Spatial Variability in Ecosystem Fluxes of Carbon and Water

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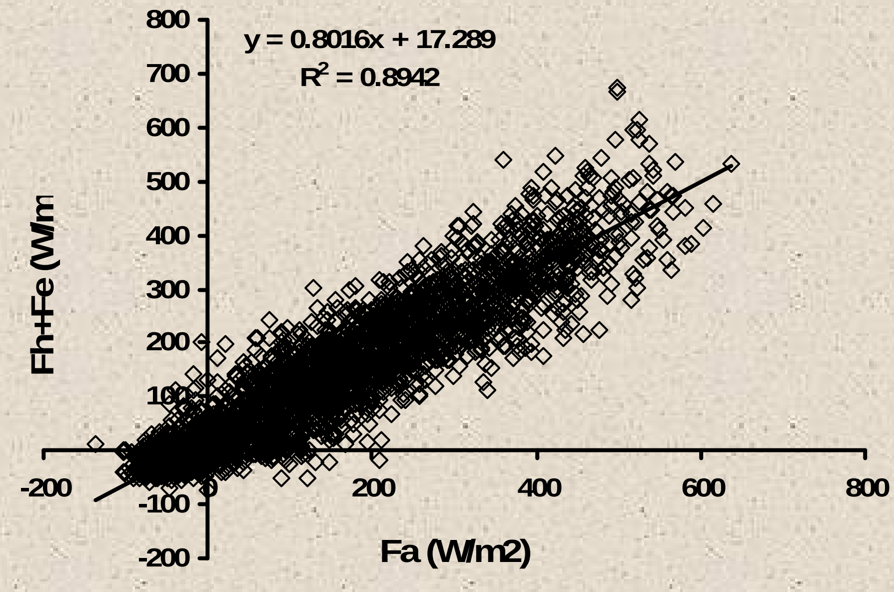
