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The Limits to Computational Growth

Digital Databases and Climate Change in the Caribbean

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Abstract

Treating the Caribbean Community Centre for Climate Change (5C) as an institution invested in computational expertise, this article draws on critical studies of data and software to examine how digital databases are involved in enacting climate governance. Specifically, I argue that digital databases gain traction for 5C practitioners in ways that inform efforts to creatively rethink the sociality of growth beyond the conventional terms of economy. In doing so, this article reveals the entangled processes of resource depletion, power, and epistemic uncertainty that transform digital databases into cultural artifacts of the Anthropocene.

Keywords: Database; Climate Change; Regionalism; Materiality

"The cry in the Caribbean has always been for more data" noted Albert Jones, a meteorology instrument technician, affiliated with the Caribbean Community Center for Climate Change (5C). We spoke in his office one afternoon about the ongoing efforts of the 5C to implement climate governance projects across the region. He explained that the cry comes from research scientists developing climate risk assessments for various issues from fisheries, housing, to water. "So, it is a two-pronged attack," Jones continued, "where yes we are trying to standardize the data collection but we here at the 5C, need to prioritize archiving—building a database—so that people have something to return to again, again, and again."

Treating the 5C as an institution invested in computational expertise, this article draws on critical studies of data and software to examine how digital databases are involved in enacting

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climate governance. Specifically, I argue that digital databases gain traction for 5C practitioners in ways that inform efforts to creatively rethink the sociality of growth beyond the conventional terms of economy. In doing so, this article reveals the entangled processes of resource depletion, power, and epistemic uncertainty that transform digital databases into cultural artifacts of the Anthropocene.

Established in 2002, the 5C has emerged in the last two decades as the leading regional nongovernmental organization (NGO) for climate governance in the Caribbean. Located in Belmopan, Belize the 5C is a Caribbean Community (CARICOM) Organization. This designation means that 5C practitioners are responsible for representing the interests of the twenty CARICOM member states and dependent territories, all of whom, with the exceptions of Haiti and Suriname, are former British colonies. The nearly two dozen 5C practitioners hail from across the region and have experience and expertise from government, research, or policy in the climate sciences, as well as economic development, marine sciences, meteorology, IT, and conservation biology. Consulting one another on a daily basis, they thrive on making project sites into laboratories for developing new concepts, collective reflection, and standards of evaluation.

Even still, 5C practitioners acknowledge that climate governance is shaped by not only diplomatic aims, but efforts to stay vigilant of how and where data moves.[1] It is worth noting that climate governance aims to create mechanisms that address risks posed by climate change that cut across scales and epistemic boundaries (Pelling 2010). Climate governance usually falls into two general categories—mitigation or adaptation. The former entails efforts to reduce or eliminate fossil fuel emissions; the latter emphasizes adjusting institutional policies to projected climatic impacts. While the meaning of the terms can blur in practice, they circulate with distinct import among member countries attending the United Nations' Conference of the Parties (COP) annual meeting.

Alongside extensive discussions of scientific reports, member countries strategize with experts at the meetings to develop projects and funding-schemes.[2] As many critics note, the

[1]Such modes of expert attention to data scarcity are related to Antonia Walford's (2012) efforts to think about the way scientific cultures generate their own "internal friction"—or self-reflective ideas about the relevance of their ideas-practices-concepts to other knowledge producers and consumers.
[2]Many different scientific reports are referenced at COP. The reports discussed are presented by the Subsidiary Body on Scientific, Technical, and Technological Advice and their related working groups or forums.

outcomes of COP are not always immediate, but they do shape expectations about how experts and member countries communicate with one another (Gupta 2010). With its emphasis on climate sciences and nationally-oriented modeling groups, the desire for data is not evenly distributed among all involved in COP.[3] Climate model projections tend to offer a point of reference for defining the scope of either mitigation or adaptation. The 2015 Paris Climate Agreement—wherein member-countries pledged to decrease carbon emissions to well below 2, preferably 1.5 degrees Celsius, compared to pre-industrial levels—is a case in point.[4] A discrete unit of information, or data point, 1.5 degrees Celsius indexes the way climate governance *will have* curtailed fossil fuel consumption to shape individual and collective coping strategies for climate change. But in gesturing to a future perfect tense, much is left unsaid about how this happens in localized contexts of engagement. The acceptance of climate change as a 'problem of governance' takes shape through varied ideas of pursuit and transformation (Vaughn 2022). Specifically, 1.5 degrees Celsius leaves invisible the large-scale technological systems—namely digital databases—supporting the expert practices that make it possible to imagine a livable future.

In the case of the 5C, digital databases are large-scale technological systems, which span a sprawling network of bureaucracies across Caribbean sovereign territories. The structure of large-scale technological systems can be examined in technical, sociological, and organizational detail. As Geoffrey Bowker and Susan L. Star (2000: 9) noted, the maintenance of large-scale technological systems often involves "missing work," or labor that goes under-appreciated in the bureaucratic coordination of resources. The 5C practitioners' concerns about the Caribbean's 'cry for more data' signals how missing work can get reproduced through daily activities. Take for instance that 5C practitioners spoke of engaging state institutions that do not prioritize the collection of meteorological data or population density—data they believe is crucial to offering a picture of the sociomaterial impacts of climate change in a given site. The promise of the 5C, thus, is not that its digital database will work like magic to change the behavior of people and state institutions in the region, to make climate governance run without a glitch. Instead, climate

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[3]Myanna Lahsen (2009) has written extensively on national traditions of climate modeling in the global South and modelers' uneven participation and inclusion in COP.

