

PARAMETER SENSITIVITIES IN CLM5

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& the LMWG



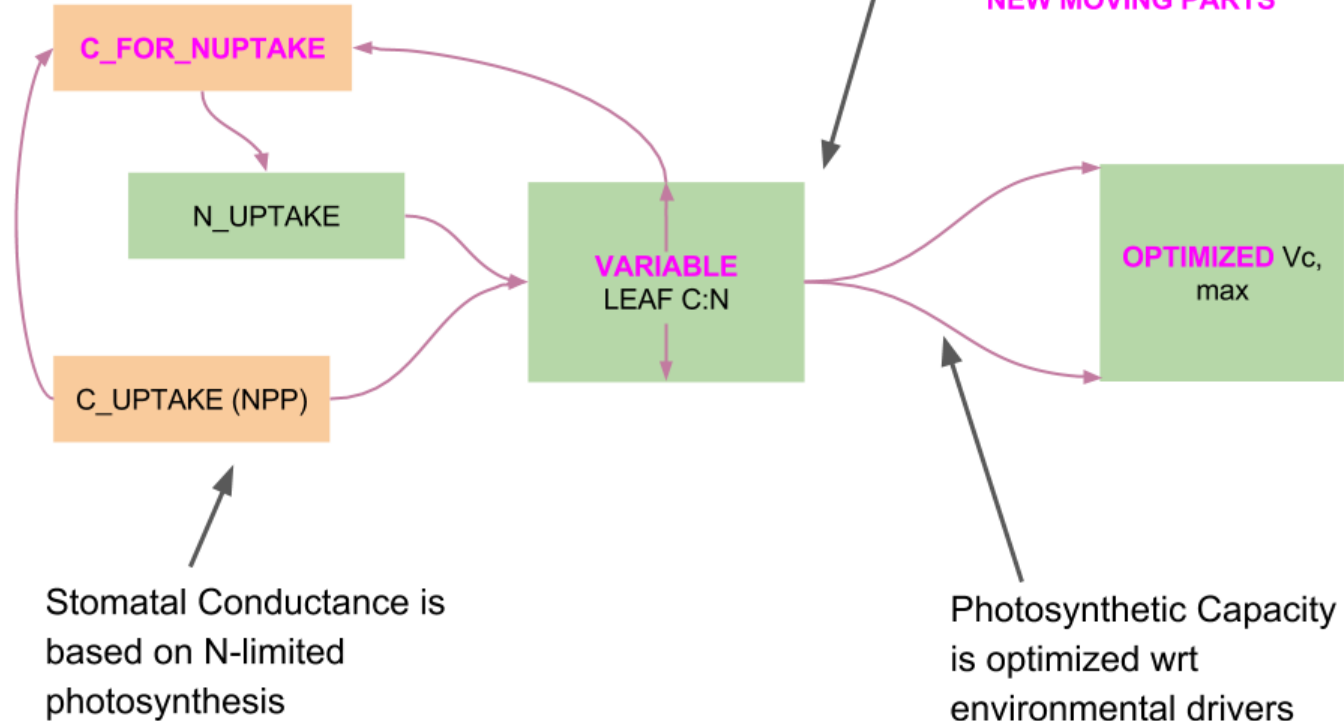
CLM5 HAS A NEW NITROGEN CYCLE

Plants pay for fixed & active
Nitrogen uptake (in Carbon)

CLM5.0

Leaf Nitrogen content
varies with the cost of N
uptake

NEW MOVING PARTS



THE NEW MODEL IS IMPERFECT!

GPP

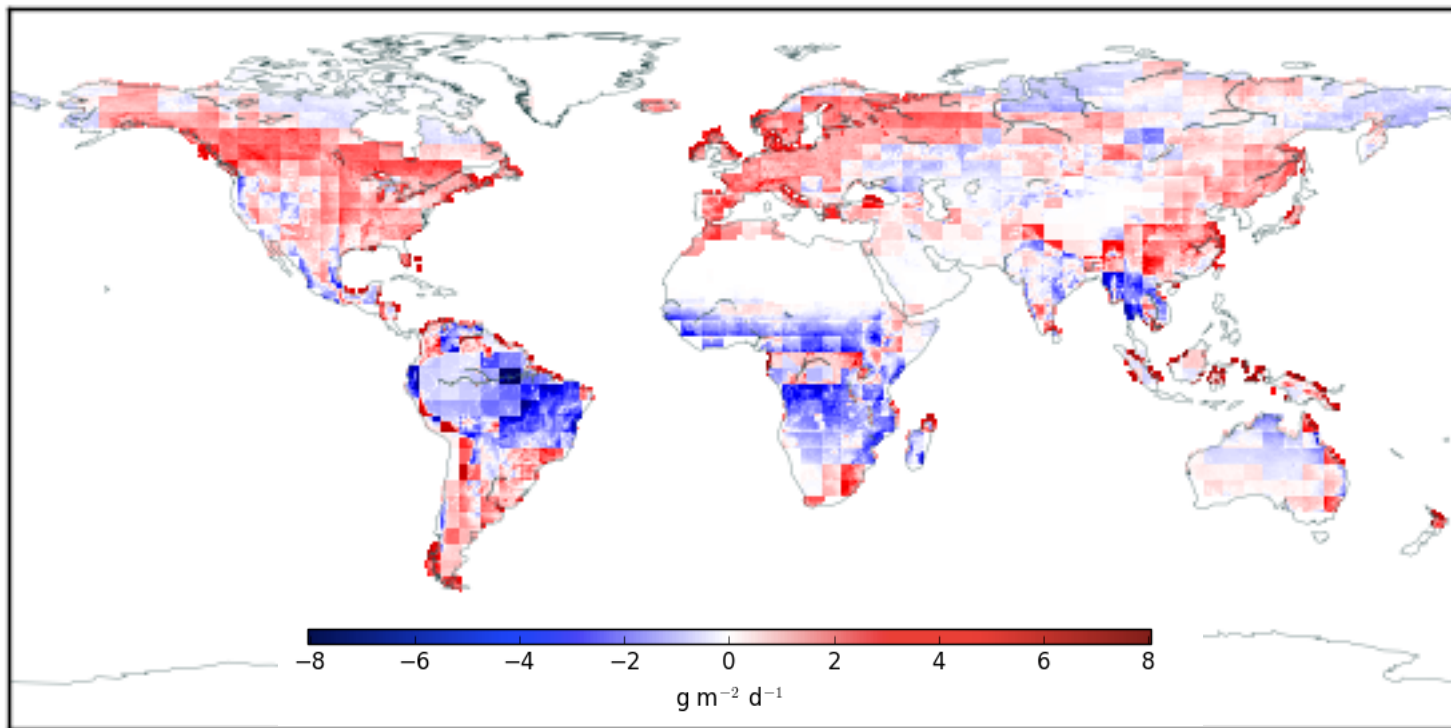
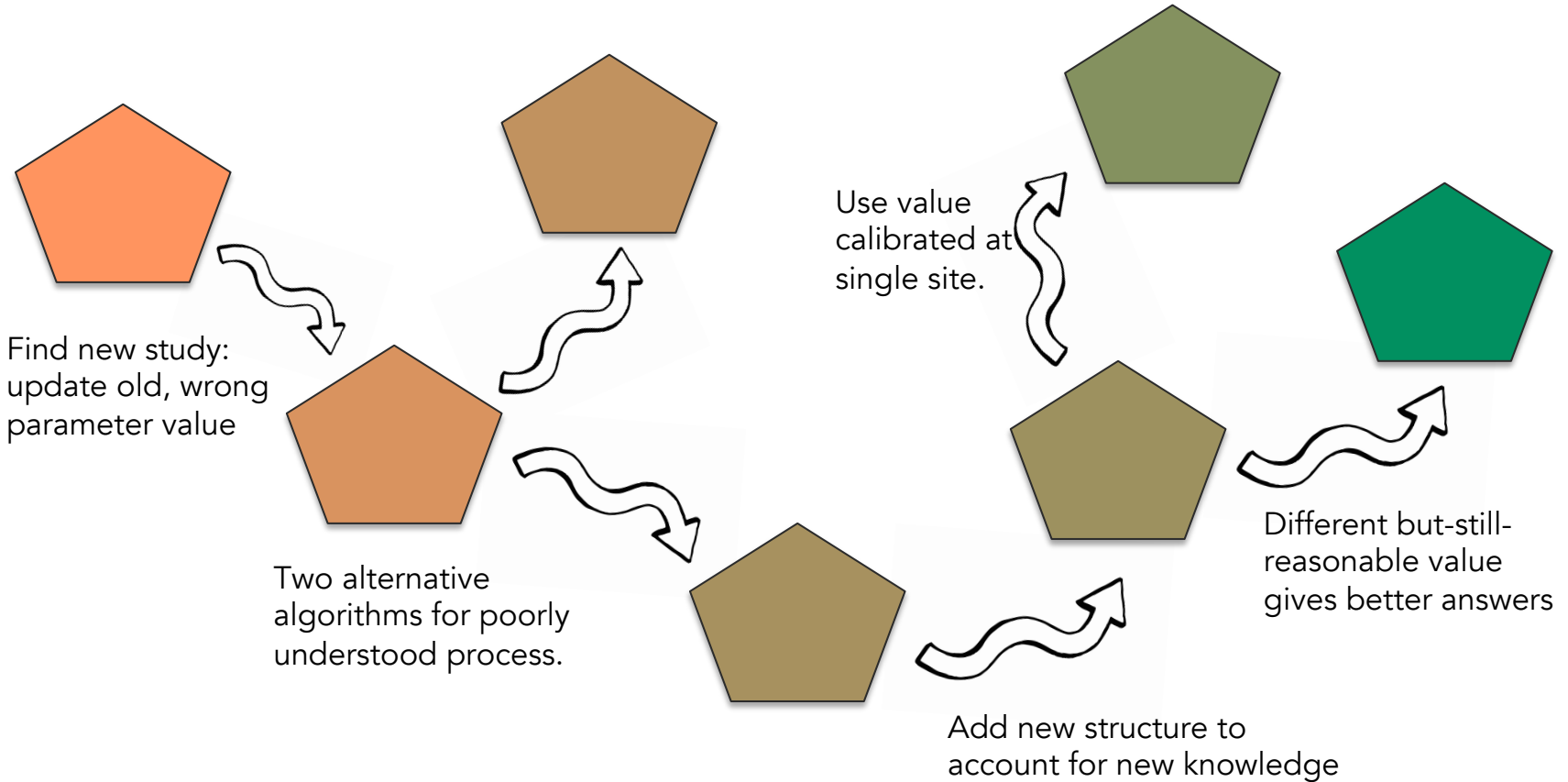


Image from Nathan Collier and <http://climate.ornl.gov/~ncf/CLM5beta/>

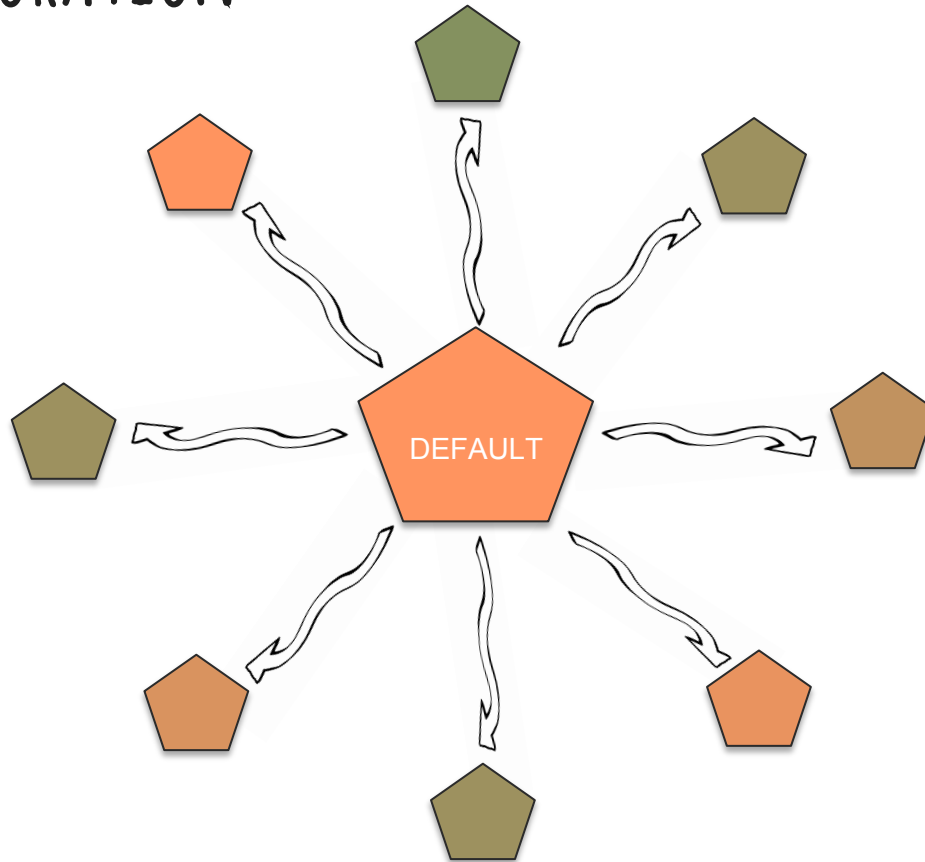
THE GAME OF CLIMATE MODEL BIASES



HOW CAN YOU TELL WHETHER PROBLEMS ARE
STRUCTURAL
OR
PARAMETRIC
?

