

Pathway to regular and sustained delivery of climate forcing datasets workshop: 28-31 October 2024, ECMWF Reading

Session 6: Sustained mode challenges

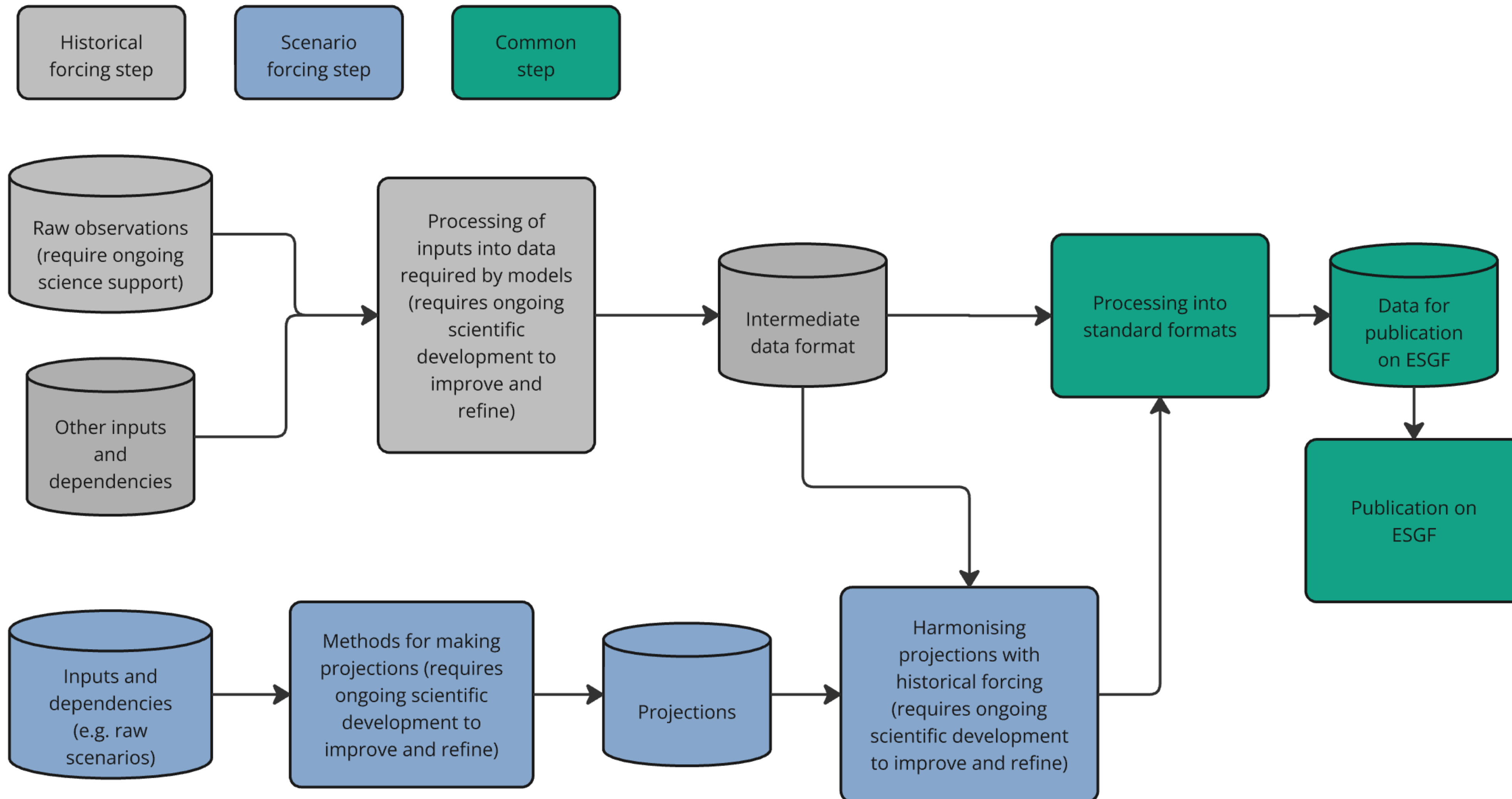
Chair: Eleanor O'Rourke

Agenda

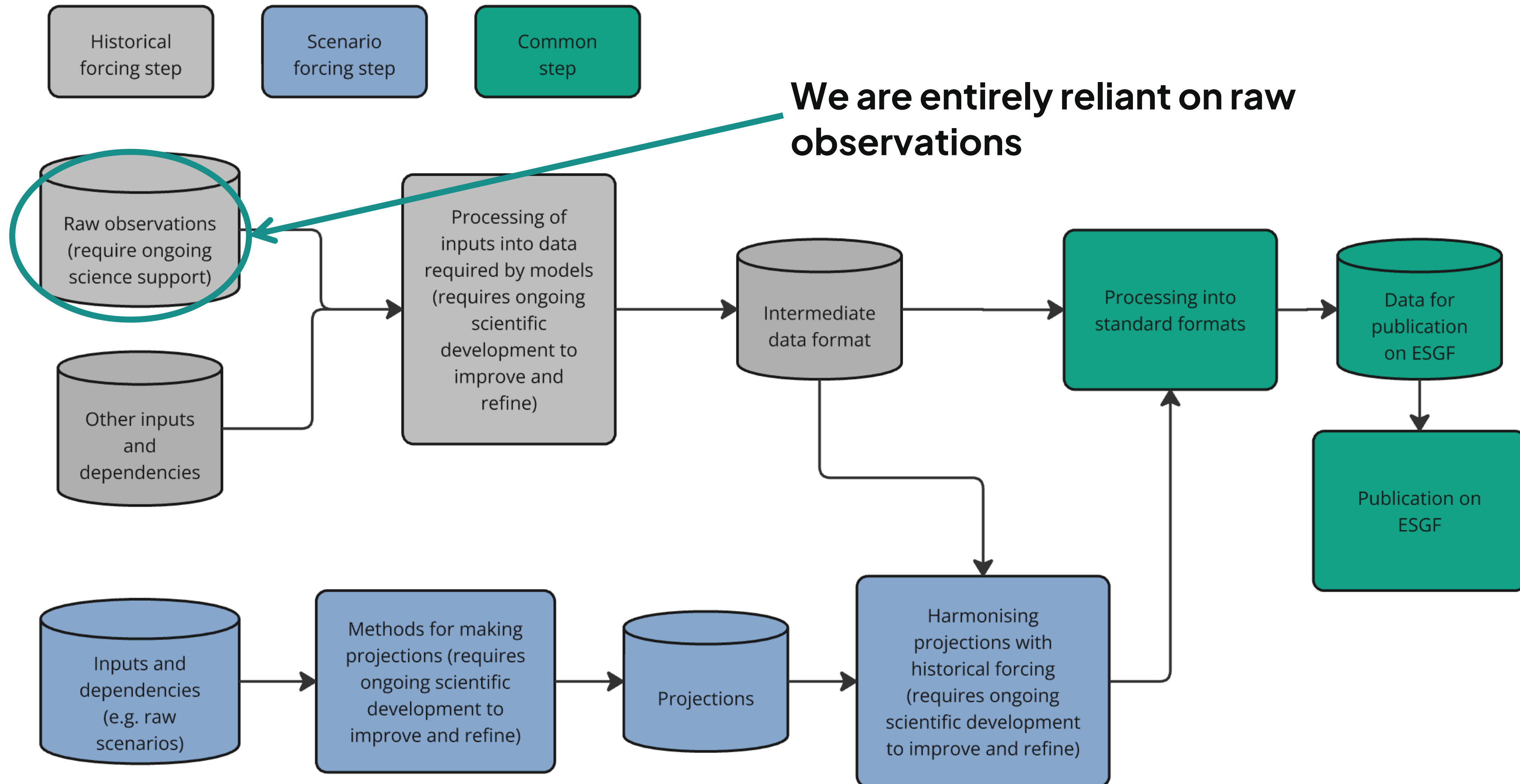
- Setting the stage
- Refining the challenges for both historical and scenario forcings
- Refining the presentation of the current process and proposed options for sustained mode for the plenary session

