

1 Tracing the evolving actor network: A social network analysis of 2 the 2018 Mayotte crisis in the press

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9 Abstract

10 The media, especially the press, play a crucial role in shaping public understanding during risk and crisis management,
11 acting as intermediaries between various actors and the public. However, their framing of sources can introduce biases
12 into these representations. Limited analysis exists regarding how press coverage portrays relationships between crisis and
13 risk management actors. Using Social Network Analysis, this study maps quotation networks in press coverage of a
14 seismo-volcanic crisis in Mayotte, a French overseas department. This approach allows for an overview of the
15 relationships between actors, highlights unique aspects related to the context and media portrayal, reveals underlying
16 representations and levels of trust among interviewed actors and visualises the network's dynamics over time. Analysis
17 revealed variations in narrative approaches among newspapers, with some focusing on specific aspects. The results show
18 that national authorities received more attention than local elected representatives, and that scientific figures dominated
19 reported speech, while the population's perspective remained relatively passive despite its centrality to the quotation
20 network. Prominent individuals held significant positions, emphasising the importance of personal connections in
21 communication and revealing a potential distrust of political and scientific institutions. This finding underscores the need
22 for greater proximity between information sources and the affected community.

23 1. Introduction

24 Risk communication is a key component of disaster risk reduction (UNISDR, 2015). Implementing an effective risk
25 communication strategy is, however, not a trivial matter and presents a complex undertaking (e.g. Mileti and Sorensen,
26 1990; Tierney, Lindell and Perry, 2001; Graham et al., 2022). There are many pitfalls at multiple stages: in the
27 communication process between actors responsible for risk monitoring and management, as well as in the process of
28 public information dissemination. It is particularly difficult when uncertainties are high, which is often the case in crises
29 related to volcanic hazards for instance (e.g. Barclay et al., 2008; Solana et al., 2017; Andreastuti et al., 2019). Mass
30 media (newspapers, television, radio) play an important role in shaping public information (see Perry and Lindell 1989,
31 pp. 47-62 or Scanlon, 2007 for an overview). In crisis situations, they are identified as the main source of information for
32 the public actively seeking for hazard-related information (Nazari et al., 2011; Poudel et al., 2015; Van Belle, 2015). This
33 is especially true for local and national media (Allan et al., 2000; Scanlon, 2007; Jin et al., 2025), and their participation
34 is thus crucial for effective warning dissemination (Lindell et al., 2006). News reports are also closely followed by crisis
35 management teams, which in turn influences official communication strategies (e.g., Lagadec, 1991; Lindell et al., 2006).

In the long term, they affect risk perception, notably by contributing to the circulation of “erroneous representations” of how individuals, groups or organisations behave during disasters (Coleman, 1993; Quarantelli, 2002; Wachinger et al., 2013; Van Belle, 2015).

Compared to other sources, newspapers, especially the daily press, are commonly seen as a more credible source of information because of their ability to provide in-depth analytic coverage (Quarantelli 2002, cited in Steelman et al. 2015). They are also widely relayed in other media or on social networks. The local press occupies a specific position in this respect, as local journalists are both interested parties and commentators on ongoing crises. The resulting coverage tends to be more regular and more detailed, and it often provides the raw material for press agencies and, through them, for other media (e.g. Nielsen, 2015; Cagé, Hervé and Viard, 2017). Studies have also demonstrated the pivotal role played by local journalists as intermediaries between risk management authorities and populations when disseminating warning messages, conveying the community’s concerns, and providing updates on the situation at the grassroots level (Scanlon, 2007). Newspapers’ coverage constitutes, therefore, an important issue for disaster research (see Harris et al. 2012; Camilleri et al., 2020; Calabrò et al., 2020; Le Texier et al., 2016; Devès et al., 2019; Devès et al., 2022b).

However, the daily press, and the media in general, cannot be considered as simple vehicles for providing information. As recalled by Aylesworth-Spink (2017), they act as “a complex mediator with specific interests and motivations”. The way the media depict an event is neither exhaustive nor neutral. There are many factors influencing the final coverage: selection of topics (Pavelka, 2014), layout and design choices (e.g. Moirand, 2006; Schindler and Krämer, 2017; Billard and Moran, 2023), political ideology and editorial policy of the newspaper (e.g. Shoemaker and Reese, 1996; Kaiser & Kleinen-von Königslöw, 2019), access to sources and their respective social status (Ploughman, 1997), and choices of contextualization (Llasat et al., 2009; Cavaca et al., 2016; Carter et al., 2018). Day-to-day journalistic practices also play a role (e.g. Boykoff and Boykoff, 2004). The way journalists tend to juxtapose the accounts of heterogeneous sources, while important for depicting a variety of viewpoints, has been shown to “blur” messages (e.g. Lejeune, 2005, Léglise and Garric, 2012, and Devès et al., 2022a), thereby reducing their clarity. These various factors can lead to conveying representations to the public that are sometimes very different from how authorities and scientists see the situation (Ploughman, 1995). They may also implicitly replicate common misconceptions (see Quarantelli, 1996) or reproduce asymmetrical power relationships between actors without questioning them (Valencio and Valencio, 2018; Devès et al., 2023).

Examining press coverage provides insights into the pivotal moments and key actors perceived by journalists covering the event, who often serve as primary observers on the scene. The use of content and thematic analyses allows for the reconstruction of the sequence of events, the mapping of actors' networks (Hijmans, 1996), and the identification of representations conveyed by the press toward at-risk communities. This is exemplified by studies like those conducted by Thistlethwaite & Henstra (2019) or Calabro et al. (2020). However, a limited number of studies analyse how relationships between actors are portrayed in the press. Do these networks of interrelations, commonly connecting crisis management actors, experts, and populations, align with the envisaged distribution of roles during crisis management planning? If disparities exist, what insights do they provide?

Examining such interrelations can be accomplished by creating maps of quotation networks, representing how actors cite or reference each other in the press text (McLaren and Bruner, 2022). This method falls within Social Network Analysis (SNA), a widely employed approach in the social and information sciences (Otte and Rousseau, 2002; Sapountzi et al., 2018). SNA utilises tools from network analysis and graph theory to investigate social structures and information

circulation within networks of actors. Past studies utilising SNA or its derivatives in the realm of disaster risk research have focused on examining misinformation and the structuring of information networks on social media (e.g., Pourebrahim et al., 2015; Kim et al., 2018), or conducting a functional analysis of crisis management organisations (e.g., Trias et al., 2019; Flecha et al., 2023). To our knowledge, there is a lack of studies utilising SNA on press data within the context of risk or crisis management. Yet, this is an important area of research, as the approach allows for: i) gaining insights into the actual organisation of actors by providing a comprehensive view of all cited actors and their interactions, allowing the detection of communities (e.g. Park et al., 2015 and Williams et al., 2015); ii) identifying actors who are prominently featured, whether due to their perceived reliability, relevance, specific social role, or accessibility to journalists, relevance in transmitting information on a subject, specific social role or accessibility to journalists; iii) examining the involvement of various actors and the evolution of this network over time; and, iv) accessing a particular representation of actors, whether active or passive in media coverage. ~~Here, this method is applied to press coverage of a seismo-volcanic crisis which began in May 2018 in the French overseas department of Mayotte.~~

~~In this article, this mapping of quotation networks method is applied to press coverage of a seismo-volcanic crisis which began in May 2018 in the French overseas department of Mayotte. This study builds upon two previous investigations. The first, by Devès et al. (2022a), focused on public information processes and identified shortcomings in both scientific and state institutional communication. The second, by Devès et al. (2023), illustrated how newspapers implicitly reproduce asymmetrical power relationships between actors (e.g., local versus national authorities, experts versus lay public). Building on these findings and using SNA methodology, this study aims to identify and compare the presence of actors according to their role in the risk reduction network, the geographical scope of newspapers (local versus regional versus national), and whether there are significant differences between newspapers.~~

Before presenting the selection of articles (Section 3.1) and methods (Section 3.2), Mayotte's geological and sociological contexts are briefly outlined, along with an explanation of why it constitutes an interesting case study (Section 2). The results are then presented (Section 4). Section 4.1 concentrates on the actors' mention frequency and form in varying newspapers. Section 4.2 focuses on whether actors' statements are displayed directly or through a third party. Section 4.3 explores the positions of the actors mentioned in the chain of quotation. Section 4.4 compares the actor network structures during several specific "moments" of this media coverage. Sections 5.1 and 5.2 discuss differences between the press representation of the actor network and the official organisation of risk and crisis management in France and its overseas territories. Finally, Section 6 concludes on the value and limitations of this approach and on future avenues of research.

2. The 2018 Mayotte seismo-volcanic crisis

Devès et al. (2022a) provide a detailed description of Mayotte's geological context and the so-called "seismo-volcanic crisis" that began in Mayotte in May 2018. This section summarises the main events and reviews the latest scientific updates, since knowledge in this area evolves quite rapidly due to ongoing, significant research efforts. A detailed chronology is provided in Figure 1.

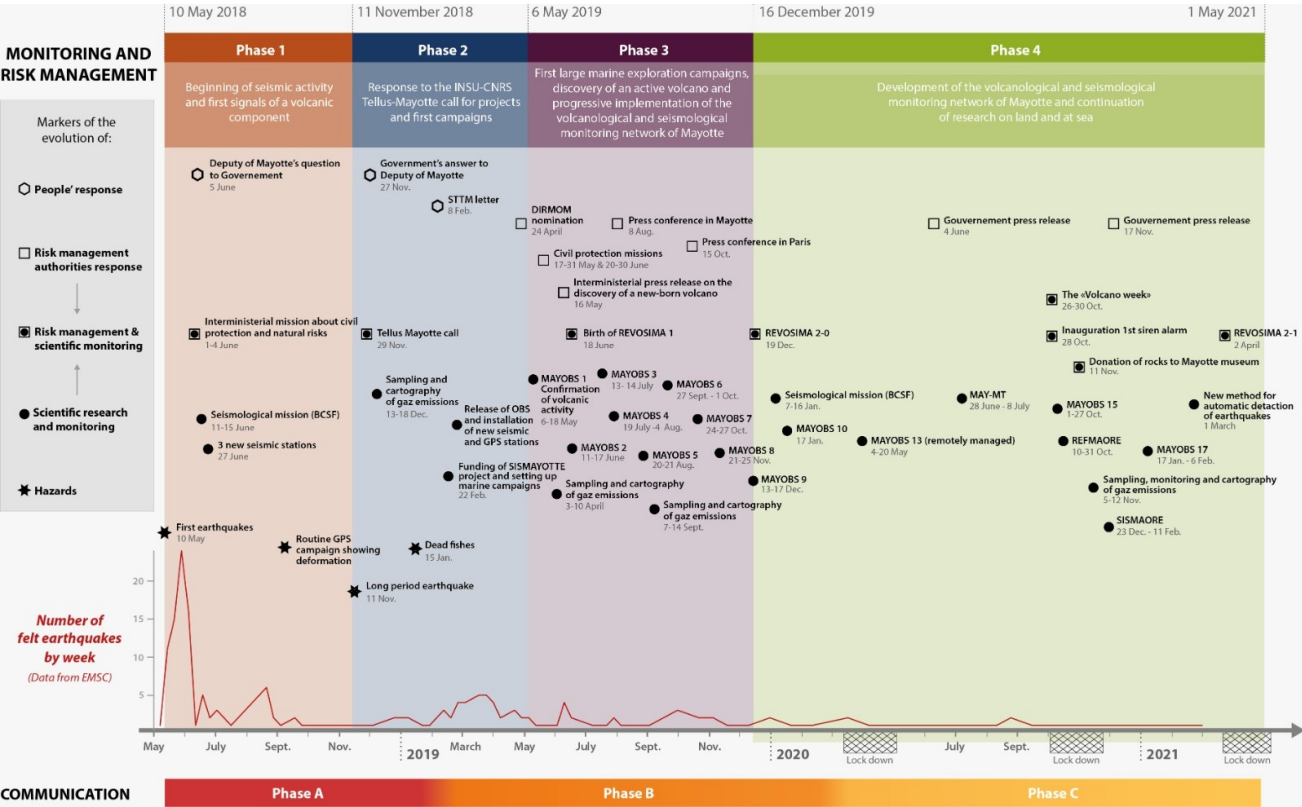


FIGURE 1 : Key phases and milestones in the response by local and national authorities responsible for risk and crisis management, as well as by scientific experts monitoring seismo-volcanic activity in Mayotte. The period covered in this study spans from the 10th of May 2018 to the 1st of April 2021. SISMAYOTTE, REFMAORE, MAY-MT, and SISMAORE refer to scientific campaigns—SISMAYOTTE was funded by “Tellus Mayotte”, while the others were supported by REVOSIMA’s institutional partners. The lockdown periods indicated correspond to those implemented in metropolitan France during the Covid-19 pandemic (most scientific institutions involved in the monitoring effort are based in metropolitan France). Notably, Mayotte experienced longer lockdowns in spring 2020 and 2021, but no formal lockdown was imposed during autumn 2020 (figure from Devès et al., 2022).

