Framework Convention on Climate Change

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Earth Information Day 2025

Informal summary report by the Chair of the Subsidiary Body for Scientific and Technological Advice

I. Background and overview

1. Earth Information Day provides an opportunity for Parties to engage with the systematic observation community to share and understand latest information, trends and projections in Earth observations to inform negotiations and wider decision-making. During Earth Information Day, messages on enhancing systematic observation, related initiatives and advancing cooperation have been recognized. Further, Earth Information Day provides a platform to identify gaps and challenges in this regard, and opportunities for addressing them.

2. Earth Information Day 2025 was held on Monday, 10 November 2025 in conjunction with the Belém Climate Change Conference. The event comprised of an opening segment, plenary session with updates from relevant organizations and initiatives, and two break-out discussions. The themes for the event were:

(a) State of the global climate system and sustaining long-term observations;

(b) Observations for supporting climate action (mitigation, adaptation, and averting, minimizing, and addressing loss and damage), and the ocean and cryosphere;

(c) Enhancing Earth observations data access and sharing, and related innovation and technologies.

3. The event was held under the overall facilitation of the SBSTA Vice-Chair, Carol Franco. An information note on the event, agenda, presentations from experts, and webcast are available on the event webpage.[1] Guiding questions for the respective thematic breakout session were provided to participants beforehand, to facilitate discussions and respond to the information needs presented by Parties and stakeholders in their submissions.

4. Parties are encouraged to consider the key messages, outcomes and discussions from Earth Information Day 2025 presented in this report, for relevant upcoming negotiations, decision-making and cooperation, with a view to effectively supporting work under the Convention and the Paris Agreement.

[1] See event page https://unfccc.int/event/Earth-information-day-2025-mandated-event.

Abbreviations and acronyms

AI	artificial intelligence
AR6	Sixth Assessment Report of the Intergovernmental Panel on Climate Change
AR7	Seventh Assessment Report of the Intergovernmental Panel on Climate Change
AMOC	Atlantic Meridional Overturning Circulation
CBERS	China-Brazil Earth Resources Satellite
CEOS	Committee on Earth Observation Satellites
CGMS	Coordination Group for Meteorological Satellites
CH_4	methane
CMIP	Coupled Model Intercomparison Project
CO_2	carbon dioxide
COP	Conference of the Parties
CORDEX	Coordinated Regional Climate Downscaling Experiment
ECMWF	European Centre for Medium-Range Weather Forecasts
ECV	essential climate variables
ESA	European Space Agency
ESMO	Earth System Modelling and Observations
EWS	Early Warning System(s)
EW4ALL	Early Warnings for All initiative
GAW	Greenhouse Gas Atmospheric Watch
GBON	Global Basic Observing Network
GCOS	Global Climate Observing System
GEO	Group on Earth Observations
GGA	Global goal on adaptation
GHG	greenhouse gas(es)
GOOS	Global Ocean Observing System
G3W	Global Greenhouse Gas Watch
IGCC	Indicators on Global Climate Change
IPCC	Intergovernmental Panel on Climate Change
LDC	least developed country
MHEWS	Multi-hazard Early Warning System(s)
N_2O	nitrous oxide
SBSTA	Subsidiary Body for Scientific and Technological Advice
SIDS	small island developing State(s)
SOFF	Systematic Observations Financing Facility
UNFCCC	United Nations Framework Convention on Climate Change
WCRP	World Climate Research Programme
WDCGG	World Data Centre for GHGs
WG	Working Group of the Intergovernmental Panel on Climate Change
WIGOS	World Meteorological Organization Integrated Global Observing System
WMO	World Meteorological Organization
WWA	World Weather Attribution

Earth Information Day 2025, Key Messages

1. The year 2025 was on track to being amongst the three warmest years on record, with global mean surface temperature of 1.42+/- 0,12 ºC, and the last 11 years, 2015–2025 have been the warmest period on record.

2. Global greenhouse gas (GHG) concentrations, based on the three key GHGs of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), reached record observed levels in 2024. The annual increase in CO_2 concentrations from 2023 to 2024 was 3.5 parts per million, being a record increase in recent observational history.

3. Ocean heat content was highest on record in 2024 and sea-level continues to rise. Glacier mass loss, which also contributed to sea-level rise, reached 1.3 metre water equivalent of ice in 2023/2024 which is the largest loss of ice on record.

4. There are advances, though with varying capabilities, in studies for attributing extreme events such as extreme rainfall, extreme heat, wildfires, droughts and hurricanes to climate change, however gaps remain in relation to access to and quality of data used to advance more studies.

5. Robust, sustained and long-term Earth observations are supporting climate mitigation, compiling GHG inventories and reporting, the assessment of economic and non-economic loss and damage, and has potential to support the monitoring of climate adaptation, through the GGA indicators.

6. Innovations such as AI and machine learning are strengthening prediction, particularly of extreme climate events, weather forecasting, and EWS, especially in developing countries, at a lower cost.

7. There are unprecedented threats to the global climate observing system and sustaining long-term observations due to a decline in in-situ networks and uncertainty in follow-up satellite missions as well as reduced support towards GCOS' work in coordinating global observations.

8. The SOFF is supporting developing countries, particularly LDCs and SIDS to close observation gaps and reach GBON compliance, and is engaging in innovative funding instruments, such as bonds to sustain financing.

II. Summary of proceedings

A. Opening segment

5. The Executive Secretary of UNFCCC, Simon Stiell recognized the role of observational data, as well as the scientific and observation community, in enhancing our understanding of the climate system and informing climate policy and action. Observational data provides the necessary information for EWS and evidence to support effective climate policies, which is particularly relevant during the IPCC intracycle period. He also highlighted the growing challenges related to the global climate observing system, particularly due to inadequate infrastructure, capacity gaps and declining support which is also eroding global cooperation. Simon Stiell stressed the need to maintain, protect and expand long-term observation systems, which are a global public good, through predictable financing and collaboration to close the data gaps, particularly in vulnerable and data-sparse regions.