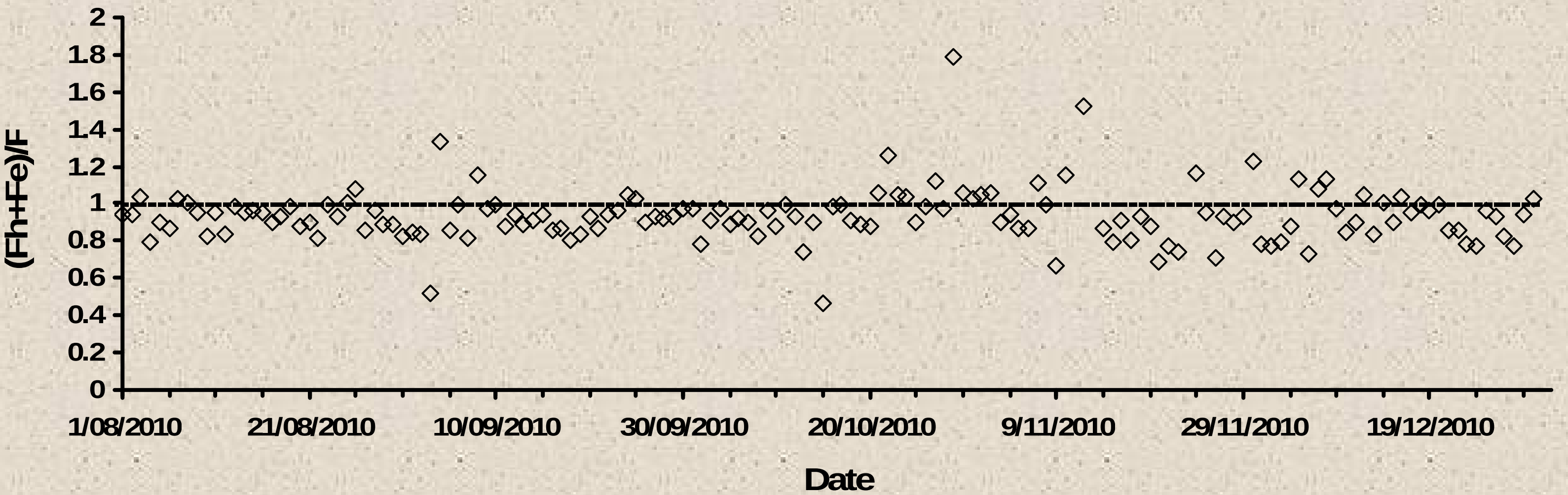
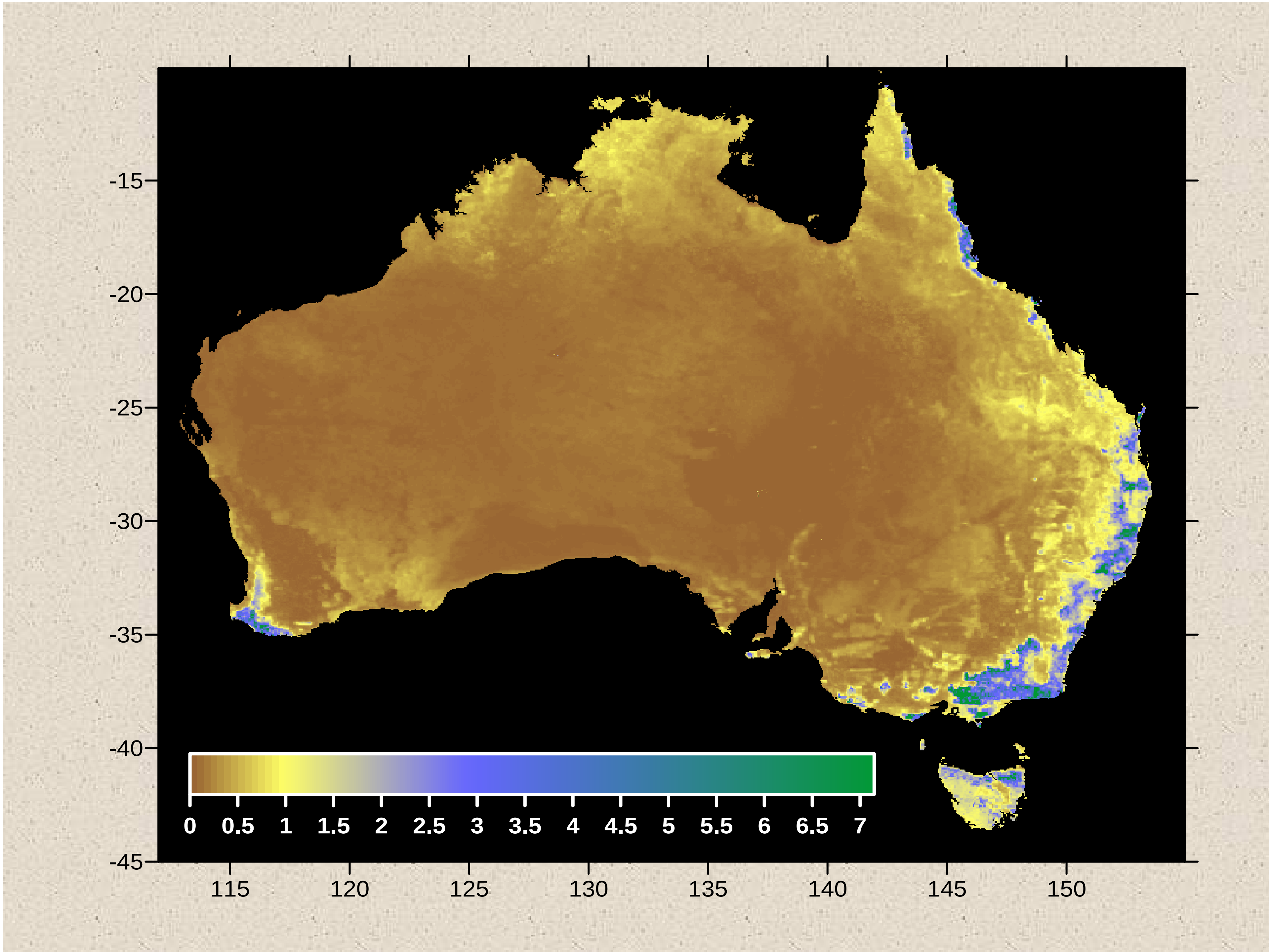
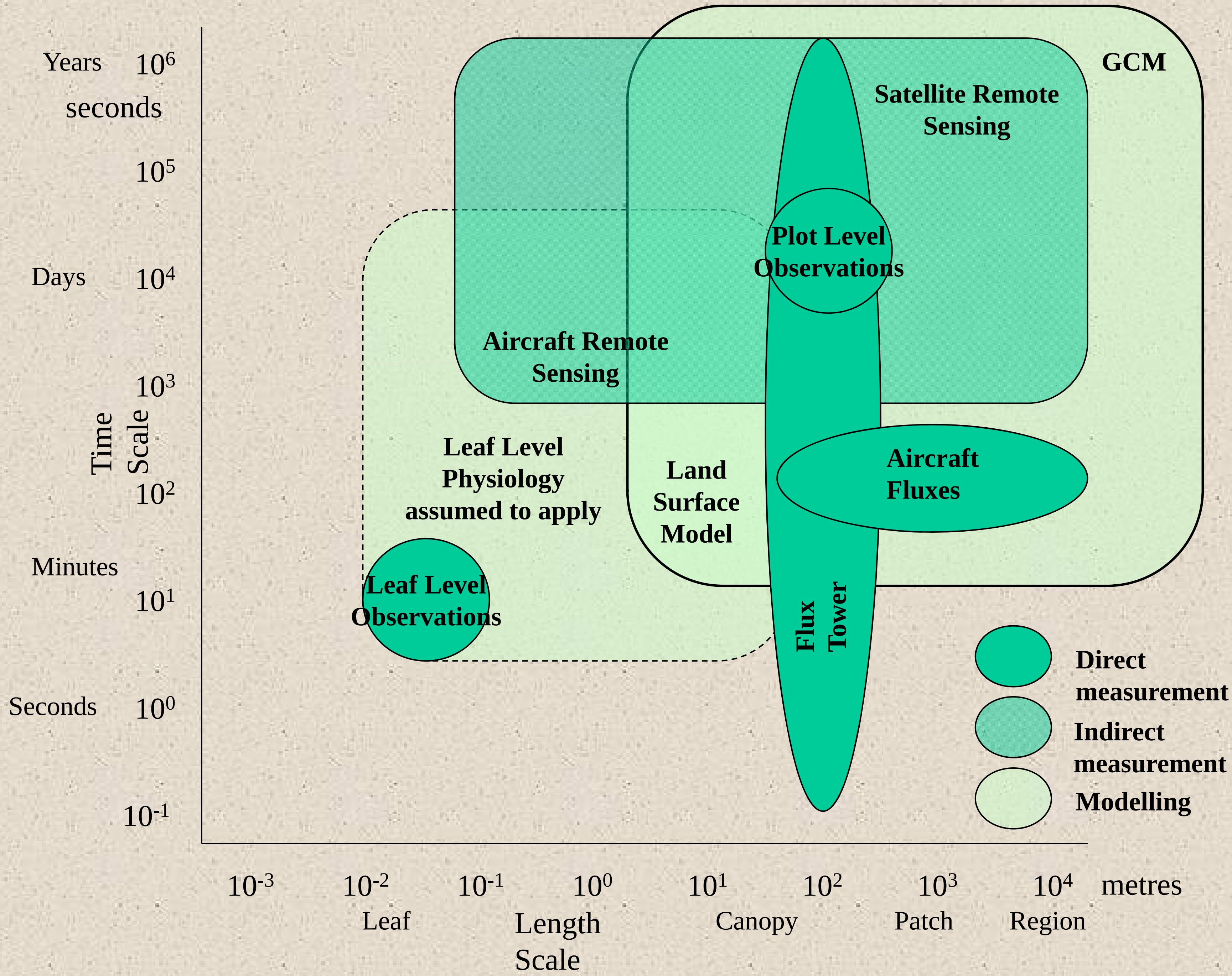
Calperum SEB: 2010



