

The Arctic Twittersphere and the Russian Invasion of Ukraine

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ABSTRACT. Social media use has grown in popularity in recent years, becoming a primary source of information for many. Several scholarly inquiries have analyzed how the Arctic region has been portrayed in traditional media. However, no study has comprehensively detailed how the region has been presented on social media. The objective of this article is to sketch the contours of the Arctic discussion on Twitter and to inquire whether significant geopolitical events impact the nature of the online discussion. Using tweets on Arctic issues published between January 2020 and August 2022, we assessed the timing, prevalence, and nature of messages about the circumpolar North. Overall, the Arctic conversation on Twitter is first and foremost an Arctic climate conversation, focusing on climate change, Arctic sea ice, and permafrost thawing. Climate issues are the most salient ones and are treated independently from other topics by online users. We assessed whether the Russian invasion of Ukraine changed this dominance. We found that the Arctic Twittersphere remained still predominantly focused on climate issues, although the invasion increased Arctic military security discussions dissociated from other diplomatic or natural-resources considerations.

Keywords: social media; Russia/Ukraine; invasion; Arctic security; Twitter; climate change

RÉSUMÉ. Ces dernières années, l'utilisation des médias sociaux a gagné en popularité, devenant une source primaire d'information pour bien des gens. Plusieurs enquêtes de recherche universitaire ont analysé la manière dont la région de l'Arctique a été représentée dans les médias traditionnels. Cependant, aucune étude n'a entrepris de démontrer en détail comment la région est présentée dans les médias sociaux. L'objectif de cet article consiste à esquisser les contours de la discussion au sujet de l'Arctique sur Twitter et à se demander si les événements géopolitiques importants ont des incidences sur la nature des discussions en ligne. À l'aide de gazouillis sur les enjeux de l'Arctique publiés de janvier 2020 à août 2022, nous avons évalué les dates, la fréquence et la nature des messages portant sur le nord circumpolaire. Dans l'ensemble, la conversation au sujet de l'Arctique sur Twitter porte principalement sur le climat de l'Arctique, plus précisément le changement climatique, la glace de mer de l'Arctique et la fonte du pergélisol. Les enjeux climatiques sont les enjeux les plus importants et ils sont traités indépendamment des autres sujets par les utilisateurs en ligne. Nous avons évalué si l'invasion de l'Ukraine par la Russie a changé cette prédominance. Nous avons constaté que la Twittersphère de l'Arctique a principalement continué de se concentrer sur les enjeux climatiques, bien que l'invasion ait eu pour effet d'intensifier la discussion sur la sécurité militaire de l'Arctique, dissociée des autres considérations diplomatiques ou des considérations propres aux ressources naturelles.

Mots-clés : médias sociaux; Russie-Ukraine; invasion; sécurité de l'Arctique; Twitter; changement climatique

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INTRODUCTION

In the span of a decade, social media became central to the dissemination of political information. Public relations and disinformation campaigns alike have attempted to influence popular perceptions, whether by playing the long game, such as favouring European far-right parties, or in high-stakes situations such as the U.S. presidential election or the Russian invasion of Ukraine.

However, we have a poor understanding of how the Arctic region is framed and talked about on social media. Empirical studies have been published that analyze Arctic coverage in traditional media (Gritsenko, 2012; Pincus

and Ali, 2016; Landriault, 2020), yet comprehensive assessment of social media coverage has escaped scholarly investigation. Rather, studies linking social media and the Arctic focused on specific phenomena taking place in the region, for example, tourism, Inuit activism, and development (Castleton, 2018; Spence, 2019; Runge et al, 2020), without looking at the overall discussion about the Arctic on social media. This article will remedy this knowledge gap and focus on how the Arctic region has been framed and which topics were salient on one social media platform: Twitter/X.

We assess whether influential geopolitical events are likely to change the dominant narratives and impact the

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topics raised by users. Messages posted by users before and after the Russian invasion of Ukraine will be studied. This event was chosen because of the seismic consequences it had on Arctic governance: the suspension of the activities of the Arctic Council and the suspension of Russia-related activities at the Barents Euro-Arctic Region marked a breaking point in Arctic co-operation. The emergence of new global geopolitical tensions and the deployment of military capabilities also represented a rupture in international relations. Did it have an impact on the nature of messages posted in the Arctic Twittersphere?

In this paper, we review to what extent media representations of the Arctic region have already been studied in scientific literature, followed by an analysis of when and how Twitter/X users post about the Arctic region. We then zero in on the Russian invasion of Ukraine and evaluate whether the invasion and its Arctic consequences had quantitative (in terms of number of posts) and qualitative (in terms of nature of content, topics) impacts on the Arctic discussions on Twitter/X.

MEDIA AND THE ARCTIC

Between 2010 and 2020, an increasing number of researchers have conducted frame and discourse analyses to detect how the Arctic is represented in various media (Christensen, 2013; Christensen et al., 2013; Wilson Rowe, 2013; Bērziņa, 2015; Pincus and Ali, 2016; Christensen and Nilsson, 2017; Padrtova, 2019). This spike in Arctic media coverage coincided with an increased attention to climate and environmental issues. Nicol, for example, analyzed topics in the Canadian press for a period of four decades and demonstrated that the region had more media visibility after 2007 (Nicol, 2013). Christensen (2013) discussed how the 2007 and 2012 minimums of Arctic Sea ice intensified media coverage of the polar region. Other factors, such as economic opportunities (Pincus and Ali, 2019) and geopolitical tensions (Klimenko, et al., 2019) are also believed to have increased attention to the region. Landriault (2020) also showed that salient events such as visits by political leaders, military exercises, and transits of cruise ships generated significant media attention, although the attention was often short-lived.

Despite the growing number of studies on Arctic media content, the literature lacks a broad analysis of media content. Indeed, most of these studies focus on the analysis of a limited number of issues or on a national context. Thus, a significant portion of Arctic press-coverage analyses focuses specifically on climate change issues (Christensen et al., 2013; Stoddart and Smith, 2016; Christensen and Nilsson, 2017; Stenport and Vachula, 2017; Padrtova, 2019; Pincus and Ali, 2019). Editors Christensen et al. (2013) discuss the role of media coverage of Arctic sea ice in the global climate-change debate. The Arctic sea ice cover and polar bears have become iconic images and are often mobilized in media communications about the global

impacts of climate change (Christensen, 2013; Christensen and Nilsson, 2017). Beyond images, media content is characterized by the predominance of scientific voices that “confirm the scientific certainty of climate change, in contrast to the focus on uncertainty that had previously dominated, particularly in the U.S. media” (Christensen and Nilsson, 2017:258). In a content analysis, Stenport and Vachula argued instead that the media reproduce an ideology in which cultural representations of the Arctic undermine Western societies’ acceptance of climate change. The media employ imagery that promotes a representation of the Arctic as otherworldly, thereby dissociating the region and its climate change from the Western sphere for the general public (Stenport and Vachula, 2017).

