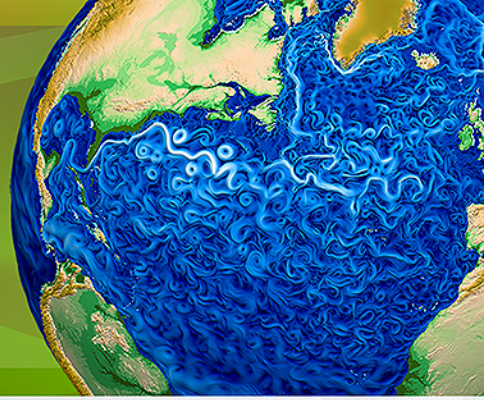
ACME
Accelerated Climate Modeling for Energy



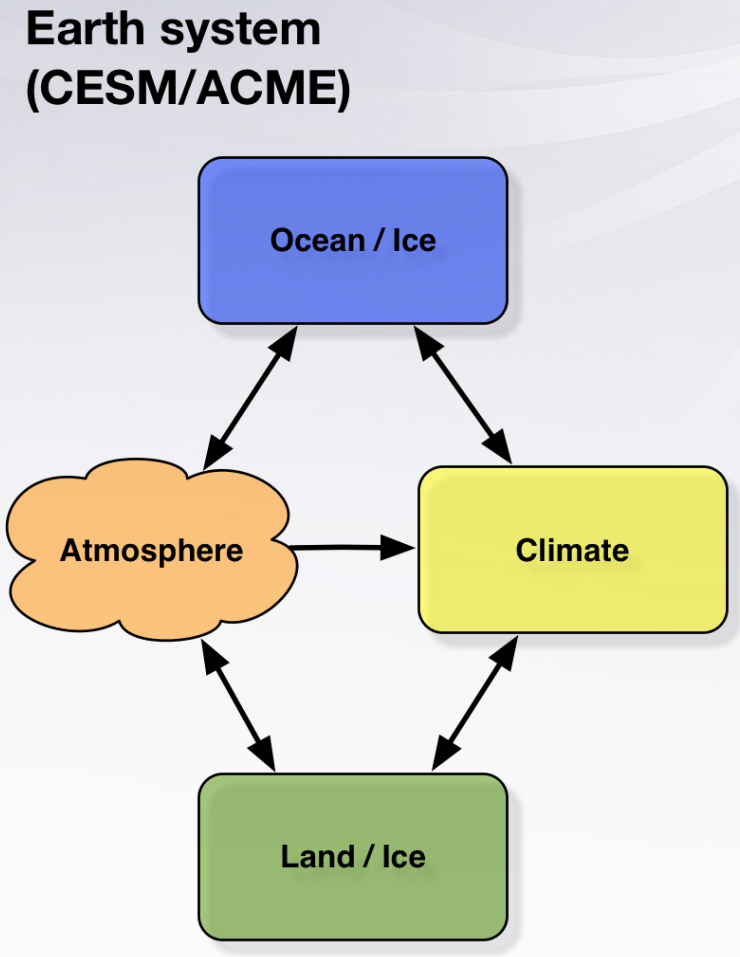
Human-Component Progress and FY17 Plans

ACME All Hands Meeting

June 9, 2016

U.S. DEPARTMENT OF ENERGY

Humans in the Earth System



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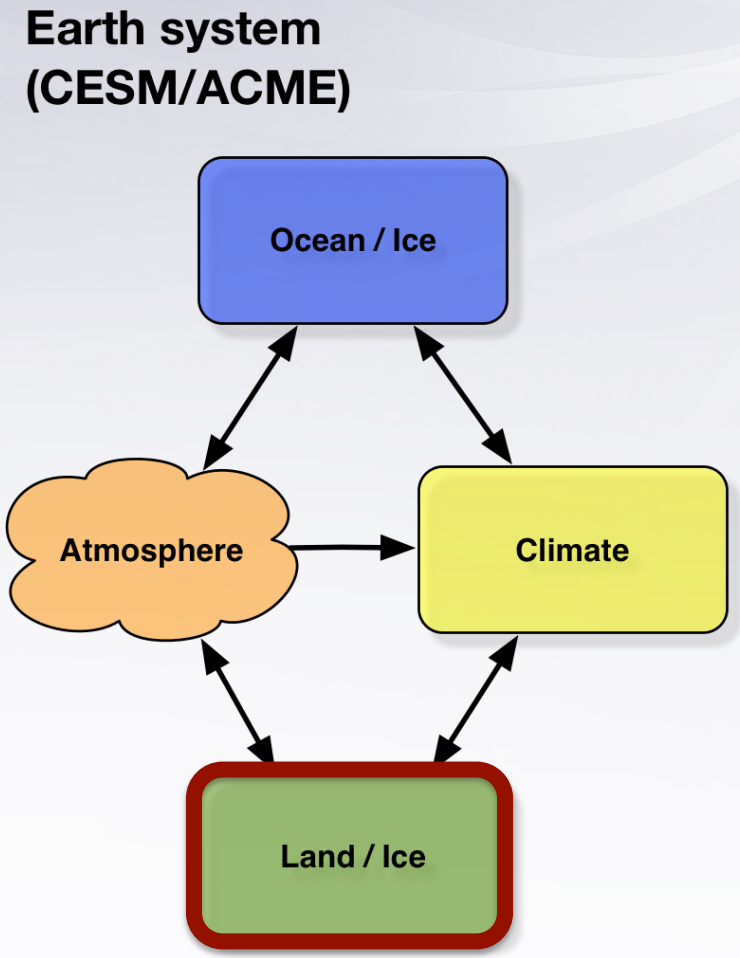

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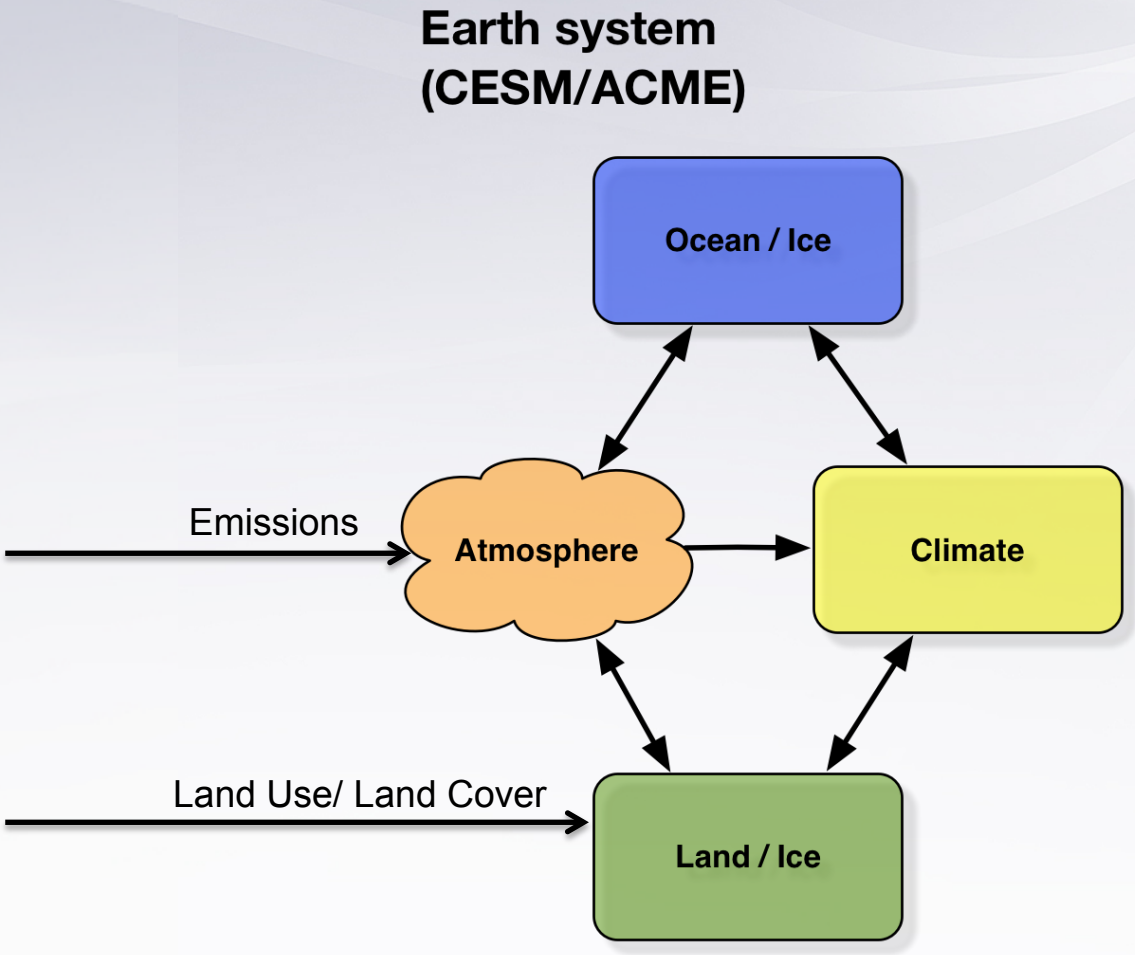

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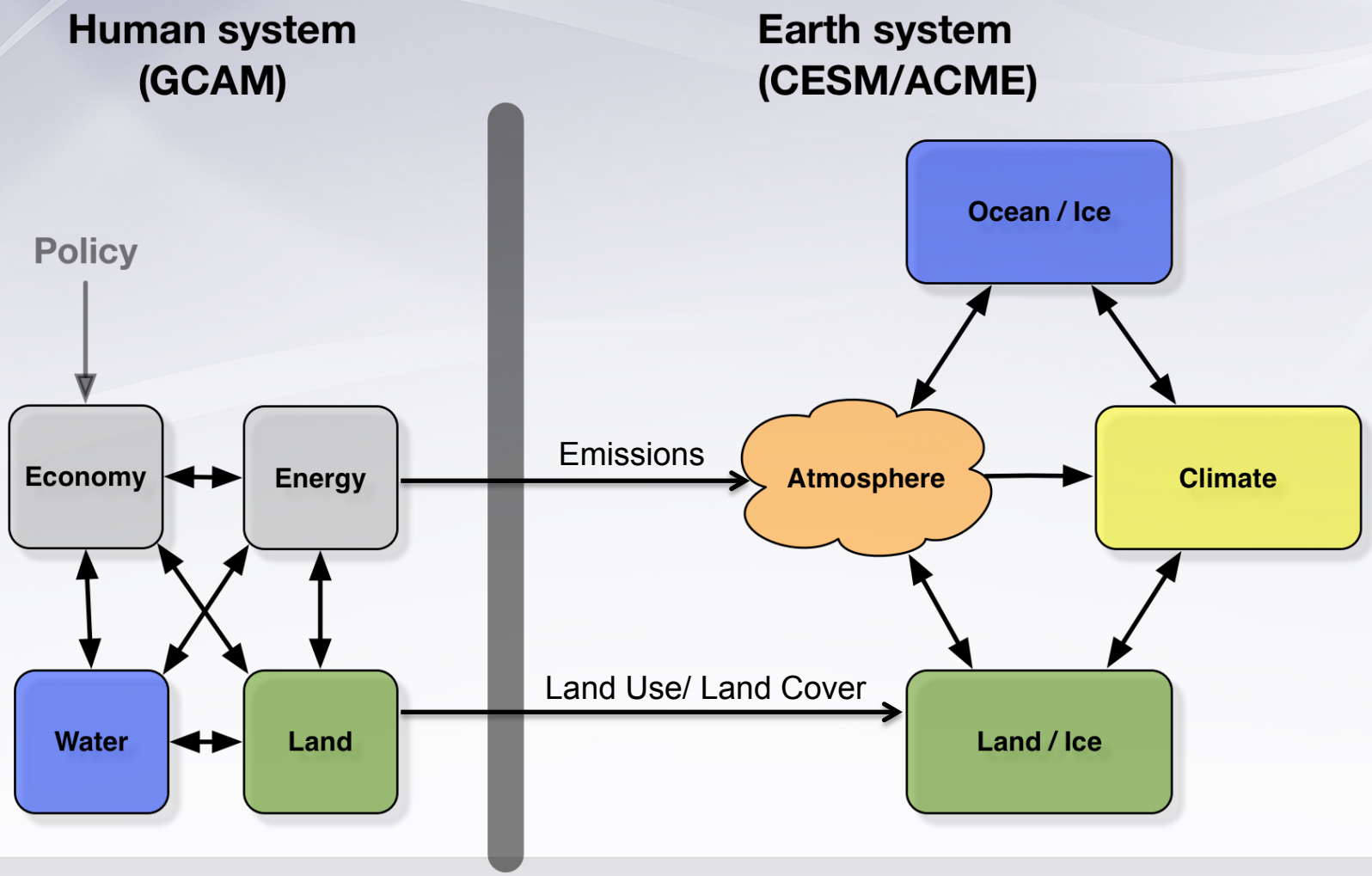