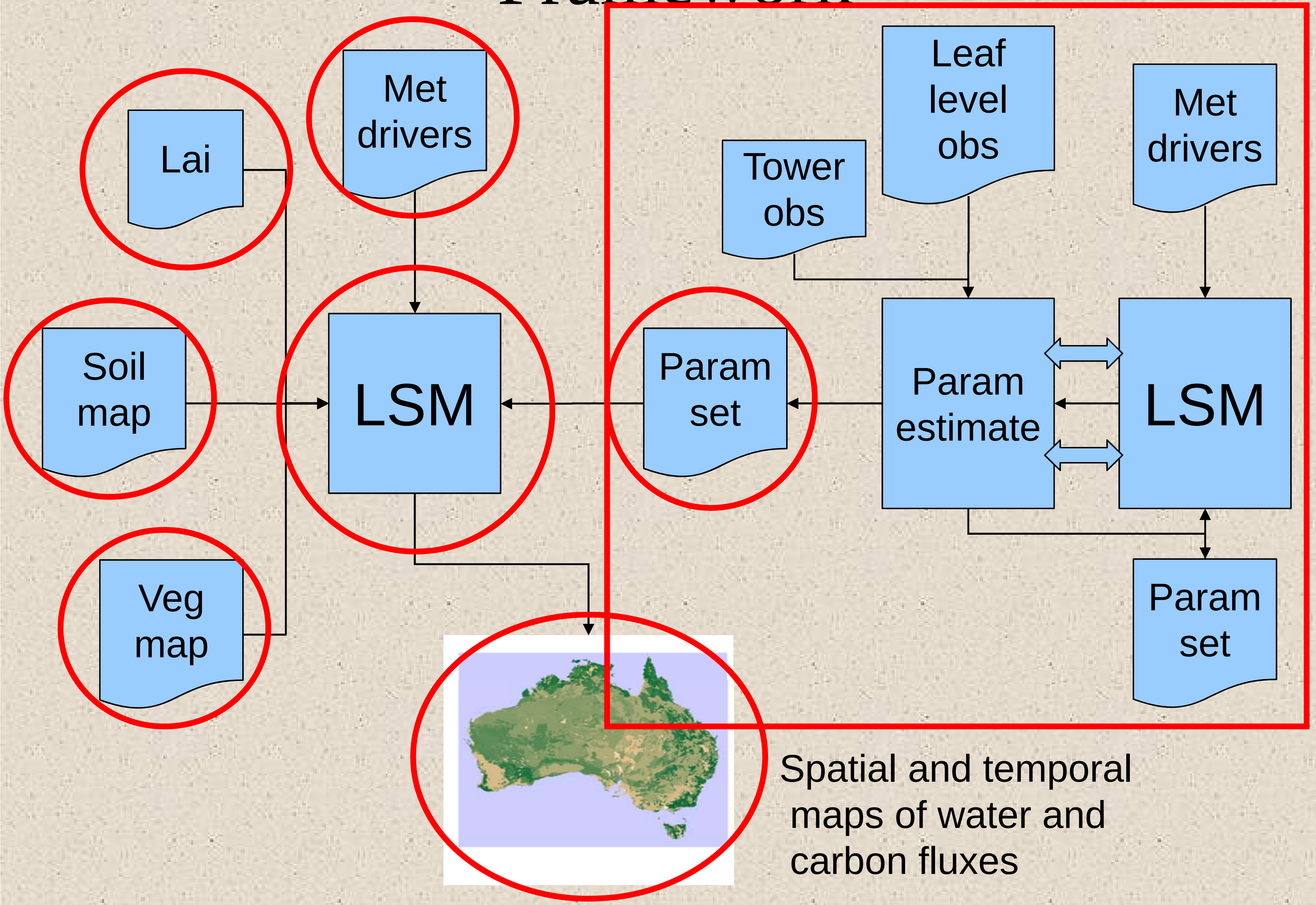



-15
-20
-25
-30
-35
-40
-45
115
120
125
130
135
140
145
150
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 6.5 7



Years
seconds
Days
Minutes
Seconds
Time Scale
10^6
10^5
10^4
10^3
10^2
10^1
10^0
10^{-1}
GCM
Satellite Remote Sensing
Plot Level Observations
Aircraft Remote Sensing
Leaf Level Physiology assumed to apply
Land Surface Model
Aircraft Fluxes
Leaf Level Observations
Flux Tower
Direct measurement
Indirect measurement
Modelling
10^{-3}
10^{-2}
10^{-1}
10^0
10^1
10^2
10^3
10^4
metres
Leaf
Length Scale
Canopy
Patch
Region

Framework


Lai
Met drivers
Soil map
LSM
Veg map
Tower obs
Leaf level obs
Met drivers
Param set
Param estimate
LSM
Param set
Spatial and temporal maps of water and carbon fluxes

What's in the parameter set?