[4]COP member countries have since referenced 1.5 degrees Celsius in novel climate activism that focuses on the adaptation needs of small island states (e. g. Sealey-Huggins 2017).

governance—as both a bureaucratic and biopolitical intervention—reveals a longer struggle the Caribbean has faced collecting data and maintaining technologies for computing.

As Jamaican political economist Norman Girvan (1989) argues, Caribbean territories have historically prioritized technology from the metropole over fostering what he calls 'indigenous' technological inventions. Building on the insights of anti-colonial theorists, he noted that relations of technological dependency are often undertheorized or ignored in liberal economic theories of growth.[5] Climate governance is a response to this blind spot in part because its computing practice, infrastructures, software, and technologies seek to interlink disparate geographies around common datasets about changing atmospheric-climatological conditions (Edwards 2013). Specifically, I deploy the term *limits to computational growth* to analyze the range of technical activities and systems of power that make visible obstacles to climate governance. In doing so, this article builds on Helen Verran's (2013) concerns for the ways in which nature come to stand in as an infrastructure of quantification. As Verran (2013: 32) notes, the epistemo-cultural properties of data are mobilized by particular practices of enumeration and the measurement of nature. To this end, I explore the limits to computational growth across two axes; firstly, in in an effort to demonstrate how computational expertise is embodied across scale; secondly, I locate the conceptual frameworks of computational expertise as partially derived from engagements with the liberal tradition's principles of growth.

The stakes of such an analysis demonstrate not only the methodological challenges of doing ethnography about digital technologies in the Anthropocene, but also gestures to the political complexities of the term Anthropocene and its value to writing a history of the present. Specifically, I suggest that the 5C is a canary in the coalmine, which gestures to a future wherein some people and places are treated as more worthy than others of *possessing data* about climate change. 5C practitioners have expressed varied ethical sentiments (e.g., joy and disgust) depending on where in the Caribbean data has been historically collected, or likewise, ignored. They express a simultaneous desire for digital databases and belief that climate governance could be something different—or at least, become explicitly invested in other ways of knowing. This critical disposition suggests that climate change requires attention to how technology plays a role in shaping the

[5] For a similar argument see Mavhunga 2014.

classification of people and places. Thus, I treat digital databases as ethnographic research objects suggestive for tracing the technological fault-lines of computational expertise in the Anthropocene.

This article draws on interviews and ethnographic fieldwork I conducted in 2018 at the 5C offices and in 2019 attending workshops associated with the 5C and a Caribbean climate modeling group based in Mona, Jamaica. In these settings, the 5C's digital database materialized in piecemeal as policy briefs, white papers, memos, PowerPoint presentations, and promotional videos. I came to know the 5C digital database not only as having an institutional but a mobile existence. The article begins with a critical engagement of the scholarship on digital databases to layout the conceptual stakes of the term the limits to computational growth. Here, my focus is on debates about how logics of programmability exist in tension with climate change. I then offer an ethnographic account of digital database development, which moves from the perspective of data collection and coding to the visual interface of the technology. Along the way, I argue that data scarcity in the Caribbean offers opportunities for a politics of mapping and power that challenge colonial relations of technological dependency. I conclude with a discussion about climate governance's seeming 'natural' dependency on digital databases, and the social and epistemic consequences of this worldview.

Digital Databases, A Reappraisal of the Limits to Growth

Digital databases run on software that dictates the real-time navigation, editing, and sorting of data as files (Dourish 2017). Therefore, digital databases would not exist without coding, or a system of rules written in a programming language (Fuller 2008). As critical software and media historian Lev Manovich (2000) argues, digital databases acquire narrative form through coding sequences that impart 'an architectural plan [that] presents different model[s] of what a world is like' (2). Take for instance that by the mid-twentieth century, digital databases became central to the operations of an array of scientific disciplines from cybernetics, ecosystem sciences, to the cognitive sciences (Bateson 2000).

However, the importance of digital databases as a modern technique of storage media is not only present at the level of content. Interlinking communication and bureaucratic systems, digital databases survive and expand through their consumption of resources (Haff 2013). They do so by capturing and redistributing massive amounts of energy from preexisting infrastructure grids, including water and electricity (Velkova 2016). Paul Edwards (2017) has suggested that digital databases and associated cloud computing ought to be treated as fueling processes of "information metabolism," insofar as their resource use is dependent on the quantity of data they store (35). One might cite longstanding digital projects such as Google's platform "Earth Engine" and the biodiversity project "The Catalogue of Life" as already existing examples of this data-driven metaphor. A contributing factor to climate change, digital databases reflect shifting relations between environment and human behavior.

In response to these difficulties, recent debates have focused on the role of digital databases—and more broadly, computational processes—in sociopolitical imaginaries of climate change (Latour and Weibel 2020). Generally, the argument is that "the earth has become programmable," through massive investments in sensory technologies that not only have the capacity to produce digital data but also to ascribe value to varied places and people (Gabrys 2016: 1). Wendy H. K. Chun (2015) reminds us that this logic of programmability exists in tension with a heightened awareness of uncertainty about the future brought about by climate change. Witness the phenomenon of climate denialism in the United States, wherein climate model outputs stir conspiracy theories. Instead of treating code as everything, Chun forcefully calls for attention to the "coarseness of data"—or how the varied uncertainty introduced by computerized and human observations mobilize climate action (695).

