Climate Change and the Future of the Earth

Climatologists claim that climate change caused by the greenhouse effect and the alteration of the oceanic currents can could the future of our planet. Paradoxically, the overall global warming would cause in some regions sharp decreases of the temperatures. For our planet it is not the first time a phenomenon of this type is has come true. In fact, such sharp changes are cyclical. It is just new for us as human beings at the start of XXI century, as passengers on this planet and unarmed spectators of this event.

What will be the future of our planet? Which new dynamic will be delineated between the worldwide powers? Will they change the political and economic priorities? Is it possible that new conflicts, caused depleting energy resources, will threaten the status quo? We do not have a sure answer, but all of this could happen. The cause? The climate. As the experts say, unexpected climatic changes could cause an epochal mutation for our planet. Within 30 years the possible climatic alterations could influence massively the way of life for entire populations, causing major migrations and modifying the geopolitical order.

A report commissioned by the Pentagon gives an exaustive picture to us of what could be the consequences for us of such climatic changes. The result? A future of adaptation in order to survive and buy up the ever decreasing energy resources. The project Vision has just started up, will try to give, therefore, one answer, although incomplete, to the simpler but complex question of the future of the world and *man*: what will become of us small beings, when faced with the power of nature? And what could we do to better manage the consequences of our actions and of progress?

The link between this project and others that Vision are carrying over (for instance, the one on the reform of global governance that begun with the seminar at the LSE, or the research on the future of the car and the transportation system that will be presented at the European Commission) will appear evident. Structural solutions will only be produced by identifying and measuring the magnitude of the changes, undestanding the opportunities that technologies provide, devising and pushing forward an ambitious agenda of institutional changes: a huge task that will require a pluridisciplinary approach that scientists and governments seem to have forgotten. An ambitious attempt that may sound visionary but that is also the only one who can provide the real possibility to succeed.

In the brave new world we are starting to venture, the discontinuities are so steep that vision and realism are not any more two opposing approaches: this is the intellectual quantum leep that we urgently need in order to get ready for “the day after tomorrow”.

The day after tomorrow*

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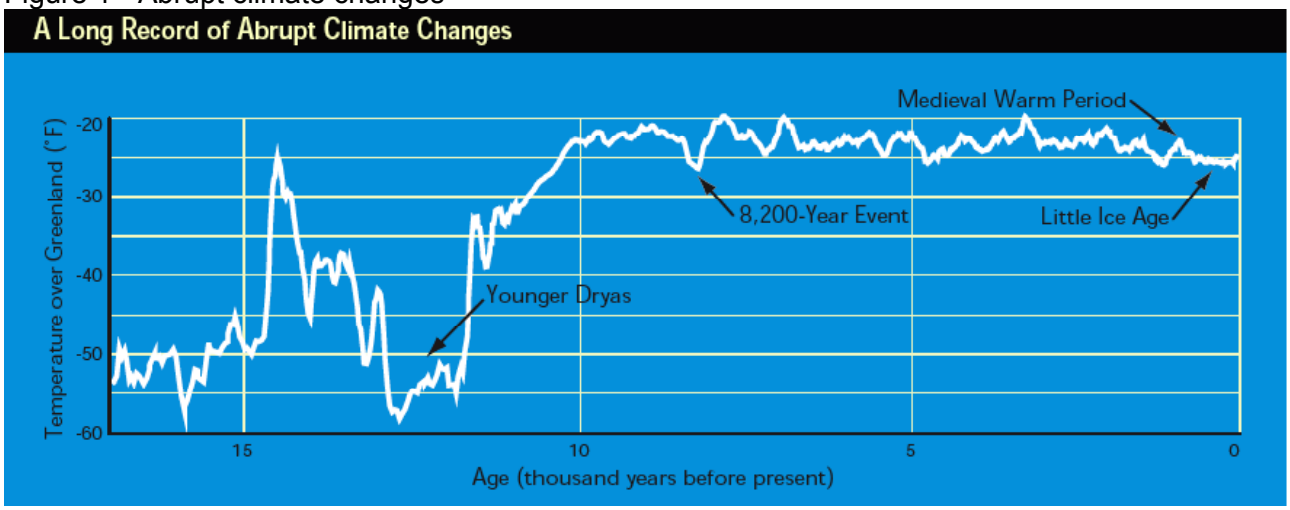
Rome - January 2005

