

The Effects of Heat and Air Pollution on the Brain and Behavior

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July 20, 2023



AMERICAN PSYCHOLOGICAL ASSOCIATION
SERVICES, INC.

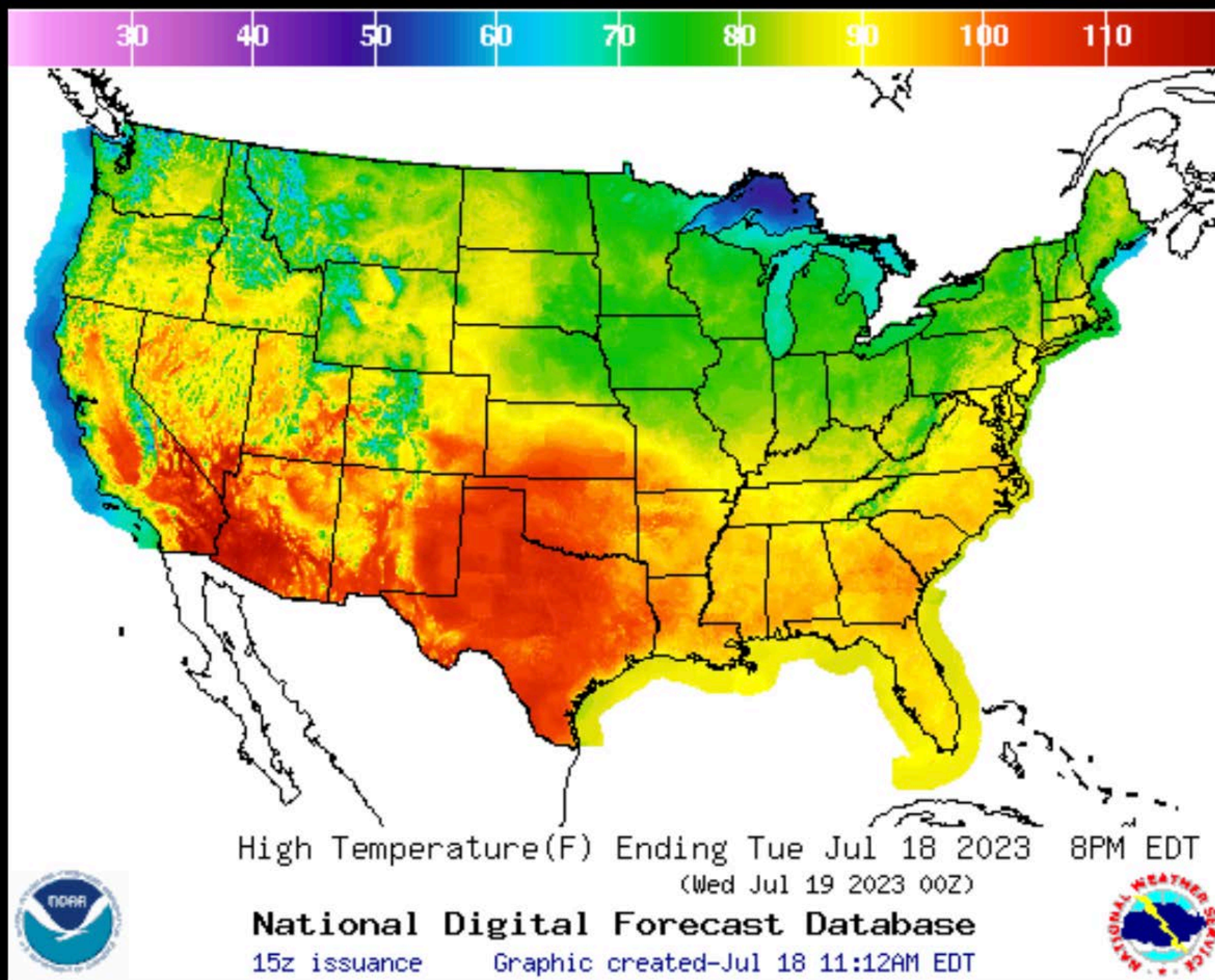


Land Acknowledgment

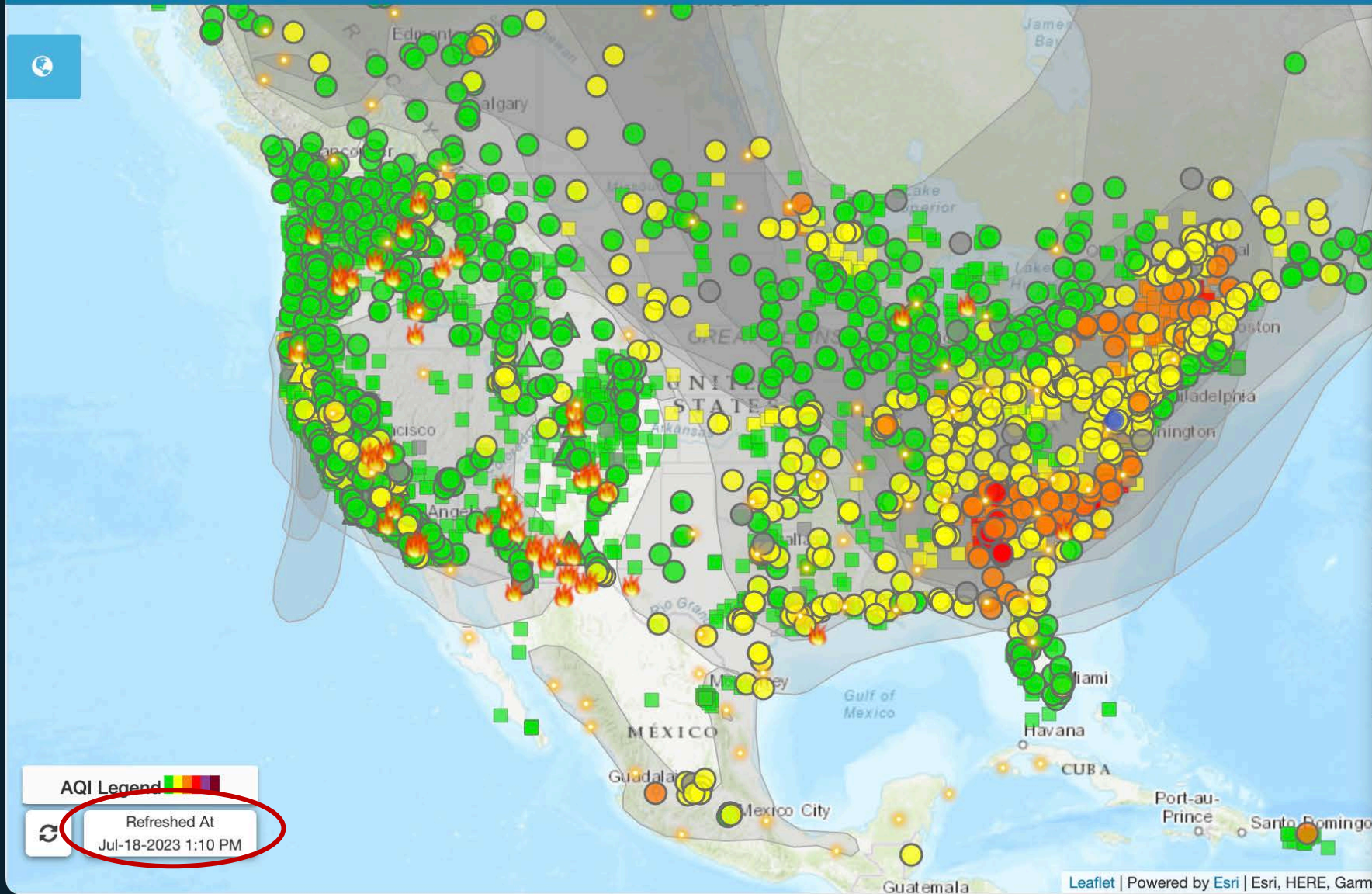
We acknowledge that in Washington, DC we are in the occupied territory of the **Nacotchtank** (Anacostan) and **Piscataway** peoples. We also acknowledge the unpaid labor and forced servitude of enslaved Africans and their descendants, whose unremitted labor and exploitation were pivotal to the rapid economic growth of our nation.

A low-angle photograph of a modern, multi-story building with a grid of windows. The building is light-colored with dark window frames. The entrance is visible at the bottom, and a decorative vertical element is on the right side.

AMERICAN PSYCHOLOGICAL ASSOCIATION



<https://graphic.al.weather.gov/sectors/conus/Week.php>



Air Quality (PM_{2.5})

☒

● Permanent Monitors

☒

▲ Temporary Monitors

☒

■ Low Cost Sensors*

*Not for regulatory purposes

shows only fine particulates.

Fire Information

☒

🔥 Large Incidents

☒

● Satellite Detections

Smoke Plumes

☒

☁ Smoke Plume Extent

Smoke Outlooks

None currently issued

Basemaps

☐ Aerial

☒ Terrain

☐ Streets

Data Sources

AQI Legend

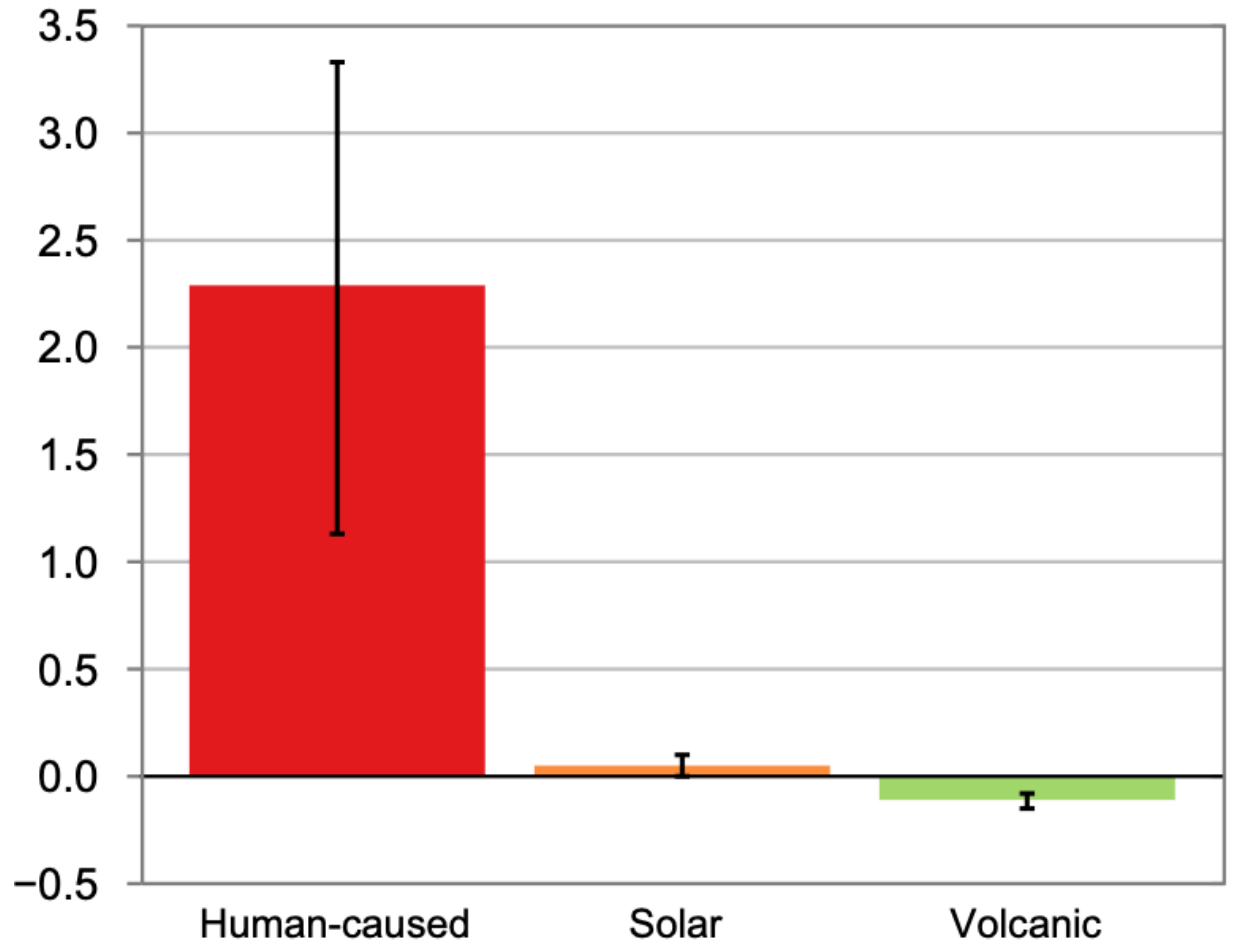
🔄

Refreshed At
Jul-18-2023 1:10 PM

It's us:

