

# Activity

1. Open 2 browser windows
  1. [pecanproject.org](http://pecanproject.org) > Tutorials > v1.5.0
  2. [http://\[\[ip.on.the.sticker\]\]](http://[[ip.on.the.sticker]])
2. Complete Demo 1
3. Objectives
  1. Run a model, explore outputs
  2. Discuss model behavior in rel'n to this morning's lecture & breakout

POWERED BY



# THE PEcAn PROJECT: PUTTING ECOSYSTEM MODEL-DATA FUSION IN YOUR POCKET

MICHAEL DIETZE

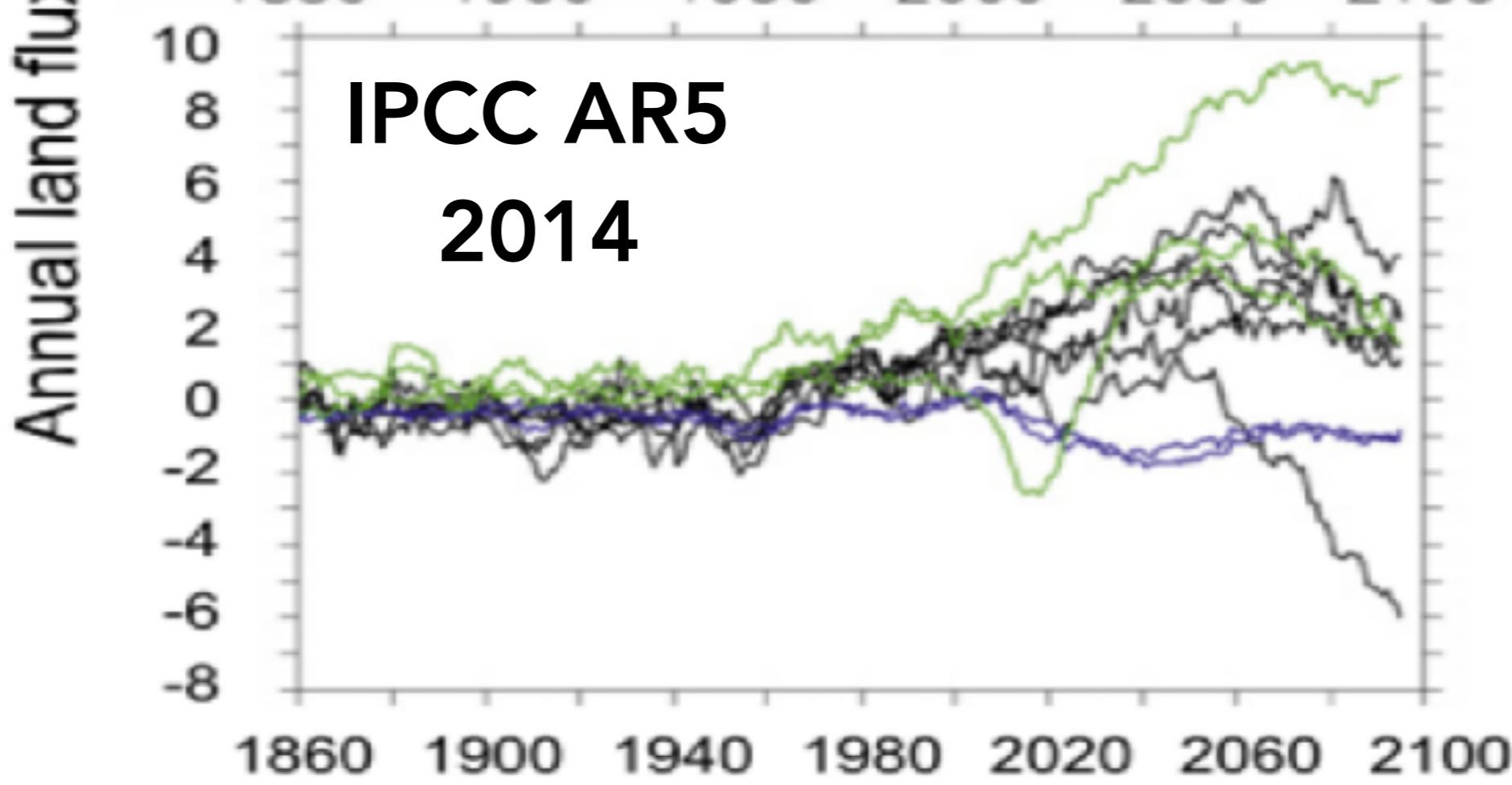
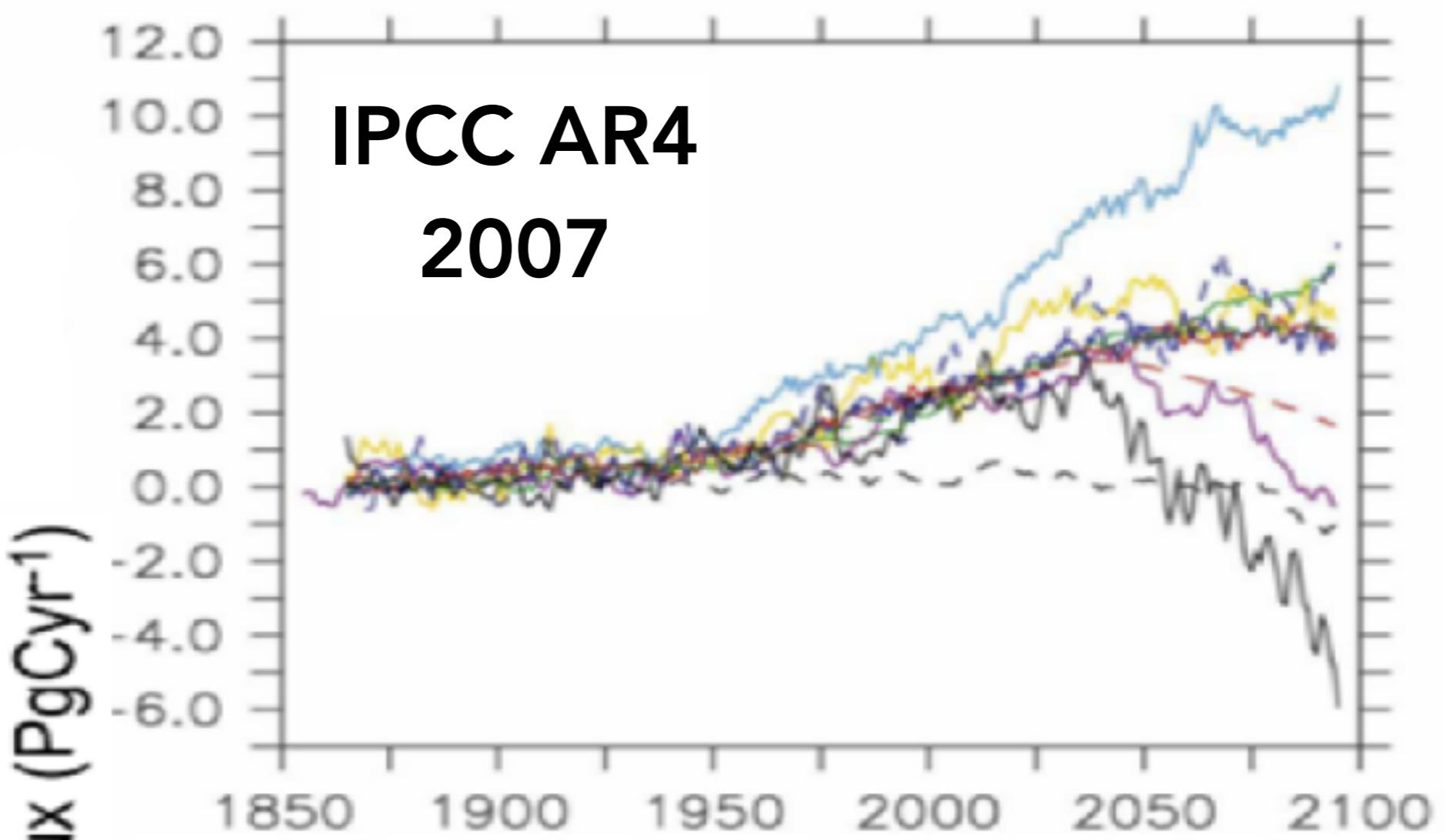
Flux Course 2017

@PEcAnProject  
@mcdietze

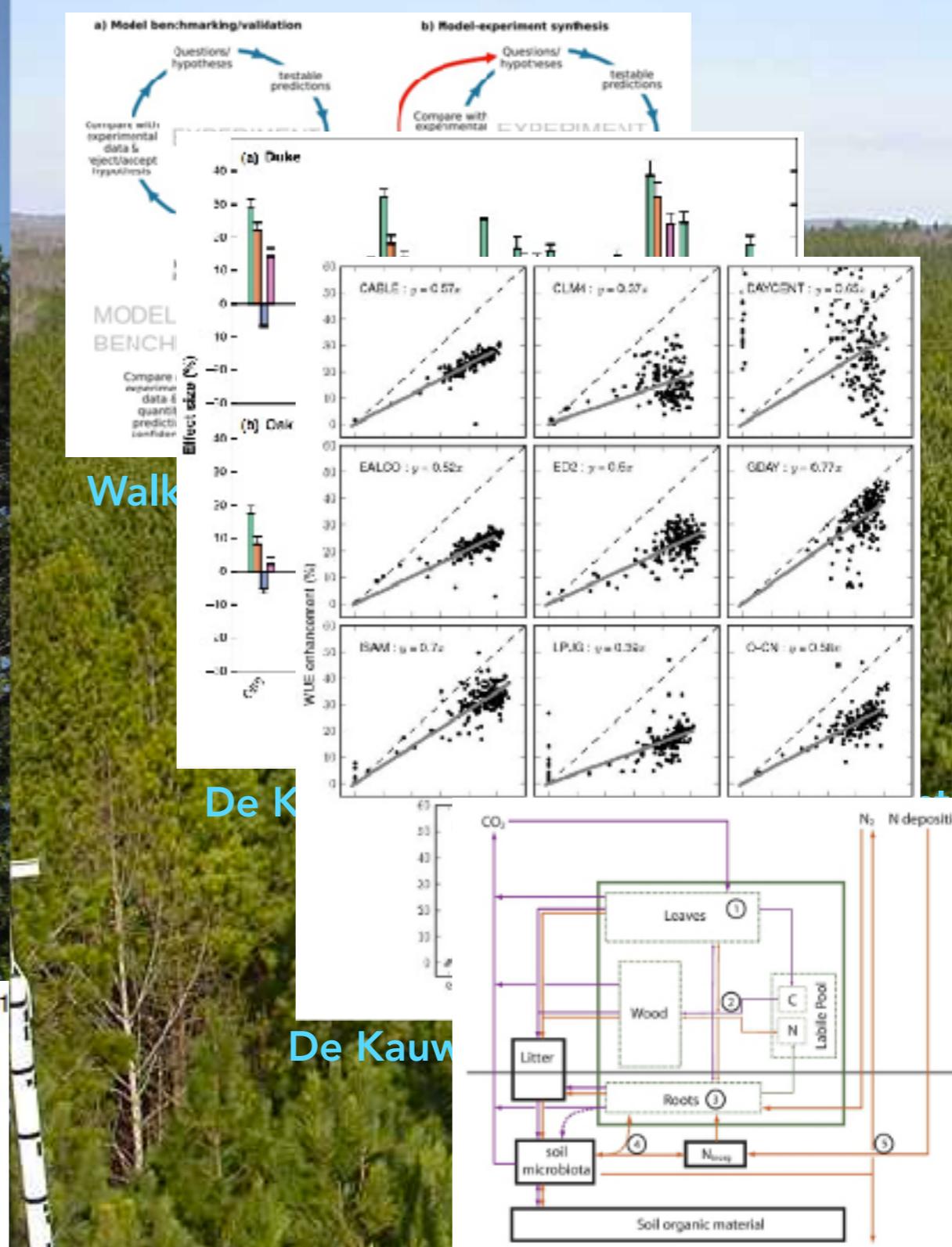
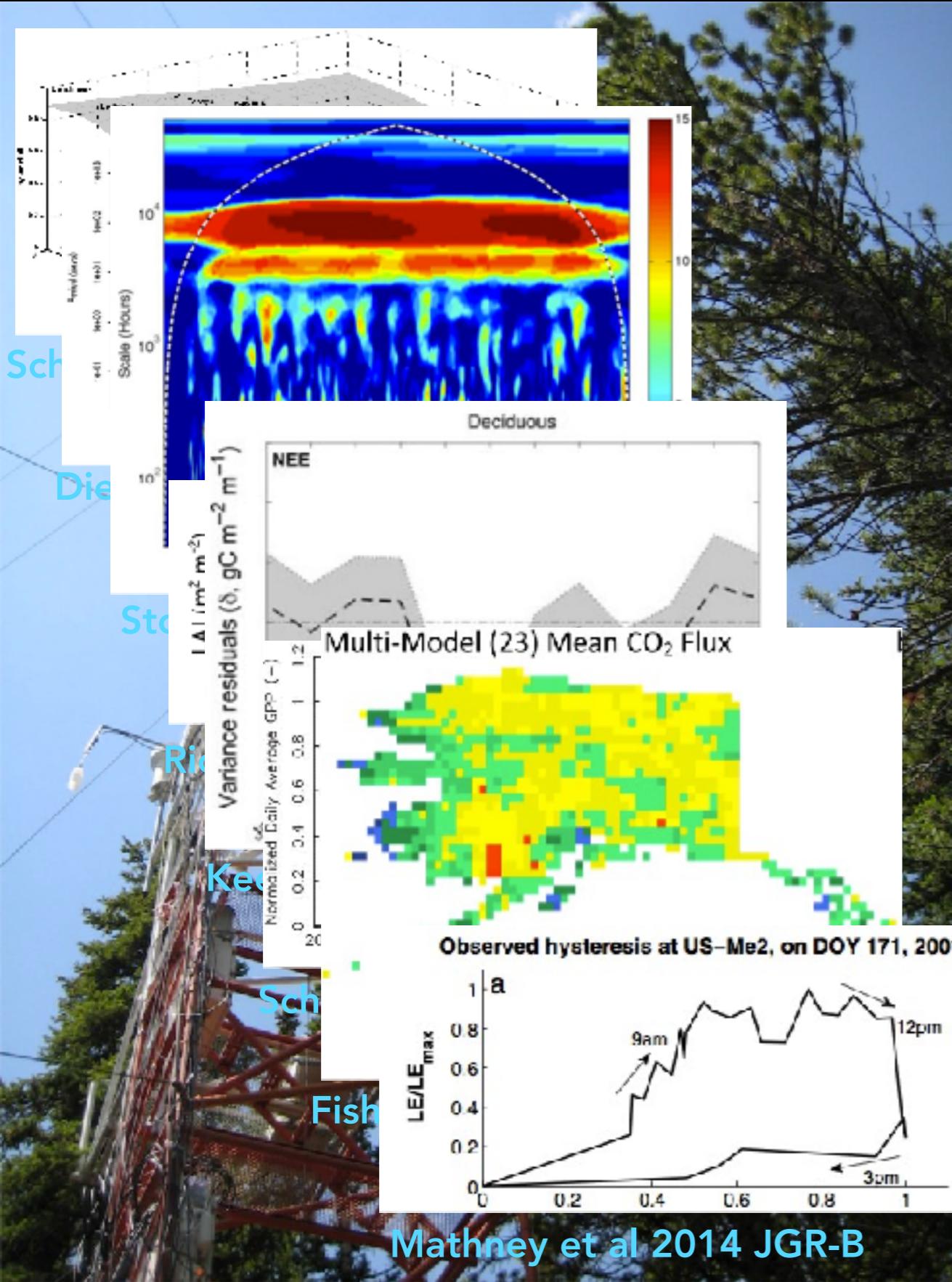




ECOSYSTEM  
SCIENCE, POLICY,  
AND MANAGEMENT  
INFORMED BY THE  
BEST AVAILABLE  
DATA AND MODELS



# MODEL-DATA COMPARISON



# CHALLENGES

- Data synthesis:  
volume, diversity
- Modeling not scalable
- Models are not accessible

MULTI-MODEL VALIDATION  
TAKES YEARS

ONLY FRACTION OF DATA  
BEING USED



# CHALLENGES

- Data synthesis:  
volume, diversity
- Modeling not scalable
- Models are not accessible

MODELING IS A COTTAGE  
INDUSTRY

INPUTS, OUTPUTS, AND  
ANALYTICAL TOOLS NOT  
STANDARDIZED

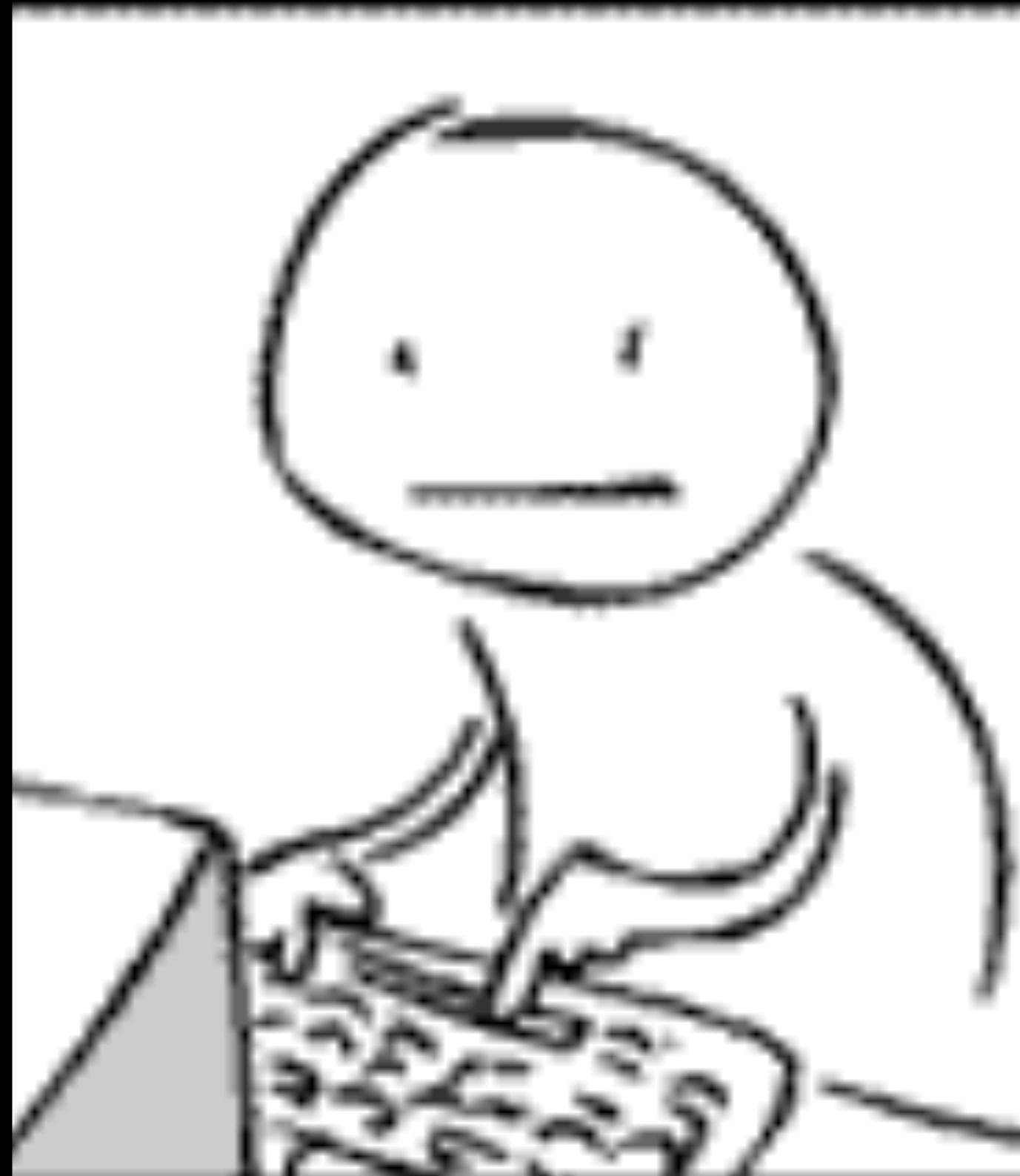
NOT SHARED OR REPLICABLE



# CHALLENGES

- Data synthesis:  
volume, diversity
- Modeling not scalable
- Models are not accessible

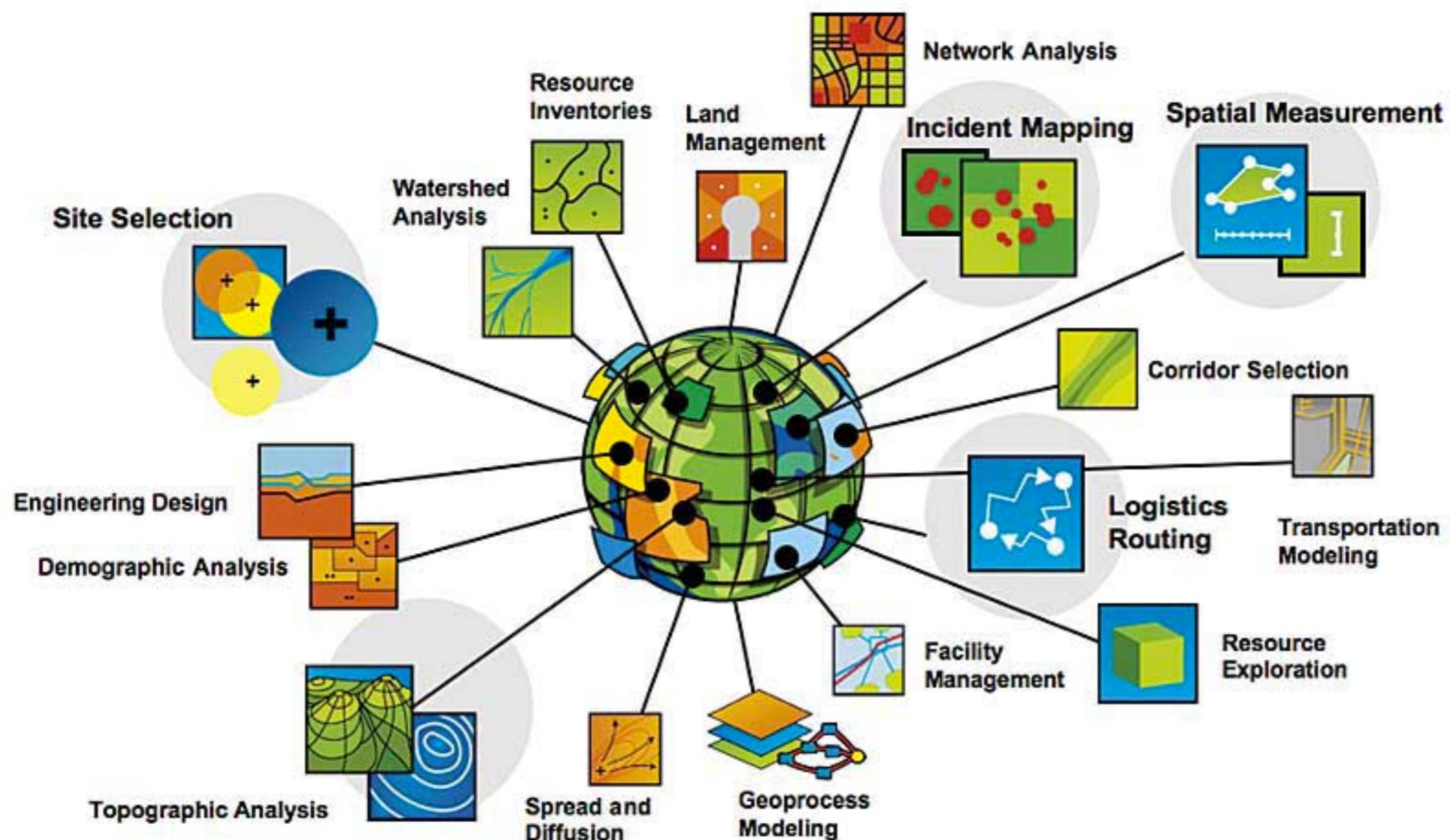
NO EASY WAY FOR NON-MODELERS TO HELP



DEVELOP AND PROMOTE ACCESSIBLE  
TOOLS FOR REPRODUCIBLE ECOSYSTEM  
MODELING AND FORECASTING

# GIS Is Being Applied Around the World

*Across Many Disciplines, Professions, and Organizations*



## Select host

Based on the host selected certain sites and models will be available. In the current version you can only pick as host  
pecan.ncsa.illinois.edu

### Host: (Show in BETY)

pecan.ncsa.illinois.edu

### Model:

All Models

SIPNET (unk)

Linkages (git)

ED2.2 (32)

ED2.2 (46)

DALEC

BioGro

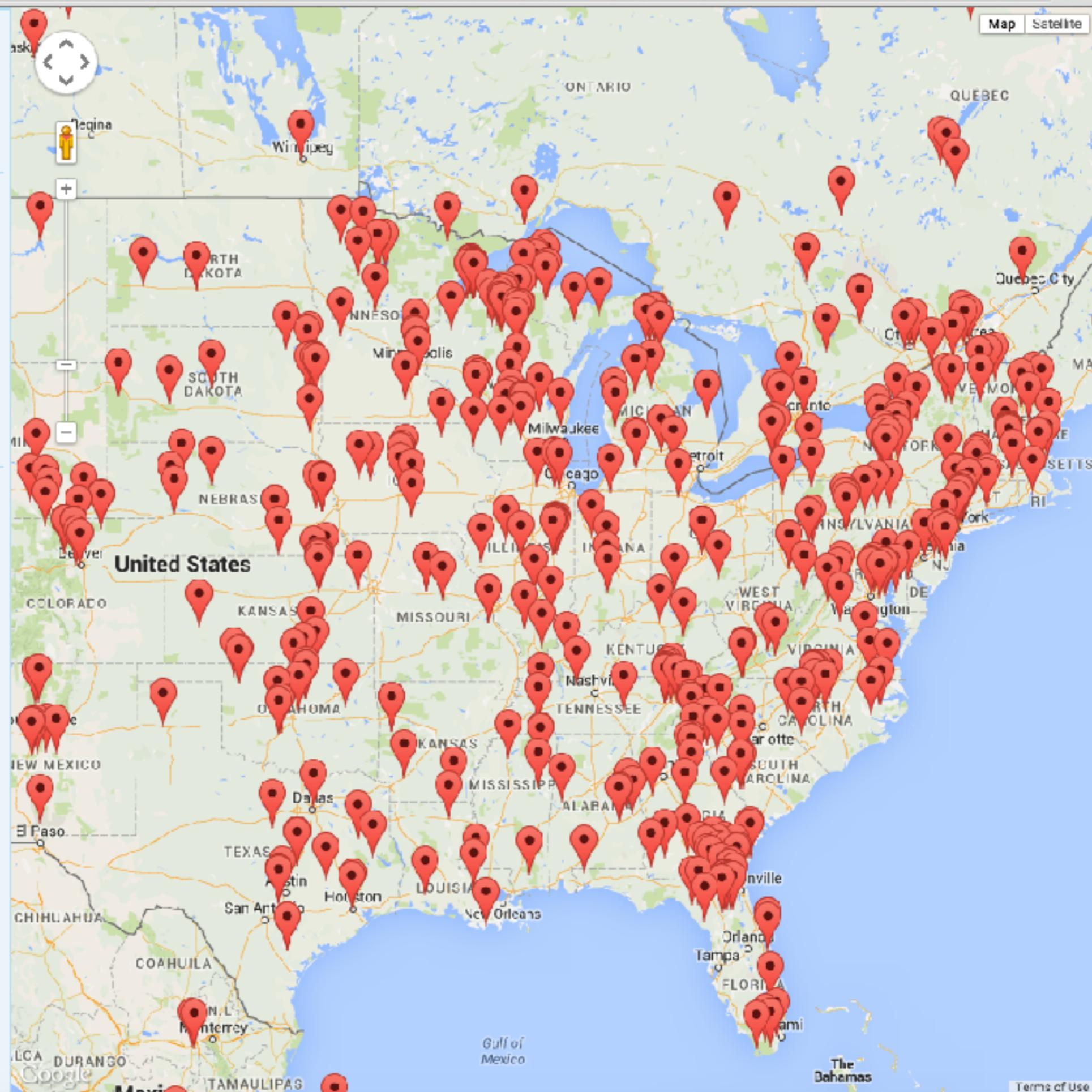
Requires a restart of this page after site is added.

