The Anthropocene, Resilience and Post-Colonial Computation

Dr. Dan McQuillan

Department of Computing, Goldsmiths, University of London, UK

Abstract

What forms of politics come with the contested ideas of the Anthropocene and resilience? Rather than taking these ideas as a given and looking at their political consequences, I will ask what politics enters at their points of construction, where they are understood as being constructed computationally. This allows me to read across from the Anthropocene and resilience to the other forms of computational anticipation that are becoming pervasive at the level of everyday life. As truth claims that depend on algorithms, I will argue that all of these constructions derive their authority from an entanglement of computation and science. Under current conditions, this entanglement brings it's own political tendencies, which can be characterised as colonial. To counter this implicit colonialism I will draw on the feminist and post-colonial approaches of standpoint theory. I believe this offers an alternative to the current entanglements of anticipatory computation, and allows us to re-work it into a post-colonial politics of algorithms and atmospheres.

Computational Constructions, Anticipatory Interventions

The Anthropocene is geology's attempt to make a motivational statement about climate change. While outlining it's genealogy, my main purpose is not to deconstruct it as a concept but to trace its entanglement with computation. Geology has traditionally assigned meaningfully long periods of time through identifiable changes in the rock record. These epochs are of the order of millions of years long, and were an essential way to order the passage of time in the geological record before there was the possibility of radiometric dating. The idea that human geophysical influence is significant enough to warrant its own epoch has been gathering pace since the 1980s (Edwards, 2013), although critics argue that naming the Anthropocene is unnecessary because there are many other ways to measure human influence on the biosphere (Scourse, 2016). They contend that the Anthropocene is a misappropriation of stratigraphic methods because affirming the importance of tackling climate change is not the role of the geological column (T. Brown, 2014). Nevertheless the idea now has scientific credibility and institutional backing, and a 2016 paper in Science determined that the current era is both functionally and stratigraphically distinct from its predecessor, the Holocene (Waters et al., 2016). But whatever the motivation, you can't start a new geological layer without a clearly defined base layer. So stratigraphy still faces the question of how to identify the smoking gun of humankind's destructive influence; is it the transition from hunting to farming, the moment Columbus arrived in America, the industrial revolution, or perhaps atomic weapons testing in the 1960s?

The Anthropocene Working Group is an officially constituted subcommission of the International Commission on Stratigraphy which has been working for some time on a sufficiently unique identifier. It recently published a paper in the journal Quaternary International proposing that the fingerprint of our collective alteration of the Earth as a geological as well as ecological system is the date of the Trinity nuclear test; the first atomic weapon explosion (Zalasiewicz et al., 2015). The stratigraphic marker is the rise in radiation levels in the rock record due to the above-ground nuclear tests of the 1950s and 1960s, when one bomb was detonated roughly every 10 days until the test ban treaty limited further atmospheric fallout. The majority of members on the panel therefore agreed that the date of the Trinity test, July 16th 1945, would be a "practical and effective" choice of base layer. But the wedding of the Anthropocene to the nuclear age in this way is a post-hoc step that somewhat obscures the fact that catastrophic man-made climate change only became thinkable in the first place through the entanglement of nuclear weapons and computation.

Since the 1970s there had been recognition that aerosols posed a risk to climate stability that was opposite to the effects of carbon dioxide; a sufficiently increased concentration could cause a decrease in global average temperatures. In 1982, Paul Crutzen & John Birks published the book 'The Atmosphere after a Nuclear War: Twilight at Noon' (Crutzen & Birks, 1982). They used two-dimensional computer models, which were the apex of climate modelling at the time, to predict what later became known as Nuclear Winter; a global darkening and cooling due to the smoke and particulates generated by firestorms following a nuclear exchange. In the midst of the Cold War, the prospect of a planet endarkened by nuclear conflict made human-induced damage to the atmosphere seem like a real and immediate possibility, which paved the way for subsequent public alarm about climate change. After the end of the Cold War, national laboratories in the USA who had been equipped with supercomputers in order to to model nuclear weapon yields, and were facing a loss of purpose, switched to climate modelling (Edwards, 2012). This made use of a lot of the same expertise in large data sets and atmospheric physics. In 2000 Paul Crutzen first used the term 'Anthropocene' to describe the influence of human behaviour on the Earth's atmosphere, and became one of the concept's most influential popularisers and advocates (Crutzen & Stoermer., 2000). The idea of the Anthropocene is built on a bedrock of supercomputing and climate change modelling. As we shall see, computing has also shaped the idea of resilience, a concept which has become increasingly important as a response to the climate crisis, amongst other things.

