

# 'restore to us the necessary BLIZZARDS': early twentieth-century visions of climatic change

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## **‘restore to us the necessary BLIZZARDS’: Early Twentieth-Century Visions of Climatic Change**

In the first issue of *BLAST* (1914), Wyndham Lewis curses the mildness of the English climate on the grounds that it renders English culture and English art weak and insipid. Imagining that a harsher climate would foster hardier forms of English art, he seeks to instigate a change in climate, calling for a ‘USEFUL LITTLE CHEMIST’ to ‘restore to us the necessary BLIZZARDS’.<sup>1</sup> Insofar as the Vorticist project centred on the embrace of immoderation, Lewis’s extravagant call to alter Britain’s climate so as to foster hardier forms of British art is consistent with the Vorticist inclination towards extremes. However, Lewis’s attribution of a determining cultural influence to climate and his endorsement of the human modification of climate also invite consideration of the views of climate and climatic change – natural and anthropogenic – that were in circulation in the early twentieth century. In order to contextualise Lewis’s suggestion that climate determines life and art, his recognition of climate as changeable, and his claim that climate could – and should – be modified through human intervention, this paper will investigate early twentieth-century conceptions of the relationship between climate and culture, the period’s awareness of past climatic changes, the theories advanced to explain these changes, and the attitudes taken towards the possibility of human-induced climatic change. It will consider not only scientific arguments but also popular visions of climatic change circulating in fiction and journalism.

Many theories regarding the causes of climatic change were in circulation by the beginning of the twentieth century. Climate historian James Rodger Fleming states:

By 1900 most of the chief theories of climate change had been proposed, if not yet fully explored: changes in solar output; changes in the Earth’s orbital geometry; changes in

terrestrial geography, including the form and height of continents and the circulation of oceans; and changes in atmospheric transparency and composition, in part due to human activities. Of course, there were many others. [...] [N]o single causal mechanism was universally accepted.<sup>2</sup>

In consequence, the early twentieth-century discourse of climatic change exhibited an uncertainty that was distinctly modernist. As G. C. Simpson, alluding in 1922 to Alfred Wegener's 1912 theory of continental drift, asked, 'Where is there solid ground from which to discuss climatic changes if the continents themselves can travel from the equator to the pole and back again in the short period of one or two geological epochs?'.<sup>3</sup> While this state of ongoing uncertainty may have been vexing for climatologists themselves, it was imaginatively generative, offering abundant matter for reflection and an open-ended invitation to literary invention.

Scholars such as Matthew Griffiths do valuable work by placing modernist texts in conversation with twenty-first-century conceptions of climate change, but there is also usefulness in registering the fact that there was a discourse of climatic change – and one that encompassed the concept of anthropogenic climatic change – in circulation in the early twentieth century.<sup>4</sup> As Fleming observes, 'the history of climate change theories and ideas' stretches back to at least the eighteenth century and moreover 'in eras other than our own, the climate has been perceived as amenable to human impact or intervention'.<sup>5</sup> The present paper contributes to the project, exemplified in the recent edited collection *Climate and Literature*, of examining the discourses of climate and climatic change in circulation in specific historical moments.<sup>6</sup> In order to preserve the sense of disjunction as well as conjunction between early twentieth-century discourse and that of the present, I will employ the then-prevalent term 'climatic change' rather than the current term 'climate change' when

discussing early twentieth-century views of climate, its susceptibility to change, and the possibility of its alteration through human intervention.

### Cursing England's Climate

The first manifesto of *BLAST* opens with a denunciation of the English climate. Lewis declares:

BLAST First (from politeness) ENGLAND

CURSE ITS CLIMATE FOR ITS SINS AND INFECTIONS [...]

A 1000 MILE LONG, 2 KILOMETER Deep

BODY OF WATER even, is pushed against us

from the Floridas, TO MAKE US MILD. [...]

CURSE

the flabby sky that can manufacture no snow, but

can only drop the sea on us in a drizzle like a poem

by Mr. Robert Bridges.

CURSE

the lazy air that cannot stiffen the back of the SERPENTINE,

or put Aquatic steel half way down the MANCHESTER CANAL. (11-12)

Lewis's description accurately reflects the climate of the British Isles, a mild oceanic climate exhibiting a relatively small range of temperature and characterised by frequent but not extreme precipitation. As Jan Golinski observes, 'It rains a lot, but intermittently and usually not very heavily. Prolonged periods of extreme heat and cold are rare'.<sup>7</sup> Key factors contributing to this moderate climate were widely recognised by the early twentieth century.

As a 1910 article in *Nature* on the action of the Gulf Stream observes, ‘it has been known for very many years that the climate of these islands and of northern Europe in general is far milder than it would have been owing to a large body of warm water flowing past its shores from the south-west’.<sup>8</sup> Likewise, Stephen Dedalus’s remark in *Ulysses* (1922), ‘All Ireland is washed by the gulfstream’ – which, Declan Kiberd observes, echoes a ‘famous line from [an] Irish geography book’ – demonstrates that the action of the current was common knowledge by this period.<sup>9</sup>

The influence of the Gulf Stream was typically regarded with gratitude: a 1905 article in the *Devon and Exeter Gazette* praises the current as ‘an old friend’, ‘a national institution’, the beneficent action of which ‘robs the British climate of its asperities’ through the ‘exceptional mildness of the south-westerly winds’.<sup>10</sup> In Lewis’s mind, however, the moderating effects of the Gulf Stream had an enervating effect upon English character and art. He complains:

SO MUCH VAST MACHINERY TO PRODUCE

THE CURATE of ‘Eltham’

BRITANNIC ÆSTHETE

WILD NATURE CRANK

DOMESTICATED

POLICEMAN

LONDON COLISEUM

SOCIALIST-PLAYWRIGHT

DALY’S MUSICAL COMEDY

GAIETY CHORUS GIRL

TONKS. (11)

Envisioning oceanic and atmospheric forces as a vast mechanical system, he regards the human and artistic forms fostered by this system as worthy only of disparagement. Painting Elizabeth Gaskell, from whose *Cousin Phillis* the curate of Eltham is drawn, as a representative of respectable Victorianism; imputing to Henry Tonks, his former teacher at the Slade, a derivative Impressionism; and disparaging both the impulse to return to nature and the aesthete's pursuit of beauty as weakness, Lewis derides the artists and audiences produced by prevailing conditions as an apathetic 'VEGETABLE HUMANITY' (15).

Lewis was not alone in this period in attributing a determining cultural influence to the environmental conditions of the British Isles, but his assessment of this influence appears distinctly contrarian when compared with most other contemporary judgements. In *The Evacuation of England: The Twist in the Gulf Stream* (1908) – a work to which I will return later – Louis Gratacap articulates a more commonly held view of the Gulf Stream as a 'marvellous oceanic flood' that 'controlled the material conditions of England's greatness [...] its wealth, its maritime supremacy, its intellectual distinction, its domestic thrift, and sunny sweetness'.<sup>11</sup> While associations of climate and character, temperature and temperament were commonplace in this period, Lewis's deployment of these associations remains deliberately discordant.<sup>12</sup>

As a polemicist who idealised the 'violent structure of adolescent clearness between two extremes', Lewis presents English character and English art as disadvantaged by a lack of stimulating conditions (30). Returning to the theme of climate conditioning art in the second *BLAST* manifesto, he contrasts the mildness of the English climate and the purported mediocrity of its art with the cultural growths fostered by more extreme environments. He remarks with envy that 'the steppes and the rigours of the Russian winter, when the peasant has to lie for weeks in his hut, produces that extraordinary acuity of feeling and intelligence

we associate with the Slav' (33). The uniformity ascribed to maritime, oceanic climates with limited temperature ranges contrasts with the extremes of temperature characteristic of inland, continental climates and furnishes Lewis with a climatic rationale for the supposed insipidity of English art.