In addition to analyses focusing on climate change, other content analyses have looked at the press coverage of the race for the Arctic. Through their analysis of media in the United States, Pincus and Ali (2016) described the increased tendency in the Western press to address environmental issues by highlighting their connection to energy and economic issues. They argue that media framing is created by outsiders with a mindset of corporate profitability for outsiders (Pincus and Ali, 2016). For example, the opening up of the Arctic is frequently discussed in relation to discourse around efforts to rapidly locate, claim, and exploit Arctic resources, creating a distortion between reality and media representations of the Arctic (Pincus and Ali, 2016). Similar conclusions were reached by Landriault (2016) while analyzing opinion pieces in the Canadian press. Both the race and struggle for the Arctic were central framing narratives relayed by editorialists and experts alike: these constructs did not match well with facts and reality on the ground.

Looking at security, Barbora Padrtova (2019) offered an analysis of media representations of the Arctic at the national level; she identified four narratives in which newspapers played a securitizing actor role by presenting the Arctic as linked to various security issues. Thus, U.S. media tended to represent the region through at least one of the following security prisms: economic security, environmental security, political and military security, or societal security (Padrtova, 2019).

Some press-coverage studies focus on the content of Russian media. In a broader analysis of national media coverage, Gritsenko analyzed Russian media content between 2011 and 2015 and showed the presence of two dominant topics in the media: energy resources and geopolitical and security dynamics (Gritsenko, 2012). Gritsenko noted a correlation between media coverage of the Arctic and changes in government policies (Gritsenko, 2012). Researchers have addressed the dichotomy between conflict and co-operation in the press. Wilson Rowe demonstrated that Russian media between 2008 and 2011 framed the Arctic as a zone of co-operation rather than conflict (Wilson Rowe, 2013). Bērziņa (2015) analyzed official governmental discourses present in Russian media and noted a difference in content between discourses

aimed at international audiences (where the focus was on co-operation) and discourses with a domestic focus (where efforts were made to address the strategic importance of the Arctic to Russia, to fuel nationalistic sentiment). Content analysis of Russian newspapers published between 2007 and 2016 illustrated the influence of events such as the conflicts in Ukraine and Syria on Russian media coverage (Klimenko, et al., 2019). An increased number of articles have as their topics the development of military activities, the military strategies of Arctic states, and the possibility of conflict (Klimenko, et al., 2019). However, this narrative was approached from a different angle than Western media, as Russian media described it as “a potential threat to Russia” (Klimenko et al., 2019:26).

The studies previously mentioned were able to generate considerable insights as to what topics, frames, and issues are most often mentioned when referring to the Arctic region. Likewise, we have a good understanding of variables contributing to increased media attention on the Arctic and agenda-setting effects caused by media outlets. However, it should be noted that the media analyses cited above concentrated almost exclusively on traditional media, especially newspapers. Only one (Landriault, 2020) devoted attention to social media, albeit as a secondary thought (only one chapter out of five). Spence (2019) represented a rare addition by assessing the circulation of policy ideas on Arctic development on Twitter. We agree with Spence on the necessity of evaluating social media content, since “the barriers that have limited the participation of different types of actors in different locations are being broken down” by social media interactions (Spence, 2019:26). Others have studied how online platforms such as Facebook, Twitter, and YouTube empowered Inuit activists or represented new avenues for expressing Inuit culture and traditions. For Castleton (2018), Facebook has played a role in expressing Inuit identity, while for Rodgers and Scobie (2015) and Wachowich and Scobie (2010) social media have allowed Inuit activists to defend traditional practices, for example with the use of the #sealfie. Others, such as Aldao and Mihalic (2020) and Runge, et al. (2020), used social media data as a data source to document Arctic tourism trends and patterns.

Although rare in comparison to traditional media analyses, these studies offer valuable contributions to understanding how users position themselves on social media and interact with others. However, these are case studies focusing on specific examples or topics (Inuit activism, tourism, Arctic development) related to the Arctic region and social media. This article aims, rather, to provide a comprehensive overview of the Arctic discussion. As such, we evaluate the main contours characterizing the Arctic conversation on Twitter, focusing on the nature, intensity, and timing of messages posted.

METHOD OF ANALYSIS

To collect tweets for our analysis, we used the R language, as it is open-source and offers multiple packages for statistical computing. Specifically, we resorted to the *academictwitteR* (Barrie and Ho, 2021) and to the *quanteda* (Benoit et al., 2018) packages. While the first package allowed us to query our tweets, the second package allowed us to prune our tweets, tokenize them, and create a document-feature matrix (DFM). It is worth noting that other packages were utilized to generate our research and that only English-language tweets were collected to create the corpus for our analysis.

Although our initial query consisted of multiple keywords, we filtered our corpus to retain only tweets that included the word “Arctic.” Other words were considered, such as “High North” or “Circumpolar North,” but they were either too niche, geographically limiting, or used sparsely in comparison to the term “Arctic.” Moreover, we also screened those tweets to exclude all messages or handles that were not referring to the Arctic region. In the end, our dataset compiled 1,555,984 unique tweets encompassing the word “Arctic,” dating from 1 January 2020 to 31 August 2022.

Using that database, we created a dictionary to decipher the prevalence and co-occurrence of topics within our sample. First, we used a latent Dirichlet allocation statistical model to perform topic modelling on the publications. This allowed us to find relevant keywords and topic associations throughout the publications. Then, we proceeded with a manual review of a randomized sampling of the publications to compare with the automated method findings. Finally, we also added relevant keywords based on literature and general knowledge of the issues. As a result, we decided to track six topics: environment, military and security, diplomacy, natural resources, animals and nature, and Indigenous issues.

While the words chosen to create our dictionary were somewhat subjective, they were chosen with the utmost diligence according to our literature review and general knowledge about issues in the Arctic region (Laver and Garry, 2000; Pennings and Keman, 2002; Benoit and Laver, 2003; Martin and Vanberg, 2007; Lowe, 2008; Slapin and Proksch, 2008; Grimmer and King, 2010; Lowe et al., 2011). Overall, our dictionary detected 1,259,108 mentions in our dataset of the keywords used to create our topics. While that number is impressive, it represents almost 40% of the tweets, which amounts to 593,675 unique interventions. To broaden our perspective, we performed some of our analysis twice: once on the dataset as a whole and subsequently on a subset containing only tweets that mentioned our topics’ keywords. It is worth mentioning that some of those tweets contained more than one theme, meaning there was an overlap of some issues in the Twittersphere.

