

PROTOCOL 3

*How do weather
forecast platforms
represent climate
change in
connection to
extreme weather
events?*

Data collection

Protocol 3 analyses the coverage of 15 extreme weather events worldwide made by a selection of five weather websites from the ones investigated in protocol 2. The events selected are all correlated to climate change according to studies from the WWA (World Weather Attribution).

Reports and articles on the specific weather phenomena are retrieved by scraping the selected websites.

SOURCES

The World Weather Attribution (WWA) is a team of researchers from several institutions worldwide born to study actual extreme weather phenomena and assess their correlation to climate change in terms of frequency and/or intensity.

SELECTION - EVENTS

Out of all the events they investigated, 15 were selected: they are all significantly correlated with climate change and varied in terms of both event type (e.g. storm) and location. A spreadsheet (Dataset P3_events) was manually compiled, mapping key metrics for each event. The saved information includes temporal and geographical coordinates as well as details on the type of event and its relation to the climate crisis.

SELECTION - WEBSITES

Out of the 50 websites analysed in protocol 2, five were selected. They comply with the following conditions:

1. they must significantly address climate change (according to protocol 2);
2. they must have an archive of weather news going back to (at least) Jan 2017.

SCRAPING - WEBSITES

A custom python script based on Selenium was used to scrape the news archive of each website. Textual information was saved from the previews of articles published in set time frames, each related to one extreme weather event.

SELECTION - ARTICLES

The scraped texts were analysed - partly manually and partly with automated filters - in order to detect all individual articles covering the selected extreme weather events. In total, 275 relevant articles were identified.

SCRAPING - ARTICLES

The articles were subjected to a second round of scraping, this time more detailed and focused not on the previews but on the article pages. Scraped information was saved into a spreadsheet (Dataset P3_Articles).

DATASETS



Datates P3_events

Including the selected 15 extreme weather events assessed by the World Weather Attribution.



Datates P3_articles

Spreadsheet with detailed information from the 275 articles by 5 websites covering the selected extreme weather events.

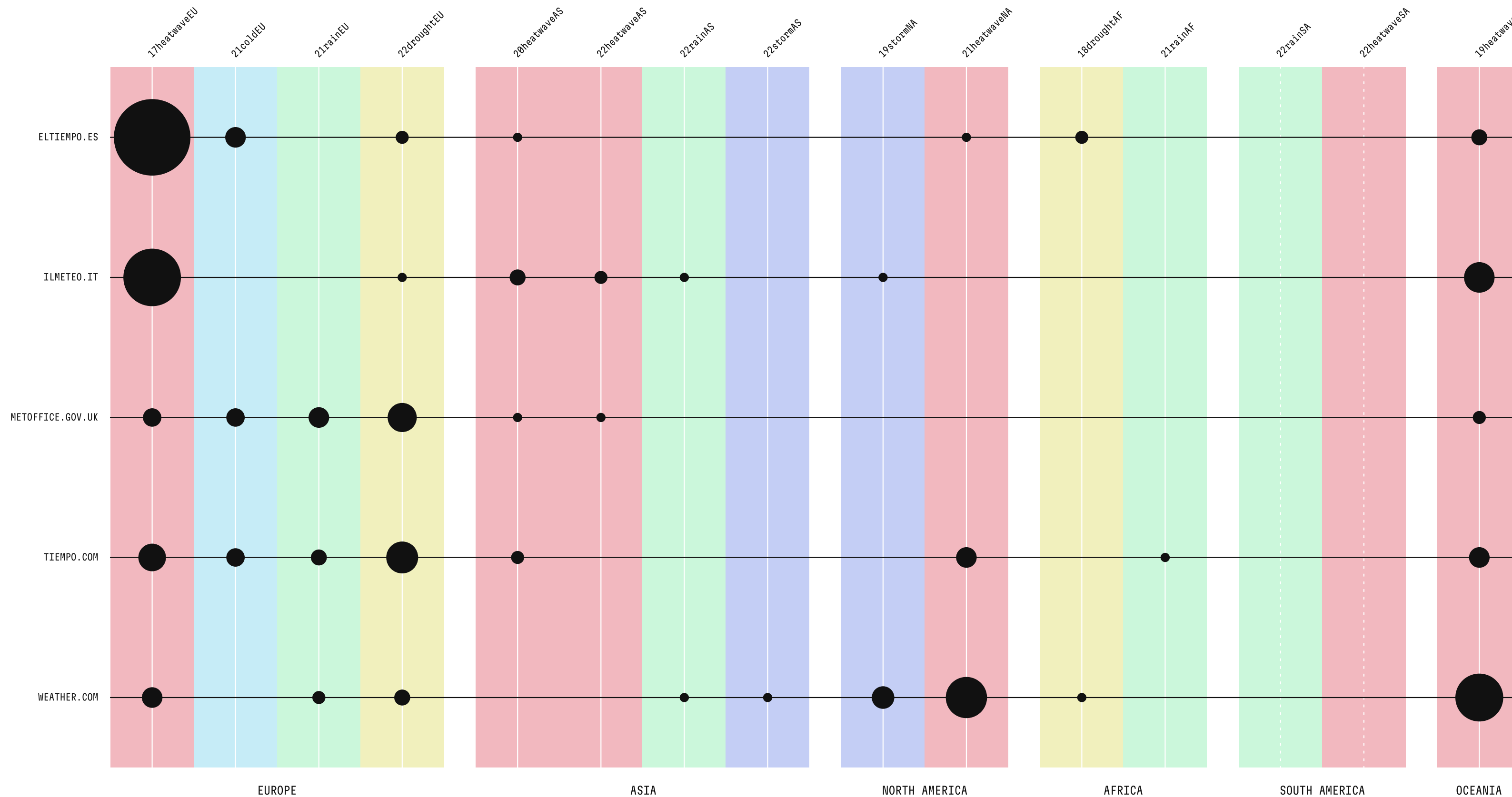
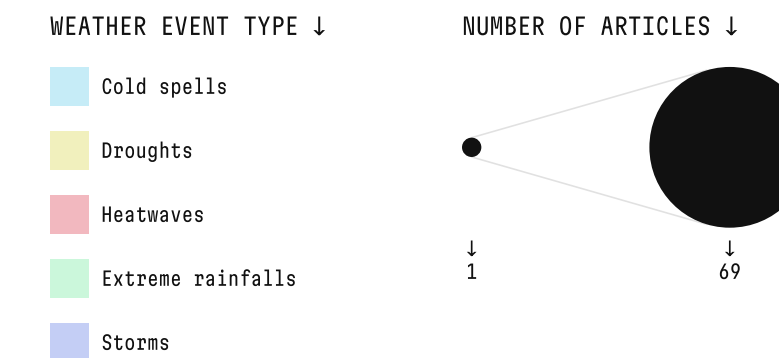
◆ P3 → DATA COLLECTION → MATRIX PLOT → VIZ 01

The visualisation on the left is a matrix plot showing the selected articles at the intersection between extreme weather events and websites:

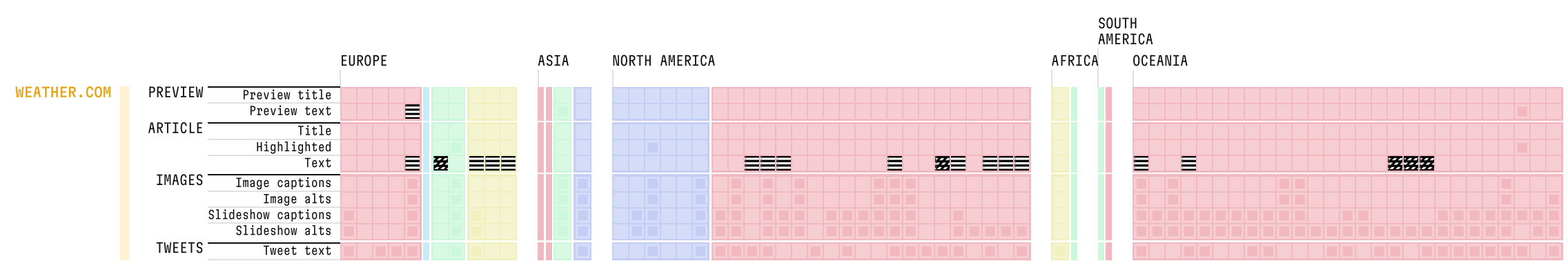
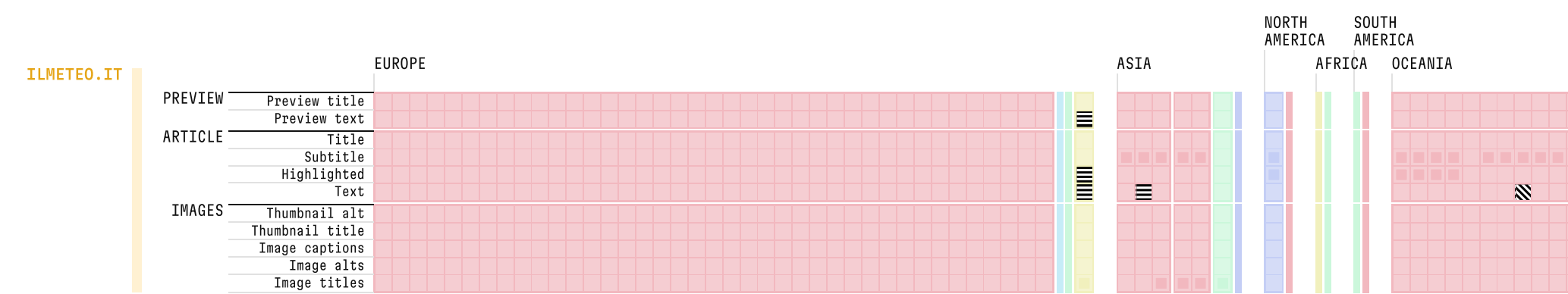
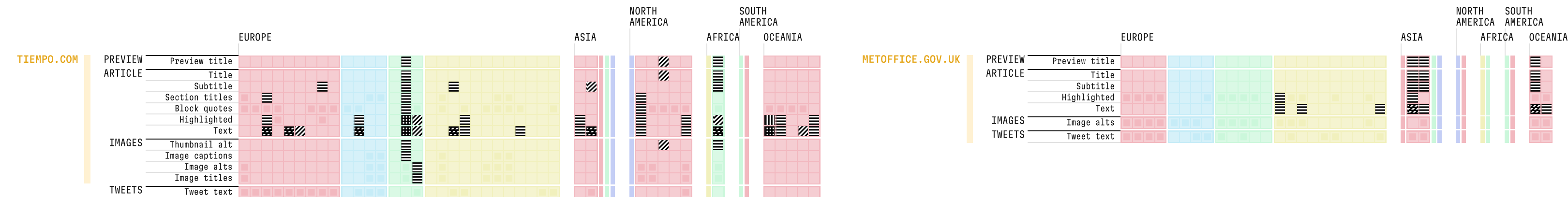
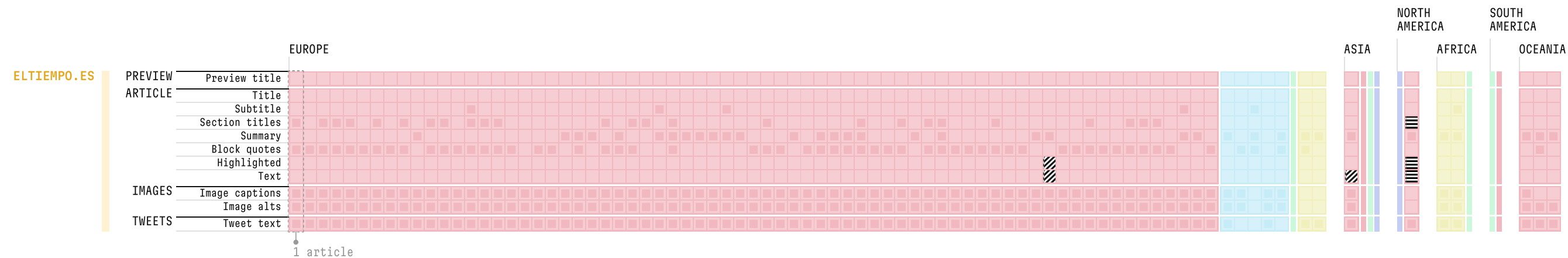
- X axis → extreme weather events < continents
- Y axis → websites

Websites are ordered alphabetically, while weather events are grouped on the basis of the continent where they took place and ordered chronologically inside each group. Event types (e.g. storm) are identified by colour.

The number of articles is represented through the size of a circle at the intersection between event and website. The absence of the circle means the absence of articles for that event in that website.



Texts



The text entries resulting from the articles' scraping were filtered in order to detect explicit references to the climate crisis and divide articles in climate-change-citing and climate-change-avoiding ones. All texts were then translated to English (when in a different language) in order to allow comparison.

SELECTION

Both texts in the preview of the articles and texts inside the article pages were included in the analysis.

FILTERING

The detection of articles that explicitly cite climate change was handled with Google Sheets' conditional formatting options. Four key terms were considered: *climate change*, *climate crisis*, *climate emergency*, *global warming* (plus their translations in the language corresponding to the considered website). Out of 275 articles, only 52 include at least one of the terms listed above.

TRANSLATION

A custom Python script based on *GoogleTrans* was used to translate all the extracted texts into a single language: English. The code ran through all the entries and saved the translations into a new csv file.

Each row of the csv file (Dataset **P3_translations**) includes both:

- the translated text;
- information on website and article from which the original text was extracted.

DATASET



Dataset P3_translations
Spreadsheet resulting from the translation of the textual entries from the articles scraping.

◇ P3 → TEXTS → MATRIX PLOT → VIZ 01

The visualisation on the left is a series of matrix plots (one for each website) showing text entries at the intersection between articles and text types:

- X axis → articles < extreme weather events < continents
- Y axis → text types

Each individual text is represented as a square which is covered by a black and white texture when it includes a climate change reference - with the texture depending on the actual term used. The purpose of this matrix plot is to map climate change references across websites and in relation to the text types (which are connected to visibility and importance).

Tag clouds – categories

Merged texts' tag clouds were further investigated: the words they contain were grouped on the basis of their meaning and in accordance with the evaluation criteria previously set.

Meaningful comparisons between all articles and climate-change-citing articles were provided through categorisation and colour coding.

CATEGORISATION

Each word from the two merged tag clouds was categorised into 1 exclusive category of 15, according to its meaning. Categories are the same as in protocol 1 and 2, and keep in consideration both the specific words in the tag clouds of all protocols and the evaluation criteria set prior to starting the analysis.

Each category can be made of 1, 2 or 3 specific subcategories. Categories and subcategories are listed and defined on the opposite page. However, the analysis initially focus on first-level categories (highlighted in orange in the list).

COLOUR CODING

A colour for each category was established, then the words in the merged texts' tag clouds were coloured according to their category of belonging. Working directly with colour on the clouds allows to see:

- variety → how many words for each category;
- frequency → position and size of words for each category.

ALL ARTICLES ↔ CLIMATE-CHANGE-CITING ARTICLES

Comparing the distribution of each colour for the two tag clouds (*all articles* and *climate-change-citing articles*) allows to go deeper into analysing whether and how communications addressing the climate crisis differ from the regular flow of news in the websites.

◆ P3 → TEXTS → TAG CLOUDS → VIZ.03

The visualisation on the right shows for each category the pair of tag clouds placed side by side, with the words falling in the category highlighted in colour.

In order to give more importance to the colours, words were replaced with rectangles through Dan Ross' *Flow Block* font. The terms falling in the category were made readable in an ordered list (most frequent to least frequent) that follows each tag cloud. Words in the *all articles* list that don't appear in the *climate-change-citing* list are faded.



