A theoretical framework for the project:

'Imagination and Innovation in Climate Science':

Introduction:

Traditionally, reflections on technology have been dominated by two extreme accounts: The instrumentalist (also called 'social constructivist') and the substantivist (or 'technological determinist'). In broad terms, the former approach 'considers technology to be largely determined by 'social' factors (such as military interests, or economic policy)', but essentially neutral. By contrast, 'technological determinism describes technology as self-determinative, and as following its own independent aim of greater efficiency"[1] (Khong, 2003). According to substantivist accounts, technology rules over the meaning of life, devaluing it.

In the last 40 years a lot of work has been put into doing away with these two extreme positions (Wiener, 1986, Latour, 1993, Feenberg, 1999). It is now well established by Philosophy of Technology and Science Technology and Society (STS) scholars that important driving forces within technology shape the way in which it comes into existence and evolves and that these forces are worth exploring.

This project aims at precisely that: exploring, opening up and looking into technology. In particular, it focuses on certain types of technologies (or should we say technological approaches?) that aim at offsetting the effects of anthropogenic climate change and that are commonly known as 'geo-engineering' or 'climate engineering'. Since these technologies are not neutral tools nor autonomous systems; what exactly are they?

[1] L. Khong, 'Actants and Enframing', 694

The answer, I am afraid, will not be given in this piece but some ideas about how the question might be approached will be advanced.

What is Geo-Engineering:

This is not the first time that climate engineering comes to our attention. A climate historian, J.R.Fleming recalls three meaningful stories that illuminate the nature of the present proposals.

> The first involves 19th-century proposals by the U.S. government's first meteorologist and other "pluviculturalists" to make artificial rain and relieve drought conditions in the American West. The second begins in 1946 with promising discoveries in cloud seeding that rapidly devolved into exaggerated claims and attempts by cold warriors to weaponize the technique in the jungles of Vietnam. The third story describes how computer modelling raised hopes for perfect forecasting and ultimate control of weather and climate—themes that continue to inform and encourage present-day planetary engineers [2]

Without going into these stories, there is a complicated past of efforts to modify the weather and climate that ranges from using bombs and explosives to make rain, to seeding clouds with dry ice in order to trigger precipitation, to modifying hurricanes using liquid nitrogen, reducing hail, altering tornadoes, augmenting snow-pack or 'diverting Artic Slope freshwater runoff'[3].

A lot of the weather modification research, especially during the Cold War, was undertaken by the military and was animated by wild imaginations of potential weather control as a warfare weapon. Although it is difficult to establish the effectiveness of

[2] J. R. Fleming, 'The Climate Engineers: Playing God to save the Planet', 51
[3] W.Travis, 'Geo-engineering the Climate: An emerging Technology Assessment', 2

these techniques, research into and practice of a wide range of weather and climate modification have not disappeared from the collective imaginations. China, for instance, is regularly involved in cloud-seeding in order to manage precipitation (it is famous that severe cloud-seeding went on in the days previous to the 2008 Olympics in order to ensure that it would not rain during the Games). Similarly, projects to increase rainfall and snow-pack are still being implemented in some parts of the US[4].

Some of these ideas have also been envisaged in the past as global projects to change the earth's atmosphere in order to create a better or more benign climate.

More recently some of these initial proposals have been recycled into possible alleviation strategies for climate change. Amongst the most farfetched we find placing sun screens or millions of mirrors into the low earth orbit or covering deserts with a reflective surface.

In 1992 the National Academy of Sciences published a Report called 'Policy Implications of Greenhouse Warming' listing a variety of possible climate engineering techniques to countervail the effects of the greenhouse effects. In July 2009, a policy statement from the American Meteorological Society recommended research into geo-engineering given the serious threat of climate change. In the last five or 6 years conferences, sandpits, workshops and enquiries on geo-engineering have mushroomed.

In September 2009 Royal Society published a report ('Geoengineering the Climate: science, governance and uncertainty') that aimed at assessing the different techniques and its feasibility (from the technical, environmental and political point of view), or, in the words of one of the participants, 'separate the wheat from the chaff'.

[4] Ibid.

A cross between the geosciences and engineering, geo-engineering is a loosely defined term that it is commonly said to include the following features: a) the intent to affect the climate, b) doing it at a large (possibly global) scale and c) doing it in a novel or innovative way (K. Caldeira, 2009). Moreover, definitions, criteria and categories are being settled within the field as we speak. A good example of this fact is the Royal Society's report division of geo-engineering techniques into two different types. The following examples will also serve to illustrate exactly what is meant today by 'climate engineering':

1) Carbon dioxide Removal (CDR from now on): These techniques focus on extracting excess CO2 from the atmosphere. They are considered relatively safe and non-intrusive in that they attempt to return the state of the atmosphere to safe concentrations of CO2. Although safe, these techniques are said to have the drawback of cost, scale of effects and most importantly, the long periods of time they take to have noticeable effects.

Amongst the most desirable ones of this type we find:

-Artificial trees: Capturing carbon dioxide from the ambient either for use or for disposal.

