www.igbp.net

International Geosphere-Biosphere Programme

ANNUAL REPORT 2013

GLOBAL CHANGE
IGBP International Geosphere-Biosphere Programme

ICSU International Council for Science

Published by
IGBP Secretariat
The Royal Swedish Academy of Sciences
Box 50005
SE-104 05, Stockholm
Sweden
Tel: +46 8 16 64 48
www.igbp.net

An electronic copy (PDF) of the IGBP Annual Report 2013 is available on the IGBP website.

Editors: Ninad Bondre, Owen Gaffney

Graphic Designer: Hilarie Cutler

Cover photographs: Top left: Joanjo Aguar Matoses;
top right: IGBP, IOC, SCOR (2013). Ocean Acidification Summary for Policymakers – Third symposium on the Ocean in a High-CO_2 World;
bottom left and background: iStockphoto.com/sandramo;
bottom right: iStockphoto.com/Bartosz Hadyniak.

Printed by Bergs Grafiska, Stockholm, to the official Nordic Ecolabelling criteria.

Readers may view, browse and/or download material for temporary copying purposes only, provided these uses are for non-commercial personal purposes. Except as provided by law, this material may not be further reproduced, distributed, transmitted, modified, adapted, performed, displayed, published, or sold in whole or in part, without prior written permission from the publisher.

While every effort has been made to ensure the accuracy of the maps included in this report, IGBP takes no responsibility for the authenticity of the same. National and political boundaries, as depicted on the maps, should not be taken to reflect IGBP's endorsement.

Contents

IGBP research ---------- page 2

The year in review ---------- page 4

Project highlights ---------- page 6

AIMES ---------- page 6
GLP ---------- page 8
IGAC ---------- page 10
iLEAPS ---------- page 12
IMBER ---------- page 14
LOICZ ---------- page 16
PAGES ---------- page 18
SOLAS ---------- page 20
GCP ---------- page 22

Communications ---------- page 24

Policy ---------- page 26

Future Earth ---------- page 28

Partnerships ---------- page 30

IGBP community ---------- page 32

National committees ---------- page 32
Scientific committee ---------- page 36
Project offices ---------- page 37
Committee Chairs/Contacts ---------- page 38
Secretariat and regional office ---------- page 40

Publications ---------- page 41

Financial ---------- page 46

Acronyms ---------- page 50

IGBP Research

IGBP began in 1987 and is sponsored by the International Council for Science (ICSU). Our vision is to provide essential scientific leadership and knowledge of the Earth system to help guide society onto a sustainable pathway during rapid global change.

The vision has three key elements:

- the planet
- the planet under pressure
- transformation in an era of rapid global change.

IGBP is a world-class provider of expertise, coordination and communication. Our research is organised around:

- major international projects representing the Earth system – the land, atmosphere, oceans and their interfaces
- synthesis, integration and modelling of the Earth system, including societies past and present
- past climate change.

Core projects*

- Analysis, Integration and Modelling of the Earth System (AIMES)
- Global Land Project (GLP)
- International Global Atmospheric Chemistry (IGAC)
- Integrated Land Ecosystem–Atmosphere Processes Study (iLEAPS)
- Integrated Marine Biogeochemistry and Ecosystem Research (IMBER)
- Land–Ocean Interactions in the Coastal Zone (LOICZ)
- Past Global Changes (PAGES)
- Surface Ocean–Lower Atmosphere Study (SOLAS)

We help coordinate and drive joint projects with our international partners on the carbon cycle, water cycle and food security and we endorse projects such as the International Nitrogen Initiative.

Joint projects and studies

- Global Carbon Project (GCP)
- Global Water System Project (GWSP)
- Global Change System for Analysis, Research and Training (START)
- Monsoon Asia Integrated Regional Study (MAIRS)
- Climate Change, Agriculture and Food Security (CCAFS)

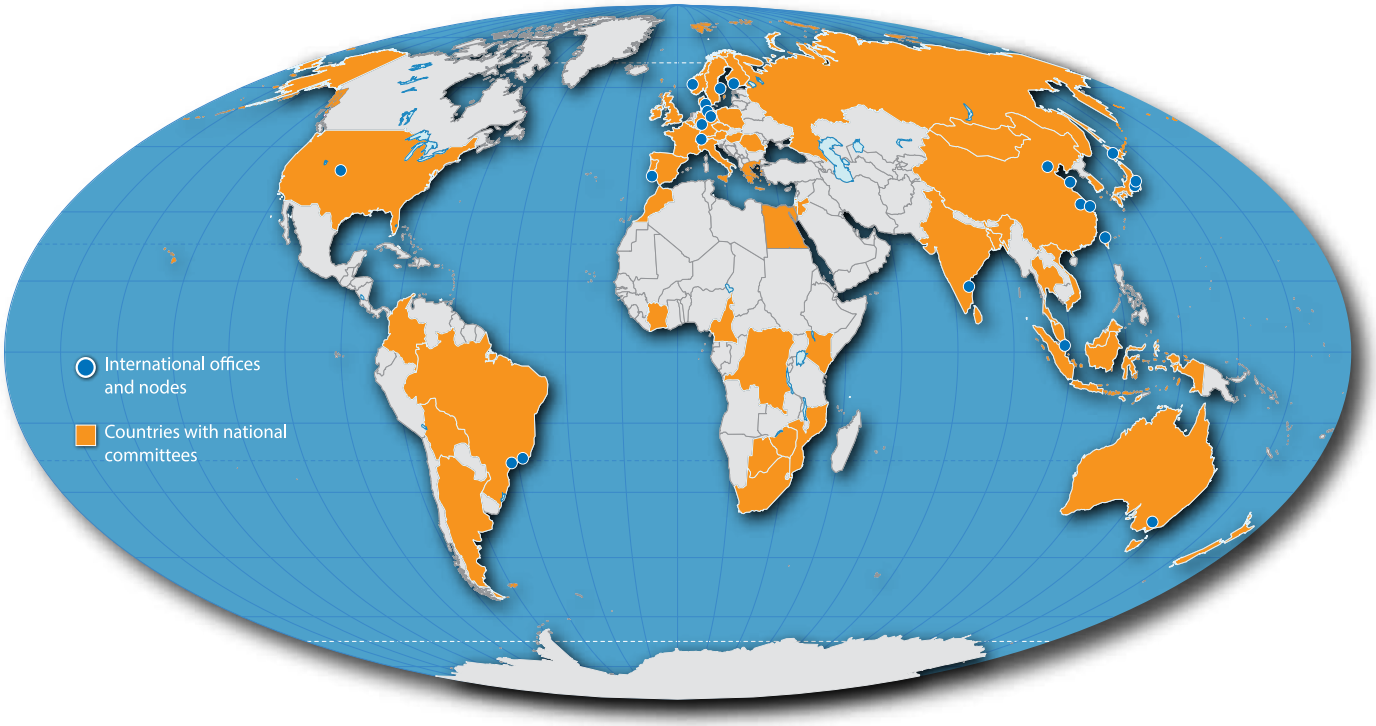
Major endorsed projects

- International Nitrogen Initiative (INI)
- Northern Eurasia Earth Science Partnership Initiative (NEESPI)

Future Earth

Future Earth is a new ten-year international research initiative. It brings together existing global environmental change programmes including IGBP. More information on page 28.

* see page 37 for co-sponsors



IGBP has 52 national committees, 8 core projects and 23 international project offices including project nodes.

THE YEAR IN REVIEW

If the quality of scientific publications is any indicator of the health of IGBP's projects then it is safe to say that they are in great shape. The papers that emerged from the projects last year tackled such diverse topics as global land-use change and oceanic carbon sinks. Collectively, this research contributed to an improved understanding of the interconnections among, for example, land-use change, air pollution, ocean acidification and ecosystems. It will help to inform decisions and policies aimed at responding to the complex challenges of the Anthropocene.

Much of the research highlighted the strength of international collaboration that has been a hallmark of IGBP since it was founded. An excellent example is the assessment of millennial-scale regional temperature variability coordinated by the Past Global Changes (PAGES) project. This endeavour was the culmination of a worldwide data collection and analysis effort that involved scientists from many different countries. In addition to the projects, IGBP's national committees also held workshops and undertook regionally relevant scientific activities.

In September last year Stockholm witnessed the launch of the Summary for Policymakers of the fifth assessment report of IPCC's Working Group I. Following the launch, the IGBP Secretariat and its partners organised a major public event that took stock of the key findings of the report. The IPCC reports are a testimony to the important contributions made by our programme: IGBP research informed the assessment and our scientists contributed as authors and reviewers. We continued to have a close working relationship with the United Nations Framework Convention on Climate Change (UNFCCC): as with previous years IGBP reported to the Subsidiary Body on Scientific and Technological Advice about the latest global-change research.

Our overarching synthesis is now well under way. In January this year we had a very productive workshop on the Anthropocene concept in Washington, DC. The workshop – co-organised by IGBP and the International Human Dimensions Programme on Global Environmental Change (IHDP) – brought together biogeochemists, modellers, historians, economists, journalists and others to explore the Anthropocene concept from different perspectives. Other components of our synthesis include a retrospective and perspective on Earth-system science, and an assessment of the projects' contributions to global-change research. The synthesis will lead to a series of papers in peer-reviewed journals.

IGBP has always placed great value in ensuring that its research is disseminated as widely as possible. Throughout last year the communications team worked closely with the projects, publishers and media outlets to fulfil this purpose. In addition to our regular products such as the *Global Change* magazine we produced a summary for policymakers on ocean acidification, several infographics and data visualisations. We were active on social media. The projects themselves continued to spend considerable effort in communicating their research. Last year they reached out to the wider community not only via traditional outlets such as newsletters but also via social media.

We held our Scientific Committee meeting in Switzerland last year, whereas the Officers met in Botswana for their annual meeting. You can read more about these meetings on page 32 of this report.

The interim secretariat for the Future Earth initiative was appointed last year. We are helping Future Earth to develop a strategic research agenda and communications products. Many of our core projects are developing new science plans to respond to the growing need for integrated research on environmental change and sustainability.

Looking ahead, all of IGBP's components – the projects, scientific and national committees and the secretariat – will continue to coordinate high-quality research and engage in training and capacity-building activities. The coming year promises to bring new collaborations, novel perspectives and innovative research.

IGBP Chair James Syvitski and Executive Director Sybil Seitzinger, June 2014.

Generous support from 40 nations ensures the continued success of IGBP. We particularly thank the Royal Swedish Academy of Sciences, which has hosted IGBP's secretariat for 27 years, and the many nations hosting IGBP's international project offices and regional offices: Australia, Brazil, China, Finland, Germany, India, Italy, Japan, Singapore, Norway, Switzerland, Taiwan and the United States.

Our research highlights the strength of international collaboration.

Executive Director Sybil Seitzinger

Chair James Syvitski

EARTH-SYSTEM MODELLING IN THE ANTHROPOCENE

Earth-system modelling is essential to the science of global change. IGBP's leading Earth-system modelling initiative is the AIMES project (Analysis, Integration and Modelling of the Earth System). It has three foci: Earth-system science, abrupt changes, and dynamics and interaction between humans and the environment at a global scale.

In 2013, AIMES agreed to lead the development of the World Climate Research Programme's "grand challenge" on the modelling of biospheric forcing factors and climate–biosphere interactions. Furthermore, AIMES is now prioritising ways to incorporate global socio-economics as integral components of Earth-system models.

In September, the IPCC launched its Working Group I summary for policymakers in Stockholm. AIMES played a central role in studies that analysed carbon cycle simulations produced by Earth-system models. These studies resulted in influential publications on the evaluation of the models against the historical record, the analysis of climate-carbon feedbacks and the impact of changes in land use.

AIMES researchers were also involved in two high-profile papers that re-examined the vulnerability of tropical rainforests to climate change. The first of these showed that year-to-year variation in atmospheric CO_2 is correlated with projected losses of tropical land carbon as a result of climate change, across the ensemble of Earth-system models (Cox *et al.* 2013). This enables the observed year-to-year variation in atmospheric CO_2 to be used as what is being termed an "emergent constraint" on future tropical carbon losses due to climate change. The results suggest losses of about 50 gigatonnes of carbon per degree celsius of warming in the tropics. The second paper (Huntingford *et al.* 2013) indicates that the Amazonian rainforest is therefore likely to be resilient to CO_2-induced climate change, but only if CO_2 fertilises tree growth in the manner currently assumed in Earth-system models.

Finally, AIMES researchers were involved in another significant study that concluded global temperature variability has not increased significantly since the beginning of the 20th century, contrary to some previous studies. To reach this conclusion, the researchers examined long-term temperature records to assess how temperature variability has changed recently. The near-constancy of global temperature variability was found to hide very significant regional variability trends. The mid-latitude regions of North America and Europe have generally seen increased variability, but the tropics have experienced slight reductions in temperature variability since 1900.

Anav A *et al.* (2013) *Journal of Climate* 26 (18), 6801-6843, doi: http://dx.doi.org/10.1175/JCLI-D-12-00417.1

Arora V K *et al.* (2013) *Journal of Climate* 26 (15), 5289-5314, doi: 10.5194/bgd-10-13603-2013

Brovkin V *et al.* (2013) *Journal of Climate* 26 (18), 6859-6881, doi: 10.1175/JCLI-D-12-00623.1

Cox P M *et al.* (2013) *Nature* 494, 341-344, doi: 10.1038/nature11882

Huntingford C *et al.* (2013) *Nature Geoscience* 6, 268-273, doi: 10.1038/ngeo1741

Huntingford C *et al.* (2013) *Nature* 500, 327-330, doi: 10.1038/nature12310

AIMES is using the new concept of "emergent constraints" to improve climate models.

AIMES research focuses on increasing knowledge of the Earth system, abrupt changes in the Earth system, and social and environmental interactions at the global scale.

CURRENT LAND-USE CHANGE IN PERSPECTIVE

One of the most debated questions about the concept of the Anthropocene relates to when exactly this proposed epoch began. For several years, the main contenders have been the beginning of the Industrial Revolution around 1800 or the beginning of the "Great Acceleration" in human productivity around 1950. A group of scientists involved in the Global Land Project contest these views arguing instead that humans have transformed ecosystems on large scales for many millennia.

Using paleoecological, archaeological and historical studies, the authors argued in the *Proceedings of the National Academy of Sciences* that land-use change by relatively small human populations has been extensive and in some regions sustained for thousands of years. The team, led by Erle Ellis from the University of Maryland, thinks that while earlier populations "likely caused widespread and profound ecological changes more than 3000 years ago," current technological advances mean many societies are using less arable land per person. They conclude: "Recent trends may represent as much a recovery as an acceleration."

