Great Western Woodlands: Response of fluxes in old-growth woodlands to annual rainfall variability.

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Terrestrial Ecosystem Research Network

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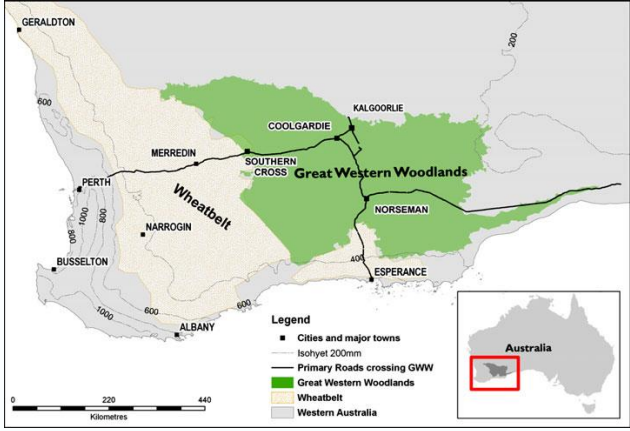
Summary

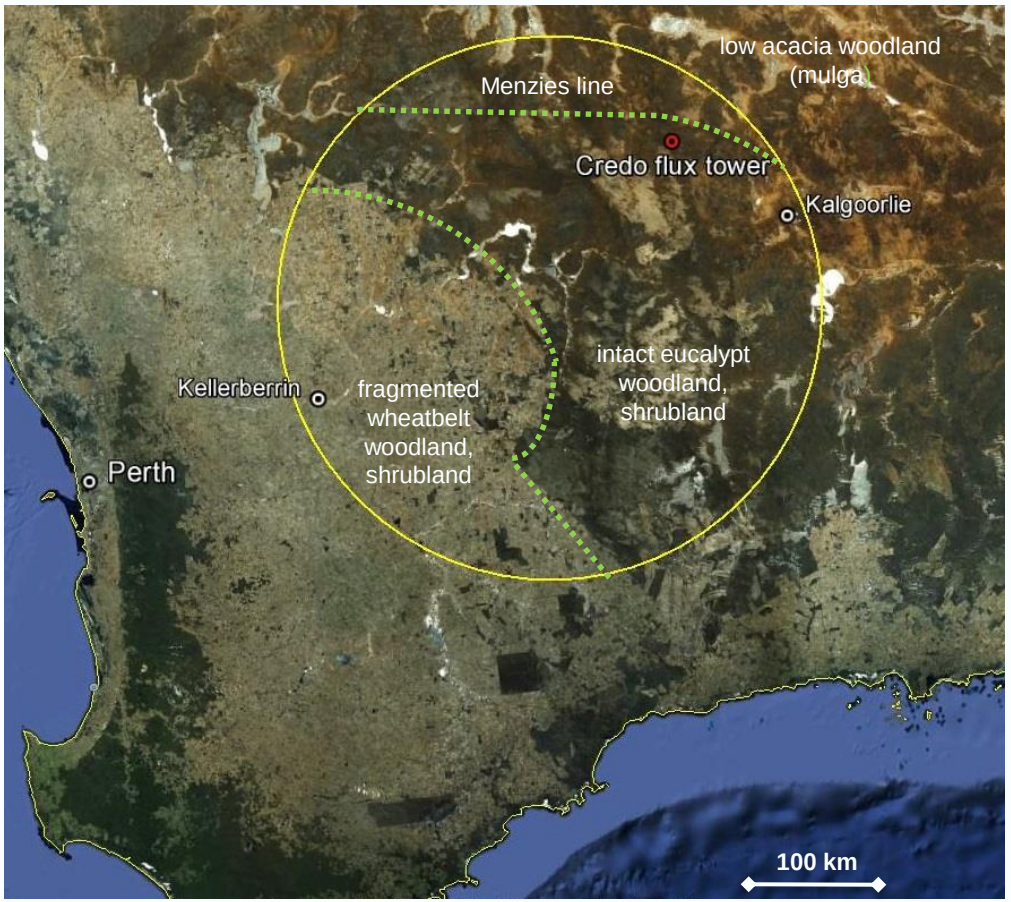
- The old-growth woodland is rainfall dependent and is either a sink or source of carbon depending on above- or below-average rainfall.
- Respiration recovers sooner than GPP from drought resulting in the site remaining a net source for a prolonged period after drought.
- VPD is a significant limitation on stomatal conductance and carbon uptake after mid-morning.
- Respiration from EC (OzFluxQC) agrees well with field data, and is most influenced by seasonal temperature.

Great Western Woodlands



- World's largest intact temperate woodland.
  - 16M hectares or three times the size of Tasmania.
- World's most arid woodland.
  - 20m tall trees persisting with <300mm annual rainfall.
- Mega-diverse. Contains:
  - 20% of Australia's plant species.
  - 30% of Australia's eucalypt species.

The Great Western Woodlands TERN supersite



Credo station

- 110 km NW Kalgoorlie / 630km from Perth.
- Ex sheep-station managed for conservation by Department of Parks and Wildlife (DPaW) WA.
- New field studies centre jointly funded by DPaW, TERN and Goldfields Environmental Management Group.
- 260mm mean annual rainfall; uniform-summer dominant.
- At the northern extent of GWW, less than 100kms south of ‘Menzies line’ that separates eucalypt woodland from mulga woodland.
- Flux tower and 1 ha plots in old growth woodlands 35km from Credo facilities.
- 'homogeneously heterogeneous' vegetation for at least 4km radius.

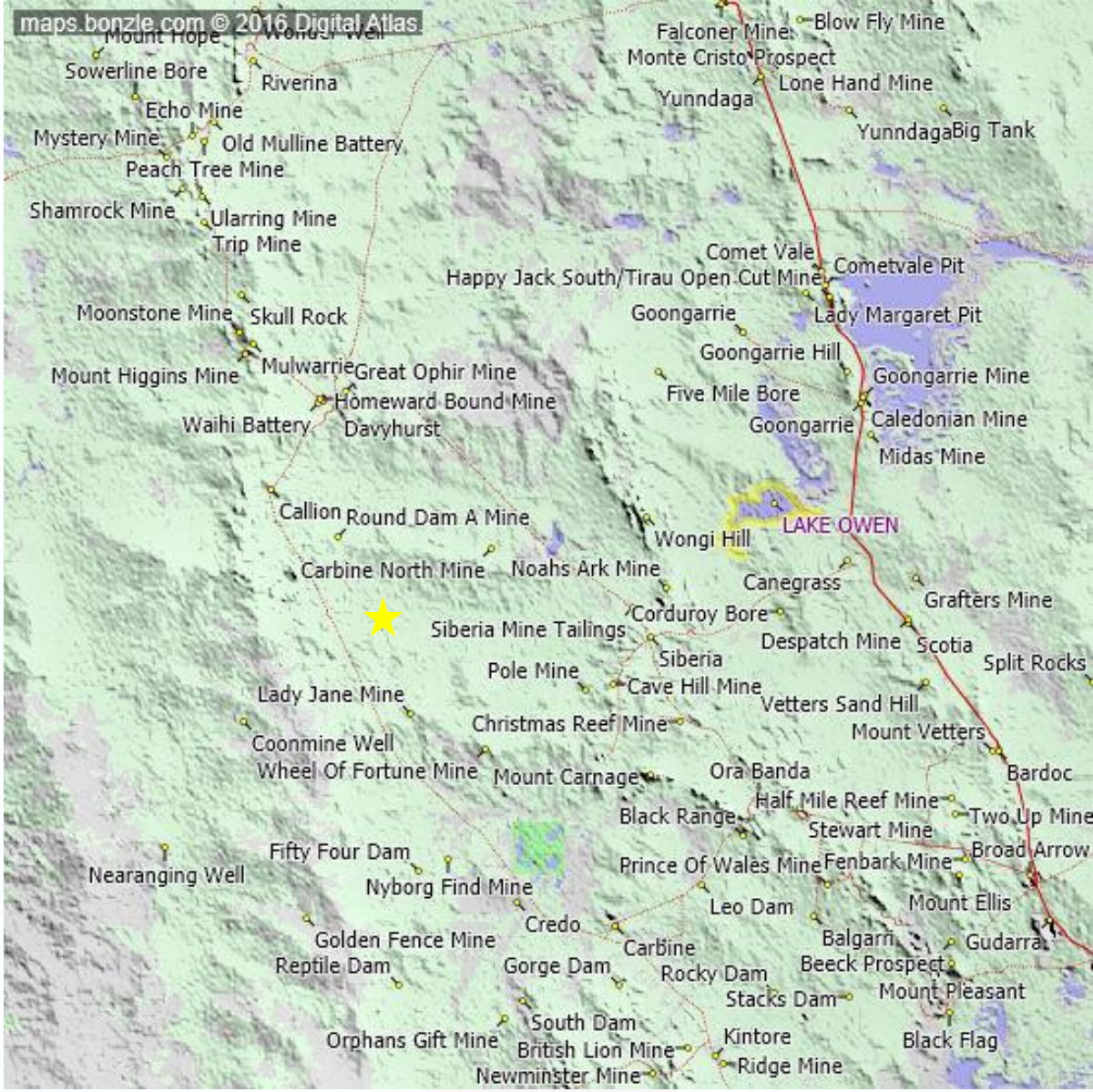
Sparse, old-growth woodland on floodplain.

Operational since December 2012.

•Saltbush, bluebush and eremophila understorey.