The idea of resilience comes from Holling's original 1973 paper on ecological systems (Holling, 1973). He was looking at the balance of predator and prey, and replaced the simple idea of dynamic equilibrium with abstract concepts drawn from systems theory and cybernetics. His seminal insight was that the population of antelope drooping by 80% is not necessarily a sign of ecological disaster, but an adaptive shift. Complex systems have multiple equilibriums, and movement between these is not a collapse of the system but rather an adaptive cycle. The system persists, although in a changed form. His approach was a watershed not just because of its embrace of complexity but because of its abstraction; rather than a description of nature rich in naturalistic observation, his paper posits a hypothetical model of predator-prey relations characterised as "trajectories in the phase plane". This was not only a mathematical but a fundamentally computational shift in understanding population dynamics. The field from which it sprang, systems ecology, had grown from ecologists engagement with the new ideas of cybernetics in the 1950's (Wiener, 1988) and systems analysis in the 1960s (Watt, 1962). Recognizing the complexity of ecological processes, the advocates of this approach wanted to strip away the simplifying assumptions of population ecologists, and were able to do so by embracing the mathematics and using computers to run simulations. Systems ecologists "need...training in mathematics and biomathematics but also FORTRAN and systems analysis" (Watt, 1966), where the FORTAN computing language was itself created by an IBM computer scientist who wanted to make it easier to compute nuclear missile trajectories (Bergstein, 2007). Going down the road of computational analysis changed Holling's own characterisation of resilience from something intuitive that might resonate with the emerging environmental movement to something specifically systems oriented and computationally grounded.

Given that the message of resilience is 'the system persists, although in a changed form,' it is perhaps easy to see how it has become a governing idea in our current era of permanent multiple crises. As a form of governmentality it constitutes us as resilient populations and demands adaptation to emergencies of whatever kind, whether it's finance, environment or security. This idea of resilience is not the colloquial idea of an ineffable quality that enables some people to bounce back from stress and adversity, but a systems approach that has migrated sideways from the science of ecological systems. It is a holistic yet abstract view that sees society's mesh of population and infrastructures as a complex system with adaptive cycles. A system that is robust in the sense that radical changes are not necessarily catastrophic if they are movements between alternative equilibria and resilience is, in essence, this higher-level adaptation. Its 'good' is not measured in the cost of that adaptation but in the persistence of the system. In governmental practice, one of the main engines of resilience is the accelerated conversion of social systems to Hayek's self-organising complexity of markets, with military intervention at the peripheries where this resisted (Dalby, 2013).

Such is the appeal of resilience in our securitised times that it became a mantra for the US Department for Homeland Security: “Ensuring Resilience to Disasters” was listed as a core Homeland Security Mission; and the National Infrastructure Protection Plan had the goal of “protection and resilience” (United States Department of Homeland Security, 2010). The systems view of populations drawn from Holling's work has meshed with a systems view of infrastructures derived from the Cold War, where the emphasis was to understand how distributed infrastructures could survive nuclear attack; the same thinking which funded research in to packet-switched networks and hence the birth of the Internet (Galison, 2001)It has become a tool of strategic planning not only because of its narrative relevance but because the production of collateral data by so many other daily and commercial activities allows resilience to be modelled and predicted. Resilience's socio-technical utility can be seen in the way the Secretary of Homeland Security was able to apply it simultaneously to people and material systems when talking about her department's work to “strengthen the resilience of…infrastructure, computer networks, and of…communities and citizens” (Napolitano, 2010). Computational methods such as Social Network Analysis are seen as predictors of community resilience to disasters (Magsino, 2009) and this modelling of resilience is carried out through large scale computational simulations of disruption in the Department of Homeland Security’s National Infrastructure Simulation and Analysis Center at Los Alamos and at the Sandia National Laboratories (Sims, 2010). Resilience has become an algorithmic predictor of social vulnerability, embedded in structures that incline towards preemptive intervention.

Resilience and the Anthropocene can be seen as grand narratives of crisis, played out at the level of populations and the planet. However, in this reading, they are closely correlated with emerging effects at the level of lived daily experience; effects which we might call algorithmic governance. I have argued that both the Anthropocene and resilience are tied to computation, as the matrix from which they emerged and as the means through which they can be thought. The consequences of their calculations are calls for anticipatory intervention. This mode of acting, of algorithmically driven prediction and preemption, is becoming present in many other areas of our lives. Our actions in the world encounteg an ever-increasing number of digital touch points, giving rise to data which can be enrolled in computational modelling and decision making. These ripples, which make our passage visible to machinic structures, are generated by websites, smartphones, financial systems, transport systems and the widening network of the Internet of Things (Mayer-Schonberger & Cukier, 2013). The data points recoro our shopping choices, viewing preferences and social networks, our friendships, our journeys and our political leanings. These streams of big data are drawn through the analytic sieve of datamining and machine learning, and meaning is assigned through finding clusters, correlations and anomalies that can be used to make predictions (Ng, 2016). The original commercial application of datamining was to predict the next set of supermarket purchases, but the potential for prediction is becoming prevalent wherever there is the notion of a risk which can be computationally calculated.

Algorithmic prediction drives the domination of high-frequency trading in contemporary stock markets (Nestler, 2014). It is also used to make decisions about pay day loans of a few hundred pounds (Morozov, 2013), where your correlation with a social network of poor debt repayers makes you more likely to get the loan on the basis that you can be subjected to a future of punishing interest rates. Datamining is present in the workplace and is used in the human resource departments of large companies like Wal-Mart and Credit Suisse to predict which employees are 'flight risks' (Silverman & Waller, 2015). Data analytics are also active on the streets; in some US states, police stop and search is targeted by prediction software like PredPol. Like resilience, predictive policing is an example of what we might call algorithmic slippage, where in this case "the same mathematics that predicts aftershocks from an earthquake is applied to the prediction of crime" (PredPol, 2015). According to the company, their software is twice as successful at predicting the blocks in which the next petty crimes will take place as human methods. Machine learning is starting to find traction in the most intimate and critical areas of social policy, such as the potential for preventing child abuse. In New Zealand, the government commissioned algorithms to predict which families are likely to abuse their children. The proposed solution uses Predictive Risk Modelling based on 132 different variables (Vaithianathan, 2012) and, "in the top decile... was 48% accurate in terms of prediction of substantiated abuse within the child's first five years of life" (Keddell, 2015). Although the implementation of this algorithm was halted by the ministry because of concerns about the way frontline workers would act on the predictions ('Govt halts abuse prediction study', 2015) there is a growing industry of predictive analytics solutions for child welfare (M. S. Brown, 2016).

