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UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

Subsidiary Body for Scientific and Technological Advice

Thirty-sixth session

Bonn, 14–25 May 2012

Item 6 of the provisional agenda

Research and systematic observation

Update on developments in research activities relevant to the needs of the Convention, including on the long-term global goal; and information on technical and scientific aspects of emissions and removals of all greenhouse gases from coastal and marine ecosystems

Submissions from regional and international climate change research programmes and organizations

1. The Subsidiary Body for Scientific and Technological Advice (SBSTA), at its thirty-fifth session, agreed that the SBSTA research dialogue on developments in research activities relevant to the needs of the Convention should continue, on a regular basis, at SBSTA 36 and beyond.¹
2. Also at its thirty-fifth session, the SBSTA invited relevant regional and international research programmes and organizations active in climate change research to provide, in the context of the research dialogue, submissions with information on developments in their research activities relevant to the needs of the Convention, including with respect to the long-term global goal referred to in decision 1/CP.16, paragraph 4, as appropriate.²
3. The SBSTA further invited Parties and regional and international research programmes and organizations active in climate change research, including marine research, to provide information on the technical and scientific aspects of emissions by sources, removals by sinks, and reservoirs of all greenhouse gases, including emissions and removals from coastal and marine ecosystems such as mangroves, tidal salt marshes, wetlands and

¹ FCCC/SBSTA/2011/5, paragraph 37.

² FCCC/SBSTA/2011/5, paragraph 40.

FCCC/SBSTA/2012/MISC.3

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seagrass meadows, with a view to identifying and quantifying the impact of human activities. This information would be considered as a theme for the next research dialogue.³

4. The secretariat has received eight such submissions. In accordance with the procedure for miscellaneous documents, these submissions are attached and reproduced* in the language in which they were received and without formal editing.

³ FCCC/SBSTA/2011/5, paragraph 43.

* These submissions have been electronically imported in order to make them available on electronic systems, including the World Wide Web. The secretariat has made every effort to ensure the correct reproduction of the texts as submitted.

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Acknowledgment: The APN welcomes and appreciates the continuing opportunity to inform, and engage in a dialogue with SBSTA on issues of global change research, capacity development and science-policy interfacing mechanisms within the Asia-Pacific region that is relevant to the convention. The present brief summarises the current main activities undertaken by APN to address some of the issues outlined in the recently published document **FCCE/SBSTA/2012/MISC.2** regards those topics for discussion at the dialogue meeting to take place during SBSTA36, taking into account developments in research activities outlined in document **FCCE/SBSTA/2007/4, Paragraph 47 (a–f)**.

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1. What is the APN:

Established in 1996, the Asia-Pacific Network for Global Change Research (APN) is a network of twenty-two member governments in Asia and the Pacific whose vision is to enable countries in the region to successfully address global change (GC) challenges through science-based response strategies and measures, effective science and policy linkages, and scientific capacity development.

As APN is an inter-governmental network, a high priority goal is to produce sound scientific results that can be made available as a supportive tool for policy-making processes. Accordingly, the APN conducts regular synthesis and assessment activities of the projects its supports in order to identify important outcomes, research gaps and/or emerging issues that could be used to support policy development.

APN is financially sponsored by the Governments of Japan (Ministry of Environment [MOEJ]; Hyogo Prefectural Government), New Zealand (Ministry for the Environment), Republic of Korea (Ministry of Environment [MEV]) and the United States (National Science Foundation [NSF]; United States Global Change Research Program [USGCRP]).

The APN goals are achieved through a number of activities selected from the APN's two main programmes, which involve **two annual open Calls for Proposals in which scientists based in APN member or approved countries can submit proposals for funding support**. The two main programmes are the *Annual Regional Call for Research Proposals (ARCP)* and the *Scientific Capacity Development Programme (CAPABLE)*. Particularly encouraged to submit APN proposals are developing-country researchers working

in collaboration with the APN's international Global Change partners including DIVERSITAS, ESSP, IGBP, IHDP, START, WCRP and their related core and joint projects.

Research and capacity building activities under the ARCP, CAPaBLE and other related initiatives of the APN focus on four scientific themes identified in the APN's Science Agenda. These are (i) **Climate Change and Climate Variability**; (ii) **Ecosystems, Biodiversity and Land Use**; (iii) **Changes in Atmospheric and Terrestrial Domains**; and (iv) **Resources Utilisation and Pathways for Sustainable Development**. Under these scientific themes, the APN supports activities that are interdisciplinary in nature and cut across natural, social, economic and political sciences.

Examples of the kinds of activities APN undertakes are:

- Promoting and strengthening GC research, including identifying gaps via syntheses and assessment work
- Identifying and developing existing methodologies and developing new methodologies and tools for effective transfer of scientific knowledge
- Strengthening the interface of policy- and decision-making processes and society in general for mainstreaming environmental concern
- Encouraging initiatives from developing countries for place-based, integrative research
- Aligning with programmes of the GC community

2. Ongoing APN Activities Relevant to the Convention:

2.1 APN Climate Synthesis Report and Work towards Springer Publication: Climate in Asia and the Pacific: Society, Security and Sustainability

The APN Climate Synthesis activities began in November 2009 and involve key scientists from the Asia-Pacific region, all of whom have been involved in APN activities either through leading APN-funded projects and/or through being a member country or expert member in the APN.

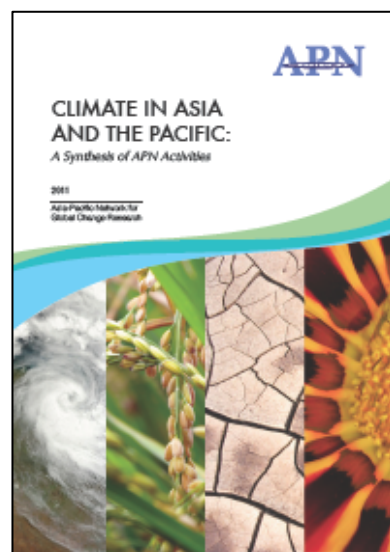
2.1.1 Climate in Asia and the Pacific: A Synthesis of APN Activities

ISBN978-4-9902500-1-0

Citation: Manton MJ, Heath, L, Salinger, J and Stevenson, LA. 2011. Climate in Asia and the Pacific: A Synthesis of APN Activities, pp78. Asia-Pacific Network for Global Change Research.

Work for the present Synthesis – Climate in Asia and the Pacific: A Synthesis of APN Activities began in November 2009 with a scoping workshop followed by an authors' workshop in August 2010. The work entailed summarizing over fifty scientific research and capacity building projects funded by the APN that had a climate-related element – whether natural climate variability and/or climate change. The contributing authors of the present synthesis report are leaders in their field and many of them are authors for the next Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCCAR5). The present report will be a useful tool not only for the IPCC, but also for scientists, decision-makers and educators as it identifies both research gaps and future research activities for the Asia-Pacific region in the context of natural climate variability and climate change.

Copies will be available at the research dialogue on 19th May 2012 and can be downloaded from the APN website at: <http://www.apn-gcr.org/uploads/reports/2011/Climate%20in%20Asia%20and%20the%20Pacific.pdf>



2.1.2 Book: To be published by Springer in its Advances in Global Change Research Series.

Following a workshop from 17-20 October 2011, in Kobe Japan, the book authors are now in the process of preparing Final Order Drafts for the Chapters outlined below. An outline of the book, which is scheduled for publication in Autumn 2012, looks at the current/emerging issues in the Asia-Pacific region, is as follows:

TITLE: Climate in Asia & the Pacific: Security, Society and Sustainability

i. Foreword

- Helen Clark of UNDP (to be confirmed)
- WCRP Executive Director (to be confirmed)

ii. Message from the Steering Committee Chair of APN

iii. List of Contributors

Chapter I: Introduction (Coordinating Lead Author: Michael Manton)

- Include purpose of the book, tools/methodologies used and opportunities for climate impact, adaptation and vulnerability assessments. There is a need to recognise the importance of Asian societies that extend from remote communities to mega-cities.

Chapter II: Climate Variability and Change (Coordinating Lead Authors: Jim Salinger & Madan Shrestha)

Section 1: Observed Climate, Variability and Trends

- o Highlight characters and drivers of climate, variability and trends across the Asia-Pacific, including extremes, glacial mass balance changes and large scales temperature , e.g. circulation and monsoon
- o Include pre-historical perspectives and variability across time-scales

Section 2: Modelling Projections and Regional Downscaling

- o Highlight regional climate modelling and downscaling for Asia-Pacific, including projections on future climate and potential applications of models outputs in projects initiated by WCRP [e.g. Coordinated Regional Climate Downscaling Experiment (CORDEX)], IITM, APCC, BoM, GCISC, IRI, etc.

Chapter III: Climate and Urbanisation (Coordinating Lead Author: Peter Marcotullio)

Section 1: Urbanisation as a driver of Climate Change

- o Highlight the needs of urban areas on food, water, and energy and hence recognise urban areas as source of greenhouse gases. Note the impact of urban design on water and energy efficiency.

Section 2: Mega-Cities (coastal and inland)

- o Highlight vulnerabilities of mega-cities to climate-related events such as sea-level rise and flooding. Note strategies for managing impacts, including urban planning.

Chapter IV: Climate and Security (Coordinating Lead Authors: Lance Heath & Elena Nikitina)

Section 1: Food Security: Agriculture and Fisheries

- o Highlight vulnerabilities and opportunities of agriculture and fisheries to climate variability and change and note strategies for managing and planning those vulnerabilities and opportunities.

Section 2: Water Security

- o Highlight vulnerabilities and opportunities of water security to climate variability and extreme events for Asia-Pacific including Himalayas, Tibetan Plateau and Pacific States. Note strategies to manage vulnerability including extreme events.
- o Include conflict resolution

Section 3: Disaster Management

- o Highlight strategies and opportunities for managing climate-related disasters

Section 4: Energy (distribution, efficiency, sources)

- Highlight vulnerabilities of energy supply to climate change and variability and extreme events. Note strategies to manage those vulnerabilities.

Chapter V: Climate and Society (Coordinating Lead Author: Kanayathu Koshy)

Section 1: Governance

- Describe capabilities and potential strategies for societies to manage climate risks at various levels of governance.

Section 2: Remote Communities

- Mountain Communities
 - Small Islands
- Highlight vulnerabilities of remote communities to climate variability and change and discuss strategies to manage those vulnerabilities

Section 3: Human Health

- Highlight vulnerabilities of human health to climate variability and change including extremes and discuss potential strategies to manage those vulnerabilities

Chapter VI: Climate and Sustainability (Coordinating Lead Author: Rodel Lasco)

Section 1: Integrated Assessment and Energy Options

- Highlight development of integrated assessment methodologies to determine sustainable energy options for Asia-Pacific region.

Section 2: Ecosystem Management

- Highlight importance of natural ecosystems in sustainable development and discuss their roles in climate change adaptation and mitigation.

Chapter VII: Future Directions for Climate Research in the Asia-Pacific Region (All CLAs)

- Highlight overall conclusion and knowledge gaps across all chapters

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2.2 Selected Ongoing Research Activities related to:

2.2.1 *Coastal and Marine Ecosystems*

[Technical and scientific aspects of sources, sinks and reservoirs of all greenhouse gases for coastal and marine ecosystems (mangroves, tidal salt marshes, wetlands and seagrass meadows), with a view to identifying and quantifying the impact of human activities]

- **(Ongoing) Impact of Climate Change on Mangrove Ecosystems in South Asia (Salik).** A 3-year collaborative project in Pakistan, India, Sri Lanka and Bangladesh.

Mangrove forests are an important ecosystem for sustaining biodiversity and livelihoods of to its dependent communities. The total mangrove cover in South Asia is estimated to be about 10,000 km². A number of commercial and non-commercial activities (like cattle grazing, firewood, timber, agriculture, small industries, etc) are carried out by local communities. Climate change drivers that threaten mangrove ecosystems include changes in sea level, hydrology (tidal and fresh water flows within mangroves), high water events, storms, precipitation, temperature, atmospheric CO₂ concentration, ocean circulation patterns, etc. Therefore, a balance is required between resources and its utilization under climate change scenarios for sustainable development of both mangrove and their dependent communities.

There is a sizeable mangrove forest along South Asian coasts that is vulnerable to climate change. Little research has been performed in this region to provide a science-based of information to evaluate impacts and vulnerability of coastal regions to climate change. The extent and composition of regional mangroves are under major change. For example, few decades ago the Indus delta mangroves were regarded as the fifth largest mangrove forest of the world, with a cover of about 350,000 hectares, but now their cover has drastically reduced to about 78,000 hectares, a loss of approximately more than 75% of the origin extension. Similar trend are also found in other South Asian countries like India, Sri Lanka, Bangladesh. Alongi (2002) reported that in last 50 years, about one-third of the world's mangrove forests have been lost. Current projections on mangroves area loss suggest that mangroves in developing countries are likely to decline another 25% by 2025 (Ong and Khoon 2003). Research efforts are needed to understand the interaction of climate change and human impacts on the vulnerability of mangroves wetlands in South Asia.

The present project seeks to provide science-based information about the impact of climate change on mangrove ecosystem in South Asia. The impacts of sea level rise, decrease in fresh water flows in the region and other climatic parameters like temperature fluctuations, precipitation etc will be carried out for developing future scenarios of mangroves forests in South Asia. Moreover, the overall vulnerability of mangroves ecosystem will be evaluated by hydrological, climatic, institutional and socio-economic assessments using hydrodynamic modelling, regional climate models, GIS and RS techniques, landscape vegetation models and applying statistical methods respectively.

This project intends to raise awareness among local and national level policy and decision makers about the potential impacts of climate change on mangroves ecosystem. This information will help to devise policies and interventions for mangroves sustainability, development and conservation by selection of appropriate site in the region to develop a conceptual institutional framework describing drivers, pressures, responses, trends and impacts on mangroves ecosystem. This will be achieved by involving distinguished researchers from participating

countries i.e. Pakistan, India, Bangladesh, USA and Sri Lanka conducting research on these issues.

Specific Objectives:

1. To examine different climatic and hydrological factors under climate change scenarios and assess their linkage and interactions on mangrove ecosystems
2. To carry out vulnerability assessment for socio-economic variable, indicators and processes those are affecting mangroves ecosystem sustainability in South Asia.
3. To develop necessary framework of adaptation/recommendations with respect to for policy and institutional intervention for mangroves sustainability and development for decision-makers at local, national and regional level.

• **(Ongoing) Mangrove Ecosystems Bioshields against Biodiversity Loss & Impacts of Local & Global Change along Indo-Pacific Coast (The Seagrass-Mangrove Bioshield Project, SMBP)** A 3-year collaborative project India, Indonesia and Philippines

In the Indo-Pacific, coastal management vis-à-vis environmental change mitigation and adaptation overly focuses on control of Malthusian over-fishing in coral reefs. It is well documented that among the coastal tropical ecosystems, coral reefs are the most popular, mangroves the most disturbed, and seagrass meadows, the least studied. Seven respected scientists and a number of collaborators from 6 countries (Australia, Japan, India, Indonesia, Philippines, Sri Lanka) are implementing the SMBP. Six sites from the four latter countries have been selected to demonstrate that a seagrass bed and mangrove forest – singly interlinked systems, serve as natural ‘bioshield’, sustaining system goods and services against local and global human and natural stressors. Adopting the Integrative Science for Society and the Environment (ISSE) framework, SMBP is phased in a way to first establish the scientific base (Phase 1: Science Establishment, 2years) and link this with academic programs and governance policies to ensure sustainability of the benefits gained (Phase 2: Capacity Building, 1 year).

Hence, we argue in favour of a growing consensus, which places seagrass-mangrove system conservation as priority, developing models of the ecosystems’ functions and health, which are the natural biological protector (‘bioshield’) in mitigating local and global changes along the region’s coasts. To be tested and promoted, these models will support decision-making and will be used to build capacity of stakeholder communities and governments so that they could utilize more efficiently ecosystem goods and services while adapting to environmental changes.

SMBP will be implemented in 4 countries: India, Indonesia, Sri Lanka, and Philippines. In the last 3 countries, seagrass is virtually unknown and in all 4, the rate of its disappearance and degradation (together with mangroves), is one of the highest in the world, and so peoples’ dependence upon them for survival.

In India, measurement of CH₄ and CO₂ nutrient fluxes and ecosystem goods and services in seagrass will be done in the Gulf of Mannar and in mangroves, in Pichavaram, both in Tamil Nadu. The area is impacted by discharges and disturbances from 47 villages. Fisheries have increasingly declined. In Indonesia, measurement of *Enhalus* seedling growth and survival, seagrass biomass and production, litter fall and ecosystem goods and services will be undertaken in Jakarta Bay, the specific area with a group of coral atoll islands, with a total area of about 12 km², two large lagoons and surrounded by well-developed fringing reefs with seagrass and mangroves. The inland area is considered as the primary source of waste and pollutants; In the

Philippines, dugong feeding behaviour will be observed and population dynamics done in Davao Gulf (south), which has a continuum of corals, seagrass, and mangroves, relatively most pristine, with dugongs and turtles. The human threats are the fishing pressure for day-to-day survival of communities. Water quality, benthic biodiversity, photosynthetic efficiency and seagrass-mangrove ecosystem goods and services will be measured in Bolinao, northern Philippines and Davao Gulf. Bolinao has a small mangrove patch, continuous with a large area of seagrass, disturbed by sedimentation and nutrient pollution from nearby fish cages and fishpens. In Sri Lanka, nutrient cycling, salinity and mangrove plant biodiversity and density will be investigated in Puttalam Lagoon, a large 327 km² lagoon, which is fed by two rivers, discharging at 2.2-8.1 m³/s. The land is used for prawn fishing, salt production, and rice cultivation.

- **(Ongoing) Tracing Nitrogen and Carbon Biogeochemical Processes in the Inter-Tidal Mangrove Ecosystem (Sundarban) of India and Bangladesh: Implications of Global Environmental Change (Mathukumalli).** A 3-year collaborative project in India and Bangladesh

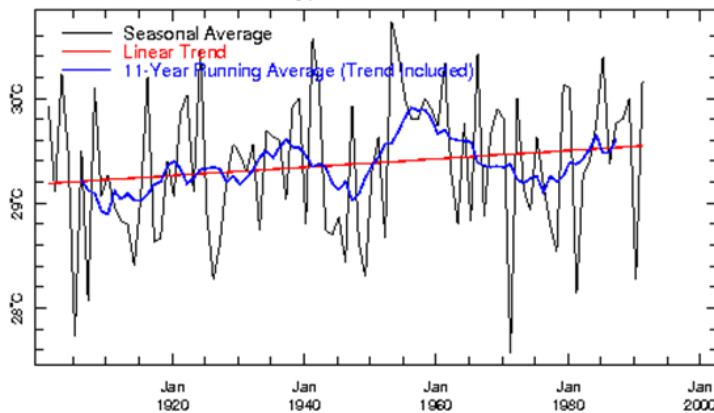
Approximately 50% of the world's human population currently lives within 100 km of a coastline. As population density and economic activity in the coastal zone are projected to increase, there is increasing interest in forecasting impacts of anthropogenic activities, land-use changes and climate on nutrient cycles and budgets. Human interventions in land use in coastal areas have increased nutrient and sediment loads, resulting in eutrophication and degradation of water quality. Owing to their high productivity and energetic exchange with terrestrial and marine ecosystems, mangroves play a crucial role in the biogeochemical cycling of carbon, nitrogen, and other nutrients. Exporting substantial amounts of terrestrial organic matter to the coastal oceans, mangroves play a key role in the regional carbon cycle. Furthermore, increasing land use change and aquaculture practices have increased nutrient discharges; have increased rates of eutrophication, changes in nutrient stoichiometry, and depletion of oxygen that has significant negative effects on the coastal biodiversity. Sundarban is the largest single block mangrove ecosystem (3861 miles²) in the World and 60% is distributed in Bangladesh and the rest 40% in India. Constantly Sundarban mangrove is degraded by rapid changes in land-use pattern/management, discharges of agriculture and aquaculture effluents and reduction in freshwater from the upstream due to the construction of dams have seriously affected the biodiversity and biogeochemical processes. Therefore, an integrated assessment is planned to evaluate the ecological and biogeochemical characteristics of mangrove to describe the biogeochemical processes in Sundarban in response to changing climate and land-use.