### Workflow

Select a model to continue

Prev

Next



## Selected Site

Set parameters for the run.

### PFT\* (Show in BETY)

deciduous  
evergreen

### Start Date\*

2004/01/01

### End Date\*

2004/12/31

### DALEC meteorology\*

Use Ameriflux  
 Use NARR

Use BrownDog

Edit pecan.xml

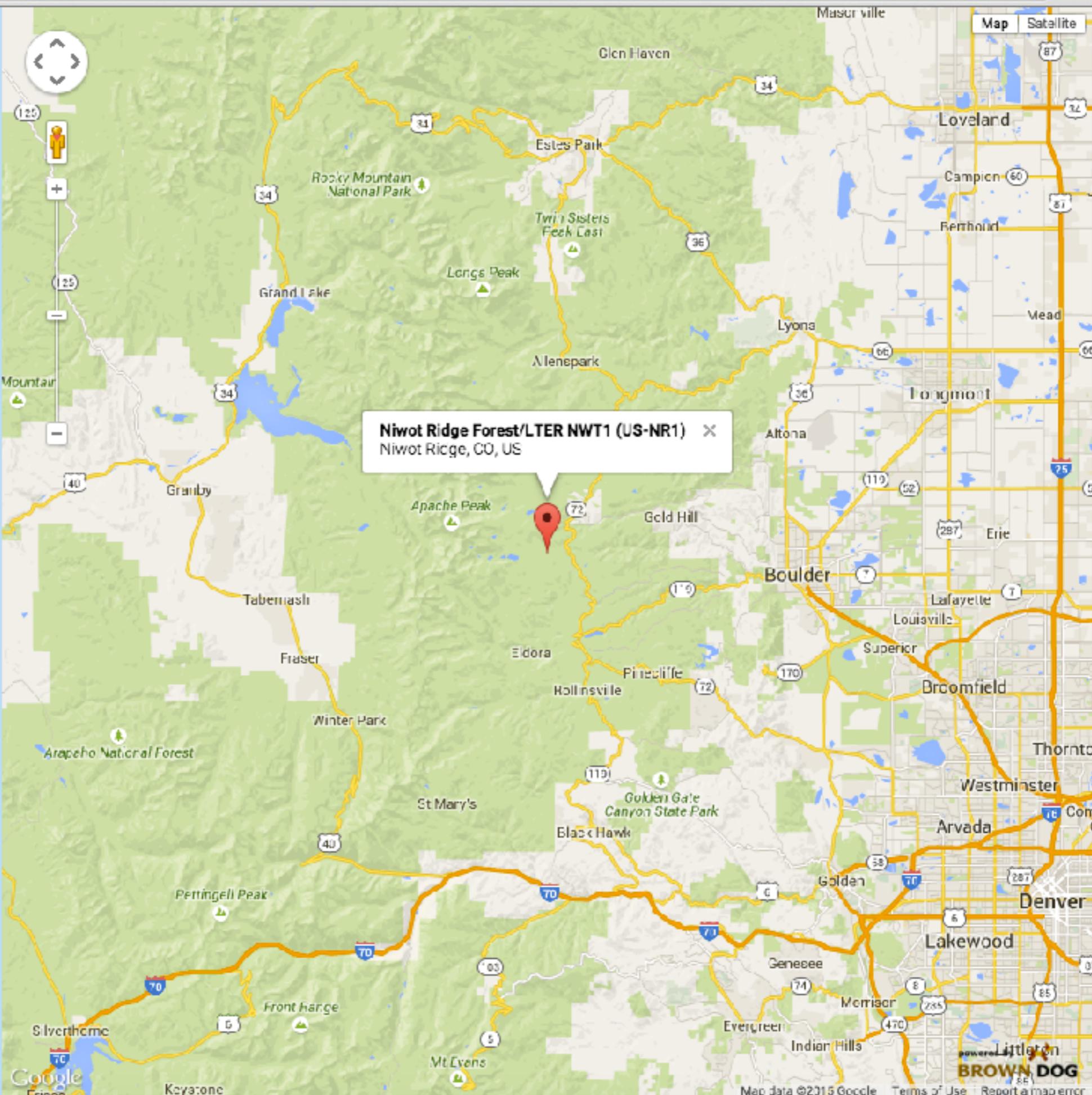
Edit model config

Advanced setup

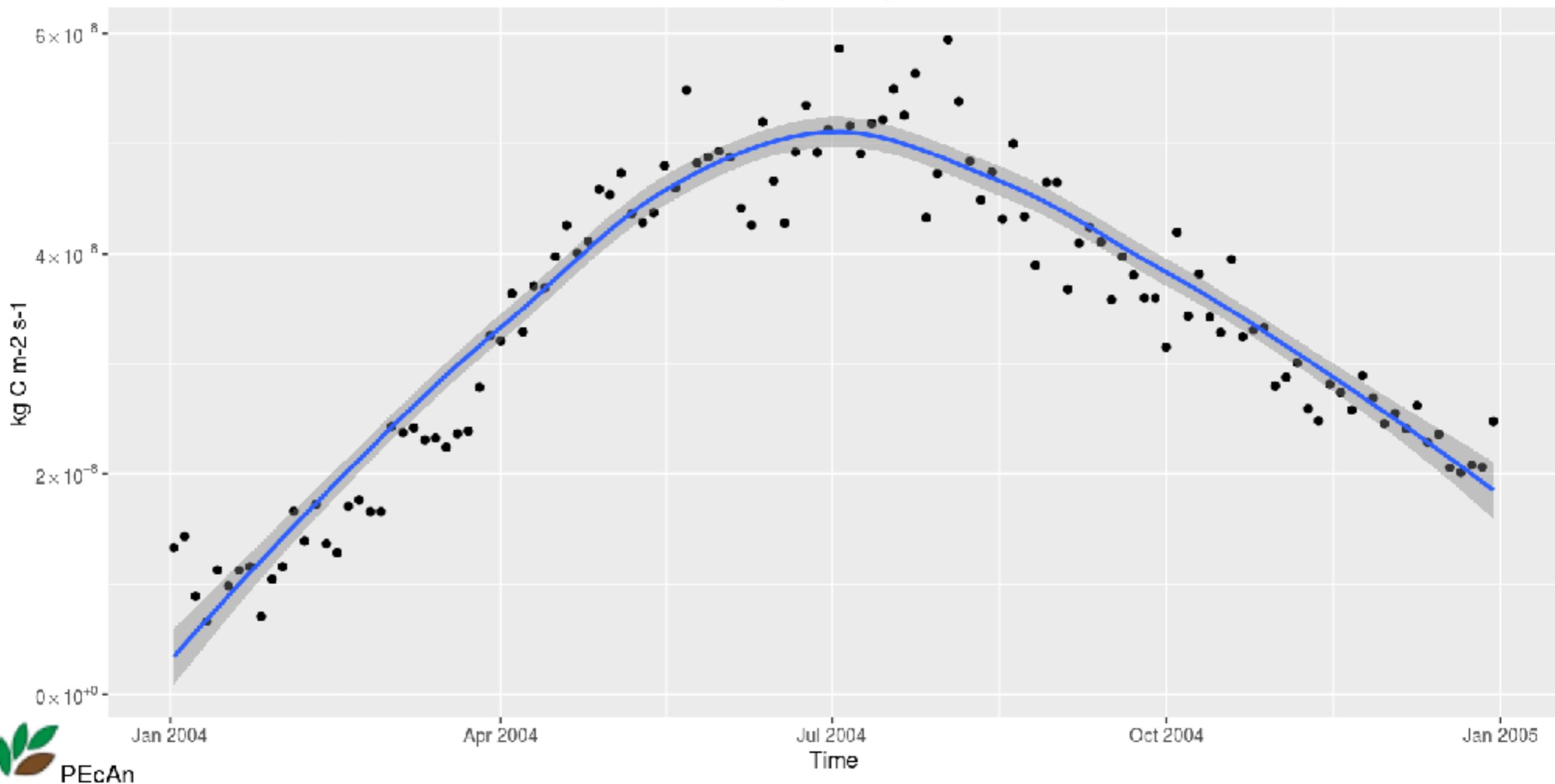
\* are required fields.

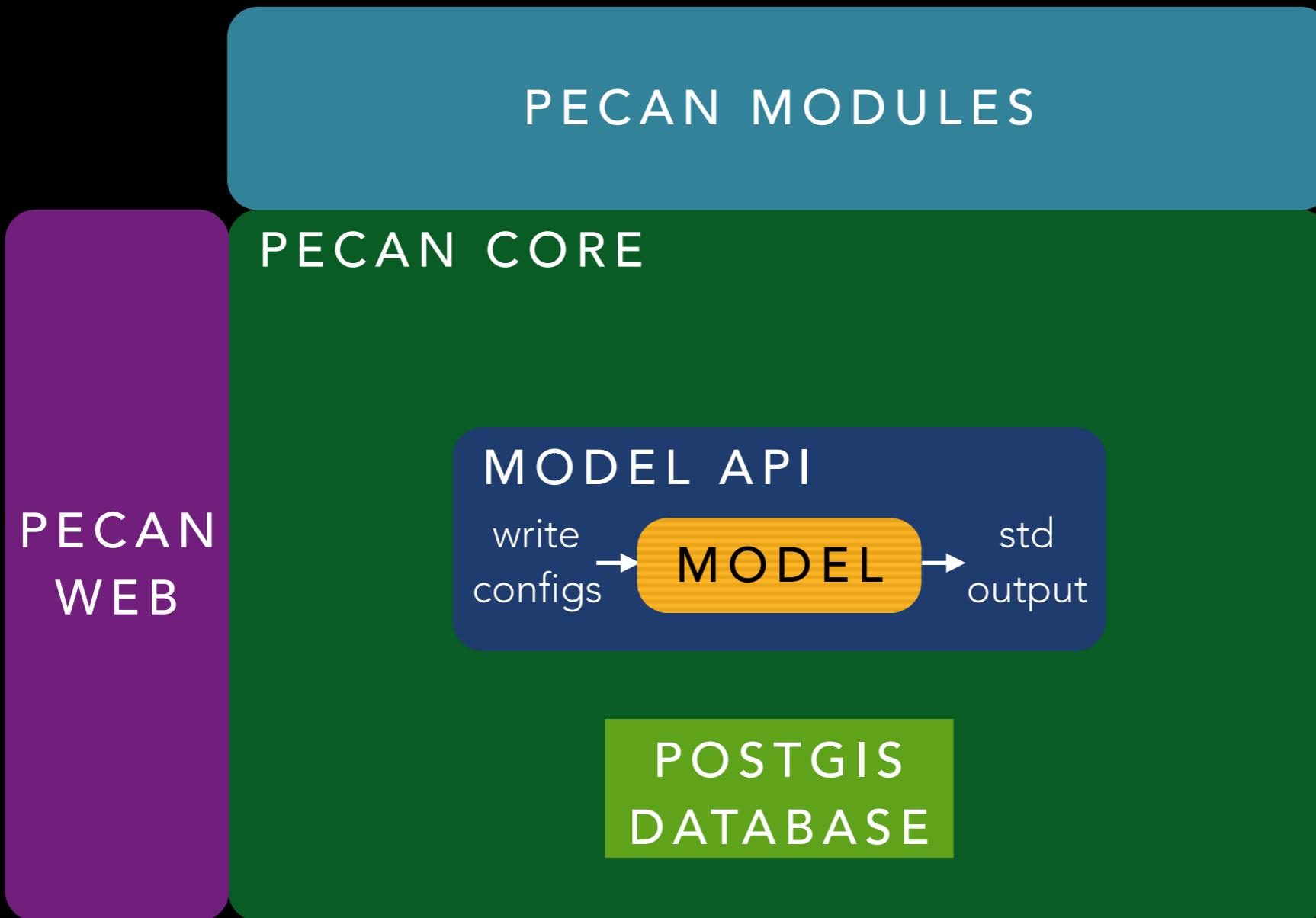
Prev

Next



### Autotrophic Respiration



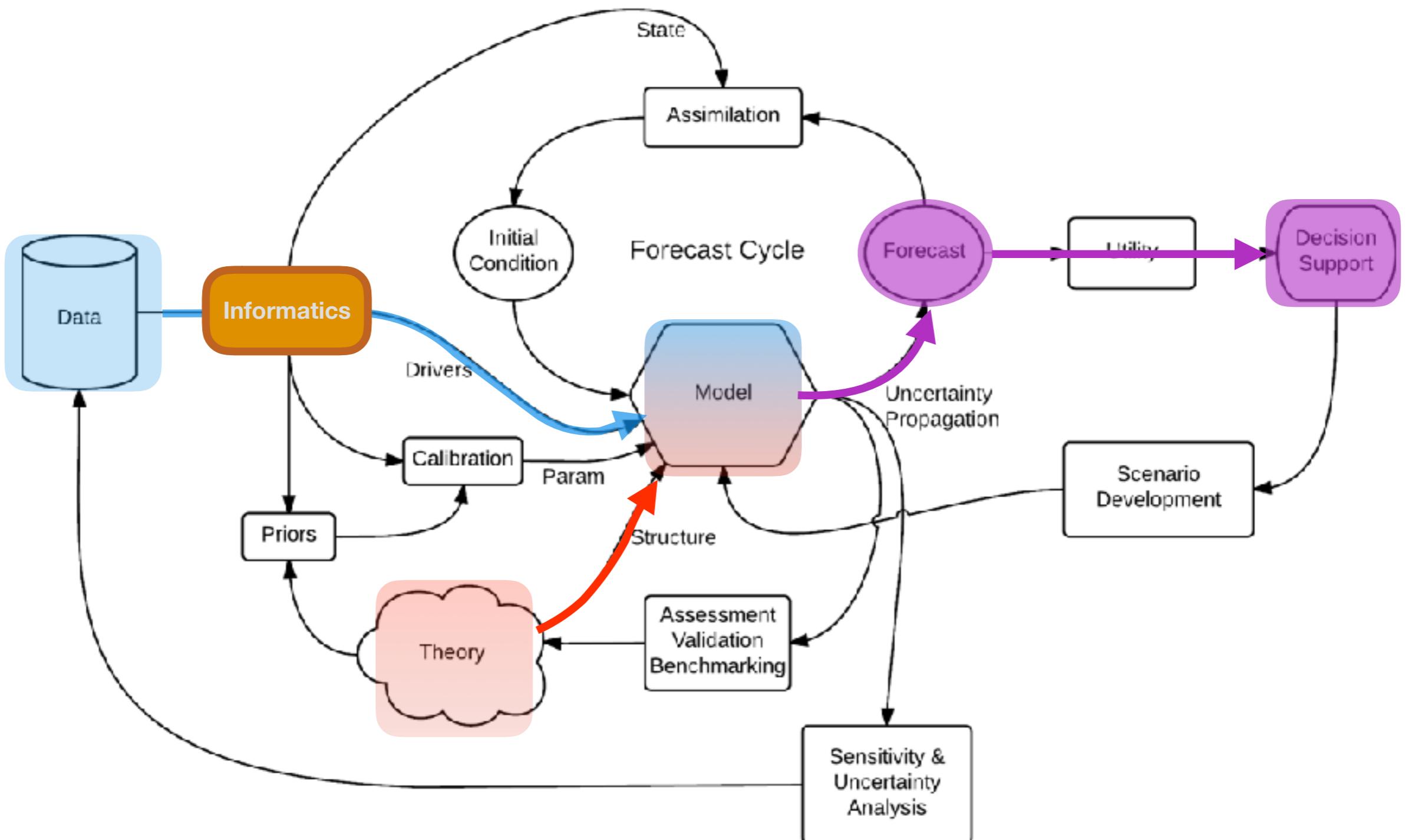


Standardized inputs and outputs

Provenance: Transparent & Repeatable

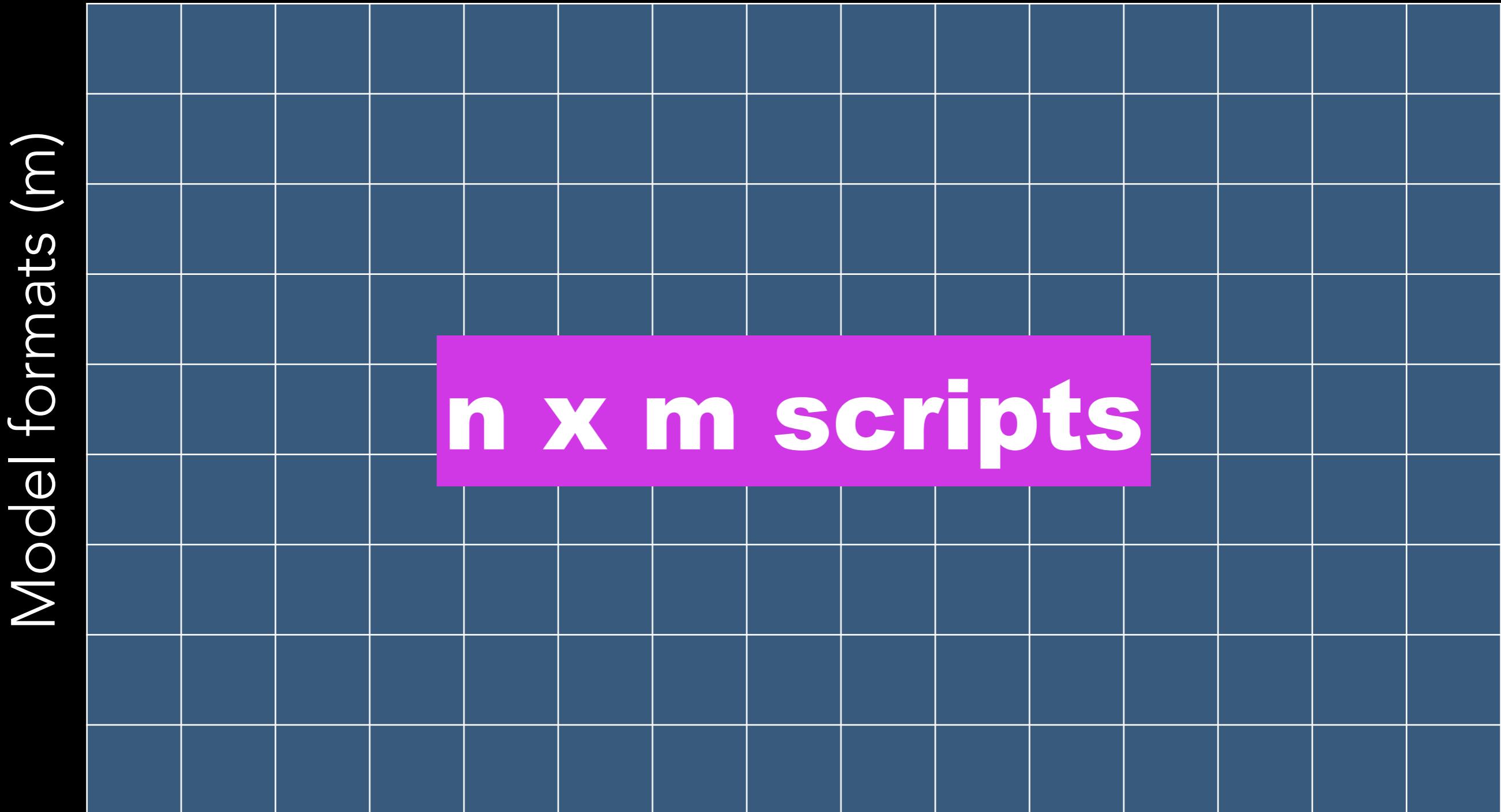
Accessible interface

Reusable tools for execution, analysis, visualization



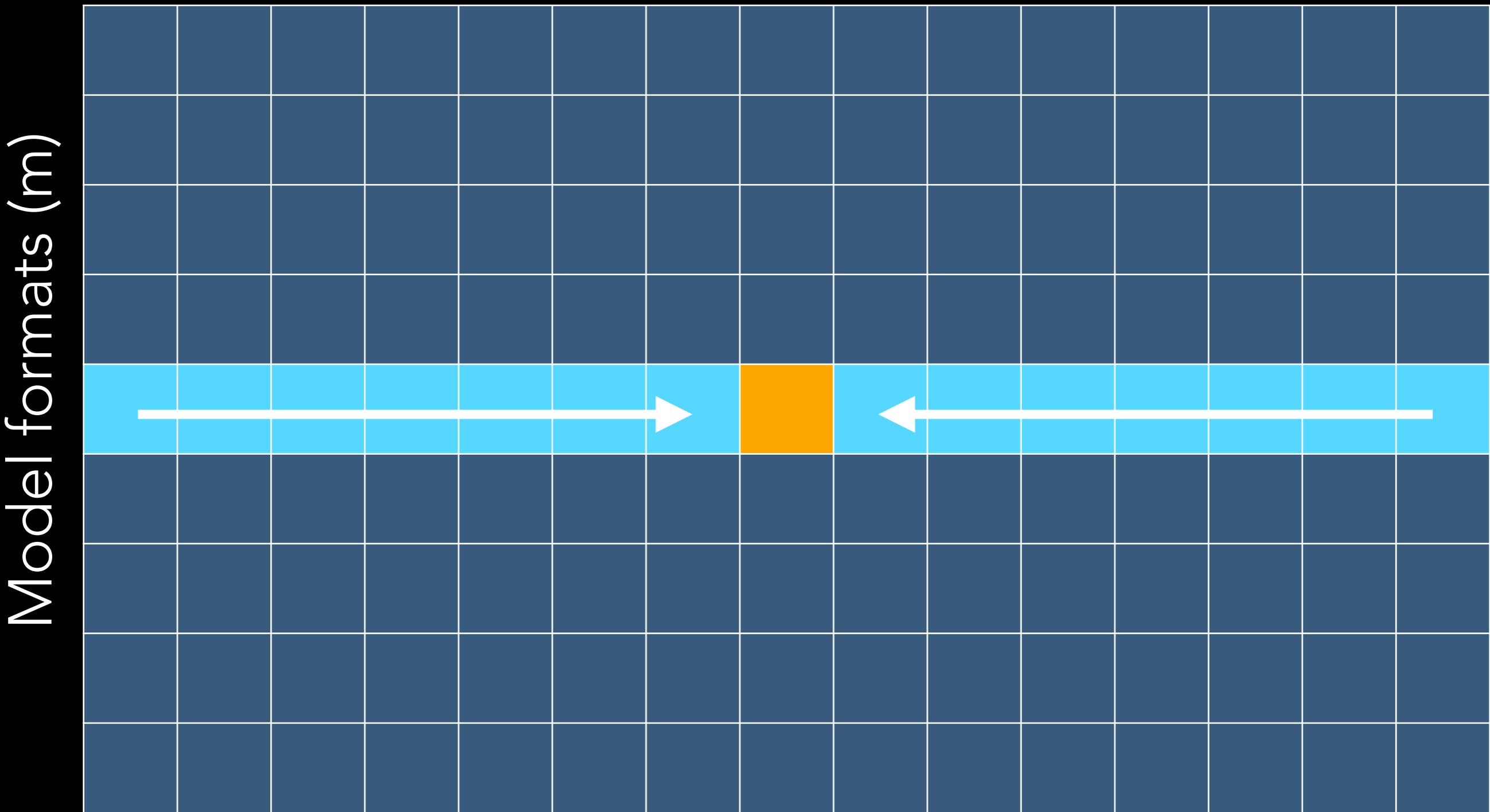
# INFORMATICS MODULES

Data formats (n)



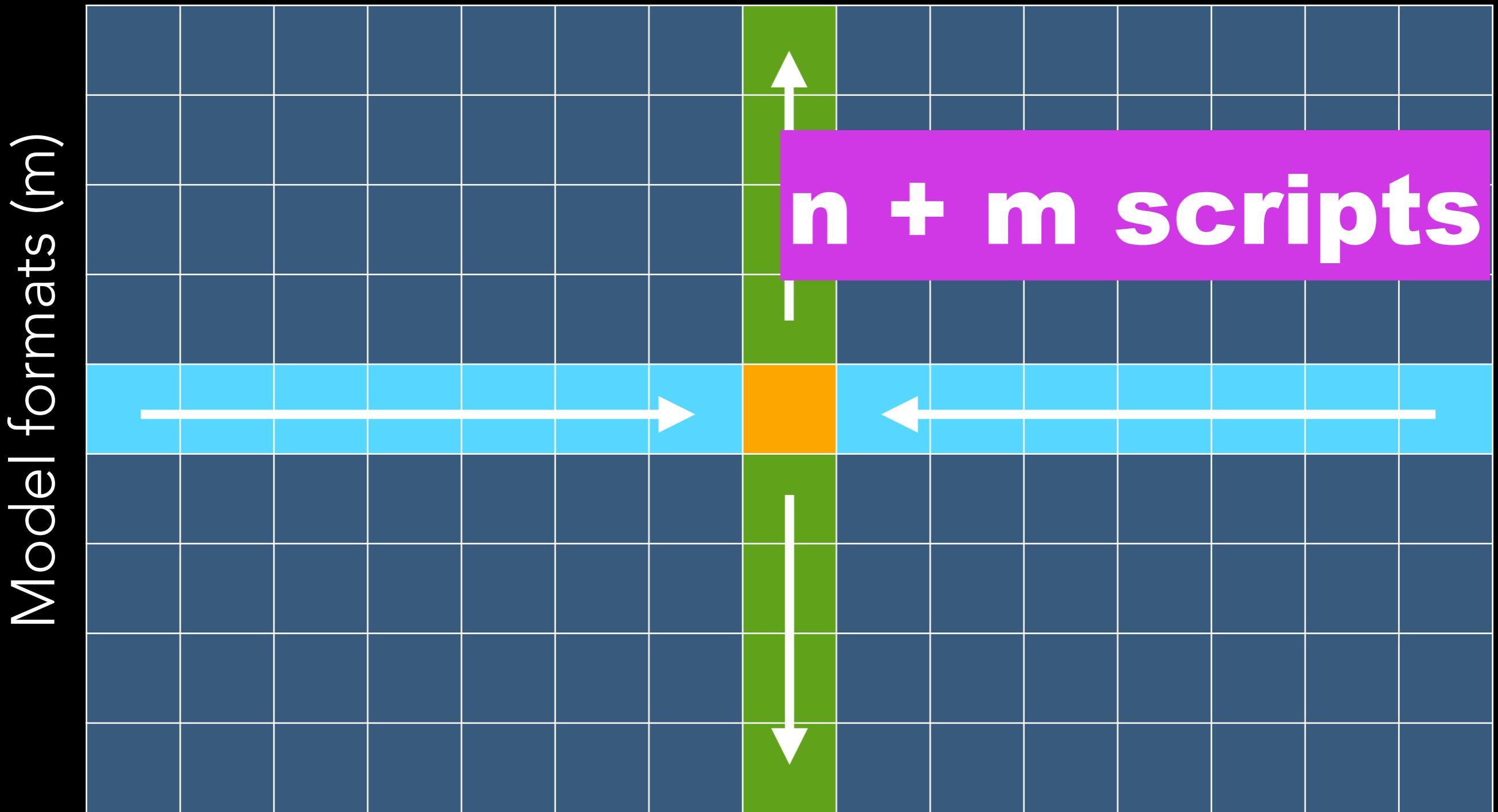
# INFORMATICS MODULES

Data formats (n)

