

Land use change and biofuel life cycle analysis

***NSF Food-Energy-Water Nexus
Workshop***

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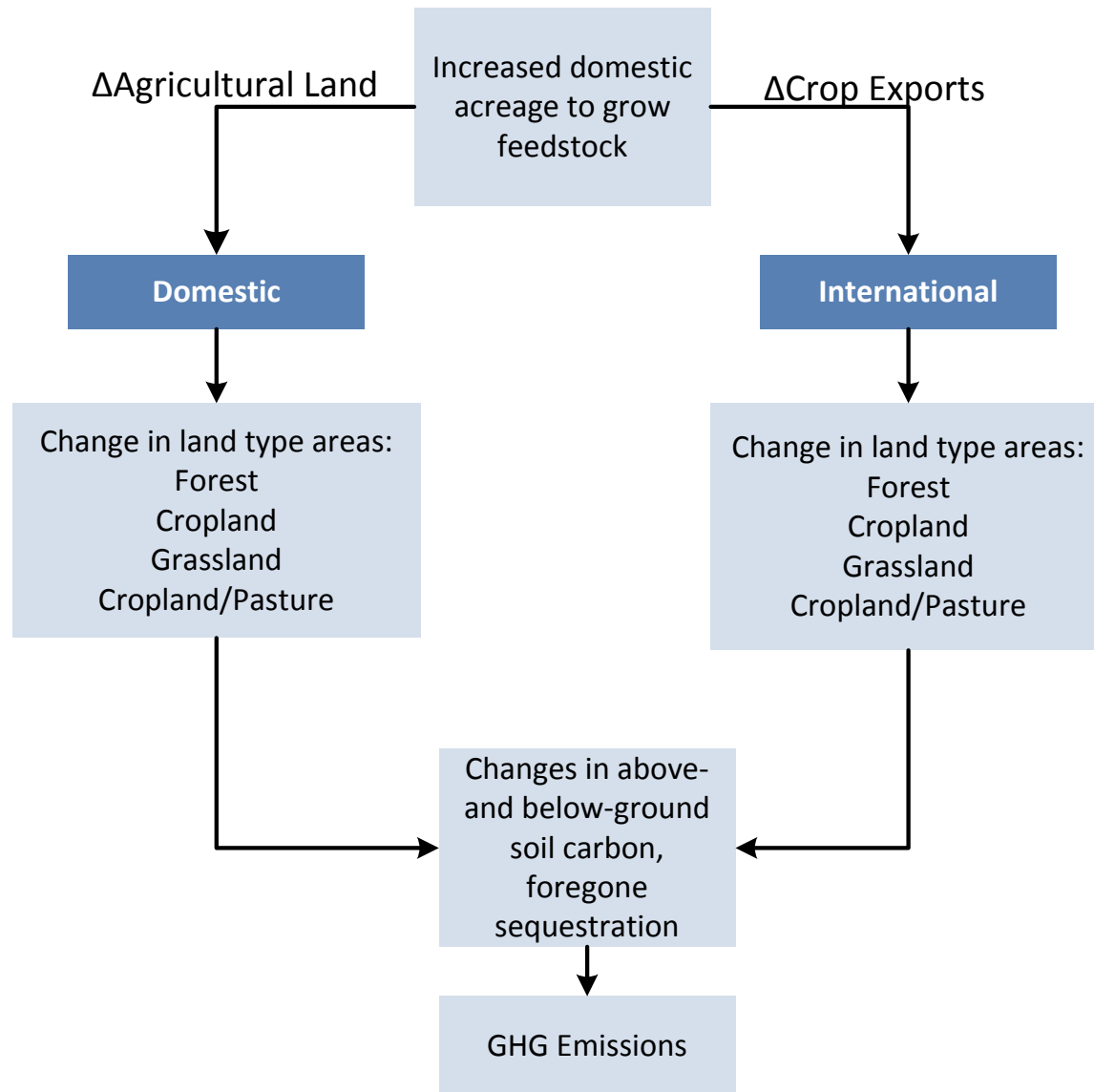


