

Report of the Ad Hoc Group on Modelling and Assessment of Contributions to Climate Change (MATCH)

1. Introduction

In 1997, Brazil proposed a method to calculate contributions of emission sources to climate change (FCCC/AGBM/1997/MISC.1/Add.3). Although the original application to emissions reduction targets was not pursued, continued interest in the scientific and methodological aspects of the proposal by Brazil led to a series of expert meetings (reported in FCCC/SBSTA/2001/INF.2), followed by model inter-comparison exercise on “Attribution of Contributions to Climate Change” (ACCC, from which some results were reported in FCCC/SBSTA/2002/INF.14).

The SBSTA, at its seventeenth session, agreed that work on the scientific and methodological aspects of the proposal by Brazil should be continued by the scientific community, in particular to improve the robustness of the preliminary results and to explore the uncertainty and sensitivity of the results to different assumptions. (FCCC/SBSTA/2002/13, paragraphs 28-30).

Subsequent to this agreement the governments of UK, Brazil and Germany took the initiative to organize an expert meeting in September 2003 that formed the Ad Hoc Group on Modelling and Assessment of Contributions to Climate Change (MATCH).

Based on the conclusions of the SBSTA, the aim of MATCH is to improve the robustness of calculations of contributions to climate change due to specific emissions sources, building on the proposal by Brazil, and to explore the uncertainty and sensitivity of the results to different assumptions. The aim is to provide clear guidance on the implications of the use of the different scientific methods, models, and methodological choices. Where scientific arguments allow, the group would recommend one method/model/choice or several possible methods/models/choices for each step of the calculation of contributions to climate change, taking into account scientific robustness, practicality and data availability. Outputs of the group are primarily articles for the peer-reviewed scientific literature.

The SBSTA recognized the relevance of this work and the opportunity of this process to build capacity in climate change science. The governments of Germany, UK and Norway have generously provided funds for participation of experts from developing countries at the MATCH meetings.

Scientific experts of the MATCH group are listed in Annex A. MATCH was guided by a Scientific Coordination Committee, consisting of several experts engaged in the research on this issue including representatives from Brazil and the UK. Administrative support was provided by Ecofys under contract to UK DEFRA. All papers, meeting details and organizational matters are published on <http://www.match-info.net>

MATCH reported progress in a side event to the SBSTA in June 2004. Experts of the MATCH group will attend the meeting of the SBSTA in May and will hold a side event on the results.

2. Results

Several articles by members of the group on calculating contributions to climate change have been published in peer reviewed journals. Details are included in the Annex B.

A first joint paper of MATCH “Analysing countries’ contribution to climate change: scientific and policy-related choices” (published in *Environmental Science & Policy, Volume 8, Issue 6, December 2005*) evaluates the influence of different policy-related

and scientific choices on the calculated regional contributions to global climate change (the “Brazilian Proposal”). Policy-related choices include the time period of emissions, the mix of greenhouse gases and different indicators of climate change impacts. The scientific choices include different estimates of historical emissions and model representations of the climate system. Results from several simple climate models were compared.

This paper finds that the *relative contributions* of different nations to global climate change—attributing only emissions of long-lived greenhouse gases—are robust, despite the varying model complexity and differences in calculated absolute changes. For the default calculations, the average calculated contributions to the global mean surface temperature increase in 2000 are about 40% from OECD90, 14% from Eastern Europe and Former Soviet Union, 24% from Asia and 22% from Africa, Latin America and the Middle East.

Policy related choices, such as time period of emissions, climate change indicator and gas mix generally have larger influence on the results than scientific choices. More specifically, choosing a later attribution start date (1990 instead of 1890) for historical emissions, decreases the contributions of regions that started emitting early, such as the OECD countries by 6 percentage points, whereas it increases the contribution of late emitters such as Asia by 8 percentage points. However, including only the fossil CO₂ emissions instead of the emissions of all Kyoto gases (fossil and land use change), increases the OECD contributions by 21 percentage points and decreases the contribution of Asia by 14 percentage points.

A second joint paper of MATCH “Attributing a fraction of climate change to a nation’s historical emissions: closure and scientific uncertainty” puts further emphasis on the *absolute contributions* to climate change and the level of scientific uncertainty related to such calculations, comparing bottom-up and top-down approaches. It first evaluates whether emission inventories of the different greenhouse gases match with globally observed concentrations, and then how well the known sources of historical radiative forcing match the observed temperature record. With this knowledge it finally calculates the absolute contribution for one of the emissions cases in the first MATCH paper for which we have complete data (emissions from Annex I countries that are also in the OECD during a test period 1990-2002). The calculations include the effect of the chain of uncertainty on the results. The submitted draft of this paper will soon be available at www.match-info.net.

