Summary report on the tenth meeting of the research dialogue
Bonn, Germany, 3 May 2018

Note by the Chair of the SBSTA

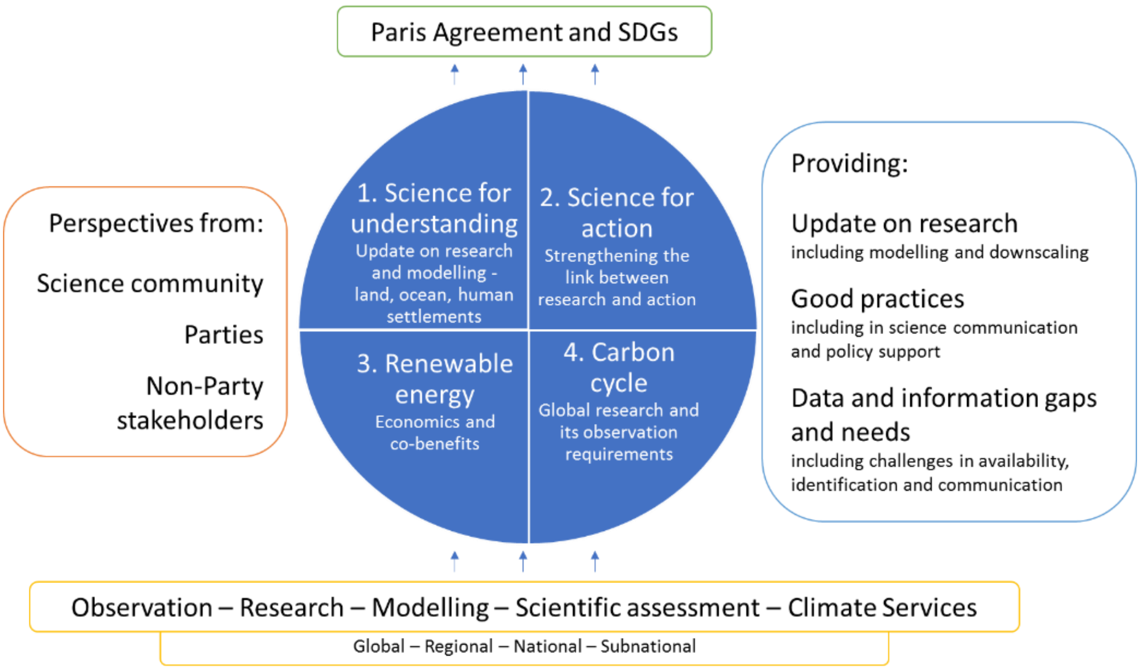
05 November 2018

Overview

The tenth meeting of the research dialogue was held in Bonn on 3 May 2018 in conjunction with the first part of the forty-eighth session of the Subsidiary Body for Scientific and Technological Advice (SBSTA 48).

Aim

The goal of the dialogue was to hold a discussion at the science–policy interface with the aim of supporting adaptation and mitigation action under the Paris Agreement based on the best available science. It focused on “science for understanding” and “science for action” as well as science on renewable energy and the carbon cycle. The dialogue made clear that fundamental science and research is still needed, but communication at the science/policy interface and exploration of the opportunities of how best to do this is also an important part of the required action that should be supported by Parties.



This year marked an anniversary for the UNFCCC process, a decade of research dialogues, with valued participation and support from Intergovernmental Panel on Climate Change, World Climate Research Programme and the large and diverse international scientific community.

Summary of key messages:

More detailed messages for the presentations and posters are provided in the main report.

1. Science for understanding
Update on research and modelling - land, ocean, human settlements

- Fundamental research is still needed to improve understanding of climate change
- Modelling is vital to understand and communicate climate change impacts from seconds to centuries and at increasing resolution
- Science must be supported through strong interdisciplinary research and multi-stakeholder partnerships, both informal and formal including indigenous and local communities, government and non-government stakeholders and sharing and building narratives of best practices
- Ongoing rapid changes in the Arctic have shifted the Arctic into a new normal, affecting the ecology, human societies and the position of the region in the global context
- Continued research on the ocean’s role in the energy, carbon and water cycles and the impact of climate change on the ocean and ocean biodiversity is critical to understand opportunities and options for mitigation and adaptation and co-benefits
- A systems approach is vital when responding to the impacts of climate change. Ecosystem-based approaches can tackle mitigation and adaptation and provide co-benefits for sustainable development. In cities vertical integration is needed to link national policies and local actions and strengthen joint undertaking toward the objectives of the Paris Agreement and the generation of co-benefits.

2. Science for action
Strengthening the link between research and action

- There is an urgency to increase communication and collaboration at the science/policy interface to respond to climate change
- Regional institutions are important to promote and exchange information at regional, national and local level and catalyze Party engagement and support
- Transdisciplinary research helps support engagement between the scientific and policy communities
- Dialogue should be facilitated, including at regional level, to help different stakeholders reconcile views on (transformative) ways forward based on the best available science.

3. Renewable energy
Economics and co-benefits

- The co-benefits of renewable energy are well recognized, but should be better quantified in order to speed up adoption
- Progress has been made in recent years on quantification for some co-benefits such as air pollution, health, energy security and employment. Studies on health already show the co-benefits and cost-effectiveness of mitigation
- The reducing cost of renewables must be factored into future models and scenarios.

4. Carbon cycle
Global research and its observation requirements

- The scientific community aims to close knowledge gaps on the carbon cycle - supported by the research, modellling and observation communities. This includes work by the global carbon project on the CO_2, CH_4 and N_2O budgets (global and regional)
- Open data and clearer reporting by Parties, including on inventories, would support this work
- Matching in-situ and remote monitoring of GHG concentrations (bottom-up approaches) with inverse modelling techniques (top-down approaches) supports reporting at national, urban and regional levels.

I. Background

A. Mandate

1. The foundation for the research dialogue was given by the Conference of the Parties (COP) decision 9/CP.11 and further focus provided by conclusions of the Subsidiary Body for Scientific and Technological Advice (SBSTA) and COP decision 16/CP.17.[1]

2. At its forty-sixth session, the SBSTA invited Parties to submit their views on possible topics and considerations for the research dialogue to be held in conjunction with SBSTA 48 (30 April – 10 May 2018), and beyond.[2]

3. Submissions were received from: the Arab Republic of Egypt on behalf of the African Group of Negotiators; Argentina, Brazil and Uruguay; Bulgaria and the European Commission on behalf of the European Union; Ethiopia on behalf of the LDC Group; Japan; and Saint Lucia on behalf of CARICOM.[3]

4. In response to these mandates and submissions, the tenth meeting of the research dialogue (RD 10) was convened on 3 May 2018 in Bonn, Germany, in conjunction SBSTA 48.[4] This report provides a summary of the presentations, posters and discussions.

5. Negotiations and subsequent conclusions on research at SBSTA 48, under SBSTA Agenda item 6 on research and systematic observation, were based on information provided at the research dialogue.[5]

B. Reports of meetings of the research dialogue

6. The SBSTA Chair has produced this summary report of RD 10 as requested by SBSTA 48.[6] The summary report as well as those from previous meetings are available online.[7]

C. Information note

7. In order to enable Parties to better prepare for RD10, the SBSTA Chair provided an information note in advance that provided background information on the approach, themes and goal for RD10. The information note also included an overview of relevant mandates and of recent activities by relevant international organizations.[8]

8. Furthermore, the Annex of the information note provides a list of all themes, experts, presentations and posters from meetings of the research dialogue to date. This list has since been updated with the information from RD10 and is now available online as a downloadable pdf file.[9]

9. The four themes for RD 10 were:

(a) Science for understanding - update on research and modelling on human settlements, oceans and land and their importance for the implementation of the Paris Agreement;

(b) Science for action - strengthening the link between the research community and action to meet the goals of the Paris Agreement;

(c) Renewable energy economics and co-benefits;

(d) Global research on the carbon cycle, and its observation requirements, in support of the Paris Agreement.

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1 An overview of the mandates founding and guiding the research dialogue are available here: https://unfccc.int/topics/science/resources/research-background.
2 FCCC/SBSTA/2017/4, paragraph 19.
3 See http://www4.unfccc.int/sites/submissionportal/Pages/Home.aspx.
4 See https://unfccc.int/process-and-meetings/conferences/bonn-climate-change-conference-april-2018/sessions/sbsta-48.
5 See SBSTA 48 report FCCC/SBSTA/2018/4, paragraphs 38–54.
6 FCCC/SBSTA/2018/4, paragraph 53.
7 See https://unfccc.int/topics/science/workstreams/research/research-dialogue.
8 Information note on the tenth meeting of the research dialogue, see https://unfccc.int/node/65505.
9 See https://unfccc.int/documents/180943.

10. The goal of the meeting was to provide a discussion forum at the science/policy interface on these four themes in support of action under the Convention and Paris Agreement.

II. Proceedings

11. RD10 took place on 3 May 2018, in conjunction with SBSTA 48 at the World Conference Centre Bonn (WCCB), Bonn, Germany. It was chaired by the Chair of SBSTA, Paul Watkinson (France).

12. The meeting started with a two hour poster session (13.45–15.45) in the foyer of the WCCB where experts presented posters on all four themes of RD 10 (as listed in paragraph 9 above) and delegates could discuss the content of these posters in detail with the experts.

13. The seated dialogue (16.00–19.00) began with two keynote presentations. The first was from Ms. Amanda Lynch, World Climate Research Programme (WCRP) who co-presented with Mr. Chris Lennard WCRP-CORDEX on WCRP: Science for Understanding, Science for Impact. Mr. Shobhakar Dhakal then presented on Outcomes of the Cities and Climate Change Science Conference (CitiesIPCC) in his capacity as Co-Chair of the Scientific Steering Committee of CitiesIPCC Conference; and on Renewable energy, economics & co-benefits, representing the Asian Institute of Technology.

14. The dialogue proceeded with two panel discussions. In the panel discussions presenters were invited by the Chair to provide short 5 minute focused overviews, looking at key outputs and ways forward, which were followed by discussion.

15. The first panel discussion focused on theme 1 of RD 10, Science for understanding - update on research and modelling on human settlements, oceans and land and their importance for the implementation of the Paris Agreement. Participants on the panel were Ms. Corinne Le Quéré, Global Carbon Project, Mr. Nicola Tollin, University of Southern Denmark, Mr. Salvatore Arico, Intergovernmental Oceanographic Commission of UNESCO (UNESCO-IOC), Ms. Sakhile Koketso, Convention on Biological Diversity (CBD), Mr. Tero Mustonen, Snowchange Cooperative and Mr. Richard Betts, UK Hadley Centre.

16. The second panel discussion focused on theme 2 of RD 10, Science for action - strengthening the link between the research community and action to meet the goals of the Paris Agreement. Participants on the panel were Mr. Seita Emori, Japan, Ms Kimberly Ann Stephenson, University of the West Indies, Mr. Chris Lennard, CORDEX-Africa, Mr. Andrew Matthews, Asia-Pacific Network for Global Change Research (APN) and Mr. Omar Defeo, Inter-American Institute for Global Change Research (IAI) and Universidad de la Republica de Uruguay & Direccion Nacional de Recursos Acuaticos.

17. All presentations and posters as well as an audio Skype broadcast of the dialogue are available online.[10]

[10] https://unfccc.int/event/tenth-meeting-of-the-research-dialogue-rd-10.

III. Summary of the dialogue

A. Keynote presentations

18. Ms. Amanda Lynch, WCRP, opened the session with a presentation on the World Climate Research Programme titled: Science for understanding, science for impact.[11]

Ms. Amanda Lynch, WCRP, World Climate Research Programme: Science for understanding, science for impact
Key messages

- Fundamental science is needed to improve understanding. Understanding prepares society for the challenges we cannot foresee, by ensuring that our knowledge foundations are broad as well as deep.
- Scientific partnerships are critical for model deployment from seconds to centuries, including:
  - Collaboration across science communities;
  - Capacity and infrastructure development;
  - Consistent support for critical work e.g. Coupled model intercomparison project (CMIP)
- Wider partnerships –social sciences, governments, industry, civil society - are critical for climate science to serve society in the 21st century to provide:
  - Co-production of knowledge, co-design of solutions;
  - Connect global to local scales for adaptation.

19. Ms. Lynch highlighted that the World Climate Research Programme (WCRP) coordinates international climate research to develop, share and apply climate knowledge that contributes to societal well-being.

20. WCRP addresses aspects of climate science that are too large and too complex to be tackled by a single nation or scientific discipline. Through international science coordination and successful partnerships, WCRP leads the way in determining the interactions between human activities and the Earth system. WCRP research provides the climate scientific underpinning for the UN Framework Convention on Climate Change, the Agenda for Sustainable Development and the Sendai Framework for Disaster Risk Reduction.

21. WCRP strives to deliver actionable, accessible, inclusive and authoritative scientific information on the Earth system.

22. The WCRP are currently developing the WCRP Strategic Plan 2019-2029. Four primary objectives underpin the strategic plan and the next decade of scientific research on the Earth system:

1 Fundamental understanding of the climate;

2 Advancing predictive skills in climate;

3 Constraining projections of the climate;

4 Connecting climate science with policy and services.

23. Further information on the strategic plan was provided in the WCRP poster the future of climate research[12] (also see paragraph 140).

24. Objective 1 is already a fundamental part of the work of WCRP. WCRP has been an integral part of progress that supports a predictive understanding of the Earth system variability, processes and feedbacks, including conclusions that the climate has changed and that human activities are responsible for the majority of this change. This is based on the **fundamental understanding** of the geophysical system through routine and novel observations, targeted field campaigns, data analyses and syntheses, and model enhancement and

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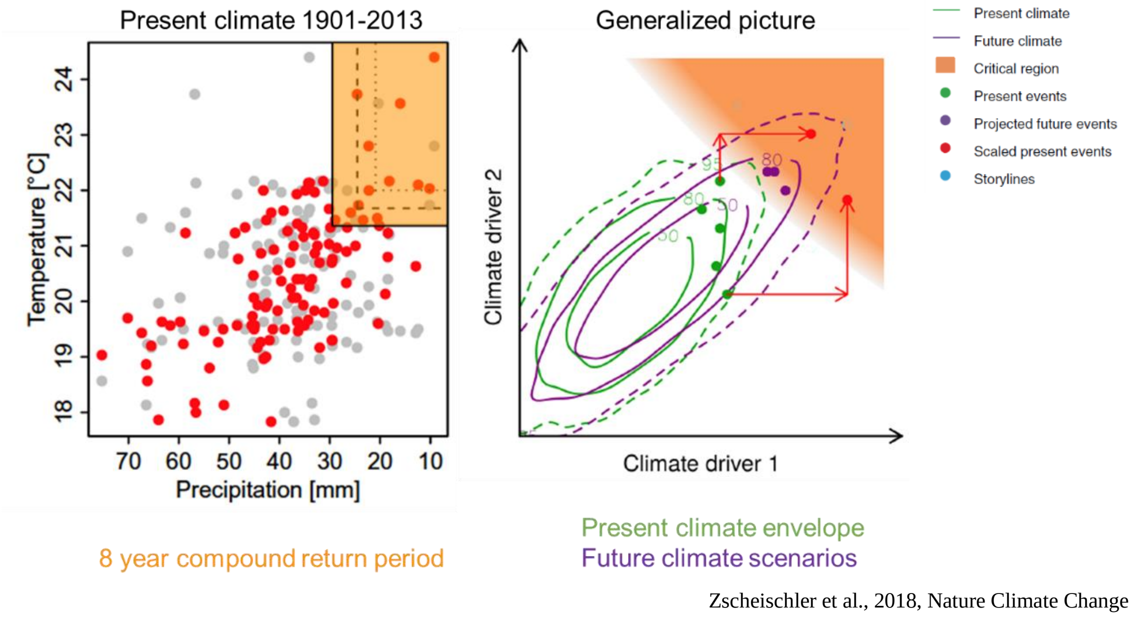
[11] See https://unfccc.int/sites/default/files/resource/0.1%20Keynote1_RD10_Lynch_Lennard_WCRP.pdf and audio broadcast 0:14:00.

[12] See https://unfccc.int/sites/default/files/resource/2.15%20WCRP_Lynch%20Scientific_Strategy.pdf.

development. Although much work has been undertaken, WCRP are working hard in bed-rock science to further improve understanding. Understanding prepares society for the challenges we cannot foresee.

25. For example, an important issue now arising is that of compound extremes. Floods, wildfires, heatwaves and droughts often result from a combination of interacting physical processes across multiple spatial and temporal scales. The combination of processes (climate drivers and hazards), in multiple dimensions of the climate system, leading to a significant impact is referred to as a 'compound event'. Ms. Lynch stated that we are already seeing a number of extreme temperature and low precipitation events. The WCRP are seeking to improve understanding of these compound extremes (figure 1).

Figure 1
Compound extremes



Source: Slide 4 of the presentation by Ms. Amanda Lynch.
The figure on the left shows that a number of compound extreme events, in this case high temperature and low precipitation, are already occurring.
The figure on the right shows the hypothetical present-day distribution of two climatic drivers and their potential future distribution. Continuous lines depict the 50th and 80th percentiles, dashed lines denote the 95th percentiles. The coloured points denote different possibilities to generate potentially critical events. The critical region is shown in orange with a blurred border to illustrate uncertainty in the estimation of its extent. The critical region can only be known if enough critical events have occurred (or can be simulated) to characterize it.[13]

26. Now society's needs are evolving, and climate science is called upon to support the knowledge required for wise mitigation and adaptation choices in a changing world. Furthermore, society's expectations of climate science are higher, as climate science is asked to deliver **improved forecasts and scenarios at finer spatial resolutions and on a wider range of timescales**, in support of prosperity and innovation, urban infrastructure, risk reduction, and energy systems. As a result, new urgencies are emerging, but also new opportunities. The same fundamental climate science, embodied by disciplinary and interdisciplinary rigor, that has underpinned past achievements must now also support these new societal needs. ecosystem function.

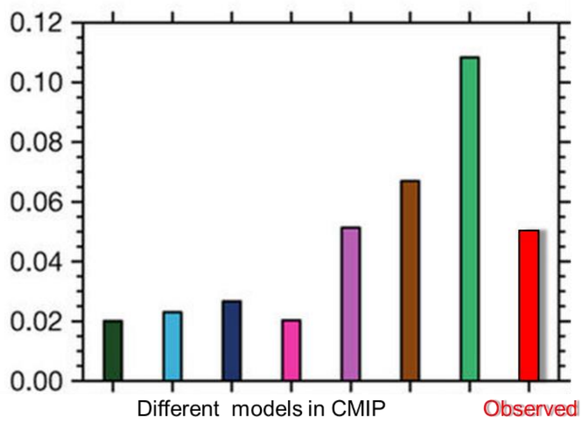
27. With objectives 2 and 3, WCRP are moving to push the envelope from predictions to projections- from a deterministic view that can be achieved through a weather forecast to a scenario that can be talk about when talking about future climate and climate change. This research **enables reduction of uncertainties** to enhance the capacities of countries and other stakeholders, for example, in emergency planning and preparedness.

28. At the same time **constraining and improving future projections reduces uncertainties** about the future climate to support resilience and adaptation. Scientific partnerships are critical for model deployment from seconds to centuries. This requires collaboration across science communities; capacity and infrastructure development and consistent support for critical work e.g. CMIP.

[13] J. Zscheischler et. al. (2018). Future climate risk from compound events. Nature Climate Change volume 8, pp 469–477. See https://doi.org/10.1038/s41558-018-0156-3.

29. For example, uncertainties in the response of vegetation to rising atmospheric CO_2 concentrations contribute to a large spread in projections of future climate change in a range of models in CMIP5. Researchers and modellers are working towards constraining these models to better reflect the observed relationship and reducing uncertainties (figure 2).

Figure 2
Representation of future ecosystem function by different CMIP5 models



Source: Slide 8 of the presentation by Ms. Amanda Lynch.
The graph shows the range of values for future ecosystem function - the annual mean atmospheric CO2 versus the amplitudes of the CO2 seasonal cycle – (increase in gross primary productivity due to elevated atmospheric CO2 concentrations) in a range of CMIP5 models compared with the observed value (in this case between 1974 and 2013 at Point Barrow, Alaska).[14]

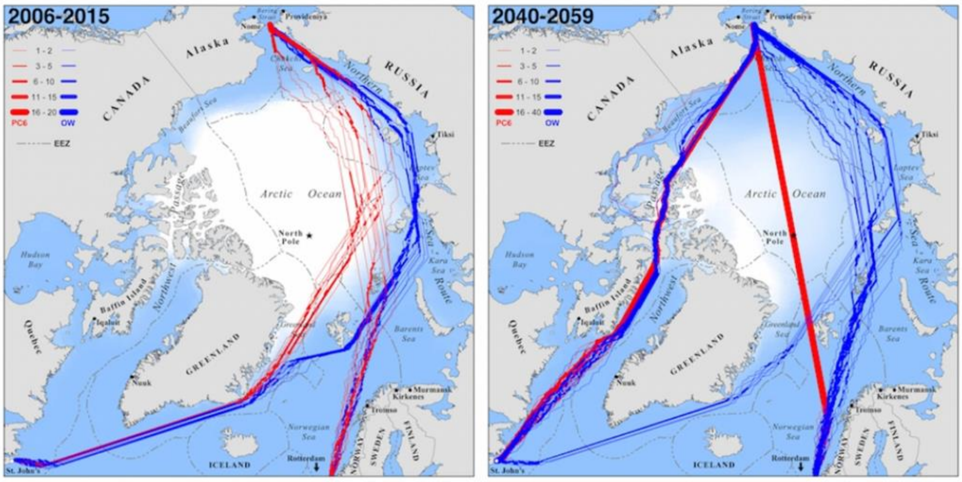
30. The next decade will bring challenges, requiring a global effort and a prepared scientific work force. The challenge is formidable: both **scientifically and technically complex**, while needing **deep engagement with the structure and limitations of social institutions at every level from local to international**. There are also clear opportunities, to **develop new partnerships for seamless operations**, to engage with exciting observational and computation technologies, to develop scientific capacities across the globe. To meet these challenges and opportunities, as part of its strategic plan.

31. WCRP will implement, facilitate and promote a set of **community-generated science initiatives**. Wider partnerships – social sciences, governments, industry, civil society - are critical for climate science to serve society in the 21st century to enable the study of co-production of knowledge, co-design of solutions and connect global to local scales for adaptation.

32. For example, reduction of sea ice in the Arctic ocean and the relationship between shipping and resource exploitation requires research and communication of economic story-lines (narratives) weaving together choices regarding future discount rates, decisions on bunker fuels, reliability of forecasts, and the marginal costs of sea ice variability (figure 3).

[14] S. Wenzel et. al. (2016). Projected land photosynthesis constrained by changes in the seasonal cycle of atmospheric CO_2 Nature volume 538, pp 499–501. See https://doi.org/10.1038/nature19772.

Figure 3
Different options in the Arctic as a result of the reduction in sea ice due to climate change



Source: Slide 11 of the presentation by Ms. Amanda Lynch.
Economic story-lines weave together choices regarding future discount rates, decisions on bunker fuels, reliability of forecasts, and the marginal costs of sea ice variability.[15]

33. Mr. Chris Lennard, WCRP CORDEX (Coordinated regional climate downscaling experiment),[16] then continued the WCRP presentation focusing on the activities of CORDEX-Africa.[17] **CORDEX is an example of the WCRP work enhancing communication of research knowledge and wider partnerships**. The information in the presentation was also presented in more detail in the CORDEX-Africa poster[18] (see paragraph 140 below).

Mr. Chris Lennard, WCRP CORDEX, Science for understanding, science for impact (cont.)
Key messages

- Climate sensitive thresholds exist in many regional biophysical and socioeconomic systems, which if crossed impact the functioning of the system
- Scale relevant climate change information is necessary to inform adaptation and mitigation actions across many sectors
- The CORDEX-Africa Impacts Atlas will provide climate and sector specific information to inform regional adaptation and mitigation actions.

34. Mr Lennard highlighted that **many systems have climate-related thresholds which if crossed have deleterious impacts on the system**. For example, crops have temperature-sensitive thresholds which, if exceeded for a specific number of days, means the crop fails; crossing heat stress thresholds in vegetation, animals and humans lead to ill health or mortality; or in the case of energy demand, crossing an energy demand threshold may lead to rolling blackouts. **Regional scale information** on the timing and magnitude of temperature change as a result of climate change is therefore crucial for informed adaptation and mitigation actions.

[15] Veland, S. and Lynch, A. H. (2017), Arctic ice edge narratives: scale, discourse and ontological security. Area, 49: 9–17. See http://doi.org/10.1111/area.12270.

[16] See http://www.cordex.org.

[17] See https://unfccc.int/sites/default/files/resource/0.1%20Keynote1_RD10_Lynch_Lennard_WCRP.pdf and audio broadcast 0:23:58.

