GEOGRAPHY AND DEMOGRAPHY

Physical Geography, Construction of Environments and Landscapes

Spatial Impacts of Climate Change

Coordinated by
Denis Mercier

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Introduction
Spatial Impacts of Climate Change: Multi-scale Issues

Denis Mercier

Sorbonne University, Paris, France

Climate change involves a change in the elements of what is known as the climate machine, often summarized in the press as a change in the temperature variable alone. However, the Earth's climate is a complex system inducing interactions between its different components: atmosphere, hydrosphere, cryosphere, pedosphere, biosphere, lithosphere and noosphere.

I.1. The impact of contemporary climate change on forest fires in Australia in 2019-2020: a systemic approach

There is no shortage of examples in the recent past to illustrate the systemic interactions related to climate change in recent decades. Gigantic fires in Australia had destroyed more than 10 million hectares (ha) in the southeast of the country by early January 2020. This is more than five times the area of the California fires of 2018 (1.8 million ha) and ten times the area of the high-profile fires in the Amazon rainforest in the summer of 2019 (0.9 million ha, see Chapter 12). Global warming increases the likelihood that fires may occur by accentuating the expansion potential of these fires, which are devastating for fauna, flora and sometimes also for human life. Indeed, the fire seasons in Australia now begin earlier in September and last longer. Climate change in Australia is measured by a reduction in annual precipitation, which contributes to the drying out of soils, vegetation and thus the potential for fires. The year 2019 was the driest year on record since 1900 according *Spatial Impacts of Climate Change,* coordinated by Denis Mercier. © ISTE Ltd 2021. to the Australian Bureau of Meteorology . At the same time, temperatures have been rising, and 2019 was also the warmest year on record in Australia since 1910. These same climate changes can be understood on another spatial scale by combining ocean and atmospheric circulation. In the Indian Ocean, the dipole reflects the temperature differential between the western and eastern parts of this ocean basin. During the positive phases of this dipole, ocean temperatures are higher in the west than in the east, favoring rainfall over East Africa and reducing rainfall over Australia and Indonesia (Kämpf *et al*. 2019). These positive phases have become more frequent and intense since the 1950s. When the Antarctic Oscillation enters a negative phase, the westerly winds surrounding the Antarctic continent, the so-called Roaring Forties and Howling Fifties, move away from the continent and move up towards mid-latitudes, generating strong winds towards land areas such as Australia (Feng *et al*. 2019). When these two phenomena occur in time, dry air masses over the eastern Indian Ocean are propelled towards Australia, which then receives less precipitation and experiences strong winds. These air masses then cross Australia's interior deserts and fall back down over the eastern part of the Australian Cordillera, which reinforces the local drying of these air masses over the southeastern part of the country by the foehn effect. In addition, these Australian fires generate dust in the atmospheric circulation and result in dust fallout on New Zealand glaciers, particularly those of Fox and Franz Josef, whose melting is likely to be accelerated by the lowering of their surface albedo, which is brownish in color due to ash and soot fallout. At its scale, this local melting of the cryosphere contributes to a global rise in sea level.

Beyond the Australian case and on a more global scale, recent research shows that a warmer planet increases the risk of forest fires (Johns *et al*. 2020). Increasing temperatures, decreased precipitation and soil moisture, combined with drying strong winds, contribute to an increase in the frequency and severity of fire-prone periods.

I.2. The impacts of contemporary climate change: a multi-scalar approach

The issues are therefore systemic and multi-scale. Societies, whatever they are and wherever they are found, must and will have to adapt to the following changes for which they are not necessarily individually responsible. This book therefore presents the different impacts of climate change according to the areas and territories under consideration.

On a global scale, all the fundamental elements of the Earth system and their interactions are mobilized by climate change: water cycle, carbon cycle, atmospheric circulation, thermohaline circulation. Although general mechanisms make it possible to understand and explain climate change, regional and local nuances show that geographical elements such as the distribution of land and oceans, the layout of landforms, coastal dynamics and human activities can minimize or, on the contrary, exacerbate the spatial consequences of general physical laws. The example of contemporary climate warming on a global scale and its amplification in the Arctic illustrate the importance of these changes in spatial scales (see Chapter 1). The melting of the marine and terrestrial cryosphere, discussed in Chapter 2, is not spatially uniform. It contributes to changing geopolitical and economic issues in the Arctic (see Chapter 3). The melting of the terrestrial cryosphere induces a rise in global sea and ocean levels, which will not affect coastlines in the same way according to their own typology (cliff coasts, deltas, etc.) or their own dynamics (subsidence, stability or uplift) and according to the way they are occupied by societies (see Chapter 4).

At the regional scale, the spatial impacts of contemporary climate change are being addressed using a variety of approaches. By modifying the cryosphere in high latitudes and high mountains, changes in climate induce changes in the paraglacial sedimentary cascade (see Chapter 5) and periglacial environments (see Chapter 6). River organisms in cold environments (see Chapter 7) and temperate environments (see Chapter 8) record climate change in different ways. The melting glaciers of Central Asia place the consequences of climate change at the heart of geopolitical issues in this region (see Chapter 9).