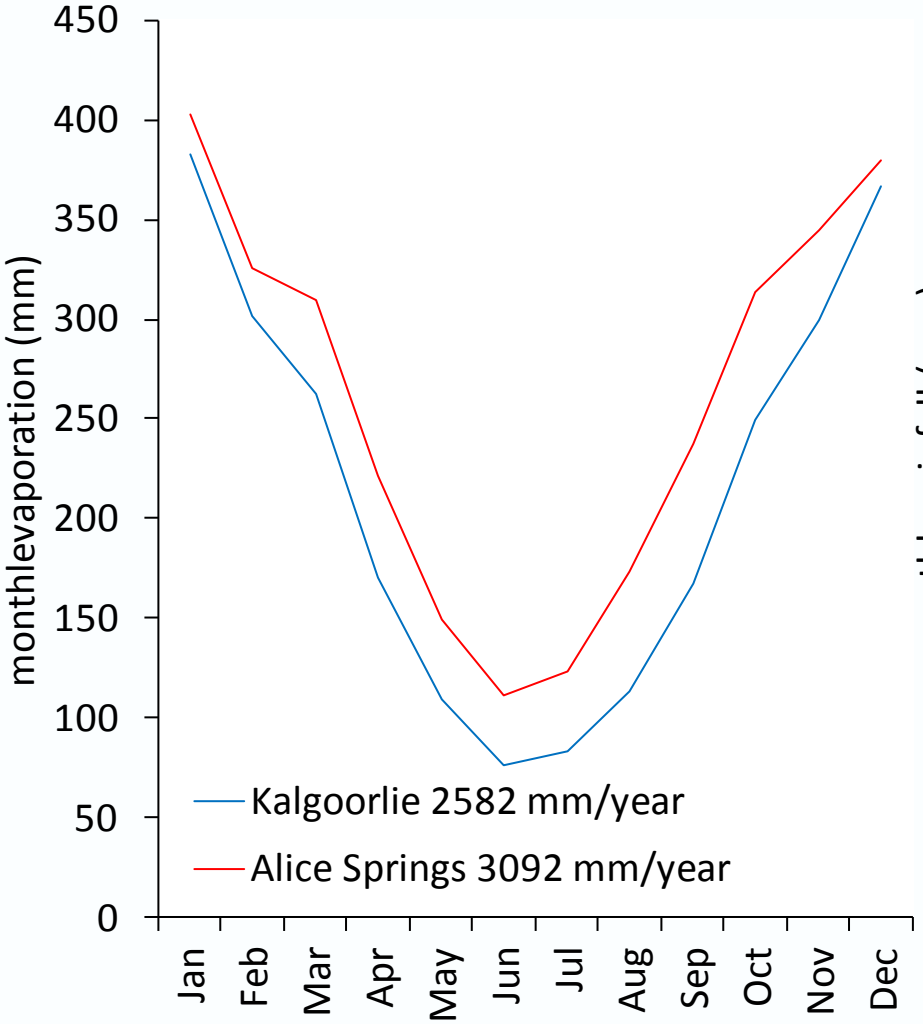
36 m tall tower; 18 m tall vegetation.

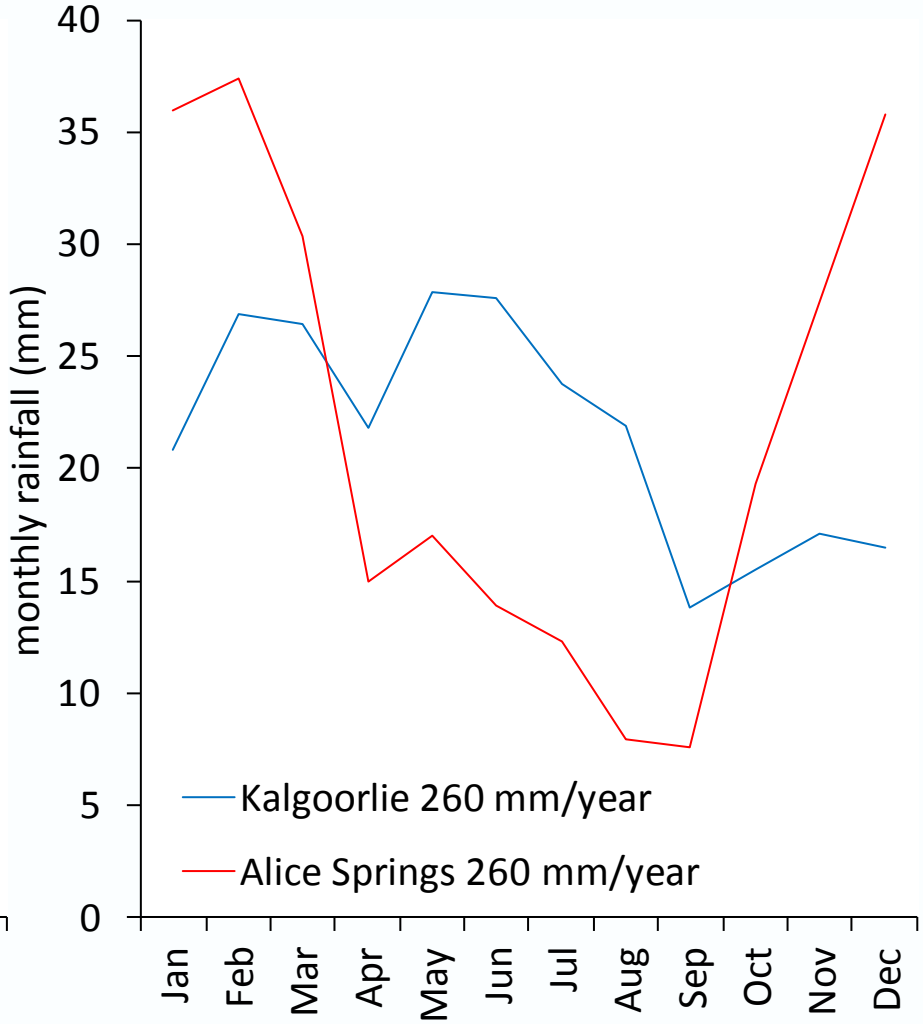
Local context



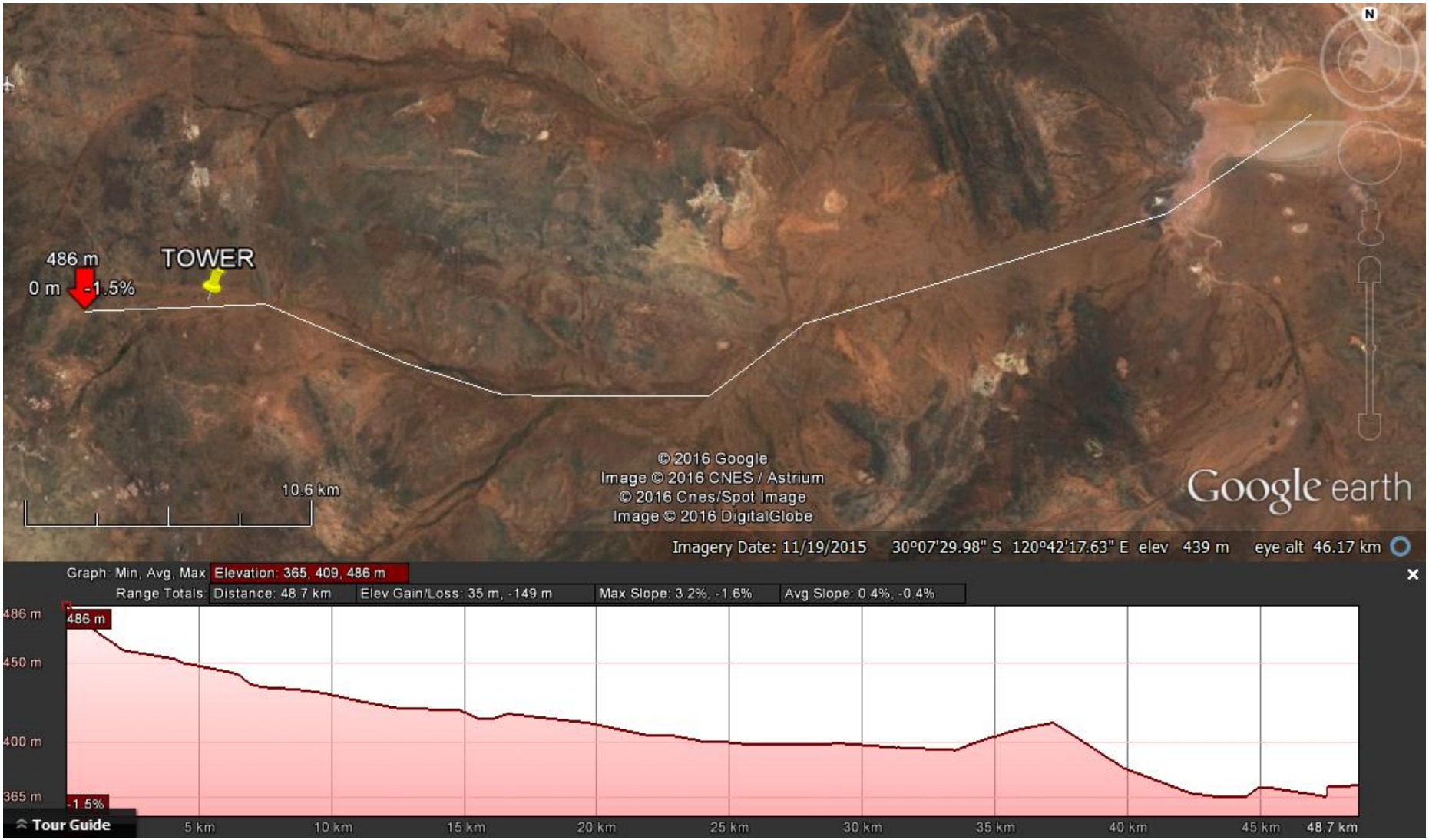
100 kms

Climate


monthlevaporation (mm)
450
400
350
300
250
200
150
100
50
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Kalgoorlie 2582 mm/year
Alice Springs 3092 mm/year


monthly rainfall (mm)
40
35
30
25
20
15
10
5
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Kalgoorlie 260 mm/year
Alice Springs 260 mm/year

Site terrain and cold air drainage.



Soils

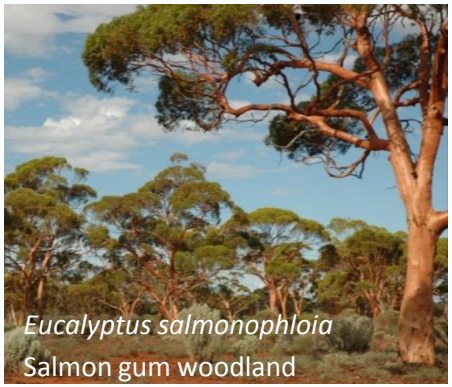
- 6-10m red clay (transported overburden) overlying >30m of in-situ weathered material (more clays). Bulk density 1.7-1.9 g/m^3 in the top 1.5m.
- Groundwater 30-45m deep and highly saline (48 mS/cm).