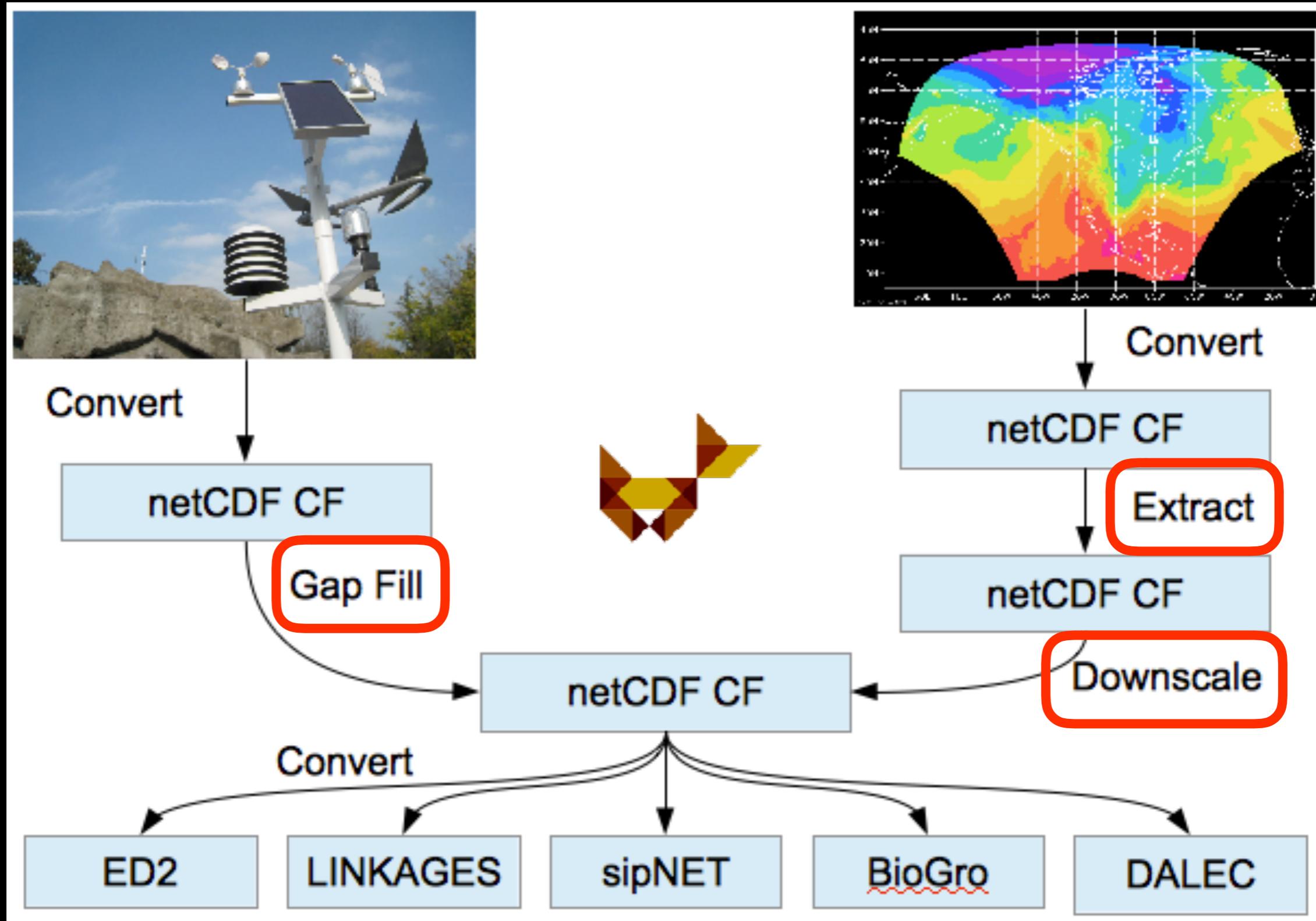


# INFORMATICS MODULES

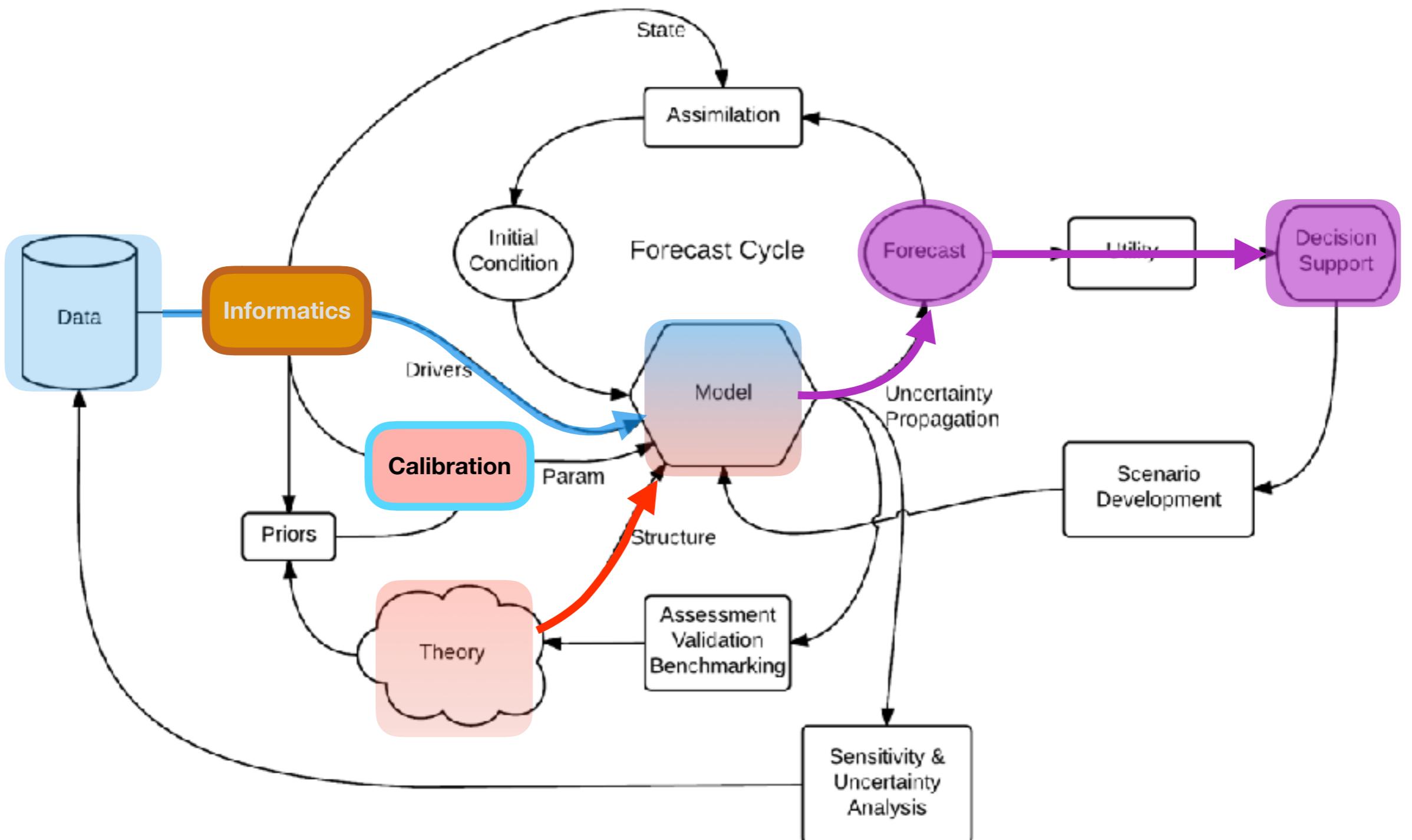
Data formats (n)



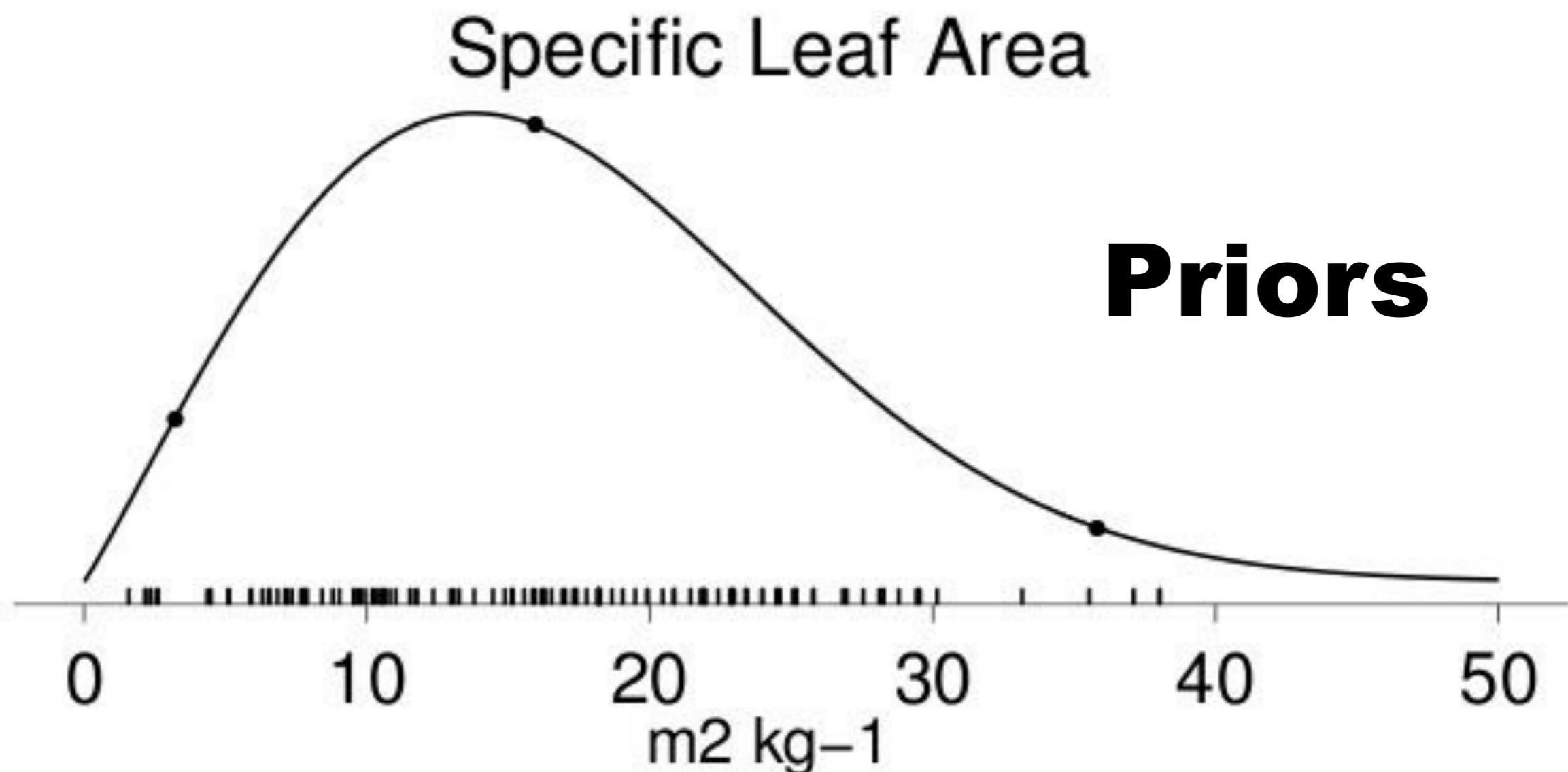
# INFORMATICS MODULES



Cowdery et al in prep



$$P(\theta|y) \propto P(y|\theta) P(\theta)$$



Data from Wright et al 2004, Graminoids

[Home](#)[Data](#)

25 records per page

Search:

## Viewing PFT

[\[+\] View Related Species](#)
[\[+\] View Related Priors](#)

Name	temp
Model Type	ED2
Definition	Late: ED's
Type	plant
Parent	
Clones	

[← All Records](#)
[Edit Record](#)

Citation	Variable	Phylogeny	Distribution Median, [95%CI]	Notes	Actions
<a href="#">Wright 2004 The world-wide leaf</a>	<a href="#">c2n_leaf - ratio</a>	herbs	gamma(6.7, 0.33) 19,[8,38] N= 379	estimated c2n_leaf from glopenet data by 48/leafN	
<a href="#">Wright 2004 The world-wide leaf</a>	<a href="#">c2n_leaf - ratio</a>	nitrogen fixer	gamma(11.18, 0.78) 14,[7.2,24] N= 39		
<a href="#">Wright 2004 The world-wide leaf</a>	<a href="#">leafN - percent</a>	nitrogen fixer	gamma(12.2, 3.34) 3.6,[1.9,6] N= 39		
<a href="#">LeBauer 2010 Unpublished Data...</a>	<a href="#">nonlocal_dispersal-fraction</a>	trees	beta(1.1, 1.5) 0.4,[0.024,0.92] N= 0		

## Listing species

Search:

Showing already related records

[Show only related results](#)

### Scientific Name

	<a href="#">edit</a>	<a href="#">Acer</a>
	<a href="#">edit</a>	<a href="#">Acer barbatum</a>
	<a href="#">edit</a>	<a href="#">Acer grandidentatum</a>
	<a href="#">edit</a>	<a href="#">Acer leucoderme</a>
	<a href="#">edit</a>	<a href="#">Acer negundo</a>
	<a href="#">edit</a>	<a href="#">Acer nigrum</a>
	<a href="#">edit</a>	<a href="#">Acer pensylvanicum</a>
	<a href="#">edit</a>	<a href="#">Acer platanoides</a>
	<a href="#">edit</a>	<a href="#">Acer rubrum</a>
	<a href="#">edit</a>	<a href="#">Acer saccharinum</a>
	<a href="#">edit</a>	<a href="#">Acer saccharum</a>
	<a href="#">edit</a>	<a href="#">Acer spicatum</a>
	<a href="#">edit</a>	<a href="#">Aesculus</a>

Search

Showing

Show c

X

X

X

X

X

X

X

X

X

[Use this record](#)

Feedback

Trait	Species	Cultivar	Mean	Statistics	Citation	Site	Treatment	QA/QC	Access Level	Actions
Amax - umol CO <sub>2</sub> m <sup>-2</sup> s <sup>-1</sup>	Acer saccharum		5.5726		Thomas 2010 Photosynthetic capac...	Haliburton Forest and Wildlife - Ontario, CA	observational : no experimental data - Thomas 2010	unchecked	4.Public	  
Amax - umol CO <sub>2</sub> m <sup>-2</sup> s <sup>-1</sup>	Acer saccharum		6.5473		Thomas 2010 Photosynthetic capac...	Haliburton Forest and Wildlife -	observational : no experimental data -	unchecked	4.Public	  
Amax - umol CO <sub>2</sub> m <sup>-2</sup> s <sup>-1</sup>	Acer saccharum									

# Tree Physiology

Article Navigation

## Photosynthetic capacity peaks at intermediate size in temperate deciduous trees

Sean C. Thomas

Tree Physiol (2010) 30 (5): 555-573. DOI: <https://doi.org/10.1093/treephys/tpq005>

Published: 23 March 2010 Article history ▾

 Views ▾ PDF Cite Permissions Share ▾

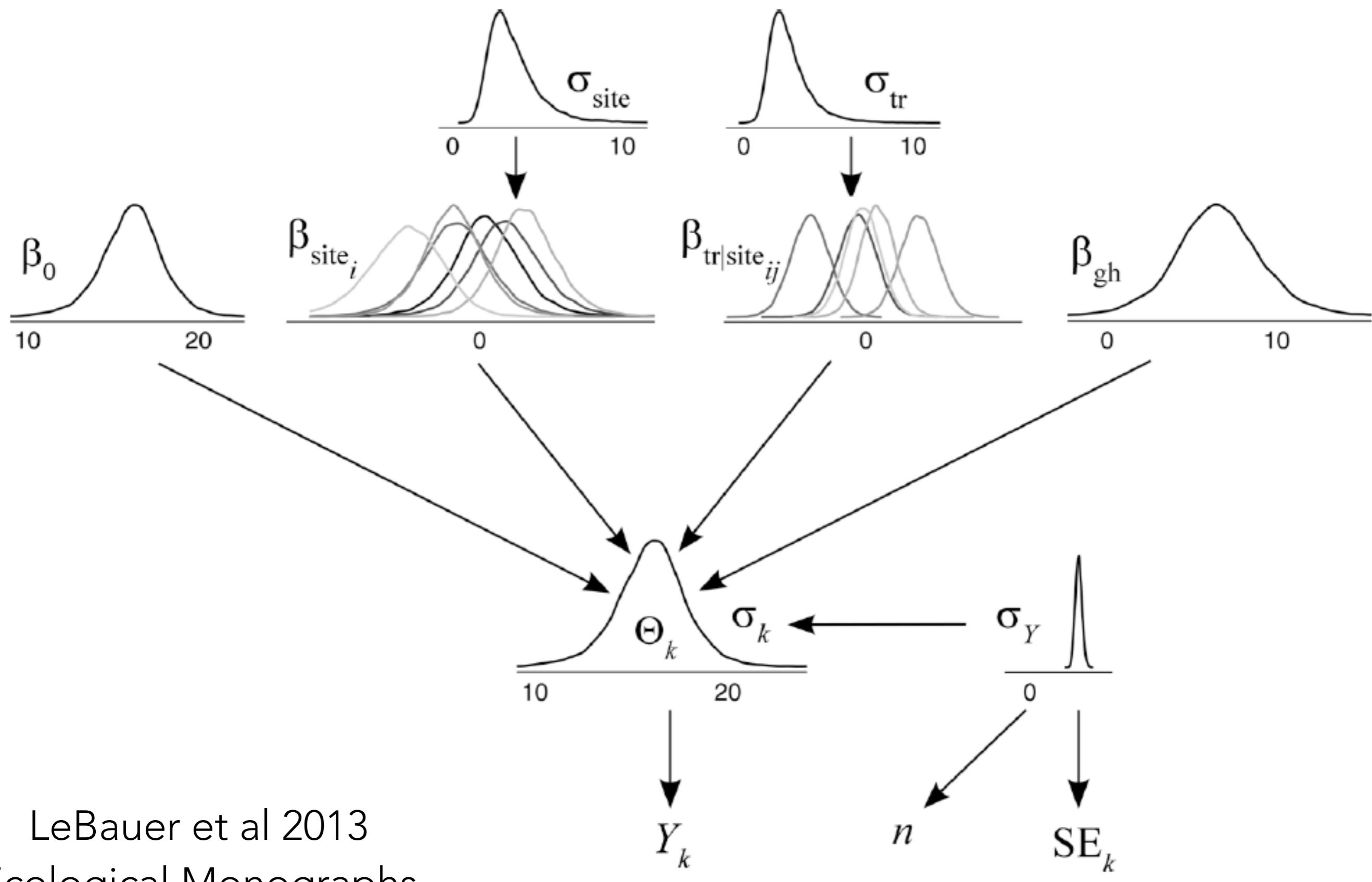
### Abstract

Studies of age-related changes in leaf functional biology have generally been based on dichotomous comparisons of young and mature individuals (e.g., saplings and mature

Record Creator Chloe Mattia

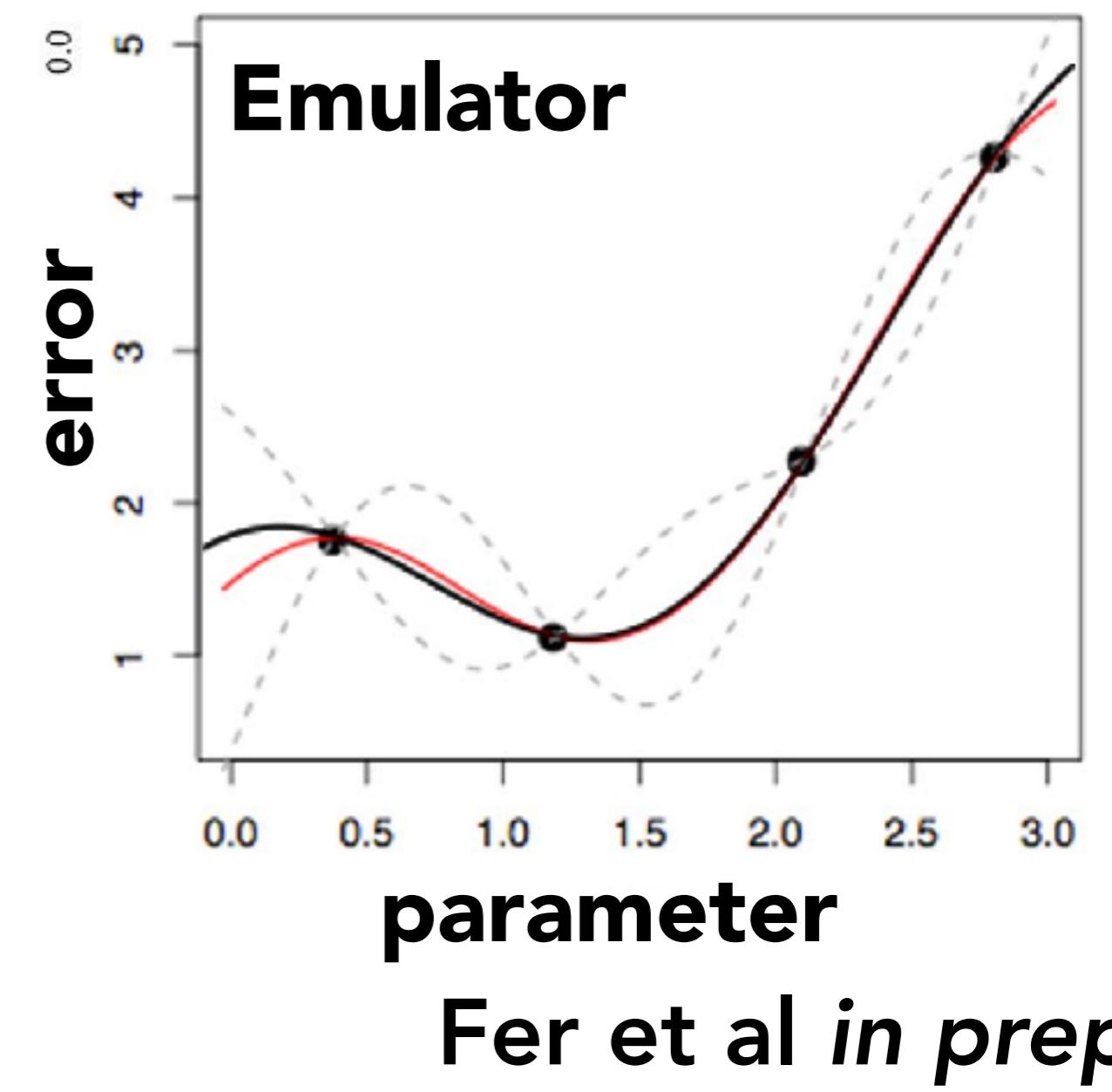
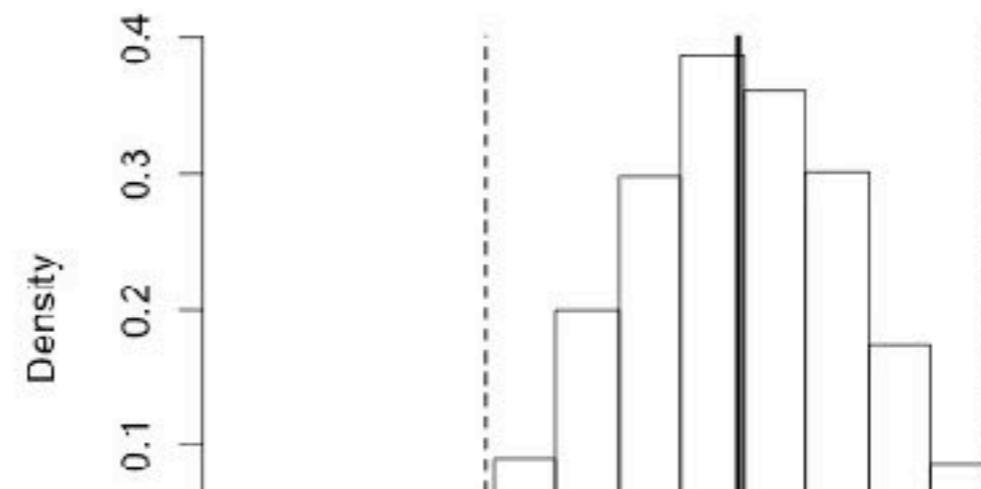
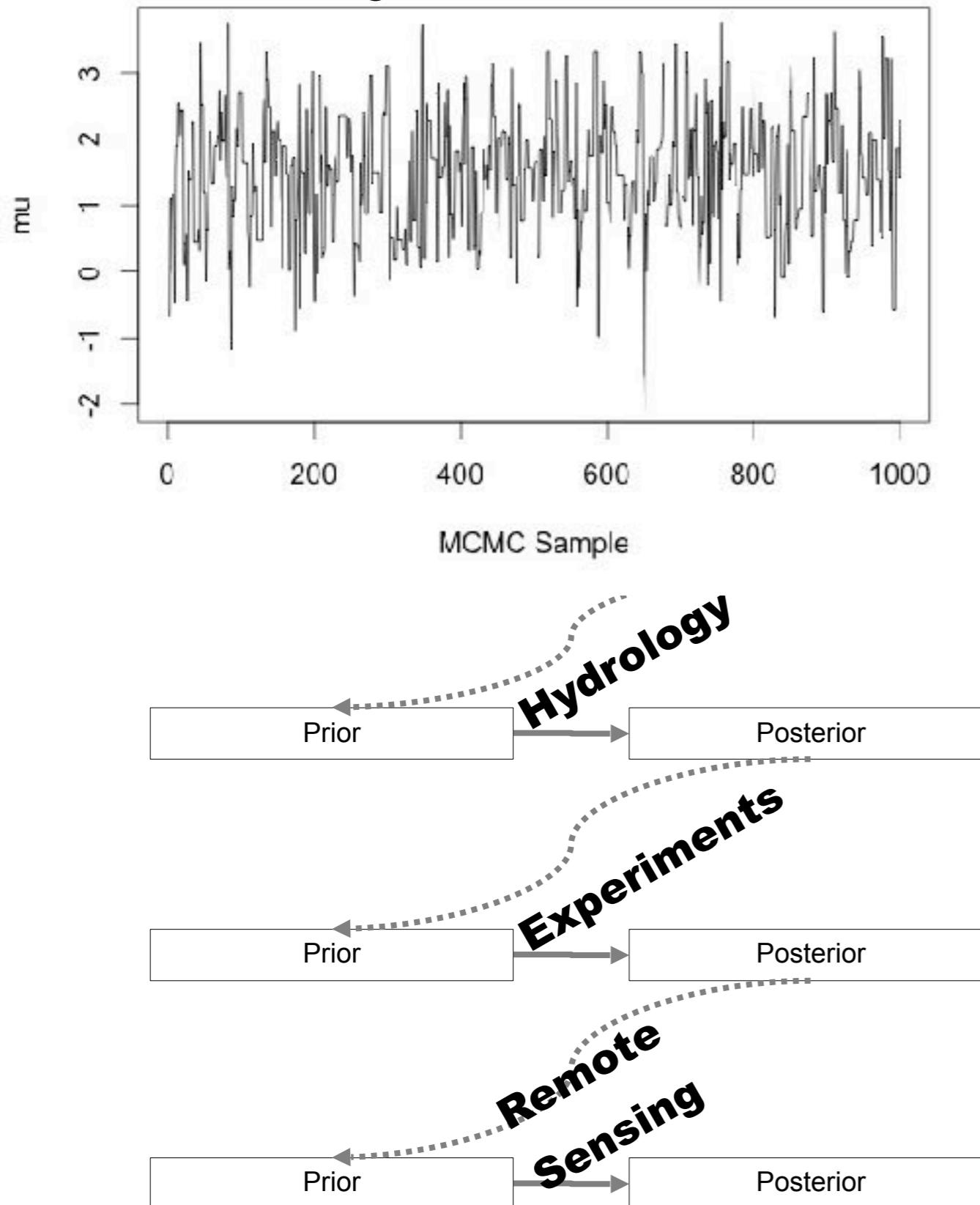
[All Records](#)[Edit Record](#)

