

# The role of climate scientists in the post-factual society

Erlend M. Knudsen and Oria J. de Bolsée

## Set-up of response

We thank the reviewer for her suggestions on the manuscript. With the changes explained below, we feel that the paper is strengthened compared to its first submission.

In the following, we go through each comment by the reviewers (reproduced here in gray text for your reference) and explain our choices of changes in accordance with these. Where changes to the text in the manuscript are made, the relevant excerpt is reproduced from the .pdf manuscript to this .docx response in *italic text*, with changes written in *italic green text*.

## Response to the review by Kristin Timm

### Reasons for climate action message success

The most important finding in this paper, in my opinion, is that the climate action message - coming from climate scientists - was the most popular (among social media video viewers). This finding is not surprising, considering communication theories like the Extended Parallel Processing Model (Witte) suggest that increasing efficacy to cope with risk is a critical part of effective risk message processing. However, this finding (or reflection) is most interesting to me considering that many climate scientists are hesitant to venture past explaining the causes and effects of climate change, into discussing solutions, for fear of being seen as an advocate and losing credibility. The authors could strengthen this paper by spending more time reflecting on and discussing the content of their climate action messages and exploring where those messages sit on a spectrum from objective to advocate. Furthermore, these reflections could be more strongly placed in the existing literature about the role of scientists in society.

Thank you for sharing your views on the manuscript. We agree that reflecting on and discussing how messages of climate action is seen in terms of climate advocacy is an important aspect following our experiences. For this reason, we have made several changes to the manuscript.

In particular, the end of the 3<sup>rd</sup> paragraph in Sect. 2 now reads:

*In line with O'Neill and Nicholson-Cole (2009) and Stoknes (2015), we highlighted the opportunities and inspiration of acting on climate change now rather than later. We communicated the ongoing and expected consequences of climate change, but in terms of relevant and experienced changes rather than fear rising from their cognitive dissonance following Extended Parallel Processing Model theory (Witte, 1992).*

Similarly, we have added a sentence on this matter in the 2<sup>nd</sup> paragraph in Sect. 4, including two references:

*Moreover, fostering constructive public conversations about science and society can, among others, improve decision-making, promote trust and credibility in scientific findings and strengthen democratic processes (Wooden, 2006; Nisbet, 2018), ultimately*

*counteracting politicization and polarization of science and post-factual movements, respectively.*

We have also expanded the 3<sup>rd</sup> paragraph in Sect. 4, which discusses the credibility of researchers. This now reads:

*Consequently, we worked hard to keep our credibility as researchers (Nordhagen et al., 2014), not partnering with organizations or initiatives on either of the climate advocacy fringes, and not favouring one political party over another. Based on the feedback received, this scientific background and endeavour to remain objective allowed us to partner with organisations otherwise not within reach, like the United Nations Development Programme (UNDP) and the World Meteorological Organization. Following the definitions by Nordhagen et al. (2014), we experienced a boost in personal and public credibility, more than outweighing a loss in professional credibility from our publication record hiatus while on the road, thus overall enhancing our researcher credibility. By being open about what role we played in public, we strove to negotiate the tension between our professional and public credibilities discussed by Nordhagen et al. (2014), in which our goal of stronger climate action on governmental level to some degree was challenged by the common academic view that researchers should remain detached from public policies. We saw our role as awareness-raisers, increasing the understanding of climate science within all societal groups.*

Moreover, we have expanded the first sentence in the 2<sup>nd</sup> paragraph in Sect. 5 with another relevant reference. This now reads:

*In our current society, we argue that the role of the 'pure scientist' (as defined by Rapley and De Meyer, 2014) is outdated and the need of the 'science communicator' and 'the honest broker of policy alternatives' (as outlined by Pielke Jr., 2007) is rising.*

Furthermore, we have expanded the 3<sup>rd</sup> paragraph in Sect. 5, also with more references, which now reads:

*For scientists at the beginning of their academic career, we support the notion by Leshner (2007), Brownell et al. (2013), Rauser et al. (2017) and Nisbet (2018) that engaging in outreach activities helps shape the research questions, giving more effective tools for narrowing the widening gap between academia and the rest of society, and eventually providing a more constructive input for policy formulation on climate change. As we see it, this will act to reduce politicization and polarization of climate change, while also depressing the breeding ground for post-factual movements. Within academia, outreach training gives us better tools in teaching, mentoring of younger students and taking part in scientific discussions, as well as contributing to better written research proposals and journal publications (Stiller-Reeve et al., 2016, and references therein).*

Finally, we have added two more references to the relevant sentences in the last paragraph in Sect. 5 on this topic, which now read:

*Now it is up to us to adapt and play our new role objectively while keeping our credibility (as discussed by Nordhagen et al., 2014). According to Rapley and De Meyer (2014), this has the potential to remove climate science from the direct firing line to leave the authority, responsibility and accountability for decisions transparently with the policymakers and the public. When done carefully, we have the potential, regardless of audience's political*

*predilection, to provide trustworthy information to the climate change discourse (Leshner, 2003; MacInnis et al., 2015; Hamilton, 2016).*

These references are:

- Leshner, A. I.: Public engagement with science, *Science*, 299, 977, doi: 10.1126/science.299.5609.977, 2003.
- Leshner, A. I.: Outreach training needed, *Science*, 315, 161, doi:10.1126/science.1138712, 2007.
- MacInnis, B., Krosnick, J. A., Abeles, A., Caldwell, M. R., Prahler, E., and Dunne, D. D.: The American public's preference for preparation for the possible effects of global warming: impact of communication strategies, *Climatic change*, 128, 17–33, doi:10.1007/s10584-014-1286-x, 2015.
- Nisbet, M.: Scientists in civic life: facilitating dialogue-based communication, American Association for the Advancement of Science, [https://www.aaas.org/sites/default/files/s3fs-public/content\\_files/Scientists%2520in%2520Civic%2520Life\\_FINAL%2520INTERACTIVE%2520082718.pdf](https://www.aaas.org/sites/default/files/s3fs-public/content_files/Scientists%2520in%2520Civic%2520Life_FINAL%2520INTERACTIVE%2520082718.pdf), 2018.
- Pielke Jr., R. A.: *The honest broker: making sense of science in policy and politics*, Cambridge University Press, New York, USA, ISBN:978-0-521-87320-8, 2007
- Stoknes, P. E.: *What we think about when we try not to think about global warming: Toward a new psychology of climate action*, Chelsea Green Publishing, Vermont, USA, ISBN:978-1-60358-583-5, 2015.
- Witte, K.: Putting the fear back into fear appeals: The extended parallel process model, *Commun. Monogr.*, 59, 329–349, doi:10.1080/03637759209376276, 1992.
- Wooden, R.: The principles of public engagement: at the nexus of science, public policy influence, and citizen education, *Soc. Res.*, 73, 1057–1063, 2006.