Specific Objectives:

2. To elucidate the biogeochemical behaviour and cycling of various ecologically important nutrients (C, N, P, and S) and pollutants.
3. To track sources and impacts of environmental pollution, and 3) exploring historical changes and perturbations in the mangrove.

Climate and hydrology in the Sundarban area were collected from various sources to understand the response of ecosystem to changes in climate. It is very clear that the air temperatures were increased at the rate of 0.4 °C/century (Fig. 1a). Similarly, climate change induced sea-level rise caused increase in salinity along the coastal Bangladesh (Fig. 1b), that indeed impede the groundwater quality and also affects the nutrient biogeochemical processes in the Sundarban mangroves.

(a) Mar-May Seasonal Average Station Temperature Values, Decadal Variability, & Linear Trend

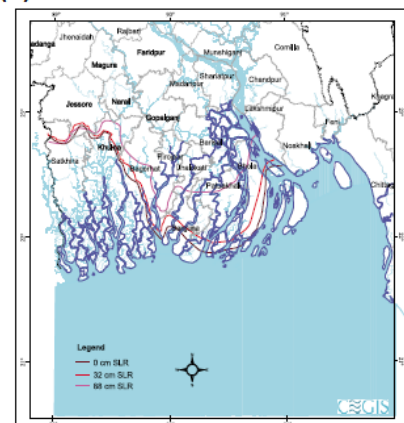


Station at (88.33E, 22.53N) CALCUTTA/ALIP; Trend: 0.3982586 degree_Celsius per century

Publications to date:

Prasad, M.B.K., 2012. Nutrient stoichiometry and eutrophication in Indian mangroves. Environmental Earth Sciences, DOI: 10.1007/s12665-011-1508-8 (in press).

(b) Sea level rise in the Bangladesh Sunbarban



- **(Ongoing) Impacts of Global Warming on Coastal and Marine Ecosystems in Northwest Pacific (Jung). A 2-year collaborative activity in Russia, Republic of Korea, China and Japan**

The western North Pacific is highly productive, supporting the largest fisheries yields in the world and high consumption of fish products by residents of its bordering countries. Recently, however, the western North Pacific has experienced dramatic changes in coastal water quality, oceanographic conditions, and ecosystem structure, driven by global climatic changes and anthropogenic interventions, such as rapidly increasing human populations and industrial activity. Understanding climatic influences on marine ecosystems and fisheries in this region has been the focus of international and multidisciplinary studies since the North Pacific Marine Science Organization (PICES) was established in 1992. Increasing scientific evidence indicates that the responses of marine ecosystems to climatic change are not simple, but vary among regions and according to the scales of the processes. However, implications of these regional differences to vulnerability and possible policies for adapting fisheries industries to climate change have not yet been explicitly studied. Here we are conducting comparative studies across NOWPAP countries (China, Japan, Korea and Russia) to evaluate regional differences in the responses of marine ecosystems to the changes in the NOWPAP sea area (33-52°N; 121-143°E; Fig. 1) and their implications in developing adaptation policies for climate change by establishing a working group composed of natural and socioeconomic scientists.

Specific Objectives:

1. Develop preliminary IBMs that combine a 3-d ocean circulation model and a simple biological model for predicting transport and recruitment of early-life stage fishes.
2. Develop fisheries economic models that can evaluate and risks and vulnerabilities of fisheries sectors to the projected changes in marine ecosystems and fisheries resources in the NOWPAP area.
3. Contrast the different vulnerabilities of the NOWPAP regions to explore the implications in developing management plans for adapting fisheries sectors to climate change

projected by IPCC AR4 (low, moderate, and high future emissions of greenhouse gases) or preferably AR5 models.

4. Investigate changes in production of fisheries due to climate changes and evaluate costing of policy changes

Publications

Kang, Y.S., Jung, S., Zuenko, Y., Choi, I., Dolgaova, N., In press. Regional differences in response of mesozooplankton to long-term oceanographic changes (regime shifts) in the northeastern Asian marginal seas. *Progress in Oceanography*.

<http://dx.doi.org/10.1016/j.pocean.2011.11.012>

2.2.2 *Land use and Land Cover Change*

[Technical and scientific aspects related to land-use and land-cover changes and other ecosystems with high-carbon reservoirs, in particular terrestrial ecosystems (e.g. tundra, peatlands and steppe), including in the context of consideration of practical mitigation options for achieving the 2°C temperature goal]

• **(Ongoing) Rapidly Changing Greenhouse Gas Budgets of South and Southeast Asia: A 3-year collaborative research activity.**

Rapid economic growth in many Asian countries has resulted in increased energy demand, which in turn is leading to increasing the global share of greenhouse gas emissions by the region. An understanding of the natural carbon exchange over the land and oceans due to tropical climate variability is also required for calculating interannual to interdecadal variations in atmospheric CO₂. The main aim of this 1st APN workshop was to assess resources available currently among the international research community working on various aspects of earth system sciences with a focus on South and Southeast Asia. The key issue discussed was the availability of data and models to work towards the establishment of the GHG budget for these two regions based on synthesis and reconciliation of top-down (atmospheric observations and inverse models) and bottom up estimates (ground based flux observations and terrestrial models). These included atmospheric measurements of GHGs, classifications of land cover and soil properties, coastal ocean biogeochemistry, forest and agriculture inventories, and remote sensing based estimates. The target GHGs are carbon dioxide (CO₂), methane (CH₄) and nitrous oxides (N₂O).

Principal Investigators: Josep Canadell and Prabir K. Patra

Introduction

Within the United Nations Framework Convention on Climate Change, countries are continuing to negotiate emission reduction targets and exploring mitigation strategies best suited to their biophysical characteristics. One of the largest impediments to advance in this front is the lack of high quality estimates of GHG fluxes in and out of natural and managed ecosystems. In this project, we have undertaken one of the most ambitious synthesis efforts to date using global and regional datasets and model outputs to constrain the regional GHG budgets of South and Southeast Asia, where the source/sink balance of GHGs has large uncertainty. For reduction of these uncertainties, analyses of land-use and land-use change, riverine carbon export, soil carbon distributions and other bottom-up estimations are being conducted. For top-down estimations (source/sink inversion from atmospheric data and models), efforts are being made to use the existing atmospheric data from various sources, as well as expansion of the present surface-monitoring network in the South Asia region.

Objectives

- (a) Reconciliation of top-down estimates using atmospheric GHG inversion models and bottom-up estimates using terrestrial biogeochemical models, remote sensing data, and flux and inventory datasets.
- (b) Observational data and numerical model results of various GHGs (CO₂, CH₄, N₂O etc.) will be analyzed and archived in a central data repository.
- (c) Access and analyze the results for the regions from 11 atmospheric CO₂ inversions, 6 global terrestrial biogeochemical model outputs, and one fire emissions product.
- (d) Discuss among the participating scientists during the proposed workshops, and share with all parties interested through peer-reviewed publications and the data repository.

Results to Date

Rapid economic growth in many Asian countries has resulted in increased energy demand, which in turn is leading to increasing the global share of greenhouse gas emissions by the region (Raupach et al., PNAS, 2007; Le Quere et al., NatGeosci, 2009). An understanding of the natural carbon exchange over the land and oceans due to tropical climate variability is also required for calculating interannual to interdecadal variations in atmospheric CO₂ (Patra et al., Tellus, 2005).

An international workshop was organized through financial supports from (1) the Asia Pacific Network (APN) funded project (ARCP2011-11NMY-Patra/Canadell), the Indian Space Research Organisation (ISRO) Geosphere-Biosphere Project (GBP) (ATCTM) at the Physical Research Laboratory (PRL), Ahmedabad. The main aim of this 1st APN workshop was to assess resources available currently among the international research community working on various aspects of earth system sciences with a focus on South and Southeast Asia. The key issue discussed was the availability of data and models to work towards the establishment of the GHG budget for these two regions based on synthesis and reconciliation of top-down (atmospheric observations and inverse models) and bottom up estimates (ground based flux observations and terrestrial models). These included atmospheric measurements of GHGs, classifications of land cover and soil properties, coastal ocean biogeochemistry, forest and agriculture inventories, and remote sensing based estimates. The target GHGs are carbon dioxide (CO₂), methane (CH₄) and nitrous oxides (N₂O).

The Project Co-Leader, Dr. Pep Canadell (GCP/CSIRO, Australia), highlighted the rapid emissions growth rates of countries in the region in 2010 superseding previous expectations and showing little effect of the Global Financial Crisis (e.g., China 9.9%, India 9.0%, South Korea 8.8%, Indonesia 7.6%). The growing global share of emissions from Asian countries is increasing the uncertainty of the global carbon budget, and more so for the targeted regional budgets; uncertainty reduction is one of the main goals of the APN effort.

Top-down observations and modeling: Michel Ramonet (IPSL/LSCE) highlighted the needs for high quality measurements, which are set at accuracy of 0.1 ppm, 2 ppb and 0.1 ppb for CO₂, CH₄ and N₂O, respectively for the upcoming Integrated Carbon Observation System (ICOS) project. Prabir Patra (RIGC/JAMSTEC) set a target for CO₂ flux estimation uncertainty for the South and Southeast Asia regions at 0.2 PgC/yr within the time span of the APN project of 3 years, by utilizing in situ and remote sensing observations in atmospheric-CO₂ inverse modeling.

The observations of most important anthropogenic GHGs are being conducted at ground based sites through national and international collaborations and onboard of commercial/research aircrafts. Initial datasets have been analysed for understanding how regional sources and sinks (fluxes) interact with the atmospheric transport and chemistry using numerical models for simulating concentrations. One of the recent finding, based on atmospheric inverse modeling, is

that the South Asia region has apparently acted as the net sink of CO₂ at a rate of 0.3±0.3 PgC/year during 2007-2008 (P. K. Patra), but most parts of the Asian region behave as a significant source of CH₄ and N₂O (K. Ishijima; RIGC/JAMSTEC). These results, however, show high uncertainty and lack of confidence at the sub-regional level so falling short from showing the role of the various GHG species on the Earth's climate system and any possible implications for climate policy development. The workshop identified the need for molecular and isotopic data of GHGs as a key development (N. K. Indira, CCMACS; M. Naja, AIRES).

The workshop also highlighted the importance of regional applications of atmospheric inversion modeling using unique regional observations not yet part of the global datasets and measurements from commercial airliners in and out of the region (eg. CONTRAIL program from NIES/MRI/JAL by Y. Niwa, MRI; C.-H. Cho, NIMR; R. Lokupitiya, USJ; P. S. Swathi, CMMACS). The use of air pollutant species, such as carbon monoxide (CO), ozone (O₃), are shown to be effective for separating biomass burning and fossil fuel emissions, both dominant fluxes in the region (L. K. Sahu, PRL), and also useful for analyzing the detrimental effects of oxidants on crop yields (S. Lal, PRL). Ozone concentration over India increased at a linear rate of ~1.4% per year in the periods of 1950s and 1990s.

Bottom-up observations and modeling: A growing role of eddy-covariance flux towers is expected in the near future given the current deployment of a network in India under the ISRO-GBP and the institutions of the Ministry of Earth Sciences, Government of India. The well-established terrestrial ecosystem models, developed primarily for the temperate region, are tuned for light use-efficiency and soil moisture stress in order to adapt them for the regional conditions. Efforts are also underway for validating the modelled gross primary productivity and heterotrophic respiration under the National Carbon Project (NCP) (R. Nayak, NRSC). N. R. Patel (IIRS) suggested that agricultural net primary productivity (NPP) has increased in the past 50 years due both due to increased yield per hectare and overall extent of agricultural land. Explicit representation of crops in terrestrial modeling has been mostly ignored so far and will require the next generation of modeling development given the predominant role of agriculture in the region (E. Lokupitiya). Site level measurements of emission footprints are constructed for CH₄ and N₂O emissions from the rice and wheat cropping fields (D. Pandey, BHU) and also discussed their emission reduction potentials (I. Rusmana, IPB). Emerging new accounting techniques based on field observations, modeling and remote sensing are providing new estimates of CH₄ emissions from Indian rice paddy fields (3.4 Tg/yr) and livestock (11.7 Tg/yr) (K. R. Manjunath, SAC). Emissions from wetlands are still highly unconstrained, particularly for Southeast Asia where extensive tropical peatlands exist. The satellite products of normalized difference vegetation index (NDVI), land cover change and land cover change, soil properties and soil carbon mapping, and agricultural practices are all identified as critical inputs for identifying the processes involved in the exchange of carbon and nitrogen in terrestrial ecosystems (T. Bhattacharya, ICAR).

The transport of terrestrial carbon to the estuaries (33 TgC/yr) and emissions from coastal oceans (6.4 TgC/yr) of India illustrates the importance of lateral transport and the coastal zones (V. V. S. S. Sarma, NIO) and the need for an Asia-wide effort (N. H. Oh, SNU; A. Koripitan, IPB). The concept of ocean acidification was also discussed in the context of rapidly changing scenario of CO₂, and oxidized sulfur (SO_x) and nitrogen (NO_x) species (M.M. Sarin, PRL).

The meeting cemented a set of initial steps towards a regional collaboration among the scientists with interdisciplinary research background who are interested in working on the budget and attribution of GHG budget to the major regions in Asia. The collaboration aims to facilitate the sharing of existing and new observations and numerical model simulations, and to

contribute to the long term implementation of the goals of the Regional Carbon Cycle Assessment and Processes (RECCAP) of the Global Carbon Project.

An improved scientific knowledge is indispensable for developing informed national policy on GHGs emission mitigation strategies and their implementation, based on the sound understanding of the behaviour of natural ecosystems and intensity of the anthropogenic activity.

A concise version of this meeting report is submitted for publication in EOS (peer-reviewed): Patra, P. K., J. G. Canadell, & S. Lal, The rapidly changing greenhouse gases (GHG) budget of Asia, EOS, Transactions, American Geophysical Union, DoI: 2011ES003689, Vol. 93, 2012.

2.3 New Opportunities for Developing Countries

2.3.1 New Opportunities Climate Change Adaptation for Developing Countries in the Asia-Pacific Region

Parties adopted the Cancun Adaptation Framework (CAF) as part of the Cancun Agreements at the 2010 COP 16/CMP 6 conferences in Cancun Mexico. In the Agreements, parties affirmed to enhance action on adaptation with the same level of priority as mitigation. At the 2011 COP17/CMP7 Conferences in Durban, South Africa, parties reaffirmed the above decision and decided on the modalities and procedures for the Adaptation Committee that supports enhanced action including engagement with, and draw on expertise of, relevant networks and centres. The objective of CAF (paras. 11-35 of UNFCCC Cancun report) is to enhance action on adaptation, including through international cooperation and coherent consideration of matters relating to adaptation under the Convention. Enhanced action on adaptation covers a wide range of fields such as:

- (i) Planning and implementing action identified in national and sub-national adaptation plans and strategies,
- (ii) Impact and vulnerability assessments,
- (iii) Strengthening institutional capacity,
- (iv) Enhancing climate related risk reduction strategies,
- (v) Research, development and diffusion of technologies, practices and processes,
- (vi) strengthening data, information, knowledge systems, education and public awareness; and
- (vii) Improving research and systematic observation.

It is particularly important to assist least developed countries to formulate and implement national adaptation plans including the above action points.

New activities

Based on the above decisions, the APN is expected to play a more important role in supporting action on adaptation in the Asia-Pacific region, particularly through regional cooperation in global change research, scientific and technical capacity building and interaction between scientists and policy-makers. More importantly, it is essential to enhance the support for member countries to achieve Goal 2 of APN, i.e., strengthening interactions among scientists and policy-makers. In this context of the CAF, it is critically important to strengthen the capacity of scientists and practitioners in our member developing countries so that they can be more effectively involved in decision-making processes on national adaptation planning, which requires regional and sub-regional cooperation. Therefore, we propose the following process to establish a new adaptation programme under the APN.

- (1) Hyogo-Funded Activity: Scoping workshop to enhance the action of APN developing country members on adaptation in the Asia-Pacific region**

APN, Hyogo Prefecture and the Institute of Global Change Adaptation Science (ICAS) of Ibaraki University will co-organize a scoping workshop to be held in Kobe, Japan. The workshop will be conducted as a new HYOGO Activity and sponsored by Hyogo Prefecture. ICAS is renowned for research activities on climate change impact assessments and adaptation in the Asia-pacific region.

The 3-day workshop will be held between August and September, 2012. The objective of the workshop will be to:

- (i) Compare recent experiences in the region to identify needs, gaps and lessons on planning and implementation of adaptation,
- (ii) Identify prioritized activities on adaptation under the CAF which should be supported by APN in regional or sub-regional scale, and
- (iii) Identify effective programmes and/or tools to support developing member countries in the region in the context of linking science and policy.
- (iv) Bring scientists, policy-makers and practitioners associated with adaptation together in one venue – both within and outside the APN member countries.

(2) Joint activity with UN-CECAR: Training course on adaptation planning and implementation in Asian-Pacific region

APN and University Network for Climate and Ecosystem Change Adaptation Research (UN-CECAR) will co-organize a training course on adaptation planning and implementation in developing countries in Asia-Pacific region. UN-CECAR is a joint initiative of more than 20 leading universities across Asia. It is committed to developing postgraduate educational and research programmes on climate and ecosystems change, adaptation and sustainability science. It has been actively conducting a series of training courses on adaptation for postgraduate students in Asian countries.

The joint training course will be held for three days back-to-back with a UN-CECAR training course in FY 2012, utilizing the above existing capacity development mechanism (venue will be decided later). It aims at raising capacity of scientist as well as practitioners that should be involved in policy making process on adaptation in respective countries.

The results of the joint activity will be reflected in the draft multi-year programme on adaptation that is described in (4) below, and that will be reported to the 18th IGM.

(3) Proposal Development Training Workshop

It is vital that countries in the Asia-Pacific region have the capacity to conduct high quality research that provides underpinning scientific support for policy-makers and policy-making processes. Under the CAPaBLE programme early-career scientists are provided with opportunities to develop their knowledge and capabilities in global change research. Since 2008, the APN has been conducting Proposal Development Training Workshops in various parts of the region. Most recently, these were held in Shanghai, New York, Kobe, Manila, Pune, China, VietNam, and Bhutan back to back with other important meetings.

Held back to back with (2) above, we are proposing that Asian adaptation students be engaged in a proposal development training workshop so that they might be able to actively engage in potential future calls for funding related to adaptation and (4) below.