Following the creation of our dictionary, we used a principal component analysis (PCA) to visualize the geospatial localization of each topic in relation to the

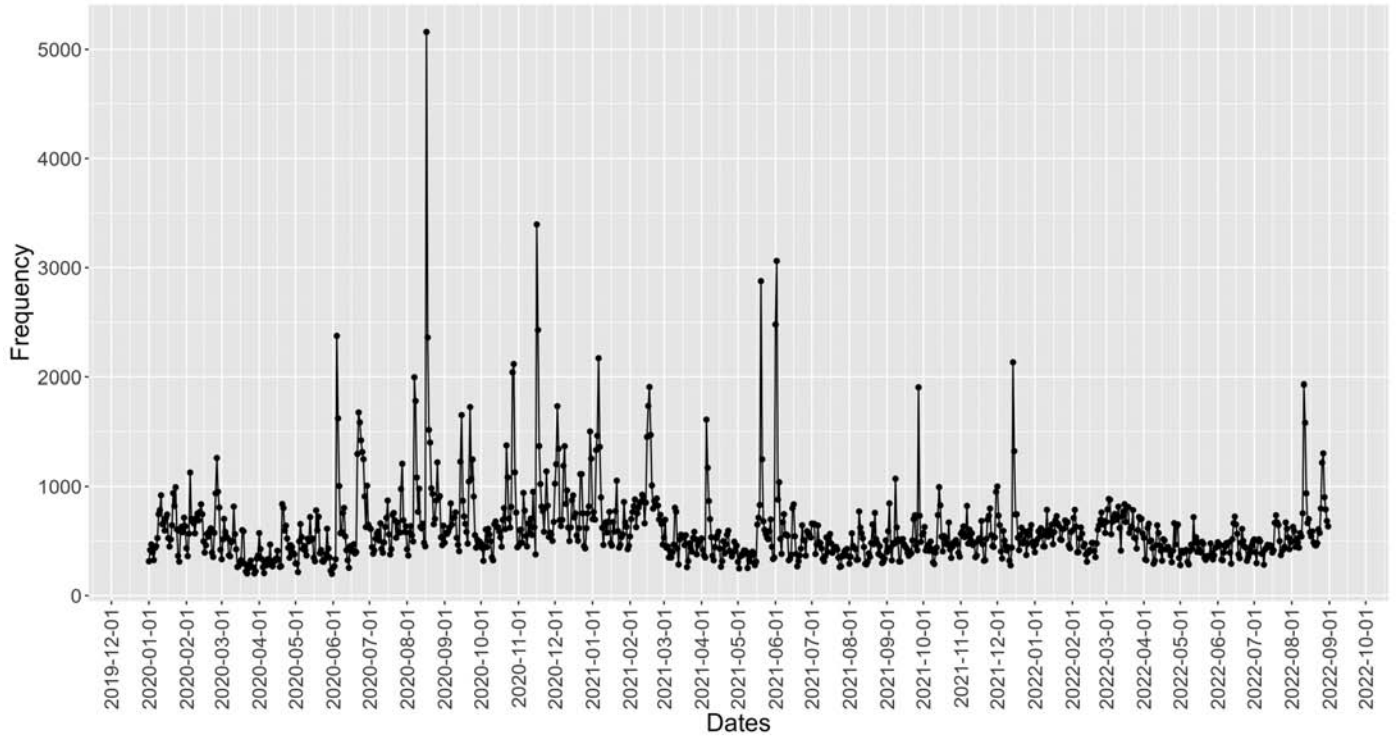


FIG. 1. Frequency of tweets from 1 January 2020 to 31 August 2022.

others. This analysis also allowed us to identify clusters, which signify that users are employing similar keywords in their posts, and correlations between topics, which mean some topics overlap each other. Moreover, we performed a paired t-test on our topics to assess whether there was a statistically significant difference in the topics discussed in the Arctic Twittersphere between two moments (Jankowski et al., 2018).

In this case study, the Russian invasion of Ukraine on 24 February 2022 was used as a point of reference. To strengthen our findings and to complement the significance level of our paired t-test, we performed a Cohen's *d* to qualify the effect size between the topics in our pre-invasion and our post-invasion samples (Cohen, 1988). In other words, this will allow us to determine whether the differences we observed between topics before and after the beginning of the Russian invasion of Ukraine were statistically significant or not.

RESULTS

The Arctic Twittersphere: Intensity and Topics

We first draw the contours of the Arctic discussions on Twitter. The number of tweets from 1 January 2020 to 31 August 2022 remained roughly stable, with a slight upward trajectory from January 2020 to February 2021 (Fig. 1). We also observed peaks at different points in the timeline, but these were short-lived, lasting a few days, and were driven by specific developments. Table 1 details the stories

driving each peak (over 3500 tweets/day). Only two peaks were the result of Arctic diplomatic initiatives: the 2021 Arctic Council Ministerial meeting and the 2021 Arctic Circle Assembly. These salient stories had to be coupled with other developments to reach this level of global notoriety, be it high-level diplomatic discussions between Russia and the United States, or the European Union unveiling a new Arctic policy. On that list, environmental issues and natural resources stories were overwhelmingly represented, especially when they took place in the United States or Russia. There was special emphasis put on either the consequences or the extent of global warming for the region (heat wave, cold wave, August 2022 report) or the environmental downfall of natural resource extraction (Norilsk oil spill, Arctic National Wildlife Refuge). Hence, heightened attention on social media differed from increased coverage on traditional media. Legislation or natural phenomena elicited more coverage on Twitter than visits from elected representatives or announcements by governmental decision-makers.

Special emphasis on environmental issues was also observed, which was later confirmed when looking at the prevalence of different topics. We tracked six topics: environmental, military, diplomatic, natural resources, animal/nature and Indigenous issues. Based on our dictionary, the Arctic discussion on Twitter was predominantly one about climate change and environmental protection (Table 2).

Arctic references on Twitter were first and foremost about climate change and its consequences, including the loss of Arctic sea ice, permafrost thawing, and wildfires.

TABLE 1. List of salient stories discussed in the Arctic Twittersphere.

