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THE EVOLUTION OF POLARIZATION IN TWITTER DEBATES: THE CASES OF U.S. PRESIDENTIAL ELECTION AND CLIMATE CHANGE

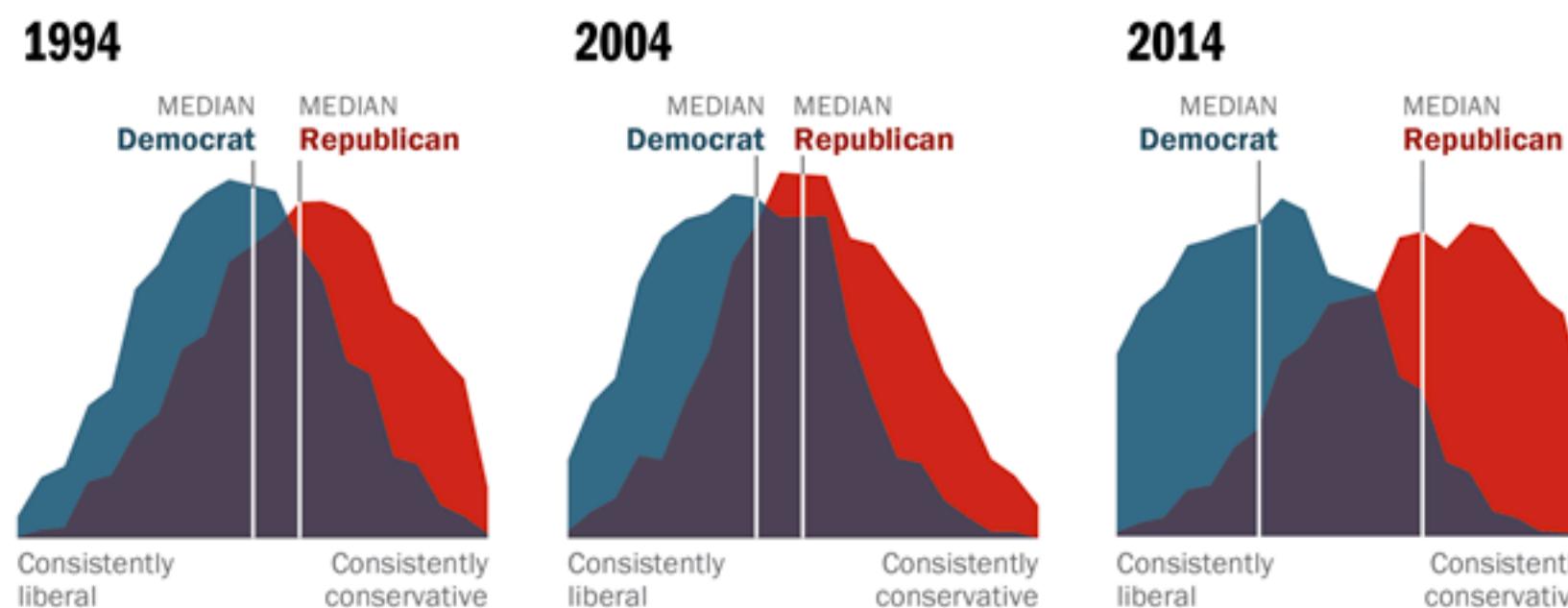
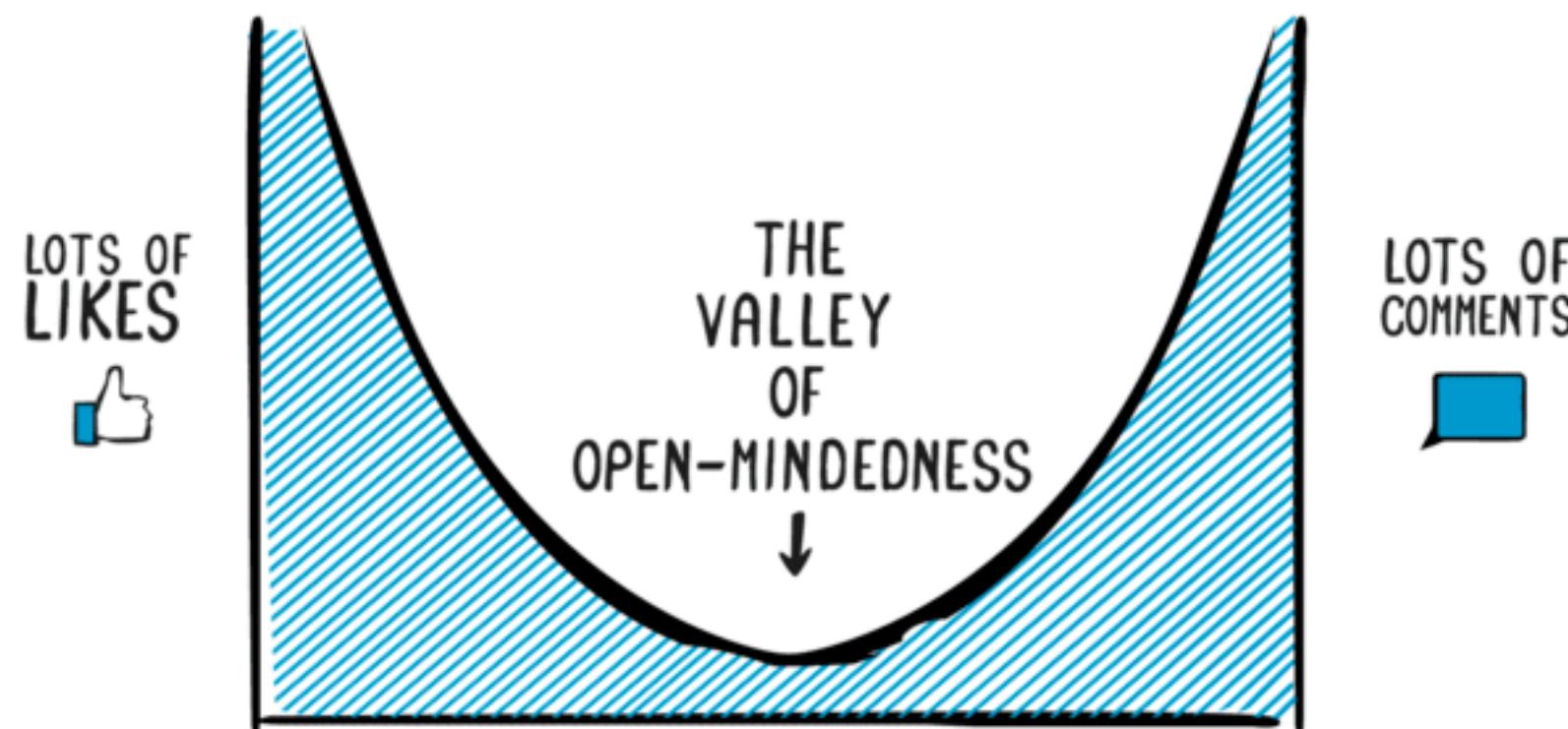
RECENT WORKS

- ▶ **Political polarization of news media and influencers on Twitter in the 2016 and 2020 US presidential elections.**
Flamino, J., Galeazzi, A., Feldman, S., Macy, M. W., Cross, B., Zhou, Z., ... & Szymanski, B. K. (2023). *Nature Human Behaviour*, 1-13.
- ▶ **Growing polarization around climate change on social media.**
Falkenberg, M., Galeazzi, A., Torricelli, M., Di Marco, N., Larosa, F., Sas, M., ... & Baronchelli, A. (2022). *Nature Climate Change*, 1-8.
- ▶ **Unveiling the Hidden Agenda: Biases in News Reporting and Consumption.**
Galeazzi, A., Peruzzi, A., Brugnoli, E., Delmastro, M., & Zollo, F. (2023). Under review at *Proceeding of the National Academy of Science*
- ▶ **Analyzing the Changing Landscape of the Covid-19 Vaccine Debate on Twitter.**
Santoro, A., Galeazzi, A., Scantamburlo, T., Baronchelli, A., Quattrociocchi, W., & Zollo, F. (2023). Under review at *Social Network Analysis and Mining*

INTRODUCTION

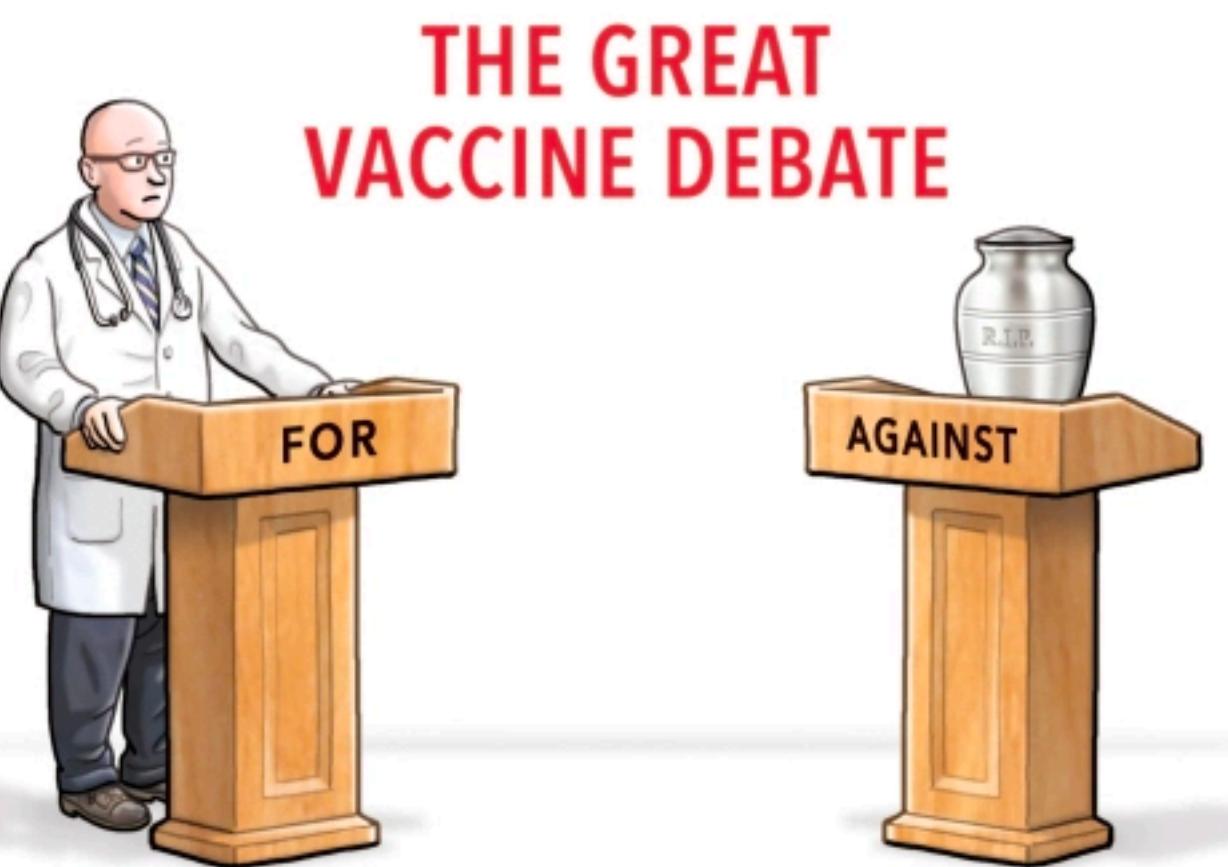
WHAT IS POLARIZATION?

POLITICAL DISCUSSIONS ON THE FACEBOOK



Poll: Mask-wearing divisions remain even as coronavirus cases spike

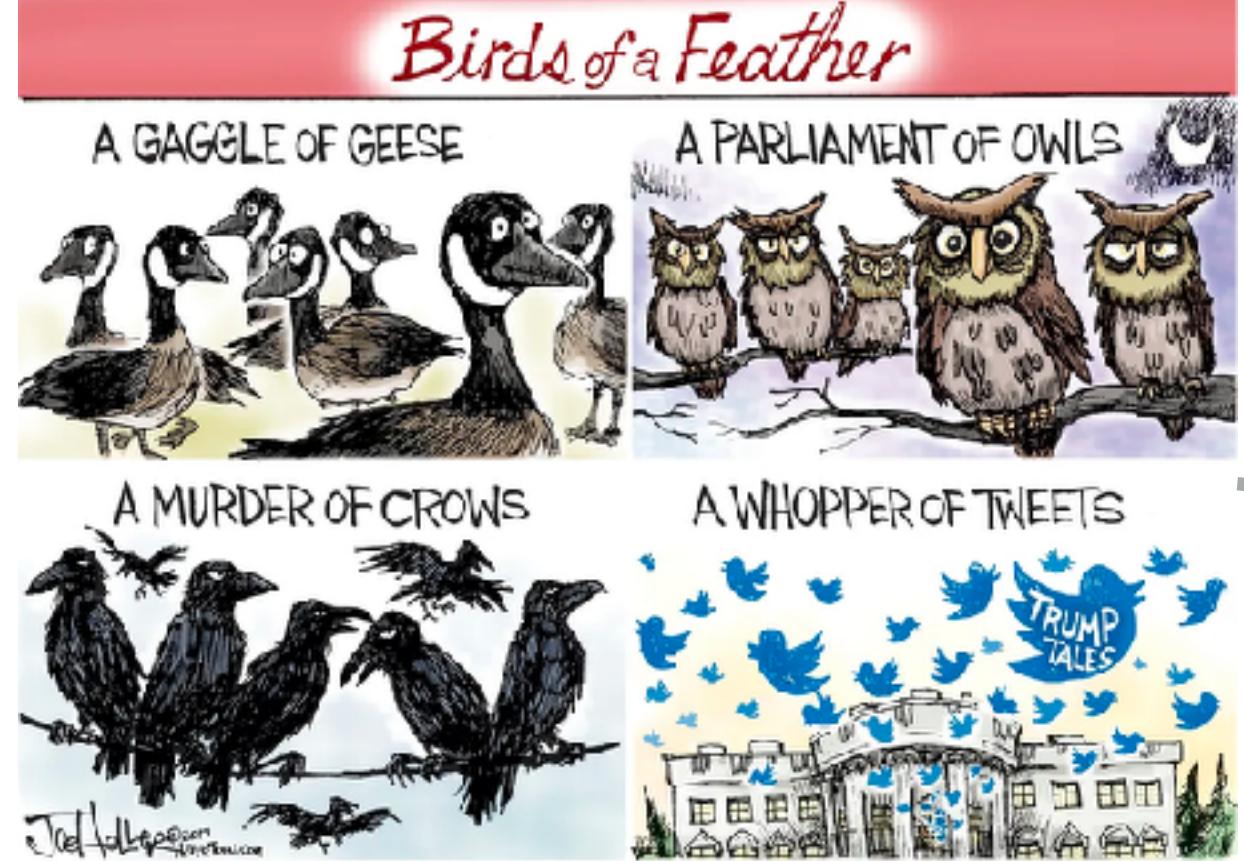
Democrats, nonwhites and elderly Americans are more likely to say they wear masks every time they leave home, a new NBC News|SurveyMonkey poll shows.



INTRODUCTION

WHY SOCIAL MEDIA DEBATE ARE POLARIZED?