6. The IPCC Chair, Jim Skea, provided updates on the commencement of work under the AR7, following the IPCC 63rd Plenary held in Lima. In his update, Jim Skea indicated that the plenary agreed on the scope of the three WG reports, the 2027 special report on cities and climate change, and the 2027 methodological reports on short-lived climate forcers and carbon-dioxide removal technologies, carbon capture utilization and storage. An update of the scoping and planned meetings of authors for the various reports and expert reviews was provided. Jim Skea also highlighted efforts being undertaken by IPCC to enhance inclusivity, diversity and equity, including by expanding access to scientific literature for authors from developing countries, securing support for chapter scientists from developing countries and holding an expert meeting on Gender, Diversity, Equity and Inclusivity.

7. The IPCC Chair affirmed that observational data is key to IPCC’s work, such as in the context of overshoot of 1.5 °C warming. AR7 will be addressing areas of low-confidence from AR6, such as on attribution, including of agricultural and ecological drought, and of specific weather events to global climate change. Further, AR7 will also place high consideration on adaptation, noting gaps in means to measure its progress, and revise and update the 1994 Technical Guidelines on assessing impacts and adaptation, and include a chapter on finance under WG II. It will also consider the linkage between climate action and sustainable development goals, including addressing distributional consequences of actions, synergies and trade-offs with biodiversity and ecosystems, conservation and restoration, as well as human rights, equity, justice and impacts on vulnerable groups. Jim Skea reaffirmed the IPCC’s commitment to facilitate consensus, based on trusted evidence from the growing body of scientific knowledge.

8. The WMO Secretary General, Celeste Saulo provided highlights of the WMO State of the Global Climate Update. According to the update, 2025 was set to being either the second or third warmest year on record, with an average temperature of 1.42 °C above pre-industrial levels, and that the past three years have been the warmest three years on record. WMO highlighted that it will be virtually impossible to limit warming to 1.5 °C without temporarily overshooting, and that it is essential to bring temperatures back to 1.5 °C by the end of the century. Further, the GHG concentrations are highest in 800,000 years with the levels between 2023 and 2024 being the highest ever measured. Further, ocean heat content is record high, and long-term sea-level rise continues, as well as the retreat of sea-ice and glaciers. Celeste Saulo also highlighted the status and progress across life-saving EWS. According to the update, countries with MHEWS has doubled since 2015, and climate services are widely informing decision-making in these countries, for instance in the health and agriculture sectors. She acknowledged advances in Earth observations, from satellite constellations to community-based monitoring systems, and data sharing, but cautioned that more investments are required to maintain the global climate observing system.

9. The Chair of the GCOS, Thelma Krug, elaborated on GCOS’ role in global climate monitoring by maintaining the ECVs which are essential to predictions and informing action. GCOS, including in collaboration with other organizations, identifies and reports the status and gaps in systematic observations, and outlines means for addressing these gaps. She expressed concern on the threats to and gaps in the observing system evidenced by decline

in in-situ networks, uncertainty in follow-up of satellite missions and barriers to data access, including historical data. For instance, Thelma Krug highlighted that there is a decrease of moored buoy stations in tropical oceans in the last 10 years, affecting the ability to understand and predict ocean-related phenomena such as El Niño and tropical cyclones. There is also a reduction in the delivery of monthly climate data globally. Thelma Krug also reported that the GCOS programme will not continue beyond 2027, without new and sustained financial support, and urged Parties to provide and sustain support to the programme for it to continue assessing and coordinating global climate observations. In regards its upcoming plans, GCOS is accelerating the preparation of the next Status Report and GCOS Implementation Plan for 2027, which will identify improvements for the global climate observing system.

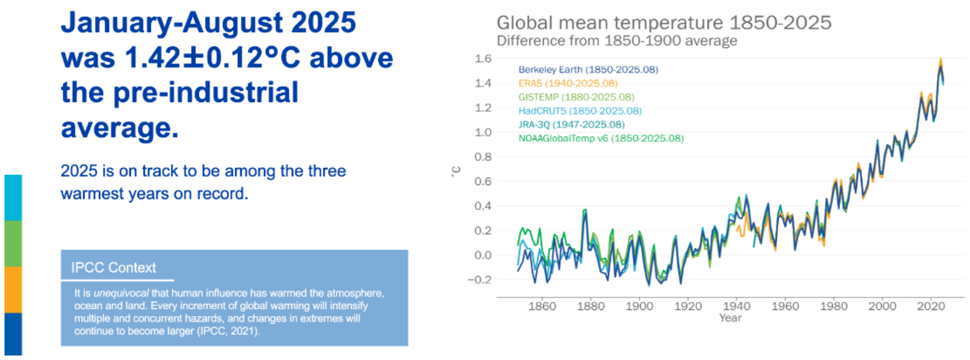
B. Updates on the State of the Climate

1. WMO 2025 State of the Climate Update

10. The Director of the WMO Integrated Global Observing System, Albert Fischer, presented the preliminary [2025 State of the Climate Update for COP 30] which combined consolidated global 2024 and preliminary 2025 data. According to the update, in 2024, GHG concentrations reached record observed levels for three key GHGs of CO_2, CH_4, and N_2O. For instance, annual average CO_2 concentrations reached 423.9 ppm in 2024, which is 53 per cent higher than the 1850–1900 average. Further, the annual increase in CO_2 concentrations from 2023 to 2024 was 3.5 ppm, being the largest rise ever recorded and a record high in recent observational history. Measurements collected since the beginning of 2025 indicate that concentration levels for three key GHGs are likely to be even higher than in 2023/2024.

11. The global mean temperature from January to August in 2025 was 1.42+/- 0,12 ºC above pre-industrial average, and 2025 was on track to be amongst the three warmest years on record, as reflected in figure 1 below, and the past 11 years have been among the warmest years on record. Further, in the hydrological year 2023/2024, glaciers lost 1.3 meters of water equivalent of ice, marking the largest nominal loss of glacier ice on record. The year 2024 was also the third consecutive year in which all 19 monitored glaciated regions recorded net mass loss. Preliminary 2025 data shows that Arctic sea-ice reached the lowest maximum extent ever recorded in the satellite era, and Antarctic sea-ice minimum extent was also below the 30-year average sea- ice levels. Additionally, ocean heat content in 2024 reached the highest levels ever recorded, and preliminary data indicates that 2025 has continued at similarly elevated levels. The long-term rate of sea-level rise has doubled from 2.1 mm per year during 1993–2002 to 4 mm per year over the past decade. Preliminary 2025 data show a slight dip in sea level, likely driven by natural variability, although this will be examined further as additional 2025 observations become available.