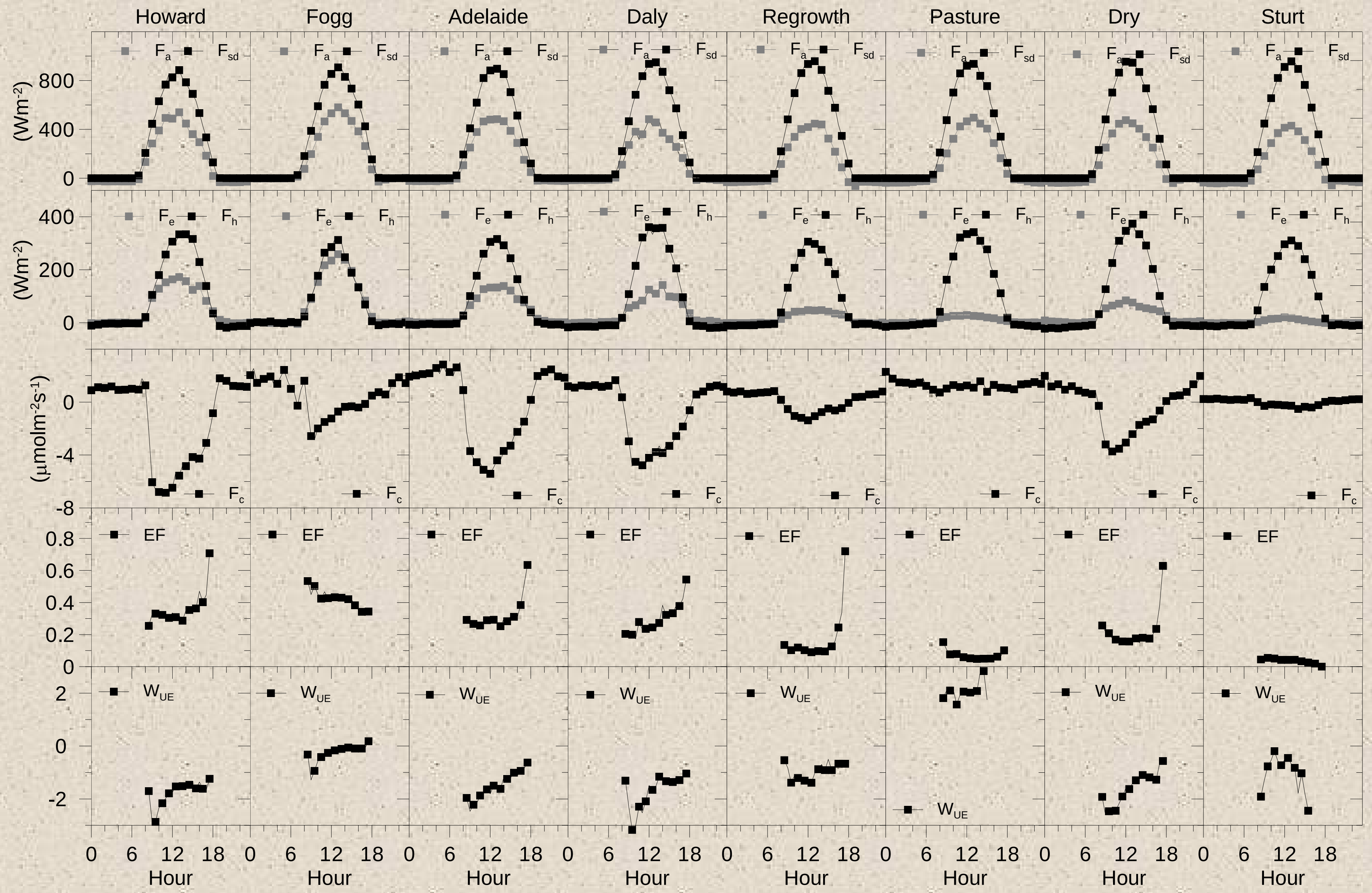
- CABLE parameter set
  - V_{cmax}, r_{p20}, r_{s20}, β, α, a_1, G_0, ...
- Wang et al, 2011
  - Maybe estimate 4 from data
- How do we constrain the parameters?
  - Constant values
  - Use other data
    - Hydrological
    - GPP (remote sensing, inventory)
  - Unconstrained

Why Can’t We Use Leaf Level Values?

- We may but we shouldn’t assume we can.
- McNaughton (1994), Raupach (1995), Raupach (1998)
  - Penman-Monteith equation
  - conservation of scalars (linear averaging of fluxes)
  - same model form at leaf and canopy scales
  - canopy-scale conductances are weighted averages of leaf-scale conductances

