The Climatic Odyssey of *Homo sapiens*

par Prof. Dr. emeritus Alain Préat, Free University of Brussels
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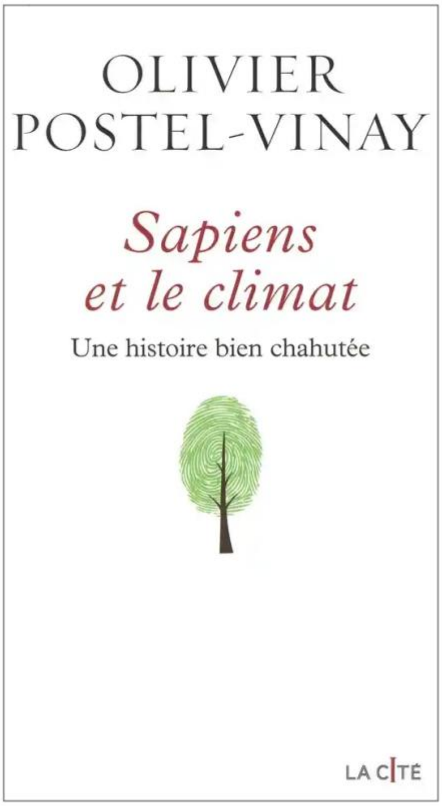
1. Introduction

At a time of climate change (or disruption for some), it's high time to read Olivier Postel-Vinay's excellent French book, 'Sapiens and the climate, a turbulent history' (original in French: *'Sapiens et le climat, une histoire bien chahutée (2022)'*, which looks at the climate changes our species has undergone since *Homo* became *sapiens*, i.e. over the past 233,000 years. What does this book tell us?

It shows us that our species has been confronted throughout its history and evolution with brutal climatic changes of durations and intensities that have no comparison with those of our own time.

This unusually meticulous essay is supported by well-documented historical accounts and facts, supplemented wherever possible by scientific data drawn mainly from archaeology, biology, chemistry, physics, geography, and geology. This perspective paints a detailed picture of the climatic changes faced by the first humans (hunter-gatherers), then by the first civilizations and finally by our modern societies.



The author moves through time and the world with the precision of a metronome, and 'icing on the cake' attempts a synthesis (last chapter) of historical facts in the light of the most recent scientific data. **Even if it is sometimes a matter of hypotheses, a powerful vision emerges showing the extent to which climate change was and is the rule in the recent history of our species, just as it has been throughout the geological history of our planet**. The author is extremely cautious in disentangling what is linked to human activity itself (e.g., agricultural practices, forest management, environmental policies, etc.) from climatic processes. **This is not, therefore, an attempt to make an *a priori* statement about the climate that is likely to explain everything.**

It is not possible to cover all the historical facts concerning all the civilizations (Asian, Australian, North, and South American, African, etc.) covered by the author, and I shall concentrate mainly on Europe *sensu lato*, and nearby regions (Arabic Plate), whose history, and sometimes climate, are familiar to us.

2. Historical dating: a headache

Before analyzing these periods, however, we need to clarify the different ways of 'counting' time in relation to today, i.e., the way in which recent chronology works, which is rather confusing because it is based on conventions that are followed differently by researchers. This point is a real headache for those who deal with recent periods. Past times are often referred to with the initials BP, for example 25,000 years BP or 25 a BP (= Before Present). BP, meaning 'before the present' (AP *-in French-* is also used, but more rarely, = *Avant le Present'* and for 'After or *Après le* (*in French*) Present', which adds to the confusion! ...), is the year considered as the present and is fixed at the first of January of the year 1950 in our calendar. This year was chosen as the reference year because it predates the nuclear tests that disrupted the distribution of isotopes used in radiochronology. **This is not a problem for distant periods, but it does pose problems for the study of recent periods, for which it is necessary to establish the origin of time more precisely. English speakers use AD (= Anno Domini) to describe the years after the birth of Jesus Christ in the Julian and later the Gregorian calendar.** In French, AD means 'after Christ'. English speakers also use **BC** for (Before Christus) for the years 'before Jesus Christ'. Other conventions exist but are less widely used. Finally, the 'Year of the Lord', decreed as 'Year 1', inaugurates the Christian era, also known as the 'common era' or 'conventional era', and is abbreviated as 'EC' (French speakers) or 'CE' (English speakers). For the years preceding those of the common era, English speakers use BCE (Before Commune Era or Before Christian Era). **BCE/CE is increasingly used in the international community, both scientific and non-scientific**. The chronological 'puzzle' is therefore a real problem, especially as it is here in this article, which involved consulting numerous references, each with its own conventions. In the case of Olivier Postel-Vinay's book (2022), the 'puzzle' is even more acute, because the author has taken, for reasons of better perception of durations, 2400 years as the unit of reference, i.e., 400 BC or one year before the execution of the philosopher Socrates (= 2400 BS, with S for Socrates). This being an unusual unit of reference, the author was obliged to mix or use other units of literature. Without wishing to reject the unit of 2400 BS, this article taken from Olivier Postel-Vinay's work will use the conventions BP, BC and AD. For ^{14}C radiocarbon dating, which is not used in the work analyzed, an adapted nomenclature is required (UK references in Nomade, 2017).

Temporal analysis in geology distinguishes between absolute time and elapsed time, two different periods or concepts. This leads to the following convention: the geochronologic data are presented as yr BP (years before present), as **ka** (age date in thousands of years or (= absolute time)), as **kyr** (time interval or 'duration' in thousands of years, e.g., between distinct age data), following the same principle as **Ma** and **Myr** (millions of years), respectively (reference here).

Olivier Postel-Vinay's book (2022) is not accompanied by illustrations or graphs. To make the duration of climatic time' easier, five figures (Figs. 1 to 5) selected from the literature are presented below. They cover the period related to the evolution of the genus *Homo* (around 2.8 Ma, Fig. 1) and that of the species *Homo sapiens* (around 250 ka, Figs. 2 to 5):

