GCOS

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GCOS Workshop on Enhancing Observations to Support Preparedness and Adaptation in a Changing Climate – Learning from the IPCC 5th Assessment Report

Bonn, Germany

10-12 February 2015

In collaboration with the Intergovernmental Panel on Climate Change (IPCC) and the United Nations Framework Convention on Climate Change (UNFCCC)

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Chair, Publications Board
World Meteorological Organization (WMO)
7 bis, avenue de la Paix
P.O. Box 2300
CH-1211 Geneva 2, Switzerland

Tel.: +41 (0) 22 730 84 03
Fax: +41 (0) 22 730 80 40
E-mail: Publications@wmo.int

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All workshop presentations are available under:

http://unfccc.int/science/workstreams/systematic_observation/items/8764.php

The GCOS Secretariat acknowledges, in particular, the support by Mary Ann Kutny, seconded from NOAA/NESDIS (USA), Joanna Post and Kushilani Wijesiri (both from the UNFCCC Secretariat), who assisted in the preparation of the Workshop and production of this final report.

Executive summary

From 10 to 12 February 2015, the Global Climate Observing System (GCOS), in collaboration with the Intergovernmental Panel on Climate Change (IPCC) and the United Nations Framework Convention on Climate Change (UNFCCC), brought together more than 70 participants for a Workshop on Enhancing Observations to Support Preparedness and Adaptation in a Changing Climate – Learning from the IPCC Fifth Assessment Report – at the UN Campus in Bonn, Germany. Participants represented the UNFCCC Secretariat and Parties, GCOS, IPCC and other United Nations Secretariat units and bodies and academic, governmental and non-governmental experts.

The goals of the Workshop were to:

- Assess the key findings and recommendations of the IPCC in the context of data availability in order to inform implementation of adaptation planning and strategies;
- Define the core sets of data, data characteristics and information technologies needed to maintain the minimum acceptable level of stewardship in the management of resources and infrastructure;
- Characterize the climate-data needs of the key sectors, including the financial services and development sectors;
- Assess the adequacy of national and regional networks and records for detection of climate trends to inform global, regional and national assessments of climate change and for developing regional and national climate risk profiles; and
- Identify paths for addressing institutional and local capacities (including National Meteorological and Hydrological Services (NMHSs)) needed to observe, monitor, rescue, archive and process and sustain climate data and networks.

Workshop participants considered the observational and research needs that could enhance systematic observations and related capacity, especially in developing countries, and aid in assessing the risks of climate change and support adaptation planning. Building on the findings of IPCC Working Group II (WG II) report to the IPCC Fifth Assessment Report (AR5) and the strategic technical guidance from the GCOS Workshop on Observations for Adaptation to Climate Variability and Change, which had been held in February 2013, participants identified the various needs across adaptation sectors.

The participants agreed that adaptation planning and assessment required a combination of baseline climate data and information, coupled with sector-specific and other economic and demographic data at regional, national and local scales. Good, publicly available and standardized data on the vulnerability of key sectors to the impacts of climate change across these spatial scales were essential. The participants also noted the need to enhance climate observation systems with special emphasis on land and oceans and the intersection of the two.

Participants noted a need for clear descriptions of the complete chain of observations-data-information-adaptation and the respective roles of GCOS and other partners to evaluate and deliver the best methods for developing adaptation strategies. A clear articulation of the value of observations to adaption is needed and one or more well-described case studies in Non-Annex I Parties to the Convention could demonstrate this value. Also needed were guidance, guidelines or references to other sources of advice on data and sources of products, as well as their limitations. In particular, those involved should ensure that the experience of developing adaptation plans and assessments were carefully documented and recorded to facilitate transfer of expertise and improvements to observation systems.

The Workshop participants agreed that GCOS:

- Had a key role in the establishment and maintenance of requirements for the collection and dissemination of national observations to specified quality standards with understood and quantified uncertainties;
- Should facilitate the documentation of the high-resolution data required for adaptation planning;
- Should identify international data centres for all essential climate variables (ECVs);
- Should ensure that the critical requirements for data latency, timeliness and availability are were clearly specified; and
- Should respond to the needs for climate observations identified in other workstreams under the Convention through the Systematic Observation agenda item and the Sustainable Development Goals.

The research and development community would need to support the development of indicators linking physical and social drivers relating to exposure, vulnerability and improved resilience, in line with national requirements.

Finally, coordination among observation systems at different scales from subnational to global would be needed to inform adaptation, particularly through relevant focal points, national coordinators and regional climate centres (RCCs) and alliances.

Workshop outcomes would inform the next GCOS Implementation Plan in support of UNFCCC and support the research and systematic observation efforts of the Subsidiary Body for Scientific and Technological Advice (SBSTA) and that of adaptation under the UNFCCC at large.

Introduction

Tomasz Chruszczow (Chair of SBSTA), Stephen Briggs (Chair of the GCOS Steering Committee) and Carlos Martin Novella (Deputy Secretary of IPCC) opened the Workshop, emphasizing the value of connecting the global climate observation and climate adaptation communities.

Mr Briggs noted that it was the role of GCOS to identify and support the observing needs arising from AR5. Adaptation brings us together – connecting society with climate change, and observing systems with decision-makers. Such connections were critical: by connecting the diverse observing systems around the world, including through GCOS and the Group on Earth Observations (GEO) we would be able to identify the broader observing requirements, engage more users and enhance the value and application of systematic observations.

Mr Chruszczow placed the workshop goals in the context of the current UNFCCC negotiations, underlining the need to translate AR5 findings for national- and local-level decision-makers. While the goal to limit the increase in global average temperature to 2°C above pre-industrial levels was global, understanding the implications at a regional and local level would require higher-resolution observing systems, integration of climate modelling into the larger sphere of climate science and the economy and science-based management of emission pathways. The Workshop came at a crucial time for both IPCC and GCOS: IPCC was considering another assessment cycle and GCOS was developing a new Implementation Plan. In 2016, we would enter a new phase for coordination between the IPCC and the UNFCCC, requiring that we better link observing requirements with agenda items on adaptation and mitigation and align more closely the observing systems community and users.

Mr Martin-Novella highlighted the importance of this collaboration for improving decisions and outcomes, noting that better data led to better research and more accurate models, which in turn, led to improved assessments.

The strong relationship and increasing collaboration among the GCOS Programme, UNFCCC and IPCC had increased the understanding among Parties of the importance of systematic observations of climate, helping to inform and improve their investments in these observations, especially in developing countries. In addition, increased interactions between GCOS and Parties had improved the GCOS Programme's understanding of the observing needs of the adaptation community. This workshop – a new collaboration among GCOS, UNFCCC and IPCC – was an opportunity to link the Parties with the providers of information and observations.

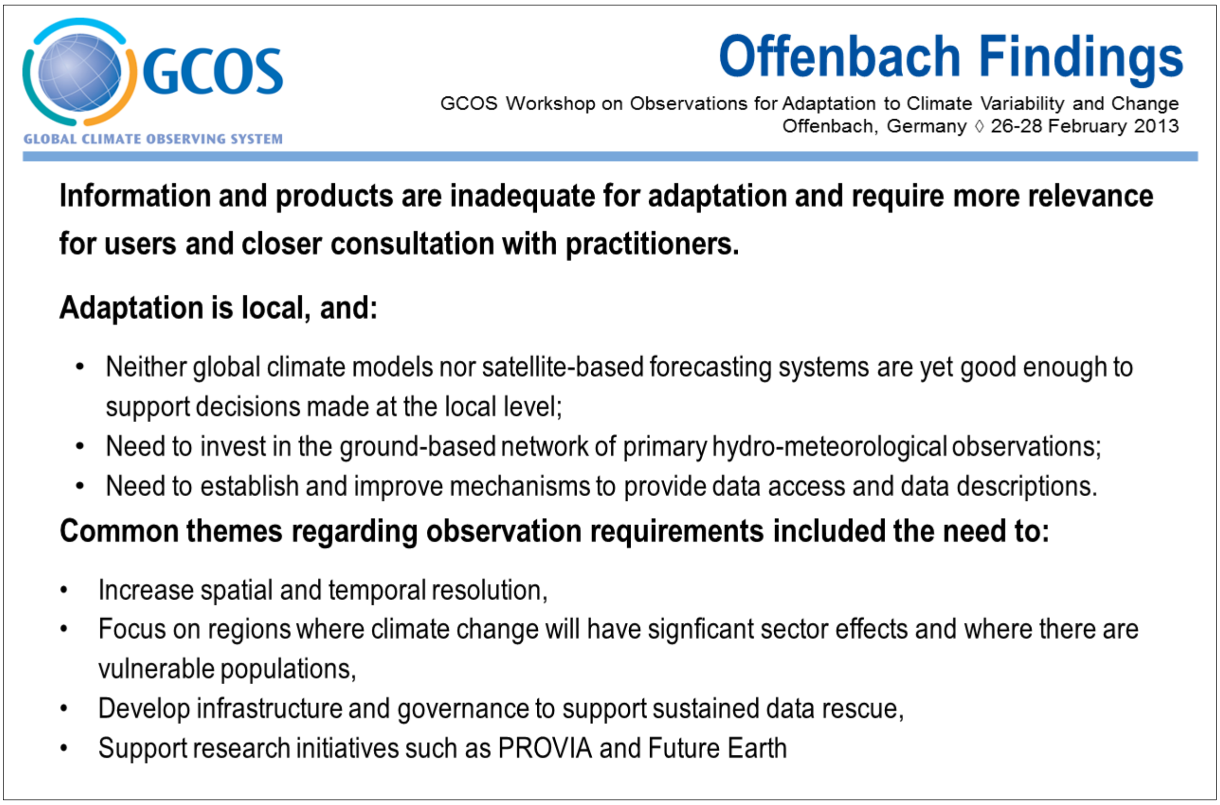
Session 1 - Assessing the key findings and recommendations of IPCC in the context of data availability to inform implementation of adaptation strategies

Chairs: Stephen Briggs (GCOS Steering Committee Chair); Tomasz Chruszczow (SBSTA Chair)

Session 1 assessed the key findings and recommendations of IPCC in the context of data availability to inform implementation of adaptation planning and strategies. The session highlighted the fact that science drove IPCC Working Group I (WG I) and informed IPCC Working Group II (WG II) and Working Group III (WG III); the Parties' needs drove WG II and WG III and their time horizons were short in relation to those of the science community. They valued attribution less for adaptation than mitigation. In addition, investing in long-term climate datasets might mitigate gaps in the understanding of climate impacts at regional and national scales and improve the ability to provide climate information at the spatial and temporal scales required for adaptation.

Stephen Briggs (GCOS Steering Committee Chair) introduced GCOS, highlighting the importance of climate observations of surface temperatures by noting that observations made in the past had unequivocally demonstrated that the climate system was warming. GCOS had been established to ensure that we were meeting the observational needs for monitoring, research and applications, with the Global Framework for Climate Services (GFCS) now providing the organizational basis for the service element. He further noted that we must enhance and sustain climate observations into the future to enable users to assess the impacts of climate variability and change, monitor the effectiveness of climate-mitigation policies, support climate-adaptation activities, develop climate-information services, promote sustainable national and economic development and meet other requirements of UNFCCC and other international conventions and agreements. Expanding and enhancing the long-term climate observation record in our oceans was required to demonstrate the total energy content of the climate system, of which surface temperatures represented only a small part. He provided an overview of the atmospheric, oceanic and terrestrial products and their associated essential climate variables (ECVs) (see Annex I for a full list of ECVs). Finally, Mr Briggs outlined GCOS plans for a status report with an evaluation of the adequacy of the Global Observing System for Climate against the ECVs that would be presented to UNFCCC by December 2015, and the development of a new Implementation Plan in 2016.

Carolin Richter (Director, GCOS Secretariat) underscored the connection between the goals of this Workshop and the findings of the GCOS Workshop on Observations for Adaptation to Climate Variability and Change, held in February 2013 in Offenbach, Germany (Figure 1). In addition, she provided an update on GCOS activities since then and noted GCOS support for GFCS. Ms Richter said that ensuring the adequacy of observing systems required GCOS to adopt an end-to-end approach to evaluating and understanding the needs of end users, including the climate adaptation and mitigation communities. Specifically, she discussed the role of ECVs, as well as other non-ECV variables required for particular sectors or applications, such as dust and snow-water equivalent and several coastal zone variables, including wave characteristics, topography (including subsidence) and bathymetry. Collecting some of these variables at the appropriate scale posed considerable challenges. The subsequent workshop discussions reinforced the connections between the Offenbach Workshop and this Workshop, particularly the finding that climate adaptation required observations on a more local scale – the smallest pixel of global models assessed by IPCC was still too large to support local adaptation.



Offenbach Findings

GCOS Workshop on Observations for Adaptation to Climate Variability and Change
Offenbach, Germany ◊ 26-28 February 2013

Information and products are inadequate for adaptation and require more relevance for users and closer consultation with practitioners.

Adaptation is local, and:

- Neither global climate models nor satellite-based forecasting systems are yet good enough to support decisions made at the local level;
- Need to invest in the ground-based network of primary hydro-meteorological observations;
- Need to establish and improve mechanisms to provide data access and data descriptions.

Common themes regarding observation requirements included the need to:

- Increase spatial and temporal resolution,
- Focus on regions where climate change will have signficant sector effects and where there are vulnerable populations,
- Develop infrastructure and governance to support sustained data rescue,
- Support research initiatives such as PROVIA and Future Earth

Figure 1: Offenbach Findings

Source: C. Richter

As Science Director for the IPCC WG I Technical Support Unit, Gian-Kasper Plattner outlined the key findings of the IPCC/World Climate Research Programme (WCRP) Workshop of the WG I AR5 Research Needs on Observations – Focusing on WCRP's Grand Challenges, held in September 2014, in Bern, Switzerland. He highlighted the headline statements from WG I including:

- Human influence on the climate system was clear:
- Changes in climate had caused impacts in natural and human systems;
- Continued greenhouse-gas (GHG) emissions would cause further warming and amplify existing risks; and
- Multiple pathways existed to likely limit warming to below 2°C.

Mr Plattner outlined the lessons learned from the IPCC/WCRP Workshop. It reaffirmed the importance of maintaining strong research links between WCRP and other partners, revisited the WCRP Grand Challenges and revised some of the key science questions that would be the focus over the coming years, determined that the goals of the WCRP Grand Challenges and the knowledge gaps identified by WG I AR5 were well aligned, and identified a need for a more comprehensive, end-to-end approach for climate assessments. Several topics recurred across the Workshop's break-out groups, including the need for increased skill in decadal timescales, the potential for an Earth System Reanalysis project and the utility and persistent need for model intercomparison projects. In addition, the Workshop identified areas where substantial uncertainties remained and which might deserve more attention through the WCRP Grand Challenges framework, including ocean (particularly deep ocean) heating and ocean circulation, understanding natural variability and forced change on annual to decadal timescales, aerosols and the interactive carbon cycle.

Konrad Steffen (Lead Author of WG I AR5, Chapter 4, and Chair of the GCOS Terrestrial Observation Panel for Climate (TOPC)) summarized the observational needs identified by WG I AR5, using examples from the Antarctic and Greenland to identify some of the key challenges. He outlined the observational and research needs for adaption to climate change as follows:

- The data availability to inform implementation of adaptation was very limited for most parts of the world and relied primarily on case studies, remote-sensing and modelling for extrapolation;
- Defining the core datasets to maintain stewardship in management of resources depended on the field of application;
- In general, networks for the detection of climate trends were inadequate, with most areas undersampled for accurate assessments, in particular those valid for the polar regions; and
- Local capabilities to observe, monitor, rescue, archive, process and sustain climate data and networks were often missing.

Mr Steffen spoke of the changes in the climate system observed by WG I, noting that the atmosphere and oceans had warmed, the amounts of snow and ice had diminished, sea level had risen and the concentration of GHGs had increased. He encouraged participants to consider whether we should prioritize adaptation in sensitive regions where climate change would have an impact first or most significantly and called attention to the need for regional understanding, noting that global sea-level rise (SLR) predictions had little meaning for the Pacific Ocean, when the regional footprint was not known or well understood.

Finally, Gerrit Hansen (Chapter Scientist for WG II AR5, Chapter 18) summarized the relevant findings of WGII AR5 Chapter 18 – Detection and attribution of observed impacts. Changes in climate had caused marked impacts on natural and human systems on all continents and across all oceans, with the Arctic emerging as a hot spot of observed impacts. The loss of unique and threatened ecosystems was of particular concern. To assess the impacts of climate variability and increase resilience, both climate variables and societal factors determining vulnerability needed to be monitored and integrated in an interdisciplinary effort. Three gaps high on the adaptation agenda were coastal erosion, impacts of extreme weather, and human systems. A lack of continued tide-gauge monitoring and limited information on floods, subsidence, sediment trapping and diversion, exposure and vulnerability limited understanding of coastal erosion and inundation in certain regions, such as West Africa. While changes in many extreme weather and climate events had been observed since about 1950, some of which had been linked to human influence, we could not at present always attribute impacts of extreme weather events to anthropogenic forcing. Moreover, impacts from recent climate-related extremes revealed significant vulnerability and exposure to current climate variability. Data on human systems were also lacking, particularly for food production including fisheries beyond wheat, maize, rice and soybean, occupational and public health, energy and infrastructure and other important sectors. Finally, Chapter 18 concluded that knowledge of observed impacts had improved vastly, high-quality observations were vital, interactions of different drivers of climate change and socioeconomic data were important, and detected and attributed impacts might not be the most relevant indicators for future risk.

Focusing on the key findings and recommendations of IPCC in the context of data availability to inform implementation of adaptation planning and strategies, the discussion among participants and speakers focused primarily on issues of scale, regional gaps in the assessments of climate impacts and how best to communicate impacts and make decisions in the face of uncertain information.

In particular, the discussion highlighted the adaptation – and engineering – communities' needs for climate assessments, observations and monitoring at regional, national and local scales. Participants noted the challenges created by the disparate quality and accessibility of regional, national and subnational data. Participants discussed the need for countries to increase their investment in monitoring and systematic observation as needed to support adaptation with an emphasis on understanding the observations that were most valuable now and those that would be most valuable in the future. Participants repeatedly raised the need to plan for the observation systems to support future action. WMO is keen to support initiatives relating to regional assessments and studies. Participants acknowledged that information needed to support the time horizons and information needs of politicians and policymakers could differ from the information needed to support the science-based work of IPCC.

In addition, recognizing the focus of IPCC on peer-reviewed science, the participants noted that gaps in data and insufficient peer-reviewed publications on specific regions might contribute to inadequately characterized impacts for some regions and nations. In particular, participants highlighted the challenges for Small Island Developing States (SIDS), for which insufficient observations and peer-reviewed publications existed to ensure adequate representation in the IPCC reports.

Session 2 - Defining the core sets of data, data characteristics and information technologies needed to maintain the minimum acceptable level of stewardship in the management of resources and infrastructure

Chairs: Ken Holmlund (Chair, GCOS Atmospheric Observation Panel for Climate (AOPC); Albert Klein-Tank (Vice-Chair, GCOS AOPC, and Coordinating Lead Author, IPCC WG I AR5, Chapter 2)

Session 2 defined the core sets of data, data characteristics and information technologies needed to maintain the minimum acceptable level of stewardship in the management of resources and infrastructure.

