Weather or Not?

Forecasting the End of Reality

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Do those that resist taking action to prevent climate crises believe that the future envisioned by climatologists and environmentalists is a fiction? Do they believe that perpetually accelerating economic growth is more realistic than widespread droughts, floods, and famines? Both the fields of climatology and finance construct futures. They do this mathematically and rhetorically. Presently, the future projected by finance exerts more influence over the world than climatology's future. Finance's future is used as a basis for decision-making (governmental and otherwise) far more often than the future of environmentalists. What do economists do differently that makes their future seem more operable than that of environmentalists? Here I examine three methods of producing future climates (near-term, medium-term, and long-term) in order to ascertain why climate crises seem inoperable to many politicians and media pundits.

Do public decision-makers consider the math and science of economists more accurate than climatology's math and science? This would be odd given that economists' predictions are consistently wrong. Economic knowledge relies on a variety of assumptions and oversimplifications. Climatology's futures also incorporate reductions, but there is much greater statistical certitude in the behaviour of CO_2 particles than that of human consumers. Statistically, then, one might expect greater confidence in climatological than financial knowledge. The belief in the economist's future, then, must be due to rhetorical rather than empirical reasons. That is, at least when considering today's dominant imperative to perpetually grow wealth, rhetoric is more real than science.

The assumption here is that if we were to believe the calamitous predictions of the climatologists, then we would necessarily do something to avert these

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predictions. Perhaps this is not true. It is possible that we can believe the predicted calamities are accurate yet do nothing to avoid them. Maybe we are just selfish and do not care about future people. Perhaps we are too lazy to change. We should have honest conversations about these dark possibilities. Less productive is upholding a belief in the ability to avert climatology's future (in which unchanged resource exploitation will make many habitats unliveable), while simultaneously pursuing finance's future (in which wealth continues to grow at a compounded rate forever). This is nonsensical. Yet this is precisely what many heads-of-state, CEOs, and people in positions of power purport to believe – that wealth can grow forever without disastrous environmental impacts.

In this article I take the unknowability of the 'subsequent' as an invitation to reconsider the relationship between the real and the imaginary, between the future and the fictional. Different societies conceive of and construct the subsequent – the yet-to-come, the future – in different manners. For societies organised around perpetual economic growth, the future is the source of wealth (Bear 2014; Reed 2014; Adkins 2017). For such societies, future expectations exert great control over decision-making in the present. As Morten Nielsen's fieldwork suggests, 'the future asserts itself by opening up the present … In a peculiar inversion of conventional linearity, the present becomes the effect of the future rather than vice versa' (2014: 170). Recent figurations of capitalist epistemology have articulated this seemingly reversed causality in which events precede their causes (Land 2011; Colebrook 2020).

Reflecting on the rhetorical success of capitalist modernity, while also drawing on conservations with meteorologists, climatologists, and computer programmers, I problematise dominant climatological means of perceiving the future. Current dialogues around climate change have been ineffective at restricting destructive resource exploitation. This ineffectiveness, I argue, stems from a misguided perception of what the future *is*. I suggest, following Elie Ayache (2010), that it is a misconception that there is an array of possible futures, each of which can be assigned a probabilistic certitude. That is, climatology frames the future as probabilistic and thereby limits its rhetorical reality, making the future appear potentially fictional.

Imagined realms are often dismissed as inferior to reality. 'Get real!' or 'You're being unrealistic' are common rebukes. The privileging of the real over the imaginary inhibits the pursuit of non-destructive futures. We have a 'crisis of imagination' more distressing than any financial crisis (Reed 2014: 77). Alternatives to today's dominant global order are considered fictitious (fanciful) by those empowered by this order. That is, alternatives are imaginary, and the exclusion of the imaginary from the real reifies the inevitability of Eurocolonial exploitation and oppression (elaborated below in discussion of early modern epistemic transitions).

Developing this argument, I maintain (1) that the concept of reality was historically developed (in the West) to control and constrict the imaginary; (2) that the reality afforded by future predictions is not tied to accuracy, and (3) that climatological future-making can borrow methods from finance to achieve more 'realness' (perceived operability). I begin with a discussion of the history of reality, which I follow with a review of methods for seeing the future and an analysis of climatological knowledge production. I conclude with considerations of economic futurity.

Really?

Historical philosophers have identified key shifts in European epistemology from the Renaissance to modernity, in which reason and rationality became favoured over subjectivity and speculation (Blumenberg 1985; Cassirer 2020). Cassirer (2020: 54) details Renaissance thinkers who severed the bonds between physics and ethics and the increasing scrutiny of those who contrived explanations according to their own fancy. Within this shift, God and theological tenets were increasingly relegated to the realm of fiction, while human reasoning became the key to unlocking reality. As Sylvia Wynter puts it, 'With the Renaissance … a mutation now took place' (1984: 31), in which rationality and reason became deified above God – 'the projection of Maximal Man over … the Maximal God' (ibid.: 29).

