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**PROGRESS REPORTS**

**Task Group on Data Support for Climate Change Assessments**

(Prepared by the Co-Chairs of the Task Group on Data Support for Climate Change Assessments)

(Submitted by the Secretary of the IPCC)

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<sup>1</sup> This revised version is being submitted with additional information appended in Annex 1.

## PROGRESS REPORTS

### Task Group on Data Support for Climate Change Assessments

This report describes the activities undertaken by the Task Group on Data Support for Climate Change Assessments (TG-Data) since the last update presented during the 53<sup>rd</sup> (bis) Session of the IPCC in March 2021.

#### 1. Salient activities since last report

##### Meetings

- Seventh TG-Data teleconference was held on 1<sup>st</sup> June 2021.
- Third (virtual) annual face to face (F2F) TG-Data meeting was held on 22<sup>nd</sup> October 2021.
- Eighth TG-Data teleconference was held on 5<sup>th</sup> April 2022.
- Ninth TG-Data teleconference was held on 27<sup>th</sup> July 2022.
- Monthly DDC managers meetings.

##### DDC membership

The United Kingdom's Department for Business, Energy & Industrial Strategy has selected MetaDataWorks (MDW) through an open bidding competition as the purveyor of the UK's contribution to the Data Distribution Centre (DDC). MDW replaces the Center for Environmental Data Analysis (CEDA) who previously played this role, but CEDA remains involved in the data curation process through an agreement with Working Group I (WGI) Technical Support Unit (TSU) and informal discussions.

***MDW was officially included in the DDC through a motion passed during the virtual F2F meeting on 22 October 2021. A new version of the Memorandum of Understanding (MoU) for Operation of the IPCC Data Distribution Centre was presented and adopted in the F2F meeting. The MoU was then signed by the institutional heads of all current DDC partners and linked at the new DDC website (<https://www.ipcc-data.org/about>). The MoU was also published at Zenodo with a DOI: <https://doi.org/10.5281/zenodo.5914483> . Outreach activities***

TG-Data together with Working Group I (WGI) have prepared the first formal outreach activity organized for the Sixth Assessment Report (AR6). This first package of outreach activities is linked to the outcomes of the [WGI report](#) that was released in August 2021. The objectives of these activities are:

- Present the main results of the WGI report.
- Engage with the regional research practitioner community over specific regional domains.
- Present the data availability with special emphasis on the Interactive Atlas (IA) providing regional information and synthesis (from the Technical Summary and the regional chapters 10-11-12-Atlas Chapters).

Considering the current pandemic context, the training workshops are being organized in a virtual mode in the form of regional webinars. A package of introductory material (videos) building on previous events (in particular the [COP-26 IPCC regional events](#) and the [official launch of the Interactive Atlas](#)) is provided in advance as context information to set the ground for the webinar. The webinars are intended for practitioners and the research

community (but also open to consultants and public sector representatives) and focus on data aspects using the facilities of the IA. These events are envisioned as interactive sessions and require registration, although they could be also followed by streaming.

As a first package, three regional events are organized in Europe, Central and South America and Africa. This is the webpage where the webinars are announced: <https://www.ipcc.ch/event/interactive-atlas-regional-webinars/>

The [European Webinar](#) took place on Friday, 18 March 2022, 11:00 - 12:00 UTC, attracting over 600 registrants. A total of 350 Europeans were invited to the Zoom meeting, and the rest were redirected to a live streaming channel. Around 150 persons attended the webinar, with four Breakout Groups, two in English (~100 and ~20); one in Spanish (with ~30) and one in French (with ~10). The [recorded video](#) has been viewed ~600 times.

The [Central and South America Webinar](#) took place on Friday, 29 April 2022, 13:00 - 14:30 UTC, attracting 690 registrants. A total of 135 persons attended the webinar, with 6 Breakout Groups, one in English, four in Spanish and one in Portuguese.

Webinars for other regions are in preparation, see [Next steps](#).

A [presentation](#) about the new DDC catalog by Adam Milward and Sabine Undorf (MDW) entitled “Climate Change Data for Everyone: Building the Catalogue for the Intergovernmental Panel on Climate Change Data Distribution Centre” was given on 17 December 2021 at the AGU 2021 Fall meeting in the session “N53A: Connecting Disciplines and Data in Earth and Environmental Synthesis Research: Enabling International and Interdisciplinary Data Discovery, Integration, and Reuse”.

Outreach activities for **Working Group III (WGIII) report** are under planning. The objectives of these activities are to:

- Engage with the regional research practitioner community over specific regional domains.
- Present the main results of the WGIII report.
- Present the data availability with special emphasis on the Scenario Explorer developed by IIASA for IPCC WGIII.

Based on the experience of WGI outreach activities, it is expected to hold the training workshops for 2022 (second semester around November) in a virtual mode. The workshops are expected to last no more than 2 hours, with some general introductions and presentation of general data relevant information about WGIII-AR6 and hands-on activities. Although the workshops will not be region specific but global in spirit, it is expected that due to time zone differences the workshops are deployed in a series of events for different regions of the world. It is expected to have a mixed audience between practitioners and researchers. It is expected that the audience will have some basic technical skills.

## **FAIR Guidelines**

A document describing recommended FAIR<sup>2</sup> practices for IPCC authors has been completed and adopted by TG-Data members at the 8<sup>th</sup> teleconference on 5 April 2022.

This document introduces the implementation of FAIR data principles into the IPCC process and reflects the four elements of FAIR to find the data, produce and reproduce figures and, finally, to document the provenance for reusability. It presents standard (basic) measures

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<sup>2</sup> Findable, accessible, interoperable and reusable

that are recommended for all digital data that is assessed, intermediate measures that achieve reproducibility of assessed digital information, for example through the use of collaborative platforms for figure development, and also full (advanced) measures to achieve reusability of digital products with complete provenance documentation. The document has been copy-edited by the IPCC Secretariat and published on Zenodo: [The implementation of FAIR data principles in the IPCC AR6 assessment process \(V1\)](#).

## **Licensing guidelines**

A second document presented at the 9th teleconference on 27 July 2022 outlines TG-Data recommendations regarding data licensing. Licenses describe the terms under which data can be used and shared. Some licenses restrict usage to non-commercial purposes, require derivative works to be published under the same license as the original material, prohibit redistribution, etc. TG-Data licensing guidelines recommend publishing IPCC final datasets under the CC BY 4.0 license, which gives data users the permission to share and modify the data, as long as the original authors are given credit and changes to the original data are indicated. The document will be formally adopted and published over the coming weeks.

## **Data curation activities**

IPCC Data Distribution Centres (DDC) at DKRZ <sup>3</sup> (Germany), CIESIN <sup>4</sup> (USA), MetaDataWorks & CEDA<sup>5</sup> (UK) and CSIC-IFCA<sup>6</sup> (Spain) are working with WG TSUs to curate input, intermediate and final datasets that are used in the assessment report (AR). These datasets are archived across the different DDCs, and cataloged on the new DDC website developed by MetaDataWorks (<https://www.ipcc-data.org/>).

The DDC data catalog is built on a new metadata specification (schema) clearly defining the expected fields and their definition. See [documentation](#) for more details. This specification is the result of cross-WG consultations led by MDW with TSUs and DDCs.

Recently, IPCC authors and contributors have made relevant datasets, code libraries and publications available through an online data curation service called Zenodo. An [IPCC AR6](#) Zenodo community was created to collect AR6 relevant datasets published on the platform. As of July 2022, the community links to five AR6 datasets.

## **Final data**

Final data sets refer to data directly underlying graphics included in the AR. As of 26<sup>th</sup> July 2022, the DDC catalog has the following datasets. Additional datasets are expected within the next few months. (See Table 1).

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<sup>3</sup> Deutsches Klimarechenzentrum

<sup>4</sup> Center for International Earth Science Information Network

<sup>5</sup> Centre for Environmental Data Analysis

<sup>6</sup> Consejo Superior de Investigaciones Científicas - Instituto de Física de Cantabria

**Table 1** Status of final dataset curation across AR6 WGs as of August 2nd, 2022. Source: Jyoti Rogers, MetaDataWorks.

| Group                  | Live | Upcoming |
|------------------------|------|----------|
| AR6 WGI                | 21   | 1        |
| AR6 WGII               | 14   | 14       |
| AR6 WGII related SROCC | 6    | 0        |
| AR6 WGIII              | 29   | 12       |
| AR6 SYR                | 0    | 5        |

WGI TSU is in the process of working with CEDA to assemble, quality control and curate and catalog final data from chapter and Technical Summary Figures. The current status is summarized in Figure 1 where dark blue shows what is being curated, yellow shows figures that are not data-based (e.g. conceptual figures or schematics) and light blue is where data is currently not available to the TSU. Efforts are underway to mobilize data that is currently not available.