The tension between programmability and uncertainty raises questions about what exactly constitutes climate action across social worlds of computational expertise. There certainly are technological innovations—such as accounting rubrics for e-waste recycling—that could potentially direct digital databases towards the use of renewable energies (Hogan 2018). In other instances, e-waste has already been transformed into its own resource for data mining (Mayer-Schönberger and Cukier 2013). But I take Chun's concern for climate action as signaling more than a call for 'better' auditing of data. Rather, she is suggesting that climate action is deeply related to processes of coding. Specifically, climate action involves computing experts learning to communicate the future impacts of climate change in ways that make visible data that *cannot* be calculated or programmed (see also Chun 2012). What springs to mind is the critical software theorist Federica Frabetti's (2014: 36) insight that "the leap beyond the programmable" is the result of a constant questioning about what the future has in store.

Climate action, thus, has had unforeseen consequences on how computing experts cultivate social relations with one another and manage expectations about technological enhancements. This is especially the case among IT specialists and the instrument technicians they consult to code data and develop the online systems for digital databases. They cultivate a professional identity rooted in collecting data while working to make data accessible to an audience beyond computing experts. Here, I draw on Gabriella Coleman's (2013: 4) insights about how a professional ethos of hacking partially emerges from "aesthetic experiences of creativity" that exceed the dictates of routine training to inspire an intense pleasure for work. "Seeking to avoid the estrangement associated with capitalist production," Coleman argues that hacking is a vehicle for mobilizing liberal ideals of fulfillment through autonomous labor (15). Climate action, I suggest, also emerges from aesthetic experiences of creativity, or moments when novel codes (or decisions to forego them) aid in the overall coordination, function and design of digital databases. While a sense of fulfillment resides in the professional self, climate action also seeks to *strategically* enhance infrastructures, machines, measuring apparatuses, and technologies for computing (see also Manovich 2013). In other words, climate action is reformulated by computing experts as a liberal aesthetic and apperception for growth.

Creating parameters for how people live with and perceive others, growth has been driven by the (re)organization of capitalism on the planet. Some critics argue that growth is central to liberalism because of its instrumentalist and utilitarian views of nature, while others offer normative theories, contending that growth is counterintuitive to modern social orders; noting that states ought to *stabilize* the management of populations and wages to a certain level (P. Ferguson 2016). Both arguments have been criticized for Eurocentrism (Rodeny 2016) and for offering an incomplete picture of how capital gets distributed across social networks (J. Ferguson 2015). Noting that growth depends on capitalists "extracting income from the future," Timothy Mitchell (2020: 84) has recently offered a third view. In the most basic terms, he suggests that growth is enabled by capitalists learning to predict the acquisition of wealth but without a necessary concern for how this pursuit can be sustained and at what cost. As he notes, there's an implicit blindness to strategies of growth, wherein the narrow focus of Western capitalist modernity on revenue has come at the expense of future generations, particularly for those deemed living on the margins of capitalist expansion. The most obvious, and perhaps controversial, expense has been climate change. Take for instance that processes of capitalist expansion and ecological feedback mechanisms do not seamlessly mesh (Tsing 2015). What's more, the environmental consequences of growth—from soil degradation to species migrations—materialize and are experienced differently depending on where one lives.

This point was first acknowledged with the publication of *Limits to Growth* (2004), a 1972 report written by an international group of environmental scientists and economists that details how the depletion of resources has threatened the existence of all life on the planet. Gaining both popular appeal and critical scrutiny, the report offers commentary on the competing market and sovereign interventions needed to reverse course. Ecological economists have since provided a wide-ranging set of refined models that describe the breakdown of complex systems in an effort to predict what future life will look and feel like for (most people) on the planet.

The argument for the limits to growth, thus, challenges liberalism's historical representation and view of nature as an infinite resource. In computational terms, the argument rests on normative judgements about the inherent efficacy of datasets to represent the climate's phases and tipping points (Liverman 2009). Some scholars have focused on how datasets of varied climatic phenomena—e.g., ice cores (O'Reilly 2017) and tree rings (Gray 2020) —are *becoming* evidence for the limits to growth. In relation to the thesis of abrupt climate change, Nigel Clark (2010) argues that the record of the earth's "volatile" climate, "condemn[s] us and other creatures to experimentation and improvisation as it is needed for *precaution and self-restraint*" (29, my emphasis). Along these lines, the limits to growth—as an argument and social phenomenon—are realized institutionally and culturally in various locations and at different times.

The work of 5C offers one example of how the limits to growth materializes and takes on practical meaning through computational expertise. Take for instance that the 5C's digital database allows for comparing the quality of varied datasets from across Caribbean governmental institutions. The comparison happens in distinct moments of database development: data collection, cleaning, and filing. By performing these activities 5C practitioners identify data that was never collected, gone missing, or miscategorized. They make decisions about what types of data can contribute to the future writing of say a white paper, the operations of computers and cyber-systems, or data analysis training. Moreover, obstacles that stand in the way of growth—from neglected weather stations to idiosyncratic funding agencies—are critical components of their computing expertise. They tend to understand these obstacles as rooted in experiences of colonialism and the way technology has been used to further an image of the Caribbean as a "place." In turn, 5C practitioners articulate a vision of growth that treats computational expertise as deeply constituted by historical processes of underdevelopment and efforts to avert it in the future.

Thus, rather than only designating a set of environmental, political, and economic views, I treat the limits to computational growth as giving expression to what Maurice Blanchot (1993) calls a limit experience: "an experience of what is outside the whole when the whole excludes every outside; the experience of what is still to be attained when all is attained and of what is still to be known when all is known" (399). The point here is that limits do not automatically inspire paralysis; they can also provoke action. This duality is demonstrated in what Albert calls the Caribbean's 'cry for more data,' as much as in his colleagues' appraisals about the 'coarseness' of data. The limits to computational growth, thus, drives varied critiques of climate governance amongst 5C practitioners, while inspiring them to become key historical actors who can contribute to the Caribbean's survival.