With this valorisation of rationality, the imaginary (dragons and witches, for example) was construed as inhibiting humanity from mastering the universe, which concurrently authorised the subjugation of people who did not use European rationality. European colonisers considered, and still consider, themselves the arbiters of reality, while the planet's colonised Indigenous were/are purportedly living in fictitious fantasies among gods, spirits, and animistic environments. People in this 'imaginary world', the thinking goes, need to be paternalistically (and often fatally) guided into colonial reality. Today's use of reality was normalised alongside developments in European knowledge production that authorized and enabled global colonial capitalism. Chakanetsa Mavhunga calls this 'knowledge racism' (2023: 9), which promotes the idea that 'the West invented science. That the West alone knows how to think…beyond the West only primitive thinking exists' (ibid.: 47).

This notion of reality serves to contain the efficacy of the imaginary. No king can exert total control over the imagination. In lieu of controlling what is imaginable, the power of imagination to induce change (to have causal impact) has been marginalised and made unbelievable. The imaginary was quarantined from the actual world. We are taught that phenomena residing in the imagination are a different breed than real phenomena; that the imaginary cannot impact the real. This is a defining attribute of Enlightened colonial thought—the construction and separation of a mutually exclusive reality and imaginary (a quick look at Google's Ngram Viewer shows a precipitous rise in the use of the word 'reality' from 1500 to today).

Prior to the Renaissance, the imagined and the metaphysical could serve as causal explanations. Certainly, for Christianity (and pretty much any spirituality), reality is not sealed off from the imaginary. Faith is belief in the unverifiable. Perhaps the imaginary's crumbling causal efficacy can be traced to the apocalyptic socio-political scramble that followed the Black Death (1347-1352), which prompted a loss of faith in Christian knowledge. Or perhaps the shift from medieval to Renaissance aesthetics marks the onset of reality's dominance – after the Renaissance, linear perspective became 'what reality looks like'; the world became realistic!

The real world of Western rationality is not divorced from the interests of empowered exploiters. Just as laws benefit those who are empowered to write them, so too is reality written to benefit those who are currently enjoying the status quo. The history of science reveals that physics developed alongside a trajectory that naturalised capitalist power (Malm 2016; Daggett 2019; Schwartz 2022). As Porter (1996: 27) writes, '[t]here has been little evidence of disharmony between the interests of science and those of … large industries'. Physics and finance have made for good bedfellows for the past 400 years, with the latter often leading the former (Mirowski 1989; Schwichtenberg 2019). For example, Einstein's landmark 1905 articulation of Brownian motion largely reproduced the conclusions of Louis Bachelier's 1900 thesis on stock pricing. 'This convergence is itself symptomatic of the trauma … that someone interested in, of all things, finance, would hit on the same mathematical formula to model their objects [as someone trying to understand laws of motion]' (Maurer 2002: 22). This confluence should not be used to naturalise Western economics, but to denaturalise Western science.

Rationality is political; it is a representation of empowered subjectivities. That is, the perceptions of people with power are given more ontological weight. This is true in modern scientific communities, as well as many non-Western traditions. The reality of authoritative perspectives is traditionally drawn from the past. However, for capitalists whose wealth lies in the future, the yet-to-come is the source of authority.

This inversion hints at the concept 'hyperstition': a fiction that actualises itself. This term was coined by Sadie Plant and Nick Land in the 1990s. Plant alludes to the computer as hyperstitional, suggesting nineteenth-century computational devices were 'assembling the processes and components from which [the computer] would eventually be built' (1998: 22). Hyperstitions play with common beliefs about the temporality of cause and effect. As opposed to saying the computer emerged from the ingenuity of individuals like Babbage or Turing, a hyperstitional reading emphasises the agency of the idea; the ability of the idea to embed itself in the past, 'as though the present were being reeled into a future which had always been guiding the past' (ibid.: 13).

Plant (1998) and Land (2011) understood hyperstition as an extension of superstition. The phenomenon called 'voodoo death', in which someone who has been cursed to death actually dies within a few days, was often categorised as superstitious by early anthropologists (Cannon 1942). The concept hyperstition, however, allows for a more generative view of the phenomenon. The common labelling of incidents such as 'voodoo death' as psychosomatic (Lester 1972) – the victim believes so strongly in the power of the curse that their physiological body shuts down, leading to death – has been unsatisfying to some anthropologists (Hahn and Kleinman 1983). Such incidents are not mental glitches; they reflect the proper functioning of social norms. More accurately, such incidents are sociosomatic or 'culturogenic' (ibid.: 3), as they stem from community beliefs and the society's agreed-upon causality (see Fanon 1967 on sociogeny).

