Recent updates to carbon emission modeling for ILUC analysis

CRC Biofuel LCA Workshop
Argonne National Lab
October 17, 2013

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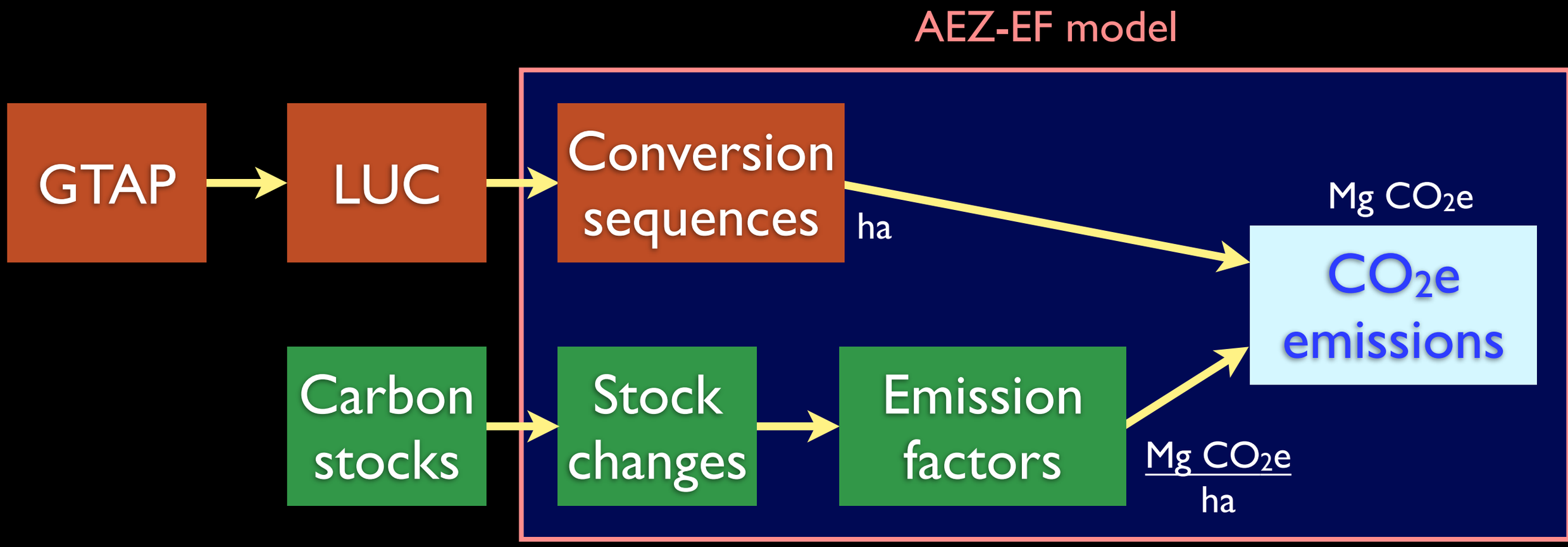
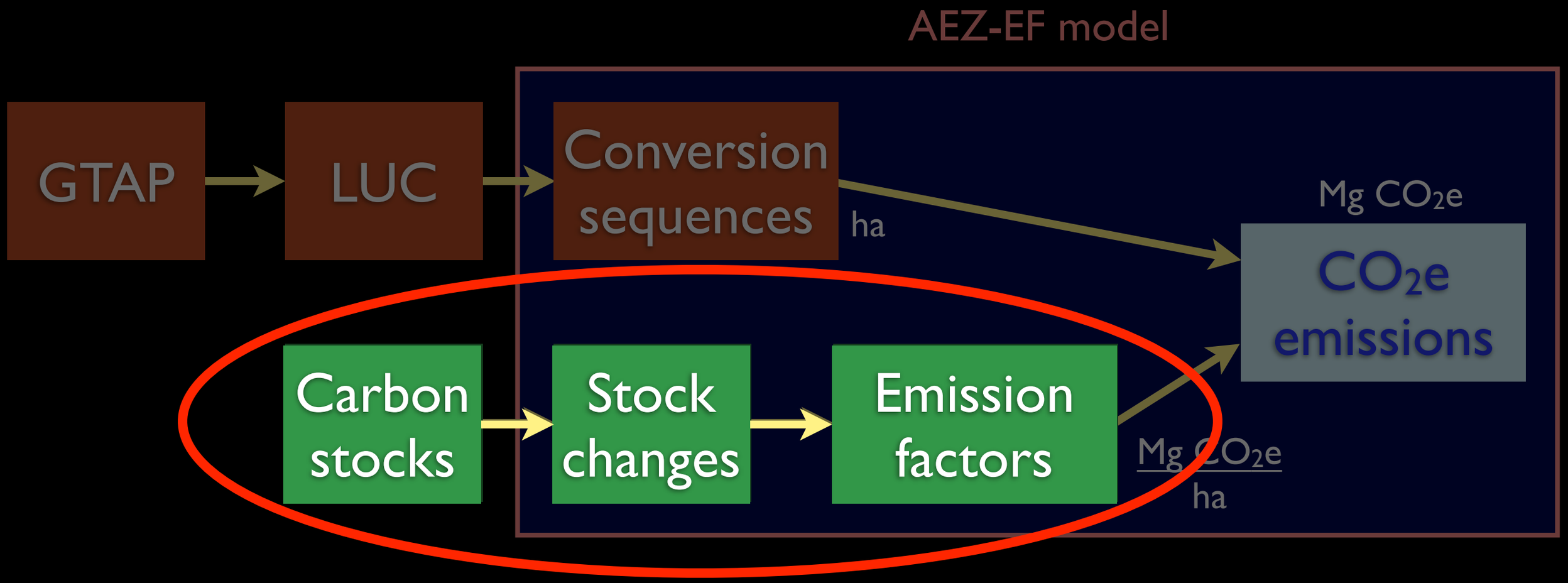
ILUC model components



