SWG on Evaluation and Diagnostics

IAMC Annual Meeting

Tsukuba, JAPAN

03 December 2019

The E&D SWG Charter

The SWG on Evaluation and Diagnostics exists to foster activities

that help describe, document and understand the performance of integrated assessment models

so as to improve model performance and reliability and

to make recommendations in the areas of priorities for community activities and standards of best practice.

This Year We Surveyed the IAMC regarding: Documentation and Validation

- We asked IAMC modeling teams to report on their teams' approaches to model validation.
- We asked for one to two PowerPoint slides summarizing each team's approach to model documentation and validation.

We Received 13 Responses

Model name	Host institution
AIM	NIES/Kyoto Univ.
BLUE, TEA	COPPE
GCAM	PNNL/Univ. Maryland
GRACE	CICERO
IGSM	MIT
IIM	IIM
IMACLIM	CIRED
IMAGE	PBL
MERGE-ETL	EPRI
MESSAGE	IIASA
PECE_LIU	Renmin Univ.
REMIND	PIK
WITCH	CMCC
Total (13)	

Almost all models had some form of documentation

Model name	Host institution	Documentation	
		Wiki	Full doc
AIM	NIES/Kyoto Univ.	X	X
BLUE, TEA	COPPE	X	
GCAM	PNNL/Univ. Maryland	X	X
GRACE	CICERO		X
IGSM	MIT		X
IIM	IIM	R	R
IMACLIM	CIRED	X	X
IMAGE	PBL	X	X
MERGE-ETL	EPRI		X
MESSAGE	IIASA	X	X
PECE_LIU	Renmin Univ.		
REMIND	PIK	X	X
WITCH	CMCC	X	X
Total (13)		8	10

X = Model Documentation

R = Use of other institution's model

MIPs most popular model validation method

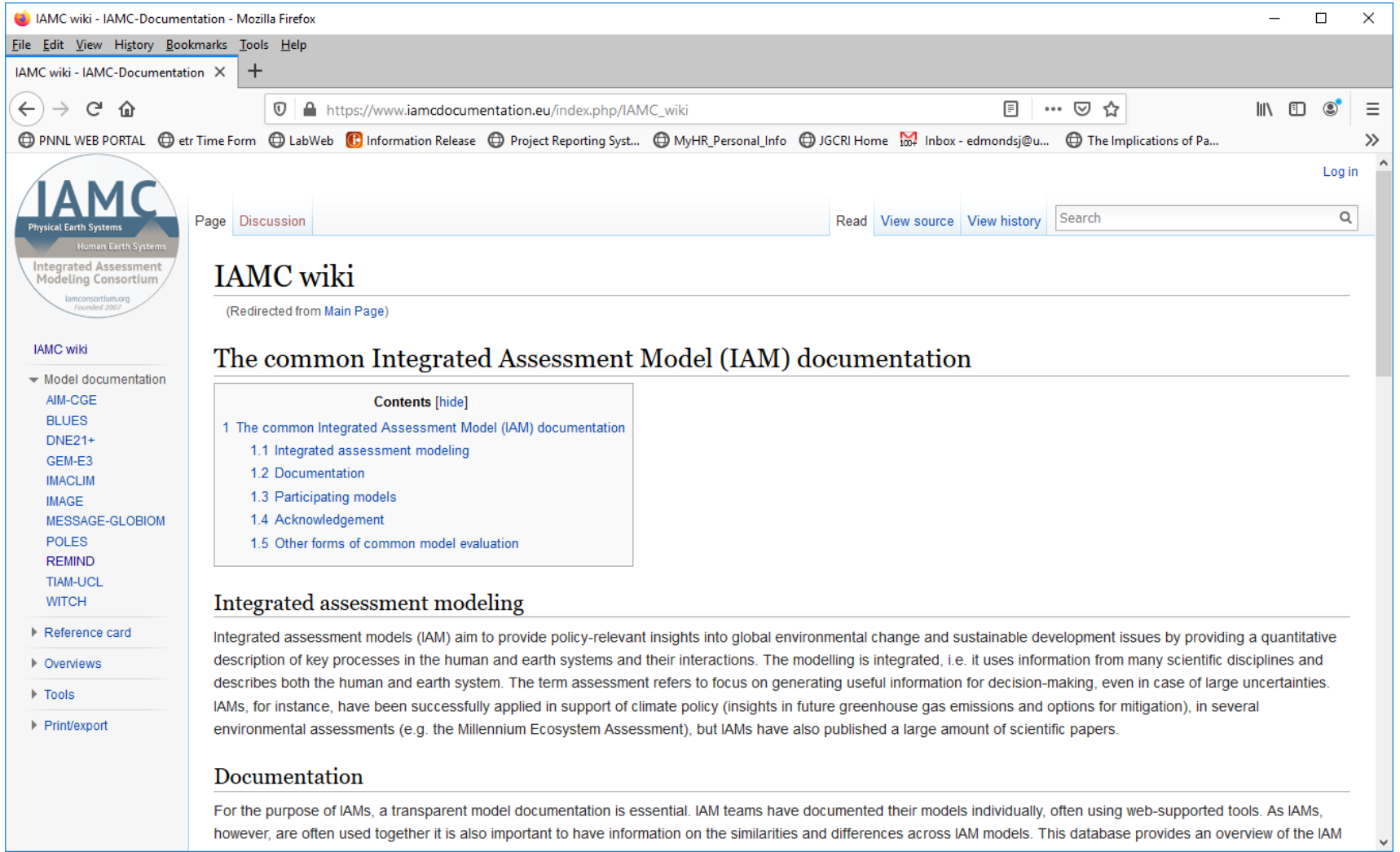
Model name	Host institution	Validation	
		MIP	Hindcasting
AIM	NIES/Kyoto Univ.	X	X
BLUE, TEA	COPPE		
GCAM	PNNL/Univ. Maryland	X	X
GRACE	CICERO		
IGSM	MIT	X	
IIM	IIM	R	R
IMACLIM	CIRED	X	X
IMAGE	PBL	X	X
MERGE-ETL	EPRI	X	
MESSAGE	IIASA		X
PECE_LIU	Renmin Univ.	X	
REMIND	PIK	X	
WITCH	CMCC	X	
Total (13)		9	5