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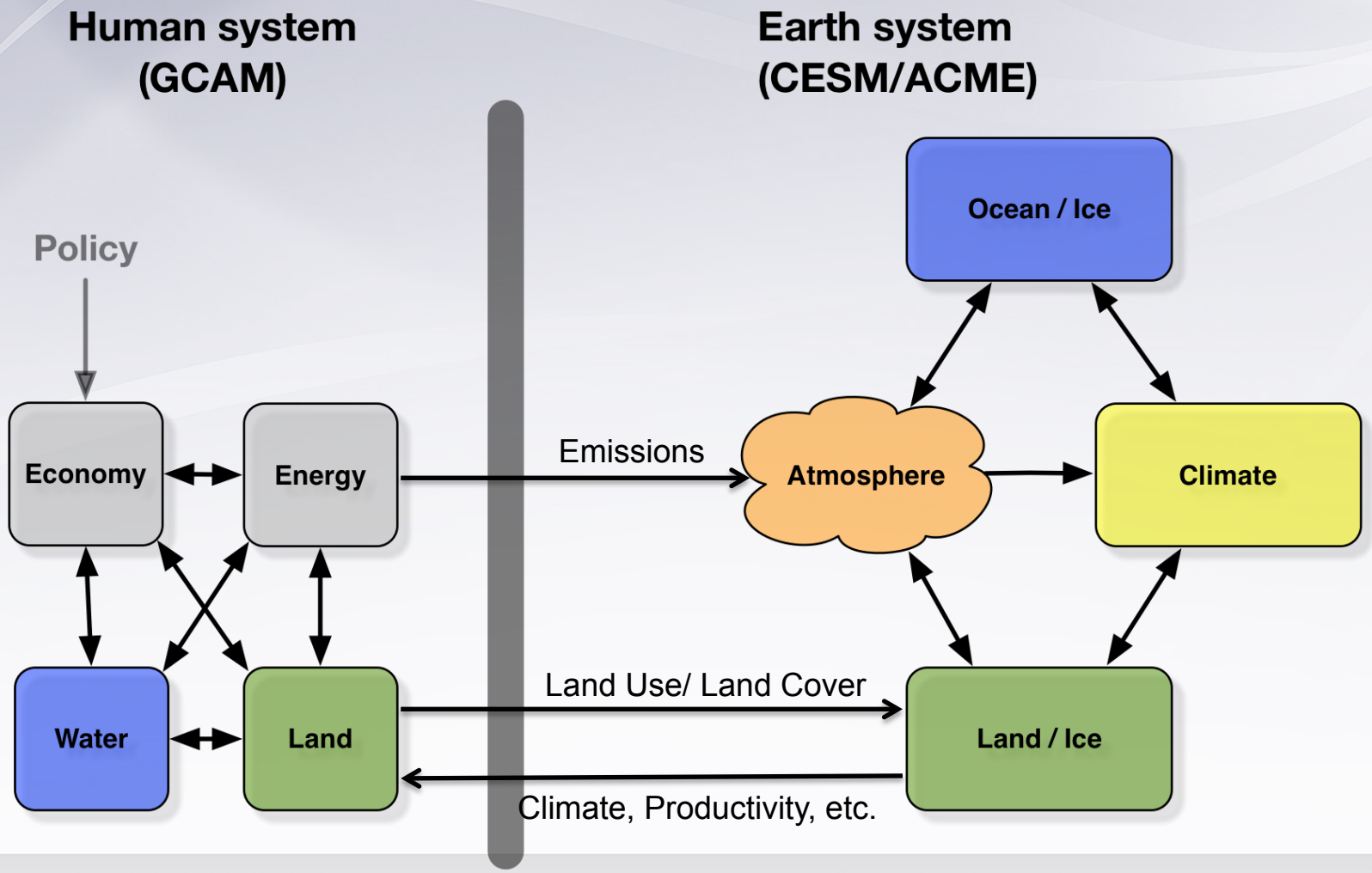
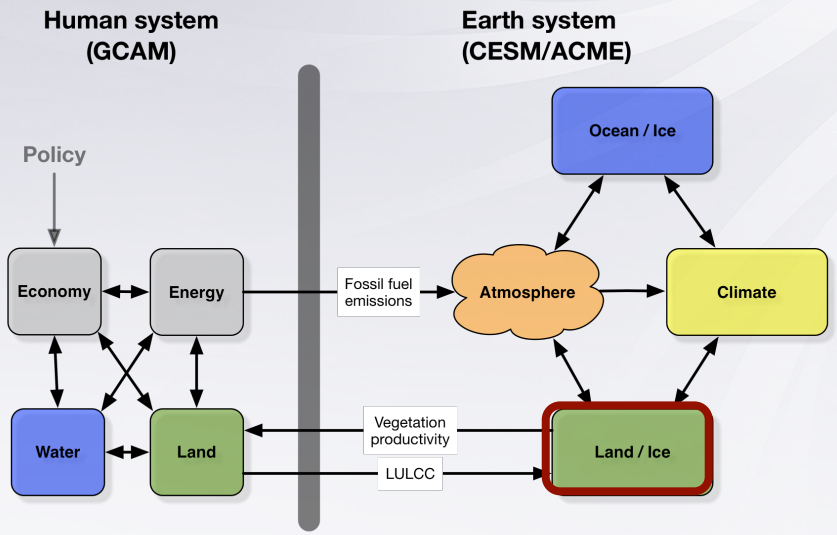


Humans in ACME

- Model Developments:
  - Crop modeling, water management, LULCC



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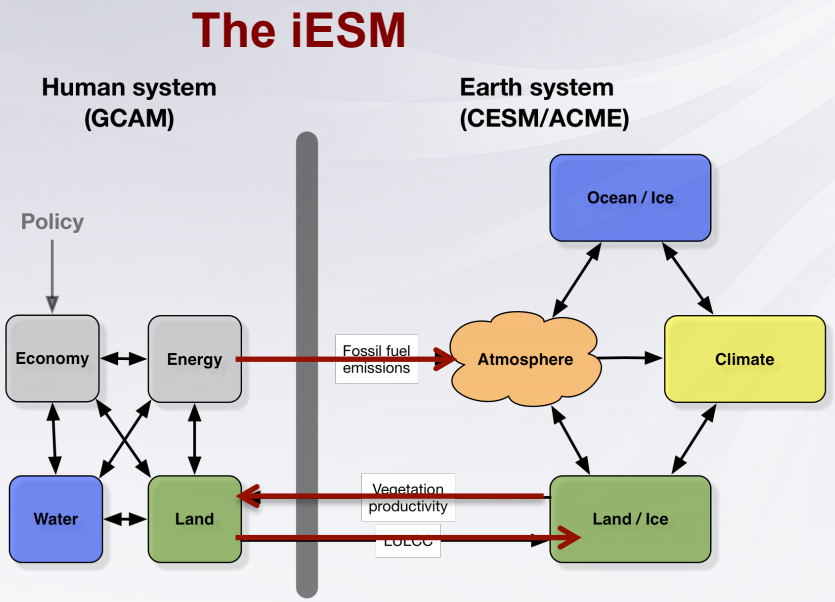

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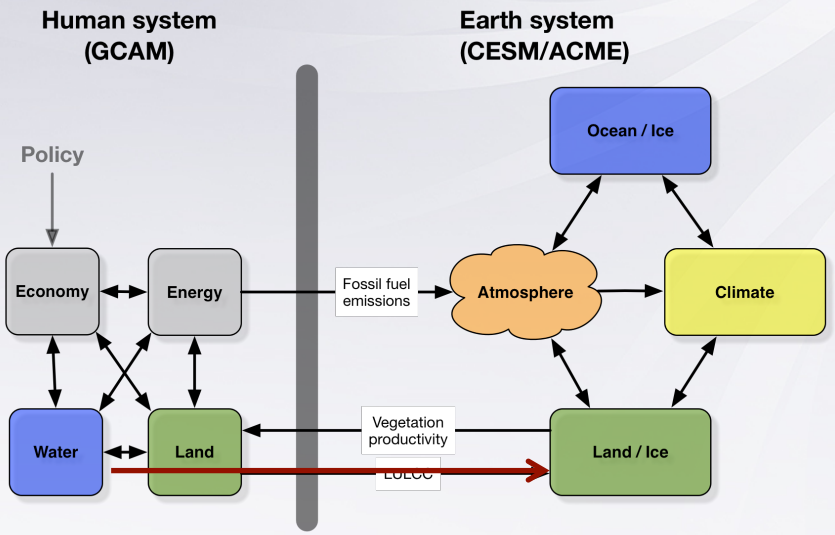

Humans in ACME

- Model Developments:
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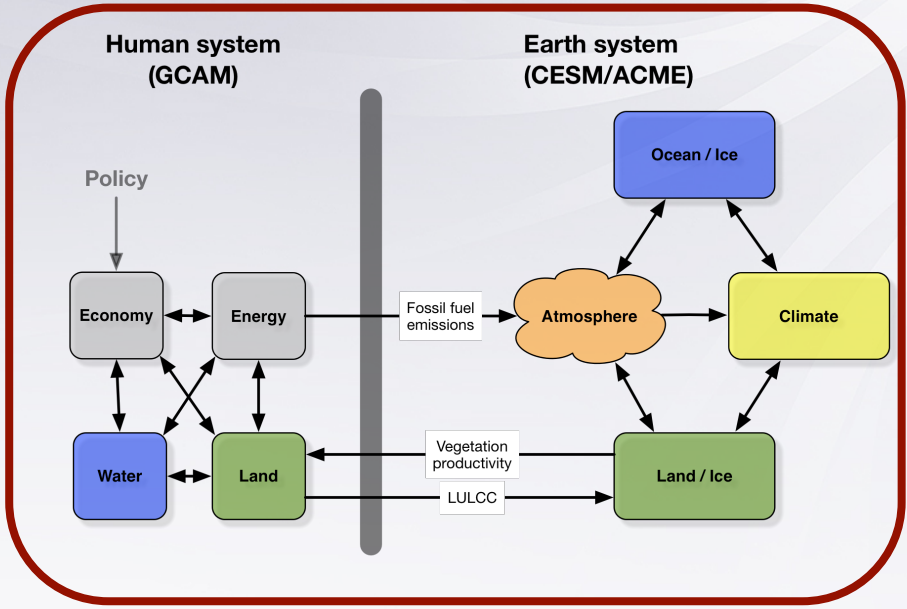
- Other Activities:
  - Scenario White Paper
  - IA-IAV-ESM Workshop