Weather

ALL ARTICLES



fire, fires, weather, air, drought, rain, clouds, climate, burning, burned, wildfires, wind, change, rainfall, storms, forecast, showers, winds, smoke, dry, rains, wildfire, pressure, anticyclone, thunderstorms, sun, storm, flames, bushfires, cheron, flooding, precipitation, meteorological, snow, blaze, meteorologist, lightning, skies, sunny, blazes, radiation, sunshine, gusts, heatwave, driest, imelda, typhoon

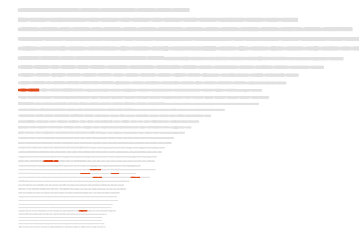
CLIMATE-CHANGE-CITING



fire, fires, climate, change, weather, drought, air, burning, burned, wildfires, dry, wildfire, winds, rain, rainfall, meteorological, smoke, flames, forecast, blaze, storms, bushfires, flooding, floods, driest, lightning, pressure, blazes, wind, droughts, humidity, anticyclone, atmospheric, meteorologist, heatwave, clouds

Causes

ALL ARTICLES



due, associated, caused, issued, affect, cause, affected, department

CLIMATE-CHANGE-CITING



due, associated, emissions, fueled, cause, greenhouse, gas, caused, affected, linked, consequences, influence, attribution, lead, result

Solutions

ALL ARTICLES



firefighters, officials, authorities, chief, agency, firefighting, sheriff, police

CLIMATE-CHANGE-CITING



firefighters, officials, agency, firefighting, brigade, department, police, noaa, nifc, authorities, management, control, minister, spokesperson, ready, beat, environmental

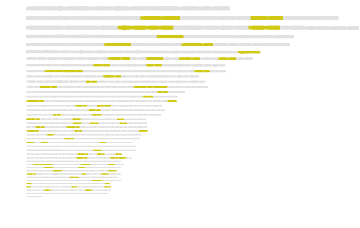
Impacts

ALL ARTICLES



high, many, extreme, record, wave, conditions, new, much, large, average, situation, even, several, rise, least, records, already, strong, first, reach, reached, risk, destroyed, warnings, intense, low, emergency, level, end, highest, help, warning, higher, important, heavy, increase, evacuation, exceed, waves, died, worst, hit, damage, deaths, need, evacuations, evacuate, great, levels, largest, lower, exceeded, events, forced, severe, water, increasing, reaching, experiencing, dangerous, evacuated, suffered, warned, significant, lot, ever, frequent, dead, numerous, devastating, death, increasingly, unprecedented, effects, problem, impacts, rising

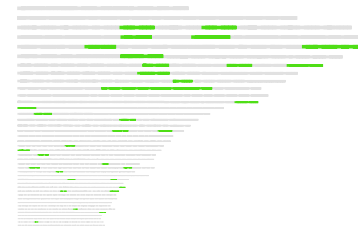
CLIMATE-CHANGE-CITING



extreme, record, high, new, wave, many, several, conditions, already, situation, least, records, much, even, large, deaths, destroyed, waves, increase, risk, reached, emergency, highest, end, help, evacuation, worst, events, first, hit, intense, rise, need, increasing, great, low, higher, reach, died, suffered, evacuations, exceptional, worse, largest, major, extremely, effects, death, level, frequent, extraordinary, historic, really, experienced, anomaly, greater, devastating, evacuated, dangerous, strong, increased, event, catastrophic, evacuate, exceeded, lot, impacts, frequency, unprecedented, ever, alltime, top, forced, exceed, disaster, important

Time

ALL ARTICLES



days, week, may, summer, year, month, day, thursday, friday, june, weekend, sunday, time, july, saturday, wednesday, tuesday, monday, years, hours, month, friday, weekend, months, august, weeks, winter, times, morning, thursday, period, right, prolonged, saturday, earlier, early, later, afternoon, spring, century, times, september, pm, january, fall

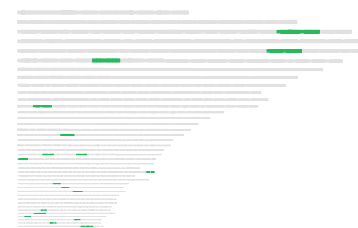
CLIMATE-CHANGE-CITING



year, summer, tuesday, days, june, time, years, july, may, week, wednesday, day, monday, season, hours, month, friday, weekend, months, august, weeks, winter, times, morning, thursday, period, right, prolonged, saturday, earlier, early, later, afternoon, spring, century, sunday, yesterday

Past & present

ALL ARTICLES



continue, since, last, now, recent, today, 2017, current, 2020, 2019, history, continues, 2021, 2022, latest, historic, currently, previous, past, continued, ago

CLIMATE-CHANGE-CITING



since, last, continue, now, recent, 2020, today, 2022, current, latest, 2019, previous, 2021, ago, past, 2017, 2018, continued, continues, currently

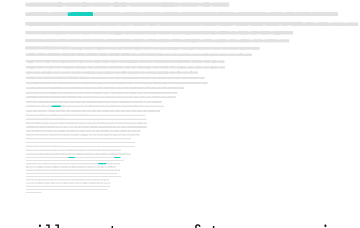
Future

ALL ARTICLES



will, next

CLIMATE-CHANGE-CITING



will, next, soon, future, scenario

Anticipation

ALL ARTICLES



can, expected, around, likely, possible, expect

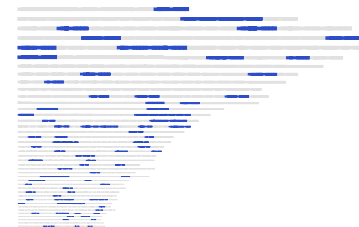
CLIMATE-CHANGE-CITING



can, around, expected, likely, estimated, seems, think, possible

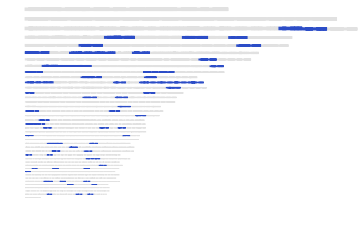
Locations

ALL ARTICLES



areas, south, peninsula, north, australia, islands, spain, europe, area, country, northern, southern, us, across, western, uk, state, canary, eastern, east, wales, national, england, west, cantabrian, county, galicia, town, northwest, continent, region, australian, southeast, states, mediterranean, regions, atlantic, coast, city, balearic, iberian, andalusia, world, california, castilla, northeast, place, arizona, italy, southwest, united, madrid, london, valley, la, houston, sydney, pyrenees, local, france, portugal, texas, ebro, arctic, catalonia, provinces, washington, places, cordoba, victoria, scotland, guadalquivir, germany, european, african, global, canada, inland, territory, capital, mancha, canberra, africa, oregon, locally, coasts, kingdom, southeastern, idaho, jaen, granada, strait, cities, land, coastal, british

CLIMATE-CHANGE-CITING



us, area, australia, areas, uk, south, across, london, country, europe, state, spain, north, global, world, arctic, california, region, county, washington, east, western, west, wales, southern, england, states, australian, national, city, siberia, canada, oregon, northwest, peninsula, northern, arizona, portland, southeast, town, idaho, regions, place, seattle, france, coast, russia, eastern, portugal, siberian, sydney, united, land, located, earth, germany, cities, pacific, victoria, africa, hemisphere, planet, sahara, ground, capital, madrid, saharan, america

Temperature

ALL ARTICLES



temperatures, heat, hot, temperature, cold, warm, degrees, 40c, tropical, °c, warming, cool, hottest, thermal, °c

CLIMATE-CHANGE-CITING



heat, temperatures, temperature, hot, warming, degrees, warm, cold, warmest, known, tropical, °c, cool, hottest, warmer, temp, celsius, cooling, heatrelated, °c

Natural environment

ALL ARTICLES



water, sea, forest, animals, river, reservoirs, mountain, mountains, koalas, environment, basin

CLIMATE-CHANGE-CITING



water, river, forest, ice, environment, natural, sea, lake

Science

ALL ARTICLES



according, miles, average, maximum, recorded, values, data, maximum, known, know, study, minimum, report, information

CLIMATE-CHANGE-CITING



according, miles, average, maximum, recorded, recorded, study, scientists, data, research, values, university, know, information, amount, researchers, reports, studies, experts, resources

Media

ALL ARTICLES



said, told, reported, video, news, say, tell, press, episode, media

CLIMATE-CHANGE-CITING



said, told, reported, news, services, weathercom, press, update, media, episodes, says, show

People

ALL ARTICLES



people, homes, residents, health, community, communities, home, man

CLIMATE-CHANGE-CITING



people, homes, residents, health, community, home, human

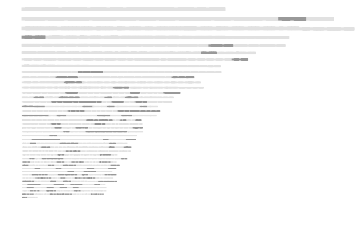
Others

ALL ARTICLES



due, associated, caused, issued, affect, cause, affected, department

CLIMATE-CHANGE-CITING



due, associated, emissions, fueled, cause, greenhouse, gas, caused, affected, linked, consequences, influence, attribution, lead, result

