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ABSTRACT

This paper examines the geopolitics of producing volumetric space. It looks at how China, through its scientific presence in the Arctic, is acting as a territorialising actor in the region, and how circumpolar states, in response, are moving to securitise these activities. First, the paper develops the concept of epistemic territorialisation, examining how scientific practices, remote sensing technologies, and the environmental knowledge that they produce act to render atmospheric, oceanic and subterranean volumes legible, and thus volumetric. The paper then maps China's efforts to acquire volumetric knowledge about the Arctic, before moving to consider how these efforts are being perceived by Arctic states. It concludes with a synopsis of the changing 21st-century political geography of geoscience in the Arctic, demonstrating how regional perceptions of China's growing presence in the Arctic cast suspicion on the country's scientific endeavours, in turn demonstrating how geoscientific practices are territorialising in ways that work across both physical and discursive registers.

KEYWORDS

China; Arctic; geopolitics; securitisation; volumes; remote sensing; Earth science; science and technology

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1. INTRODUCTION

In May 2019, in a sports arena in the northern Finnish city of Rovaniemi, straddling the Arctic Circle, dignitaries from around the Arctic region gathered for a key Arctic Council meeting. Taking the stage in Rovaniemi that day, then-United States Secretary of State Mike Pompeo told his audience of foreign ministers and diplomats that the Arctic was 'entering a new age of strategic engagement'. The region, he explained, was becoming an 'arena of power and competition', and the Arctic Ocean, the region's 'centerpiece', was rapidly taking on new 'strategic significance' (Pompeo, 2019). He went on to emphasise that the United States was seeking to work toward an open and peaceful Arctic, a region in which 'respect and transparency are the price of admission'. Leading up to the meeting, however, a senior White House official had told Reuters that Pompeo was travelling to northern Finland 'amid growing … concern about China's interests' in the Arctic, and, more cryptically, that 'Chinese actions' in the region had 'really focused everyone's minds' (Reuters, 2019). He elaborated:

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> Our Pentagon warned just last week that China could use its civilian research presence in the Arctic to strengthen its military presence, … including deployment of submarines to the region as a deterrent against nuclear attack. We need to examine these activities closely. (Pompeo, 2019)

The former state secretary's accusations revealed something critical about the emerging geopolitics of not only the Arctic region, but the entire planet. Geopolitical tensions between China and the United States are intensifying. China, aspiring to the status of a global power, is expanding its presence into increasingly far-flung places, through diplomatic overtures, trade and investment, and large-scale infrastructure projects (Chhabra et al., 2021; Shambaugh, 2013). Less attention has been paid, however, to China's ongoing efforts to acquire knowledge about remote and extreme spaces across the globe, such as the deep seabed, high seas, and the polar regions. Like the United States and the Soviet Union before it, China is mobilising scientists and sensors in order to study and monitor earthly volumes where new security and geoeconomic interests are emerging. In recent decades, these interests have reached the Arctic, where the country is fielding an increasingly sophisticated research programme to study the effects of climate change, and, to the growing concern of states bordering the Arctic Ocean, survey for natural resources, develop new sea routes, and potentially accumulate environmental knowledge in support of a future military presence, from the Arctic's atmosphere, through its icy surface to the seafloor (Brady, 2017).

This paper examines China's scientific and technological attempts at 'territorializing aerial, maritime, and subterranean spaces' in the Arctic (Billé, 2020, p. 2), as well as exploring how Chinese efforts to render the region volumetric is being perceived by the states that ring the Arctic. By attending to how science and technology are at once productive of, and subjected to, changing volumetric geopolitical imaginaries, this paper seeks to better our understanding of the changing political geography of the geosciences against the backdrop of great power competition in the 21st century (Woon & Dodds, 2021). At the conceptual level, it does this by recasting the Earth sciences within the framework of 'volumetric geopolitics' (Dalby, 2013), focusing on the politics and practices of knowing, sensing, surveilling or otherwise producing volumetric space through scientific techniques, with the aim to develop a conceptual point of departure for further research into the co-constitutive relationship of geoscience and geopolitics.

In what follows, Section 2 sketches the entangled trajectories of geopolitical competition and the Earth sciences in the 20th century (Cloud, 2001; Doel, 2003). It focuses on how the Arctic has come to be territorialised as a geostrategic and volumetric space by foregrounding the Earth-sensing practices and infrastructures that, beginning with the early Cold War period, were deployed both to open up and secure new volumetric vectors of threat, and state military planners and operators' growing need for environmental knowledge about submarine, atmospheric and glacial spaces in the Arctic (Dodds, 2010; Dodds & Nuttall, 2016). It seeks to demonstrate how geoscientific practices are territorialising in ways that work across both physical and discursive registers (Bruun & Steinberg, 2018). Section 3 builds on this historical backdrop and introduces China as a scientific and geopolitical actor in the Arctic by providing an outline of its regional research programme and emerging geopolitical and geoeconomic interests in the region. Section 4 contours the geopolitics of sensing the Arctic, examining recent attempts by China to develop its own ability to study, map and monitor the Arctic. Section 5 examines how the entrance of China as a scientific-cum-geopolitical actor in the region has been received. It maps circumpolar perceptions of the country's growing scientific presence, showing how this presence and the Arctic volume is being securitised.

Volumetric thinking is closely linked to the calculative practices and techniques that produce, stabilise as well as contest territoriality across and through earthly volumes. As Woon and Dodds (2021, p. 351) argue, 'the relationship between the Earth sciences and vertical and volumetric understandings of national and international territory is crucial to understanding future iterations of subterranean geopolitics … '. The paper seeks to show that a volumetric perspective such as the

one laid out in the following sections helps direct our attention toward the various calculative practices that constitute Arctic geopolitics. By examining the ways in which Arctic volumetric spaces are taking on new strategic significance and becoming resecuritised as a result of intensifying great power competition, this paper aims to inform further research into the volumetric geopolitics of the Arctic.