Setting the stage

Producing forcings (roughly)



Producing forcings

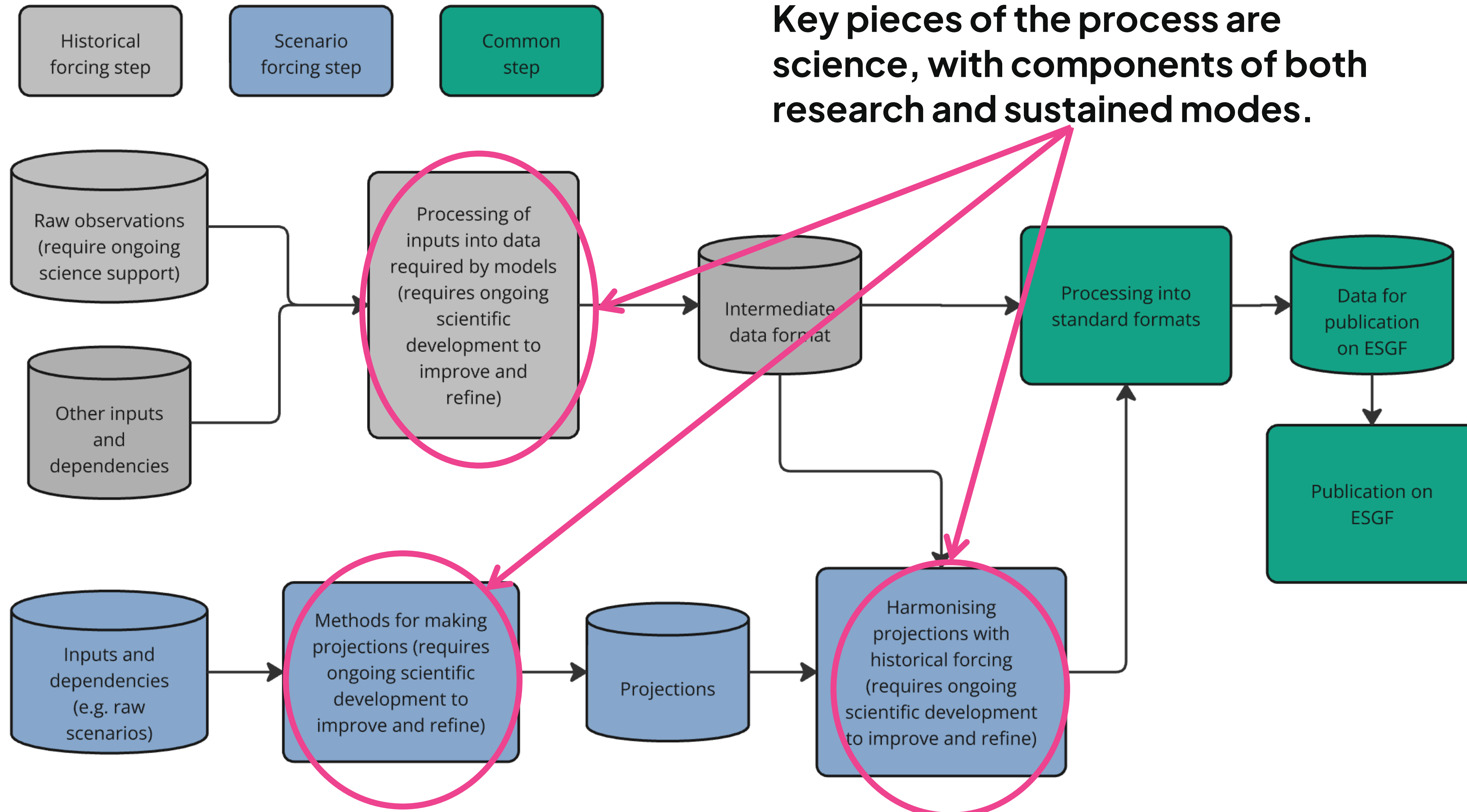


Producing forcings – who funds the raw observations

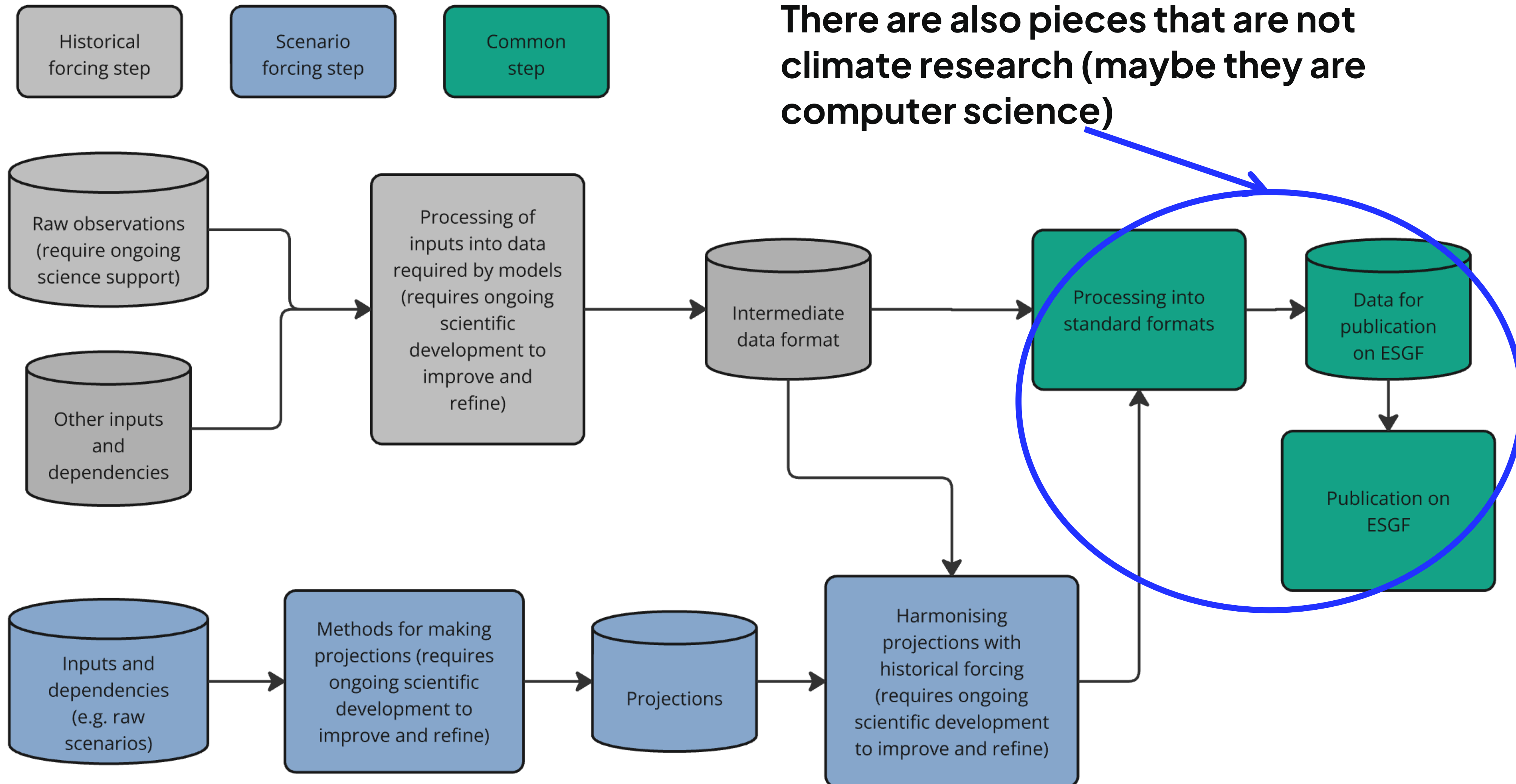
Some well known names, but otherwise surprisingly diverse (at least at the top layer, maybe they turn out to be the same)

- NASA – 5 datasets
- NOAA – 3 datasets
- UK Met Office – 2 datasets
- Lots of others fund a single dataset
 - Copernicus, ECMWF, ESA, EUMETSAT, Energy Institute, European Commission, GFZ, Governments, IAMs, ICOS, IEA, LASP, MPI-MAC, NCEI, National Agencies, SIDC, Royal Observatory of Belgium, Schmidt Sciences, UNFAO, US Gov, USGS and international industry associations, various consortiums

Producing forcings



Producing forcings



Sustained mode - meaning

- Definition will be discussed further in Plenary 1
- To give us something to work with, a starting point for the meaning of ‘sustained mode’
 - Approximately annual extensions of all input forcing data based on the latest observations
 - Definitely historical, maybe also scenarios (depends a bit on IAM and other scenario source activities)
 - ESGF publication is a key part of this work