PARAMETER EXPLORATION

One-At-A-Time
sensitivity analysis

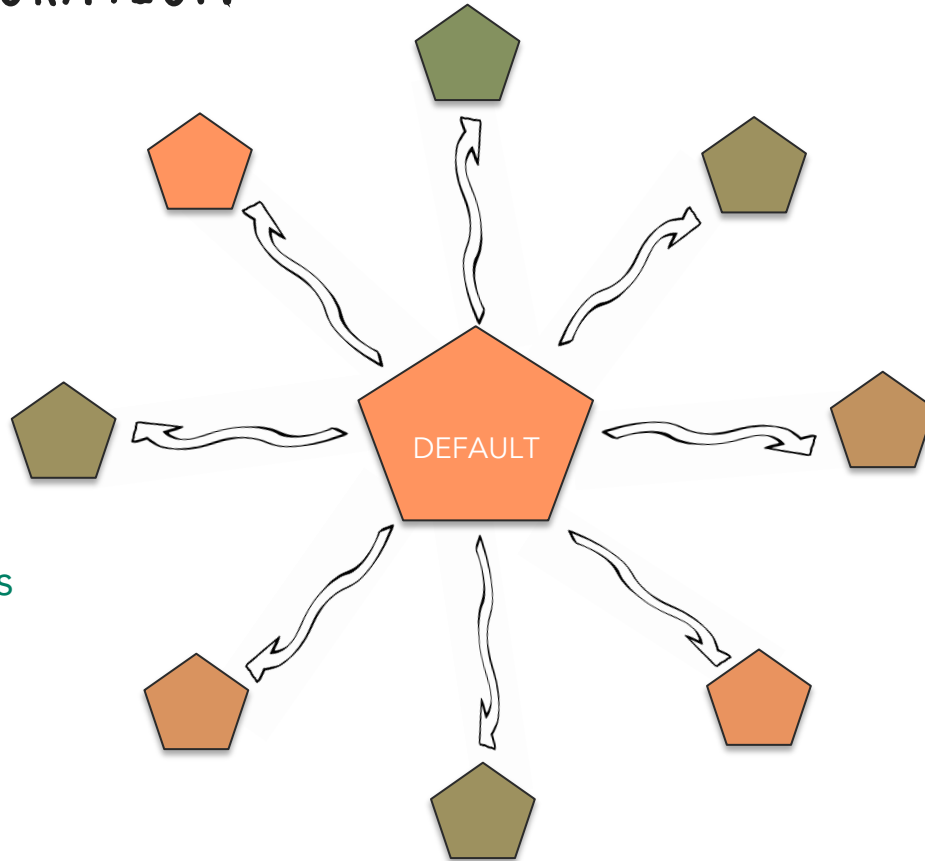


PARAMETER EXPLORATION

One-At-A-Time
sensitivity analysis

Global 4x5° runs

'Expert Judgment' to
narrow parameter fields

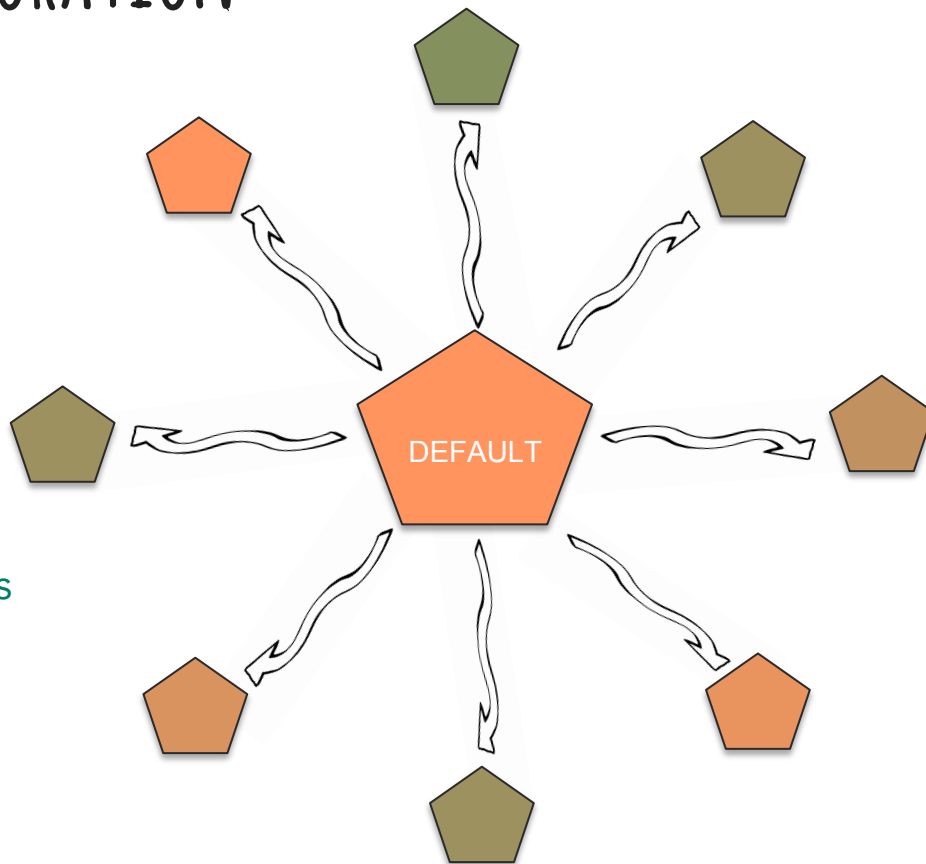


PARAMETER EXPLORATION

One-At-A-Time
sensitivity analysis

Global 4x5° runs

'Expert Judgment' to
narrow parameter fields



Spin up 'default'
version to Pre-I CO2

Perturb parameters

Run for 60 more years
at PI CO2.

Elevate CO2 to
present (380ppm)

Run for 20 more years

AREN'T WE SUPPOSED TO HAVE PARAMETERS WE CAN MEASURE?.

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Specific Leaf Area (SLA)
from TRY database

Existing Plant
Functional Types are
not a good predictor
of many traits

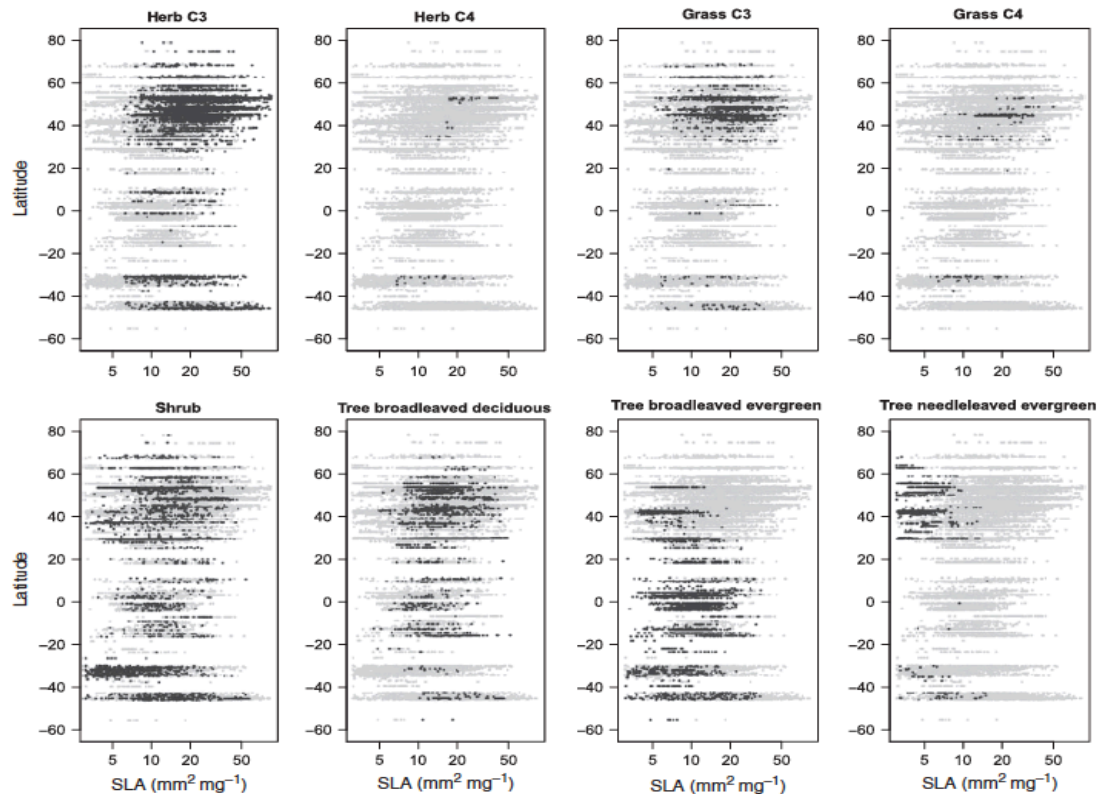
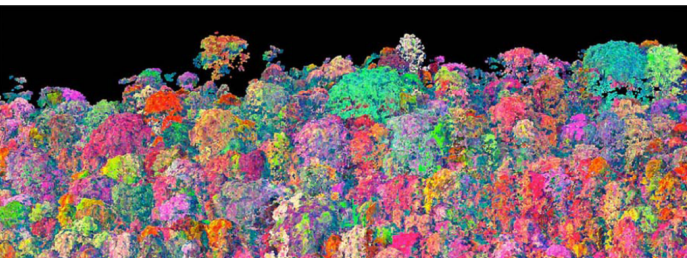


Fig. 6 Worldwide range in specific leaf area (SLA) along a latitudinal gradient for the main plant functional types. Grey, all data; black, data for the plant functional group (PFT) under scrutiny.

YES

IS IT CHEATING?