2. EPISTEMIC TERRITORIALISATION

Before considering the epistemic practices employed by China in the Arctic, it is useful to establish a conceptual vocabulary about how voluminous spaces are made legible and, in effect, territorialised. In his intervention on vertical and voluminous geopolitics, Elden (2013) urges a more critical examination of the 'calculable practices' and 'political technologies' which act to produce and maintain volumetric space. Elden's intervention suggests that geopolitics, power and security should be analysed with greater attention to their dimensionality, notably their depth and verticality, but also the techniques, political as well as scientific, involved in discerning these properties. As a useful vocabulary for studying how calculative techniques and practices are brought to bear on voluminous spaces, he offers 'volumetrics' as a concept, which he uses to address the 'means of comprehending and compelling, organising and ordering' voluminous space (p. 49).

Continuing enquiries into the political production of space, Dalby (2013, p. 40) discusses the interface between the geosciences and inter-state competition throughout the 20th century specifically, and terms the co-constitutive relationship between the Earth sciences and modern geopolitics as 'volumetric geopolitics'. Starting with the Cold War, creating, but also controlling volumetric spaces, including maritime, atmospheric, even orbital space, became military–strategic imperatives. The geophysical sciences came to play an outsize role in understanding, exploiting, as well as securing these spaces (Doel, 1997), a development which in turn has had the effect of restructuring contemporary geopolitical discourses to include remote, inaccessible and volumetric spaces. At the core of these discussions are the epistemic practices and artefacts that make knowing, monitoring and managing volumetric space possible (Dalby, 2013, p. 41). Further, these calculating efforts to produce volumetric space can better be thought of as forms of *epistemic territorialisation*. Bruun and Steinberg (2018, p. 149; see also Bruun, 2020) conceive of geoscientific practices brought to bear on the atmosphere, the subterranean, the water column and other such voluminous spaces as 'prosthetic technologies of territory', echoing Elden by noting how territory is not simply projected onto space but constructed through myriad epistemic techniques. Describing the American attempt during the Cold War to 'territorialise' ice islands in the Arctic Ocean, they observe how scientists and engineers worked to reshape these islands into strategic pieces of military infrastructure. Drawing on Braun (2000), they argue that 'research into a place's physical geography is inherently territorializing' (Bruun & Steinberg, 2018, p. 148), both through the knowledge produced but also through the presence of the knowledge-producing practices themselves. Adding to this, Ryan (2015, p. 568) develops a spatialised understanding of security as the 'territorializing practices by which knowledge, competency and agency are engineered into the material world'.

The geopolitical and technoscientific developments of the second half of the 20th centuries gave rise to what historians of Cold War science have termed the 'surveillance imperative' (Turchetti & Roberts, 2014). Starting with the Cold War, gathering information on adversaries – or potential adversaries – became 'intimately linked to collecting information about the earth' (p. 2). From the deep sea to the cryosphere, jostling superpowers securitised environs, seeking not only to acquire operational knowledge about these environments, but also to anticipate and monitor each other's movements through volumetric environments. This blurring of the geoscientific and military gaze manifested itself in the Arctic through sensory technologies such as underwater listening devices, radar and weather stations, and imaging satellites (Bousquet,

2018). It also meant that geophysical knowledge was increasingly framed as a strategic asset that needed to be secured (Krige & Barth, 2006). State power came to rely on the production and possession of scientific and technical knowledge about these volumes. The need for 'environmental legibility' was increasingly a prerequisite for states' ability to project power across space (Davis, 2020, p. 1065). Nowhere is this truer than for states' attempts at achieving mastery of volumetric spaces, which is largely predicated on states' ability to deploy and exploit large-scale sensory and information infrastructures to produce operational knowledge about said environments (Posen, 2003). These imperatives are captured in military–strategic terms such as 'situational awareness' and 'full spectrum dominance' (Johnson, 2021). And moving beyond the purely geo-strategic, scientific techniques are also trained on earthly volumes in order to assess, access, and extract subterranean resources (Bobbette & Donovan, 2021; Bridge, 2013).

Thus, the acts of rendering these spaces legible and exerting control over them are inextricably linked. They are processual, too, relying on a vast material infrastructure of sensors and other technologies, as well as the human capacity to operate and maintain them. Analytically, then, thinking volumetrically about geopolitics entails more than merely recognising that contestations over territory take place in three-dimensional space; volumetric geopolitics foregrounds the knowledge-producing practices and technologically mediated ways in which these spaces are made legible and thus governable. Further, volumetric thinking in the context of inter-state relations and the territorialisation of remote spaces offers a way to analyse these processes as overlapping and ephemeral.

Given its extreme and rapidly shifting environment, the Arctic exemplifies this very type of 'material world' where, for the past century, states have forged new ways of epistemically territorialising the region to which we now turn.

3. THE VOLUMETRIC ARCTIC

The Arctic region is not new to volumetric geopolitics. Beginning with the interwar period, the Arctic region 'became a frontier for military science, both imaginatively and materially' (Farish, 2006, p. 177). Advances in military aviation and rocketry led to the conceptualisation of the Arctic as a strategic corridor (Kikkert & Lackenbauer, 2020). Its ice-infested waters, moreover, provided cover for undersea operations; a physically sealed volume where submarines could move undetected, however perilously (Weir, 2005). These new geopolitical imperatives resulted in 'strategic military, economic, geopolitical, and national security concerns [influencing] and [shaping] most science undertakings' in the region (Doel et al., 2014, p. 60). The Arctic as a geopolitical and strategic space emerged through an assemblage of sensory and military infrastructures operating to make its volume legible for military planners and operators, manipulating these spaces for offensive purposes. As Doel (2016, p. 13) summarises, securing the Arctic transformed the region into a 'technological system, requiring not only aircraft, missiles, submarines, … but also a great store of vital new knowledge about the Arctic environment'.