[18] See https://unfccc.int/sites/default/files/resource/2.35%20WCRP_Lennard%20CORDEXAfricaImpactAtlas.pdf.

35. However, many policy decisions are (a) made using global average information and (b) have no indication of the timing of change. This information does not reflect the regional perspective nor speak to climate sensitivities of various systems. There is therefore an **urgent need to develop regional scale information that includes an indication of the timing of change to inform policy around climate change adaptation and mitigation activities**.

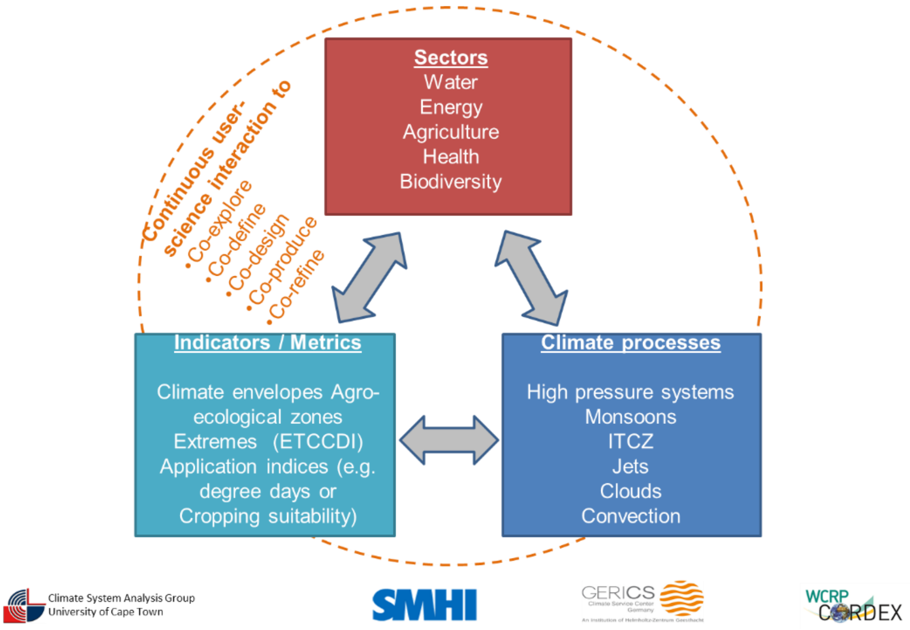
36. **The CORDEX-Africa Impacts Atlas[19] is a demonstrator project within CORDEX to assess the timing of climate sensitive threshold exceedances in selected sectors under progressively more extreme global mean temperature increases of 1.5, 2, 3 and 4 degrees Celsius of global warming**. The project investigates the timing and impact of regional climate change on reaching these global warning levels (GWLs) in key sectors identified by the Global Framework for Climate Service, namely health, disaster risk reduction, water, agriculture and energy across the African continent. Through a co-explorative investigation with sector-specific experts, indices are derived using climate and sector-specific information which will be used to assess when critical thresholds within these regional systems might be crossed that would have deleterious impacts on the system and the impacts of these threshold exceedances (figure 4).

37. The timing, magnitude and robustness of projected regional change will be presented as indices in an Atlas of regional temperature change for use by the scientific, impacts and policy making communities. A quantification of the timing of threshold exceedances in affected systems will also facilitate assessment of the cost that delayed mitigation could have in regional socio-economic systems. **This work will provide an African contribution to the sixth assessment report of the IPCC (AR6).**

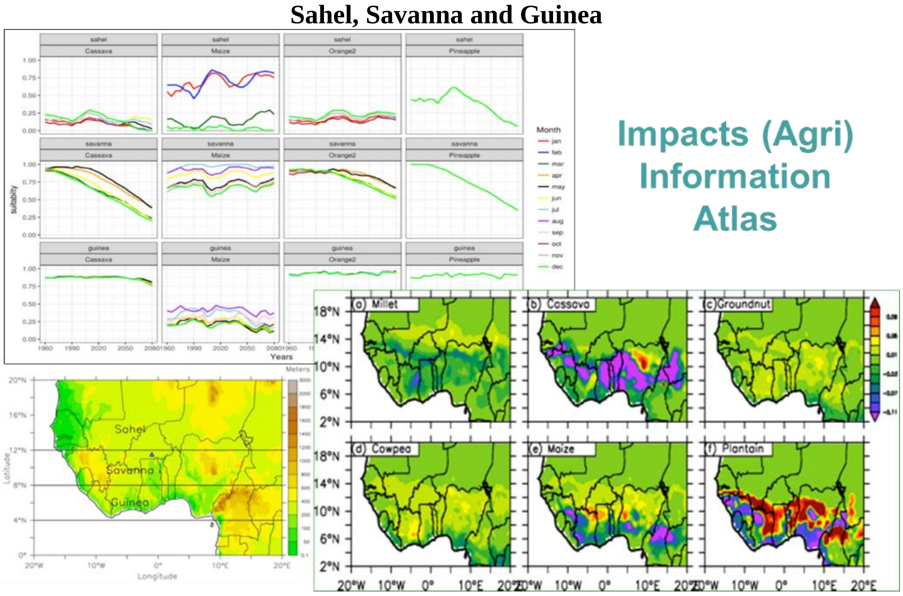
[19] See http://www.csag.uct.ac.za/cordex-africa.

Figure 4
The CORDEX-Africa Impacts Atlas

(a) Structure



(b) Example output showing future impacts on agriculture in Western Africa: Sahel, Savanna and Guinea



Source: Slide 16 of the presentation by Mr. Chris Lennard.

38. Shobhakar Dhakal then presented[20] on the Outcomes of the Cities and Climate Change Science Conference (CitiesIPCC) 5–7 March 2018, Edmonton, Canada, in his capacity as Co-Chair of the Scientific Steering Committee of CitiesIPCC Conference.[21]

Shobhakar Dhakal, CitiesIPCC Scientific Steering Committee, Outcomes of the Cities and Climate Change Science Conference

Key messages

- Cities are key to solving the challenge of climate change and highly vulnerable to its impacts
- The CitiesIPCC conference issued a joint statement "The Science We Need for the Cities We Want: Working together to implement the global research and action agenda on cities and climate change"
- A systems approach is vital when responding to the impacts of climate change in cities, which will be highlighted in this new research agenda.

39. Mr. Dhakal stated that more than half the world's population now lives in cities and 70% of cities are already dealing with the effects of climate change. Over 90% of all urban areas are coastal, putting most cities on Earth at risk of flooding from rising sea levels and powerful storms. Cities are key to solving the challenge of climate change and highly vulnerable to its impacts.

40. The conference was organized with 11 partners, including WCRP. It brought together over 700 international stakeholders and aimed to bridge and build a dialogue between different communities working on cities and climate change – academia, policymakers, urban practitioners, indigenous communities, private sector and others.

41. **The CitiesIPCC conference aimed to inspire the next frontier of research on the science of cities and climate change**. Its primary goals were to assess the state of academic and practice-based knowledge related to cities and climate change, and to establish a global research agenda based on the joint identification of key gaps by the academic, practitioner and urban policy-making communities. Specific goals were to stimulate research underpinning effective and efficient urban responses to climate change and provide inputs to the products of the IPCC.

42. The conference partners signed a joint statement on the last day of the conference **"The Science We Need for the Cities We Want: Working together to implement the global research and action agenda on cities and climate change"**.[22] All stakeholders are invited to sign this statement.

43. This global research and action agenda will be responsive and solutions oriented, engaging users from the research and IPCC, urban practitioner and policy making communities. It will highlight the importance of using a systems approach when addressing climate change in cities (figure 5).[23]

[20] See https://unfccc.int/sites/default/files/resource/0.2aSlides%20for%20CitiesIPCC_outcomes%20FINAL.pdf and audio broadcast 0:30:39.

[21] See https://citiesipcc.org.

[22] See https://citiesipcc.org/wp-content/uploads/2018/03/The-Science-We-need-for-Cities-We-want_March-7_Edmonton-1.pdf.

[23] Since the RD10, the CitiesIPCC research agenda was reported to and endorsed at the 48th Session of the IPCC, 1–5 October 2018. See https://citiesipcc.org/beyond/global-research-and-action-agenda-on-cities-and-climate-change-science/.

Figure 5
CitiesIPCC Global Research and Action Agenda

Source: Slide 14 of the presentation by Mr. Shobhakar Dhakal.

44. Mr. Shobhakar Dhakal, representing the Asian Institute of Technology, gave his second presentation on **renewable energy, economics & co-benefits**.[24]

Mr. Shobhakar Dhakal, Asian Institute of Technology, Renewable energy, economics & co-benefits
Key messages

- Renewable energy cost has rapidly reduced since the publication of AR5 in 2013
- Reduction in the cost of renewables has impacts on the cost and speed of decarbonization
- Future renewable energy cost-reduction estimations are currently underestimated in models.

45. Mr. Dhakal highlighted that co-benefits were assessed by Working Group III of the IPCC in AR5 (2014), including transformation pathways, various sectors and policies, although in only a limited number of areas such as co-benefits of climate change mitigation for energy security and air quality.[25]

46. However, **renewable energy cost has rapidly reduced since the publication of AR5, particularly solar photovoltaic** (figure 6a). At the same time the cost of battery storage is reducing (figure 6b). By 2025, the global weighted average cost of electricity from solar photovoltaic could fall by as much as 59% and concentrating solar power (CSP) by up to 43%. Onshore and offshore wind could see cost declines of 26% and 35%, respectively.

47. Mr. Dhakal stated that **co-benefits are often well characterized – but quantification is limited. Nevertheless, in recent years the quantification of co-benefits has progressed in areas such as air pollution, health, energy security and employment** (e.g. through renewable energy).

48. As reduction in cost of renewables has impacts on the cost and speed of decarbonization. If co-benefits are incorporated into the cost of climate stabilization pathways, co-benefits are expected to reduce the overall cost.

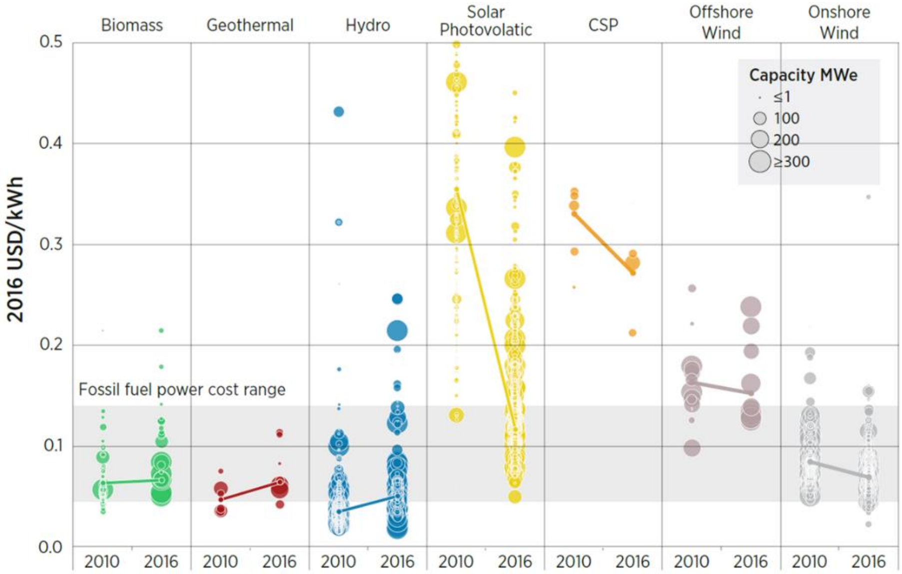
49. **Future estimations are thus currently underestimated in models**. The next generation of integrated assessment models (IAMs) and sectoral studies must find a better way to integrate renewables electricity and co-benefits including: the declining cost of storage and cost of renewable storage, especially solar PV, and onshore wind; the variable nature of renewable electricity and its integration aspects; and the wide spectrum of co-benefits in evaluating costs of climate stabilization pathways.

[24] See https://unfccc.int/sites/default/files/resource/0.2bRenewable%20Economics%20and%20Co-benefits.pdf and audio broadcast 0:41:36.

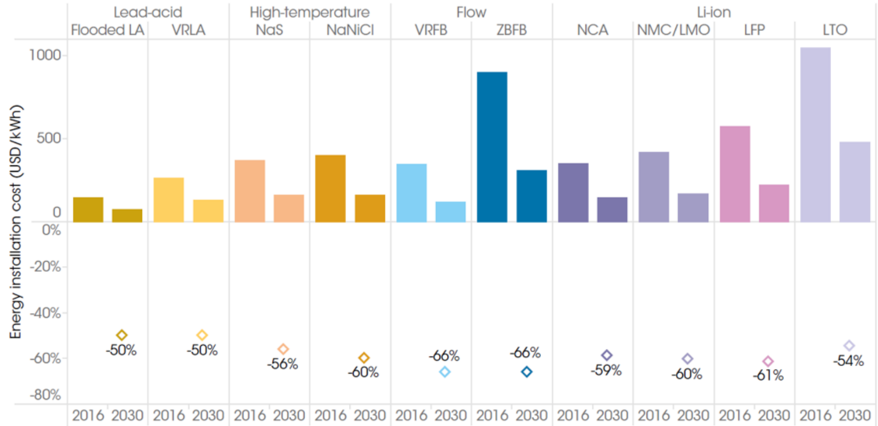
[25] Edenhofer O. et. al. (2014). Technical Summary. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Figure TS.14, page 62.

Figure 6
The decreasing cost of renewable energy and storage

(a) Global levelised cost of electricity from utility-scale renewable power generation technologies, 2010–2017



(b) Battery electricity storage systems: Installed energy cost reduction potential, 2016–2030



Source: Slides 15 and 16 of the second presentation by Mr. Shobhakar Dhakal.
Original source International Renewable Energy Agency (IRENA)
a) The diameter of the circle represents the size of the project, with its centre the value for the cost of each project on the Y axis. The thick lines are the global weighted average LCOE value for plants commissioned in each year. Real weighted average cost of capital is 7.5% for OECD countries and China and 10% for the rest of the world. The band represents the fossil fuel-fired power generation cost range.[26]
b) Note: LA = lead-acid; VRLA = valve-regulated lead-acid; NaS = sodium sulphur; NaNiCl = sodium nickel chloride; VRFB = vanadium redox flow battery; ZBFB = zinc bromine
flow battery; NCA = nickel cobalt aluminium; NMC/LMO = nickel manganese cobalt oxide/lithium manganese oxide; LFP = lithium iron phosphate; LTO = lithium titanate.[27]

[26] IRENA (2018) Renewable Power Generation Costs in 2017, International Renewable Energy Agency, Aby Dhabi. ISBN: 978-92-9260-040-2. See http://irena.org/publications/2018/Jan/Renewable-power-generation-costs-in-2017. Figure ES.1 Global levelised cost of electricity from utility-scale renewable power generation technologies, 2010–2017, page 17.

[27] IRENA (2017) Electricity storage and renewables: Costs and markets to 2030, International Renewable Energy Agency, Aby Dhabi. ISBN: 978-92-9260-038-9. See http://www.irena.org/publications/2017/Oct/Electricity-storage-and-renewables-costs-and-markets. Figure ES6. Battery electricity storage system installed energy cost reduction potential, 2016–2030, page 18.

Summary of Discussions[28]

50. **We understand the importance of co-designs and co-production for actionable information. How can we promote to share advanced efforts/good cases and to exchange data, knowledge, experiences, and techniques for climate change adaptation?**

(a) *Mr. Dhakal*: Co-design and co-production is extremely important however what is also important is how to bring the agenda forward. CitiesIPCC started the development of the research agenda, but to operationalize this agenda we also need all communities to help provide evidence-based research for policy. Thus, we need co-design and co-production for planning and for implementation.

(b) *Ms. Lynch:* There are existing networks that can share best practice – both informal and formal networks – such as between indigenous communities, government and non-government such as ICLEI and we need to use these to share best practice.

51. **Is it right to characterize air quality, energy security as co-benefits of mitigation? Would it be better to talk about the mitigation co-benefits of health policy, energy policy etc. What is the co-benefit of what?**

Mr. Dhakal: This is an important question referring to what are co-benefits? The co-benefit concept is not one-way. Synergy is needed including from the climate side –with other sectors to maximize benefits.

52. **Is CMIP6 on track to deliver the results needed by AR6?**

Ms. Lynch: CMIP6 is on track – there has been some delay in building the scenarios which feed into the climate models. However, this will not prevent the Tier 1 outputs being ready for AR6. There are 31 models in Tier 1 which contain 1.5 and 2 degree scenarios.

53. **In the WCRP programme for 2019–2020: Is special consideration being given to issues relevant to the Paris Agreement, such as the recently published 1.5°C scenario RCP1.9, or the attribution of impacts?**

(a) *Ms. Lynch:* WCRP is not policy-prescriptive but is informed by policy. The main areas where WCRP intersects with PA is through the CMIP programme with future scenarios – although it must be remembered that the current scenarios where developed two years previously as these take time and funding to develop.

(b) *Ms. Lynch:* Attribution has been a long-term activity in WCRP and will continue to be a large part of the fundamental science – we are looking particularly at attribution of extremes and a wider range of climate variables (not just the core variables).

[28] Audio broadcast 0:50:00.

B. Panel discussion 1: Science for understanding - update on research and modelling on human settlements, oceans and land and their importance for the implementation of the Paris Agreement

54. This summary of panel 1 follows the order according to the agenda. At the event, due to scheduling issues, Ms Sakhile Koketsu, Convention on Biological Diversity, gave the first presentation (see paragraph 78), followed by the other presenters.

55. Ms. Corinne Le Quéré, Global Carbon Project (GCP), presented on: **understanding the contemporary global carbon balance and its implications for monitoring emissions**.[29]

Ms. Corinne Le Quéré, Global Carbon Project, Understanding the contemporary global carbon balance and its implications for monitoring emissions
Key messages

- Carbon dioxide emissions from fossil fuels and industry are estimated at 36.6 ± 2 $GtCO_2$ for 2017, an increase in emissions compared to the previous 3 years of low or no increase
- The Global Carbon Project research community are working to address uncertainties in the estimation of global emissions and sinks so as to address the carbon budget imbalance
- Parties' could help to reduce uncertainties and support the work of the GCP, including through increasing access to existing rainfall data and providing more detailed reporting on fossil fuel use and land use
- The GCP are planning to provide 5-year carbon budgets to inform the stocktake; as well as budgets for methane and nitrous oxide (N2O), as well as develop regional carbon budgets.

56. The GCP publishes a yearly update on the **Global Carbon Budget** - the scientific understanding of CO_2 emissions and where they go in the environment.[30] Ms. Le Quéré gave a brief overview of current understanding as well as limits to current knowledge.

57. Carbon dioxide emissions from fossil fuels and industry are estimated at 36.6 ± 2 $GtCO_2$ for 2017 (figure 7). This is an i**ncrease of approximately 1.5% compared to the previous 3 years of approximately low or no rise in emissions**. Ms. Le Quéré highlighted that there is some uncertainty in these measurements and the GCP are working to verify this information with Earth system observations.

58. The Global Carbon Budget shows how these emissions fit into the larger picture (figure 8), which shows the level of global emissions (upper panel) and the sinks for these emissions (lower panel). Figure 8 shows the increase in fossil fuel and industry emissions since 1900. Land-use, land use change and forestry emissions have remained fairly constant, particularly in the last few decades – except uncertainty for these emissions is quite large (± 50%). In regards to partitioning of sinks: a little under half of emissions remain in the atmosphere, whilst the rest are taken up more or less equally by the land and ocean.

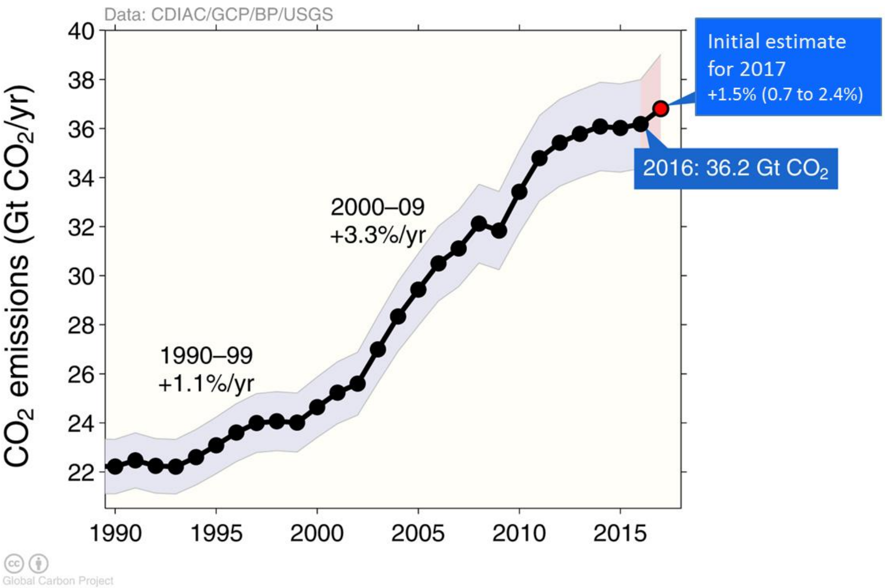
59. Ms. Le Quéré highlighted that, these estimates are carried out independently by the carbon cycle research community (approx. 70 people coming together to provide information every year). If researchers had complete understanding, the estimates of global emissions in the top panel would match the estimates of global sinks in the bottom panel. She stated that the good news is that estimates based on energy and land use change statistics, match on average very closely the estimates of the CO_2 increase in the atmosphere, land and ocean.

60. However, there are gaps (shown in light grey highlighting) in the bottom curve compared to the top. For example, the circled area shows a gap in estimates in the past decade of approximately 3 billion tonnes of CO_2. Still unknown is whether emissions are overestimated and/or the sinks are underestimated, or whether there is too much uncertainty in the natural environment to improve on these estimates and fill the gaps.

[29] See https://unfccc.int/sites/default/files/resource/1.1%20GCP_CarbonBudget_2017_for_SBSTA.pdf and audio broadcast 1:04:48.

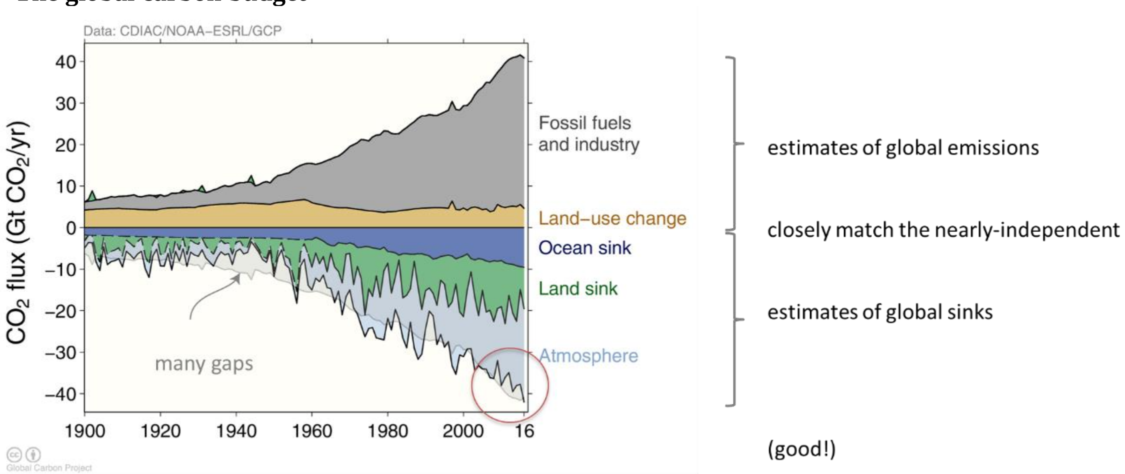
[30] See http://www.globalcarbonproject.org/.

Figure 7
Global carbon dioxide emissions from fossil fuel use and industry for 2017: 36.6 ± 2 GtCO2



Source: Slide 2 of the presentation by Ms. Corinne Le Quéré
Estimates for 2015–2017 are preliminary. Growth rate is adjusted for 2016 leap year. Uncertainty of ±1-sigma., Carbon dioxide information analysis centre (CDIAC);[31] Le Quéré et al (2017);[32] Peters et al. (2017) Global Carbon Budget[33] Fig. R. Andrew, Centre for International Climate Research (CICERO)

Figure 8
The global carbon budget



Source: Slide 3 of the presentation by Ms. Corinne Le Quéré.

[31] See http://cdiac.ornl.gov/trends/emis/meth_reg.html.
[32] See https://doi.org/10.5194/essd-2017-123.
[33] See http://www.globalcarbonproject.org/carbonbudget/.

