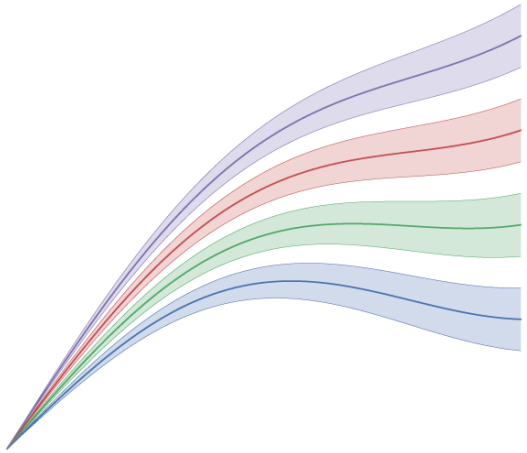
International Institute for Applied Systems Analysis
IIASA www.iiasa.ac.at

ENGAGE FEASIBILITY OF CLIMATE PATHWAYS

The Python package *pyam* for analysis, validation & visualization of integrated-assessment and energy-systems scenarios



pyam: analysis and visualization of integrated assessment scenarios

License Apache 2.0 | python ≥3.8 | mail groups.io | chat Slack

code style black | pytest passing | docs passing | codecov 95%

DOI 10.5281/zenodo.1470400 | ORE 10.12688/openreseurope.13633.2

Repository hosted on GitHub | Community supported by Groups.io slack | Documentation hosted by Read the Docs

Daniel Huppmann

NAVIGATE-ENGAGE Summer School

July 4, 2023

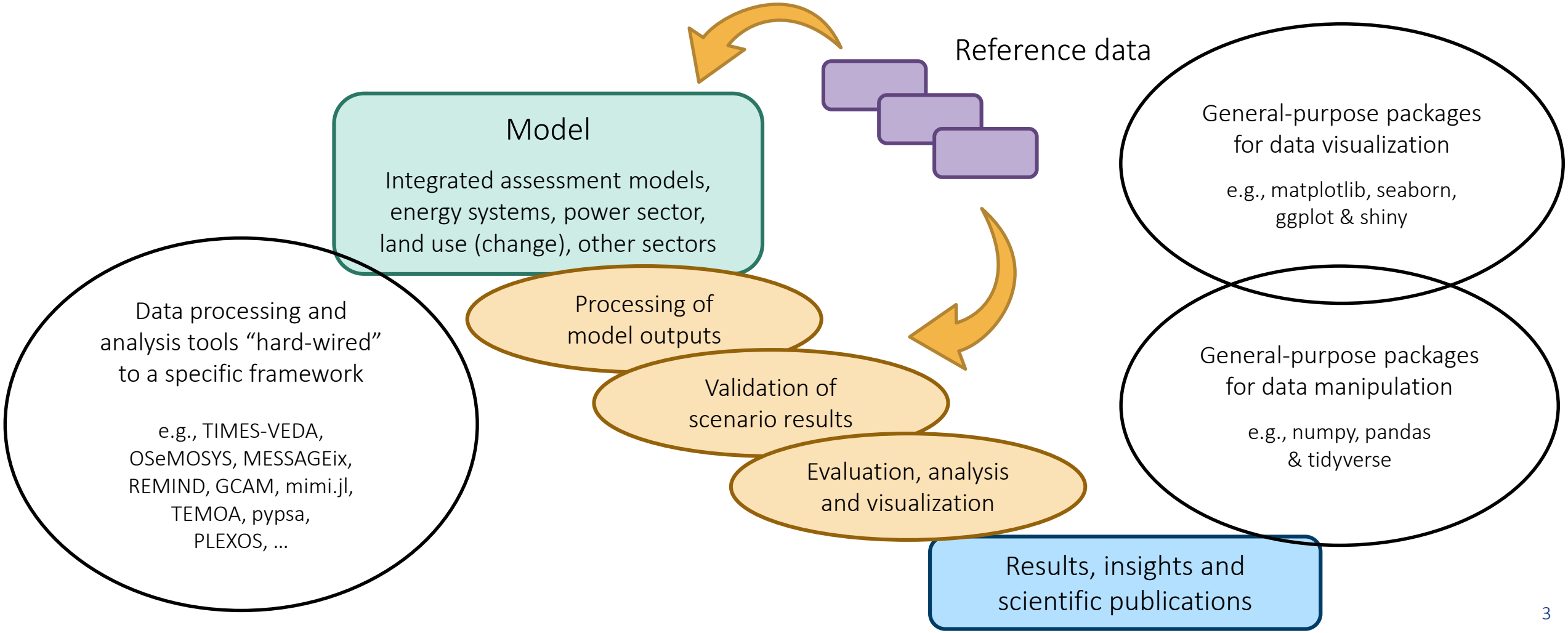
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 821471 (ENGAGE).