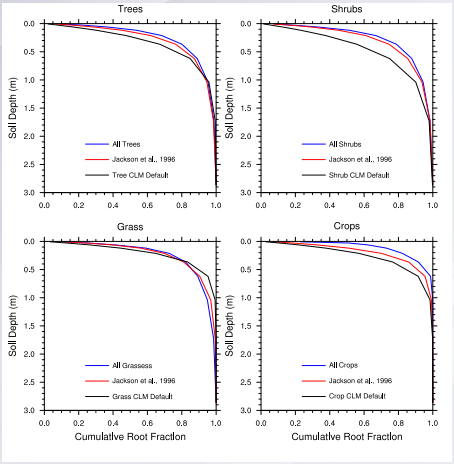


Model Development: Crops

Dynamic root model

- Root distribution optimizes water and nutrient uptake
- Dynamic rooting depth for crops

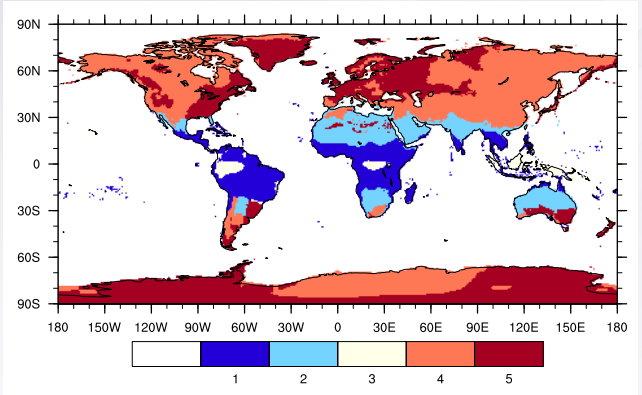
Cumulative root fraction follows observations



Crop phenology: progress on planting date

- Determine if region has precipitation or temperature seasonality
- Use temperature threshold or main wet season to diagnose month of planting
- Based on Waha et al., 2012

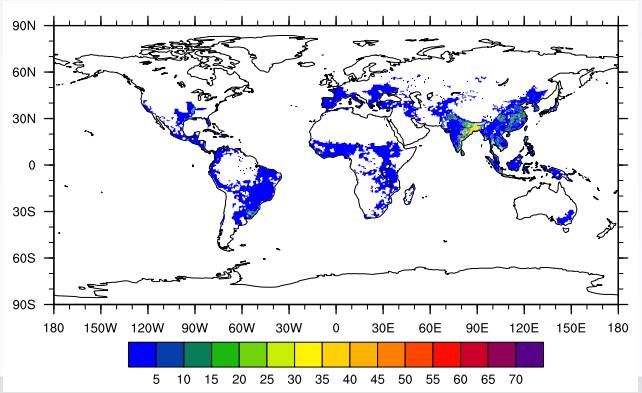
Seasonality Map:
Blue = Precipitation
Red = Temperature



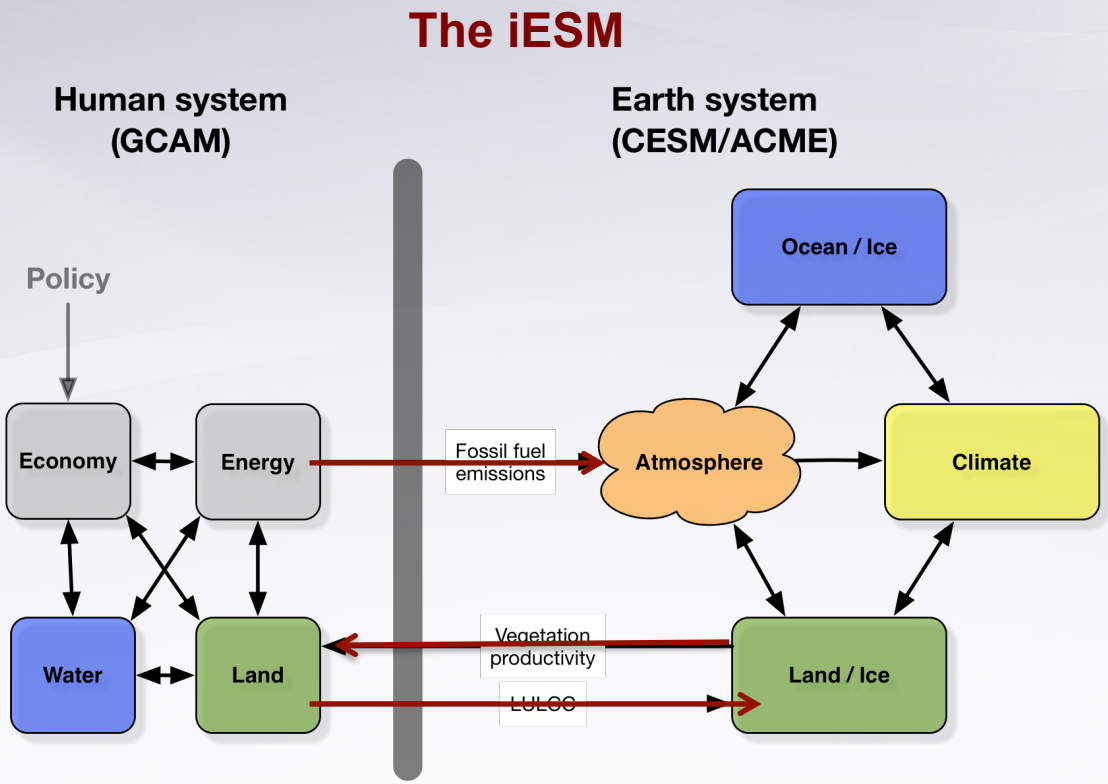
New crop types to be added:

- *Food Crops*: rice, sugarcane, rapeseed, cassava, other grain, roots/tubers
- *Bioenergy Crops*: oil palm, poplar, willow, switchgrass, miscanthus
- *Other Crops*: Cotton, fodder grass

Percent of grid cell growing rice

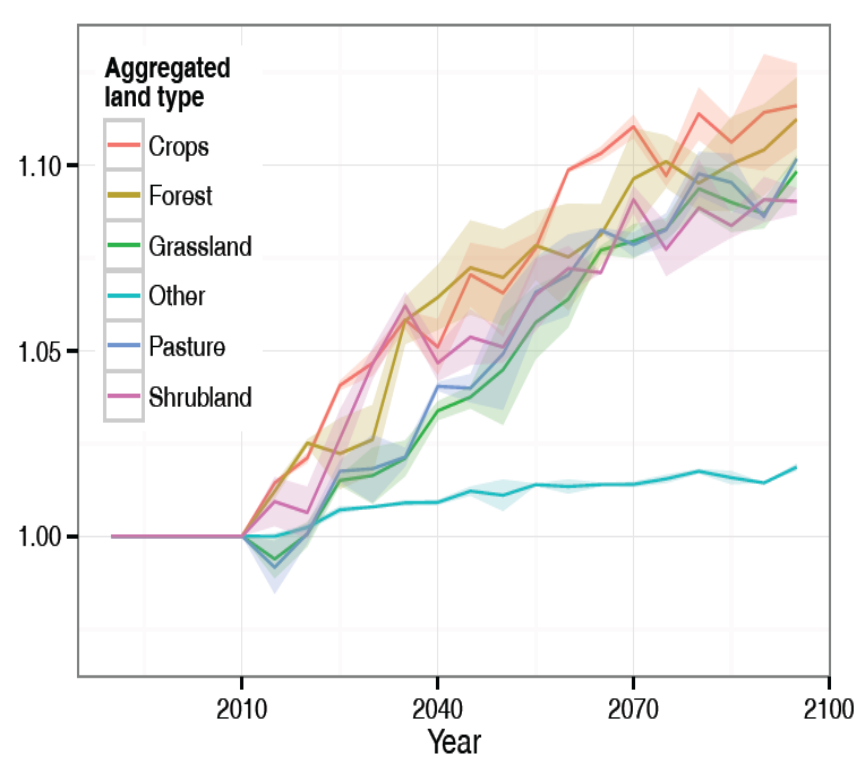


Carbon Cycle Model

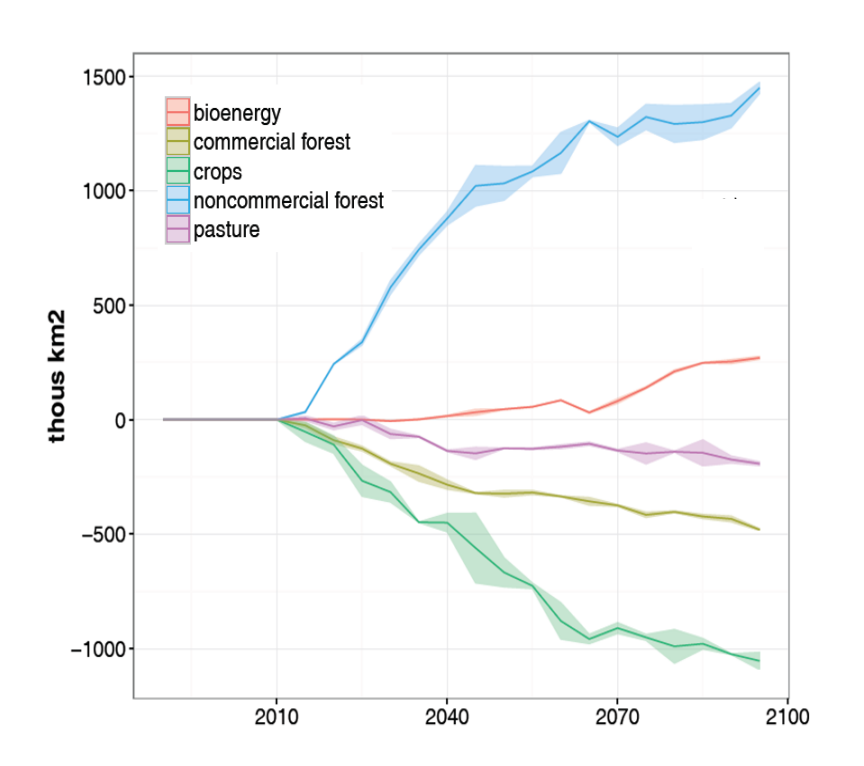


Carbon Cycle: Motivation

Change in Productivity from CLM in RCP4.5



Change in Land Cover in GCAM in RCP4.5



Source: Thornton et al. (in review)