NO

We shouldn't fit to the same data we are testing the model with

We should be able to observe model parameters

There is nothing magic about the existing parameter values

They have both observation error and real variation

It is better to calibrate objectively than iteratively

We can (and will!) be transparent about our process

We can isolate structural bias or other issues if calibration fails

We need a robust simulation of the present day to say sensible things about the future

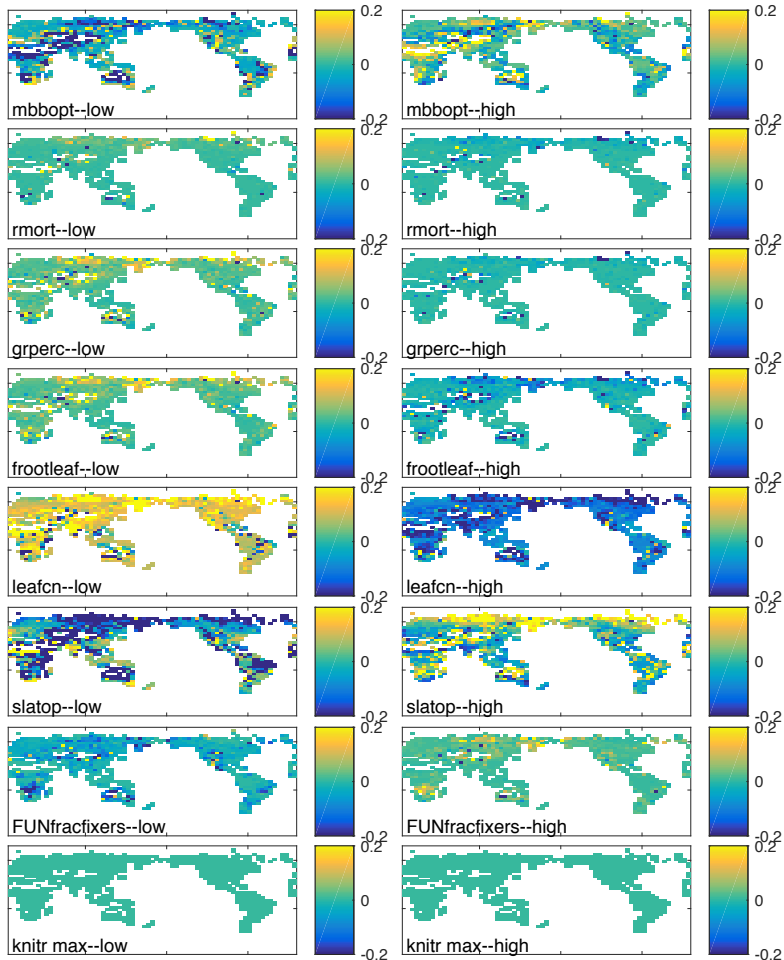
We can use only a subset of data (e.g. annual means)

THE CHOSEN ONES: REDUCED PARAMETER SPACE

cn_s1	: Soil C:N ratio pool 1	mbb_opt	: Ball-Berry stomatal slope
cn_s2	: Soil C:N ratio pool 2	N_costs	: Costs of active N uptake
knitr_max	: max rate of nitrification	denit_coef	: Denitrification coefficient
FUNfracfixers	: frac of vegetation that can fix N	denit_exp	: Denitrification exponent
slatop	: Specific Leaf Area (TRY)	ig_counts	: Fire ignition counts
leaf_cn	: Leaf C:N ratio (TRY)	baseflow	: Rate of water loss to rivers
froot_leaf	: Fine root:leaf ratio	snow	: 2 snow density parameters
gr_perc	: Growth respiration fraction	root_depth	: Exponent of root profile
r_mort	: Stem turnover rate (mortality)		