Historicity and Deferral

It is important to keep in mind the challenges the Caribbean Sea and terrain have historically posed to the development of regional networks of communication technology and data collection. The St. Lucien playwright and poet Derek Walcott (1994: 505) notes, "Visual surprise in the Caribbean is natural; it comes with the landscape, and faced with its beauty, the sigh of History." During the colonial period, laws were first proposed for joint administration between the Leeward Islands but failed to bring the varied trade interests of the colonial elite together (Payne 2014). Federation was seriously considered on the eve of decolonization with the founding of the West Indies Federation in 1958 and later, the Caribbean Free Trade Association in 1968. Both were eventually replaced, however, by CARICOM in 1973 which became responsible for overseeing the region's diplomatic and trade agreements. As some critics note, CARICOM has only been successful at cultivating a so-called "conference habit," whereby frequent meetings promote the exchange of ideas but few plans to address the deep-seated technological underdevelopment that pervades the region (Payne 2014: 23). Such was the case in 1977 at the "Science Communication in the Caribbean" workshop held in Guyana. Technocrats from across the region convened forums that detailed the "trauma" they faced exchanging data with non-Caribbeans (United Nations 1977: 4). These experiences, coupled with the relatively small size of the CARICOM single economy market, influenced CARICOM to establish institutions such as the 5C to coordinate computing expertise for regional administration.

The 5C is comprised of two groups of practitioners whose responsibilities overlap in the day-to-day execution of activities. One group includes consulting project managers who partner with scientists, stakeholders, and state officials to write and implement 5C funded grants. The other group includes IT specialists (e.g., information technology and database designers), charged with programming the 5C digital database. Unlike project managers, the majority of the IT specialists' work is limited to a specific site: virtual space that has the ambitions of archiving all data, scientific images, and documents related to climate change in the Caribbean. Expansive in scope, the 5C digital database reinforces the idea of virtual cloud storage grafting digital technologies onto historic relations of political territory, sovereignty, and difference (Hu 2015). Located on the 5C's website homepage, the digital database is organized around five working "tools" or sub-databases: Clearinghouse Search Tool, the Caribbean Climate Online Risk and Adaptation Tool, Tourism Carbon Calculator, the Knowledge Navigator, and the Coral Reef Early Warning System.

Housed in each of these sub-databases are online platforms that allow the website's users—who to date have primarily included government officials, representatives of NGOs, and community planners—to complete climate risk assessments and to access a variety of datasets that complement the assessments. Directions indicate where on the 5C website one might find datasets and links are provided for navigating external websites jointly managed or endorsed by the 5C. The digital database is designed to draw attention to the limited number of internally produced files, and in turn, advise the user to a broader infrastructure of 'external' databases. Its expert authority is shaped by a deferral of judgement about the utility of data. This deferral also motivates 5C practitioners to stay committed to public outreach and training programs that seek to inform people working across different lay communities about the 5C digital database. They seek to leverage the 5C digital database as an experimental tool for the Caribbean and its people surviving the Anthropocene.

The Internationalization of Data Collection and Institutional Expectations

Perhaps the most highly sought-after data by the 5C and associated research scientists is meteorological data. In the Caribbean, meteorological data is independently collected by national weather bureaus and shared with global agencies affiliated with the World Meteorological Association and the United States' National Oceanic and Atmospheric Association (NOAA). Designed to provide basic readings of wind, atmospheric pressure, temperature, and solar radiation, automated weather stations support not only forecasting but environmental management. Weather stations have historically contributed to agriculture, forestry, conservation, water services, and storm early warning systems. Nonetheless, the need to standardize aviation for the Caribbean's most ubiquitous industry, tourism, has contributed to the overdevelopment of weather stations at airports.

This aviation-focus has diminished and even slowed down meteorologists' efforts to create synoptic weather maps.[6] One of the primary ways in which the 5C attempts to address this issue in forecasting is by supporting national weather bureaus to diversify the location of weather stations across terrestrial, aerial, and marine sites. Maintaining weather stations typically involves specialists traveling to monitor and when needed, fixing equipment. As Albert Jones explained:

> During my 30 plus years in the Belize Meteorology Services, I went through three of these total rebuilds [weather station improvements] based on international donor funding. We practically enhanced our whole network [of weather stations] across the country when we won an outside grant...that was about every eight to ten years, we'd wait for money…We were doing that and I said that we need a different approach; this is unsustainable. And just prior to my retirement at the Meteorology Services—right before I came to 5C—I sat down with a climatologist, and I said that we need to shrink our data collection to a sustainable level where we don't have to depend too much on financing from international donors to keep a weather station alive.

[6]A synoptic weather map reflects the conditions of the atmosphere over a large area in a given moment of time.

As Jones interprets it, cycles of donor funding have implications for when and how experts from across specializations—e. g. meteorologists and climatologists—anticipate incomplete historical datasets of weather. He notes that the investment in the built environment for computing (e. g. rain gauges and barometers), reinforces the idea among donors that the meteorological agencies of places such as Belize—with historically small datasets—are 'achieving' data sovereignty. But the extent to which data sovereignty is a realistic long-term goal is shaped by a number of practical factors, such as the shifting priorities of donors, that are outside the control of national weather bureaus. In turn, the (in)consistent upkeep of weather stations ultimately structures decisions about forecasting and international scientific research programs that have the potential to supplement existing datasets. This relation of dependency dictates 5C practitioners' understandings of the limits to computational growth as shaped by the constant maintenance and repair of informational infrastructures.

