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1. Introdução

Este documento constitui a memória do Painel de Especialistas sobre Ciências do Sistema Terrestre, desenvolvido dentro da programação de atividades do Grupo Temático de Prospecção Científica e Tecnológica (GT7) do Planejamento Estratégico do INPE.

2. Cartas Convite

MINISTÉRIO DA CIÊNCIA E TECNOLOGIA
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

Ofício nº 058/2006-CPA

São José dos Campos, October 20th, 2006.

Prof. Guy P. Brasseur
National Center for Atmospheric Research (NCAR)
The Earth&Sun Systems Laboratory (ESSL)
Associate NCAR Director for ESSL
USA
Fax number: +1 303-497-8100

Dear Prof. Brasseur,

1. On behalf of the Organizing Committee, I would like to invite you to lecture and participate on the ***Expert Panel on Earth System Science***, that will take place at the National Institute for Space Research (INPE), in São José dos Campos, State of São Paulo, Brazil, from November 30th to December 2, 2006. The ***Expert Panel on Earth System Science*** is being sponsored by INPE as part of its Strategic Planning effort.

[redacted]

3. I look forward to seeing you in Brazil and, please, do contact us if you need further information (phone: +55-12-3945-7102, fax: +55-12-3945-7101, e-mail: petronio@iss.inpe.br).

Sincerely yours,

Dr. Petrônio Noronha de Souza
Member of the Organizing Committee of the Expert Panel on Earth System Science
Deputy Head of Strategic Planning and Assessment
National Institute for Space Research (INPE)

INPE 016.7

MINISTÉRIO DA CIÊNCIA E TECNOLOGIA
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

Ofício nº 060/2006-CPA

São José dos Campos, October 27th, 2006.

Prof. Jagadish Shukla
President of the Institute of Global Environment and Society – IGES
Powder Mill Road, Suite 302
Calverton
MD 20705
USA
Fax number: +1 301-595-9793

Dear Prof. Shukla,

1. To whom it may concern, the Organizing Committee of the ***Expert Panel on Earth System Science***, that will take place at the National Institute for Space Research (INPE), in São José dos Campos, State of São Paulo, Brazil, from November 30th to December 2, 2006, would like to declare that during your participation you will present one unpaid lecture titled "*A proposal for the development of Earth System Science at the Instituto Nacional de Pesquisas Espaciais*".

[redacted]

3. I look forward to seeing you in Brazil and, please, do contact us if you need further information (phone: +55-12-3945-7102, fax: +55-12-3945-7101, e-mail: petronio@iss.inpe.br).

Sincerely yours,

Dr. Petrônio Noronha de Souza
Member of the Organizing Committee of the Expert Panel on Earth System Science
Deputy Head of Strategic Planning and Assessment
National Institute for Space Research (INPE)

INPE 016.7

MINISTÉRIO DA CIÊNCIA E TECNOLOGIA
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

Ofício nº 072/2006-CPA

São José dos Campos, 24 de novembro de 2006

Ao Senhor
Dr. Antonio Divino Moura
Diretor
Instituto Nacional de Meteorologia - INMET
Brasília – DF
Fax: (61) 3344-0700

Senhor Diretor,

1. Convidamos V.Sa. a participar, na qualidade de observador, do "Expert Panel on Earth System Science", que constitui uma das atividades do Grupo de Prospecção em C&T do Planejamento Estratégico do INPE.

2. Este evento será realizado de 30 de novembro a 2 de dezembro de 2006, no Hotel Mercure, em São José dos Campos.

3. O programa preliminar do evento segue em anexo.

4. Ficaremos muito honrados com sua presença.

Atenciosamente,

Carlos A Nobre
Presidente
Comitê de Organização

cc: Dr. Gilberto Câmara - Diretor do INPE

INPE 016.7

MINISTÉRIO DA CIÊNCIA E TECNOLOGIA
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

Ofício nº 073/2006-CPA

São José dos Campos, 24 de novembro de 2006

Prof. Pedro Leite da Silva Dias
Departamento de Ciências Atmosféricas
IAG-USP
São Paulo – SP
Fax: (11) 3091-4714

Prezado Senhor,

1. Convidamos V.Sa. a participar, na qualidade de observador, do "Expert Panel on Earth System Science", que constitui uma das atividades do Grupo de Prospecção em C&T do Planejamento Estratégico do INPE.

2. Este evento será realizado de 30 de novembro a 2 de dezembro de 2006, no Hotel Mercure, em São José dos Campos.

3. O programa preliminar do evento segue em anexo.

4. Ficaremos muito honrados com sua presença.

Atenciosamente,

Carlos A Nobre
Presidente
Comitê de Organização

cc: Dr. Gilberto Câmara - Diretor do INPE

INPE 016.7

3. Programa do Evento

Expert Panel on Earth System Science

An activity of INPE's Strategic Planning (PE INPE) Group 7 on Science and Technology Forecasting

30 November – 02 December 2006

Hotel Mercure at Soyus Room

Av. Dr. Jorge Zarur 81, Torre II

São José dos Campos, SP, Brazil

Phone: +55 12 3904-2310

Program

Thursday, 30 November 2006

12:00-14:00 Opening of Registrations

14:00 Welcome by INPE's Director Dr. Gilberto Camara

The Strategic Planning of INPE Dr. Décio Ceballos

Objectives of Group 7 on S&T Forecasting Dr. Odim Mendes Jr.

