



Quantifying Impacts of Land-use and Land Cover Change in a Changing Climate at the Regional Scale using an Integrated Earth System Modeling Approach

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on behalf of

The Platform for Regional Integrated Modeling and Analysis (PRIMA)
The Integrated Multi-scale, Multi-sector Modeling (IM³) Scientific Focus Area

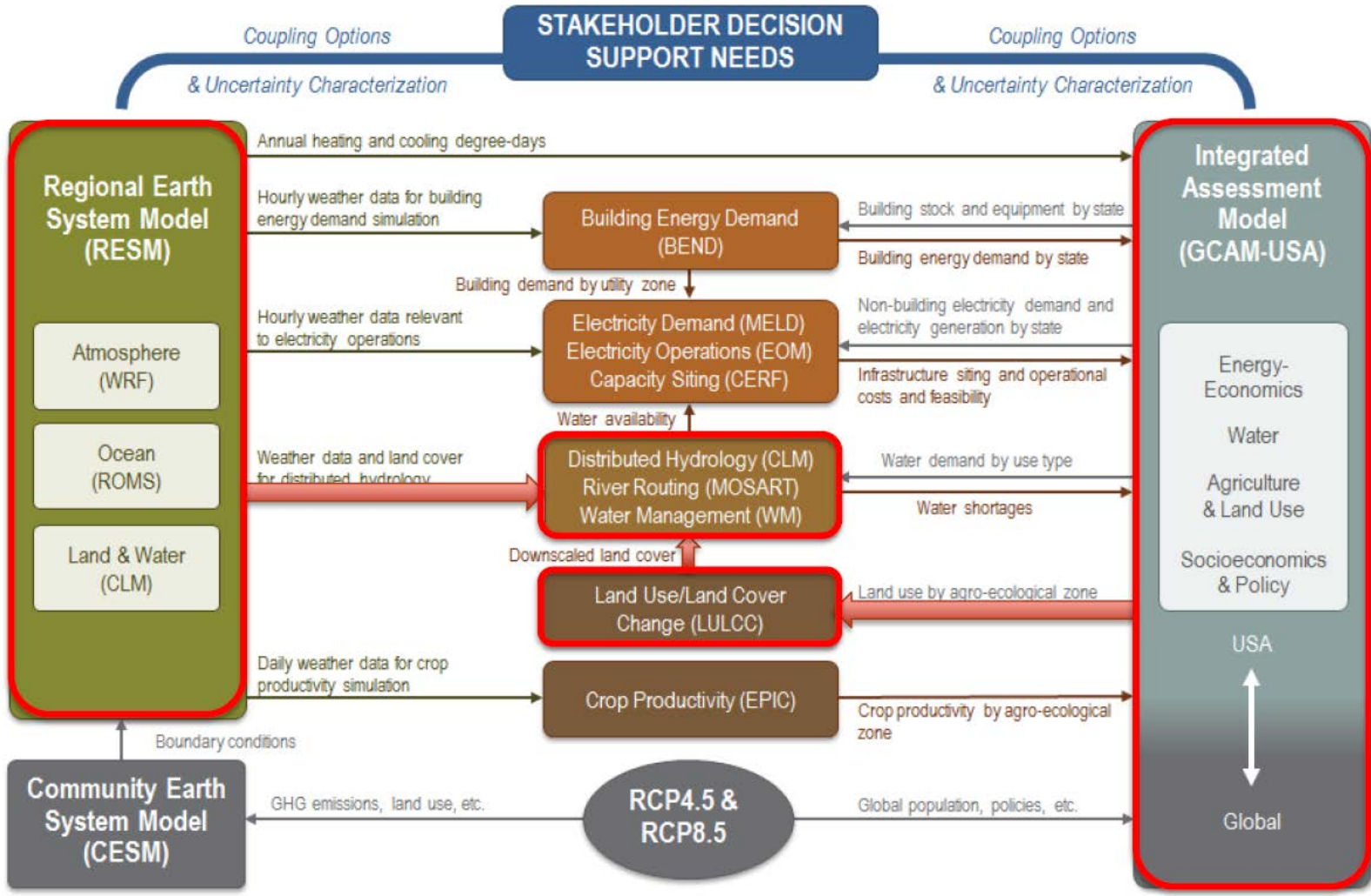
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Background and Motivation

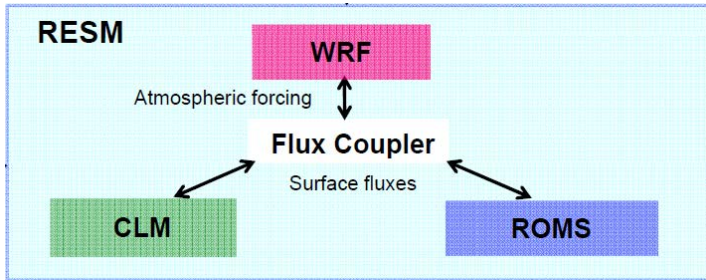
- ▶ Recent efforts have resulted in several new capabilities for representing LULCC ESMs based IAM projections;
- ▶ Considerable uncertainties remain surrounding LULCC downscaling approaches and the overall interdependencies between LULCC and other systems and sectors;
- ▶ We aim to improve our understanding of the complex interactions between LULCC and other human and natural systems by systematically exploring feedbacks between terrestrial processes and other components.