Other capacity developed as inspiration of the MATCH process: It should be noted that the MATCH process has also led to the development of capacity beyond that reported in the joint papers. For example, the first joint paper and the ACCC inter-comparison identified that for relative contributions a key scientific uncertainty derived from land-use-change emissions, particularly when considering contributions integrated over a long time horizon. Recognising this, a team from IVIG (Brazil) developed a detailed and flexible model of land-use emissions which has recently been coupled with the JCM carbon/climate model developed in UCL-ASTR (Belgium). This combination can now calculate contributions to climate change, including uncertainty distributions, for any country over any time-horizon. The complex results still require further analysis, documentation, and publication in a peer-reviewed journal. In addition, a researcher from CMA (China) visited NIWA (New Zealand) for an extended period to gain experience in modelling. These examples show that the role of the MATCH process in inspiring such north-south cooperation and capacity development should also be recognised.

3. Next steps

The two joint papers were anticipated as first steps in a series to be continued. The group agreed that the insights from these papers could naturally lead to a new paper with longer time scales including the 19th century, uncertainty per region, finer resolution of sources (countries, inside countries or over sectors), absolute and relative contributions and substantial new work on uncertainties for early emissions. Members of the MATCH group would also be eager to explore further areas of research in the same mode of working and building on the MATCH work so far. Many in the MATCH group plan to continue their work on

the scientific and methodological aspects related to contributions to climate change. If interest in this subject remains with SBSTA, then the group could report back in one to two years.

It could also be desirable to have a computer tool that could widely be used to calculate contributions to climate change of various emission sources. The user would select the specific input emission data and would make the policy choices such as time horizon and indicator. As seen in the first MATCH paper, these choices have a major influence on the results. The user might also explore the relative sensitivity to scientific uncertainties, such as ways of estimating land-use change emissions (coherently with other carbon cycle uncertainties). Several tools are already available, e.g. the Java Climate Model (www.climate.be/jcm), the FAIR model (www.mnp.nl/fair) and the CAIT tool (<http://cait.wri.org/>). Authors of some of these tools anticipate being available to demonstrate them, following a side-event at the SBSTA in May. The MATCH group would not develop a new tool, but would be available to assess and evaluate existing tools.

Annex A: Scientific experts of the MATCH group

Atsushi Kurosawa	Institute of Applied Energy, Tokyo, Japan
Atul Jain	University of Illinois at Urbana-Champaign, USA
Bård Romstad	CICERO, Oslo, Norway
Ben Matthews	Universite catholique de Louvain, Belgium
Brian O'Neil	IIASA, Laxenburg Austria
Christiano Pires de Campos	University of Rio de Janeiro, Brazil
Fabian Wagner	IIASA, Laxenburg, Austria
Gregory Bodeker	National Institute of Water and Atmospheric Research, Wellington, New Zealand
Guoquan HU	China Meteorological Administration, Beijing, China
Ian Enting	The University of Melbourne, Victoria, Australia
John van Aardenne	Joint Research Centre, Institute for Environment and Sustainability, Ispra, Italy
Luiz Gylvan Meira Filho	University of Sao Paulo, Brazil
Luiz Pinguelli Rosa	University of Rio de Janeiro, Brazil
Malte Meinshausen	Potsdam Institute for Climate Impact Research, Germany
Maria Silvia Muylaert de Araujo	University of Rio de Janeiro, Brazil
Michael Schlesinger	University of Illinois, Urbana, USA
Michiel Schaeffer	MNP/RIVM, Bilthoven, Netherlands
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Peter Stott	Hadley Centre for Climate Prediction and Research, Met Office, Exeter, UK
Promode Kant	Indira Gandhi National Forest Academy, Dehradun, India
Sarah Raper	University of East Anglia, Norwich, UK
Suzana Kahn Ribeiro	University of Rio De Janeiro, Brazil
Stephen W. Wood	National Institute of Water and Atmospheric Research, Wellington, New Zealand
Wandera Ogana	University of Nairobi, Kenya
Scientific coordination committee	
Joyce Penner (co-chair)	University of Michigan, Ann Arbor, USA
Jan Fuglestedt (co-chair)	CICERO, Oslo, Norway
Cathy Trudinger	CSIRO Marine and Atmospheric Research, Aspendale, Australia
Jason Lowe	Hadley Centre for Climate Prediction and Research, Met office, Exeter, UK
José Domingos Gonzalez Miguez	Interministerial Committee on Global Climate Change, Brazil
Michael Prather	University of California at Irvine, USA
Michel den Elzen	Netherlands Environmental Assessment Agency MNP/RIVM, Bithoven, Netherlands
Murari Lal	University of South Pacific, Suva, Fiji Islands
Xiaosu Dai	China Meteorological Administration, Beijing, China
Niklas Höhne (secretary)	Ecofys, Cologne, Germany