Figure 1
Global mean temperatures, WMO



Source: Slide 3 of Albert Fischer's presentation at EID 2025

12. Albert Fisher noted that the WMO has tracked a wide range of extreme events in the first half of 2025, including heatwaves, floods, storms such as the Tropical Storm Melissa in the Caribbean, wildfires, and droughts which had major humanitarian and economic impacts. He also noted that EWS are expanding with stronger observations and forecasting, with over

70 per cent of new nationally determined contributions submissions referencing climate services or EWS, and the number of countries reporting MHEWS has doubled since 2015, to 119. However, 40 per cent of countries particularly in vulnerable regions still lack MHEWS and continued investment in data sharing, forecasting, and local preparedness is needed to achieve universal coverage of EWS by 2027.

2. Advances in sustaining systematic observations and scalable innovations: updates from Earth observation initiatives Committee on Earth Observation Satellites and the Coordination Group for Meteorological Satellites, the Group on Earth Observations, Systematic Observations Financing Facility

13. Florence Rabier from the ECMWF presented efforts from the systematic observation community, particularly CEOS and CGMS, and the GEO in advancing Earth observations. She highlighted that space-based observations provide critical data for EWS, form long-term climate records for ECVs, and are key for monitoring climate change as well as informing sound policies. Particularly, CEOS and CGMS works closely with GCOS in line with its implementation plan, through the coordinated deployment of new satellites and development of technologies to extract increasingly robust and accurate information. She acknowledged the value of surface-based Earth observations to space investments, such as the 10000 Ships for the Ocean Initiative, a global coalition to expand ship-based observation.

14. In conveying updates related to GEO, she highlighted the new Post-2025 Geo Work Programme, which emphasizes integrating emerging technologies such as AI and machine learning, addressing observation gaps, and deploying practical solutions. Further, a new collaboration with WMO and GCOS seeks to strengthen the Earth observation value chain, with pilot projects on urban heat and ecosystem resilience. Additionally, two new National Adaptation Plan technical guideline supplements on coastal and ocean adaptation and land degradation neutrality where developed, providing governments with knowledge and tools to embed Earth observation data into adaptation planning and implementation. She also highlighted the Digital Earth Pacific and GEO Mountains initiatives, to illustrate efforts being undertaken to address gaps in Earth observation data. The Digital Earth Pacific provides AI-powered, free, decision-ready Earth observation products to 22 Pacific islands and territories. GEO Mountains recently released an updated in-situ inventory of over 150,000 observations worldwide, approximately 15 per cent of which relate to the cryosphere.

15. Markus Repnik from the SOFF, provided updates from the facility and innovations being undertaken to close the basic in-situ observation gaps. SOFF provides long-term, grant-based, peer-to-peer support to build and sustain observing networks where data are most scarce. The SOFF is addressing major support gaps in Earth observations by strengthening in-situ data in developing countries, leading to measurable improvements in weather forecasting. Impact studies show possible forecast uncertainty reductions of more than 30 per cent in Africa and up to 20 per cent in Pacific Island countries. In 2025, three years after its launch, more than 100 countries have requested assistance; 61 have received readiness support, 18 have entered the investment phase, and nine are awaiting investment funding, with over 25 additional countries expected to join in 2026. To address the funding gaps, SOFF is deploying innovative financing tools such as the proposed systematic observation impact bond,[2] which aims to mobilize a broad public-private coalition for financing and frontload resources to enable early action.

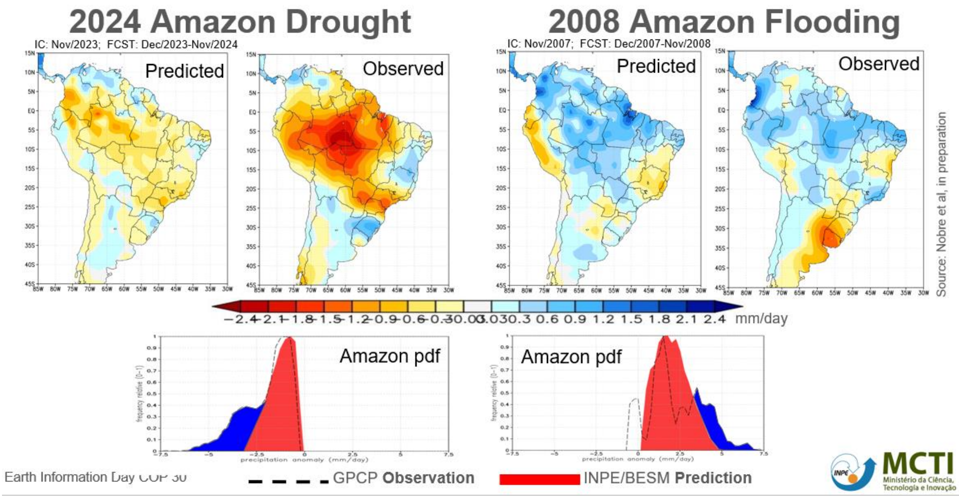
3. Integrated observation systems and innovations for supporting prediction of events and the Early Warning 4 All, Brazil's country experience.

16. Paulo Nobre from Brazil's National Institute for Space Research, INPE, presented Brazil's experience in utilizing integrated observation systems, including AI, for predictions and EWS. He highlighted the climate extremes experienced by Brazil in the past four years, which grew by 250 per cent, including the 2023-2024 drought of the Negro River in Amazon, and flooding in Porto Alegre in May 2024. The Brazilian Earth System Model Annual Prediction identifies regions where precipitation and temperature anomalies can be predicted one year in advance, as demonstrated in figure 2 below, and where predictability remains

[2] See https://un-soff.org/impactbond/.

limited, therefore enabling early assessment of drought or flood risk. Nevertheless, these predictions still face limitations, particularly in models predicting the tail of the distribution, underscoring the need for a substantial increase in high-quality, high-density, and high-frequency observational data.

