

## Summary of the 54th Session of the Intergovernmental Panel on Climate Change and the 14th Session of Working Group I: 26 July - 6 August 2021

Global surface temperature will continue to increase until at least 2050 and many of the changes due to past and future greenhouse gas (GHG) emissions are irreversible for centuries to millennia, especially changes in the ocean, ice sheets, and global sea level. From a physical science perspective, limiting human-induced global warming to a specific level requires reaching at least net-zero carbon dioxide (CO<sub>2</sub>) emissions and strong reductions in other GHG emissions.

So warns the first Working Group contribution to the Intergovernmental Panel on Climate Change’s Sixth Assessment Report. The Summary for Policymakers (SPM) approved on 6 August 2021 provides a comprehensive assessment of the physical science underpinning past, present and future climate change. Many delegates underscored that the SPM and the underlying report will be a key input for intergovernmental negotiations at the 26th session of the Conference of the Parties to the UN Framework Convention on Climate Change, scheduled to take place in Glasgow, Scotland, in November 2021.

As with all multilateral processes, the Intergovernmental Panel on Climate Change (IPCC) had to adjust its work amid the COVID-19 pandemic. First, authors contributing to the IPCC’s assessment report had to conduct virtual meetings to address comments received on their draft reports, then the Panel itself held its 53rd session (IPCC-53) online, first in a short procedural session and later in a resumed “53-bis” session that resulted in substantive decisions on the strategic planning schedule of the completion of the Sixth Assessment Report (AR6).

IPCC-54, however, truly broke new ground: delegates held a full-fledged virtual approval session for the SPM of the Working Group I (WG I) contribution to the AR6. The scale and ambition of the virtual decision-making process was unprecedented, not just for the IPCC, but for the UN system more broadly, as IPCC Secretary Abdalah Mokssit noted during the closing plenary. Over the course of 11 meeting days, about 300 delegates engaged in a line-by-line approval of the WG I SPM. Many were skeptical that this could work, noting how challenging approval processes are even under normal circumstances, but the approval concluded as scheduled,

running less than one hour past the original closing time. During the final plenary, Norway noted it was “the most well-organized approval process the Panel has ever seen” and many delegations called for using lessons learned here to inform the organization of future approval sessions.

Some of the other key messages of the SPM include:

- human influence has warmed the climate system;
- widespread and rapid changes in the climate have occurred;
- the scale of these recent changes is unprecedented over many centuries to many thousands of years;
- with further global warming, every region is projected to experience changes, with extremes, such as heavy precipitation, becoming greater in frequency and intensity;
- global surface temperature will continue to increase until at least the mid-century under all emissions scenarios considered;
- unless there are deep reductions in CO<sub>2</sub> and other GHG emissions in the coming decades, 1.5°C and 2°C will be exceeded during the 21st century; and
- the effects of strong, rapid, and sustained emission reductions in terms of global surface temperature trends will begin to emerge after around 20 years.

IPCC-54, and the 14th session of WG I conducted under its auspices, convened virtually from 26 July to 6 August 2021.

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### A Brief History of the IPCC

The IPCC was established in 1988 by the World Meteorological Organization (WMO) and the UN Environment Programme (UNEP) to assess, in a comprehensive, objective, open, and transparent manner, the scientific, technical, and socio-economic information relevant to understanding human-induced climate change, its potential impacts, and adaptation and mitigation options. The IPCC is an intergovernmental and scientific body with 195 member countries. It does not undertake new research or monitor climate-related data; rather, it conducts assessments of the state of climate change knowledge based on published and peer-reviewed scientific and technical literature. IPCC reports are intended to be policy relevant, but not policy prescriptive.

The IPCC has three Working Groups (WGs):

- WG I addresses the physical science basis of climate change.
- WG II addresses climate change impacts, adaptation, and vulnerability.
- WG III addresses options for reducing greenhouse gas (GHG) emissions and mitigating climate change.

Each WG has two Co-Chairs and seven Vice-Chairs, with the exception of WG II, which has eight Vice-Chairs. The Co-Chairs guide the WGs in fulfilling their mandates with the assistance of Technical Support Units (TSUs). In addition, the IPCC also has a Task Force on National Greenhouse Gas Inventories (TFI), also supported by a TSU, to oversee the IPCC National GHG Inventories Programme. The Programme's aims are to develop and refine an internationally agreed methodology and software for calculating and reporting national GHG emissions and removals, and to encourage its use by parties to the UN Framework Convention on Climate Change (UNFCCC).

The Panel elects its Bureau for the duration of a full assessment cycle, which includes the preparation of an IPCC assessment report that takes between five and seven years. The Bureau is composed of climate change experts representing all regions, and includes the IPCC Chair and Vice-Chairs, WG Co-Chairs and Vice-Chairs, and TFI Co-Chairs. The IPCC has a permanent Secretariat, which is based in Geneva, Switzerland, and is hosted by the WMO.

### IPCC Products

Since its inception, the Panel has prepared a series of comprehensive assessment reports, special reports, and technical papers that provide scientific information on climate change to the international community.

The IPCC has produced five assessment reports, which were completed in 1990, 1995, 2001, 2007, and 2014. AR6 is expected to be completed in 2022. The assessment reports are structured in three parts, one for each WG. Each WG's contribution comprises a Summary for Policymakers (SPM), a Technical Summary, and the full underlying assessment report. Each of these reports undergoes an exhaustive and intensive review process by experts and governments, involving three stages: a first review by experts, a second review by experts and governments, and a third review by governments. Each SPM is then approved line-by-line by the respective WG and adopted by the Panel.

A synthesis report (SYR) is produced for the assessment report as a whole, integrating the most relevant aspects of the three WG reports and special reports of that specific cycle. The Panel then undertakes a line-by-line approval of the SPM of the SYR.

The IPCC has also produced a range of special reports on climate change-related issues. The AR6 cycle includes three special reports:

- Global Warming of 1.5°C (SR1.5), which was approved by IPCC-48 in October 2018;
- Climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems (SRCCL), which was approved by IPCC-50 in August 2019; and
- Ocean and Cryosphere in a Changing Climate (SROCC), which was approved by IPCC-51 in September 2019.

In addition, the IPCC produces methodology reports, which provide guidelines to help countries report on GHGs. Good Practice Guidance reports were approved in 2000 and 2003, while the IPCC Guidelines on National GHG Inventories were approved in 2006. A Refinement to the 2006 Guidelines on National GHG Inventories (2019 Refinement) was adopted at IPCC-49 in May 2019.

In 2007, the Nobel Peace Prize was jointly awarded to the IPCC and former US Vice-President Al Gore, for their work and efforts “to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations needed to counteract such change.”

### Sixth Assessment Cycle

**IPCC-41 to IPCC-43:** IPCC-41 (24-27 February 2015, Nairobi, Kenya) adopted decisions relevant to the AR6 cycle. IPCC-42 (5-8 October 2015, Dubrovnik, Croatia) elected Bureau members for the AR6 cycle. IPCC-43 (11-13 April 2016, Nairobi, Kenya) agreed to undertake two special reports (SRCCL and SROCC) and the 2019 Refinement during AR6, and, in response to an invitation from the 21st session of the Conference of the Parties to the UNFCCC, to prepare a special report on the impacts of limiting global warming of 1.5°C above pre-industrial levels. The Panel also agreed that a special report on cities would be prepared as part of the AR7 cycle.

**IPCC-44:** During this session (17-21 October 2016, Bangkok, Thailand), the Panel adopted outlines for SR1.5 and the 2019 Refinement, as well as decisions on, *inter alia*, a meeting on climate change and cities.

**IPCC Cities and Climate Change Science Conference:** This meeting (5-7 March 2018, Edmonton, Canada) produced a research agenda to better understand climate change impacts on cities and the critical role local authorities can play in addressing climate change.

**IPCC-45 to IPCC-47:** IPCC-45 (28-31 March 2017, Guadalajara, Mexico) approved the SRCCL and SROCC outlines, and discussed, *inter alia*: the strategic planning schedule for the AR6 cycle; a proposal to consider short-lived climate forcers (SLCFs); and resourcing options for the IPCC. IPCC-46 (6-10 September 2017, Montreal, Canada) approved the chapter outlines for the three WG report contributions to AR6. During IPCC-47 (13-16 March 2018, Paris, France), the Panel agreed to, *inter alia*: establish a Task Group on Gender; and draft terms of reference for a task group on the organization of the future work of the IPCC in light of the Global Stocktake (GST) under the Paris Agreement.

**IPCC-48:** During this session (1-6 October 2018, Incheon, Republic of Korea), the IPCC accepted SR1.5 and its Technical Summary and approved its SPM, which concludes, *inter alia*, that limiting global average temperature rise to 1.5°C is still possible but will require “unprecedented” transitions in all aspects of society.

**IPCC-49:** During this session (8-12 May 2019, Kyoto, Japan), the IPCC adopted the Overview Chapter of the 2019 Refinement and accepted the underlying report. IPCC-49 also adopted decisions on the terms of reference for the Task Group on Gender, and on a

methodological report on SLCFs to be completed during the AR7 cycle.

**IPCC-50:** During this session (2-7 August 2019, Geneva, Switzerland), the IPCC accepted the SRCCL and its Technical Summary and approved its SPM. A Joint Session of the WGs, in cooperation with the TFI, considered the SPM line by line to reach agreement.

**IPCC-51:** This session (20-24 September 2019, Monaco) accepted the SROCC and its Technical Summary, and approval of its SPM, following line-by-line approval by a Joint Session of WGs I and II.

**IPCC-52:** During this session (24-28 February 2020, Paris, France), the IPCC adopted the outline for the AR6 SYR, containing a stage-setting introduction and three sections: current status and trends; long-term climate and development futures; and near-term responses in a changing climate. The Panel also adopted the IPCC Gender Policy and Implementation Plan, which, among other things, establishes a Gender Action Team. It further discussed the organization of the IPCC's future work in light of the GST, and the Principles Governing IPCC work, but could not come to an agreement.

**IPCC-53:** This session (7-11 December 2020, online), which took place virtually due to the COVID-19 pandemic, addressed the IPCC Trust Fund Programme and budget. Using the silence procedure, the Panel approved the revised budget for 2020 and the revised proposed budget for 2021.

**IPCC-53 bis:** During this session (22-26 March 2021, online) the IPCC adjusted the strategic planning schedule for the Sixth Assessment Report (AR6) cycle with regard to: modalities for the approval plenary of the WG I report in light of the COVID-19 pandemic, and the preparation of the election of Bureau members for the AR7 cycle. The Panel also established an *Ad-hoc* Group with open-ended membership to provide recommendations to the Panel on the size, structure, and composition of the IPCC Bureau for AR7.

### IPCC-54 and WG I-14 Report

IPCC Secretary Abdalah Mokssit opened the meeting, noting the IPCC is breaking ground in conducting the WG I approval session in a virtual context.

WMO Secretary-General Petteri Taalas underscored the high political interest in IPCC reports and emphasized the AR6 WG I contribution will provide a crucial input to the 26th session of the UNFCCC Conference of the Parties (COP 26). Pointing to the increased frequency in extreme weather events, he underscored the importance of early warning systems, and called for investing in adaptation and ambitious mitigation action.

UNEP Deputy Executive Director Joyce Msuya lauded the IPCC for keeping up its important work in the challenging pandemic context. She urged countries to ensure a green recovery from COVID-19 and to translate net-zero commitments into concrete action. As key priorities, she highlighted: finance for adaptation; stronger focus on nature-based solutions in updated nationally determined contributions (NDCs) to the Paris Agreement; and uniting the climate and nature agendas.

UNFCCC Executive Secretary Patricia Espinosa recalled that science consistently warned of the increase in the extreme weather events now being experienced and, noting current emissions levels put the world on a trajectory towards more than a 3°C rise in average global temperature, emphasized the need to change course. Looking

toward COP 26, she urged governments to present strategies for achieving a 45% reduction in emissions by 2030 and reaching net-zero emissions by 2050, and to submit more ambitious NDCs.

IPCC Chair Hoesung Lee lauded WG I for its comparatively quick work despite the pandemic, the increasing amount of literature to cover, and the unprecedented production of three Special Reports during the sixth assessment cycle. He said mainstreaming climate change into policy will increase the demand for science and the IPCC's value. He stressed WG I's contributions, including: attributing extreme weather to climate change; identifying global and regional climate processes; and providing a foundation for WG II and WG III.

**Approval of the Provisional Agenda:** Secretary Mokssit introduced the provisional agenda (IPCC-LIV/Doc.1), provisional annotated agenda (IPCC-LIV/Doc.1, Add.1), and proposal for the organization of work (IPCC-LIV/INF.1). The Panel adopted the provisional agenda with no comments.

**Adoption of the IPCC-53 and IPCC-53 bis Reports:** Secretary Mokssit introduced the draft reports of IPCC-53 (IPCC-LIV/Doc.2) and IPCC-53 bis (IPCC-LIV/Doc.3). The Panel adopted both reports.

Chair Lee then suspended IPCC-54 until Friday, 6 August, to allow WG I-14 to begin its work.

### Consideration and Approval of the WG I SPM

WG I Co-Chair Valérie Masson-Delmotte welcomed delegates, explaining that this is the final step in the co-design process for the WG I report that began in 2017. She noted the large volume of comments received on the first two SPM drafts, saying these comments had been carefully considered in preparing the revised SPM that was shared with delegates for discussion and approval at this session.

In opening statements, SAUDI ARABIA and CHINA underscored the need to avoid policy prescriptiveness. SAUDI ARABIA pointed to instances in the report where non-calibrated language is used, and called for clarifying uncertainties relating to the use of models and projections. CHINA called for presenting changes in mean temperature on a two to three decade-long horizon instead of in decadal terms and, considering the warming speed is overestimated, for clarifying the calculations underlying the timescale for reaching the 1.5°C mark. INDIA underscored the need for detailed discussions on the figures. TANZANIA, SOUTH AFRICA, and ZAMBIA emphasized ensuring regional balance in the presented information, especially relating to drought. INDONESIA said individual paragraphs in the report should focus on one subject only and avoid numbers and technical terms, for clarity.

Co-Chair Masson-Delmotte welcomed the comments, noting the use of non-calibrated language for statements of facts reflects past practice and that various aspects relating to figures would be taken up alongside the relevant Headline Statements.

Throughout the meeting, the different subsections of the SPM were first taken up in plenary, with delegates commenting on the different paragraphs of the subsections and their Headline Statements. Authors then met to reflect on how to address delegates' comments and propose textual revisions. Subsequently, the subsections were taken up in contact group sessions and, if needed, in huddles, before coming back to plenary for approval. The outcomes of the authors' meetings and contact group and huddle



discussions were captured in conference room papers that were published on the conference management platform.

#### **A. The Current State of the Climate**

**A.1:** This subsection addresses **human influence over the climate system**. Several delegates requested strengthening the language of the Headline Statement that “human influence has warmed the climate system, and widespread and rapid changes in climate have occurred.” LUXEMBOURG, supported by the NETHERLANDS, FRANCE, the UK, SAINT KITTS AND NEVIS, JAMAICA, IRELAND, and others, but opposed by SAUDI ARABIA, CHINA, and INDIA, proposed stating “observed warming of the climate system is unequivocally caused by human influence” to replace “human influence has warmed the climate system.” Some suggested also specifying the parts of the climate that are experiencing changes. The authors proposed “it is unequivocal that human influence has warmed the climate system” and “widespread and rapid changes in the ocean, atmosphere, cryosphere, and biosphere have occurred.” During further discussions, these two statements were modified to “human influence has unequivocally warmed the atmosphere, ocean, and land.” SAUDI ARABIA objected to “unequivocally.” Delegates noted compromise on explicit reference to warming of “atmosphere, ocean, and land,” rather than “climate system,” as these are unequivocally associated with human influence. INDIA opined that human influence has varying levels of confidence and likelihood across the three. Co-Chair Masson-Delmotte said this is a statement of fact and the authors concurred. After some discussion, SAUDI ARABIA accepted the compromise formulation with a small editorial change and the Headline Statement was approved.

**A.1.1:** On this paragraph on **observed increases in well-mixed GHG concentrations**, FRANCE, supported by SWITZERLAND, IRELAND, and the UK, proposed inclusion of a graph showing the evolution of the atmospheric concentration of CO<sub>2</sub>, methane, and nitrous oxide since 1750. Several delegates questioned the reference to 1750 instead of 1850.

Others requested a list of the main GHGs instead of “well-mixed GHGs.” Delegates also questioned the use of “overwhelmingly” in relation to the attribution to human activities and requested quantification. Delegates agreed to replace it with “unequivocally” and to specify since “2011” instead of since “AR5.” CANADA requested specifying the exact percentage of CO<sub>2</sub> taken up, which was agreed. The authors’ suggestion to specify other GHG concentrations in the footnote was accepted. In response to SAUDI ARABIA, another footnote was added to clarify that land and ocean are not substantial sinks for GHGs other than CO<sub>2</sub>. Noting that the Amazon can no longer be considered a sink, INDIA proposed stating that sink capacity is decreasing. The authors clarified that the statement refers to uptake proportions at the global level. Following further discussion, delegates accepted adding “globally” in a parenthetical clause to specify the proportion of CO<sub>2</sub> emissions taken up per year, and noting “regional differences” at the end of the sentence. The paragraph was approved without further amendment.

**A.1.2:** Regarding a paragraph on **increases in global surface temperature**, several countries suggested a 20- or 30-year, rather than a decadal, horizon. The authors noted the decadal perspective has precedents, including in SR1.5. LUXEMBOURG stressed the need to provide up-to-date information. GERMANY called for clarity and consistency regarding “temperature increase” and “global warming,” and, with several other countries, on references to “global

surface temperature,” “global mean surface temperature,” and “global surface air temperature.” SAUDI ARABIA said a footnote on trends in global mean surface temperature and global surface air temperature should better reflect the underlying report.

On the estimated increase in global surface temperature since AR5 principally due to further warming since 2003-2012, SAINT KITTS AND NEVIS, supported by SWITZERLAND, LUXEMBOURG, the US, TRINIDAD AND TOBAGO, the UK, and GERMANY, suggested more specificity with regard to some of the changes in the temperature estimates resulting from changes in methodology rather than the result of natural warming. INDIA called for acknowledging that additional warming, not new or updated datasets, is the principal driver of increased warming estimates since AR5. Both suggestions were reflected in a footnote. The UK requested information on the current rate of warming. The authors said this was not addressed in the underlying report, but pointed to information provided visually in Figure SPM.1. A statement that each of the last four decades has been successively warmer than any preceding decade since 1850 was added at the beginning of the paragraph. The authors also changed the measurement of global surface temperature increase to reflect the different years now being specified, from 0.69°C-0.95°C between 1995-2014 to 0.85°C-1.10°C from 2001-2020.

**Figure SPM.1:** This figure addresses **changes in global surface temperature**. In general comments, delegates requested: distinguishing between observational and projected data presented in the figure; adding confidence levels; and including information on additional time periods. FRANCE, supported by IRELAND, SWITZERLAND, BELGIUM, LUXEMBOURG, and JAPAN, emphasized the importance of providing visual information on trends in atmospheric GHG concentrations, urging their inclusion either in Figure SPM.1 or in a new figure, noting such a figure was included in previous reports.

