GLOBAL CHANGE NEWSLETTER

No. 27 SEPTEMBER 1996

THE INTERNATIONAL GEOSPHERE–BIOSPHERE PROGRAMME: A STUDY OF GLOBAL CHANGE (IGBP) OF THE INTERNATIONAL COUNCIL OF SCIENTIFIC UNIONS

Data and Information

The IGBP-DIS Special Issue

In his book *Des Heresibus* the 16th century philosopher and scientist Francis Bacon noted that "Knowledge is Power". Certainly knowledge is crucial to human survival and progress. However, to be of practical value it must be sufficiently complete, reliable, accessible and timely. This is why successful leaders generally exhibit good luck as well as good judgement, and it is why research is a wise investment.

The current state of knowledge concerning Global Change is problematical. A combination of rapid human population growth and unsustainable human actions are threatening the long-term health of Earth's life support systems. Existing knowledge is inadequate to predict regional impacts, or to provide reliable guidance on preventative measures. Risks and costs cannot be quantified with confidence. As a consequence, in spite of much lip service to a "no regrets" approach, there is widespread policy paralysis, exacerbated by those keen to maintain the status quo.

What can be done to close the knowledge gap? Observational data and realistic mathematical models are crucial. They provide the foundation for determining how the Earth System functions and hence for developing a practical predictive capability and a capacity to cope with surprises. Once such tools are available, the development of effective policy responses will require the empowerment and co-operation of all nations. For this to occur, existing and new knowledge will have to be disseminated and explained to all; open access will be imperative.

However, the Earth system is vast and complex. Important processes occur on space scales from the microscopic to the intercontinental and over timescales of seconds to millennia. The geosphere and biosphere are coupled by myriad connections which are subtle, difficult to disentangle and yet are fundamental to their functioning. To make progress requires a programme of research which transcends the bounds of specialised scientific disciplines and the scope of limited national scientific endeavours. This was the challenge set for the IGBP when it was inaugurated a decade ago.

How has IGBP fared? Effective mechanisms have been established to define internationally agreed research priorities, to break down traditional disciplinary barriers, and to pool and co-ordinate national effort and resources. As a result, a multiplicity of new interdisciplinary research networks has been formed, and a mass of new results is emerging. Critical to this success has been the exploitation of new opportunities to gather data on a global scale, including remote sensing from space and new ground based initiatives, and the use of information technology, both for data processing and dissemination.

Although such activities are incorporated within the research agenda of each of the individual Core Projects, the Framework Activity "Data and Information Sys-

Contents

tem" (IGBP-DIS) has fulfilled a critical role in addressing thematic data issues which cut across the broad spectrum of IGBP research, and in ensuring that an overall perspective of data needs is maintained. In particular, IGBP-DIS has placed priority on catalysing the development of data sets of value to multiple Core Projects and on ensuring that IGBP data will be properly archived and made accessible to the science community at large.

In this special edition of the Global Change NewsLetter we celebrate IGBP-DIS's past success and provide an insight into its future direction. Those familiar with the detailed recommendations of the 1995 Second Assessment Report from Working Group I of the Intergovernmental Panel on Climate Change (IPCC) will recognise that IGBP-DIS's ongoing programme of data set development focuses on internationally recognised top priority needs. Similarly its work on data management and international data co-ordination lie at the forefront. IGBP-DIS can be proud of its achievements to date, but we confidently anticipate even greater contributions to come.

In mankind's quest for a sustainable society, Knowledge is Power: DIS provides fuel.

Chris Rapley, IGBP Secretariat, The Royal Swedish Academy of Sciences, Box 50005, S-104 05 Stockholm, Sweden.

GLOBAL CHANGE NEWSLETTER

Edited by Sheila M. Lunter

NewsLetter requests and change of address information should be sent to:
Lisa Cronqvist, IGBP Secretariat
The Royal Swedish Academy of Sciences
Box 50005, S-104 05 Stockholm, Sweden
Tel: (+46-8) 16 64 48
Fax: (+46-8) 16 64 05
e-mail: lisa@igbp.kva.se

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Please note

On 18 October 1996 the phone system in France changes. A "5" will be included as the area code for Toulouse. The new numbers of the IGBP-DIS office will be:

Phone: (+33-5) 61 07 85 81
Fax: (+33-5) 61 07 85 89

La Dépêche du Midi

The staff at the IGBP-DIS office. From left to right: Martine Michou, Gérard Szejwach, Chantal le Scouarnec.

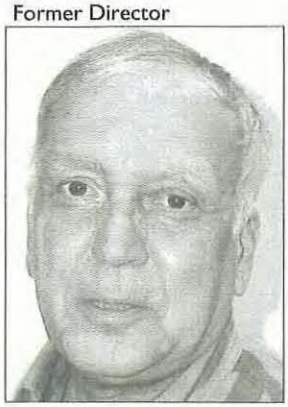
C. le Scouarnec

Participants to the 7th IGBP-DIS Scientific Steering Committee (February 1996)

S. Lunter

John Townshend, Chairman

Ichtiaque Rasool, Former Director



S. Lunter

Gérard Szejwach, Director

Data in IGBP

by John Townshend

Two years ago I gave a talk entitled "Data sets: friends or foes" at a celebration of the 60th birthday of Ichtiaque Rasool, the first Chairman and Executive Director of IGBP-DIS. The chairman of the session (and chair of IGBP's GAIM), Berrien Moore, jocularly commented that he had no doubt that data belonged to the latter category. What I had in mind in this deliberately provocative title was to recognise the tension which often exists between modellers and those concerned with creating data sets. The tension arises because available data sets may not match the needs of modellers; carefully tuned models may not improve when fed with improved data sets; validation of model outputs with actual data sets may be thwarted by the difficulty in distinguishing model limitations from those of the data sets themselves. Despite these issues the IGBP has always recognised the importance of data sets and their improvement. One key manifestation of this is the existence of IGBP-DIS, the Data and Information System of IGBP.

IGBP-DIS does not try to deal with all the data needs of IGBP: such a centralised approach would be anathema to the scientific mission of IGBP. Instead it concentrates on major deficiencies which are important to multiple programme elements of IGBP and which are either global in character or have a wide aerial extent.

IGBP-DIS has never tried to be a conventional DIS, with large amounts of computing hardware and software. Rather the distinctive role of IGBP-DIS has been to identify key data deficiencies through the activities of expert working groups and then to identify national and international agencies who will implement measures to remedy the deficiencies, both to meet their own requirements and those of the IGBP. The articles in this edition of the NewsLetter arise in no small part because of the success of this approach. Many of the data sets created through the work of IGBP-DIS are based on remotely sensed data, but ground based, *in situ* data sets are also of major importance.

Apart from creating new data sets, IGBP-DIS also has a role in ensuring that data are well managed to maximise their scientific benefits. Many disparate activities come under this heading: providing reliable meta-data (data about data) is one of the key activities since, if unavailable, access to needed data may be time-consuming or even impossible; making sure that data can be readily exchanged and accessed is also vital; guaranteeing that data are archived for their long term preservation is also an important objective. IGBP-DIS also provides guidance to ensure that the IGBP family design their own information systems in an effective manner. The forthcoming workshop with the World Data Center System is one example of our efforts in this direction. The creation of a data policy for IGBP has also been carried out by DIS during the last year.

Data are central to all IGBP's programme elements and DIS has no monopoly on success stories about data in IGBP. Included in this edition of the NewsLetter are articles highlighting important contributions to data by other parts of IGBP.

Environmental data are indeed important for the scientists of IGBP but they are also needed by other constituencies such as policy makers, weather forecasters, resource managers and many others. It is a welcome sign therefore that members of IGBP have been playing such an active role in the emerging global climate, ocean and terrestrial observing systems (respectively GCOS, GOOS and GTOS). The scientific requirements for data sets must always be recognised as having high priority, but we must work closely with others in the global observing systems to strengthen our case for improved observations.

I started this editorial by drawing a distinction between data and modelling activities, but it is increasingly recognised that this is often a false dichotomy. The raw observations we collect undergo ever more sophisticated transformations. Assimilating data sets using numerical modelling enables us to generate much more internally consistent and reliable data sets: reanalysis of the climate record is one very important activity providing us with much improved data. A related challenge for DIS is the creation of global data sets of past conditions, where information is usually very sparse, and new methods have to be developed to extrapolate our knowledge to create uniform data fields.

IGBP-DIS was founded by Ichtiaque Rasool, who set up its first office in Paris in 1992. IGBP-DIS grew out of a working group on data concentrating initially on land cover. Under his leadership its range of activities greatly expanded as did its influence in many international fora, which proved crucial to the implementation of its plans. Following the retirement of Ichtiaque Rasool, the office of IGBP-DIS has moved to Toulouse under the executive directorship of Gérard Szejwach. Support for the work of IGBP-DIS has come from many sources including the space agencies of NASA and ESA, the European Union, several French and US government agencies: more recently we have seen a major increase in support from French agencies, namely Météo-France, our hosts, CNES and very significantly the Région Midi-Pyrenées, within which Toulouse is located.

In my last year as chair of the SSC of IGBP-DIS I am delighted not only that we have had significant successes, but that DIS has the resources to maintain and expand its activities. For example, we are hoping to introduce a visiting fellowship programme for young scientists on data management.

The future contributions of IGBP will be judged in many ways. Its scientific discoveries will be long acknowledged and will form the foundation for the science of future generations. I hope IGBP will also be judged successful by those in the future who need access to long term data sets and find their work has been made possible by our efforts.

John Townshend, Department of Geography, University of Maryland, Lefrak Hall, room 1113, College Park, MD 20742-8225, USA

From the DIS Director's Desk: IGBP-DIS Today

by Gérard Szejwach

Six months have past since I took up my new position. It is time to make a quick review of what has been achieved so far and to present a view of the near term future. Looking back at the first semester I feel that, in many respects, I benefited from a number of positive factors, in particular the heritage left by Ichtiaque Rasool, as well as the constant support from the DIS Chairman, John Townshend, and the Focus-1 leader, Chris Justice. The fact that the DIS Scientific Steering Committee, the Core Project Officers meeting and the Congress took place shortly after my arrival, allowed me to get a better understanding of what was expected from me and the challenges ahead. I can proudly say that I can now expand most of the acronyms associated with the IGBP. Another extremely important positive factor is the very high level of the small team supporting me; without the efficiency and dedication of both Martine Michou, Senior Research Scientist, and Chantal Le Scouarnec, Administrative Assistant, my task would have simply been impossible.

To start with the more pragmatic aspects of the setting up of the Office, I can announce that the various Agreements between IGBP-DIS and the various partners — CNES, Météo-France, and the Région Midi-Pyrénées — are now signed. According to the terms of these Agreements the funding of the DIS Office is now secure until the end of 1999. Both ESA and NASA are fulfilling their commitment for support: ESA through direct funding of the director's position and NASA with a continuation of funding for data related meetings, data purchase or rescue, as well as for a Visiting Scientist position for the Toulouse Office, which will be advertised shortly. The European Commission has also made provision for a Visiting Scientist Fellowship, to be shared between JRC and the DIS Office. The office, located within Météo-France, where an area of about 140 square meters divided in four offices was allocated to IGBP-DIS, is now fully functional. A support office is also provided by ESA at its Headquarters in Paris.

It is in this very favourable environment that the DIS Web Pages were transferred, by David Wolf and Martine Michou, from the University of Maryland to Toulouse. After a few last minute technical difficulties, the system, largely improved and updated, is now operational. It is planned to establish a mirror site of the system in the United States. A number of support and scientific activities are ongoing and are described in other articles of the Newsletter. These activities include the support for scientific data related studies, archive support and data related meetings.

Looking into the future, my first priority is to put a strong emphasis on the Focus-2 activities. In that respect, a Focus-2 leader was selected and appointed: Günter Schreier, from DLR Germany, supported by his national Authorities, has accepted the challenge and is ready to support me and rapidly develop and implement a data management plan activity which should facilitate data access to the ensemble of the Core Projects. A joint IGBP-DIS/WDC Workshop planned to be held in Boulder, Colorado, in the first Quarter of 1997 will represent a new associated start, and Core Projects are invited to participate actively in and contribute to the Workshop. The new emerging Transect Data related DIS activities are also high on my priority list, considering the status and progress of the Focus-1 related tasks. My personal involvement in Focus-3 related activities (Data Co-ordination in an International Context, where I will continue to act as Focus leader), and my nomination as Co-Vice Chair of the Committee on Earth Observation Satellites (CEOS) Working Group on Information Systems and Services (WGISS), is another factor which should help IGBP Scientists in a better fulfillment of current and future data requirements and a better access to satellite data. (see article on page 24).

Gérard Szejwach, IGBP-DIS Office, IGBP-DIS/CNRM, 42 avenue Gustave Coriolis, 31057 Toulouse Cedex, France.

Introduction to Focus 1 Activities: Data Set Development

by Chris Justice

Developing new data sets is critical for many tasks of the IGBP. IGBP-DIS Focus 1 is concerned with the availability of data sets to meet IGBP science needs. The role of IGBP-DIS is not to collect data for individual scientists, rather it is to assist in, for example:

- developing data sets for which there is demand from more than one Core Project and where economies of collaboration can be achieved;
- developing global data sets where standardisation of regional treatment is critical;
- developing community consensus on single data sets where multiple data sets or methods are currently causing confusion to the science community;
- using the collective influence of IGBP to secure otherwise expensive or hard to obtain data.

Emphasis in these activities to date has been given to terrestrial data sets which were identified at an early stage in the development of the DIS to be poorly developed relative to IGBP needs. The Focus 1 data set activities include improving the availability of raw and derived remotely sensed data and non-remotely sensed data to the IGBP scientists. The activities and associated tasks of the DIS are outlined in IGBP Report 30.

From the evolution of Focus 1, a generic process has been developed for data set generation involving a series of focused workshops. The steps in this process are as follows:

- obtain a clear statement of data requirements driven by IGBP science needs;
- evaluate the match between the data requirements and the currently available data sets, methods and algorithms and the feasibility of new data set generation;
- develop an implementation plan and scope the required resources;
- identify the appropriate funding mechanisms to support the proposed data set development — in most cases a pilot activity is undertaken to test the proposed methods, develop prototype products and identify problem areas

associated with data set production;
- establish an advisory group to guide data set development and ensure appropriate documentation;
- establish an independent assessment process to evaluate the resulting data set;
- identify an appropriate data dissemination system to facilitate access by and feedback from IGBP scientists.

The current status of selected on-going Focus 1 activities is described in the following articles. One of the new intercore project activities within DIS Focus 1 and in conjunction with LUCC planned for 1996 is to prototype the development of CD ROM's of regional geophysical and socio-economic data sets. This pilot activity is targeted to meet the regional scientific data needs of the Kalahari Transect and the Miombo Initiative in Southern Africa and will serve as a model for improving data availability at the regional scale particularly in countries with poor Internet connectivity associated with the emerging IGBP regional transects and START activities.

Chris Justice, Global Inventory Monitoring and Modelling Studies, Code 923, Goddard Space Flight Center, NASA, Greenbelt, MD 20771, USA.

The 1-km AVHRR Global Land Data Set: An Update

by Jeffrey C. Eidenshink and John L. Faundeen

Introduction

Data from the Advanced Very High Resolution Radiometer has proven an invaluable source of information about the Earth System. For those interested in the land surface, where spatial heterogeneity is the norm, their use had been severely limited by the absence of comprehensive global data sets at the full resolution of 1 km. The need for such a data set was identified by IGBP-DIS in IGBP Report 20 in 1992. Now, four years later, after a major collaborative effort led by the EROS Data Center in Sioux Falls, South Dakota, this massive data set is being distributed to many users worldwide.

Under the guidance of the IGBP-DIS, processing standards for the AVHRR data set have been developed to meet the needs of the IGBP Core Projects and the international science community. The processing standards are for the calibration, atmospheric correction, geometric registration, and the production of global 10-day maximum normalised difference vegetation index (NDVI) composites. The vegetation index composites are the primary data source for development of a global land cover data set. The major uses of the composites are related to the study of surface vegetation cover and other land surface processes, and as a Pathfinder data set for NASA's Earth Observing System program. Details on the global 1-km data set can be found in Eidenshink and Faundeen (1994).

Data Acquisition

A network of 30 ground receiving stations, along with data recorded by the National Oceanic and Atmospheric Administration (NOAA), has acquired daily global land coverage since 1 April, 1992. The AVHRR data are acquired by NOAA's polar-orbiting series of satellites.

The data set is composed of 5-channel, 10-bit, raw AVHRR data, at 1.1-km resolution (at nadir) for afternoon passes over land and coastal zones. Data acquired by the receiving stations is sent to the U.S. Geological Survey, EROS Data Center (EDC) for archiving, processing and distribution. The EDC serves as the Land Processes Distributed Active Archive Center (DAAC) for NASA's Earth Observing System programme. Since there are no requirements to support real-time processing, the data is usually collected by the stations for several weeks to months before it is delivered to the EDC DAAC. A copy of the data set is also provided to the European Space Agency

Data Processing

The periodic temporal composites must include the minimum of the ten bands listed in Table 1. The availability of these ten bands provides users with access to the data from the 5 AVHRR channels, the NDVI, and satellite viewing geometry. The composites must be generated from radiometrically calibrated, atmospherically corrected, and geometrically registered data with widely accepted, well defined and documented processing standards.

The equations for radiometric calibration to radiance and reflectance for the visible and near infrared channels are described by Teillet and Holben (1994). The calibration coefficients for AVHRR thermal channels 3, 4, and 5 are derived onboard the satellite using a view of a stable blackbody and deep space as reference. The calibration process converts raw digital counts to radiance. The radiance values for all channels are stored with 10-bit precision.

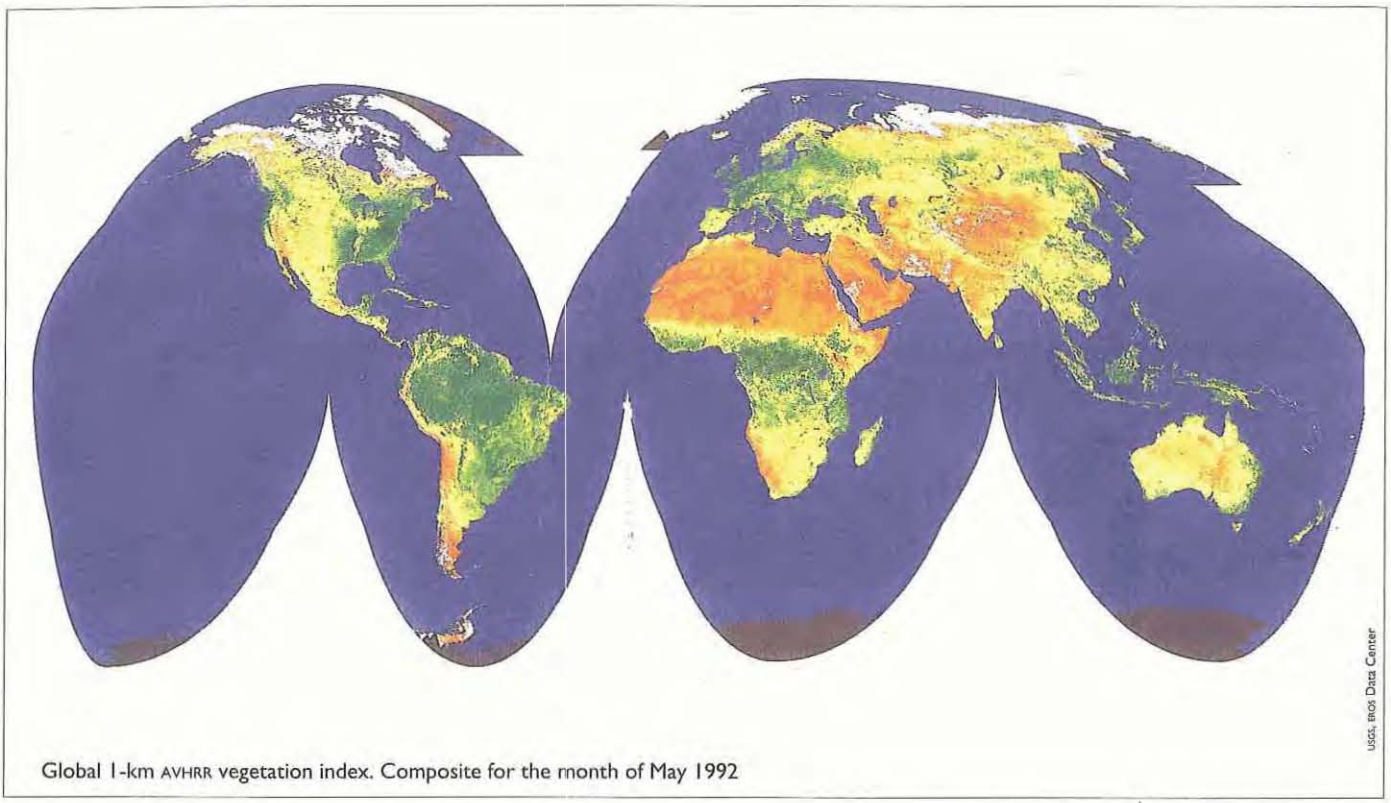
The impact of atmospheric effects on the AVHRR channel 1 and 2 data and NDVI can be significant. Four principle atmospheric factors, water vapour, aerosols, ozone, and Rayleigh scattering, are considered to have the most impact. The corrections for ozone and Rayleigh scattering are straightforward (Teillet, 1991). The corrections for ozone should be based on actual measurements derived from the Total Ozone Mapping Spectrometer (TOMS) or other appropriate sensors. Access and utilisation of these data can be difficult, thus the ozone concentration values from standard climatic tables with latitudinal and seasonal dependence is acceptable and was the approach implemented for this data set.

The input to the atmospheric correction process is radiance values from the calibrated visible and near-infrared channels. The output of the atmospheric correction process is surface reflectance (in percent) of the visible and near-infrared, albeit without corrections for water vapour and aerosols.

The NDVI is the difference of near-infrared (NIR, channel 2) and visible (VIS,

Table 1. Band description of composite images

Band	Description	Band	Description
1	AVHRR channel 1	6	NDVI
2	AVHRR channel 2	7	Satellite zenith
3	AVHRR channel 3	8	Solar zenith
4	AVHRR channel 4	9	Relative azimuth
5	AVHRR channel 5	10	Date Index



Global 1-km AVHRR vegetation index. Composite for the month of May 1992

channel 1) reflectance values normalised over the sum of channels 1 and 2 ((NIR-VIS)/(NIR+VIS)). The NDVI equation produces values in the range of -1.0 to 1.0, where increasing positive values indicate increasing green vegetation and negative values indicate non-vegetated surface features such as water, barren ground, ice, and snow or clouds. To obtain the most precision, the NDVI is derived from calibrated channels 1 and 2 data in 16-bit precision, prior to geometric registration and resampling.

