

Perspective



Coordination of Europe's climate-related knowledge base: Networking and collaborating through interactive events, social media and focussed groups

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ARTICLE INFO

Keywords

Climate services
 Climate research
 Climate modelling
 Networking
 Collaboration
 Inclusion

ABSTRACT

Knowledge of the climate is essential to manage climate-related risks. Underpinning this knowledge is a huge range of climate research and climate service activities. There has been a marked expansion of such activities and while the numerous and diverse funding streams, activities and organizations involved means that climate service development is relatively well resourced in places, there is a risk that the landscape becomes fragmented, duplicative, confusing, and inefficient. To mitigate this, the European Commission established the Climateurope project to bring coordination to Europe's climate-related knowledge base. Climateurope created a managed network to share knowledge, improve synergies and reduce fragmentation among the stakeholders. As the network evolved, we proactively strove for equality, diversity and inclusion, for example for gender, under-represented regions, and under-represented stakeholder groups. Climateurope explored and adopted innovative approaches to engaging the network members, including face-to-face networking events (Festivals), virtual networking events (Webstivals and webinars), use of arts, social media, expert groups, publications, and an active website. The mix and integration of the traditional communications, such as website, publications and expert groups, with more innovative and varied approaches, such as the Festivals, Webstivals, social media and arts, proved popular and successful in making the network active and attractive. We describe how the network and collaboration was established and managed, and we offer some recommendations for others based on our experiences, including consideration of equality, diversity and inclusion, consider strategies for growing, managing and sustaining the network, and consider a mix of virtual and physical networking events.

1. Introduction

Knowledge of the past, present and possible future climate is of great interest and use across society and is essential to help confront the climate challenge and manage climate-related risks (Lemos et al. 2012;

Lourenço et al. 2016; Brasseur and Gallardo 2016). Underpinning this knowledge is a huge range of climate research and climate service activities involving a large and growing number of actors. While there are benefits from having a diverse range of activities, without coordination this landscape becomes fragmented, duplicative, confusing and

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<https://doi.org/10.1016/j.cliser.2021.100264>

Received 15 June 2021; Received in revised form 2 November 2021; Accepted 11 November 2021

Available online 16 November 2021

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inefficient (Jacobs and Street 2020).

At the global scale, formal coordination and collaboration, particularly for national bodies such as National Meteorological and Hydrological Services, has for the past decade been offered through the Global Framework for Climate Services (GFCS) organized by UN agencies (Hewitt et al. 2020). In addition, informal collaboration is offered through the international Climate Services Partnership (CSP), open to any party who is interested. The GFCS and the CSP have enabled participating entities to be able to share knowledge and reduce duplication and fragmentation. However, being global in reach, both partnership models face a very fragmented landscape characterised by too many actors and activities to realistically be able to coordinate widely enough to avoid global duplication and fragmentation. However, at the regional scale such an ambition becomes more achievable.

Within Europe, there are several national and regional funders of climate-related activities advancing scientific information, knowledge, and research capability, as well as developing climate services of a more operational nature. The European Commission (EC) in particular is a major and long-standing funder of such activities, including projects and programmes to mainstream and make operational the provision of climate services (see for example Thépaut et al. 2018). Funding from the EC has generated, and continues to generate, a huge amount of climate knowledge, of benefit to citizens, governments, and industry within Europe and around the world. While the existence of numerous and diverse funding streams means that climate service development in Europe is relatively well resourced, the landscape is complicated and potentially confusing. The EC mandated an expert group to develop a research and innovation roadmap for climate services (Street 2016) to develop a coherent framework to avoid fragmentation and duplication of efforts between European and national funders, and to ensure better use of investments.

As a result, in 2015 the EC invested in a five-year coordination and support activity called Climateurope, to create a managed network of climate research and climate service activities and organisations. The network has been used to coordinate and integrate the various initiatives and facilitate dialogue among the relevant stakeholders to share knowledge, improve synergies, reduce fragmentation, and promote alignment. Climateurope has also been used to assess the state-of-the-art in Earth system modelling and climate services in Europe, identify gaps, new challenges and provide forward-looking recommendations for emerging needs for research and innovation in order to better target future investments and programmes (Hewitt et al. 2021). The process of undertaking the assessments, described in Section 3, created an environment for Earth system modellers and climate service actors to interact more and to be more aware of each other's capabilities, limitations and needs, all an essential part of the climate service value chain. The assessments have also informed the EC's activities towards operational climate services, such as in the Copernicus Climate Change Service (C3S).

Communication has been central to Climateurope as an effective means of making the network active and useful, facilitating collaboration, and building and sharing climate knowledge. Section 2 describes how the network was established, how it has been used and how it was proactively evolved. Section 3 describes specific networking and collaboration approaches which were developed and used. Section 4 describes the efforts made to create an equal, diverse, and inclusive network. Section 5 discusses the significance of the findings, draws some conclusions, and makes recommendations for other knowledge sharing networks to consider.

2. The approach to creating the network and collaboration

Prior to Climateurope, the climate knowledge base in Europe was growing rapidly as was the number and the quality of the associated climate services with several major programmes being established (see Fig. 1 of Street, 2016 for an illustration) but not in a well-coordinated

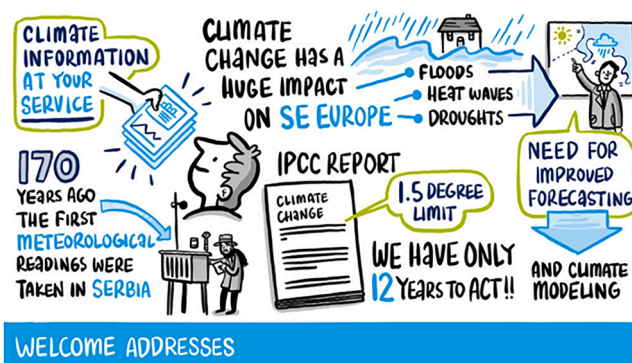


Fig. 1. A visual summary of the welcome address at Climateurope's second Festival, created in-person by Ludic Creatives (<http://www.ludiccreatives.com>).

manner. The Climateurope project formed a consortium deliberately including key European climate research and climate service initiatives. This consortium was used to create an initial focused and targeted network to immediately facilitate improved coordination and integration across major European activities. The consortium represented the Copernicus Climate Change Service (C3S), the Climate Knowledge and Innovation Community (Climate-KIC), Joint Programming Initiative – Climate (JPI-Climate), European Research Area for Climate Services (ERA4CS), the European Network for Earth System Modelling (ENES), and several major European climate research and climate service projects. To ensure alignment beyond Europe, the consortium members also had leading roles in international programmes including the World Climate Research Programme (WCRP) Coupled Model Intercomparison Project, WCRP Working Group on Coupled Modelling, WCRP Working Group on Seasonal to Interannual Prediction, WCRP Working Group on Regional Climate, the Global Framework for Climate Services, the Climate Services Partnership, the Coordinated Regional climate Downscaling Experiment (CORDEX) and its European branch EURO-CORDEX.

