Near real-time recharge calculations to Gnangara groundwater mound using eddy flux measurements

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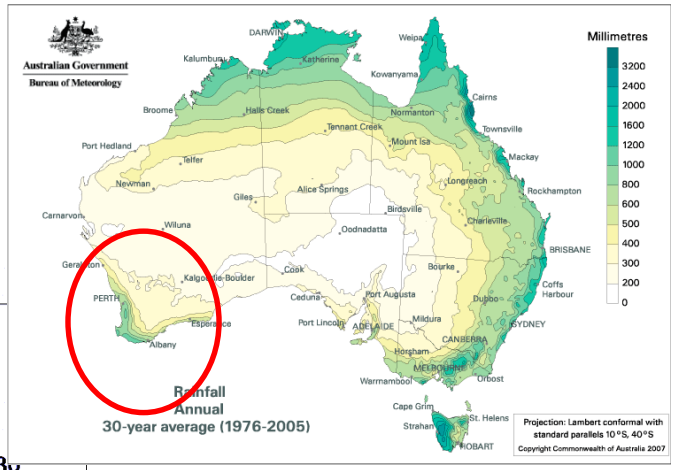
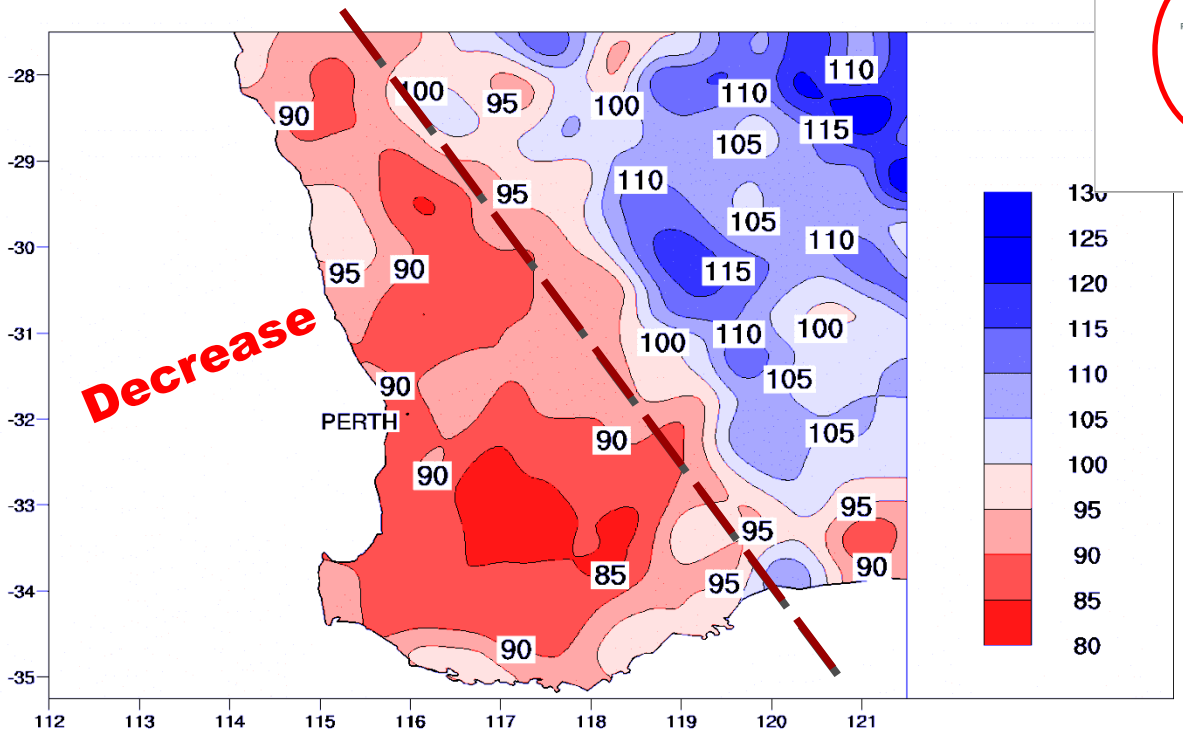
Local context – groundwater is under stress

- Drying climate is reducing stream flows to dams and recharge to aquifers
- The city of Perth with 2 million inhabitants has 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)

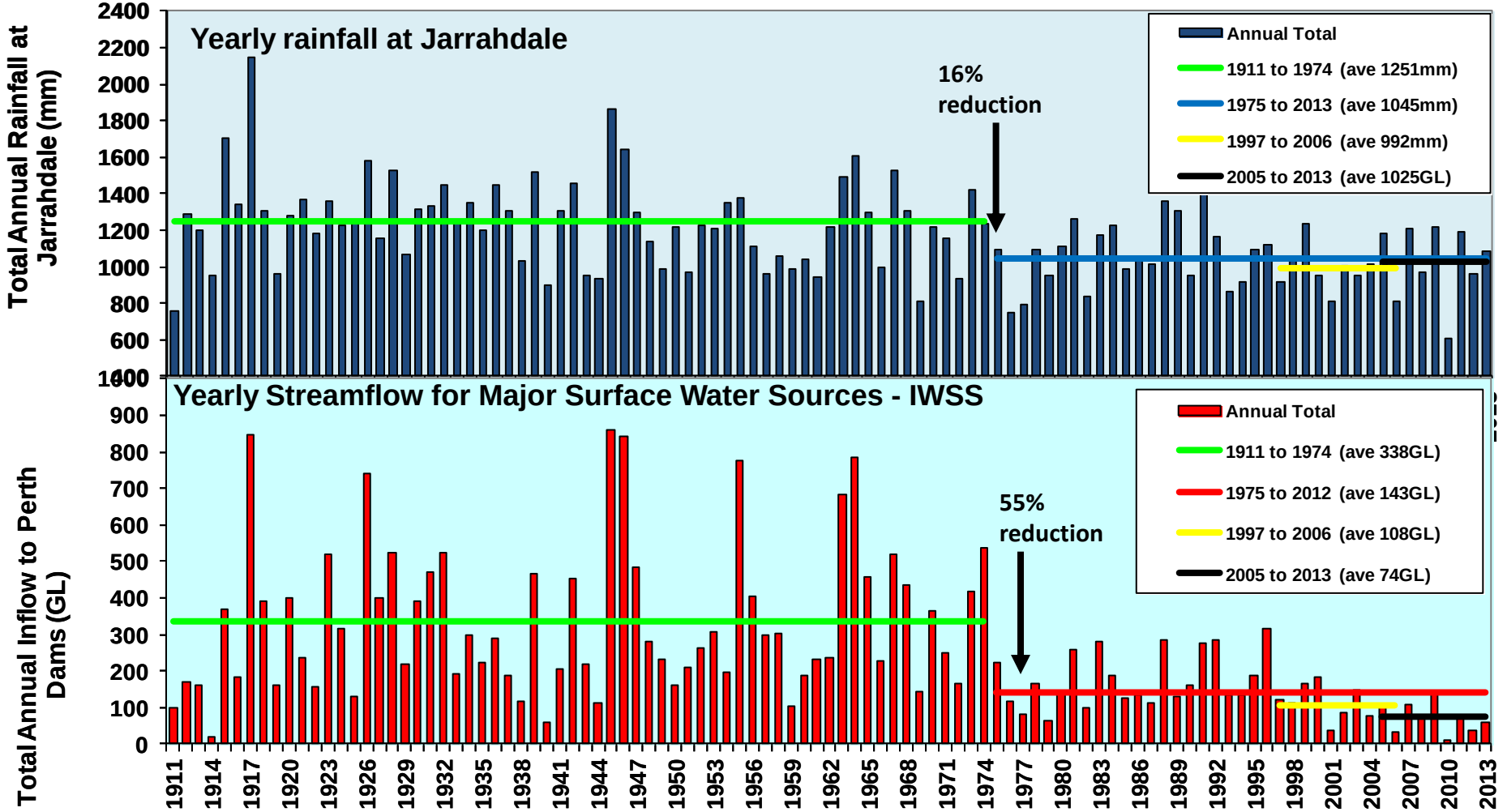
The site was selected because south-west Western Australia has had a major climate shift with a significant reduction in rainfall in the south west since the early 1970s



Last quarter century winter rain as % of previous 75 years



16% reduction in rainfall has resulted in 55% reduction in inflow into Perth dams and recharge



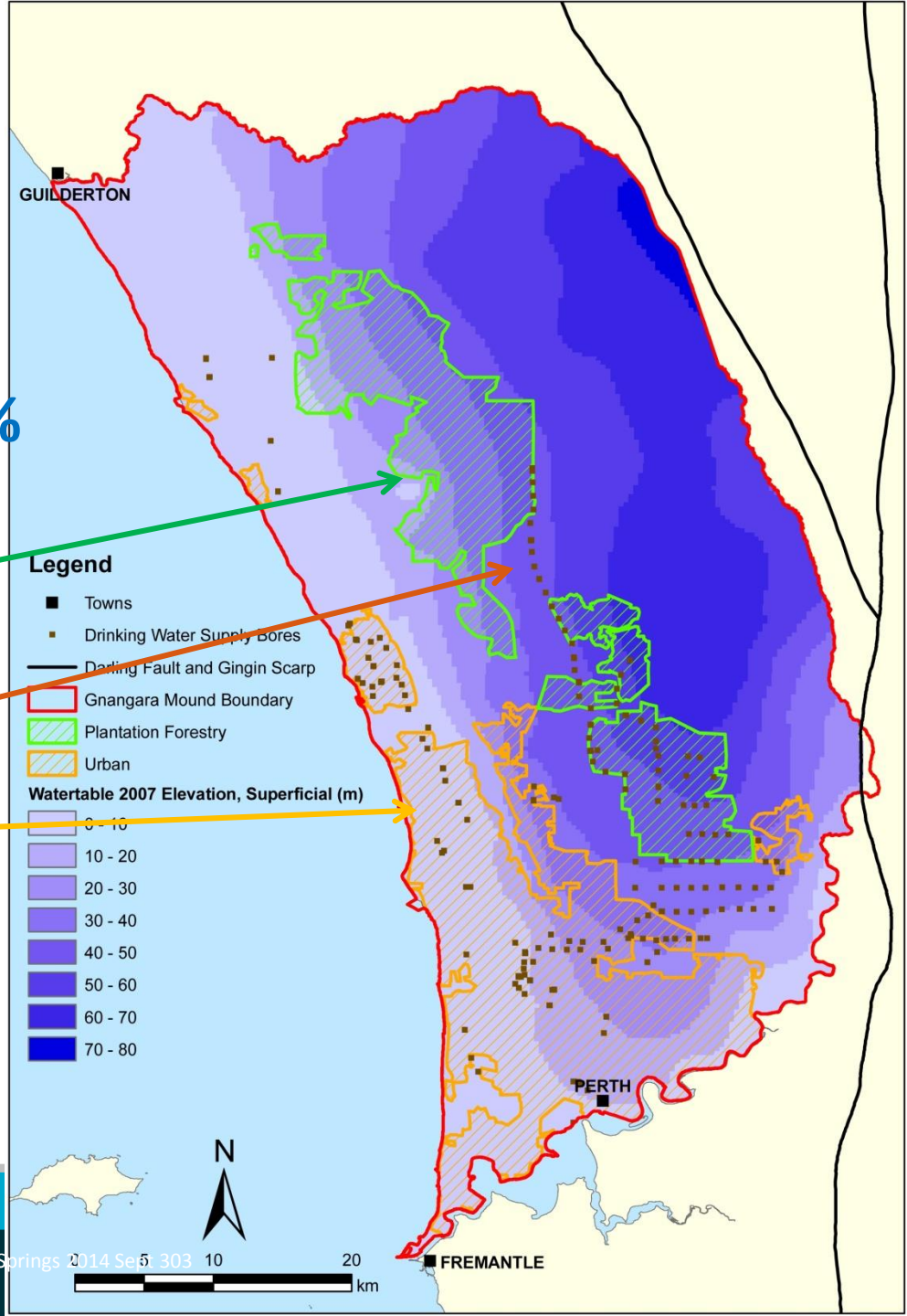
Because of reducing dam inflow, we have increased reliance on groundwater.

