International Geosphere-Biosphere Programme

Introduction

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

Research highlights

Black carbon and climate

January this year saw the publication of a comprehensive report on the role of black carbon (or soot) on climate. The report backs recent research proposing that black carbon is the second largest human contributor to global warming. It says the direct influence of black carbon on warming the climate could be about twice the previous estimates, including that in the IPCC's 4th assessment report. Accounting for all of the ways it can affect climate, black carbon is believed to have a warming effect of about 1.1 Watts per square metre (W/m^2). This is approximately two-thirds of the effect of carbon dioxide – the largest human contributor to global warming. Black carbon affects climate in complex ways: all effects must be evaluated together to determine the impact of policies aimed at cutting emissions of this substance. Based on such an evaluation, the report suggests that black carbon emission reductions targeting diesel engines followed by some types of small household stoves that burn wood and coal would have an immediate cooling impact. Because black carbon is an air pollutant that causes respiratory problems, cutting its emissions would have positive consequences for human health.

Bond T *et al*. (2013) *Journal of Geophysical Research (Atmospheres)* doi:10.1002/jgrd.50171.
http://onlinelibrary.wiley.com/doi/10.1002/jgrd.50171/abstract

2012 carbon budget

The Global Carbon Project's (GCP) annual carbon budget reported that carbon-dioxide emissions rose 3% in 2011. The study shows that global carbon-dioxide emissions in 2011 were 54% above 1990 levels. Most of the growth in emissions was from the so-called emerging economies. Chinese emissions grew 10% in 2011, or over 800 million tonnes of carbon dioxide, which is as much as Germany emits in one year. China is emitting almost as much per capita as the European

Union, about 36% higher than the global average per capita emissions. Not all emissions from developing countries are from goods produced for domestic consumption. To account for this, the budget calculated the emissions embodied in traded products. This analysis shows that the net emission transfer via international trade between the developing and developed countries has increased from 0.03 PgC in 1990 to 0.38 PgC in 2010, with an average annual growth rate of 10%. The increase in net emission transfers of 0.35 PgC from 1990 to 2008 compares with the emission reduction of 0.2 PgC in developed countries.

Peters G *et al.* (2013) *Nature Climate Change* 3: 4-6.
Le Quere C *et al.* (2012) *Earth System Science Data Discussions*, doi: 10.5194/essdd-5-1107-2012

http://www.globalcarbonproject.org/carbonbudget/

Increases in the global land and ocean carbon sinks

About half of the total CO_2 emissions is currently taken up by the land and oceans, but models predict a decline in future carbon uptake by these reservoirs. This may in turn result in a further increase in atmospheric CO_2 concentrations. However, there is little agreement about whether the rates of carbon uptake by the land and ocean have declined, remained constant or increased in recent decades. Ballantyne *et al*. (2012) used a variety of global data, including their uncertainties, to calculate changes in global CO_2 sources and sinks during the past 50 years. Their analysis showed that net global carbon uptake has increased significantly from 2.4 +/- 0.8 billion tonnes per year in 1960 to 5.0 +/- 0.9 billion tonnes per year in 2010. This amounts to an increase of about 0.05 billion tonnes of carbon per year per decade. Since 1959, approximately 350 billion tonnes of carbon have been emitted by humans to the atmosphere, of which about 55 per cent has moved into the land and oceans. Despite evidence for considerable regional variations in the uptake of carbon, Ballantyne et al show that the uptake has increased at the global scale. Why and where the increasing global carbon uptake has taken place is not clear but needs to be determined to better constrain the modern global carbon budget and predicting future carbon-climate interactions.

Ballantyne A P et al. (2012) *Nature* 488: 70-72, doi:10.1038/nature11299.

