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Implications for agriculture of +1.5° and +2.0°C global warming

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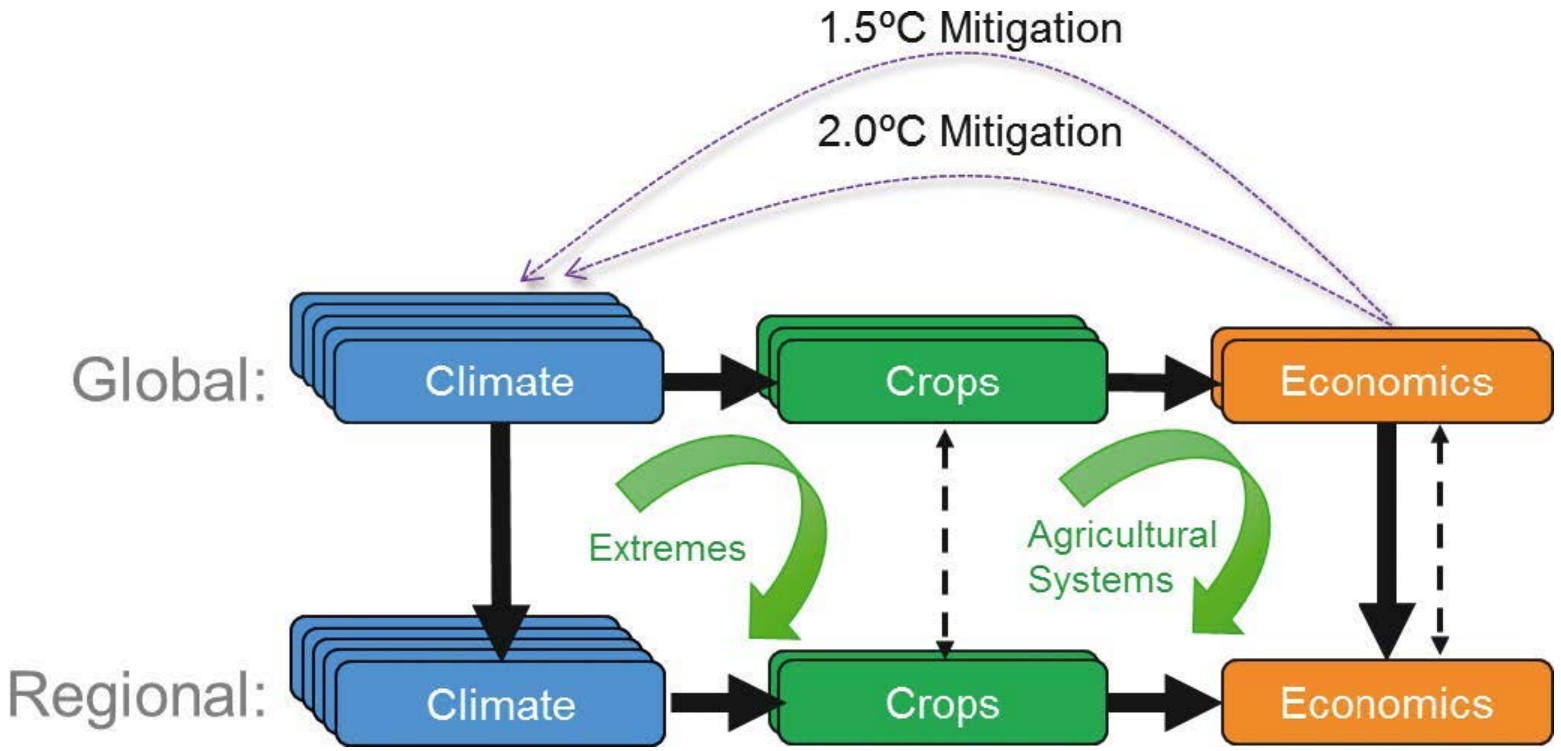
Outline