#### Historical development of the climate scientist role

The authors say on page 1, line 13, “The role of climate science in the public sphere has changed significantly since the mid-1980s.” I would like to hear more about this line of reasoning, and I recommend the authors explore some of the existing literature from science and technology studies that reflects on the role of scientists in society (i.e. *The Honest Broker*, by Roger Peilke Jr., recent work by John Kotcher et al. also explores scientists’ advocacy messages).

Based on your suggestion, we have expanded the 1<sup>st</sup> paragraph in Sect. 1 into three. These include references to “The honest broker” by Roger A. Pielke Jr. (Pielke Jr., 2007) and two of the recent works by John Kotcher (Vraga et al., 2018 and Zhao et al., 2016) and read:

*The role of climate science in the public sphere has changed significantly since the mid-1980s. Ensuing the formation of the Intergovernmental Panel on Climate Change (IPCC) and the U.S. Senate testimony of James Hansen in 1988, climate science has increasingly become a topic of political debate, media coverage and part of the daily discourse in our societies (Bolin, 2007; Ungar, 2016). Simultaneously, the scientific understanding of climate change has been rapidly expanding, with the number of climate change papers published per year exponentially growing (McSweeney, 2015) and the confidence in humans as the main cause of global warming has gone from insufficient to “extremely likely” (as defined by the IPCC First to Fifth Assessment Reports; Houghton et al., 1990; Stocker et al., 2013).*

*A corresponding increase has neither been seen in climate change legislation (Townshend et al., 2013), media coverage of climate change topics (Boykoff et al., 2018) nor in public perception of climate change (Capstick, et al., 2015; Zhao et al., 2016; Saad, 2017). Instead, the politicization and polarization of climate change has been growing, with the former referring to how the science behind political decisions increasingly are promoted and attacked by advocates and opponents and the latter referring to the growing division between elites, organisations and political parties viewing climate change as a negative consequence of industrial capitalism and those opposing such views (McCright and Dunlap, 2011). This trend is arguably most notable in the U.S. (Capstick et al., 2015; Carmichael et al., 2017), where the partisan divide on environmental voting score (as defined by the League of Conservation Voters) grew from about 25 in 1970 to about 85 in 2015 (Dunlap et al., 2016). Since then, Donald Trump was elected as the country's 45<sup>th</sup> president and has repeatedly been questioning climate science, actively working against environmental legislation and funding of his predecessor and generally making the work of climate scientists more challenging (De Pryck and Gemenne, 2017; Alderman and Inwood, 2018; and references therein). A post-factual society has arisen, in which part of its members rather accept an argument based on their emotions and beliefs than one based on scientific facts (Alvermann, 2017).*

*A post-factual political scene is not isolated to the U.S. alone; Brexit in the U.K. and the (re-)elections of Rodrigo Duterte in the Philippines, Andrzej Duda in Poland, Viktor Orbán in Hungary, Recep Tayyip Erdogan in Turkey and Jair Bolsonaro in Brazil are all examples of populist solutions trumping science-based ones (Postel-Vinay, 2017). Furthermore, the rise of social media has meant that everyone can act as journalists and editors in choosing what to post, where algorithms make sure to share posts from those with similar opinions, thus creating filter bubbles (Pariser, 2011; Alvermann, 2017; Bail, 2018). Conventional media can also reinforce filter bubbles by presenting scientific news within pre-existing worldviews of their audiences (Theel et al., 2013; Carmichael et al., 2017). Similar bubbles exist within academia, where scientists are trained to write for an already highly educated and specialized audience (Stiller-Reeve et al., 2016). Scientists are thus often seen as an elite without touch to the rest of society (Townson, 2016). For this reason, it is, more than ever, crucial to establish dialogues with those outside of academia in order to help trigger positive global changes (Leshner, 2007; Barnosky et al., 2016). Doing so, we, as scientists, need to choose our role within society carefully in consideration of the consequences for us individually and as a community (Pielke Jr., 2007; Vraga et al., 2018).*

### Data transparency

While I appreciate the presentation of the data related to the campaign, I encourage the authors to be much more transparent about who exactly was engaged in the different elements of the campaign and where they have data and where they do not. On page 2, line 23, the authors said, "A conservative estimation is that more than one million people in 45 countries were reached through conventional and social media." If it is included, I would like to see a much more detailed description of how this figure was produced. Is this based on social media impressions? Is this based on traditional media circulation rates? The analysis of the social media videos is interesting, but the authors should acknowledge the extent to which this audience is similar to or distinct from the audiences who participated in public lectures and those who engaged with the campaign through traditional news sources and the population as a whole.

To that end, I would strongly recommend the authors avoid the use of the term “general public.” From the description provided, several distinct audiences were targeted and reached during the campaign (i.e. school children, people who attended a lecture, people who watched a video on Facebook) - and each of these audiences likely has unique characteristics that are relevant when considering the authors’ final outreach recommendations. In particular, I encourage the authors to address the extent to which their campaign attracted people who already had a high interest in science or belief in climate change (see Besley, “Audiences for Science Communication” for further discussion from a US context).

Thank you for highlighting that we were not transparent enough in the manuscript. We always wished to be so, so that others can learn from our experiences. For this reason, we have tried following your suggestions and edited the text accordingly.

Hence, based on your suggestion, we elaborated on the more than one million people estimate, making it an own paragraph at the end of Sect. 2. This paragraph also touches upon how our followers differed between conventional and social media. It reads:

*A conservative estimation is that more than one million people in 45 countries were reached through conventional and social media, which included close to 250 media outlets and almost 500,000 and 250,000 reached per Facebook post and Twitter tweet, respectively. While it is probable that some of our followers on Facebook, Twitter and Instagram overlapped, the breadth of conventional media coverage meant that we were able to reach a wider span of the society. For example, our story was featured five times on CNN in English, Spanish and Arabic, while Norwegian Broadcasting Corporation aired us 14 times. None of these are likely to be seen by the average Thai, Chinese or Indonesian, but our appearance in the Thai news channel TNN24, the China News Service or the Indonesian Jawa Pos might. Similarly, where coverage in the English-language news actors The Guardian, The Huffington Post or The Daily Star plausibly caught the attention of those already aware of human-induced climate change, the more domestic-focused Le Parisien in French, la Repubblica in Italian or Correio Braziliense in Portuguese almost certainly brought climate change into new light among their readers. Additionally, we gave 80 presentations in five languages along the running route alone.*

