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The new fronts of denialism and climate skepticism

*Two years of Twitter exchanges under the microscope
Extended version*

CNRS, Institut des Systèmes Complexes de Paris Île-de-France

David Chavalarias, Paul Bouchaud
Victor Chomel, Mazyar Panahi

May 23 2023

French version Feb. 13 2023

Warnings

The [Climatoscope](#) automatically analyzes millions of tweets. The opinions expressed in these tweets are the sole responsibility of the authors and do not commit or reflect the position of the CNRS or the authors of this study.

Twitter users are not a representative sample of the population of a country, so the relative importance of the social groups highlighted in this study does not necessarily reflect their importance at the national level. However, their evolution, their strategies and the relationships they maintain on Twitter are informative about what is happening offline and on other social networks.

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About the terminology

*People who reject the main conclusions of the IPCC reports (reflecting the state of knowledge from climate science and climate change) and climate science are commonly referred to as "**climate skeptics**". In what follows, we will also refer to them as "**climate denialists**" or simply "**denialists**". Our point is not to say that a scientifically established fact is necessarily incontrovertible, but that the most legitimate facts for making future decisions are those that are rigorously established by scientists on the basis of the current state of knowledge and understanding related to the Earth system.*

*We will refer to those who accept the results of the scientific community and the IPCC's synthesis of them as "**pro-climate science**", or in short "**pro-climate**".*

*Finally, we will use the expressions "**climate warming**", "**climate change**" indifferently, the latter being nevertheless considered more precise as to the consequences to be expected from the transformations in progress within the earth system.*

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This study and the associated research were conducted within the framework of the [Climatoscope](#) and [Politoscope](#) platforms of the Paris Île-de-France Institute of Complex Systems. They were also supported by the European project NODES (LC-01967516-CNECT/2022/5162608), the Île-de-France Region, the City of Paris and, via a PhD grant, by the CFM Foundation for Research.

1 Executive summary

As early as 1912, some warned of the effects of massive CO₂ emissions into the atmosphere by the new industrial era. As early as the late 1970s, internal studies of the fossil fuel industries [made accurate projections](#) linking global warming to CO₂ emissions, predicting “dramatic environmental effects by the year 2050”. Meanwhile, these same companies, especially ExxonMobil, tried to convince the public that a causal link between fossil fuel use and global warming was impossible because the models used to model climate response were too uncertain [21].

Since the 1970s, advances in climate science have provided an increasingly clear statement of the reality of global warming (see [IPCC Group I Report](#), Chapter 1), while the [2021 IPCC Report](#) states that “it is unequivocal that human influence has warmed the atmosphere, ocean and land”.

As global warming intensifies in every region of the world (2022 being an emblematic year) and its impacts worsen, this is a critical decade to make a determined commitment to reducing greenhouse gas emissions. Despite this, we are witnessing an increase in the activity of online denialist and climate-skeptic groups and an upward revision of the emission targets of most of the oil majors that have just announced record annual profits (e.g. [BP](#)).

In France, the intensification of denialist activism has been particularly marked since July 2022 with a triple climate news: a series of extreme events, the holding of the COP27 with a strong weight of fossil industries, and finally the convergence of the stakes of global warming with those of the security of oil and gas supply due to the war in Ukraine.

Other equally worrying trends are observed in countries like the United States, with a strong increase in the proportion of bots in the denialist information space.

This study describes some of the strategies implemented by climate skeptic and denialist activists on Twitter worldwide, quantifies their effects and highlights potential geopolitical motivations alongside the political and economic dimensions already present. It is based on methodologies developed at the CNRS at CAMS and at the Complex Systems Institute of Paris Île-de-France.

Beyond “fact-checking”, this study aims at a better understanding of the circulation of different narratives related to climate change and in particular those related to disinformation.

Here are the main results and conclusions:

At the global level

- The global climate change debate on Twitter is highly bipolarized with about **30% climate denialists among Twitter accounts** that address climate issues over the period 2019-2022,
- **The COVID-19 pandemic has distracted public opinion from climate change issues** for several months,
- **Experts from the IPCC and pro-climate communities focus their messages on their**

areas of expertise while the denialist community presents inauthentic forms of expertise: a core group of accounts speaks on a multitude of topics, concentrate presumed expertise, and fabricate the majority of the denialists narratives in circulation. Some of the denialists' favorite topics reveal an **active agenda setting uncorrelated with current events.**

- Exchanges on climate change issues are largely organized around human-to-human interactions. However, **the proportion of Twitter accounts with inauthentic behaviors in the exchanges has increased significantly since 2019 on a global scale, pointing to possible astroturfing operations.**
- **The denialist community has an overrepresentation of accounts with inauthentic behaviors of +71%** compared to pro-climate communities, with **6% of accounts “probably bot”**. This phenomenon is particularly pronounced in the United States where there has been a steady increase since February 2022 in the overrepresentation of denialist accounts with inauthentic behavior (likely bots), which has exceeded 400% in 2023.
- Since spring 2022 **Twitter has become an active place of conversion to climate skepticism** while losing at the same time its status as a globalized space for the expression of opinions on climate change.
- **Pro-climate accounts flee from Elon Musk’s Twitter.** After Elon Musk’s takeover of the platform in Oct. 2022, about one third of core pro-climate accounts left the network while the activity of these communities was halved.
- The proportion of climate skeptics has been steadily increasing on Twitter over the past two years. This increase accelerated sharply following Musk’s takeover, with **the proportion of climate skeptics reaching 50% by March 2023.**

The case of France (extended version only)

- **While the French twittersphere had been relatively unaffected by climate skepticism until now, a large French denialist community was structured in the summer of 2022** on Twitter.
- **A higher proportion of accounts “likely bot”**. The proportion of inauthentic accounts in the French denialist community is 2.8 times higher than in the French IPCC community. The proportion of accounts suspended by Twitter is ten times higher.
- **The denialist community produces or relays 3.5 times more toxic messages** than the IPCC community.
- **The main influencer of the French denialist community is a newcomer to the cause after a period spent campaigning against government measures against the COVID-19 pandemic.** The transition was made at the time of the invasion of Ukraine and **he relayed pro-Putin propaganda for a time.** The account was dormant since 2012 and woke up in 2021.
- Apart from some accounts involved in the informational sphere of *Reconquête!* (French far-right), **the major part of the denialist community is not composed of political activists from traditional parties** (LFI, PS, EELV, Renaissance, LR or RN).
- **The denialist community on Twitter is mostly composed of accounts that have participated in numerous anti-system protest campaigns during the pandemic. More-**

over, out of 10 000 accounts, nearly 6000 have relayed Kremlin propaganda about the war in Ukraine.

- **The issue of the fight against global warming and the characteristics of denialist activists make this societal issue a particularly favorable terrain for foreign interference operations of the subversion type.**
- **A causality analysis shows that in the medium term, the publication of IPCC leads the debate on Twitter around climate issues.**
- **Twitter discourse from the denialist and technosolutionist communities likely hinders the dissemination of scientific knowledge and IPCC findings** by negatively affecting the online activity of climate science and climate change scientists.

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2 Introduction

As early as 1912, some warned of the effects of massive CO₂ emissions into the atmosphere by the new industrial era. As early as the late 1970s, internal studies of the fossil fuel industries [made accurate projections](#) linking global warming to CO₂ emissions, predicting “dramatic environmental effects by the year 2050”. Meanwhile, these same companies, especially ExxonMobil, tried to convince the public that a causal link between fossil fuel use and global warming was impossible because the models used to model climate response were too uncertain [21].

Since the 1970s, advances in climate science have provided an increasingly clear statement of the reality of global warming (see [IPCC Group I Report](#), Chapter 1), while the [2021 IPCC Report](#) states that “it is unequivocal that human influence has warmed the atmosphere, ocean and land”.

As global warming intensifies in every region of the world (with 2022 being emblematic) and its impacts worsen, this is a critical decade to move decisively to reduce greenhouse gas emissions. Despite this, we are seeing an increase in the activity of online denialist and climate skeptic groups, with arguments ranging from “climate change is not real” to “CO₂ is not a greenhouse gas”, to “there is no scientific consensus on climate change”, “climate change is real but caused by natural climate variability” or “climate concerns are part of a left-wing political agenda to destroy capitalism” (see also [6]).

This upsurge in climate skepticism is accompanied by a paradoxical shift in global public opinion. While 77% of people reported in 2022 that they had already observed the effects of climate change in their region, the share of people who believe that climate change is not human-induced increased by 3% globally to 28%, alongside 9% of people who simply deny climate change. This increase is particularly pronounced in France, with an 8% increase in 2022 compared to 2021^{*1}. Understanding the strategies deployed online by climate denialists to rally a minority but significant part of public opinion to their cause is a major challenge for the efficient and legitimate implementation of future public policies.

This study analyzes the evolution of climate skepticism at the global level on Twitter since 2019 and identifies the strategies used to promote it. Among other things, it characterizes the recent upsurge of climate denialism since the summer of 2022,

THE RODNEY AND OIAMATEA TIMES,
WEDNESDAY, AUGUST 14 1912.

Science Notes and News.

COAL CONSUMPTION AFFECTING CLIMATE.

The furnaces of the world are now burning about 2,000,000,000 tons of coal a year. When this is burned, uniting with oxygen, it adds about 7,000,000,000 tons of carbon dioxide to the atmosphere yearly. This tends to make the air a more effective blanket for the earth and to raise its temperature. The effect may be considerable in a few centuries.

Figure 1: As early as 1912, some warned of the effects of the massive release of CO₂ into the atmosphere by the new industrial era.

¹(*) [Observatoire international Climat et Opinions Publiques](#) - Obs’COP2022, (2022) EDF/IPSOS, 24,000 people surveyed in 30 countries.

which was marked by a triple climate news: a series of extreme events, the holding of COP27 with a strong weight of fossil industries, and finally the convergence of the stakes of global warming with those of the security of oil and gas supplies due to the war in Ukraine. Alongside the political and economic dimensions already present, we have witnessed the rise of a conspiracy trend that has become predominant among climate deniers in some countries and in particular in France. Multiple evidences are pointing toward potential geopolitical motivations.

This study is based on methodologies developed at the CNRS centers Centre for social analysis and mathematics (CAMS) and at the Complex Systems Institute of Paris Île-de-France (ISC-PIF) and its online observatories [Climatoscope](#) and [Politoscope](#).

3 Data and methodology

The [Climatoscope](#) project, which relies on the Big Data platform [Multivac](#) of ISC-PIF, has been observing Twitter debates about climate change in English and French since 2016 with more than 400 million tweets collected until early 2023. This makes it possible to deliver a picture of the evolution and diversity of the on-line discussions on a global scale.

A first [Climatoscope](#) study has characterized the diversity of climate change related scientific issues and their take-up within the public sphere (Fig. 2). This study provides an in-depth look at the social structures underlying the climate change debates, as well as the strategies of certain social groups involved in this debate. The reader will find the details of the methodologies used in this study in [3, 9, 5, 4].

The [Climatoscope](#) uses the Twitter API to collect Twitter messages containing terms related to the issue of climate change. This data collection is not exhaustive but represents a sufficiently large and diverse sample to understand the social dynamics that drive the debate around this major societal issue.

The principle of mapping social spaces in this study uses the intensity of retweets* between two accounts as an indicator of belief and representation alignment. The reliability of this indicator and this mapping methodology are exposed in [9] among others.

In short, the collection and analysis of millions of tweets and their retweets makes it possible to build the network of interac-

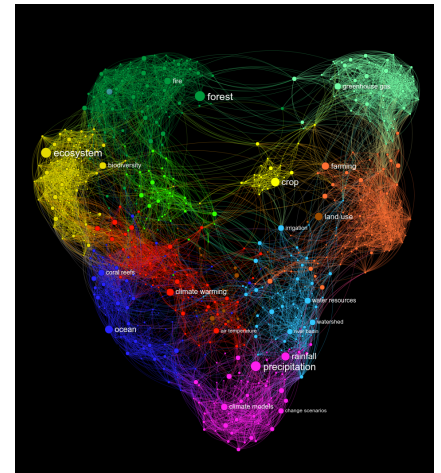


Figure 2: Mapping of climate change issues highlighted by 30k scientific papers, [Tweetoscope climatique](#), Chavalarias, David and Maziyar Panahi. 2018. [Climate Tweetoscope](#). In "14th Iteration (2018): Macrosopes for Ensuring our Well-being." [Places & Spaces: Mapping Science](#), edited by Katy Börner and Lisel Record. Created in 2015 for the [Cit  des Sciences et de l'Industrie](#) museum (Paris) on the occasion of COP21.

* The retweet is a message that is relayed from account to account without modification.

tions between Twitter accounts. In these networks, each node is a Twitter account, and two nodes are linked if one retweets the other intensively. Such an analysis is performed without having to know the content of the tweet, it is an interactional approach to social phenomena that can be completed by a semantic approach.

These interaction networks can be analyzed thanks to the tools of graph theory, which allow to identify "communities", *i.e.* groups of people having common beliefs and shared representations on a given topic. These communities are the *core* of online activists on a given topic. Finally, these networks can be visualized in such a way as to highlight these communities (structured social groups) and the relationships they maintain. Such a map is presented in Fig. 3².

The following sections present an analysis of the structure and dynamics of communities involved in climate change issues and highlight, for some of them, strategies that betray the real motivations of their involvement in this globalized debate.

Beyond "fact-checking", this study aims at a better understanding of the circulation of different narratives related to climate change, in particular those related to misinformation, which depends on the global structure of this informational space.

The first part of this report focus on the characterization of the structure of the climate debate at the global level. A second part focuses on France as a typical example of the globalization and acceleration of climate denialism, with synergies with American denialism and likely Kremlin interference.

²See also the Polito-scope's [blog](#) and [3] for popularization of this kind of mapping.

Take-home message:

Beyond "fact-checking", this study aims at a better understanding of the circulation of different narratives related to climate change and in particular those related to disinformation.

