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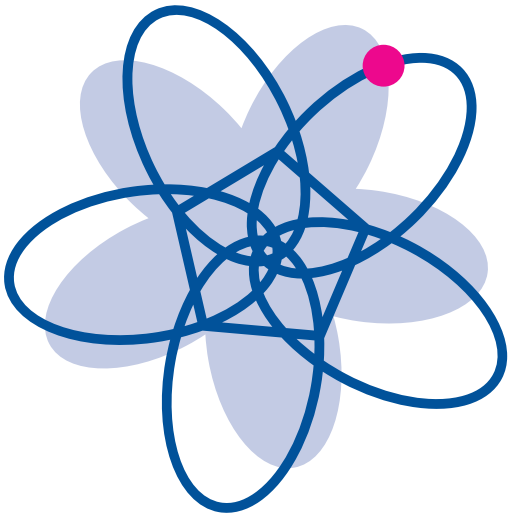

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Big ambitions and supercomputing: A case of industry engagement in climate modeling

Nils Randlev Hundebøl*

Abstract

In the late 1980's, climate change became a hotly debated public issue, a focus of interest in expanding research centers, and a problem that prompted international negotiations about future carbon dioxide regulation policies. At this time leaders of the University Corporation for Atmospheric Research (UCAR) in Boulder, Colorado, decided to join forces and establish an ambitious collaborative research project with the Electric Power Research Institute (EPRI), an energy industry based research institution, in order to strengthen UCAR's position in the US climate modeling community. The consortium that was the result of this strategic alliance is analysed in this article. The consortium brought together industry, public agencies, renowned research institutions, and distinguished scientists from all over the world and although a large variety of interests were involved the consortium found succeeded to find a common ground for a 5-year research effort. The Consortium was particularly interested in the questions of regional modeling, climate sensitivity and the scientific uncertainty of climate models and their results and transforming such knowledge to be suitable for the policy process. The consortium funded the dedication of a supercomputer to climate modeling that increased the computing capacity of UCAR's National Center for Atmospheric Research (NCAR), and it established a team to analyse the results of the supported projects. As the most lasting achievement of the consortium, the supercomputer became a step-stone for UCAR to establish a federally funded permanent

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climate simulation laboratory at NCAR.

Keywords, [Climate modeling, National Center for Atmospheric Research, Energy Industry, Private-public research cooperation, Uncertainty, Interest groups]

The following abbreviations and acronyms are used: ACACIA, A Consortium for Application of Climate Impact Assessments; ACC, Wendy Howe and Ann Henderson-Sellers, eds., *Assessing Climate Change, Results from the Model Evaluation Consortium for Climate Assessment*, (Amsterdam, Gordon and Breach Science Publishers, 1997), xxiv+418; AMP, Anthes, Richard, "About the MECCA project", in *ACC*: 1-27; CCS, Coupled Climate System initiative; CRIEPI, Central Research Institute of the Electric Power Industry; CSMP, Climate System Modeling Program; EdF, Electricité de France; EMP, Wendy Howe and Ann Henderson-Sellers, "Evolution of the MECCA project", in *ACC*: 29-51; ENEA, The Italian National agency for new technologies, Energy and sustainable economic development; EPRI, Electric Power Research Institute; GCM, General Circulation Model; IPCC, Intergovernmental Panel on Climate Change; MAT, MECCA Analysis Team; MECCA, Model Evaluation Consortium for Climate Assessment; NCAR, National Center for Atmospheric Research; NSCEE, National Supercomputing Center for Energy and Environment; NSF, National Science Foundation; PC, MECCA Policy Committee; PPA, Personal Papers of Richard A. Anthes, University Corporation for Atmospheric Research, Boulder, Colorado; PPM, Personal Papers of Peter K. Mueller, formerly Electric Power Research Institute, Palo Alto, California; TC, MECCA Technical Committee; UCAR, University Corporation for Atmospheric Research; USGCRP, United States Global Change Research Program

INTRODUCTION

This paper will analyze the establishment, organization, and activities of the Model Evaluation Consortium for Climate Assessment (MECCA). MECCA was an international consortium of industrial, academic, and governmental institutions that provided computational resources for 27 climate-modeling experiments and an associated analysis team from the spring of 1991 until the end of 1995, the time between the first and second reports of the IPCC. Co-founded by the University Corporation for Atmospheric Research (UCAR)[1] and the Electric Power Research Institute (EPRI)[2], MECCA provides a special case in the history of climate science that deserves some notice.

History of climate science has developed dramatically within the last two decades. Historians have investigated developments in the cultural and scientific understanding of climate and climate change,[3] outlined the evolving scientific understanding of the climate system and discovery of global warming[4] and analyzed the immense scientific machinery that are used in producing knowledge of global climate.[5] The history of climate science is also being enriched by memoirs of top climate scientists[6] and biographies of important scientists.[7]

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[1] A cooperation of more than 50 North American universities that runs the National Center for Atmospheric Research with funds from NSF.

[2] Research arm of the US electric utilities with headquarters in Palo Alto, California

[3] James Rodger Fleming, *Historical Perspectives on Climate Change*, (New York, Oxford: Oxford University Press, 1998), xi+194.

[4] Spencer Weart, *The Discovery of Global Warming*, (Cambridge, London: Harvard University Press, 2003), xi+228.

[5] Paul N.Edwards, *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming*, (Cambrigde, London: MIT Press, 2010), 528.

[6] E.g. Bert Bolin; *A History of the Science and Politics of Climate Change: The Role of the Intergovernmental Panel on Climate Change*, (Cambridge: Cambridge University Press, 2007), 292. Steven H. Schneider; *Science as a*

However, little has been written on the institutions and organizational settings were climate science has developed. A detailed account of NASA's atmospheric sciences, including its contributions to climate science, provides an important exception.[8] With no intention to make a general study of the institution of NCAR and its activities in climate science, this paper hopes to provide a detailed account of a part of this history, How a public-private research collaboration became central to its development in the early 1990's. In this sense the study follows the suggestion that an increasing number of detailed studies are important to provide a foundation for an advance in the understanding of the complex history of recent climate science.[9]

Recent historical investigations have dealt with the efforts of a few prominent scientists related to energy industry interest in their attempts to spread doubt and deconstruct knowledge about climate change and an extraordinary attempt to challenge parts of these results has been made.[10] Some of the events covered in this article and EPRI's interest in climate science in

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Contact Sport: Inside the Battle to Save Earth's Climate, (Washington D.C.: National Geographic, 2009), 304.

[7] James Rodger Fleming, *The Callendar Effect*, (Boston: American Meteorological Society, 2007), xv+155.

[8] Erik M. Conway; *Atmospheric Sciences at NASA: a history*, (Baltimore: John Hopkins University Press, 2008), xvii+386.

[9]Matthias Heymann, "Understanding and misunderstanding computer simulation: The case of atmospheric and climate science — An introduction," in: "Modelling and Simulation in Atmospheric and Climate Sciences," eds. Matthias Heymann, Helge Kragh, special issue, *Studies in History and Philosophy of Modern Physics* 41, no. 3 (2010), 193-200, esp. 196.

[10] Naomi Oreskes and Erik M. Conway, *Merchants of doubt : how a handful of scientists obscured the truth on issues from tobacco smoke to global warming*, (New York: Bloomsbury Press, 2010), x+345. Naomi Oreskes, Eric Conway, and Matthew Shindell, "From Chicken Little to Dr. Pangloss: William Nierenberg, Global Warmind, and the Social Deconstruction of Scientific Knowledge", *Historical Studies in the Natural Sciences* 38, no. 1 (2008): 109-152. Nicolas Nierenberg, Walter R. Tschinkel, and Victoria J . Tschinkel, "Early Climate Change Consensus at

general are related and very relevant to such discussions, but it is not the scope of this article to address these aspects. Instead the author will pursue such a study elsewhere based on materials related to what is presented here.

MECCA was developed in the aftermath of the Reagan era that had meant budget cuts and low morale among the staff at NCAR.[11] Finding it difficult to raise funds from federal sources UCAR started to look for new ways of raising money for the research at NCAR. One of such ways was the set-up of a Corporate Affiliates Program that should link UCAR with various corporations that could benefit from the atmospheric knowledge of scientists at NCAR.[12]

To NCAR MECCA funded computational resources in the early 1990's which were needed in order to support the start-up climate system modeling and keep up with the newly established and well funded institutions in Europe. The presence of the MECCA supercomputer at NCAR also provided arguments for UCAR and NCAR leaders in their efforts to establish a permanent climate dedicated supercomputer. Such a Climate Simulation Laboratory at NCAR has since the mid-1990's has been federally funded and provided a stable basic requirement for the needed access to computing resources.