61. Figure 9 shows the **carbon budget imbalance**, which is the difference between the estimated emissions and estimated sinks. The focus of the carbon research community is on improving the understanding of this imbalance and whether it is related to missing sinks and/or over-estimation of emissions.

62. Ms. Le Quéré highlighted that **Parties' could greatly help in reducing uncertainties and supporting the work of the GCP**, including through:

(a) Increasing access to/ availability of rainfall data (critical to assessment of the land carbon sink) – currently a lot of rain gauge data exists around the world they are not, as yet, openly available for research. These are needed to improve estimates of the land CO_2 sink.

(b) Increasing the coverage of surface ocean pCO_2 data, especially in high-latitude during winter. These are needed to improve estimates of the ocean CO_2 sink.

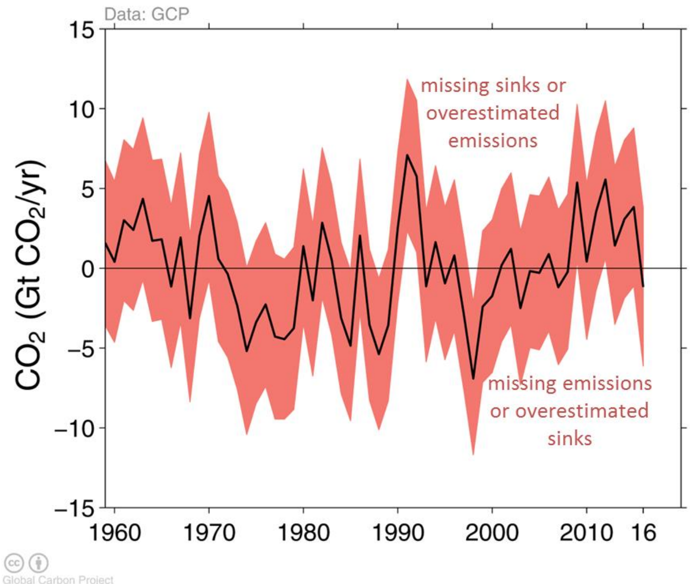
(c) Increasing the number of vertical profiles of atmospheric CO_2 concentrations in sparsely sampled regions with large carbon fluxes (such as Boreal Eurasia, Tropical Africa, Indonesia, and South America). In addition to serving as direct constraint on the fluxes, these are also the areas where satellite CO_2 observations might in the near future be used as primary data source, which need to be rigorously checked by using independent *in-situ* data.

(d) Providing more detail on reported information including: Statistics on fossil fuel emissions – information on not just how much coal is combusted but also the quality of the coal, the combustion process (such as is the coal washed or not?); and information on land cover change not just at country level – but where is the change occurring, what is the fate of the harvested products, information on the biomass such as the age of the trees.

(e) The use of remotely sensed products in forests assessments would improve their reliability beyond those based on statistics reported at the country level. Additional information on annual activities related to deforestation and forest degradation, including at the small scale (sub-national level) would improve assessment of the effect of those activities on the land CO2 sink.

63. Ms Le Quéré gave the next steps for the GCP which include **providing a 5-year carbon budget to inform the stocktake; provision of budgets for not just CO2 but also methane and (for the first time) nitrous oxide (N_2O), as well as developing regional carbon budgets (see poster on the RECCAP-2 project**,[34] paragraph 142).

Figure 9
Carbon budget imbalance (the 'gaps')



Source: Slide 4 of the presentation by Ms. Corinne Le Quéré.
The budget imbalance is the carbon left after adding estimates for total emissions, minus the atmospheric growth rate and estimates for the land and ocean carbon sinks using models constrained by observations
Source: Le Quéré et al 2017[32]; Peters et al. (2017) Global Carbon Budget[33]

[34] See https://unfccc.int/sites/default/files/resource/4.49%20RECCAP_lequere.pdf.

64. Mr. Nicola Tollin, University of Southern Denmark, presented on **Implementing the Paris Agreement: the role of human settlements**[35] including some of the outcomes from a session organized at the CitiesIPCC conference by the University of Southern Denmark in collaboration with UN Habitat, UNFCCC, Recycling Cities Network, Government of St Lucia, the city council of Quito in Ecuador, ICLEI-Local Governments for Sustainability, TH Köln - University of Applied Sciences, and within the context of the Cities and Regions Talanoa Dialogue. This session had been developed following a process, initiated

Mr. Nicola Tollin, University of Southern Denmark, Implementing the Paris Agreement: the role of human settlements

Key messages

- Vertical integration in cities is needed to link national and local action and strengthen climate change action and co-benefits
- Actions on adaptation, mitigation and cross-sectorial actions should be integrated within NDCs to generate co-benefits, including through nature-based solutions
- Moving forward involves research in order to understand urban contribution to NAPs and NDCs including:
    - modelling and quantifying co-benefits;
    - linking governance at national and local level and between sectors;
    - coordinating efforts to avoid double counting and duplication.

with the UN-Habitat report *Sustainable urbanization and the Paris Agreement*,[36] and through a range of policy dialogue, including within the framework of the Nairobi work programme. See also the poster presented by Mr. Tollin (paragraph 139).[37]

65. The session highlighted th**e importance of multi-level governance, and particularly vertical integration of national policies with local actions in cities**. The challenges identified include: lack of access to finance and technology, lack of capacity at local level, particularly in mid and small size cities (and not just global south); and the need for cost efficient integrated policies and actions (multi-sector and multi-level) that are able to generate co-benefits, using less resources.

66. Examples of integrated and systemic solutions that could generate such co-benefits include **ecosystem-based approaches and nature based solutions**. These solutions could not just provide co-benefits to tackle climate change causes (mitigation) and effects (adaptation), including slow and rapid onset events, but also provide co-benefits for sustainable development issues, growth/job creation, social inclusion/justice, preservation of biodiversity, and health.

67. Mr. Tollin explained that ecosystem based solutions are not simply planting a few trees or building a vertical forest. They are integrated solutions that: identify cities beyond their borders, within their biological region; provide a circular metabolic approach to optimise energy, materials, water, land, information etc.; re-think urban systems by design in an eco-systemic manner; provide planning as a dynamic self-adaptive process; recover intangible heritage and nature based knowledge.

68. Recommendations related to science, policy and the science/policy interface include:

(a) **More research to model and quantify co-benefits** that are local and context-related so as to avoid re-bound effects;

(b) **Improving governance** particularly in terms of vertical integration and horizontal integration at national and local level and between sectors;

(c) **Coordinating efforts** so as to avoid double counting and duplication, for example to better understand the urban contribution to NAPs and NDCs in achievement of the Paris Agreement.

[35] See https://unfccc.int/sites/default/files/resource/1.2%20RD10-Tollin_V01.pdf and audio broadcast 1:10:40.

[36] See https://unhabitat.org/books/sustainable-urbanization-in-the-paris-agreement.

[37] See https://unfccc.int/sites/default/files/resource/1.04%20SD10-SBSTA_Poster_Tollin_V01.pdf.

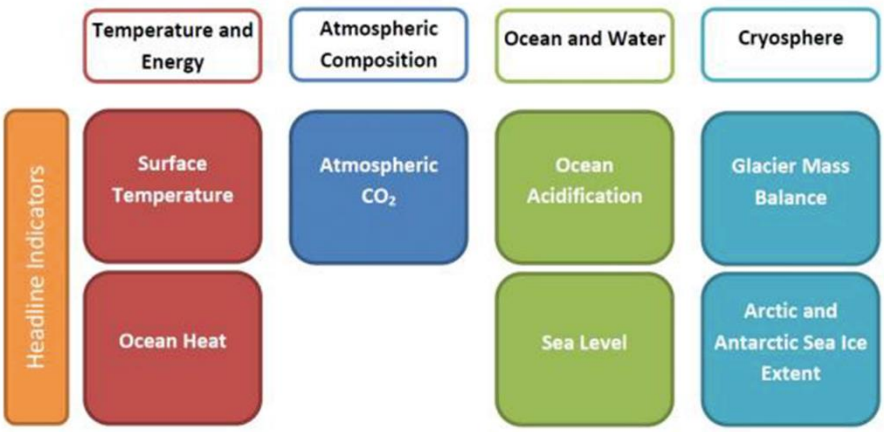
69. Mr. Salvatore Arico, Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO), presented on the **IOC ocean science contribution to the climate change science agenda.**[38] He highlighted the importance of ocean science research and the work of the IOC to the UNFCCC agenda.

Mr. Salvatore Arico, Intergovernmental Oceanographic Commission (IOC), IOC ocean science contribution to the climate change science agenda
Key messages

- Ocean research and systematic observations help us make informed decision on how the ocean can continue playing its critical role in regulating the climate system, mitigating climate change, and helping us adapt to its effects
- Concrete contributions of ocean science to the work of UNFCCC, through its SBSTA, include:
    - Match making Parties' needs in climate change science with opportunities for capacity development in ocean science;
    - Elucidating scientific and technical aspects of the global stocktake;
    - Identifying targets and developing the related methodologies to measure progress;
    - Assisting in the design of the next generation of integrated climate models and predictions;
    - Stimulating ocean science production reflecting the needs and aspirations of UNFCCC Parties.

70. Mr. Arico noted **the importance of the GCOS climate indicators for informing on the state of the climate** (figure 10). These headline indicators present the state of the climate in a simple way[39] and were recognized by the SBSTA at SBSTA 47.[40] The indicators are explained in more detail in the GCOS poster,[41] (see paragraph 140).

Figure 10
GCOS headline climate indicators

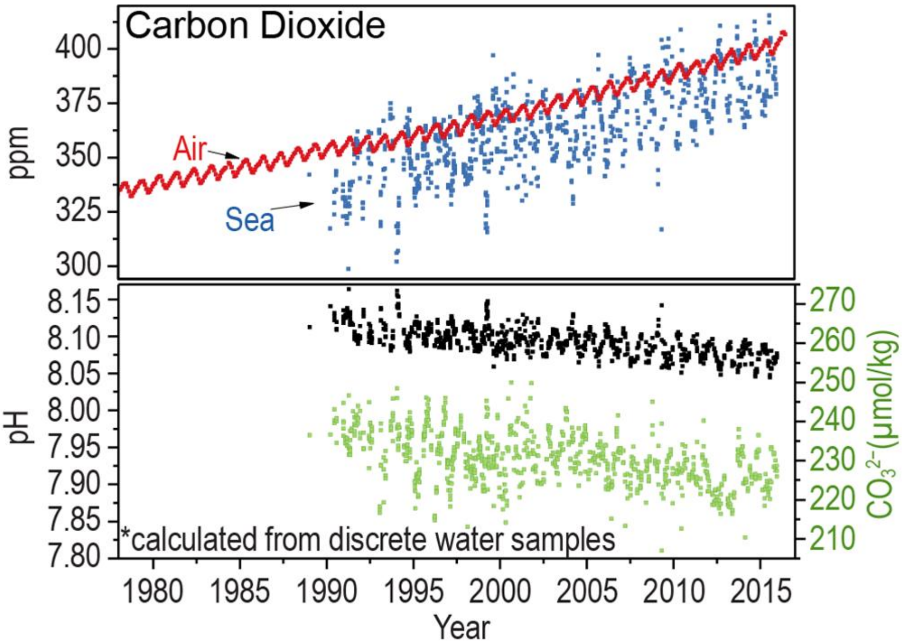


Source: Slide 3 of the presentation by Mr. Salvatore Arico.

[38] See https://unfccc.int/sites/default/files/resource/1.3%20IOC_RD_10.pdf and audio broadcast 1:19:25.
[39] See https://public.wmo.int/en/programmes/global-climate-observing-system/global-climate-indicators.
[40] FCCC/SBSTA/2017/7 paragraph 53–54.
[41] See https://unfccc.int/sites/default/files/resource/2.31%20GCOS_Richter.pdf.

71. Four of the climate indicators are ocean indicators, including ocean acidification (figure 11). The ocean absorbs about 30% of annual CO2 emissions. This has increased acidity levels in the ocean, affecting the aragonite saturation state, which is the main form of calcium carbonate used by key species to form shells and skeletal material (such as reef building corals and shelled molluscs).

Figure 11
Ocean Acidification

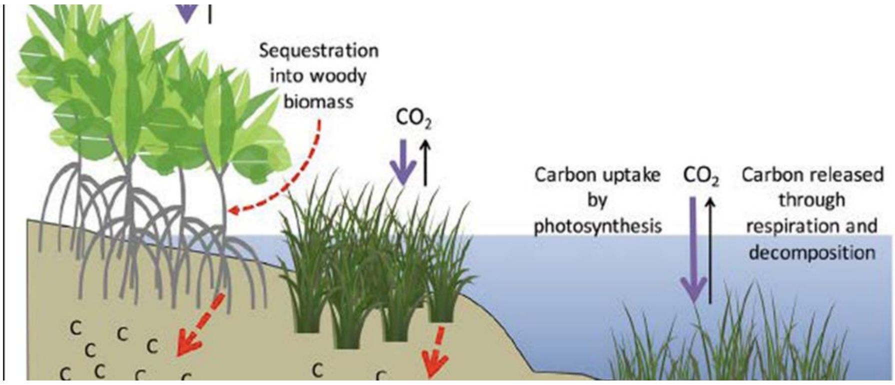


Source: Slide 2 of the presentation by Mr. Salvatore Arico.
Trends in surface (< 50 m) ocean carbonate chemistry calculated from observations obtained at the Hawai‘i Ocean Time-series (HOT) Program in the North Pacific over 1988–2015. (Figure source: NOAA, Jewett and Romanou 2017).[42]

[42] See http://hahana.soest.hawaii.edu/hot/hot-dogs/index.html.

72. Mr. Arico identified that the **methodology for quantifying blue carbon, specifically the contribution of salt marshes, mangroves and sea grasses, exists** (figure 12). He encouraged the use of these methodologies to support NDCs and match science with policy within the context of mitigation action.

Figure 12
Blue carbon and NDCs



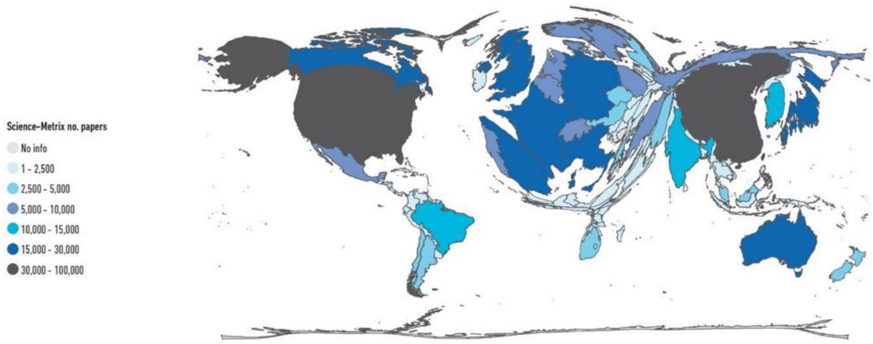
Source: Slide 4 of the presentation by Mr. Salvatore Arico.

73. Research on the ocean is important to better understand such impacts as ocean acidification, eutrophication, and ocean deoxygenation, as well as how healthy ocean systems can deliver benefits. The IOC looks forward to working closely with the UNFCCC to better support understanding, as well as support achievement of the SDGs.

74. Mr. Arico noted **the importance of linking modelling with predictions and that the scientific community are working to link ecological time series with climate models and for the outputs of this work to be considered within the context of AR6**.

75. He highlighted the seminal report on ***Global Ocean Science Report*** (2017)[43] which found that ocean science accounts for only between 0,04% and 4% of total research and development expenditures worldwide (figure 13).

Figure 13
Ocean Science accounts for only between 0,04% and 4% of total research and development expenditures worldwide



Source: Slide 9 of the presentation by Mr. Salvatore Arico.
Global Ocean Science Report (2017)

76. In order to provide a framework for action to boost research including to support climate change, the UN General Assembly has launched the ***United Nations Decade of Ocean Science for Sustainable Development* (2021–2030)**.[44]

77. Mr Arico highlighted that the IOC believe that there is a clear opportunity to matchmake party needs, including the UNFCCC, with scientific evidence and support NDCs and the global stocktake.

[43] See https://en.unesco.org/gosr.
[44] See https://en.unesco.org/ocean-decade.

78. Ms. Sakhile Koketso, Convention on Biological Diversity, presented on the **importance of terrestrial ecosystems for the implementation of the Paris Agreement**.[45] This presentation was linked to the recent publication of the regional Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services (IPBES), as highlighted in the accompanying poster (see paragraph 139).[46]

Ms. Sakhile Koketso, Convention on Biological Diversity, The importance of terrestrial ecosystems for the implementation of the Paris Agreement

Key messages

- Ecosystem-based approaches offer immediate and cost-effective benefits to both mitigate climate change and to adapt to its impacts
- Ecosystem-based approaches could provide up to half of the total greenhouse gas mitigation effort required by 2030
- Protection of ecosystems with large potential emissions of greenhouse gases upon conversion, such as forests and coastal ecosystems, is estimated to be one of the most cost effective means of climate mitigation
- Biodiversity and healthy ecosystems are important for increasing resilience and reducing risks and damages associated with climate change impacts, including acting as buffers against extreme events
- Findings from the Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services (IPBES) can support the implementation of the Paris Agreement.

79. She highlighted that ec**osystem-based approaches offer immediate and cost-effective benefits to both mitigate climate change and to adapt to its unavoidable effects**. These include: (i) reducing deforestation and other land-use change and degradation, (ii) restoring degraded lands and ecosystems, and (iii) enhancing soil management in agricultural and rangelands. Ecosystem based approached are already being included in NDCs.

80. Recent studies by the CBD[47] and others[48] demonstrate that ecosystem-based approaches may provide up to half of the total greenhouse gas mitigation effort required by 2030. The recent IPBES assessments[49] identify links between biodiversity and climate change although more research is needed to further quantify the contribution of ecosystems to mitigation and adaptation and inform on the impact of ecosystem management activities.

81. Ecosystem-based approaches are cost-effective compared to alternatives such as bioenergy and bioenergy with carbon capture and storage. For example, a recent study has shown that over 10 billion tonnes of carbon dioxide equivalent per year could be mitigated through ecosystem-based approaches by 2030 for US$100/Mg$CO_2$e or less, with about 4 billion tonnes delivered for US$10/Mg$CO_2$e or less. In contrast, cost estimates for emerging technologies such as bio-energy with carbon capture and storage range between US$40/Mg$CO_2$e and US$100/MgCO_2e.[50]

[45] Audio broadcast 0:59:10.

[46] See https://www.ipbes.net/assessment-reports.

[47] See UNEP/CBD/SBSTTA/20/INF/29.

[48] IPCC WGIII. (2014). Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[49] IPBES. (2018). Summary for policymakers of the assessment report on land degradation and restoration of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. [R. Scholes, L. Montanarella, A. Brainich, N. Barger, B. ten Brink, M. Cantele, B. Erasmus, J. Fisher, T. Gardner, T. G. Holland, F. Kohler, J. S. Kotiaho, G. Von Maltitz, G. Nangendo, R. Pandit, J. Parrotta, M. D. Potts, S. Prince, M. Sankaran and L. Willemen (eds.)]. IPBES secretariat, Bonn, Germany.

[50] Griscom et al. (2017). Natural climate solutions. Proceedings of the National Academy of Sciences of the United States of America 114: 11645–11650. doi:10.1073/pnas.1710465114.

82. Protection of ecosystems with large potential emissions of greenhouse gases upon conversion, such as forests and coastal ecosystems, is estimated to be one of the most cost effective means of climate mitigation. Many coastal and marine habitats sequester carbon at significantly high rates. For example, coastal wetlands (mangroves, tidal marshes, and seagrasses) effectively sequester up to 10 times more carbon per unit area than terrestrial forests (with 50–90% of the stored carbon residing in the soil). Biodiversity and healthy ecosystems are important for increasing resilience and reducing risks and damages associated with climate change impacts, for example they can act as buffers against extreme events, such as wetlands and mangroves and green belt vegetation around cities.[51]

83. Mr. Tero Mustonen, Snowchange Cooperative,[52] presented on **Messages of Changing Arctic**.[53] Further information was provided in the poster (see paragraph 139).[54]

Mr. Tero Mustonen, Snowchange Cooperative, Messages of changing Arctic
Key messages

- The Arctic is in the middle of a monumental system shift affecting the ecology, human societies and the position of the region in the global context
- Monitoring of Arctic change is an increasingly interesting theme for the wider scientific community, and multinational corporations, in regards to Arctic resources, transport corridors and global assessments interpreting the speed, extent and quality of change
- Indigenous and local-traditional knowledge has emerged in recent decades as a valid source of detecting ecosystem changes and implications in the Arctic
- New approaches are needed that provide responses and establishment of "safe havens" for biodiversity and indigenous peoples in the changing Arctic.

84. Mr. Mustonen stated that t**he Arctic has shifted into a new normal, affecting the ecology, human societies and the position of the region in the global context** – melting of permafrost, extreme events and lack of sea ice are some recent examples.[55]

85. Arctic sea ice is now impacted by climate change to such an extent that there will be a new ocean in the Arctic within the next few decades. Climate change is causing the largest climate-driven global redistribution of species since the last glacial maximum which is affecting ecosystem health, human well-being, and the dynamics of climate change, challenging local and regional systems of governance.[56]

86. Some of the most disturbing impacts for the region's indigenous people and traditional villages include: the holes in the permafrost appearing in the Yamal peninsula of the high Arctic and other areas; the melting of permafrost causing erosion of riversides and coastlines; and the collapse of lakes (figure 14). Most worryingly there is also release of anthrax from melting permafrost which has already caused the death of a young boy in Yamal and the need to slaughter thousands of reindeer with anthrax infection.

87. Mr. Mustonen highlighted that **new approaches are needed to provide "dynamic governance and conservation"**[57] **and establish "safe havens"**[58] **for biodiversity and Indigenous peoples in the changing Arctic**. An example of this are the efforts under way in the Atlantic salmon catchment area of *Njâuddam* River in the Finnish-Norwegian sub-Arctic. The Skolt Sámi of the river system have successfully

[51] SCBD/Secretariat of the Convention on Biological Diversity. (2016). Managing ecosystems in the context of climate change mitigation: A review of current knowledge and recommendations to support ecosystem-based mitigation actions that look beyond terrestrial forests. [Epple, C., García Rangel, S., Jenkins, M., & Guth, M.]. CBD Technical Series No. 86, Montreal, Canada.

[52] See http://www.snowchange.org/.

[53] See https://unfccc.int/sites/default/files/resource/1.ppt_RD10_Snowchange.pdf and audio broadcast 1:27:00.

[54] See https://unfccc.int/sites/default/files/resource/1.10%20SnowchangeCooperative_Mustonen.pdf.

[55] See The Arctic Council. Arctic Biodiversity Assessment (2017) https://www.arcticbiodiversity.is/ and NOAA Arctic Report Card https://www.arctic.noaa.gov/Report-Card/Report-Card-2017.

[56] Pecl GT et al. (2017). Biodiversity redistribution under climate change: Impacts on ecosystems and human well-being. Science 355(6332). See https://doi.org/10.1126/science.aai9214.

[57] Bonebrake, T et al., Managing consequences of climate-driven species redistribution requires integration of ecology, conservation and social science, Biol. Rev. (2017). See https://doi.org/10.1111/brv.12344.

[58] Pecl GT et al. (2017). Biodiversity redistribution under climate change: Impacts on ecosystems and human well-being. Science 355(6332). See https://doi.org/10.1126/science.aai9214.

established community-based monitoring [4] detecting arrival of southern insect species and extreme weather events.[59]

88. Mr. Mustonen proposed the **establishment of regional indigenous knowledge and science centres for monitoring and action across the globe** which would bring in co-production of knowledge with science to support understanding and action. This has led the Sámi to launch wide-scale Indigenous-led river ecosystem restoration.

Figure 14
Climate change impacts in the Arctic

(a) Holes in the permafrost

(b) Melting of permafrost

Source: Slide 2 of the presentation by Mr. Tero Mustonen.

89. Mr. Mustonen gave details of the **transformative project being undertaken by Snowchange Cooperative and Rewilding Europe, funded through the European Investment Bank, to restore biodiversity, degraded wetlands and boreal forests and create safe havens for birds and other wildlife and new carbon sinks across boreal Finland** (figure 15). This project combines traditional Sámi knowledge and science to advance climate equity and allow for the advancement of new types of conservation that are respectful and supportive of the indigenous and community conserved areas. Pilot sites, which include those within *Sápmi*, the Indigenous Sámi homeland, have been chosen and are already operational. This re-wilding model has the potential to be replicated to a larger scale of thousands of hectares by 2020 and potentially up to hundreds of thousands of hectares of degraded lands in Finland in the next decade.[60]

90. Mr. Mustonen encouraged Parties to participate in the project and benefit from wide-ranging opportunities that could be provided by this project to help conserve and restore new sinks and safe havens for birds and other species for all migratory bird habitats and create meaningful land-based restoration actions for mitigation using science and traditional knowledge.