CATEGORIES AND SUBCATEGORIES WITH THEIR EXPLANATIONS

- WEATHER**
 - Forecasts** → words referring to weather and weather forecasting (*e.g. meteorological*);
 - Phenomena** → words referring to weather phenomena and events (*e.g. rain*);
- CAUSES**
 - General** → words generally related to causation (*e.g. due*);
 - Climate change** → words referring to specific causes of climate change (*e.g. greenhouse*);
- SOLUTIONS**
 - Action** → words conveying the general idea of action/reaction (*e.g. fight*);
 - Institutions** → words related to institutions or governments, supposed to act against climate change (*e.g. intergovernmental*);
 - Climate change** → words related to specific behaviours connected with climate change savviness (*e.g. sustainability*);
- IMPACTS**
 - Extreme** → words conveying a sense of out of the ordinary (*e.g. extreme*);
 - Effects** → words generally related to effects (*e.g. impacts*);
 - Threats** → words related to clearly negative effects (*e.g. disasters*);
- TIME**
 - Time** → words expressing general time periods and intervals (*e.g. winter*);
- PAST AND PRESENT**
 - Past** → words expressing specific moments in the past, specifically before the moment when the data was collected (*e.g. 2019*);
 - Present** → words generally addressing the present moment (*e.g. now*);
- FUTURE**
 - General** → words generally related to future (*e.g. projections*);
 - Specific moment** → words expressing specific moments in future time (*e.g. 2050*);
- ANTICIPATION**
 - Uncertainty** → words expressing uncertainty or doubt (*e.g. might*);
 - Certainty** → words expressing certainty or confident expectancy (*e.g. sure*);
- LOCATIONS**
 - General** → general geographical terms (*e.g. longitude*);
 - Global** → words related to earth as a whole (*e.g. global*);
 - Local** → words referring to specific locations (*e.g. greenland*);
- TEMPERATURE**
 - Temperature** → words related to temperature (*e.g. heat*);
- NATURAL ENVIRONMENT**
 - Natural environment** → words related to natural environments, ecosystems and/or their elements (*e.g. mountain*);
- SCIENCE**
 - Institutions** → words related to scientists and scientific institutions (*e.g. ipcc*);
 - Studies** → words related to scientific studies and measurements (*e.g. data*);
 - Information** → words related to scientific communications (*e.g. report*);
- MEDIA**
 - Media** → words generally related to formats and channels (*e.g. photo*);
- PEOPLE**
 - People** → words connected with humanity as a group (*e.g. human*);
- OTHERS**
 - Others** → everything else;

Tag clouds – subcategories

The last textual analysis focused on climate-change-citing articles only: its purpose was to inquire deeper the representation of climate change made by weather forecast websites in connection with extreme weather events. To do that, words from the tag cloud were rearranged according to second-level categories.

CLIMATE-CHANGE-CITING

Finally, only the tag cloud regarding climate-change-citing articles was taken into consideration. Previous analysis had already provided a satisfying comparison between news in general and articles which explicitly reference the climate crisis. The focus shifted then to a more detailed exploration of textual representations of the climate crisis in the extreme weather events articles.

CATEGORISATION

The focus shifted on subcategories (second-level categorisation) from the ones previously listed and defined (complete list available on the right, subcategories highlighted in orange).

CLUSTERING

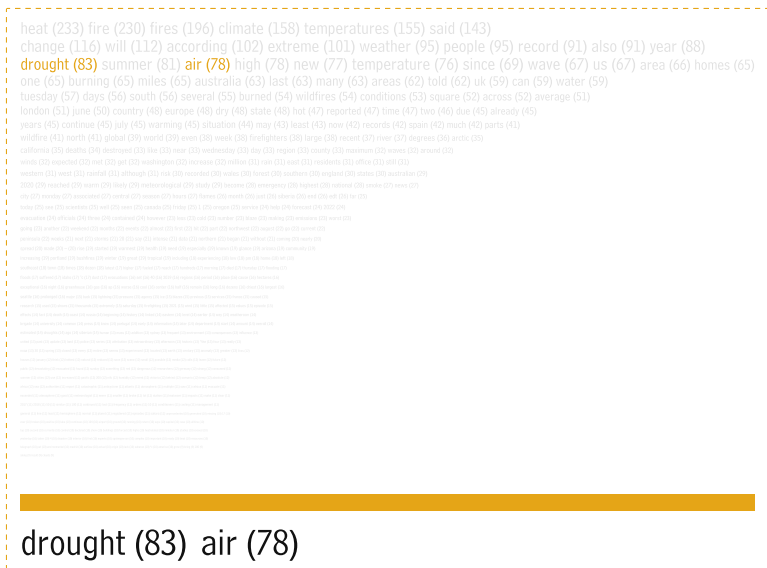
The tag cloud was broken into single words, which were then positioned according to the subcategory they belong to. The information available through this kind of display is:

- variety → how many words for each subcategory;
- frequency → size of words for each subcategory.

◆ P3 → TEXTS → TAG CLOUDS → VIZ 04

The visualisation on the right shows the words from the tag cloud grouped according to the category and subcategory they belong to. Words are readable, and their size is linked to their frequency as in the original tag cloud. Furthermore, each word is followed by its absolute frequency (in brackets).

The colour coding previously established is maintained in order to strengthen the visual clustering of subcategories in higher-level groups.



drought (83) air (78)

Weather

FORECASTS

climate (158)
change (116) air (78)

meteorological (29) forecast (24) pressure (15) atmosphere (11)

meteorologist (1)

Causes

GENERAL

due (45) associated (27) emissions (23) fueled (17) cause (14)

caused (13) affected (11) linked (14) consequences (11) influence (12) attributed (12)

had (12) read (9)

Solutions

ACTIONS

management (11) center (10) help (10) best (10)

INSTITUTIONS

firefighters (38) officials (24)

agency (15) firefighting (15) brigade (14)

department (14) police (13) team (13) ink (12)

authorities (11) review (10)

PHENOMENA

fire (230) fires (196)
weather (95)
drought (83) burning (65)
burned (54) wildfires (54) dry (48)
wildfire (41) winds (32) rain (31) rainfall (31)

smoke (27) flames (26) blaze (23) storms (21) bushfires (19)

flooding (17) floods (17) dried (16) lightning (15) blazes (15) wind (15)

droughts (14) humidity (13) anticyclone (11) hurricane (11) rain (9)

CLIMATE CHANGE

greenhouse (16) gas (14)

Impacts

EXTREME

extreme (101)
record (91)
high (78)
new (77)
many (63)
several (55)

already (45) least (43)

records (42) much (42)

even (38) large (38)

increase (32) reached (29)

highest (28) end (26) worst (23)

first (22) hit (22) intense (21) rise (19)

increasing (19) great (19) low (18)

higher (17) reach (17) exceptional (16)

worse (16) largest (16) major (15) extreme (15)

level (14) frequent (13) extraordinary (13) historic (13)

risky (13) anomaly (13) greater (13) strong (13)

increased (13) exceeded (12) hot (12) frequency (11)

unprecedented (11) ever (10) often (10) the (10) record (10)

important (10)

Time

GENERAL

year (88) summer (81) tuesday (57) days (56) june (50) time (47)

years (45) july (45) may (43) week (38) wednesday (33) day (33) monday (27) month (26) hours (27)

month (26) friday (25) weekend (22) months (22) august (22) weeks (21) winter (19) times (18) morning (17) thursday (17) period (16) night (14)

prolonged (14) saturday (13) earlier (14) early (14) later (14) afternoon (13) spring (13) century (13) january (12) winter (12) recently (12)

Past & present

PAST

since (69) last (63) recent (37)

recent (37) 2020 (29) 2020 (29) 2022 (24) latest (17)

2019 (14) previous (13) 2021 (13) ago (14) said (13) 1617 (11) 2018 (11)

continued (11)

EFFECTS

wave (67)
conditions (53)
situation (44) waves (32)

events (22) effects (14) experienced (13) read (12)

reports (11)

THREATS

deaths (34) destroyed (33)
risk (30) emergency (28) help (24)
evacuation (24) need (19) died (17)
suffered (17) evacuations (14) death (14)
deteriorating (13) evacuated (12) dangerous (12)
catastrophic (11) evacuate (11) forced (11) disaster (10)

Future

GENERAL

will (112)

next (21) soon (12) later (12) sooner (11)

Anticipation

UNCERTAINTY

can (59)

around (32) estimated (14) seems (12) then (12)

possible (11)

Locations

GENERAL

area (66)

areas (62)

south (56)

across (52) state (48)

north (41) region (33)

county (33) east (31)

western (31) west (31)

southern (30) states (30)

national (28) city (27) northwest (22)

peninsula (22) northern (21) southeast (18)

town (18) regions (16) place (16) coast (14)

eastern (14) land (13) located (13) sites (12)

hemisphere (11) ground (10) coast (10)

