Seasonal variation in recharge and water and carbon balances of Banksia woodland on Gnangara mound

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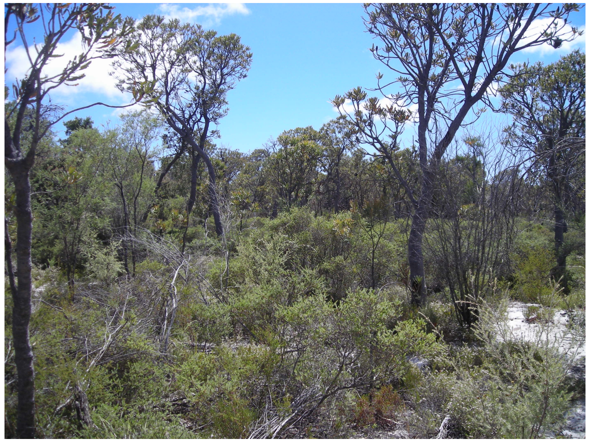
http://www.ozflux.org.au/monitoringsites

CSIRO Oceans and Atmosphere

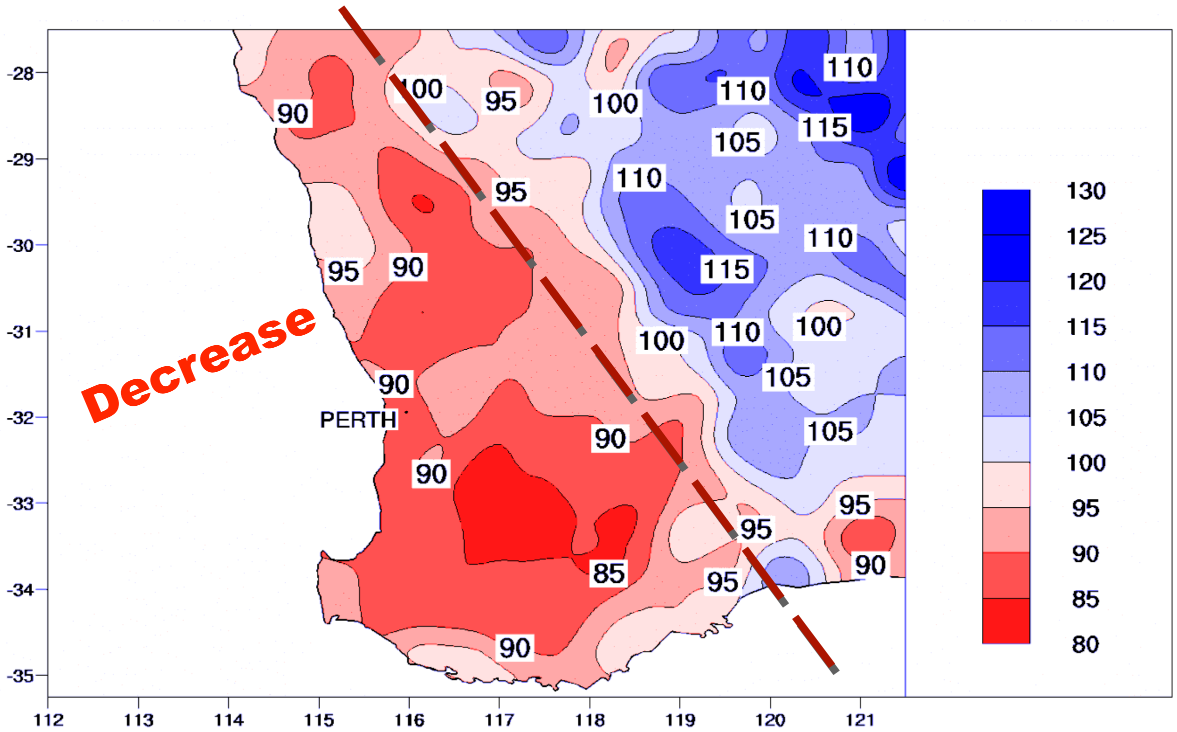
Local context –groundwater supply is under stress

- Drying climate is reducing stream flows to dams and recharge to aquifers
- Perth's increased dependence on groundwater and seawater desalination
- Banksia sand-plain woodland is the major cover on the recharge area for Australia's most important water resource
- Internationally significant wetlands under threat from warming and drying climate, and increased water demand.
- Long-term groundwater monitoring shows decline in aquifer storage at 50GL/yr NPV ~ $\$10^9$ based on next available water source (sea-water desalination)



The site has been selected because south-west Western Australia has had a major climate shift since the early 1970s with a major reduction in rainfall

Last quarter century winter rain as % of previous 75 years



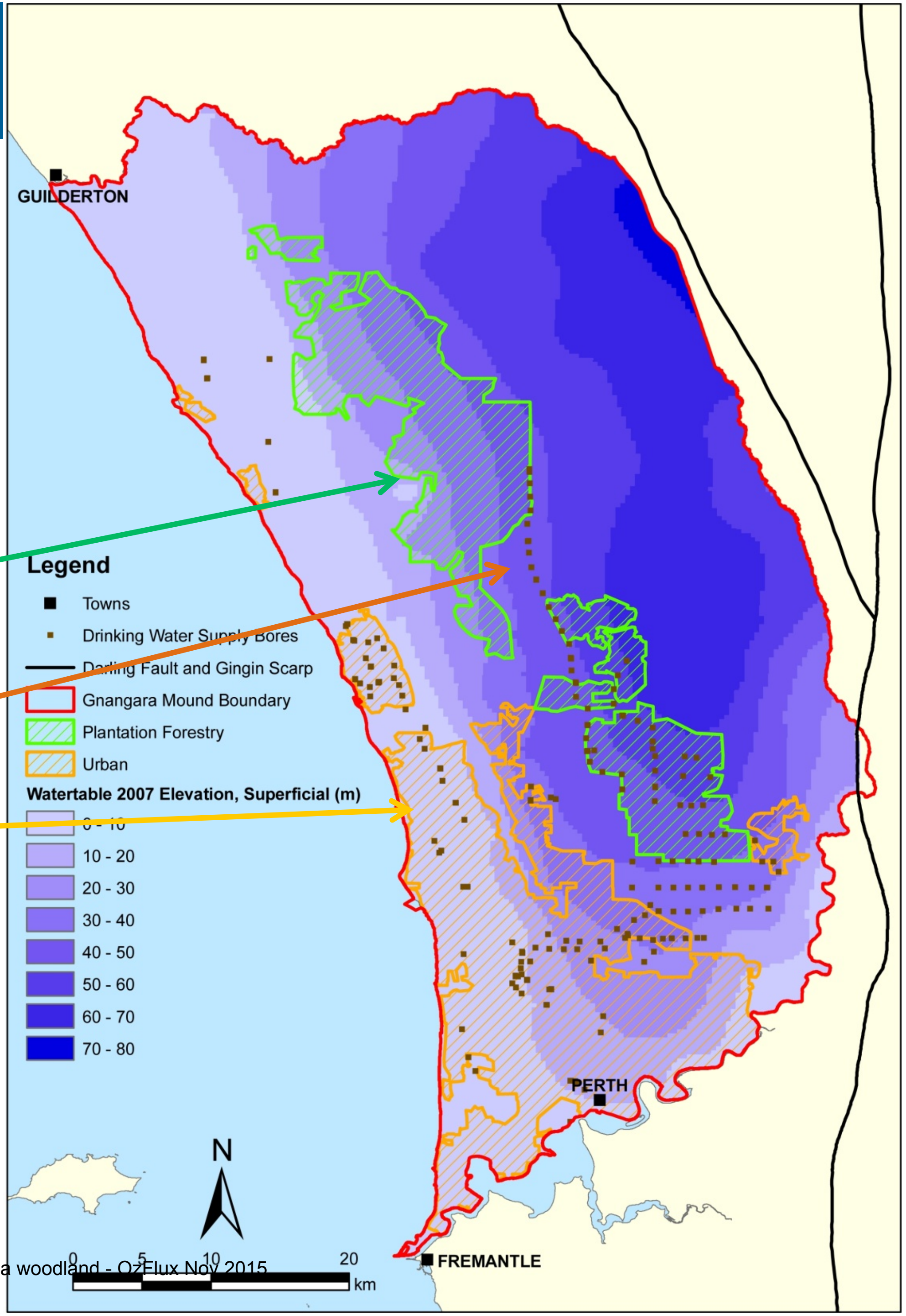
Because of reducing dam inflow, we have increased reliance on groundwater.

In 1975 it was 5% now 50%

P. pinaster plantation

Water supply bores

Urban area



The basis of the technique is to close the balances of energy, water and carbon for a ‘Control Volume’

$$R_n + A = lE + H + G \qquad P = E + R + Q + DS$$

R_n=net radiation

E=evaporation

A=advected energy

lE=latent heat

H=sensible heat

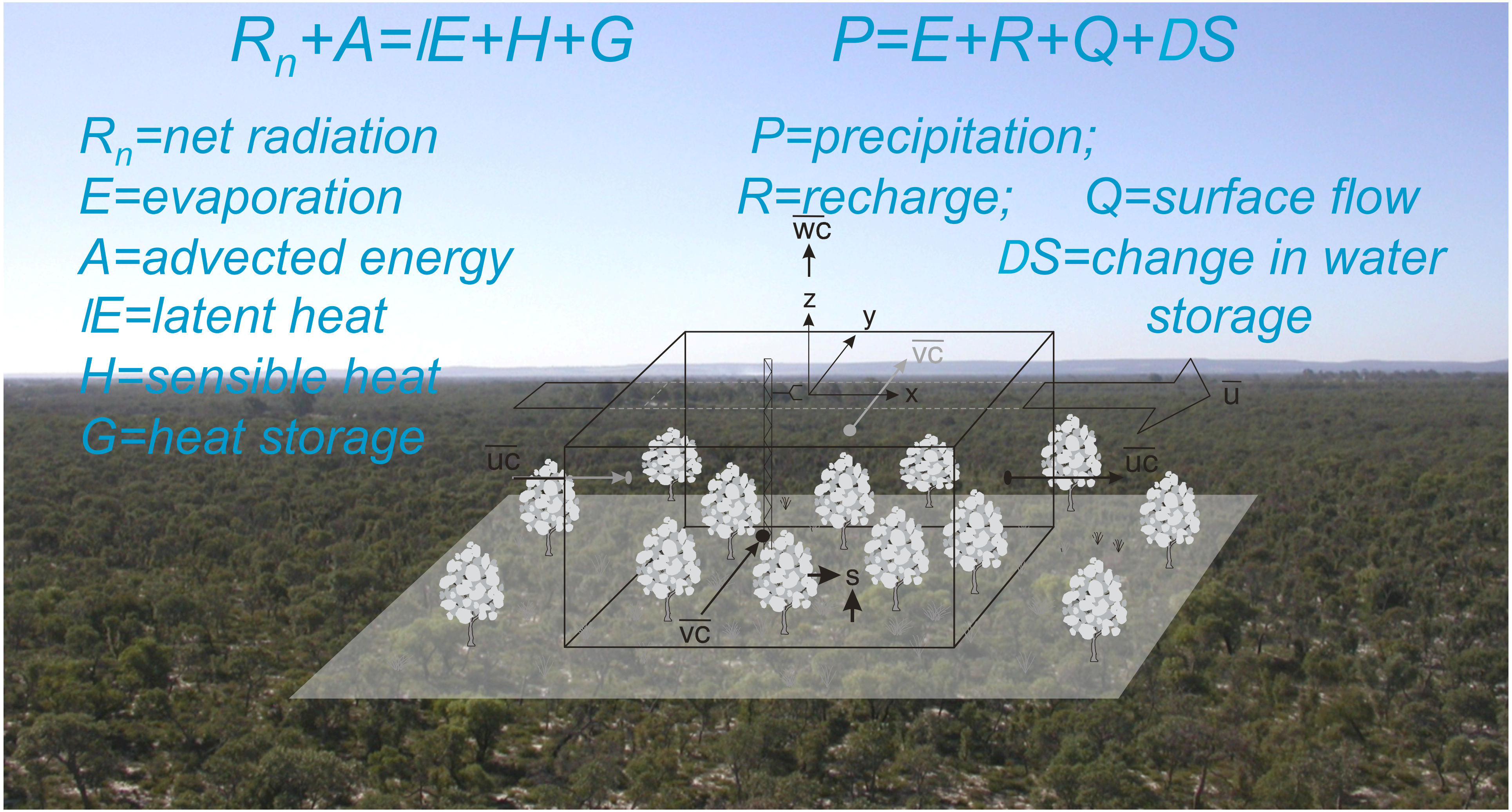
G=heat storage

P=precipitation;

