INSTITUTE ON THE

ENVIRONMENT

UNIVERSITY OF MINNESOTA

Driven to Discover℠

Big Question

How will we feed 9 billion people...
with growing appetites for meat & energy...
without compromising the environment?

Agriculture Dominates the Planet Today

~40% of global land area
~70% of global water withdrawls
~30% of greenhouse gas emissions

~2x nitrogen & phosphorus flows
massive driver of biodiversity loss

Meeting Growing Demands?

Expansion or Intensification?

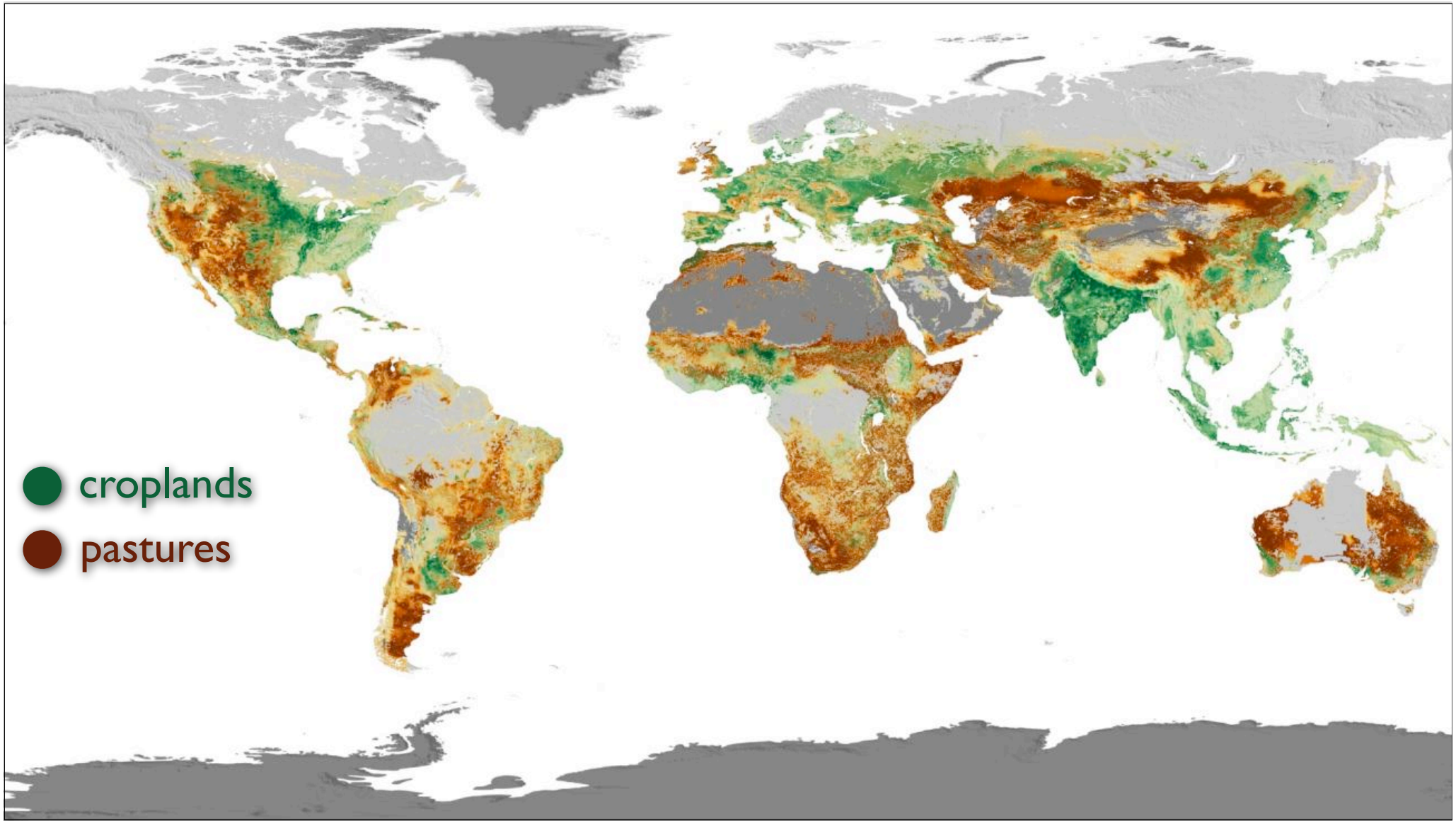
Expansion

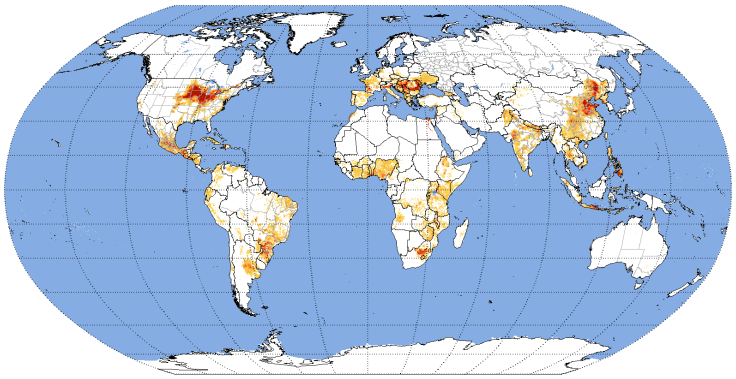
Carbon, Climate and Biodiversity Implications

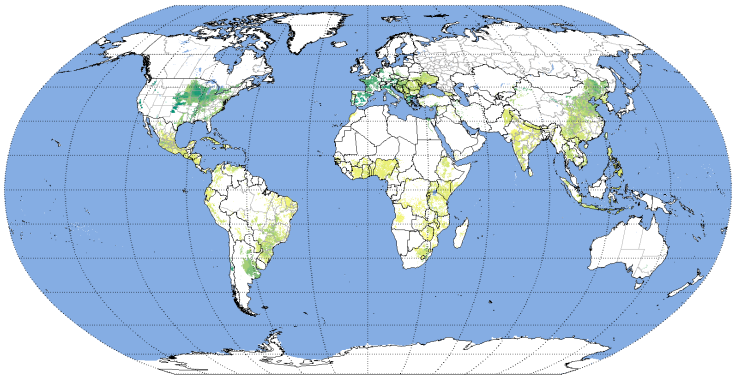
Intensification

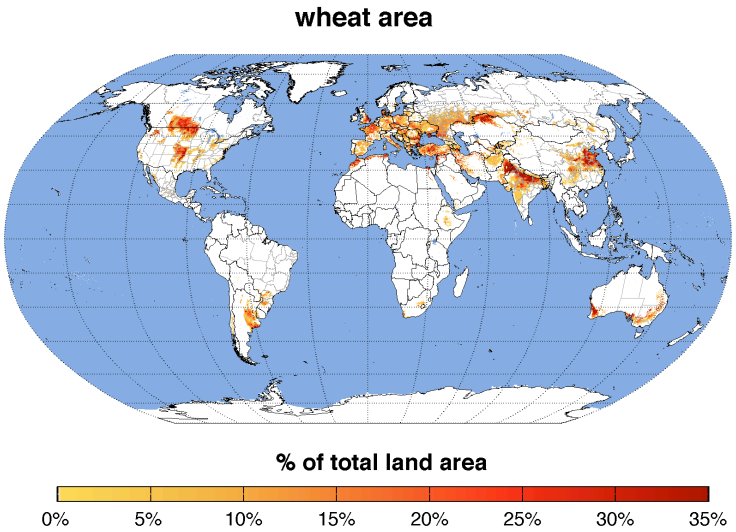
Water and Nutrient Pollution Implications

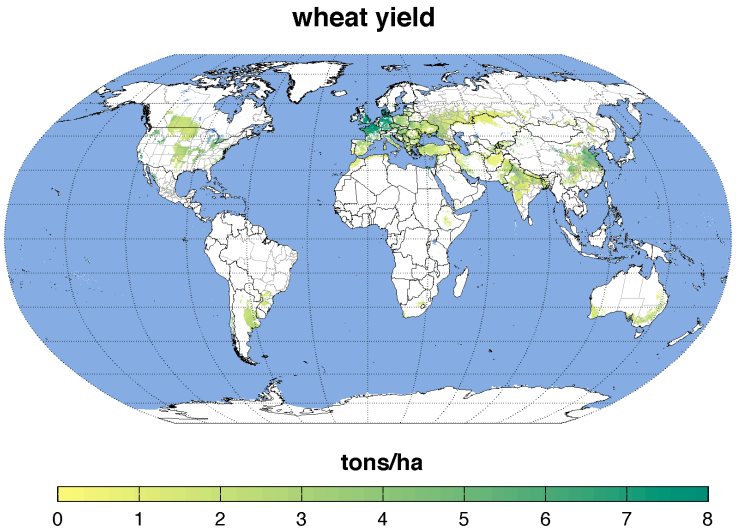
New Tools and Data to Examine Tradeoffs


croplands
pastures









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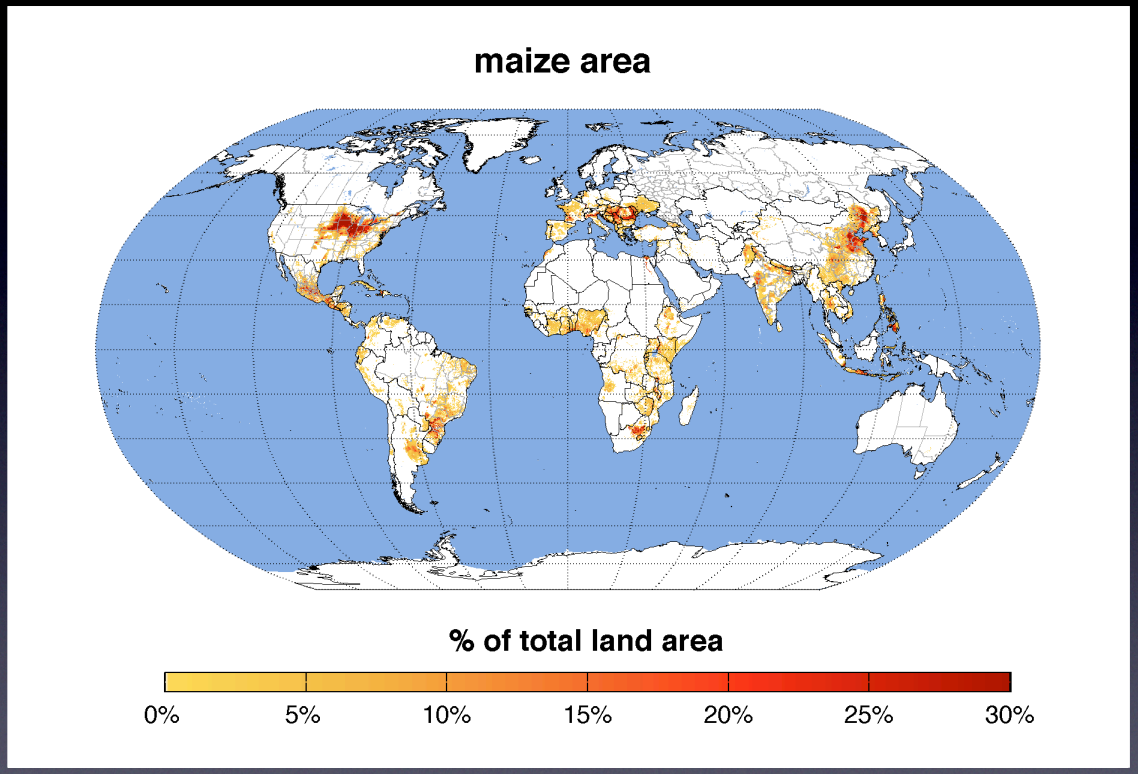

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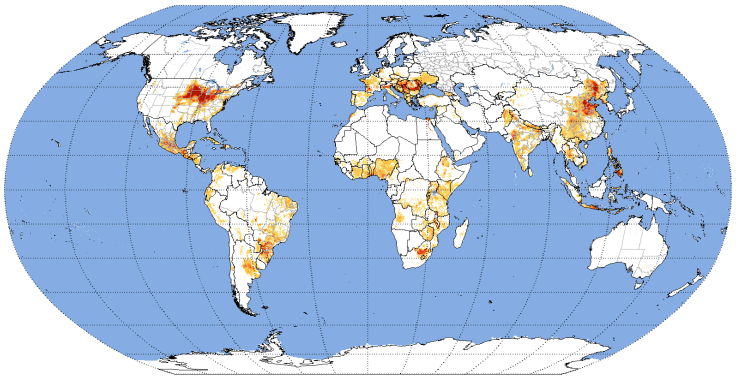

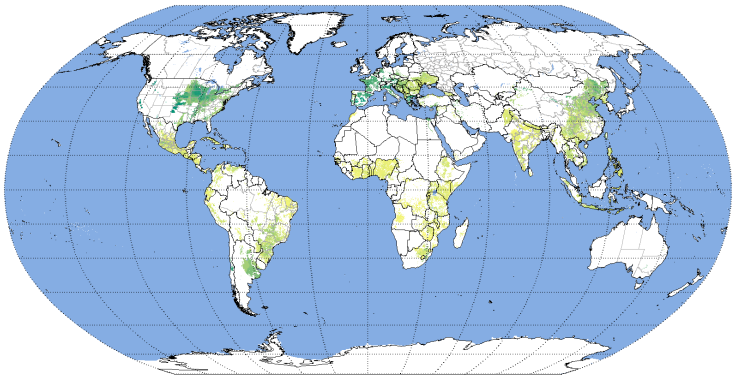

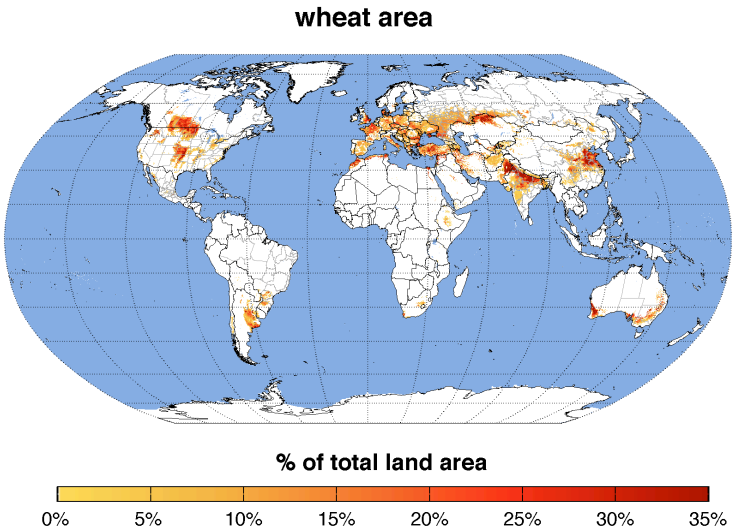

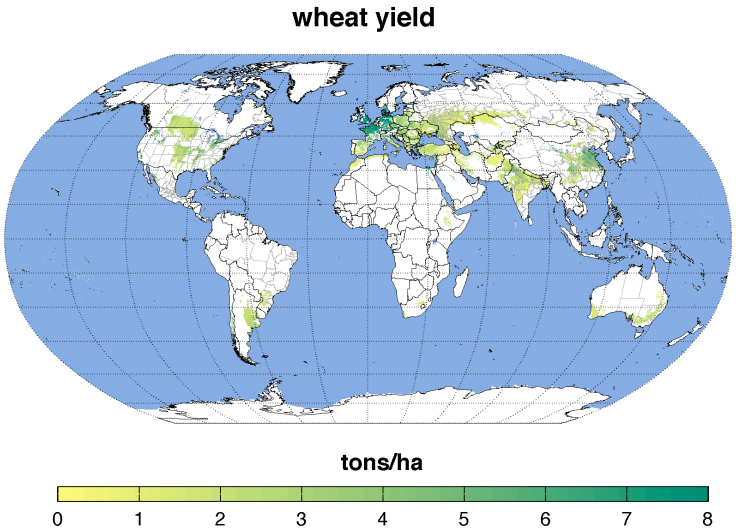

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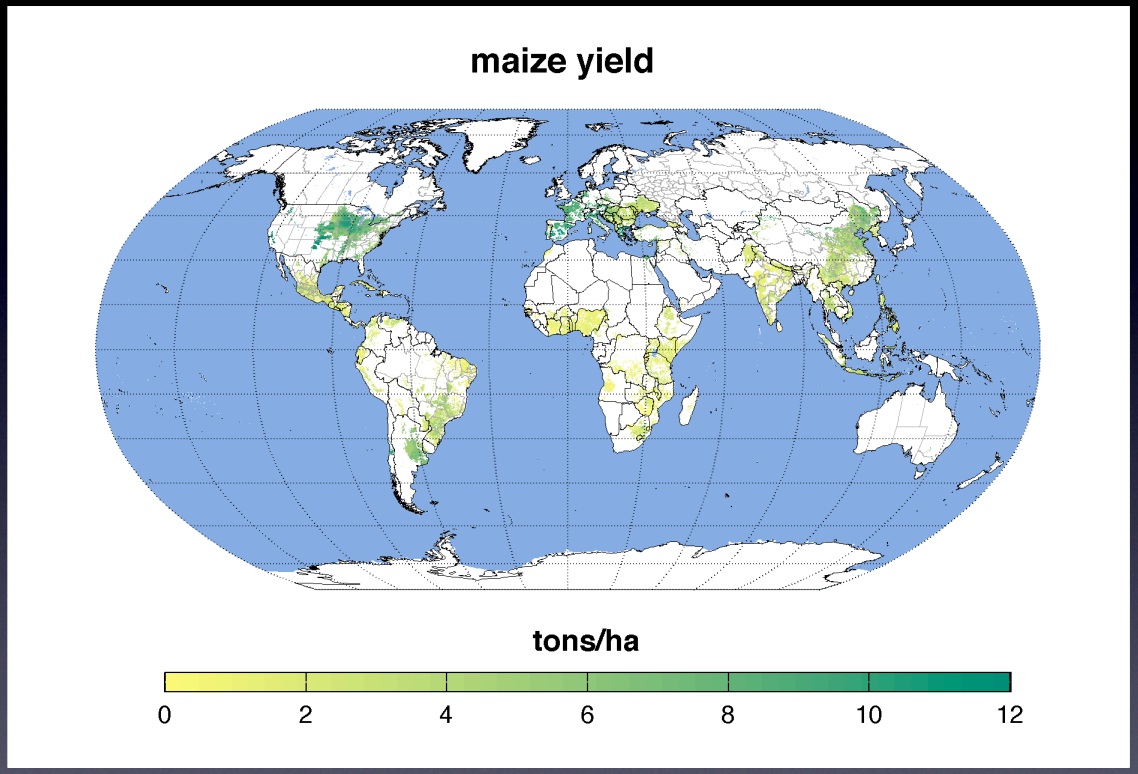

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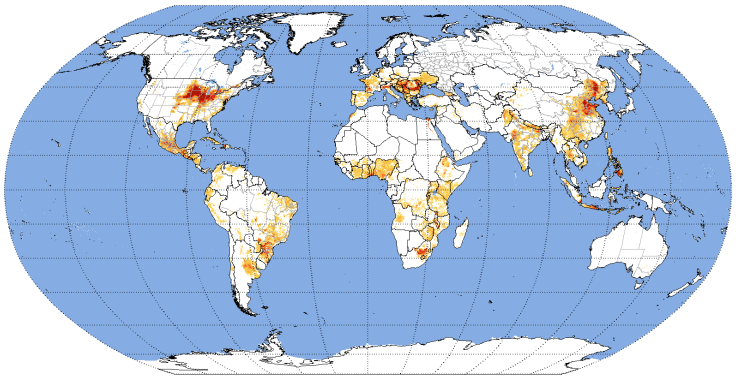