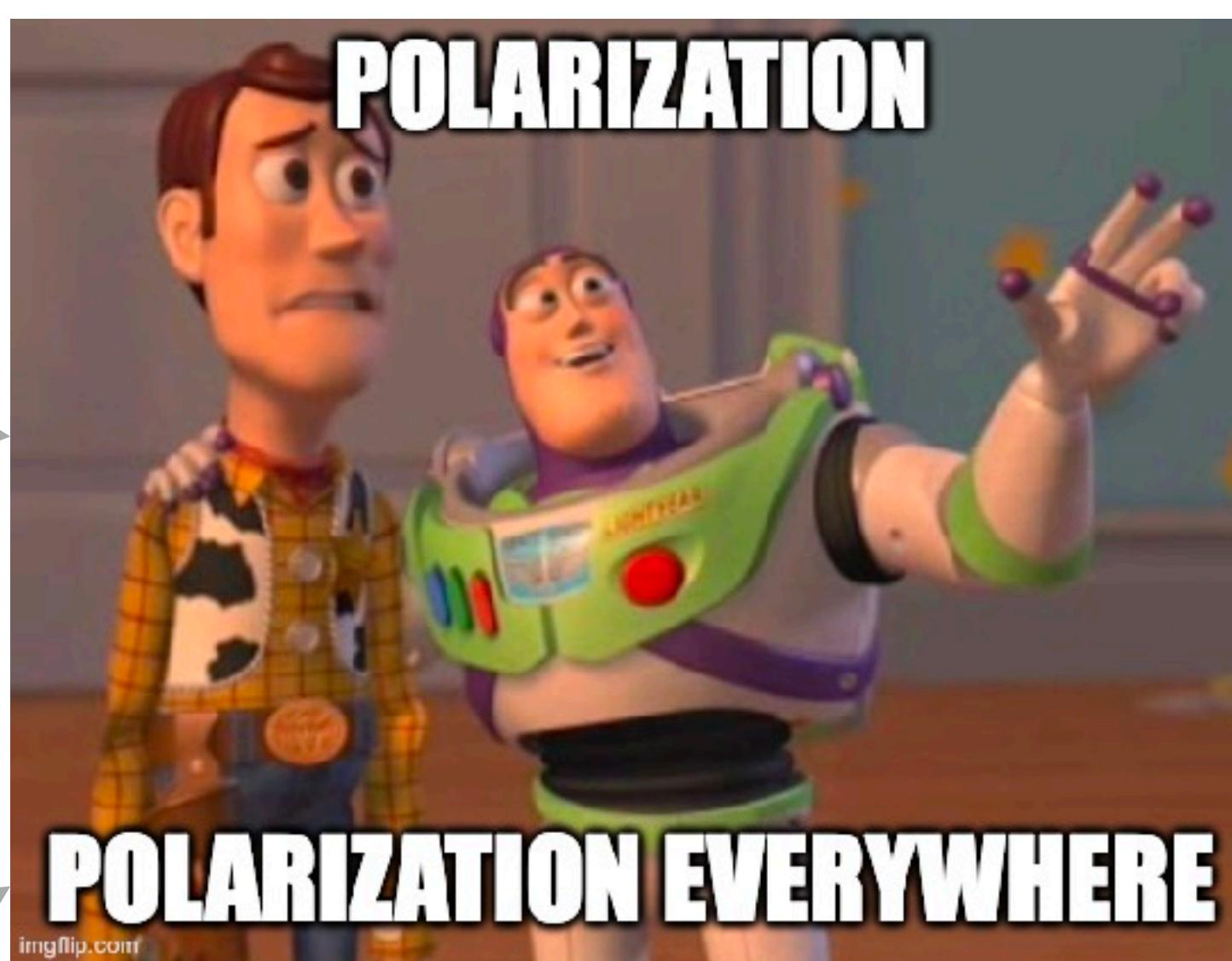
Homophily



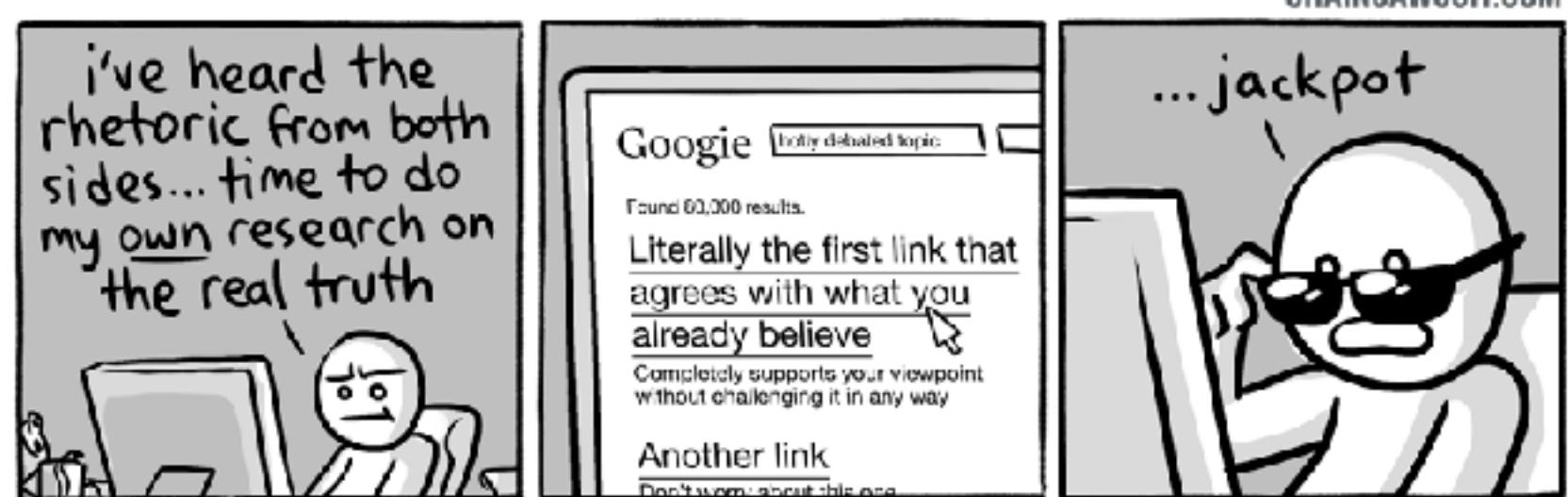
Echo chambers



POLARIZATION



Selection Bias

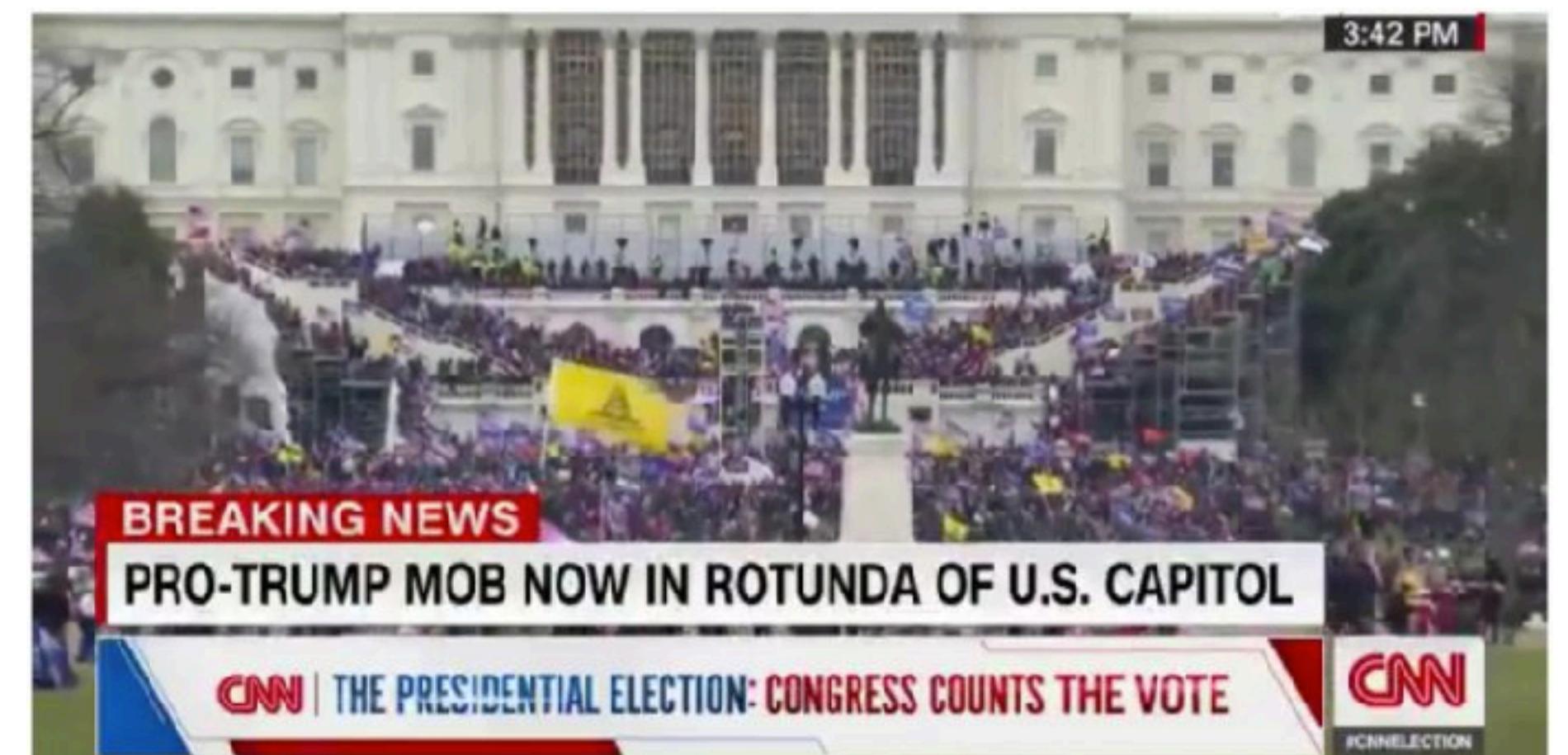


Feed Algorithm



WHY SHOULD WE CARE ABOUT POLARIZATION?

- ▶ Political deadlocks that prevent actions
- ▶ Part of the society adopt dangerous behaviours
- ▶ Individual or collective violent actions
- ▶



HOW CAN IT BE RELATED TO CYBERSECURITY?

Polarized, segregated environments are a fertile ground for bots, fake news spreading, Disinformation warfare

- ▶ Zannettou, Savvas, et al. "Disinformation warfare: Understanding state-sponsored trolls on Twitter and their influence on the web." Companion proceedings of the 2019 world wide web conference. 2019.
- ▶ Stella, Massimo, Emilio Ferrara, and Manlio De Domenico. "Bots increase exposure to negative and inflammatory content in online social systems." Proceedings of the National Academy of Sciences. 2018.
- ▶ Bessi, Alessandro, and Emilio Ferrara. "Social bots distort the 2016 US Presidential election online discussion." First monday 21.11-7 (2016).
- ▶ Sharma, Karishma, Yizhou Zhang, and Yan Liu. "Covid-19 vaccine misinformation campaigns and social media narratives." Proceedings of the International AAAI Conference on Web and Social Media. Vol. 16. 2022.

J. FLAMINO, A. GALEAZZI, S. FELDMAN, M. W. MACY, B. CROSS, Z. ZHOU, M. SERAFINO, A. BOVET, H. A. MAKSE, B. K. SZYMANSKI

POLITICAL POLARIZATION OF NEWS MEDIA AND INFLUENCERS ON TWITTER IN THE 2016 AND 2020 US PRESIDENTIAL ELECTIONS.

OVERVIEW



Twitter data of 2016 and 2020 U.S. presidential elections



873M+ tweets by 25M+ users



Third source data for assessing political leaning



Target: study the evolution of the debate, the presence of fake news, and the level of polarisation

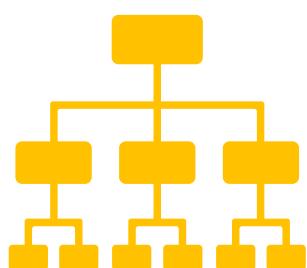
HOW TO COMPARE 2016 AND 2020?



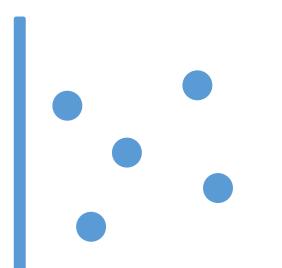
Starting point: *Influence of fake news in Twitter during the 2016 US presidential election*, Alexandre Bovet & Hernán A. Makse, Nature Communication



Source-based: how did users tweet in 2020 with respect to 2016? From which sources?



Network-based: did the structure of network interaction change from 2016 to 2020?



Which was the interplay between the interaction structure and content consumption?

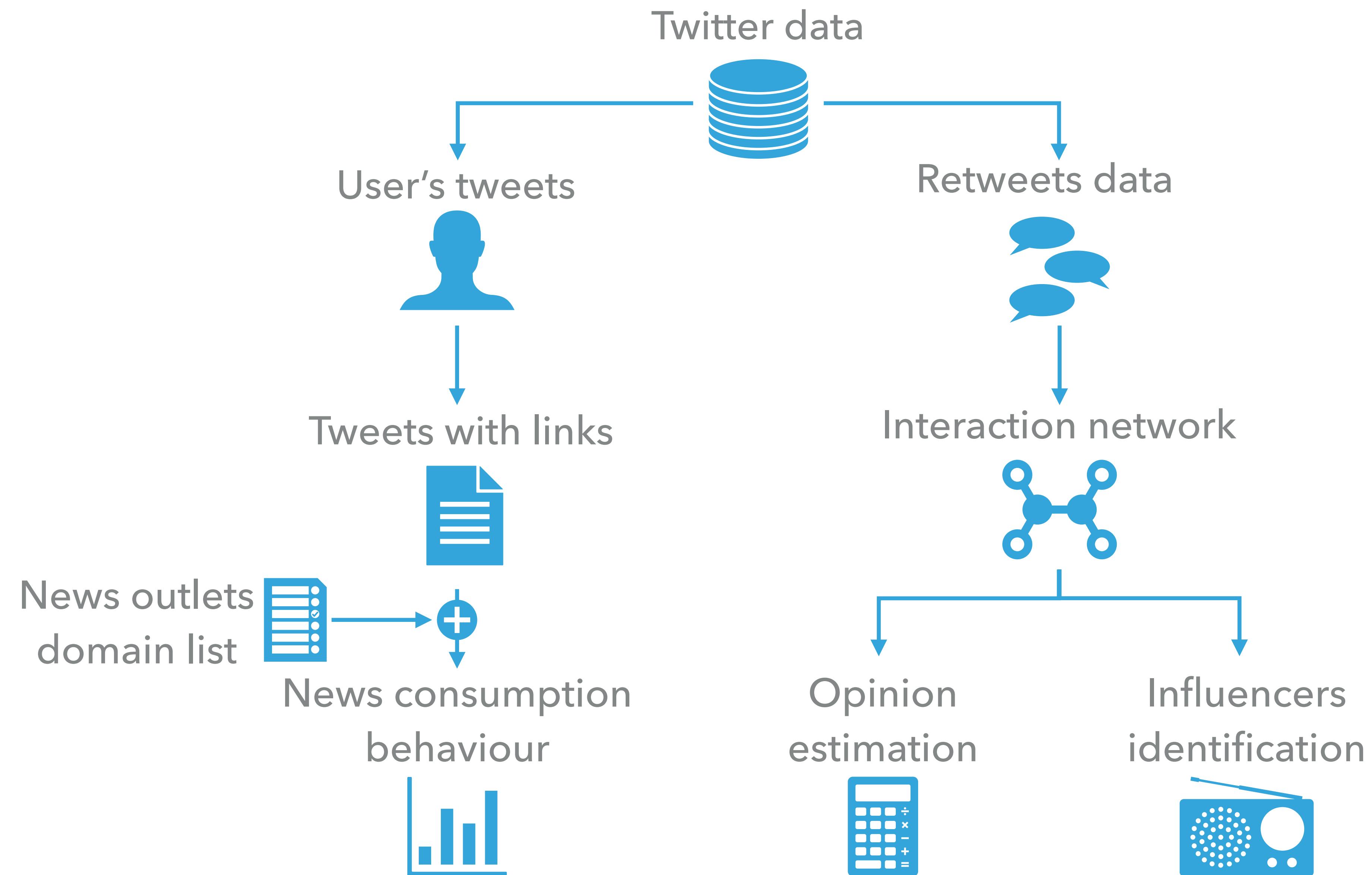
WORKFLOW

Data:

- ▶ 2016:
Trump,Clinton
- ▶ 2020: Trump,Biden

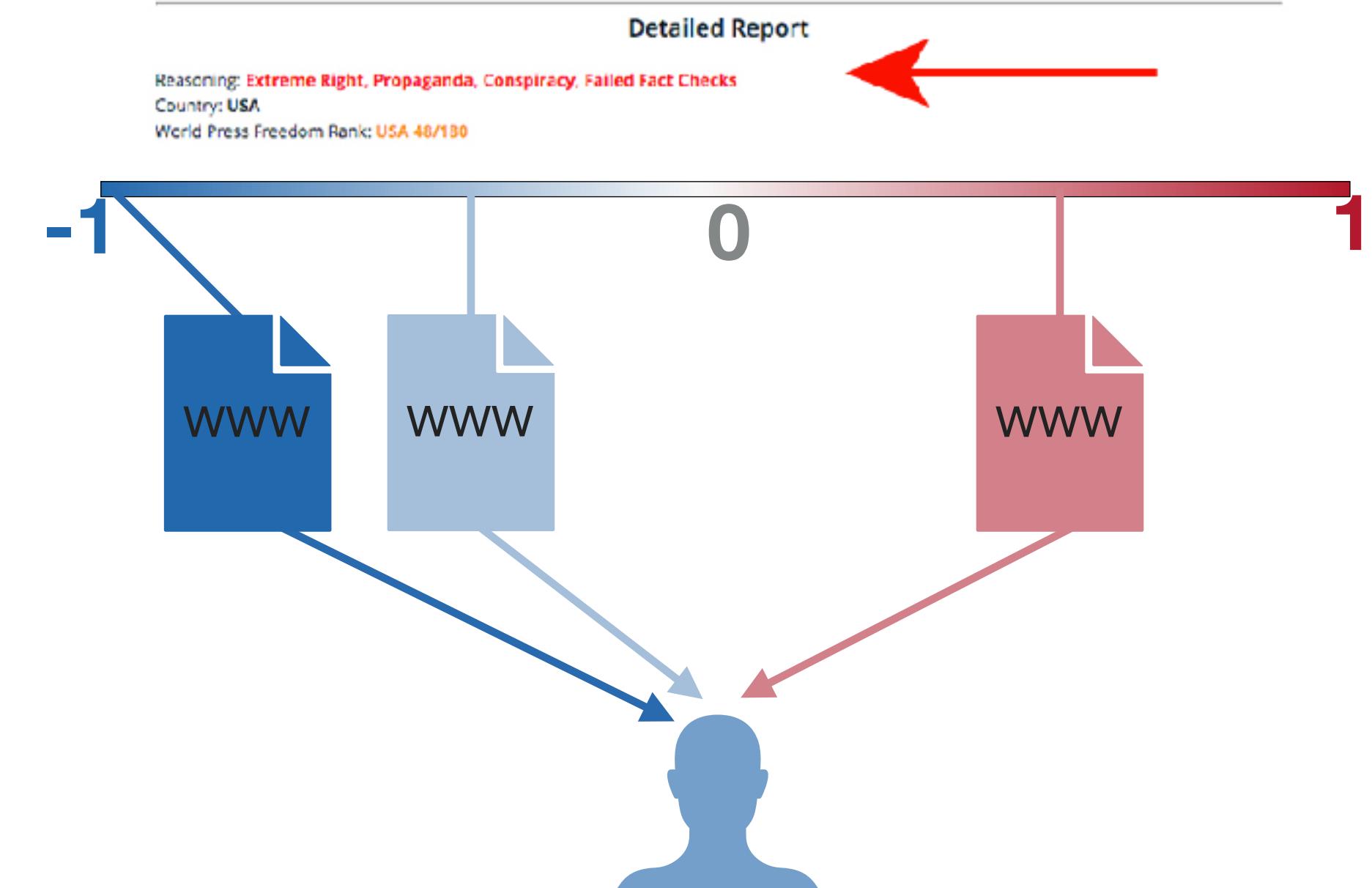
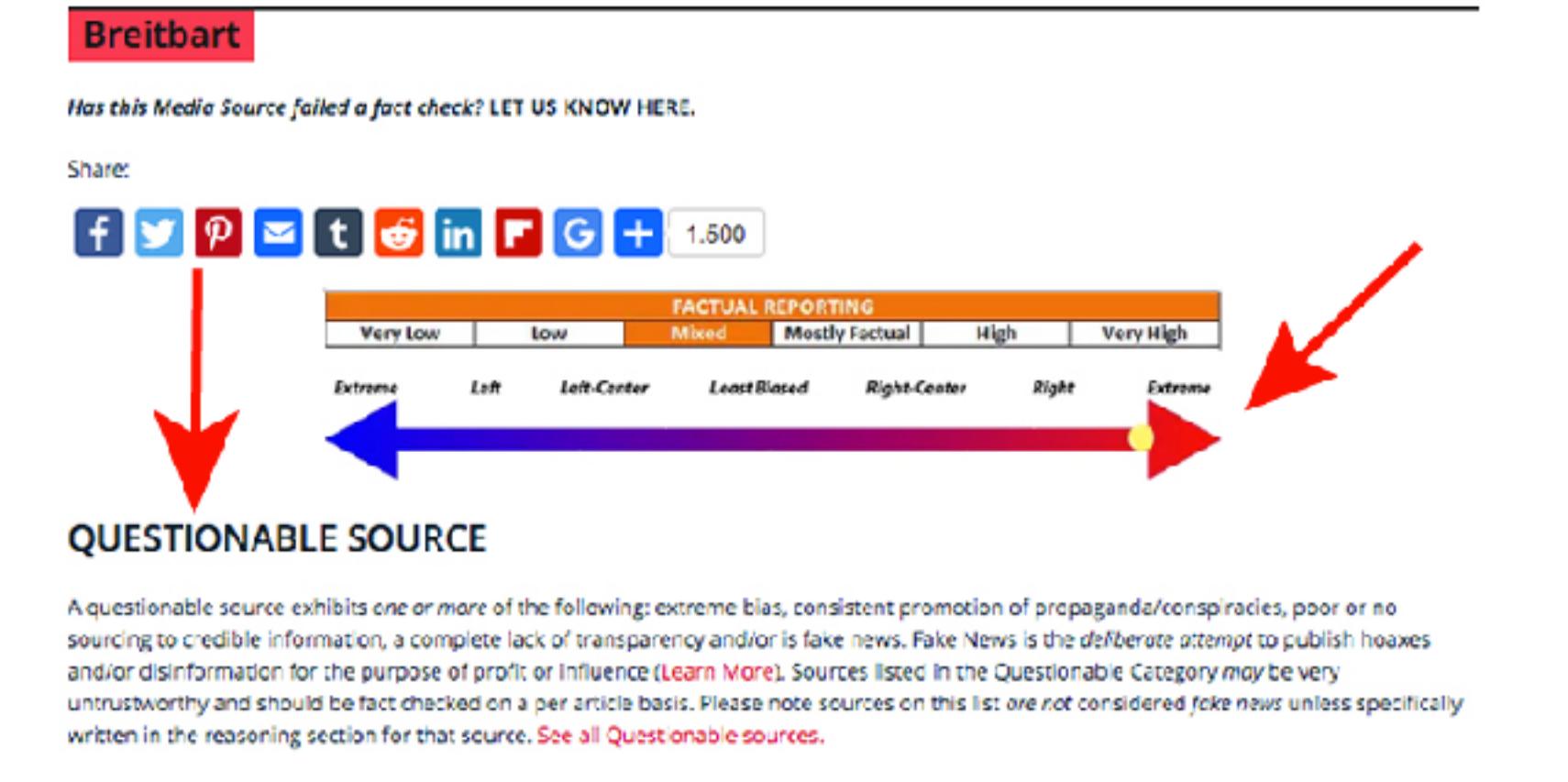
To assess the individual leaning of a user

- ▶ News Diet from timeline
- ▶ Information from its retweet network (CA)



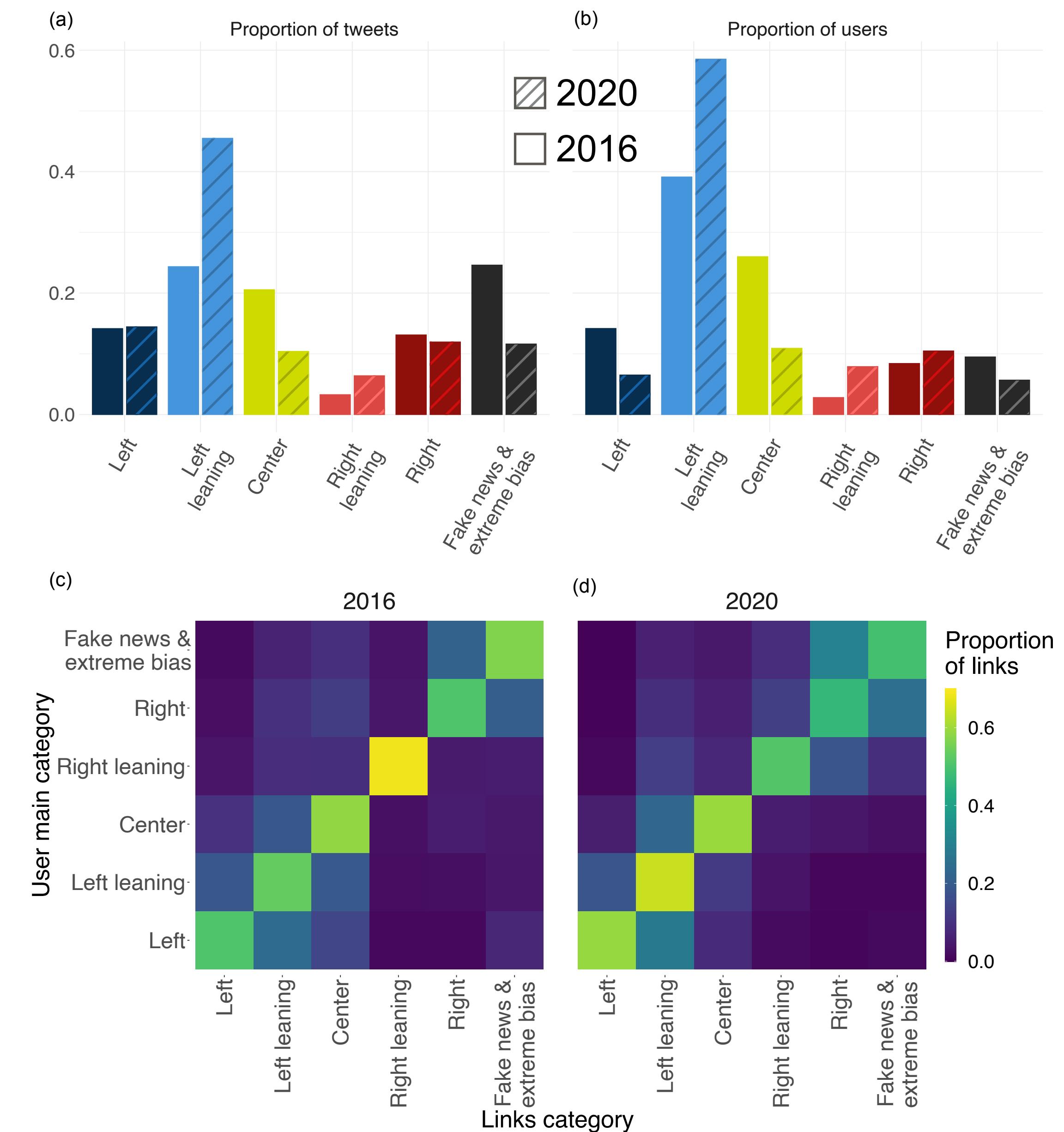
INFERRING LEANING FROM CONTENTS

- ▶ Extract tweets with URL
- ▶ Resolve shortened URLs:
<https://bit.ly/3VugEbX> → [https://www.corriere.it/sport/...](https://www.corriere.it/sport/)
- ▶ Extract domain from URLs:
[https://www.corriere.it/sport/...](https://www.corriere.it/sport/) → corriere.it
- ▶ Assign reliability/bias to each domain in News outlets list
✓ [nytimes.com](#) ✗ [breitbart.com](#)
- ▶ Compute statistics for each user



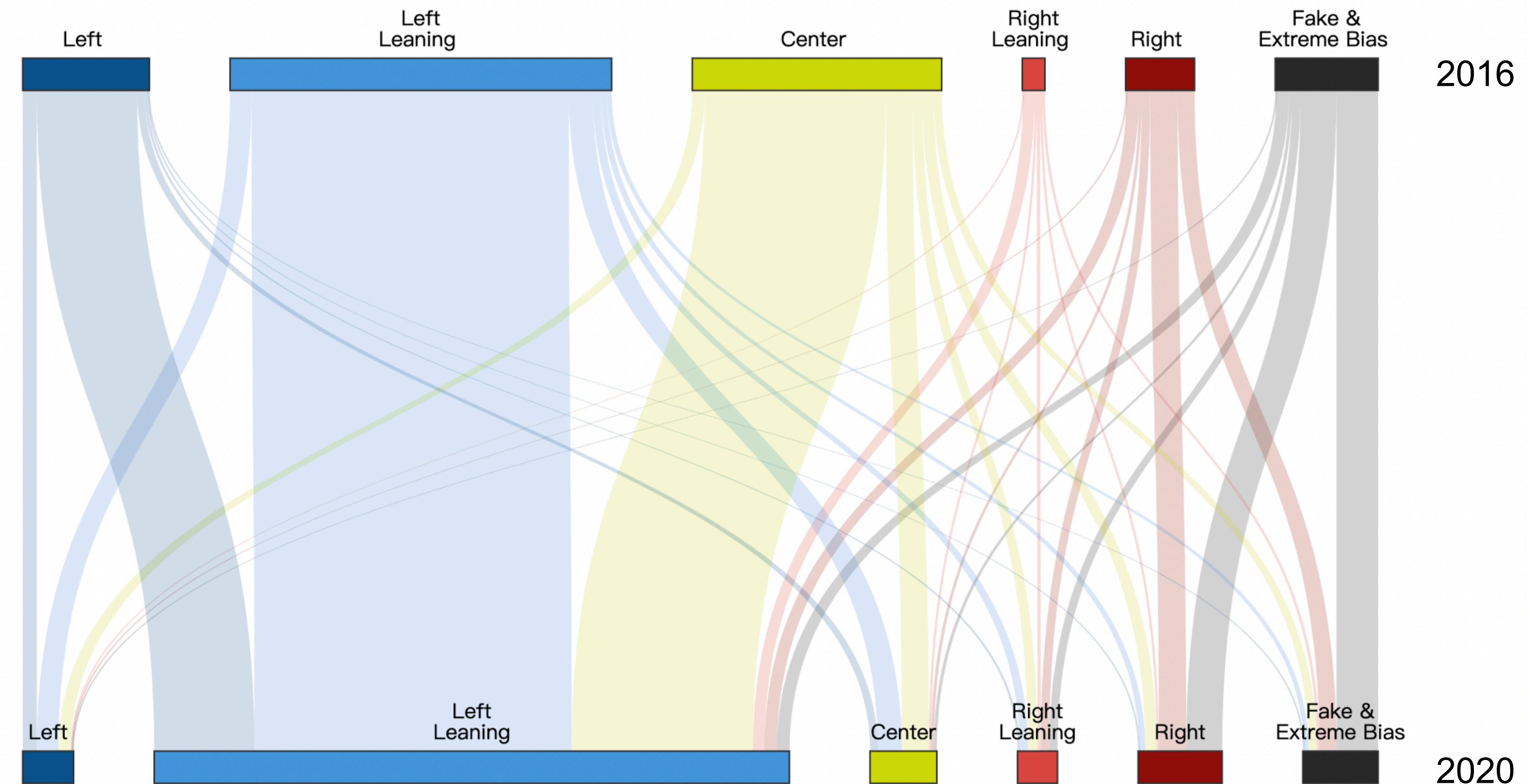
HOW THE CONSUMPTION OF NEWS EVOLVED?