X = Model Validation

R = Use of other institution's model

IAMC wiki: Model Documentation

The IAMC hosts a common model documentation resource which provides a snapshot overview

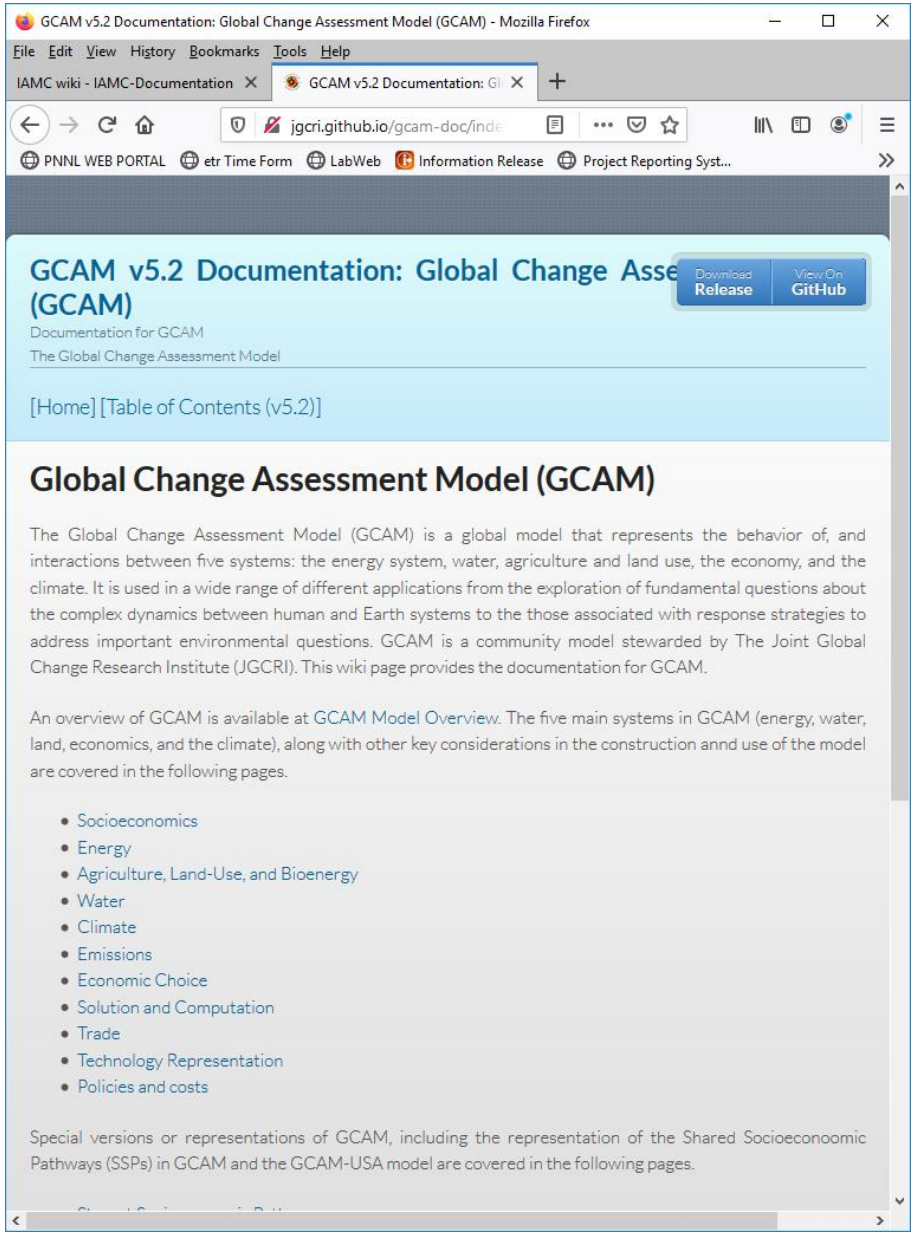


Many models have their own publicly available documentation

GCAM has both a peer-reviewed documentation and its own internal documentation.

Calvin K.V., P.L. Patel, L.E. Clarke, G.R. Asrar, B. Bond-Lamberty, A. Di Vittorio, and **J.A. Edmonds**, et al. 2019. "GCAM v5.1: Representing the linkages between energy, water, land, climate, and economic systems." *Geoscientific Model Development*. PNNL-SA-137098

How to keep everything up to date **simultaneously**?



The Asia Integrated Model (AIM)

An example of a model report to the E&D SWG

AIM Model Validation: Documentation & Availability

Model Name: Asia-Pacific Integrated Model (AIM)

Model type: Integrated Assessment Model (coupled economy, energy, land, climate system)

Model documentation: Full formulas can be found in the following free document or a book chapter.
https://www.researchgate.net/publication/303382176_AIMCGE_basic_manual

https://link.springer.com/chapter/10.1007/978-981-10-3869-3_13

Model availability: Upon request. We basically do training workshops for the users.

Model data availability: Same as above.

Community listserv: No

AIM Model Validation: Techniques

- **Hindcasting/cross-validation**
  - Energy model : Fujimori, et al. (2016)
- **Model intercomparisons**: Participation in EMF (for the current version since EMF30) as well as other model intercomparisons, e.g. CD-LINKS, AME, ADVANCE, LIMITS, AR5 and 1.5SR database.
- **Forecast trend comparison to history/"stylized facts"**