While this initial network improved the coordination and integration in Europe, Climateurope set out to expand the network to have a wider reach and include new activities and projects as they appeared, for example projects funded under the ERA4CS, C3S and the EC's Horizon 2020 Framework Programme. A strategy for the management and growth of the network was devised and regularly reviewed and updated. The first step of the strategy was to identify a list of new network members with the aim of undertaking manageable growth and include wider representation from major European climate service-related activities. The strategy included a protocol on how to contact over 300 potential new network members, making use of pre-existing contacts wherever possible, honouring existing relationships. The next step was to enable additional members, including those previously unknown to existing members, to easily join through a network membership form on the project's website, and promotion and recruitment to the network through interactions with the project's social media accounts, including Twitter and LinkedIn.

Updates to the strategy for the future growth of the network focused on making the network membership more inclusive, diverse, and covering under-represented groups. In particular, proactive targeting of the often under-represented Eastern European countries, increasing membership beyond the largely academic and service provider communities, and improving the gender balance. For example, networking events were consciously organized to involve men and women equally, targeted involvement from business communities, and were held in locations in under-represented regions of Europe. Involving business communities in climate research and climate service activities is notoriously challenging, so business contacts were proactively sourced to add to the proposed network members list, and members attended business-focussed events such as those held within the ECCA conference

in 2017, and the Climate-KIC ‘Climate Launchpad’ in 2017 to engage and share knowledge better with business communities. Additionally, the first Climateurope Festival in Valencia (see [Section 3.1](#)) was an effective means to engage with small and medium-sized enterprises, primarily from Spain. Networking at these events helped to bring in more business and private enterprise network members than would have happened otherwise.

Being in the network gave opportunities to share knowledge and collaborate with other members of the network through Climateurope events, as well as receiving newsletters and notification of Climateurope publications. The following section describes in more detail how the network was made active and useful to its members, and how the members engaged with other network members.

3. Engaging the network to facilitate collaboration and share knowledge

Creating a network of interested parties was not the end goal of Climateurope. The purpose of creating the network was to better coordinate and integrate the various initiatives and facilitate dialogue among stakeholders to share knowledge, improve synergies, reduce fragmentation, and promote alignment. Climateurope explored and adopted several innovative approaches to facilitate better integration and coordination by engaging the network members, primarily in Europe, and to some extent beyond Europe. The main approaches were face-to-face networking events, virtual networking events, use of arts, social media, expert groups, publications, and an active website, each described separately in the following sub-sections. These approaches proved to be popular with the participants based on feedback received, as well as surveys from the networking events. The project developed a communication and engagement strategy which integrated many of these approaches with improved outcomes compared to operating them in isolation. For example, the findings of the expert groups that assessed the state-of-the-art and gaps in climate services were presented to participants at networking events, and participants at networking events were able to input into the deliberations of the expert groups.

3.1. Climateurope Festivals

Instead of replicating the more academic conference style of meetings, a series of face-to-face, engaging, and interactive events was designed based on the concept of festivals common in the entertainment industry, to connect the network through a varied programme blending informal and formal talks, round table and panel discussions, and networking sessions, incorporating the arts, social media and other innovative approaches ([Kotova et al. 2017](#)). Two Festivals were held (Valencia in April 2017, Belgrade in October 2018), engaging the different actors from across Europe, and proved highly popular with participants based on feedback and surveys. Inspired by a motto “Climate information at your service”, the participants discussed benefits and challenges that climate services face in sectors such as water, ecosystems, agriculture, and infrastructure. In addition to engaging members of the Climateurope network, the Festivals proactively reached out to practitioners from local authorities and other public sector bodies, small and medium-sized enterprises, and large businesses, often under-represented in climate service networks. The second Festival was supported by the European Investment Bank, which gave more weight and focus to discussions for improving ways to design and deliver better climate services to business, and to enhance the development of a market for climate services. All sessions were live streamed on the Climateurope YouTube channel to increase attendance and enable the participation of those that could not physically be present at.

To create a unique visual identity for each Festival, and further promote the ‘Festival’ feel of the events, artists were commissioned to produce cartoons in real-time. These cartoons summarized the talks and discussions in a series of ‘scribings’, an example of which is given in

Fig. 1. The scribings were shared via social media during the festivals and have formed a useful resource for artistic engagement for the project and the wider network.

The Festival locations were chosen based on having facilities to enable the engaging, varied, and interactive sessions, and being readily accessible to participants. The Festivals were held in different parts of Europe to increase engagement from across Europe, to highlight local issues and to show local practical applications of climate services. The first Festival in Valencia had the topic of climate change and its impact on Southern Europe as a focus, and the second Festival in Belgrade had a focus on enabling greater participation from actors in Eastern Europe. The Festivals showcased numerous examples and challenges for applications of climate services and climate modelling, explored innovative formats and gave local participants the chance to get involved in the European climate service landscape. During the first Festival a session was held at Valencia’s nearby Albufera Nature Park, to provide greater insights into the real-life impact of a changing climate on ecosystems. During the second Festival a session at the Jeremic Winery near Belgrade showed the practical application of climate services in viticulture and vine production.

A third Festival was planned to be held in Latvia in north-eastern Europe in June 2020 but had to be cancelled at a late stage due to the COVID-19 pandemic impacting travel and face-to-face events. As described below, it was replaced by a series of web-based Festivals, to try to maintain the ‘Festival’ feel that was well received by participants in Valencia and Belgrade as much as possible.

3.2. Web-based festivals

The COVID-19 restrictions in early 2020 meant that in-person events were no longer possible until restrictions were lifted. The main impact was on the planned third Festival. After considering whether to postpone (to an unknown date given the uncertainties at the time) or cancel, it was decided to replace the third Festival with a trial web-based Festival (which we termed as a ‘Webstival’). As far as we are aware, this was the first such attempt to hold a large, highly interactive, and varied event online within the Earth Sciences community.

The trial proved successful based on feedback from participants, so a series of Webstivals was held. The duration of each Webstival, including the initial trial, was carefully considered, to optimise attendance and mitigate time-zone differences. Each event was scheduled for four hours, as full-day online events are often found to be tiring and increase the risk that participants may not commit to the full event ([Kershaw et al. 2021](#)). Holding events on consecutive days was ruled out for similar reasons, and so events were separated by at least a month. The Webstivals were held in June, September, October, and November 2020 to avoid the European summer holiday season. Due to their success and popularity, an additional event was organised jointly with C3S in January 2021.

