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The World Climate Research Programme (WCRP) celebrates its 40th anniversary

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Introduction

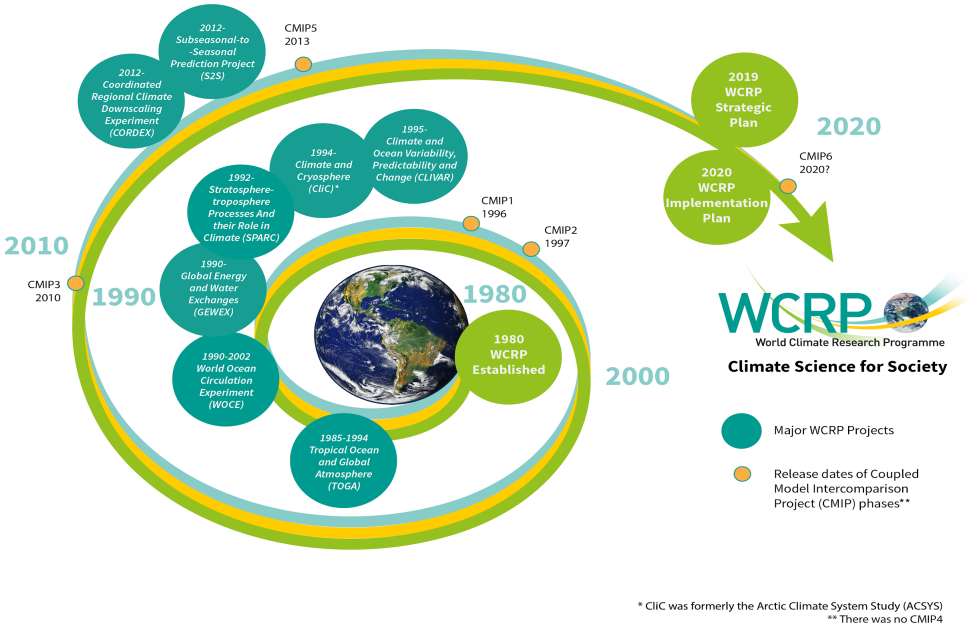

Figure 1: schematic view of WCRP history, credit Narelle Van Der Wel, WCRP secretariat.

Forty years ago, in 1979, an international programme to coordinate climate research was created: the **World Climate Research Programme** (WCRP). The 40th anniversary of the programme will be officially celebrated on December 8 in San Francisco, as part of the annual fall meeting of the American Geophysical Union (AGU). Various speakers who have been involved in the programme from near or far will give testimony to its past successes, the challenges it faces, as well as its future prospects. The celebration day will be preceded by a workshop dedicated to early career researchers and will open a week of joint sessions with the AGU and public presentations on climate research.

On the occasion of this anniversary, let us spend a moment to take a brief look back at this programme, which has stimulated the careers of many of us and which continues to serve as an international reference for all young researchers starting out in climate science.

Climate science in the 1970s and 1980s

Let's come back a few years before the WCRP was created, in order to better understand what motivated this initiative. The creation of the WCRP marks the culmination of a decade of growing concern, both among scientists and the general public, about issues related to the impact of mankind on climate.

The first major scientific conference on human impact on climate and its potential consequences was held in Stockholm in 1971[1]. During three weeks, thirty top scientists from 14 different countries wrote a report, known as the "Study of Man's Impact on Climate - SMIC", in order to synthesize the potential effects of human activities on climate. A consensus came out of this report: humans are able to affect the climate not only locally, but also globally. However, more precise scientific knowledge was needed to understand the nature and consequences of this disturbance.

It motivated new research on the subject, which was initially part of an existing programme: the Global Atmospheric Research Programme (GARP), an international programme dedicated to the study of the atmosphere, created a few years earlier by the World Meteorological Organization (WMO) and the International Council for Science (originally ICSU, now ISC since 2018). The Joint Organizing Committee (JOC) of this programme organized a conference in Stockholm in July and August 1974 entitled "Climate Physics and Modelling".

The aim of this conference was to lay the theoretical foundations of climate processes and modelling - thanks to advances in computer science, numerical tools had already been successfully used in operational meteorology, and were now also offering promising prospects for climate modelling. Following this conference, a proposal was made to WMO, the United Nations Environment Programme (UNEP) and ICSU to establish a World Climate Programme.

The latter was officially created a few years later, in 1979, following the first World Climate Conference organized by WMO in Geneva. 350 specialists from 53 different countries contributed their expertise in fields as varied as ecology, climate modelling, agriculture, economics, health, etc. These discussions resulted in a declaration that recommended international action to improve scientific knowledge of climate and to use this knowledge to "predict and prevent possible human-induced climate change that could affect the well-being of humanity" [2].