Co-Chair Masson-Delmotte underscored the difficulty of substantially modifying or adding figures at this stage in the process, stressing they are meant to provide additional information, not duplicate text. CHINA noted the relation between global surface temperature and GHG concentrations is not linear, which authors confirmed. The authors noted Figure SPM.2 conveys the information on the role of GHG emissions. WG I Vice-Chair Gregory Flato said Figure SPM.2 provides a much more robust assessment on the role of GHG emissions in driving climate change.

Responding to FRANCE, who noted such a figure was contained in previous reports, Co-Chair Masson-Delmotte said there was no figure on changes in global average CO<sub>2</sub> concentrations in the AR5 WG I SPM, pointing instead to the AR5 SYR. FRANCE underscored increased public interest in IPCC reports, noting the didactic importance of providing a key message on changes in GHG concentrations to readers who might not be familiar with these trends and proposed a new figure based on Figure TS.2.2 in the Technical Summary. The authors noted that creating such a figure would change the spirit of several sections in the report, as these show that the role of methane, for example, is not negligible. FRANCE noted that WMO produces such figures every year, and, pointing to figures in the underlying report, questioned the difficulty of adjusting these for inclusion in the SPM. NORWAY suggested adding to Figure SPM.1 a line of sight, which is the list of references in the underlying report, to the relevant figures in the underlying

report. The authors added reference to “TS.2.2” to the line of sight, which was accepted.

To a query from SWITZERLAND on solar and volcanic events being part of external natural variability, the authors clarified that all Coupled Model Intercomparison Project Phase 6 (CMIP6) simulations shown in this figure reflect both human and all natural factors so no additional information is needed. FRANCE, with NORWAY, eventually agreed to approve SPM.1 as is, but called for a graph on evolution of GHG emissions to be included in the SYR, asking that this statement be included in the WG I and IPCC-54 reports. The figure, intent, and caption were approved with no changes.

**A.1.3:** This paragraph addresses **human-caused global surface warming**. CANADA, GERMANY, and HUNGARY suggested changing “lower stratospheric cooling” to “cooling in the lower stratosphere,” which the authors supported. GERMANY, supported by IRELAND, the UK, and INDIA, preferred “temperature increase” over “global warming.” These two suggestions were accepted. The US queried how “best estimate” is determined, with the authors noting it refers to the mean. The NETHERLANDS suggested referring to well-mixed GHGs as the “dominant,” rather than “main” driver of tropospheric warming since 1979. SAUDI ARABIA preferred to keep “main,” arguing “dominant” is not IPCC-calibrated language and that “more than 50%” refers to something being “likely” rather than “very likely.” The paragraph was approved with no further amendments.

**Figure SPM.2:** Regarding this figure on **assessed contributions to observed warming in 2010-2019 relative to 1850-1900**, INDIA questioned a reference to “human influence” on observed warming. Co-Chair Masson-Delmotte clarified that this language was used in the AR5 WG I report and is part of the approved AR6 WG I outline. CANADA proposed text specifying that aerosol emissions are drivers of change both through their direct radiative effects and through their interactions with clouds. In discussions on the authors’ proposed changes to the figure, INDIA asked why the authors singled out that GHG warming is masked by aerosol cooling in the title. The authors clarified that masking is the major contribution of aerosols to climate change and this title also serves to explain some features highlighted elsewhere in the SPM. Responding to NORWAY on the relationship between panels (b) and (c) in the figure, the authors said they show contributions to warming based on lines of evidence from two complementary assessments: attribution studies and radiative forcing studies. The figure was ultimately approved with minor editorial changes in the caption for panel (b).

**A.1.4:** This paragraph addresses **precipitation changes**. BELGIUM noted the role atmospheric moisture plays in extreme precipitation events such as those seen around the world in July 2021. The REPUBLIC OF KOREA pointed to variability in storm track changes in the Northern Hemisphere. MADAGASCAR called for separate reference to the Southern Hemisphere. This was accepted. On a sentence stating that mid-latitude storm tracks have likely shifted poleward in both hemispheres since the 1980s, NORWAY asked why human influence is not mentioned. Co-Chair Masson-Delmotte explained that human influence is referenced in the new sentence in relation to the Southern Hemisphere. With that and another minor change the paragraph was approved.

**A.1.5:** This paragraph addresses **glacier retreat, decrease in Arctic sea ice area, and Northern Hemisphere spring snow cover**. Several countries requested mentioning observed ice mass

losses and recent acceleration of ice mass loss in Greenland and Antarctica, but the authors noted that this is covered in section A.4.3. In response to SAUDI ARABIA, the authors said the sea ice area change in Antarctica is not significant, so it was not included. However, after further discussion, a new sentence was accepted citing the very likely contribution of human influence to the observed surface melting of the Greenland Ice Sheet over the past two decades, but only limited evidence of human influence on the Antarctic Ice Sheet mass loss. GERMANY also requested addressing permafrost thawing, saying permafrost comprises 50% of the Northern Hemisphere, but authors noted this paragraph is about reduction in ice glaciers specifically, as in previous reports.

SWITZERLAND lamented omission of “cryosphere,” noting permafrost covers 3% of SWITZERLAND. Masson-Delmotte said words were chosen for concision and to avoid duplication of findings from the SROCC. BELGIUM cautioned against assuming policymakers have read the SROCC. Responding to SAUDI ARABIA, Masson-Delmotte said 1979 is the starting point because that is when satellite observations began. CANADA said the paragraph is inconsistent, with quantitative information provided for changes in some but not all variables. The authors cited limited availability of numbers and emphasis on a concise and readable message. Masson-Delmotte said they also focused on updating, not duplicating, information in the SROCC. The paragraph was approved, with the reference to surface melting of the Greenland Ice Sheet and Antarctic Ice Sheet mass loss.

**A.1.6:** Regarding a paragraph on **changes in the ocean**, the NETHERLANDS, supported by GERMANY, requested strengthening attribution of human-caused CO<sub>2</sub> emissions as the “main driver” of current global acidification to “dominant driver.” The authors explained that “main driver” means greater than 50% and said this attribution is stronger than in AR5.

VENEZUELA, GERMANY, and SAUDI ARABIA requested clarification of attribution to human influence. The authors replied that not all changes can be attributed to human influence, and the text on the drop in oxygen levels in many upper ocean regions was changed to read that “human influence contributed to this drop.” Other calls for changes were made by GERMANY and SAUDI ARABIA, including for reference to the natural carbon cycle as another driver of acidification. The authors clarified that the best estimate is that acidification is 100% human caused and that natural processes do not contribute substantially to changes. The paragraph was approved without further change.

**A.1.7:** On a paragraph on **global mean sea level increase**, the US proposed moving to this paragraph the sentences in A.4.3 that outline the causes of sea level rise. JAMAICA cautioned that the main message on increases in sea level rise might be lost amid the many numbers in the paragraph. On human influence being very likely the main driver of these increases since at least 1971, BELGIUM and GERMANY suggested adding “and of this acceleration.” This was not agreed. INDIA suggested stating that human influence is the “sole” driver or “sole cause,” rather than “very likely the main driver.” Co-Chair Masson-Delmotte and the authors said different elements contribute to sea level rise, including ocean heat uptake, loss of glacier mass, and melt and flow of water from Greenland. The paragraph was approved with no change.

**A.1.8:** Regarding a paragraph on **changes in the land biosphere** being consistent with large-scale warming, several delegates said the statement was too vague, especially considering it is “high

confidence.” SWITZERLAND suggested replacing “large-scale” with “global” warming, with the NETHERLANDS requesting quantification on lengthening of the growing season. These changes were accepted, with the approved text noting that the growing season has, on average, lengthened by up to two days per decade since the 1950s in the Northern Hemisphere extratropics. Responding to INDIA, the authors said most land biosphere impacts are regionally specific, explaining the focus on the one large-scale impact, the growing season. The paragraph was approved without further change.

**A.2:** This subsection focuses on the **scale of recent changes across the climate system**. Requests by TANZANIA, SAUDI ARABIA, and the UK for quantification of terms such as “recent” in the Headline Statement were not agreed for the sake of concision, and the Statement was approved without change.

**A.2.1:** This paragraph relates to **increases in GHG concentrations**. On a sentence stating that increases in CO<sub>2</sub> and methane concentrations far exceed the natural multi-millennial changes between the glacial and interglacial periods over at least the past 800,000 years while nitrous oxide increases are of comparable magnitude, the NETHERLANDS and ZAMBIA asked what they are compared to. The sentence was edited to provide clarity. SAUDI ARABIA noted it is vague to say that current atmospheric CO<sub>2</sub> concentrations are “unprecedented” in at least 2 million years. Delegates agreed to replace “unprecedented” with “higher than.” The paragraph was approved with these and other minor amendments.

**A.2.2:** This paragraph relates to **global surface temperature increases**. The US and ICELAND cautioned against comparing one decade against a multi-centennial average. CHINA suggested comparing “the Industrial Age” instead of one decade. The authors said comparing a decade to a much longer period is not a problem, noting the current decade is at the low end of where the world will be over the coming decades and centuries. IRELAND cautioned against highly scientific jargon such as “the Last Interglacial.” With some editorial changes to simplify language and add clarity, the paragraph was approved.

**A.2.3:** This paragraph relates to **glaciers and Arctic sea ice**. On a statement that global glacier retreat since the 1950s is unprecedented in at least the last 2000 years, SAUDI ARABIA questioned “unprecedented” and the 1950s starting point. NORWAY requested quantification of glacier loss. The authors said measurements on the global scale allow assessment starting in the 1950s. Ultimately the paragraph was approved with no change.

**A.2.4:** This paragraph relates to **global mean sea level rise and ocean warming**. SAUDI ARABIA urged quantifying the rates of rising and warming. CHILE and KENYA asked if warming is leading to thermal expansion and, therefore, sea level rise. The authors said there is a strong relation, but other factors are also involved, such as glaciers. The US, UK, BELGIUM, CANADA, and SAINT KITTS AND NEVIS asked to reinstate the reference to ocean acidification from an earlier draft. This request was accepted, and a statement was added that a long-term increase in surface open ocean pH occurred over the past 50 million years, and surface open ocean pH as low as recent decades is unusual in the last 2 million years. With this, the paragraph was approved.

**A.3:** This subsection addresses **weather and climate extremes**. On the first sentence of the Headline Statement, on human-induced climate change already affecting many weather and climate extremes

in every inhabited region across the globe, the US and IRELAND suggested deleting “inhabited,” highlighting that effects also manifest in uninhabited regions and the ocean. The authors noted the underlying assessment is primarily on inhabited regions, but agreed to the change. TRINIDAD AND TOBAGO called for inserting “in particular, extreme droughts and cyclones.” The authors said “many weather and climate extremes” include droughts and tropical cyclones, and that details are provided in the paragraphs. On the second sentence, which states that evidence of observed changes in extremes and their attribution to human influence has strengthened since AR5, a number of countries suggested including examples of strengthened evidence. The authors agreed to note “such as heatwaves, heavy precipitation, droughts, and tropical cyclones.” With this addition, the Headline Statement was approved.

**A.3.1:** This paragraph addresses **observed changes in hot and cold extremes** and their attribution. INDONESIA called for specifying when, in the 20th century, marine heatwaves became more frequent. JAMAICA proposed using wording on this from the Technical Summary. The US suggested referring to “the 1950s” instead of “1950” as the starting point for the increase in hot extremes, if it comes from multiple datasets starting around this time, rather than a single dataset. TANZANIA queried references to 2006 in the attribution statement for marine heatwaves. The authors explained that observational data on extreme events starts in 1950, with several references in the literature, but literature on human attribution for marine heatwaves is only available starting in 2006.

The RUSSIAN FEDERATION asked whether “high confidence” relates to the increased frequency in extreme heat and cold events, or to human influence. The authors clarified that “high confidence” relates to human influence, with changes in hot and cold extremes being “virtually certain.” SPAIN requested replacing “dominant” with “main” driver. The authors highlighted that “main” refers to a driver responsible for at least 50% of change. NORWAY proposed a definition of this in a footnote. SAUDI ARABIA requested definition or quantification of “main driver” everywhere the term appears, not in a single footnote. The Co-Chairs proposed including a footnote defining it once in each section where the term is used. This proposal was accepted. Regarding a statement that some recently observed hot extremes would have been extremely unlikely to occur without human influence on the climate system, in response to SOUTH AFRICA, the authors said “recently” means in the last five years. Noting that not all areas are experiencing hot extremes, INDIA called for specificity. The authors referred to several event attribution studies analyzing heat waves in Japan, North America, and Siberia. With these changes the paragraph was approved.

**A.3.2:** This paragraph relates to **heavy precipitation events and agricultural and ecological droughts**. SPAIN, the RUSSIAN FEDERATION, and TANZANIA queried the relationship between agricultural and ecological droughts and meteorological and hydrological droughts. The RUSSIAN FEDERATION urged deleting the sentence, saying it is within WG II’s purview. The authors said agricultural drought and ecological drought address water availability, with agricultural drought referring to moisture limitation and is defined as a specific climatic-impact driver (CID) in Chapter 12 of the underlying report, while ecological drought refers to its effects on ecological systems. Responding to EGYPT, the authors said desertification uses different metrics than these droughts.



The US requested wording on decreases in precipitation causing such droughts. JAPAN queried the evidence of increasing heavy precipitation, and suggested replacing “evapotranspiration” with “water vapor released from land and vegetation.” INDIA proposed stating that heavy precipitation has increased over “many,” not “most,” land areas because it is true for only 20 of the 45 regions in the figure. An author clarified that “most land area” refers to the fact that for regions where there is sufficient data, most parts within those regions showed an increase.

SAUDI ARABIA called for scientific quantification of attribution and specifying differences in likelihoods or confidence between statements on increases in intensity of heavy precipitation events at 1.5°C and at 2°C. TANZANIA suggested noting that data for some regions is problematic. BOTSWANA urged balance in reporting both low and high extremes of precipitation. SWITZERLAND stressed increased evapotranspiration “is due to higher temperature,” clarifying the human influence. The authors said it is also related to changes in humidity, radiation, and wind, and added a footnote defining it. The paragraph was approved with little further change.

**A.3.3:** Regarding a paragraph on **changes in land monsoon precipitation**, UKRAINE proposed using both “multi-annual” and “decadal” to reference the range from several years to several decades. The authors noted that multi-decadal refers to the range between more than 10 years and several decades. INDONESIA asked why some regions are not mentioned. The authors noted insufficient data on these regions. The US, with TANZANIA, asked whether the reference to “limited” changes in monsoon precipitation means “significant but small” or “negligible.” TANZANIA also queried why the East African monsoon is not mentioned, and the authors said Annex V (Monsoons) of the Technical Summary contains the rationale for selecting regional monsoons, explaining there is still debate in the literature on whether this counts as a monsoon. They said the precipitation changes in East Africa are dealt with in another chapter, but not treated as a monsoon. The paragraph was approved with a minor editorial change for clarity.

**A.3.4:** Regarding a paragraph on **tropical cyclones**, SPAIN, supported by NORWAY, proposed making it clearer that increases in Category 3–5 tropical cyclone occurrence and the latitude shift at which tropical cyclones in the western North Pacific reach their peak intensity, which cannot be explained by internal variability alone, are due to human input. SAINT KITTS AND NEVIS called for clarifying the statement regarding latitude shift of tropical cyclones, proposing to start with a general statement on tropical cyclones and then include more specific language on the North Pacific region. SWITZERLAND suggested replacing the reference to tropical cyclone “occurrence” with “frequency.” The REPUBLIC OF KOREA called for consistency between the SPM’s reference to “internal variability” and the underlying report’s reference to “natural variability.” Numerous countries called for greater clarity on tropical cyclones. The authors clarified that by “frequency of tropical cyclones at the global scale,” they mean the total number of cyclones for all categories of cyclones, and added clarification on this. Responding to SAUDI ARABIA, they said there is no contradiction between the paragraph and the underlying report, stating that many studies find that the associated precipitation comes from human-induced activities, but there is insufficient data for long-term trends. SAUDI ARABIA said this explanation should be included in the paragraph. This was accepted.

SAUDI ARABIA questioned the inclusion of a low confidence statement on long-term trends in frequency of all-category tropical cyclones. Co-Chair Masson-Delmotte confirmed it is past practice to refer to potentially policy-relevant scientific findings with low confidence, pointing to the SROCC SPM. She highlighted there are often misunderstandings about what aspects of tropical cyclones are changing, for example whether it is the intensity of the most intense ones or the frequency of all categories of cyclones, and said this sentence responds to specific requests to clarify this. With these clarifications, the whole paragraph was approved.

**A.3.5:** Regarding a paragraph on **compound extreme events**, TANZANIA and SOUTH AFRICA called for clarification of “fire weather.” Numerous countries queried a listing of specific regions in relation to increases in frequency of fire weather, with SOUTH AFRICA noting other African biomes, such as grasslands and savannahs, are also affected by increases in fire events. The paragraph was approved with “some regions of all inhabited continents” replacing the list of specific regions. “

**Figure SPM.3:** Co-Chair Panmao Zhai introduced this figure on **observed and attributable regional changes in weather and climate extremes**, comprising three panels of figurative maps with hexagonal “regions” synthesizing assessment of observed changes in, respectively, hot extremes, heavy precipitation, and agricultural and ecological droughts. On the title, which states that climate change is already affecting every inhabited region across the globe with human influence contributing to many observed changes in weather and climate extremes, SWITZERLAND suggested to mention human influence contributing to “some,” rather than “many,” observed changes was not accepted. The US said the figure focuses on weather events, not “climate” as suggested in the title. SAUDI ARABIA called for reflecting that only some regions have data available. Pointing to regional hexagons marked in grey to reflect insufficient evidence, numerous delegates asked why there was “insufficient evidence” to illustrate some types of change for some regions, particularly Caribbean and Pacific islands and Africa. The authors said island regions were grouped together to provide information at the scales illustrated here. TRINIDAD AND TOBAGO queried why the underlying report treats the Caribbean and Pacific regions together in some areas and separately in others, calling for the Headline Statement to reflect their concerns. Supported by TANZANIA, ANGOLA, and ALGERIA, he called for use of other literature where peer-reviewed literature is lacking. ANGOLA noted that for AR5, there was information on precipitation in Africa, generally indicating precipitation had decreased, but Figure SPM.3 contradicts AR5 in claiming insufficient evidence. The authors said the regions were aggregated at the subcontinental level to be large enough to generate a good evidence base from the modeling, to then be matched to evidence from the literature, and that much regional evidence is assessed in the underlying chapter but is insufficient to be aggregated to the scale of Figure SPM.3.

CHILE called for adding hydrological droughts to the panel on droughts. SAUDI ARABIA said consideration of agricultural and ecological droughts should be left to WG II. TANZANIA cautioned against imbalanced and inadequate representation of regional specificity, noting Africa has faced drought for decades. The US called for explicitly relating the drought panel to the main SPM text and Chapter 11. He also queried the representation of observed change only since 1950. The authors noted that some regions

experienced changes in an even later period. Zhai said the TSU can produce regional fact sheets. Masson-Delmotte noted limitations on availability of peer-reviewed scientific literature, especially for extreme events. The authors explained that SPM.3 illustrates assessment of each AR6 region as defined in the caption and the new Interactive Atlas, and that more localized changes can be reviewed in the underlying report and the Atlas. Delegates agreed to amend the legend to distinguish between low confidence due to limited agreement and that due to limited evidence, as well as between low agreement in the type of change and limited data and/or literature. The figure and its title were approved without amendments. The caption was amended to explain the changes in the figure and legend based on the discussions.

