Summary report on the eighth meeting of the research dialogue Bonn, Germany, 19 May 2016

Note by the Chair of the SBSTA

09 September 2016

I. Introduction

A. Mandate

1. The Subsidiary Body for Scientific and Technological Advice (SBSTA) at its twenty-sixth session requested that the secretariat develop and maintain the research dialogue in collaboration with invited regional and international climate change research programmes and organizations (hereafter referred to as research programmes and organizations) to inform the SBSTA of developments in research activities relevant to the needs of the Convention.[1]

2. The Conference of the Parties (COP) at its seventeenth session urged Parties, particularly developing country Parties, and invited research programmes and organizations to use the dialogue as a forum for conveying research findings and lessons learned by research programmes and organizations and for discussing needs for climate change research and research-related capacity-building, particularly those of developing countries.[2]

3. In response to these mandates, the eighth meeting of the research dialogue (RD 8) was convened on 19 May 2016 in Bonn, Germany, during SBSTA 44.[3] This report provides a summary of the posters, presentations and ensuing discussions.

B. Objective, approach and goal of the meeting

4. The information note, prepared in advance of the meeting by the Chair of the SBSTA,[4] outlines the objective, approach and goal for the meeting including: relevant mandates and ongoing activities; information on the submissions by Parties and the letter to the SBSTA Chair by the Executive Committee of the Warsaw International Mechanism for Loss and Damage, all of which provided input to the themes of the meeting;[5] the broad agenda, themes and guiding questions to steer the discussions; and an analysis of themes and presentations covered in previous research dialogues, provided in annex I of the note.

5. The two key themes for the meeting were:

(a) Thematic area 1: scientific analysis of pathways for achievement of the “well below 2 ºC” global temperature limit and limiting the temperature increase to 1.5 ºC, including global and regional transformation pathways and related impacts;

(b) Thematic area 2: The risks and impacts of slow onset events[6] as a result of climate change, particularly including temperature and those that occur in the cryosphere (sea level rise and ocean acidification) and hydrological cycle (drought).

6. The goal of the meeting was to provide a discussion forum for conveying new scientific findings and information gaps and supporting scientific knowledge and capacity-building on the two themes, in the light of the Paris Agreement.

[1] Decision 9/CP.11.
[2] Decision 16/CP.17.
[3] <http://unfccc.int/9475>.
[4] Available at <http://unfccc.int/files/science/workstreams/research/application/pdf/researchdialogue.2016.1.informationnote.pdf>.
[5] Available at <http://unfccc.int/9475>.
[6] Decision 1/CP.16, footnote 3, identifies slow onset events include sea level rise, increasing temperatures, ocean acidification, glacial retreat and related impacts, salinization, land and forest degradation, loss of biodiversity and desertification.

II. Summary of the proceedings

7. The RD8 was held on 19 May 2016, 14:30–18:00, at the World Conference Center Bonn, Germany.[7]

8. The meeting began with a one-hour poster session where experts presented posters and delegates were able to discuss content in detail with these experts. This was followed with focused presentations by experts and Parties and discussion in a round-table format. All parts of the meeting were focused on a range of aspects according to the two themes (see paragraph 5) and aligned with the goal (see paragraph 6).

III. Summary of the posters

9. There were 26 posters presented at the research dialogue. The posters provided some of the latest and emerging scientific information in support of the themes and goal of the dialogue. This section of the report provides a brief summary of, and link to, each poster. The descriptions of the posters are grouped together to assist the reader in identifying links and relevance to the different themes of the research dialogue.

A. Part 1: Conveying new scientific information and knowledge gaps

10. A poster[8] from Mr. David Carlson, World Climate Research Programme (WCRP), provided a visual update of **observed recent "surprises"** in our climate system during March and April 2016. These were the record low wintertime extent of Arctic sea ice, the record March surface air temperature of approximately 1.8 °C above pre-industrial levels, the early and extensive Greenland surface snow melt and the record high CO_2 concentrations at Mauna Loa Observatory of 407.8 ppm.

11. Three posters provided an overview of relevant work on **Earth observation**, which is the basis for recording and understanding the status of the planet (relevant for both themes 1 and 2), from the following partners: Global Climate Observing System (GCOS), Committee on Earth Observation Satellites (CEOS) and Group on Earth Observations (GEO).

i.

(a) The GCOS poster,[9] presented by Mr. Simon Eggleston, provided an **overview of how the GCOS are approaching the GCOS Implementation Plan 2016** in line with new requirements and challenges presented by observation needs under the Convention, including the Paris Agreement. The plan will incorporate the increased need for more local information to support adaptation and the provision of independent inventory methods that could support GHG reporting.

(b) The CEOS poster,[10] presented by Mr. Pascal Lecomte, identified the **ongoing commitment of space agencies**, through the Working Group on Climate,[11] to support decision making under the Convention, as outlined in the Architecture for Climate Monitoring.[12] The ECV inventory[13] is a pivotal asset of this contribution. Future plans include supporting the GCOS Implementation Plan 2016 and preparing a response to the plan, as well as regular reporting to the SBSTA.

(c) The GEO poster,[14] presented by Mr. Antonio Bombelli, described the **GEO Carbon and GHG Initiative** that aims to support the Convention by establishing a policy-relevant, long-term, global observation and analysis system for the carbon cycle and GHGs. The system will provide a common and open platform to plan and implement strategies and joint activities for GHG observation and analysis at the global level, as well as provide decision makers with timely and reliable policy-relevant information, recommendations and data-products.

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7 <http://unfccc.int/9292.php>.
8 <http://unfccc.int/files/science/workstreams/research/application/pdf/part1_wcrp_carlson_surprises_poster.pdf>.
9 <http://unfccc.int/files/science/workstreams/research/application/pdf/part1_gcos_richter_poster.pdf>.
10 <http://unfccc.int/files/science/workstreams/research/application/pdf/part1_ceos_lecomte_poster.pdf>.
11 <http://ceos.org/ourwork/workinggroups/climate>.
12 <http://www.wmo.int/pages/prog/sat/documents/ARCH_strategy-climate-architecture-space.pdf>.
13 <http://ecv-inventory.com>.
14 <http://unfccc.int/files/science/workstreams/research/application/pdf/part1_geo_bombelli.pdf>.

12. Two posters, one from the World Meteorological Organization (WMO) and one from Imperial College, London, identified **emerging independent methods for estimating and evaluating anthropogenic GHG emissions** and supporting mitigation efforts under the Paris Agreement (theme 1).

(a) The poster[15] presented by Mr. Deon Terblanche, WMO, provided an **overview of the Integrated Global Greenhouse Gas Information System** (IG3IS), an initiative[16] by WMO and its partners that combines atmospheric composition with bottom-up inventory data to better inform policy and decisions. The IG3IS intends to work in partnership with the user community including governments at all levels and private enterprises, to support the quantification of progress on emission reduction agreements (such as for countries' Nationally Determined Contributions (NDCs)); reduce emission inventory uncertainty, and inform additional mitigation actions.[17]

(b) The poster[18] presented by Ms. Heather Graven, Imperial College, described a new approach, currently under development, that uses **atmospheric observations and models to estimate fossil fuel CO_2 emissions**. Using tower-based observations of atmospheric CO_2 concentration and radiocarbon in CO_2, combined with models and remote sensing, preliminary results indicate the ability for the validation of bottom-up fossil fuel inventories to within approximately 10 per cent, with detection of less than 10 per cent changes possible. The observation network needed for a particular area depends on the emissions, topography and meteorological characteristics of that area,[19] thus this approach would not be suitable for low emission regions that produce small signals in atmospheric CO_2 and radiocarbon that are below the detection limit of about 1 ppm of fossil fuel-derived CO_2.

13. Two posters, one from the international institute for applied systems analysis (IIASA) and one from WCRP gave details on the **new shared socioeconomic pathways** (SSPs), which will be used for the first time in phase 6 of the WCRP's coupled model intercomparison project (CMIP 6) as part of the IPCC sixth assessment cycle (theme 1).

(a) The poster,[20] presented by Mr. Rogelj, IIASA, explained that the SSPs are part of a new scenario framework[21] that the climate change research community has established in order to facilitate the integrated analysis of future climate impacts, vulnerabilities, adaptation, and mitigation, including in the IPCC sixth assessment cycle. The **SSPs are based on narratives** that describe their main characteristics in a textual way. These narratives were translated into quantitative descriptions for projections of key scenario drivers, such as population, economic growth, and urbanization (see figure 3 of the poster). The SSPs were then implemented in six integrated assessment models (IAMs) to elaborate them in terms of energy system and land-use changes as well as resulting air pollutants, GHG emissions (see figure 4 of the poster) and atmospheric CO_2 concentrations (see figure 5 of the poster). The intended uses of the SSPs are for climate change analysts, not decision makers, to link impact, adaptation, vulnerability and mitigation analysis more explicitly to socio-economic development; enable better integration of mitigation, adaptation and climate impact research in future assessments; and initiate an open community process to build a richer socio-economic data repository for climate change research.

(b) The poster,[22] presented by Mr. Carlson, WCRP, provided the matrix for the new scenario framework to be undertaken in CMIP 6 and mentioned in the previous subparagraph, that facilitates the coupling of SSPs with the representative concentration pathways (RCPs) which were used during the IPCC's fifth assessment cycle (figure 1 of the poster and provided in figure 2 below). The poster also showed the baseline scenarios for atmospheric CO_2 concentrations and CO_2 emissions for each SSP (figure 2 of the poster and provided in figure 3 below).

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[15] <http://unfccc.int/files/science/workstreams/research/application/pdf/part1_wmo_terblanche_poster.pdf>.

[16] See also the Seventeenth World Meteorological Congress (cg-17), Resolution 46 <https://www.wmo.int/aemp/sites/default/files/wmo_1157_en.pdf#523>.

[17] A side event was held during SBSTA 44 on Wednesday 18 May on the IG3IS and further information on IG3IS is available in the presentation provided at this meeting, see <http://unfccc.int/files/science/workstreams/research/application/pdf/part_ig3is.pdf> and from the website <http://www.wmo.int/pages/prog/arep/gaw/ghg/IG3IS-info.html>.

[18] <http://unfccc.int/files/science/workstreams/research/application/pdf/part1_imperial_graven_poster.pdf>.

[19] For further information see also Levin, I., Hammer, S., Eichelmann, E., & Vogel, F. R. (2011). Verification of greenhouse gas emission reductions: the prospect of atmospheric monitoring in polluted areas. Phil. Trans. R. Soc. A, 369(1943), 1906-1924. <https://doi.org/10.1098/rsta.2010.0249>; and
Manning, A. J. (2011). The challenge of estimating regional trace gas emissions from atmospheric observations. Phil. Trans. R. Soc. A, 369, 1943-1954. <https://doi.org/10.1098/rsta.2010.0321>.

[20] <http://unfccc.int/files/science/workstreams/research/application/pdf/part1_iiasa_rogelj_ssp_poster.pdf>.

[21] O'Neill, B.C., Kriegler, E., Riahi, K. et al. Climatic Change (2014) 122: 387. <https://doi.org/10.1007/s10584-013-0905-2. <http://link.springer.com/article/10.1007%2Fs10584-013-0905-2>.

[22] <http://unfccc.int/files/science/workstreams/research/application/pdf/part1_wcrp_carlson_cmip6_poster.pdf>.

14. Four posters conveyed new scientific research and ongoing activities to overcome knowledge gaps in support of **monitoring of progress on limiting global warming** (theme 1).

(a) The poster[23] presented by Ms. Helene Benveniste, France, described how the Intended Nationally Determined Contributions (INDCs), which summarize domestic objectives for emissions reductions of GHGs at the 2025–2030 time horizon, lack detailed guidelines and a common format. Ancillary data are currently needed to interpret some INDCs and project GHG emissions in 2030. The poster presented a detailed **analysis of uncertainty sources** and their respective impacts on 2030 global GHG emissions. Using the REDEM software,[24] the analysis compared (1) the inferred 2030 global emissions range to pathways compatible with different temperature targets taking into account the inertia of socio-economic systems as well as (2) negative emissions (as illustrated in figure 4 of the poster). Results showed that the INDCs imply substantially larger emissions reduction rates after 2030 than foreseen during the 2010–2030 period to not exceed the 2 °C limit. This research highlighted the need for four crucial dimensions of future climate action: (1) a clearer framework regarding future NDCs' design; (2) an ambitious update mechanism in order to avoid hardly feasible decarbonization rates after 2030; (3) a careful assessment of negative emissions technologies choices and potentials; and (4) a well thought out anticipation of the necessary steep decrease in global emissions after 2030.

(b) The poster[25] presented by Mr. Joeri Rogelj, IIASA, posed two questions: (1) are the temperature objectives of Article 2 of the Paris Agreement consistent with the emissions pathways implied by the objectives of Article 4 and (2) what are the key characteristics, as well as potential differences, of pathways which stay within the global temperature limits introduced in Article 2? In response to question 1, re-analysis of AR5 WGIII data together with more recent studies,[26] indicate that **achieving a balance between anthropogenic sinks and sources of greenhouse gases in the second half of the century is consistent with returning warming to below 1.5 °C relative to pre-industrial levels by 2100**, although Article 4 is an insufficient condition in itself **and additional benchmarks are needed**. In response to question 2, key characteristics of 1.5 °C pathways include: (1) additional GHG reductions coming mainly from CO_2; (2) global CO_2 reductions beyond net zero (with net zero shortly after mid-century); (3) a rapid near-term decarbonisation of energy supply (about 70 per cent low-carbon share in 2030, and more than 95 per cent in 2050); (4) greater demand side mitigation efforts (particularly in the building and the transport sector); (5) improvements in energy efficiency (at a sustained global rate of 2.5 per cent per year until 2050); (6) higher mitigation costs (between double and triple from a 66 per cent probability pathway for 2°C); and (7) the peaking of global emissions around 2020 or earlier through the achievement of comprehensive emissions reductions in the coming decade.

(c) The poster[27] presented by Ms. Katja Frieler from the Potsdam Institute for Climate Impact Research (PIK) described the protocol of the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP) currently under development for the planned simulation exercises tailored to support the IPCC special report on impacts of global warming of 1.5ºC above pre-industrial levels and related global greenhouse gas emission pathways. ISIMIP provides consistent impact projections, forced by the same climate projections, across different sectors in an open repository[28] and supports their translation into socio-economically relevant indicators. The main goals for the scenario design include: (1) provision of socially-relevant indicators such as "number of people exposed to flooding" allowing for an assessment of the risks of displacement; (2) translation into economic damages and potential risks for long-term economic growth to update estimates of social costs of carbon; and (3) identification of hot spots subject to multiple risks, and identification of "dominant risks" to inform national adaptation plans.