A wide variety of sources has been used for this article and substantial parts are stored in the collections of persons central to the founding and organization of MECCA.[13] Although the

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the National Academy: The Origins and Making of *Changing Climate," Historical Studies in the Natural Sciences* 40, no. 3 (2010): 318-349.

[11] Evident from e.g. Delphi Question in the NCAR in-house newsletter: *Staff Notes*, 6 Dec 1985, 12 Feb 1986, 28 Mar, 1986, 18 Apr 1986.

[12] *Staff Notes*, 4 Apr 1986.

[13] The sources are personal papers of Richard Anthes and Peter K. Mueller. The Anthes Papers are expected to become part of the NCAR Archive. Mueller has previously donated a collection on his work on air emissions to the library of University of California at Davis, but the future of the rest of his collection is not decided. All sources

sources in this sense are not complete they cover in high details the correspondence between the various persons central to the development and management of MECCA, the correspondence between the MECCA managers and sponsoring and potential members, documents from the meetings of the MECCA Policy Committee (PC), MECCA's governing body, and programs and reports developed at EPRI and NCAR. As a consequence the sources provides insight to the various events, considerations and negotiation of MECCA that are put forward in this article.

The analysis suggests that MECCA was a complex scientific undertaking, which successfully accommodated a wide range of different interests. Developing this kind of cooperative research between industrial partners and research institutions was not an easy task. It required a sufficient overlap of interests and an adequate administrative structure, as well as a great deal of mutual trust, flexibility, and the willingness to compromise.

A NEW MANHATTAN-PROJECT TO INVESTIGATE CLIMATE CHANGE

In the mid-1980s a group of scientists at NCAR developed a plan to create a comprehensive climate model suited to simulating the full climate system.[14] The core idea of this initiative was the coupling of sub-models describing system elements of the earth, the atmosphere, the oceans, the land and ice masses, the biosphere and chemical cycles as well as human activities. This endeavor was called the Coupled Climate System (CCS) initiative.

The coupling of atmospheric Global Circulation Models (GCMs) with other sub-models of the earth system represented one of the important and debated research tasks in the climate modeling community at the time. A few early attempts to couple atmosphere and ocean models

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used for this article and others related to them are available to the author either as digital copies or in original print.

[14] AMP, esp. 4. The group consisted of John Firor, Stephen Schneider, Richard Anthes, Robert Dickinson, Ralph Cicerone, Robert Serafin and Edward Zipser.

had been made in the late 1960s and 1970s. From the mid-1970s to the publication of the first IPCC report in 1990 representations of clouds and of the earth's surface with land, ice, and ocean were included in the climate models. The development of dynamic ocean-atmosphere coupling represented the next major hurdle.[15] The inclusion and improvement of sub-models of the hydrosphere, the biosphere, the carbon cycle, aerosols, and atmospheric chemistry constituted further important research goals which have been achieved since 1990.[16]

Under CCS the NCAR-scientists had a vision of developing a definitive coupled model to answer fundamental questions about the relationship between man and climate. Such a model demanded significant improvements and extensions of the existing NCAR GCM, the Community Climate Model (CCM), such as the development and integration of new sub-models and an increase in the spatial resolution of the atmospheric model. The major requirement for these plans to proceed was perceived to be a new, more powerful supercomputer.[17]

According to Richard Anthes[18] CCS became NCAR's highest planning priority in 1985-1987. The costs and focus of the project, however, triggered conflict on research priorities

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[15]Spencer Weart: "The development of general circulation models of climate," in "Modelling and Simulation in the Atmospheric and Climate Sciences," eds. Matthias Heymann, Helge Kragh, special issue, *Studies in the History and Philosophy of Modern Physics* 41, no. 3 (2010): 208-217.

[16] H. Le Treut, R. Somerville, U. Cubasch, Y. Ding, C. Mauritzen, A. Mokssit, T. Peterson and M. Prather: "Historical Overview of Climate Change." In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. (Cambridge, New York: Cambridge University Press, 2007):94-127, esp. 99, fig 1.2.

[17] AMP, esp. 4-6

[18] Meteorologist, Director of NCAR Atmospheric Analysis and Prediction Division 1981-1986, NCAR Director 1986-1988 and UCAR President since 1988.

among NCAR divisions and scientists struggling for funds and disagreeing on whether or not the various sub-models were ready to be coupling considering the scientific state-of-the-art at the time. When NCAR in 1987 faced funding cuts after NSF received 10% less from the congress than suggested the initiative was not able to last and the original plan of CCS as an independent NCAR effort had to be abandoned.[19]

Instead, the basic concept of CCS was put on a broader base and incorporated into a new effort, the Climate System Modeling Program (CSMP).[20] UCAR initiated the CSMP in 1988 when Richard Anthes became UCAR President. In order to broaden the funding base for the program it was designed to include NCAR as well as university scientists with the hope of increasing the chances of raising funds from NSF, perhaps along with support from industry as the climate issue increased in political importance.[21]

On the basic level the scientific goals remained largely unaltered compared to CCS, to gain a better understanding of the complex interactions of physical and biological systems that affect the climate. Probably not coincidentally, an additional goal was put forward in this year where climate politics entered the agenda of both US and international policy discourses, providing better predictions of greenhouse gas forced warming of the global climate. The ability to use improved climate models to predict future changes was promoted in the US Global Change Research Program (USGCRP) that gradually worked its way through congress towards coordination of climate and global change research among the various agencies in the US and

[19] AMP, esp. 5-7

[20] The initiative was first called Climate System Modeling Initiative but later renamed. The later acronym is used throughout for convenience.

[21] AMP, esp. 7-9

increasing funding for earth system science. Its annual budgets eventually exceeded $1 billion.[22]

Richard Anthes put his efforts into promoting this UCAR endeavor enthusiastically in the scientific community both at NCAR and to scientists and administrators from the broader scientific community and national agencies, “One of the greatest things the NSF scientific community could do for global change (in my view) would be to create a 'Manhattan Project' to make a quantum advance in climate modeling, with emphasis on climate prediction resulting from greenhouse gas warming over the next 25, 50 and 100 years.”[23] CSMP gained support from the UCAR Board of Trustees as well as several leading scientists and administrators in late 1988 and early 1989.[24] In the following years UCAR attempted to gain funds for CSMP from governmental organizations, industry and as a new part of USGCRP.

In spring 1990, NSF offered a first small grant of $100,000 to establish a CSMP Project Office for the development of a detailed scientific program.[25] In the summer and fall of 1990 the Project Office worked out a scientific strategy. Developed especially to be a part of USGCRP, CSMP was designed to advance the predictive understanding of climate in a way that policy decisions could be guided by scientific understanding. Central to CSMP’s 10-year objectives was the development of integrated models of the earth system that could simulate global and regional natural and anthropogenic climate change on decadal and centennial time-scales.[26]

Science-editor Richard Kerr, summarised the CSMP-strategy for this new “supermodel of

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[22] Roger A. Pielke, jr, “Usable information for policy: An appraisal of the U.S. Global Change Research Program,” *Policy Sciences* 28, no.1 (1995): 39-77, esp. 40, table 1.

[23] Richard Anthes to Warren Washington and Robert Dickinson, 29 Sep 1988. Quoted in AMP, 8.

[24] AMP, esp. 8-9

[25] AMP, esp. 14

[26] Francis Bretherton and David Schimel, “A science strategy for the climate system modeling program”, draft, Oct 16 1990, PPA.

earth's climate" in an editorial in November 1990, "Different groups would build separate modules that would be slapped into a definitive model, the way the atom bomb was built within the Manhattan Project".[27] With this plan UCAR hoped to lead the US climate-modeling community, united to develop one single all-embracing climate model around the first supercomputer in the USA dedicated exclusively to climate research to be placed at the facilities of NCAR.

The NCAR-centered approach to CSMP, however, faced hostilities in the broader climate science community, afraid of draining money from other groups or undermining their independent existence. Also, the agencies which provided the bulk of USGCRP funding (the Department of Energy, NASA and NOAA) who all ran their own research programs on climate modeling took a skeptical stance towards the UCAR strategy. As a consequence CSMP was not supported by other USGCRP agencies and instead of becoming a nationally prioritized program of USGCRP NSF provided UCAR with funds for workshops and a post-doctoral fellowship program to strengthen cooperation between NCAR and university scientists in selected areas of research.[28] One single federal research strategy was infeasible and at this point funding for a supercomputer dedicated to climate modeling at NCAR had to come from other sources.

CREATING A CONSORTIUM

In the 1980s discussions about climate change became a growing concern for industry. By far the majority of energy supply was based on fossil fuels, which contributed significantly to carbon dioxide emissions. A new round of effective regulation to curb carbon dioxide emissions would have significant and long-term implications on energy production and future investments in

[27] Richard A. Kerr; "Climatologist Debate How to Model the World," *Science*, 23 Nov 1990, 1082-1083.

