Managing forests in the 21st century

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Anticipating water-demanding eucalypt tree species' responses to changes in environmental drivers

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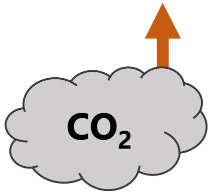
- ***These authors equally contributed to this work presentation, but it belongs to D. Nadal-Sala PhD thesis, from which a manuscript is in preparation.***

Eucalyptus saligna Sm. Stand
Sydney bkue gum

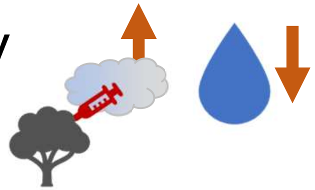
- Fast-growing water- demanding sp.
- World wide used for paper pulp and biomass production.

What do we expect as responses to changes in environmental drivers?

Eucalyptus saligna growth, promoted by



fertilization will be partially offset by



Context

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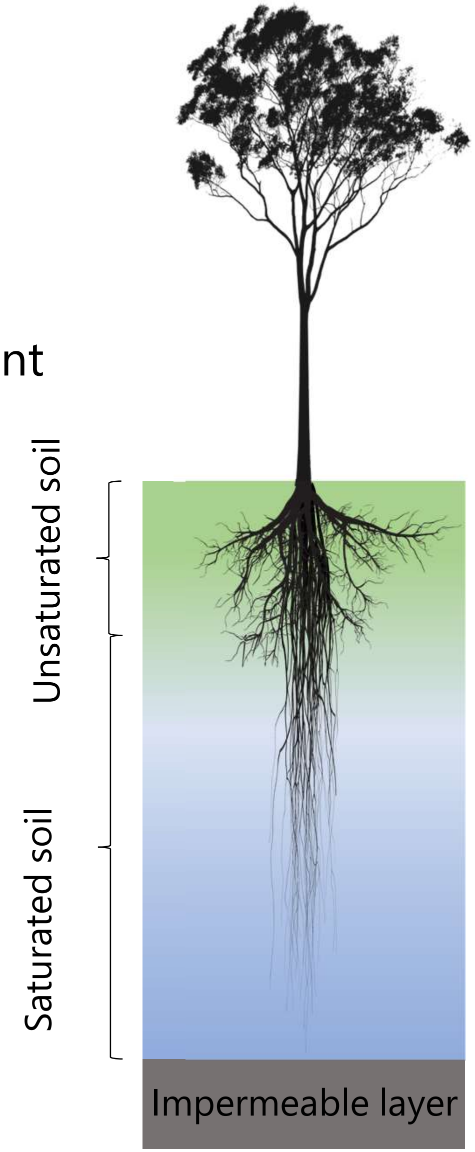
Nadal-Sala et al., (In prep)

Experimental setting available:

- Australian *Eucalyptus saligna* Sm. Stand Plantation (1000 trees ha^{-1})
- Presence of a water-saturated table
- Photosynthesis data from 1.5yr experiment
  - WTC flux data (at 400 ppm, 620 ppm)
  - Soil dry-down for five consecutive months
- In addition,10-years stem growth data with and without irrigation.

To evaluate:

- The importance of deep-water uptake
- The growth sensitivity to environmental drivers



