Simulating the ‘Greening’ of the Sahara and potential links to future precipitation change

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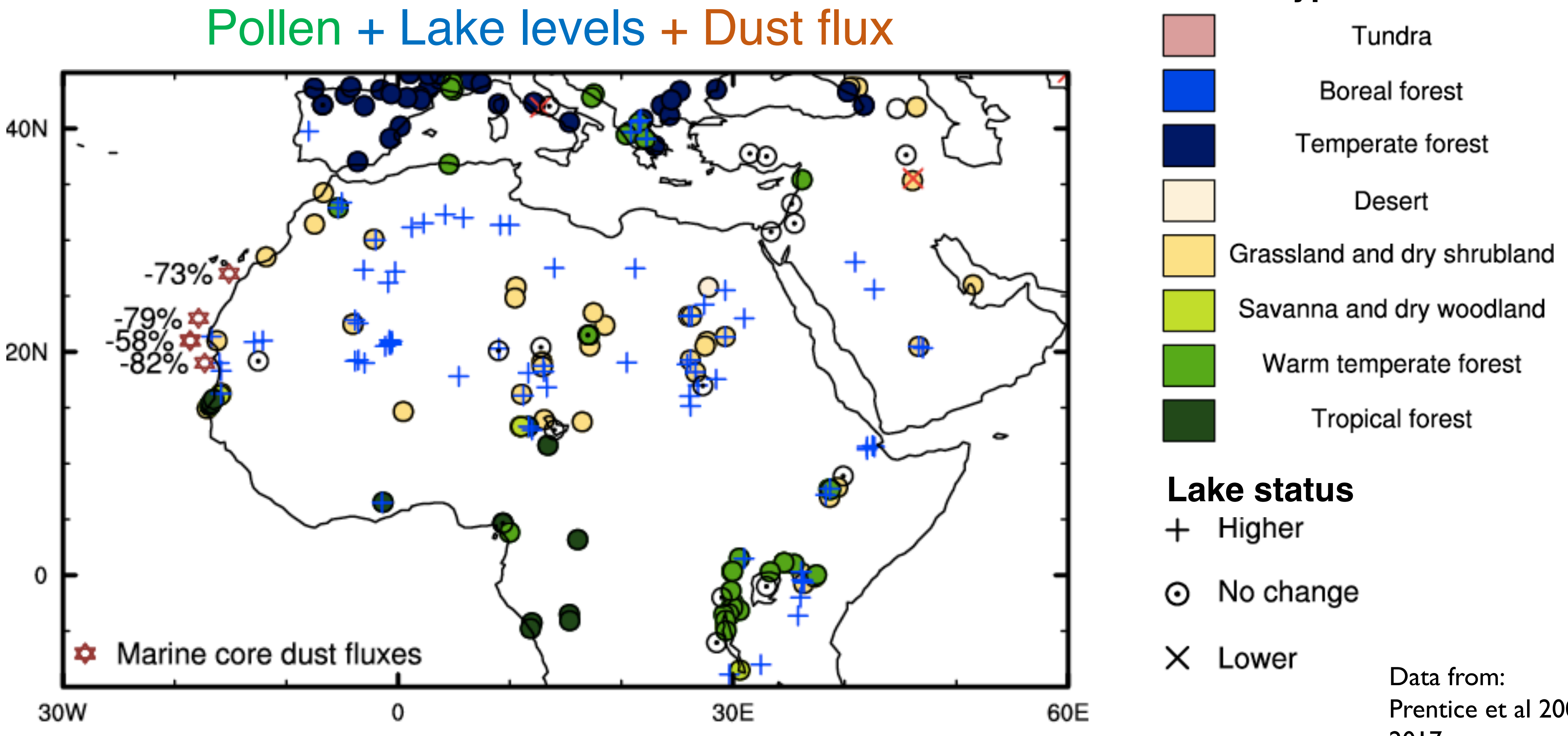
Evidence for a 'Green' Sahara 11ka – 4ka



Data from:
Prentice et al 2000, Harrison, 2017
Kohfeld & Harrison, 2000
Egerer et al 2016, de Menocal et al 2000, McGee et al 2013

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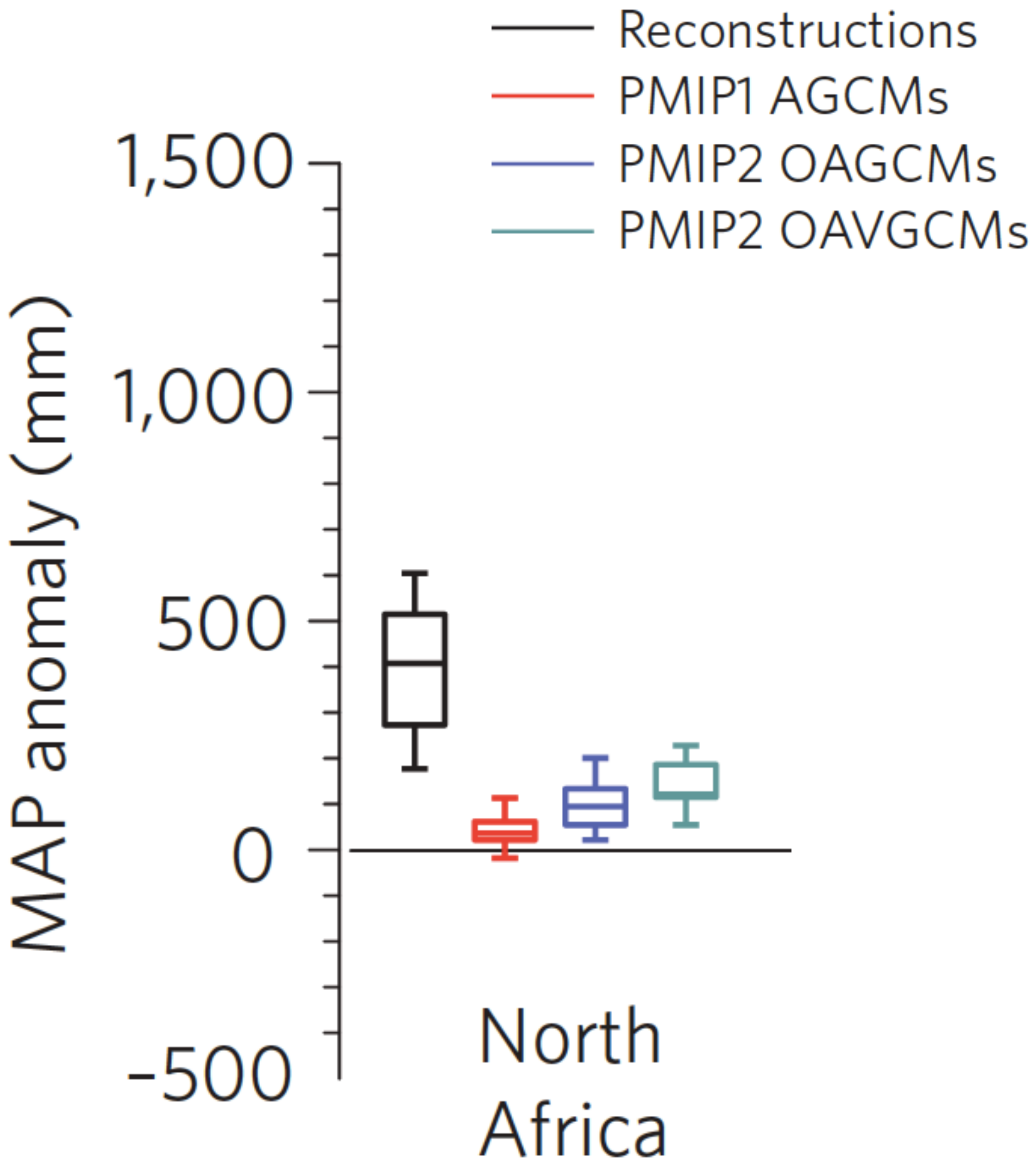
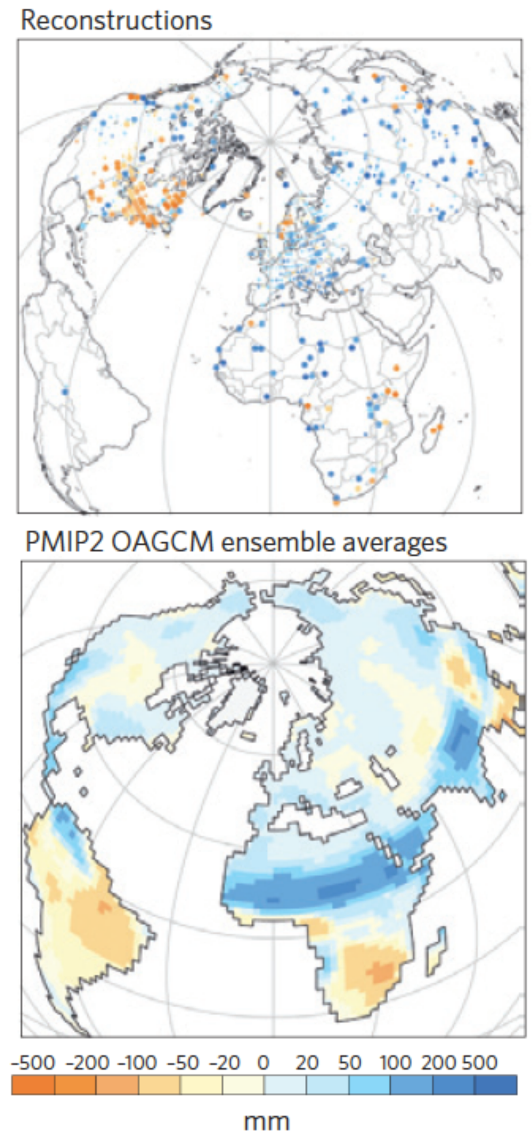
Model simulations: discrepancy