**Figure 1** Status of curation of WGI final data by WGI TSU and CEDA as of 25 July 2022. Source: Lina Sitz, WGI TSU



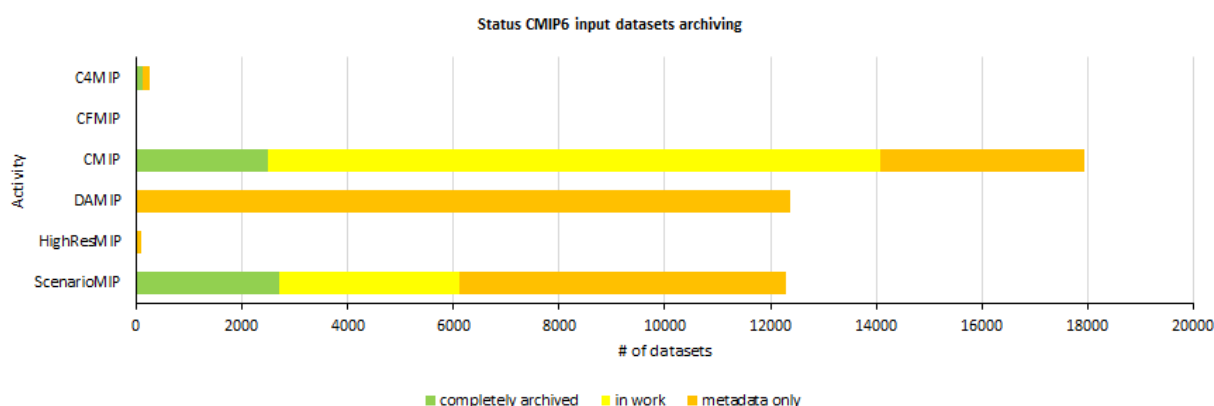
## Input data

Input data refer to source material used by IPCC authors. The focus of DDC is to archive data relied on by IPCC that are not already curated in other trusted repositories. The DDC catalog has been populated with input datasets from previous ARs, 1,646 hosted at DKRZ and 9 hosted at CIESIN.

For AR6, CIESIN has now archived the [INFORM Global Risk Index](#) dataset used in WGII. Note that WGII also uses the [World Risk Index - Vulnerability Component 2019](#), which has been published by its authors on the Zenodo platform and will be included in the DDC catalog. Similarly, a link to the [AR6 Scenarios Database](#) has been published to Zenodo, and discussions are underway to preserve a dark snapshot of the version used in the AR6 report at the DDC.

The archival of CMIP6<sup>7</sup> data at DKRZ is ongoing (see Figure 2 for the status) but is hindered by a number of challenges: incomplete list of data from authors, missing usage information, errors in dataset identifiers, reference to dataset versions that have been “unpublished” and replaced by newer versions, among other issues. TG-Data will make recommendations to improve the process for AR7.

**Figure 2** Status of CMIP6 input dataset curation as of August 1st, 2022. Source: Beate Krüss/Martina Stockhause, DKRZ



First Assessment Report (FAR) input model data at DKRZ from GISS was processed in June 2021 to create an ASCII version of the original data available in native data format. This curation measure eases data reuse by DDC users. Two datasets and 4 GBytes of data were added to the FAR Reference Data Archive, which now has a total volume of 10 GBytes.

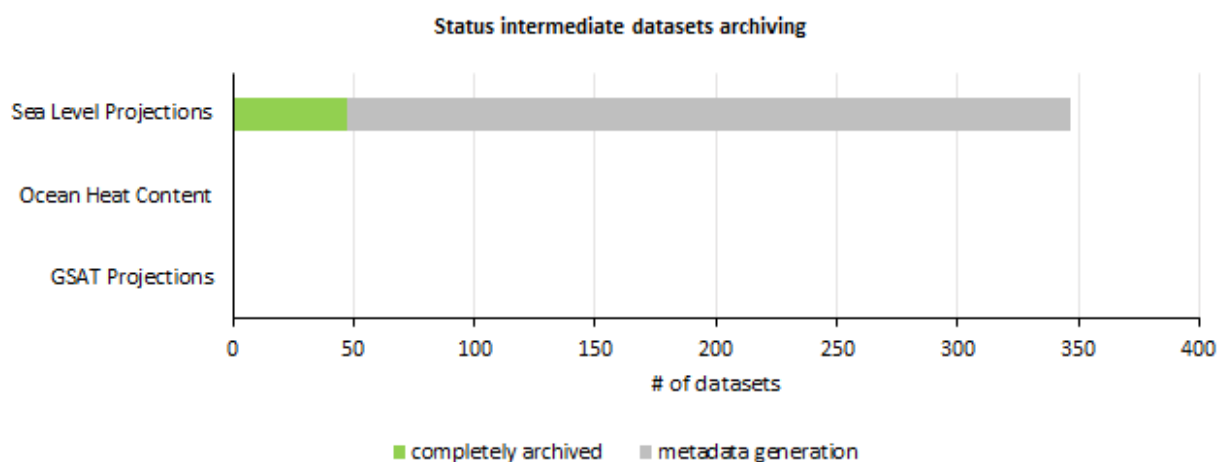
### Intermediate data

Intermediate data refer to processed data that is generated in the production of the IPCC report. A new workflow has been developed by WGI TSU and DKRZ for the curation of intermediate data. Work is underway to archive intermediate data assessed in WGI for constrained sea level, ocean heat content and global surface temperature projections (see Figure 3 for the status).

Intermediate datasets used in the production of the WGI Interactive Atlas are curated by CSIC-IFCA DDC.

<sup>7</sup> Coupled Model Intercomparison Project Phase 6

**Figure 3** Status of intermediate dataset curation as of August 1st, 2022. Source: Beate Krüss/Martina Stockhause, DKRZ



### Code archival

WGI TSU is working on the collection and archival of code libraries developed by authors for the preparation of WGI report figures. The libraries are assembled on the [WGI GitHub repository](#) and published after author and TSU quality control checks, and on completion of documentation to guide users on the resources available. The status is shown in Figure 4 from the assembly of code to publication and the assignment of digital object identifiers (DOIs) via Zenodo.

**Figure 4** Status of code archival of scripts underpinning WGI figures. Source: Diego Cammarano, WGI TSU

| Chapter | Code on IPCC WGI Github | Dedicated Figure Github Repository | DOIs |
|---------|-------------------------|------------------------------------|------|
| 1       | ⊗                       | ⊗                                  | ⊗    |
| 2       | ✓                       | ✓                                  | ✓    |
| 3       | ✓                       | ✓                                  | ✓    |
| 4       | 🕒                       | 🕒                                  | 🕒    |
| 5       | ⊗                       | ⊗                                  | ⊗    |
| 6       | ✓                       | ✓                                  | 🕒    |
| 7       | ✓                       | 🕒                                  | 🕒    |
| 8       | ✓                       | ✓                                  | 🕒    |
| 9       | ✓                       | ✓                                  | 🕒    |
| 10      | ✓                       | ✓                                  | 🕒    |
| 11      | ✓                       | 🕒                                  | 🕒    |
| 12      | ✓                       | 🕒                                  | 🕒    |
| Atlas   | ✓                       | ✓                                  | ✓    |
| TS      | 🕒                       | 🕒                                  | 🕒    |
| SPM     | ⊗                       | ⊗                                  | ⊗    |

## **2. Lessons learned on FAIR implementation for WGI**

WGI TSU and DDC team members are in the process of taking stock of the work done so far to implement FAIR principles as part of the WGI AR6. The following is a summary of the key challenges encountered that need to be addressed to develop improved guidance for AR7:

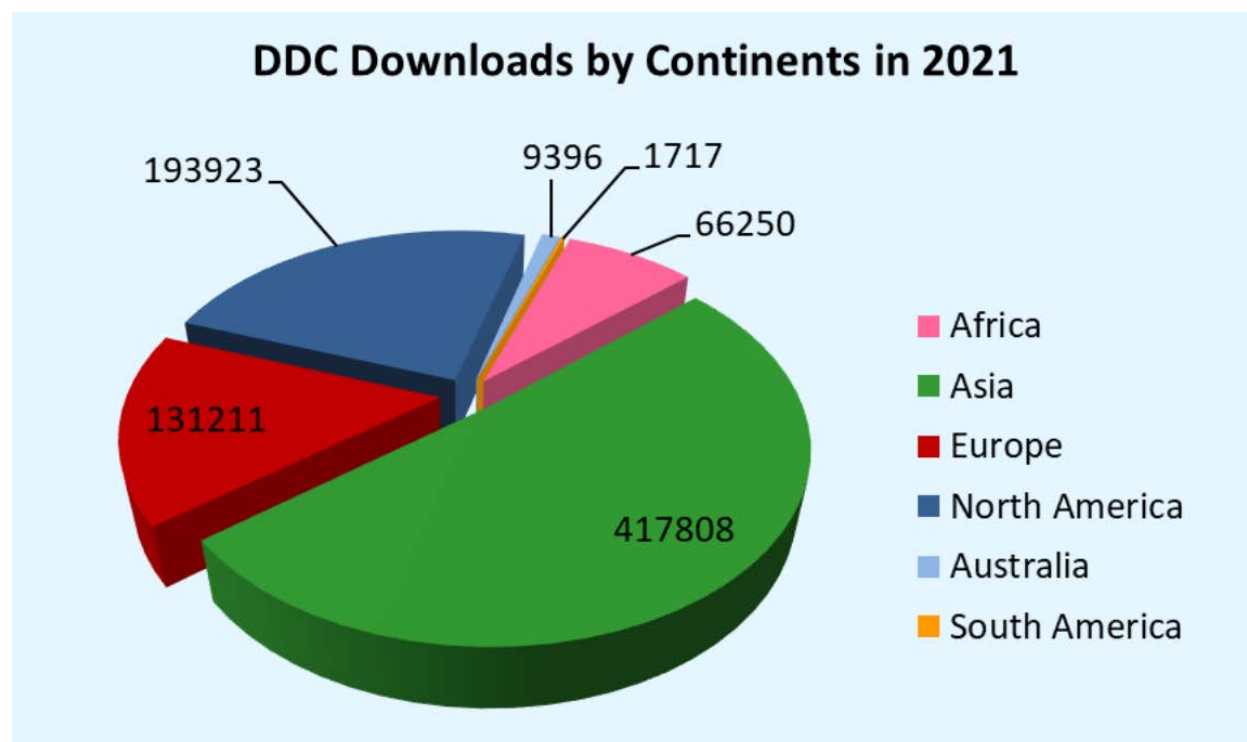
1. Novelty of the implementation of FAIR data principles - new roles, workflows for TSU and DDC.
2. Challenges faced by authors of contributing to a process put in place during the assessment.
3. Missing datasets, code and metadata.
4. Quality control process.
5. Ensuring that licensing constraints are met.
6. Challenges for established curation practices.
7. Interconnecting archived/curated data and code archived to the report.
8. Implementation of IPCC Error Protocol for data and code.
9. Time pressure towards the end of assessment.
10. Awareness building and guidance on what resources are available and for their proper use.

Lessons learned from the AR6 experience and recommendations for AR7 are being developed by the TSU and DDC representatives (Pirani et al., 2022, <https://zenodo.org/record/6992173>). To facilitate the implementation of FAIR principles, these need to be adopted as a core practice within the assessment process from the start of the AR7. Authors need to be provided with clear instructions on mandatory requirements, templates accompanied by guidance and online tools to assemble information, with a clear timeline. Dedicated TSU staff is needed to support authors and work with the DDC. Dedicated DDC resources are needed to staff this work for the duration of the cycle. Attention to resources for the end of the cycle timeline is needed since a substantial part of the archival and curation work will be completed, including fully interconnecting the code and data products with the report itself. Oversight and guidance is needed throughout the process. TG-Data has a role as a persistent group here, as well as Working Group Bureau members.

## **3. Data Access**

In 2021, 820,000 datasets adding up to 420 Tbytes were downloaded from the DKRZ archive. Ninety percent of these downloads were made through the Earth System Grid Federation (ESGF) access point. The geographic distribution of downloads per continent is shown in Figure 5. The annual DDC at DKRZ report provides additional information, including time series of downloads and a breakdown of downloads per AR cycle.

**Figure 5** Number of dataset downloads from DKRZ long-term archive (download counts) per continent for 2021. Source: Stockhause, Martina (2022). Report 2021 of the DDC at DKRZ. Available at <https://doi.org/10.5281/zenodo.5907172>



#### 4. Website

The DDC website (<https://www.ipcc-data.org/>) has undergone a complete overhaul, and the new version has been live since November 1st and has attracted 4,200 visitors up to 31 March 2022. The previous website has been archived and its content is still available. The site content has been reviewed by TG-Data members and adopted during the 2021 F2F virtual meeting.

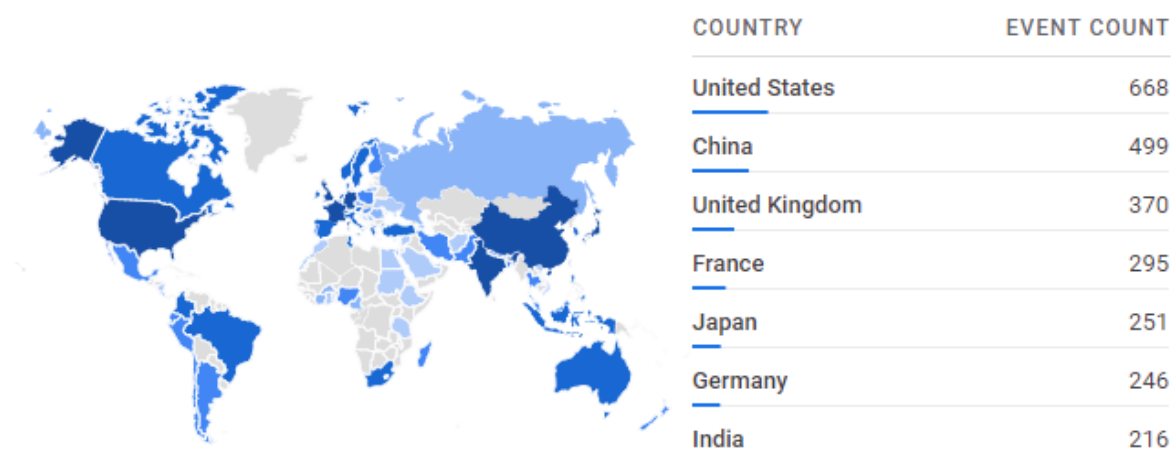
A noticeable spike in traffic has been driven by the publication of WGII's report and associated final datasets on 28 February 2022. A total of 4,200 files were downloaded from the catalog interface (Figure 6), and their geographical distribution is illustrated in Figure 7.

**Figure 6** Dataset downloads from DDC website since launch of DDC data catalog (1 November 2021 to 30 June 2022). Source: Jyoti Rogers, MetaDataWorks.



**Figure 7** Number of dataset downloads from DDC website per country from 1 November 2021 to 30 June 2022. Source: Jyoti Rogers, MetaDataWorks.

#### Event count by Country



Since last August, MetaDataWorks responded and resolved 24 service desk tickets (issues or questions from web site visitors).

On 23 March 2022 a new landing page for [AR6 data](#) was added to the web site, describing and linking key input, intermediate and final datasets for each WG.

## 5. DDC anniversary

The DDC will celebrate its 25th anniversary during IPCC-57 as it was established on IPCC-13 (25-28 September 1997). As the last remaining DDC Partner of the original group, DKRZ has published a review of its work (Stockhouse and Lautenschlager, 2022, <https://doi.org/10.5194/gmd-15-6047-2022>).