Geometric registration involves precise transformation of the image from the sensor-based projection to an earth surface-based projection. This process includes calculating a satellite model, matching ground and image-based control points, and transformation and resampling the data to a map projection coordinate system. The satellite model is also used to compute satellite zenith, solar zenith, and relative azimuth viewing angles for each pixel.

The Interrupted Goode Homolosine projection is used for this data set. The Interrupted Goode Homolosine has two important features. First, it is an equal area projection that facilitates spatial analysis. Second, it essentially divides the world into 12 regions that can be mosaicked into a global map. The regionalisation of the global map has advantages for data handling.

The composition period that is recommended for the prototype products is approximately 10 days created by month. Thus, January has three composites of 10, 10, and 11 days; February has 10, 10, and 9 or 8 depending on whether it is a leap year, and so on. This procedure has the advantage of creating calendar month composites, which is a common reporting period for agronomic and biophysical characteristics.

The recommended method for data compositing is based on the maximum NDVI. The NDVI is examined pixel by pixel for each observation during the compositing period to determine the maximum value. The retention of the highest NDVI value reduces the number of cloud-contaminated pixels and selects the pixels nearest to nadir (see figure).

Data Availability

Thus far a data set of over 70,000 AVHRR images has been archived and made available for distribution by the United States Geological Survey's, EROS Data Center and the European Space Agency. Fifty-four 10-day global composites have been completed for the interval of 1 April 1992 through 31 July 1993. The global, as well as continental, data are available through the World Wide Web at: http://edcwww.cr.usgs.gov/landdaac/1KM/1kmhomepage.html.

Currently, the data are free to the user. The data volume of a single band of a global composite can vary from 100 to 200 megabytes (compressed). While access to data is available over the World Wide Web, transferring of data to most foreign countries is difficult. The WWW interface allows spatial subsetting that can minimise the amount of data to transfer. All data are also available on tape media from the EDC DAAC. The next phase will continue the production of 10-day composites for the period of February 1995 through March of 1997.

References

Eidenshink, J.C., and J.L. Faundeen. 1994. The 1 km AVHRR global land data set: first stages of implementation. *Intl. J. Rem. Sens.* 15:3443-3462.

Improved Global Data for Land Applications (1992). IGBP Report No. 20. IGBP: Stockholm, 87pp.

Teillet, P. M., 1991, Radiometric and atmospheric correction procedures for AVHRR preprocessing in the solar reflective channels. *Proceedings of the Fifth International Colloquium on Spectral Signatures of Objects in Remote Sensing, Courchevel, France*, 1991, 511-516.

Teillet, P. M, and Holben, B. N., 1994, Towards operational radiometric calibration of NOAA AVHRR imagery in the visible and infrared channels. *Canadian J. Rem. Sens.* 20:1-10.

Jeffrey C. Eidenshink, U.S. Geological Survey, EROS Data Center, Sioux Falls, SD 57198, USA.
John Faundeen, Hughes STX Corporation, EROS Data Center, Sioux Falls, SD 57198, USA.

The DIS 1 km Land Cover data set

by Alan Belward and Tom Loveland

A number of IGBP initiatives have identified the need for improved land cover data sets for their studies of global change. The existing global land cover databases are, although valuable, unsatisfactory for various reasons, but mainly for having too coarse a spatial resolution and being somewhat dated. In addition most have a climate element as part of their classification and therefore often have an undesirable mixture of potential vs. *actual land cover. Land cover representing baseline conditions is an important input to global dynamic models, and the quality of such data defines the reliability of simulated future scenarios. In April 1992 the IGPB-DIS began a project to produce a global data set for land applications at a spatial resolution of 1-km derived from the Advanced Very High Resolution Radiometer (AVHRR). Its goal is to collect, archive and process daily data from the AVHRR for all terrestrial surfaces, and then deriving land cover data sets from this archive for the IGBP Core Projects. The work has been co-ordinated by the IGBP-DIS Land Cover Working Group (LCWG).*

The first problem addressed by the LCWG was the lack of a consistent global 1 km AVHRR data archive (Townshend, 1992). The only global AVHRR data sets were sampled, either spatially, or spatially and temporally. In April 1992 the United States Geological Survey's EROS Data Center (EDC) and the European Space Agency (ESA) working closely with the National Oceanic and Atmospheric Administration, National Aeronautic and Space Administration and the Australian Commonwealth Scientific and Industrial Research Organisation, began to co-ordinate data collection from 29 receiving stations from around the world. In the first 18 months of the project more than 4.4 Terabytes of 1 km resolution AVHRR data were archived. The data collection has continued to date (with the exception of the period September 1994 to February 1995 when there was no operational afternoon AVHRR sensor).

There are now over 48,000 satellite scenes available in the 1 km project's archive. Most of these data have been assembled into a coherent global archive. Radiometric correction, geometric correction, compositing and atmospheric correction give 10 channel, 10 day data sets (including visible, near-infrared, thermal and vegetation index data) mapped to the Interrupted Goode Homolosine Projection (Eidenshink and Faundeen, 1994). Information on the Global Land 1km Data Set is given in the previous article, and is also available at:

http://sun1.cr.usgs.gov/landdaac/1KM/1kmhomepage.html

The IGBP Core Projects have diverse land cover information requirements, and no single land cover product meets all of them. Recognising this, the LCWG focuses on four main actions:

Action 1: A global land cover classification at 1 km resolution.

Action 2: Direct parameterisation of key land cover variables (*e.g.*, albedo, and Net Primary Productivity).

Action 3: Functional classifications of vegetation / land cover (*e.g.*, seasonality).

Action 4: Data set validation.

The LCWG is currently concentrating on Actions 1 and 4, which will result in a 'fast track' IGBP-DIS 1 km global land cover data set, DISCover, by the end of June 1997. The planning for DISCover has involved some 66 scientists from 41 different organisations in 14 countries through LCWG meetings and workshops. These meetings have resulted in a land cover classification scheme, classification methodology, validation strategy and implementation plan which have been reviewed by IGBP core projects, reviewed at LCWG workshops and presented at International symposia.

It is anticipated that DISCover will be followed by other land cover products; either subsequent global versions, or as regional products designed for more local use.

The IGBP-DIS classification scheme

The initial DISCover land cover classification scheme retains key elements of the scheme proposed by Running *et al.* (1994), including removal of climate from class definitions, and reliance on ancillary remotely sensed measures, such as vegetation greenness indices, to provide relative indicators of temporal dynamics of biophysical properties.

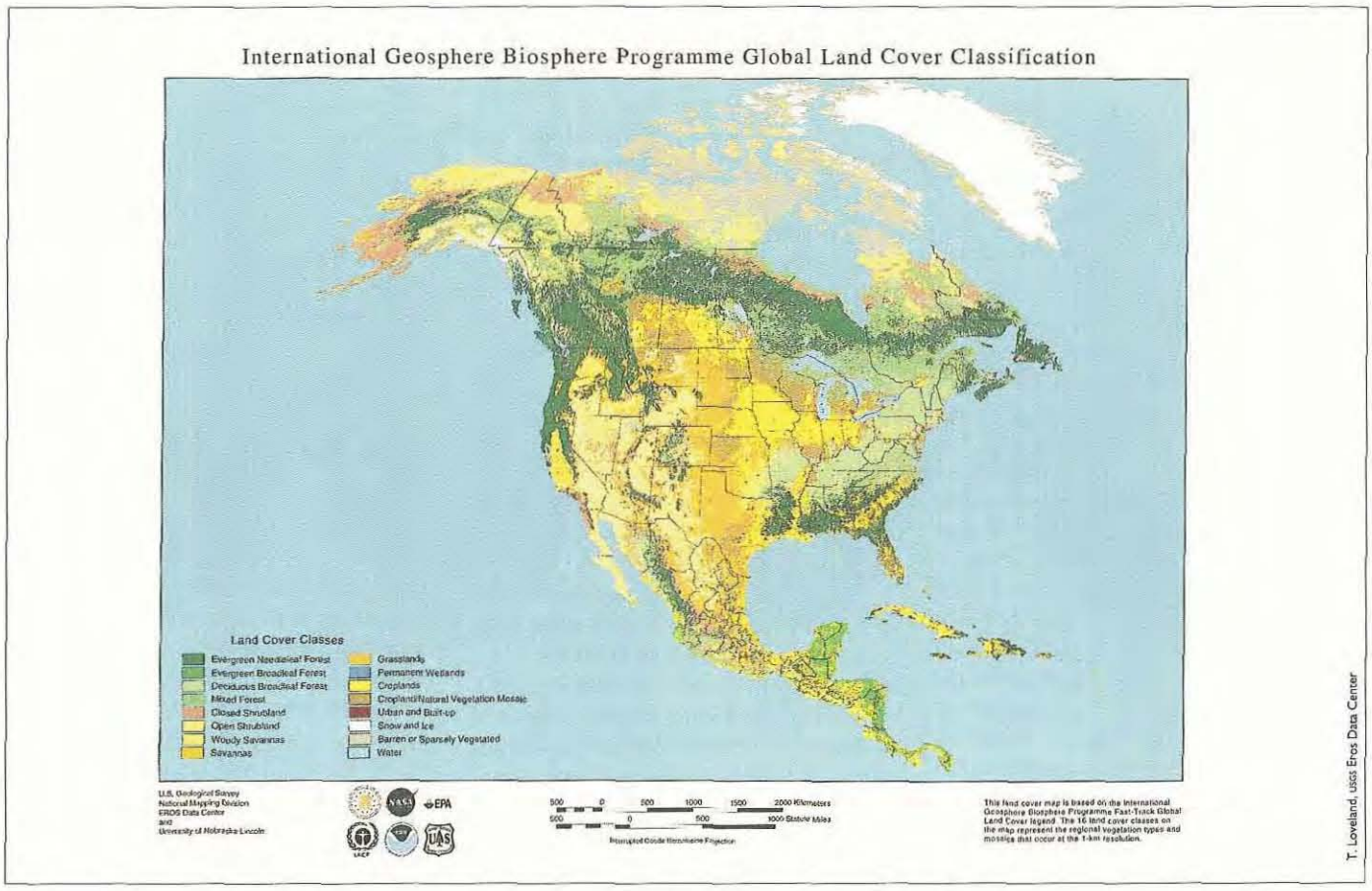
The scheme is based on definitions of three canopy components: above ground biomass, leaf longevity, and leaf type. Above ground biomass defines whether the vegetation retains perennial or annual above ground biomass, a critical question for seasonal climate and carbon-balance modelling. It is also a major vegetation determinant of the surface roughness length parameter that climate models require for energy and momentum transfer equations. Leaf longevity (evergreen versus deciduous canopy) is a critical variable in carbon cycle dynamics of vegetation, and affects seasonal albedo and energy transfer characteristics of the land surface. Leaf longevity indicates whether a plant annually must completely regrow its canopy, or a portion of it, with inferred consequences to carbon partitioning, leaf litter fall dynamics, and soil carbon. Leaf type (needle leaf, broadleaf, and grass) affects gas exchange characteristics. The classification is shown in Table 1 (p.9).

Generation of the Land Cover database

The global 1 km land cover data set is being created on a continent by continent basis. The classification approach used is based on that used in North American 1-km AVHRR land cover studies. It is based on unsupervised classification of Normalised Difference Vegetation Index (NDVI) time series, (Loveland *et al. 1991*, Brown, *et al.* 1993) with ancillary data sets, such as digital elevation models. Whilst different sets of ancillary data may be used in the classification of different areas, the methodologies are fully documented, objective, reproducible and with globally consistent output classes.

The core sampling validation strategy proposed by the land cover Validation Working Group (VWG) will provide information on the accuracies for each cover type included in the data set with roughly equal confidence ranges *a priori*, and information so that the errors of omission and commission will be applicable on a regional scale (Belward and Loveland, 1995, Loveland and Belward, 1995). The sampling procedure proposed produces unbiased estimates of cover areas and proportions at regional and global scales. Thus, areal estimates within similar-sized regions (*e.g.*, global climate model grid cells) should have similar variances. The sample will be based on visual interpretation of high resolution data (*e.g.*, Landsat or SPOT) co-registered with the AVHRR data.

In addition to this 'core sampling', Confidence Sites will be selected to test protocols for the validation methodology, aid in developing interpretation keys for visual interpretation of high resolution data, and provide more detailed information on the variability of cover types within a 1-km cell. Wherever possible local land cover information will be provided by local experts with detailed knowledge of the site. Development of Confidence Sites will be carried out in co-ordination with other IGBP initiatives such as the BAHC, IGAC, GCTE



transects, the LUCC case study sites and the DIS high resolution data test sites.

Implementation and status

A version 1 classification for North America has been completed (see figure, above), and can be accessed from the following URL:

http://edcwww.cr.usgs.gov/landdaac/glcc/glcc_na.html

First drafts of Africa and South America are complete, and version 1 releases will be available by October 1996. Eurasia will be completed by the end of 1996, and we expect that the final phase of the global classification will be completed by July 1997 (see box on p.9). The validation implementation has already begun, and operational validation will begin as soon as the global version 1 of DISCover is completed. A full validation report will be released in April 1998. By this date the complete first version of DISCover will be available. This product will consist of the classification scheme, which will include class definitions, illustrations, equivalence to other classification schemes, the classification methodology which will include a full algorithm description, the land cover data base itself, consisting of the digital 17 class map, plus the input data used to derive the classification, including both AVHRR and ancillary data, the validation methodology, including procedural manuals, descriptions of the statistical principles involved and any algorithms used, the validation data base, consisting of the high resolution imagery, the associated land cover classification, meta data describing detailed location, name and address of interpreters, etc., and any associated field data.

References

Belward A.S., and Loveland, T.R., 1995, The IGBP-DIS 1km Land Cover Project, Remote Sensing in Action, Proceedings of the 21st Annual Conference of the Remote Sensing Society, held in Southampton, UK, 11th to 14th September 1995 (RSS: Nottingham) pp.1099-1106

Brown, J.F., Loveland, T.R., Merchant, J.W., Reed, B.C., and Ohlen, D.O., 1993, Using Multisource Data in Global Land-Cover Characterization: Concepts, Requirements, and Methods, *Photogrammetric Engineering and Remote Sensing*, 59: 977-987.

Danko, D.M., 1992, The Digital Chart of the World, *Geoinfosystems*, 2: 29-36.

Eidenshink, J. and Faundeen, J. 1994, The 1 km AVHRR global land data set: first stages in implementation. *International Journal of Remote Sensing* 15: 3443-3462.

Loveland, T.R., Merchant, J.M., Ohlen, D.O., and Brown, J.F., 1991, Development of a Land-Cover Characteristics Database for the Conterminous U.S., *Photogrammetric Engineering and Remote Sensing*, 57: 1453-1463.

Loveland T.R., and Belward, A. S., 1995, The use of AVHRR data for creation of a new global land cover product for IGBP-DIS in *Proceedings of the Meteorological Satellite Data Users' Conference*, held in Winchester, UK, 4th to 8th September, 1995 (Darmstadt: EUMETSAT), pp.177 - 184.

Moody, A. and C. E. Woodcock, 1994, Scale-dependent errors in the estimation of land-cover proportions: Implications for global land-cover datasets, *Photogrammetric Engineering and Remote Sensing* 60: 585-594.

Running, S.W., Loveland, T.R. and Pierce, L.L., 1994, A vegetation classification logic based on remote sensing for use in global scale biogeochemical models, *Ambio*, 23: 77-81.

Townshend, J.R.G., (editor) 1992, *Improved global data for land applications*, IGBP report number 20.

Alan S. Belward, Space Applications Institute, Monitoring of Tropical Vegetation, Joint Research Centre of the CEC, Building 44, I-21020 Ispra, Varese, Italy.

Tom R. Loveland, United States Geological Survey, EROS Data Center, Sioux Falls, SC 57198, USA.

Table 1. The IGBP-DIS Land Cover classification

1 Evergreen Needleleaf Forests: Lands dominated by trees with a percent canopy cover >60% and height exceeding 2 meters. Almost all trees remain green all year. Canopy is never without green foliage.
2 Evergreen Broadleaf Forests: Lands dominated by trees with a percent canopy cover >60% and height exceeding 2 meters. Almost all trees remain green year all year. Canopy is never without green foliage.
3 Deciduous Needleleaf Forest: Lands dominated by trees with a percent canopy cover >60% and height exceeding 2 meters. Consists of seasonal needleleaf tree communities with an annual cycle of leaf-on and leaf- off periods.
4 Deciduous Broadleaf Forests: Lands dominated by trees with a percent canopy cover >60% and height exceeding 2 meters. Consists of seasonal broadleaf tree communities with an annual cycle of leaf-on and leaf- off periods.
5 Mixed Forests: Lands dominated by trees with a percent canopy cover >60% and height exceeding 2 meters. Consists of tree communities with interspersed mixtures or mosaics of the other four forest cover types. None of the forest types exceeds 60% of landscape.
6 Closed Shrublands: Lands with woody vegetation less than 2 meters tall and with shrub canopy cover is >60%. The shrub foliage can be either evergreen or deciduous.
7 Open Shrublands: Lands with woody vegetation less than 2 meters tall and with shrub canopy cover is between 10-60%. The shrub foliage can be either evergreen or deciduous.
8 Woody Savannahs: Lands with herbaceous and other understory systems, and with forest canopy cover between 30-60%. The forest cover height exceeds 2 meters.
9 Savannahs: Lands with herbaceous and other understory systems, and with forest canopy cover between 10-30%. The forest cover height exceeds 2 meters.
10 Grasslands: Lands with herbaceous types of cover. Tree and shrub cover is less than 10%.
11 Permanent Wetlands: Lands with a permanent mixture of water and herbaceous or woody vegetation that cover extensive areas. The vegetation can be present in either salt, brackish, or fresh water.
12 Croplands: Lands covered with temporary crops followed by harvest and a bare soil period (*e.g.*, single and multiple cropping systems). Note that perennial woody crops will be classified as the appropriate forest or shrub land cover type.
13 Urban and Built-up: Land covered by buildings and other man-made structures. Note that this class will not be mapped from the AVHRR imagery but will be developed from the populated places layer that is part of the Digital Chart of the World (Danko, 1992)
14 Cropland/Natural Vegetation Mosaics: Lands with a mosaic of croplands, forests, shrublands, and grasslands in which no one component comprises more than 60% of the landscape.
15 Snow and Ice: Lands under snow and/or ice cover throughout the year.
16 Barren: Lands exposed soil, sand, rocks, or snow and never has more than 10% vegetated cover during any time of the year.
17 Water Bodies: Oceans, seas, lakes, reservoirs, and rivers. Can be either fresh or salt water bodies.

Comments on version 1 continent by continent releases of DISCover are encouraged. The version 1 releases can be obtained from the URL

http://edcwww.cr.usgs.gov/landdaac/glcc/glcc_na.html

Comments should focus on the accuracy of the land cover map in terms of location of classes, rather than proposals for modifications to the legend.

Where WWW connections are unavailable, by contacting the DISCover Production Manager, Tom Loveland: USGS EROS Data Center, Sioux Falls, SD 57198 USA.
tel: (+1-605) 594 6066, fax: (+1 605) 594 6529, e-mail: loveland@edcsnw19.cr.usgs.gov

The current implementation schedule is as follows:

1 Version 1 classification for North America completed, comments welcome until 31 December 1996
2 Version 1 classification for South America and Africa completed in October 1996, comments welcome until 28 February 1997
3 Version 1 classification for Eurasia completed in December 1996, comments welcome until 30 April 1997
4 Version 1 classification for Australia, Antarctica, Greenland completed in June 1997

The IGBP-DIS Global Fire Data Activity

by Chris Justice

The need for a Global Fire Data Set was identified in the IGBP Data Requirements Workshop in Toulouse in 1992 to assist the modelling of trace gas emissions and ecological disturbance regimes. With the recent addition of aerosol and land use change initiatives within the IGBP, there is an increasing demand for data sets of the global distribution and temporal frequency of fire events. Coarse resolution satellite remote sensing provides the capability to monitor certain fire characteristics. Several researchers have previously used remote sensing to identify fire events at local scales.

An *ad hoc* working group was established within the DIS and met in 1993 to compare the capabilities of currently available satellite sensing systems with the data requirements from the IGBP Core Projects. The Working Group developed a community research agenda and set out to prototype various fire products from different sensing systems with different monitoring capabilities. Prototype regional data sets were derived from the NOAA-Advanced Very High Resolution Radiometer, GOES, Earth Resources Satellite -1 and Defense Mapping Satellite Program sensors. As none of the existing satellite sensing systems were designed for fire monitoring, each system has different limitations. Fire sensing requirements are being built into a number of systems currently being designed or constructed and planned for launch in the next few years. For example the EOS MODIS instrument will have a very sensitive sensor which will saturate at a higher level than previous sensors, designed to monitor active fires, and will generate daily data at 250m for burn scar monitoring.

In October of 1995 the working group assembled to examine progress and plan the next phase of the fire data set program. Data for different regions generated during this first phase activities are now planned for distribution by the DIS.

The second phase of the DIS activity will focus on the development of a daily global fast-track 1km fire product using the IGBP Global AVHRR 1km data set (see picture opposite on page 11). This data set is planned for operational implementation at the JRC Ispra starting in late 1996. Prototypes of the global active fire product are being developed by different teams within the working group. Currently, refinements are being made to the community consensus algorithm and the processing chain is under design.

An additional task in the second phase of the programme will be the design and development of a Fire Information System within a geographic information system framework to provide fire parameters of interest for the study of atmospheric chemistry, ecology and land-use change.

The third phase of the Global Fire Product programme will be to focus on determining global burned area directly from satellite, this can be prototyped using the existing satellite systems but will most likely rely on data from the planned sensing systems for improved quantification.

An additional requirement given to DIS was to develop a global emission factor data base from the existing disparate data sources. This requirement was identified early in the programme and is currently being revisited with the relevant core projects.

Chris Justice, Global Inventory Monitoring and Modelling Studies, Code 923, Goddard Space Flight Center, NASA, Greenbelt, MD 20771, USA.

The Global Soil Data Task

by Bob Scholes

Many activities within the IGBP, the IHDP and the WCRP depend on reliable data about soil properties. In order to reduce duplication of effort, and the additional source of disagreement between models which results from their using different soil data, IGBP-DIS has a task whose mission it is to make the best available soil data accessible in easy-to-use formats to the Global Change community.

The task has followed three guiding principles: complete transparency of the methods used; quality control on the input data; and care in the handling of the special spatial properties of soils. The task consists of three steps: building a global pedon database; developing methods to convert fundamental soil analytical properties into derived properties; and generating global gridded databases of the derived soil properties.