In 1975 it was 5% now 50%

P. pinaster plantation

Water supply bores

Urban area



Purpose of the facility

To measure state variables and water, energy and carbon fluxes, in ecological systems responding to change …

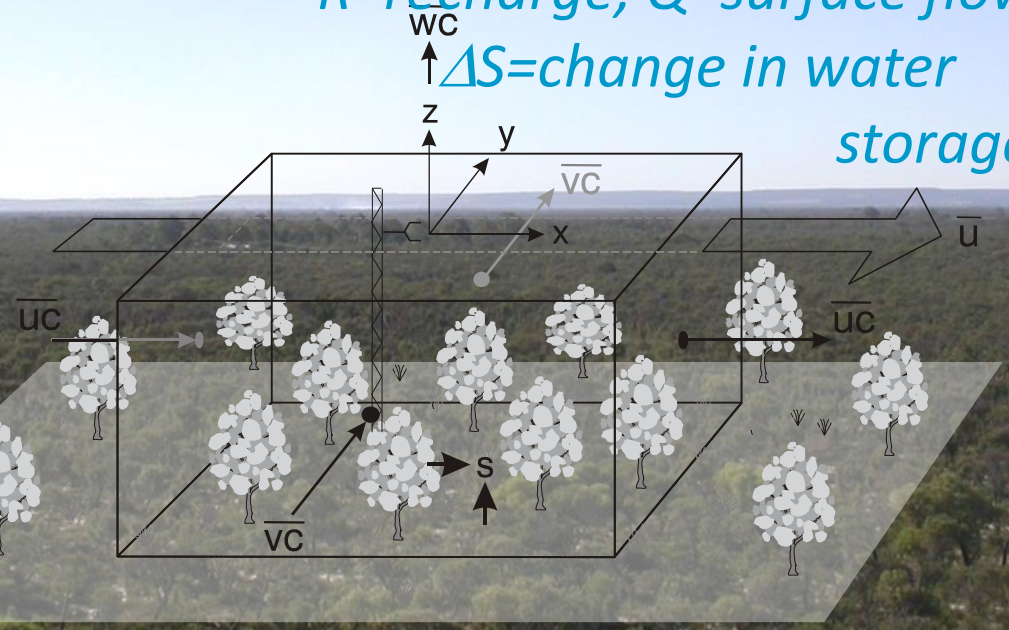
To close the water balance for a major water resource and understand the related carbon balance

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

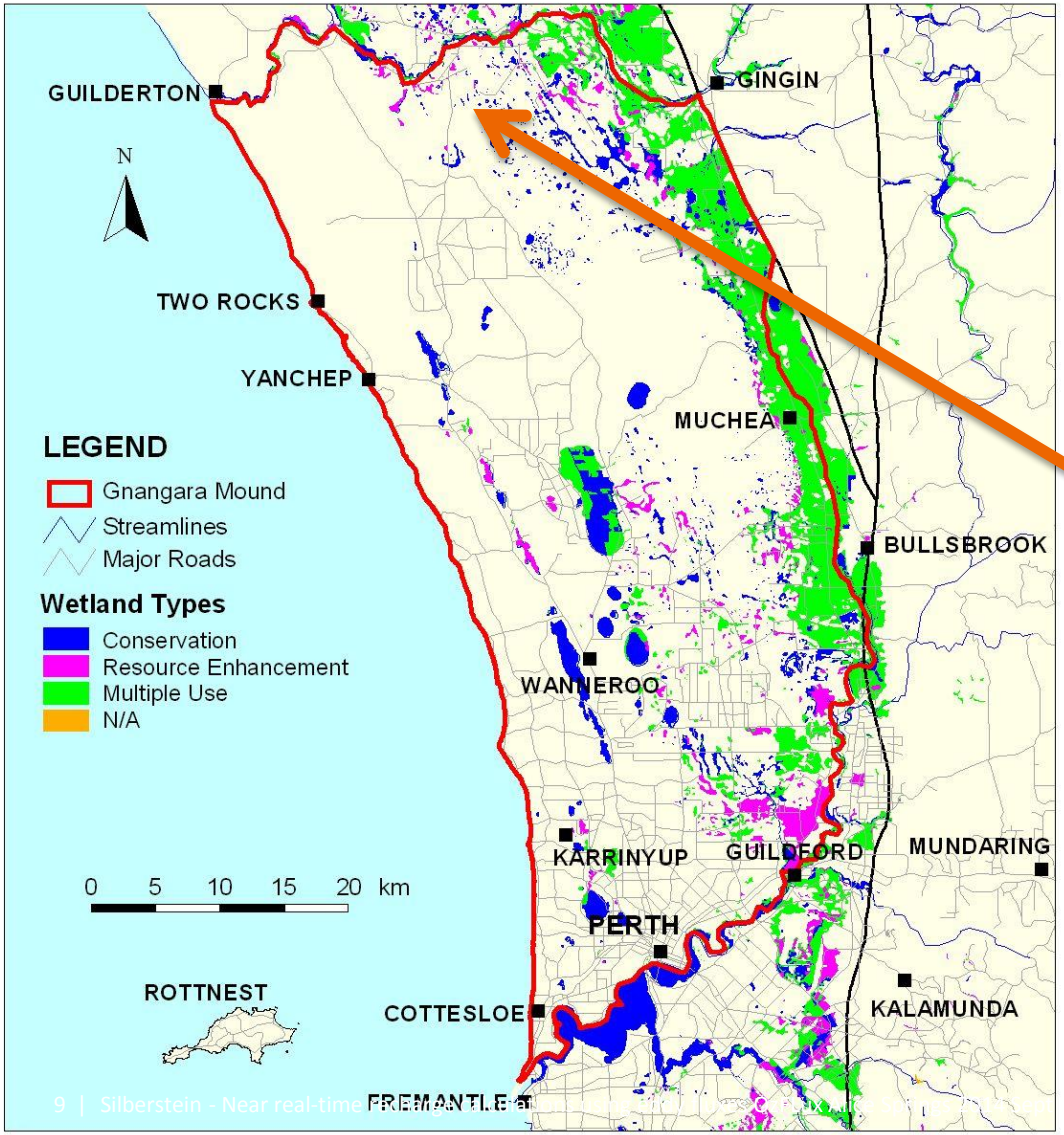
$$R_n + A = \lambda E + H + G \qquad P = E + R + Q + \Delta S$$

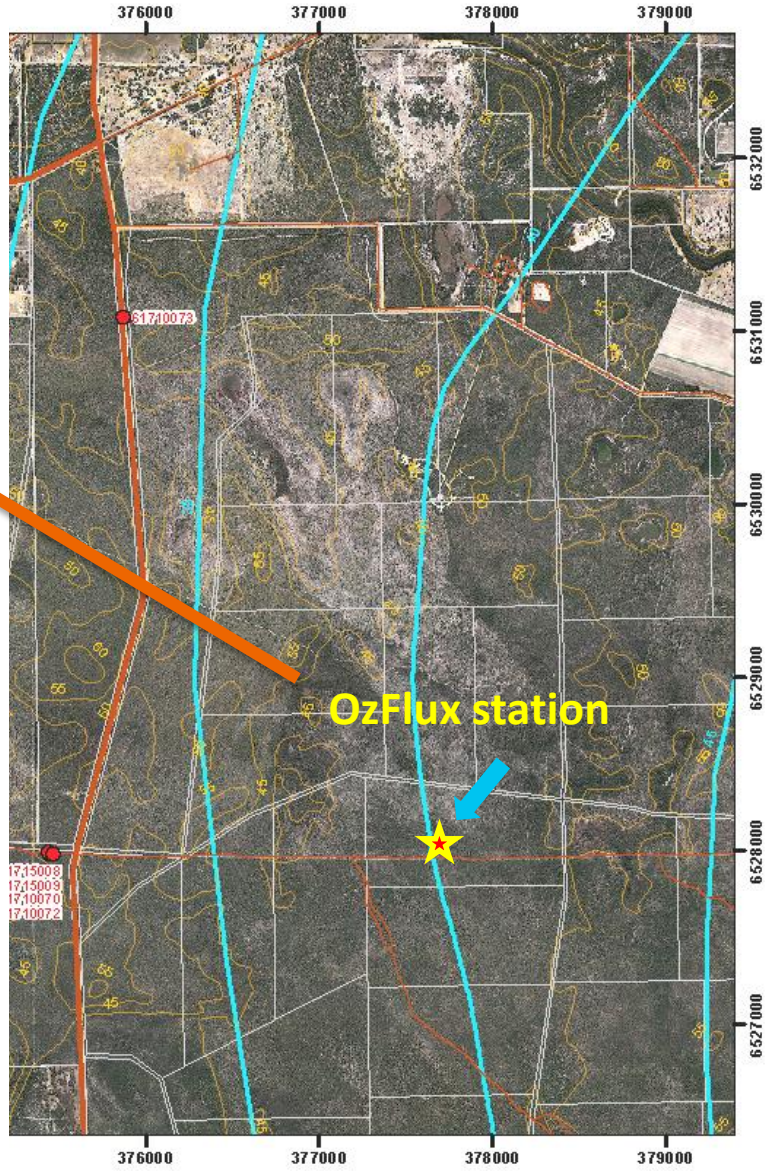
R_n=net radiation
A=advected energy
λE=latent heat
H=sensible heat
G=heat storage

P=precipitation; E=evaporation
R=recharge; Q=surface flow
ΔS=change in water storage



Gingin-Gnangara flux station 80km north of Perth





The site is chosen to understand the water use and carbon balance of the Banksia woodland and (hopefully) contribute to sustainable management of Gnangara groundwater and ecosystem