RANGES FROM LITERATURE, OR LOGIC/JUDGEMENT

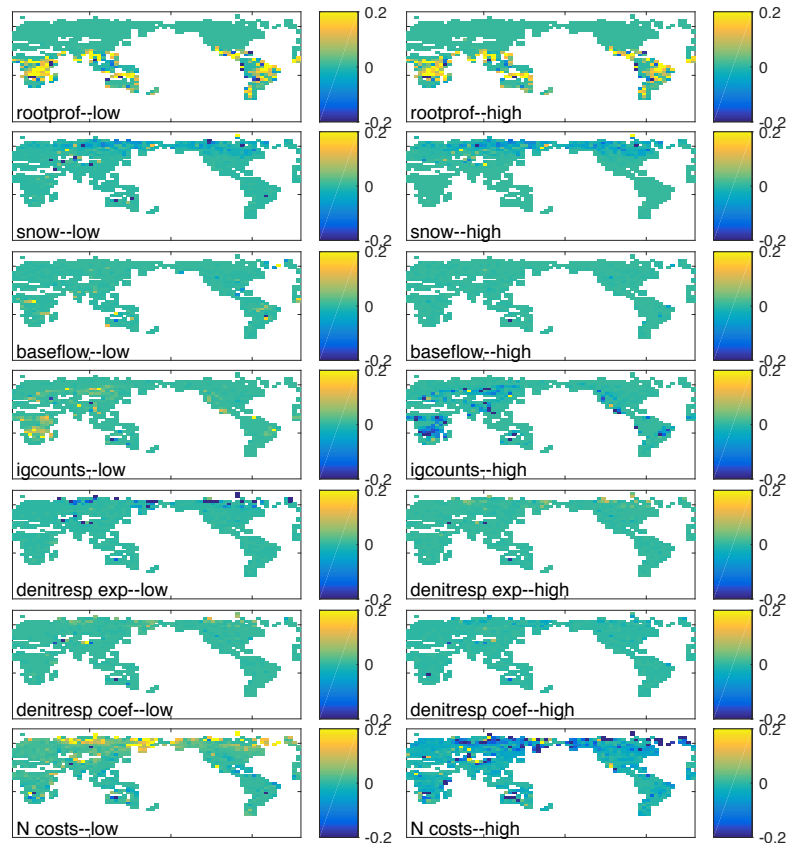
VARIABLE
PARAMETER



LOW

HIGH

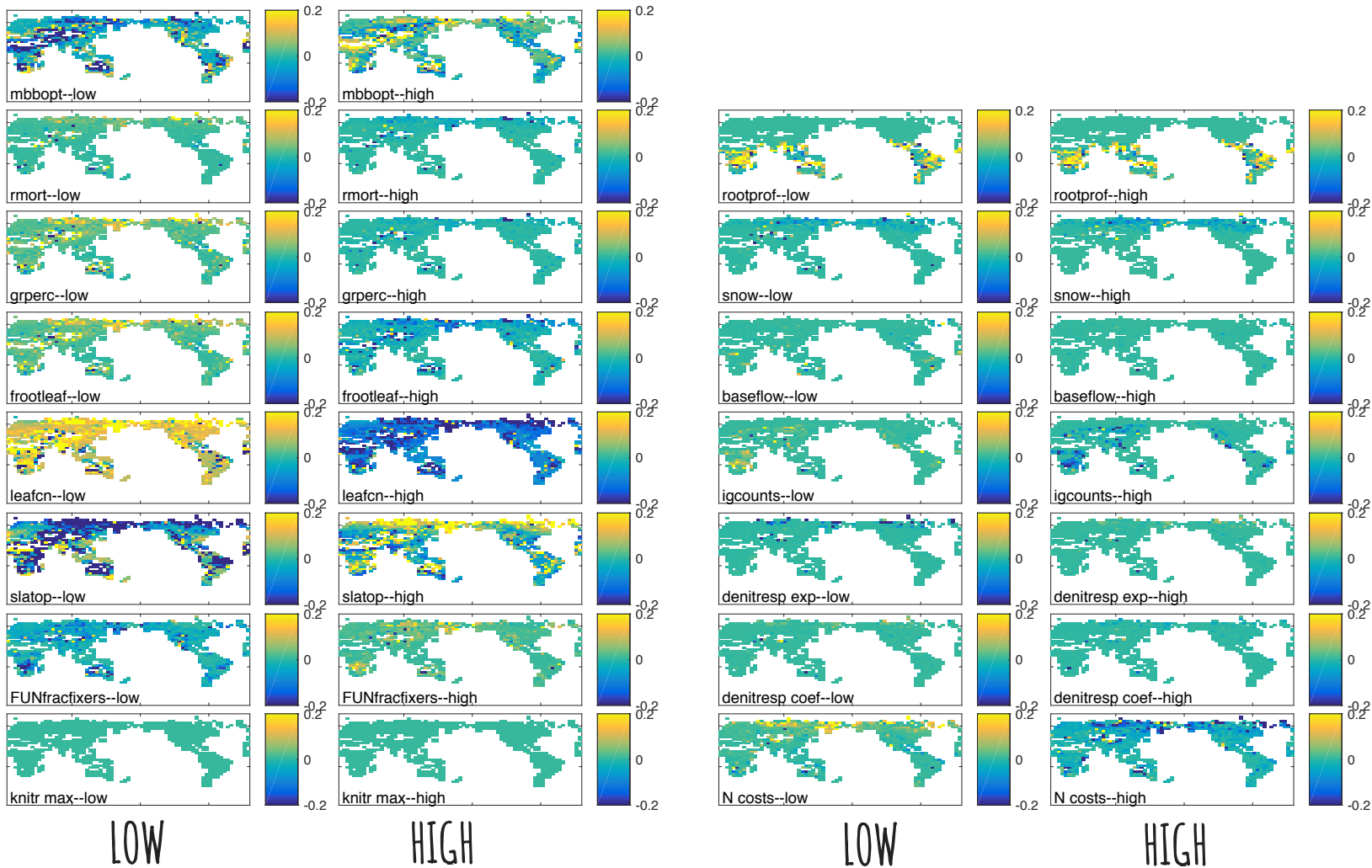
RELATIVE TO DEFAULT



LOW

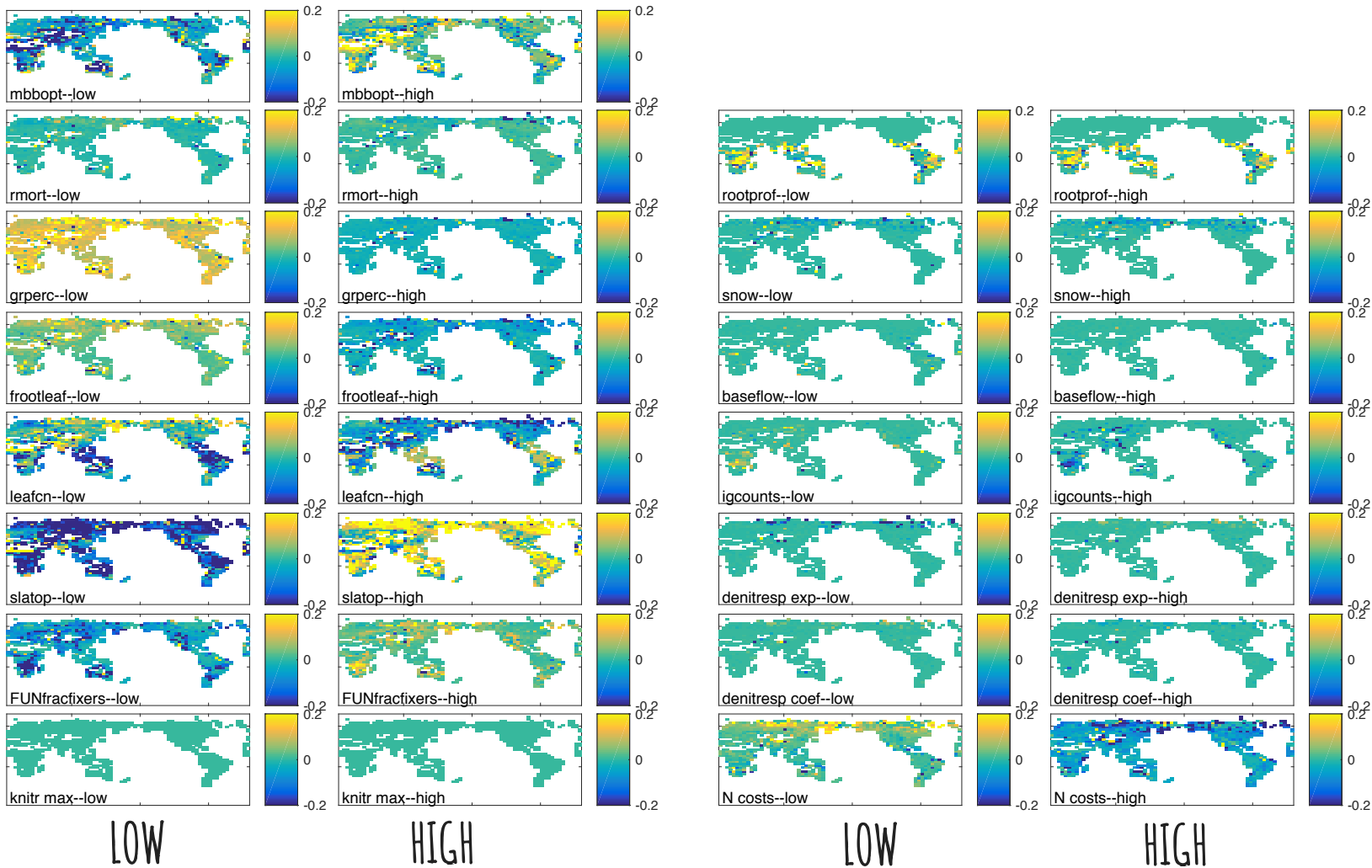
HIGH

GPP RELATIVE

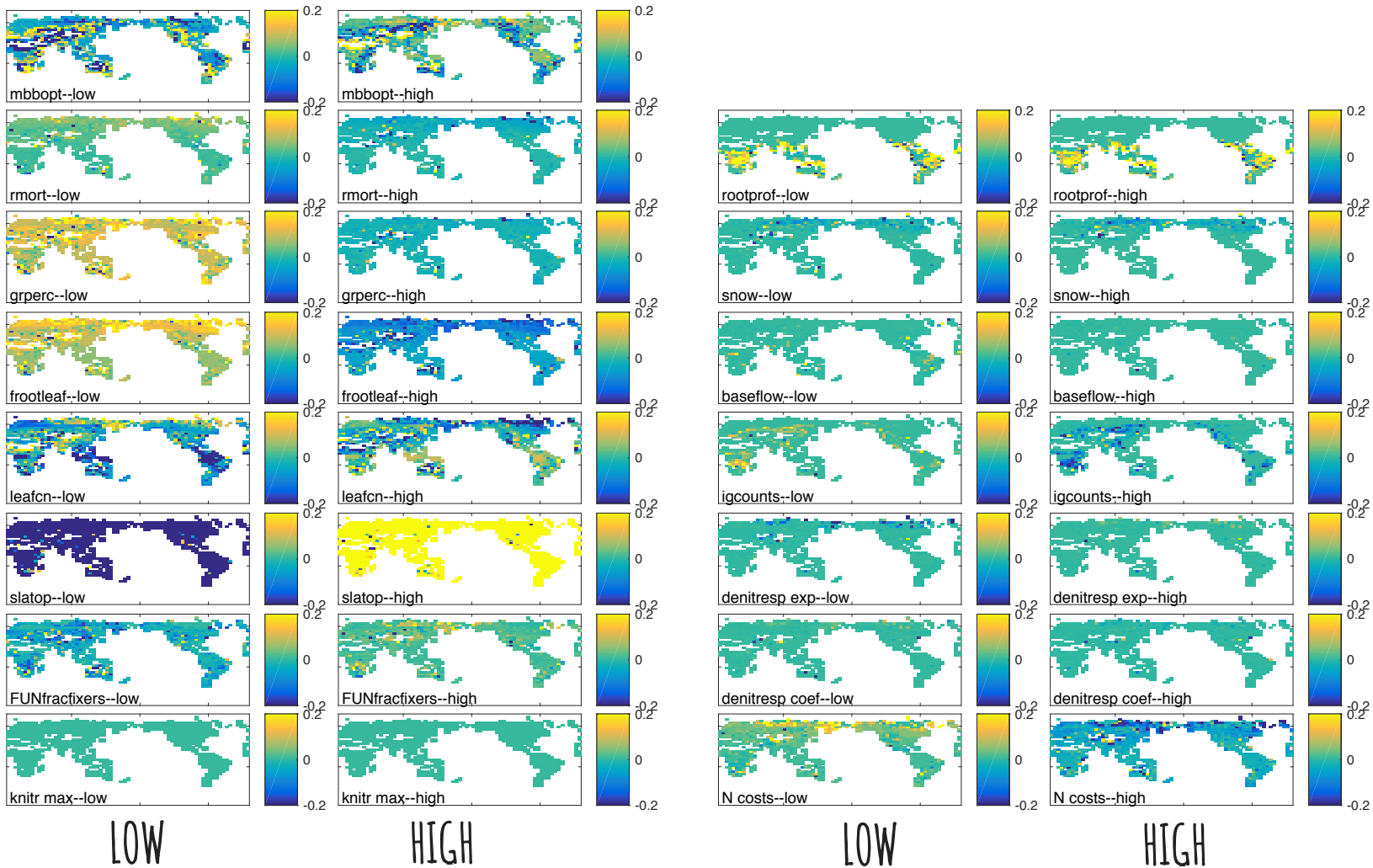


NPP

RELATIVE

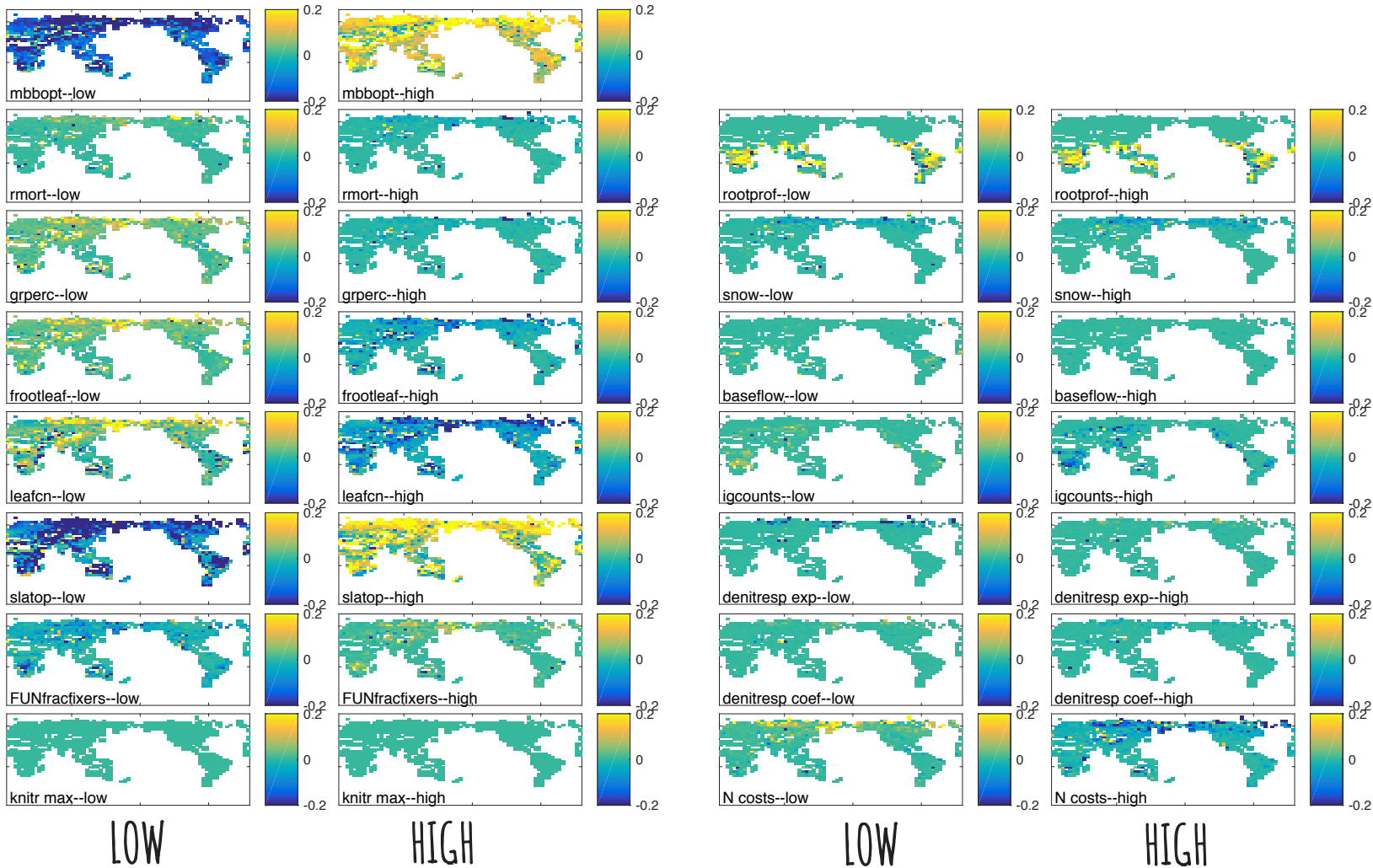


LAI RELATIVE



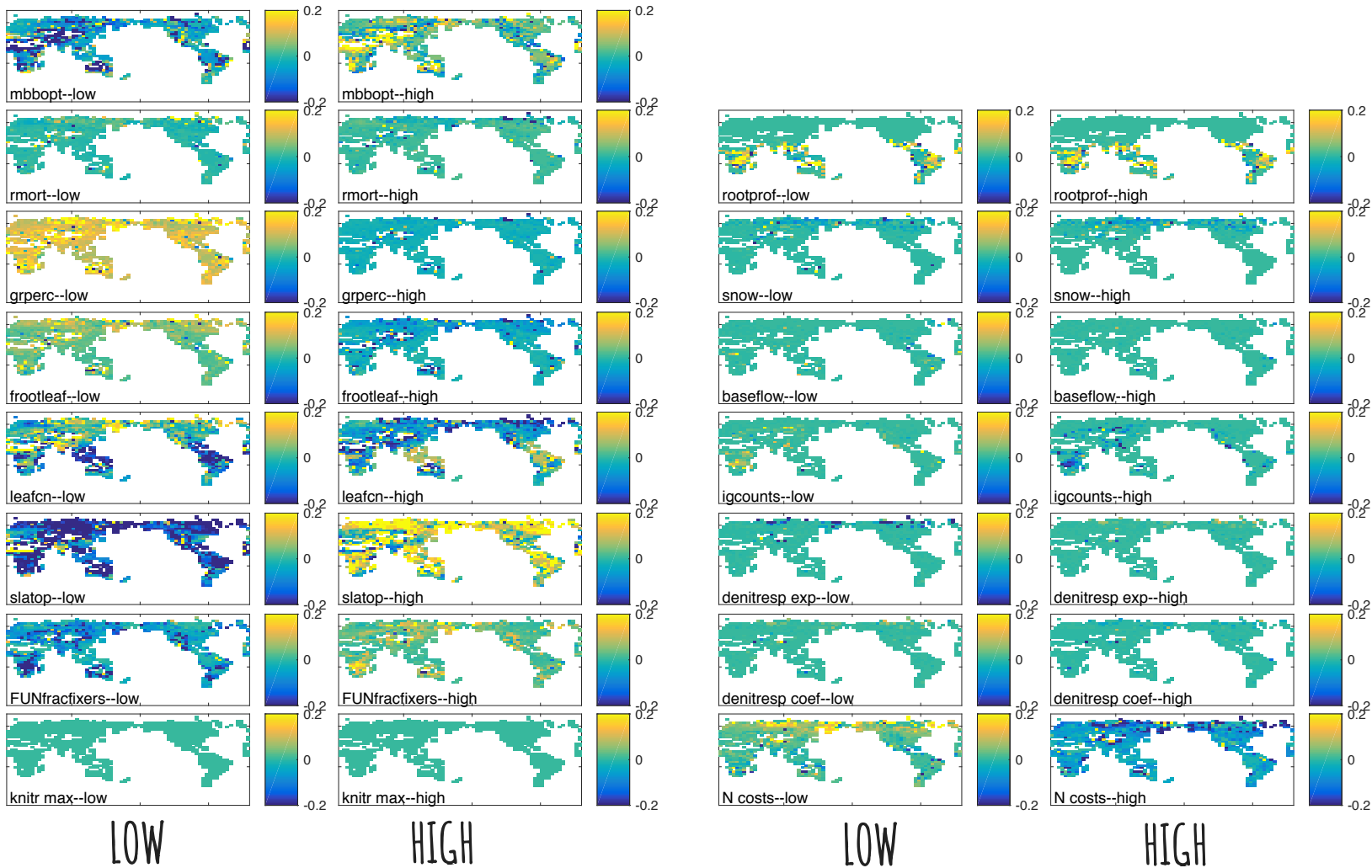
QVEGT

RELATIVE

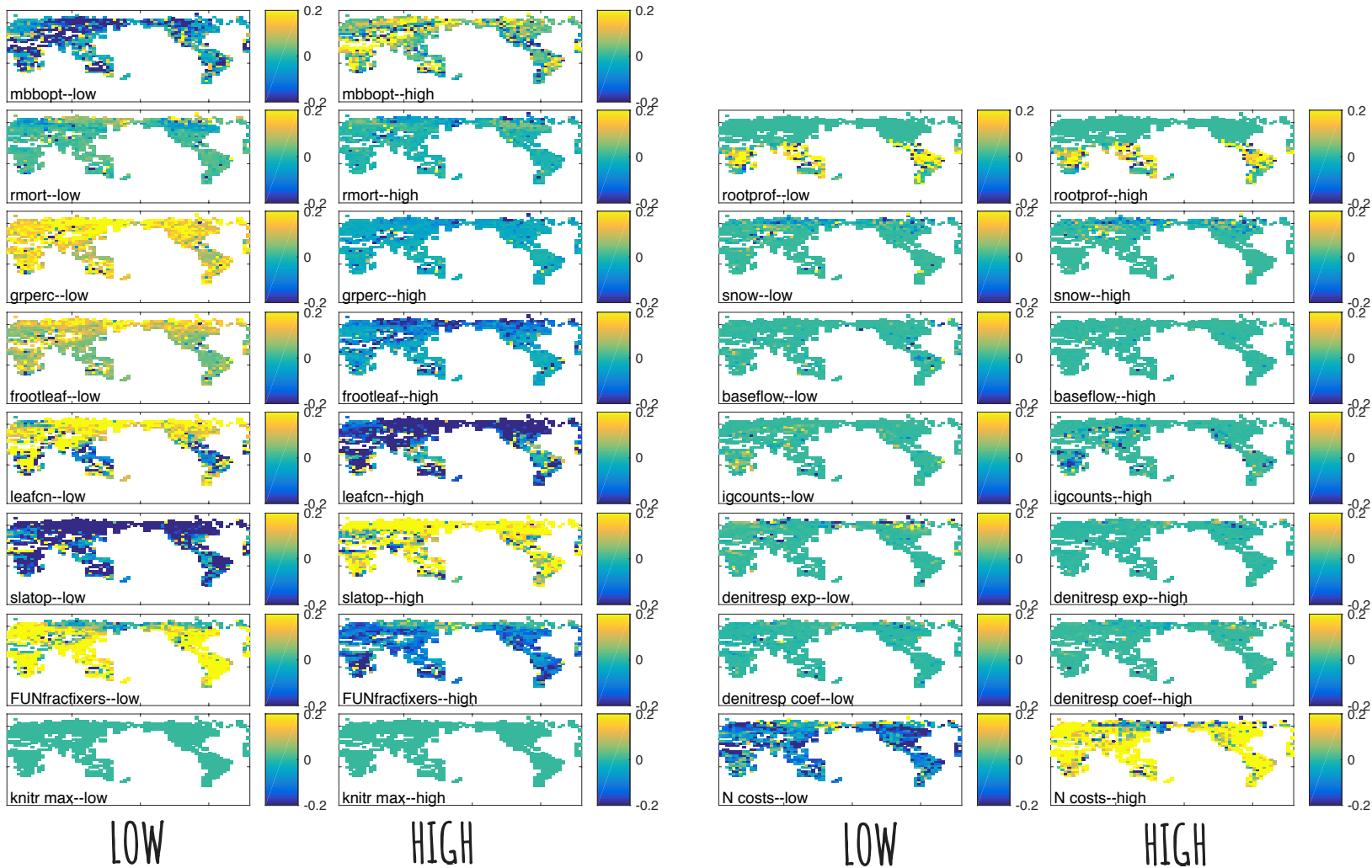


NPP

RELATIVE

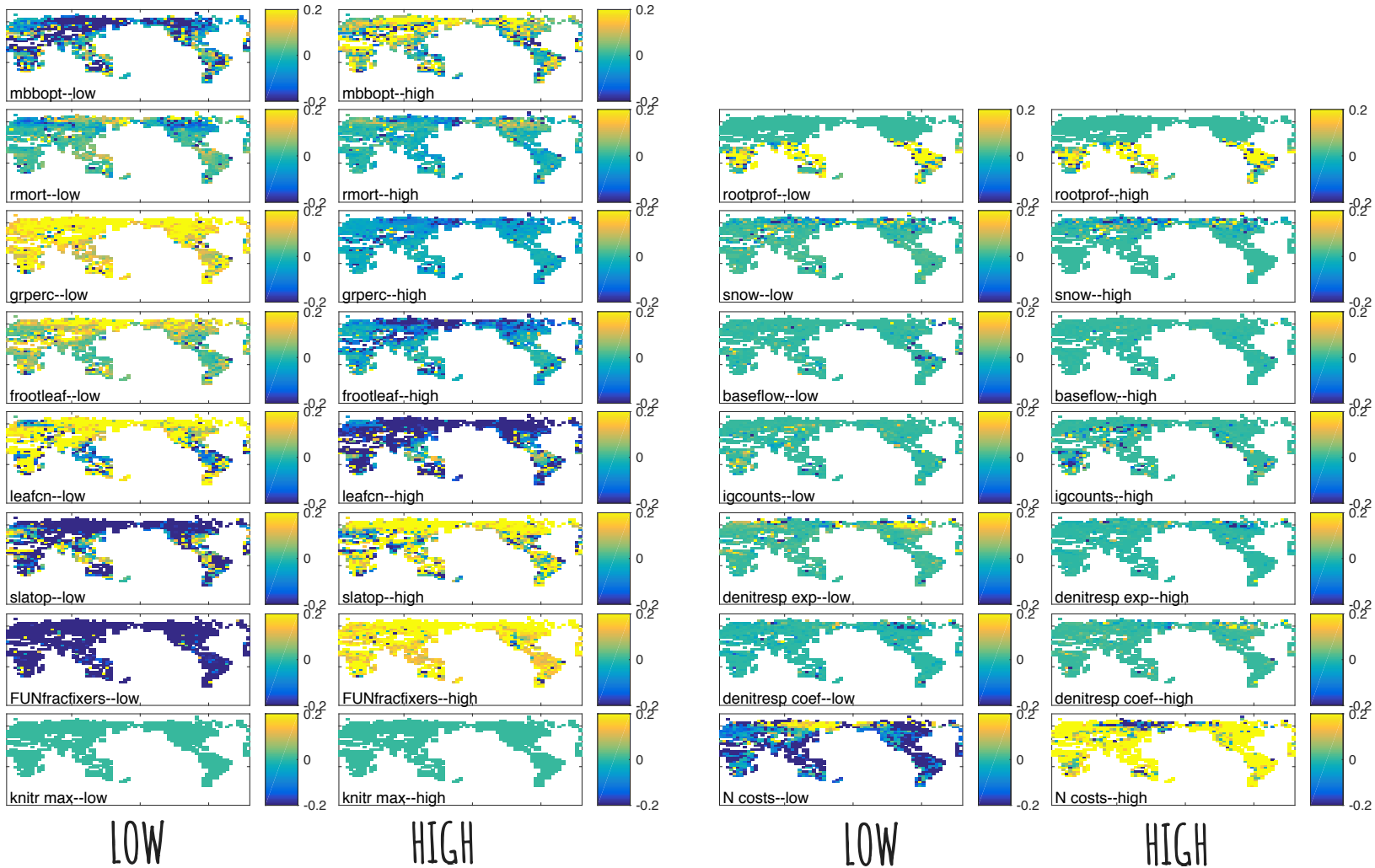


NPP FOR N UPTAKE RELATIVE



NFIX

RELATIVE



CONCLUSIONS OF PERTURBATIONS.