(4) Formulation of draft multi-year programme on adaptation

Based on the results of the scoping workshop and the joint training course, we expect to draft a three to five year programme to support action on adaptation in member countries. This programme will be presented to the 18th IGM/SPG meeting in 2013 for approval. The draft programme will include research and capacity

development activities on prioritized themes, as well as science-policy dialogues related to adaptation. If, once the draft programme is approved, it is expected that the programme will be reported and reviewed by the IGM/SPG meetings that will be held in subsequent years. We will introduce the above activities at events organized by UNFCCC and other relevant international fora.

2.3.2 New Opportunities: Low Carbon Initiatives for Developing Countries in the Asia-Pacific Region

Parties to the UNFCCC adopted the Cancun Agreements at the 2010 COP16/CMP conferences in Cancun Mexico. They agreed to work towards identifying a global goal for substantially reducing global emissions by 2050 (para. 5 of UNFCCC Cancun report). In order to achieve the global goal, both developed and developing countries agreed to enhance mitigation actions. In the case of developing country parties, parties agreed to take nationally mitigation actions in the context of sustainable development, supported and enabled by technology, financing and capacity-building (para. 48), and encouraged developing countries to develop low-carbon development strategies or plans in the context of sustainable development (para.65). At 2011 COP17/CMP7 conferences in Durban South, Africa, and parties recalled the above Cancun agreements and decided further on parties' mitigation actions.

APN has supported more than sixty research projects related to climate change and variability; a major theme in the APN's science agenda. APN has also supported workshops and training on GHG inventory compilation, sustainable technology transfer and measuring emissions from landscapes. The 15th IGM/SPG meeting, Busan, Republic of Korea (2010) hold the Low Carbon Green Growth and Development Session, which made participants share the concept on low carbon and green growth development.

Based on the results of UNFCCC conferences, it is critically important to strengthen the capacity of scientists and practitioners in developing countries so that they can be involved in decision-making processes on national strategies for low carbon and green growth. It is expected that the APN will play a significant role in enhancing scientific capacity of experts, strengthening science-policy linkages and strengthening synergies with other relevant organizations and networks that will ultimately assist in promoting low carbon technologies in developing countries in the region.

In this regard, the APN has recently established a new set of focused activities on **Low Carbon Initiatives (LCI)**. The LCI programme will be a three-year programme from April 2012 to March 2015, mainly comprised of: (i) regional-based research (ii) capacity development; and (iii) communication activities. It is estimated that proportion of fund for (i) regional research activities among the entire LCI programme will be approximately 60%. Category (iii) will include activities for communicating and collaborating with other low carbon networks in the Asia-Pacific region. For (i) and (ii), an independent call for proposals will be launched over a 6 month-period from June to December 2012, with new research and capacity development activities expected to start in January 2013.

Earth System Science Partnership (ESSP)

*Community building for new insights in climate science
and global environmental change research*

Introduction

The ESSP is a science partnership of the four international global environmental change research programmes – an international programme of biodiversity science (DIVERSITAS), International Geosphere-Biosphere Programme (IGBP), International Human Dimensions Programme on Global Environmental Change (IHDP), and the World Climate Research Programme (WCRP) - for the integrated study of the Earth system, the ways that it is changing, and the implications for global and regional sustainability.

Science highlights

Options for Agriculture in the UNFCCC

Prof Bruce Campbell (Director) or Dr Sonja Vermeulen (Head of Research), CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

New findings demonstrate the major impacts of climate change on smallholder farmers (Erickson et al., 2011) and agricultural productivity (e.g. Lobell et al. 2011). Balancing food security, adaptation and mitigation imperatives will be a major challenge of the 21st century (Vermeulen et al., 2011). Emerging options for managing the tradeoffs, from farmer to global climate change policy, are discussed, including how agriculture can contribute to climate change mitigation.

Lobell, D.B., Banziger, M., Magorokosho, C., Vivek, B., 2011. Nonlinear heat effects on African maize as evidenced by historical yield trials. *Nature Climate Change* 1, 1–4.

Vermeulen, S.J., Aggarwal, P.K., Ainslie, A., Angelone, C., Campbell, B.M., Challinor, A.J., Hansen, J.W., Ingram, J.S.I., Jarvis, A., Kristjanson, P., Lau j, C., Nelson, G.C., Thornton, P.K., Wollenberg, E. 2011. Options for support to agriculture and food security under climate change. *Environ. Sci. Policy* (2011), doi:10.1016/j.envsci.2011.09.003

Ericksen, P., Thornton, P., Notenbaert, A., Cramer, L., Jones, P. and M. Herrero. 2011. Mapping hotspots of climate change and food insecurity in the global tropics. CCAFS Report No. 5. CGIAR Research Program on Climate Change, Agriculture and Food Security.

The Impact of Regional Climate Change on Malaria Risk

Climate change will probably alter the spread and transmission intensity of malaria in Africa. Model-based estimates for the present climate (1960 to 2000) are consistent with observed data for the spread of malaria in Africa. In the model domain, the regions where malaria is epidemic are located in the Sahel as well as in various highland territories. A decreased spread of malaria over most parts of tropical Africa is projected because of simulated increased surface temperatures and a significant reduction in annual rainfall. However, the likelihood of malaria epidemics is projected to increase in the southern part of the Sahel. In most of East Africa, the intensity of malaria transmission is expected to increase. Projections indicate that highland areas that were formerly unsuitable for malaria will become epidemic, whereas in the lower-altitude regions of the East African highlands, epidemic risk will decrease. We project that climate changes driven by greenhouse-gas and land-use changes will significantly affect the spread of malaria in tropical Africa well before 2050.

The geographic distribution of areas where malaria is epidemic might have to be significantly altered in the coming decades.

Volker Ermert, Andreas H. Fink,¹ Andrew P. Morse,² and Heiko Paeth, *The Impact of Regional Climate Change on Malaria Risk due to Greenhouse Forcing and Land-Use Changes in Tropical Africa*, Environmental Health Perspectives, volume 120, number 1, 2012

Trends in CO₂ emissions

Global carbon dioxide emissions from fossil-fuel combustion and cement production grew 5.9% in 2010, surpassed 9 Pg of carbon (Pg C) for the first time, and more than offset the 1.4% decrease in 2009. The impact of the 2008–2009 global financial crisis (GFC) on emissions has been short-lived owing to strong emissions growth in emerging economies, a return to emissions growth in developed economies, and an increase in the fossil-fuel intensity of the world economy. Our estimated emissions from fossil fuel combustion and cement production of 9.1 ± 0.5 Pg C, combined with the emissions from land-use change of 0.9 ± 0.7 Pg C (ref. 8), led to a total emission of 10.0 ± 0.9 Pg C in 2010. Half of the total emissions (5.0 ± 0.2 Pg C) remained in the atmosphere, leading to one of the largest atmospheric growth rates in the past decade (2.36 ± 0.09 ppm of CO₂) and an atmospheric concentration at the end of 2010 of 389.63 ± 0.13 ppm of CO₂. Of the remainder of the total emissions (5.0 ± 0.9 Pg C), we estimated that the ocean sink was 2.4 ± 0.5 Pg C, and the residual attributed to the land sink was 2.6 ± 1.0 Pg C. The land sink was more than 1 Pg C below the strength of the sink over the previous two years, but this high variability of the land sink is well known and due to natural variability.

Peters et al., Rapid growth in CO₂ emissions after the 2008–2009 global financial crisis, NATURE CLIMATE CHANGE 2011

Permafrost Carbon Emissions

Reports of tundra fires, ancient carbon release, lake methane bubbling and gigantic stores of frozen soil carbon have been emanating from the Arctic zone in recent years. Approximately 1700 Pg (billion tons) of soil carbon (C) are stored in the northern circumpolar permafrost zone, more than twice as much C than currently exists in the atmosphere. Permafrost thaw, and the microbial decomposition of previously frozen organic C, is considered one of the most likely positive feedbacks from terrestrial ecosystems to the atmosphere in a warmer world. The overall amount, rate, and form of C released are crucial for predicting the strength and timing of this C cycle feedback during this century and beyond, yet uncertainty concerning all of these dynamics is high. We used an expert survey to quantify uncertainty and measure consensus concerning the understanding of future permafrost C feedbacks to climate change. A group of international experts in this issue was asked to provide quantitative estimates of permafrost change in response to four scenarios of Arctic warming. For the highest warming scenario presented to the group, survey results indicate that C release from permafrost zone soils could be 30–46 Pg C over the next three decades, reaching 242–324 Pg C by 2100, and potentially up to 551–710 Pg C over the next several centuries (all estimates in CO₂ equivalents). Most of the actual C release by weight is expected to be in the form of CO₂, with only about 2.3% of that in the form of CH₄. However, the higher global warming potential of CH₄ means that almost half of the climate forcing from permafrost C release was expected by this group to be a result of CH₄, produced by organic matter decomposition in wetlands, lakes, and other oxygen-limited environments. Experts projected that under the lowest warming scenario two-thirds of this release could be avoided. Across the dataset, the distribution of responses largely fit a lognormal distribution with a small number of experts estimating significantly higher impacts than the mean group response. These results highlight both the potential risk from permafrost thaw and serve to frame a hypothesis about the magnitude of this feedback to climate change.

Impacts of urbanization on national transport and road energy use

Few attempts have been made to investigate quantitatively and systematically the impact of urbanization on transport energy use for countries of different stages of economic development. After controlling for population size, income per capita and the share of services in the economy, the main results suggest that urbanization influences national transport and road energy use positively. However, the magnitude of its influence varies among the three income groups. Changes in urbanization appear to have a greater impact on transport and road energy use in the high income group than in the other groups. Surprisingly, the urbanization elasticities of transport and road energy use in the middle income group are smaller than those of the low income group. This insides can provide policy makers with insightful information on the link between urbanization and transport energy use at the three different stages of development.

Phetkeo Poumanyvong, Shinji Kaneko, Shobhakar Dhakal: Impacts of urbanization on national transport and road energy use:Evidence from low, middle and high income countries, 2012

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INFORMATION NOTE

Update on recent research activities of the EU 7th Framework Programme for Research and Technological Development in the field of Climate Change

This information note¹ has the scope of providing to the Secretariat of the UNFCCC updated information on the most recent research activities in the field of climate change undertaken under the European Union's Seventh Framework Programme for Research and Technological Development (FP7), and managed by the European Commission. This information is provided as background for the upcoming session of the Research Dialogue that will take place during the 36th session of SBSTA (14-25 May 2012, Bonn, Germany).

This information note includes an introduction to FP7, as well as a summary of scientific highlights of relevance to the Convention generated by research undertaken at European level, including with respect to the two topics explicitly identified in the SBSTA 35 conclusions (long-term global goal and technical and scientific aspects of emissions by sources, removals by sinks, and reservoirs of all greenhouse gases, including emissions and removals from coastal and marine ecosystems).

1. INTRODUCING THE EUROPEAN 7TH FRAMEWORK PROGRAMME FOR RESEARCH AND TECHNOLOGICAL DEVELOPMENT

The 7th Framework Programme for Research and Technological Development (FP7) is the EU's main instrument for funding research in Europe, including through cooperation with international partners. With its budget allocation of €50.5 billion over the period 2007-2013 it represents one of the largest research programmes in the world. The FP7 covers EU's 27 Member States and 14 associated countries². A specific feature of the FP7 is that it promotes international cooperation in the field of Science and Technology with third countries, both developed and developing. Approximately 15 percent of the total budget of FP7 is estimated to have been allocated to climate-related research. It is also estimated that about 75% of the research activities address sustainable development issues.

As the largest of the four Programmes in which FP7 is articulated, the Programme "Cooperation" supports collaborative research through projects carried out by transnational consortia. It comprises 10 thematic areas, including a specific theme on "Environment (including climate change)" with a total budget of approximately € 1.8 billion, and other six themes that are climate change-related (Energy, Transport, Industrial Technologies, Agriculture and Food, Space, Socio-economic Sciences and Humanities). Climate change is also addressed under the "Capacities", "People" and "Ideas" Programmes of the 7th Framework Programme which address respectively: a) the enhancement of research infrastructures and innovation capacities throughout Europe and international cooperation activities; b) needs of the scientific community in terms of training, mobility and career development (Marie Curie actions); and c) "frontier research" by researchers from both Europe and third countries (implemented through the independent European Research Council).

¹ The information presented in this note has been provided by staff of the European Commission and does not necessarily reflect the views of the European Commission. It is not an official submission by the European Union and it is not the result of a formal adoption procedure by the EU.

² Albania, Bosnia & Herzegovina, Croatia, Faroe Islands, Former Yugoslav Republic of Macedonia, Iceland, Israel, Liechtenstein, Moldova, Montenegro, Norway, Serbia, Switzerland, Turkey.

In addition to their activities under the 7th Framework Programme and in the context of the wider establishment of a European Research Area (ERA), the European Union and its Member States have further enhanced their cooperation through the creation of Joint Programming Initiatives (JPIs) that aim to increase the value of relevant national Research and Development (R&D) funding by concerted and joint planning, implementation and evaluation of national research programmes. In the field of climate change, two relevant JPIs have been created to tackle the themes "Agriculture, Food Security and Climate Change" (FACCE-JPI) and "Connecting Climate Change Knowledge for Europe" (JPI-Climate). Furthermore, impacts of climate change are also addressed under other relevant JPIs such as the ones on "Urban Europe", "Cultural heritage & global change" and "Healthy and Productive Seas and Oceans".

Starting from 2014, the fundamental societal challenges posed by climate change will continue to be prioritized under Horizon 2020, the new EU Framework Programme for Research and Innovation for the period 2014-2020 which is expected to be adopted by the European Parliament and the Council within the year 2013.

2. SCIENTIFIC HIGHLIGHTS FROM FP7

This section presents a summary of recent scientific highlights from selected EU-supported research projects that are of particular relevance to the UNFCCC, as well as of information on recently started projects and initiatives that are currently in the pipeline. Since this is not intended to be a comprehensive list of EU-supported research projects, further information about specific projects funded by FP7 can be searched through the CORDIS database (http://cordis.europa.eu/projects/home_en.html). Additional information on climate-related projects funded by the Environment (including climate change) Theme is available at http://ec.europa.eu/research/environment/index_en.cfm.

2.1. Climate modelling and atmospheric processes

FP7 continues to support major research in the area of climate modelling aimed at increasing understanding of climate variability, improving climate prediction and projections on decadal and centennial time scales, and assessing the risks of abrupt and irreversible change. A set of climate modelling projects supported by the EU is working on reducing uncertainties in the representation of key physical and biogeochemical processes in Earth System Models (ESMs) such as clouds, aerosols, stratosphere dynamics. Furthermore processes previously not accounted for such as the coupling of the carbon and nitrogen cycle, ice sheets melting/mass variations, permafrost thawing will be incorporated. The projects contribute to the CMIP5 initiative.

In particular, the *EUCLIPSE*³ project aims to reduce the uncertainties in the representation of cloud processes, their radiative properties and feedback on climate, concentrating its efforts on new generation ESMs. The project has already developed observational datasets, initiated case studies for different cloud types and is executing climate model runs that will be used for the AR5 of the IPCC. A key objective of *COMBINE*⁴ is to improve initialisation techniques in order to make best use of ocean observations and sea ice analysis to reduce model biases. Furthermore, the project will in-cooperate chemistry-aerosol-cloud interactions, a more realistic representation of the Stratosphere, ice sheets and permafrost in current ESMs. First model simulations are promising as they show better agreement between observations and model calculations. The recently started *EMBRACE*⁵ project aims to reduce the main systematic biases in European

³ "EU Cloud intercomparison, process study and evaluation" project (EUCLIPSE), <http://www.euclipse.eu/>.

⁴ "Comprehensive Modelling of the Earth system for better climate prediction and projection" project (COMBINE), www.combine-project.eu.

⁵ "Earth system Model Bias Reduction and assessing Abrupt Climate change" project (EMBRACE), <http://www.smhi.se/embrace>.

ESMs, targeting 3 areas: a) Moist convection and its interaction with tropical clouds and ocean circulation; b) Marine and terrestrial carbon cycle; and c) land-surface and climate interactions and their impact on regional climate. The ESMs will also be used to investigate the risk of abrupt changes to potential tipping points in the climate system, such as the stability of the Atlantic Ocean circulation and the stability of tropical and boreal forest ecosystems to global warming. Finally, the project *PEGASOS*⁶ - which will also contribute to the IPCC process - represent a major effort to reduce uncertainties related to impact of aerosol particles on climate.

There are also fundamental scientific uncertainties in characterizing both the climate and air quality impacts of short-lived gases and many aspects (for example, the regional dependence) are quite distinct to those for the longer lived climate gases already included in the Kyoto Protocol. The recently started initiative *ECLIPSE*⁷ will build on existing knowledge and use state-of-the-art chemistry and climate models to (i) improve understanding of key atmospheric processes (including the impact of short-lived species on cloud properties) and characterize existing uncertainties; ii) quantify the radiative forcing and climate response due to short-lived species, incorporating the dependence on where the species are emitted; (iii) refine the calculation of climate metrics, and develop novel metrics which, for example, consider rate of climate warming and go beyond using global-mean quantities; (iv) clarify possible win-win and trade-off situations between climate policy and air quality policy; (v) identify a set of concrete cost-effective abatement measures of short-lived species with large co-benefits.

2.2 Long-Term Global Goal and Climate Change Impacts

In order to inform the ongoing debate about the potential impacts associated with the long-term global goal to hold the increase in global average temperature below 2 °C above preindustrial levels and the possibility by the international community to consider strengthening the long-term temperature goal to a more limited warming of 1.5 °C above pre-industrial level, European researchers are investing significant efforts in reducing uncertainties in climate projections and in improving methodologies of assessing impact and vulnerabilities.

A multi-model analysis of future climate change undertaken under the framework of the ClimateCost8 project which aims at advancing knowledge of the economics of climate change has assessed three emission scenarios at both global and European scale⁹: a medium-high non-mitigation baseline scenario (A1B); a mitigation scenarios (E1), which stabilises global temperature change at about 2°C above pre-industrial level, and a high-emission scenario (RCP8.5). The analysis shows that under a medium-high emission baseline (A1B), with no mitigation, the climate models project that global average temperatures could rise by between 1.6°C and 2.3°C by 2041-2070, and 2.4°C and 3.4°C by 2071-2100, relative to the modelled baseline period used in the project of 1961-1990. However, the models project much larger temperature increases for Europe in summer, and strong regional differences across countries, for example, the Iberian Peninsula has a mean projected increase of up to 5°C by 2071-2100. The projections for the E1 (mitigation) scenario, broadly equivalent to the 2 degrees global target, only diverge significantly from A1B after 2040 (i.e. the differences only emerge in the latter part of the century). Therefore, mean global temperature is projected to increase by

⁶ "Pan-European Gas-AeroSOls-climate interaction Study" project (PEGASOS), <http://pegasos.iceht.forth.gr/>.

⁷ "Evaluating the CLimate and Air Quality ImPacts of Short-livEd Pollutants" project (ECLIPSE), <http://eclipse.nilu.no/>.

⁸ "Full costs of climate change" project (ClimateCost), www.climatecost.cc.