The seismo-volcanic crisis began on the 10th of May 2018 with an unusual seismic activity (tens of felt earthquakes in the first month alone, with a magnitude up to Mw 5.9; see BCSF 2018). This seismic crisis was linked to the formation of a new submarine eruption site, named Fani Maore, which was discovered one year later, in May 2019 (Feuillet et al., 2021), at about 50 km off the eastern coast of the Mayotte islands. From a scientific perspective, uncertainties were exceptionally high, especially in the first months of the seismic crisis, due to scarce knowledge of the geodynamical context in the area and a poor monitoring network (Saurel et al., 2021; Bertil et al., 2021; Feuillet et al., 2021). The recorded signals were poorly constrained in terms of location and magnitude and remained difficult to explain in this region. The volcanic hypothesis to explain the origin of the seismic activity did not emerge until several months later, in October 2018, and was not confirmed until May 2019. This made public communication particularly difficult and led to the development of a “technicalist bias”, with frequent, but minimalist communication from institutions that did little to help the population gain situational awareness (Devès et al., 2022a). Indeed, there was an overall feeling of a “lack of information” (Fallou et al., 2020), which led to the spread of numerous rumours to explain this phenomenon and to regular complaints from inhabitants and their representatives (see for instance the questions addressed to the government by a Member of Parliament for Mayotte, Ali, in 2018, as well as the open letter sent to the authorities and scientists by a group of citizens in February 2019; Picard, 2019). At the time of writing, the eruption of the new submarine volcano Fani Maore has ceased, and seismic activity is divided into two main clusters, active since the end of June 2018 (according to Lemoine et al., 2020), at respectively 5 to 15 km and 30 to 40 km from the coast (Feuillet et al., 2021; Saurel et al., 2021; Lavayssière et al., 2021). Most of them are volcano-tectonic earthquakes. Another sign of this still ongoing activity is the detection at 10 to 15 km off the coast of acoustic plumes associated with geochemical anomalies (22 sites observed in July 2022, MAYOBS 23). These acoustic plumes are possibly linked to gas emissions monitored prior to 2018 on Petite Terre island, Mayotte's second-largest island, east of the largest island and closer to the Fani Maore volcano. Hence, magmatic processes related to these observables are still located close to the island. As their uncertain evolution presents a significant hazard, this activity is currently being monitored by REVOSIMA (Mayotte Volcanological and Seismological Monitoring Network).

In addition to scientific uncertainties and the ensuing difficulties in public information, other factors could also have undermined the relationship between actors. For instance, there is both a geographical and a cultural gap between the scientists involved and the local populations, since most of the former are based either in mainland France or in La Réunion island and do not have many occasions to exchange with Mayotte's inhabitants. As detailed in Devès et al. (2022a), Mayotte is a multicultural archipelago with a dominant oral culture where about 37% of the population does not speak French (INSEE, 2017), which complicates risk communication from scientific institutions and the authorities in charge. It is also a particularly vulnerable territory marked by poverty and important social inequalities (Roinsard, 2014; INSEE, 2021). Since its recent departmentalization in 2011, it has been regularly shaken by social crises, one ending just as the seismic swarm began (Roinsard, 2019; Mori, 2021). Finally, there seemed to be no living memory of seismic and volcanic phenomena in Mayotte within the population. The last important earthquake was a magnitude ML 5.3 event in 1993 (Bertil et al., 2021). This, added to the underwater nature of this activity, caused confusion among inhabitants. Some of them went so far as to doubt the scientific explanations and the very existence of a volcano, even today (see testimonials in Devès et al., 2023). In this context, marked by considerable scientific uncertainties, social tensions, and the involvement of a multitude of actors, particular attention is given to identifying the obstacles and mechanisms that have hampered information flow at each link of the communication chain.

Mayotte's seismo-volcanic activity is a useful case study because: i) although the seismic-volcanic phenomenon itself has been associated with moderate impacts, in the first years of activity, it triggered a social crisis that the risk managers themselves qualified as a "communication crisis" (see questions to the government, Ali (2018) where the deputy Ramlati Ali expressed a need for information in the national assembly, and an open letter sent by a citizens' group (Picard, 2019) in which state services, elected officials, and scientists were taken to task on this subject. More details are presented in Devès et al. 2022a and b, Fallou et al. 2020, and Mori 2021 and 2022); ii) despite a large quantity of public information documents issued by scientists and the authorities (Devès et al., 2022a), the significant feeling of a "lack of information" within the exposed population documented by Fallou et al. (2020) raises questions about the transmission chain of this information to the public; iii) risks are perceived mostly indirectly by at-risk populations, which poses specific challenges for public information (Skotnes, Hansen and Krovel, 2021); iv) there are large uncertainties, some of them still ongoing as we write; and finally v) the activity is long-lasting, allowing us to study the evolution of a large coverage over time.

3. Method

3.1 Selection of articles

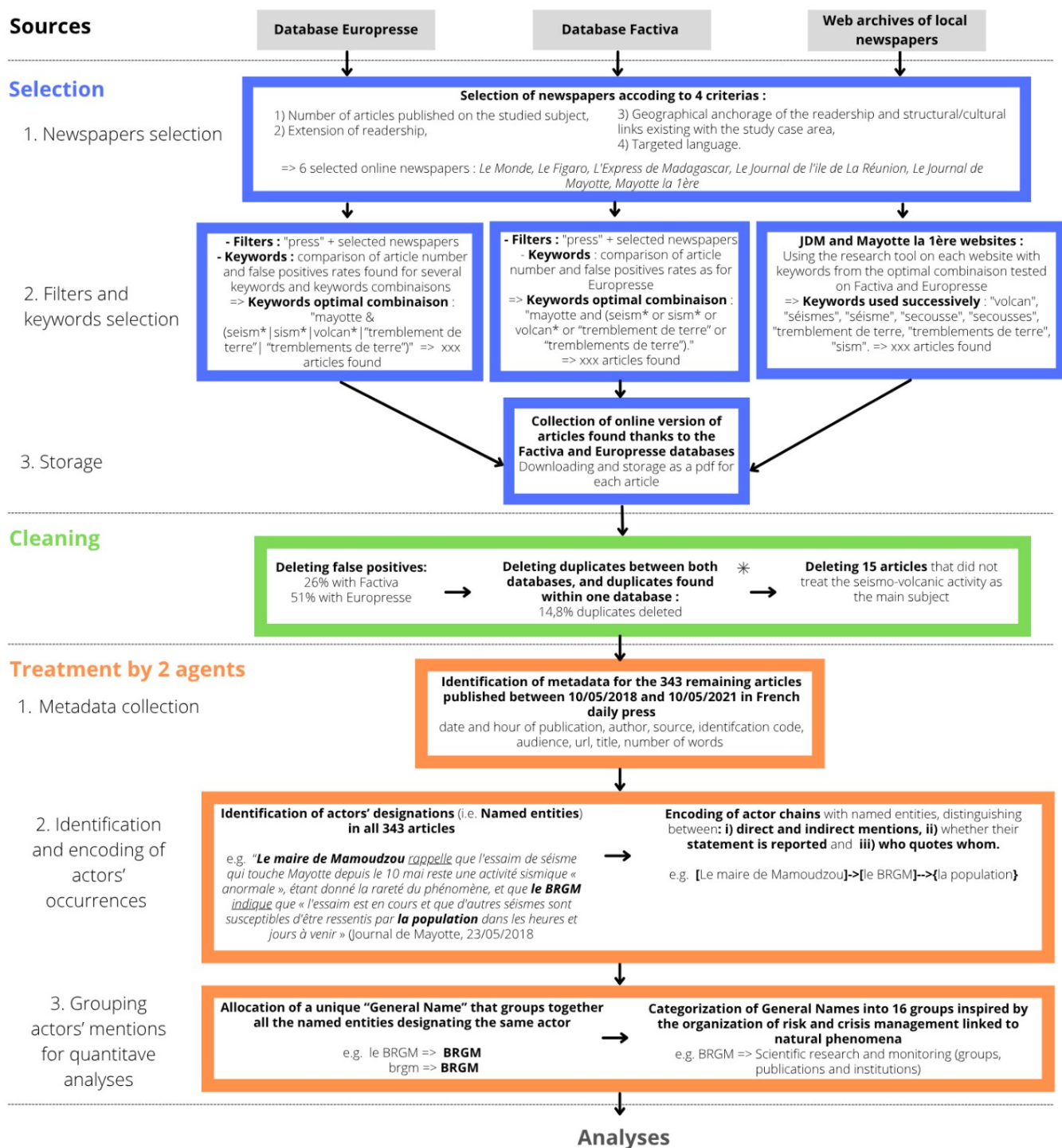
~~This study builds on two previous studies. The first, by Devès et al. (2022a), focused on public information processes and identified shortcomings in both scientific and state institutional communication. The second study, by Devès et al. (2023), illustrated how newspapers implicitly reproduce asymmetrical power relationships between actors (e.g., local versus national authorities, experts versus lay public). Building on these findings, this study aims to identify and compare the presence of actors according to their role in the risk reduction network, the geographical scope of newspapers (local versus regional versus national), and whether there are significant differences between newspapers.~~

~~To do so,~~ the same selection of articles as Devès et al. (2022b) and Devès et al. (2023) is used. This selection contains articles from six French-language daily newspapers published between the 10th of May 2018 and the 10th of May 2021. The methodology for creating this selection is inspired by Le Texier et al. (2016) and Devès et al. (2019). Newspapers were selected based on four criteria: 1) number of articles published regarding this case study, 2) breadth of readership, 3) spatial distribution of the readership along with the structural and cultural links existing between the region and the study area, and 4) a specific language (French in this study). Six French language daily newspapers were selected among 56 sources mentioning these events, addressing national (Le Monde, Le Figaro), regional (L'Express de Madagascar, Le Journal de l'île de La Réunion), and local readerships (Le Journal de Mayotte and Mayotte la 1ère); see Figure 2 and Part 1 in Supplementary Information. Articles were then collected from two types of sources: 1) Factiva and Europresse, two full-text press databases offering a selection of general and specialised, paywalled or freely accessible newspapers with regional, national, and international readerships, and 2) web archives, especially for local press articles which cannot be found in those two databases. Factiva and Europresse databases are often used by scholars to study media coverage (Severo et al., 2015, Reboul-Touré 2021, Bernier et al. 2013).

189 The resulting database is composed of 358 articles published between the 10th of May 2018 and the 10th of May 2021,
190 thus covering the first three years of Mayotte’s seismic-volcanic crisis. This selection of articles was limited to May
191 2021, after which pictures taken underwater and graphical representations of the phenomenon began to be regularly
192 broadcast by these media. This date also corresponds to when articles in the local press became less frequent. Within this
193 database, 15 articles were excluded from this study to ensure the selection contained only news items whose main subject
194 was the seismo-volcanic activity. Therefore, the final database includes 343 articles and covers the first three years of the
195 recent seismo-volcanic unrest near the archipelago of Mayotte.

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* Analysis on a representative sample of articles (74,2% of the articles in our database)

FIGURE 2: Schematic workflow for article collection and processing. The articles are selected from 3 main sources using a combination of keywords (see Supplementary Information for more details on the keyword analysis). Articles are all initially read to identify and remove false positives and duplicates. False positive and negative rates are determined on representative samples (see Supplementary Information). Each article is then read independently by 2 to 3 researchers who complete a data table with metadata and coded variables. Disagreements were discussed and resolved collectively.

204 3.2 Indicators

205 3.2.1 Actors and categories of actors

206 The term “actor” is used with a broad definition which encompasses both individual and legal entities, groups of
207 individuals sharing a common character or purpose such as a scientific mission or being impacted in the same way by the
208 crisis, but also media agencies that play an active role in communicating about the event (Agence France Presse, X
209 formerly known as Twitter, scientific journals, etc.). Places or buildings (mobile like a boat or immobile like a school)
210 may be described in the media as actors when they are named as a proxy for the individuals they host and were therefore
211 also included. Devès et al. (2022a) provides a detailed account of actors and actors categories and outlines their expected
212 roles, responsibilities, and capacities during the crisis.

213 To study the press coverage of different categories of “actors”, a double-reading process was employed. Two researchers
214 independently reviewed the articles to identify each actor or group of actors mentioned, even when they were identified
215 by professional status, by nicknames, etc. This qualitative analysis of the texts disambiguated the majority of references
216 to actors in the texts. For example, the terminology "experts" can be used to refer to scientists specialising in the hazard
217 as well as to technicians from the Bureau Veritas in charge of assessing the damage, and some actors have different
218 affiliations depending on articles due to errors or evolutions in their career (e.g. Nathalie Feuillet, a researcher, was
219 wrongly affiliated with IFREMER in some articles, such as in an article published in the Journal de Mayotte on the 7th of
220 May 2019). A careful reading of the articles was thus necessary and generally enabled the actors to be categorised.
221 Remaining actors are labelled as “unidentified” in the Divers/Unidentified category (see Part 2 in the Supplementary
222 Information). When an actor is identified in an article, their exact denomination(s) is noted (i.e., named entities) and build
223 two correspondence tables that allow us to: i) identify the different ways of naming the same actor and group them under
224 a chosen “general name” (TABLE NamedEntitiesToGeneralName in TABLE SA) and ii) group these actors into
225 categories (see TABLE GeneralNamesToCategories in TABLE SB for a correspondence table between “general names”
226 and “categories”) in order to build a structural analysis.