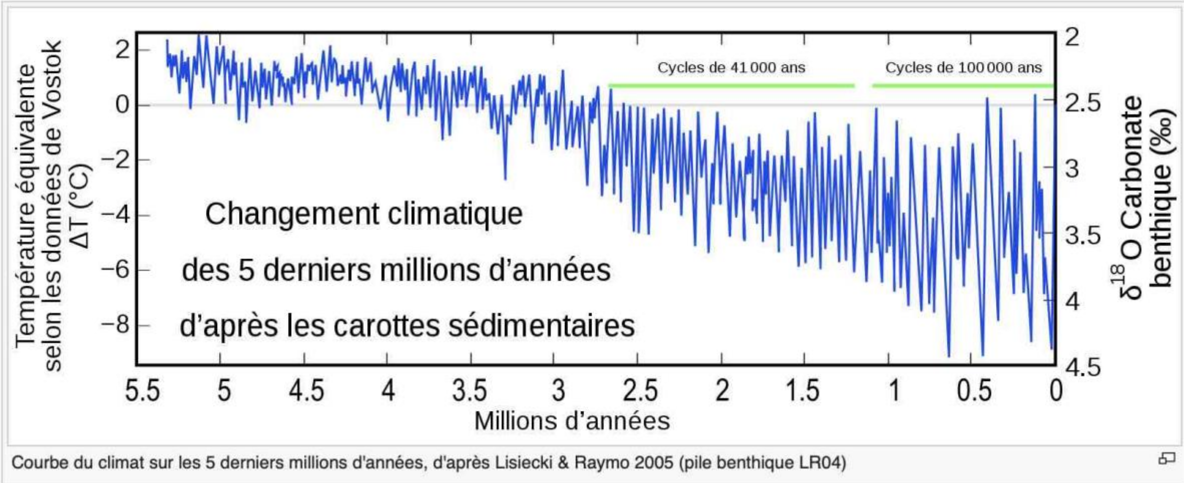


***Figure 1:** Climate variations linked to the Earth's orbital parameters over the last 5.5 million years (end of the Miocene). Transition from a cyclicity of 41,000 years to a cyclicity of 100,000 years around 1 Ma (Lower Pleistocene). Y-axis: temperature variations based on Vostok data (oxygen isotopes). Adapted from Lisiecki & Raymo, 2005. **The sharp fluctuations in temperature are linked to the Dansgaard-Oeschger cycles (here and here)**, with a warm episode or interstage and a cold episode or stage. **Each cycle begins with an abrupt rise in temperature around 10°C in just a few decades**, followed by a cooling that is initially gradual, then abrupt at the end, until it reaches the values characteristic of a stadial episode. Also see SCE.*

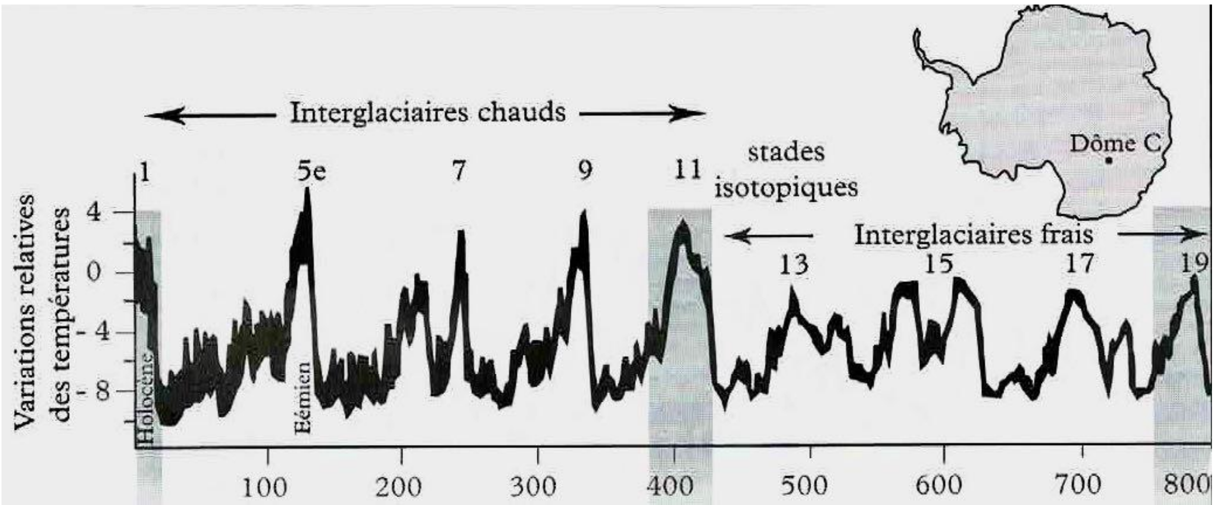


***Figure 2:** Relative temperature variations recorded at Dome C (Antarctica) in ice drilled as part of the EPICA program in Deconinck, 2014). The isotopic stages (cf. 19 to 1) shown in the figure are not discussed here. If necessary, refer to figure 2 in SCE for a discussion of the isotopic stages. Age in thousands of years (800,000 years on the right, end of the Early Pleistocene). The history of Homo sapiens begins 233,000 years ago during the Middle Pleistocene (cf. Olivier Postel-Vinay, 2022).*

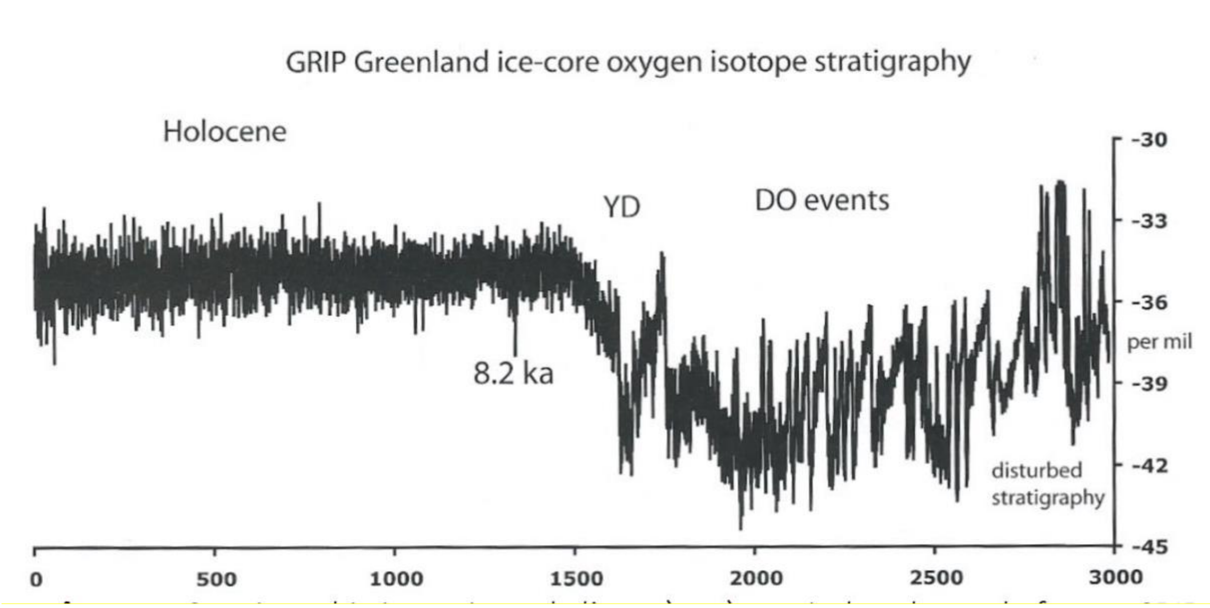


Figure 3: *Oxygen isotope stratigraphy using ice from the GRIP borehole (Greenland).*
Y-axis : δ¹⁸O values in ‰ and abscissa borehole depth in meters ([Cronin, 2010](#)). Oxygen isotopic compositions are an indicator of temperature. ***The figure clearly shows that the current interglacial (Holocene, left half of the graph) is characterized by low-amplitude temperature fluctuations (apart from a colder episode around 8.2 ka BP), whereas the Last Glacial (right half of the graph) shows frequent, rapid climate changes with large amplitudes (from 8°C to 16°C depending on the*** *δ*^{18}*O)* ***recorded by the D-O ('Dansgaard-Oeschger events') events or 'cycles'****. Nb: YD stands for Younger Dryas, corresponding to cooling 12800 years ago BP. References in SCE and here.*