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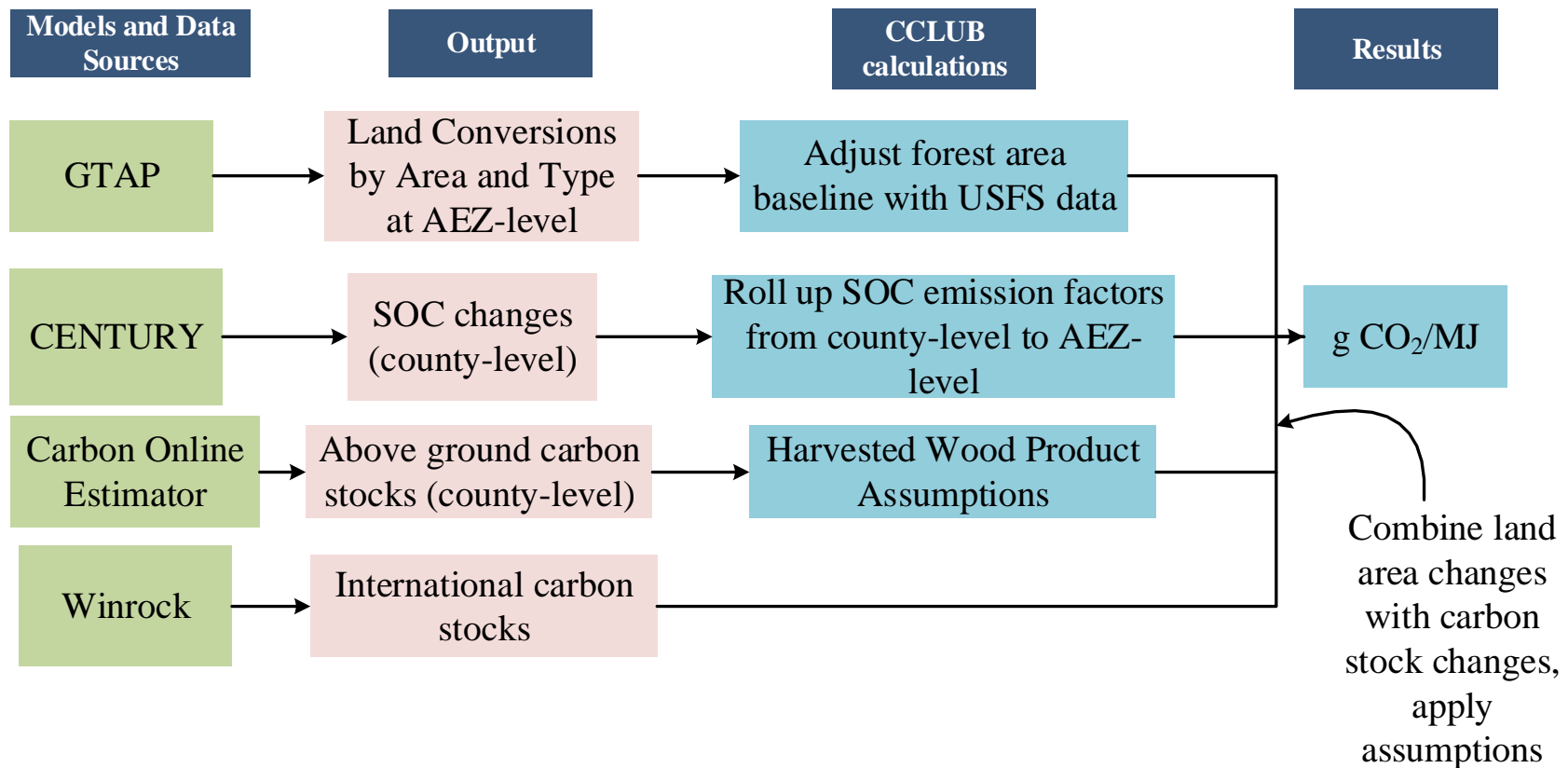


U.S. DEPARTMENT OF
ENERGY

Land-Use Change Overview



Estimating land-use change GHG emissions incorporates results from several models and data sets