Other highlights within the Global Land Project include a special issue of the Elsevier journal *Current Opinion in Environmental Sustainability*, entitled "Land System Science: between global challenges and local realities", edited by GLP Chair Peter Verburg and colleagues.

The articles in the issue synthesised many interrelated topics in land-system science divided into four main approaches: land-systems dynamics, land-use intensity, impacts of land change and governance of land systems.

A key area of examination is the notion of teleconnections and linkages between global and local phenomena. Patrick Meyfroidt from the Université Catholique de Louvain and colleagues used the concept of telecoupling to review how local processes of land-system change are affecting other, often distant, regions and how demand and policy often have indirect consequences in different world regions. The authors argue for combining place-based research and global modelling to better understand the causal links between flows of goods and services and land-system change.

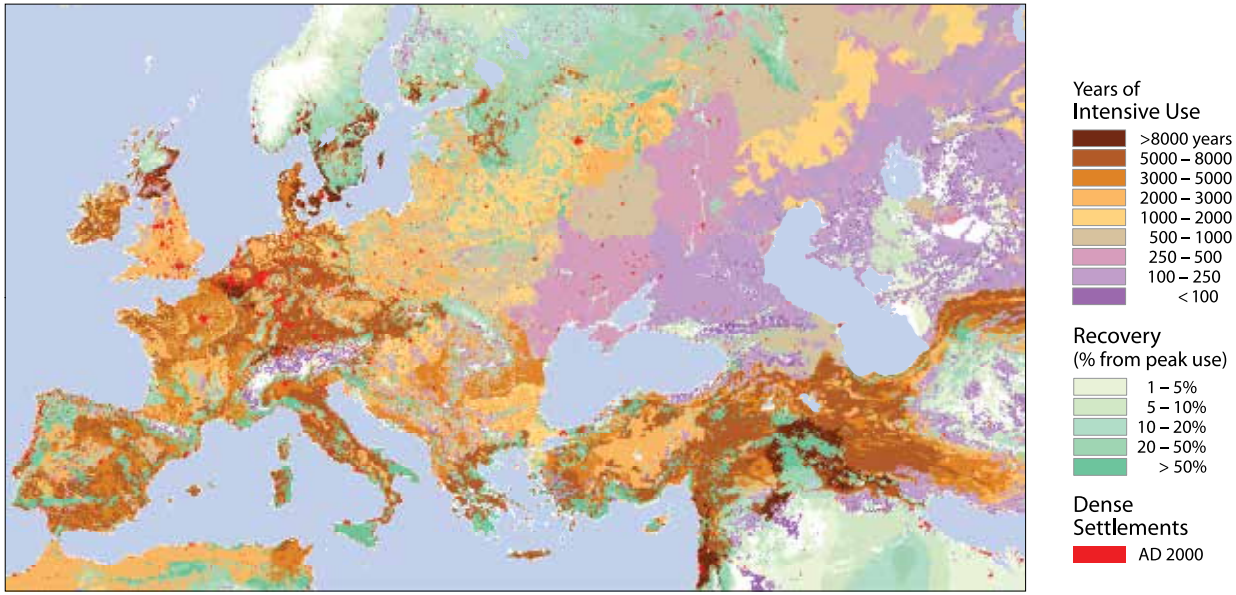
The strengths and weaknesses of remote sensing as a provider of data on land-cover change is explored by Tobias Kuemmerle from Humboldt-University Berlin and colleagues. They argue that remote sensing can struggle to derive some of the more subtle changes in land use, such as changes in land-use intensity or management and spatial organisation. In their review of the state of the art in land-use intensity monitoring, they outline major challenges, but also opportunities emerging from the availability of new technologies for mapping across different land-use types.

Finally, Peter Verburg and colleagues discuss the role of the land system within the food system, in particular the dependencies between local food-production systems and regional-to-global markets. They outline a new approach for contributing to sustainable local food-production systems in the context of a globalised food system.

Ellis E *et al.* (2013) *Proceedings of the National Academy of Sciences* 110, 7978–7985, doi: 10.1073/pnas.1217241110

Verburg P H *et al.* (eds) (2013) *Current Opinion in Environmental Sustainability* doi: 10.1016/j.cosust.2013.08.001

Earlier populations "likely caused widespread and profound ecological changes more than 3000 years ago".



Land-use intensity and its duration in Europe and part of Asia based on the KK10 model [Ellis E *et al.* (2013) Used Planet: A global history. *Proceedings of the National Academy of Sciences* 110, 7978-7985.] Researchers from the Global Land Project suggest more than 20% of the land areas of Europe and Asia were already in use by humans 3000 years ago.

IMPROVING HOW ATMOSPHERIC CHEMISTRY IS REPRESENTED IN CLIMATE MODELS

In 2014, the World Health Organization announced that air pollution is to blame for one in eight deaths each year. The WHO concluded air pollution is now the "world's largest single environmental health risk. Reducing air pollution could save millions of lives."

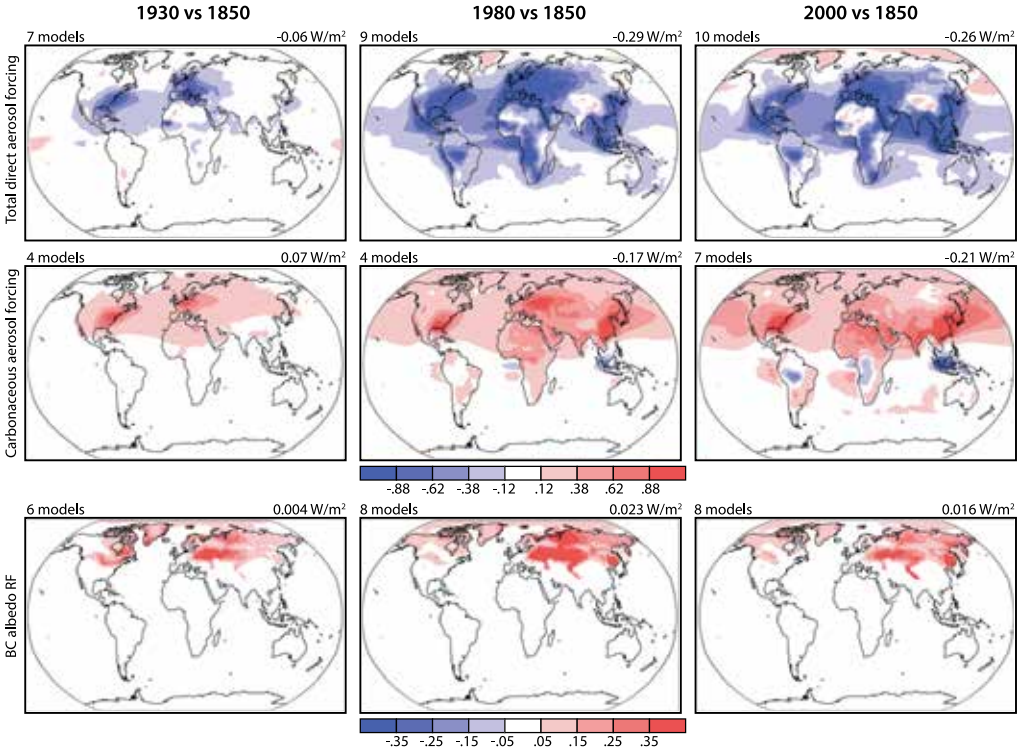
There is still a separation between air pollution and climate change in both the policy and scientific communities. The International Global Atmospheric Chemistry (IGAC) project, with its headquarters in Boulder, Colorado, coordinates research to understand air pollution, its causes and its consequences. The Air Pollution and Climate initiative led by IGAC seeks to open a science-policy dialogue on the air pollution and climate challenge. In 2013, IGAC ran a successful workshop in Boulder to bring scientists and policymakers, including WHO, together. From this workshop, a group is developing a new report: a Strategic Framework for Integrated Programs on Air Pollution and Climate Change.

As climate models develop an Earth-system approach and include additional interactions with the biosphere and other emissions including black carbon this may lead to more diversity among models. Understanding this diversity is essential to gauge the reliability of model outputs. IGAC, along with WCRP's Stratospheric Processes And their Role in Climate (SPARC) project, coordinates simulations that allow researchers to evaluate climate models to constrain uncertainties. This is known as the Atmospheric Chemistry and Climate Model Intercomparison Project (ACCMIP). Results from ACCMIP are used by the IPCC, which published its latest summaries for policymakers in 2013 and 2014.

In 2013, a group led by Drew Shindell from the NASA Goddard Institute for Space Studies published research examining ten ACCMIP models that include aerosols and compared their results with observations from, for example, satellites. Overall, Shindell and colleagues reported that models generally capture the observed magnitude of present day aerosol optical depth within 30% of observations but with a bias towards lower values. They concluded that aerosols have resulted in negative net forcing – a cooling effect – over the majority of industrialised areas and biomass burning regions through 1980. They noted a particularly strong negative forcing over East and Southeast Asia by 2000. The team remarked that "while pollution controls in North America and Europe have reduced aerosol forcing, increases in Asian emissions have more than compensated." Globally, aerosols still mask the full impact of greenhouse-gas forcing. The paper concludes that aerosols may have contributed to the relatively slow rates of global warming during recent years.

Shindell D *et al.* (2013) *Atmospheric Chemistry and Physics* 13, 2939–2974, doi: 10.5194/acp-13-2939-2013

Aerosols may have contributed to relatively slow rates of global warming during recent years.



Intercomparision of climate models that include aerosols. Columns: 1930, 1980 and 2000 (relative to 1850). Rows: multi-modal mean (Row 1: all aerosol radiative forcing; Row 2: carbonaceous aerosol radiative forcing; Row 3: black carbon albedo radiative forcing). From: Shindell D T *et al.* (2013) *Atmospheric Chemistry and Physics* 13, 2939–2974, doi:10.5194/acp-13-2939-2013

CARBON CYCLE SENSITIVITY INCREASED TWO-FOLD IN 50 YEARS

The carbon cycle is sensitive to interannual temperature variability in the tropical regions. A recent study published in *Nature* reports an almost two-fold increase in this sensitivity during the past five decades. The study was undertaken by researchers associated with IGBP's Integrated Land Ecosystem–Atmosphere Processes Study (iLEAPS).

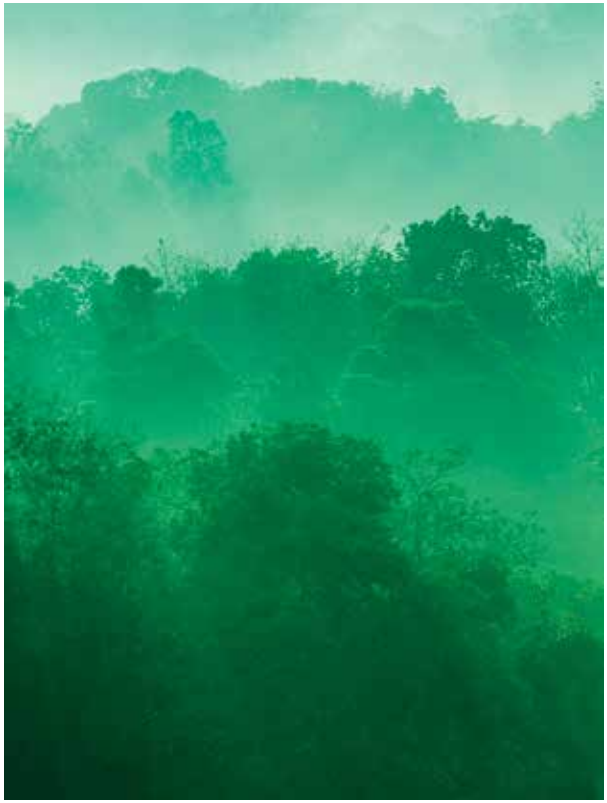
Tropical regions are under the scanner as carbon sinks in these regions are considered to be vulnerable to climate change, particularly to an increase in warming and drought. But limited data prevent a comprehensive evaluation of future changes to the sinks. This study was an attempt to harness insights from an analysis of the past five decades' worth of data.

The researchers calculated the sensitivity based on the relationship between the interannual variations in the growth rate of atmospheric carbon dioxide and the tropical mean annual temperature. Alternative explanations for the sensitivity increase were ruled out. The results indicated an increase in sensitivity from 2.6 ± 0.5 petagrams of carbon per year per degree celcius during 1960–1979 to 4.8 ± 1.0 petagrams of carbon per year per degree celcius during 1992–2011. Droughts have increased in tropical regions during the past decades, which might explain the increase in carbon-cycle sensitivity. The exact mechanism remains unclear, but changes in soil moisture might have contributed by affecting evapotranspiration.

The researchers found that most terrestrial carbon-cycle models did not capture the measured increase in carbon-cycle sensitivity. This might be because the models do not adequately represent soil temperature and moisture or the response of ecosystem respiration to climate. Although this finding calls into question the ability of the models to predict future changes in the carbon cycle, it must be borne in mind that on longer timescales other processes such as changes in soil carbon stocks, for example, are important in addition to the interannual variability of the atmospheric carbon-dioxide growth rate.

Wang X *et al.* (2014) *Nature*, doi: 10.1038/nature12915

Most terrestrial carbon-cycle models don't capture the measured increase in carbon-cycle sensitivity.



© iStockphoto.com/Ahmad Faizal Yahya

Carbon sinks in tropical regions are considered to be vulnerable to climate change, particularly to an increase in warming and drought.

IMPROVED PREDICTION OF INDIAN OCEAN PRODUCTIVITY

Climate variability affects plankton blooms in the Indian Ocean, according to researchers affiliated to IGBP's marine project IMBER. Scientists have shown that the causes of significant and predictable regional chlorophyll changes are interannual climate variability over the Indian Ocean, the Indian Ocean Dipole (IOD) and the larger-scale El Niño Southern Oscillation (ENSO). These atmospheric phenomena influence near-surface oceanography, for example sea-surface temperature and thermocline depth.

Currie and colleagues used a coupled biophysical general circulation model to separate ENSO and IOD contributions to chlorophyll anomalies in the Indian Ocean and compared the model output with remotely sensed records. They showed that IOD forcing is linked to blooms in the east of the region in autumn and in the southern Bay of Bengal in winter. ENSO influence is greater in the Somalia upwelling region and causes a decrease in autumn and winter chlorophyll by reducing upwelling winds.