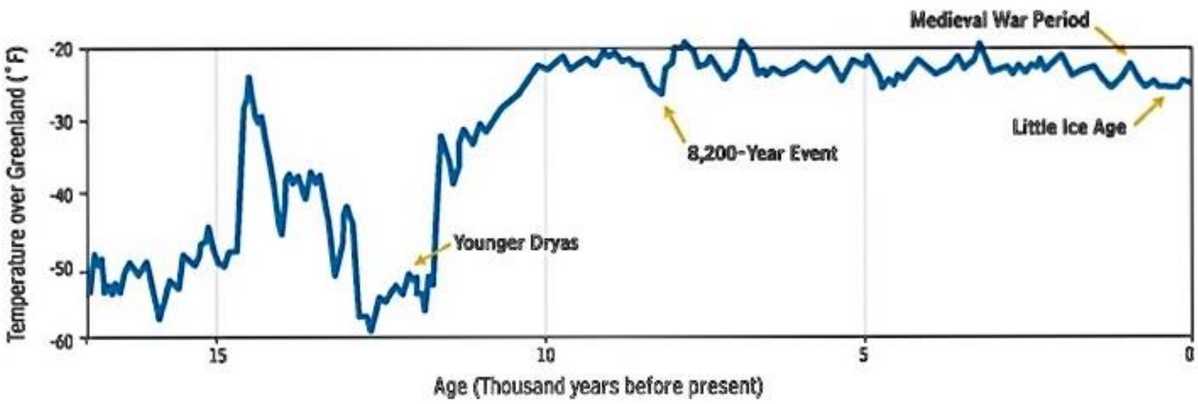


Figure 4: *Temperature variations (°F) in Greenland in the time frame of the end of the* ***Last Ice Age*** *(strong fluctuations, left) and the* ***Holocene*** *(weak fluctuations, right) according to Schartz & Randall, 2003. Nb -60°F = -51°C and -20°F = -29°C****.' War' corresponds to 'Warming'.***

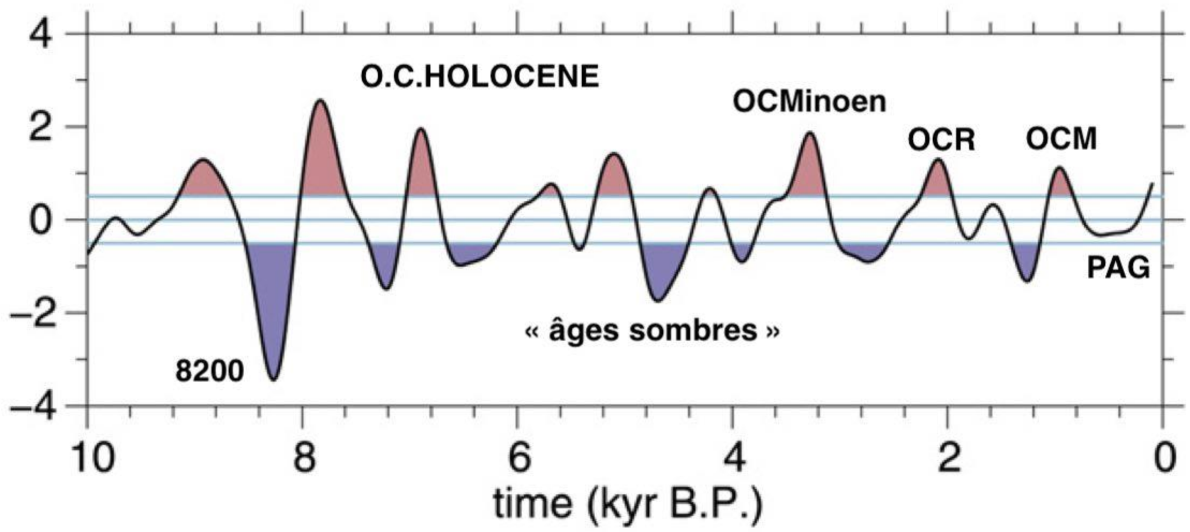


Figure 5: *Holocene temperature fluctuations (in °C, y-axis) deduced from oxygen isotope ratios in ice from the GISP2 borehole GISP2 in Wanner et al. 2011. OCR: Roman Climate Optimum, OCM: Medieval Climate Optimum, PAG: Little Ice Age. CO: Climatic Optimum, 'âges sombres': 'dark ages'. See also Spencer, 2022*. See Section 6, below.

3. Drought's cause *Homo sapiens* to leave Africa

But let's start at the beginning, with the presence of *Homo sapiens*. This was the result of a major climatic change, well documented in the literature, when *Homo habilis* and *Homo erectus* left Africa during interglacial periods in the Pleistocene. These periods marked a change in climatic regime at around 1.7 Ma (millions of years) in the Lower Pleistocene, with abrupt glacial cycles of longer duration (from 41,000 (41 kyr) to 100,000 years (100 kyr), see Fig. 1, and Nie and Fang, 2008), leading to droughts in East Africa and, ultimately, the isolation of bottlenecked populations. This encouraged genetic isolation, leading to the appearance of *Homo sapiens* around 233 ka. During these periods, the planet's orbital modification was the major process regulating the global climate (17 major glacial-interglacial cycles have been identified since 1.7 Ma, some of which are shown in Fig. 2). **The duration of interglacial phases varied from 10,000 to 20,000 years, and the transition from an ice age to an interglacial was abrupt, as shown by the sharp temperature peaks (Fig. 2). Warming is of the order of 10°C in the space of a few decades**, with equally abrupt changes in precipitation patterns and the atmospheric circulations that accompany them. The return to cold conditions was more gradual at first, followed by a rapid acceleration (Nahon, 2022).

The story takes place in Africa, more specifically along the East African Rift Fault (Omo River), which stretches for thousands of kilometers between Ethiopia and Mozambique. It should be remembered that all humans today are descended from archaic ancestors who lived in East Africa around 200-250 ka during an interglacial period (Fig. 2). Although the Great Rift Fault was initiated 30 Ma ago, most of the surrection (= 'bulging of the Rift') and aridification took place over the last 3 to 4 million years. At that time, the climate was highly variable, oscillating between severe aridity and wetter conditions as the Earth's axis oscillated cyclically, causing the precession of the equinoxes (Dartnell, 2020).