**A.4:** This subsection addresses the range of **equilibrium climate sensitivity**. The Headline Statement refers to improved knowledge narrowing the range of equilibrium climate sensitivity compared to AR5. GERMANY and FRANCE requested better linking the Statement to the content of the different paragraphs under the subsection. SOUTH AFRICA queried “past climate states” and, supported by GERMANY and IRELAND, urged quantifying “narrowing.” The authors clarified that “past climate states” refers to the Pliocene and Last Glacial Maximum. The approved statement reads that “improved knowledge of climate processes, paleoclimate evidence and the response of the climate system to increasing radiative forcing gives a best estimate of equilibrium climate sensitivity of 3°C with a narrower range compared to AR5.”

Commenting on the subsection as a whole, NORWAY called for making linkages between radiative forcing levels in this subsection and annotations used in the scenarios. FRANCE asked whether the paragraphs are based on physical retroactions or something else. SOUTH AFRICA asked if the subsection deals with all GHGs or CO<sub>2</sub> only. Delegates also requested reference to recent increases in radiative forcing since AR5 and more detail in the paragraphs about the radiative forcing provided by GHGs. The authors said the underlying report and Technical Summary provide more information about other forcing agents, specifically aerosol forcing.

**A.4.1:** This paragraph, on **human-caused radiative forcing**, states that: human-caused radiative forcing in 2019 relative to 1750 has warmed the climate system, mainly due to increased GHG concentrations, partly reduced by cooling due to increased aerosol concentrations; and that radiative forcing has increased relative to AR5, mostly due to the increase in GHG concentrations since 2011. Several delegates said this paragraph is too complex and technical for policymakers. GERMANY, supported by NORWAY, called for linking this paragraph with other paragraphs, especially A.4.2, and to Cross-Chapter Box 9.1 of the underlying report. The paragraph was modified to enhance clarity and to distinguish increase in GHG concentrations since 2011 from increases in measurements of GHG concentrations due to improved scientific understanding and changes in the assessment of aerosol forcing.

**A.4.2:** Regarding this paragraph on the **observed heating of the climate system** and the role of ocean warming among other things, several countries called for using energy metrics instead of “watts per square meter,” which was not accepted. LUXEMBOURG, with several others, suggested referring to “energy accumulation in the climate system” instead of “heating of the climate system.” The authors said the latter is now a common term in the literature but added a sentence at the beginning linking the two terms and explaining the human-caused net positive radiative forcing behind

them. The NETHERLANDS queried a statement that 2006-2018 represents an “increase” in heating of the climate system compared to 1971-2018. The authors changed the earlier period to specify the observed average rate of heating over “1971-2006,” clarifying they are both average rates and therefore the different lengths of the period do not hinder comparison. In response to SAUDI ARABIA and LUXEMBOURG, the authors specified a high confidence level for the increase in the observed average rate of heating and the amended paragraph was approved.

**A.4.3:** Regarding this paragraph on the **role of heating of the climate system on sea level rise**, CHILE proposed noting that thermal expansion differs across latitudes. The UK called for clarifying that the balance of the contribution to sea level rise over the last decade now shows ice loss as the dominant contribution, compared to thermal expansion. The paragraph was amended to specify that ice sheet and glacier mass loss were together the dominant contributors to global mean sea level rise during 2006-2018. The paragraph was approved as amended.

**A.4.4:** This paragraph presents estimates of **equilibrium climate sensitivity**. NORWAY, with SWITZERLAND and UKRAINE, said “equilibrium climate sensitivity” is too complicated for policymakers and called for consistency in terms. SWITZERLAND and UKRAINE suggested defining it here and adding the best estimate from AR5 for comparison, with GERMANY noting AR5 had no best estimate due to lack of agreement across the lines of evidence. IRELAND, with UKRAINE, asked whether AR6 used the same lines of analysis as AR5. The authors said “equilibrium climate sensitivity” has a quantitative meaning and proposed defining the term in the paragraph. GERMANY requested definition of “emergent constraints.” JAPAN queried the concept, favoring reference to “new methods for analyzing climate model results.” The authors explained the term refers to using observations to constrain the climate sensitivity coming out of the models and said clarification will be added.

Noting that equilibrium climate sensitivity relates to longer-timescale response, JAPAN, supported by IRELAND, suggested also referring to transient climate response to cover shorter-timescale response. This was not accepted. Other comments related to: whether the temperature indications were rounded; noting that values above 5°C cannot be ruled out; adding information on lines of evidence based on observations contained in the Technical Summary; and including information from this paragraph in the Headline Statement. The authors confirmed the temperature indications were rounded because the lines of evidence do not support higher precision, and noted the lines of evidence do not rely exclusively on observations but that models are integrated into all of them. They underscored progress on assessing equilibrium climate sensitivity since AR5, including more lines of evidence and ability to give a best estimate. The paragraph was amended to start with a definition of equilibrium climate sensitivity, to highlight that AR5 did not contain best estimates for this quantity, and to specify the lines of evidence in a footnote. The paragraph was approved as amended.

## **B. Our Possible Climate Futures**

**Box SPM.1: Scenarios, climate models, and projections:** Co-Chair Zhai introduced this box, highlighting that the SPM covers a range of high, intermediate, and low Shared Socio-economic Pathways (SSPs), which reflect possible future trends in GHG emissions.



**Box SPM.1.1: Scenarios:** SPAIN requested clarification of SSPs. SAUDI ARABIA, with TANZANIA, cautioned that addressing socio-economic factors is outside WG I's remit and that only mentioning declining CO<sub>2</sub> emissions by 2050 is policy prescriptive. LUXEMBOURG and NORWAY requested consistently referring to high, intermediate, and low emission scenarios rather than their technical labels. GERMANY inquired about the boundary conditions in the models used and suggested differentiating the five emissions scenarios as very low, low, intermediate, high, and very high. INDIA asked about the basis for the socio-economic assumptions, calling for common assumptions for all pathway scenarios and noting that the use of Representative Concentration Pathways (RCPs) in AR5 was much clearer. He queried the rationale for adding the lowest emissions scenario.

SOUTH AFRICA asked for a clear definition of new terms, particularly net zero, in the glossary. SAUDI ARABIA requested removal of that term. The authors noted they followed IPCC practice in not examining assumptions, only the physical science response to scenarios based on them, in assessing the literature the modeling community has produced. They said the net-negative emissions description only applies to specific scenarios, and said they added one scenario to simulate the broadness of response choices. The US said the focus on future emissions is important and should feature more prominently in the box. BELIZE suggested reflecting the implications of COVID-19 on emissions trends. The authors said the mandate of WG I does not include validating the COVID-19 recovery trajectory.

One of the main issues that came up for discussion was the choice and labeling of scenarios. Many delegates requested clarification on how scenarios were selected, noting that the literature contains more than the five selected scenarios. The authors explained that they followed IPCC practice in using an illustrative set of scenarios that is representative of the literature, noting scenarios were selected to cover the full range of available climate projections and to maximize data availability.

During discussions, there was continuing objection, most notably from INDIA, to the use of these scenarios, and their description as "core" scenarios. INDIA, supported by SAUDI ARABIA, objected to the term "SSPs" and to limiting the statement to "scenarios," saying that: the socio-economic aspects of SSPs stray into WG III's mandate; the SSPs sound like policy-prescriptive language on mitigation; use of SSPs has not improved the needed diversity of analysis given that, although CMIP6 comprises a large number of models, these five scenarios use the same limited number of assumptions in order to harmonize them with one another for comparability; and the scoping document did not specify that SSPs had to be assessed and they are "not the only way the world can be assessed." After protracted discussions, Co-Chair Zhai underscored that agreement on this is key to unlocking agreement on other parts of the SPM, as the labeling question surfaces in numerous paragraphs, noting that the label "SSP" is inherited from the literature.

FRANCE and numerous other countries argued that SSPs are scientifically rigorous, traceable, replicable, relevant to policymakers, and not under the IPCC's control. WG I Vice-Chair Gregory Flato added that SSPs are used in CMIP6 with the same specifications followed by all modeling centers to produce harmonized multi-model sets of results that build on the RCPs used in previous Assessment Reports. He noted that limited resources

allow only a limited number of scenarios to be assessed. The authors explained that governments had requested adding characterizations of the scenarios in terms of CO<sub>2</sub> as the main driver of climate change and that scenarios are selected based on availability of information, without assessment of the assumptions underlying the SSPs. They proposed adding language on this to the SSP footnote, noting the next sentence mentions alternatives. IPCC Chair Lee suggested specifying "the IPCC is neutral with regard to the assumptions underlying the SSPs." The NETHERLANDS suggested adding "SSPs do not exhaust the way we see the world," but this was not accepted by the US. Co-Chair Masson-Delmotte said the WG I glossary defines scenarios as "plausible descriptions of how the future may develop."

After further discussions, delegates agreed that the five scenarios are "illustrative" and added introductory text to a caption paragraph on Box SPM.1.1 and a statement that the illustrative scenarios start in 2015 and include five scenarios representing varying levels of GHG emissions, giving a description of each. Co-Chair Zhai also proposed adding Chair Lee's sentence at the end of the footnote, followed by "alternative scenarios may be considered or developed." SAUDI ARABIA, supported by INDIA, requested removing the descriptions of the SSPs because they refer only to CO<sub>2</sub> while the SSPs cover all GHGs. The UK argued that CO<sub>2</sub> is an important feature. Co-Chair Masson-Delmotte noted other key drivers of climate change are covered by the next sentence. The authors explained that the purpose of the box is to introduce the illustrative scenarios used across the WG I report and specifically in the SPM, not to explain the details of all the different emitting factors or trajectories. They noted that full information is provided in the underlying report. The suggestions for the SSP footnote were accepted. The UK, supported by several other countries including SAUDI ARABIA, proposed replacing "they start in 2015, and include high and very high GHG emissions scenarios in which CO<sub>2</sub> emissions roughly double from current levels by 2100 and 2050" with "they start in 2015, and include scenarios with high and very high GHG emissions and CO<sub>2</sub> emissions that roughly double from current levels by 2100 and 2050" and replicating this for the other four emissions scenarios. The paragraph was approved with these amendments.

**Box SPM.1.2: Models:** Regarding a paragraph on the changes in CMIP6 compared to CMIP5, TANZANIA called for clarifying what is meant by "new" representation of physical, chemical, and biological processes. SAUDI ARABIA said limitations and uncertainties relating to assumptions underlying the models should be made clear throughout the report, and called for delineating the changes in the models between AR5 and AR6. GERMANY, supported by IRELAND and the UK, proposed clarifying that the models are prepared by the scientific community, not the IPCC, and that the IPCC assesses the results of CMIP6. The US, supported by the UK, called for reflecting that the CMIP6 project is not yet concluded, cautioning against referring to a CMIP6 multi-model "mean." It was replaced with "ensemble mean." IRELAND, supported by the UK, suggested adding an introduction to clarify the role of CMIP6 in the assessment report. This was agreed.

SWITZERLAND requested clarifying the meaning of "large-scale indicators of climate change," pointing to illustrative examples such as global temperature or atmospheric GHG concentrations. The UK suggested noting that diverse methods were used to constrain model projections. The authors explained that the rationale for

the paragraph is to highlight important developments in the latest generation of climate models and, noting this would be too detailed to include in the SPM, said the Technical Summary contains many examples of these new developments. The paragraph was approved with no further changes.

**Box SPM.1.3: Climate sensitivity:** GERMANY, supported by LUXEMBOURG, queried the “assessed best estimate” of equilibrium climate sensitivity and to specify that net-negative CO<sub>2</sub> emissions are “also referred to as CO<sub>2</sub> removal” in the footnote explaining net negative CO<sub>2</sub> emissions. NORWAY called for using the term “climate sensitivity” consistently, not “equilibrium climate sensitivity,” and for clarifying the term in a footnote. LUXEMBOURG preferred deleting that term from Box SPM.1.3, noting it is too technical and that the policy-relevant aspect of climate sensitivity is discussed in Box SPM.1.4. This was agreed. SWEDEN requested clarification that this is an update of climate sensitivity that is not in the CMIP6 models.

The REPUBLIC OF KOREA requested consistency with the Technical Summary, explaining that high equilibrium climate sensitivity values can sometimes be traced to positive changes in cloud feedback, meaning some models may be misunderstood or misestimated.

The UK commented that difficulties in talking about the mean value for CMIP6 are discussed in Box SPM.1.2, and requested clarification that the equilibrium climate sensitivity in CMIP6 overlaps with models using a wider range than CMIP5. The reference to CMIP6 “mean equilibrium climate sensitivity” was removed. The paragraph was approved with no further amendments.

**Box SPM.1.4: Constraints:** The US requested specifying that for some quantities, no methods “yet” exist for constraining projections, given that scientists are actively pursuing this. This was agreed. In a statement that robust projected geographical patterns of many variables can be identified at a given level of global warming, independent of scenario and timing when the global warming level is reached, the authors suggested replacing “independent of scenario and timing” with “common to all scenarios and independent of timing.” This was agreed and the amended paragraph was approved.

**Figure SPM.4:** This figure addresses **future additional warming**. Delegates engaged in lengthy discussions over the heading that states that “future emissions determine future additional warming, with CO<sub>2</sub> emissions dominating.” INDIA, SAUDI ARABIA, BRAZIL, and KENYA underscored the importance of past emissions, calling for referencing cumulative emissions to avoid giving partial information. SWITZERLAND, the US, the UK, the NETHERLANDS, CANADA, SPAIN, SAINT KITTS AND NEVIS, RUSSIA, CHILE, and others emphasized retaining the authors’ heading, noting it relates to “additional” warming and presents an important finding. CHINA, supported by INDIA, SAUDI ARABIA, and TANZANIA, suggested replacing “determine” with “contribute to.” SWITZERLAND and others noted this would be misleading, underscoring the focus is on human-induced warming for which CO<sub>2</sub> is key. NORWAY, supported by GERMANY, DENMARK, TANZANIA, and the UK, suggested noting that CO<sub>2</sub> is “still” dominating. Supported by BELGIUM, the UK, and the RUSSIAN FEDERATION, GERMANY proposed adding a footnote on the role of past emissions. MEXICO noted panel (b) represents “total warming,” and suggested reflecting this in the heading. The authors clarified that “cumulative” emissions would not be accurate here, and, pointing to Chapter 4 in the underlying assessment, noted there

will be no net warming after emissions are cut to zero and that this finding is a significant scientific advance. They proposed noting that future emissions determine future additional warming, with “total warming being dominated by past and future CO<sub>2</sub> emissions.”

While many delegations preferred retaining the original heading, they expressed openness towards the authors’ suggested amendment. BELGIUM suggested clarifying it relates to future additional “surface” warming. The authors explained that warming affects all parts of the climate system, including the upper and deep ocean, not only surface temperature. Delegates eventually approved the figure with the heading stating that “future emissions cause future additional warming, with total warming dominated by past and future CO<sub>2</sub> emissions.”

Regarding a sentence in the caption to panel (a), which refers to emissions trajectories for CO<sub>2</sub> from fossil fuel use, industry, and land-use change, SAUDI ARABIA objected to the reference to these emissions sources, stating that WG I’s mandate is to consider emissions only. Co-Chair Masson-Delmotte proposed, and all countries accepted, replacing the text with reference to “emissions trajectories for CO<sub>2</sub> from all sectors.” Regarding the caption to panel (b), which deals with warming contribution by groups of anthropogenic drivers, JAPAN proposed including reference to hydrofluorocarbons (HFCs). The authors explained that the purpose of this panel is to show that CO<sub>2</sub> is the dominant driver, while figure SPM.2 shows the different drivers at play. No change was made. With these amendments and other minor amendments relating to sentence structure, the figure was approved.

**B.1:** This subsection addresses **global surface temperature increase in the near-term**.

On the Headline Statement, which states that global surface temperature will continue to increase until at least the mid-century under all emissions scenarios considered and that global warming of 1.5°C and 2°C will be exceeded during the 21st century unless deep reductions in CO<sub>2</sub> and other GHG emissions occur in the coming decades, SAUDI ARABIA and CHINA called for replacing the reference to “deep reductions” in emissions, which they said is policy prescriptive, with references to specific emissions scenarios. TANZANIA called for quantifying the notion of “deep reductions” and, with the NETHERLANDS, called for a clearer formulation than “the coming decades.” The authors noted the term “deep reductions” is extensively used in the literature as well as in SR1.5. The Headline Statement was approved without amendments.

In general comments on the subsection, SAINT KITTS AND NEVIS noted the potential impact of COVID-19 restrictions and recovery plans on near-term emissions, and also called for using IPCC-calibrated language instead of pointing to a “more than a 50% likelihood,” which is used several times in the subsection in relation to crossing specific warming levels. IRELAND, supported by SAUDI ARABIA, TANZANIA, and CHINA, called for reflecting throughout the subsection that temperature “is projected to” rather than “will” increase.

The REPUBLIC OF KOREA called for consistency regarding timeframe references throughout the report, favoring reference to near-, mid-, and long-term horizons over phrases such as “mid-century.” INDIA reiterated his call for consistent references to very high, high, medium, low, and very low emissions throughout the SPM, noting SSP terminology is policy prescriptive and confusing, and called for adding information on carbon budget in Table SPM.1.

NORWAY requested clarification on why authors sometimes refer to best estimates and at other times, present ranges.

The authors clarified that a “more than a 50% likelihood” is the exact equivalent of the IPCC-calibrated language “more likely than not.” They recalled that in a previous round of comments, several countries had called for using “more than a 50% likelihood,” which they said would be clearer to policymakers. The authors also noted that immediate effects relating to the COVID-19 pandemic are not addressed in the WG I report but might be considered by WG III.

**B.1.1.** This paragraph addresses **projected global surface temperature increases** in different emissions scenarios. NORWAY, FRANCE, SAUDI ARABIA, and CHINA queried the rationale for stating global surface temperature is “very likely” to be higher by 1.0-5.7°C as per the various scenarios, seeing that the Technical Summary presents the ranges as the “best estimate.” FRANCE asked to clarify the time interval meant by “sustained” global warming of more than 2.5°C. INDIA proposed removing SSP labels and instead refer to “lowest” and “highest” emissions scenarios considered in the report. The approved paragraph includes the intermediate emissions scenario, and refers to the scenarios as lowest, intermediate, and highest but also uses the SSP labels. It also clarifies the reference to sustained global warming of more than 2.5°C.

**Table SPM.1:** Regarding a table presenting **changes in 20-year-average global surface temperature across emissions scenarios until 2100**, distinguishing between 2021-2040, 2041-2060, and 2081-2100, BELIZE, supported by the US and GERMANY, called for clearer presentation and comparison between observed changes and scenario projections. The US called for a clearer message regarding the simulated warming from the near-term historical period of 1995-2014 and the observed warming in the period since pre-industrial times. The authors explained that the choice of table design was based on governments’ requests for simplicity in the SPM, which is why authors only included changes relative to 1850-1900. They indicated that Table 4.5 in Chapter 4 of the Technical Summary contains the full range of changes relative to both reference periods (1995-2014 and 1850-1900).