227 **TABLE 1: Denominations and definitions of categories used to group actors identified by two researchers in a database of 343**
228 **daily press articles published between the 10th of May 2018 and the 10th of May 2021 covering the first three years of the**
229 **recent seismo-volcanic unrest in the Mayotte archipelago. Categories are determined according to the organisation of risk and**
230 **crisis management in France (see Fearnley et al. (2018) and Section 2 in Part 2 of the Supplementary Information).**

Level 1 of categorization: Usual categories considered in risks and crisis management studies	
Name of categories	Definition of categories
Scientific research and monitoring (groups, publications and institutions)	Scientific groups, publications, institutions and all groups of people involved in monitoring and research on the seismo-volcanic activity in Mayotte.
Scientific research and monitoring (named individuals)	Namely identified scientists involved in monitoring and research on the seismo-volcanic activity in Mayotte.
Risks and crisis management actors	Administrative authorities involved in risk and crisis management activities

French political institutions	French political institutions involving members of the government, the French Parliament and the Senate
Public and para-public services to the population (institutions and members)	French public or parapublic services to the population
Elected local officials	Locally elected executive representatives
Mass media and associated journalists	Includes TV, radio, magazines, newspapers and associated journalists
Social media/Internet	Social media or websites
Civil society, private sector and NGOs	Civil society, private sector and NGOs
Local identified personalities	Influential figures in Mayotte
At-risk populations in Mayotte	Populations living in Mayotte and exposed to natural hazards
Educational staff and institutions	Educational staff and institutions in Mayotte and mainland France
Students and schoolers in Mayotte	Children living in Mayotte when mentioned in school contexts
Other populations	Populations living outside of Mayotte
Foreign states, communities and personalities	Foreign state actors, personalities or communities that are not involved in scientific or risk and crisis management activities
Divers/Unidentified	All actors that could not be categorised in the previous categories because unidentified, or belonging to more than one category

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232 **3.2.2 Direct and indirect mentions; reported speech and simple mention**

233 A direct mention occurs when an actor is cited in the text by the author of the article without being introduced by another
234 actor. An indirect mention occurs when an actor is mentioned through a third party in the article. For example, in the
235 sentence, “The prefecture reports that an earthquake with a magnitude of 4.0 was recorded by the Bureau of Geological
236 and Mining Research (BRGM)”, the mention of the prefecture, which is the body representing and implementing
237 government policy at the local level, is considered direct, while the mention of the BRGM is considered as indirect. This
238 distinction allows us to analyse the interactions between actor categories in the press. Specifically, it helps identify the
239 most frequent citation links, the direction of these relationships (and therefore their potential asymmetry), and, finally, the
240 central position of actors and actor categories within the citation network.

241 Reported speech and simple mentions of actors are also distinguished (see Table 2). Reported speech can be direct or
242 indirect. Reported speech is defined as any text that the journalist presents as the words or opinions of an actor, whether it
243 appears to be reported directly (e.g., with the use of quotation marks), indirectly, or even in a distorted manner. For
244 example, in the sentence: “In May 2018, when the swarm of earthquakes began to shake Mayotte, the first scientists
245 rushing to the island did not believe in volcanic activity”, “did not believe in volcanic activity” is considered to be

246 reported speech since the news item is intended to convey their beliefs. In contrast, in the sentence, “End of mission:
247 French prefect Dominique Sorain leaves Mayotte”, Dominique Sorain is “simply mentioned”.

248
249 **TABLE 2: Examples illustrating the distinctions between direct and indirect mentions, and between reported speech and**
250 **simple mentions, using the actor “prefecture”, which is the body representing and implementing government policy at the local**
251 **level, as an example.**

	Direct mention	Indirect mention
Reported speech	An actor is cited in the text by the author of the article without being introduced by another actor and its opinion is reported. “The <u>prefecture</u> confirms that no fewer than 13 tremors were recorded.” Journal de Mayotte, 05/12/2018	An actor is mentioned through a third party in the article and its opinion is reported. “On Tuesday evening, <u>they [prefecture]</u> had to deny on Twitter a rumor indicating that a strong magnitude earthquake could occur soon ‘This rumor is totally unfounded’.” Le Figaro, 05/16/2018
Simple mention	An actor is cited in the text by the author of the article without being introduced by another actor and its opinion is not reported. “The Mayotte <u>prefecture</u> activated its crisis unit this morning.” Le Figaro, 05/16/2018	An actor is mentioned through a third party in the article and opinion is not reported. “They [S.T.T.M. Facebook group members] criticized the <u>prefecture's</u> poor communication.” Mayotte la 1ère, 08/08/2019

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253 **3.2.3 Actor network analysis**

254 The system of actors depicted by the network of citations is studied to better understand the relationships between
255 individual actors, actor categories and their evolutions. This is accomplished using node-level centrality indices,
256 including in-degree, out-degree, and betweenness centrality, computed with the igraph package in R. Network diagrams
257 plot citation links with arrows, and the size of the nodes, as well as the font size of generic names, are weighted
258 according to their degree, representing the number of direct connections each node has within the citation network.
259 Unidentified actors are removed from the graphs to avoid generating false co-citation relationship structures.

260 To study the position of the actors in the citation networks (source and destination of a citation) derived from the
261 selection of articles, two node-level indicators from network analysis are used: degree centrality and betweenness
262 centrality. Degree centrality measures the number of links held by a node. It captures the extent of an actor's connections
263 in the media, through the citation process. There is a distinction between in-degree (the number of times an actor is
264 mentioned by others) and out-degree centrality. Actors with the highest out-degree values are those most active in
265 transmitting the experiences, opinions, speeches, and actions of other stakeholders (including Mayotte’s population).

Conversely, a high in-degree index indicates a central position in the network resulting from strong interest from third parties. The ratio between in-degree and out-degree centrality reveals the level of reciprocity in these interactions.

Betweenness centrality measures the number of times a node lies on the shortest path between two other nodes. The values are normalised by the number of node pairs in the graph (the direction of citations is not accounted for). A high betweenness index indicates that an actor plays an important bridging role, connecting different parts of the network. This is particularly true for the subgroups revealed by the citation patterns, either because they position themselves at the centre of the network, or because they are positioned on the periphery of several clusters.

Here, eight graphs, corresponding to the eight major periods of seismo-volcanic activity press coverage proposed by Devès et al. (2022b), are presented. This allows us to examine the evolution of the network at different periods, each characterised by the occurrence of a new triggering event (e.g., the first earthquakes, first discussions regarding the hypothesis of a volcanic origin, the discovery of the volcano, or a public conference).

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4. Results

4.1 Actors' mentions in the selection of articles

Table 3 presents a set of descriptive statistics on the frequency and form of actor mentions in this selection of articles. The publication frequency varies among the newspapers studied: the national daily Le Monde devoted 10 articles to the subject, while 190 articles were published by the local daily Journal de Mayotte. These varying publication rates result in different actor mention rates: Le Monde names 310 actors (often repeatedly), while this number peaks at 2,541 for the Journal de Mayotte. Beyond this rate effect, differences also emerge in the diversity of the actors mentioned: Le Monde, the national daily Le Figaro, and the regional daily Le Journal de l'Île de la Réunion respectively mentioned an average of 31, 20, and 20 actors per news item, while this mean value was only 13 for Le Journal de Mayotte, 12 for the local daily Mayotte la 1ère, and dropped to 10 for the regional daily L'Express de Madagascar. An inverse relationship emerges between publication rates and the average number of actor mentions per article. Ultimately, the position of actors in the citation network is largely driven by the most prolific media. This effect is controlled for in this analysis through the use of relative indicators.

Another source of variability in actor coverage lies in the balance each newspaper strikes between direct and indirect mentions, and between reported speech and simple mentions. While for most newspapers, direct mentions constitute approximately 80% of the total (compared to 20% for indirect mentions), this proportion drops to 66.7% for the national daily Le Figaro. However, this newspaper also distinguishes itself by the highest frequency of reported speech (68.6%), both for direct mentions (70.2%) and for indirect ones (65.3%). The regional daily L'Express de Madagascar also features a high proportion of reported speech (66.8%), but this is driven primarily by actors mentioned directly (74%) and applies to a much lesser extent to those mentioned indirectly (40%). The local daily Mayotte la 1ère has the lowest rate of reported speech (at 33.6%), followed by the regional daily Journal de

l’Île de la Réunion (42.7%) and the national daily Le Monde (45.5%). Consistently, the proportion of reported speech is invariably lower for indirectly mentioned actors than for those mentioned directly.

TABLE 3: Proportions of reported speech and simple mentions across the six selected newspapers. This table presents data from 343 press articles, published between the 10th of May 2018 and the 10th of May 2021, on the seismo-volcanic activity off the coast of Mayotte. An indirect mention refers to when an actor is introduced in the press discourse by a third party, as opposed to a direct mention. A distinction is drawn between actors whose speech or opinion is reported (anything presented as their word or opinion, even if distorted) and actors that are simply mentioned.

	Number of news items	Number of actors mentioned	Average number of actors mentioned per news item	Direct mention			Indirect mention			Share of direct mentions in total	Share of reported speeches in total
				Reported speech	Simple mention	Total	Reported speech	Simple mention	Total		
Journal de Mayotte	190	2541	13	1112 (57.4%)	825 (42.6%)	1937	185 (30.6%)	419 (69.4%)	604	76.2%	51.0%
Mayotte la 1ère	82	999	12	292 (36.4%)	511 (63.6%)	803	44 (22.4%)	152 (77.6%)	196	80.4%	33.6%
L'Express de Madagascar	25	259	10	151 (74.0%)	53 26.0%)	204	22 (40.0%)	33 (60.0%)	55	78.8%	66.8%
Journal de l'Île de la Réunion	21	422	20	160 (44.9%)	196 (55.1%)	356	20 (30.3%)	46 (69.7%)	66	84.4%	42.7%
Le Figaro	15	296	20	139 (70.2%)	59 (29.8%)	198	64 (65.3%)	34 (34.7%)	98	66.9%	68.6%
Le Monde	10	310	31	132 (51.8%)	123 (48.2%)	255	9 (16.4%)	46 (83.6%)	55	82.3%	45.5%

Beyond these structural characteristics, the newspapers distinguish themselves by the prominence given to different actor categories (Figure 3), revealing distinct narrative specializations. Although actors related to scientific research and monitoring (groups, publications, and institutions) are the most prominent category in all the newspapers, their proportion varies significantly from one outlet to another: they are particularly prevalent in the regional daily *Le Journal de l’Île de la Réunion*, and, to a lesser extent, in *Le Monde*, while they represent less than a quarter of the actors mentioned by the national daily *Le Figaro*. This trend is reinforced when specifically named scientific and monitoring actors are also considered.

The second most prominent category of actors is risk and crisis management actors. Here too, this proportion varies from one outlet to another, with the highest rates observed in the regional daily *L'Express de Madagascar* and in the national daily *Le Figaro*. Interestingly, at-risk populations in Mayotte do not exceed a quarter of the total share of actors mentioned in the media. In some newspapers, such as the local *Journal de Mayotte*, the relative presence of other actors is more variable from one outlet to another: for example, citations of social networks are more common in *Le Figaro* than in other newspapers, and a lower frequency of actors from French political institutions is observed in local newspapers than in national and regional newspapers (with the clear exception of *Le Figaro*).

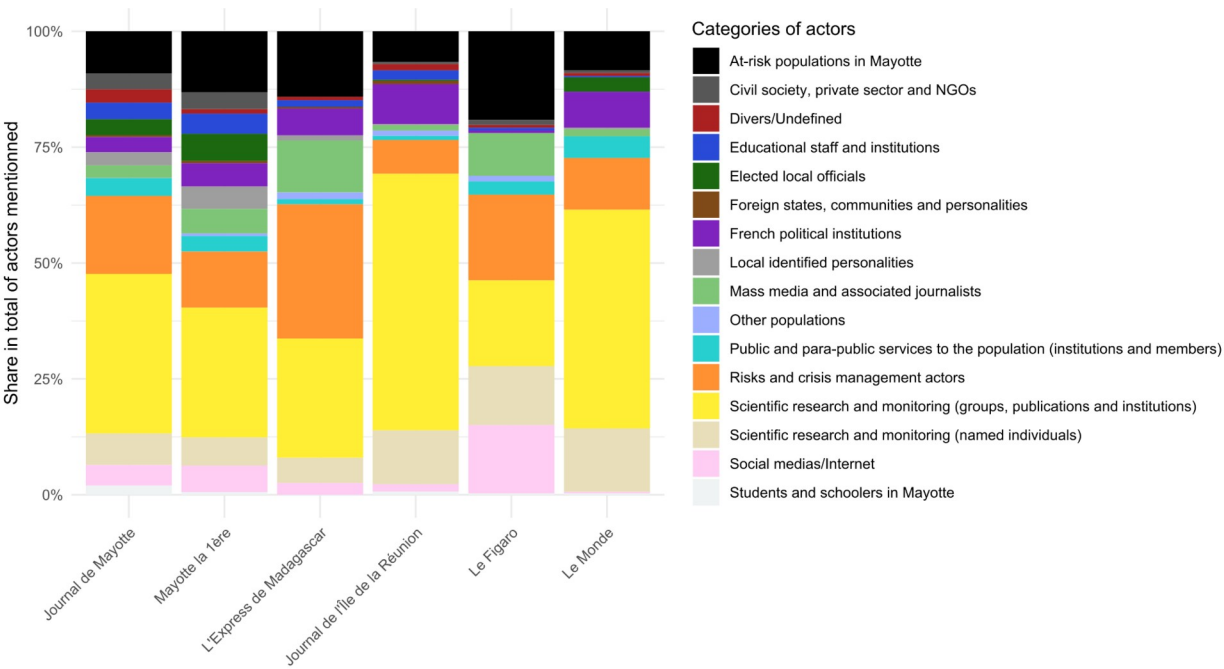


FIGURE 3: Relative share of crisis actor categories across different media outlets. The actor categories were developed based on the organizational structure of risk and crisis management in France (see Fearnley et al., 2018 and Section 2).

4.2. Direct and Indirect Speech by Actor Category

Table 4 reports the number and share of direct and indirect mentions, and of reported speech and simple mentions, by actor category in the entire selection of articles. While most actor categories are primarily mentioned directly (i.e., without an intermediary), for certain groups, indirect mentions are more common. This is particularly true for at-risk populations in Mayotte, which, in more than 40% of cases, are mentioned indirectly. The share of direct mentions is also relatively low for public and para-public services and for students and schoolers in Mayotte (over 30% indirect mentions). Conversely, specifically named scientific and monitoring actors and identified local personalities are the groups most frequently mentioned directly.

342 Significant variations exist between actor categories regarding the proportion of reported speech compared to simple
343 mentions. The analysis shows that scientific, media, and institutional actors are granted more frequent reported speech
344 than actors from civil society. For instance, the proportion of reported speech for students and schoolers in Mayotte is
345 only 10.8%, and 32.4% for at-risk populations in Mayotte. In stark contrast, it reaches 62.9% for local personalities,
346 77.2% for specifically named individuals in science and monitoring, 78.8% for mass media and associated journalists,
347 and 83.3% for social media/Internet sources. Among the categories identified, only specifically named scientific actors
348 and foreign states, communities, and personalities have a higher share of reported speech when mentioned indirectly than
349 when mentioned directly.

