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A political ecology of atmospheres: A voluminous case study of the Guiana Shield

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ABSTRACT

This paper conceptualizes a political ecology of atmospheres. It offers to political ecology, a field that features a strong territorial bias, a study of how the effects of dramas taking place on and off the Earth's land surface go on to affect other spaces and places through the air and atmospheres. This interdisciplinary contribution is valuable because, as convincingly demonstrated by scholars in cognate disciplines, a dominant focus on land as territory limits understandings of the politics of environmental change. This is due to the fact that, increasingly, spaces and places that are neither fixed nor grounded, such as the deep sea and outer space, are being shaped by capitalist expansion and relations of power. Hence, I argue for greater consideration of atmospheres in political ecology, a field that examines the often contentious relationship between the principle economic system and the environment. I develop this argument through a voluminous case study of the Guiana Shield, a highly forested, 1.7-billion-year-old Precambrian geological formation in the north of South America. I use the Guiana Shield as a spatial point of reference to argue for direct attention to be paid to the ever-evolving interplay of current and historical factors in atmospheric spaces. Combining insights from decolonial scholarship, the environmental humanities, and the wider 'volumetric' turn, I use 'weathering' as a method for analyzing the slow, microscale geological, biological, and socio-political processes through which colonial atmospheres emerged and went on to later encompass their reference points.

1. Introduction

It is unequivocal that human influence has warmed the atmosphere, ocean and land (Allan et al., 2021).

This paper conceptualizes a political ecology of atmospheres. It commences from the commonplace observation that climate change *mitigating* projects are being carried out alongside climate change *intensifying* activities in the same spatial geographies (Collins, 2021a, 2021b). The outcomes of these activities cumulate in atmospheres and then go on to affect other spaces, places, and times, in often unpredictable ways. However, within political ecology, a knowledge tradition that examines the often conflictive and contentious relationship between human and non-human nature, these processes tend to be analyzed through an implicit focus on land. This focus is rooted in European colonialism and the cartographical imagination that enabled it (Branch, 2012). Consequently, the air and atmospheres as biophysical and affective in-between spaces (McCormack, 2008), remain under-theorized in the field (See, as exceptions, Graham, 2015; Mostafanezhad & Dressler, 2021).

This paper offers to political ecology a study of how the effects of dramas that take place on and off the Earth's land surface go on to affect other spaces, places and times through the air and atmospheres. This interdisciplinary contribution is valuable because, as convincingly demonstrated by scholars in cognate discipline (see, for example, Peters et al., 2018), the territorial bias effectively limits understandings of the politics of environmental change. This is due to the fact that, increasingly, spaces and places that are neither fixed nor grounded, such as the deep sea and outer space, are being shaped by capitalist expansion and relations of power. Concomitantly, the dominance of territorial concerns in political ecology points to a missed opportunity for orienting a clearer understanding of how events in the past and present cohere and take shape through atmospheres.

I present a voluminous (Billé, 2020) case study of the Guiana Shield, a highly forested, 1.7-billion-year-old Precambrian geological formation in the north of South America (see Fig. 1). I use the Guiana Shield as a spatial point of reference to argue for direct attention to be paid to the ever-evolving interplay of the current and historical factors through which atmospheres emerge and go on to blanket and shape all things.

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Combining insights from decolonial scholarship, the environmental humanities, and the wider ‘volumetric’ turn (detailed in section 1), I use ‘weathering’ as a method for analyzing the slow and micro scalar geological, biological, and socio-political processes through which colonial atmospheres emerged and went on to encompass their reference points. I understand atmospheres to be amorphous entities that are “always in the process of emerging and transforming” – a type of ‘envelopment’ that exceeds “the entity/ies from which they emanate, acquiring a life of their own and forming particular space-times engulfing specific situations ...” . I argue that a direct focus on atmospheres has the potential to destabilize fixed, bordered, two-dimensional understandings of precarity and vulnerability in particular places or on certain parcels of land. Atmospheres offer an understanding of how the effects of risk and vulnerability to exploitative and oppressive histories remain unconstrained by the places in which they take place.

Consider as an illustration the following question – How are roughly five centuries of colonial history in the Guiana Shield impacting water availability on the other side of the South American continent? Or alternatively - how did European colonization of the Americas show up

epistemological approach (Yanow, 2000) to argue that one means of grappling with these human-environment relations is by paying more attention to atmospheres due to their ability to combine understandings of the erratic affective and physical dynamics of environmental change across time and space.

This paper is divided into two main sections. The first main section is largely theoretical in nature. In this first main section, I conceptualize an affective and meteorological engagement with atmospheres. This section is divided into three theoretical subsections. The first theoretical subsection recounts work within political ecology on the air and atmospheres. The second theoretical subsection engages with decolonial theory to recognize that the (colonial) social contexts within which these microscale processes unfold inform the shaping of atmospheres. Traces of these contexts subsequently travel along with atmospheres as they transgress manmade borders and jurisdictions. The third theoretical subsection then explains the concept of weathering, which I adopt in this paper as the method for analyzing the processes through which atmospheres emerge (Collins, 2020).