INDIA called for including carbon budgets corresponding to each scenario projection. He also reiterated the suggestion to label scenarios as very high, high, medium, low, and very low; and proposed that in the table caption, “emissions scenarios used” should be changed to “emissions scenarios considered.” The approved table states that it includes the revised assessment of observed historical warming for the AR5 reference period 1986-2005 and also moves to the main text the reference previously in a footnote on calculating changes relative to the recent reference period 1995-2014.

**B.1.2:** This paragraph presents information about **whether and when 2°C warming will be exceeded in the different scenarios**. Pointing to underlying uncertainties, several delegates, including SAINT LUCIA, the US, and the UK, said crossing times should be presented as ranges rather than mid-points. The REPUBLIC OF KOREA called for consistency in specifying likelihood expressions for the crossing time scenarios, and SAUDI ARABIA called for confidence levels to be inserted after every sentence. SAUDI ARABIA, with INDIA and CHINA, noted that as descriptions of the scenarios are included in the box, they should be deleted from the paragraph. INDIA further noted they are just part of an illustrative list and there is therefore no reason to describe them in the paragraph.

SAUDI ARABIA suggested replacing “will” with “projected to” where projections are used. The authors explained that the use of “will” was carefully chosen and means that in a given scenario or independent of a scenario, something “will happen.” They said using “projected to” would be misleading because assessment of future global temperature change is based not only on projections but on multiple lines of evidence including observations.

One of the contentious issues was the sentence stating that under the lowest GHG emissions scenario— with declining global GHG emissions from the 2020s onwards and reaching net zero CO2 emissions around 2050—global warming during the 21st century is extremely likely to remain below 2°C. The UK called for greater precision in the reference to “from the 2020s onwards.” SWEDEN proposed referring to negative emissions to complement the reference to net zero emissions. NORWAY, SWITZERLAND, and the FRIENDS WORLD COMMITTEE FOR CONSULTATION (FWCC) supported retaining the paragraph in its entirety, with SWITZERLAND calling for the presentation to be improved.

Delegates had a lengthy exchange over whether or not it is policy prescriptive to describe the CO2 trajectory under the very low emissions scenario, in which global CO2 emissions start to decline in the 2020s to reach net zero around or after 2050, followed by varying levels of net-negative CO2 emissions. CHINA, SAUDI ARABIA, and INDIA urged deleting the reference, with INDIA noting that it is not relevant to the paragraph as it relates to 1.5°C. Most other delegates preferred retaining it, underscoring that the information is policy relevant.

The final approved paragraph provides the crossing times as ranges. It further states that under the very low and low GHG emissions scenarios, global warming of 2°C is, respectively, extremely unlikely, or unlikely, to be exceeded, and moves the reference to declining CO2 emissions and net zero to the footnote.

**B.1.3:** This paragraph addresses **whether and when 1.5°C global warming will be exceeded in the different scenarios**. Several countries called for expressing the likelihood of limiting global warming to below 1.5°C in the context of all scenarios, not just the lowest emissions scenario. GERMANY underscored the risk of misinterpretation if the likelihood of staying within 1.5°C is expressed with regard to only this scenario. FRANCE supported maintaining the statement as is, noting it provides novel information. SWEDEN suggested stating that the likelihood of limiting warming to below 1.5°C “becomes successively lower with increasingly high emissions scenarios,” noting the rest of the paragraph could then focus on the lowest emissions scenario. GERMANY opposed referring to “1.6°C,” suggesting that the text should reflect the language in SR1.5 about limiting warming to 1.5°C with a temperature overshoot of no more than 0.1°C warming. Responding to SAUDI ARABIA, who called for adding a timeframe to the statement on a less than 50% likelihood of staying below 1.5°C in the lowest emissions scenario, the authors explained this is the case across time. INDIA objected to the reference to global warming of 1.5°C being “reached or temporarily exceeded,” noting these scenarios are illustrative of a range and their uniqueness should not be highlighted. The final approved paragraph contains the likelihood of limiting global warming to below 1.5°C in the context of all scenarios, and states that for the very low GHG emissions scenario, it is more likely than not that global surface temperature would decline back to below 1.5°C toward the end of the 21st century, with



a temporary overshoot of no more than 0.1°C above 1.5°C global warming.

The paragraph also has a footnote, based on a draft paragraph ultimately deleted, explaining the differences between SR1.5 and AR6. SWITZERLAND, with the US, suggested a footnote on methodological differences accounting for a ten-year difference in the 1.5°C crossing timeframe between SR1.5 and AR6. JAPAN, supported by SAUDI ARABIA, the US, and the UK, called for stating that estimating the crossing time to be ten years earlier in AR6 than in SR1.5 does not necessarily mean that projected impacts will be felt ten years earlier. SAINT KITTS AND NEVIS noted SR1.5 gave a 20-year range for the crossing time, not a median crossing year. She favored removing crossing time estimates and using probabilities as in paragraph B.1.2. The NETHERLANDS expressed strong support for the paragraph and its explanations of how the new estimate was obtained. The US, with the UK, noted that SR1.5 focused on anthropogenic global warming while this paragraph discusses surface warming values, and called for a statement that the difference in crossing time is based on methodological decisions. He suggested dropping reference to SR1.5 here as being incomparable and adding a footnote on the observation record rather than future projections. The new footnote makes no mention of the ten-year crossing timeframe difference between the two reports.

**B.1.4:** This paragraph deals with **single year variability of the global surface temperature within a 20-year average**. CHINA said the uncertainty around single year estimates are all based on the 20-year average and that the underlying report does not mention how to calculate single year estimates from the 20-year average. He noted this could be misleading given that there is greater uncertainty in the estimated value of the 20-year average, and proposed excluding reference to single years when discussing the 20-year average. Regarding the statement that around 2030, there is a 40%-60% chance that global surface temperature in a single year could exceed 1.5°C, TRINIDAD AND TOBAGO said this information should not include a specific temporal component. She questioned the meaning of “around 2030” and suggested a sentence stating that individual warming above 1.5°C could occur but that this does not mean the 20-year average has been reached.

On the sentence that global surface temperature in a single year is subject to substantial natural variability, and some single years will exceed 1.5°C change relative to 1850-1900 before the 20-year average does, China said it is possible to fall back below 1.5°C and the UK suggested adding the word “temporarily” to show that the levels can change, while others proposed changing “will” to “may.” Some countries, including the US and GERMANY, proposed deleting reference to the 20-year average and simply referring to “global warming.” SWITZERLAND and the US called for better reflecting fluctuations in both directions, with the US suggesting providing a range in “plus and minus terms” instead of a single value, which could be misinterpreted. The RUSSIAN FEDERATION proposed also referring to annual or seasonal anomalies. The UK asked if the calculation of single year estimates is consistent with the 20-year mean crossing time mentioned in B.1.3. The authors responded that the single year estimation is different since it is based on annual mean value rather than a 20-year average.

The final approved paragraph states that global surface temperature in any single year can vary above or below the long-

term human-induced trend, due to substantial natural variability. It clarifies that the occurrence of individual years with global surface temperature change above a certain level does not imply that this global warming level has been reached.

**B.2:** This subsection addresses the **direct relation between increases in changes in the climate system and increases in warming**. On the Headline Statement, many countries suggested including changes in tropical storms. CUBA underscored that there is an increase not only in the frequency and quantity of tropical storms, but also in their intensity. Several countries called for including meteorological drought, while GERMANY suggested referring to “droughts” generally. GERMANY, supported by the UK, noted that not all responses are linear, calling for replacing the reference to “direct” relation. The authors clarified that the changes highlighted here are directly related to the level of warming, irrespective of emissions pathways. The Headline Statement was approved, with an additional reference to increases in the proportion of intense tropical cyclones. In general comments on the subsection itself, SAUDI ARABIA called for replacing wording such as “many” or “larger” with quantitative information throughout the subsection. INDIA suggested addressing changes in storms and specifying which regions and basins are especially affected. SOUTH AFRICA called for differentiating between coastal and inland tropical cyclones.

**B.2.1.** This paragraph puts into perspective **land and ocean surface warming** as well as **Arctic warming and global surface temperature**. GERMANY asked why the first sentence states it is “virtually certain” that the land surface will continue to warm more than the ocean surface rather than a statement of fact. The authors clarified it is not a statement of fact because the assessment concludes that, in the near term or for low levels of global warming, internal variability can be high and temporarily mask warming.

Regarding a statement that it is virtually certain the Arctic will continue to warm more than global surface temperature, NORWAY requested quantifying the level of warming. The authors indicated there is high internal variability and estimates are affected by relatively large uncertainty. Responding to SAUDI ARABIA, the authors indicated the statements are based on multiple lines of evidence, including observations. Regarding a suggestion to use “projected to” instead of “will” continue to warm, Co-Chair Masson-Delmotte recalled it is past practice to use the term “projected” to refer to multi-model results and “will” for results based on multiple lines of evidence, such as paleoclimatic evidence and historic observations. INDIA noted that multiple lines of evidence were used to constrain model outputs and said that as long as the result is based on models, the term “projected” should be used.

The final paragraph states that it is virtually certain that the land surface will continue to warm more than the ocean surface, and that the Arctic will continue to warm more than global surface temperature. It quantifies the rate of warming with associated confidence levels.

**B.2.2:** This paragraph relates to clearly discernible **increases in the intensity and frequency of hot extremes and occurrence of extreme events** with every additional 0.5°C of global warming, even at 1.5°C warming. SAINT KITTS AND NEVIS, BELIZE, and numerous others underscored changes can be detected at much smaller increments and that “every fraction” of warming matters. The US suggested replacing 0.5°C with “steps” and specifying “some” extreme events. The authors clarified that the reference to

0.5°C is meant not as a threshold, but as an illustration that even half a degree in global warming will have a clearly discernible increase in the listed extremes. SAUDI ARABIA said “clearly discernible” does not add scientific or quantifiable information and INDIA suggested replacing “discernible” with “detectable.” The authors clarified that “discernible” here means there are substantial changes supported by observations, attribution, and models, and that this is the appropriate term here. FRANCE requested clarifying “probability” of heat waves, precipitation, and drought. CHILE, with TRINIDAD AND TOBAGO, requested mentioning “every kind of drought” rather than only “agricultural and ecological droughts.” The US asked what indices are used in measuring agricultural and ecological droughts. INDIA requested adding examples of unprecedented extremes and asked what will be manifested when 2°C or 3°C is reached.

In a sentence on the projected percentage changes in frequency being higher for rarer events, CHINA and SAUDI ARABIA asked if “rarer” events mean “low probability.” SAUDI ARABIA asked what line of evidence these changes are based on and to which scenarios they apply. MEXICO requested adding “rarer events” to the glossary. The authors emphasized that different levels of confidence apply to different extreme events, and changes in rarer events are less frequent but more extreme.

NORWAY, supported by BELGIUM and others, suggested reflecting the idea of a continuation of the effects of global warming in this paragraph, similar to what was reflected in B.2.1.

KENYA, supported by TANZANIA, TRINIDAD AND TOBAGO, SAUDI ARABIA and others, requested including reference to other types of droughts, specifically meteorological droughts. BOTSWANA noted that agricultural and ecological droughts result from meteorological droughts. The authors noted this paragraph is specific to changes with very small increments of global warming, and that there is less evidence and literature about this on hydrological droughts. Regarding meteorological droughts, he said changes go both ways, both increasing and decreasing, depending on the region. TRINIDAD AND TOBAGO nevertheless encouraged inclusion of the reference to these other types of droughts in this paragraph, noting that low confidence does not negate the need to include critical information. The final approved paragraph states that with every additional increment of global warming, changes in extremes continue to become larger. It then gives examples of changes caused by every additional 0.5°C of global warming. It outlines changes in intensity and frequency of, *inter alia*, agricultural, ecological, hydrological, and meteorological droughts.

**B.2.3:** On a paragraph giving examples of **projected regional differences in hot and cold day temperature increase**, SAUDI ARABIA asked what scenarios and lines of evidence are associated with this projection, and requested quantification of the rate of global warming. INDIA requested referencing warming in major ocean basins. FRANCE and NORWAY called for quantification of marine heatwaves. TRINIDAD AND TOBAGO requested general reference to “marine-related extremes.” The paragraph was approved with minor amendments.

**B.2.4:** On this paragraph, which relates to **intensity increase of heavy precipitation events, intense tropical cyclones, and agricultural and ecological droughts**, delegates requested: specifying what category of tropical cyclones is being referred to; providing quantitative information for the statements; including

information on increasing or extreme rainfall; and including the tropical cyclones information in the subsection’s Headline Statement. The authors proposed noting that more regions are affected by increases in “hydrological droughts (medium confidence)” in the sentence on agricultural and ecological drought, and adding a sentence stating that “changes in meteorological drought also increase with increasing global warming, with more regions affected by increases than decreases (medium confidence).” The authors noted meteorological drought is one of the drivers of agricultural and ecological drought, but is not directly related to impacts and was therefore not assessed in more detail as the focus was on the climatic impact-drivers (CIDs) with the most impacts. A lengthy debate ensued over why meteorological drought is singled out in a separate sentence, with several African countries and small island developing states (SIDS), supported by others, underscoring significant impacts from meteorological drought in their countries. They emphasized water scarcity, energy shortages, and impacts on the tourism sector, highlighting links between meteorological drought and sustainable development. Underscoring the policy relevance of meteorological drought for SIDS, TRINIDAD AND TOBAGO urged their inclusion in both B.2.2 and B.2.4. In the approved paragraph, the category of tropical cyclones is specified and there is no reference to any type of drought.

**B.2.5:** On this paragraph, which deals with **permafrost thawing, and loss of seasonal snow cover, land ice, and Arctic sea ice**, several delegates called for more quantitative information relating to levels of warming and their effect on permafrost, as well as clarification on “more frequent occurrences for higher warming levels.” Delegates also proposed including information on seasonal soil frost and timing of additional warming. CANADA sought clarification on “sea ice area” in a footnote on September monthly average sea ice area in the Arctic, rather than the more commonly used “sea ice extent.” The authors explained that “sea ice area” is a more useful description and its use is supported by the literature. CLIMATE ACTION NETWORK (CAN) INTERNATIONAL, supported by FWCC, proposed clarifying the effects of permafrost thawing by specifying that it increases the release of CO<sub>2</sub> and methane, which then increases warming. The final paragraph replaces the reference to “all assessed SSP scenarios” to “five illustrative scenarios considered in this report” and the footnote clarifies that the term “ice free” in a monthly average sea ice area of less than 1 million km<sup>2</sup> means “about 10% of the average September sea ice area observed in 1979-1988.”

**Figure SPM.5:** This figure illustrates that **changes in regional mean temperature, precipitation, and soil moisture** get larger with increasing global warming. SAUDI ARABIA, opposed by NORWAY, suggested adding quantitative information to the title. On panel (b), which shows annual mean temperature change relative to 1850-1900, BELGIUM requested noting that temperature changes in the Arctic region may be higher than 7°C, which is the highest scale shown in the figure. Noting that panel (c), on annual mean precipitation change relative to 1850-1900, says precipitation increases over high latitudes, tropical oceans, and parts of the monsoon regions but decreases over parts of the subtropics, TRINIDAD AND TOBAGO requested clarifying the definition of tropical oceans and the subtropics. The authors noted that the Atlas deals with many of the requested suggestions.

INDIA objected to references to the Interactive Atlas, questioning its role and position. The authors noted that the information on

precipitation and temperature changes at global warming levels are in Figures 4.31 and 4.32 of Section 4.6 of the underlying report, and the figure can reference these instead of referencing the Interactive Atlas. Responding to INDIA, Masson-Delmotte said the Atlas provides no new information but builds on the underlying report. Several countries supported keeping reference to the Atlas in the caption. SAUDI ARABIA questioned whether it reflects the SPM. Masson-Delmotte said it reflects the unchanged data sets used in AR6 and was part of the review process.

The IPCC Legal Officer clarified that one of the outcomes of the IPCC Expert Meeting on Assessing Climate Information for Regions, held in May 2018, was the decision to develop a WG I interactive atlas that would include maps, narrative, and assessment support tools, among others, with the aim of enabling traceability of underlying data. She said it was also one of the cross-cutting issues discussed at the AR6 Scoping Meeting held in 2017, and the interactive component is a tool to show the data assessed in the report.

INDIA noted that this is a description of the process by which the Interactive Atlas came to be part of the report, but does not speak to the status of the Atlas once it has been passed. Not wishing to hold up progress at this point, he reserved the right to return to the issue. After further discussion, delegates agreed to the authors' suggestion and Figure SPM.5 was approved.

**Figure SPM.6:** This figure illustrates that **projected changes in extremes are larger in frequency and intensity with every additional increment of global warming.** SAUDI ARABIA called for specifying the increments and adding confidence levels throughout the figure, with the authors highlighting the figure presents the spread of projections. FRANCE called for rewording references to a climate "without human influence," suggesting reference to 1850-1900, and asked why changes in 50-year events were only shown for hot temperature, not heavy precipitation and droughts as well. The authors indicated this was done for concision.

Regarding the panel on agricultural and ecological droughts in drying regions, TRINIDAD AND TOBAGO requested reference to changes in "droughts" in drying regions more generally, if the data permits, or inclusion of information on meteorological droughts.

TANZANIA, with KENYA and TRINIDAD AND TOBAGO, noted that Chapter 11 in the underlying report often refers to "drought," including meteorological drought and has information on meteorological drought at different warming levels and its increasing frequency in Africa. The authors said assessment was specifically on agricultural and ecological drought. Kenya requested explanation in the caption on why meteorological and hydrological droughts are not included. Kenya stressed Chapters 11 and 12 mention "precipitation deficits," and urged their inclusion even if minimal literature exists. The authors noted that generic information on all types of drought cannot be provided in the figure because different droughts react differently to global warming, but offered line of sight to material on other types of drought. They noted agricultural and ecological drought are related to meteorological drought but are worse in warmer climates and because of evapotranspiration.

The approved figure clarifies that projected changes are shown at global warming levels relative to 1850-1900, representing a climate without human influence. It also provides a line of sight to Chapter 11 for assessments on projected changes in meteorological and hydrological droughts.

**B.3:** This subsection deals with the **impacts of global warming on the global water cycle.**

On the Headline Statement, which states that further global warming is projected to intensify the global water cycle, SAUDI ARABIA requested quantifying "intensify" and "further global warming." THE GAMBIA requested information on impacts on regional precipitation, particularly the Sahel, with authors pointing to details on this in the subsection's paragraphs. The authors suggested specifying that "continued" global warming is projected to "further" intensify the global water cycle. Reference to "global monsoon precipitation" was also added to the Statement. With these changes, the Headline Statement was approved.

**B.3.1:** This paragraph addresses the **intensification of the global water cycle with rising global temperatures.** TRINIDAD AND TOBAGO requested clarifying reference to "tropical oceans" in a statement that precipitation is projected to increase over high latitudes and the "tropical oceans." SAUDI ARABIA again urged inclusion of all scenarios, noting all scenarios are investigated in Chapter 8 of the underlying report. The final approved paragraph contains the projected increase in average annual global land precipitation for all five emissions scenarios, and also clarifies that precipitation is projected to increase over high latitudes, the equatorial Pacific and parts of the monsoon regions, but decrease over parts of the subtropics and limited areas in the tropics.

**B.3.2.** This paragraph addresses the **intensification of very wet and very dry weather events and seasons.** SAUDI ARABIA favored "projected" over "future" changes and requested quantifying an "amplified" El Niño. In response to INDIA, authors agreed to refer to likely change in large-scale westerly winds in connection with monsoons. The paragraph was approved with these changes.

