



The Integrating Human-Earth System Dynamics (IHESD) SFA

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On behalf of the IHESD Team

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The IHESD TEAM

IHESD LEADERSHIP TEAM



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2 post-doctoral associates & 9 post-graduate researchers are being sponsored by this SFA

IHESD COLLABORATORS



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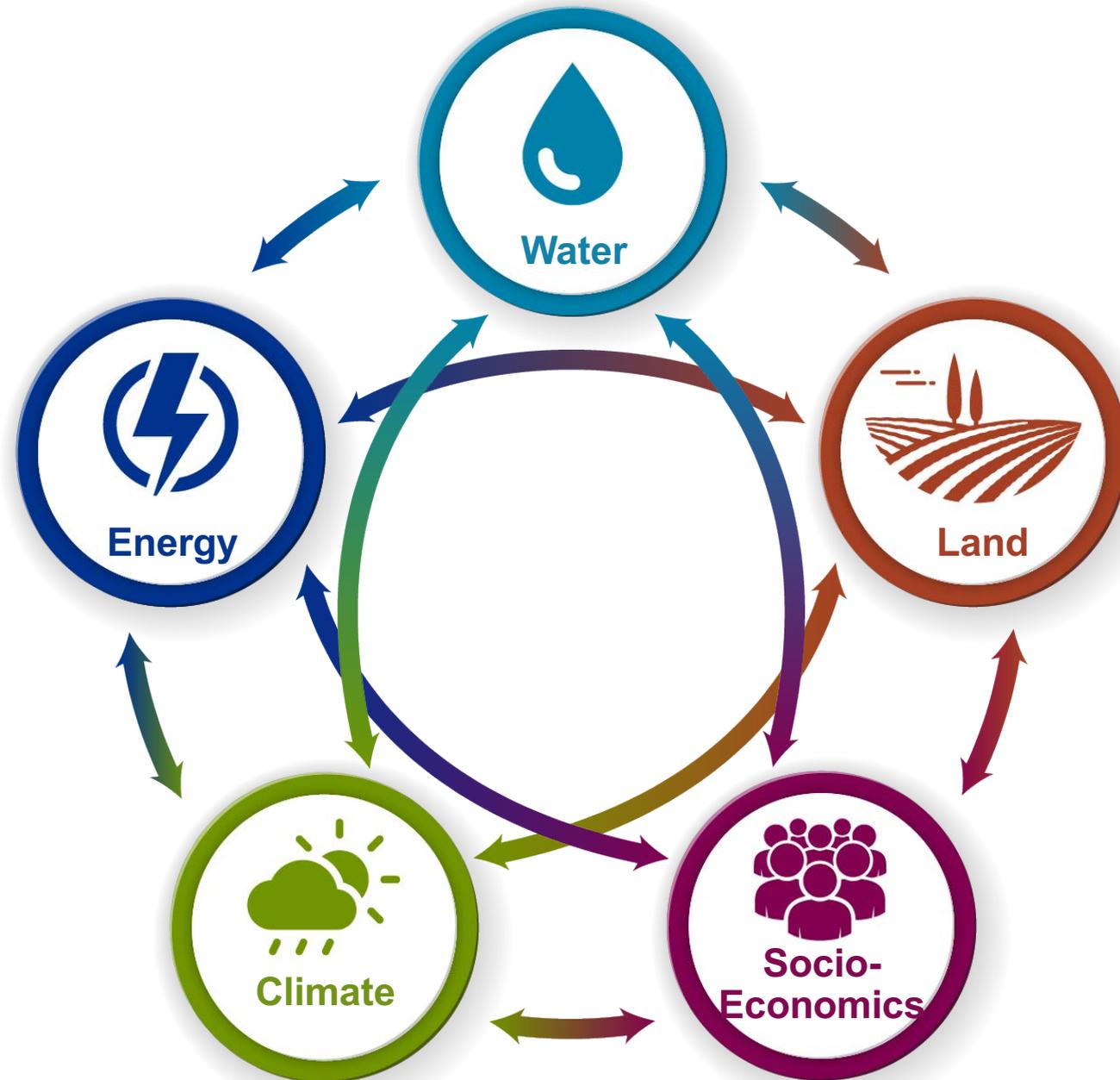
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Yuyu Zhou (ISU)

Public Policy	Ecology	Earth & International Affairs	Public & International Affairs	Marine & Atmospheric Chemistry
Environmental Physics	Mathematics & Computer Science	Astronomy	Hydrology	Operations Research
Nuclear Engineering	Economics	Political Science	Physics	Env. Studies & Mathematics of Bio.

The iHESD SFA focuses on the complex interactions among multiple human & Earth systems



Science Question

1

*How will **climate variability and extreme events** interact with evolving human systems and alter long-term human system and human-Earth system dynamics?*