Outline procedure

1. We characterised photosynthesis under two CO_2 treatments to account for photosynthesis down regulation.

2. We included limitation due to unsaturated soil water availability to our calibration.

3. We modelled deep soil water uptake importance.

4. We used gas exchange and stem growth data to evaluate the modelling performance.

5. We analysed the sensitivity to changes in rising CO2, increasing D, and reducing P.

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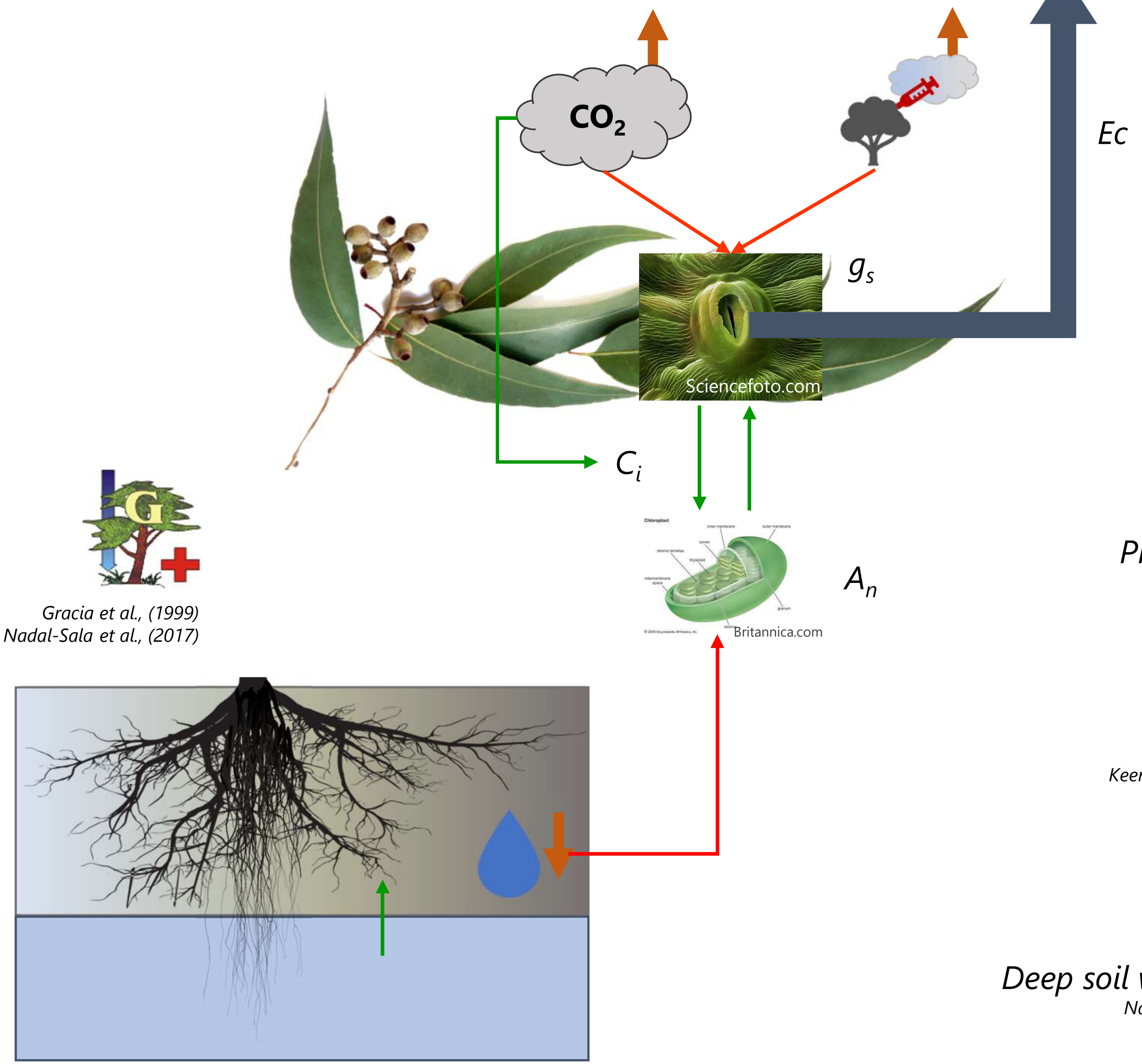
Modelling scheme tool



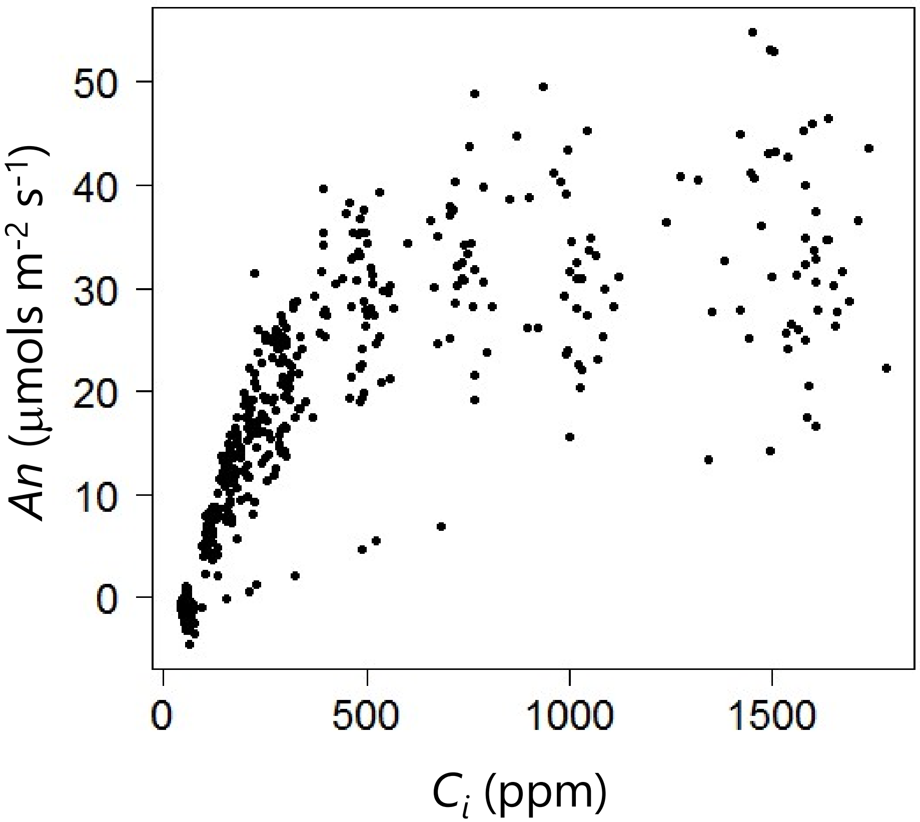
OSB model
Medlyn et al., (2011)