(d) The poster[29] presented by Mr. Ryo Mizuta, Japan, detailed how high-resolution large ensemble simulations are used to provide probabilistic information on future projections of extreme events and recent simulation results. These results include: (1) heavy rainfall that currently occurs once in 10 years increases globally on average about 30 per cent in a 4°C warmer climate, with the increase being

[23] <http://unfccc.int/files/science/workstreams/research/application/pdf/part1_france_gicn_benveniste_poster_final.pdf>.

[24] <http://redem.gforge.inria.fr/>.

[25] <http://unfccc.int/files/adaptation/application/pdf/part1_iiasa_rogelj_artilce2.4_poster.pdf>.

[26] The IPCC AR5 WGIII Scenario Database is hosted at IIASA and available at: <http://tntcat.iiasa.ac.at/AR5DB/>
Rogelj, J., M. Schaeffer, M. Meinshausen, R. Knutti, J. Alcamo, K. Riahi & W. Hare (2015). "Zero emission targets as long-term global goals for climate protection." Environmental Research Letters 10(10): 105007; and
Rogelj, J., G. Luderer, R. C. Pietzcker, E. Kriegler, M. Schaeffer, V. Krey& K. Riahi (2015). "Energy system transformations for limiting end-of-century warming to below 1.5°C." Nature Climate Change 5(6): 519-527.

[27] <http://unfccc.int/files/science/workstreams/research/application/pdf/part1_pik_frieler_isimip_poster.pdf>.

[28] <https://esg.pik-potsdam.de>.

[29] <http://unfccc.int/files/science/workstreams/research/application/pdf/part1_japan_mizuta_poster.pdf>.

greater for more rare events; (2) extreme temperature over land will increase more than the mean in central Europe and southern Brazil; and (3) in the north-western Pacific and the Atlantic, Category 4-5 tropical cyclones will increase despite a decrease in the total cyclone number.[30] All simulation results are openly available and can be used for impact assessment studies and climate change adaptation planning.[31]

15. Ms. Valérie Masson-Delmotte, IPCC, presented two posters updating information from the AR5 with **recent scientific findings in regards to two slow onset events**: sea level rise and drought (theme 2).

(a) The poster[32] on **sea level rise** highlighted how change in sea level is a major concern for coastal managers and society at large, and occurs over a wide range of temporal and spatial scales – with many contributing factors – making it an integral measure of climate change. The AR5 was able to stress an increased confidence in projections of global mean sea level, owing to improved physical understanding of the component of sea level, improved agreement of process-based models with observations, and the inclusion of ice-sheet dynamical changes. Under all RCP scenarios, the future rate of global mean sea level (GMSL) rise will not be uniform and will very likely exceed the rise observed during 1971–2010, due to increased ocean warming and increased loss of mass from glaciers and ice sheets. The stability of marine sectors of the Antarctic ice sheet in a warming climate has been identified as the largest source of uncertainty in projections of future sea-level rise. Recent scientific advances include: (1) ascertaining that potential sea-level rise from Antarctic ice sheet instability is constrained by present day observations;[33] (2) how paleoclimate data can be used to assess the response of the Antarctic ice sheet to ocean warming and/or atmospheric CO_2 concentration;[34] (3) assessing the multi-millennial commitment of the Antarctic ice sheet to future sea-level rise – with substantial ice loss only prevented in RCP2.6; (4) higher emissions lead to 0.6–3m contribution to sea level rise by 2300;[35] and (5) calibration of processes against paleoclimate sea level estimates give Antarctica the potential to contribute more than one meter GMSL rise by 2100 and more than 15 m by 2500 if GHG emissions continue unabated.[36]

(b) The poster[37] on **drought** provided an overview of recent scientific advances with regard to understanding drought variations in a changing climate. Drought produces a web of impacts across many sectors of society and economy, potentially leading to land degradation. According to AR5, there is low confidence in a global-scale observed trend in drought or dryness (lack of rainfall) owing to lack of direct observations, dependencies of inferred trends on the index choice and geographical inconsistencies in the trends. However, this masks important regional changes and, for example, the frequency and intensity of drought have likely increased in the Mediterranean and West Africa and likely decreased in central North America and northwest Australia since 1950. Extensive efforts have been devoted to emerging research areas including the relative contribution of internal variability versus anthropogenic change in North America,[38] the Middle East,[39] Australasia,[40] and Africa;[41] linkages with the long-term global temperature

[30] Mizuta et. al. (2016). Over 5000 years of ensemble future climate simulation by 60km global and 20km regional atmospheric models. *Bull. Amer. Meteor. Soc.*, *submitted*.

[31] <http://dias-dss.tkl.iis.u-tokyo.ac.jp/ddc/viewer?ds=d4PDF_GCM&lang=en>.

[32] <http://unfccc.int/files/science/workstreams/research/application/pdf/part1_ipcc_masson_delmotte_sealevel_poster.pdf>.

[33] Ritz et al. (2015). Potential sea-level rise from Antarctic ice-sheet instability constrained by observations. Nature, 2015 528, 115–118. <https://doi.org/10.1038/nature16147>.

[34] Dutton et. al. (2015). Sea-level rise due to polar ice-sheet mass loss during past warm periods. Science 349 (6244). <https://doi.org/10.1126/science.aaa4019>.

[35] Golledge et. al. (2015). The multi-millennial Antarctic commitment to future sea-level rise. Nature 526, 421–425. <https://doi.org/10.1038/nature15706>.

[36] DeConto and Pollard (2016). Contribution of Antarctica to past and future sea-level rise. Nature 531,591-597. <https://doi.org/10.1038/nature17145>.

[37] <http://unfccc.int/files/science/workstreams/research/application/pdf/part1_ipcc_masson_delmotte_drought_poster.pdf>.

[38] Griffin and Anchukaitis (2014). How unusual is the 2012–2014 California drought?, Geophys. Res. Lett., 41, 9017–9023. <https://doi.org/10.1002/2014GL062433>.
Williams et al. (2015). Contribution of anthropogenic warming to California drought during 2012–2014, Geophys. Res. Lett., 42, 6819–6828. <https://doi.org/10.1002/2015GL064924>.
Diffenbaugh et al. (2015). Anthropogenic warming has increased drought risk in California, PNAS 112 (13), 3931–3936. <https://doi.org/10.1073/pnas.1422385112>.
Cheng et al. (2016). How Has Human-Induced Climate Change Affected California Drought Risk, Journal of Climate 29 (1). <https://doi.org/10.1175/JCLI-D-15-0260.1>.

[39] Bergaoui et al. (2015). The contribution of human-induced climate change to the drought of 2014 in the southern Levant region. Bull. Amer. Meteor. Soc., 96 (12), S66-70.
Cook et al. (2016). Spatiotemporal drought variability in the Mediterranean over the last 900 years. J. Geophys.

target;[42] impact on fresh water stress in small islands;[43] and the paradigm of "wet regions get wetter and dry regions get drier".[44] New research since AR5 has expanded AR5 findings and stressed: that drought does play a role in inter-annual variability in semi-arid ecosystem net primary production, affecting the global carbon cycle;[45] that global drylands expand under a warming climate;[46] and a drying in south western North America, Mediterranean area, southern Africa, Australia,[47] central America and the Amazon (Cook et al, J. Clim., 2015).[48] Lessons from large climate model ensembles for projected change in river runoff indicate a robust between-ensemble agreement in regional drying (e.g. in southern Africa and southern Europe) and wetting trends (e.g. in the northeastern United States).[49] Gridded centennial hydroclimate reconstructions for the northern hemisphere land mass? depict similar patterns of spatio-temporal variability as observed in the instrumental period.[50]

B. Part 2: Supporting scientific knowledge and capacity-building

16. Four posters provided detail of available climate services to support scientific knowledge sharing and capacity building in support of themes 1 and 2. Posters were from the Global Framework for Climate Services (GFCS), the European Commission (EC), the National Oceanic and Atmospheric Administration (NOAA) and the United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER).

(a) The GFCS poster,[51] presented by Mr. Maxx Dilley, provided examples of how **climate services** are empowering decision makers and assisting governments to build capacity for operational climate services at the national and regional levels (he provided further information in his presentation, see paragraphs 53-57). Examples included (1) how governments and organizations will have the opportunity to offer seamless weather and climate services for managing a variety of risks on different timescales; (2) how, by improving seasonal predictions of Indian summer monsoons, forecasters will be able to assist farmers to anticipate the likely size of their crop and prepare their farming and marketing strategies; (3) observations show an increase in the number of record hot day maxima at Australian climate reference stations, with a clear upward trend in the first decade of the 21st century; and (4) how

Res. Atmos., 121, no. 5, 2060-2074. <https://doi.org/10.1002/2015JD023929>.
Kelley et al (2015). Climate change in the Fertile Crescent and implications of the recent Syrian drought, PNAS, 112 (11), 3241–3246. <https://doi.org/10.1073/pnas.1421533112>.

[40] Cai et al. (2014). Did Climate Change–Induced Rainfall Trends Contribute to the Australian Millennium Drought?, Journal of Climate. <https://doi.org/10.1175/JCLI-D-13-00322.1>.

[41] Dong and Sutton (2015). Dominant role of greenhouse-gas forcing in the recovery of Sahel rainfall, Nature Climate Change, 5(8), 757-760. <https://doi.org/10.1038/nclimate2664>.

[42] Schleussner et al. (2016): Differential climate impacts for policy-relevant limits to global warming: the case of 1.5 °C and 2 °C Earth Syst. Dynam., 7, 1–25, 2016 <https://doi.org/10.5194/esd-7-1-2016>.

[43] Karnauskas et. al. (2016). Future freshwater stress for island populations. Nature Climate Change.

[44] Greve and Seneviratne, S. I. (2015). Assessment of future changes in water availability and aridity. Geophysical research letters, 42(13), 5493-5499. <https://doi.org/10.1002/2015GL064127>.
Sedlacek and Knutti (2014). Half of the world's population experience robust changes in the water cycle for a 2 °C warmer world ERL 9(4).
Kumar et al. (2015). Revisiting trends in wetness and dryness in the presence of internal climate variability and water limitations over land, GRL 42(24), 10,867–10,875. <https://doi.org/10.1002/2015GL066858>.

[45] Huang et al (2016). Drought dominates the interannual variability in global terrestrial net primary production by controlling semi-arid ecosystems. Nature Scientific Reports 6. <https://doi.org/10.1038/srep24639>.

[46] Sherwood and Fu (2014). A drier future? Science 343 (737). <https://doi.org/10.1126/science.1247620>.
Roderick et al. (2015). On the assessment of aridity with changes in atmospheric CO2, Water Resources Research, 51, 5450–5463. <https://doi.org/10.1002/2015WR017031>.
McEnvoy et al. (2016). The Evaporative Demand Drought Index. Part II: CONUS-Wide Assessment against Common Drought Indicators, Journal of Hydrometeorology. <https://doi.org/10.1175/JHM-D-15-0122.1>.

[47] Feng and Fu (2013). Expansion of global drylands under a warming climate, Atmos. Chem. Phys., 13, 10081-10094. <https://doi.org/10.5194/acp-13-10081-2013>.
Spinoni et al. (2015). Climate of the Carpathian Region in the period 1961–2010: climatologies and trends of 10 variables. International Journal of Climatology, 35(7), 1322-1341.

[48] Cook et al. (2014). Global warming and 21st century drying. Climate Dynamics, 43, 2607-2627. <https://doi.org/10.1007/s00382-014-2075-y>.

[49] Boehlert et al. (2015). Water under a Changing and Uncertain Climate: Lessons from Climate Model Ensembles. J. Climate, 28, 9561–9582. <https://doi.org/10.1175/JCLI-D-14-00793.1>.

[50] Ljungqvist et al. (2016). Northern Hemisphere hydroclimate variability over the past twelve centuries. Nature 532, 94–98. <https://doi.org/10.1038/nature17418>.

[51] <http://unfccc.int/files/science/workstreams/research/application/pdf/part2_wmo_gfcs_dilley_poster.pdf>.

improved climate and meteorological information can be used to predict the likelihood of transmission of dengue fever where disease surveillance is weak or absent and national authorities can be alerted to potential disease spread. Such information can also be shared with neighbouring countries for sound planning and effective control of transmission.

(b) The UN-SPIDER poster,[52] presented by Mr. Joachim Post, highlighted how UN-SPIDER is enabling access to space-based data and information to contribute to **drought risk and impact quantification**, building capacities in value-adding methods and advising on implementation of this information at the national level. The poster detailed how drought monitoring and early warning systems are continuing to be strengthened through the intensified use of space-based information. Current challenges are: (1) the need to establish systematic information and documentation on drought events and integrate this into drought risk and impact assessments so as to improve knowledge on losses and damages, (2) move from drought hazard assessment approaches and indicators towards providing drought risk knowledge and impact indicators; (3) improve early warning systems with impact-based information and enhanced monitoring, (4) establish national, inter-sectoral drought policies, (5) provide capacity-building and knowledge management.

(c) The posters by the EC,[53] presented by Mr. Diogo de Gusmao-Soerensen, and NOAA,[54] presented by Ms. Marian Westley, provided a summary of the information covered in the experts' presentations, see paragraphs 72–74 and 75 respectively.

(d) The poster[55] presented by Ms. Meryl Richards from the CGIAR Research Program on Climate Change, Agriculture and Food Security highlighted, in regards to theme 1, how reducing **emissions from agriculture** can help meet ambitious limits on global temperature increase. Currently there are poor levels of technical information about how much mitigation of agricultural emissions is needed versus how much is feasible in order to meet the goals of the Paris Agreement. New research was outlined which identified that the agriculture sector must reduce emissions by 1 $GtCO_2$ eq/yr by 2030 to stay below the end of century 2°C warming limit.[56] However, plausible agricultural development pathways with mitigation co-benefits deliver only 21–40% of the mitigation needed and more investment is required to explore options, such as newly developed methane inhibitors.[57] Further highlighted was a more comprehensive goal for agriculture-related emissions of approximately 5–9 $GtCO_2$ eq/yr, or about 27 per cent of the mitigation needed across all sectors. This should include soil carbon sequestration on agricultural land, reducing land use change due to clearing for agriculture, reducing food loss and waste, and shifting dietary patterns.

17. Two posters were presented by Ms. Monika Antosik, Ms. Dawn Pierre-Nathoniel and Mr. Idy Niang of the **Executive Committee of the Warsaw International Mechanism for Loss and Damage** (ExCom) and addressed theme 2.

(a) The first poster[58] highlighted the **work of the Excom** on guiding the implementation of the Warsaw International Mechanism for Loss and Damage,[59] its functions and action areas, one of which focuses on slow onset events.

