Modelling Earth System and Human interactions (MESH) working group

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What is MESH?

• Working group within AIMES focused on Modeling Earth and Human System Interactions

• Co-chairs:
  • Kate Calvin
  • Brian O’Neill
  • Julia Pongratz
  • Ben Sanderson
  • Detlef van Vuuren
Recent MESH activities

• MESH co-organized an AGCI session in July of 2021
• Three sessions:
  • Human-Earth System Feedbacks:
    • Defining critical human-earth system feedbacks and modeling needs
    • Advances/Improving human-earth system feedbacks around land use
  • Uncertainty:
    • Model projection uncertainty due to human-earth system interactions
  • Scenario and model development:
    • Role of Human-earth system interactions in scenario and model development
    • Representation of land use in scenario and model development
    • Disruptions, shocks, and extreme events in scenario and model development
Human-Earth System Feedbacks
Are there **feedbacks** that could alter the original scenario in such a major way that the linear system breaks down?
Importance

Understanding

Extreme events are poorly understood

Ecosystem services need better representation

Traditional IAM sectors are considered best understood
Uncertainty
Are different methods to describe uncertainty preventing us to fully understand the system? Are our current methods to link human system and earth system models leading to limited understanding?
Some ideas that emerged from the uncertainty session

- **Models:**
  - Need for model diversity
  - Balancing model complexity
  - Missing feedbacks from impacts to socio-economic models in the CMIP6 simulation chain
  - Significant uncertainty in human system modeling
  - Linguistic uncertainty – what is a model? What is feasible? What is a grassland?

- **Scenarios:**
  - Concentration-driven vs. Emissions driven runs
  - Expanding scenarios (e.g., capturing transitions between SSPs, CDR, SRM)
  - Need HR, PPE and LE experiments
  - How do we develop scenarios relevant to question of the day vs. develop scenarios that are robust to changing nature of science?

- **Communication of scenarios and models**
Scenario and model development

• Does our current scenario design allow us to represent human-Earth system feedbacks?

• What improvements or changes to the scenario design are needed to represent land use feedbacks consistently?

• How do we represent shocks, extreme events, and disruptions in our models and scenarios?
Scenario and model development

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Current Scenario Design

Five Shared Socio-economic Pathways were designed to explore a range of future societal circumstances that exhibit a wide range of
- Challenges to adaptation, and
- Challenges to mitigation.
ScenarioMIP Design: Specific Scenarios

Shared Socioeconomic Pathways

- SSP1: Sustainability
- SSP2: Middle of the Road
- SSP3: Regional Rivalry
- SSP4: Inequality
- SSP5: Fossil-fueled Development

Climate (RCPs)
- 8.5
- 6.0
- 4.5
- 3.7
- 1.9

2100 forcing level (W/m²)
- Ensemble
- Long-term ext.

Overshoot
Long-term ext.

Range of IAM baseline scenarios

Tier 1
Tier 2
Tier 3

CMIP5 simulations (RCPs)

SRES
A2, B1, B2

CMIP5 simulations (RCPs)

Tier 1
Tier 2
Tier 3
Does our current scenario design allow us to represent human-Earth system feedbacks?

- Better communication of the scenario design and what it means
- Need additional axes beyond mitigation and adaptation to account for SDGs.
- Post-2100 scenarios
- Further invest in tools like emulators to achieve similar outcomes.
- Think beyond temperature being the only/main feedback effect for human-earth systems. Design scenarios around these other types of feedbacks that are potentially important but under-explored, e.g., biodiversity.
- For some questions, scenarios for 30 years are more useful.
Scenario and model development

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## Missing elements in the current treatment of land use

<table>
<thead>
<tr>
<th>Missing from IAMs</th>
<th>Missing from ESMs</th>
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</thead>
<tbody>
<tr>
<td>Biodiversity</td>
<td>Biodiversity</td>
</tr>
<tr>
<td>Mixed land types</td>
<td>Local scale effects</td>
</tr>
<tr>
<td>Biophysical effects</td>
<td>Mixed land types</td>
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<tr>
<td>Response to extremes</td>
<td>Land for energy</td>
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<tr>
<td>Lags in response times</td>
<td>Fertilizer</td>
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<tr>
<td>Irrigation details</td>
<td>Adaptation/mitigation interactions</td>
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<tr>
<td>Land for energy</td>
<td>Irrigation</td>
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Inconsistencies in the current treatment of land use

• Differences in scale
• Differences in land types and in the definition of land types
• Differences in baseline
• Difference assumptions about productivity and changes in productivity
• LULCC inconsistencies
What improvements or changes to the scenario design are needed to represent land use feedbacks consistently?

- Better communication of model structure and implications on results
- Land-related uncertainty analyses with respect to data and assumptions
- Need for further development in information exchange (standardization, harmonization)
- Fire inconsistency between reality, IAMs, and ESMs
- Design experiments with information exchange between ESM, IAM, crop model; try to calibrate against real world events such as dust bowl
- Biodiversity potentially very important for agriculture/ecosystems, with potential for feedbacks.
- Develop relevant biodiversity indicators (build from existing analytical frameworks) in the next generation of land use scenarios
Scenario and model development

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• How do we represent shocks, extreme events, and disruptions in our models and scenarios?
How do we represent shocks, extreme events, and disruptions in our models and scenarios?

- Review existing studies on shocks
- Need to improve models first and then may need to adjust scenarios design eventually
- Add low probability scenarios - but be clear that they are low probability!
- Focus specifically on tipping points and events that create them
- Assess scenarios probabilistically in IAMs! Then select based on policy objectives that should not be failed.
- Do experiments with models with observed shocks / case studies (see whether models can represent some elements; dust bowl / Covid19)
Thank you!