- Modeling framework
  - 5 climate models
  - 3 crop models
  - 2 global economic models (IMPACT and FARM)
- Scenario Framework
- Economic responses
  - Climate impacts and adaptation
  - Large-scale biomass demand
- Contributions to uncertainty in crop yield
- Conclusions and modeling challenges

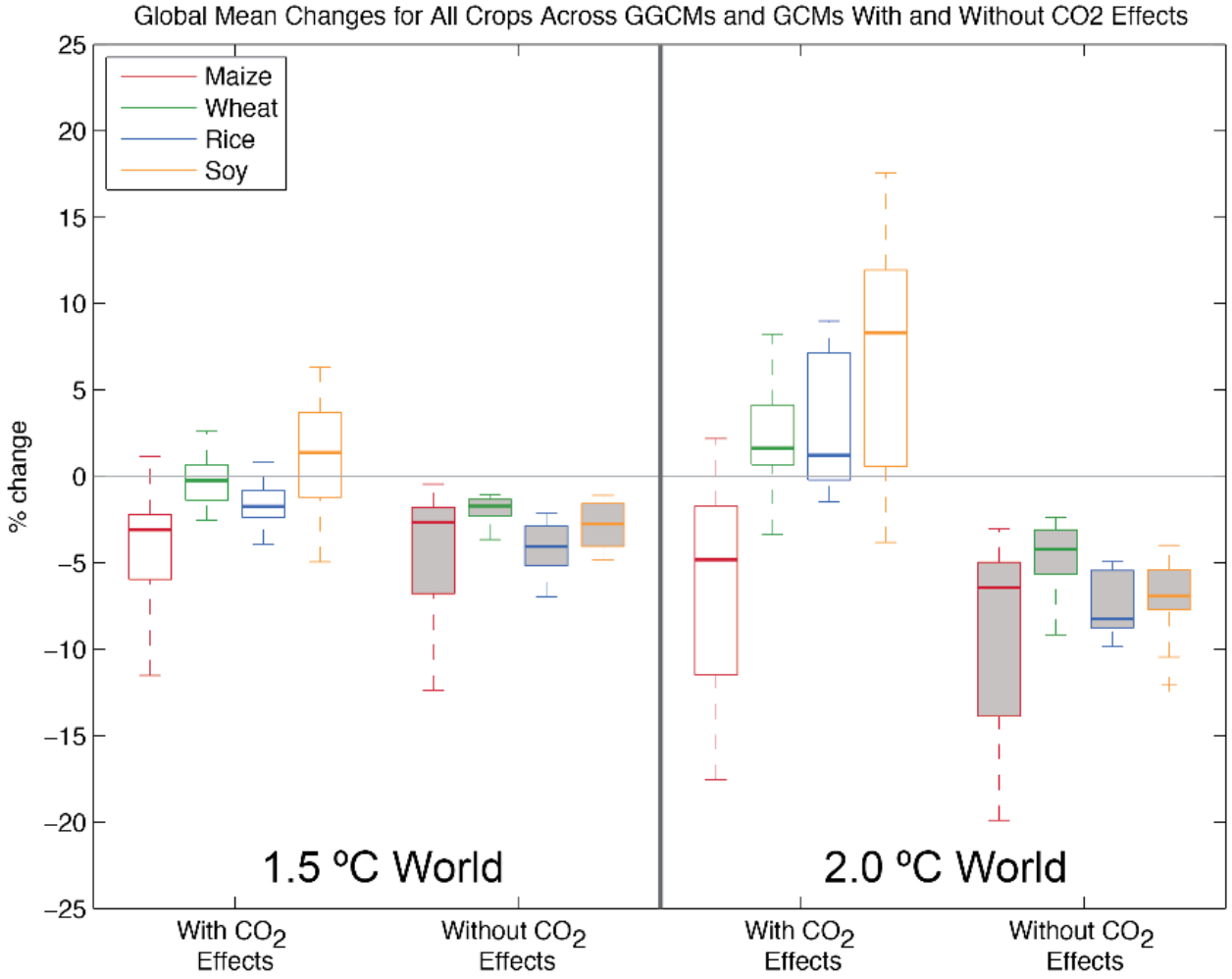
AgMIP*
Coordinated Global and Regional Assessments