⁹ Christensen, O. B, Goodess, C. M. Harris, I, and Watkiss, P. (2011). European and Global Climate Change Projections: Discussion of Climate Change Model Outputs, Scenarios and Uncertainty in the EC RTD ClimateCost Project. In Watkiss, P (Editor), 2011. The ClimateCost Project. Final Report. Volume 1: Europe. Published by the Stockholm Environment Institute, Sweden, 2011. ISBN 978-91-86125-35-6. http://www.climatecost.cc/images/Policy_brief_1_Projections_05_lowres.pdf

about 1°C by 2011-2040 relative to the 1961-1990 baseline irrespective of the emission pathway. However, under an E1 stabilisation scenario all long-term changes are significantly reduced. Average global temperatures are projected to increase by about 1.5°C by 2071-2100 compared with the 1961-1990 baseline. The stronger wetter signal in Northern Europe and the drier summer in Southern Europe are both considerable reduced. However, even under this mitigation scenario, summer temperatures in Europe are projected to increase by more than 2°C and possibly in excess of 3°C by 2071-2100 relative to the 1961-2100 baseline, highlighting the need for adaptation and mitigation. The study has also considered the RCP8.5 'high' scenario which results in a global warming of about 3.5°C by 2071-2100 relative to the 1961-1990 baseline. The analysis highlights the uncertainty in projecting future climate change and how this results in wide variations in quantification of impacts and related level of damage costs. In turn, this uncertainty also affects estimation of the costs and benefits of adaptation. However, while it is essential to recognise and try to quantify this uncertainty, it is clear that there is a need to plan robust strategies to prepare for uncertain futures, rather than using uncertainty as a reason for inaction.

The EU-funded project **IMPACT2C10** – started in November 2011 – aims at better quantifying and enhancing knowledge of climate change impacts. The project will address issues related to climate and impacts modelling, vulnerabilities, risks and economic costs, as well as potential responses, within a pan-European sector based analysis. IMPACT2C utilises a range of models within a multi-disciplinary international expert team and assesses effects on water, energy, infrastructure, coasts, tourism, forestry, agriculture, ecosystems services, and health and air quality-climate interactions. IMPACT2C introduces key innovations. First, harmonised socio-economic assumptions/scenarios will be used, to ensure that both individual and cross-sector assessments are aligned to the 2°C (and 1.5°C) scenario for both impacts and adaptation. Second, it has a core theme of uncertainty, and will develop a consistent methodological framework integrating the uncertainties within and across the different sectors. In so doing, analysis of adaptation responses under uncertainty will be enhanced. Finally, a cross-sectoral perspective is adopted to complement the sector analysis. A number of case studies will be developed for particularly vulnerable areas, subject to multiple impacts (e.g. the Mediterranean), with the focus being on cross-sectoral interactions (e.g. land use competition) and cross-cutting themes (e.g. cities). The project also assesses climate change impacts in some of the world's most vulnerable regions: Bangladesh, Africa (Nile and Niger basins), and the Maldives. The first results from this project are expected by the end of 2012.

2.3. Climate Change and Marine Ecosystems

Acknowledging the key role of the marine environment in climate regulation, as well as the impacts that climate change and other stressors are having on marine ecosystems, the FP7 has invested significantly in better understanding the dynamic interactions between marine ecosystems, climate and atmospheric processes. All relevant results of EU-funded research about climate change impacts on the marine environment have been recently collected by the **CLAMER**¹¹ project which has summarized physical, biological and socio-economic effects of climate change in different European regions, and identified main research gaps in this field¹².

A relevant and pioneering line of research under FP7 has concerned ocean acidification, studied in the two projects **EPOCA**¹³ and **MedSeA**¹⁴. EPOCA significant results indicate that, due to the uptake of CO₂

¹⁰ "Quantifying projected impacts under 2°C warming" project (IMPACT2C), www.hzg.de/mw/impact2c.

¹¹ "Climate Change and Marine Ecosystem Research Results" project (CLAMER), <http://www.clamer.eu>,

¹² CLAMER project and Marine Board (2011), "Climate Change and Marine Ecosystem Research. Synthesis of European Research on the Effects of Climate Change on Marine Environments". Marine Board Special Report, pp. 151.

¹³ "European Project on Ocean Acidification" (EPOCA), <http://www.epoca-project.eu/>.

¹⁴ "MEDiterranean Sea Acidification in a changing climate" project (MEDSEA), <http://medsea-project.eu/>.

released by humans, 10% of Arctic surface waters will become corrosive to shells and skeletons of organisms in less than 10 years, and that half will become corrosive by mid-century¹⁵. The EPOCA time series observations confirm that this region is indeed a hotspot of rapid changes resulting from ocean acidification¹⁶. Biological and ecological responses of key organisms have been analysed in this region through a large-scale mesocosm experiment in the Kongsfjord off Svalbard, Norway. Moreover, EPOCA researchers have analysed a wide range of future climate scenarios, finding out that only stringent but economically feasible carbon emission mitigation measures would limit ocean acidification over this century (32% increase in acidity instead of 100% increase without mitigation)¹⁷. In the Mediterranean area, about 30% of marine plants and animals could be lost from coastal habitats by the end of this century due to the effect of ocean acidification¹⁸. The MedSeA project is currently undertaking a deeper investigation of the ecological impacts on the Mediterranean Sea due to warming and acidification, while in the next two years it will also investigate the socio-economic effects of acidification, particularly on tourism and aquaculture.

The **CARBOCHANGE**¹⁹ project aims to quantify more accurately the ocean CO₂ uptake under climate change and how it will evolve in the future. The project (endorsed by the IMBER²⁰ and SOLAS²¹ initiatives) has contributed to the newest Global Carbon Project budget analysis which shows that the world oceans took up 26% of CO₂ emissions to atmosphere in year 2010. In particular, through extensive dataset analysis and modelling work, CARBOCHANGE has calculated that the Nordic Seas presently provide 8% of the ocean carbon sink. Observational data from the project will be used to improve existing models in order to better predict future changes in ocean carbon cycle and assess the continuous effectiveness of northern Atlantic as sinks under future climate conditions.

Finally, several projects are also addressing issues related to the sustainable management of oceans and sea in the context of a changing climate. According to a multi-model analysis carried out as a joint work of many international projects, including the EU funded project **MEECE**²², climate change could lead to a decrease of primary productivity (PP) of the global ocean between 2% and 13% at the end of the century, with large regional disparities²³. However, at present, there is still a significant lack of knowledge regarding how multiple climate-related and anthropogenic stressors impact marine populations and how impending climate changes may alter the ecology and biogeochemical cycling of oceans. As part of a multidisciplinary

¹⁵ Beaufort L., Probert I., de Garidel-Thoron T., Bendif E. M., Ruiz-Pino D., Metzl N., Goyet C., Buchet N., Coupel P., Grelaud M., Rost B., Rickaby R. E. M. & C. de Vargas. 2011. Sensitivity of coccolithophores to carbonate chemistry and ocean acidification. *Nature* 476: 80–83.

¹⁶ Olafsson J., Olafsdottir S R, Benoit-Cattin A, Danielsen M, Arnarson T S and Takahashi T. 2009. Rate of Iceland Sea acidification from time series measurements. *Biogeosciences* 6: 2661-2668.

¹⁷ Joos F., Froelicher T. L., Steinacher M. and G-K Plattner. 2011. Impact of climate change mitigation on ocean acidification projections. pp. 272-290. In: Jean-Pierre Gattuso and Lina Hansson. *Ocean acidification*. Oxford University Press.

¹⁸ Rodolfo-Metalpa R., Houlbrèque F., Tambutté É., Boisson F., Baggini C., Patti F. P., Jeffree R., Fine M., Foggo A., Gattuso J-P. and J. M. Hall-Spencer. 2011. Coral and mollusc resistance to ocean acidification moderated by warming. *Nature climate change* 1: 308–312.

¹⁹ "Changes in carbon uptake and emissions by oceans in a changing climate" project (CARBOCHANGE), <http://carbochange.b.uib.no>

²⁰ Integrated Marine Biogeochemistry and Ecosystem Research (IMBER), www.imber.info.

²¹ Surface Ocean Lower Atmosphere Study (SOLAS), www.solas-int.org.

²² "Marine Environmental Evolution in a Changing Environment" project (MEECE), <http://www.meece.eu>.

²³ M. Steinacher, F. Joos, T. L. Frölicher, L. Bopp, P. Cadule, V. Cocco, S. Coney, M. Gehlen, K. Lindsay, J. K. Moore, B. Schneider, and J. Segschneider (2009) "Projected 21st century decrease in marine productivity: a multi-model analysis", *Biogeosciences Discuss.*, 6, 7933–7981, 2009

international effort linked with similar activities in the US and Canada, the FP7 program *EURO-BASIN*²⁴ aims to better understand the basin scale processes impacting upon these ecosystems, to be able to predict likely future ecosystem states due to climate change, and to be able to integrate from the basin scale to the local scales the economically important dynamics of basin and shelf ecosystems for the advancement of ecosystem based management strategies.

2.4. Sources and sinks of greenhouse gases (GHGs) from terrestrial ecosystems

Terrestrial ecosystems play a key role in the global carbon cycle, acting both as significant sources and sinks of GHGs. Deforestation, agricultural activities and land use changes account for a significant share of global GHGs emission, while at the same time there is a huge potential for increasing carbon sequestration capacity through afforestation, reforestation and forest conservation activities; improved agricultural practices; and natural ecosystem conservation and restoration. The EU is funding a series of projects that aim at improving understanding of terrestrial carbon cycle and its response to global warming and increased climate variability resulting from climate change.

The *CARBO-EXTREME*²⁵ project investigates the effect of climate variability and extremes on terrestrial carbon sources and sinks in Europe, including soil carbon. Important findings indicate that drought is likely to become a dominant threat to carbon-cycle related ecosystem services in Central and Southern Europe. Hence, climate-related targets should consider the water cycle and its variability. Taken together, climate extremes appear to have the most diverse, largest, often lagged and longest-lasting consequences for carbon cycling in forests compared to other land-cover types.

The main objective of a new project called *GHG-EUROPE*²⁶ is to calculate more accurately the contribution of different land-use types to the emissions of CO₂, CH₄ and N₂O in Europe and propose options available in agriculture and forestry to keep carbon sinks and minimise GHGs emissions. Preliminary results shows that the land use changes leave their traces in the carbon balance of ecosystems for decades to centuries. Carbon losses occur within 10 to 20 years while carbon uptake in soils is slow so that it can take a century or more to reach the original carbon stocks. This asymmetry of 'slow in - fast out' is not adequately considered in the National Submissions of many countries under the Kyoto Protocol. The project is also developing methodologies and data as scientific background for the new activity "wetlands management". The activities contribute to the ongoing update of the IPCC Guidelines and will facilitate the implementation of "wetlands management" under future commitments.

Permafrost deposits are estimated to contain approximately 50% of the estimated global below-ground organic carbon pool and more than twice as much as the amount contained in the current atmospheric carbon pool. A projected decline in the extent of permafrost will have a major impact on the Earth system, affecting global climate through the mobilization of carbon and nitrogen stored in permafrost. The recently started EU-funded project *PAGE21*²⁷ aims to understand and quantify the vulnerability of permafrost environments to a changing global climate, and to investigate the feedback mechanisms associated with increasing greenhouse gas emissions from permafrost zones. The project will use of a unique set of Arctic permafrost investigations performed at stations that span the full range of Arctic bioclimatic zones. International collaboration is a key aspect of PAGE21 which brings together numerous European institutions and a large number of international partners from Russia, Canada, USA, and Japan.

²⁴ "European Union Basin-scale Analysis, Synthesis and Integration" project (EURO-BASIN), <http://www.euro-basin.eu>.

²⁵ "The terrestrial Carbon cycle under Climate Variability and Extremes – a Pan-European synthesis" project (CARBO-EXTREME), <http://www.carbo-extreme.eu/>.

²⁶ "Greenhouse gas management in European land use systems" project (GHG-Europe), <http://www.ghg-europe.eu/>.

²⁷ "Changing Permafrost in the Arctic and its Global Effects in the 21st Century" project (PAGE21), <http://page21.org>.

Several on-going international research cooperation projects are also active in this field. Key scientific and technical aspects related to REDD+ are addressed by the projects **I-REDD+**²⁸ and **REDD-ALERT**²⁹ through analyses and case studies in Southeast Asia (China, Indonesia, Laos, Vietnam), Africa (Cameroon, Kenya, Nigeria) and Latin America (Colombia, Peru). Main objectives include: a) Quantifying GHG emissions and removals and improving accounting (methods, default values) of the consequences of land use change for GHG emissions in tropical forest margins including peatlands; b) Developing remote sensing and community based methods for monitoring of land use change and C-stocks; c) Assessing the benefits and costs of REDD+ for livelihoods at local levels (REDD+ rent vs. opportunity and transaction costs) as well as socio-cultural 'costs' of changing lifestyles and development pathways d) Developing and testing a monitoring, reporting and verification (MRV) systems. The **CLARIS LPB**³⁰ project aims at projecting the regional climate change impacts in La Plata Basin (LPB) in South America focusing on the 2010-2040 and 2070-2100 periods, and at designing adaptation strategies for land-use and other relevant economic sectors. The project to date has: (a) improved the description of past climate variability of the region and the understanding of key processes governing the climate natural low-frequency variability; (b) produced a coordinated ensemble of regional climate change scenarios, including the various components of the hydrologic cycle and the feedbacks on land-surface-atmosphere, also in terms of extreme events; (c) investigated some adaptation strategies for agriculture and hydrology sectors, in close collaboration with local stakeholders. Another recently started FP7 project, **AMAZALERT**³¹ focuses on the Amazon region and will in particular: (a) provide models of global climate and Amazon land use, vegetation and socio-economic drivers to quantify anthropogenic and climate induced land-use and land cover change; (b) define scenarios for possible courses of action in the region, including an early warning system for detecting any imminent irreversible loss of Amazon ecosystem services.

2.5. Polar research

The Arctic region is known to be particularly sensitive to increased greenhouse gas concentrations in the atmosphere. For instance, recent results from the **ATP**³² project showed that the temperature increase in the past 50 years is almost twice as large in the Arctic (1.1°C) than on global average (0.6°C)³³. The Arctic sea ice is diminishing at an alarming rate. The sea ice extent as well as its thickness has reduced significantly leading to the fact that today the summer arctic ice volume is only about half of what it was in the 1970s³⁴. The ATP project is also looking at implications on the marine ecosystem and socio-economic impact of the warming. In particular, it is working on the identification of potential tipping points due to climate change which may have severe consequences for fishing in the region.

Building on a long line of European research on the Arctic environment and climate change, several ongoing FP7 projects are also studying its atmosphere, cryosphere, hydrosphere and/or ecosystems, and analysing

²⁸ "Impacts of Reducing Emissions from Deforestation and Forest Degradation and Enhancing Carbon Stocks" project (I-REDD+), <http://www.i-redd.eu>.

²⁹ "Reducing emissions from deforestation and degradation through alternative land uses in rainforests of the Tropics" project (REDD-ALERT), <http://www.redd-alert.eu>

³⁰ "A Europe-South America network for climate change assessment and impact studies in La Plata Basin" project (CLARIS LPB), <http://www.claris-eu.org/>.

³¹ "Raising the alert about critical feedbacks between climate and long-term land use change in the Amazon" project (AMAZALERT), www.eu-amazalert.org.

³² Arctic Tipping Points (ATP) project, <http://www.eu-atp.org/>.

³³ Timothy M. Lenton (2012): Arctic Climate Tipping Points, *AMBIO* 41(1), 10-22.

³⁴ Wadhams, P. (2012). Ice cover, ice thickness and tipping points. *AMBIO* 41 (1): 23-33.

their interplay with climate change. The **RECONCILE**³⁵ project studies the atmosphere in the Arctic in order to better quantify the effects of climate change on stratospheric ozone depletion. Specifically, this project contributed to the recent discovery in 2011 of severe loss of ozone in the region³⁶. The **ice2sea**³⁷ project meanwhile is addressing the single most important source of uncertainty in projections of future sea-level rise by advancing the understanding of melting continental ice-sheets and glaciers in the polar regions. The project has completed its observational work and is finalizing its modelling component. The results of this project will be combined with contributions to global sea-level rise from other sources (e.g. thermal expansion) to produce state-of-the-art projections of future global sea-level rise that are expected contribute to the 5th Assessment report of the IPCC. A different project, **THOR**³⁸, is exploring the effects of the melting of the Greenland ice sheet on the global ocean circulation patterns. By the end of the project a reliable system to forecast changes in the circulation patterns due to melting ice-sheets will be in place, and estimates of the probability of extreme climate events in the European and North Atlantic region will be produced. In addition, the **HYPOX**³⁹ project is enhancing monitoring of oxygen depletion due to global warming and eutrophication in various water bodies, including the Arctic Ocean.

Finally, the **ACCESS**⁴⁰ project looks at climate change as an opportunity to develop economic activities such as transport, fisheries, oil and gas extraction in the Arctic region. It will take into account the effects of these activities on climate change and propose mitigation measures as well as options for more involvement of local populations in governance and decision-making processes.

2.6. Adaptation to Climate Change

Research into the manifold dimensions of impacts, vulnerability and adaptation to climate change continue to receive significant support by the FP7. For example, the project **CLIMSAVE**⁴¹ is developing largely qualitative scenarios at the European scale in the form of stories involving the participation of a broad range of stakeholders. The scenarios are developed along two major axes: *Solutions to innovation (effective to ineffective)* and *Economic development (gradual to 'rollercoaster')*. The resulting stories will be quantified and used as input for an Integrated Assessment Platform (IAP) that will serve as an interactive exploratory web-based tool improving the understanding of surrounding impacts, adaptation responses and vulnerability under uncertain futures. Its holistic framework is intended to complement, rather than replace, the use of more detailed sectoral tools used by sectoral professionals and academics. Final results including the public access of the IAP are expected for the end of 2012.

The project **MEDIATION**⁴² addresses key elements in the chain of impact, vulnerability and adaptation to climate change such as methods and metrics for impacts and vulnerability analysis and costs of impacts and adaptation options. The components of the project (methods and tools) will be connected in an iterative

³⁵ "Reconciliation of essential process parameters for an enhanced predictability of arctic stratospheric ozone loss and its climate interactions" project (RECONCILE), <https://www.fp7-reconcile.eu/>.

³⁶ Manney et al., Unprecedented Arctic ozone loss in 2011, Nature, 2011.

³⁷ "Estimating the future contribution of continental ice to sea-level rise" project (Ice2sea), <http://www.ice2sea.eu/>.

³⁸ "Thermohaline overturning - at risk?" project (THOR), <http://www.eu-thor.eu/>.

³⁹ "In situ monitoring of oxygen depletion in hypoxic ecosystems of coastal and open seas, and land-locked water bodies" project (HYPOX), <http://www.hypox.net/>.

⁴⁰ Arctic Climate Change, Economy and Society (ACCESS) project, www.access-eu.org/.

⁴¹ "Climate Change Integrated Assessment Methodology for Cross-Sectoral Adaptation and Vulnerability in Europe" project (CLIMSAVE), www.climsave.eu.

⁴² "Methodology for Effective Decision-making on Impacts and Adaptation" project (MEDIATION), <http://mediation-project.eu>.

fashion, making use of a number of diverse case studies in different regions in Europe which combine selected regional, sectoral and cross-sectoral characteristics and policy questions. In essence, the focus will be on the development of a decision support framework as a tool capable of the evaluation and strategic planning of adaptation measures and strategies with regard to hydro-meteorological and climate changes and extremes. The common platform will provide integrated web-enabled access to the MEDIATION toolbox, as well as to literature hints, spatially resolved climate impact and vulnerability maps, knowledge about regional adaptation, and guidelines how to use the information, taking due account of uncertainties. Final results are expected by the end of 2012.