Part I

Globalized climate denialism

4 What is the structure of the climate twittersphere?

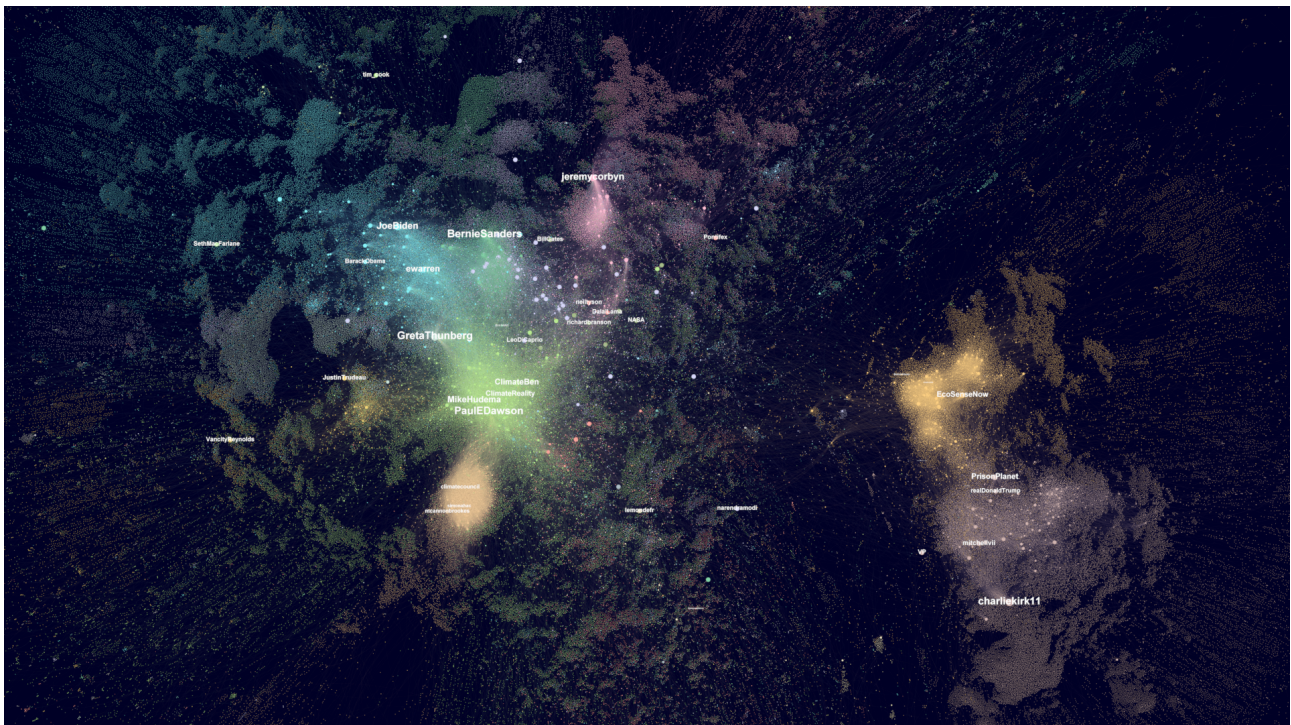


Figure 3: Climate Twittersphere in Q4 2019. Mapping of 200k Twitter accounts retweeting climate change-related content, in English or French. Each color indicates a specific community, either geographic (country level) or ideologically oriented (pro-climate science activists or denialists). On the left: pro-climate communities, on the right: climate-denialists.

Since the beginning of the Climatoscope project, as shown in Figure 3, the mapping of activists on climate change issues, regardless of time period, reveals a bipolarized debate at the global level, with two major regions clashing, one grouping Twitter communities that accept IPCC syntheses of current academic knowledge, the other region is made up of communities that do not accept them — the narratives developed by these communities will be referred to as “denialists”.

Each of these regions has communities whose boundaries coincide with geographic, political, or ideological borders. The largest and most stable pro-climate science communities in this

Take-home message: The global debate on climate change on Twitter is highly bipolarized.

English/French speaking arena are Canada, the United Kingdom, Australia, France, Germany, Pakistan, major international media (AP, Reuters, BBC, etc.), international organizations (UN, COPX, UNICEF, NASA, etc.), climate activists (Greta Thunberg, Greenpeace, etc.) and, *last but not least*, the United States of America, divided into two sub-communities: the left wing of the Democratic Party -around Bernie Sanders and Alexandria Ocasio-Cortez-, and the “mainstream” Democratic party around Joe Biden, Kamala Harris and Barack Obama.

Overall, over the last few years (January 2021 to March 2023), the core (cf. sect. 3) of pro-climate accounts that we identified on Twitter are composed of a little more than one million Twitter accounts that produced 51M tweets, 17.79% of them being original tweets, the rest being retweets (62.4%), retweets with/of comments (13.39%) or simply comments (6.37%).

As for the denialist communities, the geographical structuring is weaker, indicating greater coordination at the international level or greater geographical concentration. On the one hand, we find Donald Trump supporters and MAGA Republicans, accompanied by other leaders such as those of UKIP in England, and on the other hand, a group of influencers “experts” in climate science, who have their own audience and are densely connected to each other. It is in this latter denialist community that one finds accounts notoriously supported by the fossil fuel industries [8], such as the Heart Land Institute or the Competitive Enterprise Institute.

Overall, over the last few years (January 2021 - March 2023), the denialists communities identified on Twitter were composed of about 330,000 Twitter accounts that produced 20M tweets, 14.4% of them being original tweets, the rest being retweets (60.25%), retweets with/of comments (17.5%) or simply comments (7.8%).

5 How is the climate debate landscape evolving on Twitter?

The relationships between communities change over time, but overall, the communities at the heart of the pro-climate science region, which link all the others, are climate activists and to a lesser extent mainstream media and news agencies. Over the period from Autumn 2019 to summer 2022, the proportion of denialist accounts is roughly stable between 25% and 30%,

Take-home message:

Over the last few years (January 2021 - March 2023), we identified a core of 1M pro-climate accounts and 330k denialists accounts that have produced respectively 50M and 20M Twitter messages in English and French.

Take-home message:

These last few years, there was between 25% and 30% climate change denialists on Twitter compared to pro-climate, an order of magnitude comparable to offline surveys.

which is consistent with a 2020 WEF global survey that shows that the proportion of people believing that "global warming does not exist" or that "global warming has natural causes" was estimated at 31% in Western Europe, 41% in North America, and 33% worldwide (10,000 people surveyed in more than 30 countries).

These digital communities are dynamic social structures, their activity as well as their composition evolving over time. Years of observation through Climatoscope show that the intensity of the climate change debate is locally modulated by extreme seasonal events that may be linked to climate change (Australian bushfires, extreme heat waves or droughts), but it is also largely influenced by international events such as the COP, political events such as the 2020 US primaries – where the mainstream Democrats’ agenda was challenged by the left wing of the party (Bernie Sanders) –, or events with strong societal impacts such as the COVID-19 pandemic. The latter caused a significant drop in activity in all communities for a few months (cf. Fig. 4).

Take-home message:
The COVID-19 pandemic has for several months distracted public opinion from climate change issues.

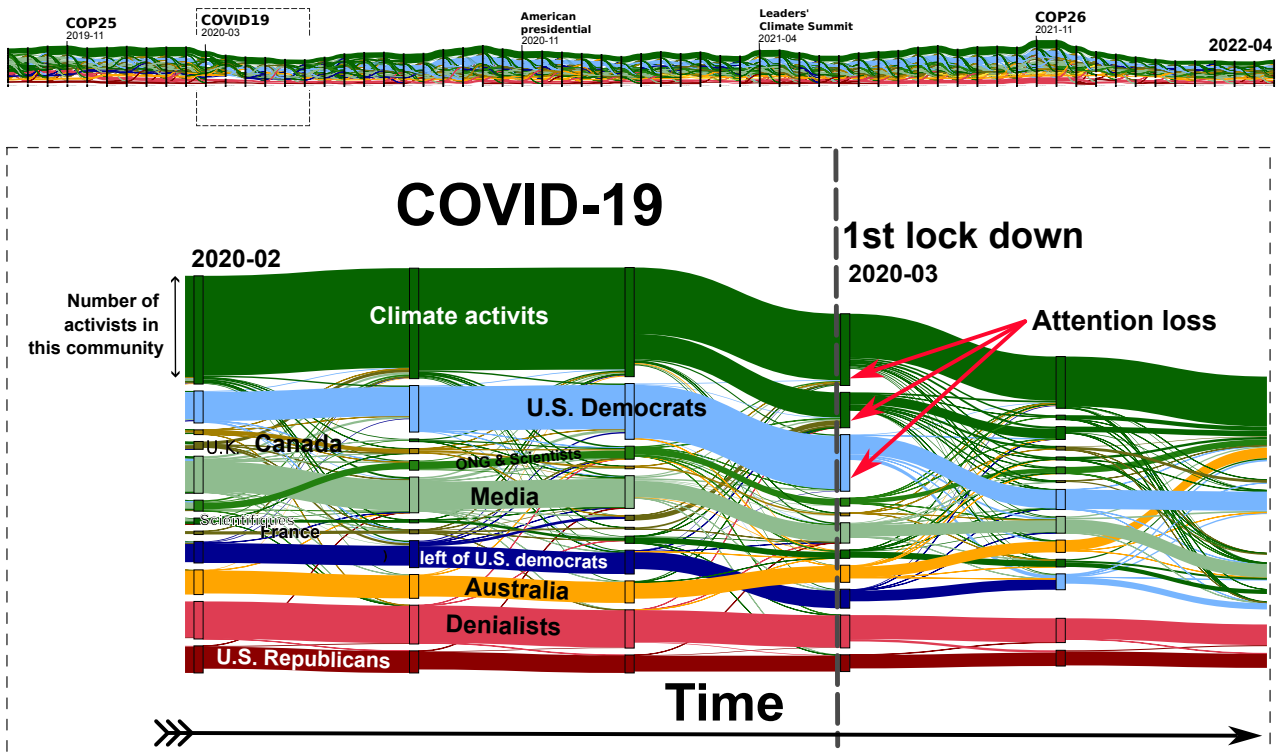


Figure 4: Evolution of the importance of different climate activists’ communities over time and news (Oct. 2019 - June 2020). The main figure corresponds to the moment when the COVID-19 pandemic became the focus of global news mechanically leading to a decrease in activity of the discussions around climate. It is a zoom of the part of the upper figure surrounded by dotted lines and labelled “COVID-19”. On this figure, we can see several peaks of activity corresponding to the summits on climate, but also to important political moments such as the American presidential elections of 2020.

This relative stability between the pro-climate and denialist communities was, however, challenged in spring 2022, with a clear resurgence of climate skepticism at the global level as depicted on Fig. 5 and Fig. 6: the relative weight of denialist communities largely increased to reach 50% in December 2022.

How is this evolution possible in a period where climate change impacts have been more visible than ever? The balance of power between digital communities is based on their ability to keep their members mobilized and to recruit new ones. Each of these phenomena has evolved in recent times on Twitter in ways unfavorable to pro-climate communities.

First, while pro-climate communities historically enrolled more new members than denialist communities (*i.e.*, accounts that were contributing to their online momentum for the first time), the trend has been reversing since April 2022 (*cf.* Fig. 5), a trend that may in part be linked to propaganda operations by the Kremlin, whose hybrid war with Europe and NATO intensified following its invasion of Ukraine (*cf.* sect. 2).

Twitter has also experienced an over-recruitment of denialists right after Elon Musk's takeover (Oct. 2022). Among the possible causes of this latest increase: the excessive amplification of toxic content by Twitter's recommendation algorithm, which became more pronounced after Musk's arrival [1] and/or Elon Musk's "amnesty" towards Twitter's banned accounts that allowed super hate and misinformation spreaders to return to the network [15].

Second, around Elon Musk's takeover of Twitter (*cf.* Fig. 6), we observe a sharp decline in the number of pro-climate activists (−33%) and supporters (−25,5%), as well as their overall daily publication rate (−33%). Again, this can be due to at least two phenomena. Changes in Twitter's recommender systems could have decreased the visibility of pro-climate tweets and/or pro-climate accounts could have deserted the platform while those who remained on the platform became less active. The latter explanation is confirmed by the data of *cf.* table 1 (33% reduction in the number of accounts that have tweeted at least once over four consecutive months). We can reasonably assume that this phenomenon is partly explained by the wave of "abuse and rude comments" against climate scientists since Musk's takeover [7], knowing that, as we show in sect. 3, denialist reactions to IPCC messages tends to silence their community and probably leads some pro-climate accounts to leave the network.

Take-home message:

Since spring 2022 Twitter has become an active place of conversion to climate skepticism while losing at the same time its status as a globalized space for the expression of opinions on climate change.

After Elon Musk's takeover of the platform in Oct. 2022, about one third of core pro-climate accounts left the network while the activity of these communities was halved.

In contrast, climate-denialists content producers experienced only a traditional seasonal decline in mobilization (−10%) and daily publication rate (−11.2%), while the activity of their relays even increased slightly.

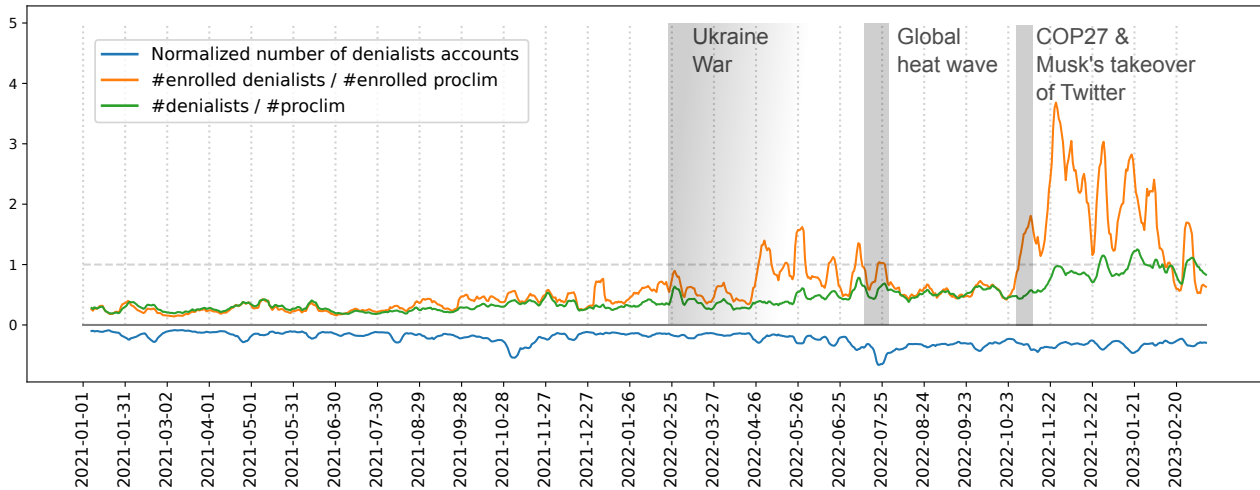


Figure 5: Global change in the relative influence of deniers on Twitter between 2021 and 2023. *In green:* The ratio of the number of denialist accounts to the number of pro-climate accounts. *In orange:* the ratio between the number of enrolled denialist accounts of the number of pro-climate accounts. Denialists gradually become the majority on Twitter with a new wave of enrollement in the spring of 2022. As a reference, the number of denial accounts (normalized to 1) was plotted in blue on an inverted scale. Data are averaged over a rolling week for better readability.

