Parameter Calibration in CLM5

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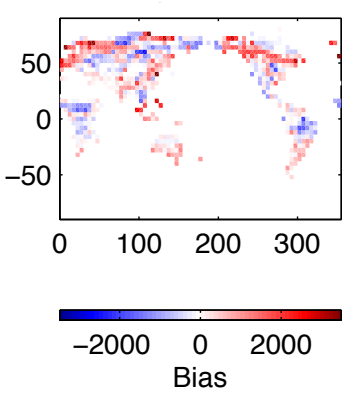
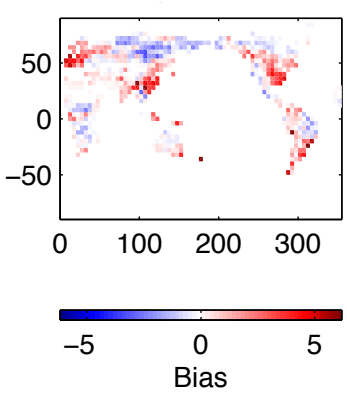
Where we are

Current CLM5 tag has:

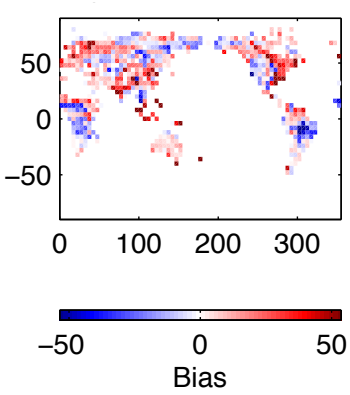
- Low Amazon GPP
- Overproductive Boreal Forest
- LAI too high in temperate forested regions
- Latent heat flux too low in Amazon



gC/m^2/year

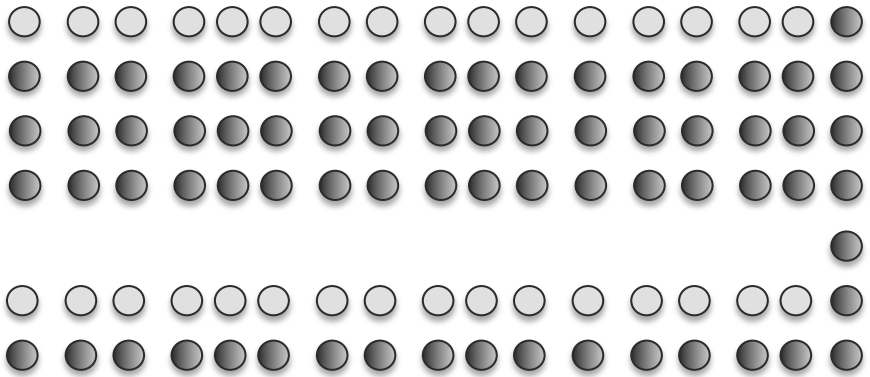


unitless



Wm^-2

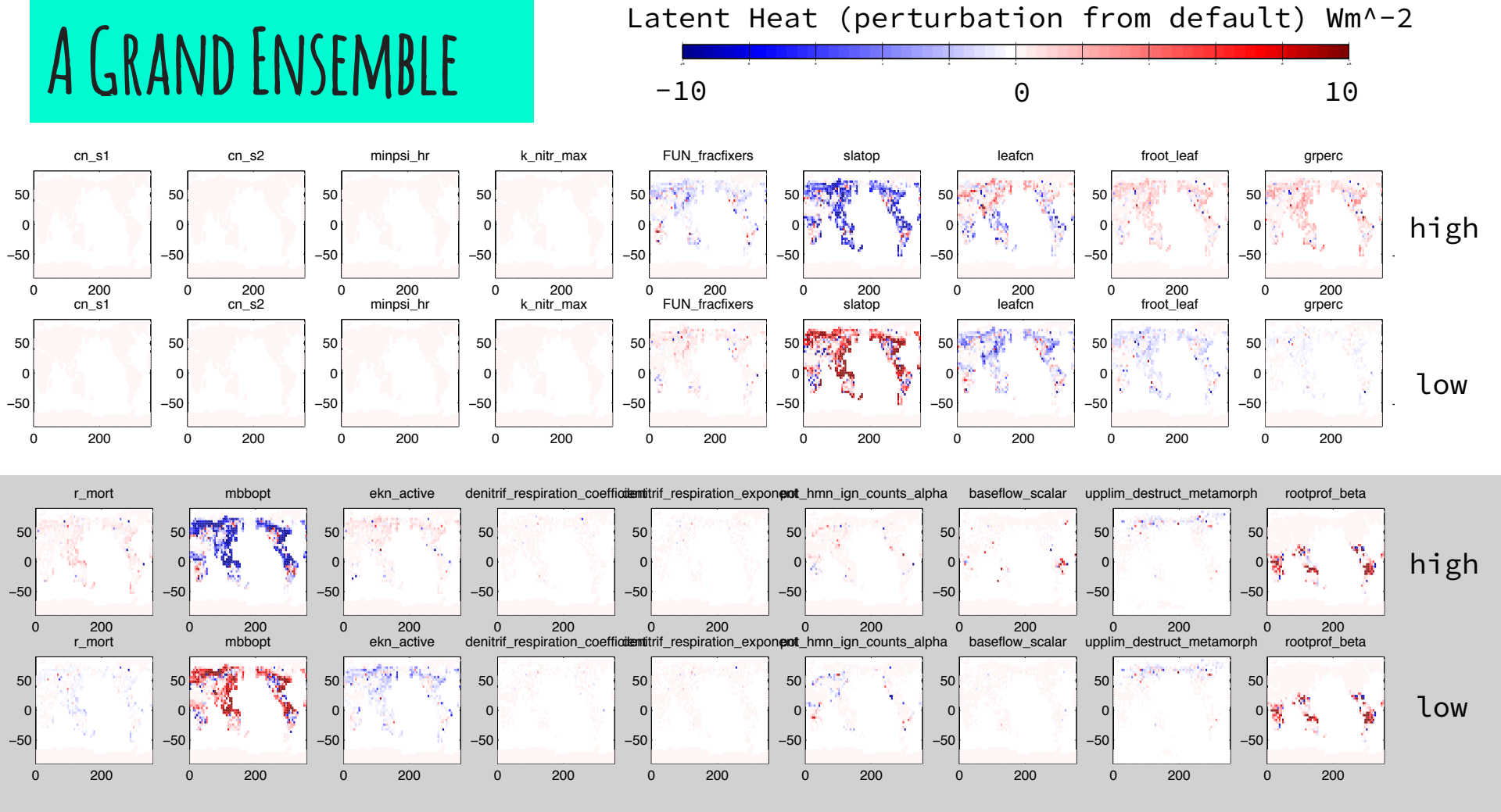
CLM5: Curse of dimensionality (big time)