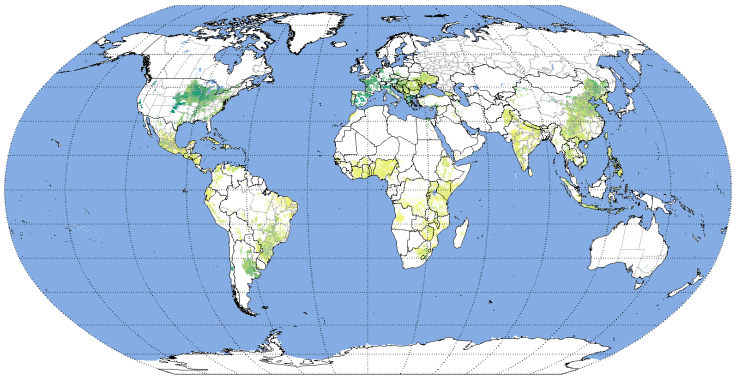

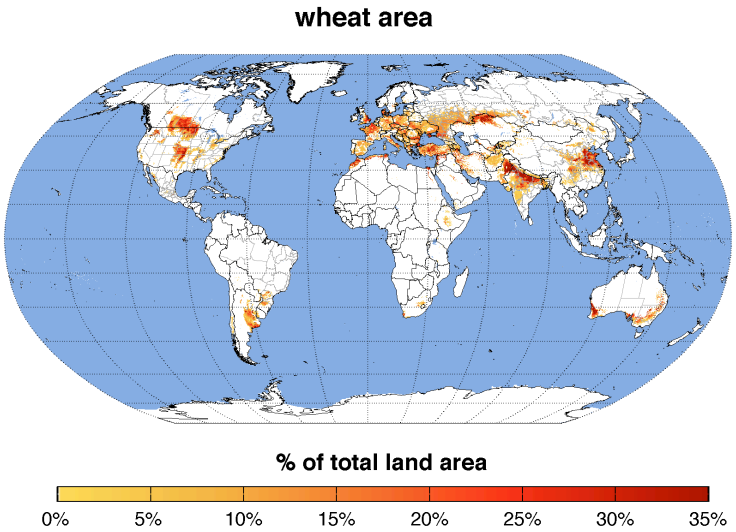

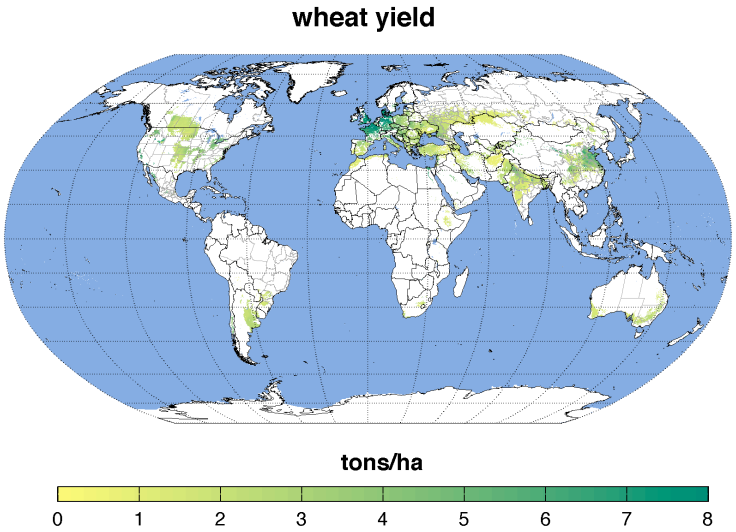

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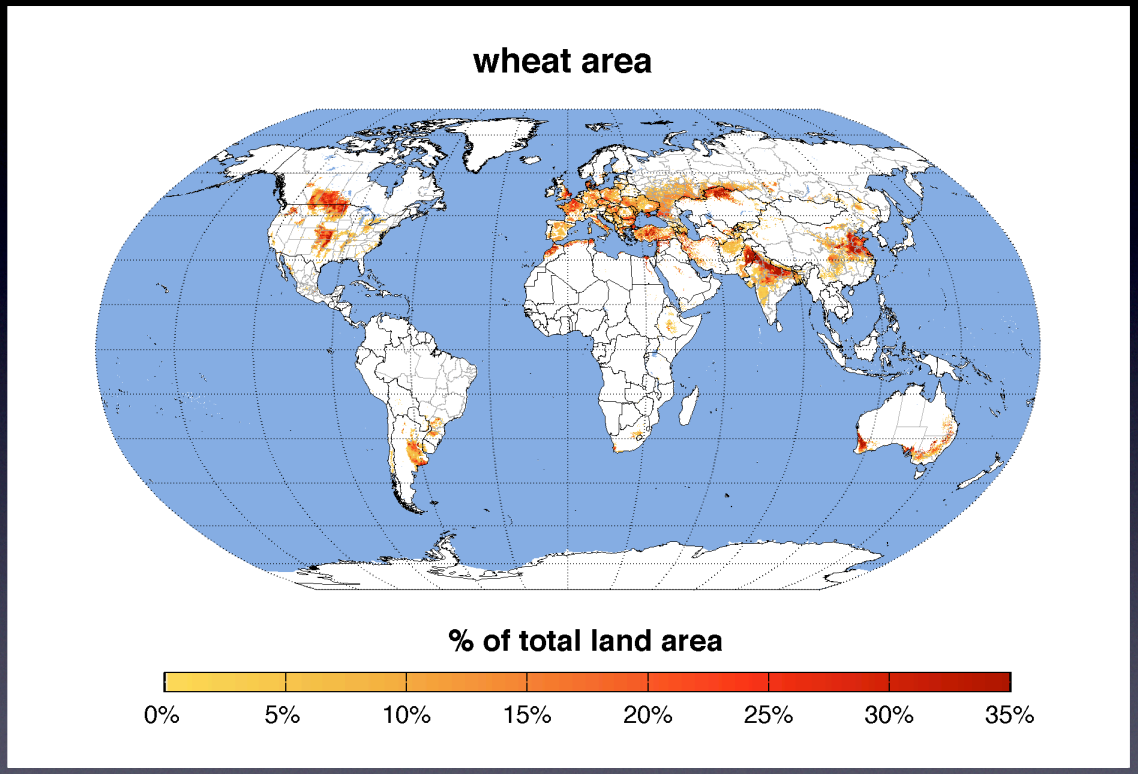

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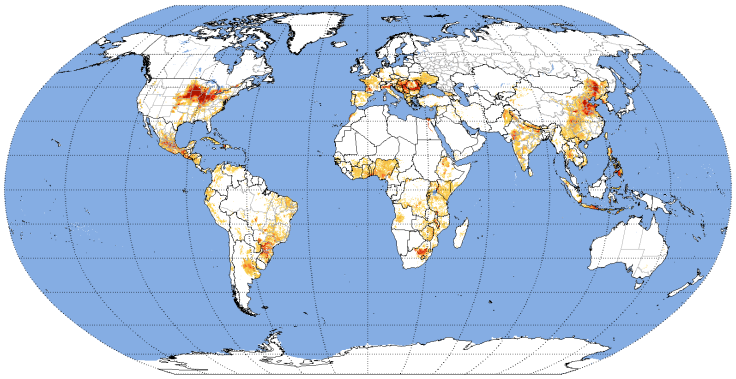

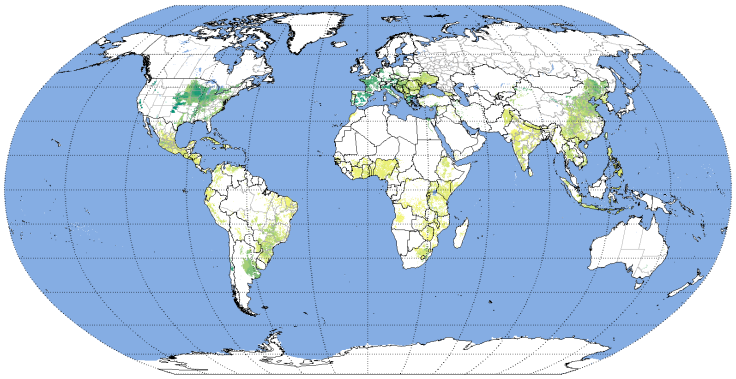

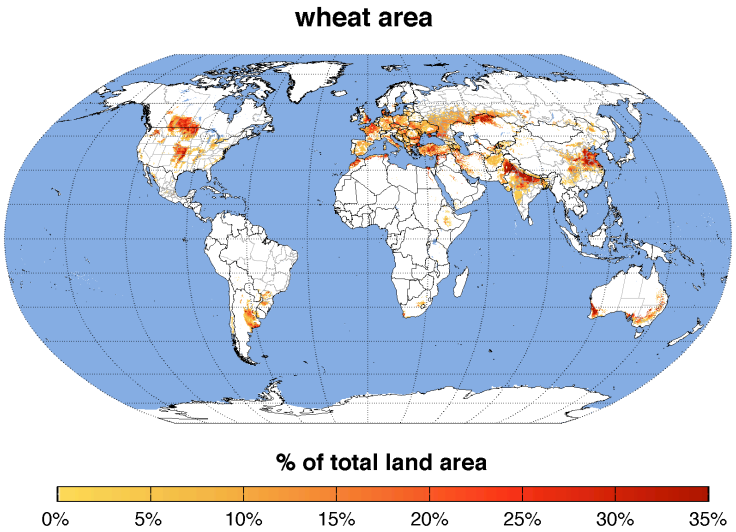

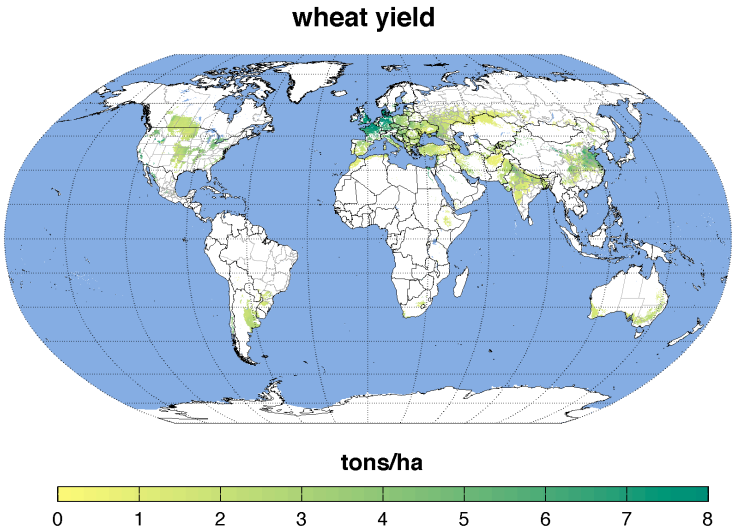

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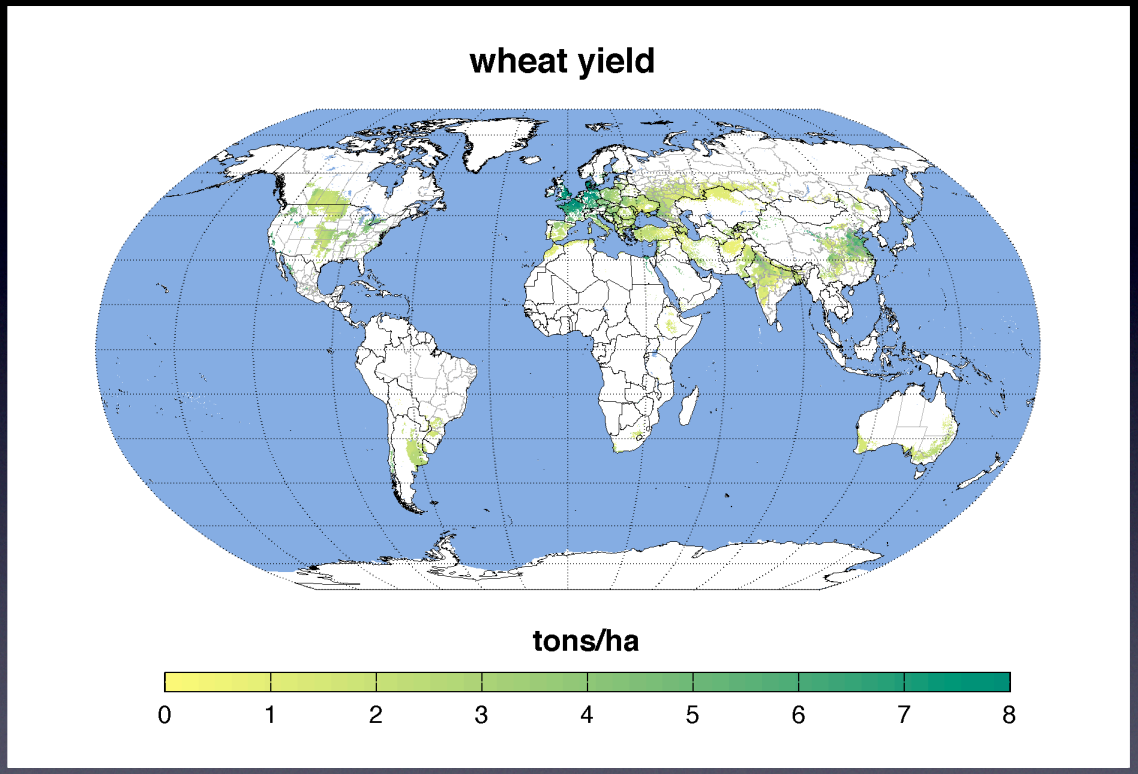

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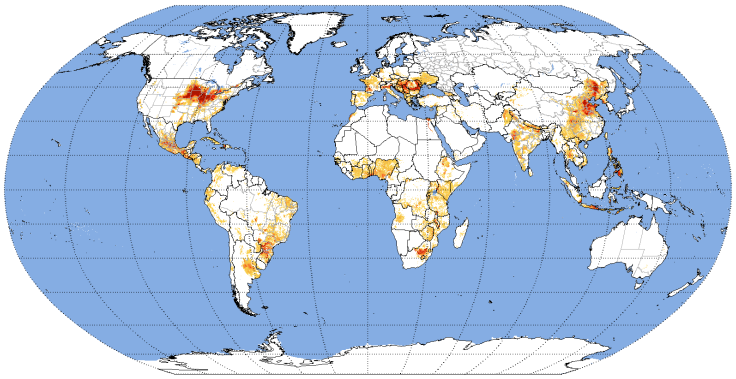

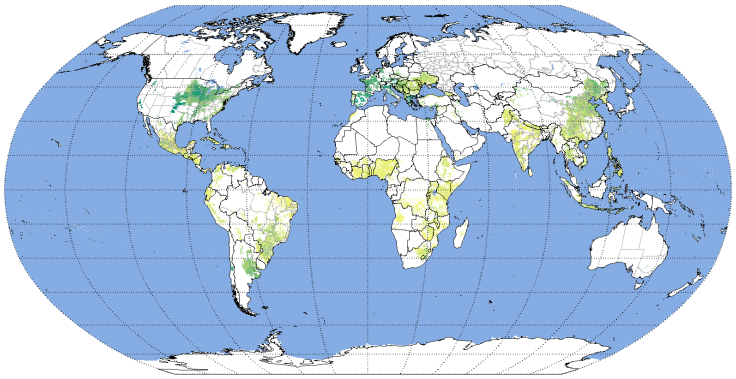

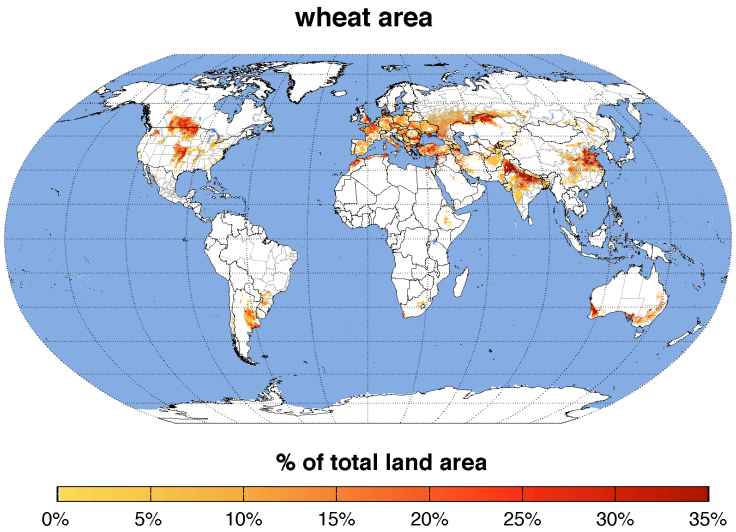

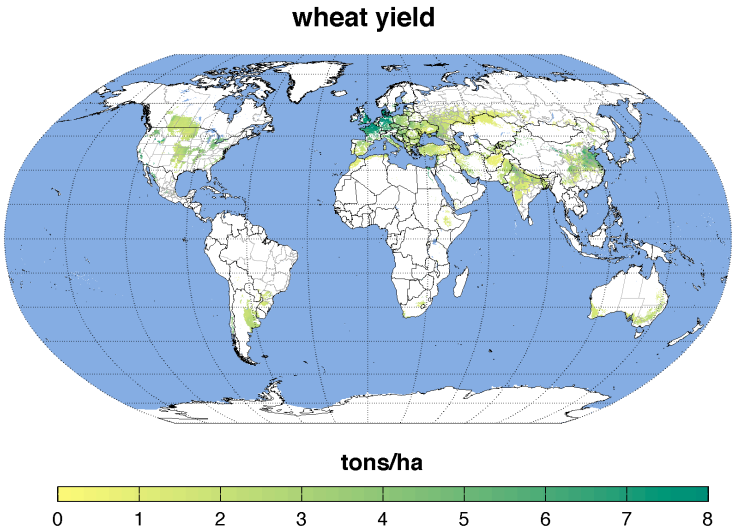

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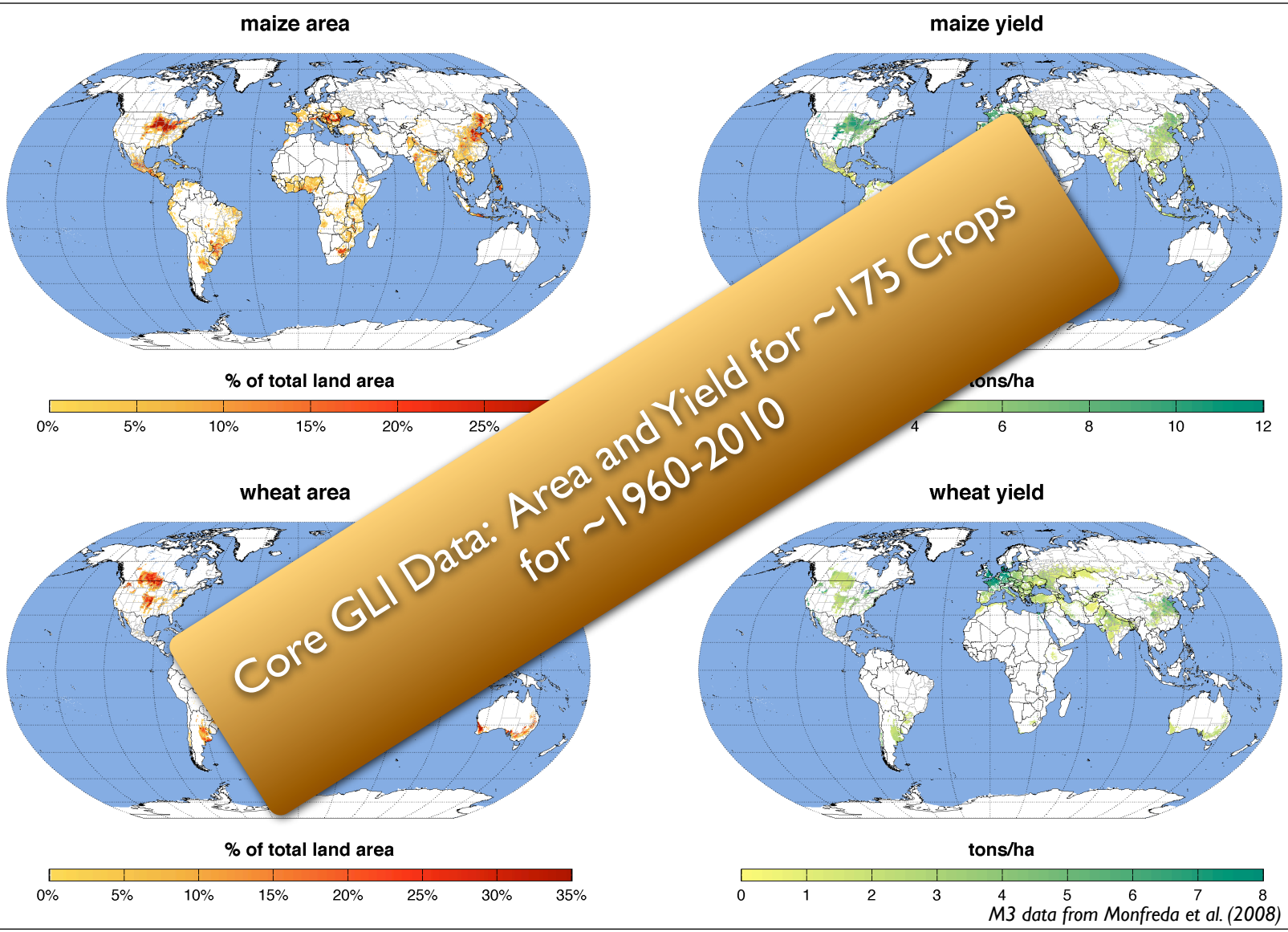
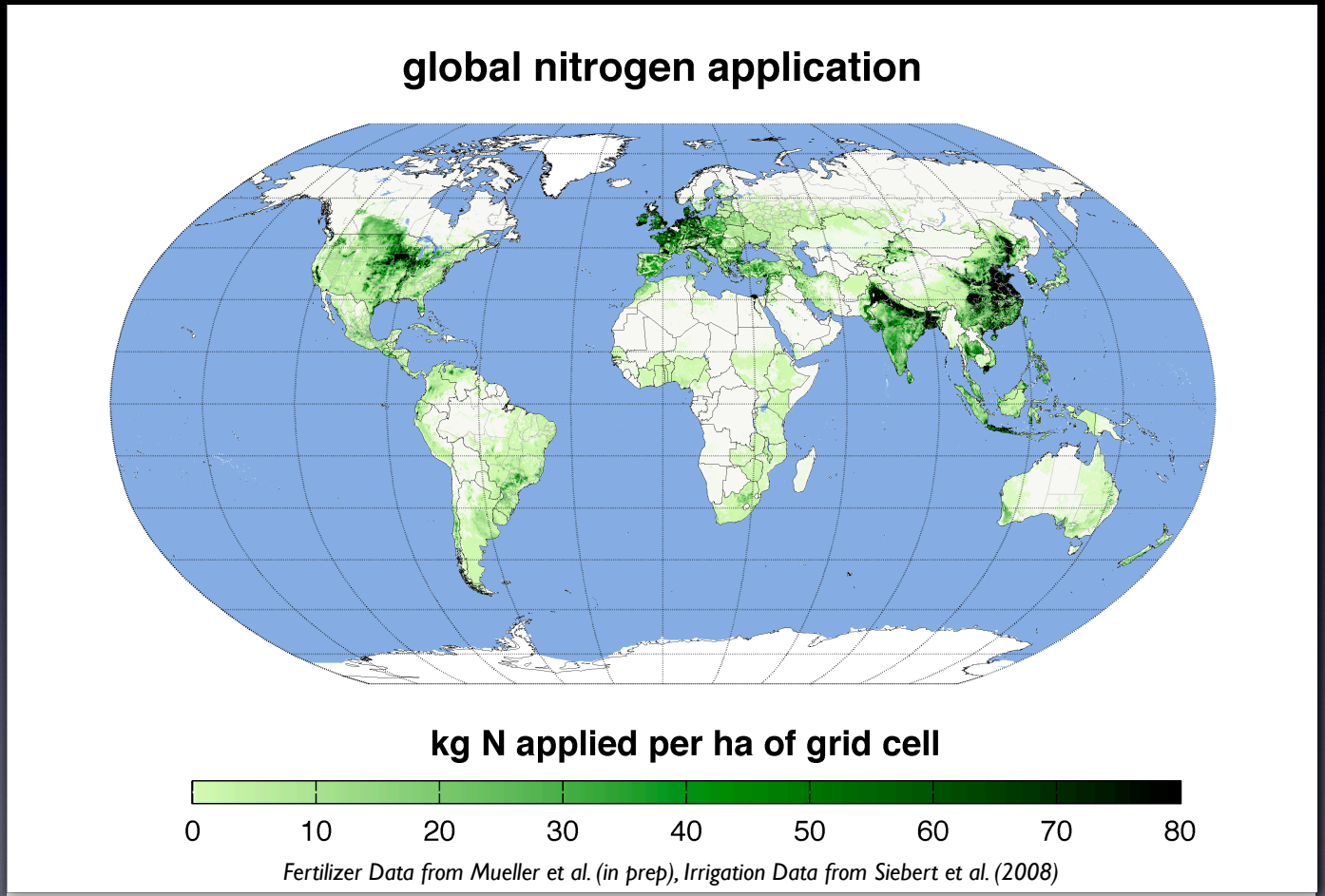