(b) The second poster[60] highlighted **how the ExCom is planning to catalyze further action** through four activities: (1) mapping organizations and the efforts carried out by these organizations; (2) establishing and strengthening collaborative channels for collecting and sharing relevant information; (3) enhancing collaboration on access to information; and (4) assessing the state of knowledge and capacity and developing recommendations which take into account regional dimensions for slow onset events. The first of these activities is currently underway.

18. Scientific findings supporting knowledge and capacity-building for slow onset events were covered by four posters, from a range of angles (theme 2).

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[52] <http://unfccc.int/files/science/workstreams/research/application/pdf/part2_unoosa_unspider_post.pdf>.
[53] <http://unfccc.int/files/science/workstreams/research/application/pdf/part2_ec_de_gusmao-soerensen_poster.pdf>.
[54] <http://unfccc.int/files/science/workstreams/research/application/pdf/part2_noaa_usa_westley_poster.pdf>.
[55] <http://unfccc.int/files/science/workstreams/research/application/pdf/part2_cgiar_richards_poster_medium.pdf>.
[56] Wollenberg et al. (2016). Reducing emissions from agriculture to meet the 2°C target. Glob Change Biol. <http://dx.doi.org/10.1111/gcb.13340>.
[57] Hristov et al. (2015). An inhibitor persistently decreased enteric methane emission from dairy cows with no negative effect on milk production, PNAS 112-134, 10663–10668. <https://doi.org/10.1073/pnas.1504124112>.
[58] <http://unfccc.int/files/science/workstreams/research/application/pdf/part2_excomld_poster1.pdf>.
[59] <http://unfccc.int/8134>.
[60] <http://unfccc.int/files/science/workstreams/research/application/pdf/part2_excomld_poster2.pdf>.

(a) The poster[61] presented by Mr. Alexandre Magnan, France, highlighted recent research showing the **contrasting futures for ocean and society as a result of slow onset climate-related** changes.[62] The level of impacts by the end of the century will strongly depend on the greenhouse gas mitigation trajectories the world will follow (as illustrated in figure 4 of the poster).[63] There are three key messages from this research: (1) the risks of impact to the ocean from climate change are high, even under the most stringent emission scenarios (RCP2.6); (2) analysis of the the current ambition of the NDCs shows that it is insufficient to reach the well below 2°C limit called for in the Paris Agreement. Accordingly, the NDCs 5-year revision process toward higher global mitigation is key to minimize the risks of impacts to the ocean and ensure room for manoeuvre for societies' adaptation; and (3) the forthcoming IPCC Special Reports, on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas (GHG) emission pathways and climate change and oceans and the cryosphere, will allow for accelerating understanding of the chains of impacts in the ocean (including on societies), and thus will be a key support for the negotiation community to rapidly develop new comprehensive reference points to avoid dangerous interferences with the climate and ocean system.

(b) The poster[64] presented by Mr. Edwin Castellanos, Inter-American Institute for Global Change Research (IAI), Guatemala, showed the results of recent research on **how capacity-building** combining local and scientific knowledge **increases adaptive capacity** to global changes for farmers in Mesoamerica.[65] The current global and regional changes, including climate change, that farmers are confronting are bigger than anything experienced by them in the past. Science must be communicated to stakeholders at three levels: (1) high-level decision makers, including political leaders; (2) practitioners in supporting organizations and middle-level technical officers in governments; and (3) local people directly impacted by multiple stressors. This imposes a challenge to scientists for several reasons: (1) each of the listed groups needs a particular communication strategy; (2) scientists often do not have the communication skills needed; and (3) even if they do, they do not have the time to do both science and communication. Thus scientific teams must work together with communication specialists and this additional expense should be supported by funding organizations.

(c) The poster[66] presented by Mr. Robert Oakes from the United Nations University – Institute for Environment and Human Security (UNU-EHS), introduced the latest results from the **Pacific Climate Change and Migration** (PCCM) project in Kiribati, Tuvalu and Nauru. Climate is already affecting patterns of human mobility in the islands and projections of trends show that the populations of Kiribati and Tuvalu and particularly of their capital cities are projected to increase dramatically, placing great strain on resources and exacerbating environmental "hotspots". The study showed that it is necessary to address the issues which are triggering migration; further build resilience and climate change adaptation into development planning to lessen the need for migration; as well as plan for and manage future population growth. Recommendations include training islanders to enable them to compete on the international labour market and be able to migrate with dignity; and promote different internal and international migratory routes which would lessen the strain on the capital islands.

(d) The poster[67] presented by Mr. Edmund Jennings from the Convention on Wetlands of International Importance (RAMSAR) examined the **wise use of wetlands to help mitigate the impacts of climate change and reduce the risk of slow onset drought events**. Wetlands are vital for human survival and provide ecosystem services including flood and storm surge protection, groundwater recharge and drought mitigation. Approximately two-thirds of global wetland area was lost in the 20th century. Recommendations from RAMSAR include: (1) manage and restore wetlands for resilience against floods and drought, including the conservation of wetlands and their ecological character in national drought management policies; (2) take action across a range of government sectors to prevent wetland loss and encourage integrated water resources management; (3) monitor slow onset drought through tools including national wetland inventories, earth observation of wetland extent, and periodic updates on the ecological character of Wetlands of International Importance ("Ramsar Sites"); (4) incentivize sustainable agriculture which maintains and restores wetland ecosystem services and restore

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[61] <http://unfccc.int/files/science/workstreams/research/application/pdf/part2_france_magnan_poster.pdf>.

[62] Magnan et al. (2016). Implications of the Paris Agreement for the ocean, Nature Climate Change. <http://rdcu.be/iigT>.

[63] Figure 4 from the poster is also referenced in the Summary report on the SBSTA–IPCC special event on advice on how the assessments of the IPCC can inform the global stocktake, see figure 8.

[64] <http://unfccc.int/files/science/workstreams/research/application/pdf/part2_iai__castellanos_poster.pdf>.

[65] Three publications to help small coffee growers face global change successfully: <http://www.iai.int/?p=10758>.

[66] <http://unfccc.int/files/science/workstreams/research/application/pdf/part2_unu-ehs_oakes_vandergeest_poster.pdf>.

[67] <http://unfccc.int/files/science/workstreams/research/application/pdf/part2_ramsar__jennings_poster.pdf>.

degraded land instead of converting further wetlands for agriculture; and (5) preserve peatlands so they can continue to store carbon, incentivizing the “re-wetting” of drained peatlands so that the water table does not fall below the peat surface.

19. A third WCRP poster,[68] presented by Mr. Carlson, highlighted the important network created and managed by young researchers to address the future of Earth System Science (YESS)[69] (themes 1 and 2).

IV. Summary of the dialogue

A. Part 1: Conveying new scientific information and knowledge gaps

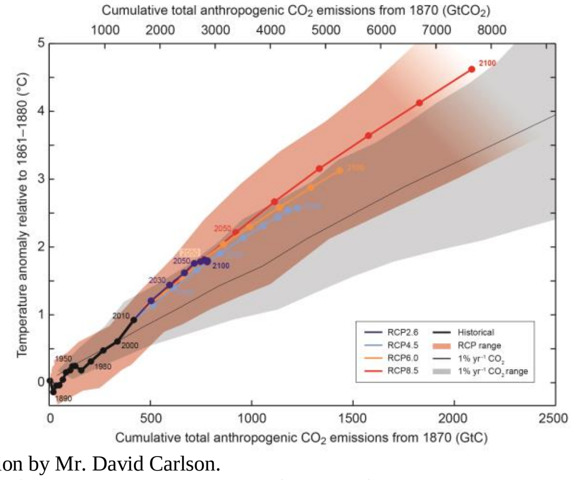
1. Presentations by experts

20. The presentations were opened by Mr. Carlson, Director of the WCRP, who began with a compelling spiral animation showing the increase in temperatures from 1850 to 2016.[70] Mr. Carlson presented on the work of WCRP in regards to addressing scenarios that limit warming in 2100 to below 1.5 °C, developments in the coordinated regional climate downscaling experiment (CORDEX)[71] and research on slow onset events.

21. Mr. Carlson explained that the coupled model intercomparison project phase 5 (CMIP 5) produced a huge amount of data for a range of RCPs. As shown in figure 1, a lot of the data relates to low-emission scenarios for temperature increases of 1.5 – 2 °C. Only about 20 per cent of the data has been analyzed for use by the IPCC fifth assessment report. All of the data has been made available by the WCRP for further analysis.[72]

22. Mr. Carlson then gave a brief overview of the coupled model intercomparison project phase 6 (CMIP 6). He highlighted the matrix for the new scenario framework that facilitates the coupling of SSPs with the representative concentration pathways, as shown in figure 2. The SSPs were also described in detail at the dialogue in two posters (see paragraph 13). An important part of CMIP 6 is the inclusion of a number of scenarios including an ultra-low emissions scenario (RCP2.0–SSP1). The outcome of CMIP 6 will be used to input into IPCC AR6, although it will not be available for the IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related GHG emission pathways to be published in 2018. A preliminary example output is shown in Figure 3.

Figure 1
Global mean surface temperature increase as a function of cumulative total global CO_2 emissions

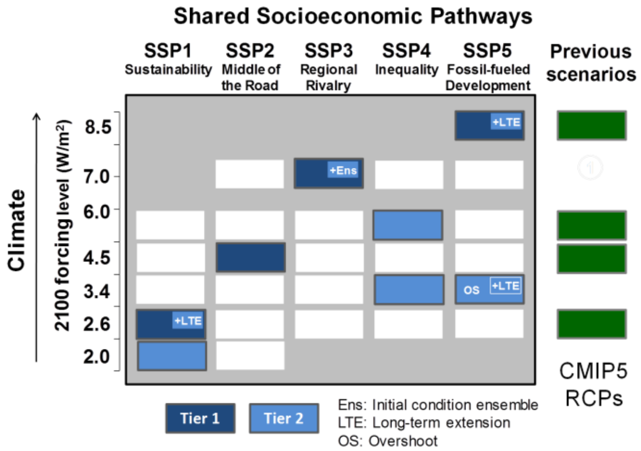


Source: Slide 5 of the presentation by Mr. David Carlson.
Note: Simulated global mean surface temperature increase as a function of cumulative total global CO_2 emissions Figure SPM.10 from IPCC, 2013: Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1–30, doi:10.1017/CBO9781107415324.004.

[68] <http://unfccc.int/files/science/workstreams/research/application/pdf/part2_wcrp_carlson_yess_unfccc.pdf>.
[69] <http://www.yess-community.org/>.
[70] <http://www.climate-lab-book.ac.uk/spirals>.
[71] <http://www.cordex.org>.
[72] See <http://www.wcrp-climate.org/wgcm-cmip/wgcm-cmip5>.

23. In regards to regional modelling, the WCRP are carrying out three climate model simulation runs at RCP2.6 for the EURO-CORDEX domain. These runs are funded and will be carried out in 2016 at high resolution of 25 km to support an EU initiative on 1.5 °C. WCRP have developed a plan for **a regional atlas and a series of indices for Africa** based on the almost 20 individual model runs already undertaken by CORDEX in the region, systematically analyzed for 1.5, 2, 3 and 4 °C, at a resolution of 25 km, and perhaps higher in some areas. The products would come out in 2017 to be available for input into the IPCC special report the impacts of global warming of 1.5°C above pre-industrial levels and related GHG emission pathways. Funding is currently being sought.

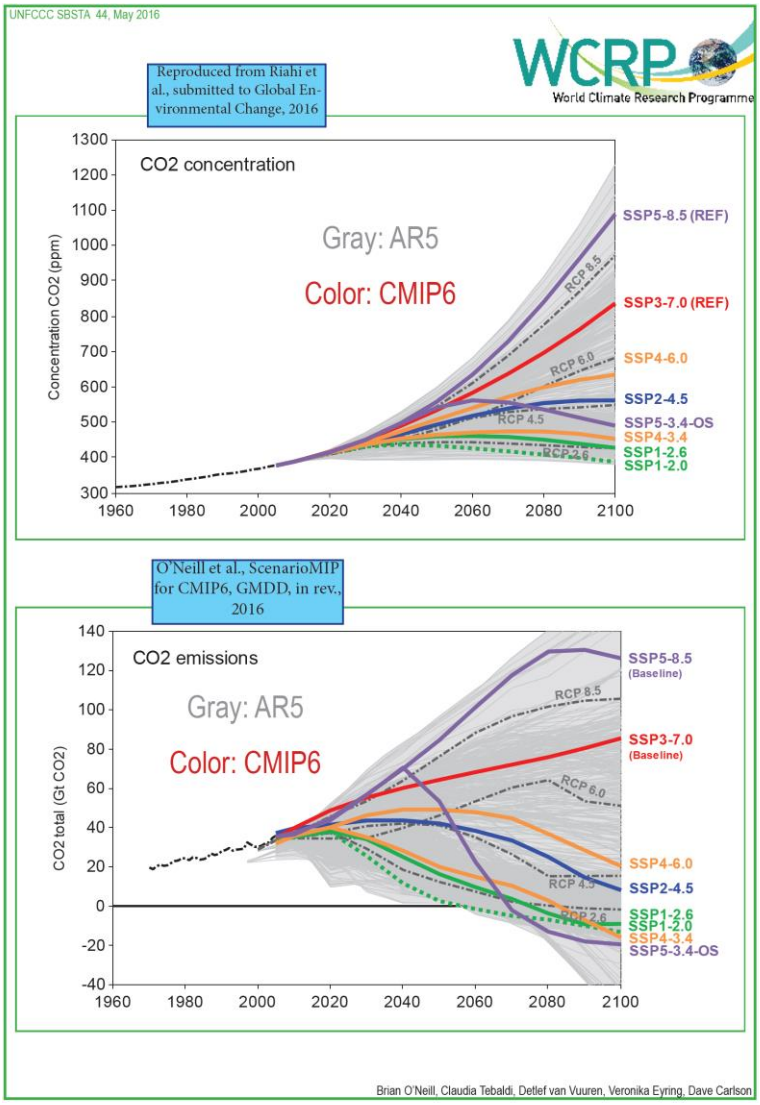
Figure 2
Future scenarios in Coupled Model Intercomparison Project 6



Source: Slide 9 of the presentation by Mr. David Carlson.[73]
Note: The matrix shows the representative concentration pathways (RCPs) and shared socioeconomic pathways (SSPs) that will be undertaken in CMIP 6 and the models that will be run at Tier 1 (>10 model runs by individual research groups) and Tier 2 (<10 model runs by individual research groups).