Figure 2
Annual Rainfall Predictions, Brazil



Source: Slide 4 of Paulo Nobre's presentation at EID 2025

17. Brazil and China have initiated the joint development of CBERS-5, the first geostationary satellite in the CBERS Programme aimed at expanding real-time observation network. CBERS-5 will provide full-disk infrared and visible imagery every ten minutes, as well as hyperspectral temperature profiles to support improved weather forecasting. Paulo Nobre also highlighted plans to expand its data-collecting satellite system into a ten-satellite constellation which will be capable of providing global observations every 15 minutes. The vision includes a national federated meteorological data system integrating satellites, drones, environmental sensors, and "AI of things" technologies, to enable high quality and frequency data for future AI-driven climate predictions.

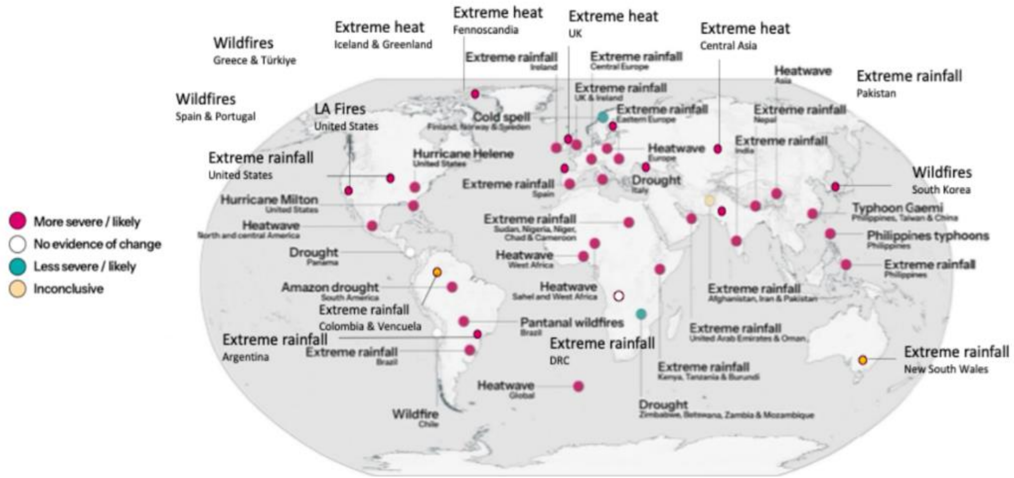
4. Occurrence and monitoring of extreme events and related attribution

18. Julie Arrighi from the WWA presented the current state of extreme event attribution through studies undertaken by the WWA, which assesses the extent to which climate change influences the frequency and intensity of extreme events. She noted that attribution capabilities vary significantly, as there is strong evidence for attributing terrestrial heatwaves, extreme cold events, and marine heatwaves, but limited evidence for phenomena such as local convective storms, extratropical cyclones, fire weather, and tropical cyclone frequency. She outlined WWA's approach, which includes monitoring global disasters, conducting multi-method hazard analyses, identifying climate-related trends, and integrating vulnerability and exposure to assess the event's context. She highlighted various attribution studies, where each study is supported by event-specific experts. For instance, during the 2023 Madagascar extreme heat, WWA concluded that an event of this magnitude would have been highly unlikely in a pre-industrial climate, while in the present climate it corresponds to approximately a one-in-five-year event, with projected increases in likelihood under a 2 °C warming scenario. The study on Hurricane Melissa indicated that a five-day accumulated rainfall was 20–50 per cent higher than under pre-industrial conditions, accompanied by increases in wind speed, humidity, and temperature that contributed to the storm's intensity.

19. The 2024/2025 map of extreme events analysed by WWA as shown in figure 3 below, notes the increasingly global distribution of climate change attributions. While early attribution work was concentrated in Europe and North America, WWA and partner institutions have expanded geographical coverage in recent years. She emphasized that advances are needed to diversify the types of events studied in each region, highlighting that

extreme heat in Africa remains significantly understudied. Further, major gaps remain in data, methods and outreach, along with the resources needed to address them.

Figure 3
Attributed extreme events 2024/2025, WWA



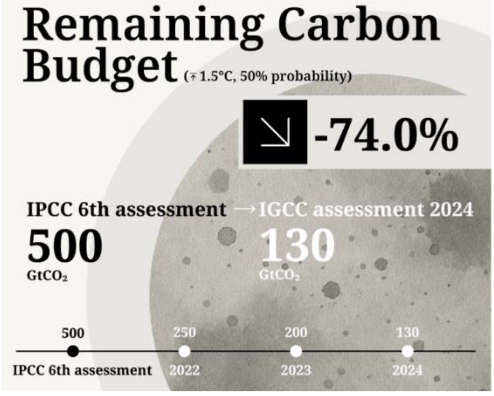
Source: Slide 6 of Julie Arrighi's presentation at EID 2025

5. Indicators of Global Climate Change Initiative

20. Piers Foster presented the work of the IGCC which periodically compiles information on climate change indicators from 54 institutions in 17 different countries resulting in an updated report on the indicators, which are consistent with the methods and datasets assessed in the IPCC AR6. According to the latest IGCC update, GHG emissions have increased by approximately 1.3 per cent since AR6, driven mainly by growing emissions from fossil fuels and industrial activities, which together account for about 70 per cent of total GHG emissions. In 2024, the observed global temperature reached approximately 1.52 °C, with the human-induced component estimated at 1.36 °C. Over the period 2015–2024, the long-term human-induced warming is estimated to average 1.22 °C.

The Earth's Energy Imbalance, EEI, continues to increase at an unprecedented rate, providing a clear signal that heat storage in the climate system is accelerating. As a result, the remaining global carbon budget has declined sharply, as illustrated in figure 4, falling from earlier estimates of around 500 billion tonnes of CO_2 to roughly 130 billion tonnes. Further, sea-level rise is also accelerating, with global mean sea-level increasing by approximately 26 mm between 2019–2024. The current rate of sea-level rise is more than double the long-term historical average. Additionally, Piers Foster specified that, according to the IGCC, the observed changes remain consistent with scientific projections, and no unexpected deviations have emerged to date. He emphasized the role of sustained systematic observations in the generation, integration and interpretation of data for climate policy and action.