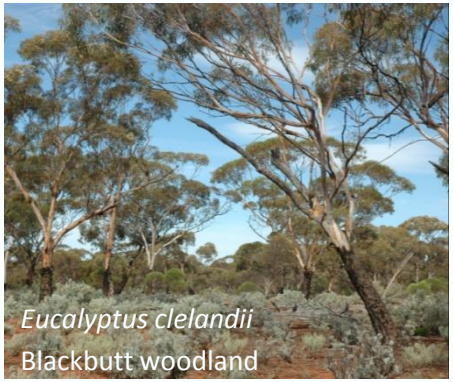
Depth	Clay	Silt	Sand	Total Carbon	Calcium Carbonate	EC	pH Level (CaCl2)	Total Nitrogen	Total Phosphorus	Total Sulphur	Exc. Calcium	Exc. Magnesium	Exc. Potassium	Exc. Sodium
cms	%	%	%	%	%	dS/m	pH	%	mg/Kg	mg/Kg	meq/100g	meq/100g	meq/100g	meq/100g
0-5	25	14	61	0.4	0.4	0.09	7.2	0.02	138	2	9.8	6.1	1.2	0.5
10-15	33	16	51	0.5	3.8	0.19	8.1	0.04	103	3	16.0	7.8	1.0	2.4
25-30	31	24	45	1.2	16.0	1.24	8.4	0.05	124	20	13.6	10.0	0.7	7.7
45-50	38	26	36	0.8	13.7	1.74	8.5	0.03	102	203	10.7	11.6	0.5	11.9
70-75	41	23	36	0.7	11.6	2.23	8.2	0.02	96	498	10.8	12.8	0.6	13.8
100-105	20	2	78	0.4	8.5	3.47	8.1	0.02	61	3340	14.2	9.8	0.4	11.0
145-150	32	15	53	0.5	5.7	1.31	7.5	0.02	45	455	13.9	9.3	0.5	8.1

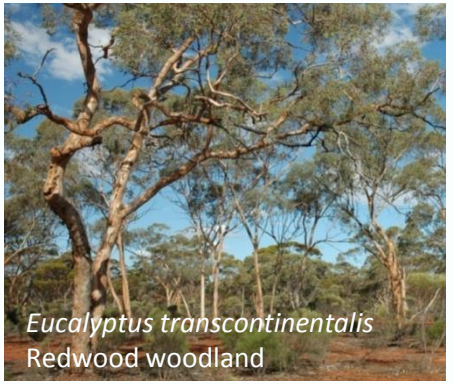
1Ha plot descriptions

Site	basal area m^2/ha	sapwood area m^2/ha	foliage cover	LAI	LA:SA m^2/cm^2
Salmongum	5.0	0.47	0.08	0.31	0.65
Gimlet	5.1	0.51	0.11	0.41	0.80
Redwood	4.9	0.53	0.09	0.26	0.48
Blackbutt	6.6	1.59	0.17	0.47	0.30

Vegetation height 15-20m.





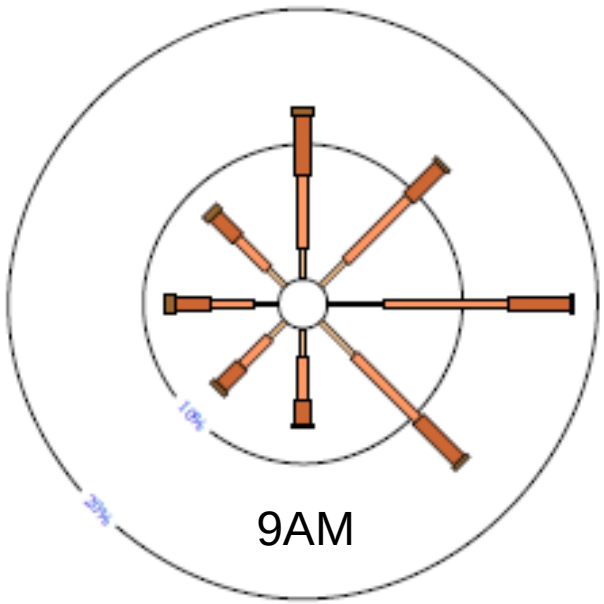


Tower measurements

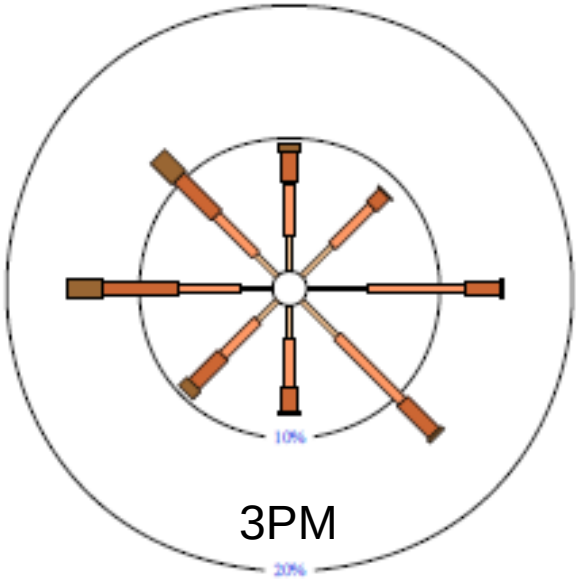
- At 36m: Radiation (CNR4 and NR lite2), carbon, water, heat and momentum fluxes (CSAT3 and LI7500A). Wind speed/direction (WS4), temp/RH (HMP155).
- At 2m: temp/RH (HMP155).
- At 8cm depth: 3*heatflux plates (Middleton CN3).
- Soil moisture at depths: 5, 10, 20, 30, 50, 70, 90, 110-140 cms (CS616).
- Soil temp at depths: 5, 10, 20, 30, 50 cm (CS107).
- No Storage system.

Where does the wind come from?

- CSAT3 points directly south.
- LI-7500A positioned north-east of sonic transducers.
- 30% of data excluded owing to northerly winds



9AM



3PM

N ↑

Other site measurements

At 1Ha plots.

- Annual: DBH (1 sites) and LAI/cover (1), floristics/ground-cover (1).
- Six-monthly: litterfall (4), groundwater depth (2).
- Continuous: band dendrometers (4), overstorey sapflow (2), bird monitoring (2).
- Photopoints, phenocams.

Questions

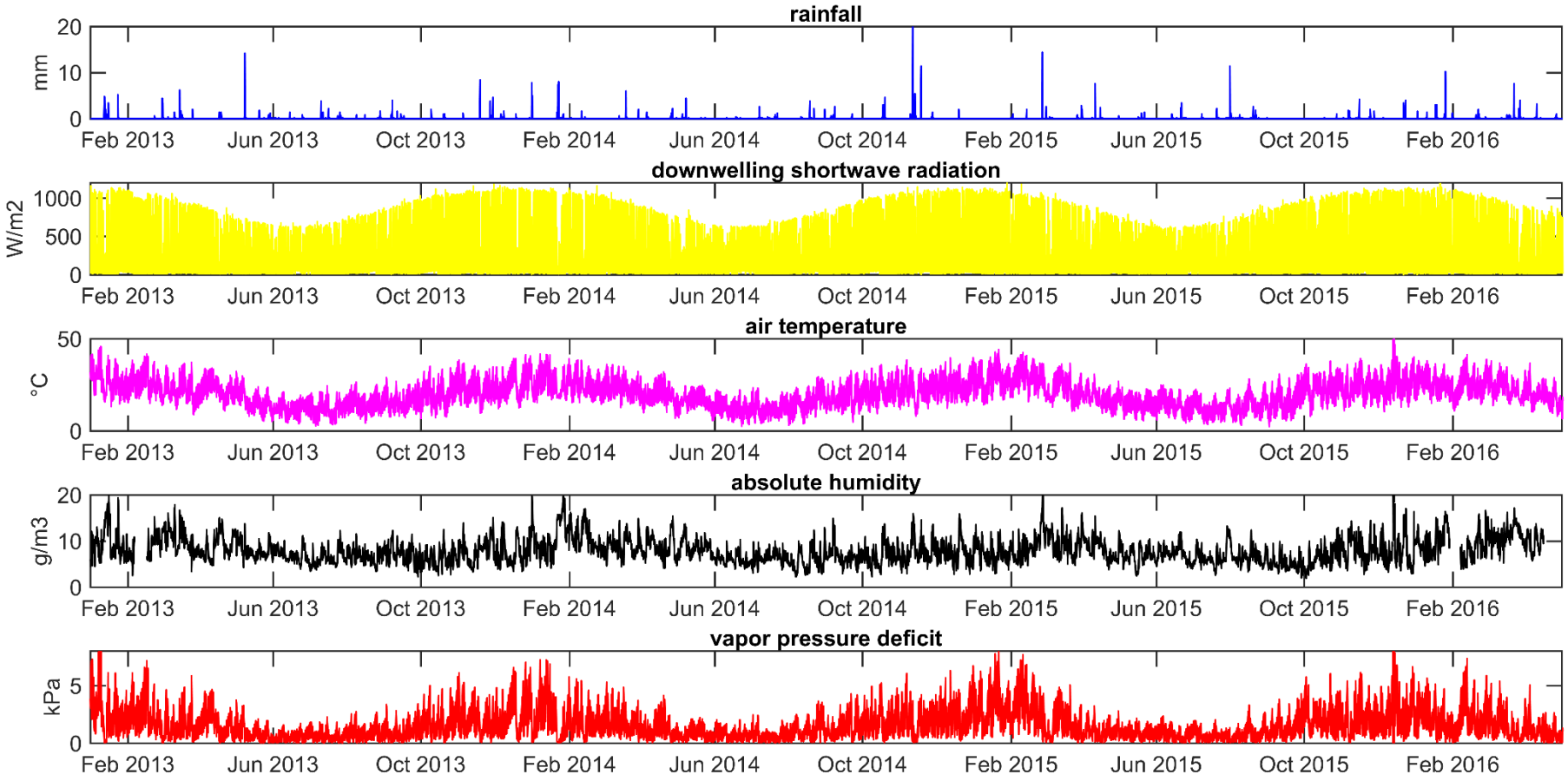
- Are these old-growth woodlands a carbon source or a carbon sink?
- How important are rainfall and VPD as drivers for energy, water and carbon fluxes?
- How does climate variability impact carbon fluxes?