Data from IMBER's Sustained Indian Ocean Biogeochemistry and Ecosystem Research (SIBER) Regional Programme should help improve prediction of interannual changes in Indian Ocean productivity, fisheries, ecosystems and carbon budgets.

IMBER has a range of other marine research activities including the Climate Impacts on Oceanic Top Predators (CLIOTOP) Regional Programme which is moving its focus to adaptation with an emphasis on developing scenarios and adaptation options for both open ocean ecosystems and the human populations that depend on them. Scientists will be working more closely with fisheries management organisations (Hobday *et al.* 2013).

In addition, IMBER works with IGBP's air-sea interactions project SOLAS on several activities. For example, researchers associated with IMBER and SOLAS published new estimates of the Southern Ocean air-sea carbon flux. The researchers, led by Andrew Lenton at CSIRO in Australia, concluded that the median annual sea-air flux for the entire Southern Ocean region is between −0.27 and −0.43 petagrams of carbon per year. However, the variability in the Southern Ocean sea–air CO_2 flux can be as large as 25% of the annual mean.

Recently, IMBER formed a human dimensions working group that aims to create an integrated and interactive natural-social science marine research community within the project.

In 2013, the IMBER project office based in Bergen, Norway spent considerable effort preparing for its open science conference June 2014 – Future Oceans: Research for marine sustainability. This promises to be one of 2014's major international conferences on marine issues.

Hobday A J *et al.* (2013) *Reviews in Fish Biology and Fisheries* 23 (4), 537-546, doi: 10.1007/s11160-013-9311-0

Currie J C *et al.* (2013) *Biogeosciences* 10, 6677-6698, doi: 10.5194/bg-10-6677-2013

Lenton A *et al.* (2013) *Biogeosciences* 10, 4037-4054, doi: 10.5194/bg-10-4037-2013

Scientists will be working more closely with fisheries management organisations.

Ethan Prater

A tuna market in Japan. IMBER's Climate Impacts on Oceanic Top Predators project aims to understand the dynamics of top ocean predator populations, such as tuna, based on both fishing and climate. The researchers aim to work closely with fisheries management organisations.

MAJOR COASTAL URBANISATION SYNTHESIS PUBLISHED

Much research exists on megacities of more than ten million people and about urban processes. Similarly extensive research abounds on coasts and their physical and ecological processes. Less is known of the point of intersection where megacities and coasts meet.

In 2013, based on a major international study sponsored by the Land–Ocean Interactions in the Coastal Zone (LOICZ) project, Mark Pelling and Sophie Blackburn, both from King's College London, published a synthesis of scientific knowledge on megacity urbanisation on the coast. The book outlined the environmental impacts, risks and management choices facing city planners including a focus on adaptation, mitigation and disaster risk management.

The book, the result of an IGBP synthesis topic led by LOICZ, brings together the work of over 60 contributing authors and an international review board. It presents the international policy and academic community with a high-quality assessment of the state of the art in areas of social-ecological-systems interaction. The publishers say this is the first global synthesis of megacities and large urbanisation on the coast. Its focus is on environmental and development challenges, climate change and disaster.

The book is part of the broader awareness that coastlines are at the frontline of the global sustainability challenge. In 2013, the leading international group of funding agencies, the Belmont Forum, named coastal vulnerability as a priority area for funding. Three of the seven proposals awarded grants under this initiative were related to LOICZ: Transformation and resilience on urban coasts; An integrated framework to analyze local decision making and adaptive capacity to large-scale environmental change: community case studies in Brazil, UK and the US; and Catalyzing action towards sustainability of deltaic systems with an integrated modelling framework for risk assessment. This is a significant achievement for LOICZ and demonstrates the value of internationally coordinated research.

In 2013, scientists associated with LOICZ examined the barriers to implementation of ecosystem-based adaptation measures on Pacific islands. It is recognised that Pacific islands are particularly vulnerable to climate change. Ecosystem-based adaptation approaches offer potential solutions for longer-term sustainability. The researchers concluded that the most significant hurdle to implementing this type of approach is the level of stable technical expertise within government departments to advise communities on opportunities and integrated planning frameworks rather than access to financial resources.

The authors recommended that Pacific island governments: 1. include consideration of ecosystem-based adaptation climate planning, 2. ensure cross-cutting policy and planning instruments have integrated objectives compatible with ecosystem-based adaptation, for example, in biodiversity and disaster management planning, and 3. increase technical capacity, that is employ staff with relevant expertise in ecosystem-based adaptation.

LOICZ's long-serving Executive Officer Harwig Kremer left in 2013 to take a position at the United Nations Environment Programme in Nairobi. Marion Glaser has been appointed interim Executive Officer. The LOICZ scientific steering committee is in the process of finding a new host for the office, currently based at the Helmholtz-Zentrum Geesthacht Institute for Coastal Research in Germany. LOICZ is supported by a network of regional nodes.

Hills T *et al.* (2013) *Sustainability Science 8 (3)*, doi: 10.1007/s11625-013-0217-5

Pelling M and Blackburn S, eds (2013) *Megacities and the Coast: Risk, Resilience and Transformation*. Routledge, London.

On small islands ecosystem-based adaptation approaches offer potential solutions for longer-term sustainability.

© iStockphoto.com/buzzbarca

Pacific islands face a range of immediate and significant environmental stressors. An ecosystem-based approach to adaptation will help but limited expertise on many islands means implementing it will be difficult.

PAST TEMPERATURE CHANGES AT THE CONTINENTAL SCALE

Last year an international team of 78 researchers published the most comprehensive reconstruction of past temperature changes at the continental scale. The research, coordinated by the Past Global Changes (PAGES) project, confirmed an overall cooling trend across nearly all continents during the last one to two thousand years. This trend was reversed by distinct warming, beginning in some regions at the end of the 19th century, say the authors in the journal *Nature Geoscience*.

The researchers reached their conclusions by integrating records from tree rings, pollen, corals, lake and marine sediments, ice cores, stalagmites and historical documents at 511 locations across seven continental-scale regions.

Temperature variations across continents were noticeably more similar within the hemispheres than between the Northern and Southern Hemisphere. "Distinctive periods, such as the Medieval Warm Period or the Little Ice Age, stand out, but do not show a globally uniform pattern on multi-decadal time scales," says co-author Professor Heinz Wanner of the University of Bern.

The most consistent feature across the regions was a long-term cooling trend. The researchers suggest that a combination of factors contributed to the trend such as an overall increase in volcanic activity, a decrease in solar activity, changes in land cover, and slow changes in the Earth's orbit.

The cooling came to an end towards the end of the 19th century. Warming in the 20th century was on average twice as large in the northern regions as it was in the Southern Hemisphere. Only one continent, Antarctica, has bucked the warming trend.

An analysis of the average temperatures over 30-year periods indicates that the interval from 1971 to 2000 was probably warmer than any other 30-year period in the last 1400 years. Going back further, some regions experienced warmer 30-year intervals. In Europe, a period during the Roman Empire between 21 and 80 AD was likely warmer than the period 1971–2000.

PAGES 2k Consortium (2013) *Nature Geoscience* 6, 339-346, doi: 10.1038/NGEO1797

Warming in the 20th century was on average twice as large in the northern regions as it was in the Southern Hemisphere.

New landmark research from the Past Global Changes project shows how climate has changed over the last two millennia by continental region. The research confirms that a long-term cooling trend ended recently and rapid warming has been observed.

AIR-SEA INTERACTIONS SYNTHESIS PUBLISHED

A recently published book synthesises research coordinated by the Surface Ocean–Lower Atmosphere Study (SOLAS), co-sponsored by IGBP. The book emerged as an outcome of Action 735 of the office of European Coordination in the field of Scientific and Technical Research.

The synthesis, initiated in 2006, entailed the development of global air–sea flux datasets of gases and aerosols. It involved more than 300 scientists mainly from Europe but also from other parts of the world. The SOLAS International Project Office played a key role in coordinating this synthesis, led by Peter Liss (former Chair of SOLAS and IGBP) and Martin Johnson.

The Southern Ocean was the focus of two recent papers published by researchers associated with the project. Kawaguchi and colleagues explored the risk posed to Antarctic krill – in particular to the successful hatching of eggs – by the projected acidification of the Southern Ocean. Krill is the key pelagic species of the region and its largest fishery resource. The researchers reported in *Nature Climate Change* that assuming IPCC's Representative Concentration Pathways 6 and 8.5 the important krill habitats of the Weddell Sea and the Haakon VII Sea are likely to become high-risk areas within a century and there is a possibility of a collapse of krill stocks further in the future.

Dufour and colleagues sought to understand how the important carbon sink of the Southern Ocean would change in response to anthropogenic climate change. In view of the changing westerly winds, could this sink be weakened due to wind-induced upwelling and subsequent outgassing of carbon dioxide? In a study published in *Global Biogeochemical Cycles* the scientists showed that this process is in part counterbalanced by eddy-driven downward transportation of oceanic carbon: this compensates for about a third of the wind-driven release of carbon dioxide into the atmosphere.

Dufour *et al.* (2013) *Global Biogeochemical Cycles* 27, 950-961, doi: 10.1002/gbc.20090

Kawaguchi *et al.* (2013) *Nature Climate Change* 3, 843-847, doi: 10.1038/nclimate1937

Liss P S and Johnson M T (eds) (2013) *Ocean–Atmosphere Interactions of Gases and Particles.* Springer, Heidelberg. http://link.springer. com/book/10.1007/978-3-642-25643-1

300 scientists participated in the synthesis.

© iStockphoto.com/Anelina

SOLAS focuses on the interface between the oceans and the atmosphere.

GLOBAL CARBON ATLAS LAUNCHED

The Global Carbon Project (GCP) provides a comprehensive policy-relevant understanding of the global carbon cycle, encompassing natural and human dimensions. Each year GCP publishes the global carbon budget. The budget receives widespread media attention. In 2013, GCP launched the budget with a new online data analytic tool for the public, scientists and policymakers – the Global Carbon Atlas.

GCP reported that in 2012 fossil-fuel emissions grew to 9.7 GtC yr^{1}, 2.2 % above 2011. Fossil-fuel emissions are estimated to grow by 3.1% in 2013, 61% above emissions in 1990.

Global CO_2 emissions continue to be dominated by emissions from China (27%), the USA (14%), the European Union (28 member states; 10%) and India (6%). Growth rates of these countries from 2011 to 2012 were 5.9% for China, –3.7% for the USA, –1.3% for the EU28, and 7.7% for India.

GCP reports that global cumulative CO_2 emissions will reach about 535 GtC for 1870-2013, about 70% from fossil fuels and 30% from land-use change. Land and ocean sinks were either stable or grew. The project reports that the current trajectory is tracking the Representative Concentration Pathway 8.5 of the latest family of IPCC scenarios which takes the planet's average temperature to about 3.2-5.4°C above pre-industrial times by 2100.

In 2013, GCP also produced a global methane budget for 2000-2009. After CO_2 methane is the second most important well-mixed greenhouse gas contributing to human-induced climate change. The level of methane in the atmosphere has increased 150% since around 1750. After over a decade of stable methane concentrations, growth resumed in 2007 and has been growing since then due to increased emissions from wetlands and the combustion of fossil fuels, although the researchers acknowledge the relative contribution of these two fluxes is uncertain.

The Global Carbon Atlas, launched in November at the UNFCCC climate negotiations, received 25,000 unique visits in its first week. The atlas was designed to be one of the major interfaces between GCP research and three distinct audiences: the general public; policymakers, NGOs, and the corporate world involved in climate-change policy and affairs; and researchers with model and other flux and pool carbon data.

GCP's Co-chair Corinne Le Quéré was a drafting contributing author on the IPCC's Fifth Assessment Report Working Group I Summary for Policymakers published in September 2013.

Le Quéré C. *et al.* (2013) *Earth System Science Data* 5, 165-185, doi: 10.5194/essd-5-165-2013.

Kirschke S. *et al.* (2013) *Nature Geoscience* 6, 813–823.

In 2013, global CO_2 emissions were dominated by emissions from China, the USA, the European Union and India.

The Global Carbon Project has developed the Global Carbon Atlas for policymakers, public and scientists. The new tool allows users to explore carbon sources and sinks on a global scale and access the data.

COMMUNICATIONS

IGBP's communications team supports IGBP's core projects, produces two issues of the *Global Change* magazine each year and an annual report, and maintains the IGBP website. The *Global Change* magazine has an international circulation of around 4000. It strives to cover the most significant research coming from IGBP's projects and beyond, and put this in a broader "Earth system" perspective.

In 2013 the team coordinated the media strategy for the launch of IGAC's report on black carbon resulting in widespread international media coverage including *The Economist*, the BBC and the *Washington Post*. We also supported the PAGES project for the publication of its 2000-year temperature reconstruction that received significant publicity.

Stockholm, the home of the IGBP secretariat, was the location for the launch of the IPCC Working Group I summary for policymakers in September 2013. The IGBP communications team worked closely with IPCC in the run-up and launch of the report and participated in a new European climate communicators network. We proposed and organised, with IPCC and local partners, a public dialogue – Climate Change: the state of the science – which took place the day after the release of the summary for policymakers. The event, a first for IPCC, attracted 500 people and over 30,000 views online.

The communications team, with Anthropocene education specialists Globaïa, produced a three-minute data visualisation summarising the IPCC report, which was launched at the UNFCCC climate negotiations in Bonn. The visualisation has received over 600,000 views online. The team also produced a data visualisation for the Global Water System Project to open its science conference – Water in the Anthropocene. The short film traces the scale of human interference in the global water cycle. It has garnered around 60,000 views. The visualisation projects are part of IGBP's public outreach website: www.anthropocene.info.

Among many speaking engagements, Executive Director Sybil Seitzinger was invited to give the prestigious Union Agency Lecture at the American Geophysical Union (AGU) conference in San Francisco, December 2013. Attracting around 24,000 scientists, AGU is the world's largest gathering of geoscience expertise.

The event was the first public dialogue for a new IPCC report.

Jonas Forare

IPCC Working Group I Co-chair Thomas Stocker presenting the state of climate science at the IGBP-sponsored Stockholm dialogue, September 2013.

