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International Geosphere-Biosphere Programme

Annual Report 2014/15

GLOBAL CHANGE IGBP International Geosphere-Biosphere Programme

ICSU International Council for Science

Published by
IGBP Secretariat
The Royal Swedish Academy of Sciences
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Sweden
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www.igbp.net

An electronic copy (PDF) of the IGBP Annual Report 2014/15
is available on the IGBP website.

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Cover photographs:
Background image: Flooding along the Shire River, Mozambique and Malawi, NASA Earth Observatory, Jesse Allen
Top left: flickr.com/Sherrie Thai
Top right: flickr.com/will668
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Printed by Bergs Grafiska, Stockholm, to the official Nordic Ecolabelling criteria.

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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.

Throughout its three decades of existence, IGBP has been 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)

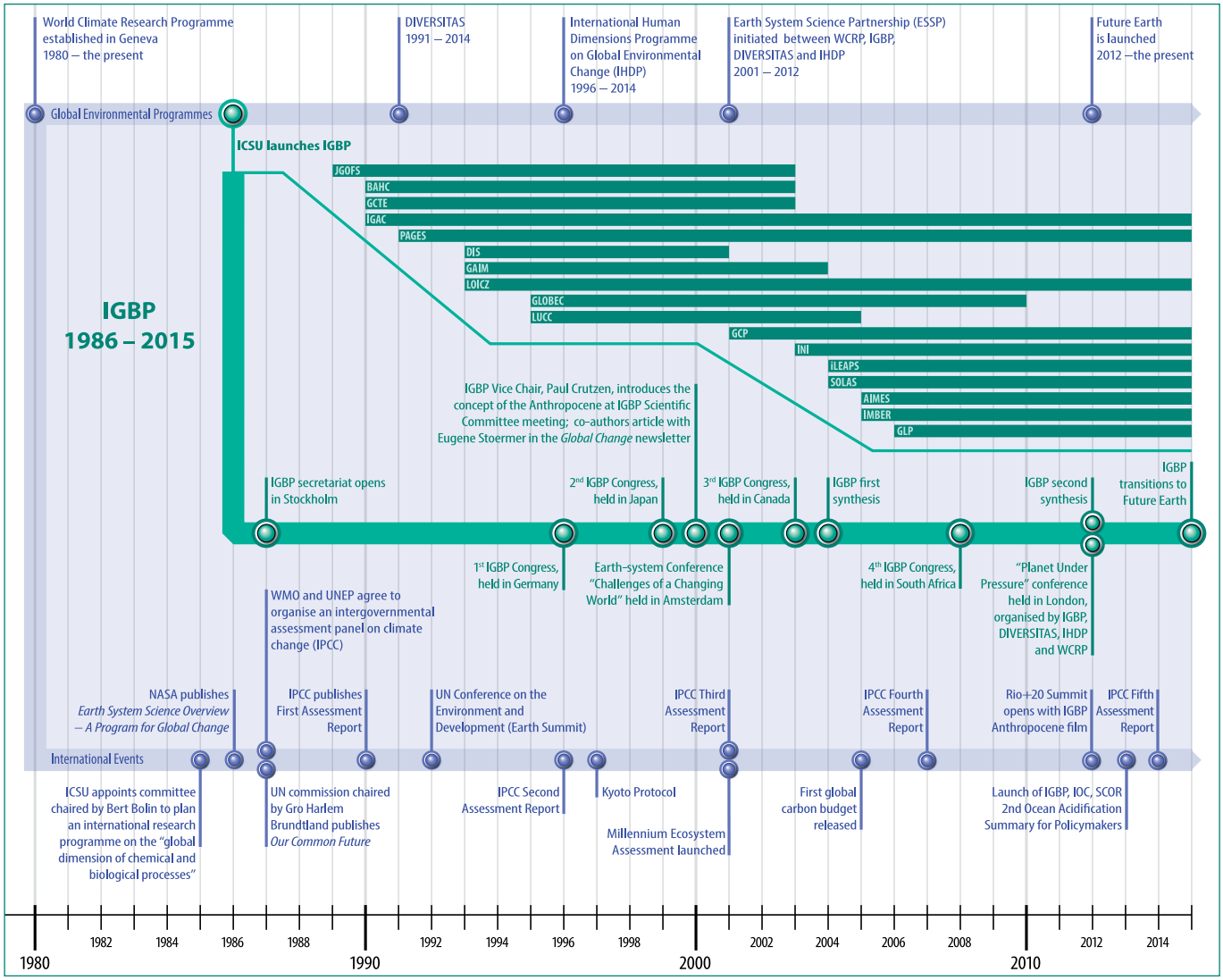
Major endorsed projects

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

Future Earth

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

* see page 30 for co-sponsors



Timeline of some of the most significant events in the history of IGBP and the global environmental change programmes. The start and end dates of projects are based on project reports and websites and IGBP documents.

THE YEAR IN REVIEW

Our projects explore various dimensions of Earth's atmosphere, land, oceans and their interfaces. Collectively, they provide an integrated look at the Earth system with an eye on cumulative human impacts, our principal object of analysis. Last year, the projects addressed issues such as past changes in the monsoon, climate impacts of land management and sea ice in the Southern Ocean. You can read brief highlights of these in our report.

IGBP's focus last year was on its overarching synthesis. In early 2014 we co-sponsored a workshop on the Anthropocene concept in Washington, DC. The workshop brought together Earth-system experts and social-science leaders to develop fresh perspectives and a more nuanced understanding of the Anthropocene. A series of synthesis papers emerging from this workshop are under review with the journal *Global Environmental Change*.

Our second programme synthesis effort is through IGBP's core projects, an effort coordinated by IGAC co-chair Paul Monks. A series of papers will appear in the journal *Anthropocene*. Our third programme synthesis will highlight IGBP's leadership and development of the discipline of Earth-system science and IGBP's contribution over the last three decades.

As always, we participated actively in various policy processes. For example, we presented the latest research on climate extremes and other topics to the Subsidiary Body on Scientific and Technological Advice (SBSTA) of the United Nations Framework Convention on Climate Change (UNFCCC). We also launched a website on ocean acidification that provides many policy-relevant resources (see page X).

IGBP has updated its "Great Acceleration" indicators, originally published in our first synthesis in 2004. The new suite of graphs, published in *The Anthropocene Review* journal (January 2015), charts the trajectory of the Anthropocene from 1750 to 2010. Similarly, we have also updated the Climate-Change Index, first produced in 2009. The index brings together four parameters: sea level, global average land-surface temperature, atmospheric carbon dioxide and Arctic sea-ice minimum.

The Climate-Change Index helps us look beyond natural variability in these parameters and provides a snapshot of the planet's climate as human pressures mount. The latest edition continues to show an unequivocal increase, reflecting continued warming of Earth's systems. The underlying trend is clearly visible. So too is the annual extent of change. A paper on the index is currently undergoing review at *Nature Climate Change*.

On 20 October last year, we celebrated our secretariat host, the Royal Swedish Academy of Sciences, and their support of our efforts during the last three decades in Sweden. The IGBP community and supporters from funding agencies and government joined us for an evening where we discussed our achievements and legacy.

As many of you know, IGBP will come to a close at the end of 2015 after three decades of facilitating high-quality science and building capacity. As with previous years we worked hard to ensure a smooth transition of our core projects to the new Future Earth programme. In December 2015, we will hold a series of science sessions as well as other events at the American Geophysical Union Fall Meeting to discuss and celebrate IGBP's legacy. Many IGBP projects and close partners will hold sessions on topics relating to global environmental change. We warmly welcome and encourage our community to participate in this landmark event.

IGBP Chair James Syvitski and Executive Director Sybil Seitzinger, May 2015

Generous support from over 30 nations ensures the continued success of IGBP. We particularly thank the Royal Swedish Academy of Sciences, which has hosted IGBP's secretariat for 28 years, and the many nations hosting IGBP's international project offices and regional nodes: Argentina, Australia, Brazil, China, Finland, Germany, India, Ireland, Italy, Ivory Coast, Japan, Norway, Portugal, Singapore, South Korea, Switzerland, Taiwan and the United States.

IGBP's focus last year was on its overarching synthesis.

Executive Director Sybil Seitzinger

Chair James Syvitski

USING SATELLITE OBSERVATIONS TO CONSTRAIN CHANGES IN TERRESTRIAL ECOSYSTEMS

Carbon-climate feedbacks involving terrestrial ecosystems will significantly affect future climate. But it is uncertain how the ecosystems themselves will respond to such change. In particular, tropical regions and the Arctic/boreal region are likely to experience disproportionately large carbon-climate feedbacks. A new study argues for a strategic combination of remotely sensed and *in situ* data to monitor such critical regions.