Carbon Cycle: Motivation

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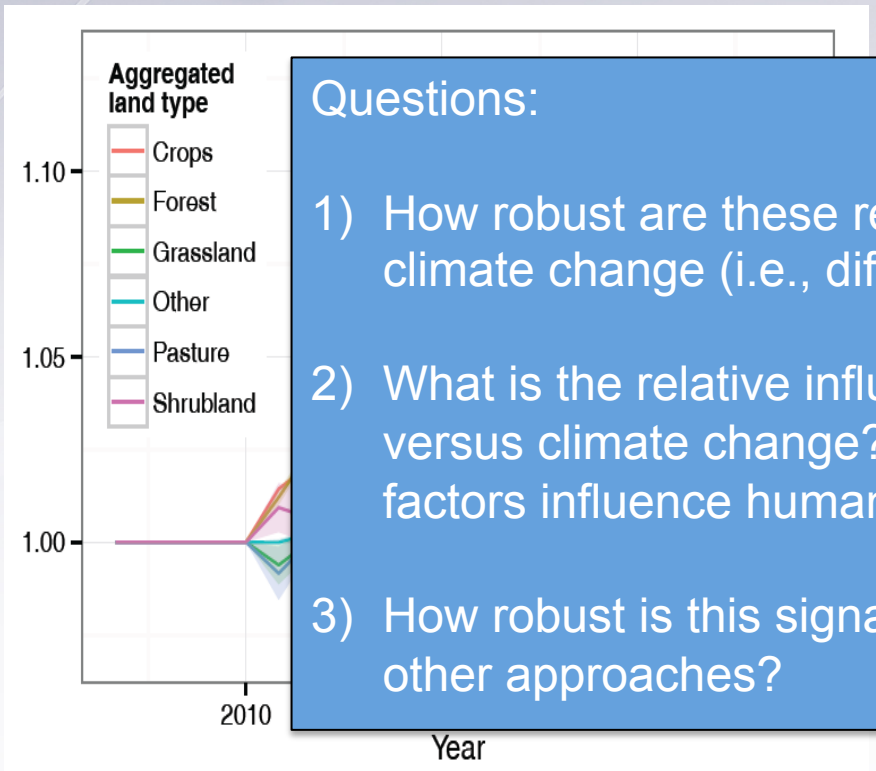

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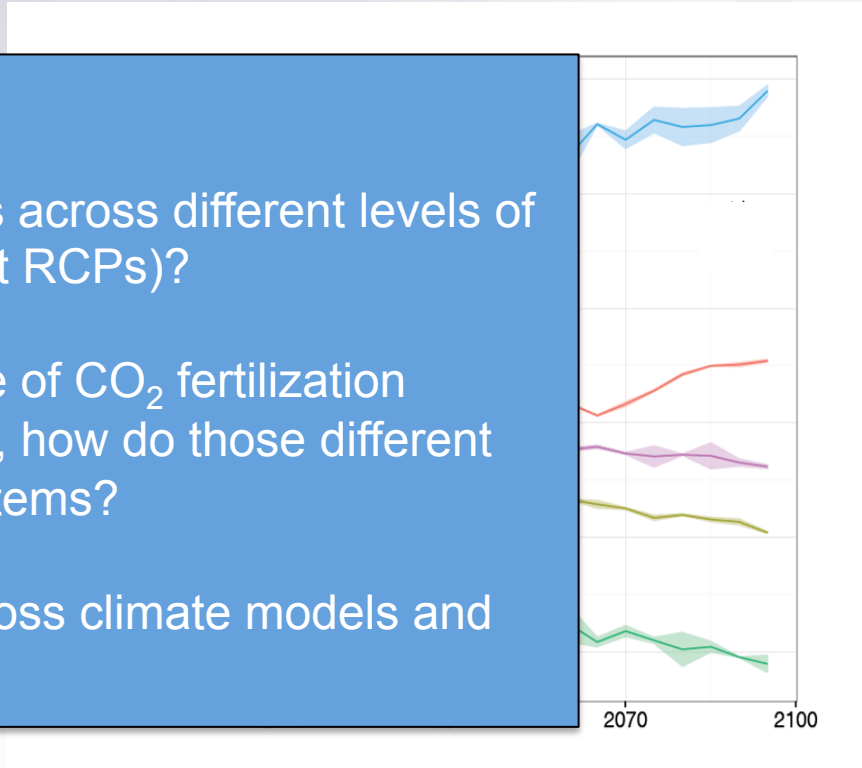

Questions:

1) How robust are these results across different levels of climate change (i.e., different RCPs)?

2) What is the relative influence of CO_2 fertilization versus climate change? And, how do those different factors influence human systems?

3) How robust is this signal across climate models and other approaches?

Source: Thornton et al. (in review)

Carbon Cycle: Preliminary Results

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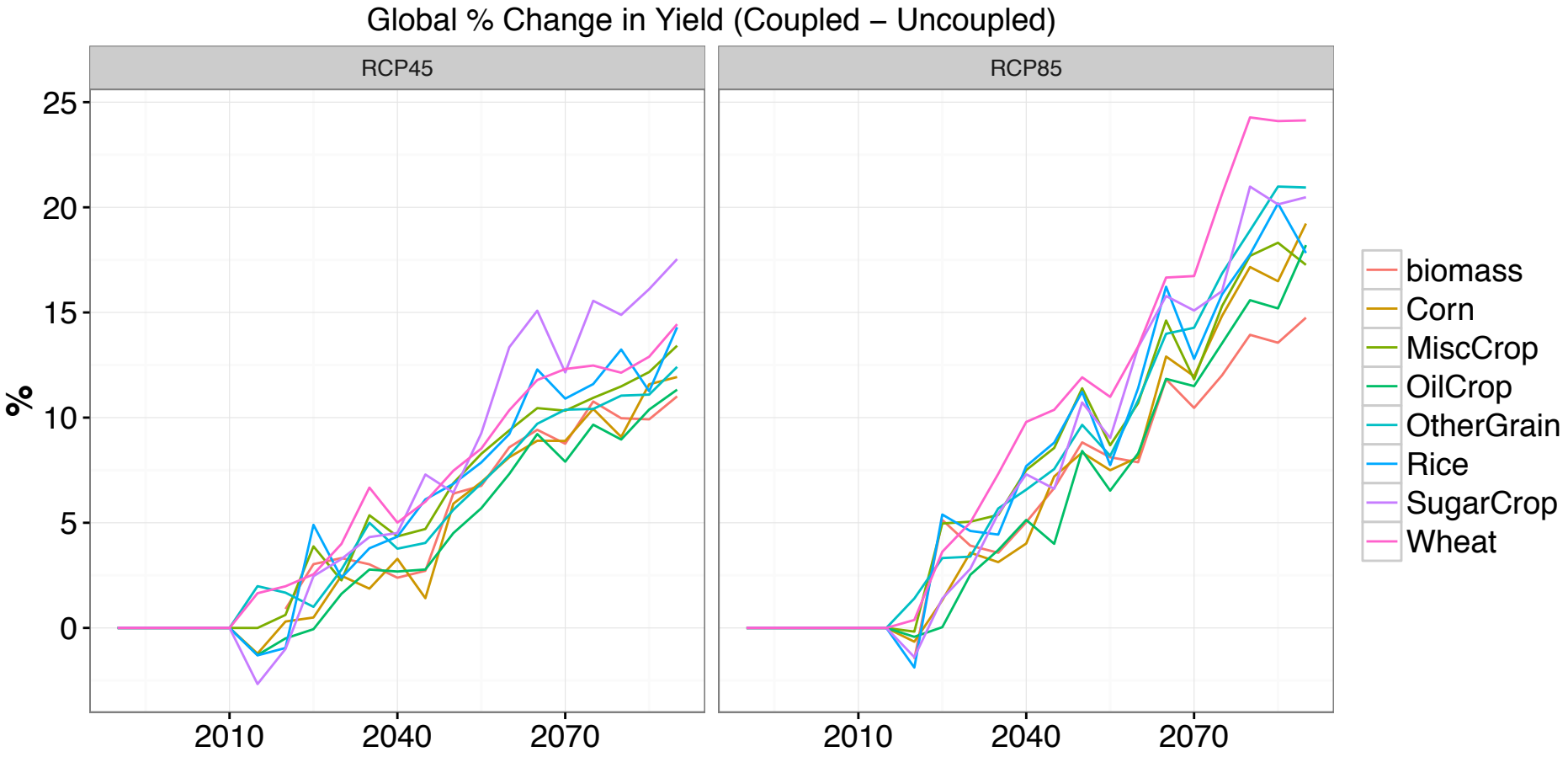

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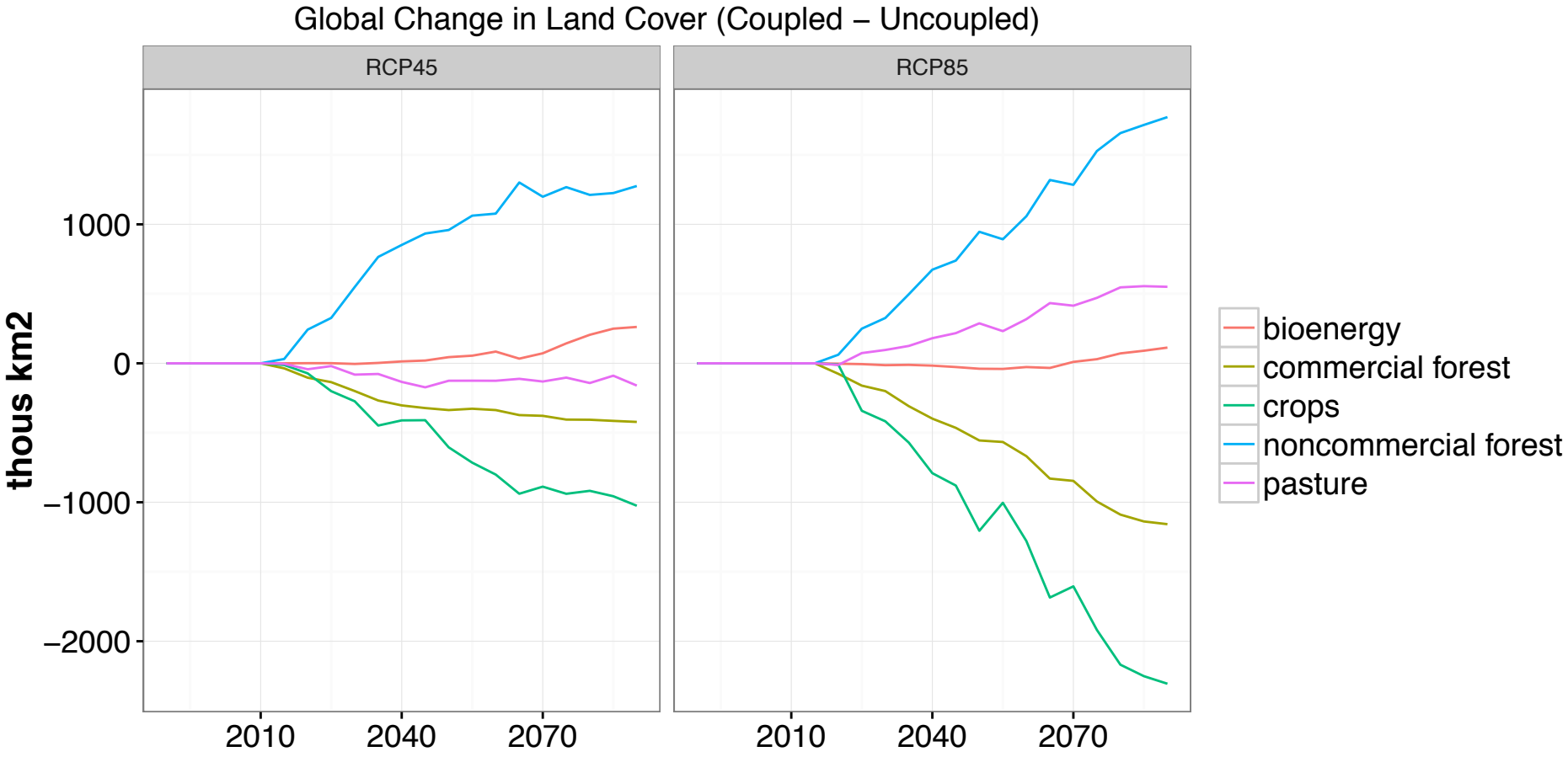