Part 1

Introduction & motivation

Introduction: From model results to scenario analysis

There are many solutions and tools for scenario analysis & data visualization, but most are tools either "hard-wired" to a modelling framework or general purpose



Better-practices for scripts for scenario analysis and data visualization

Many modelling frameworks adopt "best-practice of collaborative development", but scripts for scenario analysis are often written in an ad-hoc fashion

- A common approach to scenario analysis & data visualization
  ⇒ Write a few lines of code for a simple feature – a few features – and a little bit more …
- Caveats of this incremental approach (not always, but way too often)
  ⇒ *copy-paste* of large snippets of code from one project to the next
  ⇒ No version management for the analysis scripts
  ⇒ Insufficient documentation of code
  ⇒ No testing, no *continuous-integration*-strategy
- Why is this a problem for open & reproducible science?
  ⇒ Limited reproducibility or transparency of the results
  ⇒ Risk of errors or bugs in existing features during further development
  ⇒ Risk of errors or bugs due to dependency updates

Our vision: a community Python toolbox for energy & climate research

The pyam package offers a suite of model-independent methods to streamline the processing, analysis & visualization of scenario results

- Design principles:
  - ⇒ Harmonized data structure and formats
  - ⇒ Model-independent standardized methods for scenario analysis & visualization
  - ⇒ Modular package architecture and simple integration in other packages & workflows

- Advantages for modellers and analysts
  - ⇒ Standardized interface following the *pandas* & *matplotlib* packages
  - ⇒ Comprehensive documentation, tutorials, email list, Slack workspace, …
  - ⇒ Increased transparency & better intelligibility through shorter analysis scripts
  - ⇒ High performance implementation as `pandas.Series` statt `pandas.DataFrame`
  - ⇒ High reliability thanks to a well-testing package with a *continuous-integration*-strategy

Part 2

The pyam package

Supported data models and file formats

The package supports various formats & types of timeseries data and is currently used by more than a dozen modelling teams

Supported timeseries data formats:

The *pyam* package was initially developed to work with the *IAMC template*, a tabular format for yearly timeseries data

	A	B	C	D	E	F	G	H
1	**Model**	**Scenario**	**Region**	**Variable**	**Unit**	**2005**	**2010**	**2015**
2	MESSAGE	CD-LINKS 400	World	Primary Energy	EJ/y	462.5	500.7	...

But the package also supports sub-annual time resolution

⇒ Continuous-time formats (e.g., hourly timeseries data)

⇒ Representative sub-annual timeslices (e.g., "winter-night")

Compatible i/o and file formats:

⇒ Full integration with the *pandas* data analysis package

⇒ Tabular data (`xlsx`, `csv`) & "frictionless" datapackage format

The *pyam* package for integrated assessment & macro-energy modelling

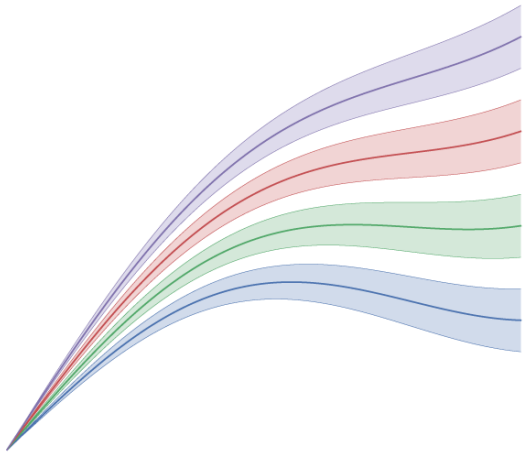
A community package for scenario processing, analysis & visualization following best practice of collaborative scientific software development

python™

Use cases and features

- ⇒ Data processing — Data i/o & file format conversion, aggregation, downscaling, unit conversion, …
- ⇒ Validation — Checks for completeness of data, internal/external consistency, numerical plausibility …
- ⇒ Analysis & visualization — Categorization and statistics of scenario ensembles, plotting library, …

D. Huppmann, M. Gidden, et al. (2021). *Open Research Europe* **1**:74. doi: 10.12688/openreseurope.13633.2



***pyam*: analysis and visualization of integrated assessment scenarios**

License Apache 2.0 | python ≥3.8 | mail groups.io | chat Slack

code style black | pytest passing | docs passing | codecov 95%

DOI 10.5281/zenodo.1470400 | ORE 10.12688/openreseurope.13633.2

Repository hosted on GitHub — Community supported by Groups.io slack — Documentation hosted by Read the Docs

#pyam_iamc

pyam-iamc.readthedocs.io

Developing a community for a community package

We made an effort to make the pyam package usable for modellers & analysts with a wide range of experience levels and scientific backgrounds

- Simple installation
  ⇒ Available via the common Python managers *pypi* and *conda*
- Open-access manuscript & comprehensive documentation
  ⇒ Several tutorials and full-fledged API documentation

Read the Docs

- For novice users or moderate-interest users:
  ⇒ An email list for announcements of new releases and questions

Groups.io

- For users interested in frequent updates, tips-and-tricks and more interaction
  ⇒ A Slack workspace with a **#helpdesk** channel

slack

- For expert users and anyone interested in contributing
  ⇒ The GitHub repo for collaborative scientific software development
  like issues and pull requests, continuous-integration workflows, release management, etc.

GitHub

Part 3

A live demo & interactive discussion

See the open-source notebook at
https://github.com/danielhuppmann/ENGAGE-pyam-tutorial

Thank you very much for your attention!

This presentation is available at https://doi.org/10.5281/zenodo.8112529

Dr. Daniel Huppmann

Senior Research Scholar – Energy, Climate, and Environment Program

International Institute for Applied Systems Analysis (IIASA)

Schlossplatz 1, A-2361 Laxenburg, Austria

huppmann@iiasa.ac.at

@daniel_huppmann

@daniel_huppmann@mastodon.social

www.iiasa.ac.at/staff/daniel-huppmann