- ▶ Reduction of Fake News and extreme bias tweets
- ▶ Reduction of tweets and users from center
- ▶ The policy implemented by Twitter may be effective to combat fake news diffusion
- ▶ Reduction of the fraction of tweets from unofficial clients (likely to be automated account)
- ▶ Decreased activity of unofficial clients



THE SHIFT OF USERS' LEANING

- ▶ Significant shift from center, left to left leaning
- ▶ Reduction of Fake & Extreme Bias

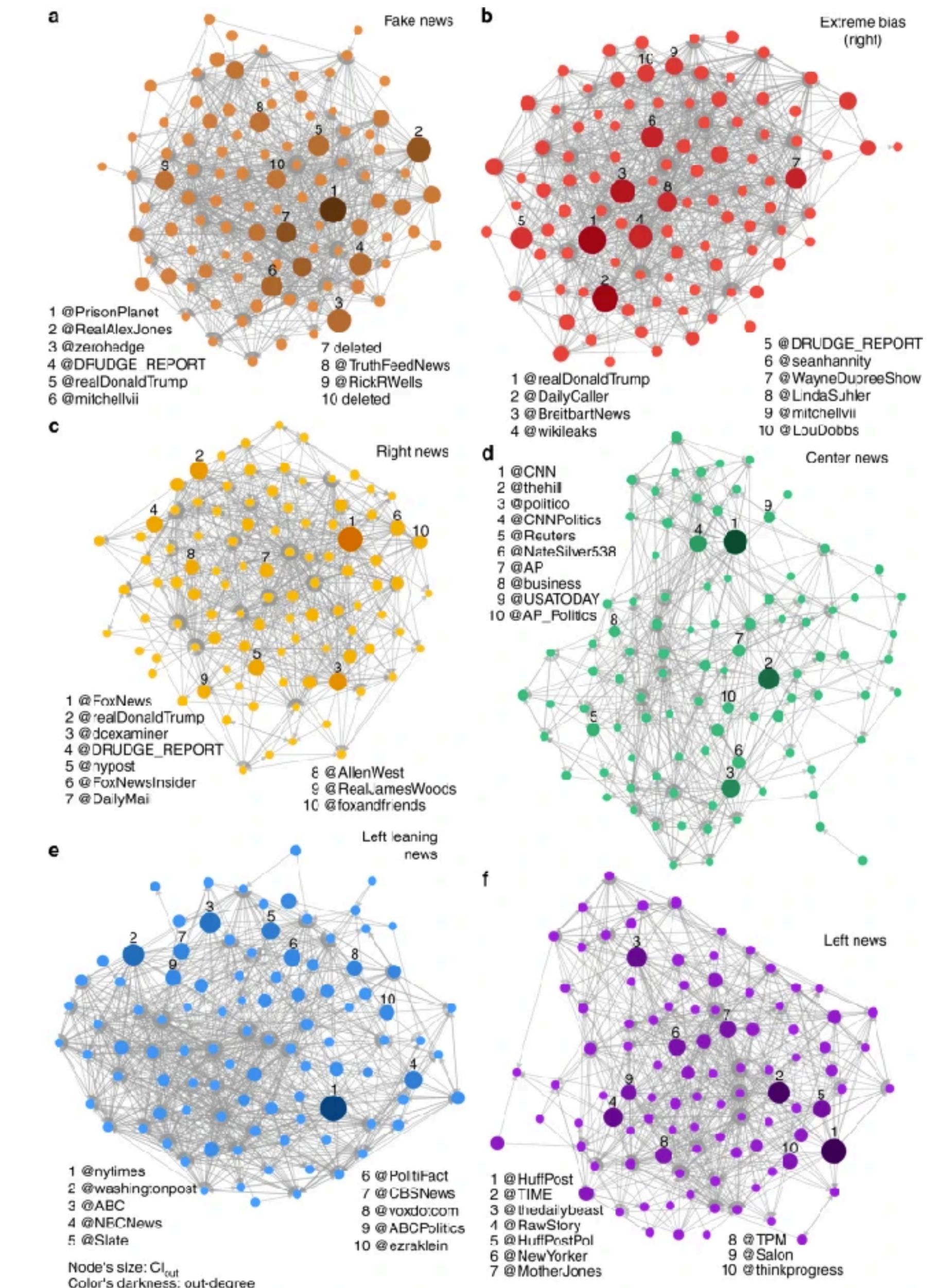


WHO LEADS THE DEBATE?

- ▶ Build Retweet network for each category (only retweets of classified links of that category)

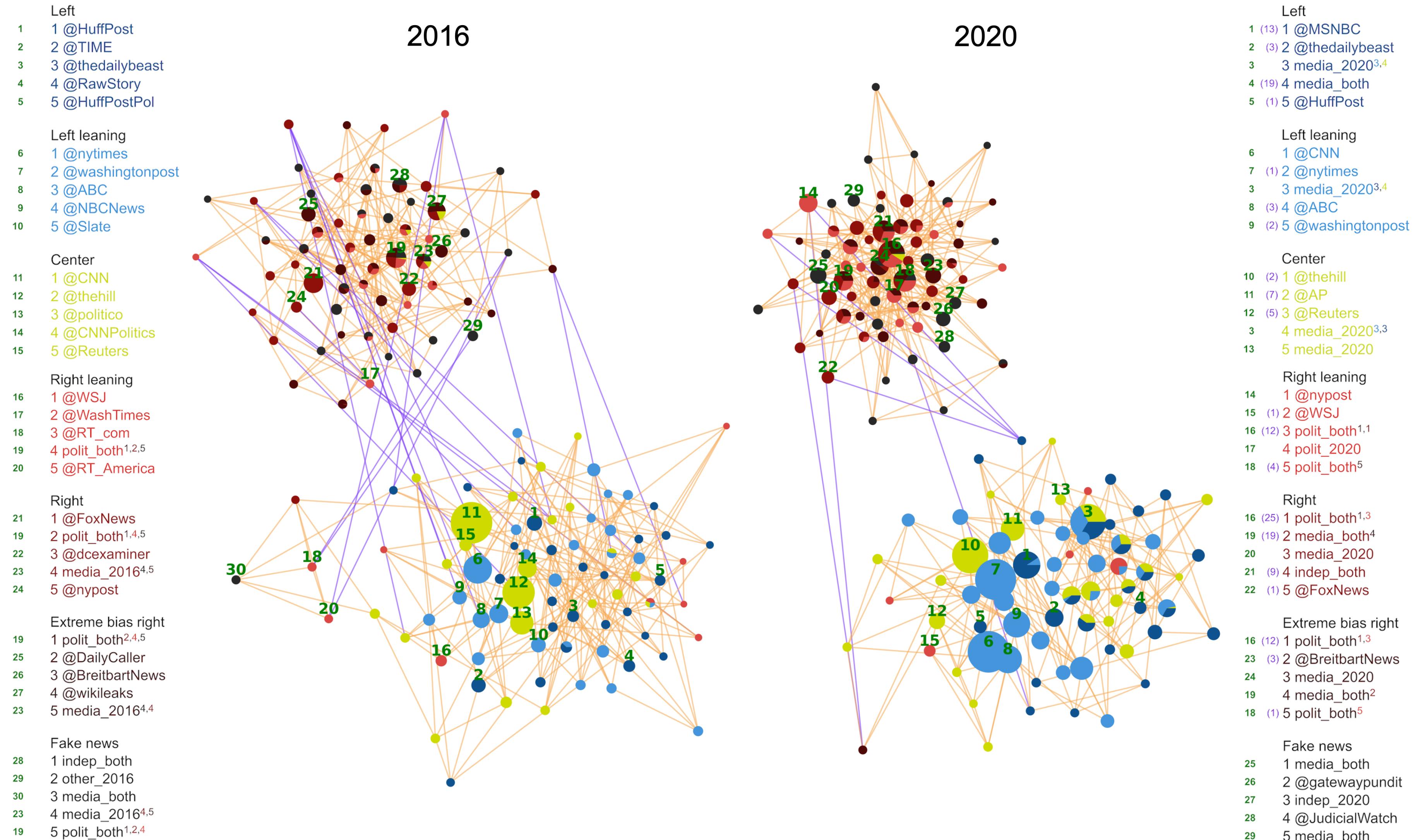
- ▶ Run **Collective Influence** algorithm to rank nodes
Morone, F. & Makse, H. A. Influence maximization in complex networks through optimal percolation. *Nature* 524

- ▶ Extract top spreaders for each category



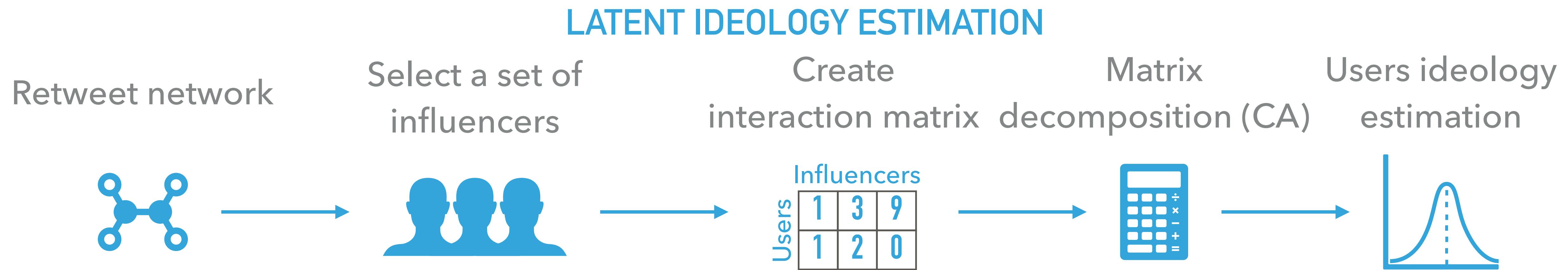
TOP INFLUENCERS SIMILARITY NETWORK

- ▶ Nodes: top 30 influencers, top 5 for each category
- ▶ Edges: cosine similarity in influencers retweeters
- ▶ Reduction of the cross ideological connections



HOW TO QUANTIFY THIS INCREASED DISTANCES AMONG COMMUNITIES?

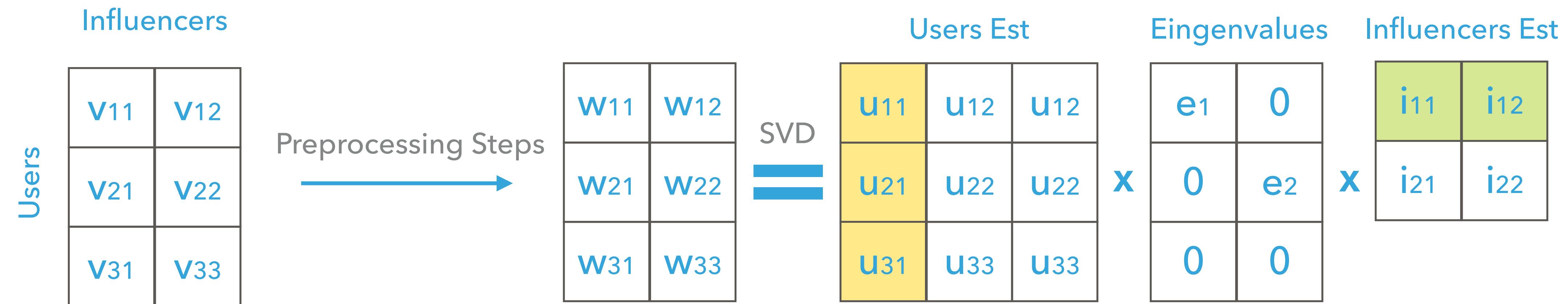
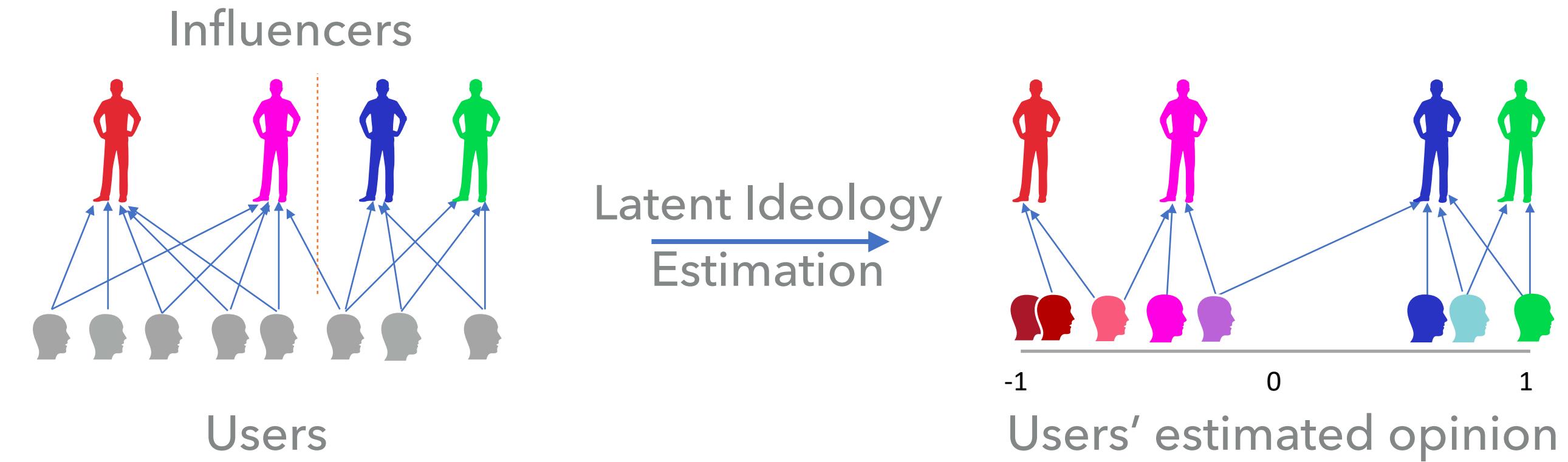
How to be sure that our results are independent of news outlets classification/shift?