**Earth's energy
balance (aka
temperature) is
being changed
almost exclusively
by human activity**

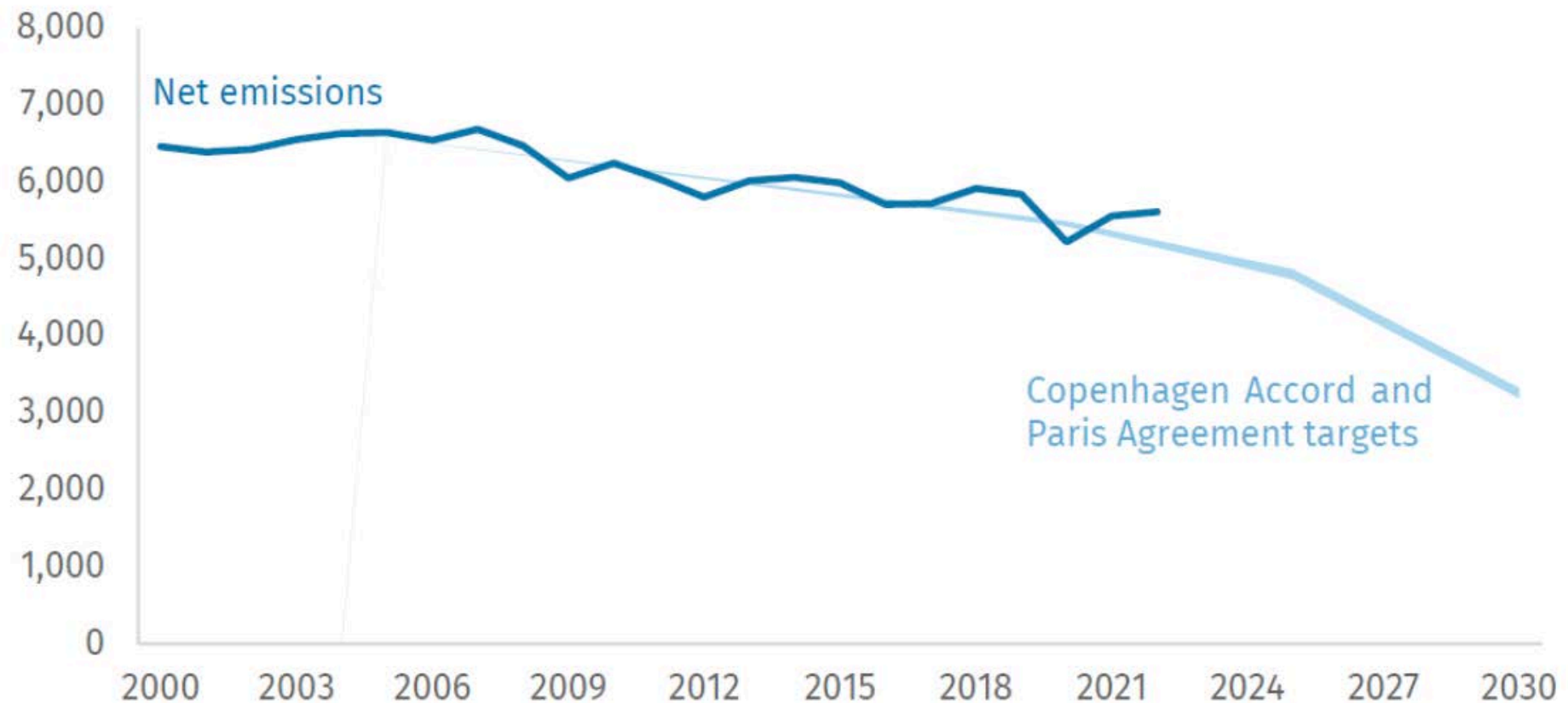
Global Annual Average
Radiative Forcing (W/m_2), 1750-2011



Recent U.S. GHG emissions, and where we need to be

Net US GHG emissions relative to international commitments

Million metric tons CO₂e, IPCC definitions, excludes international bunkers



Source: Rhodium Group

<https://rhg.com/research/us-greenhouse-gas-emissions-2022/>

The Effects of Heat and Air Pollution on the Brain and Behavior



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Heat on the Brain:

The Impact of Rising Temperatures on Mental & Cognitive Functioning

Joseph R Taliercio

Cognitive & Behavioral Consultants

New York City and White Plains



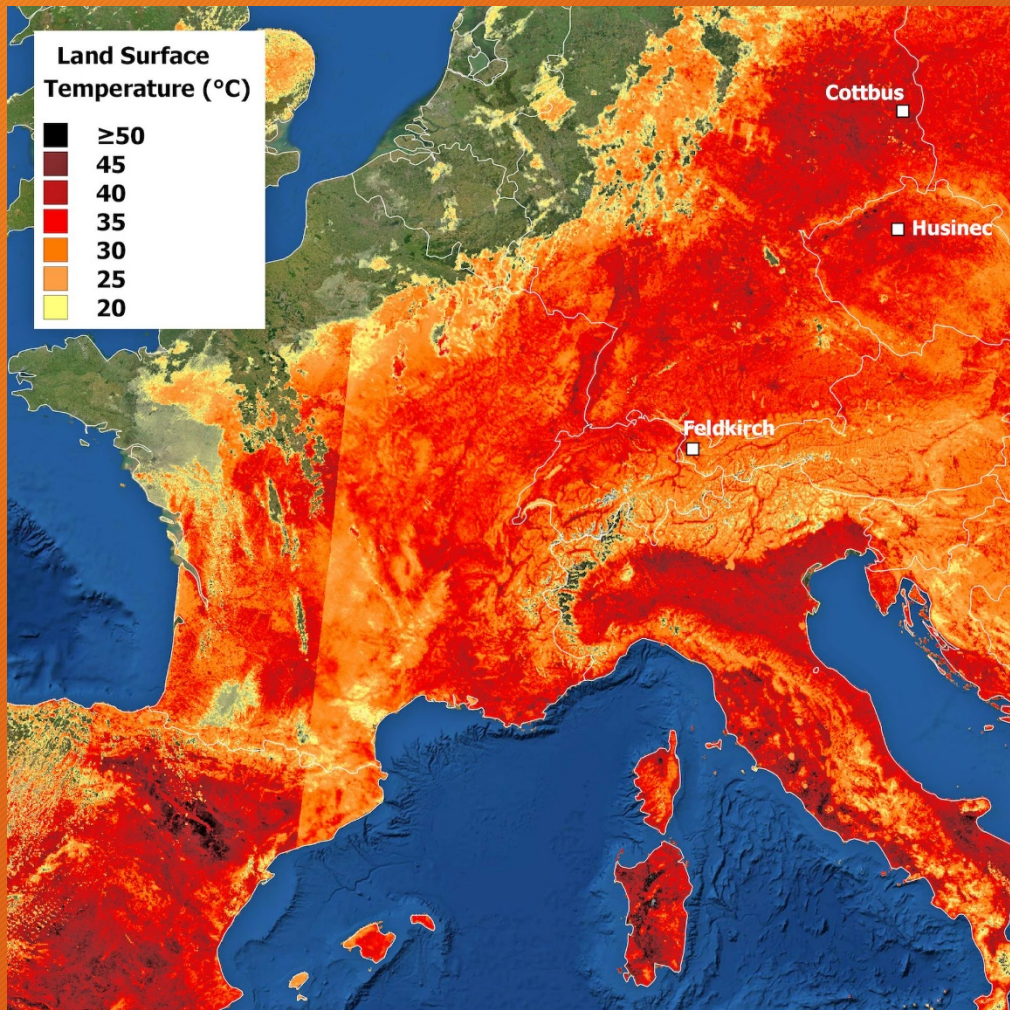
DEDICATED TO THE PSYCHOLOGY OF WELL-BEING

Conflicts of Interest

None to disclose

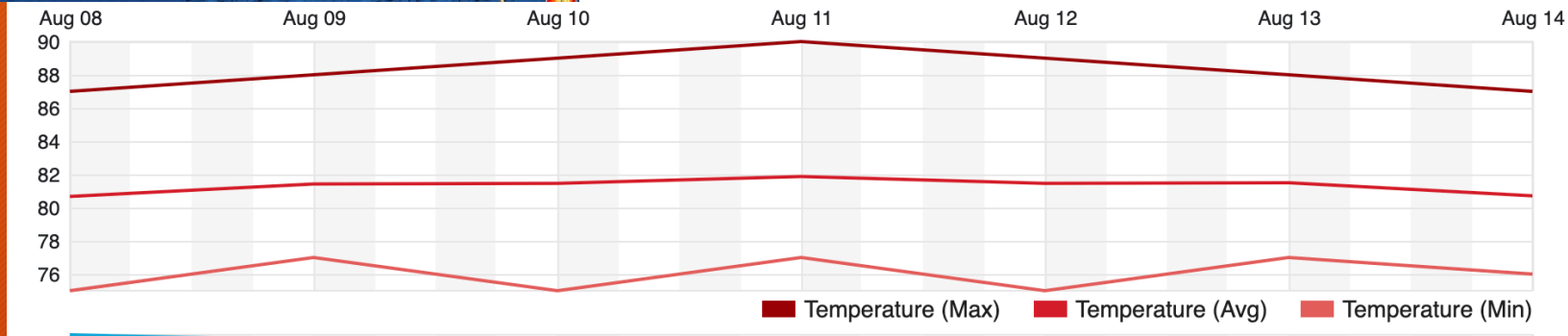
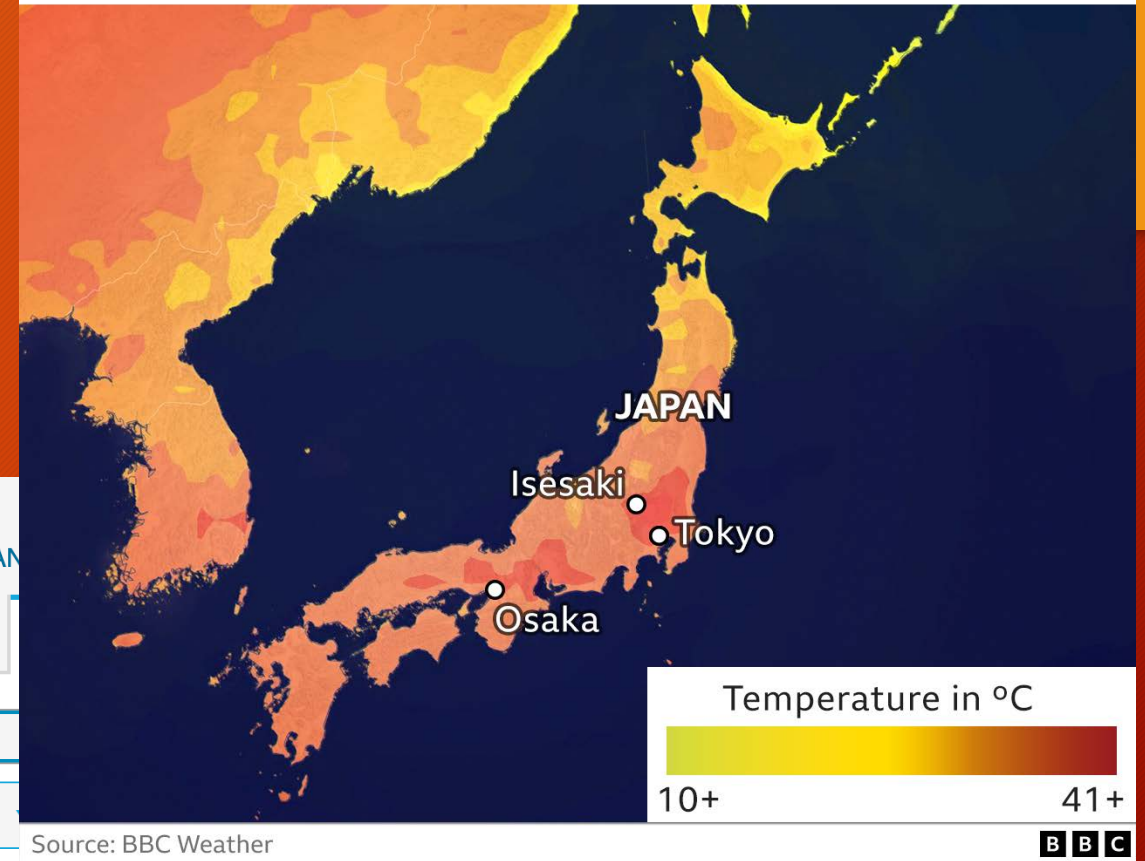
Outline