Temperature

GENERAL

heat (233) temperatures (155) temperature (76) hot (47)

warming (45) degrees (36) warm (29) cold (23) warmest (19) known (19) tropical (19) °c (17) cool (16) hottest (15) heavy (15) unless (15)

cooling (11) maximum (10) °f (10)

SPECIFIC MOMENT

CERTAINTY

expected (32) likely (29)

GLOBAL

world (39) global (39)

earth (12) planet (11)

LOCAL

us (67)

australia (63)

uk (59) london (51)

country (48)

europe (48) spain (42)

arctic (35) california (35)

washington (32) wales (30)

england (30) australian (29)

siberia (26) canada (25) oregon (25)

arizona (19) portland (19) idaho (17)

skatelle (16) france (15) russia (14) portugal (14)

siberian (14) sweden (13) united (13) germany (12)

peru (12) victoria (12) africa (12) siberia (11) north (10)

usain (10) america (10)

Natural environment

GENERAL

water (59)

river (37) forest (30) ice (15) environment (13) natural (13) sea (12) sea (10)

Science

WHO

scientists (25) university (14) researchers (12)

research (10)

WHAT

according (102)
miles (65)
average (51)

maximum (32) recorded (30)

study (29) data (21) research (19)

values (15) amount (14) value (10)

INFORMATION

know (14) information (14) report (11) research (10)

Media

GENERAL

said (143)

told (62)

reported (47)

news (27)

services (15)

weather.com (14)

press (14)

update (13)

media (12)

articles (11)

was (10) ever (10)

People

GENERAL

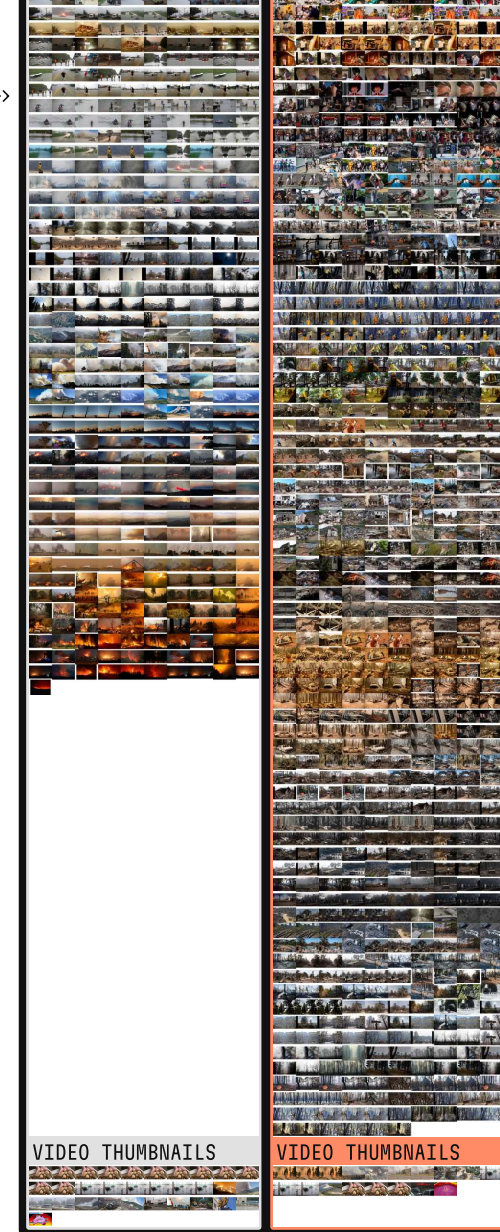
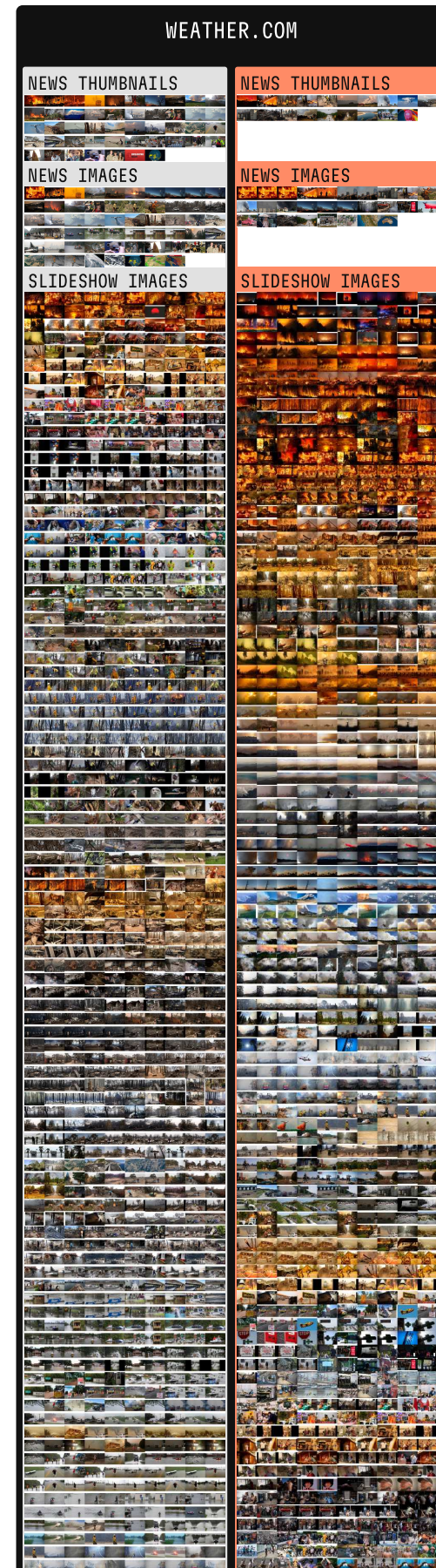
people (95) homes (65)

residents (31) health (19) community (19) home (18) human (13)

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 - Action** → words conveying the general idea of action/reaction (*e.g. fight*);
 - Institutions** → words related to institutions or governments, supposed to act against climate change (*e.g. intergovernmental*);
 - Climate change** → words related to specific behaviours connected with climate change savviness (*e.g. sustainability*);
- IMPACTS
 - Extreme** → words conveying a sense of out of the ordinary (*e.g. extreme*);
 - Effects** → words generally related to effects (*e.g. impacts*);
 - Threats** → words related to clearly negative effects (*e.g. disasters*);
- TIME
 - Time** → words expressing general time periods and intervals (*e.g. winter*);
- PAST AND PRESENT
 - Past** → words expressing specific moments in the past, specifically before the moment when the data was collected (*e.g. 2019*);
 - Present** → words generally addressing the present moment (*e.g. now*);
- FUTURE
 - General** → words generally related to future (*e.g. projections*);
 - Specific moment** → words expressing specific moments in future time (*e.g. 2050*);
- ANTICIPATION
 - Uncertainty** → words expressing uncertainty or doubt (*e.g. might*);
 - Certainty** → words expressing certainty or confident expectancy (*e.g. sure*);
- LOCATIONS
 - General** → general geographical terms (*e.g. longitude*);
 - Global** → words related to earth as a whole (*e.g. global*);
 - Local** → words referring to specific locations (*e.g. greenland*);
- TEMPERATURE
 - Temperature** → words related to temperature (*e.g. heat*);
- NATURAL ENVIRONMENT
 - Natural environment** → words related to natural environments, ecosystems and/or their elements (*e.g. mountain*);
- SCIENCE
 - Institutions** → words related to scientists and scientific institutions (*e.g. ipcc*);
 - Studies** → words related to scientific studies and measurements (*e.g. data*);
 - Information** → words related to scientific communications (*e.g. report*);
- MEDIA
 - Media** → words generally related to formats and channels (*e.g. photo*);
- PEOPLE
 - People** → words connected with humanity as a group (*e.g. human*);
- OTHERS
 - Others** → everything else;

Images



All images included in the articles - except from embedded tweets - were taken into consideration.

IMAGE COUNT

The scraping of previews and article pages returned a total of 3,538 pictures connected to the 15 extreme weather events selected (either from climate-change-citing and climate-change-avoiding news). Images from embedded tweets and social content in general were not included, since they are part of a radically different web context.

IMAGE TYPES

The selected images can be of various kind: thumbnails in the article preview, article covers, pictures inside the article page, thumbnails of videos in the article page or even images from slideshows embedded in the article page.

