IAM COMPACT

Expanding Integrated Assessment Modelling:
Comprehensive and Comprehensible Science
for Sustainable, Co-Created Climate Action

IAM COMPACT Modelling Seminars

Model Presentation: The Global Change Analysis Model (GCAM)

Basque Center for Climate Change (BC3) & University of Maryland (UMD)

The IAM COMPACT project has received funding from the European Union's Horizon Europe Research and Innovation Programme under grant agreement No 101056306.

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- The Global Change Analysis Model (GCAM) is an open-source community model developed by JGCRI (PNNL-UMD)
- It is a partial-equilibrium multisector integrated assessment model designed to explore human and Earth-system dynamics
- GCAM analyses the interdependencies between energy, AFOLU, water, emissions, and climate systems within a single computational platform from now to 2100
- The model has been widely used for IPCC scenarios, SSP pathways, and several multisector multiscale studies and reports
- In the project we will use "GCAM-IAMCOMPACT"

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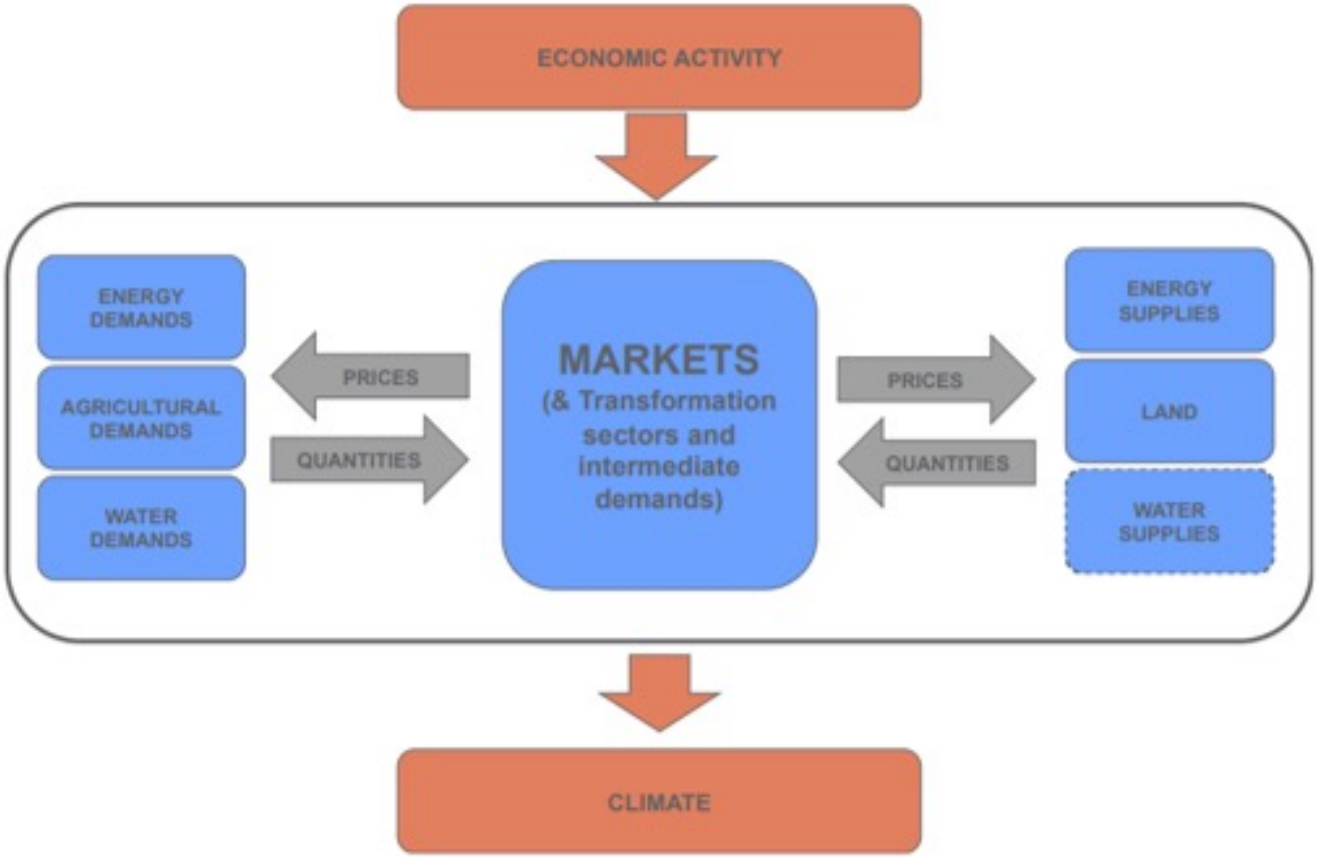
What do GCAM do?