Platform for Regional Integrated Modeling and Analysis

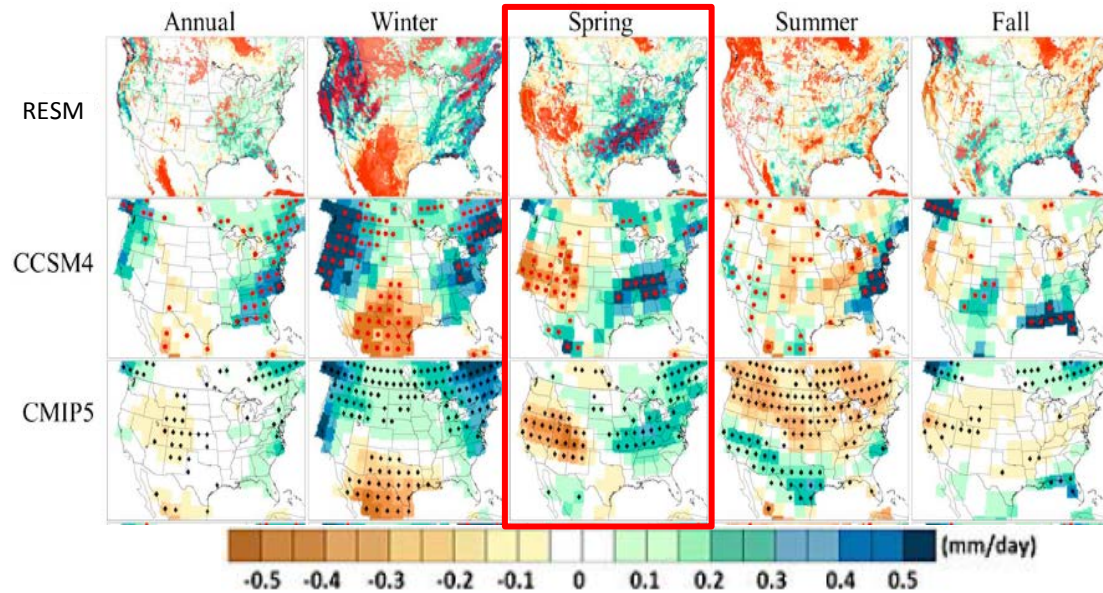


Exploring High-resolution Water Cycle Changes Using a Regional Earth System Model

- ▶ Regional Earth System Model (RESM) built for dynamic downscaling by coupling WRF, CLM, and ROMS



- ▶ RESM was applied over the conterminous United States at 20-km resolution using large-scale conditions from CESM:
 - One historical simulation
 - Two future climate projections (RCP4.5 and RCP8.5)

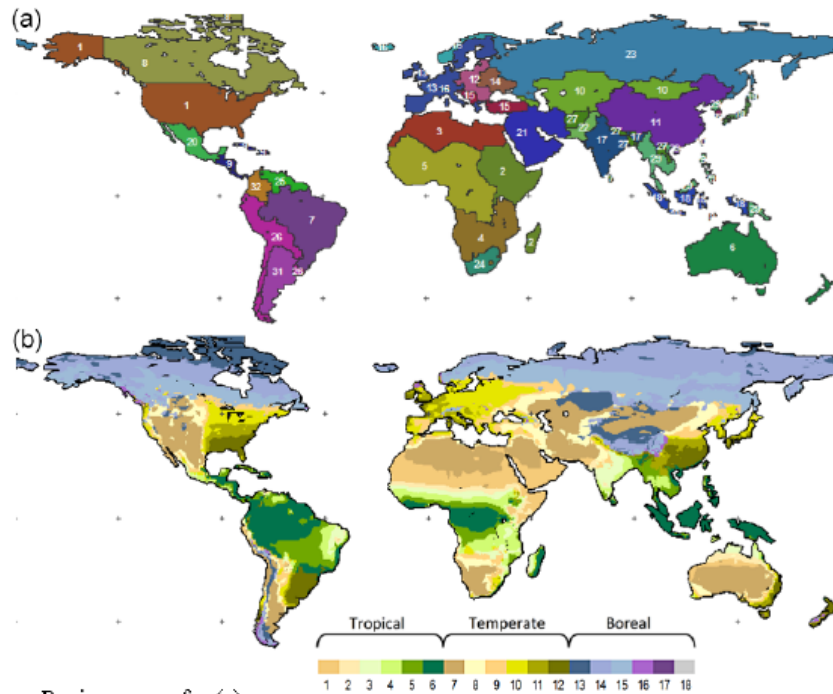


- ▶ A robust spring drying signal in the Southwest was identified across the CMIP5 archive, suggesting challenges for water resources management and agriculture over the region in the future
- ▶ The RESM simulations stand out in their ability to capture regional details and water cycle extremes

Downscale LULCC from GCAM-USA

West et al. (2014); Le Page et al. (2016)

*Projected % change in land cover by 2090
compared to the 2005 condition*



Region names for (a)

