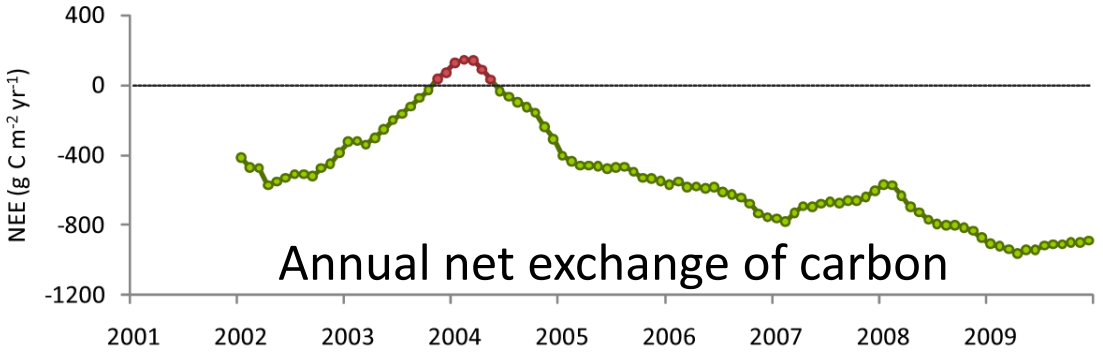

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What drives carbon exchange between a temperate sclerophyll forest and the atmosphere on time scales from hours to multiple years?

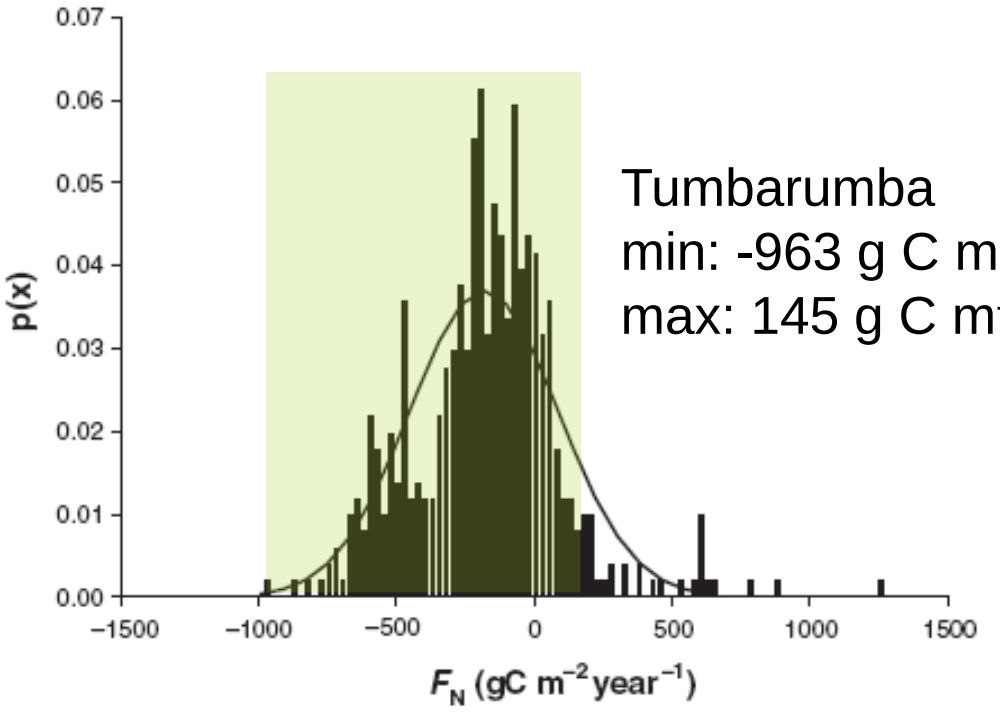
Eva van Gorsel[1], Heather Keith[2], **Helen Cleugh[1],** Vanessa Haverd[1] and Ray Leuning[1]

(1) CSIRO Marine and Atmospheric Research, Canberra, Australia
(2) The Fenner School of Environment and Society, ANU, Canberra, Australia

CSIRO

Variability of NEE, FLUXNET

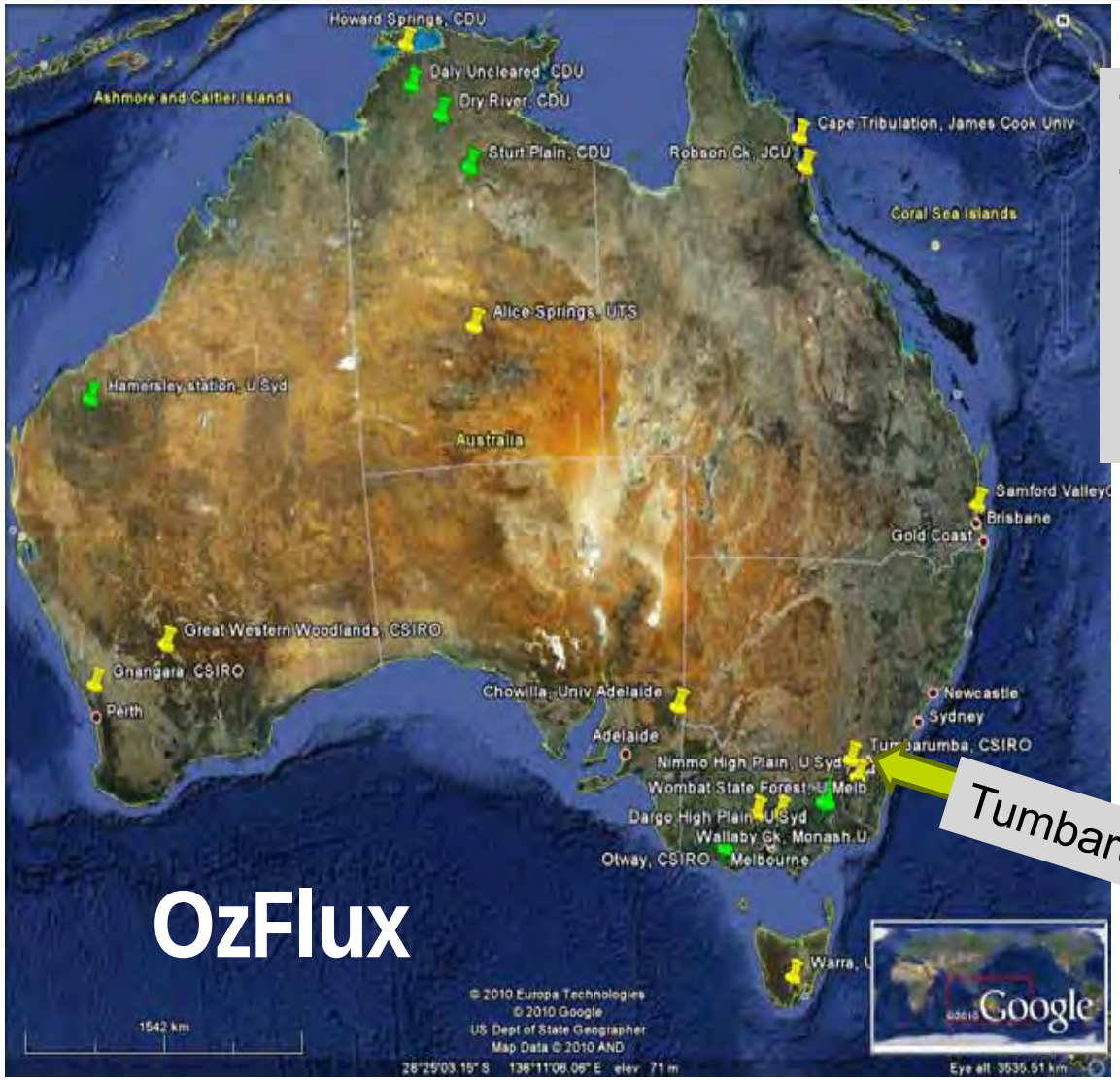
Published measurements of annual net ecosystem exchange of CO_2 (NEE) in a range of global ecosystems



Tumbarumba
min: -963 g C m^{-2} yr^{-1} Carbon uptake
max: 145 g C m^{-2} yr^{-1} Carbon efflux

