Specific achievements of André Berger

André Berger has published 327 papers, 168 in journals and 160 in books and proceedings. He has written the book "Le Climat de la Terre" which considers the past as key for the future, and was providing in 1992 an up-to-date and original synthesis of the scientific problems related to natural and man-made climatic variations. He edited 16 books, two having been considered as milestones in Quaternary research and serve as standard references. He is among the geophysicists with the largest citation index as first or single author. In January 2025, according to Google scholar citations, his total citations were 34414 with H-factor of 70. Among his 54 papers cited more than 100 times, 12 are single-author with 12462 citations. His two 1978 papers as single author are cited respectively 3031(daily insolation) and 1779 (caloric insolation) times, and his updated solution of 1991(two authors) is cited 4978 times. Since his official retirement in 2007, André Berger published 49 papers, among which 9 as first author (2 as single author).

André Berger is a Highly Ranked Scholar #1 in Paleoclimatology by ScholarGPS (https://scholargps.com/scholars/33916696533560/andre-berger). This ranking allows to assess more objectively the personal contribution of a scientist in a list of publications with many authors.

André Berger has been involved in the development of three different scientific fields related to geo-sciences (air pollution, climate change and paleoclimates) since the late 1960s. It will be shown that these fields were not necessarily popular at that time, but they became so, perhaps thanks to the contribution of persevering and far-sighted scientists like André Berger.

1. Air Pollution, dendroclimatology, persistence theory, climate and health

André Berger devoted part of his early career to air pollution modelling. He was among the first ones to promote planetary boundary layer physics as a basis to air pollution studies (1,2), in complement to the more popular Gaussian plume model (he contributed to 18 papers in journals and proceedings). As a member and later chairman of the NATO International Technical Meetings on Air Pollution Modelling and its Applications (ITM), he fostered air pollution studies by organizing and chairing symposia during more than ten years in the 1980s. ITMs have gained popularity and they were considered as reference conferences. Surely, the efforts delivered by André Berger during their early stages contributed to that success.

André Berger has also written 54 papers in journal and proceedings covering topics like dendroclimatology, persistence theory, detection of climatic changes, climate change and health, modelling climatic variations, human impacts on climate, volcanic and solar activities, desertification and abrupt climatic change. He has edited 6 books, made 204 popular conferences, 90 scientific ones and has written 160 popular papers on climate and climate changes. This is a large contribution given that, actually, these topics are not his main research streams.

1. Berger, A., Mélice, J.L., Demuth, Cl., 1982. Statistical distribution of daily and high atmospheric SO2 concentrations. Atmospheric Environment, 16(12), 2863-2877.
2. Demuth, Cl., Berger, A., Jacquart, Y., Schayes, G., 1977. A K-analytical model, including calm wind situations. 8th NATO/CCMS ITM on Air Pollution Modelling and its Applications, NATO/CCMS n°8, 610-631.

2. Astronomical theory of paleoclimates

André Berger is most known for his seminal contributions to the understanding of the Earth climate system, providing the community of paleoclimate scientists with an exceptionally precise method to compute the variations and distribution of solar radiation at the surface of the Earth over the past and future few million years.

In the 1970s, André Berger improved significantly the accuracy of long-term variations of obliquity and climatic precession used for calculating the incoming solar radiation (insolation)[1,2]. His astronomical solution has provided, for the first time, the list and the origin of all the periods characterizing the spectra of the astronomical parameters[3]. Besides the traditional periods of 21 and 40 ka (ka for thousand years), he has discovered the periods around 19 and 23 ka of precession, the period of 400 ka of eccentricity as well as the two main periods of 125 ka and 95 ka, and the 54-ka period of obliquity. These periods are extremely important. The non-linear response of the climate system to the precession periods (19 and 23 ka) is indeed the origin of the 100-ka quasi periodicity, which is the most important characteristic of the glacial-interglacial cycles of the last million years[4]. This also explains why these periods are found in geological records instead of the 21-ka period, which was the only one known until Berger's discovery. The 400 ka is fundamental because it explains why the Earth's orbit around the Sun will be circular within the next 25 ka. It happened that these frequencies match perfectly those found at the same time by James Hays and his colleagues (1976, Science) and many subsequent authors in the paleoclimate records. According to John Imbrie, the existence of the 23 and 19 ka constituted "the first most delicate and impressive of all tests for the astronomical theory".