Carbon dioxide emissions from Indian monsoonal estuaries

Some estuaries are known to be a strong source for atmospheric CO_2. However, little information is available from Indian estuaries. In order to quantify CO_2 emissions from the Indian estuaries, Sarma et al. (2012) collected samples from 27 estuaries along the Indian coast during the high discharge (wet) period. The emissions of CO_2 to the atmosphere from Indian estuaries were 4–5 times higher during the wet period as compared with the dry-period data available in the literature. The source of CO_2 emissions was attributed to the microbial decomposition of particulate organic carbon (POC) originating in the watershed, based on the positive relationship of both mean pCO_2 and POC with the rate of river discharge. The annual CO_2 flux from Indian estuaries was estimated to be 1.92 TgC, which is small compared to the anthropogenic carbon emissions from the Indian subcontinent of 508 TgC/y for 2009. The CO_2 emissions from Indian estuaries are more than an order of magnitude less than that from European estuaries (30-60 TgC/yr). The low total CO_2 emissions from the Indian estuaries are attributed, in part, to rapid flushing rates. The authors suggest that Indian estuaries may contribute a much lower percentage to the anthropogenic CO_2 emissions than hitherto hypothesized.

Sarma VVSS et al. (2012) *Geophysical Research Letters* 39: L03602, doi:10.1029/2011GL050709.

Nutrient glut

The effects (both direct and indirect) of nitrogen on climate will be explored by the IPCC in its fifth assessment report. This includes not only the increased emissions of the greenhouse gas N_2O (associated primarily with fertiliser use) but also the effect of increased nitrogen deposition on carbon sequestration and aerosol formation.

A new report highlights how humans have massively altered the natural flows of nitrogen, phosphorus and other nutrients. These alterations have boosted food production and benefited energy production. But they have also led to water and air pollution that is damaging human health, causing toxic algal blooms, killing fish, threatening sensitive ecosystems and contributing to climate change. The report on nutrients presents an assessment by nearly 50 experts from 14 countries that a 20% improvement in nutrient-use efficiency by 2020 would reduce the annual use of nitrogen fertiliser by 20 million tonnes. The researchers' analysis shows how such increased efficiency could provide a net saving worth around 170 (46 to 400) billion US dollars per year. This figure includes implementation costs and financial benefits from reduced nitrogen use and improvements to the environment and human health. The report stops short of recommending global legislation to control nutrient use, but recognises that this a global problem, especially given the global trade in agricultural products. It calls for an intergovernmental framework to address these issues, and proposes a road map of how such an agreement would look.

Sutton M A *et al*. (2013). Our nutrient world. ISBN: 978-1-906698-40-9, 120pp.
www.initrogen.org

Estimating the loss of tropical land carbon in response to climate change

Climate models suggest that two competing processes will affect the storage of carbon on land in the future. The increased atmospheric carbon-dioxide concentrations are expected to enhance photosynthesis and hence carbon storage. In contrast, the warmer climate will increase soil and plant respiration rates, leading to decreases in storage. How these processes balance out is not entirely clear and current models vary widely in terms of their projections of the change in storage of tropical carbon on land by the year 2100. Peter Cox of the University of Exeter and colleagues used a statistical relationship between a suite of climate-model outputs to estimate the sensitivity of tropical land-carbon loss to climate change. In a study published in *Nature*, they estimate that tropical land will release 53 ± 17 gigatonnes of carbon per kelvin. This value is much lower than the projections of some models (over 150 gigatonnes of carbon per kelvin) and implies that there is relatively low risk of Amazon forest dieback due to carbon-dioxide-induced global warming.

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

A region-by-region temperature history of the past two millennia

Global temperatures have increased over the last decades. Instrumental temperature measurements leave no room for qualified doubt about this observation, but reach back no more than a century and half. This length of time is insufficient to assess, for example, how Earth's climate varied in pre-industrial times. Yet, long-term records are essential if we are to understand climate variability and to isolate the effects of natural and human drivers. With this in mind, a global network of scientists have reconstructed and analyzed the climate of the last two millennia at a regional scale. A first set of temperature reconstructions, based on more than 500 sites worldwide, reveals substantial variability through time but also between regions. The data show no globally synchronous warm or cold intervals that would define a worldwide Medieval Climate Anomaly or Little Ice Age. On the other hand, robust features include a cooling over the last one to two thousand years across almost all continents, reversed by the distinct warming that began in some regions at the end of the 19th century. 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.

Ahmed M *et al*. (in press) *Nature Geoscience*

Contact:

Sybil P. Seitzinger, Executive Director IGBP: sybil.seitzinger@igbp.kva.se

Webmail:http://www.igbp.net/