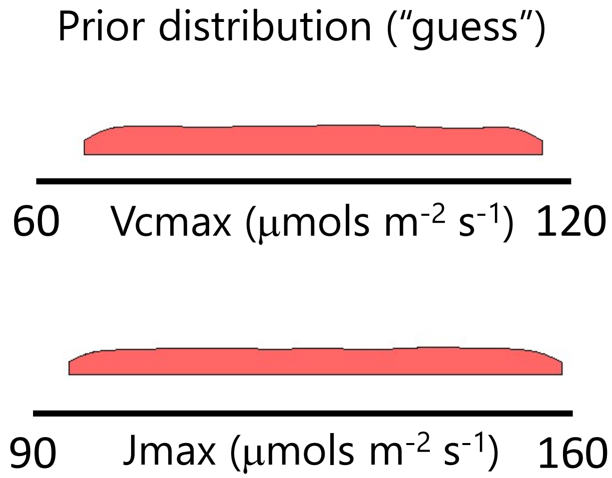
Photosynthesis
Farquhar et al., (1982)

β-model
Keenan et al., (2009, 2010)
Drake et al., (2017)

Deep soil water uptake
Nadal-Sala et al., (2019)

Photosynthesis measurements well watered conditions





- **Inverse calibration of Farquhar model** (Farquhar, 1982) from *An*/C_i measurements
- Measured *An*/C_i for **aCa (400 ppm CO_2)** and **eCa (620 ppm CO_2)** treatments.
- **Broad priors** to represent our broad initial guess.

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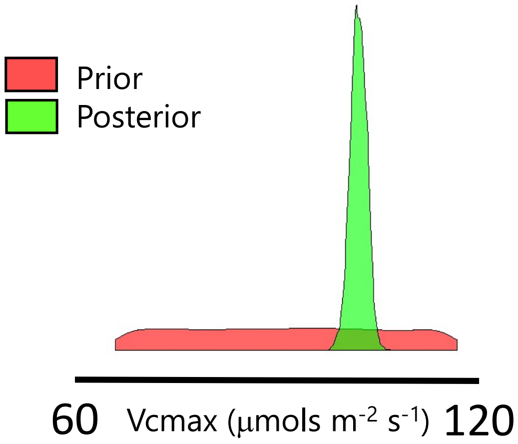
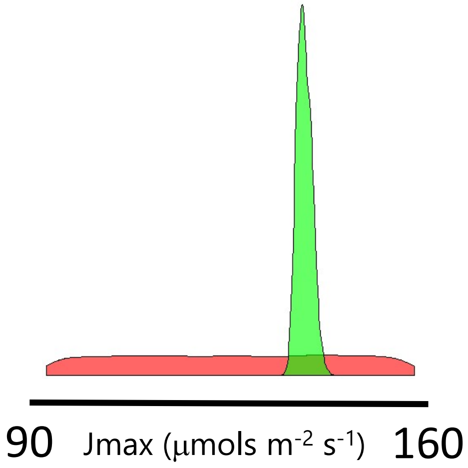
aCa