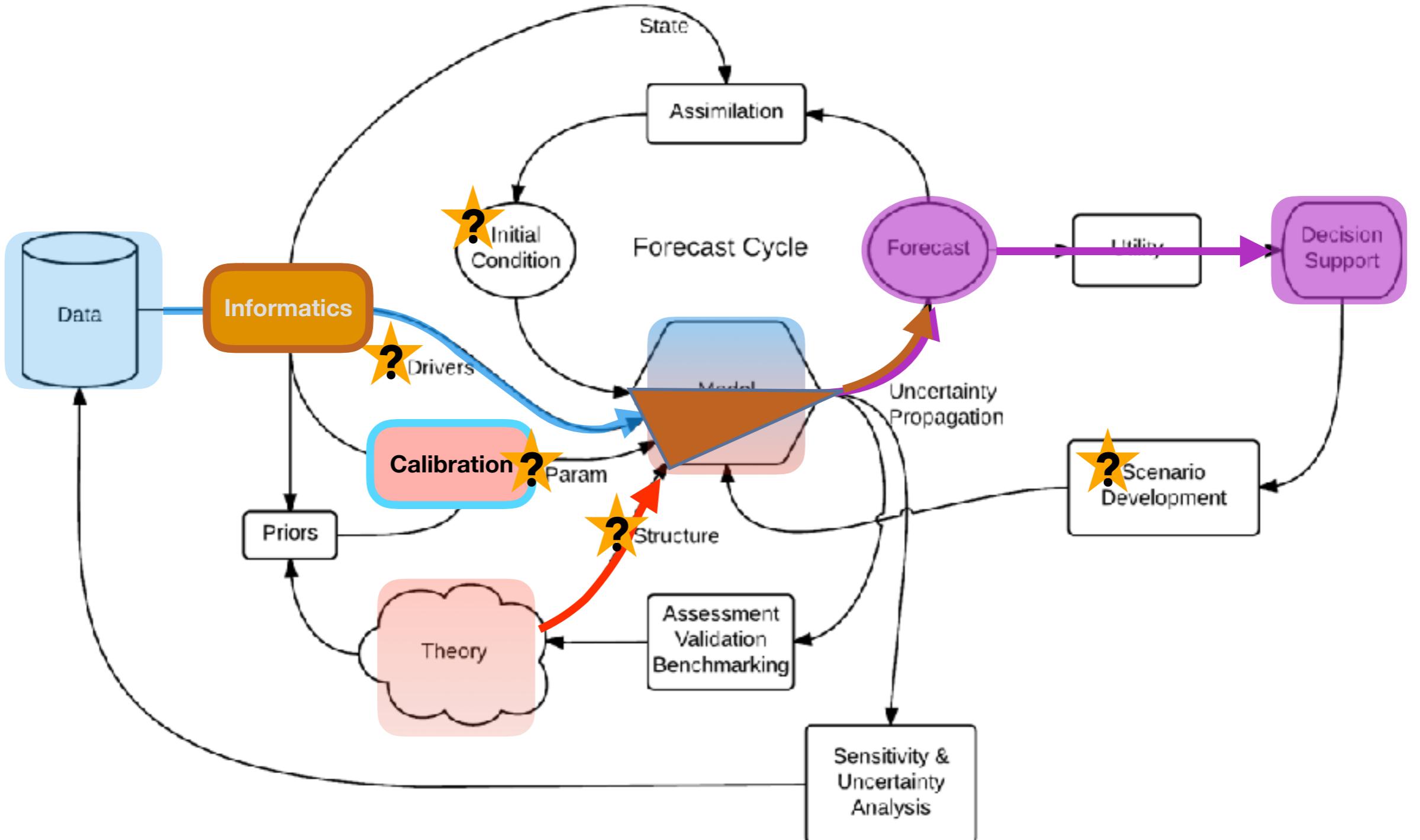
# Trait Meta-analysis



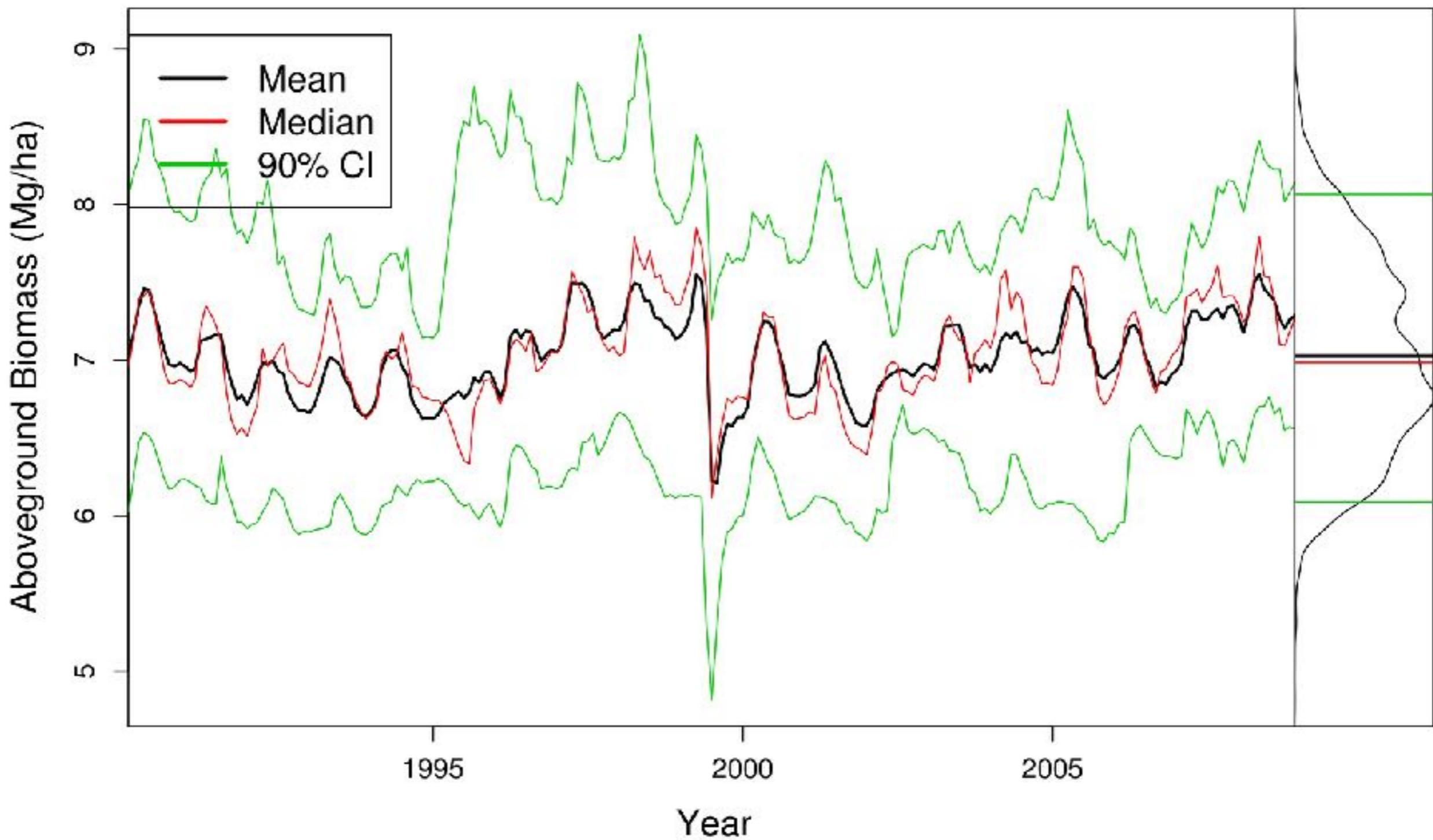
LeBauer et al 2013  
Ecological Monographs