*Agricultural Model Intercomparison and Improvement Project (AgMIP)

Scenarios for climate and crop models

- The following slide displays global average variation in yield across crops, CO_2 effect, degree of warming, climate models and crops models
- Four major field crops
  - Maize
  - Wheat
  - Rice
  - Soybeans
- Two CO_2 concentrations
  - With CO_2 effect (487 ppm)
  - Without CO_2 effect (390 ppm)
- Two worlds
  - World with +1.5°C warming
  - World with +2.0°C warming
- 15 data points within each box plot
  - 5 climate models
  - 3 crop models

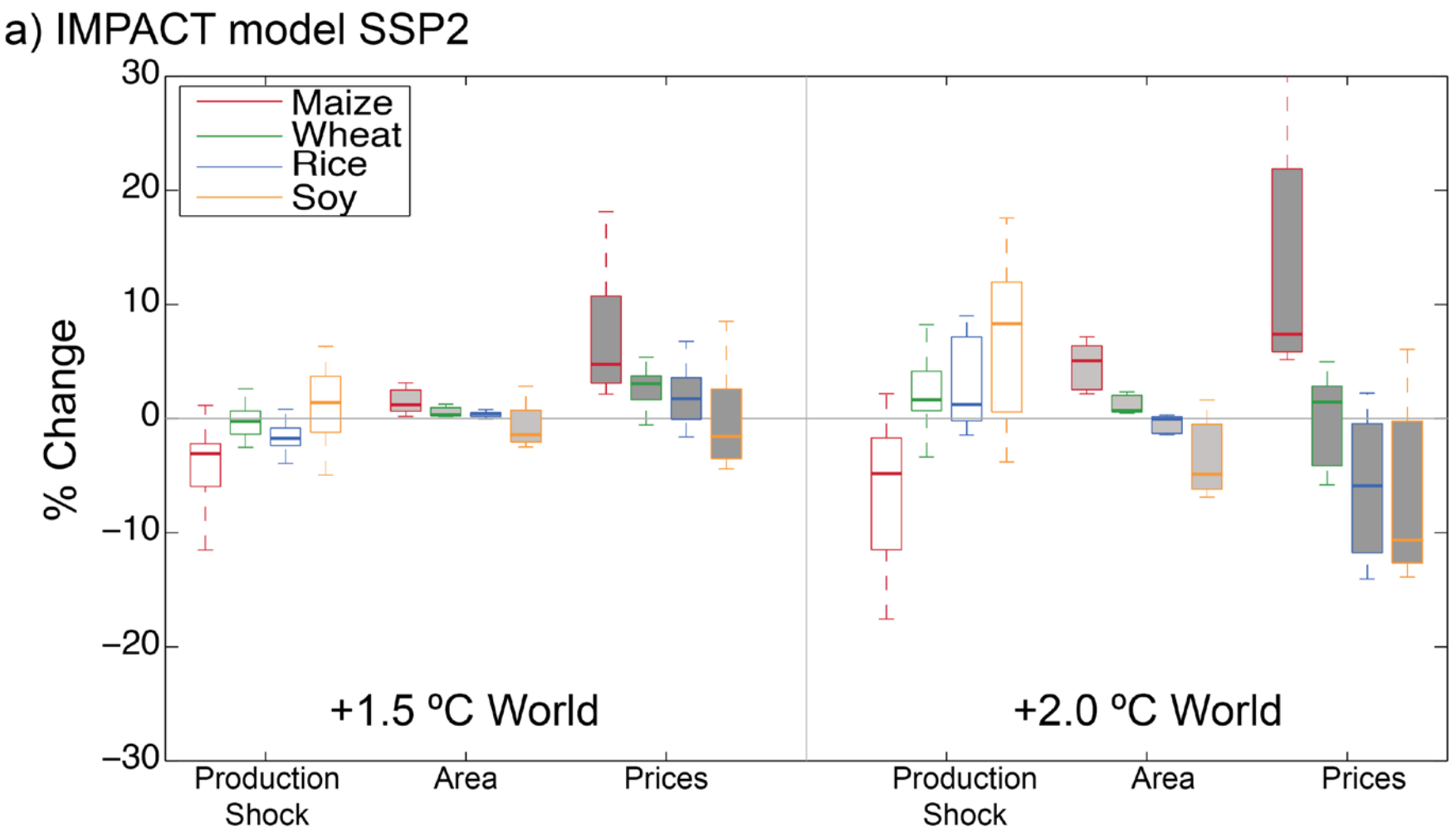


Source: Ruane et al. (2018) "Biophysical and economic implications for agriculture of +1.5° and +2.0°C global warming using AgMIP Coordinated Global and Regional Assessments," *Climate Research* 76: 17-39.

Economic Responses

- Two global economic models with 13 world regions
  - Future Agricultural Resources Model (FARM), USDA Economic Research Service
  - IMPACT, International Food Policy Research Institute
  - Simulation results for 2050
- Adaptation to climate change
  - Four crops (with CO_2 effect)
  - Percent change in area harvested (moves in opposite direction from production shock)
  - Percent change in price (also moves in opposite direction from production shock)
- Response to mitigation (large-scale biomass production)
  - At this level of warming, economic response to bioenergy demand dominates response to climate impacts
  - Cropland area declines and prices increase
  - Large increase in area for energy crops
  - Pasture area declines

Global economic model simulations (with CO_2 effect)