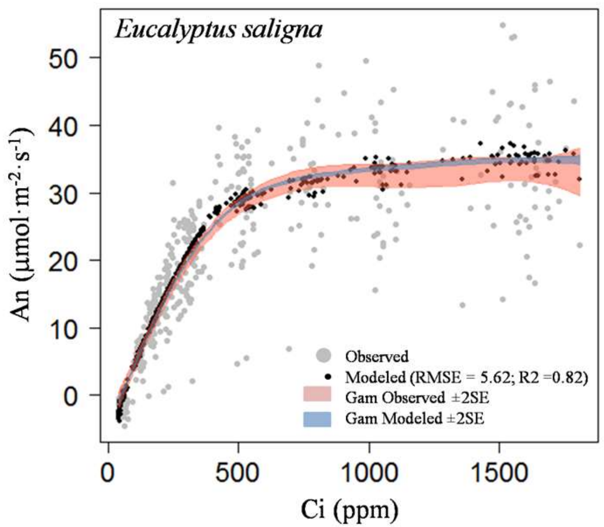




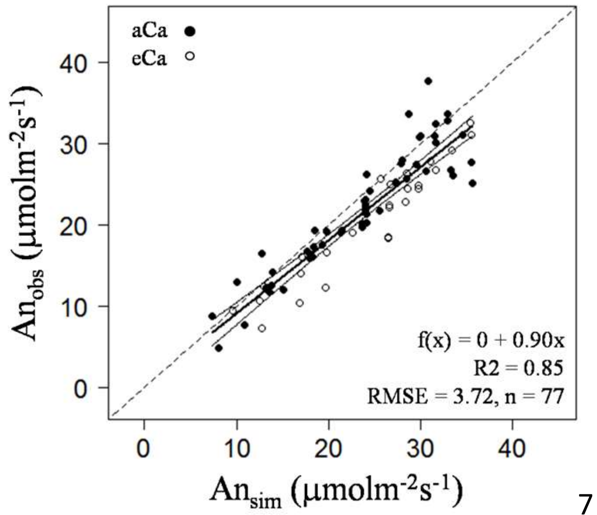
Variable	Prior		Posterior		
	Lower	Upper	2.5%	Median	97.5%
$aV_{cmax25ref}$ (μmol m^{-2} s^{-1})	**60**	**120**	**98.3**	**99.0**	**99.7**
$aJ_{max25ref}$ (μmol m^{-2} s^{-1})	**90**	**160**	**152.0**	**154.3**	**156.2**
$eV_{cmax25ref}$ (μmol m^{-2} s^{-1})	**60**	**120**	**82.6**	**87.6**	**92.3**
$eJ_{max25ref}$ (μmol m^{-2} s^{-1})	**90**	**160**	**142.5**	**145.1**	**149.0**

Down-regulation of V_{cmax} (-12%) and J_{max} (-6%) at eCa

Observed VS modeled *An*



Validation (independent data)



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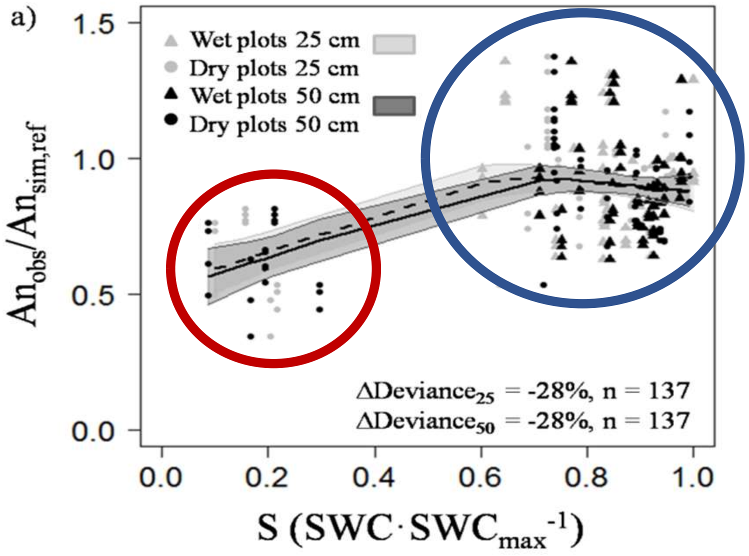
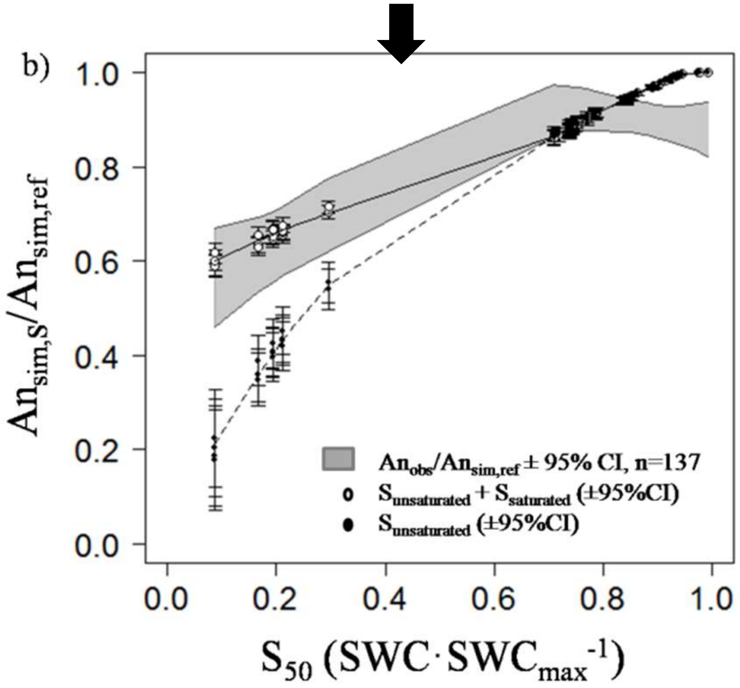
Importance of deep water uptake