Following up on the Merton Report on observations, researchers associated with IGBP's Analysis, Integration and Modelling of the Earth System (AIMES) project analysed whether there was adequate capacity to monitor critical regions. Environmental conditions and accessibility limit *in situ* observations in the tropics and the Arctic/boreal region. The researchers analysed the spatial distribution of *in situ* data for carbon fluxes, stocks and plant traits globally and also evaluated the potential of remote sensing to observe these quantities. The study shows that although infrastructure for *in situ* measurements is generally widespread, it is sparse in regions known for high carbon flux and storage. There are few observations on key parameters such as plant traits that control ecosystem carbon responses: the most diverse biome on the planet treated as a single type in models.

New satellite data products go beyond mere indices of greenness and can address spatial sampling gaps for specific ecosystem properties and parameters. Space-based techniques can help to reduce sampling bias and uncertainty about carbon-climate feedbacks. The researchers underscore the need for significantly more data in the critical regions. According to them, this need can best be met with a strategic combination of remote and *in situ* data: satellite observations could provide the dense sampling in space and time required to characterise the heterogeneity of ecosystem structure and function.

Schimel D *et al.* (2015) *Global Change Biology*, doi: 10.1111/gcb.12822.

The Merton Report can be viewed here: http://www.igbp.net/publications/themertoninitiative.html

This need can best be met with a strategic combination of remote and *in situ* data.

NASA's Goddard Space Flight Center.

According to researchers associated with the AIMES project, satellite observations could provide the dense sampling in space and time required to characterise the heterogeneity of ecosystem structure and function. The image shows the NASA-USGS Landsat 8 satellite.

CLIMATE IMPACTS OF LAND MANAGEMENT

Humans modify Earth's land surface in two ways: by changing land cover or by managing land to satisfy needs. We know that the former activity affects climate, but researchers haven't fully explored the effects of the latter. A study published in *Nature Climate Change* last year suggests that the climate impacts of land management may be similar in magnitude to those of land-cover change.

Land-cover change results from processes such as deforestation/afforestation, whereas land management refers, for example, to the use of fertilisers or different cropping practices. To investigate the climate impact of land management, a team of researchers – including some affiliated with IGBP's Global Land Project (GLP) – analysed data from observation towers located in temperate and boreal locations around the world. They also analysed satellite data for several areas around the world that displayed variations in land cover and land management but had more or less the same climate.

The analysis suggests that both land-cover change as well as land-management change affected surface temperature in a similar manner. Both processes led to temperature changes between 2 and 6 degrees Celsius. Moreover, the researchers found that changes in heat fluxes are more important than changes in albedo (reflectivity) in effecting temperature changes in the temperate zone. Although climate models increasingly account for land-cover change, they are yet to consider the impacts of changes in land management. The research team recommends reconstructing land-management changes through time so as to aid models.

The findings have a bearing on how responsibility for historical climate change is attributed. As the authors note, historical land-cover change in the United States and Europe is penalised less in political negotiations than current change in Latin America and Southeast Asia. The issue may take on a different flavour when the climate impacts of recent changes in land management – for example, the green revolutions in Europe or India – are factored in.

Luyssaert S *et al.* (2014) *Nature Climate Change* 4: 389–393, doi: 10.1038/nclimate2196

Climate impacts of land management may be similar in magnitude to those of land-cover change.

© iStockphoto.com/Steve Greer

Humans manage land in various ways: for example, applying fertilisers or employing different cropping practices. A recent study finds that the magnitude of climate impacts due to land management may be similar to those arising from land-cover change.

TRACKING ARCTIC AIR POLLUTION

A new synthesis published in the *Bulletin of the American Meteorological Society* highlights the key results emerging from the POLARCAT* initiative. Organised in conjunction with the highly successful International Polar Year, the initiative undertook several airborne campaigns in the Arctic to better understand pollution in this region.

The Arctic region is warming faster than many other parts of the world and is facing relatively rapid climate and environmental change. In addition to atmospheric carbon dioxide, short-lived climate forcers – atmospheric pollutants such as black carbon and trace gases – are considered to have a role in the region's warming. A more detailed picture of the composition and sources of such short-lived forcers can thus aid the development of more accurate models and thereby better projections of future change.

Aircraft from the United States, Germany, France and Russia participated in POLARCAT, flying from bases in Alaska, Canada, Greenland, Sweden and Russia. New data collected by these missions were complemented by data from a ship cruise as well as ground-based stations. Collectively, they provide a finer picture of the sources and composition of the pollutants as well as their transport into the region.

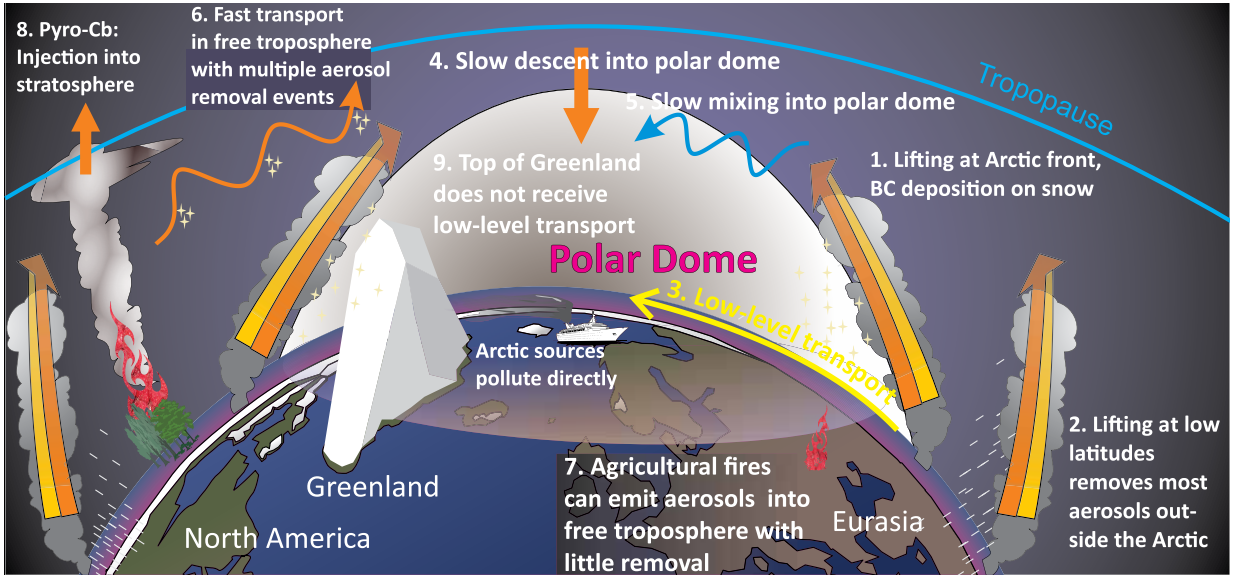
The results suggest that emissions from agricultural and boreal fires in Eurasia as well as anthropogenic emissions from East Asia were important sources of aerosols and trace gases in the Arctic during the observation period. Whereas fires led largely to organic aerosols, sulphate originated mostly from East Asia. Black carbon – a pollutant that has been implicated in warming the climate – originated from both regions.

Measurements made during the POLARCAT campaign are informing studies that are seeking to estimate how and to what extent black carbon is affecting climate in the region. The data on vertical distributions of aerosols and trace gases throughout the troposphere and the lowermost stratosphere are aiding the evaluation and improvement of climate-chemistry models.

Law K S *et al.* (2014) *Bulletin of the American Meteorological Society* 95: 1873–1895, doi: 0.1175/BAMS-D-13-00017.1

*POLARCAT stands for Polar Study using Aircraft, Remote Sensing, Surface Measurements and Models, Climate, Chemistry, Aerosols and Transport. Conducted in 2008, the initiative was co-sponsored by the International Global Atmospheric Chemistry (IGAC) and Integrated Land Ecosystem–Atmosphere Processes Study (iLEAPS) core projects of the International Geosphere-Biosphere Programme (IGBP) and the Stratosphere–troposphere Processes And their Role in Climate (SPARC) project of the World Climate Research Programme (WCRP). Several research and observations agencies from around the world contributed to the initiative.

They provide a finer picture of the sources and composition of the pollutants.



Schematic showing pathways for the transport of air pollution into the Arctic. Local as well as distant sources are implicated. From: Law K S *et al.* (2014) Arctic air pollution: new insights from POLARCAT-IPY. *Bulletin of the American Meteorological Society* 95: 1873–1895, doi: 0.1175/BAMS-D-13-00017.1

DISTINGUISHING THE ANTHROPOGENIC SIGNAL IN CHANGES TO THE TERRESTRIAL CARBON CYCLE

Decadal-scale changes in the terrestrial carbon cycle cannot be reliably attributed to human processes, according to a recent study in *Nature Climate Change*. The study included researchers associated with IGBP's Integrated Land Ecosystem–Atmosphere Processes Study (iLEAPS) project.

