Multi-agent modelling of climate change denial spread

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Abstract

As technology and modern solutions for many issues progress, efforts can still be hindered by some phenomena that exist on a societal level. A prominent example is climate change denial, where individuals reject the scientific consensus about the reality of global warming and extreme weather anomalies, claiming that it is not a problem or that human activities have not induced it. To analyze the mechanisms of spread of climate change denial, we developed a simple framework based on belief changes and implemented it as an agent-based simulation in NetLogo. The results indicate that modifying the social and media-related trust parameters helps to reduce climate change denial in artificial populations. Furthermore, facilitating greater access to and acceptance of dissimilar views could counteract the polarisation of opinions on climate change in societies, allowing for more dynamic and productive discussions.

1 Introduction

One of the major obstacles leading to inaction and only minor improvements in climate change mitigation is climate change denial. This phenomenon is driven by misinformation, conspiracy theories, and politicization of the issue (Dunlap and Jacques, 2013; Leiserowitz et al., 2021; Forchtner, 2019; Treen et al., 2022). Becoming a climate change denier and dismissing the scientific consensus is not just an intellectual decision: it involves a variety of emotions, one's identity, political views, experiences, and social influences. The resulting polarization of societies leads to conflicts, pessimism, and hindered progress (Andre et al., 2024).

Nowadays, the spread of climate change denial is primarily fueled by the availability of misinformation on various media platforms (Falkenberg et al., 2022). By interacting with filtered information, those who are skeptical of climate change become further entrenched in their views, making it increasingly difficult to change minds or encourage constructive discussions. Additionally, corporate and political interests play a role in sustaining denial, as industries reliant on fossil fuels benefit from delaying environmental regulations and policy changes (Forchtner, 2019).

The topics of belief change, false belief spread and specifically, climate change beliefs have been explored in the literature of computational modelling (Baltag and Smets, 2006; Olsson and Galesic, 2024; Kopp et al., 2018; Altoe et al., 2024; O'Connor and Weatherall, 2021). Authors decide to focus on a particular angle of the issue, allowing us to explore the angle in detail. For some of the notable works, Kapeller and Jäger (2020); Kapeller et al. (2019) presented a model to analyse how anxiety and concern can trigger pro-environmental behaviors, Janssen and De Vries (1998) incorporated management styles and their effects on pro-climate behaviors, while Baldauf et al. (2020) predicted real estate prices related to climate change risks and beliefs of the neighborhood inhabitants. In this project, we aimed to create a more general, simple framework based on trust factors.

2 Methods

Many factors influence climate change beliefs. The project is based on the idea that trust in different sources of information and openness to them influence climate change beliefs. For simplicity, we model the overall belief in climate change as a single continuous value ranging from 0 (denial attitude) to 1 (pro-climate attitude). In our hypothesis, a person's overall belief in climate change (B in Equation 1) is shaped by several factors to a different degree (the letters in the parentheses are parameters expressing the strength of influence of each factor): trust in one's own belief (t), trust in other people's beliefs (o), trust in media—both pro-climate with a more activist approach (p) and denialist media with a dismissive approach (d), see Equation 1. An individual can be influenced by beliefs of people with whom they have formed connections (links), further mediated by openness to dissimilar opinions (modeled as threshold-based zeroing of the influence if the belief is too dissimilar). The overall formula for updating the climate change belief expresses the belief in the next time step as a linear combination of the above mentioned factors weighted by fuzzy parameters (t,o,p,d), each with a range of 0–1:

$$B := t * B + o * links + p * 1 + d * 0 \qquad (1)$$

We have used the NetLogo (Wilensky, 1999) platform for our simulations. The environment for observing belief-spreading dynamics was a population of 100 agents (people). We modelled the initial distribution of beliefs in the population by sampling from normal distribution characterized by the mean initial belief and the standard deviation of the population's beliefs. Based on literature research, the average initial belief was set to 0.7, as in most societies, 60–90% of people believe in climate change (Leiserowitz et al., 2021; UNDP, 2024; Vlasceanu et al., 2024; on Climate Change Communication, 2023). The changing distribution of beliefs was visualized on the display, as the agents were assigned colors based on their state, from dark orange for denial to dark green for full belief (see Figure 1). The NetLogo interface also allowed for monitoring the count of agents with different colors (opinions), the average belief and its standard deviation in the population, and the changes throughout time.