Several European research projects have studied climate change impacts on the water cycle and provided recommendations about adaptation. The recently completed *WATCH*⁴³ project studied climate change impacts on the global water cycle with the aim to clarify the overall vulnerability of global water resources to climate change. WATCH results provide the first assessment of the global hydrological cycle on a daily time-frame at 50km grid scale resolution for the past (20th century) and future (21st century), as well as a new global analysis of water scarcity⁴⁴. Regional studies were also undertaken, focusing for instance on the Mediterranean area through the *CIRCE*⁴⁵ project which will soon publish the Regional Assessment Climate Change in the Mediterranean (RACCM) study. Current research also considers specific impacts of climate change on certain ecosystems and hydrological process. The *ACQWA*⁴⁶ project investigates the consequences of climate change in mountain regions where snow and ice are an important part of the hydrological cycle. Vulnerable groundwater and dependent ecosystems are studied under the *GENESIS*⁴⁷ project, while the *MIRAGE*⁴⁸ project studies climate change impacts on intermittent river management.

2.7. Climate Change and Natural Hazards

In the area of climate change and natural hazards, European research aims to improve understanding and modelling of climate changes related to the hydrological cycle at scales that are relevant to decision-making. At present, scientific information about water-related impacts of climate change and their socio-economic dimensions is not sufficient, especially with respect to water quality, aquatic ecosystems and groundwater. The FP7 is funding a series of on-going projects aimed at developing methods and technologies for improved assessment, forecasting and monitoring, management and mitigation of climate-related hazards, in particular floods and droughts,. For instance, the *IMPRINTS*⁴⁹ project is working on improving preparedness and risk management for flash floods and debris flow events and provides detection tools which are directly used by civil protection and meteorological services. The project *DROUGHT-R&SPI*⁵⁰ focuses on improved understanding of drought causes and impacts and on the development of early warning systems in Europe.

⁴³ "Global Change and Water" project (WATCH), <http://www.eu-watch.org>.

⁴⁴ Harding, R.J. and Warnaars, T.A. (2011), Water and global change: The WATCH Project Outreach Report. Centre for Ecology and Hydrology, Wallingford, 40pp. Available at <http://www.eu-watch.org>.

⁴⁵ "Climate change and impact research: the Mediterranean environment" project (CIRCE), www.circeproject.eu.

⁴⁶ "Assessing Climate change impacts on the Quantity and quality of Water" (ACQWA) project, www.acqwa.ch.

⁴⁷ "Groundwater and Dependent Ecosystems" project (GENESIS), www.thegenesisproject.eu.

⁴⁸ "Mediterranean intermittent river management" project (MIRAGE), www.mirage-project.eu.

⁴⁹ "Improving Preparedness and Risk Management for Flash Floods and Debris Flow Events" project (IMPRINTS), <http://imprints-fp7.eu>.

⁵⁰ "Fostering European Drought Research and Science-Policy Interfacing" project (DROUGHT-R&SPI), www.eu-drought.org.

This initiative is complemented by the *DEWFORA*⁵¹ project which establishes a strong international cooperation partnership among EU and African countries. In the same vein of international cooperation, the *CORFU*⁵² project is developing advanced strategies for improved flood management in cities in partnership with China, India and Bangladesh, while the *CLIWASEC*⁵³ cluster of projects on 'Climate change impacts on water and security' builds up cooperation among EU countries and neighbouring Mediterranean countries aimed at analysing, using a multidisciplinary approach, the effects of climate change on water and human security, and to identify effective adaptation and prevention measures. Finally, going beyond impact assessment, the *CONHAZ*⁵⁴ project has compiled and synthesised current knowledge on cost assessment methods to strengthen the role of cost assessments in the development of integrated natural hazard - including climate-related extreme events - management and adaptation planning⁵⁵.

2.8. Climate Change and Health

Climate change will affect and impact human health in different ways. In addition to direct impacts of projected temperature changes on human health (e.g. heat-waves, cold snaps) and the effects on human security of natural hazard and extreme weather events, climate change will impact on the future distribution and spread of infectious diseases, and in particular of Vector-Borne Diseases (VBDs). The impacts may be direct, in terms of outbreaks of disease among human populations, or indirect, in the form of outbreaks of diseases that affect domesticated animals or plants, and therefore jeopardise food security, agriculture-based economic activities and trade.

Amongst the FP7-funded projects working in this field, the initiatives *HEALTHY FUTURES*⁵⁶ and *QWeCI*⁵⁷ bring together European and African research to investigate the interplay between climate variability and a number of human and animal diseases with major socio-economic impacts in Africa (Kenya, Malawi, Rwanda, Senegal, South Africa and Uganda), particularly high-impact vector-borne diseases such as malaria and Rift Valley fever. Outcomes of the projects will allow health stakeholders and planners to react in a timely and cost-effective manner to reduce the severity of epidemic outbreaks and make long-term decisions regarding health infrastructure investment. Along the same lines, the project *VIROCLIME*⁵⁸ will use hydrological models to determine the effects of climate change on the variation in viral flux, and therefore in risk associated with viral disease to promote a novel approach to the management of water-related disease. Case studies from European countries and Brazil are being undertaken to produce an empirical baseline that will inform the subsequent modelling work of the project.

⁵¹ "Improved Drought Early Warning and FORecasting to strengthen preparedness and adaptation to droughts in Africa" project (DEWFORA), www.dewfora.net.

⁵² "Collaborative research on flood resilience in urban areas" project (CORFU), www.corfu-fp7.eu.

⁵³ The CLIWASEC cluster is made up of the following projects: "Climate Change, Hydro-conflicts and Human Security" (CLICO), "Climate Induced Changes on the Hydrology of Mediterranean Basins" (CLIMB) and "Water Availability and Security in Southern Europe and the Mediterranean" (WASSERMed). The cluster website is www.cliwasec.eu.

⁵⁴ "Costs of Natural Hazards" (CONHAZ) project, <http://conhaz.org>.

⁵⁵ CONHAZ project (2012), "Costs of Natural Hazards - A Synthesis", available at <http://conhaz.org>.

⁵⁶ "Health, environmental change and adaptive capacity: mapping, examining and anticipating future risks of water-related vector-borne diseases in eastern Africa" (HEALTHY FUTURES), www.healthyfutures.eu.

⁵⁷ "Quantifying Weather and Climate Impacts on Health in Developing Countries" project (QWeCI), www.liv.ac.uk/qweci.

⁵⁸ "Impact of climate change on the transport, fate and risk management of viral pathogens in water" project (VIROCLIME), www.viroclimate.org.

The health impacts of greenhouse gas (GHG) reduction policies in Europe, China and India are being studied by the projects *PURGE*⁵⁹ and *URGENCHE*⁶⁰. Both projects are experimenting different approaches to modelling of health-related exposures in different urban settings and are developing methodological frameworks to assess urban GHG reduction policies with the greatest co-benefits on health and well-being of local populations. The ultimate objective is to deliver assessment tools and guidance that are useful for the development of win-win mitigation policies for different urban areas in Europe and Asia.

Another set of projects is investigating additional health-related impacts of climate change such as the impact of increased UV radiation (*ICEPURE*⁶¹ project) and the risks associated with the potential remobilization of environmental contaminants (such as mercury, PCBs, etc.) for human population in the Arctic and Europe (*ArcRisk*⁶² and *CLEAR*⁶³) in order to gain insight into changes that may later impact other areas and assess future scenarios related to climate change.

2.9. Economics of Climate Change Mitigation and Adaptation

The area of economics of climate change is increasingly gaining prominence at the European level. In addition to the already active projects mentioned below, several projects will be launched in 2012 and 2013 to further support research on issues related to economic assessment of costs and benefits of mitigation policies at the European and global level, as well as the estimation of costs of inaction and costs and benefits of adaptation.

Amongst the already active FP7-funded projects in this field, the *CLIMATECOST*⁶⁴ project has carried out an assessment of impacts and economic costs of climate change in Europe and at the global level. This included a bottom-up sectoral impact assessment for Europe, as well as a global economic modelling analysis with sector-based impact models and utilization of computable general equilibrium models. The work undertaken under the project has been summarized in short technical policy briefs focusing on the impacts and costs related to sea level rise, river floods, energy, health and ancillary air quality benefits in Europe that are already available, while the final reports at the global level will be released before the end of the year. The project *AMPERE*⁶⁵ is carrying out an intercomparison of different energy-economy-climate models to produce more robust assessments of the costs associated with bringing about long-term emissions reductions and with promoting low carbon technology. This project will shed light on how a variety of assumptions – concerning for instance future climate policy and available mitigation options – affect the mitigation scenarios, their feasibility and cost. In its first year of life, AMPERE has analysed the scenarios produced by the range of 18 models in the case of no global climate policy. In the next year, the scenarios under a range of other assumptions will be produced. The *LIMITS*⁶⁶ project, launched in October 2011, will use key global integrated assessment models to run climate mitigation and adaptation scenarios under new

⁵⁹ "Public health impacts in URban environments of Greenhouse gas Emissions reduction strategies" project (PURGE).

⁶⁰ "Urban Reduction of GHG Emissions in China and Europe" project (URGENCHE), www.urgence.eu.

⁶¹ "The impact of climatic and environmental factors on personal ultraviolet radiation exposure and human health" project (ICEPURE), www.icepure.eu.

⁶² "Arctic health risks: Impacts on health in the Arctic and Europe owing to climate-induced changes in contaminant cycling" project (ArcRisk), www.arcrisk.eu.

⁶³ "Climate change, environmental contaminants and reproductive health" project (CLEAR), www.inuendo.dk/clear.

⁶⁴ "Full costs of climate change" project (CLIMATE COST), www.climatecost.cc.

⁶⁵ "Assessment of Climate Change Mitigation Pathways and Evaluation of the Robustness of Mitigation Cost Estimates" project (AMPERE), <http://ampere-project.eu>.

⁶⁶ "Low Climate Impact Scenarios and the Implications of required tight emission control strategies" project (LIMITS), www.feem-project.net/limits.

conditions and constraints. The policy implications will be thoroughly evaluated. Thirteen models will be used throughout the project covering a wide range of different aspects. Using these models, LIMITS will explore the implications and uncertainties in reaching a 2°C target under different assumptions regarding the remaining leeway for greenhouse gas emissions, technology availability, the participation of different regions in international climate policy, and implementation obstacles. LIMITS will place particular emphasis on the major global economies as they account for most of the emissions and host the largest mitigation capacity.

Under the Socio-economic Sciences and Humanities (SSH) theme of FP7, the EU is also supporting several projects addressing broad issues related to a transition to sustainable, low-carbon societies, and in particular the nexus among energy, environment, transport and land-use. The *PACT*⁶⁷ project investigates societal transition to a low carbon future using both "back-casting" and traditional "forecasting" on long and very-long term scales (up to 2100) and has contributed to the report "World and European Energy and Environment Transition Outlook" (WETO-T)⁶⁸ that was published at the end of 2011. Two modelling-oriented research projects called *PASHMINA*⁶⁹ and *GLOBAL-IQ*⁷⁰ are looking at long-term societal transformation in the context of global environmental change, including climate change. The SSH specific programme is also funding *SPREAD*⁷¹, a qualitative and participatory social platform on sustainable lifestyles, focusing on mobility patterns, residential sector habits and production/consumption. Finally, it also worth mentioning the EU support to foresight expert group and report called "Global Europe 2050"⁷² that tackles, amongst others, the questions of energy and climate change in both the "narrative scenarios" and in their quantification.

2.10. Geoengineering

In order to address a significant knowledge gap, the EU is supporting projects that investigate the efficacy, costs and potential side effects of various climate engineering options. The project *IMPLICC*⁷³ is currently investigating the feasibility and implications of certain solar radiation management techniques, while a new initiative for a comprehensive assessment of key geoengineering options will start in mid-2012 with the aim to address the associated risks and uncertainties, as well as socio-economic and governance issues.

2.11. Climate Change, Agriculture and Food security

Under the FP7 theme on the "Knowledge-Based Bio Economy" (KBBE), additional major research efforts are being promoted by the EU to tackle problems related to the increasing global demand for food and biomass and their environmental and climate implications. Several projects funded under this theme are directly relevant to the work done by the UNFCCC as they address both the mitigation and adaptation potential of more sustainable and climate resilient primary production systems.

⁶⁷ "Pathways for carbon transitions" project (PACT), www.pact-carbon-transition.org.

⁶⁸ European Union (2011), "World and European Energy and Environment Transition Outlook".
http://ec.europa.eu/research/social-sciences/pdf/publication-weto-t_en.pdf.

⁶⁹ "Paradigm shifts modelling and innovative approaches" project (PASHMINA), www.pashmina-project.eu.

⁷⁰ "Impacts quantification of global changes" project (GLOBAL-IQ).

⁷¹ "Social Platform identifying Research and Policy needs for Sustainable Lifestyles" project (SPREAD),
www.sustainable-lifestyles.eu.

⁷² European Union (2011), "Global Europe 2050". http://ec.europa.eu/research/social-sciences/events-191_en.html

⁷³ "Implications and risks of engineering solar radiation to limit climate change" project (IMPLICC),
<http://imPLICC.zmaw.de>.

For instance, several projects – often involving broad international cooperation with developing countries – are investigating water use in agriculture, taking into account a changing climate. The issue has been mainly tackled by improving crops drought resistance (*PGRSECURE*⁷⁴ and *DROPS*⁷⁵) and by enhancing water use efficiency in irrigated agriculture (*SIRRIMED*⁷⁶, *EAU4FOOD*⁷⁷ and the recently selected *FIGARO*⁷⁸). The projects *SMARTSOIL*⁷⁹ and *CATCH-C*⁸⁰ aim to identify and promote the best farming practices to preserve soil functions and fertility, improve production and reduce carbon emissions. In the area of livestock production, several projects deal with both animal management strategies and breeding solutions, with projects such as *ANIMALCHANGE*⁸¹ and *NEXTGEN*⁸², addressing respectively mitigation and adaptation options for sustainable livestock production under climate change, and methods to preserve farm animal biodiversity and improve sector resilience.

Other projects aim at building knowledge on the opportunities, risks and feasibility of exploiting energy crops as alternative to fossil fuels, such as *SWEETFUEL*⁸³ focusing on sweet sorghum as biomass for energy production, and the project *JATROPT*⁸⁴ on *Jatropha curcas*.

In the forestry area the project BACCARA⁸⁵ studies the effect of climate change on forest biodiversity and productivity, while the project BENWOOD⁸⁶ promoted the exchange of experience in the area of Short Rotation Forestry (SRF) in the framework of the Kyoto protocol and developed SRF guidelines and standards for land use management in CDM countries, with focus on Brazil, India, China and African countries.

2.12. Low-carbon Technologies

Within the “Cooperation” programme of FP7, additional climate change mitigation research, particularly concerning the development of low-carbon technologies, is funded under the “Energy”, “Transport (including aeronautics)” and “Information and Communication Technologies (ICT)” themes. With a budget of €2.3 billion, the Energy theme focuses on sustainable energy solutions aimed to reduce GHG emissions, including renewable energy technologies, clean coal technologies, smart energy networks, and energy

⁷⁴ "Novel characterization of crop wild relative and landrace resources as a basis for improved crop breeding" project (PGRSECURE), <http://pgrsecure.org>.

⁷⁵ "Drought-tolerant yielding plants" project (DROPS), www.drops-project.eu.

⁷⁶ "Sustainable use of irrigation water in the Mediterranean region" project (SIRRIMED), www.sirrimed.org.

⁷⁷ "European Union and African Union cooperative research to increase food production in irrigated farming systems in Africa" project (EAU4FOOD), www.eau4food.info.

⁷⁸ "Flexible and precise irrigation platform to improve farm scale water productivity" project (FIGARO).

⁷⁹ "Sustainable farm management aimed at reducing threats to soils under climate change" project (SMARTSOIL), <http://smartsoil.eu/>

⁸⁰ "Compatibility of agricultural management practices and types of farming in the EU to enhance climate change mitigation and soil health" project (CATCH-C), www.catch-c.eu.

⁸¹ "An integration of mitigation and adaptation options for sustainable animal production under climate change" project (ANIMALCHANGE), www.animalchange.eu.

⁸² "Next generation methods to preserve farm animal biodiversity by optimizing present and future breeding options" project (NEXTGEN), <http://nextgen.epfl.ch>.

⁸³ "Sweet sorghum, an alternative energy crop" project (SWEETFUEL), www.sweetfuel-project.eu.

⁸⁴ "*Jatropha curcas*, applied and technological research on plant traits" project (JATROPT), www.jatropt.eu.

⁸⁵ "Biodiversity and climate change, a risk analysis" project (BACCARA), www.baccara-project.eu.

⁸⁶ "Coordination actions in support of sustainable and eco-efficient short rotation forestry in CDM countries" project (BENWOOD), www.benwood.eu.

efficiency and savings. With a budget of €4.2 billion, the “Transport” theme includes, among its activities, the reduction of GHG emissions from both air transport and surface transport. Finally, with a budget of €9 billion, the ICT theme encompasses research on intelligent ICT-based transportation systems, as well as on solutions to prevent or reduce vulnerability and to mitigate the consequences of natural disasters.

It should also be mentioned that several European Technology Platforms (ETPs) have been established in support of FP7 planning. The ETPs are industry-led fora charged with defining research priorities in a broad range of technological areas. Amongst the established ETPs, several focus on environmental technologies aimed to reduce GHG emissions, such as the ETP for "Zero Emissions Fossil Fuel Power Plants", the ETP for "Hydrogen and Fuel Cell Platform" and the ETPs for "Photovoltaics, Wind energy and Biofuels". Furthermore, a Joint Technology Initiative (JTI) on "Fuel Cells and Hydrogen" has been set up as tool to support the implementation of the related ETPs Strategic Research Agendas through a public/private partnership financing mechanism.

Further information is available on the Europa server at <http://ec.europa.eu/research/index.cfm?lg=en&pg=who&cat=a&tips=on>.

3 EUROPEAN CLIMATE CHANGE RELATED RESEARCH INFRASTRUCTURES SUPPORTED BY FP7

FP7 supports as well – through its Capacities Programme - the management of existing European research infrastructures providing funds for networking, for granting transnational access to researchers and for developing the infrastructure potential. In the field of climate change research, projects have been granted for several observing systems and for large scale facilities, among which: ocean research vessels⁸⁷, simulation chambers for atmospheric processes⁸⁸, earth system modelling supercomputing⁸⁹, airborne research⁹⁰, arctic terrestrial research⁹¹, aerosols-clouds and trace gases⁹², non-CO2 observing system⁹³, the global ocean observing system⁹⁴.

Support has been as well granted for supporting the development of new research infrastructures, like: **EUROARGO** (the global ocean observing system), **ICOS** (the integrated carbon observing system), **COPAL**⁹⁵ (a high payload aircraft for atmospheric research), **IAGOS-ERI**⁹⁶ (instrumented commercial aircrafts for tropospheric research) and **SIOS**⁹⁷ (the Svalbard integrated Arctic earth observing system).

Several of the above mentioned infrastructure projects contribute to the various global observing systems and participate to the building of the Global Earth Observation System of Systems (GEOSS).

⁸⁷ www.eurofleets.eu.

⁸⁸ www.eurochamp.org.