 - An agreed frequency at which updates, i.e. changes in methodology that affect the entire timeseries, would be published and older methodologies would be deprecated.
 - We might want to only do this e.g. every 3 years, rather than every year, to provide better continuity and a simpler experience for users
 - We might want to ‘guarantee’ support methodologies for a relatively long period for users who need continuity, e.g. 5-10 years

Where we are today

- Forcings are mostly produced by researchers in research organisations
- Direct funding for producing CMIP forcings is the exception, rather than the norm
- We are getting better at sharing tools and knowledge, but it is definitely not perfect
 - Lots of problems are solved multiple times by different groups, rather than sharing a solution (and avoiding duplicate work)

Refining the challenges for both historical and scenario forcings



Challenges for sustained mode – supporting both research and a sustained mode

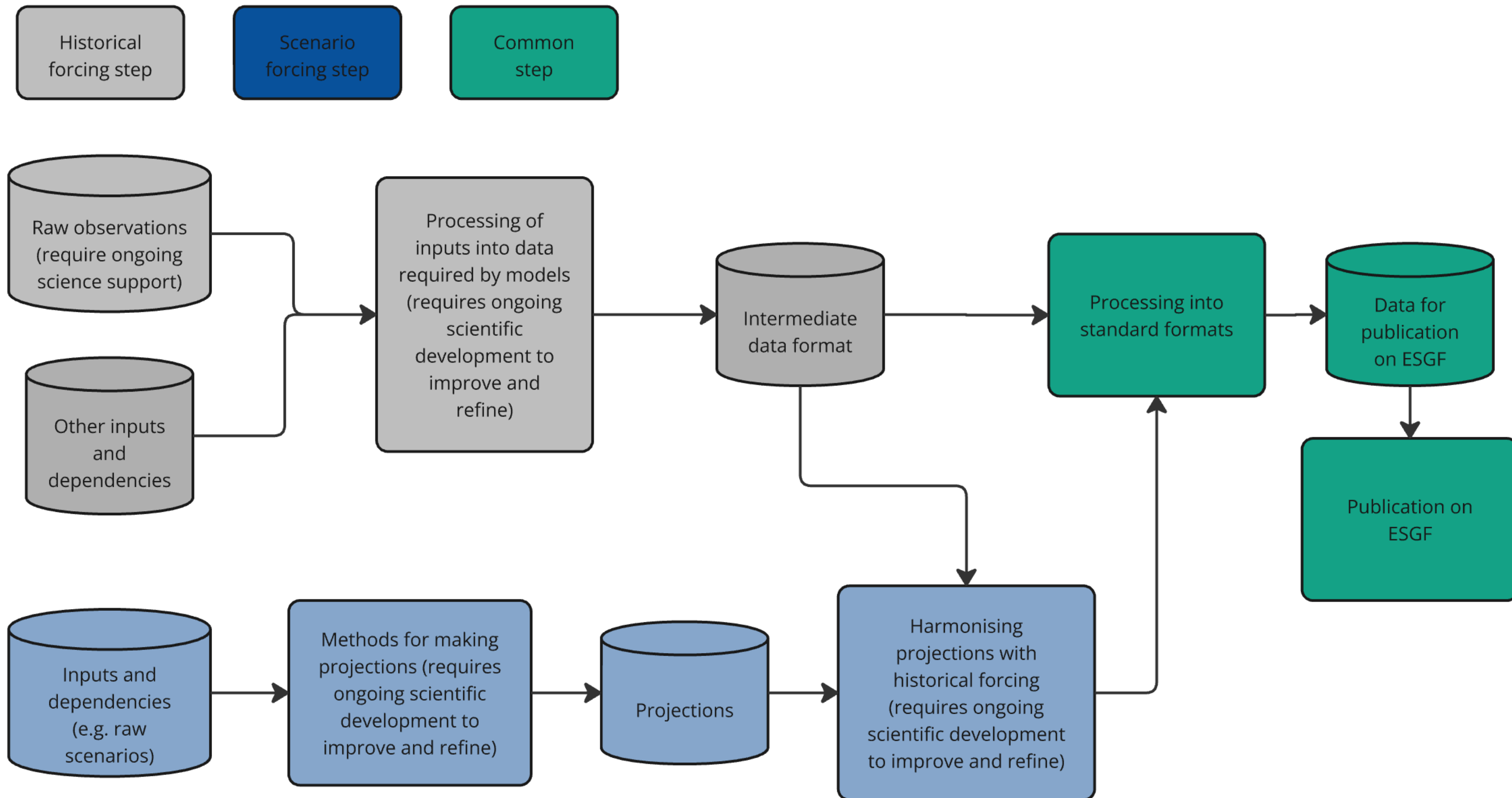
- There is still lots of research to be done
 - We're not in a position to move everything into a sustained mode tomorrow
- Supporting both research science and sustained science will be a challenge