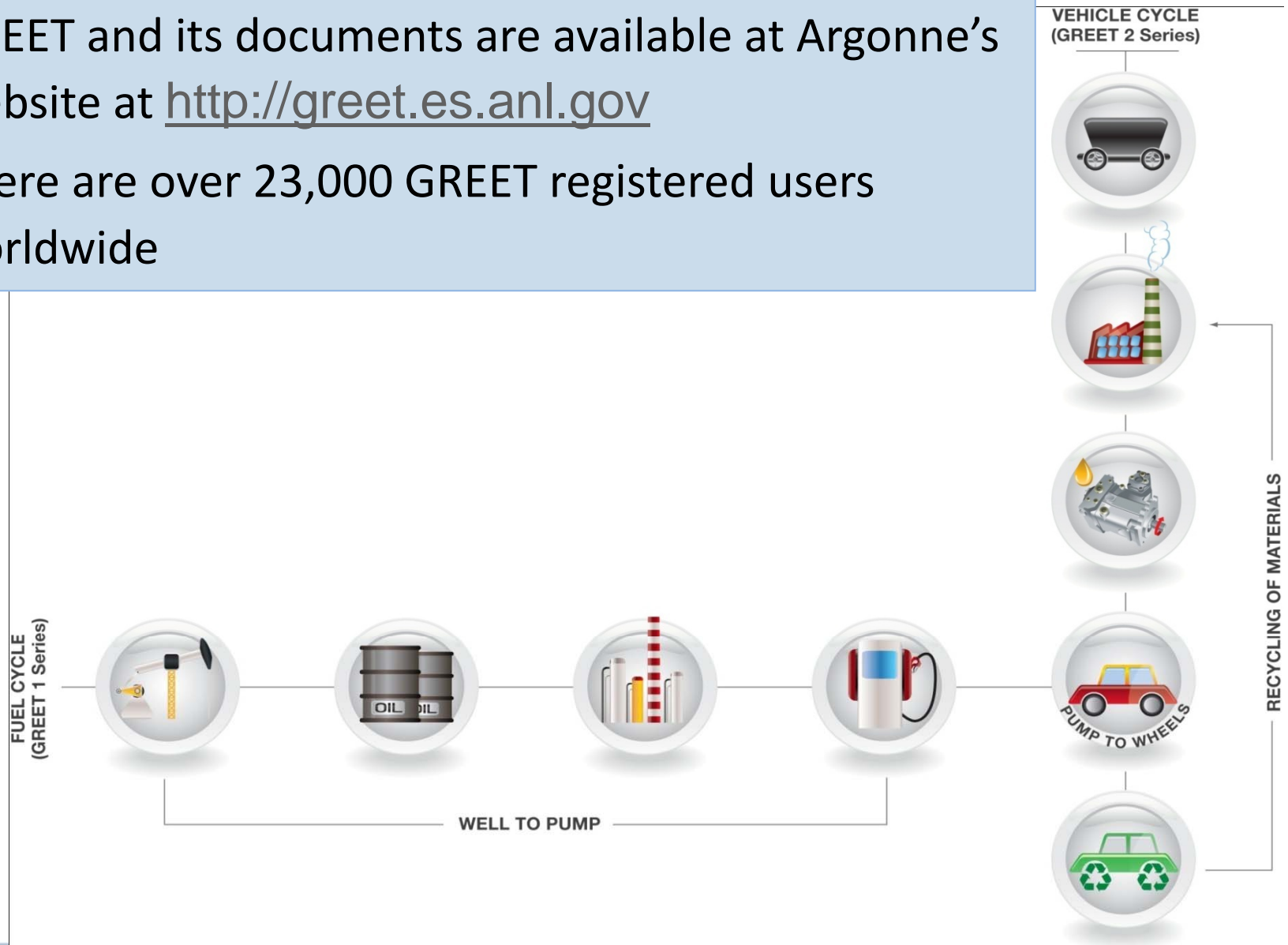


Data and calculations are contained within GREET module: Carbon Calculator for Land Use Change from Biofuels Production (CCLUB)

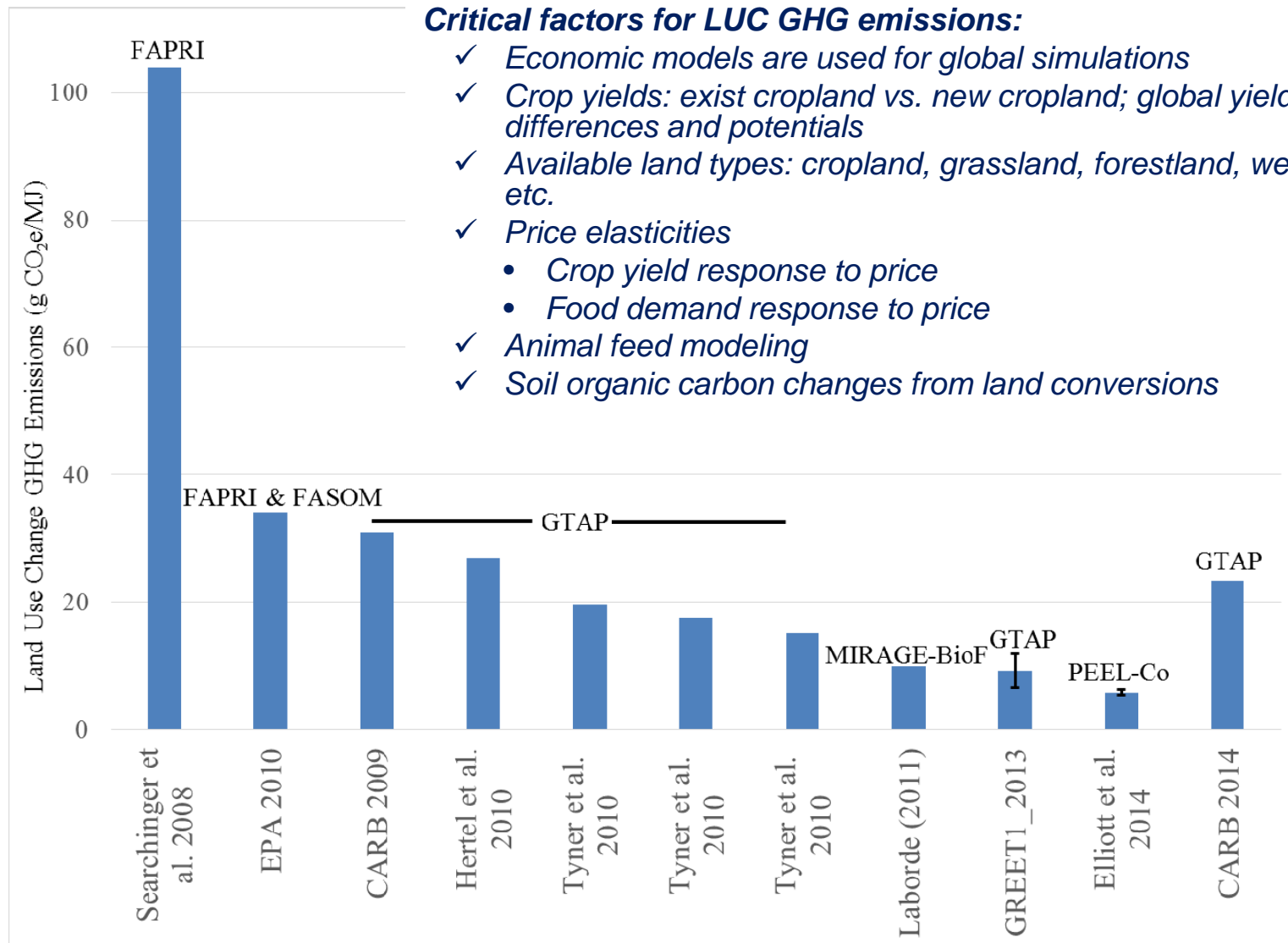


The GREET (Greenhouse gases, Regulated Emissions, and Energy use in Transportation) Model