[73] O'Neill et al. (2016). The Scenario Model Intercomparison Project (ScenarioMIP) for CMIP6, Geoscientific Model Development. <https://doi.org/10.5194/gmd-2016-84>.

Figure 3
The shared socio-economic pathways in CMIP6 and preliminary proposals of carbon dioxide emissions.

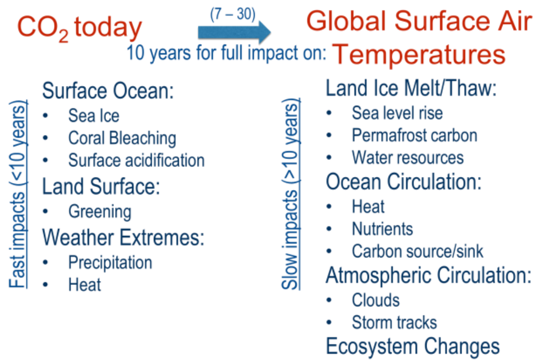


Source: Slide 10 of the presentation by Mr. David Carlson and Figure 2 of the WCRP poster described in paragraph 16.[74]
Notes: (1) The SSPs were implemented in six integrated assessment models (IAMs) to derive associated baseline and mitigation scenarios; (2)The figure shows the range of SSP baseline emissions scenarios by IAMs (preliminary data) (3) The grey area shows the range of results in CMIP5; (4) The coloured lines are the proposals for CMIP 6. (5) The green lines indicate the low emission scenarios at SSP1 – RCP2.0 and SSP1-RCP2.6.

24. Mr. Carlson then presented several slides on slow onset events. He encouraged delegates to consider them not as individual events but within a framework. He highlighted that there is a 10-year lag in the atmospheric system in regards to how CO_2 concentrations affect global air temperature. This means that the global surface air temperatures that we are experiencing today are a result of CO_2 concentrations from 10 years ago and that the CO_2 concentrations that are in the atmosphere today will directly influence the global surface air temperatures in 10 years' time. He thus emphasized that the framework would consider "fast impact" events to be those that occur within a 10-year period and slow impact events to be those that occur over periods longer than 10 years (Figure 4).

[74] Reference for figure 3a: Riahi et al. (2016). Submitted to Global Environmental Change.
Reference for figure 3b: O'Neill et al. (2016). The Scenario Model Intercomparison Project (ScenarioMIP) for CMIP6, Geoscientific Model Development. <https://doi.org/10.5194/gmd-2016-84>.

Figure 4
Fast and slow impact events



Source: Slide 15 of the presentation by Mr. David Carlson.
Notes: (1) The framework of fast-impact events and slow impact events in regards to climate change; (2) Ecosystem changes include desertification and biodiversity loss.

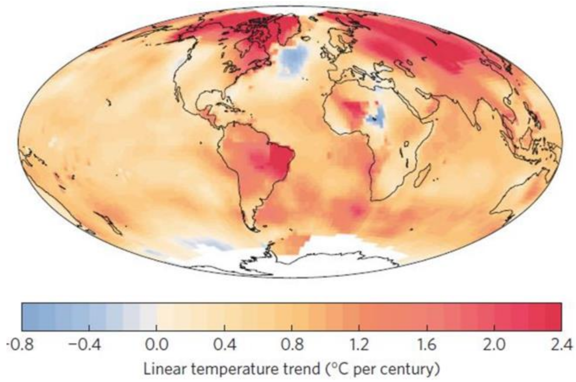
25. Mr. Carlson highlighted examples of research in regards to slow onset events:

(a) On **sea level rise,** he pointed delegates to the poster from the IPCC (see paragraph 15);

(b) On **ocean circulation**, Mr. Carlson highlighted the work of Rahmstorf et al. (2015)[75] investigating the global surface temperature trends over land and ocean for the twentieth century and the areas of cooling identified (figure 5). Although the blue area over central Africa is an artefact due to insufficient data in this region, the cooling area in the North Atlantic is likely caused by a **slowdown of the deep ocean circulation over the twentieth century**, predicted by climate models and related to freshwater flowing into the ocean from Greenland melt. This slowdown of the deep ocean circulation could have a slow but serious impact on the planet, including nutrient supply for ecosystems in the Pacific, Atlantic and Indian oceans; heat uptake by the ocean; and the capacity of the ocean at high latitudes in the north and south to function as a strong CO_2 sink.

(c) On **atmospheric circulation**, Mr. Carlson highlighted the work of Francis and Vavrus (2015)[76] which identified that there is a recent, greater than 30 per cent, decrease in jet stream winds over the North Atlantic ocean with impacts on global air flow as a result. This is new and emerging science since the completion of AR5 and the paper reports that the flow of air east to west is slower and north to south is wavier causing more cold air to move south and more warm air to move north. Impacts include blocking of storm systems so that they stay in one place for a longer time and thus the events in these storm systems, including extreme events, have longer durations.

Figure 5
Global linear temperature trend 1900 to 2013



Source: Slide 16 of the presentation by Mr. David Carlson.
Notes: The cooling in the subpolar North Atlantic is remarkable and well documented by numerous measurements – unlike the cold spot in central Africa, which on closer inspection apparently is an artefact of incomplete and inhomogeneous weather station data.[77]

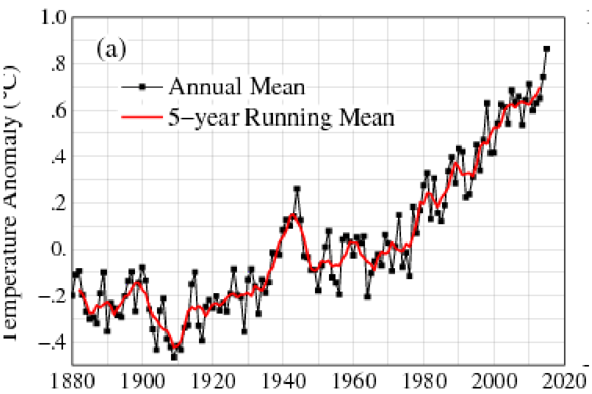
[75] Rahmstorf, S., Box, J., Feulner, G., Mann, M., Robinson, A., Rutherford, S., Schaffernicht, E. (2015): Exceptional twentieth-century slowdown in Atlantic Ocean overturning circulation. Nature Climate Change (online).
[76] Francis and Vavrus (2015): Evidence for a wavier jet stream in response to rapid Arctic warming Environ. Res. Lett. 10 014005. <http://iopscience.iop.org/1748-9326/10/1/014005>.
[77] See also <http://www.realclimate.org/index.php/archives/2015/03/whats-going-on-in-the-north-atlantic/>.

26. Mr. Carlson concluded by highlighting the current WCRP work on its Water Availability Grand Challenge where the focus is on three major food producing regions of the world: the Great Plains and Central Valley of North America, the Pannonian Basin of Europe, and the rice and wheat regions of southeast Asia. WCRP are integrating and linking their work with the work of CORDEX in these regions and thus strengthening the research base to engage with external stakeholders including agricultural regional and urban regional managers to focus on water management for these food basket regions.

27. Mr. Panmao Zhai, Co-Chair of Working Group I, IPCC, then presented on the science that has emerged since AR5 in regards to the **understanding and the gaps in knowledge on temperature change**. AR5 identified that warming of the climate system is unequivocal, and since 1950 many of the observed changes are unprecedented over decades to millennia. Each of the last three decades has been successively warmer than any preceding decade.[78]

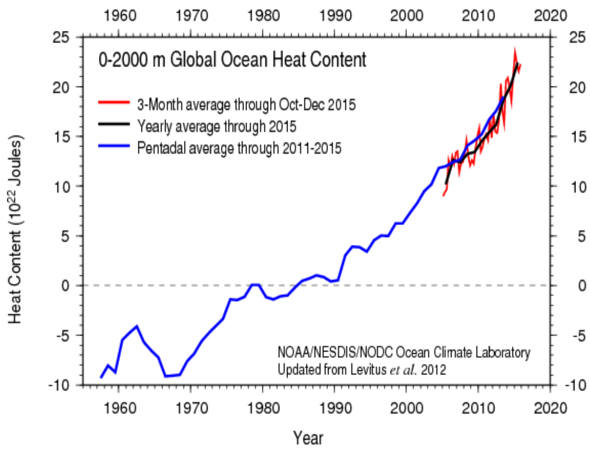
28. Recent updated observations since AR5 reaffirm that global warming is continuing in the atmosphere (Figure 6) and in the ocean (Figure 7). Mr. Zhai noted that for 2015, records show a global average increase of 1 °C but warned that this needs to be seen in context using a decadal average measurement, as there is a large amount of inter-annual and decadal variability in the climate system not related to external forcing and human activity. He further noted that, prior to the recent increase in global atmospheric temperature, the reported hiatus period in average global temperature increase was not reflected by the measurements of heat content in the ocean, where 90 per cent of the increased heat from global warming is trapped.

Figure 6
Changes in global mean temperature



Source: Slide 4 of the presentation by Mr. Panmao Zhai.
Notes: (1)Annual and five-year mean global surface temperature anomalies; (2) The base period is 1951–1980 [79]

Figure 7
Changes in global ocean heat content



Source: Slide 4 of the presentation by Mr. Panmao Zhai.
Note: Global Heat Content 1955 to present, 0–2000 meters layer[80]

29. Mr. Zhai highlighted that, in regards to future projections, the AR5 reported that global surface temperature change for the end of the twenty-first century is likely to exceed 1.5 °C relative to 1850 to 1900 for all RCP scenarios except RCP2.6.[81] He identified that **a focus in AR6 could be to narrow the projection uncertainty as well as provide more clarity on the reference period to preindustrial levels**. He stated that it is important to remember that warming will continue, but exhibit interannual-to-decadal variability and will not be regionally uniform.

30. Mr. Zhai concluded with some of the key challenges for the science community:

(a) There is a need for further work to **understand changes in diurnal temperature ranges** as these are related to agriculture, ecosystems and growing seasons.

[78] See Figure SPM.1 < http://www.climatechange2013.org/images/figures/WGI_AR5_FigSPM-1.jpg>, in IPCC, 2013: Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1–30, <https://doi.org/10.1017/CBO9781107415324.004>.

[79] <http://www.columbia.edu/~mhs119/Temperature/>.

[80] <https://www.nodc.noaa.gov/OC5/3M_HEAT_CONTENT/>.

[81] See Figure SPM.7(a) <http://www.climatechange2013.org/images/figures/WGI_AR5_FigSPM-7.jpg>.

(b) For effective impact assessments, there is a need to look more closely at **regional differences in temperature and precipitation changes**. Furthermore future projections must be combined with precipitation at the regional level as uncertainties still exist in regards to impacts. Higher temperatures plus decreased precipitation may lead to drought but higher temperatures plus increased precipitation may be a good sign for ecosystems and agriculture. Obtaining this regional information will rely on CMIP5, CMIP6 and CORDEX.

(c) There is continuing emerging research on global temperature and regional aspects, however questions exist in regards to **rates of change** under different scenarios.

(d) There are new findings on **climate sensitivity**, suggesting that the climate has higher sensitivity to aerosol and cloud processes than previously thought. Better understanding of these processes is important for multi-model spread, understanding climate response to forcing and making emission scenarios compatible with targets.

31. Ms. Carolin Richter, GCOS, presented on new findings and emerging needs in regards to **the global climate observing system**. She began by highlighting that the long-time series of data collected by the observation community form the foundation on which the science (WCRP) and assessment (IPCC) community rely, and which are ultimately vital for decision-making under the UNFCCC (see paragraph 11). GCOS and the UNFCCC have a long history including the provision by GCOS of adequacy reports in 1998[82] and 2003,[83], implementation plans in 2004[84] and 2010,[85] and progress reports on these plans in 2009[86] and 2015.[87]

32. The new GCOS Implementation Plan 2016 will be presented at COP 22. Advances from the previous plan, which is now 10 years old, include **broadening the scope to include the global Earth's environmental cycles – the energy, carbon and water cycles – and take into account the Sustainable Development Goals and the needs of the Paris Agreement**. The new plan will advise on new requirements for measures needed for adaptation and mitigation, lay out a new strategic approach to further implement the GCOS, and introduce a section on cross-cutting disciplines and on scientific and technological challenges.

33. Messages from the recent GCOS Open Science Conference, March 2016, will also be taken into account in the IP 2016. These include the need for: a comprehensive set of relevant climate indicators to assist communication; integrated observing systems for satellite and in-situ observations; decreasing the fragility of core in-situ networks; closing the carbon, energy and water cycle to completely monitor the climate system; climate research to exploit the full potential of global climate observing systems to innovate and stimulate climate services; including chemistry and biology in models as a result of advances in new sensor technologies; stressing the economic benefit of investing in observations; and making systematic observations and knowledge available to users.

34. Ms. Richter highlighted the possible new ECVs in IP 2016 (figure 8) as well as highlighting the needs that GCOS have identified in regards to the Paris Agreement (figure 9).

[82] <https://www.wmo.int/pages/prog/gcos/Publications/gcos-48.pdf>.
[83] <https://www.wmo.int/pages/prog/gcos/Publications/gcos-82_2AR.pdf>.
[84] <https://www.wmo.int/pages/prog/gcos/Publications/gcos-92_GIP.pdf>.
[85] <http://www.wmo.int/pages/prog/gcos/Publications/gcos-138.pdf>.
[86] <http://www.wmo.int/pages/prog/gcos/Publications/gcos-129.pdf>.
[87] <http://www.wmo.int/pages/prog/gcos/Publications/GCOS-195_en.pdf> or <http://www.wmo.int/pages/prog/gcos/Publications/GCOS-195_en_LowRes.pdf>.

Figure 8
Draft essential climate variables in the new GCOS 2016 implementation plan

Measurement Domain	Essential Climate Variables (ECVs)
Atmospheric	Surface: Air temperature, Wind speed and direction, Water vapour, Pressure, Precipitation, Surface radiation budget. Upper-air: Temperature, Wind speed and direction, Water vapour, Cloud properties, Earth radiation budget, Lightning. Composition: Carbon Dioxide (CO_2), Methane (CH_4), Other long-lived greenhouse gases (GHGs), Ozone, Aerosol, Precursors for aerosol and ozone.
Oceanic	Physics: Temperature, Sea Surface Temperature, Salinity, Sea Surface Salinity, Currents, Surface Currents, Sea Level, Sea State, Sea Ice, Ocean Surface Stress , Ocean Surface heat Flux Biogeochemistry: Inorganic Carbon, Oxygen, Nutrients, Transient Tracers, Nitrous Oxide (N_2O), Ocean Colour Biology/ecosystems: Plankton, Marine habitat properties
Terrestrial	Hydrology: River discharge, Groundwater, Lakes, Soil Moisture Cryosphere: Snow, Glaciers, Ice sheets and Ice shelves, Permafrost Biosphere: Albedo, Land cover, Fraction of absorbed photosynthetically active radiation, Leaf area index, Above-ground biomass, Soil carbon, Fire, Land Surface Temperature Human use of natural resources: Water use, GHG fluxes

New: Aerosols and Precursors

New: clear distinction between physics – bio-geochemistry – biology and ecosystems; heat fluxes

New: clearer emphasis on biosphere; land surface temperature; GHG fluxes

Source: Slide 6 of the presentation by Ms. Carolin Richter and the ECV table is provided from the draft GCOS Implementation Plan available for public review25 July to 5 September 2016.
Note: Current and proposed essential climate variables as part of the GCOS Implementation Plan 2016.

