IAM-IAV-ESM linkage in AIM project
- Focusing spatial resolution issues -

Kiyoshi Takahashi\textsuperscript{1}, Shinichiro Fujimori\textsuperscript{1}, Naota Hanasaki\textsuperscript{1}, Tomoko Hasegawa\textsuperscript{1}, Yasuaki Hijioka\textsuperscript{1}, Toshihiko Masui\textsuperscript{1}, Chan Park\textsuperscript{2}, Akemi Tanaka\textsuperscript{3}, Qian Zhou\textsuperscript{1}

\textsuperscript{1}National Institute for Environmental Studies
\textsuperscript{2}University of Seoul
\textsuperscript{3}National Agriculture and Food Research Organization
AIM project’s research publications based on IAM-IAV-ESM linkage

• Published
  • Hasegawa T., Park C., Fujimori S., Takahashi K., Hijjoka Y., Masui T. (2016) Quantifying the economic impact of changes in energy demand for space heating and cooling systems under varying climatic scenarios. Palgrave Communications.

• Submitted / Under review
  • Hasegawa et al., Development and Application of a Global Land-use Allocation Model Linked to an Integrated Assessment Model.
  • Fujimori et al., Downscaling Global Emissions and Its Implication Derived from Climate Model Experiments.
  • Zhou et al., Economic consequences of global climate change and mitigation on future hydropower.
Our incentives for IAM-IAV-ESM coupling

• International research trend
  • The SSP-RCP scenario framework
  • Increasing focus on the analyses of the sustainable development goals

• Domestic research project funding
  • MOEJ-S14 research project for integrated analyses of global mitigation and local adaptation
  • NIES research program for proposing integrated solution of multiple environmental problems toward sustainable society
Current AIM/CGE interaction for the integrated scenario analyses

- **Recursive Dynamic Economic model** AIM/CGE
  - MAC curve
  - Biomass supply curve
  - Land use and agriculture price
  - Energy production and consumption

- **Land allocation model** AIM/PLUM
  - Biophysical potential
  - Gridded land use

- **DICE type optimization model** AIM/Dynamic
  - GHG emissions pathway
  - Transport demand
  - Energy and carbon price

- **Simplified climate MAGICC**
  - Global mean temperature
  - Emissions downscaling AIM/DS

- **Transport model** AIM/Transport

Gridded emissions

Yield (tDM/ha) vs. Area (Mha) graphs are shown. The diagram is drawn by Fujimori.
AIM/CGE interaction with external IAV&ESM models

- Crop model
  - Crop production potential
- Health model
  - Health damage
- Biodiversity index
  - Conservation area
- Ecosystem Biodiversity model
- Gridded Land use
- Gridded emissions
- Water resource model
  - H08
  - Hydro power potential
  - Cooling water potential
- Flood model
  - CaMa-Flood
  - Flooded area and loss
- Cool/Cooling/Heating demand
- Coastal model
  - Coastal damage
- CDD/HDD model
- Climate model
  - MIROC
- Air quality model
  - CMAQ

Drawn by Fujimori
Typical challenges in linking IAM and IAV

- Spatial resolution gap
  - Aggregation / Disaggregation
- Limited number of scenario cases analyzed in IAV models
  - Impact response functions (sensitivity analyses)
- Choice of variables transferred between models
  - Avoidance of double-counting
  - Formulation in the CGE model
- Difficulty in reflective interaction between IAM and IAV
  - Land-use model as a key module for most interactions
Spatial aggregation / disaggregation

• Aggregation (IAV -> IAM ; 0.5° -> 17 regions)
  • Crops productivity
    • Food-health analysis
  • Cooling/Heating Degree Days
    • Cooling/Heating service and energy demand analysis
    • Hydropower potential based on river runoff change

• Disaggregation (IAM -> IAV/ESM; 17 regions -> 0.5° )
  • Spatial GHGs/Aerosol emission scenarios
    • Input to MIROC ESM
  • Spatial land-use scenarios
    • Input to ecosystem-biodiversity model
Impacts of climate change on food-health and its economic implications