Having described and denounced the environmental conditions of England, Lewis proceeds to recommend their alteration. Discontent with the mildness and moderation of England's present climate, Lewis nonetheless observes that 'ten years ago we saw both snow and ice here' (12). Taking this as an indication that climate is not invariable, he calls for the creation of a more extreme environment, declaring:

May some vulgarly inventive, but useful person, arise,  
and restore to us the necessary BLIZZARDS.  
LET US ONCE MORE WEAR THE ERMINE  
OF THE NORTH.  
WE BELIEVE IN THE EXISTENCE OF  
THIS USEFUL LITTLE CHEMIST  
IN OUR MIDST! (12)

Like his elaborately contrarian denunciation of England's climate, Lewis's call for human-initiated and -directed climatic change is characteristically Vorticist in its presumption and extravagance. While one's first inclination might be to read this diatribe against the English climate as more metaphorical than literal, a comment on cultural rather than physical conditions, it is also possible to situate both Lewis's opening contention that English climate determines English culture and his subsequent demand for a human-engineered change in climate in relation to early twentieth-century climatic discourses.

## Climatic Determinism

Lewis's foundational assertions in the opening manifestoes of *BLAST* that climate conditions cultural character and environment determines art reflect the discourses of environmental and climatic determinism in circulation in the early decades of the twentieth century. As geographer Kent M. McGregor defines it, environmental determinism is 'the notion that the physical environment controls or molds human behavior and limits human societies to a restricted range of outcomes, or perhaps only one possible outcome, which is thus preordained'.<sup>13</sup> Climatic determinism further narrows the causal factor, linking 'the individual and individual behaviour to some aspect of climate' or, in a wider ranging formulation, 'the climate of a place to the culture, society, and history of that place'.<sup>14</sup>

Environmental determinism was not a new concept in the early twentieth century. The premise that environment generally, and climate specifically, shaped culture and directed history had been advanced by figures from Aristotle and Hippocrates to Montesquieu and Hume.<sup>15</sup> In *The Spirit of Laws* (1748), Montesquieu claimed that 'great heat enervates the strength and courage of men and that in cold climates they have a certain vigor of body and mind which renders them capable of long, painful, great and intrepid actions'.<sup>16</sup> A century and a half later, Ellen Churchill Semple advanced a similar argument, declaring that the warm tropics constituted a 'nursery' that kept inhabitants of those regions in a state of 'arrested development' while the temperate zone subjected its inhabitants to a salutary form of compulsion that prompted invention.<sup>17</sup> Such theories were clearly committed to the construction of hierarchies of place, race, and culture that were then claimed to be natural.<sup>18</sup> In *A Passage to India* (1924), E. M. Forster attributes just such a 'theory of climatic zones' to the district superintendent of police at Chandrapore, Mr McBryde.<sup>19</sup> Lewis engages in such

differentiation on the grounds of region and race himself, declaring that ‘rebels of the North and South are diametrically opposed species’ (42).

Although Lewis’s diagnosis of England’s climate as debilitatingly mild might initially seem at odds with Semple’s praise of the temperate zone as ‘preëminently the culture zone of the earth’, Lewis simply transposes the determinist claim that warmth is enervating into the even more extreme and thus more suitably Vorticist argument that the moderate climate of temperate England is insufficiently stimulating.<sup>20</sup> However, while disparaging England’s climate and cultural forms as he finds them, mild and moderate, Lewis also develops a vision of England as he would have it, transformed both environmentally and aesthetically. He calls for the intensification of the climatic conditions of England as a means of promoting greater vigour and acuity in its art, and he articulates his ideal conception of English art through an image of plant life conditioned by its environment: envisioning the ‘specific nature of the art destined to grow up in this country’, he asserts, ‘the art for these climates, then, must be a northern flower’ (36).

In developing this cultural ideal, Lewis takes another historical period as his climatic model. He praises Shakespeare for his ‘bitter Northern Rhetoric of humour’ and declares that ‘Shakespeare reflected in his imagination a mysticism, madness and delicacy peculiar to the North’ (26, 37). Shakespeare and the Elizabethans represent to Lewis not only ‘the freest and most vigorous period of ENGLAND’S history’, but also a more bracing climate (37). Lewis’s sense of the age of Shakespeare as a more northerly time – of the Elizabethan era as another, colder country – aligns with the fact that his call for a change in climate at the outset of the first *BLAST* manifesto was a call for the *restoration* of blizzards and a return to a former cultural dispensation symbolised by the wearing of ‘THE ERMINE OF THE NORTH’ (12). His desire for cold is not a desire for wholesale climatic novelty but rather for the reinstatement of environmental conditions under which English art had formerly flourished.

Lewis's vision of the early modern period as a colder time had a basis in reality. Although instrumental temperature records do not exist for late sixteenth- and early seventeenth-century Britain, reconstructions from historical records and proxy data suggest that the late sixteenth and early seventeenth centuries were on average cooler and more given to variability and extremes of temperature than the early twentieth century. Climatologist H. H. Lamb states:

in the middle of the sixteenth century, a remarkably sharp change occurred. And over the next 150 years or so the evidence points to the coldest regime – though accompanied by notable great variations from year to year and from one group of a few years to the next – at any time since the last major ice age ended.<sup>21</sup>

Discussing the period that has come to be termed the Little Ice Age (roughly 1300 to 1850, although opinions vary on the dating of this interval), Brian Fagan describes 'centuries of unpredictability' when 'Britain and the Continent suffered through great storminess and more frequent shifts from extreme cold to much warmer conditions'.<sup>22</sup> Fagan cautions that the conception of this period as one of unrelenting cold is inaccurate, explaining, 'There was never a monolithic deep freeze, rather a climatic seesaw that swung constantly backwards and forwards, in volatile and sometimes disastrous shifts'.<sup>23</sup>

Although in Lewis's time, the concept of the Little Ice Age had yet to be proposed, there was a wide-spread perception that there had been periods of greater cold and greater variability in temperature in England's historical past. Newspapers would intermittently offer accounts of 'old-fashioned winters', describing the great frosts recorded in historical chronicles and recounted by diarists such as John Evelyn.<sup>24</sup> The best-remembered modernist reimagining of early modern climate comes in Virginia Woolf's account in *Orlando* (1928)

of a frost fair on the frozen Thames, drawn from Thomas Dekker's account of the Great Frost of 1607-08 and augmented by John Evelyn's account of the Great Frost of 1683-84.<sup>25</sup> Like Lewis, Woolf suggests a link between the character of the climate and the character of an age. Describing the temporal setting in which *Orlando* opens, Woolf's narrator declares:

The age was the Elizabethan; their morals were not ours; nor their poets; nor their climate; nor their vegetables even. Everything was different. The weather itself, the heat and cold of summer and winter, was, we may believe, of another temper altogether.<sup>26</sup>

