BAMS
Meeting Summary

Insights from Climate Tipping Point Science for the Forthcoming IPCC Seventh Assessment Report and Reflections for National Meteorological and Hydrological Services

Thomas F. Stocker,[a,b] Stephen E. Belcher,[c] Gilbert Brunet,[d] Pauline Dube,[e] Thomas L. Frölicher,[a,b] Gabriele C. Hegerl,[f] Shipra Jain,[g] Jose Marengo,[h,i] Graciela Metternicht,[j] Tim Naish,[k] Narelle van der Wel,[l] and Robert Vautard[m]

KEYWORDS:
Climate;
Climate change;
Climate services

Insights from the WCRP/IPCC Workshop

What: The WCRP/IPCC cosponsored workshop "Earth System High Impact Events, Tipping Points and Their Consequences" addressed the contentious topic of tipping transitions in Earth system components in preparation for the IPCC's Seventh Assessment Report which will feature for the first time a dedicated chapter on "abrupt changes, low-likelihood high-impact events, and critical thresholds, including tipping points in the Earth system." Lead Authors, representatives of WCRP, and invited experts clarified definitions and emphasized the growing need for regional information which will be made available through the IPCC Interactive Atlas. This will facilitate risk assessment, early warning, and adaptation to the consequences of those events and offer an opportunity for National Meteorological and Hydrological Services (NMHS) to prepare services for such events. The services are crucial players in reducing the impacts by ensuring enhanced observations, data sharing, and modeling, particularly for water-cycle and heat-related risks. Finally, six reflections are presented on how to build NMHS readiness for high-impact events and tipping points.

When: 26–28 November 2025

Where: Paris, France

DOI: 10.1175/BAMS-D-26-0119.1

Corresponding author: Thomas Stocker, thomas.stocker@unibe.ch

Manuscript in final form 15 April 2026

AFFILIATIONS: [a] Physics Institute, Climate and Environmental Physics, University of Bern, Bern, Switzerland; [b] Oeschger Centre for Climate Change Research, University of Bern, Bern, Switzerland; [c] Met Office, Exeter, United Kingdom; [d] Environment and Climate Change Canada, Gatineau, Quebec, Canada; [e] Department of Environmental Science, University of Botswana, Gaborone, Botswana; [f] School of Geosciences, University of Edinburgh, Edinburgh, United Kingdom; [g] Department of Risk and Disaster Reduction, University College London, London, United Kingdom; [h] Centro Nacional de Monitoramento e Alertas de Desastres Naturais, Sao Paulo, Brazil; [i] Post Graduate Program in International Studies, Korea University, Seoul, South Korea; [j] School of Science, Western Sydney University, Penrith, New South Wales, Australia; [k] Antarctic Research Centre, Victoria University of Wellington, Wellington, New Zealand; [l] World Meteorological Organization, Geneva, Switzerland; [m] Institut Pierre-Simon Laplace, Université de Paris, Paris, France

1. Knowledge gaps in understanding climate tipping

Our current knowledge about tipping systems and tipping points appears incoherent, is sometimes confusing, and is often incomplete, affected by the lack of robust observational evidence and uncertainty due to missing or poorly resolved coupled processes in Earth system models. This consequently runs the double risk of being either exaggerated or downplayed by the media. Both cases paralyze responses, which could reduce the risk of triggering tipping dynamics, such as more aggressive mitigation strategies, and responses to strengthening systems at risk by reducing other pressures, such as deforestation or pollution. Both cases also risk decreasing the broader public's trust in science. National Meteorological and Hydrological Services (NMHSs) are regularly confronted with media reports and other information claiming that tipping transitions are an imminent threatening consequence of anthropogenic climate change. Climate tipping is thus portrayed as an additional danger to the already growing risk of heating, drought, rising sea levels, increased occurrence and intensity of extreme events, and changes in weather patterns, all of which constitute multiple reasons for concern. Here, we reflect on the opportunities that emerge for NMHSs from the comprehensive assessment of tipping systems and conclude with six reflections to build readiness for NMHSs confronting this potential outcome of anthropogenic climate change.