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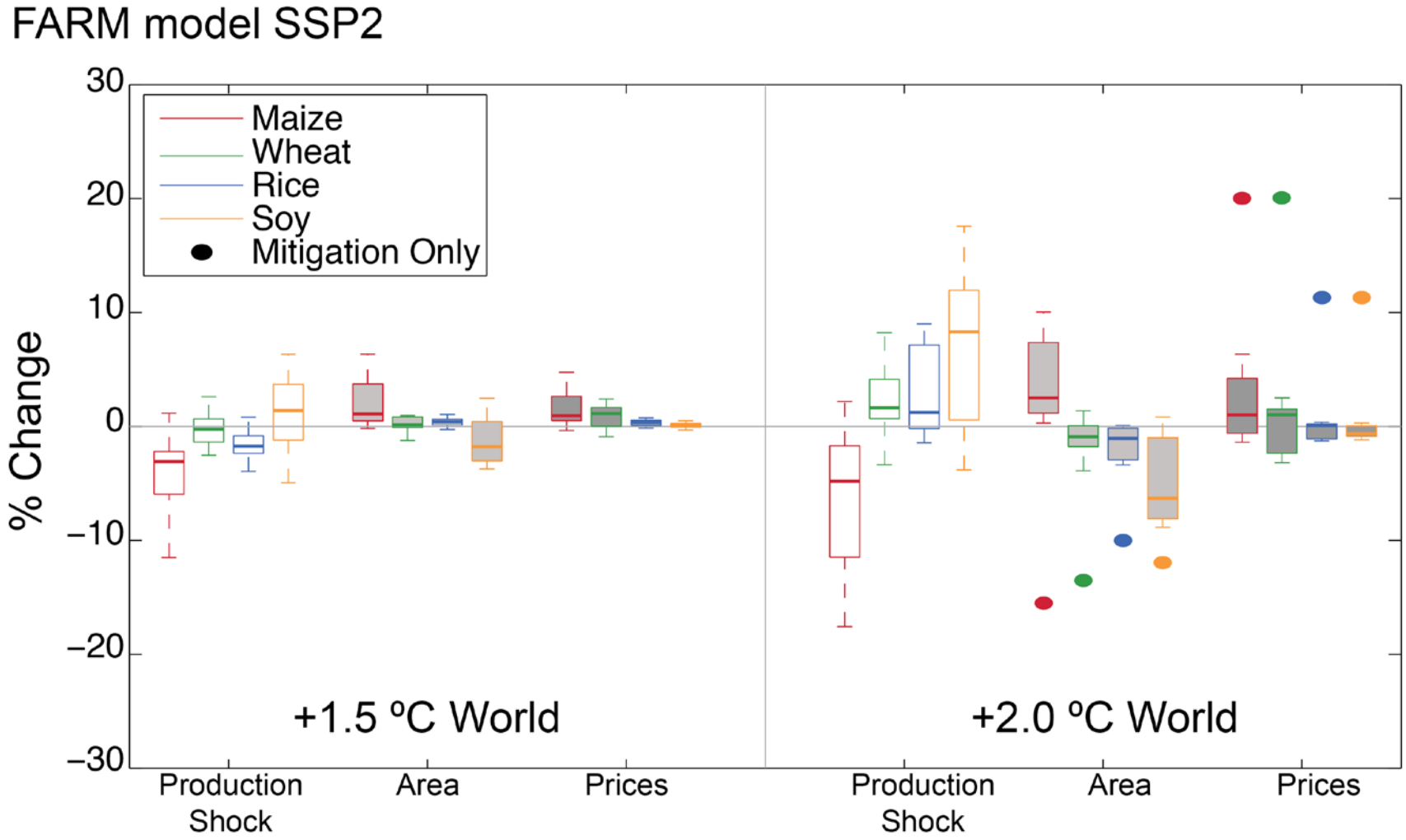