From: D. Baldocchi, 2008, *Aust. J. of Botany*

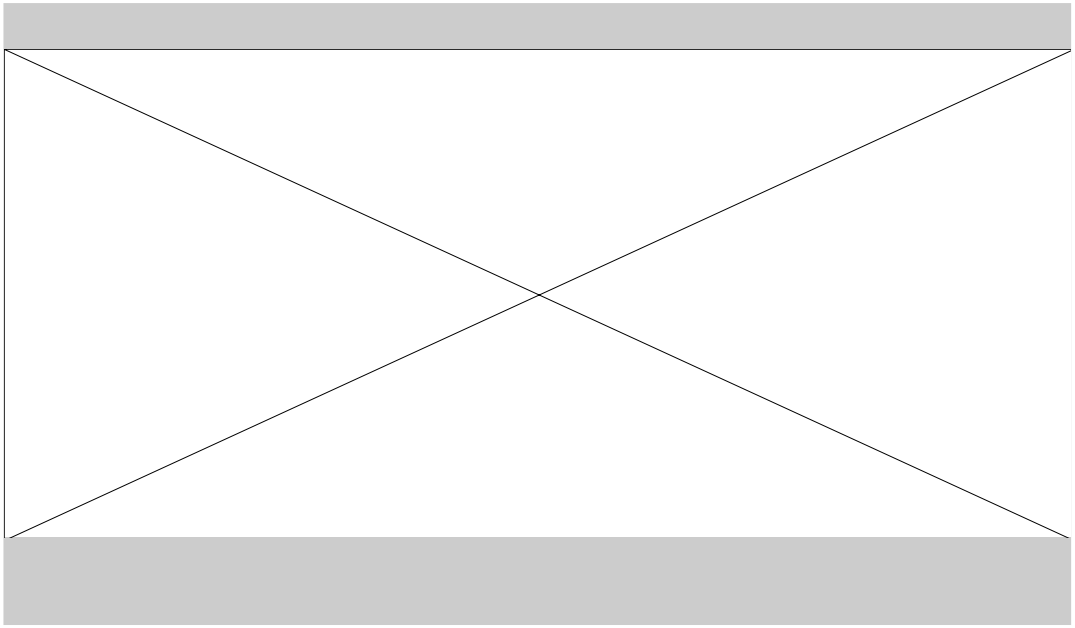
Tumbarumba Site: Part of OzFlux



Tumbarumba Flux Tower in SE highlands of NSW

Bago State Forest

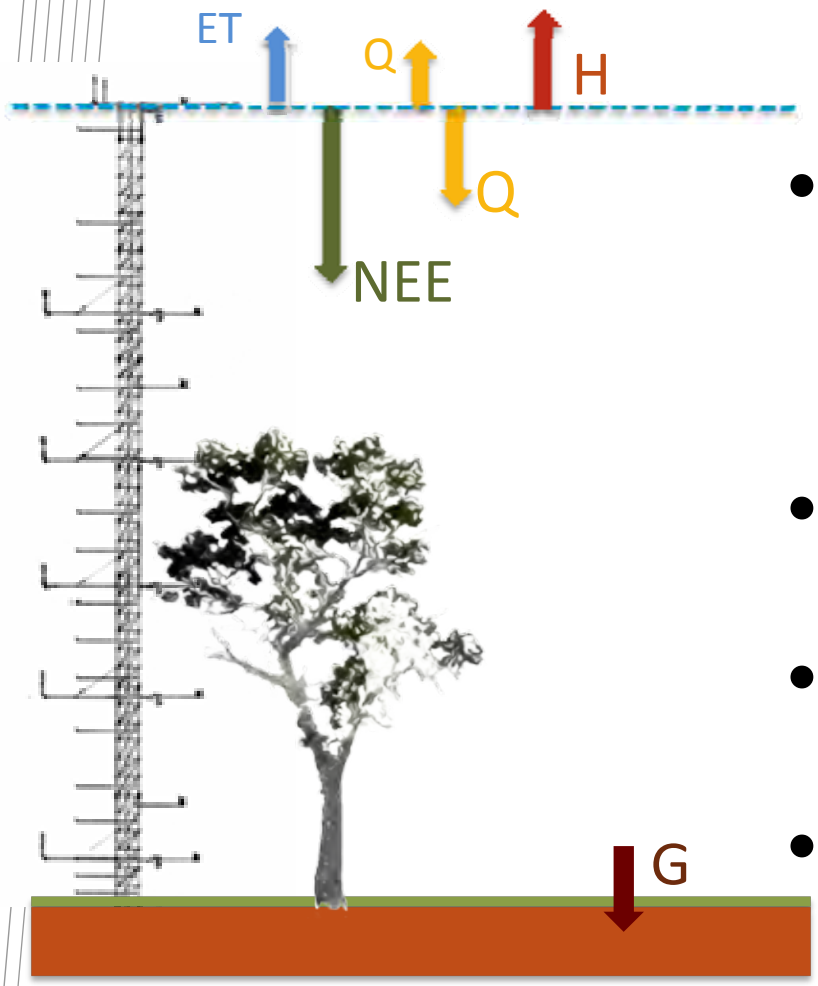
Tumbarumba Site: Topography



Photographs : Dale Hughes

- 40 m tall Eucalypt forest with a Leaf Area Index ~ 2.4
  - Alpine Ash *E. Delegatensis*
  - Mountain White Gum *E. dalrympleana*
- Forest cover and species homogenous within radius > 5 km
- Shallow basin sloping towards North

Measuring ecosystem water and carbon fluxes



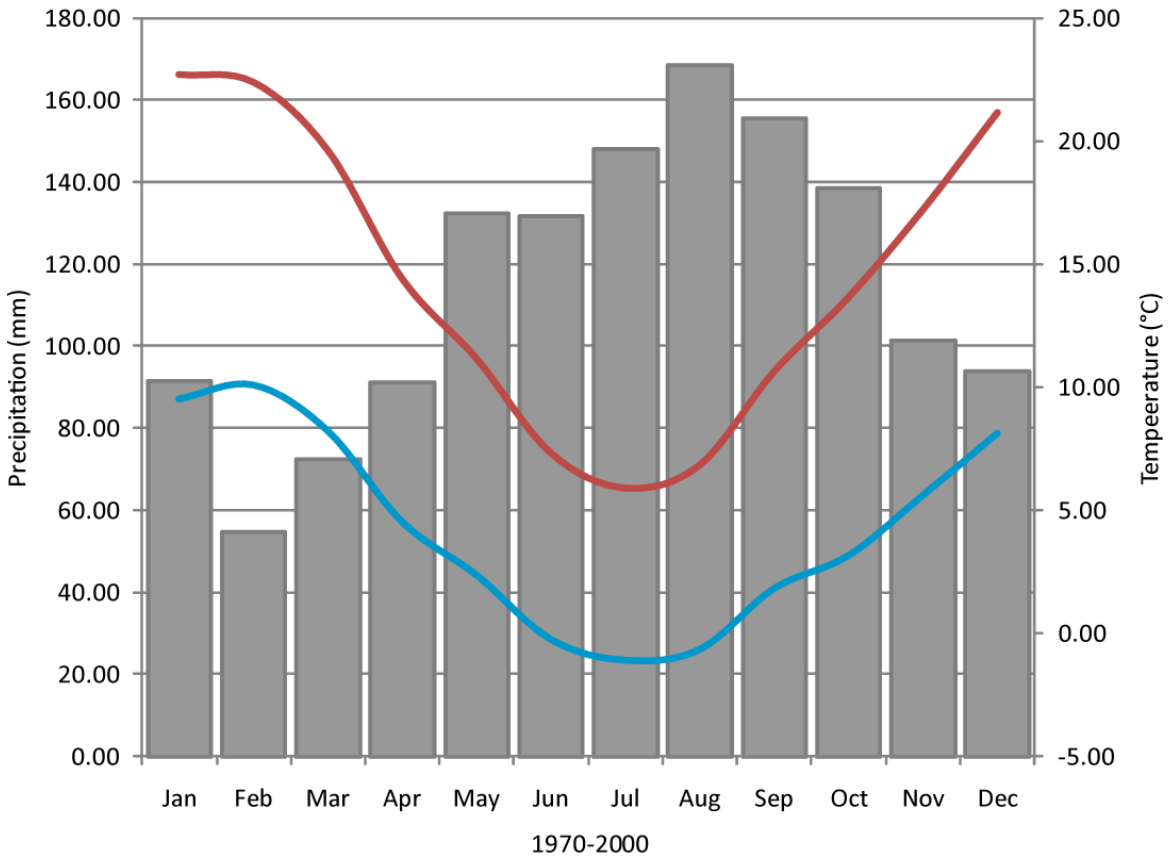
- Direct measure of CO_2 and water vapour fluxes between the canopy and the atmosphere
  - Water (λE, ET) and CO_2 (NEE)
- Energy fluxes
  - Radiation (Q) and heat (H, G)
- Above canopy, spatially-averaged over an area ~ 1 – 5 km
- Continuous – hourly to multi-annual