[28] AMP, esp.19.

energy technologies. EPRI, conducting research for the US electric utilities that would be affected by such changes,[29] responded to this challenge with an increased interest in climate science.

One direction of activity focused on the problem of climate prediction based on models. The suggestion by the Marshall institute to accelerate climate modeling effort for 3-5 years before deciding on climate policies[30] seems to have had an influence on the senior management in EPRI and its sponsoring utilities. In 1989 the EPRI President Richard Balzhiser and Robert M. White, President of the US National Academy of Engineering and former UCAR President, discussed the need for reliable climate predictions, if decisions on climate policy and investments in the public and private sectors were to be based on these models. Balzhiser and White agreed that further research would be needed to explore the reliability and applicability of existing climate predictions and cooperation between industrial partners and government institutions was an important opportunity for this.[31]

In this way EPRI's interests in climate prediction and models coincided with UCAR's intension to increase its computing facility through the efforts in CSMP. The Corporate Affiliates Program established contact with EPRI Vice President for Environment, Dr. George Hidy, and Environment Department senior scientific advisor, Dr. Ralph Perhac, in order to explore opportunities for raising funds for UCAR activities. On 8 November 1989 UCAR President Richard Anthes, Vice President Harriet Crowe and Corporate Affiliates Program Director Robert

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[29] Headquarter in Palo Alto, California. The Institute is mainly funded by US utilities. Around 1990 EPRI members produced approximately 70% of US electricity.

[30] Robert Jastrow, William Nierenberg, and Frederick Seitz, *Scientific Perspectives on the Greenhouse Problem*, (Washington D.C.:The Marshall Press, 1990), 254, esp. 67.

[31] George M. Hidy, foreword to ACC: xiii-xvi, esp. xiii

Bunting visited EPRI to discuss CSMP.[32]

Little more than two months later on 24-26 January 1990, EPRI Environment Division and UCAR arranged a collaborative "Workshop on greenhouse gases and climate change, Research need and industrial participation." At the workshop scientists discussed ways to advance climate research in light of the possibilities in climate modeling and measurements as well as the problem of leading researchers reaching retirement age and a perceived lack of young scientists entering the field.

To follow up on the connection between UCAR and EPRI after the workshop UCAR applied successfully for support to make a textbook on climate modeling and arrange a graduate summer school in 1991 in order to attract new scientists to the climate science.[33] EPRI was also invited to send representatives to the second CSMP workshop in April 1990.[34] It was at this meeting that Rick Anthes for the first time approached the representative of EPRI Environment Division Dr. Chuck Hakkarinen with the suggestion of sponsoring a NCAR-supercomputer dedicated to climate modeling.

The EPRI Environment Division had made a positive evaluation of the possibility to actively engage in climate science together with an established climate modeling center so UCAR and the EPRI Environment Division acted quickly to establish cooperation. On May 17 1990 high-ranking representatives[35] held a meeting at the EPRI headquarters to discuss a joint

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[32] AMP, esp. 10

[33] AMP, esp. 14, 20. The summer school took place on Jul 14-27 1991 at University of Wisconsin-Madison funded by EPRI and NSF. It was chaired by David Houghton and the primary source materials was the draft for the coming EPRI sponsored monograph on climate modeling: Trenberth, Kevin (ed.), *Climate System Modeling*, (Cambridge: Cambridge University Press, 1992), xxix+788.

[34] Anthes to Hakkarinen, 2 Feb 1990, PPM.

[35] Meeting Notes, 17 May 1990, PPM. Participants: Rick Anthes, Robert Street, Chair UCAR Board of Trustees,

EPRI-UCAR lease-to-purchase agreement for a CRAY XMP supercomputer dedicated to CSMP. UCAR suggested that EPRI should put forward approximately $10 million to support a supercomputer for 3 years and in turn adopt a leadership role in the allocation of computer time to scientific projects worthy of support. Experiments were to be chosen by an evaluation committee from a pool of relevant proposals submitted after an open call.[36] On 1 June UCAR sent a written draft version of this proposal to Hakkarinen and the draft was circulated within EPRI for assessment.

Different concerns emerged. Among the environmental staff the most important was the large costs, accumulating to a contribution of $12 million – with a yearly Environment Division budget of approximately $35 million and many existing projects this would consume a large amount of funds which was planned for other issues.[37] Also the relevance for utilities to support climate modeling compared to other research was questioned. However, the Head of the EPRI Atmospheric research section, Dr. Peter K. Mueller, endorsed the initiative and promoted the idea of creating a consortium so that EPRI could spread the financial load on a number of partners. He also asked UCAR to amend the proposal by emphasizing expected advances in climate prediction, which would be relevant for the utility industry for addressing production planning and federal policy issues.[38]

On July 27 1990, after a number of further suggestions and positive indications by

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Bob Serafin, NCAR director, Warren Washington, NCAR Climate Division Director, Ginger Caldwell, NCAR Scientific Computing Division Deputy Director, George Hidy, Ralph Perhac, Peter K. Mueller, and several other EPRI staff members.

[36] Ibid.

[37] Environment Division 1991-1993 Program Research Plan, Nov 1990, PPM.

[38] Neumann to Mann, 19 Jun 1990, PPM, Fawcett to Neumann, 14 Jun 1990, PPM, Shiver to Anthes, 3 Jul 1990, PPM.

Hakkarinen and Mueller, UCAR sent an official proposal to EPRI that covered details for the lease of a CRAY XMP for a period of 3 years starting October 1 1990. The total costs added up to $20.8 million of which NCAR would contribute an in-kind contribution of $8.3 million, while EPRI (and possible other sponsors) had to cover the remaining $12.5 million.[39]

The Environment Division could not navigate the EPRI internal policies fast enough to meet the short deadline in the UCAR proposal but by the end of September it had got the necessary backing of the advisory boards of EPRI (appointed by the electric utilities) and launched an internal $2.5 million application for a climate modeling project. After a review of the UCAR proposal Richard Herz, EPRI Contracts Division Director, informed Anthes that the proposal had been selected for final negotiation on December 13.[40]

After the support from the advisory boards was secured in October, the Environment Division intensified its search for additional consortium partners in the USA and abroad. UCAR had already contacted foreign institutions like Electricité de France (EdF, the French national utility company) and the Italian National agency for new technologies, Energy and sustainable economic development (ENEA, a government institution advising on environment questions) in search for CSMP-sponsors. EPRI renewed these requests and pursued existing international relations to electric companies and research institutions and suggested that the respective organizations became member of a joint consortium. In November 1990, ENEA and the Central Research Institute of the Electric Power Industry (CRIEPI) of Japan declared their willingness to contribute $1.35 million and $1 million respectively. A few months later, in February 1991, EdF

[39] Shiver to UCAR distribution, 12 Jul 1990, PPA, Hakkarinen to Shiver, 25 Jul 1990, PPA, Shiver to Hakkarinen, 26 Jul 1990, PPA, Anthes to Hakkarinen, 27 Jul 1990, PPA, Walker to Herz, 30 Jul 1990, PPM.

[40] Mueller to Walker, 1 Oct 1990, PPM, Hakkarinen, Research Project Action, 5 Oct 1990, PPM, Herz to Anthes, 13 Dec 1990, PPM.

announced its participation with a contribution of $600,000.[41]

Additionally an "Industry Liaison Meeting" was organised in Boulder on 18 October, from which EPRI hoped to gain further support for the planned climate-modeling consortium from US heavy industries. The meeting brought together representatives from major US industries and internationally recognised NCAR-scientists[42] to discuss topics such as the assessment of climate model predictions and industry investments in climate science. The meeting resolved in indications that the idea would be taken up within several corporations and the EPRI organizers corresponded with participants on the formation of a "Plan for Consortium Management".

The consortium eventually failed to gain the support of the US heavy industries – real negotiation only took place with IBM and the Motor Vehicles Manufactures Association. Already in the spring of 1990 IBM had suggested a joint project between IBM and EPRI on climate modeling which would open this market to IBM.[43] Half a year later, when the agreement between UCAR and EPRI had been established and UCAR had suggested a CRAY XMP supercomputer, EPRI hoped for cooperation that could satisfy and thereby get support from both computer manufacturers. Scientists in the NCAR Climate Modeling Section, however, interfered and opted strongly for a newer and more powerful CRAY YMP, which – after a good offer by CRAY – eventually became the choice for the project. EPRI still suggested IBM to make a cash

[41] Clemente to Anthes, 14 Nov 1990, PPM, Amano to Hidy, 13 Nov 1990, PPM, Delcambre to Anthes and Mueller, 8 Feb 1991, PPM.

[42] List of attendees, Industry Liaison Meeting, Oct 18 1990, PPM. AMP, esp. 16. Attending was representatives from General Motors, Southern Company services, Ford Motor Company, Hughes Aircraft, CRAY Research, IBM Scientific Center, American Petroleum Institute, Western Fuels Association and MITRE and among others Kevin Trenberth, Francis Bretherton and Jerry Meehl.