POLICY

Each year the UNFCCC's Subsidiary Body for Scientific and Technological Advice asks IGBP to provide the latest scientific research pertaining to climate change of relevance to national negotiators. As the Earth System Science Partnership has closed, IGBP now coordinates this activity on behalf of the global-environmental-change programmes. IGBP provides a summary of pertinent new research on issues such as black carbon, ocean acidification and climate modelling. Much of our summary draws on research by our projects and those of our partner programmes.

IGBP contributes to all stages of the IPCC assessment: it joins scoping meetings, nominating authors and reviewers, and holds joint workshops. Our projects refine their science plans to specifically address gaps in understanding highlighted by previous IPCC reports. The research coordinated by our projects is a key component of the research assessed by IPCC.

At the UNFCCC climate talks in November 2013, IGBP and co-sponsors SCOR and IOC-UNESCO, launched a summary for policymakers on ocean acidification. The summary, based on findings from the world's largest gathering of experts on ocean acidification – the 2012 Ocean in a High-CO_2 World symposium – attracted headlines in *The Economist,* the BBC and the *Washington Post.*

Experts concluded that marine ecosystems and biodiversity are likely to change as a result of ocean acidification combined with other stressors such as temperature, with far-reaching consequences for society. Based on projections, some researchers suggest the acidity of the world's oceans may increase by around 170% by the end of the century bringing potentially significant economic losses. People who rely on the oceans' ecosystem services – often in developing countries – are especially vulnerable.

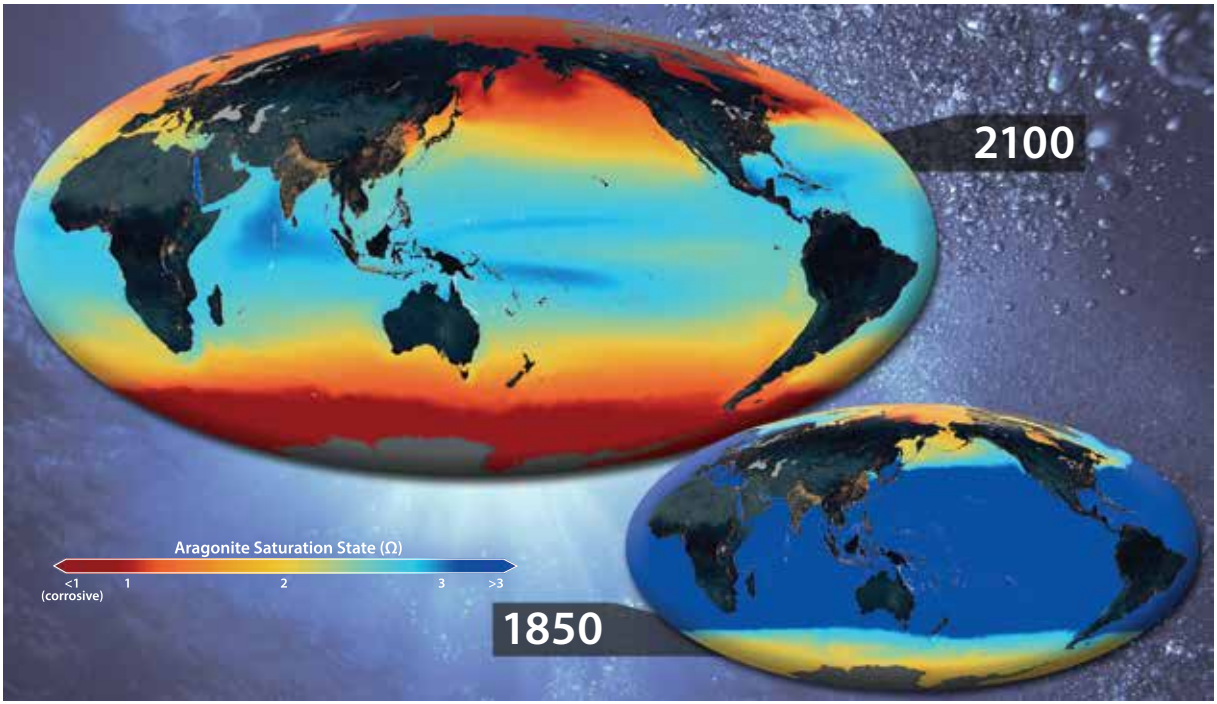
Author and symposium chair Ulf Riebesell of GEOMAR Helmholtz Centre for Ocean Research in Kiel said: "What we can now say with high levels of confidence about ocean acidification sends a clear message. Globally we have to be prepared for significant economic and ecosystem service losses. But we also know that reducing the rate of carbon-dioxide emissions will slow acidification."

One outcome emphasised by experts is that if societies continue on the current high emissions trajectory, coldwater coral reefs, located in the deep sea, may be unsustainable and tropical-coral-reef erosion is likely to outpace reef building this century. However, significant emissions reductions to meet the two-degree target by 2100 could ensure that half of surface waters presently occupied by tropical coral reefs would remain favourable for their growth. The summary contains 21 statements about ocean acidification with a range of confidence levels from "very high" to "low".

IGBP is also engaged in the international process to create a suite of universal Sustainable Development Goals. To achieve the aim of long-term sustainable development the goals and their underlying targets and indicators must be scientifically credible. IGBP's sponsoring organisation the International Council for Science is coordinating input from the scientific community. IGBP's Executive Director Sybil Seitzinger has participated in the development of a UNEP report Embedding the Environment in Sustainable Development Goals and IGBP's Director of Communications contributed to a commentary in *Nature*, Sustainable Development Goals for People and Planet.

IGBP's projects and activities are also engaged in science-policy activities. The International Nitrogen Initiative and the Global Partnership on Nutrient Management published a report, Our Nutrient World, commissioned by UNEP. And the IGAC project held a workshop in Boulder, Colorado, to bring together scientists and stakeholders working on atmospheric chemistry and human health.

Ocean acidification: We must be prepared for significant economic and ecosystem service losses.



The shells and skeletons of many marine species are made from either calcite or aragonite; both are forms of calcium carbonate. Marine researchers are particularly concerned about aragonite, which is produced by many corals and molluscs, because it is more soluble than calcite.
Source: IGBP, IOC, SCOR (2013). Ocean Acidification Summary for Policymakers – Third Symposium on the Ocean in a High-CO_2 World.

Future Earth

Throughout 2013 IGBP supported the development of the new Future Earth initiative. Future Earth aims to bring together the global-environmental-change programmes and drive a new research agenda focusing on solutions to the global sustainability challenge. It is spearheaded by an alliance of international organisations: International Council for Science (ICSU), International Social Science Council (ISSC), the Belmont Forum of funding agencies, United Nations Educational, Scientific and Cultural Organization (UNESCO), United Nations Environment Programme (UNEP) and the United Nations University (UNU).

The alliance announced the appointment of the first Future Earth scientific committee, which is chaired by former IGBP Vice-chair Mark Stafford Smith. The committee also includes two IGBP scientific-committee members: Eduardo Brondizio and Cheikh Mbow. The committee met for the first time in November in South Africa and focused on developing the Future Earth research strategy.

An interim secretariat and director (Frans Berkhout) have been appointed, based at ICSU's headquarters in Paris, and an interim engagement committee led by Robert Watson. The engagement committee includes representatives from business, the development sector, NGOs, the media and foundations.

In January 2014, Future Earth held a meeting in Washington, DC, that brought together projects of the existing global-environmental-change programmes. The aim was to focus on the research strategy and develop ideas for new Fast-Track Initiatives (modelled along the lines of the highly successful initiatives run by IGBP).

Future Earth is developing close ties with the UN's Sustainable Development Solutions Network and the new Scientific Advisory Board to Ban Ki-moon. Former IGBP Chair Carlos Nobre sits on this board, which was announced in September 2013.

Future Earth seeks to bring together the intellectual capacity of 50,000 scientists.

In 2013 Future Earth published its Initial Design Report illustrating its organisational structure and overarching research themes, appointed its first scientific and interim engagement committees, appointed an interim secretariat and launched a blog.

PARTNERSHIPS

Global environmental change programmes and Future Earth

The International Council for Science (ICSU) co-sponsors four global-environmental-change (GEC) programmes: IGBP, DIVERSITAS, the International Human Dimensions Programme on Global Environmental Change (IHDP) and the World Climate Research Programme (WCRP).

During 2013 the new ten-year Future Earth initiative has been under development (see page 28). Future Earth will bring together existing global-environmental-change programmes including IGBP.

Co-sponsors of IGBP projects

- International Human Dimensions Programme on Global Environmental Change: GLP and LOICZ.
- International Commission on Atmospheric Chemistry and Global Pollution (ICACGP): SOLAS and IGAC.
- Scientific Committee on Oceanic Research (SCOR): IMBER and SOLAS.
- World Climate Research Programme: SOLAS.

Joint projects on global sustainability

- Climate Change, Agriculture and Food Security (CCAFS)
- Global Carbon Project (GCP)
- Global Water System Project (GWSP)

Regional research, collaboration and capacity building

- Monsoon Asia Integrated Regional Study (MAIRS)
- Asia-Pacific Network for Global Change Research (APN)
- Inter-American Institute for Global Change Research (IAI)
- Global Change System for Analysis, Research and Training (START)

Monitoring, measuring and Earth observation

All major space agencies contribute to IGBP research and work closely with the IGBP research community. NASA, the European Space Agency (ESA) and the Group on Earth Observations (GEO) participate in IGBP's annual scientific committee meetings. IGBP also participates in the Integrated Global Observing Strategy (IGOS) and the Committee on Earth Observation Satellites (CEOS).

The European Space Agency is running two major activities with IGBP core projects SOLAS and iLEAPS.

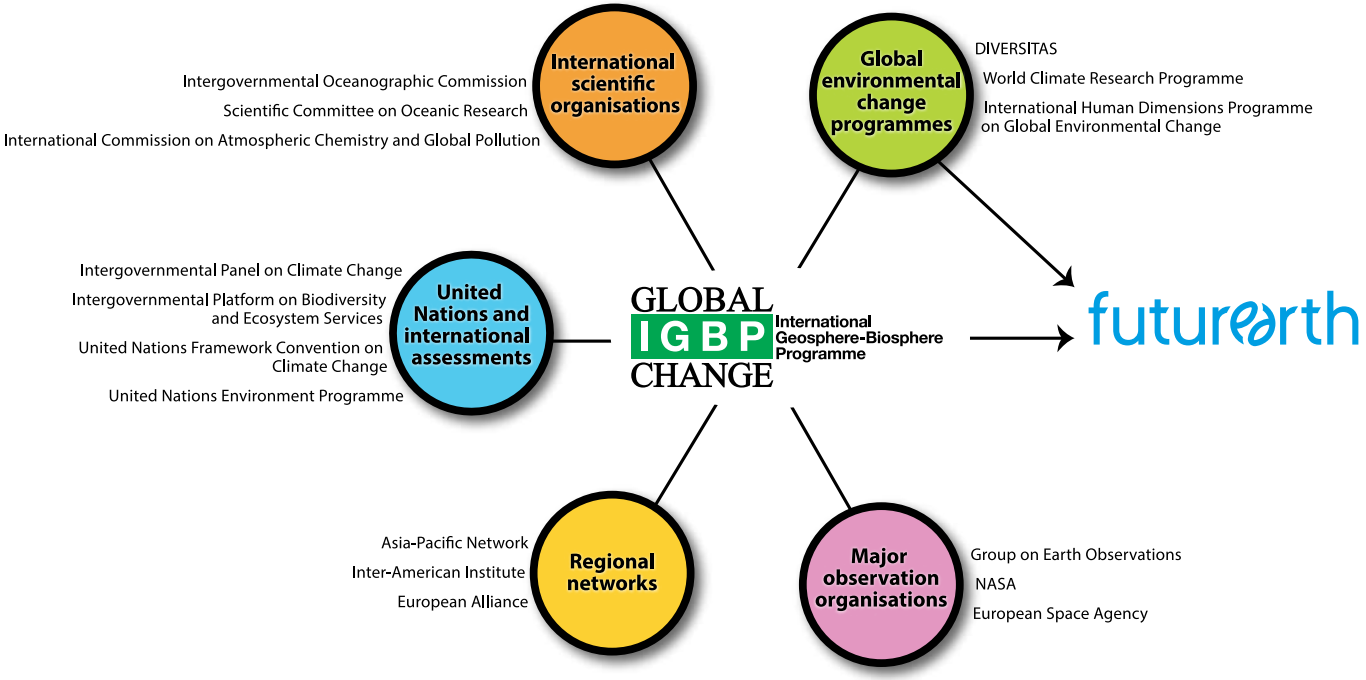
ESA-iLEAPS: the Atmosphere–Land Interaction Study (ALANIS) ran three projects investigating the use of satellite data in the northern high latitudes to:

- improve wetland-related methane emissions in land-surface models;
- better track fire emissions and identify smoke plume injection heights;
- discriminate between natural and natural aerosols from boreal forest regions.

ESA-SOLAS: the Oceanflux study also ran three projects using satellite data to:

- characterise the role of ocean upwelling processes as sinks and/or sources of greenhouse gases;
- improve quantitative air-sea flux estimates of CO2 and other greenhouse gases;
- and improve the source function of sea-spray aerosols through novel data sources.

ESA has also supported workshops and conferences with IGBP, and has financially supported IGBP and core project scientific steering committee members to attend ESA events and conferences.



IGBP works closely with the United Nations through the UN's assessment processes, and with other international scientific organisations, major observation organisations and regional networks.

National Committees

IGBP has 52 national committees. These committees coordinate regional and national activities related to global-change research including workshops and symposia. The following is a selection of some of the highlights from the national committees in 2013.

In November, IGBP held its Officers' meeting in Botswana at the invitation of IGBP Vice-chair Pauline Dube and the Botswana Global Change Committee. The committee organised a stimulating knowledge exchange symposium in the capital Gabarone that attracted scientists, business leaders and policymakers. Throughout the week, IGBP Officers worked through a substantial meeting agenda focusing on IGBP's final syntheses, including an event in 2015 to mark the achievements of IGBP, the transition to Future Earth and our other activities.

The Botswana Global Change Committee arranged many meetings between the IGBP Officers and stakeholders from policy and academia within Botswana. After two days in Gabarone the meeting moved to Maun on the edge of the famous Okavango Delta. Here IGBP Officers met the Acting Paramount Chief of Batawana Kgosi Kealitile Moremi, Dikgosana. This was the first time a group of international scientists had met with tribal elders at a *kgotla* – a public meeting. Village leaders came from a 50-kilometre radius and gathered in a traditional thatched building. IGBP Officers engaged in a lively and open discussion on global change and how it impacts the delta, for example through tourism and mining.