Energy, water and carbon balance. Jan 2013 - May 2016

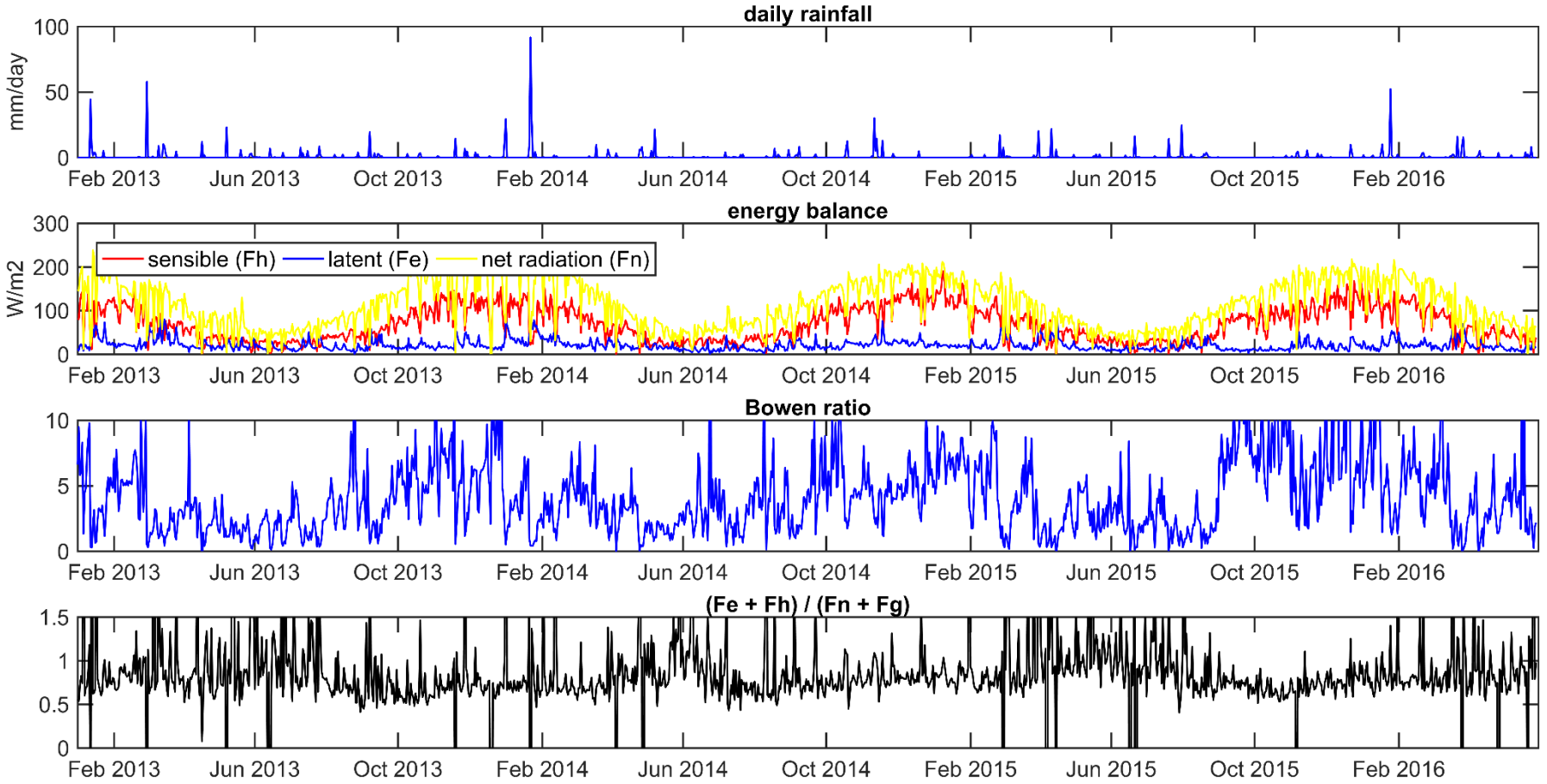
- ET / Precip = 0.83.
- (Fe+Fe) / (Fa) = 0.79.

Years	SAM	Precip	ET	Sws	Fn	Fg	Fh	Fe	(Fh+Fe)/Fa	NEE_LT	ER_LT	GPP_LT
		mm/year	mm/year	frac	W/m2	W/m2	W/m2	W/m2		gC/m2/year	gC/m2/year	gC/m2/year
2013	0.03	351	276	0.20	113	0.5	65	21	0.77	-49	356	406
2014	0.08	378	282	0.18	117	0.6	69	22	0.78	-99	414	513
2015	0.71	208	243	0.14	109	1.1	69	19	0.82	35	291	257
2016	0.93	164	110	0.15	116	-0.5	73	21	0.81	58	196	137
Total		**1102**	**910**							**-56**	**1258**	**1314**

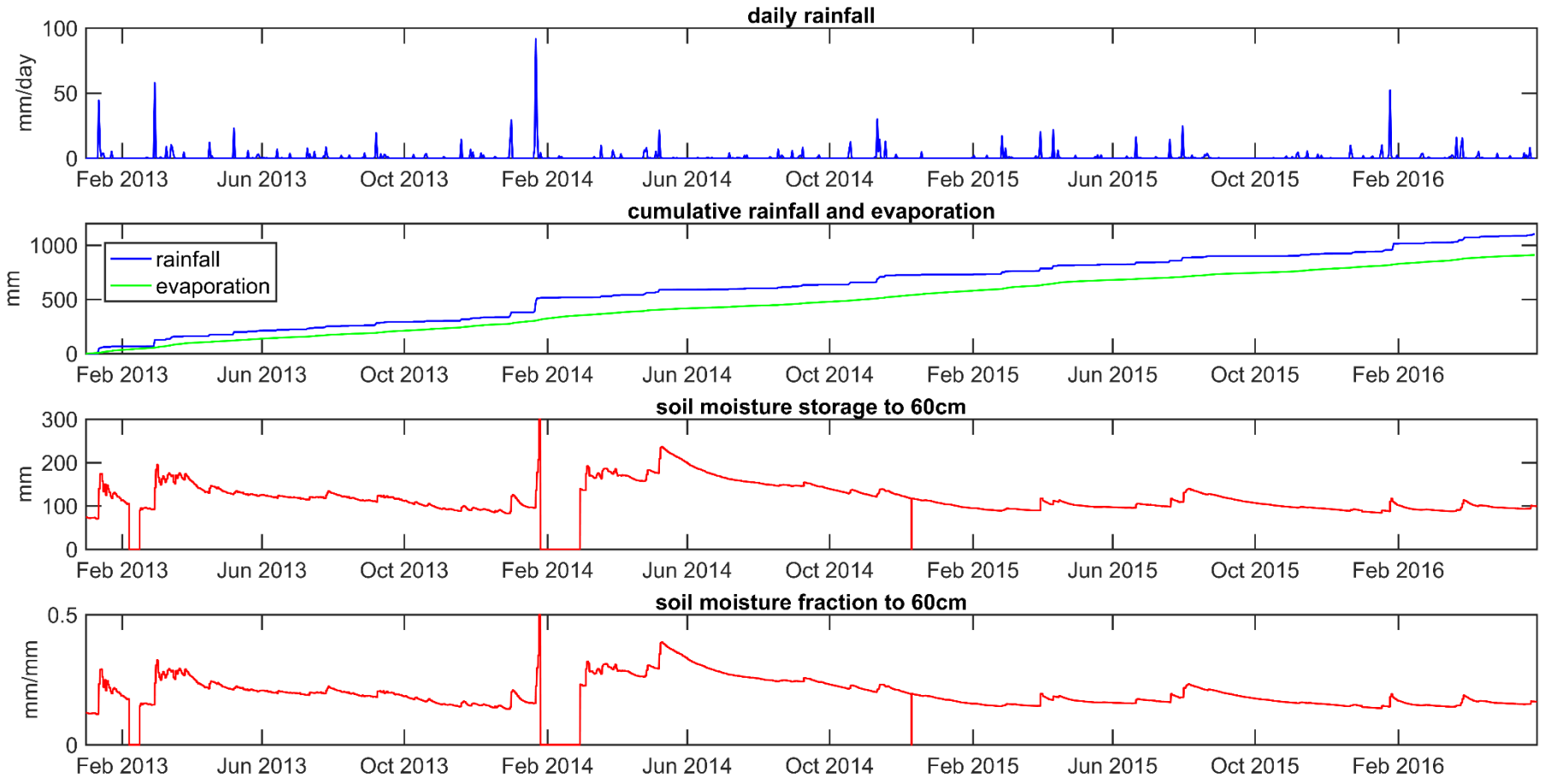
Climate


rainfall
mm
20
10
0
Feb 2013
Jun 2013
Oct 2013
Feb 2014
Jun 2014
Oct 2014
Feb 2015
Jun 2015
Oct 2015
Feb 2016
downwelling shortwave radiation
W/m2
1000
500
0
air temperature
°C
50
0
absolute humidity
g/m3
vapor pressure deficit
kPa
5