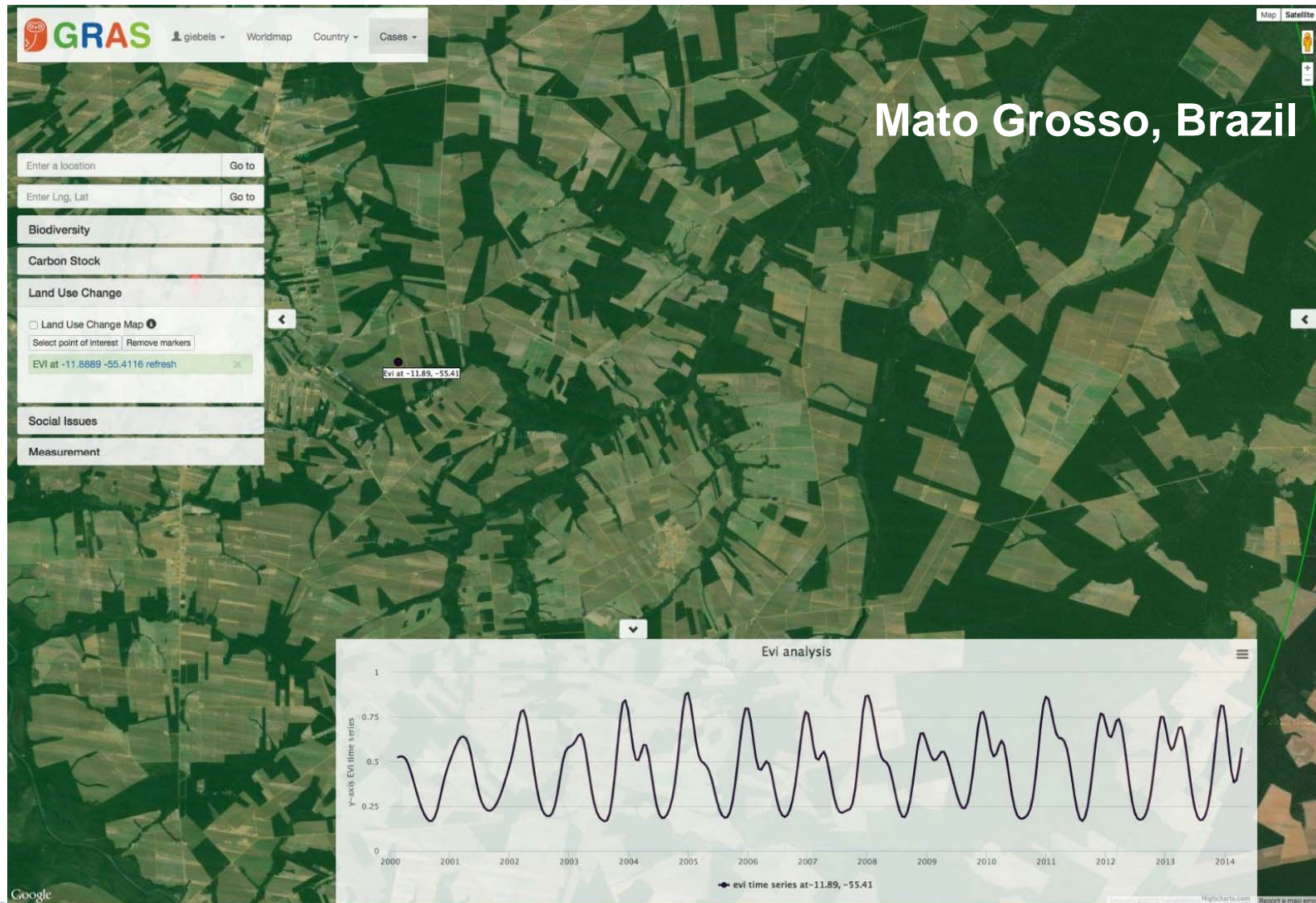
- ❑ GREET and its documents are available at Argonne's website at <http://greet.es.anl.gov>
- ❑ There are over 23,000 GREET registered users worldwide