At the local level, the impact of rainier season droughts in the western Mediterranean basin on Spanish rain-fed agriculture provides a link between regional climate dynamics and local impacts (see Chapter 10).

Multi-scalar approaches also make it possible to show the stakes of contemporary climate change on viticulture (see Chapter 11), on the scale of the Amazon basin (see Chapter 12), on the distribution of biomes (see Chapter 13) or on the distribution of birds (see Chapter 14).

In all the chapters, the examples analyzed underline the importance of geographical approaches for the study of the impacts of contemporary climate change.

I.3. References

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1
Climate Change at Different Temporal and Spatial Scales

Denis Mercier
Sorbonne University, Paris, France

1.1. Contemporary global climate change

Contemporary climate change refers to the period from 1850 to the present day and covers the period from the Industrial Revolution to the digital revolution. It also covers a period during which humanity experienced a population explosion, reaching 1 billion people for the first time in 1820. On January 1, 2020, the human population was estimated at 7.7 billion and is expected to reach 11 billion by 2100, according to the UN.

Through the use of fossil fuels (coal, oil, gas) and increased agricultural production to feed the world's growing population, these elements contribute to increasing humanity's role in the climate machine.

Since the mid-19th Century, the average global air temperature has increased by 1.1 °C. This increase has not been linear over time and Figure 1.1 illustrates the stages of this evolution. Two warming sequences help to understand this increase: the first from 1910 to 1940 and the second from 1980 to the present day, during which the increase in temperature was 0.18°C per decade. According to the World *Spatial Impacts of Climate Change,* Meteorological Organization[1], the year 2019 was the second warmest year recorded since 1850. It comes after the year 2016, which experienced a particularly intense El Niño episode, with abnormally high ocean surface water temperatures in the eastern South Pacific. These two periods of warming are interspersed by temporal sequences of cooling (from 1880 to 1910, then from 1940 to 1980).

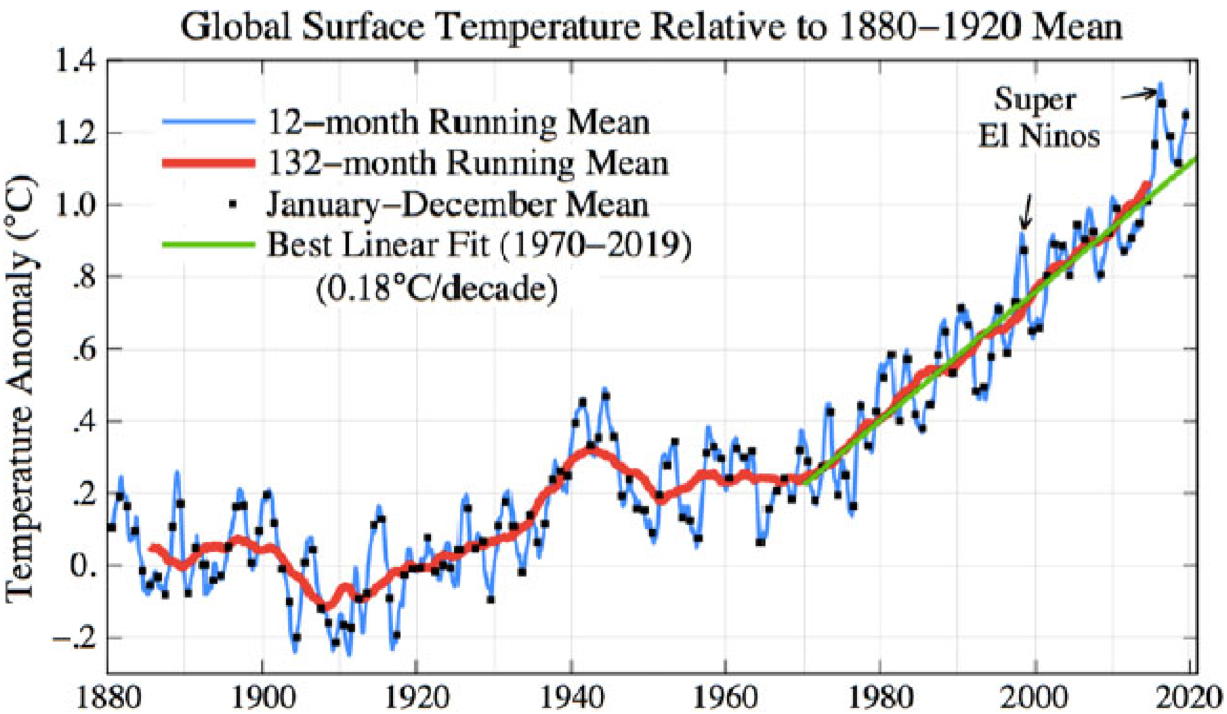

Figure 1.1. Annual mean surface temperature from 1880 to 2019 compared to the 1880-1920 mean

(source: Sato and Hansen, Climate Science, Awareness and Solutions at Columbia University Earth Institute, 2020). For a color version of this figure, see www.iste.co.uk/mercier/climate.zip

This non-linear temperature evolution over time is not spatially homogeneous (see Figure 1.2). These maps illustrate general trends. Continental land areas record this contemporary global warming better than ocean surfaces; of these continental land surfaces, those with a

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