Source: GCAM overview (here)

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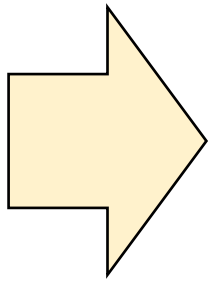
KEY ASSUMPTIONS

- Socioeconomics:
  - Population
  - GDP growth (LabProd)
- Costs or efficiencies for energy technologies
- Agricultural/land costs, crop yields, profitability, water/fertilizer requirements or carbon contents
- Water runoff/availability
- Depletable and renewable resource supply curves
- Policies in place:
  - Emission constraints
  - Temperature limits
  - RES



OUTCOMES

- ENERGY SYSTEM:
  - Demand and flows
  - Technology mix by sector
  - Energy prices
- AFOLU:
  - Land allocation
  - Forest and agricultural production by crop
  - Commodity prices
  - Food/Feed balances
- WATER:
  - Water withdrawals/consumption by region for all uses (e.g. irrigation or municipal)
- EMISSIONS:
  - GHG and air pollutant emissions by region/sector/tech (24 species)
- CLIMATE:
  - RF/T increase
  - CO2 concentrations
  - +Land/Ocean metrics (HECTOR)
- ECONOMY
  - Policy Costs
  - Carbon prices

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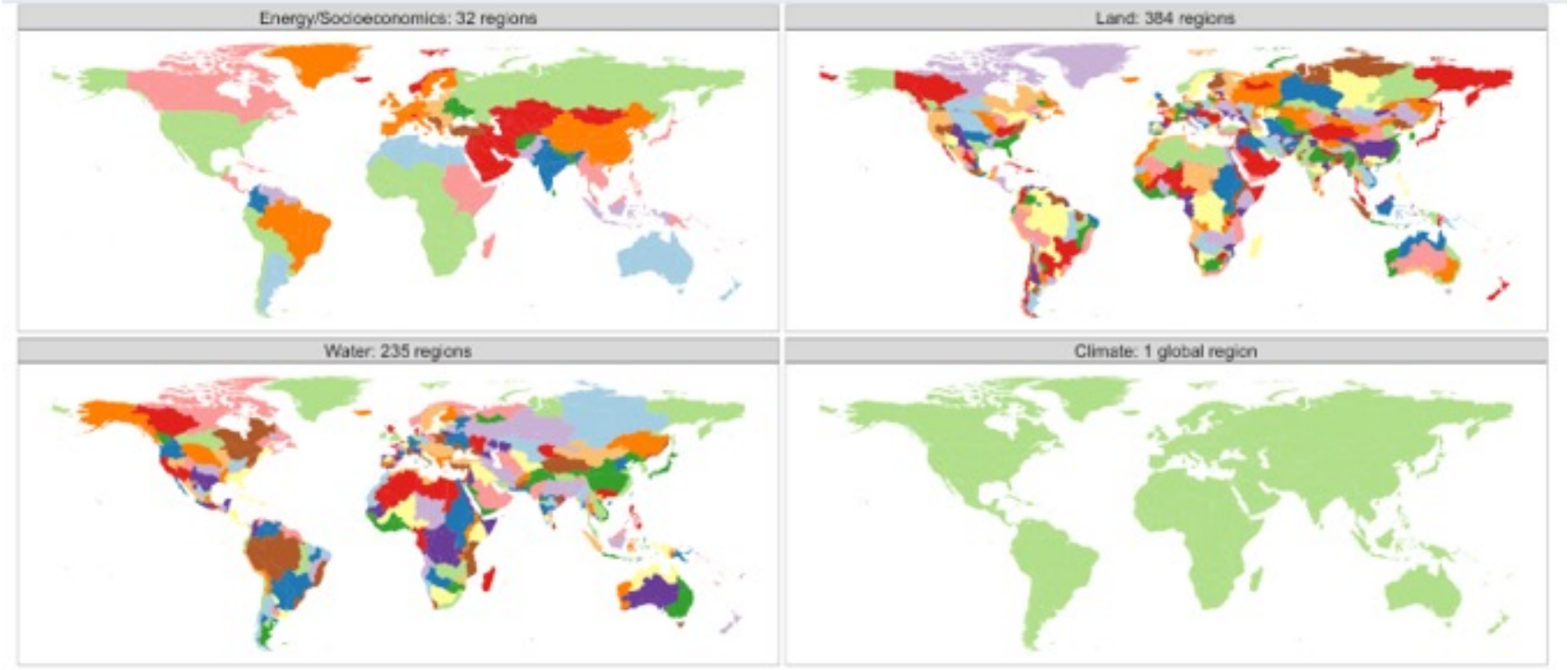