A few tens of millennia after its appearance**, *Homo sapiens* faced at least two major periods of drought (at 168 ka and 143 ka), during the penultimate glaciation (in Wainer, 2007), marked by the drying up of Lake Tanganyika and Lake Malawi, the first period lasting several thousand years, the second 20,000 years**. These two lakes (with maximum depths of 1,500 and 700 meters respectively, and which today contain more than 80% of the freshwater on the African continent) were twice drained by more than 95%. **These 'mega-droughts' affected tropical Africa from the Indian Ocean to the Atlantic coast and forced *Homo sapiens* to migrate to the caves along the South African coast (Pinnacle Point cave, 160 ka ago). So here we have *'the first climate refugees in our history'*. The sea level was about 100 meters lower. It should be noted that two episodes of drought spread over several millennia followed from 133 ka, then from 110 ka to 75 ka (**Scholz et al., 2007). The Great Lakes dried up and new populations of hunter-gatherers migrated towards the Pinnacle Point cave and settled on the South African coast. According to these authors, aridity in tropical Africa was more severe than during the Last Glacial Maximum and one of the most pronounced in the Quaternary.

After this initial exposure to extreme long-term climatological events, the penultimate interglacial, the Eemian took place between 130 ka and 115 ka BP. **This interglacial is warm, especially at the beginning (+4 to 5°C, Jouzel et al. 2007), and unstable, and will not be a long quiet river from a climatic point of view**: it will see 'average temperatures' in the oceans higher than 2°C compared with today, implying much higher temperatures on land (more than 10°C in the south of France compared with today's temperature, in the Eemian). The volume of the ice caps was reduced, especially at the beginning of the Eemian. The sea level was then 4-5 m above today's level. At that time, the volume of the ice caps was slightly less than today's, and malacology from the coasts of present-day Portugal can be found as far north as Denmark in areas now occupied by tundra (Van Vliet-Lanoë, 2013). Olivier Postel-Vinay recalls that hippopotamuses colonized the River Thames, and **that in the Swiss Alps the temperature was 4°C higher than today's for four millennia and rose by a further 2°C over the following ten millennia, probably leading to the melting of the Alpine glaciers**. The Sahara became wetter, with lakes and rivers occupied by hippopotamuses (skeletons found in the Aïr). Whole sections of the Greenland and West Antarctic ice caps collapsed. The beginning of the Eemian corresponds to a heat peak, with warmer, wetted winters than today in the northern hemisphere. The verdant Sahara was easy to cross, as were the Sinai desert and the Nile delta. *Homo sapiens* settled on the coast of the Red Sea around 125 ka and "*devoured giant clams, causing the first anthropogenic degradation of a coral mass*".

4. *Homo sapiens* faced with several very sudden climatic changes

This was followed by the Glacial Period from 115 ka to 11.7 ka BP (Figs. 3 and 4), which began in successive bursts (= Würm glaciation in Alpine nomenclature), first very early on the west coast of the North Atlantic, and later (110 ka BP) on Fennoscandia, in relation to thermohaline circulation (Van Vliet-Lanoë, 2013). The glacial maximum was reached around 21 ka BP and sea level was -120/-130 meters lower than at present. Numerous interstadials (at least seven) lasting from one to several millennia were responsible for softening. At the height of the Würm glacial paroxysms, ice (ice caps and mountain glaciers) covered almost

35% of the land surface, compared with 15-20% during the interstadials and less than 10% today (Nahon, 2022). The Würmian glaciation was not felt in tropical areas as it was in the rest of Asia.

A period of humidity lasting around 25 millennia (103 ka BP-78 ka BP) settled over northern Africa and the Near East, encouraging further *Homo sapiens* to leave Africa. *Homo sapiens* were found in Israel (Qafzeh cave) and in the Arabian Peninsula (Nefoud desert), where human skeletal remains were exhumed from a freshwater lake where hippopotamus and buffalo were also found. This wet period was also recorded in Asia, in India and Indonesia.

A new period of drought, marked by the strengthening of a glacial episode, replaced the previous one from 71 ka BP and lasted until the end of the Glacial (11.7 ka BP). As with the Eemian interglacial, this period was characterized by numerous climatic changes, particularly a period of intense drought. **During this period (63 ka BP-47 ka BP), the Sahara expanded considerably, causing the desertification of North Africa because of a climate that had become arid, leading to the second major exodus of *Homo sapiens* from Africa. In fact, we Europeans are essentially descended from this migration.** It should also be noted that this glacial episode was preceded (74 ka BP) by the eruption of the Toba super-volcano in Indonesia, which is thought to have plunged the Earth into a 'volcanic winter' for several years (Osipov et al., 2018 *in Nature*), with a decline in human populations. This eruption emitted a gigantic volume of ash that covered 1% of the planet's surface and may have darkened the sky, leading to global cooling for several decades (Dartnell, 2020). Some authors (Le Guyader, 2018) even see the disappearance of cousins of our species. Populations of *Homo sapiens* were reduced, but not wiped out. *Homo sapiens* was able to expand again in Africa (from southern Africa to tropical Africa), during a wet period a few millennia after the Toba eruption, a period during which the level of the East African lakes had risen considerably.

***Homo sapiens* then 'underwent' unprecedented climatic chaos until the arrival of our current interglacial. There have been numerous periods of extreme warming, with rises of more than 8°C and sometimes 16°C in 40-50 years**. At least ten of these extreme warming events occurred during the Upper Palaeolithic period, and there were 25 for the last glacial period (see SCE, also Capron et al. 2021).These so-called Dansgaard-Oeschger (D-O) events last between 500 and 2,500 years (sometimes up to 4,500 years) and have an asymmetric temperature profile, with rapid or abrupt warming and slow cooling. They are attributed to numerous weakenings in the strength of the Atlantic Current (AMOC) and could also be linked to volcanic activity (Lohmann and Svenson, 2020).