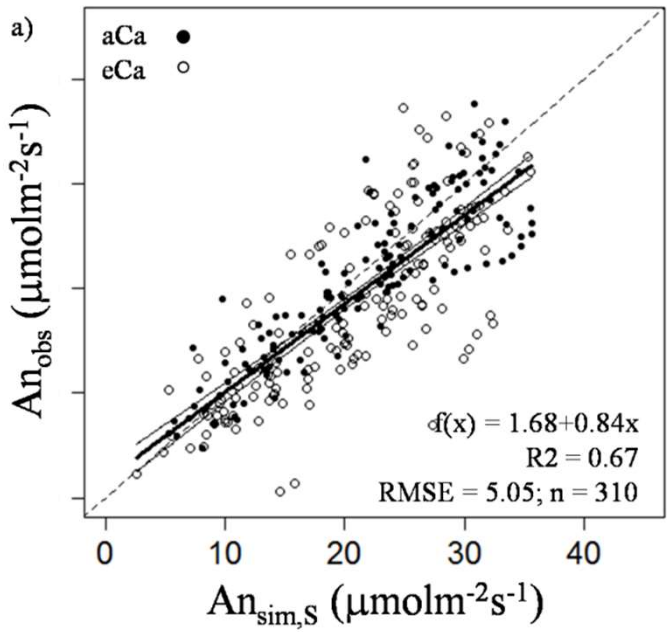


Broad priors to represent our broad initial guess

Variable	Prior			Posterior		
	Lower	Upper		2.5%	Median	97.5%
S_{min} (%)	1	10		1.1	4.3	9.6
S_{max} (%)	70	95		94.6	94.9	95.0
q	0.1	0.6		0.34	0.44	0.56
α	0.1	0.7		0.29	0.45	0.60



Validation against the whole dataset



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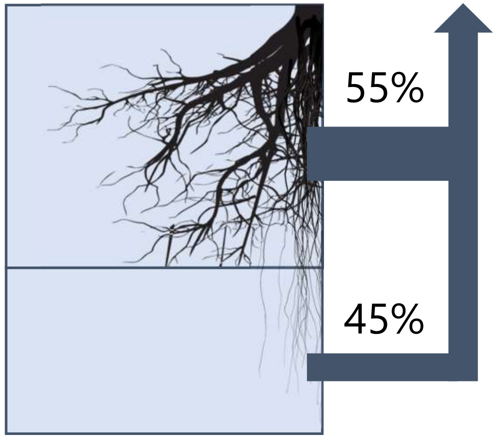
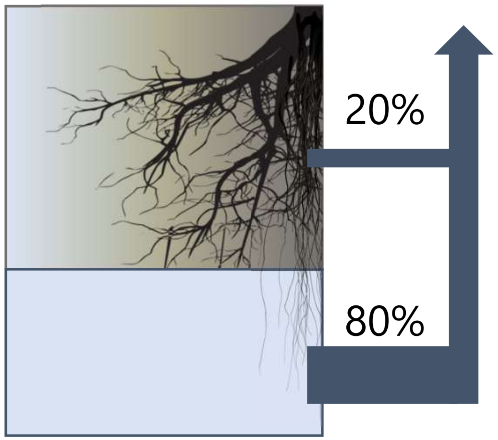
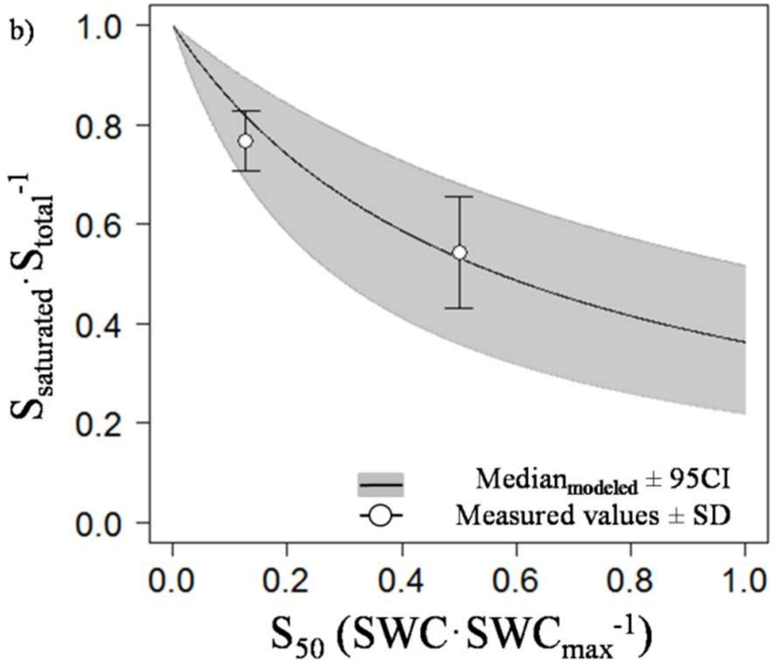
Importance of deep-water uptake