The potential for anticipatory intervention is also entering everyday life through the arrival of the so-called smart city (Hollands, 2008). The smart city consists of pervasive computation in the urban fabric, which posits continuous adaptation through a cycle of sensing-computation-actuation. Heterogeneous data streams from sensors are processed in to a dashboard of metrics that triggers automated changes. Although the primary goals of the smart city are expressed in terms of social efficiencies such as frictionless journeys to work and to the shopping centre, it has also acquired an environmental mission. Consumer smart meters, Nest home thermostats and their industrial equivalents are seen as ways to optimise energy use (VanHemert, 2013). Speed limits and traffic lights are manipulated to modify car exhaust emissions in near real-time (Bielsa, 2011). Through claims to energy efficiency and the reduction of emissions, the smart city is being held up as a boost to environmental sustainability and a response to climate change. Continuous adaptations are made to optimise flows with respect to the higher parameters of smoothness and greenness. As a multi-dimensional complex system constantly moving between temporary states of equilibrium, enrolling data both from individuals and infrastructures, the smart city becomes a climate-friendly manifestation of high-frequency resilience and a platform for algorithmic governance.

What, though, are the politics of these interventions? By probing us for proclivities of which we may or may not be aware, algorithmic governance seems to offer an apparatus with traction on security, public health and energy use. Real-time interventions plot a path where risks are preempted. But, as Brian Massumi says, this kind of preemption acts not to inhibit a future event from taking place but rather to bring the future into the present as an effect. “Preemption does not prevent, it effects. It induces the event, in effect. Rather than acting in the present to avoid an occurrence in the future, preemption brings the future into the present.” (Massumi, 2005, p8). Algorithmic preemption is effect without a cause. It is action actuated by patterns; the agency of pattern finding, probabilistic algorithms that substitute correlation for causation. The juridical basis of most societies is that if we are to be judged, we should at least know the grounds. The problem is not only that algorithmic governance introduces judgement by guesswork, as probabilistic algorithms will necessarily produce false positives, but that the nature of machine learning and big data mean that the conclusions are not necessarily reversible to human reasoning. The millions of pathways summed over, and their processing by matrices of correlation, simply can't be unpicked by hand. As a result “data mining might point to individuals and events, indicating elevated risk, without telling us why they were selected” (Zarsky, 2013, p1519). The politics of predictive algorithms is the unceasing projection of predictive patterns on to forms of life; a calculative imaginary that selects allowable forms of emergence. Thus algorithmic governance functions in the world as a form of biopolitics.

Biopolitics, Entanglement

Biopolitics, as defined by Foucault, describes the emergence of a new mode of power that is concerned not simply with being able to kill opponents (as in sovereignty) or with disciplining populations, but with ensuring that particular forms of life live (Foucault, 2008). Those forms of life become the focus of that which has to be secured as the political strategy. Biopolitics is therefore a form of governance that is hyper-alert to risk, to any threat to the security of valorised forms of life. We can see that the Anthropocene, resilience and algorithmic governance can all be seen as forms of biopolitics in operation. They all mandate anticipatory intervention to ensure the sustainability of populations, variously defined. But as Dalby highlights in his discussion of biopolitics and climate change, allowing and empowering certain forms of life to live goes hand in hand with allowing others to die (Dalby, 2013). Inclusion in the envelope of securitised well-being implies exclusion and exception. At the level of daily life, algorithmic governance is made possible by machinic processes that embed a tendency to escape due process and thus to create fluctuating states of exception, in the sense defined by Giorgio Agamben (McQuillan, 2015). And climate change is predicted to bring the risk of climate refugees, populations external to the protected object of biopolitics which threaten it and are therefore subject to sanctions such as exclusion, detention, and military intervention. It is in the borderlands of biopolitics that we see Foucault's point made clear, that " ...we need to see things not in terms of the replacement of a society of sovereignty by a disciplinary society and the subsequent replacement of a disciplinary society by a society of government; in reality one has a triangle, sovereignty–discipline-government, which has as its primary target population as its essential mechanism the apparatuses of security" (Foucault, 2008). So computationial constructs which call for anticipatory intervention, forms of biopolitics that become thinkable through computation, are entangled with the exclusion of the Other. Contemporary forms of life which are disallowed, which are allowed to die rather than allowed to live, can be defined as those outside the algorithms.