There are no nasty surprises

The model works as we might intuitively expect it to

Many alternative Nitrogen cycles (high and low fixation/loss rates) are possible within similar-looking carbon cycles.

CO₂ FERTILIZATION

Significant changes in the N cycle have previously had large impacts on CO₂ responses

What controls CO₂ response in the new model?

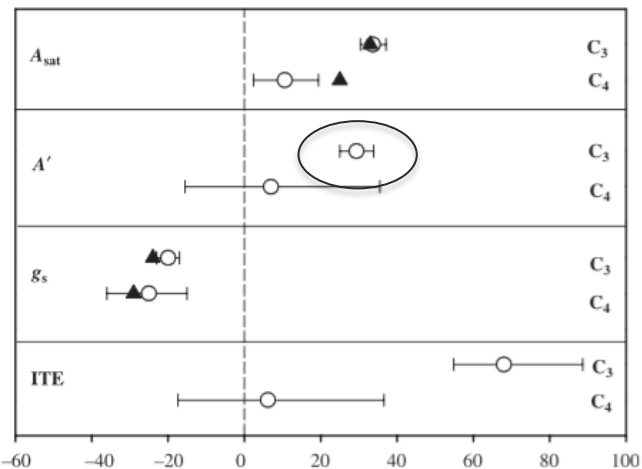
Step change to CO₂, 10 years out.

GPP FERTILIZATION

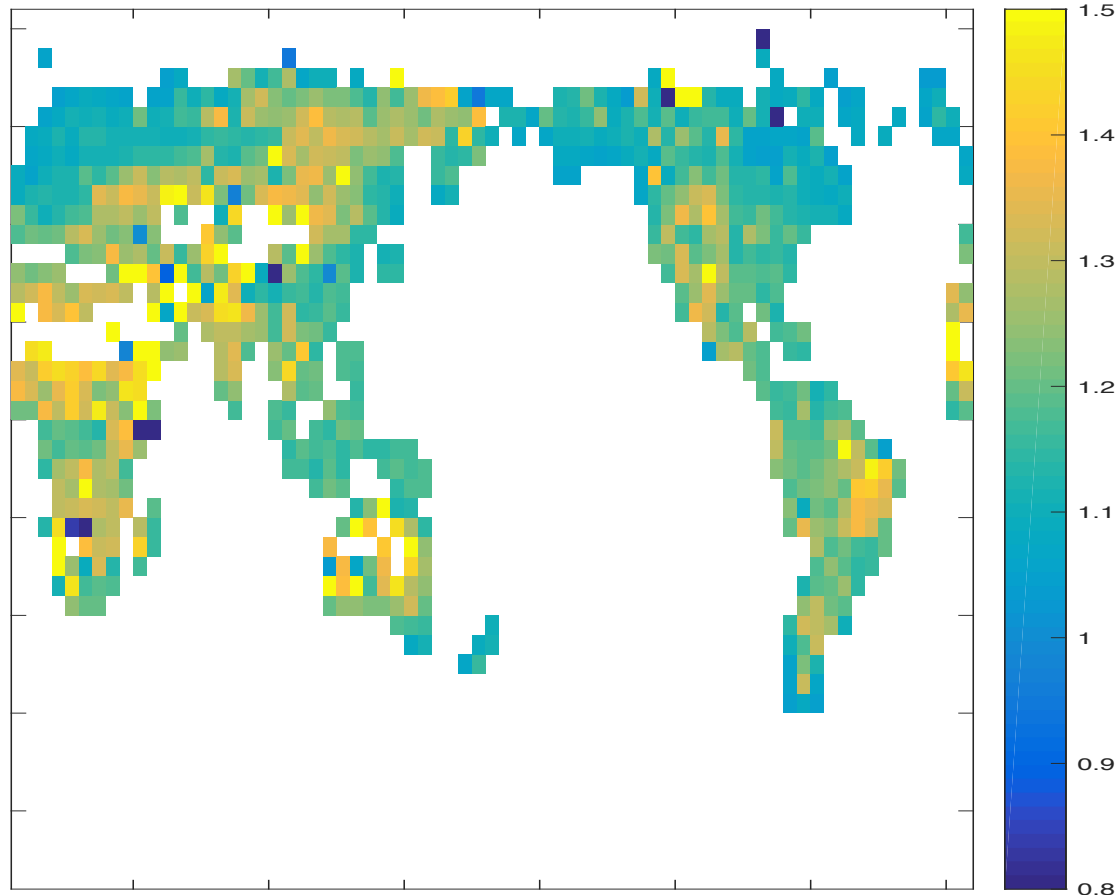
DEFAULT

380 -> 550 ppm

Ainsworth & Rogers 2004



Experimental CO₂ response
(temperature bias)