Global climate change results from the accumulation of greenhouse gases (GHG) in the atmosphere. GHG, some naturally produced and others resulting from human activities, absorb infrared radiation and return it back to the earth surface, raising world temperature. There are two undisputed basic facts: GHG are accumulating at a faster rate in the atmosphere mainly as a result of human activity, and air and sea temperatures are rising. Over the latest years an increasing body of observations, analyses and studies have led to a better understanding of climate change. A widespread consensus about the potential threats that climate change poses over human well being does exist. Carbon dioxide concentration in the atmosphere has in fact augmented by 31% since 1750 and its rate of increase has been about 1.5 ppm (0.4%) per year over the past twenty years, while during the 1990s it has increased from 0.9 ppm (0.2%) to 2.8 ppm (0.8%). Global average surface temperature has augmented over the last century between 0.4° C and 0.8° C, and is likely that the increase in temperature in the northern hemisphere has been the largest of any century during the past millennium. Moreover, snow cover has decreased of about 10% since the late '60s, and there has been a remarkable shrinking of mountain glaciers in non Polar Regions, and an increase between 0.1 and 0.2 meters of average sea level during the 20th century. Most of this observed warming is due to the increase in GHG concentration and the emissions of carbon dioxide deriving from the burning of fossil fuel are virtually certainly the determinant of the trends in CO_2 concentration in 21st century.
Most of the debates on global climate change focus, however, on gradual increases of world temperatures and marginal changes in climatic conditions. There are, unfortunately, other far less manageable scenarios, that historically occurred repeatedly to the Earth's climate, in which climate shifted abruptly and radically. This circumstance is known in the literature as abrupt climate change. The formal definition of this occurrence whose is given by the US National Research Council:

> *"An abrupt climate change occurs when the climate system is forced to cross some threshold, triggering a transition to a new state at a rate determined by the climate system itself and faster than the cause. The cause may be chaotic and thus undetectably small"* .

Fossil evidence testifies that climate can modify within a decade, determining different effects that can persist over time. The study of ice cores and oceanic records suggests that there may have been eight episodes of abrupt climate change in the last 730,000 years. For instance, about 12,700 years ago our planet experienced a cooling of almost 15°C in Greenland and substantial changes in the climate of the North Atlantic region, known as the Younger Drays. The most impressive trait of this event is that it happened in a series of decadal drops of 2.8 C° and persisted for 1,200 years. Later, Europe and North America experienced other periods of lesser cooling, for instance the one referred to as the Little Ice Age, that lasted from 1300 to 1850, brought severe winters, heavy precipitations and produced dramatic agricultural, economic and political impacts over Europe.