Adrian Simmons (Lead for the GCOS Status Report) introduced ECVs (see Annex I) and the GCOS assessment process. He noted that, while ECVS were either specific variables or groups of closely related variables (see Annex I), they were more than just a list of variables. ECVs build on existing scientific data holdings and observational infrastructure, and guidance was provided on their observation as well as the formation of products from the observations. ECVs provided one basis for an organized assessment of capabilities and needs, although this could also be organized by observing network, physical/chemical cycle or societal benefit area. The list of ECVs was last updated in the 2010 Implementation Plan – that is, re-naming ice sheets and ocean acidification and adding ocean oxygen content, soil moisture and precursors for ozone and aerosols among other changes – and the list might be updated again in 2016. Inputs to the 2015 Status Report and the 2016 Implementation Plan were varied. Some of the key ways the GCOS Steering Committee was assessing progress and current status included evaluating responses to the 2010 Implementation Plan actions, evaluating network performance and data-centre holdings, relating to key uncertainties identified in IPCC AR5, and by relating to issues raised by WCRP and other bodies. In addition to this and other workshops, two additional events would be held: a July 2015 Copernicus Workshop on

Climate Observation Requirements and a GCOS Conference on Global Climate Observation: the Road to the Future, 2-4 March 2016.

Barbara Ryan (Director of the Group on Earth Observations (GEO) Secretariat) explained how GEO objectives to improve and coordinate observation systems, advanced, broad, open-data policies fostered increased used of Earth observation data and information and built capacity to reinforce GCOS goals. GEO provided leadership in the broader community, especially at the ministerial level, given that half of the world's countries were members of GEO. A major undertaking of the GEO Climate Task was the accelerated implementation of GCOS and GCOS was the climate observation contribution to GEO.

The next two talks set the stage for identifying new needs in observing technologies for ocean acidification and land, as well as the requirements for data quality, access and stewardship.

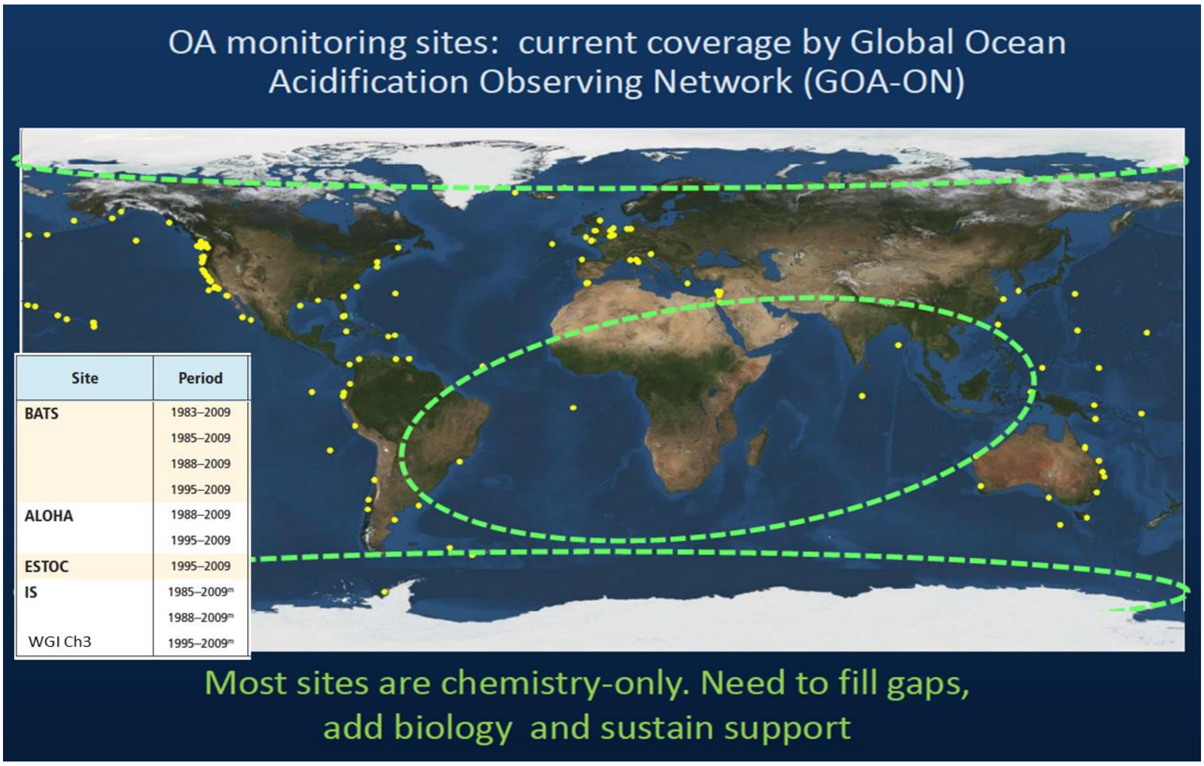


Figure 2: Ocean acidification monitoring sites

Source: H Pörtner

Hans Pörtner (Coordinating Lead Author for WG II AR5, Chapter 6) outlined the observing system needs for understanding and adapting to ocean acidification, the process by which carbon dioxide absorbed by the ocean was changing the chemistry of seawater. He noted that the ocean played a major role in climate regulation, but this had consequences; we had already observed the impacts on ocean productivity and species distributions due to ocean warming, the accumulation of carbon dioxide and deoxygenation, with the impacts varying by region. Ocean acidification could have profound impacts on ecosystems and economic activities (e.g. fishing) dependent on these ecosystems were threatened. Existing and planned observations under the Global Ocean Acidification Observing Network (GOA-ON) (Figure 2) focused on chemistry, due to recent success in developing autonomous chemistry observations.

Furthermore, sustained commitments were required to develop long-term, high-quality time series. In addition, hydrographic cruises, Volunteer Observing Ships, buoys and other autonomous systems, including wave gliders and profiling gliders augmented the system. GOA-ON aimed to develop a comprehensive observing system for ocean acidification. Efforts were needed to develop the observing system across the range of environments and habitats in the ocean and to develop observing approaches for the biological and ecosystem impacts of ocean acidification throughout the open ocean, coasts, shelf seas and coral reefs. In addition, the third driver – deoxygenation – exacerbated acidification. As with many variables, the existing observations of oxygen were mostly in the northern hemisphere. In marine animals, the strongest impacts were expected where warming, acidification and hypoxia came together. For assessments to represent adequately the threat posed by the combination of these drivers, additional observations were needed. Specifically, observation of biological impacts paralleled by the comprehensive monitoring of key climate drivers and local drivers was required. However, more work was needed to determine the requirements for biological observations. For some more autonomous observations, collaborations with the private sector – including the World Ocean Council – were an opportunity to expand the observing system.

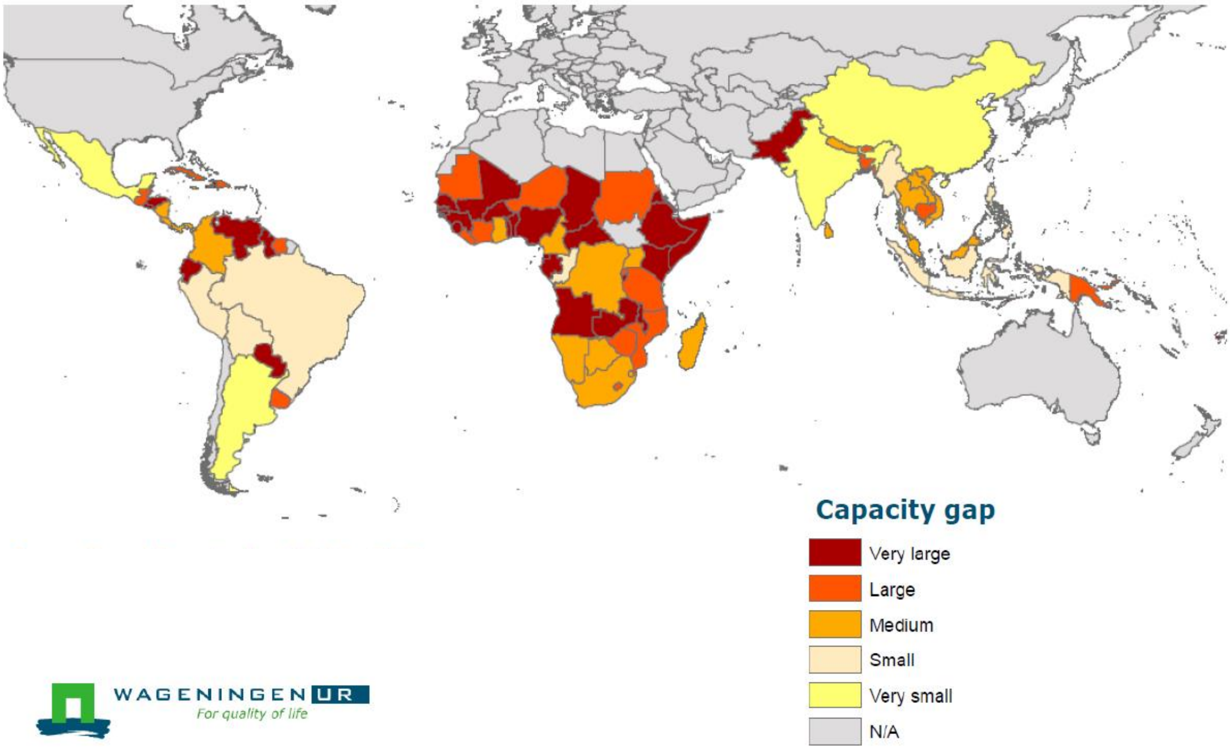


Figure 3. Forest monitoring for REDD+ – capacity gaps

Source: Romijn et al, 2012, ESP

Martin Herold (Global Observation for Forest Cover and Land Dynamics (GOFC-GOLD) outlined the needs in data quality, data access and stewardship for the terrestrial system. He stated that the UNFCCC/GCOS/ECV framework had resulted in important progress for climate observations with 11 of the 12 terrestrial ECVS being simple geophysical parameters. The exception was land cover, which was complex and for which definitions differed by user and included observations of land-use change after deforestation.

While the GCOS terrestrial counterpart (GTOS) was inactive, the Terrestrial Observation Panel for Climate (TOPC) and the technical community serve an intermediate solution (Figure 3). Communities assisted by contributing ground data to the remote-sensing methods, allowing for enhanced accuracy. The importance of the terrestrial domain was increasing in climate science and progress in ECV observation had largely focused on WG I users. The human dimension in ECVs, required for links to mitigation and adaptation, was largely absent. The dialogue among observation, mitigation and adaptation communities had begun. Global ECV monitoring and national estimation and reporting to UNFCCC were largely independent and the synergies between the two should be exploited. In addition, more emphasis on modelling in the terrestrial domain – nutrient cycling – was needed.

Finally, John Bates (Chair of the Committee on Earth Observations (CEOS) Coordinating Group for Meteorological Satellites (CGMS) Joint Working Group on Climate) assessed the observation needs in terms of data quality, access and stewardship for preparedness and adaptation. He outlined the CEOS-CGMS Working Group on Climate goals as:

- Providing a comprehensive and accessible view of the available climate data records;
- Making best use of currently available data by establishing additional climate-data records; and
- Optimizing the planning of future satellite missions and constellations to expand existing and planned climatedata records, in terms of both coverage and length.

He described the four logical architecture pillars for climate monitoring: sensing, climate-record creation, application, and decision-making. In addition, Mr Bates proposed that it might be necessary to consider requirements for Essential Climate Service Variables (ECSVs), which would share some heritage with ECVs. With respect to ECVs, however, ECSVs would require higher spatial and temporal resolution, shorter latency, sustained and routine delivery and a connection to a decision-maker for additional tailoring. Finally, he discussed the tools and best practices being developed for ECV maturity assessment and tiers of stewardship and access that could then be identified to form an end-to-end value chain using the climate-monitoring architecture based on the CORE-CLIMAX maturity concept.

The Session 2 presentations stimulated discussion around several themes: GFCS observation needs and the proposed ECSVs; gaps in ocean and terrestrial observations, including observing needs in the coastal zone, where they intersect; and the challenges of effectively communicating climate information and uncertainties across user groups.

Robust discussion centred around the core sets of data and data characteristics required to support GFCS as well as the application areas and the degree to which the existing ECVs mapped to those areas or might require consideration of a broader set of variables. While there was general agreement that ECVs represented the minimum number needed to meet essential services and this core group of variables probably provided for 80% of variance, tailored services required additional variables. The value of the additional variables was not diminished, because they were not considered essential; rather the goal with ECVs was to maximize the output or value from a minimum number of variables, recognizing that, as a variable became more specific, there was a diminishing rate of return to deeming that variable essential. In addition, parameterization of the variables might differ by sector requirements for specific spatial or temporal resolutions.

In addition, participants noted it would be helpful for GCOS to provide best practices for gathering terrestrial ECVs by identifying those best measured via in situ networks and those best measured by remote-sensing. Moreover, the complexity of governance related to terrestrial ECVs was also noted. While NMHS gather atmospheric ECVs almost exclusively, , terrestrial ECVs were governed by a variety of national agencies that might not have the same rich history of international cooperation as NMHSs.

Participants identified several areas that could benefit from reconsidering or broadening ECVs or developing sector-specific climate variables to complement them. In particular, the limitations of ocean and coastal data were raised repeatedly and, specifically, the need for collaboration – through the Intergovernmental Oceanographic Commission (IOC) and the Global Ocean Observing System – to expand the measurement of the southern oceans.

The discussion returned repeatedly to the challenges of communication: the technologies needed to maintain stewardship and promote broad dissemination of the data, the need for open-data policies to facilitate broad data-sharing, as well as meaningfully communicating the limitations of some data and the uncertainties associated with climate data and information.

The use of technology to help address some of the communication challenges was discussed. In particular, the need was stressed for technology to maintain the minimum acceptable level of long-term data stewardship, incorporate information on the quality and reliability of specific datasets and their associated uncertainties, and provide the flexibility to incorporate new datasets as needs evolved.

Moreover, the Parties and presenters raised the need for additional information on the quality of data and best practices for their use (e.g. the benefits and drawbacks of using downscaled climate information). The GEO Data Sharing Principles were highlighted as one of the best practices for promoting the full and open sharing of data for all users. Parties struggling with data access were encouraged to call for the application of the Principles, especially by those countries that were members of GEO.

Finally, there was extensive discussion of how best to communicate complex climate information across user groups, noting the varied needs of the user communities. For example, the needs of the engineering community and the limitations placed on them by national and local legal frameworks that relied heavily on historical information for regulation were discussed. The need to improve communication on a variety of levels was emphasized, from the value of making data openly available to the purpose of ECVs, to crafting messages and using language that could facilitate understanding and communication across user communities.

Session 3: Characterizing the climate data needs of the four identified key sectors, including the needs for the financial and/or development sectors

Chairs: Gerhard Adrian (WMO Intergovernmental Board on Climate Services (IBCS) Management Committee); Carolin Richter (Director, GCOS Secretariat)

Session 3 characterized the climate-data needs of the key sectors by building on the four GFCS priority areas: water; agriculture and food security; disaster-risk reduction; and health. The needs of the financial and development sectors were also considered. Once again, the discussion highlighted the need for full, free and open access to data, as well as the challenges of communicating across sectors and disciplines.

Gerhard Adrian explained why a framework for climate services was needed. The vision of GFCS was to "enable better management of the risks of climate variability and change and adaptation to climate changes through the development and incorporation of science-based climate information and prediction into planning, policy and practice on the global, regional and national scales" across the four priority areas. He noted that many countries lacked the infrastructure, technical, human and institutional capacities to provide high-quality climate services. A Framework for Climate Services would build on existing capacities and leverage them through coordination and integration across disciplines and sectors to improve outcomes in climate-sensitive sectors. The GFCS Implementation Plan identified several gaps and deficiencies, including:

- Inadequate atmospheric observations, poor observational coverage of important oceanographic variables, inadequate terrestrial observing networks;
- Need for complementary biological, environmental and socioeconomic data;
- Data policies and infrastructure for data management, as well as access to historical observational and other relevant data and derived products;
- Need to address data loss and inhomogeneity in time series; and
- Need to rescue and digitize data.

In addition, GFCS addressed the interoperability and sustainability of observing systems, focusing on cooperation at the regional level, as well as partnerships at the national level, for data-sharing and standardization. Among the next steps for GFCS implementation in World Meteorological Congress (June 2015) would consider the budget proposal, operational plan, links to the WMO technical commissions and Executive Council and a proposed data policy for climate data. Following WMO Congress the IBCS Management Committee would develop the work programme until 2018 and establish the required substructures to implement the work programme with experts from priority-area partners.

Bruce Hewitson (Coordinating Lead Author of WG II AR5, Chapter 21) summarized the regional observational needs by building on the GFCS priority areas (water, agriculture and food security, disaster-risk reduction, and health). While Chapter 21 provided several messages relevant to observations, a good understanding of decision-making contexts was essential; the information available was limited by a lack of comprehensive observations and analyses of regional climate and there was substantial regional variation in observations and projections of climate-change impacts. These encompassed a deep array of issues for regional information in observational data and the observation and adaptation communities needed to look at how the decision-making context was determined, increase the focus on the absence of observations – not just the analysis of existing observations – and find ways to improve the consistency of observations across regions.

He identified several needs including:

- Addressing the question of climate services, including a growing but unaccountable commercial sector;
- Developing equivalencies, particularly to translate observations into model equivalences and adapt observations for impact model input;
- Enhanced baselines with quantified uncertainty for evaluating models; constraining and training statistical downscaling; understanding past changes; and assessing future departures from the "normal", recognizing the heterogeneity of observing data, lack of agreement among datasets and resolution that was often incompatible with applications by decision-makers;
- Improved understanding and communication of how reanalysis data were being used increasingly instead of observations;
- Transparent communication underpinned by consistent analysis of incomplete observations;
- Examples in the form of case studies and documentation of the effectiveness of actions taken; and
- Attention to other nuances such as language/terminology, contrasting priorities and capacity, cross-cultural perceptions and ethics.

Mr Hewitson cited the following knowledge gaps and research needs described in AR5 WG II, Table 21.8:

- There was no clear understanding of how to integrate the diversity of climate-change projection data;
- The attributes of regional climate change through which impacts were manifest, such as the intensity, persistence, distribution, recurrence and frequency of weather events, were poorly understood and the information conveyed to the adaptation community was dominated by aggregates in time and space (e.g. regional or time averages), which hid the important attributes underlying those aggregated changes.
- The historical record for many regions, especially those most vulnerable to climate change, was poor to the extent that it was at best an estimate with unknown uncertainty.

Roger Pulwarty (Coordinating Lead Author of the IPCC Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX)) noted that the report addressed, for the first time, "how integrating expertise in climate science, hazards and disaster-risk management and adaptation can inform, help to reduce and manage the risks of extreme events and disasters in a changing climate". Increasing vulnerability and exposure to, or the severity and frequency of, climate events increased disaster risk. Disaster-risk management and climate-change adaptation could influence the degree to which extreme events translated into impacts and disasters. While average physical exposure was increasing, SREX aimed to show that economic factors were also crucial. Poverty and wealth were a significant part of the Prevalent Vulnerability Index, which focused on exposure and susceptibility, socioeconomic fragility and lack of resilience. Other important factors were information systems, infrastructure/technology, insurance, integrated systems and institutional capacity. The report found that reducing exposure was less challenging than reducing fragility and increasing resilience, noting that, for exposed and vulnerable communities, even non-extreme weather and climate events could have extreme impacts. SREX proposed the Solution Space, which focused on increasing resilience to changing risk, reducing vulnerability, and transformation. Risk management required early warning systems and resilience required reducing vulnerability.