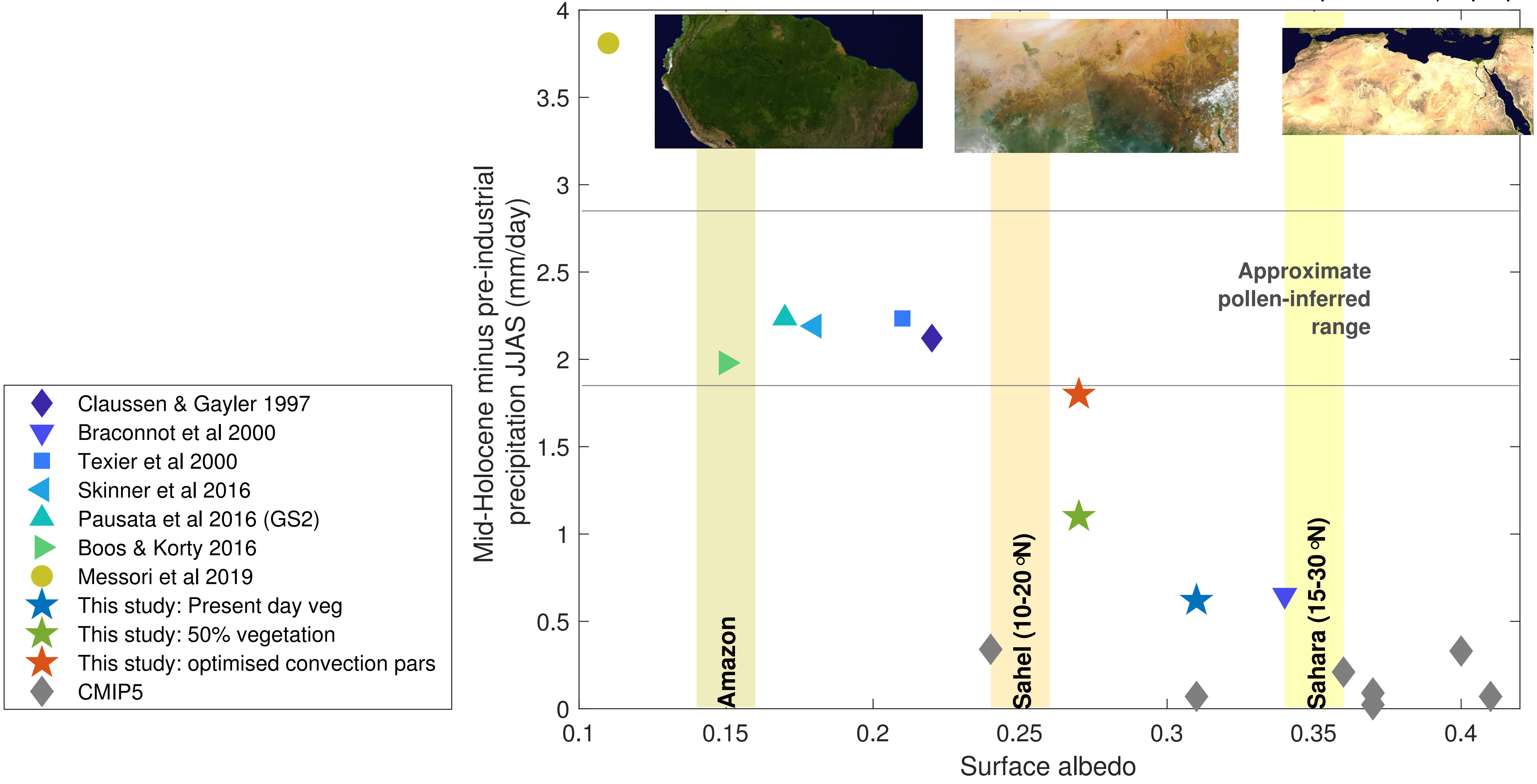




Braconnot et al 2012, *Nature Climate Change*

Model simulations: the role of albedo

Hopcroft et al, in prep.



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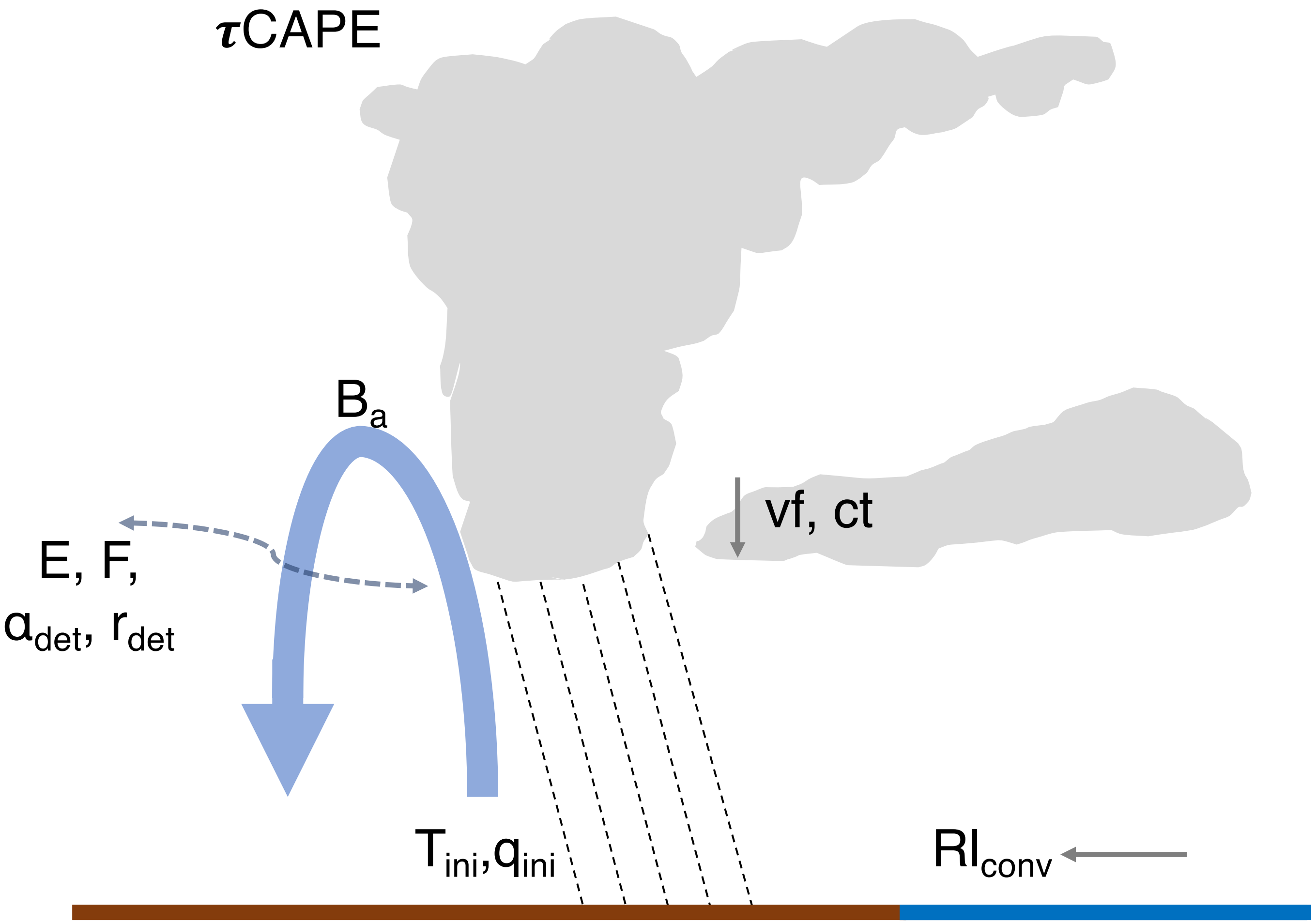
A different approach