Like Lewis again, Woolf presents changes in climate as instigating cultural changes. As the skies fill with cloud at the start of the nineteenth century, Woolf's narrator reports, 'the constitution of England was altered': damp crept into hearts, minds, and inkpots, and vegetation, population, and adjectives multiplied and swelled.<sup>27</sup>

The theory of climatic determinism encompassed conceptions of changing climate as a driver of historical events and societal change. As with the theory of climatic determinism itself, the notion that climate can change and that these changes impact human history and culture had antecedents stretching back to at least the classical period. By the start of the twentieth century, the fact of alternating glacial and genial periods (as they were then termed) on geological time scales was well established, and theories of climatic change on shorter time scales were also in circulation. Over the closing decades of the nineteenth century and the opening decades of the twentieth century, Piotr Kropotkin developed a theory that the Eurasian continent had been undergoing a process of gradual desiccation since the end of the last ice age and that this climatic trend had at intervals driven inhabitants of the continental interior outwards to less arid regions.<sup>28</sup> In 1890, Eduard Brückner posited the existence of 35-

year cycles of wet and warm or dry and cold weather.<sup>29</sup> In 1907, Ellsworth Huntington promulgated a theory of climatic pulsations, oscillations in climate with a periodicity of centuries discernible within the span of recorded history. Huntington argued that these climatic pulsations were responsible for the rise and decline of past civilizations, declaring:

With every throb of the climatic pulse [...] the centre of civilization has moved this way or that. Each throb has sent pain and decay to the lands whose day was done, life and vigor to those whose day was yet to be.<sup>30</sup>

Lewis in *BLAST* goes a step further than Huntington, arguing that a climatic regime advantageous to a given culture might be instigated through human action. In his call for the restoration of blizzards by a useful little chemist, Lewis imagines intervening in natural processes to produce new conditions that will act upon culture in the same deterministic manner as before. He envisions closing the circle of influence, transforming ‘VEGETABLE HUMANITY’, its culture, and its art by manipulating the conditions under which these forms develop (15). Lewis’s call for anthropogenic climatic change as a means of fostering Vorticist art may appear arrogant and implausible, but his outlook is not wholly inconsistent with that of his contemporaries. Scientists, journalists, and speculative fiction writers in the early twentieth century offered a range of visions of climatic change resulting from human activity. At times this change was presented as accidentally initiated, at times as deliberate; at times it was imagined as occurring slowly over the course of centuries, at times as a rapid and potentially imminent change; at times it was envisioned as beneficial, at times as catastrophic. Although Lewis’s call for cooling contrasted with the general tendency to equate cooling with climatic deterioration, his interest in climatic change and his sense of it

as a phenomenon that could be influenced or even directed by human action had parallels in contemporary scientific and popular discourse.

#### Theories of Climatic Change: Ice Ages and Carbon Emissions

One scientific discussion ongoing in this period that encompassed not only ideas of climatic change but also the possibility of anthropogenic climatic change was the investigation into the causes of ice ages. By the later nineteenth century, the fact of past ice ages was no longer disputed and attention had turned to discussions of the cause or causes of glacial periods.

Nico Stehr, Hans von Storch, and Moritz Flügel comment that there was such a ‘wealth of competing hypotheses’ that the discussion threatened to become ‘a cacophony of mere opinions’.<sup>31</sup>

The promulgation of a new scientific theory regarding the mechanism responsible for the onset of ice ages would from time to time bring the subject into wider public discussion. In 1913, both scientific journals such as *Nature* and newspapers such as the *Morning Post* carried articles outlining a theory, recently advanced by W. J. Humphreys, that volcanic dust in the atmosphere in sufficiently large quantities and for sufficiently long time periods could reduce insolation enough to bring about the onset of ice age conditions. The *Nature* article, titled ‘The Origin of Climatic Changes’, took the opportunity of this new theory to review the ‘[n]umerous theories, both probable and improbable’ that had been advanced to explain the climate’s oscillation between warm and cold periods.<sup>32</sup> Summarising the three theories then regarded as most worthy of consideration, the article lists:

the Eccentricity Theory (Croll) depending on the eccentricity of the earth’s orbit; the Carbon Dioxide Theory (Tyndall), based on the selective absorption and variation in

amount of carbon dioxide; and thirdly, the Solar Variation Theory, on the assumption of solar changes of long duration.<sup>33</sup>

The article credits Humphreys with ‘restart[ing] a topic which will no doubt call for criticism and discussion from many quarters’.<sup>34</sup> A 1913 article in the *Leicester Daily Post* entitled ‘Discovery and Invention. World-Wide Changes of Climate’ recounts the origin of Humphreys’s theory. Humphreys, observing from historical records and contemporary observations the ‘marked lessening’ of solar radiation reaching the earth’s surface in the aftermath of the eruptions of Krakatoa (1883), Mount Pelée (1902), and Katmai (1912), posited that volcanic dust thrown into the upper atmosphere by such eruptions would spread across the whole stratosphere and settle only very slowly back to earth, in the process impeding and scattering incoming solar energy and lowering the temperature at the earth’s surface.<sup>35</sup> Humphreys extrapolated from this observed short-term climatic variability to argue that, continued for long enough, the obstruction of incoming solar radiation by volcanic ash could create the conditions for a new ice age.<sup>36</sup>

Humphreys’s theory was only the latest of many theories regarding the causes of climatic change circulating in the early twentieth century, and the *Leicester Daily Post* article rehearses some of the then-prevailing theories, including the argument that ‘an excess of carbonic dioxide [sic] in the atmosphere besides profoundly affecting the life of the earth would also modify the heat receptivity of the atmosphere’.<sup>37</sup> This theory, from which the current understanding of the effect of CO<sub>2</sub> on the climatic conditions of the earth in part derives, was promulgated in 1896 by the Swedish chemist Svante Arrhenius in the article ‘On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground’. Motivated by the ‘extraordinary interest’ of the question of ‘the probable causes of the Ice Age’ and building upon the earlier work of Joseph Fourier and John Tyndall, Arrhenius set out to

determine the effect of existing levels of atmospheric CO<sub>2</sub> on the temperature at the earth's surface and the change in temperature that would result from a given change in atmospheric carbon dioxide levels.<sup>38</sup> He offered calculations of the magnitude of temperature decrease that would accompany incremental decreases in atmospheric CO<sub>2</sub> and the magnitude of temperature increase that would accompany incremental increases in atmospheric CO<sub>2</sub>.<sup>39</sup>

Also in his 1896 article, Arrhenius cites, almost in passing, the calculation of his colleague Arvid Högbom that CO<sub>2</sub> emissions from the burning of pit coal amounted to 500 million tons a year and that at this level, industrial CO<sub>2</sub> emissions ““may be regarded as completely compensating the quantity of carbonic acid that is consumed”” by natural processes such as weathering.<sup>40</sup> Arrhenius offered no specific conclusions of his own regarding the effects of industrial carbon emissions upon global temperatures in his 1896 article, but in a talk given in the same year Arrhenius returned to Högbom's calculations, commenting:

the consumption of coal on earth is so great that it produces annually a quantity of carbonic acid [...] of the same order of magnitude as, and it appears fully to be equal to, the most important and practically the only process of carbonic acid absorption operating on the earth's surface, namely weathering. Since, in addition, carbonic acid is produced in volcanic processes and other circumstances, it would seem to be probable that the carbonic acid content in the air is at present gradually rising. [...] The burning of coal alone would thus be capable of raising the temperature of the surface of the earth by somewhat more than one thousandth of a degree centigrade per annum.<sup>41</sup>