The global pedon database is based on the WISE database developed by the International Soil Reference and Information Centre (ISRIC) in Wageningen. It consists of over a thousand soil profile descriptions, including comprehensive chemical and physical analyses, from all over the world. It was assembled by combining profiles from three major international sources: the ISIS database at ISRIC, the FAO and from the US Department of Agriculture. DIS assisted by funding the translation of the USDA soil classifications into FAO soil classes. The pedon database is available upon request from ISRIC (e-mail: soil@isric.nl).

Interaction with the Global Change community led to the identification of four soil properties as being especially important and urgently required: soil organic carbon, soil total nitrogen, water holding capacity and soil thermal properties. The soil task has concentrated on developing globally-robust pedo-transfer functions (PTFs) to convert the pedon analytical data, such as sand, silt and clay content, into derived attributes such as water-holding capacity (the difference between the water content at field capacity and wilting point). The development and testing of PTFs for these attributes, for the 0-30 cm and 30-100 cm intervals, will be completed in 1996. In the second phase, PTFs for further attributes, such as rooting depth, hydraulic conductance and water regime, will be developed in collaboration with interested core projects.

Soils vary spatially over distances of as little as a few metres, and many soil properties bear strongly nonlinear relationships to the analytical data from which they are predicted. Therefore great care needs to be taken when scaling soil properties. The principles followed in the soil task have been to scale the derived property rather than the underlying analytical values, and to report the full uncertainty resulting from scaling and the inherent spatial variability of soils. The best available soil map at global scale is the FAO map. It is linked to the pedon database via the shared classification. The gridded products will be at 5' resolution, the finest supportable by the map. Users can then aggregate the soil properties to coarser resolutions. These products are anticipated to be released in early 1997.

Bob Scholes, Commonwealth Scientific and Industrial Research, Division of Forest Science and Technology, PO Box 395, Pretoria 0001, South Africa.

NOAA/AVHRR Detected High Temperature Sources: June 25, 1992

J. Kendall, NASA/GSFC

**Derived from the IGBP–DIS Global 1km data set provided by USGS Eros Data Center

The Global Land 1-km Base Elevation Digital Elevation Model: A Progress Report

by David Hastings

Background

Global topographic data are among the most important data sets for many scientific, technical, and other applications. Even when not used directly in a study, topographic data are often used in preparing visualisation tools such as perspective or stereoscopic views of terrain.

The GLOBE project is developing a 1-km gridded, quality-controlled global Digital Elevation Model (DEM). The final product is scheduled for release in 1997.

The general aims of GLOBE are:

1 Develop a 1-km global DEM, by including the best available data sets and by encouraging specialists to participate in production and review of the data. The GLOBE DEM will be made available to the world-wide research community. CD-ROM will likely be the main distribution medium.

2 Strengthen international collaboration in the development of research-quality digital global data sets. Advance technical and cultural capabilities for international collaboration in the development of such data.

3 Strengthen awareness of the need for optimal quality high-resolution global topographic information, including the provision of a focus for the timely release of currently restricted terrain data sets.

4 Supply a "pathfinder" data set to the Earth Observation community.

5 Develop a data structure (nested multi-resolution grid system) useful for future enhancements such as might come from future topographic satellite missions.

6 Give the Committee on Earth Observing Satellites Working Group on Data (CEOS-WGD) a prototype in co-operatively improving vital data.

Input data and methods used for GLOBE are:

- Data at higher resolution than GLOBE, resampled for use in GLOBE.
- Elevation contours from the 1:1,000,000 Operational Navigation Charts digitised into the Digital Chart of the World (DCW), gridded at 30-arc-second latitude-longitude spacing.

Where data from sources above are unavailable, the best available data will be used.

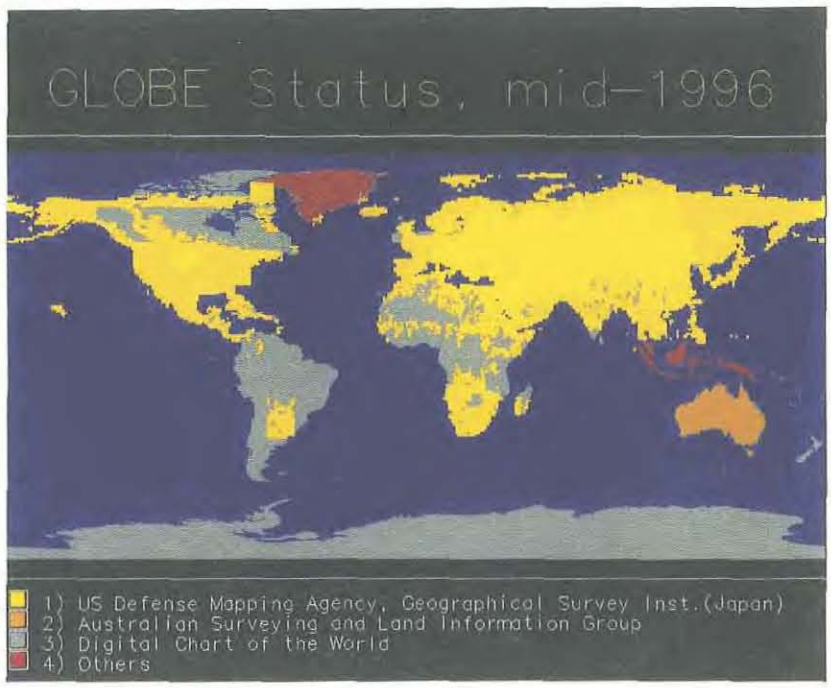
Documentation on sources, methods of derivation, quality control procedures, and data characteristics will be provided as text and figures/maps. Additional data may be developed as by-product digital data sets.

Several specialists/institutions have jointly developed the GLOBE project, which has been approved by the Auxiliary Data Subgroup of CEOS-WGD. The IGBP-DIS office is participating in GLOBE design and evaluation efforts. Since its formation early in 1992, the GLOBE project has conducted periodic meetings. These meetings have been held in conjunction with other meetings with common interests, such as the International Society of Photogrammetry and Remote Sensing Working Group IV/6's International Workshop on Global Databases.

Major GLOBE participants include:

- USGS EROS Data Center, Sioux Falls, USA (USGS/EDC)
- University College London, UK (UCL)
- DLR-German Remote Sensing Data Center, Oberpfaffenhofen, Germany (DLR)
- NOAA National Geophysical Data Center, Boulder, USA (NOAA/NGDC)
- Defense Mapping Agency, Fairfax, USA (DMA)
- Geographical Survey Institute, Tsukuba, Japan (GSI)
- Australian Surveying and Land Information Group, Belconnen, Australia (AUSLIG).

GLOBE participants, acting independently but sharing knowledge with other GLOBE participants, developed prototype methods for adapting high-resolution DEMs and Digital Chart of the World contours to GLOBE-resolution DEMs, and for adapting contributed lower-resolution DEMs to GLOBE scale.



Progress Report

The ultimate release of a GLOBE DEM will contain more moderate-to-high resolution data, at higher quality, from more sources, than originally imagined by the founding participants.

In 1994 NGDC and DMA developed terms under which DMA produced 30" DEMs from existing DEM holdings, for unrestricted use. This was a direct DMA contribution to GLOBE. 30" grids were produced as summaries of the 100 3" grid cells in each 30" cell. Maximum, minimum, and mean values per 30" output cell were provided. DMA is currently finishing up a revision/update to the 1994 version. These data are a remarkable improvement over previously unrestricted DEM coverage for much of the world.

USGS (EROS Data Center) and University College London (Photogrammetry and Surveying Department) are progressing on gridding Digital Chart of the World Contours into 30" DEMs. USGS has also cooperated with the Geographical Survey Institute of Japan to obtain and digitise some additio-nal topographic maps in areas lacking DCW contours. UCL has contributed a DEM of Antarctica, as has USGS. Other agencies continue to contribute DEMs to NGDC (as part of its 5' TerrainBase as well as GLOBE).

NGDC recently concluded a memorandum of understanding with the Australian Surveying and Land Information Group (AUSLIG). AUSLIG has provided high-density point elevations for evaluation and processing by NGDC. NGDC will produce a 30" DEM for GLOBE, containing AUSLIG data, and perhaps other data. AUSLIG's source data remain AUSLIG's, and are not redistributable by anyone other than AUSLIG. However, the regridded 30" data *are* redistributable by NGDC. Thus GLOBE will get a new grid for Australia. Currently, Australia would be the only part of the world where the data would not be completely free of distribution restrictions.

Thus GLOBE currently consists of the following components

1. Data derived directly from DEMs with resolutions higher than 30":
   - >55% of the Earth's surface contributed by DMA;
   - USA from DMA/USGS/NGDC;
   - Mexico from INEGI/USGS;
   - Australia from AUSLIG/NGDC;
   - Japan from GSI (special version for the international scientific community);
   - Italy from the Servizio Geologico Nazionale/NGDC.
2. Data derived from Digital Chart of the World and other contour maps, directly into 30" grids.
3. Data contributed at lower resolution, oversampled to 30" for GLOBE. These are mostly data currently in NGDC's TerrainBase compilation, but also include UCL's (Mullard Space Science Laboratory) Antarctic grid, and more recent contributions to NGDC for a TerrainBase update.
4. GLOBE is currently an elevation model. However, the development/release of higher resolution bathymetric data might merit inclusion in future versions of GLOBE.

Mosaicking has begun by several participants. Editing and testing will continue in 1996, for 1997 release.

Contributions Still Welcome

Please note that it is not too late for holders of DEMs to contribute to the GLOBE effort. Please contact the Secretary of GLOBE, David Hastings, if you have (or know of) data that might be contributed to GLOBE.

Exciting Prospects

Perhaps one of the most exciting developments in topography is being forged by a co-operative effort to use existing, largely proven, technology. The U.S. Defense Mapping Agency and the National Aeronautics and Space Administration have agreed to schedule a 11-day mission of the Space Shuttle in May 2000, to carry Spaceborne Imaging Radar-C (SIR-C) on a mission dedicated to cover the Earth (between about 60 degrees north and south latitudes) for deriving multi-frequency, polarimetric radar imagery and SAR-interferometric DEMs. This pioneering mission will extend existing technology by moving from prototype to global production scales. DEMs on 100 meter grid spacings are anticipated from this mission. The climate for international/interagency co-operation in topography, partly developed by the GLOBE project's partners, appears to be improving even further. We can only hope that the GLOBE DEM will be superseded by results of this space mission within a decade after GLOBE's completion.

David A. Hastings, National Oceanic and Atmospheric Administration, National Geophysical Data Center, 325 Broadway, Boulder CO 80303, USA

News from ESA

For ten months between August 1995 and June 1996 the European Space Agency operated the synthestic aperture radars on its ERS-1 and ERS-2 satellites in a "tandem" mode, observing the same swath of surface from across-track vantage points of order 100m apart and with a one day time separation. Virtually the whole of the earth's terrestrial surface was covered, providing the possiblity of generating a global DEM with 30m resolution. As yet it is not clear who will take on the mammoth task of processing the entire data set, but numerous sample DEMs have already been produced (see ESA, Earth Observation Quarterly, No. 52, June 1996).

Chris Rapley

Global Primary Production Data Initiative Update

by Dick Olson and Steve Prince

Global modelling and monitoring of net primary production (NPP) is being given high priority in IGBP owing to increasing concern over issues such as the consequences of perturbations in the carbon cycle, the impacts of global land-use change, global climate change, and global food security. Significant advances have been made in process modelling and in the use of remote sensing to monitor global vegetation. The advances in modelling and remote sensing of NPP have highlighted the lack of readily available, reliable information from field studies with which to parameterise and validate the models. The Global Primary Production Data Initiative (GPPDI) is intended to remedy this problem by identifying existing field data sets of primary production and associated environmental data. The programme is using data sets for representative sites, and extrapolating or regionalising the better data sets to grid cells sizes of up to 0.5°x0.5°. Emphasis is on variables needed to parameterise and validate primary production models, including above and below ground NPP, standing crop, LAI, climate data, site data and landscape variability.

GPPDI was launched following a meeting of ecosystem modellers organised under the IGBP-DIS, GCTE and GAIM programmes at the Potsdam Institute for Climate Impact Research (PIK) in July 1994. The IGBP-DIS Working Paper No. 12 "Global Primary Production Data Initiative Project Description" was presented and adopted at the first full GPPDI Steering Committee meeting in January, 1995 in Paris and further endorsement of the GPPDI given at a Steering Committee Meeting held at the Second Potsdam Modelling Workshop in June 1995. An international Steering Committee is assisting IGBP-DIS to oversee the activity and identify support. A Project Team and Co-ordinator are implementing the programme. The GPPDI is expected to develop a working data set in two years.

The GPPDI team consists of four components, each undertaken by a separate laboratory having expertise in the appropriate field, as follows: Oak Ridge National Laboratory (ORNL), USA; Geography Department, University of Maryland, USA; Centre d'Etudes Spatiales de la BIOsphère (CESBIO), Toulouse, France; and PIK, Germany. Work related to the GPPDI has started at the first three institutions as summarised below.

ORNL (PI- Dick Olson) - Under the auspices of the GPPDI and funding from the National Aeronautics and Space Administration (NASA), the ORNL Distributed Active Archive Center (DAAC) is compiling data from existing field measurements of net primary productivity (NPP), for a number of major world ecosystem types. The emphasis is to select global sites that are representative and have very complete data sets. Under guidance from the GPPDI, the initial NPP database emphasis was on the compilation of grassland datasets and the initial NPP data is available through the ORNL DAAC (URL http://www-eosdis.ornl.gov/ - look for "NPP" hot keys) for use by the broader research community. In FY 1997, the NPP data will be supplemented with NPP data from tropical forests, boreal forests and other existing extensive datasets (*e.g.* NPP data for 762 sites compiled by Esser and Lieth for their Osnabrück Biosphere model and the Woodlands Data Set of 117 sites compiled under the International Biome Programme). The data compilation will be performed by a post doctoral fellow (Jonathan Scurlock) having contacts with the NPP research community. Individuals are encouraged to review the existing data on the ORNL WWW site and provide comments and suggestions.

University of Maryland (PI Steve Prince) - The University of Maryland is funded by NASA under the auspices of the GPPDI to develop fields of NPP data for grid cells between 1 km^2 and 0.5 latitude by 0.5 longitude. The work was started in July, 1996 and is being conducted by Holly Strand.

CESBIO (PI - Gérard Dedieu) - This component has been identifying large a-reas of agricultural crops for which agricultural yield and NPP are available and, when possible, developing NPP and associated datasets for uniform regions of between 1 km^2 and 0.5 latitude by 0.5 longitude. The group (including Alberte Fischer, CESBIO/PIK, and Sophie Moulin, post-doc at CESBIO) is working on estimating NPP for two sites in France with initial results expected in late 1996. No funds are currently available to extend the work to other agricultural systems.

PIK (PI - Wolfgang Cramer) - The PIK group will create data sets of physical variables, including appropriate point interpolations and area measures, for point sites and areas for which NPP data are obtained. They plan to initially concentrate on climatology data; however, no funds are currently available for this component.

Dick J. Olson, Oak Ridge National Laboratory Environmental Sciences Division PO Box 2008, Bldg 1507, MS 6407 Oak Ridge, TN 37831-6407, USA

Steve Prince, Department of Geography, University of Maryland, Lefrak Hall, Room 1113, College Park, MD 10742-8225, USA

Data needs for modelling global biospheric carbon fluxes - lessons from a comparison of models

Wolfgang Cramer, Berrien Moore and Dork Sahagian

An ongoing DIS-GAIM-GCTE activity is focused on the comparison of global biospheric models, particularly with respect to their ability to estimate net fluxes of carbon between atmosphere and biosphere (NPP). Data requirements for driving and validation of these models have become elucidated during two workshops (held at the Potsdam Institute for Climate Impact Research in 1994 and 1995).

For estimates of the global carbon balance, a large amount of uncertainty centres on the role of terrestrial ecosystems. Geographically referenced gross primary productivity (GPP), net primary productivity (NPP), and heterotrophic respiration (Rh) and their corresponding seasonal variation are key components in the terrestrial carbon cycle. At least two factors govern the level of terrestrial carbon storage. First and most obvious is the anthropogenic alteration of the Earth's surface, such as through the conversion of forest to agriculture, which can result in a net release of CO_2 to the atmosphere. Second, and more subtle, are the possible changes in net ecosystem production (and hence carbon storage) re-

sulting from changes in atmospheric CO_2, other global biogeochemical cycles, and/or the physical climate system. The significant influence of the terrestrial biosphere on the global carbon balance and hence on the problem of climate change has become more widely recognised during the past two decades, and now the role of terrestrial ecosystems is central to the residence time of carbon dioxide in the atmosphere (Moore & Braswell 1994; Keeling *et al.* 1996; Melillo *et al.* 1996).

To understand the present and to predict the future role of ecosystems in this global context, observations, while necessary, are hardly sufficient, and a range of global terrestrial ecosystem models which capture the critical processes in the biosphere are needed. Several such models now exist, others are in various stages of development, and it has become possible to investigate the magnitude and geographical distribution of primary productivity on a global scale by a combination of ecosystem process modelling and monitoring by remote sensing. Biospheric flux models all somehow (explicitly or implicitly) relate geographically specific and comprehensive estimates of temperature, water availability and photosynthetically active radiation (PAR), as well as their seasonal changes, to some or all of the basic processes of photosynthesis, growth and maintenance respiration, water and nitrogen fluxes, allocation of photosynthates in the plant and the production and decomposition of litter.

Among the simulation models, two major groups can be distinguished based on the way they use various data sources. One group is essentially driven by observations made by space-borne sensors, most particularly the NOAA-AVHRR, which now provides a relatively long time series and full global coverage with high temporal resolution. These models provide a steadily improved picture of the NPP of the world's actual vegetation. In contrast, other models usually use data on climate and soils alone to derive estimates of the biological activity in the world's potential vegetation.

One of the early results that emerged from the first NPP model intercomparison workshop was that a major reason for differences between outputs of the same variable between different models was that the input data for the same variable were from different sources and carried different uncertainties (this was true for both ground-based observations such as climatic data and for remote sensing data such as AVHRR-derived NDVI). Consequently, many of these data were standardised for the second workshop. Figure 1 (top of page 15) shows an example of an important input data set, biome definition and distribution, which has not been successfully standardised throughout the models used in the intercomparison because of differences in modelling approaches, and which may account for a significant portion of the differences in resulting modelled NPP shown in Figure 2 (bottom of page 15). It is necessary to use as many standardised input data sets as possible in order to compare model formulations on the basis of modelled NPP.

A second fundamental problem of such comparisons is that the target variable, net biospheric carbon flux, cannot be measured at the appropriate spatial scale for any significant part of the globe. Direct validation of any of the models is therefore impossible, although several indirect validation methods exist (Cramer & Fischer 1996; Heimann *et al.*, in review). A third limitation concerns the quality of the existing observation data sets. For climate, a range of efforts have been made to improve available data sets for the application of biospheric models (including a May, 1996 GCTE/GAIM workshop on that topic). However, climate is only one significant variable; another one (for potential vegetation) is soils, regarding which several activities are currently underway (Scholes *et al.* 1994). The two most crucial gaps exist in the area of historical changes in global land use, which is clearly a significant element in the world's carbon balance, and in the compilation of point-based observations of biospheric fluxes.

A comprehensive data strategy for the models at the heart of the terrestrial component of the IGBP, the atmosphere-biosphere interaction models, is still lacking. The NPP model intercomparison has made it clear that existing data must be chosen and used in a standardised way if like models are to be compared, and ultimately, if complementary models are to coupled. It has also clarified data gaps which can now be filled before models can reliably simulate the role of terrestrial ecosystems in the global carbon cycle. However, it is not necessary for model development to wait until all gaps in the global observing systems are closed. Rather, IGBP can take the lead in co-ordinating existing and future data sources in a way that will optimise their utility throughout the global change research community.

References

Cramer, W. & Fischer, A. 1996. Data requirements for global terrestrial ecosystem modelling. In: Walker, B. & Steffen, W. (Ed.), *Global Change and Terrestrial Ecosystems*. Cambridge: Cambridge University Press pp.530-565.

Heimann, M., Esser, G., Haxeltine, A., Kaduk, J., Kicklighter, D., Knorr, W., Kohlmaier, G., McGuire, A., Melillo, J., Moore, B., Otto, R., Prentice, I., Sauf, W., Schloss, A., Sitch, S., Wittenberg, U., and Würth, G., Evaluation of terrestrial carbon cycle models through simulations of the seasonal cycle of atmospheric CO_2: First results of a model intercomparison study, *Global Biogeochem. Cycles*, in Review.

Keeling, R.F., Piper, S.C. & Heimann, M. 1996. Global and hemispheric CO_2 sinks deduced from changes in atmospheric O_2 concentration. *Nature* 381:218-221.

Melillo, J.M., Prentice, I.C., Farquhar, G.D., Schulze, E.-D. & Sala, O.E. 1996. Terrestrial Biotic Responses to Environmental Change and Feedbacks to Climate. In: Houghton, J.T., Meira Filho, L.G., Callander, B.A., Harris, N., Kattenberg, A. & Maskell, K. (Ed.), *Climate Change 1995 - The Science of Climate Change*. Cambridge, UK: Cambridge University Press.pp.445-481.

Moore, B., III & Braswell, B.H. 1994. The lifetime of excess atmospheric carbon dioxide. *Gl. Biogeoch. Cycl.* 8(1):23-38.

Moore, B., III, Cramer, W., Rasool, I., Sahagian, D., Steffen, W., and the Participants[1] in "Potsdam '95", global net primary productivity: Results of the Potsdam '95 IGBP NPP model intercomparison workshop (GIAM-DIS-GCTE) - Potsdam, Germany, June 20-22, 1995, First GAIM Science Conference Abstracts & Program, C-14, 1995.

Scholes, R.J., Skole, D. & Ingram, J.S. (Ed.). 1994. *A Global Database of Soil Properties: Proposal for Implementation*. Paris: IGBP-DIS, University of Paris.