Figure 9
Current identified observation needs to support the Paris Agreement

UNFCCC	Needs	
Adaptation	Meteorological data e.g. Temp, precipitation, wind, humidity Ecosystem status e.g. Ocean colour, Land cover, soil moisture Coastal zone e.g. Sea level, sea state, topography, subsidence Ocean acidity, Glaciers, Dust, Snow water equivalent…	Also need high resolution local data. Gaps exist in vulnerable areas
Mitigation	Land cover (e.g. forest monitoring to support REDD+) GHG emissions	Many forest monitoring activities exist
Transparency	GHG emissions, Land cover, above ground biomass Atmospheric composition	Validation of emission inventories
Global Stock Taking	GHG emissions, temperature, precipitation Glaciers, Ice Sheets, Sea Ice Land cover/vegetation Ocean heat content, acidity & colour, sea level Atmospheric composition,	Monitoring needs unclear
Public Awareness	Temperature, sea level, ocean heat content, summer arctic sea ice extent, glacier mass balance, snow cover, specific humidity …	Indicators to be decided
Capacity Building	GCOS Cooperation Mechanism currently focussed on meteorological data	Extend to terrestrial area?

Source: Slide 7 of the presentation by Ms. Carolin Richter.

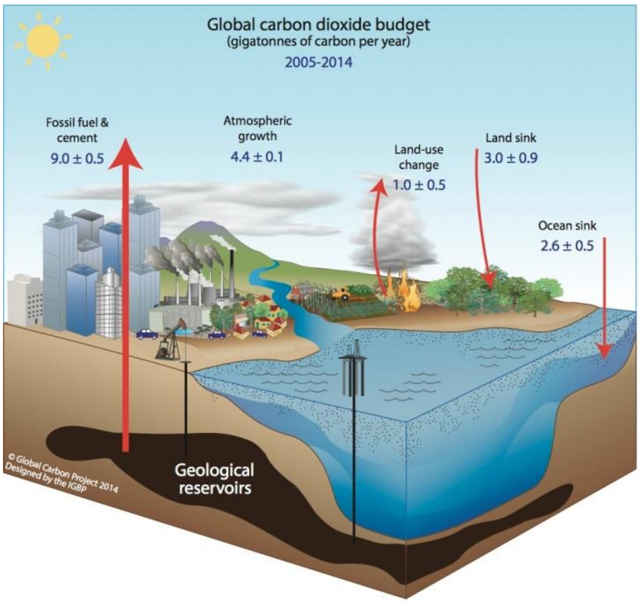
35. Ms. Masson-Delmotte, Co-Chair of Working Group I, IPCC, then presented on behalf of Mr. Philippe Ciais on new findings from the Global Carbon Project in regards to observational constraints on the global carbon budget and preliminary analysis of the 2015 anomaly. She began by highlighting that this work is only possible with a huge amount of collaboration. At present, there are 106 contributors in 68 organisations across 15 countries. All data, analysis and information is available from the Global Carbon Project[88] and Global Carbon Atlas website.[89]

36. Ms. Masson-Delmotte stated that in 2015, atmospheric CO_2 concentrations reached 400 ppm, in a year where average global temperature peaked at approximately 1 °C above pre-industrial levels and there was an extreme El Niño event which played a role in the magnitude of the temperature anomaly. She explained that changes in the atmospheric CO_2 concentration are due to changes in fluxes into the atmosphere from human activity from fossil fuels, the cement industry, land use change, as well as from human interference with the natural system, and the uptake of CO_2 by the ocean and through terrestrial

[88] <http://www.globalcarbonproject.org>.
[89] <http://www.globalcarbonatlas.org>.

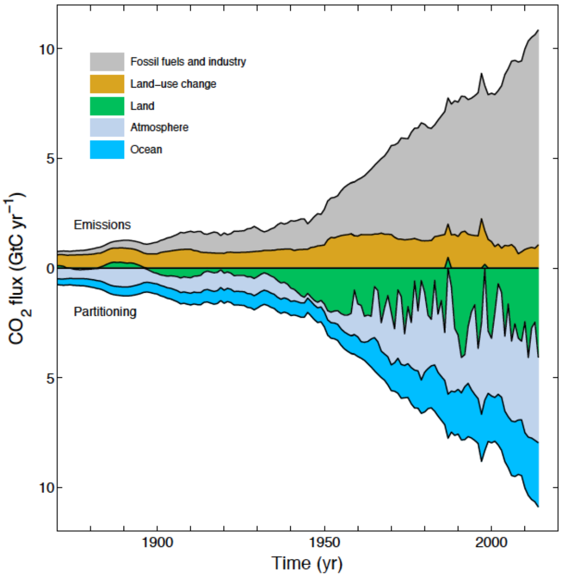
and natural ecosystems. Figure 10 shows information on the global carbon budget, updated from AR5, identifying sources and sinks of CO_2.[90] This information, represented over time, is shown in figure 11.

Figure 10
Global carbon budget – sources and sinks of CO_2



Source: Slide 6 of the presentation by Ms. Valérie Masson-Delmotte.
Note: Schematic representation of the overall perturbation of the global carbon cycle caused by anthropogenic activities, averaged per year globally for the decade 2005–2014. The arrows represent emission from fossil fuels and industry, emissions from deforestation and other land-use change, the growth of carbon in the atmosphere and the uptake of carbon by the "sinks" in the ocean and land reservoirs. All fluxes are in units of GtC yr^{-1}.
See Le Quéré et al. (2015). Global Carbon Budget 2015. Earth Syst. Sci. Data, 7, 349–396. <www.earth-syst-sci-data.net/7/349/2015/>. doi:10.5194/essd-7-349-2015.

Figure 11
Global carbon budget – Annual anthropogenic CO_2 emission and their partitioning among atmosphere, land and ocean from 1750 to 2014



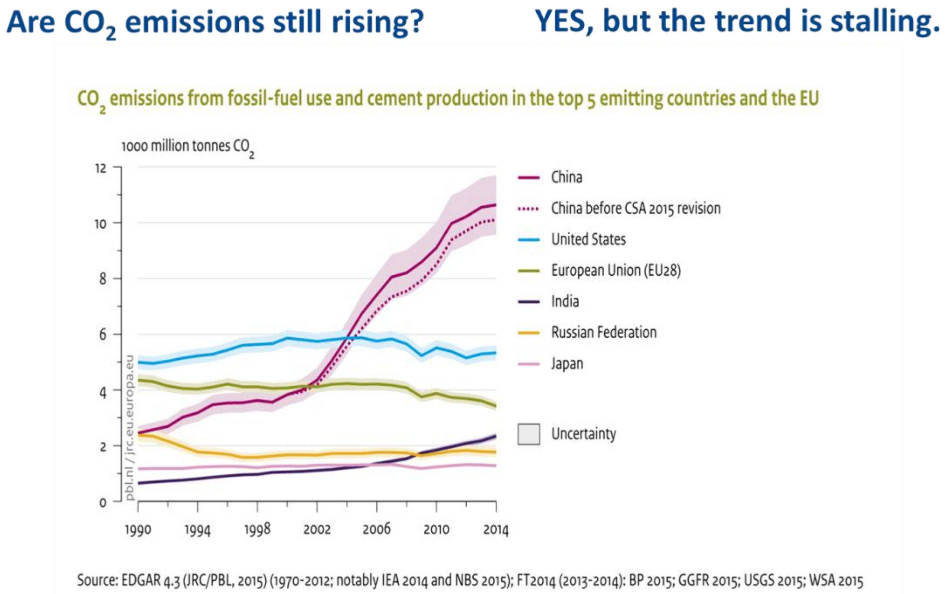
Source: Slide 6 of the presentation by Ms. Valérie Masson-Delmotte.
Notes: (1) Combined components of the global carbon budget illustrated in Figure 5 as a function of time: above the line emissions from: grey - fossil fuels and cement industry; brown – land-use change; (2) Below the line partitioning of emissions among: light blue – atmospheric increase of CO_2; green – land; dark blue – oceans; (3) All-time series are in GtC yr^{-1}.
Source data from: CDIAC/NOAA-ESRL/GCP/Joos et al. 2013/Khatiwala et al. 2013.
NB: The Global Carbon Project synthesis of global CO_2 budget for 2015 is scheduled for publication by the end of 2016.

37. Ms. Masson-Delmotte identified that **carbon dioxide emissions are still rising in six of the top emitters but the trend is stalling**[91] over the most recent two years (figure 12). However, she also pointed out that 2015 had the highest atmospheric CO_2 growth rate ever observed: 3.15 ppm. This can be seen as a paradox where although the emissions are stalling, the growth rate of atmospheric CO_2 is the highest ever (figure 13). This paradox can be explained by the variability of carbon uptake by terrestrial ecosystems (as shown by the green area in figure 11), and the role of the extreme El Niño event on terrestrial carbon uptake. Attribution of terrestrial ecosystems as sources of CO_2 in 2015 include the abnormal fire emissions in Southeast Asia,[92] droughts in Europe and Central Asia, and sources of CO_2 over tropical regions during the development of the 2015 El Niño.[93]

38. Ms. Masson-Delmotte also referred delegates to: the CO_2 report[94] which provides the vision and strategy for the EU Copernicus initiative for a **European integrated observation system** dedicated to the monitoring of fossil CO_2 emissions with independent atmospheric observations; and the work of Future Earth in supporting the public understanding of science including on the global carbon budget (slide 15 of the presentation).

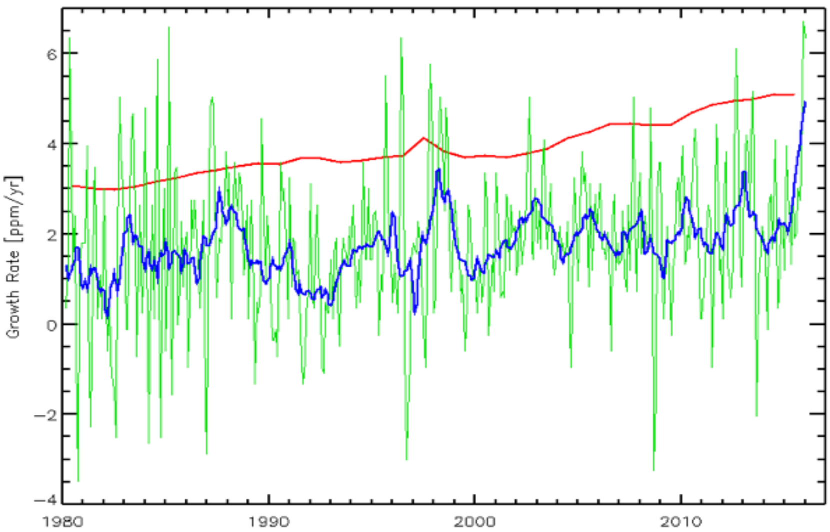
[90] Le Quéré et al. (2015). Global Carbon Budget 2015. Earth Syst. Sci. Data, 7, 349–396. <www.earth-syst-sci-data.net/7/349/2015/>. <https://doi.org/10.5194/essd-7-349-2015>.
[91] Qi et al. (2016). China's post-coal growth, Nature Geoscience 9, 564–566. <https://doi.org/10.1038/ngeo2777>.
[92] Yin et al submitted.
[93] Copernicus Core service MACC III inversion of CO2 fluxes.
[94] <http://www.copernicus.eu/main/towards-european-operational-observing-system-monitor-fossil-co2-emissions>.

Figure 12
CO_2 emissions from fossil-fuel use and cement production in the top five emitting countries and the EU



Source: Slide 8 of the presentation by Ms. Valérie Masson-Delmotte.
Note: CO_2 emissions from fossil-fuel use and cement production in the top five emitting countries and the EU since 1990.[95]

Figure 13
Growth of atmospheric CO_2 concentrations over time showing the sharp increase in 2015



Source: Slide 10 of the presentation by Ms. Valérie Masson-Delmotte.
Notes: (1) In red : CO_2 growth rate expected from anthropogenic emissions if sinks would be constant; (2) In blue : 12-months smoothed CO_2 observed growth rate; (3) In green : monthly CO_2 growth rate.
Data from NOAA ESRL Mauna Loa station,
Figure Courtesy of F.M. Bréon[96]

39. Mr. Gerald Lindo, on behalf of the Alliance of Small Island States (AOSIS), then presented on recent findings from two key papers that outline how the risks and impacts of climate change increase between 1.5 and 2 °C for slow onset events, as well as for extreme events and abrupt shifts.

[95] For further information see figure 2.2, Trends in Global CO_2 Emissions 2015 Report <http://edgar.jrc.ec.europa.eu/news_docs/jrc-2015-trends-in-global-co2-emissions-2015-report-98184.pdf>.
[96] <http://www.esrl.noaa.gov/gmd/ccgg/trends/global.html>.

40. Mr. Lindo highlighted research providing a systematic screening of the IPCC AR5 climate models that identified evidence of 37 forced regional abrupt changes in the ocean, sea ice, snow cover, permafrost and terrestrial biosphere under climate change.[97] The study showed that under 1.5 °C approximately 20 per cent of the thresholds for these abrupt changes would be crossed. At 2 °C there would be a dramatic increase to 50 per cent of thresholds crossed.

41. Mr. Lindo then detailed research providing a regional assessment of differences between 1.5 °C and 2 °C based on a consistent and comprehensive assessment of existing projections using 11 key impact indicators, including extreme events, water availability, crop yields, sea level rise and coral reefs at risk.[98] Mr. Lindo highlighted the impacts at the two temperature ranges (figure 14), in particular global sea level rise which is predicted to be 30 per cent lower at 1.5 than 2 °C – a difference which has an impact on long term sea level rise beyond the end of the century. In terms of the fraction of coral reefs at risk from annual bleaching, he stated that all scenarios are catastrophic – however, under 1.5 °C there is a chance of some ecosystem adaptation.