Core GLI Data: Area and Yield for ~175 Crops for ~1960-2010

Key Agricultural Inputs



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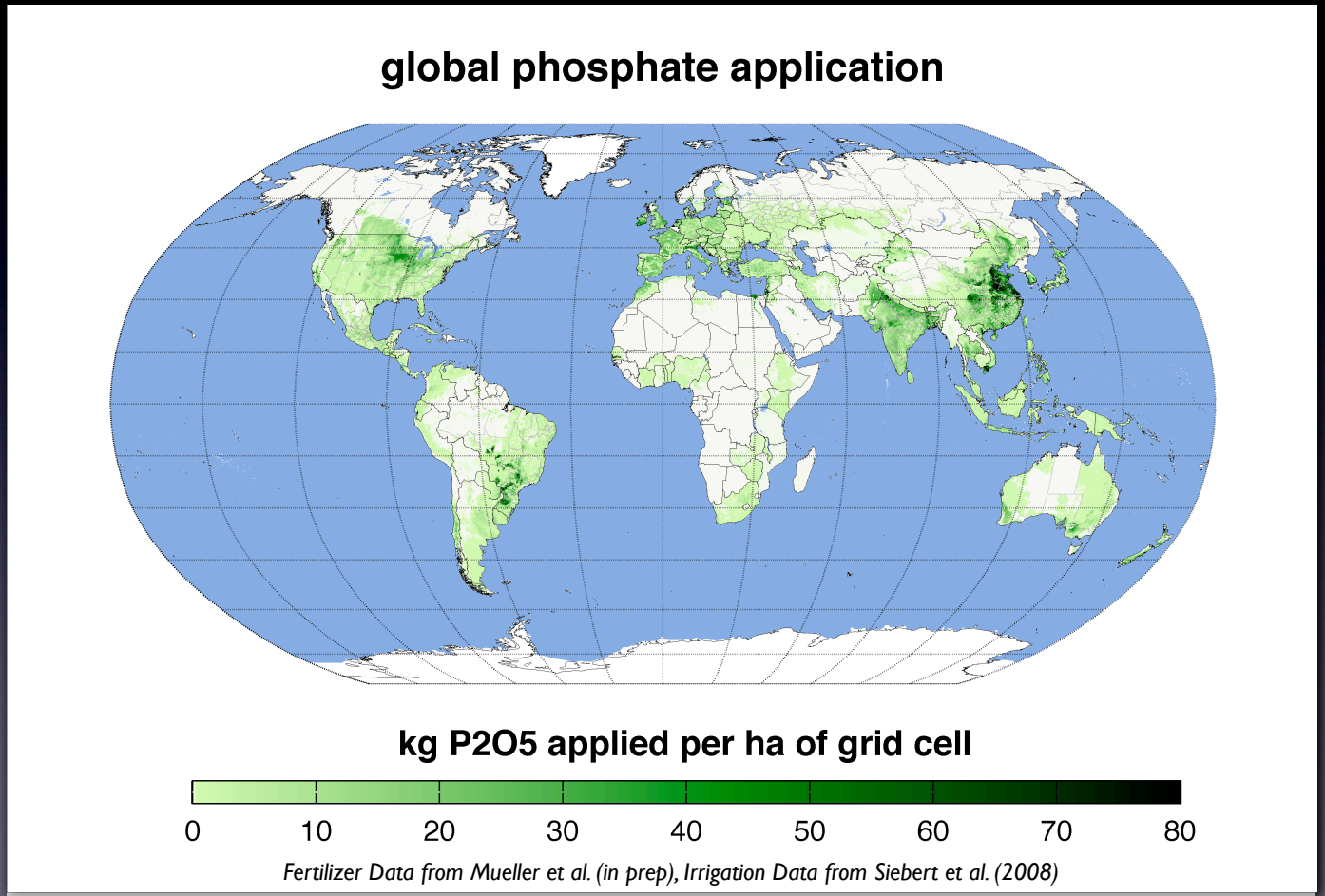

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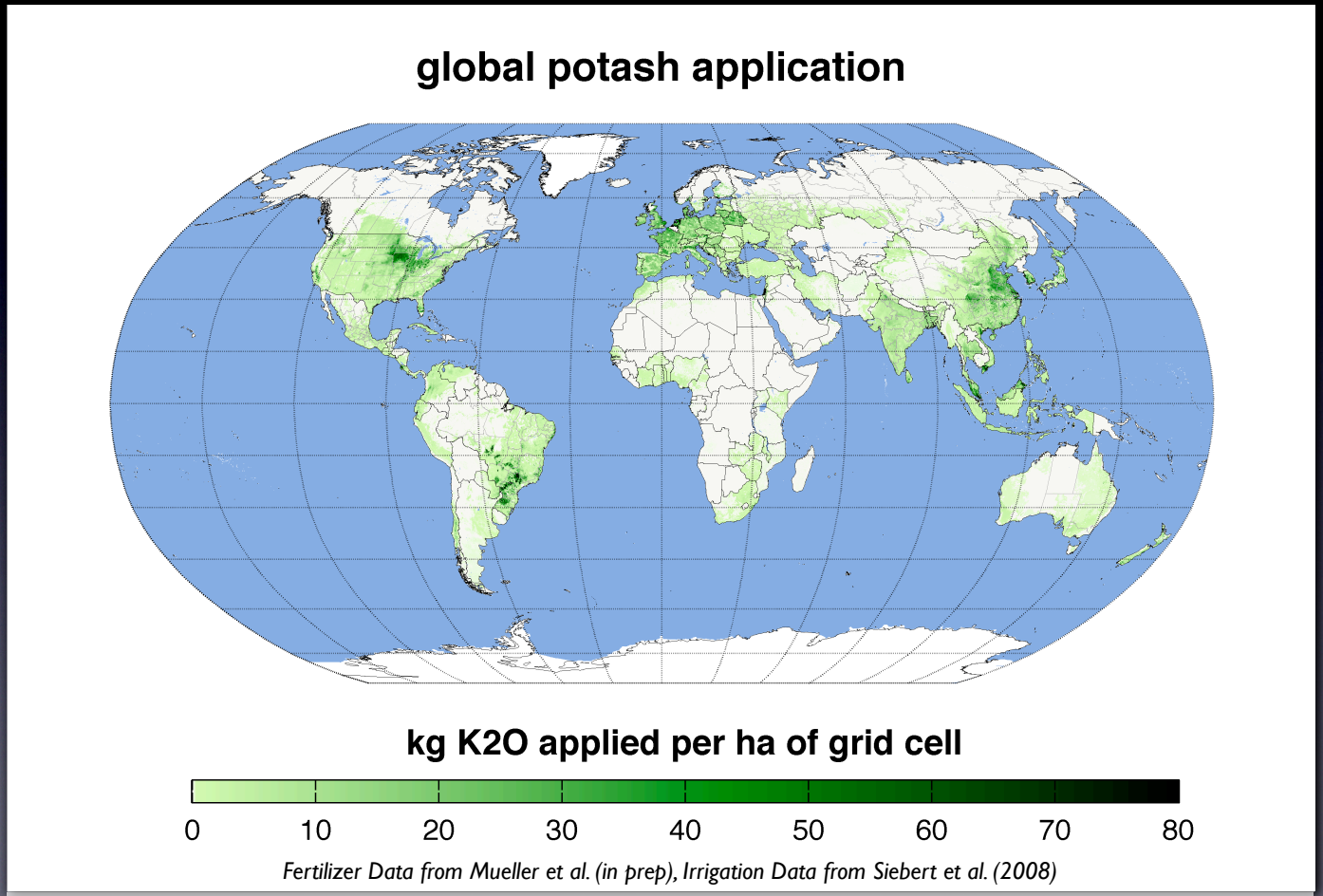

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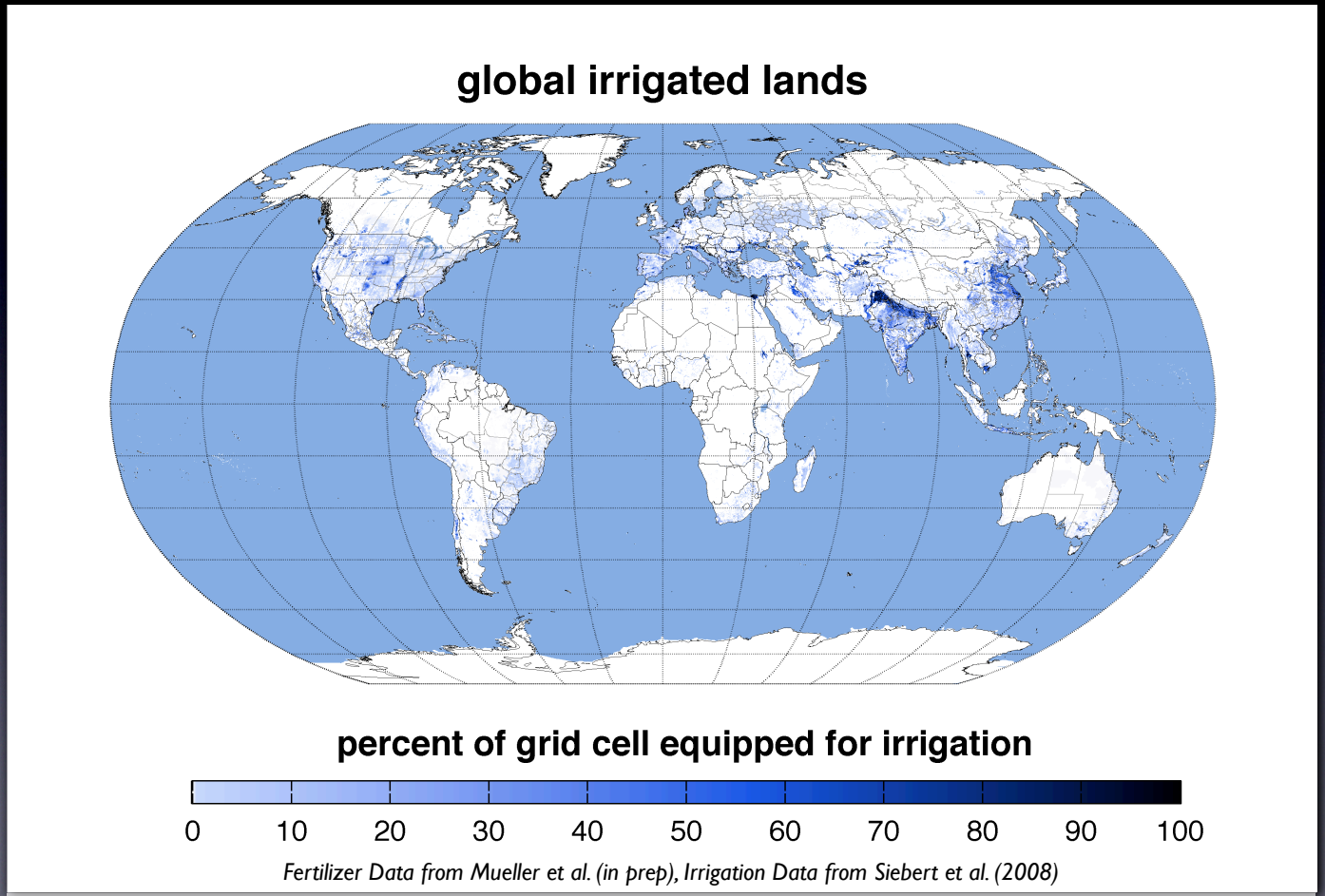

Cropland Expansion

Yield : Carbon Tradeoffs

West et al., Proceedings of the Natl. Academy Sciences (PNAS), 2010

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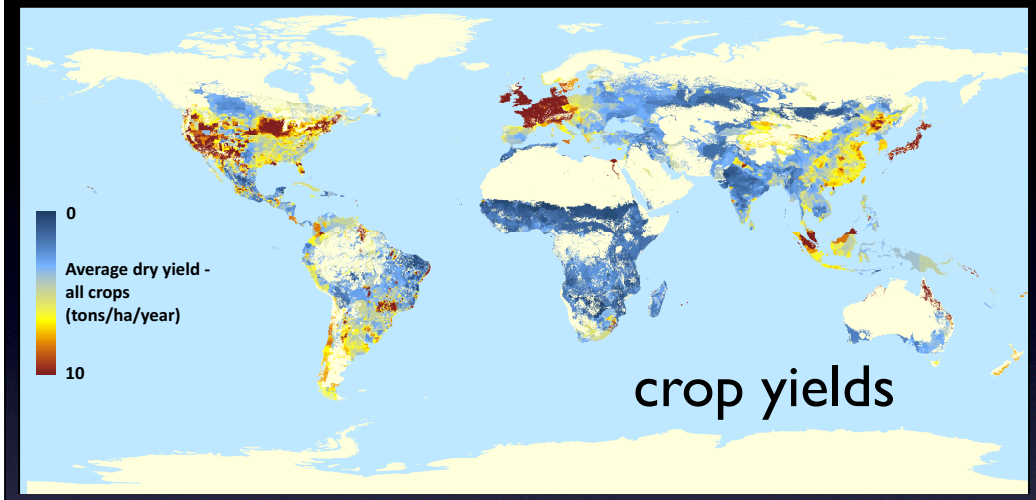

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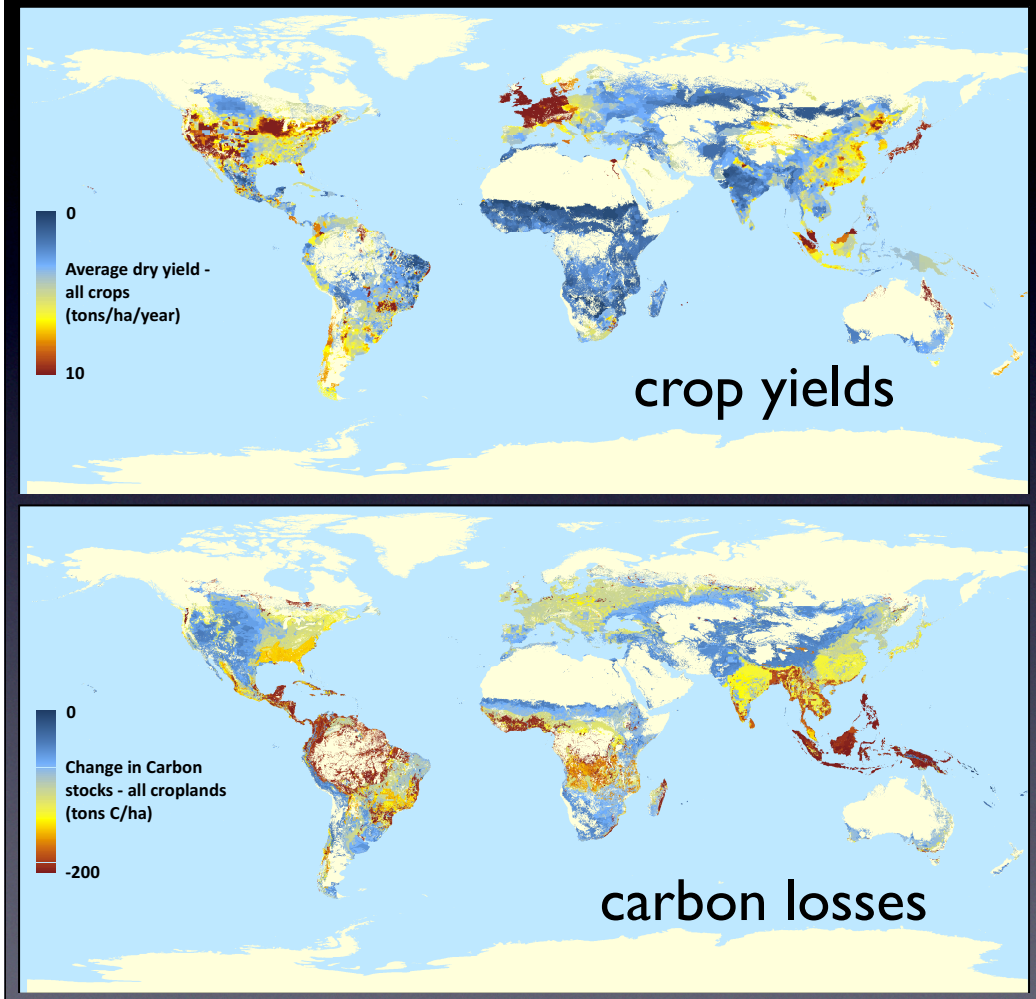

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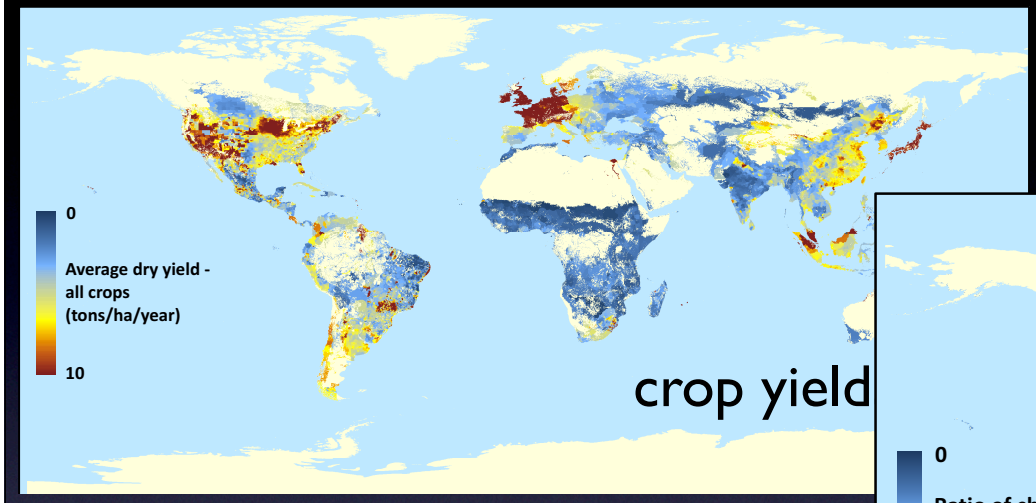