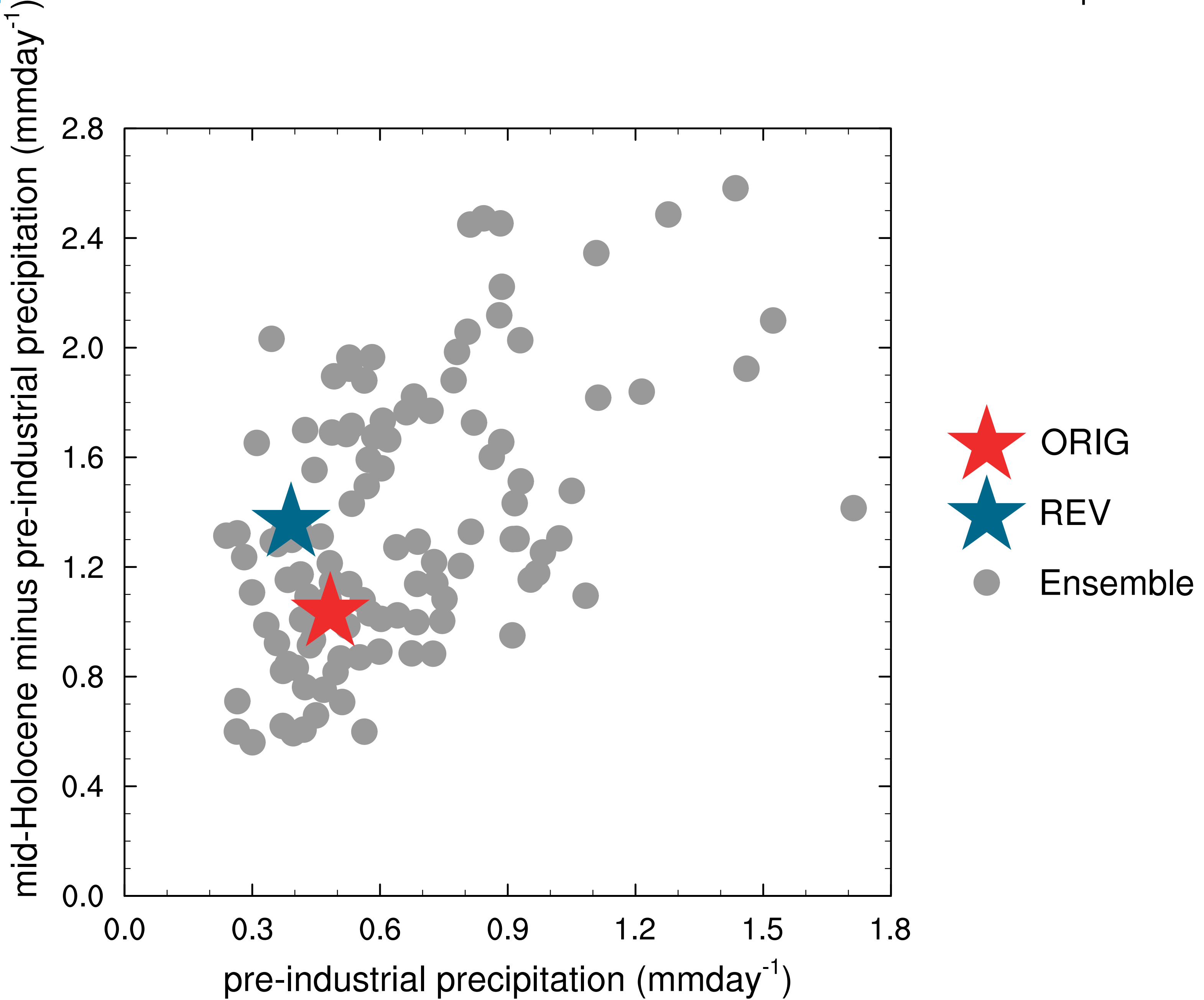
HadAM3 (Pope et al 2000, Valdes et al 2017)

3.75° x 2.75° x 19 levels

- Mass-flux convection parameterization scheme
- MOSES2.1 9-tile land surface scheme

A different approach

Hopcroft et al, in prep.



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Finding an optimal parameter set

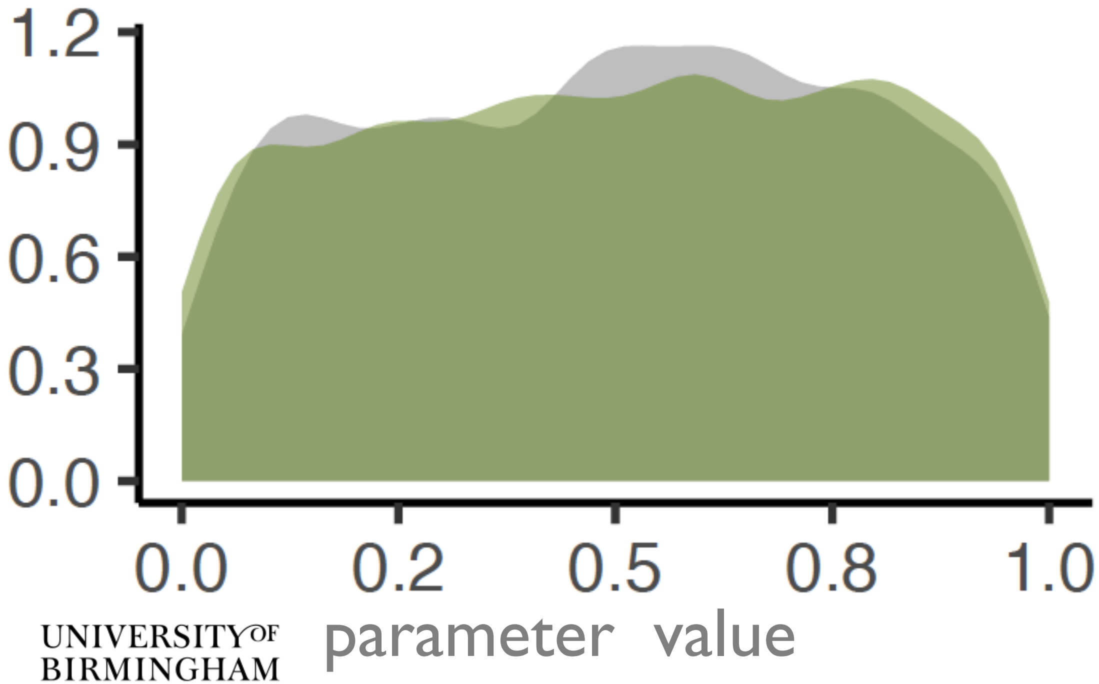
prob (parameters | observations, model, prior information)

Observational inputs

PI PIMH

Posterior Probability density function

T_{ini} Initial parcel temperature excess



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Hopcroft et al, in prep.