***Homo sapiens* has thus survived the most brutal climatic changes the planet has seen in the last two million years**. During cold spells, trees were replaced by dry tundra, ideal for hunting large mammals. The valleys of southern Europe in which *Homo sapiens* took refuge had 'average temperatures' in winter around 10°C lower than today. Extreme cold was experienced between 23 ka BP and 16 ka BP, during the Solutrean crisis, when Western regions resembled present-day Siberia, with permafrost and blizzards. Animal populations collapsed and *Homo sapiens* once again experienced a demographic bottleneck. Around 19 ka BP, the ice cap was up to 3 km thick and covered three-quarters of Great Britain as well as Scandinavia. The English Channel is a steppe irrigated by a river, and sea level is 130 m lower than today. It should be noted that the great cold periods affected the Near East less than Europe. *Homo sapiens* evolved in a shrubby steppe rather than a tundra. **This demonstrates once again (see SCE articles, particularly here) that the notion of a 'global average temperature' is unfounded.**

Two sudden climatic changes marked the end of the Late Glacial period. **Firstly, in Europe, a marked warming, with global effects, was accompanied by significant deglaciation. Part of the Arctic glaciers suddenly melted. This was the BØlling warming (from 14.6 ka to 14 ka BP), which took place during an interstadial period spanning almost 340 years: there was a seamless transition from a very cold climate to a lukewarm climate, i.e. in just a few decades from -15°C to -25°C to +20°C in winter, and from +10°C to +20°C in summer in northern Europe.** According to Toth et al.(2022) the temperature reached during this period was slightly higher than today (around +0.5°C) and the temperature jump compared with the previous cold period was 5°C. Humidity returned after a very long period of cold and drought, and rainfall increased drastically (30 to 40%) compared to the previous period, allowing the formation of soil clays to resume (Nahon, 2022), a favourable condition for agriculture. The population is growing rapidly and, instead of moving with the seasons, it is beginning to settle. This phenomenon also affected Africa and the Near East. **The sea rose by 14 to 18 meters in 340 years, ten times the current rate**, but this did not prevent *Homo sapiens* from returning to settle in England after an absence of 10,000 years. The first small villages sprang up on the edge between the dense forest to the West and the wooded steppe to the East.

A return in just a few decades to extreme glacial conditions in Europe (cold and dry), and less rigorous conditions in the Near East, took place around 10.4 ka BC and lasted for around 1000 years. **This period, known as the Recent Dryas, saw the disappearance of forests, replaced by tundra. Glaciers formed in Scotland, snow could fall from September to May and winter temperatures dropped below -20°C in our regions**. *Homo sapiens* once again abandoned our regions and was threatened with extinction. The villages of BØlling are abandoned. **The end of the recent Dryas is characterized by a sudden rise in the average annual temperature in the Northern Hemisphere of around 7°C in 50 to 60 years, with this rise reaching 10 to 12°C in even shorter periods locally (particularly in Greenland)**. The Dryas was thus a final cooling of the climate (Pisano, 2018), before the rapid warming that brought the Last Ice Age to an end and ushered in the temperate Holocene period.

5. *Homo sapiens* and the benefits of the Great Holocene Optimum

With the Holocene, we are entering a situation like the present one. However, the Holocene is not a long, quiet river either, but overall, it's much less cold than before and, above all, the warming is set to last. Warming was as rapid and more pronounced than during the BØlling interstadial period, of the order of 20°C in the European winter and 7°C in the Near East. The Mediterranean climate, with its hot summers and rainy winters, took hold. The cradle of Western civilization was born of the wealth of the Fertile Crescent, which stretched **from the Negev to the Zagros Mountains (Iran, Iraq)**, with an unprecedented development of agriculture from 8.6 ka BP. The eastern Sahara became 'semi-humid', and its northern part 'semi-arid'.

Agriculture thus became established during a major climatic optimum with the establishment of the current interglacial, which comprises several optima's ('Holocene' or 'Great Holocene Optimum', Minoan, Roman, Medieval, Current), separated by cold periods, often called dark periods, which followed each other until the Little Ice Age preceding the Current Optimum (Fig. 5 and see below). This Great Holocene Optimum (*sensu stricto*), which runs from 9000 to 5000 BP (with the cold interlude of 8200 BP, see below), can be considered to be the founding period of human history (= 'Neolithic Revolution'), characterized by a relatively stable climate. Agriculture and animal husbandry (with the wheel, the plough, animal traction, etc.), metallurgy and the birth of cities were all the result of this warm, wet period, which began in the alluvial plains of the Middle East and China.

A first major cold snap and drought occurred around 8.2 ka BP (Figs. 3 to 5), less violent than that of the Dryas, but sufficient to wipe out the populations of many occupied areas. Lake Adrar, in the center of the Sahara, dried up completely for a thousand years. This event is known as the 8200 BP climatic event and will last between 200 and 400 years. Estimates of the extent of the cooling vary according to measurement methods, but range from 1 to 5°C. The greatest drops in temperature occurred in the northern Atlantic regions, while in Europe they reached around 0.5-1°C and less than 0.5°C in the subtropical regions of the northern Atlantic. Cooling began around 8175 BP and, in less than 20 years, 'average temperatures' fell by 3.3°C. **The coldest period lasted around 60 years and is linked to the almost complete emptying of Lake Agassiz in Hudson Bay, at the level of the ice cap in the north-east of the American continent (Laurentide cap) (Bauer et al. 2004 , Holmes et al. 2016). This event had several consequences: a sharp rise in sea level (2 m/century), the shrinking of land masses (10 km/year, or 200 m/week) and the triggering of a tsunami off the coast of Norway (3 m high wave) and in the Shetland Islands (20 m high wave). Lake Agassiz thus extended to cover more than 500,000 km^2 of Canada and the northern United States.** Populations of *Homo sapiens* also declined during this cold period, with waves of migration to the east and south.

After this cold interlude, the Great Holocene Optimum resumed for more than a thousand years, and a new cold and dry period, of shorter duration than the previous one, took place from 3.54 ka BC to 3.4 ka BC. Once again, the population of the cities (which had become 'states') declined.

6. *Homo sapiens* and recent climate optima (Fig. 5)

Our recent history is directly accessible in the written documents of Minoan, Roman, Medieval, and Modern civilizations (Little Ice Age and present day).

The climate of this interglacial period, which began at the end of the Ice Age (see above), fluctuated markedly, with warmer periods (Optima's) and colder periods (Dark Periods). The 'average' temperature variations are only a few degrees (< 2°C) over several centuries

each time, so the climate situation has little in common with the Dansgaard-Oeschger events showing large and abrupt temperature variations over short periods (decades) or those of the BØlling and Dryas. However, recent climatic variations have had drastic consequences for the planet's populations and civilizations, and it is a major challenge for Olivier Postel-Vinay (2022) to have compared History and Climate on a decadal and multi-decadal scale. Before mentioning the main points, it is important to note that the dates framing the Optima's and 'Dark Periods' should be treated with caution: as climate fluctuations are not abrupt, given the small temperature amplitudes, the limits between periods may vary from one author to another, but there is unanimity on how they unfold. The succession of periods is as follows:

- **Intermediate Period: ~ 3000 BC - ~2000 BC**

- Minoan Optimum: ~2000 BC - ~1350 BC

- Greek Dark Ages: ~ ?1350 BC - ?250BC

- Roman Optimum: 250/200 BC-400 AD

- LALIA or Homeric Minimum or 'Dark Ages Cold Period': ~400-800 AD/900 AD

- Medieval Optimum: 900-1200 AD/1300 AD

- Little Ice Age : 1300 AD -1850 AD

- Modern : post-1850 AD

Easterbrook (2016) subdivides the current period as follows: 1880-1915 Cold Period; 1915-1945 Warm Period; 1945-1977 Cold Period; and 1978-2000 Warm Period.