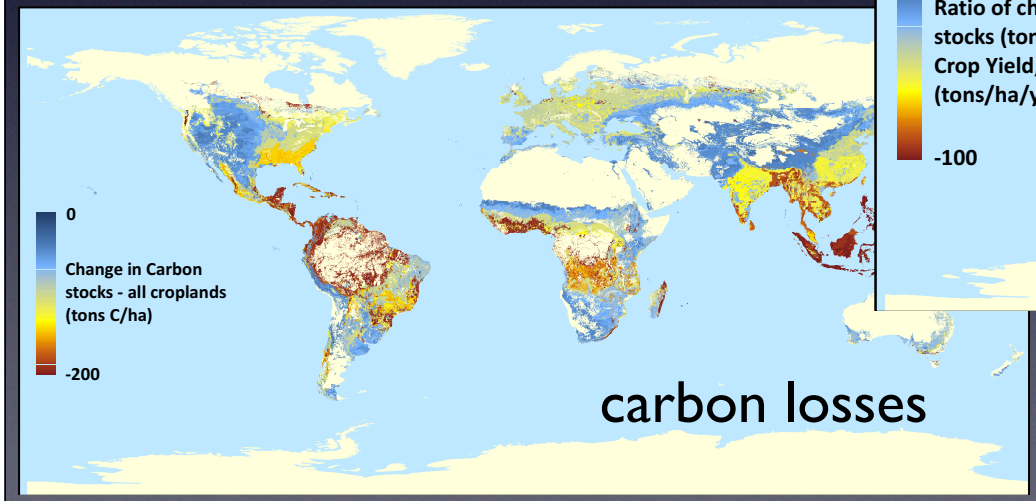

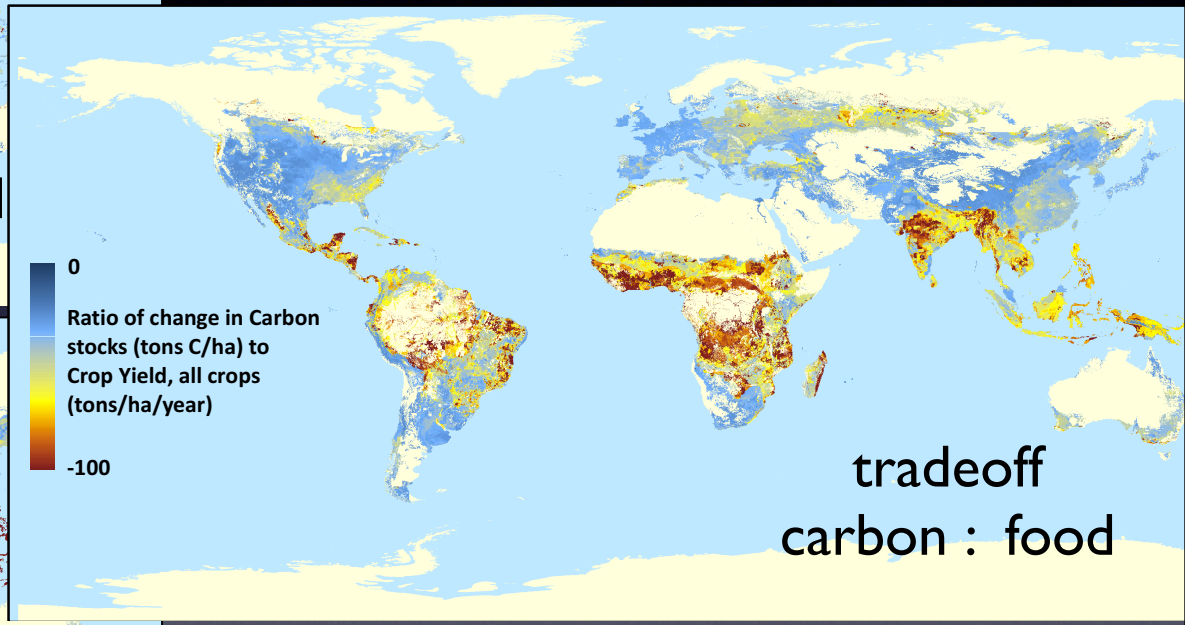

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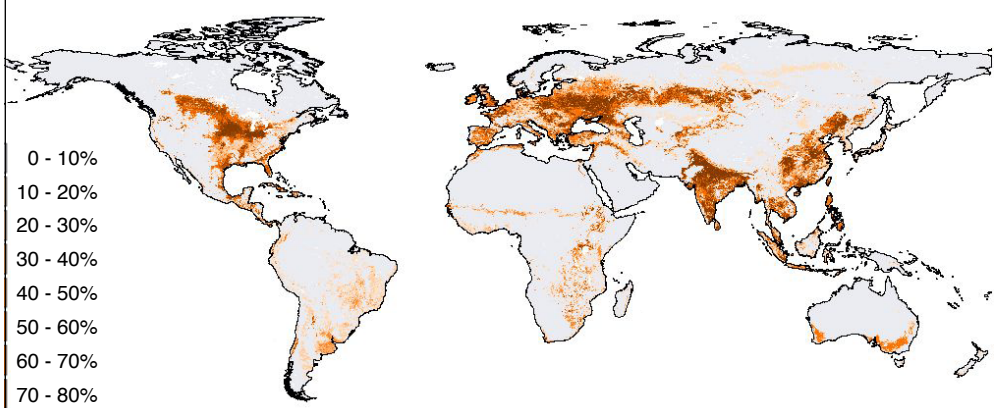
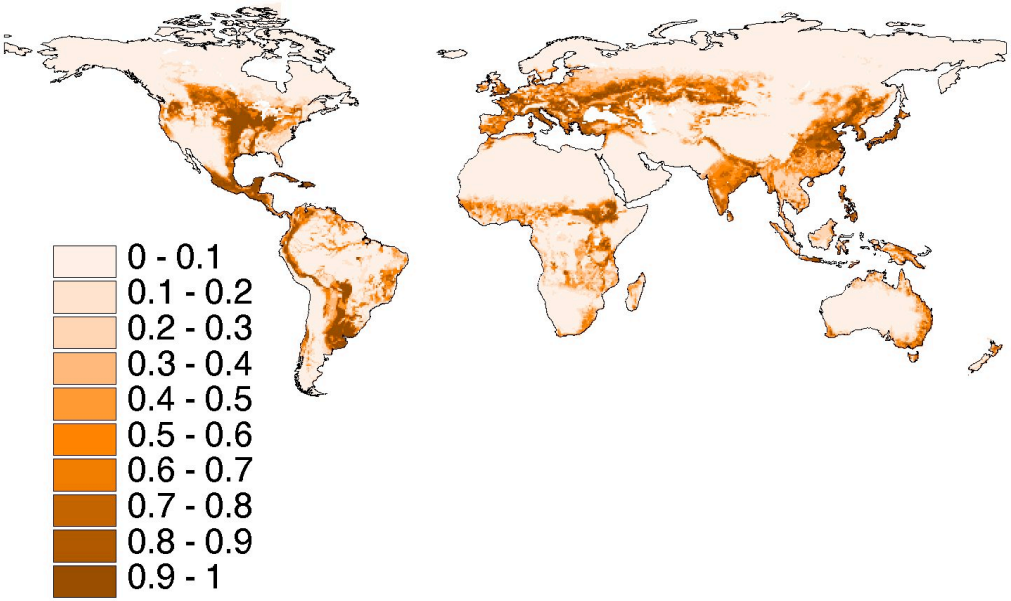
Further Expansion is Possible

Ramankutty et al., 2002





current croplands

potential croplands

Further Expansion is Possible

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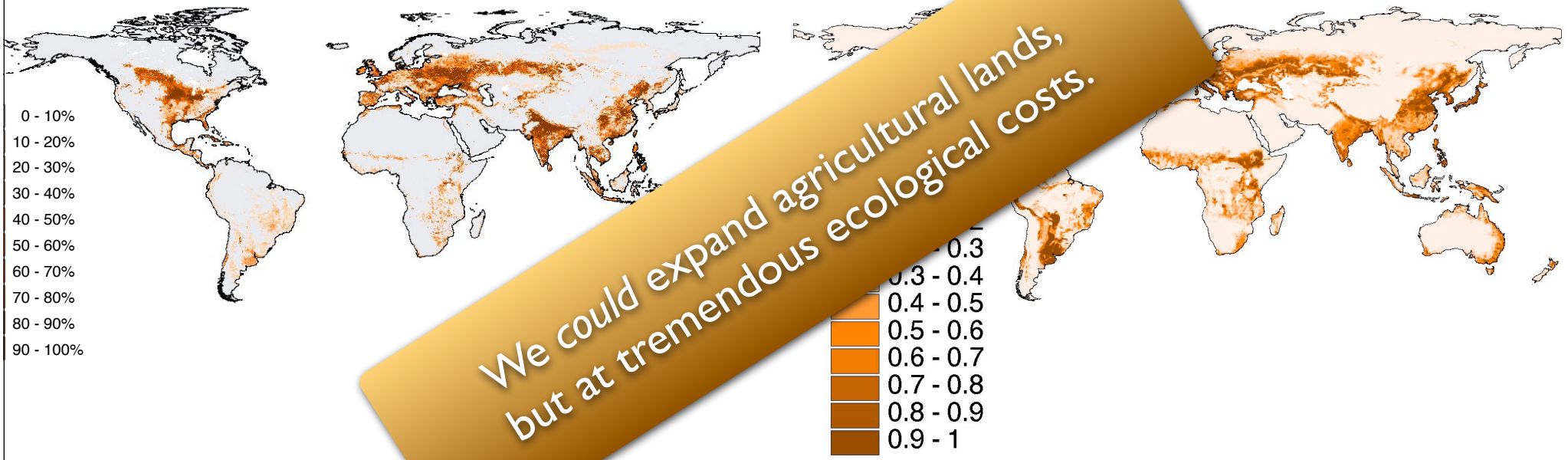


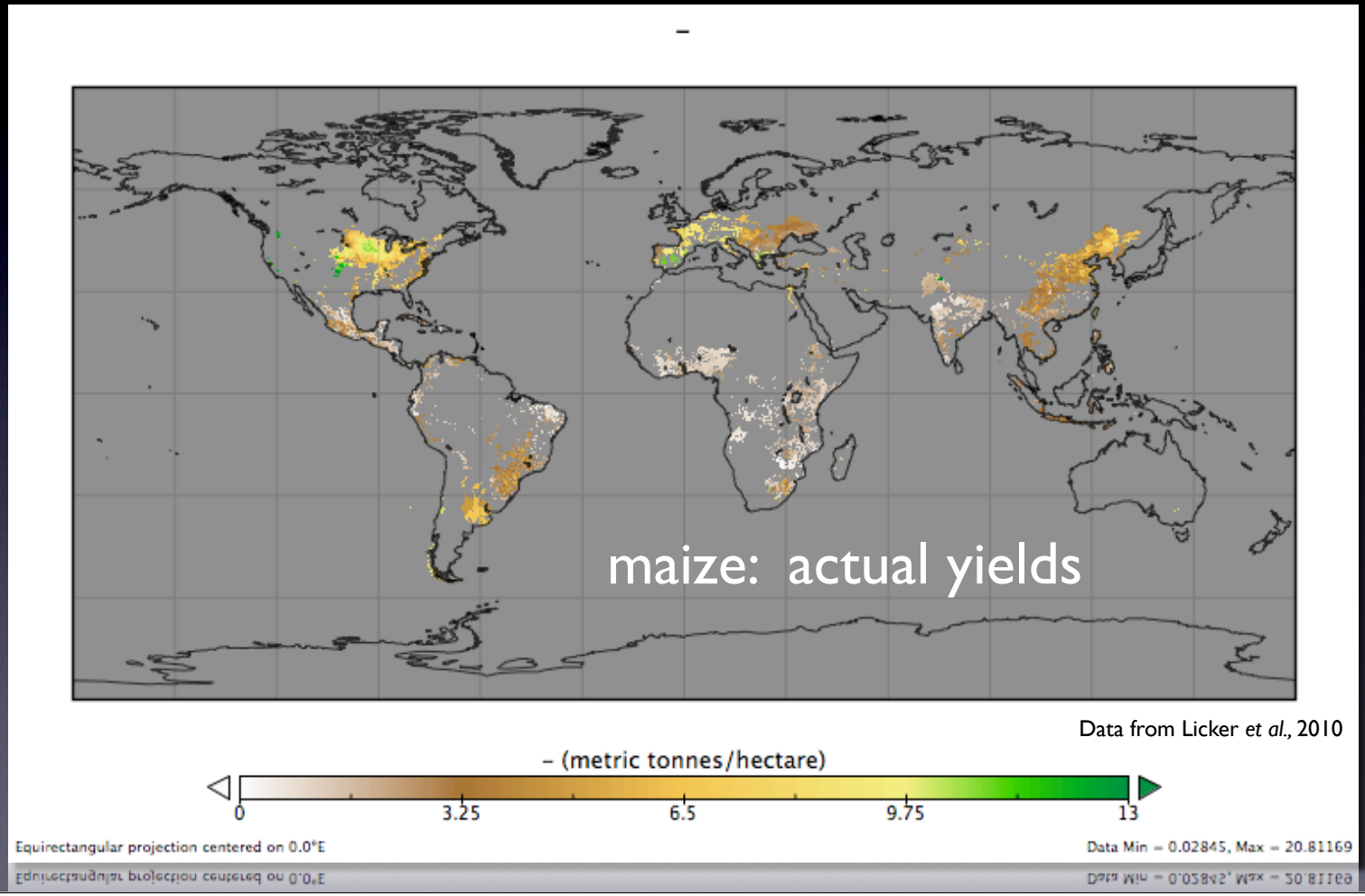
We could expand agricultural lands, but at tremendous ecological costs.

curre croplands

potential croplands

Cropland Intensification

Boosting Yields? Closing Yield Gaps?



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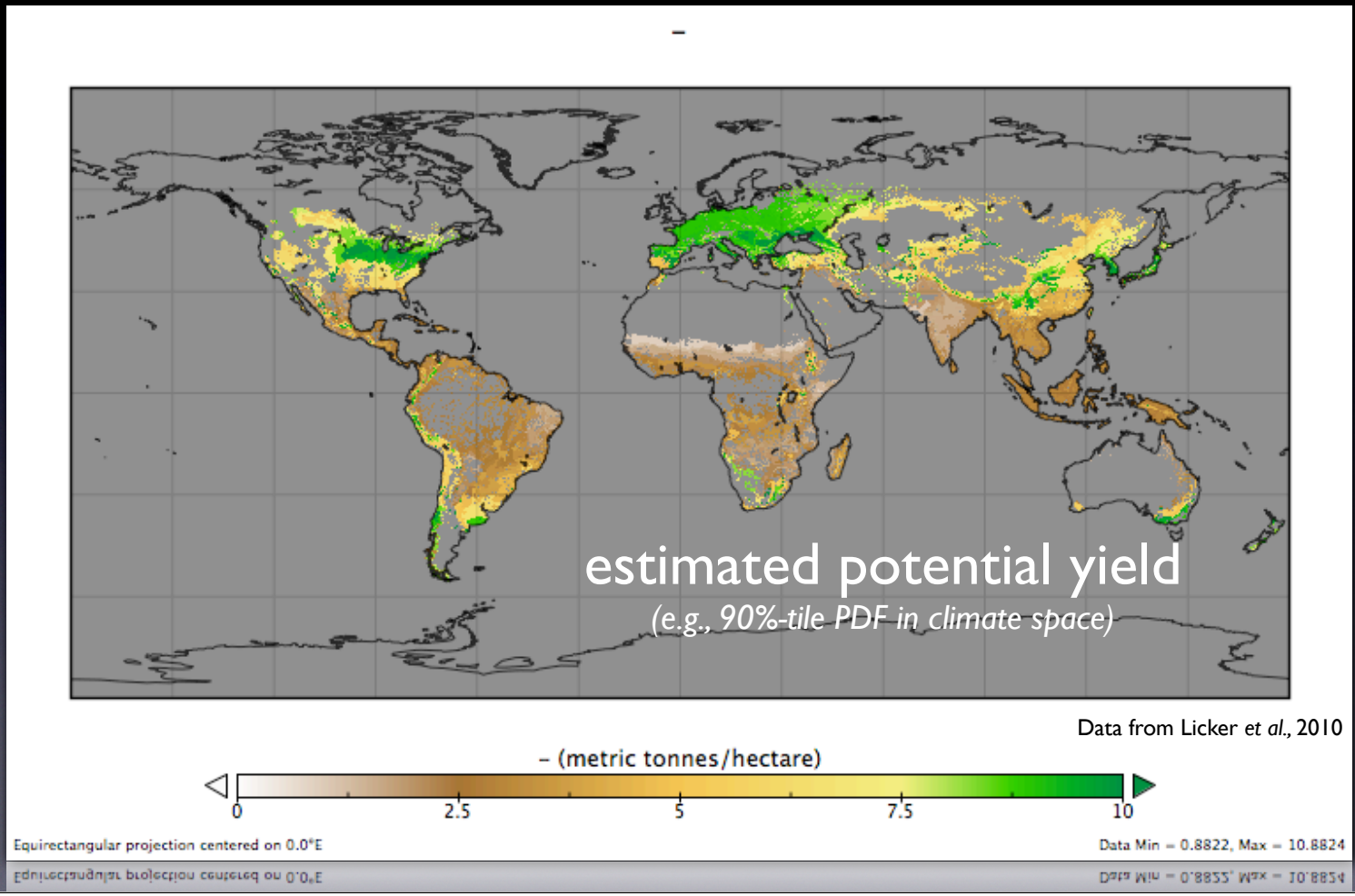

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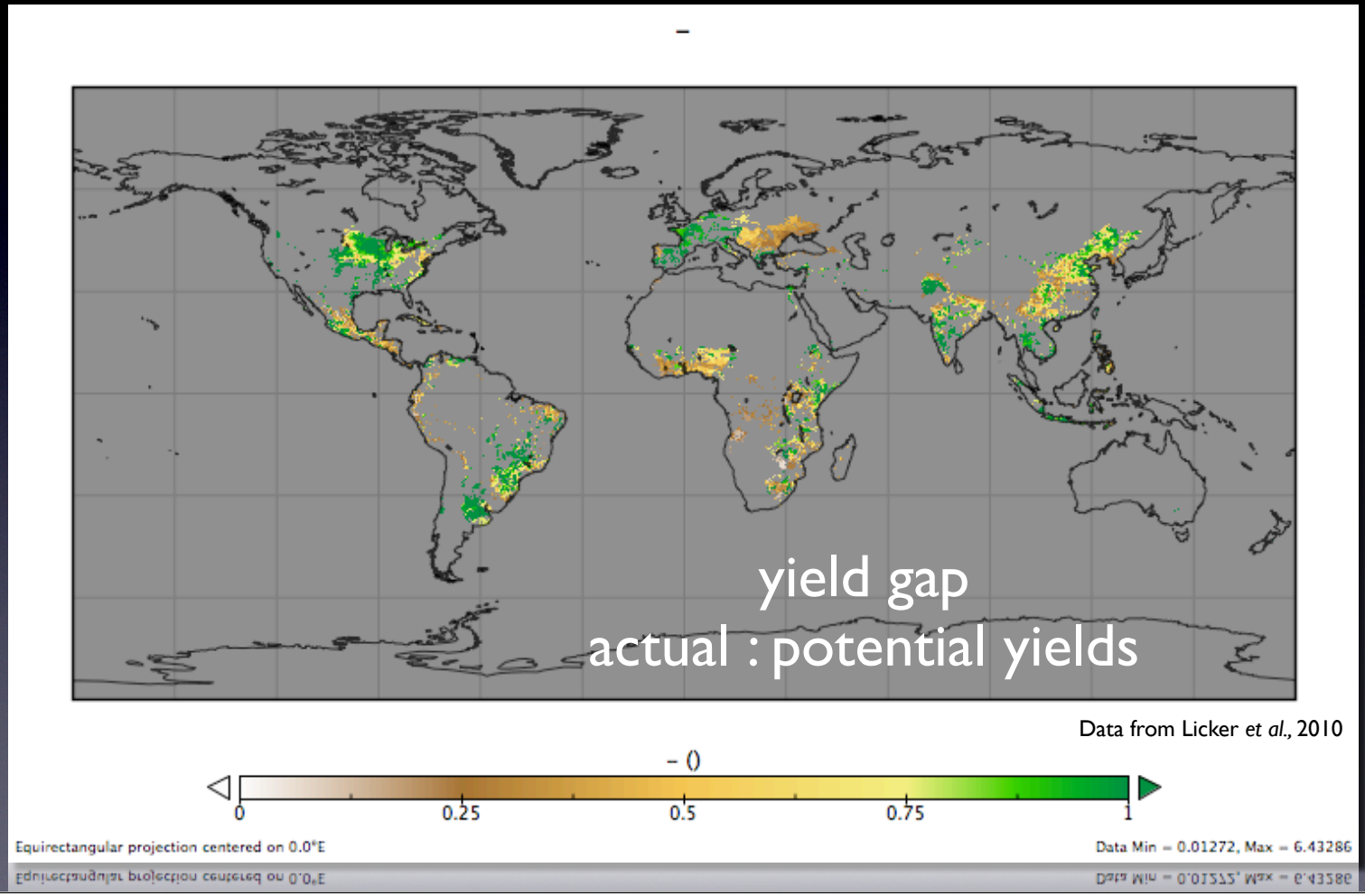