ILUC model components



Carbon pools considered

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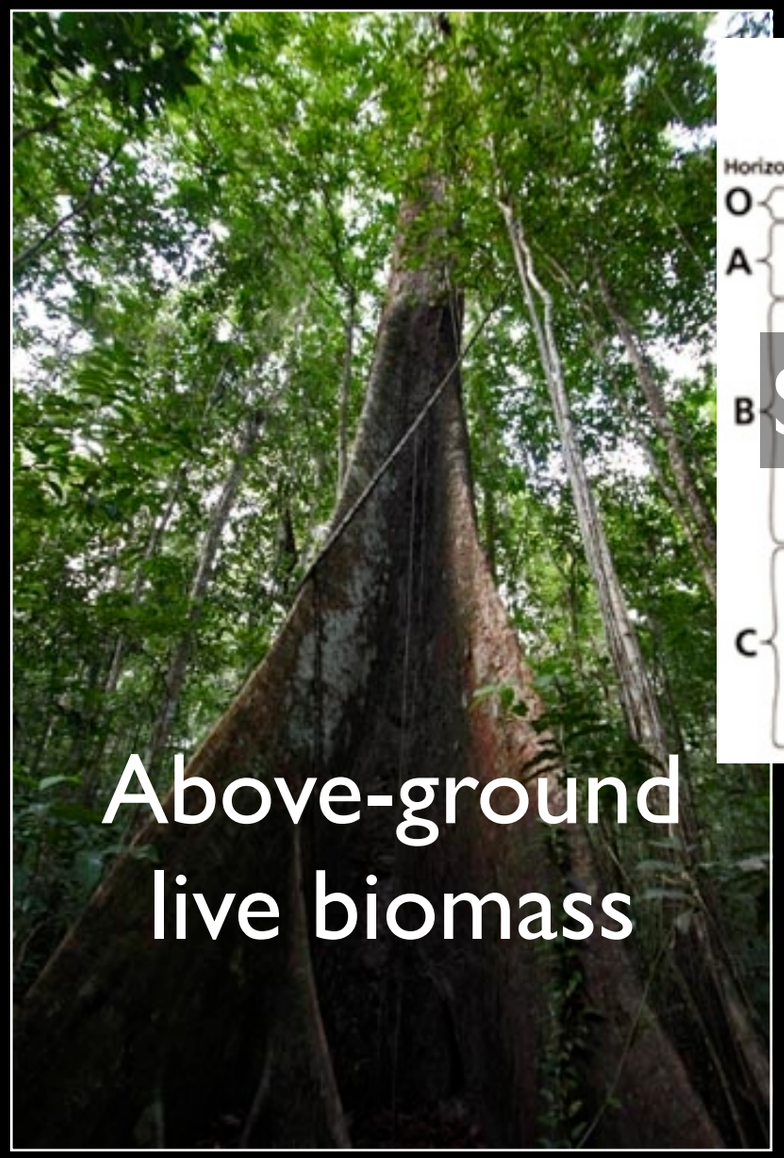
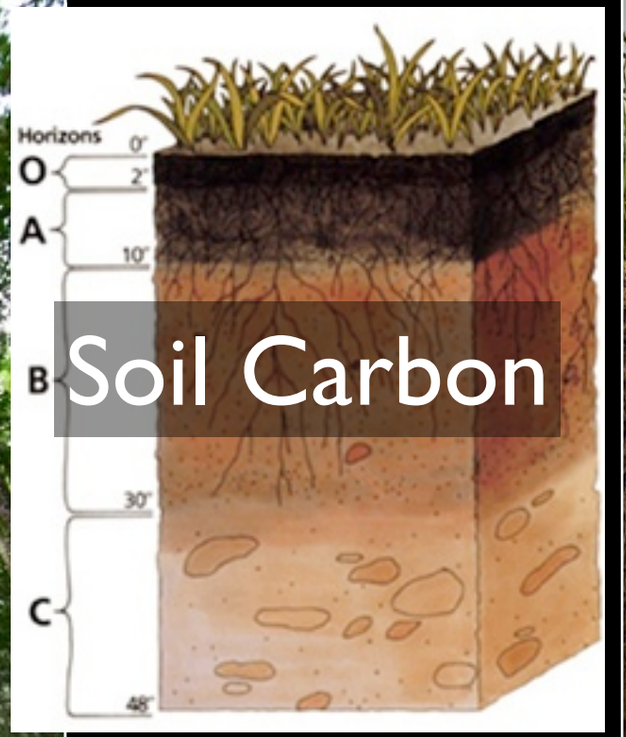
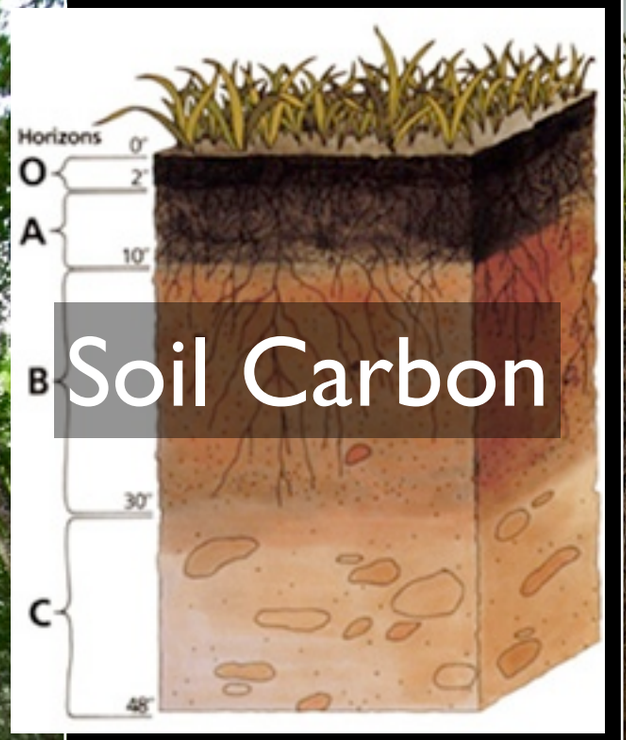




Carbon pools considered

Above-ground live biomass



Soil Carbon

Below-ground live biomass (roots)