**B.3.3:** On this paragraph dealing with **increase in monsoon precipitation and delay in the monsoon season,** delegates requested more specificity regarding the onset and retreat of monsoon precipitation, as well as information on any duration changes. The approved paragraph clarified that North and South America and West Africa are projected to experience a delayed onset, and West Africa is also projected to experience a delayed retreat in the monsoon season.

**B.3.4:** On this paragraph on a projected southward shift and intensification of Southern Hemisphere summer mid-latitude storm tracks and associated precipitation, the RUSSIAN FEDERATION requested inclusion of the North Atlantic storm tracks, with appropriate confidence statements. The authors clarified there is low confidence regarding changes in the North Atlantic, hence its exclusion. FRANCE requested noting this point in the paragraph. The paragraph was approved with this addition.

**B.4:** This subsection addresses **ocean and land carbon sinks.** The Headline Statement was approved without amendment. With regard to the subsection as a whole, INDIA questioned the use of new terminology such as "core scenarios." JAPAN called for clarification regarding whether land sinks or only natural sinks are counted towards anthropogenic emission removals, noting apparent inconsistency in how this issue is addressed. IRELAND, opposed by SAUDI ARABIA, proposed replacing emissions "removed" by land and ocean sinks with "taken up."

**B.4.1:** Regarding a paragraph on **land and ocean CO2 sinks under high emissions scenarios,** SWEDEN, supported by KENYA and the EUROPEAN UNION (EU), said the main point of this paragraph is the weakening of sinks, and called for clearer



language expressing this point. They suggested wording to the effect that while land and ocean CO<sub>2</sub> sinks will take up, in absolute terms, a larger amount of CO<sub>2</sub> under high, compared to low, CO<sub>2</sub> emissions scenarios, they will become less effective. FRANCE and SWITZERLAND, supported by SAUDI ARABIA and opposed by the NETHERLANDS, called for quantitative information about the change in the proportion of emissions that will be released into the atmosphere. Co-Chair Masson-Delmotte clarified that information about historical removals by sinks is contained in paragraph A.1.1.

SAUDI ARABIA said the text should specify whether the data relied on is observational or projection data, and should also include the uncertainty of the magnitude of the effect of direct CO<sub>2</sub> on land and carbon uptake. Co-Chair Masson-Delmotte clarified that this paragraph is about future emissions and is supported by projections.

Regarding language that land and ocean CO<sub>2</sub> sinks “will take up” a larger amount of CO<sub>2</sub>, the US asked if this is based on models or observational data. Supported by INDIA, he said if based on models, “will take up” should be replaced with “projected to take up.”

Several countries called for clarification as to which processes are included in this paragraph, whether physical, biological, chemical, or all of them. The EU called for a clearer definition of sinks in the context of this paragraph, asking whether it refers to the natural ability of ocean and land to absorb CO<sub>2</sub>, with human interventions such as afforestation being addressed elsewhere. The authors clarified that this paragraph covers natural sinks and excludes land use, and also that all processes—physical, biological, and chemical—are included. The final approved paragraph refers to “natural” land and ocean carbon sinks, notes that these sinks are “projected to take up” instead of “will take up,” and also clarifies the point about the weakening of sinks.

**B.4.2:** Regarding a paragraph on **CO<sub>2</sub> taken up by land and ocean sinks under different emissions scenarios**, several countries reiterated their call for referring to very high, high, medium, low, or very low emissions scenarios throughout the SPM instead of the less descriptive SSP numbers. Some countries also called for better clarifying that the statement is based on model projections, not observations, which was implemented. Other comments related to: adding a confidence level to the statement on land and ocean sinks turning into a weak source by 2100 under the lower emissions scenarios; noting regional variation in source-sink dynamics; clarifying that the paragraph refers to “direct” land use; and referring to emissions being “taken up” rather than “removed.” The approved paragraph refers to the rates of CO<sub>2</sub> “taken up” by land and oceans and clarifies the different emissions scenarios considered together with confidence levels.

**B.4.3.** This paragraph addresses **feedback effects between climate change and the carbon cycle and possible additional ecosystem responses to warming**. SAUDI ARABIA called for referring to GHGs rather than CO<sub>2</sub> and for either providing the full list of GHGs or none at all. The authors explained that this sentence deals with the carbon cycle feedback and therefore specifically relates to CO<sub>2</sub>. The US and GERMANY requested contextual information on specific ecosystems, or events such as wildfires, not included in all the models. The authors said everything cannot be included in a concise SPM. In response to the US, Masson-Delmotte confirmed that the simulations used carbon cycle models in response to emissions. The authors said this paragraph compares emissions-driven concentrations to be able to compare ocean and other areas, as per Technical Summary Box 5. IRELAND, with GERMANY,

suggested specifying that “increased” CO<sub>2</sub> and methane emissions from wetlands and permafrost thaw could further increase “their” GHG concentrations.

The approved paragraph includes a reference to wildfires in relation to additional ecosystem responses to warming not yet fully included in climate models; and also clarifies that it is the “magnitude” of feedbacks between climate change and the carbon cycle that become larger and more uncertain.

**Figure SPM.7:** Regarding a figure on **anthropogenic CO<sub>2</sub> emissions taken up by land and ocean sinks from 1850 to 2100 under the five core emissions scenarios**, INDIA, supported by SAUDI ARABIA, objected to the reference to “core scenarios,” stating that this language is policy prescriptive and not in line with other parts of the SPM. Throughout the SPM, reference to the “core” scenarios was changed to “illustrative” scenarios.

SAINT LUCIA, supported by BELGIUM, called for reinstating historical information relating to the period from 1850-2015, which was contained in previous versions of the figure. The UK, supported by LUXEMBOURG, BELGIUM, and IRELAND, but opposed by INDIA, said the 2015-2100 period should also be discussed. The authors clarified that they decided to include the period from 1850-2100 because future sinks depend on past emissions, and it is thereby important to consider the entire time period. They pointed out that historical emissions are included in paragraph A.1.1. After further discussions, historical information relating to the amount and share of CO<sub>2</sub> emissions taken up by land and ocean sinks during the historical period (1850-2019) was included.

Regarding references to land-use change, ARGENTINA requested addition of the word “direct” to clarify that the figure relates to direct land-use change only.

SAUDI ARABIA objected to the reference to anthropogenic sources of emissions such as fossil fuel emissions, stating that this is beyond the mandate of WG I, which is required to consider emissions only and not sources. She said the figure should also clarify the type and source of data, whether observational or projected. Co-Chair Masson-Delmotte clarified that both the approved outline for Chapter 5, as well as the WG I AR5 report, contain information on sources, where relevant. The approved caption excludes reference to anthropogenic CO<sub>2</sub> emissions sources such as fossil fuels, and instead states that the overall anthropogenic carbon emissions are calculated by adding the net global land-use emissions from the CMIP6 scenario database to the other sectoral emissions calculated from climate model runs with prescribed CO<sub>2</sub> concentrations. In addition, it clarifies that land and ocean carbon sinks respond to past, current, and future emissions, therefore cumulative sinks from 1850-2100 are presented here.

**B.5:** This subsection addresses **irreversible long-term changes due to past and future GHG emissions**. Commenting on the Headline Statement, LUXEMBOURG queried differences between “irreversible” and “unavoidable,” stressing humans can still influence impacts. The NETHERLANDS, LUXEMBOURG, and BHUTAN requested specifying “slow onset” processes, noting irreversibility can include staying at a certain level. SAUDI ARABIA requested differentiation between past and future emissions and quantitative impacts of each, and reference to climate factors, uncertainty, and historic climate transition periods. GERMANY, supported by several countries and opposed by INDIA and SAUDI ARABIA, requested mentioning tipping points. The authors said such reference would not reflect the paragraphs in B.5

nor the underlying report. The Headline Statement was approved without amendment.

Commenting on the subsection in general, SWITZERLAND and MEXICO asked to distinguish warming from past GHG emissions accumulation from projections for future emissions. SWITZERLAND asked how 2100 would look if everyone stopped emissions immediately. The authors said this section discusses other changes to the climate system, not future warming. In response to BHUTAN, authors said mountain glacier changes are omitted because they are reversible over decades. CAN INTERNATIONAL requested information on the paleological evidence of impacts of high CO<sub>2</sub> levels and warming on sea level rise.

**B.5.1:** This paragraph addresses **unavoidable changes in the ocean**, namely in terms of warming, stratification, acidification, and deoxygenation. The US suggested deleting “unavoidable,” as changes depend on unknown future radiation balance.

The REPUBLIC OF KOREA, with China, requested specifying “upper” ocean stratification. He asked why only warming in the “deep” ocean is mentioned, with the authors indicating it has a slower circulation timescale. Responding to SAUDI ARABIA, authors said confidence is high for deoxygenation but medium on the rate.

On why SSP 1-1.9 is omitted from the statement on projected future ocean warming, the authors pointed to lack of literature. SAUDI ARABIA asked why future projected changes are compared to 1971-2018, with CHINA querying their uncertainty and confidence level. The EU asked whether the changes are being compared to absolute increase or rate of change between 1971-2018. The authors again pointed to literature availability.

In addition, the reference to past GHG emissions leading to “unavoidable” future warming of the global, deep ocean was replaced with stating that past GHG emissions since 1750 have committed the global ocean to future warming. The paragraph was approved with these amendments and CHINA’s specification of “upper” ocean stratification continuing in the 21st century.

**B.5.2:** On the sentence stating with very high confidence that **glaciers are projected to continue to melt for several decades or more** even if global temperature is stabilized, CHILE, supported by BHUTAN, TANZANIA, and PERU, requested specifying “mountain and polar glaciers” instead of “glaciers.” BHUTAN requested clarifying melting of glaciers globally or only of mountain glaciers, noting different dynamics for glaciers depending on the region.

SWITZERLAND, supported by GERMANY and LUXEMBOURG, proposed inclusion of permafrost in the paragraph. GERMANY, noting that the irreversible and abrupt events referred to are also called “tipping points,” requested, with LUXEMBOURG, inclusion of that term in the paragraph.

Delegates also requested: inclusion of quantitative information; clarification of “several decades”; and information about which scenarios projections are based on; and clarification about the level of confidence for continued ice loss.

The authors clarified that: permafrost is not mentioned because physical changes in permafrost are reversible on short timescales; projected changes are independent of any future scenarios as glaciers will continue to melt even if global temperature is stabilized; “glaciers” refers to all land ice masses outside of the big ice sheets; and “tipping points” is a technical term that would require a complicated explanation in the SPM and is excluded for brevity,

and “irreversible change” is used instead as it is an easier concept to grasp.

There was continuing discussion on including reference to tipping points. The authors suggested mentioning “potentially involving tipping points” in the context of “outcomes resulting from ice sheet instability processes” and then defining a tipping point in the footnote. INDIA said “potentially involving tipping points” is speculative and did not support its inclusion. The authors proposed referencing “in some cases involving tipping points.” They gave the examples of the west and east Antarctic, which are considered to be tipping elements, and noted SR1.5 assessed that the threshold for west Antarctic Ice Sheet instability may be close to 1.5-2°C with medium confidence and in that case, only RCP2.6 led to long-term projections of less than 1 meter sea level rise. They stressed that this is the kind of tipping point consideration that is worth including. INDIA objected to a reference to “low-likelihood, high-impact outcomes” that would strongly increase ice loss from the Antarctic Ice Sheet for centuries under high GHG emissions scenarios, saying impacts are WG II’s purview and these events are speculative. Co-Chair Masson-Delmotte explained this term was used in the IPCC Special Report on “Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation” and is used in the literature, including IPCC literature, on risk assessment and reduction. Many other countries supported the text. The US said they are physical processes that can be modeled and for which there may be past evidence, so the question is not whether they can happen but how likely. The approved paragraph includes reference to mountain and polar glaciers, permafrost thaw, and tipping points, as suggested by delegates.

**B.5.3:** This paragraph addresses **projected sea level rise across scenarios over the 21st century**. EGYPT queried why this paragraph does not reference human activity, noting figure SPM.8 is about “human activity and its impact on climate systems especially regarding future centuries.” SAINT KITTS AND NEVIS called for including quantitative information. CHINA proposed using 1900 values as a reference as in figure SPM.8, instead of 1995-2014. Sweden called for including projections for 2100 in addition to the 2150 projection already included.

Pointing to the statement that it is virtually certain that global mean sea level will continue to rise over the 21st century, GERMANY requested a statement of fact here instead. Several delegates called for confidence levels to be added and for including all scenarios, not just SSP1-1.9 and SSP5-8.5. The authors explained that, consistent with usual practice, only the most extreme scenarios were included, for the sake of precision. Regarding adding confidence language, they noted that “deep uncertainty” is assessment language. This paragraph was approved with inclusion of all the emissions scenarios, as well as other minor amendments that provide additional clarity.

**B.5.4:** This paragraph focuses on **sea level rise beyond 2100**. Underscoring that sea level rise impacts will be severe even at 1.5°C of warming, TRINIDAD AND TOBAGO, supported by the US, called for adding the qualifier “medium agreement, limited evidence” to the statement that global mean sea level is projected to rise by about 2 to 6 meters if warming is limited to 2°C, as is indicated in Chapter 9 of the underlying assessment, to better differentiate it from the subsequent low confidence statement. Pointing to the statement that, with 5°C of warming, sea level is projected to rise about 19 to 22 meters and continue to rise over

subsequent millennia, INDIA and SAUDI ARABIA questioned the relevance of including low confidence statements in the SPM. GERMANY underscored the importance of such policy-relevant information. The authors highlighted the low confidence statement provides needed context to B.5.3 and is of particular importance to some countries. This paragraph was approved with amendments to aid clarity.

**Figure SPM.8:** This figure visualizes **changes in several indicators of global change**, namely global surface temperature, September Arctic sea ice area, global ocean surface pH, global mean sea level change relative to 1900, and global mean sea level change in 2300. FRANCE suggested adding information on spring snow cover in the Northern Hemisphere. SWITZERLAND suggested adding information on atmospheric concentrations of the three well-mixed GHGs (CO<sub>2</sub>, methane, and nitrous oxide). The US queried whether observational constraints were used across all panels. The UK asked why historical observations were not included.

With regard to the first panel, on sea level rise, SAINT LUCIA, opposed by INDIA, called for retaining the information on the low-likelihood, high impact storyline under SSP 8.5. Noting low confidence in the trajectory, CANADA suggested removing it and instead indicating the range across scenarios in 2100, and, with DENMARK, requested reference to an “outcome” rather than a “storyline.” The US queried whether paleoclimatic evidence was considered in the projections. JAPAN and DENMARK called for including best estimates for the projections on global mean sea level change in 2300, which the authors said are not available.

The authors noted historical observations were not included because the aim is to illustrate that human activities affect all climate system components, with some responding over decades and others over centuries, and observations are not available for all variables, such as pH. They indicated the panels on September Arctic sea ice area and global ocean surface pH are based only on projections, with the others involving multiple lines of evidence. The visual display and caption were approved without change. The figure’s headline was approved after “core” was changed to refer to the five “illustrative” scenarios used in the report.

### C. Climate Information for Risk Assessment and Regional Adaptation

**C.1:** When this subsection on the **role of natural drivers and internal variability in modulating human-caused changes** was first taken up in plenary for general comments, the RUSSIAN FEDERATION requested clarification of the relevant time scales, whether inter-annual, decadal, or otherwise. The Headline Statement on natural drivers and internal variability modulating human-caused changes, especially at regional scales and in the near term, with little effect on centennial global warming, was approved without amendment.

**C.1.1:** This paragraph deals with **decadal variability enhancing or masking underlying human-caused long-term changes**. Noting the paragraph states that internal decadal variability and variations in solar and volcanic drivers partially masked human-caused surface global warming during 1998-2012, BELGIUM requested specifying that even during this period, there were still extreme events on land, as outlined in Cross-Chapter Box 3.1. SAUDI ARABIA queried why 1998-2012 is the only time period indicated in the paragraph, and called for more quantitative information throughout the paragraph. The authors clarified that 1998-2012 is used because it is the time period assessed in AR5. The paragraph was approved, amended to

note the continued rise of hot extremes over land during the 1998-2012 period.

**C.1.2:** This paragraph addresses **projected changes in mean climate and CIDs amplified or attenuated by internal variability**. Pointing to a list of CIDs specified in a footnote, Botswana queried the exclusion of severe thunderstorms, and the authors clarified these are dealt with as an element of the wind CID. INDIA requested adding the Indian Ocean Dipole to the main internal variability phenomena listed in a second footnote. The authors explained that the phenomena included in this footnote are the ones with the greatest impact at decadal and multi-decadal timescales, and others are included in the underlying report. Other delegates suggested rephrasing the paragraph to clarify issues like “amplified or attenuated,” and the definition of CIDs. The paragraph was approved with minor changes in the footnote on CIDs and the line of sight, such as referencing relevant Atlas chapters.

**C.1.3:** This paragraph addresses the **role of internal variability and uncertainty in forcings from natural and anthropogenic aerosols on precipitation changes**. GERMANY asked why a statement on water cycle changes in the previous SPM draft was deleted. The authors indicated it was moved to B.3, which is entirely dedicated to the global water cycle. The UK asked how internal variability affects patterns of change, noting amplification or attenuation might change at different time scales. The authors noted variability is mainly inter-annual and decadal. Responding to the US on why the paragraph specifically refers to monsoon, the authors indicated monsoons are very fitting, as they have large internal variability and large modulation. The authors further indicated the near term is defined as 20 years from 2021. The paragraph was approved, referring to “decadal-to-multi-decadal” rather than “multi-decadal” mean precipitation changes.

**C.1.4:** This paragraph addresses the **likelihood for a large explosive volcano eruption to occur during the 21st century and the effects it would have**. The RUSSIAN FEDERATION suggested specifying that the paragraph not only builds on paleoclimatic but also historical evidence, which the authors confirmed. JAPAN and INDONESIA requested specifying the meaning of “large” eruption, with JAPAN pointing to the Volcanic Explosivity Index. The RUSSIAN FEDERATION, JAPAN, and INDONESIA called for stating that such an explosion “may” happen, not “will.” SWEDEN, noting the paragraph specifies near-term and long-term impacts, requested information on medium-term impacts. In answer to the US, authors clarified that near-term alteration of the monsoon circulation relates to the global monsoon system. The paragraph was amended to refer not only to paleoclimatic but also “historical evidence” informing the assessment of the likelihood that at least one large explosive volcanic eruption “would” occur during the 21st century, with a footnote specifying the average frequency and magnitude of large eruptions. With other minor edits to the role of such an eruption in temporarily and partially masking human-caused climate change, the paragraph was approved.

**C.2:** This subsection addresses **projected changes in CIDs at the regional level, differentiating between 2°C and 1.5° global warming**. Regarding the Headline Statement on further global warming projected to increase concurrent and multiple changes in CIDs in every region, with more widespread changes at 2°C and above compared to 1.5°C warming, TANZANIA queried the baseline for “further global warming.” GERMANY queried the difference between “widespread” changes in several CIDs at 2°C



versus 1.5°C. The authors explained that it means more CIDs would become evident in more regions at higher global warming levels. They said the effect of higher global warming on changes in CID magnitude has not been fully assessed, and since this Headline Statement is a statement of fact, it cannot include reference to magnitude. Co-Chair Masson-Delmotte noted more quantitative information is shown in Figure SPM.9.