The format of each Webstival was kept in the style of the Festivals by scheduling a varied agenda of talks, discussions, panels, and interactive demonstrations which would appeal to different communities interested in climate services. Emphasis was put on encouraging audience participation throughout the agenda, recognising that this is a weakness of online events. Online whiteboards, polling tools, and professional games were all used for this purpose. An innovative speed networking session was developed to try to replicate the chance meetings and socialising which occurs at physical events. This involved splitting the audience into virtual meeting rooms with 2–3 participants for a 7-minute period, before sending them into new rooms. As in the Festivals, artistic and cultural items related to climate change were included.

To promote engagement and to have a common thread across the series, the programmes were designed in the form of restaurant menus and recipe boards ([Fig. 2](#)). This ‘food service’ theme was a nod to the tagline for the Festival series: “climate information at your service”. Social media tools were also deployed to increase attendance and interaction with the Webstivals.

climateurope WEBSTIVAL 4

**Open 0900 to 1300+ CET (-1hr GMT)
THURSDAY 19TH NOVEMBER 2020**

Wines | Vinhos

Bringing a Message in a Bottle Wine sector insights – Wine & climate services parallels. Antonio Greco, Sogrape	10.20
Co-design - Balancing Content With Local Context. Practical experiences from ERA4CS projects. CitizenSensing: Tina-Simone Neset, Linköping University EVOKE: Gerald Jan Ellen, Deltaris INNOVA: Maria Matez, Climate Service Center Germany MEDSCOPE: Ernesto Rodriguez Carrino, Agencia Estatal de Meteorología INDECIS: Andrea Vajda, Finnish Meteorological Institute	10.40

Mock-tails

Coffee Cocktails Break & advertisements Becks Parfitt, UK Met Office	11.25
The Language of Climate Change Climate change in Baltic Sea region languages. Justas Kalys, Vilnius University	11.35
Capturing the Notes Through The Noise A panel discussion on the experiences of BellHouse Roop Johnstone Jocelyn Spencer-Mills, Kaleider	11.45
Visualisation of Climate Services A sparking interactive exploration. Isadora Jimenez, Barcelona Supercomputing Center	12.05
Decanting the Winner The photo competition results. Isadora Jimenez, Barcelona Supercomputing Center	12.45
Is it the Final Countdown? Closing remarks & Climateurope legacy. Chris Hewitt, UK Met Office	12.50
Climateurope Speed Networking (optional extra) An interactive opportunity to meet the community Raif Toumi, Imperial College London	13.00

Aperitives | Aperitivos

BellHouse Ice-'breaker' How is your data heard? Breakages not expected! Roop Johnstone, Kaleider	09.05
A Warming Welcome Welcome, notices & drinks menu of the day. Lola Kotova, Climate Service Center Germany	09.25
Quality Assurance & Standards for Climate Services Evaluation & quality control for climate data store Carlo Lacagnina, Barcelona Supercomputing Center	09.30
Evaluation & quality control for sectoral information systems Sam Lavender, Telespazio VEGA UK Ltd	
Quality assessment of climate service data & products: The QUACK Tool Eike Keup-Thiel, Climate Service Center Germany	
Panel Discussion Asun St Clair, Barcelona Supercomputing Center	
Water / Palate Cleanser Break Sharing the photo competition pictures Stacey New, UK Met Office	10.10

Climate Information at Your 'Service'
With compliments from the Climateurope sommeliers!

Fig. 2. An example of a menu board showing the agenda for the fourth Webstival. A wine menu theme was chosen for this event to represent a speaker who was a user of climate services from the wine industry.

The Webstival series enabled Climateurope to showcase numerous examples of climate services and Earth system modelling to a wide and varied audience. Despite being an unplanned replacement for the Festivals, the Webstivals had some advantages over in-person events: they allowed for a greater diversity of participants due to reduced travel costs and time commitments; they had a greatly reduced carbon footprint; and they encouraged innovation in the delivery of online events. The networking element of in-person events could only be partially replaced, but less formal networking (such as speed networking) was still useful to participants remotely.

Although removing the need to travel did enable a greater diversity of participants, we had challenges scheduling the timing of the events because the international audience were spread across time zones with differing working hours, meal times, and non-work responsibilities such as childcare. We recommend being mindful of such challenges when organising the scheduling, and explore options to maximise participation, such as avoiding early start or late end times.

3.3. Use of art, music, photography and culture

Opportunities to form collaborations between the arts and sciences were created throughout Climateurope, allowing the project to communicate its work to wider audiences and connect on a new level. Climateurope went beyond communicating science in a technical and graphical format by introducing art, sound, music, photography, poetry, and culture to networking events. Examples of art in the form of scribing and cartoons during Festivals and Webstivals have been described above, and music was a prominent feature at Festivals during evening networking events.

The excursions during the Festivals allowed participants to experience local cultural assets and be informed about, and experience, the relevance of climate and climate change on the local area and specific

sectors. While excursions were not possible in 2020, a 'Webstival of Culture' was devised where participants could still experience this element of the previous Festivals. For example, participants were invited to share something about the countries that have shaped their lives, and to share imagery of weather and climate, the impact of climate change or adaptation to climate change, landscapes, favourite places, urban silhouettes, or a nature-inspired scene, all of which formed a photography competition.

A different example of art was conducted through a collaboration with the Bellhouse art installation to demonstrate the possibility of translating climate data into sound. First commissioned for the EUPO-RIAS project (Buontempo and Hewitt, 2018; Johnstone et al., 2017), the art installation was due to be reinvigorated for the third (cancelled) Climateurope Festival. BellHouse translates data, images and non-verbal communication into the chimes of hand-crafted pottery bells, and challenges assumptions about how a listener as receiver of the information understands or recognises it. Wanting to keep BellHouse as part of the Webstival series, an art and science experiment was set-up for Webstival participants. Under the theme of communication and miscommunication of data, data from network and Webstival participants was featured from a provider, a policymaker and a user, and a video of BellHouse's translation was played at a Webstival.

As a final example, the 2018 Climateurope Festival was the stage for a presentation of the video "If Earth was human...", by Albanian high-school students, winners of the CRESCENDO project's climate communication contest. In this moving video, Earth is a teenage girl not feeling well, with symptoms including rising fever, dry skin, and mood swings. After running some tests, the doctor's diagnostic is clear: she's infected with humans which have caused her climate to change. The solution is even clearer: humans must work together, only then will she get better. This initiative was highly relevant not only for the students involved, who had the chance to learn more about climate science and interact

with the Festival’s participants, but also to the Festival’s participants who were confronted with the importance and effectiveness of embracing innovative communication strategies and engaging with the younger generation.