Dates	Events
3–6 June 2020	Oil spill in Norilsk, Russia
21–26 June 2020	Heat wave in Siberia
17–18 August 2020	Trump administration announces drilling plan for the Arctic National Wildlife Refuge
16–18 November 2020	Trump administration announces sale of oil leases in Arctic National Wildlife Refuge
15–19 February 2021	Cold wave over Texas, United States
18–21 May 2021	Blinken-Lavrov meeting, Arctic Council Ministerial meeting
1–2 June 2021	Biden administration suspends oil and gas leases in Arctic National Wildlife Refuge
14–15 October 2021	Arctic Circle Assembly, release of the updated European Union Arctic policy
3 February 2022	Cold wave over Texas, United States
11–12 August 2022	Release of report documenting the speed and severity of global warming for the Arctic region Passing of the Inflation Reduction Bill in the United States, with impact on Alaska

Environmental issues led all other topics with 512,795 mentions, far more than the second most discussed theme (natural resources, 318,897 mentions). The Arctic discussion was mostly concerned with presenting the Arctic region as a bellwether of global warming, but also as a measure of the speed and intensity of climate change. Examples of heat waves or wildfires in the Arctic region are often used by climate activists to frame the climate issue as a crisis or emergency, highlighting the abnormality of such phenomena. Moreover, users were focusing on specific cases and stories when engaging on the natural resources theme. Substantial attention was devoted to controversial resource development projects and their potential ecological footprint, such as the Arctic LNG 2 project, mineral extraction in Greenland, the expansion of the Mary River mine in Canada, or oil leases in the Arctic National Wildlife Refuge. It is worth noting that the diplomacy and military security topics were near the bottom of the list. The animals/nature theme was more popular, although it shared lighter content, presenting mostly pictures of the Arctic flora and fauna.

However, tweets were not all monothematic: topics were combined, and associations were drawn connecting topics and stories. For example, posts on natural resources could emphasize the potential environmental damage of a project, the impact on Indigenous communities, or the military/strategic importance of a project for an Arctic state. Likewise, a tweet on Arctic diplomacy could refer to Indigenous organizations active in Arctic fora, agreements on environmental protection or climate mitigation, or the establishment of resource management regimes. Analyzing the combinations of topics is pivotal to understanding how users associated some topics and not others.

Principal Component Analysis (PCA) of Topics

We looked at the entire timeline under study, from 1 January 2020 to 31 August 2022, to assess the prevalence of the six topics in our dictionary. A few topics appeared in tandem, as they were often connected by users. For one, the environmental theme (referring to climate change and permafrost thawing) was treated in isolation and not framed as either a diplomatic (international agreements, for example), a military (impact on different military

TABLE 2. Number of topics mentioned in tweets.

Topics	Frequency	Percentage (%)
Animals and nature	132,770	14.11
Diplomacy	30,865	3.28
Environment	440,946	46.88
Indigenous issues	25,412	2.70
Military and security	99,929	10.62
Natural resources	210,720	22.40

organizations), or an Indigenous issue (Fig. 2). More surprisingly, the environmental theme was not connected in a statistically significant fashion with the natural resources theme: extraction of strategic minerals or oil and gas deposits and the adverse effects on the climate were not often underlined. Rather, climate change was addressed separately from other topics; it focused on heat waves, record temperatures, and the consequences of global warming on the Arctic region.

A strong, positive correlation existed between two sets of topics. The diplomacy and military topics existed in tandem: messages often referred to diplomatic meetings, multilateral forums, and agreements while mentioning military capabilities, military exercises, and threats.

The natural resources and animals/nature topics were also strongly correlated. Discussions about the exploitation of natural resources intersected with posts and pictures about the Arctic fauna and flora as well as animal behaviour. The (real or potential) impact of resource development on Arctic fauna and flora represented a fusion of these two topics.

Moreover, the Indigenous issues theme was not meaningfully connected to other topics in users' posts. Messages often mentioned Indigenous Peoples, issues, and stories but without connecting them to diplomatic initiatives or environmental changes and impacts. These tweets were either celebratory, in many cases commemorating a holiday or national/international day related to Indigenous Peoples, or they mentioned Indigenous Peoples in passing while referring to a broader topic. The only theme associated with Indigenous Peoples was natural resources, but this association was weak.

Overall, three conversations emerged: one centred on the environment and climate change, one on strategic and geopolitical issues, and one on the preservation or

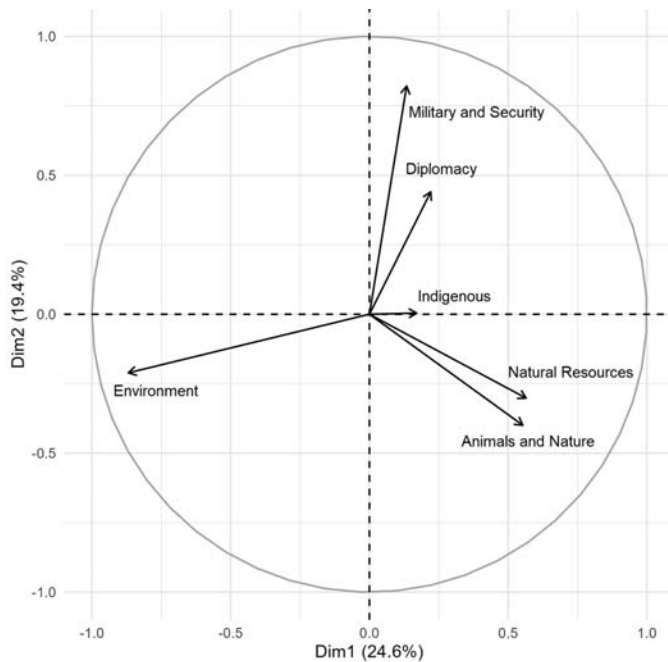


FIG. 2. PCA of Arctic topics on Twitter from January 2020 to August 2022.

exploitation of nature for commercial purposes. We expected the strategic and geopolitical issues conversation to increase in popularity after the Russian invasion of Ukraine and to spill over into other conversations; discussions about climate change or economic development in the region would then be coloured by the realignment of alliances and the geopolitical consequences of the invasion.