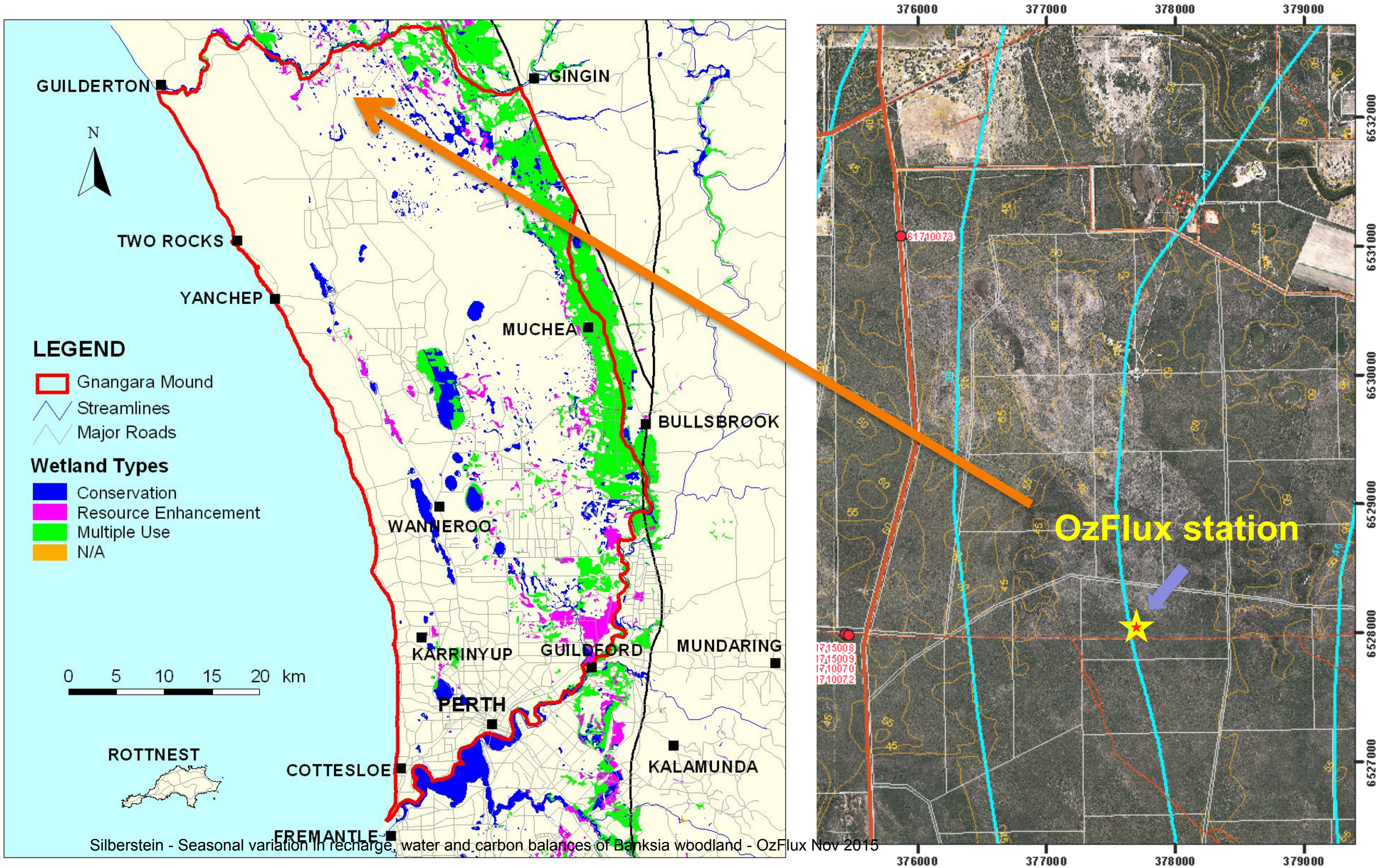
R=recharge;

Q=surface flow

DS=change in water storage



Gingin-Gnangara flux station 80km north of Perth

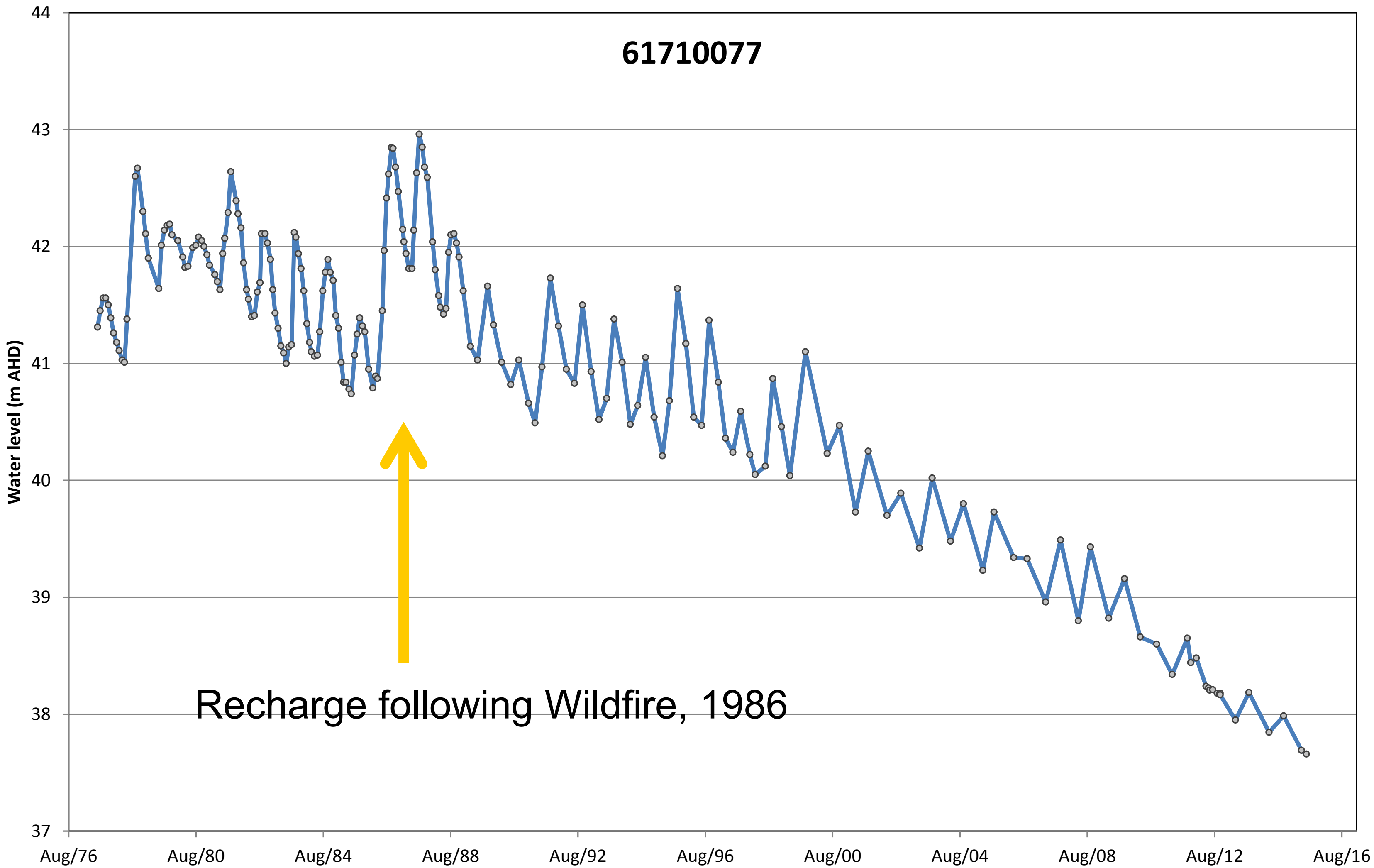


Site selected with Noongar approval …

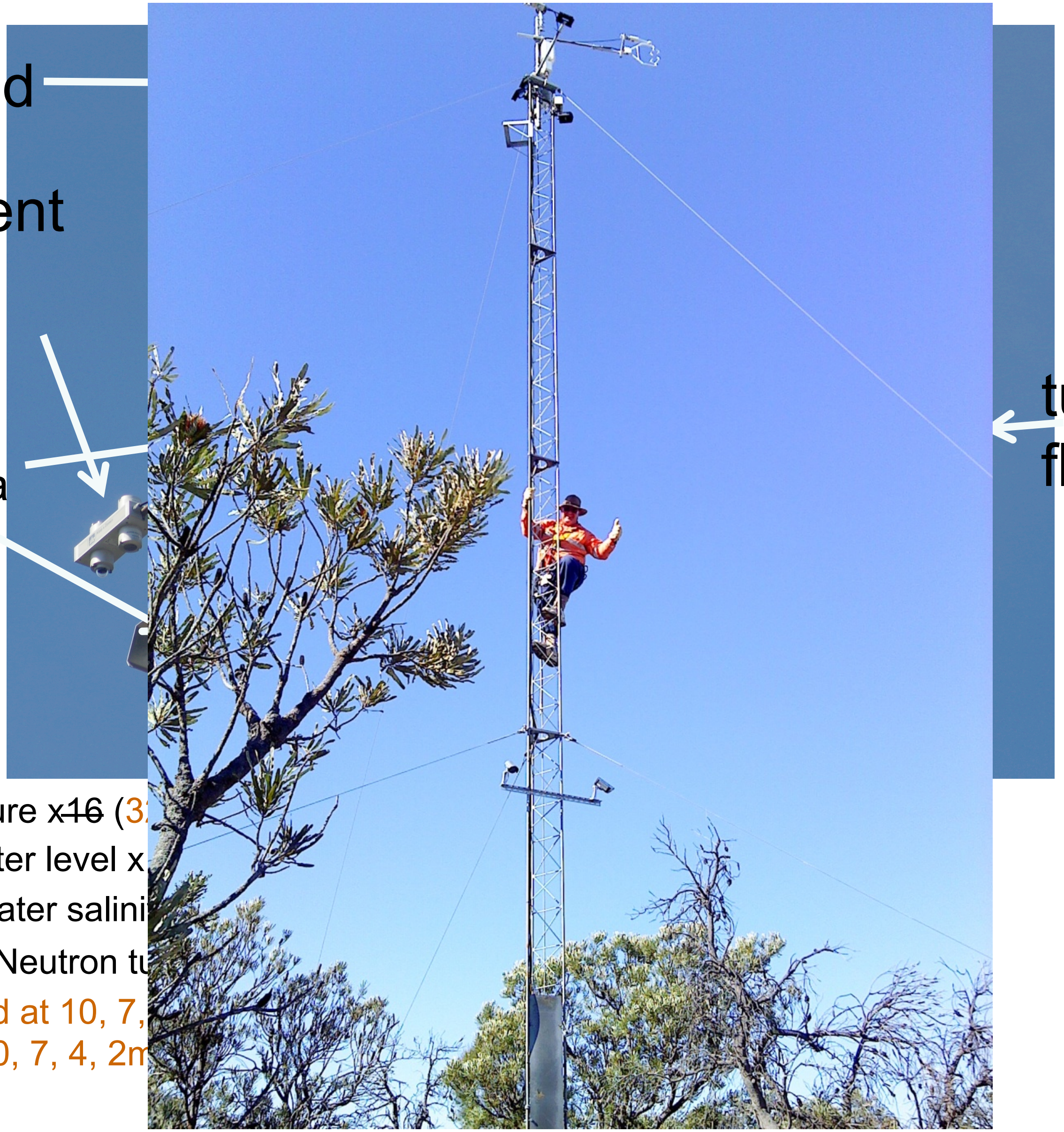
The Gnangara/Gingin site

- Elevation 50m AHD
- Banksia woodland
- Tree height ~7.5m
- Leaf Area Index ~0.8
- Biomass (est.) 38t/ha DM
- Coarse sand
- K_{sat}~5-50 m/day
- DBD=1.35g/cm^3
- Tower instruments at 15m
- Piezometers and soil moisture also 500m east and west