Harvested wood products

Litter

Understory

Dead wood

8 conversion sequences

Forestry*

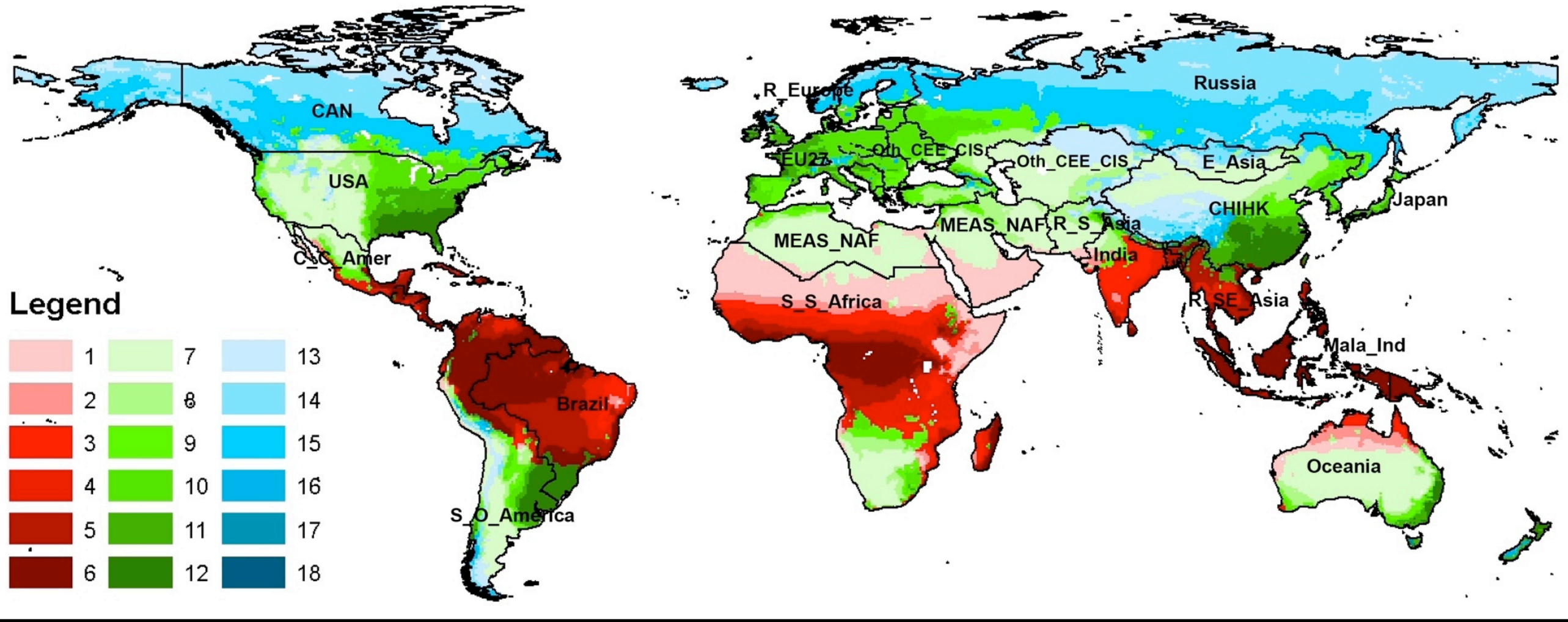
Pasture

Cropland-Pasture

Cropland

* GTAP's economic logic accounts only for accessible, economically viable forest

18 Agro-ecological zones (AEZs)



Soil and biomass C stocks for 19 regions × 18 AEZs

Example: forest soil carbon

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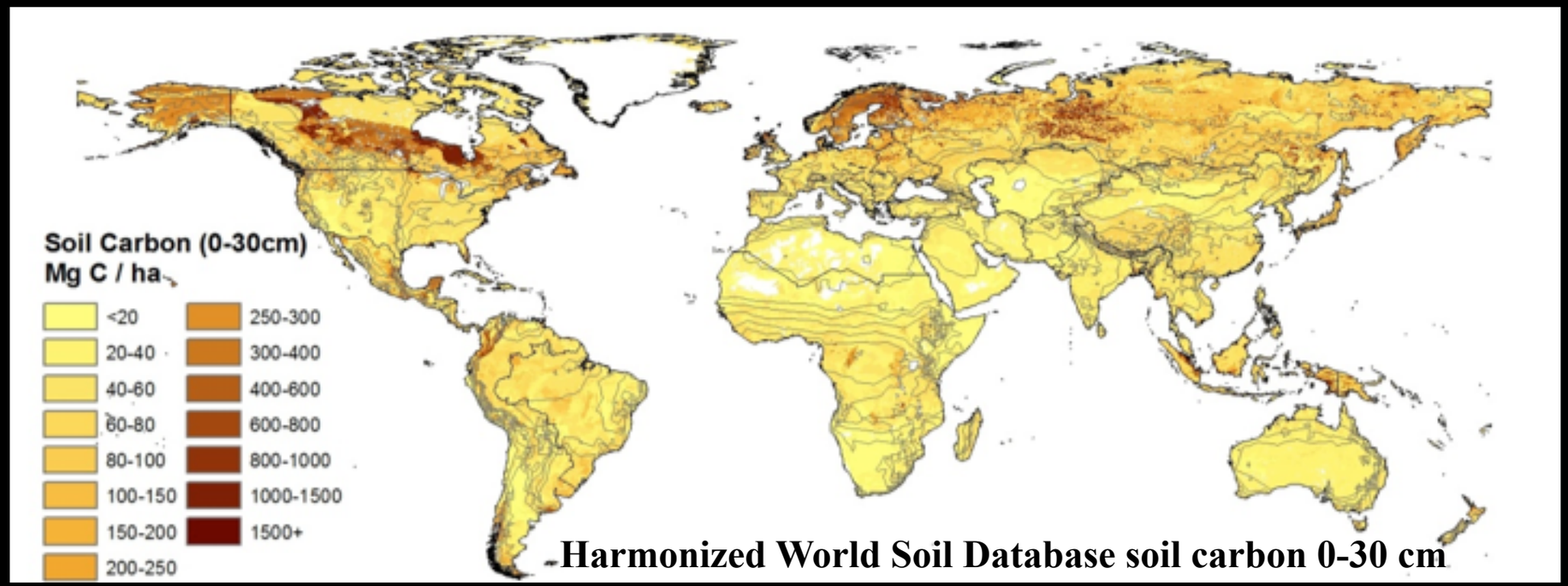
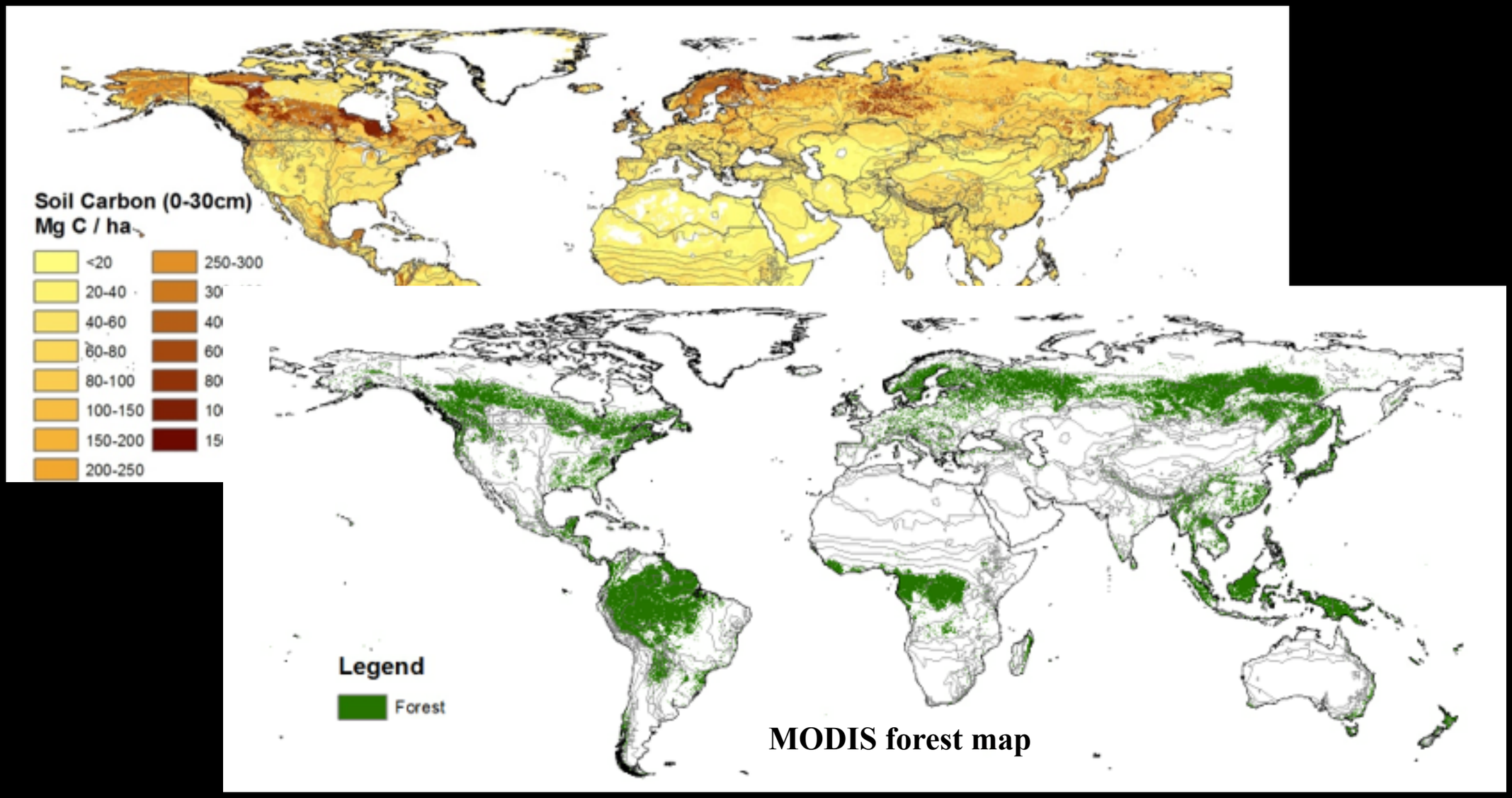
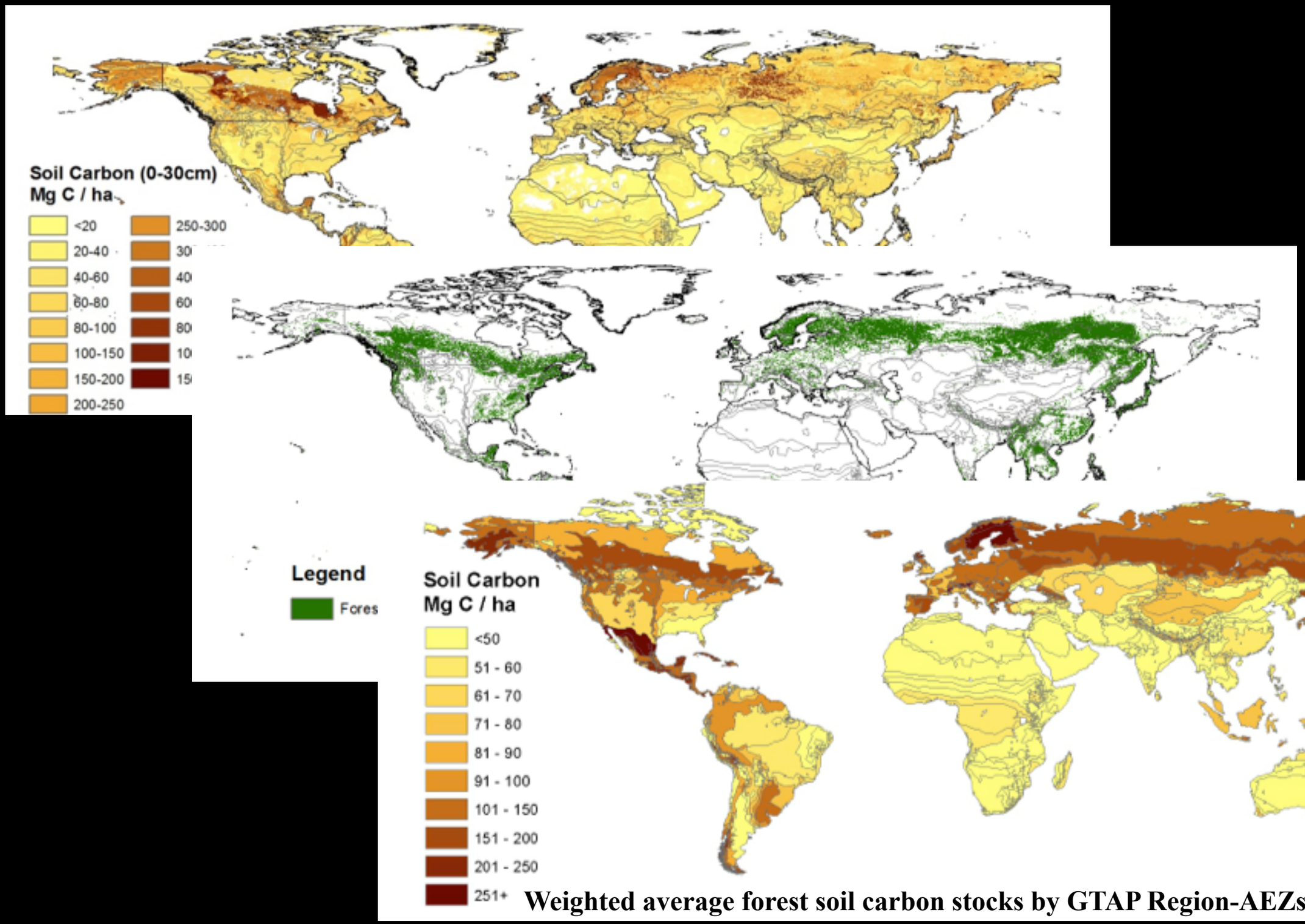