3.4. Social media

Engaging within the Climateurope network and reaching out beyond the network using social media, for example through Twitter and LinkedIn, proved to be highly effective methods of promoting events, sharing knowledge, and disseminating the outputs of the project within Europe and worldwide.

Twitter became the most popular platform and Climateurope’s Twitter account reached more people than the other platforms used in the project, with 2,292 @Climateurope followers at the time of writing from 98 different countries (Fig. 3). The largest proportion of the followers were in Europe, particularly Western and Central Europe. The Twitter account was used extensively to share project updates, advertise events and reports, and to reach out to potential new members. Tweet impressions provide a measure of how many times a tweet has been seen across the project’s twitter network and the networks of those profiles retweeting the content, providing a good indicator of the effectiveness of the tweets. After an initial spin-up in 2016, the campaign ramped up in 2017 including at the First Festival, and then remained relatively consistent from 2018 to 2020 (Fig. 4).

To ensure that the project’s tweets were seen by the intended and interested audiences, the hashtag #ClimateServices was used when composing original and/or quoted retweets. This also enabled any future analysis to be conducted using that hashtag allowing the interconnectedness of the climate services twitter network to be explored (Himmelboim et al. 2017). Additionally, during the Festivals and Webstivals similar hashtags were used, e.g. #ClimatEU18 and #ClimateEU20. The use of the hashtags for these events were monitored and compared to the number of monthly tweet impressions (the total number of times a tweet was seen). Fig. 5 for example shows the hashtag analysis for the Webstival series. The Webstival on 19 November 2020 proved to be the most popular in terms of tweet impressions with 38,100 total impressions for the month.

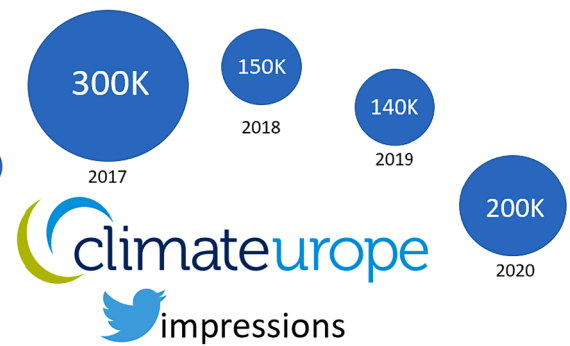


Fig. 4. The Climateurope Twitter account total tweet impressions per year from 2016 to 2020.

There was also a thriving LinkedIn account, which at the time of writing had 257 members and was still growing as a potentially self-sustaining community. With input from volunteer moderators this community could continue beyond the end of the Climateurope project as a useful legacy. The LinkedIn group for Climateurope has become an increasingly popular forum for the network to share news and information about upcoming events. LinkedIn is where network members will still be able to engage with each other under the umbrella of the Climateurope project as the other social platforms will be closed or not actively maintained now.

3.5. Webinars

An initial series of six webinars was organized to develop recommendations for gaps, challenges, and emerging needs (used as input for the expert groups described in the following section). These webinars covered climate-related research topics including the communication of uncertainty, event attribution, research infrastructure, use of climate information by the insurance and health sectors, development of climate indices, forecast quality assessment, systematic errors in climate prediction systems, the C3S, and the state of climate services in South-Eastern Europe. Each webinar consisted of two talks followed by a

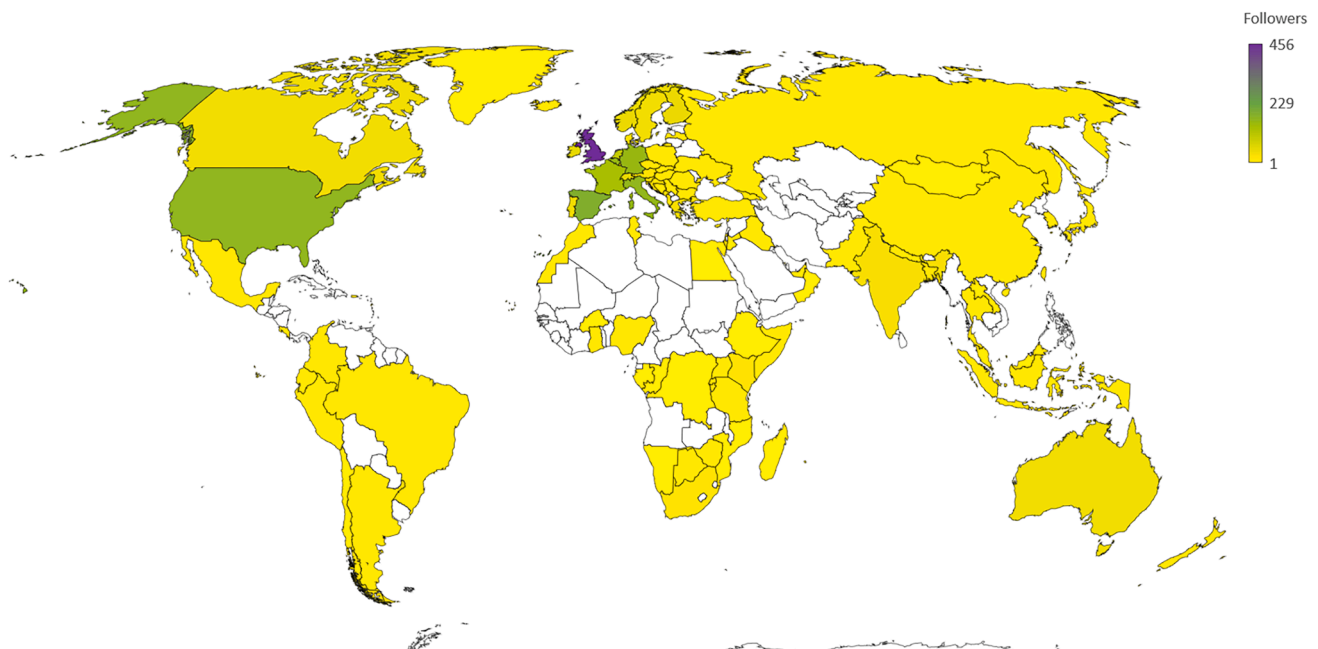


Fig. 3. Location of @Climateurope Twitter followers as of March 2021, 98 countries represented. The number of Twitter followers in each country is represented by the colour scale with darker tones representing a higher number.