- Why the focus on heat
- Impact on mental health and cognitive functioning
- Mechanisms of action
- Confounding factors
- Potential solutions



Japan is dealing with an intense heatwave

Maximum daily temperature forecast for 29 June



Welcome to the Warming Future

The New York Times | <https://www.nytimes.com/2023/05/17/climate/record-heat-forecast.html>

Heat Will Likely Soar to Record Levels in Next 5 Years, New Analysis Says



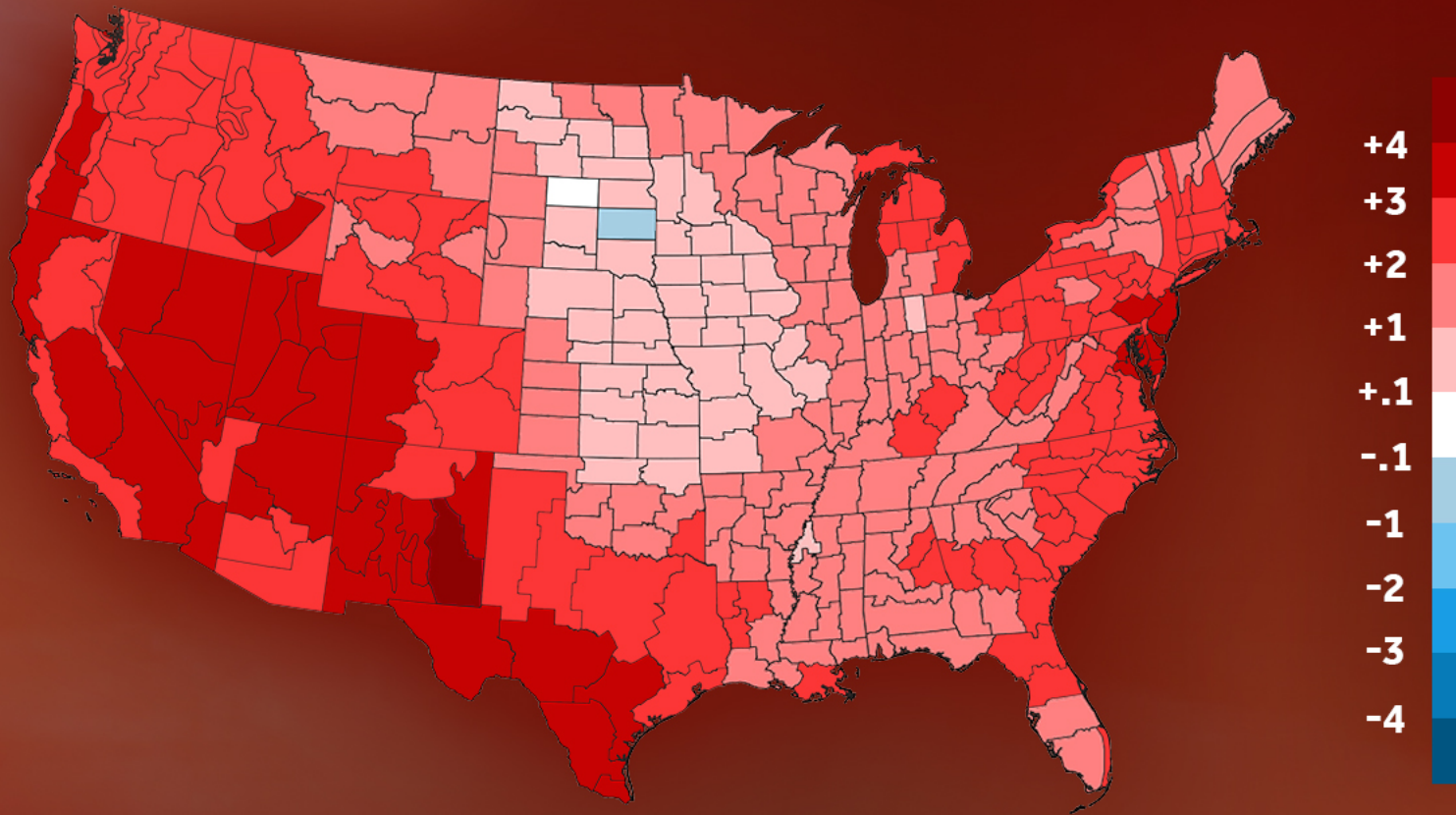
By Brad Plumer

May 17, 2023

- Next five years =
 - Violation of the Paris Climate Accords
 - 1 in 5 chance we experience the hottest year ever recorded
 - Increased humidity and heat
 - Pollution and El Niño



SUMMER WARMING SINCE 1970

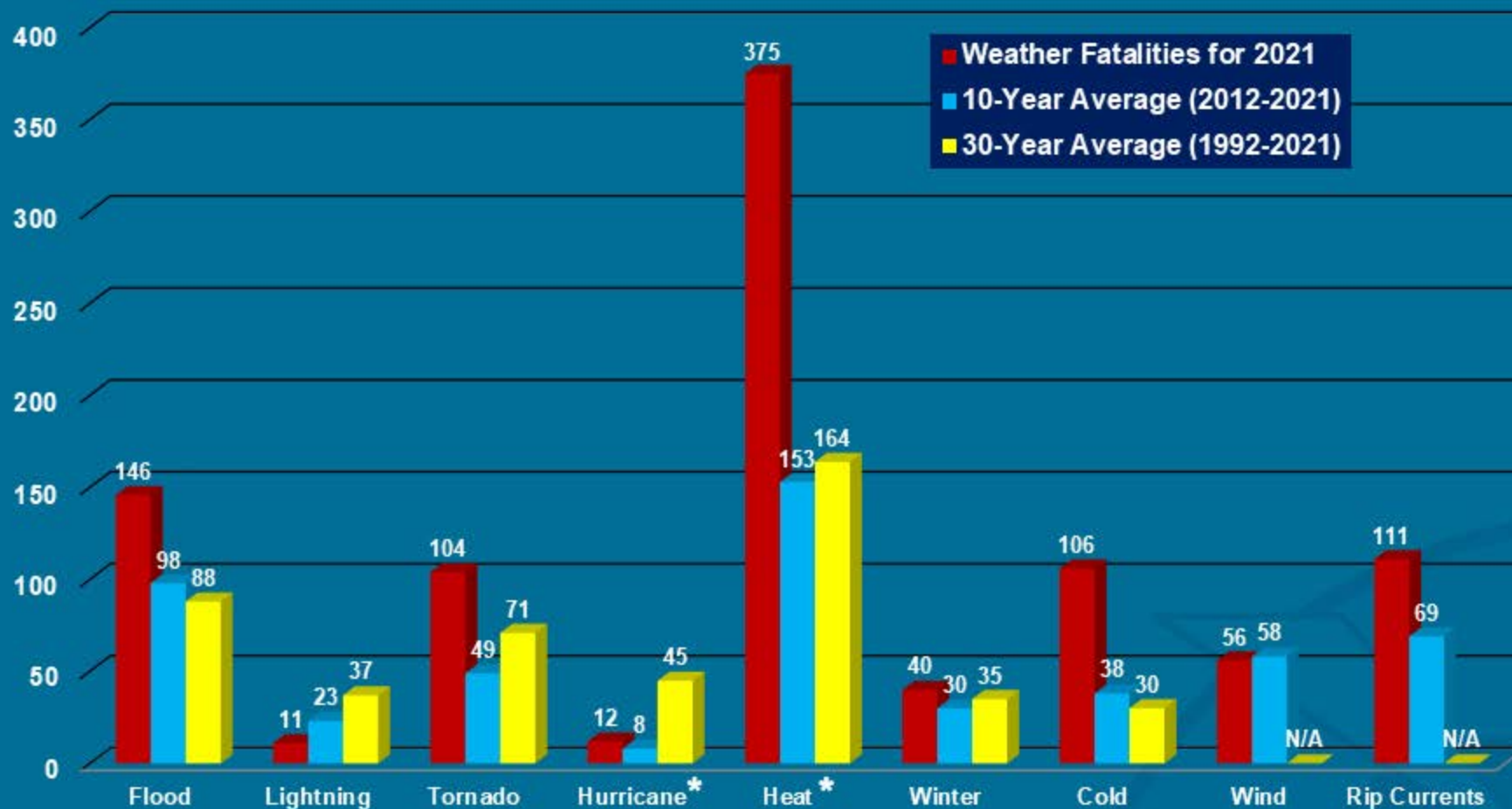


Annual average summer (June, July, August) temperature (°F)
Source: NOAA/NCEI Climate at a Glance

CLIMATE  CENTRAL



Weather Fatalities 2021



**Due to an inherent delay in the reporting of official heat fatalities in some jurisdictions, this number will likely rise in subsequent updates.*

**The fatalities, injuries, and damage estimates found under Hurricane/Tropical Cyclone events are attributed only to the wind.*

HEAT-RELATED ILLNESSES

WHAT TO LOOK FOR

WHAT TO DO

HEAT STROKE

- High body temperature (103°F or higher)
- Hot, red, dry, or damp skin
- Fast, strong pulse
- Headache
- Dizziness
- Nausea
- Confusion
- Losing consciousness (passing out)
- Call 911 right away-heat stroke is a medical emergency
- Move the person to a cooler place
- Help lower the person's temperature with cool cloths or a cool bath
- Do not give the person anything to drink

HEAT EXHAUSTION

- Heavy sweating
 - Cold, pale, and clammy skin
 - Fast, weak pulse
 - Nausea or vomiting
 - Muscle cramps
 - Tiredness or weakness
 - Dizziness
 - Headache
 - Fainting (passing out)
 - Move to a cool place
 - Loosen your clothes
 - Put cool, wet cloths on your body or take a cool bath
 - Sip water
- Get medical help right away if:**
- You are throwing up
 - Your symptoms get worse
 - Your symptoms last longer than 1 hour

HEAT CRAMPS

- Heavy sweating during intense exercise
 - Muscle pain or spasms
 - Stop physical activity and move to a cool place
 - Drink water or a sports drink
 - Wait for cramps to go away before you do any more physical activity
- Get medical help right away if:**
- Cramps last longer than 1 hour
 - You're on a low-sodium diet
 - You have heart problems

SUNBURN

- Painful, red, and warm skin
- Blisters on the skin
- Stay out of the sun until your sunburn heals
- Put cool cloths on sunburned areas or take a cool bath
- Put moisturizing lotion on sunburned areas
- Do not break blisters

HEAT RASH

- Red clusters of small blisters that look like pimples on the skin (usually on the neck, chest, groin, or in elbow creases)
- Stay in a cool, dry place
- Keep the rash dry
- Use powder (like baby powder) to soothe the rash



The General Impact on Mood

- Worsens a variety of psychiatric diagnoses (Lee et al., 2018; Montes et al., 2021; Nori-Sarma et al., 2022)
- Mortality rates increase in those with psychiatric diagnoses (Liu et al., 2021)
- Lessens presence of positive mood states, worsens negative mood states, and decreases energy (Burke et al., 2018; Noelke et al., 2016)