Annex B: Scientific articles on contributions to climate change

Joint articles by the MATCH group:

M. den Elzen, J. Fuglestedt, N. Höhne, C. Trudinger, J. Lowe, B. Matthews, B. Romstad, C. Pires de Campos, N. Andronova, 2005: "Analysing countries' contribution to climate change: Scientific uncertainties and methodological choices", *Environmental Science and Policy*, 8 (2005) 614–636

Various authors: "Attributing a fraction of climate change to a nation's historical emissions: closure and scientific uncertainty" (in preparation, draft soon available at www.match-info.net)

Articles by members of the MATCH group on the topic:

Pinguelli Rosa, Luiz , Ribeiro, Suzana Kahn. "The share of responsibility between developed and developing countries in climate change, Greenhouse Gas Mitigation". In RIEMER, P.W.F., SMITH, A. Y. and THAMBIMUTHU, K.V. Proceedings from the International Energy Agency Conference on GHG, Vancouver, 1997, Pergamon Press. 1997

Pinguelli Rosa, Luiz and Ribeiro, Suzana Kahn, 2001: "The present, past, and future contributions to global warming of CO₂ emissions from fuels", *Climatic Change* 48: 289-308, 2001

M.G.J. den Elzen, and Schaeffer, M. 2002: "Responsibility for past and future global warming: Uncertainties in attributing anthropogenic climate change", *Climatic Change* 54: 29-73

M. Andronova and M. Schlesinger 2004: "Importance of Sulfate Aerosol in Evaluating the Relative Contributions of Regional Emissions to the Historical Global Temperature Change", *Adaptation and Mitigation Strategies for Global Change*, 9, 383-390

Pinguelli Rosa, Luiz , Ribeiro, Suzana Kahn , Muylaert, Maria Silvia and Campos, Christiano Pires de ., 2004: "Comments on the Brazilian Proposal and contributions to global temperature increase with different climate responses - CO₂ emissions due to fossil fuels, CO₂ emissions due to land use change", *Energy Policy*, Volume 32, Issue 13, September 2004, Pages 1499-1510

Muylaert, Maria Silvia, Cohen, Claude, Rosa, Luiz Pinguelli and Pereira, André Santos.. "Equity, responsibility and climate change" *Climate Research* 28 (2004) pgs. 89-92

Muylaert de Araujo, Maria Silvia, Campos, Christiano Pires de and Rosa, Luiz Pinguelli. "GHG historical contribution by sectors, sustainable development and equity" *Renewable and Sustainable Energy Reviews*. Accepted in 6 July 2005, available on line

Campos, Christiano Pires de , Muylaert, Maria Silvia and Rosa, Luiz Pinguelli. "Historical CO₂ emission and concentrations due to land use change of croplands and pastures by country", *Science of the Total Environment* 346 (2005) pgs. 149-155

Cathy Trudinger, Ian Enting, 2005: "Comparison of formalisms for attributing responsibility for climate change: Non-linearities in the Brazilian Proposal approach", *Climatic Change*, Volume 68, Issue 1 - 2, Jan 2005, Pages 67 - 99

M.G.J. Den Elzen, M. Schaeffer, Paul L. Lucas, 2005: "Differentiating Future Commitments on the Basis of Countries' Relative Historical Responsibility for Climate Change: Uncertainties in the 'Brazilian Proposal' in the Context of a Policy Implementation", *Climatic Change*, Volume 71, Issue 3, Aug 2005, Pages 277 – 301

Nathan Rive, Asbjørn Torvanger, Jan S. Fuglestedt 2005: "Climate agreements based on responsibility for global warming: periodic updating, policy choices, and regional costs", *Global Environmental Change* (in press; published online)

Niklas Höhne, Kornelis Blok, 2005: "Calculating historical contributions to climate change – discussing the 'Brazilian Proposal'", *Climatic Change*, Volume 71, Issue 1, Jul 2005, Pages 141 – 173