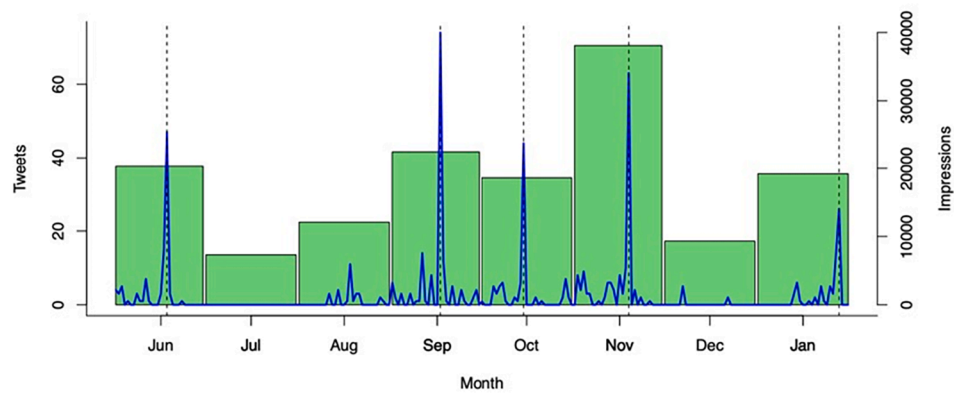


Fig. 5. Number of tweets containing the hashtag #ClimatEU20 (used during June 2020 -Dec 2020) or #ClimatEU21 (used during January 2021). Blue line shows the number of tweets, dotted vertical lines highlight the dates of the WebFestivals, bars show monthly tweet impressions.

discussion of pre-defined questions and questions from the audience, and speaker and participant guides were created.

As the series progressed, the popularity of the webinars grew, in part because they were an effective means for scientists and practitioners to keep informed of activities beyond their own areas of work. The initial series was so popular that it was decided to continue organizing webinars as a means of sharing knowledge on subjects of potential interest for the network and beyond. A further 11 webinars provided interaction and engagement between various actors, including scientists and decision-makers. The series was established with the following common structure for each webinar: two to three short presentations and ample time for questions and discussion. Presentations were given from different viewpoints and perspectives, for example one speaker to present results from a project, and one speaker giving the perspective from a company or government on the usability of the results. Several EU-funded projects (APPLICATE, CLARA, ClimInvest, EUMACS, LIFE Local Adapt, PRIMAVERA, S2S4E, SINCERE) presented their results to share their knowledge and disseminate their results, and to get feedback from potential users. Some of the webinars were organized on more general subjects including: visualization of climate data; user interaction during the development of climate scenarios; climate data quality; climate modelling research infrastructure, and blockchains. The webinars were advertised using Climateurope's website, Twitter, and LinkedIn, and also the ERA4CS and other EU-projects, thus reaching beyond the Climateurope network and extending it. The most popular webinar was on visualization of climate data with more than 300 subscribers. The presentations from the webinars were recorded and made available to a broader audience through the Climateurope website and YouTube channel, and many of the findings and recommendations provided content for the expert groups and publications (see below).

3.6. Expert groups

Groups of multi-disciplinary experts were established to share knowledge, to discuss and assess the state-of-the-art in Earth system modelling and climate services in Europe, and to provide thoughts on gaps, challenges, and emerging needs. The expert groups conducted their activities through face-to-face meetings, workshops with a wider community, webinars, and a combination of these.

Face-to-face meetings were held before the COVID-19 restrictions came into effect, both in terms of small focussed face-to-face meetings of experts as well as with wider groups of stakeholders. In the first case, the small group of experts directly discussed the topics, sharing their own expertise and knowledge, drawing on other knowledge from publications and projects, and produced well-informed and carefully considered recommendations. In the second case, workshops were conducted with a wider stakeholder group to bring in additional knowledge, expertise, and views. The outputs from the wider stakeholder group consultations

served as the basis for further focused discussions amongst the experts, who then produced recommendations.

Another way of bringing together the experts to share knowledge, discuss, assess, and provide thoughts on gaps, challenges and emerging needs was through the initial six webinars described above. The experts were drawn from national meteorological and hydrological services, research institutes and universities, private-sector actors, and intergovernmental organizations covering key sectors. This approach was adopted to better engage with the wide community and obtain broader and more relevant input from a range of target audiences, including academics and users. Each webinar focused on a different topic and provided short, focused presentations from the experts followed by lively interactive discussion on a range of cutting-edge topics, with each expert giving their views on the challenges and emerging needs linking climate research and services.

As an example of a more integrative approach, the Festivals were used to provide input to the work of the expert groups, and to share the knowledge and outputs arising from the expert groups. In addition, as a variant on the above, the outputs of the expert groups in Climateurope were improved by engaging with other expert groups, in particular a multi-disciplinary expert group established by the EC to implement the European Roadmap for climate services, which provided comments and revisions to the recommendations, and a Climate Services Projects network, facilitated by Climateurope to enhance communication and dissemination of EC-funded climate service projects and to improve synergies and reduce fragmentation.

3.7. Publications

The collection, synthesis and sharing of information with and between stakeholders was at the heart of Climateurope. Written documents in the form of easily accessible publications were a key component, with the content being relevant to all of Climateurope's other forms of engagement and communication. Five types of publication were produced, namely leaflets, reports, a publication series, policy briefings, and newsletters.

The first publicly available publication was a leaflet giving an overview of Climateurope to inform all interested parties about the project and get them involved in networking, collaboration, and knowledge sharing. Similarly, at the end of the project a leaflet was produced to highlight the main activities and outcomes of the project, constituting a piece of the project legacy.

Eight reports were produced (available at <https://www.climateurope.eu/publications-climateurope/reports-and-articles/> with 1,273 views on the website at the time of writing) of which five were published in peer-reviewed international journals to ensure wider reach and availability of key findings and knowledge generated through Climateurope's activities (Kotova et al. 2017; Hewitt et al. 2017; van den

Hurk et al. 2018; Bessembinder et al. 2019b; Hewitt et al. 2021).

A series of three detailed publications were produced (Döscher et al. 2017; Martins 2020; Martins et al. 2019) focussing on the state-of-the-art of European Earth system modelling and climate services. The first publication assessed the abilities and limitations of Earth system models in relation to climate services, with the second and third updating the state-of-the-art and further exploring the best use of Earth system models to underpin climate services, including support for their interpretation to strengthen the science base of climate services. The contribution of various network members as groups of experts provides valuable feedback and review.

Four policy briefs were produced (Buonocore and Gualdi 2017; Bessembinder et al. 2019a; Buonocore and Bessembinder 2019; Buonocore et al. 2019, available at <https://www.climateurope.eu/publications-climateurope/policy-briefs/> with 404 views at the time of writing) drawing on the content of the other publications to summarise key information in a format and language more suited to policy-makers, ranging in length from 1 to 6 pages.

Finally, six informative newsletters were produced targeted at the entire network to keep everyone informed of activities, events, and the publications described above. By 2021 there were 705 subscribers to the newsletters.