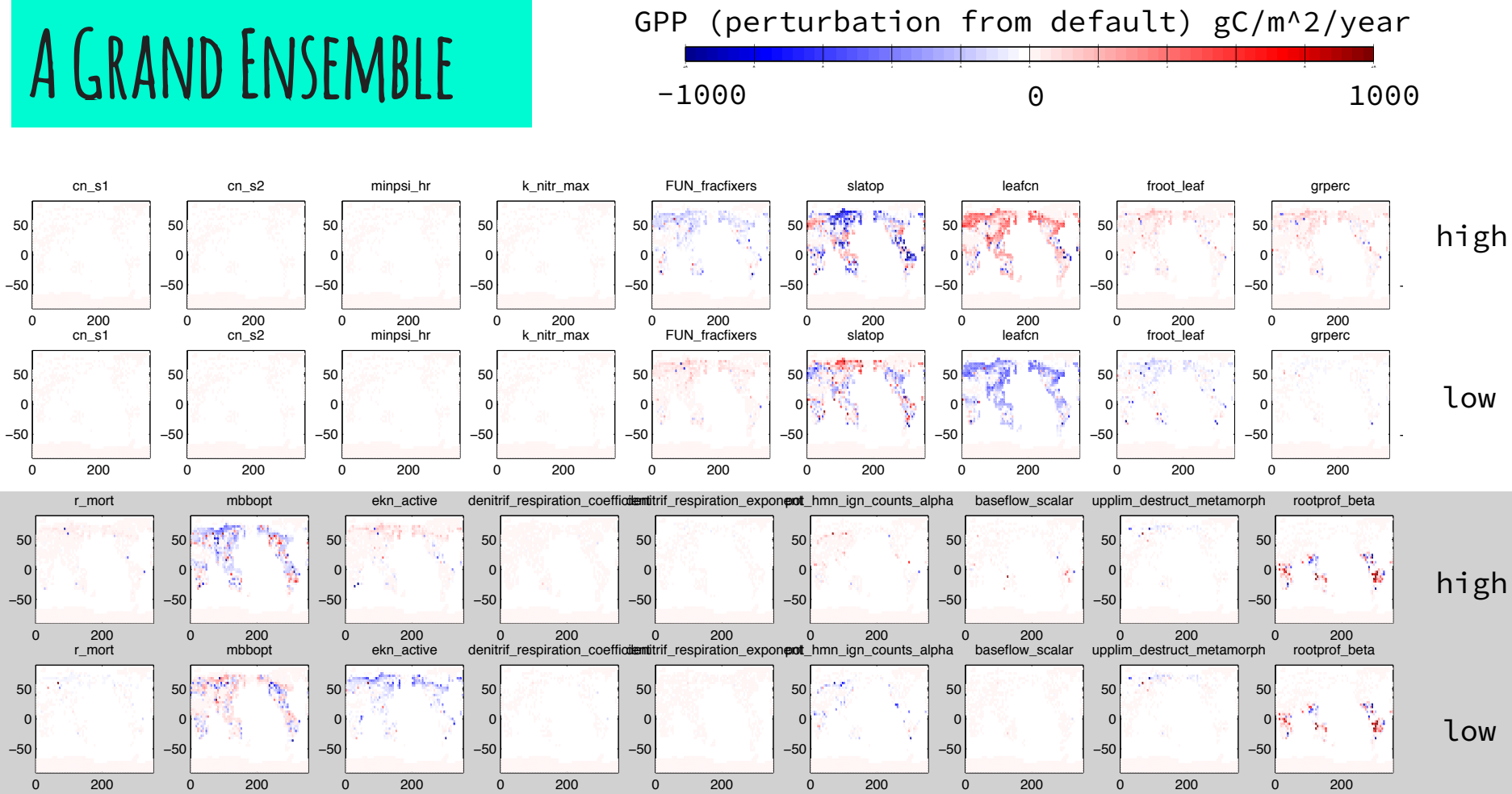
- 'cn_s1'
- 'cn_s2'
- 'minpsi_hr'
- 'k_nitr_max'
- 'FUN_fracfixers'
- 'slatop'
- 'leafcn'
- 'froot_leaf'
- 'grperc'
- 'r_mort'
- 'mbbopt'
- 'ekn_active'
- 'denitrif_respiration_coefficient'
- 'denitrif_respiration_exponent'
- 'pot_hmn_ign_counts_alpha'
- 'baseflow_scalar'
- 'upplim_destruct_metamorph'
- 'rootprof_beta'