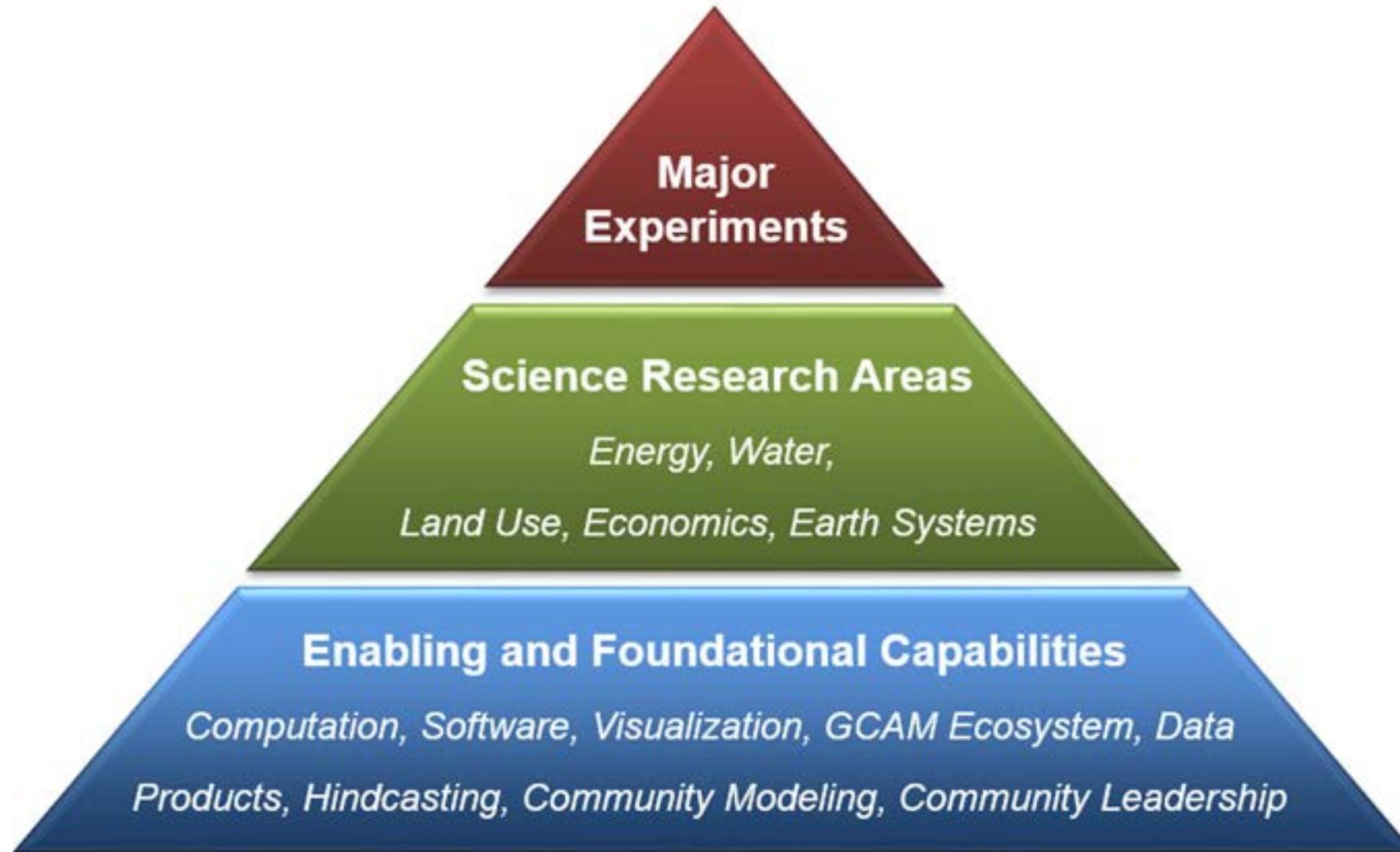
Science Question

2

*How does **uncertainty about economic decision-making** propagate through projections of land use, energy, and emissions?*

Calvin KV, P Patel, L Clarke, G Asrar, B Bond-Lamberty, RY Cui, A Di Vittorio, K Dorheim, J Edmonds, C Hartin, M Hejazi, R Horowitz, G Iyer, P Kyle, S Kim, R Link, H McJeon, SJ Smith, A Snyder, S Waldhoff, and M Wise. 2019. "GCAM v5.1: Representing the linkages between energy, water, land, climate, and economic systems." *Geoscientific Model Development* 12:677–698, <https://doi.org/10.5194/gmd-12-677-2019>.