This situation is particularly difficult for decision-makers, who often rely on information from NMHSs and whose responsibility is to safeguard lives and livelihoods, keep people safe and out of harm, and preserve ecosystems functioning. Consequently, this is why the IPCC in the scoping process of their Seventh Assessment Report (AR7) has decided—after extensive debate and negotiation—to dedicate one chapter of the Working Group I contribution to this topic. This is a novel chapter in IPCC assessments, and the intention behind including this dedicated chapter is to bring the wide and diverse body of knowledge on tipping points together in one place: what is known, what is unknown, what we can say about likelihoods and consequences, and where current limits in observations, modeling, and process understanding remain. The title of chapter 8, "Abrupt Changes, Low-Likelihood High-Impact Events and Critical Thresholds, Including Tipping Points, in the Earth System," is somewhat unwieldy, but it underlines that the notion of tipping points is just one aspect of many different, potentially dangerous responses of the climate system to the anthropogenic drivers. The variety of terms in the chapter title also reflects the broader confusion and inconsistent terminology surrounding these events, highlighting the need to better distinguish—or clarify similarities among—these concepts.

Climate tipping points are critical thresholds in a tipping system where small changes can trigger abrupt, severely consequential, and often irreversible shifts in Earth's major systems due to self-reinforcing feedback processes. Notable examples of large-scale tipping systems in the climate system that have been considered in the literature are the melting of the Greenland Ice Sheet, the collapse of the Atlantic meridional overturning circulation (AMOC), the dieback and collapse of the Amazon rain forest, bleaching of warm-water corals, an instability of the West Antarctic Ice Sheet, methane release from Arctic permafrost, or shifts of the tropical rain belts, and breakdowns or shifts of monsoon systems around the world. A climate-related tipping point can also be reached as a consequence of land-use change, for example, deforestation in the Amazon region. When tipping dynamics is triggered, it could induce changes with high local to regional, often global, impacts, increasing vulnerability and challenging adaptation strategies. For example, weather patterns and extreme climate events may be affected resulting in serious consequences for food security and human and ecosystem health. Warming, acidification, and local threats, such as industrial or touristic activities, are multiple stressors on coral communities and crossing of a tipping threshold may have already happened in some regions. Generally, crossing such points drastically amplifies global warming risks, and some tipping systems may also release carbon, challenging mitigation efforts. This must be avoided as it would indisputably constitute one aspect of "dangerous anthropogenic interference with the climate system," as referred to in Article 2 of the UN Framework Convention on Climate Change. Therefore, urgent action to stay below the agreed temperature levels is required.

2. Navigating climate tipping: Science, communication, and policy

The topic of tipping points has been on the radar of scientists since the first assessment of the IPCC in 1990, when concepts such as "abrupt change," "irreversibility," and "surprises" were used by the authors of the Working Group I report to assess the relevance of emerging information from high-resolution paleoclimatic records for the future climate evolution. Greenland ice cores, marine sediments from the North Atlantic, and lake deposits from Europe demonstrated that the climate system may exhibit rapid changes of unprecedented magnitude, particularly during phases of a changing climate background, such as the transition from the last ice age to the current Anthropocene where human influence on the functioning of the Earth system is of planetary scale. Theoretical understanding was deepened concurrently through initial modeling efforts using a hierarchy of climate models, ranging from reduced-complexity models to comprehensive Earth system models used for climate change projections. By the completion of the IPCC Fourth Assessment Report in 2007, this aspect of climate change had risen to the Summaries of Policymakers and thus was brought to the attention of all governments.

Essentially, much of the scientific work so far stems from research groups located in the Global North, i.e., the high-income countries, and therefore some biases regarding the regional impacts have resulted in the literature. For example, consequences of the collapse of the AMOC usually emphasize the significant cooling around the North Atlantic region, whereas the robust finding of a southward shift of the intertropical convergence zone and the associated regional impacts on water availability and extreme events have received less attention.

The dedicated chapter in AR7 is a great opportunity because it means that a sufficiently large and regionally diverse team of lead authors will be carrying out the assessment to provide a solid basis and establish a robust consensus in policy-relevant aspects of this potentially contentious topic. The World Climate Research Programme (WCRP)[1] has prepared the ground for this assessment well, as the topic has been studied in the WCRP Lighthouse Activity "Safe Landing Climates" since 2021. Scientists have been brought together in various formats to foster discussions and exchange ideas,

[1] WCRP is cosponsored by WMO, ISC, and INO-UNESCO.

such as a virtual tipping point discussion series, dedicated model intercomparison projects (TIPMIP and WhatIfMIP), and a WCRP writing group preparing a comprehensive review of the state of science to appear late in 2026. These bottom-up engagements culminated in a joint WCRP-IPCC workshop, entitled "Earth System High Impact Events, Tipping Points and Their Consequences" that took place in Paris, 26–28 November 2025, where 73 scientists assembled from all WMO regions, including IPCC bureau members, most of the authors of chapter 8 of Working Group I, and authors from the other two IPCC Working Groups (Hansen et al. 2026). This workshop brought in a breadth of interdisciplinary perspectives across research areas, supporting the preparation of the AR7 chapter outline at the first IPCC Lead Author meeting held in the week following the workshop.