In relation to observations, Mr Pulwarty noted that the current availability and quality of climate observations and impact data to support adaptation were inadequate for large parts of the globe and there was a need to determine the sensitivity of the driving forces to ECVs. Recommendations for systematic observation needs included:

- Acknowledging the cross-timescale nature of climate and early warning information; decadal prediction lay between initialized weather or seasonal forecasts and future climate change projections, not just "extremes" or "trends";
- Understanding and communicating the economic and social value of novel resource configurations, such as land-use, for resilience;
- Recognizing "communication" as critical, but not sufficient: more challenging was an understanding of how a society benefits from the lessons learned by particular individuals and organizations through their own, direct trial-and-error experiences;
- Creating integrated information systems; and
- Focusing on capacity and improving decisions – not just information use – and how often criteria for robustness should be considered.

In addition, there was a need to consider the following for extremes in the context of climate variability and change:

- The growing pressure for better information to support planning under changing extremes, in both frequency and intensity;
- Whether a threshold was an emergent property of some underlying set of attributes of a system, recognizing that the models were not calibrated for rapid transitions;
- The Importance of understanding how new information related to what was already known, as well as how often to reconsider criteria for "robustness"; and
- The varying needs of public- and private-sector applications, with many public-sector applications requiring a more systematic connection between early warning scenarios and recommended decisions than the the private sector.

Heike Bach (Vista Remote Sensing in Geosciences) discussed food security and production. She said that farmers must adapt their farm operations to temperature increases and changes of rainfall patterns. There were a number of significant factors impacting global food security and production, including political trends such as international treaties and directives; food safety and environmental standards and citizen participation; economic trends, including commercialization of agriculture and global risks to the economy; urbanization; environmental trends such as land-use change, climate change, water scarcity, pollution and degradation; and technological trends, including communication, the Internet and Earth observations. The challenge was to feed a population of nine billion by 2050 that would require a doubling of the food supply, even as further expansion of agriculture reduced natural resources. Climate change intensified imbalances in food supply and, in many regions, reduced water availability. Smart farming could help close the yield gap in a sustainable way: Earth observations contributed to better modelled yields but the resolution required was higher than that currently available.

Earth observations for a sustainable global food system had two pillars: governance systems and regulations for sustainability, and the supply chain, agriculture and the food industry. Geospatial information services could support each pillar, through monitoring items such as yield information; occurrence of diseases and hazards; natural disasters (flooding, drought); water demand, irrigation and availability; biomass; phenology; meteorological data; soil moisture; nutrient demand; and land use. The information needs of agricultural management and governance were challenging in terms of both quantity and content: very high spatial resolution (10–30 m), but globally available; high temporal resolution (3–7 days) and near-real-time access; and more than 50 geospatial parameters of crucial importance. The European Earth observations programme Copernicus and its international counterparts were a good start.

Ms Bach concluded that the global food system would have to double its output over the next 40 years to meet demand. Understanding that by 2070 the south should expect a 20% decrease in yield, while the north would increase by about the same percentage, the world must gear itself towards smart farming, while acknowledging and addressing a sustainability constraint. To that end, we must examine which institutional arrangements were most appropriate to enhancing integrated risk-management programmes to improve the resilience capabilities of food-insecure populations. Information and knowledge would be central to improving agricultural efficiency to support a secure and sustainable food supply. Earth observations, together with local, regional and global farm management models, were needed to support sustainable food security. The challenge was to support food security and sustainable agriculture by developing and improving scientific understanding, technological capabilities and integration capacities to exploit the full potential of Earth observations and modelling.

Tania Osejo Carrillo (World Food Programme (WFP)) provided an overview of how climate information was helping food-insecure populations build resilience (Figure 4) through a comprehensive approach, giving Ethiopia as an example. The water and energy intensity of agriculture was crucial to food security and production and made agriculture the industry most dependent on weather and climate. She highlighted the WFP’s integrated food-security early response system: Livelihoods, Early Assessment, and Protection (LEAP). LEAP had been developed by the Government of Ethiopia in collaboration with WFP and the World Bank. Crop and weather information in the form of satellite data and weather station data, along with household and baseline crop data, was the key input into the system that combined early warning with contingency planning and funding to provide early assistance in anticipation of an impending drought. LEAP software estimated, amongst other things, food production and the number of people at risk of insecurity from drought.

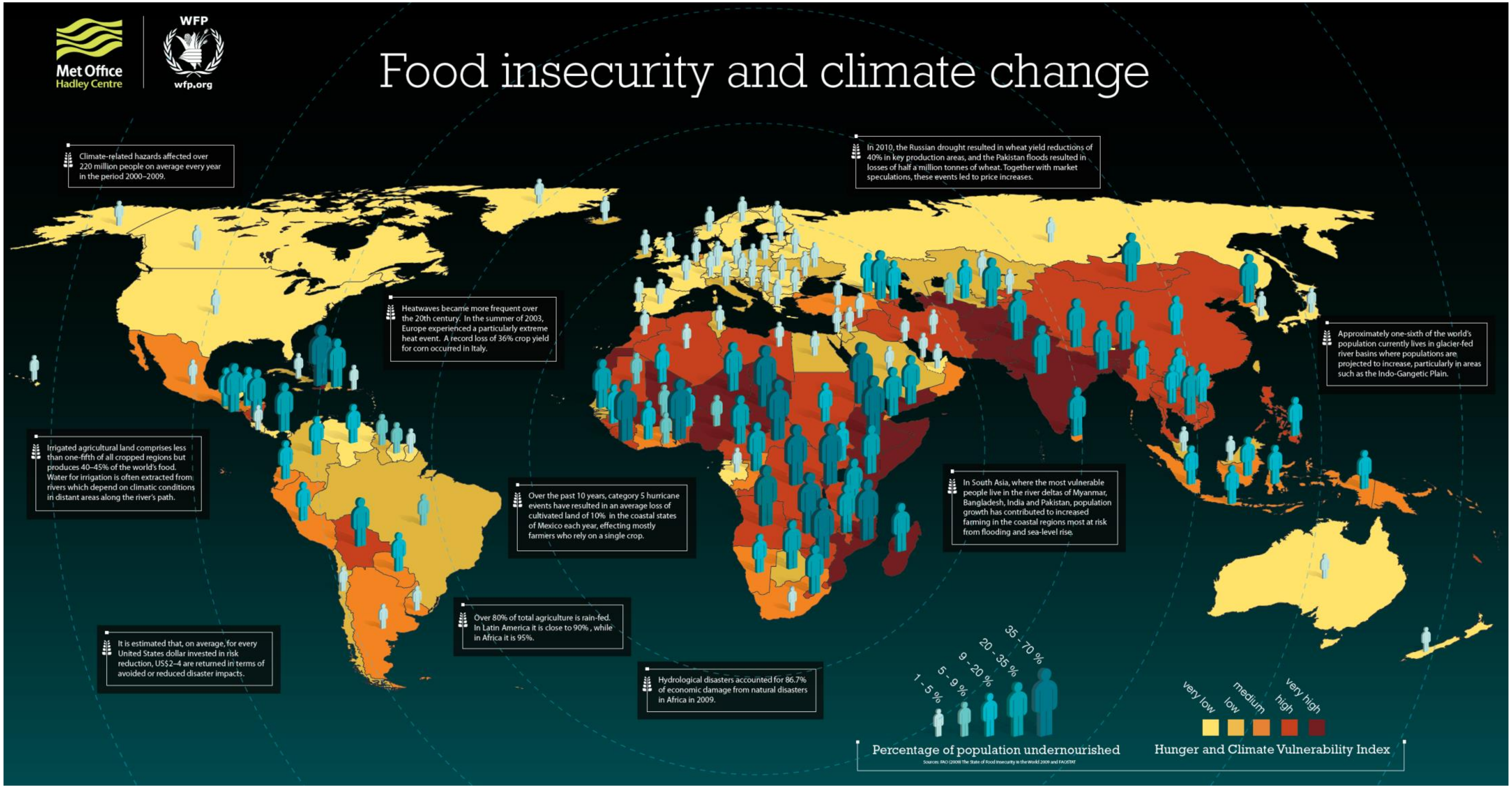


Figure 4: Food insecurity and climate change

Source: World Food Programme, UK Met Office Hadley Centre

In addition, WFP had relied on information from climate observations when it piloted the R4 Rural Resilience Initiative in Ethiopia. R4 was designed to build resilience of food-insecure smallholders through integrated risk management; build government capacity to develop and implement integrated risk-management programmes and contribute to the development of a rural financial market. A key component of R4 was risk transfer through insurance. For example, compensation for weather-related losses prevented farmers from selling productive assets and helped them recover faster.

A lesson learned from Ethiopia was that insured farmers saved 123% more than uninsured farmers, increased their grain reserves and invested more in productive assets, such as oxen, seeds and fertilizer. For women landowners, in particular, WFP found that they stopped sharecropping, increased their spending on hired labour and oxen and increased the amount of improved seeds compost.

Finally, Ms Osejo outlined WFP's three-pronged approached for building resilience that includes using climate information for planning. The approach included:

- Integrated Context Analysis at the national level, combining historical trends of food security, nutrition and food stocks with information on land degradation, roads, etc., to identify priority areas for intervention;
- Seasonal livelihood programming at the subnational level: a consultative process to design an integrated multiyear, multisectorial operational plan in the light of seasonal and gender considerations; and
- Community-based participatory planning at the local level to identify needs and tailor programme response to local requirements, ensuring ownership by the communities.

Adaptation programmes in Africa under GFCS would strengthen the use of weather and climate information to support food security and nutrition in two ways. Firstly, they would enhance national food security and early warning systems for Malawi and the United Republic of Tanzania. Secondly, they would provide direct access to weather information for production purposes through capacity-building for access, interpretation and communication of climate and weather information, community radio and/or SMS services and strengthening community-based participatory planning.

Following her presentation, valuable connections were made between the WMO Climate Outlook Forums in East Africa and WMO RCCs. WFP was also working in South-East Asia and central Asia to link climate and food security in helping adaption planning.

Joern Birkmann (Lead Author, WG II AR5, Chapter 19) presented the climate-data needs in disaster-risk reduction (DRR) and urban/spatial planning. The DRR community needed short-term and seasonal climate data for warning systems in rural and urban areas. Both DRR practitioners and urban and spatial planners needed historical data on climate variability to estimate ranges of extreme events and associated risks and climate data to assess residual risks and limits of adaptation, and for regions and provinces with high exposure and high vulnerability levels. Because DRR and urban/spatial planners operated primarily at the subnational and local scale, they required high-resolution, comparable data (e.g. heat stress, extreme floods), reliable, accessible, sustainable data, differentiated climate data (e.g. urban versus rural areas) and improved access to national networks for the detection of climate trends and climate variability.

Risk is the combination of vulnerability, hazards and exposure. Risk determined the impacts that would be felt by a community. The World Risk Index helped DRR practitioners understand risk patterns and the influence of climate change by evaluating a population's exposure to hazards, susceptibility (e.g. housing conditions, economic capacity), coping capacity (e.g. disaster preparedness and early warning, medical services, social networks) and adaptive capacity (e.g. education, gender equity, investment).

The key challenge for DRR and urban and spatial planning was identifying and characterizing complex and cascading risks in the context of extreme weather events influenced by climate change. In addition, determining how to improve the assessment of exposure and vulnerability to climatic stressors at a subnational scale was critical to effective planning for adaptation to a changing climate, as well to reducing disaster risk.

Bettina Menne (World Health Organization (WHO)) followed Mr Birkmann's presentation with a discussion of global climate observing needs from the health-sector perspective. She identified five key needs:

- Information for anticipation of extreme events and meteorological trends;
- Climate information for vulnerability, impact and adaptation assessment;
- Climate information to develop standards and norms;
- Climate information for adaptation planning, e.g. heat early-warning systems for health adaptation; and
- Climate information for mitigation, e.g. air quality.

Recognizing health as one of the GFCS priority areas, she highlighted the untapped potential of health-relevant climate and weather data across timescales. She noted that health users' perceptions of climate information across those timescales varied. The health community used short-term weather forecasts regularly, especially for heat–health warnings, as well as sand and dust warnings and advisories; their use of seasonal-to-decadal information was limited, however, with seasonal data being used by some organizations to anticipate health-system requirements. Decadal data and information were perceived largely as unreliable and their use limited to budget and workforce planning. Retrospective and historical weather and climate information was used for hindcasting.

Climate information was used to assess vulnerability and impacts. She noted that for the main health impacts by 2040, confidence was high, regarding injury, death and disease from extreme weather events. There was growing confidence in an increased risk of undernutrition in children in areas already affected by food insecurity, increased risk of food-, water-, and vector-borne infectious diseases and reduced health and labor capacity due to heat (Figure 5).

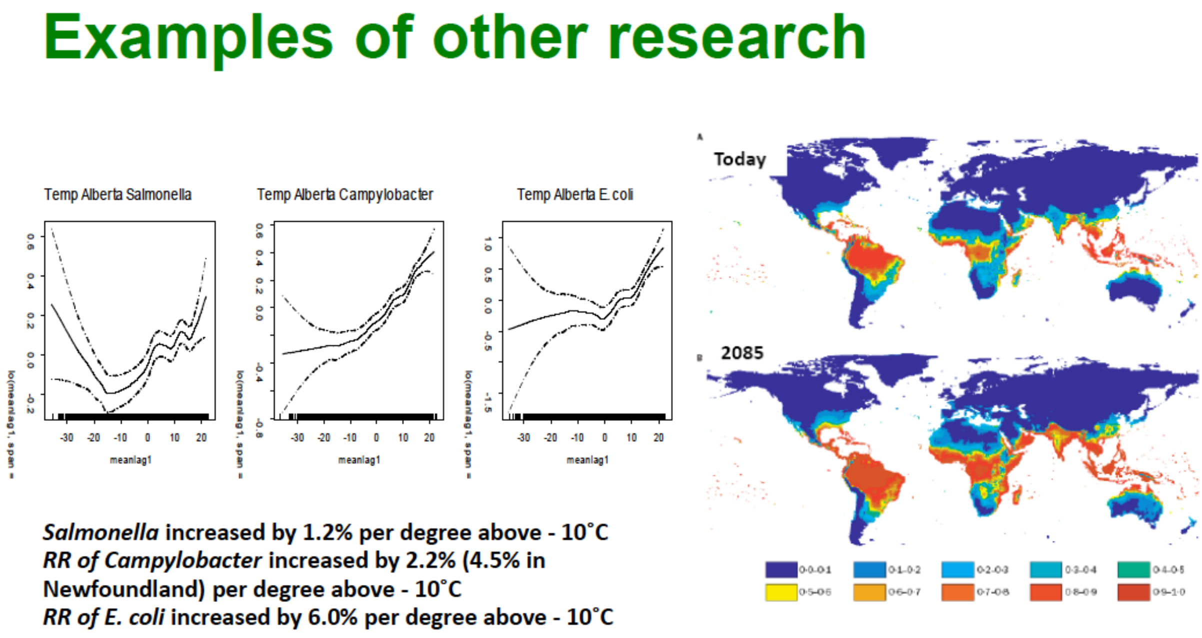


Figure 5. Salmonella incidence and temperature

Source: B. Menne, WHO

She outlined ongoing research to highlight the use of climate data in health analysis. One example was the European Provision of Regional Impacts Assessments on Seasonal and Decadal Timescales (EUROPIAS) project, which aimed to assess key knowledge gaps for important sectors and develop a few prototype prediction systems, including a climate-driven model for temperature-related mortality.

Finally, Ms Menne identified the operational needs of the health community:

- Public and freely available meteorological and climate data for use in research and assessments;
- Improved spatial and temporal resolution;
- Improvement in dialogue between providers and users of climate services;
- Public and freely available downscaled meteorological and climate data;
- Improvement in dialogue between different players and sectors to find synergies; and
- Joint efforts to avoid duplication.

Christos Mitas (Risk Management Solutions) presented the needs of the financial sector and discussed the observational needs of catastrophe modelling (Cat Models) and its role in reinsurance. He explained that Cat Models were mathematical models, calibrated on observational data, which made predictions of the money that insurance would have to pay out because of catastrophes, specifically weather-related catastrophes (e.g. tropical cyclones, extratropical cyclones, tornadoes, floods and storm surge), other natural catastrophes (e.g. earthquakes, tsunamis, epidemics, wildfires) and man-made catastrophes, such as terrorist attacks. The models were centred principally on insured areas, including Western Europe, North America and the Caribbean, Japan, Australia and New Zealand. Some attention was also given to Central and South America, central and eastern Europe, China and East Asia.

Reinsurers used the models to manage extreme risk. Cat models combined rate modelling (e.g. how many storms), hazard modelling (e.g. wind speed), exposure modelling (e.g. what type of structures), vulnerability modelling (e.g. what damage), and financial modelling (e.g. what loss). These models benefit the broader community by reducing insurance premiums, modelling mitigation (e.g. building more resistant? houses) and by mediating changes in risk due to climate change. Recent initiatives underscoring the latter include The Economic Risk of Climate Change in the US (Risky Business), Pacific Catastrophe Risk Assessment and Financing Initiative (World Bank) and Understanding Risk: The Evolution of Disaster Risk Assessment (Global Facility for Disaster Risk Reduction).

Finally, Mr Mitas outlined the greatest challenges facing the catastrophe-modelling community:

- Data availability – in particular, restrictions on government data, especially in Europe – influences the data available for modelling, with limited loss data from the reinsurance industry, diminishing the ability to validate the models; and
- Model resolution – very high-resolution inputs and outputs (e.g. tenths of metres/building level) are needed, much higher than a typical climate or even weather model.

The discussions centred around how best to acknowledge and meet both the varied observing and information needs of different sectors and the unequal understanding of the best uses and limitation of climate information. Governance of data – particularly the need for free, full and open access to data, missing data and integration across diverse datasets – was identified as a challenge.

The benefits and limitations of charging for data were discussed, with the Parties and representatives of the adaptation community expressing a preference for free and open access to climate and weather information. In addition, the Parties and adaptation experts expressed a desire for objective, legitimate, public documentation on the limits and applications of climate data and products, together with their associated uncertainties, recognizing they might vary, depending on the use of the data.

Additional attention should be devoted to the interface between users and data. The development and placement of observational interfaces impact those who can access and use the information, as well as their confidence in its quality. Improved interfaces may enhance the use of climate data by expanding the number of users and improving their ability to understand and apply the data.

Session 4 - Assessing the adequacy of national and regional networks and records for the detection of climate trends to inform global, regional and national assessments of climate change and for developing regional and national climate risk profiles

Chairs: Stefan Roesner (SBSTA representative); Florin Vladu (UNFCCC Secretariat)

Session 4 focused on assessing the adequacy of national and regional networks and records for the detection of climate trends to inform global, regional and national assessments of climate change and for developing regional and national climate risk profiles.

Part One of the session began by focusing on adaptation strategies across timescales with particular attention on adaptation planning and implementation as identified in WG II AR5, Chapter 15 and information needs of the DRR community as identified in WG II AR5 Chapter 19, and the role non-governmental organizations, such as Future Earth, may play in helping to meet the adaptation community's needs.

Roger Pulwarty (Coordinating Lead Author, WG II AR5, Chapter 15) began with an overview of the main findings of the chapter. He highlighted what was new in AR5, focusing on newer climate models and scenarios; a larger base of knowledge, including expanded treatment of human systems, adaptation and the ocean; adoption of a risk paradigm; greater emphasis on practice and social science inputs; and addressing detection and attribution.

He noted that empirical evidence from Chapters 14–17 of WG II AR5 indicated that adaptation was only now moving from awareness to planning. AR5 showed the climate-change risk and potential for adaptation for all regions (Figure 6).