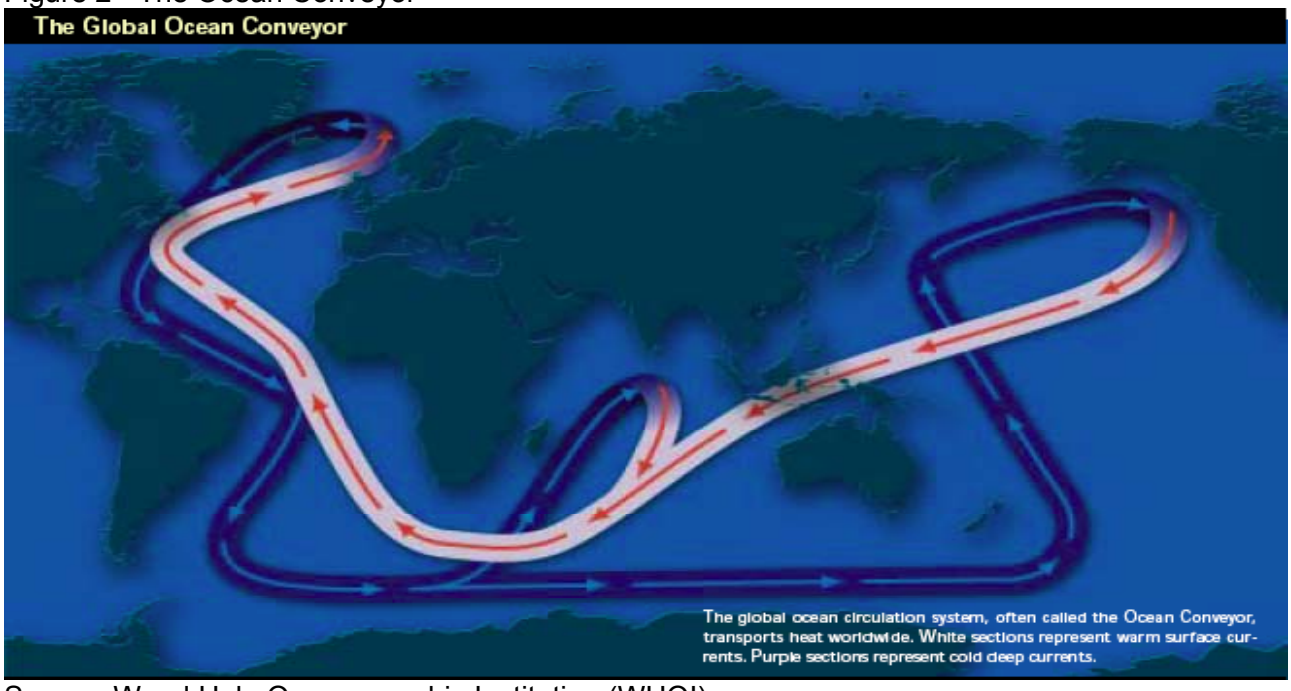
Figure 1 - Abrupt climate changes



Source: R.B. Alley, from *The Two-Mile Time Machine*

Specifically, abrupt climate change occurs when the Earth system is pushed through a threshold by either a major event like a massive volcanic eruption, or by more gradual forces altering key components of the system, such as oceans, the atmosphere, the land surface, the cryosphere.
Scientists deem that the most likely mechanism that can induce global abrupt climate change is buried in the waters of the oceans, due to their enormous heat capacity. Namely, a sharp modification of the ocean currents circulating around the Earth, the Ocean Conveyor (see Figure 2), that distribute great quantities of heat around the globe, can dramatically modify the climate of the planet.

Figure 2 - The Ocean Conveyor

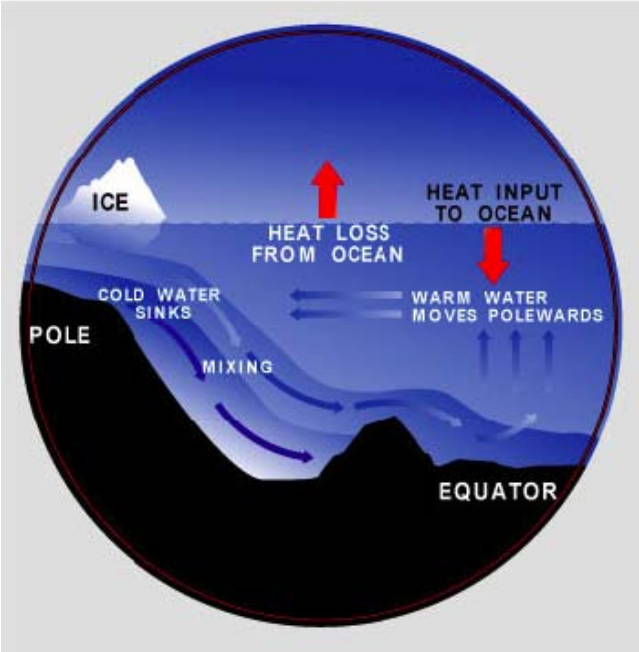


Source: Wood Hole Oceanographic Institution (WHOI)