Wolfgang Cramer, Potsdam Institute for Climate Impact Research, Dept. of Global Change and Natural Systems, PO Box 60 12 03, D-144 12 Potsdam, Germany

Berrien Moore III and Dork Sahagian, Complex Systems Research Center, Institute for the Study of Earth, Oceans, and Space, University of New Hampshire, Durham, NH, USA

[1]The following people participated in the comparison workshop and the associated data preparation: G. Churkina, G. Colinet, J. Collatz, G. Dedieu, W. Emanuel, G. Esser, C. Field, A. Fischer, L. François, A. Friend, A. Haxeltine, M. Heimann, J. Hoffstadt, J. Kaduk, L. Kergoat, D. Kicklighter, W. Knorr, G. Kohlmaier, B. Lurin, P. Maisongrande, P. Martin, R. McKeown, B. Meeson, R. Nemani, R. Olson, R. Otto, W. Parton, M. Plöchl, S. Prince, J. Randerson, I. Rasool, B. Rizzo, A. Ruimy, S. Running, D. Sahagian, B. Saugier, A. Schloss, J. Scurlock, W. Steffen, P. Warnant, U. Wittenberg

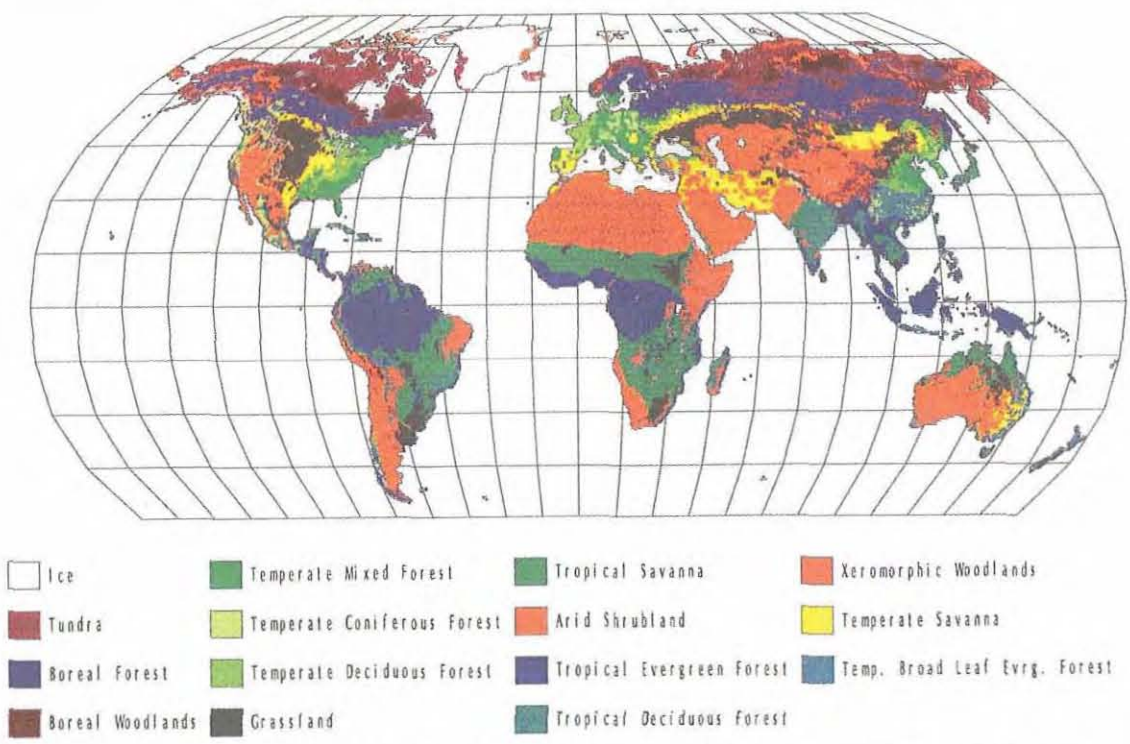


Figure 1. Biome distribution map from Moore *et al* (1995). There is no universally adopted biome definition or distribution for use in terrestrial ecosystem models.

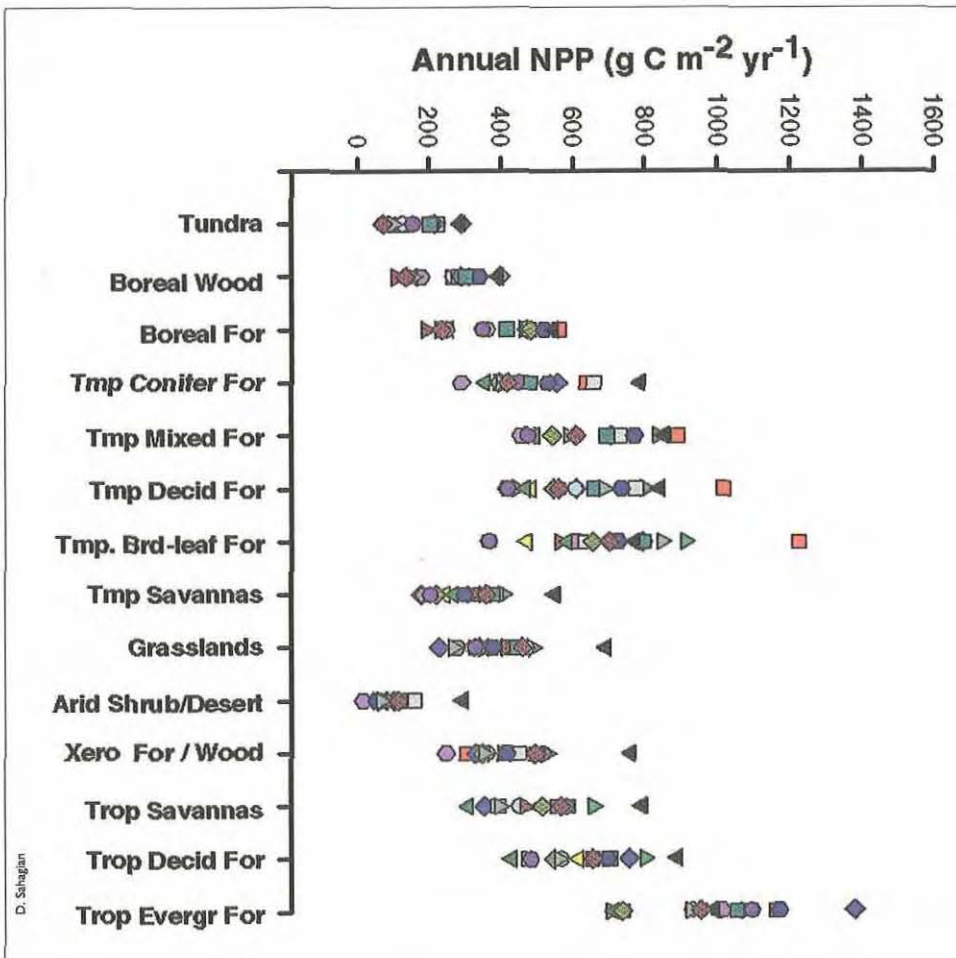


Figure 2. Net primary productivity (NPP) estimated by various models as indicated by different colours and shapes. Models are not named, and show considerable differences in NPP for each biome. For each model, NPP is *averaged over the region indicated* in each biome in Figure 1 and plotted accordingly. This allows comparison despite the fact that models used different input biome distributions. Differences between modelled NPP may in part be derived from the use of different biome definitions and distributions and other input parameters. If all input parameters could be standardised, graphs such as this one would display specific difference between model formulations, and could be used as diagnostic tools for model refinement.

Wetlands Inter-element Workshop: The IGBP-DIS Perspective

by Ichtiaque Rasool and Dork Sahagian

The IGBP inter-element wetlands workshop involving GAIM, DIS, BAHC, IGAC, and LUCC, was held in Santa Barbara, California on May 16-20, 1996. The purpose of the workshop was to establish a functional parameterisation of wetlands directed towards integrating wetland trace gas, hydrologic, nutrient, and other fluxes into regional and global biogeochemical models more effectively than presently possible. Wetlands scientists from every continent and various disciplines related to wetlands gathered and formulated a nine-parameter functional n-space into which all wetlands can be plotted uniquely. The formulation was directed jointly by field ecologists who helped define functions and by remote sensors who helped determine the types of data sets which could be brought to bear on the problem of discrimination between wetlands with different sets of parametric values. The initial nine parameters proposed by workshop participants were: Hydrology, Temperature, Primary Production, Vegetation, Soil, Salinity, Chemical Information, Transport of Organics and Sediment, and Topography/Geomorphology. These may be subsequently refined to establish a robust set of orthogonal parameters.

There are several impediments to parameter assessment globally: These are related to:

A. *Wetland extent and distribution (classification and definition)*

Information base is inadequate (missing data, poor data, poorly disseminated data sets). But compilations have been constrained by lack of agreement on definition and classification. We need to compare and relate the functional parameterisation to widely used biodiversity/conservation oriented classifications (mainly hierarchical).

B. *Uneven spatial and temporal data coverage*

Available information base is heavily biased to the northern boreal and temperate zones, but is generally poorer for tropical and southern subtropical and temperate zones. Spatial and temporal aspects need more attention (*e.g.* periodicity of inundation: permanent, seasonal, intermittent, episodic).

C. *Soils information is poor or misleading*

D. *Hydrological data is poor*

E. *Anthropogenic influences are not well accounted for.*

Considerable headway can already be made by using data products which are being developed by IGBP-DIS. The most relevant are:

- Global 1-km AVHRR data base
- Global land cover classification
- Fire data base
- Global Soils data product
- Net Primary Productivity Data Initiative
- Global 1-km topography data base
- IGBP-DIS/CEOS pilot project on High Resolution Satellite Imagery data exchange.

As more IGBP research focuses on wetlands, IGBP-DIS will work with investigators to provide existing data a well as to help develop new data products.

It is anticipated that a more detailed article covering key aspects of the wetlands workshop and the next steps envisaged for this project will appear in a future issue of the Global Change Newsletter.

Ichtiaque Rasool, 52 Boulevard Sébastopol, 5th Floor, 75003 Paris, France.
Dork Sahagian, GAIM Task Force Office, Complex Systems Research Center, Institute for the Study of Earth, Oceans, and Space, University of New Hampshire, Durham, NH, USA.

BIOME 6000: progress and plans

by Colin Prentice

The data synthesis project BIOME 6000 is sponsored by four IGBP programme elements: GAIM, GCTE, PAGES and IGBP-DIS, reflecting the fact that palaeoecological data are of central relevance to the evaluation of models that include both atmospheric and biospheric components. The project is coordinated by GAIM Task Force member Colin Prentice (Lund University, Sweden), with help from Thompson Webb III (Brown University, Providence, USA) who is in charge of data management, and an international steering committee that includes Raymonde Bonnefille (currently at the French Institute of Pondicherry, India), Brian Huntley (University of Durham, England), Geoff Hope (ANU, Canberra, Australia), Vera Markgraf (INSTAAR, Boulder, Colorado, USA) and Sun Xiangjun (Academia Sinica, Beijing, P.R. of China). The project aims to generate two main products. The first, planned for release in 1997, will be a state-of-the-art, properly documented, global data set of past vegetation for 6,000 radiocarbon years ago, based on pollen and plant macrofossil records. The second, planned for 1998, will be a similar data set for the last glacial maximum (18,000 radiocarbon years ago). There are fewer data points for the last glacial maximum (perhaps only a quarter of the number for 6,000 yr BP), but they record very large changes from today and they are needed for a wide variety of modelling studies.

The data sets will consist of reconstructed biomes, inferred from the primary data records by objective methods (Prentice *et al.* 1995). They will provide benchmarks for evaluating the results of "snapshot" studies with climate and biosphere models (*e.g.* Jolly *et al.* in press). The emphasis on using palaeodata on a site-by-site basis, as opposed to maps, is intended as an antidote to the problems that can arise when interpolations are mistaken for data, as is strikingly documented by Broccoli & Marciniak (1996), for the case of the CLIMAP sea-surface temperature map. Some form of objective analysis (*e.g.*, Guiot *et al.* in press) may be used to generate ancillary products in the form of continuous palaeobiome maps, but these will be issued with a "health warning" to the effect that interpolations are no substitute for observations! In fact, it is hoped that widespread use of the BIOME 6000 data products will focus attention on the importance of continuing to increase the coverage of palaeoecological observations, above all in the less intensively studied regions. Formal publication of the BIOME 6000 results will happen in due course, and will include all of the large number of individual palaeoecologists who have contributed data to the project.

Great progress has been made since the project's inauguration at a workshop in Hörby, Sweden in 1994 (Prentice and Webb, in press). Some of this progress is illustrated in the figure on page 17. Here are shown the patterns of palaeobiome distribution at 6,000 yr BP for Europe and

Africa. Some reconstructions for African sites are still preliminary because they are based on published data rather than on the full primary data, but this problem is in hand. Behind this figure lies a major effort by Dominique Jolly at Lund University, in assembling the data with the co-operation of all of the scientists involved, and testing and carrying out the "biomisation" procedure. For example, a test using surface pollen data (reflecting modern vegetation) across West Africa showed that the procedure can reconstruct present vegetation patterns convincingly in a region with such a large and diverse flora (Jolly *et al.*, submitted).

Africa presented a big challenge for both scientific and organisational reasons. However, we are very satisfied with the progress that has been made. We are also delighted that a new initiative, sponsored by START as well as PAGES and IGBP-DIS, starting with a major workshop this September, will now lay the foundations for a much more co-ordinated development of African pollen data collection and synthesis in the longer term. Several other initiatives are helping to extend this work to the rest of the world, through the efforts of co-operating scientists too numerous to mention here. Preliminary palaeobiome data sets have been constructed for Australia and eastern North America. A workshop dealing with both palaeolake and palaeoecological data from the former Soviet Union (FSU) and Mongolia, including many of the most active specialists from the countries of the FSU, is planned (subject to funding) to take place in Hörby in August 1996. The available data include records from Siberia and Central Asia, both regions of particular strategic importance for model comparisons. New national or regional projects in support of BIOME 6000 are starting in India, China and the Netherlands (for South America), while the development of computer-based data repositories for Latin America and Australasia/Southeast Asia continues apace. The challenge now facing BIOME 6000 is global communication and co-ordination, in order to develop a consistent global product for 6,000 yr BP. We are planning the first steps in this direction in connection with the International Palynological Conference in Houston, Texas, which will take place in June.

References

Broccoli, A.J. and E.P. Marciniak (1996) Comparing simulated glacial climate and paleodata: a reexamination. *Paleoceanography* 11: 3-14.

Guiot, J., R. Cheddadi, I.C. Prentice and D. Jolly (in press) A method of biome mapping from pollen data: application to Europe 6000 years ago. *Palaeoclimates: Data and Modelling.*

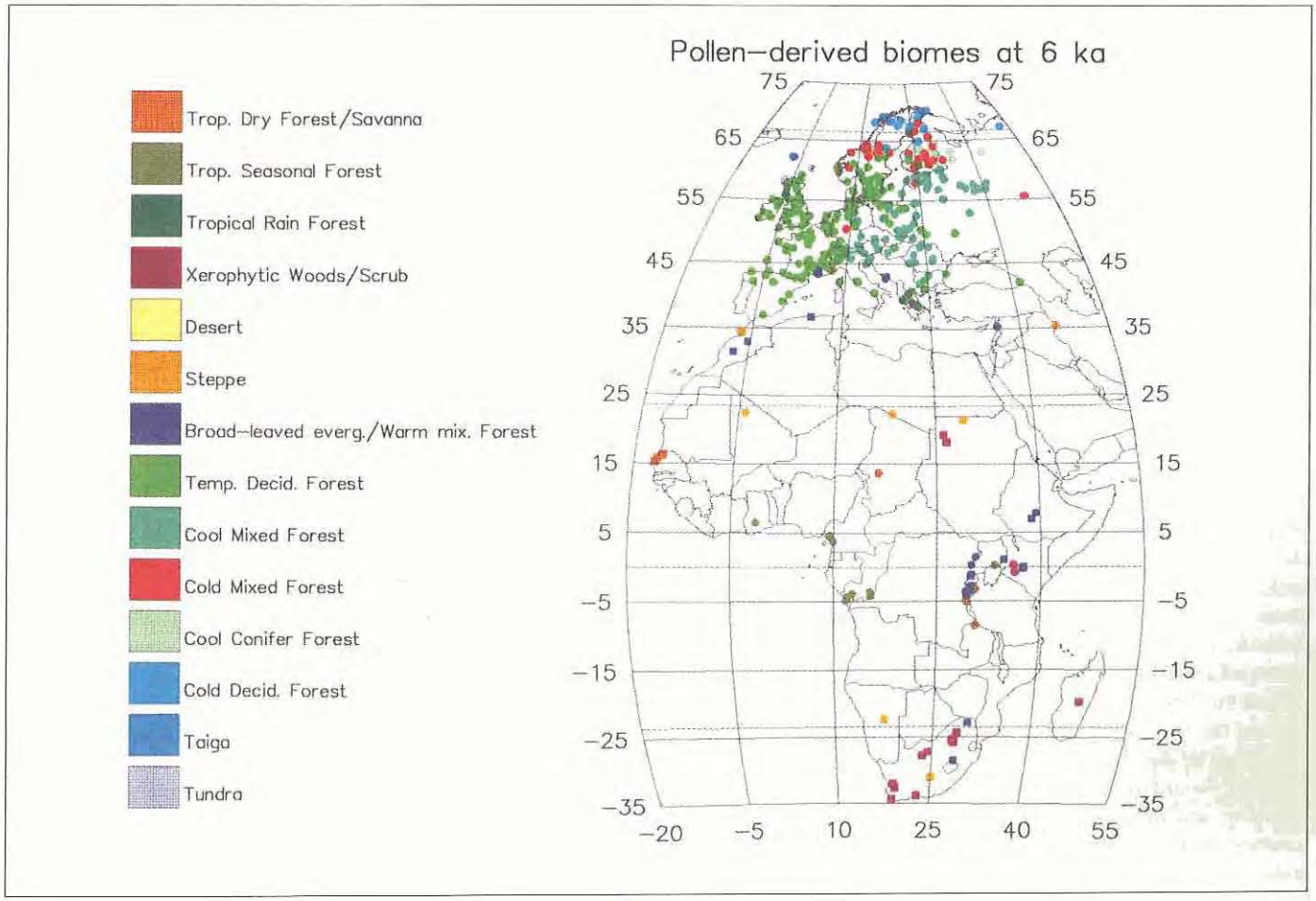
Jolly, D., Harrison, S.P., Damnati, B. and Bonnefille, R. (in press) Simulated climate and biomes of Africa during the Late Quaternary: comparison with pollen and lake-status data. *Quaternary Science Reviews.*

Jolly, D., Prentice, I.C., Guiot, J., Bengo, M., Bonnefille, R., Brénac, P., Buchet, G., Edorh, T., Elenga, H., Lézine, A.M., Maley, J., Reynaud-Ferrara, I., Riollet, G. et Vincens, A. (submitted). Reconstruction de biomes à partir des données polliniques actuelles d'Afrique de l'Ouest. *Géographie physique et Quaternaire.*

Prentice, I.C. and T. Webb III (in press) Global palaeovegetation data for climate-biosphere model evaluation. [*BIOME 6000 workshop report*]

Prentice, I.C., J. Guiot, B. Huntley, D. Jolly and R. Cheddadi (1995) Reconstructing biomes from palaeoecological data: a general method and its application to European pollen data at 0 and 6 ka. *Climate Dynamics* 12: 185-194.

I. Colin Prentice, Department of Plant Ecology, Lund University, Östra Vallgatan 14, S-223 61 Lund, Sweden.



pCO_2 Data Compilation Project

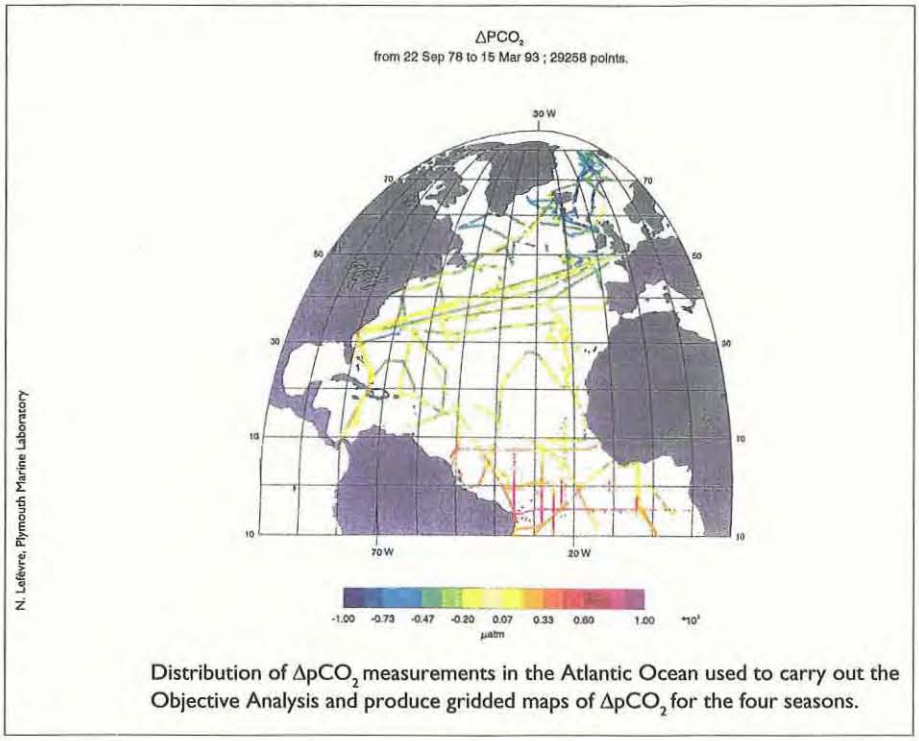
by Ichtiaque Rasool

One of the unknowns in quantifying the global carbon cycle is the flux of CO_2 between the atmosphere and the oceans and how it is changing with time. The conventional wisdom is that between 80 and 110 Gt of carbon are exchanged every year between ocean and the atmosphere. Also, it is believed that the warm equatorial waters are a net source of carbon into the atmosphere, while the colder polar and sub-polar waters are net sinks. However, measured differences in pCO_2 between oceans and the atmosphere over the globe imply a net input into the oceans of 0.8 -2.4 Gt c/yr. These numbers obviously need to be refined rather rapidly because the range of uncertainty in the estimates of net flux into the oceans (1.6 Gt c/yr) is larger than the number now quoted for the total additional carbon input to the atmosphere (1.4 Gt c/yr) by deforestation and land use! A detailed ocean-by ocean analysis of all existing ΔpCO_2 (the difference between ocean surface and atmospheric pCO_2) is clearly warranted. At the request of GAIM and JGOFS scientists, IGBP-DIS took a first step in this direction and undertook to compile North Atlantic available cruise data on ΔpCO_2 for the North Atlantic

The work was carried out by Nathalie Lefèvre, a post-doc from France. Twenty-one thousand data points of pCO_2 during cruises in the period 1978-1993, between 10°S and 80°N, have been compiled (see figure). The objective analysis approach was used to produce gridded maps for the four seasons. From the analysis it is clear that the regions north of 30°N are a sink of CO_2 for the atmosphere whereas the equatorial region (10°S-10°N) is a source. The values derived in this analysis range from +50 +/-13 μ atm at 10°S in the first quarter to -95 +/-10 μ atm at 70°N in the third quarter. Zonal means of ΔpCO_2 are in good agreement with these derived by Takahashi *et al.* using a completely different approach in the analysis.