1- USA	9- Central America and Caribbean	17- India	25- South America Northern
2- Africa Eastern	10- Central Asia	18- Indonesia	26- South America Southern
3- Africa Northern	11- China	19- Japan	27- South Asia
4- Africa Southern	12- EU-12	20- Mexico	28- South Korea
5- Africa Western	13- EU-15	21- Middle East	29- Southeast Asia
6- Australia NZ	14- Europe Eastern	22- Pakistan	30- Taiwan
7- Brazil	15- Europe Non EU	23- Russia	31- Argentina
8- Canada	16- European Free Trade Association	24- South Africa	32- Colombia

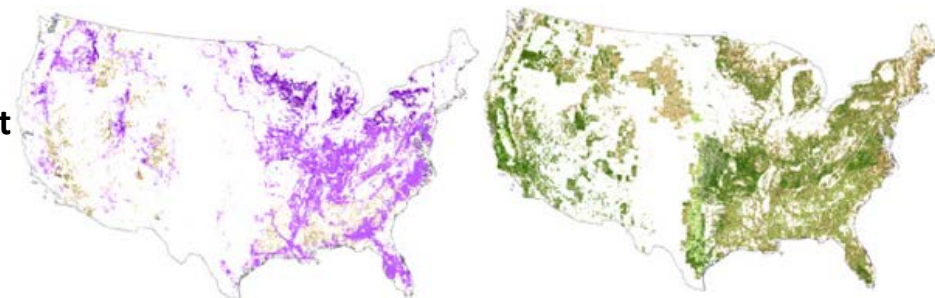
RCP8.5
Business as usual

RCP4.5
Mitigation

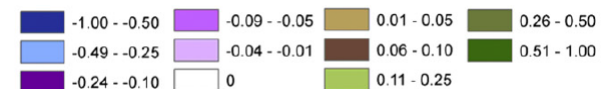
Crops



Forest



GCAM represents the world terrestrial biosphere into 283 spatial units, the result of the intersection of two spatial scales

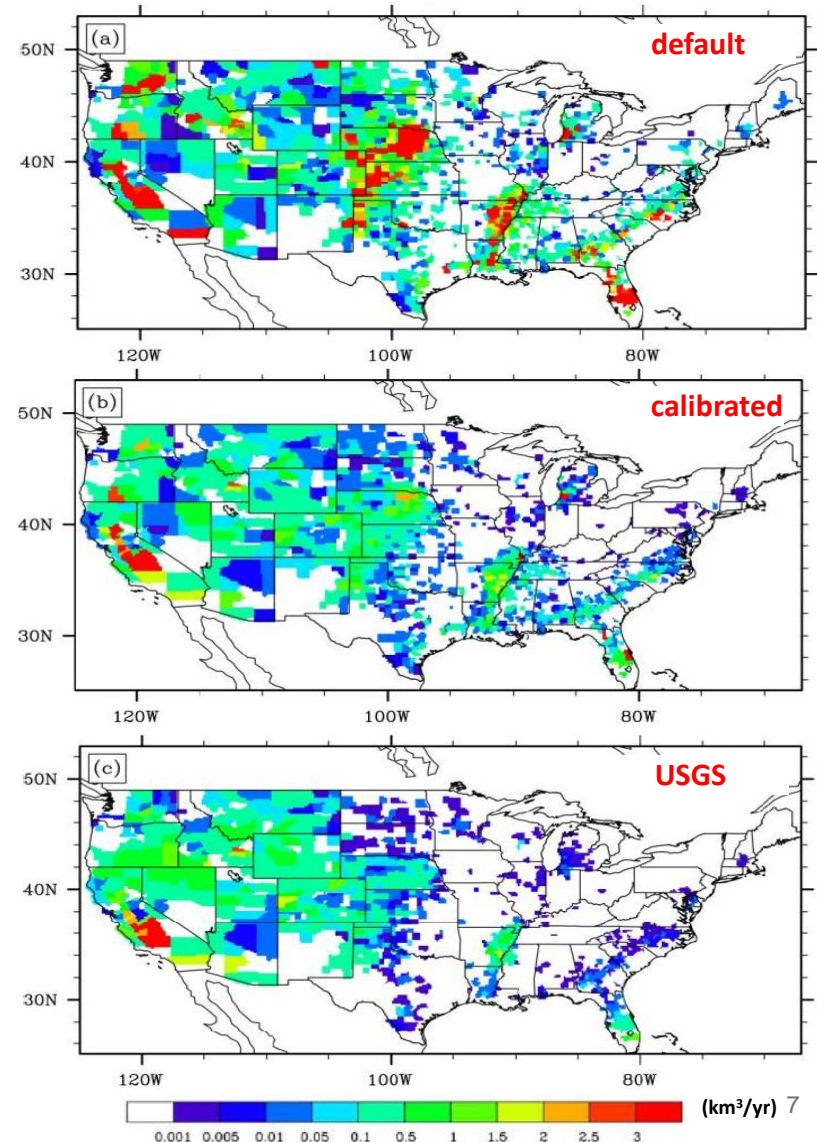


Improving the Performance of CLM in Representing Regional Agro-ecosystems and Hydrology