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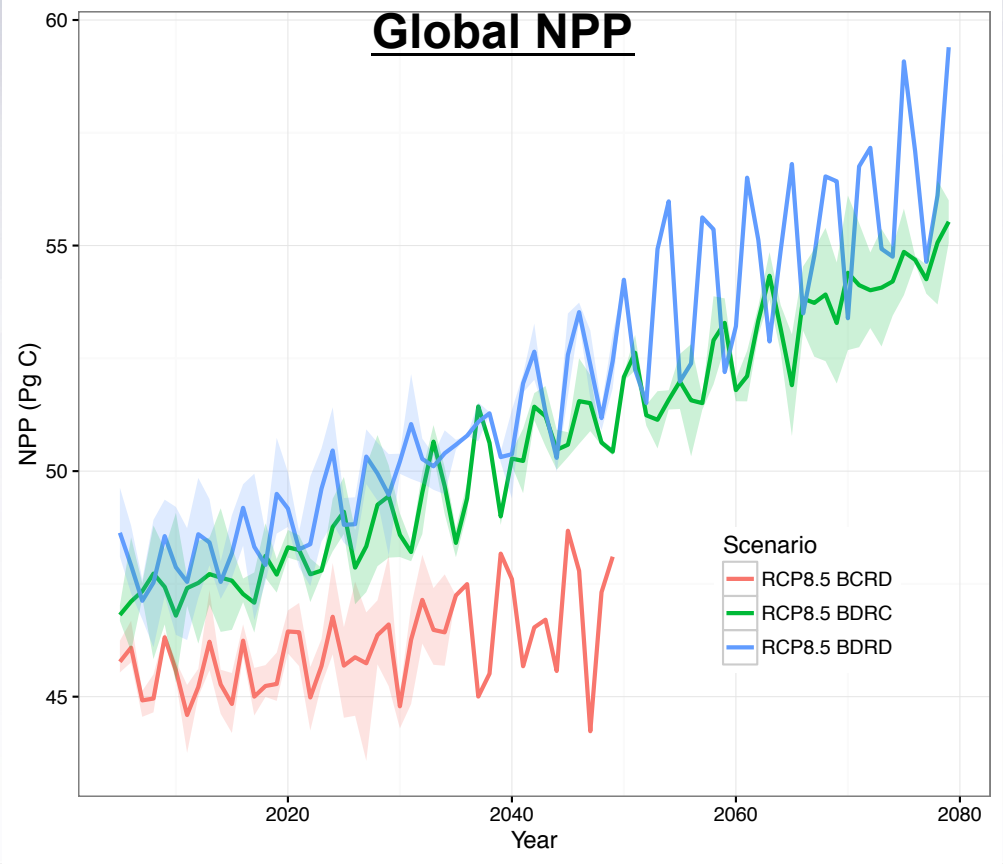

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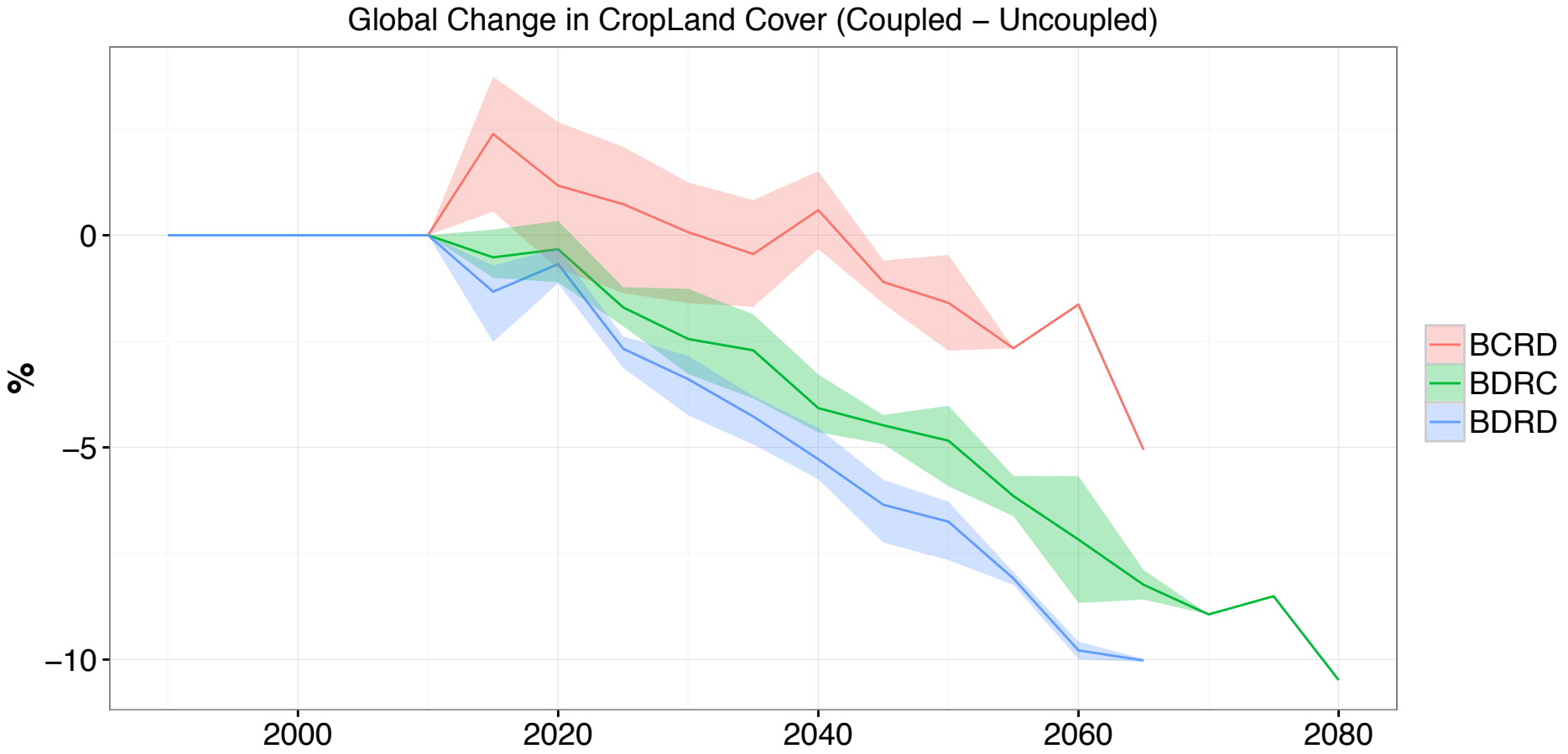

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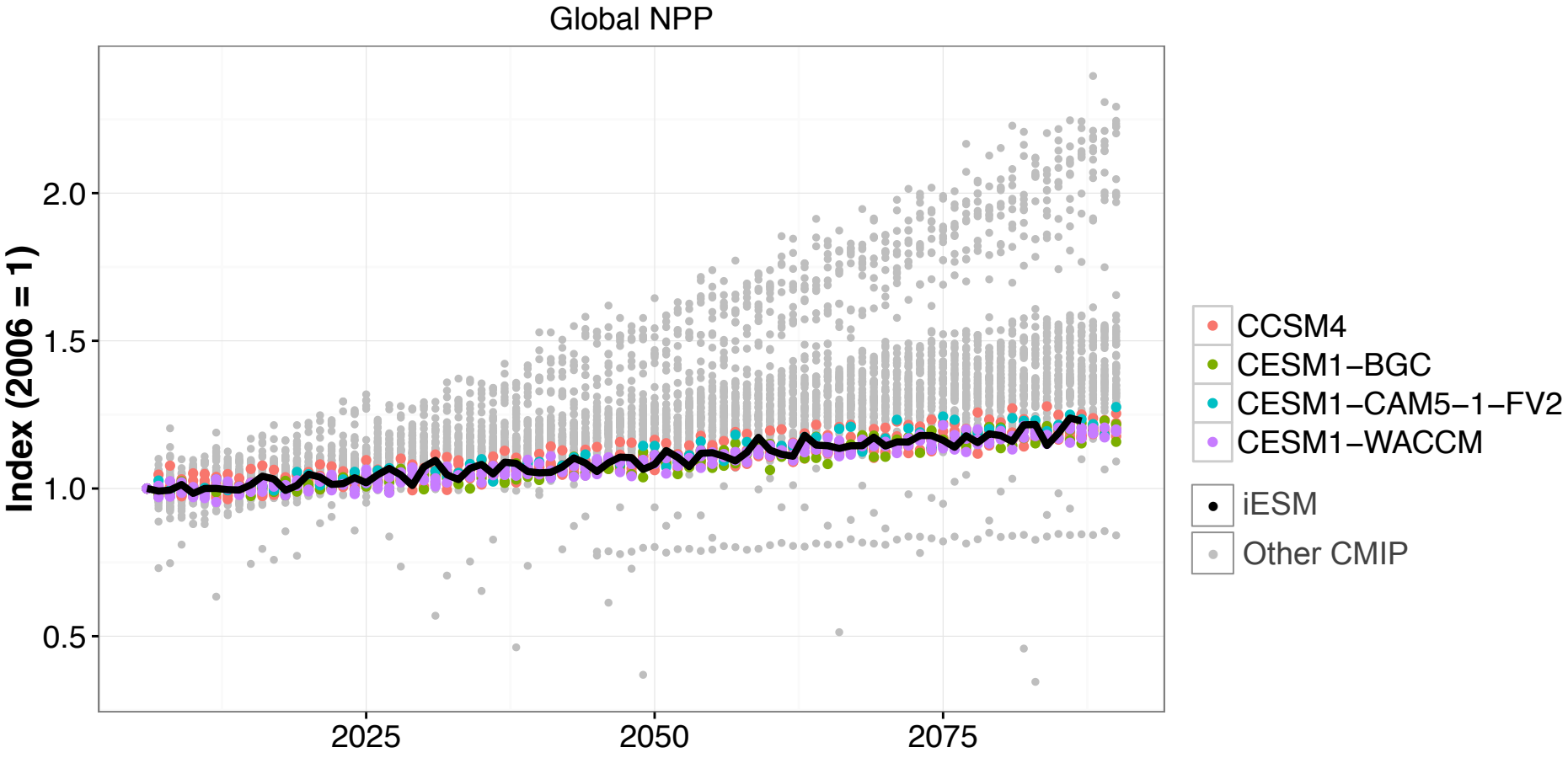

