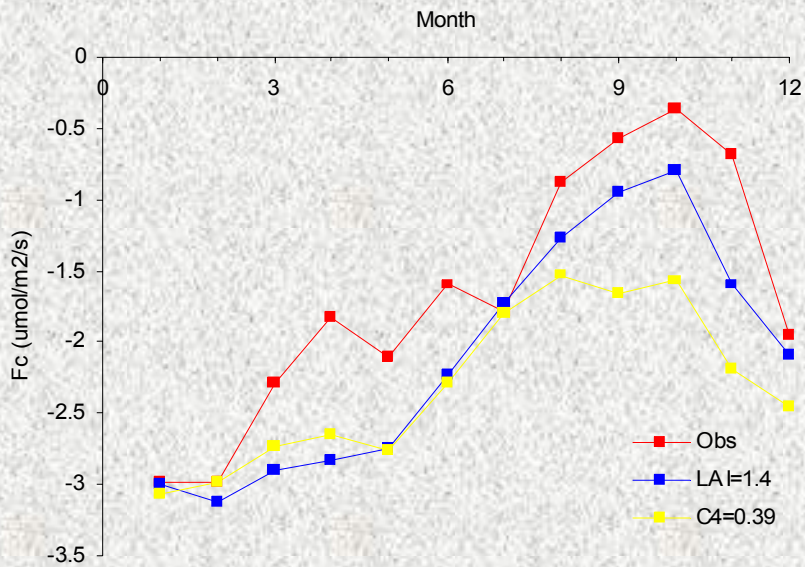
First Thoughts

- Temporal variability is twice as big as spatial variability across woody savanna
  - tussock grassland is the exception
- Can CABLE reproduce the observed temporal variability?
  - previous run using meteorology from Howard Springs for 6/2004 to 5/2005
  - Lai an C4 fraction from measurements in 2000
  - minimal tuning (Vcmax, soil properties)

Howard Springs 6/2004 to 5/2005

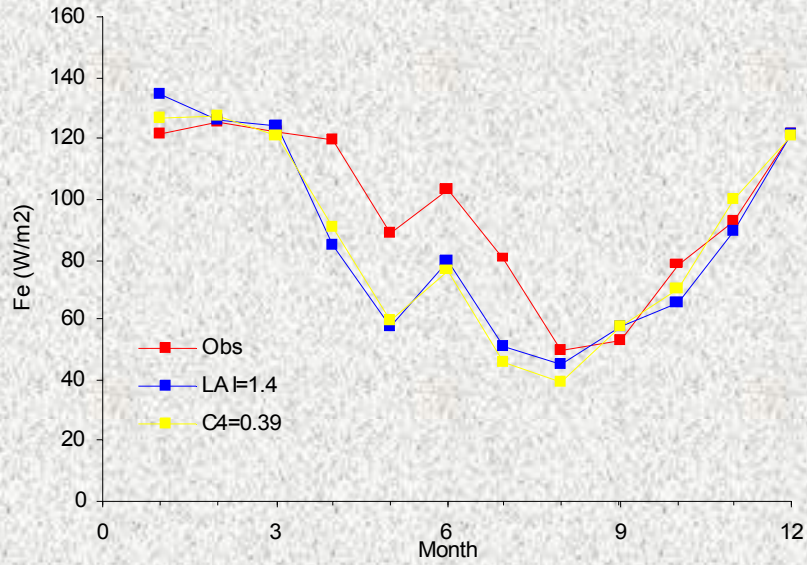


CABLE Seasonal Dynamics Howard Springs 6/2004 to 5/2005



Constant Lai, seasonal C4 (blue)

Constant C4, seasonal Lai (yellow)



Need to get C4 fraction correct to resolve seasonal dynamics in Fc

Not important for Fe

Future work

- Ongoing maintenance of NATT flux tower network
- Completion of data quality control and gap filling
- Parameter estimation at each site
  - Generalised method for interpolating parameters across heterogeneous landscape
  - Improve representation of savanna in CABLE?
- Can the model reproduce the observed spatial and temporal variability?