The arrival of new technologies of war and the subsequent constitution of volumetric domains of military operation during the early Cold War period led scientific disciplines such as geology, oceanography, meteorology and other fields to become enrolled in 'the state's arsenal of understanding' (Dennis, 2003, p. 803), as militaries sought 'to recruit the Earth itself as an informant' (Chambliss, 2020, p. 67). Moreover, the post-war proliferation of sensory infrastructures on, below and above the Earth's surface transformed these volumetric spaces into what Höhler (2002, pp. 144–145) has described as 'scientific–technical spaces'. Global conflicts throughout the first half of the 20th century and the ensuing icy rivalry between the United States and the Soviet Union pushed military planners and scientists alike to peer below the ocean surface and up through the aerial column.

The co-constitutive relationship between such calculative practices and Arctic geopolitics has continued into the 21st century. Following the end of the Cold War, coastal Arctic states began launching geoscientific missions to claim extended continental shelves in the Arctic Ocean (Lambach, 2022). The United Nations Convention on the Law of the Sea (UNCLOS), which entered into force in 1994, established a process for states to extend sovereign rights to the seabed and its resources beyond the 200 nautical mile that constitutes states' exclusive economic zone (Powell, 2010). These scientific undertakings to map the underwater geomorphology of the Arctic Ocean, coupled with climate change, renewed interest in the natural resources interred in the region, and the potential for trans-Arctic shipping, has brought new geopolitical salience to the region. In 2007, images of a submarine planting a Russian titanium flag on the Arctic seabed, below the North Pole, seemingly staking a claim to the Central Arctic Ocean, sparked global concerns over a lack of governance in the Arctic (Dodds, 2010). As Dodds and Woon (2019, p. 9) observe, the Russian flag-planting, and ensuing attempts by the Arctic states to defuse concerns about a governance gap in the region, showed the Arctic Ocean again being imagined 'as a volumetric space', possessing 'distinct opportunities for the [five littoral Arctic states] to steward and securitise its surface, columnar and subterranean dimensions'.

This newfound and increasingly global interest in the Arctic has also drawn in new state actors from outside the region. Countries keen on accessing the maritime Arctic and to take part in the governance and extraction of its resources, as well as to study its climatological connections to lower latitudes have sought to build scientific footholds in the region; one of these countries being China.

4. CHINA'S SCIENTIFIC PRESENCE IN THE ARCTIC

While the Cold War superpowers began delving into the volume of the Arctic in the 20th century, China is now joining them in the 21st century. Through regular, shipboard research excursions, the establishment of permanent research stations, and membership in many of the region's scientific institutions (Fravel et al., 2022), China has surfaced as an increasingly competent scientific actor in the Arctic. The country has maintained a scientific presence in the region since the late 1990s (Smieszek et al., 2020). Its first independent research cruise to the Arctic took place in 1999, and it opened its first permanent research station in the region on the Norwegian archipelago of Svalbard in 2004. Since then, China's Arctic research programme has grown substantially, evidenced by its participation in the fourth International Polar Year (2007–08), and the government's investment in new, state-of-the-art polar research and logistical capabilities such as the research icebreaker *Xue Long 2*, China's first domestically built polar icebreaker, which was commissioned in 2019 (Eiterjord, 2019). China is also strengthening its scientific presence in the region by introducing new sensor infrastructures to study and monitor the Arctic environment (Wei et al., 2020). This includes shipborne research equipment as well as ocean- and space-based sensors. These remote sensing technologies are enabling China to observe Arctic volumes. Speaking at the Arctic Circle Assembly in Reykjavik, Iceland, in 2015 – a major annual political conference on the region – then-Vice Foreign Minister Zhang Ming expressed China's scientific view of the Arctic, stating that the country was looking to:

> Further explore and understand the Arctic. With its unique geographic location and natural environment, the Arctic has great scientific value as an indicator of global climate change and a 'laboratory' for global scientific research. As of today, mankind's exploration and understanding of the Arctic is still limited. (Ministry of Foreign Affairs of the People's Republic of China, 2015)

This view has since been codified in the country's first official Arctic policy paper, issued in 2018. In it, Beijing emphasises its decades-long scientific presence in the region and how it is

contributing to the global pool of Arctic knowledge as key factors in legitimising its stakeholdership in the region. The policy outlines how 'understanding' the Arctic is one of its main policy objectives, followed by the ability to exploit Arctic resources and waterways, and to participate in regional governance (State Council, 2018). The Arctic region has also been incorporated into the Belt and Road Initiative, Beijing's increasingly globe-spanning connectivity strategy, with the announcement that China intends to build a 'Polar Silk Road' across the Arctic Ocean, connecting East Asia and the North Atlantic via a trans-Arctic economic corridor (Woon, 2020).