82 (!) free parameters

A Grand Ensemble

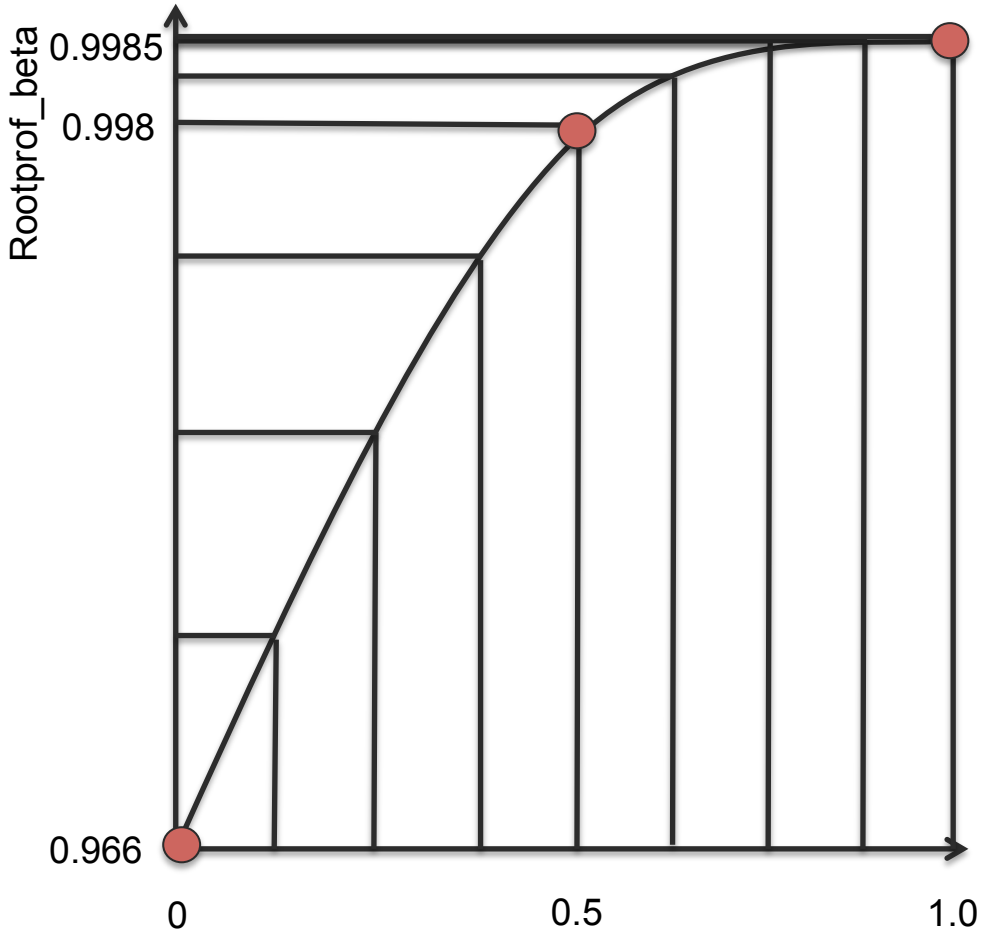


A Grand Ensemble



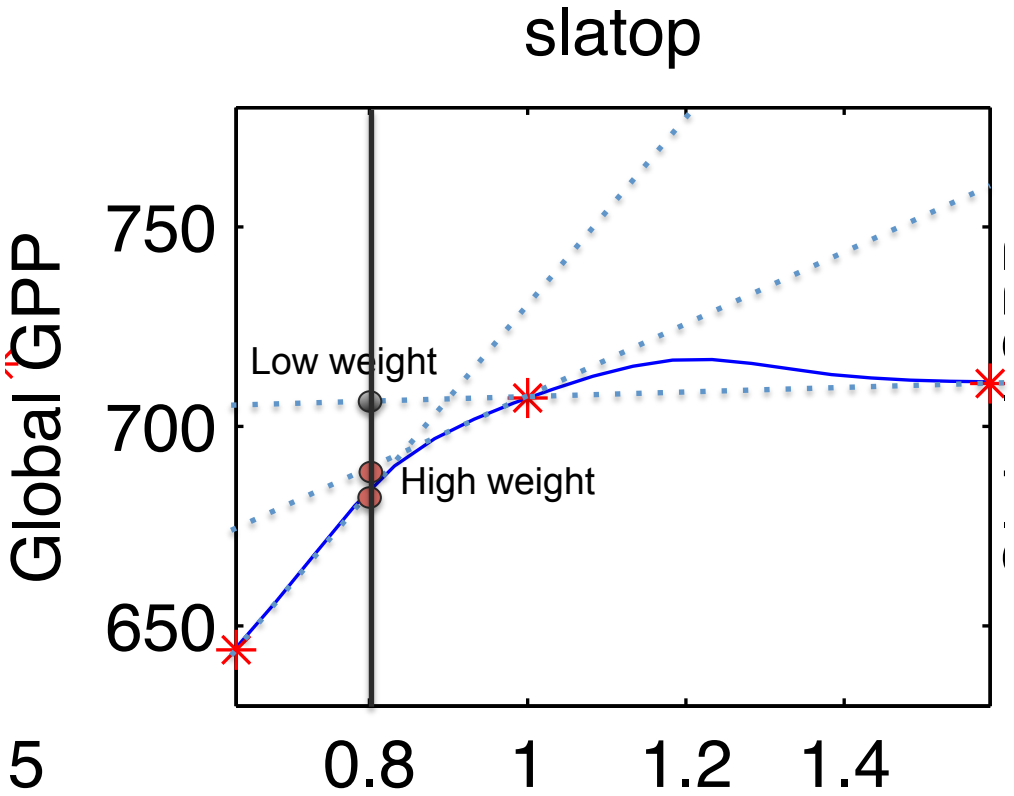
Building an Emulator

Firstly transform into a space which is representative of uncertainty in parameter