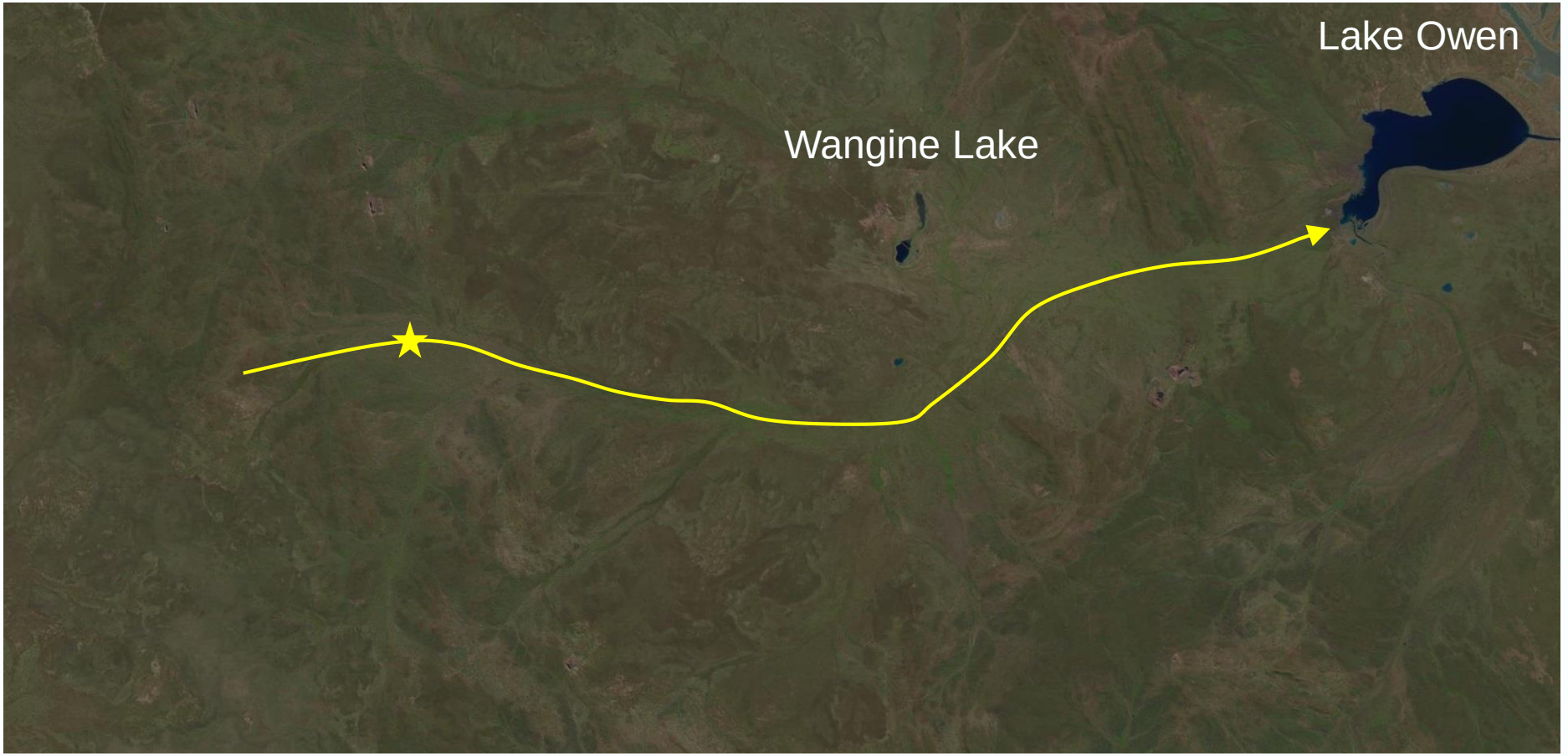
Energy balance



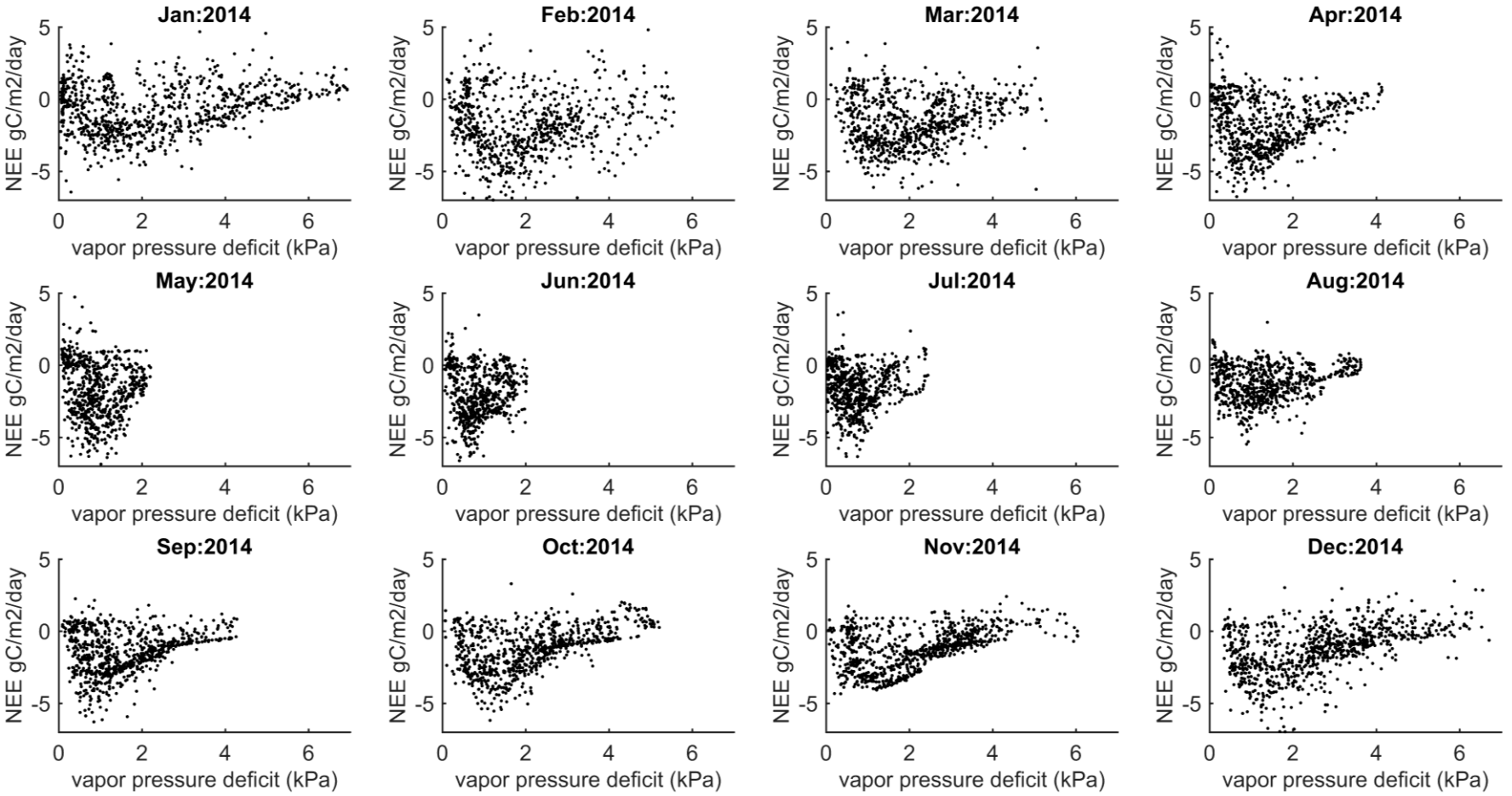
Water balance



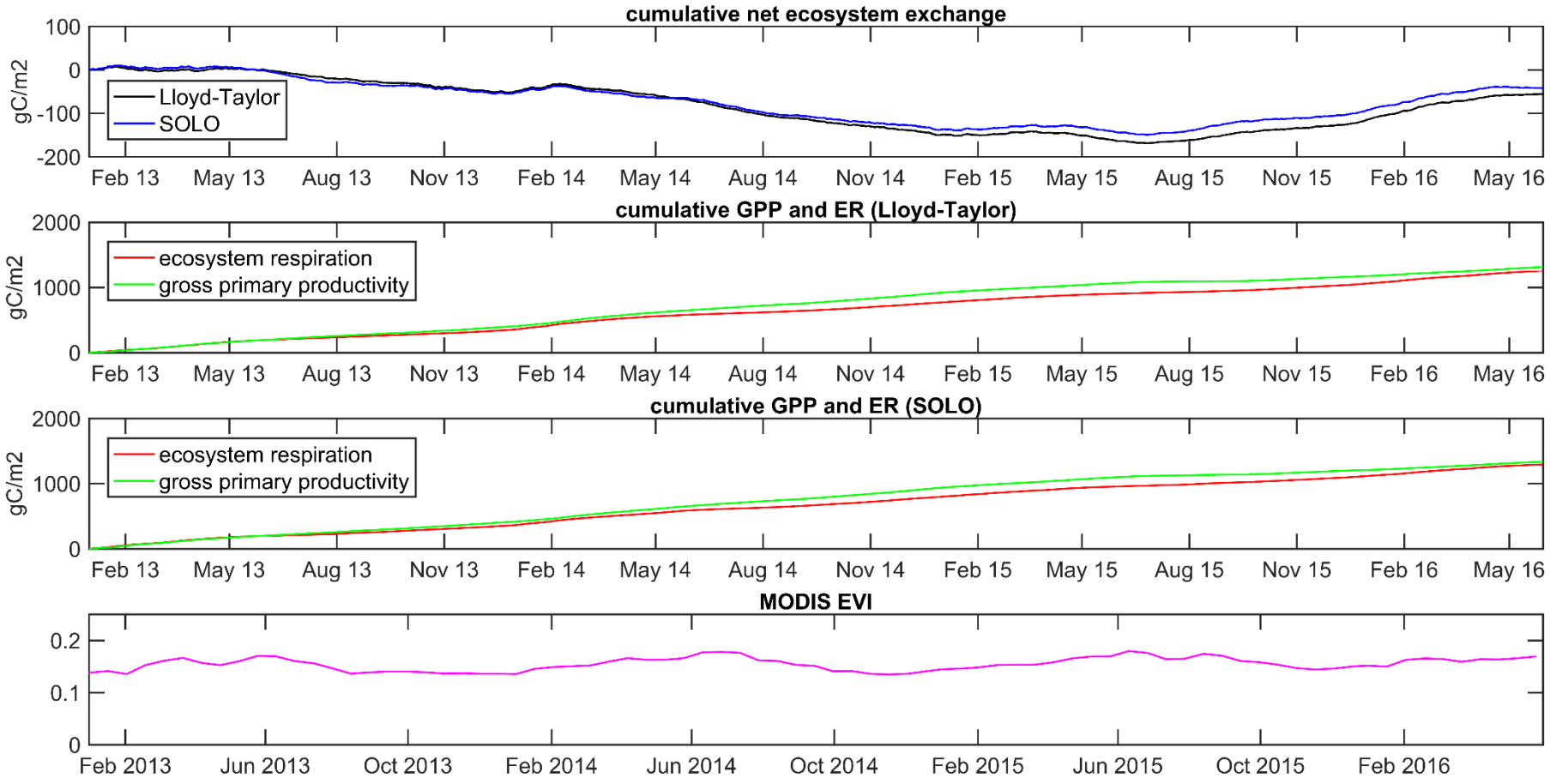
Water balance – runoff?