The second main section of the paper presents a voluminous (Billé,

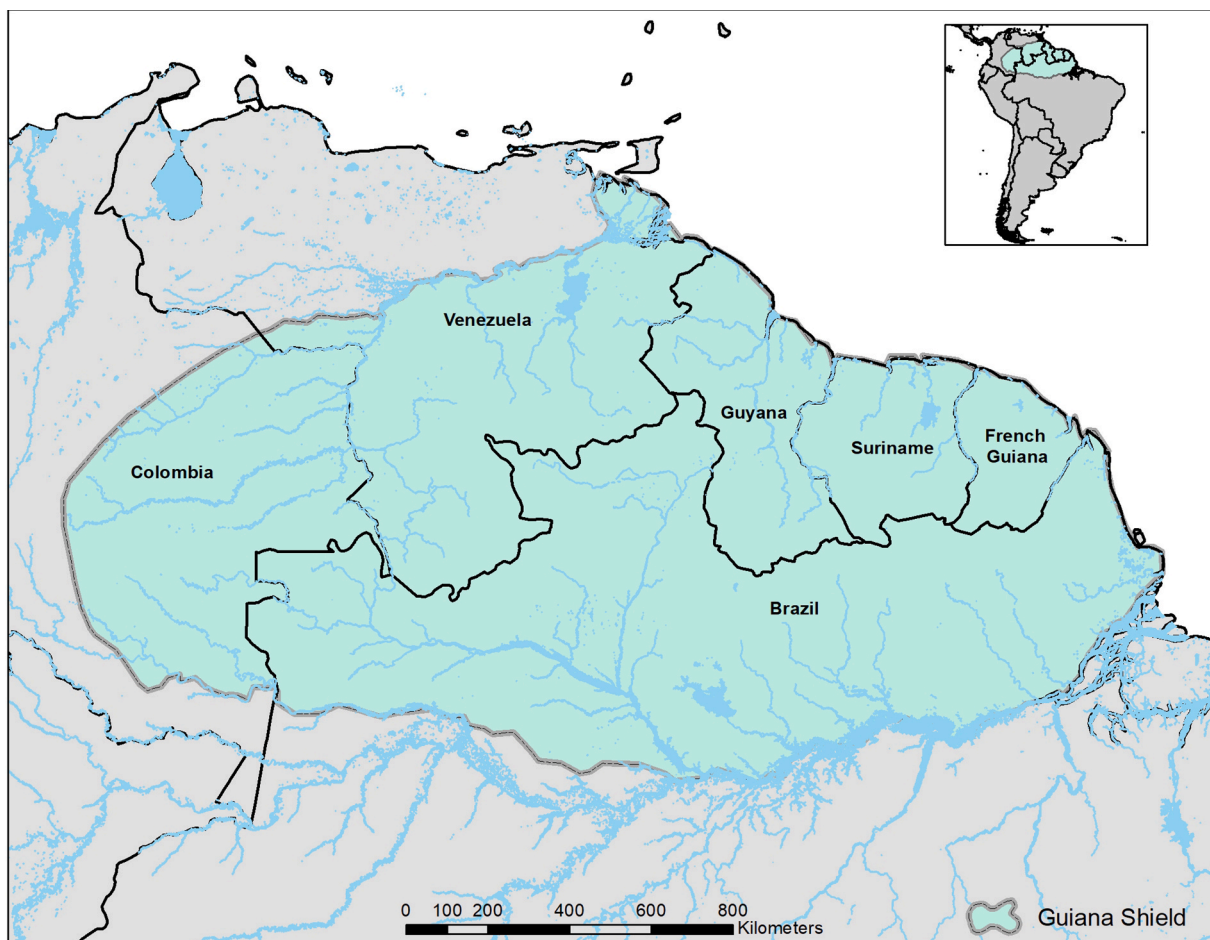


Fig. 1. A Cartographic Representation of the Voluminous Guiana Shield in the north of South America (Image Credit: Oronde Drakes).

in ice cores thousands of miles away? Naturally, there are multiple disciplinary ways through which these questions could be broached and convincing answers have already been put forward (see Bovolo et al., 2018; Koch et al., 2019).¹ In this paper, however, I build on these findings from the natural sciences and adopt an interpretive

2020) case study of the Guiana Shield. In this second main section, I

¹ In fact, these natural science findings partly inspired this study.

trace some of the geological, biological, and socio-political processes of weathering² by examining existing literature on the Shield. The effects of these processes cumulate in climate changed atmospheres, which are increasingly violent and erratic. Thus, the effects of these microscale activities move through the air and atmospheres and go on to affect other spaces, places, and times. The first subsection of the second main section charts this movement across spaces roughly categorized as two-dimensional, i.e. the surface. The second subsection does the same through three-dimensional spaces, i.e. the surface plus height and depth.³ The third subsection then addresses some of the ways through which people weathered colonial histories in the Guiana Shield. Finally, the paper's conclusion reflects on how the atmospheres that emerge from these dynamics harbor the potential to affect other places and spaces in unpredictable, occasionally violent, yet often benign ways.

2. Section 1 – The inadequacy of things

The emergence of the phenomenon referred to as climate change clearly demonstrates that human beings collude with the non-human world in ways that often bring about unintended changes in the atmosphere.⁴ Yet, political ecology has tended to examine these relationships by focusing primarily on those aspects of the world that are visible, bounded, and clearly demarcated. In so doing, the field has under-examined the aerial spaces between human and non-human nature — the mediative, connective tissue that forms the air and atmospheres (Edensor, 2012; Ingold, 2015).

In the wider social sciences, scholars have begun to explore the potential of thinking voluminously in relation to different spatial geographies, including the subterranean (Squire & Dodds, 2020), the above ground (Williams, 2010), the ocean and deep sea (Childs, 2020; Steinberg & Peters, 2015) and outer space (Beery, 2016). The atmospheric 'turn' has been similarly wide ranging and interdisciplinary, featuring insights from philosophy (Böhme, 2021; Irigaray, 1999; Sloterdijk, 2005), urban studies, urban design, architecture (Mostafavi & Leatherbarrow, 1993), environmental sociology, social policy, public health, epidemiology, and political theory. It has been particularly productive within geography (Adey, 2015; Choi, 2016; McCormack, 2008; Nieuwenhuis, 2015) as scholars examined issues related to security and climate change (Dalby, 2013), emotions and affect (Duff, 2010; Edensor, 2012; Fregonese, 2017; Stephens et al., 2017; Verlie, 2019), and even underground atmospheres (Etienne-Greenwood, 2022; Kanellopoulou, 2022; Nieuwenhuis, 2022; Trossat, 2022). In so doing, these scholars have moved past traditional, surficial, two-dimensional interpretations of the Earth toward an integration of its third, vertical, though not necessarily solid or cubic, dimensions (Braun, 2000; Elden, 2013). These scholars are increasingly recognizing that fixed, land-centered perspectives limit understandings of power and nature since economic activity and political power are increasingly being "exercised in spaces that are neither static nor "grounded" surficial units of land" (Peters et al., 2018, p. 4). Addressing this limitation therefore requires that new

ways of understanding how power is constructed and contested be adopted (Peters et al., 2018). Consequently, in this paper, I build on nascent scholarship within political ecology that argues for greater consideration of air and atmospheres within the field (Mostafanezhad & Dressler, 2021; Roberts, 2021). I commence by presenting a fuller account of existing scholarship on air and atmospheres within political ecology.