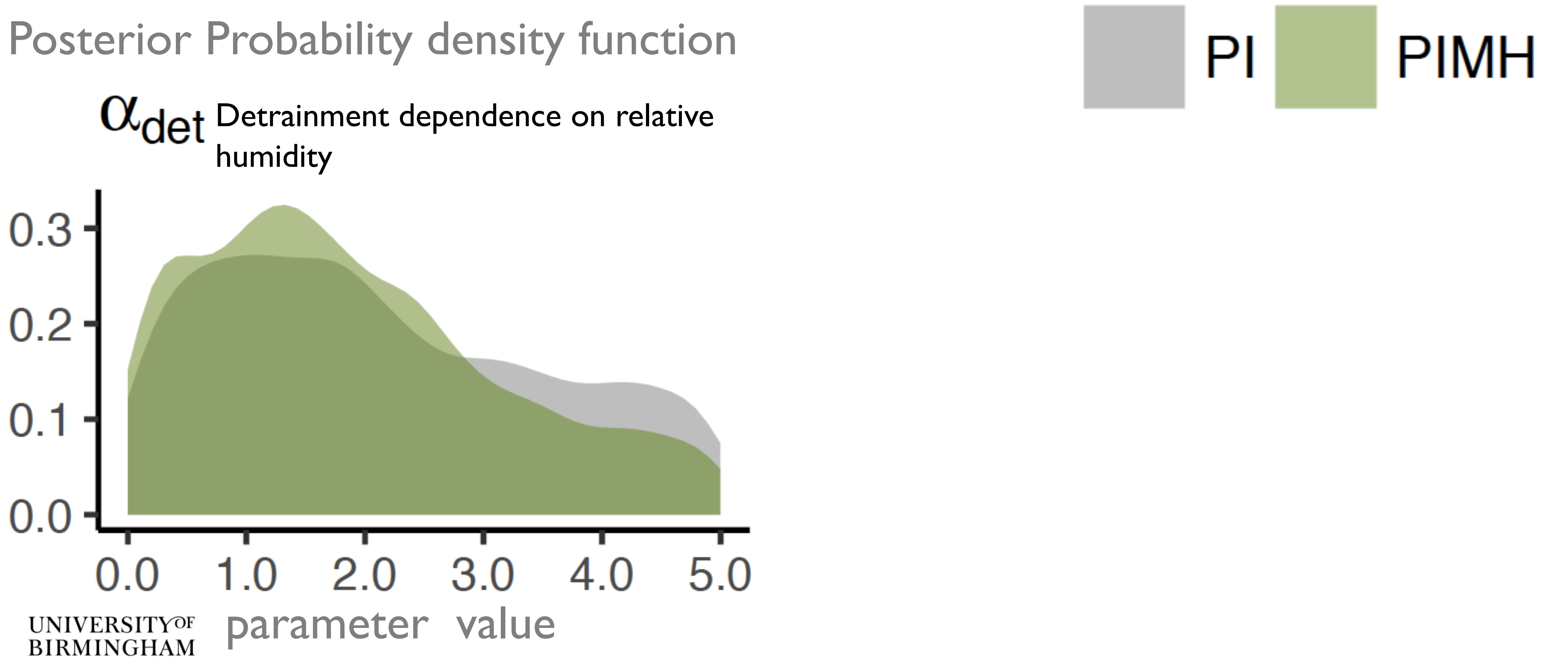
Finding an optimal parameter set

prob (parameters | observations, model, prior information)

Observational inputs

Posterior Probability density function

α_{det} Detrainment dependence on relative humidity

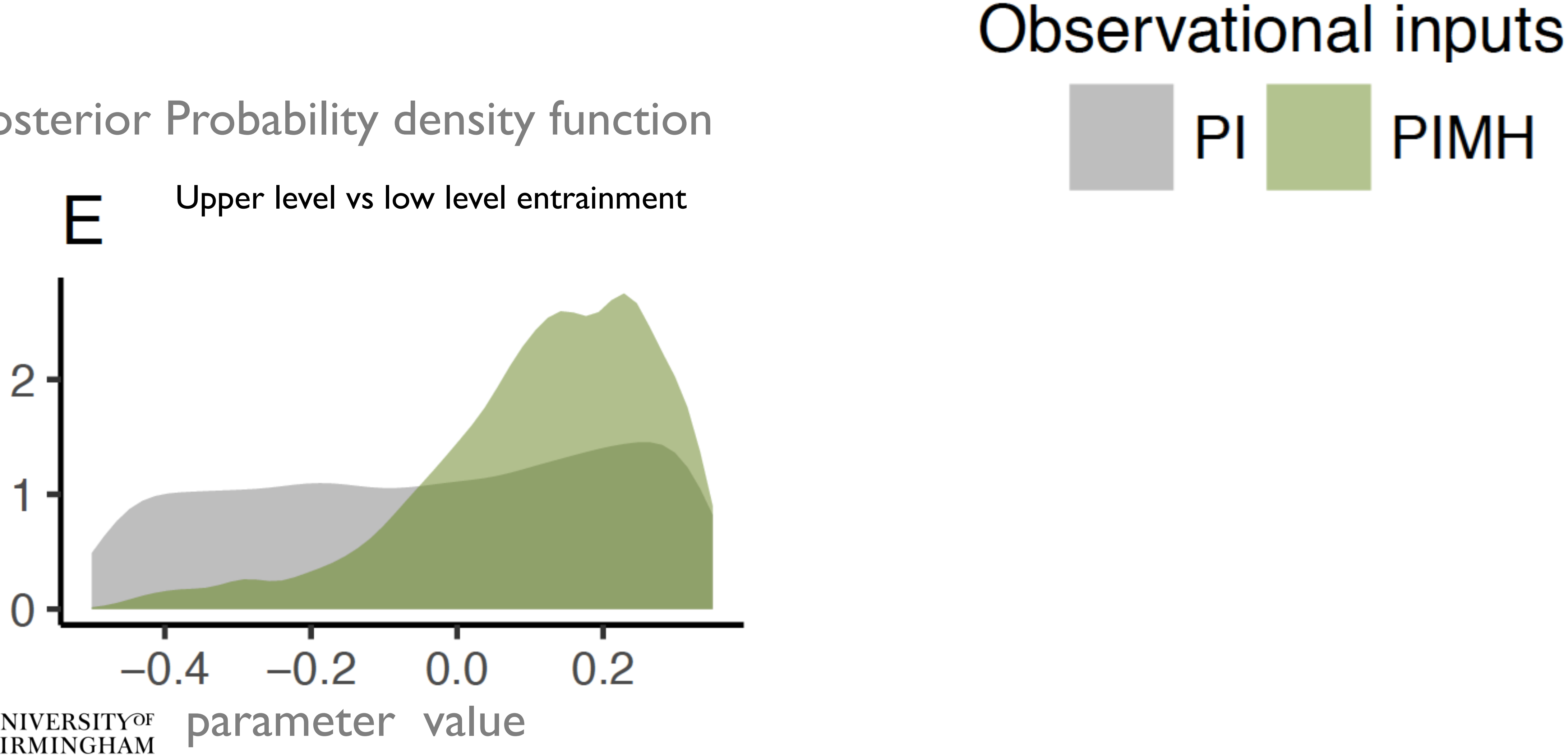


Hopcroft et al, in prep.

Finding an optimal parameter set

prob (parameters | observations, model, prior information)

Posterior Probability density function



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Hopcroft et al, in prep.