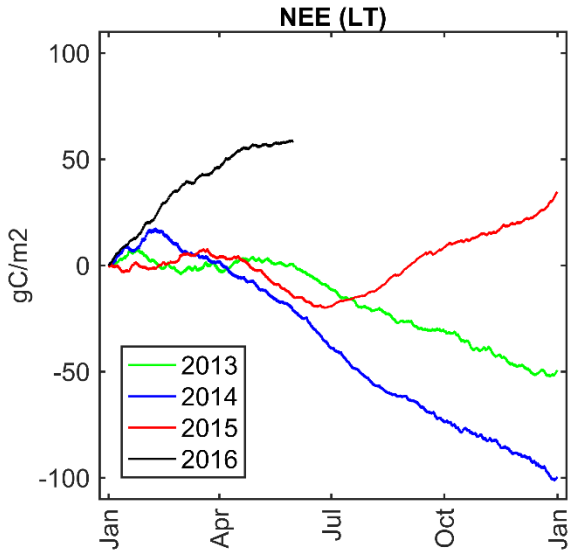
Vapour pressure deficit and gas exchange

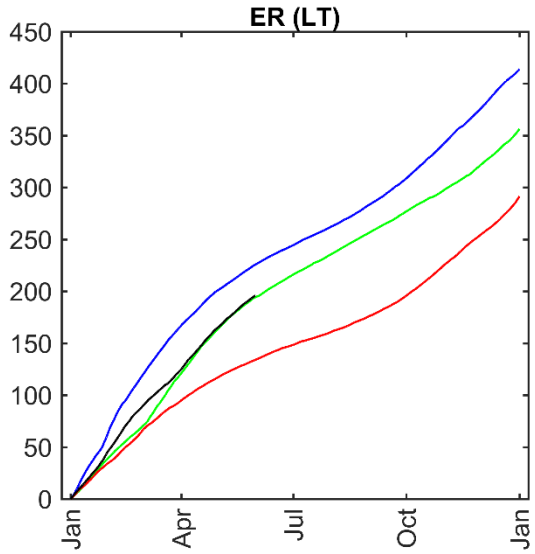


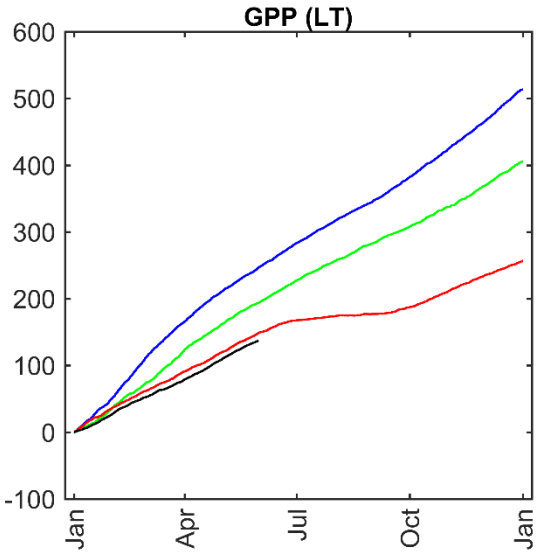
Carbon balance



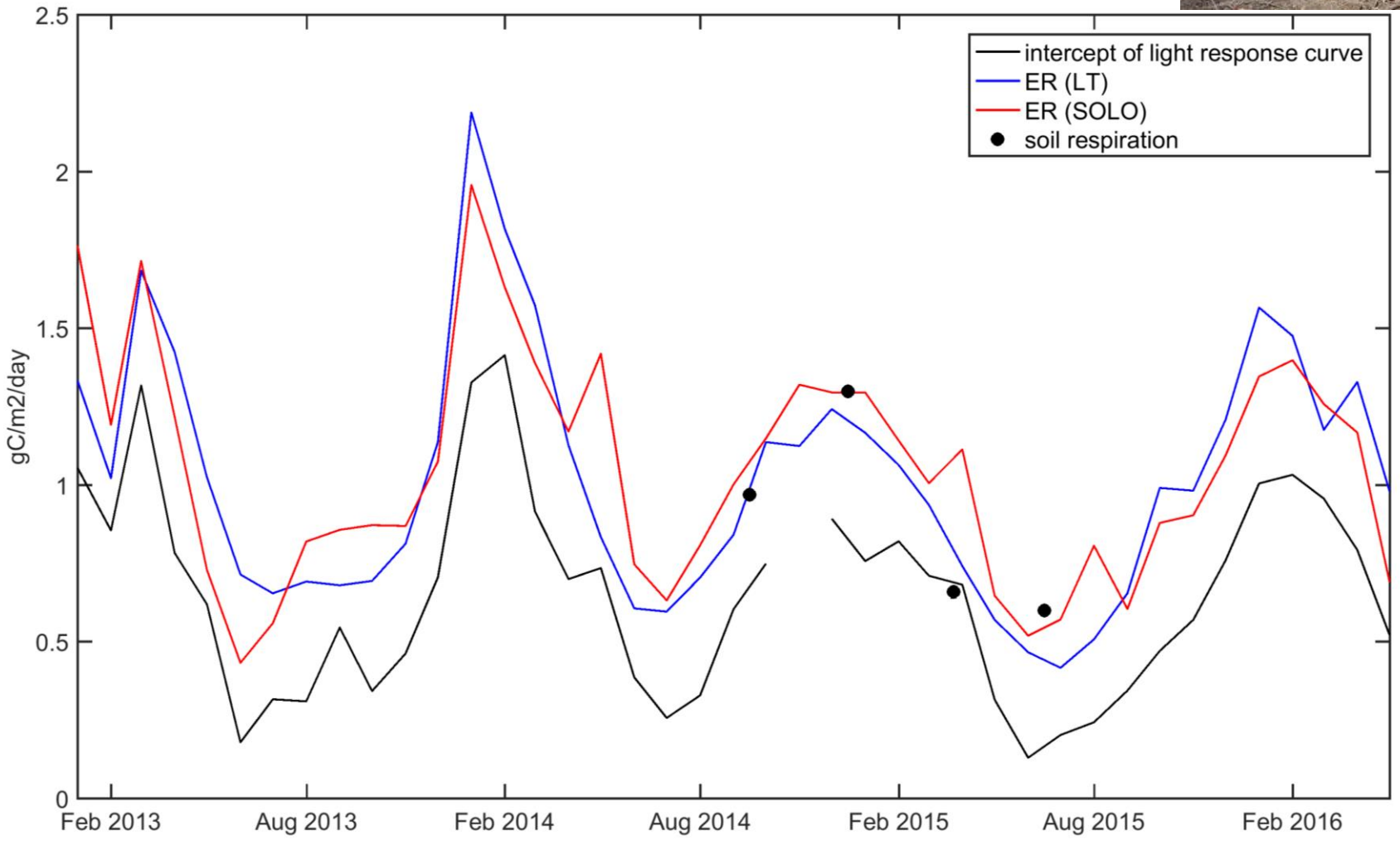
Carbon balance



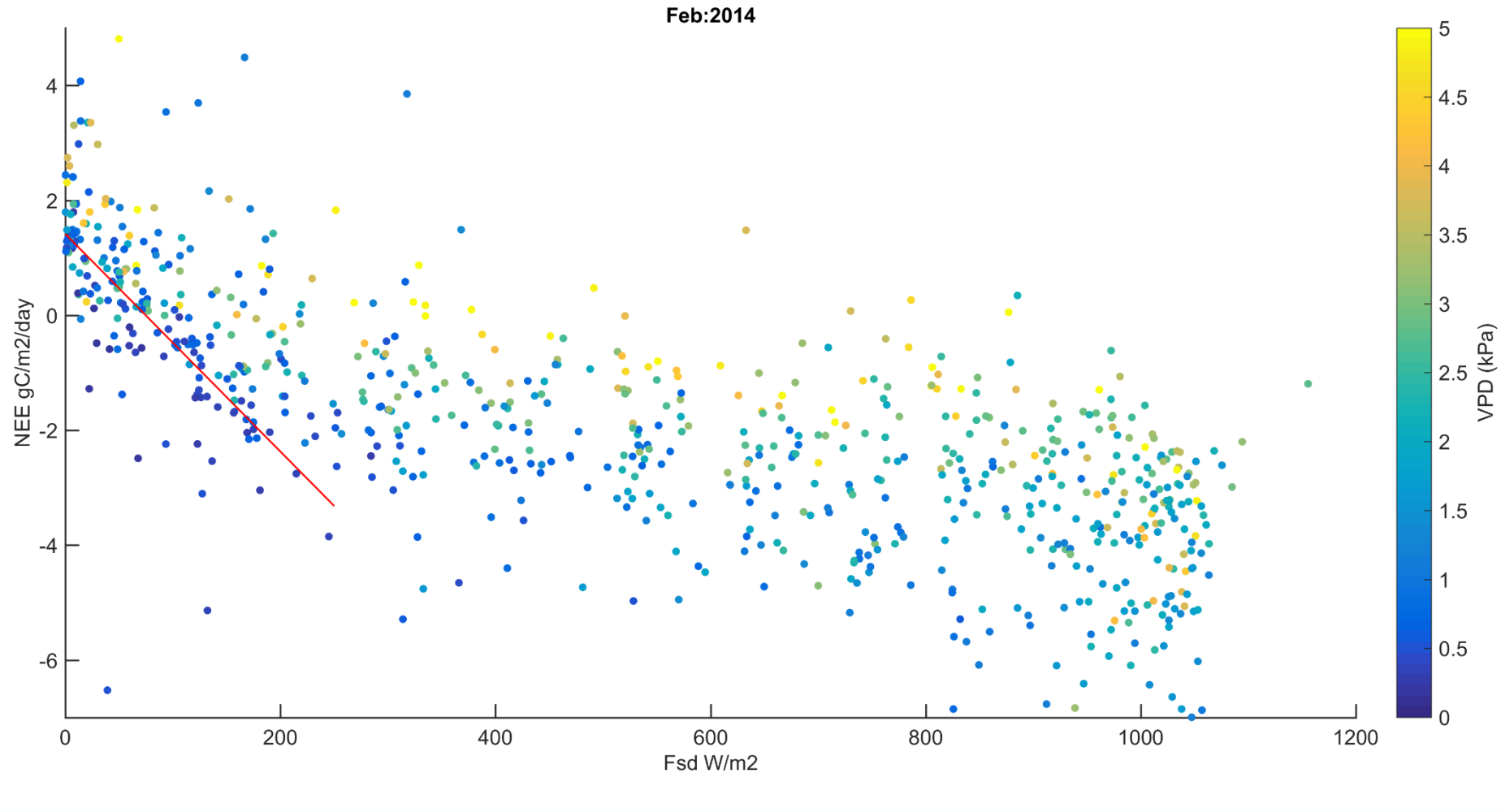




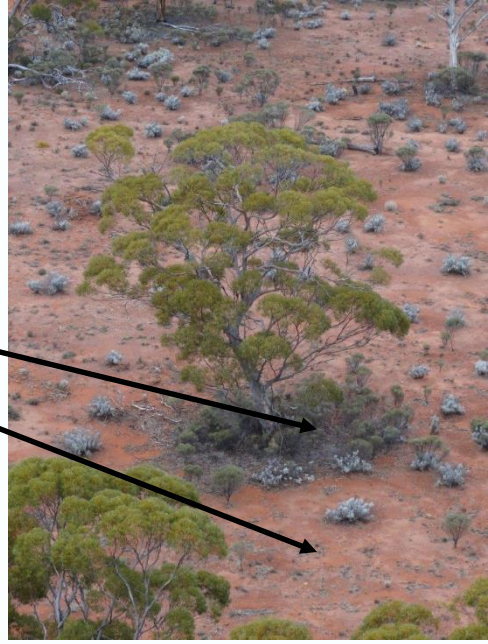
Ecosystem respiration

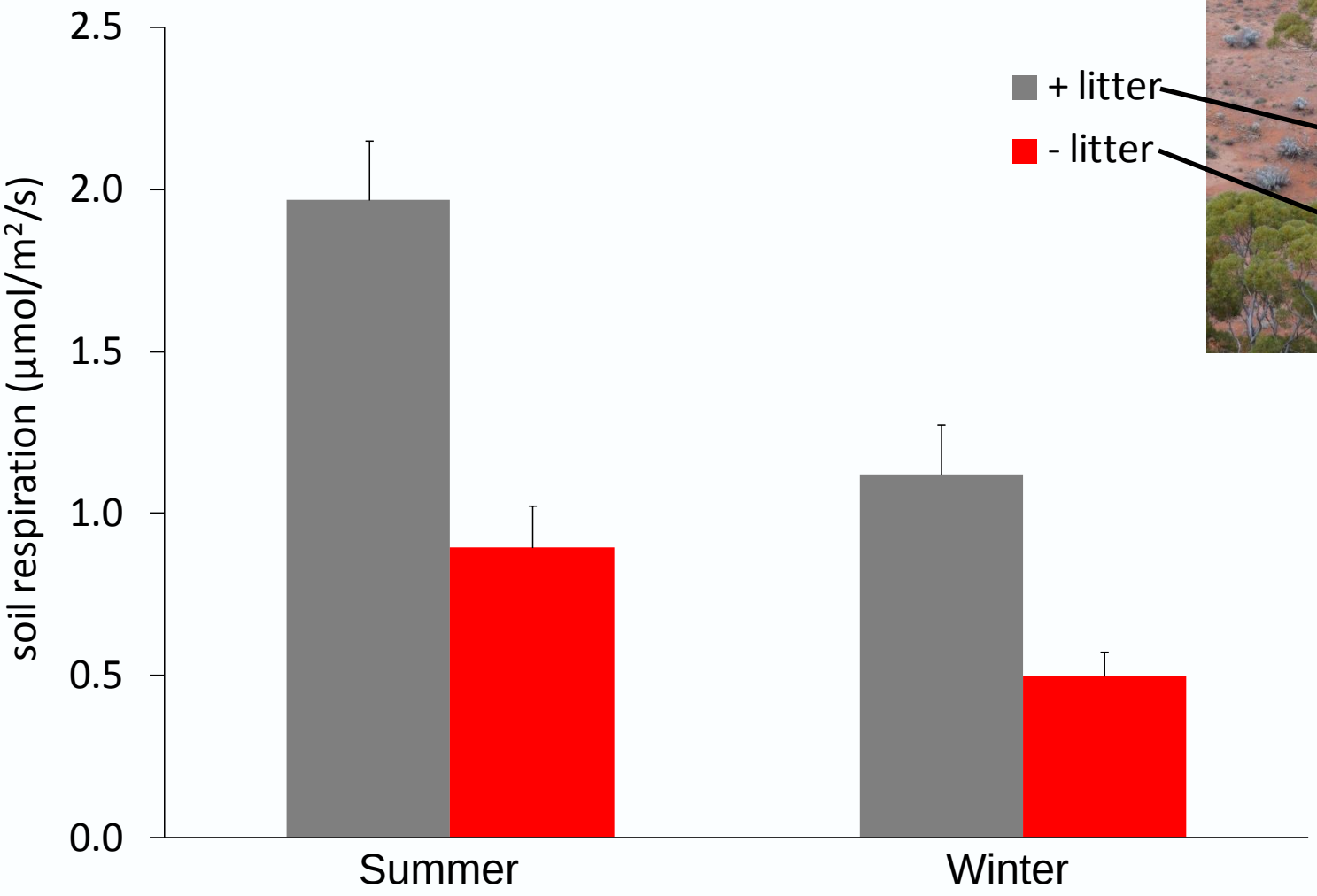


Light response curve

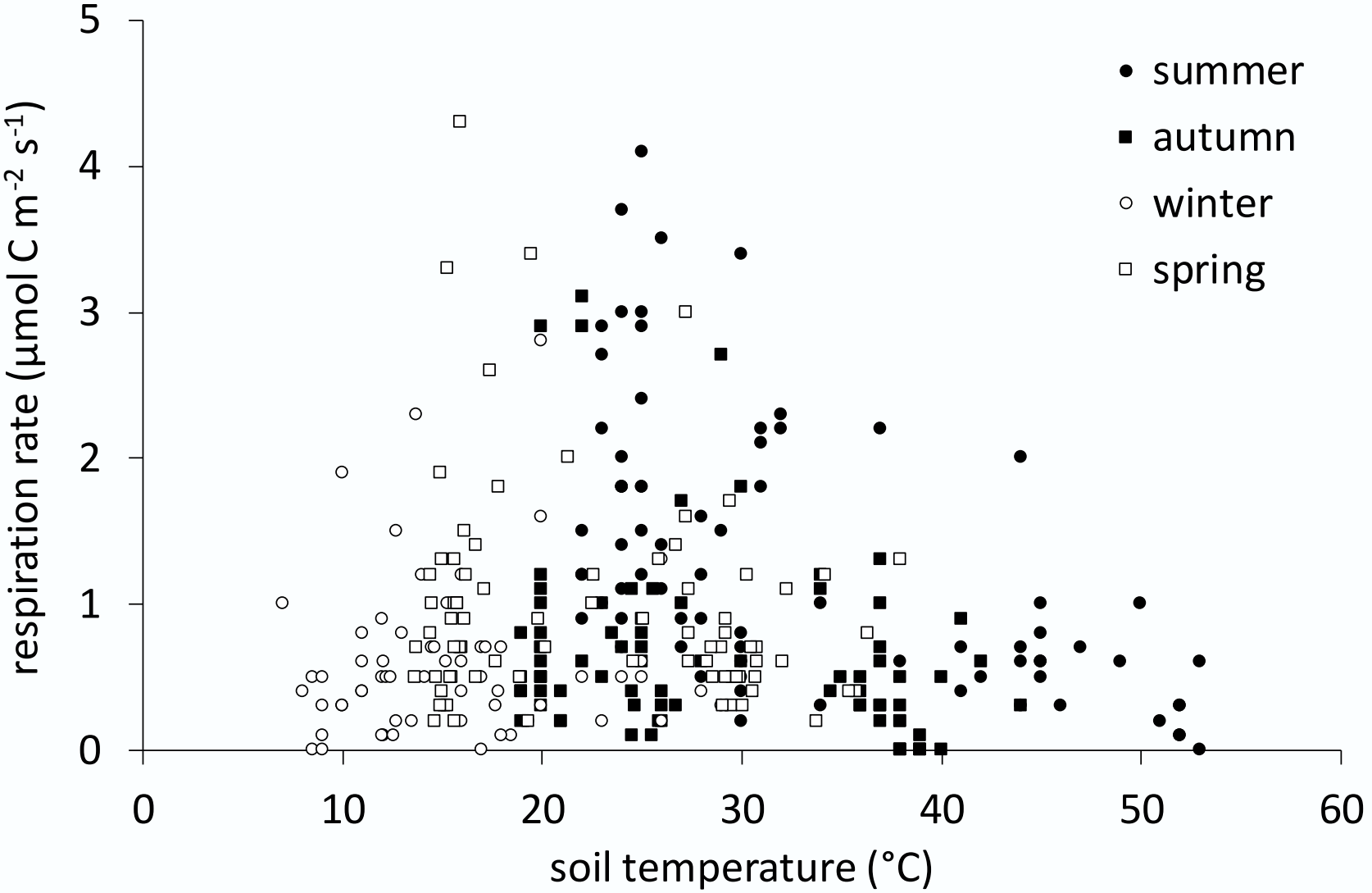


Litter versus bare-soil respiration



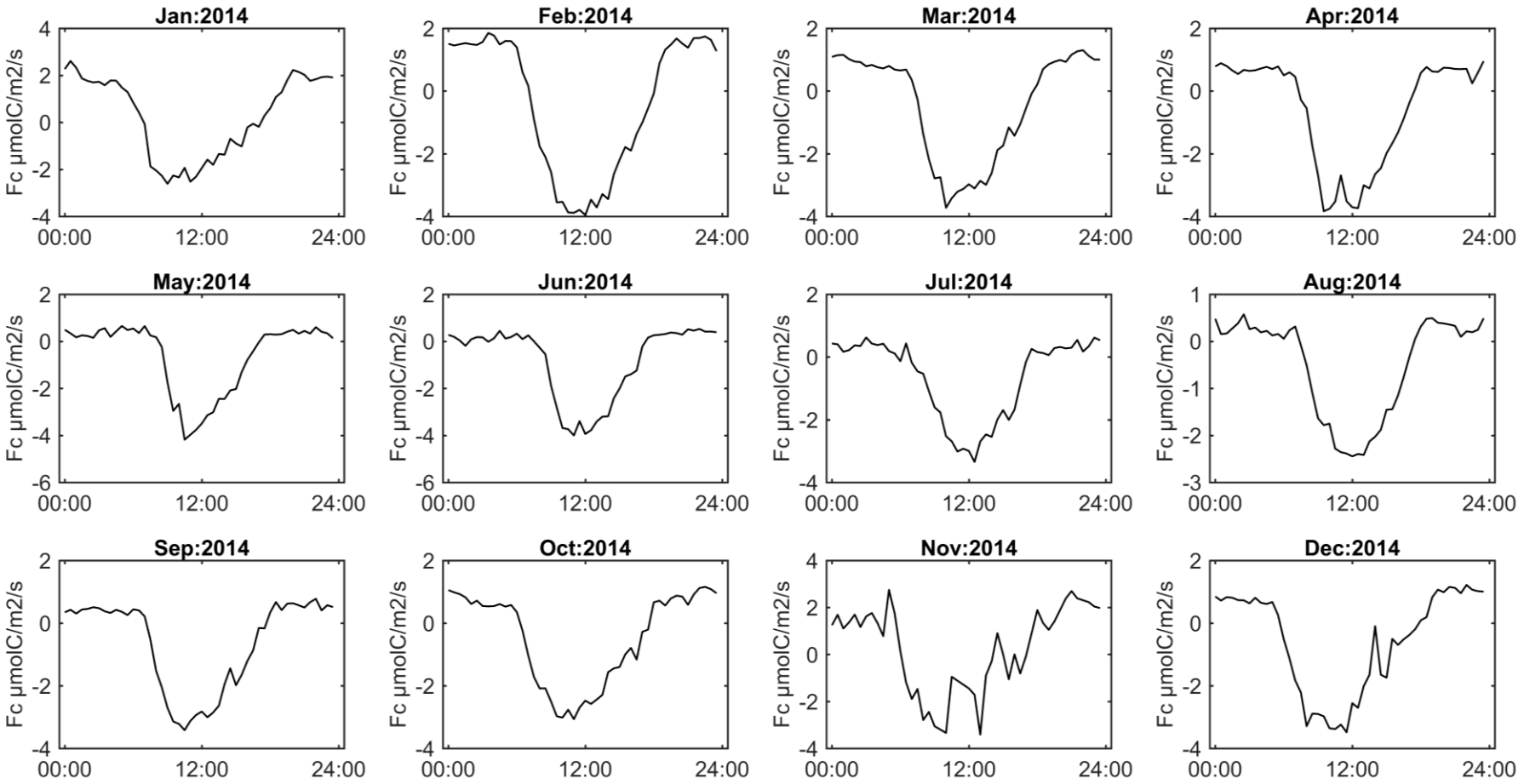


Temperature response of respiration

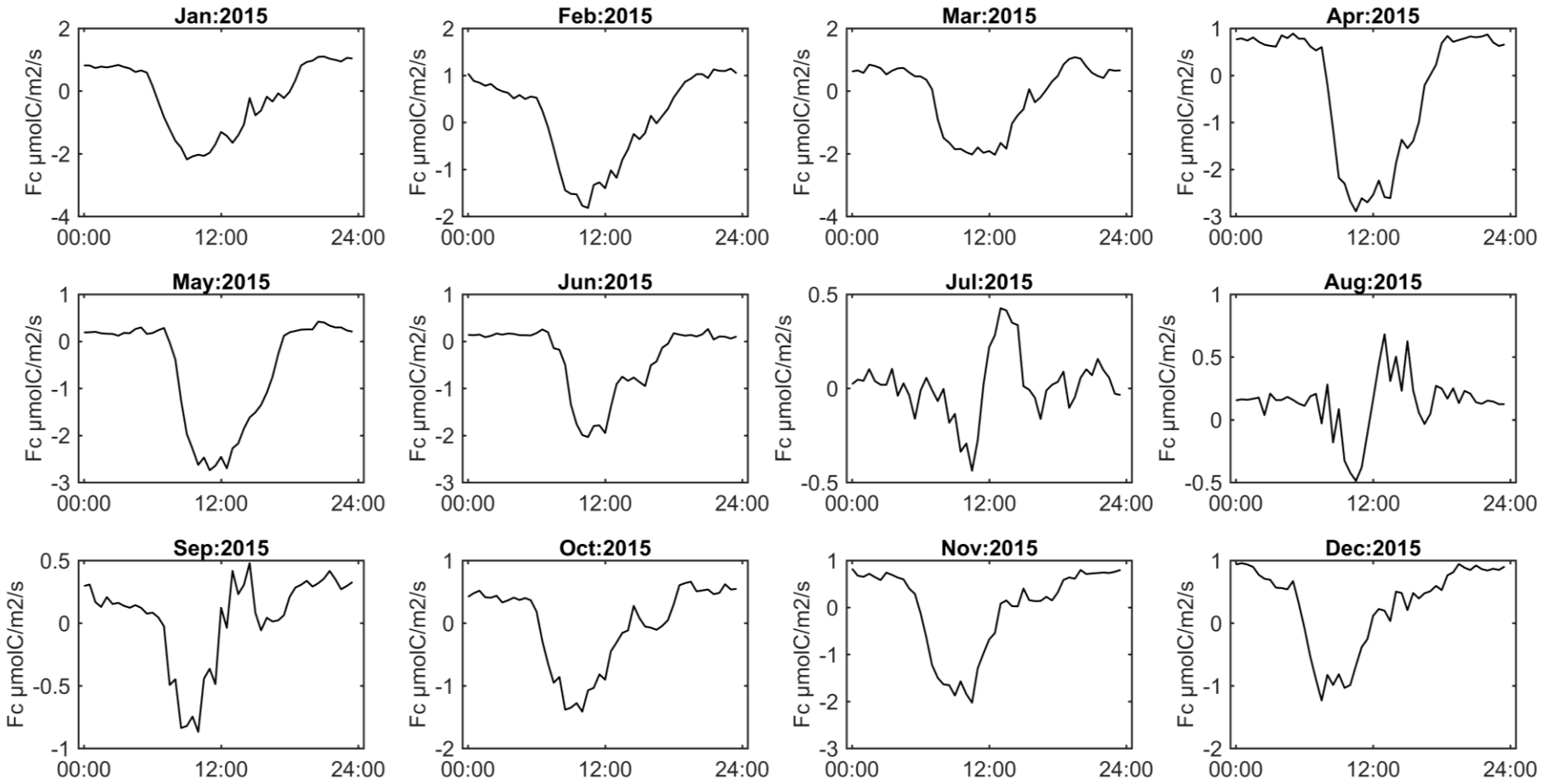


Sources of heterotrophic respiration