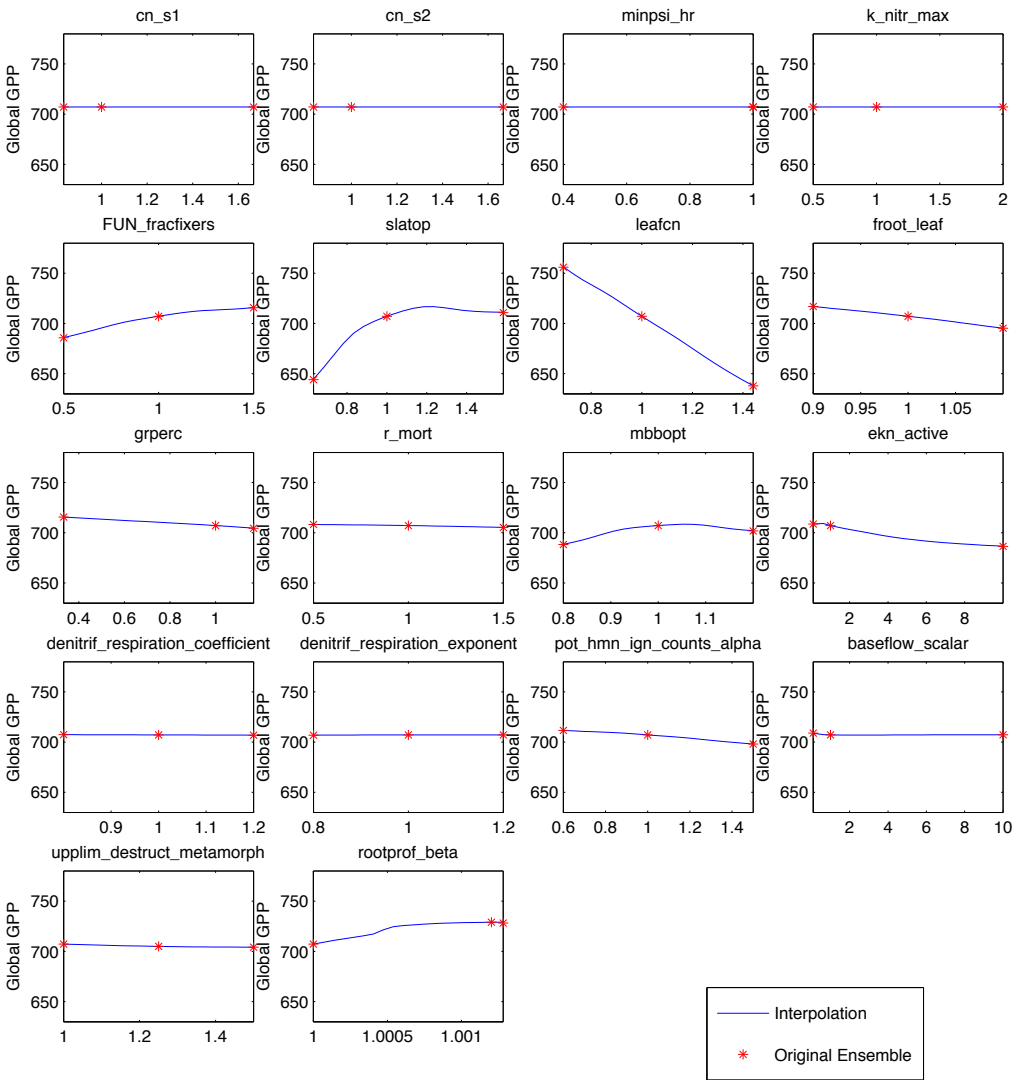
Building an Emulator

1: to calculate perturbation response for each PFT to each perturbed parameter - produce 3 linear estimates and weight by proximity

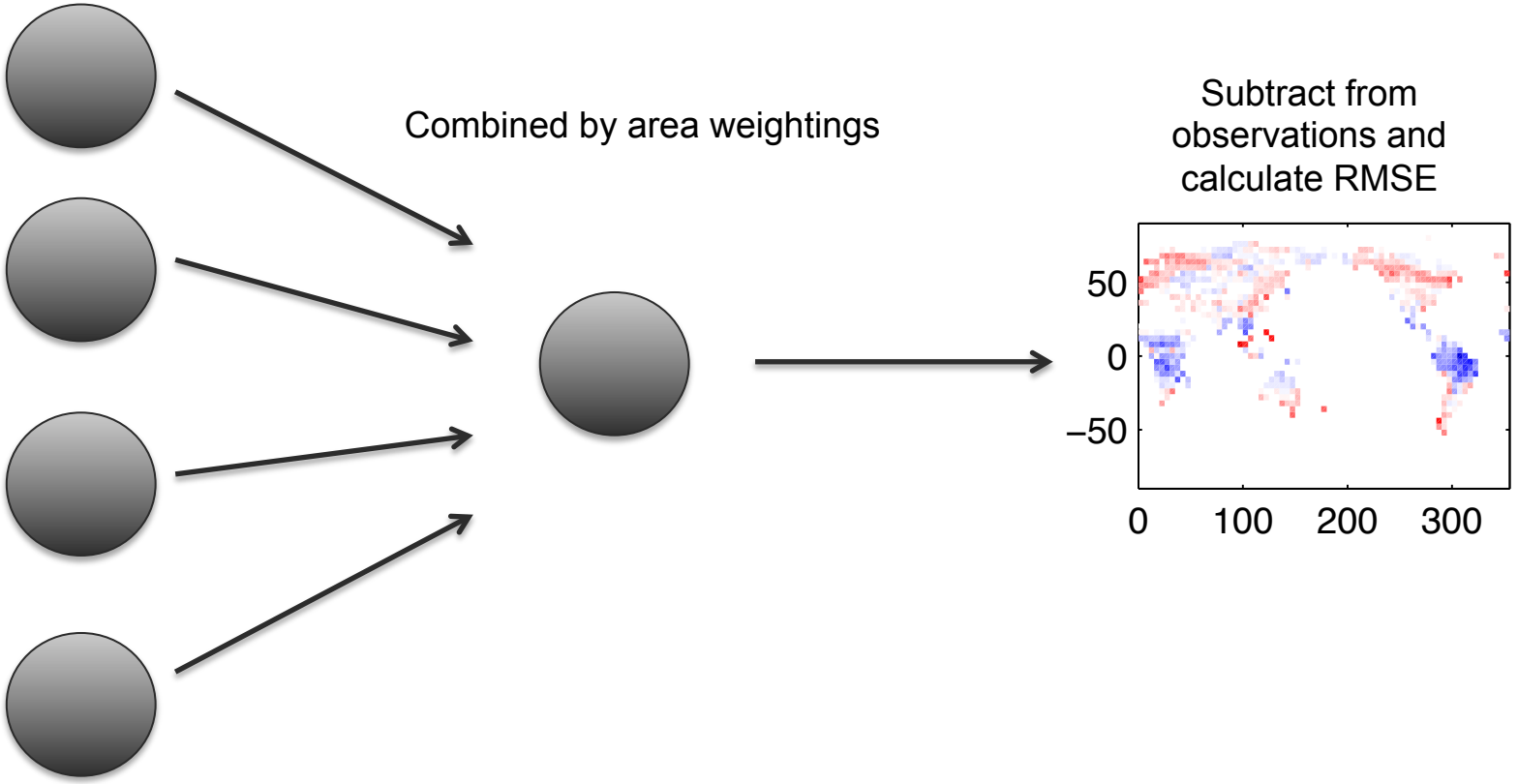


Building an Emulator

Produce an independent perturbation estimate for each parameter (from default model) and combine to give overall perturbed pattern estimate