Challenges for sustained mode – capacity

A view (perhaps slightly provocative)

- We produce data, so we have solutions to many challenges
- For a sustained mode, the issue is capacity
- So, the question: Why don't we have the capacity to support a sustained mode already?
 - Let's start with a slightly deeper dive into the current process

Challenges for sustained mode - capacity



Challenges for sustained mode – capacity

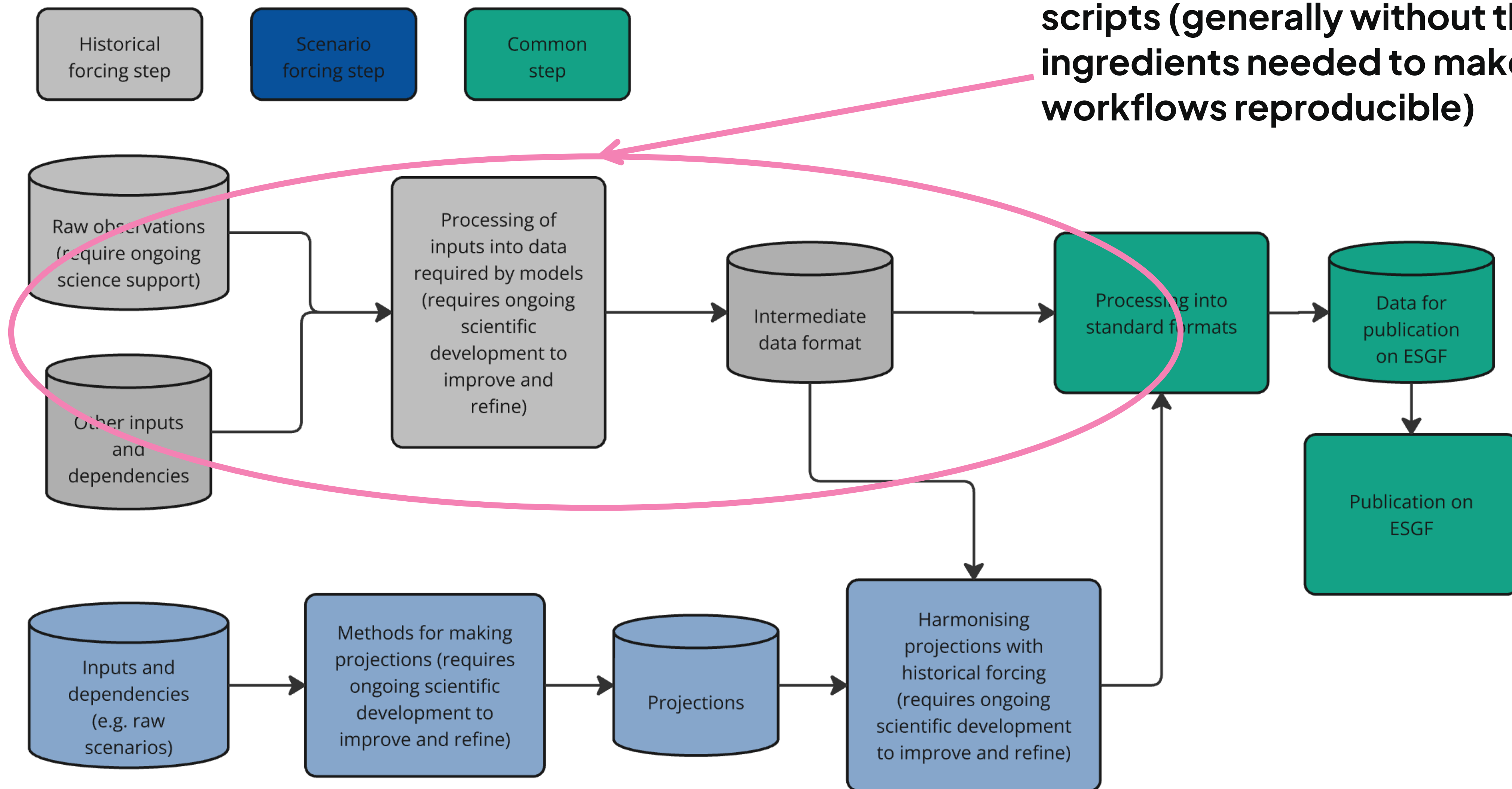
Observation 1: For a sustained mode, you need to run (basically) the same thing over and over again.

Problem with current status: Scientists are trained and funded to do new things, not the same thing over and over again. Maintenance is either unfunded or, when it is funded, scientists are currently the ones in charge of maintenance (despite that not being their expertise, aligned with key career KPIs etc.).

Result: Either no or limited capacity for the maintenance that a sustained mode requires.