Results of the study were published as IGBP-DIS Working Paper 11. A paper based on this study has been accepted for publication in the journal 'Global Atmosphere and Ocean System". Nathalie Lefèvre is now at Plymouth Marine Laboratory, UK.

Ichtiaque Rasool, 52 Boulevard Sébastopol, 5th Floor, 75003 Paris, France.



Distribution of ΔpCO_2 measurements in the Atlantic Ocean used to carry out the Objective Analysis and produce gridded maps of ΔpCO_2 for the four seasons.

Introduction to Focus 2 activities: Data Management

by John Townshend

Advertise *data management* as a session theme at a scientific conference and this will normally guarantee an almost empty room. But at this year's IGBP Congress in Bad Münstereifel, a session on this topic, arranged at the last minute, was very well attended. This is an encouraging indication of the increasing interest of IGBP in managing its data better.

Why should this apparently mundane, topic be arousing attention? Among the reasons are the fact that without good data management our scientific efforts will be diminished: valuable data will be lost perhaps for ever, data sets from different locations will be found to be inherently incompatible, reliable long term data sets will be difficult to create, data sets may be difficult to find. Effective data management ultimately will spare the individual scientist considerable effort, but conversely investments of time and effort have to be made initially for the benefits to be realised. The need for data management also arises because of the increasing volumes and diversity of data sets needed for our science.

In IGBP-DIS data management has been the subject of less effort than the definition and creation of new data sets (Focus 1). But progress has been made in some areas. The creation of novel meta-data information systems associated with high resolution satellite data has been a path-finding activity showing how graphical displays which integrate meta-data from multiple sources can be used to provide much improved information on the availability of data, reducing the work load of the user considerably. IGBP-DIS like many others has been active in exploiting the benefits of the Web and has given workshops to IGBP users to demonstrate how they can use this medium to assist them in data management.

Underpinning the whole issue of data management is that of data policy, which must be used not only to help the IGBP gain access to the data sets it needs, but must also be used as the rules governing how IGBP makes its own data sets available.

Many other issues of data management need to be addressed and to assist this process IGBP-DIS and the World Data Center System are jointly organising a workshop on this topic in early 1997.

John Townshend, Department of Geography, University of Maryland, Lefrak Hall, room 1113, College Park, MD 20742-8225, USA

DIS appoints a Focus 2 Leader

By Gérard Szejwach

It has been long recognised that Focus 2 activities (Data Management and Dissemination) have suffered from the lack of a leader. One of my first tasks, with the full support of the DIS Chair, John Townshend, was to identify the best possible person for this task. It is with great expectations that I can now announce that Günter Schreier, supported by his national authorities is now in a position to accept the challenge to become the first DIS Focus-2 Leader. As it can be noted from his short résumé (below), Günter has the relevant qualifications and experience to support me and the Core Projects, as required, in the associated Data Management and Dissemination issues.

Günter Schreier (born 1958 in Düsseldorf, Germany) studied Geophysics at the University of Munich, focusing on geology, astrophysics and fully automated computerised magnetotelluric measurements for Antarctic research. He joined the German Aerospace Research Establishment in 1985 and developed the still operational Synthetic Aperture Radar (SAR) geocoding system (GEOS), integrating various cartographic and topographic data bases with ERS and Shuttle based radar imagery.

Günter Schreier became the co-ordinator for the Data and Information Management System (DIMS) at the German Remote Sensing Data Center (DFD) in 1992 and helped to develop the Intelligent Satellite Information System (ISIS). In this framework he is invited as observer to all EOSDIS data system reviews. Since 1993 he was project manager of the phases A/B of the German Processing and Archiving Center for ENVISAT (D-PAC). Since 1987 he is active in various CEOS (Committee on Earth Observation Satellites) groups and chaired the "Auxiliary Data Subgroup" from 1991 to 1996. He initiated the CEOS GLOBE (Global Land One Kilometre Elevation) Project and acted as expert for global data sets and information systems in several review boards. Since the middle of this year he is chairman of the CEOS Subgroup on Data.

Günter has conducted several international studies for data management, information and archive systems for ESA and the European Commission. He was invited by the European Commission to define the general concept for the EUs Centre for Earth Observation (CEO) and in particular the information systems, the Enabling Services. He worked at the Joint Research Center in Ispra, Italy from late 1994 to early 1996. Since July this year Günter is Unit head at the German Remote Sensing Data Center responsible for general strategy, international relations and relation to industry.

Gérard Szejwach, IGBP-DIS Office, IGBP-DIS/CNRM, 42 avenue Gustave Coriolis, 31057 Toulouse Cedex, France.

Günter Schreier

The IGBP-DIS/CEOS Pilot Project on High Resolution Satellite Data

by David Skole

In conjunction with the Committee on Earth Observation Satellites (CEOS), the international forum of space agencies, the IGBP-DIS created the High Resolution Data Exchange Pilot Project as an effort to facilitate the distribution of high resolution remote sensing data to the global change research community. The project is testing the newly annunciated CEOS principles on data availability, which state that it is essential that all users engaged in global change research be provided with non-discriminatory access to satellite data, a goal which should be achieved within the framework of the exchange and sharing mechanisms set up by CEOS members.

The project is a collaboration of several space agencies, including NASA (for Landsat data provision), CNES (for Spot data), NASDA (for JERS and MOS data), Swedish Space Board (for Spot Data), ISRO (for IRS data), and ESA (for ERS-1 data) and five IGBP Programme Elements. The IGBP Programme Elements, including LUCC, GCTE, IGAC, START, and BAHC have been using a wide range of high resolution satellite data to support their research projects around the globe. DIS has been acting as the central co-ordinator for the project. Data are provided to the Core Projects for the marginal cost of reproducing them, who then incorporate the data into their research; this also tests the data access principles of CEOS. In turn, the Programme Elements explore the inter-use of several types of high resolution data in order to refine the scientific and technical utility of multi-sensor applications of satellite data to a range of research topics and field conditions. Such work is of vital importance as the global change research community develops techniques for multi-sensor global acquisition models.

In the case of START's involvement, the project is also testing ways to access and distribute satellite data as part of the South-east Asian region's (SARCS) capacity building efforts. Four teams studying land use and cover change in Thailand, Indonesia, Malaysia, and the Philippines are being provided with Landsat and Spot data to support their research and training activities.

In the longer term, this project will provide the basis for more operational global-scale acquisition of remote sensing data for monitoring land use and cover change, terrestrial ecosystem dynamics, atmospheric chemistry and water balance studies. This project is a foundation for large-scale data acquisition for global change research, national resource management, and international policy. With the emerging recognition in both scientific and policy circles of the necessity of having high spatial resolution analysis for many applications, this project is laying the important groundwork for the future. Over the course of the next decade the IGBP research community will be routinely acquiring and analysing thousands of high resolution satellite scenes for such applications as global land cover change assessments or verification of international agreements on greenhouse gas emissions.

David L. Skole, Complex Systems Research Center, Institute for the Study of Earth, Oceans and Space, University of New Hampshire, Morse Hall, 39 College Road, Durham, NH 03824, USA.

IGBP-DIS Prototype Global Metadata System

by William Salas

As part of the IGBP-DIS/CEOS Pilot Project on High Resolution Data Exchange, IGBP-DIS has developed a prototype global metadata system. The purpose of this system is to provide "one stop shopping" for querying centralised metadata listings of the high resolution satellite data. Existing metadata systems for high resolution data tend to only focus on a single sensor or platform (*e.g.* NASDA has their SINFONIA system for MOS-1 and JERS-1 platforms, SPOT Image has DALI/DIVA for Spot data, and EROS Data Center has GLIS for Landsat data) and not multiple sensors or multiple archives. However, this prototype system enables IGBP researchers to determine what data is available for their research site and will facilitate identification and development of high resolution data sets for regional to global scale research.

This global metadata system is a tool to graphically search on-line metadata libraries. These libraries are available for exploration and contain global coverage from Landsat, SPOT, MOS-1, JERS-1, and the India Remote Sensing (IRS) satellite. The global library contains the metadata for all US Landsat holdings (over 790,000 MSS and 200,000 TM scenes), as well as holdings from all foreign Landsat ground stations that report to the Landsat Ground Station Operators Working Group (approximately an additional 700,000 MSS and 500,000 TM scenes). In addition, the library contains metadata for three Landsat receiving stations that have not reported to LGSOWG: Thailand, Ecuador and India. The global library also contains metadata for MOS-1 MESSR and IRS-1A and IRS-1B data acquired in Southeast Asia, and SPOT XS and PAN data acquired globally. These metadata listing form a comprehensive and centralised metadata library that is extremely useful to the global change researcher interested in using high resolution satellite data.

To search the metadata library with the query and browse tool, pull-down menus are used to define a query with constraints on geographic region, sensor, acquisition date, cloud cover, and/or a number of other image descriptors (*e.g.* data quality and satellite number). The query search results are displayed graphically as rectangular polygons outlining the geographical extent or footprint of the images that meet the constraints of the query. Details of the metadata for each polygon can then be retrieved by point and click interrogation. This prototype system was developed within a GIS framework so that other ancillary data layers can be displayed simultaneously with the search results. These ancillary data layers include political borders, regional coastlines, rivers, vegetation maps, roads, and towns. The results from the queries can be saved either as tabular data or as a graphic (see figure to the right for an example of a graphic displaying search results for the Landsat TM, Spot PAN, MOS-1 MESSR, and IRS-1B LISS I data for the Southeast Asian region).

William A. Salas, Complex Systems Research Center Institute for the Study of Earth, Oceans and Space University of New Hampshire Durham, NH 03824, USA

HIMS: The High Resolution Image Information Management System

by Jean-Paul Malingreau and Etienne Bartholomé

The use of earth observation technology is rapidly expanding under the impetus of large scale application and scientific programmes. Many research activities are faced with a permanent problem of access to information about remote sensing data availability. In the case of a series of IGBP related projects for example, there is a need for accessing a sample of high resolution data which can assist in the validation of the ecosystem analysis derived from low resolution data at global scale. In the TREES Project of the European Commission over Tropical forests, there is a need for acquiring a sample of high resolution data at the pan-tropical level in order to calibrate the low resolution global analyses and to measure deforestation in often finely fragmented forest landscapes.

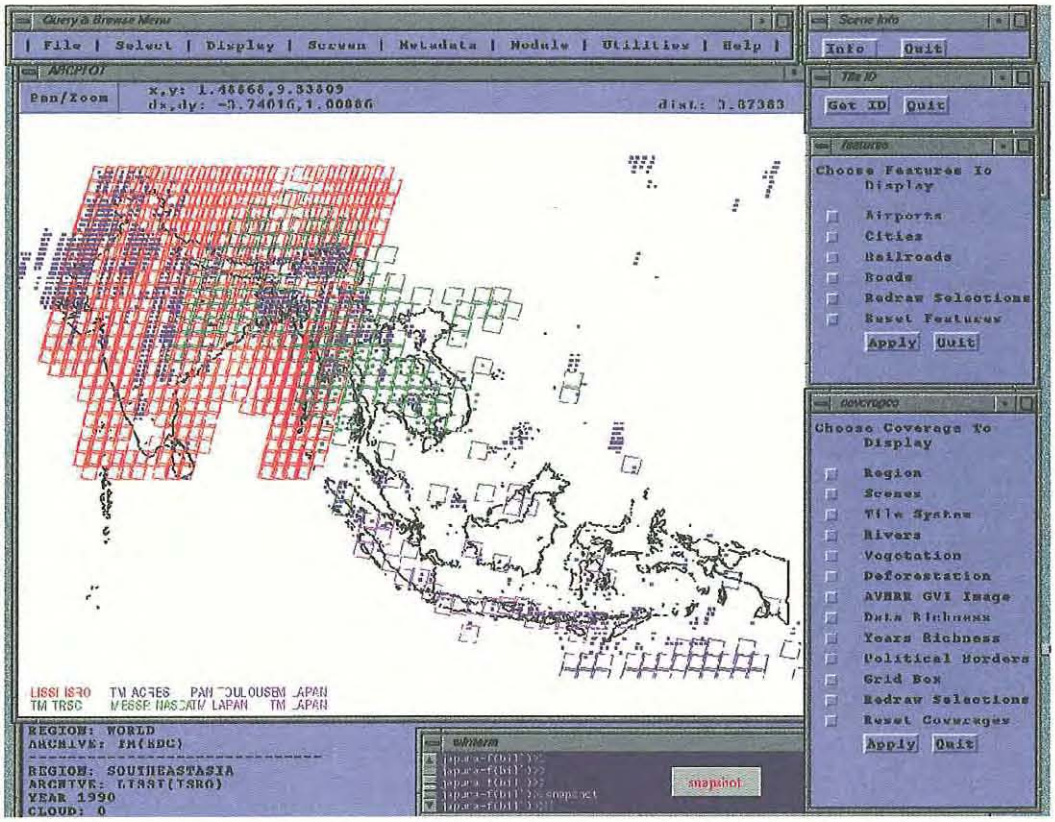
No cataloguing system today provides complete information on all high resolution acquisitions by existing remote sensing instruments. As a result, answering such a simple question as "Are there any high resolution images over my area of interest?" quickly turns out to become a long, complex and *per force* incomplete catalogue interrogation procedure. To improve upon this situation, a "one-stop shopping" concept was developed and gave rise to the HIMS (High Resolution Image Information Management System) product. It is based on a set of External Data Base Module Interfaces (EDMI) that interrogate automatically the selected data bases with a preset frequency (usually every day). Nothing else is required than access permission to these databases. A local metadata catalogue is thus constantly maintained; it is this catalogue which is interrogated by the user with a standard WWW browser. Our local database is maintained in an "off the shelf" GMS software on top of ORACLE, so that results of geographical queries can be displayed in a graphic manner.

More information can be found at URL http://wwwmtv.jrc.it/projects/hims/hims.html

A demonstration database of 5 years (1990-95) of satellite image acquisition over Africa, including SPOT, Landsat, RESURS, ERS, JERS and MOS, is also accessible.

The system is currently in a debugging phase. From September on, it will be made fully accessible to a selection of external users for evaluation. A first version of the HIMS system could then be transferred to other institutions after this phase.

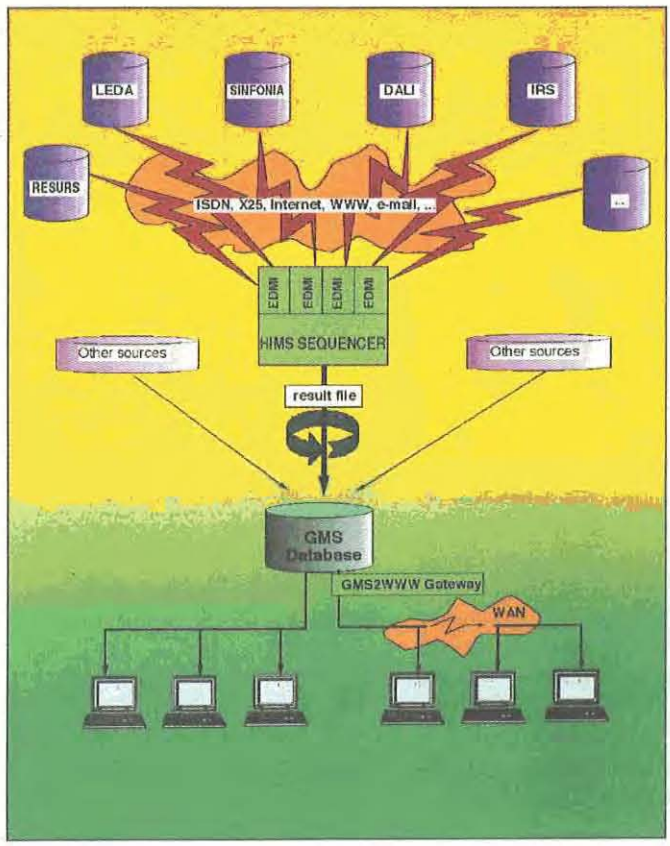
Jean-Paul Malingreau and Etienne Bartholomé, Space Applications Institute, Monitoring of Tropical Vegetation, Joint Research Centre of the Commission of European Communities, Building 44, I-21020 Ispra, Varese, Italy.



B. Saha

Search results for the Landsat TM, Spot PAN, MOS-1 MESSR, and IRS-1B LISS I data for the Southeast Asian region

Flowchart showing the principle of the HIMS system



E. Bartholomé

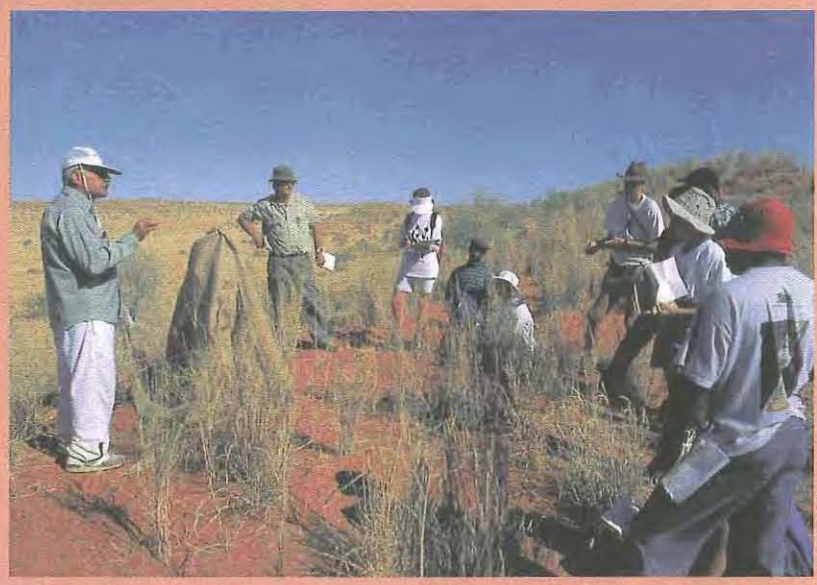
The DIS Contribution to the IGBP Transect Programme

by Chris Justice and Bob Scholes

The IGBP Transects will provide a focus for inter-Core Project research providing new data for process studies, model paramaterisation and validation of satellite derived global data sets (IGBP Report No. 36). IGBP Transects have been identified for all latitudinal belts and are in various stages of development. They also offer a unique opportunity for regional scientists to become actively involved in IGBP. To this end, partnership with the START program is fundamental to the success of the transect program. Effective data and information management systems associated with the transects will also be fundamental to their success. The research design for the transects consists of intensive process studies, extensive networks of observational studies, measurements and associated algorithms for regional scaling studies, remote sensing and modelling. Diverse types of data will be collected to address biogeochemical, ecosystem, hydrologic, atmospheric and land-use questions.

Measurements will be made by national and international scientists at different sites along the transects over several years. Plans for adequate documentation, archiving and open distribution of these data need to be addressed early in the transect design. Standards and guidelines for measurements need to be developed that will enable data intercomparison and synthesis within and between transects but will minimise the burden on the field scientist. It is unrealistic to insist that uniform procedures be applied across the range of ecosystems within and between transects, however adequate calibration of different field measurement techniques must be undertaken if quantitative comparisons are to be made.

Remotely sensed data will need to be acquired systematically for the transects at low and high spatial resolutions. Open access to these data for IGBP scientists is essential. Attention will also need to be given to spatial data standards and management. For example, the proliferation of geographic information systems and their incompatibility poses particular challenges for managing cartographic data from the transects.



R. Scholes/D. Parsons

Hal Mooney (GCTE) and Detlef Schulze (BAHC) teaching South African students about the use of deuterium for determining rooting depth in the southern Kalahari

IGBP is currently playing an important role in providing a forum for co-ordination of individual and national research programmes. Coordination of field data collection is taking place as part of the current test site co-ordination. Where possible, IGBP-DIS will facilitate this co-ordination. For example, considerable discussion occurred at the IGBP Congress concerning the co-ordination of flux tower eddy correlation measurements, transect development and data management.

The research community has gained some experience in the design of data systems to support intensive field programmes. For example the intensive field campaigns of the International Satellite Land Surface Climatology Program (ISLSCP), such as FIFE, HAPEX and BOREAS have provided a test-bed for the packaging, archive and distribution of various data types (Sellers *et al.* 1992, Justice *et al.* 1995). The NASA Landsat Global Land Cover Test Site initiative is similarly providing a pathfinding activity for the distribution of multi-resolution satellite data, generating a CD-ROM series for a number of global test sites. The CD-ROM approach to data publishing and archiving has proven a useful means to deliver data to a large number of scientists.

The role of IGBP-DIS will be to help in the design of the data management system for the transects and facilitate their implementation. Attention will need to be given to the design of the transect data system. Data collection, archiving and distribution all need to be addressed. One sensitive but high priority issue is the period of exclusive rights to data and application of data policy to ensure the wider distribution of the data.

As a first step towards transect data management, IGBP-DIS in close co-operation with LUCC and START are currently planning a pilot activity associated with transect data. This small pilot activity involving a number of core projects will develop and test some of the approaches for transect data management. The first stage of this activity will be to prototype a CD-ROM of existing multi-scale data sets. The overlapping southern African Kalahari and Miombo transects have been identified for this activity. The regional data set will need to include spatial data bases of existing geophysical and socio-economic data as well as remotely sensed data and point data. This activity will be initiated in 1996 and a design team is currently being assembled for this task. In addition IGBP-DIS will attempt to secure comprehensive high resolution satellite data for the IGBP Transects through an extension of the current high resolution data initiative.

Chris Justice, University of Maryland, Global Inventory Monitoring and Modelling Studies, Code 923, Goddard Space Flight Center, NASA, Greenbelt, MD 20771, USA.

Bob Scholes, Commonwealth Scientific and Industrial Research, Division of Forest Science and Technology, PO Box 395, Pretoria 0001, South Africa.

Data Policy for the IGBP

by John Townshend

Data policy has become an increasingly important topic for the IGBP as more of its Core Projects and Framework Activities move from planning to implementation stages. As a programme of the International Council of Scientific Unions (ICSU) various principles and guidelines already apply implicitly to the IGBP.

Since the International Geophysical Year (1957/58), ICSU has maintained a World Data Center (WDC) system, which serves to collect, store, process as appropriate, and redistribute data. ICSU lays down responsibilities on its constituent programs to ensure the free and open international exchange of data: in summary these are as follows.

ICSU programmes shall include data management plans that provide details on which data, and in which formats, shall be submitted by participants to the WDCs so that all data may be shared not only by participants but by all scientists.