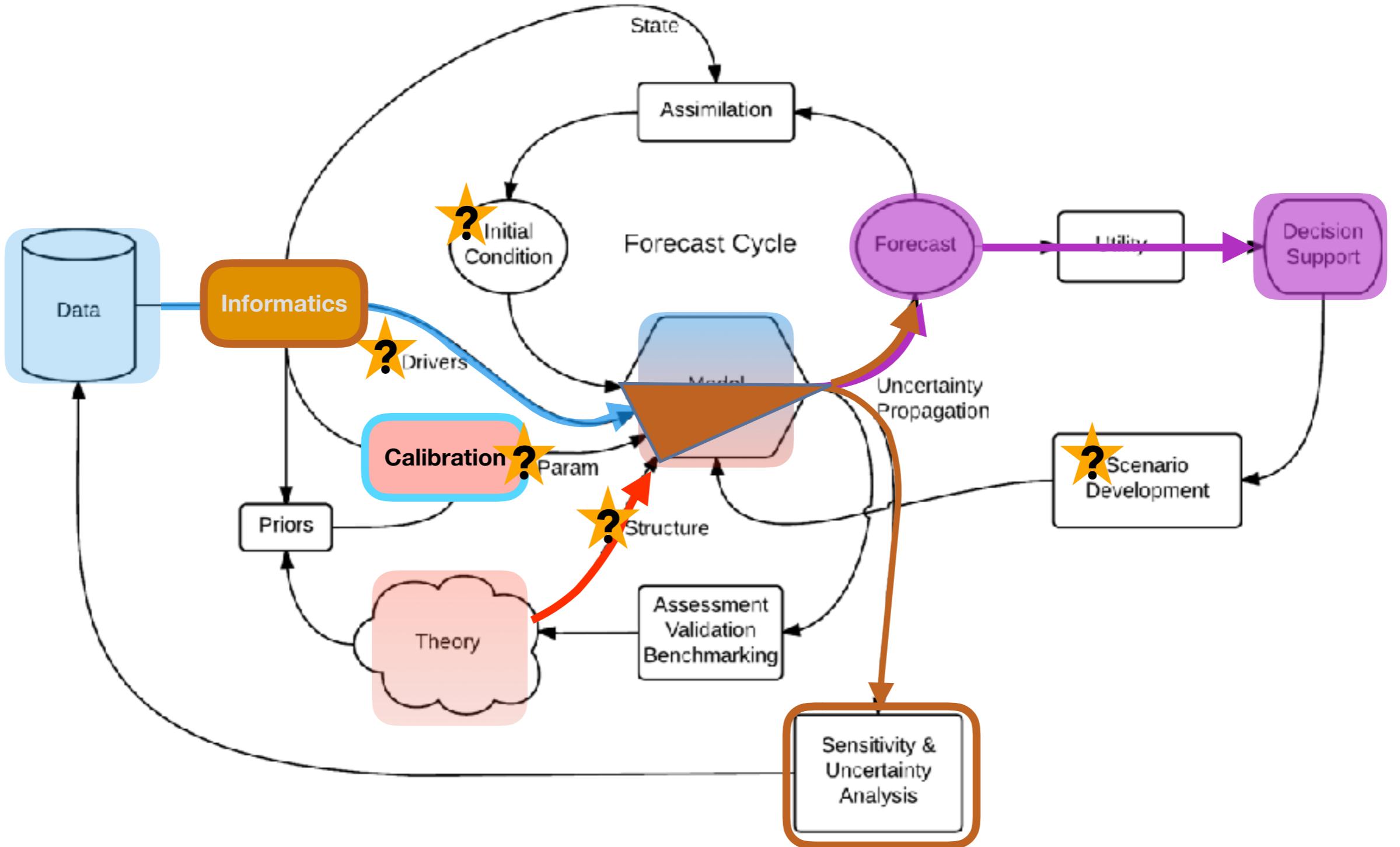
# Bayesian Parameter Calibration

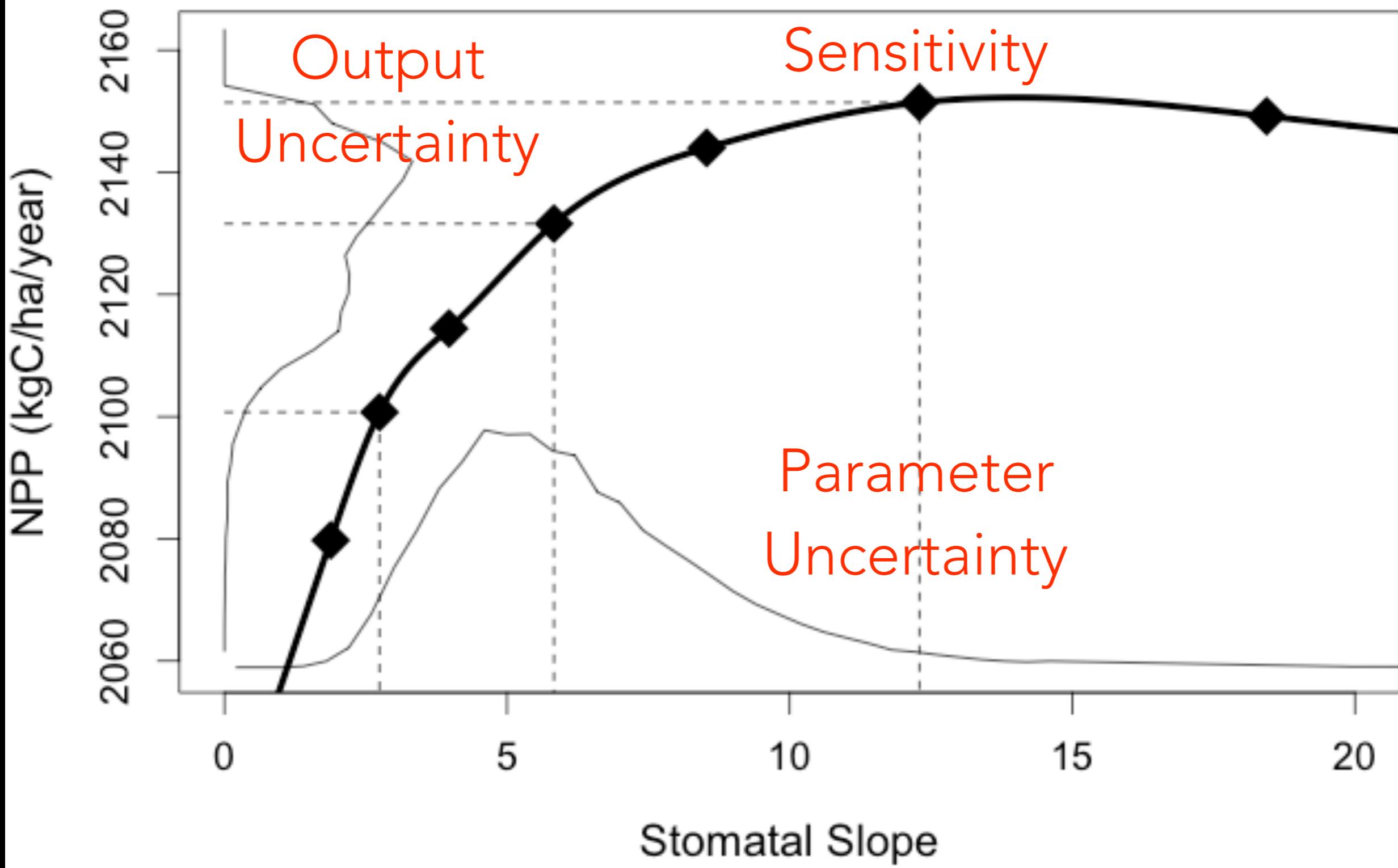




# Ensemble Estimate

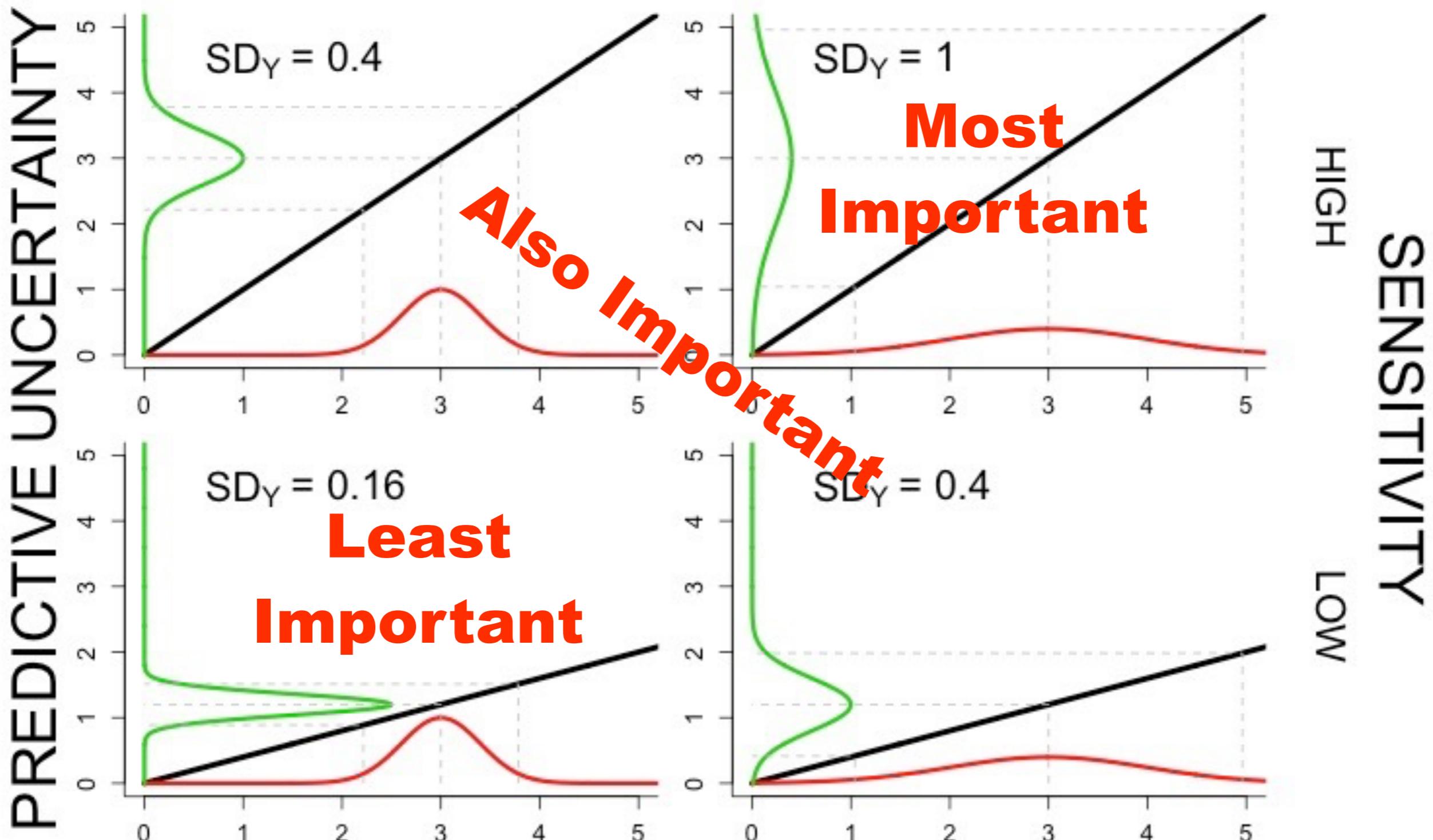






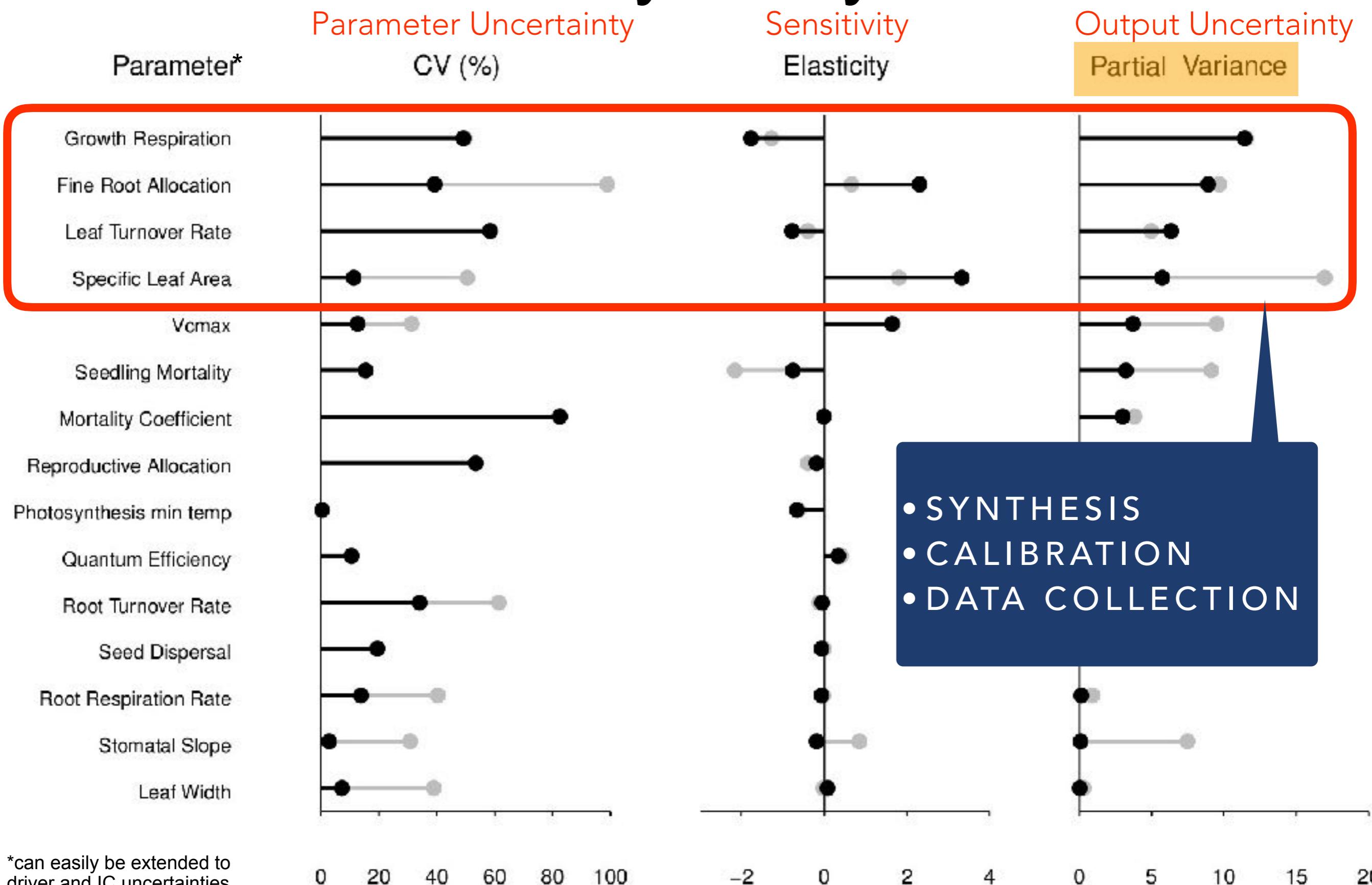
# PARAMETER UNCERTAINTY

LOW HIGH

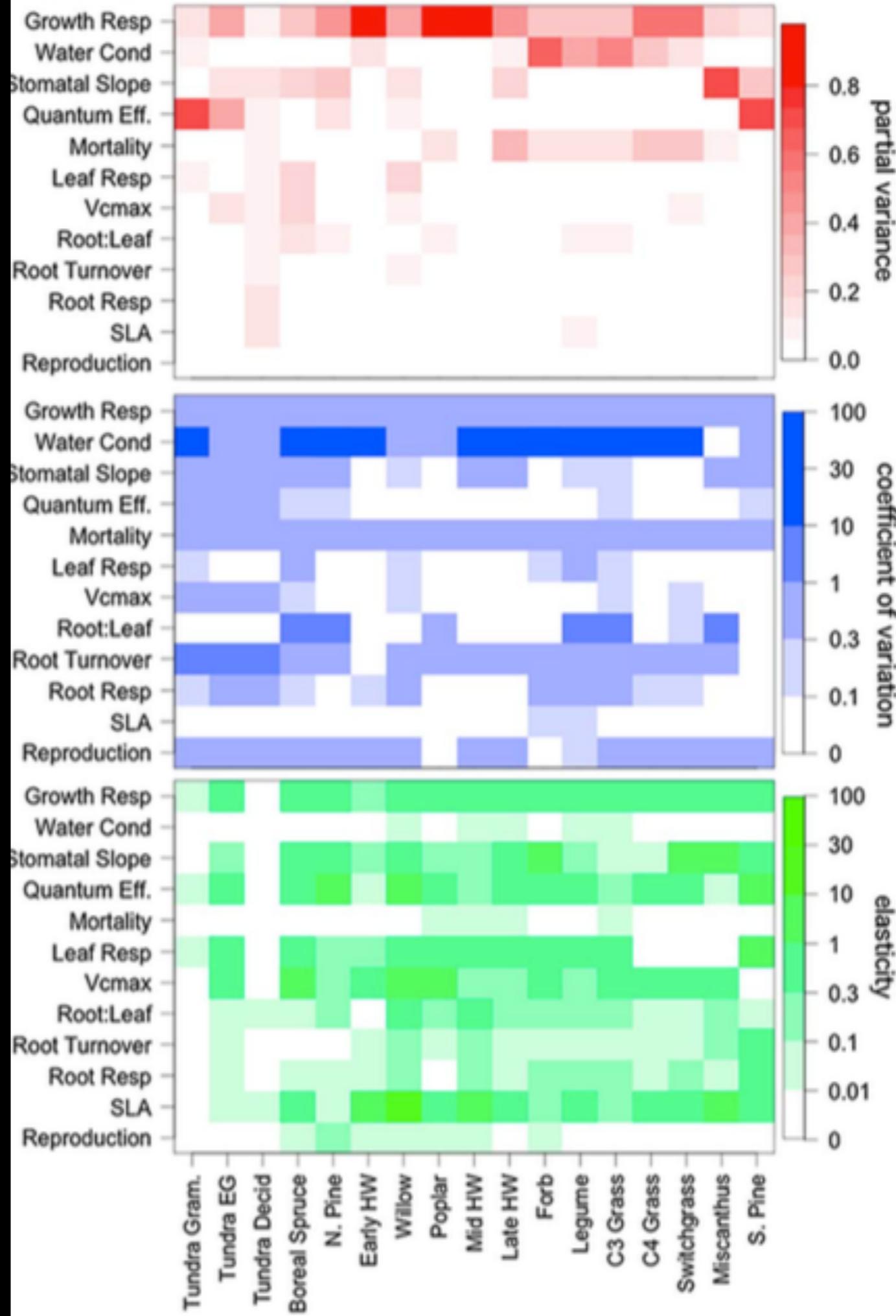


# Uncertainty Analysis

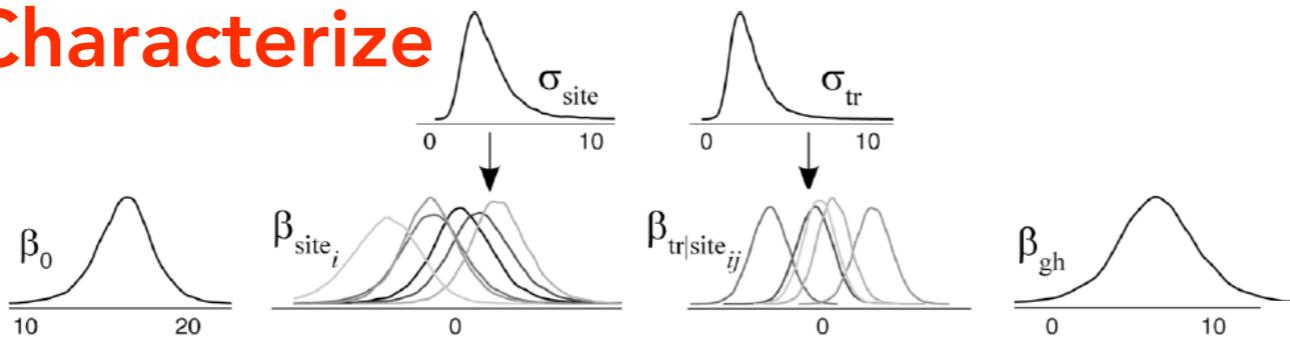
Prior  
Posterior



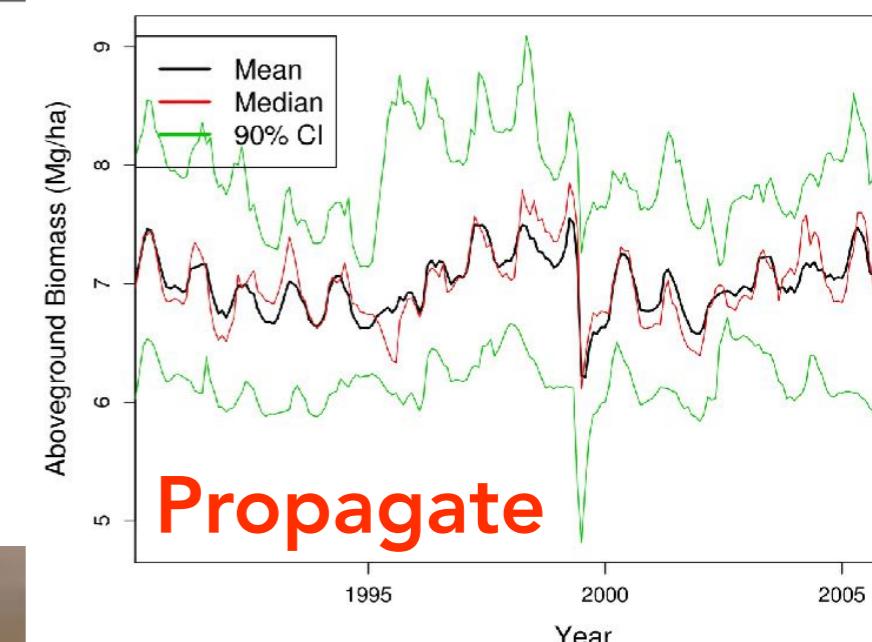
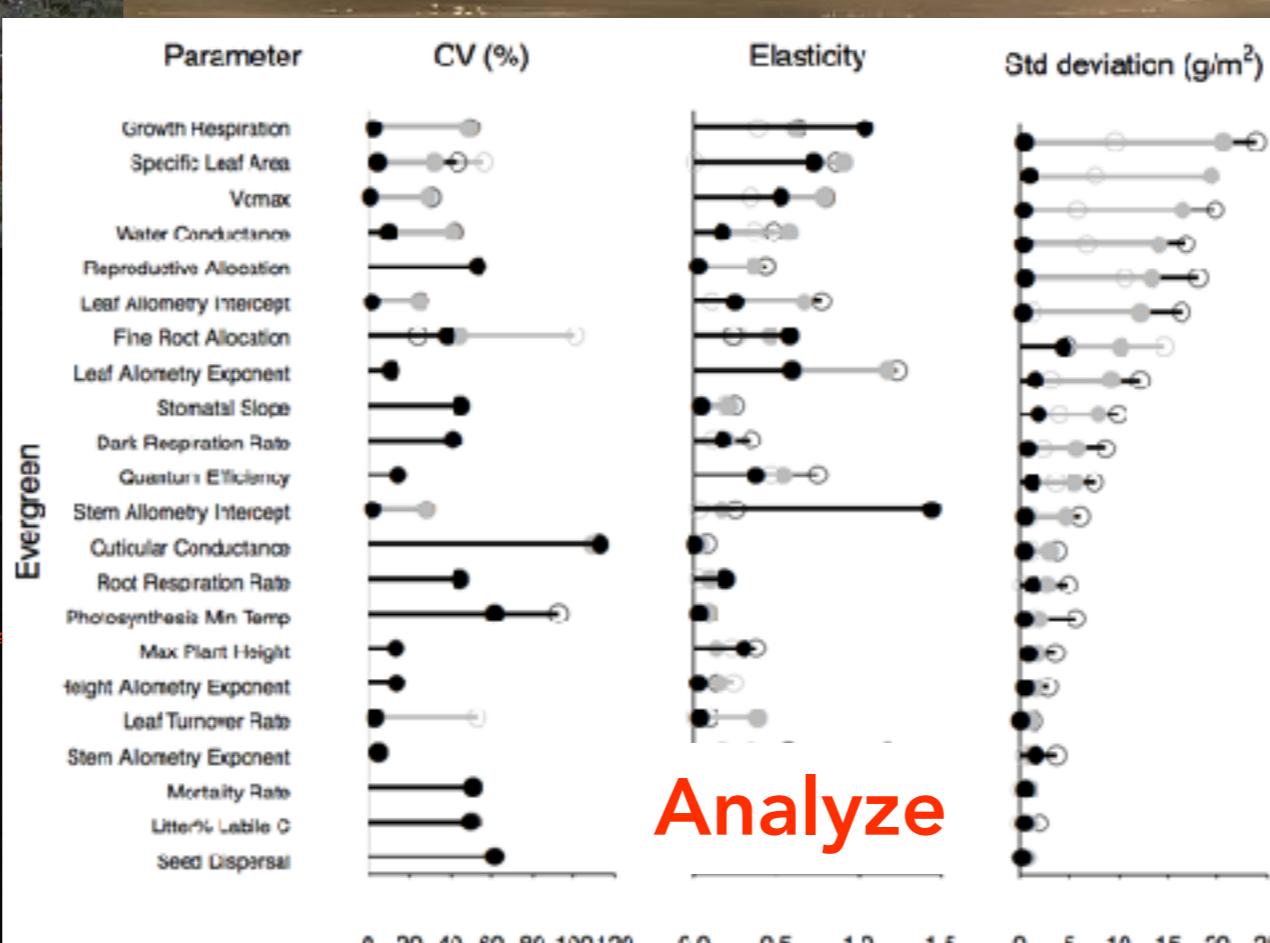
- Growth Respiration: sensitivity
- Root water uptake: data deficient
- Stomatal conductance:
  - Conif: sensitivity increases North -> South
  - Hardwood: var in data
- Quantum Efficiency: data deficient at high lat.

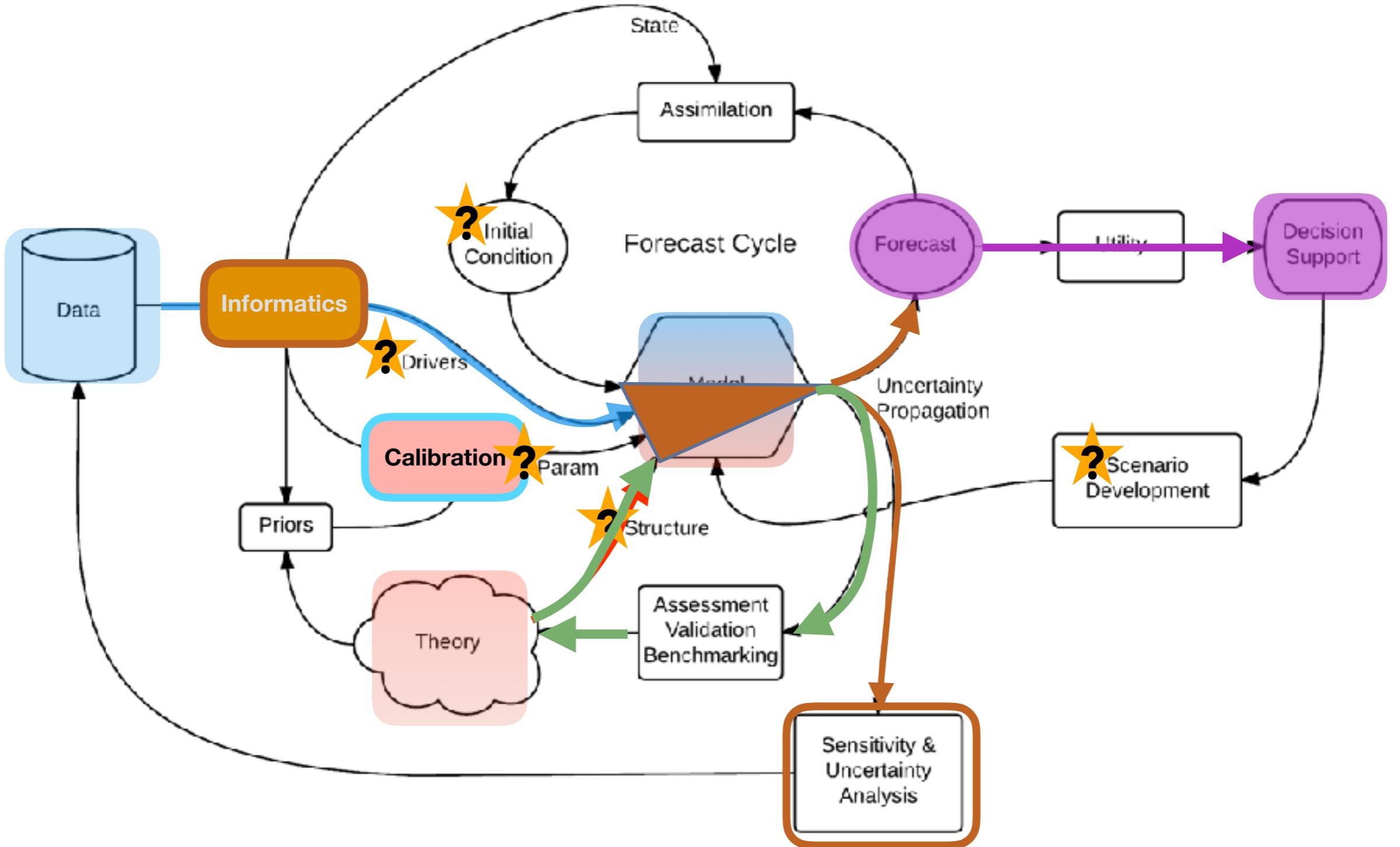


# Characterize

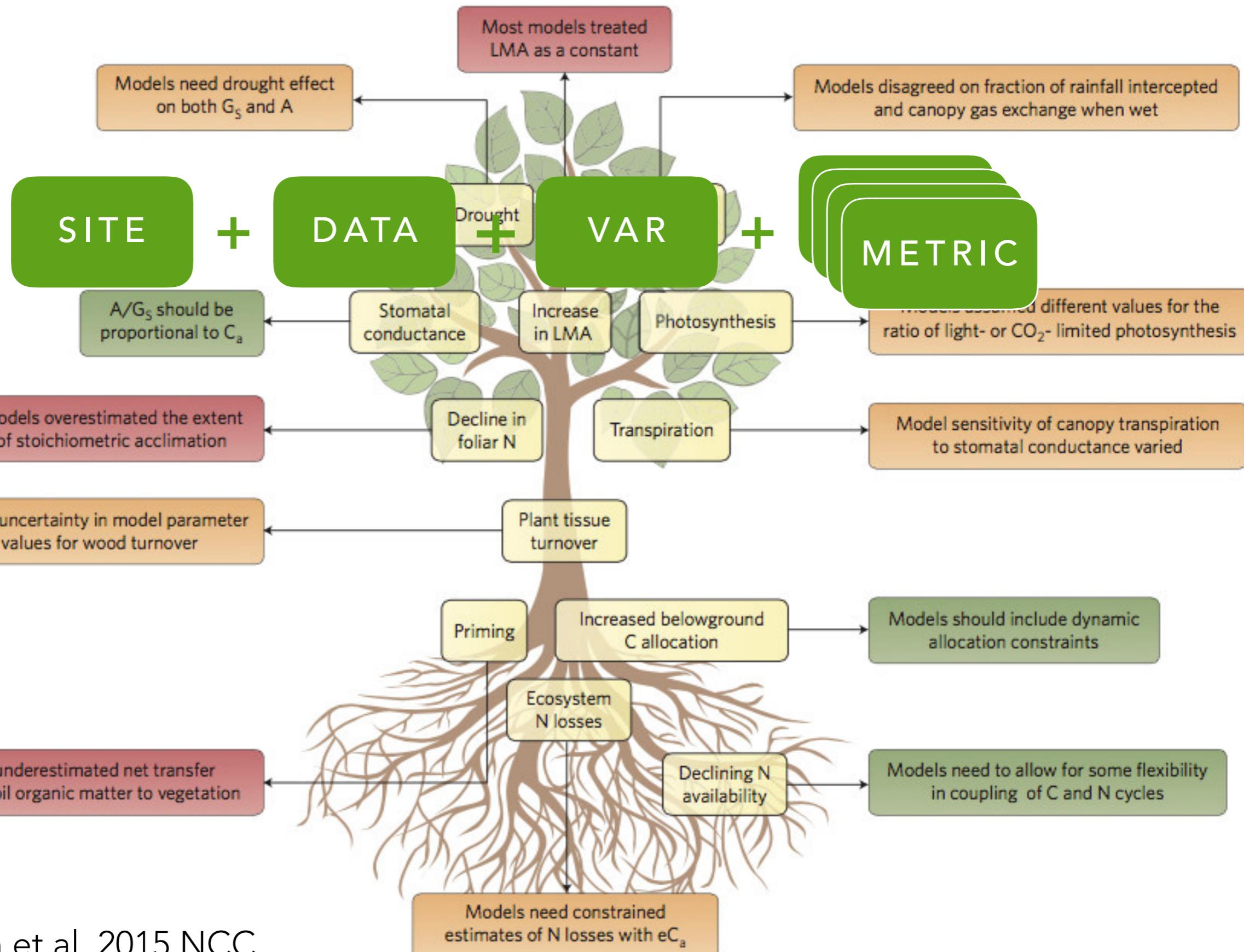
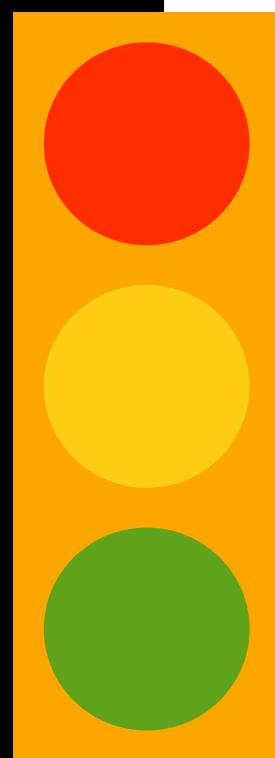


Reduce

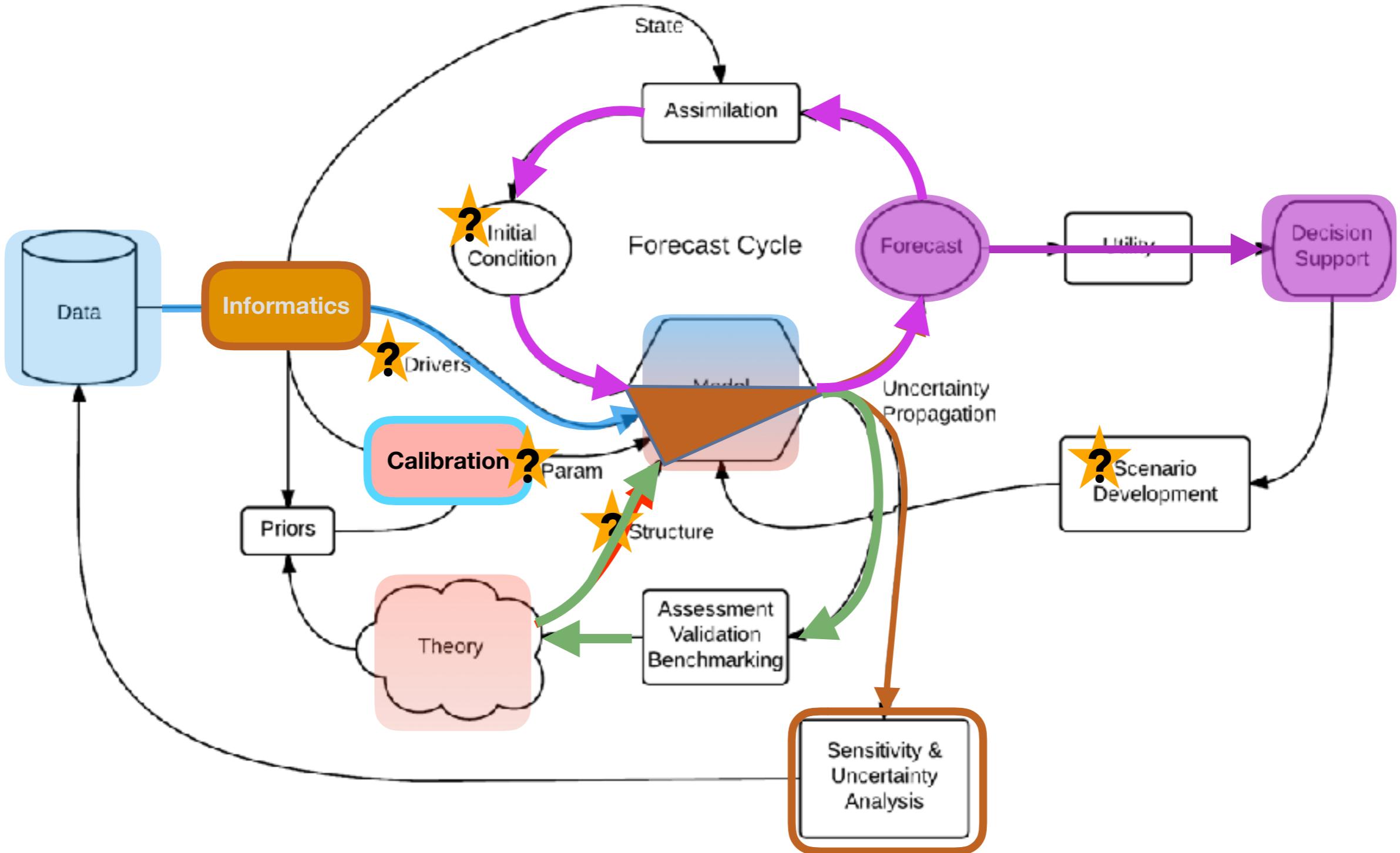




# BENCHMARKING



WHAT OBSERVATIONS  
DO MODELS NEED TO  
REPLICATE?



# FORECAST CYCLE

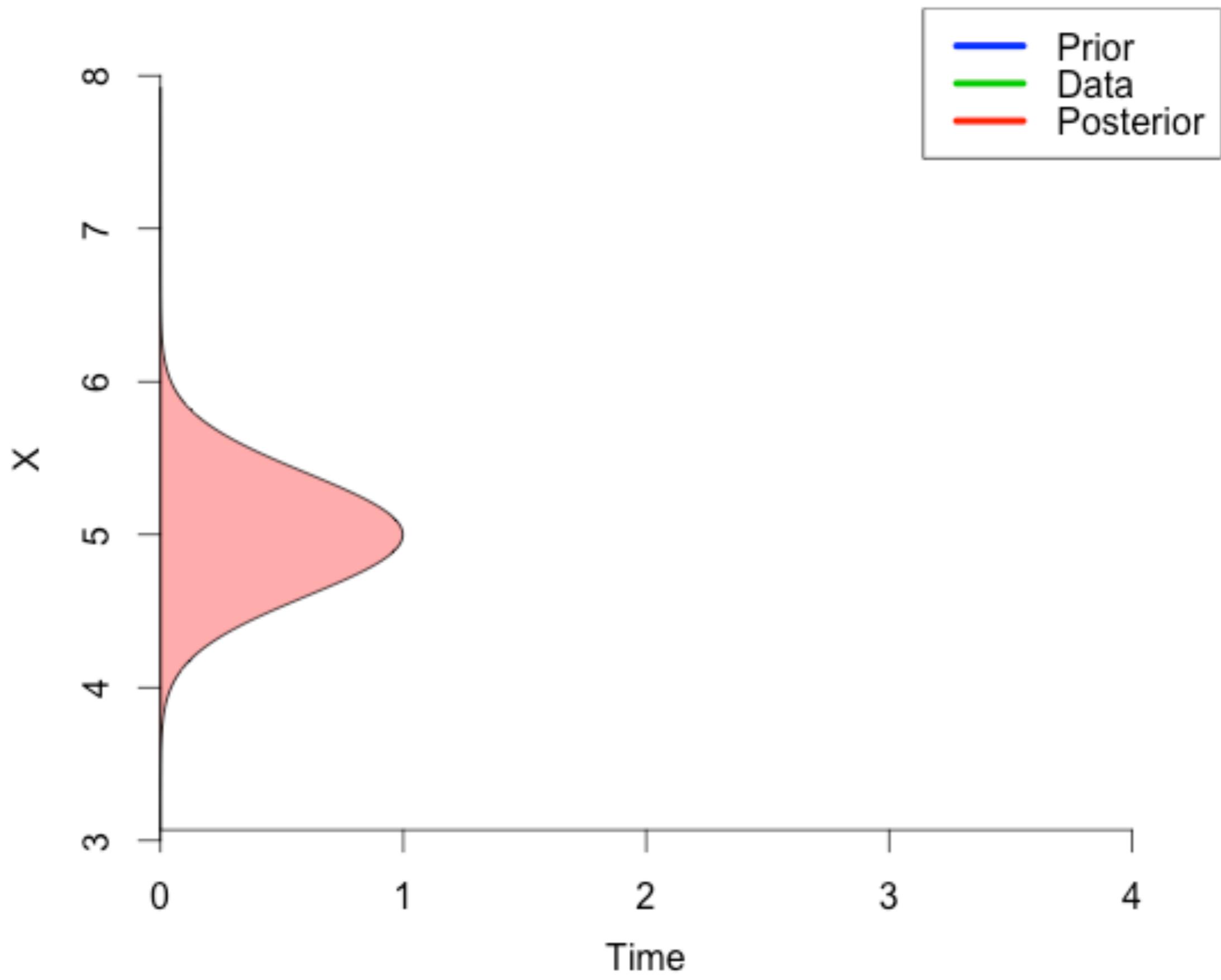
*Forecasts should be updated when new data becomes available*

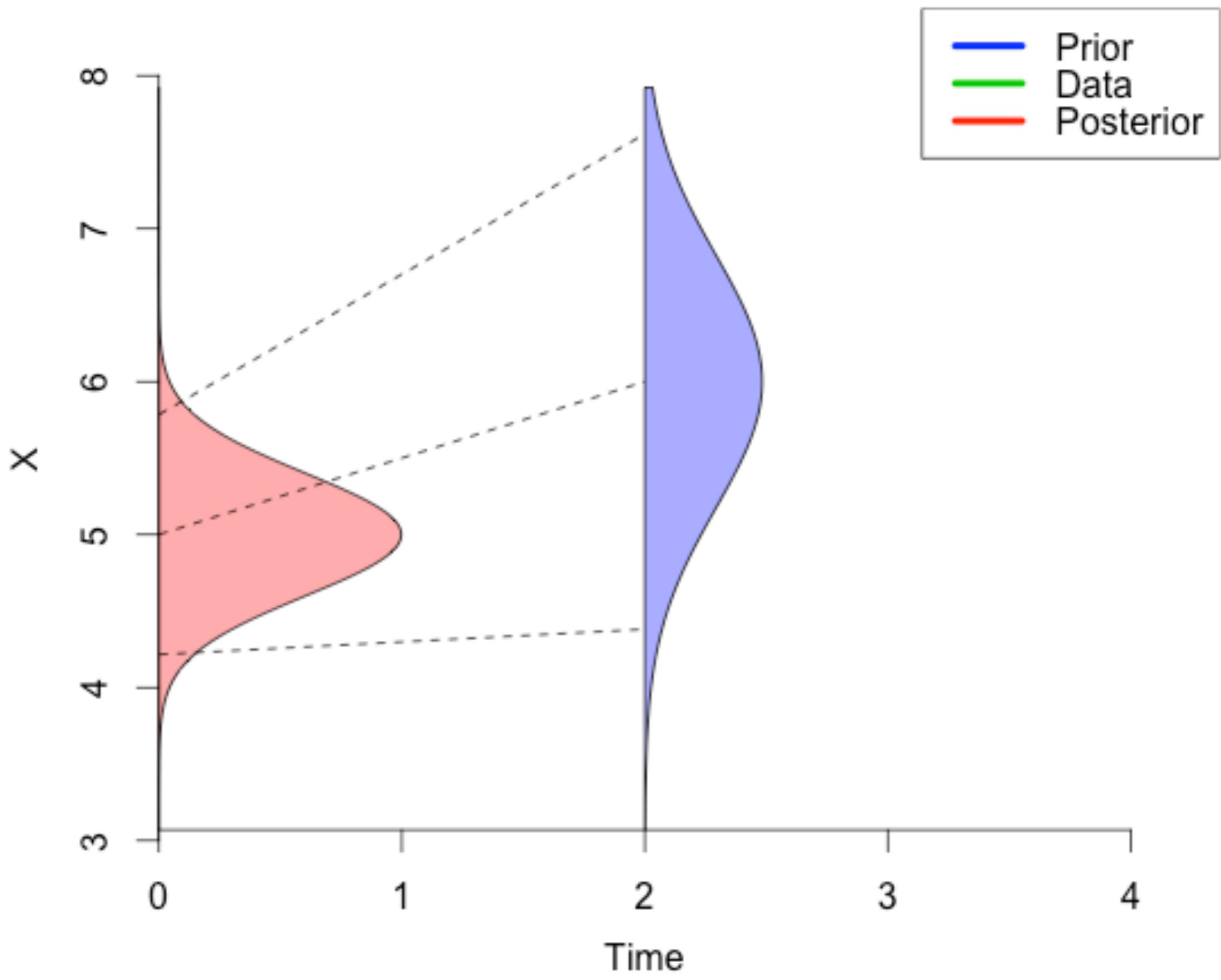
$$P(\theta|y) \propto P(y|\theta) P(\theta)$$