Estimates of LUC GHG emissions for corn-to-ethanol pathway



Double cropping increases biomass production on existing agricultural land



Soil carbon change upon land transitions depends on many factors

- Land use history
- Yield
- Climate
- Soil depth
- Management practices



Credit: P.F. Dunn



Credit: National Renewable Energy Laboratory



Credit: P.F. Dunn



Credit: Ken Goddard



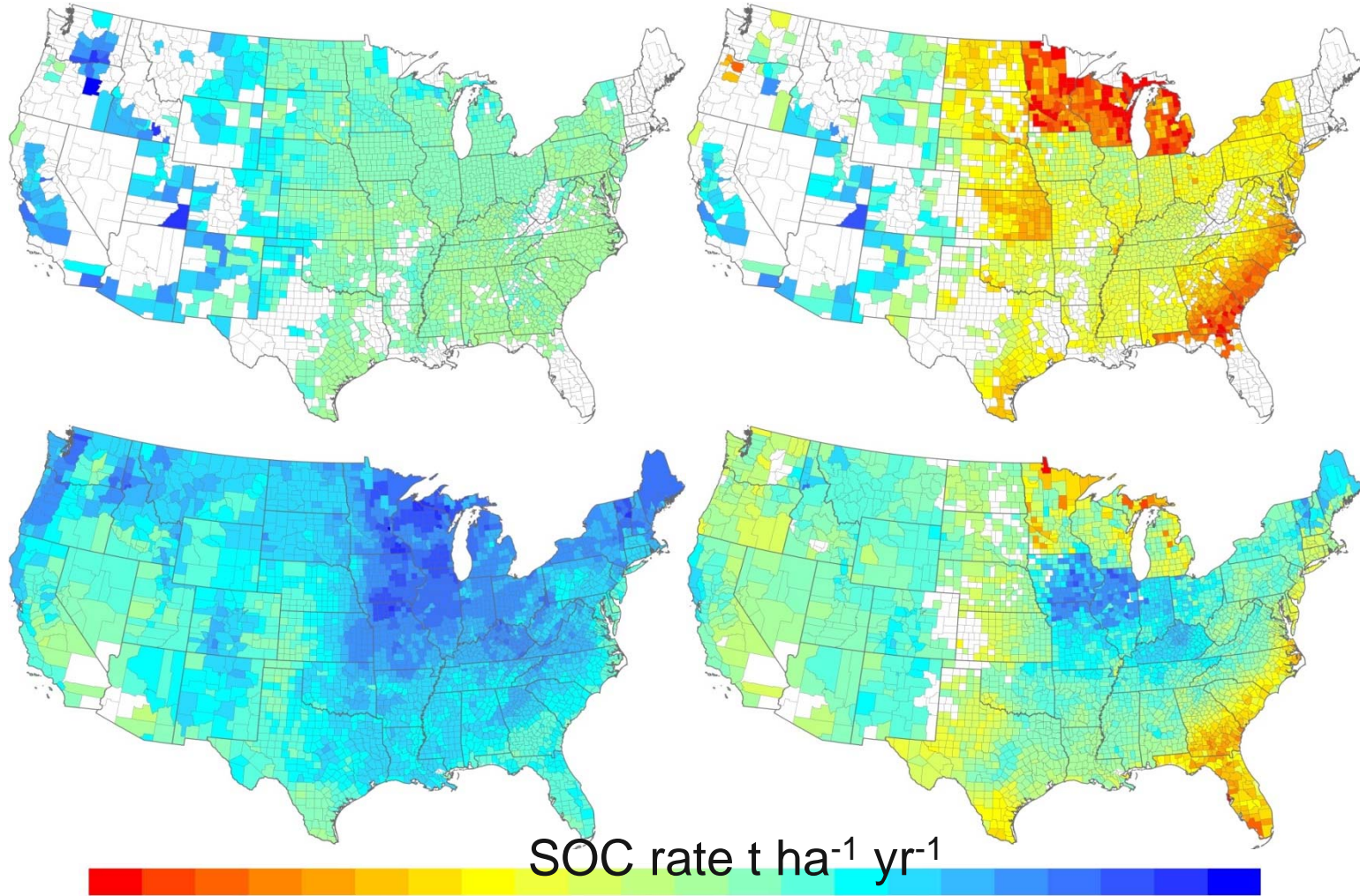
Soil organic carbon changes upon land transition are highly spatially- and feedstock-dependent