CLIMATE-CHANGE-AVOIDING ↔ CLIMATE-CHANGE-CITING

Images were classified according to whether their source article explicitly referred climate change or not. The comparison between the visual spaces of climate-change-citing and climate-change-avoiding articles allows to investigate the tendencies peculiar to representations explicitly connected with the climate crisis.

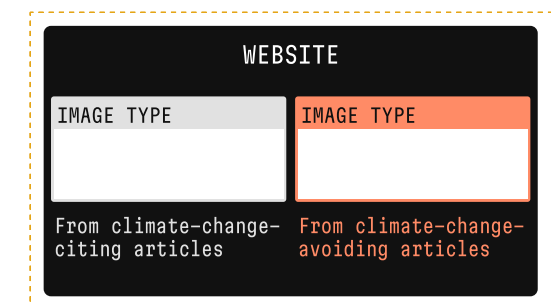
GRID MONTAGES

ImageJ was used to create grid montages, with the purpose to highlight both quantities of images in specific groups and dominant colours and visual aspects.

◆ P3 → IMAGES → GRIDS → VIZ 01

The visualisation on the left shows image grids based on image types, source websites and relation to climate change of the respective source article. Each website constitutes an enclosed group, in which types and climate-change-relation build a tabular frame which encourages comparison.

The visualisation is designed as follows:



Network

Images were arranged into a network based on AI image captioning. The network provided the base for mapping the visual representations of climate change in the websites.

VISUAL SIMILARITY

The 3,538 images were fed to Yale DHI Lab's PixPlot in order to get an interactive image network based on similarity: each picture is captioned from a previously trained neural network model, then all pictures are arranged in the space according to their content similarity.

The network can be explored through panning and zooming in the space or jumping to hotspots (image clusters). PixPlot automatically identifies some default hotspots, but they can also be created and curated by the user.

TAGGING

A static screenshot of the network was taken and manually tagged according to groups and clusters visually identified while exploring the interactive model and with the help of automatically identified hotspots.

P3 → IMAGES → NETWORK → VIZ 00

The visualisation on the right shows the 3,538 images (resulting from the scraping as previously described) displayed in the space on the basis of similarity (according to PixPlot's process of image captioning and positioning through a pre-trained convolutional neural network model).

Areas characterised by the predominance of a specific subject are outlined and tagged, even if subject clusters are often more spread around and less localised than they appear.

CLUSTERING

The network mapping was expanded into a detailed clustering of the images through the creation of a hierarchy of manually curated hotspots. The categorisation process kept into consideration the actual images' features and subjects as well as the evaluation criteria previously set. The hierarchy of (not exclusive) image clusters is visible on the opposite page.

INTERACTIVE NETWORK



PixPlot P3
Interactive network including all the 3,538 images, displayed according to image similarity and with hotspots based on images' subjects.

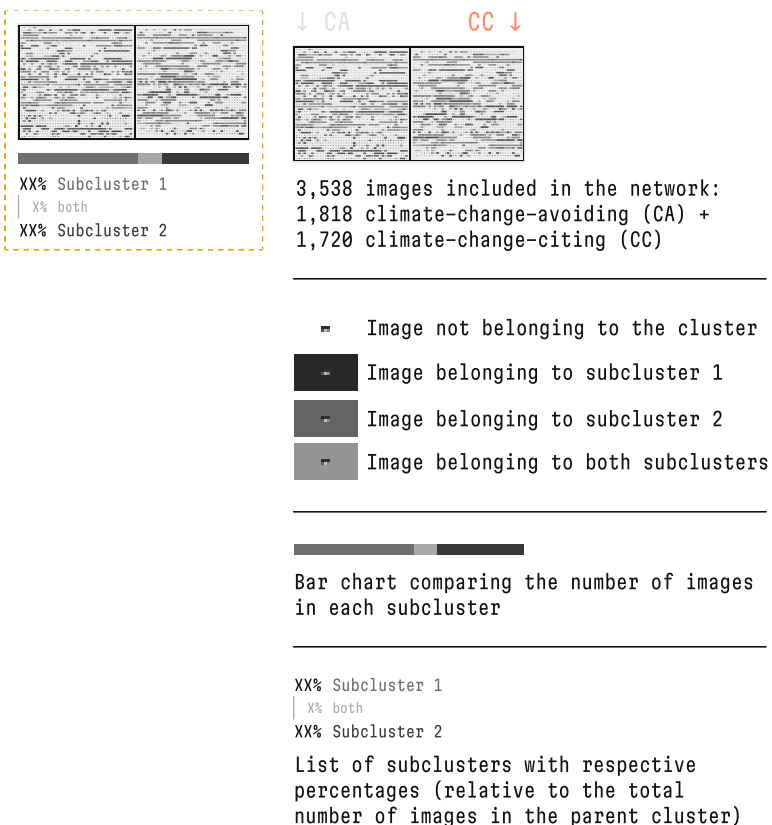


P3 → IMAGES → NETWORK → VIZ 01

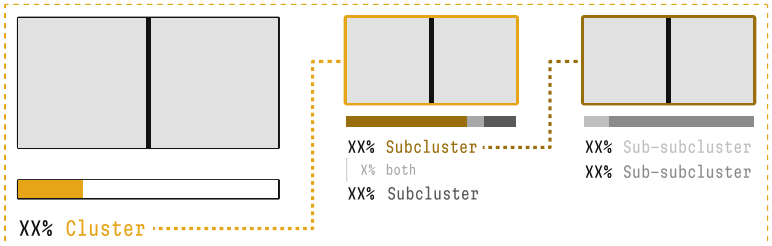
The visualisation on the right displays the cluster hierarchy and the quantity of images for each cluster and subcluster. It builds on the metadata display provided by PixPlot: images from climate-change-citing (CC) and climate-change-avoiding (CA) articles are organised in two distinct grids. colour is used to distinguish one category from the others as well as for highlighting the links in the hierarchy.

Clusters are ordered from the most populated to the least populated. Quantities are always expressed as percentages, since the most interesting comparison in that sense is that between child clusters belonging to the same parent cluster (or that of parent clusters between each other).

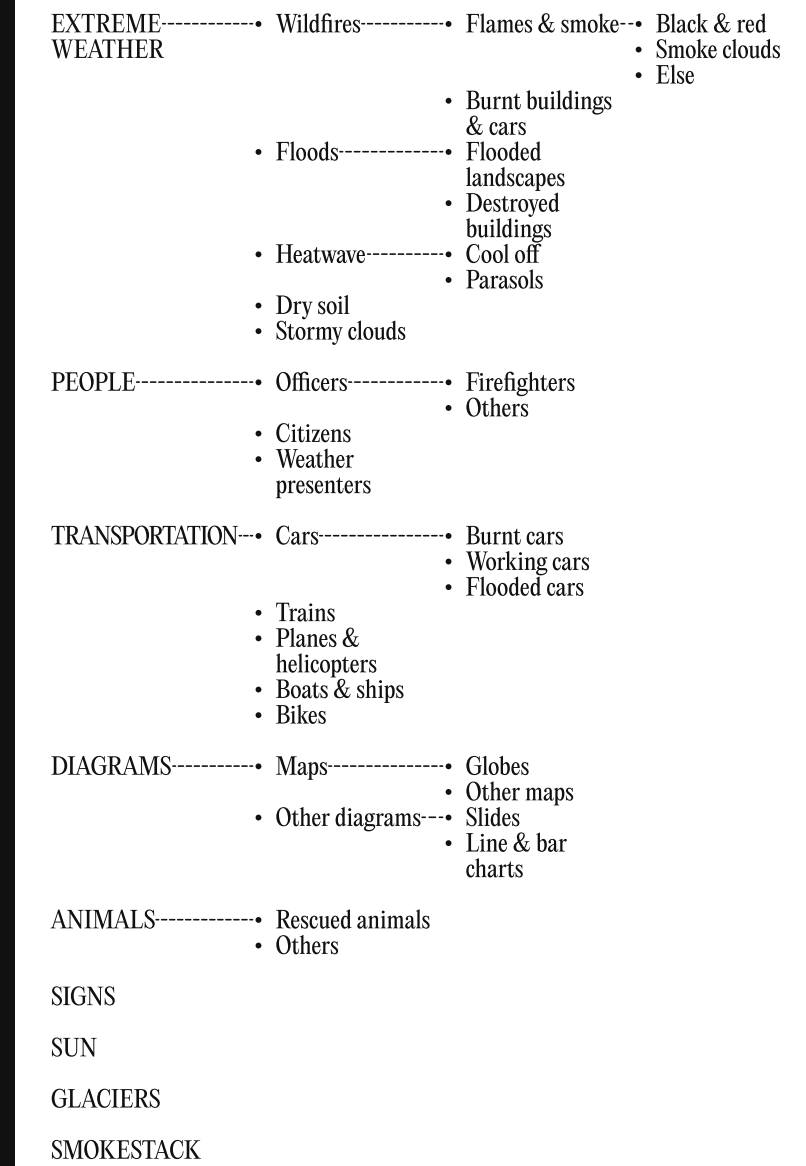
A single cluster is visualised as follows:



A family of clusters is visualised as a series of cluster visualisations connected through dashed lines and colour coding according to their hierarchy.