IGBP Officers then travelled to the Okavango Research Institute's research base deep in the delta. Guide Dr Mike Murray-Hudson's formidable knowledge of the geology, flora and fauna of this inland delta gave IGBP's Officers a deeper appreciation and understanding of this region and the changes it is undergoing.

In April 2013, the Swiss Global Change committee ProClim hosted IGBP's scientific committee meeting in Berne. This meeting began with a well-attended symposium attracting many of the leading Earth-system science academics in Switzerland.

The UK IGBP committee, sponsored by the Royal Society, met several times in 2013. The focus of the activities was on supporting the development and delivery of a major Future Earth UK "town hall" meeting aimed at informing UK researchers about the opportunities and challenges of Future Earth. The meeting, which was co-hosted by the Royal Society and British Academy, brought together expertise from the natural and social sciences and attracted over 200 people. Break-out sessions explored the three to five most exciting research questions that can be significantly advanced through the international, interdisciplinary and transdisciplinary research agenda and how the international, interdisciplinary and transdisciplinary Future Earth research agenda can help advance the science.

In a similar vein, the Sri Lankan national committee held a workshop on "Developing a Science, Technology and Innovation Agenda for Sri Lanka towards Future Earth" in the capital Colombo. The meeting was attended by the Minister of Scientific Affairs and Minister of Environment, and by Dr Mark Stafford Smith, Chair of the Future Earth Scientific Committee.

IGBP's Greek national committee held a workshop at the Academy of Athens focusing on renewal energy resources. The Cameroon national committee organised a workshop on the theme "International migrations and local development".

IGBP has 52 national committees in Africa, the Americas, Asia-Pacific and the Middle East, and Europe.

Wendy Broadgate

IGBP Executive Director Sybil Seitzinger meets the Acting Paramount Chief of Batawana Kgosi Kealitile Moremi, Dikgosana. IGBP's Officers' meeting was held in Botswana at the invitation of the Botswana Global Change Committee. Following a successful knowledge exchange symposium, the Officers travelled to Maun on the edge of Botswana's famous Okavango Delta where they met the Acting Paramount Chief. This was the first time a group of international scientists had met with tribal elders at a *kgotla* – a public meeting.

National Committees and Regional Alliances

IGBP has 52 national committees across Africa, the Americas, Asia-Pacific, Europe and the Middle East. Some of these committees are global-change committees that also represent partner programmes. IGBP also has a regional office in Brazil located at the Instituto Nacional de Pesquisas Espaciais (INPE).

IGBP national committees listed by region

Africa

Botswana
Cameroon
Congo, Democratic Republic of
Egypt
Ivory Coast
Kenya
Morocco
Mozambique
South Africa
Zimbabwe

Americas

Argentina
Bolivia
Brazil
Colombia
United States*

*Through the US National Academies

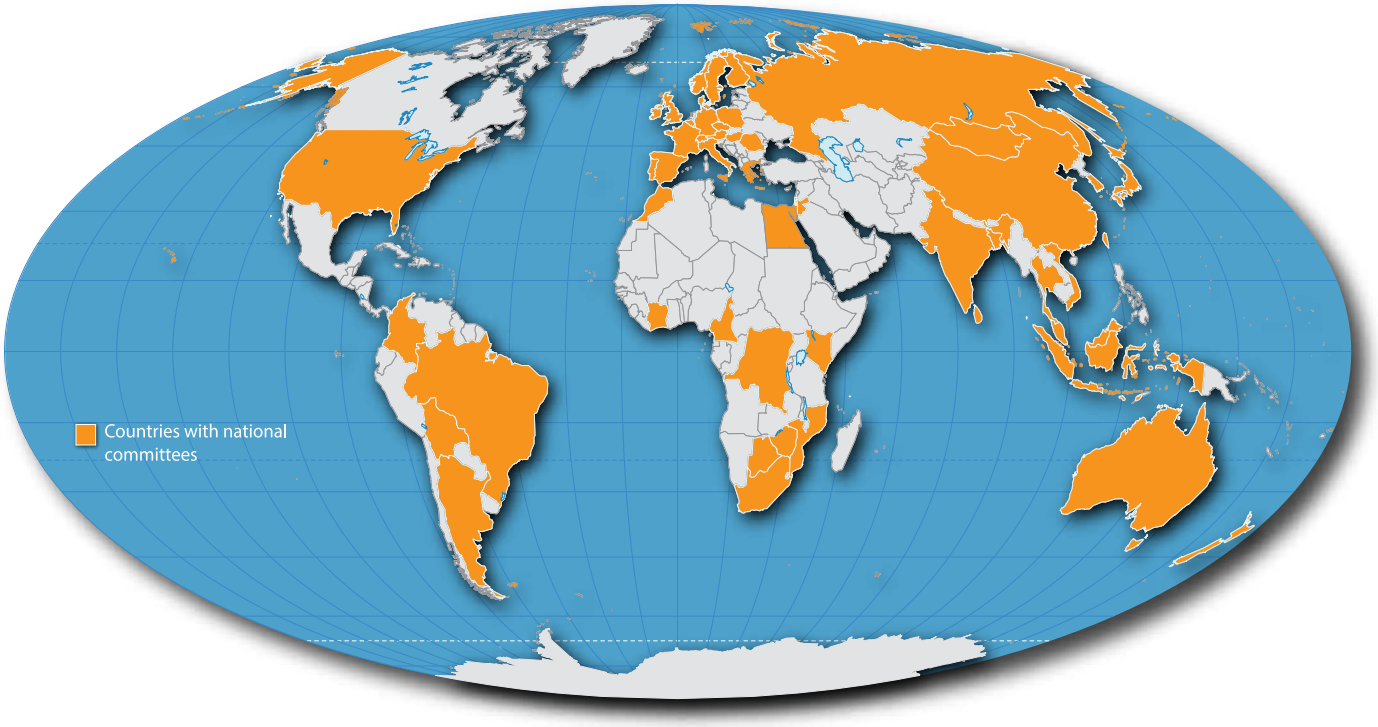
Asia-Pacific and the Middle East

Australia
Bangladesh
China: Beijing
China: Taipei
India
Indonesia
Israel
Japan
Jordan
Korea, Republic of
Malaysia
Mongolia
New Zealand
Singapore
Sri Lanka
Thailand
Vietnam

Europe

Austria
Belgium
Czech Republic
Denmark
Finland
France
Germany
Greece
Hungary
Ireland
Italy
Norway
Poland
Portugal
Romania
Russian Federation
Spain
Sweden
Switzerland
United Kingdom

National Committees



IGBP has 52 national committees around the globe.

2013 IGBP Scientific Committee

ICSU-appointed members

James P M Syvitski (Chair)
University of Colorado
UNITED STATES

Chen-Tung Arthur Chen (Vice-chair)
National Sun Yat-sen University
TAIWAN

Opha Pauline Dube (Vice-chair)
University of Botswana
BOTSWANA

Jean Palutikof (Vice-chair)
Griffith University
AUSTRALIA

Jan Willem Erisman (Treasurer)
Louis Bolk Institute
NETHERLANDS

Raymond S Bradley
University of Massachusetts - Amherst
UNITED STATES

Eduardo S Brondizio
Indiana University
UNITED STATES

Martin Claussen
Max Planck Institute for Meteorology
GERMANY

Christiane Lancelot
Université Libre de Bruxelles
BELGIUM

Jose A Marengo
Instituto Nacional de Pesquisas Espaciais (INPE CCST)
BRAZIL

Patricia A Matrai
Bigelow Laboratory for Ocean Sciences
UNITED STATES

Cheikh Mbow
World Agroforestry Centre (ICRAF)
KENYA

S K Satheesh
Indian Institute of Science
INDIA

Priya Shyamsundar
South Asian Network for Development and Environmental Economics (SANDEE)
UNITED STATES

Mitsuo Uematsu
The University of Tokyo
JAPAN

Project chairs and co-chairs

Peter Cox (Chair AIMES)
University of Exeter
UK

Hubertus Fischer (Co-chair PAGES)
University of Bern
SWITZERLAND

Allen Goldstein (Co-Chair IGAC)
University of California, Berkeley
UNITED STATES

Alex Guenther (Co-chair iLEAPS)
Pacific Northwest National Laboratory (PNNL)
UNITED STATES

Hans-Christen Hansson (Co-chair iLEAPS)
Stockholm University
Department of Applied Environmental Science (ITM)
SWEDEN

Eileen E Hofmann (Chair IMBER)
Old Dominion University
UNITED STATES

Alan C Mix (Co-chair PAGES)
Oregon State University
College of Oceanic and Atmospheric Sciences
UNITED STATES

Paul Monks (Co-chair IGAC)
University of Leicester
UK

Ramesh Ramachandran (Chair LOICZ)
National Centre for Sustainable Coastal Management
Ministry of Environment and Forests
INDIA

Eric Saltzman (Chair SOLAS)
University of California at Irvine
UNITED STATES

Peter Verburg (Chair GLP)
VU University Amsterdam
Institute of Environmental Studies
NETHERLANDS

International partner chairs

Antonio J Busalacchi (WCRP)
University of Maryland
UNITED STATES

Georgina Mace (DIVERSITAS)
University College London
UK

Partha Dasgupta (IHDP)
University of Cambridge
UK

2013 IGBP Project Offices

Core projects

Analysis, Integration and Modelling of the Earth System (AIMES)

Currently no international project office

Global Land Project (GLP)

Executive Officer: Giovana Espindola

International Project Office:
National Institute for Space Research (INPE)
São Paulo, Brazil
Nodes:
Taipei, Taiwan; Beijing, China; Sapporo, Japan

Integrated Marine Biogeochemistry and Ecosystem Research (IMBER)

Executive Officer: Bernard Avril

International Project Office:
Institute of Marine Research
Bergen, Norway
Node:
Shanghai, China

International Global Atmospheric Chemistry (IGAC)

Executive Officer: Megan Melamed

International Project Office:
University of Colorado, CIRES
Boulder, Colorado USA

Integrated Land Ecosystem–Atmosphere Processes Study (iLEAPS)

Executive Officer: Tanja Suni

International Project Office:
University of Helsinki
Helsinki, Finland
Nodes:
Nanjing, China; Tsukuba, Japan

Land–Ocean Interactions in the Coastal Zone (LOICZ)

Executive Officer: Hartwig Kremer (until August 2013)

Interim Director: Marion Glaser (from October 2013)

International Project Office:
Institute for Coastal Research, Helmholtz-Zentrum
Geesthacht, Germany
Nodes:
Rio de Janeiro, Brazil; Yantai, China; Chennai, India; Faro, Portugal; Singapore

Past Global Changes (PAGES)

Executive Officer: Thorsten Kiefer

International Project Office:
Bern, Switzerland

Surface Ocean–Lower Atmosphere Study (SOLAS)

Executive Officer: Emilie Breviere

International Project Office:
GEOMAR Helmholtz-Centre for Ocean Research
Kiel, Germany

Joint projects

Global Carbon Project (GCP)

Executive Directors:
Josep (Pep) Canadell; Sharifi Ayyoob

International Project Offices:
CSIRO Marine and Atmospheric Research
Canberra, Australia

Center for Global Environmental Research, National Institute for Environmental Studies
Tsukuba, Japan

Global Water System Project (GWSP)

Executive Officer: Anik Bhaduri

International Project Office:
University of Bonn
Bonn, Germany

Climate Change, Agriculture and Food Security (CCAFS)

Program Director: Bruce Campbell

CCAFS Coordinating Unit:
University of Copenhagen
Frederiksberg C, Denmark

2013 National Committee Chairs (or Contacts)

Africa

BOTSWANA
Opha Pauline Dube
University of Botswana

CAMEROON
Maurice Tsalefac
University of Yaoundé

CONGO, DEMOCRATIC REPUBLIC OF
Nsalambi Nkongolo
Lincoln University of Missouri
United States

EGYPT
Mohamed Saber
National Research Centre

IVORY COAST
Abdourahamane Konaré
University of Cocody

KENYA
Raphael M Munavu
Kenya National Academy of Sciences

MOROCCO
Mohammed Saïd Karrouk
Hassan II University

MOZAMBIQUE
Patricio Sande
Scientific Research Association of Mozambique

SOUTH AFRICA
Guy Midgley
National Botanical Institute

ZIMBABWE
Susan Muzite
Research Council of Zimbabwe

Americas

ARGENTINA
Mario N Nunez
Center for Atmospheric and Ocean Research (CIMA)

BOLIVIA
Jaime Argollo Bautista
Major de San Andrés University

BRAZIL
Paulo Nobre
Rede CLIMA

COLOMBIA
Germán Poveda
University of Colombia

UNITED STATES
Laurie Geller (contact)
National Academy of Sciences

Asia-Pacific and the Middle East

AUSTRALIA
Tas van Ommen
ACE CRC and Australian Government Antarctic Division

BANGLADESH
Mesbahuddin Ahmad
Bangladesh Academy of Sciences

CHINA: BEIJING
Zhongli Ding
Chinese Academy of Sciences

CHINA: TAIPEI
Chen-Tung Arthur Chen
National Sun Yat-sen University

INDIA
S K Satheesh
Indian Institute of Science

INDONESIA
Thomas Djamaluddin
National Aeronautical and Aerospace Agency (LAPAN)

ISRAEL
Dan Yakir
Weizmann Institute of Science, Tel Aviv University
Bob Lapidot (contact)
Israel Academy of Sciences and Humanities

JAPAN
Tetsuzo Yasunari
Nagoya University

JORDAN
Dia-Eddin Arafah
University of Jordan
Tareq Hussein
University of Jordan

KOREA, REPUBLIC OF
Chae-Shik Rho
The National Academy of Sciences

MALAYSIA
Ahmad Ibrahim
Academy of Sciences Malaysia (ASM)
Che Gayah Ismail (contact)
Malaysian Meteorological Department

2013 NATIONAL COMMITTEE CHAIRS (OR CONTACTS)

MONGOLIA
Togtohyn Chuluun (contact)
National University of Mongolia

NEW ZEALAND
Julie Hall
National Institute of Water & Atmospheric Research

SINGAPORE
Karina Gin
Nanyang Technological University

SRI LANKA
Janaka Ratnasiri
Sri Lanka Association for the Advancement of Science

THAILAND
Kasem Chunkao
Kasetsart University

VIETNAM
Dao Trong Thi
Vietnam National University

Europe

AUSTRIA
Georg Grabherr
University of Vienna

BELGIUM
Philippe Bourdeau
The Free University of Brussels
Oscar Vanderborght
Royal Belgian Academy of Sciences