⁸⁹ <https://is.enes.org>.

⁹⁰ www.eufar.net.

⁹¹ www.eu-interact.org.

⁹² www.actris.net.

⁹³ www.ingos-infrastructure.eu.

⁹⁴ www.euro-argo.eu.

⁹⁵ www.copal.net.

⁹⁶ www.iagos.org.

⁹⁷ www.sios-svalbard.org.

4 INTERNATIONAL COOPERATION UNDER FP7

International cooperation with third countries is an integral feature of the EU Framework Programmes for Research ranging from large-scale international collaboration efforts to the promotion of networking platforms and increased researcher mobility. All parts of the Programme are open to international cooperation. As demonstrated by several projects mentioned in this information note, participation of and collaboration with researchers from both other developed countries and developing countries is widely encouraged throughout FP7 and well beyond the specific tools supporting international cooperation. Furthermore, it should also be noted that, given the global nature of climate change, the international cooperation dimension of FP7 is particularly significant under the theme "Environment (including climate change)". In this respect, it is worth noting that already under the 6th Framework Programme (2002-2006), the "Global Change and Ecosystems" thematic programme was the one with the highest third country participation (more than €37 million granted to third country participants).

Under FP7, there are various projects, falling under the category of "**Specific International Cooperation Actions (SICAs)**", dedicated specifically to international cooperation, with a geographical focus on developing countries. Under FP7, €180 million have been budgeted to fund these activities. SICAs address research problems of mutual interest and benefit between the EU and international cooperation partner countries (ICPC). In particular, they aim to: support EC scientific and economic development through strategic partnerships with third countries in selected fields of science; facilitate contacts with research partners in third countries; and address specific problems that third countries face or that have a global character. Throughout the implementation of FP7, several calls have targeted international cooperation activities with Latin America, Africa, and Asian countries, resulting in the funding of a number of climate change-related projects, including research on the health impacts of climate change-induced droughts and desertification, on the development of sustainable energy systems, on natural resources management and climate-resilient agriculture, etc.

5 FURTHER INFORMATION ON FP7

EU's Research Portal:	www.ec.europa.eu/research
General information on FP7:	www.ec.europa.eu/research/fp7
Participants Portal (Specific information on FP7 programmes, projects and calls):	https://ec.europa.eu/research/participants/portal/page/home
CORDIS project database	http://cordis.europa.eu/projects/home_en.html
Overview of projects funded by the Environment (including climate change) Theme	http://ec.europa.eu/research/environment/index_en.cfm?pg=climate
For updates of particular collaborative opportunities in 2012 for third countries and regions:	http://ec.europa.eu/research/inco

SysTEM for Analysis, Research and Training

Introduction

START (the SysTEM for Analysis, Research and Training) is a non-governmental research organization that assists developing countries in Africa and Asia-Pacific to build the scientific expertise and knowledge needed to explore the drivers of and solutions to global and regional environmental change. Our goal is to reduce vulnerability through research-driven capacity building that informs decision-making. START's long-term commitment to building capacity through promoting multidisciplinary and multi-sectoral research and assessment activities and science-based communication has contributed significantly to enhancing the capabilities of individuals and institutions in Africa and Asia-Pacific to undertake global environmental change research.

Program highlights

Promoting adaptation research in Africa

The *African Climate Change Fellowship Program (ACCFP)*, a collaboration between the University of Dar es Salaam and START, promotes innovative research and education on adaptation in Africa. The program supports African professionals, researchers, educators and graduate students to undertake activities that enhance their capacities for advancing and applying knowledge for climate change adaptation in Africa, through Policy Fellowships, Doctoral Research Fellowships, Post-Doctoral Fellowships and Teaching Fellowships. Through two rounds of the program, nearly 100 Fellows from over 25 countries in Africa have worked at over 15 African 'host' universities and research centers to complete their studies. The Fellowships cover areas of food security, human health, ecosystem services, and disaster risk reduction.

Advancing knowledge about global environmental change, agriculture and food security

Assessments of urban and peri-urban agriculture and climate change. START in partnership with UNEP, WMO, IPCC, USAID, the University of Ghana, the University of Daressalaam and the Bangladesh Centre for Advanced Studies recently launched a 9-city assessment on urban and peri-urban agriculture and climate change. Interdisciplinary teams of scientists are carrying out the assessment in Dakar, Senegal; Tamale, Ghana; Ibadan, Nigeria; Daressalaam, Tanzania; Kampala, Uganda; Addis Ababa, Ethiopia; Dhaka, Bangladesh; Kathmandu, Nepal; and Chennai, India. The assessment focuses on how rapid urbanization and global environmental change, including climate change, could affect food production systems in and around these cities. Such production systems generate much of the non-staple foods that contribute significantly to nutritional security for urban dwellers and are a key livelihood resource of the urban poor.

African Grants Program on Global Environmental Change. In 2011, START awarded grants to research teams in 16 African countries to examine how changes in ecosystem services affect livelihoods and food security, the potential for promoting adaptation through diversification of farming systems, and climate change impacts on staple food crops. In late 2012, START will convene a Learning Forum to bring together grantees from the 16 projects and other specialists from Africa to share findings of their research, develop synthesis papers, and examine ways of more effectively communicating their findings to decision makers.

Building skills for interpretation, analysis and application of climate model data in Africa

START is partnering with the WCRP, the Climate Systems Analysis Group at the University of Cape Town, the International Center for Theoretical Physics and the Swedish Meteorological and Hydrological Institute, the Climate and Development Knowledge Network and the UNDP Africa Adaptation Programme to promote skill development for analyzing and interpreting data generated from the WCRP-led Coordinated Regional

Downscaling Experiment initiative. The training program engages African hydro-meteorology and climate experts with vulnerability and adaptation experts. Thus far, over 40 Africans have been engaged. In 2012, START, the University of Cape Town's Climate Systems Analysis Group, ACMAD and UNDP-AAP will co-convene a workshop in West Africa on interpretation and analysis of downscaled climate model data for West Africa.

Supporting adaptation planning in vulnerable cities

START's ongoing, multi-year program "Cities at Risk" is promoting and supporting the development of urban adaptive capacities in Asian coastal megacities, with particular emphasis on integrating science and policy in managing and reducing risks and vulnerabilities brought on by climate change and urban growth. The program engages scientists, city planning professionals, representatives from policy and development organizations and other civil society practitioners in visioning exercises, training on vulnerability assessments and communication initiatives. This effort is in collaboration with START's Southeast Asia Regional Research Center, the East West Center, Asia-Pacific Network, and Academia Sinica based in Taipei.

The second international conference on "Cities at Risk: Building Adaptive Capacities for Managing Climate Change Risks in Asian Coastal Cities (CAR II)" held 11-13 April 2011 in Taipei, Taiwan engaged over 80 participants and consolidated a network of researchers, decision-makers and institutions in the region. More recent activities include organization of a national science policy dialogue for North Coastal Jakarta (Indonesia) that produced a two-year action plan for climate change training and communication activities for the city. Collaborative activities with Ho Chi Minh City and Mumbai will take place in 2012.

Promoting research on disaster risk reduction and global environmental change

Integrated Research for Disaster Risk (IRDR) Program. Over the next several years, START will be engaged in international capacity building activities to support the Science Plan of the Integrated Research for Disaster Risk (IRDR) program— a global initiative co-sponsored by ICSU, the United Nations International Strategy for Disaster Reduction, and the International Social Science Council. The three IRDR priority themes are characterization of hazards, vulnerability and risk; understanding decision-making in complex and changing risk contexts; and reducing risk and curbing losses through knowledge-based actions.

During the past year START collaborated with the IRDR to establish an International Center of Excellence for IRDR at the Academia Sinica based in Taipei, Taiwan. In March 2012, START in collaboration with the Taipei Center, conducted an advanced institute on forensic investigations of disasters to train 25 Asian scientists and practitioners on factors that contribute to exposure, vulnerability, resilience and recovery from disaster events. A follow-up advanced institute will be held late in 2012. In addition, START is organizing a series of senior level international guest lecturers and visiting research fellows to contribute to the IRDR effort in Asia.

Disaster risk research in South Asia. START is collaborating with CDKN to promote policy relevant research on disaster risk reduction and climate change adaptation in South Asia. The two-year program funds interdisciplinary investigations on DRR and climate change with an emphasis on research to inform policy and decisions concerning governance at local/regional scales. A learning forum will be held near the end of the project to share results among the researcher teams, the regional scientific community, and regional policy makers and practitioner groups.

Building African Capacity for Conserving Biodiversity in a Changing Climate

This education and training program addresses the challenge of managing emerging risks to biodiversity from climate change in the biodiversity-rich Albertine Rift region of eastern Africa. The International START Secretariat and the Institute of Resource Assessment (IRA) at the University of Dar es Salaam are jointly implementing this effort with funding from the MacArthur Foundation.

The program, hosted at IRA, offers MS-level course for conservation practitioners from the region coupled with externships that allow program participants to apply knowledge from the courses to field-based conservation efforts. The MS-level course focuses on climate change risks to ecosystems and biodiversity, and explores strategies for conserving biodiversity under a changing climate. In the second round of the program, START added a training component aimed at educators from regional universities. The training component includes on-line distance learning course modules (currently under development) that will help faculty at regional universities to develop courses that fit their teaching needs.

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Website : www.start.org

Submission from the Inter-American Institute for Global Change Research (IAI)

In response to the invitation by the 35th Session of the Subsidiary Body for Scientific and Technological Advice (SBSTA) to provide information on the technical and scientific aspects of emissions by sources, removals by sinks and reservoirs of all greenhouse gases from coastal and marine ecosystems (mangroves, tidal salt marshes, wetlands and seagrass meadows), the Inter-American Institute for Global Change Research (IAI) presents in this submission, emerging research findings from its multinational Consortium for the study of ocean related global and climate changes in South America (SACC). SACC is a multinational, multidisciplinary research network led by the *Servicio de Hidrografía Naval* of Argentina in collaboration with scientists in Argentina, Brazil, Chile, the United States and Uruguay.

The upcoming United Nations Conference on Sustainable Development (Rio+20) is calling attention to the urgency of taking action to ensure the sustainable management and use of oceans and their marine resources. IAI's SACC research is conducted on the Patagonian shelf and neighboring western South Atlantic Ocean, which contains one of the most productive marine ecosystems. It is identifying the physical and biological mechanisms that control the oceanic biological production and the exchanges of CO₂ between the ocean and the atmosphere. SACC's findings are providing an understanding of regional carbon sources and sinks to inform policy-makers on possible mitigation approaches. The Patagonia shelf may play a special role in the global CO₂ balance because its nutrient supply and carbon sequestration depend on a permanent upwelling caused by ocean currents, rather than on seasonal winds as is the case of the most productive marine regions. This means that in frontal regions, where upward nutrient fluxes are quasi-continuous, productivity extends throughout the summer and early fall. Observations and numerical simulations suggest that these frontal regions are maintained by mixing induced by tides, and by the interaction between an intense slope current and the topography of the ocean floor. The productivity of lower trophic levels spreads through the food web, reaching top predators which include commercial fish, marine birds and mammals. At the same time predation (including fisheries) affects the diversity of this food chain, resulting in a close link between productivity and diversity.

The Convention on Biological Diversity (CBD) at its 10th Conference of the Parties (COP10) adopted a ten-year Strategic Plan for Biodiversity (including the Aichi Targets). CBD Parties have emphasized that the identification of ecologically or biologically significant areas and selection of conservation and management measures is a matter for States and competent intergovernmental organizations. As an intergovernmental organization, the IAI is committed to promoting international cooperation and providing scientific information to policy makers. IAI's SACC research on the Southern Brazilian Sea was discussed at a recent CBD workshop in Recife, Brazil following a request from CBD COP-10 for a series of regional workshops to be held on Ecologically or Biologically Significant Marine Areas (EBSAs) to facilitate the description of these areas through the application of scientific criteria and guidance on the identification of marine areas beyond national jurisdiction. The workshop concluded with the adoption of the southern Brazilian seas as an EBSA and a recommendation for the organization of a workshop involving other partners for the SW Atlantic.

SACC findings are improving the understanding of the energy and matter fluxes among different ocean areas and the physical and biological mechanisms that mediate those exchanges, including processes with major impact on the global carbon balance. Life in the ocean is not uniformly distributed, with abundance and biodiversity concentrated in relatively small productive spots separated by vast, less productive regions. The Patagonian shelf break has a harvest of millions of tons of fish and squid every year. Overfishing and the resulting decrease in fish population could affect zooplankton and phytoplankton communities - thereby

disrupting the ability of the ocean to capture CO₂. Such alterations of the marine ecosystem are analogous to the impact of land-use change on the continental carbon budget.

Seagrasses and mangroves are known for being ecosystem carbon sinks which can be restored, providing for mitigation and blue carbon initiatives. However, the primary production in the ocean is, in itself, a huge natural sink. Since such oceanic sinks are not evenly distributed, there is merit to identifying areas that are important sinks, and then try to manage outside impacts on those areas (nutrient inputs, overfishing, habitat destruction, etc.). This would hopefully allow for keeping the carbon removal properties of these important oceanic areas.

Phytoplankton growth plays a significant role in global climate because photosynthesis leads to the absorption of CO₂ dissolved in sea water and promotes further uptake from the atmosphere. This CO₂ absorption from the atmosphere, referred to as the biological pump, is partly responsible for the oceanic control of the global climate. Subsequent transport of the biologically fixed carbon into the deep ocean is thought to be the ultimate long-term sink for as much as 90% of the human-derived carbon dioxide, but models still do not capture all of the important mechanisms or pathways for carbon from the biologically active surface layers into the deep ocean.

The ocean uptake of about two billion metric tons of carbon per year is nearly balanced by a very large release of carbon with only a small net uptake remaining. A change in the processes controlling that delicate balance could be a game changer when it comes to predicting future atmospheric CO₂ and resulting climate change.

Oceanographic surveys over the Patagonia continental shelf and adjacent western boundary currents have revealed that the region is a strong sink of atmospheric CO₂, at rates comparable to regions of strongest CO₂ uptake in the World Ocean, such as the northern North Atlantic. The estimated uptake of 17 million metric tons of carbon per year in the Patagonian continental shelf is equivalent to all the carbon content of 100 thousand hectares of rainforest. Although carbon fluxes over continental shelves are very large, the natural fluxes only become a factor in the mitigation of anthropogenic carbon emissions if the resulting carbon sequestration changes relative to its pre-industrial size. In fact, these natural fluxes are so large, that small changes can have a major impact on the scale of our emissions reduction targets. The mitigation effect also critically depends on how long the CO₂ remains sequestered.

SACC studies have shown that the offshore currents, which are themselves controlled by the large-scale wind field, exert a strong influence on the continental shelf circulation. In the case of the Malvinas Current, this influence manifests itself in the northward spreading of cold waters derived from Patagonia up to the latitude of southern Brazil, thus creating the strong Subtropical Shelf Front. Similar transitions have been identified between the South Atlantic Bight and the Mid Atlantic Bight in the east coast of the US. The frontal region plays a significant role in the early life cycle of various commercial species in southern Brazil. The possible biogeochemical implications of these fronts still need to be investigated.

UNFCCC decision 9/CP.11 recognizes the need to enhance the contribution of developing countries to climate change research efforts, including by building the capacity of these countries to contribute to and participate in climate change research and invites regional organizations to promote a multidisciplinary approach to address research on cross-cutting issues. The IAI, through its collaborative multinational, multidisciplinary SACC network has significantly contributed to improving the research capacity of developing countries in the Americas and has had a concrete impact in the development of marine sciences in South America. SACC has created important integrated international and interdisciplinary institutional links. Without these links, continental shelf oceanography research would simply not have been possible.

Furthermore, this network has published their findings in dozens of international journals and developed the capacity of 200 young scientists from developing countries through its training activities and scholarships.

Information on scientific and technical aspects of emissions and removals from coastal and marine ecosystems needs to be integrated with similar information relating to pelagic and benthic systems in the open ocean and the deep sea, such as the Patagonian continental shelf. *SBSTA may wish to consider in its Research Dialogue, the inclusion of scientific constituencies working with all relevant marine systems that significantly contribute to carbon-related issues.*

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IAI-South American Climate Change Consortium (SACC)

http://sacc.coas.oregonstate.edu/~sacc/project_sacc_ai_crn2.php

Setting:

The continental shelf of the southwestern Atlantic (SWA) is an irregularly shaped platform that extends from the tropic of Capricorn to the southern tip of South America. With a total area of 2.7 million km² this broad and relatively smooth submarine terrace is the largest continental shelf in the southern hemisphere. Located along its western margin are some of the most important industrial and commercial centers of Latin America: Rio de Janeiro, Sao Paulo, Montevideo, and Buenos Aires.

SACC Partners:

Argentina

Servicio de Hidrografía Naval (SHN), Universidad de Buenos Aires (UBA), Centro Nacional Patagónico (CENPAT), Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP), Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Universidad del Sur

Brazil

Instituto Oceanográfico de Sao Paulo (IOUSP), Universidade Federal do Rio Grande (FURG), Instituto Nacional de Pesquisas Espaciais (INPE)

Uruguay

Programa de Ciencias del Mar y de la Atmósfera (PCMYA), Sección Oceanología, Facultad de Ciencias, Universidad de la República, Servicio de Sensores Remotos y Aeroespaciales (SSRAFAU) (Fuerza Aérea Uruguaya), Servicio de Oceanografía, Hidrografía y Meteorología de la Armada (SOHMA), Centro de Recepción, Procesamiento, Archivo y Distribución de imágenes de observación de la Tierra en Uruguay (CREPADUR)

Chile

Universidad de Concepción

United States

Rosenstiel School of Marine and Atmospheric Sciences (RSMAS), Naval Research Laboratory (NRL), Oregon State University, Woods Hole Oceanographic Institution

IAI Contact: Ione Anderson, Program Manager, ianderson@dir.iai.int

International Geosphere-Biosphere Programme

Introduction

The International Geosphere-Biosphere Programme (IGBP) is a research programme that studies the phenomenon of global change (www.igbp.net). IGBP research addresses the interactive physical, chemical and biological processes that define Earth-system dynamics, changes that are occurring in these processes and the role of human activities in these changes. IGBP contributes to new knowledge on climate change, as well as many other global environmental change issues, by coordinating research activities through the IGBP core projects and by organising workshops and synthesis activities that bring together scientists from a wide range of disciplines. The eight core projects of IGBP address processes on land, in the atmosphere and oceans, and at the interfaces between these. The projects include two integrative crosscutting projects that address future and past global changes. Many IGBP activities have considerable collaboration with other partner programmes.

Research highlights

Ocean acidification through geological time

A recent study suggests that the oceans may be acidifying faster today than they did in the last 300 million years. Based on a review of hundreds of paleoceanographic studies, the study found evidence for only one period in the last 300 million years when the oceans changed nearly as fast as today: the Paleocene-Eocene Thermal Maximum.

About 56 million years ago, a surge of carbon into the atmosphere warmed the planet and turned the oceans corrosive. In about 5,000 years, atmospheric carbon dioxide doubled to 1,800 parts per million (ppm), and average global temperatures rose by about 6°C, and ocean acidity – its pH – may have fallen by as much as 0.45 units. As many as half of all species of benthic foraminifera, a group of one-celled organisms that live at the ocean bottom, went extinct, suggesting that deep-sea organisms higher on the food chain may have also disappeared.