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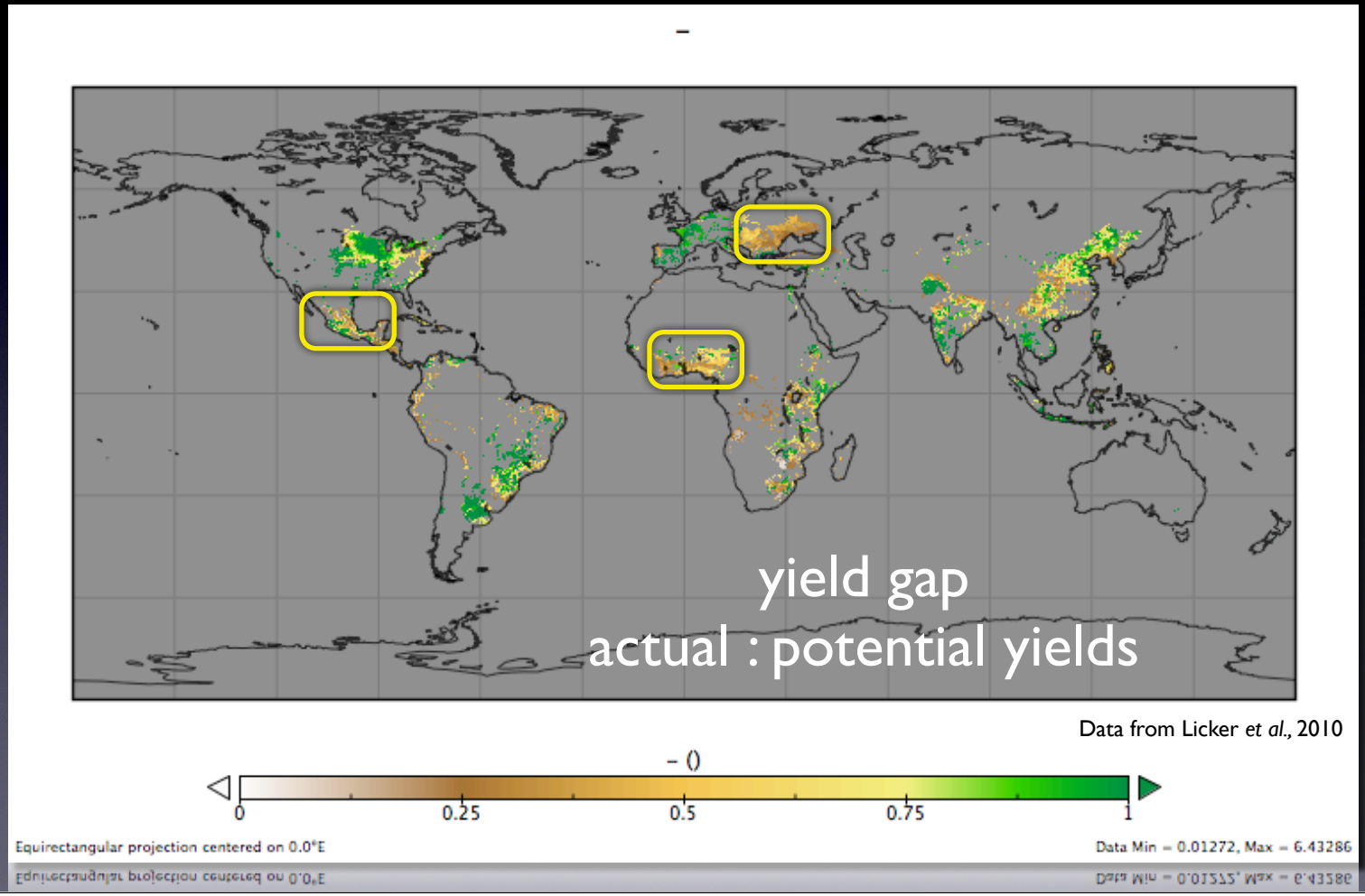

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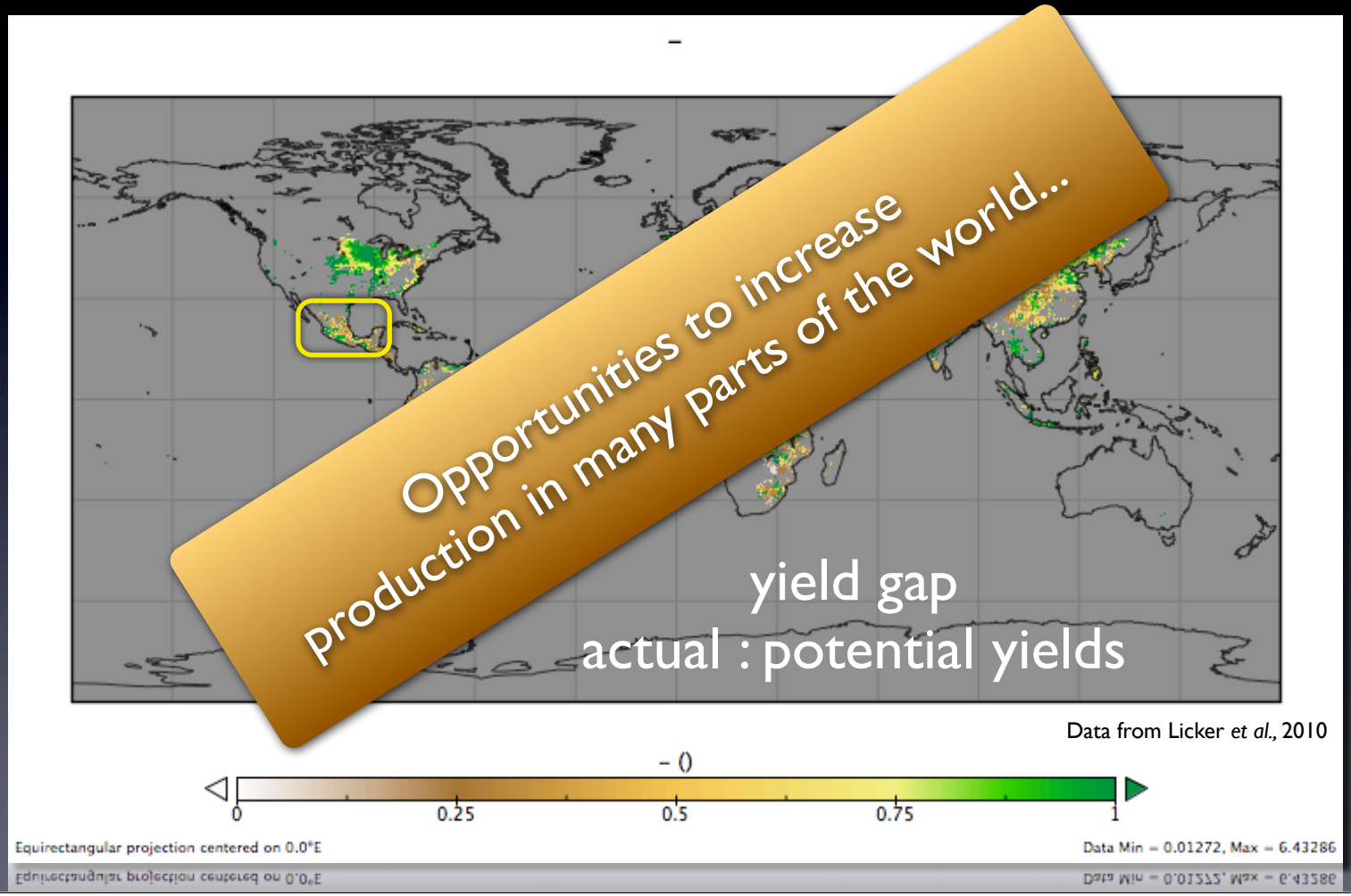
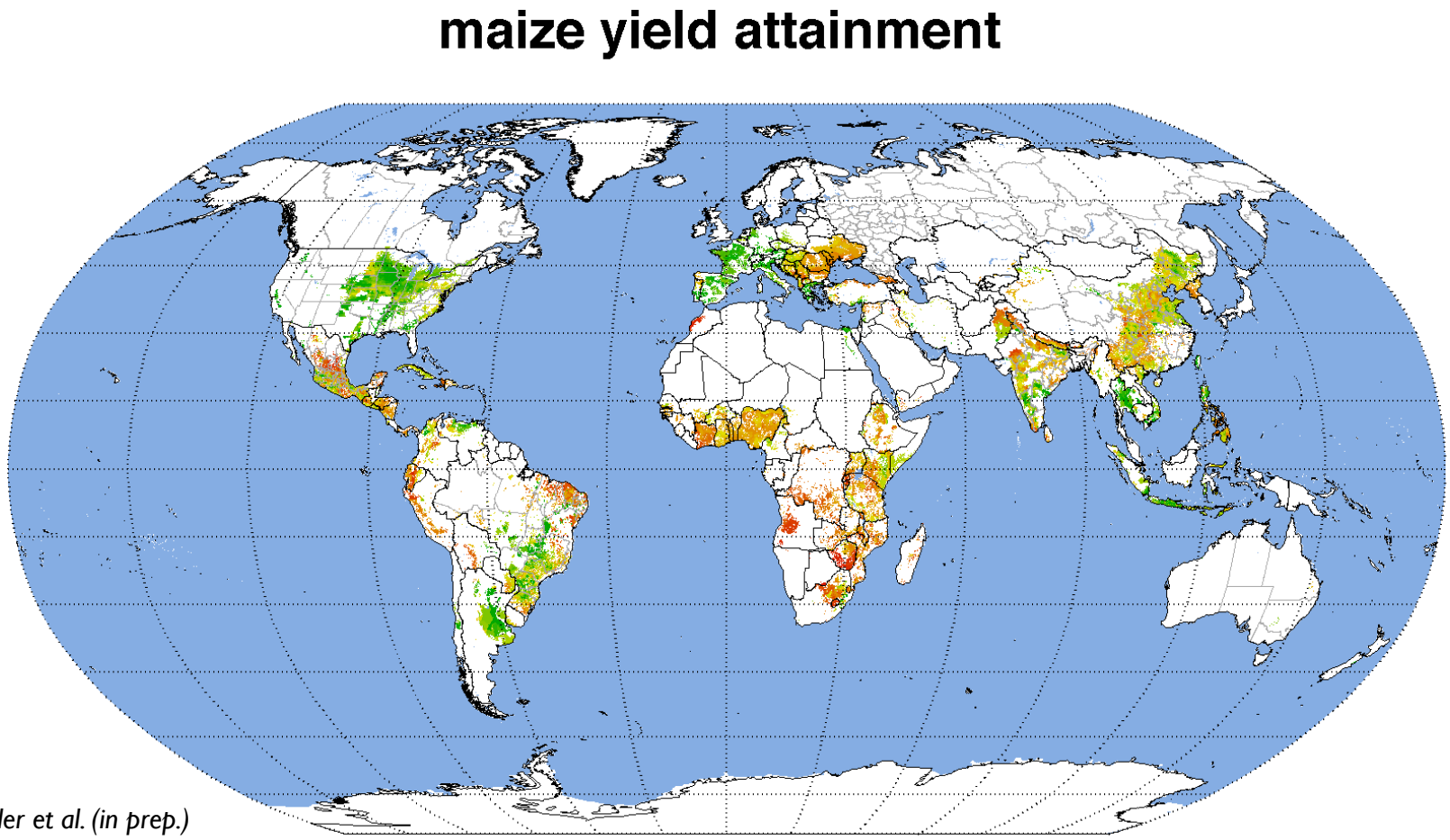
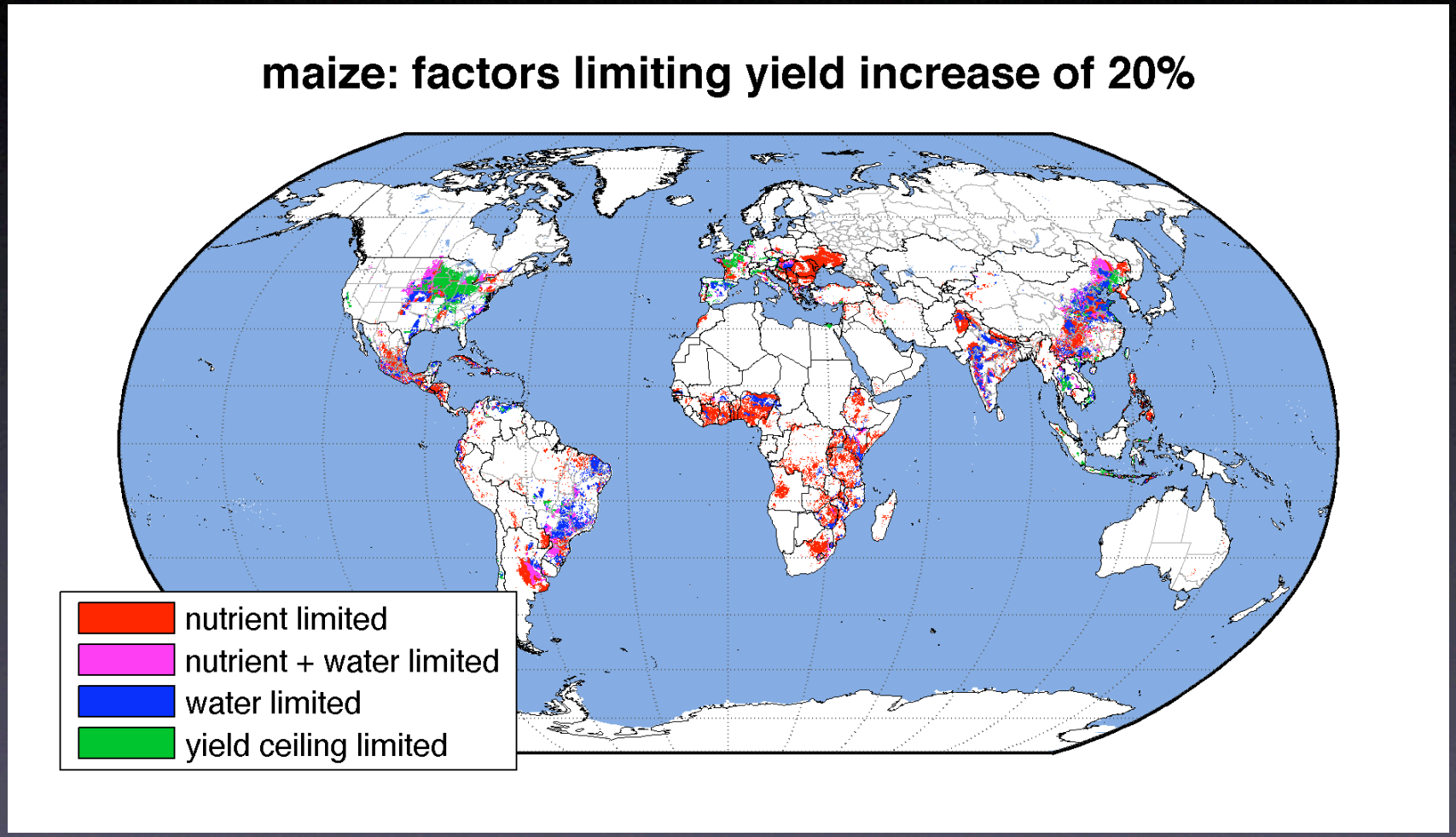


Improving Yields



data from Mueller et al. (in prep.)

What's Limiting?



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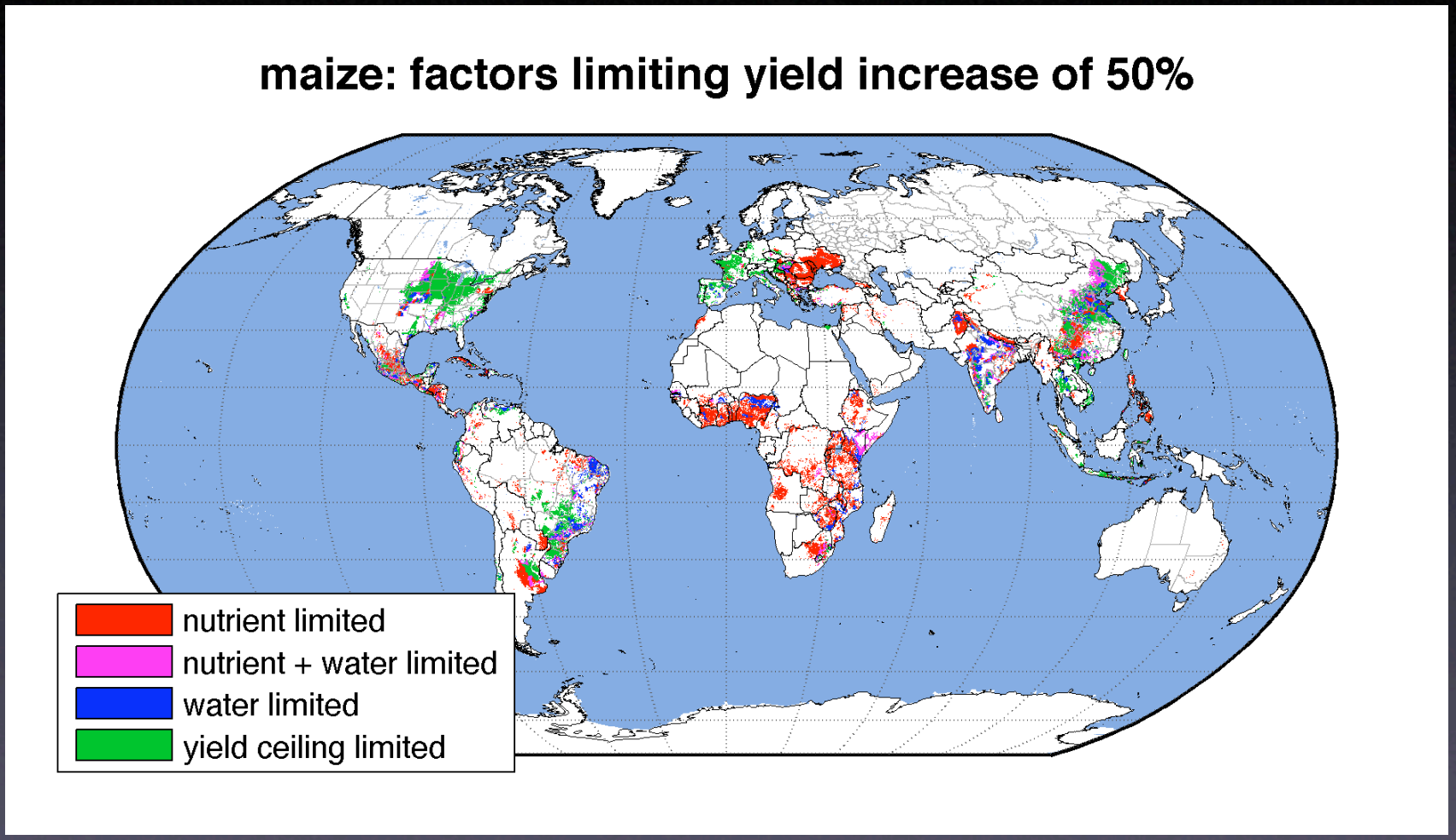