The motivation for the different types of publication was that the wide audience reached by Climateurope had different background knowledge about climate science and climate services, and so these different publication types targeted different audiences. In general, the reports and publication series were intended for readers with relatively good knowledge of climate science and services, while the leaflets, newsletters, and policy briefings (along with the website described below) were intended for everyone. There was also a difference in levels of interaction with most stakeholders keen to participate more directly in sharing knowledge and engaging in activities such as those described above only, and some only wanting to be kept informed without direct involvement in the project.

3.8. Website

The Climateurope website was conceived, designed, and implemented to provide an accessible, dynamic, and up-to-date reference for Climateurope's activities. The website evolved, adapting its structure and content to the needs that emerged, including giving an overview and links to new projects and activities that emerged across Europe. The website went beyond being a catalogue of what exists by providing information and insight into the opportunities for interaction between climate change research, climate services and the wider stakeholder community.

The content architecture was designed to provide information at different levels of complexity so that the users, with varying degrees of background knowledge, could find information on the website, with some sections offering a quick introduction to complex issues, while other sections offered more detail and in-depth content for advanced users, including content on available services, research projects and initiatives. The webinar section deserves a separate mention: all multimedia materials were collected in one section, providing biographies of the speakers, videos, presentations, and insights into specific topics.

Although English was the primary language for the website, consideration was given to breaking down language barriers for some of the general content. Thanks to cooperation between the Climateurope partners, pages were created in Bulgarian, Hungarian, Italian, Polish, Serbian, and Spanish to offer European stakeholders an additional resource.

The varied and dynamic nature of Climateurope's activities meant that the website had to respond to the needs that emerged as the project evolved. Translations, enrichment of webinars, multiplication of content produced by Webstivals, and online versions of the original Festivals, were all made easily available to everyone, thanks to the flexibility and

dynamism that were key features of the website design.

4. Equality, diversity, and inclusion

As a starting point for establishing respectful, inclusive, collegiate and legally compliant ways of working within and across the network, a gender action plan was produced at the beginning of the project. The baseline requirement for the action plan was formed from the most stringent parts of the gender equality policies of the Climateurope consortium members' organisations. The action plan covered topics including accessibility of facilities and meetings, gender balance represented within media used by the project (including the subjects of photographs, videos and interviews), use of gender-balanced language in published materials, and aiming for a diverse and balanced membership of the network and the expert groups.

Initially, the network comprised 43% women and this improved to 48% by 2021. As the network evolved and grew to encompass more countries around the world, the gender action plan aimed to improve not just the overall gender balance, but also for each individual country represented. Given the context of unequal gender representation in global scientific careers (Huang et al. 2020), the representation of women from Ireland, Italy and Croatia especially (Fig. 6) illustrates the positive impact of the action plan on improving gender balance in countries where women were heavily under-represented.

In addition to the gender action plan, the project developed a set of terms and conditions for network membership, based on the same principles as the gender action plan, and with additional agreement by all network members not to discriminate based on protected characteristics (such as age, disability, sexual orientation, religion or belief), and to facilitate a friendly and cooperative atmosphere. These inclusive principles informed the approach to developing the network, ensuring a good geographic distribution of network members (Fig. 7). Eastern European countries were particularly challenging to attract members from, so strategies were employed to help improve their representation. These included translating parts of the project website into Polish, Serbian, Hungarian and Bulgarian, and holding the second Festival in Serbia, with an intention to hold the third (cancelled) Festival in Latvia.

In addition to ensuring a good geographical distribution and balance of network members, the background and interests of the network was also an important consideration for balance. Representing and recruiting members from the across the community has been challenging in the past, particularly the users of climate services. Climateurope adopted approaches outlined in Section 2 above, guided by the inclusive principles of the gender action plan, to ensure improved representation from private companies, non-governmental organisations, intergovernmental organisations, policy makers and funding bodies. The relative proportions of network membership across 10 different categories of organisations are shown in Fig. 8 based on data provided by the members during the network registration process. Some organisations are providers of climate services, some are users of climate service, and some are both providers and users. While we were not able to uniquely categorise members as simply providers or users, we estimate that the representation of providers to users was approximately 70% to 30% respectively.

5. Discussion

5.1. Summary

The Climateurope project broke new ground and provided a framework for coordinating and integrating climate research and climate service activities across Europe and across a broad range of stakeholders, linking businesses, academia, climate service providers, funders, and policy- and decision-makers. Such activities were previously largely disparate and fragmented with little or no coordination, which is why the EC funded Climateurope. An active network was established and

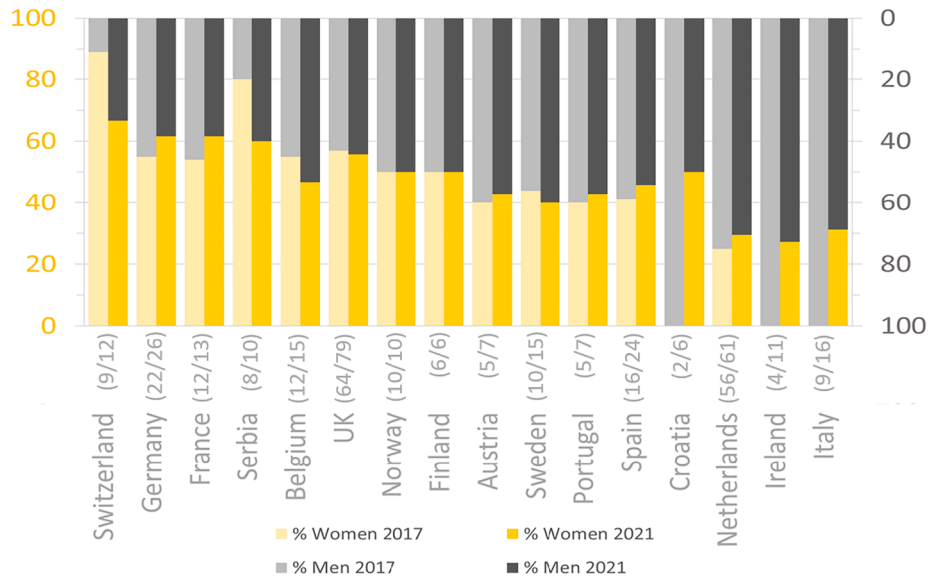


Fig. 6. Climateurope network geographic gender distribution in 2017 and in 2021. Countries with fewer than three total network members have been omitted from these graphs. Absolute figures of network participants for 2017 and 2021 respectively are noted in brackets after the country name.