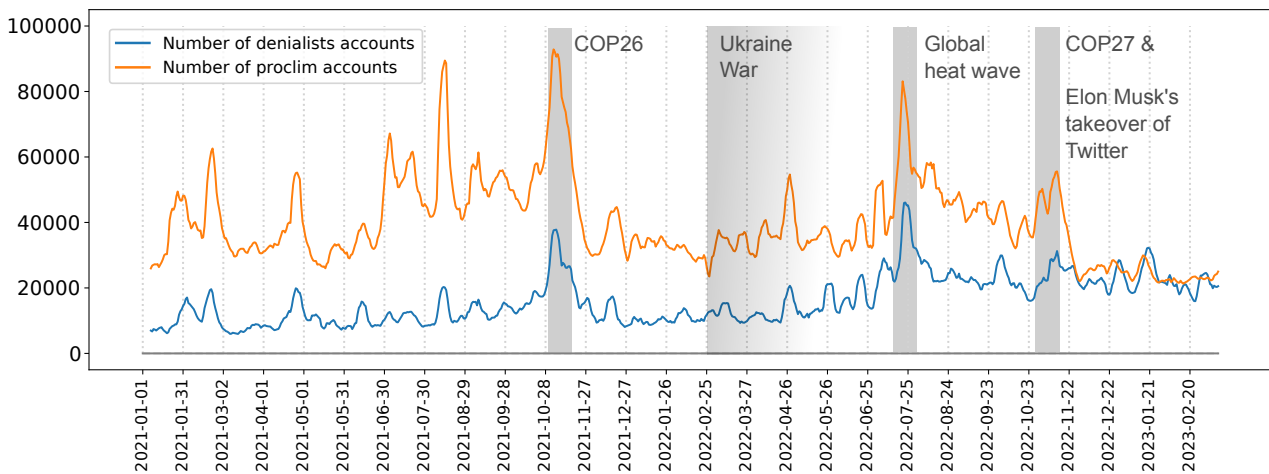


Figure 6: Worldwide evolution of number of estimated core pro-climate and climate denialists activists on Twitter between 2021 and 2023. Data are averaged over a rolling week for better readability. The two major spikes in July 2022 for pro-climate and denial activists correspond for the former to reactions to that month's extreme heat waves, and for the latter to reactions following the release of a *Project Veritas* video. This video featured a "CNN tech director" speaking "about instilling the next fear (Climate change) as COVID is no longer a fear factor in controlling Americans." This video gave a boost to the conspiracy theorists who are nowadays increasingly investing the climate change debate.

	Pre-Musk			Post-Musk			Variation			
	sources	relays	events	sources	relays	events	sources	relays	events	activity
Pro-climate	226,043	612,143	6,565,583	150,492	455,992	3,311,641	-33,5%	-25,5%	-49,5%	-33%
Denialists	95,950	219,781	3,463,239	85,531	220,960	3,089,834	-10%	+0%	-10,7%	-11,2%

Table 1: Evolution of the global activity of pro-climate and climate denialists accounts between the 92 days pre-Elon Musk (2022-07-22 to 2022-10-22) and post-Elon Musk (2022-11-22 to 2023-02-22). The term "source" refers to the number of accounts that produced original tweets. The term "relay" refers to the accounts that have produced retweets. These two sets of accounts overlap. The term "events" refer to all types of messages (tweets, re-tweets, comments).

The two major spikes in July 2022 for pro-climate and denialist activists correspond for the former to reactions to that month's extreme heat waves, and for the latter to reactions following the release of a Project Veritas video. This video – featuring a "CNN technical director" talking about "instilling the next fear (climate change) because COVID is no longer a fear factor to control Americans" – illustrates the rise of conspiracy theorists who are increasingly taking over the climate change debate and have become the a significant part of climate deniers on Twitter. As documented in sect. 2, a geopolitical explanation of this conspiracy theory approach to climate change should also be considered.

Two preliminary conclusions can be drawn from the observation of the global trends of climate Twitter exchanges in 2022. First, Twitter has become an active place of conversion to climate skepticism, as long as these new accounts are not mostly fake accounts (which does not seem to be the case, see below). Second, Twitter is losing its status as a globalized space for the expression of opinions on climate change, with a desertion of people supporting the IPCC positions. These two phenomena could reinforce each other, as the lack of contradiction makes it easier for deniers to convert new accounts on Twitter. Ultimately, this could also reinforce the offline pattern: [22] has shown on a 30 countries survey that climate denialism has gained 3% globally in 2022, and up to 8% in France.

Question : Beyond the veracity of the statements circulating within these communities, which can easily be verified with experts in the field, certain questions remain: *Are the commitments of the activists in these communities sincere? If not, what are the real motivations of their commitment to climate issues and what is the more general context in which these actors evolve?*

What strategies allow denialists to continually recruit new supporters online despite the fact that their theories are overwhelmingly contradicted by the facts? And are these supporters real? This is what we will now investigate.

6 What are the characteristics of denialists?

Let's remember that the communities of activists and the complex network they form are mathematically reconstructed independently of the content of the messages exchanged. The reason why denialist accounts are found in the same community is that they mainly retweet each other. The same is true for activists accepting the IPCC conclusions. We can now draw on this knowledge of activist types to determine how these communities differ in terms of their attitudes, skills, and the types of content they produce or relay.

Inauthentic forms of expertise

The first striking difference between pro-climate and denialists concerns the distribution of expertise within each of these categories of activists. Since it is difficult to have extensive expertise in distinct domains, it is reasonable to expect that the number of people able to talk about two different topics with a certain level of expertise will decrease as the required level of expertise increases.

This intuition can be formalized with the multi-expertise index* developed in [5], which indicates the extent to which multi-experts are present in a given community.

We first identified the arguments most often used by members of the various Twitter communities in order to identify their favorite topics. For the denialist community, we focused our analysis on the following topics/arguments: the influence of the sun, the natural variability of the climate and its cycles, the fact that CO₂ would be beneficial for plants and the planet, or the idea that global warming is simply a good thing. For the pro-climate science community, we have identified topics such as the greenhouse effect, melting ice, rising sea levels, and bush fires.

For each of the topic pairs and each of the communities, we computed the multi-expertise index, whose variations as a function of the required expertise threshold are presented in Fig. 7. We see that the pro-climate science community has an expected expertise profile (Fig. 7a): in this community, the people who are most vocal on one topic are not vocal on the others (or not to the same extent). This could be explained by the fact that only the “true” specialists of a given subject speak frequently

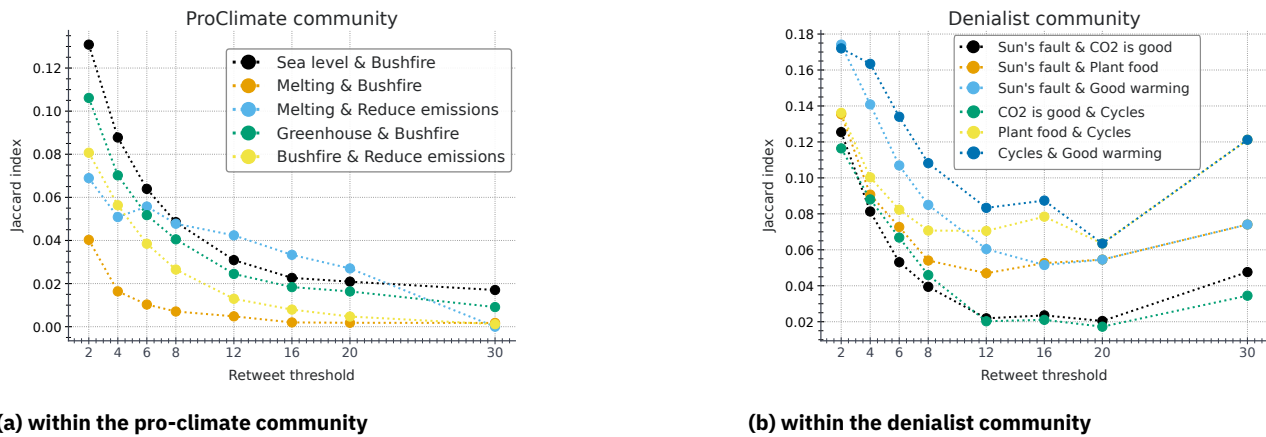
(*) The measure of multi-expertise on two topics a and b is simply the normalized proportion of accounts using both arguments at least n times, n being the expertise threshold, among all users using at least one of them (Jaccard index) [5].

Take-home message:

The experts of the pro-climate community focus their speeches on a specific subject, their field of expertise.

Take-home message:

The denialist community presents inauthentic forms of expertise, with a core group of accounts that express themselves on a multitude of topics, concentrate presumed expertise, and fabricate the majority of the narratives in circulation.



(a) within the pro-climate community

(b) within the denialist community

Figure 7: Jaccard index based on retweet threshold, calculated on online discussions that took place on Twitter in 2021.

on this subject, and speak much less on the other subjects. As for the other members of these communities, if they were to speak about several subjects, it would only be very occasionally for each of them (for example in reaction to extreme events related to climate change).

The denialist community exhibits a very different and somewhat anomalous expertise profile. While for low levels of expertise, the same initial decrease in the multi-expertise index is observed as a function of the required expertise threshold, there is a clear increase in this index for high expertise thresholds (Fig. 7b). Therefore, there are accounts that speak on all topics in large quantities. Either these topics are not really technical and, given the complexity of earth systems, do not contribute much to the debate, or these denialists speak on topics regardless of their actual knowledge of them. Either way, instead of having prescriptive power distributed across many specialists as in the pro-climate community, there is a small group of accounts within the denialist community that concentrates the presumed expertise and fabricates the majority of the narratives that circulate there.

A higher density of accounts with inauthentic behavior

One of the peculiarities of digital spaces such as Twitter is that we often interact with complete strangers or relay content of which we know nothing about the authors, their intentions or the circumstances of their creation.

For this reason, *astroturfing** is a very popular strategy for some

* **Astroturfing** is a strategy of creating a fake crowd to make it look like a grass-root movement is buying into a cause and thus gain the support of the general public.

actors of the digital worlds [2]. Properly executed, this strategy can have significant persuasive power with the general public and it is all the more easy to deploy online as it is possible to buy cheap fake accounts, operated by humans or robots, which will act according to the wishes of their buyers, artificially increasing the online presence of an idea, a person or a product (see for an example the recent “Team Jorge” case [13]). With the arrival of conversational artificial intelligences such as ChatGPT, which reduce the costs of this type of operation while increasing its effectiveness [12, 10], a resurgence of these practices is to be feared.

Is the resurgence in popularity of denialism really driven by the population or is it the result of inauthentic agenda setting by some actors? The identification of automated or highly coordinated behaviors is of paramount importance in assessing the potential presence of astroturfing on this topic.

The line between the proselytizing of an automated account or one operated by an actor paid to defend a cause and that of a grassroots supporter of that same cause is often blurred. However, it is possible thanks to artificial intelligence (AI) techniques to assign a “score of inauthenticity” to an account based on its profile and online activity, which would somehow give a probability for it to be inauthentic. A community with a higher average inauthenticity score than others would point to possible astroturfing operations.

Drawing on publicly available datasets¹ and including tens of thousands of accounts manually labeled as “probably automated” (“bots”), we trained an AI model to assign an inauthenticity score to a Twitter account based on the data we collect and relied on ISC-PIF’s big data platform [Multivac](#) to compute this score for over 13 million accounts.

On a global scale, considering all messages sent on Twitter in a 24-hour window in September 2022, a recent study estimated the proportion of bot-like accounts at 20%. Restricting the analysis to accounts involved in the Twitter exchanges collected by Climatoscope, we find that the proportion of bot accounts is significantly lower, about 7.4% internationally and about 4% in the French debate.

A richer and more subtle picture emerges when we look at the community level. Let’s define as “bot-like” the accounts having more than 50% of chances to be inauthentic according to our method. If we consider our two broad communities (pro-climate science and denialists), we observe that within the pro-

Question: Is the resurgence in popularity of denialism really driven by the public or is it the result of inauthentic agenda setting by certain actors?

Take-home message: The denialist community has an overrepresentation of accounts with inauthentic behavior of +71% compared to the pro-climate communities, with 6% of accounts “probably bot”

1 Data aggregated by Indiana University, as part of the [botometer project](#), containing thousands of bots involved in various online behaviors, such as hyperactive political bots or fake accounts purchased from multiple companies to increase a client’s follower count.

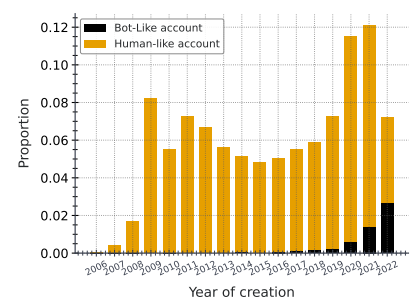


Figure 8: Proportion of accounts participating in international climate change discussions, by year of account creation, calculated on 5 million active accounts between 2020 and 2022. In black the accounts acting as “bot”, in orange the humans.

climate communities, the proportion of accounts that are “bot-like” is about 3.5%, while it approaches 6% for the denialist community (+71%). Nevertheless, the proportion of automated accounts is not uniform within these two sets. For example, the Indian pro-climate community has about 10% of “bot-like” accounts, while there are only 1.8% in the British pro-climate community.

