Responding to Global Climate Change in the Prairies

Volume III of the Canada Country Study: Climate Impacts and Adaptation

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Canada Climate Study

This is a component report of the Canada Country Study: Climate Impacts and Adaptation. In addition to a number of summary documents, the first phase of the Canada Country Study will produce six regional volumes, one volume comprising twelve national sectoral reports, and one volume comprising seven cross-cutting issues papers. This is Canada Country Study - Volume III: Prairies Regional Report.

For further information on the Canada Country Study (CCS), please contact the CCS national secretariat in Toronto at 416-739-4389 (telephone), 416-739-4297 (fax), or ccs.cia@cciw.ca (e-mail).

Ce rapport est une partie composante de L'Étude pan-canadienne sur l'adaptation à la variabilité et au changement climatique. En plus de quelques documents sommaires, la première phase de L'Étude pan-canadienne produiront six tomes régionaux, un tome comprenant douze rapports nationaux au sujet des les secteurs sociaux et économiques, et un tome comprenant sept papiers concernant, les questions polyvalentes. Ce rapport est L'Étude pan-canadienne - Tome III: Rapport Regional pour les Prairies.

Pour plusieurs renseignements concernant L'Étude pan-canadienne (ÉPC), contactez le secrétariat national de l' ÉPC à Toronto à 416-739-4389 (téléphone), 416-739-4297 (facs), ou ccs.cia@cciw.ca (poste-élect.).

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EXECUTIVE SUMMARY

REGIONAL CLIMATE SENSITIVITIES

Drought is the most significant climatic characteristic of the Prairies. Many prairie residents recall the severe drought year of 1988, and some the 'dirty 30s'. However, postglacial proxy climate data indicate that the prairies have experienced intervals of high temperatures and abnormally low precipitation over the past 1000 years which were far more severe than during this century. The most severe drought of the past 500 years in the Prairies occurred between approximately 1791 and 1800. Historically, droughts have had a return period of 30 to 50 years; this has not changed appreciably.

Droughts have had significant impacts on the economy and on aquatic and wildlife resources of the Prairie Provinces. For example, during the 1930s drought, wheat yields declined 32 percent, 200 000 farms failed and 300 000 people migrated from the southern Prairies.

After the 1988 drought, crop insurance and special drought assistance paid out over $1.3 billion to prairie cattle producers and grain farmers, an amount also supplemented by provincial support programs. Despite this support, Manitoba showed net farm income losses of 50 percent and Saskatchewan 78 percent. Export losses from agriculture were estimated at $4 billion. Due to the effects of the drought, and previous years of low prices, an estimated 10 percent of farmers and farm workers left the agriculture sector in 1988.

The droughts of the 1980s extended northward into the northwest forest. Forest effects included reduced wood volume increments, higher than normal seedling mortalities, tent caterpillar and spruce budworm outbreaks and considerable fire damage and fire suppression costs. Disturbance areas greatly increased during the 1970s and 1980s as compared to the previous 50 years.

The 1988 drought affected the energy sector in Manitoba more than in either Saskatchewan or Alberta because of Manitoba's reliance on hydroelectricity. Manitoba experienced a 4 percent decrease in hydroelectric power generation compared to "normal" years, a 72.6 percent drop in export sales from 1986/87, and a net income loss of $26.4 million. In Saskatchewan, the proportion of thermal generation and the volume of energy imports increased due to the drought's effects. Purchased electricity costs increased by 28.9 percent and operational problems were encountered at thermal power stations.

In the insurance sector, the demand for farm "rain insurance" in the northern Great Plains of the United States rose sharply during the 1988 drought. The Federal Insurance Company lost $20 million and CHUBB Corporation lost $48 million in claims that year.

In many prairie basins, the demand for water often exceeds the firm supply. The lack of available water in 1988, for example, resulted in widespread deterioration in water quality and in an increase in the consumptive use of water. This led to an increase in government assistance programs. Evaporation rates from reservoirs and lakes have been abnormally high in recent decades.

Aquatic ecosystems are sensitive to changes in temperature, salinity, general water chemistry, and the frequency and intensity of floods and droughts. Southern wetlands have undergone considerable alteration in the last several decades, suffering from both human-induced and natural changes. Drought decreases above-ground plant biomass, and species diversity and richness, and may result in local extinction of many rare species. Waterfowl populations decreased during the dry 1980s and an increase in diseases, such as avian botulism, occurred.