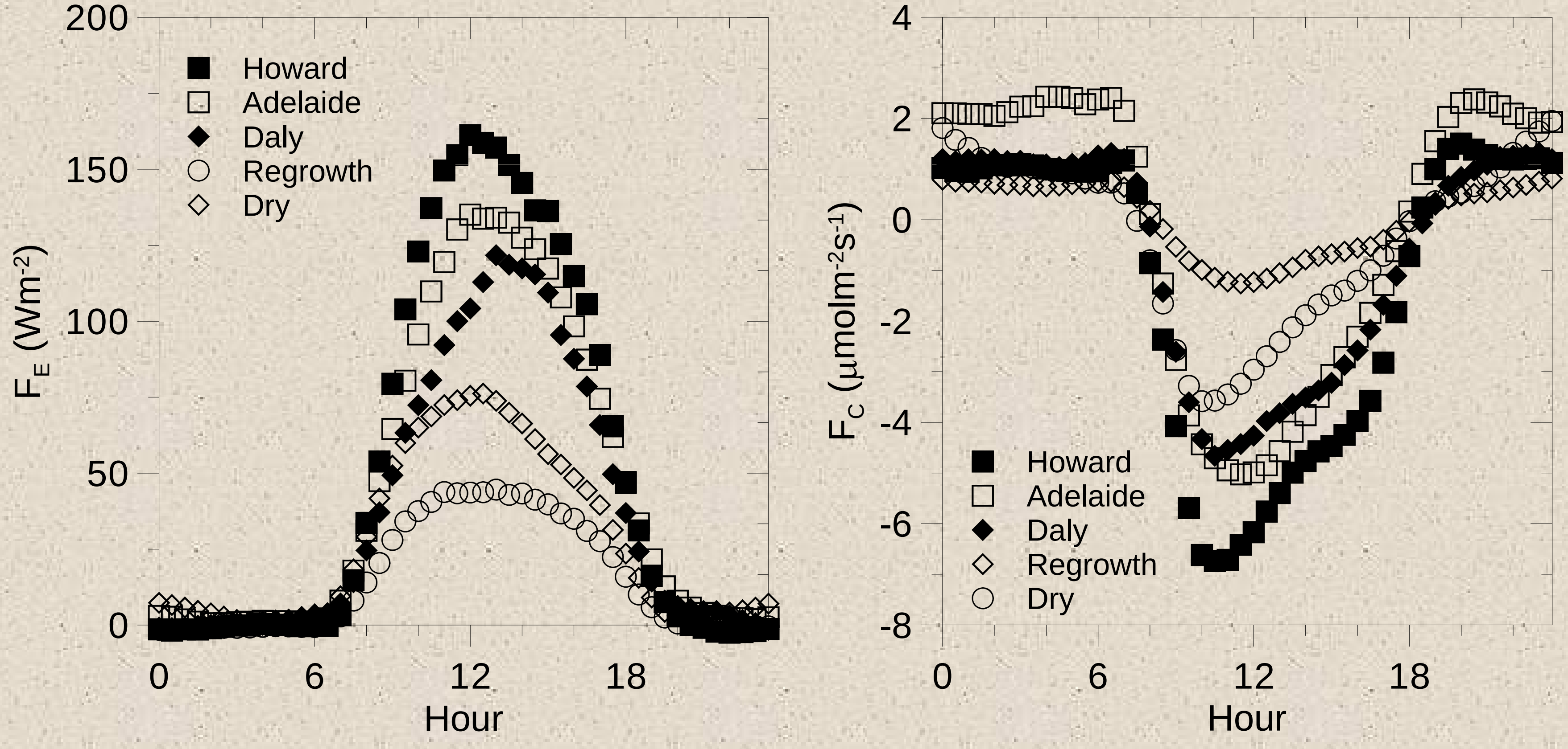
A Case Study of Spatial Variability

- 8 NATT sites
  - Howard, Fogg, Adelaide, Daly, Regrowth, Pasture, Dry, Sturt
- Late dry season September - October 2008
  - no C4 activity, only C3 trees
  - soil evaporation and respiration small
- Two questions:
  - What is the extent of the spatial variability in CO_2 and H_2O fluxes?
  - What are the main drivers of the spatial variability?

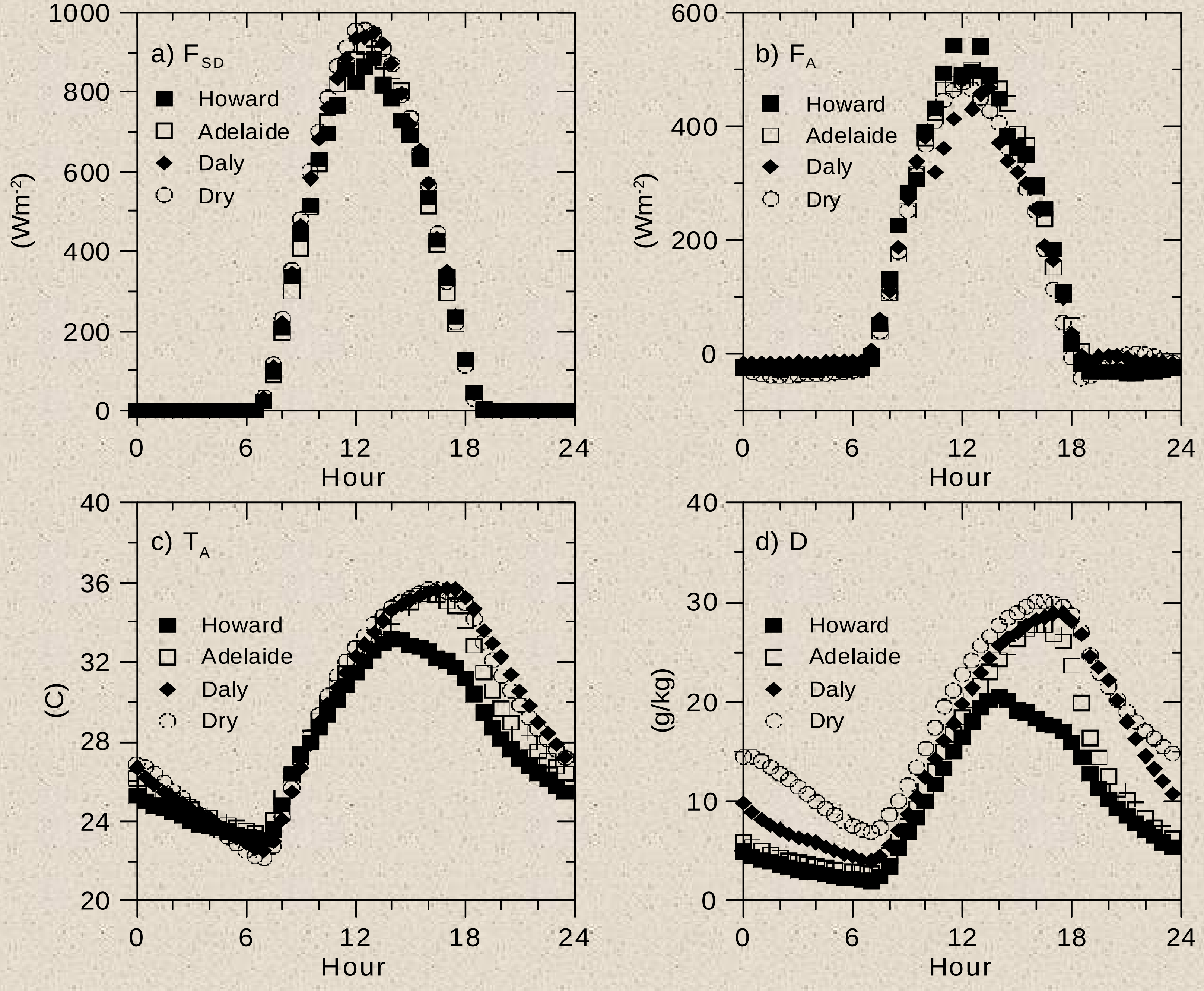


Howard
Fogg
Adelaide
Daly
Regrowth
Pasture
Dry
Sturt
F_a
F_{sd}
(Wm^{-2})
800
400
0
F_e
F_h
(Wm^{-2})
400
200
0
$(\mu mol m^{-2} s^{-1})$
0
-4
-8
F_c
EF
0.8
0.6
0.4
0.2
0
W_{UE}
2
0
-2
0
6
12
18
Hour

Site	MAP mm	Lai	ET mm/day	GPP $gCm^{-2}d^{-1}$	Re $gCm^{-2}d^{-1}$	NEE $gCm^{-2}d^{-1}$
Howard	1714	1.1±0.1	1.8±0.3	-2.9±0.4	1.8±0.1	-1.1±0.4
Fogg	1714	1±0.1	2.5±0.7	-1.5±0.4	2.3±0.2	0.8±0.5
Adelaide	1532	0.7±0.1	1.6±0.6	-2.4±0.4	1.7±0.1	-0.7±0.4
Daly	1170	0.9±0.1	1.4±0.2	-2.2±0.5	1.7±0.1	-0.5±0.5
Regrowth	1170	0.1	0.6±0.1	-0.8±0.2	0.9±0.1	0.2±0.2
Pasture	1170	0	0.3±0.1	0.1±0.2	1.4±0.5	1.3±0.6
Dry	850	0.6±0.1	0.9±0.1	-1.9±0.3	1.9±0.2	0.0±0.4
Sturt	535	0	0.1±0.1	0.2±0.4	0.3±0.3	0.1±0.6