Goals of the Expert Panel on Earth System Science Dr. Carlos Nobre

15:30 Coffee&Tea Break

16:00 Beginning of In-Depth Discussion of the Questions Posed to the Panel (See the questions posed to the Panel in the Annex)

Panel Members: Dr. Daniel Hogan, UNICAMP, Brazil

Dr. Guy Brasseur, NCAR, USA

Dr. Jagadish Shukla, COLA-IGES, USA

Session Chair: Dr. Carlos Nobre

Rapporteur: Dr. Antônio Miguel Vieira |Monteiro

18:00 Meeting adjourns for the day

Friday, 01 December 2006

09:00 Continuation of In-Depth Discussion of the Questions Posed to the Panel

Session Chair: Dr. Haroldo Velho

Rapporteur: Dr. Evlyn Márcia Leão de Moraes Novo

10:30 Coffee&Tea Break

13:00 Lunch Break

14:00 Continuation of In-Depth Discussion of the Questions Posed to the Panel

Session Chair: Dr. Antonio Lopez Padilha

Rapporteur: Dr. Antônio Miguel Vieira Monteiro

15:30 Coffee&Tea Break

18:00 Meeting adjourns for the day

18:00-20:00 Meeting of session chairs and rapporteurs

Saturday, 02 December 2006

09:00 Session Chair: Dr. Gilberto Camara

Reporting by Session Rapporteurs

10:30 Coffee&Tea Break

11:00 Final Plenary Discussion

12:30 Closing of the Meeting Dr. Gilberto Camara

13:00 Meeting ends

4. Questões Balizadoras

Questions Posed to the Expert Panel on Earth System Science

(1) What is the current status and goals of Earth System Sciences (ESS)? What are the future perspectives for the development of ESS in the coming 5, 10 and 20 years?

(2) What are the necessary observational requirements, including remote and in situ observations, and socio-economic data, to support the development of ESS in the same timeframe?

(3) What are the computer and human resource requirements for the development of ES modeling in the same timeframe?

(4) How to make more efficient the interactions of social and natural sciences within ESS?

(5) How do you see the emergence of Applied ESS in the near future? What global and regional environmental and development problems would Applied ESS help to solve?

(6) How could Brazil contribute to the global development in the area? What should be, in your view, the strategy for the development of ESS in Brazil?

5. Respostas às Questões Balizadoras

Summary Report of the Expert Panel on Earth System Science resulting from plenary discussions on the central questions posed to the Expert Panel and to the participants of the meeting.

Question_1: What is the current status and goals of Earth System Sciences (ESS)? What are the future perspectives for the development of ESS in the coming 5, 10 and 20 years?

1.1 It seems that there is no universally accepted definition of ESS. ESS can be seen as field of interaction (integration?) among disciplines. ESS is part of a process that has been going on lately. The efforts of integration indicate that ESS has risen as a demand as the next step of integrating our knowledge about the Earth. ESS is central to the [sustainable?] development of the our societies.

1.2 ESS is a new paradigm in which the Earth's environment is seen as being influenced by the dynamic interaction of natural and social systems. A key issue is to looking for a quantitative model that strongly couples the different component systems, even if there is no complete understanding of the functioning of its components.

1.3 ESS is rapidly evolving into a full-fledged field of study. One of the key issues in ESS is looking at the interfaces between its components, and the coupling between scales.

1.4 A desirable future scenario for ESS points to the following goals: + 5 years: interactive biogeochemical cycles (Carbon); + 10 years: coupled social-economic systems; + 20 years: dealing with complex social problems.

1.5 For ESS to evolve, there is a need for a full and timely sharing of data and knowledge worldwide.

1.6 Scientific agenda of ESS is broader than the climate change agenda. The ESS agenda includes Earth-Sun interactions

Question_2: What are the necessary observational requirements, including remote and in situ observations, and socio-economic data, to support the development of ESS in the same timeframe?

2.1 Most of the data that have been collected is under utilized. We should aim to maximize the use of the available environmental data (less than 10 % has been used). ESS needs a balanced allocation of resources between data production (satellites and in-situ) and data analysis.

2.2 Need for specialized data from field experiments to improve process understanding.

2.3 There is a need for routine monitoring of the environment requires the increase of the observation satellites network. ESS in Brazil could benefit from the full development of the GEOSS. There is also the need for innovative ideas on how to analyze these data.

2.4 There is a need for high quality routine "in situ" observation for ESS. This will also be a driver for new sensor technology (Geosensors Network).

2.5 Space activity is an integral part of ESS. Improvements on satellite sensor technology are needed for the various components of ESS. There is a need to improve the cost/benefit ratio of satellites to accommodate the needs for data collection and data analysis. Space activities for ESS would benefit from strong international collaboration.

2.6 Enhanced emphasis is needed on data assimilation to increase the value of observations for ESS.

2.7 Social and economic data are fully part of ESS. Their integration in ESS is a challenge that should be addressed.

Question_3: What are the computer and human resource requirements for the development of ES modeling in the same timeframe?

3.1 In next 5-10 years, the development of a new generation of ESS models and the analysis of data require a small number of dedicated petaflop computing facilities (*capability machines*) and several teraflop computing facilities (*capacity machines*) in the world. It is expected that developing countries establish teraflop computing facilities, which will be closely connected with the petaflop computing facilities.

3.2 The development of new generation of models and data assimilation brings a critical need for highly specialized human resources, coming from diverse backgrounds.

3.3 The architecture of future machines will require the development of new algorithms and code, that can only be achieved by specialized software engineers and applied mathematicians.

Question_4: How can we build stronger interactions of social and natural sciences within ESS?

4.1 ESS requires improved communication between social and natural sciences. This is a long-term process that requires both communities to develop understanding, appreciation and common languages. This requires greater familiarity of social scientists with quantitative models, and greater familiarity of natural scientists with social and economic concepts.