IMPACTS OF CLIMATE CHANGE

Most climate change scenarios for the prairies show an increase in temperature and reductions in soil moisture with a doubling of atmospheric carbon dioxide. However, some models have shown a small increase in precipitation while others predict a small decrease. In addition, not all parts of the prairies will experience the same effects.

While most climate change scenarios suggest that the semi-arid regions of the prairies can expect an increase in the frequency of drought, some literature suggests that no major change in drought frequency is likely for southern Alberta.

Agriculture

Precipitation could be the limiting factor for agricultural production on the prairies based on the current models. The predicted increases in temperature would likely lengthen the growing season but higher temperatures and lower soil moisture may adversely affect dryland agriculture. Also, increased crop production may be possible in northern regions where suitable soils exist. The extra heat would likely increase the potential risk of insect infestation.

Given the potential changes in crop production variables, average potential yields may fall by 10-30 percent.

Forest Ecosystems

The boreal forest is the ecosystem that is expected to be affected the most by future climatic changes because of its high latitude location and because of its climatic sensitivities. In general, the circumpolar boreal forest is likely to decrease in area, biomass, and carbon stock, with a move toward younger age-classes and considerable disruption at its southern boundary. Growth and productivity could improve in central and northern regions, especially on favourable sites, and decrease in the south, especially with increased droughts. Disturbances such as fire, insects, and diseases could increase.

Energy

Electricity has the potential to be severely impacted by climate change. Thermal power stations become less efficient as reservoir water temperatures increase. Hydroelectric production will have to compete with a number of other uses, primarily agricultural, for the diminishing water supply. Increased demand for water pumping and summer cooling and a decreased winter demand could push electrical utilities into a summer peak load position. Possible reduced hydropower production caused by decreasing water flow could result in increasing thermal power production with an increase in fossil fuel consumption and greenhouse gas emissions.

Insurance

Smaller insurance companies and policy holders may be unable to afford the higher premiums which will accompany the higher risk. Underwriters may also be less willing to accept this risk. Crop insurance premiums may increase, or taxpayers may be expected to carry the increased costs.

Direct health effects of global warming may include increased mortality and illness due to expected increases in temperatures and duration of heat waves, and fewer cold-related deaths. Indirect health effects may include aggravated respiratory and allergic disorders.

Recreation and Tourism

Warmer temperatures will encourage algae and plant growth, which may lead to fish kills and reduced recreational fishing at many locations. This will also reduce the quality of other water-based activities such as swimming and water skiing. The drying up of potholes that is expected to accompany rising temperatures could lead to reduced production of waterfowl.

Water Supply and Demand

Predicted prairie runoff varies from below normal to above normal, depending on the GCM scenario selected. For example, some scenarios indicate an increase in the amount of average annual precipitation, a larger number of extremes in weather, greater frequency of severe storms, increased evaporation, decreased snowpack and an earlier disappearance of the prairie snowpack.

If the magnitude and frequency of extreme events increase, existing dams and other water control structures, which were designed on the basis of the magnitudes and flood frequencies of past extreme events, might be impacted.

Because of the warmer weather there will be a greater need for good quality drinking water for livestock, wildlife and humans. More conflicts will occur among users over the limited resource.

Natural Environment

Changes in the hydrologic cycle due to climatic change are likely to affect the availability and quality of critical fish habitat. Climate warming will have major consequences for some fish species since observed climate changes have already caused mid-summer water temperatures in many mid-latitude lakes to approach the thermal tolerance of a variety of these organisms. However, increasing temperatures will allow some freshwater fish species to extend their range into higher latitudes and may cause them to disappear from what is now the southern extent of their range.

Wildlife species tied to semi-permanent or seasonal wetlands are expected to be most affected by climate change in this region.

ADAPTATION TO CLIMATE

Agriculture

During the past century, farmers, particularly in areas where extreme soil moisture deficits are common, have adapted to climate by irrigating their crops. While this has been an effective adaptation strategy in the past, this technique may become less attractive if water supplies become more uncertain. Converting to more drought-tolerant crops provides another adaptation option in some areas. Also, farmers and livestock operators have begun to diversify into specialty crops (e.g. mustard seed, dry peas and lentils) and native species such as buffalo and elk.