To 'complicate' these subdivisions, the above periods are grouped together in two broader 'Neoglacial' groups or periods (from 4.5 ka BP to the present day) following the Holocene Climate Optimum in the strict sense (initiated at 11.7 ka BP).

Olivier Postel-Vinay's book gives a detailed account of the historical events that took place in every part of the world during these optima and colder periods. These events are summarized above.

- **During the Intermediate Period**, at the time of Ur's heyday, the climate dried out and a persistent northerly wind made winters longer and asphyxiated the soil. Rainfall fell drastically, causing populations to migrate to regions where food was still available. Sumer saw its population double under the influx of refugees. The waters became saturated with salt and fruit trees dried up. The Nile could be crossed on foot. The Sahara ceased to be green. Famine raged for decades. The crisis affected almost the entire planet (Egypt, South America, India, China, etc.) and some authors (Weiss, 2000, Wiener, 2014, Wiener, 2018) saw **'the first mega-drought of the historical period' affecting the first complex civilizations (e.g. the Akkadian Empire), which collapsed mainly during the period 2300-2000 BC.**

- **The Minoan Optimum** is a very warm climatic period from 1.6 ka BC, lasting at least a millennium. The Hittites saw their towns and capitals deserted. The Etruscans, originally from eastern Anatolia, fled with their livestock. In Syria, Cyprus and the Nile delta, **pollen analysis shows a severe drought lasting 300 years**, with famines during the reign of Ramses II and the collapse of the Egyptian Empire. The decrease in the monsoon in the Ethiopian highlands led to a significant reduction in the flooding of the Nile. Populations had previously been affected by the gigantic eruption of Santorini around 1645 BC and by numerous earthquakes around the Mediterranean. This was the period of the myth of Atlantis... and, also of the decline over 150 years of the Minoan civilization, the first traces of which dated back to 3.0-2.7 ka BC during the Bronze Age.

- **The Dark Ages** are relatively little documented. Cline (2014), taken up by Olivier Postel-Vinay, devoted a book to them, focusing on the period around 1177 BC. They are said to have been 'obscure' because climatic conditions had become very severe following a marked cooling and drought in the Middle East (Babylon). Famines, earthquakes, and population migrations limited archaeological evidence and written sources. Within twenty years, the entire Bronze Age civilization in the Mediterranean (Egypt, Greece, etc.) had collapsed (the Iron Age would follow). On the basis of oxygen and carbon isotopes in speleothems, alkenones in algae and the distribution of foraminifera species, Drake (2012) has shown that the temperature of Mediterranean surface waters fell rapidly, limiting the flow of freshwater into the atmosphere and leading to a drought that was more severe than during the Bronze Age, and which persisted until the Roman Optimum.

- **The Roman Optimum or Roman Warm Period (RWP)** was marked by an exceptionally stable climate, with warm, well-watered centuries and abundant spring rains, favoring the development of Carthage and Rome around the Mediterranean. Here is a short extract from SCE on the subject (the references are in the article cited): ***"It was during this Optimum that Hannibal crossed the Alps (in 218 BC) with his elephants, a situation that is unthinkable today.*** *This Roman Warm Period (RWP), which has been known for quite a long time (at least since 1999, when it was first mentioned in an article in Nature), has remained discreet in the literature, which tends to focus more on the Medieval Climate Optimum (around the year 1000, see below).* ***However, numerous articles suggest that the RWP is the warmest Optimum in recent times, at least for the last two or three millennia****. A recent article by Maragritelli et al (2020), in Open Access in Nature, has shown that this is indeed the case, namely that the RWP was the warmest period in the last 2,000 years (by an average of 2°C compared with today in the region studied, Sicily and the western Mediterranean) and that the increase in temperature was mainly due to solar activity (Margaritelli et al., 2016).* According to Olivier Postel-Vinay (2022), ***"the years 21-50 AD represent the thirty warmest years of our era up to the 2000s,*** *with July temperatures at least 2°C higher than in the mid-20th century. The climate deteriorated around 150 AD and became more unstable from 250 AD onwards, with cooling and drought. The great Aletsch glacier in Switzerland began to* *grow again. There is a coincidence between the 'climate crisis' of the third century and the first fall of Rome. This climate crisis in the Mediterranean and Western Europe also affected Central Europe, and a terrible drought between 338 and 377 AD in the steppes of Central Asia was the cause of a migration of Huns towards Europe. On other continents too,* ***"a century-long drought, for example in the Mexico basin around 550 AD, led to the migration of populations in search of better pastures, followed by three centuries of mega-drought that saw the abandonment of the Mexican populations of Monte Alban".***

- **The LALIA episode** (**or Little Ice Age of Late Antiquity**) marked a cooling with an increase in famines. The temperature in the Mediterranean fell, and two huge volcanic eruptions in the northern hemisphere made AD 536 and AD 540 'summerless' years. **Tree rings in the Austrian Alps and Altai suggest that AD 540 was the coldest decade of the Holocene in this part of the world**. A synthesis is proposed by Büntgen et al. (2016) for the period 536 AD to 660 AD.

- **The Medieval Optimum** (or 'Medieval Warm Period' -**MWP)** is the last warmest period close to the 20th century. The first Viking accidentally arrived in Iceland in 860 AD during a storm off the Hebrides, north-west of Scotland. Erik the Red went on to discover Greenland in 982 AD. During this Optimum it was slightly warmer than today and as warm (if not warmer?) as during the first part of the Roman Optimum, from 230 BC to 40 AD. Around 1100 AD, a chronicler from Liège noted that the strawberries were ripe at Christmas... Not all winters were so mild; for example, they were colder than today between 1070 AD and 1179 AD. The Meuse froze at Waulsort (near Dinant, in Belgium) in 1143 AD. **The general trend for at least two centuries, until 1300 AD, was that it was as warm as it is today.** As for the Roman Optimum, let's take a short extract from SCE devoted to this Medieval Optimum (the references are in the article cited): "*Based on the different types of crops, the dates of harvests(in particular grape harvests), etc., historians have accumulated a great deal of paleoclimatic data and have shown, for example, that European vineyards at the time extended 500 km beyond their current northern limit (Lamb, 1964, Le Roy Ladurie, 1967, Deconinck, 2009). By the 9th century, vines were being cultivated in regions where they had previously been absent, such as Belgium, England, and Germany. It disappeared from these regions around the year 1350. During the Medieval Climate Optimum, Alpine glaciers did not extend very far, well below present-day levels (here and Le Roy Ladurie, 1967). One of the first detailed studies of this episode was carried out by*

Lamb (1964) ***of the Meteorological Office of England. Based on historical, fauna, botanical, glaciological and meteorological data, he estimated that the temperature in England was 1.2-1.4°C higher than the current 'global average temperature' and that rainfall was 10% higher****. On a global scale, higher temperatures of around 1-2°C were the rule, and locally up to 4°C higher along the coast of Greenland".*

The vine moved northwards, following Charlemagne's short warm period in 800 AD, then the climate cooled until 1200 AD with monstrous storms (Van Vliet-Lanoë et al. 2014) linked to strong instability in the jet streams (thermal contrast between the cold Arctic and the warm *tropics, as is the case today). The vine then climbed as far as southern Denmark. The Theodull glacier next to the Matterhorn in the* Alps no longer existed and the pass it covered served as a passage for trade with Italy.