Given the influencers set, the procedure is based solely on topological properties

LATENT IDEOLOGY ESTIMATION

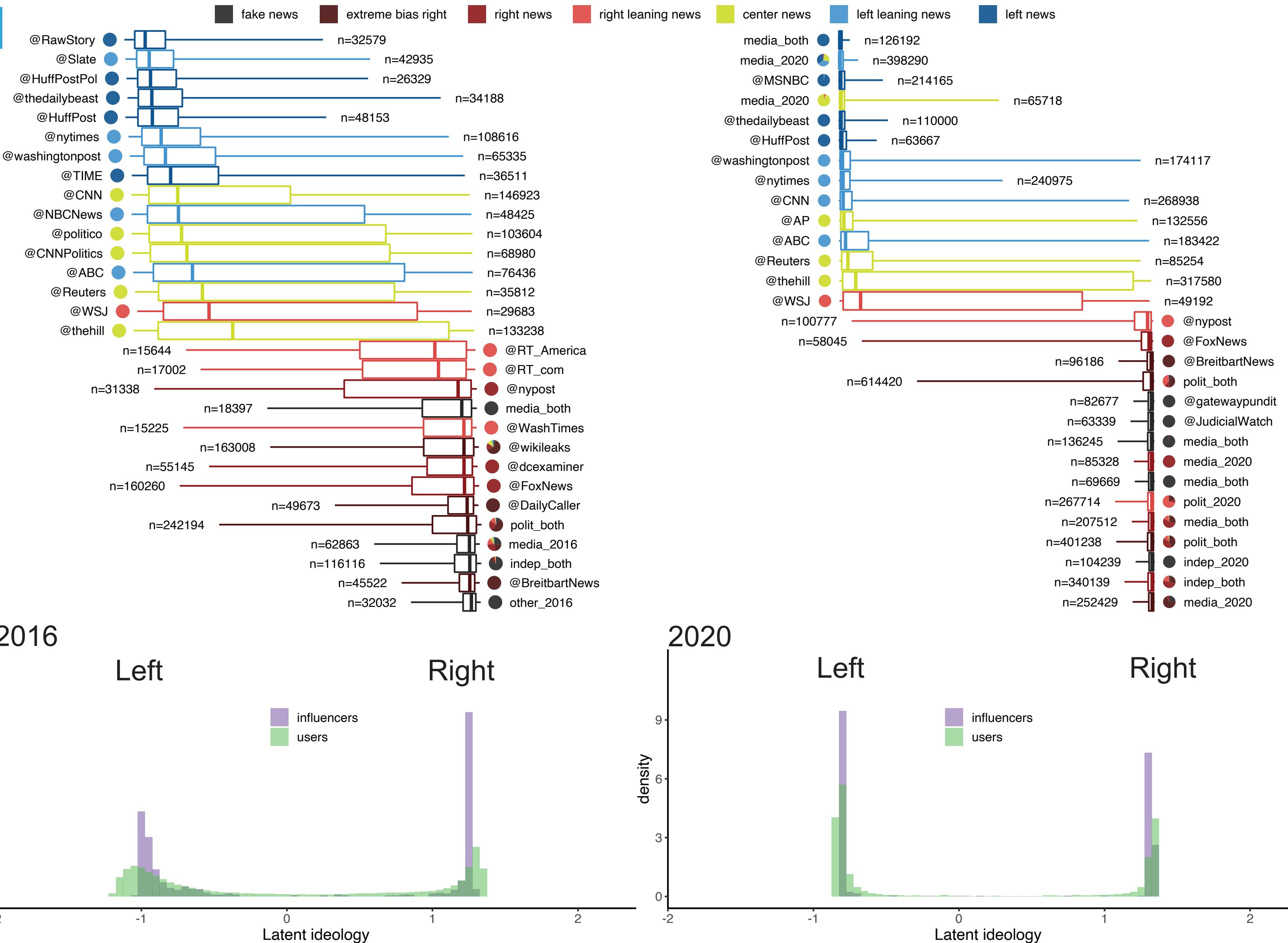
- Idea: users that retweeted the same influencers are placed closer
- Based on Correspondence Analysis
- Adapted from: Barberá, Pablo, et al. "Tweeting from left to right: Is online political communication more than an echo chamber?." Psychological science



POLITICAL POLARIZATION OF NEWS MEDIA AND INFLUENCERS ON TWITTER IN THE 2016 AND 2020 US PRESIDENTIAL ELECTIONS.

THE EVOLUTION OF POLARIZATION

- ▶ Boxplot: distribution of the retweeters' ideology for top 5 influencers
- ▶ Distribution: users and influencers distributions for top 100 influencers
- ▶ Dip Test to compare the level of polarisation
- ▶ Pearson Correlation ideology vs domain-based leaning: 0.96



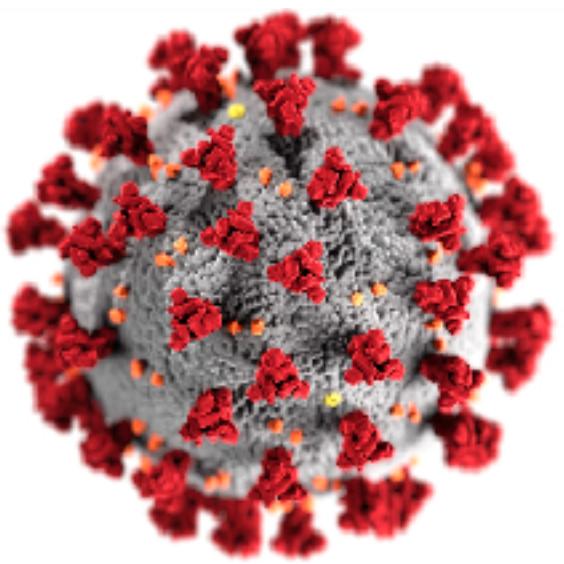
GROWING POLARIZATION AROUND CLIMATE CHANGE ON SOCIAL MEDIA

WHAT ABOUT OTHER TOPICS?



Donald J. Trump
@realDonaldTrump

Temperatures
are reaching - 60
degrees... What
the hell is going
on with Global
Warming?



M. FALKENBERG, A. GALEAZZI, M. TORRICELLI, N. DI MARCO, F. LAROSA, M. SAS, A. MEKACHER, W. PEARCE, F. ZOLLO, W. QUATTROCIOCCHI,
AND A. BARONCELLI

GROWING POLARIZATION AROUND CLIMATE CHANGE ON SOCIAL MEDIA

GROWING POLARIZATION AROUND CLIMATE CHANGE ON SOCIAL MEDIA

OVERVIEW



Twitter data of COP21 and COP26



10M+ tweets by 2M+ users



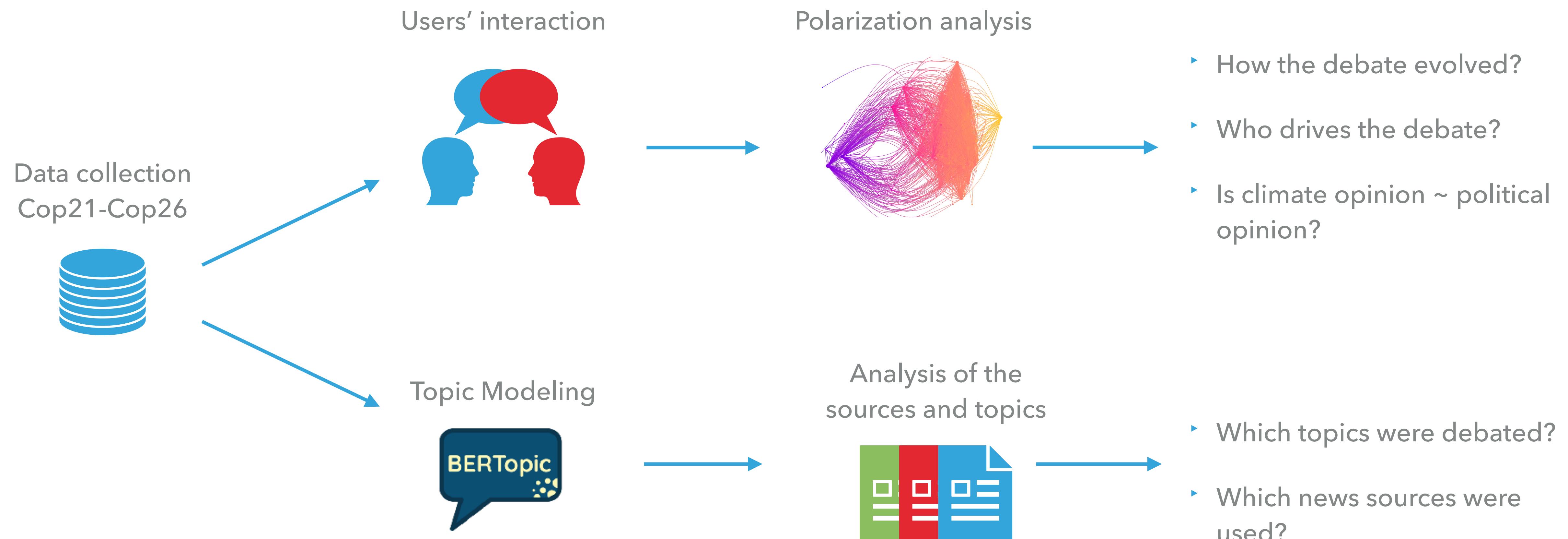
Machine learning to identify most debated topics



Target: study the evolution of the debate, the level of polarization and the role of politicians

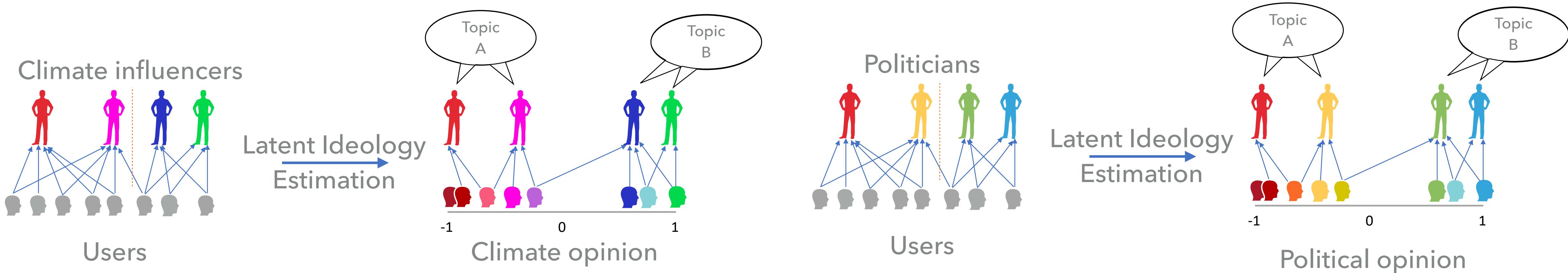
GROWING POLARIZATION AROUND CLIMATE CHANGE ON SOCIAL MEDIA

WORKFLOW



WHAT IS POLARIZATION HERE? HOW TO MEASURE IT?

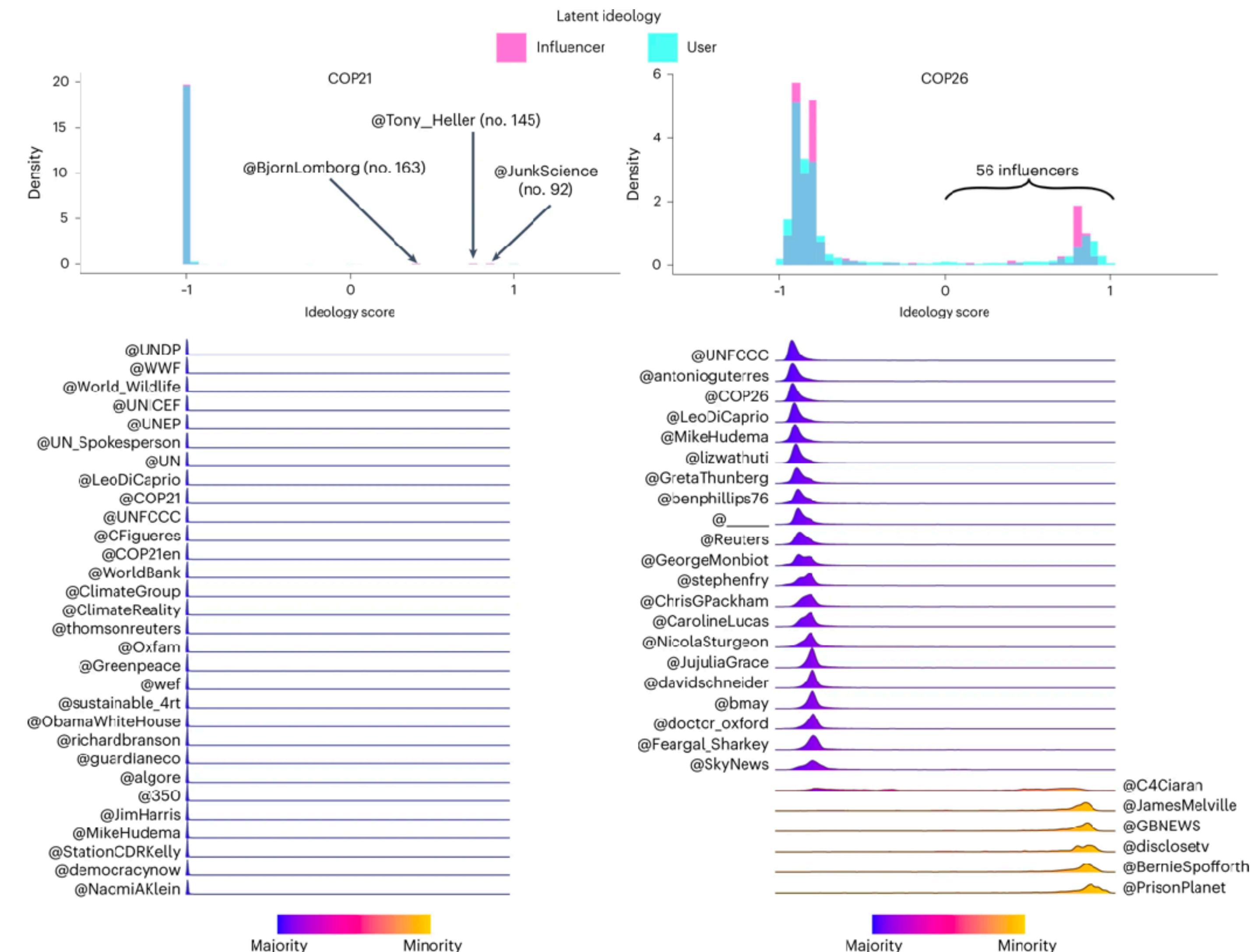
- ▶ Identify politicians and non-politicians influencers (top users by degree)
- ▶ Perform Correspondence Analysis
- ▶ Estimate political and climate opinions of users



GROWING POLARIZATION AROUND CLIMATE CHANGE ON SOCIAL MEDIA

POLARIZATION BETWEEN COP21 E COP26

- ▶ Polarization increased between cop21(2015) and cop26(2021)
- ▶ Climate sceptics (a dx) increased four times more than climate activists (a sx)
- ▶ Most of sceptics appear after 2019, probably as a response to movement such as FFF



GROWING POLARIZATION AROUND CLIMATE CHANGE ON SOCIAL MEDIA

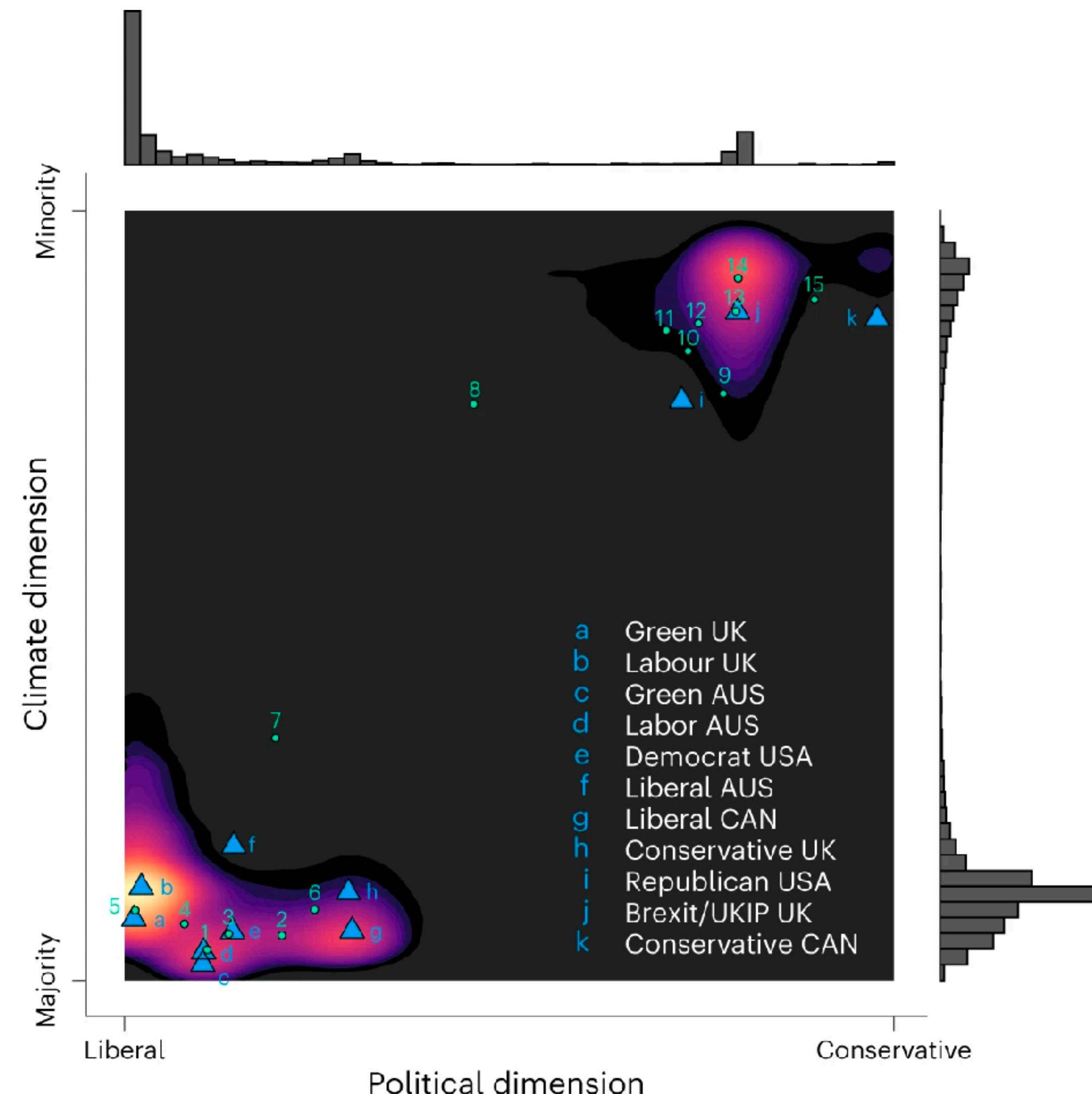
WHO LEADED THIS GROWTH?