- ▶ Incorporated groundwater pumping, and fertilization schemes into the Community Land Model (CLM);
- ▶ Calibrated CLM simulated irrigation amount and crop yields against county-level agricultural census;
- ▶ Demonstrated that irrigation, groundwater pumping, and crop management greatly alter regional water and carbon dynamics, and can influence local and regional climate;
- ▶ These tools and results are ready for integration with IAMs in a regional context

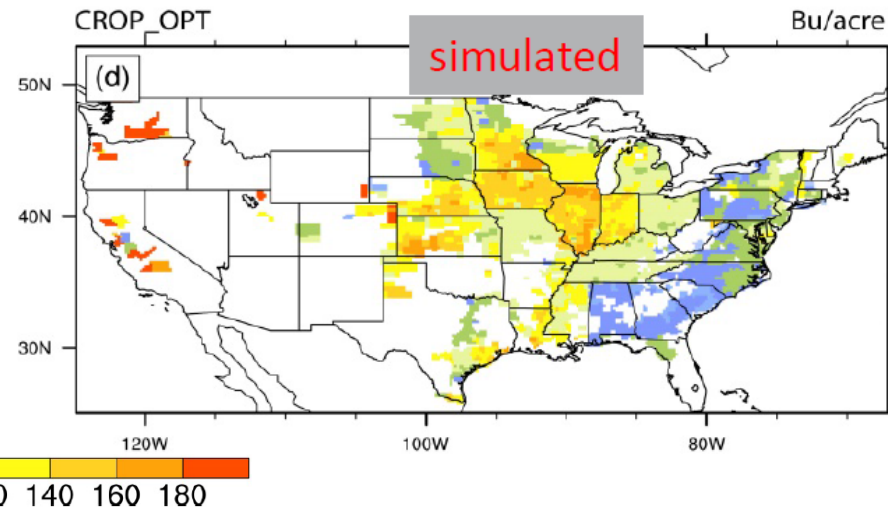
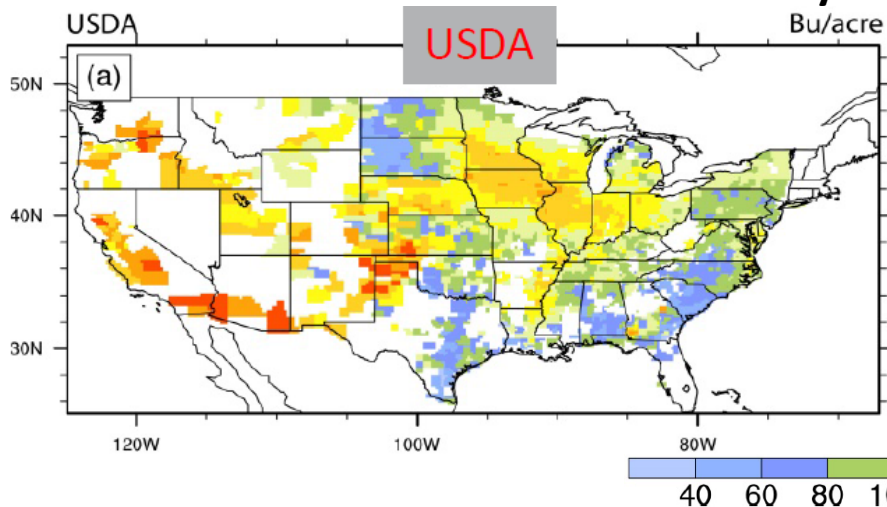
Leng G., et al. JGR, 2013; JHM, 2014

County-level irrigation amount

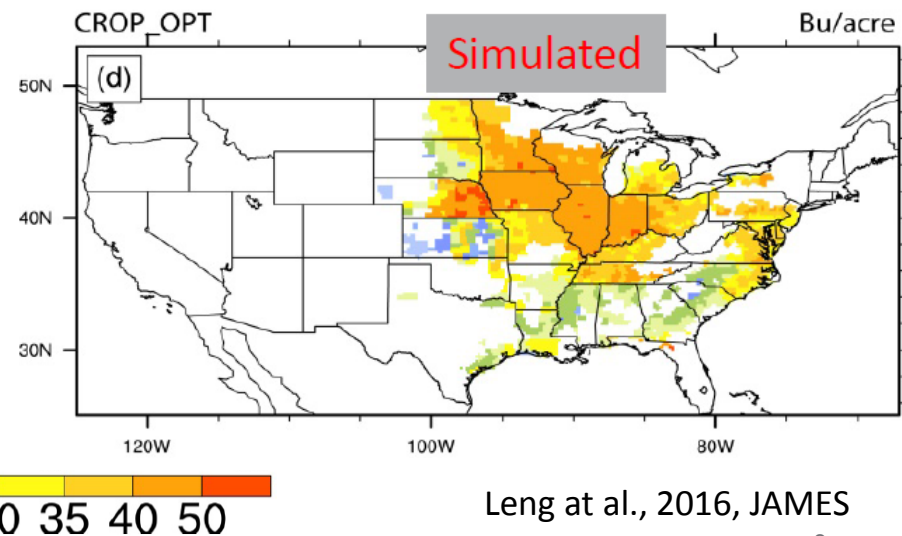
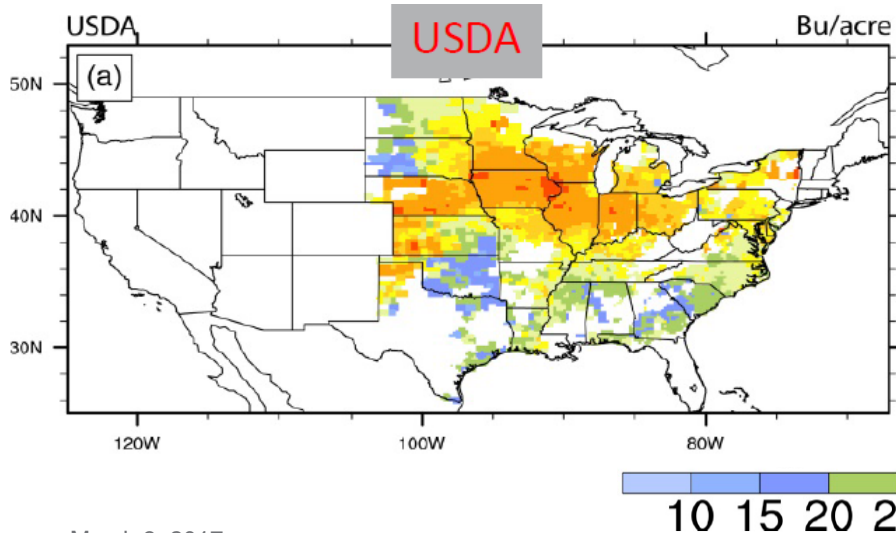