Anthropogenic climate change is expected to affect the terrestrial carbon cycle in the long term. For example, higher atmospheric carbon-dioxide concentrations will facilitate enhanced carbon storage, whereas rising temperatures may lead to carbon losses. However, natural variability on annual or decadal timescales is not considered in analyses of the 21st century carbon cycle. This makes it difficult to determine the point at which the anthropogenic signal emerges from the background of natural variability.

To address this, the researchers analysed global climate-model simulations and field data on carbon fluxes from Harvard Forest. The simulations were run assuming a radiative forcing of 8.5 Wm-2 at 2100. Interannual natural variability was evident in both the simulations and field data. The anthropogenic signal was clear in model results for the end of this century, rising above the background variability.

However, it was not possible to clearly identify it over a decade or even a few decades at the global scale. Only after 50 years was it possible to identify the anthropogenic signal at the continental scale. Its emergence varies with region, though. In Southeast Asia, for example, the signal emerges in a decade, whereas in Europe it can be discerned only at the end of the 21st century.

The study points to the need for additional work to predict changes to the carbon cycle on shorter time scales. It also recommends that Earth-system models quantify when anthropogenic forcing emerges from natural variability.

Lombardozzi D, Bonan G B and Nychka D W (2014) *Nature Climate Change* 4: 796–800, doi: 10.1038/nclimate2323

Interannual natural variability was evident in both the simulations and field data.

David Foster

Environmental Measurement Station in Harvard Forest. The researchers used measurements from this forest to explore interannual natural variability.

GLOBAL HABITAT PREFERENCES OF TUNA

Tuna is a valuable commodity accounting for almost 20% of global marine capture fisheries and significantly contributes to meeting worldwide protein requirements. Despite this, knowledge about the habitat preferences of the most economically important tuna species has been limited, fragmented and heterogeneous. This knowledge is essential to begin implementing an ecosystems approach to fisheries management.

To bridge this gap, scientists contributing to the Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) project have published a new assessment of the global habitat preferences of commercially valuable tuna in the journal *Deep-Sea Research II: Topical Studies in Oceanography*.

The authors led by Haritz Arrizabalaga from the marine research division of AZTI-Tecnalia, Spain, analysed data from 1958 to 2007 for six tuna species from the Pacific, Atlantic and Indian oceans: albacore, Atlantic bluefin, southern bluefin, bigeye, yellowfin and skipjack tunas.

The team found that all tropical tunas – skipjack, bigeye and yellowfin preferred lower oxygen environments than temperate tunas. In contrast, tunas suited to temperate waters – albacore, Atlantic bluefin and southern bluefin – preferred or tolerated relatively oxygen-rich conditions.

Among tropical tunas, yellowfin prefers a higher surface temperature range (beyond 25 degrees Celsius) than bigeye and skipjack. Of the temperate tunas, albacore avoid waters cooler than 14 degrees Celsius but Atlantic bluefin and southern bluefin like the chill and can even be found in waters at four degrees Celsius.

The authors report: "It is remarkable that this analysis suggests that there is no well-established temperature preference." They also note the Atlantic bluefin has the widest temperature tolerance range of between one and twenty degrees Celsius.

The Atlantic bluefin also displayed a "marked preference and tolerance for high salinity waters, probably linked to the role of the Mediterranean waters in their life cycle". Albacore and skipjack showed "clearly defined preferred salinity ranges". This was less obvious for bigeye, yellowfin and southern bluefin.

Finally, tropical tuna species preferred relatively stratified waters compared with temperate species. The authors conclude more work is needed to determine the relative importance of these and other environmental variables. Electronic tagging promises to elucidate more information relating to habitat preferences and tolerances. Furthermore, improved habitat models may help predict impacts of anthropogenic climate change on tuna distribution and abundance, allowing alternative management strategies to be developed.

The research was part of the IMBER CLimate Impacts on Oceanic Top Predators (CLIOTOP) programme.

Arrizabalaga H *et al.* (2014) *Deep-Sea Research II*, http://dx.doi.org/10.1016/j.dsr2.2014.07.001

It is remarkable that there is no well-established temperature preference.

© iStockphoto.com/cheekylorns

Knowledge about the habitat preferences of economically important tuna species is limited but this knowledge is essential to implement an ecosystems approach to fisheries management. IMBER researchers are plugging this gap.

COASTS IN FOCUS

Last year was one of transition for the project: its project office moved from Germany to Ireland and it received formal sponsorship from Future Earth. Accordingly, the project has renamed itself as Future Earth Coasts. The Scientific Steering Committee deliberated on future scientific and institutional directions, leading to a signpost document.

In December 2014 the project held its first internode meeting in Chennai, India, which brought together representatives of the project's regional nodes and members of the Scientific Steering Committee. The group decided to increase the project's emphasis on regional coastal assessments.

Researchers associated with Future Earth Coasts edited a special issue of the journal *Regional Environmental Change* that provides a conceptual framework that focuses on the region as a composite geographical unit which integrates subnational social-ecological units into multi-country regions to engage with global sustainability challenges. The issue expands on this framework by discussing nine case studies.

Another paper emerging from the project deals with coastal governance by focusing on case studies in South Africa and the Mississippi delta. These case studies and convergent literatures demonstrate the merits of reconceptualising coastal management as a transformative practice of deliberative governance. The South African and Mississippi delta experiences provide insights about how to develop a deliberative praxis of coastal governance based on consideration of the choice of process, timeliness, quality of process, equity and representation, connections to the policy cycle, impact, implementation and institutionalisation.

Glavovic B C (2014) *Regional Environmental Change*, doi: 10.1007/s10113-014-0727-4

Glaser M and Glaeser B, eds (2014) *Regional Environmental Change* 14 (6)

The project has renamed itself as Future Earth Coasts.

Flickr.com/ William Murphy

In 2015, Future Earth Coasts (formerly LOICZ) opened its International Project Office in Cork, Ireland.

MONSOON: DANCING TO A COMMON TUNE

A monsoonal climate is characterised by strong seasonality: the wind direction reverses annually and heavy rainfall occurs primarily during local summer. Monsoonal climate exists in various low-latitude regions of the world. The region stretching from southern to eastern Asia provides a well-known example, but monsoons also occur in Australia, Africa and the Americas. The regional monsoons have been recently proposed to be parts of an interconnected planetary-scale circulation system. A new synthesis by IGBP's Past Global Changes (PAGES) project examines the evidence for a global monsoon, today as well as in the geological past, and discusses how it might vary in the future in response to climate change.

The researchers sought to confirm the global nature of the modern monsoon by re-assessing instrumental and satellite data for the past several decades. To uncover evidence of a coherent global monsoon in the past they turned to proxies – for example methane concentrations in ice-core air bubbles for a globally averaged signal or the oxygen-isotopic composition of stalagmite calcite to capture the amount of local rainfall. They found that in modern as well as in ancient times the regional monsoon systems seem to have acted as a single global phenomenon over annual, millennial and longer timescales.

The monsoon is crucial to the economies of many regions of the world. In India, for example, agriculture is strongly dependent on monsoonal rainfall. In that context it is important to understand how the global monsoon will vary in the future. Recent research as summarised in the PAGES synthesis points to a future with increasingly frequent heat waves in the regions experiencing a monsoonal climate. Precipitation is also expected to increase significantly in a warmer climate, particularly during the summer monsoon season and in the Northern Hemisphere, and floods and droughts are expected to occur more frequently.

A key uncertainty in projecting future climate change is climate sensitivity – the response of global average surface temperature to the doubling of the atmospheric carbon-dioxide concentration. The PAGES researchers suggest that improving the representation of the global monsoon in climate models may help us to better understand the role of clouds and thereby to better constrain climate sensitivity.

Wang P X, Wang B, Cheng H, Fasullo J, Guo Z T, Kiefer T, Liu Z Y (2014) The global monsoon across timescales: coherent variability of regional monsoons. *Climate of the Past* 10, 2007–2052.

The monsoon is crucial to the economies of many regions of the world.

© iStockphoto.com/yogesh_more

A recent synthesis by researchers from the PAGES project suggests that in modern as well as in ancient times the regional monsoon systems seem to have acted as a single global phenomenon over annual, millennial and longer timescales.

AN ICY SINK

The Southern Ocean soaks up substantial quantities of atmospheric carbon dioxide, thereby helping to regulate Earth's climate. A recent study reports that Antarctic sea ice may be responsible for more than half of the carbon dioxide taken up by this ocean every year.