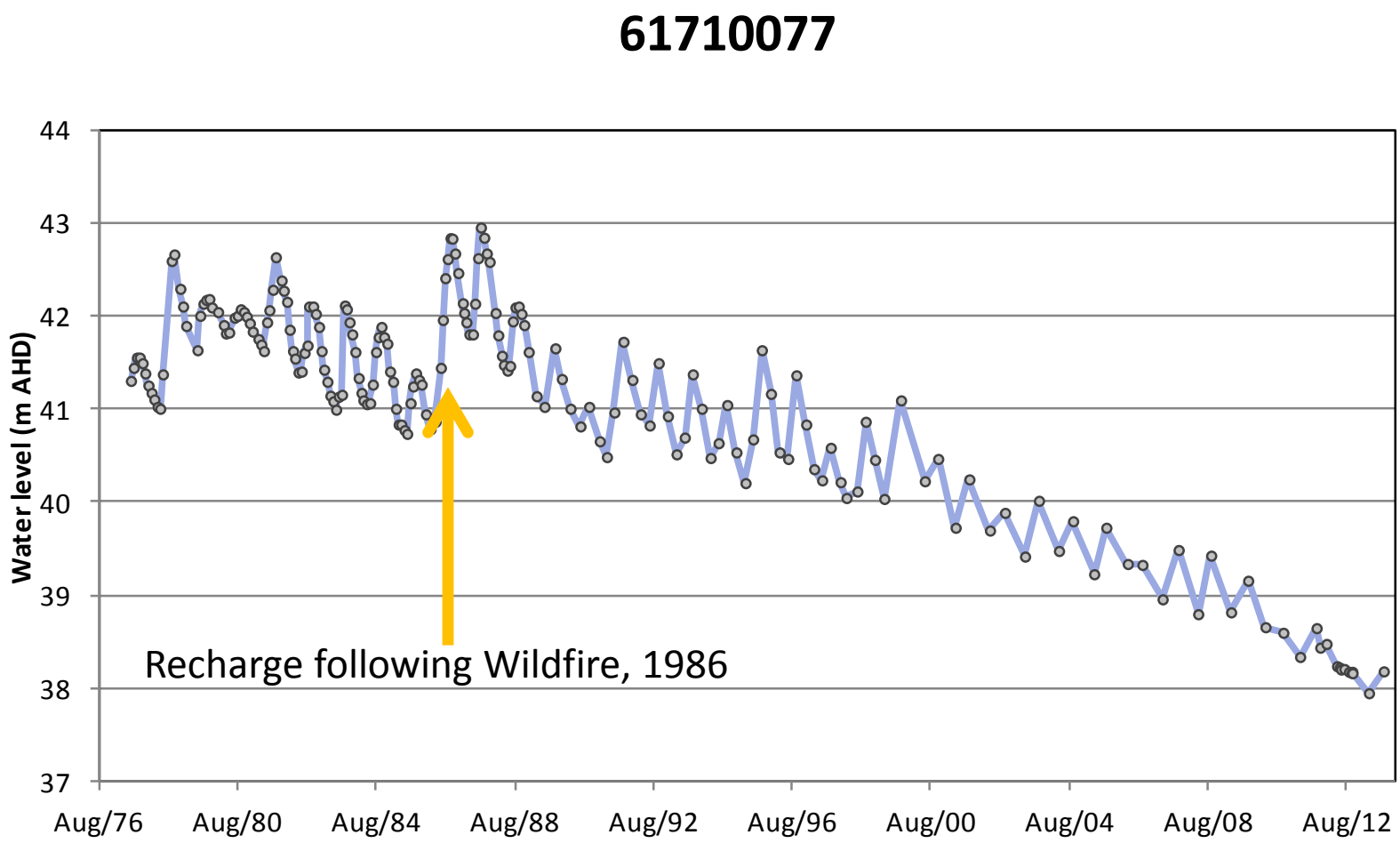
	Area (km^2)	mm	GL/yr
Input rainfall	2194	750	1646
Land use	Evaporative Water Use		
Native Bush	1048	600	629
Pines	~~225~~	~~850~~	~~200~~
Wetlands	12	800	10

Site selected with Noongar approval …

The Gnangara/Gingin site

- Elevation 50m AHD
- Banksia woodland
- Tree height ~6.5m
- 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



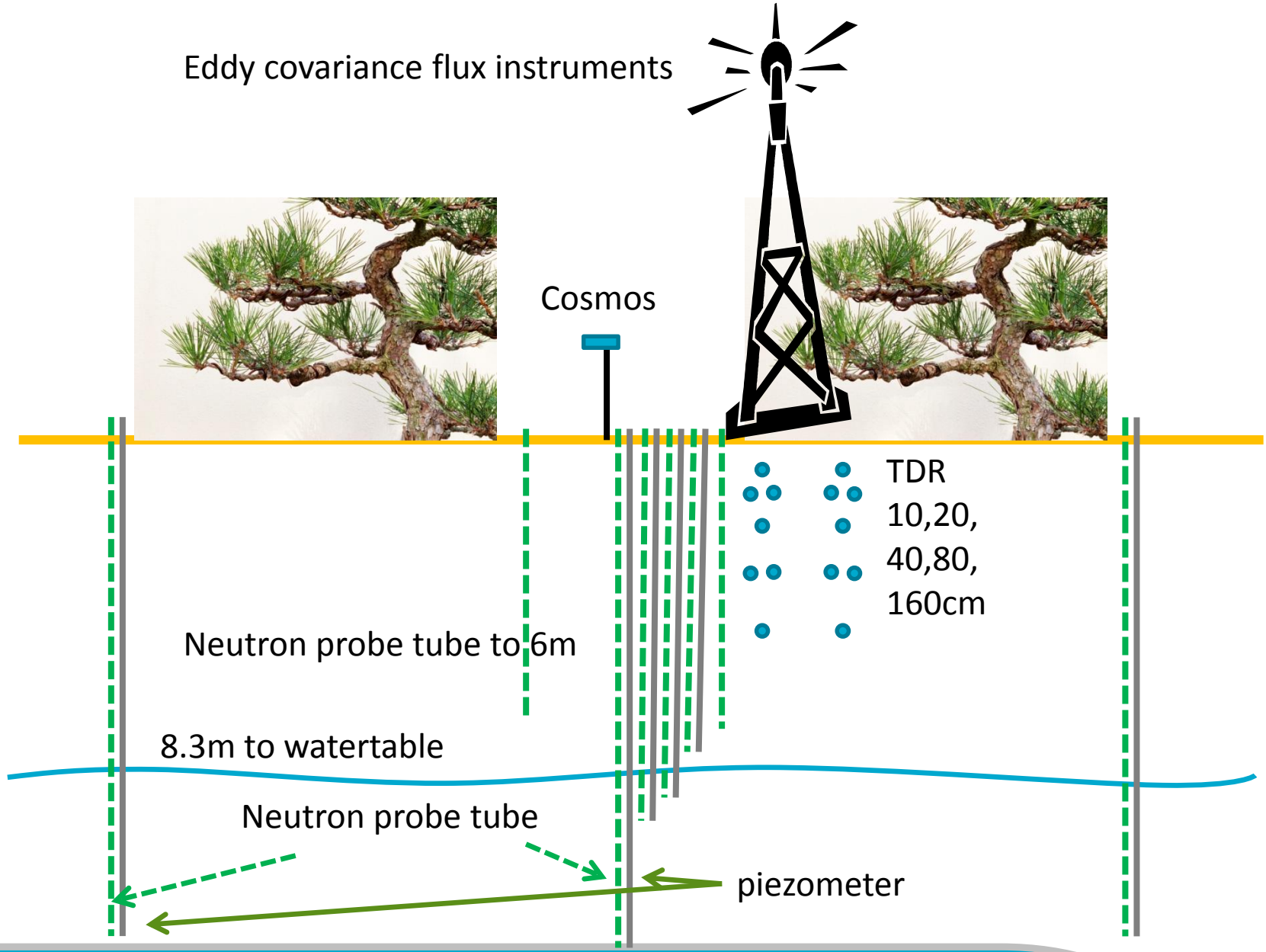
Instruments – eddy covariance

- soil moisture x16, soil temperature x 2,
- groundwater level x 3,
- soil and water salinity from 3 nests of sampling piezos (20cm screens)
- 3x3+ 1x8 Neutron tubes
- PhenoCams