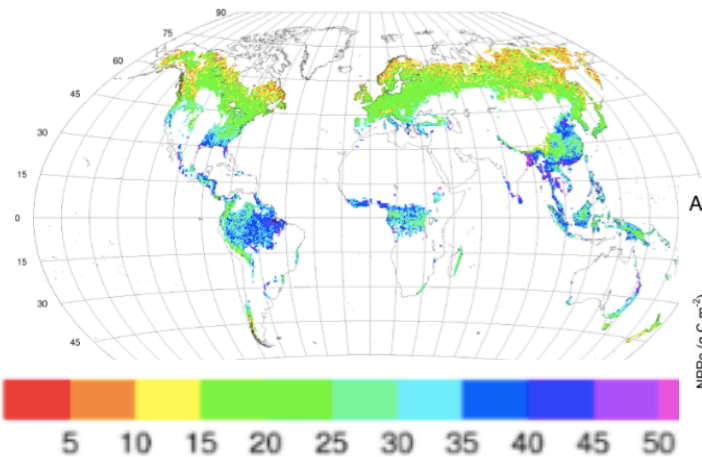


NPP FERTILIZATION

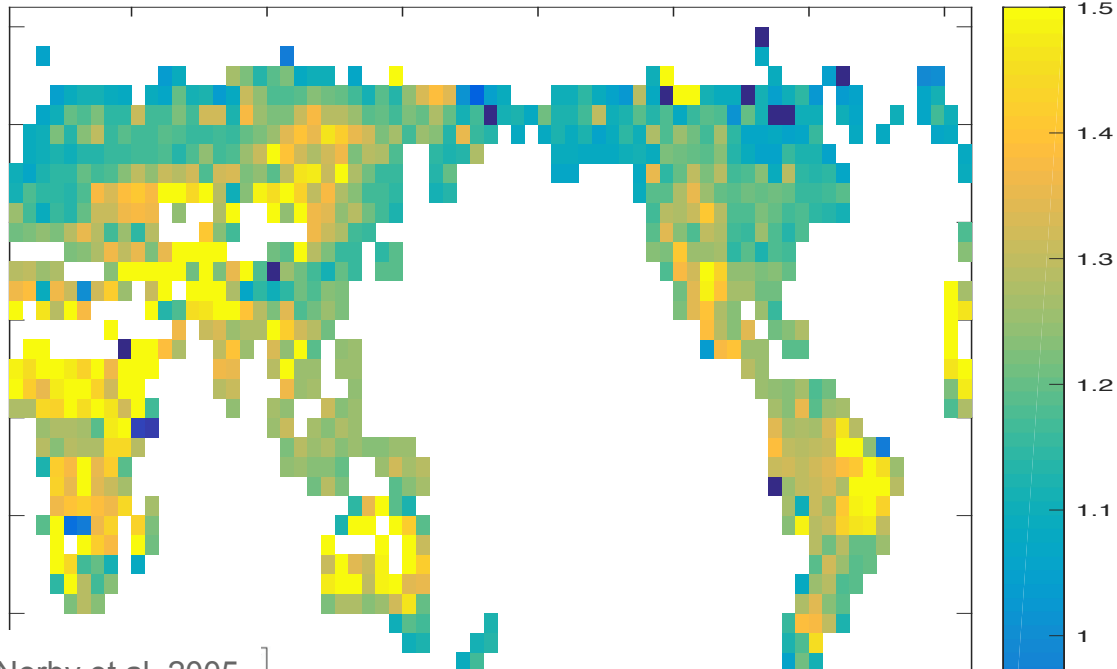
DEFAULT

380 -> 550 ppm

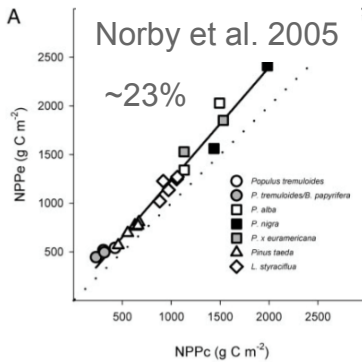
Hickler et al. 2006



LPJ-GUESS prediction



Norby et al. 2005



CO2 RESPONSE (GLOBAL)

380 -> 550 ppm

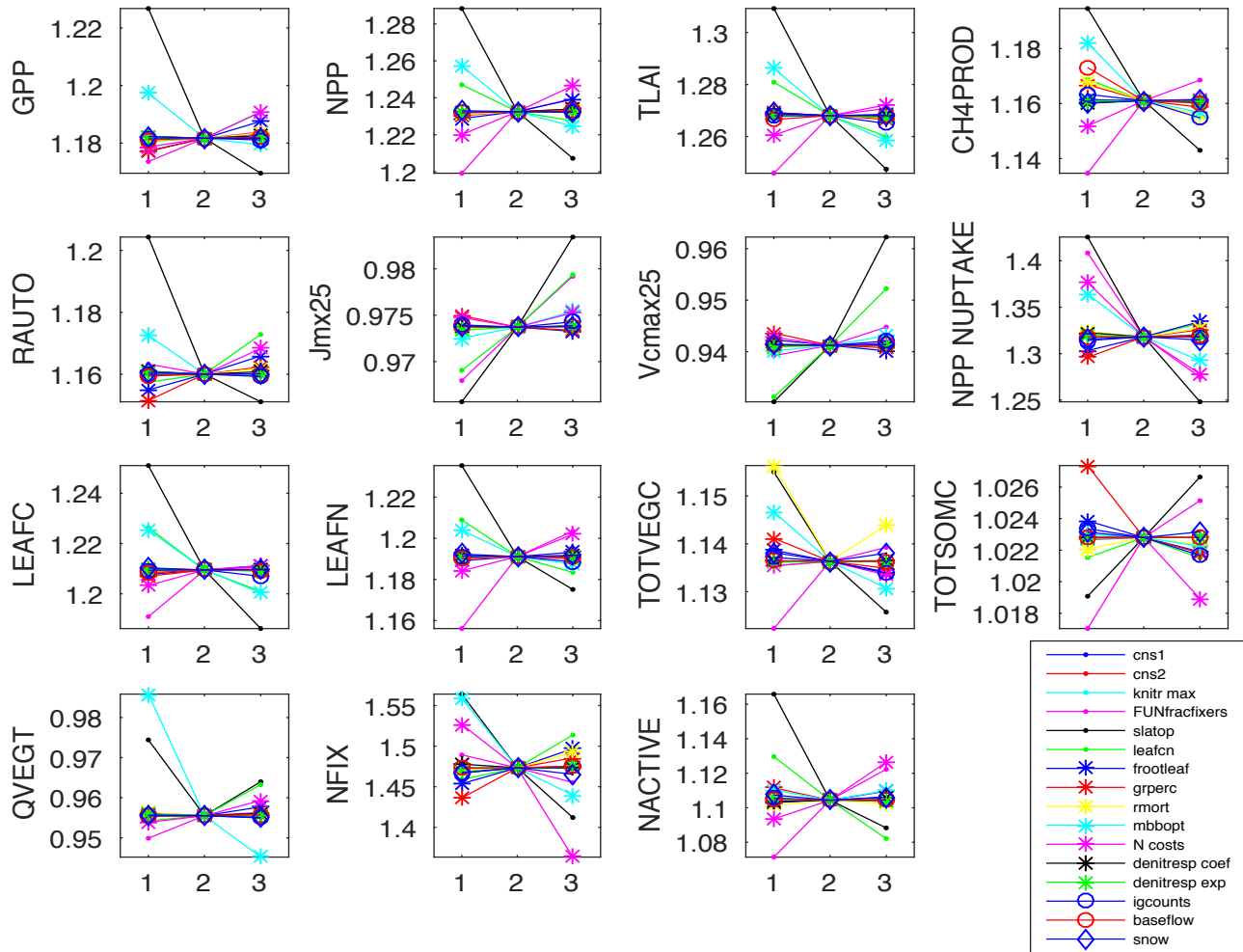
-.- slatop

-.- fracfixers

-*- mbb_opt

-*- N costs

-.- Leaf_CN



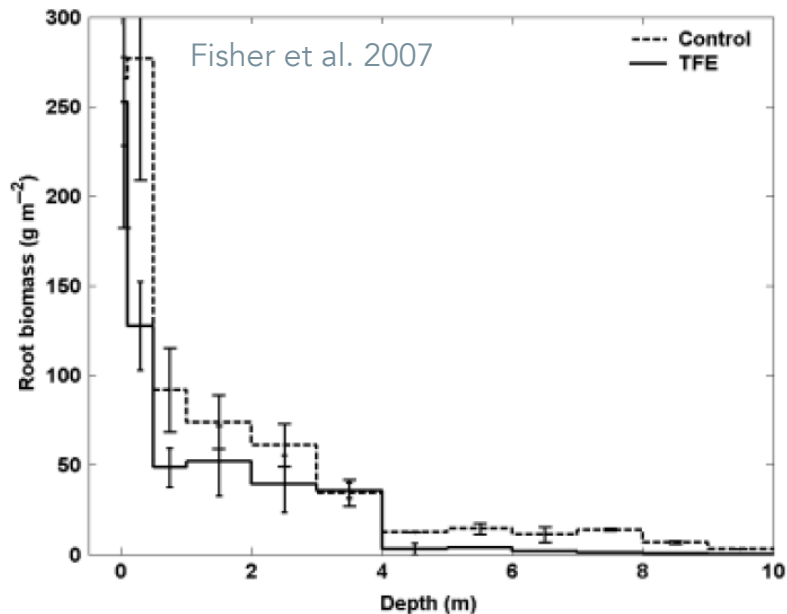
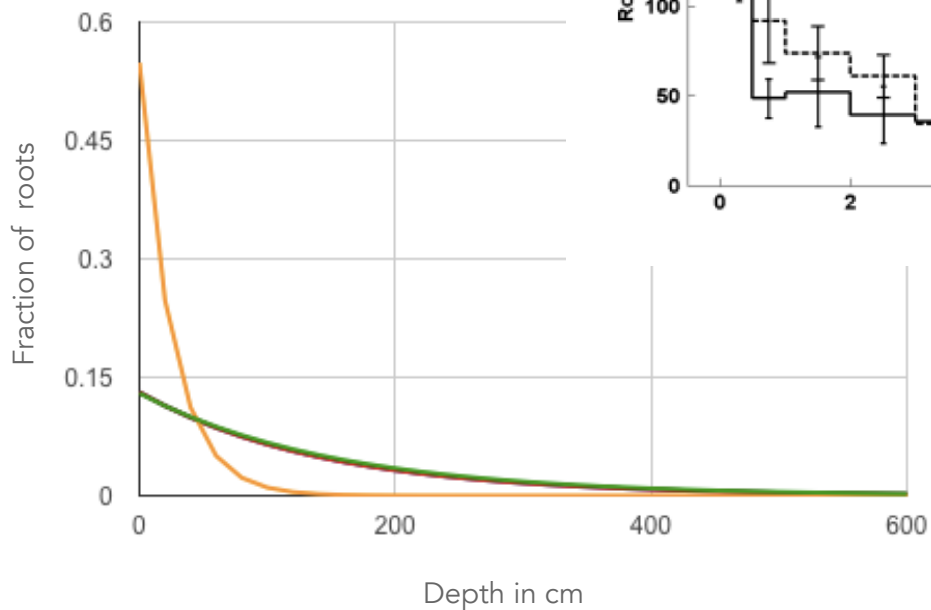
CONCLUSIONS

- We explored the response of the CLM5-beta code to parameter perturbation
- CO2 response and parameter reactions appear first-order reasonable.
- Can we use this information to reduce outstanding model biases?
- ...