Moreover, we have added a new 4<sup>th</sup> paragraph in Sect. 4, which discusses how our audiences differed among our communication forms. In this discussion, we referenced Schäfer et al. (2018) instead of Besley (2018) due to balance the already relative high number of studies from the U.S. with more from Europe, where a larger part of Pole to Paris took place. The paragraph reads:

*The nature of the Pole to Paris campaign allowed us to build an audience, which did not necessarily have a high interest in science nor necessarily a belief in climate change. This was purposefully done through several means: being on the road and therefore also meeting people who would not otherwise go to a talk about science on climate change; meeting university and school students of all grades and consequently discussing with students who often had barely heard of the science behind climate change; and finally, running and biking, which invited participants for the physical challenge that would stay over for the following talk on climate change and reached by a message they were not initially seeking. This point is also suggested by the number of the social media survey respondents indicating that they learned something new through and that got inspired by Pole to Paris (20*



*and 31 out of 37, respectively), which indicate that almost half of our followers already were literate on climate change issues but did not know what to do about it. Even though the knowledge and interest in science differ between sociodemographic groups, as suggested by Schäfer et al. (2018), we found that all our audiences had a similar interest in learning about practical actions and solutions they could put in place at a personal level.*

The reference is:

- Schäfer, M. S., Füchslin, T., Metag, J., Kristiansen, S., and Rauchfleisch, A.: The different audiences of science communication: A segmentation analysis of the Swiss population's perceptions of science and their information and media use patterns, *Public Underst. Sci.*, 27, 1–21, doi:10.1177/0963662517752886, 2018.

Finally, based on your suggestion, we have replaced the term “general public” with more specific terms for the meanings intended throughout the manuscript. The sentences, which they belong to, are reproduced here.

Excerpt of the Abstract:

*We share our experiences from the awareness campaign Pole to Paris, which engaged **non-academic audiences** on climate change issues on the roads from the polar regions to Paris and through conventional and social media.*

Excerpt of the 3<sup>rd</sup> paragraph in Sect. 3:

*This positive message of a younger generation working for an act on climate was the common theme for these three videos, which also included a more simply produced video on the motivation for why the main runner and cyclist left their offices in climate research to engage with the **society at large** (with almost 40,000 views and a reach of nearly 150,000).*

Excerpt of the 6<sup>th</sup> paragraph in Sect. 3:

*Moreover, more than half (**20 out of 37**) indicated that they learned something new through Pole to Paris, signalling the potential scientists have in bridging the gap between academia and the ~~[general]~~ public on fundamental societal issues.*

Excerpt of the 1<sup>st</sup> paragraph in Sect. 4:

***Both academic and non-academic members of society**, especially the younger ones, expressed their enthusiasm regarding the project.*

Excerpt of the 2<sup>nd</sup> paragraph in Sect. 5:

*The advancement of science **might be of little significance** if it is ignored by government as well as the **laypeople** and not suitably utilised by an educated society.*

Excerpt of the 3<sup>rd</sup> paragraph in Sect. 5:

*For scientists at the beginning of their academic career, we support the notion by **Leshner (2007), Brownell et al. (2013), Rauser et al. (2017) and Nisbet (2018)** that engaging in outreach activities helps shape the research questions, giving more effective tools for narrowing the widening gap between academia and the **rest of society**, and eventually providing a more constructive input for policy formulation on climate change.*

Breaking the filter bubbles

This paper makes an important observation about the need for scientists to engage in dialogue, especially face to face communication. These recommendations are aligned with a recent report by Matt Nisbet, for AAAS ([https://www.aaas.org/sites/default/files/s3fs-public/content\\_files/Scientists%2520in%2520Civic%2520Life\\_FINAL%2520INTERACTIVE%2520082718.pdf](https://www.aaas.org/sites/default/files/s3fs-public/content_files/Scientists%2520in%2520Civic%2520Life_FINAL%2520INTERACTIVE%2520082718.pdf)), which explains the need for scientists' engagement in civic life. Discussing this would also be valuable in the context of the role of scientists/science in society. However, I am not persuaded by the authors' assertion that their outreach efforts are the solution to climate change polarization, politicization, and the "post-truth" world. First, I think there needs to be stronger evidence of which audiences were reached in the campaign in order to make this claim. Secondly, I think these terms must be defined and explicated if they are to be used to generate recommendations for scientists. For example, what are the causes of politicization, and why do the authors think this particular outreach approach helped resolve it? Similarly, what are the causes of polarization (it is distinct from politicization), and do the authors think the campaign helped to overcome this? Why? How? Furthermore, due to the international nature of the campaign, it would be useful to understand how the effects of the outreach varied between different nations because politicization and polarization likely vary widely amongst the different nations included in the campaign.

Thank you for bringing our attention to the highly relevant work by Matt Nisbet. This is now included in the manuscript.

Excerpt of the 1<sup>st</sup> paragraph in Sect. 4:

*Engaging in two-way interaction with a range of audiences – from farmers to senators, from preschool children to retirees and from Norwegians to Bangladeshis – provided invaluable insight to our own research questions, as also highlighted by Nisbet (2018). Fortunate with these encounters, we faced questions and concerns often far from ours, which opened our eyes and ears and widened our perspectives. As reported by Nisbet (2018) and references therein, we improved our communication and listening skills and extended our professional and social network.*

Excerpt of the 2<sup>nd</sup> paragraph in Sect. 4:

*Moreover, fostering constructive public conversations about science and society can, among others, improve decision-making, promote trust and credibility in scientific findings and strengthen democratic processes (Wooden, 2006; Nisbet, 2018), ultimately counteracting politicization and polarization of science and post-factual movements, respectively.*

Excerpts of the last paragraph in Sect. 4:

*Passion united the team and contaminated our audiences, creating better dialogues in a positive feedback loop (Nisbet, 2018).*

*Most importantly, by meeting our audiences in running shoes, on a bicycle or over a beer, we connected as humans – critical to effective science engagement (Nisbet, 2018).*

Excerpt of the 3<sup>rd</sup> paragraph in Sect. 5:

*For scientists at the beginning of their academic career, we support the notion by Leshner (2007), Brownell et al. (2013), Rauser et al. (2017) and Nisbet (2018) that engaging in outreach activities helps shape the research questions, giving more effective tools for*

*narrowing the widening gap between academia and the rest of society, and eventually providing a more constructive input for policy formulation on climate change.*

The references to Nisbet (2018) is:

- Nisbet, M.: Scientists in civic life: facilitating dialogue-based communication, American Association for the Advancement of Science, [https://www.aaas.org/sites/default/files/s3fs-public/content\\_files/Scientists%2520in%2520Civic%2520Life\\_FINAL%2520INTERACTIVE%2520082718.pdf](https://www.aaas.org/sites/default/files/s3fs-public/content_files/Scientists%2520in%2520Civic%2520Life_FINAL%2520INTERACTIVE%2520082718.pdf), 2018.