Figure 14
Summary of key differences in climate impacts between a warming of 1.5 ºC and 2 ºC above pre-industrial and stylized 1.5 ºC and 2 ºC scenarios over the 21st century

	1.5°C	2°C	
Heat wave (warm spell) duration [month]			
Global	1.1 [1;1.3]	1.6 [1.4;1.8]	Tropical regions up to 2 months at 1.5°C or up to 3 months at 2°C
Reduction in annual water availability [%]			
Mediterranean	9 [5;16]	17 [8;28]	Other dry subtropical regions like Central America and South Africa also at risk
Increase in heavy precipitation intensity [%]			
Global	5 [4;6]	7 [5;7]	Global increase in intensity due to warming; high latitudes (>45°N) and monsoon regions affected most.
South Asia	7 [4;8]	10 [7;14]	
Global sea-level rise			
in 2100 [cm]	40 [30;55]	50 [35;65]	1.5°C end-of-century rate about 30% lower than for 2°C reducing long-term SLR commitment.
2081-2100 rate [mm/yr]	4 [3;5.5]	5.5 [4;8]	
Fraction of coral reef cells at risk of long-term degradation [Constant case, %]			
2050	90 [50;99]	98 [86;100]	Only limiting warming to 1.5°C may leave window open for some ecosystem adaptation.
2100	70 [14;98]	99 [85;100]	
Changes in local crop yields over global and tropical present day agricultural areas including the effects of CO_2-fertilization [%]			
Wheat Global	2 [-6;17]	0 [-8;21]	Projected yield reductions are largest for tropical regions, while high-latitude regions may see an increase. Projections not including highly uncertain positive effects of CO_2-fertilization project reductions for all crop types of about 10% globally already at 1.5°C and further reductions at 2°C.
Wheat Tropics	-9 [-25;12]	-16 [-42;14]	
Maize Global	-1 [-26;8]	-6 [-38;2]	
Maize Tropics	-3 [-16;2]	-6 [-19;2]	
Soy Global	7 [-3;28]	1 [-12;34]	
Soy Tropics	6 [-3;23]	7 [-5;27]	
Rice Global	7 [-17;24]	7 [-14;27]	
Rice Tropics	6 [0;20]	6 [0;24]	

Source: Slide 4 of the presentation by Mr. Gerald Lindo (corrected according to Carl-Friedrich Schleussner et all, Earth System Dynamics (2016), <http://www.earth-syst-dynam.net/7/327/2016/esd-7-327-2016-corrigendum.pdf>).
Note: Square brackets give the likely (66 per cent) range

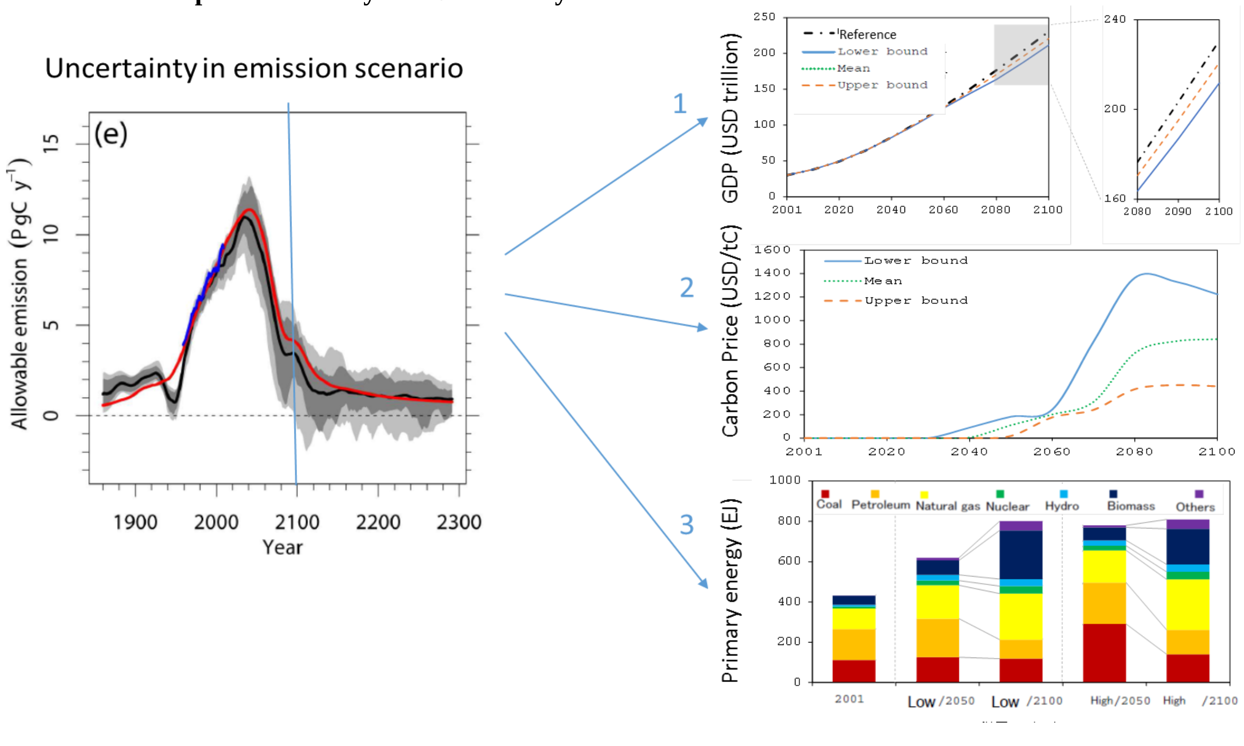
42. Mr. Michio Kawamiya spoke on the implications from coupled climate – carbon cycle modeling on socioeconomic scenario development, particularly in regards to the uncertainty ranges that currently exist. He highlighted figure 1 (see above) and its importance for determining transient climate response to

[97] Drijfhout, S. *et al.* (2015) Catalogue of abrupt shifts in Intergovernmental Panel on Climate Change climate models. *Proc. Natl. Acad. Sci.* 201511451. <https://doi.org/10.1073/pnas.1511451112>.
[98] Schleussner et al. (2016): Differential climate impacts for policy-relevant limits to global warming: the case of 1.5 °C and 2 °C Earth Syst. Dynam., 7, 1–25, 2016 <https://doi.org/10.5194/esd-7-1-2016>.

cumulative carbon emission (TCRE).[99] He stated that TCRE is one of the highlights in IPCC AR5 and often referred to as a measure for the amount of CO_2 the society can emit in order to achieve the 2 °C target. It is however equally important to grasp the **impacts of uncertainty in TCRE on socioeconomics and that efforts should be directed towards an agreement upon the best guess and uncertainty range of TCRE**.

43. He showed that a slight change in TCRE within the current range of model uncertainty may result in a significant difference in estimated mitigation cost (figure 15).[100] In this regard, the uncertainty estimate of mitigation cost should consider responses of both carbon cycle and climate to increasing CO_2.

Figure 15
Socioeconomic impact of Earth system uncertainty

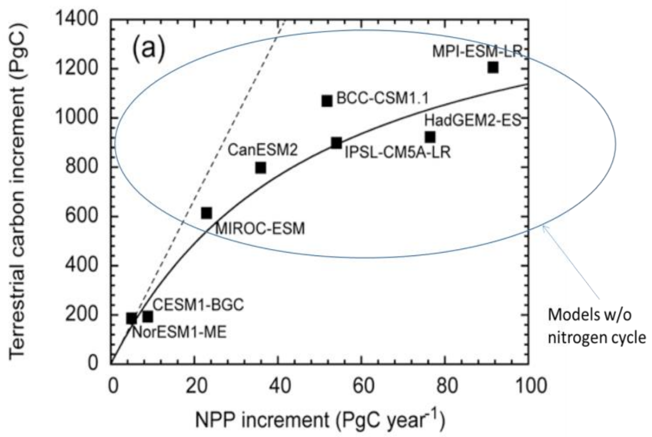


Source: Slide 5 of the presentation by Mr. Kawamiya.
Note: The intermediate stabilization scenario (RCP4.5) was used to calculate the amount of carbon that can be emitted to realize annual target concentrations and calculate: (1) GDP – in the case of a small amount of emitted carbon GDP is 4.1 per cent lower than GDP in the case of a large amount of carbon; (2) carbon price – a three-fold difference in carbon price was shown between the higher and the lower bound emission scenario targeting the same concentration scenario; (3) energy demand – the estimated total demand for primary energy in 2100 does not differ greatly between the smallest and the largest emission cases but the demand structure differs. In the largest emission case, the use of fossil fuels is relatively large. In the smallest emission case, on the other hand, the use of fossil fuels is relatively suppressed. Instead, the use of renewable energy will increase,in particular, the proportion of biomass is expected to be the largest.[36]

44. Mr. Kawamiya highlighted that there is a wide variation between models of the amount of absorption of CO_2 by terrestrial ecosystems (Figure 16), with one of the main factors causing this variation being incorporation of the nitrogen cycle into models and thus how modellers parenthesise photosynthesis. Only two models used in CMIP5 incorporated the nitrogen cycle. Although studies on this issue are in their infancy and there is no evidence that any one model is better than the other, Mr. Kawamiya stated that it is an urgent task to **incorporate the nitrogen cycle into Earth system models**, which may show more clearly how the global carbon cycle reacts to climate change and thus reduce the uncertainty in TCRE.[101]

[99] Transient climate response to cumulative carbon emission (TCRE) is defined by the IPCC as the global mean surface temperature change per 1,000 GtC emitted to the atmosphere. TCRE is likely in the range of 0.8 °C to 2.5 °C per 1,000 GtC and applies for cumulative emissions up to about 2,000 GtC until the time temperatures peak.
[100] Matsumoto, K., Tachiiri, K, Kawamiya, M (2015): Impact of climate model uncertainties on socioeconomics: a case study with a medium mitigation scenario, Computers & Operations Research, 66, 374-383. <https://doi.org/ http://dx.doi.org/10.1016/j.cor.2015.01.011>.
[101] For further information, see <https://www.jamstec.go.jp/sousei/eng/program/theme_b-1.html>.

Figure 16
Scatter in estimated CO_2 uptake by terrestrial ecosystem



Source: Slide 6 of the presentation by Mr. Kawamiya.
Note: Modeled increase of soil carbon storage (net primary production, NPP) due to CO_2 fertilization effect. Only two of the models used in CMIP 5 incorporate the nitrogen cycle.

2. Summary of the discussion

45. Several Parties recognized the importance of the information provided by the IPCC, WCRP and the Global Carbon Project and the need to intensify research on low emission scenarios. Parties enquired how the IPCC will manage the special report as results from CMIP6 will not be available by 2018. They also asked how the focus on low emission scenarios will be shaped in the sixth assessment cycle.

46. An expert from the IPCC stated that the timeline for the special report is very short, however it does allow two years for the development of new research and new papers in order for them to be cited in the report. New research includes: methodologies that are being developed that were not available for the AR5; new research initiatives using CMIP5 projections; and new model inter-comparison projects, such as Happimip,[102] that can build new knowledge. The IPCC expert stated that the information needed for the special report is a strong incentive for the research community. The report also has the opportunity to provide an incentive to Parties for new funding for research.

47. A representative of the Adaptation Committee (AC) asked the experts from IPCC, on behalf of the committee, how the uncertainty of scenarios will be reduced when there was a surprising paradox in 2015 (see paragraph 37) and thus these surprises in the climate system could make it difficult to reduce uncertainty. An expert from the IPCC stated that the role of the IPCC is to assess the available information which includes a strong focus on uncertainty. She identified that the WCRP is developing new findings and new approaches to inform climate sensitivity, particularly on the role of clouds, convection and atmospheric circulation combining both new observations and modelling. Findings from this new research should be available for the special report, or at the latest for use in AR6.

48. One Party enquired of the WCRP how much information is available in regards to ocean currents and changes in salinity in the areas where cooling has been identified in the northern Atlantic, south of Greenland (see paragraph 25). The expert from WCRP identified that there are systems that are measuring changes in the North Atlantic at 25 °N but these are expensive. Furthermore satellite measurements currently only measure surface salinity. Thus the observation community are trying to address this issue but it is difficult and expensive and long-time series are needed in order to observe trends.

49. One Party requested a post-Paris readjustment of focus for CMIP6 to prioritize the ultra-low emissions scenario as a Tier 1 scenario (see figure 2).

50. The expert from WCRP identify three issues in this regard: (1) the planet is already extremely close to 1.5 °C of warming and that needs to be recognized; (2) the scenarios are based around CO_2 emissions so it is difficult to say for a given model run that the output will be 1.5 °C, due to issues such as variations in climate sensitivity; (3) the difference in Tier 1 and Tier 2 lies in the number of modelling centers around the world that run the models – Tier 1 is when more than 10 modelling centers run models and Tier 2 is when it is less than 10 centers. For the ultra-low emission scenario to be Tier 1, more modelling centers would need to be encouraged to take this on.

[102] <http://www.happimip.org/>.

51. A Party asked what the implications of the GCOS IP 2016 were for different regions, noting the previous GCOS regional action plans,[103] in particular for small island regions and how GCOS and WCRP, can help fill data and information gaps.

52. A representative of the AC stated their appreciation of the work of GCOS in regards to the GCOS IP 2016 to enhance observations in order to support adaptation needs (see paragraphs 31-34), and stressed the importance of supporting this work and making this information more accessible and more useful for users.

53. The expert from GCOS stated that the GCOS status report 2015[104] recognized that there are deficiencies in observations for certain regions around the world and this will be taken up in the GCOS IP 2016. GCOS are now planning in 2017 to produce draft concepts for regional implementation plans which will be implemented in 2018 and beyond. Adaptation will be an important core element of these plans.

B. Part 2: Supporting scientific knowledge and capacity-building

1. Presentations by experts

54. The second part of the presentations was opened by Mr. Maxx Dilley, WMO, who spoke on the work of the **Global Framework for Climate Services** (GFCS), a priority area for the WMO and the Integrated Global GHG Information Systems (IG3IS). He explained that the GFCS define “climate services” as the processes of generating and providing information on past, present and future climate, and on the impacts on natural and human systems. They can comprise historical climate data sets, climate monitoring, climate watches, monthly/seasonal/decadal climate predictions, and climate change projections. The GFCS works in five climate sensitive sectors: water, health, disaster risk reduction, agriculture/food security and energy (including renewables) to help stakeholders’ decision-making and use of information and services appropriately, including aspects of language, probabilities and uncertainty (see paragraph 16).