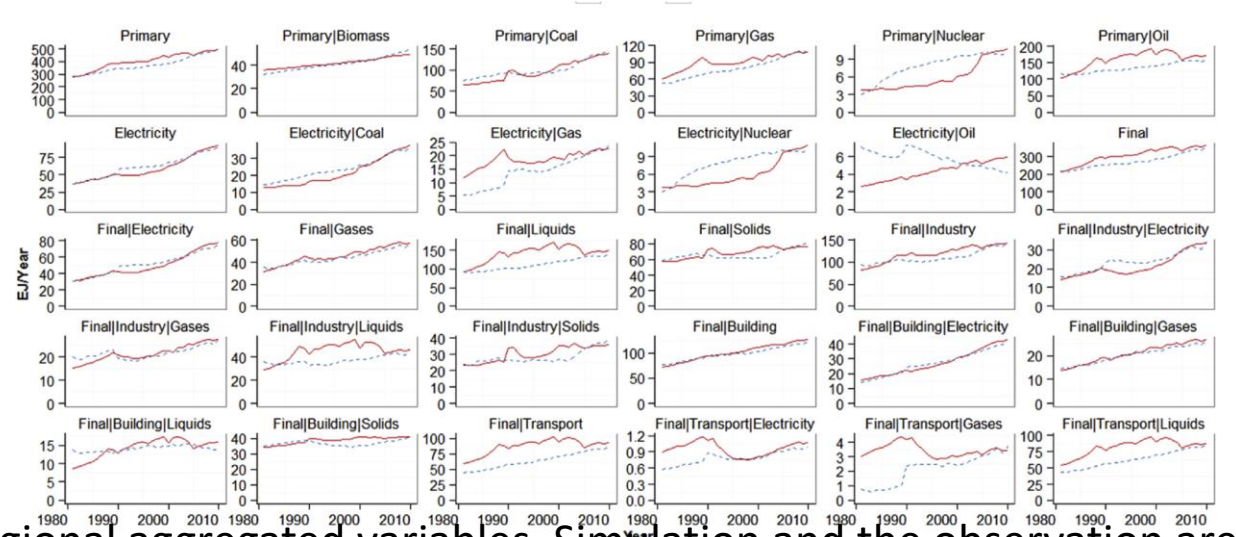


Fig. 1. World regional aggregated variables. Simulation and the observation are shown. The definition of the figure title is shown in Supporting Information in Fujimori et al. (2016).

Challenge of keeping multiple models documented and validated

- AIM CGE
- AIM ENDUSE
- AIM/SLCP tool
- AIM-SSP/RCP Gridded Emissions and Land-use data
- AIM/Trend Model
- AIM/Energy Snapshot Tool
- AIM/Energy Snapshot Tool
- AIM/climate
- AIM/impact

ReMIND/MAgPIE

An example of a model report to the E&D SWG

REMIND: Availability and Documentation

Model name: **Re**gionalized **M**odel of **In**vestments and **D**evelopment (REMIND)

Model type: Integrated Assessment Model (coupled economy, energy, climate system)

Model documentation: https://www.pik-potsdam.de/research/transformation-pathways/models/remind; https://www.iamcdocumentation.eu/index.php/Model_Documentation_-_REMIND

Model availability: Transparent source code - for the sole purpose of reading: https://www.pik-potsdam.de/research/transformation-pathways/models/remind/remind-source-code-registration;

MAgPIE: Availability and Documentation

Model name: **M**odel of **Ag**ricultural **P**roduction and its **I**mpact on the **E**nvironment (MAgPIE)

Model type: Integrated Assessment Model (land-use-system)

Model documentation: https://doi.org/10.5281/zenodo.1471526;
Peer reviewed publication: Dietrich JP, et al. (2019) *MAgPIE 4 - a modular open-source framework for modeling global land systems*. In: Geoscientific Model Development, 12 , 4. 1299-1317 p.

Model availability: Open Source at GitHub:
https://github.com/magpiemodel/magpie

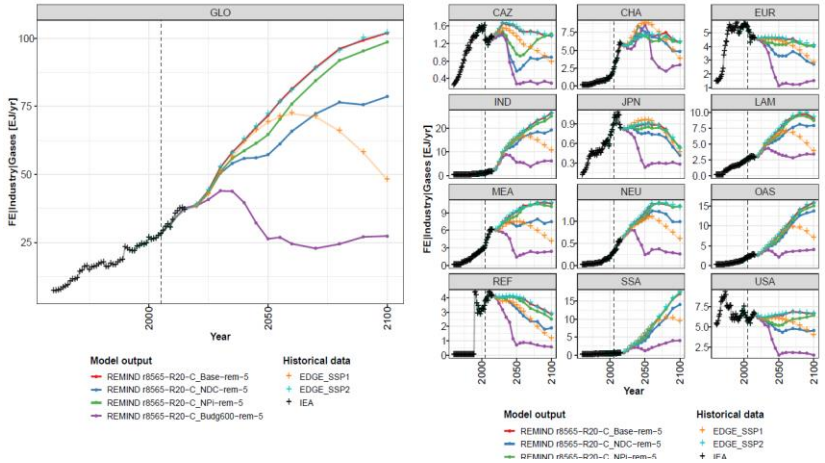
REMIND-MAgPIE: Validation of coupled system

Model intercomparisons: Participation in model intercomparisons, e.g. CD-LINKS, AR5 database, ADVANCE (VRE integration, 1.5-2°C mitigation), EMF-27, EMF30, EMF33, [LIMITS / AMPERE / RoSE]