2.1. Making space for air and atmospheres

In 1998, while advocating for the development of urban political ecology, political ecologist Raymond Bryant poignantly observed that "unequal power relations are as likely to be 'inscribed' in the air ... as they are to be 'embedded' in the land" (Bryant, 1998, p. 79). When Bryant had proposed a "third world political ecology" in the pages of this journal of *Political Geography*, he had called for an exploration of "the political sources, conditions and ramifications of environmental change" (Robbins, 2003, p. 644). For the political ecologists who seemed to have responded to that call, political concerns for the economy and local scale struggles over resources were prominent (Robbins, 2003).

Swyngedouw and Heynen, writing later from urban political ecology observed that,

The cars burning fuels from distant oil deposits and pumping CO₂ into the air, affecting people, forests, climates, and geopolitical conditions around the globe, further complete the global geographic mappings and traces that flow through the urban and "produce" London as a palimpsest of densely layered bodily, local, national and global—but depressingly uneven geographically— socioecological processes" (Swyngedouw & Heynen, 2003, p. 899).

Despite their mention of how cars burning fuel, as localized activity, go on to affect other places through the air and atmospheres, the air and atmospheres remained overlooked within political ecology until Graham (2015), another urban political ecologist, expressed surprise that "... the politics and geographies of bad or lethal air in cities remain remarkably peripheral to the huge growth of political-ecological work on the social and technological productions of nature in urban environments that has in other ways been so productive in human geography and critical urbanism over the past two decades" (Graham, 2015, pp. 193–4). Save for a few political ecology adjacent contributions, Graham noted that "Such analyses, however, remain sporadic and occasional" (Graham, 2015, p. 194). He, therefore, suggested that increased attention needs to be paid to "the political ecologies and politics of the materiality of urban air" (Graham, 2015, p. 195) especially in the context of climate change.

More recently, a few contributions to the field of political ecology have begun to build on the emerging connection between the field and the geographical literature on urban atmospheres. Asher Ghertner (2021) sought to "bring a postcolonial lens to the recent "atmospheric turn"" (Asher Ghertner, 2021, p. 1486) through his work in India. He had been inspired by Legg (2020), who, writing seemingly from outside the tradition of political ecology, observed that "The majority of the atmospheres literature focuses on a racially undifferentiated United States, Europe, and Australia, within which race is not deployed as an analytical category" (Legg, 2020, p. 778). Legg asked, "... how might we challenge the inherent whiteness of atmosphere?" (Legg, 2020, p. 778). Ghertner responded by considering "not just how "non-Western" models of atmospheric enmeshment differ from those featured in the burgeoning geographical literature on atmospheres but also how whiteness and normative racial categories are themselves maintained through atmospheres" (Asher Ghertner, 2021, p. 1486; Wright & Tofa, 2021). Hence, he joined Legg (2020) in trying to further "blur the distinction between meteorological and affective atmosphere" (Legg, 2020, pp. 777–779) - a distinction that has gripped much of the discussions on air and atmospheres taking place within the discipline of geography (Duff, 2010, p. 201; Edensor, 2012, 2015; Stephens et al., 2017).

² I take care to point out that I use 'weathering' here to refer to microscale processes that are ongoing and that occur across the long-durée as bodies, both human and non-human, relate and negotiate with the air and atmospheres. Weathering, as a term, differs markedly from debates on the 'cenes', such as the Anthropocene and Capitalocene, which are competing terms seeking to gain primacy in how we to refer to current cumulative socio-ecological epoch of geology and environmental change, more broadly.

³ In this study, I recognize that debate exists on where exactly 'the surface' begins and ends. I note, in anticipation of these questions, that the debate between where air, atmosphere and outer space begins and ends is also still unsettled.

⁴ Whenever I use the word 'atmosphere' in this paper without the 's', I am referring to the meteorological atmosphere as conventionally known. My use of the word 'atmospheres', however, signals my understanding of the atmosphere as both meteorological and affective as outlined by McCormack (2008).

So far, though, this new imaginative thought, much like the broader academic exploration of volume (Elden, 2013), has tended to over rely on the militaristic and security related aspects of atmospheres (Jackman & Squire, 2021). Similarly, emerging scholarship on atmospheres within political ecology has begun to integrate an explicit awareness of how violent atmospheres take shape and cause harm by deepening and embodying resource conflict (Mostafanezhad & Dressler, 2021). In their introduction to a special issue on violent atmospheres in Southeast Asia, Mostafanezhad and Dressler (2021) draw on a framing that aligns with the militaristic tenor of the wider body of work on volume. They describe violent atmospheres as “material and symbolic entities” that “co-produce crisis over time and space” (Mostafanezhad & Dressler, 2021, *unpaginated*). For them, violent atmospheres are “carved out by social, political, material and gaseous elements of extractive spaces, producing new “aerographies” that meld together subterranean, terrestrial and aerial space and their permeating processes of capital accumulation, extraction and crisis—from large scale conflagrations to global pandemics” (Mostafanezhad & Dressler, 2021).

Hence, Mostafanezhad and Dressler (2021) highlight a departure point from which I too proceed; that is, that while political ecologists have convincingly demonstrated the means through which intensifying, capitalist resource exploitation produces violent terrestrial environments, they have largely overlooked its shaping of atmospheres.⁵ While political ecology is itself inherently voluminous due to its focus on ecology which knows no scalar bounds (Mosquera-Camacho & Marston, 2021), its arguments are usually informed by a flat, land-based perspective (Mosquera-Camacho & Marston, 2021). This paper shifts this perspective upward by showing that the slow emergence of atmospheres through interactions between human and non-human nature need not be qualitatively violent in character or outcome (Anderson, 2009). In line with this observation, I broaden Mostafanezhad and Dressler’s (2021) critique away from the securitized overtones of the wider volumetric turn to make theoretical space for atmospheres to be conceptualized as holding a series of opposites (Anderson, 2009, p. 80), as both violent *and* benign. Therefore, the political ecology of atmospheres I develop here reframes atmospheres to refer not only to crisis and capital, but to material and symbolic entities that emerge from socio-political, economic, and biophysical processes across scales and time frames. Hence, climate change, referred to in this article’s opening quote, is but one, albeit important, atmospheric constellation.⁶ In particular contexts, however, atmospheric constellations can be understood to be colonial. I turn next to decolonial scholarship to demonstrate how atmospheres become infused by colonial histories that affectively thicken (Duff, 2010) over time.