It has a conveniently located Dept of Water piezometer with a long-term record



Instruments – eddy covariance



Average wind

4-component radiation

(+ net rad)

Digital camera

turbulent fluxes

- soil moisture x~~16~~ (3
- groundwater level x
- soil and water salini
- 3x3+ 1x8 Neutron tu
- (Plus Wind at 10, 7,
  Ta,rh at 10, 7, 4, 2m

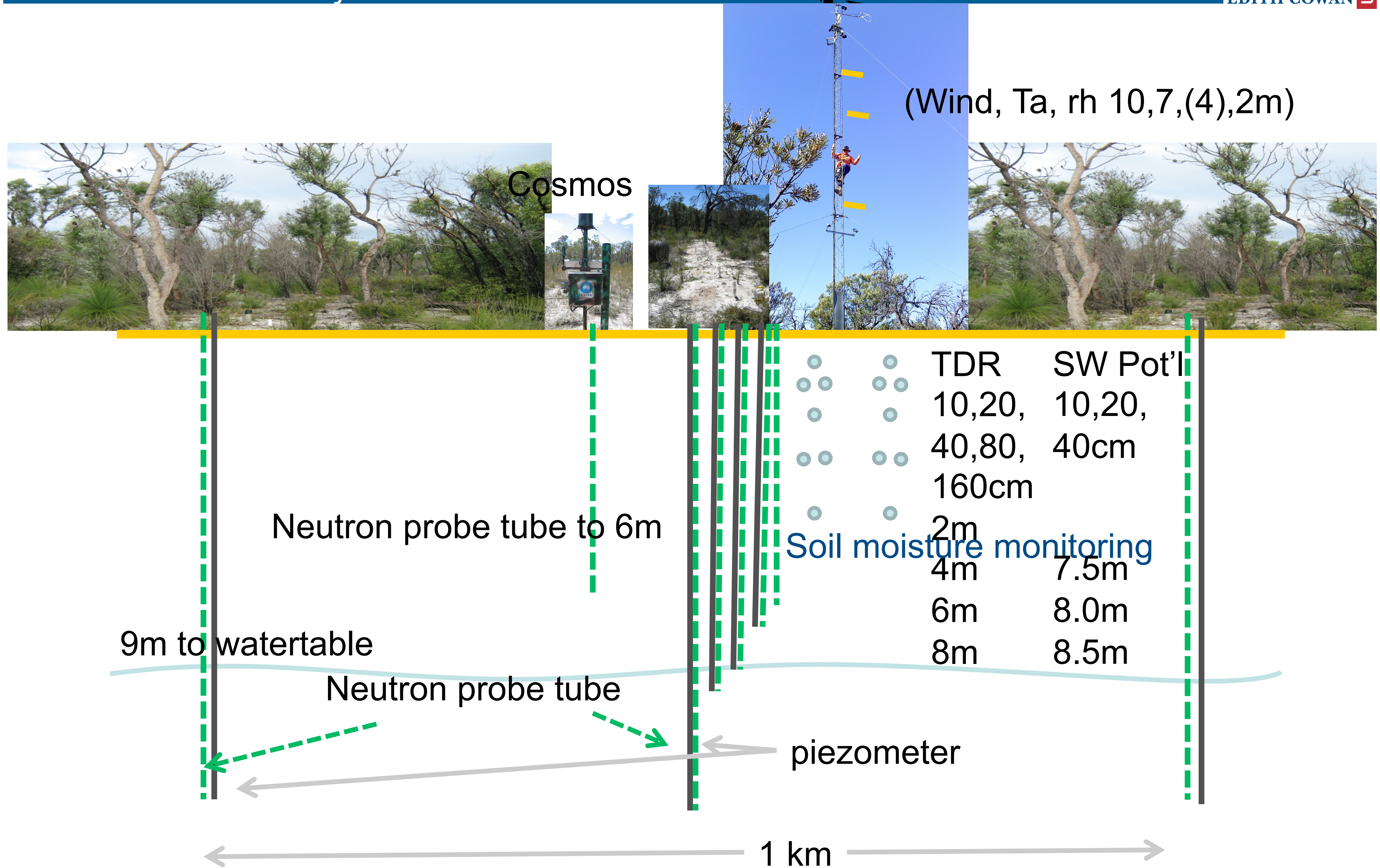
INSTRUMENT TYPE	Make	Model	Location
Open path CO_2, H_2O	LI-Cor	LI-7500	15m
3D Sonic anemometer	Campbell Scientific	CSAT3	15m
Air temperature	Vaisala	HMP155	1m, 15m
Air relative humidity	Vaisala	HMP155	1m, 15m
Net radiometer	Kipp and Zonen	CNR1	15m
Wind speed and direction	Gill	Windsonic4-L 2D sonic	15m
Precipitation	Hydrological services	CS701	2 x 0m & 2m
Soil Heat Flux plate (2 replicates)	Middleton	CN3 Huksflex	-0.05m each of 3, 3 self calibrating
Soil temperature averaging probe (2 replicates)	Campbell Scientific	TCAV	-0.02 ± 0.05m each of 2
Soil temperature thermistor	Campbell Scientific	CS107	-0.10, -0.20, -0.40, -0.80, -1.80m
Soil water content reflectometers	Campbell Scientific	CS616	-0.1 (x4), -0.2 (x2), -0.4 (x4), -0.8 (x2), -1.6 (x4)m
		CS650	-2m, -4m (x2), -6m (x2), -8m
Soil moisture (method 1)	HydroInnova	COSMOS	100m south-east of tower
Soil moisture (method 2)	Campbell	Neutron probe	Every 25cm from the surface to 12m, 3 holes
Watertable	Piezometer, In-situ pressure transducer	Troll 500	-15m, 3 piezometers, one at site, one 400m east and west