CZECH REPUBLIC
Alexander Ac
Academy of Sciences of the Czech Republic

DENMARK
Kim Pilegaard
Technical University of Denmark
Department of Chemical and Biochemical Engineering

FINLAND
Tuula Tuhkanen
Tampere University of Technology

FRANCE
Hervé Le Treut
Laboratory of Dynamic Meteorology

GERMANY (Future Earth)
Martin Visbeck
GEOMAR, Kiel

GREECE
George Contopoulos
Research Center of Astronomy, Academy of Athens

HUNGARY
Attila Borhidi (contact)
University of Pécs, Biological Institute

IRELAND
J Ray Bates
University College Dublin

ITALY
Sandro Fuzzi
National Research Council

NORWAY
Anne Lyche Solheim
Norwegian Institute for Water Research (NIVA)

POLAND
Andrzej Kedziora
Polish Academy of Sciences

PORTUGAL
Nelson Lourenço
Atlântica University

ROMANIA
Dan Balteanu
Institute of Geography, Romanian Academy

RUSSIAN FEDERATION
Evgeny A Vaganov
Russian Academy of Sciences

SPAIN
Fernando Valladares
Spanish National Research Council (CSIC)

SWEDEN
Dan Wilhelmsson (contact)
Swedish Secretariat for Environmental Earth System Sciences

SWITZERLAND
Ulrike Lohmann
Institute for Atmosphere and Climate

UNITED KINGDOM
Paul Monks
University of Leicester

IGBP Secretariat

The Royal Swedish Academy of Sciences
Box 50005, SE-104 05, Stockholm, Sweden
Tel: +46-8 166448

Ninad Bondre	Senior Science Editor
Britta Boström	Finance Coordinator
Wendy Broadgate	Deputy Director, Natural Sciences
Hilarie Cutler	Graphic Designer
Owen Gaffney	Director of Communications
Naomi Lubick	Interim Science Editor (June-December)
Sri Sahlin	Administrative Officer
Sybil Seitzinger	Executive Director
Karen Smyth	Deputy Director, Social Sciences
Charlotte Wilson-Boss	Office Manager
Ting Yiu	Finance and Administration Assistant

Brazil Regional Office

IGBP Regional Support Office in Brazil
Instituto Nacional de Pesquisas Espaciais (INPE)
Avenida dos Astronautas,
1758 - Jd. Granja
São José dos Campos, Sp 12227-010, Brazil
Tel: +55-12 3208 7338

Patricia Pinho	Science Officer
Ana Amélia Kobayashi	Assistant

PUBLICATIONS

A selection of the top scientific publications from core projects and fast-track initiatives published in 2013, or in some cases early 2014.

IGBP

Broadgate W, Gaffney O, Isensee K, Riebesell U, Urban E and Valdés L, eds (2013) *Ocean Acidification Summary for Policymakers – Third Symposium on the Ocean in a High-CO_2 World.* IOC, SCOR, International Geosphere-Biosphere Programme, Stockholm, Sweden.

Gaffney O (2014) Quiet green revolution starts to make some noise. *Nature* 505, 587, doi: 10.1038/505587a.

Griggs D, Stafford Smith M, Gaffney O, Rockström J, Öhman M, Shyamsundar P, Steffen W, Glaser G, Kanie N, Noble N (2013) Sustainable development goals for people and planet. *Nature* 495, 305–307, doi: 10.1038/495305a.

Analysis, Integration and Modelling of the Earth System

Anav A, Friedlingstein P, Kidston M, Bopp L, Ciais P, Cox P, Jones C, Jung M, Myneni R and Zhu Z (2013) Evaluating the land and ocean components of the global carbon cycle in the CMIP5 earth system models. *Journal of Climate*, 26 (18), 6801–6843, doi: 10.1175/JCLI-D-12-00417.1.

Arora V K, Boer G J, Friedlingstein P, Eby M, Jones C D, Christian J R, Bonan G, Bopp L, Brovkin V, Cadule P, Hajima T, Ilyina T, Lindsay K, Tjiputra J F and Wu T (2013) Carbon-concentration and carbon-climate feedbacks in CMIP5 earth system models. *Journal of Climate* 26 (15), 5289–5314, doi: 10.1175/JCLI-D-12-00494.1.

Brovkin V, Boysen L, Arora V K, Boisier J P, Cadule P, Chini L, Claussen M, Friedlingstein P, Gayler V, van den Hurk B J J M, Hurtt G C, Jones C D, Kato E, de Noblet-Ducoudré N, Pacifico F, Pongratz J and Weiss M (2013) Effect of anthropogenic land-use and land-cover changes on climate and land carbon storage in CMIP5 projections for the 21st century. *Journal of Climate* 26 (18), 6859–6881, doi: 10.1175/JCLI-D-12-00623.1.

Cox P M, Pearson D, Booth B B, Friedlingstein P, Huntingford C, Jones C D and Luke C M (2013) Sensitivity of tropical carbon to climate change constrained by carbon dioxide variability. *Nature* 494 (7437), 341–344, doi: 10.1038/nature11882.

Hibbard K A and Janetos A C (2013) The regional nature of global challenges: a need and strategy for integrated regional modeling. *Climatic Change* 118 (3–4), 565–577, doi: 10.1007/s10584-012-0674-3.

Huntingford C, Jones P D, Livina V N, Lenton T M and Cox P M (2013) No increase in global temperature variability despite changing regional patterns. *Nature* 500 (7462), 327–330, doi: 10.1038/nature12310.

Huntingford C, Zelazowski P, Galbraith D, Mercado L M, Sitch S, Fisher R, Lomas M, Walker A P, Jones C D, Booth B B B, Malhi Y, Hemming D, Kay G, Good P, Lewis S L, Phillips O L, Atkin O K, Lloyd J, Gloor E, Zaragoza-Castells J, Meir P, Betts R, Harris P P, Nobre C, Marengo J and Cox P M (2013) Simulated resilience of tropical rainforests to CO_2-induced climate change. *Nature Geoscience* 6 (4), 268–273, doi: 10.1038/ngeo1741.

Lenton T M and Ciscar J (2013) Integrating tipping points into climate impact assessments. *Climatic Change* 117 (3), 585–597, doi: 10.1007/s10584-012-0572-8.

Murray-Rust D, Rieser V, Robinson D T, Miličič V and Rounsevell M (2013) Agent-based modelling of land-use dynamics and residential quality of life for future scenarios. *Environmental Modelling & Software* 46, 75–89, doi: 10.1016/j.envsoft.2013.02.011.

Paasonen P, Asmi A, Petäjä T, Kajos M K, Äijälä M, Junninen H, Holst T, Abbatt J P D, Arneth A, Birmili W, van der Gon H D, Hamed A, Hoffer A, Laakso L, Laaksonen A, Leaitch R W, Plass-Dülmer C, Pryor S C, Räisänen P, Swietlicki E, Wiedensohler A, Worsnop D R, Kerminen V and Kulmala M (2013) Warming-induced increase in aerosol number concentration likely to moderate climate change. *Nature Geoscience* 6, 438–442, doi: 10.1038/ngeo1800.

Global Carbon Project

Kirschke S, Bousquet P, Ciais P, Saunois M, Canadell J G, Dlugokencky E J, Bergamaschi P, Bergmann D, Blake D R, Bruhwiler L, Cameron-Smith P, Castaldi S, Chevallier F, Feng L, Fraser A, Heimann M, Hodson E L, Houweling S, Josse B, Fraser P J, Krummel P B, Lamarque J-F, Langenfelds R L, Le Quéré C, Naik V, O'Doherty S, Palmer P I, Pison I, Plummer D, Poulter B, Prinn R G, Rigby M, Ringeval B, Santini M, Schmidt M, Shindell D T, Simpson I J, Spahni R, Steele L P, Strode S A, Sudo K, Szopa S, van der Werf G R, Voulgarakis A, van Weele M, Weiss R F, Williams J E, Zeng G (2013) Three decades of global methane sources and sinks. *Nature Geoscience* 6, 813–823, doi: 10.1038/NGEO1955.

Le Quéré C, Peters G P, Andres R J, Andrew R M, Boden T, Ciais P, Friedlingstein P, Houghton R A, Marland G, Moriarty R, Sitch S, Tans P, Arneth A, Arvanitis A, Bakker D C E, Bopp L, Canadell J G, Chini L P, Doney S C, Harper A, Harris I, House J I, Jain A K, Jones S D, Kato E, Keeling R F, Klein

Goldewijk K, Körtzinger A, Koven C, Lefèvre N, Omar A, Ono T, Park G-H, Pfeil B, Poulter B, Raupach M R, Regnier P, Rödenbeck C, Saito S, Schwinger J, Segschneider J, Stocker B D, Tilbrookv B, van Heuven S, Viovy N, Wanninkhof R, Wiltshire A, Zaehle S and Yue C (2013) Global carbon budget 2013. *Earth System Science Data Discussions* 6, 689–760, doi: 10.5194/essdd-6-689-2013.

Peters G P, Andrew R M, Boden T, Canadell J G, Ciais P, Le Quéré C, Marland G, Raupach M R, Wilson C (2013) The challenge to keep global warming below 2ºC. *Nature Climate Change* 3, 4–6, doi: 10.1038/nclimate1783.

Global Ocean Ecosystem Dynamics

Special issue of *Oceanography* vol 26 (4), Dec 2013, US GLOBEC program synthesis.

Global Land Project

Dullinger S, Essl F, Rabisch W, Erb K-H, Gringrich S, Haberl H, Hülber K, Jarošík V, Krausmann F, Kühn I, Pergl J, Pysek P and Hulme P E (2013) Europe's other debt crisis caused by the long legacy of future extinctions. *Proceedings of the National Academy of Sciences* 110 (18), 7342–7347, doi: 10.1073/pnas.1216303110.

Ellis E C, Kaplan J O, Fuller D Q, Vavrus S, Goldewijk K K and Verburg P H (2013) Used planet: a global history. *Proceedings of the National Academy of Sciences* 110 (20), doi: 10.1073/pnas.1217241110.

Seto K C and Reenberg A, eds (2014) R*ethinking Global Land Use in an Urban Era.* Strüngmann Forum Reports, MIT Press.

Turner B L, Janetos A C, Verburg P H and Murray A T (2013) Land system architecture: using land systems to adapt and mitigate global environmental change. *Global Environmental Change* 23 (2), 395–397, doi: 10.1016/j.gloenvcha.2012.12.009.

Van Asselen S, Verburg P H, Vermaat J E and Janse J (2013) Drivers of wetland conversion: a global meta-analysis. *PLoS ONE* 8 (11), doi: 10.1371/journal.pone.0081292.

International Global Atmospheric Chemistry

Abbatt J, George C, Melamed M, Monks P, Pandis S and Rudich Y (2013) Fundamentals of atmospheric chemistry: keeping a three-legged stool balanced. *Atmospheric Environment* 84, 390–391, doi: 10.1016/j.atmosenv.2013.10.025.

Bond T C, Doherty S J, Fahey D W, Forster P M, Berntsen T, DeAngelo B J, Flanner M G, Ghan S, Kärcher B, Koch D, Kinne S, Kondo Y, Quinn P K, Sarofim M C, Schultz M G, Schulz M, Venkataraman C, Zhang H, Zhang S, Bellouin N, Guttikunda S K, Hopke P K, Jacobson M Z, Kaiser J W, Klimont Z, Lohmann U, Schwarz J P, Shindell D, Storelvmo T, Warren S G and Zender C S (2013) Bounding the role of black carbon in the climate system: a scientific assessment. *Journal of Geophysical Research: Atmospheres* 118, 5380–5552, doi: 10.1002/jgrd.50171.

Dameris M, Spracklen D and Tost H, eds (2013) The Atmospheric Chemistry and Climate Model Intercomparison Project (ACCMIP) special issue. *Atmospheric Chemistry and Physics.*

Frost G J, Middleton P, Tarrasón L, Granier C, Guenther A, Cardenas B, van der Denier Gon H, Janssens-Maenhout G, Kaiser J W, Keating T, Klimont Z, Lamarque J-F, Liousse C, Nickovic S, Ohara T, Schultz M G, Skiba U, van Aardenne J and Wang Y (2013) New directions: GEIA's 2020 vision for better air emissions information. *Atmospheric Environment* 81, 710–712, doi: 10.1016/j.atmosenv.2013.08.063.

McNeill V F, Wolff E, Bartels-Rausch T and Pfeiffenberger H, eds (2013) New Perspectives on Air-Ice Chemical Interactions (AICI) special issue. *Atmospheric Chemistry and Physics.*

von Glasow R, Jickells T D, Baklanov A, Carmichael G R, Church T M, Gallardo L, Hughes C, Kanakidou M, Liss P S, Mee L, Raine R, Ramachandran P, Ramesh R, Sundseth K, Tsunogai U, Uematsu M and Zhu T (2013) Megacities and large urban agglomerations in the coastal zone: interactions between atmosphere, land, and marine ecosystems. *AMBIO* 42,13–28, doi: 10.1007/s13280-012-0343-9.

Integrated Land Ecosystem–Atmosphere Processes Study

Balch J K (2014) Atmospheric science: drought and fire change sink to source. *Nature* 506, 41–42, doi: 10.1038/506041a.

Boisier, J-P, de Noblet-Ducoudré N and Ciais P (2013) Inferring past land-use induced changes in surface albedo from satellite observations: a useful tool to evaluate model simulations. *Biogeosciences* 10, 1501–1516, doi: 10.5194/bg-10-1501-2013.

Brovkin V, Boysen L, Arora V K, Boisier J P, Cadule P, Chini L, Claussen M, Friedlingstein P, Gayler V, van den Hurk B J J M, Hurtt G C, Jones C D, Kato E, de Noblet-Ducoudré D, Pacifico F, Pongratz J and Weiss M (2013) Effect of anthropogenic land-use and land cover changes on climate and land carbon storage in CMIP5 projections for the 21st century. *Journal of Climate* 26, 6859–6881, doi: 10.1175/JCLI-D-12-00623.1.

Fleischer K, Rebel K T, van der Molen M K, Erisman J W, Wassen M J, van Loon E E, Montagnani L, Gough C M, Herbst M, Janssens I A, Gianelle D, Dolman A J (2013) The contribution of nitrogen deposition to the photosynthetic capacity of forests. *Global Biogeochemical Cycles* 27 (1), 187–199, doi: 10.1002/gbc.20026.