350
351 **TABLE 4: Key statistics on actor category mentions across all articles. Data were compiled from 343 press articles,**
352 **published between the 10th of May 2018 and the 10th of May 2021, on the seismo-volcanic activity off the coast of**
353 **Mayotte. An indirect mention refers to when an actor is introduced in the press discourse by a third party, as**
354 **opposed to a direct mention. A distinction is drawn between actors whose speech or opinion is reported (anything**
355 **presented as their word or opinion, even if distorted) and actors that are simply mentioned.**

	Number of mentions	Direct mention			Indirect mention			Share of direct mentions in total	Share of reported speeches in total
		Reported speech	Simple mention	Total	Reported speech	Simple mention	Total		
Scientific research and monitoring (groups, publications and institutions)	1762	633 (43.7%)	815 (56.3%)	1448	100 (31.8%)	214 (68.2%)	314	82.2%	41.6%
Risks and crisis Management actors	683	334 (63.9%)	189 (36.1%)	523	58 (36.3%)	102 (63.7%)	160	76.6%	57.4%
At-risk populations in Mayotte	549	122 (37.7%)	202 (62.3%)	324	56 (24.9%)	169 (75.1%)	225	59.0%	32.4%
Scientific research and monitoring (named individuals)	355	237 (76.0%)	75 (24%)	312	37 (86.0%)	6 (14.0%)	43	87.9%	77.2%
French political institutions	208	85 (53.1%)	75 (46.9%)	160	11 (22.9%)	37 (77.1%)	48	76.9%	46.2%
Social media/Internet	186	134 (90.5%)	14 (9.5%)	148	21 (55.3%)	17 (44.7%)	38	79.6%	83.3%
Mass media and associated journalists	179	120 (81.6%)	27 (18.4%)	147	21 (65.6%)	11 (34.4%)	32	82.1%	78.8%
Public and para-public services to the population (institutions and	148	31 (34.1%)	60 (65.9%)	91	7 (12.3%)	50 (87.7%)	57	61.5%	25.7%

	Number of mentions	Direct mention			Indirect mention			Share of direct mentions in total	Share of reported speeches in total
		Reported speech	Simple mention	Total	Reported speech	Simple mention	Total		
members)									
Educational staff and institutions	135	29 (31.5%)	63 (68.5%)	92	11 (25.6%)	32 (74.4%)	43	68.1%	29.6%
Civil society, private sector and NGOs	129	39 (39.8%)	59 (60.2%)	98	4 (12.9%)	27 (87.1%)	31	76.0%	33.3%
Local identified personalities	116	66 (66.0%)	34 (34.0%)	100	7 (43.7%)	9 (56.3%)	16	86.2%	62.9%
Elected local officials	111	47 (55.3%)	38 (44.7%)	85	5 (19.2%)	21 (80.8%)	26	76.6%	46.8%
Students and schoolers in Mayotte	65	6 (13.3%)	39 (86.7%)	45	1 (5.0%)	19 (95.0%)	20	69.2%	10.8%
Divers/Unidentified	64	56 (98.2%)	1 (1.8%)	57	1 (14.3%)	6 (85.7%)	7	89.1%	89.1%
Other populations	20	7 (63.6%)	4 (36.4%)	11	1 (11.1%)	8 (88.9%)	9	55.0%	40.0%
Foreign states, communities and personalities	20	5 (33.3%)	10 (66.7%)	15	3 (60.0%)	2 (40.0%)	5	75.0%	40.0%

4.3 Position of actors in the citation network

A cross-analysis of the frequency with which actors are identified as a source or recipient of a quotation in the selection of articles (Figure 4) indicates that the Prefecture of Mayotte and its main representatives play a central role in communicating about the event, as their media appearances largely lead to the mention of other actors. Many mentions of actors also originate from the X (formerly Twitter) network, which appears to be an essential primary source in the media narrative. A few local personalities also emerge as central nodes in the network, relaying information concerning a large number of actors. These include: Saïd Hachim, a geographer from Mayotte (Mahoran) who works at the Departmental Council of Mayotte and is also a PhD candidate in geography at Paul Valéry Montpellier 3 University in mainland France; ii) Lieutenant-Colonel Philippe Blanc, a member of the Directorate-General for Civil Protection and Crisis Management... who operates at a national level and was sent to Mayotte in June 2018 as a member of an interministerial delegation for civil protection...; iii) Eric Humler, scientific director of REVOSIMA... from 2019 to 2022 and in charge of the coordination of the TelluS-Mayotte mission; and iv) Frédéric Tronel, the regional director of BRGM (French geological survey) in Mayotte from 2017 to 2020. The UDAF (Departmental Union of Family Associations) emerges as a

key player in the actor citation chains within the selection of articles. In contrast, the Mahoran population and, to a lesser extent, schoolchildren, are highly cited but rarely initiate citations of other actors indicating a relatively passive position within the citation network extracted from the selection of articles. This is also the case for the French geological survey (BRGM), REVOSIMA, and the scientific community (in general), which are regularly used as a source of information by third-party actors whose words are reported (directly or indirectly) in the articles.

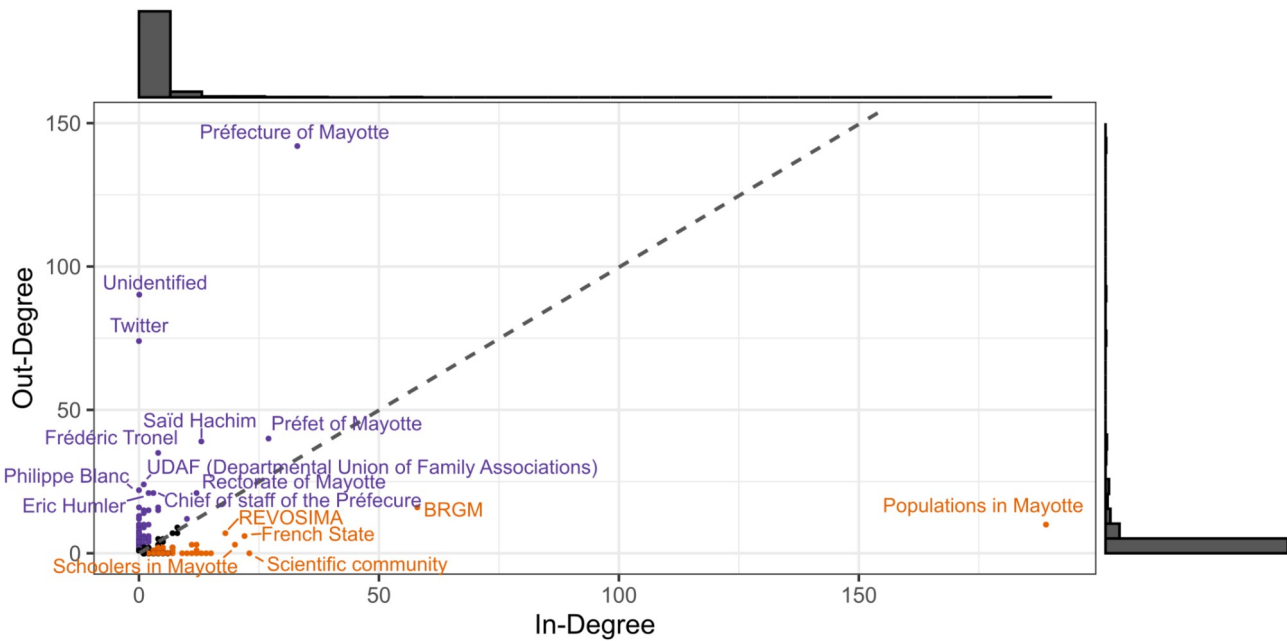


FIGURE 4: In-degree and out-degree distributions by actor category across all articles. This scatterplot shows the number of times an actor initiates a citation chain (out-degree) versus the number of times they are mentioned as a recipient of a citation (in-degree). Actors who are most often the source of the citation (and who are more often a source than a recipient) are annotated with purple labels. Conversely, actors who are most often the subject of the citation (and who are more often a recipient than a source) are annotated with orange labels.

Figure 5 shows an exponential relationship between the normalised values of the betweenness indices and the ranks, indicating a hierarchical structure of the network through the concentration of citation interactions by a small proportion of actors. The Mahoran population emerges as a key connecting element of the network of actors constructed from citation links in the media, a role also prominently filled by the local expert Saïd Hachim. The central role of the Prefect and the Prefecture, representing the French State in the department, is also evident. The scientific community as a whole, the French geological survey (BRGM), and REVOSIMA also appear to be essential elements in structuring the network, as is the social media platform X (formerly Twitter), which allows media visibility for individuals and institutions and promotes citation chains via re-tweets and mentions. Individuals with many connections also have high degrees of betweenness: Philippe Blanc, Eric Humler, and Frédéric Tronel (mentioned above), as well as Nathalie Feuillet, an observatory physicist at the Institut de Physique du Globe de Paris (IPGP) and mission leader of the first oceanographic campaigns (MayObs 1 and 2; see Feuillet, 2019 and Jorry, 2019), who, despite having lower in-degree and out-degree values, connects a relatively large number of shortest paths in the network.

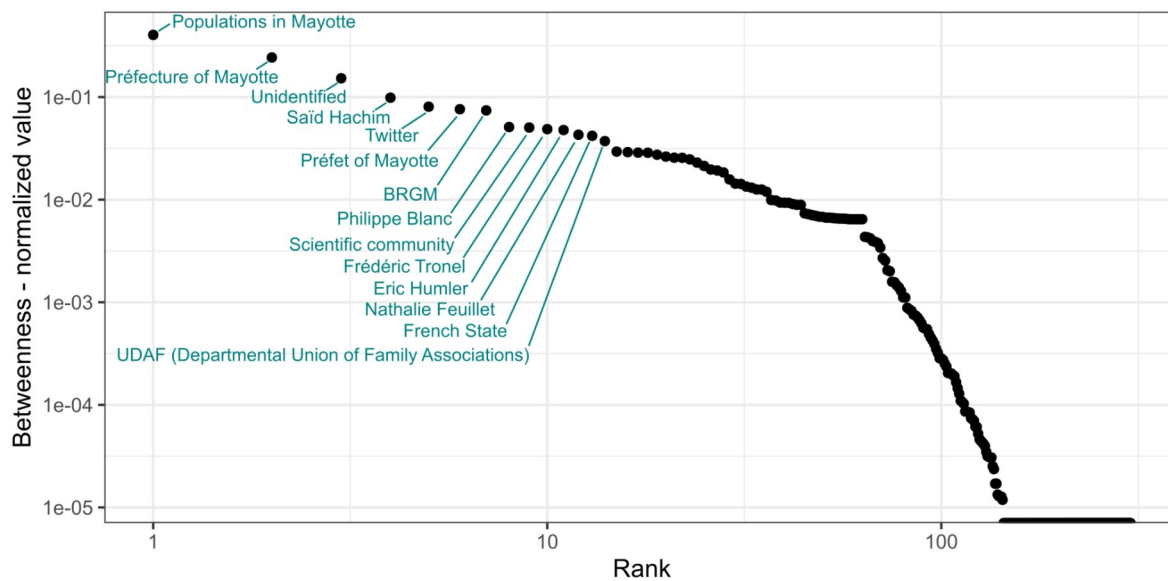


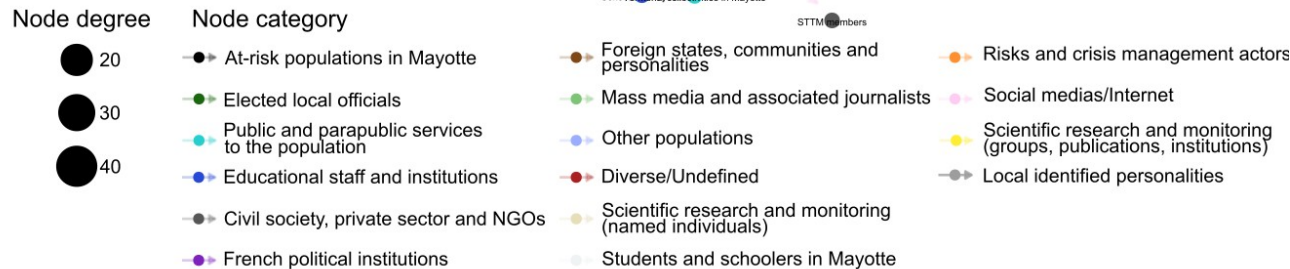
FIGURE 5: Rank-size distribution of betweenness centrality values. The plot shows the relationship between the normalized betweenness values of actors and their corresponding ranks, presented on logarithmic scales.

4.4 Actor network structure

The 126 articles published during the first months of the crisis (period 1, from the 10th of May 2018 to the 26th of July 2018) reflect a network of highly interconnected actors structured around key figures attracting a certain number of citations (Figure 6). These include the Mayotte population as a whole, the Prefecture of Mayotte and the Prefect, the Departmental Union of Family Affairs, actors of the educational system (including the rectorate, the decentralized government department for education, and teachers), but also mayors (the association of mayors, the mayor of Mamoudzou (the capital city), the mayor of Chirongui, and other municipalities), and the social network X (formerly Twitter).