Quantify bioenergy crop yields and assessing its environmental impacts

County-level Corn Yields

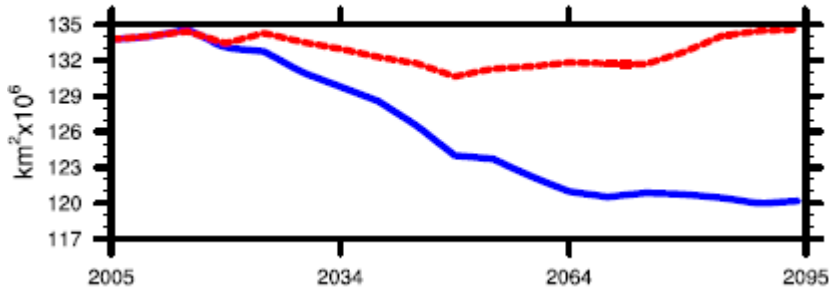


County-level Soybean Yields

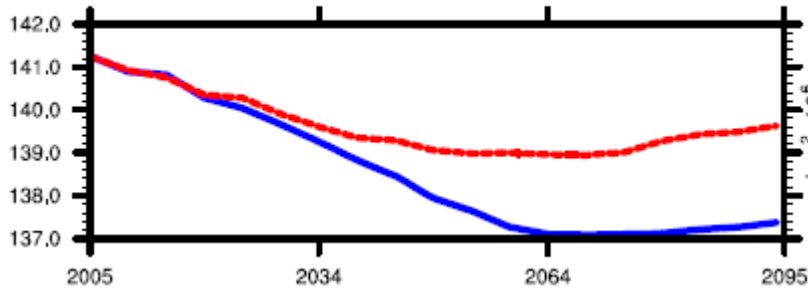


Change in land area covered by plant functional types 2005-2095

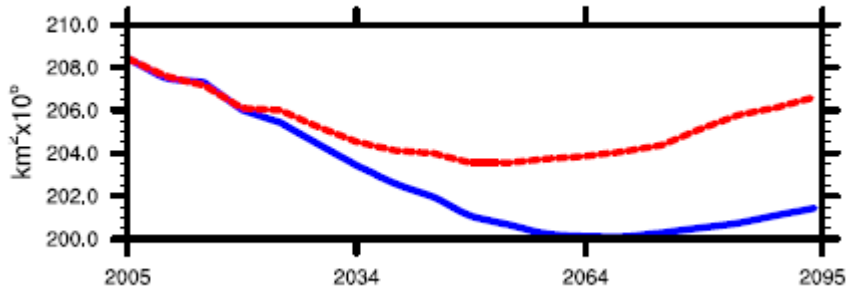
Broadleaf deciduous tree - temperate