The IHESD Science Plan



Main Experiments

- **Climate Variability and Extreme Events**

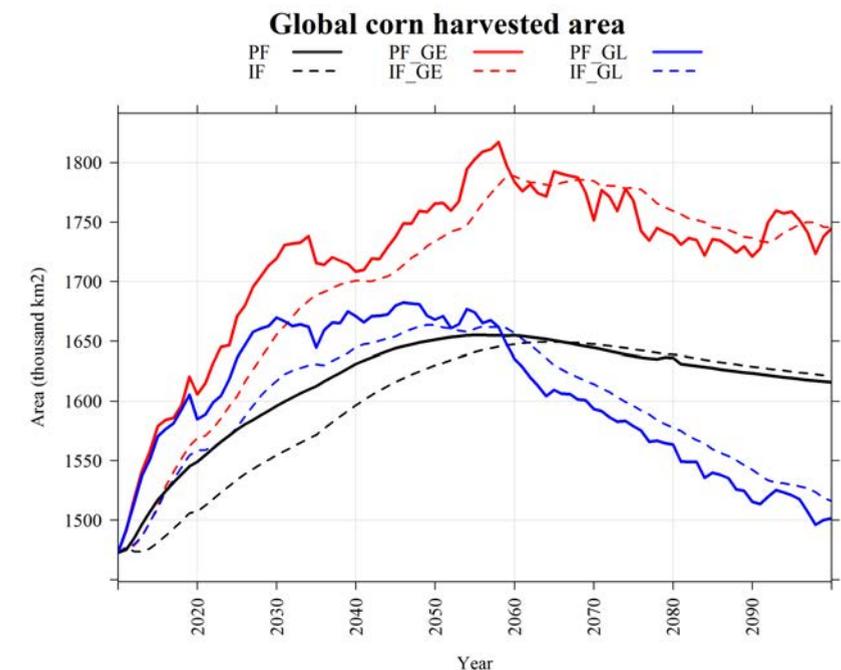
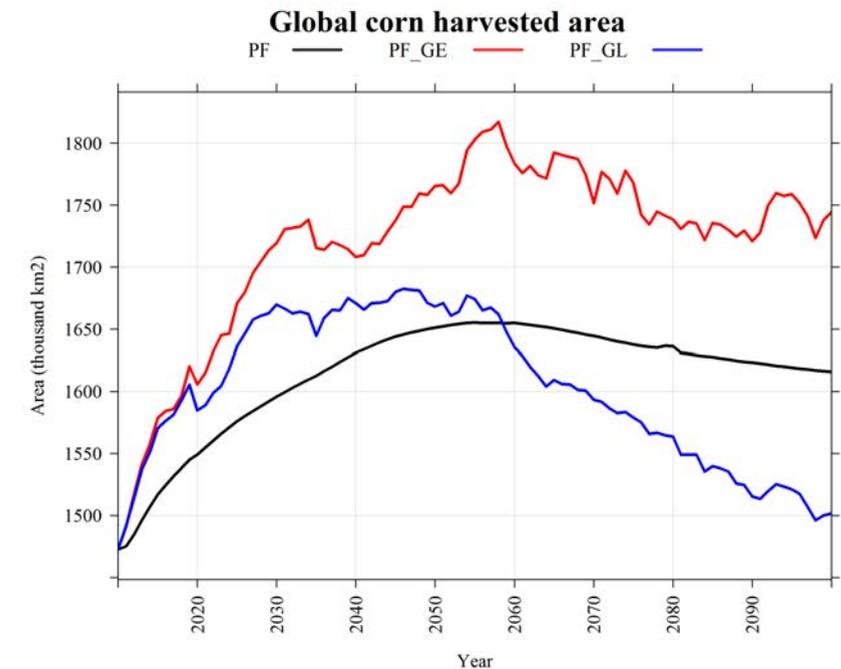
Experiment 1.1. Use GCAM to explore effects of future drought on global bioenergy and agricultural production, land use, and land-use change nationally and globally.

Experiment 1.2. Use GCAM-USA to explore how variability in future temperature and precipitation will affect investment, generation, and demand in the U.S. electricity system.

- **Uncertainty in Economic Decision Making**

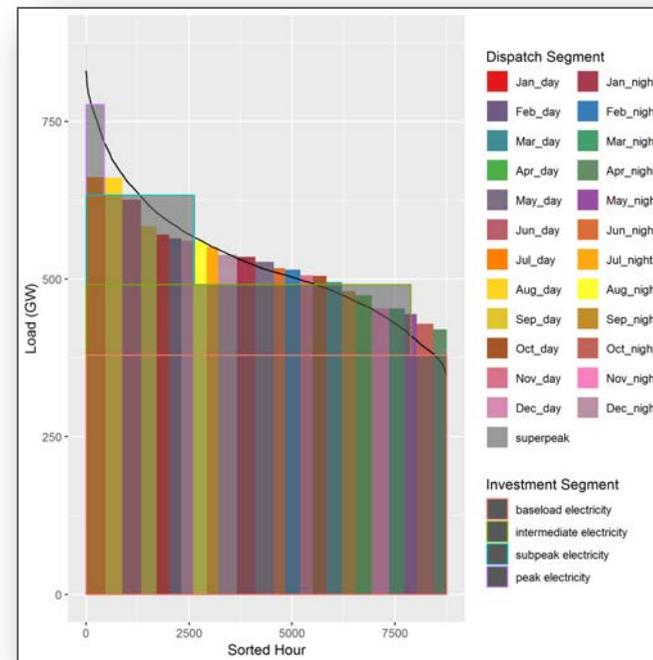
Experiment 2.1. Use hindcasting to explore how uncertainty in economic decision making about electricity sector investments propagates through electricity sector projections in GCAM.

Experiment 2.2. Use hindcasting to explore how uncertainty in economic decision making about land use choices propagates through projections of global bioenergy and agricultural production, land use and land-use change, and emissions from land use in GCAM.