How can computational constructs acquire sufficient authority to play this lead role in biopolitical regimes? I argue that this is based on the entanglement of computation and science. In the culture of the modern, empirical science is unchallenged as the most authoritative form of truth. Science is still regarded as a machine for the production of these truths, through measurement, experiment and the testing of hypotheses, and the body of scientific knowledge is seen as increasing over time so that it asymptotically approaches a full understanding of the real. In order to unpick the way this has become inseparable from computing, we need to look at the level of data and calculation. Science as always been based on data, in the form of its observations and experimental measurements, and this data is manipulated mathematically to form and test hypotheses. Scientific laws are expressed as mathematical statements operating on the data, where measurable aspects of the material world are seen to obey reproducible regularities. So it is easy to see how computation became central to science, after the emergence of electronic computers post-World War II made the mathematical manipulation of data possible at speeds and scales that were previously unattainable.

But, critically, computing not only extended science through the analysis of experimental results but by providing the facility to model physical systems. The canonical form of scientific investigation is to test a hypothesis by controlled experiment where construction of experimental conditions attempts to eliminate variation in important variables other than the one being studied. Running the experiment repeatedly allows a deductive reasoning, expressed mathematically, about the relationship between the varying quantity and the result. Modelling is a way of simulating physical experiment by running computational procedures based on a combination of known physical laws and accompanying parameterisations. The production of plausible behaviour or results from a model are an indication that the assumptions made in its construction, such as the parameters, are justifiable or valid. Computational modelling was first used during the Manhattan Project where Monte Carlo algorithms were used to model nuclear detonations (Metropolis, 1987). Fast forward to today, and the scale and power of contemporary computing resources means that modelling can be used as a way to investigate pretty much any extremely complex system. Creating a model of a system gives the investigator the power to run it under any set of initial conditions and any number of times. In 2012 the European Commission gave a grant of one billion Euros to the Human Brain Project to simulate the brain in a supercomputing cluster (Griggs, 2013). Rather than the traditional scientific approach of reductionism, investigating the increasingly more fundamental layers of a problem to unveil the basic physical laws, this approach is synthetic; taking an understanding of individual neuron activity and use clusters of processors to approach the scale of brain activity.

When considering the nature of resilience in relation to biopolitics, for example, we should account for the that part of the relationship that comes from the science and computation of complexity. In this was we can see how "the coupling of a novel account of nature produced by the complexity turn within the disciplines of ecology and economics with ‘environmental’ techniques of government constituted a novel apparatus of power/ knowledge" (Zebrowski, 2013). In the case of climate change, the science would be impossible without modelling. It is impossible to run physical experiments with parallel planets where carbon dioxide levels are different. It is also not possible to separate out one variable, as all of the factors that affect climate are strongly interacting and interdependent. Therefore modelling the Earth's climate is seen as the only way to answer vital questions about the future habitability of the plant. However this introduces its own set of complexities. Models rely on data, but there is a disjunct between available climate observations and the needs of the model. The modelled systems require regularly gridded data points encircling the planet, but actual observations are relatively sparse and very unevenly distributed. They need to be interpolated to correspond to the model data (Edwards, 2013, p. 272). Historical and even contemporary measurements of actual climatological data varies in form and quality and has to be extensively manipulated to fit the needs of a global long-term model. Even with modern supercomputing resources there is a limit to the scale at which the climate can be modelled to make it computationally tractable, in other words able to be run in a reasonable amount of time. This means working with grids of between tens and hundreds of kilometres, not modelling down to the level of individual molecules. Therefore so called sub-grid processes, that is physical processes operating at finer resolution, have to be parameterised. While choosing suitable parameters has some constraints in terms of the known physics and the plausible outcomes, it is very underdetermined and, as is typical in computer modelling, the choice of parameters has aspects of a craft as much as a science. Models are fundamentally not experiments, which is why even the Climate Change panel withdrew from calling their results 'valid' or 'verified' (Edwards, 2013, p. 349). At best they are probabilistic indicators which can acquire a level of trust, for example by roughly agreeing with the predictions of other, independent models.

Such an understanding will also give us traction on the more slippery concepts like resilience and algorithmic governance that are spawned by science-computation but have a political half-life far beyond their boundaries. The resilience of resilience is an object of inquiry by scholars, who seek to understand its adaptive spread as a key term in contemporary discourse. In his paper 'What kind of thing is resilience?' Anderson considers the fact that resilience, whatever it is, is everywhere. It has proliferated across many areas and is described in many ways; as "‘ethos’, ‘programme’, ‘ideology’, ‘concept’, ‘term’, ‘governing rationality’, ‘doctrine’, ‘discourse’, ‘epistemic field’, ‘logic’, ‘buzzword’, ‘normative or ideal concept’, ‘strategy of power’ and so on". Anderson's assertion is that taking this diversity seriously prevents a premature simplification; an erasure of difference that produces a single target for critique, especially the 'consoling' story that resilience is fig leaf for neoliberalism. It may therefore be the case that more empirical work is needed to grasp the generality and specificity of these 'resiliences' that never appear in a pure form, and absorb varying amounts of their precursors (preparedness, risk-based logics). But the argument of this paper is not that resilience is a single concept; rather, that this very diversity can be connected to the contribution of science-computation. The computational construction of Holling's resilience creates an object with the hardness of scientific authority. Dropping this in to the complex waters of the social creates ripples that are still spreading outwards. The hubris of constructing a highly reactive political concept under the banner of objectivity is typical of the science-computation matrix, and a similar proliferation across domains of life is happening with 'algorithms' and 'big data'. In this way, the proliferation of resiliences is a case study for the multiplication that politically active ideas can gain from having scientific and computational backing.

The fact that so much modern science is based on complex computer modelling has raised concerns.