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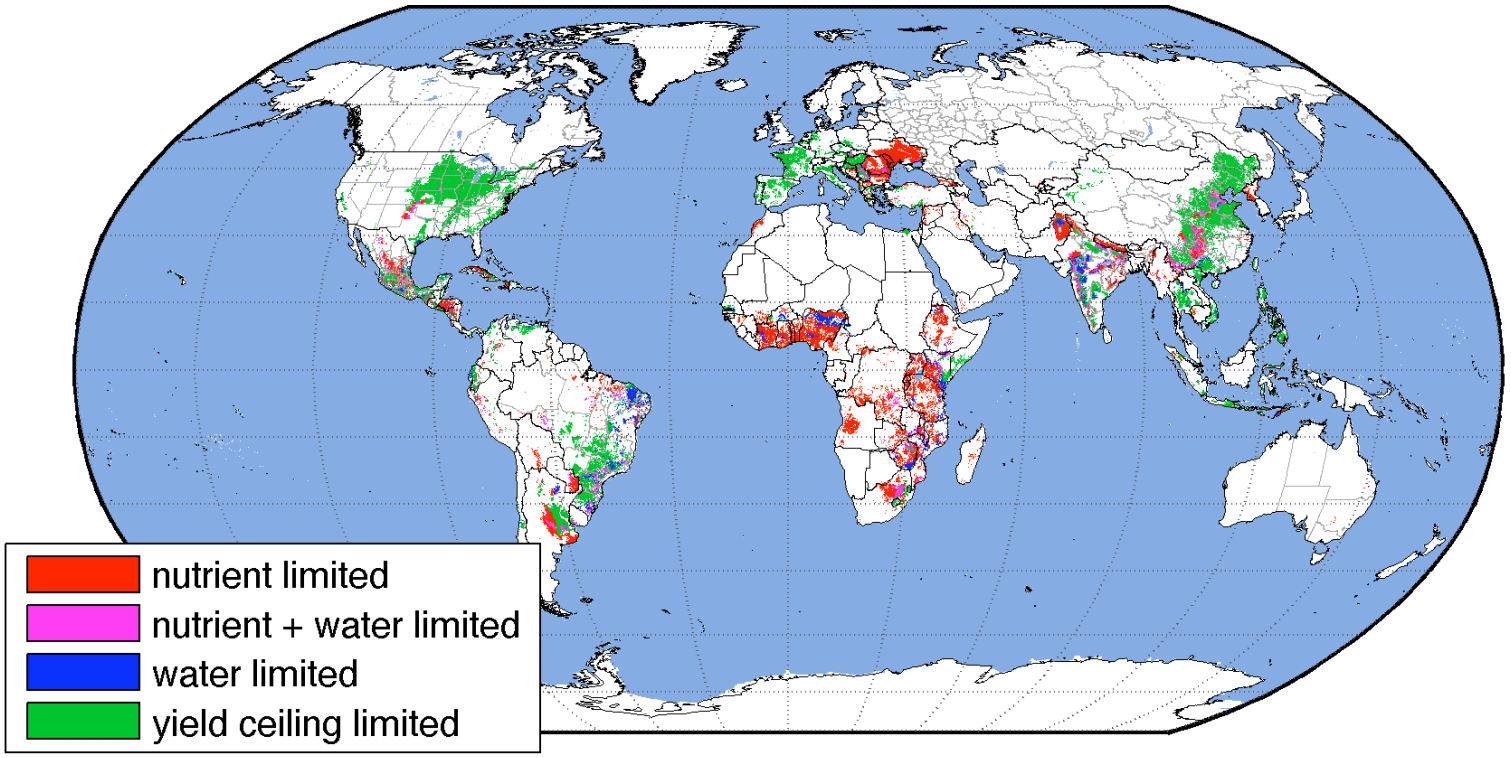
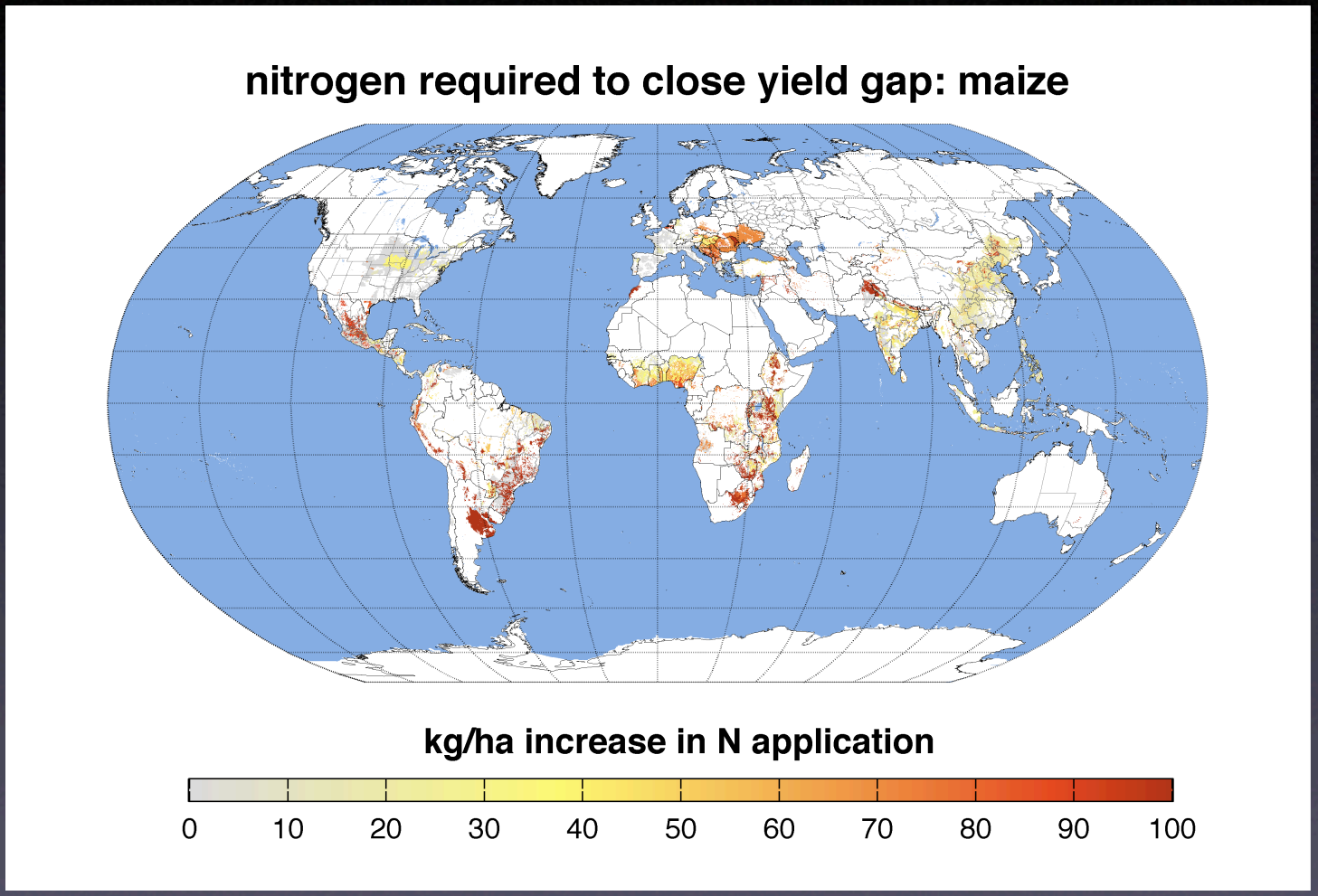


What Would it Take?



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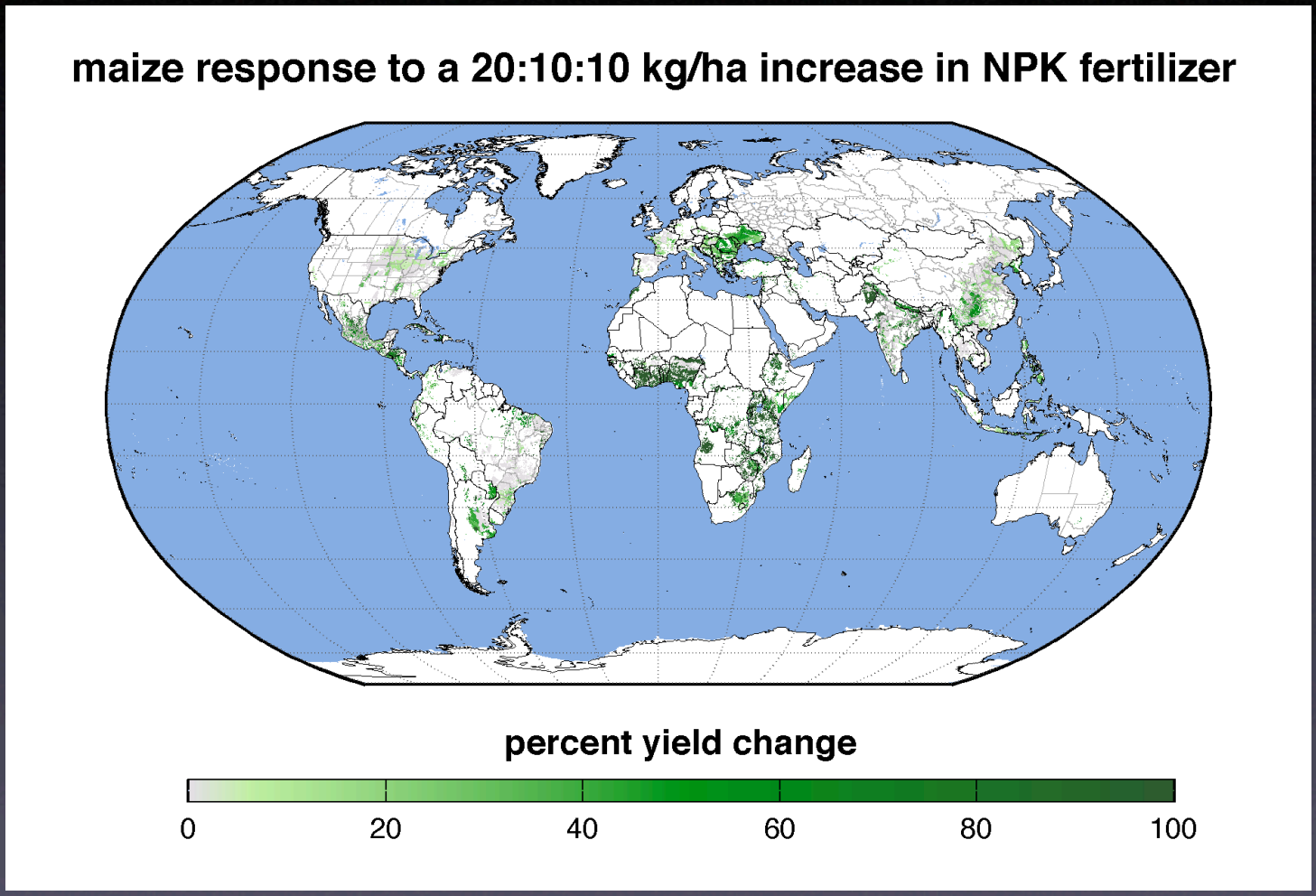

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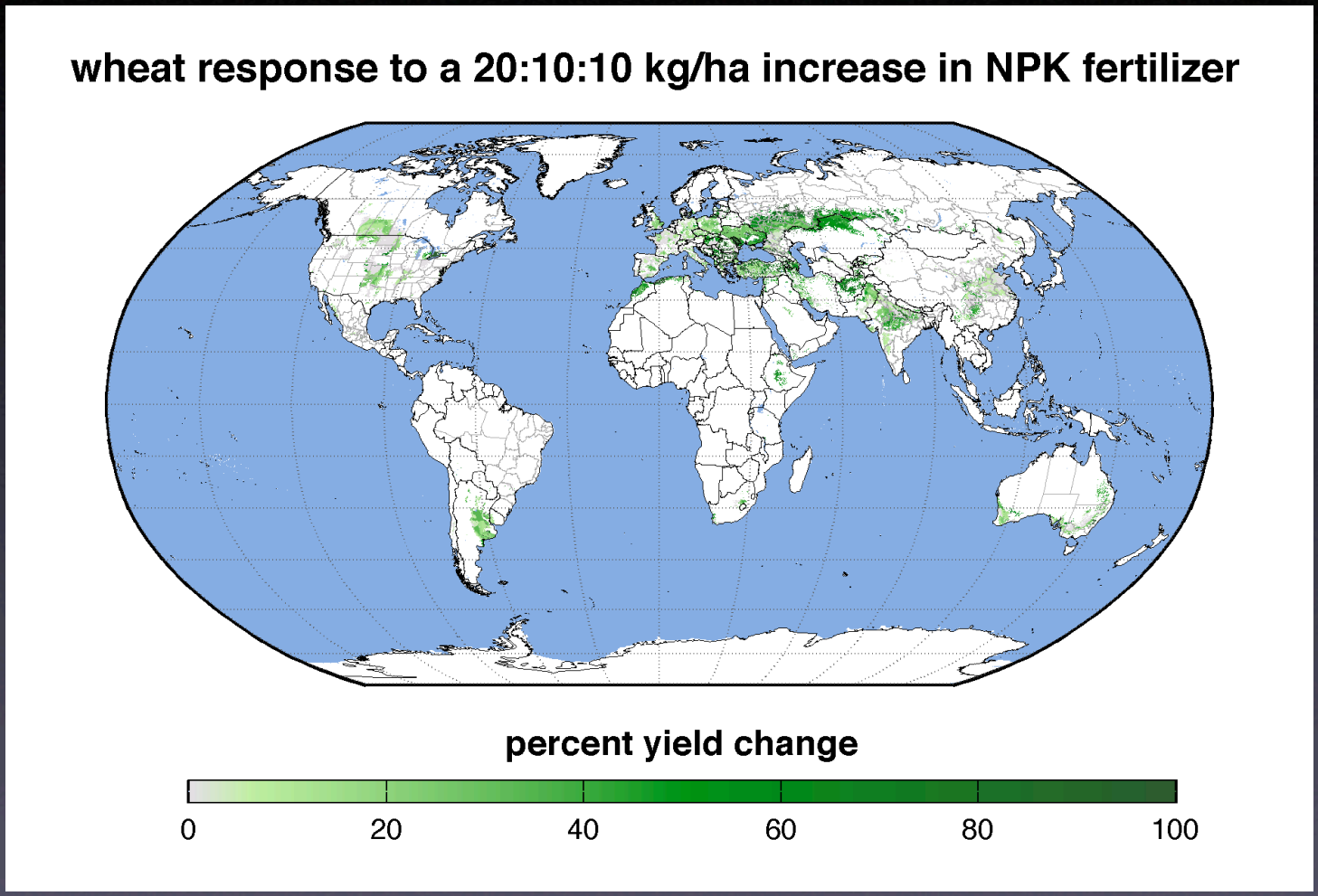
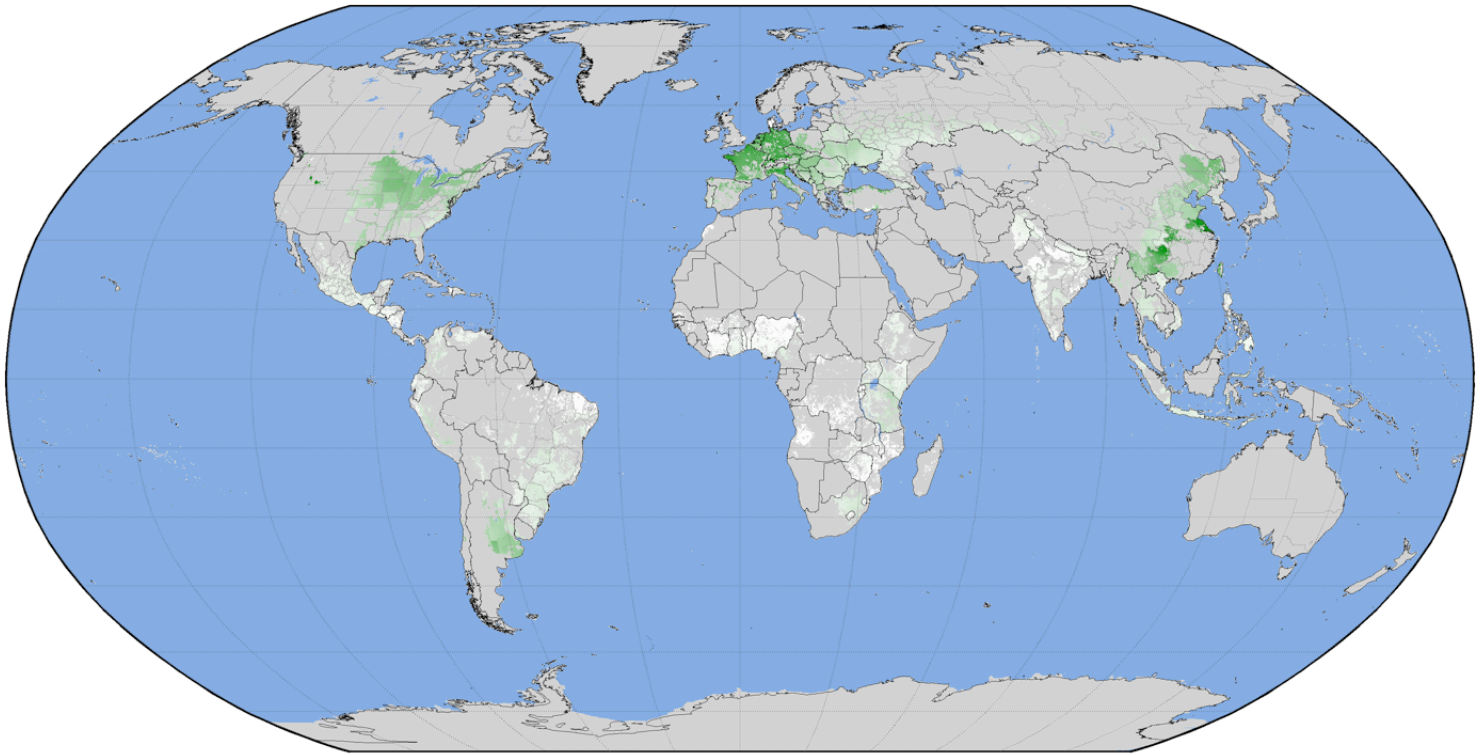


Important Opportunity

Increase Efficiency of Croplands

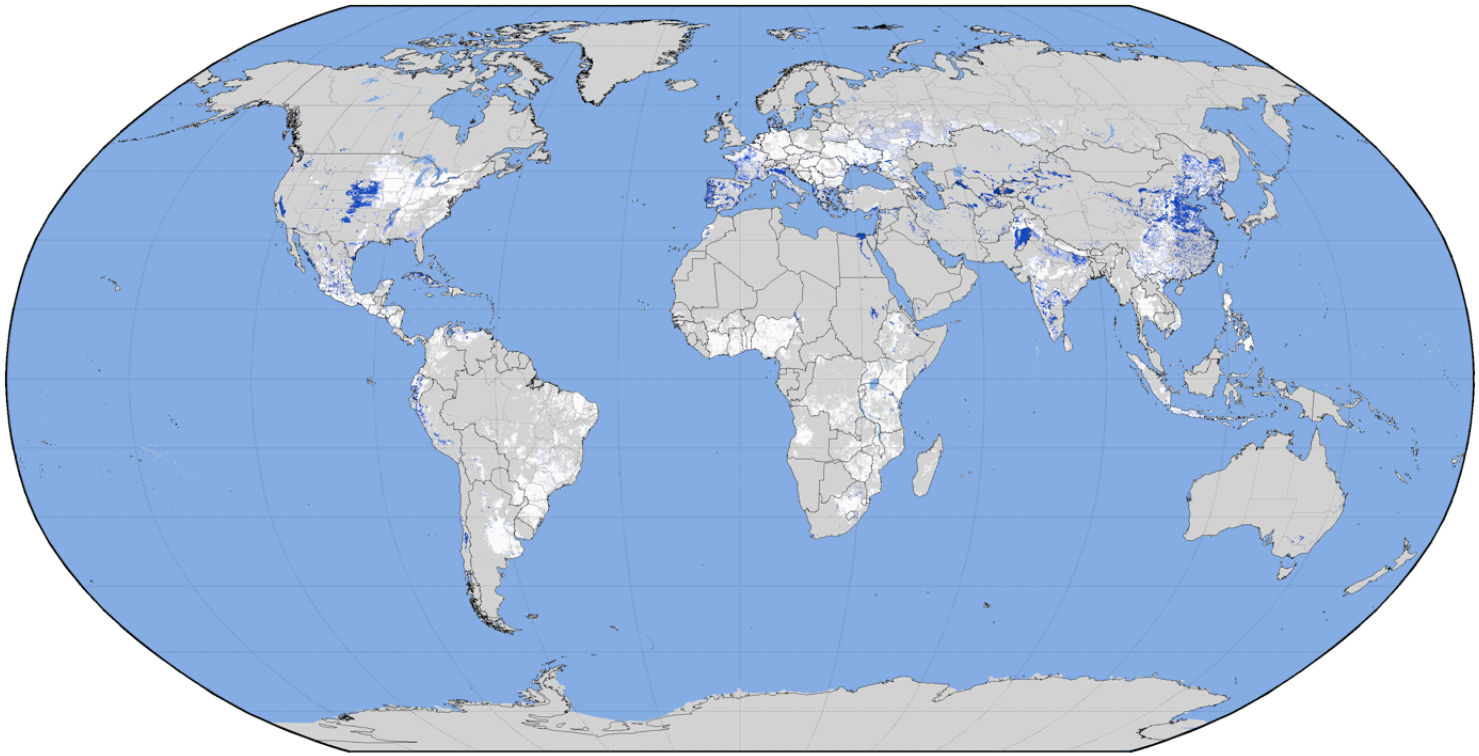
Rainfed Maize: Water Use Efficiency



Maize Production per Meter of Rainfall per Hectare (ton/m/ha)