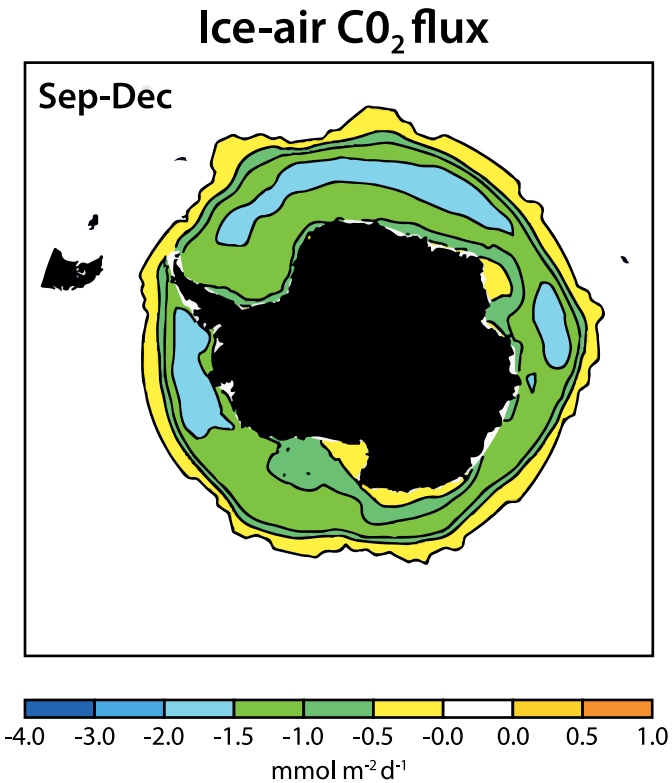
Sea ice is typically considered to be a barrier to the air-sea exchange of gases. Climate models and estimates of global air-sea carbon-dioxide fluxes thus ignore ice-covered waters. However, work from the 1970s suggested that sea ice may be permeable at a temperature above –10°C. Indeed, some recent studies have reported the air-sea exchange of carbon dioxide over sea ice.

To explore this issue further, researchers from IGBP's SOLAS project measured the fluxes of carbon dioxide across the interface of air and Antarctic sea ice in several parts of the Southern Ocean. They also documented such aspects as temperature, salinity and dissolved inorganic carbon contents. They found that increasing temperature during the summer sets off complex physical, chemical and biological processes that lead to a net uptake of carbon dioxide in the ocean areas covered by Antarctic sea ice.

The researchers used an ocean-sea ice model to scale up their field observations to the entire area of Antarctic sea ice. They found that during the spring-summer period Antarctic sea ice is a net sink of carbon dioxide, taking up a minimum of 29 million tonnes of the gas every year. The estimates in this study do not consider areas with ice concentration below 65% and flooded zones: the figure could be higher if such areas were considered.

Delille B *et al.* (2014) *Journal of Geophysical Research: Oceans*, doi: 10.1002/2014JC009941

During the spring-summer period Antarctic sea ice is a net sink of carbon dioxide.



Ice-air carbon dioxide flux over Antarctic sea ice during 1997–2007 inferred from a sea-ice model. Negative values indicate transfer of carbon dioxide from the air to the sea ice.

CHINA'S PER CAPITA EMISSIONS EXCEED EUROPE FOR FIRST TIME

In 2014, emissions from fossil fuels and deforestation reached a new record high of around 40 billion tonnes of carbon dioxide, 2.5% above 2013 levels, according to the latest carbon budget released by IGBP's Global Carbon Project.

Lead author Professor Corinne Le Quéré, Director of the Tyndall Centre for Climate Change Research in the UK, said: "We are nowhere near the commitments necessary to stay below 2°C of climate change, a level that will be already challenging to manage for most countries around the world, even for rich nations."

China, the world's largest emitter of carbon dioxide since 2006, accounts for 28% of the emissions, followed by the US (14%) and Europe (10%). For the first time, China's per capita fossil-fuel emissions exceed those of Europe.

The budget was published in the open-access journal *Earth System Science Data Discussions*. It was accompanied by three analyses relating to the two-degree climate target agreed at the Copenhagen conference in 2009.

One analysis concluded that total future CO_2 emissions cannot exceed 1200 billion tonnes for a likely (66%) chance of meeting the two-degree target. Nations have agreed that going beyond this limit risks "dangerous" climate change. At the current rate of CO_2 emissions, this 1200-billion-tonne CO_2 quota will be used up in around 30 years – or one generation.

Unless new technologies to keep carbon out of Earth's atmosphere are developed and deployed on a large scale, global emissions will need to reduce by more than 5% each year over several decades for a reasonable chance of keeping climate change below 2°C.

The world's second largest emitter, the United States, saw emissions grow 2.9%. This bucks a trend of declining emissions since 2008. While improvements have been made to reduce energy consumption and carbon intensity, economic and population growth coupled with a reversion to coal consumption are driving emissions upwards.

Emissions in the European Union, which ranks third among the biggest emitters, fell 1.8% on the back of a weak economy. Deep emission cuts in some countries offset a return to coal led by Poland, Germany and Finland. Whereas national emissions are falling, Europe exports about one third of its emissions, largely to the emerging economies. When these "consumption" emissions are accounted for, EU emissions can be seen to have only stabilised.

The budget, timed to inform the UN Climate Summit, received widespread international media coverage, including articles on the BBC, Bloomberg, *Financial Times, Newsweek, The Guardian, Der Spiegel, The Japan Times, China Daily, China Dialogue* and three articles or blogs in the *New York Times*. The FT Chinese published a commentary by two of the authors, Corinne Le Quéré and Dabo Guan.

Researchers associated with the Global Carbon Project also published new research showing how the 2010/2011 La Niña event led to a major greening across the Southern Hemisphere altering the delicate balance of the global carbon sink.

Increased rainfall, which caused widespread flooding in Australia, had a big effect on the carbon sink. In 2011, vegetation soaked up 4.1 billion tonnes of carbon. This is significantly more than usual, and around 40% of the annual emissions from burning fossil fuels.

www.globalcarbonproject.org/carbonbudget/

www.globalcarbonatlas.org

Friedlingstein P *et al.* (2014) *Nature Geoscience*, doi: 10.1038/NGEO2248

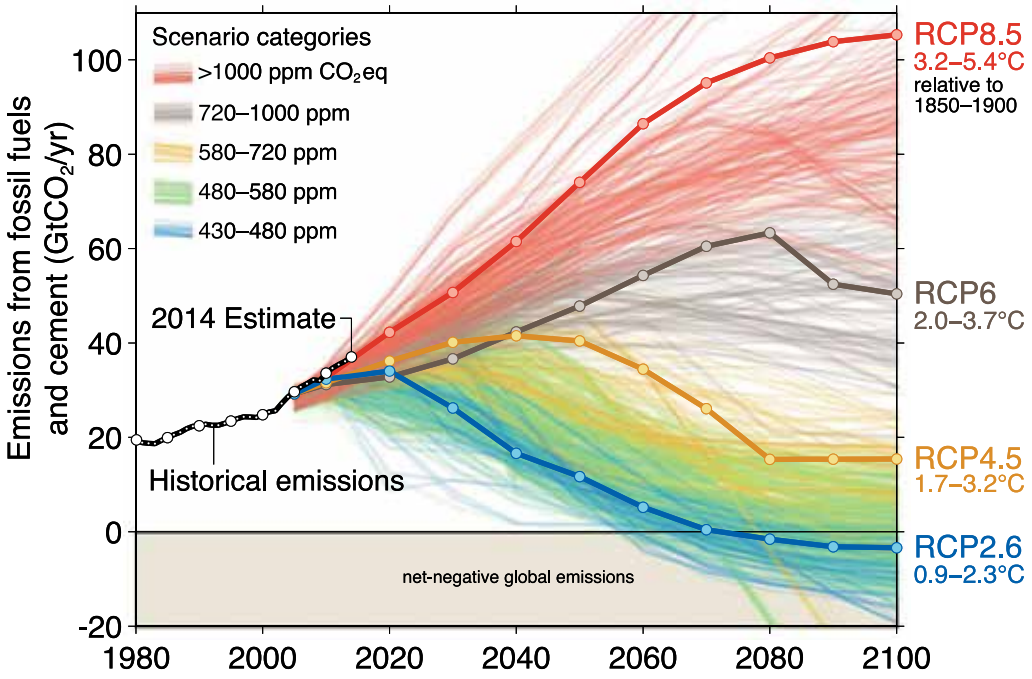
Fuss S (2014) *Nature Climate Change*, doi: 10.1038/nclimate2392

Le Quéré C *et al.* (2014) *Earth System Science Data Discussions*, doi: 10.5194/essdd-7-521-2014

Raupach M R *et al.* (2014) *Nature Climate Change*, doi: 10.1038/NCLIMATE2384

Poulter B *et al.* (2014) *Nature* 509: 600–603, doi: 10.1038/nature13376

We are nowhere near the commitments necessary to stay below 2°C.



Emissions are on track for 3.2–5.4°C "likely" increase in temperature above pre-industrial. Large and sustained mitigation is required to keep the increase in global average temperature below 2°C. Over 1000 scenarios from the Fifth Assessment of the Intergovernmental Panel on Climate Change (IPCC) are shown. Data from CDIAC/GCP/IPCC/Fuss S *et al.* (2014) *Nature Climate Change* 4, 850–853, doi: 10.1038/nclimate2392

COMMUNICATIONS

The legacy of IGBP is becoming apparent. In November, the House of World Culture in Berlin hosted an eight-day Anthropocene Campus to develop a curriculum based on the broader cultural significance of the concept.