4.2 Integration of social and natural sciences within ESS requires innovative educational initiatives.

4.3 To motivate the integration of social and natural scientists, ESS research should pose questions perceived as challenging by both communities.

4.4 Social scientists should be involved in the ESS program from the planning phase. ESS programs should create shared spaces (workshops, meetings, joint projects) where social and natural scientists can interact.

Question_5: How do you see the emergence of Applied ESS in the near future? What global and regional environmental and development problems would Applied ESS help to solve?

5.1 ESS should be a crucial element of any development program since, among other aspects, weaker sections of society are the most affected by environmental change. Therefore, some important issues on applied ESS are ecosystem management, biodiversity conservation, urbanization, food security, water availably, energy supply, carbon balance and human health.

5.2 The applied ESS should follow the paradigm of ES knowledge environment, which includes observations, modeling, outreach and applications.

5.3 A particularly important question for applied ESS is how to attain equitable social development while at the same time reducing stress on the environment.

Question_6: How could Brazil contribute to the global development in ESS? What should be, in your view, the strategy for the development of ESS in Brazil?

6.1 It is recognized that Brazil has been contributing with success to the mainstream agenda of ESS.

6.2 The unique contribution of Brazil will be to focus on the central theme of *ESS and Development*. A new program in Brazil is needed to address this issue.

6.3 The ESS program must promote capacity building, by inducing new graduate programs and establish collaboration with other programs.

6.4 The most efficient approach for Brazil is to create a leading node, strongly connected to a network of participating institutions. The scientific and technical personnel for the leading node is estimated around 200 qualified staff, including social scientists. It is recognized that INPE has the potential to manage this leading node, if adequate resources are made available.

6.5 ESS programs in Brazil should expand its scope for regular production of environmental scenarios up to decadal time scales, in close cooperation with century-scale projections by the global petaflop models.

6.6 One of the important and early outcomes of an ESS program in Brazil should be to produce a regular assessment of the *State of the Environment* for Brazil. This can be expanded for South America in cooperation with other countries.

6. Conclusões do Painel

Considerando a posição singular do INPE no cenário nacional, que conta com um centro consolidado na área de previsão de tempo e clima com extensivo uso de modelos numéricos computacionais apoiados em máquinas de alto desempenho; uma atuação e um centro consolidado na área de aplicações de dados de sensoriamento orbital e com o controle da operação de satélites e estações de coleta, recepção e distribuição de dados orbitais variados; uma interlocução importante para os sistemas de decisão nas áreas ambientais e climáticas; uma história de competência técnico-científica, que inclui grupos de excelência com trabalhos em várias das áreas associadas ao domínio de busca *Ciências do Sistema Terrestre;* uma experiência consolidada em cooperações técnico-científicas internacionais com diversos graus de participação em grandes projetos interdisciplinares e inter-institucionais, uma janela de oportunidade se apresenta para o estabelecimento de uma agenda técnico-científica avançada, mobilizadora e integradora. Para isso faz-se necessário planejar e organizar as vocações institucionais, ampliando a agenda científica para além das mudanças climáticas, com um caráter único e inovador, um foco temático na interface entre Ciências do Sistema Terrestre e uma agenda de Desenvolvimento para o País, o que requer uma organização interna para o estabelecimento no INPE de uma agenda focada em *Ciências do Sistema Terrestre e Desenvolvimento*.

7. Referências

A Study on Earth System Science. J. Shukla, Professor, George Mason University (GMU), President, Institute of Global Environment and Society (IGES), J. L. Kinter III, Director, Center for Ocean-Land-Atmosphere Studies (COLA), P. R. Houser, Director, Center for Research on Environment and Water (CREW). November 2006. **(CPA-026-2006)**

Earth System Science in Brazil: Point of View. Guy P. Brasseur, Earth and Sun System Laboratories, National Center for Atmospheric Research, Boulder, Colorado, USA. November 2006. **(ANEXO 2).**

Human Dimensions of Earth System Science: Subsídios para o Painel Internacional sobre a Ciência do Sistema Terrestre. Daniel Joseph Hogan, Universidade Estadual de Campinas, SP, Brazil. November 2006. **(ANEXO 3).**

Additional Related Documents

Can Extreme Poverty Be Eliminated? Jeffrey D. Sachs. Scientific American, September 2005.

Empowering Developing Nations. Carlos A. Nobre, IGBP Chair of Scientific Committee. Global Change Newsletter, no. 64, pp. 2-3. December 2005. (available at www.igbp.net).

Global Earth Observation System of Systems (GEOSS). 10-Year Implementation Plan. Reference Document, Group on Earth Observations, GEO 1000R / ESA SP-1284 . February 2005 (ISSN No.: 0379-6566).

The Changing Earth: New Scientific Challenges for ESA's Living Planet Programme. ESA SP-1304. July 2006 (ISSN No. 0379-6566).

The Climax of Humanity. George Musser. Scientific American, September 2005.

Anexos

1 – Lista de Participantes

Nro.	Participante	Status	E-mail
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2 – Nota Técnica do Guy Brasseur

Earth System Science in Brazil

Point of View

Guy P. Brasseur
Earth and Sun System Laboratories
National Center for Atmospheric Research
Boulder Colorado
USA

December 2006

1) What is the current status and goals of Earth System Sciences (ESS)? What are the future perspectives for the development of ESS in the coming 5, 10 and 20 years?

Earth System science (ESS) addresses the changes that are occurring at the planetary level, and the implications of these changes for global sustainability. This science refers not only to the natural sciences but also to the human dimensions. In general terms, the purpose of the ESS research is to understand the physical-ecological-anthropogenic systems as complex and dynamic and interacting entities.