With this statement, Arrhenius asserts the view that anthropogenic CO<sub>2</sub> emissions can cause climatic change. This is a key declaration in the history of climate science, but Arrhenius's

subsequent commentary on this observation is equally important as an illustration of turn-of-the-century attitudes towards the possibility of anthropogenic climatic change. Having declared that the human consumption of coal is causing a net rise in atmospheric CO<sub>2</sub>, Arrhenius proceeds to suggest that ‘we [...] have some right to indulge in the pleasant belief that our descendants, albeit after many generations, might live under a milder sky and in less barren natural surroundings than is our lot at present’.<sup>42</sup> Predisposed by both his focus of research (ice ages) and his own geographical location (northern Europe) to regard cooling as a threat, Arrhenius interprets the prospect of warming as cheering.

Arrhenius also promoted his carbon dioxide theory of climatic change and the prospect of anthropogenically induced warming to a wider reading public. In *Worlds in the Making: The Evolution of the Universe*, a work of popular science writing published in Swedish in 1906 and in English translation in 1908, Arrhenius again explains:

[C]omparatively unimportant variations in the composition of the air have a very great influence. If the quantity of carbonic acid in the air should sink to one-half of its present percentage, the temperature would fall by about 4°; a diminution to one-quarter would reduce the temperature by 8°. On the other hand, any doubling of the percentage of carbon dioxide in the air would raise the temperature of the earth’s surface by 4°; and if the carbon dioxide were increased fourfold, the temperature would rise by 8°.<sup>43</sup>

Arrhenius also returns in this work of popular science to the significance of the novel factor of anthropogenic CO<sub>2</sub> emissions. Whereas in 1896 he quoted Högbom’s figure of 500 million tons for the annual consumption of pit coal, in 1904, at the time of writing *Worlds in the Making*, he gauges the annual consumption at 900 million tons and notes the rapid rate of

increase. He therefore predicts that, even taking into account the absorptive capacity of the oceans, ‘the slight percentage of carbonic acid in the atmosphere may by the advances of industry be changed to a noticeable degree in the course of a few centuries’.<sup>44</sup> The novel factor of anthropogenic CO<sub>2</sub> emissions gave Arrhenius reason to argue that a future ice age might be deferred indefinitely through human intervention in the climate. Posing the question, ‘Is it probable that we shall in coming geological ages be visited by a new ice period that will drive us from our temperate countries into the hotter climates of Africa?’, Arrhenius replies confidently in the negative, suggesting that modern industrial development had fortuitously provided the means of averting such threats in the future.<sup>45</sup>

Arrhenius was not wholly untroubled by the rapidly rising consumption of fossil fuels. He acknowledges the concern that ‘the coal stored up in the earth is wasted by the present generation without any thought for the future’.<sup>46</sup> However, convinced as he was that the present genial climate would in time naturally give way to more glacial conditions, Arrhenius found cause for comfort in the idea that humans, by means of the burning of fossil fuels, had the power artificially to raise global temperatures. He states:

We may find a kind of consolation in the consideration that here, as in every other case, there is good mixed with the evil. By the influence of the increasing percentage of carbonic acid in the atmosphere, we may hope to enjoy ages with more equable and better climates, especially as regards the colder regions of the earth.<sup>47</sup>

As Arrhenius’s biographer Elisabeth Crawford argues, Arrhenius’s perception of human-induced warming as beneficial was shaped by his focus on the question of the causes of ice ages, a focus that inevitably brought with it a fear of cooling, a seemingly rational apprehension given that his own country of Sweden had been covered by ice in the last

glacial period. In addition to his preoccupation with cooling, Arrhenius failed to anticipate the rate at which anthropogenic carbon emissions would increase over the century to come and, by extension, the rate at which global temperatures would rise. Finally, Crawford suggests that Arrhenius's response was shaped by 'the ideology of "optimistic evolutionism"', a belief in the progressive development of humankind that prevented him from contemplating the potential liabilities of industrial advance.<sup>48</sup>

Arrhenius was not alone in responding with optimism to the idea that anthropogenic carbon emissions could alter global climate. Arrhenius's colleague Nils Ekholm, writing in the *Quarterly Journal of the Royal Meteorological Society* in 1901, approached the concept of anthropogenic climatic change with the view that the earth was in a phase of natural cooling – or, as he termed it, 'deterioration' – due to the variation of the obliquity of the ecliptic of the planet (an astronomical phenomenon which was at the time projected to cause cooling for the next 10,000 years).<sup>49</sup> Working from the assumption that future human flourishing would depend upon a capacity to counteract an astronomically induced trend of cooling, Ekholm sought means by which the natural release of CO<sub>2</sub> into the atmosphere by processes such as volcanic activity might be augmented, and he found such a means in anthropogenic CO<sub>2</sub> emissions. Ekholm went even further than Arrhenius in his vision of human-directed climatic change, suggesting the possibility of deliberately increasing the concentration of atmospheric CO<sub>2</sub> by digging 'deep fountains pouring out carbonic acid' and intervening to lessen processes, such as geological weathering, that removed CO<sub>2</sub> from the atmosphere.<sup>50</sup> By such tactics, Ekholm argued, 'it seems possible that Man will be able efficaciously to regulate the future climate of the earth and consequently prevent the arrival of a new Ice Age'.<sup>51</sup> While he admits that it is 'too early to judge of how far Man might be capable of thus regulating the future climate', Ekholm sees deliberate and directed climatic change as ushering in a 'grand' new phase of human evolution.<sup>52</sup>

Ekholm's initial motivation for considering the effects of anthropogenic CO<sub>2</sub> emissions was in fact conservative: he viewed human intervention in climate as necessary to maintain existing climatic conditions in the face of natural cooling. However, Ekholm's concluding vision of global climatic control exceeds the audacity of even Lewis's invocation of a useful little chemist to restore blizzards to England. Lewis, Arrhenius, and Ekholm are akin in the sense that all three fear or resent some natural circumstance of climate, whether it be England's mildness or the anticipated deterioration of the global climate towards ice age conditions, and all three also envision human intervention in natural processes – and chemical intervention in natural processes at that – as offering the solution to these unsatisfactory natural circumstances.

#### Theories of Climatic Change: Diverting the Gulf Stream

The theory of global warming by way of rising atmospheric CO<sub>2</sub> levels was only one of several theories of climatic change in circulation in the opening decades of the twentieth century, and it was not in fact the one that garnered the most popular attention. One concern that resurfaced in the newspaper press repeatedly over the closing decades of the nineteenth century and the opening decades of the twentieth centred on Britain's reliance on the Gulf Stream for its mild climate and the possibility that this vital climatic influence might be diverted, either through natural accident or deliberate interference.