It is implicit in the agreements by adhering bodies to the ICSU that national participation in an ICSU programme includes the agreement to submit data according to the data management plan.

In 1990, in accordance with established ICSU policies on open and unrestricted data and information exchange, data policies were proposed for IGBP-DIS. These include the statements:

> *"The IGBP places high priority on establishment, maintenance, validation, description, accessibility, and distribution of high-quality, long-term global data sets, including the synthesis or generation of new global data sets,"* and, *"Full and open sharing of the full suite of global data sets, and other data sets needed for global change studies, is the primary objective of the IGBP-DIS"* (IGBP Report No. 12).

Relying on the ICSU and WDC principles the following more detailed data policy principles were proposed and accepted at the IGBP's Scientific Committee Meeting in Australia in December 1994.

i) The IGBP requires an early and continuing commitment to the establishment, maintenance, validation, description, accessibility, and distribution of high-quality, long-term data sets.

ii) Full and open sharing of the full suite of global data sets for all global change researchers is a fundamental objective.

iii) Preservation of all data needed for long-term global change research is required. For each and every global change data parameter, there should be at least one explicitly designated archive. Procedures and criteria for setting priorities for data acquisition, retention, and purging should be developed by participating agencies, both nationally and internationally. A clearing-house process should be established to prevent the purging and loss of important data sets.

iv) Data archives must include easily accessible information about the data holdings, including quality assessments, supporting ancillary information, and guidance and aids for locating and obtaining the data.

v) International and where appropriate suitable national standards should be used to the greatest extent possible for media and for processing and communication of global data sets.

vi) Data should be provided at the lowest possible cost to global change researchers in the interest of full and open access to data. This cost should, as a first principle, be no more than the marginal cost of filling a specific user request. Agencies should act to streamline administrative arrangements for exchanging data among researchers.

vii) For those programmes in which selected principal investigators have initial periods of exclusive data use, data should be made openly available as soon as they become widely useful. In each case the funding agency should explicitly define the duration of any exclusive use period.

IGBP needs to adhere to principles of open access to data sets and availability at low cost, because it is part of ICSU and because if it inhibits the availability of its own data, this could seriously undermine the arguments used to obtain data at lower than normal costs from others.

Data sets falling under the above principles will likely include a wide variety of products including field data, processed remotely sensed data and model outputs. This places major responsibilities on IGBP scientists in terms of making data sets accessible.

The IGBP with the assistance of DIS is considering the following issues in assessing the full implications of these policies:

i) How will Core Projects decide which data sets will be made available and in what form they will be distributed?

ii) What are the cost implications of making data available? It would be prohibitively costly for any Core Project or Framework Activity to make literally all of its data available.

iii) What mechanisms will be used to ensure adequate data distribution?

iv) How will long term archiving be achieved? This includes not merely technical issues but also those concerned with how responsibility is assumed and maintained.

v) What will be the relative roles of IGBP-DIS and the Core Projects in these activities?

vi) What other agencies/organisations might be involved to take on some of these responsibilities (*e.g.* World Data Center System, WMO Data Centre System etc.).

vii) What are the responsibilities of IGBP with respect to data supplied by others which have usage or copyright restrictions?

viii) There may be significant problems associated with IGBP projects and activities using data whose distribution may be restricted by copyright: specifically to what extent can IGBP carry out its scientific programme if it has to rely on data, which can not be freely distributed to substantiate the scientific conclusions?

ix) What should be the privileges of IGBP scientists and programmes with respect to any periods of exclusive use for data collected in the name of IGBP?

x) What will be the process by which we obtain agreement from the IGBP community that they agree to and will adhere to these principles and policy?

In DIS we have been taking steps to address these questions, but clearly it will be a long-standing responsibility of IGBP-DIS to make sure that the IGBP's data policy principles are implemented. Currently IGBP-DIS is conducting an analysis of IGBP's activities to assess the implications of these data policies.

John Townshend, Department of Geography, University of Maryland, Lefrak Hall, room 1113, College Park, MD 20742-8225, USA

The IGBP-DIS Web site

by Martine Michou

The IGBP-DIS Office in Toulouse, France, maintains a World Wide Web site for the IGBP-DIS activities (URL http://www.meteo.fr/cnrm/igbp/). This site has the ambition to centralise up-to-date information on all IGBP-DIS activities, including meeting reports, pointers to IGBP-DIS data sets, and a number of graphics/image/text material.

Timeliness and completeness of the DIS Web site information rely, obviously, largely on the contribution from IGBP scientists. Collaboration between the DIS Office and scientists for additions and updates to information are not only most welcome, they are essential to ensure the success of this Web site for the benefit of the IGBP community as a whole (contact martine.michou@igbp.cnrm.meteo.fr).

Links to the other IGBP Web pages are ensured through the link to the IGBP Secretariat Web page in Stockholm. The DIS Web site also provides access to sites of high priority for the IGBP activities, such as the WCRP site, and allows users to add links in an automated way.

A "mirror" of the DIS Web site will be established in September at the National Geophysical Data Center in Boulder (USA) to facilitate and speed up access to information to the US scientists. Hard-copies of the DIS Web site content can be mailed out upon request to those who do not have electronic access to the Web.

Martine Michou, IGBP-DIS Office, IGBP-DIS/CNRM, 42 avenue Gustave Coriolis, 31057 Toulouse Cedex, France.

Focus 3 activities: Data Coordination in an International Context: The link with CEOS

by Gérard Szejwach

IGBP is an Affiliate Member of CEOS (Committee on Earth Observation Satellite). Of significant importance, it should be noted that, at the 9th CEOS Plenary, held in Montreal on October 13-15, 1995, it was decided to merge the two Working Groups (Working Group on Data and Working Group on International Directory Network) into a new Working Group on Information Systems and Services (WGISS). The Plenary appointed Helen Wood of NOAA/NESDIS to serve as a WGISS Chair, Hiroshi Kikuchi of STA/NASDA to serve as WGISS Vice Chair and Gérard Szejwach (at the time transiting from EUMETSAT to IGBP-DIS) to serve as a Vice Chair charged to facilitate interaction with users. The overall objective of WGISS as stated in the Terms of Reference is "*to facilitate data and information management and services for users and data providers in dealing with global, regional and local issues*".

The inaugural meeting of WGISS was held on November 13-16, 1995, in Moscow and was hosted by Roshydromet and the Russian Space Agency. The major part of the meeting was devoted to the future of WGISS including a Five Year Plan to be presented, for approval, at the next CEOS plenary meeting in November 1996. The second WGISS meeting took place at the Earth Observation Research Center in Tokyo on May 27-29, 1996. WGISS-2 approved Version 1.0 of the Five Year Plan. The Plan identifies six broad areas of work for WGISS: user consultation, data and information management, user services, data standards, CEOS information services, and promotion. To organise its tasks, WGISS decided to establish three subgroups: an Access Subgroup, a Data Subgroup (Chair is Günter Schreier of DARA/DLR who was just appointed IGBP-DIS Focus-2 leader), and a Network Subgroup. WGISS also established a User Panel, to help ensure that WGISS activities are suitably user-driven and meet user needs. It was decided that the User Panel would be led by Gérard Szejwach. The next WGISS meeting will be held on October 8-10, 1996, at the DLR facilities in Neustrelitz, Germany.

It should be noted that the next CEOS Plenary meeting, to be held in Canberra on November 13-15, 1996 should also review a Dossier containing Satellite Users requirements. IGBP was invited to contribute to the preparation of the Dossier (the former DIS Director, Ichtiaque Rasool, was the co-chairman of the Working Group in charge of preparing the dossier).

A summary report of the 9th CEOS Plenary in Canada is published in the CEOS Newsletter #6. All Scientists involved in IGBP projects and interested in discussing, or receiving additional information on CEOS and WGISS related activities are invited to contact the DIS Office.

Gérard Szejwach, IGBP-DIS Office, IGBP-DIS/CNRM, 42 avenue Gustave Coriolis, 31057 Toulouse Cedex, France.

Intelligence Satellite Photos Released

More than 300,000 satellite photographs collected by the U.S. intelligence community between 1960 and 1972 are now available from the U.S. Geological Survey (USGS). The Internet allows a browse through the entire collection on the World Wide Web (URL: http://edcwww.cr.usgs.gov/dclass/dclass.html). This collection adds more than a decade worth of records to the Landsat collection that has been available for civilian use since July 1972. One can compare images from the 1960's with today's images to see how our built environment and our natural systems such as lakes, rivers and streams, forests, grasslands, and other land cover have changed. The images do not only cover the United States but also much of the world.

The entire collection of more than 800,000 declassified photos is slated to incrementally reach USGS archives by the end of the summer of 1996. An online catalogue and image browse capability for the photo collection is accessible, at no charge, on the Internet through the U.S. Geological Survey's Global Land Information System (GLIS). For more information about Declassified Intelligence Satellite Photographs (DISP) and how to use the online GLIS catalogue for data searching refer to the World Wide Web DISP user guide at: URL: http://edcwww.cr.usgs.gov/glis/hyper/guide/disp

For technical information on Declassified Intelligence Satellite Photographs contact: U.S. Geological Survey, EROS Data Center, Customer Services, Sioux Falls, SD 57198, USA. Fax: (+1-605) 594 6589, E-mail: custserv@edcmail.cr.usgs.gov

The ICSU World Data Center System:

Current Status in the 40th Anniversary Year and Prospects for the Future

by Stan Ruttenberg, Treasurer and former Chairman of the ICSU Panel of the World Data Center System

A Little History

It was at their Brussels meeting in September 1955, that the ICSU Special Committee for the International Geophysical Year adopted a resolution calling for establishment of World Data Centers to house the IGY data for use by future generations of scientists. The young Turks of data, Alan Shapley and W.J.G. Beynon urged that the traditional ways of getting data would not suffice; the modern geosciences would not be well served by relying on the "old boy" network, or on published station and expedition reports with no fixed formats and no agreed-upon timetables. They also proposed a far-reaching characteristic, that data should be submitted insofar as possible in machine readable form, or at least suitable for handling by machine.

The USA National Academy of Sciences offered to establish a full set of centres, which were designated as WDC-A. The Soviet Academy of Sciences offered the same, (WDC-B) and several countries in Europe, along with Japan and Australia, offered to establish separate discipline centres (WDC-C).

The ICSU-WDC-system operated under very simple and straightforward principles:

- data would be available at no more than the cost of copying them to any "*bonafide*" scientist;
- data would be exchanged between related WDCS so as to ensure duplication of data holdings as a guard against catastrophic loss;
- any scientist could visit a data centre and use the data; and catalogues would be published.

In addition, depending on resources, data centres would help scientists find data not held in the WDC System. For the Years of the Quiet Sun (IQSY) period, the ICSU Committee on Geophysics (CIG) oversaw the operations of the WDC System. When IQSY wound down, ICSU created a Panel on the World Data Centers to continue to provide oversight and guidance and to report back to ICSU on geophysical data matters.

The system served the IGY data collection so well that ICSU agreed that the WDC-system should continue to exist after IGY and continue to collect data from regular monitoring networks, as well as from new special data-intensive programs spawned by IGY, *e.g.*, IQSY, the Upper Mantle Project which continued as the Crustal Dynamics Project, the International Magnetic Survey, the Middle Atmosphere Programme, the Solar-Terrestrial Energy Programme, the World Climate Research Programme (WCRP) and the International Geosphere-Biosphere Programme (IGBP).

Changes in the WDC-system

During the time alluded to above, geophysics evolved considerably from IGY, as well as the WDC-system. Some IGY disciplines were coalesced into Solar-terrestrial Physics, and WDCS were also combined to form new Solar-terrestrial Physics Data Centres. New disciplines were added, such as marine geology and geophysics, and crustal movements. For the discipline of meteorology, the WMO Members developed a series of data centres to handle various specialised data as well as the regular daily weather observations. Technologically, the era of paper, film and other analogue records began to be superseded by magnetic tape recording of analogue data and then by the prevalent use of digital data recording and storage.

Status of the WDC-system pre-IGBP

As the IGBP began to be organised in 1986, the WDC System comprised some 40 data centres. These data centres are voluntary, in the sense that countries establish and operate them with their own funds. The underlying thought to this is that they not only benefit the national research community but are of broader use by the entire international community. The various centres are operated within the constraints of national resources — fiscal, technical and human. As geophysical data projects grew, and the need for international geophysical data increased, the WDCS came under increasing pressures in times of level or even decreasing budgets. Fortunately, new technical advance helped the WDCS to maintain their data collection and distribution activities even under these pressures.

Present Status and Events

New WDCS for the IGBP. IGBP provided an urgent impetus to enlarge the WDC Data Center System, to serve many IGBP Core Projects falling outside the historical disciplines stemming from IGY. Much of this enlargement stemmed from strong research interests in WDC-A, but other centres are also gradually broadening their coverage to help serve IGBP research. Below is a very brief synopsis of these new centres. Additional information is available in the ICSU Guide to the World Data Center System (hard copy can be obtained from the author or on-line, see below).

Soil Information. Soil classification maps have long been used in agricultural work and also in some aspects of environmental engineering. The International Soil Science Society provides some guidance for an International Soil Reference and Information Center (ISRIC) at Wageningen, the Netherlands. ISRIC proposed in 1989 to be the first new members of the WDC System to meet IGBP needs, The WDC-C for soils is collaborating with soil scientists in IGBP, and with interested scientists in WDC-A to develop new parametrisations of soil characteristics for use in environmental models in which soils are part of the transfer of mass and energy via the biosphere between the earth's surface and the atmosphere.

Paleoclimate. The IGBP paleoclimate core projects define specific needs, within the much broader time spans of paleoclimate research, for data sets to address questions of climatic variability in the past few thousand years, and in the broader scale since the last glaciation. WDC-A for Paleoclimate, Boulder, Colorado, USA, operated by the

National Geophysical Data Center of NOAA, is well integrated into the IGBP paleoclimate research programs, and has taken the lead to collect, collate and publish many data sets needed for IGBP research.

Carbon Dioxide. Greenhouses gases, their role in climatic changes, and the role of humans in changing the atmospheric concentration of these gases, are a central part of IGBP studies. The IGBP atmospheric chemistry projects are broader than this, but for the moment there is no one centre that covers all the IGBP needs. However, the WDC-A for Atmospheric Trace Gases, operated by the Carbon Dioxide Information and Analysis Center (CDIAC), at the US Department of Energy's Oakridge National Laboratory, has a well-established procedure for producing well documented and quality-assessed data sets on trace gases. CDIAC collects data each year and produces annually a comprehensive review of research work. This document, Trends, is given broad international free circulation.

Remote Sensing Earth's Surface. The US Department of Interior's US Geological Service established a major data handling, processing and research centre at Sioux Falls, South Dakota, USA, for data from the US Landsat satellite program. This laboratory, the EROS (Earth Resources Observing Satellite) Data Center operates training programs for third world scientists (in collaboration with UN), and houses a major collection of satellite and aero data. For IGBP the WDC-A Land Remote Sensing group is collecting daily data from the 1-km land observing sensors on USA meteorological satellites, applying some corrections for calibration changes and some atmospheric effects, and derives the so-called Vegetation Index, and maps these data to produce digital global maps of the vegetation cover over most of the earth's land masses. The data are processed to be available on sets of CDs for research. These data also provide a useful time-history of how vegetation changes seasonally and inter-annually. There are some data which go back to the early 1970s, and some of these data are processed to provide a coarser vegetation cover index, but with many gaps in time and space. The full history of this project and its initiation cannot be related here, but this is one case where the IGBP-DIS and the WDC-system were somewhat ahead of the research community, in that the global 1-km project was initiated on the basis that the data community (which also include many scientists interested in using the data) could not wait until the research community had made up its mind that such a data set would be useful. Waiting would have virtually made it impossible to recover past data from older sensors and from recent improved satellite sensors and a valuable segment of the time history would have been lost.

Human Dimensions. Early in the history of IGBP, the role of human activity was considered to be an important factor in climate change. However, ICSU had no bodies dealing with the social and economic human side, and the various geophysical centres had very little data on human activities associated with geophysical changes. Thus a joint Human Dimensions of Global Change program was established through collaboration with the International Social Science Council, a counterpart to ICSU . The USA-based Consortium for International Earth Sciences Information Networks (CIESIN) had begun pilot experiments linking data activities internationally among centres which studied various human activities. In 1995, the WDC-A for Human Interactions, operated by CIESIN, was incorporated into the WDC System. This centre not only represents a new dimension to ICSU data centres but also represents a different WDC concept. WDC-A Human Interactions is a virtual data centre; it is computer-linked through international data circuits to many computers and data collections. Only a small amount of data is actually held at CIESIN itself, but it acts as the nerve and communications centre for this system. A user does not need to know where a specific data set is held, only what it is; the network will find the data set needed and deliver it to the user.

Gaps. Even during IGY itself, there was no centre for hydrological data, nor was there a centre for the broad range of atmospheric chemistry problems. These are still gaps in the ICSU WDC System. However, the data centre system operated by the national meteorological services and co-ordinated through the World Meteorological Organisation (WMO) of the UN, a number of data centres do collect and archive hydrological data and some atmospheric chemistry data. The terms of access are not the same as for the ICSU centres but at least the data are in principle available.

The most significant gap in the ICSU WDC System at present is for biospheric data. While a few centres do collect some data (*e.g.*, the global Vegetation Index Project of WDC-A Remote Sensing of the Land Surface provides one valuable biospheric data set; WDC-A Solid Earth Geophysics compiles a global ecological data set aimed for use in models), there are vast areas of data needed for GCTE and other core projects that are not routinely archived, nor is there yet a mechanism for archiving data from GTOS. The WDC Panel is actively discussing with some interested groups the possibility of establishing, in a pilot way, an ecological or biosphere data centre, and this is a matter that the IGBP community also ought to be pursuing.

All-WDC Conference, Wageningen

While the WDC System was organised during the IGY, and the first meeting to write a Guide took place in April 1957, there has not been since then a meeting of all the geophysical disciplines represented nor of the directors of all the centres. The first such meeting took place in early October 1995 through the collaboration of WDC-C Soils, and the International Agricultural Centre, Wageningen, The Netherlands. Most of the 44 WDCS were represented, along with many other data experts and representatives of major international programmes requiring geophysical and environmental data. The data needs of IGBP, for example, were discussed at Wageningen, along with its sister program the World Climate Research Program (WCRP).

One major result of the Wageningen Conference was agreement on the publication of the new Guide to the WDC System. This is now in press and hard copies will be available soon, as well as being accessible on the WWW.

A second major result was the establishment of WDC Home Pages and List Server. The home pages of individual WDCS in USA, Russia, Europe, Japan and China are linked through the following home pages:

http://www.ngdc.noaa.gov/wdc/wdcmain.html, or http://www.wdc.rl.ac.uk

The list server was created to discuss issues of mutual concern. It is accessible at: wdc_org@ngdc.noaa.gov

Future Prospects

New Officers of Panel. The ICSU Panel was re-organised at the start of 1996, with Professor Ferris Webster, School of Oceanography, University of Delaware, USA, taking over from Stan Ruttenberg, as Chairman, and Dr Anne Linn, US National Academy of Sciences, Committee on Geophysical and Environmental Data, taking over as Secretary from Henry Rishbeth. Their e-mail addresses, respectively are: ferris@udel.edu and alinn@nas.edu

Networking and Virtual Centers. As data sets become more and more interdisciplinary, more networking will be required to find data needed by researchers. This will lead to a slow evolution away from strictly discipline-oriented data centres to broader referral centres, or in some cases, virtual

centres. We are all looking closely at the CIESIN Human Interactions Data Center as a possible role model for such evolution.

WDCs in Developing Countries. The CIESIN virtual centre has many nodes in small and developing countries. As more centres adopt this mode of operation we can foresee that groups in such countries will become more closely tied to their counterparts elsewhere. It has long been the hope of this author that the IGBP/START programme, with its many regional and national nodes, would eventually become affiliated with the WDC System. The possibility is there if these groups have the desire to do so!

Conclusion

In its way, IGBP is akin, in a new age of knowledge as well as technological capability, to the IGY — an entirely new way of looking at the physical world with the significant addition of its living components. We have an opportunity ahead of us, and the scientific driver also, to be innovative and experimental in data management to support those colleagues who do research on parts of the geo-biosphere and those who try to integrate these parts through models.

The ICSU Panel on World Data Centres stands ready to collaborate in detail with the IGBP core projects and individual scientists. The story of the development, of the Global 1-km Vegetation Index project, notwithstanding the early apathy and even opposition of some scientists, contains an object lesson: If we wait until we know for sure that we need a complex and global time-continuous data set, it may be too late, for many logistic and financial reasons. The community should be prepared to make best guesses of what is needed, so that the data community has the time to organise itself and get the resources to meet the need! By doing so, perhaps some small mistakes will be made, but large delays or even brick walls will be avoided!

Stan Ruttenberg, NGDC/NOAA, Code E/GC, 325 Broadway, Boulder, CO 80303, USA. E-mail: lsrutt@ngdc.noaa.gov

Workshop on Globally Gridded Historical Climate Data Sets for Biosphere Models

by Wolfgang Cramer

On May 22-24, 1996, a workshop was held at the Potsdam Institute for Climate Impact Research, Potsdam, Germany (PIK), to approach a solution of the long-standing issue of gridded climate data sets with sufficient spatial and temporal resolution to drive the current and future generations of terrestrial biosphere models in a transient mode. To the meeting, which was funded by the Electric Power Research Institute (EPRI, Palo Alto, California, USA) and sponsored scientifically by GCTE and GAIM, a small group had been convened representing several groups who are developing such data sets or suitable algorithms for such development (from the Climatic Research Unit at the University of East Anglia (UK), the Center of Resource and Environmental Studies at the Australian National University, the National Center for Atmospheric Research in Boulder (Colorado, USA), the Centre d'Etudes Spatiales de la Biosphère in Toulouse (France) and from PIK). In addition to these modelling and data teams, the IGBP-DIS office was also represented.

Starting point of the discussion were the data needs of the groups currently developing Dynamic Global Vegetation Models (DGVMs), which were represented by members of the VEMAP and ETEMA. It was noted that an essential difference exists between the requirements of previous data collection programs (which were often related to the needs of the climatological community, such as the detection of a 'greenhouse signal') and those of the terrestrial biosphere modellers (which focus more strongly on spatial pattern even in complex topography and physical consistency between variables, and are less concerned by globally averaged trends). After discussing these data needs and the potential to satisfy them from adaptations from existing data sets, the group developed a work plan including the following items: (i) updated collection of station time series from various sources, (ii) further development and application of gridding algorithms (based on the thin-plate spline approach by M. Hutchinson, CRES-ANU) for the primary variables mean temperature and total precipitation for the twentieth century, with monthly resolution at 0.5 degree longitude/latitude, (iii) development and application of methods to derive other climatic variables from these primary ones, such as humidity, cloudiness and others, (iv) adaptation of simple weather generator (*i.e.* monthly to daily) algorithms that are adequate for global terrestrial models and are based on parameters that can be derived from global data sets. The judgement of meeting participants was that these goals are achievable within the next few years.