55. Mr. Dilley gave examples of activities that are being undertaken:

(a) Data rescue – there are about 25 countries where the GFCS is supporting data rescue (Figure 7), which is recovery of data that has been often stored on paper. To be useful, the data is recovered, digitized, quality controlled, homogenized and put into a climate data management system to provide an important tool to see, for example, what the trends are and what the return periods of extreme events are;

(b) Strengthening observing systems[105] – these systems record all daily climate variables. In some areas the density of stations is insufficient and the WMO is working to build up more stations as well as prevent some current stations from deteriorating;

(c) Regional Climate Outlook Forums (RCOFs)[106] – have been established for all developing regions to share three-to-six-month seasonal climate forecasts in real time that are consensus-based and user-relevant in order to reduce climate-related risks and support sustainable development for the coming season in sectors of critical socioeconomic significance. He outlined that, for example, with the recent El Niño event, these forums can translate information from this event into regional conditions and the National Meteorological and Hydrological Services (NMHSs) then interpret this information for the public and stakeholders. For example, the Tanzania Meteorological Agency with support from the International Research Institute for Climate and Society (IRI) has predicted high probability of heavy rainfall and flooding in the case of La Niña occurring.[107]

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[103] <http://www.wmo.int/pages/prog/gcos/index.php?name=RegionalWorkshopProgramme>.

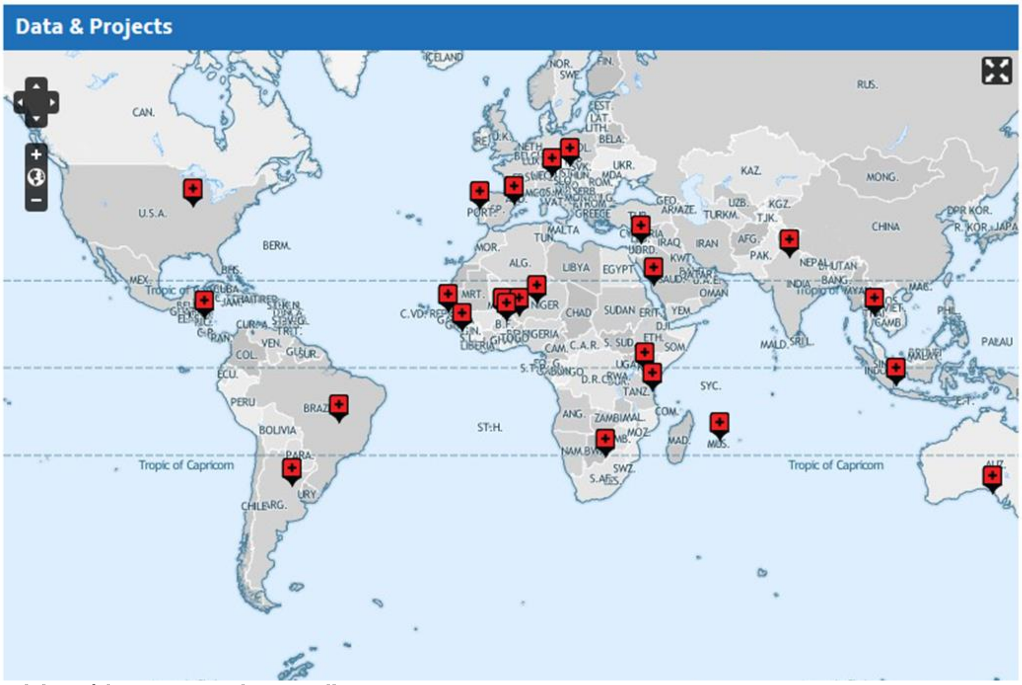
[104] <http://www.wmo.int/pages/prog/gcos/Publications/GCOS-195_en.pdf > or <http://www.wmo.int/pages/prog/gcos/Publications/GCOS-195_en_LowRes.pdf>.

[105] <https://oscar.wmo.int/surface/index.html#/>.

[106] <http://public.wmo.int/en/our-mandate/climate/regional-climate-outlook-products>.

[107] <http://maproom.meteo.go.tz/maproom/Climatology/Climate_Forecast/ENSO_Prob_Precip.html?season=May-Jul>.

Figure 17
The International Data Rescue (I-DARE) Portal



Source: Slide 6 of the presentation by Mr. Dilley.
Note: The International Data Rescue (I-DARE) Portal provides a single point of entry for information on the status of past and present worldwide to be rescued data and data rescue projects, on best methods and technologies involved in data rescue, and on metadata for data that need to be rescued.[108]

56. Mr. Dilley highlighted that NMHSs, such as the previous example from Tanzania, using climate services, are increasingly able to supply relevant climate information for decision-making to national stakeholders. He stated that if pursued systematically, comprehensively and in a sustained manner, measures to reduce negative climate impacts can lead to dramatically improved outcomes. For example, in Ethiopia, the drought of 1983–1984 caused 300,000 deaths. In 2009–2012 a drought of similar severity occurred in Somalia. Using climate information linked to decision-making, Ethiopia was able to provide support for the Somali refugees affected by the drought (Figure 18).

57. He summarized the way forward for the GFCS is to:

(a) Focus on 6–8 countries agreed by GFCS Partners Advisory Committee (PAC), to put in place comprehensive measures sufficient to demonstrate significant climate adaptation benefits, as in the example for Ethiopia;

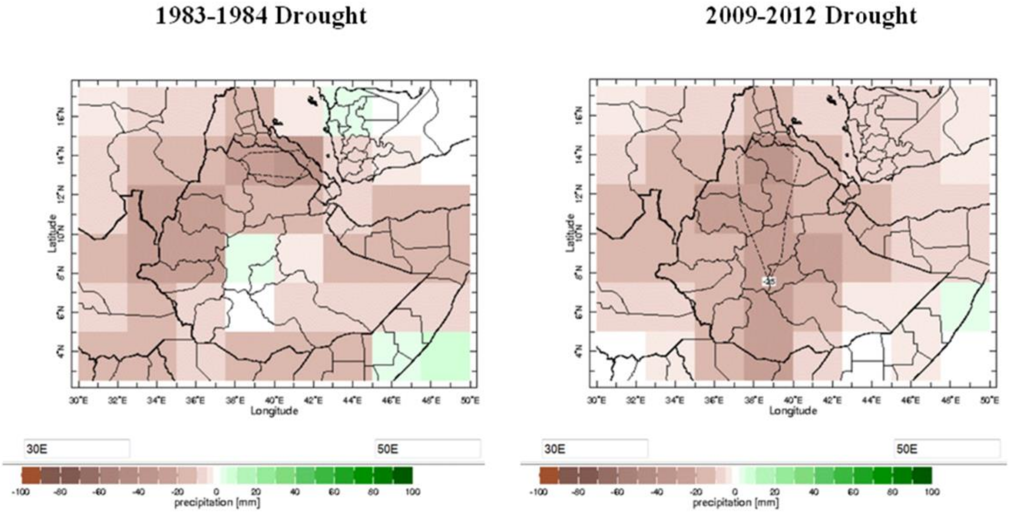
(b) The Climate Services Information System will provide a data, forecasting and decision support stream to support 70 countries in climate-sensitive decision-making;

(c) The GFCS partners are setting up coordination mechanisms in the GFCS priority areas, including through a proposal to the Green Climate Fund.

58. Mr. Dilley also highlighted the IG3IS, which is also a service to support decision-making (see paragraph 12). It allows greater precision in the measurement of GHGs in the atmosphere as well as where those GHGs are coming from in terms of location and type of emission source. This initiative will set up a global network in order to strengthen municipal, national and regional levels to implement GHG monitoring and help mitigation measures in support of the Paris Agreement.

[108] <https://www.idare-portal.org/>.

Figure 18
Rainfall anomaly maps for Ethiopia

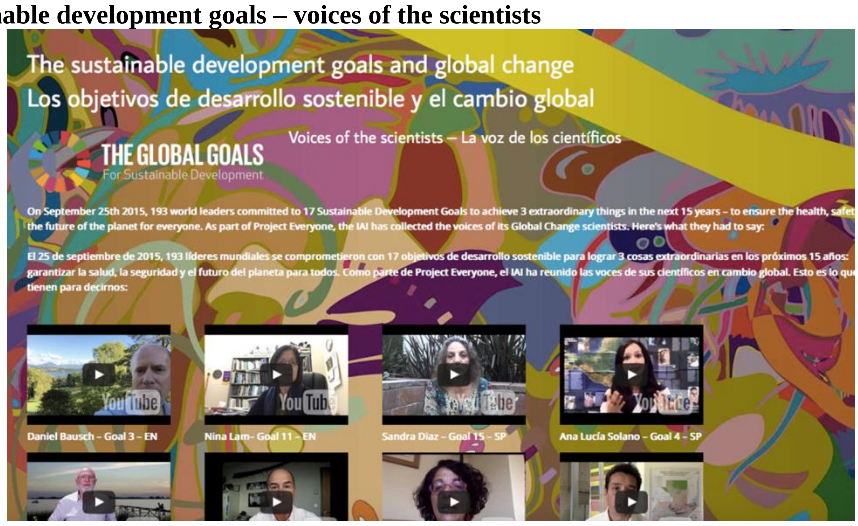


Source: Slide 10 of the presentation by Mr. Dilley.
Note: In 1983–1984, Ethiopia suffered a severe drought causing 300,000 deaths and severe hardship and loss of livelihood for thousands more (left hand side map). In 2009–2012, climate services were used to support decision-making so that Ethiopia was able to provide support to refugees from a similar drought in Somalia (right hand side map).

59. Ms. Ione Anderson then gave a presentation on the work of the IAI in connecting science and people. She highlighted the role of IAI in scientific networks such as the one led by Mr. Castellanos (see paragraph 18) in engaging a variety of stakeholders at the regional level to inform decision-making, given that the problems faced cannot be tackled by one nation as their impacts affect the region as a whole.

60. She highlighted that, to be effective, **science must be communicated to** stakeholders at three levels: **high-level decision makers**, including political leaders; **practitioners** in supporting organizations and mid-level technical officers in governments; **and local people** directly impacted by multiple stressors. This is a challenge to scientists: each of these groups needs a particular communication strategy, and scientists often do not have the time or skills to do both science and communication. It is therefore important that funding agencies recognize these communication needs and provide funds accordingly. She provided an example in regards to the sustainable development goals (Figure 19).

Figure 19
The sustainable development goals – voices of the scientists



Source: Slide 7 of the presentation by Mr. Anderson.
Note: Researchers of the IAI programmes taped video messages in English, Spanish and Portuguese based on their research to raise awareness of important issues and concerns under several themes of the United Nations goals.[109]

61. Ms. Anderson encouraged UNFCCC delegates to communicate their research needs to IAI member country representatives noting that IAI can assist member countries in identifying regional

[109] <http://www.iai.int/?page_id=9129>.

concerns that require integrated natural and social science research to solutions. She stated that IAI can work with national funding agencies in the region to, for instance, co-fund research on the impacts of a 1.5 °C temperature increase and on feasible economic and technical pathways to stay within this limit.

62. Mr. Andrew Matthews from the Asia-Pacific Network for Global Change Research (APN) then presented on their work on research and capacity-building in the region, particularly on adaptation to climate change and slow onset events. The APN have recently published their fourth strategic plan (2015–2020), based on gap analysis in the region.[110] Mr. Matthews highlighted that of the 422 projects undertaken by the APN in the 20 years since it started, 127 of these have been on adaptation. The APN has two core programmes and three focused activity frameworks supporting the science–policy interface and thus bringing policy relevant science to decision makers.[111]

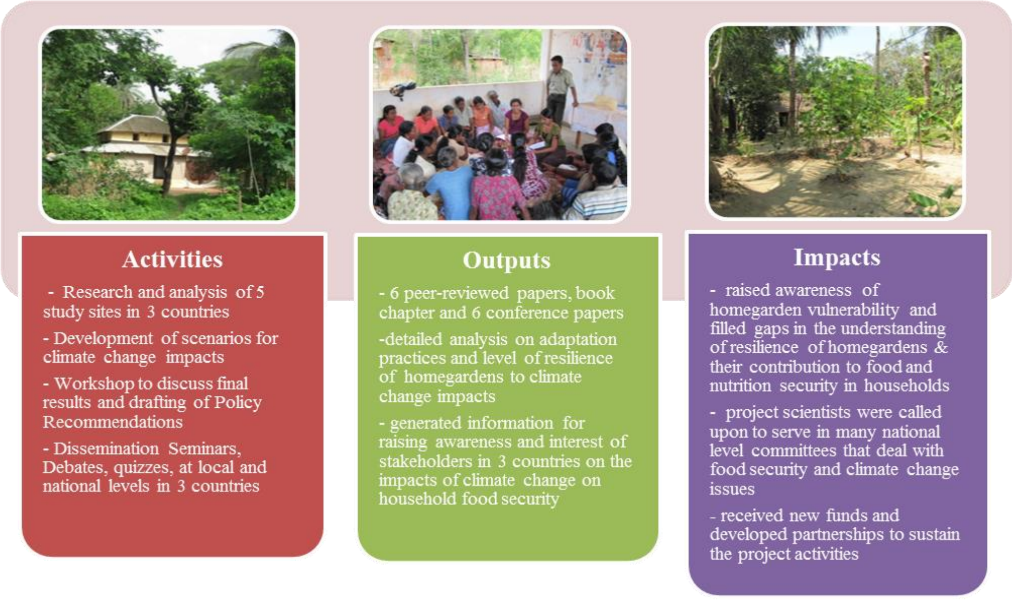
63. He highlighted two projects from the current work programme of the APN. The first example is a project in South Asia which has raised awareness on the **vulnerability of home-garden systems** to climate change and its impacts on food security (figure 20). The project is not only creating resilience but the local scientists involved have been able to bring their knowledge to the policy level. The second project looked at the impact of climate change on **food security** and biosecurity of crop production systems in small Pacific nations. Currently countries are ill-equipped and lack human capacity and the scientific networks for seeking information and advice to ensure rapid response to incursions. This pilot project is helping mobilize resources and create opportunities to help rectify this situation (figure 21).

64. Mr. Matthews identified that APN are supporting projects to mobilize scientists, policymakers and practitioners to comprehensively assess the impact of slow onset events and prepare a comprehensive response; spread awareness about loss and damage caused by slow onset events to people and ecosystems; and sensitize, engage and build the capacity of stakeholders, particularly policymakers and practitioners to develop appropriate solutions.