As has already been indicated in the discussion of Lewis's first *BLAST* manifesto, the moderating effect of the Gulf Stream upon the climate of northern Europe was common knowledge in this period. *St James's Gazette* in 1899 declared the Gulf Stream to be 'indissolubly connected [...] with the many blessings of our sacred English climate'.<sup>53</sup> However, concerns over the future course of the Gulf Stream arose as a result of the developing plan to dig a canal across the Isthmus of Panama to shorten the sea route between

the Atlantic and the Pacific. Fears that this might affect the course of the Gulf Stream were voiced as early as 1860, but the subject gained wider circulation in the wake of an 1868 lecture by a St Louis captain, Silas Bent, promoting a plan ‘to divert Equatorial water into the Panama Canal and thus to leave Europe generally, and England more particularly “out in the cold” in a very literal and unpleasant sense’.<sup>54</sup> Reporting on this plan in May 1871, *The Times* observed that Bent argued that to divert the Gulf Stream would be to do no more than to reduce northern Europe to its “normal climatic conditions”, as determined by latitude.<sup>55</sup> Bent’s argument, with its imputation of deliberate, politically motivated climatic sabotage, made a lasting impression. Twelve years after Bent’s lecture, an article in the *Globe* reflected:

most of us have soberly considered the appalling results which would ensue if some freak of nature should divert [the Gulf Stream] from north-western Europe, or if, as the Yankees have before now hinted that they might do one day, they should buy up the Isthmus of Panama and knock a hole through it big enough to let the stream out into the Pacific [...] that should bring upon us an Arctic climate and the dreary sterility of another Labrador.<sup>56</sup>

The attribution of nefarious climatic intentions varied with time and circumstance: in 1881, as the French began work on a canal across the isthmus under the direction of Ferdinand de Lesseps, the *Penny Illustrated Paper* demanded, ‘Will Mr. Gladstone permit M. de Lesseps quietly to deprive England of the Gulf Stream?’.<sup>57</sup>

The possibility that breaching the Isthmus of Panama would alter the course, functioning, and climatic effects of the Gulf Stream, with consequences for the climate of northern Europe, persisted as a topic of intermittent discussion – sometimes earnest,

sometimes not – across the decades-long efforts, first by France, then by America, to dig a canal across Panama, an undertaking that was only successfully completed in 1914. Around the turn of the century, in the wake of the failure of the French attempt to complete the canal and with American interest in the project reviving, old fears resurfaced. Newspapers resuscitated the idea that ‘the cutting of the American continent would deflect the course of the Gulf Stream and leave Great Britain with a temperature similar to Greenland’, and once again, the prospect of climatic change was framed in distinctly political terms.<sup>58</sup> *St James’s Gazette* warned of ‘threats against the Gulf Stream [...] in clear defiance of the Monroe Doctrine’.<sup>59</sup> The invocation of the political doctrine of separate spheres emphasises the enmeshment of the cultural and the climatological in this putative threat.

In 1912, as the canal neared completion, thoughts of climatic variability came again to public consciousness. The *Graphic* recalled how ‘the wiseacres of the halfpenny Post some years ago were all warning us that, once the Panama Canal was constructed, the course of the Gulf Stream would be diverted, and that Europe would experience a return of the Ice Age’.<sup>60</sup> Elaborating on this idea for the purpose of geopolitical satire in a segment titled ‘After Panama – The Deluge’, the *Graphic* remarks, ‘Possibly the Gulf Stream [...] will either be diverted by the United States or made a dutiable commodity for which we British [...] will have to pay a duty measured either in gallons or in degrees of water temperature’.<sup>61</sup> The idea of the climatic destruction of Britain by feats of American engineering served in part as a vehicle through which to articulate anxieties that the balance of political and economic power was shifting from Europe to America. Nevertheless, concerns over the divergence of the Gulf Stream were not purely analogical. Another 1912 article entitled ‘Glaciers and the Gulf Stream. Is Another Ice Age Coming?’ cautions, ‘Few of us realise how entirely we are, in matters of climate, at the mercy of the Gulf Stream’, and quotes from an article in the *Grand Magazine* that declares:

‘If by some planetary or other influence the great body of warm water known as the Gulf Stream which sweeps across the Atlantic from the Gulf of Mexico and bathes the coasts of Britain with its vivifying flood, were but to be diverted from its course ever so slightly, gone in a day would be almost all the natural advantages that have enabled the Anglo-Saxon race to occupy the predominant position it does in the world’.<sup>62</sup>

The quoted *Grand Magazine* columnist further warns that such a turn of events is “‘by no means impossible, especially in view of the way in which man is endeavouring to obtain an entire control over land and water’”.<sup>63</sup>

Perhaps the best indicator of the wide currency of the idea that the diversion of the Gulf Stream would bring about a change in the climate of northern Europe is the range of incongruous contexts in which the idea occurs in the early decades of the twentieth century. A 1902 article discussing the feasibility of supplying electricity to towns comments that ‘were there no summer season municipal electricity would be self-supporting’.<sup>64</sup> Reflecting further on the relationship between climate and the profitability of electricity as a commodity, the author brightens at the thought that ‘when the Panama Canal is completed [...] this local stumbling block will be removed, as the Gulf Stream which now warms our shores will likely set in the direction of the poles’, producing a climate much more in need of electrical heating.<sup>65</sup> The prospect of cooling also finds its way into political commentary. A 1903 article in the *London Daily News* titled ‘Not Warm Enough’ satirises Neville Chamberlain’s protectionist Tariff Reform League by likening a protectionist policy on trade to the onset of climatic cooling, suggesting that as ‘the cutting of the Panama Canal will yet further divert the Gulf Stream [...] soon Great Britain will be growing her own beavers, seals, bears, wolves, and reindeer’, which sources of wealth ‘will make up for the loss of trade in hothouse

grapes'.<sup>66</sup> A decade later, as the canal approached completion, such incongruous mentions continued. A fashion note in the *Leeds Mercury* in June 1911 reports on the popularity of hats and parasols during a recent stretch of hot weather before concluding, 'Perhaps when the Panama Canal is opened we shall find the Gulf Stream going another way. Let us, then, make the most of what remains us'.<sup>67</sup> In a similarly offhand tone, a note on the Belvoir hunt in the *Grantham Journal* for 27 December 1913 remarks:

At the time of writing, the weather is still mild and open, and, unless the Gulf Stream strays away through the Panama Canal, there appears no reason to anticipate severe weather just yet [...] so it looks as if the Belvoir Hounds will carry out their admirable Yuletide programme.<sup>68</sup>

Such casual asides on the subject of climatic change do not suggest that the diversion of the Gulf Stream elicited a great deal of genuine concern by this period; at the same time, they illustrate the fact that the idea had become something of a commonplace in popular discourse.