Although the agricultural sector is able to respond and adapt to changes in climate, governments will play a role in how the sector adapts and how quickly. Current shifts in agriculture policy are starting to allow more flexibility in production, not only in techniques, but also in products.

Forest Ecosystems

Adaptive and mitigative strategies include managing stands and landscapes to reduce the likelihood of crown fires and large area fires, managing forest fuel, prescribed burning, preserving and enhancing biodiversity, and managing forest landscapes that are becoming increasingly fragmented.

The forest products industry can adapt to ecosystem changes by salvaging dying trees, replanting with better-adapted species, or moving to those places where timber becomes more abundant. However, adaptation for non-timber aspects, such as biological diversity, is more difficult.

Some possible “no regrets” adaptive actions include implementing uneven forest age management, maintaining an over-storey cover, managing for several species, and altering harvesting regimes to protect soils and maintain productivity. These actions attempt to mimic natural processes.

Energy

One of the adaptive strategies that could be employed by industry and individuals is mitigation through actions to reduce fossil energy consumption. This, in itself, will result in the need for the energy sector to adapt to changes in energy demand.

Many energy utility companies have adopted strategies to manage their ongoing operations to adapt to climate variability. Examples include: re-examining long range load forecasts; evaluating the suitability of thermal plants compared to hydoelectic plants in light of climatic change; and operational aspects such as research into the effects of icing on conductors and improvements in methods of calculating evaporative demands.

Insurance

Insurance companies adapt to losses by increasing premiums and/or deductibles, reducing or withdrawing coverage altogether, or by making the underwriting of risk conditional on certain actions being taken by the policy holder.

On more of a practical level, another possibility is to reduce investment in companies that contribute to greenhouse emissions. The industry is also lobbying for tighter building codes that improve energy efficiency.

Recreation and Tourism

Recreationists can adapt to climatic variability and change by traveling to alternative locations with more favourable conditions, reducing participation when conditions are unfavourable, or ceasing to participate in their usual activities. People also can undertake new activities or increase their involvement in other activities.

Water Supply and Demand

Large reservoirs (there are approximately 770 significant dams in the Prairie Provinces) have been constructed on virtually every major river system in the grasslands region. These reservoirs capture spring runoff for delivery during times of drought and reduce flooding during times of peak flows. Most of these reservoirs serve multiple objectives, such as for irrigation, power production, recreation, flood protection to downstream communities, and transfering water between drainage basins.

More than 110 000 farm and community dugouts have been constructed in the prairies to store spring runoff. Many rural areas rely on groundwater supplies, either entirely or as a supplement to surface water supplies. Regional water distribution systems are also becoming a common adaptation strategy.

Formal water management policies and legislation exist for international, interprovincial and provincial-territorial river systems which specify how much water can be used within each jurisdiction.

OPPORTUNITIES FOR FURTHER RESEARCH

While our knowledge of climate variability and change within the Prairie Provinces has expanded considerably over the past couple of decades, much research remains to be initiated. Some general research questions follow for each sector. Readers should refer to the respective appendices for further detail.

Agriculture

- Why do responses differ, and what characteristics of farming make certain types of regions more vulnerable or adaptive than others?
- What non-climatic conditions influence the propensity to adapt? What are the constraints on and incentives for adaptation in the future?
- How can agriculture become more sustainable in the event of climate change?

Forest Ecosystems

- What is the nature of the current interactions between climate and the boreal forest ecosystem? What critical monitoring needs are not being met?
- What is the net effect of changes in growth and changes in disturbances over the long and short terms?
- What changes in the economic importance of the forest resource can be expected with the types of climatic changes foreseen? How sensitive is the forest industry to these changes?

Energy

- What are the sensitivities of different parts of the energy sector to climatic change? How do these compare to the sensitivities of other sectors?
- What are the best quantitative and qualitative models for use in estimating impacts and testing adaptive strategies?
- What is the balance between adequate adaptation and mitigation? What are the linkages between adaptation and mitigation?

Insurance

- How can regional climate models be improved to assist insurance companies in setting fair and realistic premiums in the face of climate change?
- What kinds of risks can insurance companies expect when covering future climate-related damages on the prairies?