For definitions and explications of polarization, politicization and a “post-truth” world, please see the Historical development of the climate scientist role above.

The 3<sup>rd</sup> and 4<sup>th</sup> paragraph in Sect. 4 discuss how we tried to overcome the polarization and politicization of climate change. Based on your suggestions, we have added some more information about how we did so. They now read:

*Consequently, we worked hard to keep our credibility as researchers (Nordhagen et al., 2014), not partnering with organizations or initiatives on either of the climate advocacy fringes, and not favouring one political party over another. Based on the feedback received, this scientific background and endeavour to remain objective allowed us to partner with organisations otherwise not within reach, like the United Nations Development Programme (UNDP) and the World Meteorological Organization. Following the definitions by Nordhagen et al. (2014), we experienced a boost in personal and public credibility, more than outweighing a loss in professional credibility from our publication record hiatus while on the road, thus overall enhancing our researcher credibility. By being open about what role we played in public, we strove to negotiate the tension between our professional and public credibilities discussed by Nordhagen et al. (2014), in which our goal of stronger climate action on governmental level to some degree was challenged by the common academic view that researchers should remain detached from public policies. We saw our role as awareness-raisers, increasing the understanding of climate science within all societal groups. Spanning the cultural differences within these groups, we tailored the message to the audiences in line with the suggestions by Somerville and Hassol (2011). These included framing climate change as a human and not only an environmental issue, focusing on the now instead of the decades ahead, leading with what we know, using a language adapted to a public discourse, being passionate, and connecting the dots between climate change and the personal experiences of the audience themselves.*

*The ten languages spoken by the highly international Pole to Paris group members helped in this way by allowing us to personally engage with a wide range of people on the roads from the polar regions to Paris. Besides, these language skills helped spread our messages even further, as suggested by the 62 % followers on Facebook speaking English, 16 % Indonesian, 6 % Norwegian, 4 % French, 3 % Spanish and 2 % German. Similarly, as suggested by Wooden (2006), the collaboration with local partner institutions (e.g., Gateway Antarctica in New Zealand, the Bjerknes Centre for Climate Research in Norway, the UK Youth Climate Coalition in the UK and Climate Generation in USA) offered experience for successful ways of science communication within each country. This collaboration also allowed us to organize what we called the Global Voices events with our partner UNDP. These were set up outside the routes of the Northern Run and Southern Cycle (Fig. 1),*



*during which youth came together to learn about climate change and how they could act upon it.*

### Renaming of title

Does the title clearly reflect the contents of the paper? No. As I explained, delving into a discussion about the “post-truth” era, polarization, and politicization requires much more explication and a different kind of data than what is provided here. I suggest renaming the paper.

We appreciate you sharing your opinions and recommendations on this matter, which we believe help us strengthen the manuscript. We have therefore tried to follow your suggestions as much as possible in the updated manuscript. Here, we tell the story of being young environmental scientists having tried to actively bridge what we see as a widening gap between science and populism, building on our experiences from Pole to Paris (the two authors ran about 2450 km and 750 km of the Northern Run in addition to backing other parts of the project, including the Southern Cycle) and other environmental awareness projects that we have been involved in.

In line with this, we have done several changes to the text, as explained above and highlighted in the updated manuscript. We have also changed the manuscript title to reflect this storyline, from “The role of climate scientists in the post-factual society” to “The role of climate scientists in the post-factual society: Reflections from the awareness campaign Pole to Paris”. With these changes, we hope and believe that the manuscript now tells a clearer story, in which we share our experiences to contribute to the scientific discussion on what role climate scientists should consider playing in the 21<sup>st</sup> century.

# The role of climate scientists in the post-factual society: Reflections from the awareness campaign Pole to Paris

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**Abstract.** The politicization of and societal debate on climate change science has increased over the last decades. Here, the authors argue that the role of climate scientists in our societies needs to adapt in accordance with this development. We share our experiences from the awareness campaign Pole to Paris, which engaged non-academic audiences on climate change issues on the roads from the polar regions to Paris and through conventional and social media. Based on these experiences, as well as those from other science communication initiatives, we suggest a way forward for climate scientists in the post-factual society.

**Slettet:** the general public

## 1 Background

The role of climate science in the public sphere has changed significantly since the mid-1980s. Ensuuing the formation of the Intergovernmental Panel on Climate Change (IPCC) and the U.S. Senate testimony of James Hansen in 1988, climate science has increasingly become a topic of political debate, media coverage and part of the daily discourse in our societies (Bolin, 2007; Ungar, 2016). Simultaneously, the scientific understanding of climate change has been rapidly expanding, with the number of climate change papers published per year exponentially growing (McSweeney, 2015) and the confidence in humans as the main cause of global warming has gone from insufficient to “extremely likely” (as defined by the IPCC First to Fifth Assessment Reports; Houghton et al., 1990; Stocker et al., 2013).

**Slettet:** Since

**Slettet:** With this development, it is, more than ever, crucial to establish dialogues with those outside academia in order to help trigger positive global changes (Barnosky et al., 2016).

A corresponding increase has neither been seen in climate change legislation (Townshend et al., 2013), media coverage of climate change topics (Boykoff et al., 2018) nor in public perception of climate change (Capstick, et al., 2015; Zhao et al., 2016; Saad, 2017). Instead, the politicization and polarization of climate change has been growing, with the former referring to how the science behind political decisions increasingly are promoted and attacked by advocates and opponents and the latter referring to the growing division between elites, organisations and political parties viewing climate change as a negative consequence of industrial capitalism and those opposing such views (McCright and Dunlap, 2011). This trend is arguably most notable in the U.S. (Capstick et al., 2015; Carmichael et al., 2017), where the partisan divide on environmental voting score (as defined by the League of Conservation Voters) grew from about 25 in 1970 to about 85 in 2015 (Dunlap et al., 2016). Since then, Donald Trump was elected as the country’s 45<sup>th</sup> president and has repeatedly been questioning climate science, actively

working against environmental legislation and funding of his predecessor and generally making the work of climate scientists more challenging (De Pryck and Gemenne, 2017; Alderman and Inwood, 2018; and references therein). A post-factual society has arisen, in which part of its members rather accept an argument based on their emotions and beliefs than one based on scientific facts (Leshner, 2007; Alvermann, 2017).