Source: GCAM documentation: https://github.com/JGCRI/gcam-doc/blob/gh-pages/overview.md

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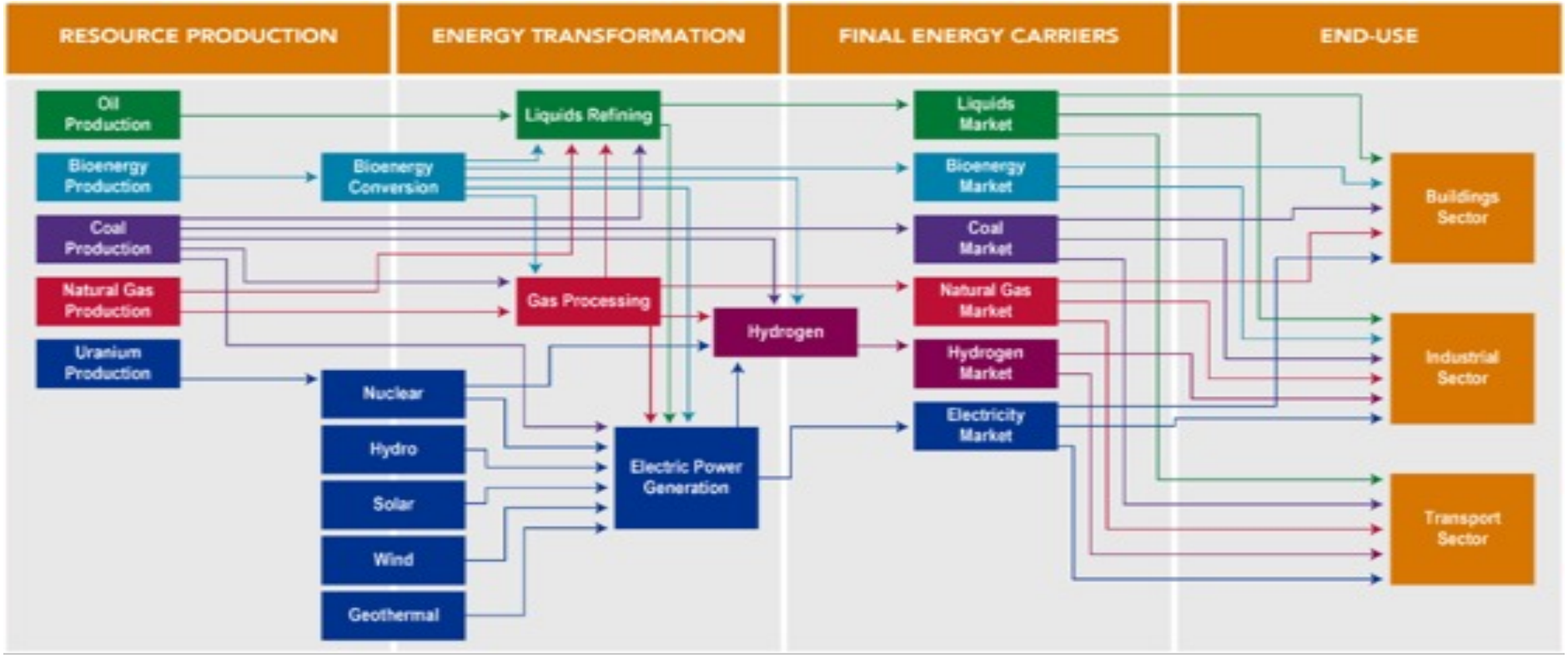
Energy system detailed representation