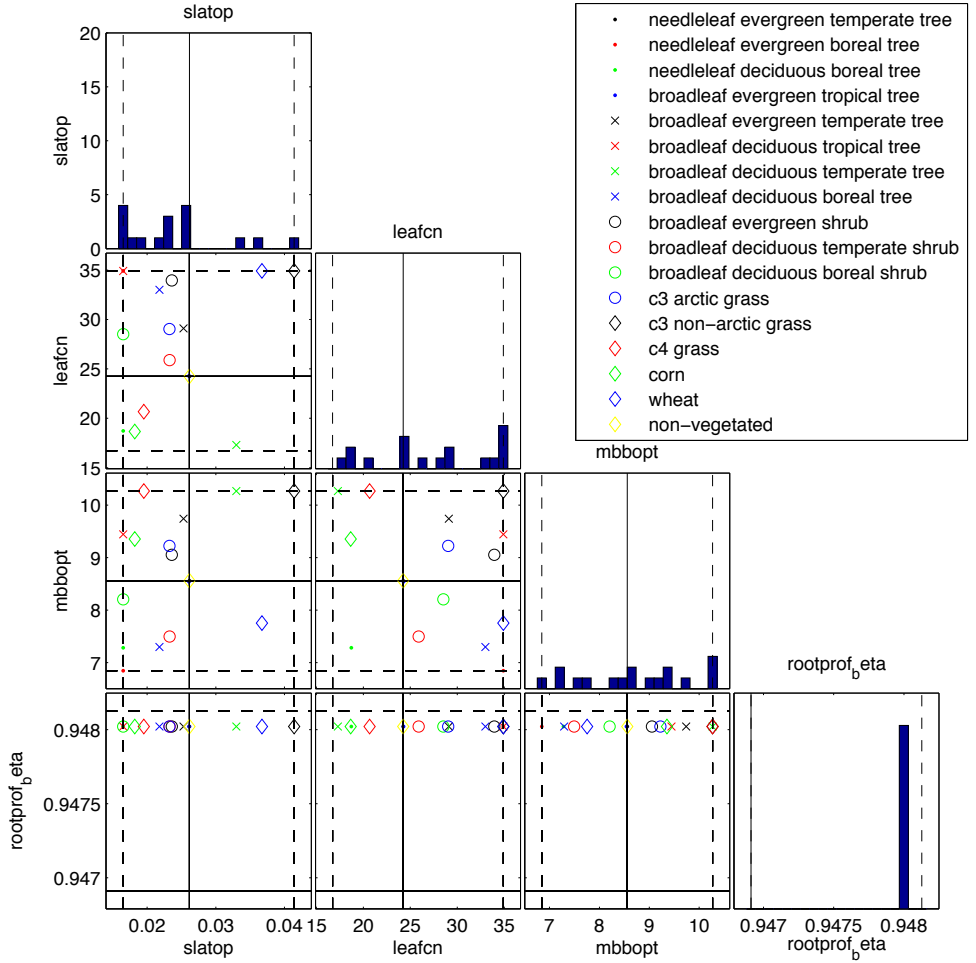


PFT-level predicted patterns



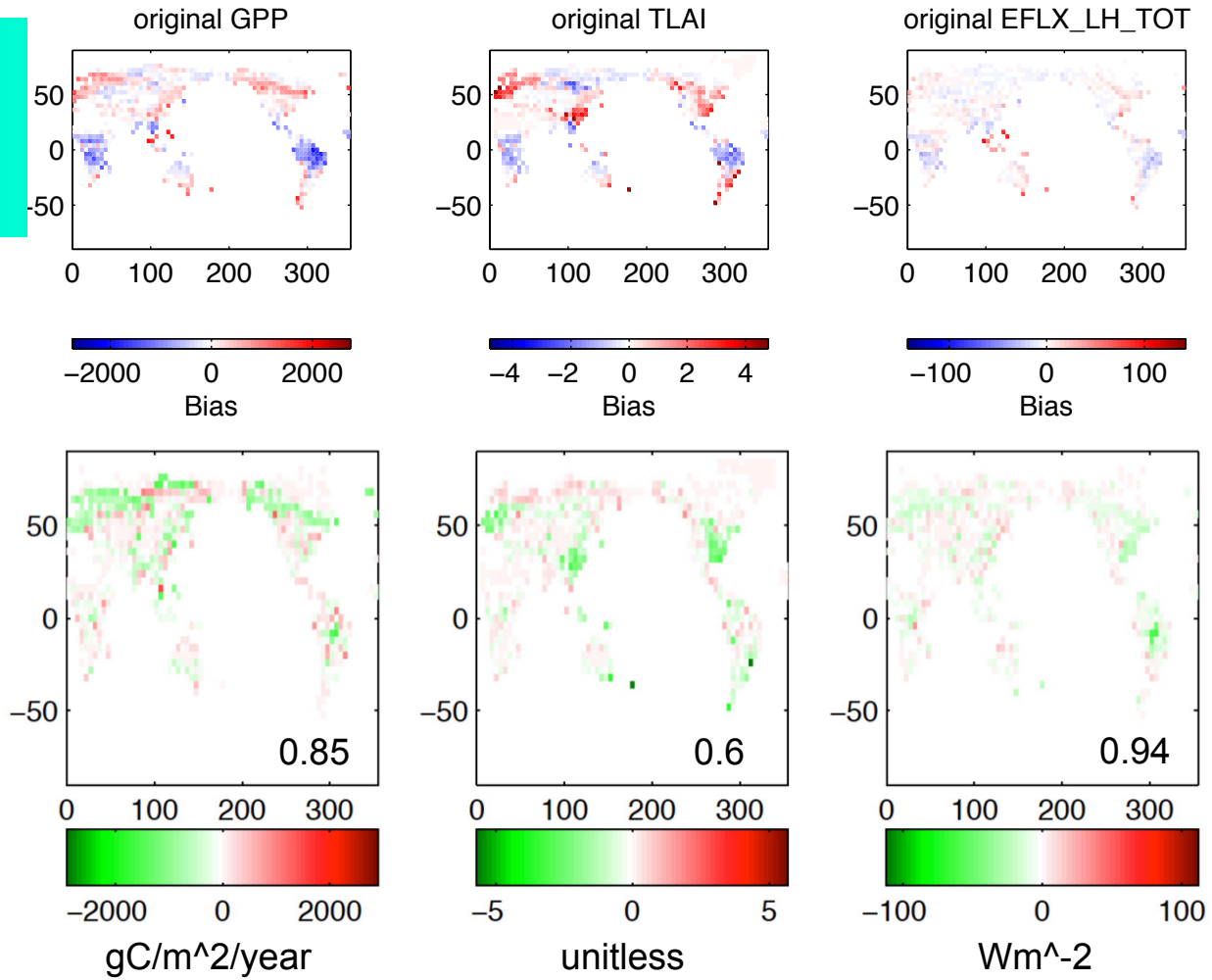
A FIRST ATTEMPT

- Combine RMSE from 3 fields to create skill metric (normalized by default case) & optimize by gradient descent algorithm.