Heat, Anger, & Aggression

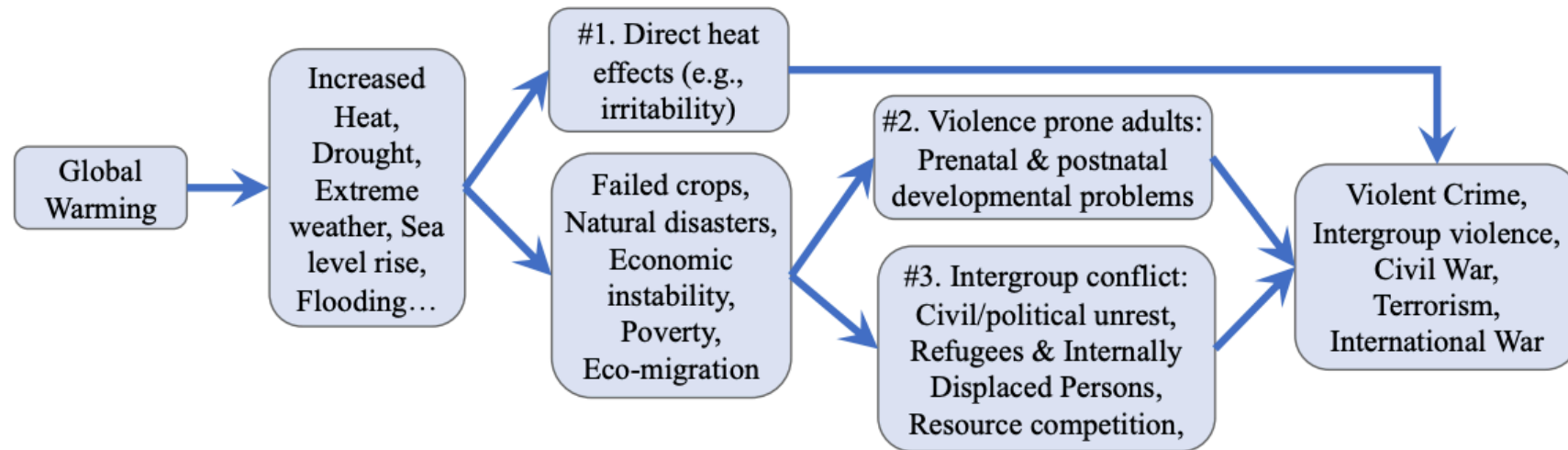


Fig. 1 Three paths through which rapid global warming increases violent behavior

Heat, Anger, & Aggression (to Self)

- Can trigger aggression in experimental studies (Anderson et al., 2000, Warburton et al., 2018)
- Suicidal behavior increases with increased heat (Burke et al., 2018; Page et al., 2007)



Cognitive Impairments



- Impulsivity (Hocking et al., 2001)
- Error and accident prone (Hancock & Vasmatazidis, 2003)
- Impaired working memory (van den Heuvel et al., 2017)

Bio-Social-Cognitive Causes

- Temperature Aggression Hypothesis (Harp & Karnauskas, 2018)
- Routine Activities Theory (Harp & Karnauskas, 2018)
- Sleep (Mukherjee & Sanders, 2021)
- Dehydration (Schmit et al., 2016)
- Inflammation (Liu et al., 2021)

Compounding Concerns

- Geography (Anderson, 2001)
- The social crowding effect on urban communities (Wang & Liu, 2023)
- The heat island effect (Hibbard et al., 2017)

HEAT ISLANDS

Temperature varies with land use



Source: U.S. EPA 2012

CLIMATE  CENTRAL

Compounding Concerns

- Geography (Anderson, 2001)
- The social crowding effect urban on communities (Wang & Liu, 2023)
- The heat island effect (Hibbard et al., 2017)
- Psychiatric medications (Martin-Latry et al., 2007))

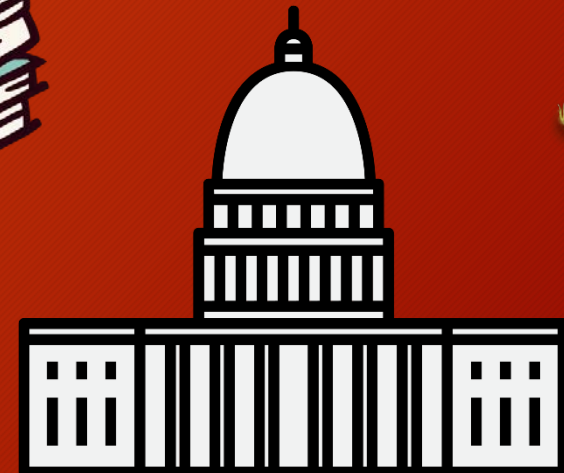
Medication	Heat Intolerance	Hypotension	Fainting from Heat	Excessive Sweating	Decreased Sweating	Reduced alertness in heat	Lethargy or Confusion in Heat
TCA's	X	X	X		X	X	X
SSRIs	X	X	X	X		X	X
SSNIs	X	X	X	X		X	X
Antipsychotics	X	X	X		X	X	X
Benzodiazepines	X	X	X			X	X

Compounding Concerns

- Geography (Anderson, 2001)
- The social crowding effect on urban communities (Wang & Liu, 2023)
- The heat island effect (Hibbard et al., 2017)
- Psychiatric medications (Martin-Latry et al., 2007))
- SES class (Benz & Burney, 2021; Hoffman et al., 2020)

Troubleshooting for Relief

- Make individual differences
- Encourage big picture changes
- Get educated, get resources, and discuss
- Integrate into clinical work
- Get political



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Neuropsychiatric, Brain and Emotional Impacts of Air Pollution

Webinar- July 20, 2023

American Psychological Association

partnership with

Climate Psychiatry Alliance & Climate Psychology Alliance -NA

Robin Cooper, MD

Associate Clinical Professor

Dept Psychiatry and Behavioral Sciences,

University of California San Francisco

Co-Founder, Climate Psychiatry Alliance (www.climatepsychiatry.org)

No Conflict of Interest



Worldwide-7 Million Premature Deaths Annually (World Health Org)

Air Pollution Greatest Environmental Catastrophe in World Today



- ❖ Air pollution kills more people worldwide each year than AIDS, malaria, diabetes or tuberculosis.
- ❖ United States and Europe, air pollution is equivalent in detrimental health effects of smoking 0.4 to 1.6 cigarettes per day.
- ❖ China :worse; on bad days, health effects of air pollution are comparable to the harm done smoking three packs per day (60 cigarettes) by every man, woman, and child.

Source: <https://berkeleyearth.org/air-pollution-and-cigarette-equivalence/>

A Psychiatrists' Perspective

It's all about feelings



It's all about the brain



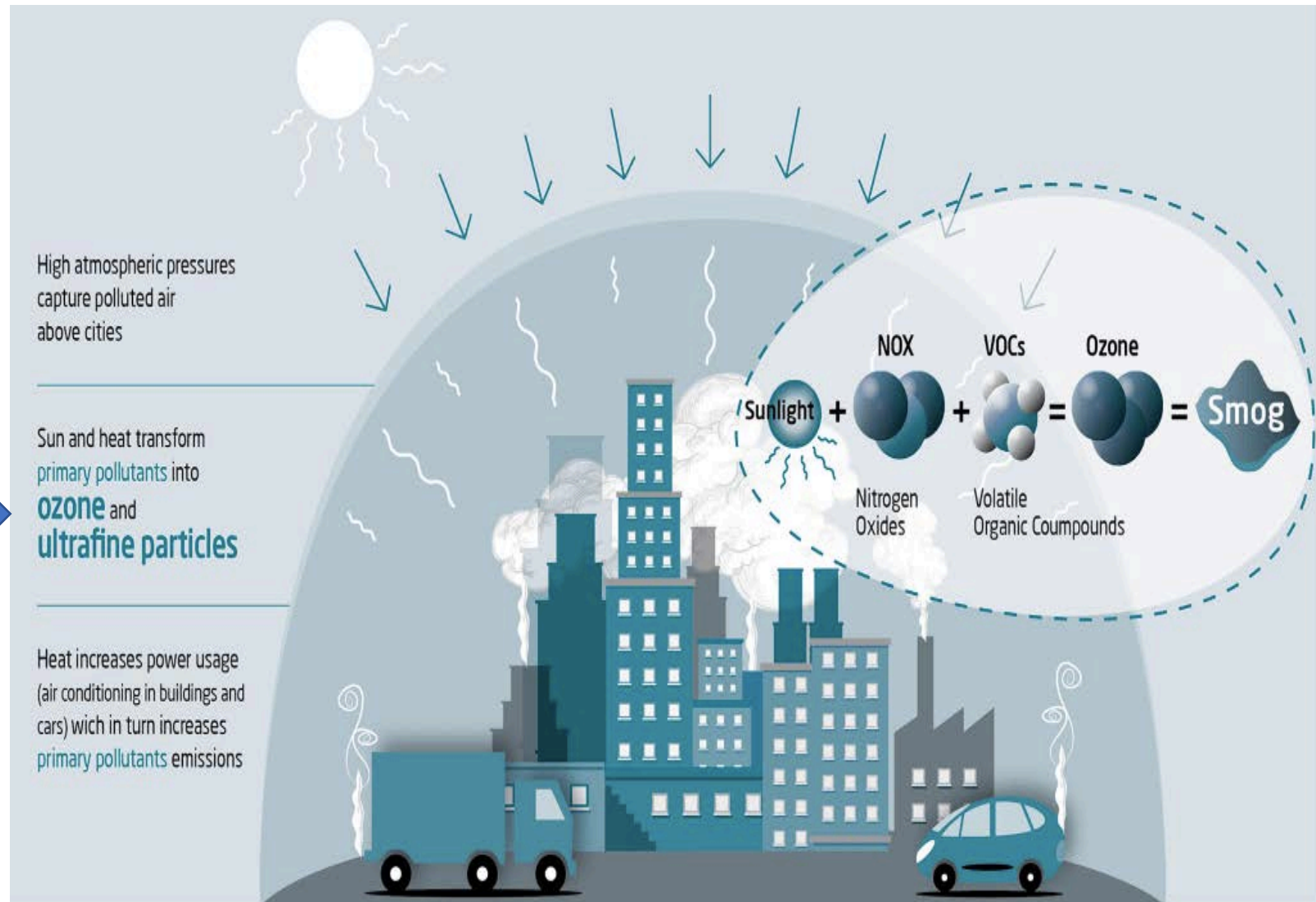
HEAT PLUS KIRST AIR POLLUTION EQUALS TROUBLE