## 6. Next steps

- Outreach activities:
  - Hold regional TG Data WGI Interactive Atlas Webinar in Africa (September 13th)
  - Organize other regional TG Data IA Webinars (Oceania, Asia, Middle East, North America)
  - TG Data WGIII Workshops will be organized after COP27 based on the Scenario Explorer developed by IIASA for IPCC WG3.
- Data related activities:
  - Review metadata schema for the DDC catalog based on experience so far.
  - Pursue data curation activities with all TSUs, including SYR.
  - Develop data citation guidelines document for the DDC
- TG Data organization
  - Planning for in-person 2022 face to face TG-Data meeting occurring on October 12-14 in Yokohama.
  - Pursue discussions on the AR6 experience and formulate recommendations for AR7.
- DDC funding:
  - DDC is not centrally funded and informal funding from the US, UK and Spain currently allows partners to deliver core data service for the IPCC. DKRZ received funding from Germany for past cycles but relies on institutional and European project funds for AR6.
  - The future of the DDC is in jeopardy as two of the four partners, DKRZ (Germany) and MetadataWorks (UK), are not funded post-March 2023
  - The DDC in consultation with relevant stakeholders has prepared a document which outlines four different options for the IPCC data distribution, including the benefits, activities and funding that would be required to support each of the options. The document is included as Annex 1.
  - The TG-Data on behalf of the DDC presents the information and options in Annex 1 to the Panel with the aim of identifying and establishing a sustainable funding model post March 2023.

## 7. Conclusions

- TG-Data thanks the IPCC Bureau, Secretariat, Working Group Technical Support Units (TSUs), DDC Centres and the supporting Governments for their continued support.
- The Panel is invited to take note of the TG-Data progress report including the information and options presented in Annex 1 with the view to provide guidance as appropriate on the sustainability and continuity of DDC activities and services.

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## Executive Summary

As the impact of human activities continue to disrupt the climate, there is an increasing risk of severe, pervasive and irreversible impacts for people and ecosystems. The IPCC provides comprehensive scientific assessments of what is known about the drivers of climate change, its impacts and future risks, and how adaptation and mitigation can reduce those risks. Trust, openness and transparency are fundamental tenets of IPCC activities; therefore, the provenance of the data used to generate insights, alongside the traceability of findings, is key to ensuring objective and complete assessments. Moreover, as data increasingly drives policy decisions, policy makers, now more than ever, need access to up-to-date, region-specific, reliable and trustworthy data.

Currently, the data underlying IPCC assessment cycles and reports is managed by the IPCC Data Distribution Centre (DDC). In support of the implementation of the IPCC's programme of work and according to the "Terms of Reference and Mandate of the IPCC Task Group on Data Support for Climate Change Assessments (TG-Data)" in [Annex 1 of Decision IPCC-XLVII-9](#) and in particular the "Guidance for DDC" in [Annex 2 of Decision IPCC-XLVII-9](#) as well as the TG-Data approved document on the IPCC FAIR Guidelines (Pirani et al., 2022<sup>8</sup>), the DDC is responsible for providing:

- a sustainable data archive that facilitates long-term availability
- a service to support consistent, widespread use of climate change-related data and scenarios
- tooling and support for authors and TSU/editors during the assessment process

Although DDC partners have managed to operate with in-kind funding from Germany, Spain, the UK and the US in the past, the future of the DDC is in jeopardy as two of the four current partners, DKRZ (Germany) and MetadataWorks (UK), are not funded post-March 2023 and funding for the remaining partners is presently not certain beyond 2024. Given the importance of the services the DDC provides to the global community, a stable long-term funding structure is needed that will allow the DDC to continue on a sustainable and secure basis. This need was recognized at the 47th session of the IPCC (13-18 March 2018, Paris), which adopted new Guidance for the DDC and stated in paragraph 5 of Decision IPCC-XLVII-9: "Take note that current in-kind contributions for the DDC as described in IPCC-XLVII/Doc.9 are not sufficient to fully implement the activities of the DDC identified in Annex 2 to this document and that these in-kind contributions are not long-term commitments. The Panel requested the Secretariat to work with the IPCC Bureau to seek additional and more sustainable resourcing options."<sup>9</sup> .

This paper outlines four different levels of service that the DDC could provide the IPCC in the next IPCC assessment cycle post March 2023 and the benefits, activities and funds needed to support each option annually. Options include:

- **Retirement of Service:** Retirement of some or all DDC partners and cessation of joint support provided. Given the mandate of the DDC, this option would contradict previous decisions and the majority of the data requirements outlined in the DDC Guidance by the IPCC would be unfulfilled. It is neither recommended nor feasible without a significant transfer of responsibilities or a change to DDC Guidance.

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<sup>8</sup> Pirani, A., Alegria, A., Al Khourdajie, A., Gunawan, W., Gutiérrez, J. M., Holsman, K., Huard, D., Juckes, M., Kawamiya, M., Klutse, N., Krey, V., Matthews, R., Milward, A., Pascoe, C., van der Shrier, G., Spinuso, A., Stockhause, M., and Xing, X.: The implementation of FAIR data principles in the IPCC AR6 assessment process, Zenodo, <https://doi.org/10.5281/zenodo.6504469>, 2022.

<sup>9</sup> [https://www.ipcc.ch/site/assets/uploads/2018/04/p47\\_decisions.pdf](https://www.ipcc.ch/site/assets/uploads/2018/04/p47_decisions.pdf) p14, IPCC, 2018

- **Skeleton Service:** Delivery of a ‘skeleton service’ with reduced support for authors and TSUs. Some DDC Partners will no longer add new data to the DDC and the available data will become increasingly outdated. Reduced support from their current levels would contradict previous decisions and although it would allow the DDC to fulfil a few of the data requirements outlined in the DDC Guidance by the IPCC, ‘technical debt’ would accumulate and inevitably this would lead to inefficiencies for authors and external users using and managing IPCC data. This is not recommended as there are significant risks to this approach and many of the data requirements outlined by the IPCC would not be fulfilled.
- **Continuity of Current Service:** Maintenance of tools, services and current support for authors/TSUs. This option would allow the DDC to provide continuity of the current service and fulfil the requirements outlined by the IPCC in the DDC Guidance in a sustainable manner.
- **Optimal Service:** Investment to support the future needs of climate data science. This option would allow the DDC to build on the foundations that have already been developed and create a service that not only meets the minimum data requirements outlined in the DDC Guidance by the IPCC, but provides the infrastructure to streamline and improve data management and enhance DDC services in the future for both the IPCC authors/TSUs and external users in the wider community.

A synthesis of funding options and outcomes is presented in Table 1. Table 2 outlines the list of activities and services that DDC can provide for each funding option, as well as the mandate for those services. Note that meeting objectives set-out in IPCC TG-Data’s FAIR Guidelines would require a level of funding consistent with option 3. The options include:

Table 1: Funding requirements for four different funding levels, including in-kind funding from DDC host institutions

| Option                           | Requirement   | In-kind funding* |
|----------------------------------|---------------|------------------|
| 1. Retirement of Service:        | CHF 0         | CHF 270,000      |
| 2. Skeleton Service              | CHF 137,130   | CHF 300,000      |
| 3. Continuity of Current Service | CHF 719,880   | CHF 300,000      |
| 4. Optimal Service               | CHF 1,538,880 | CHF 300,000      |

\*Only secured until 2024

Table 2: Services and Activities

| Service         | Activity                                                                                                                                                                                                                             | Status   | Mandate <sup>10</sup> | Option |   |   |   |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-----------------------|--------|---|---|---|
|                 |                                                                                                                                                                                                                                      |          |                       | 1      | 2 | 3 | 4 |
| Data Management | Maintenance of historical archived data from IPCC ARs and SRs within institutional or public repositories i.e. Github.                                                                                                               | Existing | 2.1                   | ☑      | X | X | X |
| Data Management | Archival, data access and support for future IPCC ARs and SRs input data from climate model future projections provided by projects of the World Climate Research Programme (WCRP) e.g. Coupled Model Intercomparison Project (CMIP) | Existing | 2.2, 2.4              | X      | ☑ | ☑ | ☑ |
| Data Management | Archival, data access and support for future IPCC ARs and SRs key intermediate datasets created by authors of IPCC WGI e.g. Sea level projections                                                                                    | Existing | 2.2, 2.4              | X      | ☑ | ☑ | ☑ |
| Data Management | Archival, data access services for future IPCC ARs and SRs key socioeconomic, observed impacts, climate-related risk data and scenarios                                                                                              | Existing | 2.2, 2.4              | X      | ☑ | ☑ | ☑ |
| Data Management | Archival, data access services for future IPCC ARs and SRs final data used to generate figures                                                                                                                                       | Existing | 2.1, 2.4              | X      | ☑ | ☑ | ☑ |
| Data Management | Data stewardship including maintenance of linkages to the digital ARs, quality control of Digital Object Identifiers                                                                                                                 | Existing | 2.5                   | X      | ☑ | ☑ | ☑ |
| Data Management | Data stewardship including IPCC Errata Protocol requirements                                                                                                                                                                         | New      | 2.5                   | X      | X | ☑ | ☑ |
| Data Management | Expanded capacity for archival of input and intermediate data and socioeconomic data and scenarios, and observed impacts data, stemming from IPCC ARs and SRs for future IPCC ARs and SRs                                            | New      | 2.4, 2.6              | X      | X | X | ☑ |
| Compliance      | Maintain compliance with current repository standards such as CoreTrustSeal or equivalent best practice standards.                                                                                                                   | Existing | 2.5                   | X      | ☑ | ☑ | ☑ |
| Coordination    | Coordinate IPCC data and infrastructure requirements with other networks, e.g., CMIP6 & wider WCRP through DDC Manager's WGCM Infrastructure Panel                                                                                   | Existing | 2.3                   | X      | X | ☑ | ☑ |
| Coordination    | Collaborate with external infrastructure and climate research and data partners that hold data or provide functions relevant to the IPCC e.g. ESGF                                                                                   | Existing | 2.3                   | X      | X | ☑ | ☑ |