While the state of the art was improving, many adaptation-planning studies were likely to underestimate their uncertainties because of the sparsity of data underpinning the analysis, as well as institutional limitations. Development of climate-risk profiles required an effective observation system, which offered the appropriate information to support business concerns. Business concerns might include direct physical impacts on the investments themselves, degradation of critical supporting infrastructure, changes in the availability of key natural resources, changes to workforce availability or capacity; changes in the customer base, supply-chain disruptions, legal liability, shifts in the regulatory environment and reductions in credit ratings.

Mr Pulwarty stated that we still lacked a comprehensive climate observing system capable of testing climate predictions with sufficient accuracy or completeness and thus were delaying decisions and action on adaptation, due to the lack of observation networks. In order to develop climate-risk profiles, the data from the GCOS community needed to include a sense of magnitude and rates of change. An important next step would be to develop prototype case studies where we could analyse impact data in specific past or present events and learn from them to show how best GCOS could interact with regional systems to provide information to support national adaptation.

Joern Birkmann (Lead Author, WG II AR5, Chapter 19) presented the systematic observation needs to support adaptation strategies across timescales for DRR and community and urban planning. He began by explaining the timescales relevant to adaptation and DRR. He noted that identifying climate-adaptation needs required an improved database of historical climate variability and the speed of climate change. Adaptation in DRR required attention to information on past extreme events: crisis scenarios. It was essential for both DRR and urban/spatial planning to consider adaptation in a multi-hazard and multi-risk context. However, planning authorities often considered past and present climate variability as more reliable information in legal disputes than forecast data from climate models, which were often too general.

He continued by highlighting the implications of climate change for DRR and urban and spatial planning. Emerging risks depended on the speed of future climatic, as well as socioeconomic, changes. Significant impacts of climate change had not yet occurred (or had not been attributed to anthropogenic climate change) and this presented an opportunity and a challenge for planning. The opportunity was that it was generally accepted that proactive measures were cheaper than doing nothing. The challenge, however, was to determine useful and acceptable proactive measures. For example, a dyke system built to allow for the impacts of future climate change during the initial building phase was economically better than making changes later.

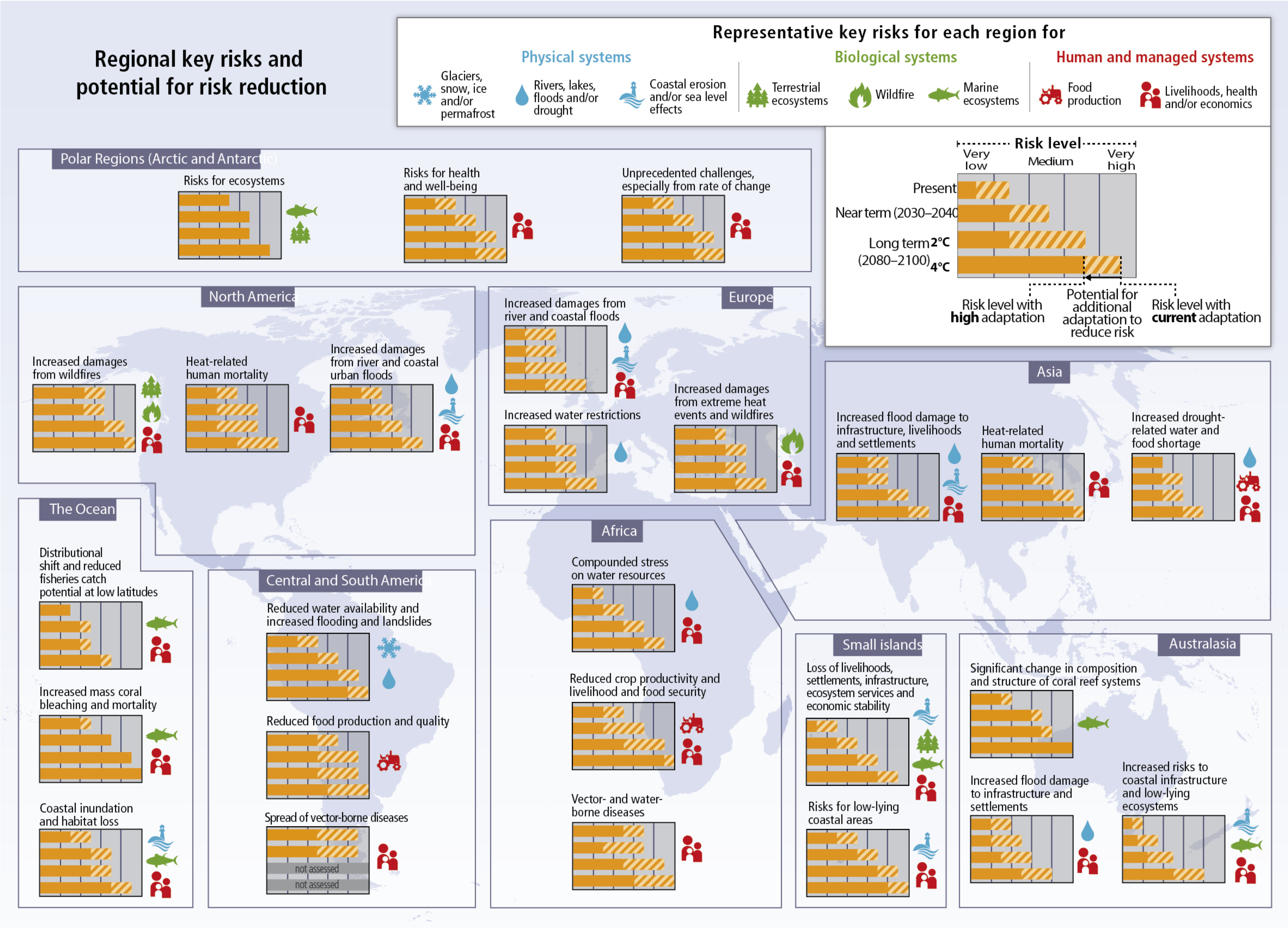


Figure 6. Representative key risks for each region, including the potential for risk reduction through adaptation and mitigation, as well as limits to adaptation. Each key risk is assessed as very low, low, medium, high or very high. Risk levels are presented for three time frames: present, near term (here, for 2030–2040) and long term (here, for 2080–2100). In the near term, projected levels of global mean temperature increase do not diverge substantially across different emission scenarios. For the long term, risk levels are presented for two possible futures (2°C and 4°C global mean temperature increase above pre-industrial levels). For each time frame, risk levels are indicated for a continuation of current adaptation and assuming high levels of current or future adaptation. Risk levels are not necessarily comparable, especially across regions.

Source: IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp. Figure SPM.8 page 14

He explained the increasing importance of attention to cascading risks. There was a need to develop models that took changing socioeconomic factors in the future into account, such as an ageing population and the increasing susceptibility of the elderly to extreme events such as heatwaves and floods. Extreme events could lead to the failure of critical infrastructure such as hospitals, transportation arteries, energy and water-treatment facilities. Within the context of a changing climate, communities faced increasing dependency on critical infrastructure services (e.g. energy, water, transportation).

To demonstrate the principles of adaption in the context of DRR, Mr Birkmann used the example of flood mitigation in Cologne, Germany. Urban planners adjusting flood zones to account for changing exposure might face resistance from private-property owners. He noted that the location of critical infrastructure within the flood zone and the actions taken by local planning authorities to address these challenges were important: for example, seasonal climate warnings allowed for temporal adaptation measures, such as mobile flood walls, which were more effective than sandbags but required additional time to set up.

Methodological challenges still existed with regard to the development of risk profiles and their monitoring and the dynamics of risks, as well as with the evaluation of different adaptation measures and their risk-reduction potential. It was important to determine how to model and account for cascading risks and risk dynamics within regional and national assessments, as well as monitoring tools. In addition, we must find a way to improve the applicability of climate-risk assessments for DRR and urban and spatial planning.

A brief discussion followed Mr Birkmann's presentation on assessing the vulnerability of critical infrastructure; assessing individual community's abilities to conduct post-event analyses and draw on lessons learned; evaluating and understanding the risk tolerance of policymakers, whose threshold for human impacts might vary, according to the hazard (e.g. lower tolerance for loss of life from natural hazards than traffic accidents); and addressing how upstream engineering may impact downstream, potentially cross-border, communities.

In the third talk of the session, Mario Hernandez (United Nations Educational, Scientific, and Cultural Organization (UNESCO)) provided an overview of Future Earth and the role the organization might play in the development of products and application of observations to adaptation. Future Earth, created to collect global knowledge to intensify the impact of research and find new ways to accelerate sustainable development, is sponsored by the Science and Technology Alliance for Global Sustainability, including the International Council for Science, the International Social Science Council, the Belmont Forum of funding agencies, UNESCO, the United Nations Environment Programme (UNEP), the United Nations University and WMO. As a global platform for international research collaboration on global environmental change and sustainable development, Future Earth aimed to:

- Provide integrated research on major global change challenges and transformations to sustainability;
- Strengthen partnerships between researchers, funders and users of research through a co-design of research;

- Use a solutions-oriented approach to generate knowledge that contributes to new, more sustainable ways of doing things; and
- Facilitate communication between science and society.

Future Earth's research criteria encouraged Earth System research for global sustainability; answered complex questions that required international collaboration; focused on regional- to global-scale problems; integrated natural, economic, engineering, arts, humanities and social sciences; and promoted co-design and co-production of knowledge.

Future Earth's main challenge was how to undertake joint research to make use of the diversity of important data by adding value through the conversion of data into information usable by other scientific disciplines, decision-makers and society.

Mr Hernandez noted that the 2013 Belmont Forum in New Delhi had underlined the need to address global environmental challenges that required a more coordinated approach to the planning, implementation and management of data, analytics and e-infrastructure through international collaboration. He advocated using existing initiatives, such as GEO, and assessing what was necessary to make the data and information beneficial to other scientific disciplines. He:

- Earth observation partners assisting in converting selected data into information usable for other scientific disciplines, decision-makers and society;
- Development of useful examples that would then motivate others to make further use of the data;
- Sharing data infrastructure with Future Earth so that data can be made accessible to other scientific disciplines; and
- Involving decision-makers and other scientific disciplines in a needs assessment for adaptation.

He observed that, in September 2015, the Millennium Development Goals would become the Sustainable Development Goals and it would be extremely useful to have space science and technology, GEO, GCOS and Future Earth contributing data and information on SLR, biodiversity and ecosystem services, extreme typhoons, displacement of local communities, socioeconomic consequences, new policies and societal transformations to name but a few.

Finally, he said that a large amount of data was available and asked who would keep this ”Earth library” available forever.

The second part of Session 4 continued on the third day of the Workshop and provided perspectives from Parties, focusing on national and regional needs for enhancing climate observations in support of assessment and implementation of adaptation and national climate-risk profiles, and an introduction to relevant work under UNFCCC.

Florin Vladu (UNFCCC Secretariat) introduced the second part of the session and encouraged speakers to focus on needs, including those for new developments such as those arising from AR5 and new requirements such as for GFCS. He stressed the importance of systematic observations to support the Convention process and the need to link it to all relevant agenda items on adaptation.

The following Parties made presentations: Brazil, China, the European Commission, Germany, Norway, Mali, the Russian Federation and the Solomon Islands.

Brazil reported intensification of climate variability and changes in the climate regime in recent years, perceived through reduced precipitation in the Sao Paulo region in the last two years (2013 and

2014), alternation of intensified droughts and floods in Amazonia (2005–2014) and a five-year continuous drought in the semi-arid north-east (2009–2014). Brazil welcomed the initiative from the previous GCOS workshop on adaptation in 2013 and noted that recommendations from the UNEP Adaptation Gap Report on emission reductions were still relevant and needed to be addressed. Brazil remarked that the country was currently elaborating its National Adaptation Plan (NAP) and developing a system for the monitoring and observation of national climate change impacts.

Construction of the Brazilian NAP had revealed information gaps and databases needed to support climate-change knowledge and the adaptation process. Gaps to be filled included improving access to the national climate information system and its customization for different types of users and including both meteorological series and results of climate-change models. Other relevant gaps included specific information on sectorial and spatial approaches, particularly for infrastructure, biodiversity and indicators for regional impact monitoring. A public consultancy during the NAP process registered public awareness of the importance of considering ecosystems in the adaptation strategy. Brazil stressed the importance of different kinds of support from the international community, including harmonized guidelines, for orienting climate-observing system construction, and the offer of institutional support and capacity-building for data-using communities (decision-makers, private sector, etc.), as well as specialized technical support for data translation into decision-making information.

China focused on two challenges: the national observation network to meet the needs of climate-change assessment and the observations system to support national climate-risk assessment. For climate-change assessment in China, rapid urbanization in the last 20 years had posed a large challenge. The environment around the climate observation sites had changed quickly, affecting the representativeness and accuracy of the data and the stability of the site, leading to uncertainty and errors in the data that were difficult to detect and remove. For example, increased uncertainties due to temperature changes in Beijing made data attribution difficult. China's current national climate-observation network was insufficient for understanding the complexity of climate spatial variation, particularly in south-west China. In the west, there were difficulties in obtaining an adequate surface observation network. As identified in AR5, climate risk differed greatly in different parts of China (Figure 7).

The challenge for climate-risk assessment was to determine the magnitude and impact of extreme events. However, data from previous events were often not available due to destruction of equipment. Furthermore, non-climate variables were was usually not acquired. The completeness and stability of observation data provided by the Global Telecommunication System also needed to be further improved to ensure regional climate assessment and climate risk prediction.

The European Commission provided an overview of the Copernicus Climate Change (C3) service[1] of the Copernicus Programme (Figure 8). This was one of the three components of the programme, which also included in situ and space components. The service was being developed and would provide a data store, with a consistent set of data variables, which would interface and coordinate with other bodies, Member States, WMO and others. The operational phase of Copernicus would start in 2018 with information being provided for 20 ECVs (five sectors) and for 33 ECVs (nine sectors) in 2020.

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[1] http://www.copernicus.eu/pages-principales/services/climate-change/

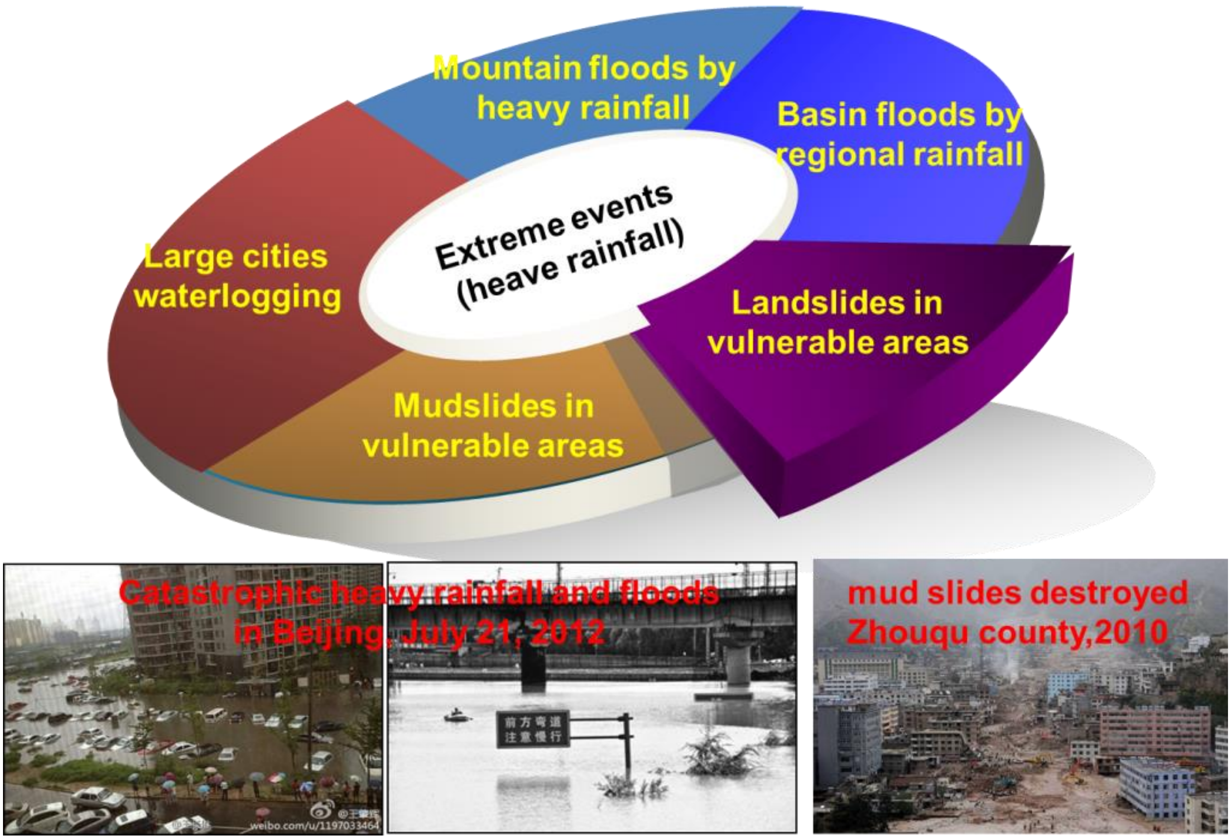

Figure 7. The climate risk is different in different areas of China.

Source: J. Guo and J. Wang

The Commission emphasized that the focus of the programme was on consistency with GCOS requirements and should feed into the Global Earth Observation System of Systems (GEOSS). With this programme, the European Union had the opportunity and ambition to become a trusted source for climate information and analysis. Products would be tailored to users' needs. Training was currently underway.

Germany stated that its spatial and temporal coverage was sufficient for climate observations. Germany had a national adaptation strategy that was implemented through action plans: implementation of actions was monitored using an indicator system of about 80 indicators. Sectorial vulnerability was currently being analysed by 16 federal agencies and one of the expectations of this exercise was to identify whether observations were sufficient at the sectorial level. Germany highlighted its inventory report, *German Climate Observing Systems*, published in 2013, that addressed 34 ECVs relevant for Germany (plus phenology as an additional source of information) and fed into the sixth National Communication. Germany noted that the National Communication reporting format was currently being revisited and that GCOS could influence how Parties reported to the Convention and made use of the information to improve a synthesis of information for their own reporting. He emphasized the importance of the GCOS national coordinator being part of the UNFCCC delegation to advise negotiations.