Critics of this general approach feel it is diverting from actual science because of the choice to scale a model, like the Human Brain project, rather than to form a testable hypothesis. They point out that modelling is not only a potential dilution of science but an introduction of a new set of complexities, the computational. Where the success of science during the Enlightenment was to discover a relatively simple set of physical laws that successfully predicted nature's patterns, the vast computing resources we now use have their own emergent complexity. "For few hundred years science was about taking things apart and understanding them, technology was about putting stuff together to do things that we wanted. Now the stuff we are putting together is so complex there's a new science, of understanding the complex behaviour of our devices" (Mirsky, 2012). In science itself the status of modelling is still a topic of lively debate. But without waiting for that debate to be resolved, and without the counterweight of the scientific community, the use of predictive modelling is spreading like a forest fire through social life, feeding on the dry tinder of big data. At least in the case of climate models there are well-founded rules for constraining the outcomes through the internal consistency of the physics and the peer review of the International Panel on Climate Change. But, as we have seen, social modelling is not subject to the same restraints. Resilience models are derived by migrating a systems analysis sideways from its ecological origins and away from the restraints of empirical science, while in the emerging field of algorithmic governance the tether to causality has been severed completely. Computation as an instrument floods Enlightenment habits with so much data that it shifts the balance away from hypotheses and introduces it's own opacities in to the heart of the process. But rather than finding a way back out of this maze by claiming a means to sever pure science from computation, I will argue for an understanding of the politics of science-computation as a basis for adopting a different approach to both. An understanding of the politics of their action in the world as science-computation can be gained by looking at pre-existing critiques of science itself.

Thomas Kuhn's publication of The Structure of Scientific Revolutions in 1962 made several influential claims about the naive view of scientific progress, arguing that instead of linear progress scientific fields undergo periodic 'paradigm shifts' which allow new modes of understanding which would have been considered invalid before (Kuhn, 1996). New and old paradigms are incommensurable; that is, embedded in conceptual frameworks so dissimilar that they don't allow the direct comparison of empirical evidence to favour one over the other. Received beliefs form an interdependent network, and theories are underdetermined by the evidence so there are multiple hypotheses that could explain a given state of reality. Thus the idea of scientific truth can never be established solely by objective criteria but depends on the consensus of a scientific community. This means the notion of what is science at any time must be influenced by social factors as it is formed within the world view of the participating researchers. In N. Katherine Hayle's formulation, we have a form of 'constrained constructivism' where 'many scientific theories can be consistent with nature's order but no one can be uniquely congruent with it' (Hayles, 2001). This modulation of science by dominant cultural assumptions is particularly visible to those who may have been excluded by them, so it is no surprise that there are substantial critiques of science from both feminist and post-colonial positions. These critiques are not saying that science is making things up, but that science is co-constructed by the natural and the social and changes with the historical social order. They are a direct challenge to the internalist epistemology of science that assumes science can produce a mirror-like reflection of a reality that is already out there and available for reflecting (Harding, 1998).

In the context of computational science, assumptions about mirroring reality not only obfuscate any critique of cultural factors in science but also blind us to the additional layer of constructed assumptions that enter at the stage of computational modelling. All forms of science-computation, whether climate modelling, resilience or algorithmic governance, draw authority from their association with objectivity, the core scientific assumption that there is a separation of reporting from the observer themselves, from their feelings, viewpoints or experiences. While this assumption has been pragmatically powerful for science, the rigorous division of thinking and feeling has, as Levins and Lewontin point out, promoted a moral detachment in scientists which, amplified by institutionalisation, has allowed scientists to work on projects which are dangerous and harmful without 'indifference to the human consequences' (Levins & Lewontin, 2009). This carries over in to computing and computing science, especially as they are focused on the 'how' rather than the 'why', and merges with them in the current wave of science and computation entanglements which starting to have a substantial impact in the world. The idea that the output is objective, because the aspect of life it is applied to has been modelled by some combination of mathematical and scientific ideas and implemented via computing, becomes potentially dangerous both at the policy level and at the level of specific instantiations, where the operator charged with acting on the predictions is likely to carry no epistemological doubts.

Capture-based Colonialism

I want to be clear about what is at stake; about what kind of politics is emerging from the transversal forms of science-computation that I have described. We can parameterise this politics by drawing further on the post-colonial critiques of science. The post-colonial view is particularly alert to the way that, operationally, science has been implicated in colonialism. The direction of development of European science was strongly influenced by the needs of the European expansion and, historically, research topics were often funded not because they were intellectually interesting as such but to solve colonialism's everyday problems, whether of navigation, disease or weaponry (McClellan & Regourd, 2000). The political risk in the entanglement of science and computation is that it will amplify this recessive gene of colonialism. Warning signs can be seen in the policy level discussions which overlay the computational models, one example of which is climate change.