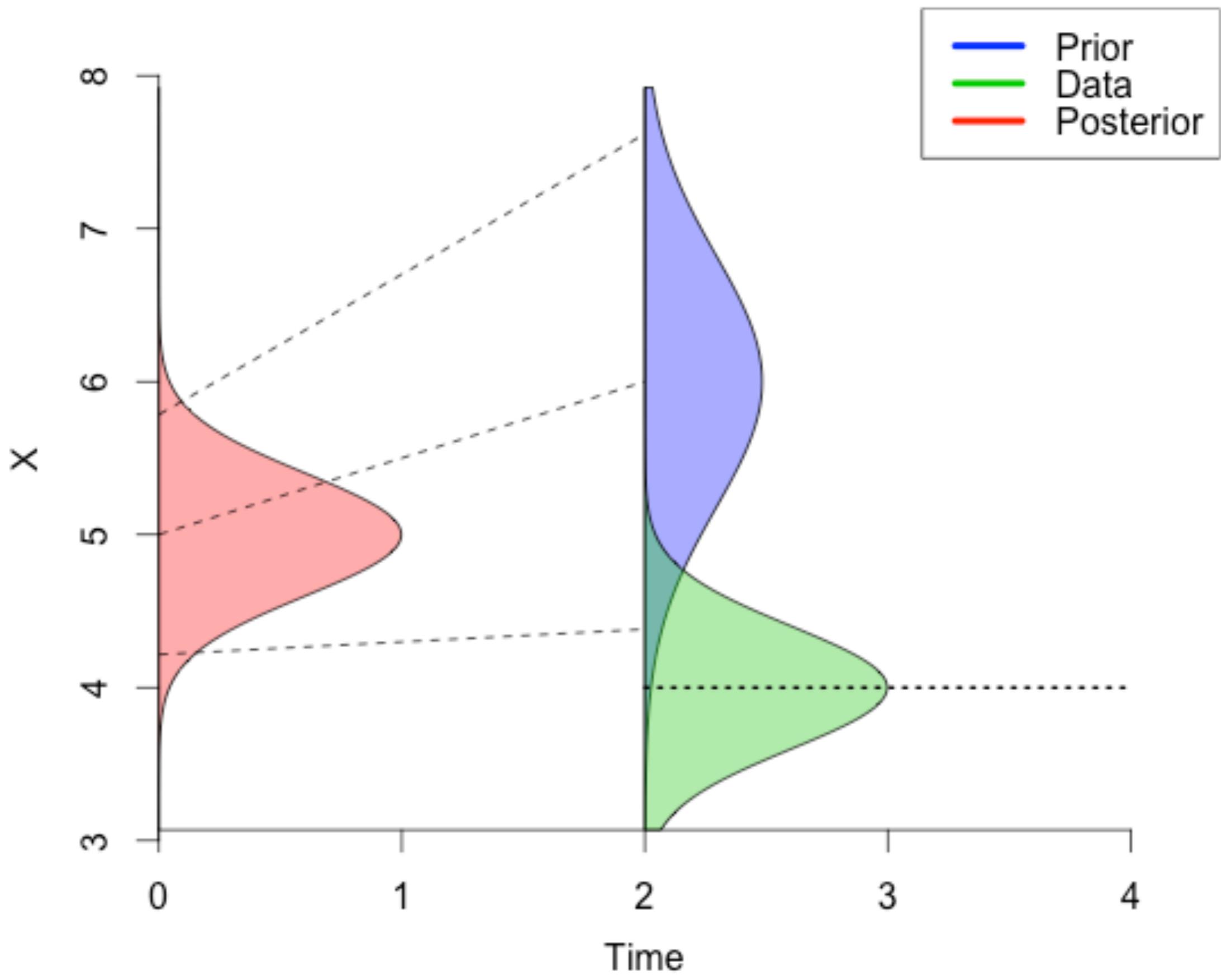
**Updated State**

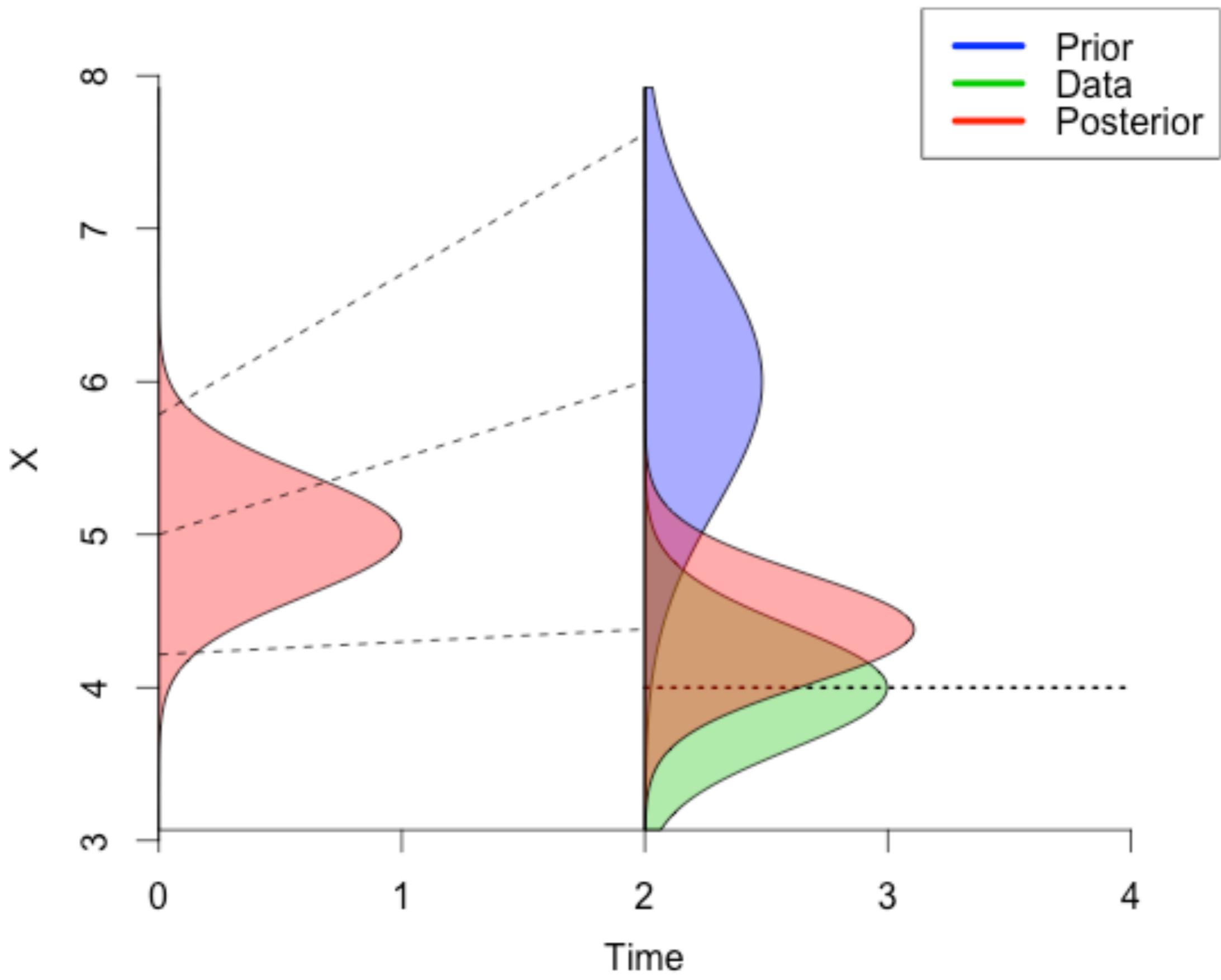
**Data**

**Model**

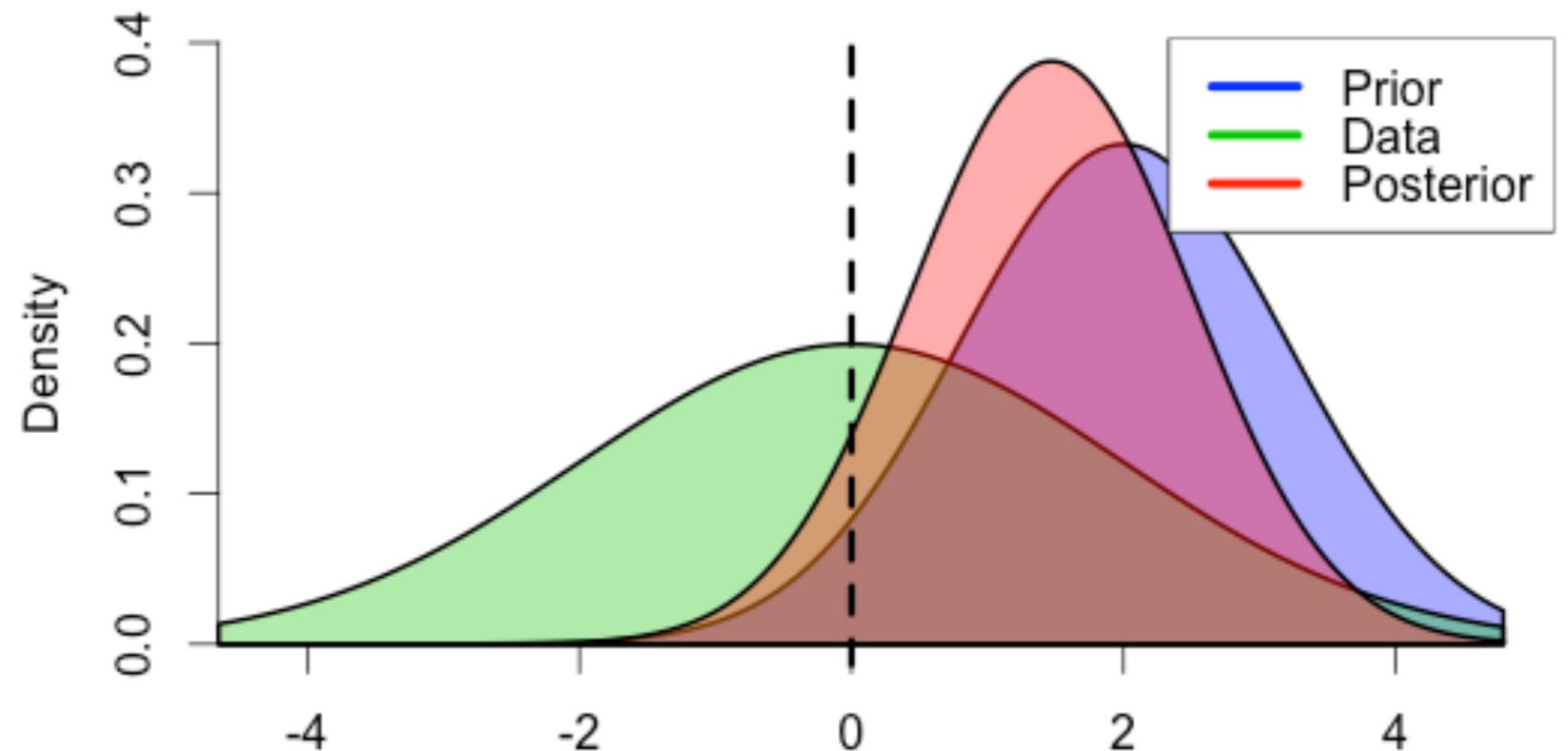




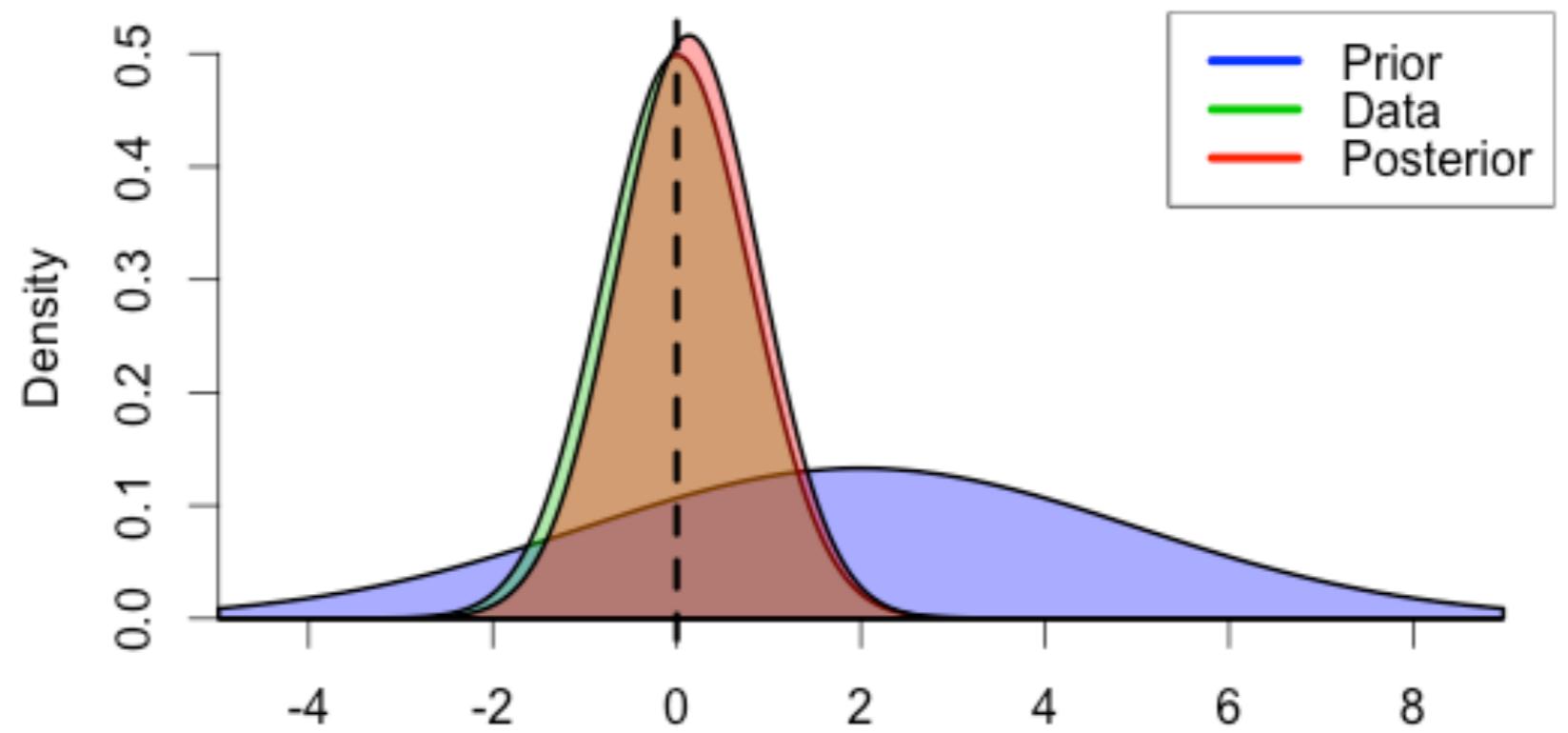




Less Precise Data

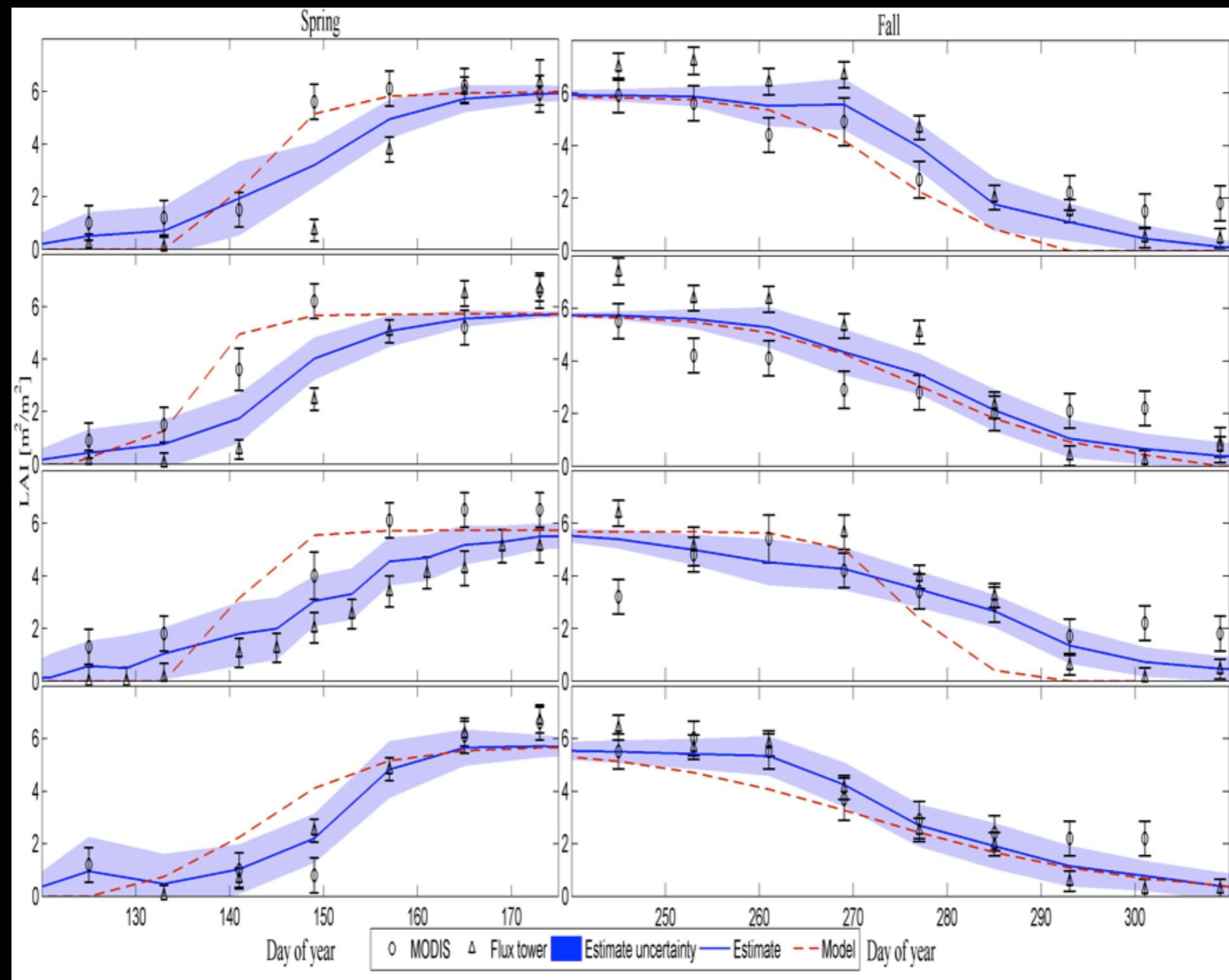


Less Precise Model

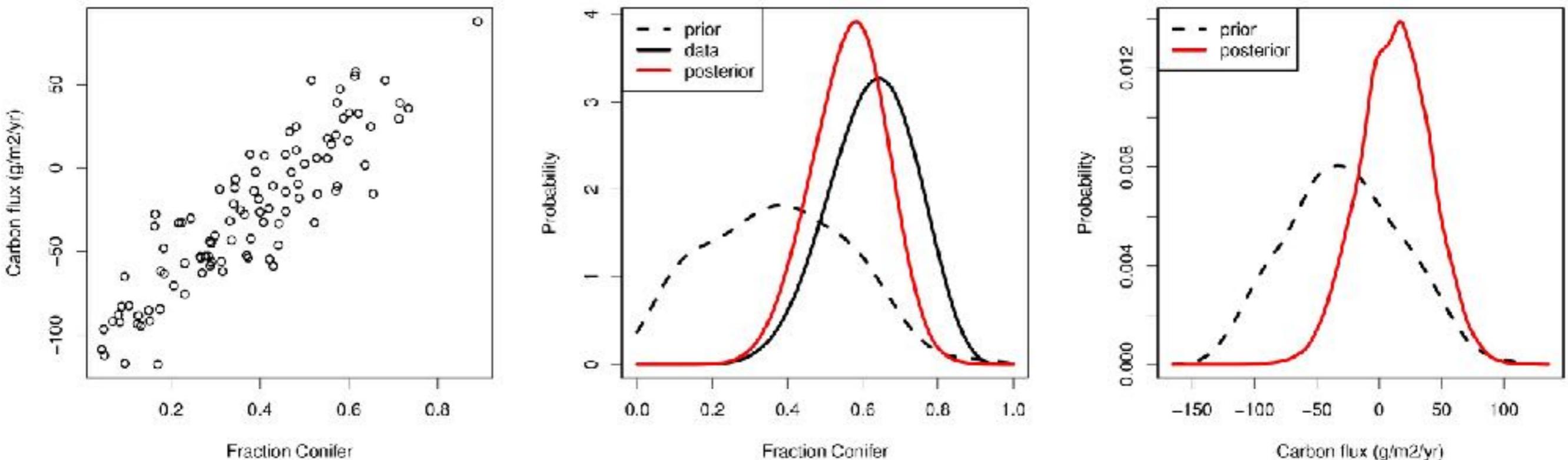


Precision controls influence

# LAI ASSIMILATION: WILLOW CREEK, WI



# State-Variable Data Assimilation

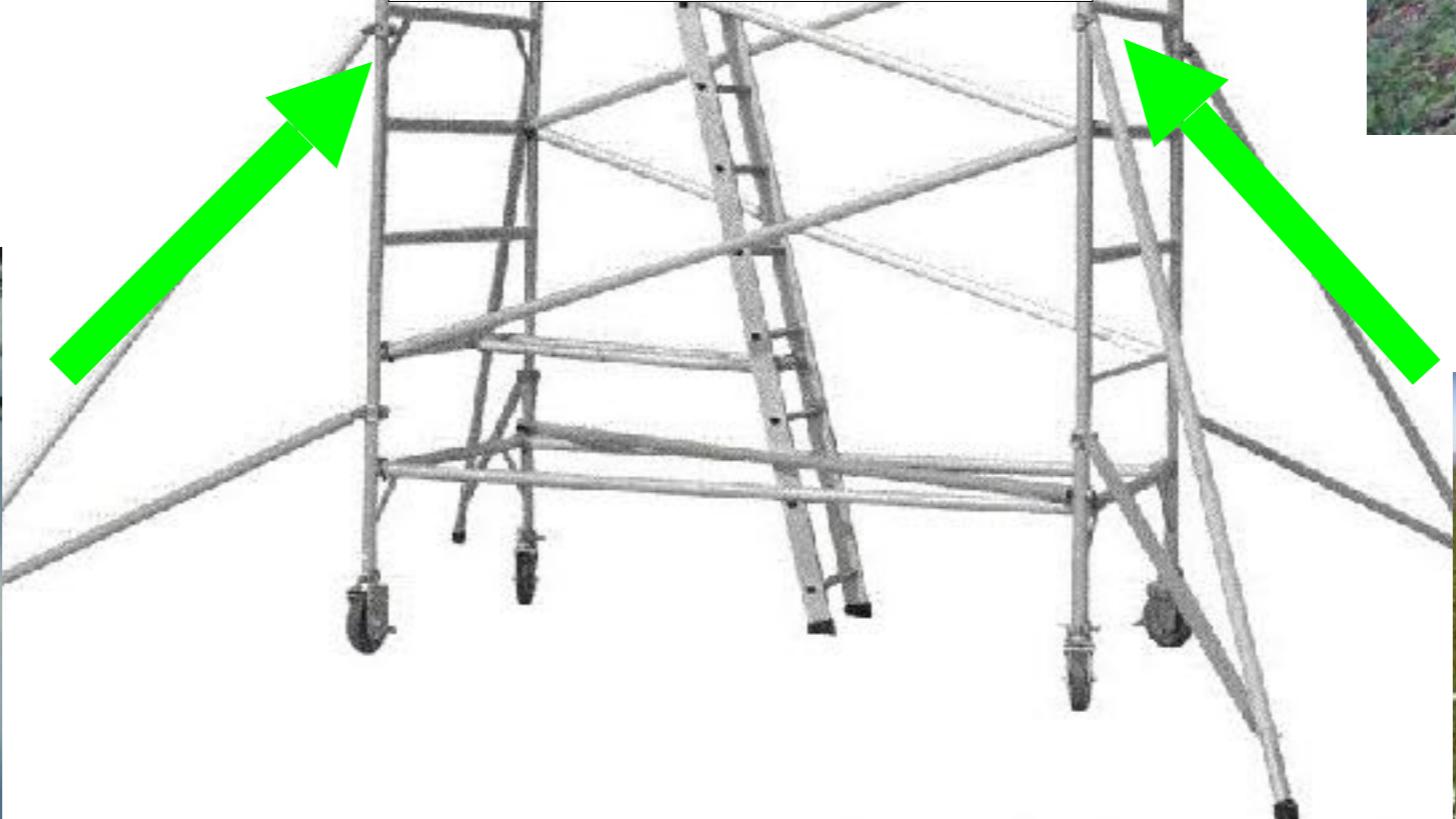
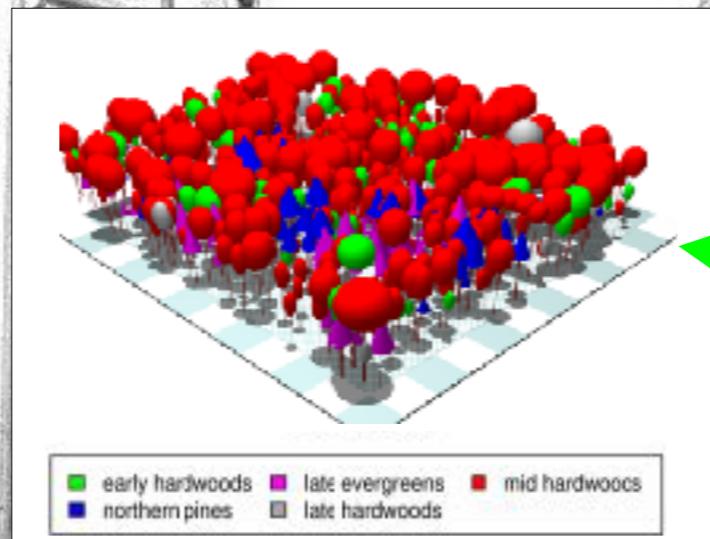
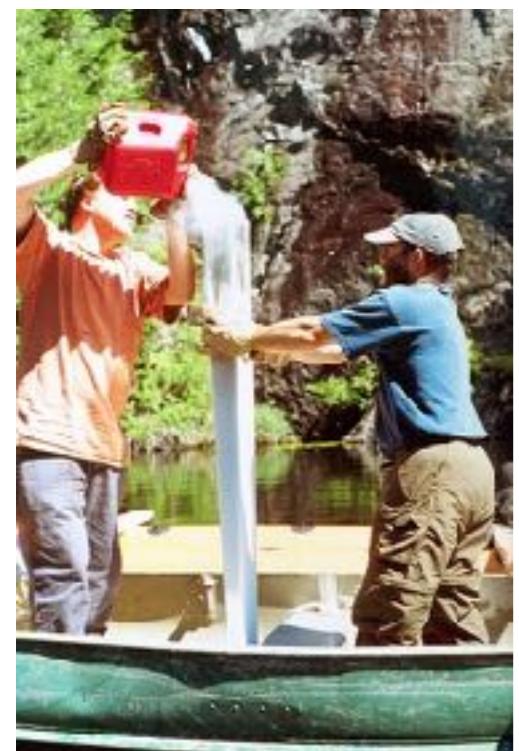
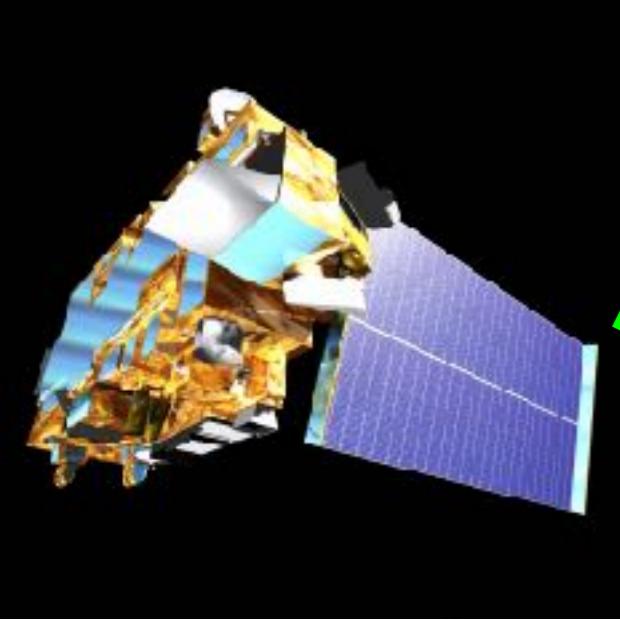