HIERARCHY OF IMAGE CLUSTERS



Network - images

Clustered images were reconnected with their visual appearance through cluster-specific wall of images based on the grouping hierarchy.

CHILD CLUSTER

All images in each low-level-cluster (clusters which don't contain other clusters) were downloaded and arranged together in creating cluster-specific image walls. The purpose of this operation was to connect the abstraction of the network with the qualitative appearance of the images, providing samples of the distinctive visual qualities in each image group.

The complete hierarchy of clusters with all low-level-clusters highlighted in orange is available on the right.

P3 -> IMAGES -> NETWORK -> VIZ 02

The visualisation on the right covers all low-level-clusters in the previously defined hierarchy. For each cluster are shown:

- the hierarchy of its parent clusters (if any);
- the number of images in the cluster;
- the position of the images in the network;
- a sample of images from the cluster (image wall).

Colours are maintained from the previous visualisation (P3 -> images -> network -> viz 01). A single cluster is visualised as follows:

CLUSTER HIERARCHY

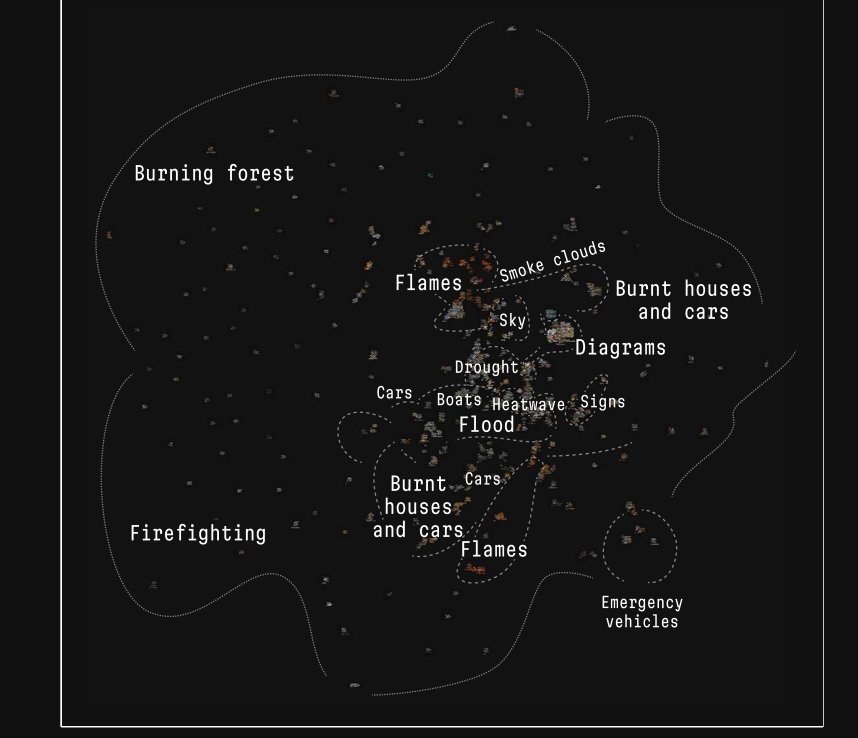
Cluster | Subcluster | Sub-subcluster | XX IMAGES



IMAGES IN THE NETWORK

The sequence of low-level-clusters' displays is followed by a miniature of the tagged network (P3 -> images -> network -> viz 00), in order to provide an easy-to-consult map of the network areas.

P3 -> images -> network -> viz 00



<p>Extreme weather ↳ Wildfires ↳ Flames & smoke ↳ Black & red 246 IMAGES</p>	<p>Extreme weather ↳ Wildfires ↳ Burnt buildings & cars 547 IMAGES</p>	<p>Extreme weather ↳ Heatwaves ↳ Cool off 42 IMAGES</p>	<p>People ↳ Officers ↳ Firefighters 765 IMAGES</p>	<p>Transportation ↳ Cars ↳ Burnt cars 296 IMAGES</p>	<p>Transportation ↳ Planes & helicopters 79 IMAGES</p>	<p>Diagrams ↳ Maps ↳ Other maps 165 IMAGES</p>	<p>Animals ↳ Others 53 IMAGES</p>	<p>Smokestack 2 IMAGES</p>
<p>Extreme weather ↳ Wildfires ↳ Flames & smoke ↳ Smoke clouds 217 IMAGES</p>	<p>Extreme weather ↳ Floods ↳ Flooded landscapes 207 IMAGES</p>	<p>Extreme weather ↳ Heatwaves ↳ Parasols 24 IMAGES</p>	<p>People ↳ Officers ↳ Others 218 IMAGES</p>	<p>Transportation ↳ Cars ↳ Working cars 230 IMAGES</p>	<p>Transportation ↳ Boats & ships 27 IMAGES</p>	<p>Diagrams ↳ Others ↳ Slides 20 IMAGES</p>	<p>Signs 78 IMAGES</p>	<p>Sun 51 IMAGES</p>
<p>Extreme weather ↳ Wildfires ↳ Flames & smoke ↳ Else 995 IMAGES</p>	<p>Extreme weather ↳ Floods ↳ Destroyed buildings 53 IMAGES</p>	<p>Extreme weather ↳ Dry soil 49 IMAGES</p>	<p>People ↳ Citizens 725 IMAGES</p>	<p>Transportation ↳ Cars ↳ Flooded cars 139 IMAGES</p>	<p>Transportation ↳ Bikes 7 IMAGES</p>	<p>Diagrams ↳ Others ↳ Line & bar charts 12 IMAGES</p>	<p>Animals ↳ Rescued animals 51 IMAGES</p>	<p>Glaciers 5 IMAGES</p>
<p>Extreme weather ↳ Stormy clouds 11 IMAGES</p>	<p>People ↳ Weather presenters 46 IMAGES</p>	<p>Transportation ↳ Trains 16 IMAGES</p>	<p>Diagrams ↳ Maps ↳ Globes 25 IMAGES</p>	<p>Animals ↳ Rescued animals 51 IMAGES</p>	<p>Glaciers 5 IMAGES</p>			

Image plot

The visual space of the articles was also examined in regard to hue and brightness values in the pictures, to detect trends and tendencies in the use of colours of climate crisis' representations.

IMAGE MEASURING

Colour values in each of the 3'538 images were measured through *ImageMeasure* for ImageJ. In particular, the process returned for each picture:

- median of brightness values;
- standard deviation of brightness values;
- median of saturation values;
- standard deviation of saturation values;
- median of hue values;
- standard deviation of hue values.

PLOT DIMENSIONS

The measures of brightness and hue were used to build a plot of images through *ImagePlot* for ImageJ. The axis of the plot were mapped as below:

- X axis → median of hue values (*hue_median*);
- Y axis → standard deviation of brightness values (*brightness_stddev*).

Each image was positioned in the plot according to its measured values.

PLOT EVALUATION

The distribution in the plot was analysed mainly in regard to the hue values, considering image density as well as recurring subjects across the x axis.

◆ P3 → IMAGES → IMAGE PLOT → VIZ 01

The visualisation on the right shows the each of the 3,538 images positioned into one of two plots: the first for images scraped from climate-change-avoiding articles, the other for images scraped from climate-change-citing articles. Inside each plot the pictures are distributed in the space according to their hue values (median mapped on X axis) and brightness values (standard deviation mapped on Y axis), as previously explained.