2.2. Colonially inflected atmospheres

Atmospheres carry with them traces of the contexts from which they emerge. In the case of the Guiana Shield, atmospheres are colonially inflected. This conception of atmospheres as colonial aligns with the arguments of Anibal Quijano, one of decolonial theory’s foremost thinkers, who highlighted the connections between global power distribution and capitalism in his elaboration of how European

colonization of the Americas formed the beginnings of the new, modern world order. Despite the formal ‘end’ of colonialism, which began in the 15th century, colonial power structures persist. This persistence can be identified both in atmospheres and in international economic structures that ensure that benefits continue to be produced for actors in the West to the detriment of those outside it.

In this analysis, Quijano (2000) connected local, place-based colonial histories in the Americas, within which the Guiana Shield is situated, with capitalism’s global expansion alongside colonial racial hierarchies. He explained that relations “between European and non-Europeans suffered a temporal alteration: all non-Europe belonged to the past, and so it was possible to think about relations between them in an evolutionary perspective” (Bhabha, 2014; Quijano, 2000, p. 221). Hence, non-Europeans were categorized according to markers that ranged from ‘primitive’ to ‘civilized’, from ‘irrational’ to ‘rational’, from ‘traditional’ to ‘modern’, from ‘magic-mythic’ to ‘scientific’, en route to eventual, but ever elusive, Europeanization and modernization. This temporal schism remains an underlying feature of Capitalist Modernity, which refers to a specific Eurocentric narrative that views Western achievements in terms of development as inherent to internal characteristics of Western countries.

Accordingly, the decolonial view of the world reads European colonization into the Eurocentric narrative of Capitalist Modernity. This view recognizes that events like the trans-Atlantic slave trade that took place between the 16th to 19th centuries, and the financial benefits reaped from it, fueled industrialization in European colonial centers, while drastically altering the relationship between human and non-human nature in different places around the world (Mignolo & Walsh, 2018). These events drove the myriad, accelerating environmental challenges currently threatening the livelihoods and ways of life of formerly colonized people, and perhaps, even modernity itself. These events also had direct and indirect material atmospheric consequences through, for example, deforestation to accommodate plantations, the forced relocation of people to labor on those plantations, and the transfer of plants for cultivation across continents (Yusoff, 2018).

Thus, my focus on atmospheres as a material space in the long *durée* harbors decolonial potential (Steinberg, 2023). It extends the temporality of atmospheres to pre-colonial times, making space for conceptualizing an otherwise, in its appeal to materiality. As Bakker and Bridge (2006) wrote in their work on water governance,

“appeal to materiality is, in part, a call for a research agenda that addresses the analytical significance of concrete differences in the material world and the way these enable and constrain the social relations ... a call for a broader anti-colonial project within geography which seeks to destabilize the discourses and practices through which are constituted the materiality of ‘others’- whether these ‘others’ be human, animate non-human, or material objects” (Bakker & Bridge, 2006, p. 21).

The political ecology of atmospheres I offer in this paper broadens understandings of atmospheres away from a normative determination on whether air is good or bad (Graham, 2015). It recognizes that air and atmospheres, like other materialities, engender “new imaginative structures for thought or politics” (Jackson & Fannin, 2011, p. 438), especially decolonial politics (Bakker & Bridge, 2006; Steinberg, 2023). It joins the work of Legg (2020) and Asher Ghertner (2021) in challenging the implicit whiteness of atmospheres across disciplines and adds to the small body of work focusing on climate change in terms of atmospheres (Dalby, 2013; Verlie, 2019). In so doing, it recognizes the elemental nature of atmospheres, in that its materiality makes life possible (Adey, 2015; Engelmann, 2015; Jackson & Fannin, 2011; McCormack, 2008; Nieuwenhuis, 2018) while teasing out the often taken for granted ways through which current, climate changed atmospheres emerge. All in all, the paper offers a heightened awareness of how seemingly disparate processes and events, some of which might have been relegated to irrelevance as the past, meet with non-human

⁵ Some political ecology (adjacent) literature, such as that of telecoupling does also provide alternative approaches to grappling with the interconnected, cross-scalar nature of environmental and social change for which I advocate in this paper. While this approach does provide a useful step toward illuminating the questions I ask, it is still land-based, linear and positivist in its orientation. Its contributions adhere to the flat, land-based cartographic imaginary I problematize.

⁶ By ‘atmospheric constellation’, I mean an atmospheric arrangement of relative permanence. Thus, while atmospheres are wide-open cumulative aerial spaces, atmospheric constellations, like climate change, are more or less stable, although not inevitable or ‘natural’.

processes and condense, dissipate, and reverberate erratically across time and space.

2.3. Weathering as method

Weathering, as means of analysis, requires that attention be paid to the multiple definitions and registers of its use in theory and in practice. In dictionary definitions of the word, weathering refers to processes that expose subjects of action to the open air and the action of the elements; processes of becoming deteriorated by excessive exposure to bad weather; or of becoming prominent or isolated by the decay or disintegration of the surrounding rock (Definition of weather, n.d.). Geologist, Vladimir Obruchev (1959) describes weathering in the ecological and geological sense as including the “breaking down of rocks, soil, and minerals as well as wood and artificial materials through contact with the Earth’s atmosphere, water, and biological organisms” (Obruchev, 1959, p. 75). Weathering, in this geological sense, occurs *in situ*, with little or no movement. Writing from the environmental humanities, Neimanis and Hamilton (2018) and Neimanis and Walker (2014), explain that weathering describes “socially, culturally, politically and materially differentiated bodies in relation to the materiality of place, across a thickness of historical, geological and climatological time” (Neimanis & Hamilton, 2018, pp. 80–81). They write that “not all bodies weather the same; weathering is a situated phenomenon embedded in social and political worlds” (Neimanis & Hamilton, 2018, p. 81). Weathering is therefore a process that brings both physical and affective dynamics into view, along with the atmospheres that emerge from their functioning.