0 5 10 15 20 25 30

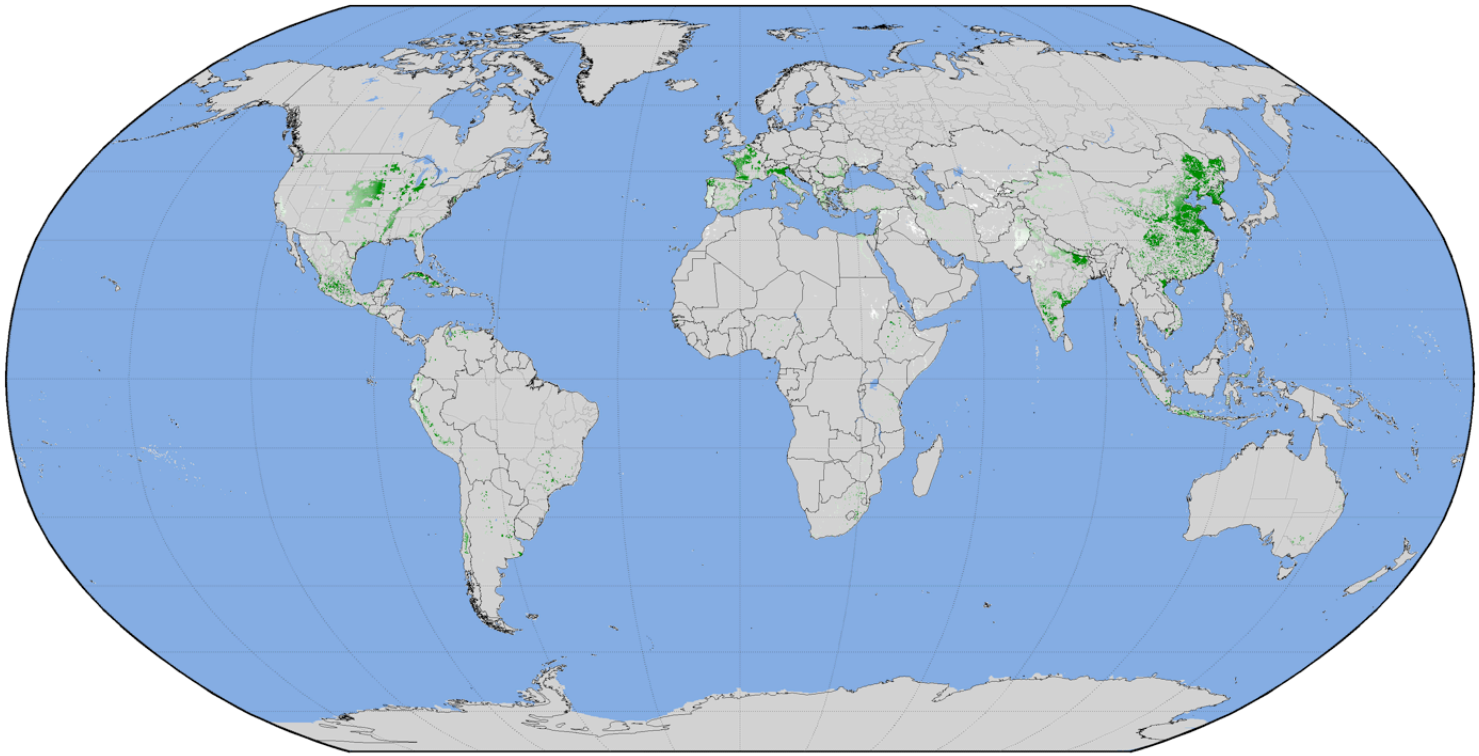
Areas of Irrigated Maize Production



% of Maize Production Area that is Irrigated

0 10 20 30 40 50 60 70 80 90 100

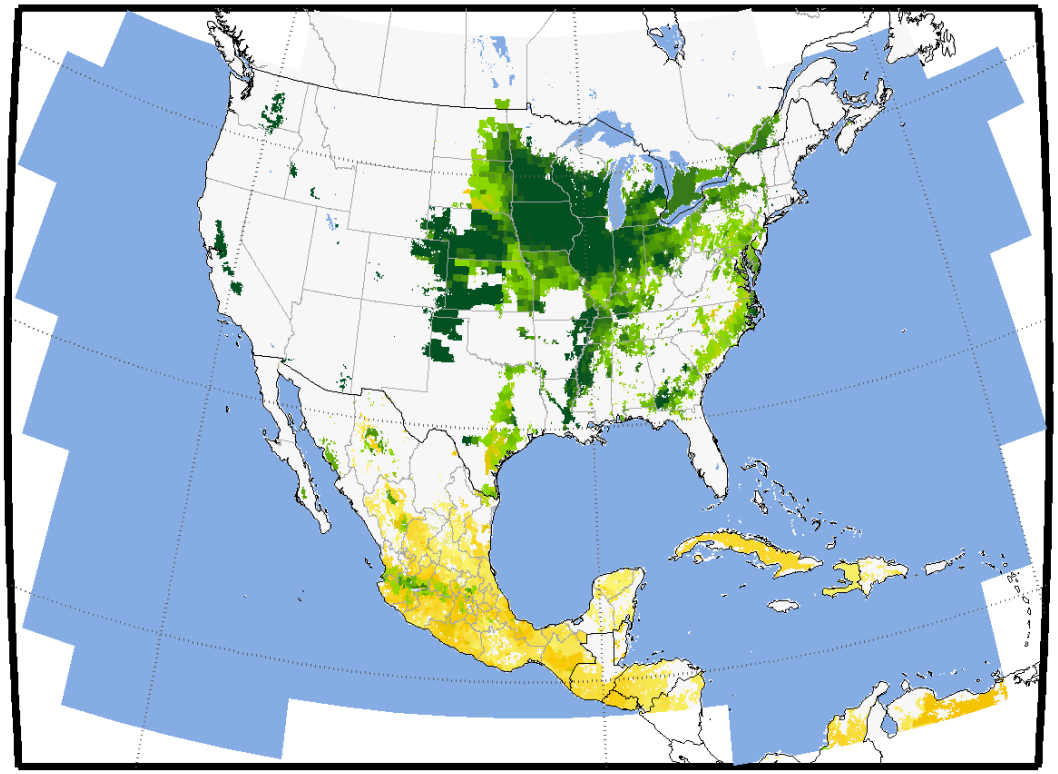
Irrigated Maize: Irrigation Water Use Efficiency



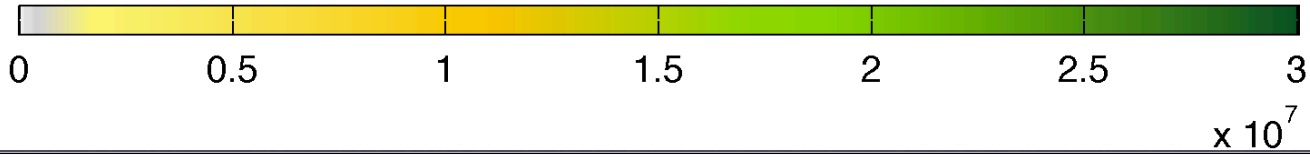
Maize Production per meter of Irrigation Water per Hectare (ton/m/ha)

