Parameter Estimation

where we are now and where we want to go

Daniel Kennedy
Project Scientist, NCAR
djk2120@ucar.edu

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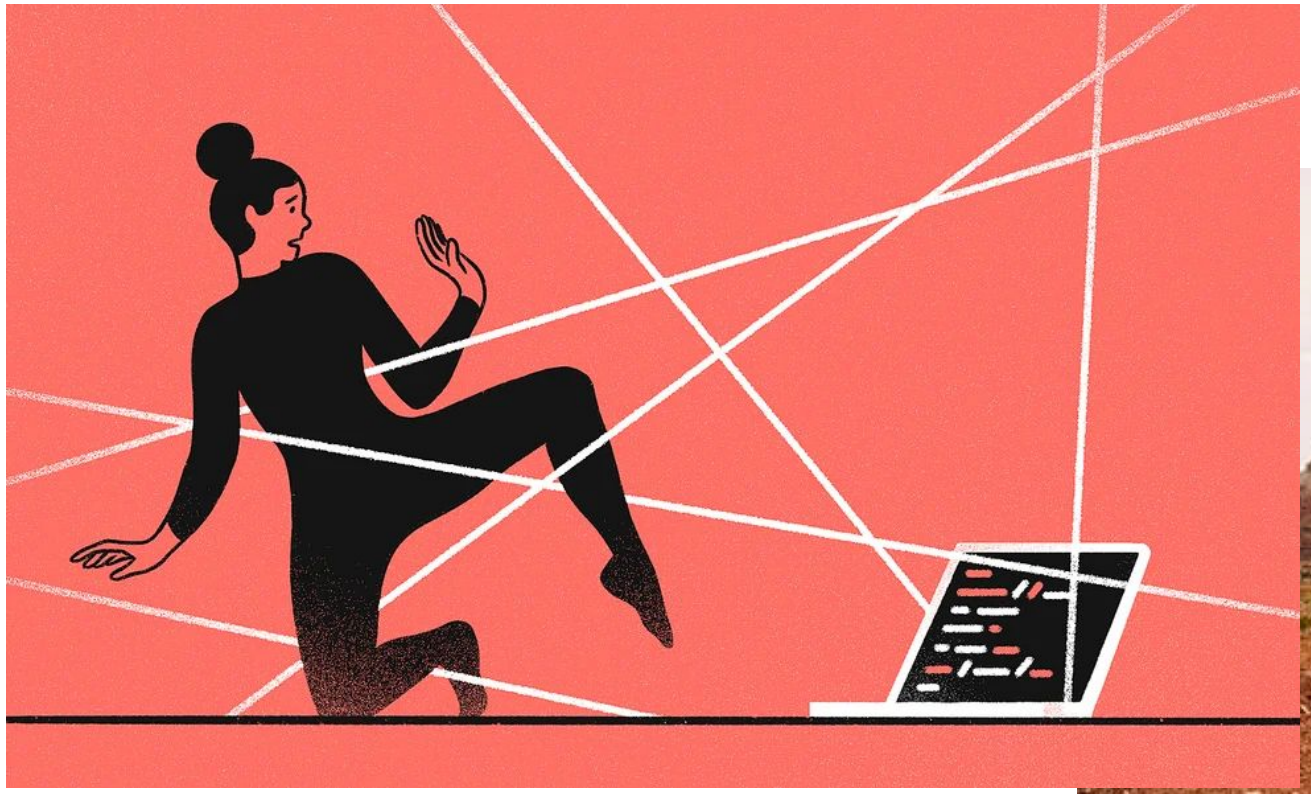
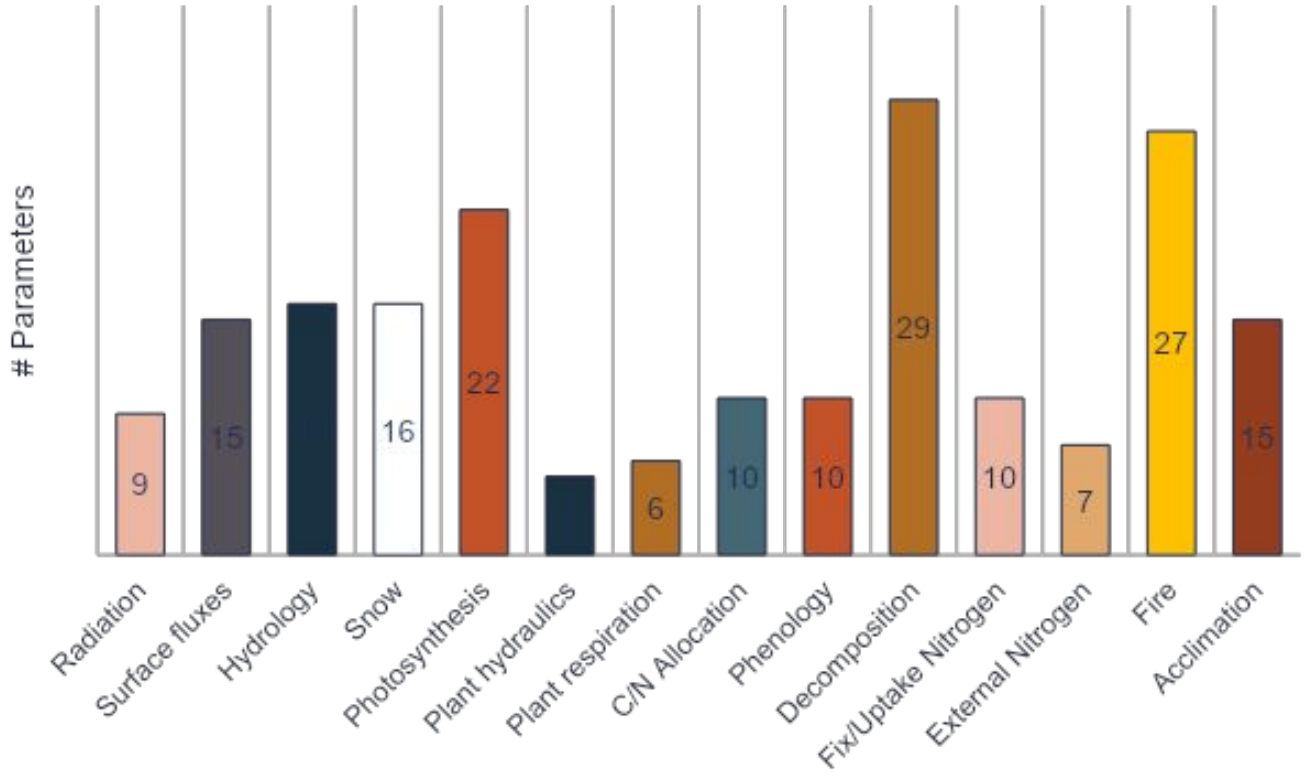
where we are now