Take for instance that one of the 5C's largest grants involves a partnership with meteorologists at the Caribbean Institute for Meteorology and Hydrology and specialists in oceanography at NOAA. Moving from terrestrial weather stations to the ocean, they have placed buoys at locations across the Caribbean Sea for the creation of a Coral Reef Early Warning System (CREWS). Each buoy consists of a weather station and acoustic doppler current profilers that measure weather patterns and ocean acidification. Much of the data collected—including air temperature, dissolved oxygen, ultraviolet temperature, and water salinity—detail the multi-scalar reality of oceans, providing insights about hurricanes to the physical motion of water below the ocean's surface. The geo-expansion of weather stations has extended the reach of the 5C's data collection program while rendering so-called extreme environments into workable and knowable spaces (see also Olson 2018).

Even so, CREWS articulations of climate governance and scientific internationalism also render visible a rather fragmented process of developmentalism at the heart of the Caribbean history of meteorological data collection. While tourism continues to serve as the main rationale for building weather stations it is also a contributing factor to the region's vulnerability to climate change. From the emission of airplane pollutants into the atmosphere to the over development of weather stations at airports, processes of growth—whether in the vein of data collection or market consumption—can seemingly make the work of 5C practitioners extremely difficult. Specifically, their work straddles a system of capitalism and funding-scientific research invested in what media historian Steven Jackson (2014) calls 'broken world thinking.' As one of the 5C practitioners, who has spearheaded aeronautical mapping surveys reminded me: "None of the climate projections look good. They are all grim. The more data we collect, the more we know it [the future] doesn't look good for places in the Caribbean." By presenting the 5C as a savior of the region, this 5C practitioner suggests that the drive for more data has become obsessive for the organization: there are infinite opportunities to discover new Caribbean frontiers where they can find even more and different kinds of data. Yet he also cautions about this desire for more data, noting that with every technological enhancement comes new commitments to infrastructural maintenance and data collection that cannot be sustained in any obvious or autonomous way by the 5C.

Consider that the CREWS' weather station sensors need to be intensely monitored and frequently recalibrated. Waves, rising sea temperatures, ocean debris, and migrating schools of fish can contribute to the severe wear and tear of weather stations. And as 5C practitioners collect (more) data for CREWS, they recognize that the region's past overinvestments in weather stations at airports can never be entirely corrected for or "fixed.". Rather, this past becomes a point of reference for justifying the ongoing enhancement of CREWS to address mounting and shifting climatological threats. Thus, past and present experiences of the limits to computational growth are often difficult to distinguish for 5C practitioners in practice. Instead, they focus their attention on ways to better anticipate where and when in the Caribbean they will encounter 'coarse' data.

Coding

From the outside, the 5C office building is rather distinct. Its white concrete block-like façade, vented shutters and windows, and roof-top solar panels resemble the turn of the 21st-century architecture of middle-class residences and private sector buildings across much of the Caribbean. Specifically in Belize, such architecture has been symbolic of development that champions capital for tourism and offshore hubs for technology and information services. The 5C's office is in stark contrast to the nearby capitol government buildings, outdoor market, and main bus station of Belmopan which mimic Pre-Columbian and brutalist architecture. Given that the office was designed to standout as distinctly modern, we are reminded that the 5C practitioners' concerns about the limits to computational growth create not only distinctions in computational expertise but also the places where experts labor and call professional home.

Beginning in the early-2000s, the 5C prioritized a job search for IT specialists to contribute to wiring office space and creating a layout for computing. Initially, IT specialists and instrument technicians had workstations with ample personal desktops but only a few servers. They spent much of their time writing grant proposals to acquire more servers which would support applications, database technologies, and hardware platforms for internet-based services. Today, much is still the same. A small and cramped office space with room for two large desks are overflowing with paper files, multiple computer screens, and phones. Adjacent is a glass door and wall that opens to a slightly larger room lined with rows of servers and computing equipment. The glass makes the two spaces appear continuous. The only border that cuts through the space is atmospheric, marked by the constant hum of the air purifiers cooling and filtering dust from the servers.

Albert Gilharry, a 5C practitioner with a background in computer programming and software development, was responsible for managing this space when I visited in 2018. Along with two other staff, he runs the day-to-day computing operations of 5C offices and communicates with project managers, state officials, universities, and research centers from across the region to acquire data for the 5C digital database. Accordingly, Gilharry works to identify the computer programming issues that could contribute to the limits to computational growth. He does this by assessing which codes would be the most efficient for categorizing and classifying data in the database. In order to do this, Gilharry often collaborates with research scientists, instrument technicians, and modelers in physics, climate sciences, and meteorology. They present Gilharry with climate model projections in technical formats that display datapoints on a grid by year or in decades. He identifies ways to translate these datapoints for non-specialists by coding them into tabular formats such as EXCEL spreadsheets. From Gilharry's perspective, the EXCEL spreadsheet standardizes an aesthetic for data analysis. There is no such thing as perfect data—"bad" or "good"—only data that has the potential to serve a future climate governance project. Still, coding can create various problems for him. Take for instance, the concerns he shared with me about codes crashing:

> I might know what, for example, temperature is—a variable in a dataset. But I wouldn't know more or less at first what is valid for temperature in a dataset with billions of records…I'd run the dataset and everything would go through, and about a quarter of the way through something comes up: unrecognizable value. And you run it again and the same thing, an unrecognizable value, every time it comes up. When that happens, you need to update the code to fix the problem. So it's not that you just restart after it [the code] crashes. No, you need to program for this situation now and program for this new situation, and this new situation, to fix the previous situation and it's always a back and forth between this situation, and this situation.