Climate at Bago State Forest (AWAP data)

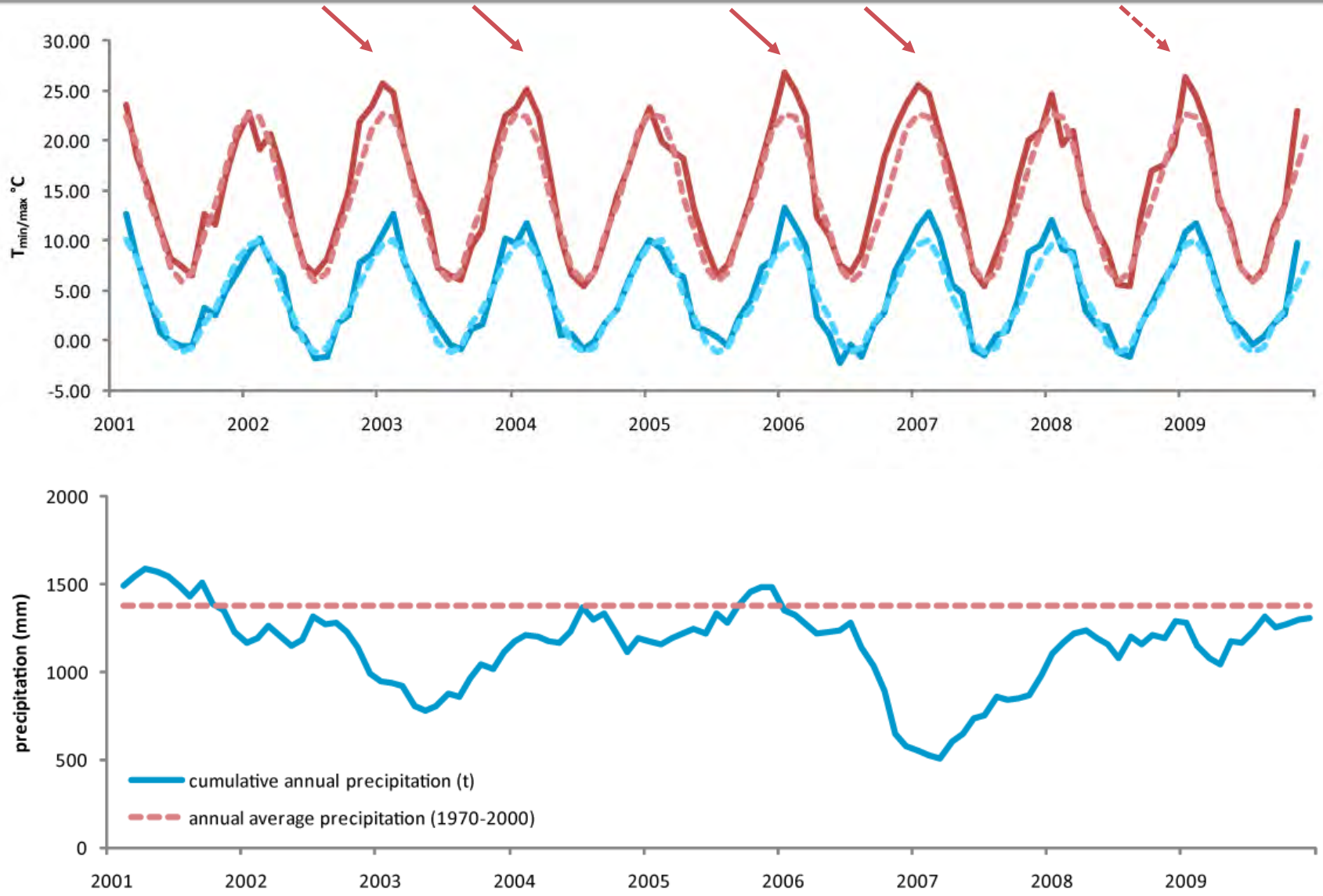
1380 mm

22.7 °C

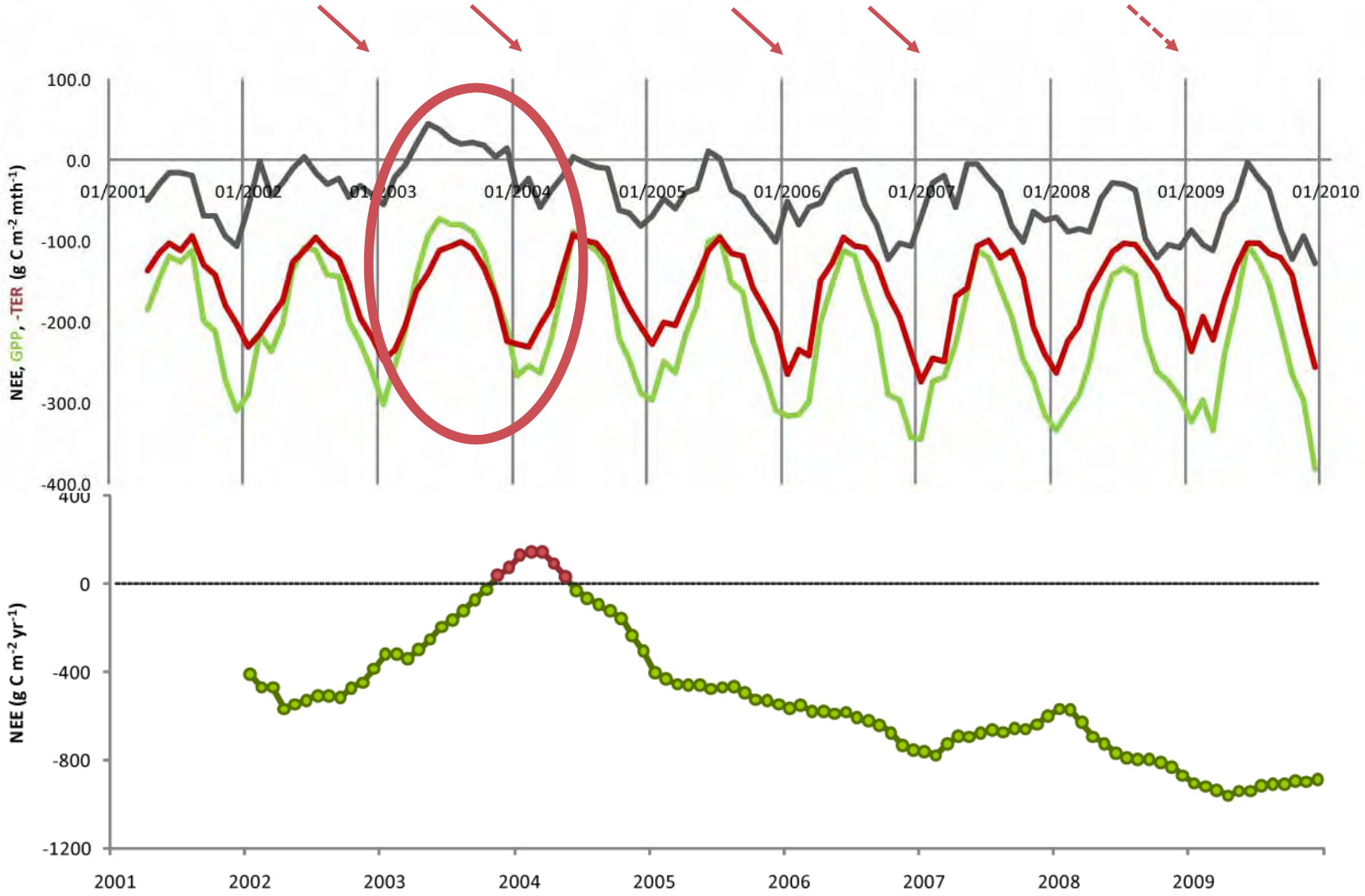
-1.09 °C



Temperature / precipitation measured at site



Ecosystem carbon fluxes vary in response to these meteorological drivers ….