Wet conditions



Dry conditions





As S_{50} dries, the proportion of **water uptake from deeper soil layers increase**

Modelled shift in water source agrees with observations from (*Duursma et al., 2011*)

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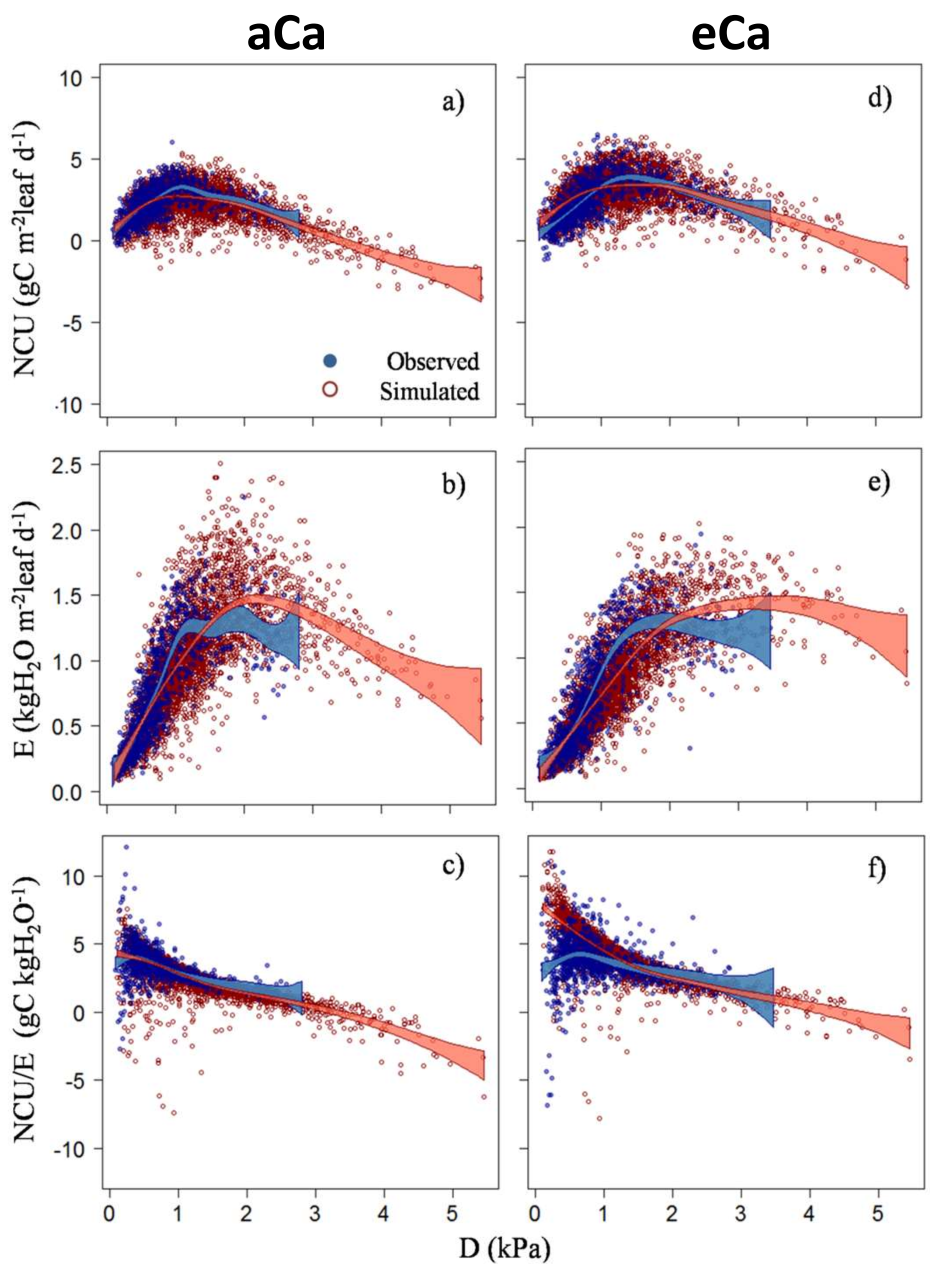
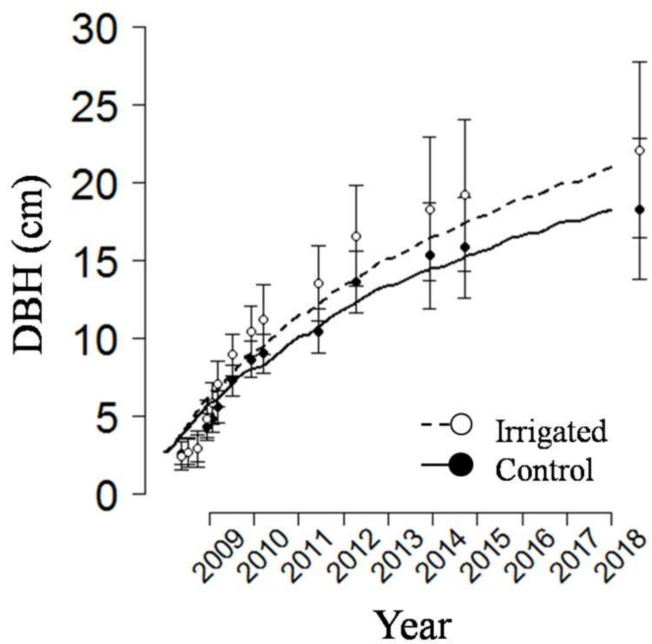
Validation at canopy and at stand level