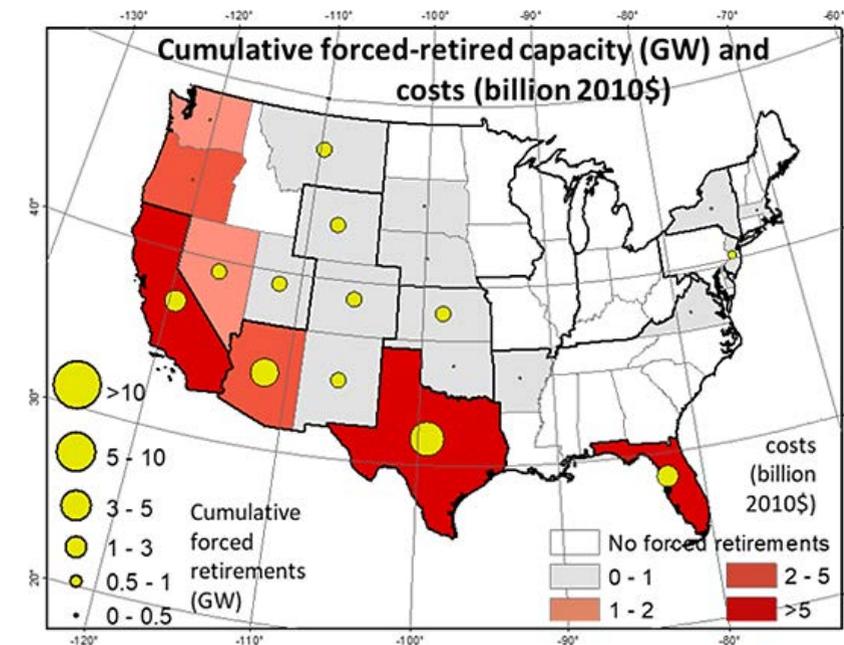


Energy Science Research Area

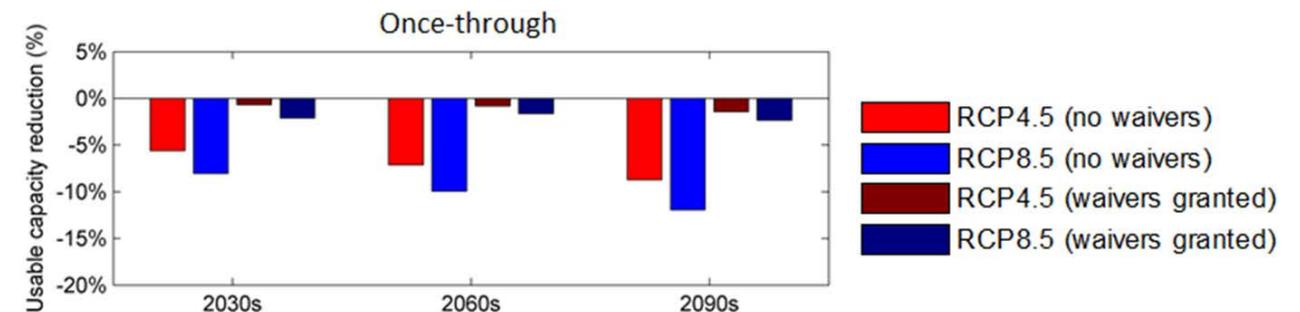
1. Develop the capability to separate investment and dispatch decisions for electricity
2. Develop the capability to model an electricity demand load profile that changes in response to climate, weather, and technology
3. Modeling the effects of climate variability and extremes on electricity generation



Wise et al. (in review)
Khan et al. (in prep.)



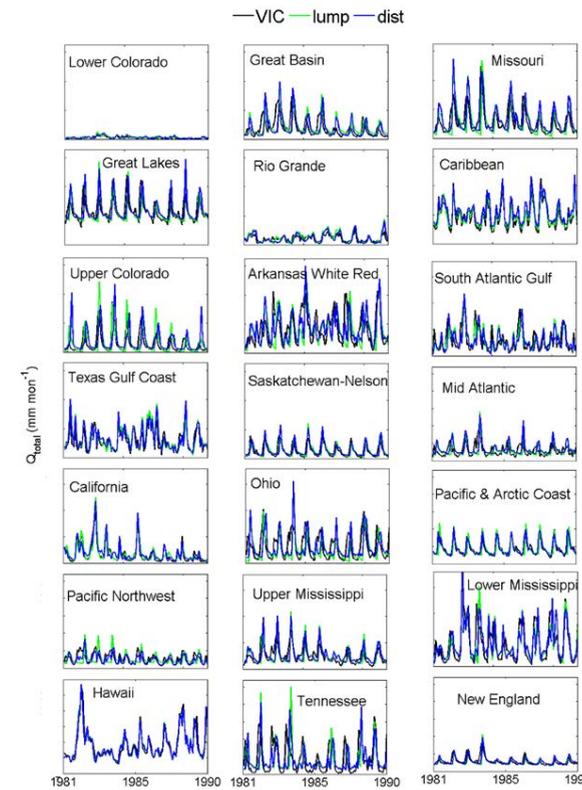
Liu et al. (2019), Nature Sustainability



Liu et al. (2017), Nature Energy.

Water Science Research Area

1. Develop a model of intermediate complexity for runoff generation in GCAM including irrigation and droughts
2. Represent intra- and inter-annual water storage and sub-annual water allocation in GCAM
3. Establish a consistent SSP storyline for water technologies