[43] Ottem to Mann, 14 May 1990, PPM.

contribution of $2.5 million, an investment that would later be offset partially by enhancement of the IBM mass storage systems at NCAR and possibly also new workstations for MECCA scientists, but IBM turned down this smaller option.[44] A member of the General Motors research staff was highly interested and corresponded several time with EPRI organizers. As a result of his work Motor Vehicles Manufactures Association was perceived to be a member in April 1991 after a struggle between General Motors and other more reluctant members. But announcing severe losses in early 1991 General Motors management withdrew its support just before the final agreements were signed and car industry did not enter the consortium.[45]

In spring 1991 all arrangements were in place for MECCA, the name and acronym coined by Hakkarinen at the Industry Liaison Meeting. The "Plan for Consortium Management" was completed and emphasized the necessity to bridge the gap between long-term basic science programs like CSMP and the short-term needs of decision makers looking for results within a three year timeframe.[46] A PC, in which every consortium member had one vote, assumed the formal leadership, chaired by Peter K. Mueller. Review of projects and recommendations on the scientific developments of MECCA were to be made by a Technical Committee (TC), to which the consortium members could put forward qualified scientists. This committee was chaired by Chuck Hakkarinen who was also the project manager and so responsible for the daily administration of the scientific projects supported by MECCA. The first meeting of the MECCA PC took place in Boulder on May 9-10 1991.

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[44] Buzbee to NCAR distribution, 12 Dec 1990, PPM, Hack to Anthes, 31 Dec 1990, PPA, Buzbee to Anthes, 2 Jan 1991, PPA; Hack to UCAR distribution, 3 Jan 1991, PPA, Hakkarinen to Anthes, 13 Mar 1991, PPM, Mueller to Hidy, 21 Mar 1991, PPM.

[45]Hakkarinen to Mueller and Neumann, 27 Mar 1991, PPM, Roth to EPRI File, 2 May 1991, PPM.

[46] Plan for Consortium Management v 7.0, EPRI 1991, pp. 10, PPM, esp. p. 4.

DEVELOPING A RESEARCH AGENDA

A basic requirement for the research consortium was the development of a coherent research plan that satisfied all consortium members and their different interests. For the discussion of research plans, a meeting was scheduled on January 28 1991 in Boulder with scientists from research institutions and potential MECCA members. This group later became the official TC.[47]

Preparation for this meeting involved various negotiations due to the different expectations, concepts and goals of the consortium members. UCAR essentially sought to realise the CSMP project. It had approached the other organisations with this goal and hence regarded the Consortium as a sponsor of advanced climate system modeling at NCAR with partial influence on the allocation of resources.

The EPRI Environment Division wanted a consortium with a strong and independent agenda. It suggested new simulation experiments including the investigation of additional forcings to the climate system like tropical deforestation and the effects of sulphate aerosols that were expected to be (and did become) important topics in the coming years. As a second goal, it sought to apply climate simulation results to various kinds of impact assessment. A third goal was the analysis of the uncertainty of simulation results, natural variability and validation of models. After initial discussions with Hakkarinen and Mueller, all EPRI goals were integrated into a draft research plan by Dr. W. Lawrence Gates, a renowned and influential climate modeler at the Lawrence Livermore National Laboratory.[48]

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[47] AMP, esp. 23. Members were Chuck Hakkarinen (Chair), EPRI, Jean-Yves Caneill, EdF, Ulrich Cubasch, MPI, Lawrence Gates, LLNL (EPRI Consultant), Gerald Meehl, NCAR, Shaw Nishinomiya, CRIEPI, Dave Schimel, UCAR, Maurizio Sciortino, ENEA, and Albert Semtner Jnr., Naval Postgraduate School.

[48] Lawrence Gates, “Experiment and analysis plan”, Jan 1991, PPM.

All foreign consortium members expected regional climate predictions for their respective regions to get more detailed knowledge of what consequences climate change might have in their region than the global models provided. Besides this regional concern EdF sought improve its hydrological research by collaborating with NCAR,[49] ENEA wanted to promote climate modeling in Italy by training Italian scientists at NCAR,[50] and CRIEPI was looking to strengthen research connections to EPRI and NCAR and build in-house competence in climate modeling on a global and regional scale. These were all interests that could be separated from a joint Consortium. Some common interests existed but a joint consortium was not the only way these could be met. However, the consortium solution was preferable to both UCAR as this was the way to raise the funds for the supercomputer they both strived for and the coming partners sought to adapt their own expectations to each other while still keeping the potential consortium members. The same could be said for EPRI with the exception that the had the possibility to join with another research center.[51]

At UCAR, Wayne Shiver, assistant of UCAR president Richard Anthes, and CSMP project scientist David Schimel prepared a draft agenda for the January meeting. It evolved around CSMP, which was taken as the common research focus of the consortium. At EPRI this was noticed and as a response called for “more of a Consortium context” to “achieve synchronisation between Consortium and UCAR-NCAR goals.” They wanted the consortium to be an autonomous endeavor with its own objectives and not as an integrated and subordinated

[49] Wendy Howe, Jean-Yves Caneill, Maurizio Sciortino, James Young, Shaw Nishinomiya, Walter Ruijgrok, Bahram Nassersharif, Robert Serafin and W. L. Gates; “MECCA consortium overview and members' views”; in ACC: 381-396, esp. 382

[50] Ferrara to Shiver, 18 Jan 1991, PPM.

[51] EPRI had connections to IBM as discussed in the previous section. EPRI also had contacts to a supercomputing center in San Diego. Mueller to Walker, 10 Oct 1990, PPM.

part of CSMP. To ensure a proper representation of EPRI goals they required an opening discussion on Consortium objectives and governance moderated by Hakkarinen as well as a discussion of the Gates plan before the committee settled the relationship with CSMP. After a delicate correspondence during the weeks up to the meeting it ended with a compromise – Anthes presented a "UCAR Perspective" after Hakkarinen's opening of the meeting, which was followed by a discussion of the Gates plan and how this could be connected to CSMP and other research programs.[52]

The meeting succeeded in uniting the different participants. Gates completed a revised, more elaborated and forward-looking research-plan in March, which represented the basis for the MECCA research program and call for proposals. Due to the discussions this revised plan looked rather different from the first version. The March-plan adopted a structure of research phases with separate objectives, as commonly used at NCAR, instead of listing specific experiments and analysis procedures suggested by EPRI in the original Gates-plan. Phase 1 of MECCA was to last six months and focus on short-term sensitivity studies in order to determine key parameters responsible for uncertainties of GCM simulations. Phase 2 covered the remaining years of the project and would include more extended tests of these key parameters based on the new version of the NCAR climate model, CCM2, a high-resolution state-of-the-art model, which was expected to be available by that stage. The new plan included comprehensive instructions on how to examine uncertainties of climate simulation results in the MECCA experiments. Furthermore, it presented a range of analysis procedures for simulation data, which climate modelers could apply in order to make simulation data applicable to impact analyses and

[52] Draft agenda, 17 Jan 1991, PPM, Neumann to Shiver, 18 Jan 1991, PPM, Draft agenda, 21 Jan 1991, PPM, Agenda, 24 Jan 1991, PPM.

regional projections.[53]

Eventually MECCA emerged as an autonomous climate-modeling project, although closely linked to the overall CSMP strategy by strengthening the climate modeling resources at NCAR – in UCAR MECCA was still regarded as a kind of industry component to CSMP.[54] The official MECCA goals read, "To quantify the probable range of future climate change; To provide policymakers with information that could be used to coordinate decisions with scientific developments; To identify key topics needing research to improve climate forecasts".[55] In this way MECCA attempted to balance the different goals involved – the scientists' interest in advancing climate models and increasing understanding of the climate system, and the interest of the energy industry and of public institutions to gain useful information on local regions for the preparation of future management decisions as well as input to the ongoing public discussions and policy negotiations. From a scientific point of view, MECCA pursued highly relevant research questions in the early 1990s. It set out to consider crucial aspects of model development and assessment, which had not been resolved, and how best to approach scientific assessments of future climate change suitable for policy making.

ORGANIZING MECCA AND ITS EARLY ACTIVITIES

On March 22 1991, immediately after Gates' research plan was finalized, an announcement for

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[53] Lawrence Gates, Experiment and analysis plan v 2.2, Mar 1991, PPM.

[54] Anthes, Richard A., Francis P. Bretherton and David. S. Schimel; "Climate System Modeling Program," paper presented at the 72nd Annual Meeting of the AMS, Jan 5-10 1992, PPA.