Intrigued students in introductory anthropology courses I teach sometimes ask if voodoo death is real. It feels insufficient to say that the magic is real enough to the people who believe in it. Proclamations like

'Witches, as the Azande conceive them, clearly cannot exist' (Evans-Pritchard 1976: 18) reek of ethnocentrism. Hyperstition collapses concepts like real, imaginary, fictitious, psychosomatic, and superstitious into each other. Reality is a mosaic cobbled together from fictions, myths, empirical data, chemical reactions, and molecular bonds. The real and the imaginary are not distinct worlds; they are co-constitutive.

Just as one society may cultivate the belief that a curse can kill, another may valorise the belief that it can accumulate wealth forever. These are hyperstitions—ideas that force themselves into reality. As ecologically apocalyptic visions are beginning to materialise, can climatologists and environmentalists imagine an alternative idea strong enough to break into the future?

Divination and prediction

The future was renegotiated during the epistemic shifts of the Renaissance and the Enlightenment. While the 'future' existed prior to modernity, it became something different within colonial-capitalist epistemology. There is always utility in knowing what will occur, and anthropology has long documented the many methods populations pursue to attain knowledge of, and control over, the subsequent.

From extispicy (reading entrails) to ptarmoscopy (reading sneezes), countless divining practices have been developed. Are the predicting, projecting, and modelling methods of today's meteorologists and climatologists qualitatively different? Is reading isotope ratios in Greenlandic ice cores an altogether different undertaking than reading the colour of goat intestines? While the statistical certitude of causal correlations between ice core composition and precipitation is greater than that of extispicy, the practice of reading an aspect of the environment for what it signals about the past or future is a similar undertaking. What is markedly different is the composition of the future. The future constructed by today's climatologists is the outcome of a trajectory of causal links going back millions of years.

Developments in dominant epistemic strategies rendered the world 'predict-able'. That is, while predictions may not always be accurate, the salient shift in temporal conception since the Enlightenment is that the world acquiesces to being predicted. The future does what the past tells it to do. If given enough information about the past, the assumption is that trajectories can be built into the future (see Laplace's demon). This assumption portrays the future as an outcome of historical effects. The primary causes among Scholastic European thinkers (ca. 800-1400 CE) were the forms of objects. Thirteenth-century scholar Albertus Magnus understood that 'the natural motion of the elements can be grasped once the form of the elements is grasped … Motion, therefore, is ontologically derivative of form, while form itself is primary and irreducible' (in Lee 2004: 77). In this view, the composition rather than the history of an object determines its future.

With the Galilean-Cartesian shift, the history of objects became the primary cause of actions and outcomes. 'In sum, the emergence of modern science can be described as a shift from a concern with forms of nature, which prevailed in scholastic thought, to an inquiry into the efficient causes of changes in the things of nature … the world becomes an effect … the result of determination' (Ferreira da Silva 2017). Under this paradigm, the trajectory is the reality: the world becomes a never-ending causal chain. If something does not contribute to the trajectory of causality being constructed by colonial teleology, it is not real.

What the future *is* has changed. The idea that the future is part of a trajectory that is the result of past events is what we call history. Euro-colonisers built a history around themselves. While many peoples tell accounts of past events, not all of them tell teleological histories. Wolf (1982) illustrated that 'the people without history' experienced regular socio-political flux and told the stories of this flux. However, the teleology of colonial history-telling is a less common temporal figuration.

Today's epistemic relation to the future relies on transforming the world into numbers. By employing data and mathematics, what might be considered speculation or divination becomes modelling and projecting – a quantified empirical past can make an 'empirical' future. 'For the Enlightenment, anything which cannot be resolved into numbers … is illusion' (Horkheimer and Adorno 2002: 4). Numbers have become increasingly valorised in knowledge production because they are championed as being indifferent to human subjectivity (Poovey 1998). Many authors have challenged this assumption. Warren (2018: 111) argues that 'Numbers are not neutral or innocuous but are weapons of pulverisation and subjection'. The use of numbers is certainly not universal among human societies (Everett 2017). According to Porter (1996: 11) 'The credibility of numbers … is a social and moral problem' (Porter 1996: 11).

Feeling the forecast

The prevailing means of knowing future environmental conditions is via computational models that process empirical measurements through mathematic formulae that are derived from our best understanding of physics. '[C]limate has the uncanny quality of being perceptible only through techniques of modelling, visualising, the calculation of probabilities, and the creation of scenarios oriented toward a modelled past and a future that does not yet exist' (Knox 2020: 22). The problem for many is the tenuous ontological status of models. Models are not reality. Models are not causes.