+



MULTIPLIERS OF ADVERSE EFFECTS



Source: <https://www.teqoya.com/air-pollution-the-heat-factor/>

Wildfire Smoke-does not respect geographic boundaries

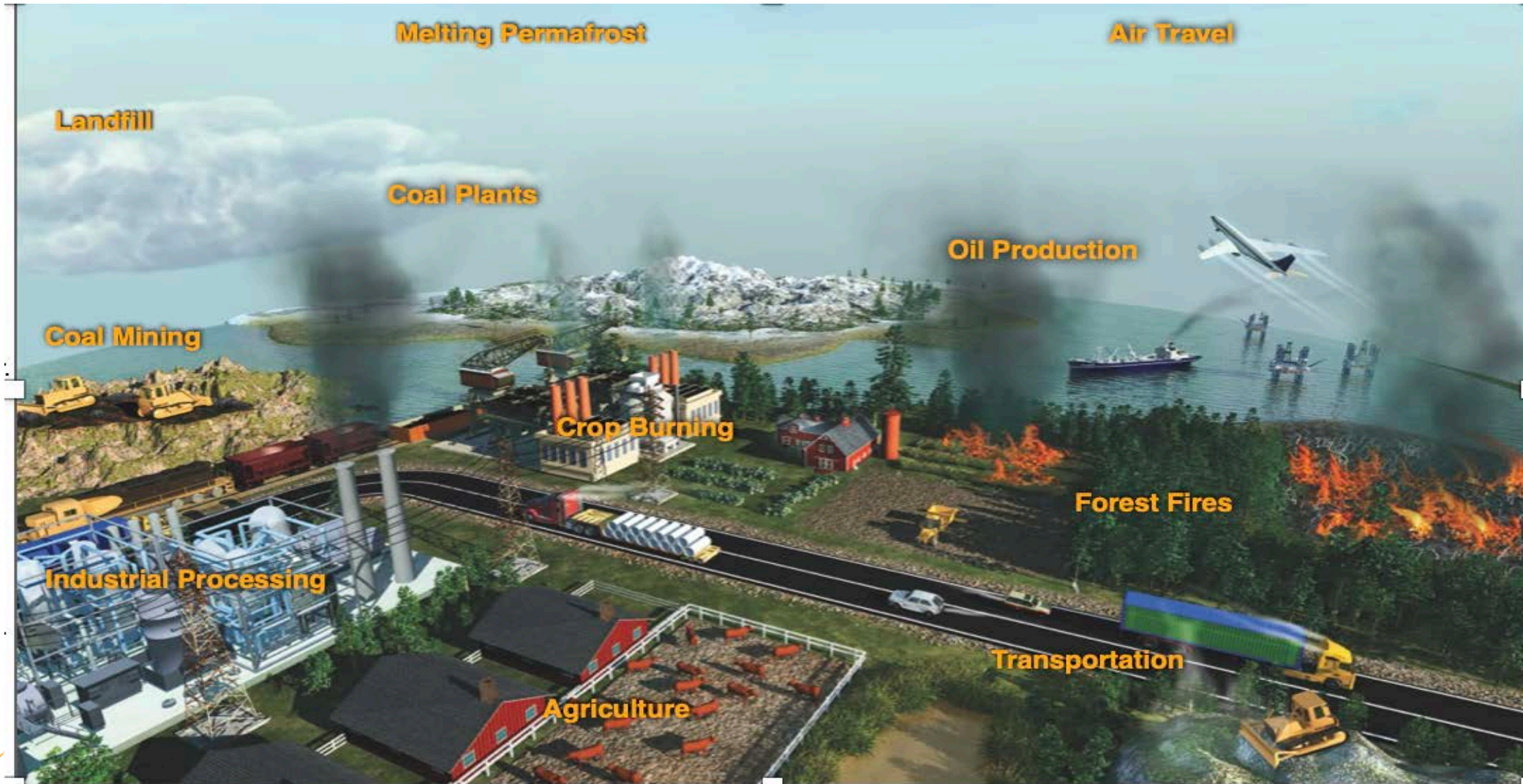


Source: <https://www.nytimes.com/2023/06/17/world/americas/canada-wildfires-season.html>

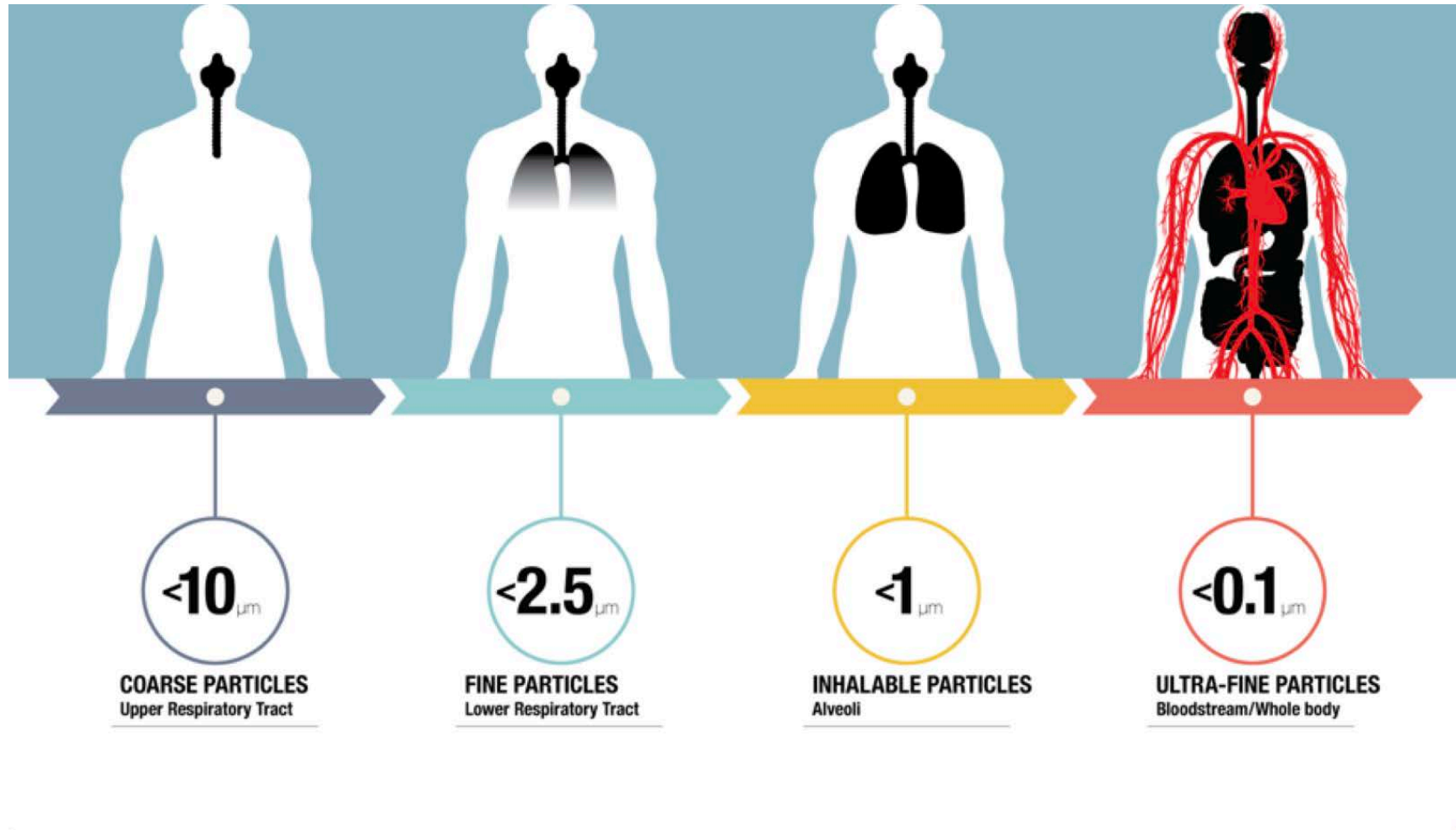


Source: <https://www.cnbc.com/2023/06/07/canadian-wildfire-smoke-nyc-residents-urged-to-stay-inside.html>

Contributions to Air-Pollution - Human Activity: Part of living in Industrialized Global World



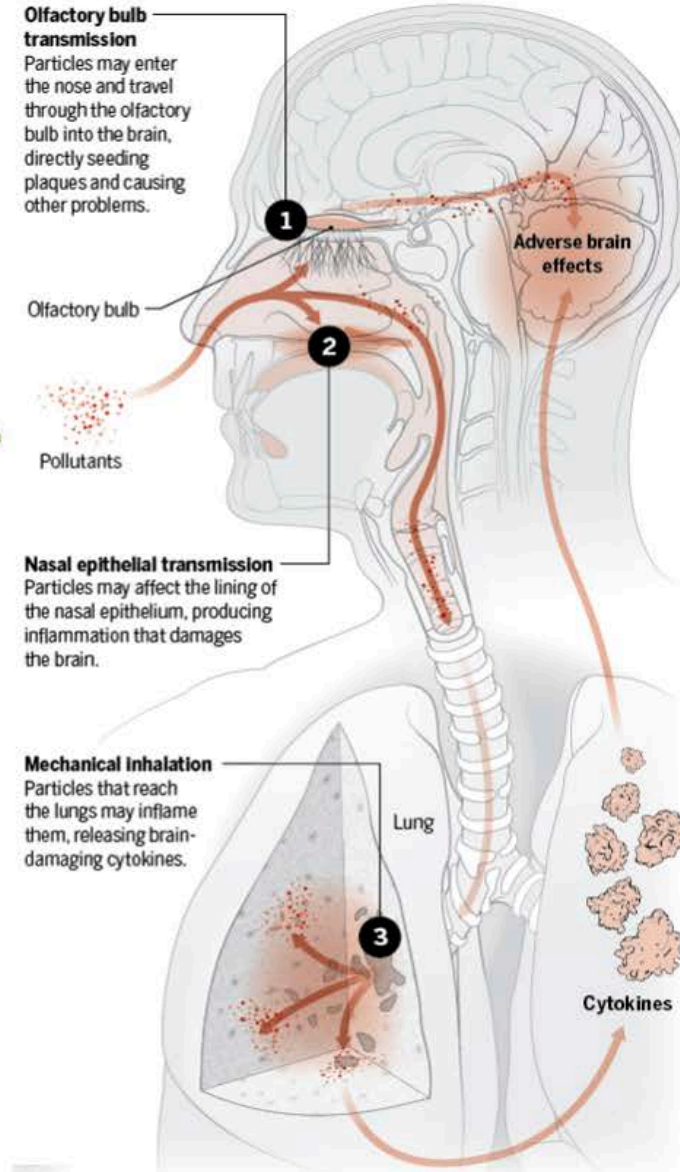
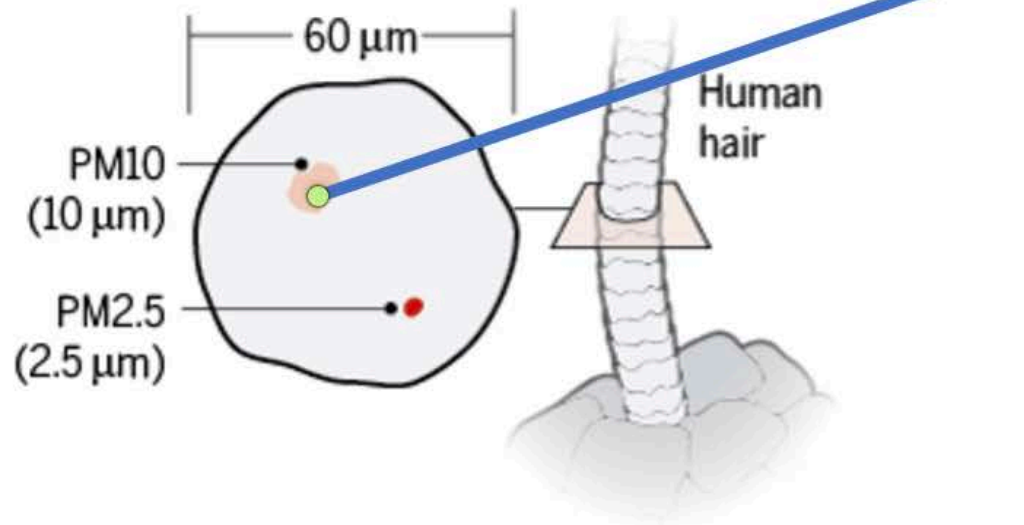
Size matters