Harmonized World Soil Database soil carbon 0-30 cm

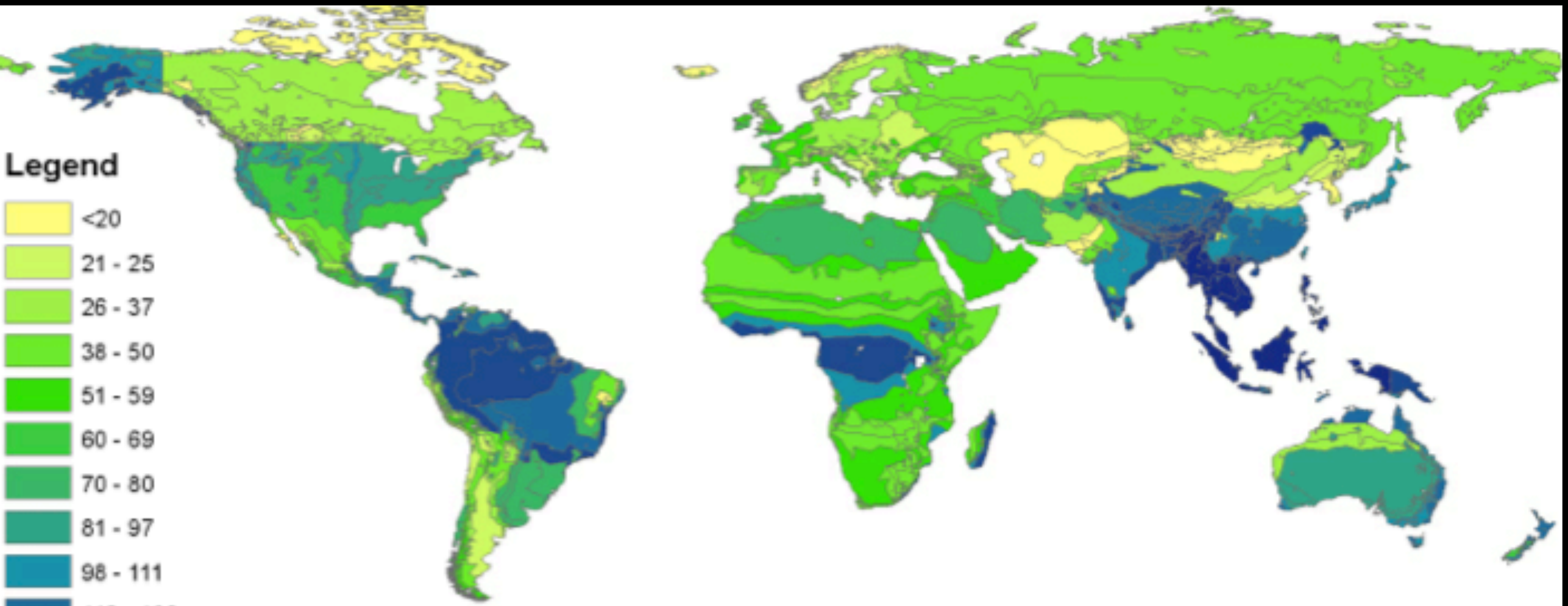
Example: forest soil carbon



Example: forest soil carbon



Weighted average forest soil carbon stocks by GTAP Region-AEZs at 30cm depth



Weighted average forest biomass C stocks

Initially aggregated to 246 countries × 18 AEZs

Further aggregated to 134 GTAP-8 regions

FlexAgg to aggregate to 19 GTAP-BIO regions

Forest vs Forestry

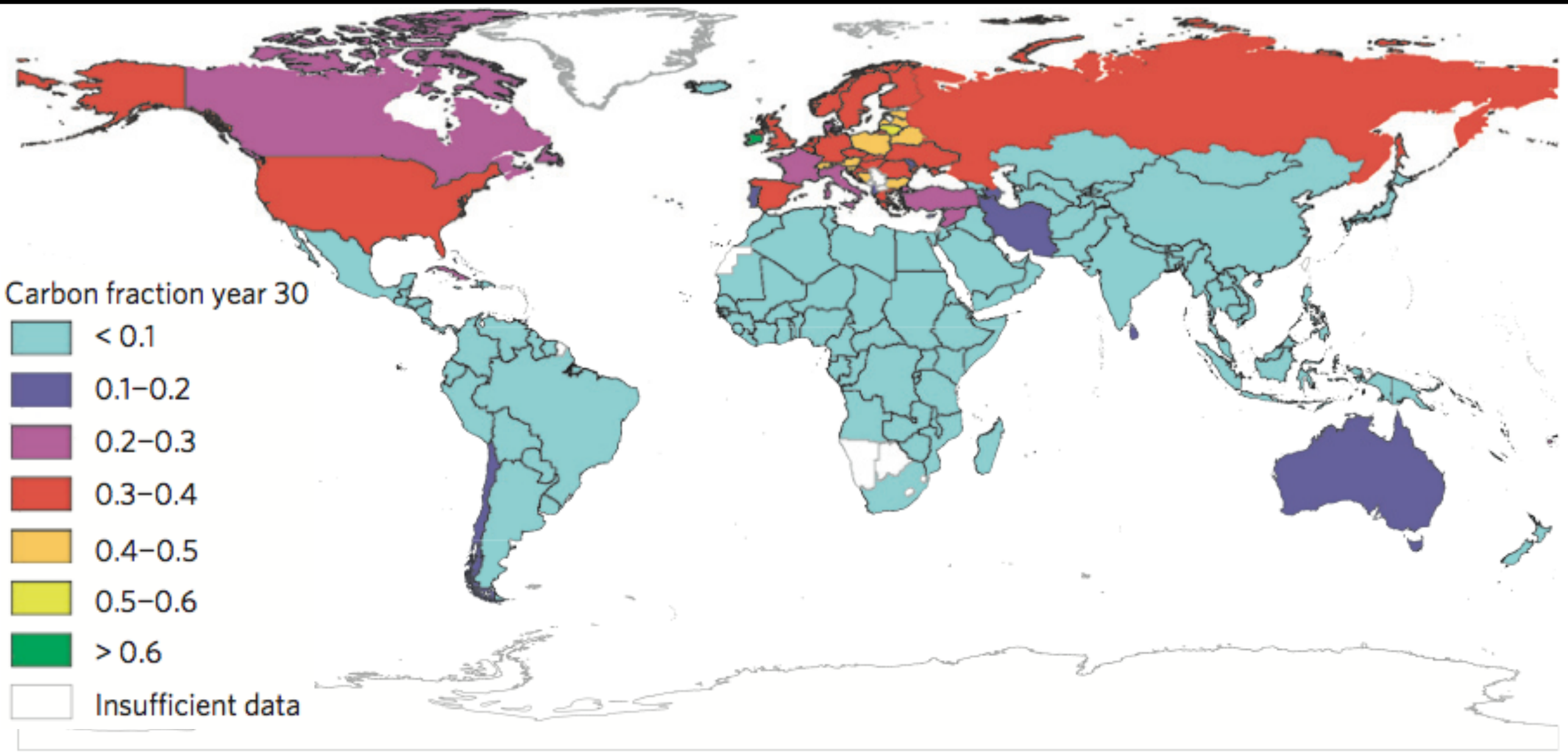
- GTAP considers only economic forest use
- Forest removal is offset by gain elsewhere (potentially underestimating emissions)
- EF model uses avg C for all forest, overestimating emissions for managed forest, underestimating emissions for natural forest.
- Goal: spatially-explicit data on managed vs unmanaged forest* and ability to bring natural forest into economic use.

* Available in the US, which accounts for perhaps 1/3 of total (+/-) change in forestry land.