-Enhanced weathering techniques: They involve accelerating the natural weathering of rocks.

-Land use changes: Afforestation or reforestation.

Amongst the less desirable ones we find:

-Ocean fertilisation: Fertilising the ocean with iron or nitrogen and phosphorus or increasing the performance of the 'biological pump' by down welling and upwelling. These techniques have not been proofed to be effective and can seriously disrupt marine ecosystems.

-Biochar: It involves harvesting biomass in a special way (as charcoal) so as to store the carbon fixed by organic matter. Cost-effectiveness and the scale needed for this technique to be useful make it unlikely viable.

2) Solar Radiation Management (SRM): They are techniques that operate by reflecting a fraction of the sunlight away from Earth so as to cool the temperature of the planet and reduce global warming. They are considered unsafe because very little is known about the possible side-effects of reducing incoming short-wave solar radiation. Another reason for their non-desirability is that they do not address the effects of excess levels of Co2 in the atmosphere (ocean acidification, for example). On the other hand, their desirability relies on the fact that they can deliver results very fast (within years or decades) and that they are likely to be affordable.

Amongst the most seriously considered in this category we find:

-Injecting reflective aerosols into the stratosphere: These techniques intend to emulate the effects of strong volcanic eruptions which release sulphur particles into the atmosphere that can block the sunlight away and reduce the temperature of the earth. Amongst the side-effects we find ozone depletion and possible serious interference with

the precipitation patterns (continued injections of stratospheric sulphur could alter the monsoon system with catastrophic results)

-Cloud albedo-enhacement (cloud whitening): it works by spraying microscopic seawater droplets into the atmosphere which can make clouds brighter and increase the reflectivity of the Earth. Again, there are worries of potential serious negative effects on precipitation patterns.

Less strongly considered are:

-Surface albedo approaches: painting roofs white or planting reflective crops. However, these techniques have not been proofed to be cost-effective and can have unwanted effects of regional weather patterns.

Noticeable, this new wave of climate engineering ideas has been triggered by certain urgency about the estate of the climate and the lack of progress in global efforts to mitigate emissions. A trend that might have also been reinforced by reports such as the 2003 Pentagon document: 'An abrupt Climate Change Scenario and its Implications for United States National Security'. In it an obscure, uncertain and potentially catastrophic climate future threatens national security in the US. One of the first paragraphs says: 'We have created a climate change scenario that although not the most likely, is plausible, and would challenge United States national security in ways that should be

considered immediately'[5]. The report ends with recommendation number 7: 'Explore geo-engineering options that control the climate'.[6]

In a not too dissimilar tone, a press release by the Royal Society reads: 'Unless future efforts to reduce greenhouse gas emissions are much more successful than they have been so far, additional action in the form of geoengineering will be necessary if we are to cool the planet (...) Our research found that some geoengineering techniques could have serious unintended and detrimental effects on many people and ecosystem - yet we are still failing to take the only action that will prevent us from having to rely on them. Geo-engineering and its consequences are the prices we may have to pay for failure to act on climate change'[7].

Not surprisingly, the Royal Society report's recommendations include: a) increased efforts towards mitigation and adaptation, b) further research on geo-engineering options 'to investigate whether low risk methods can be made available if it becomes necessary to reduce the rate of warming this century'[8], c) and further exploration of the governance issues posed by geo-engineering (developing of a code of practice and exploring regulatory issues around geo-engineering research and deployment).[9]

Arguably there is something to say about the alleged inevitability of geo-engineering research (and its possible deployment), about how its history informs the present state

[5] An abrupt Climate Change Scenario and its Implications for United States National Security', 1
[6] Ibid.22
[7] Royal Society, 'Stop emitting CO2 or geoengineering could be out only hope', 1
[8] Royal Society, 'Geoengineering the Climate', 57
[9] Aside from the technical and scientific uncertainty there are a number of social and governance issues that are at the centre of the concerns around geo-engineering. For example, the possibility of unilateral deployment, the management of the unequal effects of climate modification in different parts of the planet, concerns over commercial exploitation of such techniques or uneasiness about the possibility of non- transparent decision-making in the field .

of climate engineering and about how these early stages of reflection shape visions (both scientific and popular) of possible future climates.

Perhaps a good way to begin to explore these questions is offered by C. Castoriadis (who I have adopted as a philosopher of technology). For him technology is the concrete expression of a society's 'grasp of the world', it is at once the action and the result of constituting a 'real-rational' and hence it conveys an organisation of the world that is particular to that society (Castoriadis, 1984). It is not only that technology incorporates values (as some philosophers of technology assert) but further that it is made of networks of meaning ('significations', as he calls them) inseparable from the technical features. The interesting thing about these significations is that they are not dependent on a reality 'out there' but that they themselves delimit what is real. In short, these units of meaning stem from what Castoriadis refers to as the 'imaginary'. Therefore, it can be said that for Castoriadis technology is a world-making mechanism that revolves around imaginary (not empirical!) elements.