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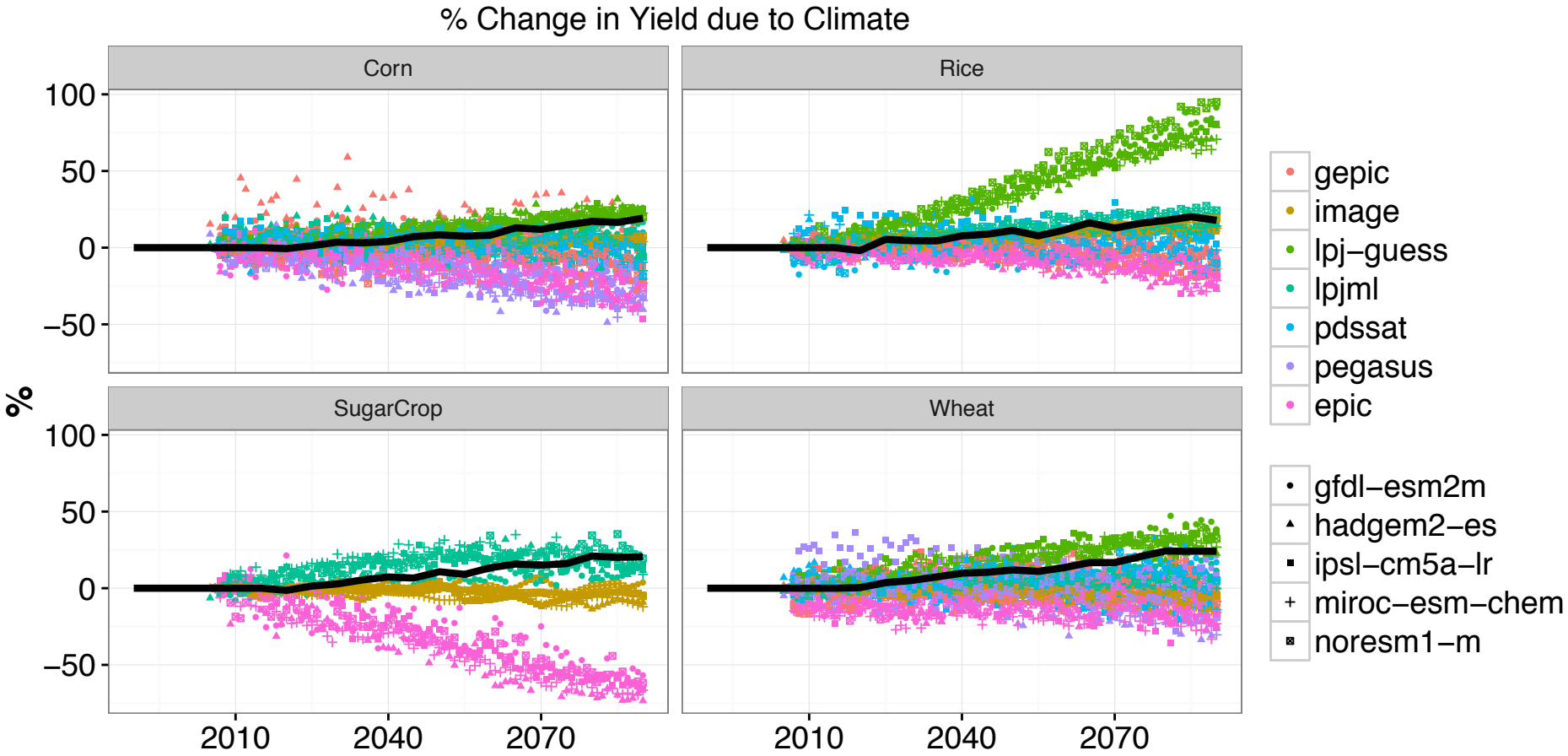

AgMIP Source: Rosensweig et al. (2014)

Carbon Cycle: Preliminary Results

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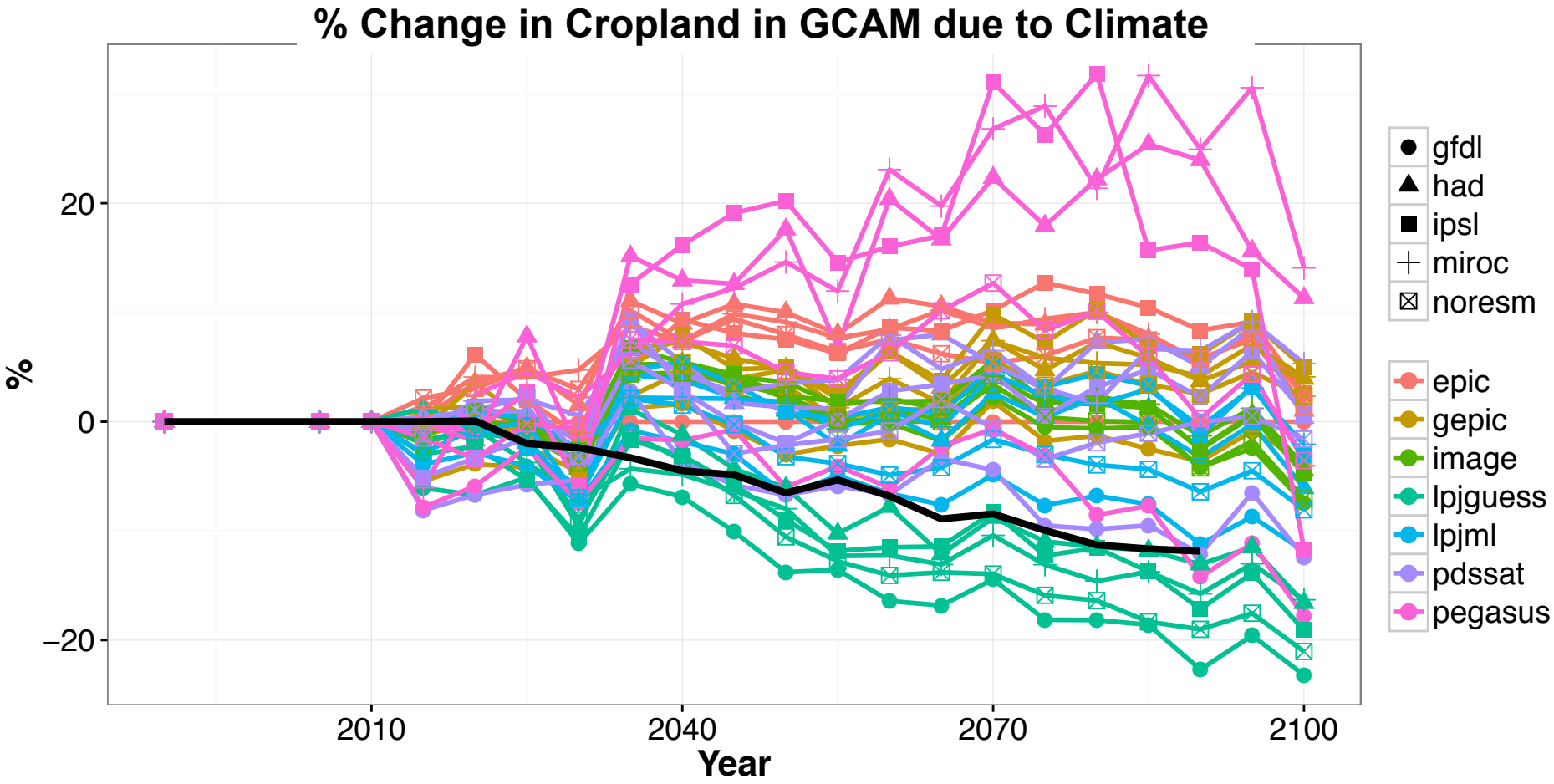
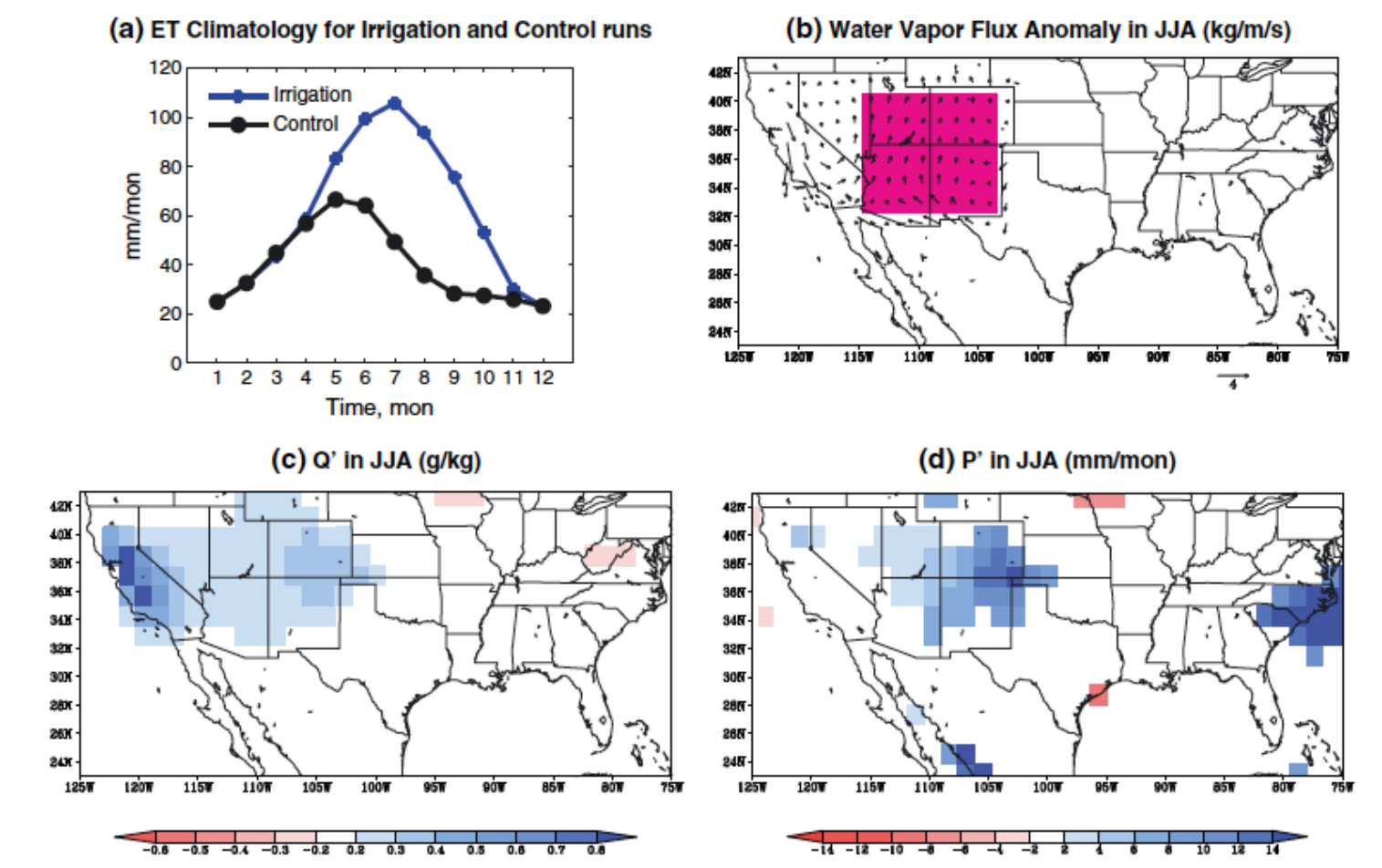


Water: Motivation



- Irrigation in Central Valley has large influence on surface evapotranspiration with statistically significant remote effects on North American monsoon rainfall

(Lo et al. 2013 GRL)

Water: Preliminary Results

- Enhance representation of irrigation in ALM
  - Irrigation amount is calibrated against FAO census data
  - Both surface and groundwater irrigation source constrained by FAO census data
  - Different irrigation methods adopted

Sprinkler irrigation: water is applied uniformly as precipitation

Flood irrigation: water is applied to the root zone in 30 minutes

Drip irrigation: Water required is immediately transpired rather than added to the soil column