In parallel with the country's first Arctic policy, the top echelon of the country's political and military establishments have begun to conceptualise the Arctic Ocean as a 'strategic frontier' (Andersson, 2021). Alongside Antarctica, outer space, the deep seabed and cyberspace, the Arctic Ocean has come to be framed by Beijing as an emerging space for global governance (Bennett, 2015). The implication is that this extraterritorial space is an arena where China ought to assert itself, ensure its access to resources, and safeguard its perceived rights against states that it views as intent on territorialising these spaces for their own benefit. To this end, President Xi Jinping has called on China's polar research community to turn the country into a 'polar great power' (Brady, 2017). Xi has also proclaimed that China must become a naval power with global reach (McDevitt, 2020), which includes the ability to operate in Arctic waters (Martinson, 2022). Chinese military leaders, moreover, have included the Arctic Ocean under what they see as 'the new commanding heights of military strategy' in the 21st century (Doshi et al., 2021, p. 11). Again, the polar regions and the Arctic high seas are envisioned as extraterritorial spaces and potential hotspots for 'strategic competition' that needs to be secured. As the *Science of Military Strategy*, an authoritative source on Chinese strategic thinking (Fravel, 2016), reads:

> Some developed countries are using their own advantages to try to monopolize and control international public spaces, creating obstacles for latecomers to enter and use them. In the scramble for new strategic spaces, military preparation and pre-positioning is important not only for guaranteeing a country's free use of international public spaces, it is also an important measure to fight for the new commanding heights of military strategy. (Doshi et al., 2021, p. 11)

This passage illustrates one of the ways in which the volumetric Arctic is being securitised in Beijing. It sees the region, its ocean and atmosphere, as holding strategic value as it seeks to expand its geopolitical reach into the polar regions and, more generally, into the global commons (Freeman, 2020). As a consequence, these policies and strategies demand that the country grows its stores of knowledge about the Arctic environment and expand its means of observing and operating in the Arctic; tasks which, unsurprisingly, has fallen to the country's scientific community.

5. THE GEOPOLITICS OF REMOTE SENSING

As noted, science forms the foundation of China's stakeholdership in the Arctic region (Paglia, 2018). China's status as an observer state in the Arctic Council, for example, which it was granted in 2013, is in large part predicated upon its continued contribution to the collective pool of knowledge about the Arctic environment (Lanteigne, 2017). In this sense, science is often framed as a way for the country to become 'socialised' into governance mechanisms in the Arctic (Su & Mayer, 2018). Science as a vehicle for diplomacy has been a source of trust-building and transparency for China as its interests in the region have expanded, more recently exemplified by its ratification of the Agreement to Prevent Unregulated High Seas Fisheries in the Central Arctic Ocean, along with other science-based governance initiatives in the region (Pan & Huntington, 2016). As Bertelsen (2020, p. 242) argues, scientific cooperation with Arctic states has made it possible for China to become integrated into the region 'without … public displays of mistrust'.

Yet, the country's scientific presence has also invoked territorial anxieties among Arctic states, as evidenced by the speech delivered by Pompeo at the opening of this paper (Pedersen, 2021). To understand this apparent contradiction, it is useful to note how scientific infrastructure such as research stations and remote sensing technologies come to have territorialising effects.

Eager to exploit new maritime passageways thawed out by the climate crisis and explore for resources in the global commons, Beijing is training its scientific workforce on the problem. Studying ocean currents, the movement of sea ice and fog, and charting the Arctic seabed are all key to developing shipping in the region. Research expeditions, satellites, underwater and atmospheric sensors are mobilised towards rendering the volumetric Arctic legible for the purpose of making it navigable for China's commercial, and, some suspect, its naval fleet. Viewed through the lens of epistemic territorialisation, this rendering – the practices, technologies and the subsequent data produced – serves to re-inscribe the Arctic following a distinct geopolitical economy.

One example of such techniques being developed to probe volumetric depths are underwater robots. Described as 'Arctic underwater autonomous/remote-controlled marine environment observation systems', China began deploying them during the country's third expedition to the Arctic Ocean in 2008 (*China News*, 2010). Four years later, during the country's fifth expedition to the Arctic, Chinese scientists deployed a 'large-scale' ocean observation buoy in the Norwegian Sea, another technological first for its Arctic research programme. The buoy allowed Chinese researchers to obtain data on ocean–atmospheric interactions in real time and was lauded as being of 'great significance to … improve China's marine monitoring capabilities' in the Arctic (Xinhua News Agency, 2012).

Following on from such research efforts, in 2014, China's Maritime Safety Administration published a navigational guide for the Northeast Passage, a set of shipping routes stretching from the Bering Strait in the eastern Arctic to the North Atlantic Ocean in the West. Containing information about local hydrological and metrological conditions, nautical charts and descriptions of ice conditions, the guide was published in anticipation of the growing number of largely commercial Chinese vessels navigating the Arctic (Ministry of Transportation, 2014). Two years later, a second guide describing the metrological and hydrological conditions on the Northwest Passage, which snakes its way through the Canadian Arctic Archipelago, was published. 'There will be ships with Chinese flags sailing through this route in the future,' Liu Pengfei, a spokesperson for the agency told reporters as the handbook was presented at a press conference in Beijing (*The Guardian*, 2016). Chinese-flagged and operated commercial vessels have since 2013 begun trading in Arctic waters, when *Yong Sheng*, a 19,000-ton cargo ship, completed a trial voyage across the Northeast Passage, sailing from the northern Chinese port city of Dalian toward the Dutch mega-port of Rotterdam. Over a dozen other Chinese cargo vessels have transited the Arctic Ocean since then, with COSCO, China's major state-owned shipping company, achieving what it has termed as the 'normalisation' of shipping activities in the Arctic (McGwin, 2018).

Visions of the Arctic Ocean as a maritime economic corridor have since crystallised into what Chinese officials and academics have come to call the 'Polar Silk Road'. The term was reportedly initially floated in the 2017 during a Chinese state visit to Moscow, where leaders of the two countries agreed to cooperate on developing shipping in the Arctic (Woon, 2020). The concept then made it into China's first Arctic policy paper published a few months later, officially incorporating the region into Beijing's increasingly globe-straddling Belt and Road Initiative. This change in rhetoric espousing a distinctly Chinese conception of the Arctic has seeped into the country's scientific discourse, too. In 2018, following the release of the Arctic white paper, as China's ninth Arctic expedition was preparing to depart from Shanghai, the logistical base for the country's polar research programme, the expedition's chief scientist told state media that they were setting off for the Arctic 'to support the building of the "Polar Silk Road"' (*China News*, 2018). Another polar expert interviewed for the occasion by the *Global Times*, a state-

affiliated media outlet, stated how 'obtaining data using self-developed instruments will strengthen China's research in the [Arctic] and give the nation a bigger voice on Arctic-related issues' (*Global Times*, 2018).