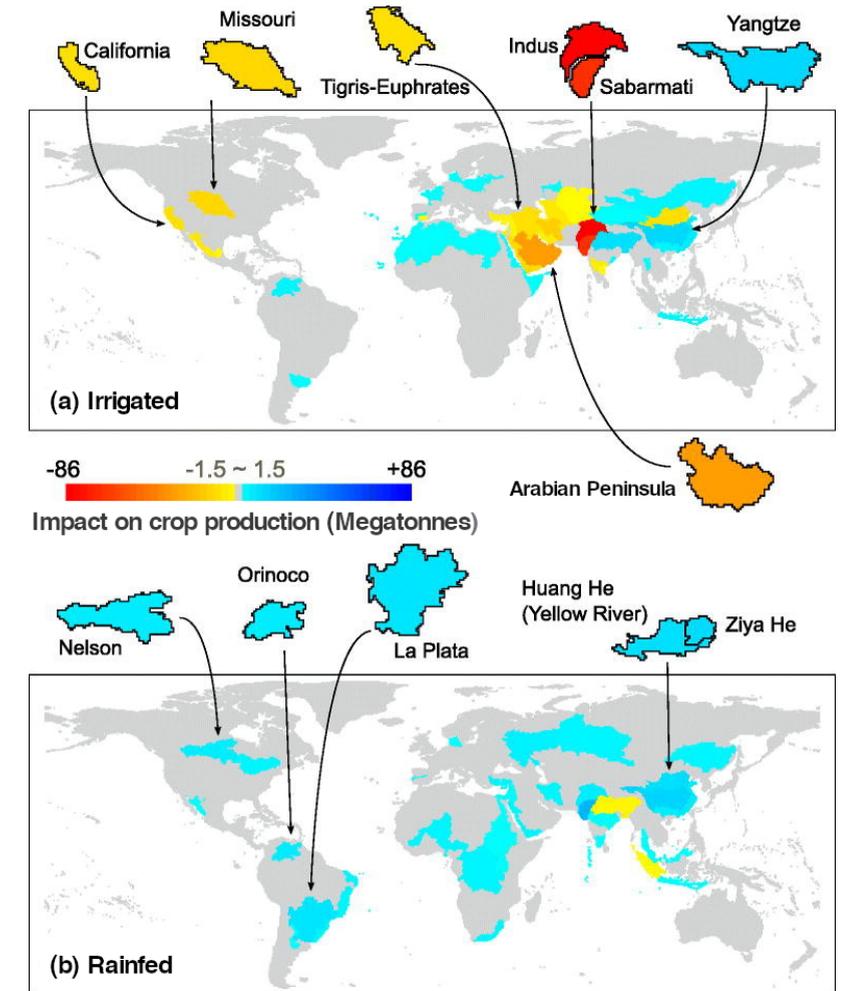


Hejazi et al. HESS (2014)

Li et al., JORS (2017)

Liu et al., GMD (2018)

Vernon et al., JORS (2019)



Yonkofski et al. (in review)

Turner et al., Earth's Future (2019a)

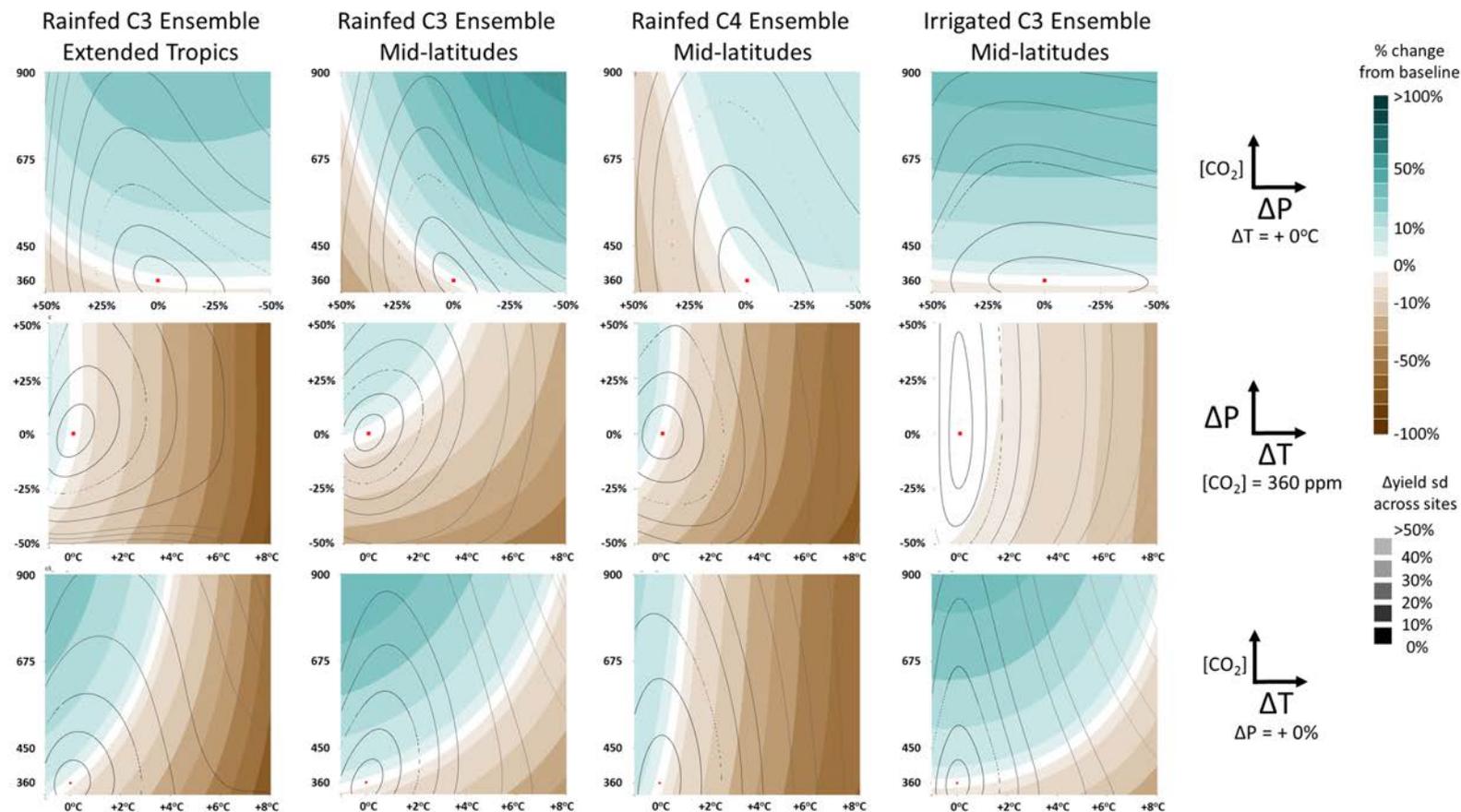
Turner et al., Science of The Total Environment (2019b)

Hejazi et al. (in prep.)

Dolan et al. (in prep.)

