A new scenario resource for integrated 1.5°C research in the context of climate change and sustainable development

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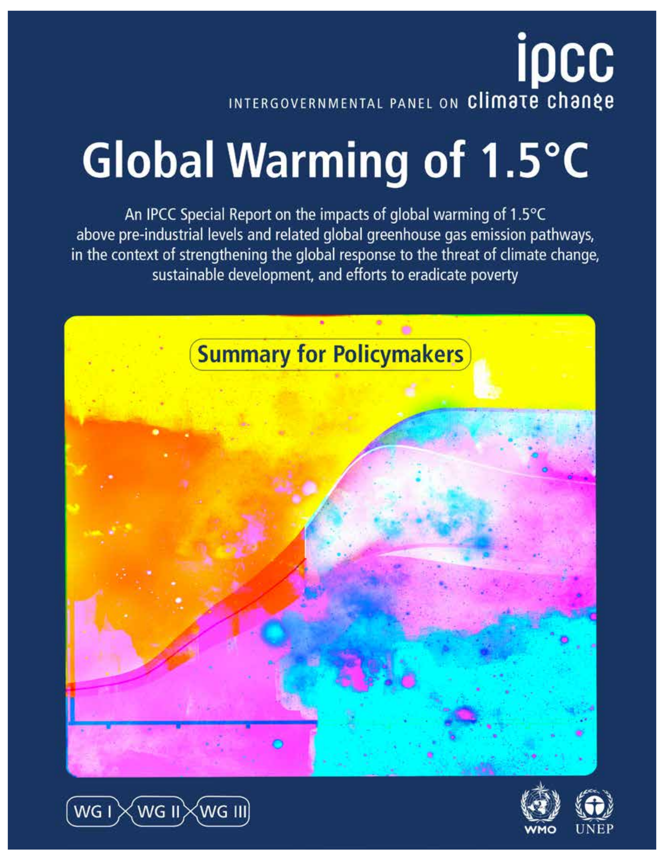


A scenario ensemble for the IPCC's *Special Report on Global Warming of 1.5°C* (SR15)

Following the Paris Agreement in 2015 to "*...pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels*", the Intergovernmental Panel on Climate Change (IPCC) prepared a Special Report on global warming of 1.5°C and related global greenhouse gas emission pathways (SR15 [1]). Among other topics, the report assessed the required system transitions and options for strengthening the global response to climate change in the context of the Sustainable Development Goals (SDG).

To support the assessment, the *Integrated Assessment Modeling Consortium* (IAMC) facilitated a coordinated and systematic community effort to compile a consolidated ensemble of quantitative,model-based scenarios with a high degree of internal consistency. [3]

Upon approval of the report by the IPCC plenary in Incheon, South Korea in October 2018, the scenario ensemble and the suite of open tools developed for the assessment were released to increase transparency and reproducibility of the scientific findings. The publication of this resource also encourages the reuse of scenario data by other research communities.