Figure 15
Restoring ecosystems in the Arctic

(a) Boreal Forests

(b) Wetlands

Source: Slide 3 of the presentation by Mr. Tero Mustonen.

[59] Mustonen T and Feodoroff P (2013). Näätämö and Ponoi River Collaborative Management Plan. Snowchange Cooperative. http://www.snowchange.org/pages/wp-content/uploads/2014/05/Naatamo_sisus_1205_p.pdf.

[60] See http://www.snowchange.org/2018/06/major-new-landscape-rewilding-initiative-launched-today-in-finland-to-address-climate-change/.

91. Mr. Richard Betts, UK Hadley Centre presented on the **impacts of climate change on extreme weather, food and water resources at 1.5°C and 2°C**.[61] This work was carried out as part of the High end climate impacts and extremes (HELIX) EU-funded project.[62] Further information was provided in the poster (see paragraph 139).[63]

Mr. Richard Betts, UK Hadley Centre, The impacts of climate change on extreme weather, food and water resources at 1.5°C and 2°C

Key messages

- The HELIX project used a new climate model run at higher resolution than used in IPCC reports to look at climate change impacts at 1.5 and 2°C of warming
- The study found an increase in maximum temperatures, highly uncertain changes in river flows which could either increase or decrease, as well as increase in food insecurity - with larger changes predicted at 2°C compared to 1.5°C
- Results from the HELIX project support evidence that greater warming will bring larger changes and potentially more severe impacts.

92. Mr. Betts showed results from the HELIX project which used a new climate model run at higher resolution than used in the AR5 reports to drive a series of impact models at 1.5 and 2°C of warming compared with pre-industrial. It found:[64]

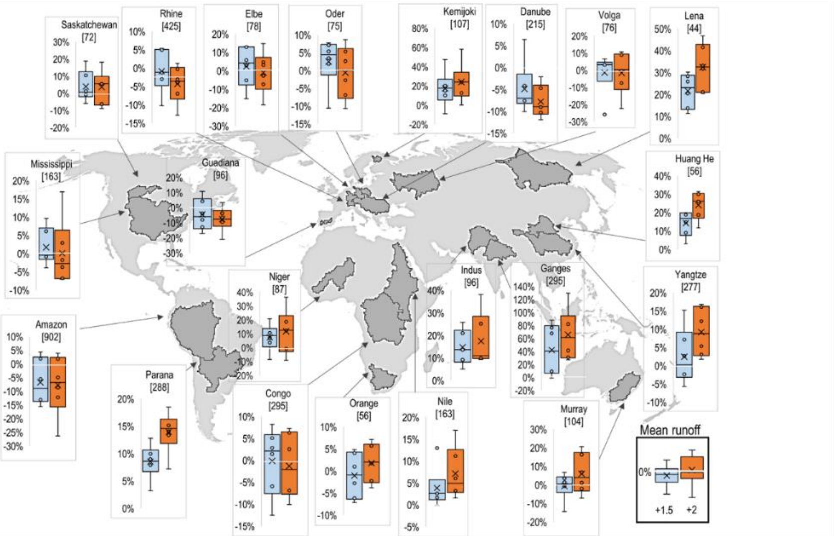
(a) Temperatures exceeded 10% of the time under present-day climate are projected to be exceeded for 5–20% of the time at 1.5°C, and 20–50% of the time at 2°C;

(b) Changes in river flows are highly uncertain, and for many rivers could either increase or decrease, with larger changes at 2°C compared to 1.5°C (figure 16);

(c) Taking the outputs of the model in mind, the project developed an index to show hunger vulnerability - **vulnerability to food insecurity depends on non-climatic factors as well as climatic factors, but generally increases with global warming** (figure 17).

Figure 16

Projected change in river flows at 1.5°C and 2°C



Source: Slide 2 of the presentation by Mr. Richard Betts.

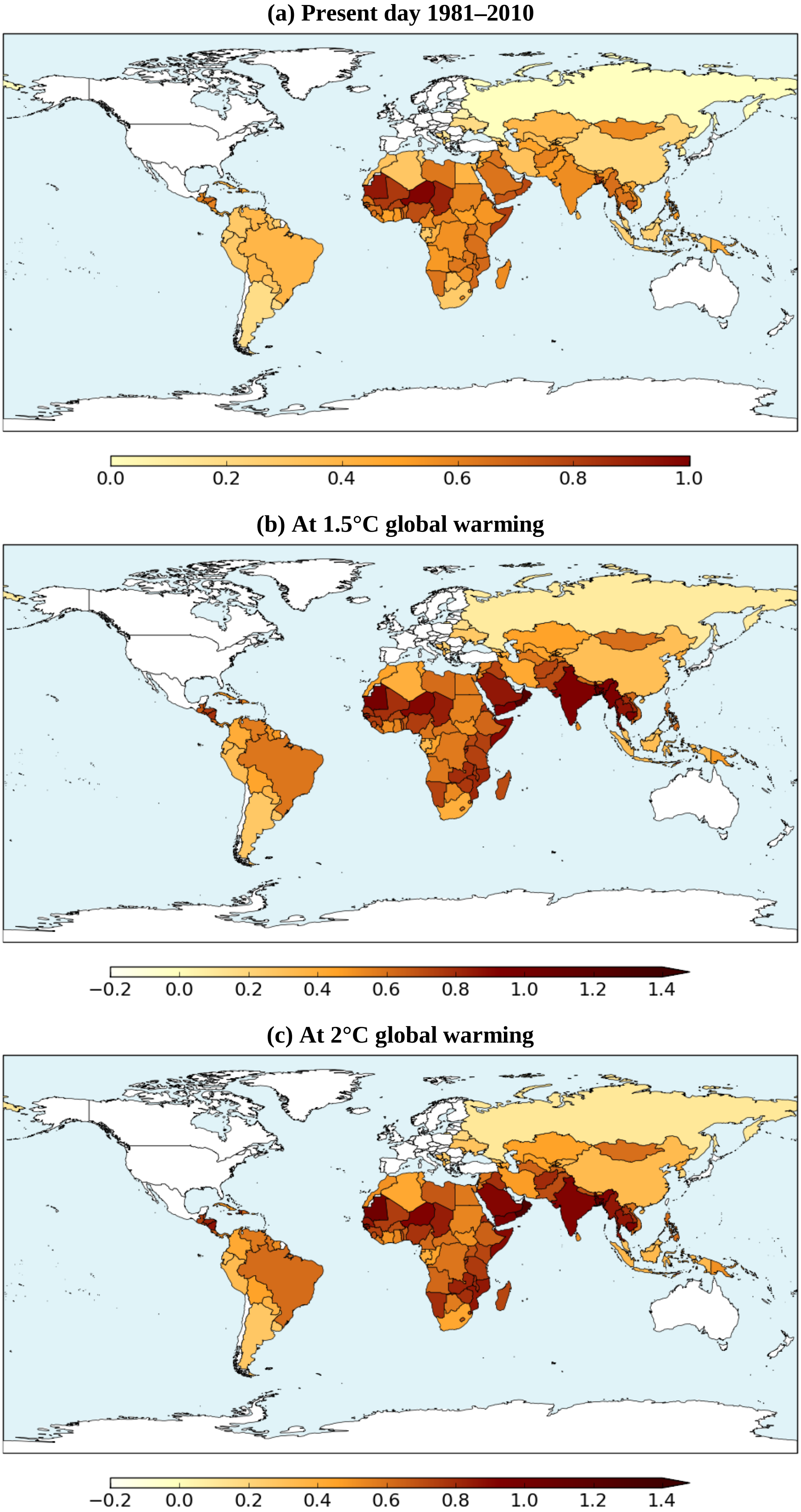
[61] See https://unfccc.int/sites/default/files/resource/1.6%20Betts_HELIX_SBSTA_030518.pdf and audio broadcast 1:34:35.

[62] See https://www.helixclimate.eu/.

[63] See https://unfccc.int/sites/default/files/resource/1.02%20Impacts%20of%20climate%20change%20at%201.5%20and%202C.pdf.

[64] Betts RA et al. 2018 Changes in climate extremes, fresh water availability and vulnerability to food insecurity projected at 1.5°C and 2°C global warming with a higher-resolution global climate model. Phil. Trans. R. Soc. A376: 20160452. See http://dx.doi.org/10.1098/rsta.2016.0452.

Figure 17
Hunger and Climate Vulnerability Index



Source: Slides 4–6 of the presentation by Mr. Richard Betts.

Summary of Discussions[65]

93. **In climate modelling and government policy, do we engage sufficiently in lifestyle/behavior/consumption in relation to mitigation of climate change, and if not, what is stopping us?**

(a) *Mr. Tollin:* One of the issues that work on circular economies looks at is the production cycle but not so much is carried out in regards to consumption – this is due to the conceptual framing of the issue. In the Paris Agreement, we have an internationally binding framework – but this is not sufficient if not coupled with bottom-up action. Thus, individuals need to change habits of behavior and consumption – something which requires awareness raising in a situation where there is little time left.

(b) *Ms. Le Quéré:* In regards to modelling – specifically energy modelling - scientists know a lot more about the production side than the consumption and demand side. Some details are known on behavior and a contribution can be made on this, but the dominant contribution is the economy in general based on fossil fuel. In regards to behavior research – the population responds much more to pull measures such as increase in ubic transport and services than pull measures such as restricting freedom.

(c) *Mr. Barron Orr, UNCCD*: The IPBES report and a range of other reports show that response to climate change is not about individual consumption, it is about telecoupling or teleconnections – that is the recognition, for example, that people are eating in one place but the land supporting this food production is elsewhere. Thus, the ecological footprint of consumption and production needs to be considered and raised at policy level before influencing sustainable individual consumption.

94. **Can we define a comprehensive ensemble of variables for integrative ecosystem observations serving climate change adaptation and mitigation as well as biodiversity conservation? And who will conduct the observations in a standardized way?**

(a) *Mr. Barron Orr: UNCCD*: There is a lot of engagement across the Conventions that could work towards this ensemble approach. The Group on Earth Observations (GEO) is pursuing a number of intiatives providing observation information in a standardized way.

(b) *Mr. Mustonen:* Biodiversity and climate change assessment is urgently needed. However, if you have co-production of knowledge with indigenous knowledge holders – the information operates in its own paradigm and epistemological context. Some of the examples from the Arctic Assessment and other work in the Arctic may provide steps forward in other regions which are trying to link knowledge and pinpoint the most urgent sites for change. We need dynamic governance of biological diversity – which means that perhaps the old model of parks and protected areas does not work anymore and what we need is dynamic governance of ecosystems and co-management with stakeholders and indigenous peoples.

(c) *Mr. Arico:* In regards to ocean observation – there is a clear set of ocean variables that are measured in the context of the GCOS implementation plan.

95. **Blue carbon in the NDCs risks blue carbon being used to offset emissions. There is no room for offsetting in 1.5 degree pathways and blue carbon uncertainties and reversal risks are high. Could you elaborate on the risk of double counting and impermanence?**

Mr. Arico: The quantification of the sequestration rates of the three systems: salt marshes, mangroves and sea grasses is reasonably clear. A global atlas of mangrove systems has just been published. In regards to coral systems, these cannot be accounted for in the case of blue carbon as they can shift from sink to source.

96. **Urbanization usually destroys eco-systems – how to imagine an ecosystem based city?**

Mr. Tollin: Nowadays most cities destroy systems, but it has not always been like that, for example Venice was managing its local ecosystem for hundreds of years. It is very important to recover this tangible *knowledge* which allows us to manage and grow together within systems.

97. **We saw a lot of things on blue carbon and there is a lot of literature on mangroves and their ability to sequester carbon. Is there any consensus how much carbon can be sequestered? We talked about ecosystem services- are these systems not fatigued due to climate change? As these systems are highly stressed are they providing the same services as 50 years ago? Such as the oceans – which are being treated as dustbins.**

Ms Le Quéré: With mangroves – we know how to quantify at the mangrove level – but upscaling is currently challenging. On the *issue* of ecosystems, these are highly stressed in regards to stressors such as

[65] Audio broadcast 1:42:00.

air pollution and nitrogen and now climate change. The impacts of stress on these systems are understood to some extent but not for some issues such as reoccurring droughts or floods. The Global Carbon Project is tracking ecosystems to look at how ecosystems are reacting to multiple stresses and understanding these responses. On the role of plastics in oceans – the response of the ocean in regards to climate change is currently at a chemical level but moving forward there are increasing impacts on ocean biology.

C. Panel discussion 2: Science for action - strengthening the link between the research community and action to meet the goals of the Paris Agreement

98. Mr. Seita Emori, Japan, presented on **Climate Change Science Communication Practices in Japan: what we have found through dialogue**.[66]

Mr. Seita Emori, Japan, Climate Change Science Communication Practices in Japan
Key messages

- It has been observed through communication practices in Japan that public opinions and stakeholder positions around climate change actions are polarized into two distinct views: technology-oriented and social reform-oriented
- The technology-oriented views are criticized as techno-optimism by one side, whilst the social reform-oriented views are unacceptable to the other side as they may sound like a threat to economic growth
- It is desirable to seek for a fusion of the two views as technological innovations are partly driven by social ideals which are then used as catalyst for social changes. Facilitating dialogue to make this happen will be a new role of climate communication.

99. He presented a number of climate communication activities that have taken place in Japan. In Weather Report 2050, a WMO initiative, the Japanese contribution by the Japan Broadcasting Corporation (NHK) in 2014[67] utilized future climate change simulations over Japan supported by the Ministry of Education, Culture, Sports, Science and Technology (MEXT).[68]

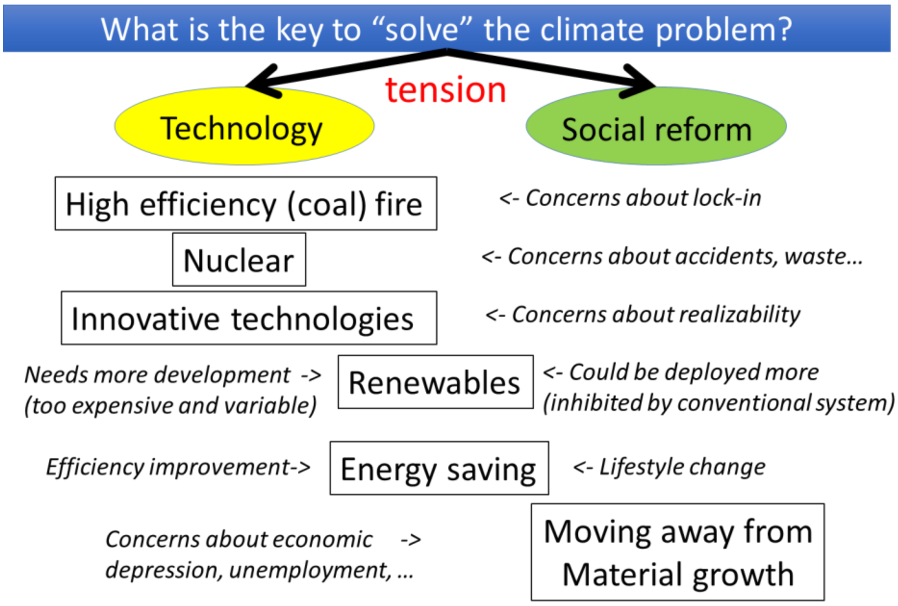
100. The Ministry of the Environment, Japan (MOEJ) has been running the **Climate Change Action Communicators programme** for four years.[69] Since it started, **over 2,000 citizen volunteers, school teachers and weather reporters are certified as communicators and providing lectures at various places in Japan to children and adults**.

101. **Stakeholder dialogues on the global climate challenges** have also been conducted under a research project called Integrated Climate Assessment – Risks, Uncertainties and Society (ICA-RUS),[70] supported by MOEJ. The stakeholders were invited from business, NGO, government sectors and also include politicians.

102. Mr. Emori explained that through these and other communication practices in Japan it has been observed that public opinions and stakeholder positions around climate change actions are polarized into two distinct views: technology-oriented and social reform-oriented (figure 18). The technology-oriented views are criticized as techno-optimism by one side, while the social reform-oriented views are unacceptable to the other side as they may sound like a threat to economic growth.

[66] See https://unfccc.int/sites/default/files/resource/2.ppt_RD10_Japan_EMORI.pdf and audio broadcast 2:00:10.
[67] See https://www.youtube.com/watch?v=TpQPOQABPxU (The video is available in Japanese with English subtitles).
[68] See http://www.jamstec.go.jp/tougou/eng/index.html.
[69] See https://ondankataisaku.env.go.jp/communicator (This website is available in Japanese only).
[70] See https://www.nies.go.jp/ica-rus/en/index.html.

Figure 18
Structure of (polarized) opinions currently observed in Japan

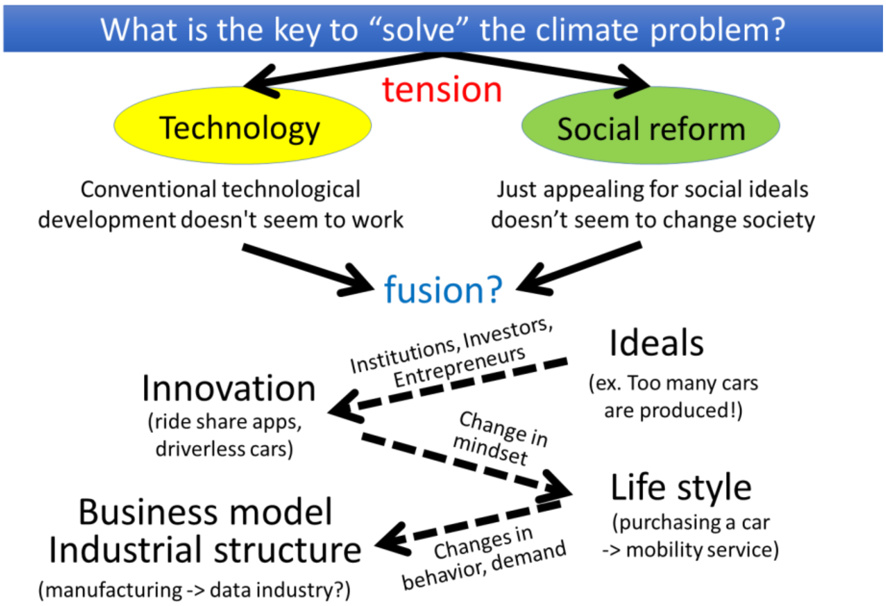


Source: Slide 2 of the presentation by Mr. Emori.

103. He highlighted that it is desirable to reconcile these two points of view and **seek for a fusion of the two views as technological innovations are partly driven by social ideals which are then used as a catalyst for social changes** (figure 19). For example – we have produced a lot of cars and should reduce these – but people do not give their cars up voluntarily. However, innovation and change of mindset from using cars to providing mobility services (perhaps including driverless cars in the future) can be partly driven by social ideas as well as the passions of investors, business and politicians to eventually change business and industry structure. This model is a transformation of public perception – with the idea of social reform and technology as complementary.

104. **Facilitating dialogue to fuse the two points of view and bring about this transformation is a new role for climate communication.**

Figure 19
Desired (and emerging?) transformation of opinions



Source: Slide 3 of the presentation by Mr. Emori.

105. Ms. Kimberly Ann Stephenson, University of the West Indies presented on the **Caribbean Regional Climate Science Initiative: Value Added and Lessons Learnt.**[71]

Ms. Kimberly Ann Stephenson, University of the West Indies, Caribbean Regional Climate Science Initiative: Value Added and Lessons Learnt

Key messages

- The Regional Climate Science Initiative was formed in response to the Caribbean region's climate vulnerability, lack of data, and growing demand from society for more climate information
- Led by the Caribbean Climate Modeller's Consortium, the initiative resulted in a regional climate science agenda which is periodically refreshed and has generally guided science activities for over 15 years
- The initiative has improved data availability, scientific capacity, and understanding of climate science in the region
- Though challenges remain, there has been an increase in consideration and use of climate data in regional impact studies, planning, and decision making.

106. She highlighted that the Regional Climate Science Initiative[72] was formed in response to the Caribbean region's climate vulnerability; lack of weather stations owing to financial constraints and consequent lack of data including historical data; and the growing demand from society for more climate information.

107. The initiative was led by the Caribbean Climate Modeller's Consortium which brought together climate modellers from different countries in the region. Each modelling group in the region provided aspects of the modelling requirements for the whole region so as to combine effort.

108. The **Consortium have been able to provide more information on the regional climate science, model impacts at 1.5 and 2 degrees C,** support making the transition between SRES to RCP scenarios, and increase the resolution of climate models. (Many global models see the Caribbean region as a large sea and not a group of small islands.)

109. The Consortium have produced some decision making tools including SMASH (Simple model for advecting storms and hurricanes), which enables users to traverse historic storms of note (GDP, damage or intensity) and run it over any country in the Caribbean region to understand the consequences of the impacts of such storms.

110. Ms. Stephenson presented the lessons learned from the initiative (figure 20). In regards to necessities for success, she highlighted:

(a) **Sharing the workload** across the modelling groups increased capacity and efficiency and reduced duplication;

(b) The need for a **cross-section of interests and disciplines** with decision makers feeding relevant information into the work;

(c) The need for **regional focal institutions** with the institutional will to carry out the project as, due to limited funding for basic climate science in the region, the funding supply was not guaranteed.

111. In regards to challenges, Ms. Stephenson highlighted:

(a) The **sparse historical data** available in the region;

(b) The **occurrence of duplication** because as an institute's work progresses, it may wish to widen its remit but this needed to be communicated within the initiative to ensure effective coordination;

[71] See https://unfccc.int/sites/default/files/resource/2.ppt_RD10_Carribbean%20regional%20climate%20science%20initiative%20.pdf and audio broadcast 2:09:40.

[72] Stephenson K et al. (2018). The Regional Climate Science Initiative, Caribbean Quarterly, 64:1, pp 11–25. See https://doi.org/10.1080/00086495.2018.1435314.

(c) The **importance of communication and translation of the science**, for example, in Jamaica Voices for climate change take the scientific information and sing it;[73]

(d) Success of the initiative meant an increasing demand for more information to support action in the region but **capacity is a challenge**;

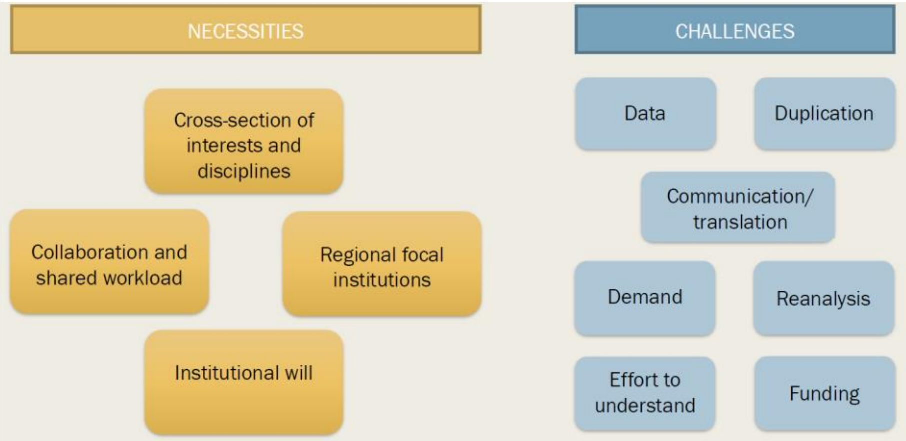
(e) The need for **more reanalysis and support for reanalysis** – the scale of global climate models is too large but also reanalysis uses historical data to validate models and the scale of this historical data is also too large – thus models need to be validated with higher resolution data;

(f) It takes effort to understand what is required and **how best to provide information**;

(g) **Funding** is a challenge - there is funding available in the region for adaptation and mitigation which is great – but funding is also needed for scientific research so as to understand climate dynamics and quantify Caribbean climate and what is connected to it – so this information can be fed into decision making on mitigation and adaptation.

112. The future work for the initiative includes continuing to bring in expertise from young researchers and ensuring that the group consists of modelers and those undertaking impact studies so as to provide information on climate change impact on, inter alia, food security, water and biodiversity.

Figure 20
Lessons learned from the Regional Climate Science Initiative



Source: Slide 4 of the presentation by Ms. Stephenson.

113. Chris Lennard, CORDEX-Africa, presented on **Co-production of actionable climate information for policy development in Africa**.[74] He presented experience from work undertaken in the context of the Future Resilience for African Cities and Lands (FRACTAL) project[75] and in the context of CORDEX-Africa. Further information is also provided in the posters[76] (see paragraph 140).