The current objectives of Earth System Sciences are therefore to perform ***fundamental*** studies of the dynamics of the earth system across spatial and temporal scales, and to assess how natural and human-driven forcing processes affect the evolution and ultimately the habitability of the planet. On the more ***applied*** side, the goal is to acquire the knowledge necessary to ***respond*** to global and regional environmental changes and to help develop a sustainable future. This requires the recognition that the earth operates as a coupled, interactive system with its atmosphere, its ocean, and its land components, and that these physical components are perturbed by human activities, and at the same time affect the socio-economic system. Earth system science must thus first understand the complex physical, chemical and biological processes that determine the evolution of the natural coupled Earth system, and then assess how these components interact with the social system.

2) What are the necessary observational requirements, including remote and in situ observations, and socio-economic data, to support the development of ESS in the same timeframe?

The first task of the scientists is to measure and to observe. A plan for global change research must include a diversity of experimental approaches and methodologies. The design of the observational system must, however, be driven by scientific objectives, even though long-term monitoring of important variables is also a necessity.

One approach relies on **space observations**. These provide global (or nearly global) coverage of physical, chemical and biological quantities, but generally little information on the vertical profiles of these quantities. Such global observations are important for extensive comparisons with models. The use of observational data in conjunction with models may require the use of assimilation techniques. A plan for Global Change research should definitely include an assimilation component.

These types of observations must be completed by **in situ field observations**. The organization of coordinated field campaigns with a suite of instruments to address specific questions is key to an observational program. The LBA program is an excellent example of such coordinate, multi-disciplinary field activities. In any case, the scientific objective of such initiatives must be clearly defined, and a good plan and detailed must be established.

Long-term monitoring programs and routine space observations should be complemented by occasional extensive field campaigns. These require the use of very accurate surface instrumentation, as well as profilers and well equipped aircraft platforms. The key here is to bring together all these experimental components, and to link them with modeling activities. The participation of modelers in the early design of field campaigns is essential for the success of an end-to-end field project.

Support for **laboratory work** may be important in relation to a given project, and should not be forgotten.

Finally, an effort for **analysis and synthesis** should be integrated with the field project, which may involve a participation of social scientists right from the beginning.

It is important that sufficient support be provided for the development, calibration, testing and inter-comparison of the instruments.

3) What are the computer and human resource requirements for the development of ES modeling in the same timeframe?

The use of sophisticated earth system (and climate) models requires the access to large computer platforms. The performance of such models remains limited by the availability of computer resources. Models become more expensive to integrate because of the need to increase **resolution**, to simulate more **complex processes** (e.g., biology, chemistry), to perform **longer integrations** (e.g., paleo-problems), and to perform **ensembles** of simulations (to account for the internal variability of the system and provide a distribution function of the predicted changes). The large centers in Europe, Japan and the United States are considering acquiring peta-scale machines by the beginning of the next decade. Such systems, with more than 10 000 and even 100 000 processors will require a rather fundamental modification of the code architecture, which means that groups of expert software engineers will have to be formed in the rather near future.

In addition, large data storage systems will be needed and should be an important aspect of the planning when upgrading computer facilities.

An important aspect for geosciences, and specifically for earth system and climate research is that the scientists have access to a **dedicated** machine. Experience shows that deep failure when the accessible machine if of general use. The machines must be configured to treat the specificity of large models that produce enormous amounts of data. My colleagues at NCAR have attempted to access the super large computer at Oak Ridge, and have not succeeded doing so, because the machine is not configured for the needs of the climate community. We know also that even the Earth Simulator in Japan cannot be easily used because of the lack of storage space and the lack of networking with the external world. The design of the system is in fact very important.

Because the acquisition of such machine is so onerous, especially when it serves a single discipline (i.e., geosciences), it needs to be open to a large fraction of the national (or even international) community. The development of “geo-collaboratories” around such supercomputing facilities and involving the participation of university partners is therefore essential. Large facilities cannot anymore be run by a single institution; the resources must be shared and the decision process must include representatives of the community and rely on peer-review processes.

Finally, the need of a competent staff to support the community has to be highlighted. The development of complex models cannot be performed anymore by natural scientists who receive some limited help from programmers. Rather, integrated inter-disciplinary modeling teams that include approximately an equal number of software engineers and physical scientists must be formed.

4) How to make more efficient the interactions of social and natural sciences within ESS?

This is a particularly difficult question. The reason is that the languages, scientific approaches, expectations, etc. are so different between the two different communities. Clearly, there is a learning process that must be initiated. First, it is important to find social scientists who are convinced that environmental issues such as climate change have an importance for the future economy and for social well-being. Second, one has to find natural scientists who are convinced that the social system can introduce feedbacks that will affect the natural system. My suggestion is to develop exploratory paths by which interfaces are established between the 2 communities. This can be done in different ways. The issue of land-use change provides an excellent example. It requires an understanding of biophysical processes, requires perhaps data from space experiments, and at the same time, an understanding of the human dimension is crucial. A second way of creating this link between social and natural sciences is to develop integrated regional studies. LBA provides an excellent example where both social aspects can be linked with biophysical aspects. A third way is to develop research priorities around societally important questions such as human health and the environment, agriculture and climate change, water and food resources and global change. A fourth way is to develop coupled natural/socio-economic models. Such models should be "balanced" models of intermediate complexity used as "toys" to explore ideas and some potentially important relations, rather than fully developed climate models with a simplified 'social routine'

When developing regional studies or initiating field campaigns in which social aspects are included, it is key to involve the social scientists as early as possible in the planning process.

A final remark: There is nothing like a single social science. Rather, "humanistic" sciences include economical, historical, psychological, social aspects. In each case, some interface with the natural sciences can be explored.