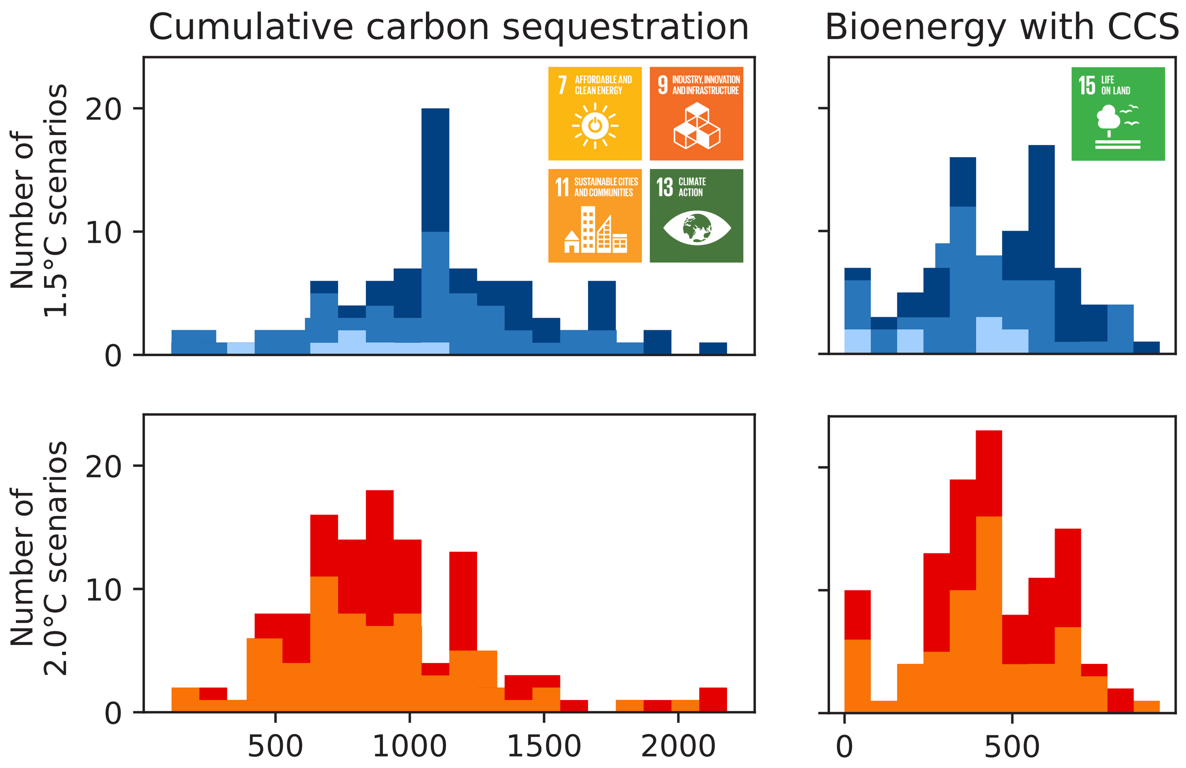
The ensemble consists of **414 scenarios** based on **17 scientific studies** submitted by **13 research teams**, categorized by climate impact and other characteristics. The data release and the suite of open tools follows the FAIR principles for open, collaborative science (see box).

The IAMC is the umbrella organization of modelling teams conducting climate change mitigation analyses (www.globalchange.umd.edu/iamc)

Two illustrative angles of analysis based on the scenario ensemble

Negative emissions and the 1.5°C goal

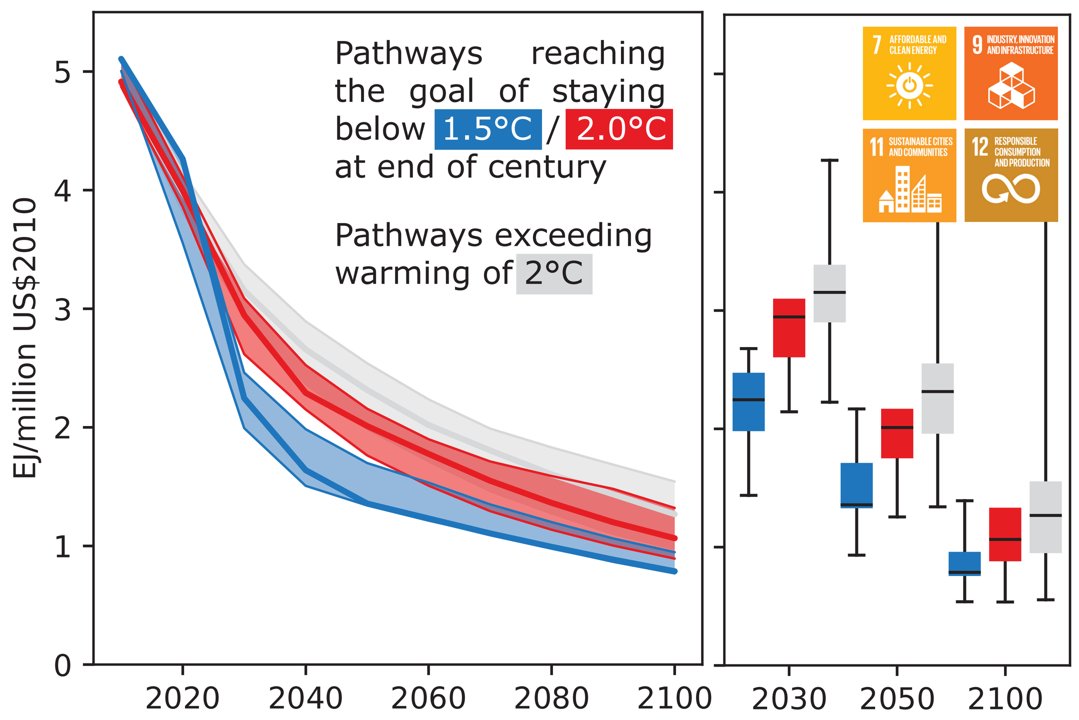
Many scenarios use negative emissions technologies such as carbon capture and sequestration (CCS) in the second half of the century to a substantial extent. The ensemble shows that not all pathways require the use of (bioenergy) CCS to reach the temperature goal.