The scientific community largely rejected the idea that the opening of the Panama Canal would result in the diversion of the Gulf Stream. In 1882, the geologist James Geikie weighed in on the subject in a widely reprinted article titled 'The Gulf Stream and the Panama Canal'. While agreeing that the diversion of the Gulf Stream from its existing course would be a catastrophe for the British Isles and the Scandinavian Peninsula, Geikie offers reassurance from a different quarter, arguing that the Isthmus of Panama 'would need to be sunk to a depth of not less than 800 feet, and perhaps even 1,000 feet' – a depth greatly exceeding that of the planned canal – for the course of the Gulf Stream to be affected by the breach.<sup>69</sup> Thus, he concludes, 'we need have no apprehension that we shall be deprived of the genial influence of our friendly Gulf Stream in the immediate future'.<sup>70</sup>

Another striking attempt to refute speculation regarding the effects of the digging of the Panama Canal upon the course of the Gulf Stream came in the form of a scale model of the world's landmasses and oceans constructed in 1889 by Arthur W. Clayden. Water directed by bellows replicated the movement of ocean currents and both the Panama Canal and Central America were represented by removable sections, so that the effects of removing first one, then both could be seen. The model was displayed at both a Royal Society soirée and a Royal Geographical Society conversazione and was enthusiastically remarked upon in newspaper reports of both events. Clayden demonstrated that the removal of the Panama Canal section of the model had no effect upon the course of the ocean currents, while the removal of the Central America section as a whole caused the current representing the Gulf Stream to pass into the Pacific. Clayden's model and the popular accounts offered of it illustrate the interest among members of both the scientific community and the newspaper-reading public in the question of the effect of the digging of the Panama Canal upon the action of the Gulf Stream.<sup>71</sup>

The reassurances offered by scientists such as Geikie and Clayden were no doubt comforting to some, but others simply modified their narratives to accommodate the proffered facts. By far the most elaborate example of this occurs in Louis Gratacap's 1908 novel *The Evacuation of England: The Twist in the Gulf Stream*. Gratacap imagines a scenario in which the digging of the Panama Canal accidentally triggers a chain of seismic events culminating in the complete subsidence of the Isthmus of Panama between Costa Rica and Columbia and the consequent divergence of the Gulf Stream into the Pacific. The withdrawal of the warming influence of the Gulf Stream from northern Europe leads in turn to the evacuation of Iceland as well as most of Scandinavia and the British Isles.

Gratacap's novel to some extent follows the expected arc of the environmental catastrophe narrative: scientific prediction ignored; human interference in natural conditions

(driven by a profit motive) triggering environmental disaster and, by extension, social upheaval and human loss. However, while presenting the subsidence of the isthmus as an environmental disaster instigated by human actions, Gratacap does not characterise the event as wholly negative. The narrative passes quickly over the direct consequences of the subsidence of the isthmus for the inhabitants of the region itself, remarking only, 'The loss of life had been considerable, but not proportionate to the stupendous agencies involved' (117). In keeping with the politically charged discussions of the Gulf Stream and the Panama Canal in the press, the American characters in Gratacap's novel are on the whole pleased that the 'titanic convulsions of nature' triggered by human engineering works have created such 'a wide and useful passage for commerce', and the narrator summarises the American viewpoint with the statement, 'if the Gulf Stream was deflected, if it meant blight for England, what of it? The United States would only become greater. [...] [T]he mutations of the earth's surface only brought to them unrivalled aptitudes for new chances, new power' (119, 125). Silas Bent's dream is fulfilled in Gratacap's narrative.

Perhaps more surprisingly, even the narrative's representative Englishman, Alexander Leacraft, views the consequences of the redirection of the Gulf Stream as 'remarkable and not altogether regrettable' (99). Although there are phases of alarm in the narrative, as the populations of first Scotland, then England are forced to flee before 'the pitiless rigor of a new dispensation in climate', Leacraft perceives opportunity in the midst of disaster, declaring, 'Perhaps the old receptacles of civilization needed emptying; their garnered seeds to be more quickly cast upon the winds of chance to germinate and flower again in the waste places of the world' (133, 162). Leacraft's friend Thomsen follows this line of argument further, declaring, 'all that has come between the present and the past, like the sundering of Damocles' sword, has saved us from the necessity of denuding ourselves of old things, turning us loose in a fresh field, where we may play high jinks with all we once venerated'

(299-300). Such statements, celebrating a clean break with the past, have the quality of an avant-garde manifesto. Meanwhile, Gratacap envisions the destruction of Britain as inaugurating a new era of imperialism. The British government is relocated to Australia to begin a 'new experiment', 'the Australian England', and Leacraft describes the departing leaders as 'pictures of Hope, lit up by the imaginative flamings of Ambition. [...] The English leaders dreamed of new achievements, a new literature, a greatness vastly exceeding all historic records' (288, 303, 287). (Incidentally, the dispersal of the population of Great Britain occurs with minimal difficulty, facilitated by bureaucratic mechanisms likened to a modern Domesday survey and aided as well by the generosity with which other nations welcome Britain's refugees.) The narrative's conclusion suggests that Leacraft's optimism is justified: Leacraft closes his story with the reflection, 'The convulsions which were so dismally foretold, in the social and political fabric [...] never occurred. They were quite lost sight of in the wonderful happenings of the world' (320). Gratacap's novel constitutes the most detailed elaboration of the premise that the Gulf Stream could be diverted, causing a rapid drop in temperatures in north-western Europe.<sup>72</sup> His coupling of an account of material destruction and social displacement with a wildly optimistic vision of political and cultural rejuvenation bears comparison to the most radical avant-garde calls for destruction as a means of renewal.

The diversion of the Gulf Stream into the Pacific was only ever presented as a possible secondary consequence of the creation of the Panama Canal. The primary purpose of the waterway was always to shorten the route of travel between the Atlantic and the Pacific. However, there were other schemes articulated in the same period that presented the diversion of the Gulf Stream as their sole or primary aim. In November 1899, British newspapers were briefly full of stories announcing a 'Yankee Enterprise' 'To Divert the Gulf Stream' 'To Give Britain a Colder Climate'.<sup>73</sup> The *London Evening Standard* reported the

‘ingenious idea’ of an American engineer, Mr. Sloper, to dig a canal through the Florida peninsula in order to ‘divert the Gulf Stream from the West Coast of Europe to the East Coast of America, and thus to transfer at least a portion of the comparatively warm temperature, with all its consequences, from the Old to the New Continent’.<sup>74</sup> *St James’s Gazette* judged the Florida Canal scheme to be even more ‘openly defiant of our comfort’ than the Panama Canal and denounced the proposed attempt to ‘lave the Eastern coasts of [America] with all those tepid streams that of immemorial right are ours’.<sup>75</sup> The Florida Canal scheme remained no more than a newspaper story, but it is notable that such a monumental engineering project could be contemplated for the sole and express purpose of redirecting an ocean current in order to alter the climatic conditions of a region.

While the Florida Canal was never more than a story, other comparably audacious plans advanced somewhat further. In 1913, a proposal aimed at creating ‘An Iceless Arctic’ was reported in several British papers. The plan, proposed by Carrloo Livingstone Riker, involved the construction of a two-hundred-mile-long jetty off the coast of Newfoundland in order ‘to completely separate the Gulf Stream and the Labrador Current’, preventing the dilution of the warm water of the former by the cold water of the latter and thereby creating ‘a literally iceless Arctic’.<sup>76</sup> In accordance with an engineer’s desire for maximum efficiency, the jetty scheme was intended to optimise the warming effects of the Gulf Stream. In this instance, heat was not to be taken from one nation for the benefit of another, but rather the heat of the Gulf Stream was to be enhanced for the benefit of all North Atlantic nations. The article quotes speculation in the *Philadelphia Record* that if the arctic explorer Robert Peary had delayed his expedition to the north pole until the completion of the jetty, he would have found the journey ““a mere pleasure jaunt”” through open water rather than an arduous ice-bound trek.<sup>77</sup> No thought is given in this article to the wider consequences that would follow from the melting of the northern polar ice.