SLIDES FOR BEN

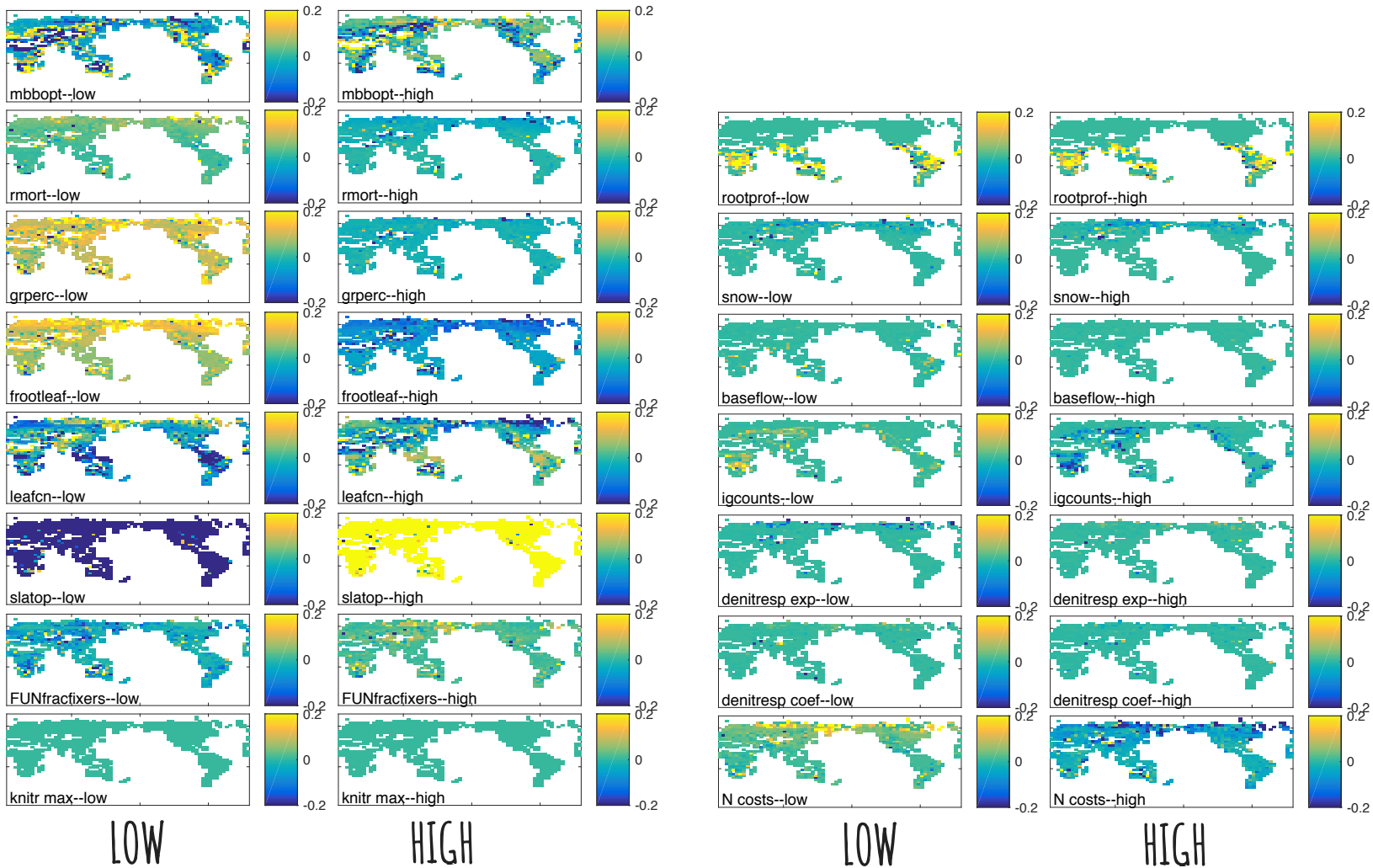
ROOT PROFILE

- Root profiles in CLM5 are from Jackson (2000) root database.
- They are far too shallow, compared with real deep-rooted tropical forest data
- Parameters adjusted to reflect this.