Source: GCAM documentation: https://github.com/JGCRI/gcam-doc/blob/gh-pages/details_energy.md

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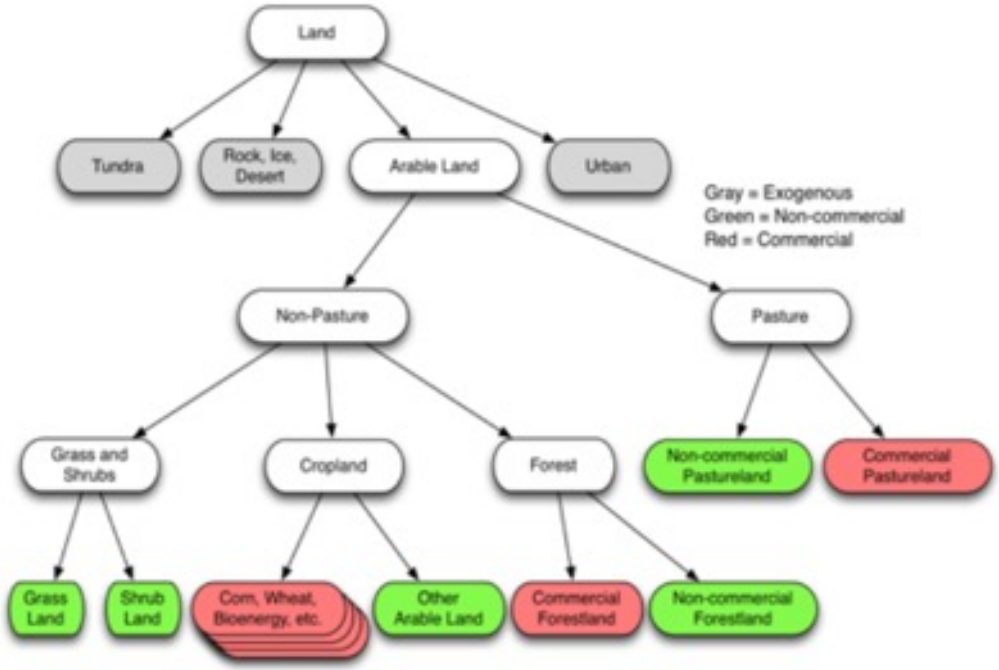
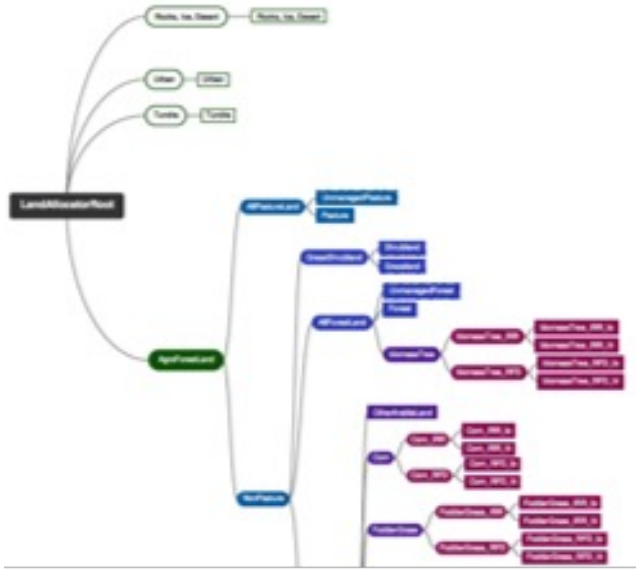
Land system detailed representation





Source: GCAM documentation: https://github.com/JGCRI/gcam-doc/blob/gh-pages/details_land.md

