Observations in the IPCC Climate Assessments
Highlights of uses and needs based on the IPCC AR6 reports

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With inputs from Peter Thorne, Frank Dentener, Hervé Douville, Raghavan Krishnan, Valérie Masson-Delmotte, Panmao Zhai, Sergey Gulev, Helene Hewitt, Baylor Fox-Kemper, Jan Fuglestad, Andy Reisinger, Elena Shevliakova, Andrés Alegria, Sandro Fedrici
234 authors, 65 countries
14,000+ scientific papers
78,000+ review comments

270 authors, 67 countries
34,000+ scientific papers
62,000+ review comments

278 authors, 65 countries
18,000+ scientific papers
59,000+ review comments
Towards the 7th IPCC Assessment cycle

2023
- Completion of the AR6 Synthesis Report (March 2023)
- AR6 Technical Support Units spinning down
- Start of the AR7: Elections of AR7 Bureau (July 2023)
- AR7 Technical Support Units start being constituted
- Hand over from AR6 to AR7, lessons learned (Fall 2023)

2024 –
- Special Report on cities and climate change
- Establishing the AR7 workplan (Working Groups, Special Reports)
- Scoping of the AR7 reports
- Authors selected
- Renewal of Task Group on Data Support for Climate Change Assessments

2028
- Global stocktake
Earth system observations are an essential driver of progress in our understanding of climate change and of informing our responses.

[Credit: NASA]
Widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred.

Annual averages
Grey indicates that data are not available.
Updated global surface temperature estimates

Last decade warmer than all prior decades on record

Challenges (data voids) in polar regions, tropical forests, deserts, developing countries

Opportunities of data rescue, centennial reanalyses, coupled reanalyses

Air-sea fluxes to understand marine lower boundary layer fluxes
Observed warming is driven by emissions from human activities

- Global greenhouse gas monitoring system
- Regional distribution, timeseries, high resolution monitoring of aerosols and short-lived climate forcers
- Observational constraints on emissions with large uncertainty
  - fugitive methane emissions
  - natural / anthropogenic sources and sinks (land)

Adapted from WGI Figure SPM.2
The Earth’s energy imbalance causes increased heating of the climate system.
"The changes we experience today will increase with further warming."
Broad agreement across multiple lines of evidence, supporting a best estimate of equilibrium climate sensitivity of 3°C, with a likely range of 2.5°C to 4°C.
Future global warming depends on future emissions of CO$_2$ and other greenhouse gases.

![Graph showing global surface temperature change relative to 1850–1900](WGI Figure SPM.8)
Future global warming depends on future emissions of CO$_2$ and other greenhouse gases.
Continued global warming is projected to further intensify the global water cycle including its variability, global monsoon precipitation and the severity of wet and dry events

- **Longer observational time series**
- **Further analysis of past and current climate variability alongside future climate change projections**
- **Projected water cycle changes have not been constrained with observations in the AR6. Progress expected:**
  - **Direct relation to global warming**
  - **Other observations to constrain the water cycle response (e.g., global land surface relative humidity).**
Climate change is already affecting every region on Earth

Heavy precipitation

**Type of observed change**
- Colour = Increase/decrease
  - Light grey: Low agreement in the type of change
  - Medium grey: Limited data and/or literature

**Confidence in human contribution to the observed change**
- ⬤⬤⬤⬤ High
- ⬤⬤⬤ Medium
  - Low due to limited agreement
  - Low due to limited evidence
Every increment in global warming will result in increased risks.
Linking climatic impact-drivers with societal and ecosystem vulnerabilities and exposure, and consequences of responses to climate change

3.3-3.6 billion people in highly vulnerable contexts

Ecosystems

1 billion people exposed to sea level rise by 2050

Responses
- Maladaptation
- Pressures on land use
Current global drought risk and its components in 1901-2010

- **Potential to develop EO applications based on info from multiple ECVs and combined with other types of data (e.g., socio-economics, demographics...).**
Adverse impacts and related losses and damages escalate with every increment of global warming

**Observations for ecosystem adaptive management**

- Enhancing the coastal monitoring network
- Early warning, cascading interactions, recovery, management interventions
- Habitat forming species, keystone species, ecosystem thresholds / tipping points
- Restoring carbon- and species-rich ecosystems
Evidence of constraints and limits to adaptation by region and sector

- Existing comparative data for adaptive capacity worldwide is at a rather coarse level.

- Spatially more resolved (sub-national) data needed
To limit global warming, strong, rapid, and sustained reductions in CO$_2$, methane, and other greenhouse gases are necessary.
Assessing collective progress in emissions reductions

- Global obs of concentrations are important to constrain regional emissions databases.
- Observing the state of biospheric C sinks, land, and the ocean to assess whether natural sinks are taking up human-caused emissions.
- Regional/national emission estimates of non-CO$_2$ emissions by observations (satellite and regional flux networks)
Reconciling estimates of greenhouse gas sources and sinks

Global net CO₂ flux due to AFOLU estimated using different methods for the period 1960 to 2019 (GtCO₂ yr⁻¹)

- Regional CO₂ emissions from land-use/land-use change
- Remote-sensing products
  - spatial and temporal land-use and biomass data
  - attribute changes to human causes or natural variability
- High resolution observations, incl. fire, regrowth, repeated deforestation
Reporting of national greenhouse gas emissions and removals