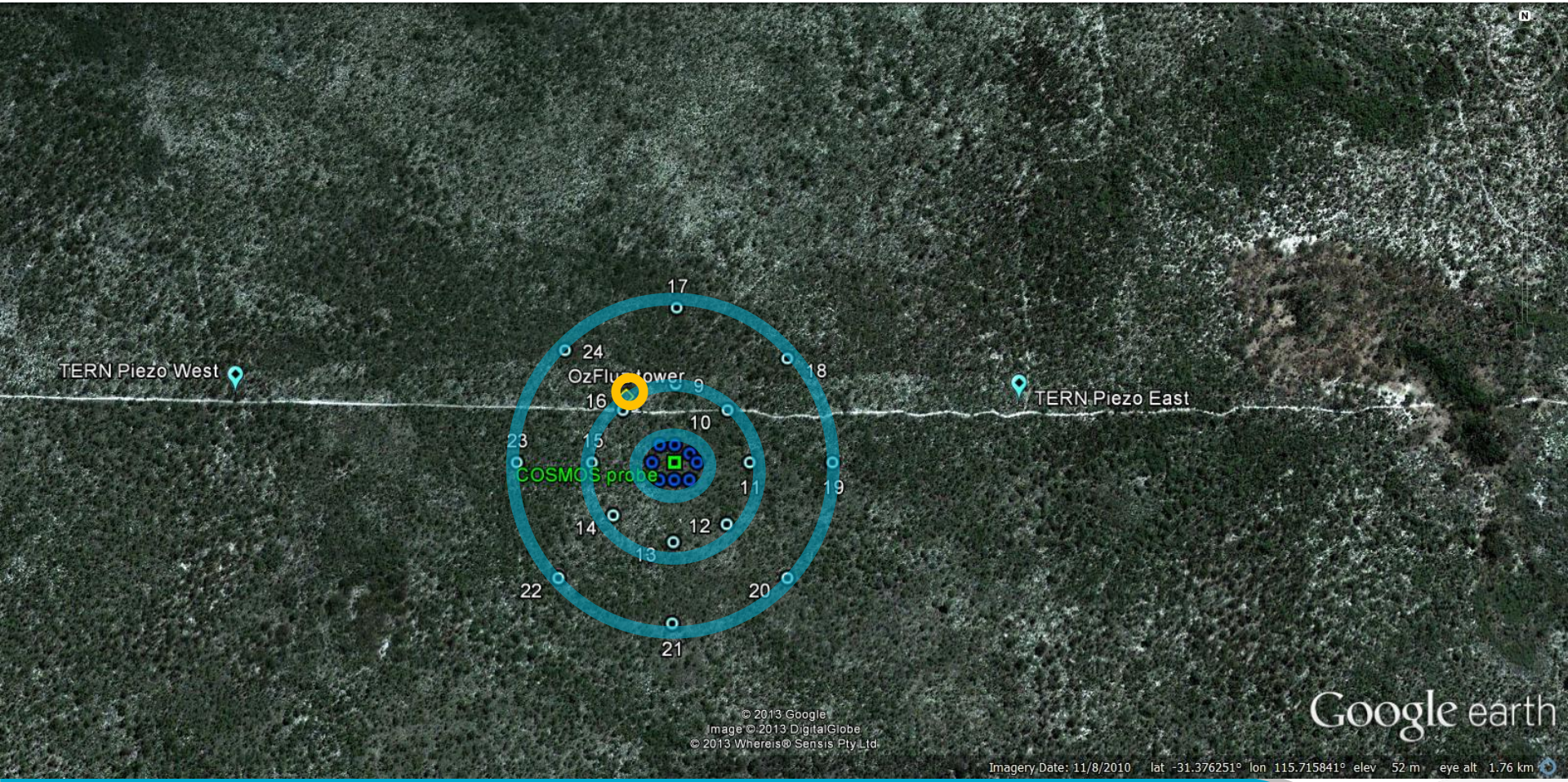
Instruments include

Cosmos - cosmic ray moisture monitoring

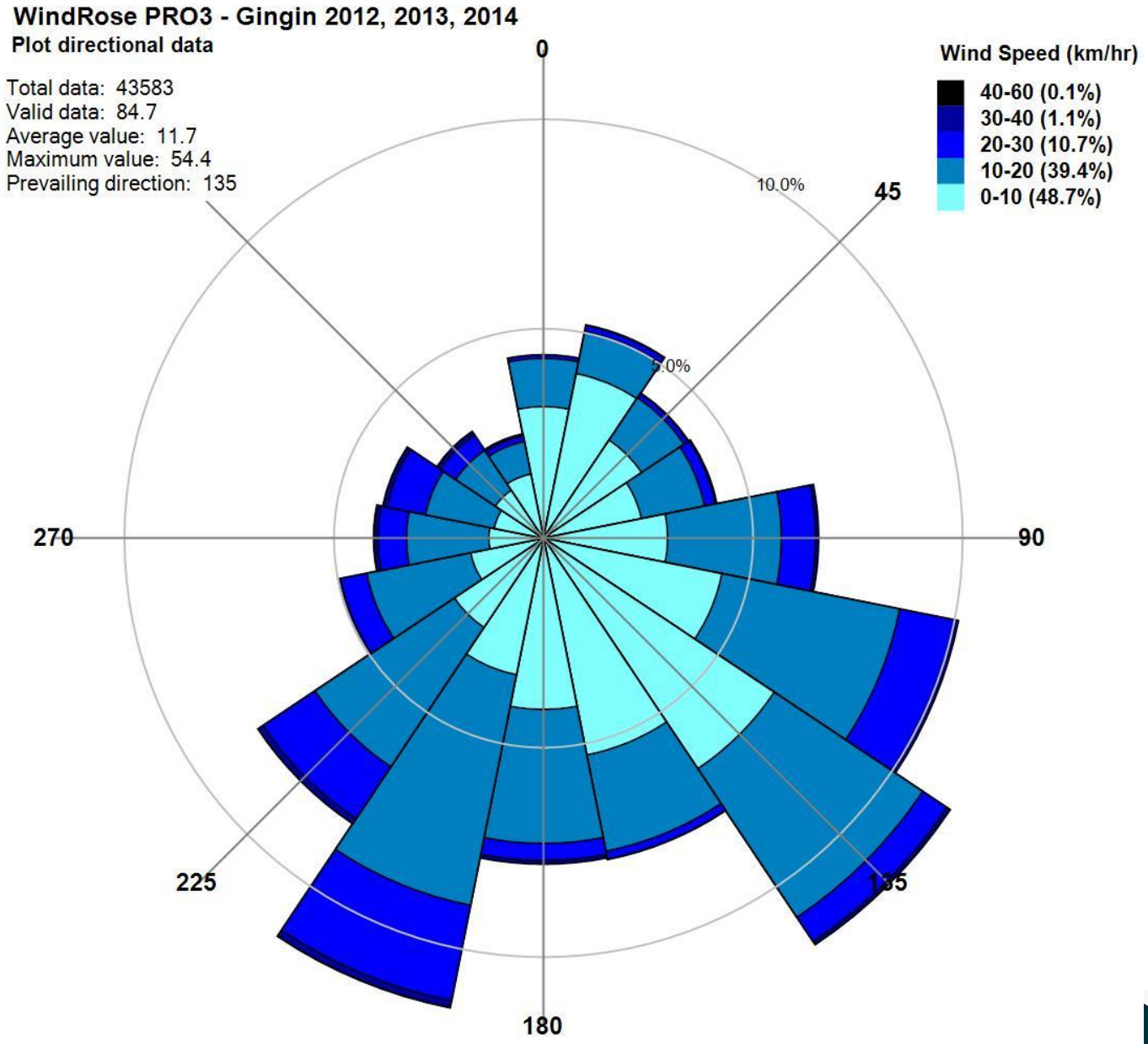
and nested piezometers


Eddy covariance flux instruments
Cosmos
TDR
10,20,
40,80,
160cm
Neutron probe tube to 6m
8.3m to watertable
Neutron probe tube
piezometer

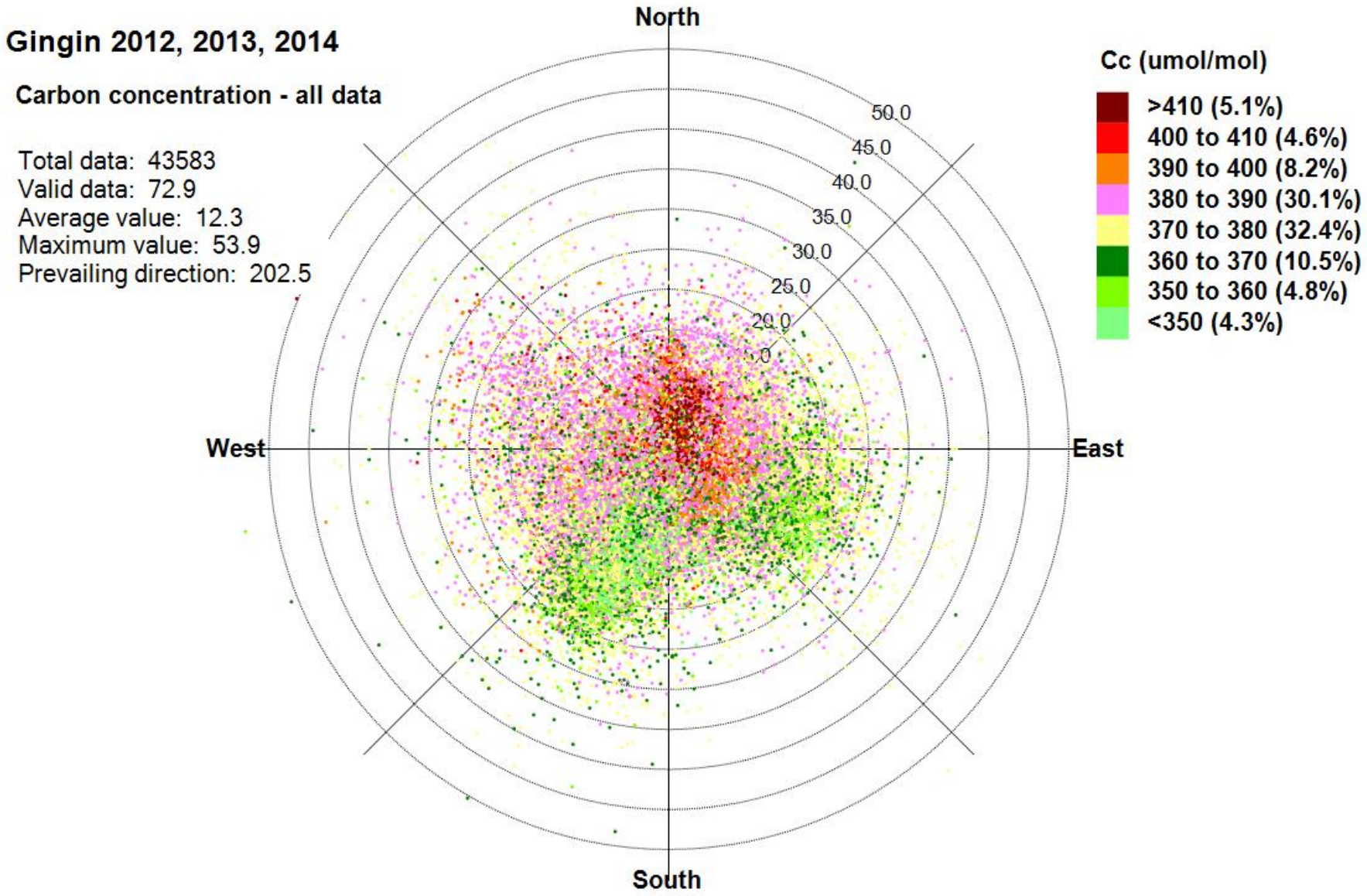
Our Cosmos probe is surrounded by concentric rings of calibration sites and a ring of standard neutron probe sites