These ambitions were further bolstered in 2019 when China's first domestically built polar research icebreaker, the *Xue Long 2,* was commissioned. Equipped with a suite of powerful sensors, including multi-beam echosounders for conducting bathymetric surveys (Brady, 2017), the state-of-the-art vessel has given China's Arctic research programme increased mobility and ability to independently study and map the Arctic Ocean. The launch of the vessel was also an exercise in national posturing, signalling a growing interest in the polar regions, and, more importantly, the capacity to act on these interests and to independently study and survey Arctic volumes (Wei et al., 2020). China now operates two polar-capable vessels for conducting research expeditions in the Arctic. It has also made use of other ships in its steadily growing fleet of distant-water oceanographic and survey vessels, such as the *Xiang Yang Hong 01*, a smaller survey vessel launched in 2015, for when its polar icebreaker duo is unavailable (Doshi et al., 2021). Together, these vessels are opening up new scientific frontiers for the country's marine and polar research and at the same time helping to unlock new geopolitical areas of interest. Scientific sensors and other devices, the geopolitical economy underpinning them, and the territorial anxieties they invoke, can, as Helmreich (2019, p. 740) notes, be read as 'symptoms' of a particular form of ocean geopolitics. They epitomise the technological outcomes of certain ways of rendering legible, controlling and securing volumetric spaces. Analysed this way, sensor networks and other forms of scientific infrastructure 'concretise real relations of territorial domination in ocean space'. The geopolitics embedded in these technical artefacts, moreover, allow for the extension of state sovereignty into extraterritorial spaces by expanding states' ability to sense and monitor environments beyond their territorial boundaries (Johnson, 2020). These devices necessitate a physical presence as well. Buoys, gliders, underwater vehicles, weather balloons and research vessels directly occupy the spaces they are sensing (Lehman, 2020). The symbolic aspect of engaging in nationally inflected scientific research in these spaces, and the spatially situated practices of Arctic research, including field expeditions, research stations, and remote sensing, all have territorialising effects, not only through the environmental information produced but also simply by establishing and maintaining a physical presence (Sörlin, 2013). When, for instance, in 2014, Chinese researchers successfully brought online the country's first self-developed ice-tethered buoys in the Arctic Ocean, carrying oceanographic sensors strung along a line reaching hundreds of metres down through the water column, Chinese state media exclaimed, 'the Arctic now has Chinese buoys' (*Science and Technology Daily*, 2014).

While constituting a physical presence in the Arctic, these sensors also represent a move toward unmanned environmental monitoring. As seen with the introduction of new ice-tethered buoys, China's entry into the Arctic has coincided with a wider shift toward remote and robotic sensing in the Earth sciences. Advances in satellite technology as well as new remote-sensing technologies such as unmanned underwater vehicles, ocean gliders and the aforementioned buoys have significantly lowered the human footprint needed for conducting environmental research in remote places (Adler, 2019; Lehman, 2018). China, which has invested heavily in developing new autonomous and remote-controlled sensors for marine and polar research (Fedasiuk, 2021), is increasingly capable of establishing and maintaining a presence in the region and monitoring the Arctic environment in ways that were previously only available to Arctic states, and which require little to no human presence. Shortly after the issuance of China's Arctic policy paper in January 2018, as foreign governments, analysts and international media debated China's territorial ambitions in the Arctic (Moscato, 2018), members of the country's ninth Arctic expedition team successfully transmitted data from an unmanned ice station in the Arctic Ocean back to their home institution in China, announcing that China had now, somewhat ironically, entered 'the era of unmanned observation in the Arctic' (*China Daily*, 2018). Chinese

scientists have also established seasonal unmanned ice stations (Xinhua News Agency, 2014), deployed state-of-the-art autonomous underwater gliders to study Arctic ocean currents (Xinhua News Agency, 2018a), and, most recently, piloted a remote-controlled underwater vehicle to the depths of the Central Arctic Ocean to conduct topographical and geomorphological research along the Gakkel Ridge (*Science and Technology Daily*, 2021).

Adding to this growing array of sensory practices, China has also begun inserting satellites into polar orbit, allowing for more consistent observation of both the Arctic and the Antarctic. It launched its first polar remote sensing satellite in 2019. Named 'Ice Pathfinder', the micro-satellite provides full photographic coverage of the Arctic and the Antarctic (Zhou, 2020). Prior to the launch, the project's lead scientist told Chinese state media that the probe 'will make up for China's lack of polar observation data and reduce its dependence on other countries' for satellite imagining technology (Xinhua News Agency, 2019). The satellite is the first of a proposed network of 24 micro-satellites orbiting over the polar regions (Zhou, 2020). And, at the same time as China flies new eyes in the sky directed at the polar regions, the international community of polar researchers has expressed concern over a possible polar 'satellite gap,' as European and American remote sensing satellites enter the final years of their service lives (BBC, 2021). Plans have also been laid by Chinese institutions to launch a synthetic aperture radar satellite into polar orbit. Described as an 'experimental satellite', it will study sea-ice change and monitor waterways in the Arctic, with the China Academy of Space Technology touting it as being able to provide both more frequent and accurate coverage than existing polar satellites, using radar to peer through cloud coverage that would otherwise blind conventional optical imagery (Xinhua News Agency, 2020). But such sensors are not entirely untethered from their objects of study. Ground stations are required for satellites to transmit their data. In December 2016, representatives from the Chinese Academy of Sciences cut the ribbon at an opening ceremony just north of the Arctic Circle, on the outskirts of the Swedish city of Kiruna, to inaugurate the China Remote Sensing Satellite North Polar Ground Station (CNPGS). Situated at the Esrange Space Centre, a state-owned space research facility, the CNPGS was the first Chinese satellite receiving station to be built overseas. Making use of the geographical advantages of being located within the Arctic Circle, the new ground station would enable Chinese researchers to retrieve satellite data at a significantly faster rate.