Chris Lennard, CORDEX-Africa, Co-production of actionable climate information for policy development in Africa
Key messages

- Moving from production of climate data/information to formulating actionable knowledge is extremely challenging
- Decision makers implicitly construct their own stories or narratives through interpretation of the complex and opaque evidence they are presented with
- Climate Risk Narratives are "conversation starters" to initiate conversations between decision makers and scientists around potential changes in climate related risks and impacts.

[73] See https://www.youtube.com/watch?v=P61VAx6wi5o.
[74] See https://unfccc.int/sites/default/files/resource/2.3%20Lennard.pdf and audio broadcast 2:21:30.
[75] See http://www.fractal.org.za.
[76] See https://unfccc.int/sites/default/files/resource/2.36%20WCRP_Lennard%20FRACTAL.pdf.

114. Mr. Lennard discussed some of the questions often faced by scientists and decision makers in regards to the requirements for climate information:

(a) What regional climate information messages are necessary? In this regard

- How do we define a region? (is it a country, catchment, city,…?);
- What is the relevant climate information for that region?

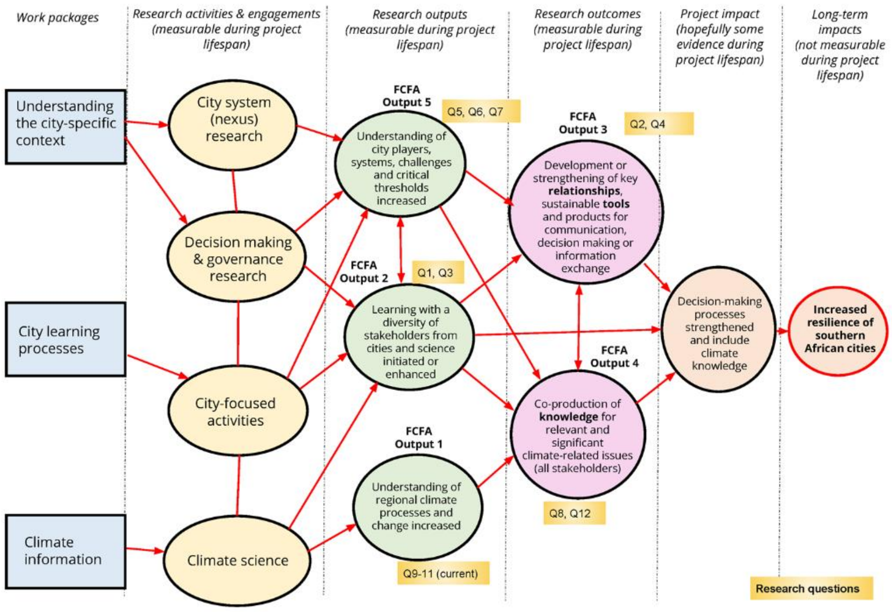
(b) How do we produce actionable regional climate information? We need

- Sustained capacity development in co-production of knowledge (on decadal scales);
- Ongoing long-term (sustainable) funded projects;
- Downscaled data (CMIP6 and CORDEX; capacity).

115. Mr. Lennard explained lessons learned in providing climate information. In the case of FRACTAL, this is city-specific information and the project has used Climate Risk Narratives to attempt to explicitly construct evidence based, physically plausible narratives of the future climate risk in a particular context (e.g. a city) including non-climate elements such as population growth and socio-economic futures in a co-production, participatory process.

116. The narratives are written with absolute certainty to avoid the pitfalls of uncertainty language and/or visualizing uncertainty. Multiple narratives are used to describe a range of possible futures given underlying uncertainty in the evidence and probabilities are not assigned to each narrative (figure 21).

Figure 21
FRACTAL – The narrative approach



Source: Slide 6 of the presentation by Mr. Lennard.
The project developed a dynamic Theory of Change to make sure the project progressed towards its stated objectives.[77]

117. **Climate Risk Narratives are "conversation starters" to facilitate starting productive conversations with decision makers around potential changes in climate related risks and impacts**. They are an iteratively evolving framework for ongoing engagement between decision makers and scientists. Decision makers and other knowledge holders can critique and change language, terminology, socio-economic futures, etc. to make the narratives more relevant to their context and climate researchers can iterate the climate evidence/interpretation to better address the non- climate context. This facilitates a co-produced set of context specific climate narratives that inform robust policy development.

118. Mr. Lennard identified some of the learning points from FRACTAL so far. For scientists, these include the different use of language between different stakeholders groups, the unpreparedness of cities to natural variability and climate, the fact that climate change is not the best entry point to discussing resilience with city officials, provision of data to other communities is not useful, and relationship building is

[77] See http://www.fractal.org.za/research/.

extremely important. For practitioners, these include the difficulty in working with and using climate information, language, importance of stakeholder engagement, receptivity – two years into the project through relationship building, decision makers are becoming receptive to action and responding to climate change.

119. He emphasized with both FRACTAL and CORDEX that **long-term sustainability of the projects is vital to gain trust with scientists from other disciplines, decision makers and other stakeholders to understand needs and requirements. In the case of CORDEX-Africa, much of the project is carried out unfunded with individuals working in recognition of the importance of this work**.

120. Mr. Andrew Matthews, Asia-Pacific Network for Global Change Research (APN), presented on **Closing the Gap: Capacity Development and Communicating Science**.[78]

Mr. Andrew Matthews, Asia-Pacific Network for Global Change Research, Closing the Gap: Capacity Development and Communicating Science

Key messages

- An array of approaches is needed to communicate science to policy makers as one size does not fit all
- Using a local language may be necessary as is explaining technical terms
- It is important to understand the policy makers' deadlines and time scales as these might well differ from that of the scientist
- Informal dialogues build trust and this allows what might be seen as simple or naive questions to be asked
- One of the most important factors is the human factor: sharing information, transferring knowledge and experiences and helping define best practice.

121. Mr. Matthews discussed some of the experience learned from the capacity building work of the APN over the last ten years. He supported the messages from the presentations by Mr. Emori and Mr. Lennard stating that **one size does not fill all, cultural differences and the background of participants must be considered, and informal dialogue is important to build trust**.

122. He cited a whole range of options for communication – and **communication and networking should go hand-in -hand to promote co-generation of information** (figure 22).

Figure 22
The context for effective communication

Source: Slide 3 of the presentation by Mr. Andrew Matthews.

[78] See https://unfccc.int/sites/default/files/resource/2.4ppt_RD10_APN_Matthews.pdf and audio broadcast 2:30:55.

123. APN have found that the communicator **builds the crucial factor of trust** by effectively **communicating** uncertainties by developing scenarios which are crucial to the planning and assessment process. **Standardized protocols** need to be in place so that indicators can be developed and reported systematically. Scenarios and uncertainty are normal concepts for scientists but often difficult conepts for decision makers to understand. Thus, scenario methodologies, capabilities and constraints need to be communicated transparently and participatory approaches need to be ensured. The co-benefits should also be considered and communicated to ensure that all stakeholders understand the rising costs of inaction

124. At the science / policy interface – APN have learned that:

(a) Scientists are often keen to present their information but for programmes suggested by scientists to be implemented, having local champions in the policy sector can really help;

(b) Researchers need to identify short-term and long-term actions when delivering scientific outcomes to policy makers and recognise policy makers' immediate needs;

(c) An effective approach to transfer scientific findings to policy planning is to hold **face-to-face discussions between scientists and policy makers and identify specific persons required for such dialogue**;

(d) Policy communities lack interest in science-policy dialogues compared with scientists. To make it more attractive **involvement of a science champion or respected person** (such as a Nobel prize winner) in the country is recommended.

125. **APN have developed toolkits that optimize climate change adaptation through enhanced community resilience through being simple, informative and cost-efficient**, designing a rapid assessment tool for community resilience to:

(a) Support climate adaptation planning across government departments;

(b) Provide useful information that can be gathered without significant expertise;

(c) Fill a critical information gap many governments have and can be used as part of regular planning processes.

126. Mr. Omar Defeo presented on **Science-policy action in South America: the hotspot of the Southwestern Atlantic Ocean**, Inter-American Institute for Global Change Research (IAI) and Universidad de la Republica de Uruguay & Direccion Nacional de Recursos Acuaticos.[79]

Mr. Omar Defeo, Inter-American Institute for Global Change Research, Science-policy action in South America: the hotspot of the Southwestern Atlantic Ocean
Key messages
- The Southwestern Atlantic Ocean is a climate change hotspot and a regional approach is needed to management
- The regional approach should include coordination and cooperation among countries; long-term scientific programs and common policy goals; and ways to communicate science at the local, national and regional levels
- Regional science/policy dialogue is vital to research impacts and communicate management options.

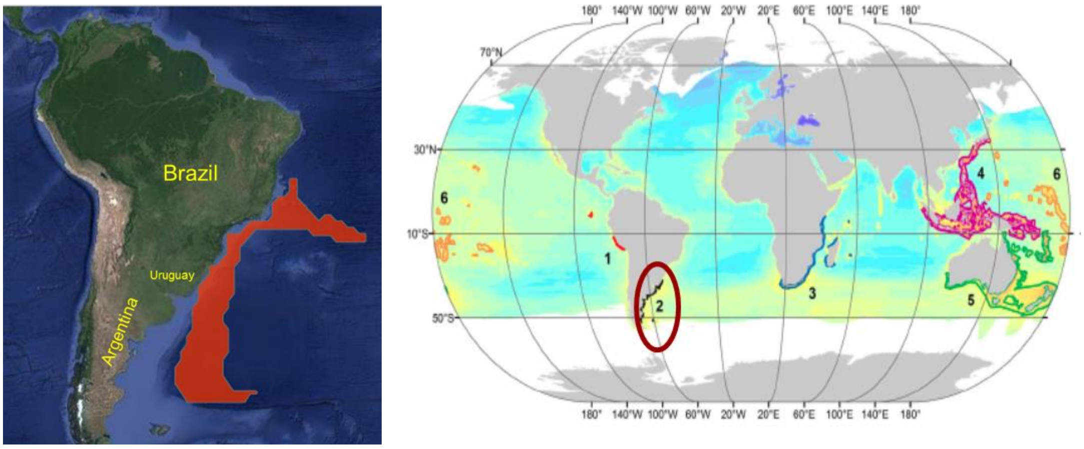
127. Mr Defeo explained that the **Southwestern Atlantic Ocean is a climate change hotspot** and to address the climate change and other issues affecting this hotspot requires a regional approach (figure 23).

128. In the southwestern Atlantic Ocean warming is occurring at several times the average global rate of warming. There is long-term increase in sea surface temperature, sea level, onshore winds (intensity and frequency), extreme events, discharge of freshwater (e.g., Rio de la Plata) and coastal erosion. There are critical effects on biodiversity and services include: mass mortalities, tropicalization, range shifts, invasive species and red tides.

[79] See https://unfccc.int/sites/default/files/resource/2.5%20ppt_RD10_IAI_Defeo.pdf and audio broadcast 2:39:07.

129. On a regional prespective in this region, impacts are on shared fisheries in large marine ecosystems with small-scale fisheries and livelihoods threatened and climate drivers affecting the vulnerability of local communities in Brazil, Uruguay and Argentina which have.

Figure 23
The Southwestern Atlantic Ocean: a biodiversity hotspot



Source: Slide 2 of the presentation by Mr. Omar Defeo.

130. **Solutions are needed beyond the borders of the states to address climate change impacts on this important regional biodiversity hotspot to provide coordination and cooperation among countries; long-term scientific programs and common policy goals; and ways to communicate science at the local, national and regional levels.**

131. Strengthening of the science/policy interface requires:

(a) **Interdisciplinary research** (such as sociologists, ecologists, oceanographers, economists, biologists) and networks for climate change and assessment and adaptation;

(b) **Social dimensions** at the core of adaptation strategies;

(c) **Targeted approaches** for management and conservation of biodiversity;

(d) **Strengthening of national adaptation plans**;

(e) **Multi-level governance improvements** for climate change adaptation;

(f) **Building of livelihood resilience** to climate change (e.g. small-scale fisheries);

(g) Development of **innovative technologies** (such as early warning systems for red tides);

(h) **Translational science** to convert science into action: a platform for communicating climate change science.

132. IAI, as an observer intergovernmental organization, is playing a critical role to explore synergies with Parties to support regional-scale actions in light of the national priorities, and to facilitate communication of science for adaptation policies.

133. Mr. Defeo stated that, as highlighted by Mr. Matthews, **a range of tools are needed to communicate the science at different levels and using different mechanisms** (figure 24). Researchers consider the southwestern Atlantic Ocean as a socio-ecological system and have brought together local knowledge and scientific information to provide effective communication of the issues and options, including booklets for fishermen, training in schools, development of co-management options to catalyze solid governance in a bottom-up approach. Mr. Defeo emphasized the importance of communication at the science-policy interface at regional level – and the research dialogue has been the first forum in which the governments of Brazil, Uruguay and Argentina have highlighted the importance of such dialogue.

Summary of Discussions[80]

134. **There is real politics involved in solving the tension between technology and social reform. Communication alone won't do it. What else is needed?**

(a) *Mr. Emori*: *There* are some examples of reconciliation of different opinions, but communication alone will not provide all the answers. Politics is an important issue. We need efforts at a range of levels that can facilitate finding solutions.

(b) *Mr Defeo*: As scientists we communicate our results to policy makers and we need to work together. On the other hand, there needs to be cooperation from all sides and targeted communication to a range of stakeholders.

(c) *Ms. Lynch*: We need to understand how political reform happens. Often the networking which produces successful case studies can be used as resources to build political momentum.

(d) *Mr. Matthews*: A lot of science is irrelevant at the first level of dialogue, it is important to understand the political will behind the issue.

(e) *Mr. Mustonen*: The short answer to this question is that only crisis will bring this forward in the policy world. However, scientists can look at an issue and ask what can we do as scientists for decision makers to understand the urgency.

Figure 24
Communicating science

Source: Slide 5 of the presentation by Mr. Omar Defeo.

135. The Chair gave the floor to Fiona Tummon to speak briefly on the **role of the early career researchers and the Young Earth System Scientist community** (YESS). She highlighted that today's young generation of scientists has grown up in a world that is much more interconnected than ever before, with interdisciplinary education and knowledge and awareness of the links between science and society. The YESS came together from the bottom-up to try and push ideas and messages forward. Early career researchers are keen to contribute and participate in interdisciplinary research and science communication – and can help support the work discussed within the dialogue.

80 Audio broadcast 2:47:30.

136. The Chair gave the floor to Ms. Michele Winthrop, **Least Developed Countries Expert Group** (LEG). She highlighted the LEG had recently conducted a comprehensive assessment process of the gaps and needs identified in NAPs. Compelling messages from this work includes the real sense that scientific research is needed and funding for this research is also needed; data and tools are required for monitoring progress, and for impact assessments for people and ecosystems; economic analysis is needed to support the unlocking of science – without funding for climate science, the base for decision making and action cannot be met or capacity for science.

137. The Chair briefly summed up the meeting highlighting that discussions showed the necessity for the virtuous circle of support for science: research – co-production of knowledge to produce policies – monitoring of policies – feed back to science and policy. However, a vicious circle can develop if pieces of this process are missing.

IV. Summary of the posters

138. This section provides an overview of the posters presented, including summary, key messages, as well as the online **link**, for each poster.

A. Posters on Theme 1: Science for understanding - update on research and modelling on human settlements, oceans and land and their importance for the implementation of the Paris Agreement

139. Twelve posters were presented on theme 1 and are summarized in the table below.

Global	
Impacts of climate change on extreme weather, food and water resources at 1.5C and 2C Richard Betts, UK Hadley centre	
Summary	The HELIX project used a new climate model run at higher resolution than used in IPCC reports to look at climate change impacts at 1.5 and 2°C of warming. A summary is provided in paragraphs 91–92.
Key messages	The HELIX project found: • Temperatures exceeded 10% of the time under present-day climate are projected to be exceeded for 5–20% of the time at 1.5°C, and 20–50% of the time at 2°C; • Changes in river flows are highly uncertain, and for many rivers could either increase or decrease, with larger changes at 2°C compared to 1.5°C; • Vulnerability to food insecurity depends on non-climatic factors as well as climatic factors, but generally increases with global warming. Results from the HELIX project support evidence that greater warming will bring larger changes and potentially more severe impacts.
Link	https://unfccc.int/sites/default/files/resource/1.02%20Impacts%20of%20climate%20change%20at%201.5%20and%202C.pdf.
Human Settlements	
Urban Climate Information for Decision Making in Cities: Local to Global Decisions and Policies Helen Cleugh and Boram Lee, WCRP	
Summary	The need for cities to adapt to, and mitigate, global climate change is driving demand for detailed information on urban climates at scales that cannot be easily met with current observing networks, regional and global climate models (RCMs and GCMs). Impact assessments and adaptation plans for our cities require high spatial resolution climate projections along with: • models that represent urban processes; • ensemble dynamical and statistical downscaling; • local-impact models. There is also an urgent need to monitor progress on climate change adaptation in urban areas, so as to reduce risk and increase resilience in the face of climate change. The foundation of urban-scale climate information includes our current high-resolution urban downscaling expertise, combined with local-impact models, and ensemble dynamical and statistical downscaling. However, there are critical knowledge gaps around downscaling to city-scales and how to assess and reduce uncertainties. This calls the research community to identify one or more Essential Climate Variables (ECVs), bio-physical and/or socio-economic, that can represent human adaptation to climate change in

	cities, in collaboration with research partners (WCRP, GCOS, etc.) as well as through the assistance/advice of relevant stakeholder across the finance and insurance sectors. Urban adaptation ECVs could be: • biophysical (e.g. changes in green canopy area); • socioeconomic (e.g. investment in adaptation); • linked to urban form and layout and the use of energy efficient construction materials and coatings. Several potential urban adaptation ECVs have been identified, mainly related to the biophysical characteristics of the urban environment.
Key messages	The scientific community in collaboration with research partners (WCRP, GCOS, etc.) as well as through the assistance/advice of relevant stakeholder across the finance and insurance sectors is developing a set of urban ECVs. Robust bio-physical and/or socio-economic ECVs will feed directly into local and global climate change policy; such as through monitoring urban environmental adaptation progress and through time and (possibly) against targets.
Link	https://unfccc.int/sites/default/files/resource/1.03%20WCRP_Lee%20Urban%20indicators.pdf.
Knowledge gaps for urban climate action Nicola Tollin, University of Southern Denmark	
Summary	The poster detailed outcomes from the session at the CitiesIPCC conference, 2018, on Supporting NDCs implementation in urban areas and vertical integration of climate actions. A summary is provided in paragraphs 64–68.
Key messages	A number of knowledge gaps were identified at the CitiesIPCC side event on supporting NDCs in urban areas and vertical integration of climate actions: • Monitor urban content of NDCs and NAPs in order to assess ambitions and progress of national policies and local actions. • Integrate adaptation and mitigation, and cross-sectorial actions within NDCs, to generate co-benefits, also through nature based solutions. • Create multilevel governance, multi-stakeholder collaborative platforms for NDCs development and implementation. • Use urban resilience framework and urban resilience observatories to define common but differentiated assessment framework adaptable to specific national and local circumstances.
Link	https://unfccc.int/sites/default/files/resource/1.04%20SD10-SBSTA_Poster_Tollin_V01.pdf.
Oceans	
Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC); Hans Pörtner, IPCC Co-Chair WGII and Katja Mintenbeck, IPCC WGII Technical Support Unit (TSU)	
Summary	At its 43rd Session in Nairobi, Kenya, in April 2016 the IPCC decided to prepare a special report on climate change and the oceans and cryosphere, to be finalized in September 2019. The SROCC is one out of six special reports to be developed during the IPCC Sixth Assessment Cycle. The outline of the SROCC was developed during the scoping meeting in Monaco (December 2016) and approved and adopted by the IPCC Panel in April 2017. The special report includes six chapters and at least one cross-chapter box, and is developed by 106 selected experts with different expertises from all over the world.

	The SROCC will comprehensively address most policy-relevant issues to guide adaptation activities and decision-making.
Key messages	The SROCC builds on scientific questions that emerged from invited government proposals for special reports to be prepared during the IPCC Sixth Assessment Cycle. The SROCC is developed under joint scientific leadership of IPCC Working Group I (Physical Science Basis) and Working Group II (Impacts, Adaptation, and Vulnerability). The Report will provide a cross-cutting assessment including (i) the role of the oceans and cryosphere in the climate system, (ii) risks, vulnerability, and impacts in natural and human systems, and (iii) responses to enhance resilience, adaptation options, their limits and trade-offs. The new and updated information presented to decision makers in this Special Report will inform the design and implementation of appropriate policies and actions.
Link	https://unfccc.int/sites/default/files/resource/1.05%20IPCC_SROCC.pdf.
Ocean Acidification: The Other Carbon Dioxide Problem;Hans Pörtner, IPCC Co-Chair WGII and Katja Mintenbeck, IPCC WGII Technical Support Unit (TSU)	
Summary	The poster presents key results from the German research network BIOACID (Biological Impacts of Ocean Acidification). 250 scientists from 20 German institutions participated in this project that has been funded by the German Ministry of Education and Research from 2009 and 2017. Their results clearly indicate that ocean acidification and warming, along with other environmental stressors, impair life in the ocean and compromise important ecosystem services it provides to humankind. The ocean has taken up about a third of the carbon dioxide (CO2) released into the atmosphere by human activities. When absorbed by seawater, the greenhouse gas triggers chemical reactions: carbonic acid is produced and the concentration of carbonate ions decreases. Marine organisms that build their shells or skeletons from calcium carbonate are particularly affected but also non-calcifying species are challenged in acidifying waters. Responses of individual species may also impact other parts of the food web and marine communities indirectly. Ultimately, the interaction of effects even has consequences for important ecosystem services such as the uptake and storage of carbon dioxide, food provision from fisheries or the recreational and cultural values of the ocean.
Key messages	Ocean acidification and warming affect the diversity of marine life as well as important services the ocean provides to ecosystems and humankind. The ability of organisms to withstand ocean acidification may become constrained if they are also exposed to additional stressors such as warming, excess nutrients, loss of oxygen, limited food, reduced salinity or pollution. Marine life may be able to adapt to ocean change through evolution and thereby compensate for negative effects. However, since ocean acidification happens extremely fast compared to natural processes, only organisms with short generation times, such as microorganisms, are able to keep up. Ocean acidification and warming reduce the survival rates of early life stages of some fish species. This will likely reduce recruitment of fish stocks and ultimately fisheries yields. Ocean acidification reduces the ocean’s ability to store carbon.
Link	https://unfccc.int/sites/default/files/resource/1.06%20IPCC_Oceanacidification2.pdf.
Global Synthesis of the Response of Marine Taxa to Ocean Acidification Hans Pörtner, IPCC Co-Chair WGII and Katja Mintenbeck, IPCC WGII Technical Support Unit (TSU)	
Summary	The poster shows some results from a comprehensive meta-analysis carried out as part of the German research network BIOACID (Biological Impacts of Ocean Acidification).

	The study combines results on the impacts of ocean acidification on almost 500 different marine species from more than 650 published studies. Anthropogenic carbon dioxide (CO_2) emissions cause the partial pressure of CO_2 (PCO_2) to rise in the atmosphere and the oceans, resulting in shifts in ocean chemistry including its acidification. Climate-related ocean acidification may affect marine species and ecosystems in different ways, adding to the impacts of ocean warming and deoxygenation. A meta-analysis of the impacts of ocean acidification on marine species was carried out in the framework of the German research network BIOACID (Biological Impacts of Ocean Acidification). The study elucidates and assesses the responses of almost 500 different species from more than 650 published studies at different PCO2 levels. The analysis of the data shows that the amount of negatively affected species increases with increasing ocean acidification in all investigated animal taxa, but sensitivity to different levels of PCO2 differs between taxonomic groups. Sensitivity of species strongly differs between calcifying and non-calcifying taxa and among calcifying taxa also varies depending on type of calcification. Non-calcifying macroalgae seem to be the least sensitive group and may even benefit from ocean acidification.
Key messages	The percentage of negatively affected species clearly increases with increasing ocean acidification in all investigated animal taxa, but sensitivity differs between taxonomic groups. Calcifying groups, in particular some macroalgae, molluscs (gastropods and bivalves) and echinoderms (e.g. sea urchins) but also corals, are particularly sensitive, while non-calcifying macroalgae and some microalgae may benefit from increasing carbon dioxide concentrations and ocean acidification. Larvae seem to be the most vulnerable life stages among animal taxa, and tropical species seem to be more sensitive than species from temperate regions.
Link	https://unfccc.int/sites/default/files/resource/1.07%20IPCC_Oceanacidification1.pdf.
The IOC ocean science contribution to the climate change science agenda Salvatore Arico, UNESCO-IOC	
Summary	The poster provides an overview of how ocean science, which consists of research, observation and assessments, can support adaptation and mitigation For summary see paragraphs 69–77 above.
Key messages	Ocean research and systematic observations help us make informed decision on how the ocean can continue playing its critical role in regulating the climate system, mitigating climate change, and helping us adapt to its effects. Concrete contributions of ocean science to the work of UNFCCC, through its SBSTA, include: • Match making Parties' needs in climate change science with opportunities for capacity development in ocean science; • Elucidating scientific and technical aspects of the Global Stocktake; • Identifying targets and developing the related methodologies to measure progress; • Assisting in the design of the next generation of integrated climate models and predictions; • Stimulating ocean science production reflecting the needs and aspirations of UNFCCC Parties.
Link	https://unfccc.int/sites/default/files/resource/1.08%20SBSTA%202018%20IOC.pdf.
Terrestrial	
Importance of terrestrial ecosystems for the implementation of the Paris Agreement Sakhile Koketso, Convention on Biological Diversity (CBD)	

<table>
<tr><td>Summary</td><td>The poster summarises how ecosystem-based approaches offer immediate and cost-effective benefits to both mitigate climate change and to adapt to its unavoidable effects in support of the Paris Agreement and the SDGs.