SAUDI ARABIA opposed the reference to “2°C and above” and requested an upper range. After authors and Co-Chair Masson-Delmotte indicated the underlying assessment contains references to changes in CIDs at different warming levels, such as from 3-5°C but also up to 6.9°C, the Headline Statement was approved, noting that changes in CIDs would be even more widespread and/or pronounced for higher warming levels.

Commenting on the subsection as a whole, INDIA questioned why the subsection only focuses on 1.5°C and 2°C scenarios, calling for clarifying the significance of the difference between these thresholds and noting that current emissions rates place the world above 2°C in the future. He requested more quantitative information in the subsection’s paragraphs, questioning why confidence levels seem higher in the SPM than warranted by the underlying report. The authors pointed to two footnotes summarizing the regional breakdown and the confidence levels when the confidence level is not the same in all regions, noting more details are provided in the Technical Summary and underlying report. They clarified that not all CIDs are affecting all regions, noting the CID framework serves to lay the groundwork for the risk assessment in WG II.

**C.2.1:** This paragraph relates to **projected changes in CIDs, with changes, such as more frequent exceedance of extreme heat thresholds, being larger at 2°C than at 1.5°C, and affecting all regions.** Co-Chair Masson-Delmotte noted it was challenging to identify which findings to highlight in the SPM, pointing to the larger amount of literature covered in AR6 than in AR5, especially with regard to balancing specificity and generality. GERMANY queried the reference to “all” regions projected to experience further increases in hot CIDs and decreases in cold CIDs, and asked whether both intensity and frequency of extreme heat thresholds increase at higher temperatures. Responding to a question from TANZANIA, the authors said “exceeding extreme heat thresholds more frequently” means that the threshold is exceeded on more days per year. INDIA sought clarification on what changes and what does not at the two levels of global warming. An author said all the changes observed in a region are larger at 2°C than at 1.5°C warming. Responding to CHILE, the authors explained that loss of sea ice in the Antarctic is not mentioned because there is only low confidence about overall trends regarding sea ice in the Antarctic. The paragraph was approved with minor editorial changes and additions to the line of sight.

**C.2.2:** This paragraph relates to **projected changes in heavy precipitation and associated flooding and in different types of droughts at 1.5°C global warming.** SAINT KITTS AND NEVIS, supported by TRINIDAD AND TOBAGO, lamented the continuing imbalance in regions represented in available regional assessments, and called for adding information on the Caribbean and Pacific islands. TRINIDAD AND TOBAGO and JAMAICA noted that paragraph C.2.3 on changes at 2°C warming includes information on the Caribbean region, querying the rationale for including it in one but not the other. TANZANIA, supported by BOTSWANA, reiterated his request to include messages on meteorological

droughts somewhere in the SPM. Pointing to Chapter 12 of the underlying report, the authors explained that this paragraph considers agricultural and ecological droughts because they are more directly related to impacts across sectors. INDIA asked what “intensify” means given multiple time scales and reference periods and, noting the line of sight refers to several Atlas chapters, whether the Atlas would be discussed. Co-Chair Masson-Delmotte said the Atlas chapters have already been subject to review. The authors said all changes mentioned in the paragraph refer to a present-day baseline unless specified otherwise. The paragraph was approved with the addition of a reference to increases in meteorological droughts projected in a few regions.

**C.2.3:** This paragraph addresses **projected changes in heavy precipitation and associated flooding as well as different types of droughts at 2°C warming and above.** TANZANIA, supported by KENYA, CHILE, and ALGERIA, called for including reference to meteorological and hydrological droughts in this paragraph, in addition to the agricultural and ecological droughts already referenced. The authors explained that meteorological droughts are not referenced because they are not connected to the substance of the paragraph and hydrological droughts are not included because of limited evidence. SWITZERLAND, supported by EGYPT, noted that the consequences of a temperature increase are already being experienced and suggested stating that a temperature increase will cause these consequences “to continue.” SAUDI ARABIA called for deleting the reference to 2°C “and above.” Masson-Delmotte noted that: governments had requested its addition in their final review; the authors confirmed the phrase reflects their assessment and the evidence; and SAUDI ARABIA had agreed to that language in the contact group. SAUDI ARABIA agreed, asking that use of that phrase be clarified in the future. The paragraph was approved with editorial changes aimed at increasing its clarity as a stand-alone message, additional information on hydrological and meteorological droughts, and additions to the line of sight.

**C.2.4:** This paragraph relates to **changes in different types of CIDs.** CHINA said the first sentence, which states that “changes in more CIDs across more regions are projected at 2°C and above compared to 1.5°C global warming,” is difficult to understand and suggested using language from paragraph C.2.3. The authors said the sentence is structured this way because the focus is on the notion of “more CIDs in more regions” being projected to change at 2°C and above compared to 1.5°C. SWITZERLAND asked if the sentence on “low confidence in potential future changes in other CIDs” relates to changes consistent or inconsistent with global warming. The authors said the low confidence relates to insufficient evidence. The US suggested referring to tropical cyclones “and/or” extratropical storms, instead of just “or,” noting some regions experience both. The paragraph was approved, with the first sentence restructured to: improve clarity, capture the US suggestion, and specify low confidence “in most regions” with regard to potential future changes in some other CIDs.

**C.2.5:** This paragraph relates to **projected sea level rise and associated extreme events.** To improve readability, KENYA suggested beginning the first sentence by noting that it is “very likely” to “virtually certain” that regional mean relative sea level rise will continue throughout the 21st century. INDIA requested adding information on which regions currently show accelerated sea level rise, with authors clarifying the paragraph focuses on future projections and said the issue of acceleration in sea level rise is

addressed from a global perspective elsewhere in the report. SAINT LUCIA suggested clarifying that the rate of sea level rise varies across emissions scenarios and called for including information on this from the underlying assessment. Co-Chair Masson-Delmotte noted that global mean sea level rise projections are addressed in B.5.3. The paragraph was approved with some editorial changes and an addition to the line of sight.

**C.2.6:** This paragraph addresses the **interplay between urbanization and climate change on the climate of cities**. The REPUBLIC OF KOREA expressed confusion over reference to frequency in relation to extreme sea levels and suggested referring to extreme sea level events for consistency with paragraph C.2.5 and the SROCC. TANZANIA highlighted that effects differ depending on the form of urban development. BRAZIL called for differentiating between cities in developed and developing countries, pointing to differences in infrastructure and adaptation capacity. Co-Chair Masson-Delmotte and the authors underscored the paragraph is grounded in physical science aspects, for example relating to the form of cities, water fluxes, and wind patterns, and noted the adaptation dimension is captured by WG II.

INDIA, with SWITZERLAND and BRAZIL, requested a footnote defining “urbanization.” Masson-Delmotte noted the dictionary definition of “urbanization” as “the process by which towns and cities are formed.” The authors added it is the transformation of a natural area into an urban area. Delegates agreed to Masson-Delmotte’s suggestion to add it to the glossary and the paragraph was approved, referring to “urbanization” instead of “urban development” throughout.

**C.2.7:** Regarding a paragraph on **projected increases in the probability of compound events**, the US noted the underlying report shows many impacts are relevant for tropical forest regions and coastal cities, asking for this to be captured in the paragraph. INDIA asked to mention thunderstorms and lightning, in addition to heatwaves and droughts. FWCC welcomed the comparison between 2°C and 1.5°C and called for further clarifying impacts at 3°C and above, noting this would be an “important reality check of where we are currently heading.” The authors explained that the rationale for referring specifically to heatwaves and droughts, and to crop-producing areas, lies in the linkages between them. The paragraph was approved with minor editorial changes and an addition to the line of sight.

**Figure SPM.9:** This figure presents a synthesis of the number of AR6 WG I reference **regions where CIDs are projected to change**. The US suggested specifying that all regions are “projected to” experience changes in at least five CIDs, instead of “will,” and specifying this is the case “at 2°C warming.” LUXEMBOURG requested adjusting the visualization so that the upper end of scales on the number of regions aligns with the maximum number of land and ocean regions considered. CANADA called for specifying the number of regions for which each CID is applicable, noting that for instance, only some regions have snow glaciers. The REPUBLIC OF KOREA and the US requested clarifying whether changes relate to increases in frequency, intensity, or duration, noting this is not evident for all CIDs. The NETHERLANDS, SPAIN, and MEXICO called for presenting information in a more region-specific manner to increase policy relevance. Other comments related to: reinstating a map showing the regions that are considered in the figure; including meteorological droughts; and referring to coastal and “open ocean” CIDs, instead of “oceanic.” The US asked what

type of assessment was conducted for agricultural and ecological droughts, noting some indices are highly dependent on temperature. The authors noted they did not use any metric based on temperature, primarily relying on soil moisture. The figure was approved, with revisions including the addition of an “envelope” representing the maximum number of regions for which a CID is relevant.

**C.3:** This subsection addresses **low-likelihood outcomes**. On the Headline Statement on low-likelihood outcomes being impossible to rule out and being part of risk assessment, INDIA objected to such speculative language. SAUDI ARABIA said the uncertainty was unhelpful. DENMARK, supported by NORWAY, LUXEMBOURG, GERMANY, SAINT KITTS AND NEVIS, MEXICO, FRANCE, and SPAIN, underscored that low-likelihood high-impact events are highly policy-relevant. Several countries requested specifying “tipping points,” and DENMARK, LUXEMBOURG, and the UK requested further examples, such as Amazon diebacks. JAPAN preferred “risk to be considered” or “risk” over “risk assessment.” GERMANY and the US requested adding naturally-caused high-impact events to the Headline Statement as it appears in C.3.5. The Headline Statement was approved with an addition to the line of sight.

**C.3.1:** This paragraph relates to **high-warming outcomes**. Noting that “regional precipitation” is the only CID specified in the paragraph, SPAIN asked whether it is the most important one. Regarding a sentence on CIDs exceeding their assessed very likely ranges if global warming exceeds the very likely range for a given GHG emissions scenario, with potentially very large impacts and high risks for human and ecological systems, GERMANY and INDIA queried “very large impacts.” INDIA and SAUDI ARABIA said “impacts” are outside WG I’s mandate. Masson-Delmotte said Chapter 12 assesses climate change information for regional impact and risk assessment, citing discussions on risk assessment between the WGs. The paragraph was approved with amendments specifying examples of “low-likelihood” high-warming outcomes such as more intense and more frequent heatwaves and heavy precipitation.

**C.3.2:** On this paragraph dealing with **occurrence of low-likelihood, high-impact outcomes in all GHG emissions scenarios**, delegates called for: inclusion of quantitative information; more specificity regarding levels of probability in the different scenarios; and addition of levels of confidence. During discussion, the paragraph was revised to: note likelihood that, high-impact outcomes “could” occur, rather than “may;” specify the reference to tipping points “of the climate system;” and add forest dieback as another example of abrupt response. The paragraph was approved after the authors clarified that “cannot be ruled out” is the best estimate that can be given since no actual likelihood assessment can be made for issues with deep uncertainty such as a strongly increased Antarctic Ice Sheet melt.

**C.3.3:** On this paragraph, which projects **increasing frequency in compound events of low-likelihood in past and current climates as global warming increases**, delegates called for: clarifying what “become more frequent” and “higher chance” of high intensity, longer, and/or spatially larger events mean. Delegates also called for: including levels of probability, as well as regional data; providing examples of these compound events; and clarifying whether this paragraph deals with compound or extreme events. The authors explained that there are many events, and it would be difficult to list them all in the SPM, but Chapter 11 of the underlying report contains several examples. They further explained

that compound events include extreme events. The paragraph was approved, setting the scene with “if” global warming increases instead of “as” it increases and referring to a higher “likelihood” instead of a higher “chance.”

**C.3.4:** On this paragraph relating to the **decline or collapse of the Atlantic Meridional Overturning Circulation (AMOC)**, INDIA said the collapse of the AMOC before 2100 is a very remote possibility and would only affect African and Asian monsoons even if it were to happen. The EU called for more information on the AMOC decline, noting this is more likely than collapse. GERMANY requested including “impacts on Europe” and referencing that future AMOC decline is dependent on the emissions scenarios until at least the 2060s, as discussed in Chapter 9 of the underlying report. The paragraph was approved, noting the AMOC is very likely to “decline,” rather than “weaken,” referring to the water cycle instead of the “global” water cycle, and with an additional reference to “drying in Europe” as a result of an abrupt collapse in the AMOC.

**C.3.5:** This paragraph addresses **low-likelihood, high impact outcomes of unpredictable and rare natural events** such as a sequence of large explosive volcanic eruptions. The US queried the purpose of the paragraph, with INDIA suggesting deletion unless its meaning and policy relevance can be clarified. SPAIN called for specifying the interactions that these volcanic eruptions could have with the climate in order to clarify what could happen. The paragraph was significantly revised during the discussions, by, *inter alia*, referring to “unpredictable and rare natural events” and adding context on the past occurrence and effects of a sequence of large explosive volcanic eruptions “within decades.”

The NETHERLANDS suggested referring to events “not related to human influence on climate” instead of “not associated with anthropogenic emissions,” and referring to the illustrative set of scenarios “referred to” rather than “assessed” in this report. On the intent of the paragraph, noting reference made to volcanic eruptions in C.1.4, Co-Chair Masson-Delmotte explained that C.1.4 addresses the likely event of a single eruption in the near term, as part of natural variability, while this paragraph addresses low likelihood but large effects events such as a “sequence” of very large volcanic eruptions that would have significant effects at centennial scale. She also clarified that, contrary to a single eruption for which a likelihood can be estimated, such events are not included in scenario-based projections due to their inherent unpredictability. The authors further highlighted that the paragraph serves to provide a holistic physical science assessment to inform the work of WG II. The paragraph was approved with the suggestions from the Netherlands.

#### **D. Limiting Climate Change**

Following INDIA’s objection to “socio-economic pathways,” the chapeau of Section D was amended to refer to “projections of climate and air pollution.”

**D1:** This subsection addresses **what it would take, from a physical science perspective, to limit human-induced global warming**. With regard to the Headline Statement noting that limiting human-induced global warming to a specific level requires reaching at least net-zero CO<sub>2</sub> emissions and strong reductions in other GHG emissions, the RUSSIAN FEDERATION, SOUTH AFRICA, CHINA, and SAUDI ARABIA opposed referring to the need for “strong” emissions reductions, noting this is policy prescriptive. TANZANIA asked for clarification as to the differences between “strong” and “deep” emissions reductions, calling for

consistency in terminology. KENYA called for quantifying the notion of deep emissions reductions. SOUTH AFRICA inquired why reference is made to “net-zero CO<sub>2</sub>” only, instead of net-zero GHG emissions. SAUDI ARABIA underscored that “net zero” is policy prescriptive and should be replaced with neutral language.

With regard to the second headline sentence, that strong, rapid and sustained reductions in methane emissions would also limit the warming effect of reducing aerosol pollution and would improve air quality, IRELAND cautioned against creating the impression of tradeoffs between methane and aerosols, and noted aerosols mask warming and their emissions should be reduced. INDIA, supported by SAUDI ARABIA, called for adding reference to limiting CO<sub>2</sub> emissions to a carbon budget. The Headline Statement was approved, with a specification on the need for “limiting cumulative CO<sub>2</sub> emissions” and referring to the “warming effect resulting from declining aerosol pollution” rather than “warming effect of reducing aerosol pollution.”

In general comments on this subsection, INDIA underscored the effect of past emissions on the remaining carbon budget. CHINA requested clarification of the definition of “carbon budget,” noting the underlying report refers, in some instances, to a balance of sources and sinks, and in other instances, to the amount of carbon that can still be emitted by humans considering cumulative emissions. She also called for clarifying the relationship between “net-zero CO<sub>2</sub>” and reductions in other emissions. SAUDI ARABIA said all GHGs should be addressed, not singling out specific gases in certain contexts. MEXICO called for addressing black carbon.

**D.1.1:** This paragraph addresses the **near-linear relationship between cumulative anthropogenic CO<sub>2</sub> emissions and global warming**. SAUDI ARABIA, with the RUSSIAN FEDERATION, referred to the general problems they had identified in the D.1 subsection. Underscoring that CO<sub>2</sub> represents 85% of GHG emissions in most countries, SWITZERLAND questioned the opposition to referencing CO<sub>2</sub>, given its role in driving climate change and the fact it represents the largest share of most countries’ emissions. The UK proposed adding an explanation of the role of other GHGs in limiting warming. Supported by SAINT KITTS AND NEVIS and BRAZIL, he added that language on net-zero is within WG I’s mandate and is not policy prescriptive. The authors said increase in global surface temperature applies only to CO<sub>2</sub>, which is why the paragraph refers to it.

Discussions centered on the implications of the near-linear relationship between cumulative anthropogenic CO<sub>2</sub> emissions and the global warming they cause, that stabilizing human-induced global temperature increase at any level requires anthropogenic CO<sub>2</sub> emissions to become net zero and that requirements for limiting warming to a specific level can be quantified in terms of a carbon budget. INDIA stressed reaching net zero is a precondition, “but insufficient,” for stabilizing temperature increase, and preferred combining this sentence with the next one, that “limiting warming to a specific level implies limiting cumulative CO<sub>2</sub> emissions to within a carbon budget.” The NETHERLANDS said there are two separate messages: to reach net zero and to stay within the carbon budget to reach a specific temperature. The authors said reaching net zero is a precondition for stabilizing human-induced temperature increase at any level, but to limit temperature to a specific level emissions must stay within a carbon budget. They said the requirement of reaching net-zero CO<sub>2</sub> for stabilizing temperature at any level is a new insight building on literature since AR5 that quantifies what happens



after ceasing CO<sub>2</sub> emissions. FRANCE, with LUXEMBOURG, the NETHERLANDS, and the US, requested clarifying that net-zero CO<sub>2</sub> would not be sufficient to stabilize temperature levels, pointing to the potential effects of increasing methane emissions. Many countries supported CANADA's suggestion of "geophysical requirement" rather than "precondition." SAUDI ARABIA and INDIA preferred stating that reaching net zero is a "precondition but insufficient."

The RUSSIAN FEDERATION and INDIA asked to clarify the concept of "carbon budget." Supported by IRELAND, SWITZERLAND suggested referring to the "remaining" carbon budget, noting this refers to the amount of emissions until a certain level in emissions is reached, starting from current emissions levels, and called for adding a footnote with more information. Delegates agreed to add a footnote definition, but debated its wording at length, with INDIA and BRAZIL emphasizing the role of historical cumulative CO<sub>2</sub> emissions. One proposal suggested differentiating "total carbon budget," starting from the pre-Industrial period, and "the remaining carbon budget" when referring to a specified date in relation to a given maximum level of warming. Various proposals were made, based on wording from the glossary as well as the underlying chapter's frequently asked questions (FAQ) text and various combinations and alterations thereof. Delegates eventually converged on adding a comprehensive footnote, which includes language approved for Figure SPM.4 that historical cumulative CO<sub>2</sub> emissions determine to a large degree warming to date, while future emissions cause future additional warming; and addresses other anthropogenic climate forcers and the differentiation between carbon budget as expressed compared to pre-industrial period and the remaining carbon budget.

JAPAN asked to specify that the range of the likely increase in global surface temperature identified in AR6 is not only narrower than in AR5, but also than in SR1.5. GERMANY, with SAINT KITTS AND NEVIS, asked whether the authors could provide median value for transient climate response to cumulative carbon emissions (TCRE).