CARBON POLLUTION AND NEUROINFLAMMATION

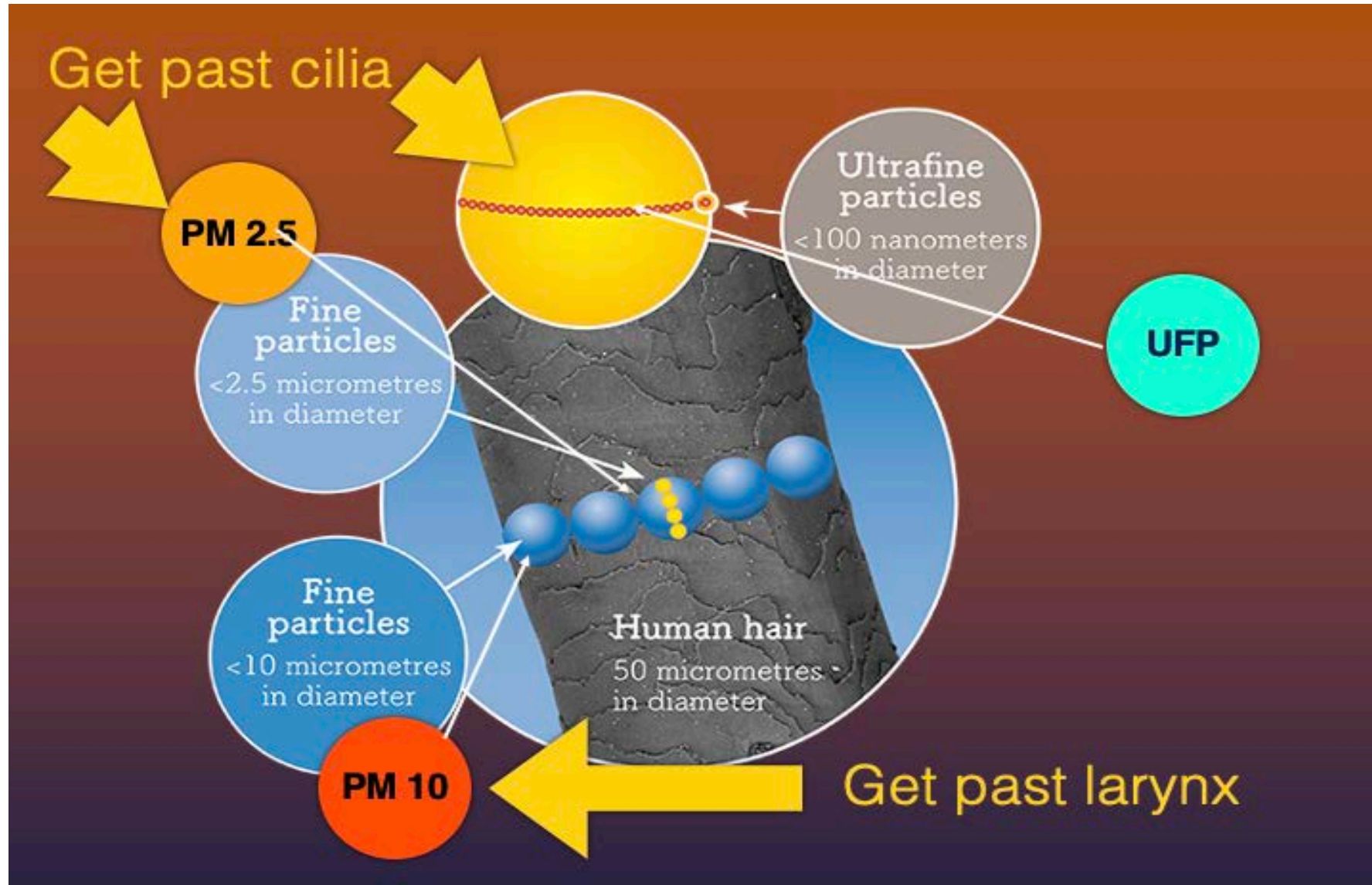
Beyond fine

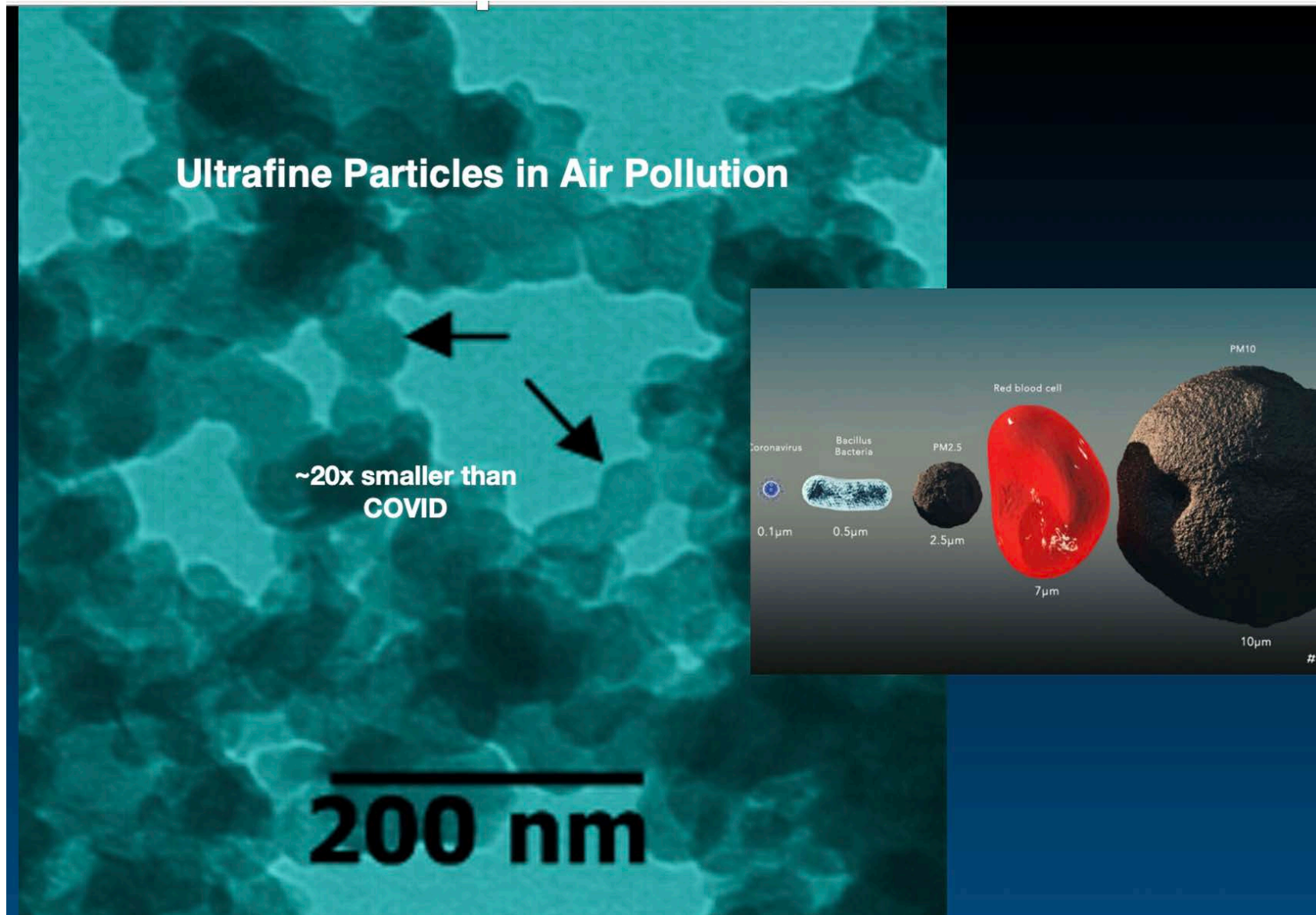
Pollutant particles are classified and regulated by size, although "ultrafine" pollutants of about $0.2\text{ }\mu\text{m}$ are unregulated. The smaller the particle, the more damage it may do the brain.



SCIENCE

Types of Fine Particles in Air Pollution



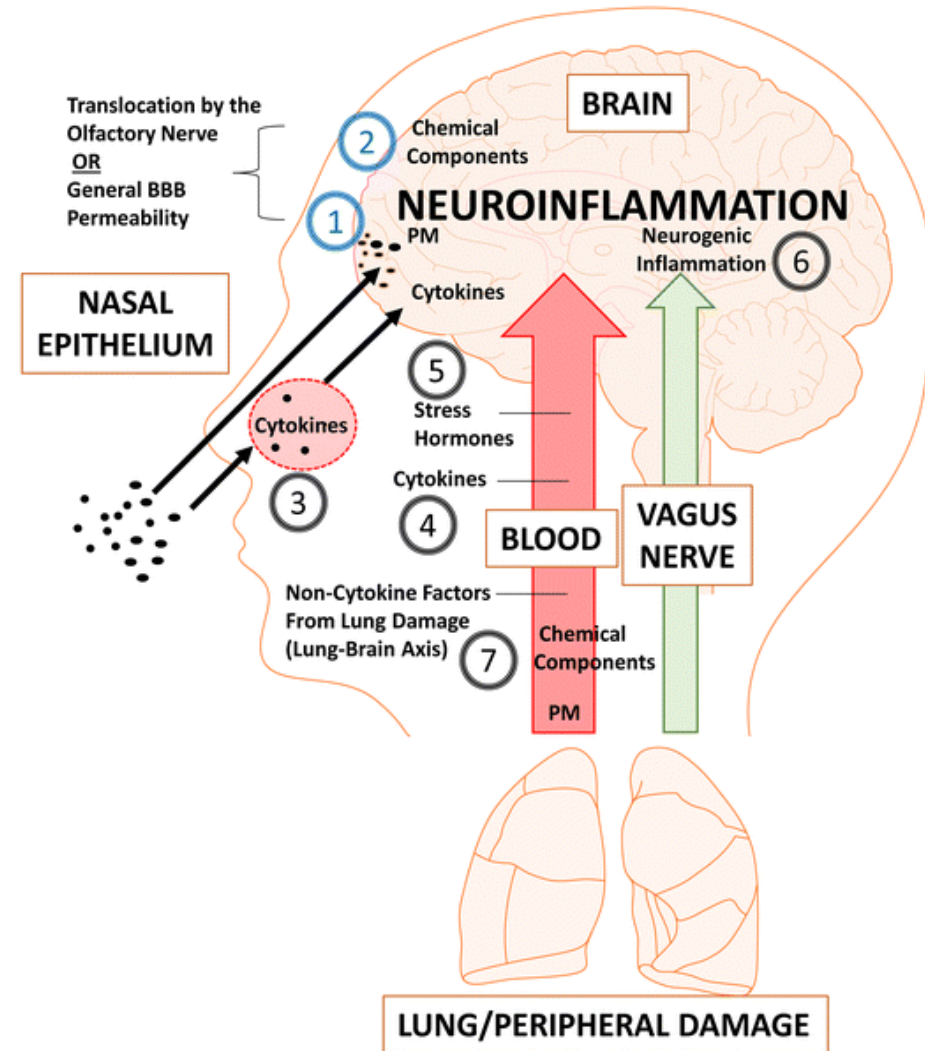


UFP under electron microscope: High surface charge cause particles to clump together.

Proposed Mechanism of Damage:

- ❖ Access to brain thru olfactory nerve or blood stream and breakdown of blood-brain barrier
- ❖ Direct impact on CNS of toxicants, impacts on microglia
- ❖ Pro-inflammatory reaction – cytokines into brain directly or circulating cytokines thru blood stream –vagus nerve one pathway
- ❖ Reactive Oxidative Stress

RESULT: CELLULAR DAMAGE-DEATH



Source : Jayaraj, R et al (2017)