The Impact of the Russian Invasion of Ukraine on the Arctic Twittersphere

Relatively isolated from global geopolitical dynamics, the Arctic region has been deeply impacted by the Russian invasion of Ukraine. The Arctic Council, created in 1996, suspended its activities for the first time on 3 March 2022, following the start of the Russian invasion. Starting in June 2022, only activities not involving Russia were continued by the other Arctic states. Great uncertainty plagued the Council afterward, with states unsure about the possibility or the timing of a return to normal and pre-invasion level of co-operation. The invasion also convinced Sweden and Finland to apply to join the North Atlantic Treaty Organization (NATO), in order to join forces with fellow Western states against an expansionist and aggressive Russia. This change spurred questions about the potential consequences for Arctic security. Add to this mix, the suspension of Russian participation in subregional mechanisms such as the Barents Euro-Arctic Region and we were confronted with a more antagonistic, uncertain Arctic political landscape.

The expectation was that the turbulence and interrogations would generate more public attention, and that discussions would multiply to make sense of

these new dynamics and predict future courses of action. Quantitatively, we did not observe an increase of posts in the Arctic Twittersphere after the start of the Russian invasion of Ukraine. On the contrary, we detected a downward trajectory after 24 February 2022, with a faint rebound in July 2022. Brief periods of saliency were spotted for the term “Arctic Council” on 3 March 2022 (suspension of activities of the Council) and 8 June 2022 (statement announcing partial resumption of activities), but those were short-lived and did not stimulate broader reflection for most users. Other salient stories after 24 February 2022 were only remotely connected to the Arctic: the signing of the Canada/Denmark agreement on Hans Island (14 June), the passing of the Inflation Reduction Bill in the U.S., and the release of a report on the impact of global warming on the Arctic (11–12 August), or the visit of the NATO secretary general to Canada (26 August). Hence, the invasion and its Arctic consequences did not capture public attention on Twitter in a sustainable fashion, even when faced with a highly uncertain future.

To get a more accurate picture of the impact of the Russian invasion of Ukraine on the Arctic Twittersphere, we decided to divide our corpus into pre-invasion tweets, from 24 August 2021 to 23 February 2022, and post-invasion tweets, from 24 February 2022 to 23 August 2022. Therefore, we were able to determine whether there were significant changes, and to measure the effect size on the Arctic region topics by comparing their appearance in the two time periods. We identified three clusters of conversation based on our topics, namely (1) environment, (2) military/security and diplomacy, and (3) Indigenous issues, natural resources, and animals and nature. That is, we concluded there was an overlap between military/security and diplomacy topics in the content of the discussions posted by users and that the same type of correlation can be observed between the Indigenous issues, natural resources, and animals and nature topics. As for the environment topic, it stands on its own, which means it does not include (or rarely includes) the lexicon of the other topics. While those clusters of conversation are all interesting, the section below focuses mainly on the strategic and geopolitical issues created by the diplomacy and military/security topics.

While the pre-invasion PCA revealed similarities with the overall timeline, we observed a surge in the correlation between the military/security topic and the diplomacy topic. We assumed that the rise of tensions between Russia and Ukraine influenced the discussion of the Arctic region in the Twittersphere and brought forth a stronger linkage between those two topics as the prospect of a military conflict escalated and diplomatic talks were underway. As for the post-invasion PCA, we distinguished a disconnection from the diplomacy and military/security topics. Even though they remain correlated, those topics were more independent in the post-invasion timeline than in the pre-invasion timeline. In other words, the Arctic military discussion became more and more dissociated from diplomatic

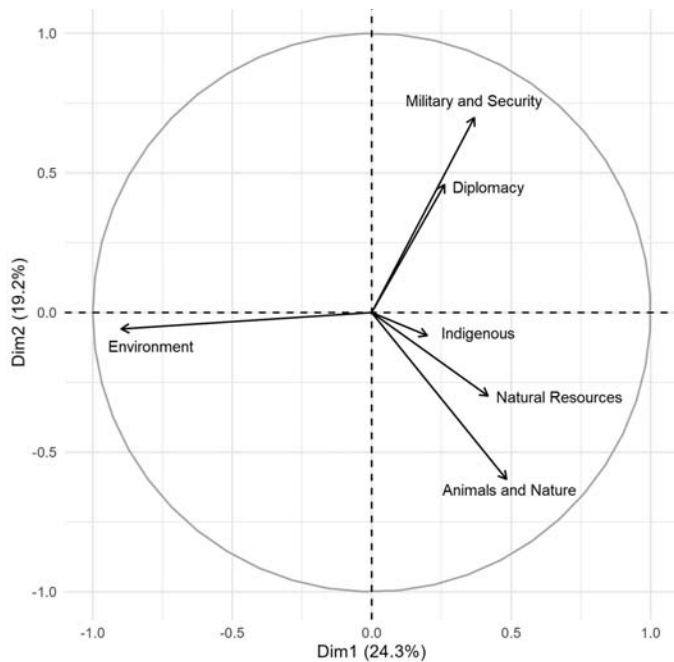


FIG. 3. PCA of Arctic topics on Twitter from 24 August 2021 to 23 February 2022.

initiatives and became a topic of conversation rather than being tied to diplomatic engagement or forums. We also observed an inversion of the topics on the right side of the PCA, meaning changes occurred in the composition of the components, which is a linear combination of the original features in our dataset (Fig. 3).

We compared the pre-invasion PCA with the post-invasion PCA and only exposed statistically significant ($p < 0.05$) shifts in our dataset on the diplomacy and military/security topics. Foremost, the correlation between the first component (which has the highest variance) and the diplomacy theme went from 0.32 in the pre-invasion timeline to 0.65 in the post-invasion timeline. Additionally, the coefficient of determination between the first component and the diplomacy theme went from 0.10 in the pre-invasion timeline to a staggering 0.42 in the post-invasion timeline. Therefore, we can assume that the discussion of the Arctic region in the Twittersphere changed drastically as the diplomacy theme went from second last (in contributing to the first component in the pre-invasion timeline) to being the main contributor in the post-invasion timeline. This soaring of the diplomacy theme can be explained by an increase in messages about diplomatic meetings, partnerships, and co-operation, the need for Western governments to react against Russia's action towards Ukraine, and also the uncertainty about the future of Arctic governance and the Arctic Council. Furthermore, the correlation between the first component and the military/security theme got a slight boost, moving from 0.32 in the pre-invasion timeline to 0.42 in the post-invasion timeline. While the coefficient of determination between the first component and the military/security theme increased from 0.11 in the pre-invasion timeline to