The proportion of accounts with inauthentic behaviors in climate exchanges has seen a sharp increase since 2019 globally on Twitter (Fig. 8 - note that the near absence of these accounts before 2019 may be due to their suspension by Twitter moderation). This evolution may be the product of an intensification of efforts by malicious actors practicing astroturfing.

For example, there has been an abnormal and steady flow of new “bot-like” accounts since the end of February 2022 for the North American and Australia communities that added +400% of such accounts by the end of 2022 compared to the end of 2021 (see Fig. 9). The same phenomena is observed for France (*cf.* sect. II).

As we will see below, other evidence reinforces the impression that the denialist community is likely to be the site of astroturfing and subversion practices. However, it should be noted that the proportion of “likely-bot” accounts remains very low, to the extent of our detection capabilities, as the global debate seems mostly organized around human interactions.

Some denialist topics have inauthentic temporal patterns

By focusing on the level of topics of discussion rather than individual accounts, some parts of the denialist community reveal a very particular form of social organization that relies on the ability of a few to influence the flow of information, a form of organization already documented in other domains (*cf.* [20]). The most likely hypothesis is that the hyperactivity of some accounts on a few topics drives the information agenda.

Looking at some of the topics mentioned above, one can find this type of organization in the activity of denialist communities. For example, looking at the daily volume of tweets on a topic such as “the CO₂ is good for plants”/“there would be no life without CO₂”, a near-weekly cycle emerges over the period of November to December 2019 (Fig. 10) while over the same period the pro-climate community shows no activity. This sug-

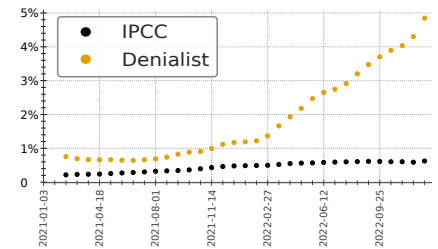


Figure 9: Evolution of the proportion of “bot-like” accounts for North America (USA & Canada) and Australia.

Take-home message:

Exchanges on climate change issues are largely organized around human-to-human interactions.

However, the proportion of Twitter accounts with inauthentic behaviors in the exchanges has increased significantly since early 2022 on a global scale and in particular in the U.S.A, Canada, Australia and France, pointing to possible astroturfing operations.

Take-home message:

Some of the denialists’ favorite topics reveal a planning of public agenda unconnected to current events.

gests that some denialist accounts are establishing narratives that they then work to schedule in a planned manner. As noted in [5], this example of scheduling can help find accounts with anomalous behavior.

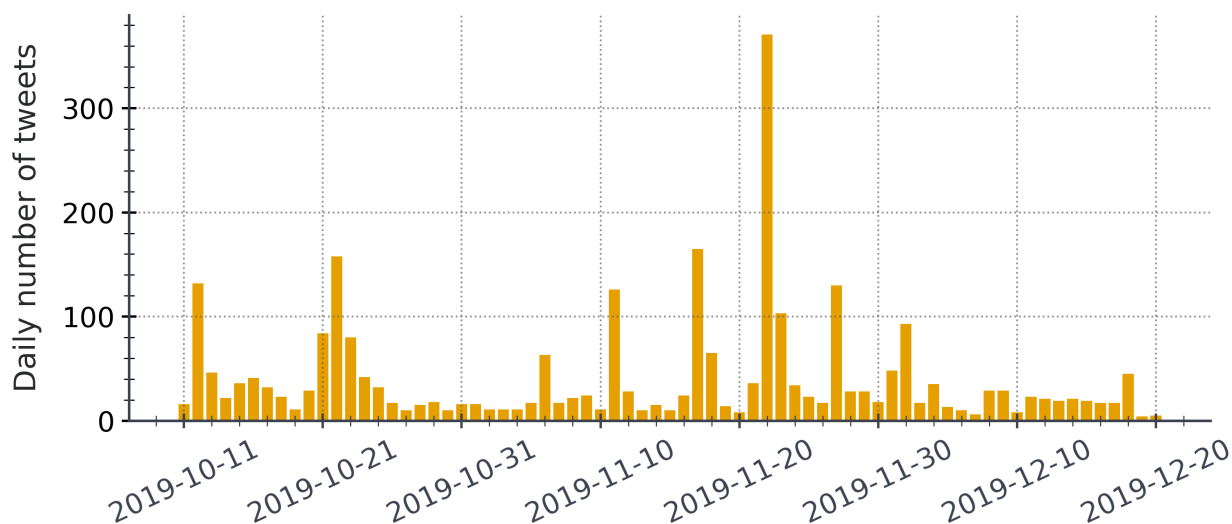


Figure 10: Number of tweets describing CO₂ as a “plant food” by climate denialists, as a function of time. This "comb" structure is inauthentic.

7 Intermediate conclusion

Climate denialist communities exhibit "coordinated inauthentic behavior" that aims to deceive people. They compensate for their minority position through overactivity, astroturfing, and ongoing recruitment of new supporters, and sustain themselves in part because they are in a globalized environment that gives these first two options a large-scale impact.

Recent events – Elon Musk’s takeover of Twitter and the war in Ukraine – have furthermore given the Twitter denialists a new impetus that has allowed them to significantly increase their influence.

As revealed by a detailed analysis of the French climate twitter-sphere (see extended version, Part II), a geopolitical dimension must also be considered to explain this resurgence.

Part II

The rise of climate denialism: the case of France

So far, we have identified the specific or frequent characteristics of climate-denialist communities at the global level. We will now analyze the situation in France which, according to recent global surveys, is experiencing an exceptional intensification of climate denialism (+8% in just one year) and is fairly representative of what is happening or may happen in other countries. Several clues point to a geopolitical dimension on this highly divisive approach of this societal issue.

1 A new flavor of climate denialism

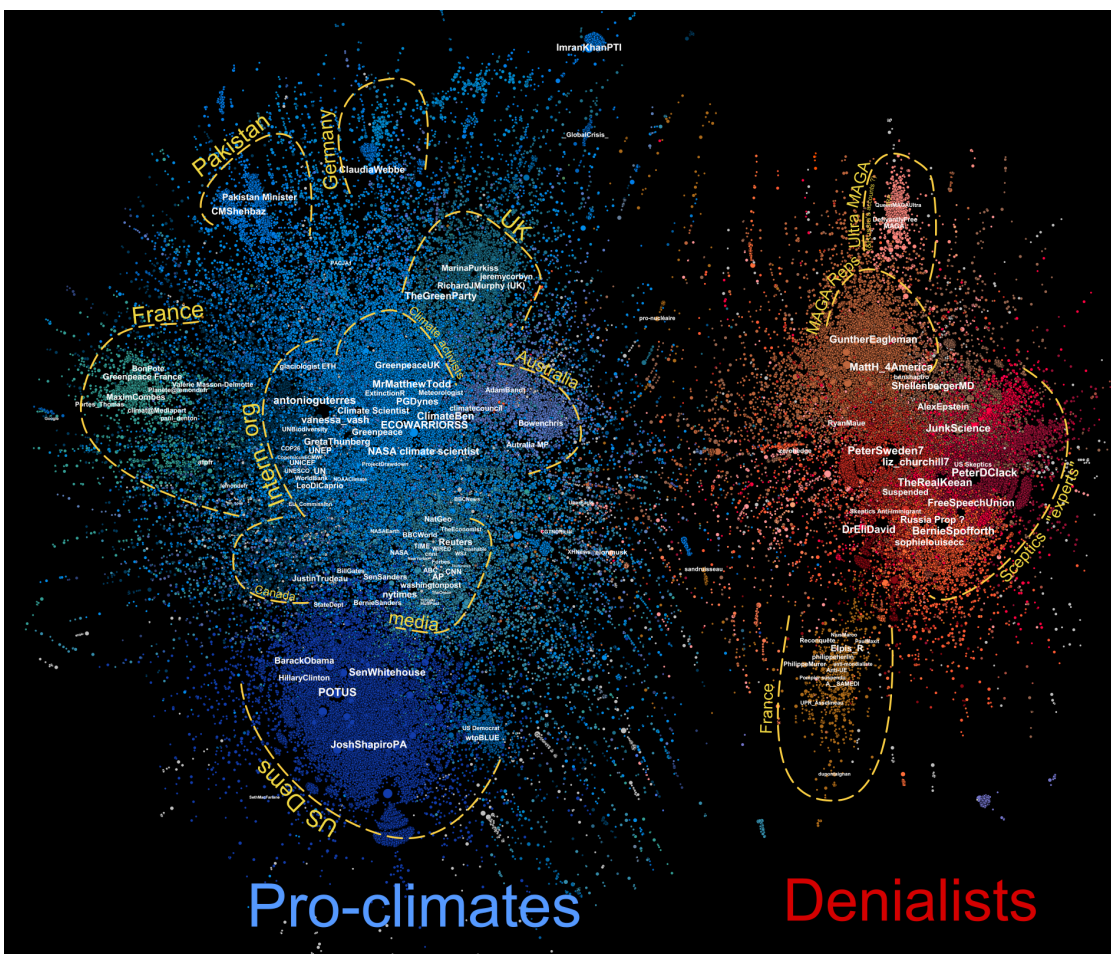


Figure 11: Global climate Twittosphere in the fall of 2022.

Mapping of 2023 actors

Until recently, we did not observe in the climatoscope a very structured French denialist community. Things seem to have changed since the summer of 2022, with the birth of a community of several thousand accounts relaying denialist content (bottom right of the figure 11).

Take-home message:

A large French denialist community was organized in the summer of 2022 on Twitter.

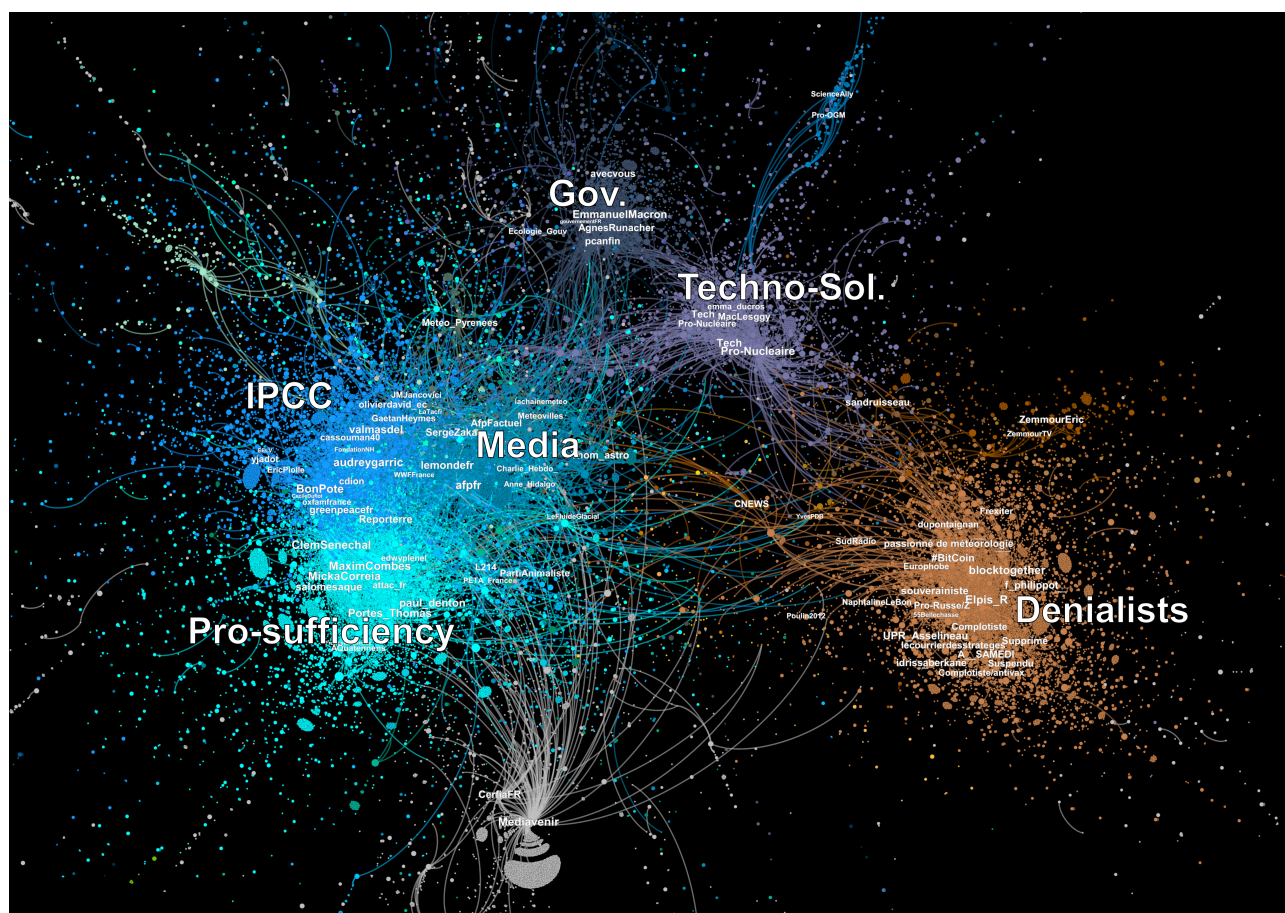


Figure 12: French climate Twittosphere in the fall of 2022. [Animated video]

What are the characteristics of this French denialist community? This is what we are going to analyze in order to better understand how the issue of action against climate change could open a new front of division within the populations (which is already the case in other countries, such as the United States).

Let’s zoom in on the set of French Twitter accounts in the figure 11. The analysis of this sub-network of accounts allows us to characterize the main actors of this debate in France over the period from January 2021 to December 2022. For the sake of readability of this report, even if it is always delicate to summarize the opinions of a group by a single label, we have tried to give them names as close as possible to the arguments they

Table 2: French communities: number of accounts and number of tweet over the period 2021-2022.