$$P(\theta|y) \propto P(y|\theta) P(\theta)$$

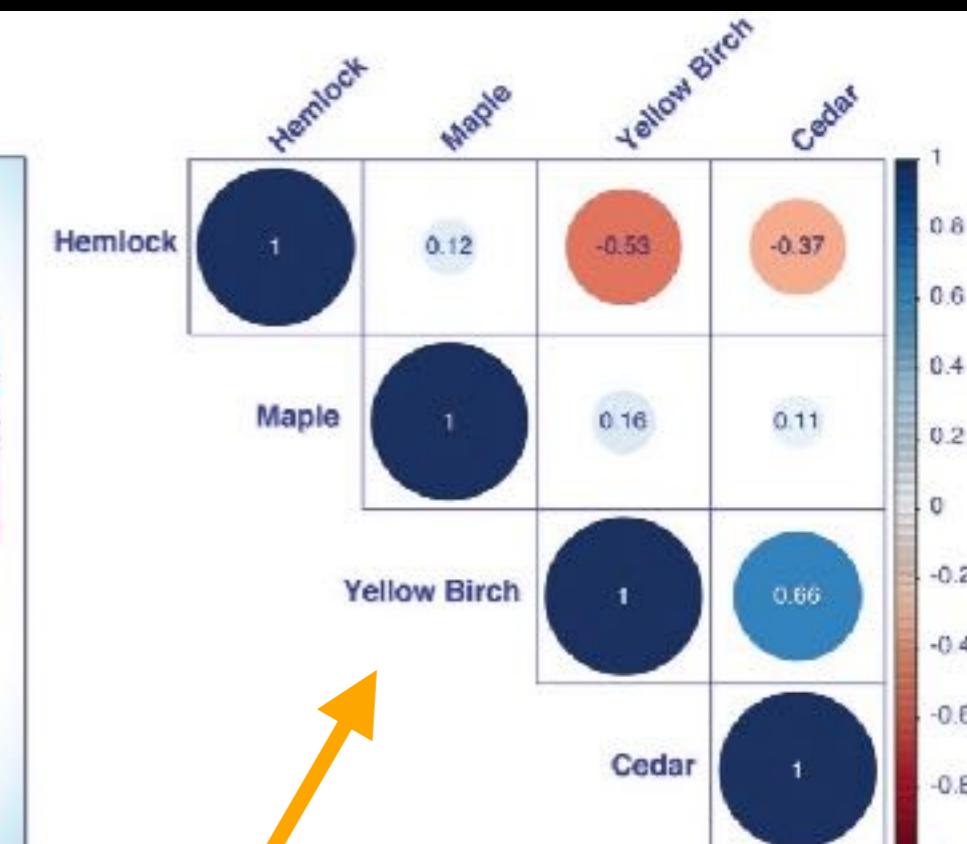
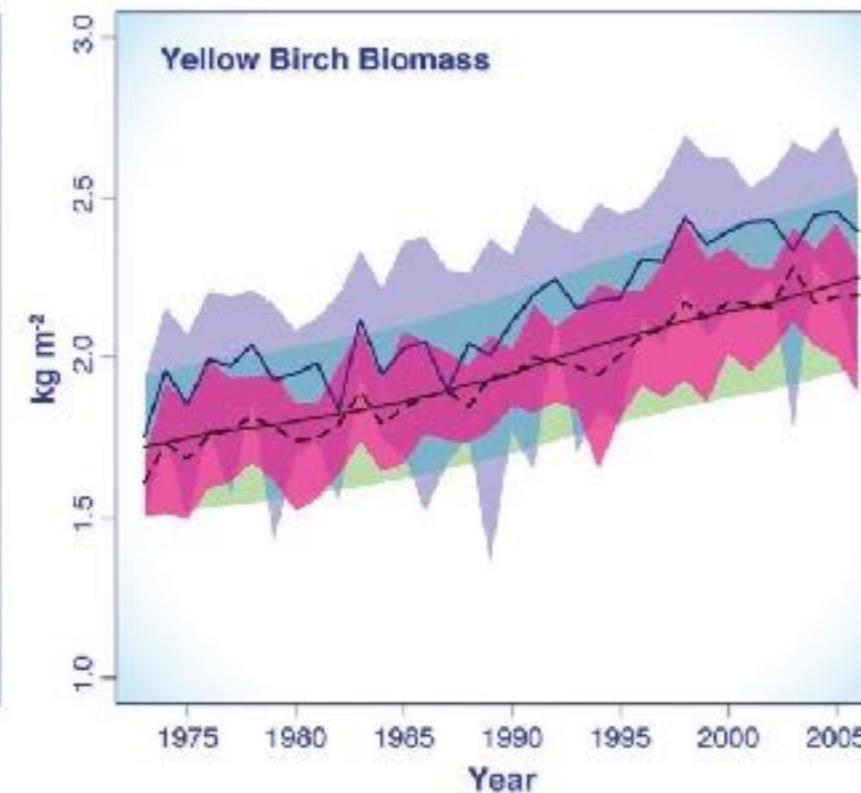
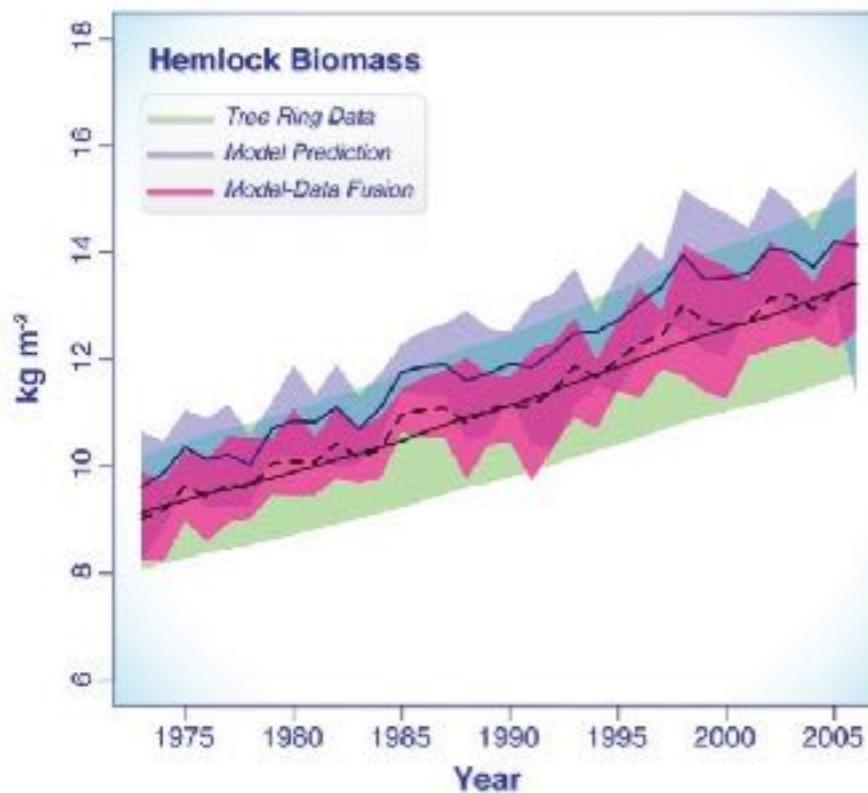
**Updated State**

**Data**

**Model**



# GENERALIZED ENSEMBLE FILTER

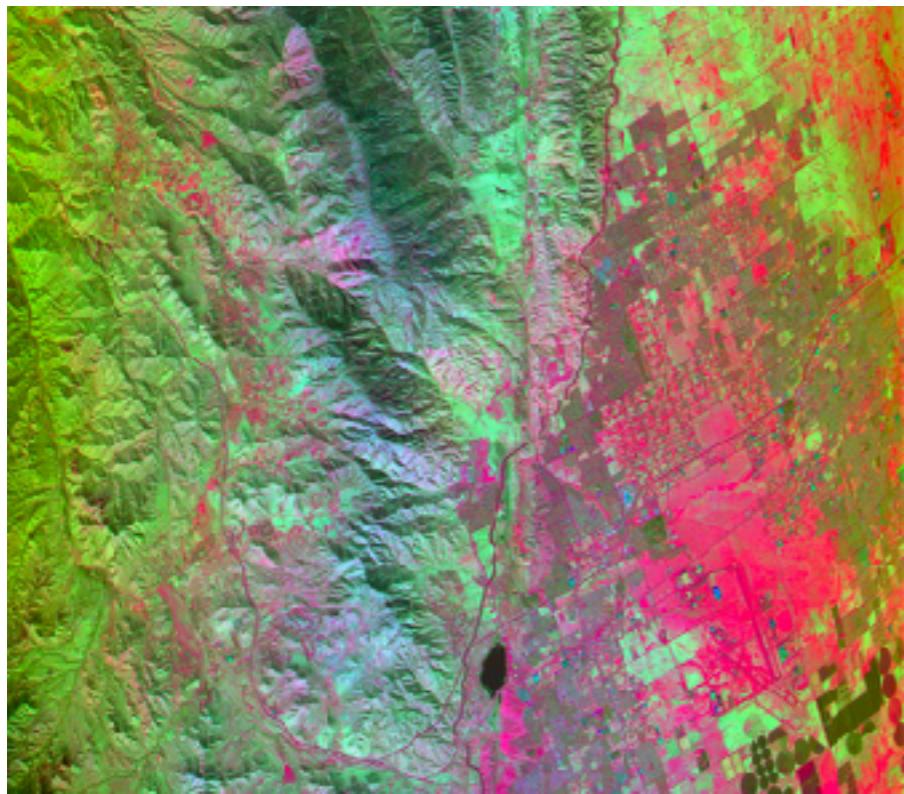


## Multivariate Tobit

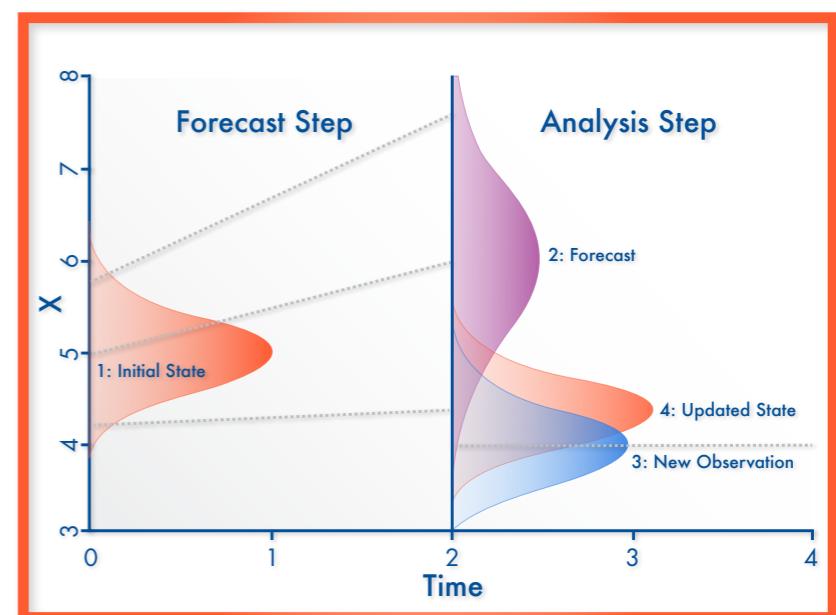
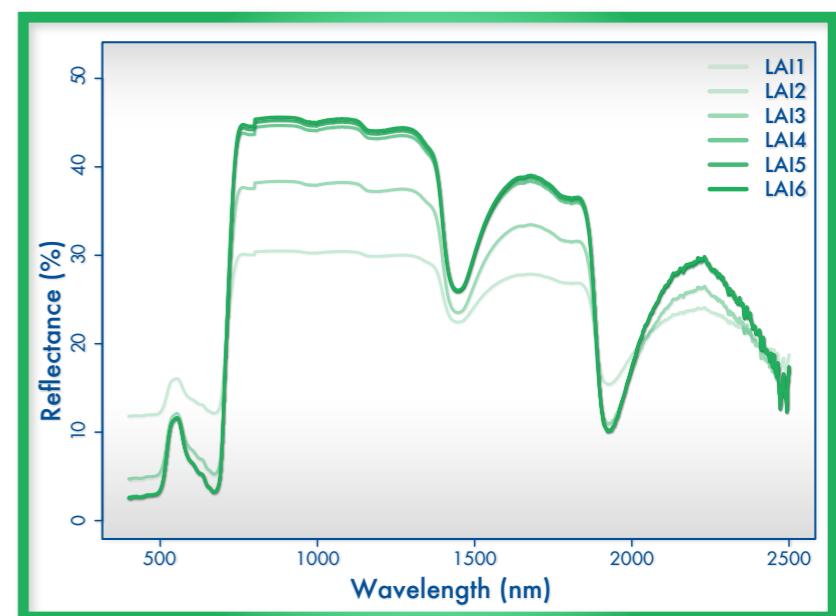
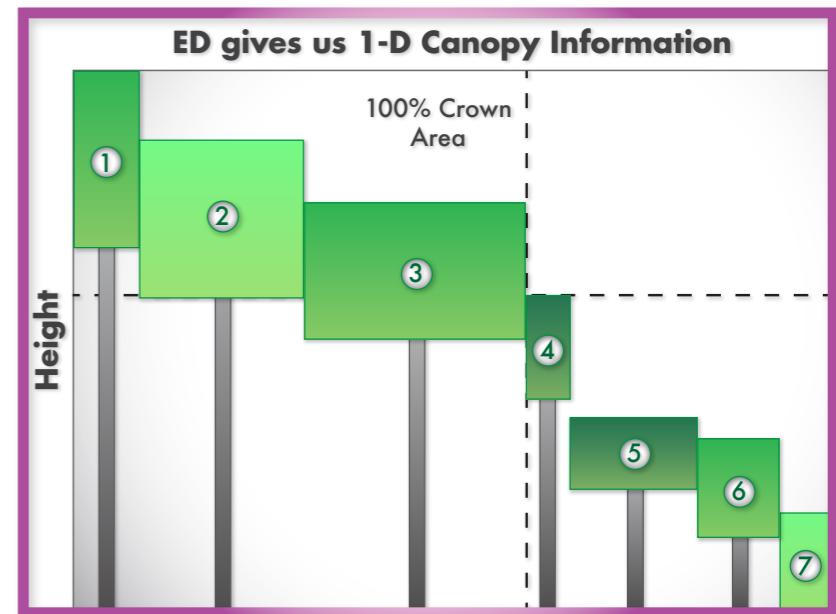
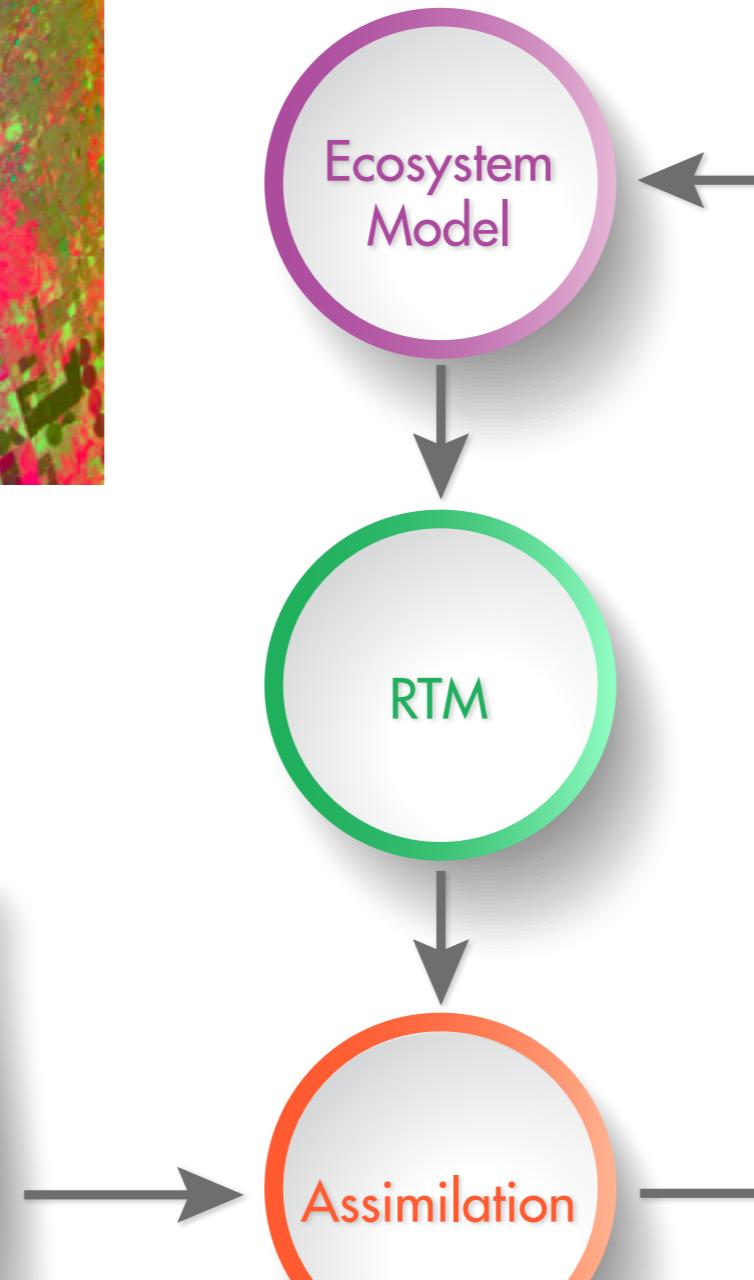
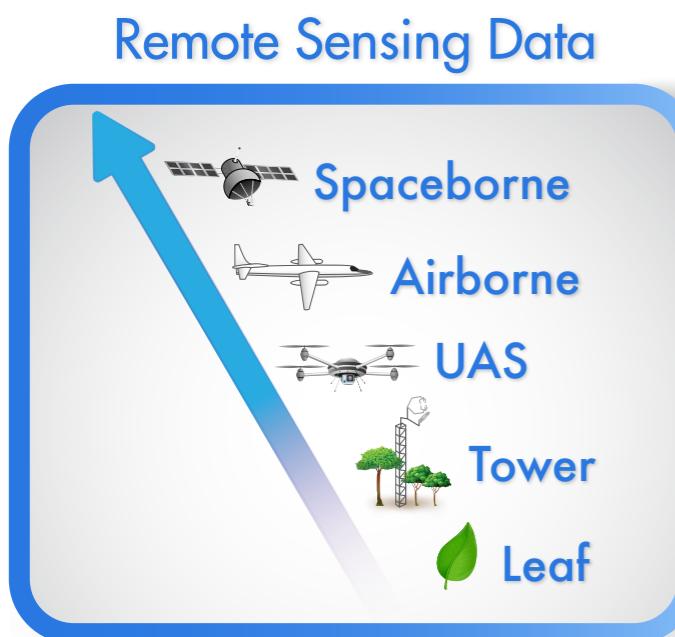
- Range restrictions
- Zero inflated

Estimated Process Error

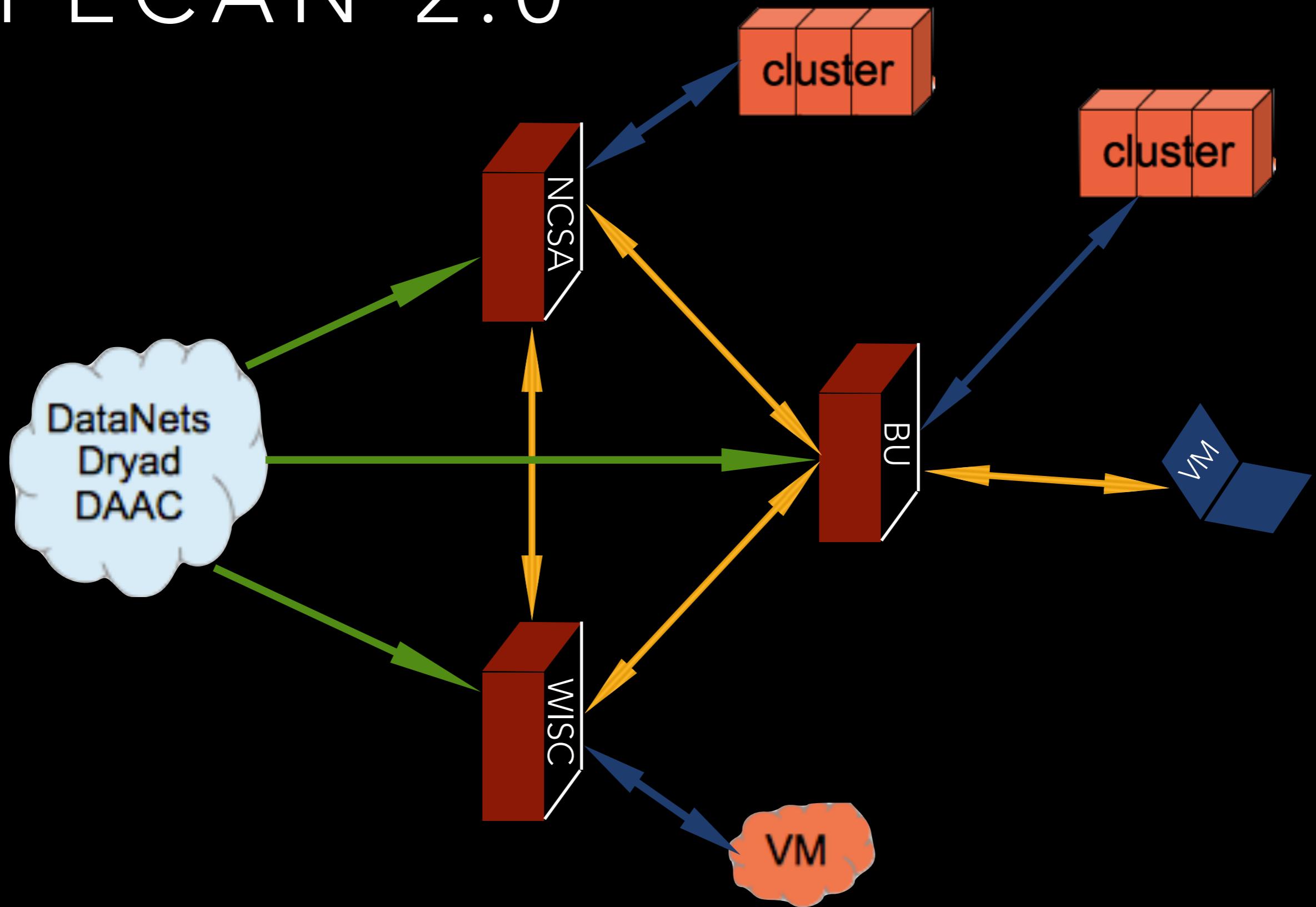
Raiho et al *in prep*



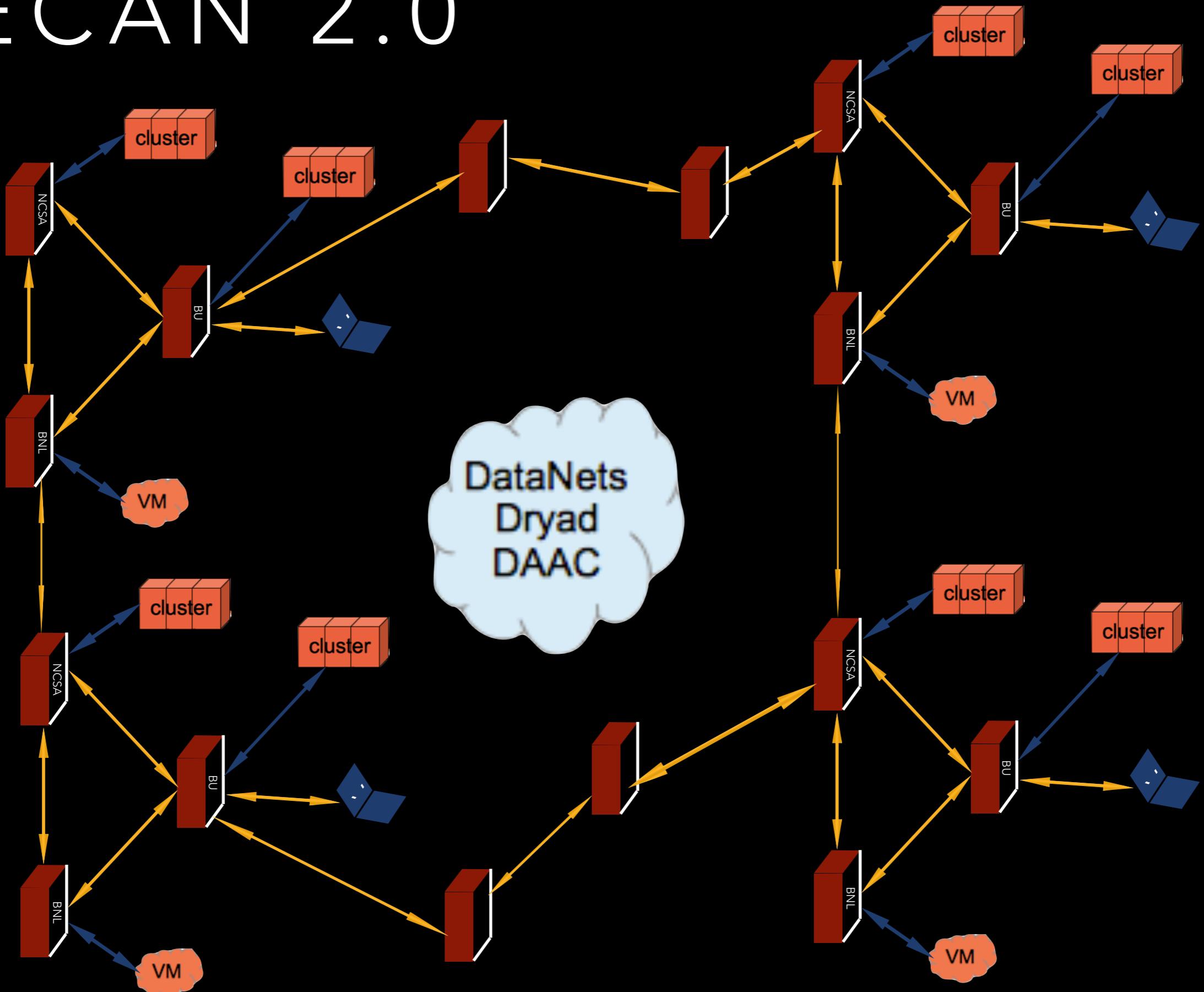
HyspIRI Airborne Campaign



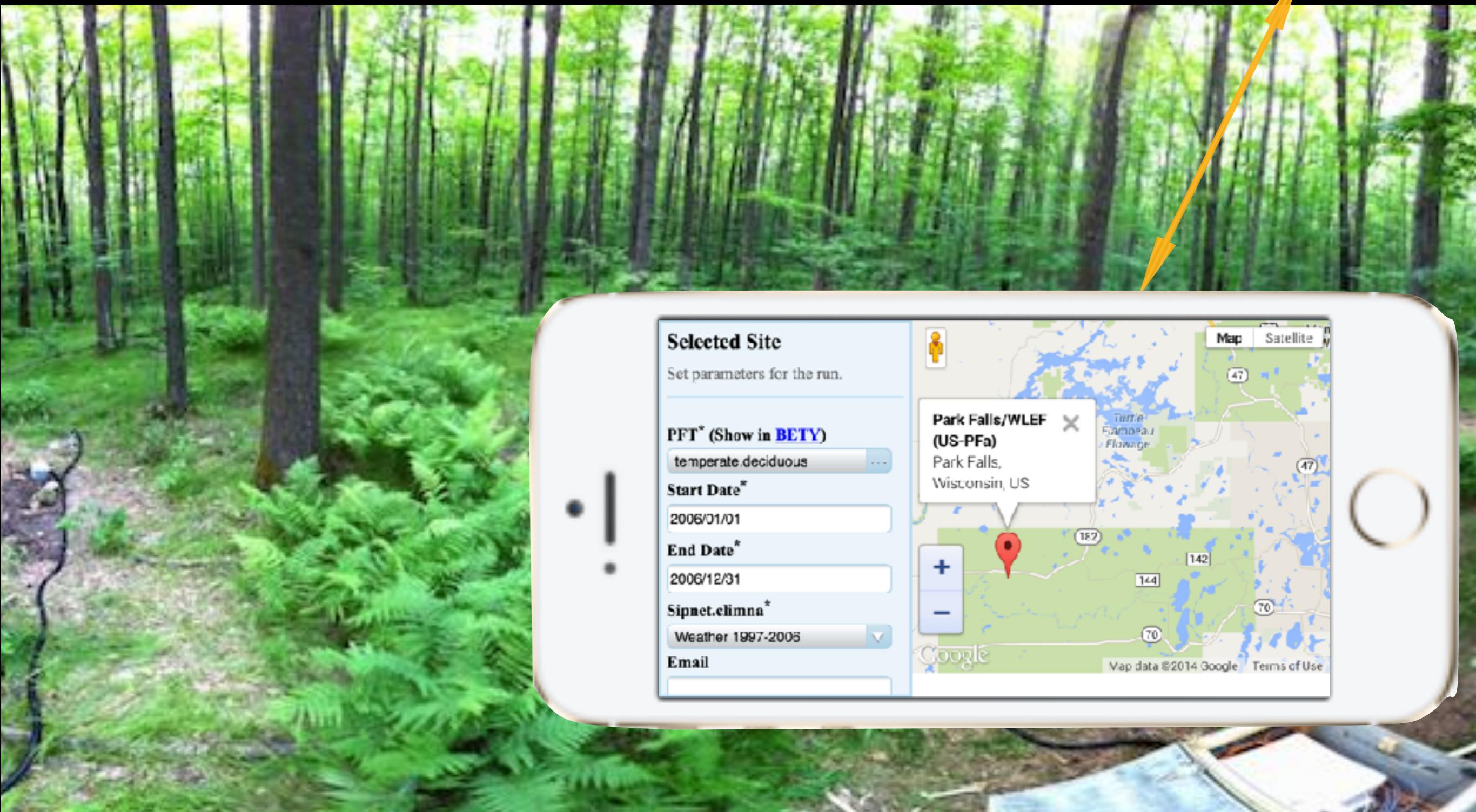
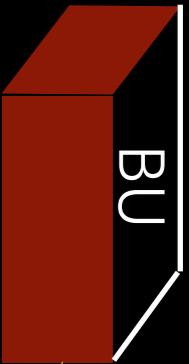
# PECAN 2.0