Recreation and Tourism

- What are the economic costs of creating favourable conditions for recreation?
- What resource conflicts exist due to competition for scarce resources, such as water? What legislation or other instruments can be developed to resolve these conflicts?

Water Supply and Demand

- How can regional climate models be improved to assess the impacts of climate change on water supply and demand? What is the potential for more extreme climate events?
- What socioeconomic impacts will exist in areas such as municipal water use, tourism and recreation, agriculture and power generation under a warmed climate?

Aquatic Ecosystems

- What are the linkages between climate change and the hydrologic cycle, and the chemical and biotic structure and functioning of aquatic ecosystems?
- How can short-term, intensive monitoring studies be integrated with existing past environmental data and quantitative predictive models?

Wildlife and Biodiversity

- What are the synergistic effects of UV-B radiation, water chemistry, and agricultural chemicals on Canadian prairie amphibians?
- What are the possible impacts on wetlands under a changed climate?

PREFACE

INTRODUCTION

The Canada Country Study

Climatic variability and change will impact Canadian people, flora, and fauna, and will have social and economic implications throughout the country. There is an urgent need for a national comprehensive and integrated evaluation of existing knowledge concerning the impacts of climate variability and change on Canada, as well as potential adaptive responses to such changes.

The Canada Country Study (CCS): Climate Impacts and Adaptation responds to this need. In presenting this national perspective, it draws upon studies of a number of regional, sectoral and cross-cutting issues, of which this volume is one.

The study was initiated by Environment Canada (EC) and is being lead by the Environmental Adaptation Research Group, a component of EC's Atmospheric Environment Service located in Downsview, Ontario. Among the participants are representatives of various levels of government, the university community, the private sector and non-governmental organizations.

In providing Canadians with a balanced, realistic picture of what climate change and variability means for Canada as a whole, the CCS effort builds upon a number of sectoral and regional impact studies that have been completed during the past decade. These studies tend to emphasize one of three approaches: i) modelling - generally quantitative analysis of impacts associated with a range of climate change scenarios; ii) monitoring - real time observations of environmental response to recent and ongoing climate variability; and, iii) paleoenvironmental analysis - utilizing past environmental changes and proxy climate data to provide analogues for impacts of future climate change.

The CCS will provide information to Canadian policy makers in the public and private sectors, socio-economic decision makers, the scientific community both domestically and internationally, non-governmental organizations, and the general public.

Work on the CCS is divided into two phases. Phase I began in the summer of 1996 and will conclude in the fall of 1997. Phase I, the subject of this report, determines '*where we are now'* by synthesizing existing impacts and adaptation research for selected climate-sensitive sectors in the three Prairie Provinces, the identification of knowledge gaps, and the development of recommendations for future research. It also builds *regional involvement* of federal, provincial, academic and NGO people.

Phase II, which is expected to begin in late 1997 and extend over approximately a five-year period, will address the knowledge gaps and recommendations for future research.

In Phase I, a number of summary reports will be published - a national policy makers summary, a national plain language summary, and six regional plain language summaries. In addition, the basis of these summaries - 25 component studies and papers - are being published in eight volumes as follows:

- Vol. I - British Columbia and Yukon
- Vol. II - Arctic
- Vol. III - Prairies
- Vol. IV - Ontario
- Vol. V - Québec
- Vol. VI - Atlantic
- Vol. VII - Sectoral (comprising 12 national papers on agriculture, built environment, energy, fisheries, forestry, human health, insurance, recreation and tourism, transportation, unmanaged ecosystems, water resources and wetlands)
- Vol. VIII - Cross-Cutting (comprising seven national papers on changing landscapes, domestic trade and commerce, extra-territorial influences, extreme events, integrated air issues, sustainability, and the two economies).

Report structure

Eight key climate-sensitive areas or sectors in the Prairie Provinces were selected for analysis. These are: agriculture, forestry, energy, insurance, recreation/tourism, water supply and demand, aquatic ecosystems, and wildlife and biodiversity. These sector assessments were prepared by experts and were subjected to detailed external review. A ninth assessment, summarizing our knowledge of proxy records of postglacial climate in the Prairie Provinces, was also prepared. The assessments, attached to this volume as appendices, form the basis of this report.