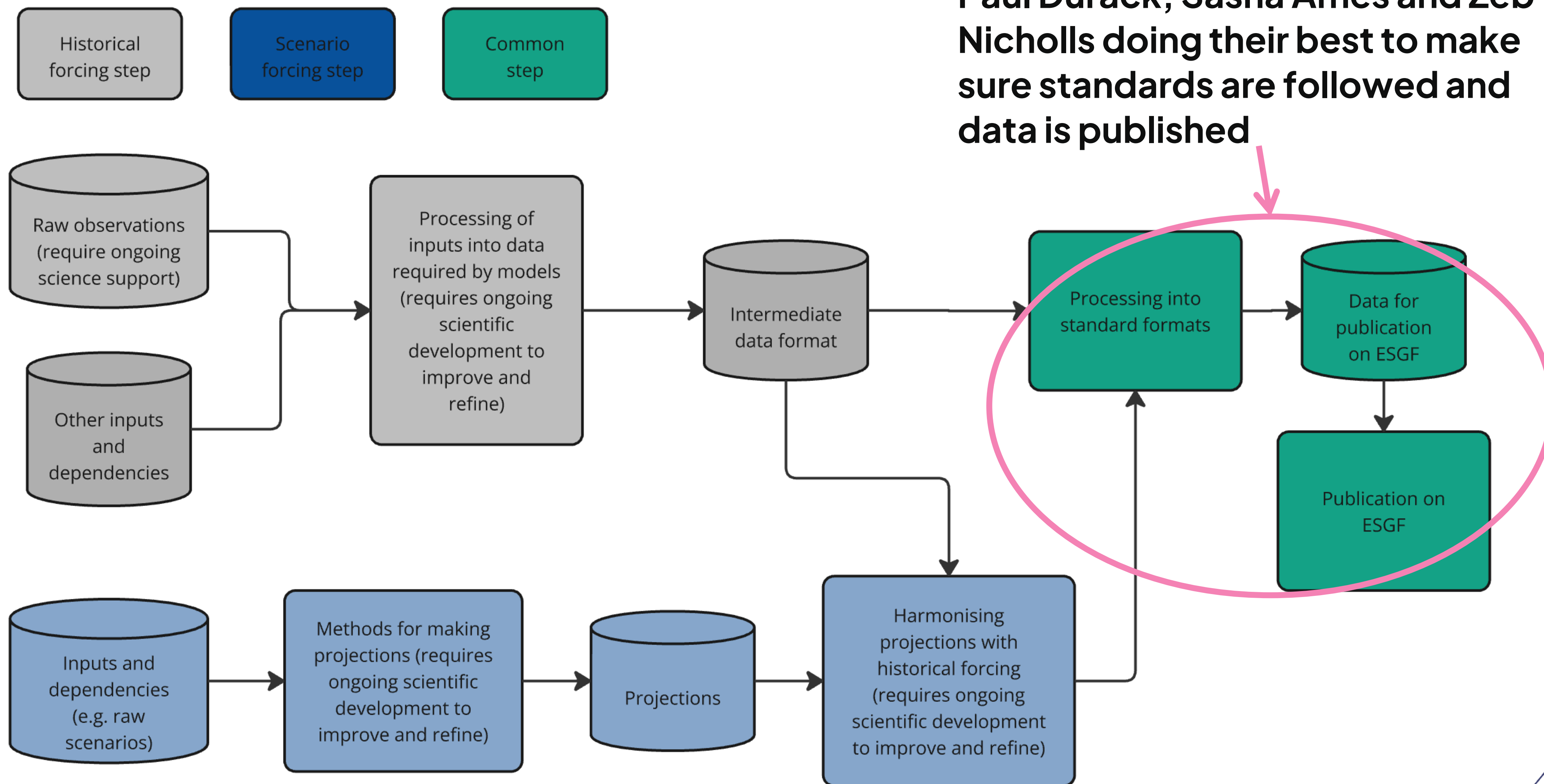
Challenges for sustained mode - capacity

Forcing providers running local scripts (generally without the key ingredients needed to make workflows reproducible)



Challenges for sustained mode - capacity

Paul Durack, Sasha Ames and Zeb Nicholls doing their best to make sure standards are followed and data is published



Challenges for sustained mode – capacity

Observation 2: For a sustained mode, you need capacity to handle all the data, check metadata etc..

Problem with current status: Limited capacity to provide guidance and ensure standards, with high reliance on relatively few people.

Result: Challenges for data providers due to limited support and shared tools. Not everything is caught, so users don't have as smooth an experience as they could.

Challenges for sustained mode – capacity

We don't have the capacity to support a sustained mode already because it's no-one's job

There aren't enough people whose entire job is to provide a solid base for climate science. Put another way: a chemistry lab with no lab technicians would be a disaster. In climate science, we have labs without lab technicians, and we all pay the price.

Challenges for sustained mode – capacity

How can we get the capacity we need?

- Research scientists?
 - Seems not ideal, because: a) wrong skills, b) wrong working modes and c) misaligned with career incentives
- Sustained science team
 - Could work (there are models we could learn from)
 - Could be very expensive
 - Requires very good organisation and coordination

Challenges for sustained mode – capacity

A provoking quote from Stevens (2024, <https://doi.org/10.1029/2023AV001086>)

- “In retrospect it now seems clear that attempting to establish and maintain operational rigor within the research environment is counter productive”

I’m not sure I completely agree, but it leads to an interesting question:

What is the right working model for sustained mode science?

Challenges for sustained mode - prompting discussion points

- How do we build capacity for sustained science for forcings?
 - How do we support the research that is needed alongside the sustained mode?
 - How do we build expertise?
 - Where should the expertise sit?
 - How do we organise ourselves so there is a smooth link between raw observations, research science and sustained science over multiple years?
- Could CMIP experiments become routine, rather than a huge lift?
 - In other words, could we spend 10% of effort every year, rather than 100% of effort once every five years.

Refining the presentation of the current process and proposed options for sustained mode for the plenary session

Refining the presentation for the plenary

- In Plenary 2, we will present a summary of these challenges
- The summary is intended to be a helpful guide for the funders panel
- ZN will also try and refine this in reaction to plenary 1, which will better define what a sustained mode means and user requirements
- Link to presentation for Plenary 2: <https://office.wcrp-cmip.org/Products/Files/DocEditor.aspx?fileid=10062>

Status of each dataset

A thought

- We need information like this, i.e. information about the state of our science, to ensure we are putting effort in the most effective places

Can't do everything everywhere all at once, but we do need to track everything everywhere all at once

Anthropogenic short-lived climate forcer (SLCF) and CO₂ emissions

Basic info

- Anthropogenic short-lived climate forcer (SLCF) and CO₂ emissions
 - CEDS-CMIP-2024-07-08 (and CEDS-CMIP-2024-07-08-supplemental)
- Key contacts:
 - Historical: "Smith, Steven J (PNNL-JGCRI)" <ssmith@pnnl.gov>, "Hoesly, Rachel M" <rachel.hoesly@pnnl.gov>
 - Scenarios (in addition to the above): Matthew Gidden <gidden@iiasa.ac.at>, Jarmo Kikstra <kikstra@iiasa.ac.at>
- Did you provide forcings for CMIP6? yes
- Any key papers/references:
 - <https://github.com/JGCRI/CEDS> (README is very helpful)
 - Hoesly et al., 2018: <https://gmd.copernicus.org/articles/11/369/2018/gmd-11-369-2018.html>

Status of current methods

- For historical forcings, the status of our method for temporally extending is: in development
- For historical forcings, the status of our method for updating is: stable
- For scenario forcings, the status of our method for making projections and harmonising is: stable