First, a basic analysis of all parameters was run, with experiments adjusting the values to a minimal, moderate, and maximal value (OAT method). Based on that, further experiments with finer adjustments (increments of 0.1 from 0 to 1 to sample each parameter's range) were conducted for the most influential parameters (trust_others, trust_proclimate_media, trust_denial_media, accept_states_distance_others, accept_states_distance_media). Moreover, scenarios resembling situations in the real world were translated into the model's parameters to see what the outcomes were and how they could inform suggestions for climate change communication and climate change denial reduction. The scenarios included the following situations: an information vacuum, an echo chamber with pro-climate dominance and with a denial dominance, a balanced debate, a tight-knit value-driven community scenario, a current general trend and a full openness to different opinions.

The code for the model is available at `https://www.comses.net/codebases/6ea81a36-4341-447e-a152-89d4b6bebeae/releases/1.0.0/`.

3 Results

The results suggest that paying particular attention to factors related to trust in others, specific media sources, and openness to dissimilar opinions could help reduce climate change denial and polarization. Higher trust in others in populations with already high belief, lower trust in denialist media, higher trust in pro-climate media, and receptiveness to other people's opinions can increase the average belief in climate change and eliminate extreme denialism. A more detailed report will be in our prepared journal publication.

4 Discussion

Even with this simple framework, the findings highlight the importance of fostering trust in credible information sources and encouraging open discussions. Combating misinformation, promoting scientific literacy, and creating spaces for constructive dialogue could help bridge the gap between differing points of view. If societies prioritize trust and informed decision making, it may be possible to reduce polarization and accelerate progress toward meaningful climate action.

To achieve the desired outcomes, the suggested strategies to implement and encourage in policy makers and social media platforms could be educational campaigns on media literacy and changes in social media algorithms. Improving media literacy can help reduce the influence of misinformation (Lewandowsky et al., 2012). Prioritizing trust in credible sources and informed decision-making could reduce polarization, leading to faster and more effective climate action (van der Linden et al., 2015).

References

Altoe, F., Moreira, C., Pinto, H. S., and Jorge, J. A. (2024). Online fake news opinion spread and belief change: A systematic review. *Human Behavior and Emerging Technologies*, 1:2024.

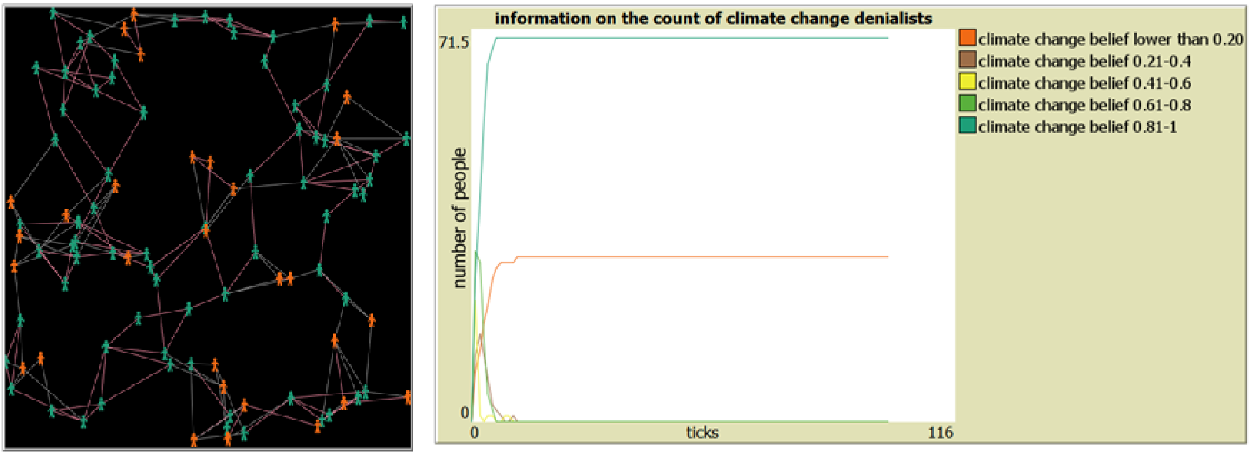
Andre, P., Boneva, T., Chopra, F., and Falk, A. (2024). Globally representative evidence on the actual and perceived support for climate action. *Nature Climate Change*, 14(3):253–259.