The eight sector assessments were based primarily on the author's knowledge and review of the applicable literature. The authors were guided in this task by the following questions (note that the questions are designed to focus the author and to stimulate thought, and may be less important for some sectors while other questions may be more important):

1. *Why might climate change be a problem for this sector?*
2. *What do we know about the connection between current climate variability, including current climate extremes, and this sector (if anything)? How sensitive might this sector be to a warmer and a wetter or drier climate?*
3. *What may occur in this sector of the economy or the environment if a global warming occurs over the next 50 to 80 years? (This will be based on a review of the literature, the author's knowledge and hypothetical "What-if" scenarios).*
4. *So what? Will these changes affect people in any way? (For example, will the climate change impacts outlined in question 3 have any impact on human activities such as urban development, tourism, agriculture, trade, social problems, conflicts such as water vs. free trade, competition for hydroelectric power, land claims etc.).*
5. *Will other effects, for example population growth or forest over-harvesting, overwhelm any climate change impacts on people? Or will climate change exacerbate these other effects?*
6. *What should be done? While there is a need for more plausible climate change predictions in the Prairies, is more research needed on climate change impacts, and if so, where should we concentrate? Should we focus on reducing greenhouse gas emissions? Should we develop and begin the implementation of some sort of adaptation measures?*

The report is organized into six chapters. The first two chapters provide the regional context of geography, population, economics and climate. The other four chapters summarize our knowledge of regional climate sensitivities, possible climate change impacts, climate adaptations, and opportunities for further research. The Executive Summary identifies the key points made in this report.

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THE CLIMATE BACKGROUND

Climate change and variability

Climate may be thought of as a description of the regularities and extremes in weather for a particular location. It is also, however, naturally variable; from our own experience, we know that one summer is often warmer than another, or one winter is colder or snowier than another. Such variability is a normal feature of a stable climate, and is related to changes in ocean currents or sea-surface temperatures, volcanic eruptions, alterations in the sun's output of energy, or other complex features of the climate system some of which are not yet fully understood. It is not safe to assume that the variability of the present climate system is adequately represented by the comparatively short instrumental meteorological record, and hence it is important to integrate this record with proxy climate data derived from ice cores, tree rings, lake sediments and other sources to assess climate dynamics.

Natural large-scale climate shifts (or climate changes, such as those that resulted in past ice ages or warm interglacial periods) are driven by long-term alterations in the position of the Earth with respect to the sun. Such alterations can be reflected in changes in the composition of the Earth's atmosphere, an important characteristic of which is the occurrence of certain greenhouse gases (such as carbon dioxide and methane). These gases keep the Earth's surface and atmosphere from cooling too rapidly and help to maintain surface temperatures within the range needed to support life.

Greenhouse gas concentrations have been observed to be lowest during periods of cold climate (ice ages) and highest during warm periods. This connection is of concern because human activities since the beginning of the industrial revolution over 200 years ago (mainly involving the burning of fossil fuels) have greatly increased the concentration of such gases in the atmosphere. Scientists expect to see a doubling of the atmospheric composition of carbon dioxide, for example, within the next century. The increase so far is already considered to have had a discernible effect on the Earth's climate, an effect which is expected to continue.

Models and scenarios

In order to understand how the world's climate may respond, elaborate supercomputer models of the climate system are used. Known as general circulation models or GCMs, these models are used to simulate the type of climate that might exist if global concentrations of carbon dioxide were twice their pre-industrial levels. Although the models disagree about many of the details of a doubled carbon-dioxide climate, the results of the simulations all agree that the Earth would be warmer, on average (with more warming occurring towards the poles), and would experience overall increases in both evaporation and precipitation. These simulations of climate are referred to as "GCM-driven scenarios" - distinct from actual forecasts for the future - since they depict a possible future based on certain assumptions about atmospheric composition. The most recent report of the Intergovernmental Panel on Climate Change (IPCC - *qui vive*), issued in 1995, projects an increase in global surface temperature of 1 to 3.5°C over the next 100 years. This may be compared with the observed increase of 0.3 to 0.6°C over the past 100 years.