Figure 4
Remaining carbon budget, IGCC



Our 2024 assessment	Synthesis
130 $GtCO_2$ (from the start of 2025)	The most recent estimate of human-induced warming brings us closer to 1.5°C, reducing the 1.5°C remaining carbon budget This budget would be exhausted in a **little more than three years** at current emissions levels

C. Thematic break-out discussions

Two thematic break-out sessions were held in parallel, providing a platform for scientists, the systematic observation community and policymakers to engage on the thematic topics by sharing information, experiences, good practices, lessons and gaps, and opportunities. Each break-out session included sharing of information and experiences by expert presenters from relevant institutions and countries, and an open exchange of views informed by the guiding questions[3], followed by a reporting back session. The first breakout session was facilitated by Gabriel Kpaka (Sierra Leone) and Patricia Nying'uro (Kenya), and the second breakout session was facilitated by Frank McGovern (Ireland) and Leonardo Steil (Brazil).

1. Breakout discussion 1: Observations for supporting climate action, and the ocean and cryosphere

21. During the session, experts presented on and illustrated Earth observation tools, progress, opportunities, and gaps for supporting climate policy and action, particularly for climate mitigation, national inventory reporting, assessing loss and damage, and monitoring adaptation actions. Participants also discussed the status of ocean observations, including for across various geographic regions, and cryosphere changes and monitoring. Further, the session reflected on advancements in technologies, investment needs, and the importance of partnership and collaborations to enhance systematic observations. The section presents a summary of the presentations and discussions that were held.

(a) Earth observation for the assessment of economic and non-economic loss and damage

22. Coral Pasisi, from the Pacific Community, a principal scientific and technical body representing 27 member states in the Pacific region, highlighted how Digital Earth Pacific is transforming open satellite data into actionable Earth intelligence, helping the island nations to assess both economic and non-economic loss and damage. Coral Pasisi highlighted that extreme weather events cost Pacific countries millions of United States dollars annually, and major events such as cyclones can generate losses exceeding five times a nation's gross domestic product. Insufficient global investment in both climate mitigation and climate adaptation is directly linked to rising loss and damage. Further, existing assessments of loss and damage still under capture non-economic loss and damage, underscoring the need to strengthen data, methodologies, and measurement systems.

23. Across the Pacific region, Coral Pasisi elaborated three major barriers that limit Earth observation uptake for assessing loss and damage, which are: (a) restricted access to affordable, consistent and long-term satellite observations; (b) limited national analytics and data infrastructure; and (c) shortages of sustained technical capacity. In addressing these

[3] The agenda for EID 2025 with a full list of moderators, rapporteurs and expert presenters can be accessed here https://unfccc.int/sites/default/files/resource/DRAFT%20AGENDA%2010th%20nov.pdf.

challenges, the Digital Earth Pacific processes open-access global satellite data locally using cloud-based infrastructure and delivers decision-ready, consistent, and comparable long-term information products for every Pacific island country. Through co-design and strong local ownership, the programme builds national capacity to interpret and apply Earth observations data for policymaking, disaster management, and reporting. Examples of Digital Earth Pacific applications in the region includes using satellite-derived water extent data to map king-tide inundation in Tuvalu, detecting drought-affected water bodies during El Niño in Papua New Guinea, mapping mangroves and seagrass for supporting ecosystem loss-and-damage monitoring, identifying erosion hotspots and blue carbon accounting, with scalable products already developed. Digital Earth Pacific had an initial investment of EUR 1.4 million from the Government of New Zealand and EUR 5.6 million from other eight funding sources. Scaling the platform requires an additional EUR 18 million, to enable SIDS to monitor climate impacts through the programme.

(b) Advances in ocean monitoring and experiences in enhancing prediction and modelling

24. Karina von Schuckmann from GOOS elaborated on efforts being undertaken and challenges in ocean monitoring, prediction, and presented an update related to the status of the AMOC. The GOOS aims to deliver standardized, high quality and long-term ocean data in real-time globally. Recent growth in in-situ ocean observing networks were driven primarily by the expansion of autonomous observing technologies, such as Argo profiling floats. However, the efforts were offset by declines in other components of the observing system, including drifting buoys and ship-based oceanographic observations, caused by global budget constraints. Sustained investment in ocean observing infrastructure, along with improved coordination, is essential to close these gaps and maintain current momentum. Persistent systemic challenges include vulnerability to financial and geopolitical disruptions, limited long-term sustainability of observing infrastructure, and the need for broader and more diverse partnerships, as reflected in the GOOS Status Report 2025. According to GOOS, the Southern Ocean is still the most under-observed region, and observations of the deep ocean remain extremely limited. Further the lack of robust deep-ocean baselines constrains the assessment of climate services and impacts, resource management and climate action strategies. She highlighted priority areas to address the gaps, as reflected in figure 5 below, which also require coordinated efforts globally.

Figure 5
GOOS priority areas for deep-ocean monitoring

Source: Slide 7 of Karina von Schuckmann's presentation at EID 2025

25. Karina Von Schuckmann also presented on status of the AMOC, and stressed the complexity of ocean change, with models producing conflicting results ranging from minor variability to a potential future collapse of the AMOC. This uncertainty, driven by limited ocean and deep-ocean observations, underscores the urgent need for a systematic and robust observing system especially of the deep ocean to better understand AMOC and its global climate implications. Further, significant gaps remain in ocean carbon and GHG observation and delivery systems. In response, GOOS has developed a costed strategy to address these gaps by expanding technologies across four priority areas: ensuring the long-term sustainability of coordinated ocean GHG observing networks; co-designing observations and services to meet the needs of existing and emerging user groups, including stronger

integration with the satellite community; substantially strengthening data management operations; and exploring innovative models to enable private sector engagement.

(c) Observations for GHG inventories and reporting

26. Clement Albergel from ESA[4] presented on advances, opportunities, gaps and needs in advancing Earth observations for GHG inventories and reporting. He highlighted that different approaches are used to estimate GHG budgets, including top-down atmospheric inversions and bottom-up methods based on bookkeeping, process-based models, and activity data combined with emission factors. While global GHG budgets predominantly rely on top-down and process-based approaches, most national inventories submitted under the UNFCCC are prepared using IPCC bottom-up methodologies. To enhance transparency, accuracy, and consistency with real-world emissions, the IPCC encourages Parties to verify reported emissions using independent data sources. Satellite-based observations provide systematic, global, and continuous measurements that can complement national inventories, while its use remains limited. For instance, atmospheric inversion approaches offer significant potential for quality control and independent evaluation of national reports, provided that careful distinctions are made between managed land and natural versus anthropogenic fluxes.