200
150
100
50
0
F_E (Wm^{-2})
Howard
Adelaide
Daly
Regrowth
Dry
0
6
12
18
Hour
4
2
0
-2
-4
-6
-8
F_C ($\mu molm^{-2}s^{-1}$)
Howard
Adelaide
Daly
Regrowth
Dry
0
6
12
18
Hour



a) F_{SD}
Howard
Adelaide
Daly
Dry
(Wm-2)
Hour
b) F_A
(Wm-2)
c) T_A
(C)
d) D
(g/kg)

Plant Response to D

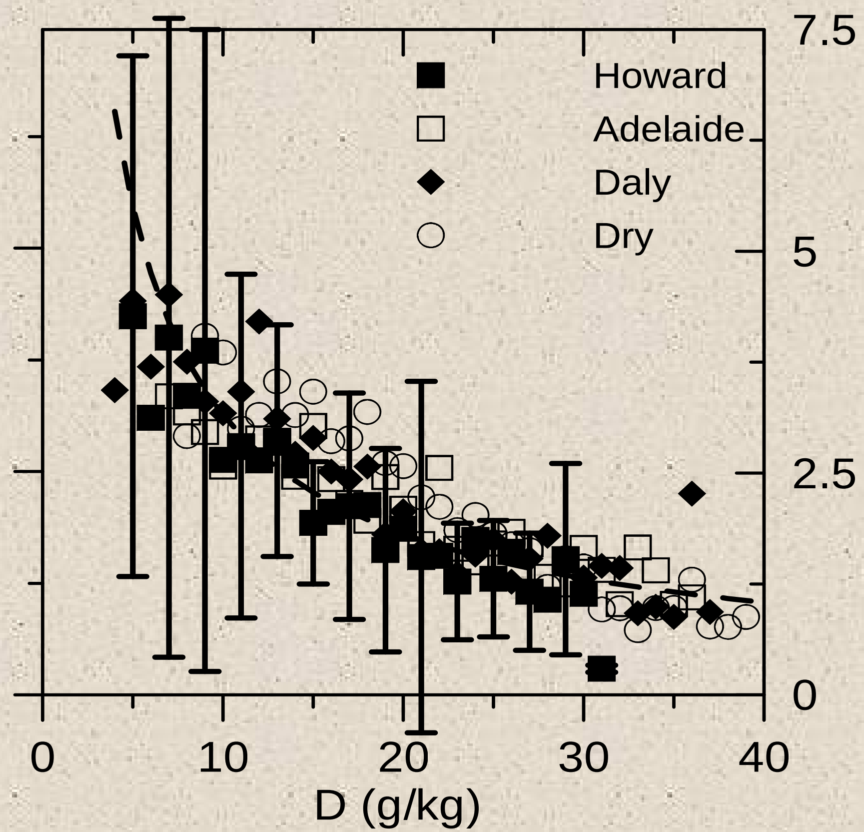
$$A = g_s\left(c_a - c_i\right) = g_s c_a\left(1 - c_i/c_a\right)$$

$$E = 1.6 g_s\left(q_s(T_{leaf}) - q_a\right)$$

$$W_{UE} = \frac{A}{E} = \frac{c_a\left(1 - c_i/c_a\right)}{1.6D} \propto \frac{1}{D}$$

$W_{UE} \propto D^{-0.8\pm0.2}$

No systematic difference between sites



Form of the D Response

1) Lasslop et al, 2010

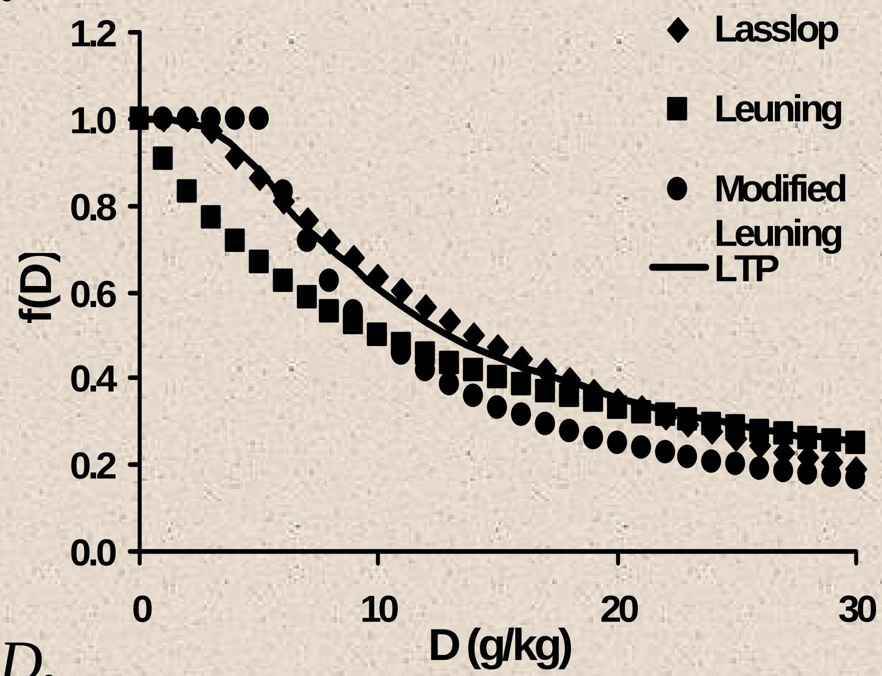
$$f\left(D\right)=\begin{cases}1, D<D_0\\ \exp(-k(D-D_0)), D\geq D_0\end{cases}$$