In this paper, while building on those insights, I also understand weathering to be a process that influences and generates weather patterns (Collins, 2020). The concept supports analyses of how climate changed atmospheres emerge due to its “simultaneous reference to the earth’s natural and physical processes of resilience and change, and to atmospheric constellations of nature and climate change that can be directly experienced in a palpable way” (Collins, 2020, p. unpaginated). However, I note that weather is “an insufficient signifier of the climate” (Collins, 2020, p. unpaginated), due, in part, to its capricious variability. Once situated “along a clear linear timeline and mapped longitudinally and latitudinally” (Collins, 2020, p. unpaginated), however, certain more stable, atmospheres come into view. Deploying this understanding of weathering to study the work and functioning of the highly forested, geological formation referred to as the Guiana Shield permits me to pinpoint the slow, ecological, and social processes that take place over the long *durée*. These processes and their effects eventually go on, through non-linear, atmospheric processes, to generate and magnify affective and biophysical atmospheres, and subsequent processes of weathering, both in their point of origin and further afield.

With this conceptualization of atmospheres and discussion of weathering as analytical method now in place, in Section 2, I move toward demonstrating how the cumulative effects of the weathering of people, rocks and vegetation fuel the emergence of thick (Duff, 2010) racialized and colonial atmospheres in and through the Guiana Shield. I do this by paying attention to the biophysical and social processes of weathering alongside each other.

3. Section 2 –A Voluminous case study of the Guiana Shield

This second main section of the paper presents a voluminous case study of the Guiana Shield. As highlighted in the introduction, this section comprises three subsections. In the first subsection, I tease out some two-dimensional aspects of weathering the surface of the Shield. In the second subsection, I integrate considerations of height/verticality to explore some of the third dimensions of weathering in and through the Shield. In the final subsection, I briefly account for the weathering of people in and through European colonization of the Guiana Shield.

3.1. Two-dimensional surface weathering

From sufficient altitude, the Shield resembles an old weathered island surrounded by flat Tertiary and Quaternary sediments (Gibbs & Baron, 1993, p. 22).

Climate change, an atmospheric constellation, was unintentionally brought into being through interactions between human beings and the non-human world. While there remains much debate on the exact point in time at which it began its ascendance to engender the current stage of precarity in which the world now finds itself (Yusoff, 2018), it is clear that climate changed atmospheres (Verlie, 2019) emerged over time, melding together activities that took place in the past with those unfolding in the present, both atmospheric and otherwise. Its emergence is often situated in European colonization of vast portions of the world (Haraway, 2015) and in the industrialization that this colonization enabled (Ferdinand, 2021).

Colonial histories are baked into the statal and spatial demarcation of the Guiana Shield and its current political governance by the independent countries of Colombia, Venezuela, Guyana, Suriname, and Brazil, the first two of which gained independence from Spain, the third from Great Britain and the fourth from the Netherlands. French Guiana, also part of the Shield, is still a part of France. In geological terms, however, the Guiana Shield is significantly less fragmented. It is known to be a stable formation that has gone unaffected by mountain building activity for a thousand million years. The Shield is a massif of hard Proterozoic rocks that is located between the Orinoco and Amazon River basins (Gibbs & Baron, 1993). Its soils have poor to very poor nutrient content because its parental rocks are low in mineral content. This poor nutrient rock results in low nutrient soil because “[s]oil is the layer of weathered material overlying bedrock” (Thompson and Turk, 1998, p. 106) that supports plant life. The Guiana Shield was formed and weathered geologically over the long *durée*, contributing to, and being shaped by its surrounding atmospheres.

Over millions of years, the rocks of the Shield were exposed to the environmental influences with which they contend daily, such as heat, rain, water, and wind. In other words, they were weathered by the elements. The rocks are battered by the elements and worn down by plants and tiny organisms. They are subjected to sunlight that heats them up. Nightly, they cool down. Altogether, these variations in temperature cause the expansion of the rocks during the day and the contraction of the rocks during the night. Although these processes are largely unnoticeable to unmediated human observations, so gradual that they are almost always imperceptible to the human eye, their repetition day in and day out weakens the particles. Water is also involved in these processes of weathering. As the rocks erode, microscopic cracks are created that allow them to absorb more moisture. The repetition, of being wet and dried out by the rain and sun aids in breaking down their internal bond (Price, 1995).

Notably, water speeds up processes of their weathering. It brings with it gases from the atmosphere that might have previously interacted with external processes, such as the burning of gas, which might have left traces of carbon dioxide behind. Hence, water infused with carbon dioxide traces and other such elements speeds up processes of weathering. The actions of plant and fungi species also play a role, as their lichens colonize even the smoothest rocks. Wind carries the spores of lichens into the cracks developing in the rock. These lichens stick to the surface, often aided by the rain. As they germinate, the lichens become securely wedged in the rocks. They draw on the moisture they manage to absorb from the rocks and eventually disintegrate the rock’s surface by expanding and deepening its cracks, further prying them apart.

Over time, grains of sand and dust adhere to the rock, filling the cracks and hastening processes of weathering. Even tree roots get involved in causing rock particles to break down. Eventually, dust amasses to such a degree that a layer of soil appears. This soil provides the conditions necessary for supporting the growth of more vegetation.

The seeds of these plants also fall into the cracks, aided by the wind, rain and dust (Jain, 2014; Obruchev, 1959). Eventually, lichen colonies germinate, and vegetation overwhelms the lichens to work their way down into the cracks of the rock, resulting in a further corrosion of the surface of the rock. As cracks widen and more dust, along with the remains of dead grass and roots are collected there, a place materializes where shrubs, trees and larger types of vegetation take hold and spread their roots. As the vegetation grows, their roots wedge the rocks further apart. Natural forces of dew, heat and frost also affect the rock, wearing down its internal cohesion (Jain, 2014).

In the words of geologist Vladimir Obruchev:

From a rock subjected to weathering, the rain washes away liberated grains ... The rain, as it collects in grooves, slowly wears away nicks in the rock. The wind, on the other hand, acts to disperse liberated sand and dust particles and carries them away (Obruchev, 1959, p. 75).

Through this gradual process of loss, proliferation, and change, the Guiana Shield was and continues to be weathered into being, unceasingly being shaped by its exposure to the elements. Through these slow ecological processes, a layer of soil appeared, which then lay the foundation for vegetation that became the Amazon rainforests. Through these slow actions,⁷ the Guiana Shield is made able to influence weather through its vegetation, demonstrating the generative capacity of soil that was weathered into being, shaping atmospheres as it does so (see Fig. 2).