Gatti L V, Gloor M, Miller J B, Doughty C E, Malhi Y, Domingues L G, Basso L S, Martinewski A, Correia C S C, Borges V F, Freitas S, Braz R, Anderson L O, Rocha H, Grace J, Phillips O L and Lloyd J (2014) Drought sensitivity of Amazonian carbon balance revealed by atmospheric measurements. *Nature* 506, 76–80, doi: 10.1038/nature12957.

Keenan T F, Hollinger D Y, Bohrer G, Dragoni D, Munger J W, Schmid H P and Richardson A D (2013) Increase in forest water-use efficiency as atmospheric carbon dioxide concentrations rise. *Nature* 499, 324–327, doi: 10.1038/nature12291.

Law B (2013) Biogeochemistry: nitrogen deposition and forest carbon. *Nature* 496, 307–308, doi: 10.1038/496307a.

Morton D C, Nagol J, Carabajal C C, Rosette J, Palace M, Cook B D, Vermote E F, Harding D J and North P R J (2014) Amazon forests maintain consistent canopy structure and greenness during the dry season. *Nature* 506, 221–224, doi: 10.1038/nature13006.

Oswald R, Behrendt T, Ermel M, Wu D, Su H, Cheng Y, Breuninger C, Moravek A, Mougin E, Delon C, Loubet B, Pommerening-Röser A, Sörgel M, Pöschl U, Hoffmann T, Andreae M O, Meixner F X and Trebs I (2013) HONO emissions from soil bacteria as a major source of atmospheric reactive nitrogen. *Science* 341 (6151), 1233-1235, doi: 10.1126/science.1242266.

Reichstein M, Bahn M, Ciais P, Frank D, Mahecha M D, Seneviratne S I, Zscheischler J, Beer C, Buchmann N, Frank D C, Papale D, Rammig A, Smith P, Thonicke K, van der Velde M, Vicca S, Walz A and Wattenbach M (2013) Climate extremes and the carbon cycle. *Nature* 500, 287–295, doi: 10.1038/nature12350.

Wang X, Piao S, Ciais P, Friedlingstein P, Myneni R B, Cox P, Heimann M, Miller J, Peng S, Wang T, Yang H and Chen A (2014) A two-fold increase of carbon cycle sensitivity to tropical temperature variations. *Nature* 506, 212–215, doi: 10.1038/nature12915.

Integrated Marine Biogeochemistry and Ecosystem Research

Ashjian C J, Harvey H R, Lomas M W, Napp J M, Sigler M I F, Stabeno P J and Van Pelt T I (2012) Understanding ecosystem processes in the eastern Bering Sea. *Deep Sea Research Part II: Topical Studies in Oceanography* 65–70, 1–316: 23 papers.

Cowie G, Kitazato H, Hood R H, Naqvi S W A and Gooday A (2013) Current biogeochemical and ecosystem research in the northern Indian Ocean. *Biogeosciences*, 10–11 (special issue 138): six papers.

Dawe E G, Mueter F J and Pálsson Ó K (2012) Effects of climate and predation on subarctic crustacean populations. *Marine Ecology Progress Series* 469, 191–306: nine papers.

Denman K, Feely R, Gattuso J-P, Pörtner H-O, Riebesell U, Schmidt D and Waite A (2013) The ocean in a high-CO_2 world III. *Biogeosciences* 10 (special issue 129): 19 papers.

Drinkwater K and Pepin P (2013) Norway-Canada comparison of marine ecosystems (NORCAN). *Progress in Oceanography* 114, 1–126: eight papers.

Landry M R and Kishi M J (2013) Sensitivity of marine food webs and biogeochemical cycles to enhanced stratification. *Progress in Oceanography* 119, 1–108: ten papers.

Lenton A, Tilbrook B, Law R M, Bakker D, Doney S C, Gruber N, Ishii M, Hoppema M, Lovenduski N S, Matear R J, McNeil B I, Metzl N, Mikaloff Fletcher S E, Monteiro P M S, Rödenbeck C, Sweeney C and Takahash T (2013) Sea–air CO_2 fluxes in the Southern Ocean for the period 1990–2009. *Biogeosciences* 10, 4037–4054, doi: 10.5194/bg-10-4037-2013.

Liu K-K, Kang C-K, Kobari T, Liu H, Rabouille C and Fennel K (2013) Biogeochemistry and ecosystems in the western North Pacific continental margins under climate change and anthropogenic forcing. *Biogeosciences* 10–11 (special issue 125): 23 papers.

Riebesell U, Gattuso J-P, Thingstad T F and Middelburg J (2013) Arctic Ocean acidification: pelagic ecosystem and biogeochemical responses during a mesocosm study. *Biogeosciences* 10 (special issue 120): 21 papers.

Salinger J, ed (2013) Climate and oceanic fisheries. *Climatic Change* 119 (1): 16 papers.

Young J, Olson R and Rodhouse P (2013) The role of squids in pelagic ecosystems. *Deep Sea Research Part II: Topical Studies in Oceanography* 95, 1–224: 22 papers.

Zhang J, Su J, Tong L and Tang Q (2013) Spring bloom processes and the ecosystem: the case study of the Yellow Sea. *Deep Sea Research Part II: Topical Studies in Oceanography* 97, 1–116: 12 papers.

Zhang J, Morrison J, Siringan F and Yeemin T (2013) Coral Reefs under the Climate and Anthropogenic Perturbations (CorReCAP): an IOC/WESTPAC approach. *Deep Sea Research Part II: Topical Studies in Oceanography* 96, 1–96: 12 papers.

Land–Ocean Interactions in the Coastal Zone

Bremer S and Glavovic B C (2013) Mobilizing knowledge for coastal governance: re-framing the science-policy interface for integrated coastal management. *Coastal Management* 41 (1), 39–56, doi: 10.1080/08920753.2012.749751.

Bremer S and Glavovic B C (2013) Exploring the science-policy interface for Integrated Coastal Zone Management in New Zealand. *Ocean and Coastal Management* 84, 107–118, doi: org/10.1016/j.ocecoaman.2013.08.008.

Day J W, Moerschbaecher M, Pimentel D, Hall C and Yanez-Arancibia A (2013) Sustainability and place: how megatrends of the 21st century will impact humans and nature at the landscape level. *Ecological Engineering* (in press), doi: org/10.1016/j.ecoleng.2013.08.003.

Forbes D L, James T S , Sutherland M and Nichols S E (2013) Physical basis of coastal adaptation on tropical small islands. In: Understanding and Managing Coastal Change in Small Islands (Hay J E, Forbes D L and Mimura N, eds). *Sustainability Science* 8, 327–344, doi: 10.1007/s11625-013-0218-4.

Hills T, Carruthers T J B, Chape S and Donohoe P (2013) A social and ecological imperative for ecosystem-based adaptation to climate change in the Pacific islands. *Sustainability Science* 8 (3), doi: 10.1007/s11625-013-0217-5.

Kremer H, Nicholls R, Ratter B M W and Weisse R, eds (2013) *Risk and Management of Current and Future Storm Surges.* Springer.

Lesack L F W, Marsh P, Hicks F E and Forbes D L (2013) Timing, duration, and magnitude of peak annual water levels during ice breakup in the Mackenzie Delta and the role of river discharge. *Water Resources Research* 49, 8234–8249, doi: 10.1002/2012WR013198.

Pelling M and Blackburn S, eds (2013) *Megacities and the Coast: Risk, Resilience and Transformation.* Routledge, London.

Xu H, Wolanski E and Chen Z (2013) Suspended particulate matter affects the nutrient budget of turbid estuaries: modification of the LOICZ model and application to the Yangtze Estuary. *Estuarine, Coastal and Shelf Science* 127, 59–62, doi: 10.1016/j.ecss.2013.04.020.

Past Global Changes

Cook E R, Krusic P J, Anchukaitis K J, Buckley B M, Nakatsuka T, Sano M and PAGES Asia2k members (2013) Tree-ring reconstructed summer temperature anomalies for temperate East Asia since 800 C E. *Climate Dynamics* 41, 2957–2972, doi: 10.1007/s00382-012-1611-x41.

Dearing J A (2013) Why Future Earth needs lake sediment studies. *Journal of Paleolimnology* 49 (3), 537–545, doi: 10.1007/s10933-013-9690-1.

de Vernal A, Gersonde R, Goosse H, Seidenkrantz M-S and Wolff E, eds (2013) Sea ice in the paleoclimate system: the challenge of reconstructing sea ice from proxies. *Quaternary Science Reviews* 79, 1–8, doi: 10.1016/j.quascirev.2013.08.009.

Galbraith E D, Kienast M and NICOPP working group members (2013) The acceleration of oceanic denitrification during deglacial warming. *Nature Geoscience* 6, 579–584, doi: 10.1038/ngeo1832.

Hanhijärvi S, Tingley M P and Korhola A (2013) Pairwise comparisons to reconstruct mean temperature in the Arctic-Atlantic region over the last 2000 years. *Climate Dynamics* 41 (7–8), 2039–2060, doi: 10.1007/s00382-013-1701-4.

Horton B P, Rahmstorf S, Engelhart S E and Kemp A C (2014) Expert assessment of sea-level rise by AD 2100 and AD 2300. *Quaternary Science Reviews* 84, 1–6, doi: org/10.1016/j.quascirev.2013.11.002.

Lorrey A, ed (2013) Australasian climate over the last 2000 years: the PAGES AUS2K synthesis. *Journal of Climate.* Special issue of the Australia2k group. http://journals.ametsoc.org/page/PAGES_AUS2K (five articles published, three in press).

Moore C M, Mills M M, Arrigo K R, Berman-Frank I, Bopp L, Boyd P W, Galbraith E D, Geider R J, Guieu C, Jaccard S L, Jickells T D, La Roche J, Lenton T M, Mahowald N M, Marañón E, Marinov I, Moore J K, Nakatsuka T, Oschlies A, Saito M A, Thingstad T F, Tsuda A and Ulloa O (2013) Processes and patterns of oceanic nutrient limitation. *Nature Geoscience* 6 (9), 701–710, doi: 10.1038/ngeo1765.

Nicholson S E, Nash D J, Chase B M, Grab S W, Shanahan T M, Verschuren D, Asrat A, Lézine A-M and Umer M (2013) Temperature variability over Africa during the last 2000 years. *The Holocene* 23 (8), 11, doi: 10.1177/0959683613483618.

Ocean2k Project Members (2012) Ocean2k: placing historical marine conditions in the context of the past 2000 years. *CLIVAR Exchanges* 58, 17/1, 15–17.

PAGES 2k Consortium (2013) Continental-scale temperature variability during the past two millennia. *Nature Geoscience* 6, 339–346, doi: 10.1038/ngeo1797.

Schmidt G A, Annan J D, Bartlein P J, Cook B I, Guilyardi E, Hargreaves J C, Harrison S P, Kageyama M, LeGrande A N, Konecky B, Lovejoy S, Mann M E, Masson-Delmotte V, Risi C, Thompson D, Timmermann A, Tremblay L B and Yiou P (2014)

Using palaeo-climate comparisons to constrain future projections in CMIP5. *Climate of the Past* 10, 221–250, doi: 10.5194/cp-10-221-2014.

Seddon A W R, Mackay A W, Baker A G, Birks H J B, Breman E, Buck C E, Ellis E C, Froyd C A, Gill J L, Gillson L, Johnson E A, Jones V J, Juggins S, Macias-Fauria M, Mills K, Morris J L, Nogués-Bravo D, Punyasena S W, Roland T P, Tanentzap A J, Willis K J, Aberhan M, van Asperen E N, Austin W E N, Battarbee R W, Bhagwat S, Belanger C L, Bennett K D, Birks H H, Bronk Ramsey C, Brooks S J, de Bruyn M, Butler P G, Chambers F M, Clarke S J, Davies A L, Dearing J A, Ezard T H G, Feurdean A, Flower R J, Gell P, Hausmann S, Hogan E J, Hopkins M J, Jeffers E S, Korhola A A, Marchant R, Kiefer T, Lamentowicz M, Larocque-Tobler I, López-Merino L, Liow L H, Mcgowan S, Miller J H, Montoya E, Morton O, Nogué S, Onoufriou C, Boush L P, Rodriguez-Sanchez F, Rose N L, Sayer C D, Shaw H E , Payne R, Simpson G, Sohar K, Whitehouse N J, Williams J W, Witkowski A (2014) Looking forward through the past: identification of 50 priority research questions in palaeoecology, *Journal of Ecology* 102 (1), 256–267, doi: 10.1111/1365-2745.12195.

Surface Ocean–Lower Atmosphere Study

Carpenter L J, MacDonald S M, Shaw M D, Kumar R, Saunders R W, Parthipan R, Wilson J and Plane J M C (2013) Atmospheric iodine levels influenced by sea surface emissions of inorganic iodine. *Nature Geosciences* 6, 108–111, doi: 10.1038/ngeo1687.

Francey R J, Trudinger C M, van der Schoot M, Law R M, Krummel P B, Langenfelds R L, Steele L P, Allison C E, Stavert A R, Andres R J and Rödenbeck C (2013) Atmospheric verification of anthropogenic CO_2 emission trends. *Nature Climate Change* 3, 520–524, doi: 10.1038/nclimate1817.

Gattuso J-P, Mach K J and Morgan G (2013) Ocean acidification and its impacts: an expert survey. *Climatic Change* 117, 725–738, doi: 10.1007/s10584-012-0591-5.

Kapsch M-L, Graversen R G and Tjernström M (2013) Springtime atmospheric energy transport and the control of Arctic summer sea-ice extent. *Nature Climate Change* 3, 744–748, doi: 10.1038/nclimate1884.

Law C S, Brévière E, de Leeuw G, Garçon V, Guieu C, Kieber D J, Kontradowitz S, Paulmier A, Quinn P K, Saltzman E S, Stefels J and von Glasow R (2013) Evolving research directions in Surface Ocean–Lower Atmosphere (SOLAS) science. *Environmental Chemistry* 10, 1–16, doi: org/10.1071/EN12159.

Lenton A, Tilbrook B, Law R M, Bakker D, Doney S C, Gruber N, Ishii M, Hoppema M, Lovenduski N S, Matear R J, McNeil B I, Metzl N, Mikaloff Fletcher S E, Monteiro P M S, Rödenbeck C, Sweeney C and Takahash T (2013) Sea–air CO_2 fluxes in the Southern Ocean for the period 1990–2009. *Biogeosciences* 10, 4037–4054, doi: 10.5194/bg-10-4037-2013.