Broadleaf deciduous shrub - temperate



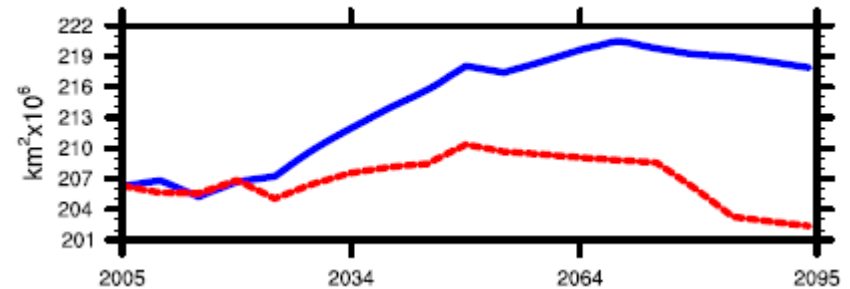
C3 grass



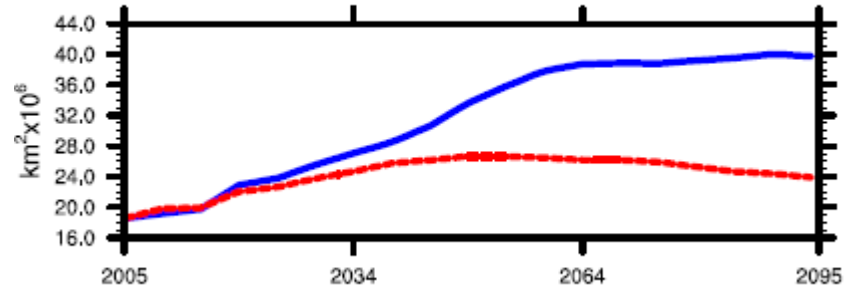
year



— RCP8.5
— RCP4.5 Rainfed crop



Irrigated crop



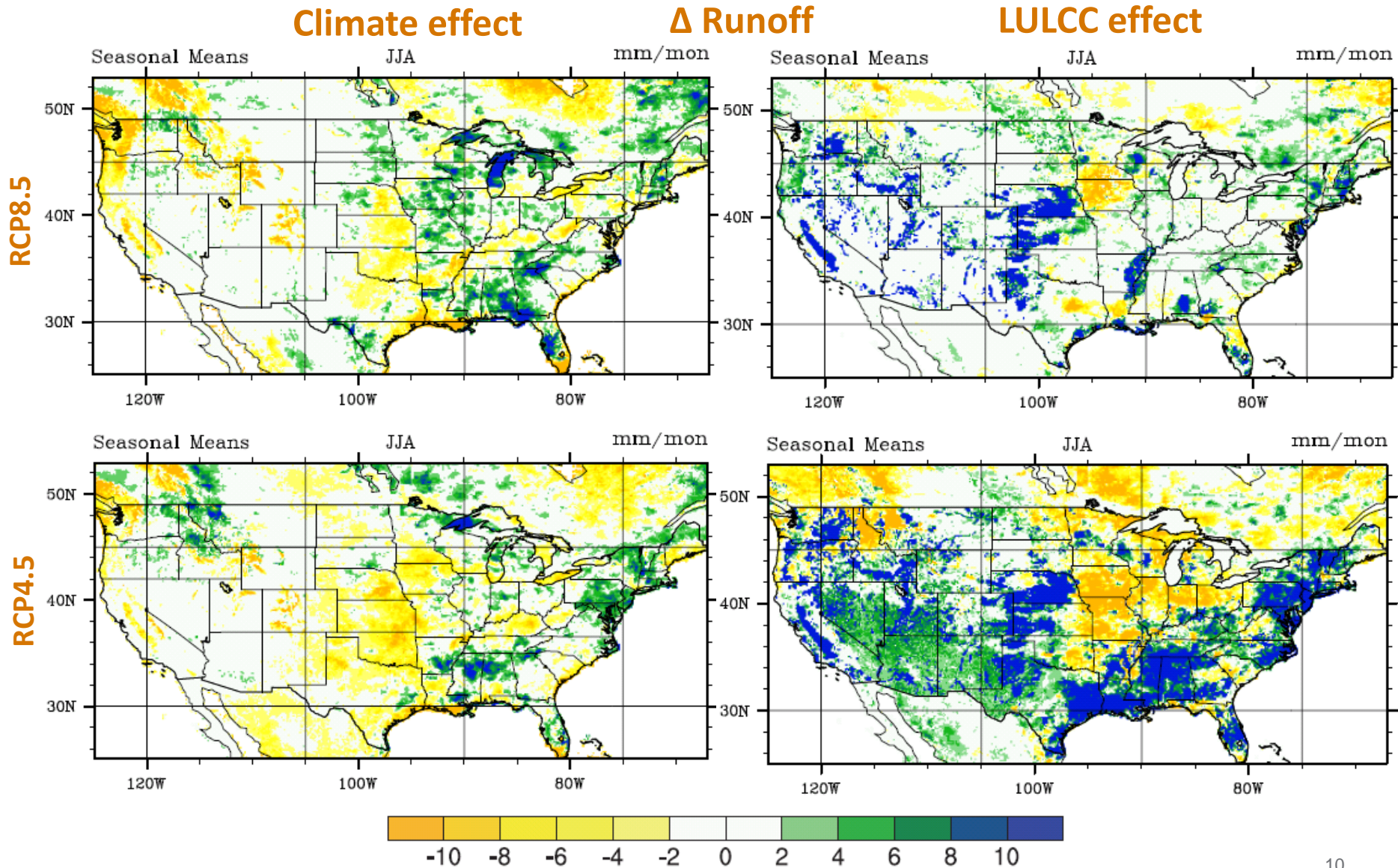
year

Benefit of climate mitigation might be damped by LULCC at the local to regional scales