5 A post-factual political scene is not isolated to the U.S. alone; Brexit in the U.K. and the (re-)elections of Rodrigo Duterte in the Philippines, Andrzej Duda in Poland, Viktor Orbán in Hungary, Recep Tayyip Erdogan in Turkey and Jair Bolsonaro in Brazil are all examples of populist solutions trumping science-based ones (Postel-Vinay, 2017). Furthermore, the rise of social media has meant that everyone can act as journalists and editors in choosing what to post, where algorithms make sure to share posts from those with similar opinions, thus creating filter bubbles (Pariser, 2011; Alvermann, 2017; Bail, 2018). Conventional media can also reinforce filter bubbles by presenting scientific news within pre-existing worldviews of their audiences (Theel et al., 2013; Carmichael et al., 2017). Similar bubbles exist within academia, where scientists are trained to write for an already highly educated and specialized audience (Stiller-Reeve et al., 2016). Scientists are thus often seen as an elite without touch to the rest of society (Townson, 2016). For this reason, it is, more than ever, crucial to establish dialogues with those outside of academia in order to help trigger positive global changes (Leshner, 2007; Barnosky et al., 2016). Doing so, we, as scientists, need to choose our role within society carefully in consideration of the consequences for us individually and as a community (Pielke Jr., 2007; Vraga et al., 2018).

20 In this manuscript, we argue that the scientific community was not prepared for the intense politicization of climate change science (as defined by Zürn, 2014), which has occurred over the past several decades. However, we also contend that while climate polarization has reached new levels in the last few years (Dunlap et al., 2016), it is not too late for scientists to adapt to the highly charged political environment in which the very science of climate change is often discussed. Rapley and De Meyer (2014) argue that there is a gap between the role of the climate science community and the needs of society. As young environmental scientists having actively tried to bridge this gap, we here share our experiences from climate change awareness initiatives, discuss their pros and cons, and discuss possible ways forward for the climate science community in terms of its interaction with society at large.

## 2 Our initiative: Pole to Paris

30 In early 2015, the authors co-established the non-governmental organization Pole to Paris. The aim of the initiative was to raise awareness of the threats posed by climate change, to people on our path as well as those reached virtually. However, it separated itself from most climate outreach actions by attempting to highlight the human-induced consequences of climate change rather than focusing on the pure scientific facts that underpin the reality of Earth's dynamic climate system. Following the unexpected collapse of the 15<sup>th</sup> Conference of the Parties (COP 15) to the United Nations Framework Convention on Climate Change (UNFCCC) in Copenhagen in 2009, the 2015 21<sup>st</sup> COP (COP 21) in Paris was regarded by many in the

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scientific, political and civil society communities as the last opportunity to begin to tackle climate change as a global community. (Bäckstrand and Lövbrand, 2016; de Moor, 2017). Thus, the Pole to Paris project was purposefully timed, ahead and leading to COP 21, in an attempt to galvanise support for a new global agreement in our wide society, as public awareness of climate change in a country is positively related to the unconditional climate mitigation targets of that country, as later suggested by Drummond et al. (2018).

- Slettet: and
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- Slettet: agreement, the Pole to Paris project was purposefully timed to lead on...
- Slettet: road ending in Paris.

The Pole to Paris project focused on reshaping the way scientists engage with the public on climate change issues. The nature of the problem – being a long-term process on a planetary scale – makes it difficult for individuals to grasp and engage with. In an attempt to remove this abstractness, we, as scientists, decided to hit the road in order to share climate science knowledge with people on the ground as well as collect their stories of experienced changes to share them through our platforms. Two journeys from the poles were mapped out: the 10,000-km long bicycle ride – the Southern Cycle – from Christchurch (New Zealand) and the 3,000-km long run – the Northern Run – from Tromsø (Norway), both finishing in Paris during COP 21 (Fig. 1). These journeys were led by two climate scientists, who left Christchurch and Tromsø shortly after completing their PhDs in Antarctic and Arctic climate change, respectively. 7.5 and 4 months later, respectively, they reached Paris. They were supported by the eight other Pole to Paris team members, whose backgrounds ranged from environmental and political science to web and product design. While all members actively contributed to Pole to Paris by various means from their locations around the world, five of them also joined the main cyclist and runner for part of the journeys. Of the ten team members, only the main cyclist and runner were working full-time on the project (i.e., without getting paid), while the others had studies or jobs to balance simultaneously. Whereas we were all in our 20s, the four female and six male team members represented eight different countries.

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The public were invited to get behind the Southern Cycle and Northern Run journeys and actively become engaged in the climate dialogue in real time. The adventure component also helped to attract media attention, giving the project a platform to communicate the facts about climate change and the importance of COP 21 to the wider audience by engaging them in the journeys. Crucially, along the way, we held talks in schools, universities and many other public venues and were joined by other cyclists and runners for part of the distances. This created a two-way communication, in which we openly engaged the public to hear their perspectives and concerns about climate change before respectively responding to them, as suggested by Leshner (2003). We collaborated with our partners to create events, and we shared stories from the road through conventional and social media. This provided a unique opportunity to interact with members of society not usually reached by the scientific discourse. In line with O'Neill and Nicholson-Cole (2009) and Stoknes (2015), we highlighted the opportunities and inspiration of acting on climate change now rather than later. We communicated the ongoing and expected consequences of climate change, but in terms of relevant and experienced changes rather than fear rising from their cognitive dissonance following Extended Parallel Processing Model theory (Witte, 1992).

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A conservative estimation is that more than one million people in 45 countries were reached through conventional and social media, which included close to 250 media outlets and almost 500,000 and 250,000 reached per Facebook post and Twitter tweet, respectively. While it is probable that some of our followers on Facebook, Twitter and Instagram overlapped, the breadth of conventional media coverage meant that we were able to reach a wider span of the society. For example, our story was featured five times on CNN in English, Spanish and Arabic, while Norwegian Broadcasting Corporation aired us 14 times. None of these are likely to be seen by the average Thai, Chinese or Indonesian, but our appearance in the Thai news channel TNN24, the China News Service or the Indonesian Jawa Pos might. Similarly, where coverage in the English-language news actors The Guardian, The Huffington Post or The Daily Star plausibly caught the attention of those already aware of human-induced climate change, the more domestic-focused Le Parisien in French, la Repubblica in Italian or Correio Braziliense in Portuguese almost certainly brought climate change into new light among their readers. Additionally, we gave 80 presentations in five languages along the running route alone.