The Berger's astronomical solution[1,2,5] is so good that it was and still is now used to provide insolation forcing for climate models and a dating of climate records over one million years. It was even used to constraint the age of a paleomagnetic boundary (the Bruhnes – Matuyama Reversal) under the leadership of Nicholas Shackleton[6], a constraint that was subsequently verified by radiometric dating.

André Berger has also fostered understanding the origin of the 100-ka period in astronomy[7] and in paleoclimate data[4]. He has identified the instability of the astronomical periods and the 1300-ka period in the amplitude modulation of obliquity[8,9]. He has unrevealed the relationship between the different periods of the astronomical parameters[10], and has projected the evolution of the astronomical periodicities over tens to hundreds of millions of years[11,12]. André Berger has also focused on an accurate calculation of the long-term variations of the daily irradiation[2], seasonal irradiation using the elliptical integrals[13], and caloric irradiation[14]. He has shown that the long-term variations of the daily insolation are much larger than those of the caloric insolation of Milankovitch and are totally appropriated for climate models. He has predicted the existence of a half-precession cycle in the irradiation of inter-tropical regions[15], a periodicity which has now been found in geological records. He has demonstrated that the total amount of energy received during an astronomical season depends on obliquity only[13]. He has proven that the daily insolation is primarily a function of precession, rather than of obliquity, contrary to the Milankovitch caloric insolation, and that the daily insolation is a more adequate variable to model the long-term variations of climate in response to the astronomical forcing.

His research then focused on different aspects of the astronomical theory of paleoclimates. For example, André Berger and his colleagues calculated in the early nineties the impact of the very long-term variations of the elements of the Earth-Moon system on the frequencies, amplitudes and phases of the astronomical parameters[11]. They found that the obliquity and precession periods must have shortened because of tidal dissipation. This prediction turned to be confirmed in paleoclimate data from the Cretaceous. The success has encouraged a new generation of astronomers to provide refined astronomical solutions valid over several tens of millions of years.

Aware of the importance of a rigorous and adequate modelling for better understanding climatic variations, André Berger developed with his team a climate model of a new kind[17]. It represented fairly crudely the atmosphere (although on a physical dynamical basis) but the computing time spared by the clever simplification could be invested to calculate the interactions with other climatic components, such as the ocean, sea-ice and ice sheets and to extend the calculation over one million years at least. We are in the early nineties. The first Earth Model of Intermediate Complexity (EMIC) was born. The rigour with which the model was designed and assembled made it the first complete mathematical tool usable to understand and predict glacial-interglacial cycles at a mechanistic level (The term 'EMIC' was in fact introduced by Ganopolski and co-authors in a paper published in 1998 in Science, and then expanded by M. Claussen in a paper devoted to these models in 1999).

André Berger was, once more, ahead of this time; the EMIC models are now recognized by the climate community to be a useful link between the general circulation models and conceptual models. EMIC allow us to put into a common framework the long-term climatic variations, to analyse interactions between the Earth's climate components and to quantify the resulting feedbacks. Based on such climate models, André Berger showed the importance of the long-term variations of insolation to simulate the glacial-interglacial cycles[18,19], the possible exceptional length of our interglacial[20,21], the importance of the 400-ka period in searching for analogues of our present-day and future climate[22], the relative role of the multiple feedbacks involved in the explanation of the glacial-interglacial cycles[23]. In particular, André Berger and his team were among the firsts in the early 1990s to emphasize the significant amplification of water vapour in the response of the climate system to both the astronomical and greenhouse gas forcings during the last glacial-interglacial cycles. They also underlined the fundamental role of other feedbacks like those associated to albedo and temperature, land surface cover and snow field albedo, the isostatic rebound, the ice sheets and the carbon cycle. Moreover, their experiments stress the connexions between the slow climatic changes and the rapid (e.g. anthropogenic) changes.