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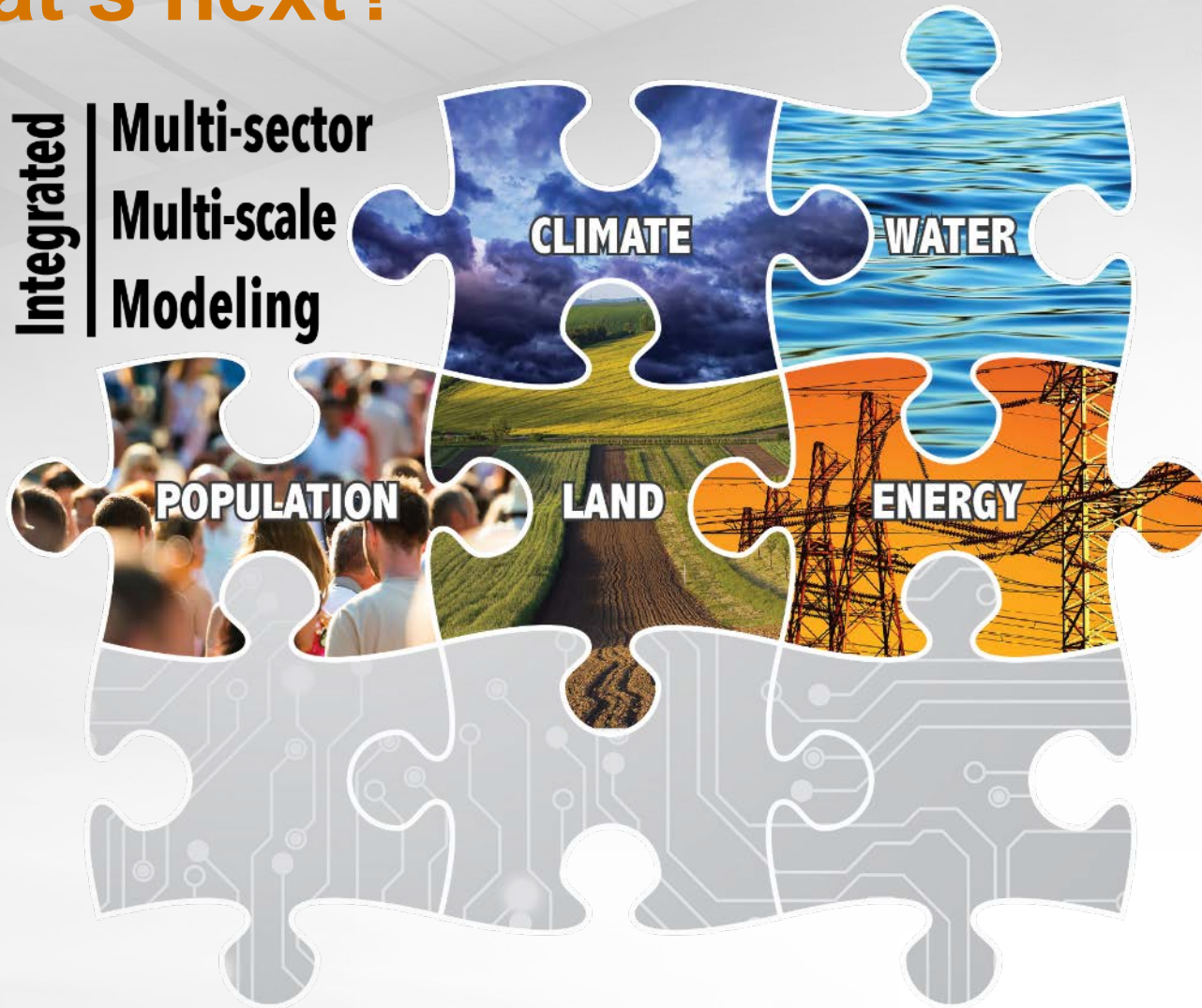


What's next?