For summary see paragraphs 78–82 above.</td></tr>
<tr><td>Key messages</td><td>Ecosystem-based approaches offer immediate and cost-effective benefits to both mitigate climate change and to adapt to its impacts.

Ecosystem-based approaches could provide up to half of the total greenhouse gas mitigation effort required by 2030.

Protection of ecosystems with large potential emissions of greenhouse gases upon conversion, such as forests and coastal ecosystems, is estimated to be one of the most cost effective means of climate mitigation.

Biodiversity and healthy ecosystems are important for increasing resilience and reducing risks and damages associated with climate change impacts, including acting as buffers against extreme events.

Findings from the Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services (IPBES) can support the implementation of the Paris Agreement.</td></tr>
<tr><td>Link</td><td>https://unfccc.int/sites/default/files/resource/1.09%20CBD%20Koketso_0.pdf.</td></tr>
<tr><td colspan="2">Saami Climate Knowledge from Utsjoki
Tero Mustonen, Snowchange Cooperative</td></tr>
<tr><td>Summary</td><td>The Arctic is in the middle of a monumental system shift affecting the ecology, human societies and the position of the region in the global context – melting of permafrost, extreme events and lack of sea ice are some recent examples.

The poster presents first-hand experience, challenges and response integrating research and indigenous knowledge from the peoples in the region.

For summary see paragraphs 83–90 above.

Sámi knowledge holder Hans Kitti voiced a need for change in order to redirect the poor state of the Earth. "It is depending greatly on the world situation. Instead of lots of talking, the whole attitude in the world should change, totally. We can see the results of poisoning the nature in countries where forests have perished. I see that the forest is the lungs that breathe and balance this interaction between the atmosphere and the earth. People don't understand [what they are ruining]. It would be much richer to live in a nature that has not been burdened and exploited." While there is a wealth of oral histories and traditional knowledge of climate change impacts and observations from the Arctic, we should not forget the endemic knowledge and wisdom connected with these lifeways as Mr. Kitti demonstrates.</td></tr>
<tr><td>Key messages</td><td>The Arctic is in the middle of a monumental system shift affecting the ecology, human societies and the position of the region in the global context.

Monitoring of Arctic change is an increasingly interesting theme for the wider scientific community, and multinational corporations, in regards to Arctic resources, transport corridors and global assessments interpreting the speed, extent and quality of change.

Indigenous and local-traditional knowledge has emerged in recent decades as a valid source of detecting ecosystem changes and implications in the Arctic.

New approaches are needed that provide responses and establishment of “safe havens” for biodiversity and indigenous peoples in the changing Arctic.</td></tr>
<tr><td>Link</td><td>https://unfccc.int/sites/default/files/resource/1.10%20SnowchangeCooperative_Mustonen.pdf.</td></tr>
<tr><td colspan="2">Land Degradation Neutrality (LDN): A Framework for Maintaining Ecosystems and Human Well-being under a Changing Climate
Sasha Alexander & Barron Joseph Orr, United Nations Convention to Combat Desertification (UNCCD)</td></tr>
</table>

Summary	The poster communicates how Land Degradation Neutrality (LDN) seeks to maintain or enhance land based natural capital and the ecosystem services that flow from it through integrated land use planning for measures to avoid, reduce and reverse land degradation. Approaches such as conservation, sustainable land management and restoration/rehabilitation contribute to climate mitigation and adaptation and other multiple benefits for achieving SDGs. The poster also highlights the role of land based interventions in building ecosystem resilience and human well-being and the pivotal role of soil organic carbon to the successful implementation of Paris Agreement.
Key messages	Land-based ecosystems play a vital role in regulating climate. Soils of the world's agroecosystems have lost 25 to 75% of their original soil organic carbon pool, amounting to 42 to 78 Gt of carbon, of which 18 to 28 billion tonnes were lost through desertification. Land Degradation Neutrality (LDN) can support maintaining or improving land based natural capital and the ecosystem services that flow from it. LDN can improve conservation, sustainable management and restoration of land bringing positive environmental, economic and social impacts, as well as contribute to multiple benefits including climate change and ecosystem resilience.
Link	https://unfccc.int/sites/default/files/resource/1.11%20SPI_POSTER_web.pdf.
Five reasons stopping mangrove deforestation makes a whole lot of sense for climate change mitigation in Indonesia; Christopher Martius, Center for International Forestry Research (CIFOR)	
Summary	Peatlands and mangroves play a critical role in global climate change mitigation. As significant carbon sinks, their protection is essential for halting the release of damaging emissions. These ecosystems also provide livelihoods for communities and important sources of food, water and biodiversity. Mangroves are tree ecosystems in coastal intertidal areas. Globally, one-quarter of all mangrove forests are found in Indonesia; they store 3.14 billion tonnes of carbon. During the last three decades, 40 percent of Indonesian mangroves have been destroyed, mainly due to aquaculture. Approximately 190 billion tonnes of emissions are released annually as a result of Indonesian mangrove destruction.
Key messages	Preventing further destruction of mangroves is critical for reducing carbon emissions. Efforts are underway at the global, regional and country levels to address these challenges and meet important climate change targets, but more needs to be done to protect the role of these unique, carbon-rich ecosystems in the global climate balance.
Link	https://unfccc.int/sites/default/files/resource/1.11%20SPI_POSTER_web.pdf.
For Peat's sake: The Facts Christopher Martius, Center for International Forestry Research (CIFOR)	
Summary	Peat, built from partly decomposed vegetation buried under water, can be founded in a wide variety of climates, from tropical rainforests to permafrost regions. Despite covering 3–5 percent of the earth's surface, peatlands contain more than 30 percent of carbon stored in soil worldwide. In tropical areas, such as Indonesia, the development of palm oil and wood pulp plantations has caused peatlands to be drained and cleared, often by fire, and replanted, resulting in the release of enormous levels of carbon dioxide to the atmosphere, and, – in fires - of fine particulate matter that causes respiratory diseases.

	Cutting carbon emissions from peatlands is an essential part of meeting vital environmental targets like the SDGs and the Paris Agreement. Several international, regional and country-level efforts are underway to protect and restore peatlands, including: • Global Peatlands Initiative, led by top experts and institutions to save peatlands and to prevent carbon from being emitted into the atmosphere; • At the COP21 talks in Paris, a map of global peatlands hotspots was launched, showing where the most urgent action is needed to reduce emissions; • In Indonesia, the Government has set up the Peatlands Restoration Agency and has pledged to restore two million hectares of peatlands by 2020; • Analysis of different ways to stop fires and deforestation in the first place, as studies have shown that restoration efforts can never fully regain lost carbon.
Key messages	As peatlands are such incredible carbon stocks, they pose a great risk for contributing to climate change: the 15% of peatlands that have been drained contributed 5% of total anthropogenic CO_2 emissions. Cutting carbon emissions from peatlands is an essential part of meeting vital environmental targets like the SDGs and the Paris Agreement.
Link	https://unfccc.int/sites/default/files/resource/1.12%202%20CIFOR%20SBSTA%2048%20RD-poster_3_6448-infographic%20for%20peats%20sake.pdf.
Carbon burial and land building in low-laying tropical coastal wetlands Christopher Martius, Center for International Forestry Research (CIFOR)	
Summary	In this poster, CIFOR scientists assessed two contrasting mangrove forests in Indonesia to find that properly managing entire catchments of coastal wetlands, including mangroves, may aid in climate change mitigation. Sediment accretion and carbon burial rates were evaluated across three hydro-geomorphic zones – interior, fringe and mudflat – in the mangroves of West Papua and North Sumatra. West Papuan mangroves are highly productive and protected, and found to have high amounts of decomposed litter and roots even following logging. By contrast, North Sumatran mangroves are intensively used and degraded due to past aquaculture development, with limited biomass and organic material despite revegetation efforts. Results differed across the two sites. Average annual sedimentation rates in West Papuan mangroves ranged between 0.4–6.1 millimeter per year compared to 3.7– 5.6 millimeter per year in North Sumatra. The maximum carbon burial rates in West Papua (36 gram carbon per square meter and year) were half of those found in North Sumatra (59 gram carbon per square meter and year). Sedimentation in West Papua was lower specifically in the fringe and interior zones. However, depending on the zone, sedimentation rates of mangroves, particularly if kept in natural conditions or carefully managed, were found to be sufficient to cope with the Intergovernmental Panel on Climate Change (IPCC) high scenario (RCP 8.5) of sea level rise of 0.7 meters in less than 100 years. This means that mangroves in these sites and under these conditions would have a chance of surviving sea level rise, continuing to provide coastal protection. This adaptive capacity of coastal ecosystems has been so far underestimated. Coastal wetland ecosystems, including mangrove forests, are known to sequester more than three times as much carbon as terrestrial forests, and much of this is stored in sediment below ground.
Key messages	It is important to improve the integration of mitigation and adaptation in climate change strategies (NDCs, REDD+ strategies) involving mangroves. It will support joint mitigation and adaptation as stipulated in the Paris Climate Agreement.

Link	https://unfccc.int/sites/default/files/resource/1.13%20CIFOR%20SBSTA%2048%20RD-poster_1_-%20Carbon%20burial%20and%20land%20building%20in%20low-laying%20tropical%20coastal%20wetlands%2012_Print.pdf.
Human exposure in the coastal zone Joachim Post, German Aerospace Center	
Summary	Open Earth observation data and remote sensing technologies provide data and information bases that are necessary for the development of adaptation strategies. These include information on climate-related and anthropogenically caused changes in land use and land cover, as well as related trends and variabilities in agricultural productivity and the condition of ecosystems. The longest open remote sensing data sets go back to the 1980s allowing for long-term time series information such as on the spatio-temporal development of settlement areas, water bodies (floods), or coastal morphology. Remote sensing-based technologies can be used to monitor and evaluate a range of measures for adaptation to climate change: agricultural adaptation measures (e.g. irrigation systems, dam construction, agroforestry systems, adapted crop rotations, erosion-inhibiting vegetation barriers) or adaptation measures for the protection of sensitive zones such as coastal ecosystems (e.g. mangrove protection and regeneration, afforestation, protection forests) can be recorded, observed and assessed. This study examined a wide range of geo-spatial data-sets for the entire continental coast of Asia (100km width) to provide potential coastal development indicators. Lessons learned include: Global products relating to the same parameters can differ widely depending on definitions, derivation methods and scales. Modelers and researchers adopting and integrating existing open Earth observation/GEO products must be sensitive to the quality of their input data sets. Often data products are selected without explicitly considering the suitability of the data for the specific application, despite the fact that uncertainties due to data selection and handling can be in the same order of magnitude as uncertainties related to the representation of the process under investigation (Verburg, Neumann, and Nol 2011,974, Kuenzer et al. 2014). Inconsistencies and knowledge gaps can be bridged by studies exploring such data inconsistencies, by improved documentation of available products, and by an increased effort of the Earth Observation community to provide high-quality products including quality layers, especially for heterogeneous areas (Kuenzer et al. 2014). Enhanced coordination between terrestrial EO networks and programs can foster harmonization and increase transparency, related to the spatial, temporal and thematic heterogeneity of the basic EO/GEO reference data and derived products. In turn, this would help users find and utilize observations and derived products and ultimately contribute towards meeting the objectives of international agreements and conventions.
Key messages	There are highly unequal distributions of coastal development indicators in Asia, with large differences between and within different countries. A clear trend of increasing anthropogenic structures is evident with decreasing distance to the coast. Open Earth observation/GEO data products have unexploited potential to be used for developing indicators at continental scales (integrating socio-economic data and multidisciplinary modelling approaches) as the basis for exposure monitoring and adaptation needs assessments at continental and global scale.
Link	https://unfccc.int/sites/default/files/resource/1.14%202018-05-02_SBSTA48ResearchDialogue%20_PL.pdf.

B. Posters on Theme 2: Science for action – strengthening the link between the research community and action to meet the goals of the Paris Agreement

140. Twenty-seven posters were presented on theme 2 and are summarized in the table below.

<table>
<tr><th>Global level</th><th></th></tr>
<tr><td colspan="2">The Future of Climate Research
Boram Lee, WCRP Joint Scientific Committee</td></tr>
<tr><td>Summary</td><td>The poster presents the new Scientific Strategic Plan for the World Climate Research (2019–2029), highlighting WCRP's new directions and aspirational research goals, based on the critical need for fundamental climate science that will prepare society for challenges that we may not yet foresee.

A summary is provided in paragraphs 18–32 above.</td></tr>
<tr><td>Key messages</td><td>Fundamental science is needed to improve understanding. Understanding prepares society for the challenges we cannot foresee, by ensuring that our knowledge foundations are broad as well as deep.

Scientific partnerships are critical for model deployment from seconds to centuries, including:
• Collaboration across science communities;
• Capacity and infrastructure development;
• Consistent support for critical work e.g. Coupled model intercomparison project (CMIP).

Wider partnerships –social sciences, governments, industry, civil society - are critical for climate science to serve society in the 21st century to provide.
• Co-production of knowledge, co-design of solutions;
• Connect global to local scales for adaptation.</td></tr>
<tr><td>Link</td><td>https://unfccc.int/sites/default/files/resource/2.15%20WCRP_Lynch%20Scientific_Strategy.pdf.</td></tr>
<tr><td colspan="2">Best Practices for Science Communication: An Early Career Research Perspective
Fiona Tummon, YESS Community, Young Hydrologic Society and Association of Polar Early Career Scientists</td></tr>
<tr><td>Summary</td><td>Science communication fosters collaboration and innovation, builds support for science and encourages informed decision making.

Early career scientists have the energy, passion, and skills to actively contribute and steer climate research in a truly interdisciplinary direction.

See also paragraph 135 above.</td></tr>
<tr><td>Key messages</td><td>Science communication should be an integral part of any scientific education.

Early Career Networks can bring new perspectives and help recruit the next generation of leaders.

Early Career Researchers (ECRs) actively contribute and steer climate research in a truly interdisciplinary direction. It is of great value, immediate and long term, to facilitate opportunities for ECRs to contribute to research and communication activities.</td></tr>
<tr><td>Link</td><td>https://unfccc.int/sites/default/files/resource/2.16%20WCRP_Tummon%20YESS%20Community.pdf.</td></tr>
<tr><td colspan="2">Cataloguing high impact events;
Omar Baddour, World Meteorological Organization (WMO)</td></tr>
<tr><td>Summary</td><td>The WMO Congress at its 17th session (Cg-17) in 2015 emphasized the need for systematic characterization and cataloguing of weather, water and climate events in a form that allows data on losses and damage to be cross-referenced to the associated phenomena. Resolution 9 of this session decided to "standardize weather, water, climate, space weather and other related environmental hazard information", and develop identifiers for cataloguing extreme and high-impact weather, water and climate events.</td></tr>
</table>

	In order to implement Cg-17 resolution 9, WMO organized an international workshop on cataloguing and managing information on extreme events, 20–22 November 2017.[81] The workshop, attended by experts from a wide range of relevant disciplines, developed an innovative approach for cataloguing of events. The approach leverages international standards and is versatile and flexible enough to account for complex relationships among various event types. It involves assigning a universally unique identifier (UUID) number - a 128-bit number used to identify information in computer systems- to each event and incorporating the UUID and key attributes of the event into a data record. Key attributes contained in the data record include information that define the event, such as event start and end times, spatial extent, and event type. The approach also involves a standard typology which contains an initial list of event types with which losses and damage are potentially associated. The WMO Regional Association for Europe decided to test the proposed approach - the test phase should start in 2018 and continue over a sufficient period to deliver results and recommendations relevant for operationalization of the approach for adoption at the eighteenth session of the WMO Congress in 2019.
Key messages	The Seventeenth Session of the World Climate Congress (Cg-17) decided to standardize hazard and extreme event information, including the creation or adoption of a system of assigning a unique identifier to each event so that events can be catalogued and linked to data on associated damages and losses. Information will be validated with relevant Technical Commissions and adopted by the Executive Council and WMO decision-making bodies. WMO has submitted this innovative approach to the L&D Excom.
Link	https://unfccc.int/sites/default/files/resource/2.18%20WMO_Baddour%20CataloguingHighImpactEvents.pdf.
Key findings in the WMO Statement on the State of the Global Climate in 2017 Omar Baddour, World Meteorological Organization (WMO)	
Summary	WMO issues a Statement on the State of the Global Climate based on data provided by National Meteorological and Hydrological Services (NMHSs) and other national and international organizations. The SBSTA has mandated the WMO to submit the statement to the second SBSTA session of every year. The statement presents an update of the key climate indicators as well as humanitarian and socio-economic aspects.

[81] See http://www.wmo.int/pages/prog/wcp/wcdmp/meeting/international-workshop-extreme-events.html.

<table>
<tr><td>Key messages</td><td>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<tr><td>Link</td><td>https://unfccc.int/sites/default/files/resource/2.19%20WMO_Baddour%20ClimateStatement2017.pdf.</td></tr>
<tr><td colspan="2">How can you contribute to advancing work on loss and damage?
Executive Committee of the Warsaw International Mechanism for Loss and Damage</td></tr>
<tr><td>Summary</td><td>The scientific community has a unique and irreplaceable role in advancing the work on loss and damage associated with extreme weather events and slow onset events. The COP encourages the Executive Committee of the Warsaw International Mechanism (WIM Excom) to enhance collaboration with relevant expert groups outside of the Convention, and to improve access to, and interaction with scientific research organizations with expertise in science relevant to loss and damage to ensure that the best available science is highlighted in the work of the Warsaw International Mechanism (Decision 4/CP.22).</td></tr>
</table>

	The Executive Committee of the Warsaw International Mechanism guides implementation of its functions through its workplan. The activities of the workplan provide the research communities with concrete entry points, enabling them to align their work for the short- and medium timeframe. The current five-year rolling workplan of the Excom is clustered in five strategic workstreams, to enhance cooperation and facilitation in relation to slow onset event, non-economic losses, comprehensive risk management approaches, human mobility, and action and support.
Key messages	Relevant individuals and organizations can contribute to advancing work on loss and damage associated with climate change impacts by: • Becoming part of the slow onset events database; • Sharing case studies and know-how through the Fiji Clearing House for Risk Transfer, and register through RISK TALK to participate in an online community of risk transfer; and/or • Joining the roster of experts of the Warsaw International Mechanism for Loss and Damage.
Link	https://unfccc.int/sites/default/files/resource/LD_Research%20Dialogue_2018.pdf.
Transforming Knowledge for Climate Action Kaela Slavik, Future Earth	
Summary	The Future Earth poster highlighted three different projects aiming to transform science into action. i. **PREPdata**,[82] is a free, open source data platform that provides the accessible, curated data that decision-makers need to analyze vulnerability and build climate resilience. It allows users to easily access highly credible climate, physical and socioeconomic datasets from sources like NASA, NOAA, USGS, ESA and more; map them to visualize a specific region's vulnerability; track the indicators most relevant to their work on customizable dashboards; request that data providers add new tools or datasets to PREPdata; and share their stories with adaptation practitioners around the world. In 2018, the Partnership will work with partners at city, state and national levels across the globe to use PREPdata to plan for climate change. ii. **10 Science Must-Knows on Climate Change**,[83] was a collaborative effort of Future Earth and the Earth League to summarise current Earth-system science and economic research to highlight ten facts which underpin climate negotiations. Released at COP23, the idea was to remind everyone, including the negotiators, of the unprecedented risk climate change poses to humanity and therefore the very reasons why climate action is important. iii. **The Carbon Law Accelerator**, which is builds on the Roadmap for Rapid Decarbonization by Rockström et al. (2017) which states that to have a good chance of staying under 2 degrees, global emissions need to peak no later than 2020 and we need to halve emissions every decade until 2050. The idea is to target leaders in the digital sector to empower their industry to lead this transition from incremental to exponential action on climate across the global economy by giving them the tools to become planetary stewards by 2020.
Key messages	Demand for climate information is on the rise, but data are often hard to find, access and use. We need to improve access to useful data and empower communities and businesses to better plan for and build climate resilience. We need to remind people – and negotiators – why climate action is so important, by highlighting key crucial climate-relevant facts from across Earth-system science as well as economic and social research. Global emissions need to peak no later than 2020. This can be achieved by following a simple rule of thumb: halving emissions every decade until 2050. This requires a move from incremental to exponential action across the global economy. Digital, open source tools empower sectors, including the digital and ICT sectors, to take climate action into their own hands. Across the entire ICT sector, emissions have peaked, demonstrating that decarbonisation can contribute to driving value growth. The CEOs of the world's most valuable and disruptive

[82] See https://prepdata.org.
[83] See http://www.futureearth.org/news/cop23-10-science-must-knows-climate-change.

	companies (e.g. Apple, Facebook, Google, Microsoft, Intel, Tesla) are in a unique position to drive transformation. They are already providing the essential leadership in their companies and in their industry.
Link	https://unfccc.int/sites/default/files/resource/2.20%20Future%20Earth_Slavik%20Transforming%20knowledge.pdf.
The IPCC's work on communications Marion Ferrat, IPCC Working Group III Technical Support Unit	
Summary	The IPCC has two main communications goals: • to communicate its assessment findings and methodologies, by providing clear and balanced information on climate change, including scientific uncertainties, without compromising accuracy; • to explain the way the IPCC works, selects its authors and reviewers and produces its reports and other products. This will promote the understanding of the reports and underpin its reputation as a credible, transparent, balanced and authoritative scientific body. The IPCC decided to embed work on communications and stakeholder engagement from the start of the 6th assessment cycle. It is providing communication and engagement strategies and timelines for all reports and coherence of messages across Working Groups. It is carrying out engagement and outreach activities with stakeholders worldwide, including: civil society, education sector (schools, universities, early career researchers), museums, business and finance communities, and the media Stakeholders are helping the IPCC shape its work and increasing the reach of its reports and activities, such as the IPCC website, a handbook for IPCC authors, improve accessibility of IPCC visuals, develop FAQs, and understand Party priorities.
Key messages	The IPCC is embedding communications and stakeholder engagement in its work from the start of the 6th assessment cycle. The IPCC is carrying out engagement and outreach activities with stakeholders worldwide. Stakeholders are helping the IPCC shape its work and increase the reach of its reports and activities.
Link	https://unfccc.int/sites/default/files/resource/2.21%20Communications_Poster_Final.pdf.
Mitigation scenarios relevant for policymaking: IPCC Working Group III approach in the Sixth Assessment Cycle Marion Ferrat, Jim Skea, IPCC Working Group III Technical Support Unit	
Summary	IPCC member governments asked for AR6 to focus on options for decarbonization pathways and to anticipate the global stocktake. The Working Group III Co-Chairs want to increase policy relevance by strengthening the links between insights from scenarios and the potential steps to mitigate climate change. Four ways in which the Working Group III contribution to the IPCC 6th Assessment Report will use scenarios is: 1. Link long-term aims and near-to mid-term considerations There is a need to better understand the near-term implications of the Paris Agreement. What are the implications for policy and investment decisions in the next few decades? In a new chapter Mitigation and development pathways in the near-to mid- term, AR6 will explore options on the same time scale as Nationally Determined Contributions. 2. Unpack feasibility What is possible in models may not be possible in the real world, and vice versa. AR6 will unpack the feasibility of different levels of climate ambition by addressing enabling conditions. It will consider the technological, economic, societal and institutional dimensions of scenarios. 3. Understand the social and economic dimensions of mitigation scenarios

<table>
<tr><td></td><td>The IPCC is including alternative perspectives in its assessment of scenarios by bringing modellers and social scientists together in chapter teams. AR6 will include a new chapter Demand, services and social aspects of mitigation that will include considerations such as patterns of development and social acceptability of mitigation options.