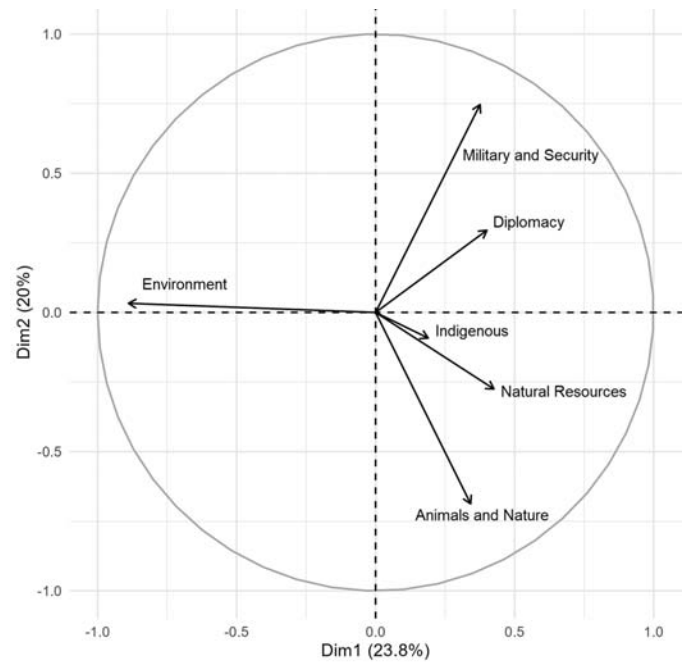


FIG. 4. PCA of Arctic topics on Twitter from 24 February 2022 to 23 August 2022.

0.18 in the post-invasion timeline, it remained below the average, meaning it was not a relevant variable to retain in the constitution of the first component (Fig. 4).

Moreover, we noticed a drastic change in the correlation between the second component (which had the second highest variance) and the diplomacy theme: it went from 0.61 in the pre-invasion timeline to -0.31 in the post-invasion timeline. On the one hand, the strength of the correlation decreased significantly between the two variables. On the other hand, there was a shift in polarity between the two variables. The coefficient of determination between the second component and the diplomacy theme went from 0.37 in the pre-invasion timeline to 0.10 in the post-invasion timeline. Consequently, the diplomacy variable lost its relevance in the geospatial positioning of our tweets inside the second component in the post-invasion timeline. Regarding the correlation between the second component and the military and security theme, the strength of the association remained alike: from 0.61 in the pre-invasion timeline to -0.62 in the post-invasion timeline. However, we noted a transposition in the polarity between the second component and the military/security theme. At odds with the results of the impact of the diplomacy theme on the second component, the military/security theme remained a relevant contributor to the geospatial localization of our tweets inside the second component: it went from 0.34 in the pre-invasion timeline to 0.39 in the post-invasion timeline.

According to these results, we were able to establish the existence of a geospatial reorganization in the content of the discussion of the Arctic region in the Twittersphere, based on our thematic dictionary and two primordial observations. First, the post-invasion timeline brought forth

TABLE 3. Paired t-test, all tweets (n = 536,253).

Topic	Pre-Invasion mentions	Post-Invasion mentions	<i>p</i> -Value (n = 536,253)	Effect size (n = 536,253)
Animals and nature	20,038	20,510	0.00	0.03
Diplomacy	4692	5658	0.00	0.04
Environment	88,698	67,733	0.00	0.07
Indigenous issues	4345	4296	0.00	0.01
Military and security	15,795	27,061	0.00	0.15
Natural resources	20,444	25,972	0.00	0.08

Table 4. Paired t-test, only tweets mentioning at least one keyword (n = 192,007)

Theme	Pre-invasion mentions	Post-invasion mentions	<i>p</i> -Value (n = 192,007)	Effect size (n = 192,007)
Animals and nature	20,038	20,510	0.00	0.03
Diplomacy	4,692	5,658	0.00	0.05
Environment	88,698	67,733	0.00	0.19
Indigenous	4,345	4,296	0.24	0.01
Military and security	15,795	27,061	0.00	0.24
Natural resources	20,444	25,972	0.00	0.10

the importance of the diplomacy theme as the principal contributor to the geospatial localization of our topics in the first component. Second, there was an inversion of polarity concerning the correlation between the diplomacy and military/security topics with the second component. These findings indicated the need to push our inquiry further into the differences between the pre-invasion and post-invasion timelines in the discussion of the Arctic region in the Twittersphere.

By using a paired t-test, which compares means taken from our topics at two different times in both timelines and datasets, we were able to discern statistically significant variations for all topics. We also measured the effect size of those fluctuations to qualify the impact of those changes between the timelines. To gain better insights on the variation of our topics, we calculated the *p*-value and the effect size twice. First, we considered all the tweets covering the Arctic region from 24 August 2021 to 23 August 2022 (548,554 unique tweets). This allowed us to get an overall view of the transformation of our topics within the Arctic region Twittersphere. Second, we removed all the tweets covering the Arctic region that didn't mention at least one keyword from our dictionary. This left a sample size of 196,578 unique messages covering both timelines, which granted an insight into the variations of the topics themselves.

As shown in Tables 3 and 4, the most talked about theme in both the pre-invasion and post-invasion timelines was the environment. While remaining the most talked about theme in our sample, the number of tweets on the environment theme dropped from 88,811 in the pre-invasion timeline to 67,790, in the post-invasion timeline, a 31.01% decrease between the periods. Although this change is statistically significant, the effect size is trivial: 0.08 in the complete dataset. Even with a substantial reduction in mentions over both timelines, the impact of the Russian invasion of Ukraine seems to have had an inconsequential effect on the

environment theme; it remains the focus of the discussion of the Arctic region in the Twittersphere. By contrast, the effect size for the environment theme jumps to 0.20 when we restricted our dataset to tweets that included our thematic keywords. Hence, the effect size for that theme between the pre-invasion and post-invasion timelines would no longer be trivial but small. This change can be explained by a dilution effect caused by the methodology of calculus of the effect size. Moreover, it also means that the environment theme gained traction between the pre-invasion and the post-invasion timeline.

The second most discussed theme on the Arctic region in our collected tweets refers to natural resources. Between the pre-invasion and post-invasion timelines, tweets containing mentions of keywords relating to natural resources increased by 21.82%. Although more Twitter users were writing about that theme, the effect size, in both our datasets, points towards a trivial impact between the two periods. Consequently, even if the Russian invasion of Ukraine had a statistically significant effect on the overall number of tweets dedicated to natural resources, that effect remained inconsequential. Nonetheless, the sheer increase in mentions indicates that more people were tweeting about the natural resources of the Arctic region. This change was linked to the fluctuations in energy markets and the sanctions imposed by Western states on Russia's energy sector. The importance of this theme is likely to lessen as time progresses.