65. Mr. Matthews listed a number of relevant projects being undertaken under the APN climate adaptation framework[112]. He gave an example of an APN project enhancing the capacity of policymakers and practitioners in India, Sri Lanka and Nepal on loss and damage related to slow onset events in the region. The project is supporting better understanding of slow onset events by policymakers and practitioners, who are already involved in adaptation and its integration into policies. The project is aimed at diagnosing the extent to which understanding is limited and what approaches can be developed linking with existing work in relation to disaster risk reduction, climate change adaptation and development policies and practices.[113]

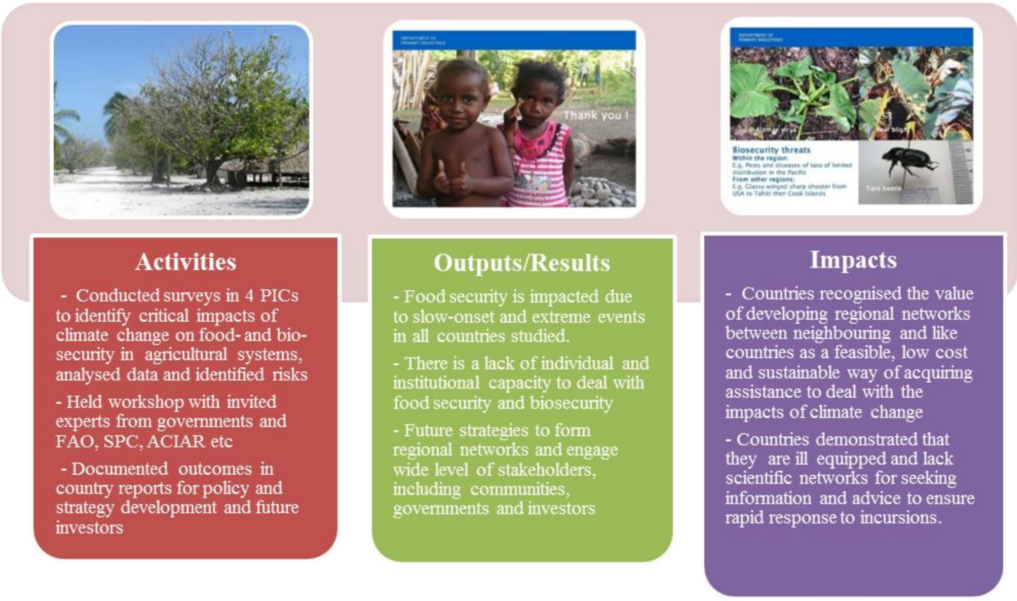
[110] <http://apn-gcr.org/r/4sp>.
[111] See figure 12 ResearchDialogue.2015.2.SummaryReport <http://unfccc.int/files/adaptation/application/pdf/researchdialogue.2015.2.summaryreport.pdf>.
[112] <http://www.apn-gcr.org/programmes-and-activities/focused-activities/climate-adaptation-framework/>.
[113] <http://www.apn-gcr.org/resources/items/show/1980>.

Figure 20
Vulnerability of home-garden systems to climate change and its impacts on food security in south Asia



Source: Slide 8 of the presentation by Mr. Matthews.
Notes: (1) Countries engaged: Bangladesh, India and Sri Lanka; (2) Summary of activities, outputs and impacts.[114]

Figure 21
Impact of climate change on food security and biosecurity of crop production systems in small Pacific nations



Source: Slide 9 of the presentation by Mr. Matthews.
Notes: (1) Countries engaged: Australia, Kiribati, Tonga, Tuvalu and Vanuatu; (2) Summary of activities, outputs and impacts.[115]

66. Mr. Espen Ronneberg from the Secretariat of the Pacific Regional Environment Programme (SPREP) provided perspectives from the Pacific on slow onset events and emphasized the **importance of regional knowledge to understand regional impacts and extremes**.

67. Mr. Ronneberg provided information on the limited observations and monitoring of slow onset events in the region. In regards **to sea level rise**, he stated that the Pacific region does have a good data set going back 25 years for sea level rise, but that there is only one station per country in the region and there are gaps in the data sets. There is some monitoring of coral bleaching but at least 140 more sites are

[114] For further information see <http://www.apn-gcr.org/resources/items/show/1585>.
[115] For further information see <http://www.apn-gcr.org/resources/items/show/1571>.

required. There is extremely **limited monitoring of the ocean** and several more hundred stations are needed. In regards to saline intrusion, there are some studies in some member countries but these are not systematic and cannot provide a detailed overview of impacts per country.

68. He highlighted that the region is suffering from four main impacts: ocean acidification, sea level rise, sea surface temperature and impacts on atoll islands – drying, saline intrusion and wave intrusion. These impacts are compounded by insufficient research in the region.

69. Current actions include a project on ocean acidification, supported by New Zealand and Monaco, that has provided four new monitoring stations and pilot sites. A workshop on ocean acidification[116] was held at the SIDS Conference 2014,[117] which highlighted new research to strengthen resilience and identified that adaptation options are limited although SPREP is examining the possible options.

70. Mr. Ronneberg stated that gap analysis on loss and damage has been carried out in three countries and shown that there is regional need for capacity-building, sector/national assessments and risk analysis, ongoing training programmes, in-country expertise, and establishment and expansion of observation and monitoring. There is a major requirement for technical and financial support for the long-term.

71. Mr. Diogo de Gusmao-Soerensen, European Commission (EC), presented on research and innovation in regards to **climate services** in the EU. He identified that the EU defines climate services as the transformation of climate-related data and other relevant information into products, tools and services that support adaptation, mitigation and disaster risk management (see paragraph 53 for WMO definition). They focus on four sectors: energy, water, health and agriculture/food security.

72. Mr. de Gusmao-Soerensen provided an example of project work from each of these sectors as follows:

(a) ECLISE project[118] – investigated the impact of climate change on hydropower potential in the Ume River Basin in Sweden, the Alpines and Apennine regions, and the Somes River Basin in Romania to help decision-makers estimate energy generation, transmission, distribution and use;

(b) ENHANCE project[119] – provided a good example of an EU-wide fluvial flow risk assessment tool has which been created to support flood forecasting, drought management and associated policy formulation across the EU;

(c) EUROPIAS project[120] – focused on agriculture and food security (funded under the EC’s seventh framework programme), this project provides integration of seasonal climate forecasts, including into: the Livelihoods Early Assessment and Protection (LEAP) system used in Ethiopia[121] to provide a food security early warning system used by the Government of Ethiopia to estimate the number of people who will be in need of food assistance due to drought; and in Project Ukko[122] which provided detailed discussion within the project on how best to use the science to effectively provide climate services for wind power and portray clear messaging to provide seasonal forecasting to energy companies and citizens around the world;

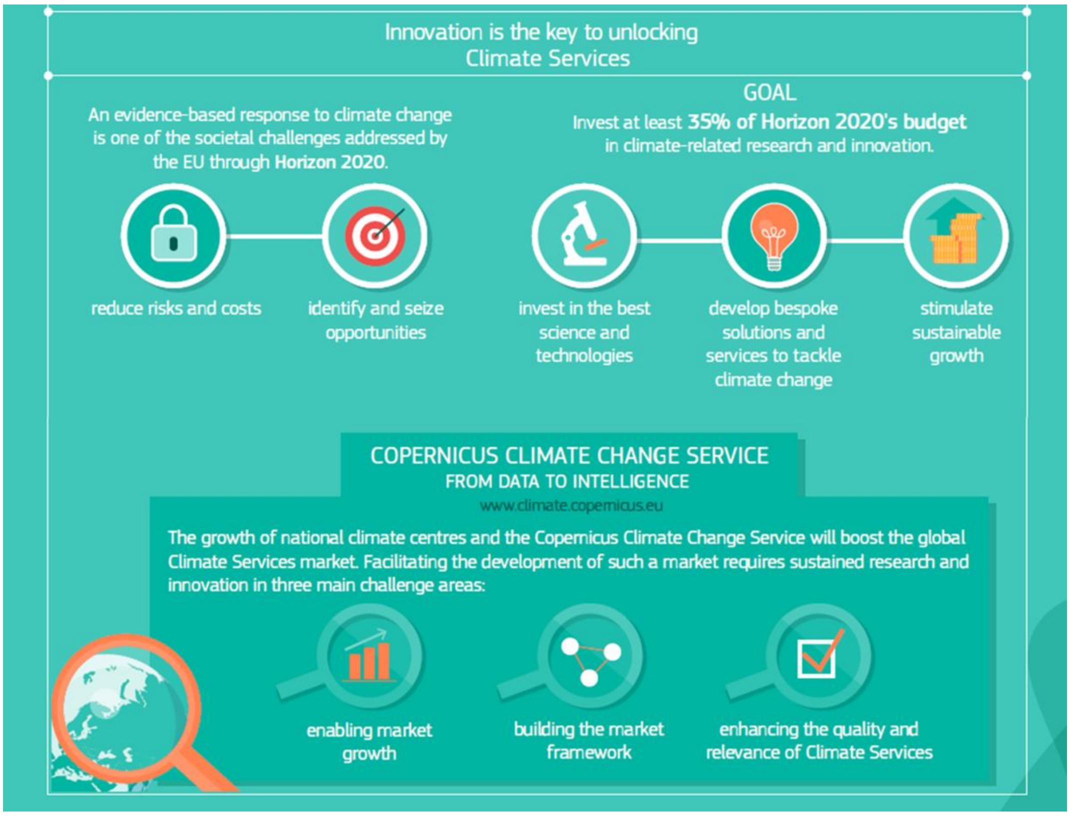
(d) PURGE project[123] – studied air quality and health impacts of strategies to reduce GHG emissions in urban centers in Europe, China and India and how this project has changed these health impacts;

(e) COPERNICUS Climate Change Service[124] – will combine observations of the climate system with the latest science to develop authoritative, quality assured information about the past, present and future states of the climate in Europe and worldwide.

73. Mr. de Gusmao-Soerensen finished by stressing that success of climate services depends entirely on partnerships, strong collaboration and design and implementation of innovative solutions together. This is a key part of the EU Horizon 2020 programme, which now has a global outreach (Figure 22).

[116] <http://www.sids2014.org/index.php?menu=1566>.
[117] <http://www.sids2014.org>.
[118] <http://www.eclise-project.eu>.
[119] <http://www.enhanceproject.eu>.
[120] <http://www.euporias.eu>.
[121] <http://www.euporias.eu/prototype/leap-ethiopia>.
[122] <http://www.project-ukko.net>.
[123] <http://purge.lshtm.ac.uk/project>.
[124] <http://climate.copernicus.eu>.

Figure 22
EU Climate Services and Horizon 2020



Source: Slide 12 of the presentation by Mr. de Gusmao-Soerensen.
Note: The EU's Research and Innovation Roadmap for Climate Services provides a coherent and focused framework that sets out priorities for building a market for Climate Services as part of the Horizon 2020 programme.[125]

74. Ms. Westley, National Oceanic and Atmospheric Administration (NOAA) presented on the **challenge of translating climate research into useful products and services**. She stated that research and development (R&D) happens in one area and the products or users of that R&D happen in a different area – and those areas can be separated by source of funding, by representing different communities of people, and by different incentives. In the middle there is a gap in, for example, funding and/or understanding. She stressed the importance of investing in this gap to translate research into useful products and services (figure 23).

75. Ms. Westley shared examples from NOAA on how they are attempting to fill this gap and provide effective climate services for decision-making:

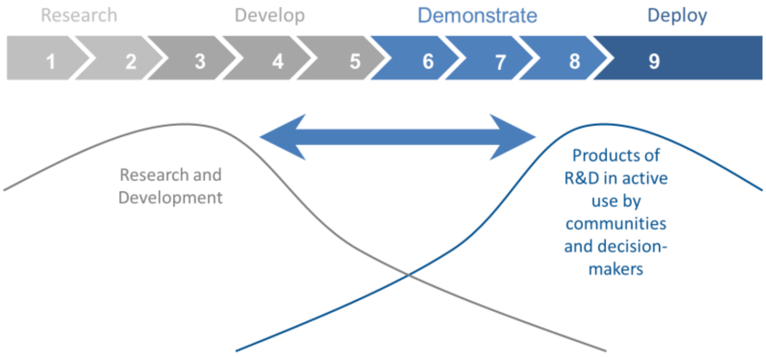
(a). In regards to **sea level rise**, NOAA has provided a tool for coastal managers and scientists to visualize sea level rise and coastal flooding impacts.[126] Using nationally consistent data sets and analyses, the data, maps and photographs provided can be used at several scales to help gauge trends and prioritize actions for different scenarios. Ms. Westley highlighted that Superstorm Sandy in 2012 hit the New Jersey shore with a two-meter storm surge. NOAA partners engaged with communities in the areas using the tool to understand how to improve resilience against future extreme events and long term sea level rise for decision-making at personal and community level.

(b). In regards to **ocean acidification**, NOAA and partners have been working long term on ocean acidification and have, amongst other monitoring and research, developed an ocean acidification data portal.[127] This portal along with aquaculture research supports shellfish growers on the Pacific coast who use the information to understand when sea water acidity is high and young oysters in hatcheries are most vulnerable and thus modify the environment in their hatcheries.

[125] <http://goo.gl/FbZl5T>.
[126] <https://coast.noaa.gov/slr>.
[127] <http://www.ipacoa.org/Explorer>.

(c). In regards to **drought**, NOAA has a number of drought tools,[128] but it is also funding social science work to better understand resilience, for example, in regards to considerations for climate change and variability adaptation on the Navajo Nation.[129]

Figure 23
Research and useful knowledge



Source: Slide 13 of the presentation by Ms. Westley.
Notes: The gap between research and development communities and the communities using this information. The blue arrow highlights the importance of investing in this gap to translate research into useful products and services.

2. Summary of the discussion

76. One Party asked about the capacity of the meteorological community to be able to provide weather and climate predictions for three months to 30 years. Another Party enquired about the ongoing data rescue work by the WMO and what specifically was being undertaken in the Pacific, noting the limitation of climate data in these areas and identifying that ocean acidification information is a key knowledge gap, particularly in the southern hemisphere.

77. The expert from WMO identified that there is a variation in capacities for forecasting at different time scales. At the seasonal timescale, forecasting is good and widely available. However decadal forecasting is still in development. In regards to data rescue in the Pacific, he referenced I-DARE (see Figure 7) to show what projects are planned or ongoing worldwide.

78. One delegate asked for further information on the IG3IS objectives and processes to support the global stocktake and transparency framework.

79. An expert explained that IG3IS is using collected climate information already available to guide solution pathways to inform mitigation. Taking on board lessons learned from Lima and Paris, IG3IS uses bottom-up, practical, focused steps to provide high-frequency, low-latency trend assessment to enable countries to identify if they are on track to meet emission reduction pledges (see paragraph 12).

80. One Party identified that the concern for many developing countries, particularly in Africa, is being able to provide and package scientific information to adequately inform policymaking.

[128] <https://www.drought.gov/drought/>.
[129] <http://www.colorado.edu/law/content/considerations-climate-change-and-variability-adaptation-navajo-nation>.