Community	Size	Tweets
Denialists	9.7k	449,4k
pro-sufficiency	8.3k	359,7k
IPCC	6.3k	285,4k
Medias	5.4k	162,2k
Technosol.	4k	207,7k
Gov.	2.5k	88,5k
Far-right	0.9k	20,1k

develop after a close qualitative and quantitative analysis of the profiles that compose them (see also sect. 2) and some of their tweets (cf. sect. 3).

As shown in the table 2, the most important sub-community is a denialist community (which appeared in July 2022), but whose size remains much smaller than that of the whole pro-climate science communities. The most frequent keywords in the profile descriptions of its members are typical of alt-right, far-right or conspiracy accounts. The top 5 five in descending order of frequency, are: *freedom* (76), *right* (69), *patriot* (68), *truth* (57), *frexit* (46).

As for the pro-climate science communities, Several components are clearly distinguishable:

- The community of scientists who contributed to the IPCC reports and their first relays (hereinafter called “IPCC community”)
- The “pro-sufficiency”^{*} community led by pro-climate science activists (associations, NGOs and political activists). Most frequent keywords: *policy* (105), *journalist* (102), *left* (86), *science* (72), *feminist* (63),
- A community whose members, without denying the anthropic origin of climate change, believes that there are solutions, such as nuclear power, which make some of the measures defended by other pro-climate advocates superfluous. We will hereafter refer to as “techno-solutionists”. Some of the techno-solutionists are also strongly against the idea of “degrowth”. Most frequent keywords: *policy* (77), *science* (74), *liberal* (55), *innovation* (44), *right* (40).

* Sufficiency policies are a set of measures and daily practices that avoid demand for energy, materials, land and water while delivering human well-being for all within-planetary boundaries. See [IPCC AR6 WGIII SPM](#).

As we can see, the main difference between techno-solutionist and pro-sufficiency communities is that members of the former often they describe themselves as liberal or right-wing while members of the later they describe themselves as left-wing.

Last, there are one community structured around the mainstream media and an other structured around government communication, both of which relay pro-climate information.

Here are, for each of these communities, one of the most retweeted messages in the climatoscope over the period from 2022-09-01 to 2023-01-27:

- **IPCC** "CLIMATE CRISIS. [2023-01-03] "Who could have predicted the climate crisis?" Emmanuel Macron's formula during his greetings

(a) CRISE CLIMATIQUE. «Qui aurait pu prédire la crise climatique ?» La formule d'Emmanuel Macron lors de ses vœux a fait réagir. Depuis plus de 40 ans, les alertes sur le réchauffement de la planète se succèdent."

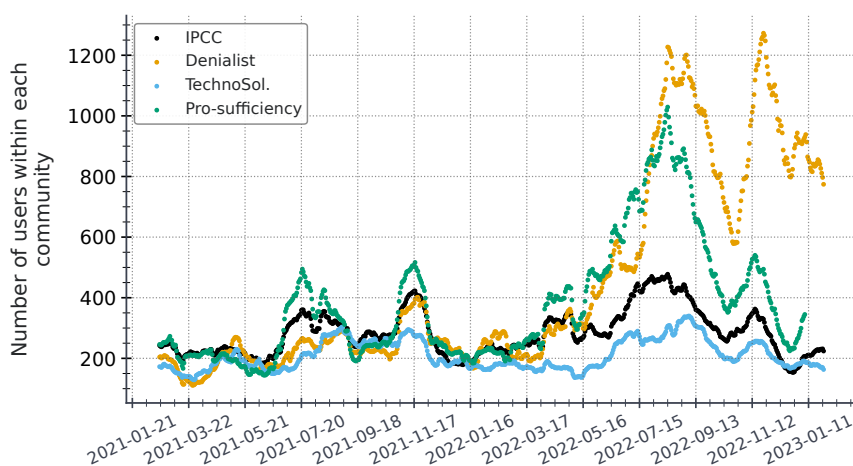


Figure 13: Daily number of active Twitter accounts belonging to the “IPCC”, “denialists”, “technosolutionists”, “pro-sufficiency” communities (one month moving average)

caused a reaction. For more than 40 years, warnings about global warming have followed one another."^a, @Inafr_officiel
TweetId: 1610321373595074560

- **Pro-sufficiency** [2022-07-19] "In the end, with 3 flights in 3 days, the journey of Martin Bouygues' plane will have emitted 70 tons of CO2. This is the equivalent of the emissions of an average French person in 7 years."^b Account following private jets
TweetId: 1549507278285557760
- **Technosolutionnists** [2022-03-02] "If the \$5,000 billion invested in renewables had been invested in nuclear power, the latter would now produce more than half of the world's electricity and greenhouse gas emissions would have fallen by 18%."^c Columnist
TweetId: 1499122034936270855
- **Media & gov.**, [2022-04-04] "Humanity has less than three years to reverse the curve of greenhouse gas emissions, the main culprits of climate change, if it wants to keep a livable world warn UN climate experts in a new report."^d Digital native media
TweetId: 1511011798039900166
- **Denialists** [2022-09-10] "Astrophysicist and founder of Weather Action, Piers Corbyn, confirms that global WARMING/ CLIMATE CHANGE, etc., is an absolute CANULAR. "The climate has always changed, but it has NOTHING to do with HUMANS Subtitled in French @AlexisResurrect [RT video]"^e Canadian denialist
TweetId: 1568429932774133760

(b) "Au final, avec 3 vols en 3 jours, le périple de l'avion de Martin Bouygues aura émis 70 tonnes de CO2. C'est l'équivalent des émissions d'un français moyen en 7 ans.

(c) "Si les 5,000 Mds de \$ investis dans les renouvelables l'avaient été dans le nucléaire, ce dernier produirait aujourd'hui plus de la moitié de l'électricité mondiale et les émissions de gaz à effet de serre se seraient contractées de 18%".

(d) [2022-04-04] "L'humanité dispose de moins de trois années pour inverser la courbe des émissions de gaz à effet de serre, principales responsables du changement climatique, si elle veut conserver un monde vivable alertent les experts climat de l'ONU dans un nouveau rapport #AFP "

(e) "L'astrophysicien et fondateur de Weather Action, Piers Corbyn, confirme que le RÉCHAUFFEMENT planétaire/le CHANGEMENT CLIMATIQUE, etc, c'est un CANULAR absolu. « Le climat a toujours changé, mais cela N'A RIEN à VOIR avec L'HOMME Sous-titré en Français @AlexisResurrect"

The growth of the French denialist community

The analysis of the evolution of the size (Fig. 13) and activity (Fig. 14) of the different French communities since January 2021 shows a clear evolution of the power relations between communities.

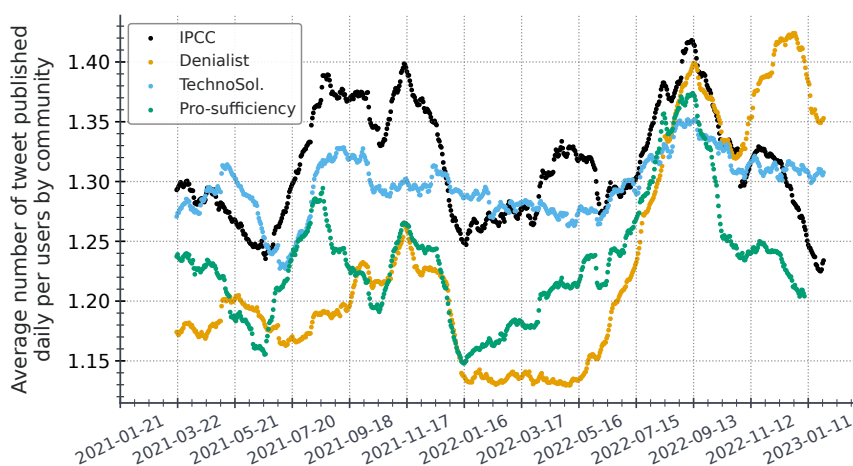


Figure 14: Average number of tweets published daily by accounts belonging to the “IPCC”, “denialist”, “technosolutionist” and “pro-sufficiency” communities over time (moving average over one month)

Community size : In 2021, the number of active Twitter users belonging to the “IPCC”, “denialist”, “techno-solutionist” and “pro-sufficiency” communities, varied correlatedly and in similar proportions, as shown in Fig. 13. However, by 2022, the balance of power between communities has changed dramatically, with the sizes of the “denialist” and “pro-sufficiency” communities more than doubling, coupled with strong temporal fluctuations. The first massive increase in denialist accounts occurred during the French presidential election cycle³.

The second occurred at the same time as the November 2022 United Nations Climate Change Conference in Sharm El Sheikh, Egypt, which also corresponds to the period when Elon Musk, after buying Twitter, decided to shut down entire departments dedicated to moderation and set out to reinstate suspended accounts.

The analysis of the average activity of the members of these communities (Fig. 14) shows that the “denialist” and “pro-sufficiency” communities are the most volatile, and the relative importance of the denialist community has increased considerably, reaching about ten thousand active accounts.

³Presidential campaign in April 2022 and legislative campaign in June.

Table 3: Proportion of “likely-bot”

Community	Jan, 2021	Dec, 2022
IPCC	1.0%	2.2%
Denialists	1.4%	6.2%
TechnoSol.	0.9%	2.2%
Pro-sufficiency	0.7%	2.7%

2 The facets of French denialism in a globalized environment

Astroturfing the French way

By calculating the inauthenticity score on all the accounts of the French communities, the denialist community turns out to have a much higher score than the others whatever the observation period.

Moreover, its average inauthenticity score increased by more than 340% between 2021 and 2023, with a very strong acceleration in February 2022 starting from Putin’s invasion of Ukraine and the French presidential campaign (see Fig. 15). It increases continuously since then, so that at the beginning of 2023, the proportion of accounts “probably bots” is 2.8 times higher within the denialist community than within the IPCC community (cf. Table 3).

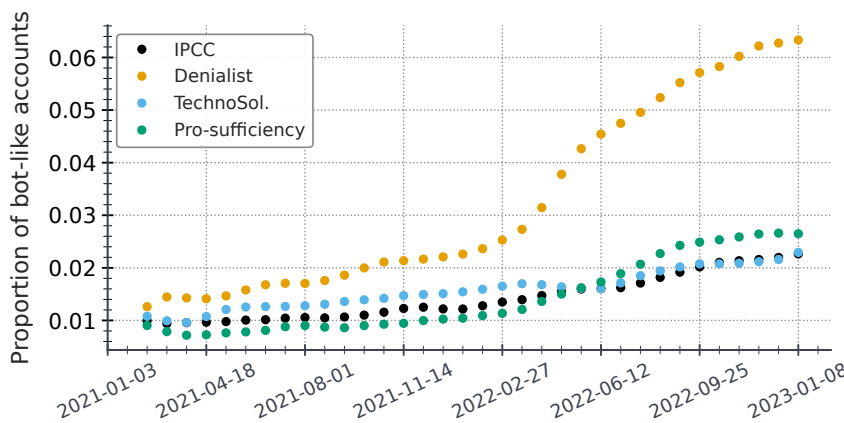


Figure 15: Proportion of accounts with inauthentic behavior by community (one month rolling average). The inauthenticity score of the denialist community has been growing rapidly since February 2022 and exceeds that of the IPCC community by 180%.

Not surprisingly, the denialist community is also the one with the highest proportion of suspended accounts, but with a particularly high ratio: more than 10 times compared to the IPCC community (see table 4).

As a reminder, the old Twitter moderation rules stated:

Table 4: Proportion of suspended and active accounts in February 2023

Communauty	Susp.	Act.
IPCC	0.7%	93.4%
Denialists	7.4%	89.2%
TechnoSolu.	2.5%	93.6%
Pro-sufficiency	1.8%	92.0%

Take-home-message:

The proportion of inauthentic accounts in the French denialist community is 2.8 times higher than in the IPCC community.

The proportion of accounts suspended by Twitter is ten times higher.

“*Abusive Tweets or behavior: We may suspend an account if it has been reported to us as violating our Twitter Rules surrounding abuse. When an account engages in abusive behavior, like sending threats to others or impersonating other accounts, we may suspend it temporarily or, in some cases, permanently.*” – [Twitter help center](#)

The French denialist community develops a toxic discourse

By exploiting a natural language processing model trained to detect toxic content—whether it be obscenities, insults, threats, attacks on gender or religion—we measured the tone of the speeches of actors from different communities. From this point of view, there is a glaring difference between the denialist community and the IPCC community. . Indeed, as shown in Fig. 16, the proportion of messages identified as "toxic" circulating in the denialist community is 3.5 times higher than that of the IPCC community, and 1.5 times higher than that of pro-sufficiency community.

This observation corroborates the fact that there are ten times more suspended accounts in the denialist community. Regarding the first reactions to the French publication of our study, the over-toxicity of the denialist community reached +373.3% compared to the IPCC community (see 3), with estimated weights of 60.88% for "insult", 23.71% for "obscene" and 5.71% for "identity attack" contents.

Take-home-message:

The French denialist community produces or re-lays 3.5 times more toxic messages than the IPCC community.

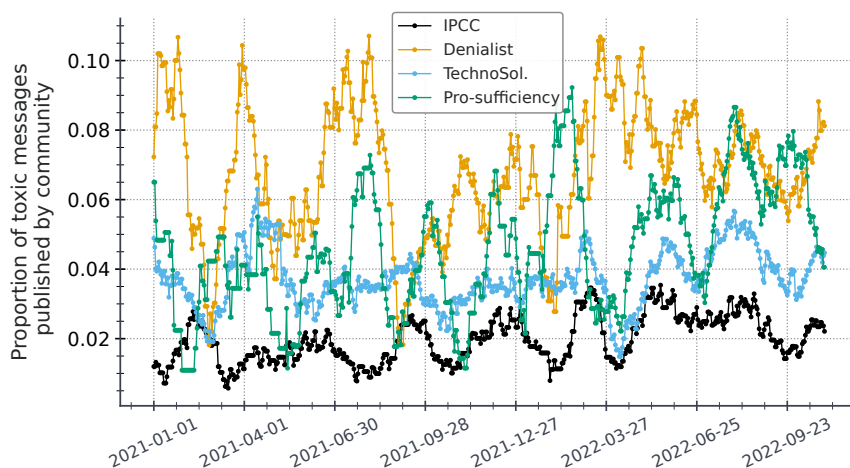


Figure 16: Proportion of toxic messages posted by each community

Denialism, a concept that works well in export

To understand the origin of this new French-style denialism, we can focus on the most active accounts of this new community. Graph theory proposes several indicators to measure the influence of an account, such as the *PageRank* (invented by Google for its search engine) or the *eigenvector centrality*.