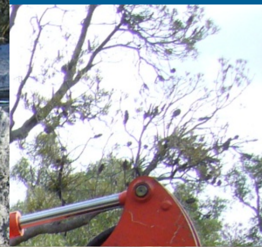
Instruments include

Cosmos - cosmic ray moisture monitoring

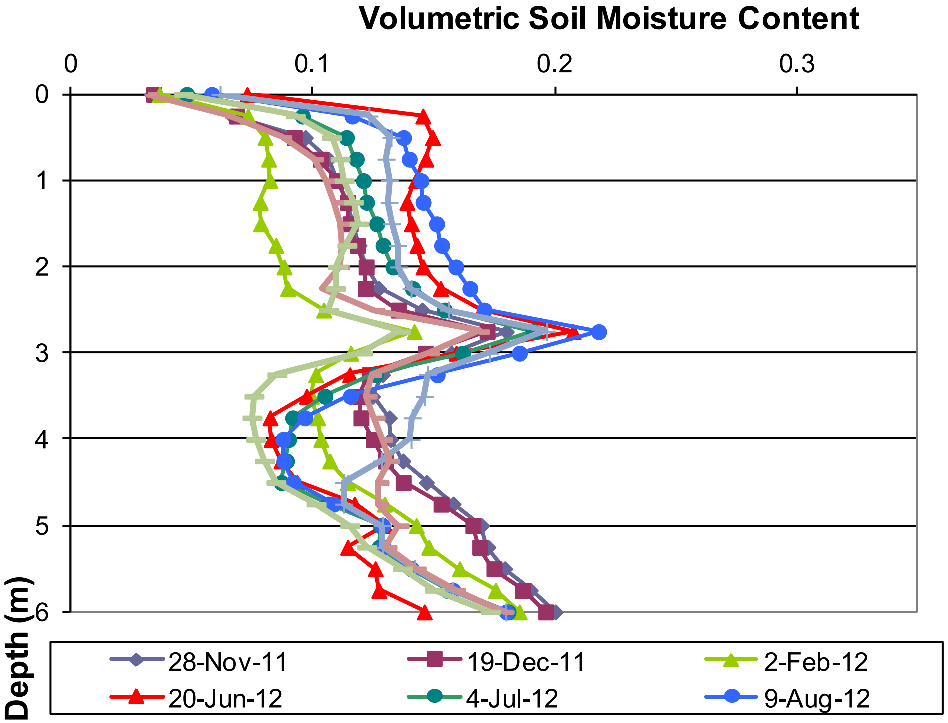
and nested piezometers

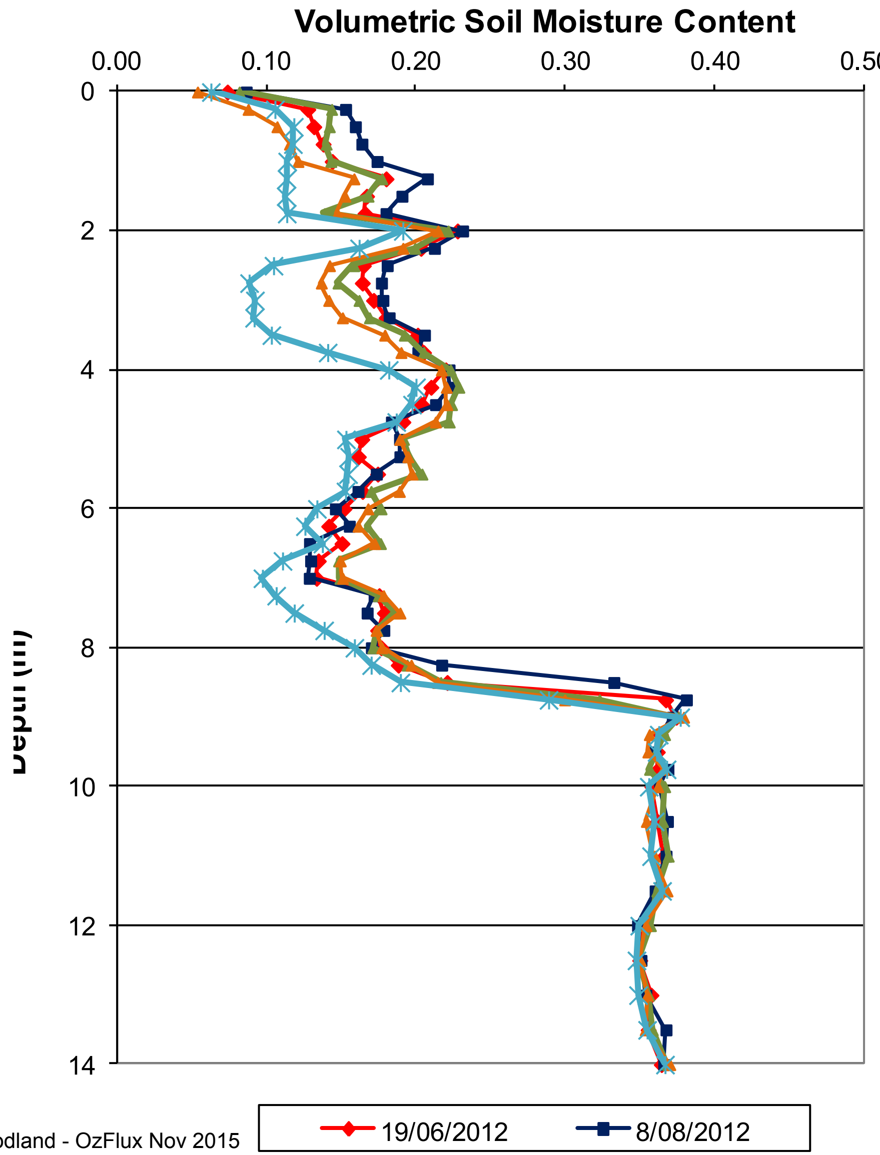
Eddy covariance flux instruments



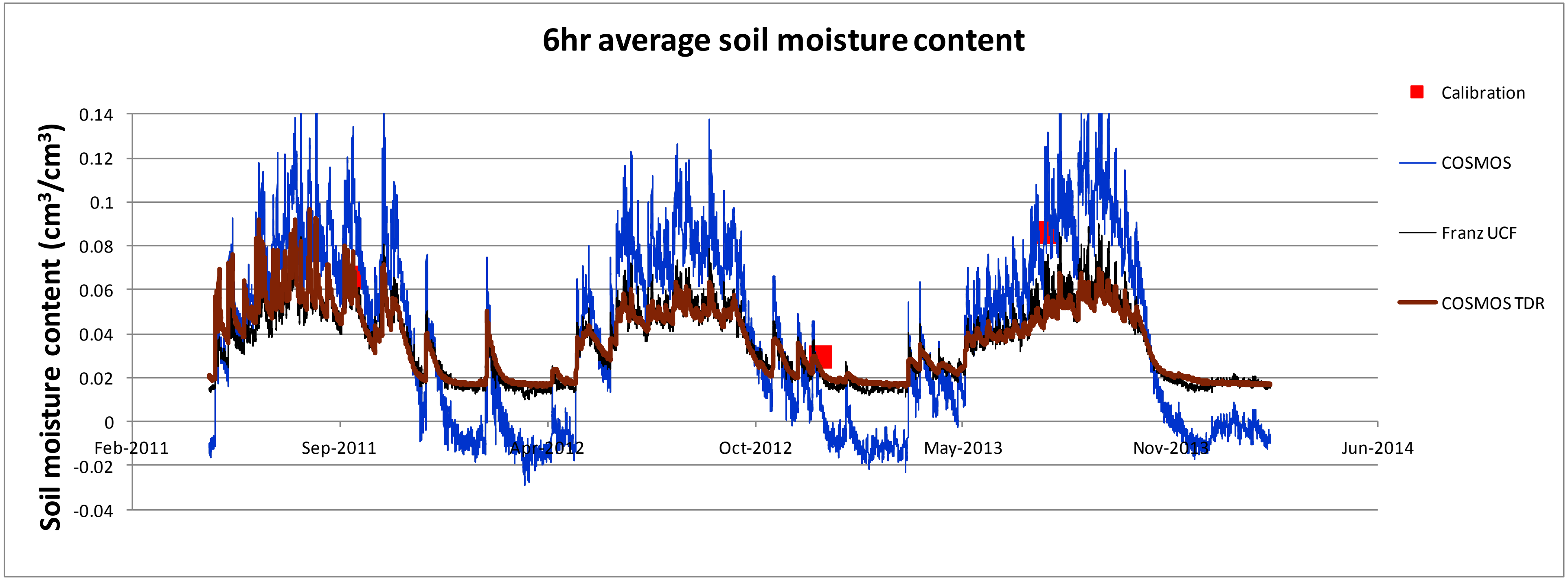


Soil moisture profiles around the COSMOS





Soil moisture trends at COSMOS



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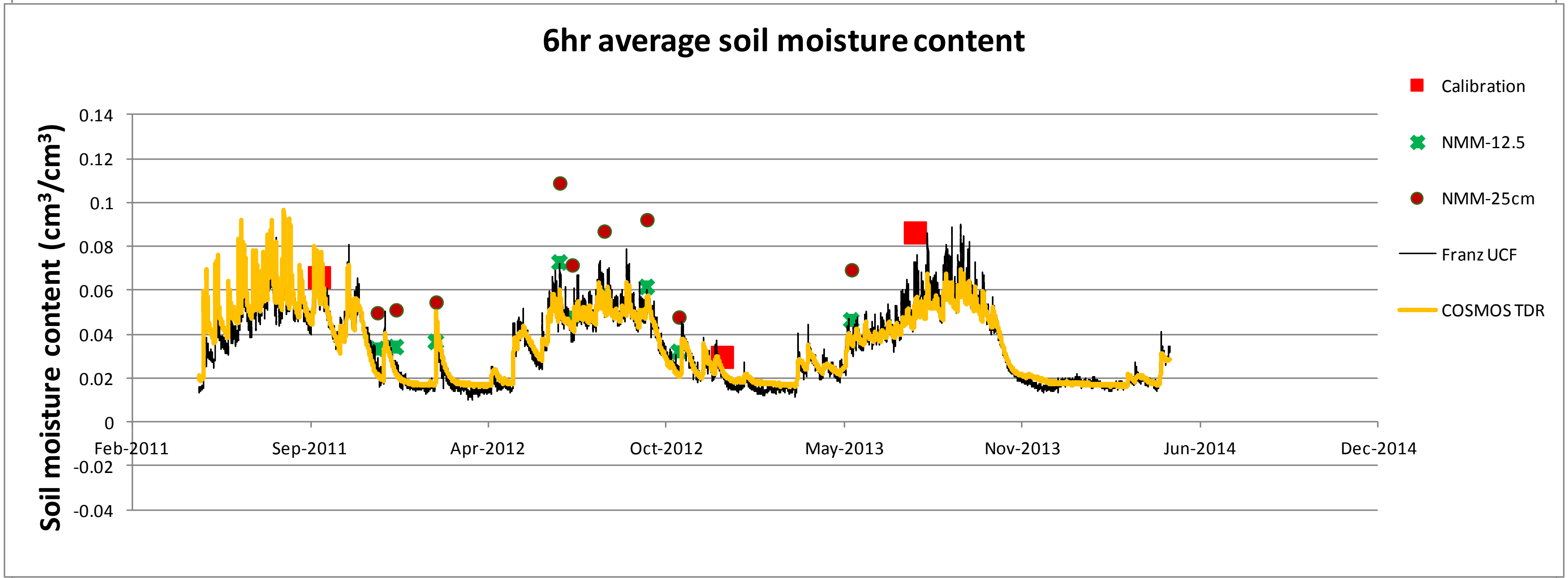
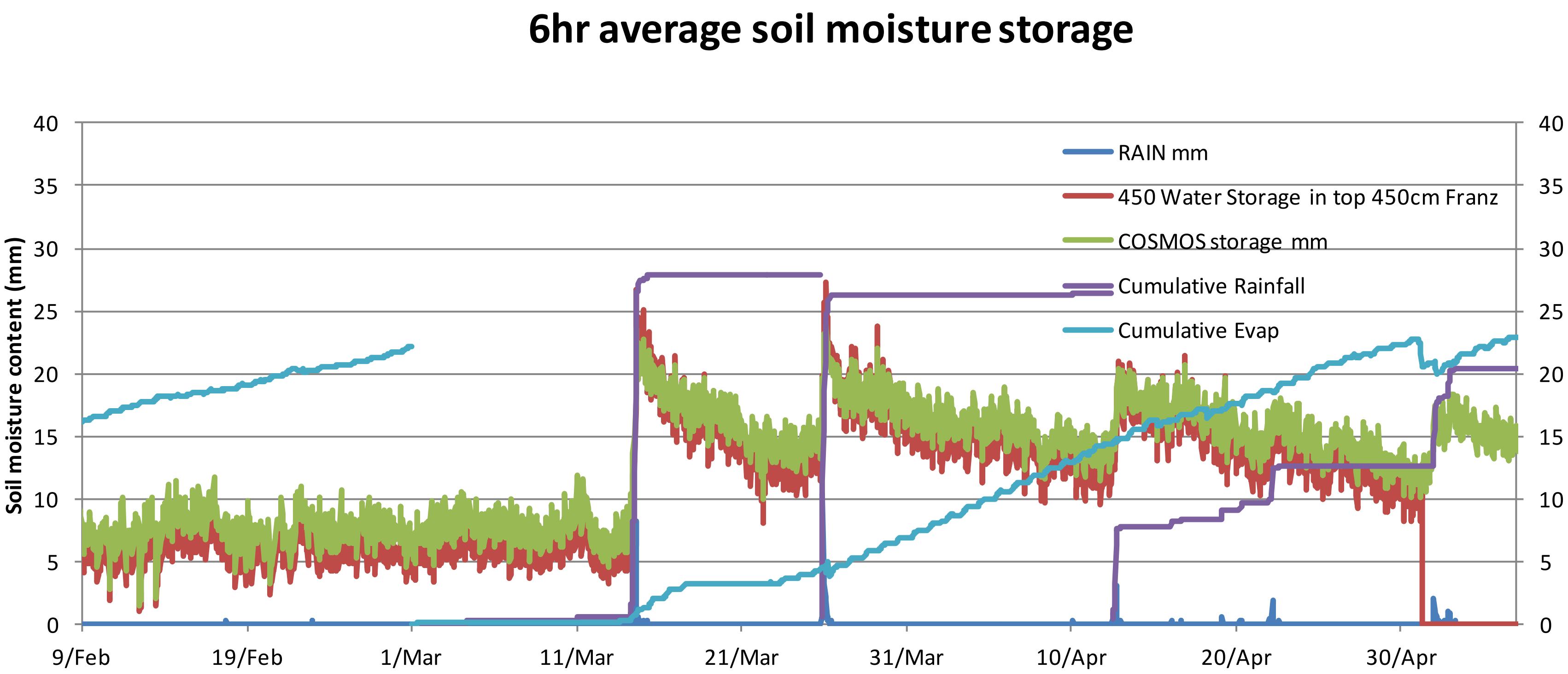
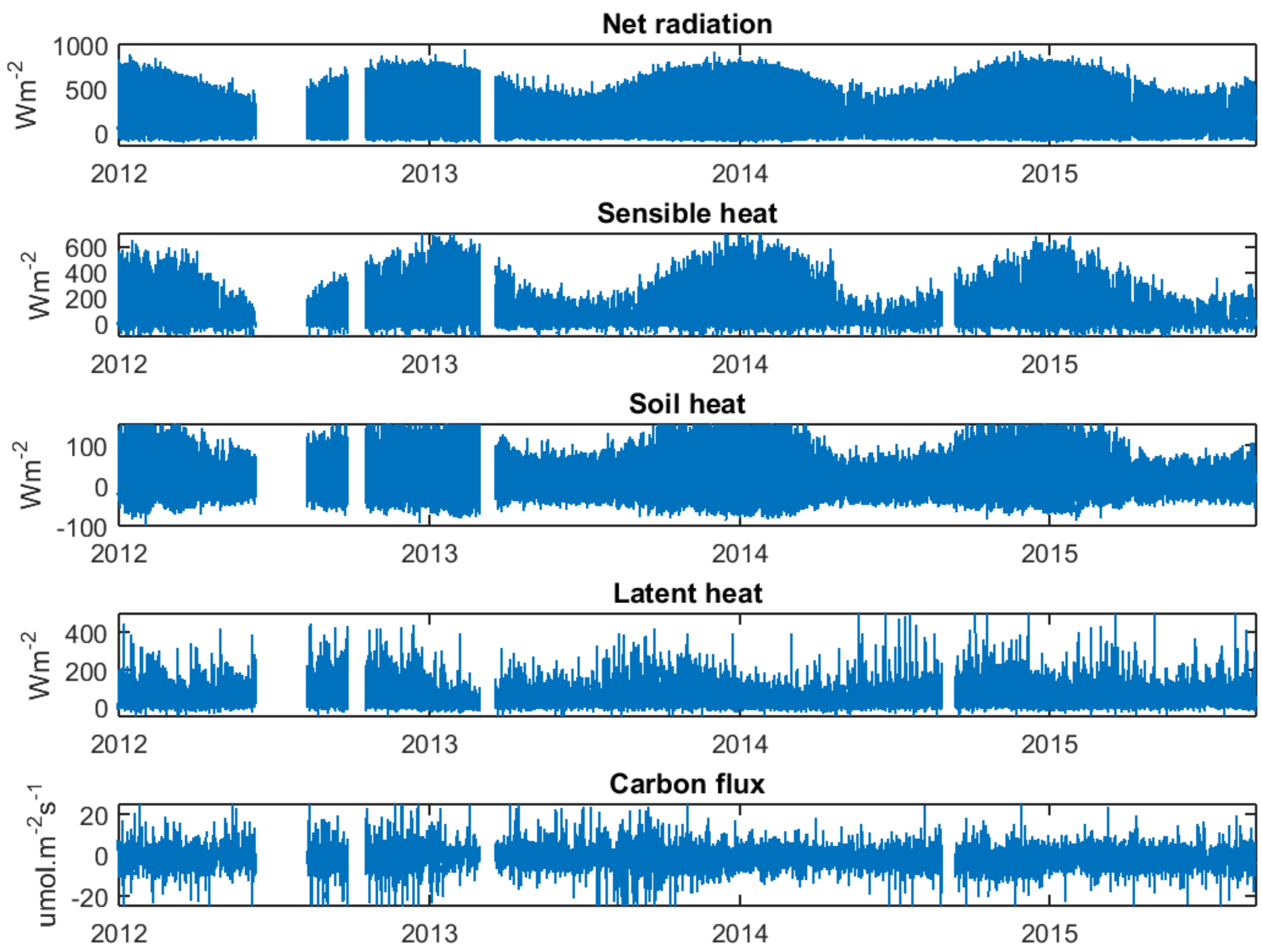