Gilharry summarizes the common database architecture called relational database systems, which involves sorting a data item by criteria (Dourish 2014). In a relational database, each data (e. g. temperature) is organized into tables. Each column records information of the data, for instance, one might represent the highest degree in a month, another the national location of that temperature reading, and so on. If the computer does not recognize an input, Gilharry reassesses the code, or, in some instances, starts processing a new one from scratch. When this happens the data within the digital database is not deleted, only the elements of the table and the way data is organized into sub-sets changes.

For Gilharry, the coding of relational databases requires periods of intense and focused work. Unrecognizable values are inevitable and provide opportunities for him to enhance his skills in coding. Identifying unrecognizable values requires creativity insofar as it involves attention to how computer crashes enact 'nested situations' of uncertainty that are not necessarily accounted for in standard coding methods. He has to learn how to mix and match sequences to decide which data cannot be used and will ultimately go absent in climate governance projects. Given the region's exposure to hurricanes and intense rainfall, projects addressing flooding and farming were especially relevant to Gilharry. But it was tricky for him to identify decadal means of rainfall because not every territory had data that covered the same time period. As Ratner and Ruppert (2019: 3) argue, cleaning data incorporates judgements about *how* coding "sustains a bifurcation between data production and data projection." In this way, coding may lend a particular perspective on the different ways in which IT specialists express pleasure and a sense of professional pride in being the first 'line of defense' *against* the datasets that contribute to the limits to computational growth.

Thus, aesthetic experiences of creativity may not only present themselves through the formalism of coding language, but also in the status of the IT specialist and programmer as laborer at the center of an organization's social life and mission. Gilharry's coding decisions, in other words, depend on being both creative *and* efficient, not only attending to the coarseness of datasets but also making other people aware of their incompleteness. Coding large datasets, such as climate model projections, may span days if not weeks. Rather than sit around and wait for a crash, Gilharry spends much of his working hours developing user trainer materials for the digital database.

Along with a team of staff, he travels the region lecturing at state ministries about the 5C and how to use its online tools. Gilharry's team offers details about the content of the digital database and seek advice from attendees about data that could potentially enhance climate governance projects. While attendees may arrive with varied skillsets and training in climate risk assessment, the objective is that they leave with some understanding about the operations of the 5C digital database. In this respect, the digital database does not carry the same import for all experts across the region. At one workshop in Jamaica, I observed attendees move fluently between conversations about model parametrizations to the inherent dangers, opportunities, and ethical dilemmas of a Caribbean climate research agenda invested in geoengineering. Offering immediate and practical solutions for data sharing and storage, they spoke about how they could contribute to Intergovernmental Panel on Climate Change (IPCC) reports that draw on their experiences with the 5C.

In such conversations, Gilharry prompted attendees to speak candidly about their experiences of the limits to computational growth which included the difficulties of organizing research contracts with foreigners, to lack of computing power and servers, delayed funding from international NGOs, and the migration of elite researchers. In turn, Gilharry's own coding decisions were reinforced by the location of workshops and his encounters with attendees seemingly just getting by or making do within a global system of IPCC-sponsored climate sciences.

Whether from the perspective of the 5C office's architectural design, coding, or the conference-workshop circuit, the 5C digital database has become an end in itself. "In my personal opinion," Gilharry noted, "you can't just throw away data that took millions of dollars to produce. You have to keep it; that's just the right thing to do in my opinion. You don't know if one day you need it or if it can help explain why a project fails." With every record saved, Gilharry argues, a climate governance project has the potential to take on an additional agenda while underscoring a particular regional network of computation and scientific research. Moreover, the desire not to waste data transforms coding into an activity that seeks transparency and replication across computing platforms no matter the sovereign territory.

As Gilharry further explained, "You can't assume say someone searches for data in Jamaica and moves North and then to a part of Cuba, some people may want data on Jamaica and move across to Central America and then to Suriname, so you can't just separate [the data] based on how you feel. It has to be what makes the most mathematical or computational sense." The problem Gilharry describes, therefore, is that the limits to computational growth is not solely engaged with issues of managerialism but also concerns about epistemic inclusion. He recognizes that the 5C digital database cannot account for all of the environments, cultural heterogeneity, weather-climatic events, and lived experiences of vulnerability in the region. His energies as a coder, nonetheless, also anticipate political struggle because they give meaning to an unstable, or at least transforming, sense of regionalism brought about by climate change. Without coders like Gilharry, the future of the Caribbean would only materialize as model *projections* with no real content or motivation for change. In its most ambitious phrasing, the 5C digital database may also create a rationale for the 5C to insist on "bottom-up" or participatory climate risk management as the wave of the future. This seemingly democratic appeal to lay expertise, depends on the 5C creating online platforms that can inspire not only investments in more data but alternative ways of knowing and defining growth.