4. Improve transparency

AR6 will be more explicit about assumptions, trade-offs, and uncertainties in scenarios, including demonstrating how value judgements have been made. An annex on scenarios and modelling methods will explain what insights scenarios can provide and their limitations.</td></tr>
<tr><td>Key messages</td><td>The Working Group III contribution to the IPCC 6th Assessment Report will use scenarios to:
• Link long-term aims and near-to mid-term considerations;
• Unpack feasibility;
• Understand the social and economic dimensions of mitigation scenarios;
• Improve transparency.</td></tr>
<tr><td>Link</td><td>https://unfccc.int/sites/default/files/resource/2.22%20Scenarios_Poster_WG3_Final.pdf.</td></tr>
<tr><td colspan="2">Office for Climate Education – An international initiative on Climate Change Education
Pierre Léna, David Wilgenbus, Lydie Lescarmontier, Office for Climate Education</td></tr>
<tr><td>Summary</td><td>Responding to the Paris Agreement, particularly Article 12, numerous scientific institutions and NGO’s met in Erice (Italy) in September 2017 and decided to create an Office for Climate Education (OCE).

Objectives include providing teachers with high quality, multilingual and free educational resources promoting an active pedagogy (inquiry--based learning etc.). These resources will be developed jointly with the scientific community, in phase with the publication of the upcoming IPCC reports during the sixth assessment cycle 2018–2022.</td></tr>
<tr><td>Key messages</td><td>The Office for Climate Education (OCE) and its network will provide teachers with high quality, multilingual and free educational resources.

The OCE's resources promoting an active pedagogy will be developed jointly with the scientific community and the expertise of a pedagogic and scientific committee.

The OCE will deliver a Summary & Tools for Teachers alongside each IPCC report due between 2018 and 2022.

Four pilot regions will be targeted by the OCE's actions in the first years: Africa (Benin, Senegal, Côte d'Ivoire, Madagascar), Asia (Malaysia, Indonesia, Thailand), America (Mexico, Chile, Colombia), Europe (France, Germany).</td></tr>
<tr><td>Link</td><td>https://unfccc.int/sites/default/files/resource/2.23%20PosterOCE_Bonn_final.pdf.</td></tr>
<tr><td colspan="2">The importance of 2030 action for reaching the Paris climate goals
Elmar Krieglar, Potsdam Institute for Climate Impact Research</td></tr>
<tr><td>Summary</td><td>The poster presents research coordinated by PIK, particularly on the ADVANCE project.[84] This was a collaborative project to develop a new generation of integrated assessment models to explore different policy options for mitigation that consider energy demand, consumer heterogeneity, technological change and uncertainty, and supply-side bottlenecks.

A robust decarbonization strategy emerges for 1.5°C and 2°C pathways: Early and sustained reductions of energy demand, power sector decarbonisation by 2050, accelerated electrification and more limited substitution of residual fossil fuel use with low carbon alternatives in the transport and industry sectors.</td></tr>
<tr><td>Key messages</td><td>Strengthened near term action in least cost 1.5°C / 2°C pathways leads to ~40% / ~23% reduction of fossil fuel CO2 emissions from 2015 levels.

Trade-offs exist between mitigation ambition until 2030, transitional challenges over the period 2030–50, and carbon dioxide removal requirements.</td></tr>
</table>

[84] See http://www.fp7-advance.eu.

	Following NDCs until 2030 induces a substantial carbon lock-in with long-lasting effects reaching beyond 2050. Strengthening the NDCs for 2030 reduces costs as well as technical and climate risks.
Link	https://unfccc.int/sites/default/files/resource/2.24%20Kriegler_ADVANCE_poster_SBSTA_03_05_2018_final.pdf.
Changes in the occurrence of extreme events at different levels of global warming Katja Frieler, The Inter-Sectoral Impact Model Intercomparison Project (ISIMIP)	
Summary	The poster presented the projected changes in the global and national land area affected by six categories of extreme events as generated within phase 2b of the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP2b). The ISIMIP2b scenarios are designed to elicit the contribution of climate change to impacts arising from low-emissions climate-change scenarios. The impact models used are forced by climate simulations from three different global climate models (pre-industrial + historical climate + future projections for RCP2.6 and RCP6.0). Socio-economic conditions are assumed to vary according to historical observations (e.g. land use patterns) and held fixed at 2005 levels for the future projections. The pure effect of global warming on the occurrence of extreme events is isolated by factoring out the effects of socio-economic development.
Key messages	Global warming has increased and will further increase the global land area affected by river floods, tropical cyclones, crop failure, wildfires, droughts, and heat waves. The historical warming by 1°C since the beginning of the industrial revolution alone has almost tripled the global land area affected by these events. Particularly strong increases are projected for droughts and heat waves. For most event categories, increases are projected to be stronger in low compared to high-latitude countries.
Link	https://unfccc.int/sites/default/files/resource/2.25%20Frieler_Poster.UNFCCC.pdf.
International model cooperation: Insights on moving from current policies and NDCs to 2°C and 1.5°C Detlef van Vuuren, Heleen van Soest, PBL Netherlands	
Summary	The poster presented the COMMIT project: Climate Policy assessment and Mitigation Modeling to Integrate national and global Transition pathways. The COMMIT projects aims to provide: • Improved modelling of national low-carbon emission pathways; • Improved analysis of country contributions to the global ambition of the Paris Agreement. It will undertake international model cooperation to provide insights on moving from current policies and NDCs to 2°C and 1.5°C.
Key messages	There is a significant gap between the aggregate effect of current policies and NDCs and between NDCs and required emissions reductions for 2°C and 1.5°C in 2030. An integrated approach will ensure that climate policy creates multiple co-benefits (e.g., reducing air pollution and improving health), but avoids generating detrimental side-effects (e.g., deteriorating access to clean energy or food security). Nearly complete decarbonisation of power sector needed by 2050, accelerated electrification & more limited reduction of carbon intensity of fuel use in energy end use sectors. Enhancing transparency and accountability through strengthening the monitoring and evaluation of policies to assess progress towards multiple objectives is required. Committed funding and financial mechanisms to reduce financial risks for investors become increasingly important as policies mature.
Link	Poster not online as information shown on poster is not yet published

The sea level legacy of delayed mitigation action Carl-Friedrich Schleussner, Climate Analytics	
Summary	The poster showed that the timing of peaking CO_2 emissions under the Paris Agreement will be decisive for sea level rise over the next 300 years. The research quantified the effect of near-term and long-term emissions constraints of the Paris Agreement on climate-driven sea level rise until 2300 using a contribution-based methodology. The project estimated meeting the Paris Agreement targets would still result in median sea-level rise between 0.7 and 1.2 m, if net-zero greenhouse gas emissions are sustained until 2300, varying with the pathway of emissions during this century. Temperature stabilization below 2°C would be insufficient to hold median sea-level rise until 2300 below 1.5 m. The research found that each 5-year delay in near-term peaking of CO_2 emissions increases median year 2300 sea-level rise estimates by ca. 0.2 m, and extreme sea-level rise estimates at the 95th percentile by up to 1 m.
Key messages	Peaking global CO_2 emissions as soon as possible is crucial for limiting the risks of sea-level rise, even if global warming is limited to well below 2°C. Each 5-year delay in near-term peaking of CO_2 emissions increases median year 2300 sea-level rise estimates by ca. 0.2 m, and extreme sea-level rise estimates at the 95th percentile by up to 1m. Temperature stabilisation below 2°C is insufficient to hold median sea-level rise until 2300 below 1.5 m. Every 10 years of temperature overshoot over 1.5°C adds around 4 cm of median sea-level rise in 2300. The results underline the importance of near-term mitigation action for limiting long-term sea-level rise risks.
Link	https://unfccc.int/sites/default/files/resource/2.27%20RD10_SeaLevelRise_Mengel_Schleussner.pdf.
Key Climate Change Indicators from the Ocean; 2017 Update Ms Anny Cazennave, WMO	
Summary	In terms of global average, sea level is one of the best indicators of climate change as it integrates changes occurring in the Earth's climate system in response to unforced climate variability as well as natural and anthropogenic forcing factors, e.g., net contribution of ocean warming, land ice melt, and changes in water storage in continental river basins. Temporal changes of some components are directly reflected in the global mean sea level time series. Study of the sea level budget provides constraints on missing or poorly known contributions, e.g., warming of the deep ocean undersampled by current observing systems, or still uncertain changes in water storage on land due to human activities (e.g. ground water depletion in aquifers). Global mean sea level corrected for ocean mass change allows one to independently estimate temporal changes in total ocean heat content, from which the Earth's Energy Imbalance can be deduced. The total ocean heat content, the global mean sea level, and the global sea level budget, are considered among the global climate indicators (see paragraph 70 above). Although the altimetry record is unanimously recognized[85] as an invaluable product that informs on how much sea level is rising globally in response to global warming and how it changes regionally in response to the natural internal climate variability, it is extremely important to ensure sustained and ever more accurate observations of global and regional sea level variations from space. A longer sea level record with increased accuracy (fulfilling the GCOS requirements) will help answer still imperfectly understood scientific questions such as: Does the recently recorded sea level rise acceleration represent a long-term shift towards a new climate regime? How large and possibly abrupt near future changes in the contributions of the ice sheets will affect the global sea level? How much heat has already reached the deep ocean? Can we

85 See WCRP Global Sea Level Budget Group, Global Sea Level Budget 1993-present, Earth System Sciences Data, in review, 2018. See https://www.wcrp-climate.org/news/science-highlights/1363-gsb-1993-present; Dieng HB et. al. (2017). New estimate of the current rate of sea level rise from a sea level budget approach, Geophysical Research Letters, 44. See https://doi.org/10.1002/2017GL073308; Nerem RS et. al. (2018) Climate Change Driven Accelerated Sea Level Rise Detected In The Altimeter Era, PNAS. See https://doi.org/10.1073/pnas.1717312115.

<table>
<tr><td></td><td>accurately constrain the Earth's energy imbalance and its temporal variations with improved global mean sea level observations? Is the regional variability in sea level only due to internal climate variability or can we already detect the fingerprint of anthropogenic forcing? When should the anthropogenic signal emerge out of the natural variability? Which regions will be affected first?</td></tr>
<tr><td>Key messages</td><td>Needs in regards to ocean ECVs include:
• A long accurate full depth ocean heat content record for monitoring the Earth's energy imbalance (von Schuckmann et al., 2016)[86] -> sustained Argo network with global coverage + deep Argo;
• A long accurate global and regional sea level record ->sustained altimetry missions;
• Regular estimates of closure of the sea level budget at global and regional scales -> process understanding, constraints on missing contributions and Earth Energy Imbalance, detection & attribution studies, validation of climate models;
• A global, multi-mission coastal altimetry data set (does not exist yet) -> important for studying coastal impacts of global change and developing adaptation strategies.</td></tr>
<tr><td>Link</td><td>https://unfccc.int/sites/default/files/resource/2.28_WMO_Cazennave_Ocean%20indicators.pdf.</td></tr>
<tr><td colspan="2">Essential Climate Variables for addressing the Paris Agreement
Cat Downy, European Space Agency / Committee on Earth Observation Satellites</td></tr>
<tr><td>Summary</td><td>The European Space Agency's (ESA) Climate Change Initiative programme produces long time series of satellite data for climate scientists by merging different satellites and sensors. Emphasis is put on creating stable datasets of ECVs that include quantified details on the accuracy and uncertainties in the data. This means these data products are specifically adapted to climate applications.

ESA works in collaboration with the Copernicus Climate Change Service[87] (C3S), providing prototypes of Climate Data Records that are then taken up to run operationally under C3S. This Research & Development phase is essential to providing a fully functioning service under C3S.

The Climate Change Initiative data sets address all of the Global Climate Indicators;[88] a set of seven parameters that describe the changing climate without reducing climate change to only temperature. They comprise key information for the most relevant domains of climate change, and include: surface temperature, ocean heat, atmospheric carbon dioxide, ocean acidification, sea level, glacier mass balance, Arctic and Antarctic sea ice extent. These Global Climate Indicators are intended to be a concept that can be used to tell stories about climate change in a way that can be understood by non-experts.


</td></tr>
<tr><td>Key messages</td><td>Discussion on climate change and its impacts often centres on the 1.5°C or 2°C targets but in reality, climate change impacts go beyond temperature. The GCOS Climate Indicators have been selected to demonstrate the range and speed of climate change (see below).

Long time series of satellite data records can provide vital information on the seven headline climate indictors of: surface temperature, ocean heat, atmospheric CO2, ocean acidification, sea level, glacier mass balance, and Arctic & Antarctic sea ice change.

Research and development on creating long time series of satellite climate data sets is essential to provide a fully functioning Climate Change Service.

All data is open and free to access via a dedicated portal.[89]</td></tr>
</table>

86 Von Schuckmann et al., An imperative to monitor Earth's energy imbalance, Nature Climate Change, 6, pp 138–144, 2016.
87 See https://climate.copernicus.eu/.
88 See https://public.wmo.int/en/programmes/global-climate-observing-system/global-climate-indicators.
89 See http://cci.esa.int/.

<table>
<tr><td>Link</td><td>https://unfccc.int/sites/default/files/resource/2.29%20ESA_Downy%20ECVs.pdf.</td></tr>
<tr><td colspan="2">GEO Work Programme and the Paris Agreement
André Obregon, Steven Ramage, Group on Earth Observation (GEO)</td></tr>
<tr><td>Summary</td><td>Earth observations enable informed and effective policy and decision making for climate change mitigation and adaptation. GEO is working to enhance global observations systems in support of the Paris Agreement.

Open data policy has gone from the exception to the global norm since the inception of GEO and following work by organizations such as the G20 and the OECD. This is reinforced as a growing number of GEO Member countries adopt and pursue broad open data sharing practices. With the corresponding increase in available open Earth observations data, end-user oriented initiatives developed through the GEO Work Programme are creating real impact on a wide range of global challenges.

GEO's impact is highlighted by some examples: the GEO Global Agriculture Monitoring (GEOGLAM) initiative is improving food security by generating actionable information on future agricultural production of four major crops in order to reduce price volatility; AirNow-International provides the public, such as the City of Shanghai, with daily air quality forecasts; and the Global Forest Observations Initiative (GFOI) supports national forest monitoring systems to reduce deforestation.</td></tr>
<tr><td>Key messages</td><td>Earth observations enable informed and effective policy and decision making for climate change mitigation and adaptation.

Several activities across the GEO Work Programme, including agriculture, biodiversity, forests and oceans, support elements of the Paris Agreement.

A GEO Climate Workshop will be held on 13 June in Geneva to enhance the understanding of how Earth observations can support the implementation of the Paris Agreement.</td></tr>
<tr><td>Link</td><td>https://unfccc.int/sites/default/files/resource/2.30%20GEO-WP.pdf.</td></tr>
<tr><td colspan="2">Sustained Observations to support the Paris Agreement
Carolin Richter, Global Climate Observing System (GCOS)</td></tr>
<tr><td>Summary</td><td>Systematic observations are vital for the Paris Agreement. Observations are needed to both implement actions and to monitor the progress and impacts.

Observations are needed to understand the current state of the environment at a global level. GCOS is promoting a small set of Climate Indicators that present the state of the climate in a simple way (see Global Climate Indicators).[90] The geographic distribution of the changes in the parameters is also available (e.g. Sea ice extent anomaly).

See figure 10 above.

In some areas, the use of observations is well established, for example, forest and land use/land cover monitoring. In other areas, such as observing the progress of adaptation, its use still needs to be demonstrated, such as the potential remote sensing of implementation of adaption actions: ameliorating urban heat extremes.

In many cases, adaptation planning will be based on the outputs of reanalysis and downscaled models, these depend on systematic sustained observations to maintain their accuracy.

GCOS is supporting all these uses of observations in order to support the Global stocktake and Paris Agreement.</td></tr>
<tr><td>Key messages</td><td>Systematic Observations are fundamental to implementing the Paris Agreement and monitor its progress.

The GCOS headline climate indicators present the state of the climate in a simple way.</td></tr>
<tr><td>Link</td><td>https://unfccc.int/sites/default/files/resource/2.31%20GCOS_Richter.pdf.</td></tr>
<tr><td>Regional and</td><td></td></tr>
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[90] See https://public.wmo.int/en/programmes/global-climate-observing-system/global-climate-indicators.

national level	
Lima Adaptation Knowledge Initiative: Closing climate change adaptation knowledge gaps Barny Dickson, UN Environment / UNFCCC Secretariat	
Summary	The Lima Adaptation Knowledge Initiative (LAKI)[91] addresses knowledge barriers that impede the implementation and scaling up of adaptation action. The LAKI seeks to catalyze improved access to data, information and knowledge in an appropriate form for end-users including policy makers and practitioners. Through facilitated science-policy-practice dialogues with multistakeholder expert groups, the first phase of the LAKI has identified 85 priority adaptation knowledge gaps in six subregions: Andean, North African, Southern African, Western Asian, Hindu Kush Himalayan, and Indian Ocean island countries. Each priority gap was categorized by thematic area, knowledge user(s), and gap cluster. There are five different gap clusters: (1) lack of data (2) lack of access to existing knowledge (3) lack of actionable knowledge (e.g. in need of repackaging) (4) lack of tools and method to process knowledge into an actionable form and (5) a mix of two or more of these factors. The first and third clusters refer to gaps where further research is needed. By categorizing the gaps in this way, experts are better able to identify commonalities and pinpoint synergies for more efficient, cost-effective responses. For example, subregions or sectors with similar gaps may be able to implement coordinated responses that help to close multiple knowledge gaps simultaneously.
Key messages	Across the six subregions, the higher number of priority knowledge gaps related to a lack of data fell under the thematic areas of water resources, coastal areas, and agriculture. A lack of actionable data (cluster 3) was most often the cause of priority knowledge gaps related to agriculture as well as forestry and biodiversity. Other areas with research gaps (cluster 1 or 3) included health, energy, and human settlements.
Link	https://unfccc.int/sites/default/files/resource/2.32%20LAKI_Poster_Final.pdf.
Climate scenario data for NAPs Claas Teichmann, Climate Service Center Germany (GERICS)	
Summary	Projected future global climate data was produced in the WCRP CMIP5 effort in a coordinated well defined way.[92] It is a set of simulations based on the Representative Concentration Pathways (RCPs) and serves as a basis for the IPCC Assessment Report 5. With the current ongoing CMIP6 effort, a new generation of projected global climate model data is being created.[93] At the regional scale, CORDEX[94] provides an internationally coordinated framework to improve regional climate scenarios. It harmonizes model evaluation activities and the generation of multi-model ensembles of regional climate projections for the land-regions worldwide. Global and high-resolution regional climate data is accessible via the Earth System Grid Federation[95] or via the regional CORDEX points of contact. Guidelines of how to use climate data are available.[96] Recently the EURO-CORDEX community published a guidance document, which can be applied to regional and global climate data, too.[97] The main steps towards the assessment and use of present and future climate in a region are described in the following. It is essential to build on existing knowledge and climate information, which are available in many regions of the world. Climate data should be analysed and the specific regional requirements should be assessed. If the requirements cannot be met with the available data and information, new simulations tailored to the region should be conducted.

[91] See http://www4.unfccc.int/sites/nwp/Pages/item.aspx?ListItemId=23181&ListUrl=/sites/nwp/Lists/MainDB.
[92] See https://www.wcrp-climate.org/index.php/wgcm-cmip/wgcm-cmip5.
[93] See https://www.wcrp-climate.org/wgcm-cmip/wgcm-cmip6.
[94] See https://www.cordex.org, and Giorgi F. et. al. (2009). Addressing climate information needs at the regional level: the CORDEX framework, WMO Bulletin 58(3), pp 175–183.
[95] See https://esgf-data.dkrz.de.
[96] See Mearns L. et al. (2003), see http://www.ipcc-data.org/guidelines/dgm_no1_v1_10-2003.pdf and references therein.
[97] See https://guidelines.euro-cordex.net.

	Analysis of regional climate data for the South African region was conducted in the frame of the SASSCAL project[98] and presented as an example.
Key messages	Climate models deliver a valuable tool for the assessment of potential future climate change. Users have to know how to interpret the data of climate models and consider, also, that climate models are suspect to uncertainty. Never rely a decision on the output of a single model or emission scenario. Build on existing knowledge and expertise. Regional expertise is essential.
Link	https://unfccc.int/sites/default/files/resource/2.33%20Teichmann__Climate-scenario-data-for-NAPs_Poster__GERICS_2018-05-03__final.pdf.
The WCRP Coordinated Regional Climate Downscaling Experiments (CORDEX) Chris Lennard, WCRP	
Summary	The coordinated regional downscaling experiment (CORDEX)[99] is a WCRP mandated programme to produce downscaled climate data for all land regions of the globe. To date the programme has facilitated the production of downscaled data over 14 regional domains and has made these data freely available on the Earth System Grid Federation (ESGF). The CORDEX vision is to advance and coordinate the science and application of regional climate downscaling through global partnerships. This is achieved through: • a better understanding of relevant regional/local climate phenomena, their variability and changes; • an evaluation and improvement of regional climate downscaling models and downscaling techniques; • the production of a coordinated sets of regional downscaled projections globally; • fostering communication and knowledge exchange with users of regional climate information.
Key messages	The CORDEX vision is to advance and coordinate the science and application of regional climate downscaling through global partnerships. Six key challenges and five cross cutting themes focus activities across the CORDEX domains, promote cross domain interaction, and allow for close interaction with users of climate data. The next phase of CORDEX is to produce high resolution data (~22km) over the 14 regional domains: • The next phase of CORDEX is to improve interaction between climate modellers and user communities working with climate data.
Link	https://unfccc.int/sites/default/files/resource/2.34%20WCRP_Lennard%20CORDEX.pdf.
The CORDEX-Africa Impacts Atlas Chris Lennard, WCRP	
Summary	The CORDEX-Africa Impacts Atlas[100] is a demonstrator project within CORDEX to assesses the timing of climate sensitive threshold exceedances in selected sectors under progressively more extreme global mean temperature increases of 1.5, 2, 3 and 4 degrees of global warming. A summary is provided in paragraphs 33–37 above.
Key messages	Climate sensitive thresholds exist in many regional biophysical and socioeconomic systems, which if crossed impact the functioning of the system. Scale relevant climate change information is necessary inform adaptation and mitigation actions across many sectors.

[98] See http://sasscal.org and Weber et al. (2018), see https://doi.org/10.1002/2017EF000714.
[99] See http://www.cordex.org.
[100] See http://www.csag.uct.ac.za/cordex-africa.

	The Cordex-Africa Impacts Atlas will provide climate and sector specific information to inform regional adaptation and mitigation actions.
Link	https://unfccc.int/sites/default/files/resource/2.35%20WCRP_Lennard%20CORDEXAfricaImpactAtlas.pdf.
Communicating Climate Change Information through Climate Risk Narratives Chris Lennard, C. Jack, University of Cape Town (FRACTAL)	
Summary	Climate risk narratives are "conversation starters" to facilitate starting productive conversations with decision makers around potential changes in climate related risks and impacts. The poster discusses experience from the Future resilience for African cities and land (FRACTAL) project.[101] A summary is provided in paragraphs 113–119 above.
Key messages	Moving from production of climate data/information to formulating actionable knowledge is extremely challenging. Decision makers implicitly construct their own stories or narratives through interpretation of the complex and opaque evidence they are presented with. Climate Risk Narratives are "conversation starters" to initiate conversations between decision makers and scientists around potential changes in climate related risks and impacts.
Link	https://unfccc.int/sites/default/files/resource/2.36%20WCRP_Lennard%20FRACTAL.pdf.
The Caribbean Regional Climate Science Initiative Kimberly Stephenson, University of the West Indies	
Summary	The Regional Climate Science Initiative was formed in response to the Caribbean region's evident climate vulnerability, lack of data, and growing demand from society for more climate information. A summary is provided in paragraphs 105–112 above.
Key messages	The Regional Climate Science Initiative was formed in response to the Caribbean region's climate vulnerability, lack of data, and growing demand from society for more climate information. Led by the Caribbean Climate Modeller's Consortium, the initiative resulted in a regional climate science agenda which is periodically refreshed and has generally guided science activities for over 15 years. The initiative has improved data availability, scientific capacity, and understanding of climate science in the region. Though challenges remain, there has been an increase in consideration and use of climate data in regional impact studies, planning, and decision making.
Link	https://unfccc.int/sites/default/files/resource/2.37%20The%20Regional%20Climate%20Science%20Initiative_Poster.pdf.
Recent progress of Japan's regional downscaling project (SI-CAT) and CORDEX Asia Empirical-Statistical Downscaling (ESD) Koji Dairaku, Japan	
Summary	The Asia-Pacific regions are increasingly threatened by large scale natural disasters. Growing concerns that loss and damages of natural disasters are projected to further exacerbate by climate change and socio-economic change. Climate information and services for risk assessments are of great concern. Fundamental regional climate information is indispensable for understanding changing climate and making decisions on when and how to act. To meet with the needs of stakeholders such as National/local governments, spatio-temporal comprehensive and consistent information is necessary and useful for decision making. The poster reported recent progress of Japan's regional downscaling project Social Implementation Program on Climate Change Adaptation Technology (SI-CAT)[102] and CORDEX Asia Empirical-Statistical Downscaling (ESD).