3.2. Three-dimensional vertical weathering

The Guiana Shield and the forests rooted in the soil resulting from its slow processes of weathering go on to allow the Shield to generate atmospheres and to influence current and future atmospheres and weather patterns. These forests are one of the few remaining relatively intact forest ecosystems on Earth. A quotation from the work of Gibbs and Baron is demonstrative of some of the vertical dimensions at play in the forests (Gibbs & Baron, 1993) that bring the third dimension of emerging atmospheres into view. The authors describe the experience of an unknown geologist whose view of the forests orients attention upward, demonstrating verticality well:

The close-pressing trees, large and small, instinctively draw one's gaze upward, looking for light. But the crown of the forest, 30–40m above, forms a dense canopy. Only where a forest giant has finally given up the struggle and fallen, dragging down its neighbours in a long roar of sound, only then is there a chance of seeing clear sky, and a place for the geologist to read his [sic] instruments without much difficulty, or to eat his sandwiches beside one of the clear streams that he may be fortunate enough to find (Gibbs & Baron, 1993, p. 3).

The trees, understood in this way, can be seen as standing erect to such an extent that they obscure the light. As the unnamed geologist finds, the forests grow skyward, standing so closely together that they can block out the sun. For the single human in these forests, the trees of the Guiana Shield can seem gigantic, requiring that vision move increasingly upward if one is desirous of finding the sky. Yet, the trees remain firmly rooted in the soil, mediating between it and the air above and encircling it, forming its mass through its intake of carbon dioxide with well-known carbon emission mitigating effects (see Fig. 3).

⁷ I note here that my categorization of these processes as two-dimensional is somewhat arbitrary because the limits of the surface are not easy to define. These processes are not merely two-dimensional as water, roots, vegetation, microbes etc. move vertically. Nonetheless, I categorize them here as two-dimensional to distinguish their *more* surface based orientation from their vertical ones.

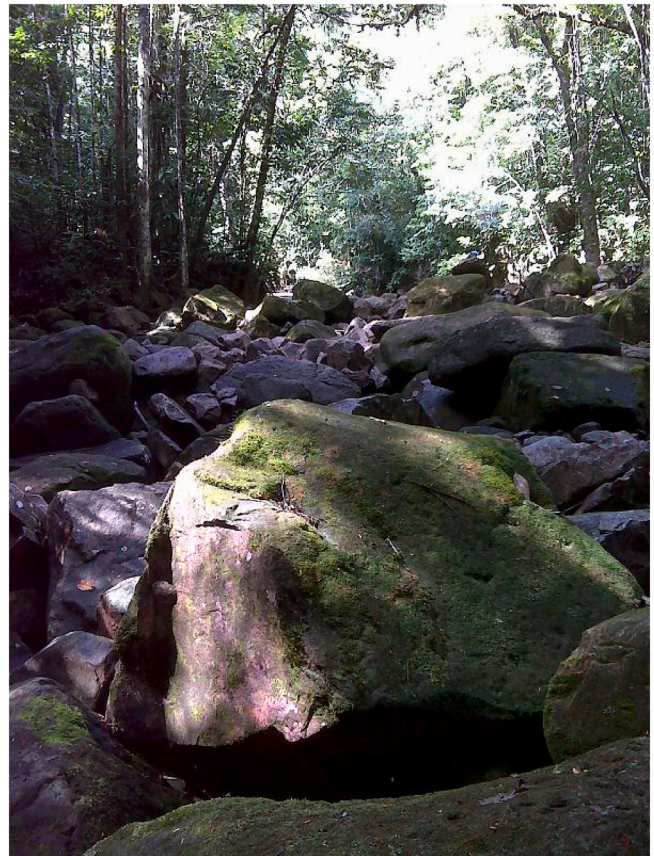


Fig. 2. The relationship between weathering rock and vegetation in the Guiana Shield (Photo Credit: Oronde Drakes).

Forests and their processes of carbon sequestration depend on interactions with the air. Their work is vital for attempting to create some balance between the production and absorption of oxygen and carbon dioxide. They play a key role in sequestering carbon from the atmosphere in the fight to mitigate climate change. The forests are “nurtured within the vertical space between air and land, remaining horizontally stationary but vertically unconstrained, except perhaps by other trees competing with each other and with the human within them for access to the sun's light” (Collins, 2020, p. unpaginated).

The vertical but spatially unconstrained dynamics of the work of these forests is seen in the observation that they act as guardians of the water cycle of the South American continent. Hydrologist Isabella Bovolo observed that:

deforesting less than a third of the Guiana Shield, in areas currently under threat from mining, logging, and agricultural activities, could result in significant changes in the water cycle across the continent. This includes large variations in temperature and precipitation affecting areas 4000 km away, impacting ecosystems and economies, with consequences for society (Bovolo et al., 2018, p. 1).

Hence, the forests of the Guiana Shield are important for the wider Amazon forest basin since land-use change in the Guiana Shield, “even if small in spatial scale, but occurring in particularly sensitive hot-spots, can alter the flow of atmospheric rivers, with large consequences” (Bovolo et al., 2018, p. 1). Therefore, mining and the deforestation that enables it in the Guiana Shield is likely to have an outsized, reverberating impact on the ability of the wider Amazon forests to respond to further climatic changes through their mediation with the air and atmospheres. The deforestation taking place there also limits the ability of the forests to sequester carbon to mitigate climate change and to influence rainfall.



Fig. 3. Cracks of light in the forests of Brownsberg Nature Park, Suriname (Photo Credit: Collins, 2014).

3.3. The people who weather

People in the Guiana Shield, both past and present, interact with and magnify these biological and geological processes of weathering (Collins, 2020, p. unpaginated). They themselves have weathered colonial histories, while acting as agents who intensify the weathering of soil, and vegetation in ways that go on to affect other places and spaces through atmospheres. European colonizers, well known to have been driven by a thirst for resources, consolidated their dominance in the Guiana Shield, in part, through mining (Collins, 2019) for minerals beneath the soil, an activity whose racialized mediations between surficial, subterranean, and above ground activities demonstrate the overlapping relationship between affective and biophysical weathering and its atmospheric effects, as discussed in this subsection.