[55] Electric Power Research Institute, "Model Evaluation Consortium for Climate Assessment: Addressing Uncertainties Associated with the Prediction of Future Climates", *IEEE Power Engineering Review*, Jul 1992: 15-17, esp. 15, PPM.

MECCA phase 1 including a call for proposals was sent out. Based on recommendations from the TC, the MECCA PC decided at its first meeting on May 9-10 to support four experiments out of 17 proposals.[56] Active project work could start as soon as the Cray YMP supercomputer was in place. Additionally, six proposals were selected for potential support subject to further clarification.[57]

There had turned out to be fewer proposals of a more limited scope than the MECCA TC had hoped for. In order to increase the creativity of proposals and win the support of more "eminent scientists" for MECCA the Committee recommended making the research plan less prescriptive which was endorsed by the PC. As a consequence the final research plan from August 1991 was less restrictive but it did not have the coherence of a coordinated research project as it lacked the analysis suggestions that should go across the different experiments to make them easily suitable for impact studies etc.[58] The number of supported projects in phase 1 increased to 14 experiments, most of which were consistent with the research phase's overall focus on sensitivity studies, but not particularly suited to cross-project analysis.[59]

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[56] Experiments chosen for support were: David Williamson, NCAR: Grid scale sensitivity; Ann Henderson-Sellers, Macquarie University, Australia: Tropical deforestation; Barry Saltzman, Yale University: GCM sensitivity to varying CO2 concentrations; and Warren Washington et al, NCAR: GCM sensitivity to ocean-coupling scheme.

[57] PC Meeting Minutes, May 1991, esp. 3-4, PPM

[58] Chuck Hakkarinen, Experiment and analysis plan v 3.1, Aug 1991, PPM. Hakkarinen today agrees to this assessment.

[59] HSS, esp. 31-34. Experiments included those mentioned in footnote 55 and the following: Filippo Giorgi, NCAR, et al.: Regional climate change scenarios for the United States and Europe, Starley Thompson, NCAR, et al.: GCM surface sensitivity experiments, T.N. Krishnamurti, Florida State University: Climate modeling with emphasis on tropical rain, Wei-Chyung Wang, State University of New York at Albany: Assessment of the climate effect of other greenhouse gases, Bryant McAvaney, BMRC, Australia: Sensitivity of an atmospheric GCM to mass flux schemes,

A range of further issues central to MECCA phase 1 featured on the agenda of the first PC meeting. The three most prominent topics were the questions of how to analyse and use the results of MECCA experiments, the presentation of MECCA results for the public, policy makers and at the forthcoming United Nations Conference on Environment and Development in Rio de Janeiro in June 1992, and how to obtain the additional funding needed for the full project.

The MECCA research plan had suggested the establishment of a central analysis team which would coordinate the evaluation of results of the simulation experiments and subsequent impact analysis. In May 1991 the PC members approved the formation of such a team and put Hakkarinen in charge of hiring a leading scientist to head the team before August. The task proved impossible, however, as such a coordination team was new to climate modeling and unique to MECCA. The role and work of the analysis team leader hadn't been defined sufficiently clearly in the original plan for a leader to be appointed. So, at the next PC meeting in Rome held on October 1-2 1991 Peter K. Mueller and Jacques Delcambre of EdF were charged with providing a specification. This was finally approved at the PC meeting in Palo Alto on February 27-28 1992 and the search for a leader could start in earnest.[60]

The MECCA PC pursued the ambition for MECCA to become a visible and respected contributor to climate science. At the same time, they sought influence on public discussions through the marketing of the Consortium's activities in the public sphere and the dissemination

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Valentin Meleshko, Voikov Main Geophysical Observatory, Russia: Sensitivity of equilibrium climate in a GCM to cloud parameterisation schemes, William Holland, NCAR, et al: Sensitivity of climate simulations to changes in ocean circulations, Edwin Schneider and James Kinter, University of Maryland: Internal variability in long-term climate simulations, Robert Chervin, NCAR, and Bert Semtner, Naval Postgraduate School: Sensitivity of ocean model circulation to atmospheric forcing, Tim Kittel, NCAR: Regional climate change impacts on northern great plains ecosystems.

[60] PC Meeting Minutes, Oct 1991, esp. 3, PPM, PC Meeting Minutes, Feb 1992, esp. 3, PPM

of results to industrial and governmental stakeholders. To achieve these goals it was decided in May 1991 to establish a Communications Office, and a professional agency was hired.[61] The Communications Office prepared a "Marketing Plan for North America" for the October PC meeting with a strategy "to position MECCA as an innovative, scientifically credible project."[62] The plan outlined a range of activities aimed at scientists, industry, policy makers, and the public to achieve this objective. MECCA should establish a unique identity, communicate MECCA activities and plans to all target audiences, and search solicitation from outside by creating an advisory panel and enter into discussions with parties interested in the climate issue. Last but not least, the final goal was to deliver key results to analysts and policy makers.

The Communication Office, however, were not particularly successful in its efforts and MECCA received limited coverage in the media and the other efforts to engage the stakeholders never made it to discussion in the PC. The news releases produced only found their way to local newspapers or energy journals and the representation of MECCA in Rio turned out to be very limited – the Communications Office had a small exhibition stand at the Global Forum, a public venue parallel to the conference mainly organized by NGO's, where it displayed background information on MECCA. The message delivered by the Communication Office in general was that MECCA sought to accelerate climate modeling and provide the results to policy makers in order to make "better" climate policy. It also tried to distance more obstructive industry groups like the lobby organizations of Western Fuels Association.[63] For the UN Conference in Rio 1992

[61] The office was operated under a MECCA/EPRI contract by an independent contractor: Science & Technology Management, Inc., Brookfield Wisconsin.

[62] MECCA Communications Office, North American Marketing Plan v. 1.4, 23Sep 1991, pp. 9, esp. p. 2, PPM.

[63] Ross Gelbspan, *The Heat is On*, (New York: Addison-Wesley, 1997), viii+278, esp. 34-35.The Information Council on the Environment funded by Western Fuels Association had begun a campaign to promote the views of

it sent out four MECCA findings that stated that as the CO2 concentration became higher the temperature increase of additional CO2 would level of,[64] pointed to dissimilarities between predicted and measured temperature trends in the arctic, highlighted the different effect by the various greenhouse gases and pointed to a needed increase in computer power if improved projection on the regional scale were to be made. MECCA publicly suggested a policy that emphasized more than just actions on CO2 emissions and that policy should be based on scientific projections and analysis of these that emphasized question central to society – questions which MECCA itself tried to answer.[65]

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so-called greenhouse skeptics like Pat Michaels, Robert Balling and S. Fred Singer.

[64] This leveling of must not be confused with an overlap between the absorption bands of CO2 and water wapor, a claim that held merit in the early 20th century but was challenged by the work of scientists like Guy S. Callendar and Gilbert Plass. Basically the leveling of stemmed from the effect that an increase of e.g. 100ppm CO2 would have a lower effect when the general atmospheric levels were high than if the atmospheric levels were lower. For a detailed discussion that is more complex and suggests that the water wapor bands might saturate at increasing level of water wapor in the atmosphere as a result of increase in CO2 see the article the finding was based on: Oglesby, Robert J. and Saltzman, Barry: "Equilibrium Climate Statistics of a General Circulation Model as a Function of Atmospheric Carbon Dioxide. Part I: Geographic Distributions of Primary Variables", *Journal of Climate* 5, no.1: 66-92

[65] Articles on the new NCAR-supercomputer printed in: *Denver & The West*, Jun 17 1991, PPM, *Rocky Mountain News*, Jun 17 1991, PPM, *Daily Camera*, Jun 17 1991, PPM, *The Scientist*, Jul 8 1991, PPM, *Environmental Science and Technology* Vol. 25 no. 8 (1991), PPM, *The Energy Daily*, 15 Aug 1991, PPM, *Power Engineering*, Aug 1991, PPM, as well as the newsletters of EPRI and Edison Electric Institute, Aug 1991, PPM. Several news releases were produced in relation to announcements of the foundation MECCA and new MECCA members without being covered. The *Journal of the Air and Waste Management Association* published one of the news releases produced in relation to the Rio Summit in its Sep 1992 issue (pp. 1218-1219)**,** in which the presence of MECCA at Rio was described. Head of the communication office, Dennis Kois, published a letter in *The Electricity Journal*, in which he presented the MECCA approach to climate modelling and policy making as a "middle" approach between the ones suggested by the Marshall Institute and The Investor Responsibility Research Center, which both had a long article

A funding gap of approximately $7 million existed in 1991 for the full project duration of three years and MECCA needed additional consortium members in order to proceed beyond the first 15 months, the minimum lease time in the CRAY-contract. Because of this financial uncertainty the first research phase was prolonged so that it lasted the full 15 months of the initial lease. Work on phase 2 would only begin when additional funding was secured.[66]

The funding problem proved to be harder to solve than the question of project analysis. At the October-meeting the funding gap had increased to $9 million because of lower in-kind contributions by NCAR. Potential partners existed, but an extension of the consortium had not yet materialised. Both ENEA and EdF refused to increase funding, CRIEPI announced potential further support from the Japanese industry and EPRI considered increasing its contribution. As a result, the PC decided to stop future allocation of cash to the supported scientists and only provide computer resources to experiments, a resource the committee believed would be dramatically increasing.[67] Japanese computer manufacturer Fujitsu had indicated an interest in joining the consortium and had suggested donating a supercomputer of an estimated value of $15 million, which would dramatically increase the potency of MECCA computer resources.