<sup>10</sup> Mandate derived from [https://www.ipcc.ch/site/assets/uploads/2018/12/Guidance\\_DDC.pdf](https://www.ipcc.ch/site/assets/uploads/2018/12/Guidance_DDC.pdf)

|                    |                                                                                                                                                                                                                                  |          |                         |   |   |   |   |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-------------------------|---|---|---|---|
| Coordination       | Expanded user outreach, webinars, attendance at forums and enhanced collaborations with external infrastructure and research partners                                                                                            | New      | 2.3, 2.5                | X | X | X | ✓ |
| User Support       | Support for community data users provided through DDC service desk, climate data expert staff at DKRZ, CIESIN; user support for IPCC applications (the Interactive Atlas)                                                        | Existing | 2.5, 2.6                | X | ✓ | ✓ | ✓ |
| User Support       | Support with tools and guidance for authors during future IPCC ARs and SRs collecting data, documentation and provenance information required for DDC data archival and for citing/referencing the used input data in the report | Existing | 2.1, 2.2, 2.3, 2.4      | X | X | ✓ | ✓ |
| User Support       | Expanded support for underserved regions, communities, disciplines                                                                                                                                                               | New      | 2.5                     | X | X | X | ✓ |
| Thought Leadership | Recommendations for best practices in climate data management, e.g., data citation, and participation in relevant IPCC Expert Meetings and Working Group activities                                                              | Existing | 2.6                     | X | X | ✓ | ✓ |
| Thought Leadership | Contribute to IPCC TG-Data activities and initiatives; provide long-term perspectives on data stewardship in the context of climate challenges                                                                                   | Existing | 2.6                     | X | X | ✓ | ✓ |
| Thought Leadership | Enhanced contribution to domain specific standards e.g. Force11, COPDESS, RDA etc.                                                                                                                                               | New      | 2.6                     | X | X | X | ✓ |
| Tooling            | Enhanced support for additional virtual workspaces and collaboration platforms that provide access to requested input datasets and common software packages to support IPCC authors                                              | New      | 2.1, 2.2, 2.3, 2.4      | X | X | X | ✓ |
| Tooling            | Hosting and support for DDC website <a href="https://www.ipcc-data.org/">https://www.ipcc-data.org/</a> including data catalogue, guidance, visualisations, service desk, reporting and secure data repository.                  | Existing | 2.1, 2.2, 2.3, 2.4, 2.5 | X | ✓ | ✓ | ✓ |
| Tooling            | Continued maintenance and updates for IPCC digital tools, such as the WGI Interactive Atlas                                                                                                                                      | Existing | 2.3, 2.5, 2.6           | X | X | ✓ | ✓ |
| Tooling            | Expanded technical support for cloud migration, metrics, access tools                                                                                                                                                            | New      | 2.1, 2.2, 2.3, 2.4, 2.5 | X | X | X | ✓ |
| Tooling            | Expanded support and development of IPCC digital tools, such as the WGI Interactive Atlas                                                                                                                                        | New      | 2.3, 2.5, 2.6           | X | X | X | ✓ |

## Context

The Intergovernmental Panel on Climate Change (IPCC) provides comprehensive and objective, and, therefore, authoritative scientific assessments of highest global policy relevance. The corresponding data and information needs to be of high-quality and equally accessible to researchers, policy makers, stakeholders, and societies all over the world in the long term. Equally important is the provision of relevant data, tools, and guidance for the IPCC authors, editors, and reviewers during the assessment cycle.

The DDC was established at IPCC-13 in 1997. Germany and the United Kingdom kindly offered to execute a shared DDC operation through the Deutsches Klimarechenzentrum (DKRZ) and the Climatic Research Unit (CRU), and Finland kindly offered to contribute guidance and training through the Finnish Meteorological Institute (FMI). During the Second Assessment cycle, IPCC Working Group II (WGII) had requested the lowering of barriers to using data from future climate projections provided by the Coupled Model Intercomparison Project (CMIP) of the World Climate Research Programme (WCRP). The present DDC shares operations based on a MoU (DDC, 2021)<sup>11</sup> among four DDC Partners: DKRZ (Germany), the Center for International Earth Science Information Network (CIESIN, Columbia University, USA), the Spanish Research Council (CSIC, Spain), and MetadataWorks (UK). The IPCC renewed DDC's Guidance in 2018 (IPCC, 2018)<sup>12</sup>, specifying DDC roles and responsibilities as:

- Archive and provide transparency, traceability, and stability of data and scenarios used by the IPCC in its reports, available at the DDC or elsewhere.
- Archive and provide transparency, traceability and stability of data and scenarios underpinning key figures and tables, and headline statements in the IPCC reports.
- Collaborate as appropriate with data centres that hold data or provide functions relevant to the IPCC in a transparent manner, under the oversight of the TG-DATA, in close liaison with the three IPCC Working Group Technical Support Units (WG TSUs), to provide information on relevant data and scenarios.
- Curate new datasets unavailable and not long-term preserved elsewhere and link to external data sets of relevance.
- Improve data, tools and guidance materials for supporting IPCC authors and enhance data services and support for external users, especially in developing countries.
- Contribute to sustainable structure established and approved by the IPCC to provide observed and model data and information relevant at regional scales.

Based on this guidance, DDC, WG TSUs and TG-Data experts developed and implemented the IPCC FAIR guidelines for data handling in the Sixth Assessment cycle with the purpose for enhanced transparency and accessibility of digital information and improved traceability and reproducibility of IPCC findings in the key aspects (Stockhouse et al., 2017, Pirani et al., 2022)<sup>13 14</sup>.

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<sup>11</sup> Xing, Xiaoshi, Stockhouse, Martina, Gutiérrez Llorente, José Manuel, & Irwin, Courtney. (2021). Memorandum of Understanding (MoU) for Operation of the IPCC Data Distribution Centre. Zenodo.  
<https://doi.org/10.5281/zenodo.5914483>

<sup>12</sup> [https://www.ipcc.ch/site/assets/uploads/2018/12/Guidance\\_DDC.pdf](https://www.ipcc.ch/site/assets/uploads/2018/12/Guidance_DDC.pdf)

<sup>13</sup> Pirani, A., Alegria, A., Al Khourdajie, A., Gunawan, W., Gutiérrez, J. M., Holsman, K., Huard, D., Jukes, M., Kawamiya, M., Klutse, N., Krey, V., Matthews, R., Milward, A., Pascoe, C., van der Shrier, G., Spinuso, A., Stockhouse, M., and Xing, X.: The implementation of FAIR data principles in the IPCC AR6 assessment process, Zenodo,  
<https://doi.org/10.5281/zenodo.6504469>, 2022.

<sup>14</sup> Stockhouse, M. and Lautenschlager, M.: Twenty-five years of the IPCC Data Distribution Centre at the DKRZ and the Reference Data Archive for CMIP data, *Geosci. Model Dev.*, 15, 6047–6058, <https://doi.org/10.5194/gmd-15-6047-2022>, 2022.