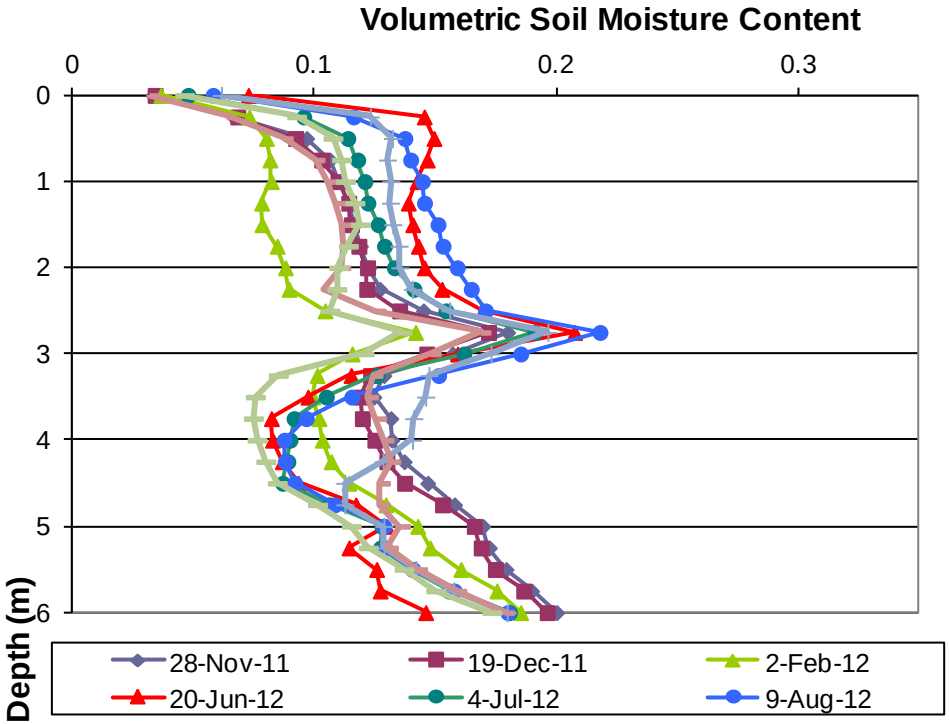
Wind environment

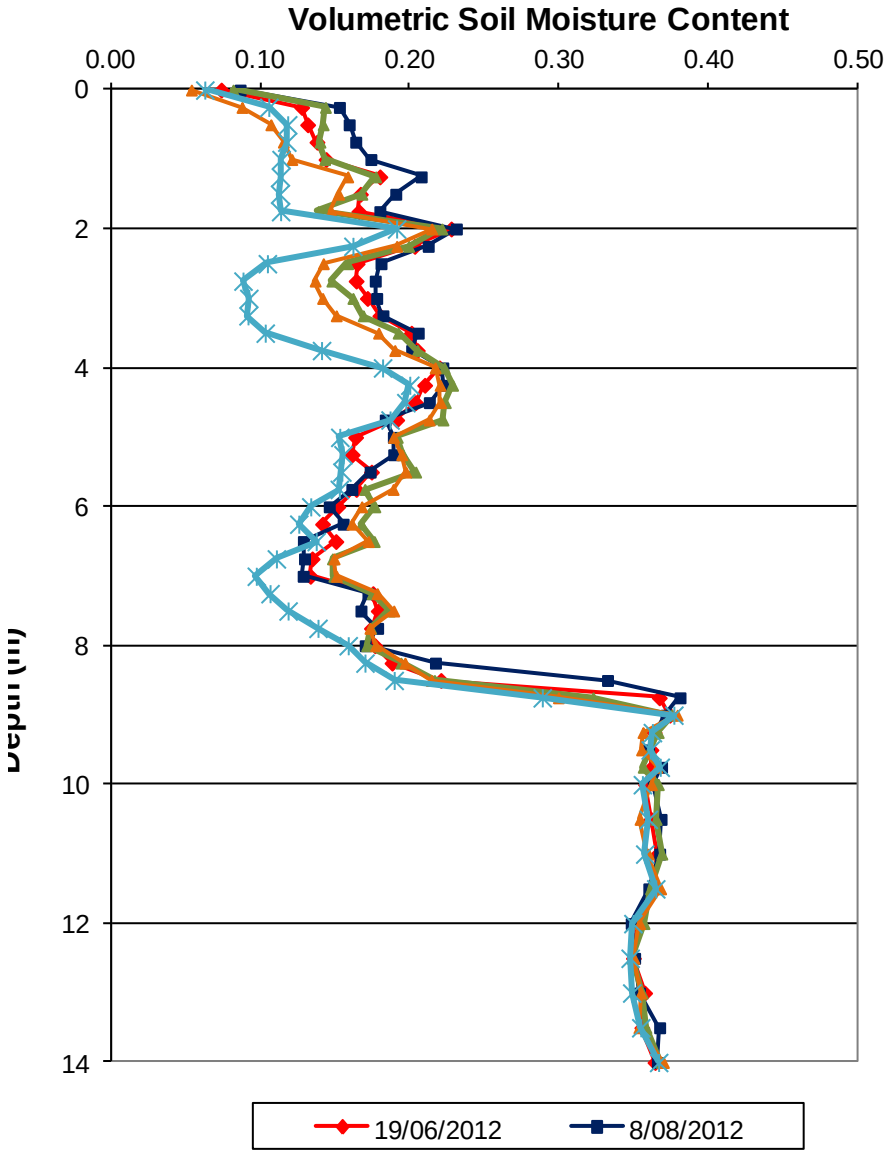


CO_2 "environment"



Soil moisture profiles around the COSMOS





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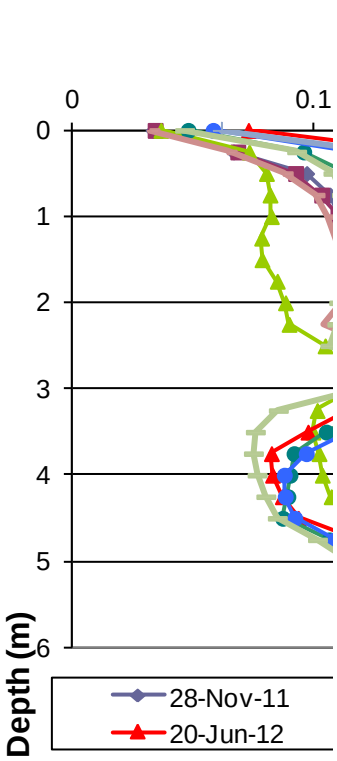
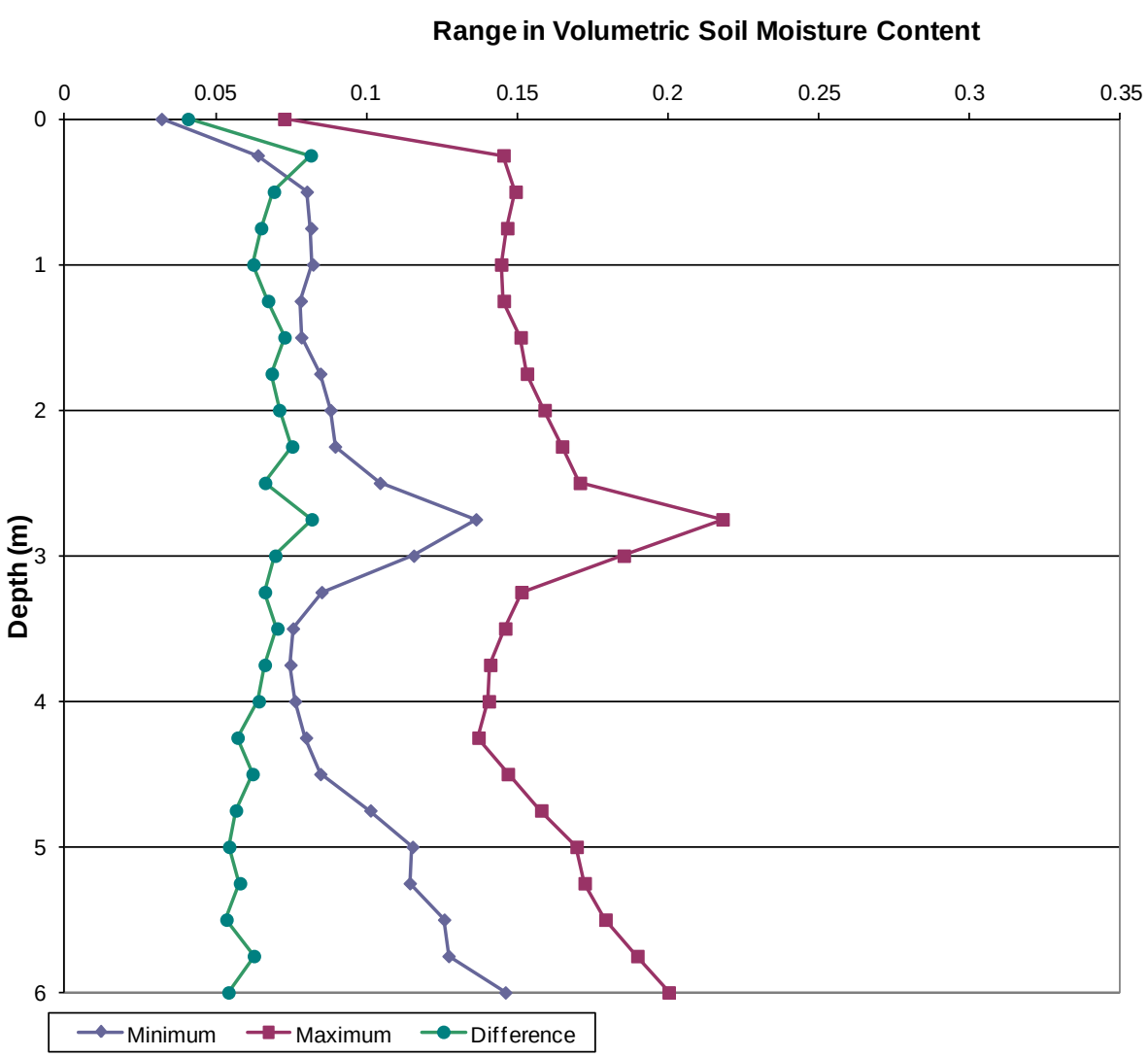
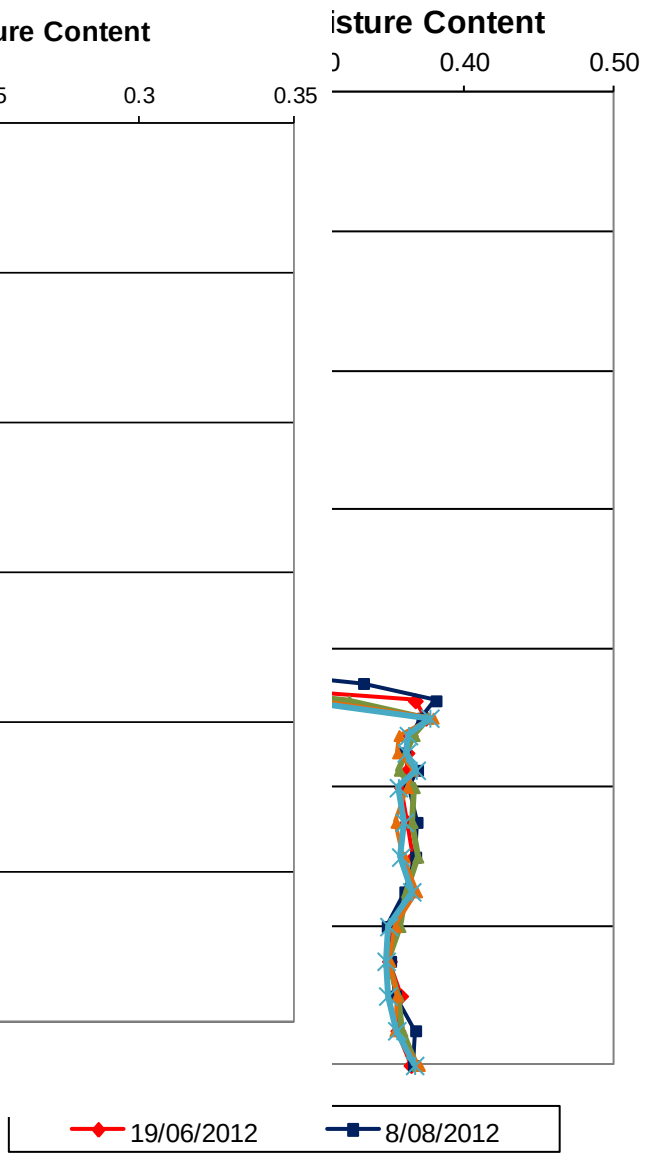
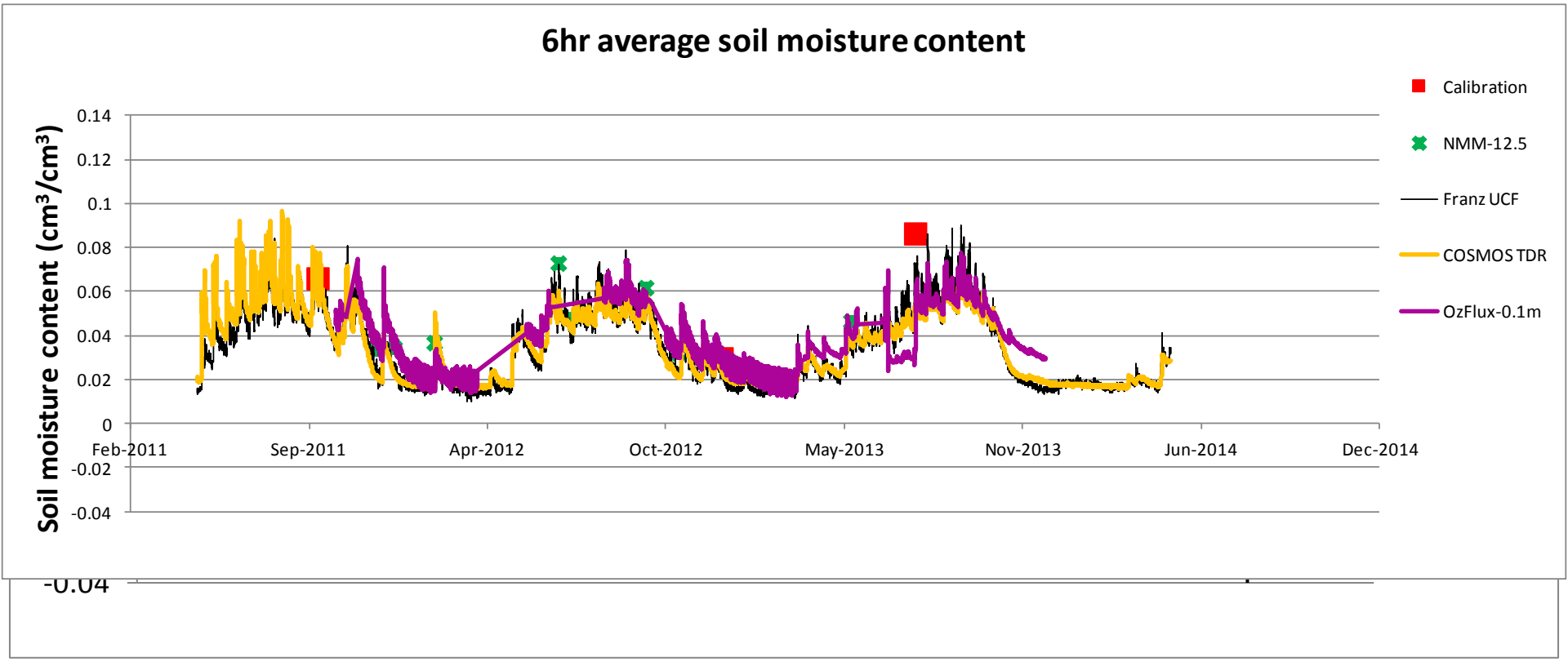