Digital Databases and Mapping Practices

Taken together, weather stations and coding transform the 5C digital database into a tool that not only operates to create and discipline policy motivations, but that seeks to map the epistemic-territorial boundaries of the Caribbean. Thus, a primary goal of the 5C digital database is the principle of hyperlinking, which is constitutive of the broader applications of the internet to enable and multiply the connections between people and places.[7] As Gilharry explained, the 5C digital database user should not be overwhelmed with information about climate change. "Anyone," he continued, "should just be able to go to the website and find what they are looking for and not have to weed through endless datasets." Gilharry's concerns about cataloguing advance an understanding of databases and portals that play on themes of mapping. `

If data is 'never raw but always cooked' (Gitelman 2013), digital databases are above all experienced by the information the database designer chooses to display or leave off a webpage to make it navigable for a user. Thus, mapping is a practice for communicating and enabling the visualization of complex information to digital database users. As Gilharry notes, accessibility is a major concern of digital database development: the user-subject gains consciousness of the 5C digital database depending on how easy it is to find data on the 5C website. In the same light, the attraction users might have for the 5C digital database is for its instructions that can transport them to another web-portal to collect data and information. This means that the design of digital databases is never local in any definitive sense. Rather, Gilharry must always stay alert to any graphics or instructions that might create obstacles to 'a user-friendly experience' in the collection of data and connecting to the content of other virtual domains and sources.

There is a different kind of logic to Gilharry's appreciation for cataloguing and accessibility than that of control, which has been described and claimed for modernist mapping practices. Digital databases may enact a specific strategy that Manuel de Landa (2000), following Gilles Deleuze, calls 'diagrammatic thinking,' which produces a future image of habits, transgressions, and ways of knowing the world. The 5C digital database, in other words, mobilizes a principle of/for mapping Caribbean territory that confronts its long history of a limits to computational growth. The users' activities on the website offers a model for envisioning climate change in the Caribbean while speculating about how climate change might be experienced differently as climatic risks shift in intensity over time.

The specific design-layout and pictorial ways of presenting data and information in the 5C digital database convey not only the Caribbean's so-called 'scarcity of data problem' but also its possible solutions. As Gilharry notes, the 5C digital database still exists as a loose arrangement of

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[7] I thank an anonymous reviewer for helping me clarify this point.

datasets—some data is missing or has yet to be collected. Thus, the 5C digital database is a living cultural artifact of the Anthropocene: its value and capacity to reconfigure the spatial possibilities of climate governance projects is in question with every new user-visitor to the 5C website. I now turn to the 5C database's user interface, to further elucidate how the mapping practices of the digital database become integral to climate governance.

Perhaps the most notable and widely accessed of the 5C digital database tools is the Caribbean Climate Online Risk and Adaptation Tool (CCORAL). A search engine for "climate resilient decision making," CCORAL provides guidance on how to implement what the 5C calls climate risk management portfolios. On the CCORAL landing page, the user is instructed to select the country where their activity will take place. When the user selects a country, a welcome screen directs them to describe the activity for which they would like to create a climate risk management portfolio. CCORAL rates and labels a country's activity as having a "low," "medium," or a "high" climate influence. Evaluating the "bundle of climate influences" on the country's activity directs the user to identify and prioritize a variety of climate scenarios from sea-level rise, flooding, to droughts. The user can edit and reenter information about the country's activity as often as they choose. After CCORAL assesses the climate influence on a country's activity, the user is given a set of recommendations for developing a climate risk management portfolio with the aid of CCORAL's "Clearinghouse Database."

Searchable by country, the Clearinghouse Database is an archive of active and completed project reports and scientific literature. If, for instance, the subject of a climate risk management portfolio is fisheries and sea-level rise in St. Lucia, national and regional scientific studies on marine and coastal climate change impacts are offered. Yet, the Clearinghouse Database is only helpful insofar as there are available documents. When I searched on 'fisheries' and 'St. Lucia' in December 2020 there were only seven available documents, none of which actually related to fisheries. There were policy briefs on agrotechnology, economic development, and climate projections for marine and coastal zone impacts across the region but not for St. Lucia specifically. As this indicates, it is quite possible for the user to travel through CCORAL without finding their interests well represented. CCORAL attempts to remedy this problem by providing links to 160 freely available reports that contain "vulnerability, risk, adaptation option identification and adaptation assessments." By the end of the review process, the user is advised to reference climate risk management sourcebooks approved by global aid institutions including the United Nations and the World Bank.

The landing page for CCORAL is a political map. CARICOM member states are highlighted in yellow and other non-CARICOM states are represented by national flag. The interactive map zooms in and out and drags the landmasses in cardinal directions, which allows the user to visualize the region in parts or as a whole. At the highest resolution the region is detailed as sovereign territories; at its lowest resolution, the region is encapsulated as landmasses adjacent to Central America and South America and bordered by the Caribbean Sea and Atlantic Ocean. DeLoughrey and Flores (2020) have argued that the modern history of mapping in the Caribbean privileges the aerial and continental perspective of the earth. Reinforcing the "balkanization caused by different European colonial empires," they argue that such mapping has the effect of erasing critical cultural practices that redirect attention to locally narrated histories of the region (DeLoughrey and Flores 2020: 136).

Playing with the CORRAL map's resolution responds to this legacy of territorial balkanization by privileging a perspective of the Caribbean that enables users to observe the region's risks on the ground. Through the CORRAL map the Caribbean is grasped as a series of identifiable locations that in the future are intended to become well-protected, fortified, and secured from storms. The 5C website contributes to the ongoing struggle over who/what governs the Caribbean as intensified winds, shifting temperatures, and rising sea levels reconstitute regional borders. The 5C responds to the consequences of this shifting territoriality with CORRAL; the acronym plays on the word corral, a verb that means to 'gather together and confine,' the exact opposite of the 'antagonism' associated with the word balkanization. CORRAL draws attention to the modernist fields of history, communication, and power that are being unsettled by climate change.