**Sieltet:** (e.g., airing on CNN and TNN Thailand 24 and published in The Guardian and National Geographic) and almost 500,000 and 250,000 reached per Facebook post and Twitter tweet, respectively

### 3 Direct successes

Looking into the numbers from social media in more detail, the authors in 2018 conducted a statistical analysis on the reach of the videos created by Pole to Paris and shared through Facebook. These videos spanned from 20 seconds to 6 minutes in length and showcased the life on the road from the Poles to Paris (i.e., challenges and joys of the run and bike ride), the various impacts associated with climate change along the way (e.g., coral bleaching in Australia from raising CO2 levels and temperature, air pollution in China from carbon-intensive coal use, and glacial melt in Antarctica, Norway, and the European Alps from shifting precipitation patterns and increasing summer temperatures), and on the importance of climate action at COP 21 and home. Of the total of 42 videos, we focused the analysis on the 32 in the most active period from June to December 2015. Figure 2 shows some of its key results.

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Of the 226 346 total video views after three seconds, 56 130 (25 %) were still there after 30 seconds and 16 703 (7 %) at 95 % of the video length (Fig. 2a). Of these views, 89 % (after three seconds) to 97 % (at 95 % of the video length) were unique (not shown), meaning that almost all videos were watched once. Similarly, the organic viewers (as compared to the ones reached through ads) were more enduring, accounting for 74 % of the views at 95 % video length compared to 58 % after three seconds (Fig. 2a). Sorted by topic, the climate action videos were on average by far the most popular, making up 82-87 % of the watched videos at the three video lengths (Fig. 2b). In comparison, the videos on the effects of climate change became relatively less popular over the length of the videos, comprising 11 % after three seconds and 8 % at their 95 % length. This contrasts the videos on the journeys themselves, which correspondingly rose from 6 % to 11 % of watched videos at the respective times.

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The three most popular videos were thus, unsurprisingly, videos that promoted action on climate change through hopeful messages. The by far most popular video (with more than 100,000 views and a reach of nearly 500,000) focused how young



inhabitants of Southern Pacific islands feel the effects of climate change through ongoing rising sea levels and get together to fight against it. This positive message of a younger generation working for an act on climate was the common theme for these three videos, which also included a more simply produced video on the motivation for why the main runner and cyclist left their offices in climate research to engage with the society at large (with almost 40,000 views and a reach of nearly 150,000).

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5 Out of our social media followers (more than 6,200 on Facebook, 1,200 on Twitter and 650 on Instagram), most of the Facebook ones were in the age group 25-34. This is perhaps explained by the fact that we were ourselves a team of millennials. Possibly more interestingly, the second largest group of followers was made of Generation Z (people born in the mid-1990s to the mid-2000s), pointing to the added reach of social media compared to other science communication tools, as also pointed out by Bowman et al. (2015).

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10 Generally, the later videos in the analysis period were more popular, also pointing to the increasing reach of Pole to Paris as the awareness project gained traction with kilometres covered, events held along the way, and mentions in the media. Even when the project reduced its activity after COP 21, the influence was still there, as exemplified by reaches of more than 100,000 on the less frequent Facebook posts in early 2016.

15 Correspondingly, while not posting regularly anymore, the authors were still able to reach some of Pole to Paris' followers via our still active social media channels with a survey in 2018. The survey asked a range of questions. These included whether respondents followed Pole to Paris online, whether they learned anything new as a result of Pole to Paris, whether they found Pole to Paris to be a source of inspiration. Interestingly, one of the key findings was that respondents were fairly evenly split on what they considered to be the most interesting aspects of the project. Several of the 37 respondents highlighted more than 20 one aspect, with 14 answers favouring the actual journeys from the Poles to Paris, 16 the same for the physical challenge of running and biking, 18 the scientific message on climate change, and 17 the human face that Pole to Paris put on climate change through stories from the ground.

25 In line with the statistical analysis of the Facebook videos, the fact that the scientific message was seen more interesting than the journeys themselves, indicates that a project like Pole to Paris can find success in disseminating scientific information to a wider audience. Among other key findings from the survey, 31 out of 37 respondents reported that Pole to Paris inspired them in some way. This is also a strong indicator that unconventional projects in the vein of Pole to Paris can find success in connecting with non-scientific audiences in positive ways. Moreover, more than half (20 out of 37) indicated that they learned something new through Pole to Paris, signalling the potential scientists have in bridging the gap between academia and the public on fundamental societal issues.

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Interpreting these numbers, one should keep in mind that the survey respondents already were followers of the climate awareness project Pole to Paris and thus not necessarily representative of the average population. The three-year lag of this 35 feedback to the project compared to its most active period also introduce some uncertainty of remembrance and probably

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explain why less than 1 % of our social media followers responded to the survey. This small respondent rate meant that the answers not necessarily represented those of a typical follower. Moreover, the time passed since their publications limited the statistical analysis here to Facebook videos, as other social media data no longer were available. Even so, we believe the numbers presented in this manuscript offer valuable insight on the worthiness of time spent on Pole to Paris and can help the outreach community in learning from our efforts.

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#### 4 Indirect successes

As also mentioned by Barnosky et al. (2014), the direct success of an initiative like Pole to Paris is almost impossible to quantify. Indirectly, the Pole to Paris team members took great value from being able to share climate science with our audiences and listen to their experiences of climate change. Engaging in two-way interaction with a range of audiences – from farmers to senators, from preschool children to retirees and from Norwegians to Bangladeshis – provided invaluable insight to our own research questions, as also highlighted by Nisbet (2018). Fortunate with these encounters, we faced questions and concerns often far from ours, which opened our eyes and ears and widened our perspectives. As reported by Nisbet (2018) and references therein, we improved our communication and listening skills and extended our professional and social network. Both academic and non-academic members of society, especially the younger ones, expressed their enthusiasm regarding the project. Both shared how it inspired them to find the courage needed to make changes in their own lives. The Paris Agreement, of which Pole to Paris was one of numerous initiatives building public support for, was arguably a better outcome of COP21 than the climate science community could have hoped for and, as later similarly suggested by Drummond et al. (2018), might have been influenced by that awareness raised among people.