Wolfgang Cramer, Potsdam Institute for Climate Impact Research, Telegrafenberg, P.O.Box 60 12 03, D-144 12 Potsdam, Germany

Further information on IGBP-DIS can be found in:

IGBP in Action: Work Plan 1994-1998 (1994). IGBP Report No. 28. Stockholm: IGBP, 151pp.
IGBP Global Modelling and Data Activities 1994-1998 (1994). IGBP Report No. 30. Stockholm: IGBP, 87pp.

Please direct your requests to:
Ms. Lisa Cronqvist, IGBP Secretariat, The Royal Swedish Academy of Sciences, Box 50005, S-104 05 Stockholm, Sweden. Fax: (+46-8) 16 64 05, E-mail: lisa@igbp.kva.se

Teaming up to meet IGBP Paleoenvironmental Data Needs

Jonathan Overpeck, Robert Webb, and David Anderson

The World Data Center-A (WDC-A) for Paleoclimatology was created in 1992 at the US National Geophysical Data Center (NOAA-NESDIS-NGDC) explicitly to serve the paleoenvironmental data needs of ICSU, and in particular IGBP-PAGES (Past Global Changes). A global revolution in "paleodata" sharing has taken place since that time, serving as a tribute to the influence of PAGES, the IGBP, and many dedicated paleoenvironmental scientists around the world. Consequently, we now have an effective, ever-expan-ding data foundation for paleoenvironmental research. This article highlights how the World Data Center System teamed up with the IGBP, and the international network of "paleo-scientists," to develop an effective standard in scien-ce-driven data management.

The scientific motivation for the WDC-A for Paleoclimatology, and its role as the data co-ordination centre for PAGES, was clearly set forth from the earliest days of PAGES planning led by H. Oeschger and J. Eddy. Paleodata are needed to understand the full range of natural environmental variability and its causes, to anticipate possible "surprise" behaviour in the climate system, to evaluate and improve predictive models, and to separate anthropogenically induced environmental changes from those forced by natural processes. Large spatial arrays of interdisciplinary data from a broad spectrum of biological (*e.g.*, trees, corals, fossils), geological (*e.g.*, sediments, cave deposits), cryospheric (*e.g.*, ice cores and glaciers) and human (*e.g.*, ancient documents) sources have to be integrated and made easily accessible to all. The WDC-PAGES partnership has thus served as a catalyst to bring the "paleo-perspective" to bear on an ever increasing number of critical global change issues.

Several aspects of WDC-A/PAGES data management history have been key to success. The co-location of the WDC-A at a major geophysical data centre (NGDC is home to five World Data Centers) provided invaluable infrastructure and advisory help. Following a major 1993 PAGES workshop, "Global Paleoenvironmental Data," numerous smaller workshops (15 so far) and advisory groups have served to develop data-specific protocols for quality control/documentation, strategies for encouraging data contributions, and ways to make the data users most satisfied. The PAGES Scientific Steering Committee, and participants in PAGES scientific activities, have also provided input necessary to ensure that WDC-A data management strategies best serve science objectives. A PAGES data management plan, compatible with the criteria developed by IGBP-DIS, the ICSU Panel on World Data Centres, and a PAGES community consensus, is set forth in PAGES Report 95-2 (soon to be available via the Internet).

The WDC-A for Paleoclimatology serves as the data *co-ordination* centre for PAGES, and as such, is much more than a data archive centre. A look at what is "co-ordinated" (Figure 1, top of page 29) highlights the broad partnerships behind the PAGES data management success. Nearly 1,000 individuals presently submit or request data from the WDC-A each month. This substantial load, coupled with the small size of the WDC-A staff (four data managers, a computer engineer and three part-time scientists), and the fact that original data sources range widely from packrat-urine cemented fossils, to complex geochemical measurements, and to model output (Table 1, below), necessitates a heavy reliance on allied data management efforts and technology. When a large body of data from a particular source has to be ingested, a "Data Cooperative" is established (usually at a university or other laboratory) to handle the job in co-ordination with the WDC-A. National and regional data centres also play an invaluable role in providing the co-ordinated data management needed for PAGES science, as do data co-ordination efforts allied with specific PAGES or other paleoenvironmental science activities. The WDC-A thus strives to make sure many disparate disciplinary data management efforts add up to an interdisciplinary sum that is greater than all the parts.

Data from nearly 10,000 sites around the world reside at the WDC-A, and this number grows weekly. To meet the needs of users around the world (approximately 100 countries so far), the WDC-A has adopted a multi-pronged approach. First, the Internet has been tapped to provide fast and inexpensive data access. Search engines, data browsing/access software tools and useful information are all available via FTP (ftp.ngdc.noaa.gov) and the WWW (http://www.ngdc.noaa.gov/paleo/paleo.html). Slow Internet links across the Atlantic have been circumvented via a transparent "mirror" site hosted by Médias-France. However, in recognition that many of the IGBP community are not blessed with satisfactory Internet access, data are also distributed on magnetic media (at the cost of reproduction or in exchange for data contributions). Plans include optical media in the future.

The range of data managed at the WDC-A for Paleoclimatology is extremely di-

Table 1. Some sources of paleoenvironmental data that are archived at the WDC-A for Paleoclimatology

- borehole measurements
- corals
- fluvial deposits
- fossil mammals
- glacial deposits
- historical documents
- lake level data
- loess
- molluscs
- ocean sediments
- packrat middens
- paleosols
- plant macrofossils
- tree-ring data
- cave and spring calcite
- eolian deposits
- fossil insects
- fossil pollen
- glacier mass balance
- ice cores
- lake/mire sediments
- long instrumental records
- noble gases in ground water
- other eolian deposits
- paleolimnological data
- periglacial features
- sea level variations
- treeline movement data

verse and interdisciplinary. Table 1 lists many of the prominent sources of information that can be tapped to understand past changes in the atmosphere, oceans, cryosphere and biosphere. An emphasis was originally placed on data particularly relevant to the two PAGES temporal streams (the last 2,000 years, and the last few glacial cycles), but the WDC-A also serves to coordinate data for all other periods of Earth history. Both the raw data and the data derived from these original observations are archived, so that users can not only get quantitative reconstructions of past climatic conditions, they also have access to the data on which the reconstructions were based. The hope is that new improved interpretative methods will be applied to the rich PAGES data legacy in years to come.

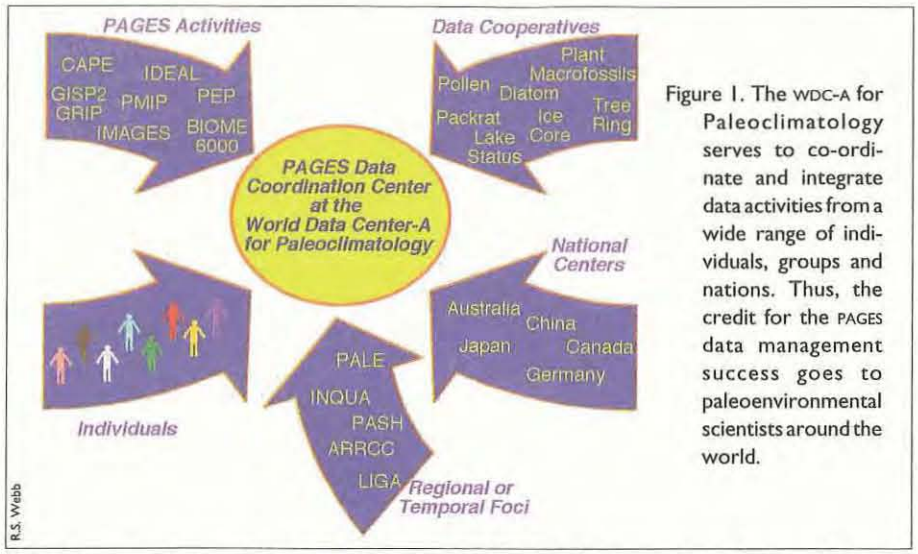


Figure 1. The WDC-A for Paleoclimatology serves to co-ordinate and integrate data activities from a wide range of individuals, groups and nations. Thus, the credit for the PAGES data management success goes to paleoenvironmental scientists around the world.

A key to PAGES data management success has been the community development of highly useful tools for data browsing, access and manipulation. Several data co-operatives have developed software tools widely used by their colleagues for specific types of data. The International Tree-Ring Data Bank (ITRDB), for example, has developed a suite of tools that serve as incentives for putting tree-ring data into a common format. Similarly, the development of the impressive global fossil pollen databases has been hastened by widely adopted tools provided by E. Grimm and J. Keltner. In order to provide easy browsing and access of all data types a WDC-A team led by W. Gross developed the PaleoVu tool (Figure 2, below). This GUI (graphical user interface) tool, available to run on most desktop personal computers (Mac or Windows), allows the user to search WDC-A holdings of time slice (*e.g.*, mapped paleoclimate or vegetation) or time series data, to plot the data for comparison with other maps/series, and then output the data in one of several convenient formats. User feedback goes into making these, as well as other tools distributed by the WDC-A, ever-better incentives to achieve greater participation and more numerous data contributions.

Another incentive that has been developed is the "IGBP PAGES/World Data Center-A for Paleoclimatology Data Contribution Series." This recently implemented data publication series gives contributors and data-users unique citations for datasets, which are often more complete or updated from those published in the scientific literature. Peer-review is effectively provided by the data contribution protocols set up for each type of data by experts in that area of the science. The data contribution series will help to make it precisely clear which datasets are used in future research efforts, and also ensure that contributors get credit for the use of their data. Finally, the contribution series elevates the status and usability of data significantly as the scientific research community moves to electronic publishing. In the future, hypertext links between papers and data will result in cross-referencing to future papers (linked in a two-way manner back to the data) as well as past papers, in essence providing data users with the most comprehensive data documentation possible.

Much of the overall success of the WDC-A/PAGES relationship can be attributed to the close partnership between scientists and data managers. The hope is that this partnership will serve as a model for other ICSU efforts to make data management more responsive to the needs of the scientists who ultimately collect and quality control the data. The partnership also serves to bring scientists from all parts of the world into the data and information sharing arena. Constant close interactions with the international science community will ensure that the success of the WDC-A/PAGES partnership continues to grow in the future.

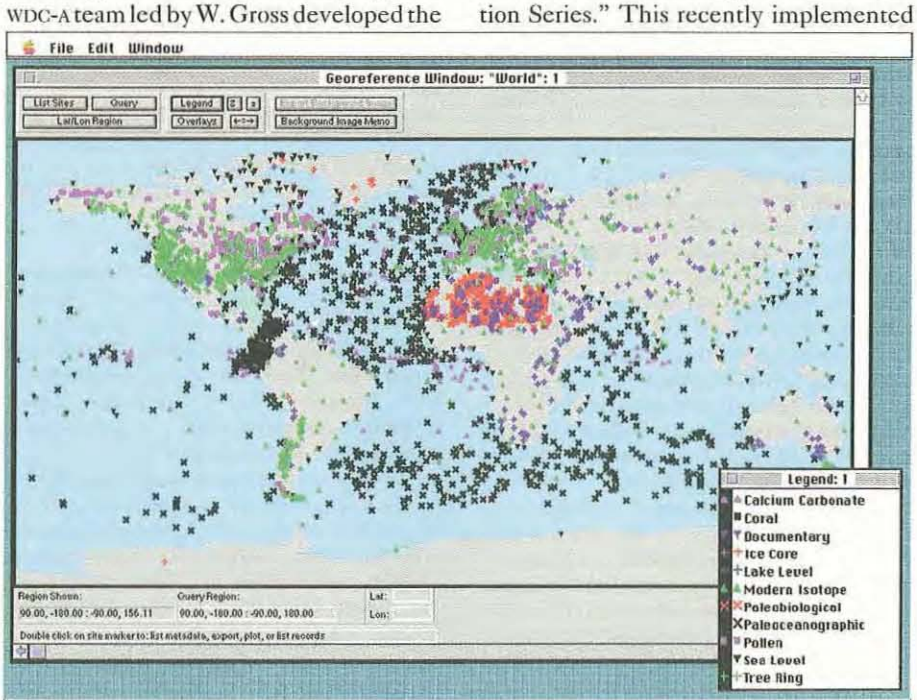


Figure 2. A range of software tools, including PaleoVu, are available from the WDC-A that make the browsing and accessing of paleoenvironmental data easy. The availability of tools and data over the Internet and by diskette ensures that no one is excluded from the world of PAGES data sharing.

Jonathan Overpeck, Robert Webb, and David Anderson, World Data Center-A for Paleoclimatology, NOAA National Geophysical Data Center, Boulder Colorado 80303 USA.

IGBP and Other Meetings

*Only meetings marked with * are open for all scientists to attend. All other meetings are by invitation only*

September, Firenze, Italy
GCTE Wheat Network Workshop.
John Ingram, GCTE Focus 3 Office, Center for Ecology and Hydrology, Maclean Building, Crowmarsh, Gifford, Wallingford OX10 8BB, UK. Fax: (+44-1491) 692 313, E-mail: j.ingram@ioh.ac.uk

September, Hawaii, USA
PAGES-CLIVAR Annual Records of Tropical Systems (ARTS) Workshop.
J.E. Cole, INSTAAR, University of Colorado, Campus Box 450, Boulder CO 80309, USA. Fax: (+1-303) 492 6388, E-mail: coleje@spot.colorado.edu

7-18 September, Durham NH, USA
SARCS/LUCC Southeast Asia Modelling Workshop.
Amador Argete, SARCS Secretariat, Bangkok, Thailand. Fax: (+66-2) 255 4967, E-mail: amador@start.or.th

12-13 September, Bergen, Norway
JGOFS Executive Meeting.
Roger Hanson, JGOFS Core Project Office, Center for Studies of Environment and Resources, High Technology Centre, University of Bergen, N-5020 Bergen, Norway. Fax: (+47-55) 324 801, E-mail: jgofs@uib.no

12-15 September, Paris, France
PAGES PEP III (Pole-Equator-Pole Afro-European Palaeoclimatic Transect) Workshop.
Françoise Gasse, Laboratoire d'Hydrologie et de Géochimie Isotopique, Université de Paris Sud, Bâtiment 504, Orsay, Cedex 91405, France. Fax: (+33-1) 64 46 59 38, E-mail: gasse@geophy.geol.u-psud.fr

14-18 September, Castle Thurnau, Germany
Symposium on "Water Flux Regulation in Forest Stands" in co-operation with EUROFLUX/BAHC/BITÖK.

14-20 September, Berlin, Germany
GCTE Synthesis Workshop 1.
Will Steffen, GCTE Core Project Office, CSIRO, Division of Wildlife and Ecology, PO Box 84, Lyneham ACT 2602, Australia. Fax: (+61-6) 241 2362, E-mail: w.steffen@dwe.csiro.au

16-17 September, Boulder CO, USA
TEACOM-APN Workshop on Regional Climate Modelling.
Congbin Fu, Laboratory of Climate Research, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029, P.R. of China. Fax: (+86-10) 6204 5230, E-mail: fcb@ast590.tea.ac.cn

18 September, Washington DC, USA
6th START Bureau meeting.
International START Secretariat, Suite 200, 2000 Florida Avenue, NW, Washington, DC 20009, USA. Fax: (+1-202) 457 5859, E-mail: start@dis.start.org

19-21 September, Washington DC, USA
10th START Scientific Steering Committee Meeting.
International START Secretariat, Suite 200, 2000 Florida Avenue, NW, Washington, DC 20009, USA. Fax: (+1-202) 457 5859, E-mail: start@dis.start.org

21-27 September, Washington DC, USA
ICSU Executive Board Meeting, ICSU General Committee Meeting, ICSU Science Symposium and ICSU General Assembly.

24-25 September, Paris, France
DIS Focus 1: 3rd High Resolution Satellite Data meeting.
Gérard Szejwach, IGBP-DIS Office, 42 Avenue G. Coriolis, F-31057 Toulouse, France. Fax: (+33) 61 07 85 89, E-mail: gerard.szejwach@igbp.cnrm.meteo.fr

23-28 September, Paris, France
23th Session of the Intergovernmental Council with BAHC participation.
UNESCO, 7 Place de Fontenoy, 75352 Paris Cedex 07-SP, France. Fax: (+33-1) 45 67 16 90

25-28 September, Toledo, Spain
START/ENRICH Mediterranean Meeting.
Jean-Louis Fellous, MEDIAS-FRANCE, CNES, BP 2102, 18, Av. Edouard Belin, 31055 Toulouse Cedex, France. Fax: (+33) 61 28 29 05, E-mail: fellous@medias.cst.cnes.fr

TBA, Nairobi, Kenya
PAGES/IAEA/WMO/START Workshop on African Contribution to Global Network of Isotopes in Precipitation (GNIP).
Eric Odada, Department of Geology, University of Nairobi, Nairobi, Kenya. Fax: (+254-2) 449 539/446 138, E-mail: odada@uongeol.rio.org

October, Honolulu HI, USA
NOAA/IGP/START-APN Preparatory meeting for Asia/Pacific Regional ENSO Pilot Activities (tentative).
Candyce Clark, NOAA. Fax: (+1-301) 427 2082, E-mail: clark@ogp.noaa.gov

1-4 October, Victoria Falls, Zimbabwe
Workshop on Reducing Climate-Related Vulnerability in Southern Africa.
Candyce Clark, NOAA. Fax: (+1-301) 427 2082, E-mail: clark@ogp.noaa.gov

7-9 October, Ispra, Italy
GLOBEC Small Pelagic Fishes and Climate Change, Modelling Workshop.
Liz Gross, SCOR, Department of Earth and Planetary Sciences, Johns Hopkins University, Baltimore, MD 21218, USA. Fax: (+1-410) 516 4019, E-mail: scor@jhu.edu

11 October, Barcelona, Spain
LUCC Core Project Office Inauguration.
Caroline Nuñes, LUCC Core Project Office, Institut Cartogràfic de Catalunya, Parc de Montjuïc, E-08038 Barcelona, Spain. Fax: (+34-3) 426 7442, E-mail: carolinen@icc.es

14-18 October, Lagos, Nigeria
Joint JGOFS/LOICZ Continental Margins Task Team Workshop on Biogeochemical Budget for Coastal Oceans, Nigeria. To be held concurrently with IOC/JGOFS/LOICZ joint planning meeting for the second IOCEA cruise in the Gulf of Guinea.
LOICZ Core Project Office, Netherlands Institute for Sea Research, PO Box 59, 1790 AB Den Burg - Texel, The Netherlands. Tel: (+31-222) 369 404, Fax: (+31-222) 369 430, E-mail: LOICZ@nioz.nl

14-18 October, Bangkok, Thailand
SARCS Database Workshop.
Jariya Boonjawat, START-SEA RRC Interim Director. Fax: (+66-2) 251 2951, E-mail: bjariya@netserv.chula.ac.th

16-22 October, Batemans Bay, Australia
GCTE Focus 2 Workshop on Plant Dispersal and Migration in Response to Climate Change.
Lou Pitelka, Ecological Studies Program, Electric Power Research Institute, USA. Fax: (+1-415) 855 2950, E-mail: lpitelka@eprinet.epri.com

18-23 October, Seoul, Korea
IGBP Officers Meeting.

21-24 October, Paris, France
GCTE Foci 3 and 4/SCOPE/DIVERSITAS/EU-TERI/TSBF Collaborative Programme Workshop The Functional Role of Soil Biota under Global Change: An Ecosystem-level Perspective.
Luc Abbadie, Ecole Normale Supérieure, CNRS-URA 258, Laboratoire d'Ecologie, 46 Rue d'Ulm, 75230 Paris Cedex 05, France. Fax: (+33-1) 44 32 38 35

22-24 October, Chicago, USA
International IGAC-TRAGEX Workshop.
Keith Smith, IERM, University of Edinburgh, West Mains Road, Edinburgh EH9 3JG, UK. Fax: (+44-131) 667 2601, E-mail: k.a.smith@ed.ac.uk

Third week October
*SARCS Coastal Zone Open Science Meeting.
Amador Argete, SARCS Secretariat, Bangkok, Thailand. Fax: (+66-2) 255 4967, E-mail: amador@start.or.th

26-30 October, Hanoi, Vietnam
SARCS/WOTRO/LOICZ Workshop "Integrated socio-economic and biophysical modelling".
LOICZ Core Project Office, Netherlands Institute for Sea Research, PO Box 59, 1790 AB Den Burg - Texel, The Netherlands. Tel: (+31-222) 369 404, Fax: (+31-222) 369 430, E-mail: LOICZ@nioz.nl

29-31 October, Kyoto, Japan
*International Conference on Water Resources and Environmental Research "Towards the 21st Century".

30 October-1 November, Hanoi, Vietnam
9th SARCS Meeting.
Amador Argete, SARCS Secretariat, Bangkok, Thailand. Fax: (+66-2) 255 4967, E-mail: amador@start.or.th

October/November, Durham NC, USA
GCTE Focus 1 Workshop: FACE Technologies: Objectives, Approaches, Progress.
Boyd Strain, Duke University, Botany/Phytotron Building, PO Box 90340, Durham NC 27708-0340, USA. Fax: (+1-919) 660 7425.

November, Delhi, India
GCTE Rice Network Business Meeting, at the International Crop Science Congress.
John Sheehy, GCTE Rice Network Leader, International Rice Research Institute, PO Box 933, 1099 Manila, Philippines. Fax: (+63-2) 817 8470, E-mail: jsheehy@irri.cgnet.com

November, Manila, Philippines
SARCS Greenhouse Gas Research Synthesis Workshop (tentative).
Amador Argete, SARCS Secretariat, Bangkok, Thailand. Fax: (+66-2) 255 4967, E-mail: amador@start.or.th

November, TBA
Micro Workshop on Miombo Woodlands Transect Project (tentative).
Eric Odada, Department of Geology, University of Nairobi, Kenya. Fax: (+254-2) 449 539, E-mail: pagesnbo@form-net.com

4-5 November, Seoul, Korea
6th TEACOM Meeting.
Congbin Fu, Laboratory of Climate Research, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029, P.R. of China. Fax: (+86-10) 204 5230, E-mail: fucb@bepc2.ihep.ac.cn

4-7 November 1996, Kyoto, Japan
*BAHC-LUCC Joint Inter-Core Project Symposium on Interactions between the Hydrological Cycle and Land Use/Cover.
Dr. M. Sugita, Environmental Research Center, University of Tsukuba, Ibaraki 305, Japan. Tel: (+81-298) 53-2537, Fax: (+81-298) 53 2530, E-mail: BAHC-LUCC@erc2.suiri.tsukuba.ac.jp

4-9 November, Lima, Peru
GCTE Potato Network International Training Workshop and GCTE Cassava Network Launch.
John Ingram, GCTE Focus 3 Office, Center for Ecology and Hydrology, Maclean Building, Crowmarsh, Gifford, Wallingford OX10 8BB, UK. Fax: (+44-1491) 692 313, E-mail: j.ingram@ioh.ac.uk

8-9 November, Kyoto, Japan
TEACOM Workshop on Land Use in East Asia.
Dennis Ojima, NREL, Colorado State University, USA. Fax: (+1-970) 491 1965, E-mail: dennis@nrel.colostate.edu

10-12 November, Beijing, P.R. of China
Chinese BAHC Workshop

11-13 November, Baltimore MD, USA
GLOBEC Scientific Steering Committee Meeting.