Finding an optimal parameter set

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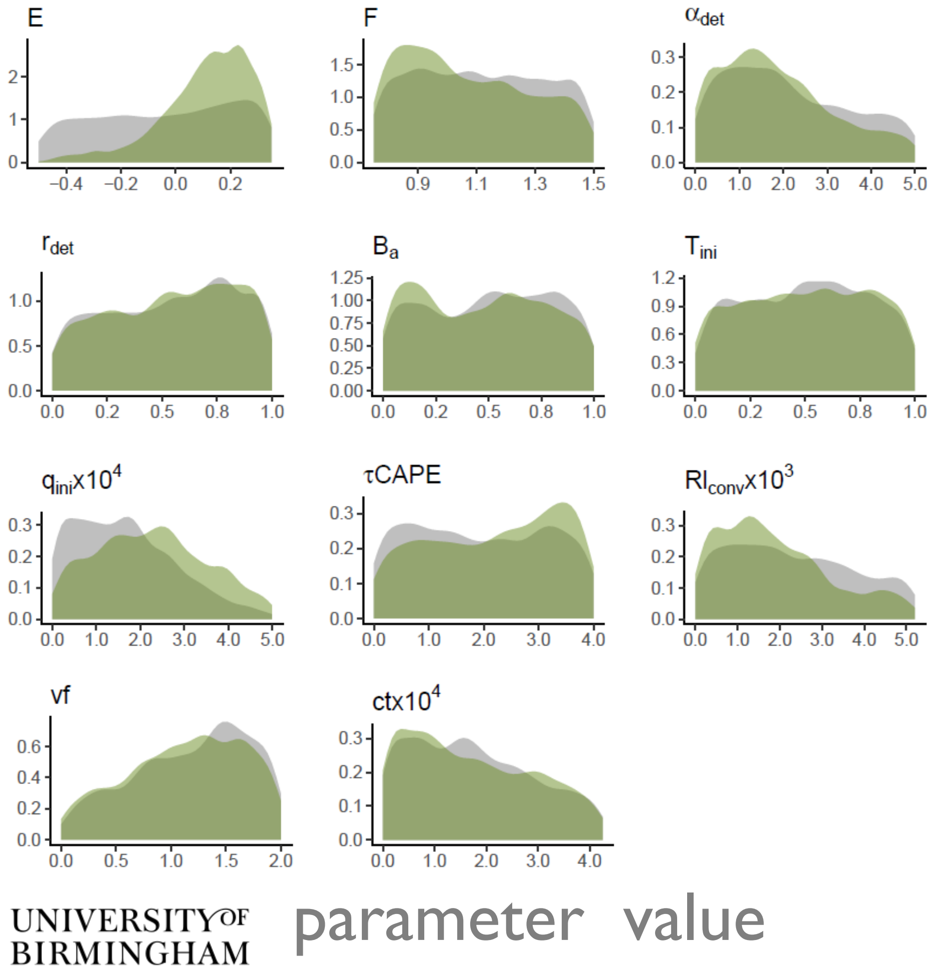