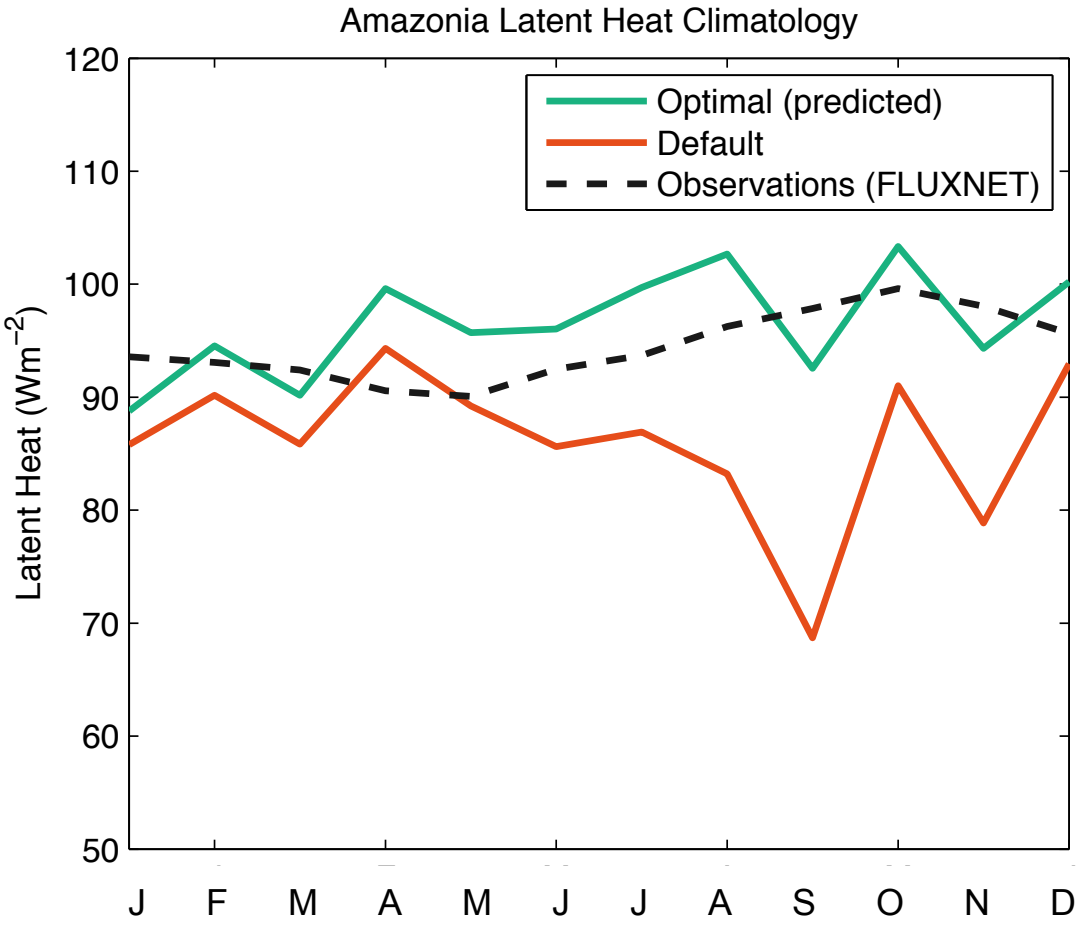
A FIRST ATTEMPT

- Boreal GPP bias reduced by 50%
- LAI temperate biases significantly reduced
- LH biases improved slightly
- Amazon GPP bias persistent