Liz Gross, SCOR, Department of Earth and Planetary Sciences, Johns Hopkins University, Baltimore, MD 21218, USA. Fax: (+1-410) 516 4019, E-mail: scor@jhu.edu

12-15 November, Santa Barbara CA, USA

GCTE Synthesis Workshop 2.

Will Steffen, GCTE Core Project Office, CSIRO Division of Wildlife and Ecology, PO Box 84, Lyneham, ACT 2602, Australia. Fax: (+61-1) 241 2362, E-mail: wls@cbr.dwe.csiro.au.

13-15 November, Toulouse, France

DIS Focus 1: Fire Working Group Meeting

Gérard Szejwach, IGBP-DIS Office, 42 Avenue G. Coriolis, F-31057 Toulouse, France. Fax: (+33) 61 07 85 89, E-mail: gerard.szejwach@igbp.cnrm.meteo.fr

20 November, Cairo, Egypt

Present-Day Desert and Paleomonsoons: Record from the Eastern Sahara. Symposium on occarsion of the Centennial of the Egyptian Geological Survey.

Stefan Kroepelin, INQUA-PAGES Paleomonsoons Project, Free University of Berlin, Podbielskiallee 62, 14195 Berlin, Germany. Fax: (+49-30) 841 00363, E-mail: skroe@zedat.fu-berlin.de

25-29 November, New Delhi, India

START/APN/IHDP/GCTE Workshop on Human Dimensions of Global Environmental Change in Asia.

A.P. Mitra, SASCOM, National Phsycial Laboratory, Hillside Road, New Delhi 110 112, India. Fax: (+91-11) 575 2678, E-mail: apmitra@doe.ernet.in

26-29 November, Wageningen, Netherlands

Impacts of Global Change on Tree Physiology and Forest Ecosystems.

G.M.J. Mohren, DLO Institute for Forestry and Nature Research, PO Box 23, 6700 AA Wageningen, Netherlands. Fax: (+31-317) 424 988, E-mail: g.m.j.mohren@ibn.dlo.nl

November/December, TBA

DIS Focus 1: Soils WG meeting.

December, TBA

SARCS/LUCC Synthesis Workshop (tentative).

Amador Argete, SARCS Secretariat, Bangkok, Thailand. Fax: (+66-2) 255 4967, E-mail: amador@start.or.th

December, TBA

Workshop of JGOFS Task Team on Synthesis and Modelling.

Trevor Platt, Bedford Institute of Oceanography, PO Box 1006, Dartmouth, NS B2Y 4A2, Canada. Fax: (+1-902) 426 9388, E-mail: tplatt@ac.dal.ca

December, TBA

Workshop on Kalahari Ecosystems Transect (tentative).

Robert Scholes, CSIR, South Africa. Fax: (+27-12) 841 2689, E-mail: bscholes@csir.co.za

2-5 December, Bogor, Indonesia

START/WCRP/GCTE Climate Variability and Rice Production Workshop.

Will Steffen, GCTE Core Project Office, CSIRO, Division of Wildlife and Ecology, PO Box 84, Lyneham, ACT 2602, Australia. Fax: (+61-1) 241 2362, E-mail: wls@cbr.dwe.csiro.au.

2-6 December, Melbourne, Australia

SPARC 1st General Assembly on Stratospheric Processes and their Role in Climate.

David Karoly, SPARC 96, CRC for SH Meteorology, Building 70, Monash University, Clayton, VIC 3168, Australia. E-mail: spare96@vortex.shm.monash.edu.au

Late 96/early 97, TBA

Land Use and Climate Impacts on Fluvial Systems Workshop.

Robert Wasson, Research School of Pacific Studies, Australian National University, Canberra, Australia. Fax: (+61-6) 249 3770, E-mail: robert.wasson@anu.edu.au

Late 96/early 97, TBA

The Use of Stable Isotopes in selected Paleoarchives Workshop.

Frank Oldfield, PAGES Core Project Office, Bärenplatz 2, 3011 Berne, Switzerland. Fax: (+41-31) 312 3168, E-mail: pages@ubeclu.unibe.ch

Late 96/early 97, TBA

Paleorecords, in speleothems Workshop.

Frank Oldfield, PAGES Core Project Office, Bärenplatz 2, 3011 Berne, Switzerland. Fax: (+41-31) 312 3168, E-mail: pages@ubeclu.unibe.ch

1997

TBA, Accra, Ghana

START/NAF Workshop on Land Use/Land Cover Change in Northern Africa (tentative).

G.T. Aygepong, University of Ghana-Legon. Fax: (+233-32) 500 310., E-mail: rsau@ncs.com.gh

TBA, Santa Barbara CA, USA

Joint IGBP-BAHC/GCTE/DIS Workshop on Large-scale Pattern and Process in Root System Structure and Dynamics.

Bhaskar Choudhury, NASA-GSFC, Code 974, Greenbelt, MD 20771, USA. Fax: (+1-301) 286 1758 and Chris Field, Carnegie Institution of Washington, Stanford CA, USA. Fax: (+1-415) 325 6857

6-10 January, Lima, Peru

GCTE Potato Network international training workshop and GCTE Cassava Network Launch, International Potato Center (CIP)..

John Ingram, GCTE Focus 3 Officer, Center for Ecology and Hydrology, Maclean Building, Crowmarsh Gifford, Wallingford, OX10 8BB, United Kingdom. Fax: (+44-1491) 692 313, E-mail: j.ingram@ioh.ac.uk

8-9 January, Reduit, Mauritius

SASCOM/IGAC Workshop on Acrosol, Biomass Burning and Acid Rain.

A.P. Mitra, SASCOM, National Phsycial Laboratory, Hillside Road, New Delhi 110 112, India. Fax: (+91-11) 575 2678, E-mail: apmitra@doe.ernet.in

10 January, Reduit, Mauritius

4th SASCOM Meeting.

A.P. Mitra, SASCOM, National Phsycial Laboratory, Hillside Road, New Delhi 110 112, India. Fax: (+91-11) 575 2678, E-mail: apmitra@doe.ernet.in

11-22 January, Siwa Oasis, Egypt

INQUA-PAGES Workshop on Continental Signals of Paleomonsoon Dynamics in Africa: Interhemispheric Perspectives.

Stefan Kroepelin, INQUA-PAGES Paleomonsoons Project, Free University of Berlin, Podbielskiallee 62, 14195 Berlin, Germany. Fax: (+49-30) 841 00363, E-mail: skroe@zedat.fu-berlin.de

21-23 January, Santa Barbara CA, USA

DIS Focus 1: Land Cover Working Group Meeting.

Alan Belward, Space Applications Institute, Monitoring of Tropical Vegetation, Joint Research Centre of the CEC, Building 44, I-21020 Ispra, Varese, Italy.

30 January-1 February, Potsdam, Germany

ExCom Meeting BAHC SSC.

IGBP-BAHC Core Project Office, Institute for Climate Impact Research, PO Box 601203, D-14412 Potsdam, Germany. Fax: (+49-331) 288 2547

TBA, Japan

GCTE Rice Network: FACE and TGT (Temperature Gradient Tunnel) CO_2 Planning Workshop.

K. Kobayashi, National Institute of Agro-Environmental Science, Tsukuba, Ibaraki 305, Japan. Fax: (+81-298) 38 8211, E-mail: clasman@niaes.affrc.go.jp

24-28 February, Norwich, UK

12 th SC-IGBP Meeting.

10-13 February, Honolulu HI, USA

WCRP/IGBP Joint LSP-SVAT and Hydrology Workshop.

Piers Sellers, National Aeronautics and Space Administration (NASA), Goddard Space Flight Center, Code 624, Hydrological Sciences Branch, Greenbelt, MD 20771, USA. Fax: (+1-301) 286 0239, E-mail: piers@imogen.gsfc.nasa.gov

12-15 February, Santa Barbara CA, USA

BAHC Focus 1 SVAT Workshop.

Steven Running, School of Forestry, Montana Forest and Conservation Experiment Station, University of Montana, MT 59812-1063, USA. Fax: (+1-804) 982 2137, E-mail: swr@ntsg.umt.edu

17-19 February, Cotonou, Bénin

START/WCRP/SCOWAR (ICSU) Workshop on Climate Variability, Water and Agriculture in Sub-Saharan Africa: Food Security Issues (tentative).

Abel Afouda. Fax: (+229) 30 08 39

March, Kathmandu, Nepal

SASCOM Meeting on Dynamics of Land Use/Land cover Change in the Hindu Kush-Himalayas (tentative).

Lisa Graumlich, Institute for the Study of Planet Earth, University of Arizona, Tucson AR 85748, USA. Fax: (+1-520) 621 5004, E-mail: graumlich@ltrr.arizona.edu

March, Tucson AZ, USA

DIS Focus 1: Soils Pedo Transfer Function meeting.

Sorrosh Sorooshian, Dept. of Hydrology and Water Resources, University of Arizona, Tucson, AZ 87521, USA. Fax: (+1-602) 621 1422

3-12 March, Nairobi, Kenya

African GAIM/START Modelling Workshop.

Dork Sahagian, GAIM Task Force Office, Institute for the Study of Earth Oceans and Space, University of New Hampshire, Morse Hall, 39 College Road, Durham, NH 03824-3525, USA. Fax: (+1-603) 862 1915, E-mail: gaim@unh.edu

4-6 March, Barcelona, Spain

8th IGBP-DIS Scientific Steering Committee Meeting.

Gérard Szejwach, IGBP-DIS Office, 42 Avenue G. Coriolis, F-31057 Toulouse, France. Fax: (+33) 61 07 85 89, E-mail: gerard.szejwach@igbp.cnrm.meteo.fr

17-21 March, Cape Town, South Africa

Climate Change Impact Assessment Workshop for Africa.

International START Secretariat, Suite 200, 2000 Florida Avenue, NW, Washington, DC 20009, USA. Fax: (+1-202) 457 5859, E-mail: start@dis.start.org

March/April, TBA

IGAC Conference on "Global Measurement Systems for Tropospheric Composition".

April, Boulder CO, USA

DIS/WDC: Data Management Requirement Workshop.

Jonathan Overpeck, Paleoclimatology Programme, National Geophysical Data Center E/GC, National Oceanic and Atmosphere Administration (NOAA), 325 Broadway, Boulder, CO 80303-3328, USA. Fax: (+1-303) 497 6513, E-mail: jto@mail.ngdc.noaa.gov

April, Bogor, Indonesia

GCTE Activity 3.4 Workshop: Complex Agroecosystems - "Time Zero" Workshop.

John Vandermeer, Division of Biological Sciences, University of Michigan, Ann Arbor, Michigan 48109, USA. Fax: (+1-313) 747 0844, E-mail: john.vandermeer@um.cc.umich.edu

April, Arizona, USA

GCTE Wheat Network Workshop.

John Ingram, GCTE Focus 3 Officer, Center for Ecology and Hydrology, Maclean Building, Crowmarsh Gifford, Wallingford, OX10 8BB, United Kingdom. Fax: (+44-1491) 692 313, E-mail: j.ingram@ioh.ac.uk

1-3 April, Barcelona, Spain

GAIM Task Force Meeting

Dork Sahagian, GAIM Task Force Office, Institute for the Study of Earth Oceans and Space, University of New Hampshire, Morse Hall, 39 College Road, Durham, NH 03824-3525, USA. Fax: (+1-603) 862 1915, E-mail: gaim@unh.edu

14-18 April, Utrecht, Netherlands
GCTE Soil Erosion Network Water Erosion at Catchment Scale Model Comparison and Sensitivity Analysis Workshop.
Christian Valentin, ORSTOM, Institute Français de Recherche Scientifique pour le Développement en Coopération, BP 11416, Niamey, Niger. Fax: (+227) 722 804

23 April-3 May, Rabat, Morocco
IAHS 5th Scientific Assembly, Workshop W1: Scaling Issues in the Coupling of Hydrological and Atmospheric Models.

17-19 May, Argyll, Scotland (UK)
JGOFS Scientific Steering Committee Meeting.
Roger Hanson, JGOFS Core Project Office, Center for Studies of Environment and Resources, High Technology Centre, University of Bergen, N-5020 Bergen, Norway. Fax: (+47-55) 324 801, E-mail: jgofs@uib.no

20-22 May, Toronto, Canada
Joint IGAC-SPARC Conference on Global Measurement Systems for Atmospheric Composition.

20-26 May, Argyll, Scotland (UK)
JGOFS Symposium on Synthesis and Modelling.
Trevor Platt, Bedford Institute of Oceanography, PO Box 1006, Dartmouth, NS B2Y 4A2, Canada. Fax: (+1-902) 426 9388, E-mail: tplatt@ac.dal.ca or: Graham Shimmield, Dunstaffnage Marine Laboratory, PO Box 3, Oban, Argyll, Scotland. Fax: (+44-1631) 65518, E-mail: g.shimmield@ed.ac.uk

28-30 May, Missoula MT, USA
BAHC SSC-Meeting.
BAHC Core Project Office, Potsdam Institute for Climate Impact Research, PO Box 601 203, 14412 Potsdam, Germany. Fax: (+49-331) 288 2547, E-mail: bahc@pik-potsdam.de

June, Potsdam, Germany
Net Primary Productivity Model Intercomparison workshop.
Dork Sahagian, GAIM Task Force Office, Institute for the Study of Earth Oceans and Space, University of New Hampshire, Morse Hall, 39 College Road, Durham, NH 03824-3525, USA. Fax: (+1-603) 862 1915, E-mail: gaim@unh.edu

June/July, TBA
Joint NAFCOM/SAFCOM Meeting: 5th NAFCOM Meeting and 6th SAFCOM Meeting (tentative).
Cory Fleming, International START Secretariat. Fax: (+1-202) 457 5859, E-mail: cfleming@dis.start.org

June/July, Lake Tahoe NV, USA
GCTE Focus 1 Workshop: Comparative Analysis of Forest Responses to Atmospheric CO_2 Increase and Global Environmental Change.
Boyd Strain, Duke University, Botany/Phytotron Building, PO Box 90340, Durham NC 27708-0340, USA. Fax: (+1-919) 660 7425.

July, Birmensdorf, Switzerland
GCTE Focus 2 Workshop on Comparison of Forest Patch Models.
Dr Harald Bugmann, Potsdam Institute for Climate Impact Research, PO Box 601203, (Telegrafenberg), D-14412 Potsdam, Germany. Fax: (+49-331) 288 2600, E-mail: bugmann@pik-potsdam.de

1-9 July, Melbourne, Australia
Joint IGAC/GCTE Symposium: Closing the Budgets of CO_2, CH_4 and N_2O. Symposium 22 at the IAMAS/IAPSO General Assembly on Earth, Ocean, Atmosphere: Forces for change.
P.J. Fraser, CSIRO Division of Atmospheric Research, Private Bag No.1, Mordialloc, Victoria 3195, Australia. Fax: (+61-3) 586 7600, E-mail: pjf@dar.csiro.au
Information for the IAMAS Assembly on http://www.dar.csiro.au/pub/events/assemblies/info.html

13-19 July, Suva, Fiji
START Planning Meeting for Oceania (tentative).

August, Longyearbyen, Svalbard
JGOFS Symposium on Photosynthesis Measurement.
Egil Sakshaug, Trondheim Biological Station, Institute for Marine Biochemistry, University of Trondheim, Erling Skakkesgt. 47, N-7013 Trondheim-North, Norway. Fax: (+47) 7359 1597, E-mail: egil.sakshaug@vm.unit.no

24-30 August, Krasnoyarsk, Russia
PAGES/GCTE Workshop on Spatial-Temporal Dimensons of High Latitude Ecosystem Changes.
Eugene A. Vaganov, Institute of Forest SB RAS, Akademogorok, Krasnoyarsk, 660036 Russia. Fax: (+7-3912) 43 36 86, E-mail: evag@ifor.krasnoyarsk.su

September, Manhattan KS, USA
GCTE Soil Erosion Network Wind Erosion Model Comparison and Sensitivity Analysis Workshop.
Christian Valentin, ORSTOM, Institute Français de Recherche Scientifique pour le Développement en Coopération, BP 11416, Niamey, Niger. Fax: (+227) 722 804

14-20 September, Niamey, Niger
START/BAHC/GCTE Workshop on Vegetation and the Hydrological Cycle in the Sahel.
Lekan Oyebande, Faculty of Environmental Science, University of Lagos, Nigeria. Fax: (+234-1) 822 644, E-mail: lekan@infoweb.abs.net

October, TBA
JGOFS/LOICZ Continental Margins Task Team Workshop.
Julie Hall, NIWA, Ecosystems, 100 Aurora Terrace, PO Box 11-115, Hamilton, New Zealand. Fax: (+64-7) 856 0151, E-mail: hall@hamilton.niwa.cri.nz

October, UK
JGOFS Arabian Sea Synthesis Workshop.
Peter Burkill, Plymouth Marine Laboratory, Prospect Place, West Hoe, Plymouth PL1 3DH, UK. Fax: (+44-1752) 670 637, E-mail: p.burkill@pml.ac.uk

11-13 November, Nagoya, Japan
IGAC/IGBP Symposium.
Hajime Akimoto, 4-6-1 Komaba, Meguro-ku, Tokyo 153, Japan. Fax: (+81-3) 3481 4562, E-mail: akimoto@atmchem.rcast.uk-tokyo.ac.jp

November, TBA
Fifth Scientific Advisory Council Meeting (SAC V).
IGBP Secretariat, The Royal Swedish Academy of Sciences, Box 50005, S-104 05 Stockholm, Sweden. Fax: (+46-8) 16 64 05, E-mail: sec@igbp.kva.se

TBA
Synthesis Meeting for the Planning Group on North Atlantic Ocean.
Mike Fasham, James Rennell Centre, Chilworth Research Centre, Gamma House, Chilworth, Southampton SO1 7NS, UK. Fax: (+44-1703) 767 507, E-mail: mjf@ub.nso.ac.uk

1998

First quarter, TBA
JGOFS Training Course on Synthesis and Modelling.
Trevor Platt, Bedford Institute of Oceanography, PO Box 1006, Dartmouth, NS B2Y 4A2, Canada. Fax: (+1-902) 426 9388, E-mail: tplatt@ac.dal.ca

February/March, TBA
Second GCTE Science Conference.
Will Steffen, GCTE Core Project Office, CSIRO Division of Wildlife and Ecology, PO Box 84, Lyneham, ACT 2602, Australia. Fax: (+61-1) 241 2362, E-mail: wls@cbr.dwe.csiro.au.

April, London, UK
*PAGES Open Science Meeting.
Frank Oldfield, PAGES Core Project Office, Bärenplatz 2, 3011 Berne, Switzerland. Fax: (+41-31) 312 3168, E-mail: pages@ubeclu.unibe.ch

19-25 August, Seattle WA, USA
Joint 5th IGAC Scientific Conference and 9th CACGP Symposium on Global Atmospheric Chemistry.
Patricia Quinn, NOAA/PMEL/OCRD, Building 3, 7600 Sand Point Way NE, SEattle, WA 98115, USA. Fax: (+1-206) 526 6744, E-mail: quinn@pmel.noaa.gov

Publications

IGBP Report Series

IGBP Report No.37
IGBP Northern Eurasia Study: Pospectus for an Integrated Global Change Research Project (1996). Edited by W.L. Steffen and A.Z. Shvidenko. Stockholm: IGBP, 95pp.
Lisa Cronqvist, IGBP Secretariat, The Royal Swedis Academy of Science, Box 50005, S-104 05 Stockholm, Sweden.

Programme Elements

GLOBEC
Small Pelagic Fishes and Climate Change Program. Report of the First Planning Meeting., La Paz, Mexico, 20-24 June 1994 (1996). GLOBEC Report No. 8. 72pp.
Roger Harris, Chair, Plymouth Marine Laboratory, Prospect Place, Plymouth PL1 3DH, UK.

PAGES
The PAGES/CLIVAR Intersection: Providing the paleoclimatic perspective needed to understand climate variability and predictability. Coordinated research objectives of the International Geosphere-Biosphere (IGBP) and World Climate Research (WCRP) Programmes. Report of a joint IGBP-WCRP Workshop, Venice, Italy, November 1994 (1996). Edited by J.-C. Duplessy and J.T. Overpeck. 48pp.
PAGES Core Project Office, Bärenplatz 2, CH-3011 Bern, Switzerland.

National Research

Netherlands
Long-term Perspective 1996: Space for Ecological Modernization, Summary (1996). Rijswijk: Advisory Council for Research on Nature and Environment (RMNO), 20pp. (Publication RMNO nr.116b, 1996).
Advisory Council for Research on Nature and Environment, PO Box 5306, NL-2280 HH Rijswijk, The Netherlands.

Germany
World in Transition: Ways Towards Global Environmental Solutions. Annual Report 1995 of the German Advisory Council on Global Change. (1996). Berlin: Springer, 235pp.
German Advisory Council on Global Change (WBGU), Secretariat at the Alfred Wegener-Institute for Polar and Marine Research, Columbusstraße, D-27568 Bremerhaven, Germany.

Related Organisations

Ecosystem Geography (1996). By Robert G. Bailey. New York: Springer, 204pp. Ecosystem Geography brings the geographer's tools-maps. scales, boundaries, and units to the study of ecosystems.
Springer Verlag, Heidelberg Platz 3, D-14197 Berlin, Germany. Price: US$ 34.50.

SSRC
Annual Report 1994-1995 of the Social Science Research Council (1996). 151pp.
Social Science Research Council, 810 Seventh Avenue, New York, NY 10019, USA.

Web Pages

JGOFS	http://ads.smr.uib.no/jgofs/jgofs.htm
NC Malaysia	http://www.kjc.gov.my/~igbp
UK GER	http://www.nerc.ac.uk/ukgeroff/welcome.htm

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