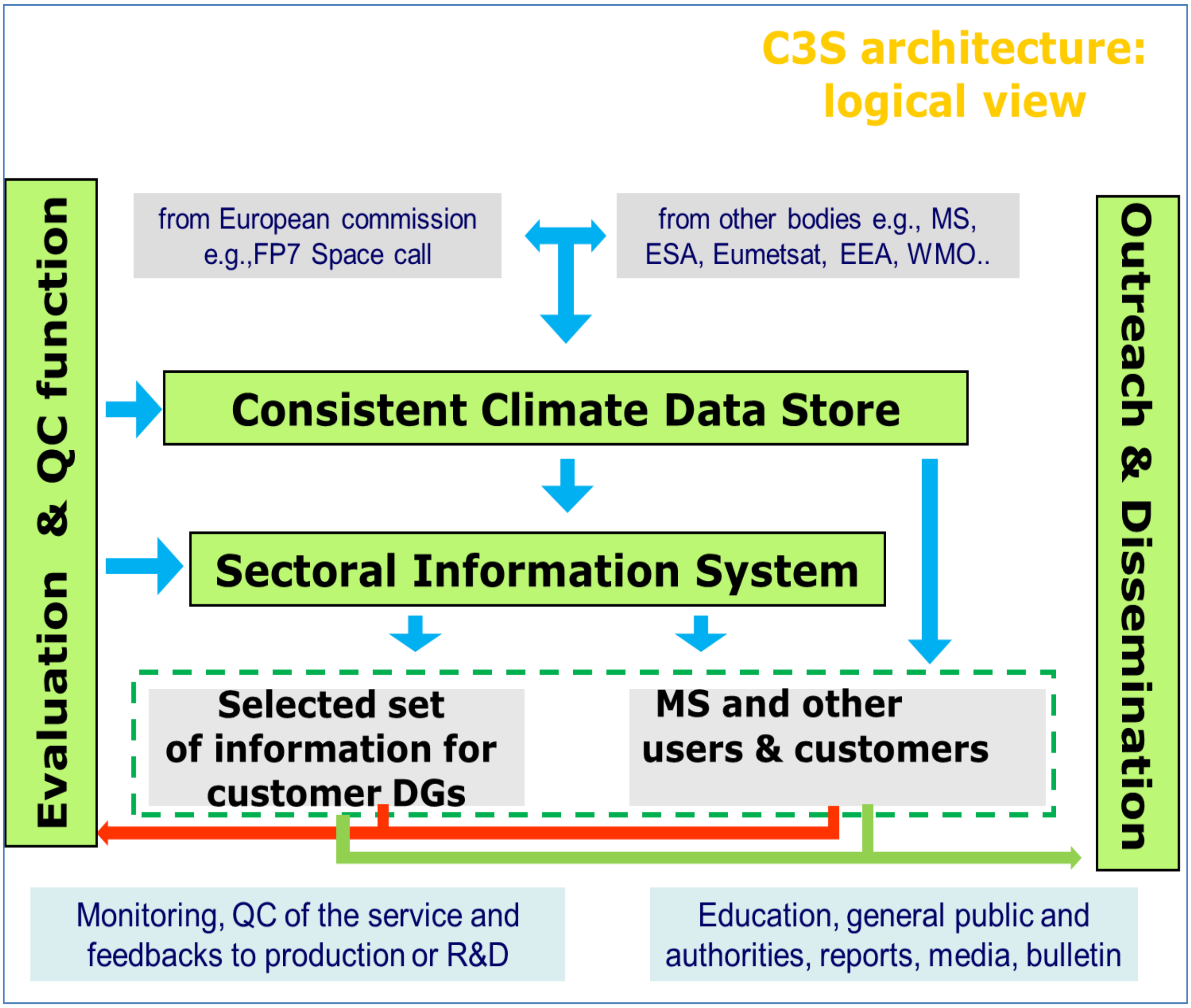

Figure 8: Copernicus Climate Change (C3) service

Source: H. Zunker

At the regional scale, European countries were working together to save money and act jointly. This included the EUMETNET (Network of European Meteorological Services) Observations Programme, aiming at improving general weather forecasting and climate monitoring over Europe; the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) ()with operational satellites for weather and climate; and the WMO RCC network. These all provided datasets, climate-monitoring products and long-range forecasts. With regard to climate-risk profiles, Germany had developed the German climate atlas[2], to help assess risk at the national and local levels. Challenges included using the data from the past, including digitizing data that had been recorded on paper and developing monitoring products from satellites, such as the EUMETSAT Satellite Application Facility on Climate Monitoring hosted by the Deutscher Wetterdiest and radar-based quantitative precipitation monitoring (RADOLAN).

[2] www.deutscher-klimaatlas.de

Norway presented the model for producing its NAP, which had been developed between 2007 and 2013. Pilot projects in 13 cities had fed into the process, along with continuous research. Challenges for adaptation included building capacity and resources in municipalities, particularly those with small populations. Current activities to strengthen the knowledge base to support adaptation included downscaling to 11 x 11 km grids, and for hydrological models to 1 x 1 km. The Government was working closely with scientists to link information for advice on SLR and storm surges.

The Norwegian Government had appointed a committee to evaluate current legislation on urban runoff water and make proposals for amendments to provide a better framework for the municipalities, although more observations were needed to build better statistics, especially in urban regions. Norway was working together with neighbouring countries to learn from their experience. At present, Norway had no indicators for climate-change adaptation. The Norwegian Environment Agency had been requested to investigate how to develop these indicators. Success factors in adaptation had been identified as: cooperation between governmental actors across

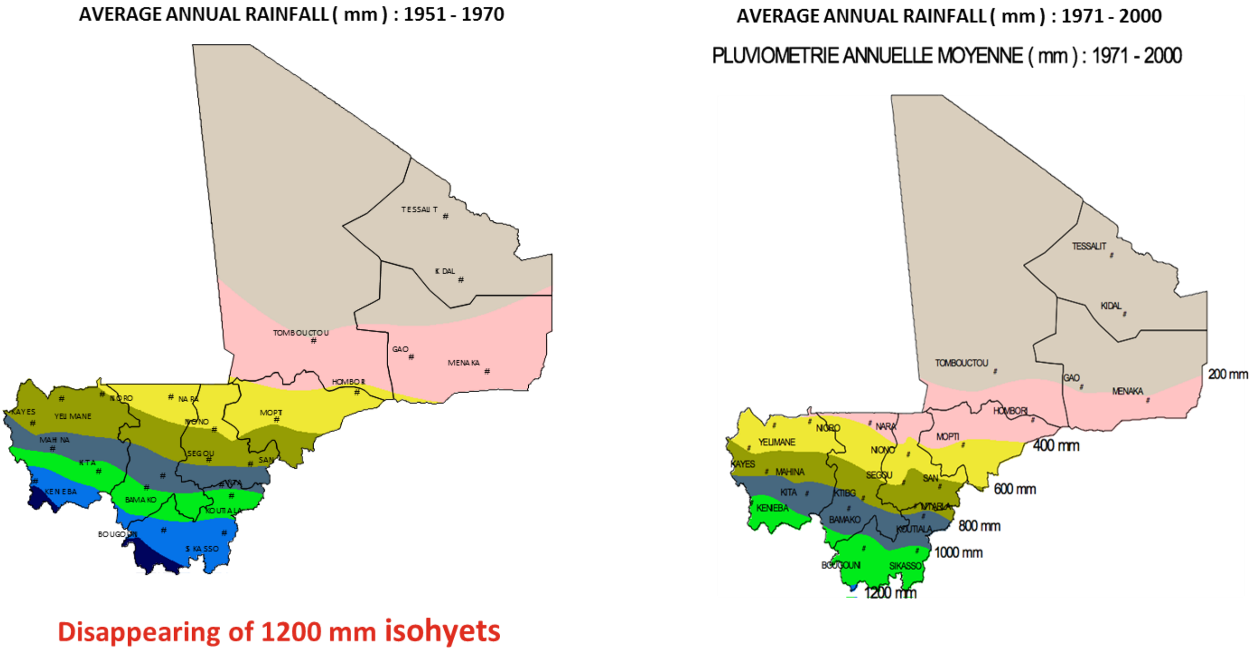

Figure 9. Rainfall reduction, Mali

Source: A. Konate, Mali Meteo

sectors and levels; getting all actors involved – governments, businesses, science and the public; increasing and sharing knowledge and competence; gaining and sharing lessons learned from adaptation actions and results; increasing and maintaining capacity-building at various levels; and the need to integrate adaptation actions now. Norway noted that the expectations for data accuracy grew with downscaling.

Mali highlighted the challenges it faced in enhancing systematic observation and related capacity. Mali-Météo had been created in 2012, replacing the National Directorate of Meteorology, in the Ministry of Infrastructure and Transport. Mali-Météo was required and empowered to raise its own financial resources from both the public and private sectors. The young agency was confronted with numerous challenges to meet its mandate of providing reliable and timely weather, water and climate information and analysis to a wide range of public and private information users. The weather-network observation system in Mali was limited, with no observation at all in the north, due to the crisis there. The country had seen the disappearance of 1 200 mm isohyets between 1951 and 1970 and a general reduction or decrease in rainfall and descent of isohyets southwards (Figure 9). An example was given of the effects of climate change in Timbuktu, where sand dunes had replaced many areas of vegetation around the city since 1976.

Mali-Météo faced many challenges, including data acquisition, strengthening the observation network, data processing and dissemination and staff capacity-building to sustain actions, as well as the fragile, if not deplorable, condition of the paper archives that had never been scanned and were deposited in a single location.

The Russian Federation reported on the continuation of science in the country, despite difficult economic conditions. These included regular climatic observations in a network of 1 800 surface meteorological stations, including 458 reference network stations, which covered a representative area and long time series – more than 50 years – of observations that would not be closed or relocated; and 135 GCOS Surface Network reference stations, including four stations in the Antarctic and 238 stations in the Regional Basic Climate Network. Automated systems were operating at all stations, although verification of precipitation measurements was difficult, because the tipping-bucket raingauge did not work correctly in Russian climate conditions.

An assessment report on climate change in the Russian Federation had been produced.[3] Important aims included ensuring the required quality and long-term homogeneity of climate data. Russian data were freely available from the Russian Research Institute of Hydrometeorological Information-World Data Centre in Obninsk.[4]

The Solomon Islands discussed enhancing observations nationally and in the wider Pacific region to support preparedness and adaptation in a changing climate. The Solomon Islands were very vulnerable to climate variability and change and extreme events and vulnerability was increased, owing to a limited observation network and lack of data to assess risk. The national Government had recently implemented a policy to strengthen the meteorological observing network. Through National Adaptation Programme of Action (NAPA) documentation and a project on food security, the Solomon Islands had been able to secure new equipment for automatic weather stations and two telemetric gauges. The data from these would feed into the national database. The Solomon Islands reported on various projects, such as those in the health and agriculture sectors. The speaker cited the need for a strategic approach to regional observation systems.

Abias Huongo (UNFCCC Least Developed Countries Expert Group (LEG)) presented the emerging needs for data and climate observations in support of NAPs and the work of LEG. The least developed countries (LDCs) were dealing every day with loss of life, livelihoods and infrastructure caused by the lack of effective national observation systems, which would allow them to prevent those diverse losses and address adaptation issues.

He cited the important aspects of data and systematic observation under NAPs including:

- Data and systematic observation were crucial to support medium- and long-term planning, implementation, monitoring and review of progress (Figure 10); Data should be assembled,

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[3] http://voeikovmgo.ru/

[4] http://meteo.ru

collected and processed to support assessment of impacts, climate-change risks and vulnerabilities;

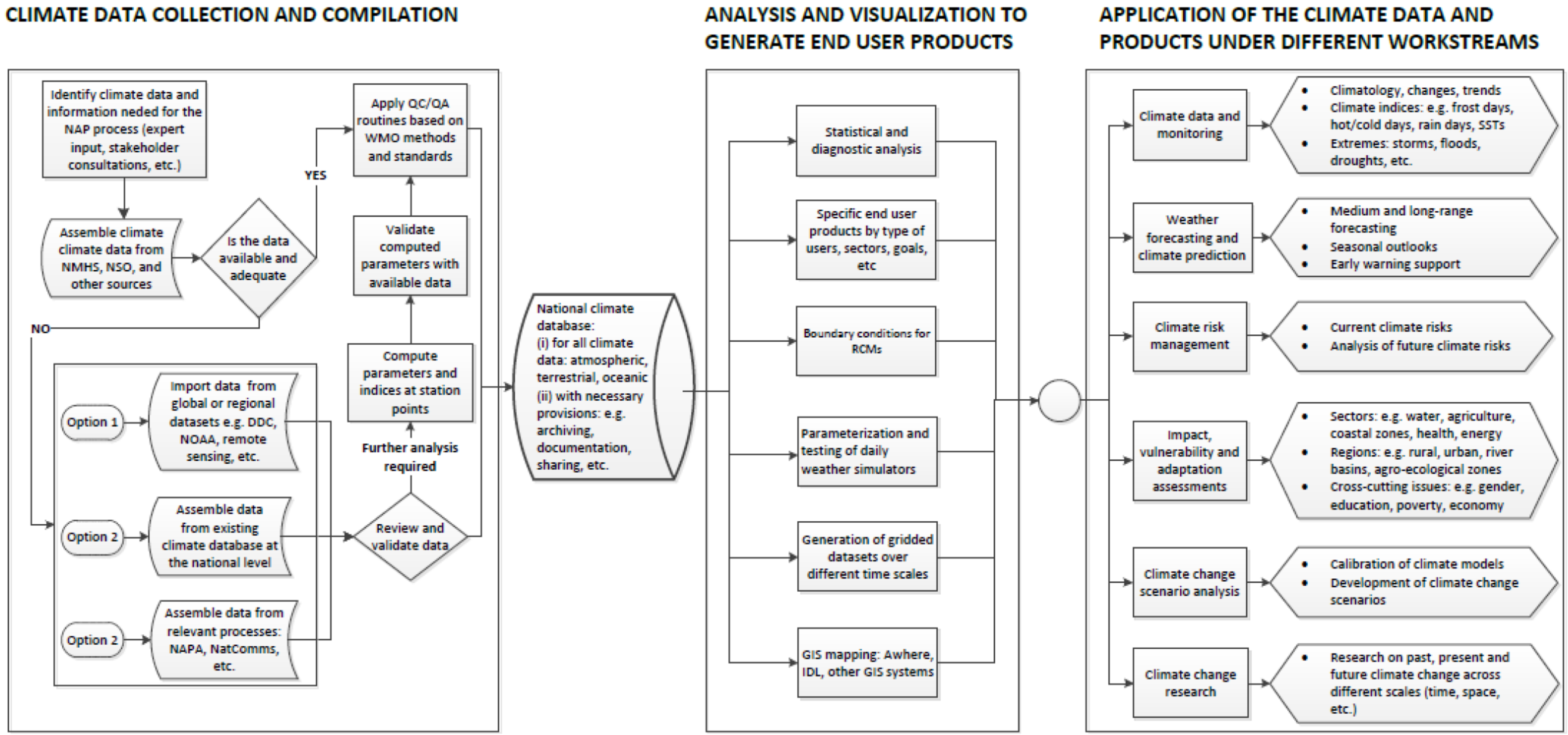
- The NAP process would build on data and information from a variety of sources, including NAPA, assessments under the National Communication and relevant activities;
- Data structures would vary by country and should build on existing systems such as those used by different ministries and national centres (e.g. NMHSs, national statistical offices).

Capacity and resource requirements of LDCs for NAPs and other adaptation work included the need for:

- Data on a scale relevant for LDCs;
- Access to the latest techniques for data collection (e.g. satellite data);
- Capacity-building for data needs, identification, data collection, management and rescue;
- Support to develop physical and technical infrastructure for data collection and management;
- Support for the maintenance of climate observation networks and climate information services.

LEG was working to address some of the capacity needs, including through regional training, NAP Expo, gaps and needs workshops, collaboration with technical agencies and NAP Central.[5] Several LDCs had embarked on their NAPs and it was expected that most countries would have them ready for implementation before 2020.

[5] http://www.unfccc.int/nap



Notes:

1. A list of essential climate variables is available at <https://www.wmo.int/pages/prog/gcos/index.php?name=EssentialClimateVariables>.
2. Acronyms: NMHS = national meteorological and hydrological services; NSO = national statistics offices; QC = quality control; QA = quality assurance; GIS = geographical information system; IDL = international data library; NOAA = National Oceanic and Atmospheric Association; GSOD = Global Summary of the Day.
3. Options 1, 2 and 3 under climate data collection and compilation are not exclusive to each other.
4. Information on the NAP process, the NAPs, guidelines and other additional information is available at <unfccc.int/nap>.

Figure 10: Working with climate data in the NAP process

Source: K Radunsky

Klaus Radunsky (UNFCCC Adaptation Committee (AC)) made a presentation on the linkages between systematic observation and the work of AC. He noted that AC was mandated to provide technical support and guidance to the Conference of the Parties; strengthen, consolidate and enhance the sharing of relevant information, knowledge, experience and good practice; promote synergies and strengthen engagement with organizations, centres and networks; provide information and recommendations for consideration by the Conference of the Parties (COP); and consider information with a view to recommending what further actions might be required. The current AC work plan comprised three work streams: technical support and guidance to the Parties on adaptation action; technical support and guidance to the Parties on means of implementation; and awareness-raising, outreach and information-sharing. The AC work plan was being revised for 2016 and would take into consideration the importance of systematic observation; the gaps in data and resulting needs; global initiatives, such as GFCS, that could contribute to closing gaps speedily; opportunities presented by monitoring and evaluating projects to feed information back into the adaptation process; the NAP process and the opportunities presented to close up gaps in analysis.

Miwa Kato (UNFCCC Secretariat) spoke about the linkages between systematic observation and loss and damage work in the context of the two-year work plan of the Executive Committee on Loss and Damage[6]. The Warsaw International Mechanism for Loss and Damage had been established by COP 19 in 2013. It included a mandate to complement, draw upon the work of, and involve, as appropriate, existing bodies and expert groups under the Convention, as well as on that of relevant organizations and expert bodies outside the Convention, at all levels, to address loss and damage associated with impacts of climate change. These included extreme events and slow onset events in developing countries that were particularly vulnerable to the adverse effects of climate change.

COP 19 established an Executive Committee (Excom) to guide the implementation of the Mechanism, including addressing information needs and enhancing collaboration and synergies thereunder in order to promote comprehensive risk management. As Excom's mandate had provisions to establish a thematic expert/technical panel to support the implementation of the two-year work plan, Ms Kato emphasized the opportunity for the systematic observation community to engage with the new Excom and help shape the work so as to support the mandate to achieve effective collaboration, better coherence and improved synergies among different processes, institutional arrangements and organizations.

Session 4 Discussions

The challenges and questions addressed by all Session 4 speakers are provided in Annex II. They formed the basis for much of the discussion in the session.

A recurring theme throughout the Session 4 discussions was how to build capacity for users to access and use data. Some of the data-access challenges identified were better access to free, high-quality data, ability to archive historical data, standardization of information and improved understanding of how to translate climate data into relevant, usable information at the regional, national, subnational and sectorial levels. Data gaps were also highlighted, for example, gaps in marine and coastal observation were needed to better support coastal zone adaptation.

[6] www.unfccc.int/6056

Connecting people and data was essential to building capacity. Linking adaptation practitioners and sector-specific experts with GCOS national coordinators and GEO focal points would improve access to, and understanding of, climate data. Encouraging Parties to nominate coordinators and include them in national UNFCCC and GEO delegations would support better integration and understanding. Those coordinators had the capacity to link with those doing adaptation work and regional and national advocates and experts. International guidelines and/or guidance documents from GCOS and the international community could provide methodological guidance to inform national and subnational assessment of adaptation. To support the work of the Convention, systematic observation should also be better linked and more directly with relevant UNFCCC agenda items to develop knowledge-sharing approaches and build advice to the UNFCCC Subsidiary Body for Information and SBSTA and vice versa.

Using regional offices and/or workshops to strengthen synergy and coordinate data-sharing and support would also provide a link to RCCs' provision of datasets and monitoring products and encourage them to identify champions to promote and carry on the work. Those RCCs and networks could also provide information to committees and processes under UNFCCC. Resources to buy and maintain equipment were needed but equally important was training people on the ground, which was essential to create an operational observation information system.

In addition, the discussion stressed the need for a science-based, systematic approach to adaptation planning. The importance and difficulty of identifying indicators for adaptation should not be underestimated. Examples were available, including Kenya, which referred to its experience in identifying indicators.[7] Methodological guidance to inform national and subnational assessments of adaptation was needed. As indicated by the experience of some Parties, including Brazil, the NAP process could be useful in identifying gaps in data and indicators.