- Enhanced long-term preservation of digital objects underpinning the report and its preparation including input data, analysis scripts and final data:
  - Curation of the data with rich documentation by a thorough review process; and
  - Stewardship of the data on the long term (keeping data accessible and meaningful; error treatment/version control according to the IPCC Errata Protocol);
- Traceability of key statements of the report by archival and documentation of the figure creation process; and
- Giving credit for input data providers and possibility of receiving credit for analysis scripts and final data preparation.

AR6 WGI has summarised the lessons learned and recommendations for AR7 (Pirani et al., 2022a).

**The DDC is not centrally funded and relies on funds from four nations, Germany, Spain, the UK and the US; and on project and institutional funds. In-kind funding currently allows partners including DKRZ (Germany<sup>15</sup>), CIESIN (US), CSIC (Spain) and MetadataWorks (UK) to continue to deliver core data service for the IPCC. However, the future of the DDC is uncertain as DKRZ (Germany) and MetadataWorks (UK) are not funded post-March 2023.**

## Looking to the future

### Challenges

Increased data volumes, and heterogeneity of data quality distributed over a growing number of climate data centres across the world, make the management of data and scenarios that underpin climate research increasingly challenging. Specifically, the diversity and amount of data relevant to IPCC assessments have greatly increased over the assessment cycles and are expected to increase further. The sustainability of IPCC data and data services that underpin the ARs/SRs is essential to keep policy decisions traceable in the long-term. Moreover, the adoption of new online tools/products as part of the latest assessment report (in particular the WGI Interactive Atlas) requires additional effort and resources to ensure traceability and reproducibility.

IPCC authors are confronted with an increasingly complex landscape of relevant data to analyse during the assessment, including:

- more diverse data sources;
- higher frequency and resolution of data;
- new data science and modelling methods; and
- more diverse sectors and systems affected by climate change.

Data from different disciplines needs to be carefully reviewed, analysed for uncertainties and limitations, and transformed and integrated as essential inputs into the assessment process. Figures that accurately and clearly convey the results of such assessment efforts are critical to IPCC reports. As a result, chapter author teams require significant storage resources for the increasing input data volume together with compute resources for data analysis provided through collaboration platforms with guidance and technical support. Tools and tool components, for consistent and exhaustive collection of information on the complex figure creation process aren't provided currently and yet they are of increasing importance to support IPCC authors, editors, and DDC coordinators, as well as the IPCC review process. Furthermore as the figure creation process and its components

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<sup>15</sup> DDC Partner DKRZ is underfunded for AR6 as it has no national funds; different project funds not dedicated to DDC are used in addition to DKRZ's in-kind funding for operations and data archival; project funding after 03/2023 is uncertain.

are stored at different DDC Partners, making these seamlessly discoverable for consumers of IPCC assessments, is challenging as well.

Benefits:

The IPCC Data Distribution Centre (DDC) has played a key role in the preservation, accessibility, and reusability of vital data and associated information, beginning with the second IPCC Assessment Report released in 1995. By helping to ensure continuity between assessment cycles, the DDC enables the research community to build on previous assessment results more consistently and transparently—with particular emphasis on increased engagement of developing country scientists and on broader assessment of climate impacts and adaptation. In this way, the DDC represents a critical contribution to the IPCC's integrity and its guiding principles of comprehensiveness, objectivity, openness and transparency.

The DDC manages key data sets underlying reports, delivering benefits for the IPCC and the climate change community including:

- **Trust.** The diverse audiences of IPCC assessments including policy makers count on IPCC procedures to be guided by comprehensiveness, objectivity, openness and transparency and the reports' key statements to be traceable and as reproducible as possible. Therefore, data used as inputs must be of high-quality, clearly labelled and documented, and provided through reliable and sustainable data services.
- **Long-term data preservation.** Data and associated documentation underpinning assessment reports are preserved in a long-term, trustworthy certified repository, and thus remains openly accessible in an inclusive manner to future users
- **Access.** Scientists and other stakeholders are able to readily access both current and past IPCC data and associated documentation for review, further studies, and decision making and other applications.
- **New research.** IPCC data is considered state-of-the-art, and constitute valuable starting points for novel research by early career scientists, for extending research to underserved regions, communities, and sectors, and for interdisciplinary education and training
- **IPCC author support.** Authors of IPCC ARs and SRs are supported by collaboration platforms providing access to requested datasets and common analysis packages through the DDC to assess data and create figures; and receive technical assistance and support when needed.
- **Coordination between IPCC authors, editors and the DDC.** The DDC provides templates, tools, such as the DDC data catalogue, for data archival to support the authors documenting data such as input data citations and provenance information on the final data creation process. Additionally, technical interfaces have been set up for data archival and documentation by the responsible DDC Partners in collaboration with the corresponding WG TSU. Technical assistance and support can be requested if needed.
- **IPCC editor and review support.** Editors and reviewers of IPCC reports are able to more readily and efficiently trace data transformation and use, identifying and characterising problems, limitations, and uncertainties and providing feedback to authors.
- **Data services.** Scientists and other stakeholders especially in developing countries with low internet bandwidths are supported with suitable services and guidance to access parts of the available high-volume data for their applications.
- **Discovery.** Users who are particularly interested in data that have been vetted and analysed in IPCC assessments are able to find the data and associated documentation quickly and efficiently.

- **Informed policy.** As specific regions or places begin to take action to address climate changes, they need more specific data and information for the areas and time periods of interest, drawing on detailed data sets available through the DDC or on methods used in IPCC reports applied to new or updated input data.
- **Signposting.** DDC integrates with other data providers and external resources that are associated with the AR/SRs but not stored within the DDC repositories
- **Public engagement.** The DDC provides an additional entry point for data-oriented external users to learn about its data and to obtain information relevant to data and scenarios (e.g., via the Interactive Atlas).
- **Secondary uses.** In light of the interconnectedness of climate change and other global challenges, interdisciplinary data vetted or created through IPCC assessment activities – such as global surface air temperature or sea level projections or other intermediate datasets – are likely to have applications and uses well beyond their use in IPCC assessments and special reports. Examples are climate services providing sectoral data and information.

#### Opportunities:

As recognition of the urgency of climate challenges increases, the DDC is in a unique position to facilitate the work of the IPCC as the latter begins focusing on the seventh assessment cycle and to extend the IPCC's utility and impact in a variety of ways. In close collaboration with TG-DATA, the DDC could work to:

- Improve the visibility and accessibility of DDC data and other input data sources through new APIs and other machine-to-machine connections;
- Support increased data access and use by underserved regions, sectors, groups, and scientific disciplines;
- Improve the accessibility for developing countries by second order technical compute services to reduce the data transfer volume;
- Fill in gaps in IPCC data archival to improve the scientific record since the start of the IPCC;
- Expand regional-to-local data and data services to facilitate wider uptake and use of IPCC data and information by regional and local stakeholders;
- Improve documentation of data usage in IPCC reports and in climate change applications and decision making;
- Improve the quality and efficiency of data selection, evaluation, integration, and documentation in future IPCC assessment and special reports;
- Provide leadership and best practices in key international organisations involved in scientific data stewardship and climate-related data management, such as the ISC World Data System and CODATA, the Research Data Alliance (RDA), the Group on Earth Observations (GEO), and WCRP; and
- Coordinate IPCC requirements and timelines with important input data and infrastructure providers, such as WCRP projects like CMIP7 and ESGF.

In past AR cycles, the IPCC did not require WGs to preserve IPCC data. User requests for data were sent to the Secretariat, which relayed them to the TSUs, which then communicated with CLAs to identify the scientists responsible for the data in the hope that they kept a copy. Other user requests were directed to individual DDC Partners and in case of unavailability communicated to the TSU. With AR6, TG-Data asked WGs to follow FAIR guidelines and work to preserve data, at least those that underpin SPM and TS material. The IPCC has the opportunity to set policy for future ARs and whether to:

- (A) adopt FAIR principles and requires WGs to make IPCC data Findable, Accessible, Interoperable and Reusable; or
- (B) leaves decisions on FAIR practices to individual WGs, chapters or authors.