Greenland had 'average annual temperatures' 2-4°C higher than today. I won't repeat the discussion on the 'erroneous' meaning of 'global average temperature', which has already been discussed in SCE (here and here), but it should simply be remembered that the MWP was characterized by high temperatures, at least equal to today's, and probably higher. ***Numerous historical indicators clearly show that the MWP was indeed a particularly warm but unstable period*** *(see Figure 4 in SCE).*

Let's conclude this Medieval Optimum with the much-discussed question of temperatures. According to Olivier Postel-Vinay (p.207) "*After decades of sometimes heated debate, paleoclimatologists confirm that the summers between 1100 AD and 1320 AD were hot and dry, with temperatures 1°C to 2°C higher than those of the 1961-1990 reference period".*

- **The Little Ice Age** (**LIA**) put an end to the Medieval Climate Optimum with the appearance of an increasingly cold period, illustrated in Brueghel's paintings and characterized by a strong surge in Alpine glaciers. Emmanuel Le Roy Ladurie (1967, 2009) gave an excellent summary of this period, which was taken up by SCE (*the references are in the article cited): "the first signs of this appeared at the end of the 16th century, precisely in 1588 in the Swiss Alps, when the Grindelwald glacier broke through its terminal moraine*. ***From then on, the end of the decade and the next three centuries saw glaciers descend ever further into the valleys, with all the damage that implies.*** *A chronology of 'aggressive' glacial eruptions has been established based on numerous historical documents (dates of grape harvests, dating of fossil trees found under moraines, moraine advances and changes in topography). The historical peaks of the Alpine glaciers were in 1599-1600 and between 1640 and 1650.* ***From 1660 onwards, there was a moderate ebb in the Alps, reflecting climate variability on a decadal scale.*** *These periods of advance ('glacial floods') and ebb are the rule throughout these centuries of generally colder weather. These refluxes are also less than the refluxes of our warmer era: for example, the Alpine retreat at the end of the 17th century and the extreme beginning of the 18th century was limited to 500 m at most, compared with 1 to 2 km in the 20th century.* ***It should be noted that these oscillations are local on a multi-decadal scale (between 25 and 50 years), as shown by the positions of the terminal glacial tongues*** (*Lliboutry, 1964). For this author, this time lag is due more to (local) meteorological factors than to the intrinsic characteristics of glaciers (reaction time, size, flow). In the end, the paroxysmal phases of the alpine glaciers of the Little Ice Age occurred in 1660-1610, 1628, 1640-1650, 1676-1680 and 1716-1720, most of the time with much larger glaciers than in the 20th century. Periods of secondary recession sometimes occurred, with a horizontal retreat of 200 to 300 m at Chamonix in 1784-1790, for example. The peak period for glaciers in the northern hemisphere was around 1740-1750.*

The retreat then began in the 1860s and 1870s, affecting all the Alpine glaciers: *the scale of the retreat was considerable, and for the first time in three centuries a point of no return was reached quickly. The Mer de Glace (Chamonix) retreated by 150 m in one year (1867-1868) and by 757 m in ten years (4 Nov. 1868 - 27 Sept. 1878), i.e., 76 m per year. The multi-century* *phase of glacial flooding is therefore over, and the current period is beginning. The warming will be marked by later first snows and earlier last snows, reflecting the shortening of the cold season. To visualize these oscillations, see Figure 3 in SCE, taken from Emmanuel Le Roy Ladurie (2007), which traces the complex history of the great Alpine glaciers from the 16th to the 20th centuries.*

These events are also documented by Olivier Postel-Vinay, who extends their geographical scope outside Europe: *"famines, pandemics, recurring sandstorms and snowstorms (1368, 1587, 1618) in Beijing and the Yangtze delta in China. In 1587, the population of the Yellow River fed on herbs and wild plants... In Guangxi, people ate each other, and corpses littered the ground... The cold deepened in December 1633 and the middle course of the Yellow River was frozen over... The starving ate even the seeds found in goose droppings...".* A volcanic eruption in the Philippines accentuated the effects of the Little Ice Age. **In Europe, "*the wine froze in the cellars and had to be broken with an axe... the ink froze in the inkwells... the Rhine and the Rhône froze to the bottom of their beds... the port of Marseille froze... it rained 600-gram hailstones...*"**. *The eruption of the Tambora volcano in Indonesia in 1815, which injected sulphur aerosols into the atmosphere, was felt in many regions: "a year without summer called the year of the beggar in Germany... famine and epidemic in Ireland... destruction of crops in the United States... dramatic drought in South Africa... famine in Yunnan...".*

Outside Europe, where it was defined, the Little Ice Age saw a series of mega-droughts in the 14th and 15th centuries, with no equivalent today, lasting several years and decades (almost a century) in Asia, in northern China, central India and southern Vietnam. They were linked to a particularly active monsoon regime (Sinha et al. 2010).

- **The Modern period** also saw many climatic hazards. Here are just a few of the events mentioned by Olivier Postel-Vinay: *"**In the 1930s, the Dust Bowl in the central plains of the United States was the country's greatest climatic disaster**. The arrival of tsunamis of particles of earth and sand as high as a skyscraper or more buried everything.... Crops were wiped out by the layer of dust, or 'black blizzards', up to 6 m in places, and livestock died...". The event is linked to several years of widespread drought accompanied by a sharp rise in temperatures. "**Other, even more severe droughts spread over several decades had already affected this territory**, leading, for example, to the disappearance of the Pueblo civilization at the end of the 13th century". In the 1930s, the USSR "experienced a series of catastrophic droughts from the Ukraine to the Urals. A chill was felt throughout the northern hemisphere, from Europe to China... In 1956, the lagoon froze in Venice and in France the vines froze.... In England, it was the coldest winter since 1740...".*

Warnings of a mini return of the Little Ice Age or of global cooling' are making the headlines in the media (Newsweek, New York Times, Time). One example is Stephen Schneider,1978 announcement of 'The Coming Ice Age'. Olivier Postel-Vinay mentions a NASA report (1971) showing that the density of aerosols in the atmosphere far outweighs the warming effect of the increase in carbon dioxide: **"this report concludes that an increase of only a factor of 4 in the average concentration of aerosols may be sufficient to cause a temperature decrease of 3.5 degrees**".

With temperatures once again mild, the global cooling thesis was shelved and replaced in 1988 by the thesis of unprecedented anthropogenic global warming (Hansen, 1988). Since then, global warming has been entirely explained by the 'CO_2 button', and all other explanations have been rejected. SCE was born to protest this 'diktat' and to advocate a critical analysis of current climatology. For SCE, it is natural phenomena that regulate climate fluctuations, and the anthropogenic contribution to current warming, if real, is very small (see the list of authors here).