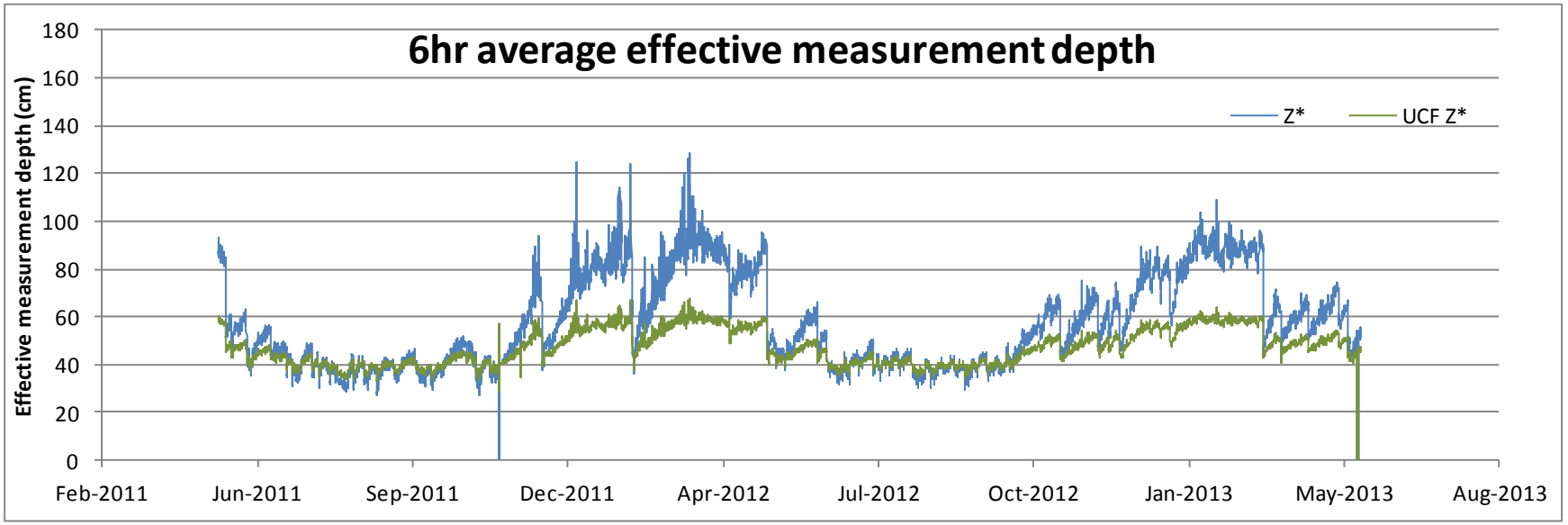




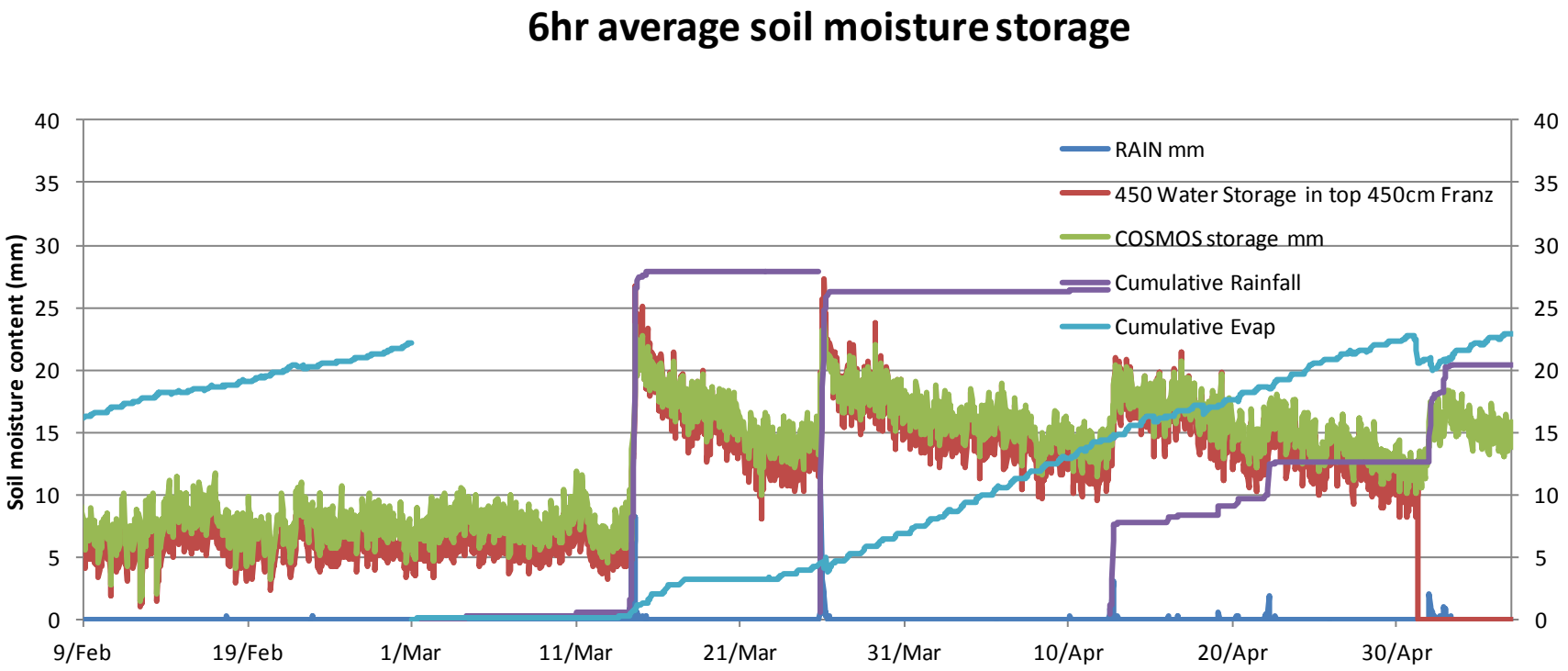
Soil moisture trends at COSMOS



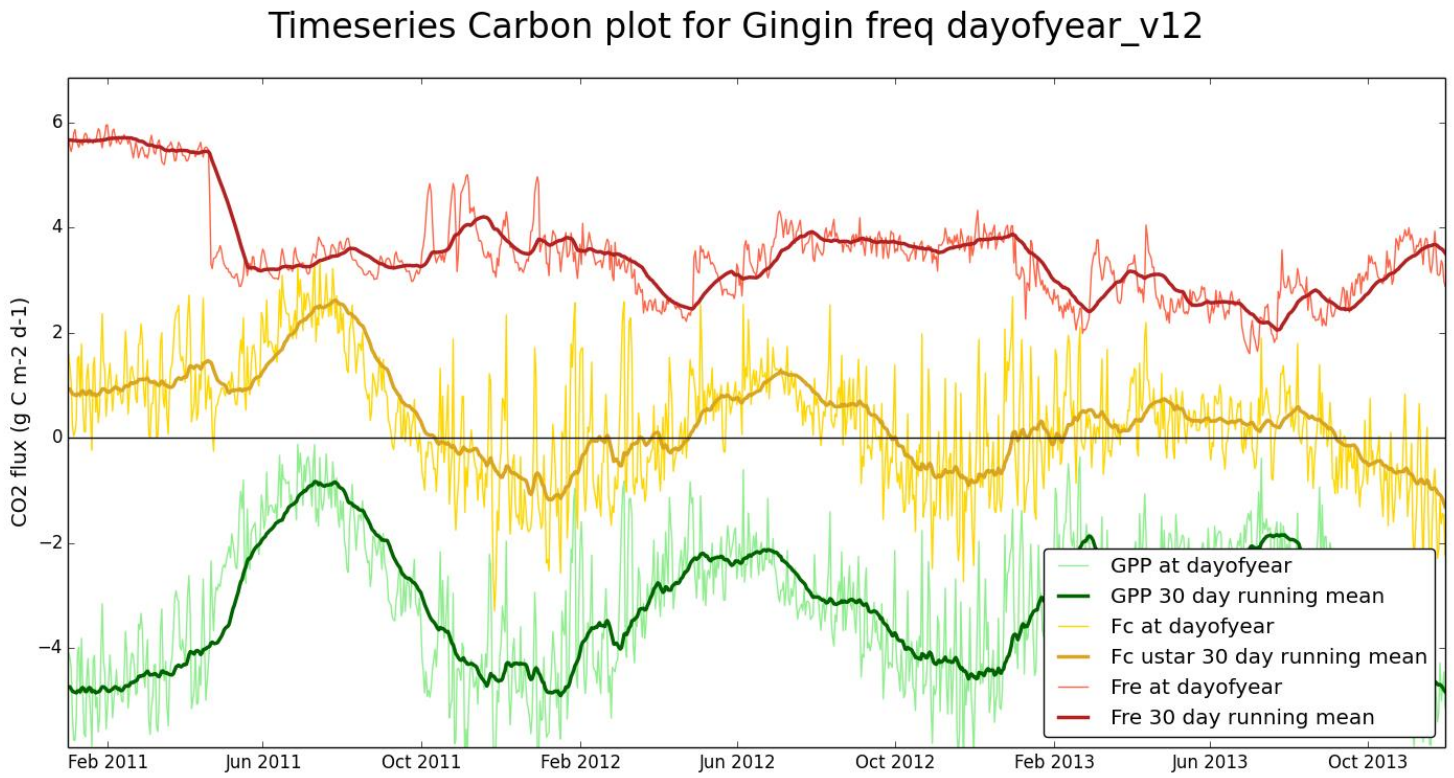
Soil moisture effective measurement depth