More model updates

- Prior version: crop biomass = TEM-based NPP
  - Location-specific for "representative" crop
- Crop biomass now taken from GTAP
  - Location- and crop-specific
  - Responsive to yield changes in GTAP
- N_2O emissions associated with soil C loss

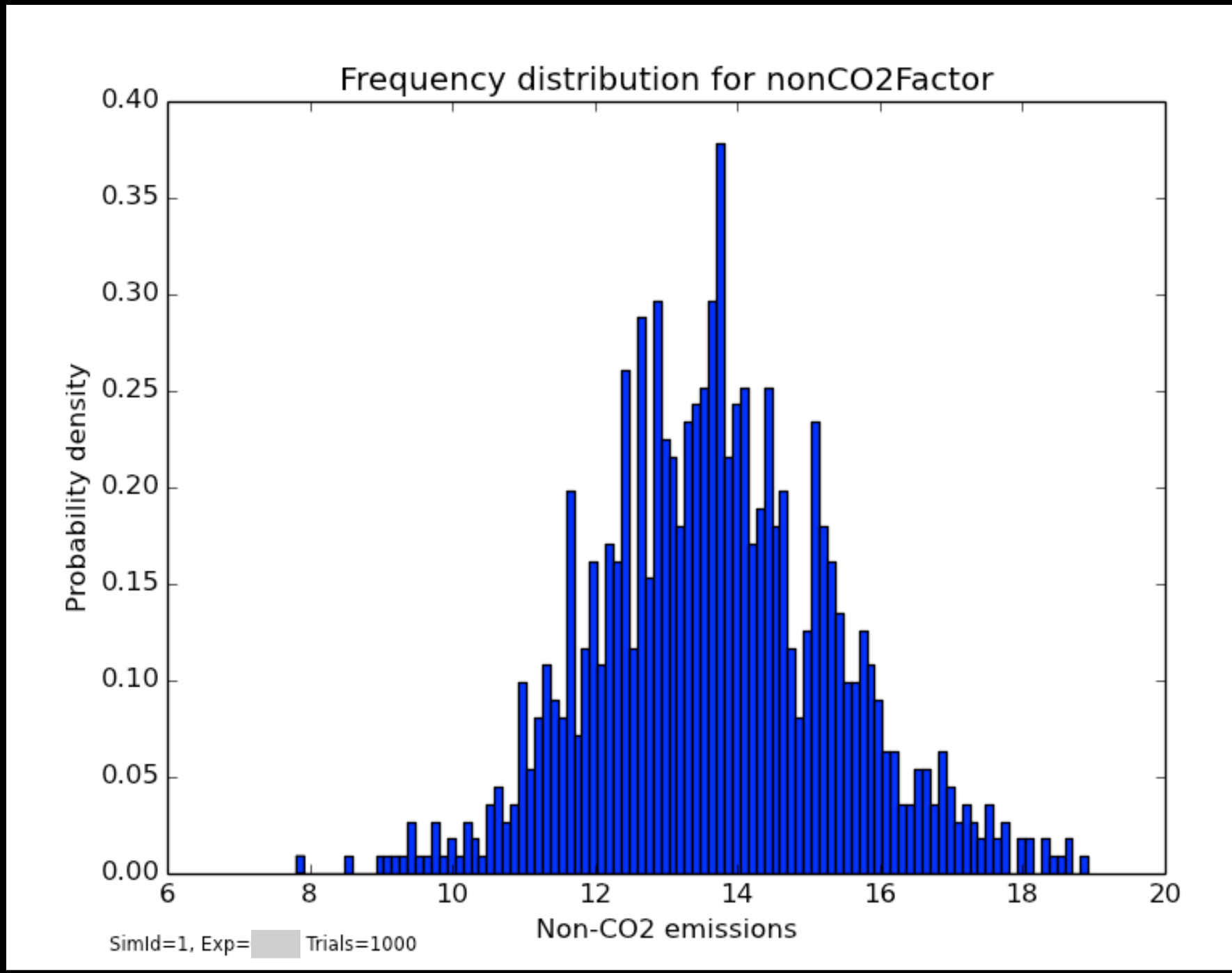
Carbon in HWP after 30 years



Earles, Yeh, and Skog (2012)

Non-CO_2 emissions

- N_2O from crop fertilization
- CH_4 from rice and livestock
- % change from GHG inventory



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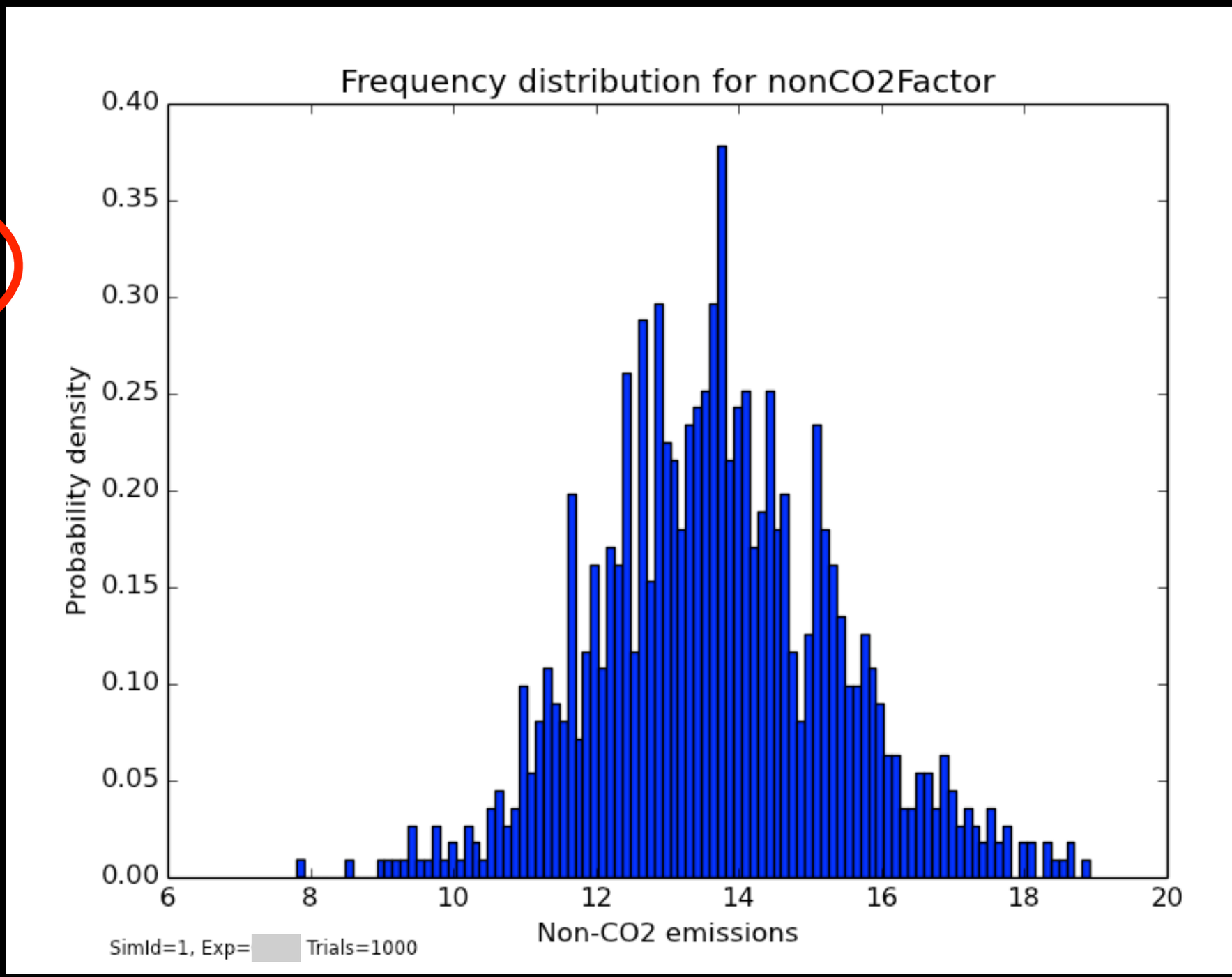


2 versions of AEZ-EF model

Excel

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	EF Model								Result:	15.2			Crop biomass da	
2														
3		Results lookup table					Deforest. %		Dry biomass stocks					
		n Factor n to	P CO2e	F CO2e nk	rage of and		as tal fores		live	live	shoot		carbon ss)	Carbon
8	Brazil-2	331	-421	274	334		96%		16	5	0.31		8	3
9	Brazil-3	495	-596	386	499		96%		68	20	0.30		34	1
10	Brazil-4	602	-691	479	606		96%		111	32	0.28		56	1
11	Brazil-5	826	-912	681	830		96%		202	54	0.27		101	2
12	Brazil-6	907	-928	756	908		96%		236	63	0.27		118	3
13	Brazil-10	527	-526	412	527		96%		107	31	0.29		53	1
14	Brazil-11	389	-426	343	390		96%		75	22	0.30		38	1