0 5 10 15 20 25 30

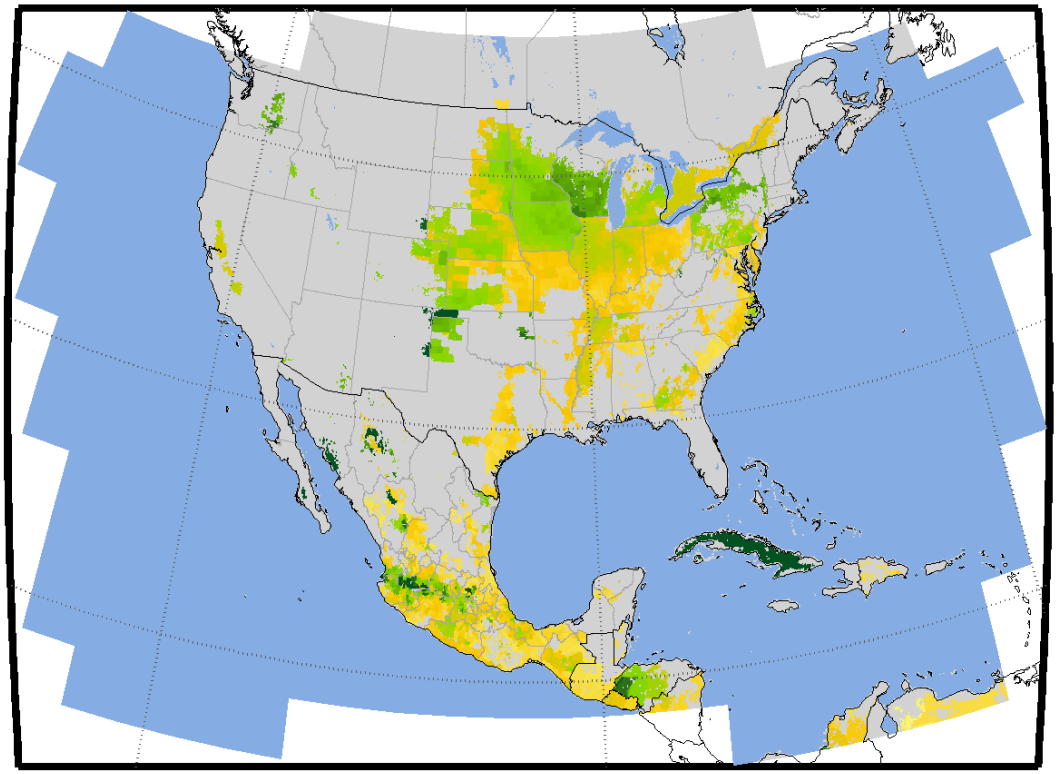
Maize calories produced



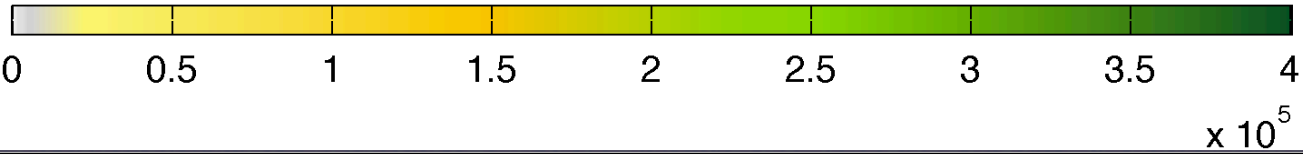
kcal produced per hectare



Maize calories produced per Nitrogen applied



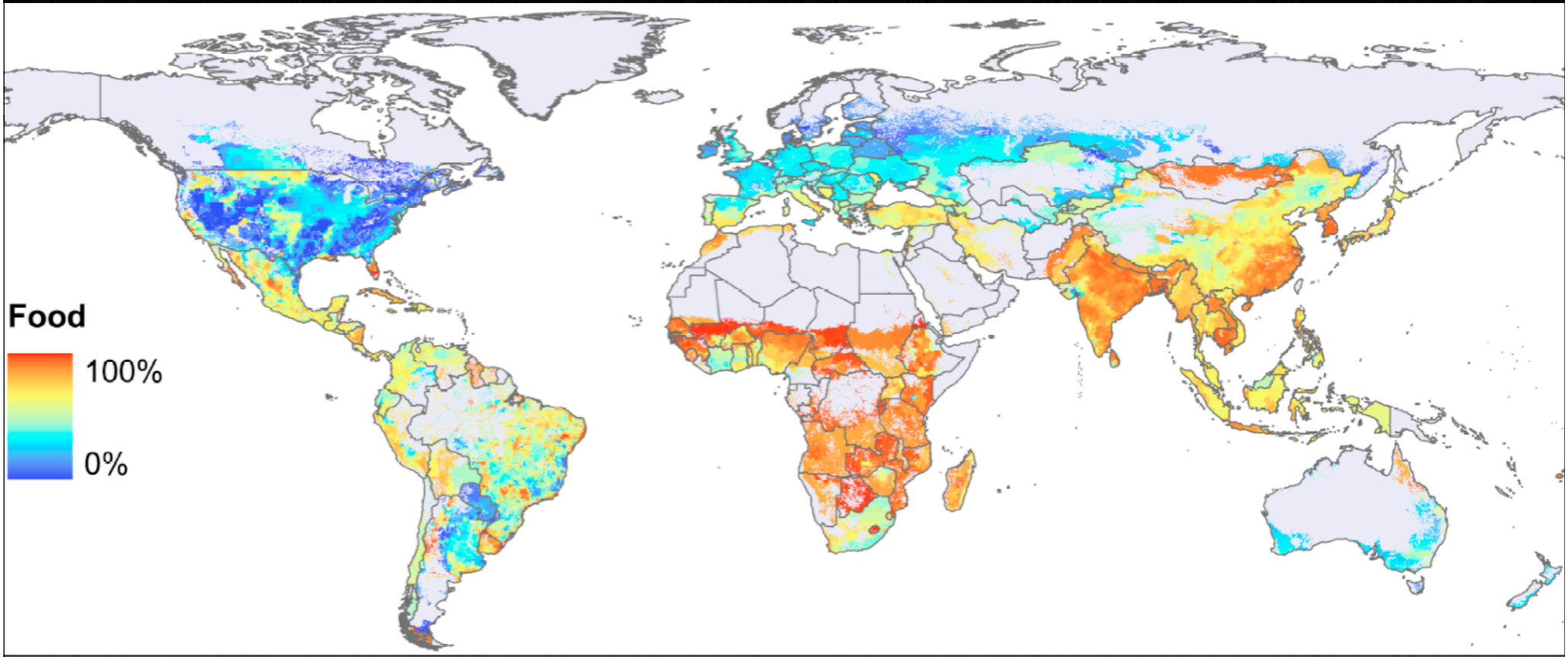
kcal produced per kg N applied



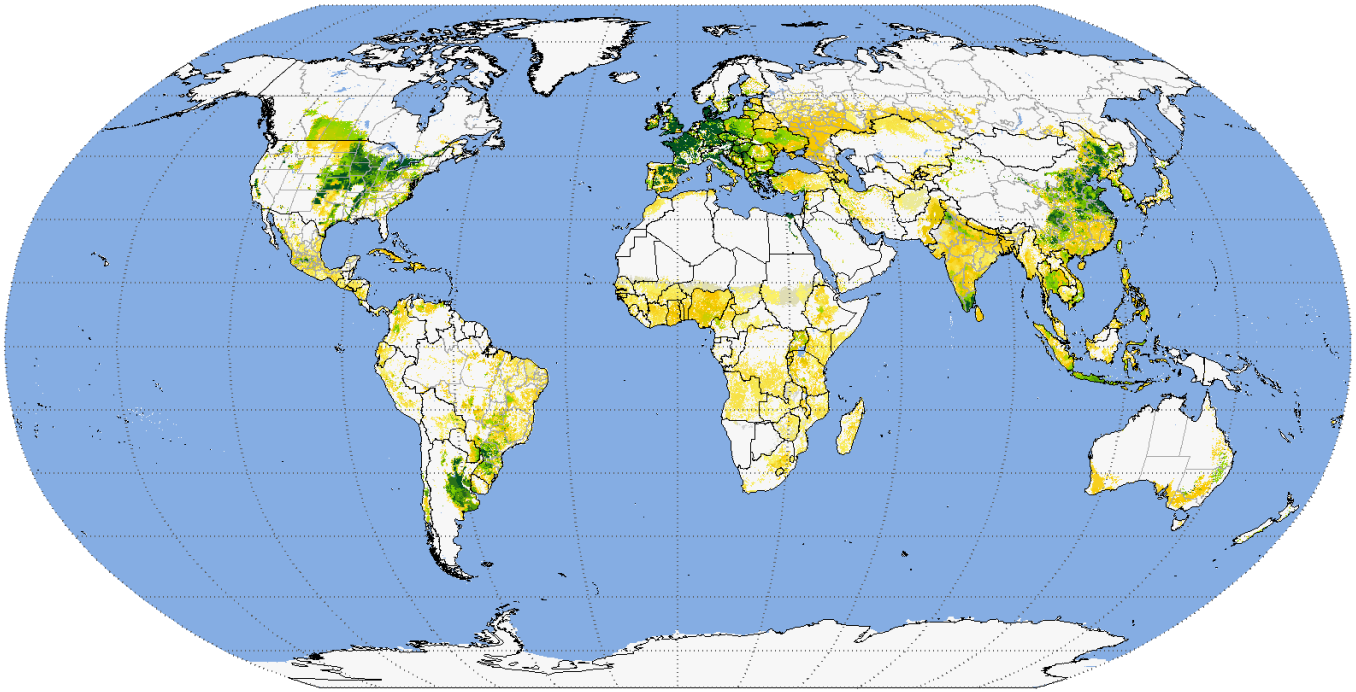
Another Possibility

Change Allocation of Crops

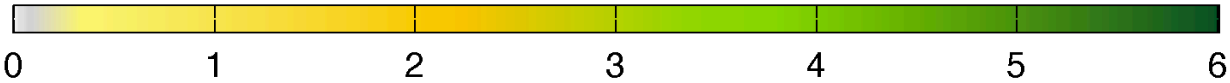
Food (Direct) from Crops



Major crops, calories produced

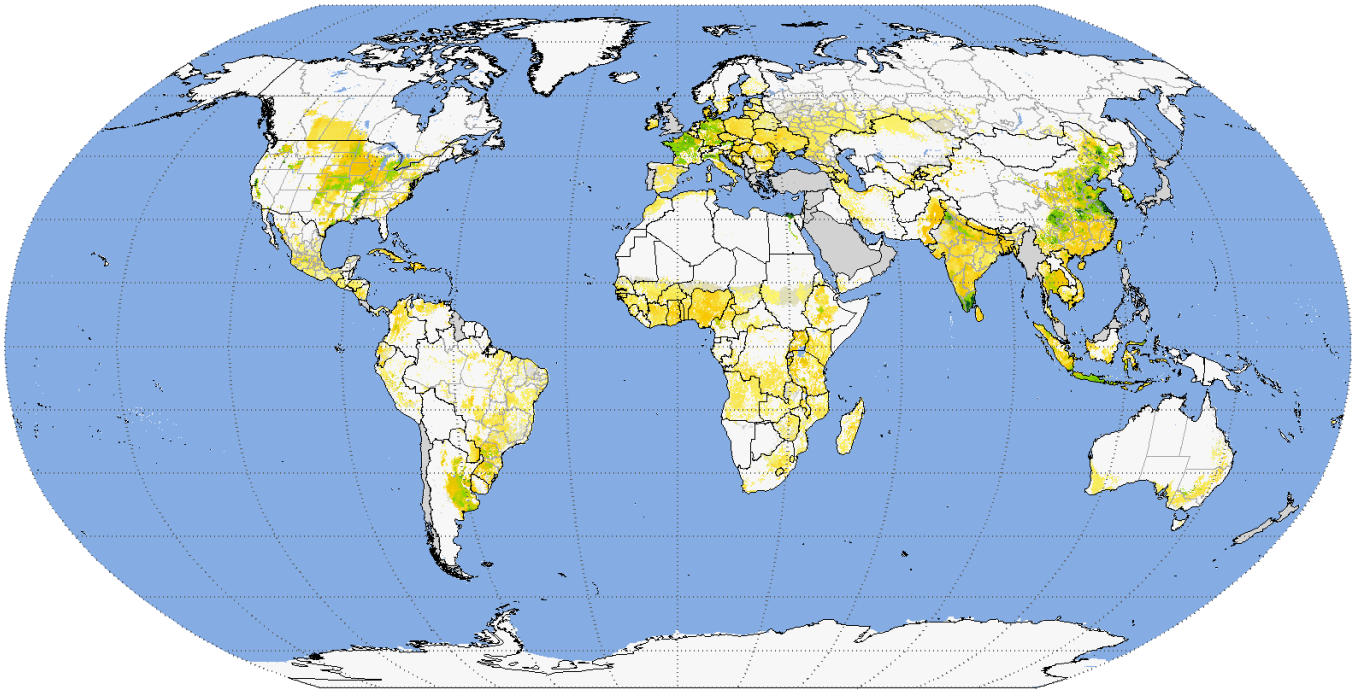


kcal per hectare

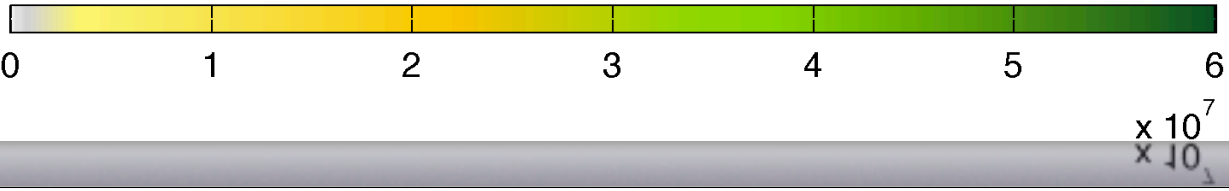


x 10^7

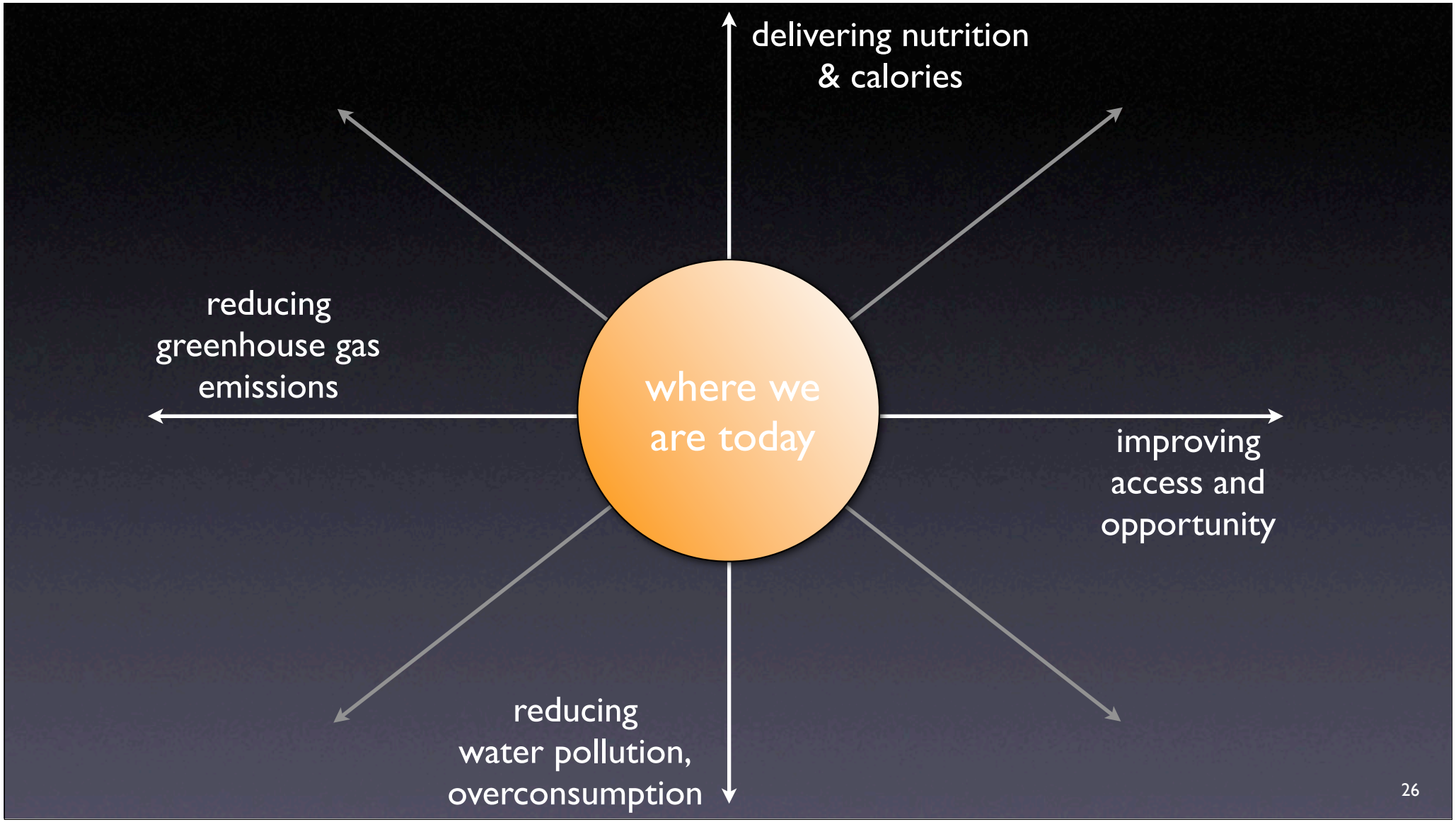
Major crops, calories delivered to humans

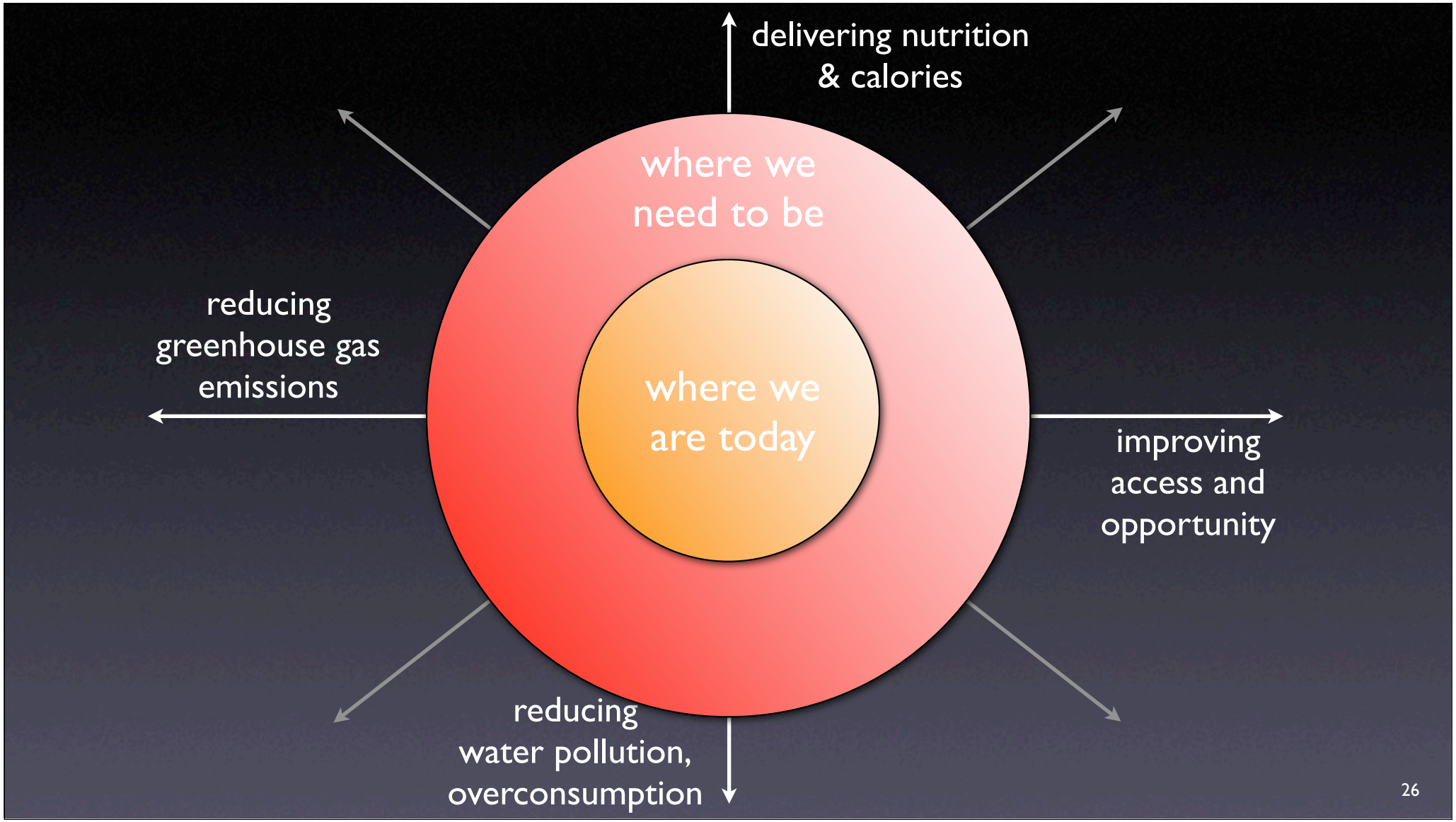


kcal per hectare



Moving Forward


delivering nutrition
& calories
reducing
greenhouse gas
emissions
where we
are today
improving
access and
opportunity
reducing
water pollution,
overconsumption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reducing
water pollution,
overconsumption

Freezing Agricultural Footprint

Sustainable Intensification

Optimize Yield : Water : Nutrients

More Efficiency in Food System

Thank You

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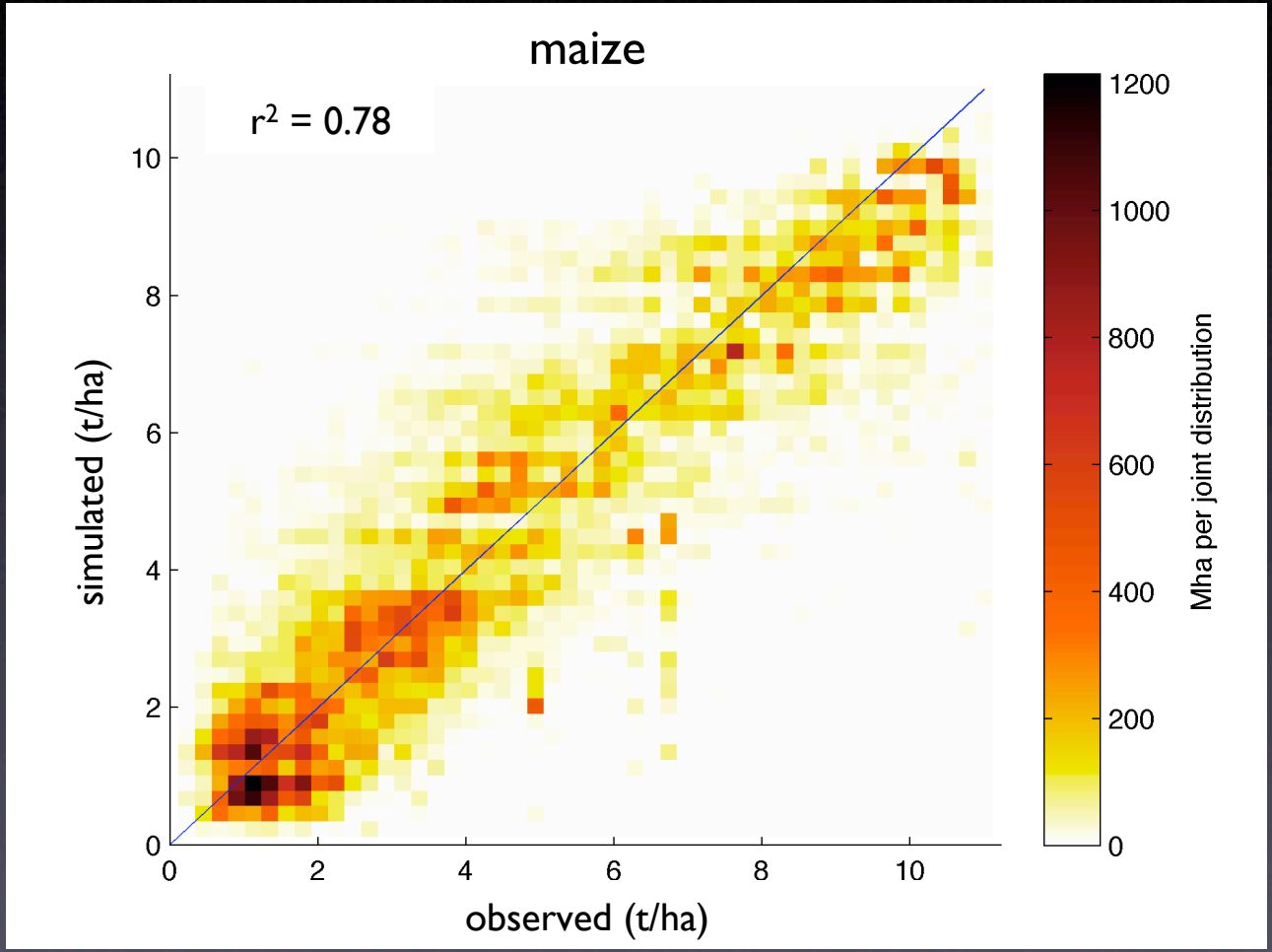
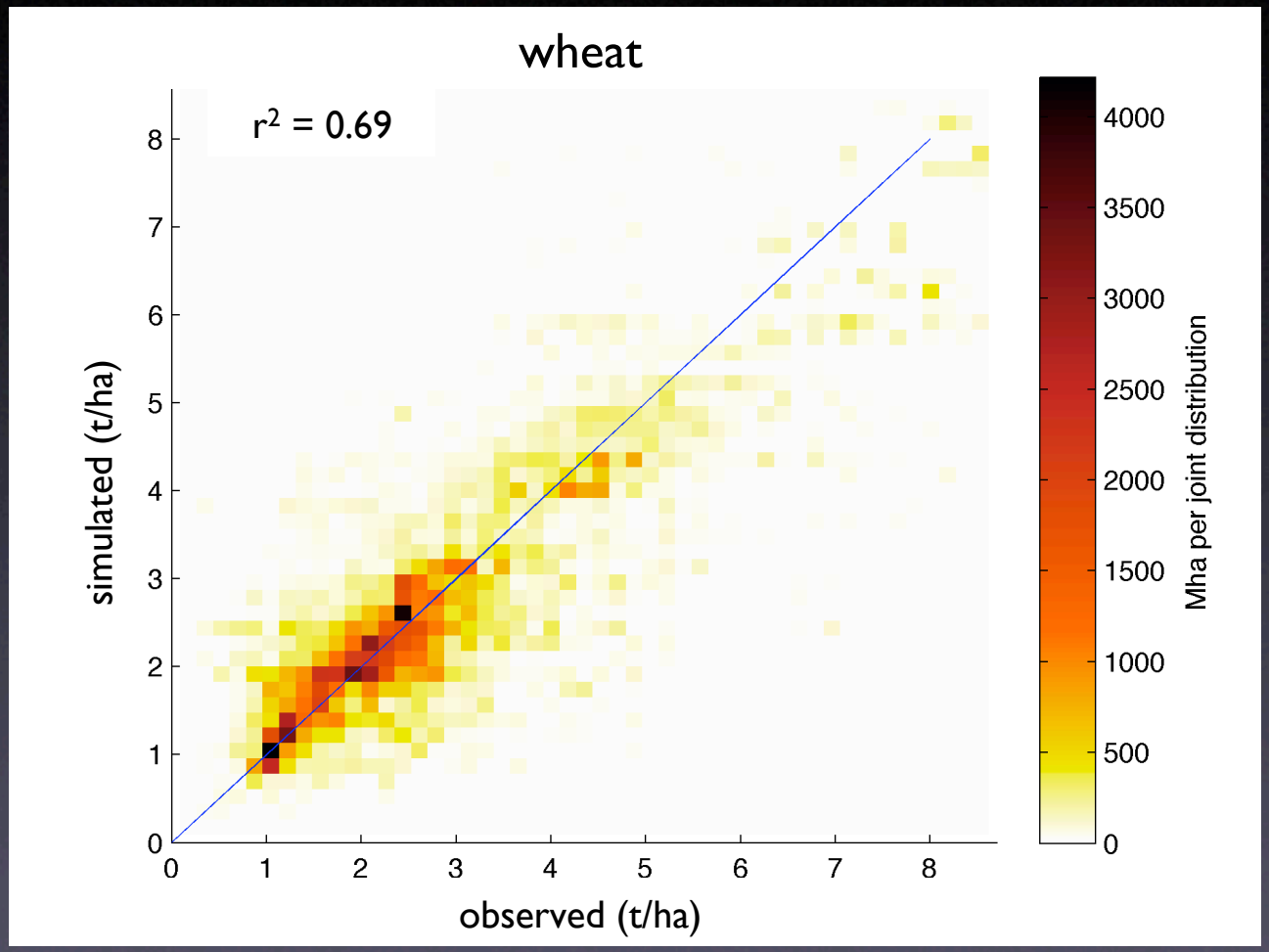
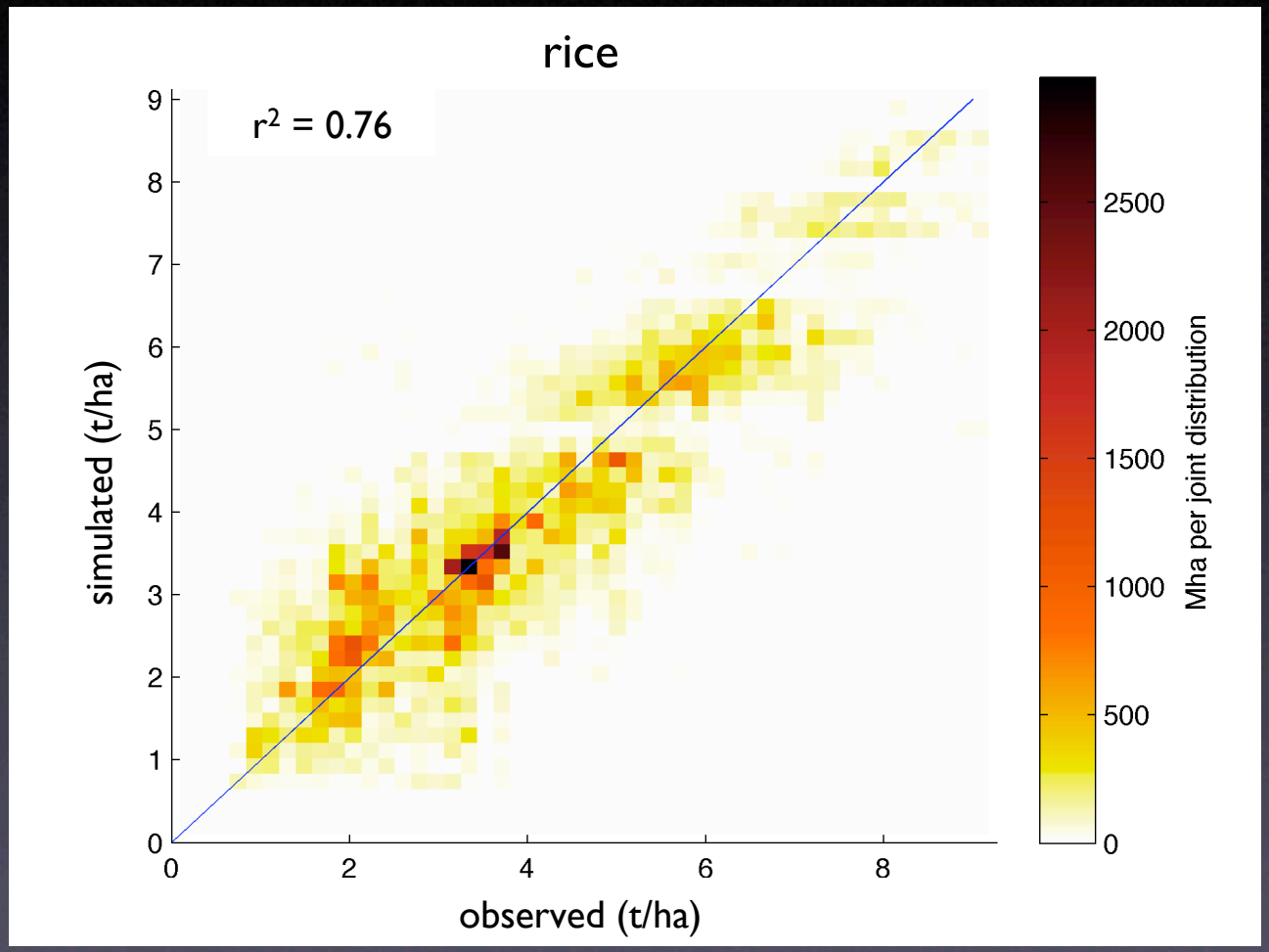
GLI Yield Model



GLI Yield Model



GLI Yield Model



Possible "Solution Wedges"?

Possible "Solution Wedges"?

precision agriculture...

better tillage practices...

cover cropping & buffer strips...

drip irrigation & rain harvesting...

new genetics & new crop varieties...

shifting dietary preferences...

reducing waste in food system...

changing economic incentives to farmers...

reforming foreign aid programs...