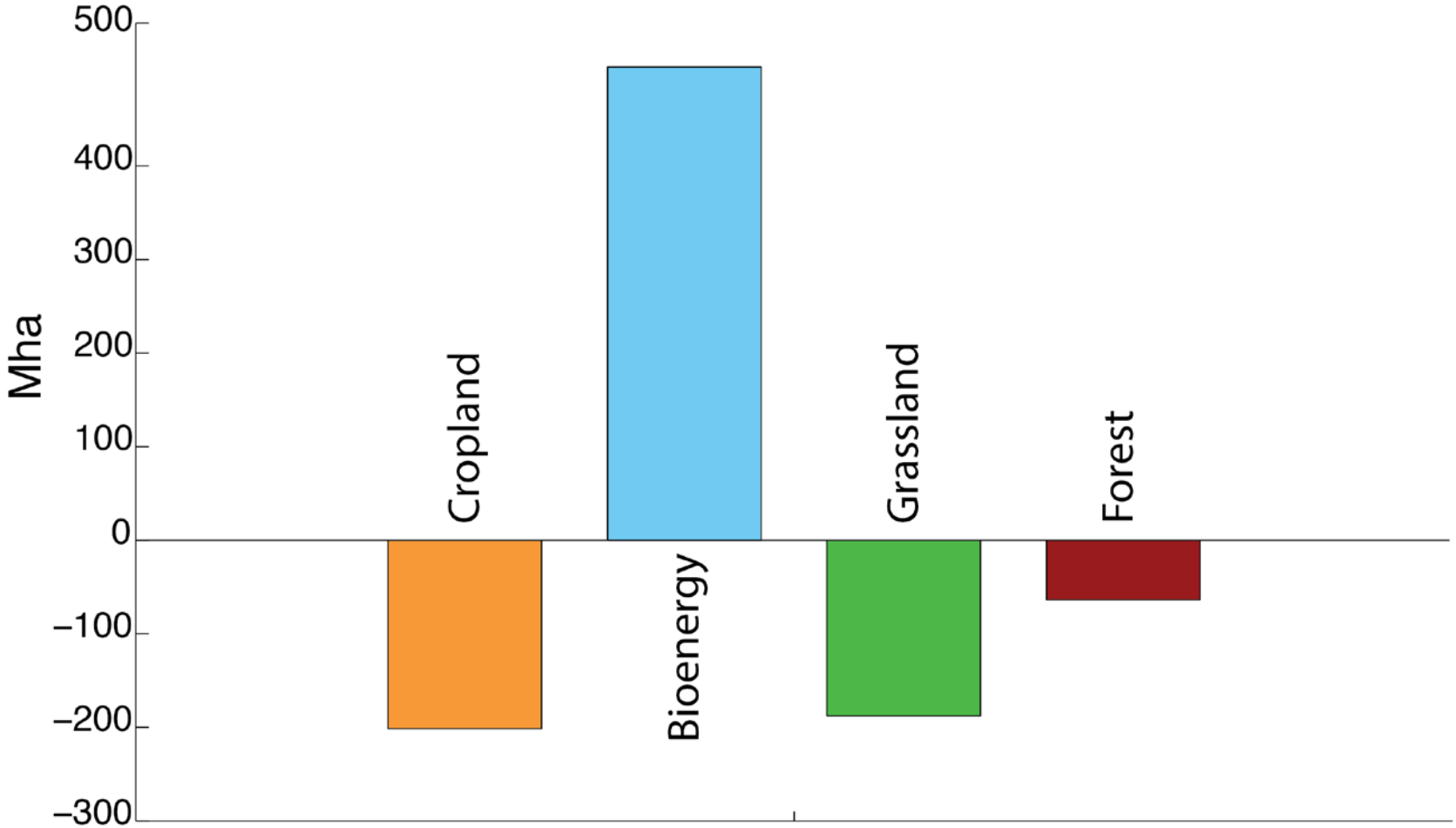
Global economic model simulations (with CO_2 effect)