where we are now

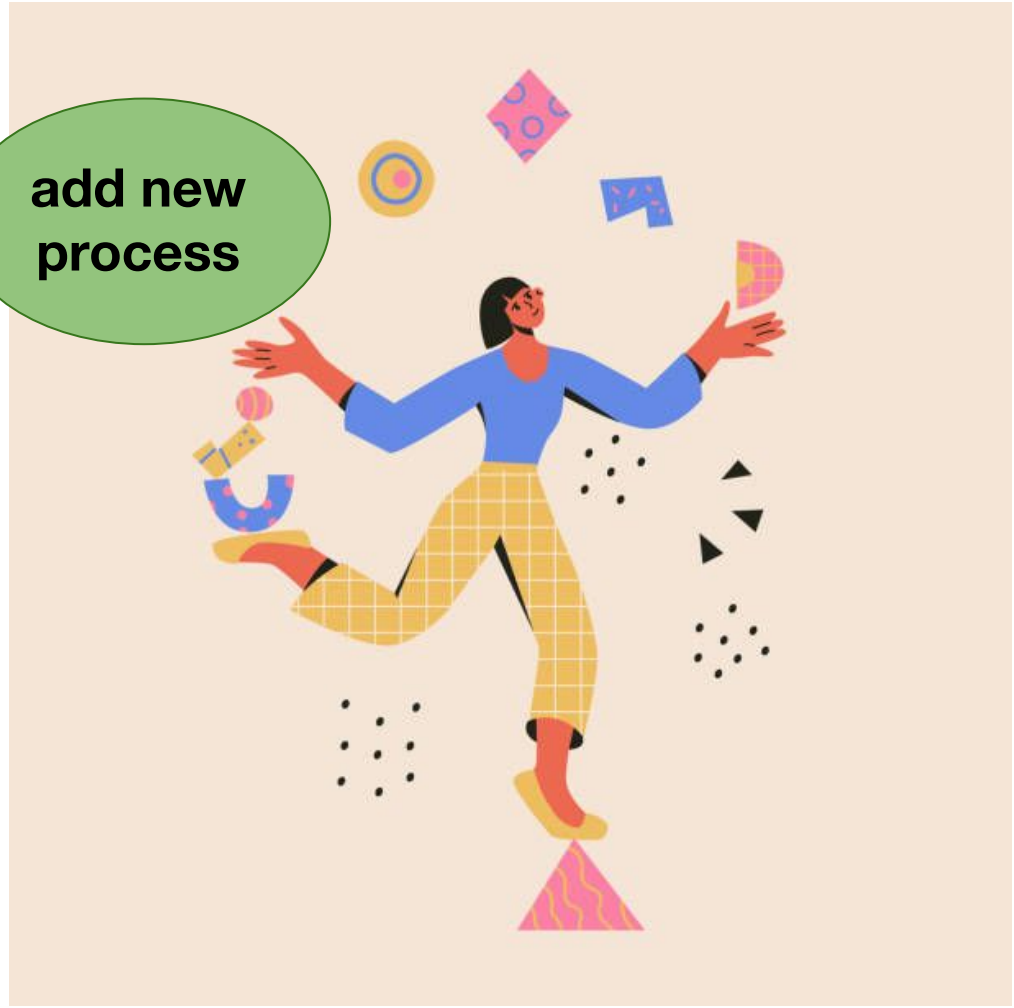




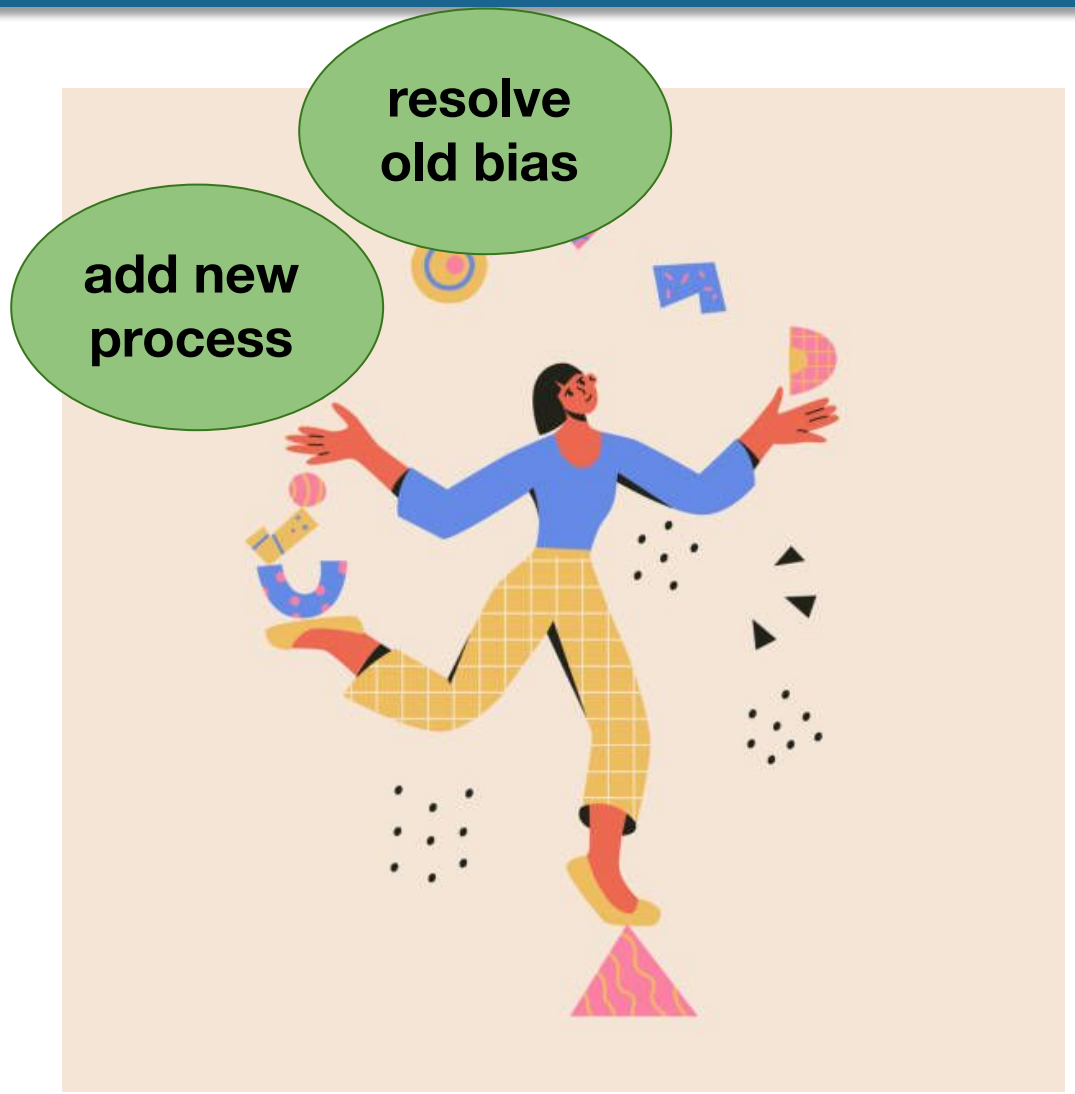
Approximately 200 parameters in CLM5-BGC

many processes, many parameters

a delicate balancing act



a delicate balancing act



a delicate balancing act

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PRINCIPLES

- objectivity
- no hand-tuning
- parameters “from the literature”

a delicate balancing act

PRINCIPLES

- objectivity
- no hand-tuning
- parameters “from the literature”

very difficult in practice

a delicate balancing act

PRINCIPLES

- transparent
- reproducible
- effectively leverage available information

a delicate balancing act

parameter optimization

is it cheating?

parameter optimization

basic physics of climate
are well-established

full complexity is immense,
-> parameterizations

parameter optimization

parameter selection is always occurring

should be more transparent!

drawbacks of hand-tuning approach

1. Difficult to diagnose structural improvements
2. Challenging to incorporate new parameterizations
3. Impractical requisite knowledge base
4. Doesn’t scale well with increasing complexity

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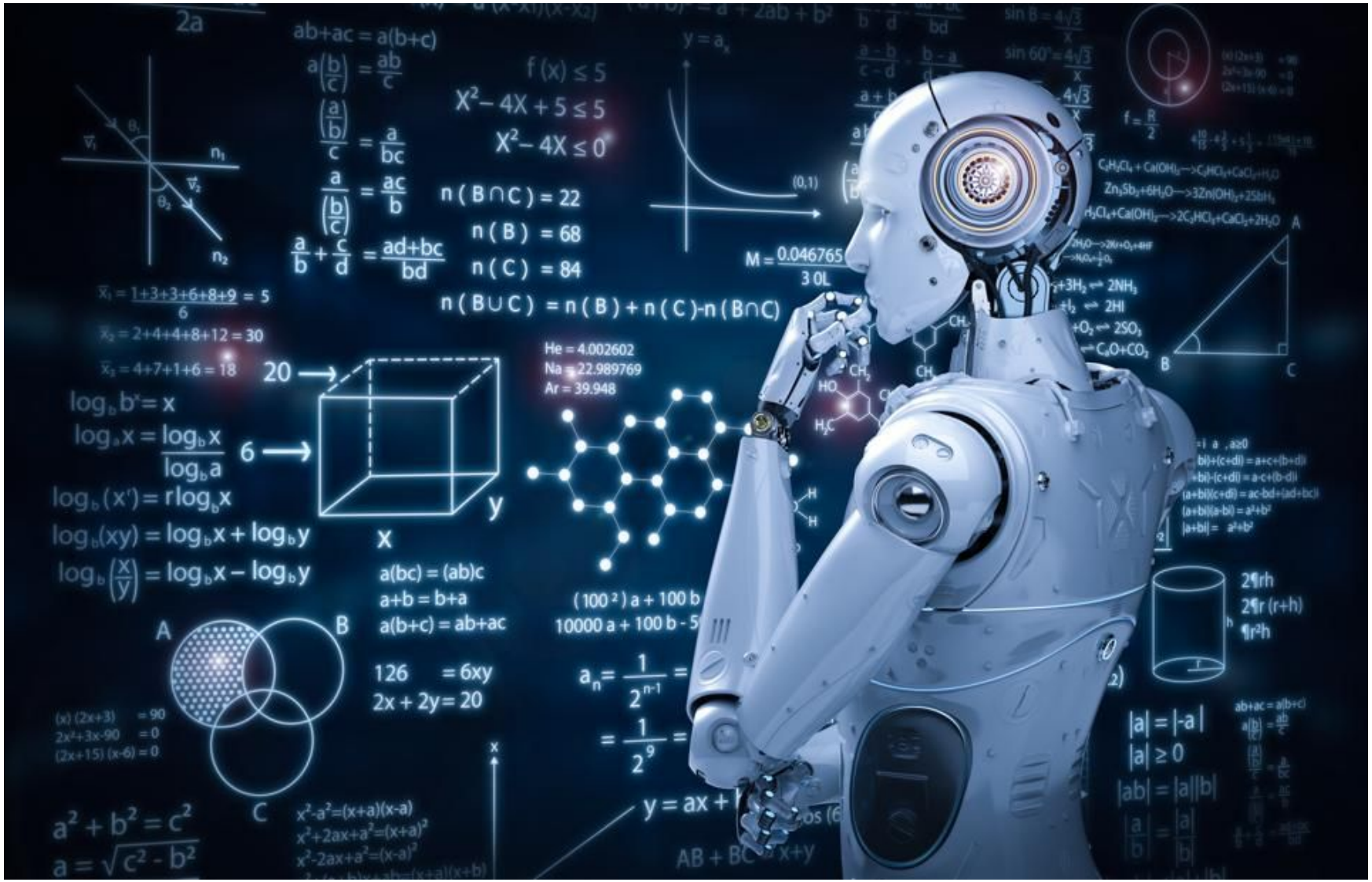
Hand over the reigns to machine learning