Models are built from trillions of datapoints collected from a variety of observational technologies and run through exascale computational simulations. Models are facsimiles of the future. 'In a well-designed numerical simulation, one could manipulate variables at will and observe their effects on outcomes in a way that no other technique could hope to match' (Edwards 2010: 115). Modelling requires extensive computational power. For example, the Geophysical Fluid Dynamics Laboratory – Earth System Model (2M) (GFDL-ESM2M)

> has approximately one million lines of code, of which ~349,515 are dedicated to atmospheric permutations, ~12,059 to ice, ~35,666 to land, and ~224,292 to oceans. The amount of code in Global Climate Models (GCM) is typically … about the same as the Hubble telescope and the Mars Curiosity Rover, and significantly less than CERN's Large Hadron Collider (~50 million lines of code). (Schwartz 2021: 112)

All climate models include numerous parametrisations; that is, parameters indicating how systems are supposed to behave in the absence of perfect information. This is a primary source of uncertainty in climate models.

In studying the statistical reliability of climate models, Wendy Parker (2011) asks what the significance is of several different models agreeing that the global temperature will be 1°C to 2°C higher by the middle of the twenty-first century. What does the agreement of the models say about the 'future truth-capturing abilities of today's ensembles?' (ibid.: 586). She concludes:

> While it is true that today's state of the art climate models are constructed using an extensive body of knowledge about the climate system and that they generally deliver results that are (from a subjective point of view) quite plausible in light of current scientific understanding, their individual reliability in indicating the truth/falsity of quantitative predictive hypotheses of the sort that interest today's scientists and decision makers remains significantly uncertain. (ibid.: 597)

Parker's argument is that any single climate model is not made statistically more likely to represent future conditions even when more and more models agree. Antonia Walford (2013: 23) adds: 'In the end, accruing more and more perspectives does not seem to add up to anything, especially when the profusion of new perspectives seems to inhibit one's ability to countenance others. The overarching problem seems to be how to make new knowledge at all.' To this end, Hulme (2012: 30) fears that 'Climate models have become a prosthetic to human moral and ethical deliberation about long-term decision-making'.

Embedded in the fear of confusing the model with the 'real future' is the idea that there is a 'real future', and that the future is not intrinsically fictional – 'the fiction of futurity itself' (Reed 2014: 83). Patricia Reed fears that 'models drive a reality that drives models ad infinitum' (ibid.: 89). Maurer (2002) laments a blurring of reality with the model of reality – a lament that again points to a confusion over what exactly the future is. Is it the continuation of a calculable trajectory? Or is it a negotiation? Physicist Tim Palmer (2015) has freshly suggested building imprecision into computer models in order to make our reality-simulating algorithms echo the chaos of the climate system. He argues that 'We should question whether all scientific computations need to be performed deterministically – that is, always producing the same output given the same input – and with the same high level of precision' (Palmer 2015: 32).

Short-term futures

Are bigger futures more fictional than smaller ones? Is a two-hour future more real than a two-hundred-year future? As we stray into the future, the trustworthiness of climate forecasts becomes increasingly suspect. Today, it remains impossible to reliably forecast weather conditions beyond ten days. Yet despite occasional misses, weather forecasts for the next 24 hours are pretty reliable. Many of us plan our day around the morning forecast, making wardrobe choices based on the day's meteorology.

We afford daily forecasts so much reality that we may not register that they are models. Indeed, in an email correspondence with a meteorologist from the National Oceanic and Atmospheric Administration (NOAA), I mentioned that I was interested in prediction. The meteorologist took slight umbrage at my word choice. They wished to make clear that they were not making predictions but were forecasting, and that this should be considered a distinct practice. The meteorologist did not like the uncertain connotation of 'prediction' and viewed forecasts as a temporal map of the imminent. Contradicting Alfred Korzybski's famous quip, the map *is* the territory in short-term forecasting.

The Weather Company is 'the world's leading weather provider' (their words). This meteorology conglomerate began as the cable TV network The Weather Channel, but was bought by IBM along with many other smaller meteorology companies (such as Weather Underground). The Weather Company is part of IBM's Consumer AI branch. I spoke to a representative from this department about the forecasting process and the relationship between forecasting and computation. The representative told me that Deep Thunder, one of The Weather Company's proprietary models, makes 26 billion daily forecasts (9.5 trillion yearly) and combines the 'hyper-local, short-term custom forecasts developed by IBM Research with The Weather Company's global forecast model'. The representative explained:

> To create a single forecast, 178 individual forecast models are pulled within Weather's analytical system, combining a wide variety of government and private forecast models. Machine-learning algorithms weigh factors like temperature or precipitation from each forecast based on geography, time, weather type, and recent forecast accuracy. The system then blends those weighted contributions to arrive at a single synthesised forecast that provides the best possible accuracy available.