Within the venue, an exhibition entitled the Dark Abyss of Time included an aluminium display table. Etched onto it were IGBP's *Global Change* magazine and meeting papers from IGBP's scientific committee meeting in Cuernavaca, Mexico. The exhibition included large video interviews with Executive Director Sybil Seitzinger and past committee members: for example, Paval Kabat, now director of IIASA, based in Vienna.

Germany is also host to another Anthropocene exhibition, this time at the Deutsches Museum in Munich. The exhibition, which features German versions of data visualisations created by IGBP, will run through 2015. In Brazil, the new Museum of Tomorrow due to open in 2015 and being built in Rio de Janeiro, will also host IGBP materials, for example the Great Acceleration graphs and the IGBP climate-change index.

We published two issues of the *Global Change* magazine during the year. The May issue covered the crisis of the world's deltas, megacities and the Sustainable Development Goals. In December, carbon took centre stage. We devoted almost the entire magazine to "the Carbon Issue" with in-depth analysis of crop-burning in South Asia, peak emissions in China and the greening of the Southern Hemisphere.

In October, IGBP held an event at the Royal Swedish Academy of Sciences in Stockholm to celebrate the legacy of the programme in Sweden. The event coincided with the IGBP Officers' Meeting and Future Earth hub meeting, both being held this year in the Swedish capital. Many colleagues past and present discussed the achievements of the programme, including IGBP's first director, Thomas Rosswall.

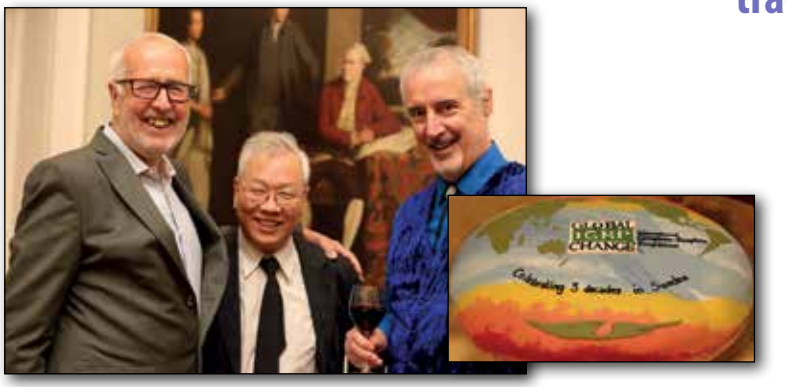
In September, the Global Carbon Project released the annual carbon budget in advance of the UN Climate Summit in New York (see page 22). IGBP communications worked closely with the project team to develop the media strategy. The budget received widespread media coverage, particularly in China.

Also in the year, we launched a new website dedicated to the issue of ocean acidification: www.ocean-acidification.net. The site is co-sponsored by the UNESCO Intergovernmental Oceanographic Commission and the Scientific Committee on Oceanic Research.

The IGBP communications team worked with ICSU and Future Earth to develop and edit the new widely-acclaimed Road to Paris blog (www.roadtoparis.info) and to write and edit articles for the Future Earth blog (www.futureearth.info), for example on the IGBP-IHDP Anthropocene workshop in Washington DC, in January 2014.

Throughout 2015, the communications team will archive IGBP's key publications throughout its history, publish a final issue of the *Global Change* magazine with contributions from colleagues past and present, and work with the scientific team to finalise the second IGBP synthesis.

IGBP's legacy is spreading beyond traditional academic disciplines.



Thomas Rosswall, Arthur Chen and Kevin Noone joined the IGBP event at the Royal Academy in October 2014 to celebrate three decades of global change research in Sweden.

IGBP archive material on display at the Dark Abyss of Time exhibition at the Anthropocene Campus in Berlin.

IGBP published two issues of the *Global Change* magazine focusing on the carbon cycle and deltas.

POLICY

IGBP works at the interface between science and international policy. Our key policy stakeholders are UNFCCC, IPCC, ICSU and UNESCO's Intergovernmental Oceanographic Commission. Our projects also interact with these organisations and others.

In June, Sybil Seitzinger presented the latest climate-related findings to the UNFCCC's Subsidiary Body for Scientific and Technological Advice (SBSTA) in Bonn. Dr Seitzinger, who was representing the four global-environmental-change programmes, reported on issues such as climate extremes and biodiversity.

In November, the IPCC published the complete Fifth Assessment Report (AR5). IGBP works closely with IPCC on the development of each assessment and many researchers involved in IGBP projects participate in the assessment.

In 2013, the Ocean Acidification summary for policymakers was published by IGBP, SCOR and UNESCO-IOC. In 2014, we published three translations of the summary, in French, German and Spanish. In addition we launched an Ocean Acidification website containing many policy-relevant resources including the summaries. www.ocean-acidification.net

The Global Carbon Project continues to publish its policy-relevant annual carbon budget. This year's budget was accompanied by three analyses in *Nature Climate Change* and *Nature Geoscience* assessing how nations could divide the remaining carbon budget (see page 22). The budget was released in advance of the UN Climate Summit in New York.

One of the key events in 2015 will be the UN General Assembly agreement of the Sustainable Development Goals. IGBP has supported ICSU and Future Earth to ensure the targets underlying the goals are grounded in science and add up to long-term sustainability.

Stafford Smith M (2014) *Nature* 513, 281, http://www.nature.com/news/un-sustainability-goals-need-quantified-targets-1.15933

Griggs D *et al.* (2014) *Ecology and Society* 19 (4), 49, http://dx.doi.org/10.5751/ES-07082-190449

Gaffney O (2014) *Global Change* 83, 20–23.

We launched an Ocean Acidification website containing many policy-relevant resources.

In 2014, IGBP published translations into Korean, German, French and Spanish of our Ocean Acidification summary for policymakers (sponsored by UNESCO-IOC and SCOR) and launched a new website on ocean acidification www.ocean-acidification.net

FUTURE EARTH ANNOUNCES VISION, RESEARCH AGENDA AND DIRECTOR

IGBP fully supports the ten-year initiative Future Earth, and its new framework to integrate global sustainability research internationally. In 2014–15 IGBP and our projects worked closely with the Future Earth interim team to develop the programme.

In February 2015, Future Earth announced its first Executive Director, Paul Shrivastava, who will be based in the Montreal hub of the new programme.

In July 2014, the Science and Technology Alliance for Global Sustainability announced the location of Future Earth's five global hubs: Boulder (US), Montreal (Canada), Paris (France), Stockholm (Sweden) and Tokyo (Japan). Teams representing each of the hubs are meeting regularly to discuss how Future Earth will function.

In November, the full Engagement Committee was announced, chaired by former Indian Environment Minister Jairam Ramesh. The committee met for the first time along with the scientific committee in Buenos Aires in December.

In the same month Future Earth launched its Vision for 2025. The vision outlines what Future Earth will contribute over the coming decade "for people to thrive in a sustainable and equitable world". It sets out an ambitious, holistic framework for research and capacity mobilisation. Central to achieving the vision is a commitment to co-design and co-produce knowledge in collaboration with societal partners to develop solutions-oriented research that responds to the sustainability challenges facing society.

In December, Future Earth issued its Strategic Research Agenda. The agenda focuses on three themes: understanding how the planet is changing; deploying integrated, interdisciplinary science to address urgent sustainable development needs; and transforming development to be more sustainable in the long term.

The eight global sustainability challenges driving this agenda are:

- delivering water, energy, and food for all;
- decoupling carbon emissions from economic growth;
- safeguarding land, freshwater and marine natural assets;
- building healthy, resilient and productive cities;
- promoting sustainable rural futures;
- improving human health by incorporating global change concerns;
- encouraging sustainable consumption and production patterns;
- improving governance and early warning systems to respond to complex future threats.

It is anticipated many of the projects of three global environmental change programmes – DIVERSITAS, IGBP and the International Human Dimensions Programme on Global Environmental Change (IHDP) – will fall under the banner of Future Earth. This process of transition is now well under way. IHDP closed in mid 2014 and Diversitas closed at the end of the year. The IGBP secretariat will remain open until the end of 2015.

www.futureearth.org

The Future Earth vision outlines what it will contribute "for people to thrive in a sustainable and equitable world".

In 2014, the interim secretariat for Future Earth published the Strategic Research Agenda and the Vision 2025 report. Future Earth's 5 hubs became operational in April 2015.

PARTNERSHIPS

Global-environmental-change programmes and Future Earth

In 2014, two global-environmental-change programmes co-sponsored by the International Council for Science (ICSU) – the International Human Dimensions Programme on Global Environmental Change (IHDP) and DIVERSITAS – came to a close. IGBP had a longstanding association with both programmes. IGBP and the World Climate Research Programme (WCRP) are continuing to coordinate international, collaborative research.