[101] See http://www.fractal.org.za.
[102] See https://si-cat.jp/en.

Key messages	SI-CAT has been developing reliable technologies to find climate change adaptation measures in collaboration with researchers of geoscience, social science and humanities, and officials of local governments from the beginning of the project. A large number of multi-model ensemble near-term (2026–2050) regional climate scenarios with 1km horizontal grid-spacing over Japan have been developed. The uncertainty range information of the regional climate scenarios support various regional adaptation measures and informed decision making on when and how to act. Based on the SI-CAT experiences, the CORDEX Asia ESD (Empirical Statistical Downscaling) group enhances and integrates the science and application of downscaling activities in Asia by sharing and exchanging data, knowledge, and techniques.
Link	https://unfccc.int/sites/default/files/resource/2.38%20JAPAN_Poster_SBSTA%28RD10%29_DAIRAKU_20180501_dairaku.pdf.
Making regional climate scenarios to assess the impact of climate change in Southeast Asian countries - Climate change projection using Non-Hydrostatic Regional Climate Model (NHRCM) Toshinori Aoyagi, Japan	
Summary	The poster presented the climate studies conducted by the Meteorological Research Institute (MRI) of the Japan Meteorological Agency (JMA), on climate change scenarios at various scales (from global to national scales). The dynamical downscaling method was used with their non-hydrostatic regional climate model (NHRCM). MRI has invited researchers from southeast Asian countries in order to conduct cooperative research projects on climate change projection around their homelands since FY2012. There have been 24 invitees as of the end of FY2017. MRI has lectured on the technique of the dynamical downscaling and has supported the invitees to make their own climate scenarios targeted on their homeland countries. Some of the local climate scenarios for Philippines,[103] Vietnam,[104] Thailand, and Indonesia, which were made by the invitees, were validated by the reproducibility of present climate, such as temperature and precipitation, and were used to estimate the change of future climate. These southeast Asian climate scenarios have contributed to model inter-comparison projects in southeast Asia. The scenarios will be passed to the assessment researchers, and the scenarios will be used as important information for adaptation research.
Key messages	Dynamical downscaling using the Non-Hydrostatic Regional Climate Model (NHRCM) has been utilized for climate studies in Japan. MRI/JMA has invited many researchers from Southeast Asian countries in order to conduct cooperative research projects on climate change projection in their homelands since FY2012. The Southeast Asian climate scenarios, produced by these invited researchers, have contributed to model inter-comparison projects across Southeast Asia including Philippines, Viet Nam, Thailand and Indonesia. The scenarios have also contributed to promote and establish fruitful cooperation between climate researchers and impact assessment researchers in the countries involved.
Link	https://unfccc.int/sites/default/files/resource/2.39%20JAPAN_AOYAGI.pdf.
Local knowledge networks and climate change adaptation in coastal communities Jeremy Pittman, IAI & University of Waterloo, Canada	
Summary	The Uruguayan Yellow Clam fishery is a small-scale fishery, which occurs largely in the community of Barra del Chuy. The fishery has recently been impacted by reoccurring red tides and mass mortalities, which are potentially related to climate change and lead to fisheries closures. The poster presented results of research on the drivers of local knowledge networks for climate change adaptation in the Uruguayan Yellow Clam fishery. The fishers were surveyed to

103 Cruz FT et al. (2016), see http://doi.org/10.2151/jmsj.2015-059. And Cruz FT and Sasaki H (2017), see http://doi.org/10.2151/sola.2017-003.

104 Kieu-Thi X et al. (2016), see http://doi.org/10.2151/jmsj.2015-057.

<table>
<tr><td></td><td>document their understand the role of family ties and shared beliefs about resilience in driving the structure of the knowledge networks.</td></tr>
<tr><td>Key messages</td><td>Decision making by families in regards to fishery practices in the Uruguayan Yellow Clam fisheries show that:
Local norms around family are critical to consider when advancing adaptation;
Family members have divergent beliefs about their resilience.
The implications include:
• The diversity of perceptions within family networks could promote more creativity in solving adaptation-related problems;
• The diversity of perceptions also suggests that a clear vision for adaptation could be lacking at the community-level.</td></tr>
<tr><td>Link</td><td>https://unfccc.int/sites/default/files/resource/2.40%20IAI_poster.pdf.</td></tr>
<tr><td colspan="2">Assessing climate-related risks for adaptation planning in West Africa: A science-based service implemented at the West African Science Service Center for Climate Change and Adapted Land Use (WASCAL)
Yvonne Walz, United Nations University Institute for Environment and Human Security (UNU-EHS)</td></tr>
<tr><td>Summary</td><td>The United Nations University – Institute for Environment and Human Security (UNU-EHS) conducted research to develop tools and methods for assessing vulnerability to and risk of floods and droughts in West Africa.[105]
Following this, a handbook of tools and methods on vulnerability and risk assessment for practitioners was co-developed with and implemented at the West African Science Service Center on Climate Change and Adapted Land Use (WASCAL) Competence Center (CoC) with the overall aim to make these tools and methods accessible and usable for stakeholders and practitioners in the field of disaster risk management.
The handbook[106] has now become a tool of WASCAL's Risk Assessment Service in order to scientifically support national and regional risk assessment efforts and enhance (transboundary) adaptation and development planning in West Africa. The handbook is structured into the following three components:
• PART I represents the practical guidelines for assessing hazard, vulnerability and risk to climate-related hazards - using a stepwise approach from Step 1 (Planning the Assessment) to Step 4 (Risk Assessment), providing different options, which take into consideration different availabilities of resources or professional skills and expertise;
• PART II provides the scientific and technical background documentation for the practical guidelines;
• The REPORT TEMPLATE helps to document the results in a uniform and structured way and allows the comparison of data and results of different assessments, e.g. between countries.
One result of this guided approach is to assess climate-related hazards, vulnerability and risk of local communities. The resulting risk profiles inform decision makers about the contribution of individual indicators of Exposure, Susceptibility and Capacity.
This "understanding of risk" through the underlying drivers and their individual contributions provide the entry point to design targeted measures to reduce vulnerability and risk and develop relevant strategies to adapt to climate-related hazards in relation to the given context.</td></tr>
<tr><td>Key messages</td><td>UNU-EHS in collaboration with WASCAL has developed a handbook of tools and methods on vulnerability and risk assessment for practitioners.</td></tr>
</table>

105 Asare-Kyei, D et al. (2017). Development and validation of risk profiles of West African rural communities facing multiple natural hazards. PLoS ONE 12(3): e0171921, see https://doi.org/10.1371/journal.pone.0171921.

106 Walz, Y. et al. (2017). Risk Assessment in West Africa: A handbook for practitioners. Version I – part I, part II and report template (August 2017), see http://collections.unu.edu/view/UNU:6482#viewAttachments.

	The handbook aims to support national and regional risk assessment efforts and enhance (transboundary) adaptation and development planning in West Africa. The handbook can be used to complement hazard early-warning systems that are in place in most of the countries, and allows to take the next step from re-active disaster management to proactive disaster risk prevention and reduction, including adaptation planning. The assessment (part 1 of the handbook) provides baseline information which can be used for • Monitoring risks in the future through repeated risk assessments; • Evaluating the effect of implemented adaptation measures towards disaster risk reduction.
Link	https://unfccc.int/sites/default/files/resource/2.41%20SBSTA_Poster_Climate%20risk%20assessment%20for%20adaptation%20planning_Walz_et_al.pdf.

C. Posters on theme 3: Renewable energy economics and co-benefits

141. Four posters were presented on theme 3 and are summarized in the table below.

Co-benefits of Climate Change Mitigation: Building New Alliances – Seizing Opportunities – Raising Climate Ambitions in the New Energy World of Renewables Ayodeji Okunlola and Laura Nagel, Institute for Advanced Sustainability Studies (IASS)	
Summary	Climate protection measures and strategies can deliver numerous benefits: from improvements in human health to fewer conflicts over resources, and a reduced dependency on energy imports. Given their capacity to incentivise governments to implement sustainable, climate-friendly energy policies, co-benefits of climate change mitigation will play an important role in efforts to advance climate change mitigation policies and accelerate the global transition towards renewable energies and help limit the dangerous consequences of global warming. Co-benefit assessments can be important drivers of ambitious and effective climate policy. They can focus on tangible, near-term benefits for specific actors and interest groups; contribute to building strong alliances for ambitious and progressive climate and renewable energy policy and action; and helps to overcome long-lasting political deadlocks – particularly between environmental, economic, and industrial policies. However, only some of the social and economic co-benefits of renewable energy have been quantified, often based on different methods, making it difficult to synthesize findings on a country level. As a result, many opportunities for highlighting the benefits of climate change mitigation activities to policy makers and private investors have been lost. The poster describes the COBENEFITS project, funded by the International Climate Initiative and led by the Institute for Advanced Sustainability Studies (IASS). This project analyses the social and economic opportunities presented by renewable electricity production and supply for our partner countries Vietnam, India, South Africa, and Turkey and connects identified opportunities to political deliberations on ambitious climate policy and action.
Key messages	Fostering the opportunity-oriented narrative of climate policy and mobilizing the social and economic opportunities of renewable energy will be essential to build strong political momentum and to rally cross-sectoral support, while keeping the pressure for bold and timely climate action. In order to build coalitions across sectors for ambitious and timely climate policy and action, co-benefit assessments should address specific stakeholder interests associated with particular social and economic co-benefits. Country-specific and voluntary co-benefit assessments can be instrumental for the effective implementation of the NDCs.
Link	https://unfccc.int/sites/default/files/resource/3.42%20FutureEarth_Poster_V007_MS.pdf.

Broad Benefits of Energy Transition towards 2050 Toshiaki Nagata, International Renewable Energy Agency (IRENA)	
Summary	The poster provides an overview of the benefits of the transition to renewable energy by 2050. The energy transition cannot be considered in isolation from the socio-economic system in which it is deployed. The close interplay between the energy sector and the socioeconomic system alters the socio-economic footprint and generates a number of benefits in terms of GDP, employment and human welfare.
Key messages	Energy transition towards 2050, chiefly through enhanced renewable energy deployment and improved energy efficiency, will bring significant socio-economic benefits. These include higher GDP growth, more employments and increased global welfare, compared to the scenario with existing and currently planned policy measures. IRENA estimates that renewable energy and energy efficiency measures will provide over 90% of CO_2 emission reductions required for meeting the long term global goal to limit the temperature rise to well below 2 degree celcius. Renewable energy deployment will contribute to various aspects of the Sustainable Development Goals (SDGs). The contributions will relate to access to affordable and clean energy, sustainable agri-food chains, water-energy-food nexus, employment and economic growth, and sustainable cities and communities.
Link	https://unfccc.int/sites/default/files/resource/3.43%20IRENA%20Nagata.pdf.
Health co-benefits from air pollution and mitigation costs of the Paris Agreement María José Sanz, Basque Centre for Climate Change	
Summary	Although the co-benefits from addressing problems related to both climate change and air pollution have been recognised, there is not much evidence comparing the mitigation costs and economic benefits of air pollution reduction for alternative approaches to meeting greenhouse gas targets. The poster presents the outcomes of a study examining the extent to which health co-benefits would compensate the mitigation cost of achieving the targets of the Paris climate agreement (2°C and 1·5°C) under different scenarios in which the emissions abatement effort is shared between countries in accordance with three established (IPCC) equity criteria.[107]
Key messages	Health co-benefits substantially outweighed the policy cost of achieving the target for all of the scenarios that were analysed. In some of the mitigation strategies, the median co-benefits were double the median costs at a global level. The ratio of health co-benefit to mitigation cost ranged from 1.4 to 2.45, depending on the scenario. At the regional level, the costs of reducing greenhouse gas emissions could be compensated with the health co-benefits alone for China and India. The proportion the co-benefits covered varied but could be substantial in the European Union (7–84%) and USA (10–41%), respectively. The extra effort of trying to pursue the 1·5°C target instead of the 2°C target would generate a substantial net benefit in India (USD3·28–8·4 trillion) and China (USD0·27–2·31 trillion), although this positive result was not seen in the other regions.
Link	https://unfccc.int/sites/default/files/resource/3.44%20Poster%20UNFCC_MJ_0.pdf.
The Potential, Viability and Co-benefits of Developing Wind Energy to Mitigate Climate Change in the Caribbean Lawrence Pologne, Caribbean Institute for Meteorology and Hydrology (CIMH)	

[107] Markandya A et al. (2018). Health co-benefits from air pollution and mitigation costs of the Paris Agreement: a modelling study. The Lancet Planetary Health 2 (3), e126–e133.
See https://doi.org/10.1016/S2542-5196(18)30029-9

Summary	The poster presented the results from a study to evaluate the potential, viability and co-benefits of developing wind power as a reliable and sustainable energy source in the Caribbean, under a changing climate in the near to medium term. Wind speed projections under the IPCC A2 emission scenario were analyzed, using a regional climate model, for three future climate periods: the near-term (2018–2030), the medium-term (2031–2050) and long-term (2051–2074).
Key messages	In the Caribbean, wind speeds are expected to change by ±10%. In Barbados, this equates to average wind speeds ranging from 5.4 to 6.6 m/s. Applying these wind speeds to economic sensitivity analyses for a selected wind turbine reveals that the net present value and the internal rate of return are positive. The levelized cost of energy would fluctuate between US$0.08 and US$0.13 per kWh. This is competitive when compared to the average cost of diesel generated electricity in the Caribbean of US$0.34 per kWh, showing wind energy as an economically viable alternative to fossil fuel. A wind-based 3 MW power plant generating 20,000,000 kWh of "clean energy", would result in the reduction of Greenhouse Gas (GHG) emissions by 8600 tons of CO2eq annually.
Link	https://unfccc.int/sites/default/files/resource/3.44.5%20windenergy_cobenefits.pdf.

D. Posters on theme 4: Global research on the carbon cycle, and its observation requirements, in support of the Paris Agreement

142. Six posters were presented on theme 4 and are summarized in the table below.

Support of the implementation of the Paris agreement: Role of the Integrated Global Greenhouse Gas Information System (IG3IS); Phil de Cola, WMO	
Summary	In recognition of the progress that has been made in atmospheric research, measurement and modelling, WMO is developing the Integrated Global Greenhouse Gas Information System (IG3IS). IG3IS promotes measurement-based approach that helps to improve the knowledge of the national emissions, provides actionable information at the needed spatial, temporal and sectoral resolution and helps to inform the "stock take" (trends) of emission reduction strategies over time. The poster outlines the main IG3IS principles. The poster presented the IG3IS principles and a number of national and city-scale examples. In the United Kingdom, the detection of a large discrepancy between inverse modelling of atmospheric measurements and the reported inventory for the refrigerant HFC-134a led to a revision of the UK's inventory by correcting the emission factor for HFC-134a losses from mobile air-conditioning. In New Zealand, inverse model analysis of atmospheric measurements indicates that the terrestrial biosphere in New Zealand is a much stronger net annual CO2 sink. Around the world, a number of research projects have developed and tested methods for independent estimation of greenhouse gas emissions on urban scale such as the Los Angeles / Paris Megacity Project, and Recife, Brazil. This work has established urban greenhouse gas information methods that combine atmospheric monitoring, advanced inventory data-mining and model analyses. Furthermore, a project detecting methane super-emissions and leaks in North American oil and gas supply chain will be upscaled through IG3IS implementation.
Key messages	IG3IS aims to support the success of post-COP21 actions of nations, sub-national governments, and the private sector to reduce GHG emissions through a measurement-based approach that: • Supports efforts to reduce uncertainty of national emission inventories; • Provides actionable information at the needed spatial, temporal and sectoral resolution; • Helps to inform the "stock take" (trends) of emission reduction strategies over time.

Link	https://unfccc.int/sites/default/files/resource/4.45%20WMO_deCola%20IG3IS.pdf.
Climate change and air quality mitigations: why should we do it together Phil de Cola, WMO	
Summary	All anthropogenic activities (energy production, transportation, industry, agriculture, waste management) are responsible for the emission of gaseous and particulate pollutants that modify atmospheric composition. The same source injects into the atmosphere both climate forcers and pollutants. The poster shows different impacts of emitted substances on both pollution levels and climate. Currently, these two environmental challenges are viewed as separate issues, which are dealt with by different science communities and within different policy frameworks. Integrated policy options that take into account the feedbacks between air quality and climate constitute the best environmental policy strategies in terms of both social and economic costs. The poster highlights that there are emission reduction policies that provide the opportunity of simultaneously improving air quality and mitigating global warming (win-win policy options), but there are also strategies that can be beneficial only for climate or only for air quality. Some policies are articulated in the WMO/UNEP Assessment of black carbon and tropospheric ozone. Recent research shows that reducing short-lived climate pollutants (SLCPs) is needed to reach the Paris Agreement goals but in order to also attain the SDGs, these policies to reduce SLCPs need to be adopted as a near-term goal over the next 25 years, due to future impacts from air pollution and cumulative warming. The 'Multiple Benefits Pathway' attempts to limit the rate of temperature rise and other impacts on health and ecosystems.[108]
Key messages	Many emission reduction policies provide the opportunity of simultaneously improving air quality and mitigating global warming (win-win policy options). However, there are mitigation options that may provide benefits in one aspect, while worsening the situation in the other (win-lose policy options). An integrated approach is needed to evaluate the air quality-climate policies. Integrated policy options that take into account the feedbacks between air quality and climate constitute the best environmental policy strategies in terms of both social and economic costs.
Link	https://unfccc.int/sites/default/files/resource/4.46%20WMO_deCola%20AQ%20and%20Climate.pdf.
Integrated and coordinated in-situ carbon and greenhouse gas observations towards policy-relevant knowledge Emmanuel Salmon, Integrated Carbon Observation System (ICOS)	
Summary	As the European pillar of in situ GHG observations, the **Integrated Carbon Observation System (ICOS) provides data and services that are of high relevance for policy-makers** in their efforts to combat climate change. It **promotes scientific cooperation to reduce global knowledge gaps** about observations of GHG fluxes and atmospheric concentrations, as well as estimations of carbon sources and sinks. The poster described two ICOS projects. The Horizon2020 SEACRIFOG project is a **design study for a GHG observation system on the African continent.** The aim is to foster collaboration and interoperability of research infrastructures in Europe and in Africa, in order to deliver data needed at the global level and inform the evaluation of climate-smart agriculture practices to improve food security. A significant effort is made in terms of capacity-building actions and identification of financial resources. The VERIFY project aims to **enhance the accuracy of national and regional GHG budgets**. In situ observations will support inventories that rely on statistical data and allow to measure the effectiveness of emission reduction policies. A comprehensive reconciliation of officially reported and observation-based budgets will contribute to support the effective implementation of the Paris Agreement.

108 Shindell D et al. (2017). A climate policy pathway for near- and long-term benefits, Science, 356(6337), pp 493–494. See https://doi.org/10.1126/science.aak9521.

Key messages	Wide utilization of climate data needs more collaboration between scientific and policy-making actors. The Integrated Carbon Observation System (ICOS) is the European pillar of GHG observations and provides data and knowledge in support of UNFCCC and IPCC. ICOS data are invaluable to reduce the uncertainty in national CO2 sinks, help improve emission inventories and contribute to the global stocktaking. In particular, ICOS (together with other environmental Research Infrastructures) can help assess the complex terrestrial emissions.
Link	https://unfccc.int/sites/default/files/resource/4.47%20ICOS_SBSTAposter_v2.pdf.
Updates from the GEO Carbon and Greenhouse Gas Initiative Hans Dolman, GEO	
Summary	The GEO Carbon and GHG Initiative (GEO-C) is a global endeavour to promote interoperability and foster integration in the sector of greenhouse gas measurements. The final users, in addition to the scientific community, are countries and decision-makers that can benefit from the improved information flow, and use it to design efficient climate change policies. All activities and deliverables of the GEO-C Initiative are aligned and adapted to address the global climate policy agenda, and particularly to contribute to the successful implementation of the Paris Agreement.
Key messages	GEO-C provides a global forum to identify the complementary roles and responsibilities within the carbon observation landscape. A Steering Committee has been formed with representatives from CEOS, GCOS, IPCC, WMO, UNFCCC and other stakeholders, as well as a GEO-C Secretariat (hosted by ICOS). Immediate outputs include the development of a GEO-C White Paper with a common roadmap and a mapping of the carbon observations landscape, aiming to support planning, outreach and communication efforts.
Link	https://unfccc.int/sites/default/files/resource/4.48_GEO-C_Dolman.pdf.
Observations to assess the regional carbon cycle: RECCAP-2 Corinne Le Quéré, Philippe Ciais, Global Carbon Project	
Summary	When top-down and bottom-up estimates of surface CO2 fluxes are compared, they agree quite well at the global scale. However, there are large inconsistencies in regional budgets and their inter-annual variability. The RECCAP-1 project was established from 2011–2014 and delivered a synthesis of the mean carbon balance and change over the period 1990–2009 for all subcontinents and ocean basins.[109] However, the project also exposed large data gaps and uncertainties that prevent current systems from delivering information to support climate policies or to resolve carbon– climate feedbacks. We are now in a position to address some of the gaps and limitations flagged in RECCAP-1. The European Space Agency is helping to fund the Global Carbon Project to undertake a second round of the RECCAP assessment. This project will: • Establish the mean carbon balance of large regions of the globe at the scale of continents and large ocean basins, including their component fluxes; • Provide higher spatial resolution and annual updates for the global and regional carbon balance with the aim of improving the quantification and understanding of drivers, processes, and hot spot regions, essential for predicting the future evolution of any carbon-climate feedback; • Build on the experience from RECCAP-1 to address the growing demand for the capacity to measure, report on, and verify the evolution of regional fluxes and the outcomes of climate mitigation policies; • Evaluate the regional 'hot-spots' of inter- annual variability and possibly the trends and underlying processes over the past two (or more) decades by combining available long-term observations and modelling;

[109] See http://www.globalcarbonproject.org/reccap/index.htm.

	• Enable the use of global remote sensing products in the establishment of regional CO2 budgets, specifically the Essential Climate Variable data sets from ESA's Climate Change Initiative programme.
Key messages	Regional details on or insights into processes driving carbon fluxes have not, to date, been incorporated into efforts addressing the annual updates of the global carbon budget, issued by the Global Carbon Project. The just-started RECCAP-2 project (Regional Carbon Cycle Analysis and Processes) will provide a consistency check between the sum of regional fluxes and the global budget anomalies of CO2 fluxes. This will be a unique measure of the level of confidence in scaling carbon budgets up and down. RECCAP-2 will mobilise the international carbon cycle research community through the action of the Global Carbon Project towards the organization of the coordinated production of regional CO2 budgets consistent with the global carbon budget from GCP, allowing a better interpretation and fast track analysis of global year to year anomalies in the carbon cycle. RECCAP-2 will enable the use of global remote sensing products in the establishment of regional CO2 budgets.
Link	https://unfccc.int/sites/default/files/resource/4.49%20RECCAP_lequere.pdf.
Advanced Determination of Sources and Sinks of Methane Franziska Frank, German Aerospace Center	
Summary	The poster presented an advanced method to determine global methane sources, which includes comprehensive atmospheric observations and a state-of-the-art chemistry climate model. The MERLIN Atmospheric Methane Lidar Mission aims at a highly precise quantification of methane sources up to high latitudes. The model-based inverse optimization of emission inventories combines observations and statistical estimation methods to reduce uncertainties in methane sources. The model results further reveal the decisive impact of methane sinks on the emission estimation. Especially global OH still includes large uncertainties and its contribution to the global methane burden is currently highly debated. Results of the observation system simulation experiment show an Uncertainty reductions on CH_4 emissions are 59% between (30°S–30°N), 84% between (30°N–50°N), and 53% for continental high latitudes above 50°N. Furthermore, it is concluded that to reduce present uncertainties in the global methane emissions, sources and sinks must be considered jointly.
Key messages	Current estimates of methane emissions still include large uncertainties. An advanced method is presented to reduce these uncertainties using comprehensive atmospheric observations and a state-of-the-art chemistry climate model. The MERLIN atmospheric methane Lidar Mission aims at a highly precise quantification of methane sources up to high latitudes. The model-based inverse optimization of emission inventories combines observations and statistical estimation methods to reduce uncertainties in methane sources. Model results further reveal the decisive impact of methane sinks on the emission estimation. Especially the contribution of global OH on the global methane burden is currently highly debated.
Link	https://unfccc.int/sites/default/files/resource/4.50%20DLR_Frank%20Methane.pdf.