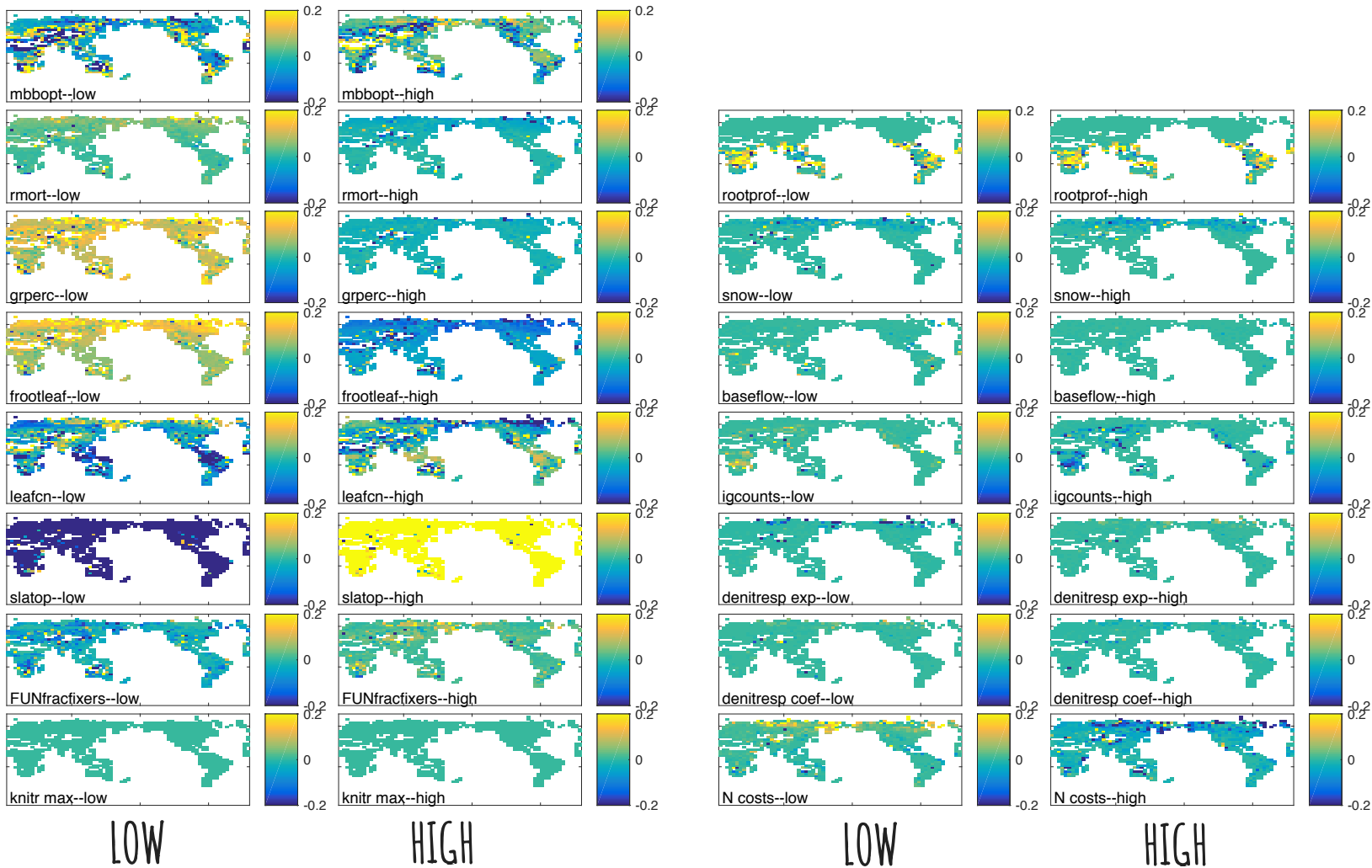
LAI

SHALLOW
RELATIVE



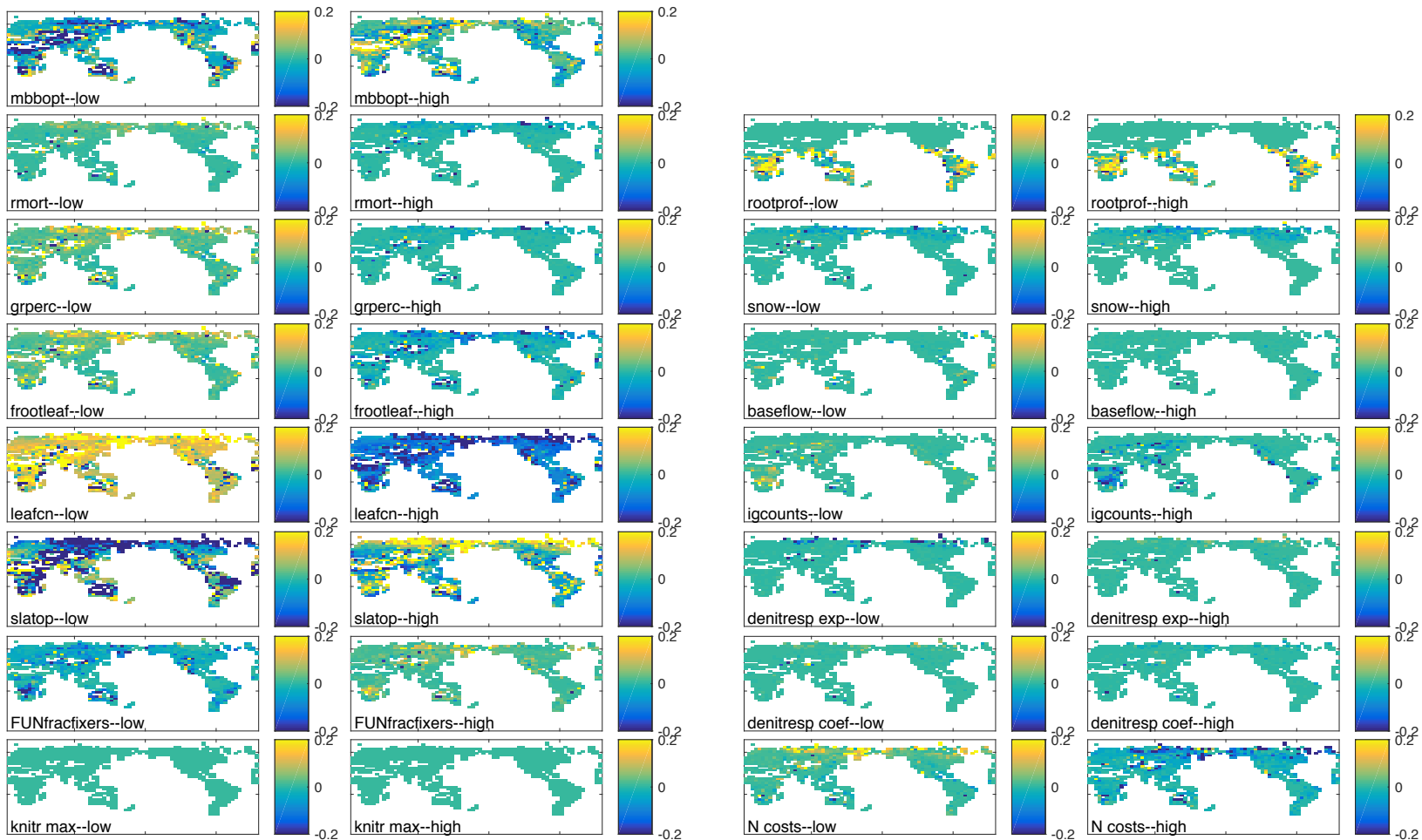
LAI

SHALLOW
RELATIVE



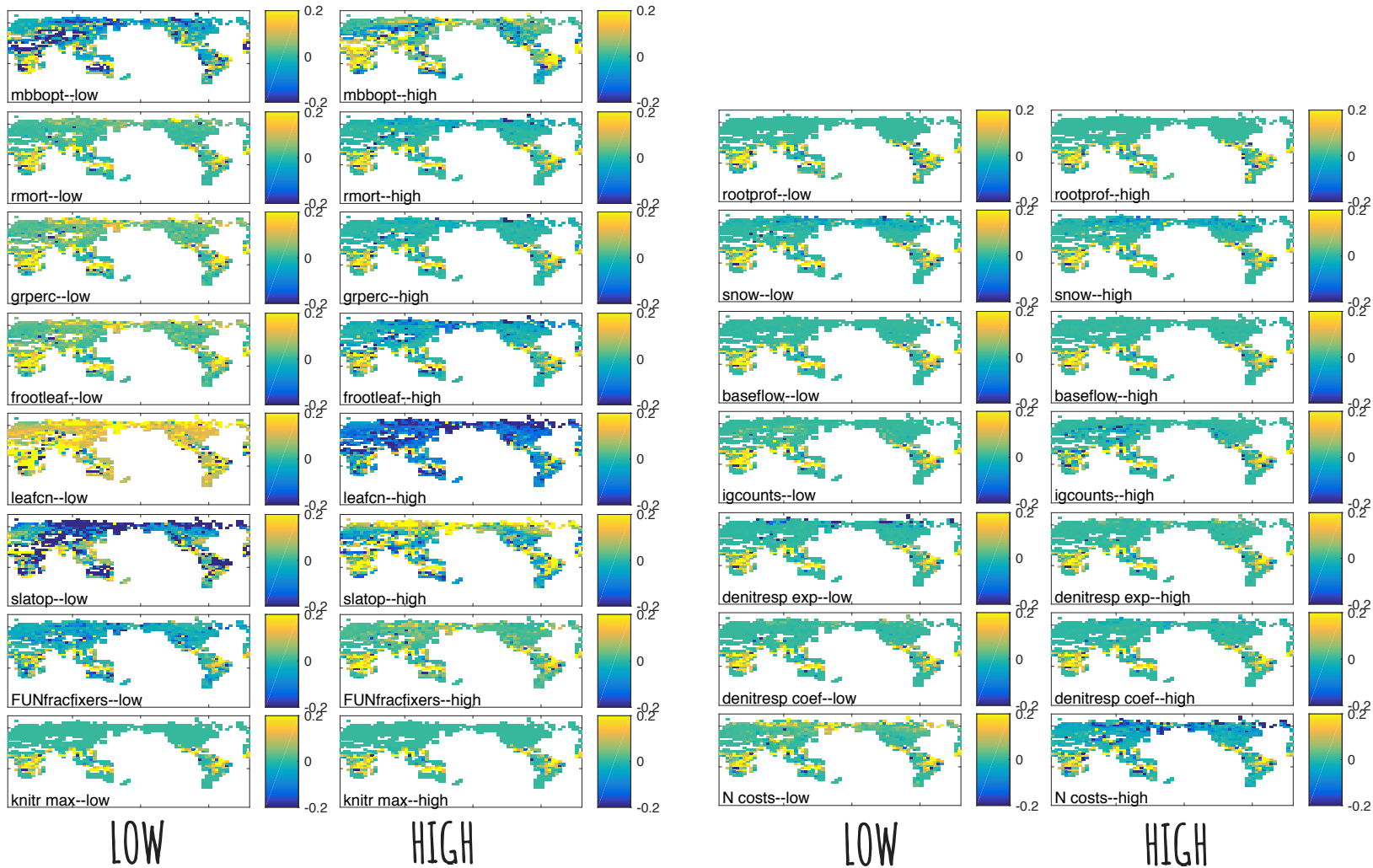
GPP

SHALLOW
RELATIVE



GPP

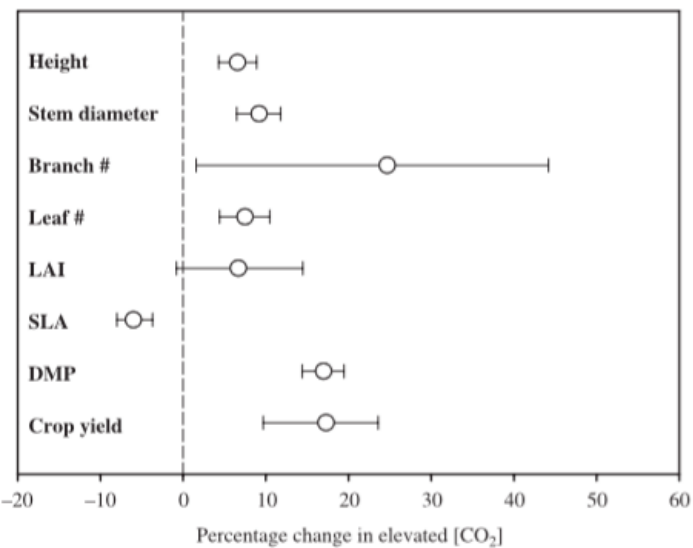
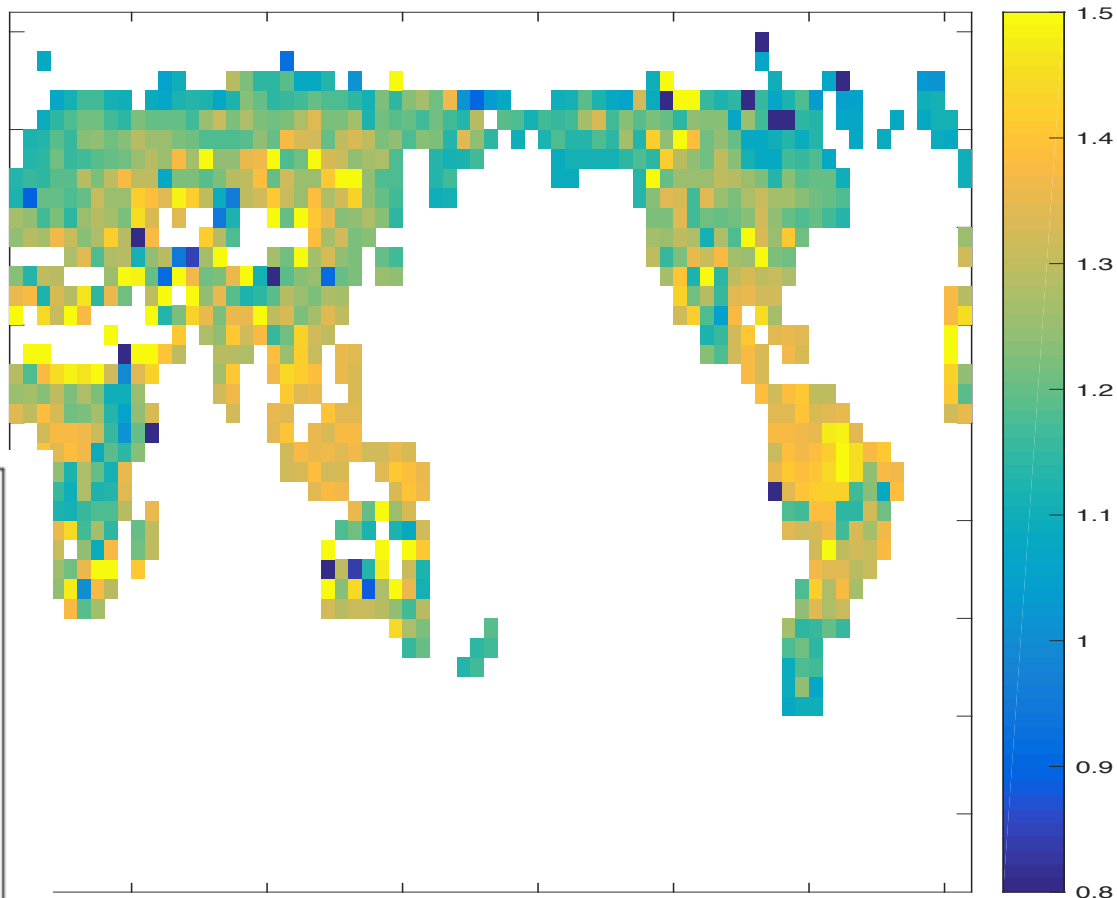
DEEP
RELATIVE



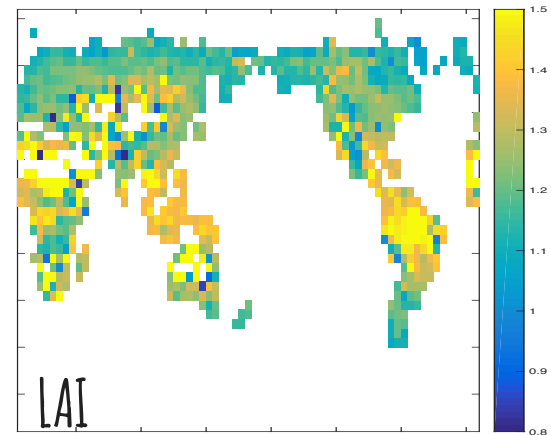
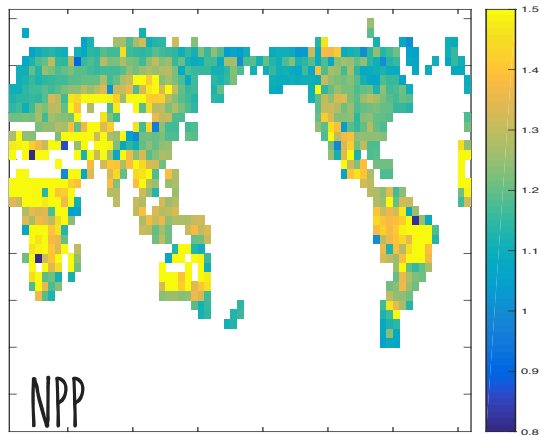
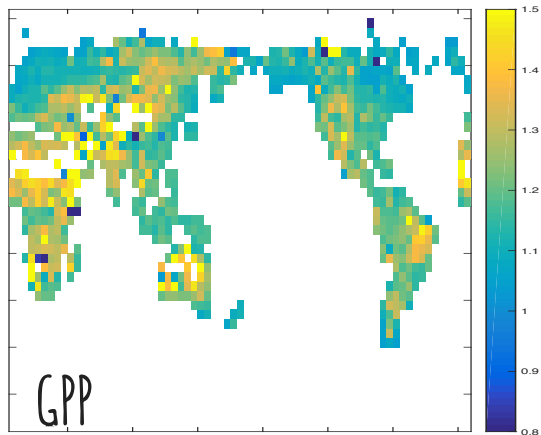
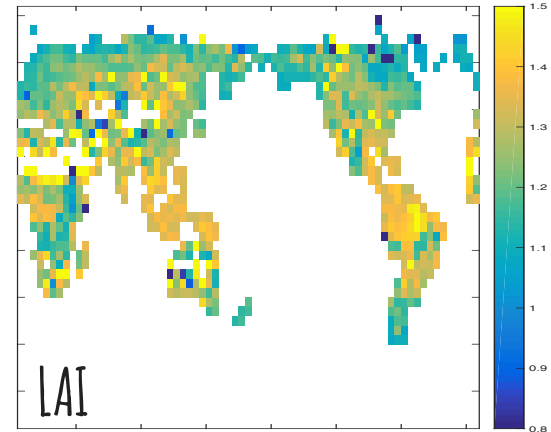
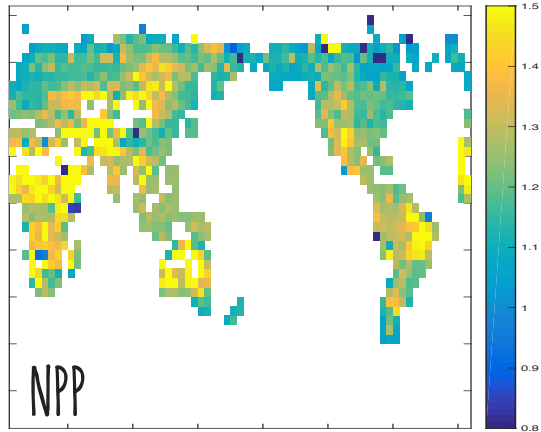
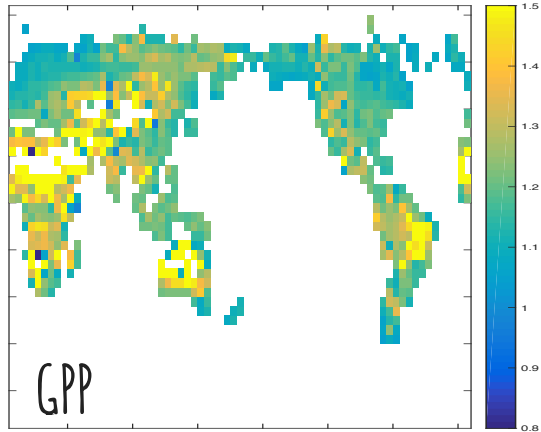
LAI FERTILIZATION

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280 -> 380 ppm



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