The citation network is extensive, and all categories of actors are present with the exception of local personalities (although many groups made up of members from civil society, associations, and businesses appear in the network). Interestingly, while the citation chains from the entire selection of articles show paths between actors belonging to the same category, the network itself presents a certain heterogeneity. The Prefecture of Mayotte relayed information from local and other national risk and crisis management actors, but also from scientific research and monitoring institutions, groups, and publications, and was cited by and communicated through a variety of mass media and social media. The articles in this selection also make it possible to link the Prefecture of Mayotte to the Mahoran population, as well as to various public and parapublic services such as hospitals. Thus, the Prefecture emerges as the central actor in the management of this first period of the seismo-volcanic activity, which is in accordance with its official mandate for public safety and State representation. Notably, the Prefect's interventions and mentions in the press do not link him to the same actors as the institution he represents. His communications were aimed at the civilian population and representatives of civil society and associations,

Period 1: 05-10-2018 to 07-26-2018
First months of the sismo-volcanic crisis



the citation network for the second period, derived from 29 articles published between the 5th of October 201

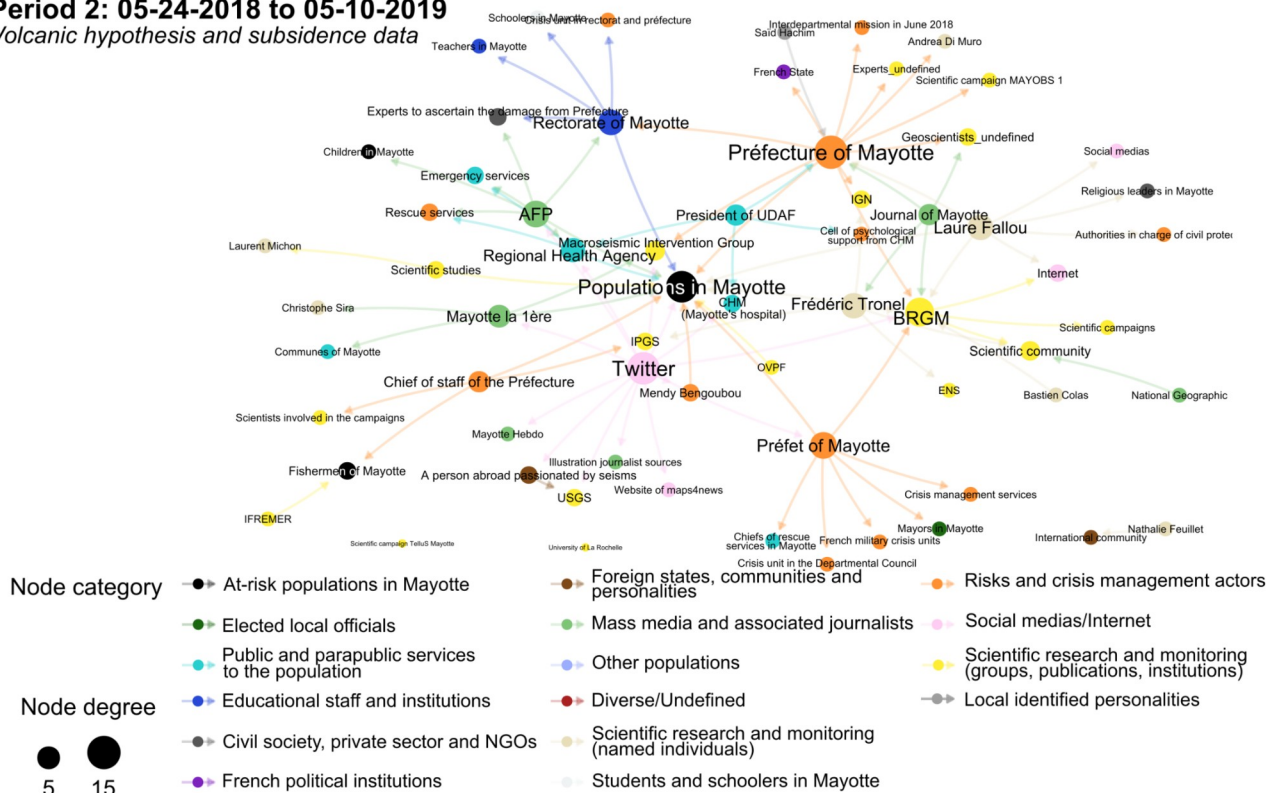
February 2019, is shown in Figure 7. These articles focused on the emergence of the volcanic hypothesis and the first subsidence data. As in the first period of the crisis, the population (cited by numerous actors but never initiating a citation) is at the centre of the network. The Prefecture and the Prefect (and to a lesser extent, the Prefect's chief of staff) still emerge as central nodes, initiating numerous citations. Only the Prefecture, as an institution, receives a significant number of citations in return (19 citations, 10 for the Prefect), from various actor categories. Once again, the institution is separated from its two key figures (prefect and chief of staff) within the citation network, with the exception of common citations of the population and the BRGM. The BRGM is also the destination of numerous citations (24) from scientific actors, which allows it to partially aggregate them within the network. Two scientific personalities stand out for the number and diversity of co-citation links they create: Laure Fallou and Frédéric Tronel. The first is a sociologist at EMSC (Euro-Mediterranean Seismological Centre) who wrote an academic paper highlighting the emergence of a mistrustful atmosphere and the circulation of misinformation due to a lack of scientific information linked **to** the scarcity of seismic data. Although Fallou et al. (2020) was published in 2020, it was also the subject of a public communication at

the General Assembly of the European Geosciences Union in April 2019. The second was the regional director of BRGM in Mayotte between 2017 to 2020.

In contrast, Nathalie Feuillet (an observatory physicist), the University of La Rochelle in mainland France, and the Tellus Mayotte oceanographic mission from IPGP are isolated. Christophe Sira, a macroseismic surveyor and member of the Groupe d'Intervention Macrosismique, and Laurent Michon, a research professor at the University of La Réunion island, are also separated from other scientific actors. Likewise, Bastien Colas and Mendy Bengoubou, two of the three members of the delegation of specialists in civil security and natural risks dispatched by two ministries (Ministry of Ecology and Ministry of the Interior) to assess the seismo-volcanic activity on site in June 2018, are cited separately from each other and from the interdepartmental mission itself, while the third expert, Lieutenant-Colonel Olivier Galichet, is not mentioned in the selected articles. Once again, actors in the medico-social world, who initiate citations of various actors, have intermediate positions in the network, while actors in the educational world are more isolated than during the previous period. Another important distinction is the introduction of a first identified local personality, Saïd Hachim, in the network. In this subset of articles, he only cites the Prefecture, as he relayed and detailed a note from the institution mentioning the volcanic origin hypothesis derived from the latest GPS data. Local fishermen also appear in the network of actors via citations from IFREMER and the Prefect's chief of staff, following the discovery of deep-sea dead fish about 50 km east of the coast.

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Period 2: 05-24-2018 to 05-10-2019
Volcanic hypothesis and subsidence data



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FIGURE 7: Actor citation network following the emergence of the volcanic hypothesis and first subsidence data.

The third period studied corresponds to the discovery of the underwater volcano and covers 36 articles published from the 16th of May 2019 to the 30th of August 2019. Figure 8 depicts its actor co-citation network. Compared to the previous periods, the central connecting role of the population is diminishing, while the position of local actors acting

466 either as relays for residents' voices (such as the Facebook group Signalement Tremblement de Terre Mayotte, or
 467 S.T.T.M.) or as relays for scientific voices (such as Saïd Hachim) is strengthened. Philippe Blanc, as a member of a Civil
 468 Security mission on volcano-related risks, also appears as an important source of citations in the network, mainly for
 469 other risk and crisis management actors, without receiving any citations in return. The same is true for Jean-Michel
 470 Audibert, who was part of the same mission for civil security; the two actors are only connected by their shared citation
 471 of the Mahoran population.

472 The various ministries involved in crisis management and the French state are only indirectly connected to each other,
 473 reflecting segmented cooperation networks, even within the framework of inter-ministerial actions. The Ministry of
 474 Overseas Territories introduces numerous actors into the citation network, including REVOSIMA (Mayotte's
 475 volcanological and seismological monitoring network), which was created on the 18th of June 2019, and a hypothetical
 476 future observatory in Mayotte, which is still in the planning stage at the time of writing. The network of scientific actors
 477 is more structured and includes more numerous, diverse, and international actors than in the previous periods. Indeed, the
 478 recording of the waves of a very-long-period earthquake all over the world on the 11th of November 2018 has attracted
 479 the attention of international institutions and media in addition to that of scientific and political authorities at the national
 480 level (Hosseini and Sadaoui, 2021). Notably, the scientific actors named by Eric Humler or via the X (formerly Twitter)
 481 network differ from those named by Saïd Hachim, who mainly relays the names of scientists with whom he had
 482 published an atlas of natural risks and vulnerabilities of Mayotte in 2014 and discusses the MayObs campaigns. Several
 483 social networks, the Facebook group S.T.T.M., and two local newspapers appear as important nodes of the citation
 484 network, mainly citing other media, the Mahoran population, scientists (with the exception of the S.T.T.M. Facebook
 485 group), public institutions, and the actors of the MayObs oceanographic campaigns carried out from the Ifremer ship
 486 *Marion Dufresne*. Interestingly, the members of the MayObs oceanographic campaigns are not cited by the same actors,
 487 reflecting a sequencing of the actors mentioned in the media as the oceanographic campaigns progress (the Prefecture,
 488 the Prefect, and X (formerly Twitter) for the 1st campaign; the Ministry of Overseas and Saïd Hachim for the 4th, while
 489 interministerial communiqués do not distinguish between the different missions).

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Period 3: 05-16-2019 to 08-30-2019
Discovery of the volcano

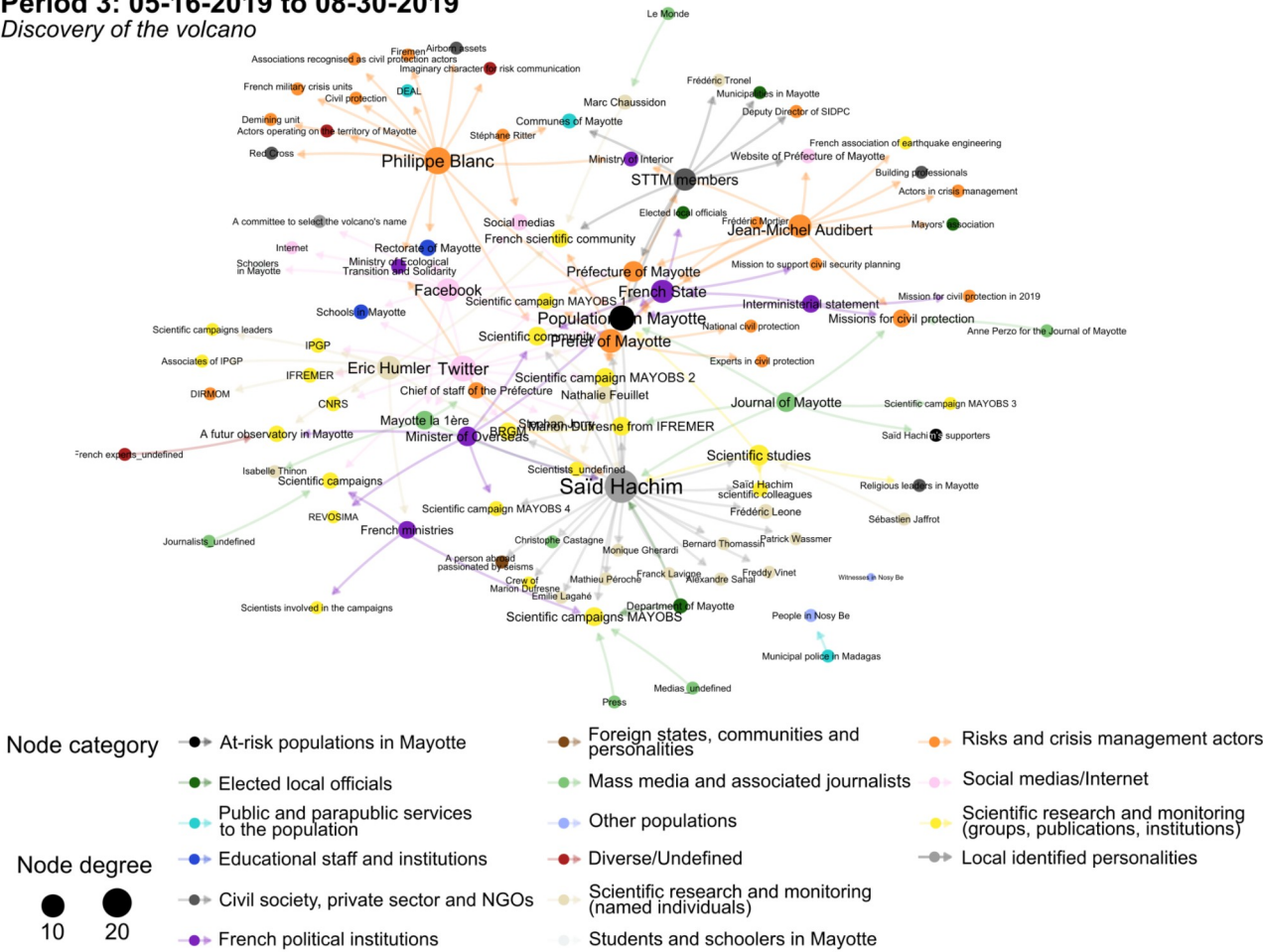


FIGURE 8: Actor citation network from press coverage following the discovery of the volcano.

Period 4 focuses on a specific event within Period 3: a conference for local elected officials and the press, organized by the Prefecture and led by scientists involved in the volcano's discovery. This period covers 6 articles published between the 31st of July 2019 and the 9th of August 2019.