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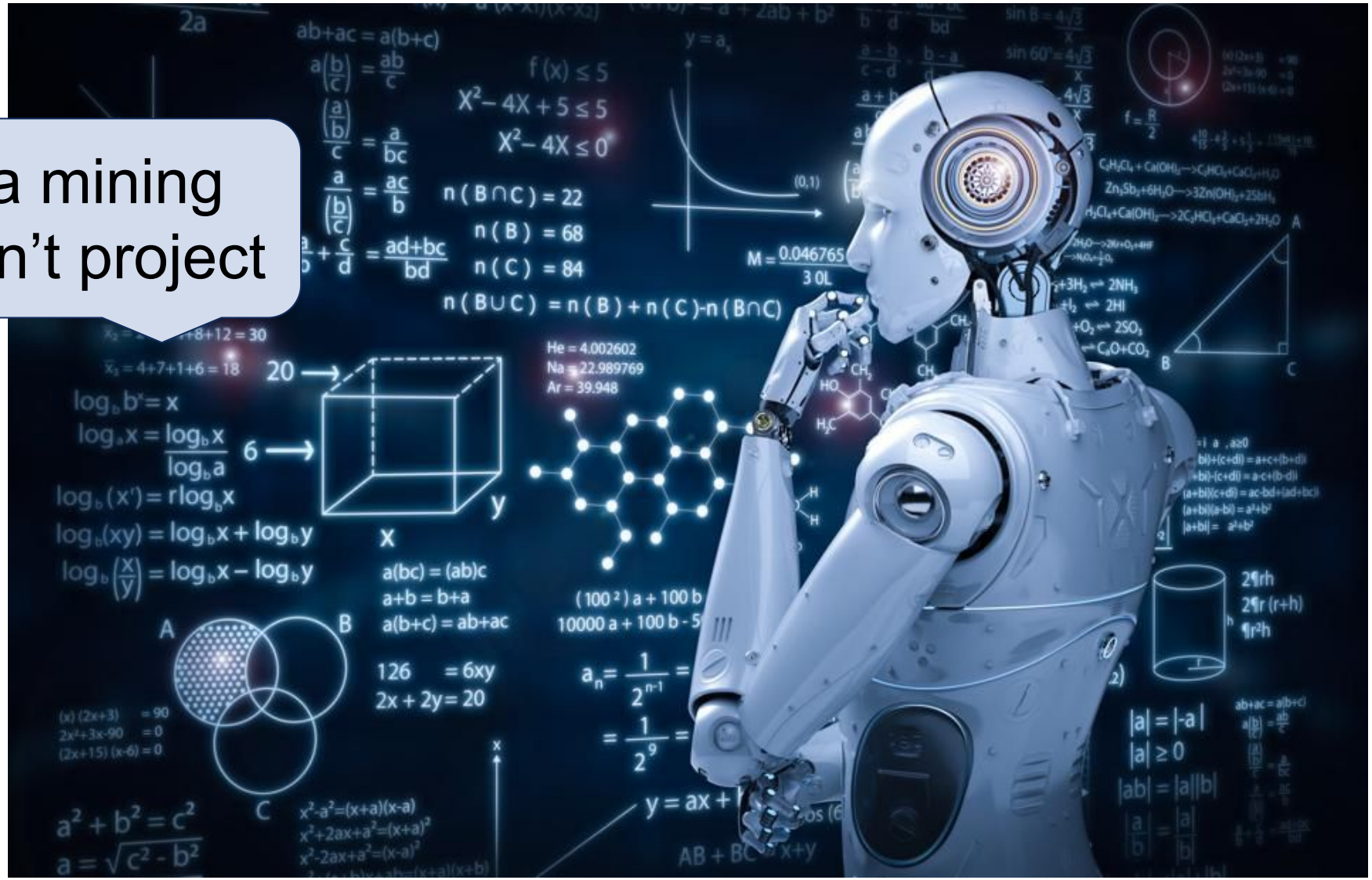
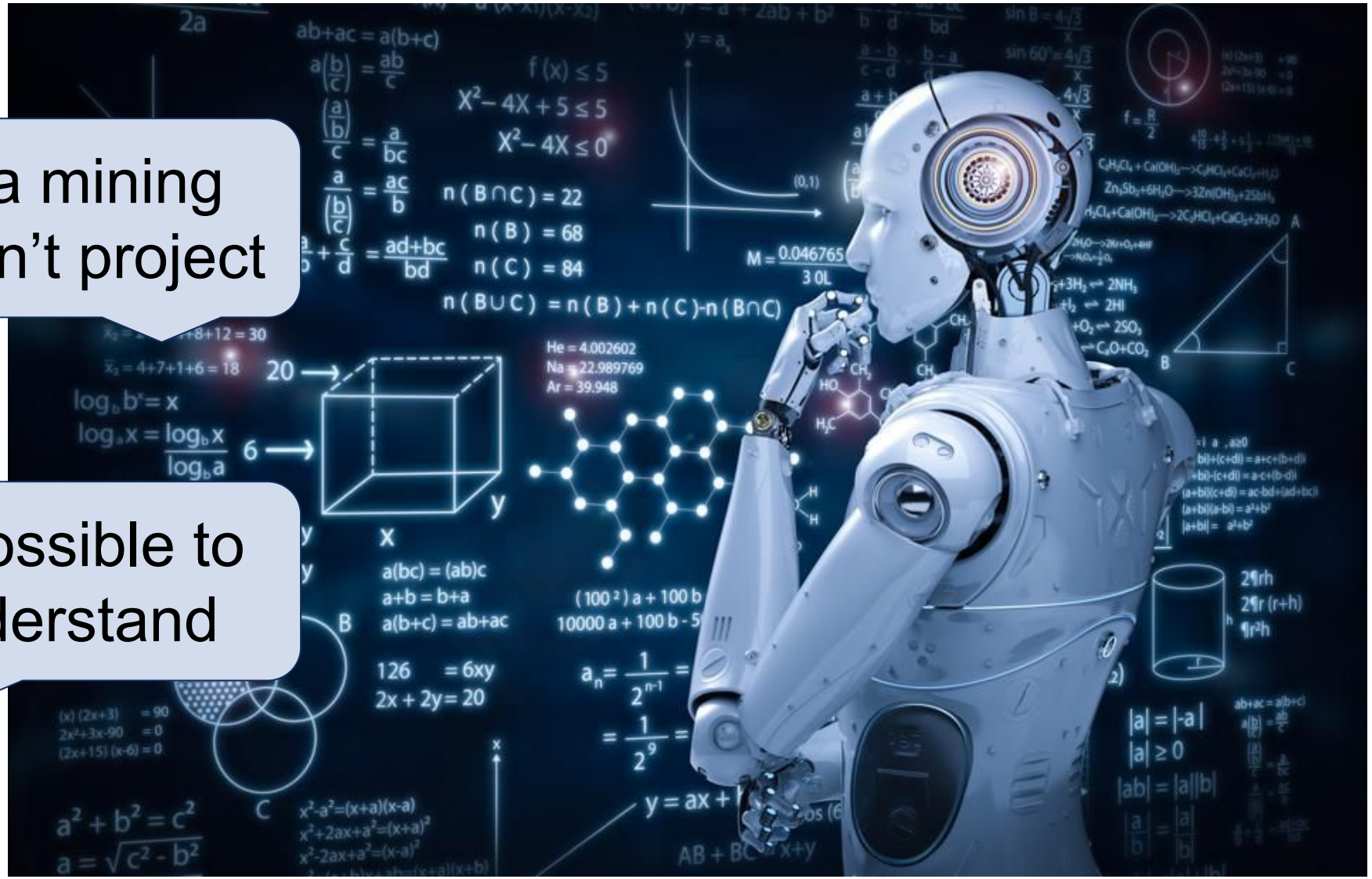