In a 2019 report detailing China's space programme, the Swedish Defense Research Agency, a government research agency under the Swedish Ministry of Defense, stressed that satellite data retrieved from the Swedish ground station might ultimately come to serve Chinese military purposes, as images relayed through the Kiruna station could be used to complement Chinese military intelligence and satellite surveillance operations (Lindström & Rydqvist, 2019). Following the release of the report, the research agency told the Swedish national broadcaster that the country had been 'too naive about China's intentions and the country's systematic collection of data and technology', arguing that the Chinese space programme was 'essentially completely militarised', something which had not been accounted for when the cooperation agreement to operate the Kiruna station was signed in the early 2010s (SVT, 2019) Then, in September 2020, the government-owned Swedish Space Corporation, which operates the Esrange Space Centre, as well as ground stations in Australia, Chile, and a host of other countries, stated that it would not renew its contracts with China or enter into any new ones with Chinese partners, including the newly opened CNPGS in Kiruna. 'The geopolitical situation has changed since these contracts were signed in the early 2000s,' a senior representative of the Swedish company told Reuters. 'We have to assess where we can do business and it's harder for us to make that assessment regarding the Chinese market now,' the representative added (Barrett & Ahlander, 2020).

The Chinese Academy of Sciences has also announced a partnership with the Finnish Meteorological Institute to establish a joint research centre for space observation, located in

northern Finland. The proposed centre will 'enhance cooperation' on satellite-based cryospheric research in the Arctic, 'which will provide information from the Arctic region for use in climate research, environmental monitoring, and operational activities, such as navigation in the Arctic Ocean' (Xinhua News Agency, 2018b). Neither of the partners have so far given a timeline for when the facility might open. However, as with the Swedish ground station, security concerns may have prompted Finland to mothball the project. In 2018, a delegation of Chinese polar researchers approached the local government in Kemijärvi, another town in northern Finland, a short distance from the where proposed observatory would be located, with a proposal to purchase the town's airfield. The intention being to use it for research overflights over the Arctic Ocean (Nilsen, 2021). The bid by the Chinese delegation, which reportedly included personnel from the military attaché at the Chinese Embassy in Helsinki, was ultimately blocked by the Finnish Defense Forces (Kopra & Puranen, 2021). Satellites and ground stations again serve to illustrate how producing and transmitting information about the environment, however remotely, come to have territorialising effects (Bennett & Eiterjord, 2023). As with drone technology (Shaw, 2016), a greater reliance on remote sensing and surveillance from afar has effected a change in how we ought to conceive of territory, sovereignty and security, and their technoscientific underpinnings (Del Casino et al., 2020; Wall & Monahan, 2011).

But such infrastructures – the physical installations, networks and sensors that make environmental monitoring possible – possess more overtly territorialising properties as well, establishing a national footprint in far-flung regions (Geissler & Kelly, 2016; Salazar, 2013). In late October 2001, the flag of the People's Republic of China was raised in Longyearbyen, a town on Spitsbergen Island and the world's northernmost permanent settlement, sat midway between the Norwegian mainland and the North Pole. The flag-raising ceremony marked the opening of China's first research station in the Arctic, a three-year field station set up by the newly established Chinese Arctic science expedition. As Chinese state media noted then, studying the Arctic 'is important for research into global climatic changes, oceanology, glaciology and other sciences', noting that besides the region's 'rich reserves of oil, natural gas, krill and other resources', the Arctic is 'of great value in military and aviation fields' (*People's Daily*, 2002). Three years later, in 2004, the country's first permanent Arctic research station was inaugurated in the town of Ny-Ålesund, also on Spitsbergen. Formerly a coalmining town, the settlement has since transformed into an international hub for climate and polar research. Today it houses research facilities from over a dozen different countries, including the United States, India and Japan. The Svalbard Treaty, first signed in 1920, grants Norway sovereignty over Spitsbergen and the other islands that make up the Svalbard Archipelago. At the same time, the treaty also provides other signatories with the right to conduct commercial and, by extension, scientific activities on Svalbard. As a treaty signatory, China avails itself of this opportunity. Its research station, named the Arctic Yellow River Research Station (Liu, 2021), is a located in a characteristically bright red building with an entranceway flanked on each side by a pair of Chinese guardian lions – statues historically found guarding the entrances of imperial palaces and other government buildings, but which in modern times have also become architectural markers abroad where Chinese diaspora have settled down (Pedersen, 2021).

Observers have noted, with some concern, that in many cases, these research stations come to have the 'sheen of flag-showing foreign missions' (Pedersen, 2021, p. 414), serving as platforms for non-Arctic governments eager to gain a strategic foothold in the Arctic. Such stations can best be thought of as spatial interfaces 'between science, politics, industry, environmentalism, and international law in the polar regions' (Wråkberg, 2009, p. 73). Research stations such as these are similar to other forms of 'base-building,' then, in that they offer a form of extraterritorial presence which can be leveraged toward diplomatic and strategic ends (Harkavy, 1982). Speaking specifically of polar research stations, Roberts and Paglia (2016, p. 896) observe how in the Arctic 'the imperative to control territory through science' has been 'complemented by a more general

sense that science may confer a sense of legitimate belonging that need not coincide with exclusive notions of sovereignty'. Scientific practices, through geographical presence as well as by the geographical and environmental knowledge that these practices produce, serve to generate forms of 'symbolic territory' (Powell, 2008; Sörlin, 2013). Whether as symbolic territory or a form of strategic presence, in the case of the Arctic, scholars have warned that such stations 'could potentially embolden some state actors, including great powers, with regional aspirations – and become a real security challenge for host nation Norway' (Pedersen, 2021, p. 417).