As shown in Figure 9, Nathalie Feuillet acts as an intermediary, connecting the part of the network structured around Saïd Hachim with the S.T.T.M. Facebook group. She creates this link via her citation of the Prefecture which quotes, and is quoted, by the S.T.T.M Facebook group. Without this connection, the actor network appears fragmented, even among key actors: scientists, state representatives (the Prefecture, the Prefect, and his chief of staff), the Interministerial Defense and Civil Protection Service (SIDPC), as well as the Ministry of Overseas Territories and the Ministry of Ecological and Inclusive Transition. Frédéric Tronel and Isabelle Thinon are the only scientists cited by other actors: Tronel is cited by the S.T.T.M. Facebook group, while Thinon is cited by the local news broadcast *Mayotte la 1ère*. This low presence of named scientific actors is compounded by the absence of specific scientific institutions, which are instead referred to abstractly as 'the scientific community'.

Period 4: 07-31-2019 to 08-09-2019
Conference for local elected officials and the press

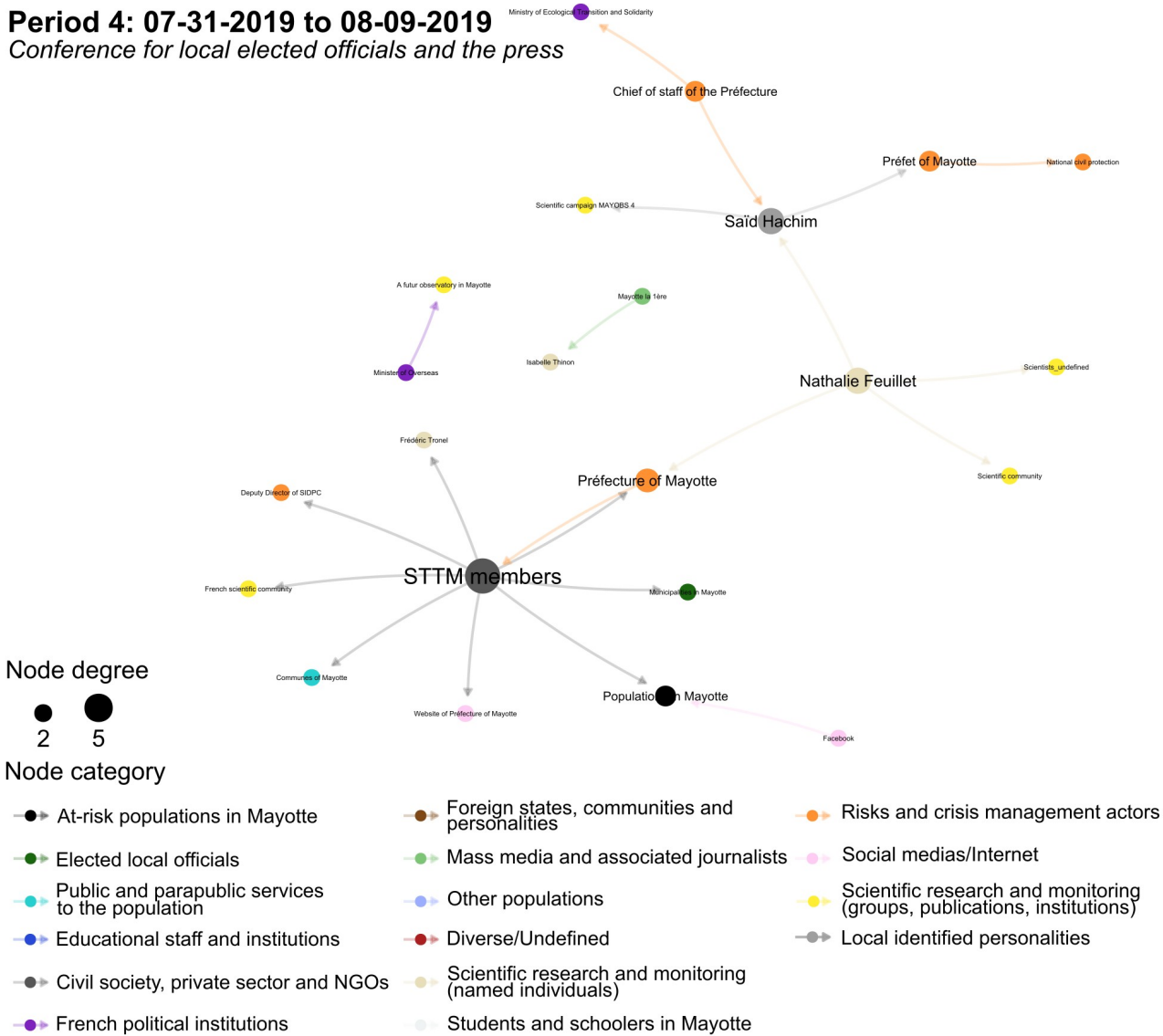


FIGURE 9: Actor citation network from press coverage of the conference for local elected officials and the press.

Period 5 (Figure 10) focuses on a second specific event within Period 3: the visit of the Minister for Overseas France to Mayotte. This period covers 3 articles published between the 27th of August 2019 and the 30th of August 2019. As depicted in Figure 10, the number of cited actors is low. The Minister for Overseas France occupies a central place in the network, as they mention five other actors: the scientific actors responsible for studying the phenomenon (REVOSIMA and the underwater observation campaign MayObs 4), the scientific community more generally, the local expert Saïd Hachim, and the Mahoran population (also cited by the Prefect). The isolated mention of the French State by Frédéric Mortier (from the interministerial delegation for major overseas risks, DIRMOM) and a separate mention of local elected officials can also be noted.

Period 5: 08-27-2019 to 08-30-2019
Visit of the Overseas Minister

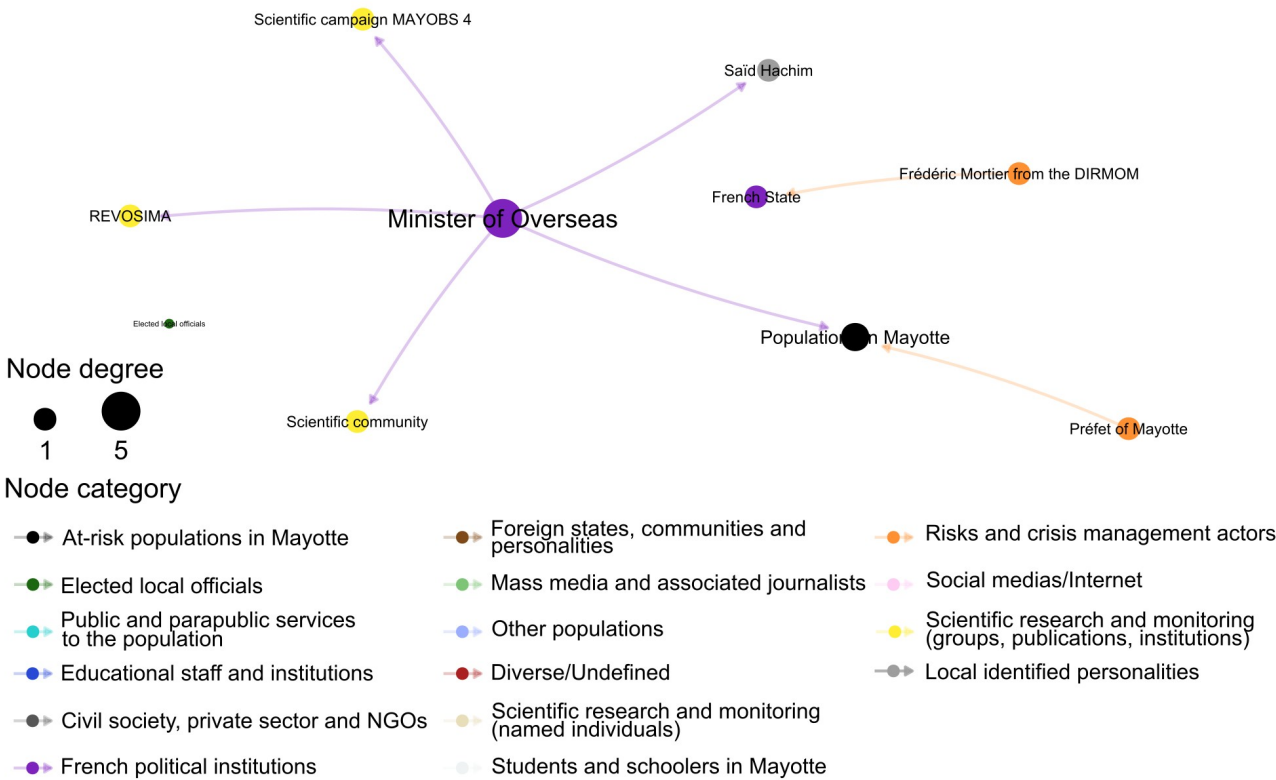


FIGURE 10: Actor citation network from press coverage of the Minister for Overseas France's visit to Mayotte.

Eight articles in the selection of articles cover the period from the 4th of September 2019 to the 26th of October 2019 (Period 6, Figure 11). This period encompasses a scientific conference held at IGP headquarters in Paris, immediately followed by a public conference hosted by scientists and ministerial officials.

Interestingly, REVOSIMA (once again solely cited by the Ministry of Overseas Territories) is isolated from the rest of the citation network (Figure 11), even though it brings together the actors in charge of the volcanological and seismological monitoring of Mayotte. It is, nevertheless, the only scientific institute explicitly named, as the citation network gives a more central place to individual scientists than to institutions. The actor network is more fragmented than in previous periods, and its sub-networks are respectively organised around: Nathalie Feuillet (who received citations from various media); Eric Humler (quoting populations from other French overseas departments); the chief of staff of the Prefecture (citing the communes of Mayotte and territorial authorities in general); and the journal *Sciences et Vie* (citing Nathalie Feuillet and encompassing the scientific community and French research institutes). Several isolated citations again point to the Mahoran population (from scientists Virginie Duvat and Frédéric Tronel, but also from the Prefecture of Mayotte and from a local elected official from the capital city, Mamoudzou). Once again, the Prefecture of Mayotte is separated from the Prefect and his chief of staff within the citation network. For the first time, the Prime Minister is cited by an actor—specifically, the deputy in charge of development in Mamoudzou—regarding a letter sent to the Prime Minister to point out the effects of subsidence on urban development.

Period 6: 09-04-2019 to 10-26-2019

Scientific conference at IPGP with the press

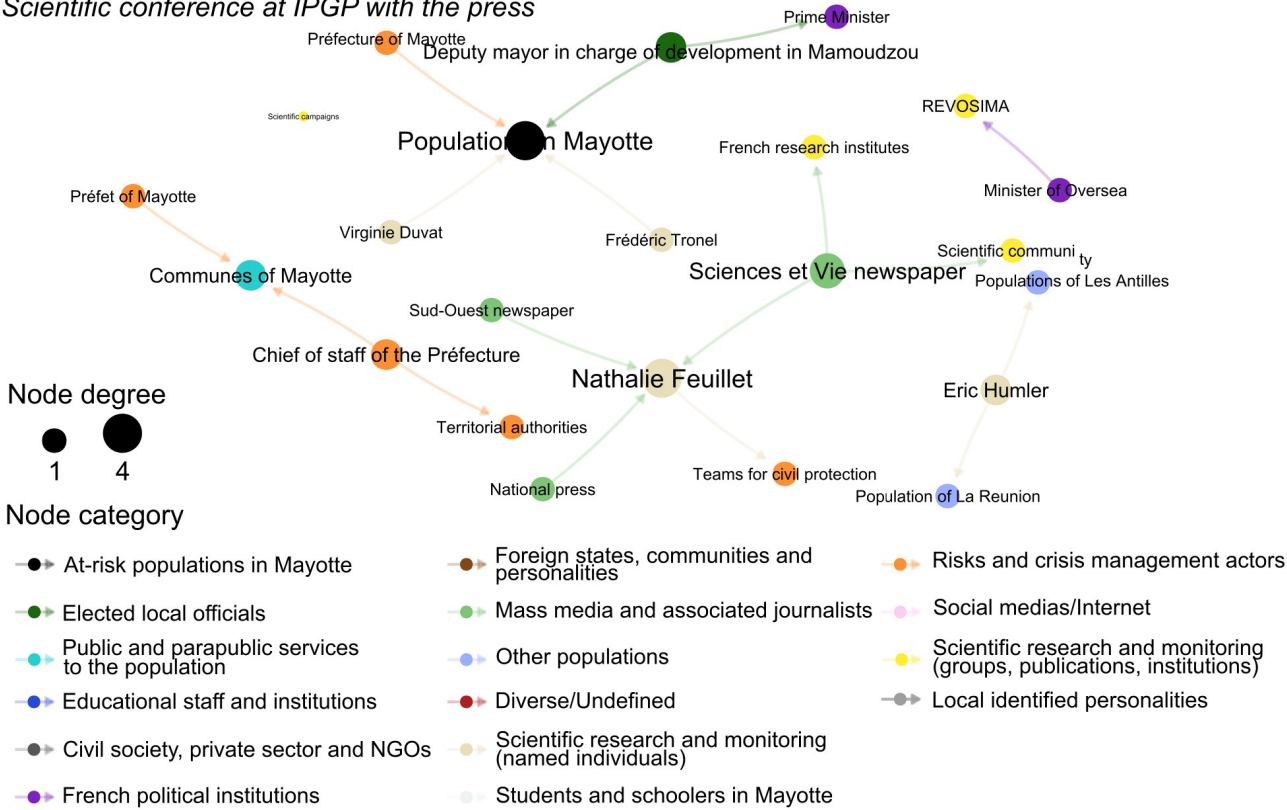


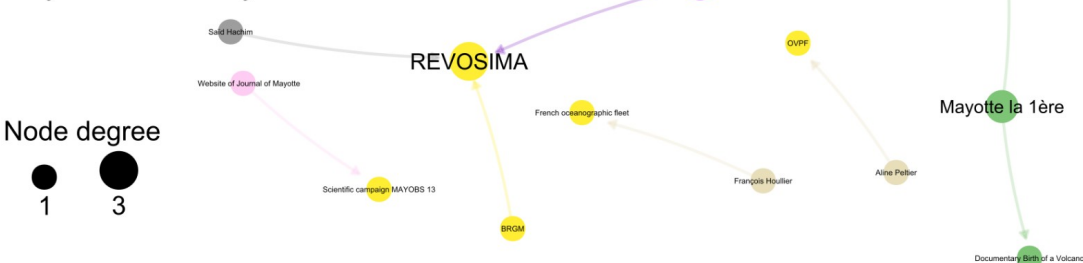
FIGURE 11: Actor citation network from press coverage of the scientific and public conferences.