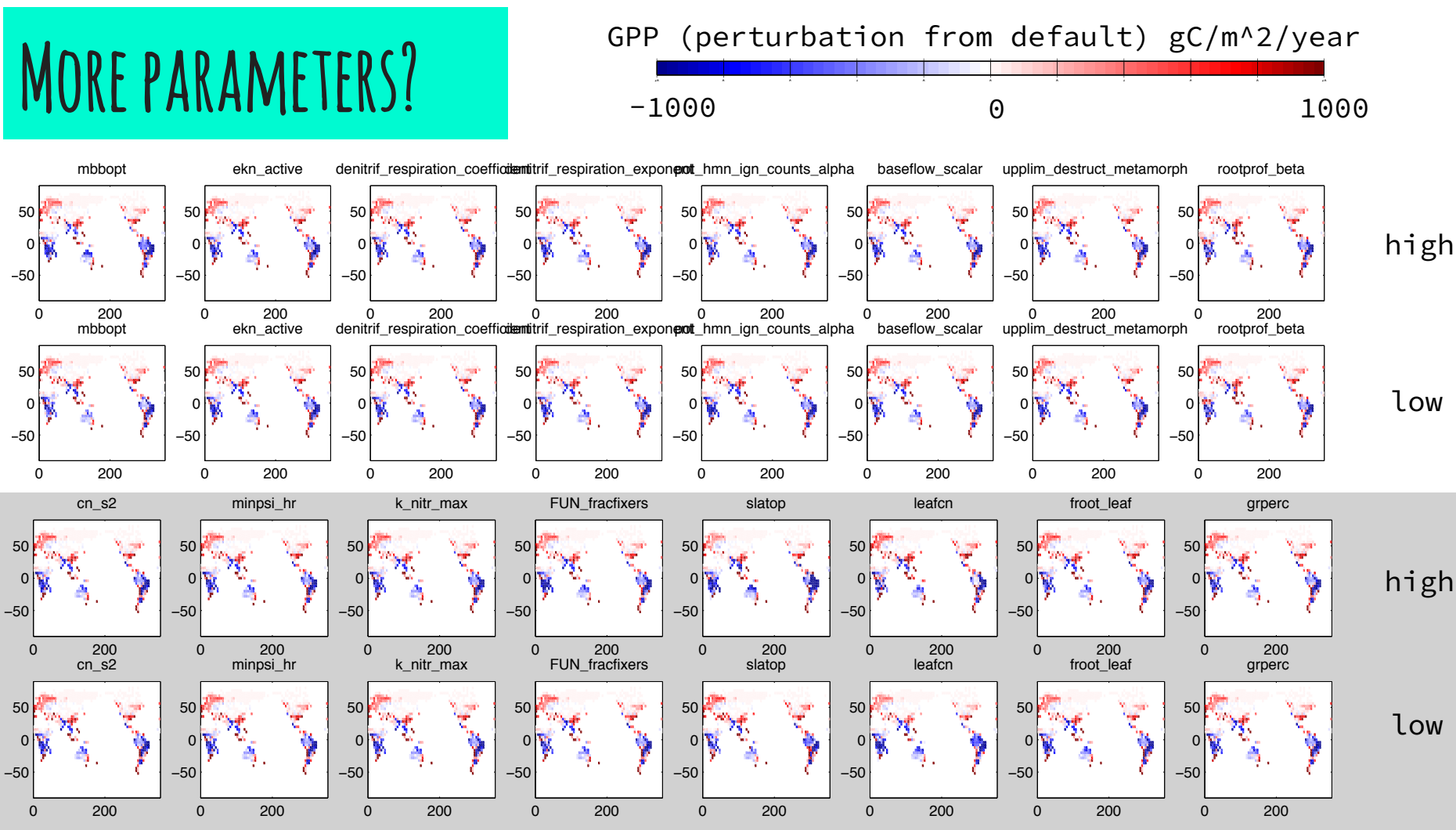


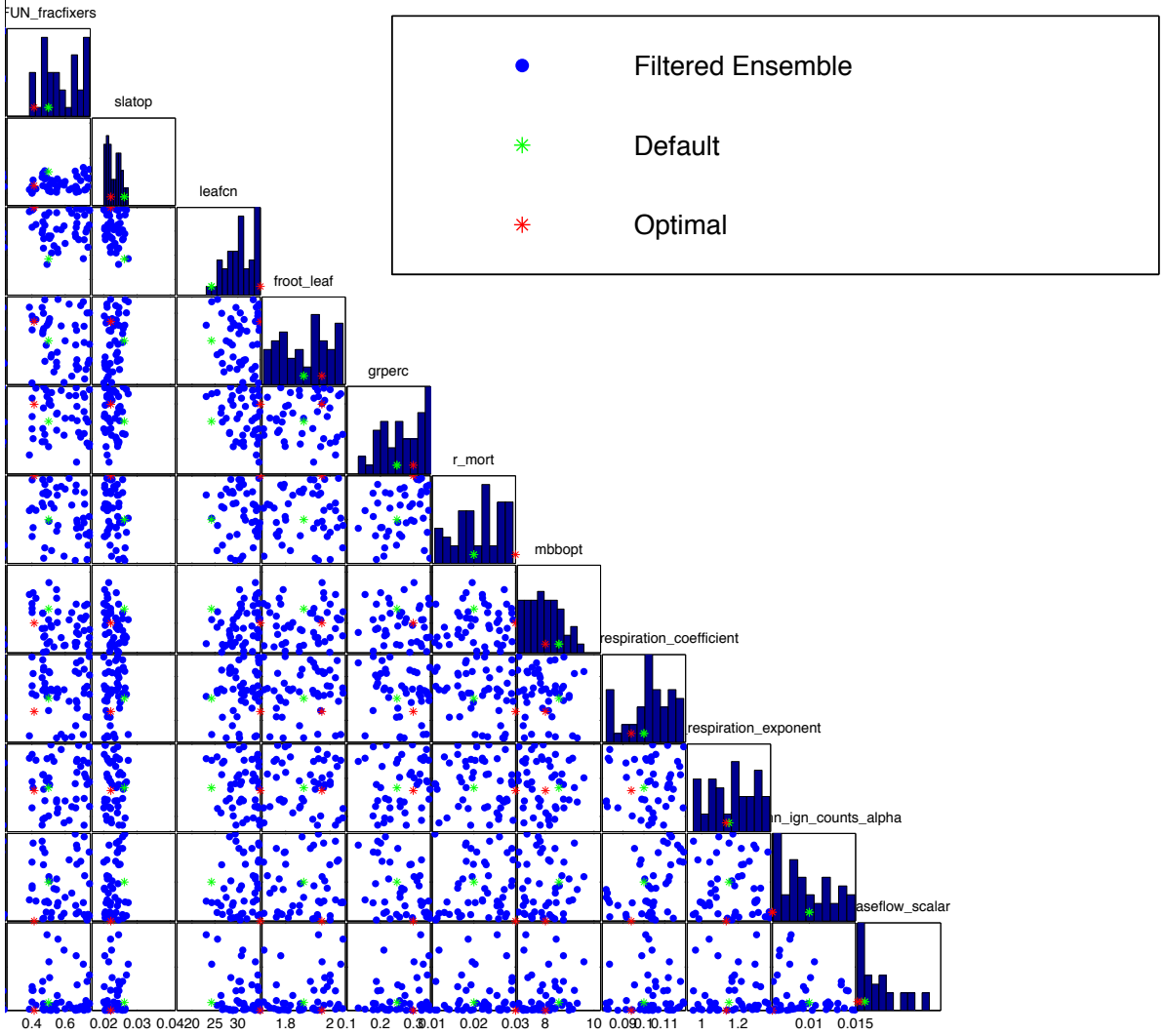
A FIRST ATTEMPT

Find best tradeoff of RMSE minimization with pan-PFT scaling of parameters



More parameters?