Connecting people across regions (north-south and south-south disciplines and sectors could facilitate capacity-building and sharing of best practices. The development of case studies would be an important next step to better support the above opportunities.

Session 5 - Identifying paths for addressing institutional and local capacities (including NMHSs) needed to observe, monitor, rescue, archive and process and sustain climate networks

Chairs: Ed Harrison and Roger Pulwarty (GCOS Steering Committee members)

Session 5 focused on systematic observation in support of adaptation strategies across climate timescales. Ed Harrison and Roger Pulwarty and Ed Harrison led a discussion to identify pathways for the delivery of effective information on the spatial and temporal scales required to make decisions, underpinned by observations that were fit for purpose. Following a discussion highlighting a need for ocean- and coast-related best practices, many participants identified the need for exemplars showing the availability of observations and current state of knowledge for extremes of critical concern and links between GCOS-provided data and information and regional and local

[7] See Kenya National Climate Change Action Plan http://cdkn.org/wp-content/uploads/2013/03/Kenya-National-Climate-Change-Action-Plan.pdf

observational systems, assessments and services. Case studies on SLR and water resources were proposed, which the participants acknowledged as a positive approach. Participants agreed that the first such exemplar would be focused on SLR (including coastal inundation). Participants identified the need to understand the impact of different weather and climate events combined with scenarios of SLR as crucial in developing hazard profiles for emergency planning and vulnerability, impact and adaptation assessments and a major development concern. The expected outcomes of the exemplar included:

- Articulation of requirements for observations of regional sea-level variability and change and the range of spatial/temporal scales (involving decision-makers on the ground, working in disaster response/risk management to town planning, coastal infrastructure and coastal ecosystem management);
- Assessing the observing system to deliver observations on required scales and strengthened integration of satellite/in situ observing system on scales required;
- Understanding uncertainties/errors in model predictions at regional scales, requirements for observations and how predictions could be improved;
- Articulation of requirements for products, predictions and indices to meet decision-making requirements;
- Articulate end-to-end delivery for a number of regions or environments; and
- Identification of feedback mechanisms.

The form of the exemplar would be determined by volunteers and available resources, but would likely take the form of a desktop case study, white paper, workshop, session at the GCOS Science Conference or other conference, or a combination of thereof.

Participants discussed the societal importance of sea-level information on different time- and spatial scales, particularly for Small Island Developing States, together with a need to identify what was known and unknown regarding sea-level variability and change, required disaster-risk management and warning systems, coastal zone management approaches (i.e. natural and manmade coastal defences, planning/zoning options) and coastal ecosystem management and services assessments.

Determining the measures needed for reducing and managing impacts, the exemplar would address the requirements for sea-level observations (including spatial and temporal scales) and the design and status of observing systems including:

- Tide gauges (Global Sea Level Observing System (GLOSS) network);
- Satellite sea-surface height and gravity missions, development of swath and coastal altimetry applications and their calibration;
- Coastal geomorphology information;
- Coastal ecosystem mapping (above and below high tide, dunes, mangroves, reefs, etc.),
- River flow (stream gauges);
- Wind speeds.

In addition, the status of sea-level products and modelling would be evaluated.

Groups that should be engaged in the exemplar included, but were not limited to: the Global Ocean Data Assimilation Experiment (GODAE) Ocean Surface Topography Science Team (OSTST), Coastal Altimetry Task Team, GODAE OceanView Coastal Ocean and Shelf Seas Task Team, GLOSS, sea-level reconstruction experts, sea-level modelling experts, data and information delivery, the adaptation-research community and decision-makers across the range of applications and range of countries – developed, developing, urbanized and islands.

Gaps identified included:

- Insufficient tide-gauge data and limited accessibility of the data that did exist;
- Inability to capture current fast changes, which would require a denser network of sensors; and
- Underutilization of current observations systems, which limited the community's ability to demonstrate how data were used in adaptation and their value therein, as well as how to improve their use in the future

The Parties addressed several other issues, including the need to address procedural matters, a requirement to move beyond projections, identification of capacity concerns which could necessitate workshop(s) with local practitioners in addition to, or in place of, a case study; the need for international granting processes – such as the Global Environment Facility – to better support the needs of local users by reducing limitations on acquisitions that impeded their ability to procure the observing systems and capabilities they wanted/needed.

A key recommendation from this session was to develop regional exemplars on the role of GCOS and climate observations informing preparedness and adaptation related to selected GFCS priority areas such as water resources, health, food security/agriculture or disaster-risk reduction.

It was agreed, with the input of Jamaica and the Solomon Islands, that an effort focused on SLR as impacting regional and local disasters development, would be valuable to all the participating groups and that an exemplar on this case would be developed (see below). Others such as for water resources might then follow.

It was also noted that the need for data analysis could not be overlooked. The WCRP Coordinated Regional Climate Downscaling Experiment programme had a number of flagship projects to model at high resolution. The UK Department for International Development were about to set up three regional studies in Africa over 40-year timescales that would clearly identify gaps in observations.

Observations for climate adaptation: sea-level exemplar

Outline for discussion

Katy Hill, Roger Pulwarty

GCOS "Champions": Roger Pulwarty (GCOS SC), John Wilkin (GCOS Ocean Observations Panel for Climate).

As noted in the IPCC, the US(and other) national climate assessments, thermal expansion of the world's oceans and melting of glaciers and ice sheets from climate warming had contributed to SLR of approximately 1.7 mm/yr over the last century and even higher rates (3.2 mm/yr) over the last several decades. Superimposed on this trend were ocean–atmosphere circulation dynamics producing significant regional inter-annual mean sea level variability and additional geomorphological and bathymetric dynamics that determined local sea levels. This variability could be expressed as low-frequency, multi-month mean sea-level anomalies, as well as higher-frequency storminess changes in storm-surge event along the coast from altered seasonal storm-track tendencies. Impacts were also felt in water resources through saline intrusion into near-shore aquifers, especially during dry seasons and drought, and pollution loading and temperature increases in the coastal and estuarine areas.

A wide range of estimates for future global mean SLR had been found throughout the scientific literature and assessments. There was currently little coordinated, cross-national effort to identify agreed global mean SLR estimates and how these filtered to regional and local scales to inform coastal planning, policy and management. At present, island and coastal managers were left to identify global SLR estimates through their own interpretation of the scientific literature or the advice of experts on an ad hoc basis. Yet, for the greater part of the US coastline, relative sea level[8] had been rising over the past 60 years, consistent with the global trend. Important common benefits for risk management and adaptation might be derived from a multi-scale assessment of regionally specific SLR and applications: These included:

- Disaster-risk management and warning systems (floods, storm surges);
- Coastal flood management, coastal defences, town planning/zoning;
- Coastal water resources and ecosystem management;
- Coastal and maritime commerce.

Type of activity

Participants in the Bonn Workshop proposed the development of an exemplar that would provide an integrated view (global, regional, national, local) of key variables, such as SLR (and attendant variables), would provide valuable information sources for affected nations. GCOS defined ECVs required for climate observations in support of UNFCCC. In the implementation of UNFCCC, the suite of required observational data may extend beyond the current GCOS ECVs. The goal here was to link existing capabilities of GCOS with the existing observations and monitoring networks employed in order to provide reliable multi-scale assessments of SLR to support GFCS and other climate services' implementation requirements.

[8] Relative sea level: the height of the sea with respect to a specific point on land.

It was proposed that a session at the GCOS Science Conference be devoted to the case study identifying adaptation planning and implementation needs and the mechanisms for linking GCOS-scale and regional monitoring to improve estimates of SLR risk. A desktop case study would begin by focusing on a region of high vulnerability. In Bonn, it was suggested that this approach showed promise for forming the basis and design criteria for regional workshops focused on showing the complementary value of GCOS with regionally specific information to guide preparedness, adaptation and climate services.

The activity would assess (see also "Expected outcomes" below):

- Status of observing system (and uncertainties);
- Tide gauges required for capturing regional variability and change;
- Satellite SSH and gravity missions and applications (OSTST and Coastal Altimetry Task Team) and their calibration;
- Coastal geomorphology;
- Coastal ecosystems (above and below high tide, dunes, mangroves, reefs, etc.);
- Impacts from previous events – nuisance flooding and potential exacerbation by increased SLR;
- Status of sea-level products and modelling in the region of interest and adequacy for monitoring SLR and developing projections;
- Sea Sea-level research community, including the WCRP Sea Level Grand Challenge;
- Sea Sea-level modelling groups, including GODAE OceanView Coasts and Shelf Seas Task Team (COSS TT), the Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) Expert Team on Operational Ocean Forecasting;
- Improvements in monitoring needed to predict sea-level change and impacts (including from storm surge, loss of wetlands) on coastal communities;
- Products that integrated all relevant spatial scales of sea-level change that allowed decision-makers to visualize the potential impacts of coastal inundation across timescales and apply that information to community resilience planning decisions;
- Strengthening GCOS engagement with these communities.

Engagement: a preliminary list of groups to engage

- Sea-level research community (e.g. WCRP Sea Level Grand Challenge);
- Satellite SSH (OSTST and Coastal Altimetry Task Team);
- Tide-gauge networks (GLOSS);
- Sea-level modelling community, including the JCOMM Expert Team on Operational Ocean Forecasting, GODAE OceanView COSS TT;
- Data/information requirements and delivery (GFCS, insurance community);
- Adaptation-research community (PROVIA);
- Decision-makers (port authorities, coastal zone management units) and development agencies (across a range of countries, islands and coastal regions such as Central America and the Caribbean or the Mediterranean Basin);
- Agencies and organizations engaged in monitoring (GEO, the US National Aeronautics and Space Administration and National Oceanic and Atmospheric Administration, National (and regional) Meteorological and Hydrological Services).

Expected outcomes

- Articulation of requirements for observations of regional sea-level variability and change and the range of spatial/temporal scales (involving decision-makers on the ground) that cross temporal and spatial scales;
- Identification of uncertainties/errors in model predictions at regional scales and how they could be reduced;
- Strengthened integration of satellite/in situ observing system on scales required;
- Articulation of requirements for products, predictions and indices to meet decision-making requirements;
- Development of an end-to-end (monitoring, projections, risk-assessment, communication and embedding in practice) exemplar potentially transferable to other regions and problems;
- Feedback into observational priorities, gaps assessment for risk management and development needs for responding to coastal inundation;
- Engagement and increased awareness by stakeholders of sea-level-change data availability, monitoring and adaptation strategies;
- Improved coordination across GCOS and its research, monitoring and services partners.

Conclusion

An integrated approach to national adaptation planning and assessment that fully involved Parties, the research community and observations, through UNFCCC, IPCC and GCOS and other international partners, was established and promoted through the Workshop. The respective roles of UNFCCC, IPCC and GCOS were as follows:

- UNFCCC: the NAP process;
- IPCC: methodological guidance and regional assessments;
- GCOS: facilitating and enhancing systematic observations.

The main outcomes and overarching themes of the Workshop were identified and agreed upon as follows.

- The complete chain/cycle of observations-data-information-adaptation and the role of GCOS and other partners, needed to be clearly described in order to deliver/inform best methods and evaluation of adaptation strategies;
- It was essential to generate good, publicly available and standardized data, in particular at regional, national and local levels, on the vulnerability of key sectors to the impacts of climate change.
    - In particular, improving climate observations systems with a special emphasis on terrestrial and ocean observations, as well as observations in the coastal zones where these two areas intersect was repeatedly identified as a priority need;
- Adaptation planning and assessment required a combination of baseline climate data and information, coupled with national data relevant to the specific aspects of adaptation (including different sectors) in question
- The value of observations to adaptation should be clearly articulated.

  - One or more well-described case studies in Non-Annex I Parties could be used to demonstrate the value of observations to adaptation;
- GCOS should help respond to the needs of climate observation identified in other work streams under the Convention through the agenda item on systematic observation and the Sustainable Development Goals;
- Guidance and guidelines (or references to other sources of advice) on data and sources of products, as well as their limitations, were needed. In particular:
  - A key role for GCOS was to establish and maintain requirements for the collection and dissemination of national observations to specified quality standards with understood and quantified uncertainties;
  - High-resolution data, required for adaptation planning, needed to be documented (especially for non-meteorological data). GCOS could facilitate this by providing advice on what was needed;
  - GCOS should identify international data centres for all ECVs;
  - The experience of developing adaptation plans and assessments should be carefully documented and recorded to enable transferable expertise and improvements to observation systems; and
  - Requirements for data latency, timeliness and availability were critical and should be clearly specified.
- Coordination activities among observation systems at different scales from subnational to global to inform adaptation should be promoted through relevant focal points and national coordinators, as well as RCCs and alliance;
- The research and development community needed to support the development of indicators linking physical and social drivers relating to exposure, vulnerability and improved resilience in line with national requirements.

As mandated by SBSTA, GCOS would provide the report of the Workshop before the 43rd session of SBSTA in November/December 2015. In addition, GCOS would inform WMO Congress in May 2015 and the IOC Assembly in June 2015 about the outcomes of this Workshop.

Annex I – List of essential climate variables

Domain	Essential climate variables
Atmospheric (over land, sea and ice)	*Surface*[9]*:* air temperature, wind speed and direction, water vapour, pressure, precipitation, surface radiation budget *Upper-air*[210]*:* temperature, wind speed and direction, water vapour, cloud properties, Earth radiation budget (including solar irradiance) *Composition:* carbon dioxide, methane and other long-lived greenhouse gases[11], ozone and aerosol supported by their precursors[12]
Oceanic	*Surface*[13]*:* sea-surface temperature, sea-surface salinity, sea level, sea state, sea ice, surface current, ocean colour, carbon dioxide partial pressure, ocean acidity, phytoplankton *Subsurface:* temperature, salinity, current, nutrients, carbon dioxide partial pressure, ocean acidity, oxygen, tracers
Terrestrial	*Hydrological:* river discharge, water use, groundwater, lakes, soil moisture *Cryospheric:* snow cover, glaciers and ice caps, ice sheets, permafrost *Biological:* land cover, fraction of absorbed photosynthetically active radiation, leaf area index, soil carbon, albedo *Ecological:* above-ground biomass, fire disturbance

[9] Including measurements at standardized, but globally varying heights in close proximity to the surface

[10] Up to the stratopause

[11] Including nitrous oxide (N_2O), chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs),hydrofluorocarbons (HFCs), sulphur hexafluoride (SF_6), and perfluorocarbons (PFCs)

[12] In particular nitrogen dioxide (NO_2), sulphur dioxide (SO_2), formaldehyde (HCHO) and carbon monoxide (CO)

[13] Including measurements within the surface mixed layer, usually within the upper 15 m

Annex II – Questions and challenges

Invited experts for Sessions 1–4 were asked to provide one question and one challenge in advance of the Workshop. These tables show the questions and challenges organized by session.

Session 1

Questions

- What observations help to make the right decisions about adaptation and mitigation measures?
- Uncertainties: IPCC lays much emphasis on the quantification and communication of uncertainties in its assessment in order to best serve policymakers and the public. What are the areas within the GCOS science domain where progress is most needed in order to be able to reduce key uncertainties in future IPCC assessments?
- Which are the sensitive regions on Earth where climate change will have the first or most significant impact? Should we implement adaptation in sensitive regions first – or what are the priorities?
- Is the attribution of observed impacts to anthropogenic forcing of the climate system a central requirement for effective adaptation approaches?

Challenges

- Support climate services with the information (data) currently available.
- Regional information: bridging the gap between global- and regional-scale climate information resulting from international programmes such as GCOS or WCRP.
- Regional changes are most important but least known: global sea-level rise prediction has little meaning for the Pacific Ocean when the regional footprint is unknown or not well understood.
- To assess the impacts of climate variability and increase resilience, both climate variables and societal factors determining vulnerability need to be monitored and integrated in a transdisciplinary effort.

Session 2

Questions

- Does the concept of ECVs and the functioning of the assessment process remain appropriate, fit for purpose, relevant, useful …?
- Has there been progress on Actions C22 and C23 of the 2010 Implementation Plan or on essential ecosystem records?
- What are your perceptions of the current state of climate observation and related products and services?
- Could other communities have the same kind of well-established framework as GCOS provides regarding ECVs?
- How can GCOS/IPCC help inform and coordinate national and international agencies to establish observation programmes for the joint, continuous and reliable study of physical, physicochemical and biological indicators of climate change and climate-change impacts in ocean regions?
- How to expand the GCOS/ECV framework to make terrestrial/land observations more relevant for purposes of mitigation and adaptation?
- How can GCOS/IPCC work with application and decision-making experts to rapidly identify climate service requirements, including quality and access/timeliness, for a few ECVs of highest priority?

Challenges

- Multiple requirements emerging from different essential variables (ECVs, essential ocean variables, essential biodiversity variables).
- To take into account biological parameters and their regional specificities to inform the evolution of monitoring for combined ocean warming, acidification and hypoxia, as well as their specific regional impacts.
- Stimulus and actions needed by UNFCCC to better integrate and coordinate: global (research) observations; national estimation and reporting; and monitoring and implementation of local actions (for mitigation and adaptation).
- The move to support climate services requires a shift in focus from detection of anthropogenic climate change on large space- and long timescales to identification of the requirements to support applications and decision making for a subset of the ECVs.

Session 3

Questions

- Which priority inadequacies and/or gaps in our observational data, if addressed, would bring the greatest advance in value for research on regional climate projections and for the adaptation and decision-making communities?
- What actions and work are needed to show and/or increase the value of existing observations for impact assessments and warnings and adaptation? Where and how do we address the gaps?
- How to bridge the gap between GCOS observations from coarse scale to field scale most relevant for agricultural management?
- What are the best/most appropriate institutional arrangements needed to enhance integrated risk-management programmes to improve resilience capabilities of food-insecure populations?
- How to improve the assessment of exposure and vulnerability to different climatic stressors at subnational scale?
- What information at what level of scale can be made available at the subnational level by GCOS? What is its relation with the global climate services?
- Are there any plans at the main climate-modelling centres in Europe to open-source their climate models?
- As a key information gap relates to the so-called "adaptation deficit", how can we assess this across sectors?

Challenges

- Develop methods and processes to integrate probabilistic risk management based on past events and trends, with resilience strategies based on scenarios of rates of change, potential surprise and cumulative risks across climate timescales.
- Develop integrated observation and modelling systems that address the needs of vulnerable sectors, resources and investment strategies that characterize changing rates and transitions.
- Develop and improve scientific understanding, technological capabilities and integration capacities to exploit the full Earth observations? and modelling potential to support food security and sustainable agriculture.
- Achieve data quality according to final user needs and find the most effective modalities of communication to improve direct access to information.
- Identification and characterization of complex and cascading risks in the context of extreme weather events influenced by climate change.
- Anticipation of events and long-term trends of a transboundary nature, as well as multiple-layer integrated systems
- Restricted access to climate observations from governments, mainly in Europe.
- There is need for a better assessment of global adaptation costs, funding and investment, as studies estimating the global costs of adaptation are characterized by shortcomings in data, methods, and coverage (IPCC AR5, Chapter 17).