Original structure as released in 2011
"Matrix" version–arbitrary regionalization

python™

```
694        #
695        # Emissions for each RegionAEZ object are computed upon instantiation.
696        #
697        def run(self):
698            dataSrc = self.dataSrc
699
                                obj = RegionAEZ(dataSrc, reg, aez)
706                             obj.computeEmissionFactors()
707                             obj.computeTransitions()
708                             total += obj.computeEmissions()
709                         else:
710                             obj = None
711                         gridRow.append(obj)
```

Runs on Mac, Linux, Windows
Facilitates Monte Carlo simulation

GTAP Technical Papers

Improved Estimates of Soil and Biomass Carbon Stocks for Global Economic Models

Holly Gibbs, Sahoko Yui, and Richard Plevin

AEZ-EF: A model of greenhouse gas emissions from land-use change for use with AEZ-based economic models

Richard Plevin, Holly Gibbs, James Duffy, Sahoko Yui, Sonia Yeh

ILUC Monte Carlo Simulation

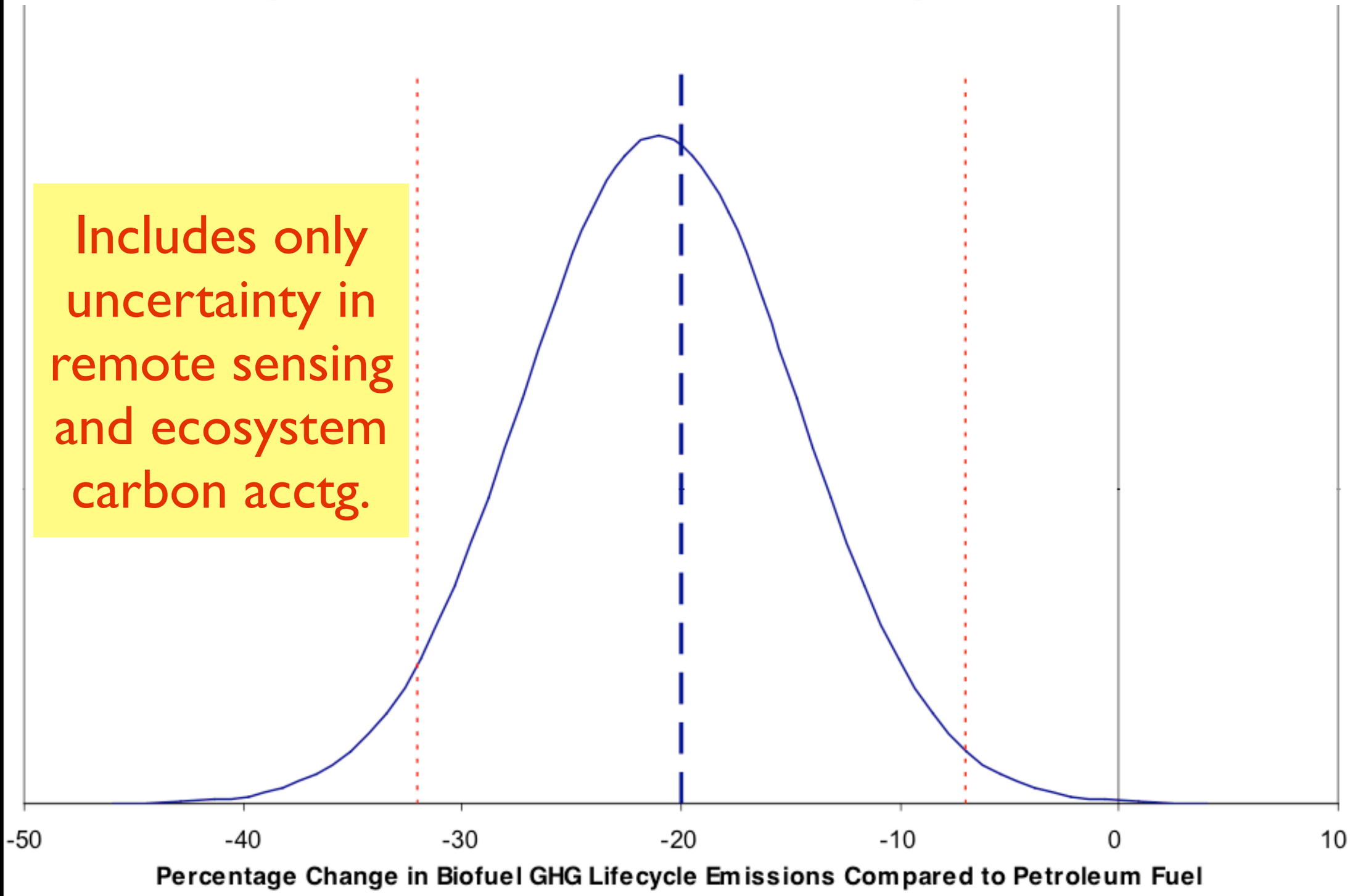
Motivation

- Systematic approach to sensitivity analysis
- Identifies most sensitive parameters and model components; guides further research
- Provides an estimate of expected value
- GTAP's SSA can't identify sensitive parameters, represent skewed distributions, or incorporate EF uncertainty coherently

US EPA's RFS2 analysis

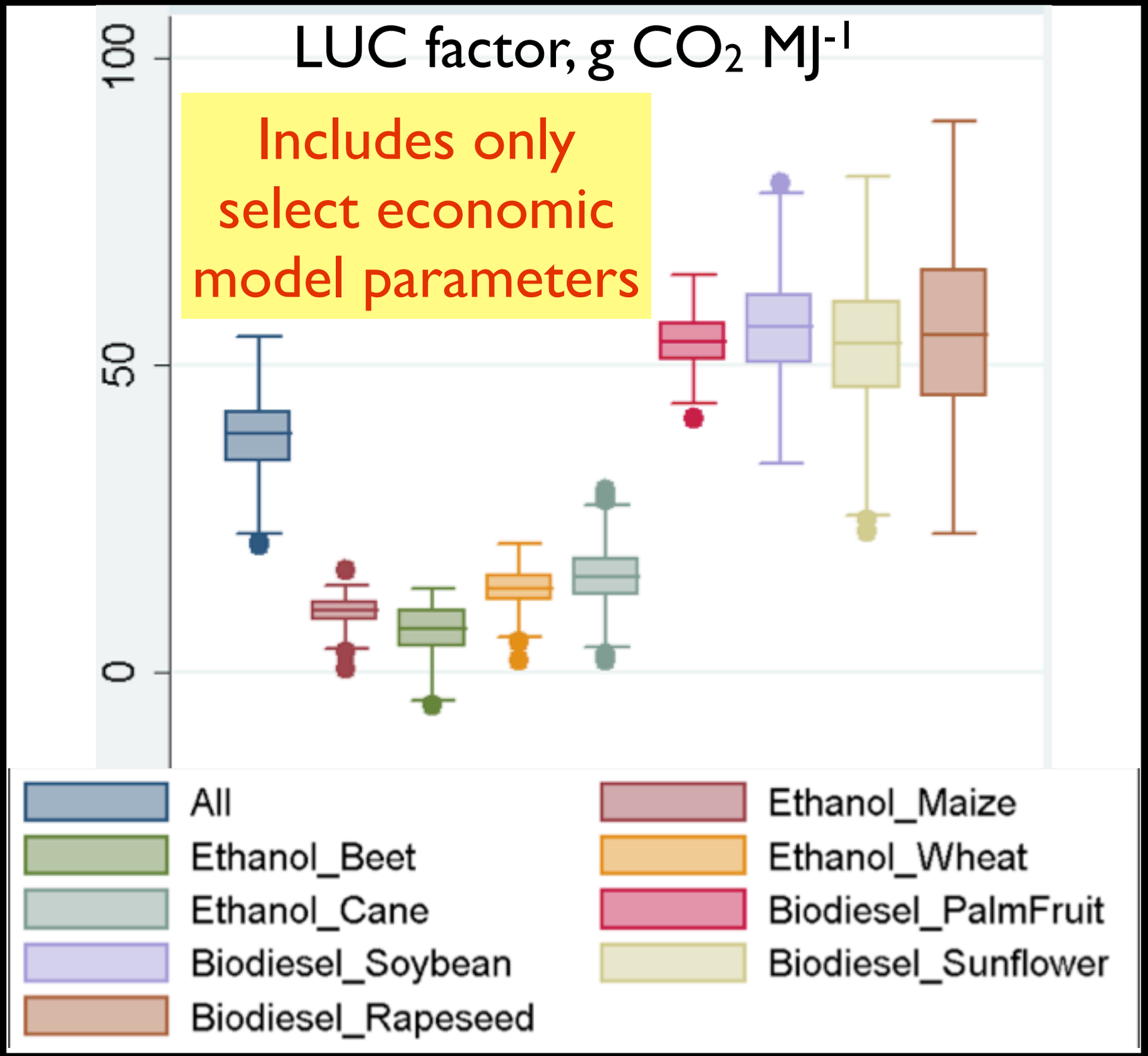
2022 average corn ethanol, NG-fired dry mill, 37% wet DGs

Includes only uncertainty in remote sensing and ecosystem carbon acctg.