Baldauf, M., Garlappi, L., and Yannelis, C. (2020). Does climate change affect real estate prices? only if you believe in it. *The Review of Financial Studies*, 33(3):1256–1295.

Baltag, A. and Smets, S. (2006). Dynamic belief revision over multi-agent plausibility models. *In Proceedings of LOFT, vol. 6*, pages 11–24.

Dunlap, R. E. and Jacques, P. J. (2013). Climate change denial books and conservative think tanks: Exploring the connection. *American Behavioral Scientist*, 57(6):699–731.

Falkenberg, M., Galeazzi, A., Torricelli, M., Di Marco, N., Larosa, F., Sas, M., and Baronchelli, A. (2022).



Obr. 1: An example of the simulation display showing a polarized population.

Growing polarization around climate change on social media. *Nature Climate Change*, 12(12):1114–1121.

Forchtner, B. (2019). Climate change and the far right. *Wiley Interdisciplinary Reviews: Climate Change*, 10(5):e604.

Janssen, M. and De Vries, B. (1998). The battle of perspectives: a multi-agent model with adaptive responses to climate change. *Ecological Economics*, 26(1):43–65.

Kapeller, M. L. and Jäger, G. (2020). Threat and anxiety in the climate debate—an agent-based model to investigate climate scepticism and pro-environmental behaviour. *Sustainability*, 12(5):1823.

Kapeller, M. L., Jäger, G., and Füllsack, M. (2019). Social norms and the threat of climate change: An agent-based model to investigate pro-environmental behaviour. *Conference of the European Social Simulation Association*, pages 445–457.

Kopp, C., Korb, K. B., and Mills, B. I. (2018). Information-theoretic models of deception: Modelling cooperation and diffusion in populations exposed to "fake news". *PloS One*, 13(11):e0207383.

Leiserowitz, A., Roser-Renouf, C., Marlon, J., and Maibach, E. (2021). Global warming's six americas: a review and recommendations for climate change communication. *Current Opinion in Behavioral Sciences*, 42:97–103.

Lewandowsky, S., Ecker, U. K. H., Seifert, C. M., Schwarz, N., and Cook, J. (2012). Misinformation and its correction: Continued influence and successful debiasing. *Psychological Science in the Public Interest*, 13(3):106–131.

O'Connor, C. and Weatherall, J. O. (2021). Modeling how false beliefs spread. *The Routledge Handbook of Political Epistemology*, pages 203–213.

Olsson, H. and Galesic, M. (2024). Analogies for modeling belief dynamics. *Trends in Cognitive Sciences*.

on Climate Change Communication, Y. P. (2023). Yale climate opinion maps 2023. `https://climatecommunication.yale.edu/visualizations-data/ycom-us/`. Archived at: `https://web.archive.org/web/20250228102818/`.

Treen, K., Williams, H., O'Neill, S., and Coan, T. G. (2022). Discussion of climate change on reddit: Polarized discourse or deliberative debate? *Environmental Communication*, 16(5):680–698.

UNDP (2024). People's climate vote. `https://peoplesclimate.vote/`. Archived at: `https://web.archive.org/web/20250228103359/https://peoplesclimate.vote/`.

van der Linden, S., Leiserowitz, A., Feinberg, G. D., and Maibach, E. (2015). The scientific consensus on climate change as a gateway belief: Experimental evidence. *PLOS ONE*, 10(2):e0118489.

Vlasceanu, M., Doell, K. C., Bak-Coleman, J. B., Todorova, B., Berkebile-Weinberg, M. M., Grayson, S. J., and Lutz, A. E. (2024). Addressing climate change with behavioral science: A global intervention tournament in 63 countries. *Science advances*, 10(6):eadj5778.

Wilensky, U. (1999). Netlogo. Center for Connected Learning and Computer-Based Modeling, Northwestern University. Evanston, IL. `http://ccl.northwestern.edu/netlogo/`.