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Schimid and Petri (2017) have argued that those in the scientific community who actively attempt to communicate the seriousness of climate change to a wide audience often are met with attempts "to discredit their scientific credibility, or to criticize the studies that are used or their underlying methods and models." As communicators of the scientific consensus, we inevitably experienced these tactics from climate sceptics in online fora. Mostly, the criticisms were from individual citizens and directed at us personally. Out on the roads to Paris, however, fact-based messaging was highly welcomed. Meeting people where they are, in their own communities, communicating with them in their own terms, constantly trying to adapt our language to our audience, undeniably contributed to this. Considering the politicized division of the media themselves (e.g., Brüggemann and Engesser, 2017), this positive experience of direct engagement supports the suggestion by Gauchat et al. (2017) that science participation and outreach could rebuild the credibility among communities most critical of scientists. Moreover, fostering constructive public conversations about science and society can, among others, improve decision-making, promote trust and credibility in scientific findings and strengthen democratic processes (Wooden, 2006; Nisbet, 2018), ultimately counteracting politicization and polarization of science and post-factual movements, respectively.

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5 Consequently, we worked hard to keep our credibility as researchers (Nordhagen et al., 2014), not partnering with organizations or initiatives on either of the climate advocacy fringes, and not favouring one political party over another. Based on the feedback received, this scientific background and endeavour to remain objective allowed us to partner with organisations otherwise not within reach, like the United Nations Development Programme (UNDP) and the World Meteorological Organization. Following the definitions by Nordhagen et al. (2014), we experienced a boost in personal and public credibility, more than outweighing a loss in professional credibility from our publication record hiatus while on the road, thus overall enhancing our researcher credibility. By being open about what role we played in public, we strove to negotiate the tension between our professional and public credibilities discussed by Nordhagen et al. (2014), in which our goal of stronger climate action on governmental level to some degree was challenged by the common academic view that researchers should remain detached from public policies. We saw our role as awareness-raisers, increasing the understanding of climate science within all societal groups. Spanning the cultural differences within these groups, we tailored the message to the audiences in line with the suggestions by Somerville and Hassol (2011). These included framing climate change as a human and not only an environmental issue, focusing on the now instead of the decades ahead, leading with what we know, using a language adapted to a public discourse, being passionate, and connecting the dots between climate change and the personal experiences of the audience themselves.

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20 The nature of the Pole to Paris campaign allowed us to build an audience, which did not necessarily have a high interest in science nor necessarily a belief in climate change. This was purposefully done through several means: being on the road and therefore also meeting people who would not otherwise go to a talk about science on climate change; meeting university and school students of all grades and consequently discussing with students who often had barely heard of the science behind climate change; and finally, running and biking, which invited participants for the physical challenge that would stay over for the following talk on climate change and reached by a message they were not initially seeking. This point is also suggested by the number of the social media survey respondents indicating that they learned something new through and that got inspired by Pole to Paris (20 and 31 out of 37, respectively), which indicate that almost half of our followers already were literate on climate change issues but did not know what to do about it. Even though the knowledge and interest in science differ between sociodemographic groups, as suggested by Schäfer et al. (2018), we found that all our audiences had a similar interest in learning about practical actions and solutions they could put in place at a personal level.

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30 The ten languages spoken by the highly international Pole to Paris group members helped in this way by allowing us to personally engage with a wide range of people on the roads from the polar regions to Paris. Besides, these language skills helped spread our messages even further, as suggested by the 62 % followers on Facebook speaking English, 16 % Indonesian, 6 % Norwegian, 4 % French, 3 % Spanish and 2 % German. Similarly, as suggested by Wooden (2006), the collaboration with local partner institutions (e.g., Gateway Antarctica in New Zealand, the Bjerknes Centre for Climate Research in Norway, the UK Youth Climate Coalition in the UK and Climate Generation in USA) offered experience for successful ways of science communication within each country. This collaboration also allowed us to organize what we called the Global Voices events

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with our partner UNDP. These were set up outside the routes of the Northern Run and Southern Cycle (Fig. 1), during which youth came together to learn about climate change and how they could act upon it.

The experiences from Pole to Paris were, however, not unique. Other initiatives have been launched over the last few years to increase climate change awareness and train scientists in more effective science communication. We were some of the 1.07 million people globally to take part in March for Science April 22, 2017. The series of rallies and marches defending the vital role science plays in our everyday lives was a direct result of the opposing direction on science policy taken by the current administration in the White House compared with its predecessor. However, March for Science has also been criticized, as it runs the risk of creating a false picture of scientists being more driven by ideology than evidence (Nature supports the March for Science, 2017).

Furthermore, the authors have been involved in other more or less politically charged outreach projects. For instance, Climate Communication Cologne is an effort launched at the University of Cologne whose main objective is to facilitate science communication to a wide non-academic audience. This takes place in various forms, such as workshops, stand-up comedy or videos, and in various arenas, from schools and universities to pubs and online communities. Another example is Will You Hear Us, a documentary on the tradition of caged birds in Indonesia, which has become unsustainable due to the ever-increasing demand for wild songbirds and poses a huge threat on biodiversity. Both authors are currently also writing comic books on climate change adaptation and mitigation and on biodiversity loss for high-school and elementary school students, respectively.

Common for all these initiatives is the eagerness to communicate science in ways that engage the layperson. To help us – and the reader of this manuscript – learn from our efforts, we ideally would have set up a more standardized feedback scheme for our audiences during the active period of Pole to Paris. The feedback we did receive – in personal conversations and in online commentary fora – were most likely anomalously positive and negative, respectively. We could surely also have benefitted from more planning before undertaking these journeys, but this might have compromised the journeys themselves. Being the only two fully “working” (i.e., without getting paid) on the project, the two climate scientists of Pole to Paris – the lead cyclist and runner – had just completed their PhDs before taking on the journeys, while the other eight in the team had full time commitments to studies or employers to balance, which did not provide much room for further planning. This, along with the widely varying time zones the team members were based in and often lack of internet accessibility out on the Southern Cycle and Northern Run, meant that team meetings were less regular than what would have been ideal for making sure we were all pulling in the same direction.

Passion united the team and contaminated our various audiences, creating better dialogues in a positive feedback loop (Nisbet, 2018). We cycled and ran out with rough plans and adapted along the way as engagement created opportunities (e.g., the Global Voices events and United Nations program partnerships) or disasters imposed limitations (e.g., the Nepal earthquake and Paris terror attacks). Similarly, even though we had scientific and communicational training to start with, we learned a lot

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by doing. Most importantly, by meeting our audiences in running shoes, on a bicycle or over a beer, we connected as humans, which is critical for effective science engagement (Nisbet, 2018). While we strongly acknowledge the need for publishing research papers to further develop scientific questions, we emphasize that the findings thereof are incomplete if not shared with the society at large.