The Fujitsu contribution did not materialize, however, as complaints and lobbying by CRAY at the US national political level forced Fujitsu to withdraw the offer.[68] At this time UCAR made an attempt to find a compromise to join the competing manufacturers CRAY and Fujitsu in MECCA but as EPRI's attempt with CRAY and IBM it failed. Instead UCAR, CRIEPI

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in the previous issue, PPM. MECCA UNCED flyer, Jun 1992, PPM, PC Meeting Minute, Feb 92, esp. 2-3, PPM.

[66] PC Meeting Minutes, May 1991, esp. 5-8, PPM.

[67] PC Meeting Minutes, Oct 1991, esp. 3-4, PPM.

[68] Kris Herbst, *Supercomputing Review*, Jan 1992, p. 21-22, PPA.

and Japanese partners began to establish a new collaboration in Japan.[69]

Early in 1992 the Dutch energy consulting company KEMA joined the consortium and provided $100,000 for 1992 with the option of making the same amount the following year. Also EPRI increased funding which now officially added up to $3.9 million. ENEA, on the other hand, reduced its commitment considerably from $1.35 million to $900,000.[70] In spite of funding uncertainties, the PC decided to continue MECCA and prepare to proceed into phase 2. The committee members were optimistic about attracting new partners and negotiating increased contributions from present consortium members. They also estimated that it would be possible to renegotiate the contract with CRAY in order to decrease the cost of computer lease for the years to come.[71] CRAY acceded to this request and with some additional minor budget changes Mueller could announce a second phase of MECCA in September 1992 – although it seemed likely that computing activities would need to be stopped some months earlier than planned to decrease a funding gap of $4.2 million.[72]

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[69] Anthes to UCAR distribution, 2 Jan 1992, PPA, Issue Paper: Joint U.S./Japan Climate Change Research Laboratories, draft, Mar 5 1993, PPA, Anthes to Boright (Deputy Secretary of State), 10 Aug 1993, PPA.

[70] These are the amounts of the MECCA Status Summary of 27 Feb 1992, PPM. The EPRI Research Project Change of 10 Feb 1992, PPM, shows that the EPRI Environment Division applied for a total EPRI contribution of $8.2M. It seems this larger amount is more correct and was an EPRI maximum contribution. Probably EPRI only made the lesser amount official in an attempt to increase contributions from current members and find new sponsors, indicated by the fact that EPRI later was willing to double additional amounts by other members and apparently paid the shortfalls without further applications.

[71] PC Meeting Minutes, Feb 92, esp. 4, PPM

[72] Mueller to PC, 2 Sep 92, PPM.

THE MECCA ANALYSIS TEAM

One issue surrounding the organisation of MECCA experiments was the tension between a bottom-up (as with the final research plan of August 1991) and a more strictly defined top-down research approach (suggested in the plan of March 1991). In February 1992 the TC recommended strengthening a top-down organisation of forthcoming experiments to make them suitable for analysis in the coming phase 2. Since MECCA had established itself as a credible research project by attracting ”world-class scientists” for phase 1 the committee suggested to support experiments more relevant to the specific goals of the proposed MECCA Analysis Team (MAT).[73]

In July 1992, MECCA succeeded in appointing Ann Henderson-Sellers, a leading climate scientist,[74] as head of MAT. MAT’s goals were to, “Ensure systematic examination of existing and future MECCA projects; synthesise MECCA assessments with results from other international projects; and relate model uncertainties to questions of importance to policymakers”.[75] With Henderson-Sellers in charge MAT immediately started a range of activities and introduced new energy to MECCA.

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[73] PC Meeting Minutes, Feb 1992, esp. 3-4, PPM

[74] Henderson-Sellers, D.SC., PhD in meteorology, started her career at the University of Liverpool (1977-1988) before she became Professor and Director of the Climate Impacts Center at Macquarie University, Sydney, 1988. She was Lead Author of the IPCC Second Assessment Report (SAR), Working Group 1, Chap. 5, and Contributing Author to Chap. 3, 6, as well as Working Group 2, Chap. 1. She also contributed to the IPCC Third Assessment Report and the Fourth Assessment Report. She is a Fellow of the Royal Astronomical Society, American Geophysical Union and American Meteorological Society. She has led a number of international climate research projects and is an ISI highly cited scientist in geosciences http://hcr3.isiknowledge.com/author.cgi?id=4875&cb=7188, 21 Oct. 2009.

[75] EMP, esp. 34

Shortly after its establishment MAT sent out a questionnaire to all Principal Investigators (PI) of phase 1. In this questionnaire MAT asked for access to project results and for help with the analysis of results. While most modelers supported MECCA in general, they proved reluctant to spend their own time on MAT related projects and the evaluation of results for addressing policy issues. Henderson-Sellers summarised the scientists most frequent responses with some irony, "(a) 'we'd like to help but we're too busy'; (b) 'not our job and we're not interested'; (c) 'what we do is complex and interesting, policy making is done in newspapers'"[76] – the efforts that did not pertain to their main research interests. The scientists were satisfied to receive computing time in order to conduct their planned experiments but they wanted to do science rather than impact analysis for policy purposes.

Despite the unwillingness to work with MAT the questionnaire proved important as it suggested that modelers distrusted the methods of impact analysis and feared that GCM-simulation data could be used in unjustified ways.[77] MAT-correspondence with analysts on the other hand showed that they felt neglected and desired many more parameters than the modelers provided.[78] Henderson-Sellers wanted to resolve this problem and hoped that MAT could become a sort of mediator between both groups. GCM-modelers had to recognise the importance and needs of impact-analysis. At the same time analysts had to understand the limitations of GCM-data and use them in ways appropriate to the status of the results. As a tool to facilitate better mutual exchange, MAT developed a "MECCA Archive of Daily Data" and the "MECCA

[76] Henderson-Sellers, A., W. Howe, K. McGuffie; "The MECCA analysis project," *Global and Planetary Change* 10 (1995): 3-21, esp. 15.

[77] Ibid, esp. 14

[78] Ann Henderson-Sellers and Wendy Howe; "MECCA achievements and lessons learned"; in *ACC*: 359-380, esp. 368-69

Protocol." In the MECCA Archive of Daily Data eight relevant parameters from six MECCA experiments were collected in standard format that could be distributed to analysts upon request through the MECCA Protocol, that provided a well-defined structure and format for exchanging knowledge in a manner that both met the analyst's needs of climate data and the scientific constraints on the GCM simulated results.[79]

The MECCA Archive of Daily Data was also needed for another proposed task – the intercomparision of simulation results from different GCMs in MECCA. Around 1990 model construction was not the only major concern in the climate modeling community, model validation had also become an issue. Due to the inherent limitations of model validation, so-called "Model Intercomparison Projects" (MIP's) became an increasingly important approach to evaluating model performance from the late 1980s onwards.[80] The comprehensive international Atmospheric Model Intercomparison Projects had started in 1989[81] and Henderson-Sellers herself was personally involved in the Project for Intercomparison of Landsurface Parameterisations, which started in the early 1990s.[82] Henderson-Sellers suggested intercomparison of MECCA experiments though it was not initially planned. In the TC Hakkarinen and Gates supported this suggestion strongly and it was officially approved by the

[79] EMP, esp. 38-39

[80] See e.g.: Lenard, Johannes, and Eric Winsberg: "Holism, entrenchment and the future of climate model pluralism," in "Modelling and Simulation in the Atmospheric and Climate Sciences," eds. Matthias Heymann, Helge Kragh, special issue, *Studies in the History and Philosophy of Modern Physics*, 41, no.3 (2010): 253-262.

[81] W. Lawrence Gates, "AMIP: The Atmospheric Model Intercomparison Project"; *PCMDI Report No. 7*, Dec 1992 - updated Mar 1997, http://www-pcmdi.llnl.gov/publications/PCMDIrept7/AMIPexp.html (accessed 2 Mar 2011).

[82] Henderson-Sellers, A., K. McGuffie, A. J. Pitman; "The Project of Intercomparison of Land-surface Parameterization Schemes (PILPS): 1992 to 1995"; *Climate Dynamics* 12, no. 12 (1996): 849-859.