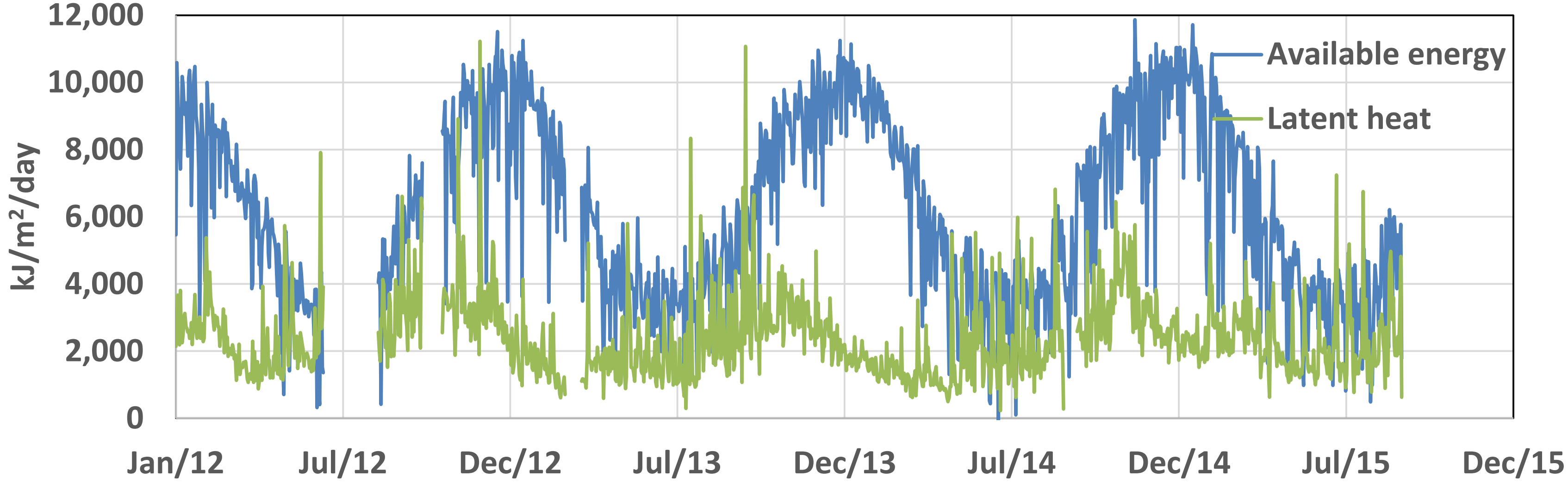
Soil moisture storage, rainfall and evaporation