Cumulative carbon sequestration from 2020 until 2100 (in Gt CO_2); cf. Figure 1 [3]

Decoupling of economic growth and energy demand

All scenarios meeting the goal to keep warming below 1.5°C at the end of the century exhibit rapid decoupling of GDP and energy consumption. Decreasing energy intensity indicates higher efficiency and suggests that demand reduction is a critical mitigation policy.



Energy efficiency computed as total final energy per per unit of GDP

FAIRness for open research

The *FAIR Guiding Principles* [6] are domain-independent desiderata that can be applied to a wide range of scholarly outputs. To assist transparency and reproducibility, data and metadata (including source code) must be:

- Findable (unique persisten identifier, rich metadata)
- Accessible (retrievable using standard protocols)
- Interoperable (formal vocabularies, references)
- Reusable (clear licence, community standards)

The IAMC data template

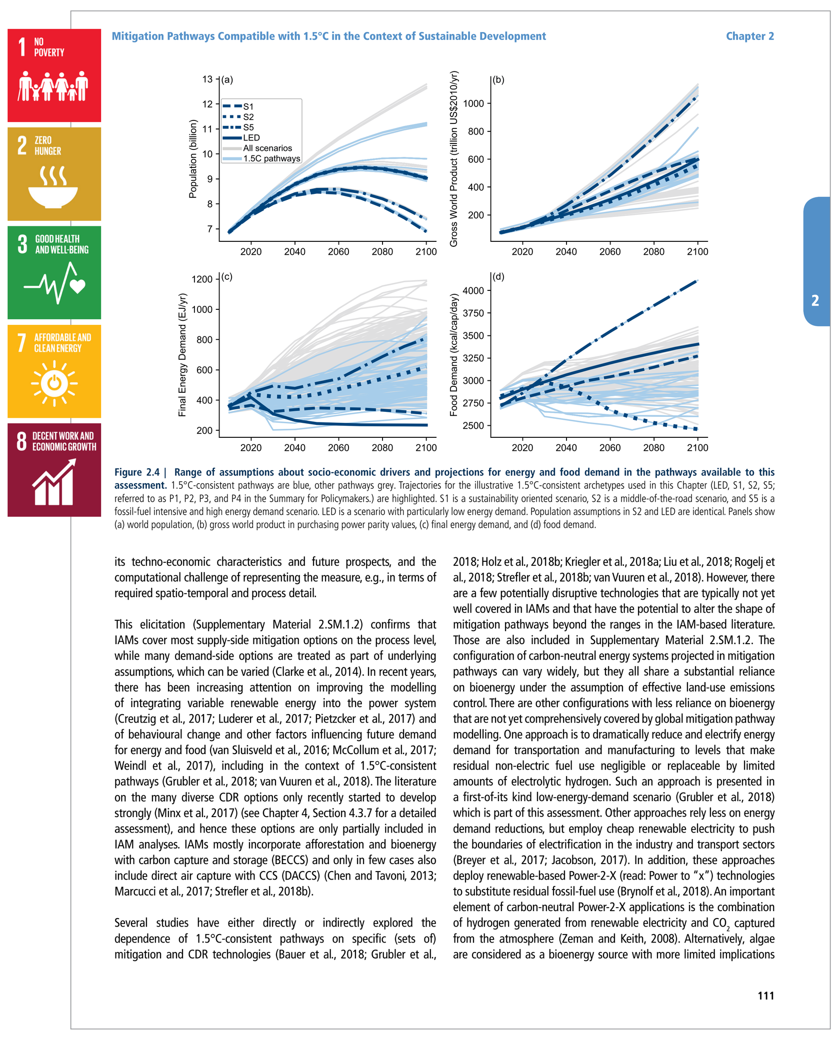
The scenario data was collected in the data format used by the IAM community for model comparison projects.

	A	B	C	D	E	F	G	H	I
1	Model	Scenario	Region	Variable	Unit	2005	2010	2015	2020
2	MESSAGE	CD-LINKS 400	World	Primary Energy	EJ/y	454.5	479.6	...	...