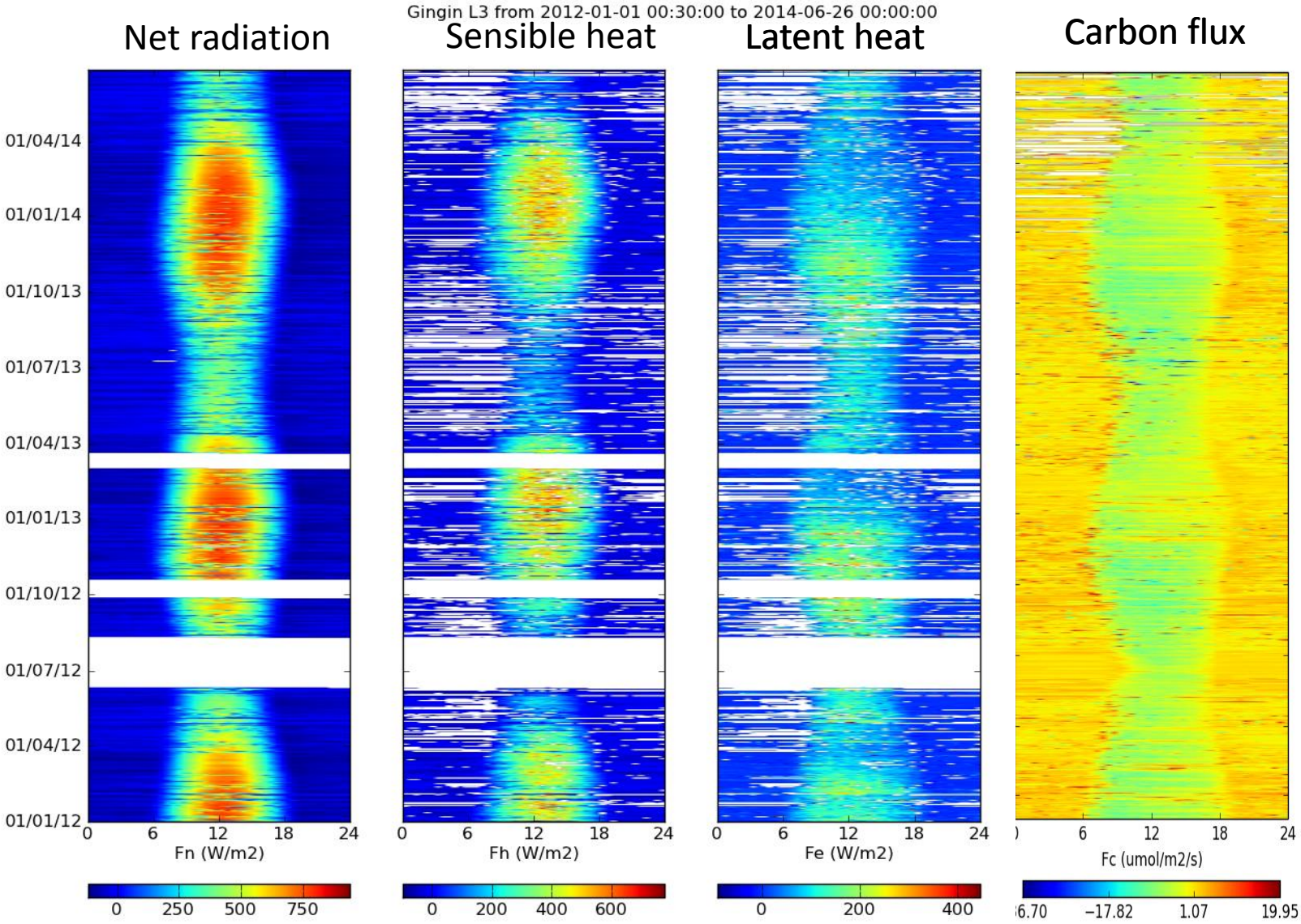


Soil moisture storage, rainfall and evaporation

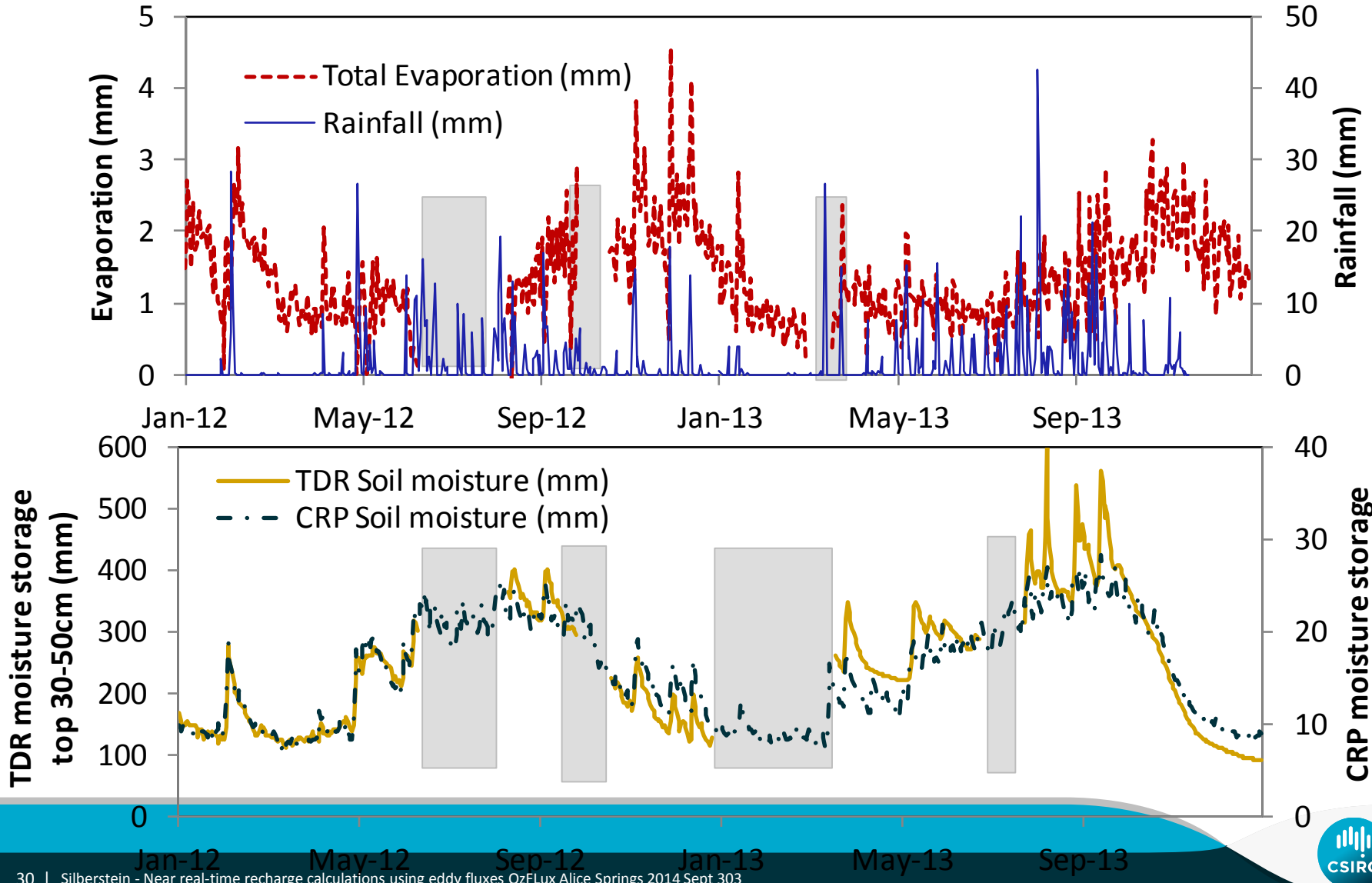


DINGO Carbon fluxes

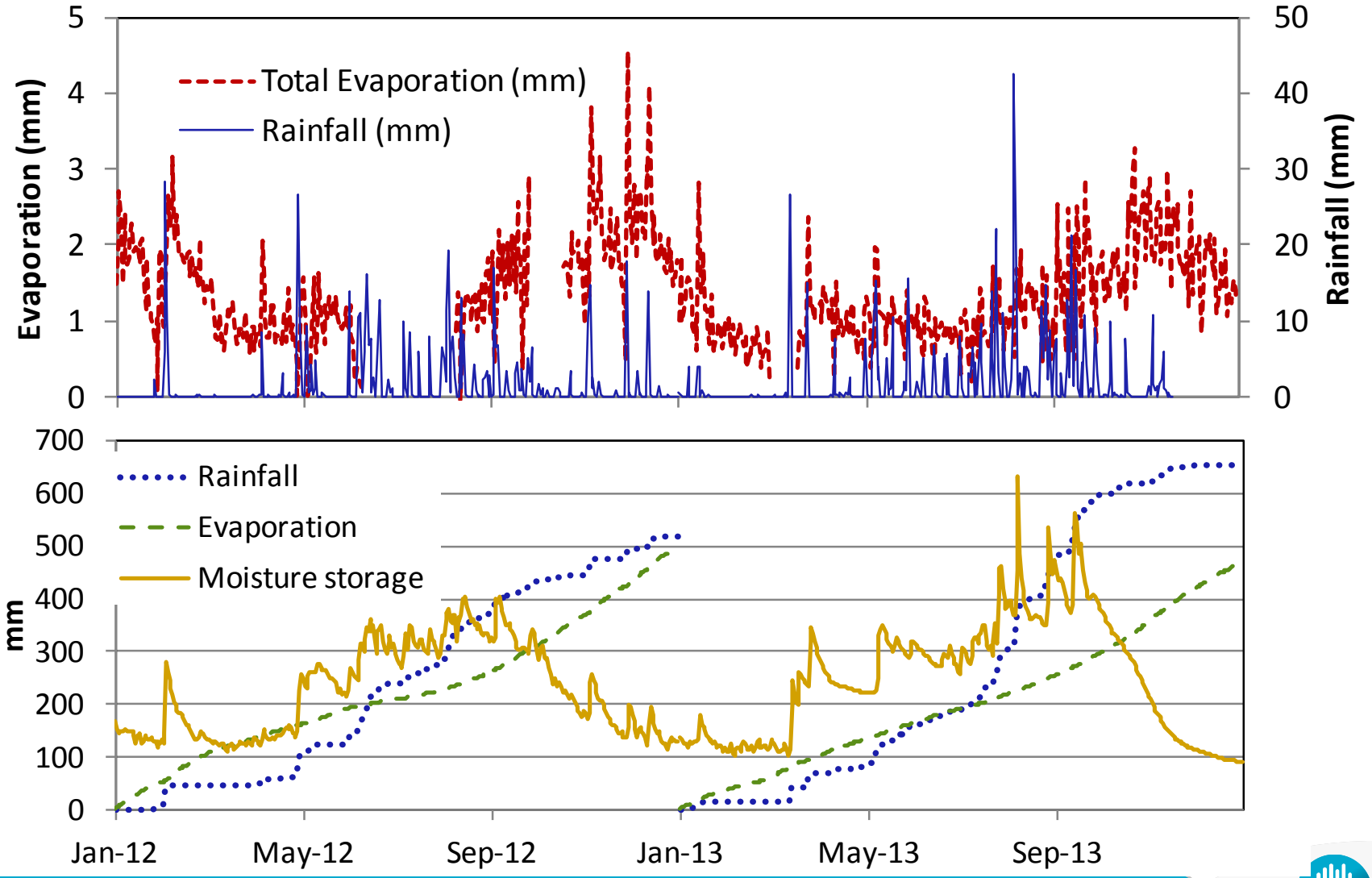



Gingin L3 from 2012-01-01 00:30:00 to 2014-06-26 00:00:00
Net radiation
Sensible heat
Latent heat
Carbon flux
01/04/14
01/01/14
01/10/13
01/07/13
01/04/13
01/01/13
01/10/12
01/07/12
01/04/12
01/01/12
0 6 12 18 24
Fn (W/m2)
0 250 500 750
Fh (W/m2)
0 200 400 600
Fe (W/m2)
0 200 400
Fc (umol/m2/s)
−17.82 1.07 19.95