3. Workshop format and key insights for the WMO and NMHS communities

Here, we briefly summarize the proceedings of this workshop to update the WMO and broader NMHS community on "Tipping Points," one of the three emerging topics that were identified as important by the WMO Scientific Advisory Panel and approved at the WMO Executive Council EC-78, Decision 10.

The cosponsored workshop began with an overview and critical appraisal of the concepts and perceptions of High Impact Events and Tipping Points (HIETP) from the perspective of the three IPCC Working Groups and of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). It included an explanation of the process of communicating complex scientific assessment results up to the Summary for Policymakers, emphasizing the value of compact, quotable headline statements for effective communication.

Working Group I's chapter 8 will serve as a consolidated reference point from which other Working Groups assess impacts, adaptation and mitigation options, and future pathways associated with these particular climate system responses. Building on the IPCC's AR6 Interactive Atlas of Climate Change Projections—an open, queryable platform underpinned by WCRP CMIP6 multimodel ensembles—the inclusion of targeted HIETP simulations and threshold visualizations (e.g., Greenland Ice Sheet stability, AMOC slowdown or collapse, Amazon dieback, monsoon regime shifts) would allow users to explore the consequences of crossing critical thresholds across regions and time horizons. This functionality would strengthen WGII's quantitative impact assessments and vulnerability mapping and provide NMHSs with decision-ready information for impact-based forecasting and the design of early warning systems (e.g., anticipating compound heat–drought risks, coastal inundation linked to ice-sheet instability, or seasonal rainfall shifts affecting food security). The risk framework, widely used by Working Group II, is a powerful approach for assessing HIETPs and translating them into "burning embers" plots produced by the research community, which would be strengthened if such a result were to emerge from an IPCC assessment. IPBES insights on potentially irreversible changes in warm-water corals and their role for marine ecosystems, marine life, and species extinction, as well as rain forest reduction and dieback and their impact on biodiversity, add critical ecosystem dimensions. Coupling ecosystem and sectoral impact models to the Atlas would enable cross-community integration, foster coordination between IPCC AR7 and the IPBES Second Global Assessment and directly inform NMHS operations and national adaptation planning.

A general concern was repeatedly expressed in this workshop. As mentioned above, tipping research has traditionally been done by researchers in the Global North. While not much different from the situation in other topics, this imbalance was enhanced by several dedicated research programs addressing the topic of tipping elements in the climate system in the last decade (e.g., successive EU framework programs). However, with consistent capacity building since the inception of WCRP and later IPCC, strong climate science has developed also elsewhere (e.g., in China) and now contributes to a broader understanding of these specific issues. A recent example is monsoon research by groups and institutes in affected regions. This will bring to the fore much needed information on regional impacts. Increased leadership by, and cooperation with, researchers from the Global South in defining and carrying out research in tipping dynamics and regional impacts are therefore necessary to solidify the knowledge base.

a. Evolving definitions of tipping points: Toward cross-WG alignment. Discussion on the definition of tipping points and related terms took up a significant part of the early workshop. New perspectives have emerged, such as moving away from "low likelihood," reflecting that with ongoing climate change, likelihoods may increase or thresholds may be reached sooner. Additionally, the understanding that low likelihood is often poorly quantified in the presence of deep uncertainty can paralyze responses, as it is an ineffective communication tool. A shift from low likelihood to increased likelihood has been established for extreme events such as heat waves, dry spells, or heavy precipitation but also applies to HIETPs, thus requiring more focus on these outcomes of human-induced climate change. In AR6, the term "low-likelihood high-impact events" referred to events with both low and unknown probabilities, which led to confusion. One of the key recommendations of this workshop was to clearly distinguish between low and unknown likelihoods and to establish separate definitions for each. The process of reaching consensus on these definitions will continue as part of the AR7 process, with particular emphasis on cross–Working Group collaboration and consistency.

b. New science insights. The workshop also focused on various tipping elements in the climate system and the most recent scientific insights. A more regional approach to ocean circulation tipping points is now emerging as the subpolar gyre in the North Atlantic and circulation systems in the Southern Ocean are increasingly studied with respect to their tipping potential. For instance, the subpolar gyre may interact with the larger-scale AMOC and exhibit independent thresholds which would give rise to spatially limited changes and impacts, e.g., in the Labrador Sea, rather than global consequences such as expected from a spin-down of the AMOC under continued warming. New proposed feedback processes between ice shelves and the ocean will stimulate the analysis of model simulations in the ongoing model intercomparison projects under the auspices of WCRP. The potential of tipping of the Amazonian rain forest has triggered new studies on the role of atmospheric circulation and the regional atmospheric water cycle, as well as regional deforestation, in stabilizing or destabilizing these ecosystems. Equally, other important rain forest areas in the Congo Basin in Africa and Southeast Asia need to be considered, and related information would be central for NMHSs in those regions. The same considerations apply to the various monsoon systems around the world where tipping behavior cannot be excluded and where impacts of monsoon changes on society and ecosystems would be harmful even if these changes are linearly related to the forcing.