To compute the copious data involved in forecasting, in 2019 The Weather Company introduced IBM-GRAF, a model that handles 3.5 petabytes of data per day, achieving the '"holy grail" for global numerical weather forecasting – the ability to run at a resolution so fine that no approximations are needed to simulate how individual thunderstorms behave'. IBM's description of forecasting capacity is revealing:

> Deep Thunder can also analyze weather for targeted areas retrospectively, and use machine learning-based weather impact models to help businesses more precisely predict how even modest variations in temperature could potentially have an impact on their business, from consumer buying behavior to how retailers should manage their supply chains and stock shelves; how insurance companies can analyze the impact of past weather events to assess the validity of insurance claims related to weather damage; or how utility companies can mine and model historical data of damage caused to power lines or telephone poles and couple that information with a hyper-local forecast to better plan for how many repair crews would be needed, and where. (IBM 2016)

It is not incidental that IBM is buying up meteorology services. IBM's interest in The Weather Company is driven by its Artificial Intelligence research. Those 26 billion daily forecasts are created not by meteorologists but by computational algorithms. The Weather Company representative boasted about their 'human-over-the-loop' (HOTL) forecast method, a progression from the human-in-the-loop (HITL) method that utilises human oversight. The 'over' in the HOTL system denotes that no human intervention is necessary in the production of the model.

The prognosticating practices of big meteorology are more about increasing probabilistic confidence in models – producing as many tomorrows as possible. The Weather Company is only incidentally concerned with weather, insofar as it makes good data, thus abetting its computational forecasting knowledge for commercial applications. The meteorology service DarkSky.net employed no meteorologists or atmospheric scientists, only computer scientists (personal communication). DarkSky was bought by Apple, exemplifying the trend of tech companies purchasing meteorology companies (and their copious data) to train their AI systems.

Medium-term futures

The most politically contentious and distressing forecasts of today are those that project climates for the next few decades. The Intergovernmental Panel on Climate Change (IPCC) has published regular reports since 1990 compiling the most up-to-date science and assessing the planet's climates a century in advance. These reports have grown increasingly dire. In 2018, the IPCC released a report advocating that nations aim to keep global warming from exceeding 1.5°C since industrialisation (the average temperature between 1850-1900).

The assessment suggests that if we do not reduce CO_2 emissions to near zero by 2030, there is a high probability that we will exceed 1.5°C. The report focuses on the distress (ecological and political) that 1.5°C of warming would cause, and offers potential steps for avoiding the worst-case scenarios of this future. Global warming above 1.5°C, the authors argue, could have irreversible effects on the planet's ecosystems. The authors express little confidence, based on atmospheric and political conditions, that the warming trend can be stemmed before reaching 1.5°C of warming by 2030.

The report offers banal observations, such as 'Limiting global warming to 1.5°C compared to 2°C is projected to lower the impacts on terrestrial, freshwater and coastal ecosystems and to retain more of their services to humans' (IPCC 2018: 10). The report notes that all pathways for keeping global warming below 2°C through 2100 entail drastic alterations of global social organisation – a total restructuring of dominant planetary energy systems: 'broad transformations in the energy; industry; transport; buildings; and agriculture, forestry and other land-use sectors' (ibid.: 112).

The report indicates that more than 1.5°C warming will result in a world in which predictive capacity based on historical conditions will begin to break down – conditions will become unprecedented, statistical certitude will be compromised. The IPCC's projected world beyond 2°C warming will no longer be amenable to prediction based on trajectories built of collected data. That is, the colonial epistemology of time-binding (chaining the world to causes and effects) will be untenable. The billions of datapoints we have collected will be useless in the face of heretofore unseen planetary conditions. 'In climate and weather modeling, time does not run out. What in fact runs out is the predictability of the model. When the model is no longer able to predict convincingly … what runs out is knowledge' (Walford 2013: 30).