5) How do you see the emergence of Applied ESS in the near future? What global and regional environmental and development problems would Applied ESS help to solve?

After decades of extensive work to project the evolution of climate over centuries (see IPCC), it is important to somewhat review and adjust the existing strategy.

First, stakeholders are not particularly interested to know what climate will be in one or two centuries. Rather, they would prefer to know what to expect in the short term, and to learn about the probability for some significant climate change. This implies that we will have to consider simulating a large ensemble of rather short-term cases (typically 20-30 years or so), with adequate assimilation of the initial values (specifically regarding the ocean).

Second, rather than providing classic quantities obtained from global climate models, stakeholders will be interested by impacts at the regional scale. What are the effects of climate changes on the hydrology and land cover in specific regions? How will the ecosystem goods and services be modified? What are the impacts in terms of flooding or desertification? What will be the impacts on air quality, agriculture, fisheries, food production, biodiversity, coastal development? What are the responses that society will have to develop to mitigate the effects of to provide the best adaptation conditions?

It is clear that the organization of integrated regional studies will be a good approach to address such questions, to bring together different groups of scientists and decision-makers, and to develop education projects towards capacity building.

Third, even when dealing with the global scale, the question posed by the scientific community should perhaps be reversed: Rather than requesting climate and earth system scientists to make projections based on forcing scenarios (e.g., emissions, land-use), one could ask: What should society do to avoid reaching dangerous situations? What should we do, for example, to maintain the global temperature change below a given target (for ex. 2C)? Or changes in regional precipitations below a specified value? By posing the problem in these terms, it is clear that we need to bring together multi-disciplinary teams and one poses a central question for society. Of course, we should recognize that the solution may not be unique and that there is room for some value-related decisions.

Fourth, the development of assessments is an important aspect of applied earth system science. These assessments have been extremely valuable, and have led to international agreements such as the Montreal Protocol and the Kyoto Protocol. It is important that such assessment be conducted by the scientists themselves, and that a firewall be established between the scientists and the decision makers.

Fifth, there is an increasing need to provide real-time information to the public about the state of the environment. The contribution of Brazilian scientists to international initiatives such as GEOSS is therefore important. For example, the need to know in real time for Brazilians the location and intensity of large fires, and their impact on atmospheric visibility calls, for example, for the development of an operational chemical weather system with analysis and prediction capability. Other similar systems for other land- and ocean-related quantities including extreme/rare events are important. It would be important for Brazil to have access to satellite-based early warning systems for natural hazards.

Sixth, the study of new economic approaches to climate-related questions should be developed. An example is provided by the management of the carbon trading system.

6) How could Brazil contribute to the global development in the area? What should be, in your view, the strategy for the development of ESS in Brazil?

Brazil has a community of talented scientists. The organization of a large campaign like LBA, for example, has created a really strong community focusing on Earth system science, with strong international links. This extraordinarily important result must be maintained and the community needs to define new challenges.

There are several ways by which the community can organize itself. One way is to create some centralized institution that will have the critical mass and access to modern facilities to develop earth system programs in Brazil. Another approach is to keep a decentralized organization and create strong networks between existing and dispersed groups. The networking is probably the preferred approach since it opens the possibility to include a large diversity of groups and scientists. INPE could be the central node for such a decentralized system.

Once this network is established, it is important to develop an inclusive strategic plan and an implementation strategy. It is also good to develop a metrics system by which one can measure the degree of progress towards the strategic goals. Such plan must highlight a few good scientific objectives, the tools that are needed to reach these objectives (models, field campaigns, data management, aircraft, satellites, etc.) as well as the expertise that will be needed.

Beside these research intensive projects, it is important to start thinking about more applied aspects. Why not create some kind of climate service or atmospheric/land service by which information on the environmental state of the region would be provided operationally. The focus would be on the current state and some predictions for the next days. Examples of products could be chemical weather information (air pollution, ozone, aerosols, visibility, stratospheric ozone and UV-B, etc.), the location and intensity of fires, emissions and urban plumes, etc…

Another priority is to further develop a comprehensive climate model, and to extent it beyond the physical climate system, and so should become an earth system model. It is important for these models to be able to provide regional information (for example by nesting regional models into the global model). Such models could be the basis for providing relatively short term predictions on the state of the earth system.

Much of the work in Brazil has focused on the role of the Amazon in the earth system. This is unique and should e continued in the future. More work on the coupling between the carbon cycle and hydrology in this region is needed. However, an important question in the vicinity of Brazil is the role of the tropical Atlantic, the transport of dust from Africa, the fertilization of the biosphere, the formation of tropical depression and of hurricanes, the sources of stratospheric tropical waves, etc.. This is perhaps a topic where some interesting work could be done.

Finally, it seems important to me to continue to study the role and importance of urbanization in South America. These are societally important questions, and integrated questions need to be answered in this area.

Of course, I am mentioning quite general directions. What is, of course, needed, and what should be addressed by the Brazilian community is the definition of "researchable" questions. These should appear in the strategic plan and implementation strategy.

3 – Nota Técnica do Daniel Hogan

Human Dimensions of Earth System Science

Subsídios para o Painel Internacional sobre a Ciência do Sistema Terrestre

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Introduction

Unlike the experience of many fields, the social sciences[1] were not led to the study of the environment through the gradual development of their major paradigms – what Kuhn called "normal" or incremental science. On the contrary, it was the irruption of serious environmental problems, and above all, of socio-environmental movements, and the social conflict embedded in these movements, that placed the issue on social science agendas. While initial approaches in the seventies tended to be ad hoc attempts to delimit the field of environmental social science, the field today is thriving and diversified, with more clearly defined research orientations.