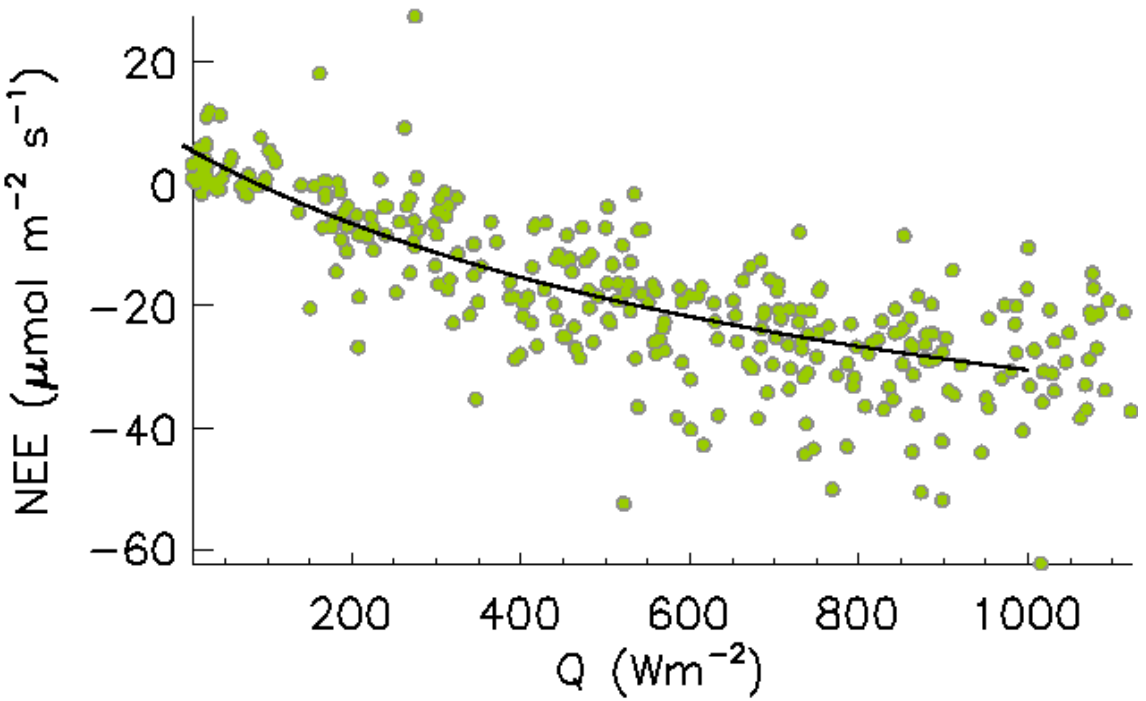
.. and also disturbance

Leaves damaged by insect attack (psyllids) in summer 2002 – 03; severely damaged leaves shed in autumn 2003

Modelling net ecosystem exchange of CO_2 (NEE)

Hyperbolic light-response curve (Michaelis-Menten)

$$NEE = \frac{\alpha\beta Q}{\alpha Q + \beta} + \gamma$$



canopy light utilization efficiency (μmol C J^{-1})

b maximum CO_2 uptake rate of canopy at light saturation (μ mol C m^{-2} s^{-1})

terrestrial ecosystem respiration (μmol C m^{-2} s^{-1})

Modelling net ecosystem exchange of CO_2 (NEE)

include temperature dependence of respiration

$$NEE = \frac{\alpha\beta Q}{\alpha Q + \beta} + \delta \exp\left(\varepsilon T_s\right)$$

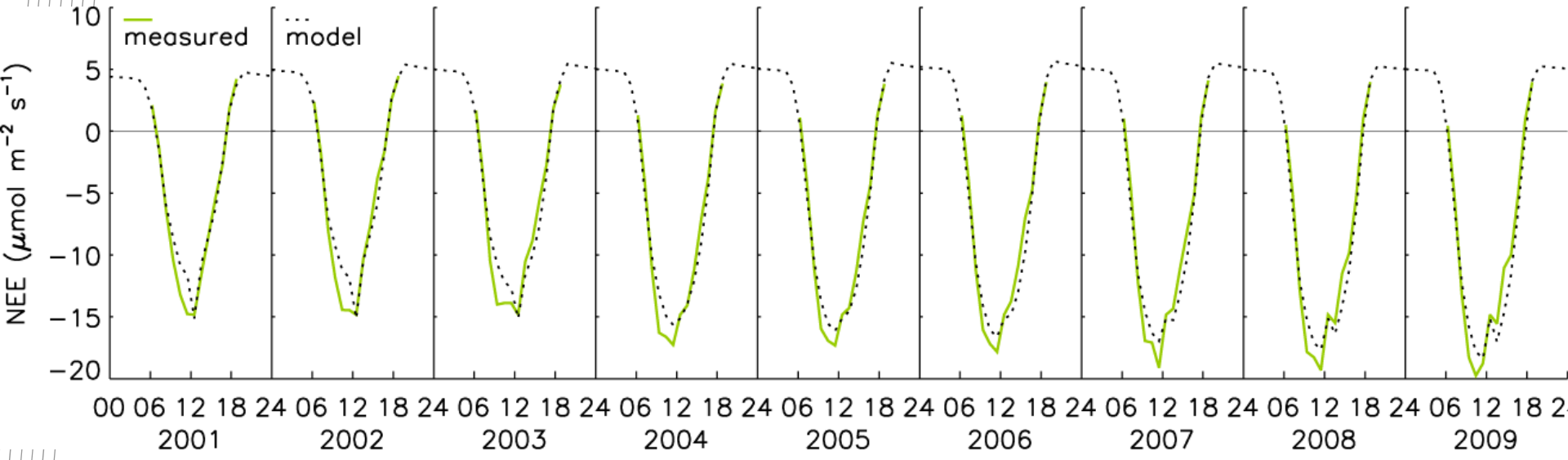
include dependence on vapour pressure deficit (VPD)

$$\beta = \begin{cases} \beta_0 \exp\left(-k(VPD - VPD_0)\right) ; & VPD > 10\ hPa \\ \beta_0 ; & VPD < 10\ hPa \end{cases}$$