The contentiousness of the medium-term future is evident in discussions over 'hot models', which are models that predict significantly hotter future conditions than would be expected based on other models deened more plausible. For example, in the 2018 report of the Coupled Model Intercomparison Project phase 6 (CMIP 6) of the World Climate Research Programme, a subset of models projected end-of-century warming of up to 5.6°C, compared with CMIP5's high-end estimate of 4.7°C. Many climatologists have dismissed these hot models and downplayed their reality, suggesting they do not incorporate the past correctly into their constructions of the future. Climatologists themselves seem unwilling to believe their own worst-case scenarios. The reluctance may have less to do with the unbelievability of temperature rise than with the increased widening of possible futures. CMIP6 produced a range of 1.8–5.6°C, whereas CMIP5 in 2014 produced a range of 2.1–4.7°C. Some climatologists (Sherwood et al. 2020) emphasise a need to narrow the spectrum of possible futures. That is, they hope they can build a more precise future by using more data and enjoying greater computational capacity. As in Walford's (2013: 30) research with Amazonian meteorologists, the goal is to close the gap between what is observed and what is expected, 'for when these are the same thing, the model is actualizing the future'.

The resistance to 'hot models' has been so great that the IPCC's 6th Assessment report (2021) recalibrated the projections to produce a spectrum of possible future end-of-century warming to 2.6–4.1°C. The IPCC eliminated from its future the possibility of a world of 5.6°C of warming. Some climatologists refute this elimination of 'hot models', finding

> that models with higher sensitivity better represent some key climatic processes … While they were unable to provide robust physical explanations for their findings, it is worth noting that at the regional scale, hot models may provide valuable information that may be more important than the global warming trend for impact modelers (Rahimpour et al. 2023).

The relationship between evidence and reality is telling in 'hot models'. They have been shown to more accurately match weather conditions that are empirically observed in the present (Williams et al. 2020). However, the models are accused of lacking robust physical explanations for why they work. That is, they have been accused of not using the past correctly (paleoclimatology) as a determinant of future contingency. Williams et al. (2020: 8), whose experiments show the accuracy of 'hot models' over small time-scales, suggest 'the changes responsible [for hotter results] are improving the realism of the model'. What kind of realism is this? Paul Edwards' (2010: 345) work with climatologists shows that 'realistic' is 'an adjective referring not to accuracy but to the inclusion in the model of all physical processes that influence the climate'.

Long-term futures

The agent-based modelling program NetLogo allows users to run climate simulations thousands or millions of years into the future. The NetLogo climate model is a very rudimentary example of how Earth's climate system works, specifically the warming effect of greenhouse gasses such as CO_2. Running this model and tinkering with the variables, I produced a world of +14°C warming 114,888 years into the future.

The autors of the model, Tinker and Wilensky (2007), aknowledge that this model is an overly simplified simulation with no consideration of wind, precipitation, sea ice, and other meteorological circumstances. It is just meant to simulate the flow of heat energy on Earth and the role of greenhouse gasses like CO_2. The model operates on variables for cloud cover, CO_2, sun-brightness, and albedo effect (how much sunlight the planet's surface reflects or absorbs). Users of the model may alter these variables to experiment with how they impact the warming of the planet. As users increase the sun-brightness or add more CO_2, the temperature rises; as they increase albedo and add clouds, the temperature levels off or declines.

In this model, a sunlight ray turns into heat energy when it is absorbed by the earth (a function of the amount of albedo). This heat (depicted as red dots) randomly moves around 'inside' the earth, and the temperature is related to the total number of red dots. Some of this heat transforms into infrared (IR) light that heads toward space, carrying off energy (cooling). Tinker and Wilensky (2007) write: 'The probability of a red dot becoming IR light depends on the earth's temperature. When the earth is cold, few red dots generate IR light; when it is hot, most do' (Tinker and Wilensky 2007). Each IR light carries the same energy as a sunlight ray. The IR light goes through clouds but can bounce off CO_2 molecules, thus trapping heat on the planet.

> There is a relation between the number of red dots in the earth and the temperature of the earth … Thermal energy is added by sunlight that reaches the earth as well as from infrared (IR) light reflected down to the earth. Thermal energy is removed by IR emitted by the earth. The balance of these determines the energy in the earth, which is proportional to its temperature (Tinker and Wilensky 2007).

The user interface of the NetLogo program makes it an engaging pedagogical tool for discovering the *reality* of the greenhouse effect. Users can alter the code directly by changing the weight given to certain variables or by modifying the variables in the user interface. While my model ran, I modulated the variables somewhat experimentally, attempting to get the temperature to rise and fall. Thus, the temperature I generated should not be confused with a prediction, a projection, or an approximation of the planetary temperature 114,888 years in the future. Rather, it is an experimental future.

Finding the fiction

What can be learned about the reality of the future from these modelled glimpses into subsequent climates? Near-term futures appear to be afforded an inevitability, as evidenced by the NOAA meteorologist's haughty insistence on distinguishing between forecasts and predictions. It is as though the near-term future is as solvable as a math equation. That is, there exists a correct solution to tomorrow's weather; you only have to insert all the numbers correctly. The use of near-term meteorology as a marketable commodity, as pursued by IBM's Consumer AI division also gives these futures a veneer of reality – targeted near-term forecasts are made into commodified objects.