Socio-economic conditions

Undernourishment/Risk of hunger

Health impacts

Economic implications

Climate change

Adaptation

Hasegawa et al., 2014

Mitigation

Hasegawa et al., 2015, EST

Hasegawa et al., 2015, ERL

Ishida et al., 2014

Ishida et al., 2014

Hasegawa et al., 2016
Consequence of Climate Mitigation on the Risk of Hunger

**Methods**

- Climate mitigation policy: RCP2.6/BaU
- Socio-economic conditions: SSP2
- Climate conditions (RCP2.6/8.5/No change)
- Crop model

**AIM/CGE model**

Mean food calorie intake

<table>
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<tr>
<th></th>
<th>RCP2.6</th>
<th>RCP8.5</th>
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<td>Change in calorie intake [kcal/day/cap]</td>
<td>0</td>
<td>0</td>
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<td>-15</td>
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</tbody>
</table>

Global population at risk of hunger

- 2050 with NoCC: 2950 kcal/cap/day
- 2050: 90 mil.
- 2005: 2680 kcal/cap/day
- 2005: 830 mil.

- Mean food calorie intake
- Change in population at risk of hunger

- Change in crop yields (median)

Hasegawa et al., 2015, EST
Economic implications of health impacts through undernourishment: SSP3-RCP8.5 in 2100

- **Direct impacts** (changes in labor force & healthcare costs): -0.1–0.0% of Global GDP

- **Indirect impacts** (value of lives lost): -0.4-0.0% of Global GDP; -4.0% at most in regional levels

![Graph showing changes in GDP and proportion of GDP by region.](image-url)
Economic impact of changes in energy demand for space heating and cooling systems under varying climatic scenarios

Hasegawa et al., 2016, Palgrave Communications
Economic consequences of global climate change and mitigation on future hydropower

Step 1: Physical model
- Climate scenario
  - H08
  - Regional EEC (with CC)

Step 2: Economic model
- Mitigation scenarios
- SSP2 (GDP, Population)
- AIM/CGE
  - Input
  - Models
  - Output
  - HG
  - Electricity structure
  - GDP

(a) GDP change rate [%]
- Brazil
- Turkey
- Middle East
- Rest of Africa
- EU25
- Oceania
- Rest of South America
- Rest of Europe
- North Africa
- Japan
- Southeast Asia
- United States
- Rest of Asia
- India
- China
- Canada
- Former Soviet Union

(b) EEC: Economical exploitable capacity
- Middle East
- Turkey
- Brazil
- Oceania
- Rest of Africa
- Rest of Europe
- Rest of South America
- North Africa
- EU25
- Japan
- United States
- Southeast Asia
- Rest of Asia
- China
- India
- Canada
- Former Soviet Union

EEC: Economical exploitable capacity
Zhao et al. Submitted.
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  • Formulation in the CGE model

• Difficulty in reflective interaction between IAM and IAV
  • Land-use model as a key module for most interactions
The impact response function is a database of country-averaged data from sensitivity analyses calculated by a process-based model.

We developed an impact response function for productivities of maize, wheat, paddy-rice and other 11 crops with two explanatory variables, change in annual mean temperature (ΔT) and change in annual mean precipitation (ΔP), using the M-GAEZ model.

Base period: 1961-1990
Incentives for IAM-IAV-ESM coupling

• International
  • The SSP-RCP framework
  • Increasing focus on the analyses of the sustainable development goals

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NIES Research Program: Development of global SD scenario

1) Development of novel global IAM and quantitative SD scenarios using the IAM
2) Downscaling of the quantified socio-economic scenarios

Narrative storylines of socio-economic development

Quantification by region

Scenario development

Global LCS scenario - Climate impact scenario

From LCS scenario to SD scenario

Model application

Development of novel IAM at global scale

Feedback

Environmental reconstruction
Low carbon society
Safety and security
Natural symbiosis
Resource recycle

Environment
Economy
Society

Spatial information of socio-economic development
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Summary of the talk

• Most of the recent efforts for linking IAM-IAV in the AIM project have been the consideration of climate change impacts on specific sectors in AIM/CGE.

• Based on the development of tools for spatially downscaling the CGE results (e.g. AIM/PLUM for land-use scenario), we are going to extend the integration with IAV & ESM models further.