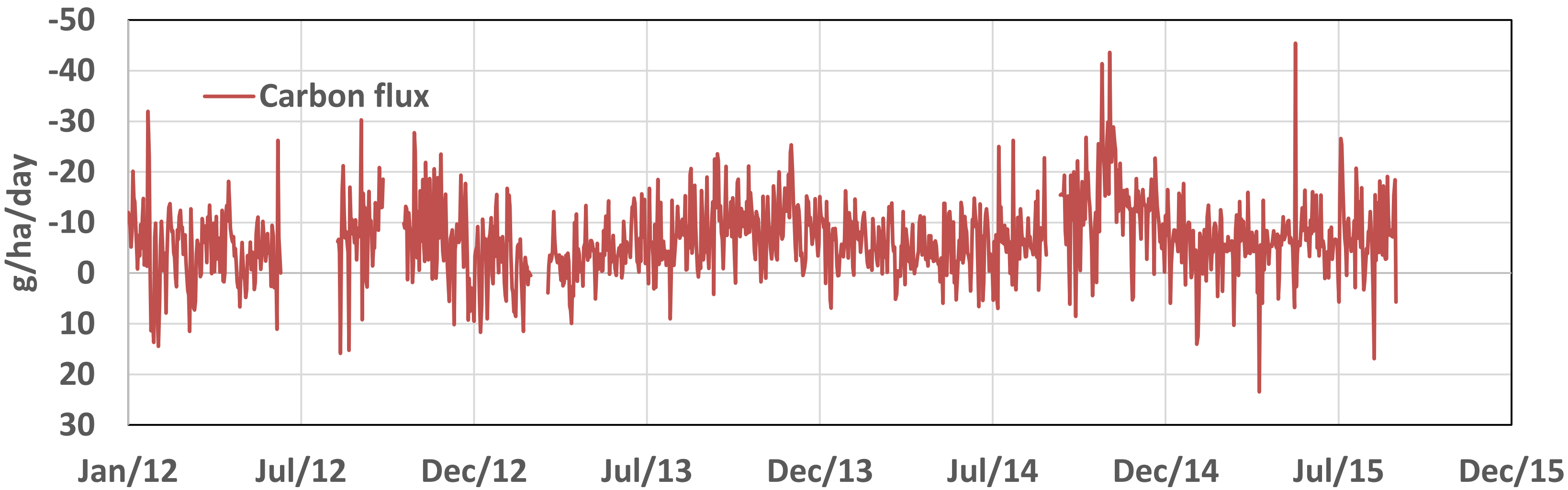


Energy and carbon fluxes at Gingin

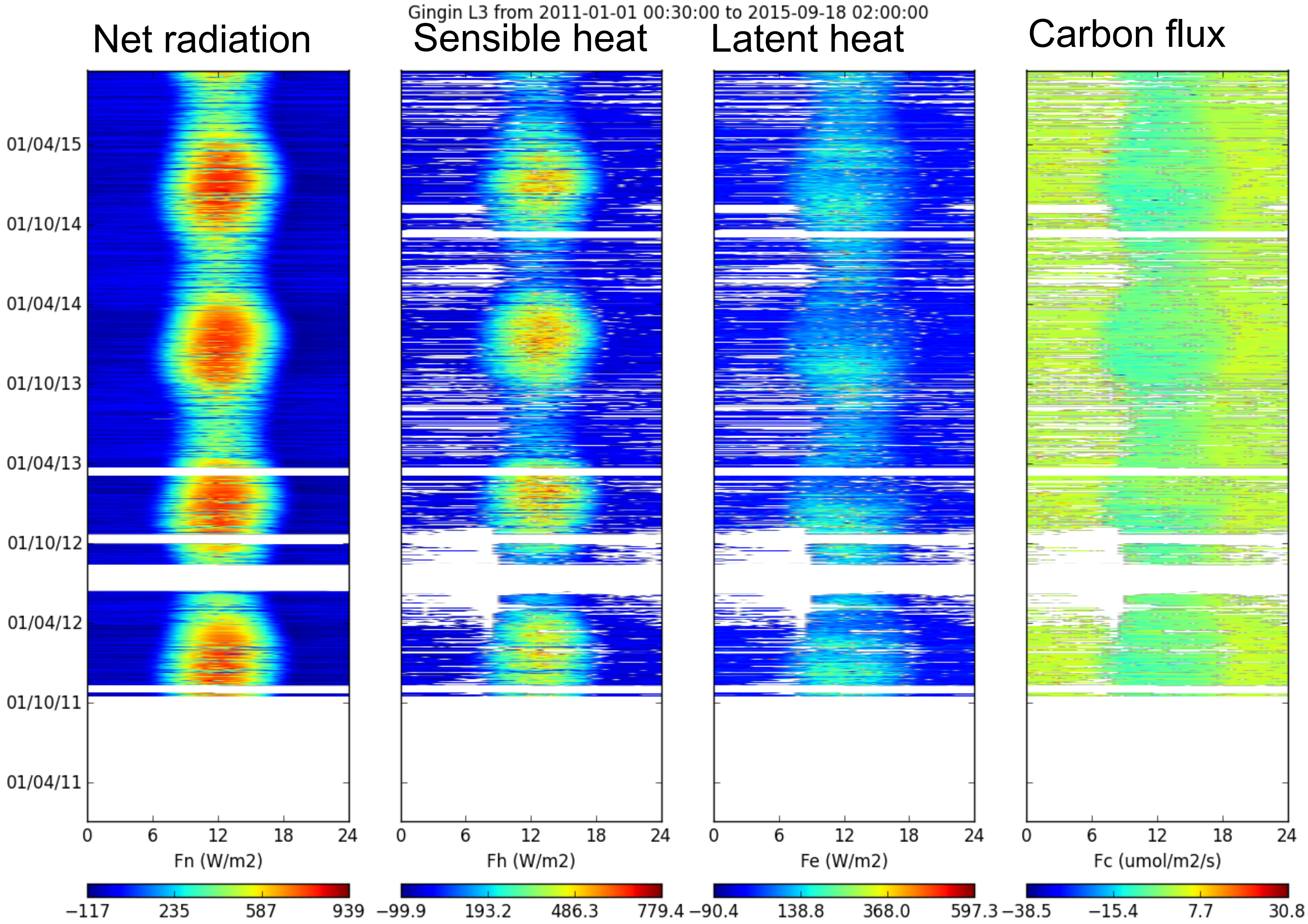


Water and carbon fluxes at Gingin

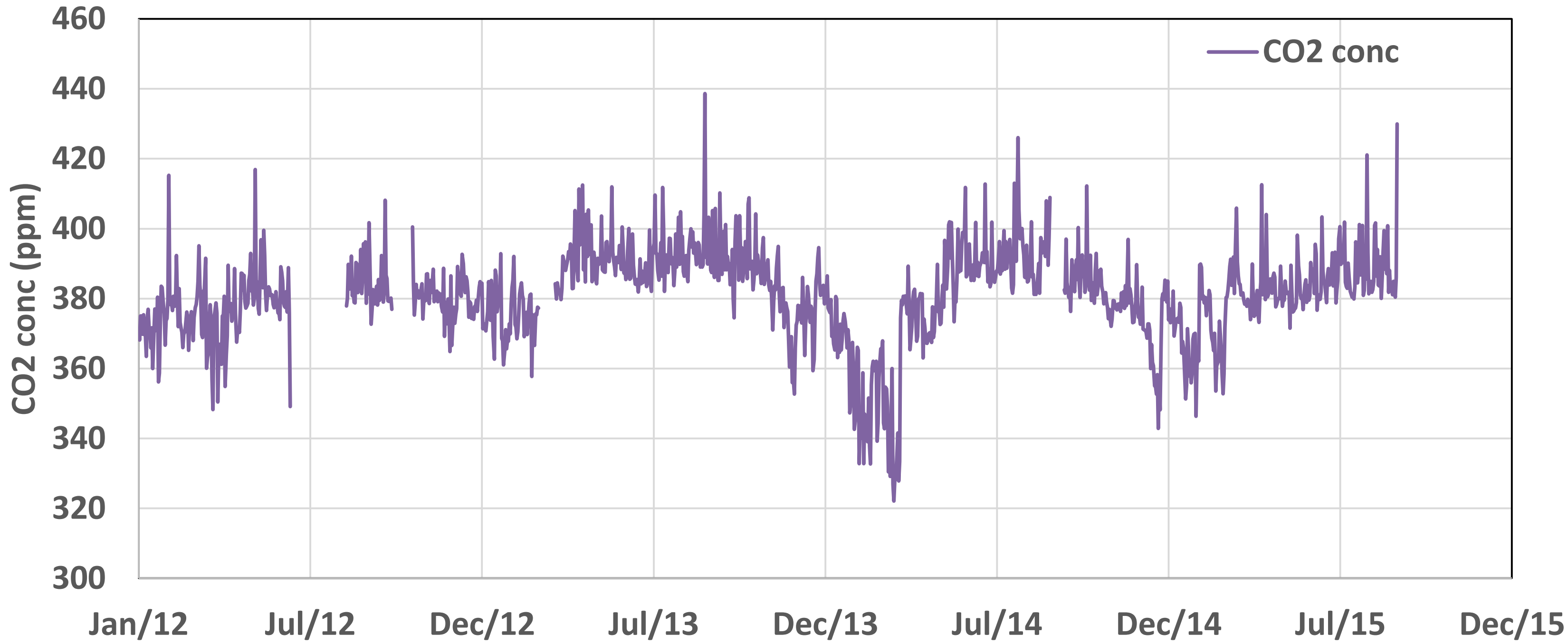




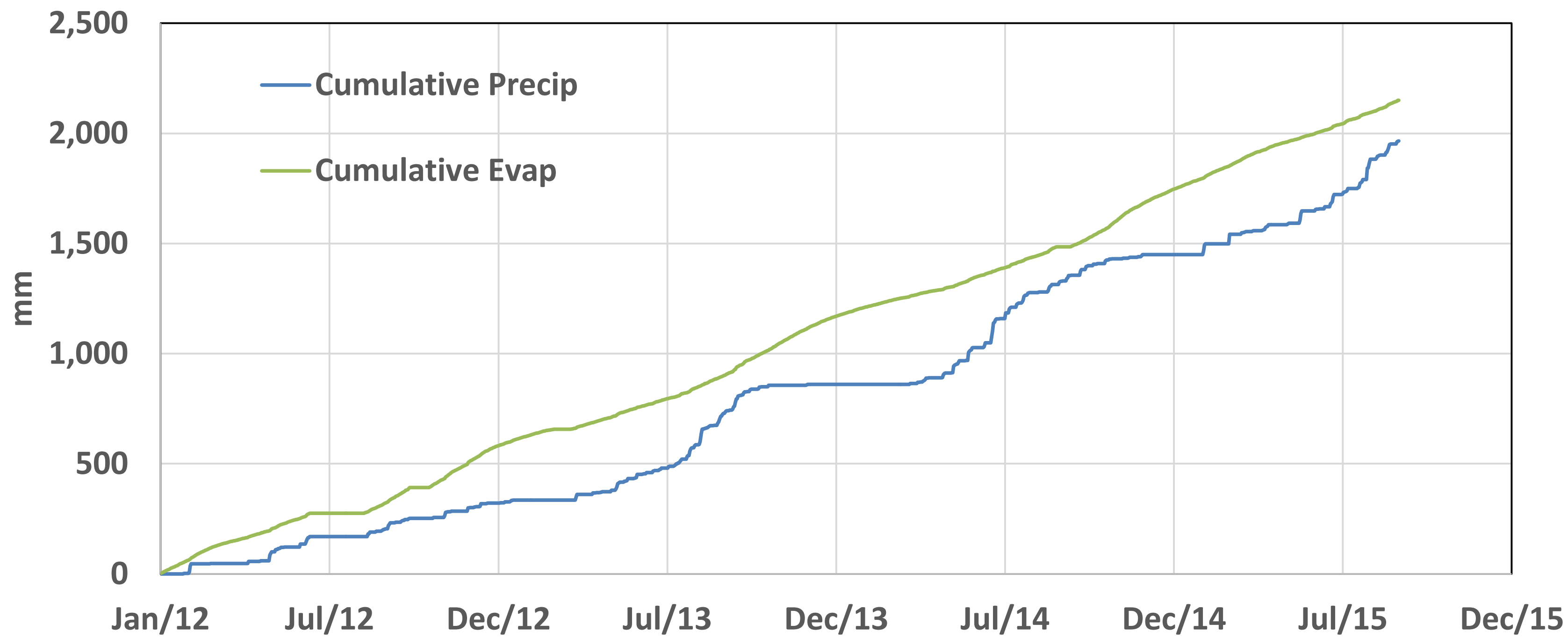
Flux data over *Banksia* woodland

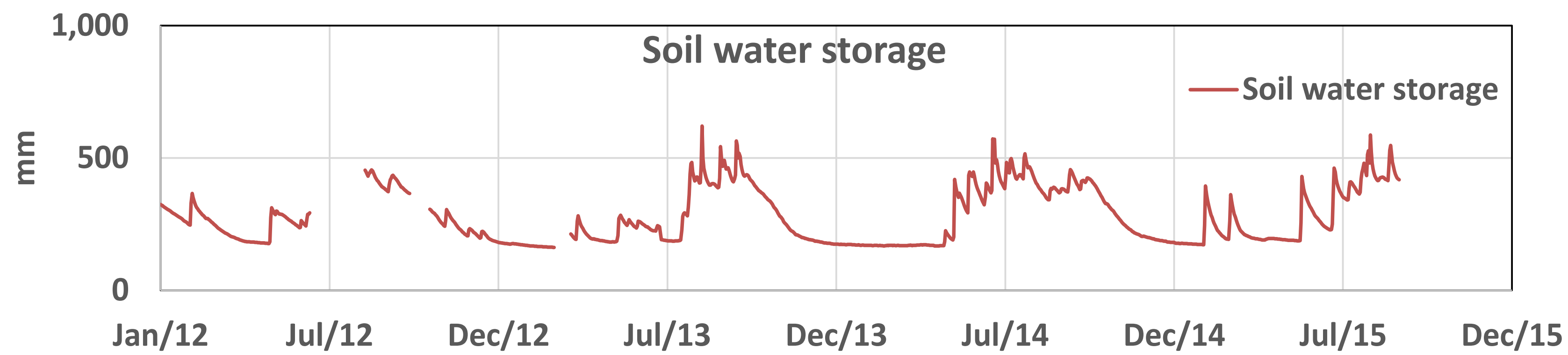


Carbon dioxide concentration and water

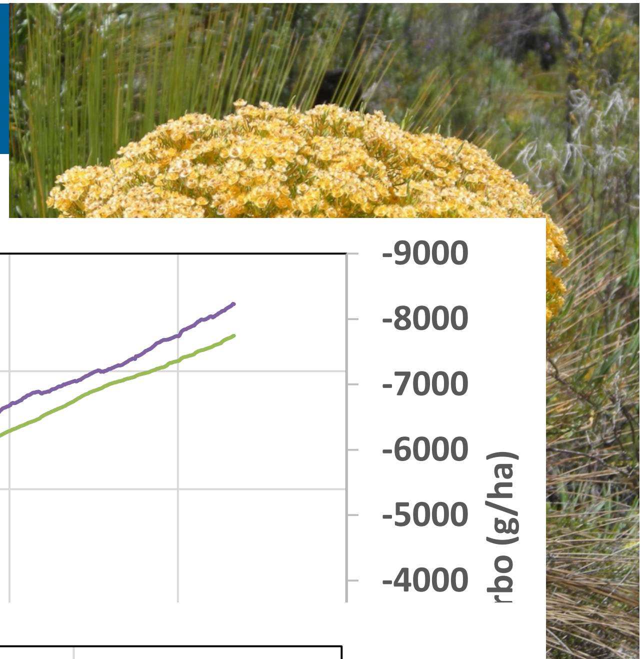


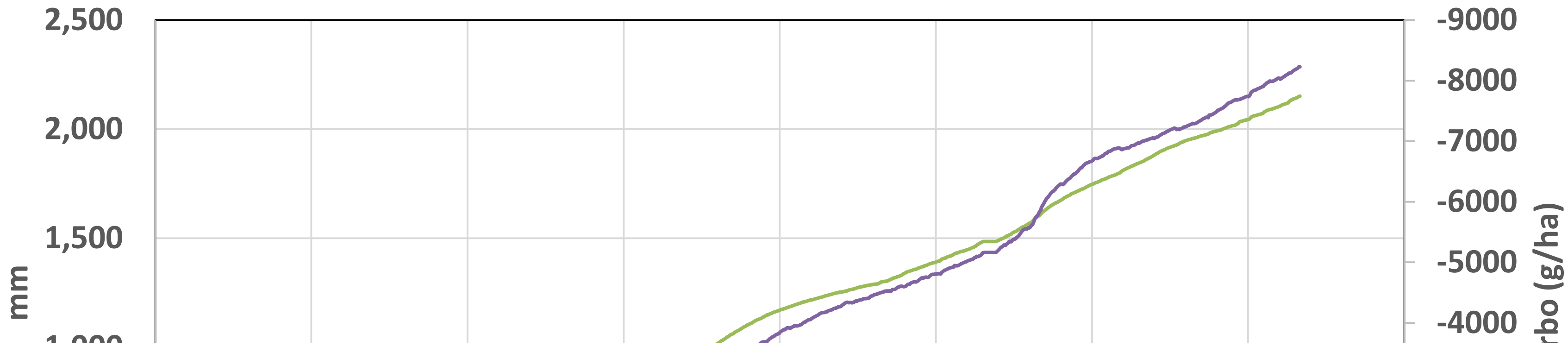
Progressive water balance