27. ESA has developed a comprehensive framework to process atmospheric inversion results and translate them into products that are directly relevant for evaluating national GHG inventories. By integrating satellite observations, in-situ measurements, and atmospheric transport models, ESA produces spatially explicit estimates of anthropogenic emissions and land carbon sinks, including fossil fuel CO_2 emissions for major emitting regions. ESA also assesses global land carbon stocks and fluxes, revealing significant changes in the capacity of terrestrial ecosystems to act as carbon sinks. For instance, analyses indicate that the Amazon region lost approximately 370 million tonnes of carbon during the 2010–2020 decade, with south-eastern areas already transitioning to a net carbon source, while forest carbon uptake in Europe has declined by nearly 30 per cent over the past decade due to increased harvesting, forest aging, climate extremes, and disturbance events. ESA is also conducting large-scale field assessments in Brazil to reduce uncertainties related to terrestrial carbon emissions from the Amazon. ESA-supported analyses have also identified discrepancies between Earth observation-based estimates and national inventories arising from differences in forest area definitions and removal factors, reflecting gaps and the need for further improvements. Collectively, these ESA's efforts aim to improve transparency in emissions accounting, support data sharing, improve emission and removal factors, and enhance the reliability, transparency, and accountability of national GHG reporting, in line with the enhanced transparency framework under the Paris Agreement. Upcoming satellite missions will deliver much denser sampling of atmospheric CO_2 and CH_4 to support this work, including ESA's CO_2 monitoring and MicroCarb missions.

(d) Monitoring adaptation actions, including global goal on adaptation, and building resilient futures

28. Aida Diongue-Niang from Senegal reflected on the opportunities and role of Earth observations for monitoring adaptation actions, particularly under the United Arab Emirates Framework for Global Climate Resilience. She highlighted that the GGA indicators,[5] as reflected in the GGA decision FCCC/PA/CMA/2025/L.25, paragraphs 3–13,[6] establishes a direct link between adaptation outcomes and observation systems. Indicators 3–9 addresses climate change impacts across thematic areas while indicators 10–13 focuses on adaptation processes and planning, notably through impact, vulnerability, and risk assessments. Several sub-indicators, such as 10 (a, c, d, e and f) herein explicitly reference observation systems, including the establishment of multi-hazard monitoring and forecasting systems, EWS, and climate information services. She stressed that EWS are among the most cost-effective adaptation measures, but their effectiveness depends on timely, interoperable data flows,

[4] Co-author, Thais M Rosan, University of Exeter.

[5] List of GGA indicators as of 10 November 2025 was https://unfccc.int/documents/649629.

[6] The final list of GGA indicators as of 21 November 2025, https://unfccc.int/documents/655022, is used to refer to GGA indicators in paragraphs 28-29 of this report.

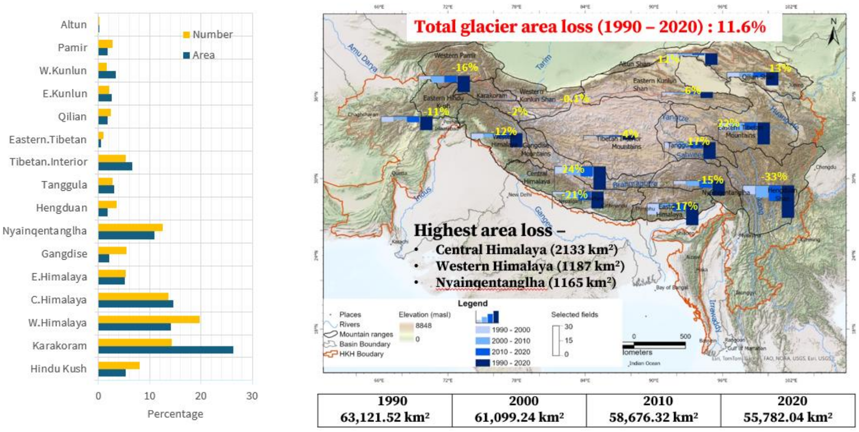
from observation through forecasting to communication. Effective monitoring and projection of climate-related hazards relies on comprehensive observing systems spanning the atmosphere, ocean, land, hydrosphere, and cryosphere, and across local to global scales, some of which are tracked through ECVs.

29. The GCOS Adaptation Task Team, established in 2021 enhanced how global climate observations can support adaptation, including through case studies on urban heat, ocean extremes, and wildfire management. For example, wildfire risk assessment was found to draw on 30 key products, with 25 derived from 18 GCOS ECVs, demonstrating the multi-purpose value of climate observations for hazard, exposure, and vulnerability analysis. Aida Diongue-Niang also described the persistent gaps in observational data and capacity, in developing countries, particularly LDCs, and SIDS, caused by challenges in sustaining in-situ observing networks, ensuring data quality, and integrating Earth observation into policy processes, thereby exacerbating climate risks. Further, these gaps also limit the ability to assess observed trends and future hazards, as evidenced in the IPCC AR6, where insufficient data especially in parts of Africa restricted assessments of precipitation trends and extreme sea-level projections. She stressed that while space-based observations are expanding rapidly, in situ observations remain indispensable for maintaining robust climate records and for effective local hazard monitoring and provision of high-quality climate data on hazards, exposure, and vulnerability. Additionally, sustained investment in long-term observing systems, enhanced capacity in data-sparse regions, open data policies, and interoperability across national and international systems are key to strengthening the link between GGA monitoring and systematic observation.