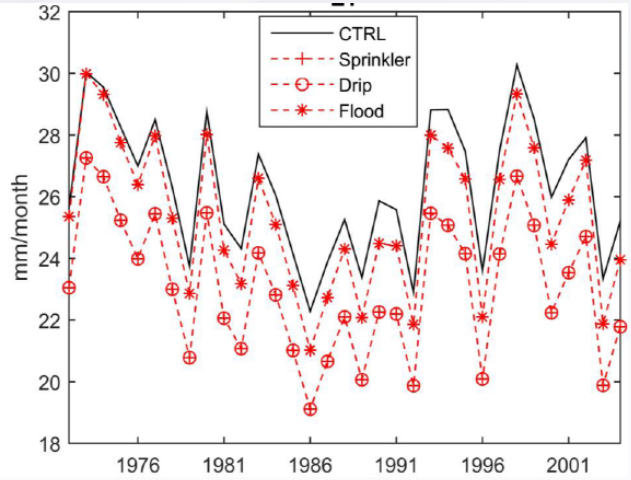
Water: Preliminary Results

- Numerical experiments with offline ALM

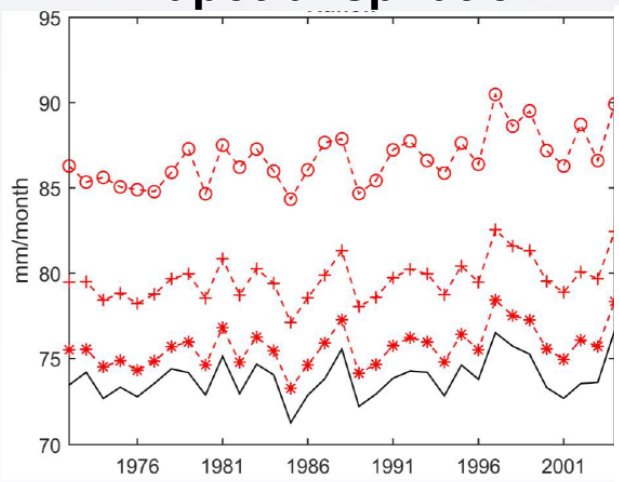
Name	Climate dataset [simulation period]	Irrigation	Calibrated	Pumping
CTRL	Qian Data (1972-2004)	no	---	---
IRRIG		yes	Yes	no
PUMP		yes	Yes	Yes
Drip		yes	Yes	Yes
Flood		yes	Yes	Yes
Sprinkler		yes	Yes	Yes

- Irrigation increases ET and reduces runoff and groundwater storage
- Irrigation effects on ET are largely dependent on the irrigation methods

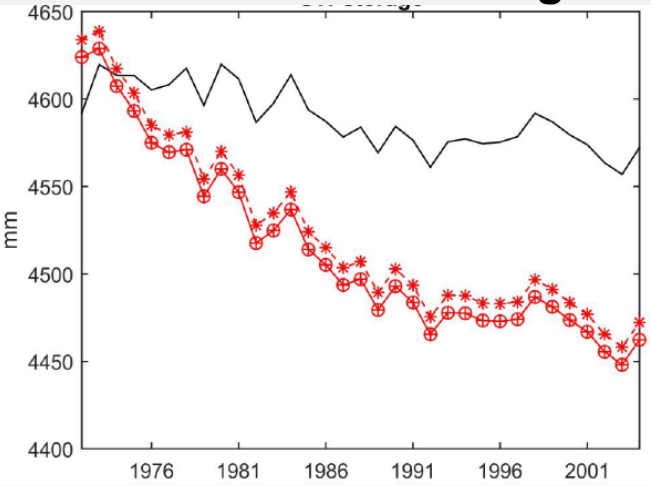
Runoff



Evapotranspiration



Groundwater storage



Scenarios: Background

- CMIP includes future scenario experiments, designed to address various science questions of interest to the international community
  - GCAM has provided scenarios to CMIP (e.g., RCP4.5 in CMIP5, SSP4 in CMIP6)

- Objective:
  - Identify science questions of interest to ACME or the U.S.
  - Describe how scenarios can help answer those questions

Scenarios: Emerging Themes

Scenarios: Emerging Themes

Carbon Cycle

Scenarios: Emerging Themes

Forests

Carbon Cycle

Scenarios: Emerging Themes

Forests

Carbon Cycle

Disturbances

Scenarios: Emerging Themes

Forests

Carbon Cycle

Water Cycle

Disturbances

Scenarios: Emerging Themes

Forests

Carbon Cycle

Water Cycle

Disturbances

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Scenarios: Emerging Themes

Bioenergy

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Scenarios: Emerging Themes

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Carbon Cycle

Water Cycle

Disturbances

Sea Level Rise

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Scenarios: Emerging Themes

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Scenarios: Emerging Themes

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Water Cycle

Disturbances

Air Quality

Sea Level Rise

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Scenarios: Emerging Themes

Methane

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Bioenergy

Renewable Energy

Extremes

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Mitigation

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Bioenergy

Renewable Energy

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Water Cycle

Disturbances

Air Quality

Sea Level Rise

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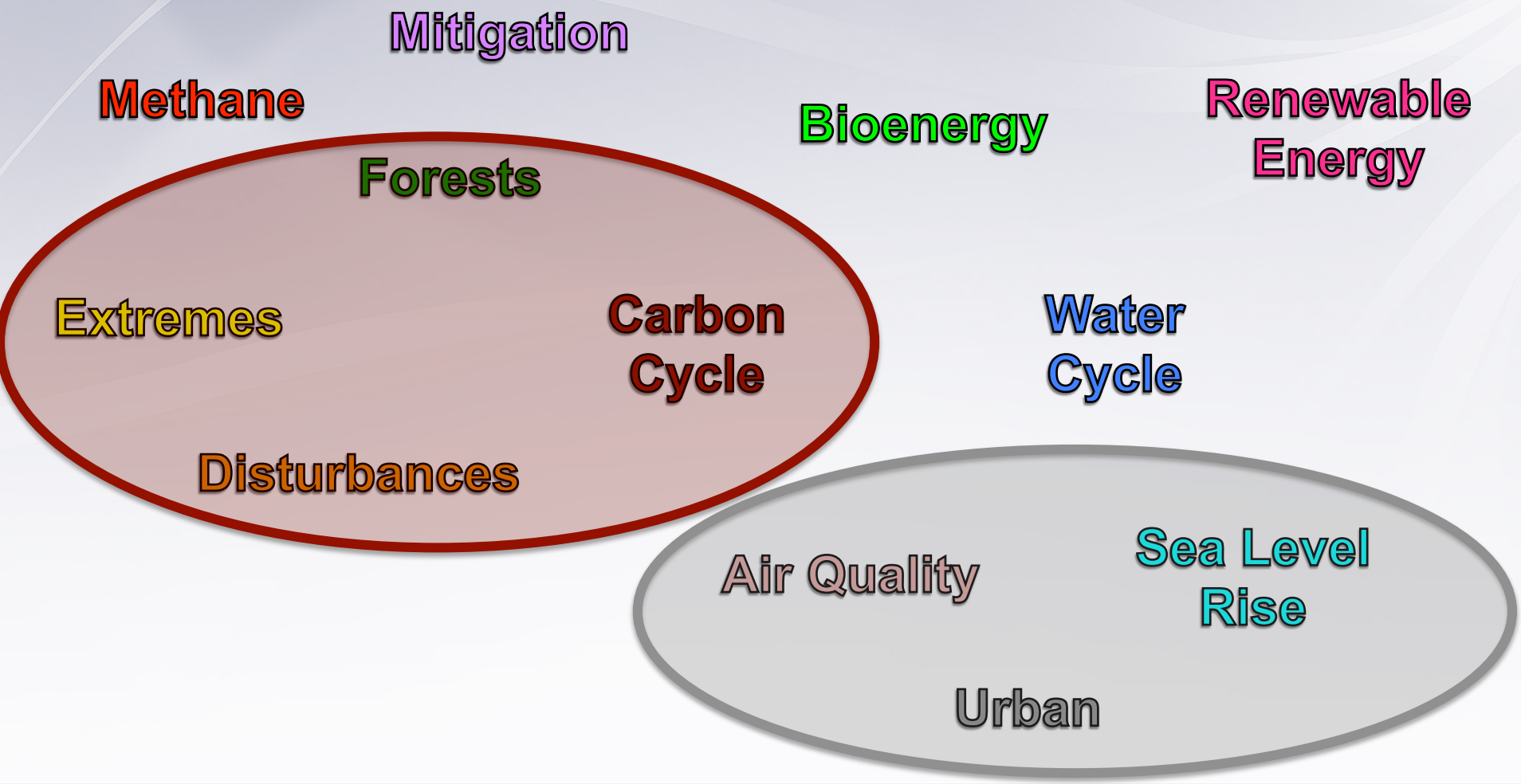

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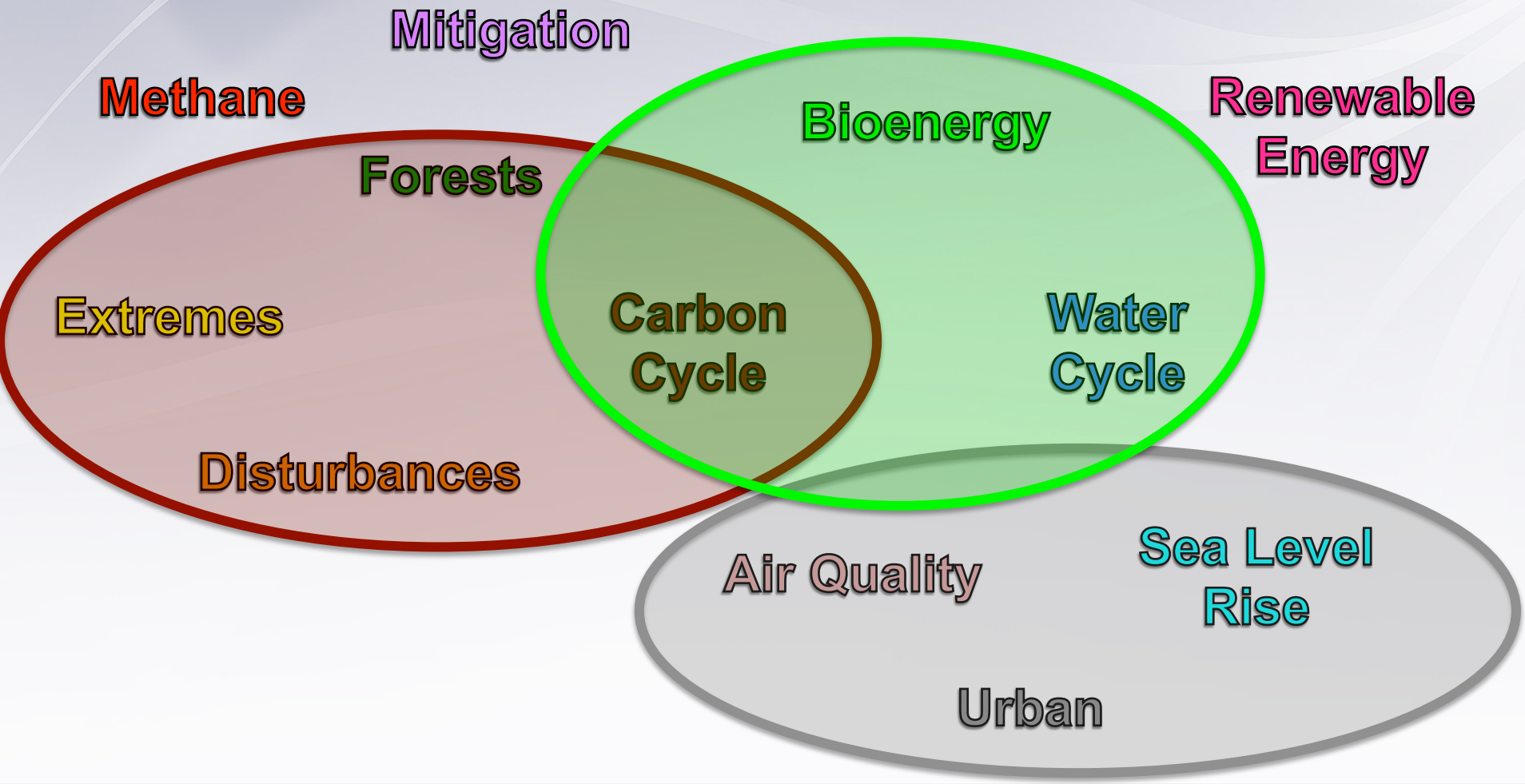