Session 4

Questions

- What are/ought to be the roles of the impacts, adaptation and vulnerability research community, development programmes and public and private climate services in helping to secure and sustain coordinated global climate observational networks?
- How to model and account for cascading risks and risk dynamics within regional/national assessments and monitoring tools? How to improve the applicability of climate-risk assessments for DRR and community planning with regard to specific tools, early warnings and environmental assessments?
- Should we consider an official custodian for the extremely valuable digital library of Earth observations generated by 40+ years of satellite data collection?
- What types of climate information are needed for climate-proofing development and to inform financing decisions?
- How can international networks and organizations help to establish an international harmonized pattern for data collection, share, systematization and dissemination across countries to support climate-change monitoring and adaptation measures? Which organizations can lead this process?
- How to ensure the data quality of the observation for climate variability and change? How to secure expensive observations in the deep ocean over the next decades?
- Are datasets available which could be incorporated in the C3S proof-of-concept phase (”water“, ”energy“, etc.)? How to make full use of existing data? How to translate such data into meaningful information for decision-makers?
- What kinds of metrics/indicators are most suitable to monitor and evaluate societal processes that are impacted by climate change?
- Which system of observation for tomorrow?
- How can national and regional needs on systematic observation be addressed in Pacific island countries?
- How to overcome gaps in research and systematic observation in LDCs??
- What are the most significant gaps with respect to the detection of climate trends, which ECVs do they relate to and how do they vary by region?

Session 4 (continued)

Challenges

- To integrate across the diversity of observational data to construct common information products that are open-access, represent a derived best estimate, spatially continuous, quality-controlled, quantified uncertainty and, most importantly, are aligned to the scale and attribute needs of priority user communities.
- Improving methodology for developing risk profiles, monitoring/dynamics of risks and evaluating and assessing different adaptation measures and their risk-reduction potential.
- To make all climate data accessible to, and usable by, other scientific disciplines, including how to integrate with non-climate data (socioeconomic, health, etc.).
- Making available and communicating the needed climate information to inform decision at the project/programme level to different stakeholder groups.
- Translation of raw data into useful information for different users, specifically decision-makers, society, researchers and the private sector, also considering institutional design.
- The uncertainties and the influence of the observation are difficult to remove from the data.
- Managing access to third-party datasets, i.e. standardization, quality control, availability, compliant with INSPIRE (European Commission), timing, resource maintenance, value of datasets (e.g. spatial and temporal representativeness).
- How to fulfil the very high and growing expectations from practitioners when spatial and temporal resolution is increased?
- Renewal of observing equipment, ensuring good coverage of the country and managing acquisition of increasing amounts of data from satellites and models.
- To identify the best approach to support national and regional observation systems in Pacific island countries.
- Insufficient technical capacity to deal with research and systematic observation.
- What are the most significant gaps with respect to the detection of climate trends, which ECVs do they relate to, and how do they vary by region?
- What needs to be done in order to close the above gaps efficiently and speedily?

Annex III – Workshop agenda

Enhancing observations to support preparedness and adaptation in a changing climate – Learning from the IPCC Fifth Assessment Report

GCOS Workshop in collaboration with IPCC and UNFCCC

10–12 February 2015

UNFCCC Secretariat

Bonn, Germany

The three-day Workshop, organized by GCOS in collaboration with IPCC and UNFCCC, will consider the observational and research needs for adaptation to climate variability and change. It aims to enhance systematic observations and related capacity, especially in developing countries, in the light of the detection of observed impacts, exposure and vulnerability to climate change and in support of assessing the risks of climate change and adaptation planning. It therefore aims to further support the work on research and systematic observation under the Subsidiary Body for Scientific and Technological Advice (SBSTA) and that of adaptation under UNFCCC at large. The Workshop will build on the findings of the WG II report to the IPCC AR5 and of identified strategic technical guidance from the GCOS Workshop on Observations for Adaptation to Climate Variability and Change. The event will address observational needs in a number of sectors, currently in the focus of evolving climate services, such as analysis needs for water, agriculture and food security, disaster-risk reduction and health.

Specific workshop goals include:

1. Assessing the key findings and recommendations of the IPCC in the context of data availability to inform implementation of adaptation planning and strategies.
2. Defining the core sets of data, data characteristics and information technologies needed to maintain the minimum acceptable level of stewardship in the management of resources and infrastructure.
3. Characterizing the climate-data needs of the key sectors, including the financial services and development sectors.
4. Assessing the adequacy of national and regional networks and records for detection of climate trends to inform global, regional and national assessments of climate change and for developing regional and national climate-risk profiles.
5. Identifying paths for addressing institutional and local capacities (including NMHSs) needed to observe, monitor, rescue, archive and process and sustain climate data and networks.

DAY 1 Tuesday, 10 February 2015

8:00 – 9:00 Registration of participants

9:00 – 9:45 **Welcome**

Opening and welcoming remarks

- Stephen Briggs, GCOS Steering Committee Chair
- Tomasz Chruszczow, SBSTA Chair
- Carlos Martin Novella, IPCC Deputy Secretary

9:45 – 12:20 **Session 1**

Facilitators: Stephen Briggs (GCOS Steering Committee Chair) and Tomasz Chruszczow (SBSTA Chair)

Brief introduction to the GCOS Programme: Stephen Briggs

Workshop Goal 1 – Assessing the key findings and recommendations of IPCC in the context of data availability to inform implementation of adaptation strategies

Introductory talk: Outcomes of the GCOS Workshop on Observations for Adaptation to Climate Variability and Change, held in February 2013 in Offenbach, Germany (Carolin Richter, Director, GCOS Secretariat)

Introductory talk: IPCC WG I reporting on the outcome of the IPCC/WCRP Workshop of WG I AR5 findings "Research needs on observations – focusing on WCRP's Grand Challenges", held in September 2014 in Bern, Switzerland (Gian-Kasper Plattner, Science Director, IPCC WG I Technical Support Unit)

Introductory talk: Summary/overview of identified observational needs from AR5 WG I (Konrad Steffen, Lead Author, IPCC WG I AR5, Chapter 4, and Chair, GCOS Terrestrial Observation Panel for Climate)

Introductory talk: IPCC AR5 WG II, Chapter 18 – Detection and attribution of observed impacts (Gerrit Hansen, Chapter Scientist, IPCC WG II AR5, Chapter 18)

Discussion

12:30 – 14:00 Lunch

12:30 – 18:00 Session 2

Facilitators: Ken Holmlund, Chair, GCOS Atmospheric Observation Panel for Climate (AOPC) and Albert Klein-Tank, Vice-Chair GCOS AOPC and Coordinating Lead Author, IPCC WG I AR5, Chapter 2

Workshop Goal 2 –Defining the core sets of data, data characteristics and information technologies needed to maintain the minimum acceptable level of stewardship in the management of resources and infrastructure.

Talk 1: Introductory talk on essential climate variables and the GCOS assessment process (Adrian Simmons, Lead for the GCOS Status Report)

Talk 2: Overview talk on activities with regard to GEO Societal Benefit Area Climate and GEO data-sharing/management principles (Barbara Ryan, Director, GEO Secretariat)

Expert talks:

- New needs in observing technologies: ocean and acidification (Hans-O. Pörtner, Coordinating Lead Author, IPCC WG II AR5, Chapter 6)
- Land (Martin Herold, Global Observation for Forest Cover and Land Dynamics (GOFC-GOLD))
- Needs in data quality, data access, stewardship, etc**.** (John Bates, Chair, Committee on Earth Observations Coordinating Group for Meteorological Satellites Joint Working Group on Climate)

Discussion (led by session facilitators): Identification of possible research gaps in IPCC report, etc.

19:00 Social gathering (non-hosted)

Braunhaus Bönnsch, Bonn

DAY 2 Wednesday, 11 February 2015

9:00 – 13:00 Session 3

Facilitators: Gerhard Adrian (GFCS Management Committee) and Carolin Richter (Director, GCOS Secretariat)

Workshop Goal 3 – Characterizing the climate data needs of the four identified key sectors, including the needs for the financial and/or development sectors

Brief Introduction: Global Framework for Climate Services (Gerhard Adrian, GFCS Management Committee)

Introductory Talk 1: Summary/overview of observational needs for different regions (Bruce Hewitson, Coordinating Lead Author, IPCC WG II AR5, Chapter 21)

Introductory Talk 2: Summary of the IPCC Special Report on extreme events (Roger Pulwarty, Coordinating Lead Author, IPCC Special Report on Extreme Events)

Sector-related talks

- (*Withdrawn*) Freshwater/water resources/terrestrial and inland water
- Food Security and Production (Heike Bach, Vista GmbH)
- How climate information is helping food-insecure populations to build resilience through a comprehensive approach (Tania Osejo Carrillo, World Food Programme)
- Disaster-risk reduction (Joern Birkmann, IPCC WG II Lead Author, IPCC WG II AR5, Chapter 19)
- Health issues (Bettina Menne, WHO)

Economic sector talks

- Risky business – observational needs (Christos Mitas, Risk Management Solutions)
- (Withdrawn) Economics of adaptation - opportunities and needs (Reinhard Mechler, Lead Author, IPCC WG II AR5, Chapter 17)

Discussion (led by session facilitators)

13:00 – 14:30 Lunch

14:30 – 18:00 Session 4

Facilitators: Stefan Roesner (SBSTA representative) and Florin Vladu (UNFCCC secretariat)

Workshop Goal 4 – Assessing the adequacy of national and regional networks and records for detection of climate trends to inform global, regional and national assessments of climate change and for developing regional and national climate-risk profiles.

Adaptation strategies across climate timescales

- Adaptation planning and implementation (Roger Pulwarty, Coordinating Lead Author, IPCC WG II AR5, Chapter 15)
- Information needs in the DRR management community (Joern Birkmann, Lead Author, IPCC WG II AR, Chapter 19)
- Future Earth – Observational needs (Mario Hernandez, Future Earth)

Discussion (led by session facilitators)

DAY 3 Thursday, 12 February 2015

9:00 – 12:00 Continuation of Session 4

Facilitators: Stefan Roesner (SBSTA representative) and Florin Vladu (UNFCCC Secretariat)

Party perspectives focusing on national and regional needs for enhancing climate observations in support of assessment and implementation of adaptation and national climate-risk profiles

Expert talks from Parties Brazil, China, European Commission, Germany, Norway, Mali, Russian Federation, Solomon Islands

Expert talks Introduction to relevant UNFCCC work

- Needs for data and climate observations emerging in support of NAPs and the work of LEG (Abias Huongo, Vice-Chair, LDC Expert Group)
- Linkages between systematic observation and the work of the Adaptation Committee (Klaus Radunsky, Adaptation Committee)
- Linkages between systematic observation and the work of the Executive Committees on loss and damage (Miwa Kato, UNFCCC Secretariat)

Discussion (led by session facilitators)

12:00 – 13:00 Lunch

13:00 – 16:00 Session 5

Facilitators: Carlos Martin Novella (IPCC Deputy Secretary), Stephen Briggs (GCOS Steering Committee Chair) and Stefan Roesner (SBSTA representative)

Workshop Goal 5 – Identifying paths for addressing institutional and local capacities (including NMHSs) needed to observe, monitor, rescue, archive and process and sustain climate networks

Discussion: Toward smart practices (Ed Harrison and Roger Pulwarty, GCOS Steering Committee Members)

Using observations, reanalyses and projections to inform thinking about, and decision-making for, adaptation issues involves many choices. Based on the work that has been done so far, we'd like to foster a conversation among interested parties about some recommended approaches. This group discussion will seek to identify some areas of agreement for which draft best practices might be developed and propose steps to take such efforts forward.

Summary of main findings of the Workshop

16:00 Closure of the Workshop

Annex IV – List of participants

Parties

Algeria

Mr Riad Ladji
Master of research
Research Centre on Physical and Chemical Analysis (CRAPC)
PO Box 384, Bou-ismail,
42004, Tipasa
Algeria
Tel.: +213 2432 5774
Mobile: +213 6 6037 0090
Fax: +213 2432 5774
E-mail: rladji@hotmail.com

Belize

Mr Dennis Gonguez
Director/Chief Meteorologist
National Meteorological Service of Belize
Philip Goldson International airport
Ladyville
Belize
Tel.: +501 225 2012
Mobile: +501 601 4530
Fax: +501 225 2101
E-mail: dgonguez@hydromet.gov.bz

Brazil

Ms Mariana Egler
Environmental Analyst
Dra. Planejamento Energético e Ambiental
MMA/SMCQ – Climate Change Secretariat
SEPN 505 Norte, Bloco "B"
Edifício Marie Prendi Cruz, Sala 301
Brasília
Brazil
Tel.: +61 2028 2608
Mobile: +61 8302 7936
E-mail: mariana.egler@mma.gov.br

Ms Andrea Araujo
Analyst on Science and Technology
Ministry of Science, Technology and Innovation
Esplanadas dos Miniterios, Bloco E s.258
Brasilia
Brazil
Tel.: +55 63 2033 8074
Mobile: +55 63 9632 9252
E-mail: anaraujo@mcti.gov.br

China

Mr Jiankai Wang
Deputy Director
Division of Surface Observation
Department of Integrated Observations CMA
Haidian District
Beijing
China
Tel.: +86 10 6840 6421
Mobile: +86 135 2183 7129
Fax: +86 10 6217 9786
E-mail: wjkaoc@cma.gov.cn

Ms Jianxia Guo
Professor
No. 46 Zhongguancun South Street
Beijing
China
Tel.: +86 10 5899 5872
Mobile: +86 135 2032 1209
Fax: +86 10 6840 9001
E-mail: gjxaoc@cma.gov.cn

European Commission

Mr Hugo Zunker
Policy Officer
European Commission
DG for Internal Market, Industry,
Entrepreneurship and SMEs
Unit K2 - Copernicus Services
Avenue d'Auderghem 45 (BREY 09/069)
B-1049 Brussels
Belgium
Tel.: +32 2 297 1936
E-mail: Hugo.Zunker@ec.europa.eu

France

Mr Sylvain Mondon
Programme Officer
Ministère de l'Ecologie, du Développement
durable et de l'Energie
92055 La Défense CEDEX
Tel.: +331 4081 9284
Mobile: +336 3304 3788
E-mail: sylvain.mondon@developpement-
durable.gouv.fr

Germany

Ms Christiane Textor
Head of German IPCC-Coordination Office
Project Management Agency
Part of the German Aerospace Center
Heinrich-Kon-Strasse 1
53227 Bonn
Germany
Tel.: +49 228 3821554
Mobile: +49 172 699 7929
Fax: +49 228 3821540
E-mail: christiane.textor@dlr.de

Jamaica

Mr Jeffery Spooner
Director
Meteorological Service
65 3/4 Half Way Tree Road
Kingston 10
Jamaica
Tel.: +1 87 6960 8990
Mobile: +1 87 6577 3752
Fax: +1 87 6960 8990
E-mail: j.spooner@metservice.gov.jm

Kazakhstan

Ms Assel Kishkimbayeva
Senior Researcher, Kazhydromet
Abay Ave. 32
Almaty 050022
Kazakhstan
Tel.: +7 72 7267 5217
Mobile: +7 70 7170 7023
E-mail: vip.kissel@mail.ru

Kenya

Mr David Adegu
Coordinator, GHG Inventory System
Ministry of Environment, Water and Natural
Resources
P O Box 30126
00100 Nairobi
Kenya
Tel.: +254 20 273 0808/9
Mobile: +254 7 2181 3102
Fax: +254 20 273 4722
E-mail: adegubuluku@gmail.com

Mali

Mr Adama Konate
Head Service Meteorological Network
Agence Nationale de la Météorologie du Mali
(Mali Météo)
Bamako
Mali
Tel.: +223 2020 6204
Mobile: +223 6655 4111
Fax: +223 2020 2110
E-mail: konadamou@gmail.com

Marshall Islands

Mr Nover Juria
Climate Program Specialist
National Weather Service
Majuro Weather Service Office
P O Box 78
Majuro 96960
Marshall Islands
Tel.: +692 247 5705
Mobile: +692 456 3233
Fax: +692 247 3078
E-mail: Nover.Juria@noaa.gov

Norway

Mr Ole-Kristian Kvissel
Senior Adviser, Section for Climate Science and Adaptation
Norwegian Environment Agency
Grensevingen 7
0661 Oslo
Norway
Tel.: +47 7358 0500
Mobile: +47 9343 1034
E-mail: ole.kristian.kvissel@miljodir.no

Russian Federation

Ms Svetlana Gavrilova
Department head of the meteorological network, Voeikov Main Geophysical Observatory
St. Karbysheva 7
Saint Petersburg
Russia
Tel.: +7 81 2606 6392
Mobile: +7 91 1778 4471
Fax: +7 81 2297 8661
E-mail: mo_ggo@mail.ru

Saudi Arabia

Ms Noor Al Daham
International Policies Analyst
Ministry of Petroleum and Mineral Resources
P O Box 247
Riyadh 11191
Saudi Arabia
Tel.: +9665 5584 3123
Mobile: +9665 5584 3123
E-mail: noor.daham@mopm.gov.sa

Solomon Islands

Mr Lloyd Tahani
Deputy Director Meteorology
Solomon Islands Meteorological Service
P O Box 21
Honiara
Solomon Islands
Tel.: +67 72 4218
Mobile: +67 7745 8690
Fax: +67 72 3029
E-mail: l.tahani@met.gov.sb

Tuvalu

Mr Tauala Katea
Scientific Officer
Tuvalu Meteorological Service
Private Mail Bag
Funafuti
Tuvalu
Tel.: +688 20736
Mobile: +688 900454
E-mail: tauala.k@gmail.com

Representatives of UNFCCC bodies

Adaptation Committee Representative

Mr Klaus Radunsky
Director
Federal Environment Agency
Spittelauerlände 5
A-1090 Vienna
Austria
Tel.: +43 13 1304 5534
Fax: +43 13 1304 5959
E-mail: klaus.radunsky@umweltbundesamt.at

LEG Vice-Chair

Mr Abias Huongo
Director
Ministry of Environment
Largo Bressane Leite No 29
2nd Andar
Luanda
Angola
Tel.: +244 9 2332 5668
E-mail: huongoam@hotmail.com

SBSTA Chair

Mr Tomasz Chruszczow
National Focal Point
Sustainable Development Department
Ministry of the Environment
52/54 Wawelska St.
00-922 Warsaw
Poland
Tel.: +48 22 579 2318
Fax: +48 22 579 2318
E-mail: tomasz.chruszczow@mos.gov.pl

Representatives of United Nations Secretariat Units and bodies

Intergovernmental Panel on Climate Change WGI-TSU

Mr Gian-Kasper Plattner
IPCC WGI TSU
University of Bern
Falkenplatz 16
3012 Bern, Switzerland
Tel.: +41-31-631 5622
Fax: +41-31-631 8742
E-mail: plattner@climate.unibe.ch

UN SPIDER

Mr Juan Carlos Villagran de Leon
Programme Officer
UN-SPIDER
Platz der Vereinten Nationen 1
53113 Bonn
Germany
Tel.: +49 228 815 0678
Fax: +49 228 815 0699
E-mail: juan-carlos.villagran@unoosa.org

Mr Joachim Post
Senior Expert
Space Technology for Disaster Management
UN-SPIDER
Platz der Vereinten Nationen 1
53113 Bonn
Germany
Tel.: +49 228 815 0676
Fax: +49 228 815 0699
E-mail: joachim.post@unoosa.org

Ms Anne Pustina
Associate Expert
Information and Media
UN-SPIDER
Platz der Vereinten Nationen 1
53113 Bonn
Germany
Tel.: +49 228 815 0683
Fax: +49 228 815 0699
Email: anne.pustina@unoosa.org

United Nations University

Mr Matthias Garschagen
Head of VARMAP Section
United Nations University
Platz der Vereinten Nationen 1
53113 Bonn
Germany
Tel.: +49 228 815 0289
E-mail: garschagen@ehs.unu.edu

World Health Organization

Ms Bettina Menne
Programme Manager
Climate Change, Green Health Services and Sustainable Development
WHO European Centre for Environment and Health
Platz der Vereinten Nationen 1
53113 Bonn
Germany
Tel.: +49 228 815 0422
Mobile: +49 172 734 9641
Fax: +49 228 815 0440
E-mail: menneb@who.int