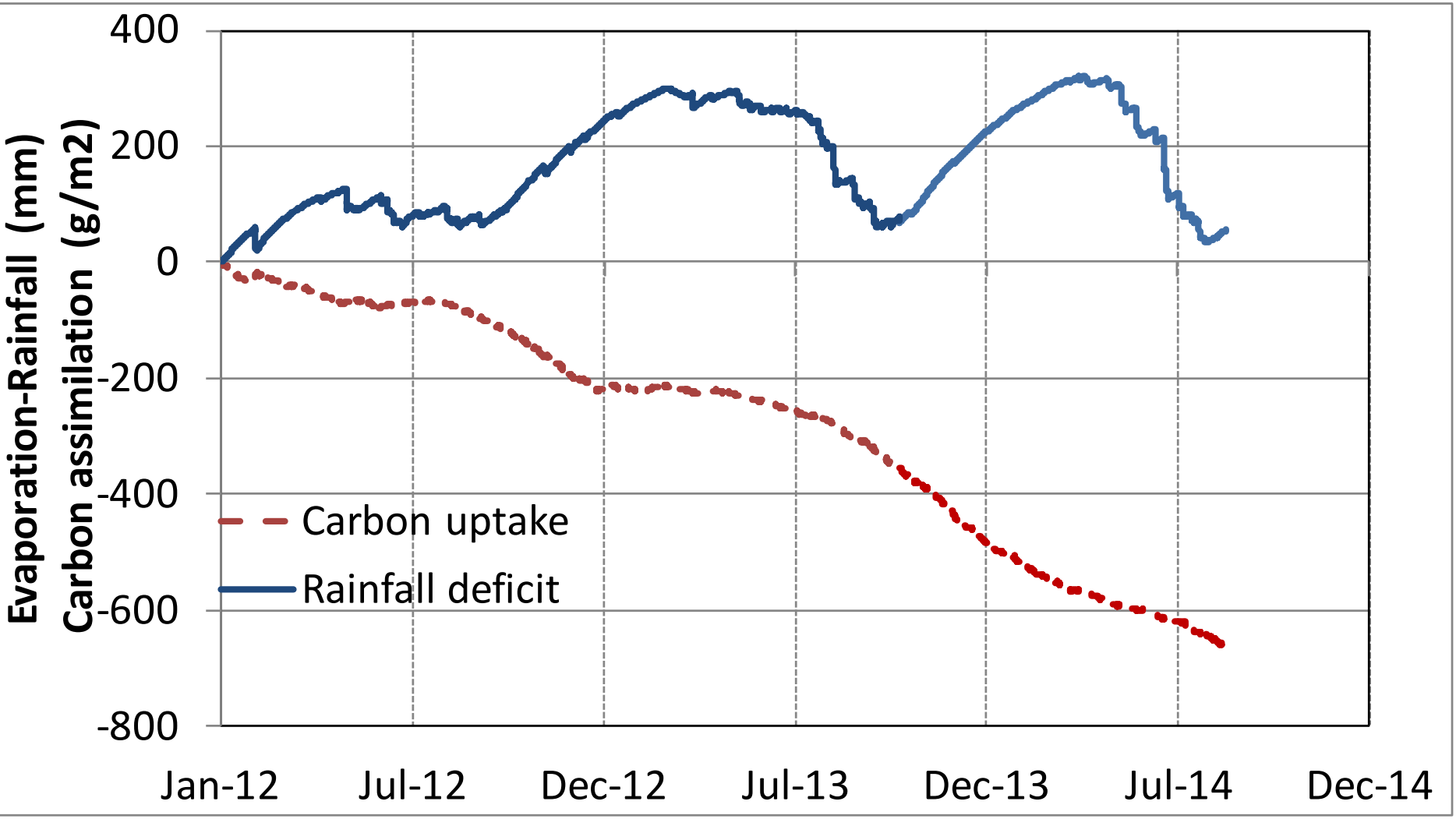
Water fluxes and soil moisture at Gingin



Water fluxes and soil moisture at Gingin

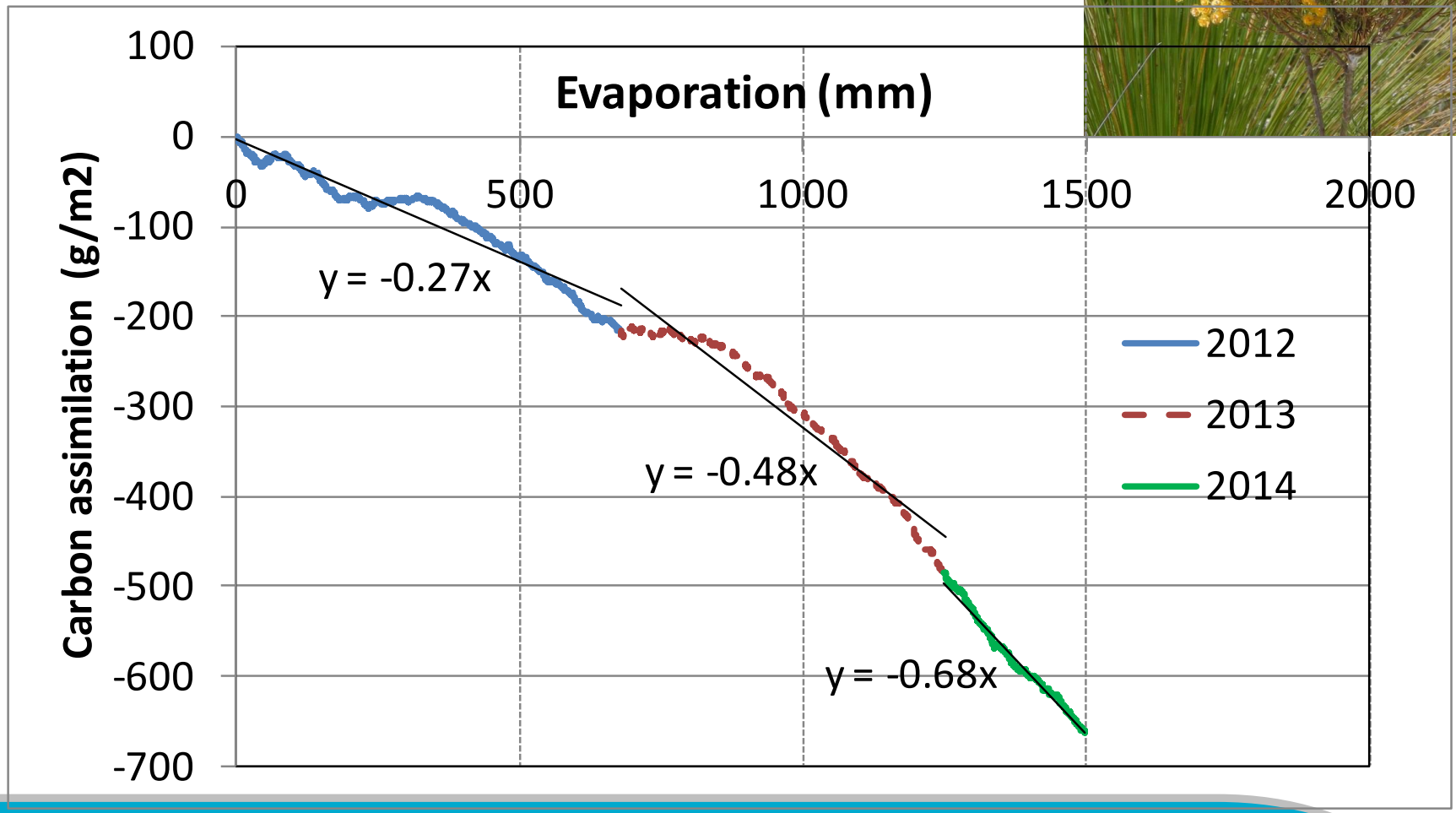


Cumulative water and carbon fluxes



Carbon assimilation efficiency:

Carbon flux *vs* evaporation



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 in 2012 was zero,
  in 2013 was 100- 150mm
  2014 looks negative
- Accumulated ~700kg C/ha in 3 years

Thank you

Land and Water/Climate and Atmosphere Theme
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