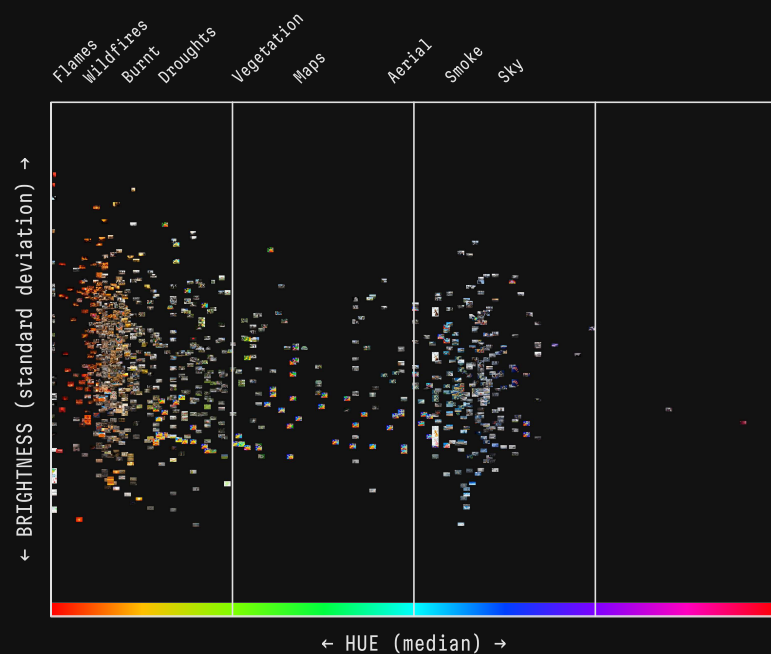
The plot is split vertically into 4 portions of equal width, according to hue values:

1. red to green (X1);
2. green to light blue (X2);
3. light blue to purple (X3);
4. purple to red (X4).

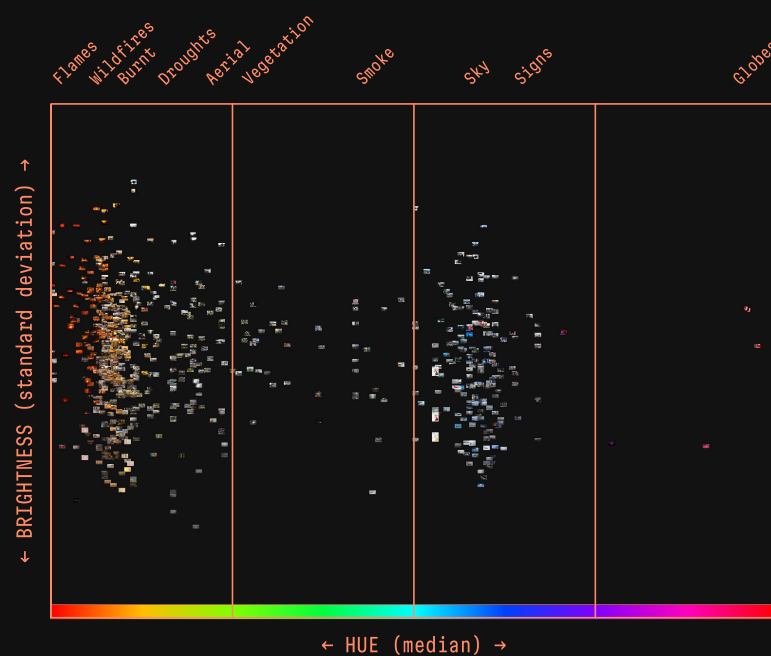
The purpose of those portions is to facilitate the evaluation of image density in relation to hue values.

Recurring subjects for specific hue areas are noted above the plot.

IMAGES FROM CLIMATE-CHANGE-AVOIDING ARTICLES



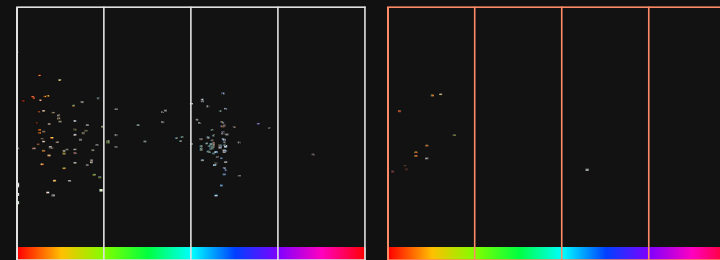
IMAGES FROM CLIMATE-CHANGE-CITING ARTICLES



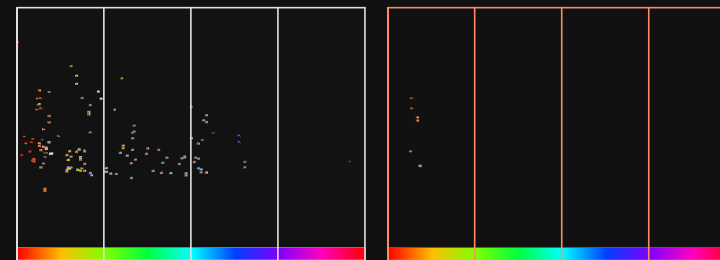
CLIMATE-CHANGE-AVOIDING

CLIMATE-CHANGE-CITING

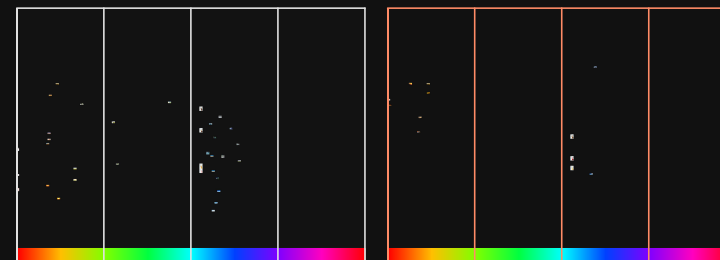
eltiempo.es



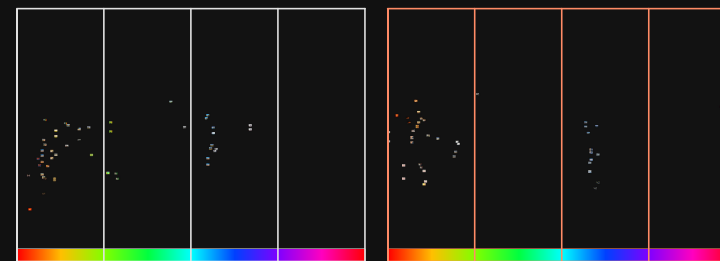
ilmeteo.it



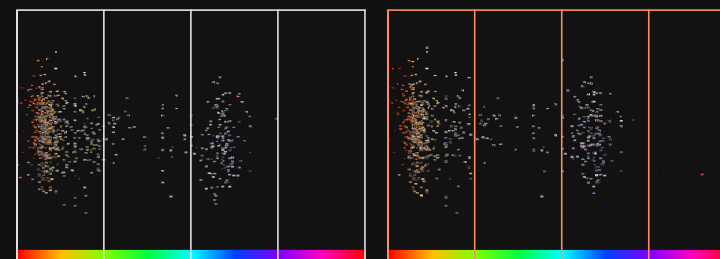
metoffice.gov.uk



tiempo.com



weather.com



WEBSITE-BASED

Website-specific image plots were also built with *ImageMeasure* and *ImagePlot* for ImageJ. Each website includes two plots: the first for images scraped from climate-change-avoiding articles, the other for images scraped from climate-change-citing articles. The axis of the plots were mapped as below:

- X axis → median of hue values (*hue_median*);
- Y axis → standard deviation of brightness values (*brightness_stddev*).

Each image was positioned in the respective plot according to its measured values.

The axis of every individual plot include the same range of values, in order to make them comparable. The evaluation of website-based plots in relations to the global plots is also encouraged, in order to detect cross-website tendencies as well as website-specific features in the use of colours.

CLIMATE-CHANGE-AVOIDING ↔ CLIMATE-CHANGE-CITING

The classification based on climate change relation (according to whether the source article explicitly referred climate change or not) remains. The plots provide another opportunity of comparison between the visual spaces of climate-change-citing and climate-change-avoiding articles.

◆ P3 → IMAGES → IMAGE PLOT → VIZ 02

The visualisation on the left shows the image plots at the intersection of websites and climate change reference. As in previous visualisation (P3 → images → image plot → viz 01), images are distributed in the space according to their hue values (median mapped on X axis) and brightness values (standard deviation on Y axis).

Each plot is split vertically into 4 portions of equal width, according to hue values:

1. red to green (X1);
2. green to light blue (X2);
3. light blue to purple (X3);
4. purple to red (X4).

The purpose of those portions is to facilitate the evaluation of image density in relation to hue values for visual spaces connected to specific websites.