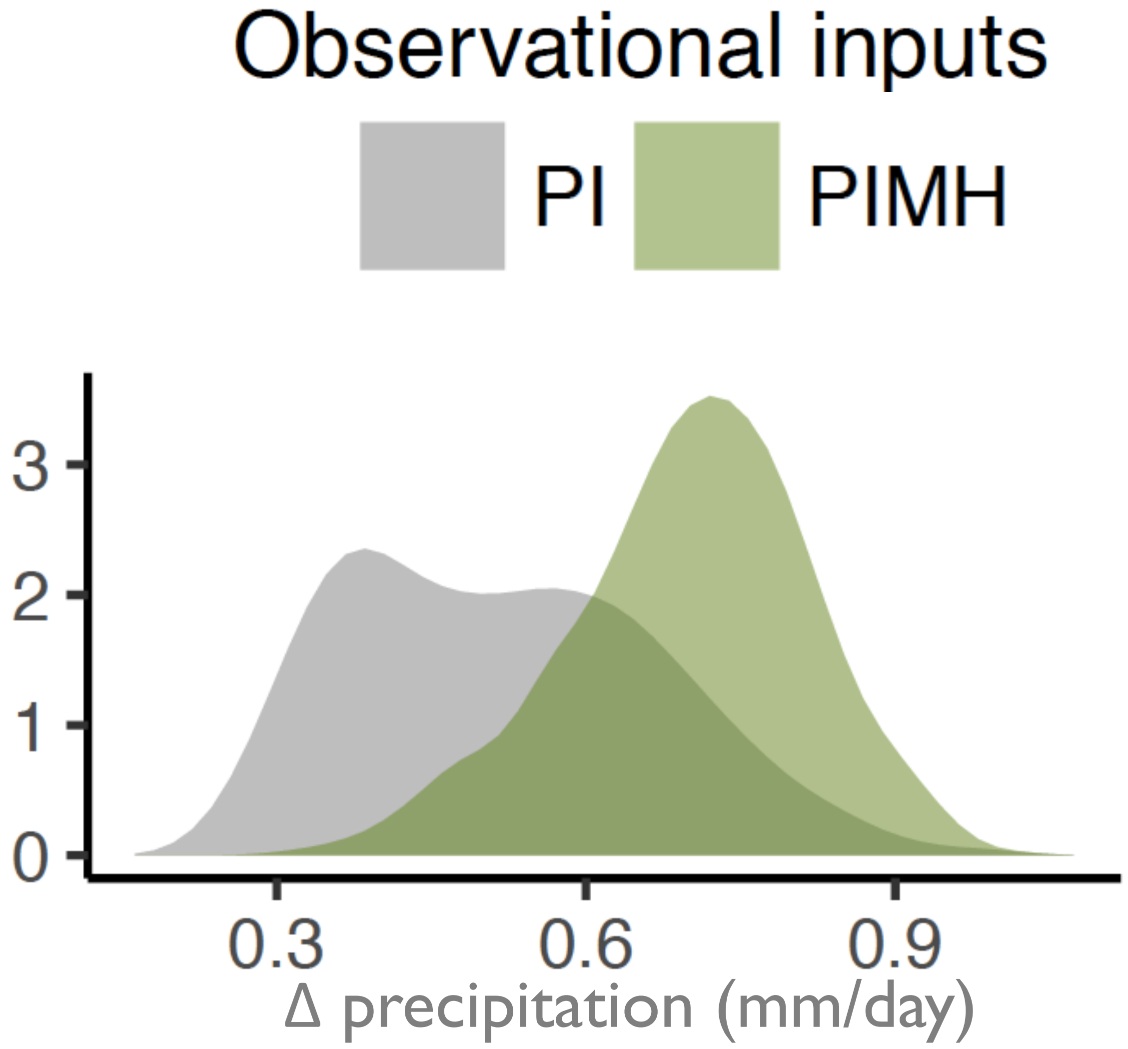

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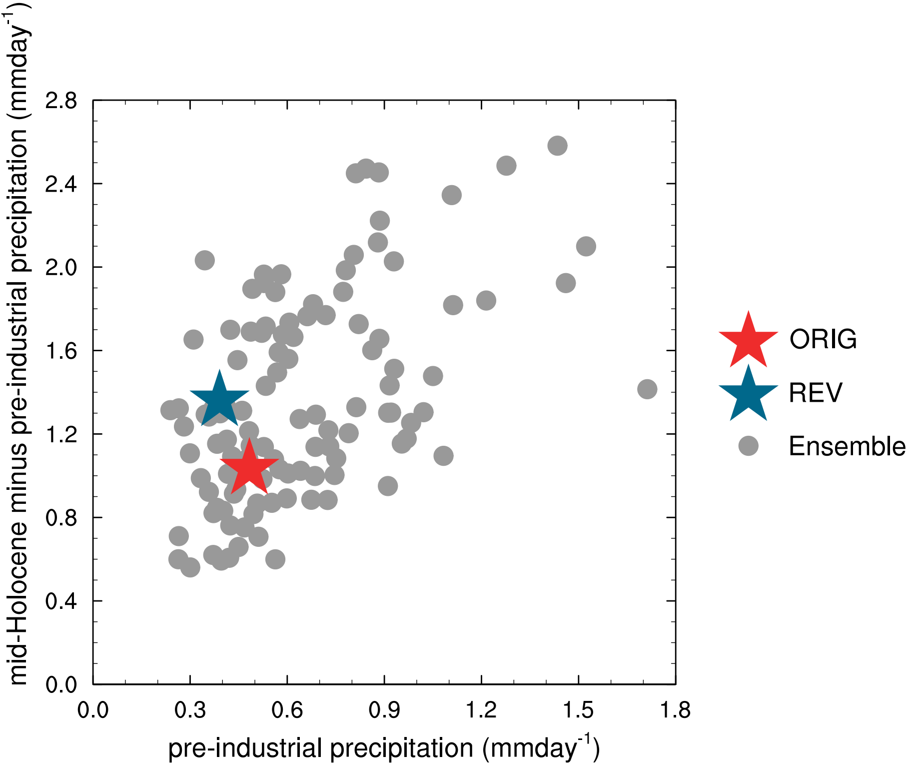
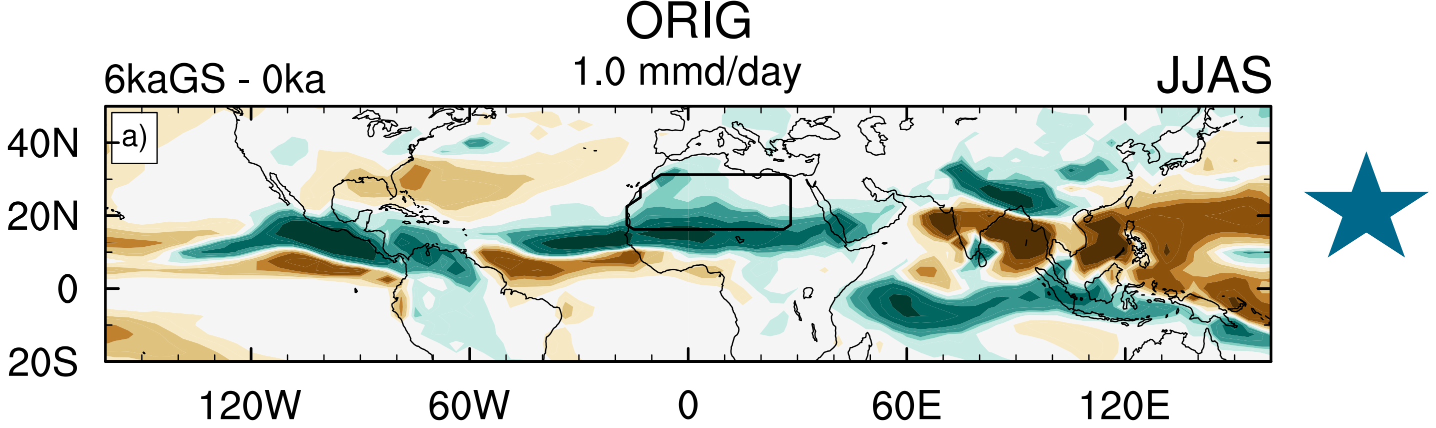
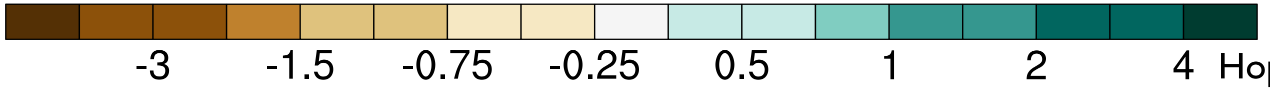
Hopcroft et al, in prep.

New parameters in the climate model







Hopcroft et al, in prep.