Period 7, which extends from the 4th of May 2020 to the 28th of September 2020 and covers the missions MayObs 13-1 and MayObs 13-2, is covered by 7 articles from the selection of articles. Its citation network is shown in Figure 12. For the first time, REVOSIMA appears as a central node of the network, although the number of nodes and links is limited by the small number of articles. REVOSIMA is cited by local expert Saïd Hachim and by the Prime Minister, but also by BRGM, one of its member institutions. The Prime Minister also cites IPGP separately from REVOSIMA, even though IPGP is one of the institutions responsible for it. The network of scientific actors appears generally fragmented during these two missions. Notably, the documentary "Birth of a volcano" produced by Crestar Productions and L'éolienne and broadcast on *Mayotte la 1ère* is not relayed by any actor other than the channel.

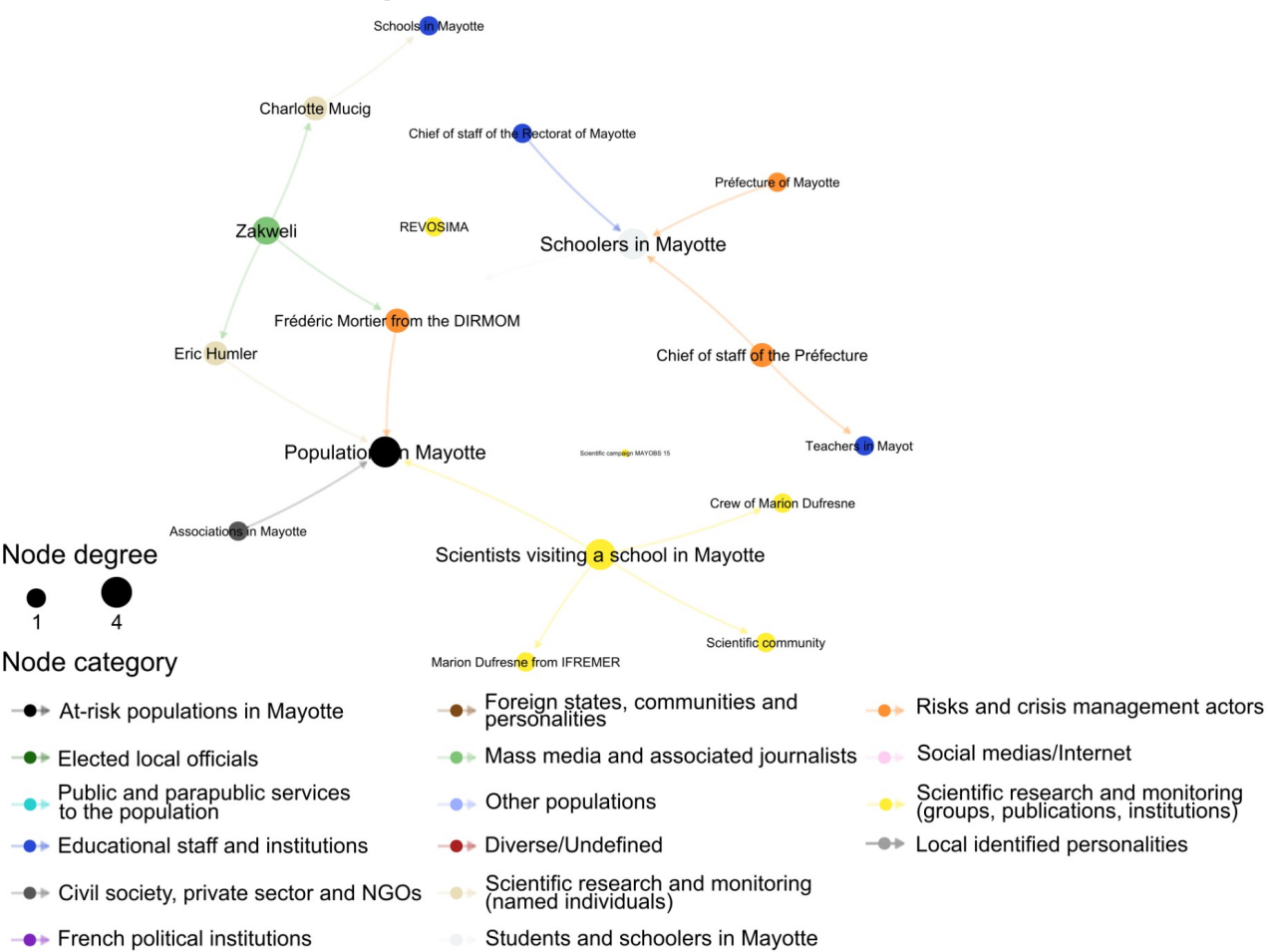
The last period extends from the 28th of October 2020 to the 3rd of November 2020 and covers two events recounted in 6 articles: the "Volcano Week" and the first siren alerts in the municipality of Dembéní. The actor network (Figure 12) is structured around two main components. The first is organised around Mahoran schoolchildren and includes citations from the chief of staff of the Mayotte Rectorate, the chief of staff of the Prefecture, and from the Prefecture itself. Teachers in Mayotte are also part of this citation chain, as they are cited by the chief of staff of the Prefecture. Interestingly, schools in Mayotte (mentioned as actors) belong to the second citation sub-network, of which they form the periphery through a citation by Charlotte Mucig, who was in turn cited by the TV and radio show *Zakweli* broadcast by *Mayotte la 1ère*. The show *Zakweli* also links Eric Humler and Frédéric Mortier, both of whom cite the Mahoran population. The latter is also cited by unidentified Mahoran associations, as well as by scientists visiting Mahoran

562 schools during the Volcano Week, who also mention the MayObs missions on the ship *Marion Dufresne* either explicitly
563 or implicitly. Finally, REVOSIMA appears fully isolated from the other actors.
564
565

Period 7: 05-04-2020 to 09-28-2020
MayObs 13-1 & MayObs 13-2



Period 8: 10-28-2020 to 11-03-2020
"Volcano week" and first warning siren in Dembéni



566
567 **FIGURE 12: Actor citation networks during two key periods. In Period 7, the focus is on the organisation and execution of two**
568 **campaigns at sea, MayObs 13-1 and MayObs 13-2. In Period 8, attention shifted to two communication initiatives from the**
569 **Mayotte Prefecture: the “Volcano Week” (a series of conferences and activities for schoolers) and the installation of the first**
570 **public warning siren on the territory.**

571 **5. Discussion**

572 Mass media play a key role in risk and crisis communication, serving as the main information source for millions of
573 people regarding natural, political, and social events (e.g. Gamson and Modigliani, 1989; Allan et al., 2000; Dixon et al.,
574 2008; Aday, 2010). They influence people's perceptions of various actors involved in understanding, monitoring hazards,
575 and managing their effects, as well as their performance during events (Harris et al., 2012). Despite the focus on
576 newspaper representations rather than those among populations, and the use of articles from six non-specialist French-
577 language newspapers, this study provides a comprehensive insight into media narratives during the seismic-volcanic
578 crisis in Mayotte from May 2018 to May 2021. The inclusion of additional local, regional, and national daily papers in
579 different languages and other media forms could deepen the analysis. However, the chosen selection of articles, primarily
580 from the non-specialist daily press, remains a strong candidate for studying representations conveyed by the media as a
581 whole (Cagé et al., 2017). This is especially true given that this selection includes *Mayotte la lère*, an outlet that operates
582 across multiple platforms (TV, radio, and a website) and produces content in both French and Shimaore, ensuring a wide
583 local audience, and considering the dynamics and complementarity between quantitative and qualitative analyses
584 facilitated by written press data.

585 When examining the results, it is crucial to acknowledge the influence of journalistic practices. Newspapers, acting as
586 mediators in the broadest sense, have their own practices and priorities in collecting and disseminating information. Daily
587 newspaper journalists, who are often generalists with diverse profiles and working methods (Ruellan, 1992), are
588 commonly bound by the constraint of tight deadlines. This limitation may affect their ability to access multiple sources or
589 to investigate the context in depth. Consequently, they tend to prioritise information that is deemed reliable, easily
590 accessible, and of interest to their readership (van Belle, 2015). Geographic proximity to events influences coverage (e.g.
591 Cavacas et al., 2016), with local journalists having easier access to the field and local actors. This is evident in the
592 composition of the selected articles, with a predominant 78% (and 54% in *Journal de Mayotte* alone) being published in
593 local newspapers. These local articles typically take the form of concise press releases offering updates on the latest
594 developments. In contrast, national newspapers, faced with the challenge of engaging a readership approximately 8,700
595 km away and not directly impacted by events, tend to favour less frequent but more extensive publications providing
596 summaries or in-depth analyses (see section 4.1: an average of 20-31 actors are mentioned per article in national
597 newspapers, compared to around ten in local newspapers). This also influences the selection of quoted sources, with local
598 journalists relying more on local actors and national journalists adopting alternative strategies, such as using social
599 networks (e.g., X and Facebook for national dailies like *Le Figaro* and *Le Monde*) or relying on news agencies like AFP
600 (Agence France-Presse), or their local counterparts (Lecheler and Kruikemeier, 2016), directly, or indirectly, via
601 associated press (e.g. Reuters) who provide articles for international media based on local reporting. This is illustrated
602 here by *Le Figaro* and *Le Monde*, which present a comprehensive view of the involved actors, albeit with less ease in
603 reporting their statements. Given their time constraints, journalists typically favour sources they consider legitimate and
604 relatively easy to access. For instance, the municipality of Chirongui stands out, as the mayor at the time remained in
605 office from 2008 to 2020, and her team appears to have been particularly active and well integrated into the local
606 community. Also, it hosted the delegation of specialists in civil security and natural risks dispatched by two ministries
607 (Ministry of Ecology and Ministry of the Interior) (*Journal de Mayotte*, the 6th of June 2018) and this event served as an
608 entry point for the presentation of the group in the local press. Another example is the UDAF (Departmental Union of
609 Family Associations) which emerges as a key player in the actor citation chains within the selection of articles. This can

be explained by the meeting they organised on the 5th of June 2018 to relay people's experiences and promote dialogue between local actors (among them, state institutions, public and para-public services, local elected representatives, etc.) regarding measures to be taken at the start of the seismic crisis (Le Monde, the 14th of June 2018; Journal de Mayotte, the 1st of June 2018), which was relayed by both local and national press. The choice of sources may vary based on editorial stance (Shoemaker and Reese, 1996; Kaiser & Kleinen-von Königsłow, 2019). For example, in this context, local newspapers, which are seemingly inclined to emphasise the local context in comparison to national and regional newspapers, exhibit a lower rate of reported speech from French political institutions. As observed in these findings and reinforced by Ploughman (1997), journalists tend to have more accessible and regular contact with certain types of sources, including public institutions, officials, or high-profile personalities, who are consequently more prominent in the news.

Having acknowledged the influence of journalistic practices, this study shows that using this method to scrutinise press coverage also allows the identification of actor groups typically present in a crisis context related to a natural phenomenon (e.g. Fearnley et al., 2018; Trias et al., 2019; Gonzalez, 2022). First of all, the main trio in crisis management emerges as the most mentioned and quoted actors in this network: scientists overseeing monitoring, authorities responsible for civil protection, and at-risk populations (Fearnley et al., 2018; Devès et al., 2023). Other categories, such as mass media, social networks, civil society, public and para-public services, and even humanitarian aid associations (e.g. the Red Cross), are also well-represented. However, the latter are less prevalent than in other crises, likely due to the limited physical impacts (e.g., minor building damage and few injuries). Notably, international actors, including personalities, newspapers, communities, and states, are also present, which suggests the importance of these external points of view as reported by other actors within the crisis narrative. This is also highlighted in previous studies as indicative of a growing interconnection between actors in the disaster risk reduction context on an international scale (e.g. Trias et al., 2019). In the case of this very local, small-scale crisis, the mere presence of international reactions becomes an event worth reporting by others. The actors involved in crisis management, organised by the Organisation de la Réponse de Sécurité Civile (ORSEC) in France, are also represented. Under the ORSEC framework, mayors coordinate emergency services and public facility management (hospitals, schools, etc.) if the event is local. If damage extends department-wide and surpasses the capacity of town halls, the Prefecture assumes control. Ultimately, the crisis is managed by the regional headquarters (EMZCOI for Mayotte), then by the French government if the lower levels are overwhelmed. However, here, despite the limited physical impact of this crisis, it was mainly the Prefecture and national civil protection services (under the responsibility of ministries) that were mentioned and whose speech was reported. Local elected representatives, including mayors, are surprisingly less present than other actors who theoretically play a lesser role (such as civil society, local personalities, and public and semi-public services, including education staff), while the regional headquarters is rarely mentioned. These asymmetries in representation partly reflect Mayotte's unique situation as a French overseas department, with part of its administration, including the regional headquarters, based more than 1,400 km away in Reunion Island. This region, while distant from the mainland, poses specific challenges requiring a substantial response from the national authorities responsible for crisis management (Cottureau, 2021; Roinsard, 2022; Duchesne, 2023). Another specific feature also observed in several overseas departments is a lesser degree of cooperation between local elected representatives and national representatives located in these departments (Lemerrier et al., 2014; Gillet et al., 2023). Overall, we obtain an overview of the diverse actors involved in this crisis

management and communication, aligning with findings from other studies using similar (e.g. Rajput et al., 2020) or different methodologies (e.g. Villodre and Criado, 2020; Calabro et al., 2020).