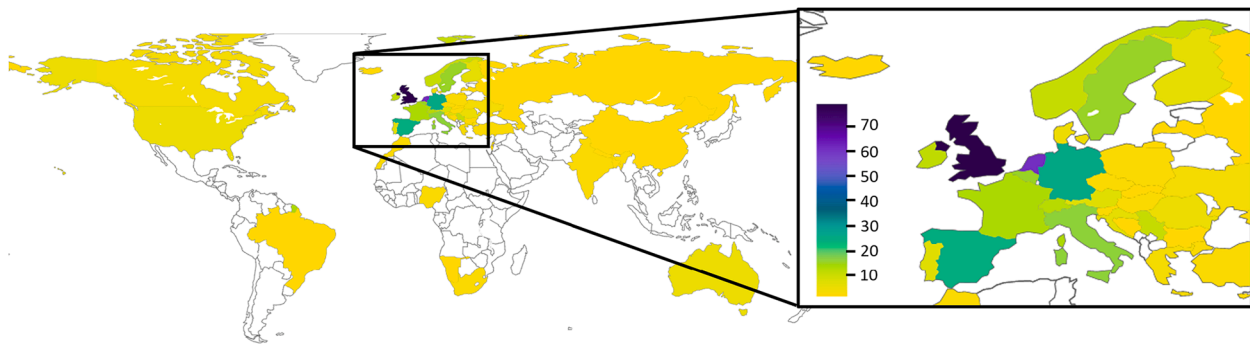


Fig. 7. Global network distribution globally (left) and in Europe (right) as of 2021. The number of network members in each country is represented by the colour scale with darker tones representing a higher number.

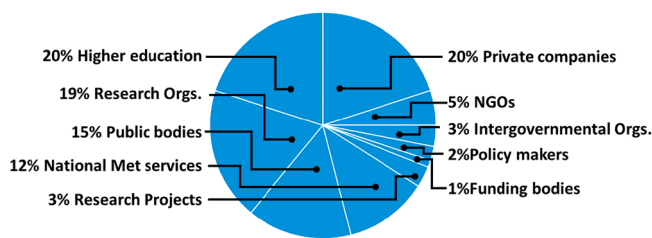


Fig. 8. Composition of the Climateurope network (as of 2021).

managed, growing from about 25 people at the start to about 400 by the end of the project. Knowledge sharing and collaboration among the network members was enabled through enhanced and integrated communication activities, such as interactive events, widespread use of social media, and focused groups, thereby improving synergies, reducing fragmentation, and better aligning activities.

Having a strategy for growing and managing the network and reviewing and evolving the strategy meant that shortcomings in the network could be readily identified and reacted to. Equality, diversity, and inclusion were a conscious concern, in particular relating to gender balance and less well represented communities such as from Eastern Europe and from beyond the academic and climate service provider communities. More needs to be done, but Climateurope did have some

successes and made improvements, as noted above. The Climateurope network also engaged with other networks, such as those of C3S, JPI-Climate, ERA4CS, ENES and Climate-KIC. However, engagement with networks from other communities, such as those within industry, to broaden the reach further could be useful if done in a manageable way.

The network was also used to undertake expert assessments of the state-of-the-art in climate research and climate services in Europe, identifying knowledge gaps and scientific and technical challenges, and providing recommendations for future needs for research and innovation in these areas. The assessments were published as a range of reports and policy briefings and have influenced the EC’s long-term Horizon Europe Framework Programme. The dialogue which occurred between the Earth system modelling community and the climate services community (who substantially differ in their approach, language, characteristic scales of work and interaction with stakeholders), improved awareness of the other community and improved common working.

The communication activities brought the network together as a community and ensured broad reach for the project’s activities and participants. Climateurope reached audiences through traditional mechanisms including a website, scientific publications, expert groups and workshops, as well as through alternative ways of communicating, such as social media including the use of Twitter, LinkedIn, and webinar series, which have been archived as a series of videos through YouTube and the Climateurope website for those unable to participate live. The most prominent networking activities were the Festivals held physically

in Valencia and Belgrade which brought the network together through a varied and interactive programme, as opposed to a traditional conference or workshop. These were succeeded by the innovative series of online Webstivals in response to the travel restrictions brought on by the COVID-19 pandemic. A series of videos have been made from the Festivals and eye-catching cartoon art has been used as a way of recording the outcomes. Climateurope's social media accounts help promote the videos and other Climateurope activities, including relevant news stories from the network members.

In terms of engagement and reach, the Festivals, Webstivals, expert groups and to some extent the webinars had the most direct and intense interaction and engagement amongst participating network members, allowing effective sharing of knowledge. The website, reports, policy briefings, and publications had less direct interaction and engagement, being more about informing people by pushing knowledge to the audience, but their reach and the amount of knowledge shared has been greater.

Having a communication and dissemination strategy which developed and evolved through the integration and use of communication tools meant that Climateurope was well positioned to cope with unfolding or unexpected situations, most notably with the abrupt and dramatic turn of events that arose from the unforeseen ban on travel and face-to-face meetings due to the COVID-19 pandemic. This potential showstopper to the project's collaboration and networking plans meant we had to adapt, forcing us to abandon the final face-to-face Festival and trial an online web-based 'Festival' approach. The new approach created an opportunity to increase participation and collaboration of the network around the Webstivals, and in the end proved highly successful with participants based on feedback, raising questions over the necessity for (so many) face-to-face meetings.

5.2. Conclusions and recommendations

While Climateurope established, grew, and managed a network to help coordinate Europe's climate-related knowledge base and build collaborations, in some areas the successes were more limited or could have been done differently with the benefit of hindsight and an evolving landscape. A missed opportunity in hindsight is that perhaps the network could have been used to fill gaps such as quality standards for climate services and associated ethics. Although these were beyond the original scope of Climateurope, other activities in this space are commencing, and the Climateurope network could now be used to help fill such gaps. Also, while progress was made improving gender balance and the geographic spread of engaged actors as discussed above, the distribution still had imbalances. There may be historical biases behind the inequalities, but efforts must continue to further improve the situation. Language may have been a barrier and using local languages would help to reach and engage a broader audience. Climateurope originally planned to only conduct activities in English, but some efforts were made to go beyond English, for example a Spanish Twitter account at the First Festival, translation of a limited number of webpages as described above, as well as translations in several of the different partner institutes' internal and outreach activities. Automated translation tools could also be considered, however, such tools can struggle to properly cope with abbreviations, metaphors and cultural terms (Miraz et al. 2016) and ideally would need proof-reading.