Agriculture and Land Use Science Research Area

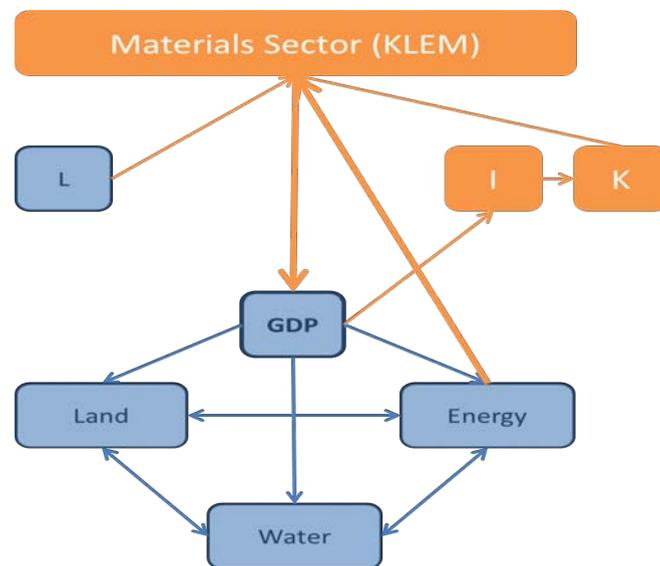
1. Create response functions for bioenergy and agricultural yields and water use efficiency
2. Separate planting and harvesting decisions in GCAM
3. Include inter-annual responses to agricultural surpluses & deficits



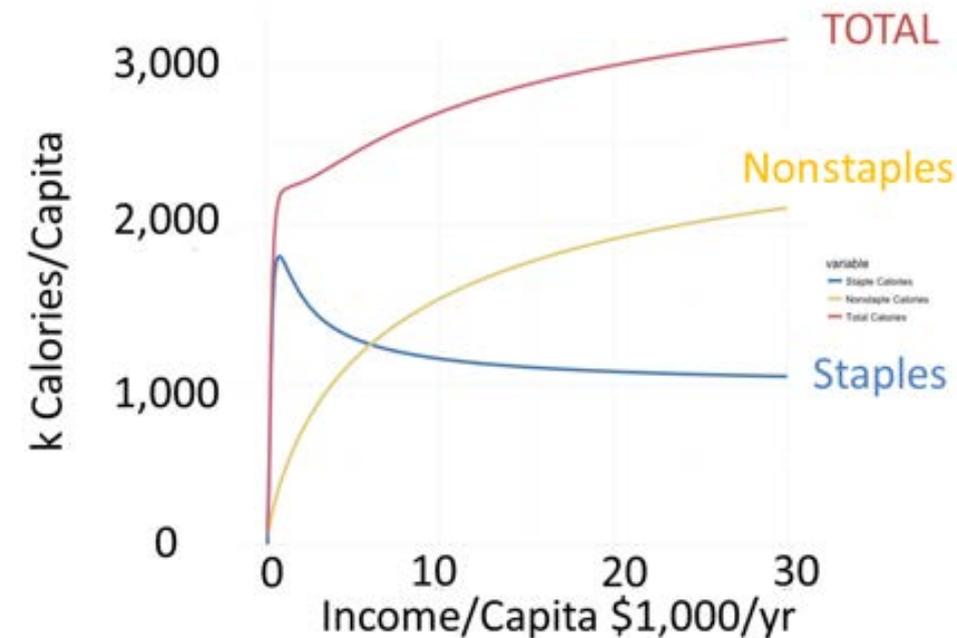
Economics Science Research Area

1. Improve technology choice representations
2. Improve the representation of energy/agriculture and trade effects on aggregate economic activity
3. Improve the representations of demands for agricultural commodities