The long-term climate model is the most unrealistic; it is arbitrary, simplified, and detached from physical processes. This should make it a fiction. However, it is also the most hands-on model. Users can 'look under the hood' and manipulate it themselves. In a sense, I *made* this climate. Moreover, while the long-range temperature represents 100,000 years hence, in the universe of the model it is not 'predicting' the future. Rather, it is speeding up time to arrive at the future early. The model churned through 100,000 iterations (years) at a rate greater than one year per second. These factors combine to make this long-range future feel less imaginary; perhaps not real, but a symbolic object.

The most important of these three futures is the medium-term model. Climatic conditions for the next few decades, such as those published by the IPCC, are the most studied, calculated, and modelled, yet this copious study inversely relates to the trust placed in such projections. More than distrust, these decadal climate projections often offend and induce anger. When confronted with a model that predicts 2°C warming by 2030, some people interpret this as a subtle attack on their way of life. This reactionary attitude drives inaction on climate change. It drives fatalist sentiments asking why 'we' should reduce fossil fuel consumption if China or India continues to expand fossil fuel extraction.

Scepticism toward medium-range futures may also be due to the probabilistic language used to express temperatures in 2030, 2050, or 2099. The IPCC report cautioning against 1.5°C of warming is not a straightforward prediction. Rather, it says there is a 66 percent chance of keeping warming below 1.5°C if we only emit 420 more gigatons of CO_2. If we emit 580 gigatons, the possibility of staying below 1.5°C drops to 50 percent. If we emit 840 gigatons, the possibility of staying below 1.5°C falls to 33 percent. In any case, there is no scenario where the probability of staying below 1.5°C is greater than 66 percent.

As Max Ajl (2021: 63) states, 'It is understandable that such numbers are difficult to metabolize politically'. Ajl dismisses the dream of continuing economic growth and drawing down CO_2 emissions as unrealistic (ibid.: 66). As he points out, what is real and what is possible reflect political negotiations and values:

> … there is no way to know what has 'no chance' of being eventually implemented, which goals are 'unattainable', and what is a 'waste' of time and what is not. These are arguments that hide in the cloak of pragmatism but are really about political values. Strictly speaking, sharp and immediate reductions in consumption and immediate sustainable energy conversions are possible. (ibid.: 68)

Jacques Lacan (1978) famously proposed three registers of mental experience: the Real, the Imaginary, and the Symbolic. While the three climate models studied here are not psychological states, the models' output does induce psychological reactions that could potentially be mapped onto Lacan's schematic. Perhaps near-term meteorology forecasts could be considered 'Real', medium-term projections considered 'Imaginary', and long-term models considered Symbolic. The future is simultaneously real, imaginary, and symbolic – that is, the future is a psychological terrain. The future illustrates that the real and the imaginary are not mutually exclusive – they need each other. The unknowability of the future, its imaginability, makes it come to life. Only hypothetically abstracted mathematico-geometric postulates are totally knowable, and therefore timeless (1+1=2 does not have a future). If not for the fictional, reality would lose its contingency and time would stop!

Fixing the future

Elie Ayache, examining the temporality of finance, questions probabilistic reasoning of the sort used in the IPCC report, asking '[H]ow we can relate to the future outside prediction?' (2010: xvii). His question aims to rethink the future's ontology. Most provocatively, Ayache suggests probability 'may just have to end!' (ibid.: 17). In place of probability and prediction, Ayache suggests the act of trading (or 'playing' in a less finance-centred reading) – that is, the future as a negotiation (as opposed to the future as a probability).

Ayache's (2010) sketch echoes hyperstitional thought. He suggests that through writing trades, actualities give birth to the immaterial possibilities that border reality; it becomes clear what *could* have been (possibilities are born). The derivative is particularly representative of this self-fulfilling capacity as it 'represents the emergence of a self-expanding, self-valorising money form' (LiPuma 2017: 51). According to this line of thinking, possibilities never happen. Ayache (2010: 16) writes, 'possibility as a whole is a backward narrative. It is only later, after the real has actually taken place, that we can say of the corresponding possibilities, which appear to us clearly at the time, that they will have led to the real and will have made it possible'. He goes on:

> … possibility does not precede the real. The realisation of possibility is not the selection of a particular possibility among a set of alternatives and the later addition of reality to it … possibility is a fabrication; it is a copy of the real and therefore it can only succeed it. Reality takes place; it takes the entire place (what else is there?) and possibility is subsequently imagined … True events create their own possibilities – the possibilities that will have led to them. Therefore, possible events are never realized. They are real and then they 'become' possible (ibid.: 31).