2) Leuning

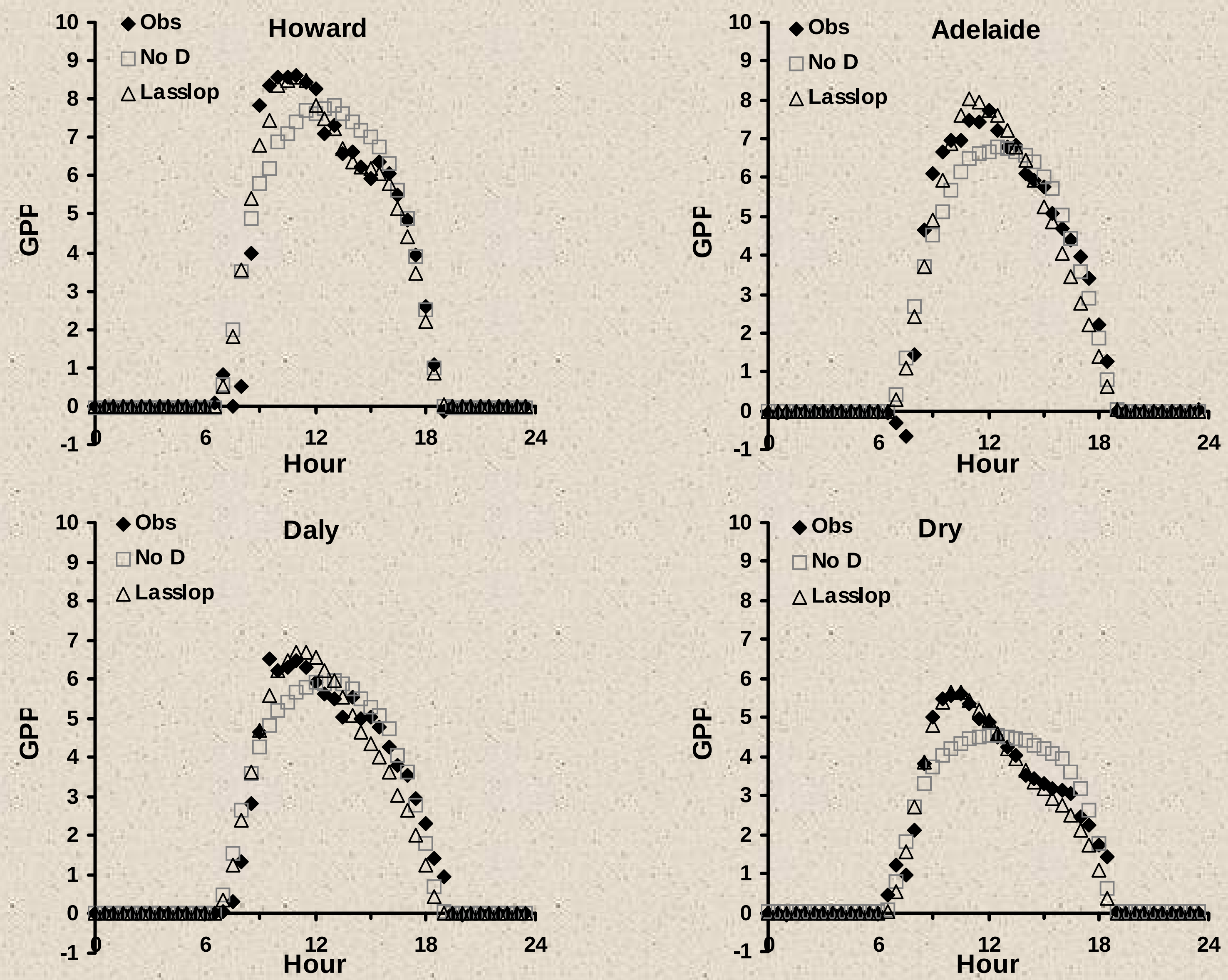
$$f\left(D\right)=\frac{1}{\left(1+D/D_0\right)}$$

3) Modified Leuning

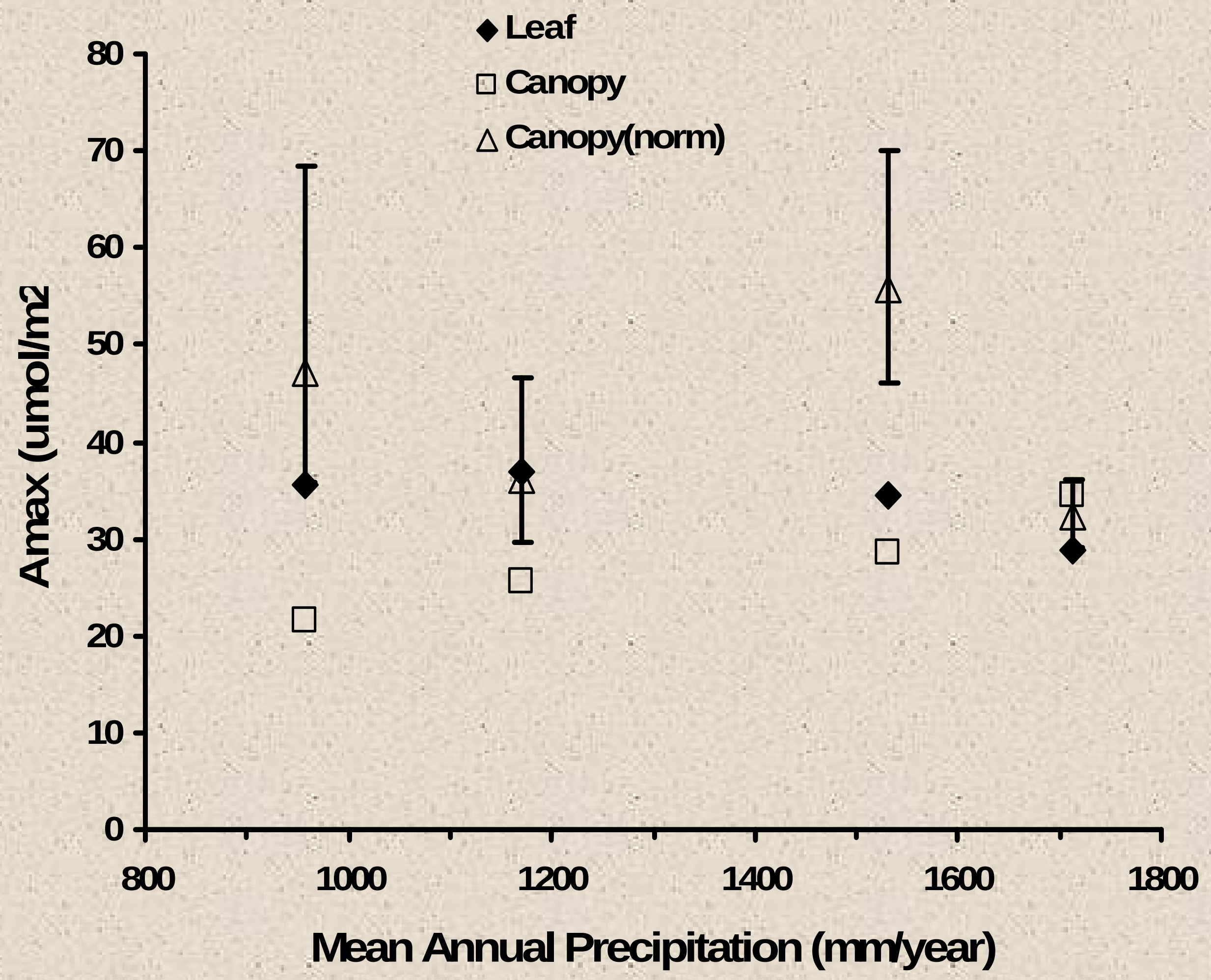
$$f\left(D\right)=\begin{cases}1, D<D_0\\ \dfrac{1}{\left(1+\left(D-D_0\right)/D_0\right)}, D\geq D_0\end{cases}$$