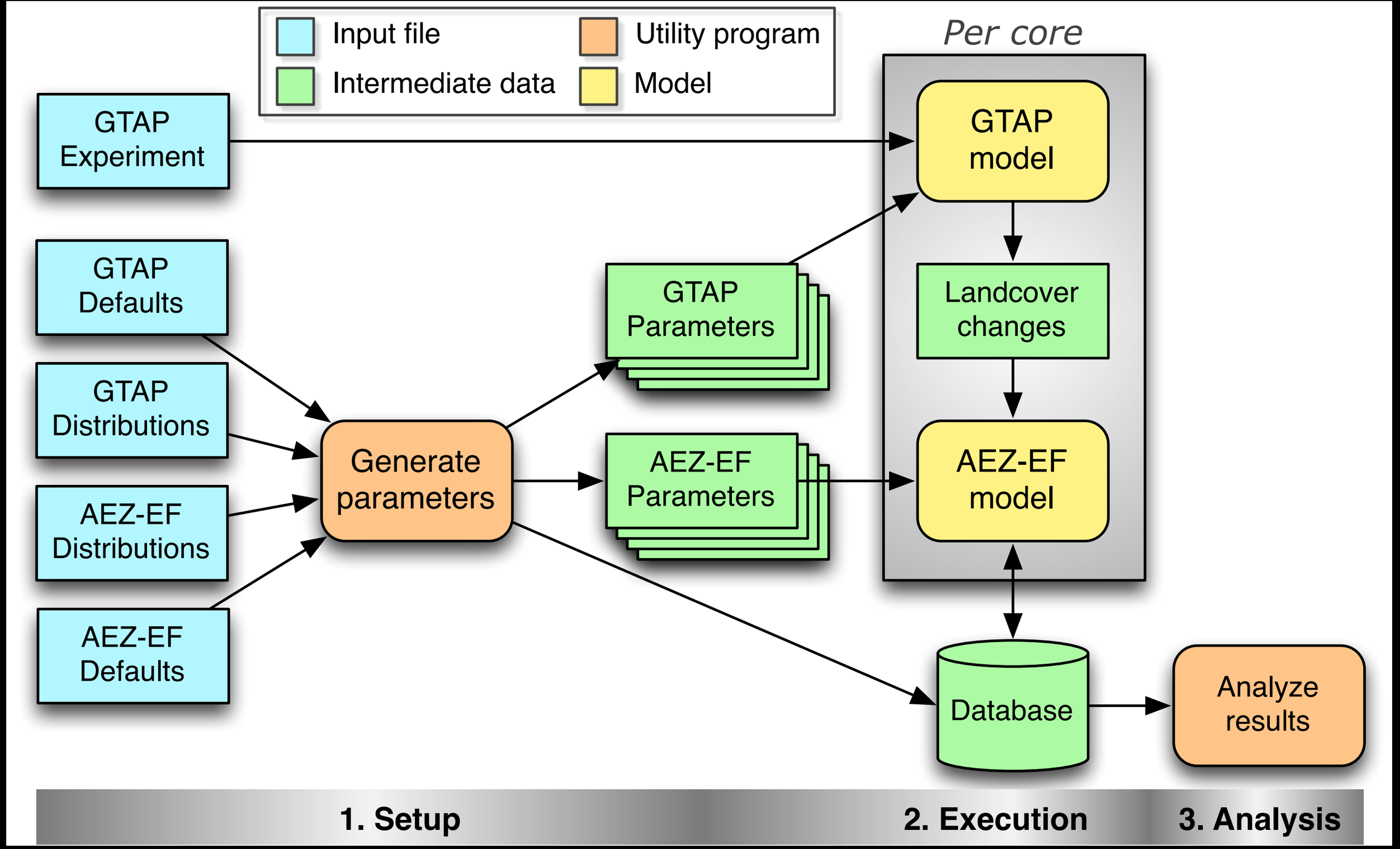
Source: USEPA 2010, p. 480.

IFPRI analysis for EU



Source: Laborde/IFPRI (2011)