Some indigenous communities and African countries are dissenting voices at the Conference of the Parties (COP) talks on climate change. They are the most vulnerable and will be the first to bear the brunt. Yet they have had little role in bringing about increased levels of CO2, which is the side-effect of industrialisation, nor do they have the most influential positions at the talks, which are dominated by those same economic powerhouse nations who are responsible for the problem in the first place. When Sudanese diplomat Lumumba Di-Aping, who was the chief negotiator for the G77 group of developing nations at the United Nations Climate Change Conference 2009 (COP15), called a meeting of African delegates to say that "we have been asked to sign a suicide pact" (Whiteman, 2009) by agreeing to accept a two degree rise of global temperatures above pre-industrial levels he was broadly dismissed, even though desertification is already fueling war and famine in parts of Africa. Certainty about global warming, and therefore the grounding of the Anthropocene, is based on Global Circulation Models of climate that calculate a single average temperature rise as the key climatological variable. As Adrian Lahoud points out, the consideration of global warming through a single global figure rather than local ones is both a technical and a political decision(Forensic Architecture, 2014). The uncertainty in predicting regional and local temperature rises would be technically more challenging, with greater uncertainties, but the single figure masks the above mentioned politics of varying impact. By accident or design, modelling can reinforce existing inequalities of power. In the case of algorithmic governance, it opens up whole new territories of colonialism.

The first act of colonialism is to capture territory with the objective of extracting value and exerting control. The emergence of algorithmic control as capture was predicted by Phillip Agre when he wrote his 1994 paper on the 'capture model' (Agre, 1994). His observations were based on the introduction of computation into factories and corporate offices but they are even more applicable to the era of big data. The capture model suggests that tracking data can lead to the reorganisation of work and daily life. Studying the stages by which computational logic was introduced in to organisations, Agre described the steps as analysis, articulation, imposition, instrumentation and elaboration. Existing activities are analysed and re-expressed as a grammar of ways in which they can be machinically strung together. The overall model is then imposed and people are required to (re)organise their work so it is parseable in the new grammar. This is instrumented by software that records the activity and other software that analyses it. In the capture model, the captured activity becomes a computational representation of the world. Crucially, while the capture model claims to represent the activities, it actually involves a modulation of those activities to fit with the model and to align with the preferences of those imposing the model. As Agre says, it is "crucial to appreciate the senses in which the imposition and instrumentation phases constitute a reorganization of the existing activity, as opposed to simply a representation of it". Through algorithmic governance the capture model is extended to new areas of life including the social and, through wearables and implantables, the body. The captured data becomes part of the agile modelling of life through machine learning and smart systems, with the object of extracting value and exerting control.

Data capture is, in a real sense, the capture of territory. As in historical colonialism, the effect of capture is to shift the locus of control and decision making. No sooner has a new zone of life become metricated through technical systems than decision making with that data is shifted to the colonial metropolis of the cloud. Another key marker of colonialism is Othering; the process of rendering persons or groups as 'other' and therefore able to be justifiably exploited. This is what data does, in the context of datamining. The datafication of subjects, whether considered as individuals or, to use Deleuze's term, as data 'dividuals' (Deleuze, 1992) that are reassembled in different ways, is the algorithmic equivalent of Othering. The experiences which follow do not flow from a recognition of the subject as a person, of any order, but as a flexible assemblage of data points that flow through the algorithms. We can see some recognition of this emerging order in critiques of Uber's algorithmic management (Rosenblat & Stark, 2015), as drivers experience new forms of force at work and employment starts to include jobs that are “below the algorithm” (Kobie, 2016).

Resilience thinking is the subjectivity of those captured by a complexity that can only be expressed computationally. This thinking arises from the application of resilience to the psychological as well as the ecological, where virtue is in coping and adaptation to the inescapable fact of complex change. Some entities, like the UNDP [url], adopt resilience thinking as empowering because it has a focus on a positive potential of dealing with change rather than treating populations as incapable victims. But while resilience thinking is "geared towards unblocking and sustaining adaptive capacities of individuals and systems" (Schmidt, 2013, p177) its correlate is defusing the concept of other kinds of human agency. The complex system is a relational socio-ecology and “the vast number of system interrelationships lead to unpredictable patterns” have “a dynamic of their own that is [only] partly open to explicit human direction” (Baser & Morgan 2008, p16). The distributed agency of an irreducible reality exceeds human apprehension and overflows the idea of an autonomous human subject who could attempt to change it. The new grounds truths are those produced by computational machinery, while "what makes us human and what constitutes the specifically human agency, from a resilience perspective, are not autonomy and the transformation of the external world but the fact that we have an inner life which equips us exceptionally well with adaptive capacities, such as attitude adjustment and expectation management" (Schmidt, 2013, p198). In this light, resilience thinking updates the mentality that Fanon critiques in *Black Skin, White Masks* (Fanon, 2008); it is the colonised mentality of algorithmic capture.

Algorithmic colonialism is the settlement and control of areas of data life by a corporate and government entities. Thus, a colonial politics of computational anticipation can arise from the 'neutral' superposition of science and computation, that is to say, the entanglement of science and computation that doesn't raise any questions about accompanying problems of cultural perspective. Given the nature of the processes involved, could things be otherwise? What challenges can we raise to an undesirable unfolding of consequences through science-computation? The social cost of computation as such is usually challenged through a discourse of rights, that is, on the basis of privacy and surveillance or transparency and accountability. As I have already indicated, the historical challenges to science are more epistemological, especially those from feminist and post-colonial movements. I suggest we extend these epistemic challenges, under the banner of standpoint theory, to address the problematic entanglement of computation and science. This can be mobilised in a practical way to precipitate a post-colonial politics of science-computation.