# PECAN 2.0



# REAL-TIME MONITORING, SYNTHESIS, & FORECASTING



# CONCLUSIONS

- Data synthesis:  
Informatics & analysis tools to tackle volume, diversity
- Common API, standards, and web 2.0 sharing to help make modeling scalable
- Web-based tools to help make models accessible
- Bayesian analysis tools for tackling challenges of data-model synthesis & assessing uncertainties

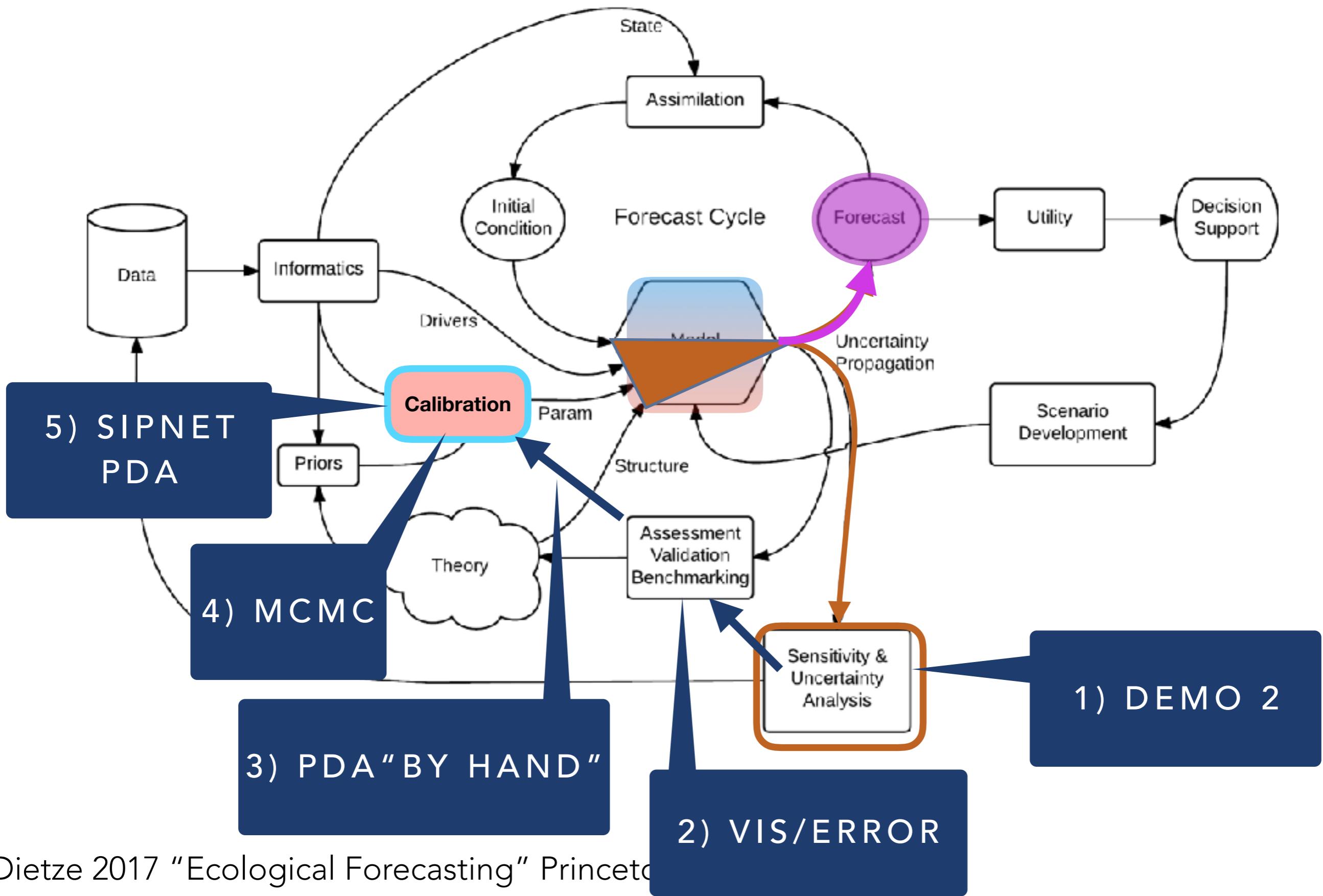
<http://pecanproject.org>

[\*\*https://github.com/PecanProject\*\*](https://github.com/PecanProject)

PECAN TEAM: ELIZABETH COWDERY, CARL DAVIDSON, ANKUR R. DESAI, XIAOHUI FENG, BRADY HARDIMAN, TONY GARDELLA, RYAN KELLY, ROB KOOPER, DAVID LEBAUER, JOSHUA MANTOOTH, KENTON MCHENRY, AFSHIN POURMOKHTARIAN, BRETT RACZKA, SHAWN SERBIN, ALEXEY SHIKLOMANOV, TONI VISKARI, AND DAN WANG

NSF 1062547, 1062204, 1241894, 1261582, 1318164, 1346748,  
1458021, NASA 13-TE13-0060, Amazon AWS Education Grant

# HANDS ON



# DEMO 2

Prior  
Posterior

## Parameter Uncertainty

CV (%)

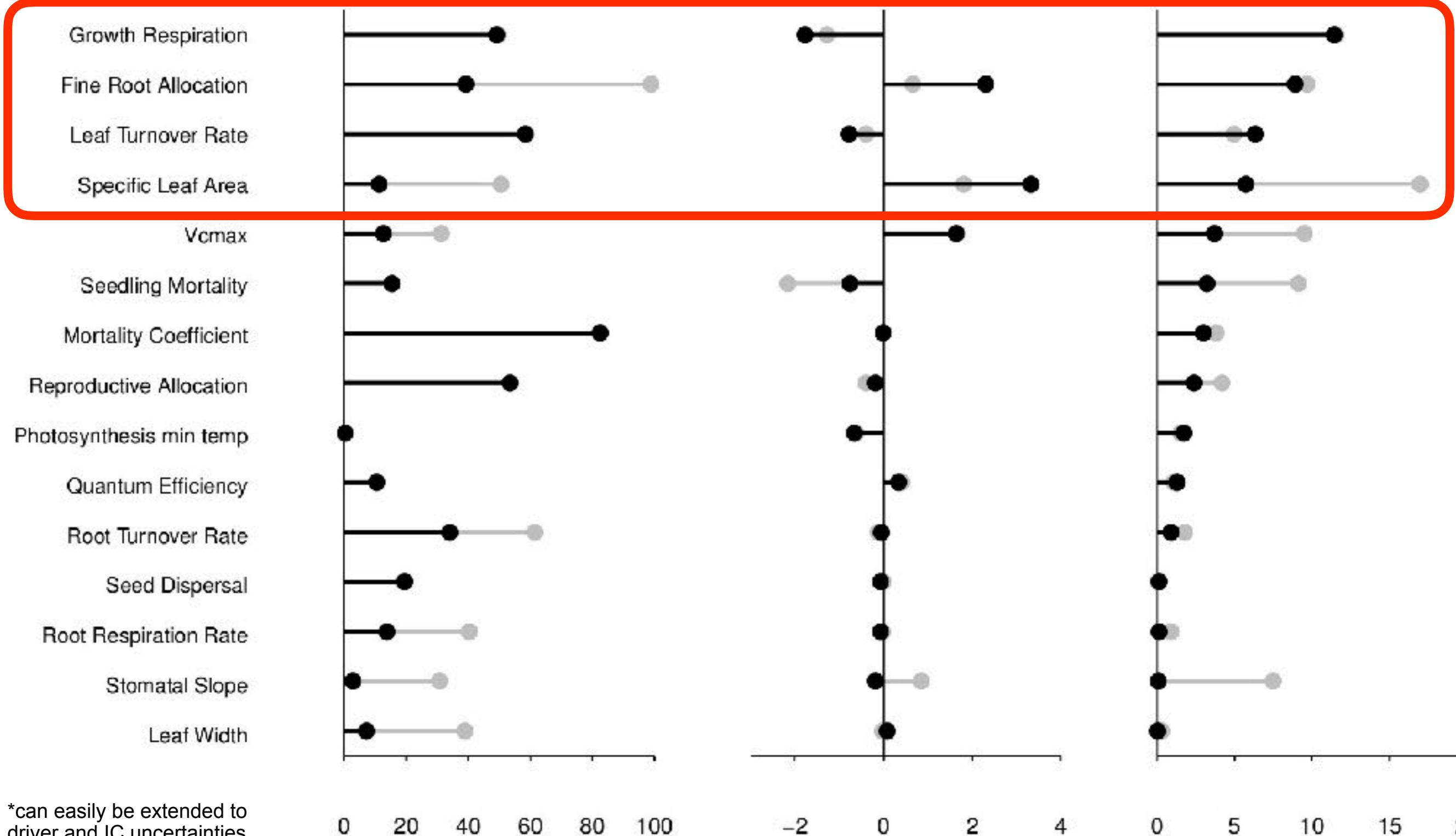
## Sensitivity

Elasticity

## Output Uncertainty

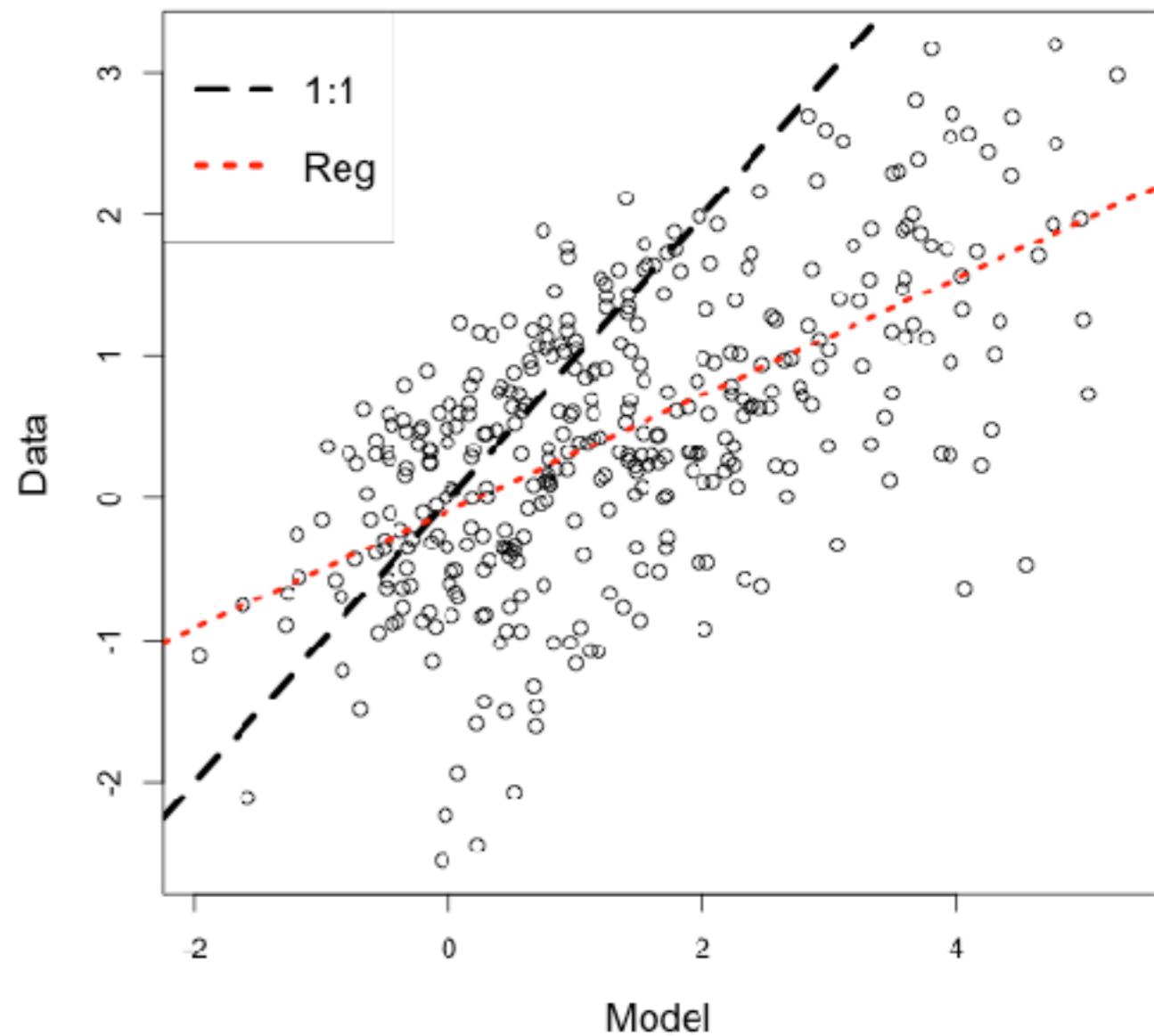
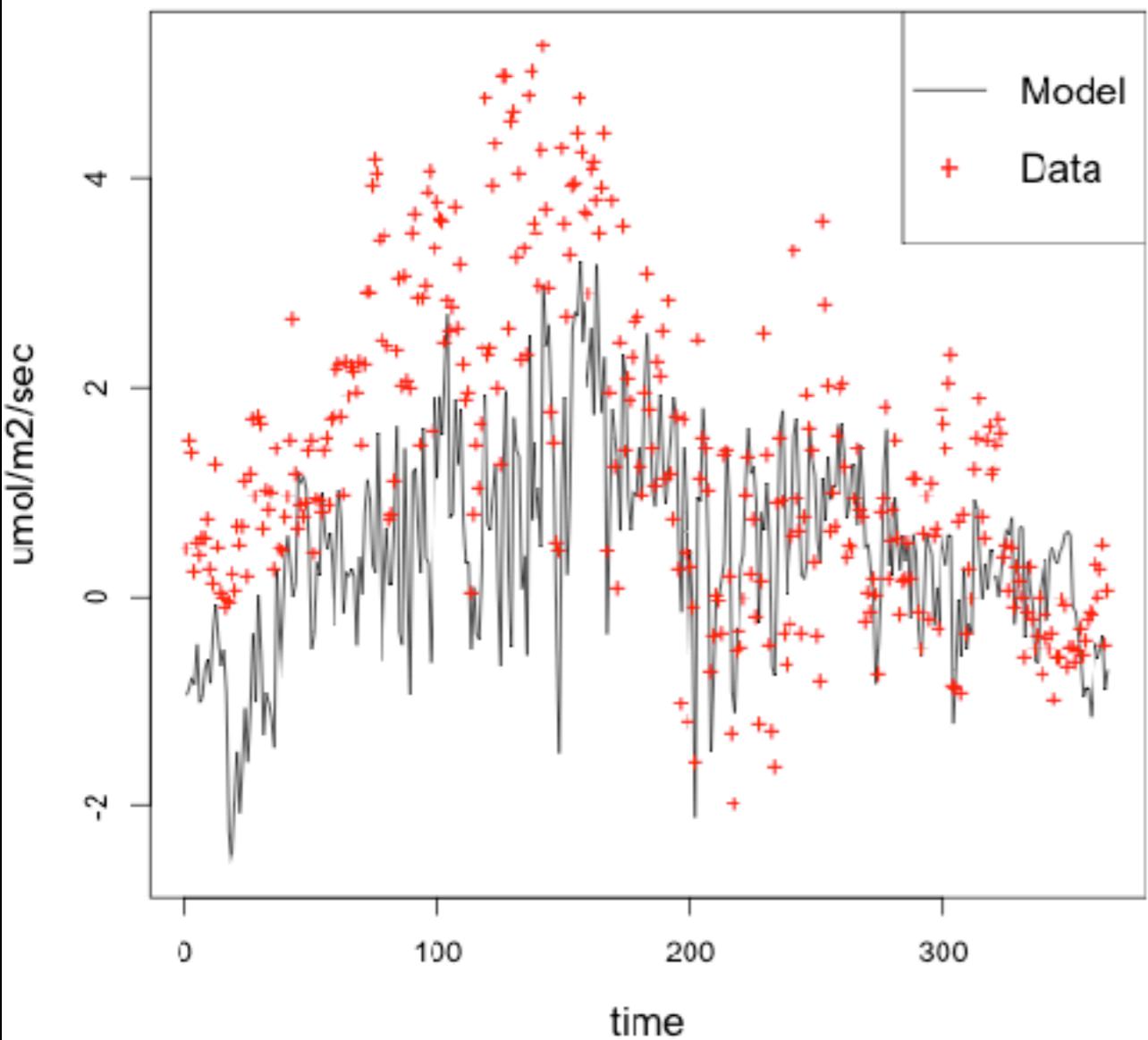
Partial Variance

Parameter\*

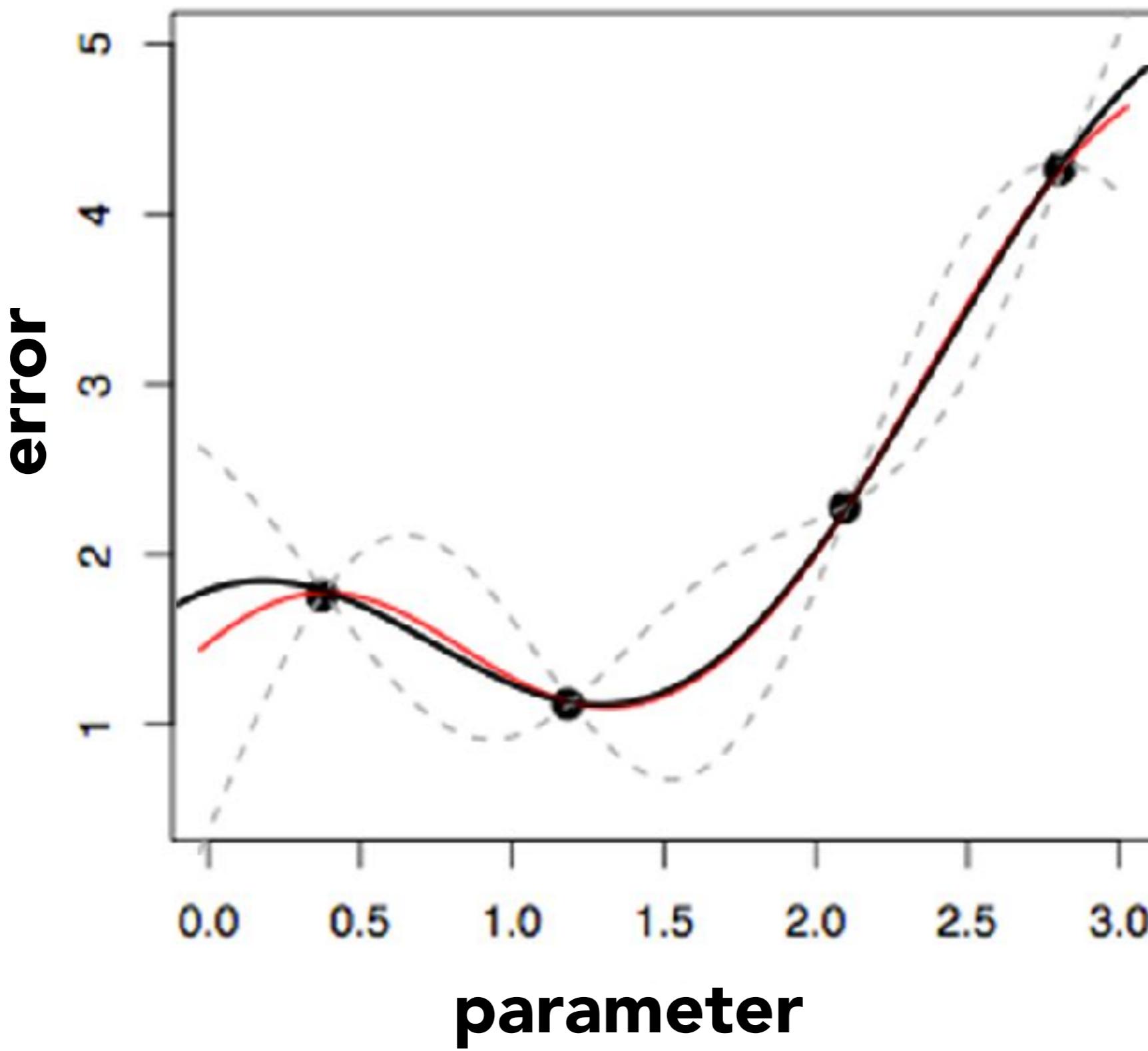


\*can easily be extended to driver and IC uncertainties

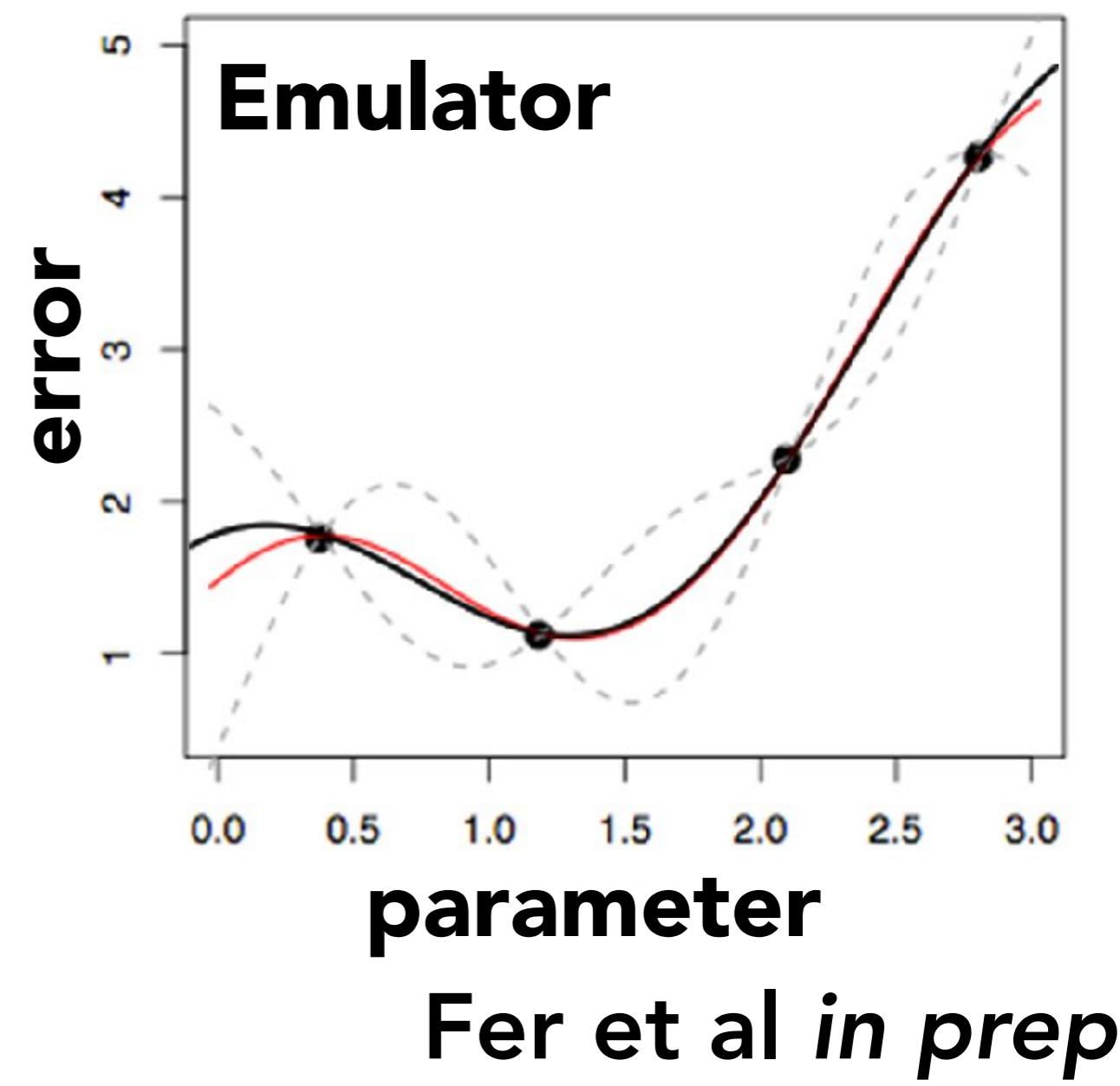
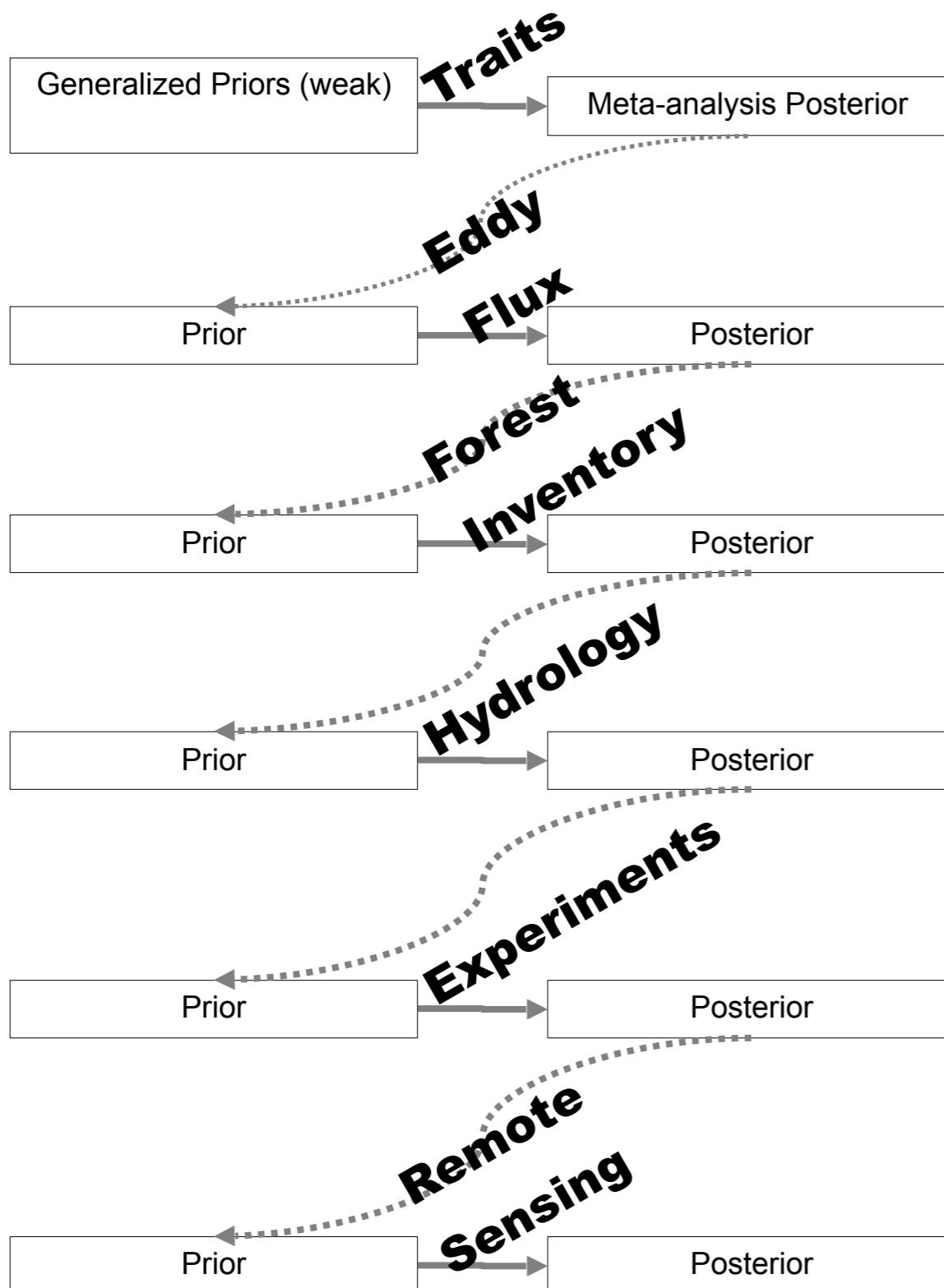
# "ANALYZE OUTPUT"



# DA by hand - “sensitivity”



# MCMC



# Bayesian Parameter Calibration