Prior to the colonial experience, the indigenous inhabitants of the forests of the Guiana Shield were diverse and nomadic. After being confronted by European colonizers in the late 1400s, the communities were forced to move away from the Shield's coastal areas over time (Griffiths & La Rose, 2014). As a result, they limited their spread to the forested areas while the colonizers went on to establish colonies and plantations on the coasts. In search of labor for the plantations, the colonizers began exploiting enslaved indigenous people and subsequently, disadvantaged, indentured Europeans brought to the region to work. However, after some time, as the plantations grew larger and the price of European indentured servants rose, the colonizers began to turn towards Africa to supply their labor demands. They began to relocate large numbers of enslaved people from the continent to work on the plantations under abhorrent conditions, a practice they maintained for centuries.

These oppressive events did not take place without resistance. The establishment of maroon communities in the Surinamese rainforests by

runaway Africans exemplify the rebellions waged against the colonizers (Colchester, 1996) of the Guiana Shield. The maroon community members learned how to survive in the initially unfamiliar forests, in part, from their encounters with indigenous communities. After years of conflict, peace treaties were eventually signed between the European colonizers and the maroon communities in the 18th century that allowed the communities the ability to live under their own governance arrangements in the forests, unbothered by subsequent colonizers. The indigenous communities also benefited from separately inked peace treaties with the colonizers in the 17th century (Heemskerk, 2005). Still, the colonizer's thirst for resources had not been quenched by the wealth generated by the coastal plantations.

Mining for gold, bauxite, and other minerals, currently the main driver of deforestation in Guyana and Suriname, was encouraged by the colonizers. The hunt for base metals was explicitly bound up with events taking place in the colony that became Guyana (Gibbs & Baron, 1993). In Suriname, the development of geological maps and surveys was also tied to the large bauxite industry that subsequently developed in Suriname, along with its hydroelectric scheme and the petroleum industry (Gibbs & Baron, 1993). Hence, while geology's development can be traced back to the demand for finding mineral deposits in prehistoric times (Gibbs & Baron, 1993), its development intensified during European colonization (Braun, 2000; Simpson, 2019; Willems-Braun, 1997). The pursuit of the subsoil and the deforestation that enabled it was, therefore, inextricably tied to the exploitative practices that defined slavery and indentureship during colonialism in the Guiana Shield and to the formation of the eventually independent states of Guyana and Suriname within the Shield that still reflect those racial hierarchies (Collins, 2021a).

After centuries of exploitation, the enslaved Africans were emancipated in the 19th century. Still in need of labor, however, the colonizers turned toward Asia and back to Europe to fill the demand for indentured servants. Different groups of people were then brought to the area from these locations to populate the coasts under varying degrees of exploitation. In the forests, however, despite the colonizer's previous acquiescence to maroon and indigenous rights to live freely in the peace treaties, Suriname's constitution upon its independence in 1975 did not recognize collective indigenous and tribal claims to the land (Heemskerk, 2005) or the resources above or below it in either vertical direction. All land within the Surinamese border that was not individually held was deemed the national patrimony of the Surinamese state, a situation that left communities in the forests in a precarious state of existence.

Some maroon communities were disadvantaged even further when a hydropower dam, constructed with the intention of providing low-cost electricity to the energy intensive bauxite mining industry, was built by the colonial government a few years before Suriname's independence in 1975. The dam's construction forced the relocation of some maroon communities to mineral rich areas labelled 'trans-migratory' by the colonial government in order to signify that the communities would again be moved at a later date. To date, however, this planned relocation has not taken place and the situation has been inherited by the independent government. The maroon communities, for their part, turned to gold mining to earn a living after again finding themselves in unfamiliar environments. Maroon communities in Suriname have thus weathered overlapping systems of exploitation, including forced relocation to unfamiliar lands, successful and unsuccessful attempts to enslave them, and the unfamiliarity of the Amazon forests within which they were eventually able to settle, albeit precariously. These factors inform their modern dominance in gold mining with all its weathering geological, biological, social, deforesting, and unconstrained atmospheric effects.

In the colony that eventually became independent Guyana, rights to the land surface remain a sore point for indigenous communities. The seizure of power by British colonial powers from the Dutch colonial in the nineteenth century, had seen community land rights invalidated. Hence, the ability to grant access to land surface and to determine laws

that enshrine that access went to the then British colonial, and now independent state government. Indigenous communities in Guyana now have their land rights access enshrined in law through the Amerindian Act which serves as the legal basis on which their access is established. Unfortunately, however, the efficacy of the act is questionable. The act is being challenged by a variety of interests external to those communities, such as those of gold miners, who are also African dominated because only the emancipated Africans had been able to venture into the forests during the colonial period, an option they took up to find avenues to support themselves in the post-emancipation period (Collins, 2019).

The Amerindian Peoples Association, an organization that represents indigenous people in Guyana, explained that inequitable and discriminatory norms that took root within colonialism in the country continue to be manifested in the Guyana's national legal framework (Dooley & Griffiths, 2014), despite the country's independence. These customs maintain the notion that all land that is not privately titled land, and hence the sub- and above-soil, is the exclusive domain of the state, which now routinely grants forestry and mining concessions, exploiting both the resources above and below the soil, in the areas Amerindians consider their own (Hook, 2019) and showing how contestation to land rights awarded through colonialism is already being waged beyond the surficial claims to territory in ways that could be read as vertical (through the associated claim on the forests and vegetation), voluminous (through the simultaneous claim on the above-, below- and surface of the ground) and atmospheric.

The colonial histories that informed the current state of claims to minerals, land and forests in the Guiana Shield were embryonic of racial hierarchies, as identified in the decolonial scholarship recounted in Section 1, that saw white people as sitting at the pinnacle of social structures (Quijano, 2000). In Suriname, creoles, the descendants of formerly enslaved people who live in urban areas in Suriname, became influential in Suriname's politics. Maroon communities remained mostly in the forests, keeping a skeptical eye on creole influence and dominance on the coast. Over time, racialized economic separations in Suriname diminished somewhat on the densely populated Surinamese coast. However, as a legacy of colonial histories, these racialized separations remain strong in forests, spiraling outward through atmospheres to influence the racial hierarchies underpinning Capitalist Modernity (Quijano, 2000) in the Guiana Shield and elsewhere.