In the last hundred years, rising carbon dioxide from human activities has lowered ocean pH by 0.1 unit, an acidification rate at least 10 times faster than 56 million years ago. The Intergovernmental Panel on Climate Change (IPCC) predicts that pH will fall another 0.2 units by 2100, raising the possibility of substantial changes in marine ecosystems.

Hönisch B et al (2012) The geological record of ocean acidification. *Science* 335, 1058

See also the following publication for a synthesis of the latest knowledge on ocean acidification:

Ocean Acidification, edited by JP Gattuso and L Hansson, Oxford University Press

Synthesis of the most recent information about the consequences of ocean acidification to inform both future research agendas and marine management policy.

Erosion along the Arctic coasts

A new classification of the Arctic Ocean coastline, published recently, assembled information on 1315 coastline segments totaling more than 100,000 km. The mean erosion rate was found to be about 0.5 m/year, with high local and regional variance, and rates as high as 30 m/year were reported in some places. Erosion rates show a weak positive correlation with volumetric ground ice content ($r^2=0.23$). The highest mean erosion rates in the Arctic Ocean occur in the Beaufort Sea, the East Siberian Sea and the Laptev Sea. Rapid warming, loss of sea ice and potential for increased wave energy in the Arctic suggest a high potential for more rapid coastal erosion, particularly on ice-rich coastal plain shores, threatening the stability of built infrastructure in coastal communities and the integrity of coastal ecosystems supporting subsistence economies.

Lantuit, H et al (2011). The Arctic Coastal Dynamics database: a new classification scheme and statistics on Arctic permafrost coastlines, Estuaries and Coasts. DOI information: 10.1007/s12237-010-9362-6, published on-line 2011-02-01.

Related reference:

Forbes, D.L. (editor) (2011): State of the Arctic Coast 2010: Scientific Review and Outlook. International Arctic Science Committee (IASC), Land-Ocean Interactions in the Coastal Zone (LOICZ), Arctic Monitoring and Assessment Programme (AMAP), International Permafrost Association (IPA). Helmholtz-Zentrum, Geesthacht, Germany, 178 p. <http://arcticcoasts.org>.

REDD+ implementation in Africa

Several challenges will need to be overcome to pave the way for effective implementation of the UN-sponsored Reducing Emissions from Deforestation and forest Degradation (REDD) initiative in Africa, according to a recent analysis. Among the challenges are the existence of a number of redundant and parallel initiatives, and weak technical and institutional capacities.

REDD+ goes beyond deforestation and forest degradation, and includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks. According to the report, REDD+ implementation in Africa faces challenges from the prevalent socio-political context. Western notions of property rights, improved governance, local participation and sustainable development have at times proven to be contentious. Land tenure is a particularly tricky issue, for the complexity in Africa is incompatible with the conventional concept of property rights and there is little clarity about who – the state, local/traditional government and individuals – partake of the perceived benefits accruing from the implementation of REDD+ schemes. The report's authors state that the regulations and expectations associated with REDD+ need to better reflect the ground realities in Africa.

Mbow C et al. (in press) Challenges and Prospects for REDD+ in Africa: Desk Review Of REDD+ Implementation in Africa. GLP Report 5. GLP-IPO, Copenhagen.

Co-benefits of reducing black carbon and tropospheric ozone precursors

The harmful health effects of black carbon and tropospheric ozone are well known, as is the adverse effect of the latter on crops. But their climate effects are complex and less well understood. A study published in Science now suggests that cutting down on black carbon and methane – a precursor of tropospheric ozone – could prove to be a win-win solution. Besides leading to obvious health benefits, it could reduce global mean warming by around 0.5°C by the middle of this century.

The research team first used a model to test the effectiveness of hundreds of pollution control measures. Based on the climate impact of the measures, they came up with a list of measures that both improve air quality as well as reduce warming. Of the top 14 measures that together achieve most of the reduction in warming, 7 address black carbon and 7 address methane. The team's analysis suggests that if implemented simultaneously with substantial reductions in carbon-dioxide emissions, it might be possible to limit global warming to <2°C during the coming 60 years.

Whereas the benefits in terms of reduced warming would be spread more or less evenly around the world, the benefits for health and improved crop productivity would be particularly marked in certain parts of the world. For example, hundreds of thousands of premature deaths could be avoided in India and China, and along with the United States, these countries could also witness large increases in crop yields. The study's authors state that the co-benefits of reducing black carbon and methane emissions could provide strong incentives for appropriate policies.

The study emerged from the UNEP/WMO Integrated Assessment of Black Carbon and Tropospheric Ozone.

Shindell D et al. (2012) Simultaneously mitigating near-term climate change and improving human health and food security. *Science* 355: 183-189.

Link between nitrogen and climate probed

Human perturbations of the nitrogen cycle cause adverse health and environmental effects but might have a positive short-term impact on Earth's climate (small net cooling) suggests a synthesis of recent work initiated by IGBP. There are many complicating factors, however, and the report resulting from this activity points out that current knowledge is insufficient to fully quantify the complex links between nitrogen and climate.

During pre-industrial times, the nitrogen and carbon cycles were in a state of equilibrium. But since humans began converting atmospheric nitrogen into reactive forms to make fertilisers, the nitrogen cycle has been profoundly altered. An effect on the carbon cycle, and thus climate, was to be expected. The direct effects include warming due to the release of nitrous oxide, a potent greenhouse gas, whereas indirect effects include stimulating the growth of terrestrial vegetation that sequesters carbon, thereby causing cooling. A key challenge is to quantitatively evaluate whether the overall effect is one of warming or cooling. The answer might depend on the timescales considered: cooling in the short term and warming in the long term.

Erisman J W et al (2011). Reactive nitrogen in the environment and its effect on climate change. *Current Opinion in Environmental Sustainability* 3: 281–290.

Research relevant to greenhouse-gas emissions and removals from coastal and marine ecosystems

Carbon dioxide (CO₂), nitrous oxide (N₂O) and methane (CH₄) are among the most important greenhouse gases associated with coastal and marine ecosystems. Coastal and marine ecosystems are diverse and there are many region-specific characteristics; the vast amount of literature on these environments is difficult to summarise briefly. Nevertheless, below we first provide a quick overview, followed by a couple of examples from recent research findings from IGBP's Surface Ocean-Lower Atmosphere Study (SOLAS) project.

After considerable research during the past years, we now know with increasing certainty that on a global scale the margins of continents – the sites of coastal ecosystems – are net sinks of CO₂, absorbing approximately 0.36 Pg C per year (Chen 2010 and references therein). However, it is important to bear in mind that there is considerable spatial and temporal variation. For example, many estuaries and mangrove ecosystems are net sources, although the areas involved are much smaller than the continental margins as a whole.

In contrast, continental margins tend to be net sources of CH₄ (approximately 0.1*10¹² moles per year) to the atmosphere (Chen 2010 and references therein). The most important source of the methane is the fermentation of organic-rich sediments along the continental shelf. However, methane hydrate deposits can also serve as important sources in certain regions. Recent observations from the Arctic (Shakhova et al., 2010) show that methane is leaking out of reservoirs in the seabed along the East Siberian Arctic Shelf, aided by thawing of permanently frozen ground due to exposure to warming in the region. Methane is a potent greenhouse gas and large deposits are predicted to occur in the seabed in the Arctic region. In view of increasing warming of the Arctic, methane emissions might increase considerably in the future and it is important to monitor this region carefully.

Continental margins also release N₂O to the atmosphere (net sources), a process that is expected to intensify as nitrogen from agriculture and energy production is transported by rivers to coastal regions. Globally, N₂O emissions from estuaries roughly doubled between 1970 and 2000 (from 0.14 to 0.28 Tg N/yr) due to increased river N loading from anthropogenic sources (Kroeze et al., 2010). The open waters of continental shelves are also a source of N₂O, releasing about 0.6 Tg N per year to the atmosphere associated primarily with natural inputs of N from the open ocean. However, rivers inputs also contribute.

Emissions of N₂O from estuaries and continental shelves can also increase as a consequence of the spread and intensification of eutrophication and hypoxia (Codispoti 2010). Both N loading and increasing temperature are associated with the expansion of hypoxia. However, increases in N₂O emissions associated with the expansion of hypoxia are not well quantified. A recent review suggests that N₂O production in oxygen-deficient zones is globally significant (especially in the open ocean), but awaits quantification (Naqvi et al. 2010). For the open ocean, atmospheric deposition of reactive nitrogen due to human activities is estimated to lead to N₂O emissions of 1.6 Tg N per year in the year 2000 (Duce et al. 2008). Those estimates are very preliminary and are in the process of being refined.

Codispoti L A (2010). Oceans. Interesting times for marine N₂O. *Science* 327:1339-1340.

Kroeze C, Dumont E and Seitzinger S P (2010). Future trends in emissions of N₂O from rivers and estuaries. *Journal of Integrative Environmental Sciences* 7: 71-78.

Chen C-T A (2010). Cross-boundary exchanges in of carbon and nitrogen in continental margins. In: Liu K.-K et al (eds), *Carbon and Nutrient Fluxes in Continental Margins. Global Change – The IGBP Series.* Springer-Verlag Berlin Heidelberg 2010. 561-574 pp.

Shakhova N et al (2010). Geochemical and geophysical evidence of methane release over the East Siberian Arctic Shelf. *Journal of Geophysical Research* 115: C08007, doi:10.1029/2009JC005602.

Seitzinger S P and Kroeze C (1998). Global distribution of nitrous oxide production and N inputs in freshwater and coastal marine ecosystems. *Global Biogeochemical Cycles* 12: 93.

Duce R A et al. (2008). Impacts of atmospheric anthropogenic nitrogen on the open ocean. *Science* 320: 893-897.

Naqvi S W A et al (2010). Marine hypoxia/anoxia as a source of CH₄ and N₂O. *Biogeosciences* 7: 2159–2190.

Arctic coastal waters a net sink of CO₂

Annual air–sea exchange of CO₂ in Young Sound, NE Greenland was estimated using pCO₂ surface-water measurements during summer (2006–2009) and during an ice-covered winter (2008). All surface pCO₂ values were below atmospheric levels indicating an uptake of atmospheric CO₂. The observation that the surface water is undersaturated in pCO₂ in both summer and winter implies that Young Sound is a sink for atmospheric CO₂ on an annual scale. The average annual uptake of atmospheric CO₂ was estimated at 2.7 mol CO₂/m² per year for the study area, which is lower than estimates from the Greenland Sea.

A warmer future climate is expected to increase the amounts of melt water, which would act to lower surface-water pCO₂ levels. As these main factors identified to cause low surface-water pCO₂ levels all respond to warming, it is highly likely that annual air–sea CO₂ exchange in Young Sound, and potentially the East Greenland coastal region, will change in response to global warming.

Sejr, M. K., Krause-Jensen, D., Rysgaard, S., Sørensen, L. L., Christensen, B. P., Glud, R. N., 2011. Air-sea flux of CO₂ in Arctic coastal waters influenced by glacial melt water and sea ice, *Tellus B.*, 63B, pp.815-822.

<http://solas-int.org/aboutsolas/organisationandstructure/solasnetwork/reportsdenmark/DenmarkJan2012.pdf>.

Carbon exported from Nordic Seas to deep North Atlantic

A recent study shows that the dominant exchange of carbon in the Nordic Seas region takes place across the Greenland-Scotland Ridge. The Nordic Seas are the ocean area connecting the North Atlantic with the Arctic Ocean. Horizontal transport of carbon in the region is almost two orders of magnitude larger than the uptake

from the atmosphere: 12.3Gt of carbon is imported annually and 12.5Gt carbon is exported. An annual export of about 0.09Gt anthropogenic carbon (excess carbon resulting from perturbations of the “natural” carbon cycle) is expected from the Nordic Seas to the deep North Atlantic. This is a crucially important pathway for removing the climatically important CO₂ from the atmosphere to the interior ocean and thus helps moderate the potential global warming of global fossil fuel combustion and land-use change.

Jeansson, E., Olsen, A., Eldevik, T., Skjelvan, I., Omar, A. M., Lauvset, S. K., Nilsen, E. Ø. R., Bellerby, G. J., Johannessen, T. and Falck, E., 2011. The Nordic Seas carbon budget: Sources, sinks and uncertainties. *Global Biogeochemical Cycles*, doi: 10.1029/2010GB00396.

<http://solas-int.org/aboutsolas/organisationaandstructure/solasnetwork/reportsnorway/NorwayJan2012.pdf>.

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Paper no. 7: International Human Dimensions Programme on Global
Environmental Change

**International Human Dimensions Programme on Global
Environmental Change (IHDP)**

Introduction

By means of its multi-disciplinary teams of scientists and its integrated, long-term research on cutting-edge themes, IHDP is at the forefront of mobilizing and integrating social science research to the largely natural sciences-dominated GEC debate. Thereby, it effectively addresses the drivers of, impacts on and potential responses to Global Changes, including Climate Change. The recent activities and achievements of IHDP and its projects are outlined hereafter.

Science Highlights

Earth system governance, policy interaction

The earth system governance research has produced findings on a wide range of topics, ranging from the role of side-events in climate change negotiations to the political influence of the IPCC, the governance implications of the concept of planetary boundaries, and the governance of REDD+. ESG also contributed to its main goal of exploring political solutions and novel, more effective governance systems to cope with global environmental change through the accomplishment of various activities, publications and science-policy interaction. Successful events, such as the open-science conference in Colorado and the Policy Assessment in support of the Rio+20 conference, significantly enhanced ESG's global network of partner institutions and researchers. One of the project's highlights was recent accomplishment of a policy assessment with key policy recommendations regarding the institutional framework for sustainable development as well as a recent publication in *Science* arguing for fundamental reforms of global environmental governance and drawing from the assessment.

Biermann, Frank, Kenneth Abbott, Steinar Andresen, Karin Bäckstrand, Steven Bernstein, Michele M. Betsill, Harriet Bulkeley, Benjamin Cashore, Jennifer Clapp, Carl Folke, Aarti Gupta, Joyeeta Gupta, Peter M. Haas, Andrew Jordan, Norichika Kanie, Tatiana Kluvánková-Oravská, Louis Lebel, Diana Liverman, James Meadowcroft, Ronald B. Mitchell, Peter Newell, Sebastian Oberthür, Lennart Olsson, Philipp Pattberg, Roberto Sánchez-Rodríguez, Heike Schroeder, Arild Underdal, Susana Camargo Vieira, Coleen Vogel, Oran R. Young. 2011. Transforming Governance and Institutions for a Planet under Pressure. Revitalizing the Institutional Framework for Global Sustainability: Key Insights from Social Science Research. Planet under Pressure Policy Brief, 3.

Modern lessons in sustainability from the ancient Maya

IHOPE encourages the testing of human/environment system models against the integrated history to explore options for the future of humanity. In a particular research activity iHope draws conclusions regarding the capacity to cope with climate change and other challenges in modern tropical cities, by investigating the experiences of past societies, such as the Maya of Central America. Modern cities in developing countries, particularly in tropical regions, are experiencing unprecedented population growth and encountering strain on water, food and energy resources. With climate change and increasing energy costs, these cities are poised to either fail to adapt to changing conditions, or will continue to maintain themselves drawing on resilient social-ecological support systems. iHOPE gains insight into the fate of modern tropical cities by examining resilience of past societies such as the Maya.

S. Van der Leeuw, S., R. Costanza, S. Aulenbach, S. Brewer, M. Burek, S. Cornell, C. L. Crumley, J. A. Dearing, C. Downy, L. J. Graumlich, S. Heckbert, M. Hegmon, K. Hibbard, S. T. Jackson, I. Kubiszewski, P. Sinclair, S. Sörlin, and W. Steffen. 2011 Toward an integrated history to guide the future. *Ecology and Society* 16(4):2.

Urbanization, climate change adaptation

UGEC continued its focus on climate change adaptation in urban areas and developed essential research findings in this context during the past year. Besides the organization of a training workshop on ‘Urban Responses to Climate Change in Asia’, held in Taiwan, UGEC also conducted studies in this field and generated essential findings. One major research result shows that disaster risk reduction and climate change adaptation converge and interplay in the context of urban areas. The awareness of these connections started to change how researchers and practitioners conceive and approach the analysis and management of urban climate risk and associated impacts and response activities.

Rosenzweig, C., Solecki, W.D., Hammer, S., Mehrotra, S. (Eds.) (2011). *Climate change and cities: First assessment report of the Urban Climate Change Research Network*. New York, NY: Cambridge University Press.

Climate change risks and risk governance

Working on the topics of Extreme Risks and Vulnerability & Adaptation the IRG-Project combines a multi-institutional, interdisciplinary team of natural scientists, social scientists, engineers, policy makers as well as educators around the world who develop and apply theoretic, mathematic and computational tools for the decision making processes in the case of large-scale disasters around the globe. For this purpose the project developed eleven new initiatives in 2011, including a workshop for science policy interaction on ‘Climate Change Risks, Low-carbon Society and Green Development’ that was conducted in Nanjing, China.

Global Land Project

GLP started preparing its synthesis phase and continued its cooperation with IHDP’s core project UGEC. Following the jointly organized International Conferences of GLP and UGEC, which focused on the linkage between urbanization, land and landscapes, and climate change, both projects worked together in a joint workshop in 2011, discussing and developing a vision for a new conceptual framework of urban-land teleconnections that would enable a novel approach to local-to-global-scale land use change processes. Among many other results, a major outcome of the 2010 GLP conference was published in the journal *Science* in November 2011 discussing the topic of ecosystem services.

Kinzig, A.P., Perrings, C., Chapin III, F.S., Polasky, S., Smith, V.K., Tilman, D. and Turner II, B.L., 2011. Paying for Ecosystem Services – Promise and Peril. *Science*, Vol.334, no.6056, pp.603-604. DOI: 10.1126/science.1210297

Inclusive Wealth Report

Unless the yardsticks which society uses to evaluate progress are changed, the continued downward spiral of the planet’s natural systems will continue. Traditional indicators such as GDP and HDI have basic limitations as measures of social progress. Neither GDP/capita nor HDI reflect the state of the natural environment and both focus on the short term, with no indication of whether current well-being can be sustained. In this context, a prominent indicator for addressing the weaknesses in contemporary measures is ‘Wealth’ that relies on the stocks of different assets: Natural, Manufactured, and Human Capital. The Inclusive Wealth Report (IWR) features Inclusive Wealth as a comprehensive measure to track societal well-being.

The IWR is a United Nations University International Human Dimensions Programme on Global Environmental Change (UNU-IHDP) initiative with support from the United Nations Environment Programme (UNEP), in collaboration with the UN-Water Decade Programme on Capacity Development

(UNW-DPC) and the Natural Capital Project, Stanford University. The project aims at developing the first report on the wealth and changes in the wealth of nations, with a particular focus on Natural Capital. In the long-term, the project aims at producing a series of IWR's on a biennial basis. The first Inclusive Wealth Report will focus on a selection of 20 countries worldwide, with a special emphasis on developing countries, covering the 1990-2008 time period. It will be launched at the Rio+20 conference in 2012.

Assessment of human drivers of and responses to global environmental change

The Social Sciences and Humanities Assessment of Global Change is an international process that will provide policymakers and the public with "state of the art" scientific information on the behavioral and cultural drivers of global environmental change, as well as likely and preferred behavioral and cultural responses. It seeks to outline best practices for the social, cultural economic and political transition to sustainability by improving the information available for decisions and by informing and inspiring relevant stakeholders to press for necessary change. The Assessment will be guided by key questions identified through a participatory process with policymakers within governments and international conventions, and users within the academic and business communities and civil society.