As for the animals and nature theme, we noticed only a slight variation between the pre-invasion and post-invasion timelines, going from 20,065 to 20,600 mentions respectively, a 2.60% variation over the compared periods. Even if that difference is statistically significant, the effect size for that theme is trivial at best (or null in both datasets). The same can be said about the Indigenous issues theme. While we observed a decrease of 1.01% in mentions related to that theme between the pre-invasion and post-invasion

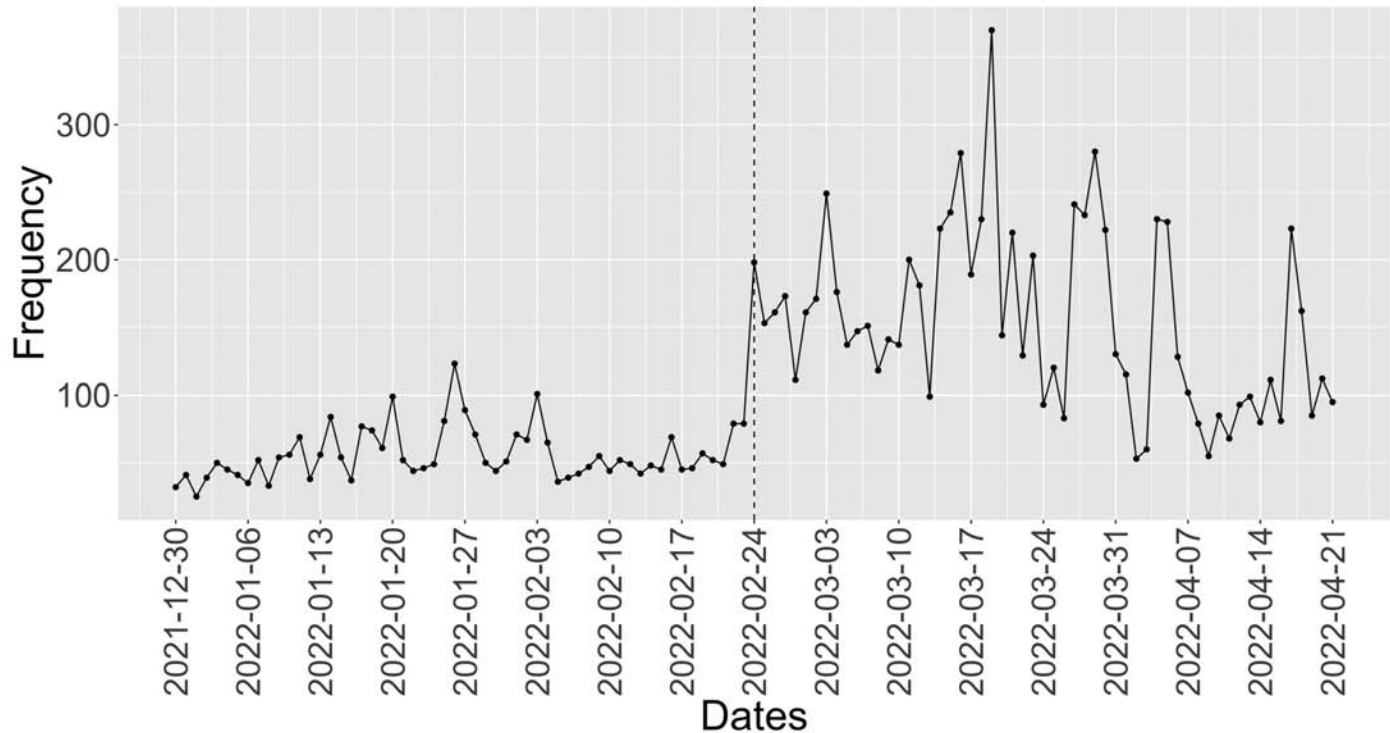


FIG. 5. Arctic tweets addressing military and security issues eight weeks before and after the Russian invasion of Ukraine.

timelines, from 4348 to 4301, the effect size remains null. Moreover, when we only keep the dataset containing tweets with at least one keyword mentioned, we observed that the paired t-test was no longer statistically significant. Therefore, we can conclude that the Russian invasion of Ukraine has had no impact on the fluctuation of those topics in the Arctic Twittersphere.

Regarding the diplomacy theme, we observed the third-highest growth in mentions (19.03%), going from 4702 mentions in the pre-invasion timeline to 5807 mentions in the post-invasion timeline. Even though the difference between those periods is statistically significant in both datasets, the effect size of the variations is trivial or very small at best. Accordingly, we can postulate that the Russian invasion of Ukraine did slightly influence the mentions of keywords associated with the diplomacy theme in the Arctic Twittersphere. The suspension of activities at the Arctic Council can explain this effect. It remained small, however, as the attention to the Council was short-lived, and the Arctic discussion that was mostly focused on climate change did not fundamentally change.

Finally, our collected tweets indicate an increment of 42.71% in military/security theme mentions across both periods, going from 15,835 remarks in the pre-invasion timeline to 27,641 remarks, in the post-invasion timeline. Moreover, this variation is statistically significant in both datasets with a small effect size. Therefore, we can confirm that the Russian invasion of Ukraine had an impact on the Arctic Twittersphere by increasing the number of mentions of military and security theme keywords. Even if the impact on the overall discussion was small, it remains the

strongest variation and effect size among all the topics in our analysis.

Overall, our findings suggest that the Russian invasion of Ukraine had a negative impact on the discussion about environmental issues in the Arctic Twittersphere. However, the post-invasion timeline saw an increase, with varying impacts, in tweets about natural resources, diplomacy, and military/security topics. It also shows no real impact on tweets mentioning animals and nature or mentions of Indigenous issues across the Arctic Twittersphere. Furthermore, our results suggest that the most statistically significant change in the discussion happened on the military/security theme. Therefore, it seems appropriate to examine this element further and to find out when the shift in the discussion occurred.

As we can observe in Figure 5, the beginning of the Russian invasion of Ukraine on 24 February 2022 (full vertical line) marks a sharp increase of mentions in the Arctic Twittersphere. With the naked eye, we can instinctively see a difference in mentions between the pre-invasion and post-invasion timelines.

Nonetheless, we are trying to pinpoint the exact moment at which we see a statistically significant change in mentions coupled with the similar effect size that our previous results indicated. Those findings are displayed in Table 5. On the one hand, we observed that we need to consider at least three weeks to see a statistically significant difference in mentions of the military/security theme between the pre-invasion and post-invasion timelines. On the other hand, we noticed that the effect size only reached our previous findings after four weeks. In the specific case

Table 5. Paired t-test, military, and security tweets only.