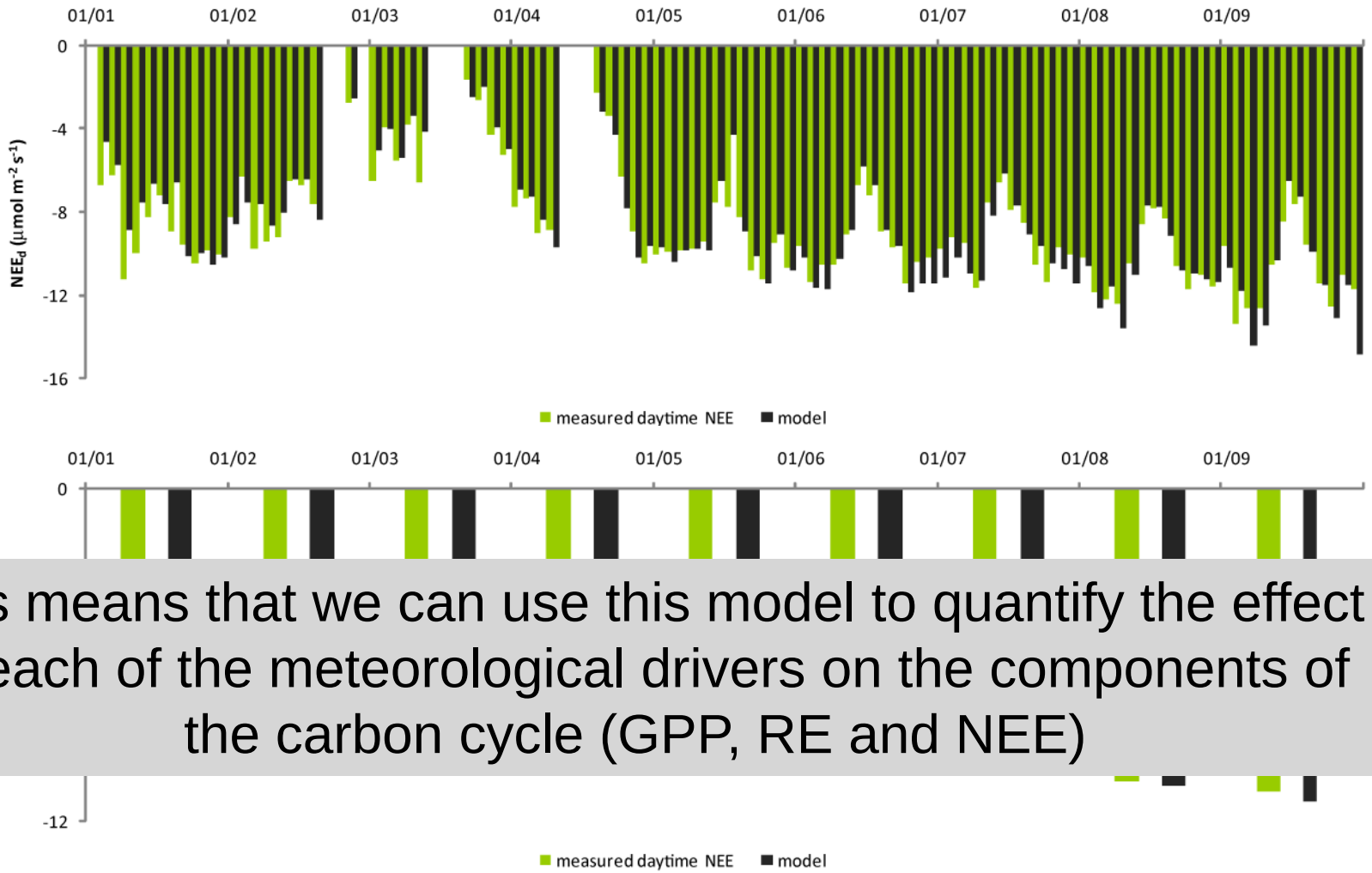
30 day moving window

Model performance

Captures diurnal variability …

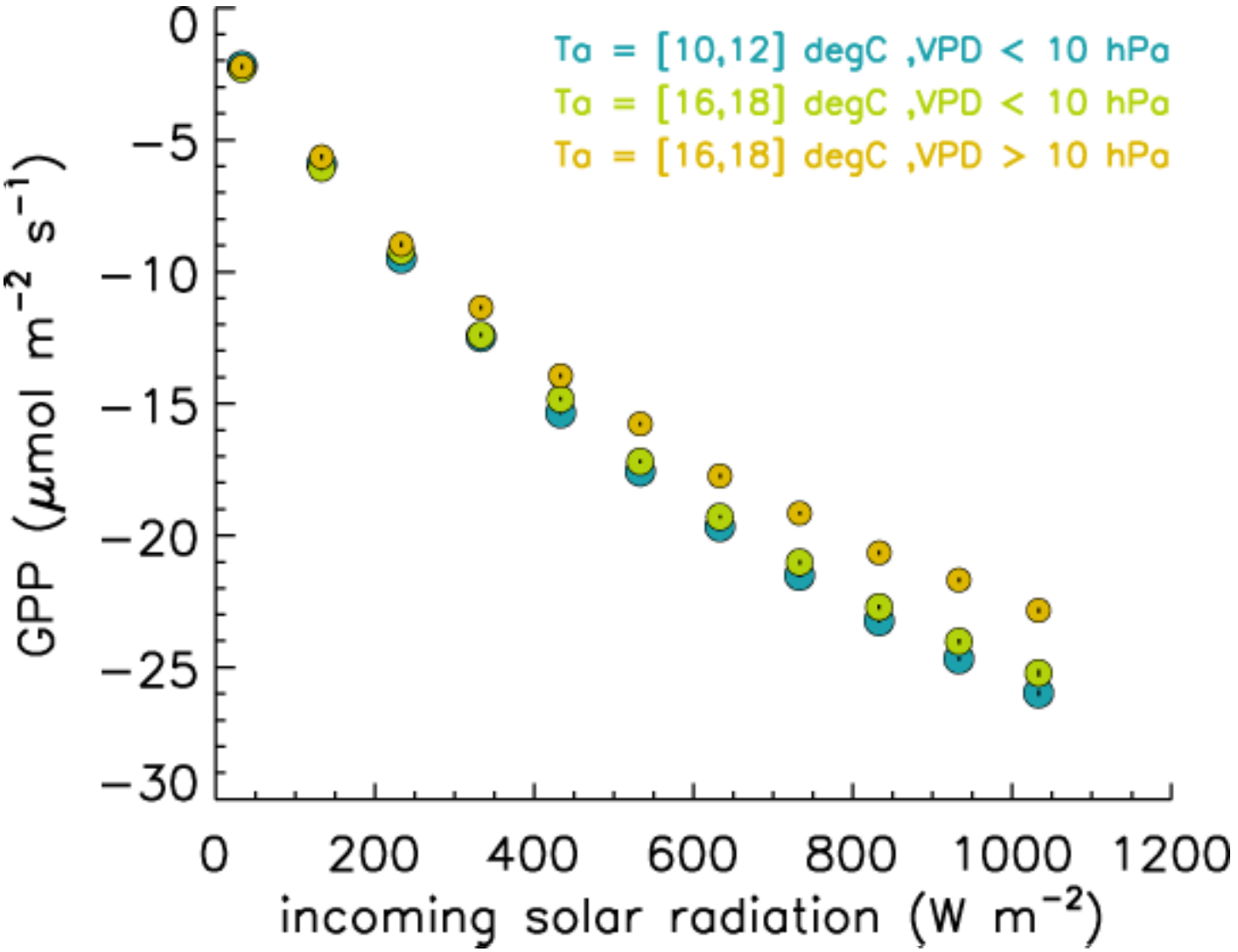


Model performance

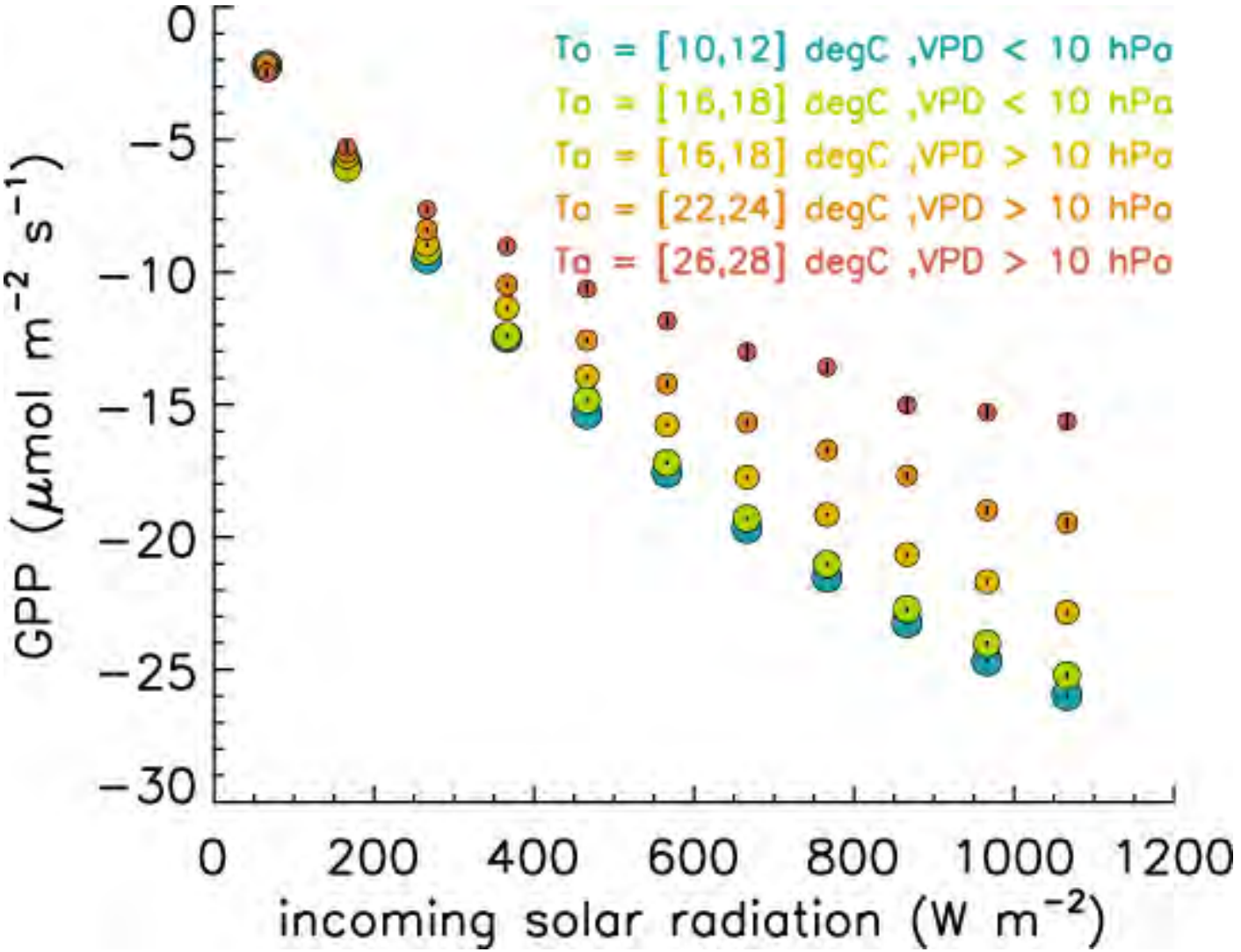


This means that we can use this model to quantify the effect of each of the meteorological drivers on the components of the carbon cycle (GPP, RE and NEE)