- ‘Temporally extending’ means adding extra data to the end of existing forcings data, without altering already existing data
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- ‘Stable’ means that the methods have been used consistently, but are not used in a ‘sustained mode’ way (e.g. they require specific people to run them, aren’t automated, aren’t used regularly)
- ‘Sustained mode’ means that the forcings are produced routinely in at least a semi-automated way

Raw observations used

- Huge number: https://github.com/JGCRI/CEDS/wiki/Data_and_Assumptions
- IEA energy statistics – IEA
- EDGAR – European Commission
 - Periodic concern about funding, it is a very useful data set!
- Metal production volumes – USGS and international industry associations
- Energy institute activity data – Energy Institute
- NASA SO2 point source catalogue – NASA
 - <https://so2.gsfc.nasa.gov/measures.html>
 - Funding a bit unclear
- Country-level emission inventories – local governments

Open biomass burning emissions

Basic info

- Open biomass burning emissions
 - DRES-CMIP-BB4CMIP7-1-0
- Key contacts:
 - Historical: Margreet van Marle <Margreet.vanMarle@deltares.nl>, guido.vanderwerf@wur.nl
 - Scenarios (in addition to the above): Matthew Gidden <gidden@iiasa.ac.at>, Jarmo Kikstra <kikstra@iiasa.ac.at>
- Did you provide forcings for CMIP6? yes
- Any key papers/references:
 - Van Marle et al., 2017: <https://gmd.copernicus.org/articles/10/3329/2017/>
 - <https://www.globalfiredata.org/related.html#gfed4>
 - Updates from <https://essd.copernicus.org/articles/9/697/2017/>

Status of current methods

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 - GFED5 being developed as we speak, unlikely to be ready in time for CMIP7 because we have to wait for publication first
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Raw observations used

- VIIRS fire data - NASA
 - Operational product
 - [comment on quality of link with the provider]
- ECMWF weather data - ECMWF
 - Increasingly important for future
 - [comment on quality of link with the provider]

Land use

Basic info

- Land use
 - UofMD-landState-3-0
- Key contacts:
 - Historical: Louise Chini <lchini@umd.edu>, gchurtt@umd.edu
 - Scenarios (in addition to the above): multiple land-use modelers at Integrated Assessment Model centers
- Did you provide forcings for CMIP6? yes
- Any key papers/references:
 - Hurtt et al., 2020: <https://gmd.copernicus.org/articles/13/5425/2020/gmd-13-5425-2020.html>
 - Chini et al., 2021: <https://doi.org/10.5194/essd-13-4175-2021>
 - <https://luh.umd.edu/>

Status of current methods

- For historical forcings, the status of our method for temporally extending is: stable
 - We temporally extend the historical land-use forcing data annually for use in the Global Carbon Budget
 - For historical forcings, the status of our method for updating is: stable
 - We update the entire time series of the land-use forcing data annually for the Global Carbon Budget. We also will often incorporate new data inputs as part of this process to correct or better represent land-use in key regions/time-periods.
 - For scenario forcings, the status of our method for making projections and harmonising is: stable
 - We have a stable algorithm for producing harmonized land-use scenarios, although the pre-processing of Integrated Assessment Model data can be time-consuming and require customized handling.
-
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Raw observations (and input datasets) used

- HYDE – Copernicus Land Change lab (Utrecht University)
 - We have a long history of working closely with the HYDE data providers
 - <https://landuse.sites.uu.nl/hyde-project/>
- FAO Wood Harvest and Agricultural Data – United Nations Food and Agriculture Organization
 - This data is updated and provided online annually. We have also directly collaborated with researchers at FAO.
 - <https://www.fao.org/faostat/en/#home>
- Landsat and GEDI remote sensing data – NASA
 - Good links to data providers
- Integrated Assessment Model land-use data – multiple sources
 - We have good connections with most IAMs and have worked with them for many years on harmonizing future land-use scenarios

Greenhouse gas concentrations

Basic info

- Greenhouse gas concentrations
 - CR-CMIP-0-3-0
- Key contacts:
 - Historical: Zebedee Nicholls <zebedee.nicholls@climate-resource.com>, Malte Meinshausen <malte.meinshausen@climate-resource.com>
 - Scenarios (in addition to the above):
- Did you provide forcings for CMIP6? yes
- Any key papers/references:
 - Meinshausen et al., 2017: <https://gmd.copernicus.org/articles/10/2057/2017/>
 - Meinshausen et al., 2020: <https://gmd.copernicus.org/articles/13/3571/2020/>

Status of current methods

- For historical forcings, the status of our method for temporally extending is: in development
 - Have never done it before, but methods are clear and quite straightforward
 - For historical forcings, the status of our method for updating is: stable
 - For scenario forcings, the status of our method for making projections and harmonising is: in development
 - Methods clear, making software stable is next step
- ‘Temporally extending’ means adding extra data to the end of existing forcings data, without altering already existing data
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Raw observations used

- AGAGE network– Sponsored by NASA but with participation from multiple institutes around the world
 - We have links with some key people, but we could definitely do a better job of explaining what we need and giving AGAGE visibility in our outputs
 - Participating institutes <https://tolnet.larc.nasa.gov/missions/agage/about/participating-institutions>
- NOAA global monitoring laboratory – NOAA
 - We have links with some key people, but we could definitely do a better job of explaining what we need and giving NOAA visibility in our outputs
 - Monitoring sites all over the world, unclear how exactly they're funded
- HadCRUT5 (or other temperature observations) – UK Met Office
 - No link (would be surprised if HadCRUT team knew we used their data apart from our citations). We could definitely give better visibility in our outputs.
 - Ice core projects (less relevant for live updates)
- Ice core projects (less relevant for extensions)
 - CSIRO Law Dome Ice Core
 - European project for ice coring in Antarctica
 - NEEM ice coring project (now finished, not sure if there is a follow up)

$^{13}\text{CO}_2$ and $^{14}\text{CO}_2$ forcings

Basic info

- $^{13}\text{CO}_2$ and $^{14}\text{CO}_2$ forcings for C4MIP
 - ImperialCollege-1-1
- Key contacts:
 - Historical and scenarios: Heather Graven <h.graven@imperial.ac.uk>
- Did you provide forcings for CMIP6? yes
- Variables provided
 - delta13co2-in-air and Delta14co2-in-air
 - CMIP6 and CMIP7 variables dependent on the forcing: 13C and 14C in land and ocean carbon stocks and fluxes
- Any key papers/references:
 - Historical - Graven et al. 2017 <https://gmd.copernicus.org/articles/10/4405/2017/gmd-10-4405-2017.html>
 - Future SSPs - Graven et al. 2020 <https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2019GB006170>
 - Graven et al. 2024 <https://www.science.org/doi/10.1126/science.adl4443>