The physical science basis of HIETPs has been extensively studied due to years of coordinated efforts by WCRP. While consensus is lacking in several key areas, such as whether a system that has tipped in the past will be susceptible to similar tipping behavior under climate change, the specific time frames or warming levels at which these tipping points might be reached, and the potential for cascading effects between tipping systems, the recent workshop has demonstrated that valuable information is now available. This information facilitates a more comprehensive assessment of the potential impacts associated with HIETPs.

While IPCC Working Group II has no dedicated chapter on HIETP, it is essential to gather and present evidence on impacts from, and vulnerability to, HIETPs in an easily accessible form, e.g., in a separate section of the Technical Summary, or cross-WG boxes. A prerequisite for quantitative impact assessment will be the availability of HIETP information in the interactive Atlas mentioned above. It will be compiled by Working Group I, with strong involvement of Working Group II scientists and experts. Linkages between adaptation and mitigation will be assessed by Working Group III, and particular attention should be paid to costs that are incurred by impacts of HIETPs. This will provide crucial information for the definition of safe pathways in the coming decades. With respect to adaptation, the role of NMHSs cannot be overestimated.

4. Six reflections to build NMHS readiness for HIETPs

1) As scientific research increasingly produces information on the regional aspects of HIETPs, NMHSs and climate services must enhance their capacity to interpret this information. It is crucial to assess the spatial and temporal implications of climate change outcomes for early warning systems and disaster risk reduction strategies. Specifically, NMHSs often focus on short-term warnings, such as flash floods resulting from heavy rainfall within hours, while also long-term changes that may occur over seasons, months, years, or even decades need to be considered.
2) Continued and enhanced observations by NMHSs and targeted multinational monitoring programs should include tipping systems. They can produce important data for model development and training machine learning tools, particularly with HIETPs. Free and unlimited access to such data is essential to develop inclusive and comprehensive adaptation tools and effective mitigation strategies.
3) Affirmative support of, and coordination through, international scientific programs such as WCRP can facilitate the integration of modeling and observations, providing a foundation for future monitoring systems focused on particularly impactful tipping points. This includes science that represents the interactions between physical science, ecosystems science including vegetation dynamics, and society, as societal choices and responses are a key component of some tipping systems.
4) NMHSs should prioritize HIETPs that are associated with the water cycle due to the immediate impact on vulnerable communities. Monitoring monsoon systems via WMO regional centers and international NMHS networks, in collaboration with scientists, experts, the disaster management community, and local populations, is essential. Glacier retreat and runoff need to be monitored for impacts on water resources, flood and summer drought risk. A comprehensive regional modeling effort, coordinated, e.g. by WCRP, is critical for enhancing our understanding of monsoon and hydrological systems, which are vital for global water resource management.
5) NMHSs should also prioritize HIETPs that are associated with the thermal status of the atmosphere. Data, monitoring, and forecasting of heat waves, most importantly in urban areas, can empower health experts to take precautionary action to protect the most exposed communities. A coordinated interdisciplinary modeling effort, involving WCRP and health experts, would permit more specific risk assessment and prevention.
6) In the long term, NMHSs and relevant government agencies should be aware of the potential impact of tipping transitions on regional patterns of global sea level rise. While consequences may only develop decades from now, they are relevant for coastal planning already today.

Ultimately, the role of NMHSs in adaptation is indispensable and cannot be overstated. Investment in observation and modeling is a fundamental prerequisite for responsibly preparing for the impacts and consequences of HIETPs based on future generations of weather and climate models.

Acknowledgments. The contribution of Lauren Stuart (WMO) is gratefully acknowledged.

Reference

Hansen, G., N. van der Wel, P. M. Abbott, T. Naish, and R. Vautard, Eds., 2026: Earth system high impact events, tipping points and their consequences. WCRP and IPCC Workshop Rep., WMO 1399, 72 pp., https://doi.org/10.59327/WMO/WCRP/IPCC/HIETP.