Hand over the reigns to machine learning

data mining doesn't project

impossible to understand

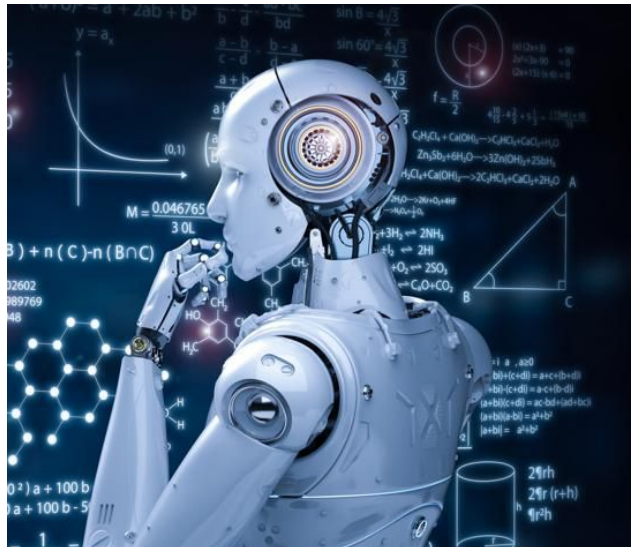


Finding the happy medium

unsustainable

unscientific

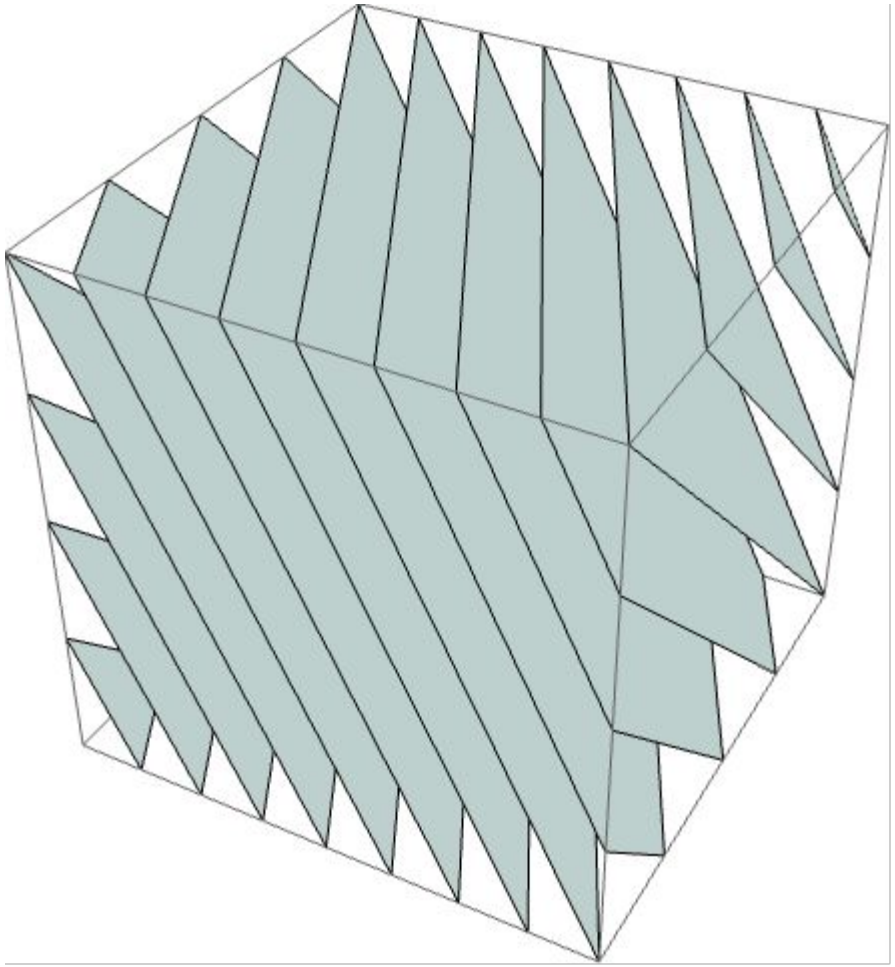
progress?



discerning parameter response via PPE

Parameter perturbation experiments

- choose a set of parameters
- vary them strategically
- learn about the model



discerning parameter response via PPE

Parameter perturbation experiments

- choose a set of parameters
- vary them strategically
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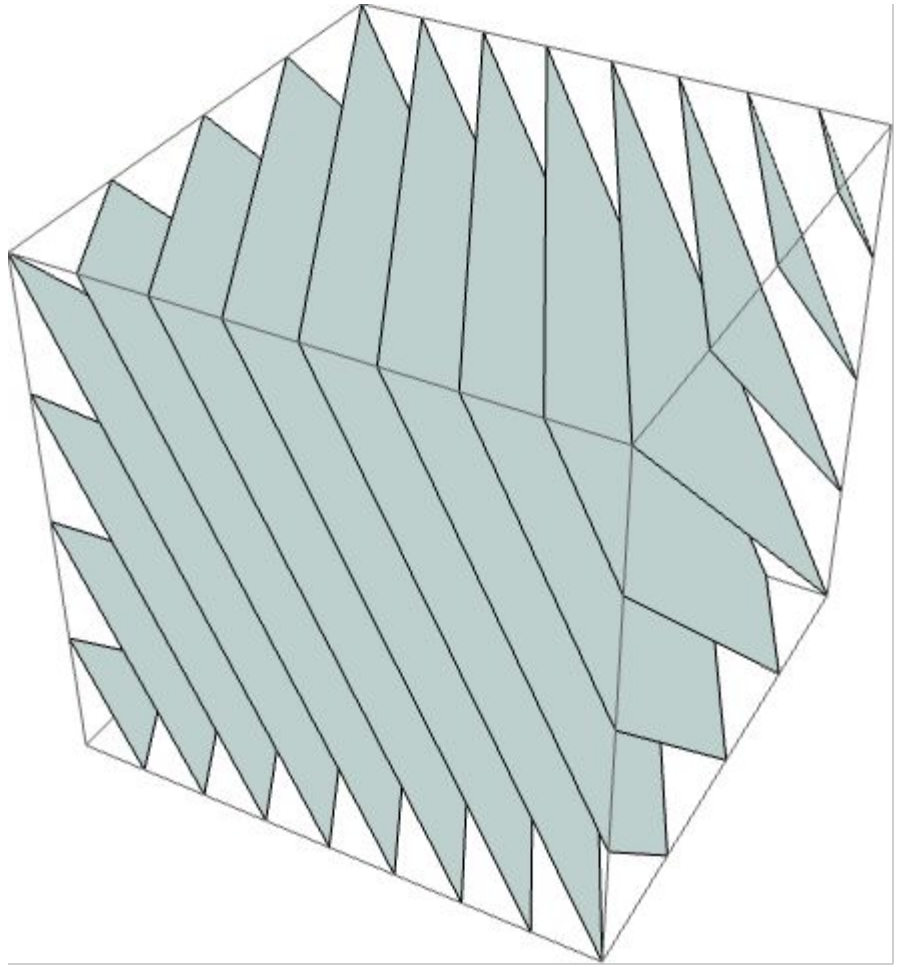
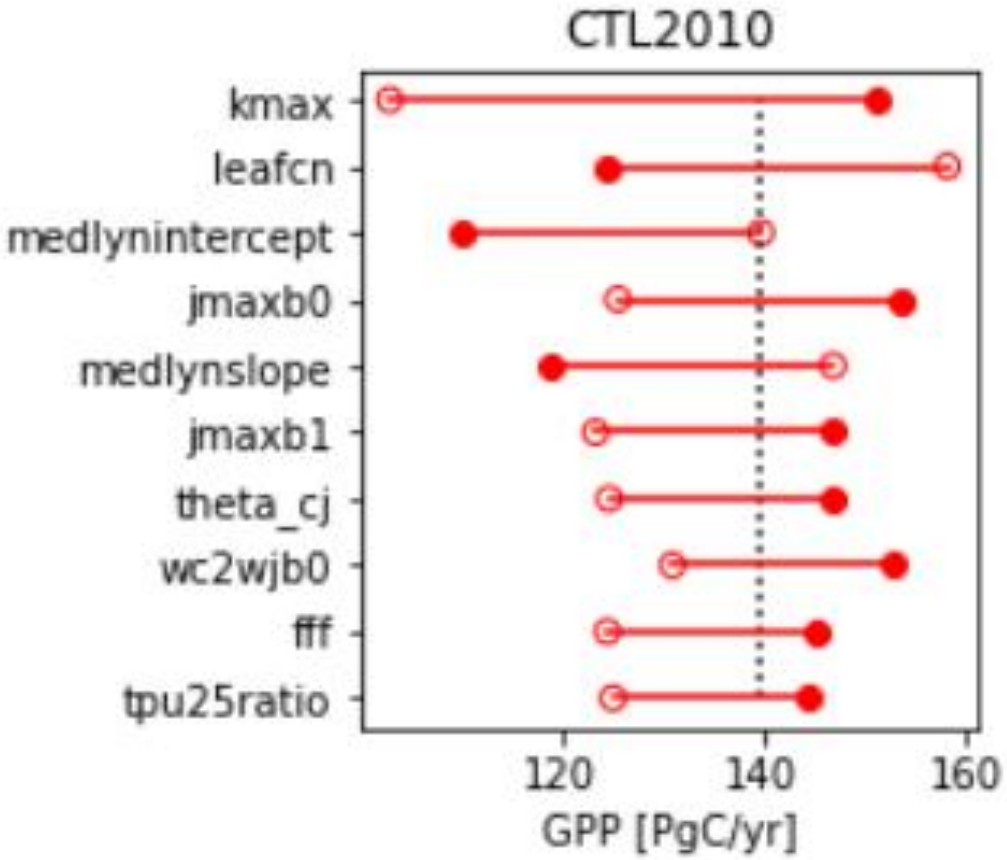
leverage knowledge to set parameter values