Cropland Pasture

Forest

Corn

Miscanthus

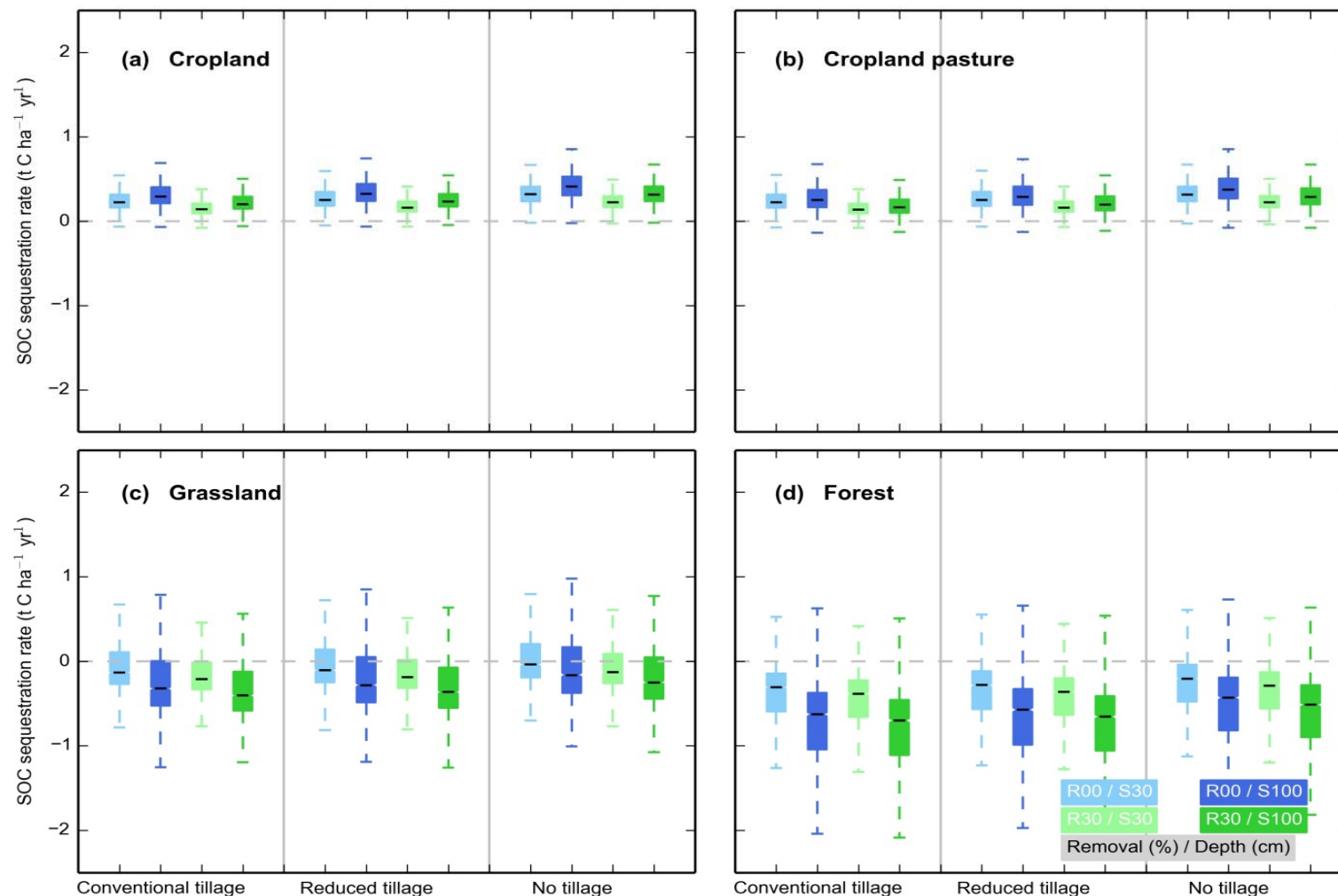


SOC rate $\text{t ha}^{-1} \text{yr}^{-1}$

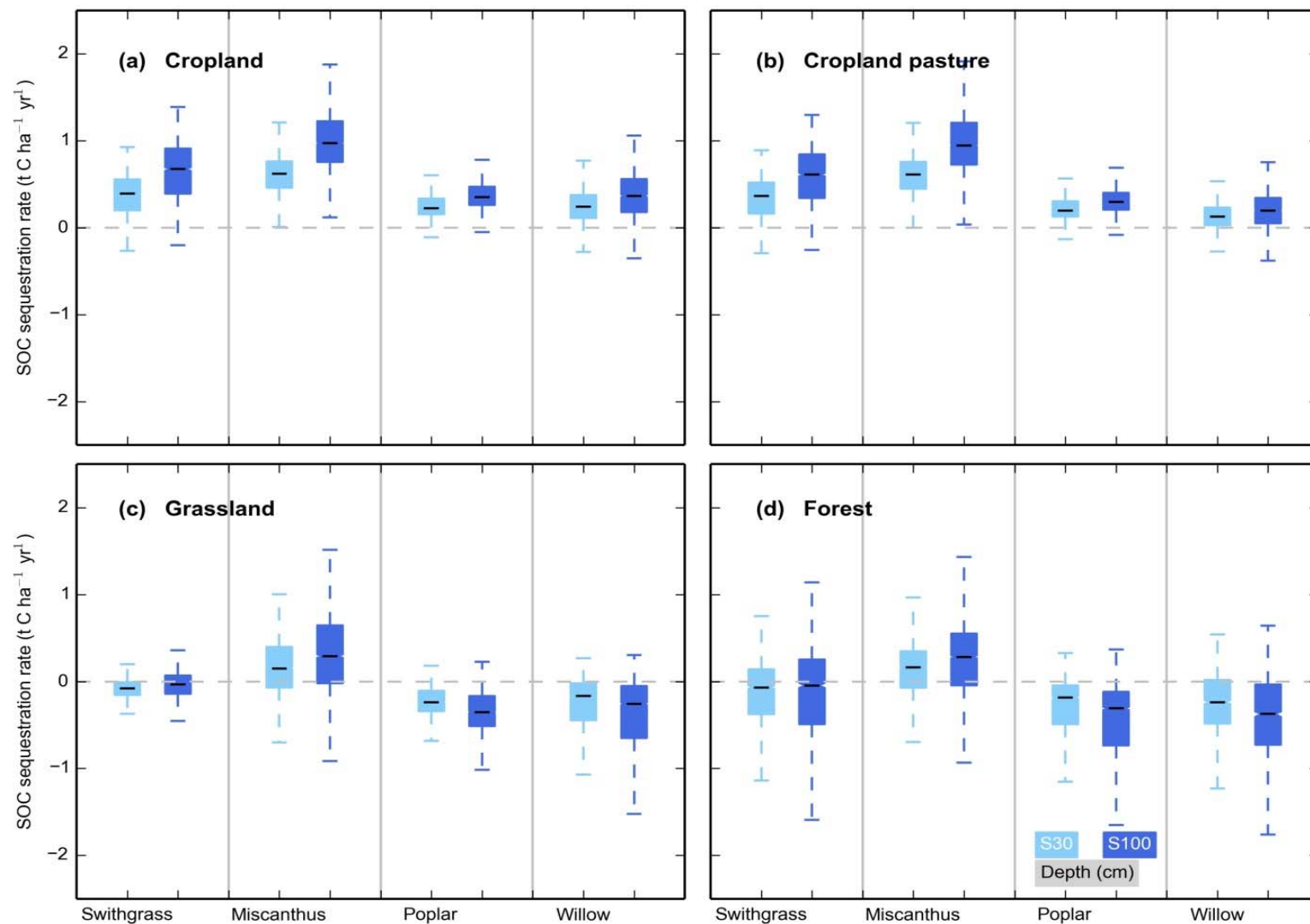
<-2.0 -1.8 -1.6 -1.4 -1.2 -1.0 -0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 >2.0