Disagreements about the sovereignty over these research stations have recently come to the fore. In 2019, the Norwegian Research Council's draft research policy for Ny-Ålesund, which sought to regulate and ultimately narrow down the scope of permitted research activities, was opposed by the Chinese delegation. In its response to the draft policy, the delegation argued that the Norwegian government was overstepping its mandate and that China, as a treaty signatory, had unilateral control over the research activities conducted at the Chinese station (Svalbardposten, 2019).

Although such controversies might not appear to concern Arctic volumes directly, research stations are key components of the volumetric geopolitics of the Arctic. As with the buoys and robots and satellites noted above, these facilities afford states the ability to intervene in the region geopolitically. By housing sensors for conducting scientific observations and antennas for receiving remotely sensed data from satellites, these places at once occupy places and help render them. China's second Arctic research station, the China–Iceland Arctic Observatory, was formally inaugurated in 2017. The station, which lies tucked away in a valley in northern Iceland, has attracted suspicion from certain corners ever since it was announced in 2013. A former official from the Organization of Security and Co-operation in Europe noted in 2014 that China might want to use the station to surveil NATO airspace. When asked about these suspicions, an Icelandic representative from project replied, 'Why build a station here in the valley to spy on us? Much easier to rearrange some of their satellites to spy on us' (Thiesing & Lawless, 2016). Accusations of espionage were brought up again during the opening of the station, when the Icelandic vice-chair of the project told a journalist there was 'was no equipment in the building capable of telling China anything they didn't already know'. Gesturing to one of his Chinese colleagues, he quipped that 'If he's a spy, then I'm James Bond' (Schreiber, 2018).

Here we should consider what Lehman (2018) has termed the geosciences new 'sensing relations' – the changing divisions of labour between humans and machines in sensing the Earth – and examine these geopolitically. As the global geopolitical landscape shifts toward a more contentious relationship between, in this case, China and the West, the political geography of sensing volumetric spaces is changing, too. Oceanography, meteorology, and other fields of geoscientific or atmospheric research that take scientists or their sensors into the field are invariably bound up with broader geopolitical processes: *who* performs what types of research, and *where* are not innocent questions, but rather points of entry for us to problematise the territorialisation of volumetric and remote spaces.

Such concerns over Chinese sensory presence in the Arctic were visible in 2015, when, at a gathering of Chinese and Canadian polar researchers at the Canadian Embassy in Beijing, Yang Huigen, director of the Polar Research Institute for China, reportedly stated during a question-and-answer session that China was interested in establishing a long-term research station in Canada's Northwest Territories. The seemingly off-handed comment made headlines, with one Canadian newspaper reporting, 'In a sign of China's growing ambitions to extend its global reach, its researchers now say they covet Canada's northern landscape for the knowledge they might glean' (Vanderklippe, 2015). During the event, a second senior Chinese scientist explained:

> We are interested in not only science, but also … oil and gas. … In that sense, we need to have information, access to all this data, in order to make informed decisions. … In the past, if Chinese scientists

> wanted to have access to Canadian or Russian territories, we have faced tremendous obstacles to have permitting [*sic*]. If we had a permanent establishment, it would be much easier. (Vanderklippe, 2015)

The Canadian national broadcaster similarly reported that 'China has been interested in Arctic resources for years', quoting a Canadian political scientist who stated that he was 'Not at all concerned that we, Canada, cannot well protect our sovereign interest … while at the same time finding important areas of co-operation and common interest with China' (CBC, 2015). In an interview two days later with the state-affiliated *Global Times*, Yang denied having made the suggestion (*Global Times*, 2015). Yet, as one Canadian Arctic expert tellingly put it when asked for a comment about the case to Canadian media, 'Do you necessarily want to give a state that is that authoritarian a set of abilities to observe within the North?' (Vanderklippe, 2015).

6. SOVEREIGN KNOWLEDGE AND SECURITISED VOLUMES

With China emerging as a global power, with stated aspirations of becoming both a naval and polar power, knowledge about Arctic volumes – its water column, sea ice cover, underwater topography as well as weather patterns – is increasingly being reframed as a strategic resource. As a result, the volumetric Arctic is becoming more securitised. Framing environmental knowledge in terms of sovereignty goes some way toward explaining this dynamic. Dodds and Nuttall (2016, p. 88), drawing on Virilio (1989), illustrate the contentious politics of rendering volumetric space: 'the side that can see further and extensively, can gather more information, which can react quicker and whose reach is longer and deeper, has the potential to be the most powerful'. This accentuates the 'zero-sum aspects of scientific undertakings', amounting to a form of 'strategic science' (Cloud, 2001; Doel et al., 2014), namely any '[scientific] activity that potentially advances relative national power and influence through strategic presence' (Pedersen, 2021, p. 4). The Arctic, when conceived of volumetrically, emerges here as an 'exclusive operational area' (Pedersen, 2021, p. 104), at once a technoscientific space and a military–strategic space, where outside knowledge about its volumetric spaces have implications for the national security of Arctic states.

In point of fact, Pompeo, in his speech that opened this paper, invoked the spectre of a China gaining enough knowledge about the geophysical Arctic, particularly its maritime volumes, to the extent that the country could operate its own nuclear-powered submarines in the Arctic Ocean. This statement rested on an assessment made earlier that year by the US Department of Defense. In its annual report assessing the military capabilities of the People's Liberation Army, China's armed forces, the Pentagon warned about the country's activities in the Arctic region, going so far as to dedicate a section to China's capabilities in the Arctic. Among the possibilities included in the report was the concern that China's 'civilian research could support a strengthened Chinese military presence in the Arctic Ocean', including 'deploying submarines to the region as a deterrent against nuclear attacks' (Office of the Secretary of the Department of Defence, 2019).