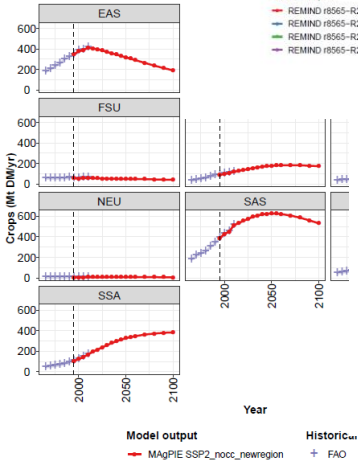
Model parts: sensitivity analysis for different parts of the model:

- **Economics:** Luderer, G. et al. "Economic Mitigation Challenges: How Further Delay Closes the Door for Achieving Climate Targets." *Environmental Research Letters* 8, no. 3 (September 1, 2013)
- **Fossil sector:** Bauer, N. et al. "Global Fossil Energy Markets and Climate Change Mitigation – an Analysis with REMIND." *Climatic Change* 136, no. 1 (May 2016)
- **Renewables:** Ueckerdt, F. et al. "Decarbonizing Global Power Supply under Region-Specific Consideration of Challenges and Options of Integrating Variable Renewables in the REMIND Model." *Energy Economics* 64, no. Supplement C (May 1, 2017)

REMIND-MAgPIE: Validation of coupled system

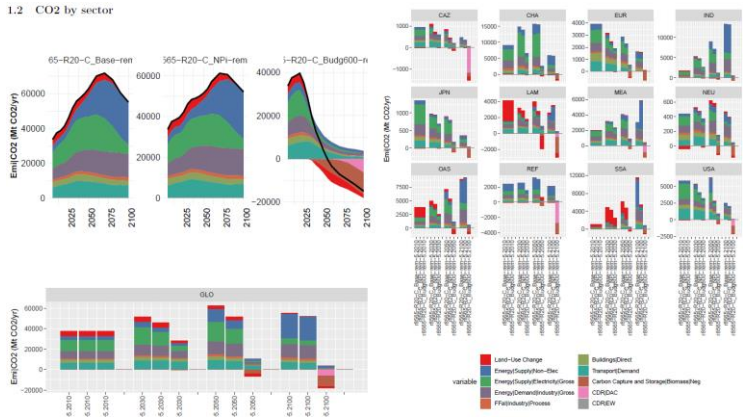


Model calibration: calibrate REMIND to match GDP and final energy trajectories



Model validation: automated generation of validation document including

1) plots of model results,
2) comparision with historical data and trends and
3) trafficlight system



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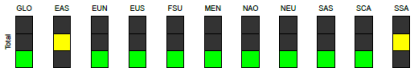

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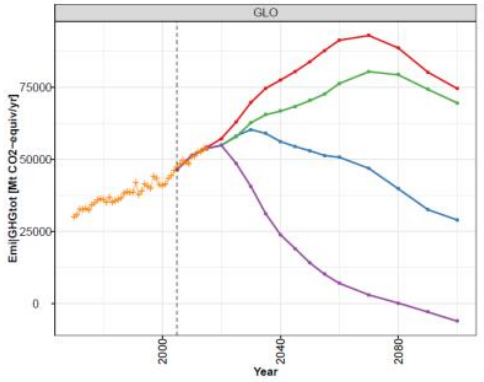

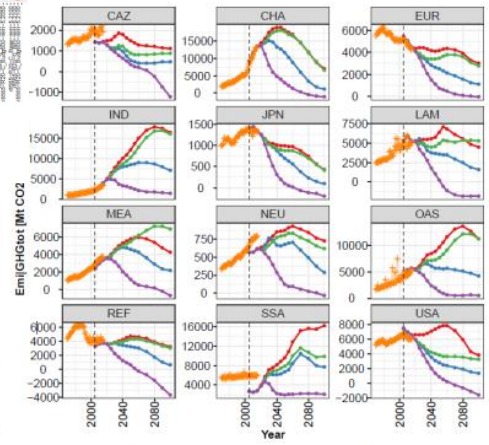

Where do we go from here?

- Do we want to create a web link to model documentation?
- Do we want to develop good practice guidelines?
- Do we want to consult with our Advisory Council on how other disciplines handle these issues?
- Model documentation journal.