Sceptics in cop26 have a conservative/populist political leaning, activists are more liberal

Different topics debated by the two communities

However, some topics are common and bridge the two factions

- 1 Anti-Morrison
- 2 Biodiversity & Localism, Women at COP, Climate Finance, Youth,
- 3 Climate Justice Decolonise Climate
- 4 Sustainable Transport
- 5 Activists for Climate Action
- 6 Climate Crisis
- 7 Anti-Johnson
- 8 Anti-Sturgeon
- 9 Climate Alarmists
- 10 Wind Energy & Nuclear
- 11 Thunberg Cult
- 12 Chinese Absence, Vaccine Passports
- 13 Anti-Biden, Didn't Vote Green, Arctic Ice, Climate "Scam", Benefits of Warming
- 14 Illegal Immigration, Net Zero Referendum, Private Jets, Hypocrisy, CO₂
- 15 Anti-Trudeau



DIVE INTO THE SCEPTICS PROSPECTIVE

- 1** Anti-Morrison
- 2** Biodiversity & Localism, Women at COP, Climate Finance, Youth,
- 3** Climate Justice Decolonise Climate
- 4** Sustainable Transport
- 5** Activists for Climate Action
- 6** Climate Crisis
- 7** Anti-Johnson
- 8** Anti-Sturgeon
- 9** Climate Alarmists
- 10** Wind Energy & Nuclear
- 11** Thunberg Cult
- 12** Chinese Absence, Vaccine Passports
- 13** Anti-Biden, Didn't Vote Green, Arctic Ice, Climate "Scam", Benefits of Warming
- 14** Illegal Immigration, Net Zero Referendum, Private Jets, Hypocrisy, CO₂
- 15** Anti-Trudeau

Claim type	Topics	Representative tweet extracts
(1) Global warming isn't happening	9, 13, 14	"ALL the current data say the opposite. Arctic Ice Extent at a 6 year high, volume up 17% on last year when all models predict most warming will occur at The Poles. You're talking shite" "@COP26 You have been lying to the public and mocking them for decades with your climate scam"
(2) Human-generated greenhouse gases are not causing global warming	13, 14	"What % of Atmosphere is made up of CO2?? A: 0.04% Of that 0.04%, humans create 3%, or 0.0012% = FCUK ALL!!"
(3) Climate impacts are not bad	9, 13	"@COP26 What 'climate change'? Thriving polar bears. Record coral cover. Stable ice-sheets. Bumper snow. Greening planet. Reduced wildfires. Increased Pac island land. Fewer hurricanes. Antarctica record cold winter. CO2 causation not proven. CO2 beneficial."
(4) Climate solutions won't work	10, 12, 13, 14	"We didn't vote for this impoverishing green socialist nonsense." "China is not going to COP26. So what's the point?"
(5) Climate movement/science is unreliable	9, 11, 13, 14, 15	"It's amazing - and desperate IMO - that alarmists are STILL hanging on to the presumption that the Maldives are about to go underwater any time soon, even after 30 odd years of failed claims that it is imminent!" "More blah blah blah from the Thunberg cult, none of whom have reduced their carbon footprint 1 jot"

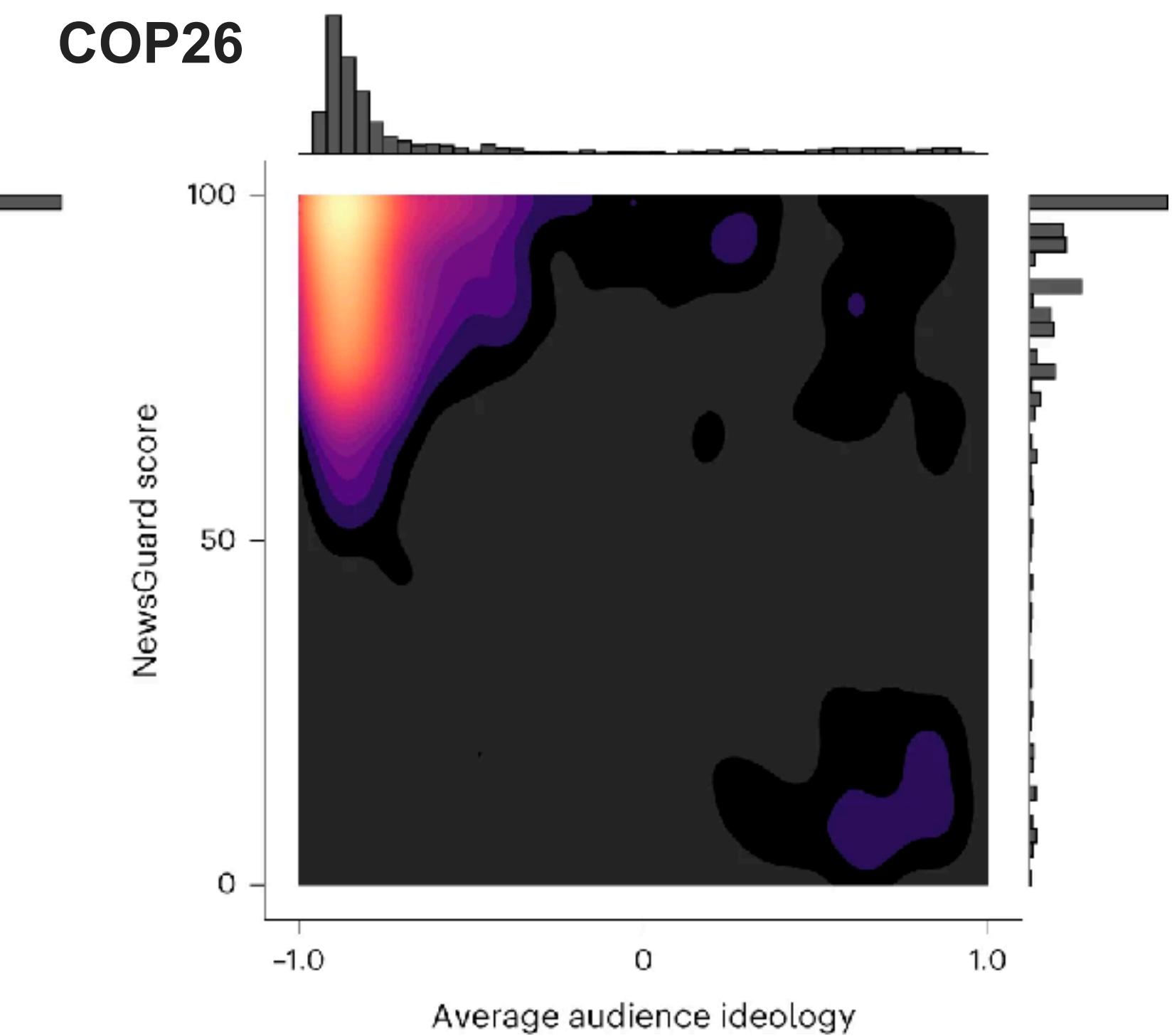
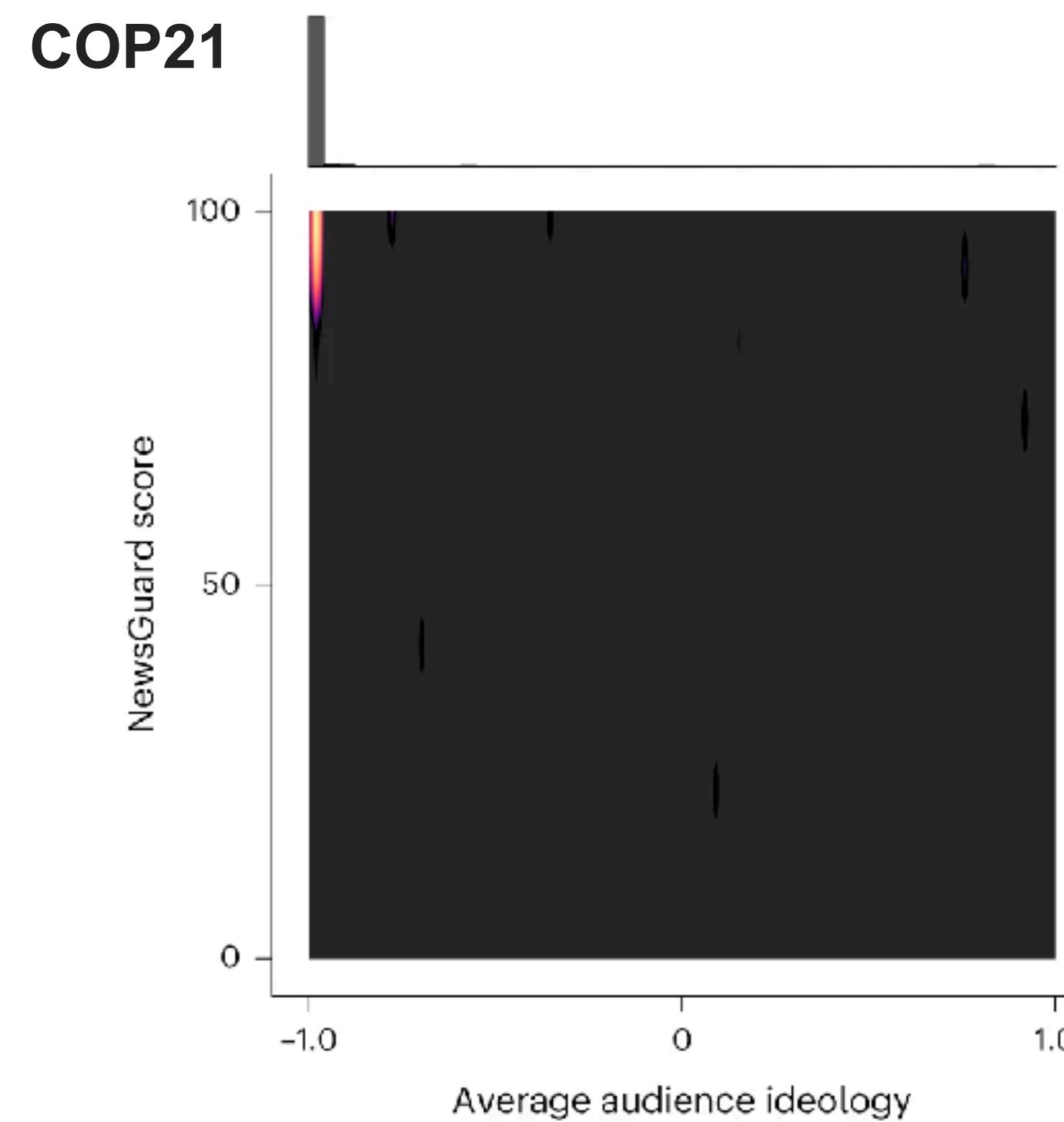
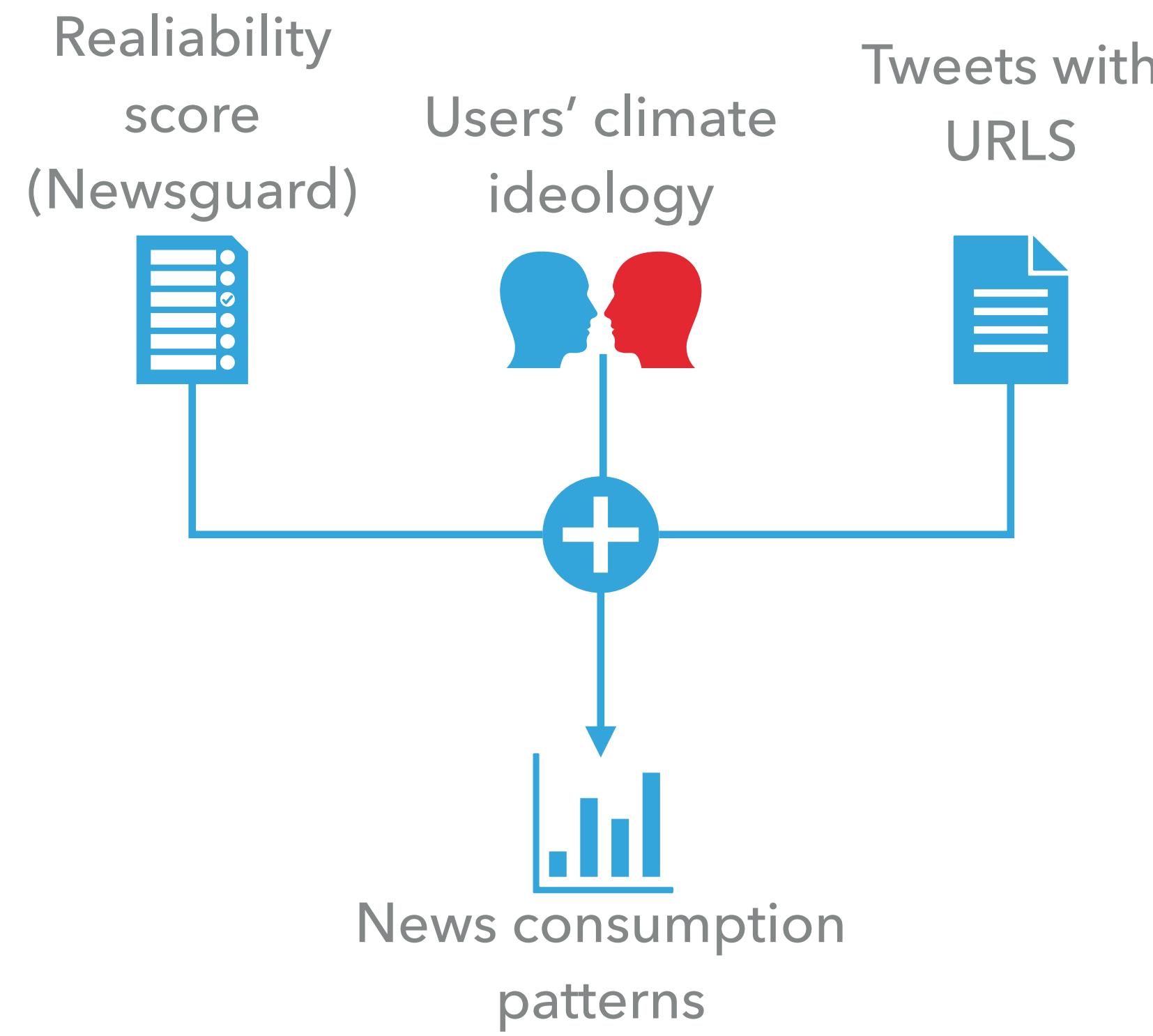
GROWING POLARIZATION AROUND CLIMATE CHANGE ON SOCIAL MEDIA

WHICH SOURCES ARE USED BY THE TWO COMMUNITIES?