AIR POLLUTION: An Acute and Slow-Moving Disaster

Drives Climate Change & Directly Effects Health

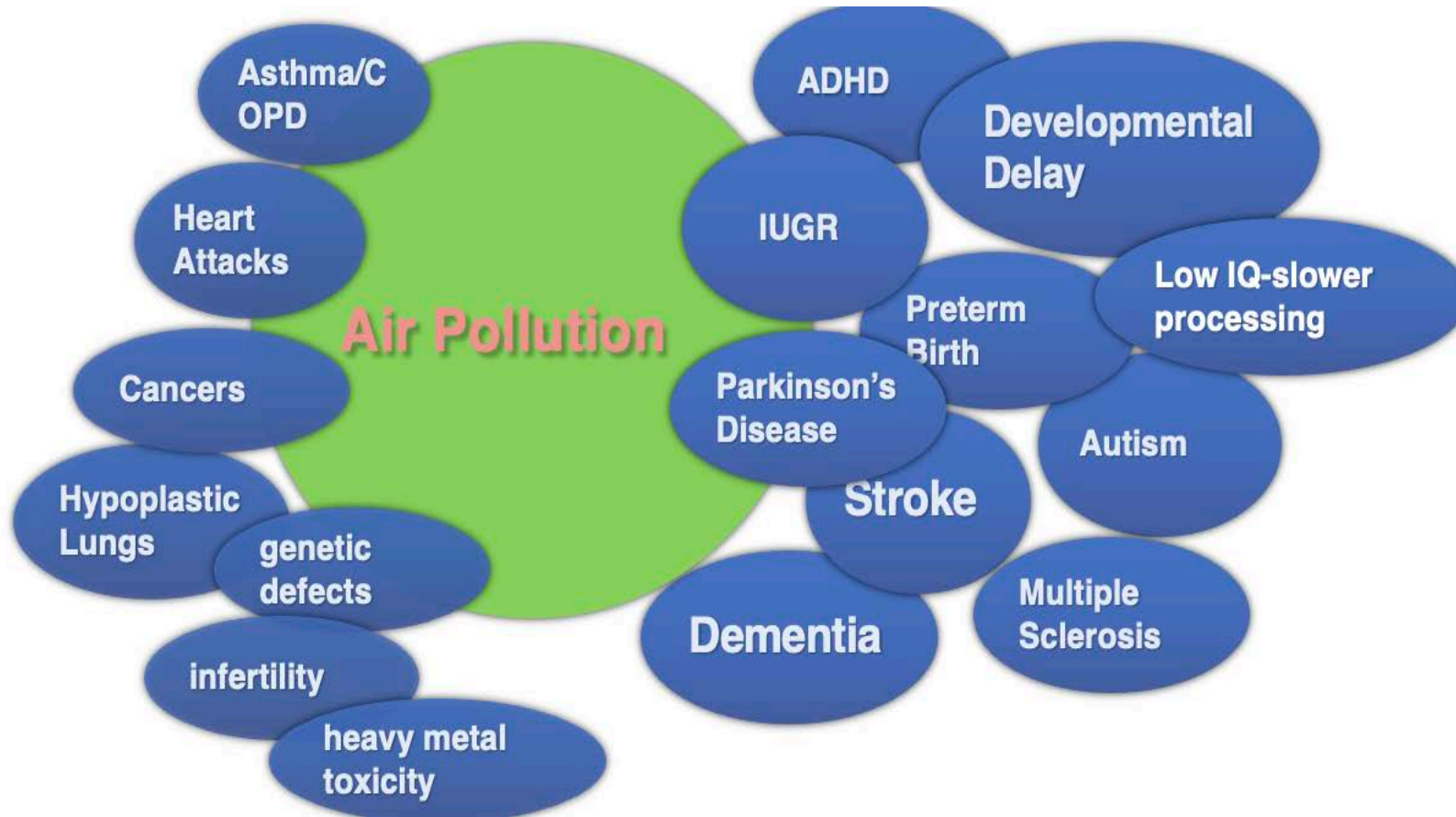


- Acute exposure with respiratory distress, asthma
- Vulnerable populations of medically ill, elderly and children
- Children even more restricted outdoor activity
- Increase of anxiety, distress

Toxicity of Air Pollution: Disorders across the entire life span

Medical-physical

Neuropsychiatric Disorders



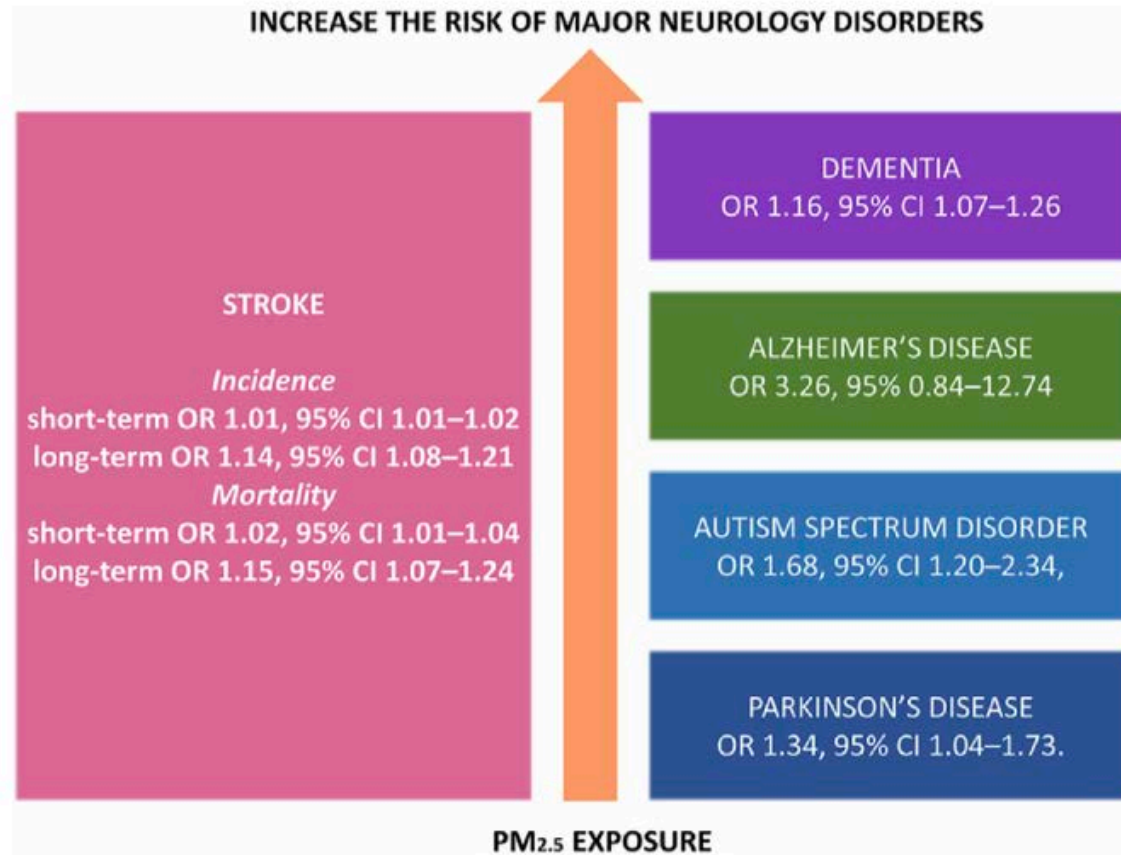
Neurotoxicity: Impacts on Fetus and Children

- **Small head circumference**
- **Disruption of left hemispheric prefrontal white matter**
- **Smaller volumes, right parietal and bitemporal**
- **Increased rates of Autism esp with intrauterine exposure and infancy**
- **Lower IQs, Slower Processing Speed**
- **Decreased memory and academic performance**
- **Increased rates of ADHD and Behavioral Problems**
- **Neurodegenerative markers of Parkinson's & Alzheimer's disease**



Perera, F.P. (2017). 'Multiple Threats to Child Health from Fossil Fuel Combustion: Impacts of Air Pollution and Climate Change', *Environmental Health Perspectives*. 125(3), pp. 141-148

Neurotoxicity : Impacts on Adults



2-4 fold increase in rates of dementia-especially for women

Fu, et al. The association between PM_{2.5} exposure and neurological disorders: A systematic review and meta-analysis.
Sci Total Environ 2019 Mar 10;655:1240-1248

What about feelings?



- **More mental health hospitalizations & ER visits:**
Acute exposures-short term depression, anxiety, bipolar illness, psychosis, suicide
- **Higher rates anxiety and depression-** acute and longer-term exposure
- **Increases in General Mental distress** especially when associated with acute exposures & events

SEROTONIN AS REGULATOR

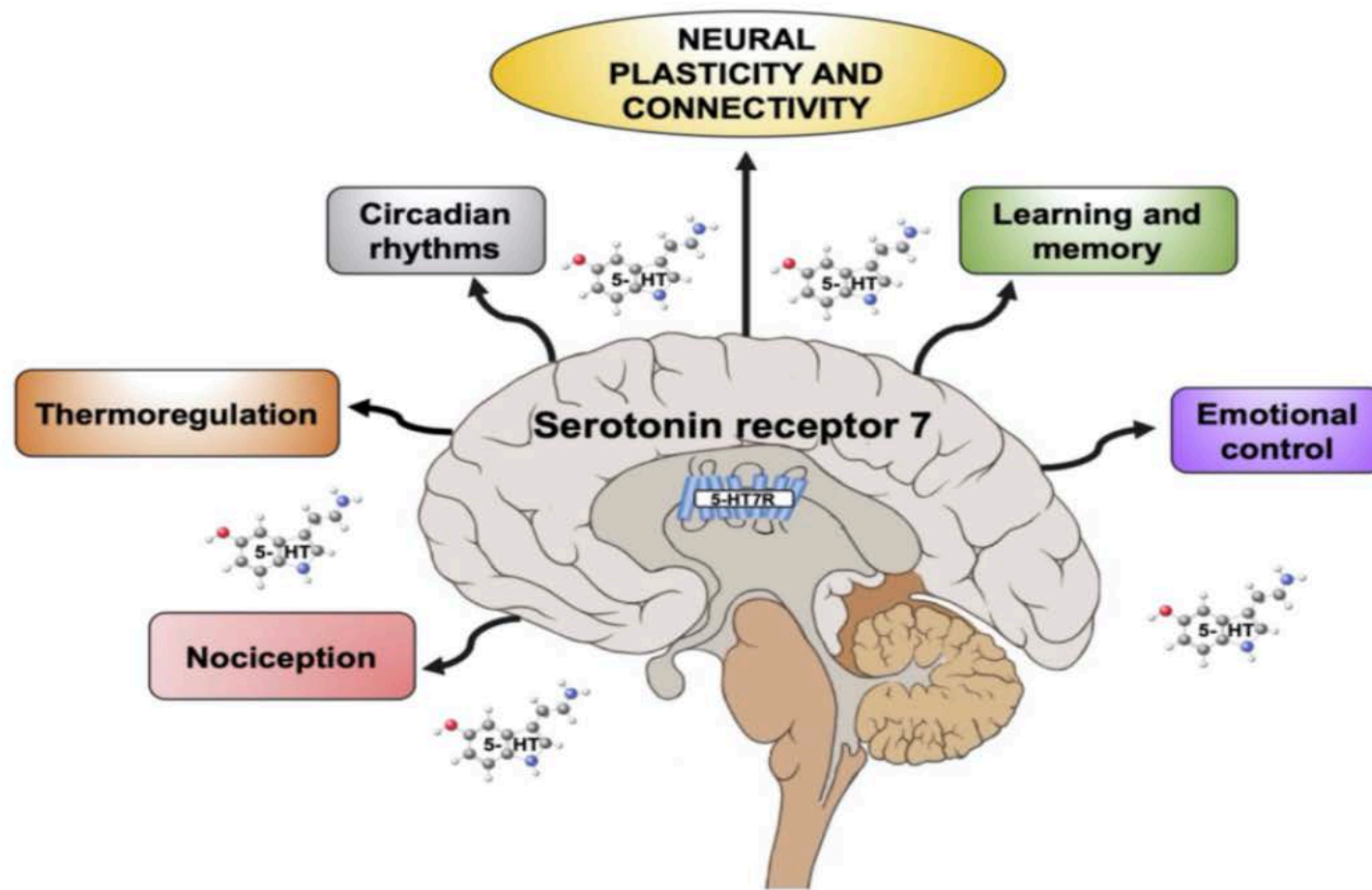


Image: Crispino, M.; Volpicelli, F.; Perrone-Capano, C. Role of the Serotonin Serotonin Receptor 7 in Brain Plasticity: From Development to Disease. *Int. J. Mol. Sci.* **2020**, *21*, 505.

Long term vs. Short term (acute exposure)?