Following these recommendations, WMO and ICSU formalized the creation of the World Climate Programme, one component of which was intended to coordinate climate research: the WCRP. The International Oceanographic Commission of UNESCO also became an official co-sponsor in 1993.

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[1] Jacques Merle, Bruno Voituriez, Yves Dandonneau, Le changement climatique : histoire et enjeux, Club des Argonautes.

[2] « Declaration of the World Climate Conference », in *Proceedings of the World Climate Conference - A Conference of Experts on Climate and Mankind* (Genève, 1979), 713.

The creation of the WCRP, its main projects and programmes

Figure 2: a few of the climate research pioneers, participants in 1985 JSC session. First row: Bert Bolin (first IPCC Chair), John Houghton (WCRP Chair 1982-84), Joseph Smagorinski (first WCRP Chair 1980-81) and Pierre Morel (first Director of WCRP); second row: Bo Döos (Secretary of the GARP scientific committee) on the left, John Mason (WCRP Chair 1985-88) on the right.

WCRP was initially built around existing initiatives, which it integrated into its research program. In particular, in the early 1980s, the global oceanographic community was about to launch two major international programmes: the World Ocean Circulation Experiment (WOCE) and the Tropical Ocean Global Atmosphere (TOGA) experiment.

WOCE had the ambition to make the oceanographic community enter the scene of global scientific projects. Until then, the exploration of the seas had been based on a few independent institutes - a.o. the Ifremer in France, the Scripps Institution of Oceanography and the Woods Hole Oceanographic Institution on the west and east coasts of the United States respectively, the Alfred Wegener Institute in Bremerhaven, Germany. The latter occasionally organized ocean observation cruises, but in isolation and without coordination on a global scale.

In response, WOCE set itself the objective of observing the three major ocean basins - Atlantic, Indian and Pacific - almost simultaneously over a ten-year period. For oceanographers, this programme met an objective similar to that of meteorologists a few years earlier with the

launch of the first satellites - to have synoptic observations all around the globe. But this time, the area at stake was not the atmosphere, but the oceans.

While WOCE aimed to monitor the oceans as a whole, TOGA was a joint ocean-atmosphere project focusing on tropical areas. Launched in 1985 for ten years, the programme aimed to better understand the interaction between the tropical ocean and the atmosphere, in particular the prediction of the El Niño phenomenon. To achieve this, the programme used the first numerical models that coupled the atmosphere and the ocean. But for these models to be realistic, they had to be initialized and compared with accurate observations. A network of buoys was therefore installed along the tropical belt and complemented measurements of oceanographic and merchant vessels, tide gauges and satellite observations.

Unlike TOGA and WOCE, which were originally oceanographic initiatives, the Global Atmospheric Energy & Water Experiment (GEWEX, later renamed Global Atmospheric Energy & Water Exchanges) was created in 1982 as an initiative of the WCRP. The aim was to better understand the role of water in the climate system. Climate models faced great difficulties in taking into account the water cycle and the resulting energy exchanges. Major uncertainties remained, in particular about the various components of the water cycle at a global level and the consequences of an increase in CO2 concentration on this cycle.

GEWEX was created to define and communicate priorities for scientific research on the subject. Although the programme itself could not afford to fund research, it allowed promising initiatives to be part of a global collaboration with well-defined long-term objectives. In addition to ensuring consistency in the conduct of research, this gave individual projects a strong argument for obtaining support from their respective funding agencies.[3]

Other similar projects then emerged, such as Climate and Ocean Variability, Predictability, and Change (CLIVAR), which succeeded TOGA and WOCE in the study of the oceans, Arctic Climate System Study (ACSyS), dedicated to the study of the Arctic, which was later included in Climate and Cryosphere (CliC), or the SPARC (Stratosphere Troposphere and their Role in Climate) programme focusing on the role of the stratosphere in climate. More recently, the CORDEX (Coordinated Regional Climate Downscaling Experiment) programme was created to promote the development of regional-scale climate modelling, and the sub-seasonal to seasonal forecasting project (S2S) was established jointly with the World Weather Research Programme (WWRP) and the Coupled Model Intercomparison Project (CMIP, see below) to extend meteorological forecasts to seasonal range.

Main scientific successes of the programme

Through these various projects, the goal of the WCRP is not to conduct scientific work itself, but to facilitate or catalyze research carried out in universities, meteorological services or laboratories. The programme thus provides a reference framework for both individual researchers and national funding agencies. While the main objectives of the programme are set by the sponsoring bodies, WMO, ISC and IOC, the definition of projects is the responsibility of coordination committees composed of scientists chosen by their peers.