Similar racialized dynamics and hierarchies also developed in Guyana that saw different ethnic groups comprising the population spatially separated in terms of residence patterns and economic earners. The forest communities' turn toward using the materials around them in ways that marginally worsen climate change and myriad other environmental changes have roots in their attempts to weather, as in survive, the vagaries of colonialism (Collins, 2019) and its associated rise of Capitalist Modernity. In these ways, the activity of gold mining, in particular, brings both affective and physical processes into view, as it demonstrates the overlapping relationship between the surficial, subterranean, and above ground. In so doing, weathering, both in terms of the weakening of rock, the colonial exploitation of people, and the process of influencing the capacity of the forests to sequester carbon from the atmosphere by uprooting or degrading them, can be recognized as taking place in and through the Guiana Shield. Through these and other activities, atmospheres, including climate changed ones, emerge, and remain unconstrained by the borders of the Shield itself.

4. Conclusion – spiraling outward through non-linear atmospheres

Returning to one of the questions posed in the introduction – How are roughly five centuries of colonial history in the Guiana Shield (an affective concern) impacting water availability on the other side of the South American continent (an ecological concern)? Building on answers to this and related questions of ecosystem connectivity in the natural sciences, I suggested in this paper that the overlapping processes of

biophysical, historical *and* social weathering that took place in the Shield cumulate in atmospheric outcomes that affect the hydrological cycle in the Shield, the wider Amazon Basin and localities further afield. In so doing, I presented what I conceptualize as a voluminous political ecology of atmospheres, as part of a larger effort to push the boundaries of political ecology by further challenging its longstanding territorial bias (Mosquera-Camacho & Marston, 2021).

Deploying the concept of weathering as an analytical method, taken from the environmental humanities literature (Neimanis and Hamilton, 2018, 2018, 2018), I traced some of the slow, microscale geological, biological, and socio-political processes through which colonial atmospheres emerged and went on to encompass their reference points.⁸ I situated over four centuries of colonialism and its frenzy of oft-violent activity within longer term, human and non-human atmospheric processes that resulted in an intensification of ecological processes to the point of undermining their sustainability.⁹ This far-removed focus on weathering called into question the difference between weathering as the non-human wearing down of rock by wind and rain, and the human-induced weathering of rock through mining and other extractive activity. As a consequence, the approach adopted here is not automatically defined by the quality of the atmospheres emergent from these histories and interactions (see Mostafanezhad & Dressler, 2021).

In line with decolonial insights, I suggested that the racialized, colonial structuring of the populations of the Guiana Shield had a similar out-spiraling, social effect on structuring racialized capitalist relations within the emergent system of world capitalism. This system continues to see control of the capitalist system reside overwhelmingly in the hands of white Westerners with the resources and labor being provided by formerly colonized states and non-white people (Quijano, 2000). This out-spiraling effect is both physical and affective. It carries with it traces of the exploitative histories and the racialized structures that engender them. Through colonialism, people joined the slow, cyclical process of weathering rock and influencing weather patterns by degrading forests, cutting them down, or even by maintaining them. They do this as they participate, willingly and otherwise, in racialized, economic relations that weather the Shield (Collins, 2021a). Further, the actions and circumstances of forest-dwelling communities show how colonialism continues to affect the climate-changing present and future, multiplying vulnerabilities across non-linear time and space through mediative, meteorological and affective atmospheres.

Racialized social climates are, therefore, bound up in these processes. They magnify the exposure of disadvantaged groups to the negative aspects of weathering and motivate these groups to contradictorily deepen their engagement in processes that further speed up the biophysical processes of weathering, as seen in the case of small-scale gold mining in the Guiana Shield. While these events confirm that not all bodies weather the same (Neimanis & Hamilton, 2018), they highlight that the socially differentiated weathering of bodies in and through the Guiana Shield has ripple effects on meteorological and affective atmospheres in other parts of the globe – ripple effects that are perceptible only through atmospheric, voluminous thinking unconstrained to the vertical, oblique, and linear (Elden, 2013).

The out-spirality and circularity implicated in the operation of atmospheres plays a central role in the extent to which the Guiana Shield and the wider Amazon basin can continue to support the ecological and carbon sequestration functions with which human society is increasingly concerned. The circularity or spirality of these processes is demonstrated as the biophysical and affective processes of weathering overlap. Their cumulative effects then go on to diminish the ability of forests covering the Guiana Shield to maintain the hydrological function of the Amazon rainforest, with severe ramifications for the rest of the world (FAO,

⁸ By reference points, I mean the activity or area/location on a cartographic map from which atmospheric affecting activity originates.

⁹ Seen, for example, in climate change.

2022). Fossil fuels, being now produced in increasing quantities in the territorial waters of the Guiana Shield (Collins, 2021b), are especially prominent in these discussions and will likely further intensify these cyclical, weathering dynamics. The atmospheres expected to emerge from the intensification of weathering dynamics are likely to be increasingly inhospitable to human and non-human life (Allan et al., 2021).

The voluminous political ecology of atmospheres charted here demonstrates that although atmospheres can indeed appear flattening, numbing us into a state of constancy (Philippopoulos-Mihalopoulos, 2016), they are not top-down, fixed or unyielding. Rather, atmospheres emerge through slow, sometimes sudden, and violent, cumulative interactions across millennia that go on to affect other spaces and places, speeding up at times and remaining relatively still at others. Nonetheless, I warn against false equivalence between human versus non-human processes in the search for connection (Buscher & Fletcher, 2020) but suggest instead that the myriad, cross-scalar ways through which atmospheres emerge, retain characteristics of their origin points, and go on to affect other places and times is deserving of greater attention. Accordingly, I join Mosquera-Camacho and Marston (2021) in their invitation to scholars to enrich the “emergent theories of vertical and volumetric space” (Mosquera-Camacho & Marston, 2021, p. 14) with “the justice-oriented specificity of political ecology” (Mosquera-Camacho & Marston, 2021, pp. 14–15) through this reminder that power relations are also manifested through air and atmospheres (Bryant, 1998).

CRedit authorship contribution statement

Yolanda Ariadne Collins: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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