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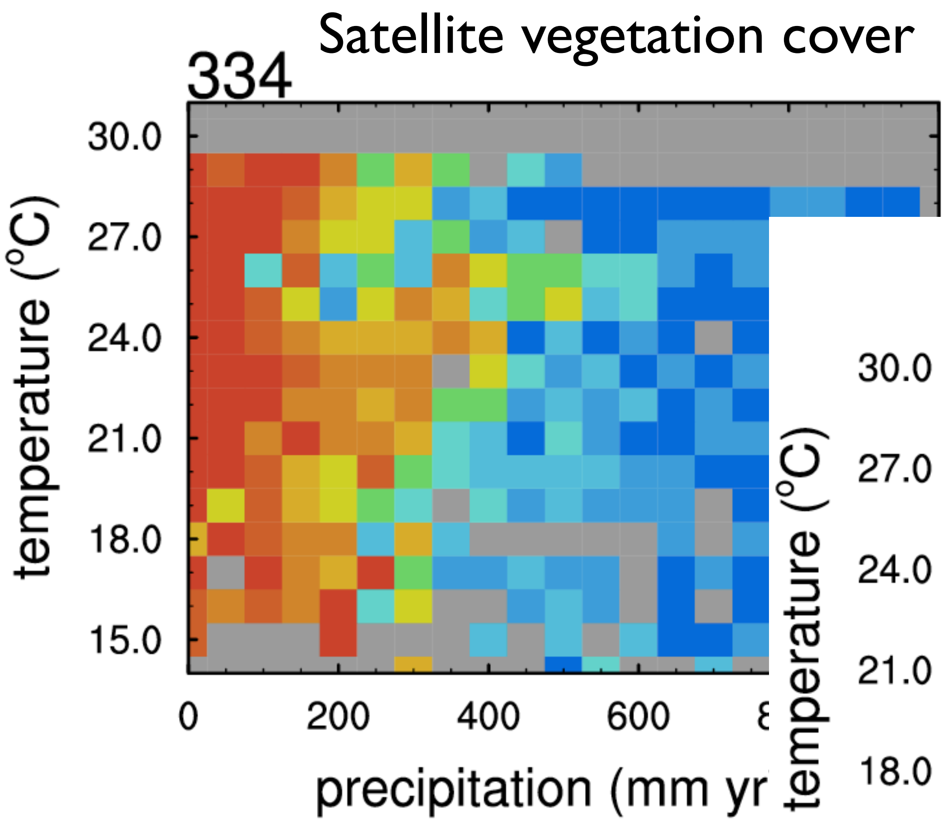
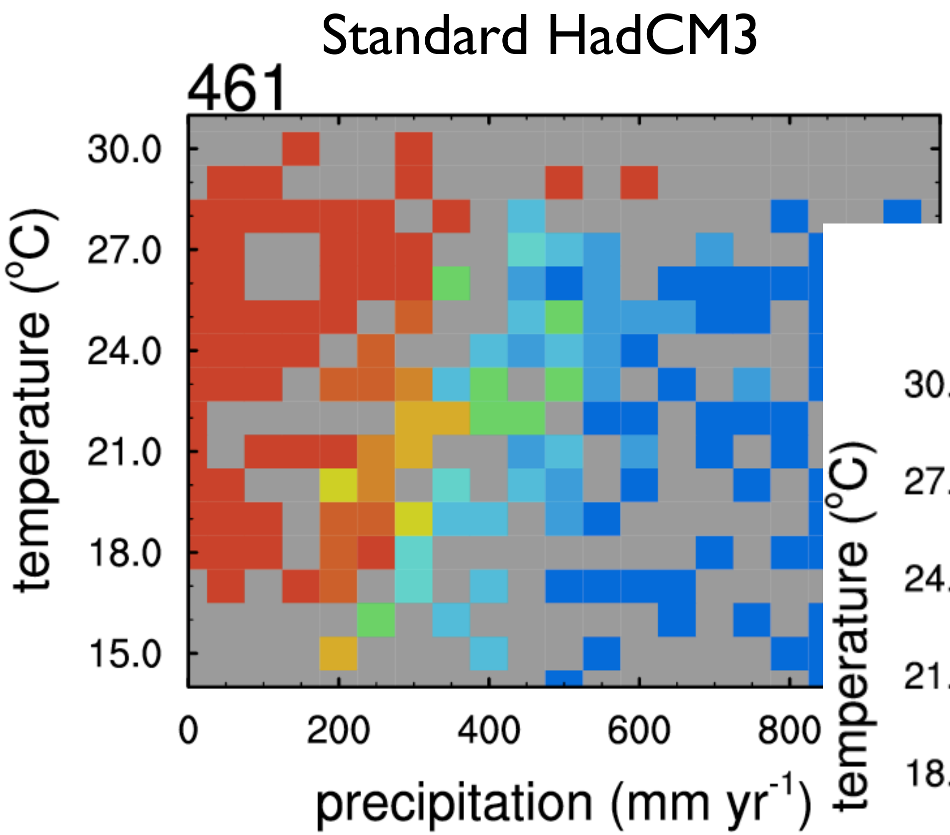
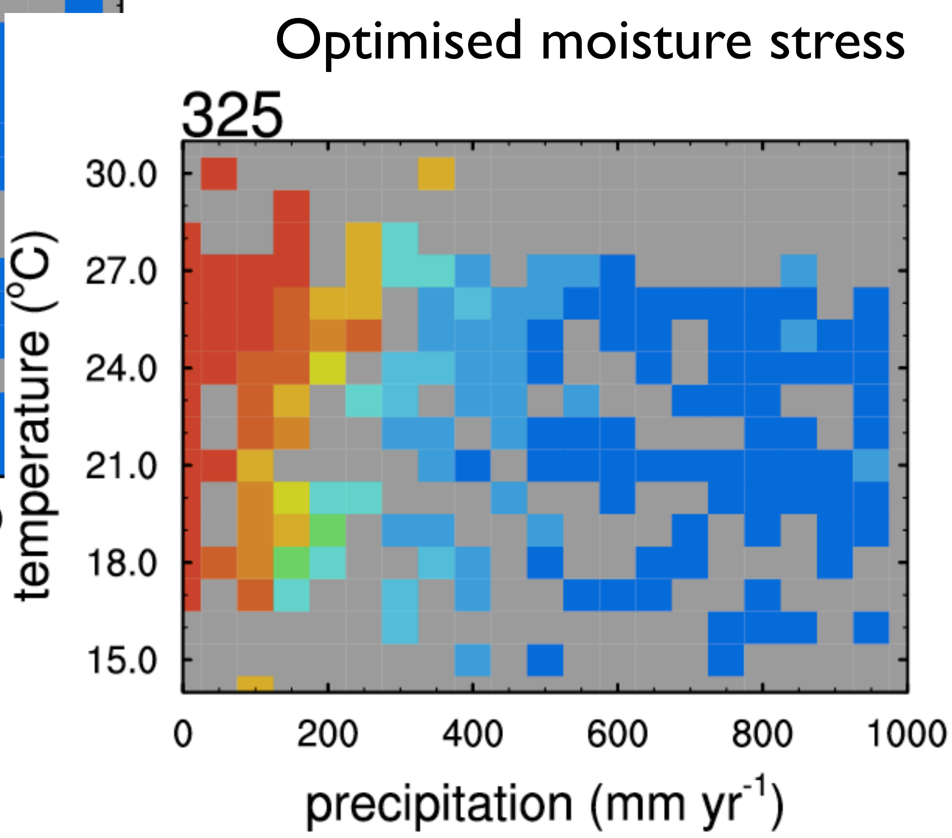
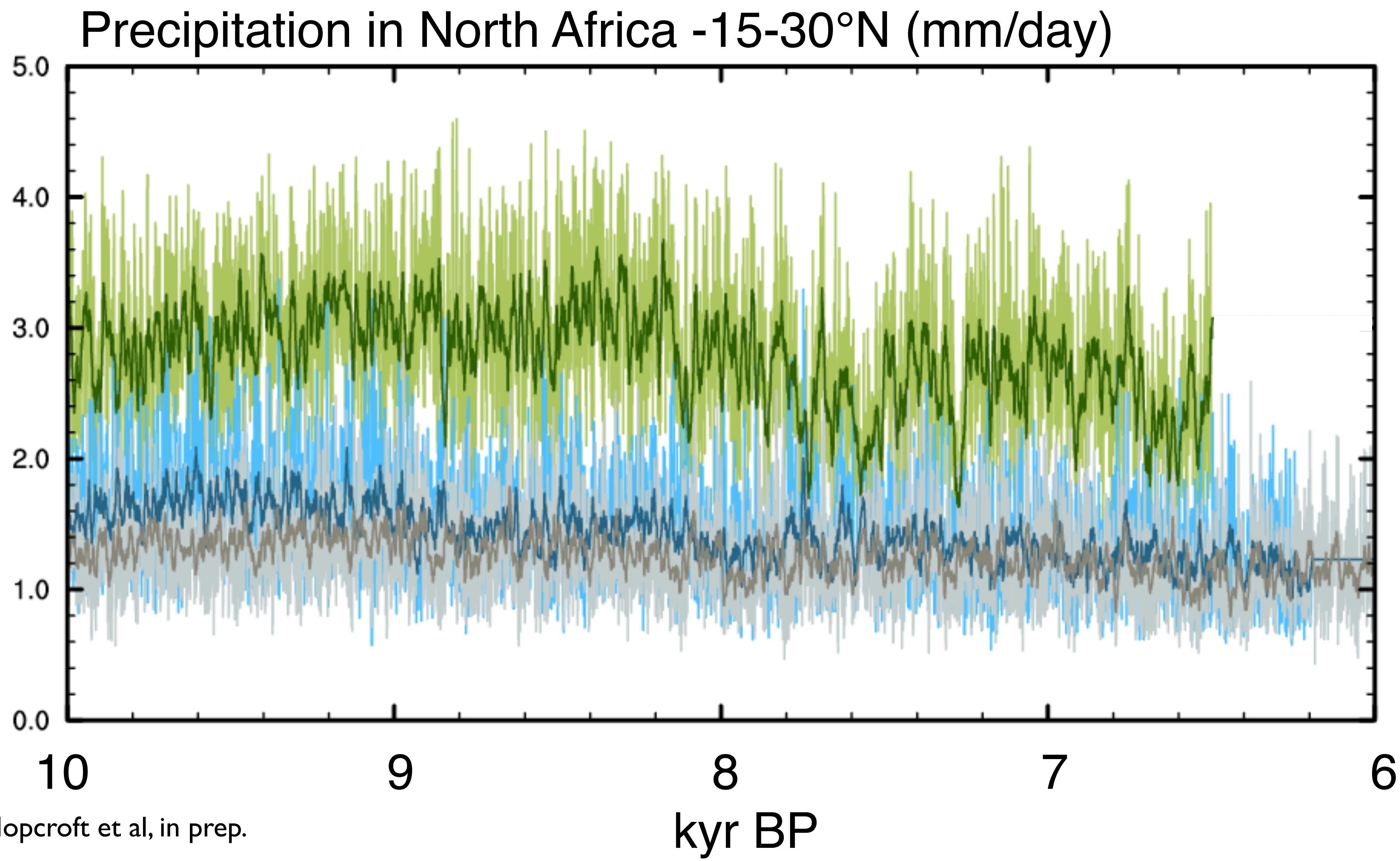
Results with modified soil moisture stress







Transient Holocene simulations 10 kyr – 2kyr BP



Hopcroft et al, in prep.

PMIP4 21ka-9ka Deglaciation (Ivanovic et al 2016), **extended to present day**

Orbit (every timestep)

$CO_2/N_20/CH_4$ (every timestep)

Ice-sheets & sea-level (every 500 years)

HadCM3

3.75°x2.75°x19L (atmosphere)

1.25°x1.25°x20L (ocean)