Ongoing work with CLM

One-at-a-time experiment:

- 200 parameters
- perturbed up and down
- spinup, then run for ten years



w/ Katie Dagon, Dave Lawrence and the CLM PPE WG

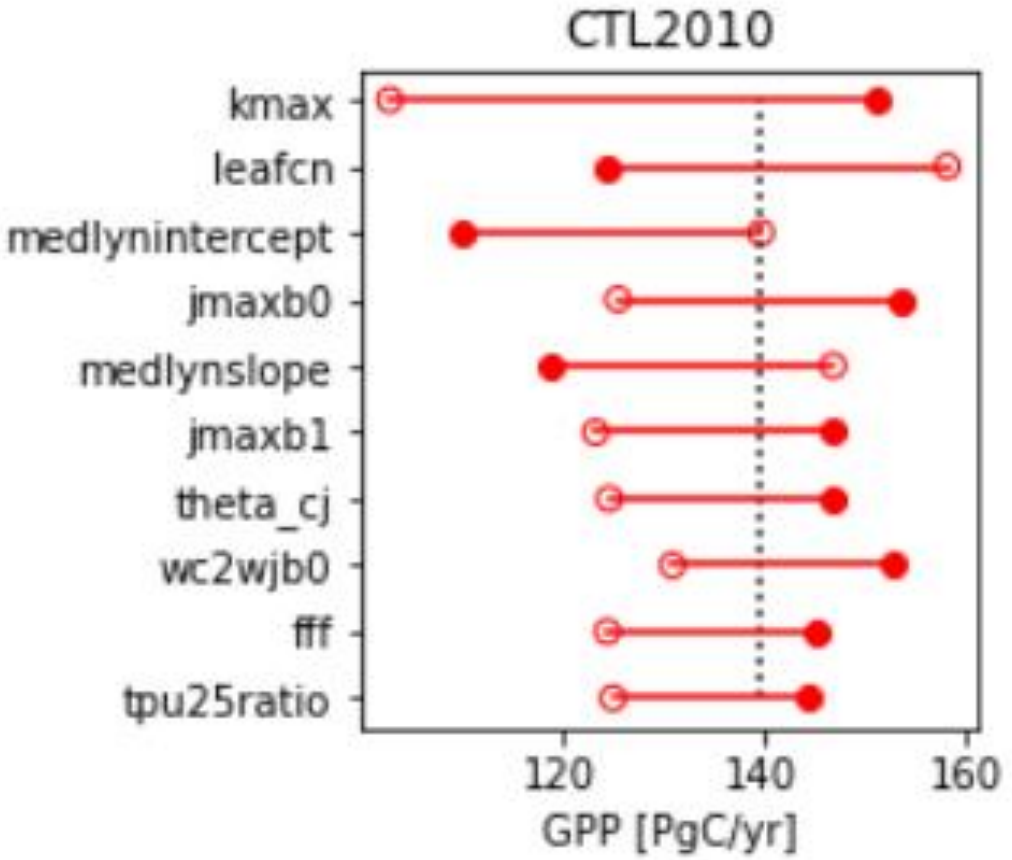
Ongoing work with CLM

One-at-a-time experiment:

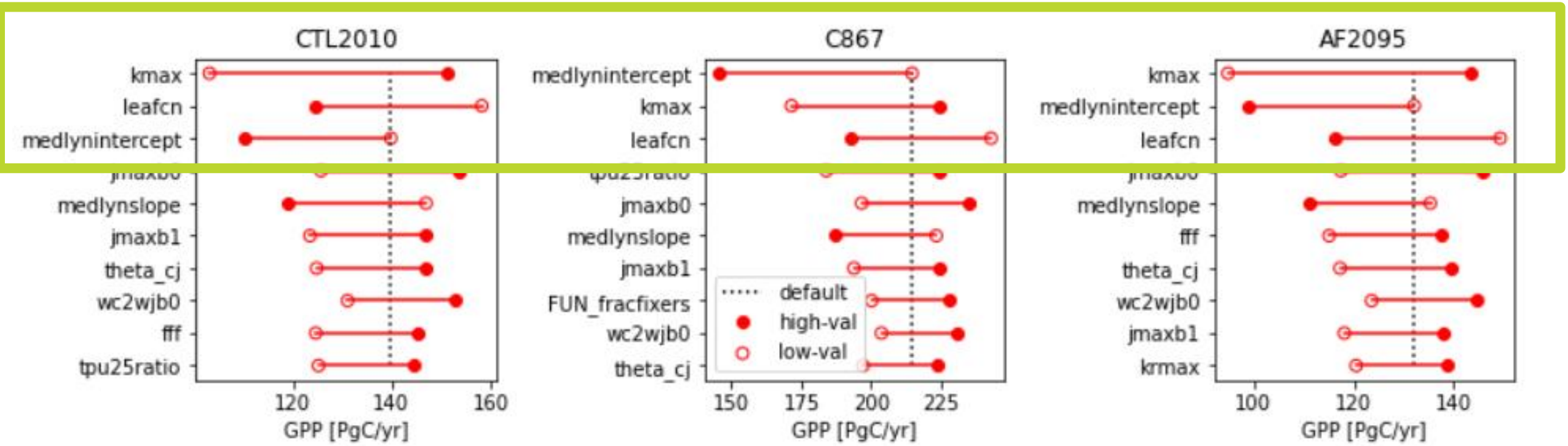
- 200 parameters
- perturbed up and down
- spinup, then run for ten years

Six scenarios:

- Control (2010 climate/CO_2)
- Hi/low CO_2
- 1850/2100 climate
- + nitrogen deposition



Which parameters have the largest effect on GPP?



control ensemble | high CO_2 | future climate

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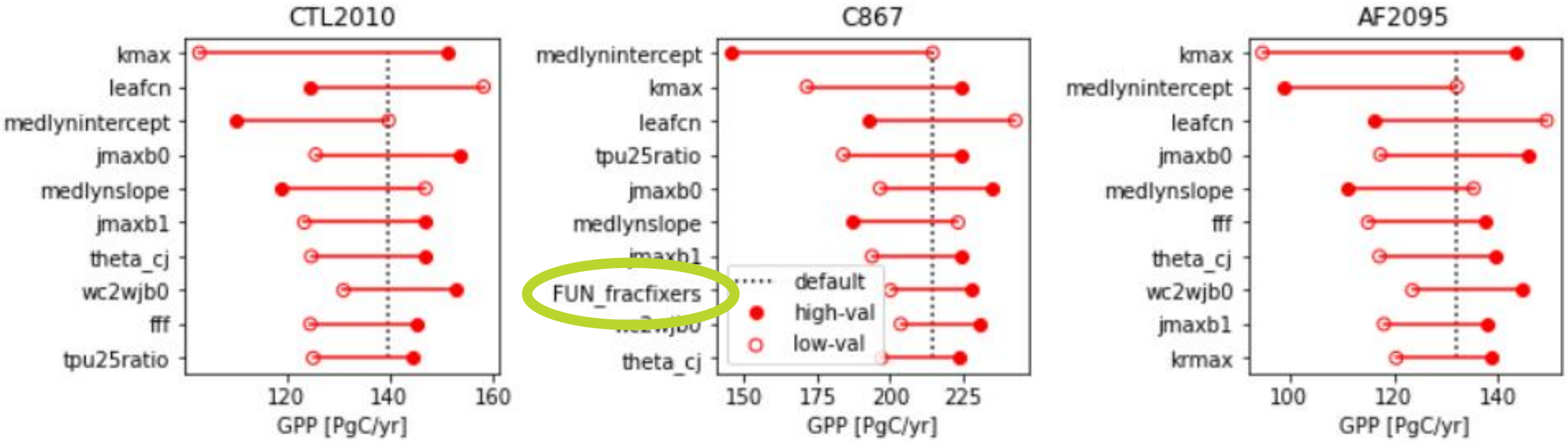