7. The Odyssey of *Homo sapiens*

Having travelled through the history of *Homo sapiens* over nearly 233,000 years, what can we conclude from this formidable odyssey recounted by Olivier Postel-Vinay? Certainly, that climatic fluctuations have constantly accompanied the journey of *Homo sapiens* at every moment on the entire planet. **But above all, these fluctuations were of an intensity and duration that have nothing in common with the current situation, which is really nothing exceptional compared with what *Homo sapiens* has regularly endured**. Detailed analysis shows that no period is homogenous in terms of climate at planetary level, and regional or local differences are always present at any given time. This alone is enough to reject the notion of a 'global average temperature' that occupies the 'front page' of our media preoccupations.

The current period is an ordinary one, part of a multi-century fluctuation of low thermal amplitude that cannot be compared with the fluctuations of the past, with those of the D-O events and their abrupt temperature rises (> 10°C) in just a few decades. These abrupt events have just been demonstrated in the Upper Jurassic (Kimmeridgian, around 155 Ma ago), a non-glacial period (in Boulila et al. 2022) with, as with Pleistocene Dansgaard-Oeschger (D-O)cycles, temperature increases of 15°C in just a few decades. In view of these abrupt thermal events, the current warming appears to be very moderate, and is simply or routinely part of the multi-century oscillations of low thermal amplitude of the Holocene, which is reflected in the succession of optima's and colder periods discussed above (Fig. 5). These periods are themselves subject to small fluctuations (Le Roy Ladurie, 1967).

Olivier Postel-Vinay (2022), stressing that he is not a scientist, puts forward a number of hypotheses to account for the climatic fluctuations experienced by *Homo sapiens*. There's no point in discussing them here, as some have already been discussed in SCE, but let's mention them in no particular order: cosmic rays from exploding stars acting on cloud cover (Henrik Svensmark), astronomical or orbital parameters of the Earth (Milankovic cycles), fluctuations in the Intertropical Convergence Zone (ITCZ), oceanic oscillations, for example the North Atlantic Multidecadal Oscillation (AMO), also the Pacific Decadal Oscillation (PDO), the Antarctic Oscillation ... Arctic Oscillation... Indian Ocean Dipole..., El Nino cycles, solar irradiation (particularly solar sunspots), jet streams and volcanism. Other natural processes are also known in the literature but are not included in this book. Certain events experienced by *Homo sapiens* are interpreted in the light of the natural processes described above by the author. A single example is Campbell (2016) "*periods of reduced global temperatures coincide with reduced solar irradiance and few or no sunspots, as was the case during the Oort Minimum [c. 1010-1050], the Wolf Minimum [c. 1292-1342], the Spörer Minimum [c. 1416-*

1534], the Maunder Minimum [c. 1654-1714] and the Dalton Minimum [c. 1790-1830]. Conversely, periods of higher irradiance and sunspot activity are associated with 'global warming'. The climate changes reported by Olivier Postel-Vinay are expressed in different ways throughout the Odyssey of *Homo sapiens*, suggesting that the natural processes at work are varied and interact, and that there is no single mechanism to explain these different types of climates and their fluctuations.

8. Conclusion

Olivier Postel-Vinay's book shows us that climate fluctuations are already the rule on small time scales. Decades are 'our daily life' and changes will be anchored in each generation, while changes over centuries will be passed down through the generations, either in oral traditions or in written records. Climate changes beyond the centuries (millennia or more) will be highlighted by historians, but above all by scientists.

At the end of this article, it must be said that the current period is nothing special compared with those of the past, which were much more violent and had far-reaching consequences for marine and terrestrial ecosystems. However, this is not the way things feel now, and the climate alarmism (and fear) that it engenders is 'misleading' our societies. Let's not forget that since the beginning of direct thermometric measurements, the 4 main temperature series we have (terrestrial and satellite thermometers) show that the global temperature of the lower troposphere has risen by ± 0.8°C in 138 years (between 1880 and 2018), which **currently corresponds to around 0.01°C/year for the last 30 years** (with 0.11°C/**decade** over the oceans and 0.18°C/**decade** over land (Scafetta 2021 **,** Spencer 2022). According to the IPCC (2019), the temperature increase since the industrial era is between 0.8°C and 1.2°C. Every day, the media remind us that this rise is exceptional and, what's more, that anthropogenic CO_2 is the cause, i.e., the main culprit, according to the accepted terminology.

The history we have just gone through has taught us that *Homo sapiens* has seen many others, whether in terms of temperatures, storms, mega-droughts, floods, variations in sea level, their duration, etc., all linked to natural processes. Today, the climate is very often confused with pollution (see, for example, the youth marches for the climate, a subject already addressed by SCE), with poor management of our urban planning, agricultural, forestry and coastal practices, etc.

Our vulnerability to climatic events is not linked to the climate but to our very poor management of marine and terrestrial ecosystems, attributable to our blind actions. We have put ourselves in a very weak position about climatic events, even though they are not the most extreme today, and have nothing to envy of those of the recent past.

Easterbrook (2016): "*Greenland ice cores have generated a huge amount of climatic data. Ancient temperatures, measured using oxygen isotopes the ice, can be accurately dated from annual dust layers in the ice dating back 100,000 years. The $\delta^{18}O$ data clearly show remarkable swings in climate. In the past 500 years, Greenland temperatures have fluctuated back and forth between warming and cooling about 40 times, with changes every 25-30* *years*. **Comparisons of the intensity and magnitude of past warming and cooling climate changes show that the global warming experience during the past century pales into insignificance when compared to the magnitude of profound climate reversals over the past 25,000 years**. *At least three warming events were 20-24 times the magnitude of warming over the past century, and four were 6-9 times the magnitude of warming over the past century. The magnitude of the only modern warming that might possibly have been caused by CO_2 (1978-2000) is insignificant compared to the earlier periods of warming".*

In conclusion, the successions and interactions of natural phenomena reported for only a short period (233 ka) in Olivier Postel-Vinay's book (2022) show that climatology is still a young and highly complex science. Olivier Postel-Vinay has dealt with this subject in a 'fascinating and dispassionate manner' (Rittaud, 2022). There is still a great deal we need to know to gain a fuller understanding of the events reported. It makes no sense, against all odds, to reduce them to CO_2 alone (see SCE), which probably plays a very small role (*in* SCE et SCE, van Wijngaarden and Happer, 2020, Clark et al. 2021). Geology, over the last 4.567 billion years, has shown that natural processes are complex because of their interactions on different timescales, and that there is no reason for the current alarmism (Clintel, 2022). Let's hope that *Homo sapiens* finally recognizes this and makes the right decisions, rather than plunging headlong into a senseless... and extremely costly decarbonization (Homewood, 2022). There are other urgent matters on the planet!