- Good agreement with observed C and H_2O fluxes responses to D
- Model also reproduces the positive effect of irrigation



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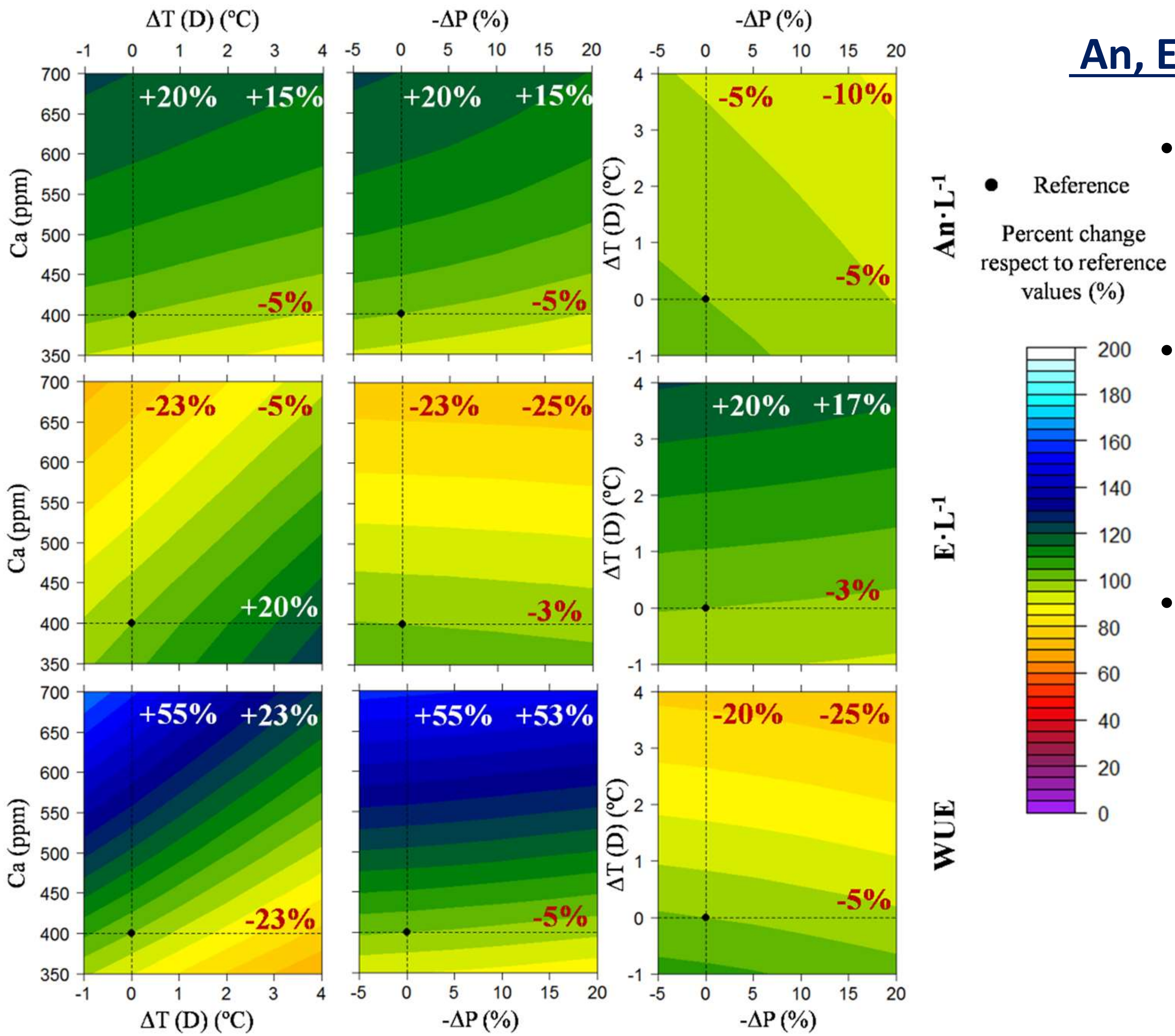
An, E and WUE Sensitivity