The paragraph was approved with the additional footnote and reference to SR1.5 and a best estimate for TCRE of 1.65°C.

**D.1.2:** Regarding a paragraph on estimates of **remaining carbon budgets**, SAUDI ARABIA and GERMANY called for specifying the uncertainties referenced, with GERMANY also calling for an aggregate of these uncertainties to be included in Table SPM.2. IRELAND asked for clarification of the paragraph's reference to projected warming "of associated" non-CO<sub>2</sub> emissions. INDIA called for specifying the range of possible increases or decreases in remaining carbon budget estimates related to changes in the dependencies pointed to in the paragraph. The authors noted the intention was to keep this paragraph concise and readable, and leave detailed information for Table SPM.2. The paragraph was approved, referring to "global temperature limits" rather than "chosen warming levels," to global surface temperature change "after global anthropogenic CO<sub>2</sub> emissions reach net zero" rather than "after cessation of CO<sub>2</sub> emissions," and to projected warming "from" non-CO<sub>2</sub> emissions.

**Table SPM.2:** This table presents **estimates of historical CO<sub>2</sub> emissions and remaining carbon budgets**. CHINA asked if the various temperature rises for pre-industrial levels outlined in the table relate to different scenarios. GERMANY called for the uncertainties to be specified in the table, saying the explanations

on uncertainties in the footnotes are unclear. The REPUBLIC OF KOREA noted that the 1.5°C and 2°C warming levels are closely related to the Paris Agreement goals and questioned the inclusion of the 1.7°C warming level, which he said has limited policy relevance. The RUSSIAN FEDERATION said the table needs to be clearer, especially about the percentages in the column outlining the estimated remaining carbon budgets from 1 January 2020, asking why these percentages were selected and also why they were not rounded up, for instance, specifying 15% instead of 17%, and 30% instead of 33%. With regard to these percentages, INDIA suggested that instead of referring to "likelihood of limiting global warming" the column should state "likelihood of limiting to target temperatures." The authors explained that: the 1.7°C warming level was included at governments' request as an intermediate step between 1.5°C and 2°C; the three middle percentages (33%, 50%, and 67%) are the ones provided in AR5; and the additional two were included at the request of governments who wanted one level on either side of this previous range (one step lower and one step higher), to reflect uncertainties. The table was approved, with revisions aimed at enhancing clarity, quantitative specification of uncertainties, and the specification that estimated remaining carbon budgets are calculated from the beginning of 2020 "and extend until global net zero CO<sub>2</sub> emissions are reached."

**D.1.3:** Regarding a paragraph on **re-assessment of the remaining carbon budget compared to previous reports**, Japan called for inclusion of a clear explanation on why the carbon budget estimates are similar to those in SR1.5 and the UK called for quantification of the differences in carbon budgets between SR1.5 and AR6. SAUDI ARABIA said the paragraph should spell out the exact factors giving rise to the similarities in budgets. She also noted that Chapter 5 of the Technical Summary states that the remaining carbon budget can increase or decrease by 550 GtCO<sub>2</sub> and suggested including this variation in this paragraph.

The authors explained why the carbon budgets in SR1.5 and AR6 are similar to each other, but larger compared to AR5, indicating that between AR5 and SR1.5, there were a lot of new methods and evidence that enabled improvements in assessing the remaining carbon budgets. They said these new methods and evidence were used in SR1.5 but since SR1.5, not many improvements or changes have been made. The paragraph was approved with the addition of a footnote on the differences in estimates for the remaining carbon budget consistent with limiting warming to 1.5°C and 2°C in AR6 compared to AR5.

**D.1.4:** This paragraph focuses on **anthropogenic carbon dioxide removal (CDR)**. Cautioning against policy prescriptiveness, SAUDI ARABIA opposed reference to "net zero CO<sub>2</sub> or net zero GHG emissions," and said CDR falls outside WG I's mandate. INDIA called for deleting a sentence on what CDR methods "could be used" for, noting this is policy prescriptive, and cautioned against promoting a mitigation discussion that falls outside the WG I mandate. GERMANY suggested the sentence be rephrased as a statement of purpose on what CDR methods aim to achieve. CANADA, supported by the UK, GERMANY, and others, underscored the value of this paragraph and suggested further highlighting the role of CDR in lowering global surface temperature after reaching a peak. The UK proposed referring to CDR implemented "at a scale where removals exceed emissions" instead of "at a larger scale." Several countries objected to referring to "methods" to remove CO<sub>2</sub>. The authors clarified that "CDR

methods” is the language used in the assessment, specifically in Chapter 5, and said they preferred to retain this language to be consistent.

Delegates had a lengthy debate over a mention of potentially wide-ranging side effects on biogeochemical cycles and climate, which can affect water availability and quality, food production, and biodiversity. The UK asked authors to clarify which side effects of CDR are positive and which are negative. SAUDI ARABIA said providing information on positive or negative effects of CDR is outside the WG I mandate, and, saying the paragraph provides incomplete information, called for deleting it. GERMANY thanked the authors for including information on CDR side effects and called for adding information on near-term risks of temperature overshoot so that it stands in relation to the information on risks associated with CDR. The authors clarified that CDR side effects on biogeochemical cycles are included in the approved outline of the AR6 WG I report and therefore fall under the purview of WG I. They recalled that information on other side effects was included in response to strong demand by several governments and expert reviewers. Responding to SWITZERLAND, they clarified that WG I only assessed CDR’s effects on water availability and quality, food production, and biodiversity, although there are many other effects they did not assess.

FRANCE, supported by the EU, suggested replacing “potentially wide-ranging effects” with “side effects of CDR at large scale.” The authors noted previous lengthy discussions that resulted in the deletion of “side effects.” They proposed referencing “potential negative and positive effects of CDR” for biodiversity, water and food production. FRANCE said the current language gives the idea that CDRs are possibly or almost a solution to climate change, but noted this is different from what science and the underlying report state, which is that large-scale CDR has negative effects.

Other comments related to: including information on nature-based solutions, with CHILE noting data is available and that these approaches are less risky; addressing solar radiation management (SRM); and making reference to the Sustainable Development Goals (SDGs). The authors clarified that CDR not only refers to purely technological solutions but also includes nature-based solutions, which are not specifically addressed here but are taken up in more detail in Chapter 5 of the underlying report. They preferred not to reference the SDGs, as these were not part of the assessment. Co-Chair Masson-Delmotte indicated a synthesis of aspects related to SRM can be found in the Technical Summary, in Box.TS.8, and said SRM will be addressed in further detail by WG II and III, including in relation to aspects such as risks to humans and nature, ethics, and governance.

CLIMATE ACTION NETWORK INTERNATIONAL and FWCC underscored the need to focus on reducing emissions rather than relying on CDR, noting CDR technologies are still nascent and certain CDR types would require significant energy inputs.

After further discussion, the paragraph was approved, specifying that CDR has the potential to durably store CO<sub>2</sub> in reservoirs, and, if implemented at a scale where anthropogenic removals exceed anthropogenic emissions, aims to lower surface temperature. The footnote now refers to “potential negative and positive effects” rather than “potential side effects” of CDR” for biodiversity, water, and food production.

**D.1.5:** This paragraph addresses the effects of CDR. INDIA queried the technical basis of the explanation that a given amount of

CO<sub>2</sub> sequestered by CDR will result in a smaller amount of decrease in atmospheric CO<sub>2</sub> because CO<sub>2</sub> removal from the atmosphere would be (only) partially counteracted by CO<sub>2</sub> release from the land and ocean. He asked if this implies a lower rate of carbon sink in land and ocean. IRELAND and BELGIUM asked if ocean degassing and release from land is really similar to the way anthropogenic CO<sub>2</sub> emissions result in a smaller increase in atmospheric CO<sub>2</sub> because a proportion of the emissions is taken up by land and ocean sinks, as the paragraph states, and requested qualification and quantification of such releases. SAUDI ARABIA said the paragraph is not within WG I’s mandate to provide clear information on the physical science of climate change and noted examples of ambiguous language in the paragraph. The authors said the paragraph is within the approved outline calling for WG I’s assessment of the climate change implications of CDR. They said quantitative information is lacking but the statement gives general information and refers readers to the associated section of the Technical Summary. They also noted that this paragraph does not assume negative CO<sub>2</sub> emissions so the statement that CO<sub>2</sub> removal from the atmosphere would be partially counteracted by CO<sub>2</sub> release from land and ocean is correct.

The RUSSIAN FEDERATION queried what general signal this paragraph is meant to provide and suggested revising the sentence to provide a clear message. GERMANY underscored that the issue of the asymmetry of the carbon cycle that affects the efficiency of CDR options should be clarified. SWITZERLAND emphasized specifying quantitative estimates rather than only referring to “a proportion” of emissions taken up by land and ocean carbon sinks.

After several rounds of discussions, with authors tabling text proposals, delegates converged on a revision, which starts by clarifying that anthropogenic CO<sub>2</sub> removal leading to global net-negative emissions would lower the atmospheric CO<sub>2</sub> concentration and reverse surface ocean acidification. The paragraph also underscores the notion of fluxes in referring to “release and uptake” “from or to” land and ocean carbon pools, and specifies that the atmospheric CO<sub>2</sub> decrease from anthropogenic CO<sub>2</sub> removals could be up to 10% less than the atmospheric CO<sub>2</sub> increase from an equal amount of CO<sub>2</sub> emissions, depending on the total amount of CDR. The paragraph was approved as amended.

**D.1.6:** This paragraph addresses the **long-time scale for reversing course on climate changes other than global surface temperature increase even with global net-negative CO<sub>2</sub> emissions**. CANADA suggested clarifying such changes could continue for decades to millennia “on their current trajectory and cannot be reversed.” SAUDI ARABIA objected to the paragraph singling out CO<sub>2</sub> emissions and said discussion of CDR is outside WG I’s mandate. IRELAND requested specifying that sustaining global net-negative CO<sub>2</sub> emissions, which would gradually reverse course on the global surface temperature, goes “beyond levels required to compensate for non-CO<sub>2</sub> GHGs.” The authors suggested specifying that the course reversal relates to global “CO<sub>2</sub>-induced surface temperature increase.” The paragraph was approved with the authors’ proposal and with a note that other climate changes would continue “in their current direction” for decades to millennia.

**D.1.7:** This paragraph addresses the **effects of reductions in anthropogenic aerosols and non-CO<sub>2</sub> GHG emissions**. INDIA cautioned against entering the territory of mitigation and called for deletion of two sentences, the first noting that the total warming from methane, aerosol, and ozone changes is lower in scenarios with air pollution controls and sustained methane mitigation, and

the second noting that methane mitigation partially counteracts global warming from aerosol reductions and contributes to improved air quality by reducing global surface ozone. SAUDI ARABIA suggested moving these sentences to WG II or III. Co-Chair Zhai said CDR is within the approved outline and scope of WG I and Chapter 6 of the outline refers to air quality and global surface ozone. SWITZERLAND said this paragraph perhaps “synthesizes” too much information, but policymakers need this scientific information for addressing mitigation. He noted WG I’s mandate is to provide the scientific basis for understanding the complexity of all the interactions, but asked the authors to consider a more straightforward statement of the elements in the paragraph. MEXICO stressed the importance of WG I providing information to WGs II and III on the impact of air pollution on climate change.

Delegates highlighted various aspects that should be better spelled out in the paragraph, among others: that warming by radiative forcing by gases in the atmosphere is possibly partially masked by methane and aerosols, with masking being different from warming itself; and reductions in short-lived aerosols show rapid impacts. IRELAND cautioned against conflating the methane and aerosol issues, noting that, independently of aerosols, reducing methane emissions helps reduce warming. AUSTRALIA noted the methane and aerosols counteract each other due to their similarly short atmospheric lifetimes. Responding to IRELAND on a quantification of “strong and sustained methane emission reductions,” the authors said “sustained” means lasting for more than a decade and “strong” means around 20% per decade. Delegates approved a restructured paragraph, with more clarity on the different messages on net warming and net cooling effects, clarification that because of the short lifetime of both methane and aerosols these climate effects partially counterbalance each other, and references to “five illustrative scenarios.”

**D.1.8:** This paragraph addresses the **need to achieve global net-zero CO<sub>2</sub> emissions to stabilize CO<sub>2</sub>-induced global surface temperature increase**, and the **difference between net-zero CO<sub>2</sub> emissions and net-zero GHG emissions**. Several delegates said the paragraph is too complex and technical, requesting simplification. SAUDI ARABIA said the statement on the requirement for net-zero emissions is policy prescriptive. INDIA questioned the need for the entire paragraph. The authors explained that this is the only place in the SPM that distinguishes between the net-zero CO<sub>2</sub> concept and net-zero GHG, stressing the importance of this information. SAUDI ARABIA, supported by INDIA but opposed by the US, proposed deleting the first two sentences, on stabilization of CO<sub>2</sub>-induced warming requiring achieving net-zero CO<sub>2</sub> emissions, and on the difference between this and achieving net-zero GHG emissions, respectively. The US suggested adding that GHGs reaching net zero entails net-negative CO<sub>2</sub> emissions. Brazil proposed putting the footnote, that the report does not recommend an emissions metric, into the main text. The authors confirmed the paragraph is not policy prescriptive and is within WG I’s remit.

LUXEMBOURG, supported by the NETHERLANDS but opposed by INDONESIA, proposed deleting the last two sentences referring to emissions pathways that reach and sustain net zero GHG emissions defined by the 100-year global warming potential and defined with new approaches that combine rates of change in emissions of short-lived GHGs with emissions of long-lived GHGs, respectively. SAINT KITTS AND NEVIS, supported by the US, suggested deleting the sentence related to new approaches.

Regarding a comment on needing more detail about new approaches, the authors said the paragraph is already very detailed and noted the trade-off between having more detail and becoming too technical. INDIA called for clarifying the term “climate response” in a statement that for a given GHG emission pathway, the pathways of individual GHGs determine the resulting climate response, whereas the choice of emissions metric used to calculate aggregated emissions and removals of different GHGs affects when the aggregated GHGs are calculated to become net zero. The authors agreed to include a footnote with the glossary definition of that term. Responding to INDIA’s further request to clarify the definition, Co-Chair Masson-Delmotte noted it is practice not to alter glossary definitions inserted into the text. The paragraph, with that footnote, was approved with syntax changes and without reference to pathways that reach and sustain net zero GHG emissions defined with new approaches resulting in approximately stable temperatures.

**Figure SPM.10:** Many countries lauded the clarity of this figure on the **relationship between cumulative CO<sub>2</sub> emissions and the increase in global surface temperature**. JAPAN called for clarification about whether the relationship between cumulative emissions and temperature increase is assessed in a consistent manner, especially with regard to future emissions. GERMANY underscored the need for consistent use of terminology and urged referring to either “global surface temperature increase” or “global warming.” INDIA reiterated his call for revising the labeling of the scenarios. With regard to the figure’s heading stating that “every tonne of CO<sub>2</sub> we put in the atmosphere adds to global warming,” INDIA called for the deletion of the “we.” GERMANY expressed discomfort at the specific reference to a “tonne” of CO<sub>2</sub>, noting that smaller amounts also have an effect. SAUDI ARABIA said non-CO<sub>2</sub> GHGs should be considered with respect not only to warming but also to cumulative emissions.

The authors noted that the warming referred to here is human-induced warming, which is calculated for each point in time, and is therefore different from other metrics. They noted that the figure focuses on CO<sub>2</sub> because it is the dominant anthropogenic climate forcer and that that holds true across a wide range of scenarios. On a query from CHINA and INDIA on why the figure only goes up to 2050 instead of the more common 2100 timescale, the authors further clarified that there is high confidence in the relationship between cumulative CO<sub>2</sub> emissions and warming only until 2050, and underscored they preferred showing the high confidence domain. On a statement that there is limited evidence on the evolution of warming in response to net-negative CO<sub>2</sub> emissions, CANADA suggested specifying that there is limited evidence on “the proportionality of the evolution” of warming. The authors proposed referring to limited evidence “supporting the quantitative application of TCRE under net negative CO<sub>2</sub> emissions.” The figure was approved with the authors’ suggestion.

**D.2:** This subsection addresses the **effects resulting from the low or very low GHG emissions scenarios**. Regarding the Headline Statement, referring to the effects of “strong, rapid, and sustained reductions of CO<sub>2</sub> and non-CO<sub>2</sub> emissions,” SAUDI ARABIA, with SOUTH AFRICA, CHINA, INDIA, and BRAZIL, noted policy-prescriptive language and called for providing the full range of options across scenarios. BRAZIL stressed differing responsibilities and equity. With CHINA urging more scientific expressions, the authors indicated that “strong, rapid and sustained” describes the two lowest emissions scenarios. SOUTH AFRICA called for



more elaboration and quantification and, opposed by INDIA and MEXICO, asked whether “CO<sub>2</sub> and non-CO<sub>2</sub> emissions” could be referred to as “GHGs.” MEXICO said the text is not prescriptive but informative and helpful for decision-making. The US supported being more specific on which scenarios are being referred to.

The UK stressed that changes would occur on several timescales, noting that atmospheric concentrations of emissions are detected in the short-term but climate changes in the longer term. Noting the important co-benefits of emissions reductions, NORWAY urged mention of the SDGs. The Headline Statement was revised to refer to specific emissions scenarios rather than “strong, rapid, and sustained emissions reductions,” and to highlight that trends of global surface temperature and other CIDs show discernible differences under these contrasting scenarios.

**D.2.1:** This paragraph addresses temporary **changes in emissions trends associated with measures to reduce the spread of COVID-19**. Several countries called for properly explaining the effects of aerosols and their short-term nature, in order to ensure policymakers understand their impacts. The authors noted that COVID-19 occurred very late in the assessment period and there is limited literature on this. Regarding the reference to “small temporary increase in total radiative forcing,” they explained that “temporary” means the emission reductions do go away once the containment measures end and “small” refers to the overall size of other types of forcing discussed in the report, that is, the total effect of anthropogenic radiative forcing. This paragraph was approved with a reformulation on the effects of aerosols, and additionally noting that atmospheric CO<sub>2</sub> concentrations continued to rise in 2020, with no detectable decrease in the observed CO<sub>2</sub> growth rate.

**D.2.2:** Regarding this paragraph on **linkages between GHG emission reductions and air quality**, many delegates opposed referring to “rapid decarbonization,” with some also opposing reference to climate change “mitigation.” Many called for referring to specific emissions scenarios that would lead to global air quality improvements, which was accepted. The NETHERLANDS suggested stating that further implementation of air pollution controls relying on existing technologies would improve air quality more rapidly “than even the lowest emissions scenario” instead of “than climate change mitigation.” Following a comment raised by INDIA on projected improvement from combined efforts to reduce air pollutants and GHG emissions, the authors proposed, and delegates accepted, replacing the last sentence in the paragraph with more specific information. The paragraph was approved, noting that, from 2040, further improvements are projected in scenarios that combine efforts to reduce air pollutants as well as GHG emissions, with the magnitude varying between regions. A footnote was also added to define “near term” as 2021-2040.