Whatever the indicator considered, the Twitter account *Elpis_R* (21.4k subscribers as of 21/05/2023), whose activity on Twitter has more than doubled since this summer, appears to be by far the most influential in this community during the study period.

What is the profile of this account? Let's start by specifying that the account is anonymous and has a male profile picture retrieved from an image bank. For this reason, we decided to mention this account with its real Twitter handle and call it "he / his / him", although there is no guarantee that this account is owned by one and the same person. This account was created in July 2012, but had only 27 followers in September 2021, which means that it was a dormant account between 2012 and 2021.

Elpis_R defines himself (as of 21/05/2022) as "*Climate Science Research (Independent) - Climate Realist - Alarmists Ignore The Geological Climate Record*" (note that he describes himself in English with elements of language borrowed from American denialists, but produces the majority of his tweets in French).

By reconstructing the network of interactions of *Elpis_R* from the global data of the climatoscope, it appears that this account serves as a bridge (cf. Fig. 17) between the French information space and the community of Anglo-Saxon influencers "experts" in climatology (cf. above). If this is not sufficient to attribute any geographical origin to it, it nevertheless points to a convergence of interests at an international level in climate misinformation, as has already been documented on other subjects such as COVID-19 (see *Toxic Data* Ch. 11 [3]).

To defend its point of view, the account *Elpis_R* develops a rhetoric that can be analysed with the "4D" approach, developed to investigate Kremlin propaganda [17], illustrated figure 19: *Dimiss* ("if you don't like what your critics say, deny the allegations on the ground, or denigrate the one who makes them"), *Distort* ("if you don't like the facts, distort them"), *Distract* ("if you're accused of something, turn the attention away by launching accusations elsewhere"), *Dismay* ("if you don't like what someone



Take-home-message:The main influencer of the denialist community is anonymous and newly acquired to this cause after having been dormant for almost ten years and then antivax and having relayed Russian propaganda during the invasion of Ukraine. He uses a very clear pseudo-scientific discourse to make people believe in his expertise.

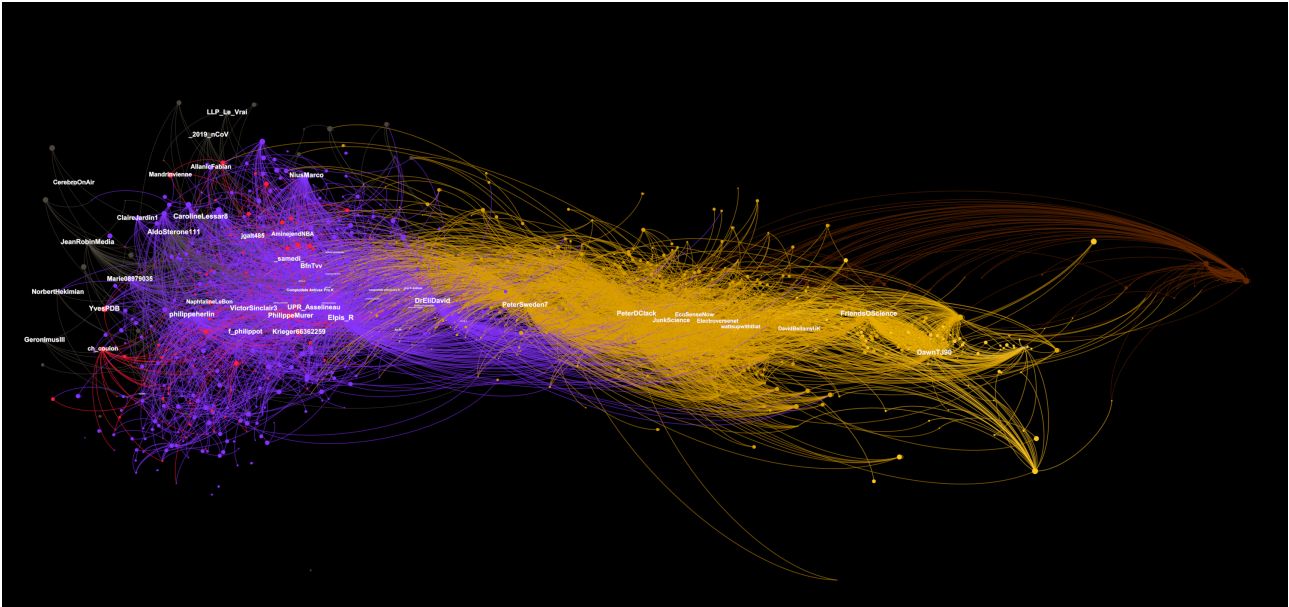


Figure 17: Core of the information flow network between U.S. and French denialists (dense network of second neighbors of Elpis_R)

else is up to, try to scare them”).

He complements these 4Ds with a fifth that is perhaps the most important in promoting climate inaction: *Doubt*. Overall, this approach implements a strategy popularized by Sun Tzu, a Chinese general of the VI century BCE that also starts with a "D": *Divide your enemies* [11].

Note that in the example 19-e, *Elpis_R* presents a truncated excerpt from an IPCC report that says exactly the opposite of what it implies, namely:

"The climate system is a coupled non-linear chaotic system, and therefore the long-term prediction of future climate states is not possible. Rather the focus must be upon the prediction of the probability distribution of the system's future possible states by the generation of ensembles of model solutions. Addressing adequately the statistical nature of climate is computationally intensive and requires the application of new methods of model diagnosis, but such statistical information is essential."
IPCC TAR WG1, Working Group I: The Scientific Basis.

When someone pointed this out to him, the interaction came to a screeching halt, proving that this was not an attempt to convince on the basis of proven facts.

Elpis_R is also one of those accounts that spread contradictory messages, such as "there is no global warming" along with



Figure 18: Example of contradictory misleading messages. The first relays a tweet saying “From 1998 to 2015, the temperature did not increase unlike the CO₂”, the second states “Nobody denies that climate change exists. Climate has always changed but there is no proof it is linked to our emissions.”

Key words used to define the themes: "CO₂", "warming", "climate".
Covid : "covid", "vaccination", "vaccine"
Russia: "poutine", "russie", "ukraine", "Zelensky"

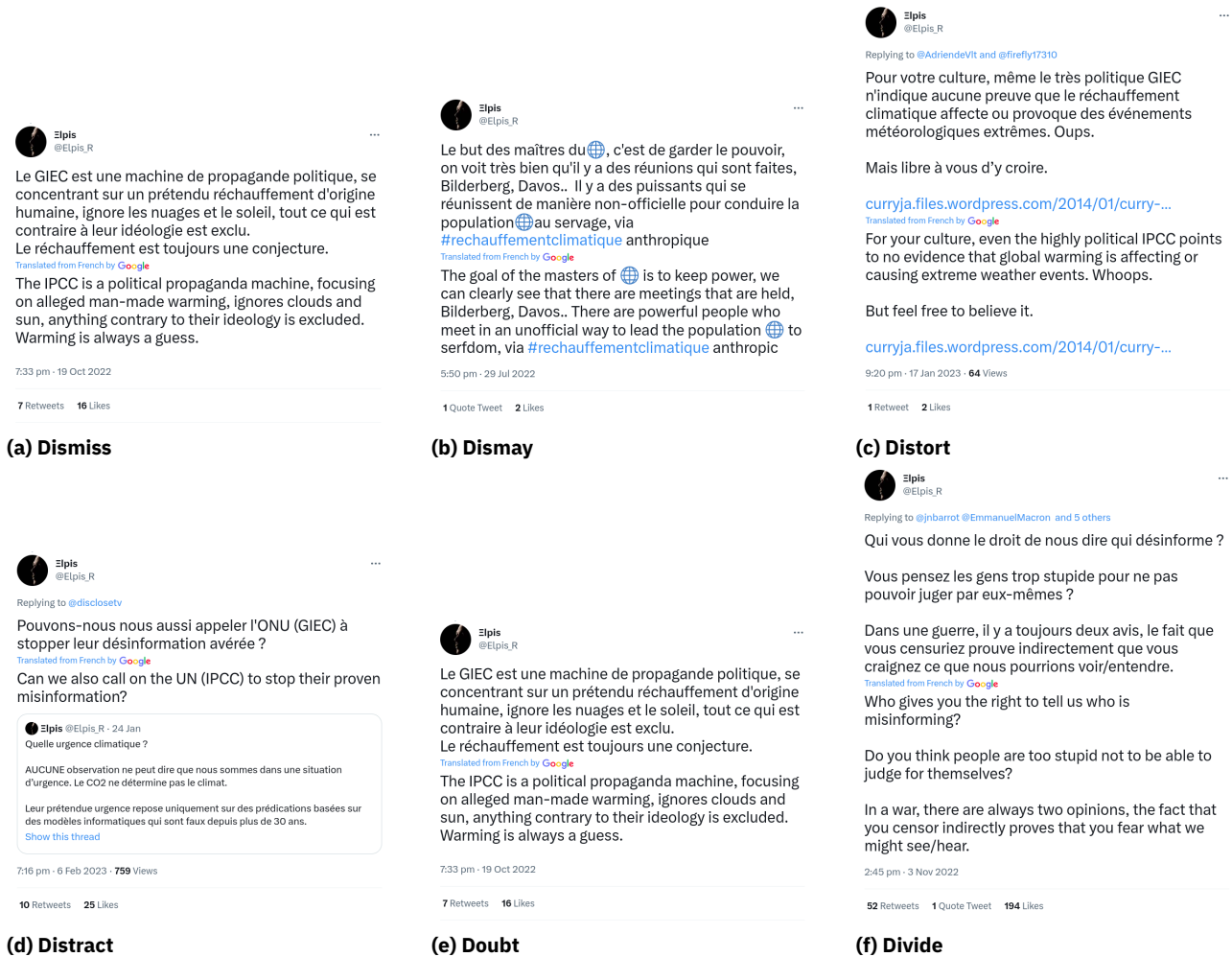


Figure 19: Examples of messages from Elpis_R. The images and videos have been hidden for readability reasons. The English translations of the tweets are also displayed.

"the climate has always changed and warming is not due to our emissions" (Fig. 18).

Elpis_R specifically attacks IPCC members as well as climate science and climate change scientists, with several daily posts, some of them very technical.

His climate activism is however quite recent. As shown in Fig. 20, prior to the spring of 2022, this account had a long period of anti-vax activism, with the transition between these two periods taking place through a phase* where he was the discreet relay of the pro-Kremlin propaganda that flooded the social networks at the beginning of the war in Ukraine. In fact, before defining himself as "Climate Science Research (Independent)", he defined himself between 2021-12-23 and 2022-06-10 as "Biostatistician, (data analyst)" and indicated at other times in his profile wanting to "Reinform against this Orwellian propa-

(*) From 25/02/2022 to 31/07/2022. Example the 11/03/2022 (sic) " Inform you, it is now official that there are well bio lab US in Ukraine, because you denounce Russian lies, whereas you make only swallow the Western media propaganda The Occident and the USA them did nothing but lie for each war since years "

or the 20/04/2022 in answer to @BHL admiring Zelensky : You are a disgrace dear sir, it is high time that the warlord that you are eclipses, you defend Nazi militias, a corrupt regime, put in place by the USA, which has been bombing Russian speakers for more than 8 years. "

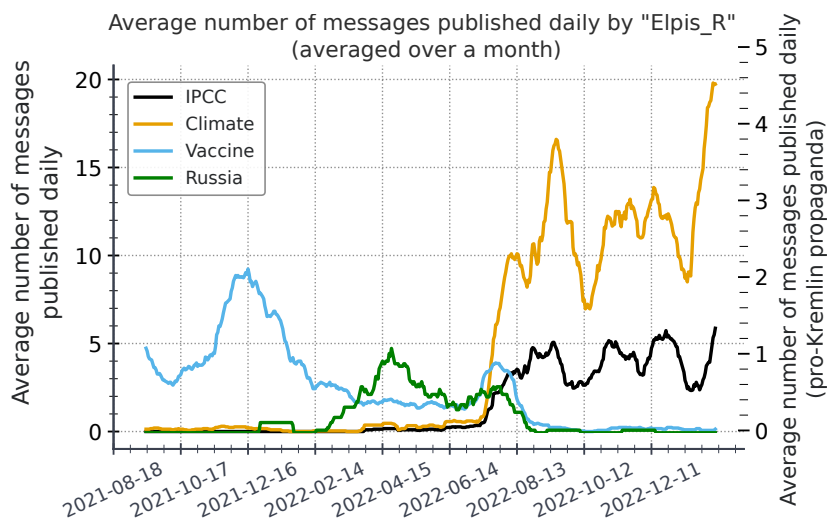


Figure 20: Daily number of messages from the account *Elpis_R* on some key themes. Warnings: the plot of messages relaying Kremlin propaganda has been drawn on another scale for questions of readability.

ganda”, or to be a “Free spirit, for a fair information and not biased by the systemic corruption which gangrene this world”.

One of his profile description even once referred to his profile on vk.com, the Russian Facebook controlled by the Kremlin [16], that he has since deleted (see sect. 4 for all changes). A snapshot of Nov 8 2021 by the [WayBackMachine](https://www.waybackmachine.org/) of his VK homepage shows that of the nine archived messages posted by *Elpis_R* on its wall between 3/07/2021 and 11/10/2021, eight were “vaccin alarmist” and one warned about the impending food shortage due to the pandemic. Nothing on climate change...

Elpis_R thus appears to be an opportunistic digital anonymous activist, whose real motivations are obviously not those displayed in his profile. It is however his denialist period which allowed *Elpis_R* to gain in visibility in France, making him pass in six months, from less than 1000 followers (July 2022) to more than 19k.