During 2014 the Future Earth initiative continued its development (see page 28). A new director and a globally distributed secretariat with five hubs were announced. Future Earth will bring under a common umbrella the research communities associated with IHDP, DIVERSITAS and IGBP (when it closes at the end of 2015), and will partner actively with WCRP.

Co-sponsors of IGBP projects

- International Human Dimensions Programme on Global Environmental Change (until June 2014): 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

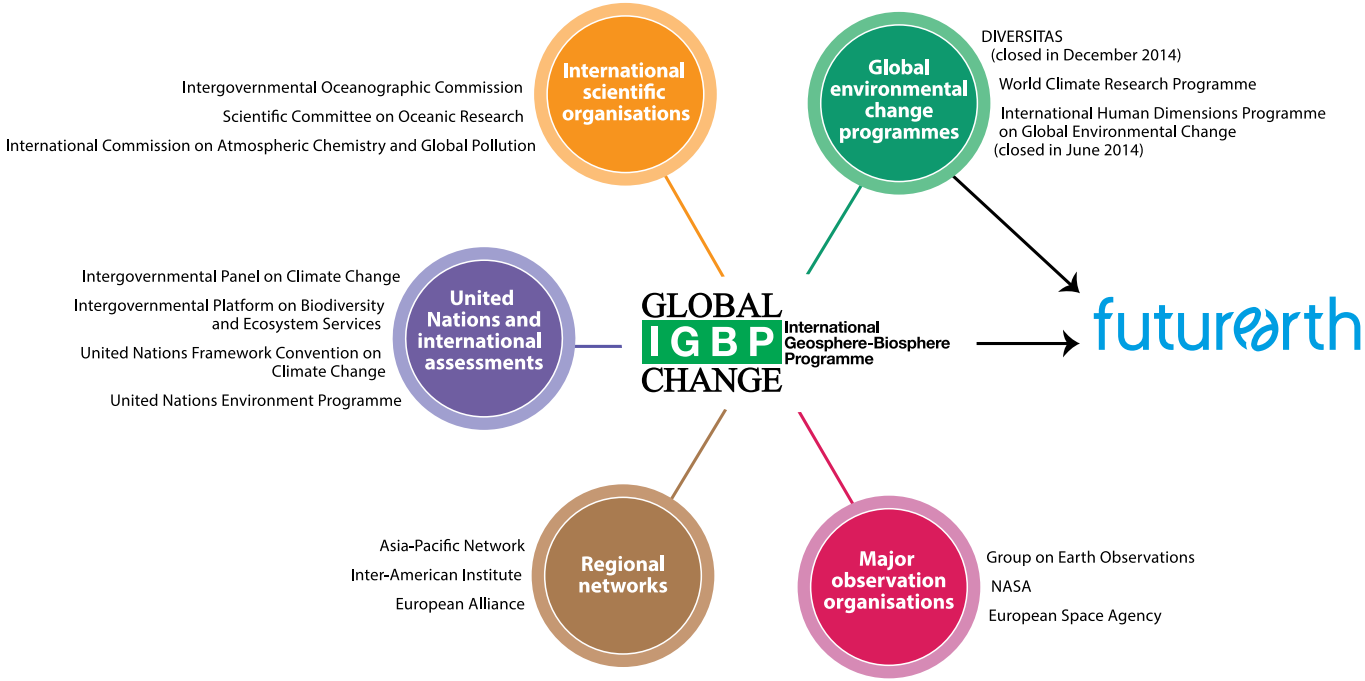
- Climate Change, Agriculture and Food Security (CCAFS)
- Global Carbon Project (GCP)
- Global Water System Project (GWSP)

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).



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.

The Future of National Committees

National committees were considered to be an integral component of IGBP when it was founded. At present the programme has over 40 committees around the world. As Future Earth takes over the coordination of international global-change research it will need to evaluate how national committees or other national structures will help to advance its vision. A first step in this regard is a report on national committees produced by a team led by Dan Wilhelmsson of the Swedish Secretariat for Environmental Earth System Sciences (SSEESS).

The team undertook a consultative process to explore the nature and structure of national-level coordination for Future Earth. Its findings are based on responses to questionnaires as well as interviews and discussions with members of some national committees and the secretariats of the global-change programmes.

The report finds that national committees have made "important scientific, communicative, administrative and financial contributions to the work of the GEC programmes and thereby have a proven potential". However, the capacity of committees to deliver on their mandate has varied widely in view of the diversity in their structures, functions and levels of organisation. The global-change programmes have had limited resources to fully engage with even the well-functioning national committees. As a result, only a small number of committees have been in regular communication with the programme secretariats.

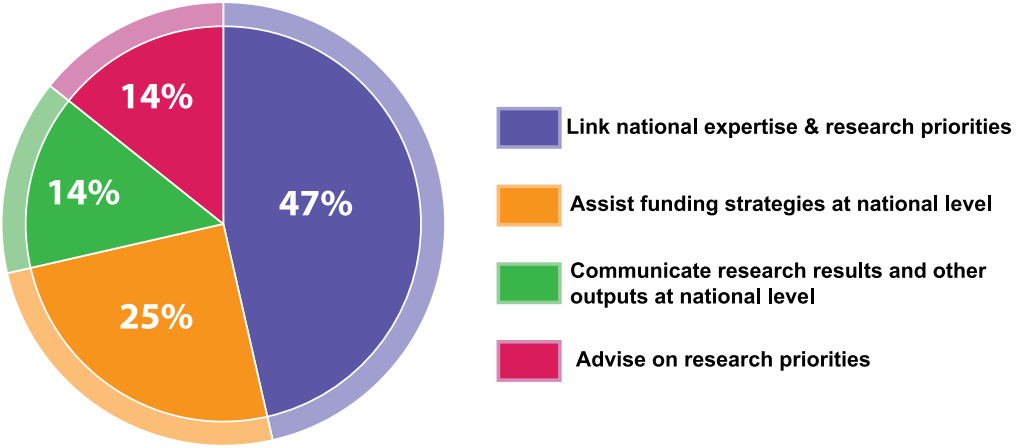
The report recommends that Future Earth provides clear strategic guidance to and develops a coherent communication strategy in relation to the national committees. Future Earth's global secretariat should be involved in, or at least be consulted about, the formation of new committees. National committees should have a broader representation of stakeholders and, ideally, take the form of national networks.

The report notes divergent views about the nature of the relationship between Future Earth and national committees. Two end-member scenarios emerged: a) national committees and regional nodes as integral and formalised parts of Future Earth and b) independent national committees loosely affiliated with Future Earth. Ultimately, it will be important to take into consideration each country´s needs, interests and capacity while forming Future Earth national committees.

Wilhelmsson D *et al.* (2014) Investigating the potential of national committees in Future Earth. Unpublished report submitted to Future Earth interim secretariat. 29 pp.

National committees should have a broader representation of stakeholders.

Most important contribution as a national committee



A survey of national committees reveals that almost half of the respondents consider "linking of national expertise and research priorities to the programme" as their most important contribution to the global-change programmes.