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Raw observations used

- Data sources - SIO, NOAA, CSIRO, UC Irvine, U Heidelberg, ICOS, GNS Science, ANSTO
- Funders - National Agencies, Schmidt Sciences, ICOS

Stratospheric volcanic SO₂ emissions and aerosol optical properties

Basic info

- Stratospheric volcanic SO₂ emissions and aerosol optical properties
 - UOEXETER-CMIP-1-1-3
- Key contacts:
 - Historical: Thomas Aubry <t.aubry@exeter.ac.uk>
 - Scenarios (in addition to the above): Thomas Aubry <t.aubry@exeter.ac.uk>
- Did you provide forcings for CMIP6? no
- Any key papers/references:

No single reference yet but our datasets critically relies on:

 - Kovilakam et al. (2022), <https://doi.org/10.5194/essd-12-2607-2020>
 - Sigl et al. (2015), <https://doi.org/10.1038/nature14565>
 - Carn (2022), <https://doi.org/10.5067/MEASURES/SO2/DATA405>
 - Aubry et al. (2020), <https://doi.org/10.1029/2019JD031303>

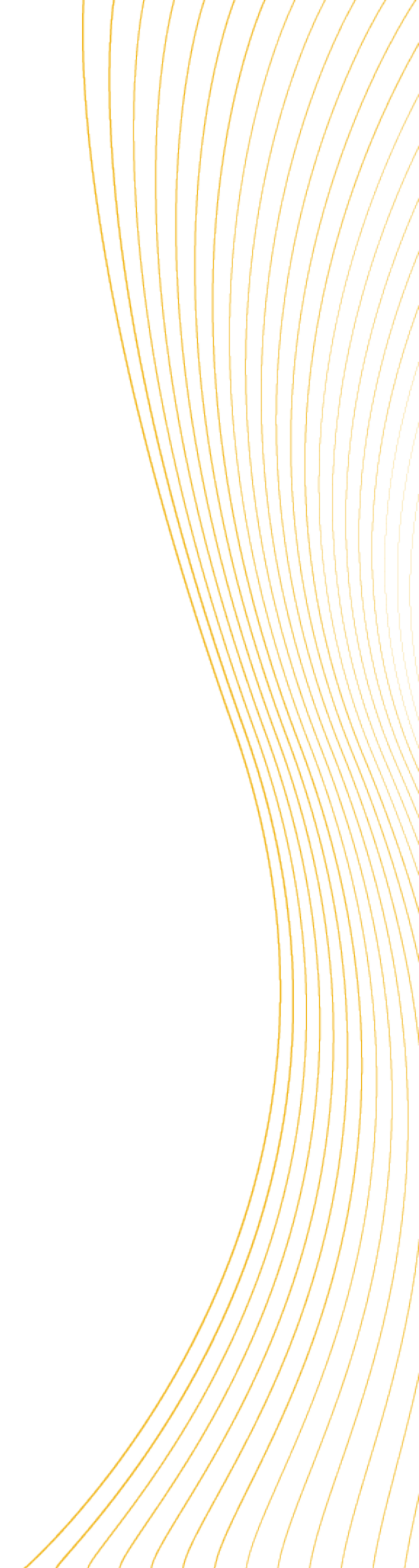
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Raw observations used

- NASA – MSVOLS02L4 satellite emission dataset – NASA
 - Good link with primary project lead Simon Carn
 - Unknown funding sustainability, no immediate concern on satellite capabilities
- NASA – GloSSAC satellite aerosol optical property dataset
 - Good link with primary project lead Mahesh Kovilakam
 - Unknown funding sustainability, important concern on future satellite capabilities (globally, not just NASA)
- Ice-core volcanic sulfur records
 - Good links with the ice core/volcano community
 - Numerous project leads, datasets, and funders involved globally
- Smithsonian’s Global Volcanism Programme (GVP) – US Gov Funded
 - Inactive link with relevant contact but could be activated
 - Feels like a safe dataset in terms of sustainability but who knows in an uncertain funding environment
- Volcanological records
 - Good link with volcanology community
 - Beyond GVP above, loads of projects leads, datasets and funders involved globally



Ozone concentrations

Basic info

- Ozone concentrations
 - FZJ-CMIP-x-x
- Key contacts:
 - Historical: Michaela Hegglin <m.i.hegglin@fz-juelich.de>
 - Scenarios (in addition to the above): N/A
- Did you provide forcings for CMIP6? yes
- Any key papers/references:
 - Skeie, R. B., G. Myhre, O. Hodnebrog, P. J. Cameron-Smith, M. Deushi, M.I. Hegglin, L. W. Horowitz, R. J. Kramer, M. Michou, M. J. Mills, D. J. L. Olivie, F. M. O'Connor, D. Paynter, A. Sellar, D. Shindell, T. Takemura, S. Tilmes, T. Wu, Historical total ozone radiative forcing derived from CMIP6 simulations, npj Climate and Atmospheric Science, 3, 32, <https://doi.org/10.1038/s41612-020-00131-0>, 2020
 - Checa-Garcia, R., M. I. Hegglin, D. A. Plummer, D. Kinnison, K. P. Shine, Historical tropospheric and stratospheric ozone radiative forcing using the CMIP6 database, Geophys. Res. Lett., 45, doi:10.1002/2017GL076770, 2018.

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Raw observations used

- ESA CCI_ozone
 - Long-term, high-quality Climate Data Records
 - Multiple ozone variables: total column ozone, vertically resolved limb satellites, nadir viewing satellites
- SPARC Data Initiative
 - Long-term, stratospheric zonal mean climatologies from limb satellite sounders
 - Different national and international space agencies
 - Hegglin, M. I. et al.: Overview and update of the SPARC Data Initiative: comparison of stratospheric composition measurements from satellite limb sounders, Earth Syst. Sci. Data, 13, 1855–1903, <https://doi.org/10.5194/essd-13-1855-2021>, 2021.

Nitrogen deposition

Basic info

- Nitrogen deposition
 - FZJ-CMIP-x-x
- Key contacts:
 - Historical: Michaela Hegglin <m.i.hegglin@fz-juelich.de>
 - Scenarios (in addition to the above): N/A
- Did you provide forcings for CMIP6? yes
- Any key papers/references:
 - None available.