BOTH

Short term:

- ❖ Mood changes and anxiety
- ❖ Trigger psychotic episodes
- ❖ Attention
- ❖ Learning; children in school
- ❖ Behavioral disturbances in children

Long term:

- ❖ Birth outcome differences
- ❖ Learning differences in children
- ❖ Dementias
- ❖ Other Neuro-degenerative disorders
- ❖ Chronic Depression

Inequities in Air Pollution

American Lung Association-State of Air Report, 2023



❖ **People of color are 3.7 times more likely than white people to live in a county with three failing grades**

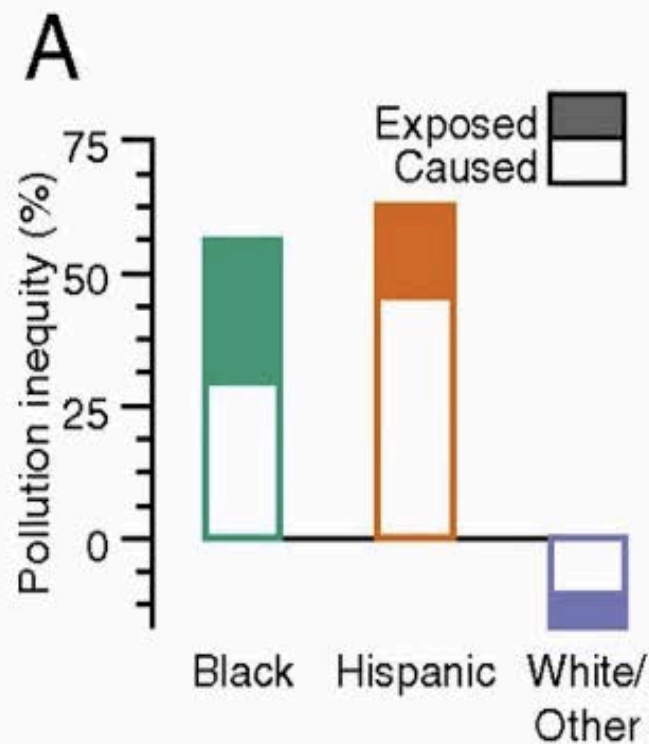
❖ **People experiencing poverty**—More than 14.6 million people with incomes meeting the federal poverty definition live in counties that received an F for at least one pollutant. Nearly 2.6 million people in poverty live in counties failing all three measures.

ALA-SOAR Three measures

1)Ozone Pollution Daily; 2)Short-term Particulate Pollution; 3)Annual (year-round) Particulate Pollution and ozone levels

Measures by Counties with Grading System ranking

Picture source: Emily Rose Bennett for The New York Time- April 4-28-21



White Americans have a “Pollution Advantage”

- experience 17% less air pollution exposure than is caused by their consumption

Black & Latino Americans have a “Pollution Burden”

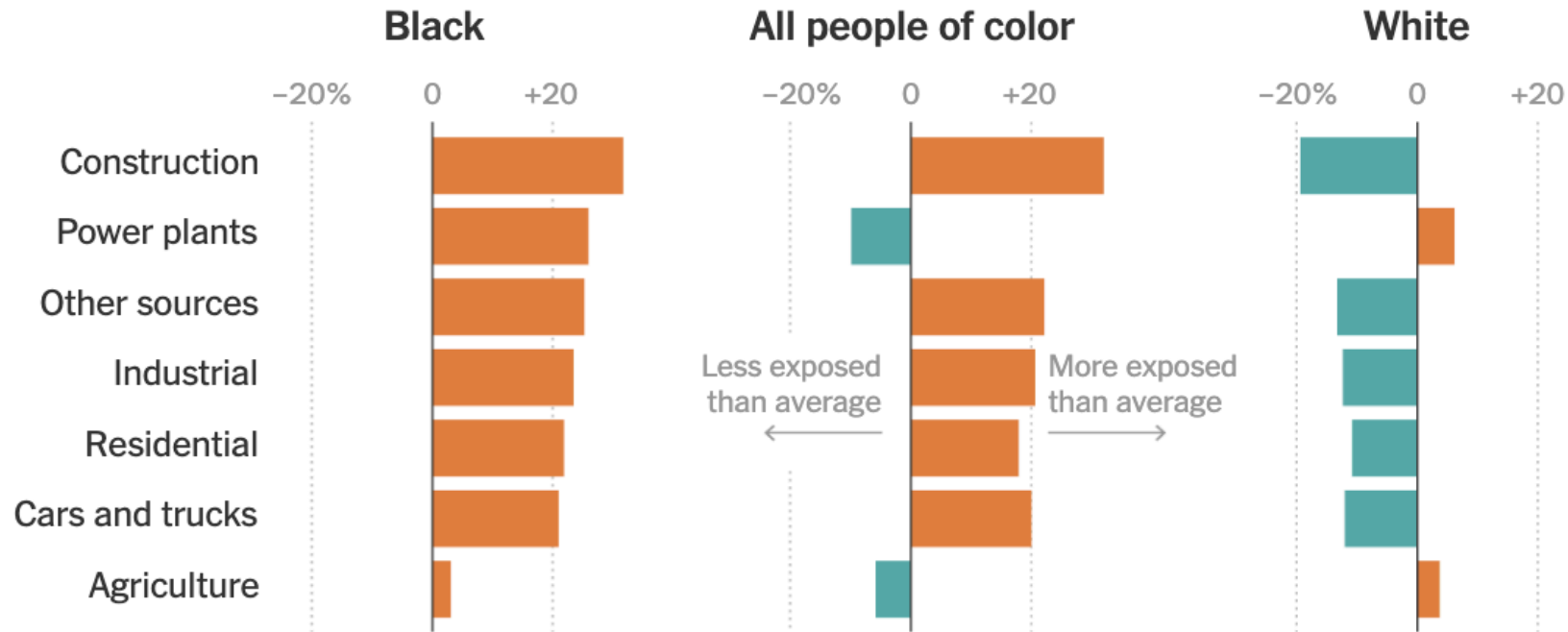
Black Americans – 56% more exposure than their consumption

Latino Americans – 63% more exposure than their consumption

Tessum, C.W., et al. (2019). Inequity in consumption of goods and services adds to racial– ethnic disparities in air pollution exposure. *Proceedings of the National Academy of Sciences* 116(13):6001–6006.

Biggest Pollution Disparities

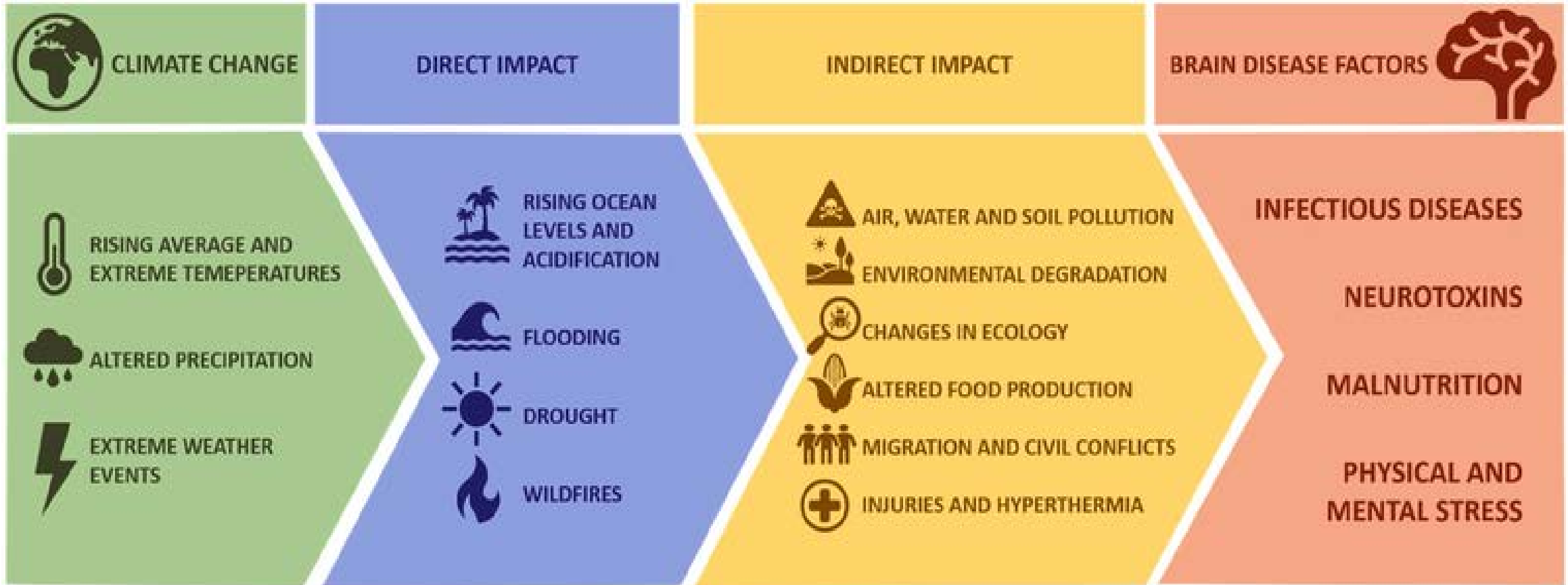
Nationwide, Black people are exposed to greater-than-average concentrations of PM 2.5. People of color face more exposure from almost every type of source, while white people are less exposed.



Other sources include pollution from commercial cooking, off-highway vehicles and equipment, and others. The cars and trucks category includes direct pollution as well as road dust.

Source: Tessum et al., Science Advances., 2021. By The New York Times, April 28, 2021

Climate change and Brain Impacts



Ruszkiewicz, J et al. Brain Diseases in changing climate. Environ Res 2019,Oct: 177: 108637.



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This is not an act of GOD:
there are things we can do

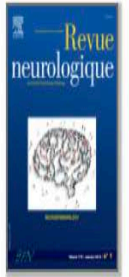
“Air pollution has become a major issue in public health concern (for children) . What can we do? Improving air quality and identifying the young urbanites most at risk of neurodegeneration are key goals for protecting our residents.

However, solutions have to come from official policies and politics’.



Revue Neurologique

Volume 172, Issue 1, January 2016, Pages 69-80



Neuroepidemiology

Air pollution, a rising environmental risk factor for cognition, neuroinflammation and neurodegeneration: The clinical impact on children and beyond

L. Calderón-Garcidueñas^{a, b}, E. Leray^c, P. Heydarpour^d, R. Torres-Jardón^e, J. Reis^f  

Areas policy engagement-Advocacy Requires engagement with organizations

- Implement stricter emissions standards for vehicles and industry
- Implement stricter emission standards for all pollutants-include UFP
- Address poor housing standards for populations at risk
- Revitalize urban forests
- Implement renewable energy
- Make public and active transportation options more effective and accessible alternatives to driving
- Develop and support clean technologies
- Address root causes of climate change-limits to extraction, transport and combustion of fossil fuels
- VOTE

<https://climateatlas.ca/climate-change-air-quality-and-public-health>

Managing Smoke and Air Pollution exposure- mitigation

<https://www.climatepsychiatry.org/wildfire-smoke-toolkit>

Graphic created by Jacob Lee, MD, Climate Psychiatry Alliance



Some Guidelines during Smoke Exposure

<https://www.climatepsychiatry.org/wildfire-smoke-toolkit>

- **Stock up on medications.**
- **Monitor air quality in your area**
 - apps or websites like [Purple Air](#) or [AirNow](#).
- **Use an N95 mask–**
- **Protect the air in your home**
 - close windows, block window and door gaps with damp towels, set AC units to recirculate the indoor air
- **Use a certified HEPA filter indoors.**
 - Create a [homemade filtration device](#).
- **Monitor for medical symptoms; contact physician**
- **Take extra precautions for kids**
- **Pets are also at risk**, limit outdoor exposure time.

Manage Anxiety during Smoke Exposure

<https://www.climatepsychiatry.org/wildfire-smoke-toolkit>

- ❖ Write it down to slow it down
- ❖ Use deep breathing
- ❖ Manage panic attacks with cool towels
- ❖ Turn a breathing exercise into a game---Geared toward young children
- ❖ Use a behavior chain analysis to map out a coping strategy ahead of the next emergency

Brain Chain Analysis : technique is to practice making a map of the chain of events that led up to a specific moment when you felt particularly distressed.

Contributed by Laura Carter Robinson and Dan Murphy of Climate Psychology Alliance-North America

Resources for Managing Air Pollution

❖ Climate Psychiatry Wildfire Smoke Toolkit

❖ <https://www.climatepsychiatry.org/wildfire-smoke-toolkit>

❖ CDC Climate Health Videos

❖ <https://www.cdc.gov/climateandhealth/videos.html#airq>

❖ EPA Air Pollutants Resources

❖ <https://www.epa.gov/criteria-air-pollutants>

❖ Wildfire Smoke Resources

❖ <https://www.cdc.gov/air/wildfire-smoke/default.htm>

❖ <https://www.cdc.gov/disasters/wildfires/>

❖ Track Air Quality Where You Live

❖ <https://www.airnow.gov>

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Questions and Discussion

Thank you: it takes a village
Gratitude to colleagues in Climate
Psychiatry Alliance for ideas,
some materials & slides

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