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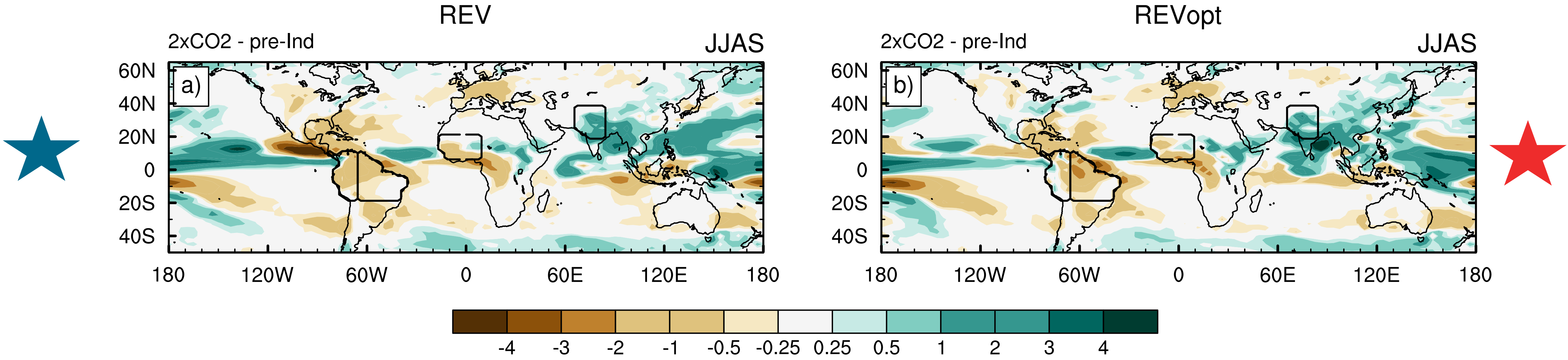
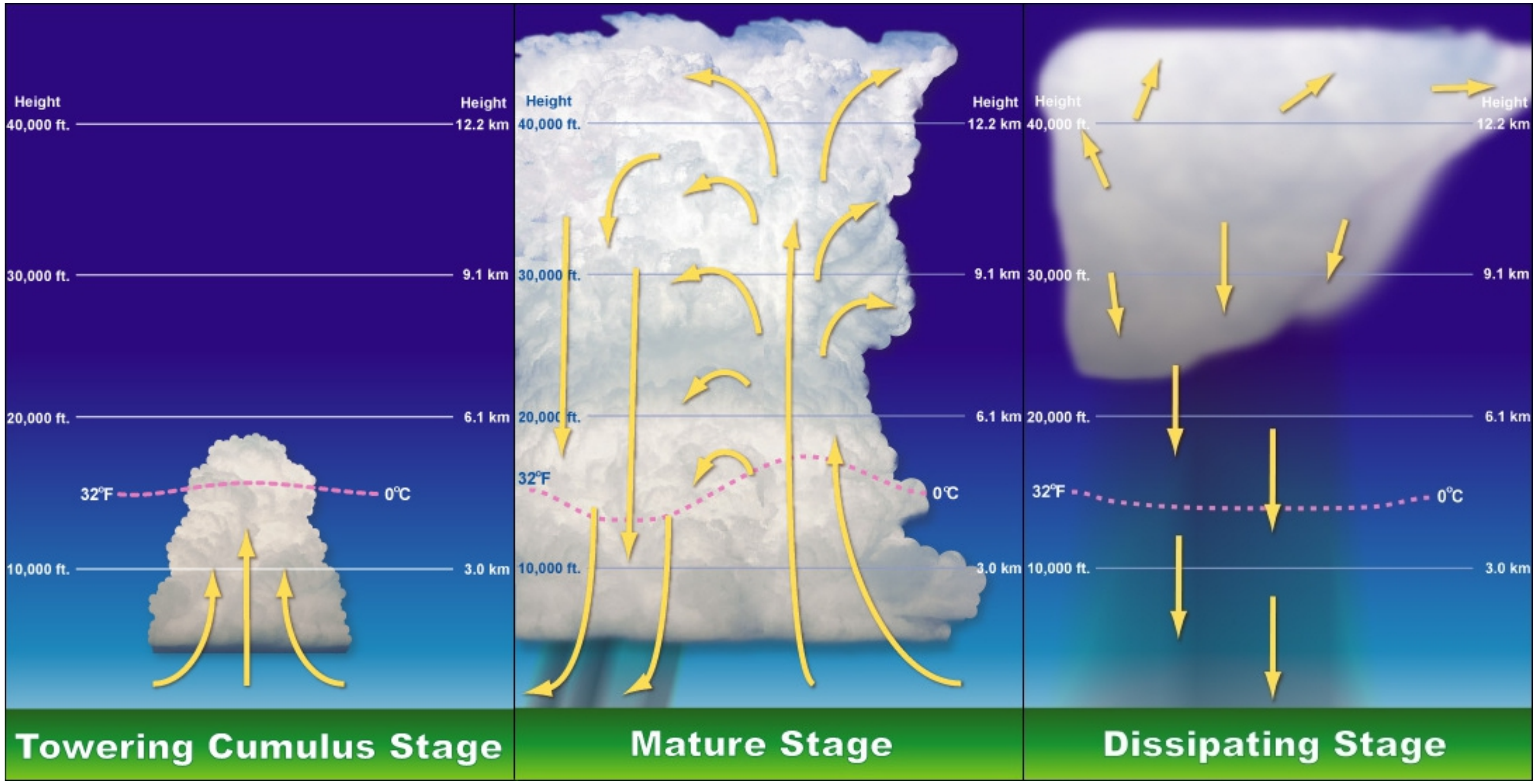
Optimal parameter set in 2xCO_2 simulations

Hopcroft et al, in prep.



Limitations: Entrainment/detrainment

Mixing of convective air masses and surrounding environment



Currently:
Mixing = constant

New:
Mixing = f(recent convective activity)

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Willet & Whitall, 2017, Met Office Forecasting Report

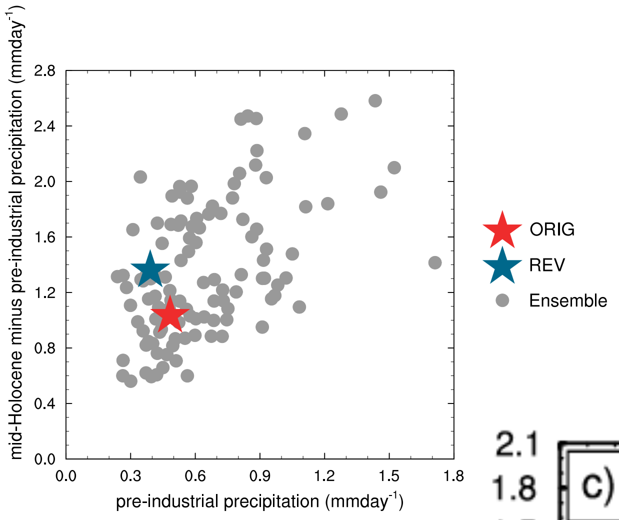
Summary

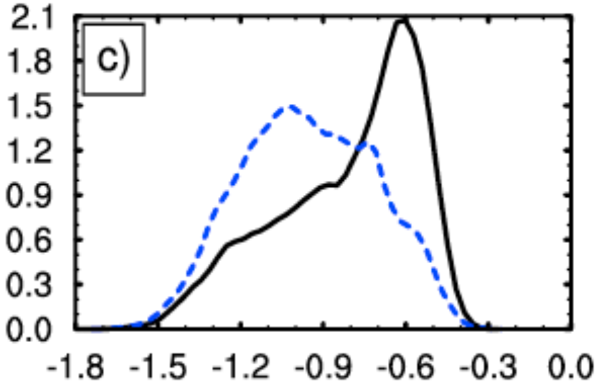
Convection parameter changes can allow simulation of 'Green Sahara'

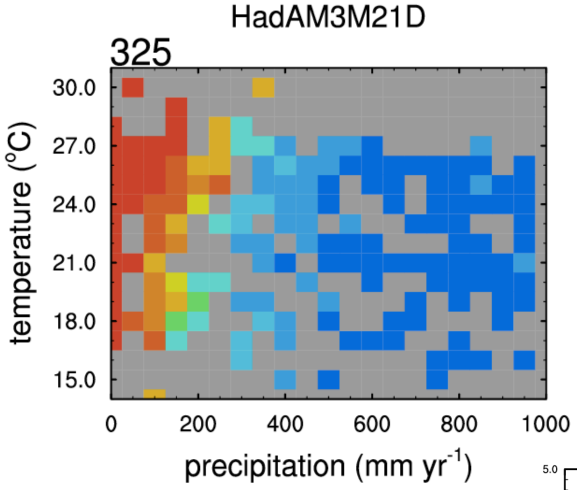
This also generally increases precipitation changes in a $2xCO_2$ simulation

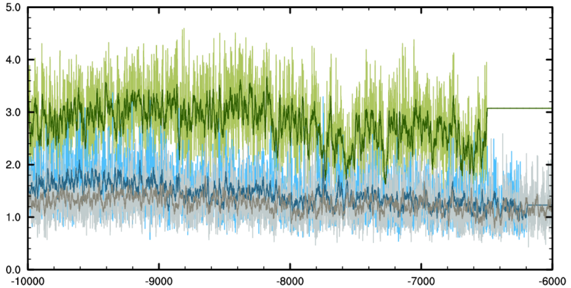
Improved soil moisture stress required for vegetation response

Transient simulation shows the combination of the 2 is crucial









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