Post-colonial computing

The current application of science-computation to provide a grounding for culture, that is, for shared beliefs and practices, is exhibiting snow blindness. Dazzled by the power of abstracting the world and manipulating it algorithmically, driven by the intoxicating availability of more and more data, there is no stopping to ask who's reality it is that is being produced. As with science before it, these are seen as questions for other people to answer. The brave new world of Data Science resists the claim that it is anything other than a neutral computational craft which, like the mathematical language of science, can reveal unseen orderings in our messy reality. We are only starting to become aware of the friction that will be generated by these truth claims, as when police in Chicago defend their predictive heat list of 'future shooters' against accusations of racism by referring to its algorithmic basis (Gorner, 2013). This is where standpoint theory becomes important. It highlights the fact that value-neutrality is not value neutral, that abstractness and formality express distinctive cultural features not the absence of all culture. From a post-colonial point of view, claims for modern science as universal and objective are "a politics of disvaluing local concerns and knowledge, and legitimating outside experts" (Bandyopadhyay & Shiva, 1988). The science-computation matrix is subject to the same post-Kuhnian assessment that the success or persistence of certain practices cannot be justified as a purely internal truth, but should acknowledge that the epistemic status of sciences and technologies are always socially negotiated.

Feminist and post-colonial critiques of science provide leverage on the entanglement of science and computation by offering a more nuanced approach to the idea of objectivity. Rather than making assumptions about a single universal objectivity, they recognise that the current scientific method is good at removing individual bias or problematic experimental results, but is unable to identify culture-wide assumptions that shape the selection of particular aspects of reality as significant and therefore particular theoretical models as 'truth'. This critique is known as standpoint epistemology, or standpoint theory (Harding, 1992). It is concerned with the way that assumptions, discursive frameworks and conceptual schemes generated by certain ways of life shape the way dominant groups think about both the natural world and about social relations, and the way those assumptions get baked in to the way everyone else gets to understand the world. As a response, standpoint theory follows Donna Haraway's call for a position that takes embodied responsibility, against the presentation of an objective and neutral view which is by it's own definition above, outside of, unlocated, and therefore can't be held to account (Haraway, 1988). Haraway argues for situated and embodied knowledges as the grounding for rational knowledge claims, and against the normal scientific 'view from nowhere', which she calls the trick of the God view. Standpoint theory suggests that positions of social and political disadvantage can actually become sites of analytical advantage because they are alert to the culture-wide assumptions that prevailing ideas of objectivity have missed. Identifying those assumptions doesn't have to undermine science, but can bring a stronger version of objectivity. Objectivity is strengthened by surrendering a claim to neutrality that hides the social history of science itself. I therefore believe that, as a general approach, standpoint epistemology is well suited to helping untangle the broader matrix of science and computation which is rolling out across society.

We are presented with foreclosures of the future across all scales; from grand narratives about the planet to Google's Prediction API (Google, 2015). The skeleton key to unlocking this forfeiture is not to abandon the benefits of computation but to change the kind of authority and objectivity being sought. This means, as standpoint theory recommends, "starting thought from marginalised lives" (Hirsh, Olson, & Harding, 1995, p193), whatever marginalised may mean in a given context. We need to ask in what ways our wonderful infrastructures of computation and collaboration can be re-grounded in the lives they affect, rather than concealing their hegemonic tendencies by material and metaphorical distancing. Whether the computing of cloud circulation or the misleading idea of cloud computing, the mechanisms of computational anticipation need to be brought back to something that enables a democratised affect and agency. To get a glimpse of what this might mean in practice we can again draw a parallel with science, by examining the emerging field of citizen science.

The term citizen science marks out a contested territory. Some claiming the name are simply collecting data for experiments designed by scientists or participating in online crowdsourcing to scale scientific pattern recognition. In other projects, participants are involved in every step of the process, from framing research questions to collecting data to interpreting results and deciding on actions. These projects can be seen as applications of critical pedagogy to the practice of community science. That is, following Paulo Freire, the collective investigation of their conditions and the exploration of methods for changing them (Freire, 2000). These empirical projects are attentive to Donna Haraway's point about prosthetics; that we are already cyborgs in relation to our ways of knowing the world. It is in the intricacies of these visualization technologies in which we are embedded that we will find metaphors and means for understanding and intervening in the patterns of objectification in the world-that is, the patterns of reality for which we must be accountable. In these metaphors, we find means for appreciating simultaneously both the concrete, 'real' aspect and the aspect of semiosis and production in what we call scientific knowledge (Haraway, 1988, p589).
Recognising this embeddedness in technical ways of knowing, the wider question for a citizen science project is to ask what form of social recomposition becomes possible; what change in the production of knowledge of the physical world can also be, at the same time, a political formation.