In brief, the equatorial sun, warming the ocean surface, enhances evaporation and leaves the water saltier. The Gulf Stream pushes warm and salty water up to Europe and the East Coast of the US, moderating the climate of the North Atlantic region through the release of this heat to the atmosphere, that augments the average winter temperatures as much as 5° C. Alas, the conveyor can slow down and shut down, as it did several times in the past, for example during the Younger

Drays. This would produce a reduction in heat delivery in the North Atlantic and a substantial cooling throughout the region. This malfunctioning can be basically induced by the changing degree of salinity of North Atlantic water. In fact, the warm, salty water of the Gulf Stream, reaching the North Atlantic, releases heat to the atmosphere, becomes colder and denser, and thus begins to sink. This water then flows south slowly at great depths and eventually reaches all the oceans. The plunge of these enormous amounts of cold and salty water triggers the Ocean Conveyor. At the same time, it draws salty tropical surface water to the north to replace the sinking water. This process is named "thermohaline circulation" (see Figure 3).

Figure 3 – The thermohaline circulation



Source: The National Research Council

If North Atlantic water did not sink, the ocean conveyor would be weakened or interrupted, existing currents would be altered and the Earth's climate patterns would radically change. Climate simulation models suggest that the North Atlantic region would cool 3° to 5° C.

Therefore, the question is: what can modify the degree of salinity of the North Atlantic to an extent capable of undermining the thermohaline circulation? The answer is: an influx of fresh water lying atop saltier and denser water that insulates the surface of the North Atlantic, reducing the heat transfer and diluting the salinity. When the North Atlantic water goes down a certain, unknown, degree of salinity it stops sinking. The primary force driving the ocean conveyor could therefore swiftly diminish, with great climate impacts within a decade.

As a matter of fact, oceanographers unanimously point out the degree of salinity of the North Atlantic has diminished dramatically for the past 40 years, and especially in the last decade. Besides, they have noticed signs of possible slowdown of the Ocean Conveyor: the flow of salty and cold water from the Greenland and Norwegian seas has in fact reduced by 20% since 1950.

Though scientists have not precisely determined yet the causes of this process, there is the suspect, among the scientific community, that the freshening of North Atlantic is due mainly to the melting of Arctic sea ice, and to increased precipitation over the Arctic sea or entering it via the great rivers flowing into it.

Both factors, actually, are worsened by climate change. Global warming, paradoxically, could therefore bring a "big freeze"!

Specifically, the shift of the conveyor could rapidly and deeply cool down the entire Northern hemisphere and significantly alter the climate patterns all over the world. The main characteristics of the day after tomorrow scenario could be the following:

- annual average temperatures would drop by up to 2.8° C in North America and Asia and 3.4° C in Europe; winter storms and wind would intensify, magnifying the impacts;
- annual average temperatures would increase by up to 2.2° C throughout Australia, southern Africa and South America;
- droughts would persist in critical agricultural and water resource regions in Europe, North America, and Africa.

These climate patterns, in turn, could destabilize the geopolitical setting, provoking conflicts due to resource constraints such as:

- food shortages due to the collapsing of agriculture;
- decreased availability of fresh water due to droughts and altered precipitation patterns;
- disrupted access to energy supplies due to extensive sea ice and storminess.

A recent report (An abrupt climate change scenario and its implications for United States national security, by Peter Schwartz and Doug Randall, published in February 2004) commissioned by the Pentagon, delineates a bleak scenario of abrupt climate change originated by an interruption in the thermohaline circulation.

Figure 5 – The Schwartz-Randall scenario

Source: Peter Schwartz and Doug Randall

According to this report the changing climate patterns would affect agriculture, fish and wildlife, water and energy. Crop yields, would fall by 10-25% and would be less predictable as key regions shift from a warming to a cooling trend. As some agricultural pests die due to temperature changes, other species spread more readily due to the dryness and windiness – requiring alternative pesticides or treatment regiments. Commercial fishermen would be not ready the massive migration of their prey. With only five or six key grain-growing regions in the world (US, Australia, Argentina, Russia, China, and India), there would be insufficient surplus in global food supplies to offset severe weather conditions. Catastrophic shortages of water and energy supply could not be promptly overcome.