PC.[83]

The efforts of MAT led to a number of products. MAT researchers published the first Climate Atlas with intercomparison of climate simulation results[84], a regional atlas of changes in temperature and the hydrological cycles in the Western USA for the case of doubled carbon dioxide concentration. MAT also made a comprehensive edited book on MECCA scientific results intended for the policy maker or interested layman, a video, and a CD providing descriptions and selected parts of MAT's work for broad circulation and which could be used to present MECCA and its results to a wider audience. The protocol and exchange of data to impact analysts were used for several studies.[85]

In an attempt to provide MAT with a range of suitable experiments a new call for proposals for MECCA phase 2 with a deadline of October 13 1992 was launched in the preceding August. The call referred to but did not strictly follow the research plan agreed the year before, which suggested a focus on high resolution transient forcing experiments. Instead the objectives of MAT were given particular attention, with experiments related to uncertainty analysis and model evaluation being given special priority.[86] However, as the proposals began to arrive and the selection of experiments took place it became clear that the shift in direction could not be met.

The experiments of phase 2 proved in essence rather similar to the experiments of phase

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[83] Henderson-Sellers, e-mail correspondence with author, 8 Jul 2009.

[84] Henderson-Sellers, A. and Hansen, A.M., *Climate change atlas: greenhouse simulations from the model evaluation consortium for climate assessment*, (Dordrecht: Kluwer, 1995), 159.

[85] EMP, esp. 38-45

[86] MECCA Program announcement phase 2, PPM.

1 and were not particularly suitable for MAT's analysis.[87] It proved impossible to MECCA to have the climate modelers do more than continue with their established research interests and rather than pause the project and try yet another call this bottom-up approach of following the proposals of individual scientists without strict guides was accepted for this second phase as it had been for the first phase of the project.

BETWEEN FUNDING GAPS AND FUTURE PLANS

After MECCA phase 2 was announced two small members joined the consortium at the end of 1992, but MECCA's financial situation was still not settled. The electricity company Southern California Edison joined MECCA in late 1992 and contributed $200,000 and the National Supercomputer Center for Energy and the Environment (NSCEE) at the University of Nevada

[87] Henderson-Sellers and Howe, "MECCA achievements ", (ref 78), esp. 366; EMP, esp. 34. Experiments supported: Wei-Chyung Wang, State University of New York at Albany: Model assessment of the enhanced climate effect, phase 2, Filippo Giorgi, NCAR, et al: Development of regional climate change scenarios for Europe and East Asia, Warren Washington and Gerald Meehl, NCAR: Greenhouse-gas climate sensitivity experiments with improved coupled atmosphere and ocean models, Robert Dickinson, University of Arizona: Development of state-of-the-art interactive land model for greenhouse projections, Linda Mearns, NCAR, and C. Rosenzweig, GISS: Simulated crop response to climate change in the US Great Plains using scenarios from a nested regional climate model, Joseph Tribbia, NCAR et al.: Assessing the reliability of climate simulations: High resolution experiments, H.L. Tanaka, University of Tsukuba, Japan: To evaluate the basic performance of climate models with respect to the transfer and scale interaction in the wave-number domain, William Holland, NCAR et al.: Morth Atlantic-Mediterranean conveyer belt experiments, Joyce Penner, LLNL et al.: Climate studies of the direct and indirect effects of sulfate aerosols, Tim Kittel et al., NCAR: Applying GCM output to ecological impact studies; Lawrence Mysak, Canada: Interannual variability of arctic sea ice in coupled GCMs, Ulrich Cubash, MPI, Germany: Regional climate evaluation intercomparison among GCMs, Chuck Hakkarinen, EPRI: Applying GCM outputs to integrated assessment.

also assumed membership and provided access to a supercomputer of an estimated value of $500,000. Japanese CRIEPI increased its contribution by $400,000, while ENEA again reduced its funds by the same amount. The funding gap for the year 1992 added up to $1.2 million, leaving an estimated $3.4 million for the full project lacking. At its meeting in Paris in December 1992 the PC discussed early terminating of computer activities due to the lack of funds but a decision on termination by the end of 1993 was postponed until the next meeting in July in Hakone, Japan, giving time to try to raise further funds once again. EPRI prepared once again to contact potential industrial partners in other sectors that again proved not feasible. Additionally, EPRI attempted to find governmental support for the approach taken in MECCA in the new Clinton administration,[88] but only the Environment Protection Agency (EPA) joined in 1993 as the last MECCA member providing $90,000 for one MECCA subproject.

Given the persistent funding problems, the PC decided at its meeting in Hakone in July 1993 to cease the CRAY-lease at the end of 1993. Some selected experiments could be shifted to the supercomputer at NSCEE and together with the analysis in MAT these could continue until early 1995. The remaining experiments had to be terminated unless further funding appeared.[89]

With the pending risk of losing the supercomputer, UCAR entered into new negotiations with CRAY and reached an agreement so that the YMP would remain at NCAR on favorable terms if NCAR ordered an upgrade of CPU time in 1994. This was backed up by NSF, which together with UCAR worked on making the climate dedicated supercomputer at NCAR permanent with funds mandated from the new Clinton administration.[90] In order to raise funds to support the supercomputer before the federal agreement was completed UCAR offered MECCA

[88] Balzhiser, Draft letter, 1993, PPM, Mueller and Balzhiser email-correspondence, Mar 1993, PPM

[89] PC Meeting Notes, Jul 1993, esp. 6, PPM

[90] AMP, esp. 22. This led to establishment of the Climate Simulation Laboratory at NCAR, funded by NSF.

to buy 5000 CPU hours at approximately half the cost of the earlier agreement with CRAY. MECCA accepted and based on this arrangement most experiments could be completed, but new experiments had to wait for additional funding.[91]

The decision to cease computer activities at the end of 1993 became in practice a change of Consortium focus despite the later UCAR-agreement. As the initiation of new model experiments was stopped, the analysis and application of results became the prime focus. The PC wanted to use Ann Henderson-Sellers' status to increase MECCA's involvement in the IPCC process and hoped to deliver input to both the IPCC working group 1 on science and working group 2 on impacts for the second IPCC report. In February 1994, MECCA and Macquarie University arranged a working group 1 workshop on use of GCM data for regional climate studies in Sydney. In May 1995, MECCA organised a working group 2 symposium on regional impact assessment in Palo Alto, which was held in connection with a MECCA-PI symposium. MECCA also supported the IPCC GCM-data archive at the German Max Planck Institute of Meteorology, one of the leading European climate research centers.[92]

Hakkarinen and Henderson-Sellers participated in several conferences in order to establish MECCA in the scientific community and promote cooperation and the exchange of MECCA data for impact analyses.[93] Other activities included a repetition of the graduate summer school of 1991 based on the EPRI funded monograph edited by Trenberth, this time arranged and held by Henderson-Sellers at Macquarie University in February 1993. The participants mainly

[91] Mueller to PC, 4 Feb 1994, PPM

[92] PC Meeting Notes, Feb 1994, PPM; PC Meeting Notes, May 1995, PPM; Presentation, WG1 Initiative on Regional Climate Evaluations, Dec 1993, PPM.

[93] MECCA Update, Mueller 2 Sep 1992, esp. 4, PPM, Brescianini, C., W. Howe and A. Henderson-Sellers, "The delivery of Climate change Projections: The MECCA analysis project", Hanford Symposium on Health and the Environment, 18-21 Oct 1993, PPM.

came from the southern hemisphere and Henderson-Sellers added a "southern perspective" to emphasize special problems of the global South and how their position on the climate issue could be strengthened.[94] In January 1994, EPRI received the annual "Award for Outstanding Services to Meteorology by a Corporation" from the American Meteorological Society for its efforts in "advancing the application of global climate modeling."[95]

What the future of the collaboration should be after phase 2 also became a priority consideration. While the PC had already informally put forward the suggestion of an upgrade of MECCA at its October 1991 meeting (based on the expected new Fujitsu Supercomputer), serious discussions about a MECCA phase 3 started in late 1992. Wayne Shiver, Richard Anthes and NCAR Director Robert Serafin had worked out a concept for the continuation of MECCA to be discussed at the PC Meeting in December 1992. They suggested changing MECCA in a number of ways in order to strengthen the development of policy-relevant impact assessment. Their suggestions included the adoption of a new mission statement to characterize the project as "an international scientific global change modeling facility dedicated to addressing questions of practical importance to society."[96] The discussion continued throughout 1993, and a concept for a "High Profile Option" was created under the leadership of David McNelis from NSCEE after the meeting in Hakone[97] but this did not gain importance as UCAR again took the lead in an attempt to renew the efforts to suit its general plans.

UCAR intended to restructure and strengthen its international collaborations, partly based

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[94] Giambelluca, Thomas W. and Henderson-Sellers, Ann (eds.), *Climate Change: Developing Southern Hemisphere Perspectives* (Chichester: John Wiley & Sons, 1996), 488. AMP, esp. 20.