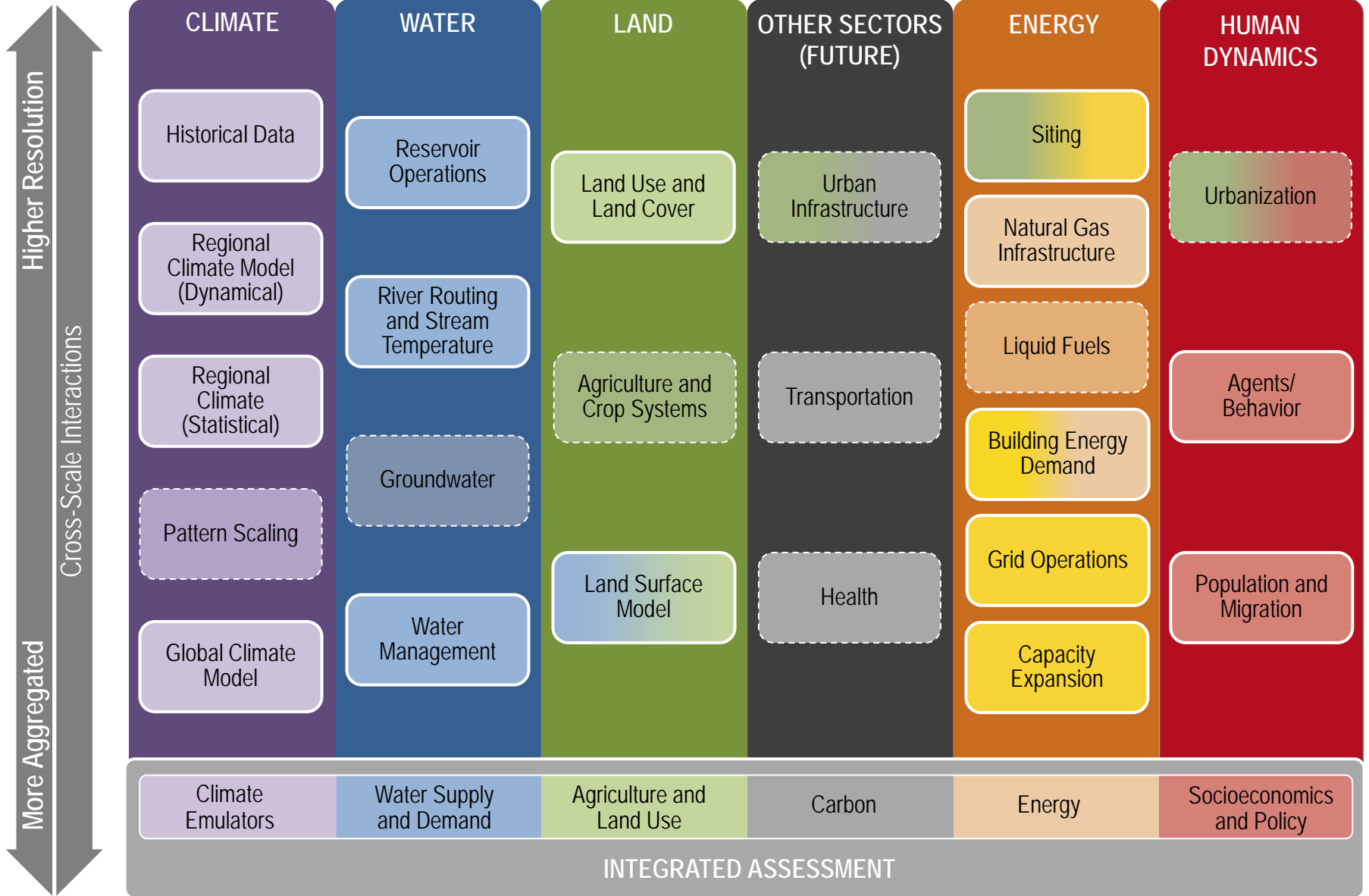


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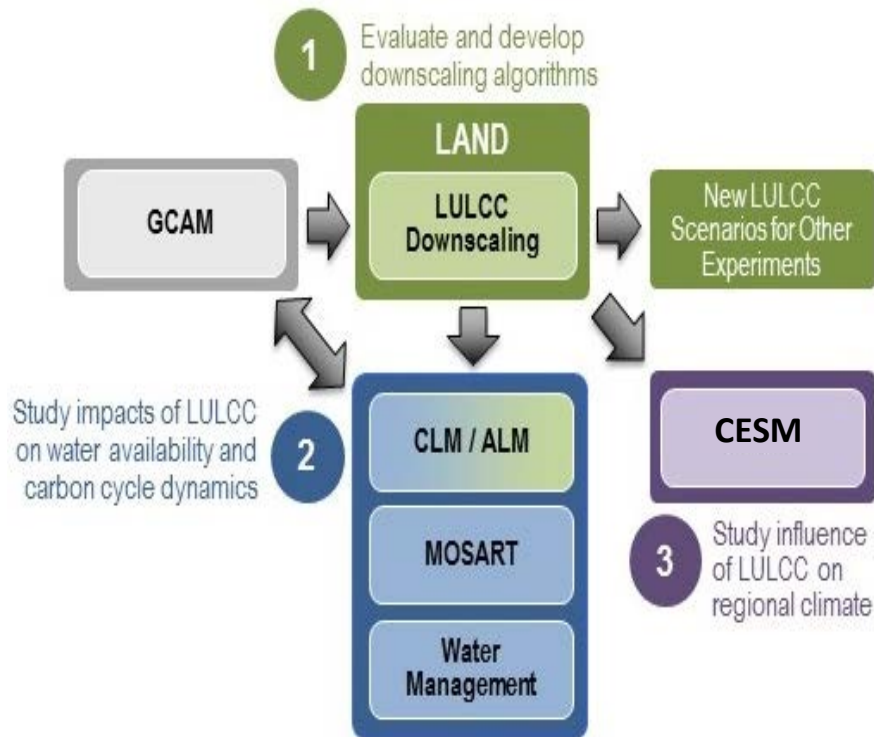
Scientific Focus Area



Land Use and Land Cover Change (LULCC) Research Thrust Area

Questions:

- ▶ How might socio-economic and biophysical factors drive regional LULCC under future climate change, adaptation, and mitigation scenarios?
- ▶ Will projected LULCC lead to regional or seasonal water deficits?
- ▶ Will LULCC-induced perturbations to surface properties influence regional climate?



Activities:

- ▶ Evaluate and enhance LULCC downscaling algorithms (using input from GCAM and population dynamics thrust area)
- ▶ Quantify impacts of LULCC on water availability, carbon cycle dynamics, and regional climate
- ▶ Provide new LULCC scenarios for other projects/activities

Acknowledgement

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