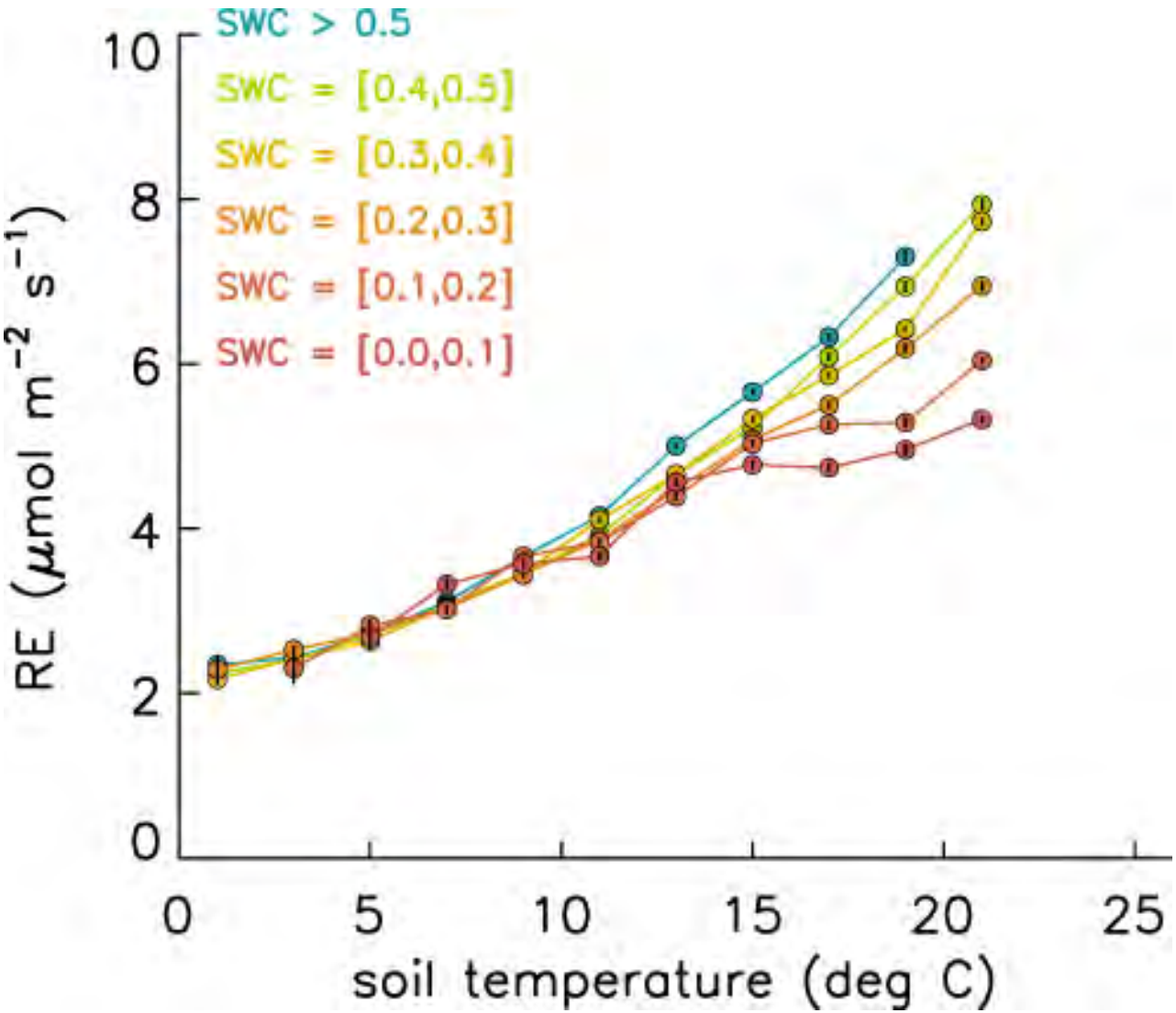
Ecosystem assimilation (GPP) 2001-2009



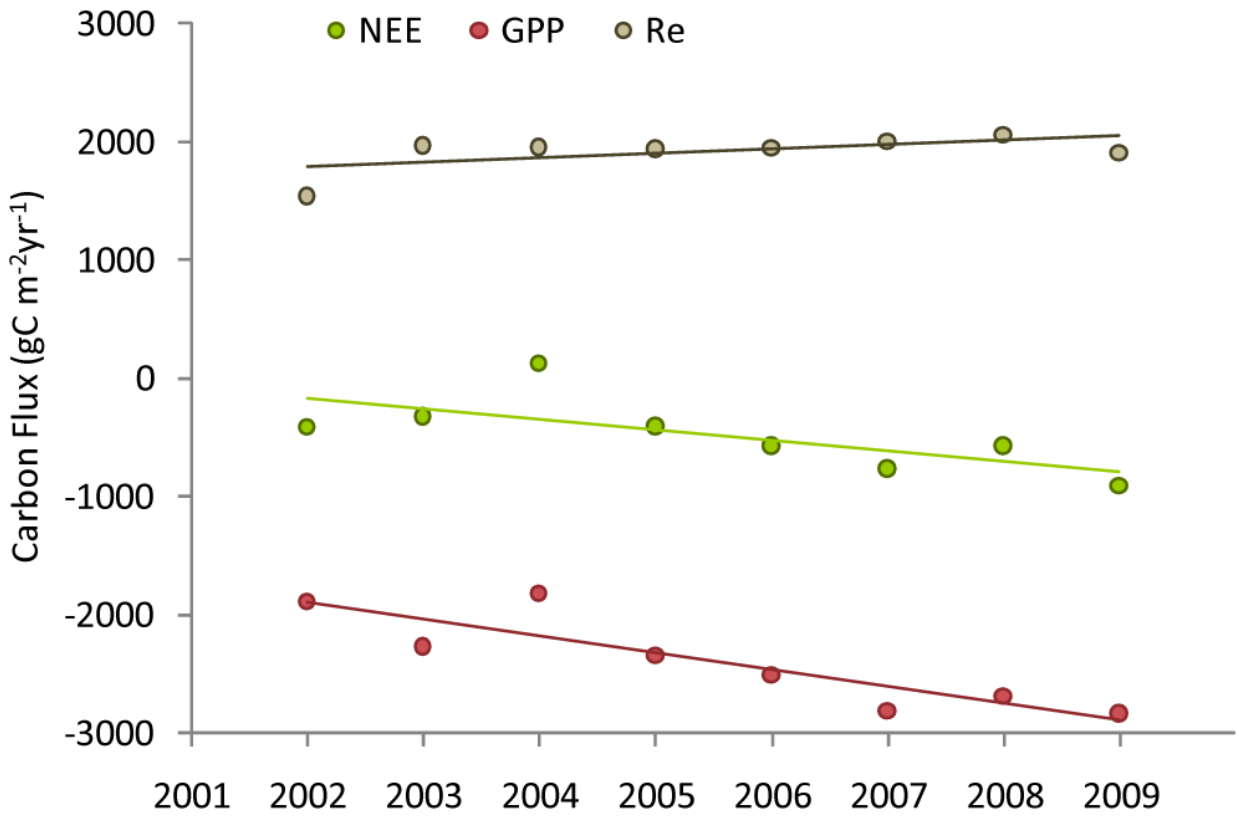
Ecosystem assimilation (GPP) 2001-2009



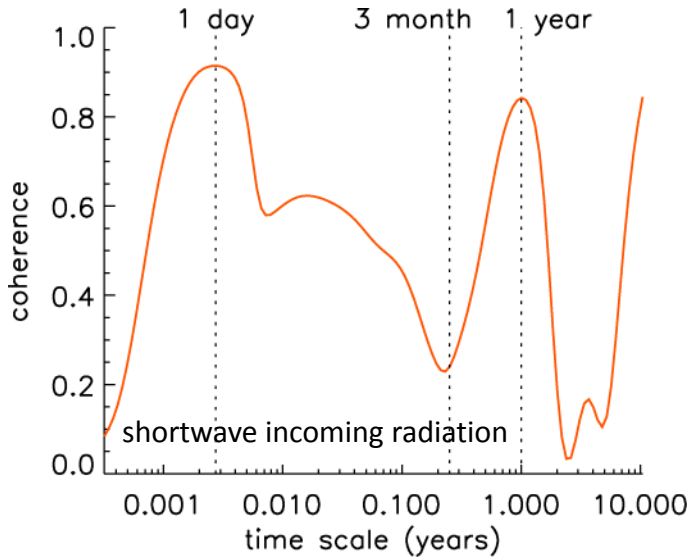
Ecosystem respiration (RE) 2001-2009

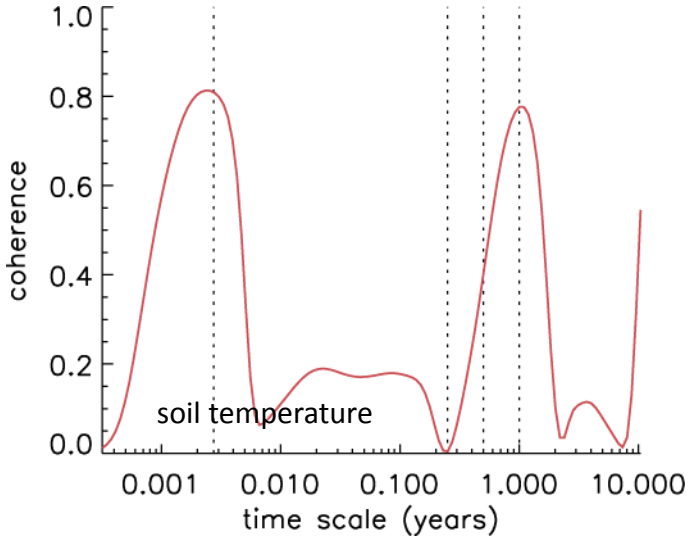


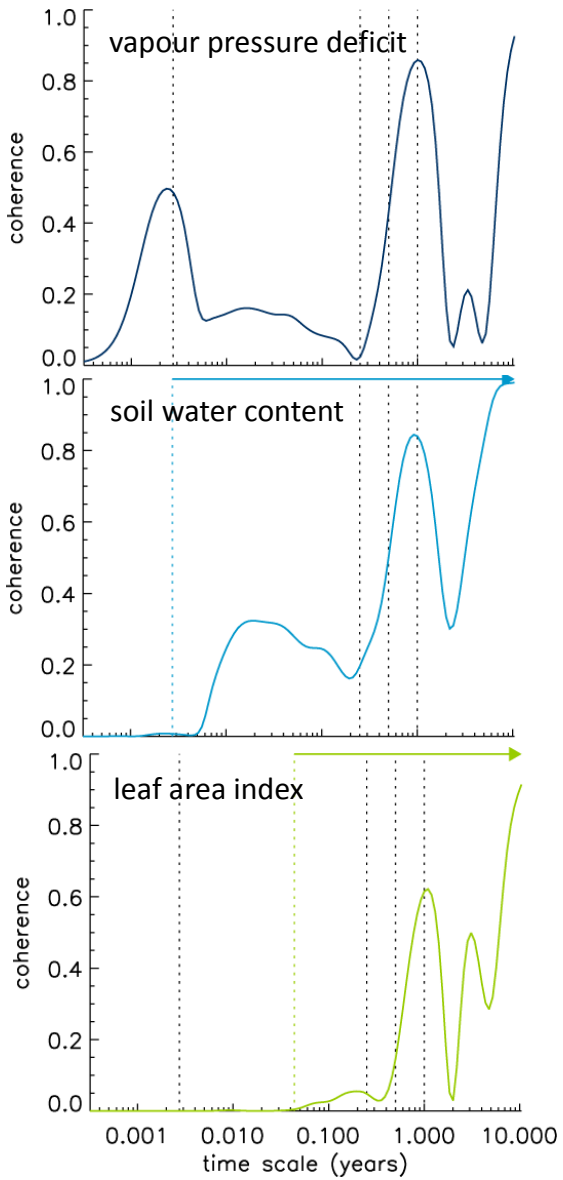
NEE, GPP and RE



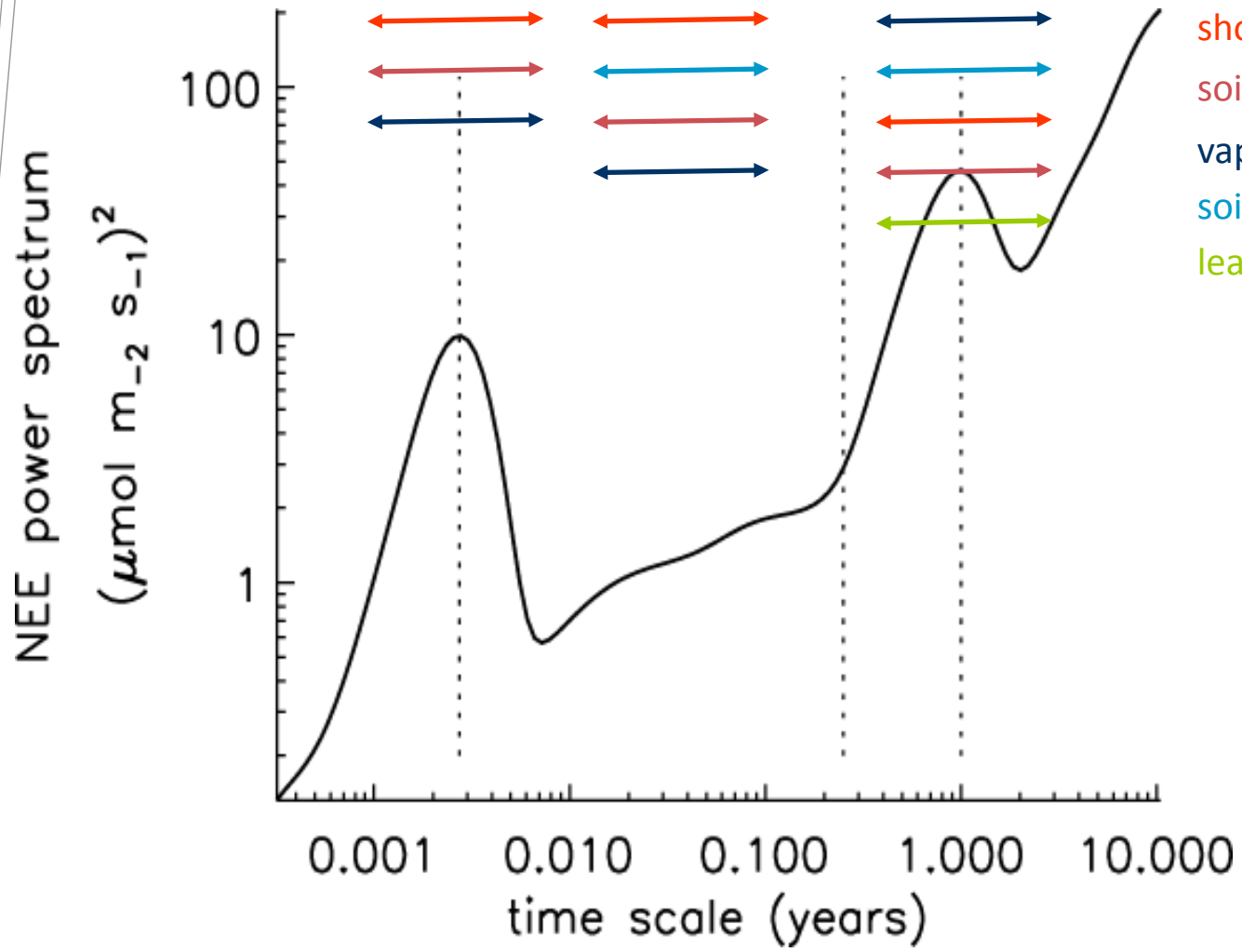
Timescales of variability: Drivers and fluxes [2002-2009]







Timescales of variability: Drivers and fluxes [2002-2009]



Conclusions / Summary (1)

Highly dynamic forest ecosystem where the CO_2 fluxes:

Respond mainly to the meteorological drivers:

- radiation and soil temperature [hourly]
- radiation and SWC [seasonal]
- VPD, SWC and radiation [annual]
- LAI and SWC [multi annual]

Are subject to stress caused by meteorological drivers

- Drought (low soil moisture → RE / high VPD → GPP)
- Disturbance – insect predation that is linked to antecedent weather conditions → GPP