[3] Ludovic Touzé-Peiffer, *Le climat : de l'observation à la modélisation, Éditions Matériologiques* (2018).

Over the past forty years, advances in climate research have largely resulted from the development of spatial and *in situ* observing systems, but also from improved computational facilities that have enabled extraordinary development of numerical models, data processing and assimilation methods. Benefiting from the opportunities offered by these new tools, WCRP has played an essential role in developing an understanding of the climate system difficult to imagine forty years ago. Research institutes have their own science policy, and many recent scientific advances could have taken place without the WCRP. However, the international coordination created by the WCRP has allowed synergy and sharing between research teams, promoting scientific advances, communication and interaction between partner countries.

Some examples of progress that owe much to the WCRP can be cited: an understanding of the climate system by taking into account its different components, atmosphere, ocean, continents, cryosphere and their interaction; quantifying this interaction and establishing a history of it; increasingly complete and accurate modelling of the climate system associated with the development of sophisticated methods for assimilating data of all types; the reanalysis of past climates that are particularly accurate over much of the 20th century; the development of climate change projections that focus on the 21st century and take into account possible greenhouse gas emission scenarios; the development of seasonal, multi-year and regional prediction capabilities... This list is far from exhaustive and gives an idea of the variety of research areas covered by the various WCRP projects.

WCRP, present and future

WCRP's objectives have evolved over these forty years, while maintaining the dual strategy of climate change and anthropogenic climate impact, based on scientific advances and societal demand for "useful" benefits. Climate science review and strategy meetings such as the one which will take place this year in San Francisco have been held regularly, with consultation of the scientific community and involvement of the supervisory authorities in the evolution of the programme's strategy. The previous one was held in Denver in October 2011 under the title "Climate Science for Society" and had led to the identification of a number of challenges for climate research in the current decade: melting ice and its global consequences; clouds, circulation and climate sensitivity; carbon effects in the climate system, weather and climate extremes, water in the global food basket, regional sea level changes and coastal impacts, short-term climate prediction (from a few years to a decade).[4]

In addition to the scientific results themselves, WCRP inputs should be highlighted in the assessments of the Intergovernmental Panel on Climate Change (IPCC). A significant part of the conclusions set out in the Panel's reports were indeed obtained under the WCRP banner. In particular, the results of CMIP are now at the core of the IPCC reports. This programme consists of an intercomparison of climate models of all major modelling centers around the world. It allows, among other, to compare future climate simulations based on the most complex models currently in use, under different economic development scenarios. The fact that those projections have served, through the IPCC, as a reference for the development of global climate change policies, particularly the Paris Agreement in 2015, illustrates how far WCRP's influence has spread beyond the scientific community. Among other examples of societal contributions, WCRP also undertakes to support the build up of an international

[4] Asrar Ghassem and James W. Hurrell editors, *Climate Science for Serving Society,* Springer Netherlands (2013).

community of young researchers, essential for future scientific developments, and encourages public awareness of climate research.

What about the future prospects of the WCRP? The last periodic evaluation of the WCRP by its sponsors dates back to 2018 and served as a reference for the establishment by the Joint Scientific Committee (JSC) of a new strategic plan for the programme, in consultation with the scientific community. This strategic plan guides the programme's mission around four pillars: "(1) advancing the fundamental understanding of climate system processes, variability and change (2) predicting short-term climate change (3) refining the ability to anticipate climate system change scenarios (4) supporting the theoretical and practical development of the integration of the social and natural sciences in climate matters".[5] In line with the historical objectives of the programme, these long-term strategies recall that despite the significant progress achieved during its past forty years, the WCRP has still many challenges to address.

Concluding remarks

It is of course impossible to summarize in a few paragraphs the contributions of a programme such as WCRP, but we hope that these few lines will give the reader the desire to read in more detail the documents mentioned here or those available on the WCRP website (see https://www.wcrp-climate.org/), or even, for those who can, to attend the 40th anniversary celebration in San Francisco.

In its relatively short life, the WCRP has played a key role in the transformation of climate science, transformation which has contributed to change the perception of our environment and societal priorities. Coordination methods developed by WCRP serve as examples in other domains where science-society interface is important, such as biodiversity and oceanography. We hope that the momentum given by WCRP to climate science since 1980 will be perpetuated in the coming decades, contributing to streamline a wide community and promoting its visibility and potential societal outcomes. We wish WCRP and the scientific community it represents a lot of success for its forty years and future projects.

[5] WCRP Joint Scientific Committee (JSC), World Climate Research Programme Strategic Plan 2019-2028, WCRP Publication (2019).