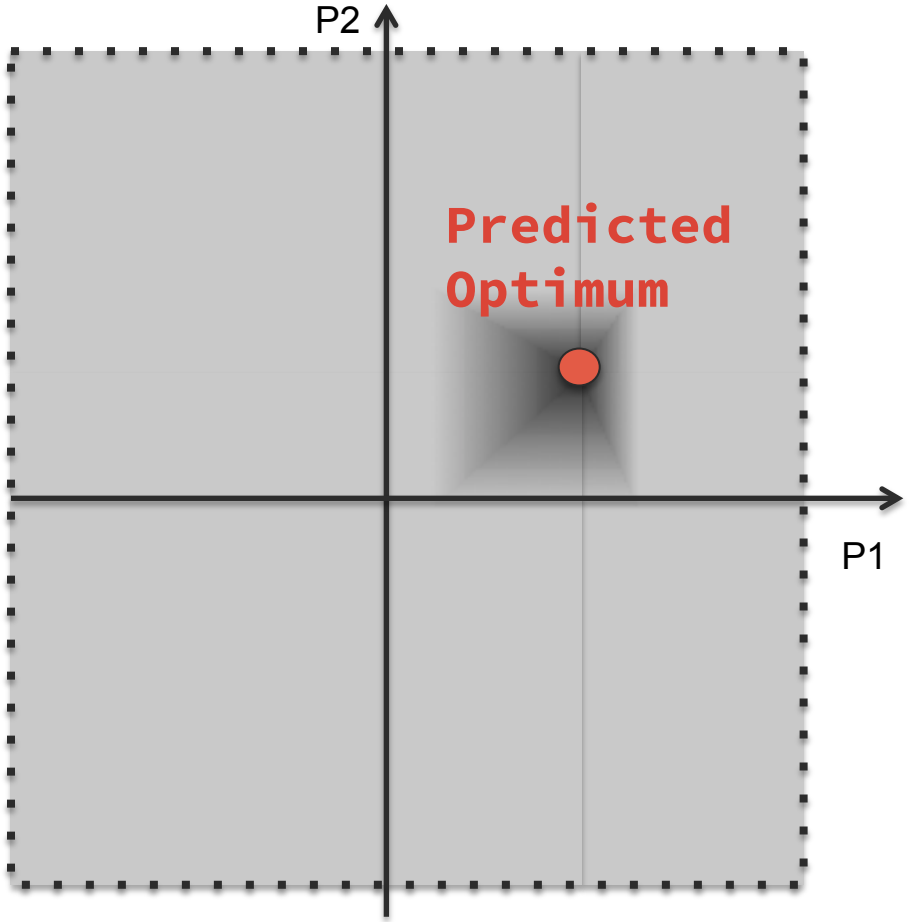




A New Frontier

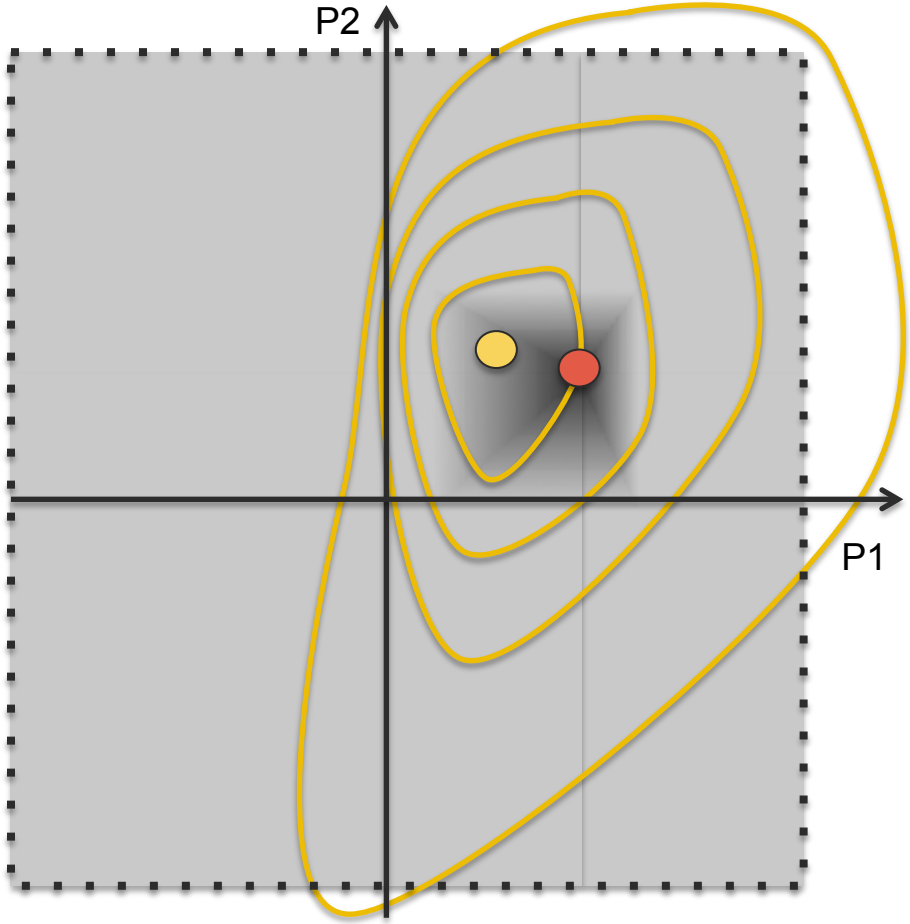
Optimization process yields multiple climatologically acceptable solutions: allowing for an ensemble of future simulations with different carbon cycle response

Next steps



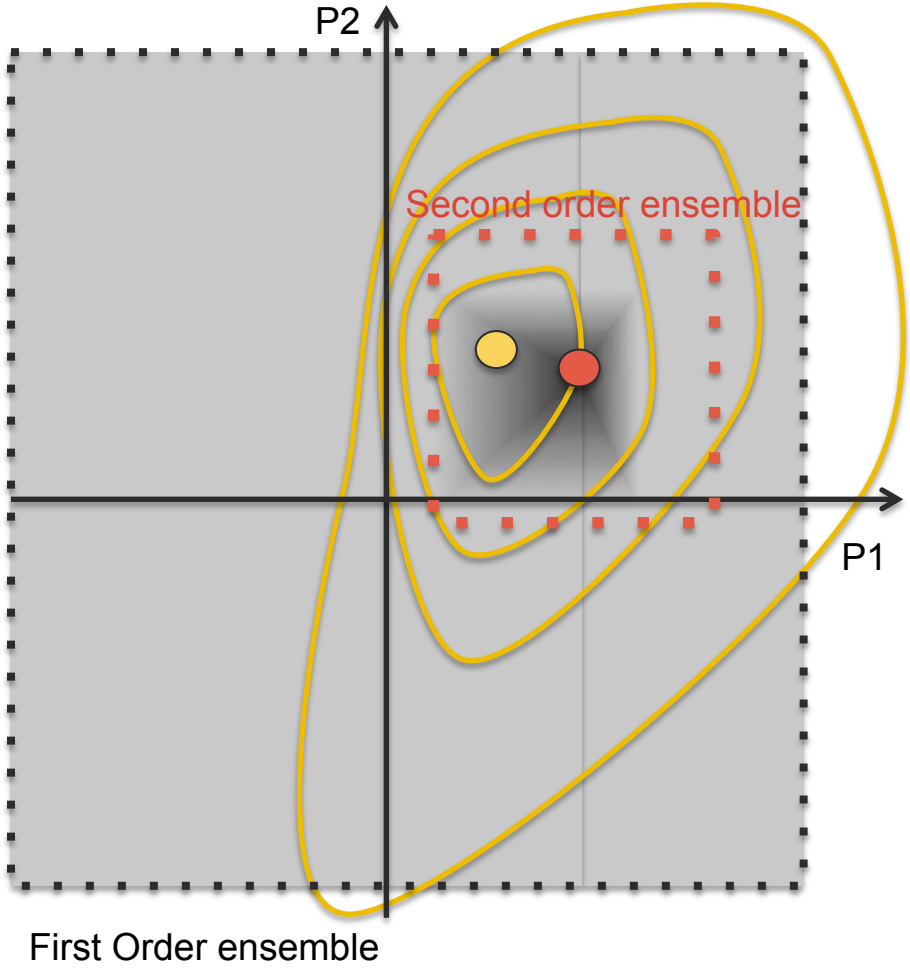
First Order ensemble

Next steps



First Order ensemble

Next steps



Conclusions

- Emulation system designed to provide PFT-specific parameter recommendations to minimize RMSE bias in CLM, given a single-perturbation input
- Early results suggest that GPP biases in temperate forests might be correctable with parameter changes, as well as Amazon latent heat flux bias
- Amazon GPP biases remain persistent: need additional parameters, or are all simulations under water stress?
- Next steps: new ensemble with deeper rooting depths & cross-term testing, run test case with ‘optimal’ parameters
- Maybe next steps: produce emulator from Latin Hypercube sample (IMAGE collaboration)?

Conclusions

- Partial solutions include suppressing convective tunneling (letting CLUBB deal with high level instabilities)
- Sub-grid orographic drag parameterization decreases bias east of the Andes
- Optimization of CLM parameters suggests deeper roots can help with dry season LH fluxes
- To do: PFT level optimization, coupled simulations with optimized CLM parameters