National Committees and Regional Alliances

IGBP has 51 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

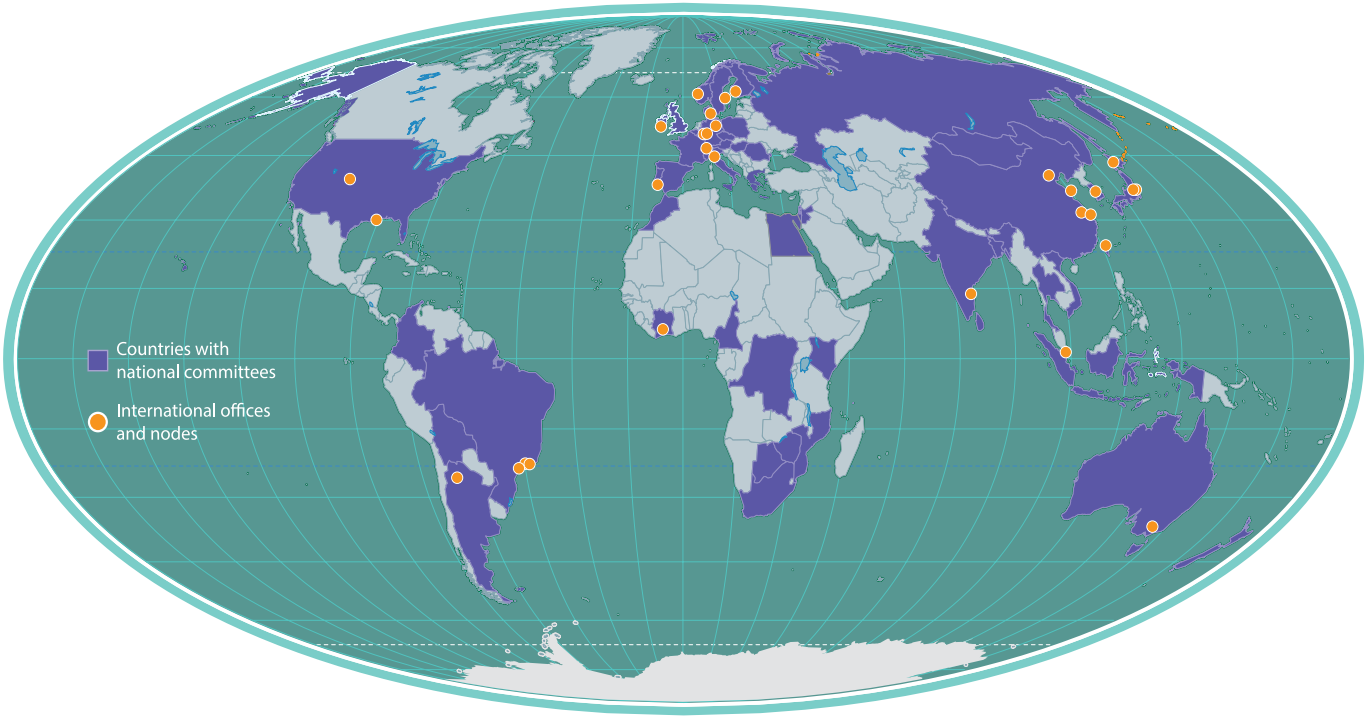
Asia-Pacific and the Middle East

Australia
Bangladesh
China: Beijing
China: Taipei
India
Indonesia
Israel
Japan
Jordan
Korea, Republic of
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 51 national committees around the globe and 30 project offices and nodes.

2014 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 (Co-chair AIMES)
University of Exeter
UK

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

Veronique Garçon (Chair SOLAS) (since January 2015)
LEGOS
FRANCE

Eric Saltzman (Chair SOLAS) (rotated off in mid-2014)
University of California at Irvine
UNITED STATES

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

Mark Lawrence (Co-chair IGAC) (since January 2015)
Institute for Advanced Sustainability Studies
GERMANY

Paul Monks (Co-chair IGAC) (rotated off in December 2014)
University of Leicester
UK

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

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

Sander van der Leeuw (AIMES Co-Chair)
Arizona State University
USA

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

International partner chairs[1]

Guy P Brasseur (WCRP)
Climate Services
Max Planck Institute for Meteorology
GERMANY

[1] IHDP and DIVERSITAS closed in 2014

2014 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: Sébastien Boillat

International Project Office:
National Institute for Space Research (INPE), São Paulo, Brazil
Nodes:
Tucumán, Argentina; Beijing, China; Bonn, Germany; Abidjan, Ivory Coast; Sapporo, Japan; Taipei, Taiwan

Integrated Marine Biogeochemistry and Ecosystem Research (IMBER)

Executive Officer: Einar Svendson[2]

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
European Project Office:
Bologna, Italy

Integrated Land Ecosystem–Atmosphere Processes Study (iLEAPS)[3]

Executive Officer: Nurmira Jamangulova

International Project Office[3]:
Nanjing, China
Nodes:
Tsukuba, Japan; Nanjing, China; Seoul, South Korea; Helsinki, Finland

Future Earth Coasts

formerly Land–Ocean Interactions in the Coastal Zone (LOICZ)

Executive Director: Martin le Tissier[4]

International Project Office:
IMERC Office, National Maritime College of Ireland, Cork, Ireland
Nodes:
Rio de Janeiro, Brazil; Yantai, China; Chennai, India; Faro, Portugal; Singapore; Baton Rouge, Louisiana, USA

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; Ayyoob Sharifi

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)

Programme Director: Bruce Campbell

CCAFS Coordinating Unit:
University of Copenhagen Frederiksberg C, Denmark

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2 Took over from Bernard Avril in February 2015

3 The project office was located at the University of Helsinki, Finland, through December 2014, led by Tanja Suni.

4 Took over from Interim Director Marion Glaser in February 2015

2014 National Committee Chairs (or Contacts)[5]

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
National 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 (Future Earth)
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

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

MONGOLIA
Togtohyn Chuluun (contact)
National University of Mongolia

NEW ZEALAND
Julie Hall
National Institute of Water & Atmospheric Research

2014 NATIONAL COMMITTEE CHAIRS (OR CONTACTS)[5]

SINGAPORE
Karina Gin
National University of Singapore

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
University Antwerp

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 (Future Earth)
Markku Kulmala (Chair)
University of Helsinki

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
Mike Jones
Trinity College Dublin

ITALY
Giuseppe Scarascia Mugnozza
University of Tuscia

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
Emili Casamayor
Center for Advanced Studies of Blanes (CEAB-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

5 Note that some national committees have now reconstituted themselves as Future Earth national committees

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 (until October 2014)
Wendy Broadgate	Deputy Director, Natural Sciences (until January 2015)
Hilarie Cutler	Graphic Designer
Owen Gaffney	Director of Communications (until February 2015)
Linlin Olsson	Finance Coordinator (from October 2014)
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
c/o Earth System Science Center at INPE
CST - Building Beta, Room 58
#1758, Av dos Astronautas, Jd. Granja
São José dos Campos, SP 12227-010, Brazil

Jean Ometto	Acting Liaison (from early 2014)
Patricia Pinho	Science Officer (Until early 2014)
Ana Amélia Kobayashi	Assistant

PUBLICATIONS

A selection of the top scientific publications from core projects and synthesis initiatives published in 2014 and early 2015.

IGBP

Steffen W *et al.* (2015) *The Anthropocene Review* 2: 81-98, doi: 10.1177/2053019614564785.

Analysis, Integration and Modelling of the Earth System

Modak A and Bala G (2014) Sensitivity of simulated climate to latitudinal distribution of solar insolation reduction in solar radiation management. *Atmospheric Chemistry and Physics* 14, 7769–7779, doi: 10.5194/acp-14-7769-2014.

Rounsevell M, Arneth A *et al.* (2014) Towards decision-based global land use models for improved understanding of the Earth system. *Earth System Dynamic* 5, 117–137, doi: 10.5194/esd-5-117-2014.

Schimel D, Pavlick R, Fisher J, Asner G, Saatchi S, Townsend P, Miller C, Frankenberg C, Hibbard K and Cox P (2015) Observing terrestrial ecosystems and the carbon cycle from space. *Global Change Biology*, doi: 10.1111/gcb.12822.

Schimel D, Stephens B B and Fisher J B (2014) Effect of increasing CO_2 on the terrestrial carbon cycle. *Proceedings of the National Academy of Sciences* 112 (2), 436–441, doi: 10.1073/pnas.1407302112.

Global Carbon Project

Le Quéré C, Moriarty R, Andrew R M, Peters G P, Ciais P, Friedlingstein P, Jones SD, Sitch S, Tans P, Arneth A, Boden T A, Bopp L, Bozec Y, Canadell J G, Chevallier F, Cosca C E, Harris I, Hoppema M, Houghton R A, House J I, Jain A K, Johannessen T, Kato E, Keeling R F, Kitidis V, Klein Goldewijk K, Koven C, Landa C, Landschützer P, Lenton A, Lima I D, Marland G H, Mathis J T, Metzl N, Nojiri Y, Olsen A, Ono T, Peters W, Pfeil B, Poulter B, Raupach M R, Regnier P, Rödenbeck C, Saito S, Sailsbury J E, Schuster U, Schwinger J, Séférian R, Segschneider J, Steinhoff T, Stocker B D, Sutton AJ, Takahashi T, Tilbrook B, van der Werf G R, Viovy N, Wang Y P, Wanninkhof R, Wiltshire A and Zeng N (2014) Global Carbon Budget 2014. *Earth System Science Data Discussions,* doi:10.5194/essdd–7–521–2014.

Raupach M R, Davis S J, Peters G P, Andrew R M, Canadell J G, Ciais P, Friedlingstein P, Jotzo F, van Vuuren DP and Le Quéré C (2014) Sharing a quota on cumulative carbon emissions. *Nature Climate Change* 4, 873–879, doi:10.1038/NCLIMATE2384.

Fuss S, Canadell J G, Peters G P, Tavonie M, Andrew R M, Ciais P, Jackson R B, Jones C D, Kraxner F, Nakicenovic N, Le Quéré C, Raupach M R, Sharifi A, Smith P and Yamagata Y (2014) Betting on Negative Emissions. *Nature Climate Change* 4, 850–853.

Friedlingstein P, Andrew R M, Rogelj J, Peters G P, Canadell J G, Knutti R, Luderer G, Raupach M R, Schaeffer M, van Vuuren D P and Le Quéré C (2014) Persistent growth of CO2 emissions and implications for reaching climate targets. *Nature Geoscience* 7, 709–715.