In Cop21 we have almost only reliable sources

During COP26 the volume from unreliable sources increased

Unreliable sources are used almost exclusively by sceptics



A. BAQIR, A. GALEAZZI, A. DROCCO, F. ZOLLO

SOCIAL MEDIA POLARIZATION REFLECTS SHIFTING POLITICAL ALLIANCES IN PAKISTAN

GROWING POLARIZATION AROUND CLIMATE CHANGE ON SOCIAL MEDIA

OVERVIEW



Twitter data of Pakistani Politicians
from 2018 to 2022



200K+ tweets and 2,5M+ users



5 years of Ideology analysis to study
political shifts



Target: study how the evolution of
the political alliance reflects on
online polarization

FROM 2018 TO 2022 PAKISTANI POLITICS UNDERWENT SIGNIFICANT CHANGES

- ▶ 2018: PTI won election, Imran Khan leading government
- ▶ 2020: PML-N + PPP form the opposition coalition PDM
- ▶ 2022: PTI members defected and eroded its parliamentary majority, leading to government overturn

Imran Khan: former Pakistan prime minister sentenced to three years in jail

Khan arrested in Lahore after court ruling bans him from politics for five years for corruption



■ 'Don't sit silently at home': arrested ex-Pakistan PM Imran Khan appeals to supporters - video

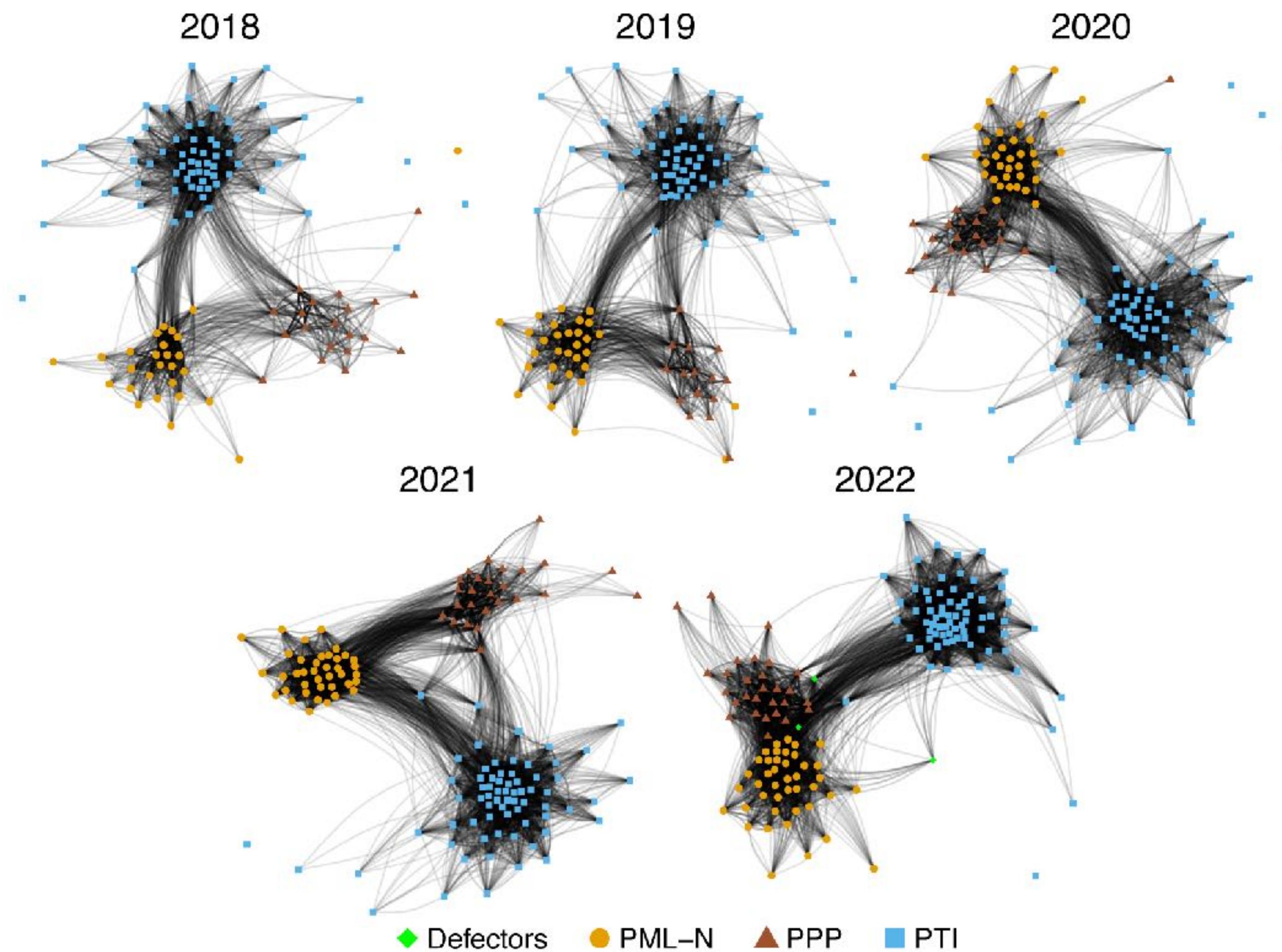
SOCIAL MEDIA POLARIZATION REFLECTS SHIFTING POLITICAL ALLIANCES IN PAKISTAN

COSINE SIMILARITY NETWORKS

Nodes = politicians

Edges= Retweeters similarity

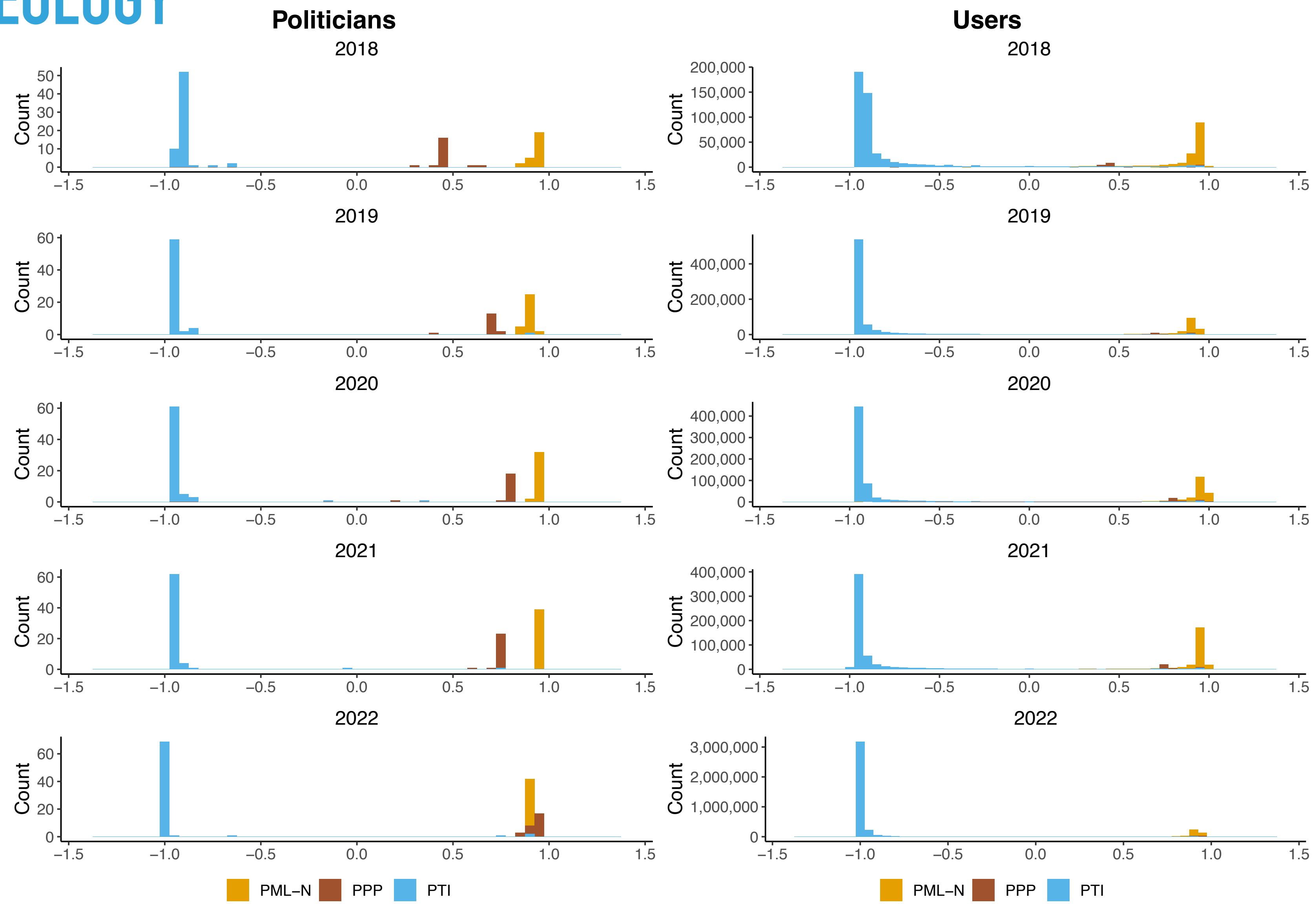
Data: 1 year for each graph



SOCIAL MEDIA POLARIZATION REFLECTS SHIFTING POLITICAL ALLIANCES IN PAKISTAN

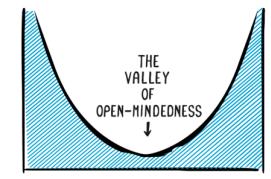
EVOLUTION OF LATENT IDEOLOGY

- ▶ Polarisation increased over time
- ▶ Ideology shifts mirror the evolution of political alliances
- ▶ Dramatic increase of users' participation in 2022



CONCLUSIONS

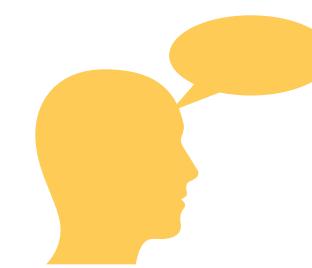
POLARIZATION IN ONLINE DEBATES



Polarization increased between 2016 and 2020 US elections, between COP21 e COP26, and between 2018-2022 in Pakistani politics



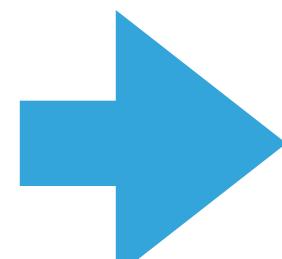
- In US this growth is due to the shift from center to left/right
- In COP to the increased presence of climate sceptics
- In Pakistan, to the evolution of political alliances



- In US debate, the discussion is lead much more by individual accounts for the right-leaning community
- In COP debate, the two communities debates about different topics, with some exceptions
- In Pakistan, a dramatic increase of users' participation in 2022



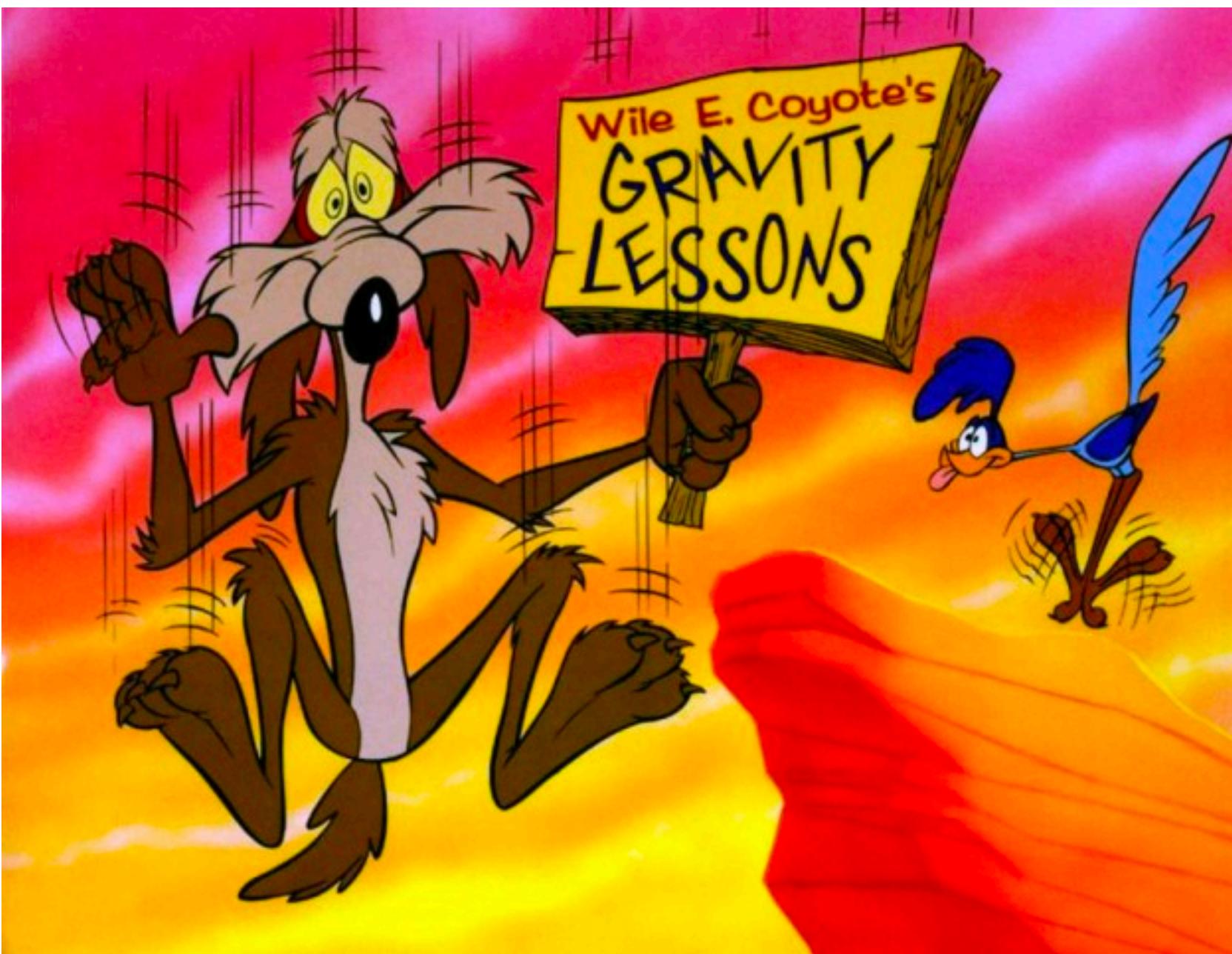
- In US debate, the presence of reliable sources and automated account decreased
- In COP debate, unreliable sources tend to be used only by sceptics



High polarization may increase the risk of violent actions and political deadlocks that inhibit actions to mitigate problems such as climate change.
It can be exploited to perform information warfare and spread disinformation to influence democratic processes such as referendum or political elections

SO, IT IS SO SIMPLE?