Open tools to facilitate exploration and analysis

Scenario assessment in the SR15

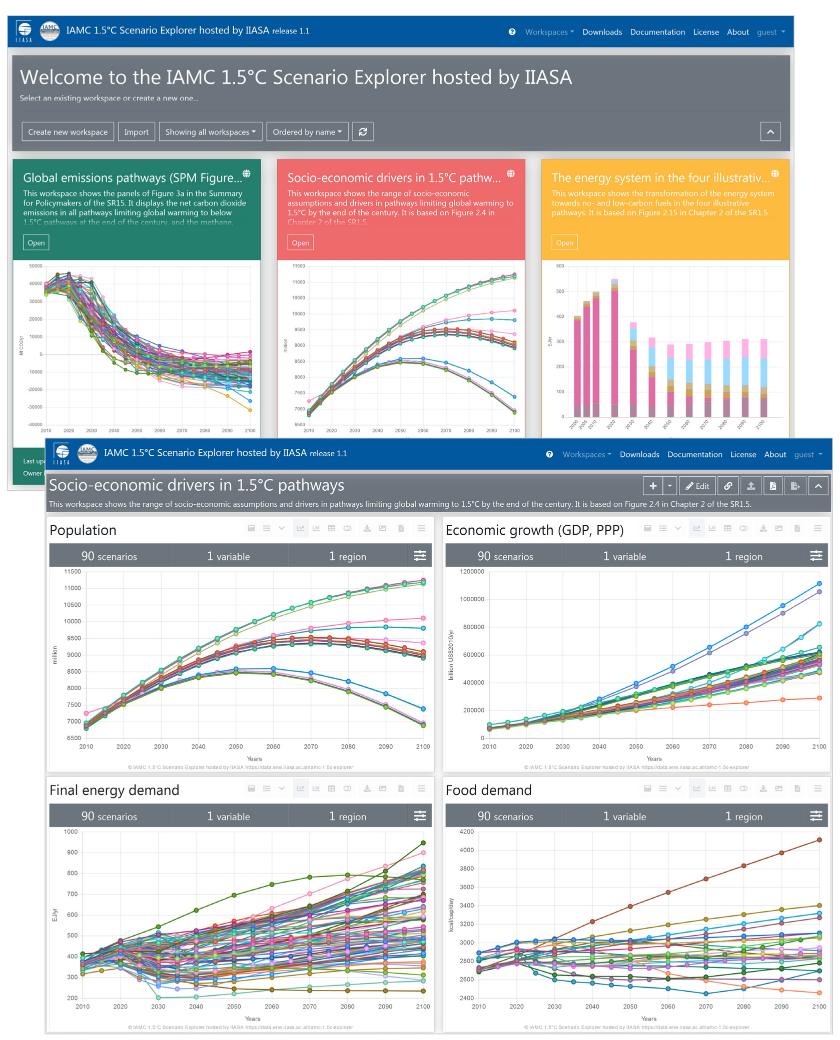
The Special Report [1] draws on quantitative pathways to evaluate synergies & trade-offs of mitigation policies across many indicators related to sustainable development.



Page 111 and Figure 2.4 of Chapter 2, SR15 [1]