GCAM-Macro models feedbacks to the economy from the energy system

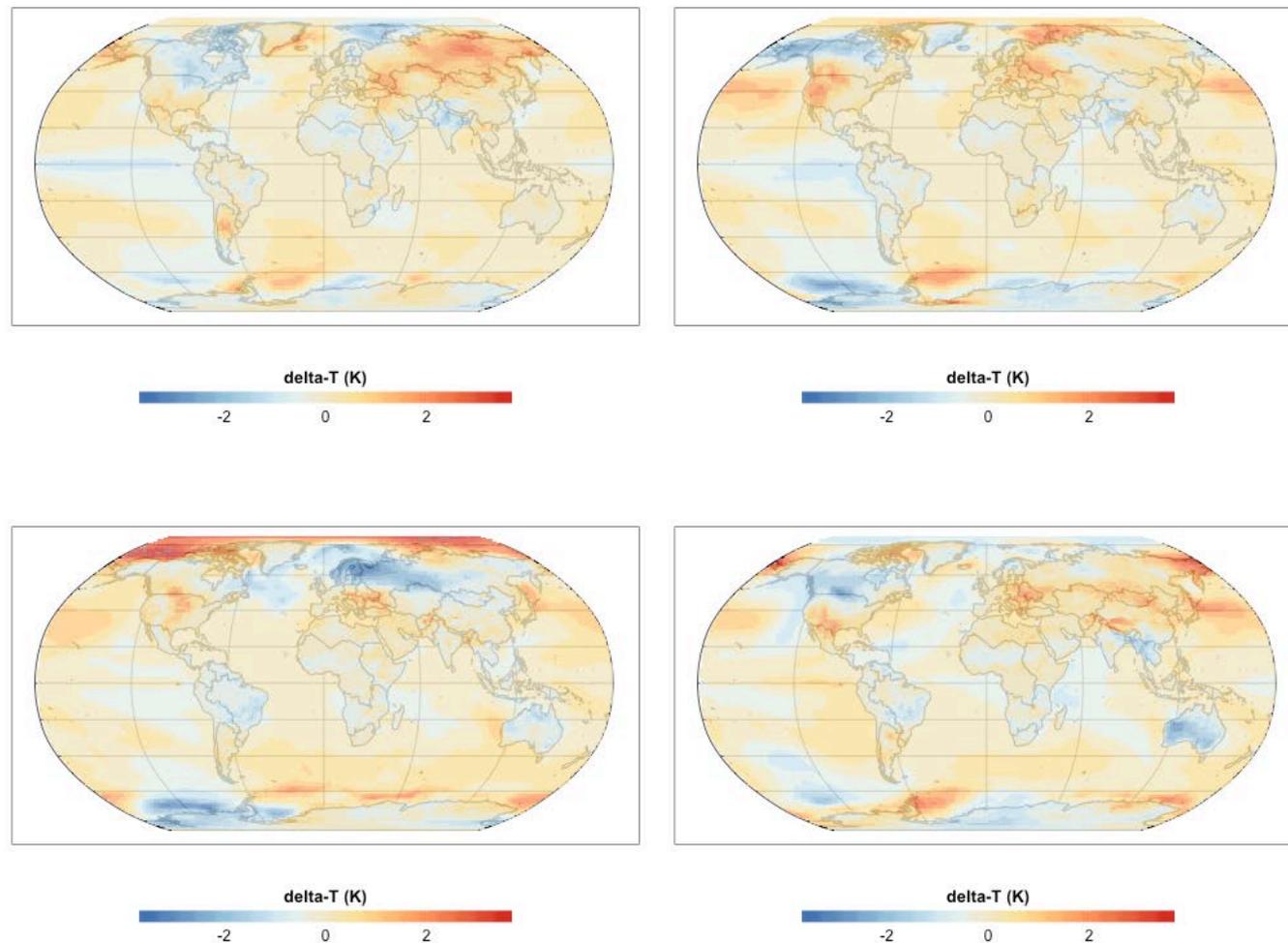


A new global food demand model (demands that saturate at high per capita incomes)



Climate Model Characterization, Emulation, and Downscaling Science Research Area

1. Improve Hector's emulation of Earth System Models
2. Develop the capability to produce probabilistic outcomes in Hector
3. Downscaling temperature and precipitation using Hector

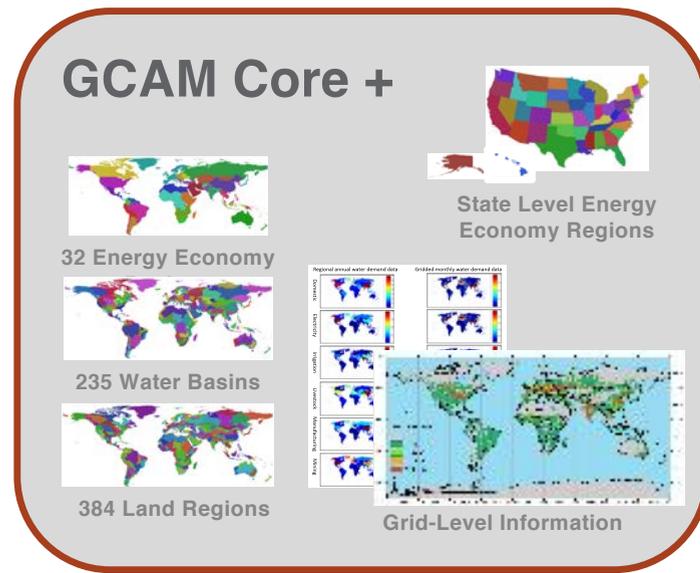


4 Variability Fields
Produced by ESM
Temperature Field
Emulator. Each panel
depicts the 2025
temperature distribution
for a different simulation
of the same scenario.

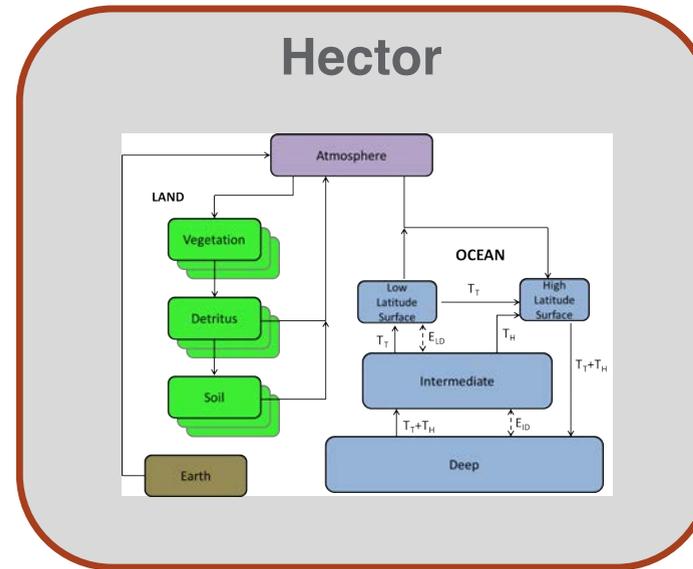
Kravitz et al. 2017.
Lynch et al. 2017.
Link et al., 2019.
Snyder et al., in review.