Although, like the Florida Canal scheme, the Newfoundland Jetty project never became a reality, the idea received enough support that ‘a Bill for an appropriation of 100,000 dollars for the creation of a proposed Federal Commission to make preliminary investigations with a view to carrying out the undertaking’ was introduced to Congress by New York Congressman William Calder, and engineering authorities linked to the Panama Canal project and to the United States Army ‘expressed belief in the practicability of Mr. Riker’s plan’.<sup>78</sup> As with the plan for the Florida Canal, the significance of the Newfoundland Jetty scheme lies in the fact that its sole objective was the diversion of ocean currents for the purpose of altering climatic conditions.

Contemporary popular discussions reveal a degree of apprehension regarding the possible effects of human intervention – deliberate or otherwise – in climatic systems, but they also reveal a countercurrent of optimism running through not only speculative fiction but also scientific and public discourse. While Lewis’s summoning of blizzards remains extravagant, it is on a continuum with a municipal electricity supplier’s optimistic anticipation of falling temperatures, Gratacap’s vision of a new England in Australia, and schemes such as the Florida Canal and the Newfoundland Jetty.

## Conclusion

There was a discourse of climatic change, one with many strands – scientific and popular, fictional and non-fictional – in circulation in the early twentieth century. Aspects of this discourse, most notably Arrhenius’s recognition that anthropogenic CO<sub>2</sub> emissions could significantly alter the concentration of CO<sub>2</sub> in the atmosphere and that this could result in a rise in global temperatures, have become central to the early twenty-first-century understanding of anthropogenic climate change. However, alongside these continuities between early twentieth-century perspectives and current views, there are discontinuities that

make strange the attitudes of early twentieth-century scientists and engineers, speculative fiction writers and avant-garde polemicists.

One key difference between the current discourse of climate change and the early twentieth-century discourse of climatic change concerns the question of intentionality. Griffiths, writing of twenty-first-century notions of climate change, characterises anthropogenic climate change as change that is ‘unintentionally engendered’ by human activity.<sup>79</sup> However, early twentieth-century writers engage with the notion of anthropogenic climatic change as something that might – and perhaps should or even must – be deliberately instigated as a means of regulating environmental conditions for human benefit. This view was not universal amongst early twentieth-century commentators, but it was a clearly discernible strand of thought. The anthropogenic modification of climate was recommended at times on the grounds of the maintenance of existing conditions in the face of natural trends of climatic deterioration (Ekholm), at times as a form of gradual climatic improvement (Arrhenius), and even at times as a means of geopolitical manoeuvring (Bent, Sloper). Lewis was undeniably contrarian in his views – while others feared the onset of cooling, he sought means to summon blizzards – but, preferences for the glacial or the genial aside, his presumptuousness aligns with contemporaneous scientific and popular speculation. In spite or perhaps because of his vociferous embrace of extremes, Lewis is less an outlier from than an exemplar of early twentieth-century views on the cultural impact of climate, the susceptibility of climate to change, and the capacity of human beings to dictate the conditions of their environment.

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<sup>1</sup> Wyndham Lewis, ‘Manifesto’, *BLAST*, 1 (1914), 11-43 (p. 12). Further references to Lewis’s ‘Manifesto’ are given after quotations in the text.

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- <sup>2</sup> James Rodger Fleming, *Historical Perspectives on Climate Change* (Oxford: Oxford University Press, 1998), p. 108.
- <sup>3</sup> G. C. Simpson, 'Preface', in *The Evolution of Climate*, by C. E. P. Brooks (London: Benn, 1922), pp. 5-8 (p. 8).
- <sup>4</sup> Matthew Griffiths, *The New Poetics of Climate Change: Modernist Aesthetics for a Warming World*, Environmental Cultures Series (London: Bloomsbury Academic, 2019).
- <sup>5</sup> Fleming, p. 4, p. 8.
- <sup>6</sup> *Climate and Literature*, ed. by Adeline Johns-Putra, Cambridge Critical Concepts (Cambridge: Cambridge University Press, 2019).
- <sup>7</sup> Jan Golinski, *British Weather and the Climate of the Enlightenment* (Chicago: University of Chicago Press, 2011), p. 3.
- <sup>8</sup> H. Bassett, 'The Gulf Stream Drift and the Weather of the British Isles', *Nature*, 84 (14 July 1910), 44. The distinction between the Gulf Stream and the North Atlantic Drift was not consistently registered in writing of this period.
- <sup>9</sup> James Joyce, *Ulysses*, ed. by Declan Kiberd (London: Penguin, 2011), p. 18, p. 948n18.12.
- <sup>10</sup> 'Tuesday, December 12, 1905', *Devon and Exeter Gazette*, 12 December 1905, p. 5.
- <sup>11</sup> Louis Gratacap, *The Evacuation of England: The Twist in the Gulf Stream* (New York: Brentano's, 1908), p. 122. Further references to this work are given after quotations in the text.
- <sup>12</sup> Joyce's allusion to the Gulf Stream may similarly be read as ironising the pious and patriotic discourse surrounding the current. See Maria McGarrity, *Washed by the Gulf Stream: The Historic and Geographic Relation of Irish and Caribbean Literature* (Newark: University of Delaware Press, 2008).
- <sup>13</sup> Kent M. McGregor, 'Huntington and Lovelock: Climatic Determinism in the 20<sup>th</sup> Century', *Physical Geography*, 25.3 (2004), 237-50 (p. 237).
- <sup>14</sup> *Ibid.*, p. 237.
- <sup>15</sup> Daryn Lehoux, 'Climatic Agency in the Classical Age', *Climate and Literature*, pp. 60-75 (pp. 71-72); Fleming, pp. 16-18.
- <sup>16</sup> Montesquieu, *The Spirit of Laws: A Compendium of the First English Edition*, ed. D. W. Carrithers (Berkeley: University of California Press, 1977), p. 276.
- <sup>17</sup> Ellen Churchill Semple, *Influences of Geographic Environment, on the Basis of Ratzel's System of Anthro-Geography* (New York: Holt, 1911), p. 635.
- <sup>18</sup> Jessica Howell, 'Climate and Race in the Age of Empire', *Climate and Literature*, pp. 163-78.
- <sup>19</sup> E. M. Forster, *A Passage to India*, ed. by Pankaj Mishra (London: Penguin, 2005), p. 156.
- <sup>20</sup> Semple, p. 634.
- <sup>21</sup> H. H. Lamb, *Climate, History, and the Modern World*, 2nd edn (New York: Routledge, 1997), p. 212.
- <sup>22</sup> Brian Fagan, *The Little Ice Age: How Climate Made History, 1300-1850* (New York: Basic, 2000), p. 49.
- <sup>23</sup> *Ibid.*, p. 48.
- <sup>24</sup> 'An Old-Fashioned Winter: Advantages and Disadvantages', *Sheffield Daily Telegraph*, 6 February 1907, p. 6; 'An Old-Fashioned Winter', *Manchester Courier and Lancashire General Advertiser*, 18 February 1902, p. 6; 'The Pleasures and Penalties of Frost', *The Queen, The Lady's Newspaper*, 13 December 1902, p. 985.
- <sup>25</sup> Alexandra Harris, *Woolf in Winter* (Southport: Virginia Woolf Society of Great Britain, 2015), pp. 9-10. The freezing of the Thames was due in large part to climatic conditions but it was also influenced by anthropogenic factors. The closely spaced piers of Old London Bridge aided the formation of ice.