Poulter B, Frank D, Ciais, Myneni R, Andela N, Bi J, Broquet G, Canadell J G, Chevallier F, Liu Y Y, Running S W, Sitch S and van der Werf G R (2014) Contribution of semi-arid ecosystems to interannual variability of the global carbon cycle. Nature 509, 600–603, doi:10.1038/nature13376

Global Land Project

Adhikari S, Shoutwort J and Nagendra H (2014) Understanding forest loss and recovery: A spatiotemporal analysis of land change in and around Bannerghatta National Partk, India. *Journal of Land Use Science*, doi: 10.1080/1747423X.2014.9.

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FINANCIAL

IGBP activities are predominantly funded by contributions from over 30 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 2014 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 2014

National contributions received arranged by level of contribution

1	USA	12	China: Taipei	23	New Zealand
2	Sweden	13	China: Beijing	24	Ireland
3	Germany	14	Austria	25	Portugal
4	France	15	Korea	26	Hungary
5	UK	16	Argentina	27	Indonesia
6	Italy	17	Poland	28	Greece
7	Japan	18	Finland	29	Malaysia
8	Russia	19	South Africa	30	Egypt
9	Norway	20	Czech Republic	31	Bangladesh
10	Australia	21	India	32	Iceland
11	Switzerland	22	Israel	33	Kenya

* Some countries pay above this scale.

FINANCIAL STATEMENT

Income and expenditure for the year ending December 2014

INCOME*	EURO
National contribution	1,178,363
Synthesis grants	43,137
Other network income	7,281
Interest on bank account	23,453
Reallocated from previous year	24,441
Carry-over network funds from previous year	355,054
TOTAL INCOME	**1,631,729**

EXPENDITURES	EURO
Core Science Projects	225,851
IGBP Synthesis and Fast-track Initiatives	116,642
Celebration	48,562
Communications and Publications	182,246
Partner Activities	58,713
Future Earth	57,903
Scientific Committee and Officers	300,897
Funding and Budget	73,347
National Committees and Adhering Bodies	8,950
Secretariat Administration	202,872
IGBP Closure Process	3,441
TOTAL EXPENDITURES	**1,279,424**
Reallocated funds for next year	170,000
Carry-over network funds **	**182,305**

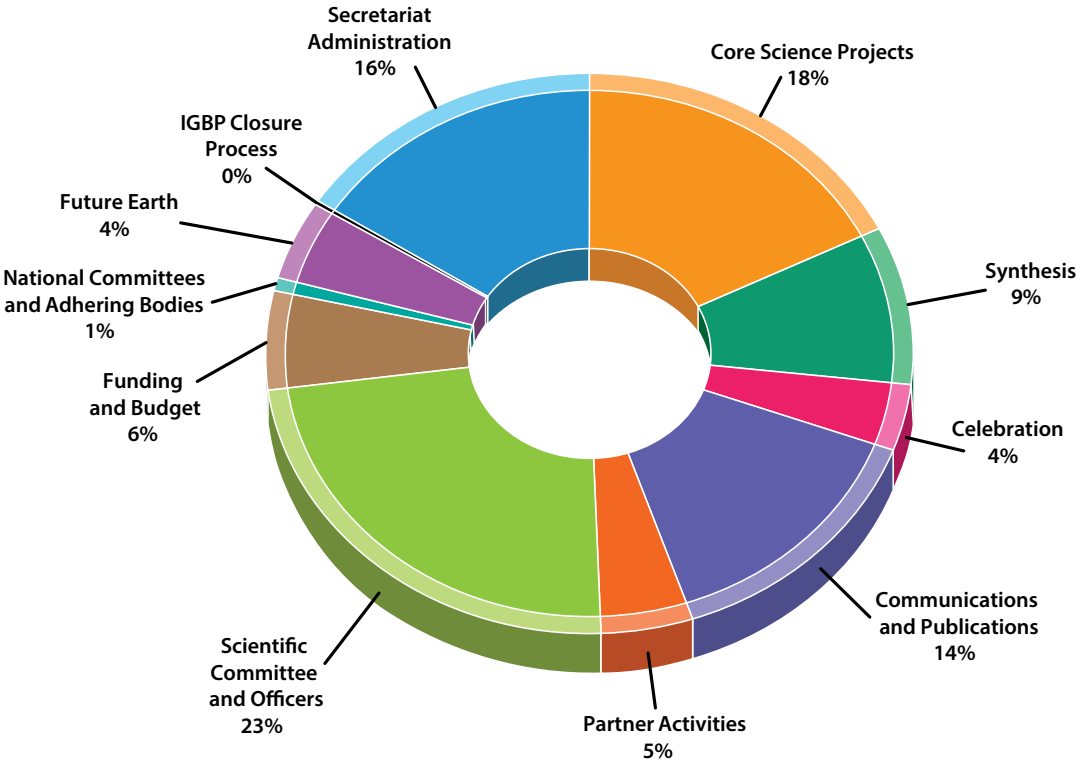
* In addition to the income listed:

- India contributed EURO 55,500 in in-kind support for the IGBP SC meeting
- IGBP received EURO 140,000, the annual grant for European Space Agency activities

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

PROPORTIONAL EXPENDITURE 2014

(Excluding administered grants)



Percentage of budget used for core activities.

2014 FUNDING FOR INTERNATIONAL CORE PROJECT OFFICES

Project	Country/Organisation	USD	EURO
AIMES USA	IGBP 2014 + carry-over from 2013	34,418	27,500
	AIMES Total Income	**34,418**	**27,500**
GLP* Brazil	INPE-Brazilian National Institute for Space Research	309,970	272,540
	IHDP	19,000	15,151
	IGBP 2014	17,209	13,750
	GLP Total Income	**346,179**	**301,441**
IGAC USA	US NASA	98,112	78,391
	US NOAA	96,317	76,957
	US NSF	98,112	78,391
	European ACCENT Plus	23,653	18,898
	IGBP 2014	34,418	27,500
	IGAC Total Income	**350,612**	**280,137**
iLEAPS Finland	University of Helsinki, Department of Physics	250,313	200,000
	Finnish Meteorological Institute	43,805	35,000
	IGBP 2014	34,418	27,500
	iLEAPS Total Income	**328,536**	**262,500**

* Estimated figures from May 2014.

Project	Country/Organisation	USD	EURO
IMBER Norway	US NSF via SCOR	80,000	63,920
	Institute of Marine Research, Norway, and Research Council of Norway	400,500	320,000
	Other external funding sources for 2014 project-wide events: OSC, ClimEco4	270,337	216,000
	IGBP 2014	17,209	13,750
	IMBER Total Income	**768,046**	**613,670**
LOICZ Germany	Institute for Coastal Research, Helmholtz-Zentrum Geesthacht, Germany	250,313	200,000
	IHDP	17,018	13,598
	IGBP 2014	17,209	13,750
	LOICZ Total Income	**284,540**	**227,348**
PAGES Switzerland	Swiss NSF (1 August 2014–31 July 2015)	412,374	329,487
	US NSF (1 August 2014–31 July 2015)	436,843	349,038
	IGBP 2014	34,418	27,500
	PAGES Total Income	**883,635**	**706,025**
SOLAS Germany	BMBF, Germany (1 Jan 2013–31 Jan 2014)	77,797	62,160
	GEOMAR, Germany	75,094	60,000
	US NSF via SCOR	29,662	23,700
	Xiamen University, China	1,061	800
	CNRS – French National Centre for Scientific Research	7,958	6,000
	Other sources	49,437	39,500
	IGBP 2014	17,209	13,750
	SOLAS Total Income	**257,710**	**205,910**

ACRONYMS

ACCENT	Action on Climate Change through Engagement, Networks and Tools
AIMES	Analysis, Integration and Modelling of the Earth System
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
ESSP	Earth System Science Partnership
EU	European Union
GCP	Global Carbon Project
GEC	global environmental change
GEO	Group on Earth Observations
GLP	Global Land Project
GWSP	Global Water System Project
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
IGOS	Integrated Global Observing Strategy
IHDP	International Human Dimensions Programme on Global Environmental Change

ACRONYMS (CONT.)

iLEAPS	Integrated Land Ecosystem– Atmosphere Processes Study
IMBER	Integrated Marine Biogeochemistry and Ecosystem Research
IMERC	Irish Maritime and Energy Resource Cluster
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
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
OSC	Open Science Conference
PAGES	Past Global Changes
PNNL	Pacific Northwest National Laboratory
SANDEE	South Asian Network for Development and Environmental Economics
SCOR	Scientific Committee on Oceanic Research
SOLAS	Surface Ocean–Lower Atmosphere Study
SPARC	Stratosphere-troposphere Processes And their Role in Climate
START	Global Change System for Analysis, Research and Training
SBSTA	Subsidiary Body for Scientific and Technological Advice
UNEP	United Nations Environment Programme
UNESCO	UN Educational, Scientific and Cultural Organization
UNFCCC	UN Framework Convention on Climate Change
WCRP	World Climate Research Programme
WMO	World Meteorological Organization

International Geosphere-Biosphere Programme