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Water system detailed representation

Xanthos

Water Runoff

Renewable water

Supply curves

Non-renewable water

Desalinated water

Water supply -- Agriculture

Water supply – Non-agricultural uses

Source: GCAM overview (here)

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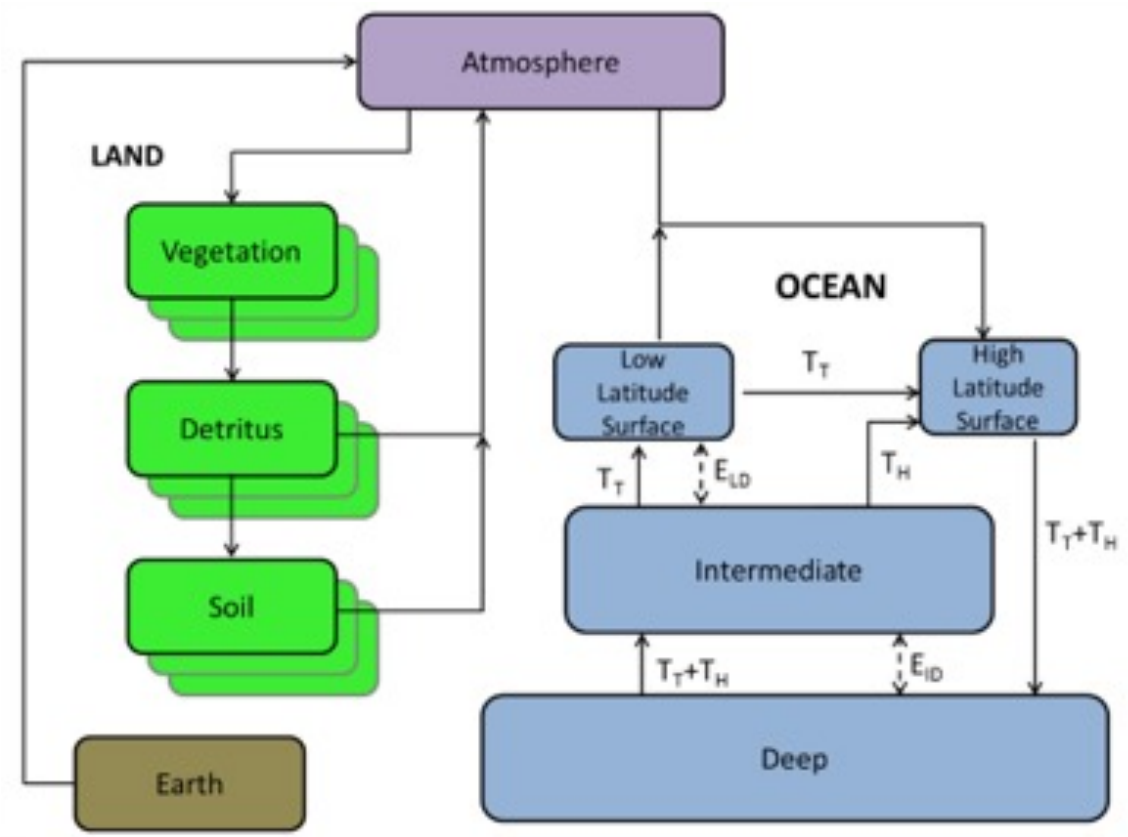
GCAM EMISSIONS

CO2, CH4, N2O, CF4, C2F6, SF6, HFC23, HFC32, HFC43-10mee, HFC125, HFC134a, HFC143a, HFC152a, HFC227ea, HFC236fa, HFC245fa, HFC365mfc, SO2, BC, OC, CO, VOCs, NOx, NH3



Source: GCAM documentation: https://github.com/JGCRI/gcam-doc/blob/gh-pages/hector.md

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Climate policies:
- Carbon tax
- CO2/GHG emission constraints
- Limit Global Mean Temperature/RF/CO2conc

Energy system
- Energy tax/subsidies
- Constraint on the deployment of any energy carrier
- RES
- Energy intensity standard

AFOLU system
- Land constraints (afforestation policies)
- Bioenergy constraints
- Change the protected land areas
- Tax LUC emissions