The CORRAL map, thus, is designed to make visible material relations that contribute to the limits to computational growth while providing resources to address climate change. I am not suggesting that it charts a clear path forward for dismantling liberal structures and logics of growth across societies. Rather, the CORRAL map gestures to the varied kinds of cultural and world-making projects of which the limits to computational growth are associated and in relation to the environments which it takes meaning.

I have encountered other modes of climate governance in the Caribbean that simultaneously rely on climate data but also recognize the role of local oral histories and craftlike traditions in the *initial* design of projects. The Guyana Mangrove Restoration Project comes to mind, with its emphasis on apiarists contributing knowledge of bee migrations and mangrove (re)generation to engineers as they model sea-level rise and map coastal erosion (Vaughn 2017). While not always a seamless effort at representation or engagement, the GMRP attests to how erosion contributes to mangroves' so-called vulnerability. Relying on these human and more-than-human modes of sea defense, ultimately, the project enacts a process of diagrammatic thinking that is similar to the CORRAL mapping. In both projects, the limits to computational growth are not envisioned as autonomously constructed nor dependent on the extraction of nature but rather by responding to nature (e.g. mangroves and weather patterns) as agents of history. What's more, they are committed to reformulating social and technical mapping practices. But how to sustain creativity in the face of varied forms of climatic crisis and potential catastrophe remains a key issue.

I want to suggest that such creativity has long been deployed beyond the technocratic arenas of climate governance. One possible reference for mapping practice builds on ways of knowing scale and regionality that are more than computational. Art historian Kobena Mercer (2017: 38) describes this practice as "mapping the abstract sublime." Mercer attributes the practice to Guyanese-British artist Frank Bowling whose large-scale acrylic paintings of continental landmasses, particularly South America, challenge realist renderings of political territory [Fig. 1]. Mercer (2017: 38) writes, "[Bowling] sought to undermine and disalign the formless and the contentless as signs of both terra nullius and a seemingly disinterested objective modernism." Created between 1969-1971, the map series grapples with themes of memory and absence, reflecting Bowling's personal experience of emigration and movement, between British Guiana, Europe, and America. Bowling's attention to the 'formless and contentless signs of terra nullius' remind us that efforts to make the earth (and its territories) "programmable" are always fraught with ethical questions and processes of social displacement.

Moving from questions about representation to praxis, thus, the limits to computational growth is about convincing Caribbean peoples that the seemingly impossible can happen in their life time: the complete disappearance of the region as a bounded set of sovereign territories. But whether this ever happens, is beside the point. The 5C has made certain assumptions that there is no such thing as the perfect dataset that will project an image of the future. They imagine all possible ways in which the classification and storage of data, may or may not become critical to the region's survival. And in doing this imaginative work, the 5C offers not only a strategy for climate governance, but an emerging space for their critique of it.

Conclusion

Digital databases for climate governance are both compelling and unsettling large-scale technological systems. On the surface, they are archiving models, images, and reports that help people anticipate how the future will be filled with risk instead of its aversion. But upon closer examination digital databases are doing much more. They are rewriting the history of the planet. From the perspective of the 5C, the Caribbean's experience of computing has been uneven. The regional experience of technological underdevelopment is in-part an effect of its geographic 'balkanization.' In turn, the 5C has leveraged its digital database as a tool to re-unify the region. This investment depends on 5C practitioners' ongoing efforts to improve the digital databases' reach across political, linguistic, and cultural borders. The 5C reveals that digital databases take up geopolitical and planetary space in ways that: deplete resources, reconstitute treaties across land, air, and sea, and often necessitate cultural reinterpretations of the meaning of data, its circulation, and its transformation into information. Digital databases are distinctively planetary in both their experimental and historical scope.

Taking into account the operations of digital databases, critical appraisals of capitalism fall short of explaining the underlying pessimism—or at least—the subtle dissatisfaction that computational experts invested in climate governance projects express. As treaties to reduce carbon emissions appear insufficient and world energy consumption unfolds at a relentless pace, they keep collecting and storing data for a dangerous future that appears impossible to avoid. Thus, the term limits to computational growth does not only index the coordination of machines but also computational experts' shifting professional commitments to forms of epistemic inclusion and the democratization of climate action.

The 5C's IT specialists and instrument technicians, in particular, seek professional fulfillment as they confront a range of challenges in digital database development and computing. Instead of solely relying on technical know-how, acts of creativity (and tinkering) sustain confidence when: jostling to repair weather stations and fund research programs, coding incomplete datasets, and ultimately, searching for effective ways to communicate uncertainty about climate change to not only lay audiences but to each other. In other words, creativity materializes not only in the body-mind of the laboring professional but also in the built environments of computing. The limits to computational growth thus move beyond debates about the 'origins' of the Anthropocene, to instead consider the various complex and challenging endeavors for imagining climate change under different regional and epistemic conditions.

Imagining livable futures, thus, revives questions about the values people ascribe to technological enhancements for data management. Transnational and regional climate initiatives such as the 5C have been essential 'expert and cultural brokers' of such value judgements. So, when practitioners such as Albert Jones remind us that the Caribbean is a place that is "[crying] for more data" he is not only gesturing to the importance—and perhaps necessity—of an expert subjectivity invested in communicating the nuances of climate change. He is also foregrounding what it entails to become an expert that seeks to galvanize ethical thought and practice across difference for the survival of the planet.

Figure 1. Frank Bowling, "South America Squared", 1967. Acrylic on canvas, 243 x 274 cm. Rennie Collection, Vancouver. VG Bild-Kunst, Bonn 2017. *Source*: https://www.hausderkunst.de/en/explore/picture-galleries/bildergalerie-frank-bowling

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