## Options

The following proposal seeks to, at a minimum, establish a sustainable data service for the IPCC, through the DDC, for the next 5-7 years. Continuation of the DDC is essential in establishing coherence between assessment cycles and ensuring that the data underlying IPCC reports continues to be FAIR (findable, accessible, interoperable and reusable). DDC services include:

### **DKRZ (Germany, Stockhause and Lautenschlager, 2022<sup>16</sup>):**

- Archival of input data from the Coupled Model Intercomparison Project (CMIP) of the World Climate Research Programme (WCRP) used in ARs
- Archival of key intermediate datasets created by authors of IPCC WGI, for AR6:
  - Sea level projections
  - Ocean Heat content
  - Assessed Global Surface Air Temperature projections
- Long-term preservation of input and intermediate datasets in compliance with current repository standards as specified by the World Data System (WDS) of the International Science Council (ISC)
- Long-term data stewardship including IPCC Errata Protocol requirements and maintenance of linkages to the digital ARs
- Coordinate IPCC data and infrastructure requirements with CMIP6 and the wider WCRP through DDC Manager's WGCM Infrastructure Panel (WIP) membership
- Collaborate with external infrastructure and climate research partners
- Contribute expertise to international fora on best practices in data long-term preservation and data citation as well as domain-specific data and metadata standards
- Contribute to joint service desk, joint DDC catalogue, DDC web pages and other core joint DDC services, maintain Zenodo Communities for DDC and TG-Data, and contribution to core TG-Data membership obligations including outreach
- Contribute to the best practices for data handling within IPCC including the IPCC FAIR Guidelines development/formulation, communication and implementation, e.g. through participation at IPCC Expert Meeting on Assessing Climate Information for Regions in 2018 and joint organisation of WGI Training on Data and Software Development in 2019 together with TSU and former DDC Partner CEDA
- User support for data from climate data expert staff at DKRZ
- Serving as IPCC TG-Data representative in the IG Publication
- For AR6, Virtual Workspaces as collaboration platforms were provided in support of IPCC authors.

### **CIESIN (USA):**

- Archiving of selected socioeconomic data and scenarios and associated materials (e.g., literature databases) used or developed in ARs and SRs
- Archiving of observed impacts data
- Archiving of climate-related risk data (e.g., global risk indexes)

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<sup>16</sup> Stockhause, M. and Lautenschlager, M.: Twenty-five years of the IPCC Data Distribution Centre at the DKRZ and the Reference Data Archive for CMIP data, Geosci. Model Dev., 15, 6047–6058, <https://doi.org/10.5194/gmd-15-6047-2022>, 2022.

- Deep archiving (limited access) of specific versions of data used in IPCC assessments or special reports, when data are available currently from other sources
- Development or hosting of guidance materials on socioeconomic scenarios, climate impacts data, and other selected topics
- Development or contributing to DDC and TG-Data guidance documents (e.g., IPCC data licence and data citation)
- Coordination of DDC policies, best practices, and procedures with TG-Data and relevant organisations involved in data stewardship (e.g., WDS, CODATA, RDA, GEO, UN GGIM)
- Joint management on the DDC website and pages, DDC catalogue, and other core joint DDC services and infrastructure to support the services
- Contribute to the joint service desk, and to core TG-Data membership obligations including outreach.
- User support on relevant data from expert staff at CIESIN.

#### **CSIC (Spain):**

- Hosting, maintenance and user support for the AR6 WGI Interactive Atlas
- Archival of key intermediate datasets created by authors of IPCC WGI, for AR6: Atlas datasets
- Contribute to the joint service desk, and to core TG-Data membership obligations including outreach
- Virtual Workspaces and collaboration platforms in support of IPCC authors
- Contribute to the best practices and IPCC guidance for data handling within IPCC including the implementation of FAIR data principles.

#### **MDW (UK):**

- operation and maintenance of the current DDC website
- updates to website and metadata schema
- enhancing utility to make data, scenarios and guidance easier to find, understand and access
- providing a service desk and wiki for IPCC data to serve the needs of the global community more effectively
- tool for authors to onboard IPCC data and make it open and FAIR
- coordination of new partners and existing members.

### **Option 1: Retirement of service**

Retirement of some or all DDC partners and cessation of joint support provided (requirement: 0 FTE, in-kind: 1.8 FTE)

#### **DKRZ:**

- Long-term preservation of DDC data holdings as part of DKRZ's obligations as Regular Member of the World Data System; DKRZ voluntary contribution to the project would be limited to 0.3 FTE covered by DKRZ in-kind funding

#### **CIESIN:**

- CIESIN would continue to maintain its existing DDC holdings, if necessary transferring them to Columbia University's institutional archive for long-term access
- CIESIN would not necessarily add data from future assessments to its DDC collection
- CIESIN would likely continue to work with ICONICS and other data sources to archive relevant scenario data, whether or not used by the IPCC.

#### **CSIC:**

- Continue hosting for the AR6 WGI Interactive Atlas but no user support and no resources available for maintenance, updates errata, etc.

#### **MDW:**

- DDC html pages would be transferred to another party nominated by the IPCC
- DDC archived website would be transferred to another party nominated by the IPCC
- Data holdings from <https://www.ipcc-data.org/> would need to be transferred to a nominated party or stored in a github repository. If transferred to a Github repository the data would cease to be compliant with FAIR principles.
- Data Catalogue tooling and hosting for publishing and curating data would be withdrawn
- No support for coordination with TSUs

### **Drawbacks:**

*Key findings of the IPCC ARs becoming non-transparent and non-traceable over time and DDC ceases functioning as a unit.*

- No guarantee that data used in IPCC ARs are preserved.
- High-volume input and intermediate data like CMIP will not be archived due to the high costs.
- No long-term stewardship of the IPCC data, which includes version control and error treatment according to the IPCC Error Protocol and maintenance of links to the digital AR6, limiting the reuse of the data.
- IPCC results may not be traceable once authors have moved on and data is lost
- Additional burden on IPCC authors.
- No consistency in data formats and standards, generating confusion and complexity for end-users, and limiting the reusability of the data.
- No central access point for IPCC data.
- IPCC data would not meet FAIR data guidelines i.e. Findable, Accessible, Interoperable and Reusable
- No consistency of personnel and institutional knowledge across assessment cycles

- No support for users of IPCC data
- Reduction in trust, accountability, equity of access, data discovery, new research, informed policy, signposting, public engagement, no secondary uses
- No ex-officio membership of TG-DATA

**Benefits:** No cost for IPCC.

**Further Comments:** Option 1 is not feasible. IPCC authors would be responsible for making their data publicly available in the next ARs. This will be associated with costs in case of high-volume data. Although a small subset of historical data could be transferred to a basic file store for archival, i.e. github or Zenodo, the volume of DKRZ's data is too high for this solution.

## Option 2: Skeleton service

Delivery of a 'skeleton service' with reduced support for authors/TSUs (requirement: 0.6 FTE, in-kind: 1.8 FTE)

### DKRZ:

- Long-term preservation of DDC data holdings as part of DKRZ's obligations as Regular Member of the World Data System (0.3 FTE)
- Limited contribution to joint DDC and IPCC tasks (0.4 FTE):
  - Limited contribution to help desk, joint DDC catalogue, DDC web pages and other core joint DDC services and core TG-Data membership obligations
  - Long-term data stewardship including errata treatment according to IPCC Error Protocol so that data records continue to be maintained

### CIESIN:

- Continued archiving and support of selected IPCC socioeconomic data and scenarios, and observed impacts data, stemming from IPCC ARs and SRs (0.75 FTE)
- Limited contribution to joint DDC and IPCC tasks, participation in TG-DATA (0.25 FTE)

### CSIC:

- Continue hosting, user support and maintenance (including errata) for the AR6 WGI Interactive Atlas (0.3 FTE)
- Limited contribution and support to join DDC and IPCC tasks (0.2 FTE)

### MDW:

- Operation and maintenance of the current DDC website
- Tool for authors to onboard IPCC data and make it open and FAIR
- Limited coordination (0.2 FTEs), therefore responsibility for remaining activities would be transferred to TG-DATA and TSUs

## Drawbacks:

### ***Incomplete data archival without long-term stewardship***

- No additions of CMIP input data and important intermediate data for future cycles
- No coordination with CMIP and WCRP i.e. DDC will no longer have the ability to recommend and influence CMIP infrastructure development
- No dedicated support capability for TSUs and authors within each cycle - TSUs and authors do not have access to data expertise from DDC
- Only selected data supported; likelihood that broader range of data are not consistently preserved and accessible
- No validation / review of data
- Messy data uploaded,
- Less transparent and traceable data,
- integrity of IPCC reports and underlying data could be questioned
- Limited coordination across cycles
- Limits to contributions to data governance policy / standards / best practice for IPCC data
- No tooling for high volume data included - data will not be connected to the report - no traceability between report and specific datasets used