Qin et al., *GCB Bioenergy*, 2015, submitted

Conversion of cropland to corn with stover removal shows mostly increasing SOC; conversion of grassland or forest shows largely decreasing SOC



Conversion to energy grasses tends to increase or maintain SOC; conversion to short rotation woody crop production can cause it to decline



LUC GHG emissions are important contributor to ethanol life-cycle GHG emissions

	Land use change GHG emissions (g CO ₂ eq MJ ⁻¹)			Well-to-wheel GHG w/o LUC (g CO ₂ eq MJ ⁻¹)	Well-to-wheel GHG w/ LUC (g CO ₂ eq MJ ⁻¹)
	Domestic	International	Total		
Corn	1.4–4.3 (1.5–3.7)	5.0	6.4–9.3 (6.5–8.7)	57.1	63.5–66.4 (63.6–65.8)
<i>Miscanthus</i>	-22.3–-16.3 (-12.5–-8.4)	2.2	-20.1–-14.1 (-10.4–-6.2)	13.5	-6.7–-0.6 (3.1–7.3)
Gasoline					94

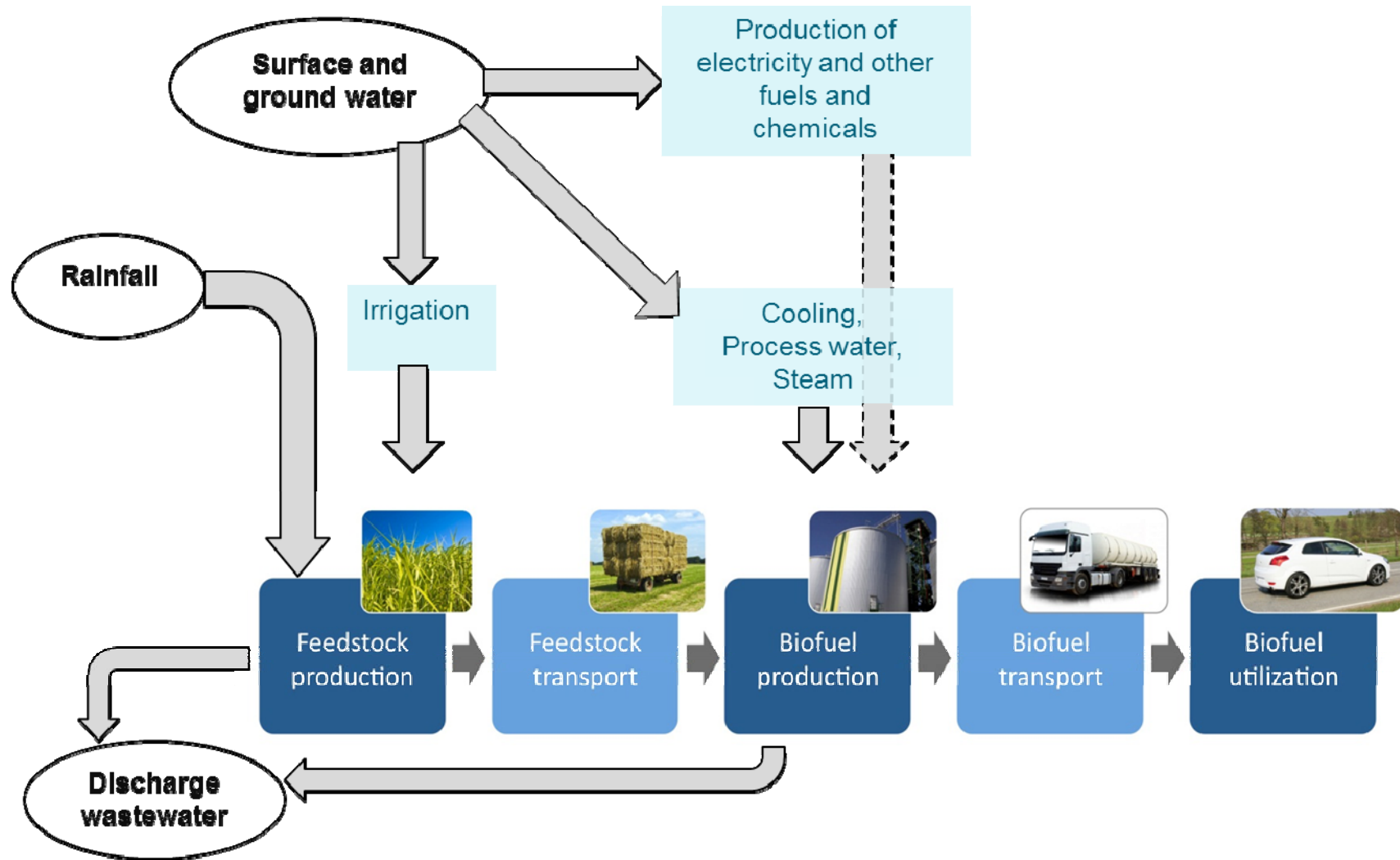
LUC GHG emissions reflect both SOC changes *and* what types of land are predicted to be impacted.