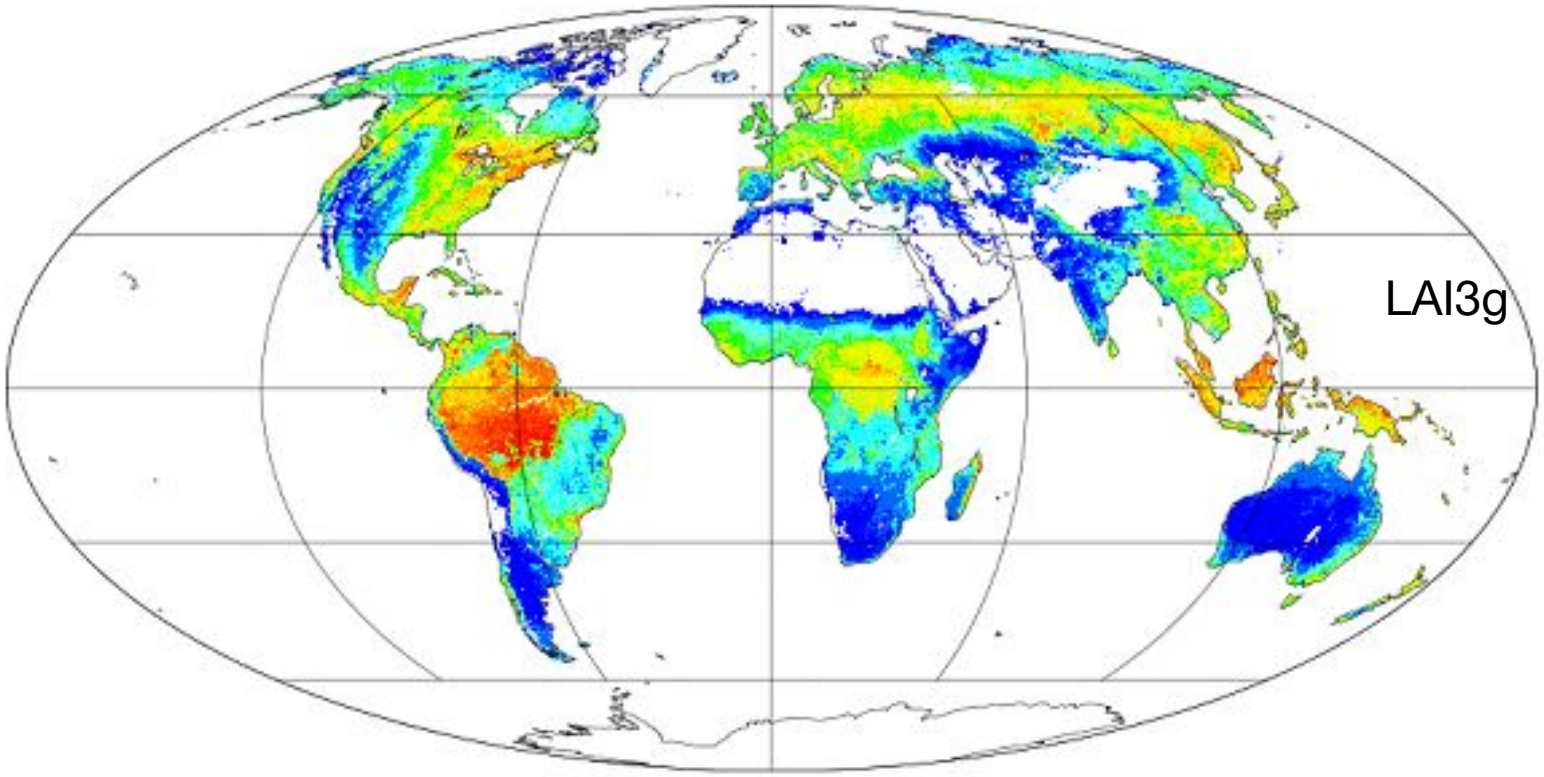
control ensemble

high CO_2

future climate

LAI calibration

1. Subset 32 parameters
2. Run repeat ensemble
3. Discern optimal parameter set(s)

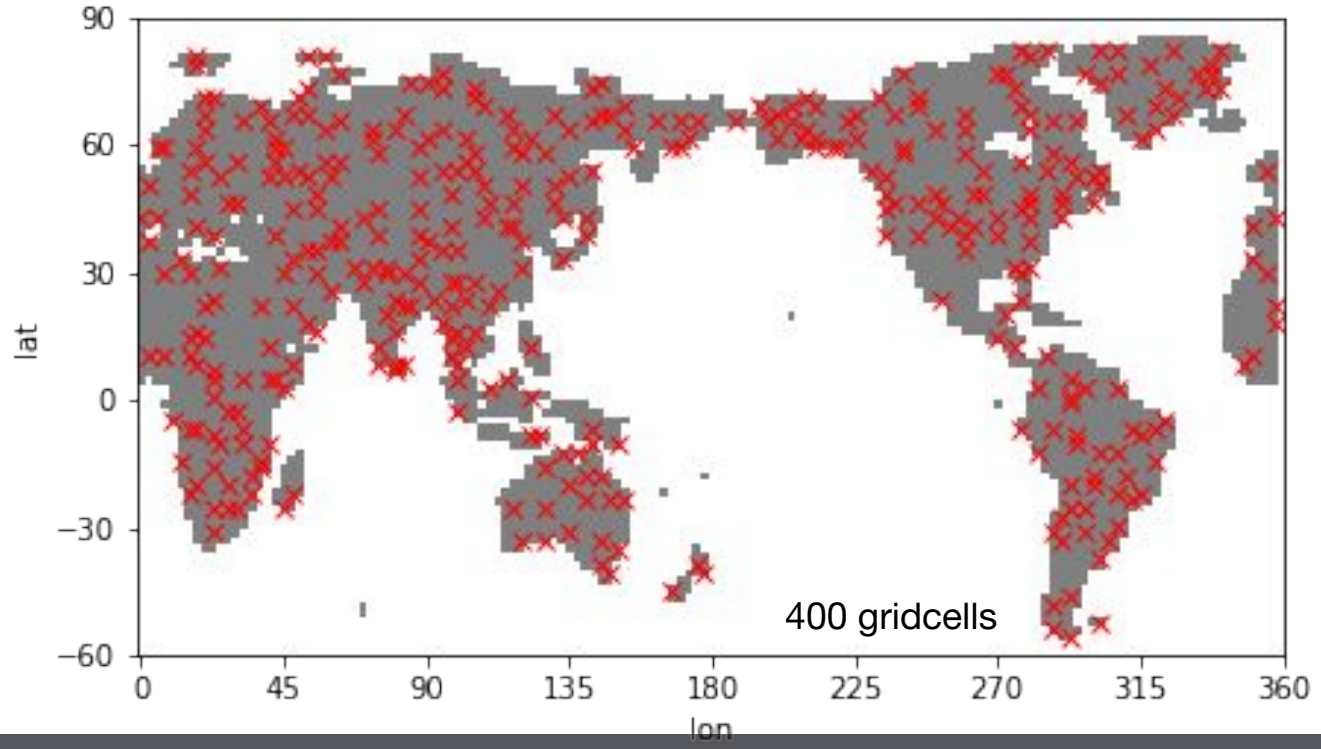


https://doi.org/10.3334/ORNLDAAC/1653

Cost management

1deg= 21013 gridcells
2deg= 5666 gridcells

400 gridcells can reasonably replicate global mean, stdev, and transient model output
(see Hoffman et al. 2013, *Landscape Ecology*)