Conclusions / Summary (2)

The response to these combined stressors resulted in:

- reduced leaf area
- reduced stomatal conductance and photosynthetic capacity
- reduced assimilation
- reduced biomass increment
- increased mortality

Effect of disturbance (insects) on ecosystem assimilation is greater than on ecosystem respiration

Carbon sink turned to a source for several months

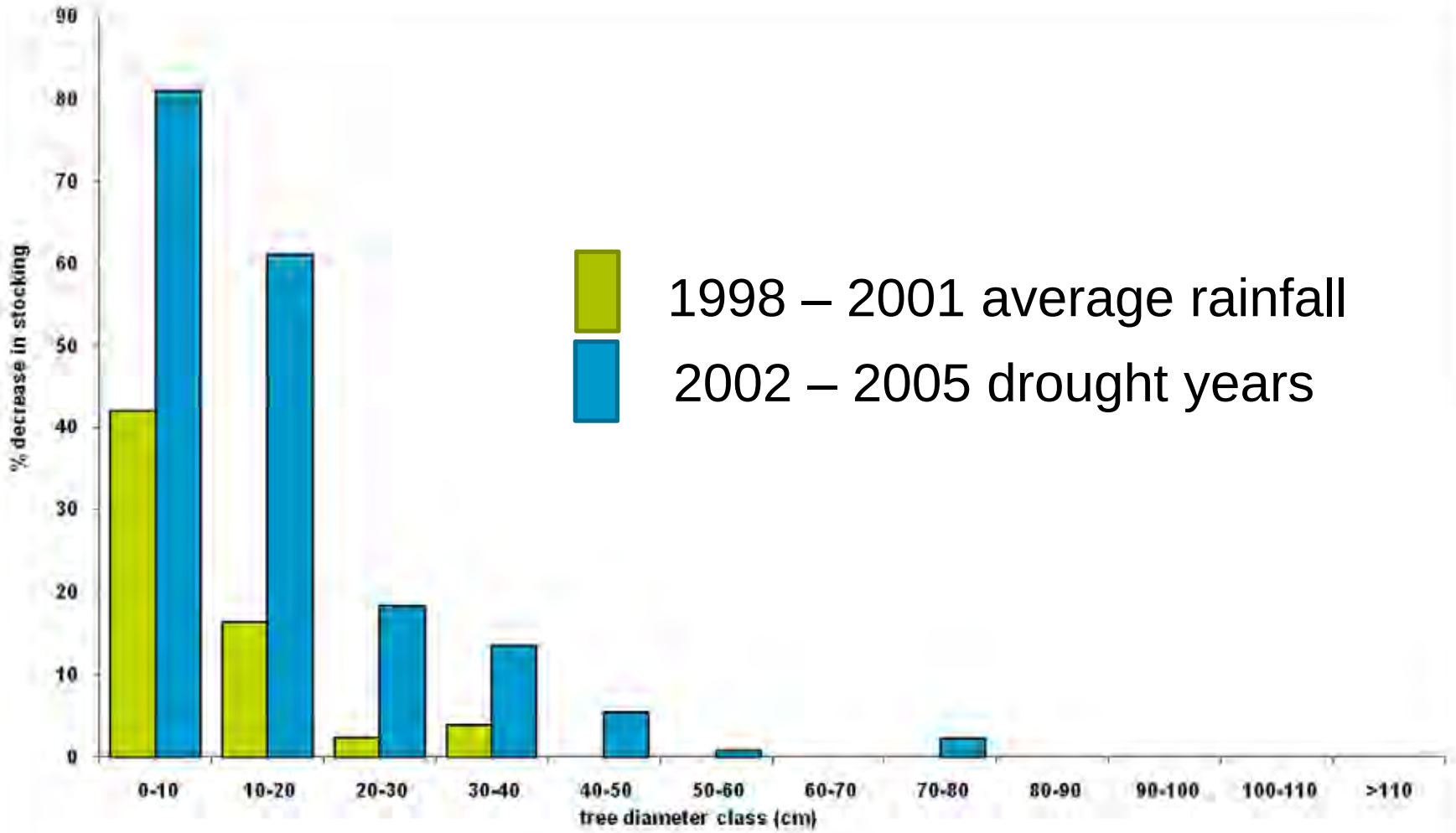
CSIRO Marine and Atmospheric Research
Helen Cleugh

Email: helen.cleugh@csiro.au
Web: www.cmar.csiro.au

Thank you

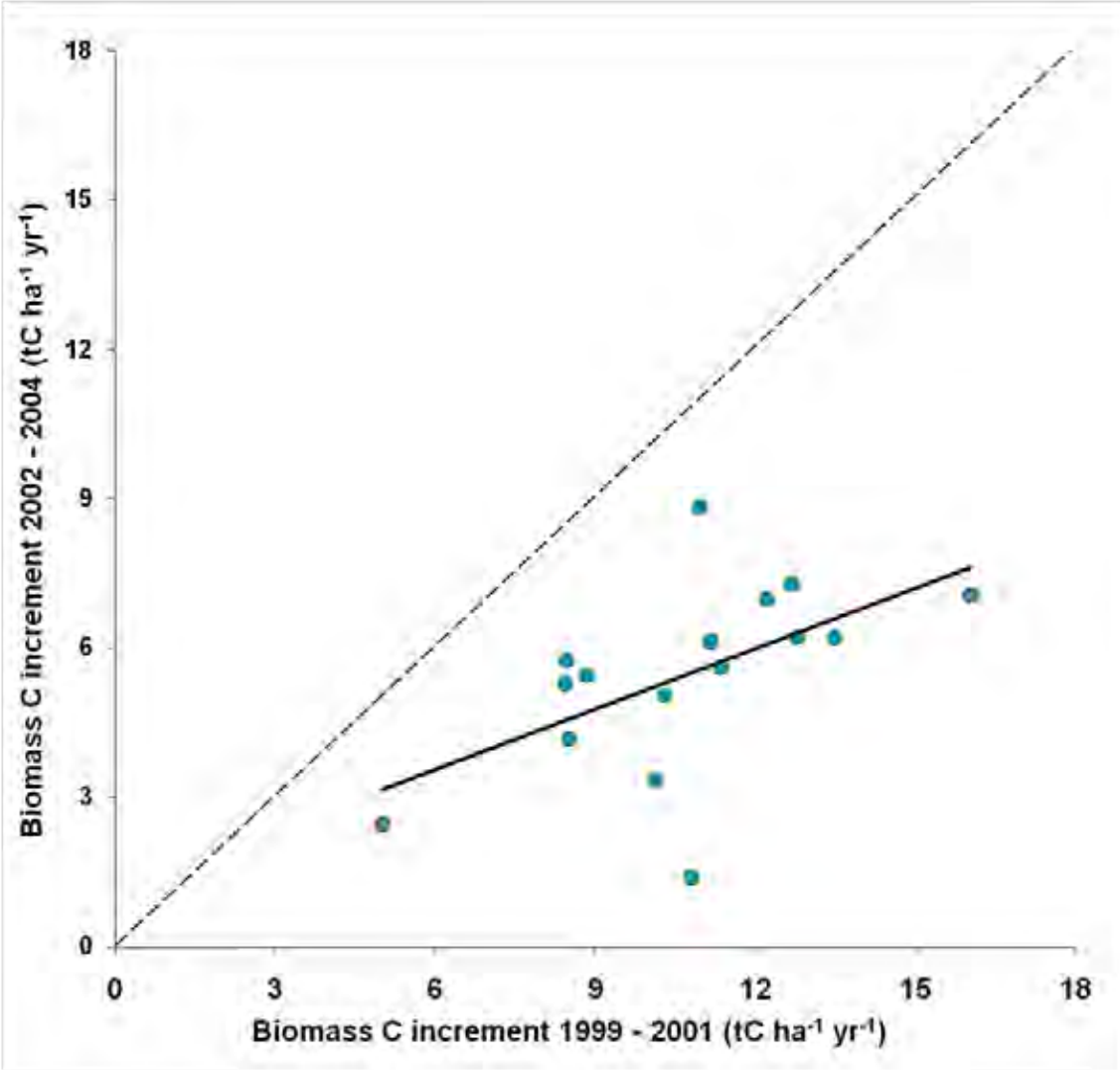
Contact Us
Phone: 1300 363 400 **or** +61 3 9545 2176
Email: enquiries@csiro.au **Web:** www.csiro.au

… as does tree mortality



… and biomass increment

drought years



average rainfall