(e) Cryosphere changes monitoring and updates, the Hindu Kush Himalaya region

30. Sudan Bikash Maharjan from the International Centre for Integrated Mountain Development, presented on decadal glacier changes and responses to cryosphere events in the Hindu Kush Himalayan region. He highlighted the significance of the region, which forms 9 per cent of the global glaciers, serving a source for many perennial rivers and directly supports 240 million people’s lives and livelihoods. He also highlighted the advances made in observation and monitoring of the region, including through the contribution of satellite data, leading to consistent and systematic data generation and understanding of decadal changes within and across the region. However, recent studies and observations indicate decadal changes and decline in glaciers in the region, as reflected in figure 6 below, with higher area loss rate recorded in the eastern and southern region. For instance, the Yala glacier retreated by 784 metres and lost 66 per cent of its area in the past 50 years. Sudan Maharjan also presented observed fragmentation and surging of glaciers, as well as recent disasters recorded in the region, on floods, draining of lakes, avalanches, some leading to loss of lives and displacement. He highlighted that extreme events will become more frequent in the region, due to climatic changes, and resources from International Centre for Integrated Mountain Development, such as for modelling water resources, coupled with transboundary cooperation are essential to averting the impacts.

Figure 6
Distribution and decadal changes of glaciers in the Hindu Kush Himalayan region



Source: Slide 5 of Sudan Bikash Maharjan’s presentation at EID 2025

(f) Discussions

31. The Arctic Monitoring and Assessment Programme, AMAP, highlighted the observed changes in the Arctic and their impacts on the global climate, as reflected in the Arctic Climate Change Update 2024. A representative from AMAP highlighted that climatic changes are occurring at a faster rate in the Arctic, where warming is three times faster than the global average, extreme events are more common, acidification is faster than other ocean basins, and the Arctic cryosphere is shrinking rapidly, contributing to sea-level rise. Further, current climate models project continued rapid warming of the Arctic as well as sea-ice loss, with impacts on the global climate, Arctic landscape, ecosystems, and lives and livelihoods of Indigenous communities. The representative encouraged Parties to intensify climate mitigation efforts to slow down these changes, and advance climate adaptation and resilience, as well as strengthening related Indigenous knowledge systems. Participants also discussed the role of different observation types, particularly in situ and space-based, in strengthening observations, challenges related to monitoring anthropogenic and natural emission sources, and advancing ocean monitoring, prediction, and modelling for small island States.

2. Breakout discussion 2: Earth observations data access and sharing, and related innovation and technologies

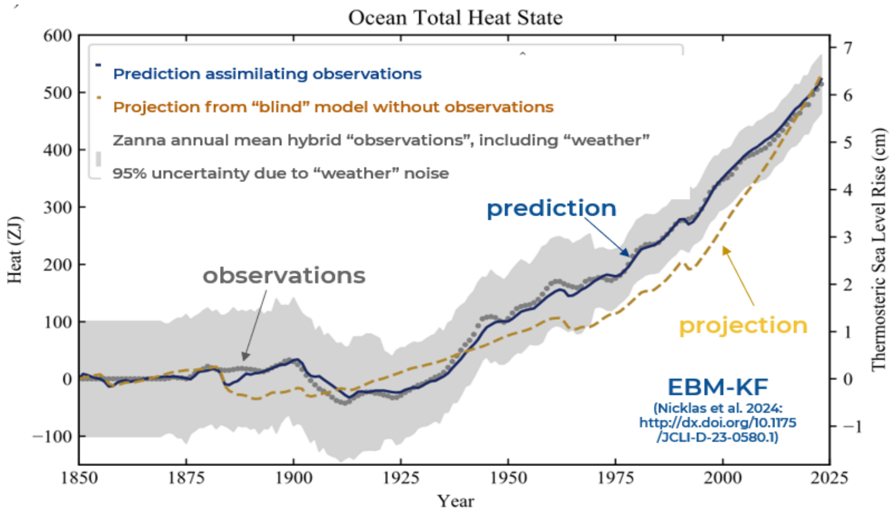
32. During the breakout session, participants discussed efforts aimed at enhancing equitable access to Earth observations data, including historical data, and ongoing processes for strengthening data interoperability while ensuring high-quality and trusted data. Further, the breakout discussion examined the role of innovative approaches, particularly, AI and machine learning in Earth observations and climate-related services.

(a) Climate data use and the connection between local observation networks and global outputs

33. Baylor Fox-Kemper from Brown University[7] and co-chair of ESMO, a core project under WCRP, presented on the CMIP which focuses on projections of future climate and understanding past and present climate changes as well as near- term observations. He demonstrated how observations interact with climate models, through data assimilation and initialization (informing predictions), as shown in figure 7 below, acknowledging the complexity in this regard, including from inter-annual variability.

[7] Co-Author Susanne Tegtmeier (University of Saskatchewan, Canada).

Figure 7
Initialization and data assimilation for predictions, ESMO



Source: Slide 4 of Baylor Fox-Kemper's presentation at EID 2025

34. Under WCRP's ESMO, a new working group on observations for researching climate was established to facilitate collaboration in related research and developing common standards and frameworks to enable coordination between modelling communities, satellite agencies and data providers. The working group will also focus on exploring emerging technologies such as machine learning and kilometre-scale observations, advancing predictions including reanalysis work, and supporting attribution related studies. It will also support the interaction between global and local observations and models. In demonstrating how global outputs such as CMIP support regional and localized climate information, Baylor Fox-Kemper indicated that the CORDEX supports the production of more regional projections after CMIP projections. In collaboration with local and regional experts and stakeholders, the CORDEX domain teams run regional weather and climate projections, across 14 regions, including by making comparisons with local observations and addressing any local concerns.

(b) Efforts in sustaining long-term observations, data sharing and analysis of atmospheric GHGs and ocean variables

35. Toshinori Aoyagi from the Japan Meteorological Agency presented on the country's efforts in maintaining long-term observations and related data management. Japan recently celebrated 150 years of observing key climate variables including air temperature, precipitation and GHGs, which are observed from various platforms including ocean vessels and ground sites. The country operates the WDCGG under WMO's Global Atmospheric Watch framework since 1990, where it provides GHG concentration data across globe. Toshinori Aoyagi illustrated the steady increase in access, determined through downloads, of the archived data by various users and for various purposes including research and satellite calibration. The meteorological agency also disseminates information on the analysis of global CO_2 distribution using flux maps, atmospheric transport models, and data, such as flux adjustments, from the WDCGG. The agency calculates optimized atmospheric CO_2 concentrations and the information available shows both mean annual concentrations and monthly variations.