WMO/GCOS Secretariat

Ms Carolin Richter
Director
GCOS Secretariat
World Meteorological Organization (WMO)
7 bis, Avenue de la Paix
P O Box 2300
CH-1211 Geneva 2
Switzerland
Tel.: +41 22 730 8275
Fax: +41 22 730 8052
E-mail: CRichter@wmo.int

Ms Katherine Hill
GCOS Secretariat
World Meteorological Organization (WMO)
7 bis, Avenue de la Paix
P O Box 2300
CH-1211 Geneva 2
Switzerland
Tel.: +41 22 730 8083
Fax: +41 22 730 8052
E-mail: KHill@wmo.int

Mr Simon Eggleston
GEO Secretariat
World Meteorological Organization (WMO)
7 bis, Avenue de la Paix
CH-1211 Geneva 2
Switzerland
Tel.: +41 79 924 2415
Fax: +41 22 730 8052
E-mail: seggleston@wmo.int

Mr Stephen Briggs
Chair, GCOS Steering Committee
European Space Agency (ESA)
Atlas Building, Harwell-Oxford
Didcot
Oxfordshire OX11 0QX
United Kingdom
Tel.: +44 123 544 4269
E-mail: stephen.briggs@esa.int

Mr Omar Baddour
Chief, Data Management Applications Division
GCOS Secretariat
World Meteorological Organization (WMO)
7 bis, Avenue de la Paix
P O Box 2300
CH-1211 Geneva 2
Switzerland
Tel.: +41 22 730 8268
Fax: +41 22 730 8021
E-mail: OBaddour@wmo.int

Mr Robert Stefanski
Chief, Agricultural Meteorology Division
World Meteorological Organization (WMO)
7 bis, Avenue de la Paix
P O Box 2300
CH-1211 Geneva 2
Switzerland
Tel.: +41 22 730 8305
Fax: +41 22 730 8181
E-mail: rstefanski@wmo.int

WMO/GEO Secretariat

Mr André Obrégon Flores
GEO Secretariat
World Meteorological Organization
7 bis, Avenue de la Paix
CH-1211 Geneva
Switzerland
Tel.: +41 22 730 8484
Fax: +41 22 730 8520
E-mail: aobregon@geosec.org

Ms Barbara Ryan
Director
GEO Secretariat
World Meteorological Organization (WMO)
7 bis, Avenue de la Paix
Switzerland
Tel.: +41 22 730 8505
Fax: +41 22 730 8520
E-mail: bryan@geosec.org

WMO/UNEP Intergovernmental Panel on Climate Change

Mr Carlos Martin-Novella
Deputy Secretary
Intergovernmental Panel on Climate Change (IPCC)
7 bis, Avenue de la Paix
CH-1211 Geneva 2
Switzerland
Tel.: +41 22 730 8247
Fax: +41 22 730 8025
E-mail: Cmartin-novella@wmo.int

World Food Programme

Ms Tania Osejo Carrillo
Climate Adaptation Consultant
Climate Resilience for Food Security,
Programme and Innovation Division, OSZIR
World Food Programme
Via Cesare Giulio Viola 68/70
Parco dei Medici
00148 Rome
Italy
Tel.: +39 06 6513 2257
Mobile: +39 34 5118 1326
Fax: +39 06 659 0632
E-mail: tania.osejo@wfp.org

Experts

Alfred-Wegener-Institute

Mr Hans-Otto Poertner
Alfred-Wegener-Institute for Polar and Marine Research
P O Box 120161
Am Handelshafen 12
Bremerhaven 27570
Germany
Tel.: +49 471 4831-1307
Fax: +49 471 4831-1149
E-mail: Hans.poertner@awi.de

CMCC

Mr Antonio Bombelli
CMCC
IAFES - Impacts on Agriculture, Forests and Ecosystem Service
Via A. Pacinotti 5
I-01100 Viterbo
Italy
Tel.: +39 076 1171 0299
Mobile: +39 328 3244840
Fax: +39 076 1171 0731
E-mail: Antonio.bombelli@cmcc.it

Deutscher Wetterdienst

Mr Gerhard Adrian
President
Deutscher Wetterdienst (DWD)
Frankfurter Strasse 135
63067 Offenbach am Main
Germany
Tel.: +49 69 8062 4200
Fax: +49 69 8062 4130
E-mail: gerhard.adrian@dwd.de

Mr Stefan Roesner
Deutscher Wetterdienst (DWD)
Frankfurter Strasse 135
63067 Offenbach am Main
Germany
Tel.: +49 698 062 0
Fax: +49 698 062 4484
E-mail: Stefan.Roesner@dwd.de

Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR)

Mr Helmut Staudenrausch
Raumfahrtmanagement & Erdbeobachtung
Königswinterer Str. 522-524
53227 Bonn
Germany
Tel.: +49 228 44 7594
Fax: +49 228 44 7792
E-mail: helmut.staudenrausch@dlr.de

European Centre for Medium-Range Weather Forecasts

Mr Adrian Simmons
2 Greystoke Court
Crowthorne RG45 7LS
United Kingdom
Tel.: +44 1344 773721
Fax: +44 1344 773721
E-mail: Adrian.Simmons@ecmwf.int

European Space Agency

Mr Mark Doherty
Head of the Exploitation and Services Division
ESA – ESRIN
Via Galileo Galilei
00044 Frascati (RM)
Italy
Tel.: +39 06 9418 0550
Fax: +39 06 9418 0552
E-mail: Mark.Doherty@esa.int

Mr Frank-Martin Seifert
Earth observation Application Engineer
ESA – ESRIN
Via Galileo Galilei
Casella Postale 64
00044 Frascati
Italy
Tel.: +39 06 9418 0560
Mobile: +49 157 7779 5862
Fax: +39 06 9418 0552
E-mail: Frank.martin.seifert@esa.int

EUMETSAT

Mr Kenneth Holmlund
Head, Remote Sensing and Products Division
EUMETSAT
Eumetsat-Allee 1
64295 Darmstadt
Germany
Tel.: +49 160 9054 2093
E-mail: Kenneth.holmlund@eumetsat.int

Florida State University

Mr Mark Bourassa
Department of Earth, Ocean and Atmospheric Science
College of Arts and Sciences
The Florida State University
Tallahassee, FL 32306-4520
United States of America
Tel.: +01 850 645-4788
E-mail: mbourassa@fsu.edu

Future Earth

Mr Mario Hernandez
Chief Remote Sensing
Natural Sciences Sector
Division of Ecological and Earth Sciences
UNESCO
1 rue Miollis
75732 Paris Cedex 15
France
E-mail: mariohernandezvaldes@gmail.com

GOFC-GOLD

Mr Martin Herold
GOFC-GOLD Land Cover Project Office
Department of Environmental Science
Wageningen University
Droevendaalsesteeg 3
6708 PB Wageningen,
The Netherlands
Tel.: +31 31748 1276
E-mail: martin.herold@wur.nl

International Council for Science

Ms Lucilla Spini
Head of Science Programmes
International Council for Science (ICSU)
5, rue Auguste Vacquerie
75016 Paris
France
Tel.: +33 1 4525 0329
Mobile: +30 33 5824 5416
Fax: +33 1 4288 9431
E-mail: lucilla.spini@icsu.org

Royal Netherlands Meteorological Institute

Mr Albert Klein-Tank
Royal Netherlands Meteorological Institute (KNMI)
P O Box 201
3730 AE De Bilt
The Netherlands
Tel.: +31 30 220 6872
Mobile: +31 6 4691 0004
Fax: +31 30 221 0407
E-mail: Albert.klein.tank@knmi.nl

National Oceanic and Atmospheric Administration (NOAA)

Mr John Bates
National Climatic Data Center
NOAA Satellite and Information Service (NESDIS)
151 Patton Ave
Asheville, North Carolina 28801
United States of America
Tel. +1 828 271 4378
E-mail: John.j.bates@noaa.gov

Mr D.E. Harrison
Pacific Marine Environmental Laboratory
NOAA Research
7600 Sand Point Way NE
Seattle, Washington 98115
United States of America
Tel. +1 206 526 6225
E-mail: d.e.harrison@noaa.gov

Ms Mary Ann Kutny
International and Interagency Affairs Division
NOAA Satellite and Information Service (NESDIS)
1335 East-West Highway
Silver Spring, Maryland 20910
United States of America
Tel. +1 301 713 7050
E-mail: Mary.ann.kutny@noaa.gov

Mr Roger Pulwarty
Climate Program Office and Earth Systems Research Laboratory
NOAA Research
325 Broadway
Boulder, Colorado 80305
United States of America
Tel. +1 303 497 4425
E-mail: Roger.pulwarty@noaa.gov

Potsdam Institute for Climate Impact Research

Ms Gerrit Hansen
Research Domain 1 - Earth System Analysis
Potsdam Institute for Climate Impact Research (PIK)
Telegrafenberg 31
14473 Potsdam
Germany
Tel.: +49 331 288 2611
Mobile: +49 176 2004 9592
E-mail: Gerrit.Hansen@pik-potsdam.de

Risk Management Solutions

Mr Christos Mitas
Risk Management Solutions (RMS) Ltd
Peninsular House
30 Monument Street
London, EC3R 8NB
United Kingdom
Tel. +44 207 444 7768
Mobile: +44 759 5657 746
Fax: +44(0) 207 444 7760
E-mail: Christos.Mitas@rMscom

Swiss Federal Research Institute

Mr Konrad Steffen
Director
Swiss Federal Research Institute (WSL)
Zürcherstrasse 111
CH-8903 Birmensdorf
Switzerland
Tel.: +41 44 739 2455
Fax: +41 44 739 2575
E-mail: Konrad.steffen@wsl.ch

University of Amsterdam

Mr Han Dolman
Department of Earth Sciences
VU University Amsterdam
De Boelelaan 1085
1081 HV Amsterdam
The Netherlands
Tel.: +31 20 598 7358
E-mail: Han.dolman@vu.nl

University of Cape Town

Mr Bruce Hewitson
University of Cape Town
Environmental & Geographical Science Dept.
Private Bag
Rondebosch
7701 Cape Town
South Africa
Tel.: +27 21 650 2784
E-mail: Hewitson@csag.uct.ac.za

University of Stuttgart

Mr Joern Birkmann
Universität Stuttgart
Institut für Raumordnung und Entwicklungsplanung
Pfaffenwaldring 7
70569 Stuttgart
Germany
E-mail: Joern.birkmann@ireus.uni-stuttgart.de

Vista GmbH

Ms Heike Bach
Vista GmbH - Remote Sensing and Modeling for Hydrology, Agriculture and Environment
Gabelsbergerstraße 51
D – 80333 München
Germany
Tel.: +49 89 5238 9802
Fax: +49 89 5238 9804
E-mail: bach@vista-geo.de

Voeikov Main Geophysical Observatory

Ms Anastasiia Repeeva
Voeikov Main Geophysical Observatory
7, Karbyshev Str.
194021 St Petersburg
Russian Federation
Tel.: +7 812 297 4390
E-mail: mo_ggo@mail.ru

Mr Alexander Zaytsev
Voeikov Main Geophysical Observatory
7, Karbyshev Str.
194021 St Petersburg
Russian Federation
Tel.: +7 812 297 4390
E-mail: a.zaitsev@main.mgo.rssi.ru

World Federation for Engineers

Mr Darrel Danyluk
Maison de l'UNESCO
1 rue Miollis
75015 Paris
France
Tel.: +1 40 3238 0379
Mobile: +1 40 3689 0379
E-mail: ddanyluk@shaw.ca

World Glacier Monitoring Service

Ms Isabelle Gärtner-Roer
Science Officer
World Glacier Monitoring Service (WGMS)
Department of Geography
University of Zurich
Winterthurerstrasse 190
CH-8057 Zurich
Switzerland
Tel.: +41 44 635 5139
E-mail: isabelle.roer@geo.uzh.ch

UNFCCC Secretariat

Resource Person

Ms Balgis Osman Elasha
Climate Change Expert
CCIA R01
Abidjan, Côte d'Ivoire
Mobile: +225 5446 7962
E-mail: balgis@yahoo.com

UNFCCC Secretariat

Mr Youssef Nassef
Coordinator
Adaptation Programme
Secretariat of the United Nations Framework
Convention on Climate Change
P O Box 260 124
D-53153 Bonn
Germany
Tel.: +49 228 815 1416
Fax: +49 228 8151999
E-mail: ynassef@unfccc.int

Mr Iulian Florin Vladu
Manager
Science & Review sub-programme
Adaptation Programme
Secretariat of the United Nations Framework
Convention on Climate Change
P O Box 260 124
D-53153 Bonn
Germany
Tel.: +49 228 815 1422
Fax: +49 228 815 1999
E-mail: fvladu@unfccc.int

Mr Paul Desanker
Manager
National Adaptation Plans & Policy
sub-programme
Adaptation Programme
Secretariat of the United Nations Framework
Convention on Climate Change
P O Box 260 124
D-53153 Bonn
Germany
Tel.: +49 228 815 1362
Fax: +49 228 815 1999
E-mail: pdesanker@unfccc.int

Ms Joanna Post
Programme Officer
Science & Review sub-programme
Adaptation Programme
Secretariat of the United Nations Framework
Convention on Climate Change
P O Box 260 124
D-53153 Bonn
Germany
Tel.: +49 228 815 1602
Fax: +49 228 815 1999
E-mail: jpost@unfccc.int

Ms Miwa Kato
Programme Officer
Impacts, Vulnerability & Risks sub-programme
Adaptation Programme
Secretariat of the United Nations Framework
Convention on Climate Change
P O Box 260 124
D-53153 Bonn
Germany
Tel.: +49 228 815 1168
Fax: +49 228 815 1999
E-mail: Mkato@unfccc.int

Mr Motsomi Maletjane
Programme Officer
National Adaptation Plans & Policy sub-programme
Adaptation Programme
Secretariat of the United Nations Framework
Convention on Climate Change
P O Box 260 124
D-53153 Bonn
Germany
Tel.: +49 228 815 1324
Fax: +49 228 815 1499
E-mail: mmaletjane@unfccc.int

Ms Uazamo Kaura
Programme Officer
Mitigation, Data and Analysis Programme
Secretariat of the United Nations Framework
Convention on Climate Change
P O Box 260 124
D-53153 Bonn
Germany
Tel.: +49 228 815 1474
Fax: +49 228 815 1999
E-mail: ukaura@unfccc.int

Ms Joanne Chin Sang
Fellow
Science & Review sub-programme
Adaptation Programme
Secretariat of the United Nations Framework
Convention on Climate Change
P O Box 260 124
D-53153 Bonn
Germany
Tel.: +49 228 815 1139
Fax: +49 228 815 1999
E-mail: jchinsang@unfccc.int

References

Alves Finco, M.V. and W. Doppler, 2010: Bioenergy and sustainable development: The dilemma of food security and climate change in the Brazilian savannah. *Energy for Sustainable Development,* 14: 194–199.

Fargione, J., J. Hill, D. Tilman S. Polasky, and P. Hawthorne, 2008: Land clearing and the biofuel carbon debt. *Science*, 319: 1235-1236.

Harvey, M. and S. Pilgrim, 2011: The new competition for land: Food, energy, and climate change. *Food Policy*, S4S51.

Mitchell, S., M. Harmon and K. O'Connell, 2012: Carbon debt and carbon sequestration parity in forest bioenergy production. *GCB Bioenergy*, doi: 10.1111/j.1757-1707.2012.01173.x

Powlson, D., A. Whitmore and K. Goulding, 2011: Soil carbon sequestration to mitigate climate change: a critical re-examination to identify the true and the false. *European Journal of Soil Science*, 62: 42–55.

Smith, P., 2005: An overview of the permanence of soil organic carbon stocks: influence of direct human-induced, indirect and natural effects. *European Journal of Soil Science*, 56: 673–680.

Tubiello, F., M. Salvatore, S. Rossi, A.Ferrara, N. Fitton and P. Smith, 2013: The FAOSTAT database of greenhouse gas emissions from agriculture. *Environmental Research Letters*. 8 doi:10.1088/1748-9326/8/1/015009.

Wollenberg E. and M.L. Tapio-Bistrom, 2012: *Climate Change Mitigation and Agriculture*. Earthscan LLC, London, 419 pp.

WWW

Workshop Website: http://bit.ly/SystematicObservations2015
Introduction to GCOS and the Essential Climate Variables:
http://www.wmo.int/pages/prog/gcos/Publications/GCOS_poster_FINALpdf%20%281%29.pdf

The Concept of Essential Climate Variables in Support of Climate Research, Applications, and Policy, Bulletin of the American Meteorological Society (AMS), 95, 1431–1443:
http://journals.ametsoc.org/doi/abs/10.1175/BAMS-D-13-00047.1

Report of the joint GCOS/GOFC-GOLD Workshop on Observations for Climate Change Mitigation, *Geneva, Switzerland, 5-7 May 2014:*
http://www.wmo.int/pages/prog/gcos/Publications/gcos-185.pdf

Workshop on IPCC AR5: Lessons Learnt for Climate Change Research and WCRP, International Space Sciences Institute, Bern, Switzerland, 8-10 September 2014: http://www.wcrp-climate.org/ipcc-wcrp-about

COP 19, Warsaw 2013, Side Event: Dialogue with the systematic observation community on activities relevant to the Convention:
http://unfccc.int/science/workshops_meetings/items/7916.php

GCOS-166 GCOS Workshop on Observations for Adaptation to Climate Variability and Change, Offenbach, Germany, 26 – 28 February, 2013: http://bit.ly/Offenbach2013

Review of the Long Term Global Goal to reduce GHG emissions so as to hold the increase in global average temperature below 2°C above pre-industrial levels:
http://unfccc.int/science/workstreams/the_2013-2015_review/items/6998.php

National Adaptation Plans:
http://unfccc.int/adaptation/workstreams/national_adaptation_plans/items/6057.php

Work Programme on Loss and Damage:
http://unfccc.int/science/workstreams/systematic_observation/items/8764.php
National Communications
Annex 1:
http://unfccc.int/national_reports/annex_i_natcom/submitted_natcom/items/7742.php
Non-Annex 1: http://unfccc.int/national_reports/non-annex_i_natcom/items/2716.php

IPCC Fifth Assessment Report (AR5): http://www.ipcc.ch/report/ar5/

IPCC Working Group II Contribution to AR5: http://www.ipcc.ch/report/ar5/wg2/
Summary for Policy Makers: http://ipcc-wg2.gov/AR5/images/uploads/WG2AR5_SPM_FINAL.pdf
Full Report: https://ipcc-wg2.gov/AR5/report/full-report/

IPCC Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX): http://www.ipcc-wg2.gov/SREX/

Risky Business: "The Economic Risk of Climate Change in the U.S.: http://riskybusiness.org/
World Bank Pacific Catastrophe Risk Assessment & Financing Initiative: http://pcrafi.sopac.org/

Global Facility for Disaster Risk Reduction, "Understanding Risk: "The evolution of Disaster Risk Assessment" https://www.gfdrr.org/sites/gfdrr/files/publication/Understanding_Risk-Web_Version-rev_1.8.0.pdf

GCOS Secretariat
Global Climate Observing System
c/o World Meteorological Organization
7 *bis,* Avenue de la Paix
P.O. Box No. 2300
CH-1211 Geneva 2, Switzerland
Tel: +41 22 730 8275/8067
Fax: +41 22 730 8052
Email: gcosjpo@wmo.int