Note: The mitigation scenario is run independently of climate impact scenarios

Source: Ruane et al. (2018) "Biophysical and economic implications for agriculture of +1.5° and +2.0°C global warming using AgMIP Coordinated Global and Regional Assessments," *Climate Research* 76: 17-39.

c) FARM model SSP2 with Mitigation - Land Use Changes



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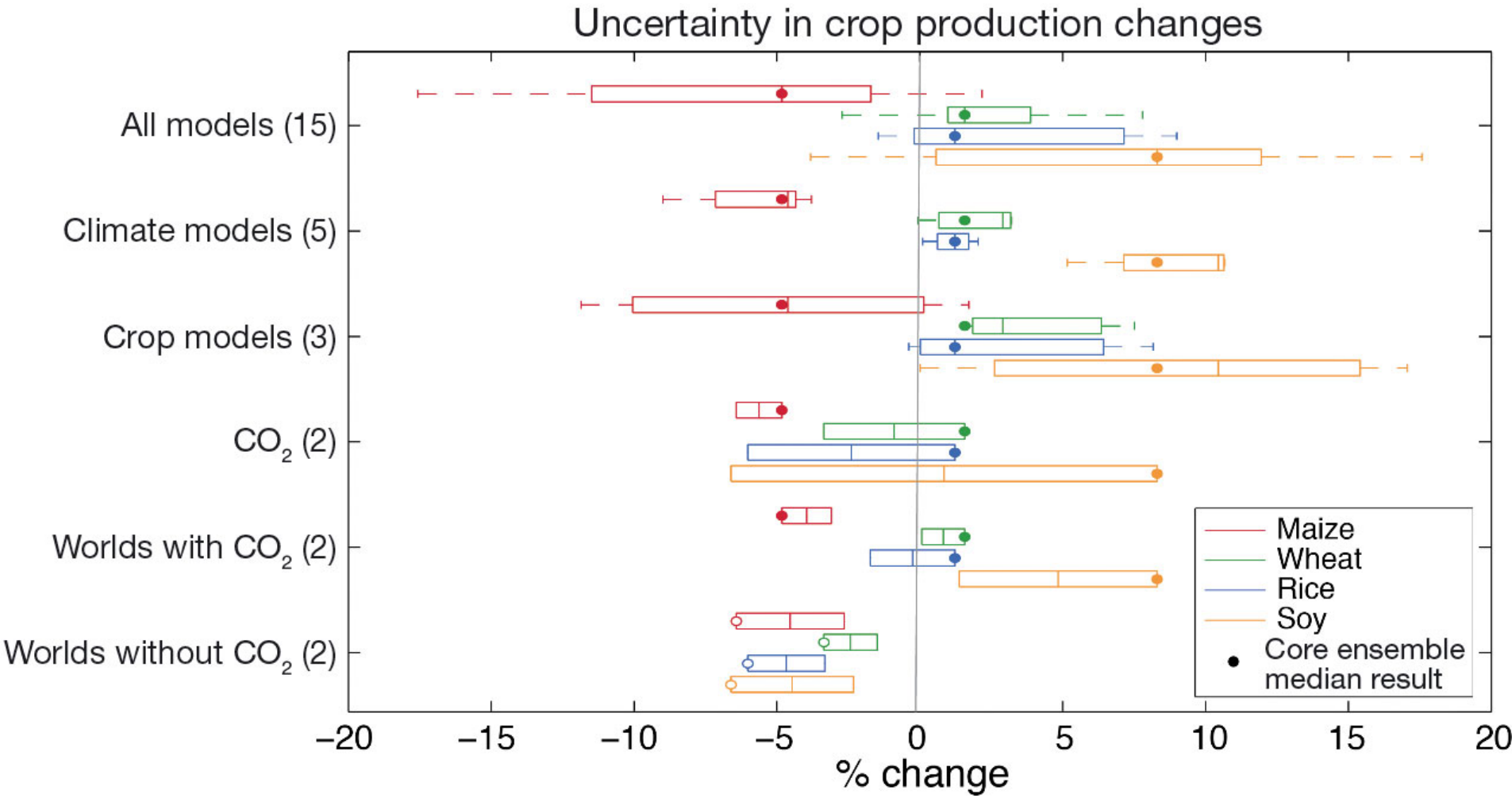
Contributions to Uncertainty

- Core scenarios (15)
  - Definition
    - 5 climate models x 3 crop models
    - Shared Socio-economic Pathway 2 (middle of road)
    - With CO_2 effect
    - World with +2.0°C warming
  - Variation across all models
  - Climate models only
  - Crop models only
- Other yield comparisons
  - With and without CO_2 effect (+2.0°C warming)
  - Amount of warming (+1.5°C and +2.0°C warming) with CO_2 effect
  - Amount of warming (+1.5°C and +2.0°C warming) without CO_2 effect



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Conclusions and Modeling Challenges

- Key results from models
  - Variation introduced by crop models is greater than variation across climate models
  - Change in crop yield is generally negative without CO_2 effect
  - At this level of climate stabilization (+1.5°C and +2.0°C), economic response to bioenergy demand dominates response to climate impacts
- Significance of agricultural productivity
  - Increasing demand for animal products with rising per-capita incomes
  - Land competition between energy crops and food crops for a growing population
  - Growing more food on less land in mitigation scenarios
- Realism of reference scenario
  - UN medium population projections for 2050 have increased from 9.3 billion to 9.8 billion people
  - Consider alternative reference scenarios based on Shared Socio-economic Pathways (SSPs)
- Realism of electricity generation for mitigation scenarios
  - Highly stylized in most global models
  - Improve representation of bio-electricity relative to wind and solar
  - Introduce electricity storage over day-types and seasons