For its first Phase, the CCS does not follow a single climate scenario. It reflects the range of scenarios that have been used as a basis for the various papers and reports appearing in the scientific literature. In general, the main model scenarios used come from one of five GCMs which have been developed in Canada, the United States, or the United Kingdom. *

While there is an increasing level of comfort with the validity of GCM results at the global scale, such comfort decreases when we look at the regional scale. For Canada there are broad areas of agreement in model results including warming over much of the western and northern areas, but there is also some disagreement between models as to the location and magnitude of areas of surface temperature or precipitation change, particularly in eastern Canada. This disagreement is reflected in the words of uncertainty that appear at times in this volume of the Canada Country Study.

THE INTERNATIONAL CONTEXT

International concern about the future of our climate has been building steadily over the past 20 years. One of the first important international conferences to look at the issue was held in Canada in 1988 - The Changing Atmosphere: Implications for Global Security. Also that year, the IPCC was established by the World Meteorological Organization and the United Nations Environment Programme with a mandate to assess the science of climate change, its environmental and socio-economic impacts, and possible response strategies. The IPCC subsequently published formal assessments in 1990 and 1995, with a third to follow in 2000 or 2001.

In 1992, the United Nations Conference on Environment and Development was held in Rio de Janeiro and resulted in consensus on a Framework Convention on Climate Change (FCCC). This Convention's objective is "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system". It has now come into force and involves commitments to actions including emissions reductions, assistance to developing nations, reporting on emissions inventories, scientific and socio-economic research to reduce uncertainties, as well as education and training. Canada's domestic response to the FCCC has been its National Action Program on Climate Change.

To date, as the objective of the FCCC would suggest, much of the international emphasis on response strategies for dealing with the impacts of climate change has focussed on reducing emissions of greenhouse gases. A very important complement to such reductions is the need to understand the impacts of and to adapt to changing climate. The Canada Country Study is one of Canada's responses to recognizing the importance of climate impacts and adaptation.

CLIMATE IMPACTS AND ADAPTATION

The major concern arising from the climate change issue is the impact it may have on our environment, our economy, and therefore, on the way we live both now and in the future.

In Canada, we are accustomed to dealing with variations in climate both geographically and seasonally across the country. These variations have many impacts that can reverberate through natural and man-made systems, including water resources, vegetation and wildlife, agricultural practice, forestry and fisheries, energy supply and demand, buildings and roads, recreation and tourism, the insurance industry, and human health.

At present, there are many good examples of our ability to adapt to the range of current climate conditions which we face collectively in our economy and as individuals in our everyday life. If we depend upon wildlife species for sustenance, we follow them when migratory routes change; we plant different types of crops in different locations at different times of the year; we construct roads and buildings using designs that are compatible with ground conditions or with differing snow and wind loads; we build ships and other marine platforms capable of withstanding expected wave heights and sea-ice conditions; we locate recreational facilities and events where they can benefit from appropriate climate conditions, such as sufficient snow for skiing or enough wind for sailing.

Although considerable uncertainties exist about the nature of future climatic changes and particularly their associated regional impacts, this does not preclude a proactive approach to the development of adaptive strategies. GCMs now are able to provide a reasonable range for climatic parameters under enhanced CO_2 conditions, and analogues for all but the most extreme of these can be found in the last 10 000 years of the earth's history. These analogues allow identification of critical vulnerabilities in environmental systems in the absence of significant human impact. Assessment of future impacts must integrate these natural vulnerabilities with the increasing stresses imposed by human activities.

When thinking about adaptation as a way to respond to current climate and we then consider an on-going climate change and its impacts, we look for answers to the following questions so that our future planning can be done most effectively:

- What are the impacts of a changing climate and how will they affect me and my family through our lives?
- Are decisions being made today which will increase our vulnerability in the future because they are not taking such impacts into account?
- Will the approaches we use to adapt to the current climate still be workable in the future, or will new approaches be necessary to adapt to changes beyond our historical experience?
- Will the rate of changing climate allow enough time to adapt?
- Should society become more adaptable or flexible to changes in climate than it is now, and if so, how?

The Canada Country Study is aimed at helping to answer some of these questions.

- CCC92 - Canadian Centre for Climate Modelling and Analysis 2nd Generation model
- GFDL91 - Geophysical Fluid Dynamics Laboratory model (US)
- GISS85 - Goddard Institute for Space Studies model (US)
- NCAR93 - National Center for Atmospheric Research model (US)
- UKMO95 - UK Meteorological Office model

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