Although many social scientists thus came to study the social determinants and consequences of environmental change, they were even more unprepared to incorporate *global* changes in the scope of their work. The problems of global warming and the rise in sea levels, in particular, were remote from social science concerns, occurring on temporal and spatial scales which their research paradigms did not contemplate. And unlike environmental issues in general, global change did not at first generate socio-political movements which commanded their attention. The early calls for social science involvement came from physical scientists who clearly saw that human activity was responsible for the acceleration of changes observed in world climate. It would be necessary to engage social scientists in these efforts if current trends were to be modified. The challenges of inter and multi-disciplinary research, always stretching the vision – and often the patience – of "normal" scientists, are considerably amplified when collaboration seeks to bridge the gap between natural and social science.

These considerations are important for understanding the development of what has come to be called the human dimensions of global environmental change; the pace, institutional framework, geographical extent and (relevant) success of these developments; as well as the timid response of Brazilian social science. Most importantly, they are essential for tracing a strategy of promoting and supporting social science involvement in Earth System Science in Brazil.

International research on the human dimensions of global environmental change

Three related initiatives have been fundamental in establishing the scientific agenda, promoting exchange and publishing and disseminating results of human dimensions research. The Open Meeting of the Human Dimensions of Global Environmental Change Research Community, as a venue for these activities was first organized at Duke University in the United States, in 1995, followed by meetings in Austria (1997), Japan (1999), Brazil (2001), Canada (2003) and Germany (2005). While the Human Dimensions Program of the International Social Science Council (launched in 1990) and, since 1996, the International Human Dimensions Programme on Global Environmental Change, with support of several countries, have been active in the preparation of the Open Meetings, each has been independently organized, with the election of a Steering Committee at each meeting. This loose association of researchers, centers, national and international agencies permitted the identification of a research community, whose identity has consolidated over time. The second, more structured initiative was the creation of the IHDP itself in 1996. Since the completion of its core project on Land Use and Land Cover Change (co-sponsored with IGBP) in October 2005, the IHDP has six Core Science Projects:

[1] Social sciences, broadly understood. In Brazil, following French traditions, the field of *human* sciences includes social sciences, economics, history, demography, social psychology as well as several applied fields.

- Global Environmental Change and Human Security (GECHS)
- Institutional Dimensions of Global Environmental Change (IDGEC)
- Industrial Transformation (IT)
- Urbanization and Global Environmental Change (UGEC)
- Land-Ocean Interactions in the Coastal Zone (LOICZ) (co-sponsored with IGBP)
- Global Land Project (co-sponsored with IGBP and successor of LUCC and the IGBP core project on Global Change and Terrestrial Ecosystems)

The Vienna Open Meeting was the moment when competing topics were sorted out, and LUCC and the first three of the above projects were selected.[2] Researchers who participated in these projects first produced a Scoping Report for the IHDP Scientific Committee; when approved, this was followed by a Science Plan, a Scientific Steering Committee, the preparation of an Implementation Strategy, and collaborative research. Successive Open Meetings, meanwhile, widened the range of topics, some of which evolved as core projects.

Brazilian human dimensions research

The third related initiative was the participation of the national academies of science. In many countries, the academies established national committees and created formal lines of research support. Most of the significant work on human dimensions has been the fruit of these activities.3 Sixteen countries have created National Committees on Human Dimensions and another 16 have created Global Change Committees which integrate human dimensions into the larger research community.The Academia Brasileira de Ciências accompanied these moves, creating a Human Dimensions Committee in 1997. One consequence of this decision was a bid by Brazil to hold the 4th Open Meeting in Rio de Janeiro in 2001.4 The preparation and the implementation of this meeting was, without doubt, the most significant activity of the Committee, and had as a major objective the mobilization of the Brazilian Environmental Social Science community, increasing interest and involvement in climate research. While this meeting coincided with the creation of the National Association for Graduate Studies and Research in Environment and Society (Anppas), which unites Graduate programs on society and the environment and promotes well-attended national meetings on a biannual basis, the

[2] Among the projects **not** selected was GOES – the Global Omnibus Environmental Survey, a project which would have conducted periodic international surveys to monitor public opinion on global change. Led by the Survey Research Center of the University of Michigan, GOES was the first project to mobilize the Brazilian Social Science community. In the year preceding the Vienna meeting, researchers from Unicamp, USP, UFMG, UnB and ISER met several times, in Brazil and at the University of Michigan, to prepare this project. While the IHDP did not select it as a core project, GOES was carried out in the late 1990s. Without international funding, it proved impossible to carry out a national survey in Brazil, although pre-testing was done in Campinas, Belo Horizonte, São Paulo and several other sites. The results are published in Peter Ester, Henk Vinken, Solange Simões, Midori Aoyagi-Usui (eds.), Culture and sustainability: a cross-national study of cultural diversity and environmental priorities among mass public and decision makers, Dutch University Press, 2003. It includes chapters by S. Simões, E. Viola and D. Hogan on partial Brazilian surveys.

[3] Google provides a measure of the success of these activities: a search for *climate change* produced approximately 212,000,000 results, while a similar search for *human dimensions of climate change* produced approximately 11,200,000 results, nearly 20% of the total.

[4] On this occasion, the Committee organized a book of commissioned chapters to present Brazilian views on human dimensions to the international community. This book, D. Hogan and M. Tolmasquin (eds.), Human Dimensions of Global Environmental Change: Brazilian Perspectives, Rio de Janeiro, Academia Brasileira de Ciências, Rio de Janeiro, 2001, remains one of the few publications on human dimensions in Brazil.