**Benefits:**

- Consistency of personnel and institutional knowledge across assessment cycles
- Ex-officio membership of TG-DATA
- DDC continues to function as a unit albeit with reduced capacity
- Self-service data archival provided for authors

**Costs:**

- DKRZ: 0.7 FTE (0.5 FTE covered by DKRZ in-kind funding)
- CIESIN: 1.0 FTE (assumed to be covered by NASA SEDAC funding)
- CSIC: 0.5 FTE (assumed to be covered by CSIC funding)
- MDW: 0.2 FTE and tooling/hosting costs for DDC data catalogue

### Option 3: Continuity of current service

Maintenance of tools, services and current support for authors/TSUs (requirement: 4.3 FTE, in-kind: 1.8 FTE)

#### DKRZ:

- Long-term preservation of DDC data holdings as part of DKRZ's obligations as Regular Member of the World Data System (0.3 FTE)
- Limited contribution to joint DDC and IPCC tasks (0.4 FTE)
- Enhanced contribution to joint DDC and IPCC tasks (0.1 FTE):
  - Enhanced contribution to joint service desk, joint DDC catalogue, DDC web pages, maintenance of the Zenodo communities for DDC and TG-Data, and other joint DDC services
  - Enhanced contribution to TG-Data activities including outreach and best practices for IPCC's data handling
  - Enhanced long-term data stewardship including errata treatment according to IPCC Errata Protocol including maintenance of linkages to the digital ARs
- Networking and contribution of expertise (0.1 FTE):
  - Collaboration with external infrastructure and climate research partners like ESGF, ES-DOC, ENES-RI.
  - Contribute expertise to international fora on best practices in data long-term preservation and data citation as well as domain-specific data and metadata standards Force11, COPDESS, RDA , OGC.
- Coordination of IPCC and DDC requirements for CMIP input data with WCRP on aspects like data request, timelines, and infrastructure requirements (0.1 FTE)
- Archival and long-term preservation of CMIP input data and core and important intermediate data for future cycles up to a volume of 1 PB (1 FTE)
- IPCC author support (0.5 FTE):
  - Provide collaboration platforms with access to selected datasets in the data pool and common software packages (provided pro-bono)
  - Access to compute and disk storage resources (*subject to approval by DKRZ's Scientific Steering Committee and within limits of **non-funded HPC resource pool***). Hardware costs for collaboration platform/virtual workspaces for WGI authors may need further funding beyond the free-resource pool<sup>17</sup>
  - Tools and guidance to provide provenance information including CMIP input, intermediate and final data information sufficient for archival in the DDC and supporting a smooth transition of intermediate and final data to the DDC; in collaboration with communities providing software packages used by WGI authors like ESMValtool

#### CIESIN:

- Archiving and support of broader range of IPCC socioeconomic data and scenarios, and observed impacts data, stemming from IPCC ARs and SRs (1.5 FTE)
- Continued contribution to joint DDC and IPCC tasks, participation in TG-Data, and coordination with external networks (0.5 FTE)

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<sup>17</sup> Provision of resources is subject to approval by DKRZ's Scientific Steering Committee. A reliable cost estimation is not possible because the demand from IPCC authors is unknown and the future development of energy prices is unpredictable. Access to DKRZ's data pool including CMIP data and provision of common tool packages is granted free of charge.

**CSIC:**

- Continue hosting, user support and maintenance (including errata) for the AR6 WGI Interactive Atlas (0.3 FTE)
- Contribution and support to join DDC and IPCC tasks (0.2 FTE)
- Expanded user support and outreach and enhanced support for improved guidance for IPCC authors and users of the DDC in coordination with the DDC Partners including webinar for authors. (1 FTE)

**MDW:**

- operation and maintenance of the current DDC website
- improved user interfaces to make data, scenarios and guidance easier to find, understand and access (0.1 FTE)
- service desk and wiki for IPCC data to serve the needs of the global community more effectively (0.1 FTE)
- tool for authors to onboard IPCC data and make it open and FAIR
- coordination of new partners and existing members (0.4 FTE )

**Drawbacks:*****We may miss additional opportunities to further invest in the future of climate science***

- No provision for virtual workspaces to support IPCC authors
- Limited resource to invest in additional digital and online data tools for the IPCC
- Underserved regions, communities, disciplines do not receive expanded support
- No budget for additional public engagement for external users that would improve the accessibility and usage of DDC materials

**Benefits:**

- Consistency across assessment cycles
- Continued trust, accountability, equity of access, data discovery, new research, informed policy, signposting, public engagement, no secondary uses
- Ex-officio membership of TG-DATA
- IPCC meets FAIR data guidelines
- Authors provided with ongoing support
- Opportunity to continue thought leadership activities
- Resource available for collaboration and coordination with external parties

**Costs:**

- DKRZ: 2.5 FTE (0.5 FTE covered by DKRZ in-kind funding)
- CIESIN: 2 FTE (1.0 FTE covered by NASA in-kind funding)
- CSIC: 1 FTE (0.5 FTE covered by CSIC in-kind funding)
- MDW: 0.6 FTE and tooling/hosting costs for DDC data catalogue

#### **Option 4: Optimal service**

Investment to support the future needs of climate data science (requirement: 9.5 FTE, in-kind: 1.8 FTE)

##### **DKRZ:**

- Long-term preservation of DDC data holdings as part of DKRZ's obligations as Regular Member of the World Data System (0.3 FTE)
- Limited contribution to joint DDC and IPCC tasks (0.4 FTE)
- Enhanced contribution to joint DDC and IPCC tasks (0.1 FTE)
- Networking and contribution of expertise (0.1 FTE)
- Coordination of IPCC and DDC requirements for CMIP input data with WCRP on aspects like data request, timelines, and infrastructure requirements (0.1 FTE)
- Archival and long-term preservation of further 0.5 PB of input data and important intermediate data for future cycles (0.3 FTE)
- Enhanced data access services for humans and machines with a special focus on volume reduction before data transfer in support of developing countries with low internet bandwidth (1 FTE)
- Contribution to enhanced and improved guidance for IPCC authors and users of the DDC in coordination with the DDC Partners including webinar for authors (0.2 FTE)

##### **CIESIN:**

- Expanded archiving and support of broader range of IPCC socioeconomic data and scenarios, and observed impacts data, stemming from IPCC ARs and SRs (2.0 FTE)
- Expanded contribution to joint DDC and IPCC tasks, participation in TG-Data, and coordination with external networks (1.0 FTE)
- Expanded support for underserved regions, communities, disciplines (0.5 FTE)
- Expanded technical support for cloud migration, metrics, access tools (0.5 FTE)

##### **CSIC:**

- Continue hosting, user support and maintenance (including errata) for the AR6 WGI Interactive Atlas (0.3 FTE)
- Contribution and support to join DDC and IPCC tasks (0.2 FTE)
- Expanded user support and outreach and enhanced support for improved guidance for IPCC authors and users of the DDC in coordination with the DDC Partners including webinar for authors. (1 FTE)
- Virtual workspaces for IPCC author support with access to selected datasets and common software packages (1 FTE)

##### **MDW:**

- operation and maintenance of the current DDC website
- improved user interfaces to make data, scenarios and guidance easier to find, understand and access (0.5 FTE)
- service desk and wiki for IPCC data to serve the needs of the global community more effectively (0.2 FTE)
- tool for authors to onboard IPCC data and make it open and FAIR
- coordination of new partners and existing members (0.8 FTE)

**Drawbacks:**

- Increased investment needed

**Benefits:**

- Consistency across assessment cycles
- IPCC meets FAIR data guidelines
- Continued trust, accountability, equity of access, data discovery, new research, informed policy, signposting, public engagement, no secondary uses
- Expanded data access and use by underserved regions, communities, sectors
- Faster and deeper integration of IPCC data and outputs into climate change decision making from local to global scales

**Costs:**

- DKRZ: 4 FTE (0.5 FTE covered by DKRZ in-kind funding)
- Hardware costs for collaboration platform and virtual workspaces for WGI
- CIESIN 4 FTE (1.0 FTE covered by NASA in-kind funding)
- CSIC: 2 FTE (0.5 FTE covered by CSIC in-kind funding)
- MDW: 1.5 FTE and tooling/hosting costs for DDC data catalogue