It is noteworthy that only 3% of the messages of this denialist influencer are categorized as “toxic” according to our model, a rather polite strategy to win over public opinion. This strategy goes hand in hand with his desire to project the image of an “expert” who claims to have read thousands of articles, with many highly technical tweets that take out of context or distort the results of academic articles.

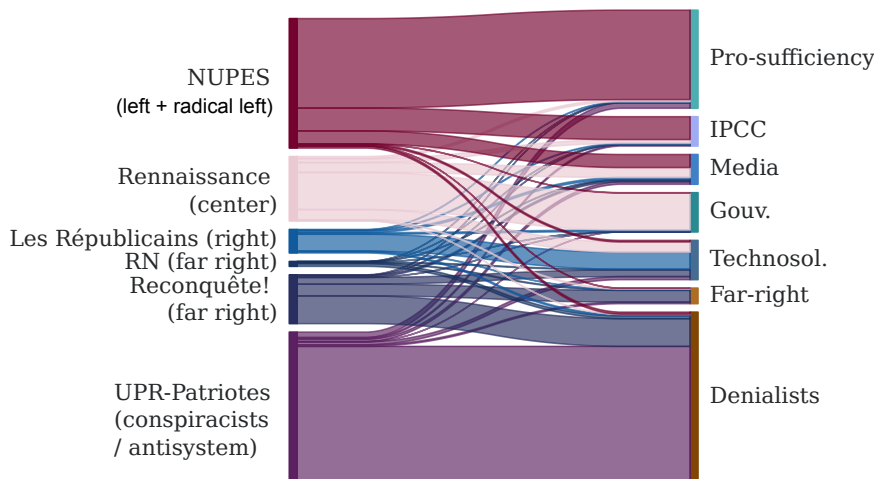


Figure 21: Shared accounts between the French political twittosphere (Politoscope, left) and the French climate twittosphere (Climatoscope, right) [18,060 shared accounts]. The width of the bands indicates the number of accounts that are shared by the different categories.

The ideal ground for subversion operations

As we will see, the success of the account *Elpis_R* is probably due to the fact that it acts on a favorable ground, where a whole community is already predisposed to listen to anti-system and conspiracy speeches.

How did a community of nearly ten thousand denialists build up around *Elpis_R* in a few months? What types of accounts have bitten into this misinformation? In addition to the larger fraction of "bots", which may have helped to prime the pump, this subversion operation benefited from a particularly favorable terrain against a background of health, economic and social crises.

In order to better qualify this terrain, we mobilized the [Politoscope](#) platform (CNRS/ISC-PIF), which is the equivalent of the climatoscope in the field of French political activism. Since 2016, it has been mapping the French political twittosphere [3], its evolutions and the attempts to manipulate French public debates.

Comparing the landscapes of interactions around political and climatic issues as on the figure 21 allows us to better qualify the state of mind of the French denialist community.

Take-home-message:

Apart from a significant proportion of accounts involved in the informational sphere of the French far-right, the denialist community is not composed of political activists from French traditional parties (LFI, PS, EELV, Renaissance, LR or RN).

Take-home-message:

The denialist community on Twitter is composed mostly of accounts that participated in the anti-sanitary dictatorship protest during the pandemic.

The first thing to note is that, apart from a significant proportion of accounts involved in the informational sphere of Reconquête! (French far-right) who briefly addressed the climate issue during the 2022 presidential campaign, the denialist community is not composed of political activists from traditional parties (LFI, PS, EELV, Renaissance, LR or RN). As the figure shows, the vast majority of the accounts that make up the community and relay political information come from the community that was formed around Florian Philippot and François Asselineau during the Covid-19 pandemic in reaction to a “sanitary dictatorship”.

As documented in *Toxic Data* (Chavalarias D., Flammarion 2022), this community, now one of the most important in the political twittosphere, emerged in November 2020 after the announcement of the discovery of the vaccine against COVID-19. Anti-vax, and more generally “antisystem”, this community has been the seat of a radicalization of its members, under the effect of conspiracy speeches, disinformation and most probably astro-turfing from the Kremlin.

Another remarkable fact is that the denialist community has a core group of several thousand accounts that have participated in numerous opportunistic “antisystem” campaigns (Fig. 22). Among others, we have been able to demonstrate that more than 1,400 of them have participated in the following digital campaigns¹: the [social crisis in Guadeloupe](#) of summer 2021, the [Freedom Convoy](#) of January-February 2022, the [conspiracy theory around the variant Omicron](#) (Nov 2021 - Jan. 2022) and more generally the contestations of the governmental measures put in place to fight against the COVID-19 pandemic observed via the [covidoscope](#)²; and finally at the [relay of Kremlin propaganda](#) and the pro-Putin indignation against the measures taken by Europe in reaction to the invasion of Ukraine. If we consider only this campaign, nearly 6,000 denialist accounts (60% of the community) have also participated in relaying the Kremlin’s propaganda since the beginning of the war in Ukraine.

We can therefore see that the composition of this French digital community, which is the only one that can really be described as a denialist or a climate skeptic, is very particular because it has almost no intersection with the traditional political parties. Accustomed to social conflicts of all kinds, it is also distinguished by the type of disinformation that circulates, the degree of toxicity of its messages, the abnormal proportion of “probably bots” accounts, its appetite for relaying Kremlin pro-

1 Click on the links to see the video. This hard core is always found in the community around Florian Philippot or François Asselineau.

2 The covidoscope is an observatory of Twitter exchanges around the COVID-19 pandemic

Take-home-message:

The denialist community is made up of a hard core of a few thousand accounts that intervene opportunistically in many digital social agitation campaigns. About 6,000 of them (60%) have relayed the Kremlin’s propaganda since the beginning of the war in Ukraine.

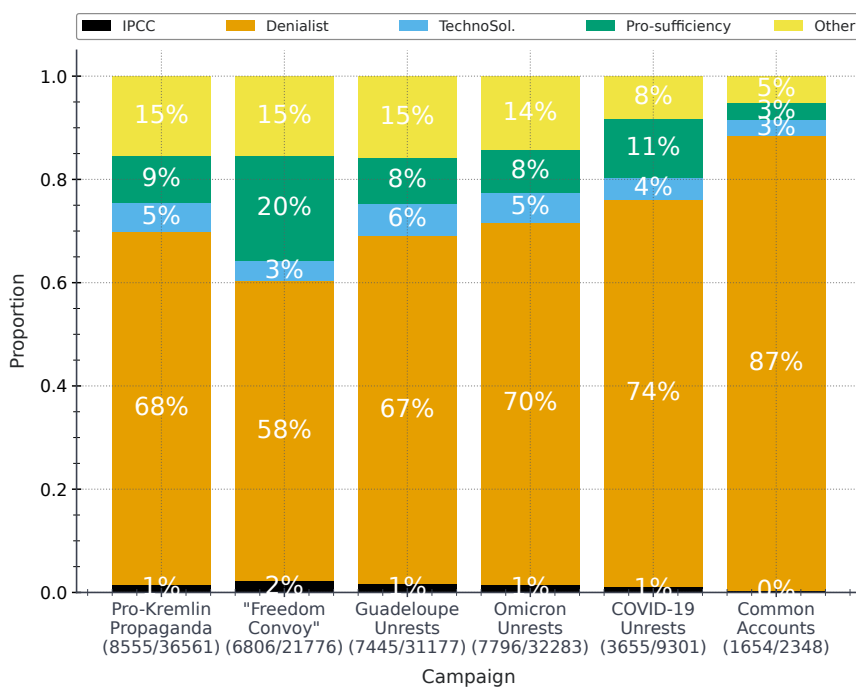


Figure 22: The French denialist community includes a hard core of more than 1,400 accounts that have participated in five other opportunistic “antisystem” campaigns identified in the Politoscope and in the Covidoscope (CNRS/ISC-PIF). It should be noted that nearly 6k denialist accounts out of 10k have also relayed Kremlin propaganda about the war in Ukraine. The numbers in brackets indicate the number of common accounts between the climate map of Fig. 12 and the campaign considered, out of the total number of accounts of these same campaigns.

paganda and the practices of its leaders.

In fact, this denialist community is integrated into a wider international and geopolitical context where subversive actions are regularly deployed.

Recall, for example, that the Kremlin has had since 2013 the [Internet Research Agency](#) (IRA), a troll factory created by Yevgeny Prigozhin, which is known to have interfered several times in the American elections, but also to be active in the field of disinformation throughout the world, including Africa (where Mali and Burkina Faso have just kicked France out). Prigojine is also the creator of the Wagner group, a private militia that has been committing abuses in Ukraine since the beginning of the war.

Finally, numerous research and investigative works have shown that totalitarian states such as Russia or China have long been

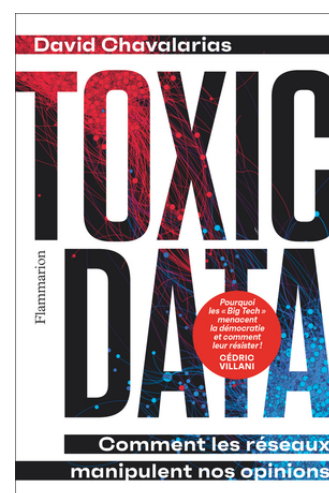


Figure 23: The exploitation by the globalized pro-Kremlin far right of the COVID-19 pandemic to build powerful Twitter communities sensitive to conspiracy arguments has been documented in *Toxic Data*. It is precisely these communities that provide today fertile ground for the resurgence of climate denialism.

waging a hybrid war on social networks, with the strategy of amplifying divisions within democracies in order to weaken them (cf. *Toxic Data*, Ch.8 & 9). Let's also remember that fossil gas and oil energies are at the intersection of the questions of the fight against global warming, of geopolitical tensions between Russia and Europe since the war in Ukraine and of social tensions in France since the yellow vests.

In this context, the fact that the French denialist community is largely made up of Twitter accounts receptive to Kremlin propaganda and converted to climate skepticism at the time of the war in Ukraine, after having been anti-vax for several months, is troubling to say the least.

The issue of climate change is an area where governments are being urged by a part of the of the population to take strong action, involving major changes in the lifestyles of all citizens. Many of them will only accept these measures if the results are worth it. Instilling doubt and misinformation about the reality of climate change in some communities, while heightening awareness of the climate emergency in others, is therefore a very effective way to destabilize governments by placing them at the center of conflicting demands from their citizens. Whatever the policy adopted, social revolt is guaranteed.

Sowing division in this way is inexpensive and risk-free for potential agitators because, unlike in dictatorships, it is not illegal to engage in this kind of activity.

Since informational warfare, which relies on the division of populations, is now part of the panoply of strategic weapons at the geopolitical level, it is highly probable that the issue of the fight against climate change will become an active field of subversion in the near future, if it is not already the case.

3 Does denialism on Twitter have measurable effects?

The rise of denialism on social networks like Twitter creates, as we have seen, hostility between digital communities and division, but are there other measurable effects?

To better understand the complex dynamics that take place between communities, we performed a causality analysis using the causality detection methods developed in [5, 14, 18]. In

Take-home-message: the issue of the fight against global warming and the characteristics of denialist activists make this societal issue a particularly favorable terrain for foreign interference operations of the subversion type.

Take-home-message: In the medium term, it is the IPCC's reports that are most likely to put climate issues on the agenda.

short, we seek to know to what extent the activity of a given community – in terms of volume of tweets published – influences the activity of another community, in other words, whether or not the future activity of one community depends on the past activity of another community. These causalities are determined using the causal network discovery algorithm PCMCI⁴.

⁴Runge et al. [19]

This type of analysis can answer several questions: Does an *A* community have the capacity to influence the debates within a *B* community over the long term (a few weeks)? Does a *B* community react immediately (a few hours) to the actions of an *A* community?

The first question is addressed by Fig. 24. The aggregation of the activity over a week (with a half-week overlap between two consecutive measurements for more stability) shows that the different communities evolve together, except for the couple {denialists, media} which are mutually independent. The activity of the denialist community is caused by that of the IPCC community, with a latency of half a week. The same is true for the media community, which reacts to the activity of the technosolutionist community, suggesting that the latter has some influence on the media agenda, at least on Twitter.

Take-home-message: Twitter rhetoric from the denialist and technosolutionist communities likely hinders the dissemination of scientific knowledge and IPCC findings by negatively impacting the online activity of climate science and climate change scientists.

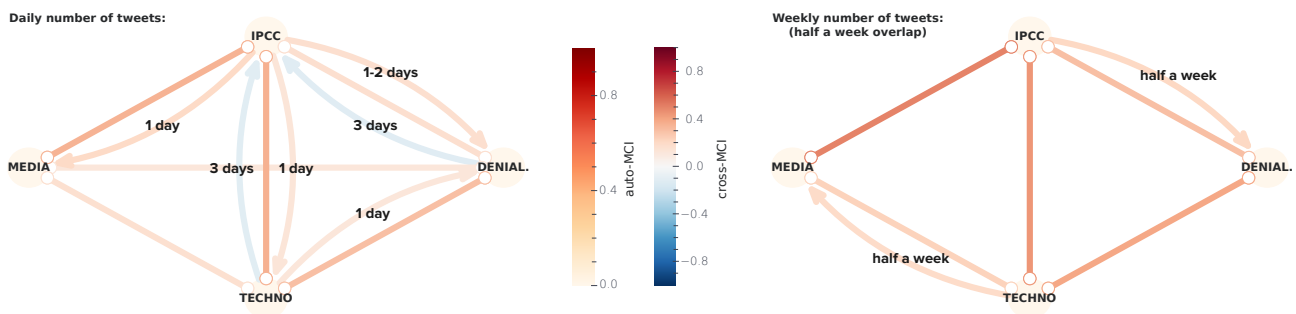


Figure 24: Causal graph of the number of tweets from the communities, with a significance level of 0.01 and 0.03 for daily and weekly (with an overlap of half a week) activity respectively. Determined by the PCMCI algorithm [19], node colors correspond to self-MCI (Momentary Conditional Independence), edge colors correspond to cross-MCI, undirected edges reflect co-evolution while directed edges reflect a causal link.