Open Meeting did not significantly increase participation of Brazilians in this field and global environmental change continues to be a little-explored theme at Anppas meetings.5

The reasons for this are important to consider as INPE considers a program on Earth System Science. In the first place, the National Committee has been inactive6. The international experience synthesized above makes it very clear that a pro-active role on the part of concerned institutions is fundamental. An important obstacle to consider is the lack of response of the environmental social science community itself. In a country of such pressing environmental problems, long-neglected and still without the necessary priority, immediate problems at the local, regional and national level monopolize the attention of researchers and students.7 In a field as new as environmental social science, graduate students and their theses are a major source of new knowledge. The issues which inspire students to seek out the 40 or so graduate programs in environmental sciences in Brazil are those to which they have been exposed in their role as citizens. Global climate change is not one of them.

Breaking this vicious circle of exclusive attention to pressing local problems would be an important contribution of INPE's initiative. In this respect, international experience is a useful guide. Four core projects galvanized the nascent "human dimensions of global environmental research community" for more than a decade. Such focusing was important for two reasons.

First, sub-communities of researchers were organized into interdisciplinary, inter-institutional and international networks on themes sufficiently few in number and limited in scope to able to be able to conduct comparative research and synthesize results in fifteen years. Projects interested in this exchange submitted their plans, which were accepted as part of the Scientific Committee's scope.8 The exchange and visibility provided by the Open Meetings and publication and dissemination of results by the IHDP created a space for this research which had been lacking in conventional, disciplinary-oriented organizations. This collective effort, potentialized by the network established by each core project, was fundamental in forging effective programs, creating training possibilities and advancing knowledge. This focusing favored cumulative results, which gave both visibility and legitimacy to the field.

Secondly, the IHDP was realistic in the choice of core projects, not identifying as central issues the Big Questions: What are the human activities causing climate change and How do we stop them? Rather, they took as starting points themes already the object of research, whose connection to global change is not always self-evident, focusing on intermediate relations rather than direct connections between human actions and climate change. The four major issues are areas in which environmental social scientists had a

[5] The IHDP's Annual Report for 2004-2005 registers eight researchers from Brazilian institutions, only three of whom are social scientists. The other five became involved in human dimensions research as an aspect of their research in the exact sciences. Of the three social scientists, none participate in a core project: Eduardo Viola was co-chair of the 2005 Open Meeting; Roberto Guimarães is a member of the IHDP Steering Committee; and Daniel Hogan is a member of the Steering Committee of the Population-Environment Research Network, a joint activity of the IUSSP and IHDP.

[6] The Committee's most recent activity was a workshop in Campinas in 2004, whose objective and final decision was a proposal to unite the Human Dimensions Committee with the Brazilian IGBP, under the aegis of the Academy of Sciences. See Hogan, D., et. al. (2005) Proceedings of the National Workshop on Global Environmental Change: A New Scientific Agenda in the Brazilian Context, Campinas, Brazil, September 2004.

[7] This attitude does not derive from any isolation of this community from international debate; indeed, Brazilian environmental social science has been at the forefront of research, participating intensely in international fora.

[8] The IHDP does not finance research, but the identification of a project with one of the core projects has proven useful in securing funding; the principal gain for participating groups has been through the collective work of defining concepts, research strategies and research designs, as well as the exchange of results.

tradition of work but whose center of attention had not been climate change. Thus, *land-use and land-cover change* had been studied in name of the loss of forest cover (to monoculture, cattle-raising and lumbering) and its impact on traditional livelihoods of small farmers and Indians; in the name of the demographic occupation of new territories; and in the name of the loss of biodiversity. Understanding the social, political, demographic and economic consequences of changes in land-use and land-cover would prove to be an important link between human activity and the carbon cycle – with its inherent effects on climate change.

Environmental change and human security, in the same way, moves from common concerns in the social science community to refocusing the issues in terms of climate change. What has been called the *risk society* places humankind in a new, vulnerable relationship to the world, and environmental issues are among the principal factors involved. Whether in the various approaches to *food security* (from labeling to diet patterns to transgenics to outright hunger), or by way of exposure to thousands of chemical compounds whose cumulative effect is unknown, or from the conflicts around such essential resources as water, the perspective of environment and security provides a path for incorporating the concern for the effects of climate change on health and community well-being.

The study of *institutions* is among the most traditional pursuits of sociology. The creation and development of institutions in the environmental field has generated much research in both North and South in the last quarter-century, as the environmental issue has become embedded in contemporary societies. Indeed, the institutionalization of environmental protection and of environmentalism itself is a major fact of our times. For sociologists and political scientists who study institutions, the move to focusing on the role of environmental and resource regimes, or of other institutions such as trade and investment regimes in causing/confronting global environmental changes is a logical step, one for which the conceptual basis has been well established.

The study of *industrial transformation* brings some reluctant participants into the discussion. Economics – most especially in Brazil – has not been at the forefront of environmental social science. Industrial transformation, however, has been a central issue for economists, and the move to more environmentally friendly production processes; the use of alternative fuels; production which is less energy- and materials-intensive are issues which tie into some of the most basic links of human activity to climate change.

Among the newer core projects is that on *urbanization*. The environmental changes associated to urbanization had already been identified by the Brazilian Committee as central issues from the perspective of developing countries in 2000, when a chapter on the topic was commissioned for the book mentioned above. The rapid pace of urbanization in Brazil, especially in Amazônia and in the cerrado, and all of the profound changes this has meant in national life mean that this process is related to all of the issues mentioned above. As one of the major transformations of Brazilian life in recent decades, its implications for values, behavior and national priorities related to climate change are multiple and profound. From the IHDP's point of view, this is an issue which is set to take off as a core project.