Light Use Function & GPP

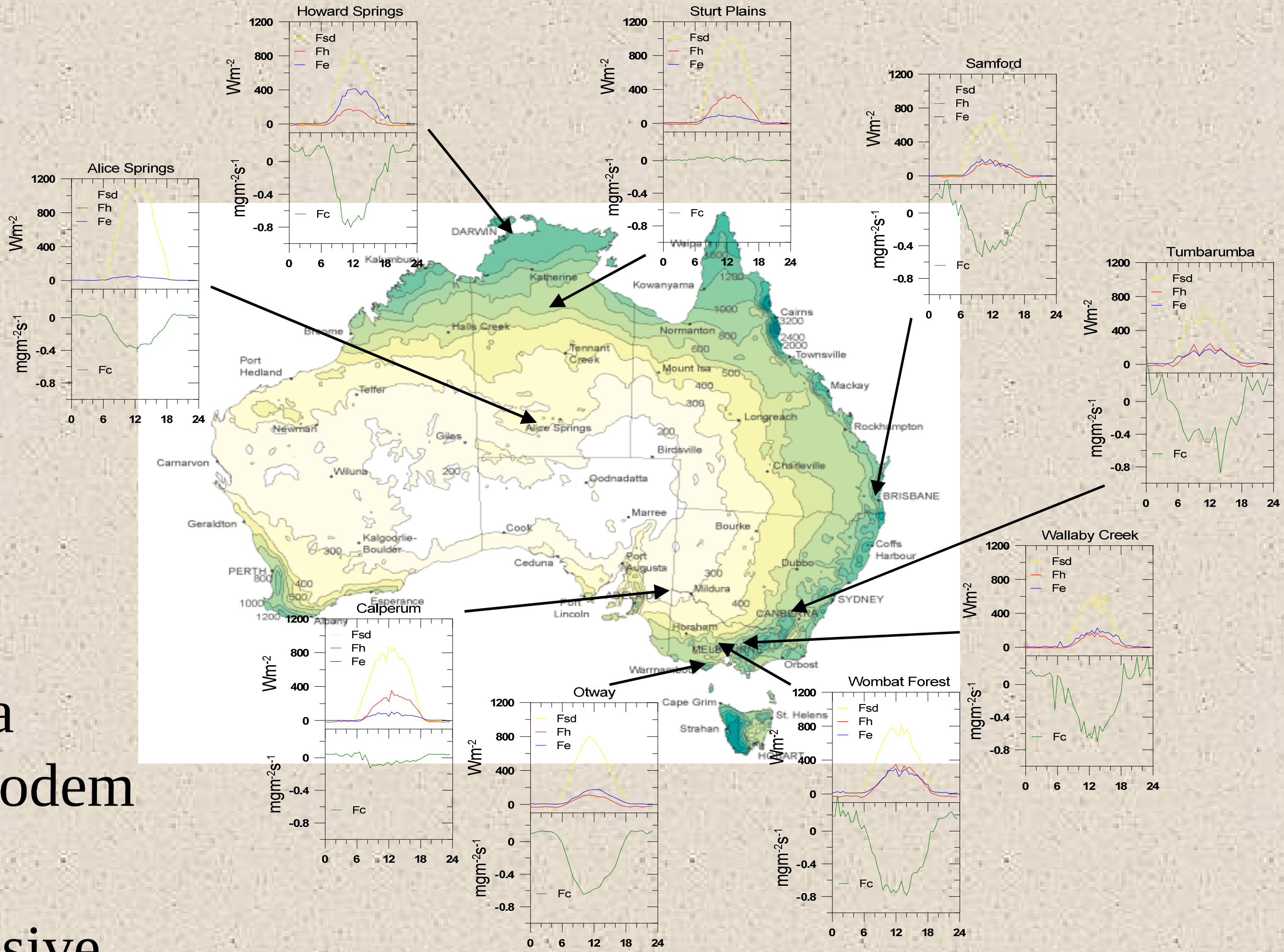


A_{max}: Leaf and Canopy Values



Conclusions

- Main driver of spatial variability between the NATT sites in the late dry season is ecosystem type and land use.
- Humidity deficit is the only meteorological driver with a significant gradient along the transect.
- Plant response to D shows no significant change with MAP.
- Canopy-scale Amax normalised by Lai is consistent with leaf-scale measurements.
  - Largest uncertainty is due to uncertainty in Lai.



- 9 sites with data collection by modem
- 1/11/2010 to 7/11/2010 inclusive
- Basic QC only (not rotated, no gap fill, no u* threshold)