Mean daily carbon flux - 2014



Mean daily carbon flux - 2015



Conclusions

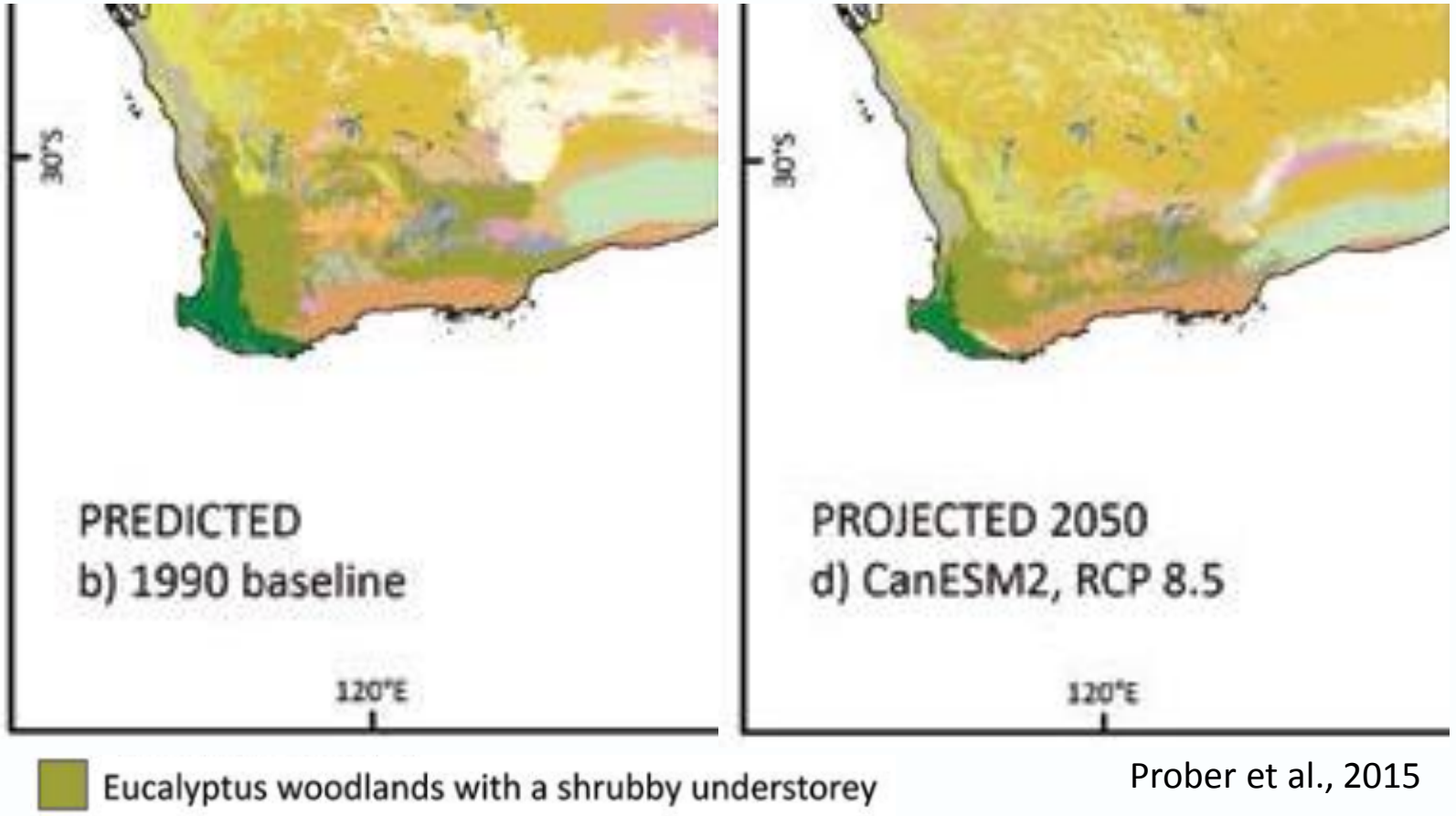
- The old-growth woodland is either a sink or source of carbon depending on above- or below-average rainfall.
- Respiration recovered sooner than GPP from drought resulting in the site remaining a net source for a prolonged period after drought.
- VPD is a significant limitation on stomatal conductance and carbon uptake after mid-morning. This is accentuated by prolonged periods of low rainfall.
- Respiration from EC agrees well with field data, and is most influenced by seasonal temperature.

Questions 1/2

- How much of the 17% missing rain is run-off?
- What is the cause of the 20% missing energy balance?
- How important are cold air drainage and carbon storage at the site?
- Is the high ratio of ER to GPP in 2015-2016 due to heterotrophic respiration? Or photo-oxidation?

Questions 2/2

- Will future climate trends result in old-growth woodlands being a net source or sink of carbon, and will they persist?



Prober et al., 2015

In south-western Australia, there is a clear suggestion that the Mulga line (the boundary between *Eucalyptus* and *Acacia* dominated vegetation) will protract southwards under the hotter scenario, leaving significantly less area suitable for *Eucalyptus* forests and woodlands.