[95] Award Acceptance, Draft, 2 Feb 1994, PPM.

[96] Shiver, Anthes and Serafin to PC, 24 Nov 1992, on p. 5, PPM.

[97] McNelis, Impact assessment based on coupled GCM results, draft, Feb 1994, PPM.

on its contacts in MECCA, and UCAR president Richard Anthes wanted Wayne Shiver to take a leading role in MECCA and the development of MECCA's future. UCAR out this forward for the meeting in Sydney in February 1994 and the Consortium members accepted the directions UCAR suggested. While they in general reconsidered the future of the Consortium the UCAR plans were moving quickly and might turn out as a favorable option and if not the engagements could stop.

A subcommittee chaired by NCAR Director Serafin assumed the task to work out a more detailed research plan for a new consortium to follow MECCA.[98] Based on this work Tom Wigley, a leading climate scientist, prepared the plan for a new cooperative project, "A Consortium for Application of Climate Impact Assessments" (ACACIA). The proposal aimed at strengthening the link of GCM-modeling and impact analysis to improve integrated assessments of climate change based on the lessons from MECCA and identifying and evaluating uncertainties in GCMs and impact models.[99]

Potential funds from new industry and utility members in the US and Australia had been identified in early 1994, but none entered MECCA or ACACIA,[100] although Henderson-Sellers managed to gain support for MAT from the Australian coal industry for analysis of MECCA results.[101] Consequently, supercomputing had to slow down in August 1994 and all experiments – completed or not – were terminated at the end of the year. ACACIA was presented and discussed at the PC meeting in Rome in December 1994.

A last PC meeting was held in San Francisco in December 1995 to wrap up the project

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[98] Anthes to PC, 12 Jan 1994, PPM; PC Meeting Notes, Feb 1994, esp. 2, PPM.

[99] Tom Wigney, Action Plan for ACACIA, draft, 25 Nov 1994, PPM.

[100] Mueller to PC, 25 Nov 1994, PPM, Hakkarinen to PC, 26 Nov 1994, PPM.

[101] See. e.g. Sascha Schubert, "Commentary", in ACC: 271-280.

and review the final ACACIA proposal and the draft of the book on MECCA, *Assessing Climate Change*.[102] MECCA's total deficit of $2.5 million was covered by EPRI.[103] UCAR ran ACACIA until 2001 but only supported by CRIEPI, KEMA and EPRI.[104]

FEATURES OF AN UNUSUAL ENTERPRISE

MECCA was a rather unusual climate simulation research project. As a collaboration of public research centers and agencies, industry-based research institutions and industrial corporations it included an uncommon mix of participants. The establishment of a collaboration with such diverse partners pursuing different interests and representing different professional cultures and styles was not a simple and straightforward endeavor.

Accidentally, NCAR/UCAR's funding problems and search for increasing supercomputer power in the late 1980s coincided with EPRI's growing interest in developing expertise in climate simulation as climate became a national and international policy issue. NCAR did not have a central position in USGCRP, and UCAR felt a pressure to develop NCAR's climate modeling capacity quickly in order to keep up with developments in climate research that were accelerating in other agencies and the new strong centers in Europe. EPRI, on the other hand, felt the pressure to enter into a stronger engagement in climate science in order to be better prepared for public and political discussions, negotiations about regulative issues and decision-making in

[102] PC Meeting Notes, May 1995, PPM.

[103] MECCA balance of 29 Nov 1995, PPM. According to the MECCA administration total contributions of the consortion members in US$ were: EdF 800,000; ENEA 500,000; CRIEPI 1,600,000; EPRI 6,700,000; KEMA 200,000; EPA 90,000; SCE 300,000; MECCA in-kind contributions: UCAR 7,100,000; EPRI 600,000; NSCEE 500,000; PI's 10,000,000; KEMA 40,000.

[104] Bob Serafin, Acacia Meeting Report, 11 Dec 2000, PPA.

the utility industry in times of climate change. This constellation represented a unique window of opportunity for a collaboration which both partners eventually seized.

From the outset it was realized that some central coordination of the projects had to take place in order to make ends meet in the complex public-private construction. The mix of interests gave new perspectives to climate science projects, most notably the attempt to provide a link between separate research communities through systematic impact analysis using model results. Despite a suggested strong top down structure had to be softened in order to attract scientific projects, MAT became an active interface, which attempted to moderate and connect the multiple interests and directions, scientific, political and industrial goals, basic research and application, scientific investigation and public communication.

The scientists involved followed their basic research with no intention or even reluctance on their part of applying the results of their models to questions demanded for policy making. In the word of Gates in his evaluation, "Most climate modelers are primarily interested in improving (their) climate models, but have been less inclined to undertake studies leading to the quantification of the uncertainties involved in the modeled changes due to increasing greenhouse gases and even less interested in studies of climate impacts and their relationship to policy questions. MECCA's initial desire to focus on these latter issues was therefore met with a certain amount of skepticism."[105] The scientists had other goals than actively engaging in matters of policy and public debates and as the consortium in the end decided to value well-recognized scientists and creative proposals rather than insisting that the suggested experiments and procedures was carried through the experiments turned out to be a broad set of studies of model sensitivity, parameterisations and regional climate modeling with limited coordination between the projects.

[105] Howe et al. 1997, "MECCA consortium overview", (ref 49), esp. 396.

So as the project progressed, some of the original ambitions of EPRI proved rather awkward to attain and had to be adapted to the actual time consuming practice of developing climate models, of which EPRI had no experience of prior to MECCA. As Hakkarinen conceded when reflecting on the goal of reducing model uncertainties, "After the first few years of MECCA effort, it became more obvious to me that […] my goal of reducing modeling uncertainties [would be] a very optimistic, and probably naive, one. Over time, it became apparent to me that MECCA could be viewed as successful even if it merely succeeded in *identifying* uncertainties and pathways toward addressing these uncertainties, rather than expecting that MECCA would actually be able to reduce the uncertainties."[106]

To UCAR, however, the dedication of a new supercomputer exclusively to climate simulation alone represented step forward in the US research landscape. As it in the mid-1990's was decided by congress to establish permanent climate dedicated supercomputer after the change of administration in 1993 the experience and accelerated results at NCAR as a consequence of the MECCA supercomputer became a core argument for NCAR and UCAR leaders throughout 1993 and 1994 for placing a permanent climate-dedicated supercomputer at NCAR. The Climate Simulation Lab was established in 1995 with federal funds through USGCRP.[107] In this way MECCA became a central event in the developments to improve the climate modeling facilities at NCAR.

With a total budget of around $30 million MECCA was small compared to the enormous size of national and international climate research programs. Nonetheless, as a single research project it provided substantial contributions to climate research in the early 1990s. MECCA succeeded in maintaining a 5-year climate modeling and analysis effort despite the different

[106] Chuck Hakkarinen, e-mail correspondence with author, 2 Aug 2009.

[107] AMP, esp. 21-23

goals and motivations of the consortium members and some experiments opened research questions. The interest of consortium members in regional climate change and its impacts led to some of the very few regional simulation results in the IPCC 1995 report. Other important projects included investigations with high resolution models and long integrations, and simulations with other GHGs than CO2 – included in the IPCC 1992 report – and sulphate aerosols – where results from MECCA came too early for the second IPCC report and were superseded by newer results of other groups before the report was published.[108]

Overall, the consortium members expressed satisfaction with the accomplishments of the project. They regarded the effort a success with respect to research, ideas and bridging both different scientific communities and different sponsoring entities but on the other hand acknowledged that full implementation of many of the ambitious plans had been limited.[109] The MECCA Publications Bibliography, which listed publications based on research in MECCA, included in November 1995 one book, a special issue of the journal *Global and Planetary Change*, 10 book chapters, 60 journal papers and 13 papers in conference proceedings and reports, with the bibliography at that time still growing.[110]

MECCA promoted the ambitious and important idea of bridging basic science and application in relation to policy decisions – a problem that was evident also in the process of the first IPCC report[111] – and it produced a number of results and first products. MECCA had an impact on the scientific state-of-the-art in selected areas of research and the organisation

[108] Henderson-Sellers and Howe, "MECCA achievements", (ref 78), esp. 373.

[109] Howe et al., "MECCA consortium overview", (ref 49), Hidy "foreword", (ref 31).

[110] Appendix A of the Action Plan for ACACIA, November 1995, PPM. The list included publications which were published, in print or accepted.

[111] Steven H. Schneider, "Three reports of the Intergovernmental Panel on Climate Change", *Environment* 33, No.1 (1991): 25-30.

contributed to a growing scientific community by dedicating a supercomputer for climate science at NCAR until the federal policy process found such funds.

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