Le Quéré C, Peters G P, Andres R J, Andrew R M, Boden T, Ciais P, Friedlingstein P, Houghton R A, Marland G, Moriarty R, Sitch S, Tans P, Arneth A, Arvanitis A, Bakker D C E, Bopp L, Canadell J G, Chini L P, Doney S C, Harper A, Harris I, House J I, Jain A K, Jones S D, Kato E, Keeling R F, Klein Goldewijk K, Körtzinger A, Koven C, Lefèvre N, Omar A, Ono T, Park G-H, Pfeil B, Poulter B, Raupach M R, Regnier P, Rödenbeck C, Saito S, Schwinger J, Segschneider J, Stocker B D, Tilbrook B, van Heuven S, Viovy N, Wanninkhof R, Wiltshire A, Zaehle S and Yue C (2013) Global carbon budget 2013. *Earth System Science Data Discussions* 6, 689–760, doi: 10.5194/essdd-6-689-2013.

Levasseur M (2013) Impact of Arctic meltdown on the microbial cycling of sulphur. *Nature Geoscience* 7, 691–700, doi: 10.1038/ngeo1910.

Liss P S and Johnson M T (2013) *Ocean-Atmosphere Interactions of Gases and Particles.* Springer, Heidelberg.

Moore C M, Mills M M, Arrigo K R, Berman-Frank I, Bopp L, Boyd P W, Galbraith E D, Geider R J, Guieu C, Jaccard S L, Jickells T D, La Roche J, Lenton T M, Mahowald N M, Marañón E, Marinov I, Moore J K, Nakatsuka T, Oschlies A, Saito M A, Thingstad T F, Tsuda A and Ulloa O (2013) Processes and patterns of oceanic nutrient limitation. *Nature Geoscience* 6, 701–710, doi: 10.1038/ngeo1765.

Pérez F F, Mercier H, Vázquez-Rodríguez M, Lherminier P, Velo A, Pardo P C, Rosón G and Ríos A F (2013) Atlantic Ocean CO_2 uptake reduced by weakening of the meridional overturning circulation. *Nature Geoscience* 6, 146–152, doi: 10.1038/ngeo1680.

Pratt K A, Custard K D, Shepson P B, Douglas T A, Pöhler D, General S, Zielcke J, Simpson W R, Platt U, Tanner D J, Huey L G, Carlsen M and Stirm B H (2013) Photochemical production of molecular bromine in Arctic surface snowpacks. *Nature Geosciences* 6, 351–356, doi: 10.1038/ngeo1779.

Fast-Track Initiatives and Synthesis

Pelling M and Blackburn S, eds (2013) *Megacities and the Coast: Risk, Resilience and Transformation.* Routledge, London.

FINANCIAL

IGBP activities are predominantly funded by contributions from over 40 countries around the world. The IGBP national contribution scale is based on the United Nations Scale of Assessments (in percent).* The IGBP scale is adjusted so that the total from all contributors will cover our central budget.

The national contributions for 2013 supported the operation of the IGBP Secretariat, the meetings of the Scientific Committee of IGBP and the Scientific Steering Committees of IGBP core projects, syntheses, IGBP contributions to the joint projects of the former Earth System Science Partnership, IGBP interactions with other partner organisations, and communication and outreach activities.

National contributions 2013

National contributions received arranged by level of contribution

1 United States of America
2 Sweden
3 Germany
4 France
5 United Kingdom
6 Japan
7 Italy
8 Russia
9 Canada
10 Norway
11 Netherlands
12 Australia
13 Brazil
14 Switzerland
15 China-Taipei
16 Belgium
17 China-Beijing
18 Austria
19 Korea
20 Argentina
21 Poland
22 Finland
23 South Africa
24 Czech Republic
25 India
26 Israel
27 New Zealand
28 Ireland
29 Hungary
30 Indonesia
31 Greece
32 Malaysia
33 Egypt
34 Thailand
35 Bangladesh
36 Botswana
37 Iceland
38 Kenya
39 Romania
40 Colombia

* Some countries pay above this scale.

FINANCIAL STATEMENT

Income and expenditure for the year ending December 2013

INCOME	EURO
National contribution	1,244,046
In kind support Scientific Committee and Officers' meeting*	108,825
Other network income	8,041
Interest on bank account	21,493
Reallocated from previous year	75,883
Carry-over network funds from previous year	399,304
TOTAL INCOME **	**1,857,592**

EXPENDITURES	EURO
Core Science Projects	287,488
IGBP Synthesis & Fast-track Initiatives	125,855
Communications and Publications	265,213
Partner Activities	106,667
Future Earth	83,072
Scientific Committee and Officers	304,683
Funding and Budget	63,955
National Committees and Adhering Bodies	10,698
Secretariat Administration	217,061
Professional Development	13,405
TOTAL EXPENDITURE	**1,478,097**
Reallocated funds for next year	24,441
Carry-over network funds ***	**355,055**

* Switzerland (SC-meeting)
EURO 108,825

Botswana (Officers' meeting)
To be confirmed

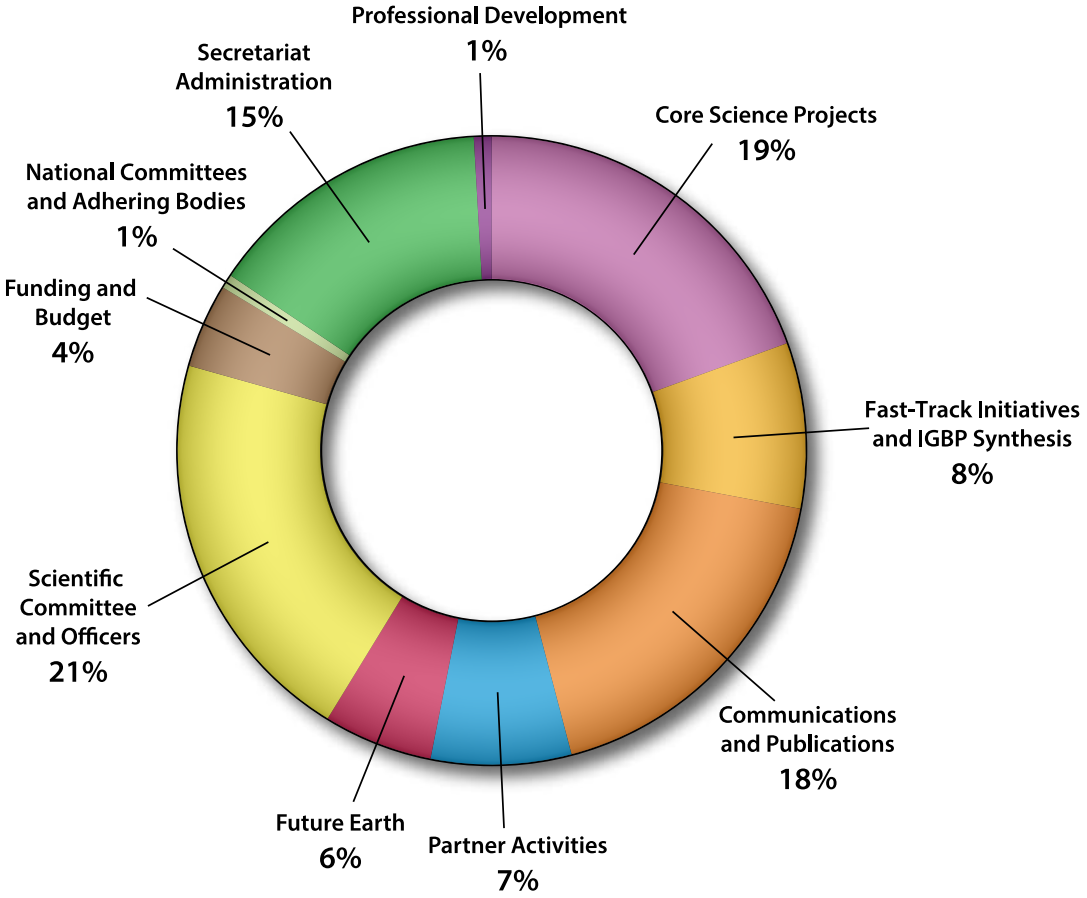
** In addition to the income presented above, IGBP received the annual grant for European Space Agency activities. EURO 140,000.

*** Carry-over funds to support operating expenses during the first half of the year.

Note: IGBP has a reserve fund at the Royal Swedish Academy of SEK 1.5 million that is not included in the financial report.

PROPORTIONAL EXPENDITURE 2013

(Excluding administered grants)



Percentage of budget used for core activities.

2013 FUNDING FOR INTERNATIONAL CORE PROJECT OFFICES

Project	Country/Organisation	USD	EURO
AIMES* USA	IGBP 2013 + carry-over from 2012	29,625	22,337
	AIMES Total Income	**29,625**	**22,337**
GLP** Brazil	INPE-Brazilian National Institute for Space Research	300,000	226,200
	IHDP	19,000	14,326
	IGBP 2013	18,236	13,750
	GLP Total Income	**337,236**	**254,276**
IGAC USA	US NASA	98,112	74,663
	US NOAA	96,317	41,840
	US NSF	98,112	74,663
	European ACCENT Plus	23,653	18,000
	IGBP 2013	36,472	27,500
	IGAC Total Income	**352,666**	**236,666**
iLEAPS Finland	University of Helsinki, Department of Physics	265,252	200,000
	Finnish Meteorological Institute	46,419	35,000
	IGBP 2013	36,472	27,500
	iLEAPS Total Income	**348,143**	**262,500**

* AIMES is in the process of restructuring.

** Estimated figures from May 2013.

Project	Country/Organisation	USD	EURO
IMBER Norway	US NSF via SCOR	50,000	36,600
	Institute of Marine Research, Norway, and Research Council of Norway	420,000	302,000
	Other sources for IMBIZO III, 2nd CLIOTOP Symposium, ESSAS, HDWG, SIOA activities	156,000	114,200
	IGBP 2013	18,700	13,750
	IMBER Total Income	**644,700**	**466,550**
LOICZ Germany	Institute for Coastal Research, Helmholtz-Zentrum Geesthacht, Germany	397,878	300,000
	IHDP	19,000	13,598
	IGBP 2013	18,236	13,750
	LOICZ Total Income	**435,114**	**327,348**
PAGES** Switzerland	Swiss NSF (1 August 2013–31 July 2014)	425,360	319,885
	US NSF (1 August 2013–31 July 2014)	360,993	270,745
	IGBP 2013	36,667	27,500
	PAGES Total Income	**823,020**	**618,130**
SOLAS Germany	BMBF, Germany (1 Jan 2013–31 Jan 2014)	89,861	67,755
	GEOMAR, Germany	79,576	60,000
	US NSF via SCOR	25,000	19,260
	Xiamen University, China	1,061	800
	CNRS - French National Center for Scientific Research	7,958	6,000
	IGBP 2013	17,847	13,750
	SOLAS Total Income	**221,303**	**167,565**

ACRONYMS

ACCENT	Action on Climate Change through Engagement, Networks and Tools
ACCMIP	Atmospheric Chemistry and Climate Model Intercomparison Project
AICI	Air–Ice Chemical Interactions
AIMES	Analysis, Integration and Modelling of the Earth System
AGU	American Geophysical Union
ALANIS	Atmosphere–Land Interaction Study
APN	Asia-Pacific Network for Global Change Research
ASM	Academy of Sciences Malaysia
BMBF	Federal Ministry of Education and Research (Germany)
CCAFS	Climate Change, Agriculture and Food Security
CEOS	Committee on Earth Observation Satellites
CIMA	Center for Atmospheric and Ocean Research (Argentina)
CLIOTOP	Climate Impacts on Oceanic Top Predators
CNRS	French National Centre for Scientific Research
CSIC	Spanish National Research Council
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DIVERSITAS	An international programme of biodiversity science
ESA	European Space Agency
ESSAS	Ecosystem Studies of Sub-Arctic Seas
ESSP	Earth System Science Partnership
EU	European Union
FTI	Fast-Track Initiative
GCP	Global Carbon Project
GEC	global environmental change
GEO	Group on Earth Observations
GLOBEC	Global Ocean Ecosystem Dynamics
GLP	Global Land Project
GWSP	Global Water System Project
HDWG	Human Dimensions Working Group
IAI	Inter-American Institute for Global Change Research
ICACGP	International Commission on Atmospheric Chemistry and Global Pollution
ICRAF	World Agroforestry Centre
ICSU	International Council for Science
IFM-GEOMAR	Leibniz Institute of Marine Sciences
IGAC	International Global Atmospheric Chemistry
IGBP	International Geosphere-Biosphere Programme

ACRONYMS (CONT.)

IGOS	Integrated Global Observing Strategy
IHDP	International Human Dimensions Programme on Global Environmental Change
iLEAPS	Integrated Land Ecosystem–Atmosphere Processes Study
IMBER	Integrated Marine Biogeochemistry and Ecosystem Research
INI	International Nitrogen Initiative
INPE	Brazilian National Institute for Space Research
IOC	Intergovernmental Oceanographic Commission
IPBES	Intergovernmental Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
ISSC	International Social Science Council
LAPAN	National Aeronautical and Aerospace Agency, Indonesia
LOICZ	Land–Ocean Interactions in the Coastal Zone
MAIRS	Monsoon Asia Integrated Regional Study
NASA	National Aeronautics and Space Administration
NEESPI	Northern Eurasia Earth Science Partnership Initiative
NIVA	Norwegian Institute for Water Research
NOAA	National Oceanic and Atmospheric Administration
NSF	National Science Foundation
PAGES	Past Global Changes
PNNL	Pacific Northwest National Laboratory
SANDEE	South Asian Network for Development and Environmental Economics
SCOR	Scientific Committee on Oceanic Research
SIBER	Sustained Indian Ocean Biogeochemistry and Ecosystem Research
SIOA	SOLAS-IMBER Ocean Acidification working group
SOLAS	Surface Ocean–Lower Atmosphere Study
SPARC	Stratospheric Processes And their Role in Climate
START	Global Change System for Analysis, Research and Training
UNEP	United Nations Environment Programme
UNESCO	UN Educational, Scientific and Cultural Organization
UNFCCC	UN Framework Convention on Climate Change
UNU	United Nations University
WCRP	World Climate Research Programme

International Geosphere-Biosphere Programme