Forrest Hoffmann and Nate Collier

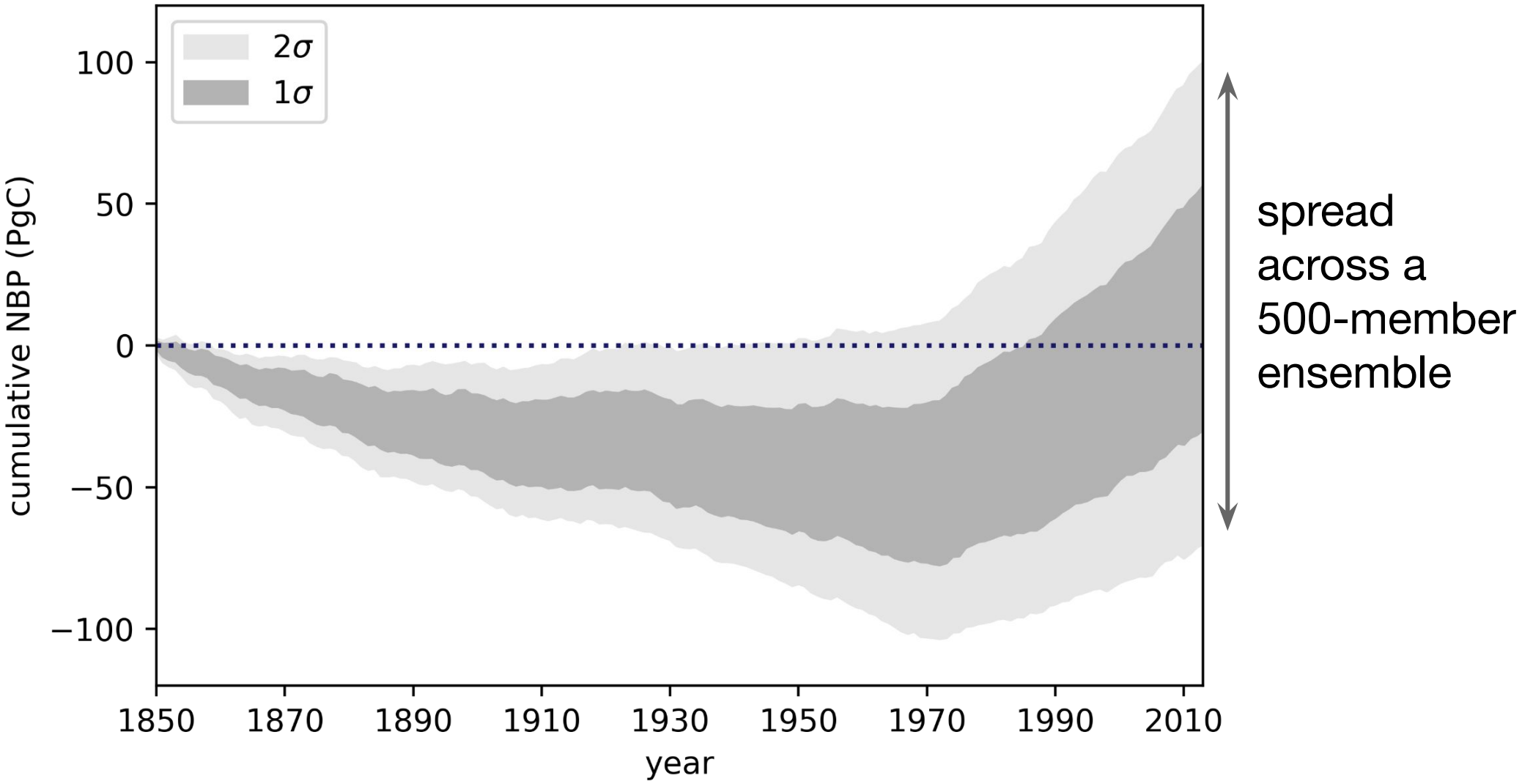
50x reduction from sparsegrid

another >10x reduction via CN-matrix

Lu et al. 2020

2 million pe-hours →
3000 simulations (CLM5-PPE)

Parametric uncertainty in the land carbon sink



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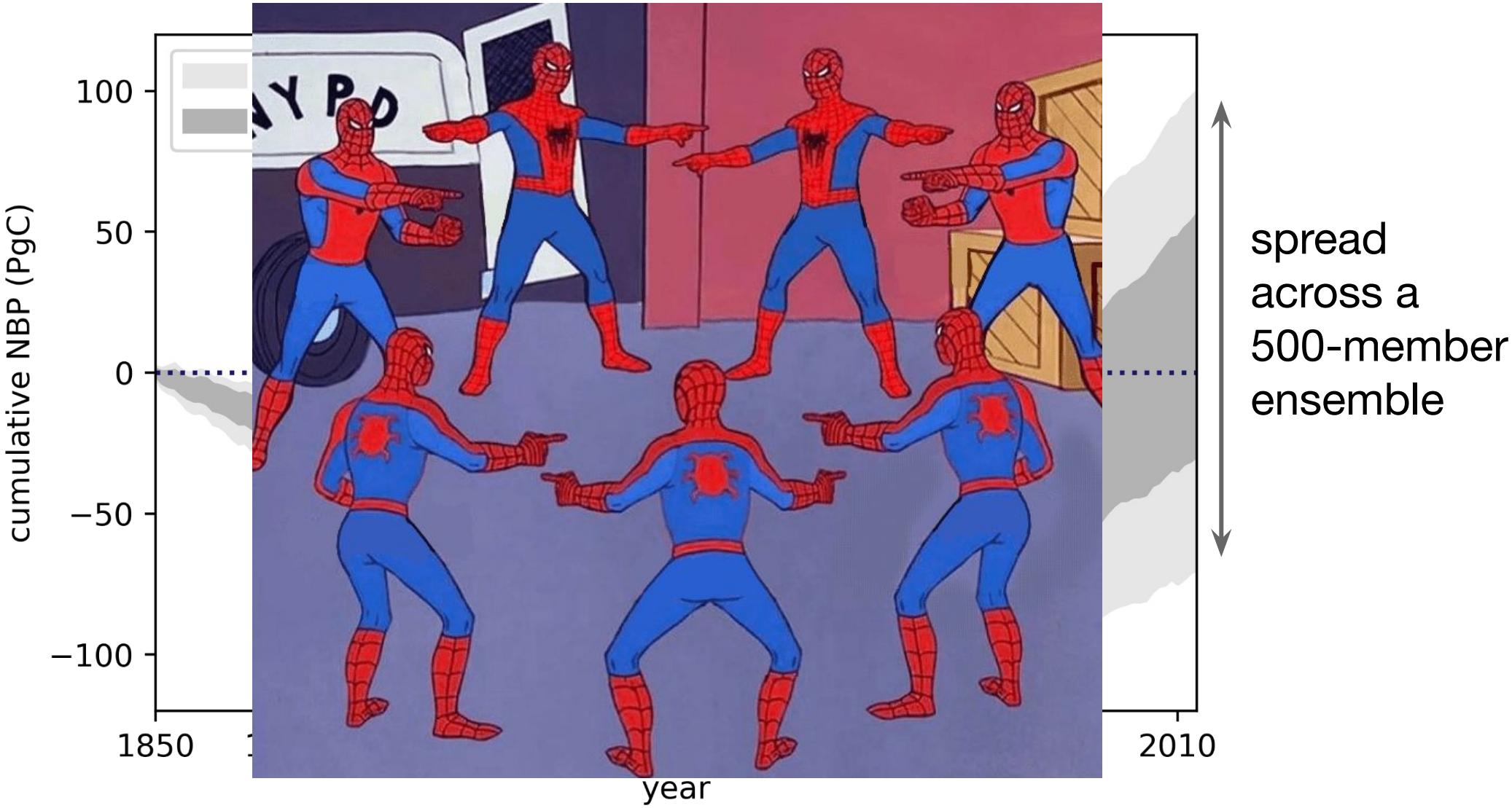
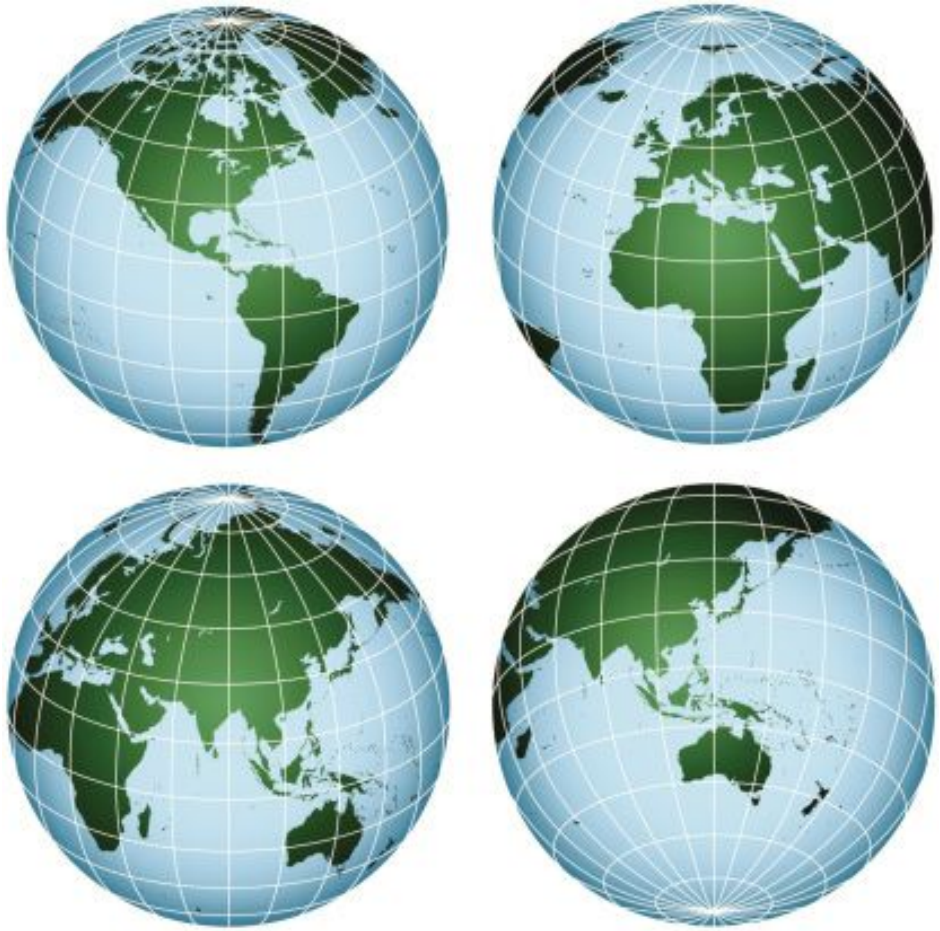