I am suggesting, therefore, that a parallel movement of critical citizen computation is both possible and necessary. The invasion of all areas of life by algorithms claiming to know more than we do about what we want, or what we will do next, is in full swing. But algorithmic means themselves are becoming more accessible to citizens, and in forms that can be deterritorialising as much as territorialising (Deleuze & Guattari, 2004). A prototype of this algorithmic differentness is the blockchain, the technology behind bitcoin. Transactions can be trusted because of an algorithmic mechanism called 'proof of work' which is basically incorruptible because it is implemented through a cryptographic hashing function. The result are distributed, trustable records that don't require a centralised authority. However, the import of the blockchain for citizen computation doesn't rest only on the idea of trust. Like machine learning, the blockchain is a mechanism for pattern production that maps on to the social, but in different way. For one thing, it is a mechanism of data distribution rather than data concentration; rather than sucking in forms of social and scientific big data, the blockchain ledger is a permanent record maintained by a vast and distributed network of peers. As such, as a transparent and distributed base layer for encoding social rules, the blockchain addresses various collective action problems such as the so-called tragedy of the commons. Mackenzie writes about the unexplored social potential in the patterns of datamining, asking whether the functions that generate the data "might also diagram different forms of association". In the same way, algorithmic technologies like the blockchain may enable the rediscovery of forgotten non-market patterns. "Bitcoin is not really about the loss of power of a few governments, but about the possibility for many more people to experiment with the building of new constituencies" (Roio, 2013)

Looking backwards from the idea of the Anthropocene, we can see that to anticipate sustainability for a fragile planet it is necessary to extend science beyond strictly traditional methods. However, climate modelling has only extended science along the computation axis. If it had drawn more from proposals like Post-Normal Science (Funtowicz & Ravetz, 1993) it would have built-in the idea of reflection by extended stakeholder communities including, first and foremost, those directly affected by an issue. Such a model of science-computation would act as a restraint for its more feral cousins, resilience and algorithmic governance. Rather than accepting algorithms as agents of disempowerment, or as recapitulations of older colonial technologies, we can exploit the fact that the process of capture is not a closed one. An overlooked aspect of Philip Agre's capture model is his emphasis on de-capture, or different articulations. Agre points out that, as form of grammar, any capture model can be used to express a huge variety of sequences of meaning, including the concrete possibility for expressing alternatives. Within every assemblage is a latent general assembly, in the sense of the Occupy movement, and in the case of science-computation assemblages this democratic dimension is in urgent need of discovery.

Conclusions

This paper has attempted to perform a stratigraphy of computational culture; not to claim a new epoch or even era of algorithmic governance, but to highlight a boundary layer of over-reliance on calculative anticipation. Computational prediction is a powerful tool, but it produces neither 'truth' nor 'good'. Thoughtlessly allowing it to become the grounding for our shared beliefs and practices, in other words our culture, is likely to return us to colonial patterns of relations.

In the General Circulation Models of climate change, virtual global systems are spun up from scratch without initial conditions or data until they settle in stable states; these become predictions of possible future worlds. They are, in their own way, are a vivid concresence of the techno-scientific God view. That is not to say that those models are useless, that the climate isn't being changed by human intervention, that we don't have the makings of a crisis, or that we shouldn't intervene urgently. Rather the opposite. It is to call for a critique focused on the form with which the truth of change is established and the implications that brings, especially in terms of politics and (dis)empowerment. The 'distanced' mode of establishing truth through computation has spread to general society without any concomitant effort to develop a praxis, that is to say a reflective practice with an ethical disposition. The securitised modelling of social resilience to future crises, climate or otherwise, becomes active in the present as a driver of biopolitics. The new extractive data industries race to colonise every corner of our experience, othering us as datafied subjects, and seizing the future through predictive calculations and preemptive interventions. Abstraction has erased political agency.

This praxis will come through a subjectivity whose standpoint is a co-presence with the world. Faced with the idea of the Anthropocene there is "the possibility of infusing resilience narratives with intersubjectivity" (Powell, Larsen, & Bommel, 2014, p135), that is, a subjectivity that goes beyond a conception of humans contending with nature to a see ourselves simply as one species of persons in a pervasive field of reciprocating persons. The idea of intersubjective resilience proposes that "beyond the scientific realm, and within local contexts, there are a plethora of legitimate perspectives on global environmental change processes held by stakeholders. Rather than relying on reified scientific narratives, research should work to empower these perspectives and practices" (i*bid.*). However powerful our computational tools become, and however complex the narratives they underpin, they are not necessary for the sense of responsibility and accountability called forth by standpoint epistemology. We don't need computational prediction to know when life is out of balance. In 1977, at a time when computational climate modelling was still taking its first stumbling steps, a statement from the Haudenosaqunee (Iroquois) nation was delivered to the first United Nations Conference on Indigenous People in Geneva. Drafted by John Mohawk and approved by their Grand Council of Chiefs (Curl, n.d.) the 'Basic Call to Consciousness' articulates a world view that combines shared agency with deep responsibility. "The air is foul, the waters poisoned, the trees dying, the animals are disappearing. We think even the systems of weather are changing. Our ancient teaching warned us that if Man interfered with the Natural Laws, these things would come to be. When the last of the Natural Way of Life is gone, all hope for human survival will be gone with it" *A Basic Call to Consciousn*ess, 1978 (as cited in Mander, 1991, p191)

Standpoint epistemology offers an alternative to computational colonialism. “A standpoint is not the same as a viewpoint or a perspective, for it requires both science and a political struggle” (Harding, 1998, p. 150). We need not just to critique entanglements of science and computation but to re-work them in to a post-colonial politics of both algorithms and atmospheres. Different approaches to science have shown us a way to intervene in the wider patterns of objectification in the world because “only partial perspective promises objective vision” (Haraway, 1988, p583), and this commitment to the messy ambiguities of the analogue signals the return of politics over algorithms and the subsumption of calculative prediction to the imaginative vision of social movements.

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