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- <sup>26</sup> Virginia Woolf, *Orlando: A Biography*, ed. by Rachel Bowlby (Oxford: Oxford University Press, 1992), p. 26.
- <sup>27</sup> *Ibid.*, pp. 218-19.
- <sup>28</sup> Prince Kropotkin, 'The Desiccation of Eur-Asia', *The Geographical Journal*, 23.6 (June 1904), 722-34.
- <sup>29</sup> Eduard Brückner, *Klima-Schwankungen Seit 1700* [Climate Variation since 1700] (Wien, Germany: E. Holzel Olmutz, 1890).
- <sup>30</sup> Ellsworth Huntington, *The Pulse of Asia: A Journey in Central Asia Illustrating the Geographic Basis of History* (New York: Houghton, Mifflin and Company, 1907), p. 385. Huntington's views were regarded with scepticism by many of his academic contemporaries, for he advanced sweeping claims for which he lacked substantiating evidence, but he was a prolific writer of works of popular science, so his ideas had wide currency.
- <sup>31</sup> 'The Nineteenth-Century Discussion of Climate Variability and Climate Change: Analogies for Present Debate?' Max-Planck-Institut für Meteorologie, Report No. 157. (Hamburg: Max-Planck-Institut für Meteorologie, 1995), p. 4.
- <sup>32</sup> 'The Origin of Climatic Changes', *Nature*, 92 (25 December 1913), 479-80 (p. 479).
- <sup>33</sup> *Ibid.*, p. 479.
- <sup>34</sup> *Ibid.*, p. 480.
- <sup>35</sup> 'Discovery and Invention. World-Wide Changes of Climate', *Leicester Daily Post*, 13 May 1913, p. 5.
- <sup>36</sup> *Ibid.*, p. 5.
- <sup>37</sup> *Ibid.*, p. 5.
- <sup>38</sup> Svante Arrhenius, 'On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground', *Philosophical Magazine*, 5.41 (April 1896), 237-76 (p. 267).
- <sup>39</sup> *Ibid.*, p. 265.
- <sup>40</sup> *Ibid.*, p. 270.
- <sup>41</sup> 'Excerpt of notes from lecture given at Stockholm University on 3 February 1896', printed in Swedish in *Nordisk Tidskrift* 14 (1896), 121-30, reprinted in Henning Rodhe, Robert Charlson, and Elisabeth Crawford, 'Svante Arrhenius and the Greenhouse Effect', *Ambio*, 26.1 (Feb 1997), 2-5 (p. 4).
- <sup>42</sup> *Ibid.*, p. 4.
- <sup>43</sup> Svante Arrhenius, *Worlds in the Making: The Evolution of the Universe*, trans. by H. Borns (New York and London: Harper, 1908), p. 53.
- <sup>44</sup> *Ibid.*, p. 54.
- <sup>45</sup> *Ibid.*, p. 61.
- <sup>46</sup> *Ibid.*, p. 63.
- <sup>47</sup> *Ibid.*, p. 63.
- <sup>48</sup> Elisabeth Crawford, 'Arrhenius' 1896 Model of the Greenhouse Effect in Context', *Ambio*, 26.1 (Feb 1997), 6-11 (p. 11).
- <sup>49</sup> Nils Ekholm, 'On the Variations of the Climate of the Geological and Historical Past and Their Causes', *Quarterly Journal of the Royal Meteorological Society*, 27.117 (Jan 1901), 1-62 (p. 60).
- <sup>50</sup> *Ibid.*, p. 61.
- <sup>51</sup> *Ibid.*, p. 61.
- <sup>52</sup> *Ibid.*, p. 61.
- <sup>53</sup> 'Notes', *St James's Gazette*, 4 November 1899, p. 4.
- <sup>54</sup> 'Oceanic Circulation', *The Times*, 25 May 1871, p. 4.
- <sup>55</sup> *Ibid.*, p. 4.
- <sup>56</sup> 'The Gulf Stream', *Globe*, 15 July 1880, p. 6.
- <sup>57</sup> 'News in a Nutshell', *Penny Illustrated Paper*, 5 February 1881, p. 83.

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- <sup>58</sup> ‘A Great Engineering Proposal’, *Dundee Courier*, 6 December 1900, p. 4.
- <sup>59</sup> ‘Notes’, p. 4.
- <sup>60</sup> ‘In Memory of the Worst of Summers’, *Graphic*, 4 September 1912, p. 6.
- <sup>61</sup> *Ibid.*, p. 6.
- <sup>62</sup> ‘Is Another Glacial Period Coming?’, *Grand Magazine*, 10 (November 1905), p. 697-98, in ‘Glaciers and the Gulf Stream’, *Kirkintilloch Herald*, 17 July 1912, p. 3.
- <sup>63</sup> *Ibid.*, p. 5.
- <sup>64</sup> ‘Electric Lighting’, *Ludlow Advertiser*, 15 March 1902, p. 5.
- <sup>65</sup> *Ibid.*, p. 5.
- <sup>66</sup> ‘Not Warm Enough’, *London Daily News*, 15 September 1903, p. 6.
- <sup>67</sup> ‘Humours of the Heat’, *Leeds Mercury*, 8 June 1911, p. 4.
- <sup>68</sup> ‘The Belvoir Hunt’, *Grantham Journal*, 27 December 1913, p. 4.
- <sup>69</sup> James Geikie, ‘The Gulf Stream and the Panama Canal’, *Globe*, 6 January 1882, p. 7.
- <sup>70</sup> *Ibid.*, p. 7.
- <sup>71</sup> ‘The Royal Society Soirée’, *St James’s Gazette*, 9 May 1889, p. 12; ‘Royal Geographical Society’, *London Daily News*, 24 June 1889, p. 3; ‘Ocean Currents’, *Morning Post*, 14 May 1889, p. 3; ‘Foreign News’, *Illustrated London News*, 18 May 1889, p. 6.
- <sup>72</sup> Other works of speculative fiction in this period also engage with the idea of the diversion of the Gulf Stream and with it a drop in Britain’s temperatures as an element of their narrative: Henry Crocker Marriot Watson’s *The Decline and Fall of the British Empire; or, The Witch’s Cavern* (1890) and George Griffith’s ‘The World-Masters’ (1902) both allude to or enact this scenario. However, Gratacap’s novel is the only work to take this premise as its central focus.
- <sup>73</sup> ‘Yankee Enterprise’, *York Herald*, 3 November 1899, p. 4; ‘To Divert the Gulf Stream’, *Nottingham Evening Post*, 2 November 1899, p. 4; ‘To Give Britain a Colder Climate’, *Newcastle Daily Chronicle*, 3 November 1899, p. 5.
- <sup>74</sup> ‘A Florida Canal’, *London Evening Standard*, 2 November 1899, p. 5.
- <sup>75</sup> ‘Notes’, *St James’s Gazette*, 4 November 1899, p. 3.
- <sup>76</sup> ‘An Iceless Arctic’, *Globe*, 8 September 1913, p. 10.
- <sup>77</sup> *Ibid.*, p. 10.
- <sup>78</sup> *Ibid.*, p. 10.
- <sup>79</sup> Griffiths, p. 49.