Additionally, the results underscore the emergence of various actors or groups of actors within the population, a facet that is not treated homogeneously in official or legal texts. In particular, several local figures can be identified, as has been noted in other case studies (e.g. Devès et al., 2019). The temporal evolution of the network yields several insights. The notably dense network observed during the first two weeks of the seismic crisis reflects both the unprecedented nature of the hazard and the initial difficulty faced by the media, and by many of the actors interviewed, in identifying reliable or authoritative sources. This is unsurprising, as the hazard had no precedent in living memory on the island (Cripps & Souffrin, 2020), and the only scientific institution present at the onset of the crisis was the BRGM. This highly disorganised yet progressively clarifying and structuring network appears to exemplify a form of crisis information-seeking behaviour, as observed in other contexts (e.g. Heverin & Zach, 2011; Krakowska, 2020), though here it occurs in a situation where authoritative sources were not yet clearly established. In the absence of recognised institutional referents, certain local personalities, such as Saïd Hachim, increasingly occupy central positions within the network. This is also consistent with a post-colonial context, in which there may be a degree of mistrust towards authorities, and where local actors are more readily cited by local media outlets. Even when the scientific community began organising in 2019 around the creation of REVOSIMA (Mayotte's Volcanological and Seismological Monitoring Network), scientific actors—although present—remained relatively marginal in terms of visibility, often appearing as isolated nodes within the communication network. REVOSIMA itself also remained largely peripheral in the network, even more than six months after its establishment. Time appears to have worked against the institution, with information sources and actor networks already well established, making it difficult for REVOSIMA to integrate effectively among them. Nevertheless, the local figure Said Hachim progressively introduced scientists from mainland France, as well as from REVOSIMA, into the media discourse while reporting their speeches and mentions maritime campaigns. However, he himself was rarely cited in return by these actors. His role thus aligns more closely with that of a mediator, facilitating the circulation of scientific information, rather than an alternative expert in direct opposition to institutional authorities, as it has been observed in other studies (e.g. Devès et al., 2021).

During the examination of who is granted a voice in media coverage, several key observations emerge. Firstly, primary sources of information (often introduced or relayed by other actors quoted in the article) do not necessarily align with journalists' sources. This discrepancy may arise due to limited access to a primary source, as elaborated earlier (either due to geographical distance, time constraints, etc.), or the preference for another source deemed more legitimate, more accessible, or because of implicit or explicit issues of representation (see Carlson, 2009 and Grassau et al., 2021). This opens a window into the newspapers' networks, the hierarchy of their trust, and the perceived legitimacy of interviewed sources. As identified in a qualitative analysis (Devès, Moirand and Le Vagueresse, 2023), scientific actors notably dominate reported speeches, both from the article authors and third-party actors. Consequently, they are considered the most reliable or, at the very least, the most legitimate to express themselves, even surpassing the authorities responsible for crisis management and civil protection. While other studies have recognized scientists as "bridges" and "focal points" among various actors (Trias et al., 2019), the notable overrepresentation of scientific figures and institutions is noteworthy here. This could be attributed to journalists focusing on short-term issues like hazard descriptions, impacts, and emergency operations (Devès et al., 2019) or the complexities arising from scientific uncertainties requiring focused attention (Valencio and Valencio, 2018). Scientific actors, being perceived as those with the knowledge, are considered

closest to understanding the phenomenon and thus are positioned to make recommendations (Oreskes, 2019). Apart from scientific personalities and institutions, the analysis indicates that media and institutional actors also benefit from greater media reach for their statements compared to actors from civil society. This proximity of journalists to institutions, as highlighted in other case studies (e.g. Ploughman, 1997; Wintterlin, 2020), and their reliance on the publications of their counterparts when direct sources are unavailable (Coddington and Molyneux, 2023) are common practices. On the other hand, social media sources have a higher share of reported speech than other mass media, reflecting the increasing use of social media as information sources due to their detailed coverage of current events (e.g. Lindsay, 2011; Lecheler and Kruikemeier, 2016), potentially facilitating two-way communication between institutions and the public (Feldman et al., 2016; Kim and Hastak, 2018b). Two-way communication has the potential to facilitate cooperative decision-making (Renn, 2009), to draw upon local knowledge in order to improve understanding of field-level dynamics (Lindell et al., 2006), and, in turn, to strengthen public engagement and contribute to the development of trust (Leiss, 1996; Renn, 2009). However, Pourebrahim et al. (2019) argue that this potential is largely underutilized, showing that X (formerly Twitter) is dominated by authorities primarily engaged in one-way communication rather than interacting with their audiences (see also Watters and Williams, 2011). A more focused analysis would be needed to explore this in the present case. Throughout the coverage, populations in Mayotte and, to a lesser extent, schoolchildren are frequently cited, but as discussed in this qualitative analysis, they are not often the origin of citations, indicating a relatively passive position within the citation network extracted from this dataset. Despite this, the population is central to the network and is cited by numerous actors. In the general imagination, its protection is the reason for the organisation of this network, but its opinion is seldom expressed, even in local media, which tend to apply pre-constructed news templates (Jemphrey and Berrington, 2000). This perpetuates an asymmetrical and hierarchical representation favouring those perceived to hold knowledge (scientists, institutions in charge of civil protection) at the expense of the inhabitants' perspective, who find themselves in the position of being subjected to the crisis and being protected (Valencio and Valencio, 2018; Gonzalez et al., 2022). Journalists' common practices make it challenging for them to distance themselves from this representation (Cavaca et al., 2016). This result is explored and assessed for this case study by Devès et al. (2023), who also demonstrate that these representations are integrated by various actors in crisis management, particularly within at-risk populations.

That being said, it is worth underscoring that named individuals hold a significant position in this network. Despite the context where crisis and risk management, as well as communication, are organised and framed by established institutions (ministries, prefectures, town halls, scientific institutions responsible for monitoring), individual sources with clear identities tend to contribute more to reported speech compared to institutions. Specifically, named scientists take the lead over their institutions when examining whose speeches these articles mostly report. Moreover, local personalities are mainly quoted when directly mentioned, while the reverse is true when they are indirectly mentioned. Even in the case of crisis managers, individuals such as the Prefect, Cabinet Director, or ministerial envoys clearly stand out from their respective institutions within the network (see section 4.4.). Admittedly, these personalities are often associated with an institution. Oreskes (2019) highlights this aspect in her essay "Why trust science?", using scientists as an example. She contends that trust in an individual is primarily conferred as a member of a professional community with a shared body of knowledge. Butts et al. (2007) also found that coordinating roles, which include information flow, are influenced by the formal institutional status or position within an organisation. This is compounded by the journalistic practice of conducting interviews, which involves collecting an institution's stance through the discourse of one of its

representatives. Individuals act as entry points to information for journalists, relaying the messages of their institutions, colleagues, or, in all cases, a community. Hence, they play the role of hubs, or "guardian nodes" as mentioned by Flecha et al. (2023). However, this interpretation needs qualification based on interviews with inhabitants, analysed in Devès et al. (2023). On one hand, these interviews highlight the importance, according to Mayotte's inhabitants, of embodying information or words with a name or a face. On the other hand, they reveal a significant distrust towards political and even scientific institutions. In this study, we observed that featuring the director of the local BRGM branch over the national director was prioritised, and even the Prefect over representatives of the ministries, although the latter have visited the area. Also, the local geographer, Saïd Hachim, is given prominence over members of the scientific monitoring network, even in situations where they are present during campaigns at sea or interventions with schoolchildren. Similar observations were made in two other independent studies: Cripps and Souffrin (2020), which emphasises a general distrust towards official discourse, and Bedessem et al. (2023), which found confidence in scientists without being able to determine if this extends to trust in their institutions. In such circumstances, one might question whether there exists a gap between the representation of journalists and that of local populations, accentuated by a journalistic bias towards institutions that journalists identify as reliable and easily accessible. Regardless, there is a clear need for proximity—geographical, if not cultural—between sources, given the evident dominance of cited personalities when they are on-site. With regard to local personalities in particular, their emergence in press coverage occurs later than for others, perhaps attributable to a search for new sources to compensate for the perceived lack of information on the spot (Fallou et al., 2019). In any case, the over-representation of individuals compared to institutions raises questions and warrants further investigation.

This approach offers: i) an overview of the interrelationships between all actors involved in managing this crisis; ii) highlights specificities linked to the context and media coverage; iii) reflects implicit representations and bonds of trust between actors; and iv) visualises the network's dynamics over time and how it is disrupted and reorganised after the occurrence of new events. It could be further refined to incorporate not only the quantitative frequency of actor citations, but also qualitative information indicating whether references in the press discourse are positive, negative, or neutral—thereby offering a more nuanced and precise understanding of their media representation. Furthermore, this approach also aligns with theoretical frameworks discussed in recent studies, which have proven relevant for studying risk and crisis management and governance, such as Actor-Network Theory (ANT) (e.g. Beck and Kropp, 2011; Neisser et al., 2014; Bielenia-Grajewska, 2020) and Assemblage Theory (McGowran and Donovan, 2021). This study aligns with this theoretical background in several ways. First, it involves an empirical examination of interrelations and associations among actors operating in a simultaneously complex, uncertain, and ambiguous context. Our perspective on these actors is both relationalist and functionalist: it is the flow of discourse, itself structured by the roles these actors play in relation to one another, which creates and shapes this network. Moreover, these various actors are networks themselves, and they are considered on an equal footing, including the media used to constitute the dataset. This analysis also depicts the dynamic nature of this network and how it can be affected by the emergence of new actors, relationships, arrangements, or any other disruptive element, including non-human factors (see section 4.4). Finally, this study illustrates and enhances our understanding of the patterns of ordering. Its originality lies in the fact that this method is applied not only to study the network of actors in the context of crisis management or governance but also to explore the representation that certain actors (the media) have of information circulation in this crisis management context. The use of Actor-Network Theory (ANT) and Assemblage Theory is relevant in this approach, considering their application to discuss the role of

mobilisation in communication (Bielenia-Grajewska, 2020) and the compatibility of ANT with media theory (Couldry, 2008, and Belliger and Krieger, 2015). ~~Could be improved~~

6. Conclusion and perspectives

This study provides a mapping of citation and reference networks of actors identified in 6 daily newspapers as involved in the flow of information during seismo-volcanic crisis management in Mayotte from 2018 to 2021. In addition to providing an overview of the interrelationships between these actors, it offers a dynamic representation of how the networks evolve over time, including the emergence of key referent sources around which the network gradually becomes structured, as well as how they can be disrupted and reorganised following the occurrence of new events. The method also reveals the standard organisation of crisis management as well as specific features linked to the particular context of Mayotte or its portrayal in the media. This method also reveals implicit representations and bonds of trust among these actors and aligns with results from more detailed analyses. Key findings include an overrepresentation of scientific actors, both among actors cited in the articles and among actors introduced by a third party, which emphasises the centrality of scientific discourse in a context where the manifestations of the hazard are mainly visible through their instruments. This finding also calls for further research to explain the feeling of an “information vacuum” highlighted by Fallou et al. (2019) among inhabitants, despite the abundant communication from scientists and authorities documented by Devès et al. (2022a) and their overrepresentation in the media discourse evidenced here. Another important result is the central representation of individuals over institutions, which suggests varying trust placed in individual versus institutional discourse. The tension between national and local actors is evident, a pattern also observed in similar contexts in other overseas departments. From an operational point of view, these results provide key insights for identifying individuals that have proved decisive in the flow of information. The fact that these networks are not always interconnected, especially around REVOSIMA (Mayotte volcanological and seismological monitoring network) which is sometimes completely isolated, also emphasises the need for diversified information channels to ensure more efficient information flow.

Both networks of actors in a crisis management context and media representations of information flow are analysed in this study. However, this method can have numerous other applications, such as comparing representations between different groups of actors by applying it to several different text corpora (scientific or official press releases, media articles, experience reports, etc.) or studying the morphogenesis and evolution of a specific actor, by focusing on a particular actor and/or a given period (for instance, to study scientific collaboration as portrayed by the media). It is also a first step towards other explorations. For example, it could be refined to identify the actors cited in support of or in opposition to a given statement and study how these actors perceive each other. Ultimately, it could also generate datasets for artificial intelligence (AI) training to automate the mapping of actor networks and information flow from a heterogeneous corpus of texts. Finally, this reproducible method can be used for other case studies around the world. It can also be analysed in other ways to study how scientific information flows from where it is produced to the media, to explore tensions between information and entertainment in media discourse, and to compare media coverage of the same events at different geographical scales (national, regional, local).

Author contributions

MHD and MLT conceptualized the study and handled project administration. They also developed a methodology for data collection. MHD conducted the keyword selection and analysis. LLV was responsible for data collection, storage, and processing. MLT and LLV designed the method used for identifying and encoding actor citation chains. MLT created the figures and produced the scripts for the analysis. MLT, MHD and LLV conducted all analyses. LLV and MLT wrote the original draft of the manuscript, while MHD undertook the final revision and editing. All authors discussed the results and contributed to the final manuscript.

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Data availability

Due to copyright restrictions, the full text of the articles used in this study cannot be publicly shared. However, an attribute table is available online on the IPGP Dataverse platform (<https://dataverse.ipgp.fr/privateurl.xhtml?token=7269cab5-784a-4e85-9653-64b2784f9f48>). This table provides links to the original articles’ URLs on newspaper websites, and key features such as newspaper name, publication date, authorship, readership, and title (see Supplementary Information for further details). Requests for further information or access to the complete database should be directed to the corresponding author. The analysis code used and all supplementary materials are also accessible at the same Dataverse repository.

Competing interests

The authors declare that they have no conflict of interest.

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