## 5 5 An adapted scientist

Based on these experiences, we identified some key components for successful science communication with non-academic audiences:

- 10 - Relevance  
Make sure your message is relevant to your audience and engage with them in familiar setting, with a familiar format and through a familiar language.  
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- Listening  
Let the audience ask questions and put forward their understanding.  
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- Positivity  
Smile and try to focus on the possibilities rather than the doomsday.  
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- 15 - Perseverance  
Learn by doing; all experiences are valuable.  
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- Passion  
Knowledge of the topic is the door to communicating science, passion for it the key.  
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**Formater:** Innrykk: Venstre: 1,27 cm, Ingen punktmerking eller nummerering
- 20 In our current society, we argue that the role of the 'pure scientist' (as defined by Rapley and De Meyer, 2014) is outdated and the need of the 'science communicator' and 'the honest broker of policy alternatives' (as outlined by Pielke Jr., 2007) is rising. The advancement of science might be of little significance if it is ignored by government as well as the Jaypeople and not suitably utilised by an educated society. Publishing an academic paper is unfinished business. As Barnosky et al. (2014) argue, it is only the beginning if our aim is to help society solve problems. However, current training of becoming scientists is not  
**Slettet:** 'pure scientist'  
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- 25 fulfilling the current need of society for clear science communication and policy engagement (Leshner, 2007). Thus, we argue that more emphasis should be put on communication and media, policymaker and pseudoscepticism interaction training and less on the published record.  
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- 30 For scientists at the beginning of their academic career, we support the notion by Leshner (2007), Brownell et al. (2013), Rauser et al. (2017) and Nisbet (2018) that engaging in outreach activities help shape the research questions, giving more effective tools for narrowing the widening gap between academia and the rest of society, and eventually providing a more constructive input for policy formulation on climate change. As we see it, this will act to reduce politicization and polarization of climate change, while also depressing the breeding ground for post-factual movements. Within academia, outreach training  
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gives us better tools in teaching, mentoring of younger students and taking part in scientific discussions, as well as contributing to better written research proposals and journal publications (Stiller-Reeve et al., 2016, and references therein).

5 Whether we like it or not, climate science and scientists have become part of the daily political and media discourse. Now it is up to us to adapt and play our new role objectively while keeping our credibility, (as discussed by Nordhagen et al., 2014). According to Rapley and De Meyer (2014), this has the potential to remove climate science from the direct firing line to leave the authority, responsibility and accountability for decisions transparently with the policymakers and the public. When done carefully, we have the potential, regardless of audience's political predilection, to provide trustworthy information to the climate change discourse (Leshner, 2003; MacInnis et al., 2015; Hamilton, 2016). To prepare us for such a "wicked" problem  
10 (as defined by Lorenzoni et al., 2007), we argue that communication training with actors beyond academia is indispensable.

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#### Author contributions

EMK led the design and writing of the manuscript and carried out the statistical analysis. OJdB helped writing and designed the social media survey.

#### Competing interests

15 The authors declare that they have no conflict of interest.

#### Acknowledgements

We would like to thank the whole Pole to Paris team and everyone we encountered along the way. We also acknowledge the support from the Transregional Collaborative Research Center (TR 172) "Arctic Amplification: Climate Relevant Atmospheric and Surface Processes, and Feedback Mechanisms (AC3)", which is funded and by the German Research  
20 Foundation (Deutsche Forschungsgemeinschaft; DFG) and allowed EMK to write about our experiences for the benefit of science communicators globally.

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**Slottet:** Positive Engagement With Climate Change Through Visual...

**Slottet:** Iconic Representations

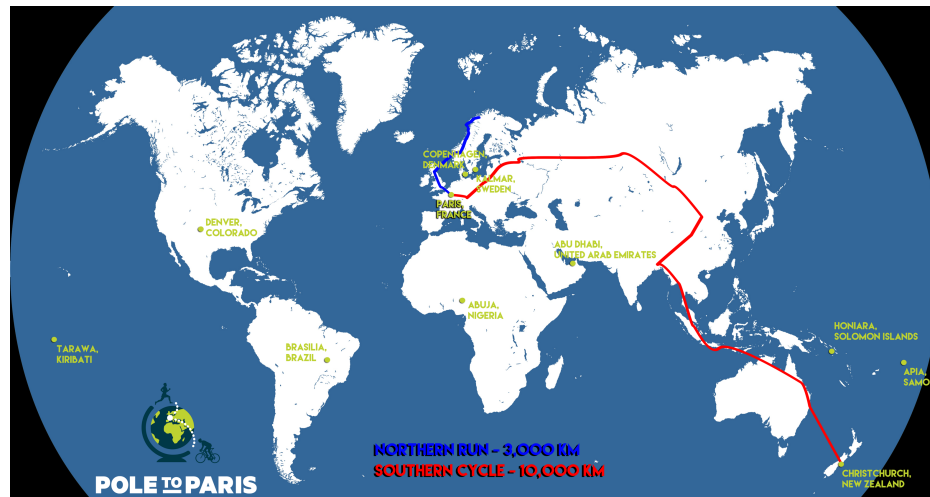
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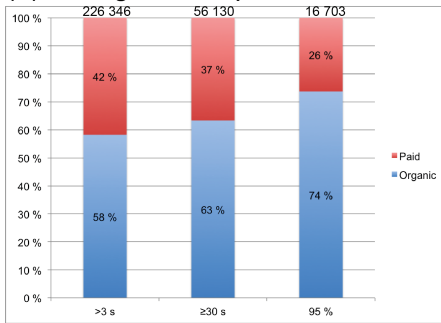
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10 Figure 1: Map of the two Pole to Paris journeys: the Northern Run (blue trajectory) and the Southern Cycle (red trajectory); as well as the Global Voices events organized in collaboration with partners (green dots).



(a) All organic vs. paid views



(b) Average topical views

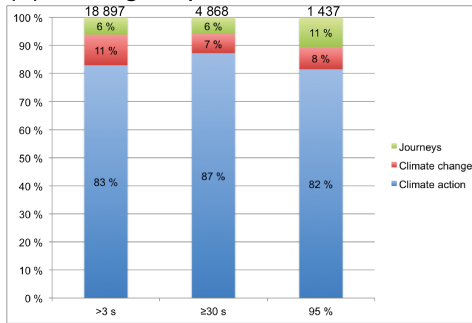


Figure 2: Percentages of total Facebook video views after three seconds (>3 s), at 30 seconds (or to the end, whichever came first; ≥30 s), and at 95 % of the video length (including people that skipped to this point; 95 %) for (a) organic (i.e., not paid; blue columns) and paid (red columns) views and (b) videos on climate action (blue columns), climate change (red columns) and the journeys themselves (green columns). Numbers above the columns in (a) and (b) represent total and average views, respectively.

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