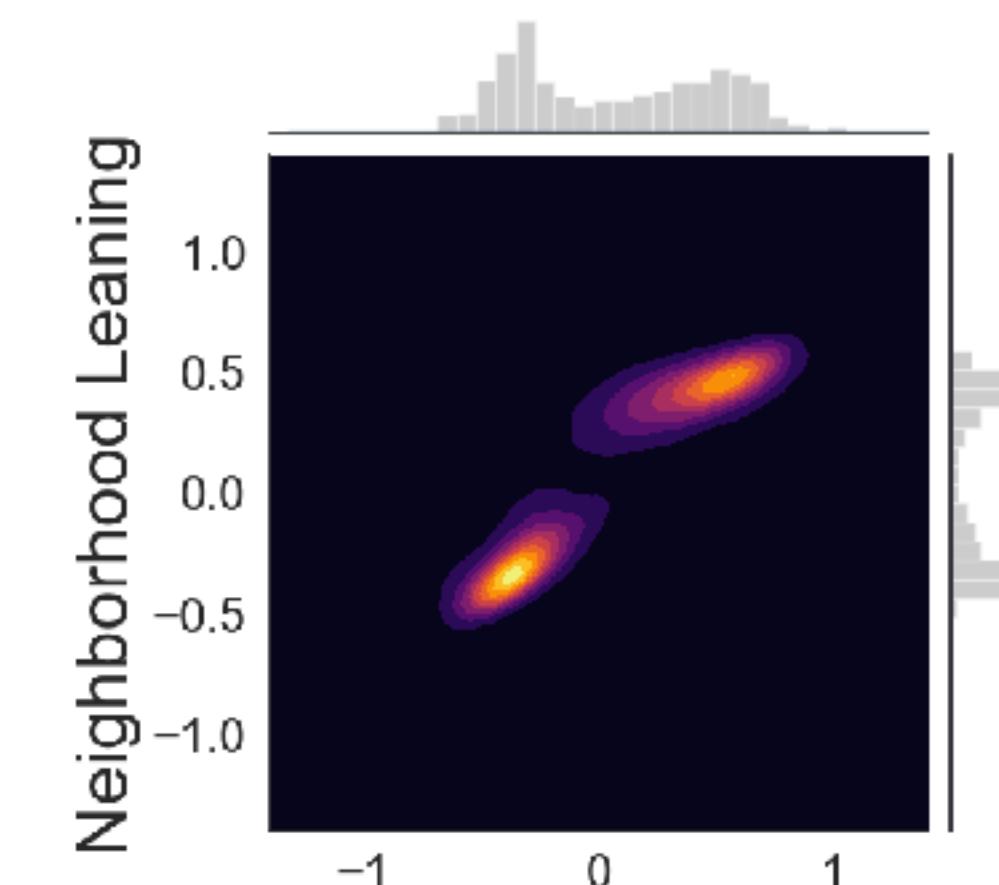
Ideology seems to be a powerful methods, but why it works and which are its limitations?



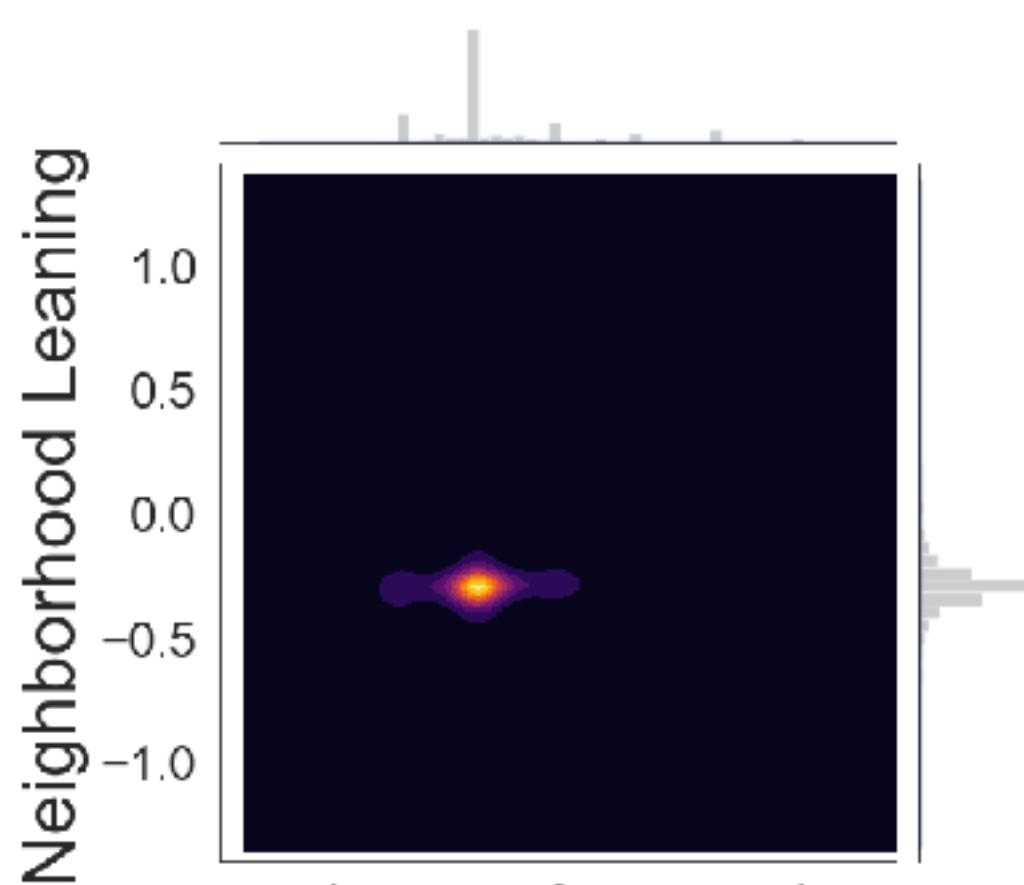
WHY IDEOLOGY WORKS?

Because users tend to be coherent in their behaviour and forms communities sharing similar consuming contents

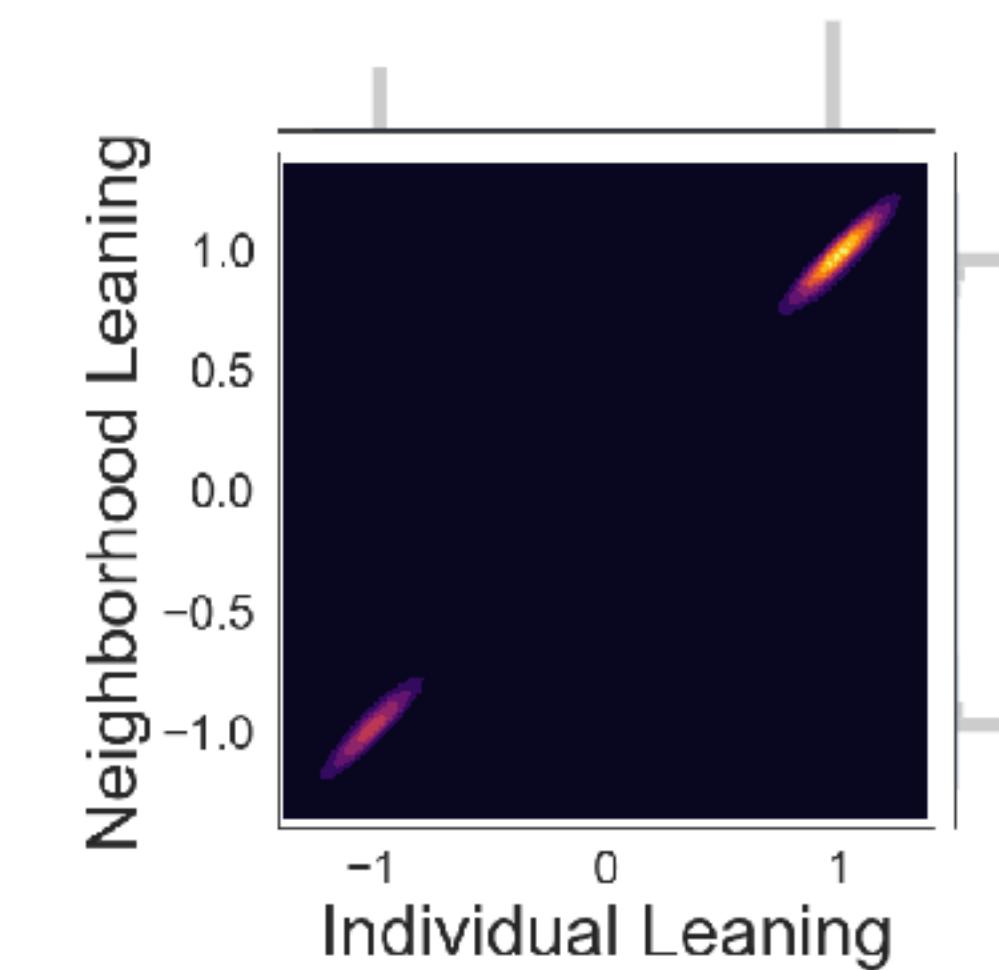
Cinelli, M., De Francisci Morales, G., Galeazzi, A., Quattrociocchi, W. and Starnini, M., 2021. The echo chamber effect on social media. *Proceedings of the National Academy of Sciences*



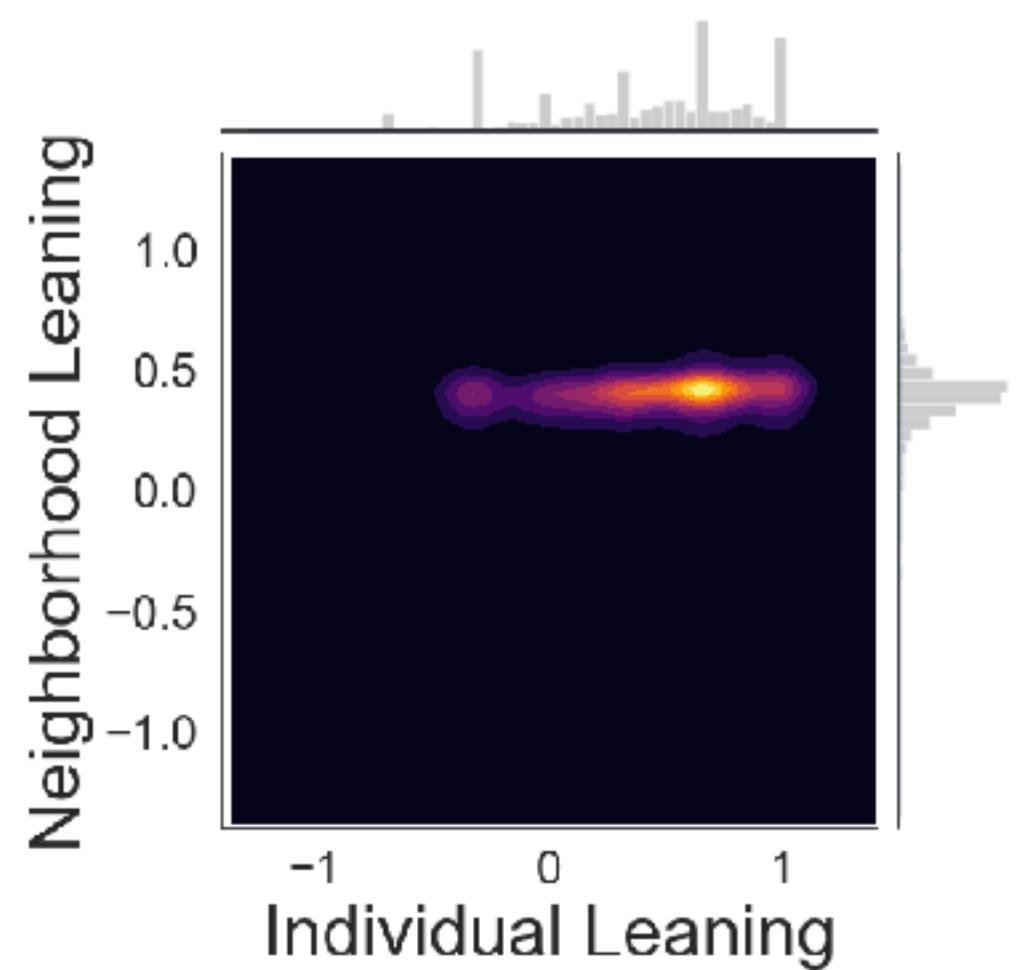
Twitter (Abortion)



Reddit (Politics)



Facebook (Vaccines)



Gab

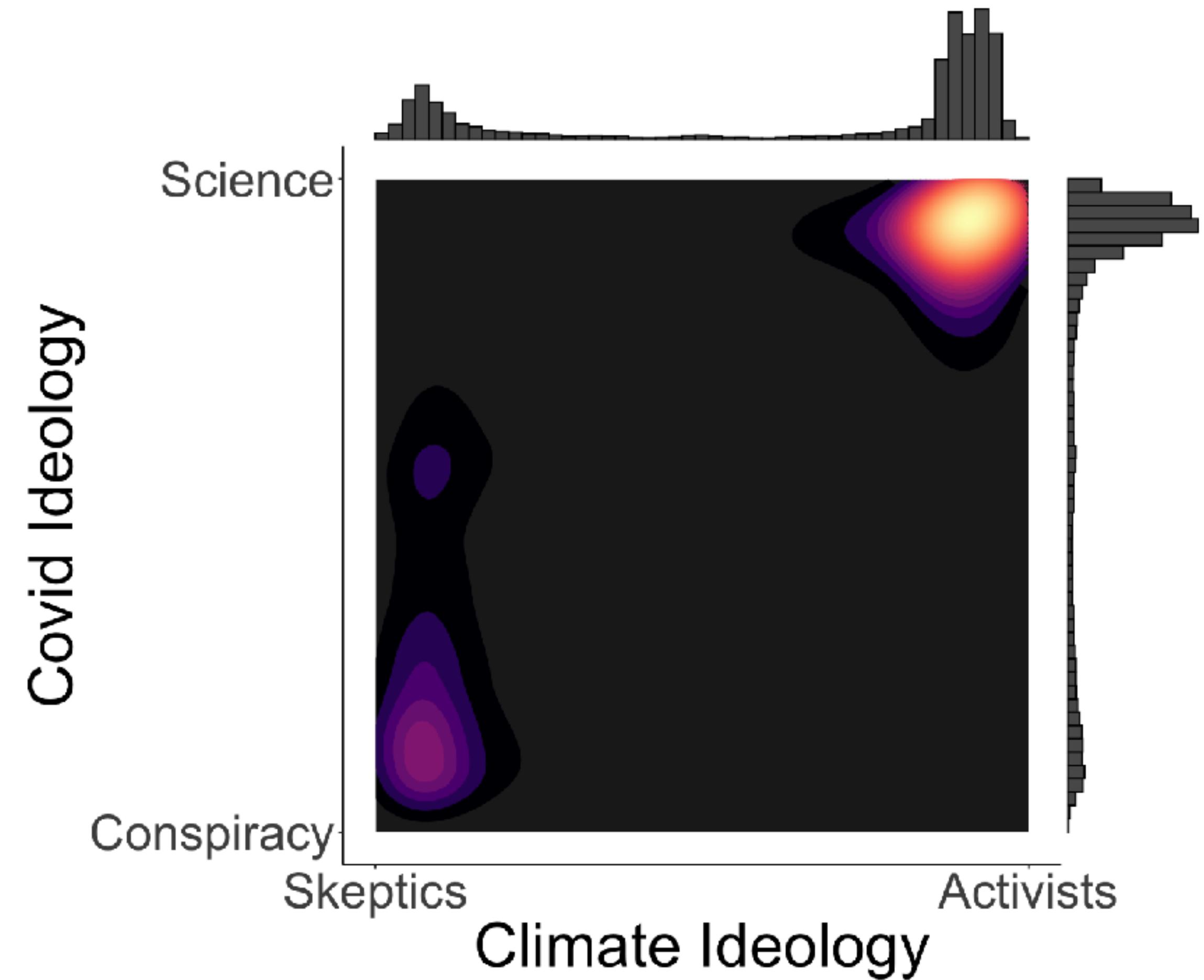
WHERE IT FAILS?

Where ideology fails:

- ▶ When data are not complete enough (e.g YouTube)
- ▶ When data are not rich enough
- ▶ When there are other factors that segregate users (e.g. geographical conflation)

FUTURE WORKS

- ▶ We sampled the debate: can we do it dynamically?
- ▶ Are communities from different debate “coherent”
- ▶ Who leads the debate and drives the attention on different topics?



THAT'S THE END, FOLKS!

THANK YOU!

CRAZIE!

Contact: alessandro.galeazzi@unive.it
 @ DeveloperGale