Figure 24 answers the second question and highlights a complex set of feedback loops. First, all communities co-evolve with each other, which is usually explained by external factors, such as real-life events, that drive different communities to be more or less active on climate topics. In parallel to this co-evolution, the activity of the IPCC community on one day influences the activity of the media, technosolutionist and denialist communities on the next day, (and again on the second day for the denialist community). On the other hand, the ac-

tivity of the IPCC community is itself negatively impacted by that of the technosolutionists and denialists three days later, which would tend to show that the reactions of the denialists and technosolutonnists to the interventions of the IPCC community have, each in their own way, the capacity to reduce the activity and thus the audience of the latter.

This complex dynamics is illustrated by the analysis of the first reaction the the French pre-print publication of our study (see [3](#)). In addition to the divisive effects observed above, the discourses of the denialist and techno-solutionist communities are probably succeeding in slowing down the dissemination of scientific knowledge and the IPCC's conclusions to a certain extent by modifying the perception of both the urgency to act and the ability to act now by relying on several components (technology, but also preservation and restoration of ecosystems and control of demand (sufficiency-related aspects).

Part A

Appendices

1 Before Twitter closes ...

In the current context, where Elon Musk is considering cutting off researchers' access to Twitter data, we probably won't be able to conduct these kinds of studies in the future. But you can help us prepare for the next move and contribute to a better understanding of the impact of digital platforms and misinformation campaigns on society.

Whether on Google, YouTube, Facebook or Twitter, the Internet user is alone with the recommendation algorithm. There is no publicly available data to know to what extent the information presented to him is neutral or on the contrary distorts reality in one direction or another.

To overcome this, we have developed [Horus](#), a browser extension that will help you better understand the biases of GAFAMs when they feed you information, the first step towards regaining control of your digital environments. From the analysis of what these platforms show you, Horus will indicate in a synthetic way if they expose you in a privileged way to certain contents, concerning French politics, or the climate (as illustrated by the figure 25). In particular, **Horus allows you to estimate your exposure to climate misinformation on Twitter.**

To participate in the Horus survey, go directly to the [Chrome](#) or [Firefox](#) store or visit [the project page](#).

Take-home-message:

You can estimate your exposure to climate misinformation on Twitter by installing the Horus plugin on [Chrome](#) or [Firefox](#) store or by visiting [the project page](#)

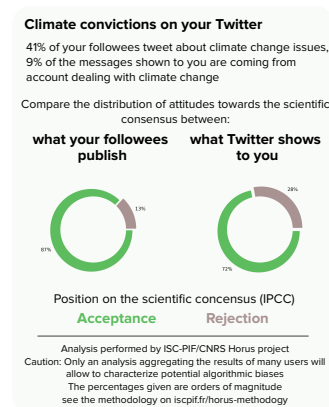


Figure 25: Example of analysis of a user's exposure to content from denialists rendered by the Horus project.

2 Twitter profiles analysis

In order to give a better intuition of the differences between the pro-climates communities, we provide here the tagclouds of the profiles description for the denialist, techno-solutionist and pro-sufficiency communities. The main difference between techno-solutionist and pro-sufficiency communities is that members of the former often they describe themselves as liberal of right-wing while members of the later they describe themselves as left-wing. As for the denialist community, we find a vocabulary that is typical from alt-right, far right and conspiracist: freedom, patriot, truth, frexit, Zemmour, etc.



(a) Denialists. Most frequent words: *freedom, right, patriot, truth, frexit, policy, left, zemmour, never, nature.*



(b) Techno-solutionists. Most frequent words: *policy, science, liberal, innovation, right, journalist, freedom, former, agriculture, contractor*



(c) Pro-sufficiency. Most frequent words: *policy, journalist, left, science, feminist, history, freedom, culture, justice, insoumis.*

Figure 26: Tag clouds of profile description per community.

3 Analysis of the reaction to the first publication of this study

A first version of this study was published as a pre-print in French in order to analyze the reactions of the different communities to such studies. The 7,718 original tweets published within twelve days of the pre-print release have been collected, 1,604 being produced by accounts categorized in Fig. 12.

These tweets have generated a total of 2.4M impressions, 1.3M retweets, 17.7k likes and discussions involving 3,920 replies and 400 quotes.

The patterns of the reactions of the 1,604 categorized accounts matches what is described in sect. 3, namely that denialist and techno-solutionist communities tend to tweet in reaction to IPCC community's posts, and that these reactions are far more toxic than those of IPCC community members.

More specifically, the denialists' reactions to this study has an overall toxicity score 373.3% higher than those of IPCC (cf. table 5, with estimated weights of 60.88% for "insult", 23.71% for "obscene" and 5.71% for "identity attack").

On the other hand, the techno-solutionist community has an over toxicity of 106.7% and the pro-sufficiency community of 26.7%. These levels of toxicity of these two latter communities could be explained mainly because this study has generated polemical Twitter exchanges between members of the techno-solutionist and pro-sufficiency communities on the question of techno-solutionism or its definitions, although this was not at all the focus of the study. These exchanges reveal the strong antagonism between these two communities which, although they both accept the anthropogenic origin of climate change, spend time confronting each other on the response to be made. On the other side, the media and government communities have an average score respectively of -36.4% and -93.9% lower than the one of IPCC community.

Note that although the denialist community has been the most active in terms of tweets, its impression numbers is far below the one of IPCC (more than twenty times less), which puts their influence on Twitter into perspective.

The detailed analysis of the reactions to this study (close reading of tweets, quantitative analysis the NLP tools [GarganText](#) and analysis with ChatGPT) give more insight into the overall

motivations of each communities and confirms that these groups are homogeneous in their approach to climate change issues and associated research findings:

- **The techno-solutionists' reactions** emphasize several issues :
 - **Defending nuclear power:** Some members of this Twitter community actively defend the use of nuclear power as a viable solution to climate change. They believe that nuclear power should play a central role in the energy transition.
 - **Criticism of the name "technosolutionist":** Some messages question the categorization of pro-nukes as "technosolutionists" and point out that this can lead to a problematic assimilation with climate skeptics. They suggest that there is a need to distinguish between the different shades of opinion within the pro-nuclear community.
 - **Questioning the Climatoscope Study:** Several posts questioned the methodology and conclusions of the Climatoscope study mentioned in the tweets. Some feel that the study lacks nuance and that the categories used are simplistic, which undermines its credibility. Many simply denigrate the study or its authors without further arguments.
 - **Criticism of anti-nuclear activists:** Some tweets criticize anti-nuclear activists, accusing them of blocking progress in the fight against climate change by opposing the use of nuclear power. Some also question the anti-nukes' vision for funding alternatives.
- **The denialists' reactions** highlights several aspect of their mindset:
 - **Rejection of consensus on climate change and denigration of IPCC.** They express an ideological position that challenges the scientific consensus on climate change. Some users criticize the behavior of climate scientists, accusing the IPCC of ethical violations and ignoring uncertainty. They go so far as to consider their work as fraudulent.
 - **Victimization and call for debate.** They reject the idea of categorizing individuals and accuse those who call them "denialist" of sowing discord. Some users feel that being labeled as a climate skeptic or denialist for questioning the IPCC's dire scenarios and expressing doubts about proposed actions is unfair.

Table 5: Number of Original tweets in reactions to the French pre-print of the study (Feb. 13-25 2023) with the total number of impressions and average toxicity per community .

Community	Tweets	Impressions	<Relative toxicity>	<Toxicity>
IPCC	334	492,388	0.015	0%
Pro-sufficiency	227	357,302	0.019	+26.7%
Techno-sol.	399	115,147	0.031	+106.7%
Denialists	485	31,614	0.071	+373.3%
Medias	114	11,291	0.007	-53.3%
Gov.	45	993	0.004	-73.3%
Total / avg	1,604	1,008,735	0.065	

They believe that debate is a more productive means of action than simply discrediting them (although, as we have already mentioned it, they refuse in practice to debate in the sense of a discussion that would aim at finding a common vision of the world).

– **Attacks on the CNRS and the authors of the study.**

Some users also criticize the CNRS (Centre national de la recherche scientifique) for what they see as the decrepitude of the organization. They denounce an extremist religious totalitarianism that refuses any other explanation or consideration. Some use extremely toxic language that is common in conspiracy circles such as "pedophile".

- **Members of the pro-sufficiency community** accurately relay the results of the study and also raise concerns about the dissemination of scientific knowledge and IPCC findings due to the presence of denialists and technosolutionists on Twitter.
- **Members of the IPCC Twitter community** accurately relay the results of the study, emphasize the importance of the recognition of climate change due to human influence and criticizes the practices of disinformation and manipulation aimed at sowing doubt about this scientific reality. They support scientific research and warns against the consequences of polarizing society on scientific issues.

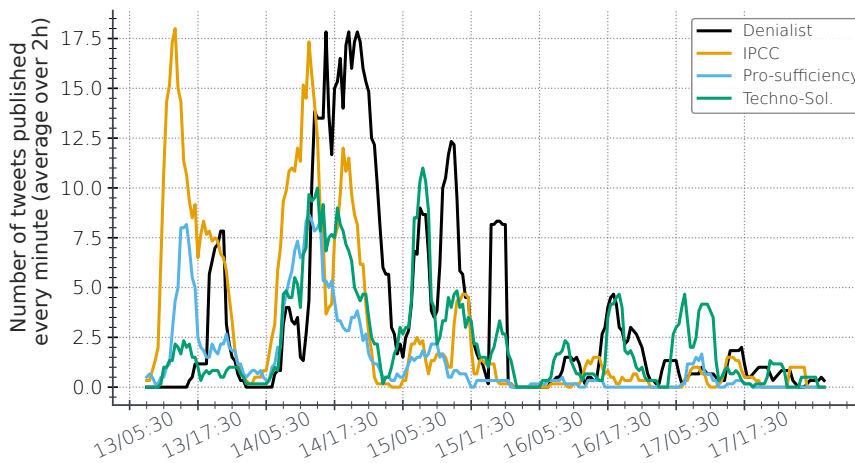


Figure 27: Reaction to the first French pre-print of our study within five days of release. Number of tweets per minute, averaged over 2h.

4 Evolution of Elpis_R profile descriptions

Each record is organized as follow : | Profile description | first date of capture | Account Id| Account screen name | number of followers |

- | Réinformer contre cette propagande Orwellienne, à travers une autre optique que celle de la pensée unique. | 2021-09-02T15:45:41Z| 634541534| Elpis_Real| 27 |
- | Ne remettez pas en question l'autorité, regardez la télé, la science est votre dieu, restez endormi http://vk.com/real_elpis http://gettr.com/user/real_elpis | 2021-11-16T00:49:53Z| 634541534| Elpis_Real| 76 |
- | Biostatisticien, (data analyst) Esprit libre, pour une information juste et non biaisée par la corruption systémique qui gangrène ce monde. Je bloque les trolls | 2021-12-23T20:21:37Z| 634541534| Elpis_R | 276 |
- | Biostatisticien - Data Analyst Esprit libre, pour une information juste et non biaisée par la corruption systémique qui gangrène ce monde. | 2022-04-16T11:13:39Z| 634541534| Elpis_R | 620 |
- | Esprit libre, pour une information juste et non biaisée par la corruption systémique qui gangrène ce monde. | 2022-06-10T16:20:43Z| 634541534| Elpis_R | 696 |
- | Débranché de la matrice depuis le 11/09/2001. | 2022-

- 06-26T18:23:49Z| 634541534| Elpis_R | 711 |
- | null | 2022-06-29T12:39:42Z| 634541534| Elpis_R | 740 |
 - | « L'ennemi n°1 est l'ignorance... » Julian Assange. « Ceux qui ne peuvent se souvenir du passé sont condamnés à le répéter. » George Santayana. | 2022-07-02T11:36:03Z| 634541534| Elpis_R | 829 |
 - | « L'ennemi n°1 est l'ignorance... » Julian Assange. « Ceux qui ne peuvent se souvenir du passé sont condamnés à le répéter » George Santayana. | 2022-07-06T15:40:09Z| 634541534| Elpis_R | 864 |
 - | « L'ennemi n°1 est l'ignorance » Julian Assange. « Ceux qui ne peuvent se souvenir du passé sont condamnés à le répéter » George Santayana. | 2022-07-17T15:57:49Z| 634541534| Elpis_R | 924 |
 - | 97% des scientifiques sont d'accord avec celui qui les finance. Les 3% restants sont bannis des réseaux sociaux et discrédités sur Wikipédia. | 2022-07-17T18:44:25Z| 634541534| Elpis_R | 925 |
 - | 97% des scientifiques sont d'accord avec celui qui les finance. Les 3% sont bannis des réseaux et discrédités sur Wikipédia. +0,2°C sur 40ans. Météo≠Climat | 2022-07-22T21:41:29Z| 634541534| Elpis_R | 948 |
 - | 97% des scientifiques sont d'accord avec celui qui les finance. Les 3% sont bannis des réseaux et discrédités sur Wikipédia. +0,2°C sur 40ans Météo≠Climat | 2022-07-27T13:22:51Z| 634541534| Elpis_R | 1915 |
 - | 97% des scientifiques sont d'accord avec celui qui les finance. Les 3% restants sont bannis des réseaux et discrédités sur Wikipédia. Météo≠Climat | 2022-08-14T10:29:51Z| 634541534| Elpis_R | 2294 |
 - | 97% des scientifiques sont d'accord avec celui qui les finance. Les 3% restants sont bannis des réseaux et discrédités sur wikipédia. Météo≠Climat | 2022-10-15T00:13:28Z | 634541534| Elpis_R | 5387 |
 - | Recherche en science du climat. | 2022-10-15T23:39:46Z | 634541534| Elpis_R | 5451 |
 - | Climate Science Research. | 2022-11-02T23:49:35Z| 634541534| Elpis_R | 8470 |
 - | Climate Science Research - Climate Realist - Alarmists ignore the geological climate record. | 2023-01-28T18:16:38Z| 634541534| Elpis_R | 17227|

- | Climate Science Research (Independent) - Climate Realist - Alarmists Ignore The Geological Climate Record. | 2023-01-30T16:56:12Z| 634541534| Elpis_R | 17566|

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