- **The main driver** for gas fluxes in *E. saligna* is projected to be **eCa**.
- **Increasing D reduces An** and **increases transpiration**. It also reduces WUE.
- **The limitation on photosynthesis** due to **increased D is similar** than the one imposed by **reduced P**.

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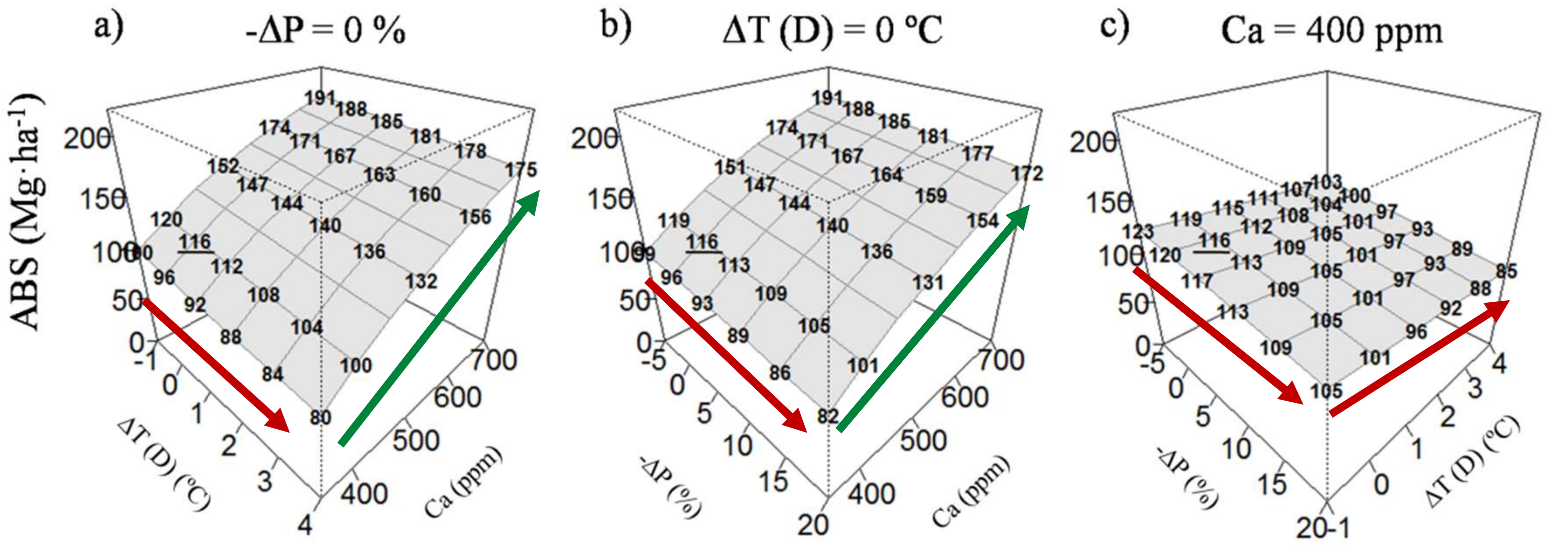
Aboveground biomass stock (ABS Mg ha^{-1}) sensitivity responses



Aboveground biomass stock (ABS Mg ha^{-1}) **increases ~60%** after 10 years of simulated growth **at eCa**.

Combined **reductions in P** and **increases in D** limit this fertilization **down to a 35% increase in ABS**

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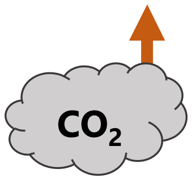
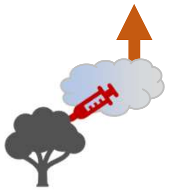
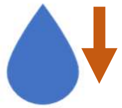
In summary

- Farquhar model, and β-model + Deep water uptake models calibration
- Exhaustive step by step validation procedure based on measurements
- *Eucalyptus saligna* **strongly dependent** on deep water reservoirs
- 

projected to be **the main environmental driver** (fertilization)
- **Aridity** increases due to   is **likely to constrain** eCa fertilization

Thank you!