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Raw observations used

- National monitoring network China.
 - Currently only used for validation.
 - Exploratory use.
 - Xu, W., Zhang, L. & Liu, X. A database of atmospheric nitrogen concentration and deposition from the nationwide monitoring network in China. *Sci Data* 6, 51 (2019).
<https://doi.org/10.1038/s41597-019-0061-2>
- Icecore data.
 - Currently only used for validation.
 - Exploratory use.
 - L. G. Thompson et al. Annually Resolved Ice Core Records of Tropical Climate Variability over the Past ~1800 Years. *Science* 340, 945-950 (2013). DOI:10.1126/science.1234210

Solar



Basic info

- Solar
 - SOLARIS-HEPPA-CMIP-4-4
- Key contacts:
 - Historical: Bernd Funke <bernd@iaa.es>
 - Scenarios (in addition to the above): Thierry Dudok de Wit <ddwit@cnr-orleans.fr>
- Did you provide forcings for CMIP6? yes
- Any key papers/references:
 - Funke et al., 2024: <https://gmd.copernicus.org/articles/17/1217/2024/gmd-17-1217-2024.html>
 - <http://solarisheppa.geomar.de/cmip7>
 - CMIP6 forcing: Matthes et al., 2017: <https://gmd.copernicus.org/articles/10/2247/2017/>

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Raw observations used

Solar Irradiance CDR – NOAA, NCEI, LASP (University of Colorado)

- Good links to PI of dataset

SILSO Sunspot index and Longterm Solar Observations – SIDC, Royal Observatory of Belgium

GFZ Potsdam Geomagnetic indices

AMIP sea-surface temperature and sea-ice boundary forcing

Basic info

- AMIP sea-surface temperature and sea-ice boundary forcing
 - PCMDI-AMIP-1-1-9
- Key contacts:
 - Historical: Paul Durack <durack1@lnl.gov>
 - Scenarios (in addition to the above): N/A
- Did you provide forcings for CMIP6? yes
- Any key papers/references:
 - <https://pcmdi.llnl.gov/mips/amip>
 - Taylor et al., 2000 <https://pcmdi.llnl.gov/report/ab60.html>

Status of current methods

- For historical forcings, the status of our method for temporally extending is: stable up to December 2022
- For historical forcings, the status of our method for updating is: in development – the NOAA-OISST v2.0 data was discontinued in March 2023, and so new SST data is being investigated – a new PCMDI-AMIP-2 dataset will be generated
HadISST v2.4 is being reviewed to update this data from 1850 to 2023
- For scenario forcings, the status of our method for making projections and harmonising is: N/A
 - ‘Temporally extending’ means adding extra data to the end of existing forcings data, without altering already existing data
 - ‘Updating’ means updating the entire timeseries, rather than just adding extra data on the end
 - ‘In development’ means that the methods either don’t exist, or are being used but are not yet stable
 - ‘Stable’ means that the methods have been used consistently, but are not used in a ‘sustained mode’ way (e.g. they require specific people to run them, aren’t automated, aren’t used regularly)
 - ‘Sustained mode’ means that the forcings are produced routinely in at least a semi-automated way

Raw observations used

Old SST

- UK MetOffice - [funder]
 - HadISST v1.x – originally obtained in ~2007 but no longer available, deprecated by HadISST v1.1 (which itself has been changing through time) - 187001 - 198110
 - <https://www.metoffice.gov.uk/hadobs/hadisst/>
- NOAA
 - NOAA-OISST v2.0 – originally obtained in 198111 and temporally extended over time, with the latest version obtained in May 2023 providing a temporal extension to 202212
 - ftp://ftp.cpc.ncep.noaa.gov/precip/PORT/sst/oimonth_v2

New SST

- Good question, likely UK MetOffice HadISST v2.4 (185001-202312), with a temporal extension with a “real-time” data product which is under investigation
- [Not publicly accessible](#)

Sea-Ice

- EUMETSAT OSI-SAF-430
 - <https://osi-saf.eumetsat.int/products/sea-ice-products>

66 These are repackaged by numerous groups, including HadISST and OISST v2.1, plus others

Aerosol optical properties/MACv2-SP

Basic info

- Aerosol optical properties/SPv2
 - GEOMAR for historical
 - University Heidelberg for scenarios
- Key contacts:
 - Stephanie Fiedler <sfiedler@geomar.de> (to be updated in November)
- Did you provide forcings for CMIP6? yes
- Any key papers/references:
 - Stevens et al., 2017: <https://gmd.copernicus.org/articles/10/433/2017/>
 - Fiedler et al., 2017: <https://agupubs.onlinelibrary.wiley.com/doi/10.1002/2017MS000932>
 - Fiedler et al., 2019: <https://gmd.copernicus.org/articles/12/989/2019/>
 - Fiedler et al., 2021: <https://www.sciencedirect.com/science/article/pii/S0169809521004221?via%3Dihub>
 - Fiedler et al., 2023: <https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2023GL104848>

Status of current methods

- For historical forcings, the status of our method for temporally extending is: stable
- For historical forcings, the status of our method for updating is: stable
- For scenario forcings, the status of our method for making projections and harmonising is: stable

- ‘Temporally extending’ means adding extra data to the end of existing forcings data, without altering already existing data
- ‘Updating’ means updating the entire timeseries, rather than just adding extra data on the end
- ‘In development’ means that the methods either don’t exist, or are being used but are not yet stable
- ‘Stable’ means that the methods have been used consistently, but are not used in a ‘sustained mode’ way (e.g. they require specific people to run them, aren’t automated, aren’t used regularly)
- ‘Sustained mode’ means that the forcings are produced routinely in at least a semi-automated way

Raw observations used

- Max-Planck-Institute for Meteorology Aerosol Climatology – no external funder
 - Development finished
 - Developer Stefan Kinne has retired
- Temporal scaling depends on emission data (indirectly dependent on all of the emissions' sources raw observations for SO₂ and NH₃)

Population

Basic info

- Population
 - TBD
- Key contacts:
 - Historical: TBD
 - Scenarios (in addition to the above): TBD
- Did you provide forcings for CMIP6? no
- Any key papers/references:
 - TBD

Status of current methods

- For historical forcings, the status of our method for temporally extending is: TBD
- For historical forcings, the status of our method for updating is: TBD
- For scenario forcings, the status of our method for making projections and harmonising is: TBD

- ‘Temporally extending’ means adding extra data to the end of existing forcings data, without altering already existing data
- ‘Updating’ means updating the entire timeseries, rather than just adding extra data on the end
- ‘In development’ means that the methods either don’t exist, or are being used but are not yet stable
- ‘Stable’ means that the methods have been used consistently, but are not used in a ‘sustained mode’ way (e.g. they require specific people to run them, aren’t automated, aren’t used regularly)
- ‘Sustained mode’ means that the forcings are produced routinely in at least a semi-automated way

Raw observations used

- [Source] - [funder]
 - [Comment on 'quality' of link with source]
 - [comment]

Refining the presentation of the current process and proposed options for sustained mode for the plenary session

Refining the presentation for the plenary

- In Plenary 2, we will present a summary of these challenges
- The summary is intended to be a helpful guide for the funders panel
- ZN will also try and refine this in reaction to plenary 1, which will better define what a sustained mode means and user requirements
- Link to presentation we will refine: <https://office.wcrp-cmip.org/Products/Files/DocEditor.aspx?fileid=10062>

Thank You

Zebedee Nicholls

Slide author