Expanding the Interactions Between Systems

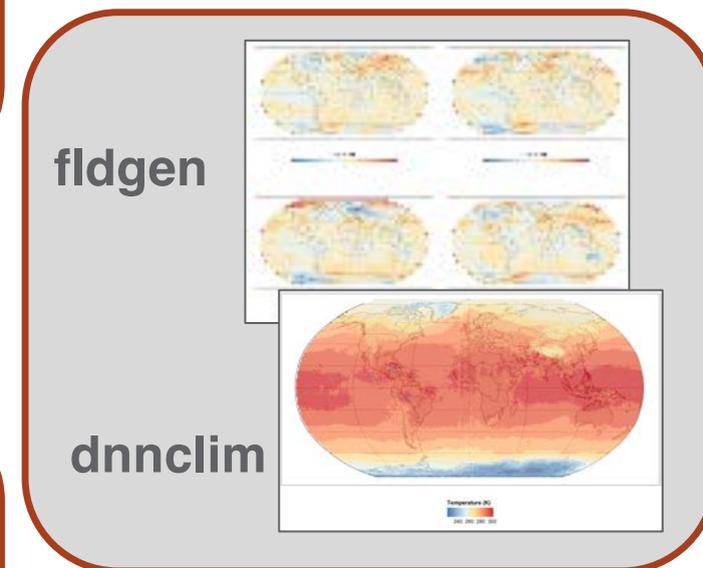
Human Systems
Dynamics (Emissions,
Land Cover)



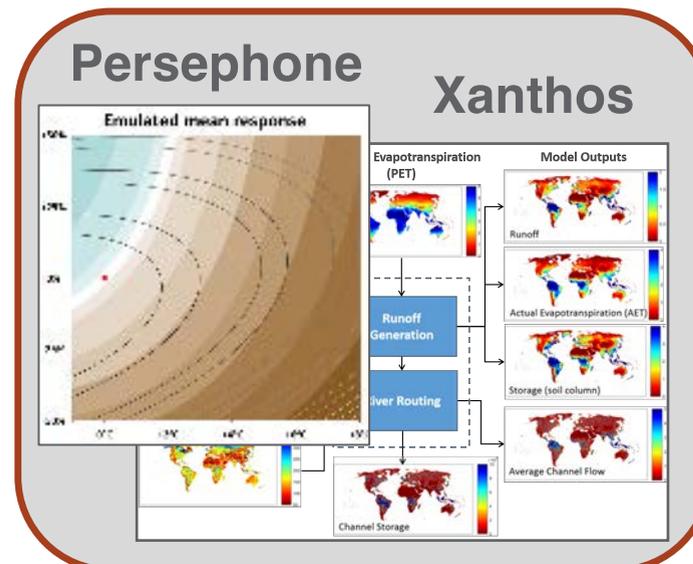
Global Mean Surface
Temperature



Spatially and Temporally-
Resolved Precipitation
and Temperature



Water Availability and
Agricultural Yields



Name	Description		Version	Date
GCAM	Integrated multisector model	https://github.com/JGCRI/gcam-core	55.1.3	2019-02-22
Tethys	GCAM sectoral water spatial and temporal downscaling	https://github.com/JGCRI/tethys	1.22.0	2019-05-29
Xanthos	Global hydrologic modeling framework	https://github.com/JGCRI/xanthos	2.33.1	2019-05-08
gcamland	GCAM land allocation model	https://github.com/JGCRI/gcamland	1.0	2018-06-04
rgcam	GCAM data extraction library for R	https://github.com/JGCRI/rgcam	1.0.00	2019-05-0404
gcamdata	GCAM data system	https://github.com/JGCRI/gcamdata https://doi.org/10.5281/zenodo.1249932	1.0	2018-05-19
gcammaptools	GCAM geospatial visualization library	https://github.com/JGCRI/gcammaptools	0.4.2	2018-05-03
Demeter	GCAM land downscaling	https://github.com/IMMM-SFA/demeter	1.1.0	2019-05-29
Hector	Reduced-form climate model	https://github.com/JGCRI/hector	2.3.0	2019-05-22
pyhector	Python Hector Interface	https://github.com/openclimatedata/pyhector	22.3.0	2019-05-22
fldgen	ESM emulation	https://github.com/JGCRI/fldgen	22.0.0-rc.1	2019-03-25
hydro-emulator	Hydrologic Emulator	https://github.com/JGCRI/hydro-emulator	1.0	2018-01-30
Moirai	Land Data System	https://github.com/JGCRI/moirai	33.0.0	2019-03-05
pygcampygcam	Python GCAM workflow and support tools	https://github.com/JGCRI/pygcam	1.66.2	2019-02-20
gcamrpt	GCAM report generation tool	https://github.com/JGCRI/gcamrpt	0.2	2017-09-21
CMIP5_patterns	CMIP5 mean patterns of temperature and precipitation	https://github.com/JGCRI/CMIP5_patterns	1.0	2017-09-01
GCAM-LAC-dashborad	GCAM visualization tool	https://github.com/JGCRI/GCAM-LAC-dashboard	1.0	2018-01-26
modelinterface	GCAM support tool to help create XML inputs and view results from and XML DB output	https://github.com/JGCRI/modelinterface	5.1	2018-07-09
gcam_reader	Python package to interact with GCAM output databases from a Python environment	https://github.com/JGCRI/gcam_reader	0.1.0	2019-05-29
food-demand	GCAM food demand model	https://github.com/JGCRI/food-demand	1.1.4	2019-03-11
cassandra	Human-earth system multiscale model coupling framework	https://github.com/JGCRI/cassandra	1.0.0	2019-06-06
an2month	Use CMIP 5 data to approximate monthly data from annual data	https://github.com/JGCRI/an2month		
pygis	Python-based Geographic Information System (GIS) utilities	https://github.com/JGCRI/pygis	0.1.0	2019-05-29
persephone	Crop model yield change emulation	https://github.com/JGCRI/persephone	1.0.0	2018-09-13
rgis	R-based GIS utilities	https://github.com/JGCRI/rgis	0.1.0	2019-05-29



Thank you