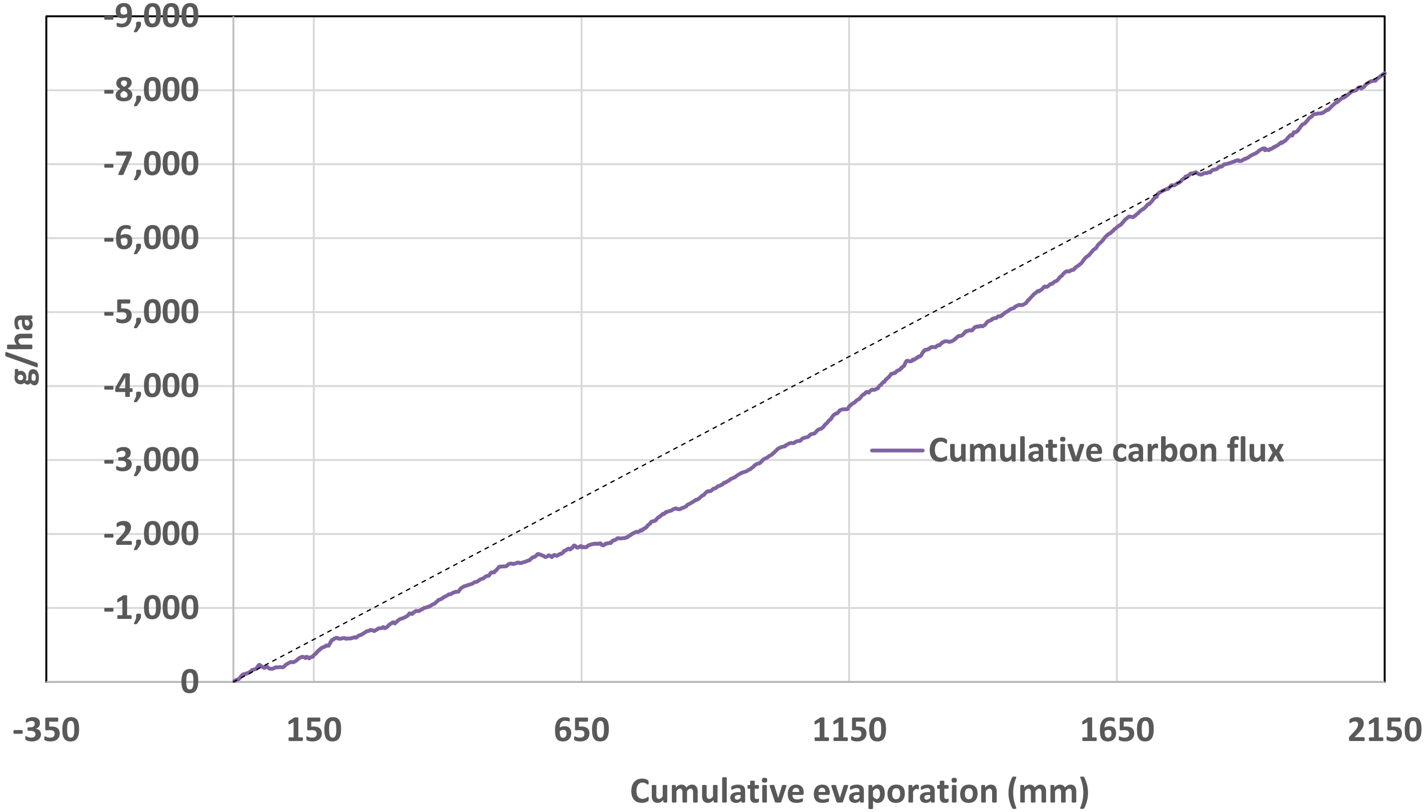




Carbon assimilation efficiency:
Carbon flux *vs* evaporation

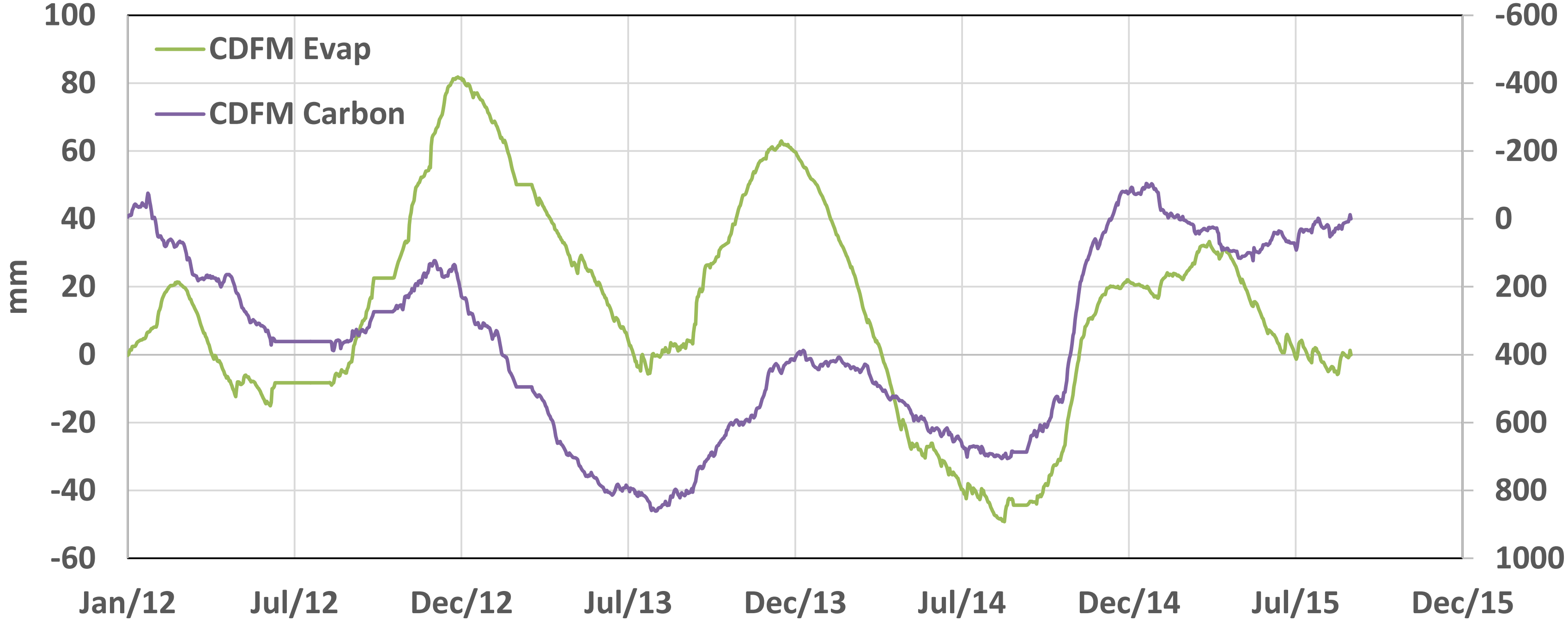




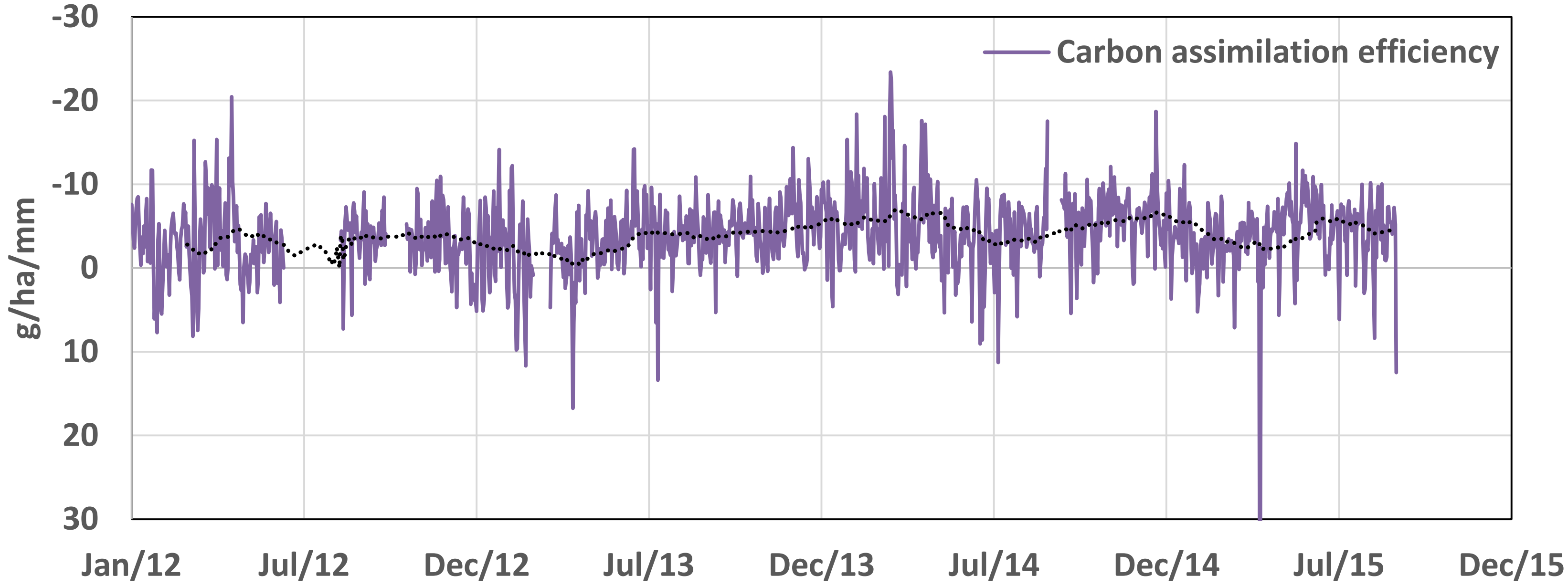


Carbon assimilation and water use (Evap)

Daily rate relative to the average



Carbon assimilation efficiency in the Banksia



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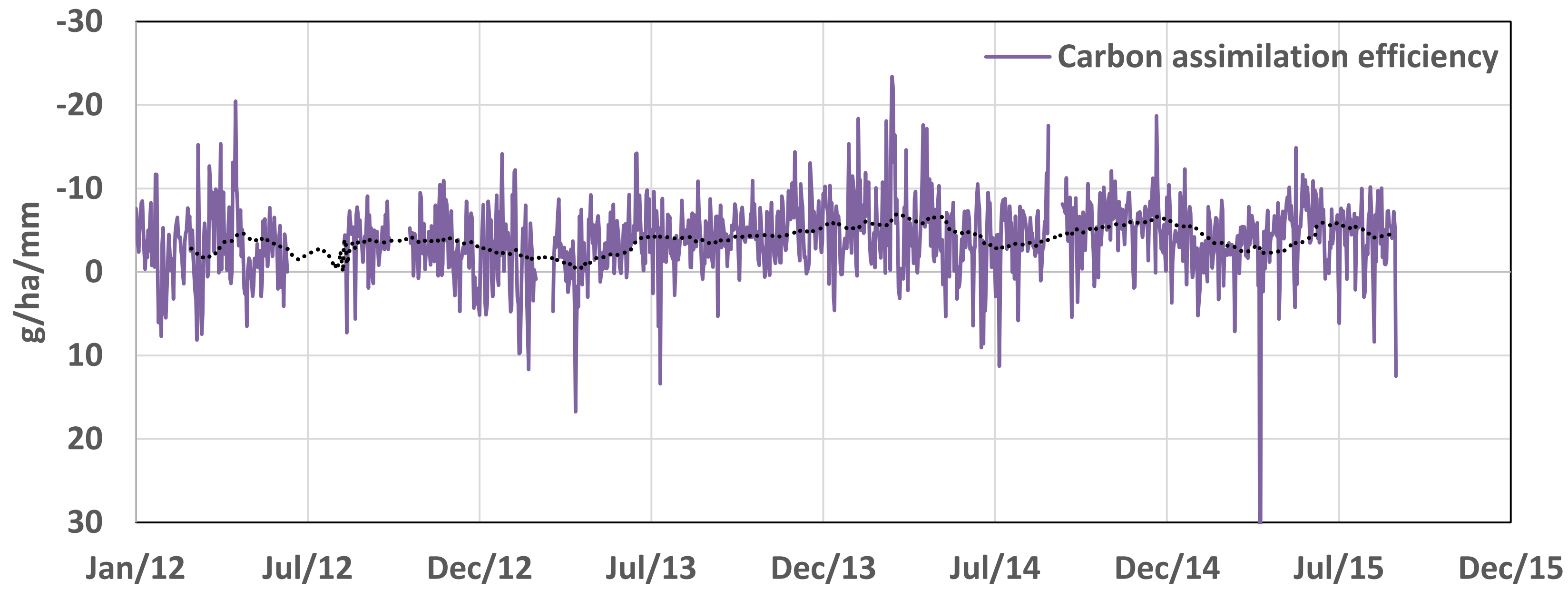
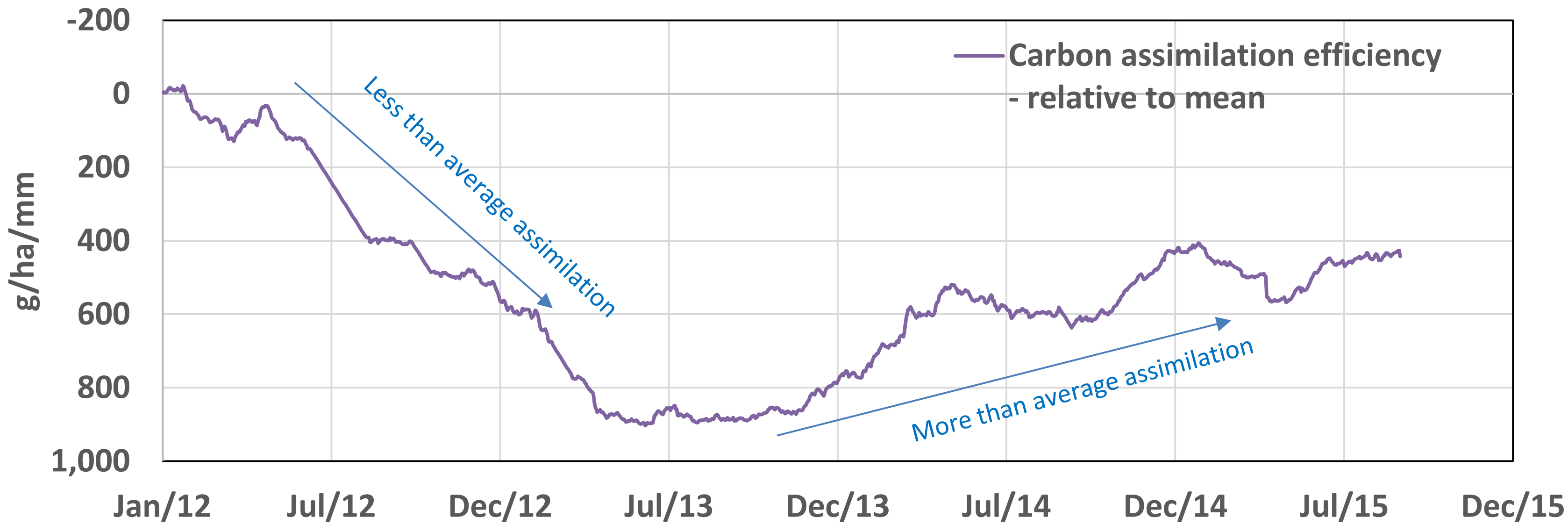
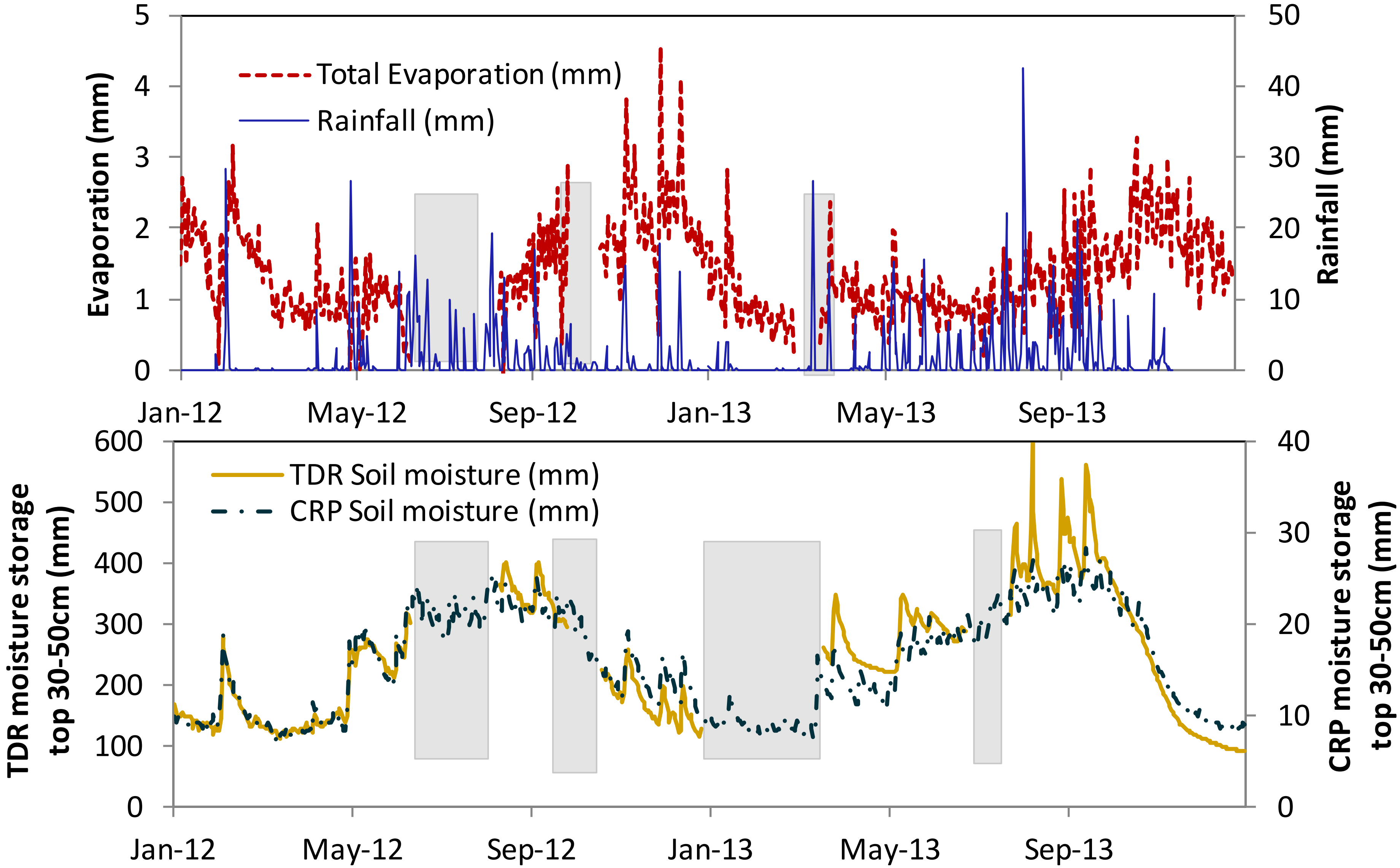