Weeks	Pre-invasion tweets	Post-invasion tweets	P-Value	Effect Size
Week 1	407	1,377	0.38	0.05
Week 2	756	2,384	0.58	0.02
Week 3	1,141	3,790	0.00	0.17
Week 4	1,584	5,179	0.00	0.27
Week 5	2,078	6,488	0.00	0.21
Week 6	2,521	7,404	0.00	0.24
Week 7	2,858	7,963	0.00	0.23
Week 8	3,131	8,832	0.00	0.24
Week 9	3,424	9,294	0.00	0.24
Week 10	3,744	9,734	0.00	0.23
Week 11	4,070	10,449	0.00	0.23
Week 12	4,483	11,126	0.00	0.22
Week 13	4,804	11,597	0.00	0.22
Week 14	5,134	11,996	0.00	0.23
Week 15	5,474	12,413	0.00	0.22
Week 16	5,805	13,294	0.00	0.22
Week 17	6,118	13,734	0.00	0.22
Week 18	6,487	14,185	0.00	0.21
Week 19	6,844	14,604	0.00	0.22
Week 20	7,220	14,978	0.00	0.22
Week 21	7,640	15,270	0.00	0.22
Week 22	9,828	15,580	0.00	0.29
Week 23	10,340	15,906	0.00	0.28
Week 24	10,681	16,269	0.00	0.27
Week 25	11,019	16,635	0.00	0.27
Week 26	11,315	17,378	0.00	0.27

of the Russian invasion of Ukraine, we can conclude that the time lapse needed to attain a statistically significant difference in mentions of the military/security theme in the Arctic Twittersphere with a small effect size would be at least four weeks (28 days). Moreover, the effect size seems to grow in strength over time, indicating that this theme was further talked about in the post-invasion timeline than in the pre-invasion timeline over the same amount of time. It stabilized after five months, however.

Four reasons can explain the lack of immediate change in the prevalence of the military/security theme post-invasion and the increased attention after one month. First, social media users were focused on the immediate military fallout of the invasion, for European security in general and for Eastern European security particularly, but also in the post-Soviet space: Arctic military security was an afterthought and one difficult to directly link at first to the Russia-Ukraine war. Users' time is always a finite resource: posting about Ukraine or following developments linked to the invasion monopolized users' time and attention. In this sense, while all eyes were on Ukraine, the Arctic region was less salient in users' minds. Second, the major Arctic development in the first few weeks post-invasion was not military in nature: the suspension of activities at the Arctic Council could not be meaningfully connected to the military/security theme.

A third explanation is more circumstantial in nature. The military exercise Cold Response, hosted by Norway with the participation of 30,000 soldiers from NATO countries, began on 14 March 2022. Military exercises typically attract considerable attention on social media because they are salient and visible events, offer appealing visual

content, and are the subject of considerable public relations campaigns from states and international organizations (in this case, NATO). The timing of this exercise so close to the beginning of the Russian invasion, and its location, in a country neighbouring Russia, attracted the attention of online users and experts. The exercise lasted only two weeks, however, and the effect of the drills on social media coverage would have been only transitory. Another explanation is more plausible to account for the long-term increased interest in the military/security topic.

We had to wait after the first few weeks of the Russian invasion of Ukraine to detect significant long-term military developments linked to the Arctic region. These took the form of an emerging reflection in Sweden and Finland to join NATO. Hence, the more significant effect measured starting on week four occurred at the same time as Sweden and Finland were airing initial hints about their possible NATO candidacies: on 16 March 2022, the Government of Sweden initiated security policy deliberations, while the Government of Finland announced on 17 March 2022 that it was preparing a new report on "changes in the current security environment" (Ministry for Foreign Affairs of Finland, 17 March 2022). Both processes were heavily focused on the Russian invasion of Ukraine and explored different avenues to respond to Russian aggression. Subsequent developments tied to the NATO accession of these two nations (decision announcement, formal request to join, signature of the accession protocols, etc.) increased the saliency of this theme from May to August 2022.

CONCLUSION

Overall, our study demonstrates the main characteristics of the Arctic discussion on Twitter. The environmental frame dominates all other ones: the perception that the region is the bellwether for climate change is the most prevalent on the global platform. Hence, the Arctic discussion on Twitter is first and foremost a climate discussion. The popularity of specific topics online matter as they influence public opinion and frame the most common representations of the region. In turn, public opinion can then limit the options available to decision-makers and render some decisions unpopular. While it is outside the purview of this study to rigorously test and measure the impact of public opinion on government, we know that seven of the eight Arctic states are democratic: the nature and level of information the public possesses about the Arctic can act as a deterrent or incentive for governments to act. Additionally, understanding the topics and structures of Arctic discussions on Twitter provides baseline measures to draw the contours of the Arctic Twittersphere. Deviations from this baseline allow us to more efficiently detect malign information campaigns and disinformation operations carried out by rival nations.

This fundamental popularity of environmental issues was not affected by a once-in-a-generation geopolitical

development: the Russian invasion of Ukraine did not substantially alter the nature of the Arctic Twittersphere. This observation points to the difficulty of changing dominant narratives and altering the threat perception of citizens online: social media discussions are based more directly on the preferences of the audience/users than traditional media. However, we did detect an increase in posts addressing Arctic military topics: the Russian invasion of Ukraine spilled over into the Arctic military discussion. This change was not immediate: social media attention only increased when Arctic-specific reactions to the invasion started to be observed.

This research was exploratory in nature; more work needs to be done to fully grasp how the Arctic region is portrayed on social media. Mapping influencers' networks, the level of disinformation circulating about the Arctic region, and the North/South divide on social media are pertinent avenues for future research. Identifying the content posted by different types of users, while time consuming, would also shed light on the identity of users spreading specific ideas or representations of the region. One limitation would stem from the language of the corpus used in our analysis. Our research limits itself, for example, to English-language

tweets. Therefore, we strongly encourage researchers to further investigate potential differences between languages on Arctic-related tweets, especially on polemic topics such as the Russian invasion of Ukraine.

Moreover, endogenous variables must also be assessed. Social media platforms changing their own rules and operating principles may affect the nature of Arctic content posted on them. Changes in ownership, for example, might matter more than exogenous factors such as geopolitical developments. In particular, Elon Musk's takeover of Twitter may have significantly altered the nature of online discussions, including Arctic discussions, on that platform. Rigorous and empirical assessments are needed to better understand this influencing mode of political communication.

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