• GHG fluxes - direct measurements for verification (and potential refinement) of inventory estimates
• Timeseries of land cover/land use area data across time
• Consistency in terminology and classifications of sources/sinks and associated natural and anthropogenic GHG fluxes
• Assessing the use of atmospheric observational data and inversion models for verification of national inventory estimates

Methane sources and sinks for four decades from atmospheric inversions with the budget imbalance
There are options available now in every sector that can at least halve emissions by 2030

- Improved quantification of anthropogenic and natural greenhouse gas fluxes and emissions modelling
- Better understanding of the impacts of climate change on the mitigation potential and permanence
- Improved (real time and cheap) measurement, reporting and verification
- Monitoring in light of net zero
While the quantity, quality and diversity of climate system observations have grown since AR5, the loss or potential loss of several critical components of the observational network is also evident.
Building an integrated global observing system long-term to inform decision making

- Use of multiple observational products
- Validation for climate models, use of community standards and tools
- Long-term consistent datasets
- Regional information, high resolution, urban-scale
- Constraining estimates from multiple sources of evidence
- Rates of change and emergence
- Early warning and monitoring
- Verification of emissions
- Importance of free and open data, facilitate use of latest products
- Engagement in, and support of, the assessment process
The IPCC Climate Report shows how taking action now can move us towards a fairer, more liveable world.
Data, Tools and Methods Used across the WGI Report

Major Developments and Their Implications
- Observational Data and Observing Systems
- Major Expansions of Observational Capacity
- Threats to Observational Capacity or Continuity
- New Developments in Reanalyses
## Annex I: Observational Products

Coordinating Lead Authors:
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Lead Authors:
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### Table AI1 | Observational products used by Working Group I in the Sixth Assessment Report.

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<th>Name</th>
<th>Version</th>
<th>Type</th>
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<th>Section(s)</th>
<th>Time Period</th>
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<td>Reanalysis</td>
<td>3-hourly 2° × 2°, 24-vertical levels</td>
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<td>NOAA-CIRES 20th Century Reanalysis (20CR)</td>
<td>3</td>
<td>Reanalysis</td>
<td>3-hourly 0.5° × 0.5°</td>
<td>2.3.1, 3.3.3, 3.7.1</td>
<td>1851–2020</td>
<td>Silvinskas et al. (2019) <a href="www.esrl.noaa.gov/psd/dataset/20thC_Reanalysis">www.esrl.noaa.gov/psd/dataset/20thC_Reanalysis</a></td>
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<td>In situ</td>
<td>Daily</td>
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<td>10.2.1</td>
<td>1961–2010</td>
<td>Aalto et al. (2016) <a href="www.csc.fi/~oportin">www.csc.fi/~oportin</a></td>
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<td>Advanced Global Atmospheric Gases Experiment (AGAGE)</td>
<td>In situ</td>
<td>Up to 36 times per day Point-based</td>
<td>2.2.3, 2.2.4, 5.2.2, 5.2.3</td>
<td>1978–2020</td>
<td>Prinn et al. (2018) <a href="http://agage.mit.edu/data">http://agage.mit.edu/data</a></td>
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Regional climate information
10 Linking global to regional climate
11 Weather and extreme events
12 Climate information for regional impact & risk assessment
13 Regional climate change Atlas

Large scale climate change
2 Changing state of the climate system
3 Human influence on the climate system
4 Future global climate

Climate processes
5 Global carbon and other biogeochemical cycles
6 Short-lived climate forcers
7 The Earth’s energy budget
8 Water cycle changes
9 Oceans, cryosphere, sea change
Regional climate information
10 Linking global to regional climate
11 Weather and extreme events
12 Climate information for regional impact & risk assessment
13 Regional climate change Atlas
A novel tool for flexible spatial and temporal analyses of much of the observed and projected climate change information underpinning the Working Group I contribution to the Sixth Assessment Report, including regional synthesis for Climatic Impact-Driver (CID) drivers.

https://interactive-atlas.ipcc.ch/
## FAIR Data and Code – Figure Data Tables

- Figure traceability (which input datasets were used and giving the data creators credit)
- The data tables can also include links to code
- License type

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<th>Type</th>
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<td></td>
</tr>
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</table>
FAIR Data and Code

**Long term data archival via IPCC Data Distribution Centre** - [www.ipcc-data.org](http://www.ipcc-data.org)

- CMIP6 snapshot
- Assessed ‘constrained’ datasets
- Figure data
- WGI Interactive Atlas full provenance and reusability

**Code**

- WGI Github Repository - [github.com/IPCC-WG1](https://github.com/IPCC-WG1)

**Citations**

- Data and code are published via the DDC catalogue or with Zenodo
- Please also cite the full relevant (e.g. chapter) citation.
Lessons learned for AR7

• **Ease of integration of multiple lines of evidence e.g. with community data standards and documentation, analysis tools, facilitated data access**

• **Documentation and curation of data assessed in the report for transparency and FAIR principles for open science**

• **Cataloguing datasets and literature assessed in the report**

• **Greater integration of data products, including links to other WGs by means of interactive tools to support user access and exploration**

• **Coordinated community support of the assessment and small author teams**
Thank you

www.ipcc.ch

Interactive Atlas: interactive-atlas.ipcc.ch

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