Water fluxes and soil moisture at Gingin



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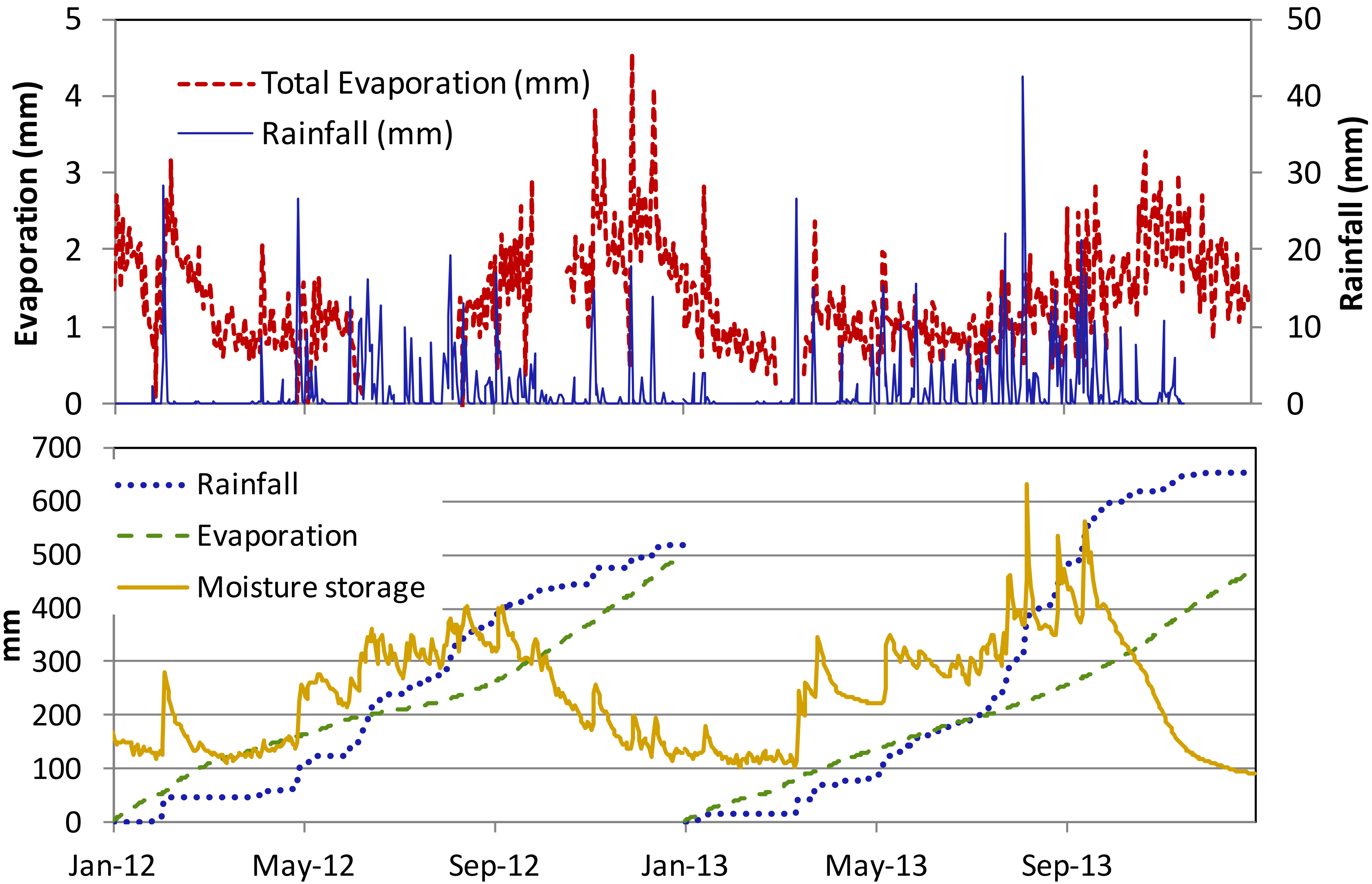

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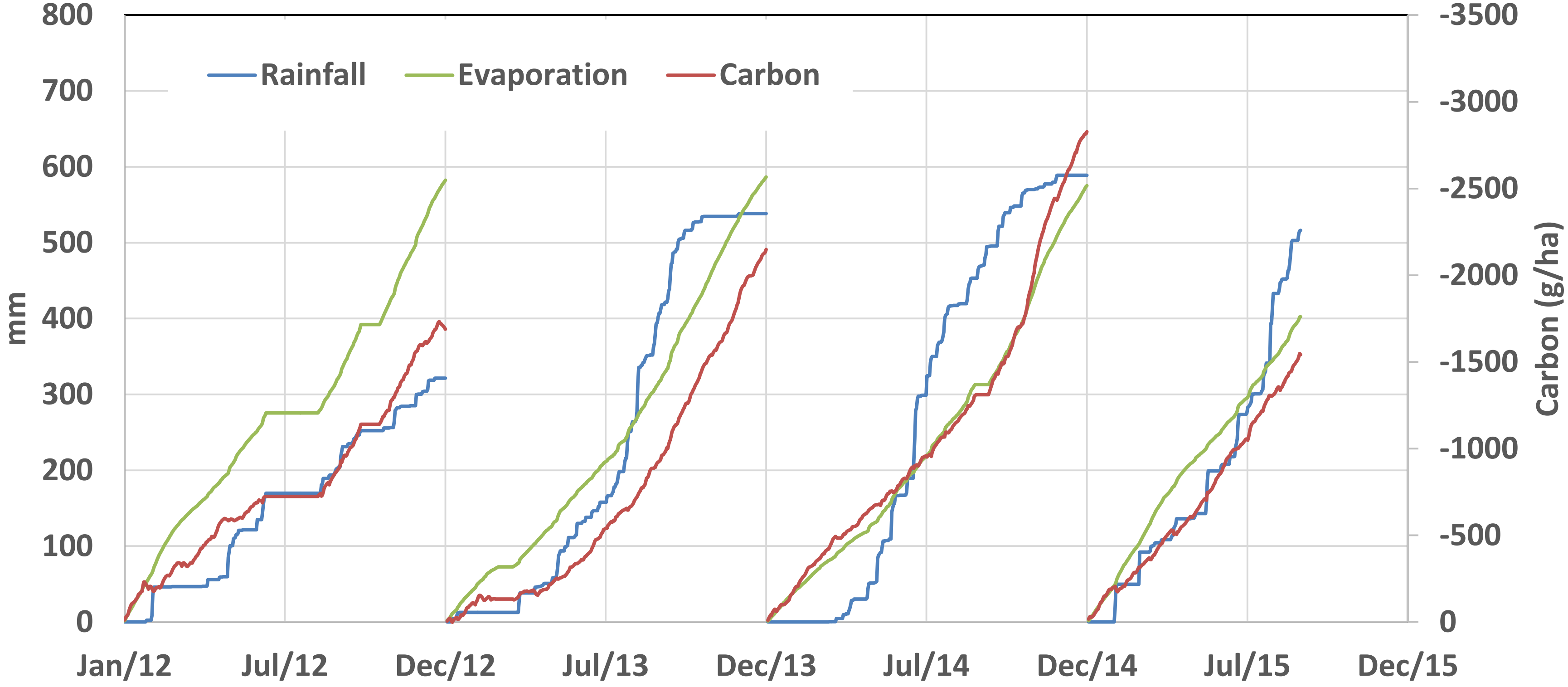
Water fluxes and carbon accumulation



2012-2015 water and carbon balance

	Rain	Evap	Carbon	Carbon/ Rain	Carbon/ Evap	Recharge ~(Rain-evap)
2012	321	582	-1688	-5.3	-2.9	-261
2013	538	587	-2148	-4.0	-3.7	-49
2014	589	575	-2827	-4.8	-4.9	14
2015*	516	402	-1542	-3.0	-3.8	114

Conclusions

- Gingin COSMOz running since May 2011
  OzFlux station ~running since October, 2011
- For the first time evaporation is being measured at approaching "management scale" and recharge to the groundwater calculated in near real time
- Recharge is variable in season and year
- Carbon assimilation is highly dependent on season and year
- Collaboration welcome

THANK YOU

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