A particular area that we would like to highlight is that despite the large expansion in the climate service market in Europe over the lifetime of the project, Climateurope did not engage the private sector and users of climate services as much as the public sector and the providers of climate services. Such a situation has existed for a long time and so a different approach to the private sector and users of services could prove more successful. For example, approaches building partnerships and collaborations right across the value chain (Porter 1985) for climate services, having more users involved in the planning and initiation of the project, and engaging with existing business networks and professional

associations could prove successful, although such approaches are not guaranteed to work and difficult to implement in practice. Nevertheless, the network has provided valuable lessons to bridge the gap between climate service providers and users. For example, a common and agreed terminology of climate observations, Earth system modelling and climate services was established for both communities to work with (<https://www.climateurope.eu/climate-and-society/at-a-glance/definitions/>), and climate service visualisation practices were showcased and led to recommendations for future developments (Terrado et al. 2021).

Based on all the above, we have the following five recommendations and reflections for future networking activities that aim to share knowledge and facilitate collaboration, be they similar projects or networks elsewhere in the world or a follow-up activity in Europe building on Climateurope.

1. The project had a well thought through strategy for growing and managing the network from the outset. While having a strategy is important, we recommend that such strategies are reviewed and updated in an agile way to take account of new situations and learning. For example, while we anticipated having imbalances in network representation relating to gender and locality, it was only as our network started to be formed and evolved that we could identify specific issues and shortcomings in our network approach and communication activities which led us to devise a more targeted approach to strive for better equality, diversity and inclusion through both our targeting of network members and also our networking and communication activities.
2. Related to the above, we recommend that equality, diversity, and inclusion are fully considered and planned for at the outset for creating networks for sharing knowledge. Not doing this may well lead to significant gaps in expertise and knowledge from certain groupings. Going even further, involvement of the younger generation, including those of school and college age, should be considered, particularly for topics like climate change which will affect the younger generation for decades to come, and similarly greater involvement of the communities that are most vulnerable to climate-related hazards should be considered. Engagement can take place via citizens assemblies (for example, Devaney et al. 2020), engagement activities in research projects, research centres and universities (such as the CRESCENDOSchools activities, <https://www.smhi.se/en/research/research-departments/climate-research-at-the-rossby-centre/2.4373>), and public science events such as the European Researchers' Night (Jensen et al. 2021). The use of art, music, photography, and culture, as shown by Climateurope, could also be considered to help build bridges between different communities.
3. The project had a well thought through strategy for communication and dissemination which helped establish a platform for sharing knowledge and collaborating, but as with our comment about the networking strategy, it is important to review and update the communication and dissemination strategy. For example, when the Climateurope project was first designed, social media wasn't as widely used as it is today, but project participants championed greater use of social media both as a standalone activity and also to embed it within the planned communication activities, such as the Festivals where a 'Twitter Wall' was prominently displayed so that live Tweets were clearly visible as the Festival was underway, providing a more interactive experience for participants physically in attendance as well as remotely. Such an approach also helped with equality, diversity and inclusion.
4. The online virtual Webstivals created an unplanned opportunity to increase the number and diversity of people able to participate and collaborate, by reducing or removing some of the barriers that exist for attending physical meetings, such as the cost (in time, money, and carbon emissions) and inconvenience of travel, and physical space limits. The Webstivals also provided more opportunities for the network to meet, potentially paving the way towards a genuine

community of practice (Wenger et al. 2002). The virtual meetings were designed to replicate the in-person Festivals by offering an engaging program and they can serve as inspiration for future online events. The Webstivals proved to be a successful alternative to the planned face-to-face meeting, with some advantages as listed above, which raises questions over the necessity for so many face-to-face meetings. However, there are also some disadvantages, for example it is hard to have such interactive and spontaneous discussions using videoconferencing tools, and it is hard to replicate the interactions and connections, often unplanned, that take place over coffee, food, out of work social interactions, and just 'bumping into' people at face-to-face events. So, we would promote a mix of virtual and physical events and see the online events as an opportunity to increase the networking opportunities rather than replace them.

- If networks are created as part of a project, or other time-limited activity, then the legacy of the project needs to be considered at the outset and throughout the project, to ensure that whatever framework or platform is established can have use and value even when the project ends, and ideally can easily be taken up by others. The outputs from Climateurope will remain accessible online via the website www.climateurope.eu which is being hosted as a static site until December 2025, and also the Climateurope YouTube channel. The publications are available in the public domain. The network will remain active through the Climateurope LinkedIn group, which will remain live, and volunteer led. The webinars and Webstivals proved to be an unplanned and unexpected success and there is interest in continuing these through other projects. However, the most significant legacy of Climateurope is likely to be the community that has grown up, a community that will have forged new connections, many of which will last well beyond Climateurope. At the time of writing the EC are looking to have a new project commence sometime in 2022 and such a project can easily draw on Climateurope's legacy and the Climateurope community is ready to engage in this to continue and grow the network.

While these conclusions and recommendations are based on experiences gained within Europe, they are relevant and applicable anywhere in the world, either for new networks or existing networks. The innovative approaches through interactive events, social media and focussed groups, and the aims for equality, diversity and inclusion are all potential blueprints for other networks. Benefits to the participants of being active in the Climateurope network have included the collaboration and knowledge sharing. In addition, a less fragmented landscape has been of benefit to all stakeholders whether in the network or not, compared to the largely disparate climate-related activities in Europe that existed before.

CRedit authorship contribution statement

Chris Hewitt: Conceptualization, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. **Janette Bessembinder:** Writing – original draft, Writing – review & editing. **Mauro Buonocore:** Writing – original draft, Writing – review & editing. **Tyrone Dunbar:** Writing – original draft, Writing – review & editing. **Natalie Garrett:** Visualization, Writing – original draft, Writing – review & editing. **Lola Kotova:** Writing – original draft, Writing – review & editing. **Stacey New:** Visualization, Writing – original draft, Writing – review & editing. **Paula Newton:** Writing – original draft, Writing – review & editing. **Rebecca Parfitt:** Visualization, Writing – original draft, Writing – review & editing. **Carlo Buontempo:** Writing – original draft, Writing – review & editing. **Francisco Doblas-Reyes:** Writing – original draft, Writing – review & editing. **Francesca Guglielmo:** Writing – original draft, Writing – review & editing. **Daniela Jacob:** Writing – original draft, Writing – review & editing. **Erik Kjellström:** Writing – original draft, Writing – review & editing. **Aleksandra Krzic:** Writing – original draft, Writing – review & editing. **Helena Martins:** Writing – original draft, Writing – review & editing.

Alessia Pietrosanti: Writing – original draft, Writing – review & editing. **Marta Terrado:** Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

This work was funded by the Horizon 2020 Framework Programme of the European Union: Climateurope - Linking science and society, Project ref. 689029. The views expressed are purely those of the authors who were all involved in the project and may not under any circumstances be regarded as stating an official position of the European Commission. Thank you to Rob Groenland and two anonymous reviewers for helpful comments on the paper.

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