spread
across a
500-member
ensemble

CLM PPE Coordinated Projects

- Land-atmosphere interactions (Univ Washington)
- FATES PPE (NCAR)
- NEON site calibration (Auburn Univ)
- ET recession timescales (Oregon State)
- Arctic river flow (NCAR)
- Land influence on drought (NCAR)
- Hydrologic sensitivity (Cornell Univ)
- Tropical carbon cycle interannual variability (JPL)
- GPP response to permafrost thaw (NAU)



djk2120@ucar.edu

repeatable insight generation

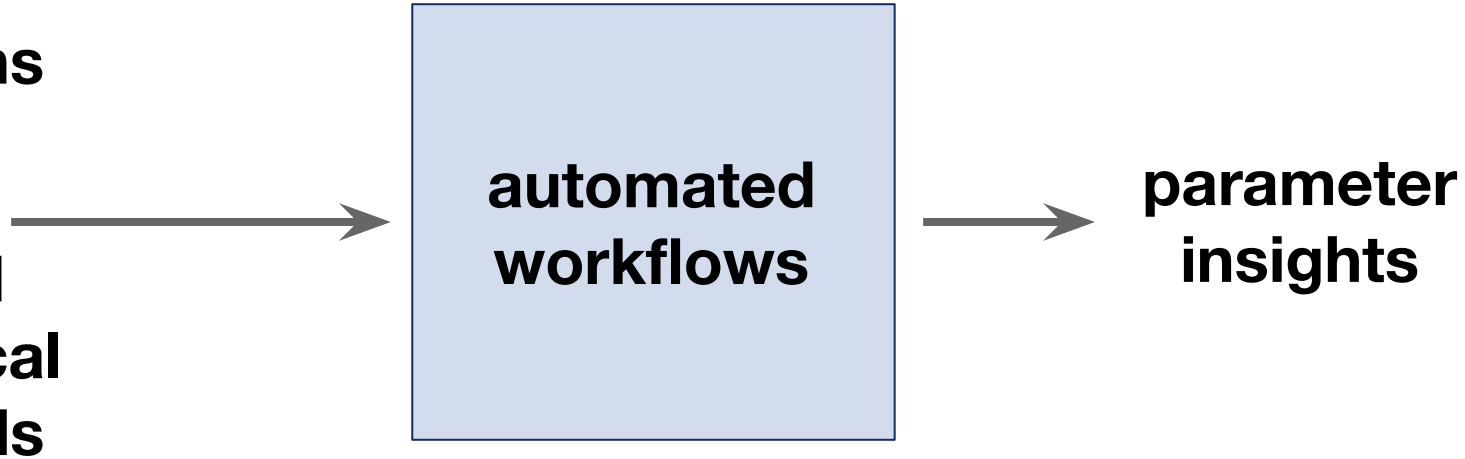
fast model

quick
repeatable
transparent

observations

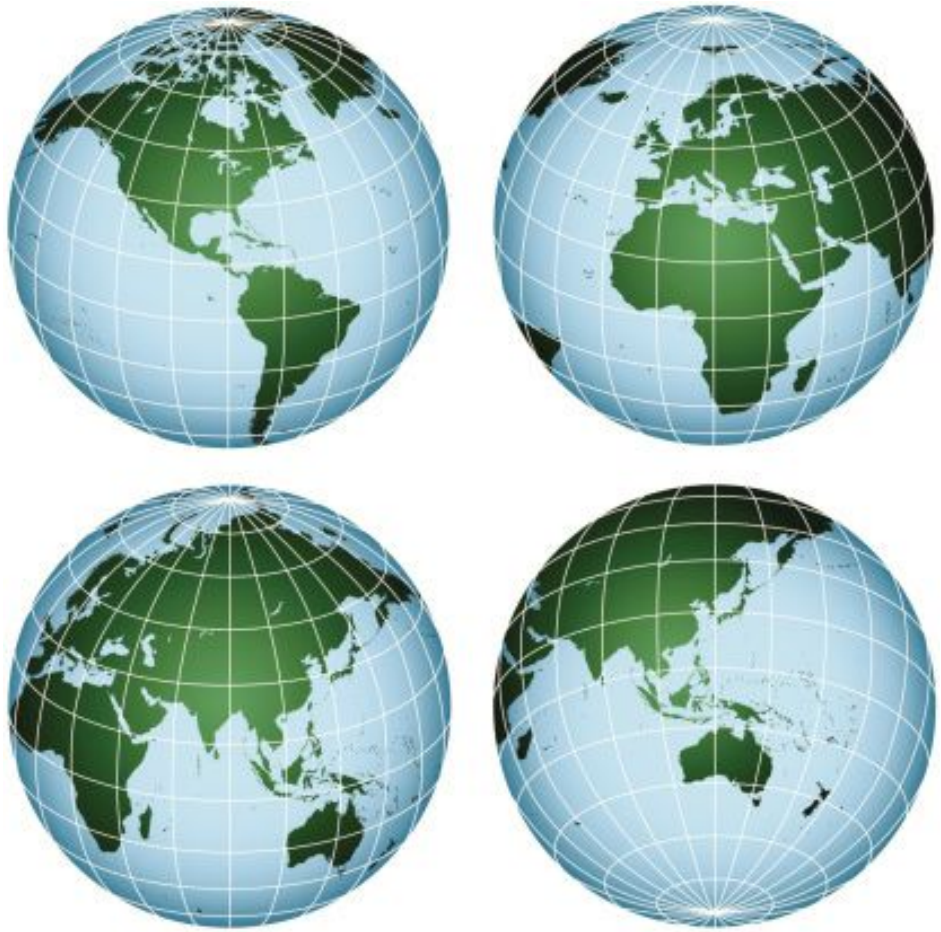
sound
numerical
methods

parameter
ranges



parameter
insights

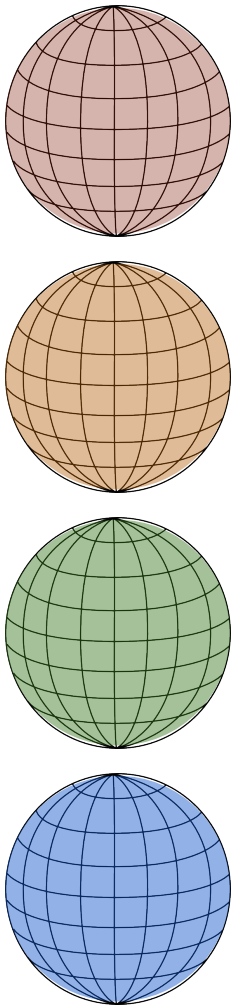
Conclusions



- We are able to run large ensembles of CLM
  - 2500+ simulations with BGC
  - investing in the infrastructure this easy/repeatable
- Two valuable community datasets
  - one-at-a-time perturbations (200 params)
  - latin hypercube perturbations [LAI] (32 params)
- PPE working group meets ~monthly
  - email dlawren@ucar.edu to join the list

github.com/djk2120/ppe_tools
github.com/djk2120/clm5ppe

Conclusions



- PPE's are a valuable tool for learning about a model
- Optimize computer and human resources
- Need more transparency in model tuning

github.com/djk2120/ppe_tools
github.com/djk2120/clm5ppe

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