36. On oceanographic observations, the Japan Meteorological Agency has been observing salinity and temperature, for at least 100 years, and also measures partial pressure of CO_2. For instance, observations of partial pressure of CO_2 across the northwest Pacific shows large seasonal variations. The year-to-year increases in sea surface partial pressure of CO_2 demonstrates that CO_2 is emitted in summer and absorbed during the winter period. Observations of ocean acidification also indicates that this is progressing as a result of CO_2 absorption. He noted that ocean observations are temporary and spatially sparse, and efforts are being undertaken with researchers to process discrete datasets and derive relationships

amongst different variables. This involves interpolating the data across time and space for more accurate representation.

(c) AI-based forecasting for EWS over the Greater Horn of Africa

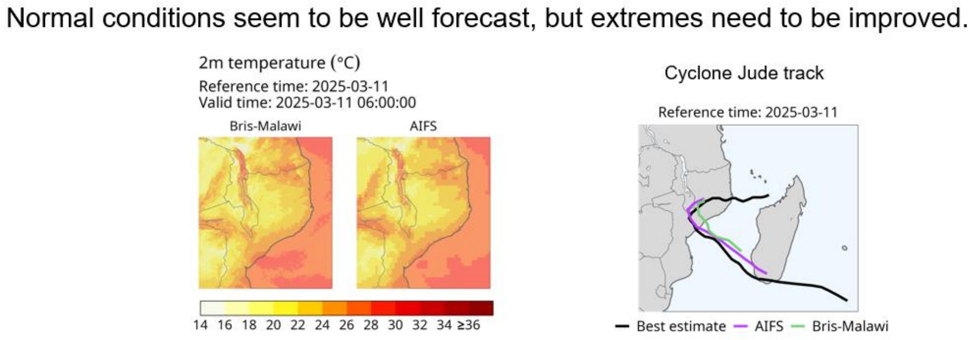
37. Shruti Nath from the University of Oxford illustrated how AI-based forecasting is supporting regions that do not have the necessary computational resources and capabilities, such as the horn of Africa, in lieu of traditional numerical weather models. Shruti Nathi elaborated on the climate extremes experienced across the horn of Africa, such as droughts and floods, including due to persisting El Niño and La Nina phenomena. She further indicated that there is limited capability and low ability to generate relevant ensembles for modelling, leading to limited ability to measure and understand climate risks. Similarly, there are associated high computational related expenses for generating forecasts. Accordingly, accurate forecasting using AI-supported models would effectively support EWS for anticipatory action in the region, in collaboration with partners. Shruthi Nathi presented a hybrid system, relying on satellite-data which was developed and uses both numerical prediction weather outputs and AI. The model learns structural errors and creates a more accurate ensemble as well as using forecast variables to generate warnings. Case studies from Kenya and Rwanda were shared, where standard desk top computers are used, with simple computational capabilities and AI-trained models, to generate large ensembles and inform EWS. She further highlighted the positive value added from the AI model in relation to averted costs, related to high-risk events.

(d) Artificial Intelligence for EW4ALL in Malawi: Lessons from the WMO Climate Risk and EWS pilot project

38. Lucy Mtilatila from the Department of Climate Change and Meteorological Services in Malawi presented efforts being undertaken in the country to strengthen EWS using AI tools for forecasting, prediction and improve services offered to various sectors. Under the Climate Risk and EWS pilot project, Malawi adopted a forecast-in-a-box system, using the Bris model from Met Norway, which was tested and modified in response to the country's needs. The approach utilizes AI to enhance weather prediction and support timely EWS, with minimal computational needs. The Department of Climate Change and Meteorological Services in Malawi also received related capacity support for the system's operation. To utilize the forecast-in-a-box system, initial conditions are accessed from the ECMWF and are ran using the department's computers, and thereafter visualized. The ECMWF's Artificial Intelligence Integrated Forecasting System model, a global openly accessibly AI model, is used in the forecast-in-a-box-system. According to Lucy Mtilatila, the system is flexible and as such supports the meteorological department with daily tasks, strengthens EWS and impact-based forecasting. Products that have been derived from the system, such as on extreme events, include the simulation of Cyclone Jude in May–June 2025, which also demonstrated the need for continuous improvements of the system and models as reflected in figure 8 below.

Figure 8

Tropical Cyclone Jude forecast using Artificial Intelligence Integrated Forecasting System and Bris Malawi



Source: Slide 10 of Lucy Mtilatila's presentation at EID 2025

(e) Earth observations data access and sharing

39. Raul Cordero from the University of Groningen illustrated the needs and means for strengthening access to observations data, and experiences on how data access and sharing is supporting decision making in Chile. Foremost, he illustrated current gaps in the generation of observational data, particularly in the global south, and its implications for the diverse climatic zones. He also highlighted the potential of generating rich observational data for countries with diverse geographies such as Chile. He called for quality-controlled climate data to be accessible, including for supporting research and innovation, and actionable, serving as a basis for decision-making. For instance, Earth observations data can ably support climate mitigation and the just transition by informing solar or wind electricity generation potential. Further, it can support hazard and risk assessments, climate services and early warning of extreme events and hazards, as well as preparedness and response under climate adaptation. For instance, recently, Chile utilized Earth observations to detect droughts and heatwaves. To enable the strengthening of data access and sharing, Raul Cordero stressed the need for regional data-sharing alliances, the integration of local knowledge, investment in human capacity and advancing of AI and machine learning in data utilization.

(f) Discussion

40. Participants discussed the role and contribution of national observation institutions in generating climate data for climate services and EWS, as well as challenges in integrating national climate data into global outputs (including IPCC-related), such as differing standards of measurements. During the discussions, some experts highlighted the efforts by WMO in coordinating national meteorological agencies in this regard, and encouraged improved coordination amongst the observation community. Further, participants also discussed the scope and quality of data required for AI-supported models for EWS, resolution constraints faced by small island States and countries with complex terrains in this regard, and the need to improve data quality and usability. Experiences and information on the accuracy and gaps in the consistency of models and observations related to ocean GHG sinks were also discussed, while recognizing the contributions of emerging technologies and satellite-based observations.