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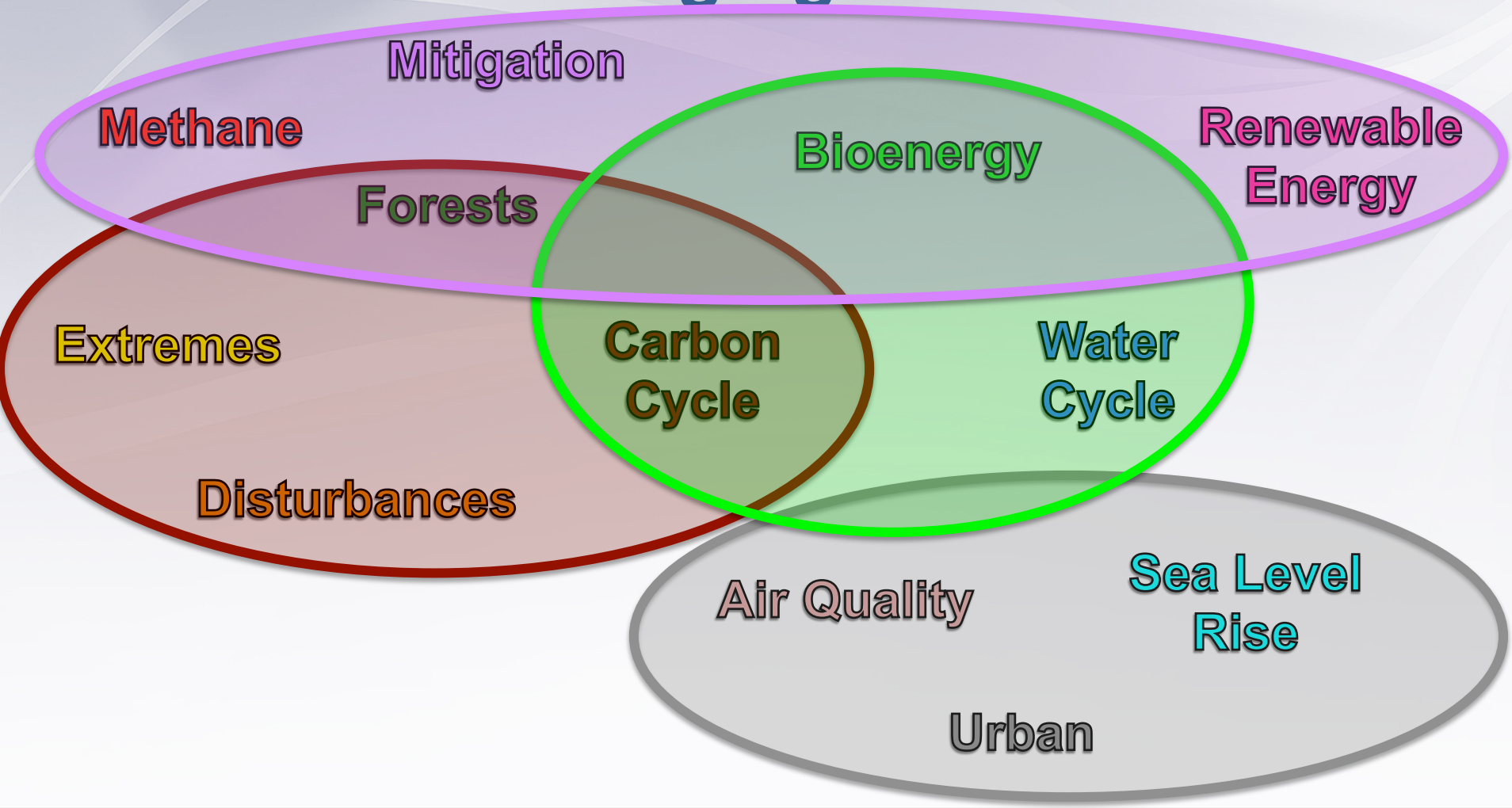


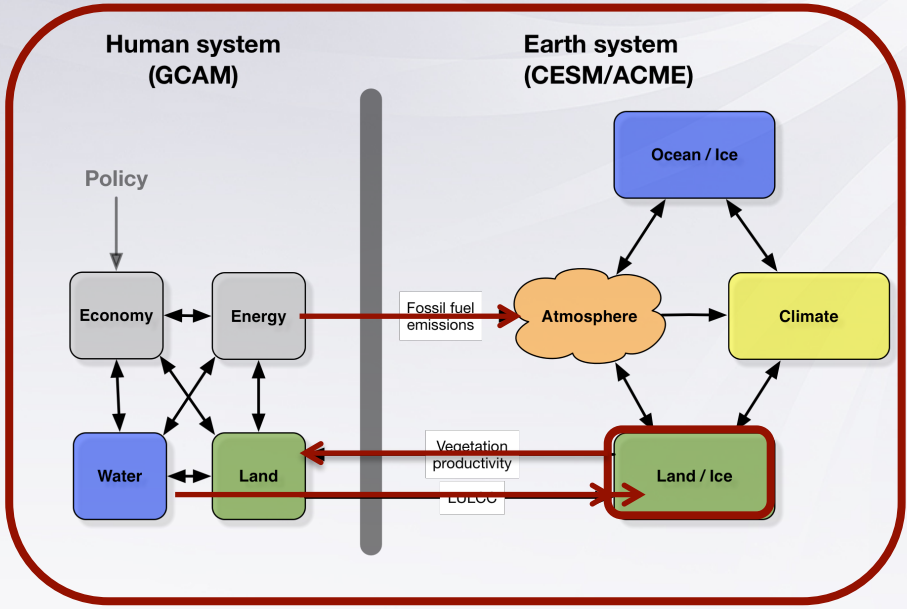
Scenarios: Synthesis

- Emerging themes:
  - Urban, including air pollution and coastal inundation
  - Carbon cycle and land under contrasting pathways
  - Water, including constraints on energy
  - Energy-climate interactions

- Other considerations:
  - Links to CMIP6
  - Uncertainty characterization
  - Overshoot

Summary

- Model Developments:
  - Crop modeling, water management, LULCC
- Experiments:
  - Carbon Cycle: Decomposing CO_2 & Climate
  - Water Cycle: Exploring the effects of irrigation
- Other Activities:
  - Scenario White Paper
  - IA-IAV-ESM Workshop



Future Plans

Model Developments

- High Priorities:
  - Moving the coupling code from CESM1.1 to ACME
  - Updating to the most recent GCAM

- Future Model Development Options:
  - Improving translation of LULCC from GCAM to ACME
  - Expanding the coupling to new variables

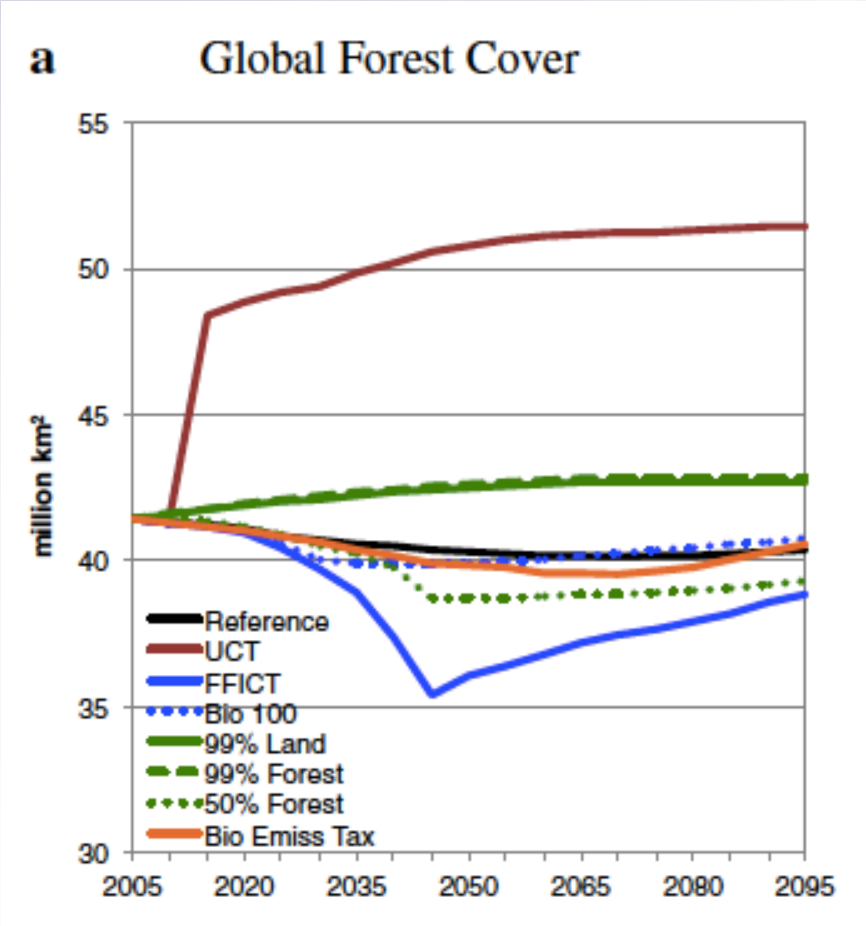
Experiments

- Highest Priority:
  - Completing the two ongoing experiments

- Other Options:
  - Implications of land-based mitigation options
  - Expanding the water experiment to include feedbacks to the human system
  - Simultaneously considering water & carbon limits on human systems
  - Implementing scenarios from either CMIP6 or the ACME Workshop

Experiment: Land-Based Mitigation

- Motivation:
  - Land Use, Land Cover Change can have significant implications for climate.
  - IAMs rely heavily on bioenergy and afforestation as mitigation strategies, but these analyses typically ignore biogeophysical effects and exclude climate impacts.
- Science Questions:
  - What are the effects of land-based mitigation on climate?
  - How will the inclusion of climate feedbacks alter the potential for land-based mitigation options?



Source: Calvin et al. (2014)

Scoping Activities

- Exploring when, what, and how to couple human-Earth systems:
  - Workshop: July 25-29, 2016 in Snowmass, CO
  - Experiments:
    - Identify which human systems are most sensitive to climate and vice versa
    - Explore implications of different coupling methodologies
    - Hindcast experiments that systematically incorporate feedbacks

Summary

- Model Developments:
  - Updating coupling to use ACME and more recent GCAM versions
  - Enhancing the coupling
- Experiments:
  - Land-based mitigation
  - Two-way water feedbacks
  - Water + Carbon
  - Scenarios
- Other Activities:
  - Workshop
  - Scoping Experiment