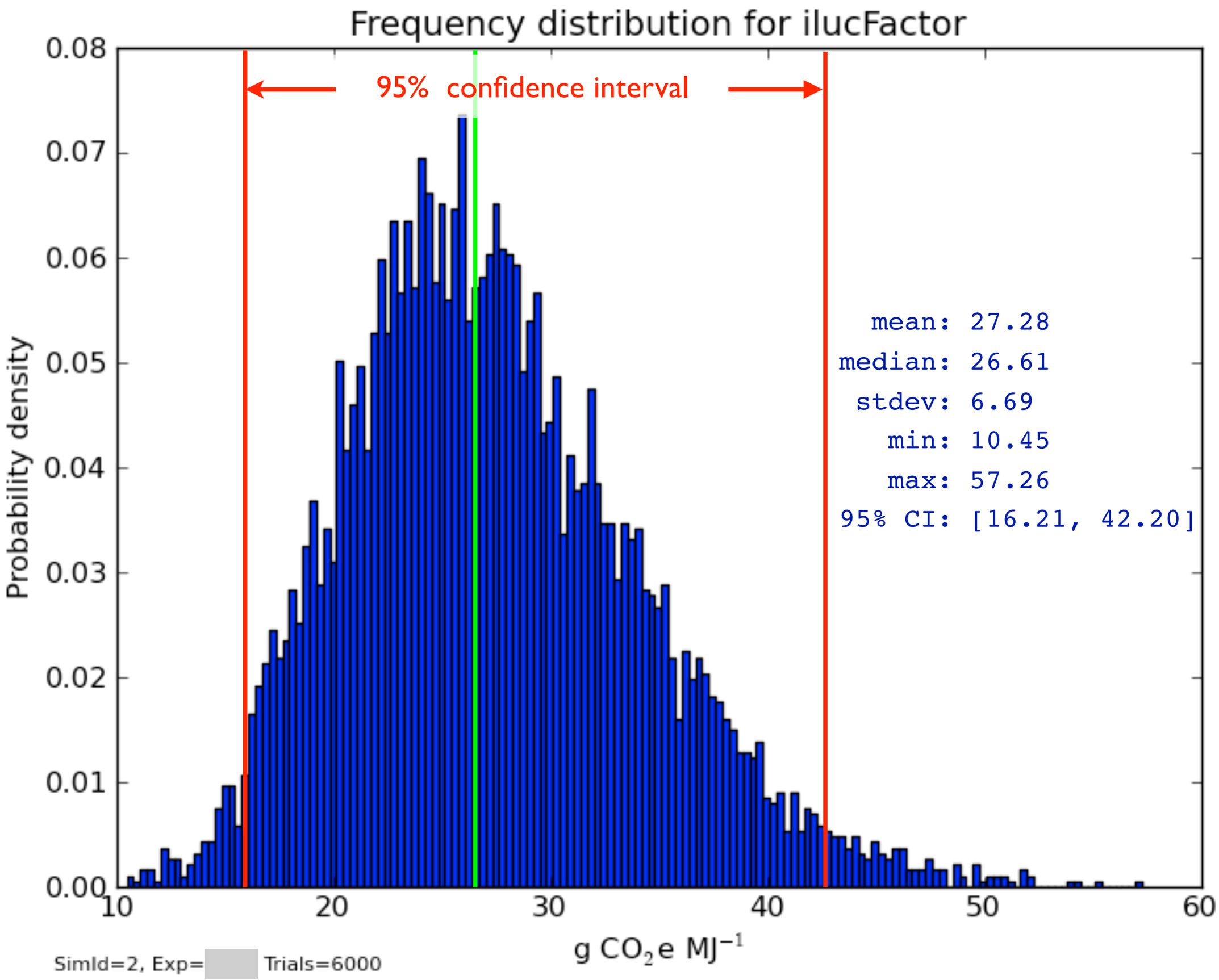
ILUC Monte Carlo System

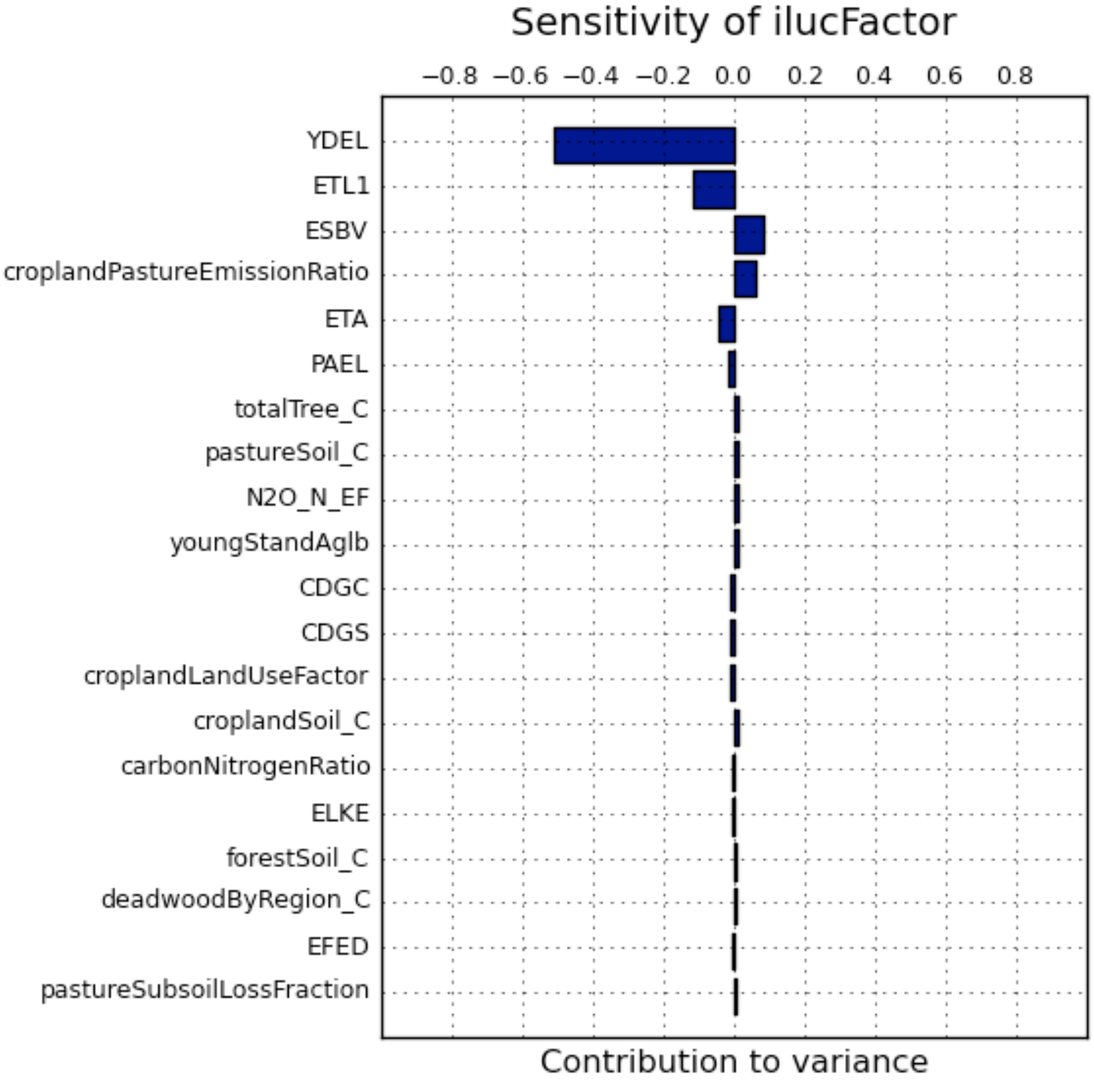


NERSC

- National Energy Research Scientific Computing system
- Carver: liquid-cooled IBM iDataPlex system
  - 9,984 processor cores
  - Linux operating system
  - Runs ~10 GTAP trials per minute
  - 1000 trial in ~90 minutes

Source: NERSC.gov


Frequency distribution for ilucFactor
95% confidence interval
mean: 27.28
median: 26.61
stdev: 6.69
min: 10.45
max: 57.26
95% CI: [16.21, 42.20]
Probability density
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
10
20
30
40
50
60
g CO2e MJ−1
SimId=2, Exp= Trials=6000



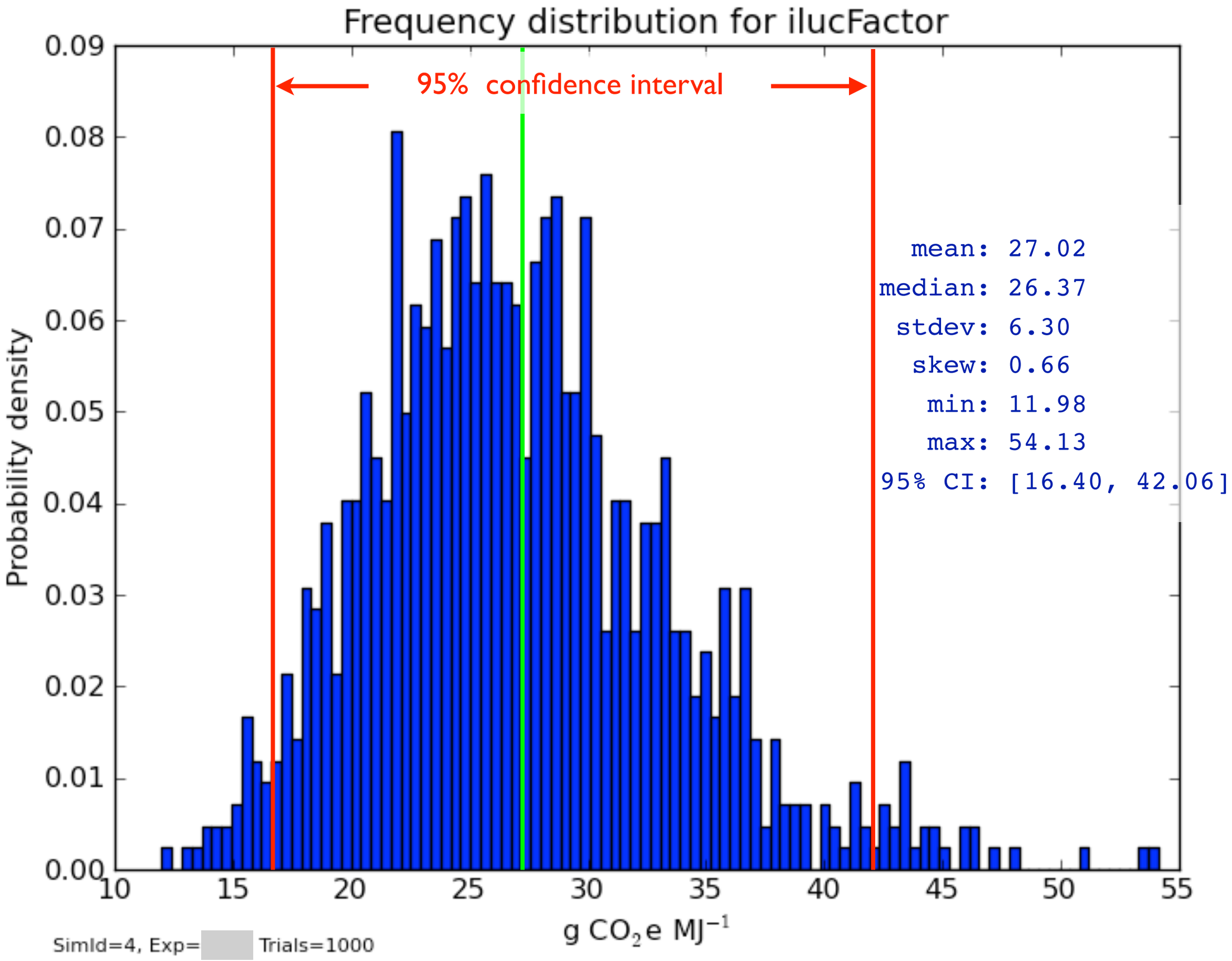
Price-yield elasticity

El. trans. forest/crop/past

El. subs. primary factors
- mainly forestry

Marginal land productivity

Pasture yield elasticity


Frequency distribution for ilucFactor
95% confidence interval
mean: 27.02
median: 26.37
stdev: 6.30
skew: 0.66
min: 11.98
max: 54.13
95% CI: [16.40, 42.06]
Probability density
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
10
15
20
25
30
35
40
45
50
55
g CO2e MJ−1
SimId=4, Exp=
Trials=1000