**D.2.3:** This paragraph relates to the **emergence of climate system responses under low or very low GHG emissions scenarios, taking into account internal and natural variability**. Many countries asked for clarification on the response of other climate variables emerging later than changes in temperature and stressed the need for elaboration on near-term effects on global temperatures being masked. SWEDEN said the issue is when there is an effect and whether it can be detected, saying some climate variables will show detectable changes earlier than others. NORWAY suggested noting the effects of reduction in global surface temperature trends first and then explaining that these effects may be masked by natural variability. SAUDI ARABIA said “strong,

rapid, and sustained” emissions reductions are linked to specific scenarios, calling for information relevant to all. The authors said large ensemble modeling, for investigation of mitigation relative to natural variability, is new and the literature focuses on the lowest and highest emissions scenarios. The paragraph was approved with structural revisions.

**D.2.4:** This paragraph relates to **differences in the magnitude of changes in CIDs beyond 2040 across emissions scenarios**. INDIA, with SAUDI ARABIA, called for reformulating the statement that “strong, rapid and sustained emissions reductions would lead to substantially smaller changes in CIDs beyond 2040 than under high GHG emissions scenarios” in more neutral language. INDIA requested including the intermediate scenario. The authors said information on extreme events is limited by the literature available and noted high and low emissions scenarios show the most difference in effects and the highest confidence levels. On SAUDI ARABIA’s query regarding “substantially smaller,” the authors said this is rooted in comparing the differences between the scenarios and the different global warming levels and suggested specifying changes in “a range of” CIDs. LUXEMBOURG and BELGIUM noted that changes in CIDs will continue beyond 2100. The UK asked whether signals on extremes will begin before 2040, given AR6’s finding that deferring emissions reductions will produce temperature increases ten years earlier than previously projected. The US said there are many extreme events, not just the sea level events and events exceeding dangerous heat thresholds that are mentioned. SWITZERLAND and others noted heavy precipitation. BELGIUM requested clarifying “change” as positive or negative. The authors said CIDs can be either and were not assessed for that. The paragraph was approved, with addition of information across all scenarios and additional reference to heavy precipitation and pluvial flooding.

### *Closing of WG I-14*

On Friday, 6 August, Co-Chair Masson-Delmotte opened the resumed WG I-14 plenary, inviting the WG to approve the SPM and accept the underlying report. SAUDI ARABIA requested additional time to review the final SPM and the WG I plenary was suspended for an hour to enable a review of the draft.

When the plenary resumed, Co-Chair Masson-Delmotte noted part of a footnote was not legible and introduced the Approved Summary for Policymakers (IPCC-LIV/Doc. 4, Rev.1) and the Changes to the Underlying Scientific-Technical Assessment to ensure consistency with the approved Summary for Policymakers (IPCC-LIV/Doc. 5, Rev.1). WG I-14 approved the SPM and accepted the underlying report, which were then submitted to IPCC-54 for its acceptance.

### *Closing of IPCC-54*

After the closing of WG I-14 on Friday, 6 August, IPCC Chair Lee invited the Panel to accept the actions taken by WG I at its 14th session (IPCC-LIV/Doc. 4, Rev.1 and IPCC-LIV/Doc. 5, Rev.1).

INDIA asked for clarification about the status of the Interactive Atlas provided with the report. SWITZERLAND asked for reassurance that the Interactive Atlas represents the content of the SPM and the underlying report. SAUDI ARABIA noted that the Interactive Atlas had not been subject to line-by-line approval. IPCC Vice-Chair Fatima Driouech clarified that the Atlas does not contain any new data. WG I Co-Chair Masson-Delmotte explained that it is not an element of the SPM, but of the underlying scientific and

technical report, noting that the AR5 also had an Atlas that contained static maps. The IPCC Legal Officer clarified that the Interactive Atlas is not part of the SPM and is not subject to the approval process.

The Panel then accepted the actions of WG I-14 with regard to the approval of the AR6 WGI SPM and the acceptance of its underlying scientific and technical assessment.

The REPUBLIC OF KOREA requested that the name “East Sea” be used concurrently with “Sea of Japan” throughout the report to refer to the body of water that lies between the Japanese Archipelago and the Korean Peninsula, and that their statement be attached to the IPCC-54 report. JAPAN objected, noting that “Sea of Japan” is the name used in official UN publications. Both delegations asked for their statements to be recorded in the report of the meeting.

All delegations expressed resounding gratitude for the commitment of authors, the WG Co-Chairs, TSU staff, and the Secretariat for their dedication, and thanked France and China for their support to WG I. Many spoke of the spirit of compromise and collaboration; several paid tribute to the “WG I family.”

Delegates noted that despite the virtual working conditions, the session was able to undertake its work efficiently, and complimented the Secretariat and TSU for the excellent arrangements and running of the meeting. Many called for lessons learned to inform the organization of future approval sessions. UKRAINE, CANADA, and SPAIN suggested holding hybrid approval sessions. Many also highlighted the Interactive Atlas as a crucial and policy-relevant output, especially for developing countries with limited access to climate data.

Noting that the world is rapidly exhausting the remaining carbon budget to stay within the objectives of the Paris Agreement, INDIA highlighted that the report will inform “those who seek to do their utmost to meet the challenge of tackling climate change.” TANZANIA emphasized how important the report will be for the countries most vulnerable to extreme events. ICELAND called it a major milestone, and TRINIDAD AND TOBAGO proclaimed this “a momentous moment for SIDS.”

The UK, as the host of UNFCCC COP 26, highlighted that the WG I report is a timely reminder of the overwhelming evidence for the need to increase ambition on reducing GHG emissions and adapting to climate change, noting it is a key input to COP 26.

WG I Co-Chairs Masson-Delmotte and Zhai highlighted the immense level of teamwork and dedication required to make the finalization of the report and the approval process possible. Zhai underscored the many comments received during the preparation of the report and the SPM and expressed appreciation to everyone for working in a respectful, supportive manner. Masson-Delmotte highlighted the increased workload stemming from the unprecedented number of Special Reports prepared during the Sixth Assessment cycle, in addition to the WG reports, urging governments to make good use of them.

IPCC Secretary Mokssit noted this occasion marks the first time in history that a successful approval process has taken place virtually within the UN system, noting that it was the result of many factors, including excellent leadership, coordination and collaboration among the many people and entities involved. He said the Secretariat is proud to work with the IPCC community and dedicated to providing good deliverables.

IPCC Chair Lee expressed gratitude to the authors, the WG I Co-Chairs, and everyone involved in the successful completion of

the report. He expressed satisfaction that the IPCC was able to host a virtual process supporting the scientific rigor of its assessment. He gaveled the meeting to a close at 2:45 pm CEST (UTC+2).

### **A Brief Analysis of IPCC-54**

With “listen to the science” elevated to a mantra by the Fridays for Future movement, public attention for the assessment reports of the Intergovernmental Panel on Climate Change (IPCC) has significantly heightened since the last Summary for Policymakers (SPM) of a Working Group (WG) I report was approved in 2013. The Special Report on Global Warming of 1.5°C (SR1.5), published in 2018, was referred to in the media as “a wake-up call” about the stark difference in impacts materializing at 1.5°C compared to 2°C, and now the latest WG I report puts into even more poignant perspective the world’s current trajectory towards 3°C warming.

The WG I report, which assesses the physical science basis of the climate system and climate change, is the first of three WG reports contributing to the IPCC’s Sixth Assessment Report (AR6). It is the most natural science-focused of the three reports, and, in many ways, lays the groundwork for the WG II assessment on impacts, adaptation, and vulnerability, and the WG III report on mitigation options. The line-by-line approval of the WG I SPM during this session was a stress test for how the discussions in the other two WGs might go, especially given their focus on issues with far more direct and intense ramifications for governance. With the entire WG I approval process conducted virtually, it also constitutes an important reference to inform other multilateral processes, not all of which have yet made the jump to virtual decision-making.

This brief analysis explores how well the WG I SPM approval process performed in this regard and highlights some of the report’s key scientific insights.

#### ***The (Virtual) Process***

Preparing assessment reports is a massive undertaking under the best of circumstances. The WG I report on the physical science basis references over 14,000 peer-reviewed publications and authors addressed close to 75,000 comments from expert reviewers and governments on the report and over 3,000 comments from governments on the SPM. The final approval of the SPM, too, is a complex process, where authors have to respond to government delegates’ questions and suggestions on the fly while still ensuring the scientific accuracy of any changes. This requires intense coordination among the different authors and with the WG Co-Chairs who facilitate the process.

Working virtually introduced a new dimension to this process. This virtual approval session was an unprecedented exercise, made possible by an impressive level of engagement by all participants, careful planning, impressive technical arrangements and support, and a significant investment of time. Delegates joined from around the world, working odd hours and long days. Most days featured three, three-hour long plenary sessions and just as many parallel author meetings and contact group discussions, meaning delegates were working more than 13-hour days over two weeks of meetings. As the end of the session drew near, the days got even longer.

Much was done to ensure the process ran as smoothly as possible. In the closing plenary, Norway even underscored it was “the most well-organized approval process the Panel has ever seen” and many delegations called for using lessons learned to inform the organization of future approval sessions. The approval plenary

was extended from one to two weeks and, just as during in-person meetings, the Co-Chairs convened huddles, albeit in virtual breakout rooms, to break deadlocks and return consensus text to the plenary for approval.

As the meeting progressed, discussions became more iterative, and items were taken up for approval in plenary as soon as possible after progress was made in contact groups or huddles. At times, this proved challenging. For instance, China, Saudi Arabia, and the US each asked the Co-Chairs to anticipate as best as possible, when specific issues would be addressed, to ensure the relevant delegates were present, given that meeting times went well beyond normal working hours in all time zones and many delegations had a staff rotation system in place.

Overall, the virtual setting did not hinder the process. On occasion, speakers had to repeat their statements because of poor audio quality or other technical glitches, and on other occasions, when delegates sharing a room had their microphones and speakers on simultaneously, participants were greeted with a robotic echo. Yet, these issues were not a significant disturbance. All plenary sessions featured simultaneous interpretation across all six official UN languages and—although not totally accurate and entirely wrong for statements not in English—the video conferencing platform provided an automatic transcript of the conversation, which sometimes proved quite useful for confirming speakers' proposals. A positive side-effect of the virtual setting was the ability to zoom in on the shared screen, which greatly facilitated discussions on the many figures in the report and text suggestions, and will be a much-missed feature when in-person meetings resume.

However, the virtual setting had its drawbacks: the meeting was physically draining due to time-zone differences and nighttime work, and the meeting lacked much of the sense of community an in-person meeting can engender. As many noted, delegates working during their nighttime were often not fresh or alert enough to propose concrete wording, even when they wanted to. Usually, the willingness of delegates to propose text speeds up the process, compared to the extra loop of waiting for authors to table a proposal intended to address delegations' comments. Similarly, seasoned delegates wondered whether targeted informal discussions between specific delegations might not have helped smooth out some of the lengthier talks that slowed down progress. As often noted, the SPM is a joint product of scientists and governments, and this feeling is more palpable with everyone in the same room, rather than spread out over home offices across the world.

### ***The SPM Story***

As Sweden highlighted during the meeting, “the SPM provides a story of the climate from the past to the future,” and this story is alarming:

- human influence has warmed the climate system;
- widespread and rapid changes in the climate have occurred;
- the scale of these recent changes is unprecedented over many centuries to many thousands of years;
- with further global warming, every region is projected to experience changes, with extremes, such as heavy precipitation, becoming greater in frequency and intensity;
- many changes due to past and future greenhouse gas (GHG) emissions are irreversible for centuries to millennia, especially changes in the ocean, ice sheets, and global sea level;
- global surface temperature will continue to increase until at least the mid-century under all emissions scenarios considered;

- unless there are deep reductions in CO<sub>2</sub> and other GHG emissions in the coming decades, 1.5°C and 2°C will be exceeded during the 21st century;
- from a physical science perspective, limiting human-induced global warming to a specific level requires reaching at least net-zero CO<sub>2</sub> emissions and strong reductions in other GHG emissions; and
- the effects of strong, rapid, and sustained emission reductions in terms of global surface temperature trends will begin to emerge after around 20 years.

Throughout the meeting and in the report, authors highlighted key advances since the publication of the AR5 and the Special Reports of the sixth assessment cycle. Key among these is greater understanding of the likelihood of crossing the 1.5°C global warming level between 2021-2040: which ranges from “very likely” under the very high GHG emissions scenario, to “more likely than not” under even the very low GHG emissions scenario. This means that, even under the very low emissions scenarios, there is more than a 50% likelihood that the 1.5°C global warming level will be crossed before 2040. Methodological advances allowed better estimates of the observed increase in global surface temperature thus far, putting it on average 1.09°C higher in 2011–2020 compared to pre-industrial times, with a range of 0.95-1.20°C. The authors also noted that the evidence of observed changes in extremes and, in particular, their attribution to human influence, has strengthened since AR5.

### ***The SPM Dance***

The SPM is a well-crafted document, with the entire review and approval exercise intended to balance the objective to convey key messages in a concise manner while maintaining scientific accuracy. Yet, while full credit is due to all the government delegations, who come very-well prepared to engage with the authors on clarifying terms and bringing in a reality check on what is just too much scientific jargon for policymakers and laypeople to understand without at least a definition (equilibrium climate sensitivity, anyone?), the issues that usually take most time to resolve are of a different nature. Delegates often repeated the mandate for the SPM is to be “policy relevant, not policy prescriptive.” Yet what this means to different countries and stakeholders varies greatly—and here lies the crux of many of the lengthier debates that arose during the approval process.

There was much debate, for example, over a figure originally noting that “future emissions determine future additional warming, with CO<sub>2</sub> emissions dominating.” With there being pretty clear lines between who contributed the most to past emissions and whose emissions are continuing to increase, thereby contributing the most to future emissions, the finding did not resonate the same with every country. Authors pointed to the narrative that unfolds across the sets of figures in the SPM, starting with observed warming, the contribution of GHG emissions up to now, and present-day impacts, before turning to future warming and future impacts. But government representatives are cautious to ensure that every element of the SPM is in itself balanced in terms of the benefits and burdens placed on different countries. The figure now notes that “future emissions cause future additional warming, with total warming dominated by past and future CO<sub>2</sub> emissions.”

Clearly, issues vary in importance to countries depending on their situation, and this is to be expected. Many African countries and small island developing states (SIDS) made a strong case for specific messages on meteorological and hydrological droughts



to be included in the SPM, which originally focused heavily on agricultural and ecological droughts. They emphasized how, for instance, meteorological droughts contribute to water scarcity and energy shortages, noting significant impacts on sustainable development. The reasons for not including information on meteorological droughts varied from limited relevance to the specific section under consideration, to limited evidence and literature in the sections where it was relevant, but interested countries were quite insistent, noting “low confidence does not negate the need to include critical information.” SIDS also repeatedly underscored that “every fraction of a degree matters” when it comes to global surface temperature increase, and stressed the crucial importance of information on projected sea level rise and low-likelihood, high-impact outcomes with regard to ice sheet instability. Not all countries are equal in terms of vulnerability. What to some might be a negligible low-confidence finding may be essential for informing risk assessment in those countries that fear their entire country may become submerged.

A sticking point in the discussions was the labeling of emissions scenarios that laid the foundation for the report. This specifically related to the so-called Shared Socio-economic Pathways (SSPs), which make projections on how global society, demographics, and economics might change over the next century—that is, how the world could develop—and how this would affect trends in greenhouse gas emissions. India underscored that SSPs are “not the only way the world can be assessed” and emphasized the five scenarios use “the same limited number of assumptions.” Numerous other countries argued that SSPs are scientifically rigorous, traceable, replicable, relevant to policymakers, and not under the IPCC’s control. This issue will surely flare up again in future. So will debates over achieving net-zero emissions and the potential and risks of carbon dioxide removal, which will be addressed in far more detail by WG III.

### Looking Ahead

For a time, it seemed the COVID-19 pandemic might put a damper on the finalization of the WG I contribution. But with this approval process completed, authors and delegates succeeded in limiting delays in the timeline for completing the AR6. Sticking to the anticipated timeline is key to ensuring the AR6 informs the global stocktake established under the Paris Agreement, which aims to assess the world’s collective progress towards achieving the Agreement’s objective and long-term goals, and is scheduled to take place in 2022-2023. The IPCC had already adjusted its mode of work after the onset of the pandemic in 2020, and this meeting demonstrated that a virtual SPM approval can be done when needed. A seasoned delegate, however, cautioned that compared to the other WGs, “this was the easiest one,” noting virtual approvals of the remaining SPMs will likely be even more draining.

The next big milestone on the climate agenda is of course the 26th session of the Conference of the Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC), scheduled to take place in November 2021 in Glasgow, Scotland. This IPCC meeting provided the scientific underpinning to the UNFCCC Executive Secretary’s call, expressed during the opening plenary, for governments to present strategies for achieving a 45% reduction in emissions by 2030 and reaching net-zero emissions by 2050. Moreover, considering the ongoing uncertainty about the ability of SIDS and least developed countries to participate

in-person at the COP, given the continued pandemic, this virtual approval session also gives food for thought on alternative meeting arrangements.

### Upcoming Meetings

**UNFCCC COP 26:** The 26th session of the Conference of the Parties (COP 26), the 16th meeting of the Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol (CMP 16), and the third meeting of the Conference of the Parties serving as the Meeting of the Parties to the Paris Agreement (CMA 3) will convene. **dates:** 1-12 November 2021 **location:** Glasgow, Scotland, UK **www:** [unfccc.int/process-and-meetings/conferences/glasgow-climate-change-conference](https://unfccc.int/process-and-meetings/conferences/glasgow-climate-change-conference)

**IPCC-55 and WG II AR6 Approval Plenary (WG II-12):** This session is expected to focus on the approval of the WG II contribution to the AR6, which assesses climate change impacts, adaptation and vulnerability. **dates:** 14-18 February 2022 (TBC) **location:** Germany **www:** [ipcc.ch/calendar/](https://ipcc.ch/calendar/)

**IPCC-56 and WG III AR6 Approval Plenary (WG III-14):** This session is expected to focus on the approval of the WG III contribution to the AR6, which assesses the mitigation of climate change. **dates:** 21-25 March (TBC) **location:** UK **www:** [ipcc.ch/calendar/](https://ipcc.ch/calendar/)

**IPCC-57:** The focus of this session will be on the approval of the Synthesis Report, which integrates the findings of the three WGs and the three Special Reports already released in this assessment cycle. **dates:** 26-30 September 2022 (TBC) **location:** Geneva, Switzerland **www:** [ipcc.ch/calendar/](https://ipcc.ch/calendar/)

For additional upcoming events, see [sdg.iisd.org/](https://sdg.iisd.org/)

### Glossary

AR5	Fifth Assessment Report
AR6	Sixth Assessment Report
CAN	Climate Action Network
CDR	Carbon dioxide removal
CID	Climatic-impact driver
CMIP	Coupled Model Intercomparison Project
CO2	Carbon dioxide
COP	Conference of the Parties
FWCC	Friends World Committee for Consultation
GHG	Greenhouse gases
IPCC	Intergovernmental Panel on Climate Change
RCP	Representative Concentration Pathways
SDGs	Sustainable Development Goals
SIDS	Small island developing states
SPM	Summary for Policymakers
SR1.5	Special Report on Global Warming of 1.5°C
SRM	Solar Radiation Management
SROCC	Special Report on Ocean and Cryosphere in a Changing Climate
SSP	Shared Socio-economic Pathways
SYR	Synthesis Report
TCRE	Transient climate response to cumulative carbon emissions
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WG	Working Group
WMO	World Meteorological Organization