Prevailing colonial thought has presupposed that there is a future and predictions about that future can be made that are either correct or incorrect. Climatologists offer such predictions. Climatology's future relies on how accurately it adheres to reality. Finance, however, is under no such constraint. Finance is unbeholden to any notion of its future 'coming true'. Thus to a large extent, finance makes its own future, plays with the future. This is how and why it can pursue perpetually accelerating economic growth; because it is unbeholden to material finitude. The future is neither true nor false.

Basing actions solely on true-ness, legitimises inaction because climatological futures are always potentially 'wrong' in a manner that does not inhibit finance.

The financial future differs considerably from the climate future. Climatologists try to accurately model future conditions that will come to pass. That is, the climate future is composed of one true set of conditions, which climatologists endeavour to reveal. Finance's future is not based on predicting and constructing one accurate and true future. Rather the opposite: The emphasis is on creating flux and variability. Finance is 'a way to construct an unknown future' (Konings 2018: 23). Finance relies on the future being unknowable. That is where the profit comes from: unknowability. For finance, subsequence is profitable precisely because its properties cannot be known. 'Profits in derivative markets only derive from pricing volatility, they require a constant … supply of variance' (LiPuma 2017: 33). Uncertainty is not a glitch; it is the goal.

Oddly, if we would treat the climate future more like finance's future (that is, if we cared less about statistical accuracy), then perhaps we could pursue less ecocidal behaviours. I am not suggesting a pursuit of profit maximisation or the neoliberalisation of climatological knowledge (that would be suicidal). Yet finance, seemingly unlike climatology, has an ability to (re)configure the future. The interests of finance dominate policy-making around the world. The world bends to financial interests. Climatology has no such power.

Future possibilities are not out there. Possibilities are what could have, but did not, happen. Finance is able to change the future because it does not have to wait for it. Climatology is unable to change the future because it must wait to be proven correct or incorrect. We can no longer wait on climatology to fix the future. Can we behave as though *we have already* prevented climate apocalypse, just as financiers behave as though their wealth has already grown forever? This does not mean doing nothing. Rather, as Alenka Zupančič (2016) suggests in her analysis of *Zeno's Conscience*, in order to end a self-destructive behaviour, one must end ending. That is, if you stop ending smoking you no longer smoke. If you know a practice has no end, there is no value in undertaking it, as its timelessness renders it useless. No scarcity equals no value. Could the same be said of fossil fuel consumption? Or is this a psychoanalytic fantasy?

Tomorrow never knows

Hans Vaihinger (1924) developed an epistemic system he called the philosophy of 'As … if', which articulates the use of fiction as a way of knowing. Conveniently, Vaihinger uses Adam Smith's economics as his exemplar. In *Wealth of Nations*, Smith eliminates indeterminate variables like emotions to explain the operation of a perfect economy of totally rational consumers and producers. As Vaihinger notes, 'Smith didn't regard himself as dealing with more than a fiction. Smith intended his assumption merely provisional … These assumptions don't correspond to reality and deliberately substitute a fraction of reality for the complete range of causes and facts' (1924: 20). Smith 'insisted that, if he could describe the market as it ought to be, he would be able to help make the ideal real' (Poovey 2008: 139). Unlike Adam Smith, climatologists view the absence of variables as problematic and are apologetic for the reductions they perform.

Economics is much less accurate at identifying causes and making predictions than climatology. Yet, politicians listen to the advice of economists much more often than that of climatologists. Why? Is the economy more important than the environment? Maybe, but more immediately, it is because economics does not need to be right or wrong. The meteorologists, climatologists, oceanographers, and palaeoclimatologists I have spoken to always emphasise eliminating uncertainty and incorporating more datapoints. Finance, by contrast, is utterly dependent on uncertainty.

What environmentalists lack is a compelling fiction. They are relying on being proven right. But the future is written in fictions like the South Sea Bubble of 1720, 'a period during which the continuum that linked fact to fiction became invisible or ceased to matter' (Poovey 2008: 82). Or as Nina Boy (2014: 183) has it, 'as money was becoming more fictional, fiction was becoming … more realistic'.

Under capitalism, the future is a rhetorical device for facilitating compound growth rates. Today we use the future to grow wealth, but the climatological data warns that we are running out of future. We may have reached 'peak future' (before peak oil). When Isaac Asimov wrote his fictions in the 1950s, the future was nearly infinite. In today's fictions the end of the world is imminent. Rather than relying on climatological data, environmentalists may be better served by pursuing post-capitalist fictions. Regarding the future, Crapanzano writes, 'It is more than contingency that frightens us. It is the artifice of factuality' (2003: 17).

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