An interactive scenario explorer

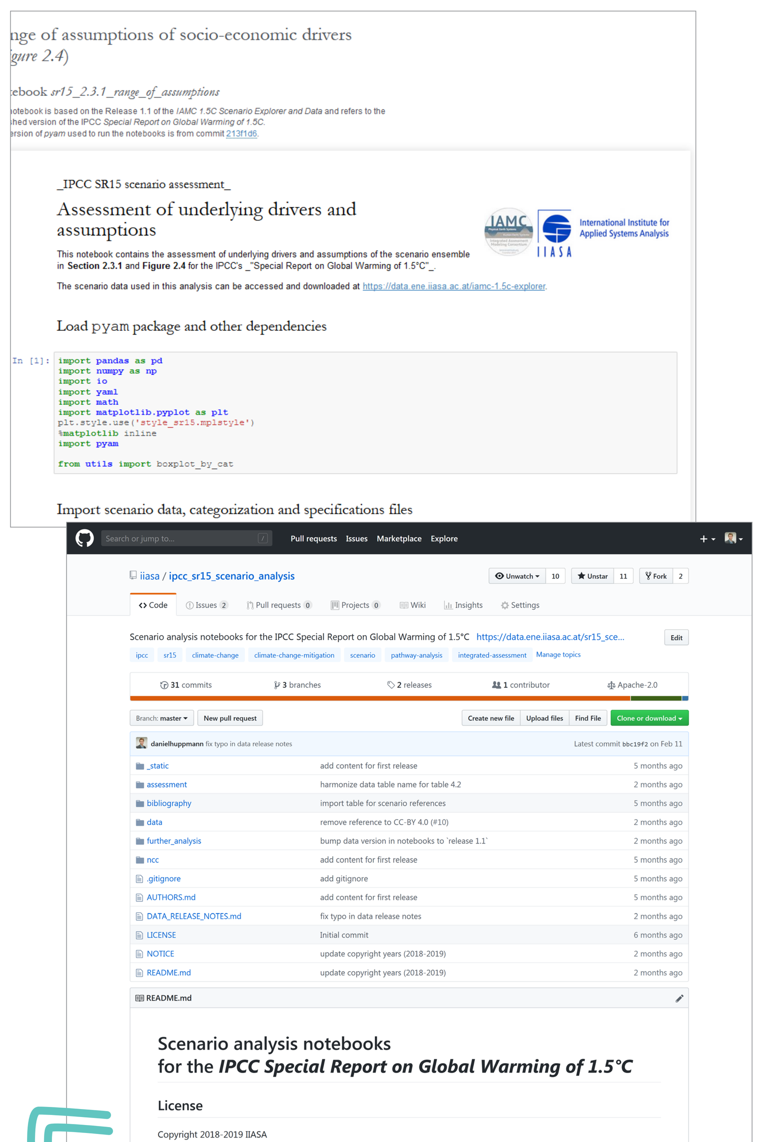
The online explorer [4] provides an intuitive entrypoint to the scenario ensemble, including metadata, documentation and cross-references to underlying publications.



url: data.ene.iiasa.ac.at/iamc-1.5c-explorer

Open-source analysis notebooks

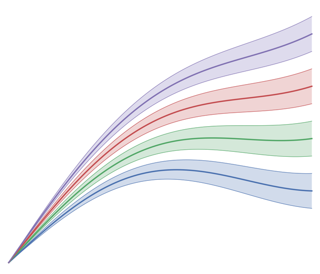
The scripts and notebooks used to generate many figures and tables in the SR15 are available on GitHub under the open-source APACHE 2.0 license. [5]




```
$ git clone git@github.com:iiasa/
  ipcc_sr15_scenario_analysis.git
```

A Python package for the IAM community

python



pyam: analysis and visualization of integrated assessment models

License Apache 2.0 | passing | coverage 85% | pypi v0.1.2 | Anaconda Cloud 0.1.2 | DOI 10.5281/zenodo.1491662 | JOSS 10.21105/joss.01095

The *pyam* package [2] facilitates open, collaborative analysis of integrated assessment and climate models.

Repository: github.com/IAMconsortium/pyam
Documentation: pyam-iamc.readthedocs.io

References

[1] IPCC (2018) *Global warming of 1.5°C*. World Meteorological Organization, Geneva, Switzerland. url: www.ipcc.ch/report/sr15/

[2] Gidden, M. and Huppmann, D. (2019). pyam: a Python Package for the Analysis and Visualization of Models of the Interaction of Climate, Human, and Environmental Systems. *Journal of Open Source Software* 4(33):1095. doi: 10.21105/joss.01095

[3] Huppmann, D., et al. (2018). A new scenario resource for integrated 1.5°C research. *Nature Climate Change* 8:1027-1030. doi: 10.1038/s41558-018-0317-4

[4] Huppmann, D., Kriegler, E., Krey, V., Riahi, K. Rogelj, J., Rose, S.K., Weyant, J., et al. (2018). *IAMC 1.5°C Scenario Explorer and Data*. Integrated Assessment Modeling Consortium & IIASA. doi: 10.22022/SR15/08-2018.15429

[5] Huppmann, D., et al. (2018). *Scenario analysis notebooks for the IPCC Special Report on Global Warming of 1.5°C*. IIASA. doi: 10.22022/SR15/08-2018.15428

[6] Wilkinson, M.D., et al. (2016). The FAIR Guiding Principles for scientific data management and stewardship. *Scientific Data* 3:160018. doi: 10.1038/sdata.2016.18

CD-LINKS | Federal Ministry of Education and Research | Bundesministerium Bildung, Wissenschaft und Forschung | SENSES | ClimateWorks Foundation

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