As far as analogues to the Holocene are concerned, the intercomparison between the last nine interglacials shows that the greenhouse gases play a dominant role on the variations of the annual mean temperature of both the Globe and the southern high latitudes, whereas insolation plays a dominant role on the variations of tree fraction, of monsoon precipitation and of the northern high latitude temperature and sea ice. It shows also that MIS11 and 19 are in very close agreement with MIS-1, although MIS-11 is a warm interglacial only because of its high CO2. The warmest interglacials MIS-5 and 9 have to be considered with great care when compared to present-day climate and its future given their totally different astronomical forcing.

The experience gained at the astronomical time scale has helped André Berger and his team to study also the transient response of the climate system to the progressive increase of the greenhouse gases concentration and sulphate in the atmosphere, and to volcanic and solar activities over the more recent times[24]. In the mid-1990s he questioned whether human activities can interfere with the natural evolution of climate at the geological time scale. He and his team were the first to point out that, contrary to what was generally thought, our interglacial might naturally last relatively long because, related to the 400-ka eccentricity cycle, the Earth's orbit around the Sun is progressively becoming a circle[21]. The analogy with what happened 400 ka ago led them to conclude, before data were available, that the interglacial at that time must also have been much longer than usual, a prediction confirmed later by the ice core record drilled at Dome C by the EPICA community. This 400-ka cycle has in fact practical policy relevance in searching for past analogues of present-day and future climate. The Earth's orbit becoming a cycle and additionally an atmospheric CO_2 concentration being already higher than any time over the last 800 ka, the mid-range IPCC scenarios will, according to André Berger and co-authors[21], result in a complete melting of the Greenland ice sheet over the next 5000 years – a prediction confirmed by other modelling groups later – and the climate system will not recover before several tens of thousands of years.

Berger also contributes to the current debate about anthropogenic climate change[25,26]. His achievements concern climate variations of the Holocene[27,28] and the transient response of the climate system to the progressive increase of greenhouse gases and aerosols, in addition to other natural forcing factors (astronomical forcing, volcanoes and solar activity[27,29]). He continues to inject original ideas in the scientific community. In papers published as early as in the 1990s[20,22,30], he defended the idea that, as the present Earth's orbit around the Sun is almost circular, we may well be living in an exceptionally long interglacial, so that the climatic change induced by human activities would have a very long impact over the next 100,000 years due to the interference between anthropogenic and astronomical forcings on climate. This provocative idea has pushed the paleoclimatic community to test it and to look for analogues[22] of our present-day and future climate.

Since 2015, André Berger has intensively collaborated with young researchers of his group but also with scientists at the international scale. Their publications concern in particular the past interglacials[16], East Asian summer monsoon[31] and abrupt changes[32]. André Berger continued also to publish papers related to his work on the astronomical theory[33,34].

Besides his outstanding scientific accomplishments, André Berger has also been involved in science policy and climate change since the mid-seventies. He displayed a profound commitment to communicate the importance of climate issues through lectures and organisation of symposia on climate change and variability. Noteworthy, the "Erice School on Climatic Variations and Variability, Facts and Theories", that he organised in 1980[35] is probably the first one bringing together theoreticians and field scientists working on climatic changes at all times scales. He then continued to promote climate change research by devoting part of his time in the organization of the first Programmes on Climatic Changes of the Commission of the European Communities. André Berger has also been active in 13 Committees and other Advisory Groups in the European Union, including the very first one in the early eighties. Just to give an example, he chaired the External Advisory Group on Global Change, Climate and Biodiversity in 2000-2002 and was a member of the Scientific Committee of the European Environment Agency between 2002 and 2008.

André Berger also offers huge amount of his time to train research scientists, stimulate a multi-interdisciplinary approach of the Earth system problems, and foster international collaboration strengthening the relationship between geophysics, geochemistry and geosciences in general. André Berger is deeply convinced of the importance of informing and teaching the public about environmental science and managed to transform this conviction in practical, day-to-day action. André Berger appreciates the complexity of the Earth system and the danger that humanity is inflicting on itself because of an unreasonable use of natural resources. In this context, his academic career is exemplary because not only did he acquired high scientific respectability among large groups of climatologists, oceanographers, bio-ecologists and geologists engaged with him in research, but also did he unify these communities around the challenges faced by modern civilisations.

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