The Assessment will be undertaken at multiple levels, including a global Social Science Assessment Panel, and regional coordination nodes bringing together regional scientists to conduct assessments using scientific literature from that region. And, while the Assessment will directly respond to the demand and information needs of governments and conventions, it will also place major emphasis on communication to business and civil society in recognition that these actors are as influential as governments in causing change. The Assessment will be undertaken by a global network of some 500+ social scientists and humanities scholars in collaboration with interdisciplinary environmental change researchers. IHDP will administratively support it.

Climate Change Research, Including Marine Research, on Technical and Scientific Aspects of Greenhouse Gas Emissions and Removals from Coastal and Marine Ecosystems

IHDP's core project LOICZ is working to support sustainability and adaptation to global change in the coastal zone. LOICZ supports adaptation to global change by linking natural and social sciences with knowledge of coastal communities at global, regional and local scales. The project's research in 2011 led to the identification of key coastal syndromes and appropriate responses. Of research interest were geographic hotspots of coastal vulnerability encompass the Arctic, small islands, river mouth systems, deltas and estuaries and urbanized coasts. A first status report of rapidly changing Arctic coasts has been published and the DPSIR framework was applied to coastal megacities.

Major findings of LOICZ coastal zone research included the worldwide decline of seagrass habitat and biodiversity. It also showed that changing material transfers along the continent-ocean interface in Brazilian rivers can be attributed to land use changes and global climate change. A further research activity of the project is the IGBP synthesis on Coastal Megacities. The analysis comprises impacts of megacities on coastal ecosystem goods and services, and welfare. It explores global change pressures, geo risks and opportunities for sustainable development.

Newton, A., Carruthers, T.J.B. & Icely, J. (2011): The coastal syndromes and hotspots on the coast. *Estuarine Coastal and Shelf Science* 96(1): 39-47. DOI information: <http://dx.doi.org/10.1016/j.ecss.2011.07.012>.

Howarth, R.W., Swaney, D.P. Billen, G. Garnier, J. Hong, B. Humborg, C. Johnes, P. Mörth, C.-M. and Marino, R.M. (2011). Nitrogen Fluxes from Large Watersheds to Coastal Ecosystems Controlled by Net Anthropogenic Nitrogen Inputs and Climate. *Frontiers in Ecology and the Environment*. DOI information: <http://10.1890/100178>.

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Website: <http://www.ihdp.org>

World Climate Research Programme: Scientific Foundation for Decision Making

Introduction

Contact: The World Climate Research Programme (WCRP) supports a number of high priority scientific research activities with the aim of facilitating analysis and prediction of Earth's climate system variability and change for use in an increasing range of practical applications of direct relevance, benefit and value to society.

WCRP held a successful Open Science Conference (OSC) on 24-28 October 2011, in Denver, Colorado, USA, under the theme "Climate Research in Service to Society. The conference counted more than 1900 participants from 86 nations, including 541 young scholars and 300 scientists from developing nations. Through a community synthesis of research findings, the scientists at the conference assessed the current state of knowledge on climate variability and change, identified the most urgent scientific issues and research challenges, and ascertained how the WCRP can best facilitate research and develop partnerships critical for progress. The conference participants identified several major scientific themes and priorities based on the daily presentations and discussions which include: (1) the need for prediction of the Earth System bridging the physical climate system with biogeochemistry, the socioeconomic and humanity sciences such as the "Future Earth: Research for Global Sustainability"; (2) the opportunity, provided by new satellite observations, to make a quantum leap in understanding of clouds and aerosols and their contributions to climate sensitivity; (3) the necessity of skillful climate information on regional scales, embodying the so-called "seamless prediction" in support of Global Framework for Climate Services; (4) the importance of quantifying "true" uncertainty in climate predictions; (5) the challenges and opportunities of predicting how natural modes of climate variability will modify the "forced" anthropogenic component of climate change over the coming years to decades; (6) the increasing importance of establishing the predictability of polar climate, with possible opening of the Arctic and international policy for commercial shipping and extraction of natural resources; (7) the need to better understand the causes of extreme events and attribution studies in near real-time; (8) the challenges of improved predictions of future sea-level change on regional scales, which will require knowledge of cryospheric, thermospheric, gyre circulations, storm tracks, and tidal amplitudes; and (9) the need to train and empower the next generation of climate scientists.

A major emerging theme was the need for actionable science. Decision makers need climate and other scientific information to guide decisions. The demand for and importance of understandable information about climate is increasing, especially as extreme weather and climate events and their adverse impacts on natural ecosystems and global economic development increase in frequency and severity. More information on the conference is available at <http://conference2011.wcrp-climate.org>.

On-Going WCRP Research Activities relevant to UNFCCC

Climate Projections

More than 22 modeling groups from around the world are currently running the Coupled Model Intercomparison Project Phase 5 (CMIP5) experiments that represent the most ambitious multi-model inter-comparison and analysis project ever attempted. This and previous phases of CMIP have been organized and coordinated by the WCRP Working Group on Coupled Models (WGCM). The CMIP5 consists of four major

categories of experiments and analysis based on model simulations. They are: 1) Atmosphere-Ocean Global Climate Models (AOGCMs , with components of atmosphere, ocean, land and sea ice); 2) Decadal prediction simulation sets (AOGCMs initialized with observations); 3) high-top models (AOGCMs with increased vertical extent to reach well into the stratosphere); Earth System Models (ESMs, with inclusion of at least a coupled carbon cycle in an AOGCM). Model data are openly available from the Earth System Grid Federation, an international distributed data archival and access system, and more information can be found on the Program for Climate Model Diagnosis and Intercomparison (PCMDI) web page (<http://cmip-pcmdi.llnl.gov/cmip5/>). Ultimately, these results will be available through the peer-reviewed publications for use in the 5th IPCC Assessment Report (AR5).

Decadal Predictability and Predictions

The enhanced focus on the WCRP CMIP5 near-term climate prediction (to about 2035) is promising exciting developments in the coming years such as the assessment of the benefit of different initialization methods, the formulation of predictions with useful skill over regions and for variables still unexplored or the development of post-processing methods that allow the integration of forecast information from different forecast systems. As already happened in the field of seasonal forecasting, the combination of model improvement, better observational datasets (for both initialization and verification) and a better understanding of the processes at the origin of the interannual to multi-decadal predictability should lead to more skillful multi-year predictions in the future, as well as to an increase benefit from a better informed society.

Seasonal and Interannual Forecasts

Progress in seasonal prediction depends on improvements in the building blocks of seasonal prediction systems: the models, observations and data assimilation systems, as well as improved forecast verification and a more effective transfer of information to forecast users, increasing forecast value. The WCRP Working Group on Seasonal to Interannual Prediction (WGSIP) is coordinating a multi-model, multi-institutional set of hindcast experiments – the Climate system Historical Forecast Project (CHFP, <http://www.wcrp-climate.org/wgsip/chfp/index.shtml>). The CHFP aims to explore there untapped sources of predictability on seasonal to interannual timescales due to interactions and memory associated with all the elements of the climate system (Atmosphere-Ocean-Land-Ice). These experiments provide a baseline assessment of current seasonal prediction capabilities using the best available models of the climate system and data for initialisation, as well as of IPCC class climate models in seasonal prediction mode. They provide a framework for assessing current and planned observing systems, and a test bed for integrating process studies and field campaigns into model improvements.

The WCRP WGSIP provides an effective interface between the operational community engaged in long-range predictions and the research community engaged in exploring new sources of prediction skill, improvements in long-range prediction methodologies, and other scientific questions of relevance. Improvements in seasonal prediction skill that are derived from the implementation of best practices are expected to be quasi-immediate. Improvements in the building blocks of seasonal prediction systems will continue in the next years and longer and ongoing research into new sources of predictability in the climate system are expected to lead to operational improvements on the longer term.

Regional Climate Information

The provision of climate information at regional to local scales is an important requirement to support informed decision making in response to potential climate change. Such information is needed to assess the impacts of climate change on human and natural systems, enabling the development of suitable adaptation and risk management strategies at the regional to local level.

The WCRP CORDEX project (http://wcrp.ipsl.jussieu.fr/SF_RCD_CORDEX.html) has a twofold purpose to 1) provide a framework to evaluate and benchmark model performance (Model Evaluation Framework); and

2) design a set of experiments to produce coordinated climate projections and estimated uncertainties (Climate Projection Framework). The first step in CORDEX is to evaluate the performance of various Regional Climate Downscaling (RCD) methods for the recent past, both to help define the reliability of future projections and to identify areas requiring improvement. For each region a set of evaluation and diagnostic teams are being formed whose tasks include the design of a set of benchmark regional metrics for model evaluation and the collection of suitable, quality-controlled observations to support this task. However, in a number of regions of the world, access to reliable regional climate change information is extremely limited. One example is Africa. It is in these regions the collaboration developed through CORDEX is expected to bring the largest benefits. With this in mind the international community decided to target Africa for an intensive collaboration with an aim to produce a significant matrix of regional climate change projections, both to support the 5th Assessment report of the IPCC (IPCC AR5) and to provide useful climate information to decision-makers involved in climate risk management and adaptation planning. Similar teams are in the process of being formed for the other CORDEX domains in Asia and South America.

Detection and Attribution of Climate/Weather Extremes

Research on “Climate Extremes” is one of the WCRP cross-cutting activities and it is focused on the design of an intercomparison framework through which both observations and climate model representations of extremes and projections of climate can be assessed, and by which changes in climate extremes can be better evaluated and communicated to the decision makers. The overall aim of this activity is to accelerate progress on the prediction/projection of climate extremes with a focus on developing capabilities and products, which facilitate practical applications for stakeholders in regions/sectors around the world.

Drought has been identified as an important focus of the WCRP extremes activity and a major international workshop was organized in March 2011 in Barcelona, Spain (<http://drought.wcrp-climate.org/workshop/>). Among the key recommendations of this workshop is the development of an experimental global drought information system (GDIS). The timeliness of such an effort is evidenced by the wide array of relevant ongoing national and international (as well as regional and continental scale) efforts to provide drought information, including the US and North American drought monitors, and various integrating activities such as GEO and the Global Drought Portal. In addition to the evolving drought information systems, there are a number of other emerging capabilities that could become important components of any GDIS. These include regional and global experimental hydrological forecasting capabilities and a number of national and international near real time global multi-model seasonal (short term climate) forecasting capabilities. Also relevant are two additional action items that arose from the WCRP drought workshop to develop a drought catalogue, and to conduct coordinated research on specific high-profile case studies of past droughts. WCRP is will focus on the steps necessary to develop a GDIS that builds upon the extensive world-wide investments that have already been made in developing drought monitoring, drought risk management, and short term climate prediction capabilities. The success of a GDIS will be measured by its ability to provide timely drought-related information and predictions that can inform decision-making.

Emerging issues in climate change research

New Results from CMIP5

New results are emerging from analyses of the multi-model data that are part of the Coupled Model Intercomparison Project Phase 5 (CMIP5). The spread of projections in CMIP5 AOGCMs is roughly the same as the previous generation of models in CMIP3. Most first generation of ESMs produce comparable first order results to AOGCMs, but also include the additional capabilities of ESMs. Patterns of future change of temperature and precipitation, equilibrium climate sensitivity, and spread among CMIP5 models are similar to previous generations of models and present the opportunity to better understand the spread. This increases confidence in these results.

CMIP5 provides many more capabilities and new types of climate change information: (1) carbon cycle feedback, quantifying sources and sinks of carbon for land vs ocean, allowable emissions for different levels of mitigation in the RCP scenarios, ocean acidification, physiological effects of vegetation changes; (2) high resolution time slices to study tropical cyclones; (3) decadal climate prediction for short term climate change and possible climate shifts; (4) paleoclimate simulations that allow analysis of climate response across past, present and future climates, and that provide “out of sample” insights to build model credibility and provide possible constraints on the nature and magnitude of future climate change; (5) analysis of cloud feedbacks; (6) revisiting of forcing and feedback better helps to interpret the spread of model projections; and (7) attempts to relate 20th century model biases to projections.

New types of results include: (1) Atlantic multidecadal variability appears to be more predictable than Pacific multidecadal variability; (2) critical thresholds for Arctic sea ice loss; (3) regional climate regimes such as the Indian Ocean Dipole and its connections to east African rainfall; (4) changes in monsoon onset characteristics; (5) role of salinity and patterns of changes connected to the hydrological cycle and ocean response; (6) tracking regional ocean heat content changes and relation to regional patterns of sea-level rise; (7) mechanisms for regional precipitation and temperature changes and extremes—Caribbean drying, SE US wetter, drying Amazon, connecting Arctic sea ice loss to European cold extremes, atmospheric rivers and extreme precipitation, importance of circulation changes, blocking, what will not change in a future climate is also useful information.

Indices of weather and climate extremes (coordinated by ETCCDI) are being calculated for the CMIP5 models and for the reanalyses data, and will be made available for users to analyze through a data base, initially from the Canadian Center for Climate Modeling and Analysis (CCCma), and subsequently on the PCMDI web site.

New Results from CORDEX-Africa

10 Regional Climate Modelling (RCM) groups have downscaled ERA-interim data for 1989-2008 on the common Africa CORDEX grid. All these groups have also committed to making at least one climate projection run for the CORDEX-Africa domain, with some groups planning more than one with different CGCM (Coupled General Circulation Model) forcing. A model evaluation/diagnostic team has now been formed for Africa, consisting of 30 scientists from a range of disciplines and representing the majority of sub-Saharan Africa. While there are inter-model differences, the majority of the RCMs capture the ITCZ (InterTropical Convergence Zone) well, with accurate estimates of seasonal rainfall amounts. In fact the ensemble mean bias, when calculated against any one of the four observation data sets, is of similar magnitude, or smaller, to the differences across the 4 observations. The main message we wish to convey at this early stage is that a lot of high quality simulated climate information will be available for the African continent within the next few months.

For practical use in West Africa it is important that models can simulate the onset date of the monsoon, as well as the monsoon duration, intra-seasonal variability within the monsoon season and its north-south propagation. A number of the RCMs simulate the overall monsoon cycle quite accurately, with a few capturing the northward jump in the monsoon seen in early July in the observations, the ensemble mean having a particularly good representation of this phenomenon. A feature common to a number of the RCMs is that during the southward march of the monsoon, in October to November, precipitation rates are overestimated. More work is required to fully characterize the ability of the CORDEX RCMs to simulate climate variability over Africa. This effort is underway now, in preparation for the climate projection phase of CORDEX, which will begin for Africa and other regions in the coming months.

New Re-Analyses of Global Observations

Reanalysis is a scientific method for developing a comprehensive record of how weather and climate are changing over time. In it, observations and a numerical model that simulates one or more aspects of the Earth

system are combined objectively to generate a synthesized estimate of the state of the system. A reanalysis typically extends over several decades or longer, and covers the entire globe from the Earth's surface to well above the stratosphere. Reanalysis products are used extensively in climate research and services, including for monitoring and comparing current climate conditions with those of the past, identifying the causes of climate variations and change, and preparing climate predictions. Information derived from reanalyses is also being used increasingly in commercial and business applications in sectors such as energy, agriculture, water resources, and insurance.

The mid-1990s saw the emergence of reanalysis products of more uniform quality covering longer periods, for example by the US National Center for Environmental Prediction (NCEP), ECMWF, the Japan Meteorological Agency and others. For example, ECMWF's two most recent reanalyses, ERA-40 and ERA-Interim, illustrate perfectly the positive benefit of improved observing and forecasting systems on medium-range forecasting and climate monitoring.

ERA-40 covered the period 1958-2001. It used an assimilating model with a 125 km quasi-uniform grid, 60-level vertical resolution and a three-dimensional variational (3D-Var) analysis. Otherwise, it used a version of the ECMWF forecasting system that was operational in 2001. ERA-Interim runs from 1979 to the present, and uses 80 km horizontal resolution, 60-level vertical resolution, and otherwise a 2006 version of the ECMWF system, including four-dimensional variational (4D-Var) analysis. The new webpage <http://reanalyses.org/> provides researchers with detailed data descriptions, data access methods, analysis and plotting tools of reanalysis datasets created by different climate and weather organizations. In addition, the site is used to discuss these reanalyses, how they compare with each other and with observations. WCRP is convening the 4th International Conference on Reanalysis in Silver Spring, USA, on 7-11 May 2012 with the objective of fostering communications between reanalysis development centers and the research community with a focus on an Earth System approach to reanalysis.

Regional Research, Analysis and Modelling Capacity Development

WCRP partnered with WMO, GCOS and ICPAC to execute a World Bank-sponsored project on climate risk reduction for the Greater Horn of Africa countries (http://www.wcrp-climate.org/CB_projects_GFDRR.shtml). A series of three coordinated workshops brought together climate practitioners and users to assess available climate data and information for water resources and agriculture, and to identify best practices and gaps that need to be filled. The overall objectives of the workshop programme were to help ensure that attention is given by countries in the GHA region to observation and data needs, to demonstrate the use and value of regional models, to provide advice on model limitations, and to improve capabilities across the GHA for using data records and model projections for adaptation planning. WCRP was successful in adopting the materials and process developed for the Horn Africa for the regional capacity development in West Africa with the help from some African scientists and through a partnership with UNDP and WMO Regional Program.

Regional knowledge assessments were and will be conducted in West Africa, East Africa, and South Asia in 2011 and 2012 through a partnership between the WMO/WCRP, IPCC, UNEP, START, the University of Ghana, University of Dar es Salaam and the Bangladesh Centre for Advanced Studies. The effort is being supported through a European Commission, UNEP, USAID and USGCRP-funded project entitled '*Understanding the Findings of the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report, Climate Change 2007 - Integrating Climate Change Adaptation and Mitigation in Development Planning*'.

The regional knowledge assessments utilizes key findings of the IPCC 4th Assessment Report, Climate Change 2007, as the basis upon which to frame issues of climate change impacts, vulnerability, adaptation and mitigation, and draws upon a wide array of additional sources, including peer reviewed literature published since the 4th Assessment Report pertaining to regional issues, grey literature (i.e. institutional or technical reports, working papers, theses, conference proceedings, statistical bulletins, etc.), and peer-

reviewed literature published in non-English languages, which are not normally assessed by the IPCC. The assessments collect and synthesize available knowledge on region and country specific issues of relevance to climate change adaptation and mitigation decision-making, identify knowledge gaps that are critical to decision-making, and prioritize research and assessment needs for adaptation and mitigation decision support.

WCRP, in partnership with START, is developing regional research capacity for Asia and Africa in conjunction with the CORDEX. CORDEX presents an unprecedented opportunity to advance knowledge of regional climate responses to global climate change, and for these insights to feed into on-going climate adaptation and risk assessment research, policy planning, and development in the region. A consortium of organizations consisting of the WCRP, the University of Cape Town's Climate Systems Analysis Group (CSAG), START, the International Centre for Theoretical Physics, the Swedish Meteorological-Hydrological Institute, and the Climate and Development Knowledge Network initiative have developed an analysis and training program to provide an initial assessment of CORDEX output for Africa that is regionally focused and prioritized to the continent's knowledge needs. The training programme focuses on skill development in working with climate model results, analysis of CORDEX datasets, and compilation and writing of analytical results. Participants in the training programme are grouped into teams according to the sub-regions they represent and their respective areas of expertise.

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