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- Can climate pledges/NDCs limit global warming below the objectives? (Wise et al 2009; Fawcett et al 2015; Ou et al, 2021a)
- Which are the implications for SDGs of alternative climate scenarios? (Iyer et al 2017; Moreno et al under review)
- What are the multisector effects of the deployment of different energy technologies? (Ou et al 2021b; Yu et al 2020)
- Which are the consumption/welfare implications of agricultural productivity changes due to climate change, trade, or ozone? (Calvin et al 2020; Zhao et al 2022; Sampedro et al 2020)
- How does alternative socioeconomic development pathways affect future energy system and which are the multisector/multiscale implications? (Calvin et al 2017; Sampedro et al 2021)
- Which are the Food-Energy-Water implications of negative emission technologies? (Fuhrman et al 2020; Iyer et al 2021)

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SDG-relevant linkages

SDG	Official Indicator		Indicator used	Model combination
Zero Hunger	2.c	Indicator of food price anomalies	Food price	GCAM
Zero Hunger	2.3	Agricultural productivity	Relative agricultural yield loss attributable to O_3 exposure	GCAM + *rfasst* (Sampedro et al., 2020b)
Clean Water and Sanitation	6.1	Equitable access to affordable drinking water	Water price	GCAM
Clean Water and Sanitation	6.4.2	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources	Groundwater withdrawals per capita	GCAM
Affordable and Clean Energy	7.1.1	Proportion of population with access to electricity	Household energy costs	GCAM
Affordable and Clean Energy	7.2	Renewable energy share in the total final energy consumption	Non-biomass renewable energy share	GCAM
Sustainable cities and communities	11.6.2	Annual mean levels of fine particulate matter in cities	PM 2.5 concentration	GCAM + *rfasst* (Sampedro et al., 2020a)
Climate Action	13	GHG emissions reduction*	Total and per capita GHG emissions	GCAM
Life Below Water	14.3	Minimize the impacts of ocean acidification	Ocean pH	GCAM + Hector (Hartin et al., 2015; Iyer et al., 2018)
Life on Land	15.1.1	Forest area as a proportion of total land area	Relative forest cover	GCAM

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Source: Moreno et al, under review

Some references

GCAM documentation:

- GCAM-v6 documentation: https://jgcri.github.io/gcam-doc/ ; cite at https://zenodo.org/record/6619287#.Y1pWx3ZByUk
- Github documentation: https://github.com/JGCRI/gcam-doc
- Model discussion site: https://github.com/JGCRI/gcam-core/discussions

Subset of relevant papers:

- Calvin, K., Patel, P., Clarke, L., Asrar, G., Bond-Lamberty, B., Cui, R.Y., Di Vittorio, A., Dorheim, K., Edmonds, J., Hartin, C. and Hejazi, M., 2019. GCAM v5. 1: representing the linkages between energy, water, land, climate, and economic systems. Geoscientific Model Development, 12(2), pp.677-698.
- Ou, Y., Iyer, G., Clarke, L., Edmonds, J., Fawcett, A.A., Hultman, N., McFarland, J.R., Binsted, M., Cui, R., Fyson, C. and Geiges, A., 2021. Can updated climate pledges limit warming well below 2° C?. Science, 374(6568), pp.693-695.
- Iyer, G., Calvin, K., Clarke, L., Edmonds, J., Hultman, N., Hartin, C., McJeon, H., Aldy, J. and Pizer, W., 2018. Implications of sustainable development considerations for comparability across nationally determined contributions. Nature Climate Change, 8(2), pp.124-129.
- Calvin, K., Bond-Lamberty, B., Clarke, L., Edmonds, J., Eom, J., Hartin, C., Kim, S., Kyle, P., Link, R., Moss, R. and McJeon, H., 2017. The SSP4: A world of deepening inequality. Global Environmental Change, 42, pp.284-296.
- Fuhrman, J., McJeon, H., Patel, P., Doney, S.C., Shobe, W.M. and Clarens, A.F., 2020. Food–energy–water implications of negative emissions technologies in a+ 1.5 C future. Nature Climate Change, 10(10), pp.920-927.

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Thank you!

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