Corn: When forests converted, soil carbon lost

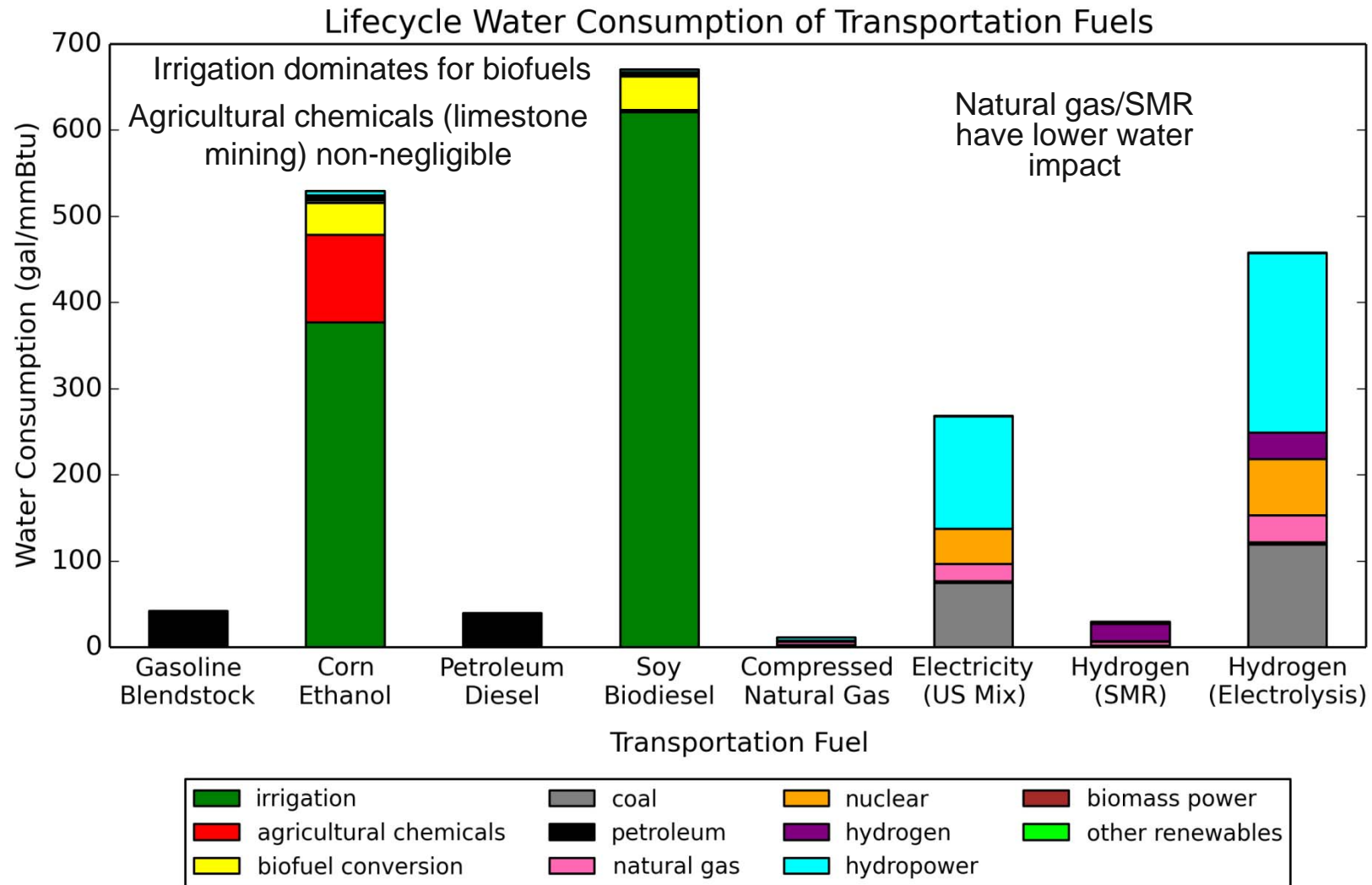
Miscanthus: When cropland-pastureland converted, soil carbon increases.



Biofuel water use accounting



Detailed water life-cycle analysis of fuel pathways



Conclusions

- Land use change impacts soil carbon change and life-cycle greenhouse gas emissions from biofuel production. The impacts can be better understood with improved models and datasets.
- Soil carbon change is highly spatially-specific and feedstock dependent.
- Further LUC associated impacts should also be addressed, for example double cropping.
- Water use is also important for biofuel production. Conventional corn and soybean biofuels consume a large quantity of water, especially in irrigation.



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References

- <https://greet.es.anl.gov/>
 - GREET™, CCLUB
- <https://greet.es.anl.gov/publications>
 - Manual: GREET, CCLUB
 - Report: LUC-SOC, water consumption, LCA updates (since 1990s)