Imaginaries:

The imaginary is a concept that has gained considerable attention in STS and Sociology of Technology circles in the last few years and on which there is an extended literature. Here I only aim to sketch some points that might be of interest in relation to geo-engineering. Although its origins are to be found in J. Lacan in the context of psychoanalysis, its meaning has suffered a number of interesting mutations. The imaginary for Castoriadis is a system of meaning that gives unity to the social structure, the 'invisible cement' that holds society together (*The Imaginary Institutions of Society*,

1987). It organises categories, delimits what is real, what is possible and what is not possible and constitutes meaning. As D.P.Gaonkar puts it: 'It is only through the first mediation of the imaginary that we are able to conceive of the real in the first place and to make elementary distinctions between form and content, object and image, the original and the copy'[10]. The concept of God, for instance, does not stem or rely on an empirical observation and it is not a rational element either. It is rather an imagined category around which meaning is arranged and configured, a 'world-disclosing element' (Habermas, 1987) that opens up new horizons of meaning. In the same way new landscapes of 'significations' are constantly being generated by other imagined elements. Imagination is not derivative of reality but rather constitutes what is real: We find similar ideas in B. Anderson's *Imagined Communities* (1983) in which nationalism is seen, to paraphrase, not as 'the awakening of nations to self-consciousness' but as the invention of 'nations where they do not exist'. We do not know our fellow members but still, 'in the minds of us all lives the image of their communion'. This strong imaginary is mobilised and transported by the interaction between printing and Capitalism.

Some more recent accounts have left behind Castoriadis' abstraction and Andersons' Marxist frame and have explored other corners of the imagination. Social imaginaries are for these scholars ways to understand 'the social that become social entities themselves'. They are not ideas, philosophies or "objective" entities, but implicit understandings that make possible and underlie common practices[11]. For A. Appadurai, for example, the imagination is 'an organized field of social practices', 'a form of negotiation between sites of agency (individuals) and globally defined fields of

[10] D.P.Gaonkar, 'Toward New Imaginaries', 7
[11] D.P.Gaonkar, Toward New Imaginaries, 4

possibility'.' The imagination is now central to all forms of agency, is itself a social fact, and is the key component of the new global order"[12].

Detailed explorations of the role of imaginations within the world of technoscience[13] have also been carried out. In particular, the notion of 'imagination' has been found useful to understand how technoscientific innovation develops, how emergent futures are imagined and how they help understand the present. This imaginary dimension is embedded in the daily practices of technoscience (Marcus, 1995).

Yet other ramifications have investigated the ways in which imaginaries are constitutive of governance (Bloomfield, 2009) and how the co-production between politics and technoscientific development takes place. For example, they have explored the way in which these 'collectively imagined forms of social life and social order' are 'reflected in the design of nation specific (…) technological projects"[14].

Future Imaginaries:

Climate engineering technologies are future-oriented and therefore, by definition, imagined (Bloomfield, 2009). They make the future manageable by being envisaged[15]. Current speculations about the future of geo-engineering will greatly define how these systems will develop (not only the techniques themselves, but also how and which relations will be established between the different players –industry, government, science– or how regulation will be configured). These social imaginations

[12] A. Appadurai, "Disjuncture and Difference", Modernity at Large, 31, 1996

[13] STS scholars tend to use the term 'technoscience' instead of technology highlighting the interrelatedness of technology and its social context, the co-production of knowledge and historical nature of science and technology

[14] S. Jasanoff & S-Y Kim. 'Containing the Atom',120

[15] None of the geo-engineering techniques exists at the moment but some of them (ambient air capture for instance) are very close to being technically efficient.

prepare the ground for action to take place and for practices to develop. In other words, they set the stage for technoscience to unfold. As Jasanoff & Kim put it: social imaginaries 'at once describe attainable futures and prescribe futures' (ref!). Hedgecoe&Martin similarly claim that that 'speculative claims made about the future of [pharmacogenetics]' (…) 'are fundamental to the dynamic processes that create new socio-technical networks'[16].

Similarly one suspects that in the case of geo-engineering there might be unspoken assumptions about desirable future climates or implicit understandings around the role of technology in fulfilling different planetary needs (which 'publics' are prioritised or how needs are negotiated within different nations) that might carry powerful consequences. Presuppositions about what is it that geo-engineering techniques want to achieve, may for example, have important material effects.

This research aims at detecting these imaginaries within geo-engineering and understanding the processes by which different socio-technical configurations are established. It will involve understanding how multiple, overlapping and conflicting narratives are negotiated amongst the different communities within geo-engineering research (e.g. climate modellers and engineers, for instance, publics and governments, international regulatory bodies and individual nations…).

The methodology used will be targeted semi-structured interviews with different players involved in the field.

By inviting reflection upon our research findings from participating climate scientists and engineers, we will further explore ways to enhance transparency and accountability

[16] A. Hedgecoe & P. Martin, 'The Drugs do not Work', 328

of the scientific community both in relation to academic research but also to the wider public communities who are implicated in and affected by advances in climate research.

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