Similar observations have been made by intelligence agencies in other Arctic states, too. In 2021, the Norwegian Intelligence Service included for the first time a section dedicated to China's activities in the Arctic in their own annual threat assessment. China's first domestically built polar research icebreaker, *Xue Long* 2, featured in an accompanying image with a caption stating, 'China bolsters its capability to operate in the Arctic' (Norwegian Intelligence Service, 2021, p. 10). The report highlighted how 'China's intentions in the [Arctic] are questioned by other powers', particularly when it comes to activities 'that can be used for both civilian and military purposes, such as activities in space and various types of research' (Norwegian Intelligence Service, 2021, p. 77). A report released by the Danish Intelligence Service in 2020 drew a more explicit link between China's Arctic research programme and its potential military interests

in the region, noting that although 'specific Chinese military activity in the Arctic is still very limited', it is 'likely that some of China's efforts to build up Arctic knowledge and capabilities for Arctic operations will be a concerted effort between civilian and military actors, where civilian research results can also be used by the military' (Danish Intelligence Service, 2020, p. 20). The report concluded that China's activity in the region is increasing when it comes to 'knowledge and capability build-up within fields such as climate research, space research, research on satellite communication, and Arctic navigation' (p. 20).

Analysts have warned of the possibly malign intentions of China's scientific presence in the Arctic. A 2021 policy report by researchers at the Canadian Global Affairs Institute asks whether China's two polar-capable research vessels, *Xue Long* and *Xue Long 2*, are in fact 'trojan dragons' that have, under the guise of civilian scientific research and climate science, made it possible for China to enhance its knowledge of the Arctic environment and map Arctic resources, knowledge which, the report notes, 'supported its announcement of a Polar Silk Road in 2018' (Millard & Lackenbauer, 2021, p. 25). The authors see these research vessels as platforms for China to gain, amongst other things, operational knowledge about the region. The report concludes that, 'in addition to its overt scientific goals, [*Xue Long*] was and is intentionally employed under the cover of science and scientific collaboration to intentionally normalize … China's presence in the region and the [Chinese Communist Party's] revisionist self-assertion as a near-Arctic nation' (Millard & Lackenbauer, 2021, p. 24). Other expert observers have likewise called for Arctic governments to face up 'to China's military interest in the Arctic', flagging Beijing's submarine ambitions in the Arctic (Brady, 2019), and raising the country's recent underwater acoustic research in polar waters as an example that might facilitate a military–and thus more volumetric–presence in the region (Martinson, 2022). Others have attempted to soothe these concerns (Lajeunesse & Choi, 2022; Tunsjø, 2020). Nevertheless, these controversies tell us something critical about not only Chinese activities in the Arctic, or the perceptions of these activities, but of the intersecting, overlapping, and often conflicting attempts to territorialise volumetric space. Chinese efforts to render the Arctic legible becomes in this sense another layer of the 'Arctic as a palimpsest', reterritorialising the region according to a different geopolitical calculus (Dodds, 2010, p. 66). Further, such forms of territorialisation, techno-scientifically mediated as they are, problematizes conventional notions of both territory and sovereignty by enabling forms of 'remote presence', or even remote control (Bennett & Eiterjord, 2023; Shaw, 2016).

In August 2019, a few months after Pompeo's fiery Rovaniemi speech, Jens Stoltenberg, Secretary-General of NATO, stated in a televised interview that China was 'coming closer' to Europe and that the security organisation was recalibrating its focus in order to, among other things, 'counter China's presence in the Arctic' (Meredith, 2019). At an event hosted by the Atlantic Council in 2021, when asked about the security implications of China's growing interest and presence in the region, the secretary-general responded that:

> And increased Chinese interest and presence … just increases the importance of the Arctic, also with a potential new sea route, a North-East sea route from Europe to Asia. And all of this matters for our security. So therefore, NATO is also increasing its focus and its presence in the Arctic. (NATO, 2021)

Later that same year, during an interview with journalists from the *Financial Times*, the NATO chief, hinting at China's new remote and volumetric presence in the far north, warned that 'China is coming closer to us. … We see them in the Arctic' (Khalaf & Foy, 2021).

7. CONCLUSIONS

This paper has sought to point to the importance of examining the epistemic underpinnings of volumetric geopolitics, and to foreground the practices and technologies that turn space legible.

China is emerging as a new state actor wielding scientific research as a political technology to (re)render Arctic volumes legible, driven, in the eyes of many foreign observers, by an at times indistinguishable mixture of environmental, geo-economic and military–strategic interests. It has shown how the Arctic, when conceived of as a volumetric space, is being territorialised and securitised. It has described in some empirical detail China's scientific footprint in the Arctic, and, by analysing these activities through the lens of epistemic territorialisation, shed light on the changing geopolitics of Arctic science. The paper has provided a snapshot of the perceptions that Arctic states hold regarding China's scientific presence in the region as a way to underline how the changing geography of knowledge about the Arctic's earthly volumes amounts to a form of epistemic territorialisation.

Following Russia's invasion of Ukraine in February 2022, however, circumpolar cooperation has collapsed, with the seven remaining Arctic states deciding to pause the work of the Arctic Council. Academic boycotts by European and North American universities and research institutions against their Russian peers have all but frozen research collaboration with the country. The war is also urging NATO further north, with Finland having gained membership to the defense alliance and Sweden seeking to do the same. At the same time, Russia's militarisation of its Arctic territories continues. More work needs to be done to understand how renewed geopolitical competition is impacting the ways in which international science is conducted in the Arctic.

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