Conclusions

A reading of the international experience recommends both focusing on a limited number of themes and choosing themes in consonance with this experience. These issues are currently the object of research by the Brazilian environmental social science community, even though researchers have not often identified the link with climate change, much less with the nascent Earth System Science. An analysis of projects funded by Fapesp, for example, in the environmental field does not identify potential social science researchers for Earth System Science. They are to be found, not in self-declared climate researchers (perhaps a small number of geographers), but in a diversified group of researchers whose incorporation of a climate change dimension is both desirable and feasible.

A strategy which combines three components will be necessary for the long-term success of an integrated, multidisciplinary Earth System Science:

1) The incorporation of social science in the core curriculum of training programs in Earth System Science. Even with careful planning and good intentions of all concerned, however, this integration will take time. Expectations of reaching common understandings of the links involved, if they are not to be frustrated in the short term, must focus on the long term.

2) Research activities which explicitly require the contributions of distinct disciplines. Collaboration must be based on the idea that Earth System Science will not annul a disciplinary focus, denying legitimacy to inherited paradigms in the various scientific fields. Rather, it will break down rigid notions which mark disciplinary frontiers, creating more porous boundaries which will eventually transform the disciplines concerned as well as further the goals of interdisciplinary work. Since all research activity of a program in Earth System Science need not be equally interdisciplinary, a strategy for human dimensions will identify a limited number of questions for an initial phase. If these questions are chosen among fields already the object of social research, such as those mentioned above, the chances for success will be greater. Success itself, of course, breeds success. All concerned will be more willing to expand their research interests when the initial work has brought tangible rewards.

3) The selective incorporation of social researchers from outside Brazil. In the long term, a reliance on foreign researchers would not produce the desired result of engaging Brazilian social scientists in this endeavor. It is clear, however, that other social science communities have advanced faster and farther in the direction of Earth System Science. Participation of a limited number of such social scientists would be stimulating for all parties. International cooperation is surely an important component of all aspects of a program in Earth System Science. Considering the limited scope of Brazilian social science work on global environmental change, however, the risk of such cooperation taking on an aspect of tutoring will have to be considered.

Questions on Earth System Science

1. text is Human Dimensions of Earth System Science (and this will be the basis of my remarks, even trying to follow the outline provided by the Questions)
2. my own experience:
    a. related to lucc research; population distribution processes related to development processes in São Paulo and Brazil's Center-West
    b. open meetings IHDP
    c. comitê nacional
    d. interdisciplinary research
        i. participation
        ii. administrative responsibility
    e. Amsterdam declaration
    f. John Lawton, Science editorial, 2001
    g. Ojima em Beijing
3. so when I look at Earth System Science as result of all this process (IHDP, IGBP, Diversitas, WCRP), I see a move to
    a. interdisciplinary collaboration
    b. greater integration of approaches and research results
    c. if not a new science, a more unified view of a new scientific field in which different disciplines can adjust their methodologies and especially their questions, in light of the methodologies and questions of other disciplines.
    d. Not a move to dissolve disciplines, but to soften the boundaries so that we can communicate better and answer better, questions with a new focus.
    e. SO: when I then look at what the self-defined Earth System Science programs in US and European universities are doing, and the questions they ask, the staff they have, I don't see any continuity between the international programs and Earth System Science.
    f. With few exceptions, there is no biology and no sociology
4. INPE's history [read Gilberto Câmara and Carlos Nobre] has been different, over the last 10 years.
5. so, inclusion of "human dimensions" is not surprising; but there's not much in the way of guidelines or previous experience to light the way.
6. in the next 5, 10, 20 years, an Earth System Science which seeks to integrate social sciences into the process will be faced with a generalized consensus in the scientific community, a well-considered willingness on the part of INPE, but very timid practical experience in the real world.
7. unlike what one can see in Earth System Science programs on the web, the goals will be closer and reached sooner if a program is modeled on the experience of these international programs mentioned earlier.

8. as far as human dimensions are concerned, progress will depend on patience and that scarce academic value of humility; on creating specific research programs; and introducing students to the variety of research perspectives, some of which are still remote from climate change.
9. on observational requirements: from a human dimensions perspective, there has been indeed a good deal of progress which leaves social scientists better prepared today:
    a. georeferenced data bases
    b. integration of information from remote sensing with ground-level information;
    c. a move to multi-method strategies, which combine qualitative and quantitative techniques in the same research project
    d. specifically, the requirements will depend on the projects chosen in an initial strategy.
10. human resource requirements: progress from a human dimension perspective will depend on integrating social scientists into research projects and establishing collaboration with centers of excellence in human sciences. Easy to say, but it's a long road.
11. social/natural science interactions: more below
12. Applied Earth System Science: from a human dimension perspective, there are two directions:
    a. I believe the most direct and immediate gains would be from work on land use and land cover change; both transformation of forest into farms, fragmentation of forests, and urbanization patterns which consume land at rates far beyond population growth rates.
    b. An emphasis on adaptation to climate change, not just evaluating impacts of human activities, or *correcting* human activities, but what societies will have to do to prepare for the changes which are inevitable.
13. vou ler as conclusões do texto que preparei:

Conclusions

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7) It will also be important to incorporate social scientists' definitions of the problems, their formulation of the questions. I.e., we won't get far if the approach is to write terms of reference for what is needed from social scientists and contract the research needed. Social science views of the problems are likely to include concerns which may seem remote to natural scientists, but engaging them means meeting them at least half way. This will be especially challenging in Brazil, where empirical, quantitative social science does not have the same predominance as in other countries (specifically, in the US).