As far as the world regions are concerned, the Schwartz-Randall report envisions a frightening portrait. Europe would be hit hardest: the climate in north-western areas would be colder, drier, and windier, a Siberian situation. Southern Europe would experience less dramatic impacts, but still would undergo sharp intermittent cooling and rapid temperature shifts. Reduced precipitation would produce soil loss, contributing to food supply shortages.

The United States would experience colder, windier, and drier weather that would make growing seasons shorter and less productive throughout the East Coast, and longer and drier in the southwest. Desert areas would face increasing windstorms, while agricultural areas suffer from soil

loss due to higher wind speeds and reduced soil moisture. The change toward a drier climate would especially be pronounced in the southern states.
China, with its high need for food supply given its vast population, would be hit hard by a decreased reliability of the monsoon rains. Longer, colder winters and hotter summers caused by decreased evaporative cooling because of reduced precipitation would undermine the already difficult energy and water supplies.
In Bangladesh persistent typhoons and a higher sea level would create violent storms that would cause significant coastal erosion, making much of the country nearly uninhabitable.
East Africa would face slightly warmer weather, but at the same time would be weakened by persistent drought.
These climate patterns would, furthermore have, profound geopolitical impacts and would pose different and new types of threats to national security. According to the authors, conflicts may be triggered by a desperate need for natural resources such as energy, food and water rather than by ideology, religion, or national honour. Possible conflicts scenarios are depicted in the following figure.

Figure 5 – Conflict scenarios due to climate change

	Europe	Asia	United States
2010-2020	2012: Severe drought and cold push Scandinavian populations southward, push back from EU 2015: Conflict within the EU over food and water supply leads to skirmishes and strained diplomatic relations 2018: Russia joins EU, providing energy resources 2020: Migration from northern countries such as Holland and Germany toward Spain and Italy	2010: Border skirmishes and conflict in Bangladesh, India, and China, as mass migration occurs toward Burma 2012: Regional instability leads Japan to develop force projection capability 2015: Strategic agreement between Japan and Russia for Siberia and Sakhalin energy resources 2018: China intervenes in Kazakhstan to protect pipelines regularly disrupted by rebels and criminals.	2010: Disagreements with Canada and Mexico over water increase tension 2012: Flood of refugees to southeast U.S. and Mexico from Caribbean islands 2015: European migration to United States (mostly wealthy) 2016: Conflict with European countries over fishing rights 2018: Securing North America, U.S. forms integrated security alliance with Canada and Mexico 2020: Department of Defense manages borders and refugees from Caribbean and Europe.
2020-2030	2020: Increasing: skirmishes over water and immigration 2022: Skirmish between France and Germany over commercial access to Rhine 2025: EU nears collapse 2027: Increasing migration to Mediterranean countries such as Algeria, Morocco, Egypt, and Israel 2030: Nearly 10% of European population	2020: Persistent conflict in South East Asia; Burma, Laos, Vietnam, India, China 2025: Internal conditions in China deteriorate dramatically leading to civil war and border wars. 2030: Tension growing between China and Japan over Russian energy *	2020: Oil prices increase as security of supply is threatened by conflicts in Persian Gulf and Caspian 2025: Internal struggle in Saudi Arabia brings Chinese and U.S. naval forces to Gulf ,in direct confrontation

Source: Peter Schwartz and Doug Randall

There are still some uncertainties regarding the "when" and "if" of abrupt climate change. Much work remains to be done to improve our understanding of the history, mechanisms, policy, and social implications of the envisaged scenarios.
Anyway, any future abrupt climate change might have large and unanticipated impacts, and therefore a better understanding of the causes and implications may increase the possibility of mitigation and adaptation strategies and could make responses more effective.

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**The title of this article was inspired by the movie "The day after tomorrow" directed by Roland Emmerich (2004)*
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