ATM515 Aerosol Physics

Lecture 2: Overview of aerosols and research issues

1

Overview

Aerosol and aerosol properties

Importance of atmospheric aerosols

2

Definition: Aerosols are suspended particulate matter (liquid or solid) – suspended in a fluid. In terms of atmospheric aerosols, this fluid is <u>air</u>.

Example of aerosols or particles in the atmosphere:

- Dust/Sand
- Sea salt
- Smoke (black carbon, primary organic carbon, sulfate,…)
- Pollen
- Fungus, spores, bacteria
- Water droplets, fog
- Volcano ash
- Sulfate aerosol, nitrate, ammonium
- Secondary particles
- Micro-plastics
- Metal particles
- Non-tailpipe particles

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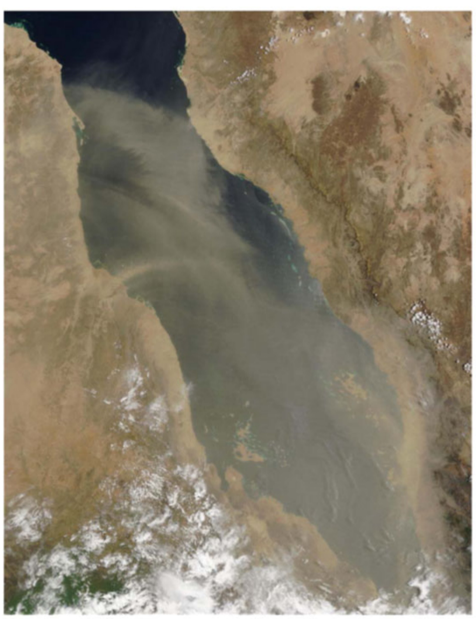
Dust Storm



Dust storm over the red sea.

Dust storm over Denver, Colorado. (Source: worldgeography.com)

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Sea Spray

Sea Salt (Giant CCN)

Microorganisms

Geo-engineering

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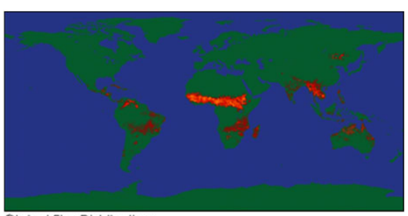
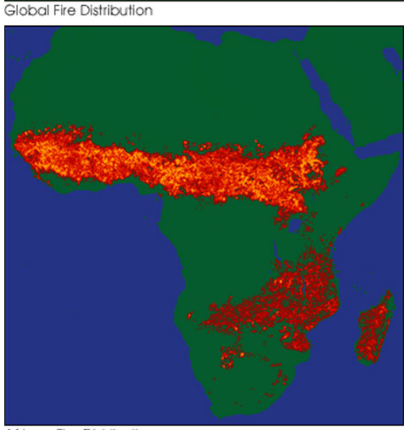
Biomass Burning



Global Fire Distribution



African Fire Distribution

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Anthropogenic Emissions

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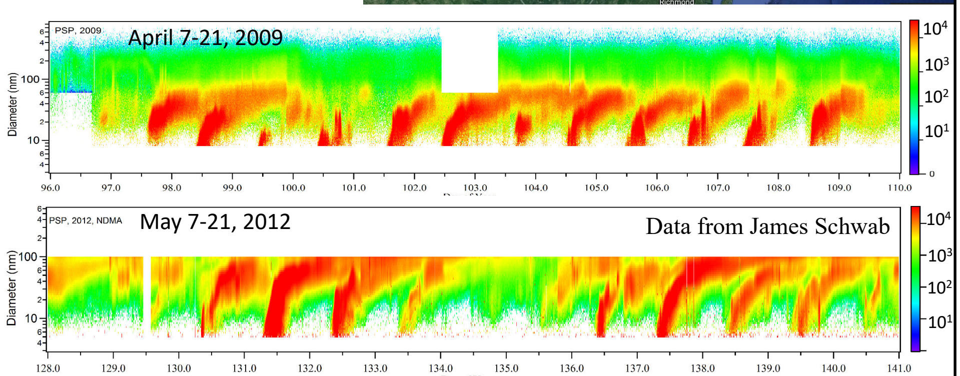
New particle formation (NPF) in the atmosphere



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Aerosol properties:

- Size,
- Composition, Mixing State,
- Phase (liquid or solid), Shape,
- Mass Concentrations, Number Concentrations,
- Surface Area,
- Optical properties,
- Efficiency to act as cloud condensation nuclei or ice nuclei,
- ...

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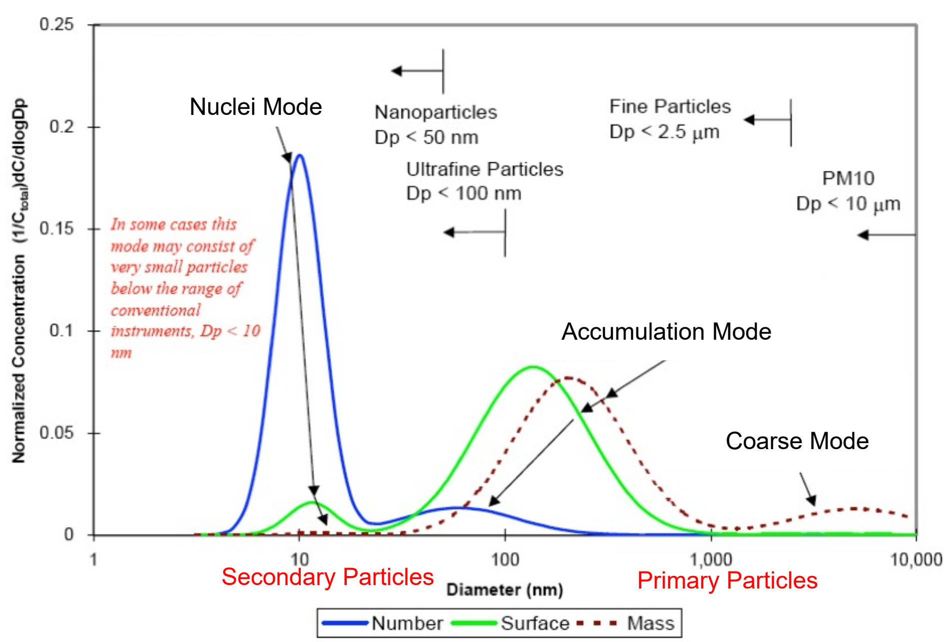
Particle number, surface area, and mass size distributions



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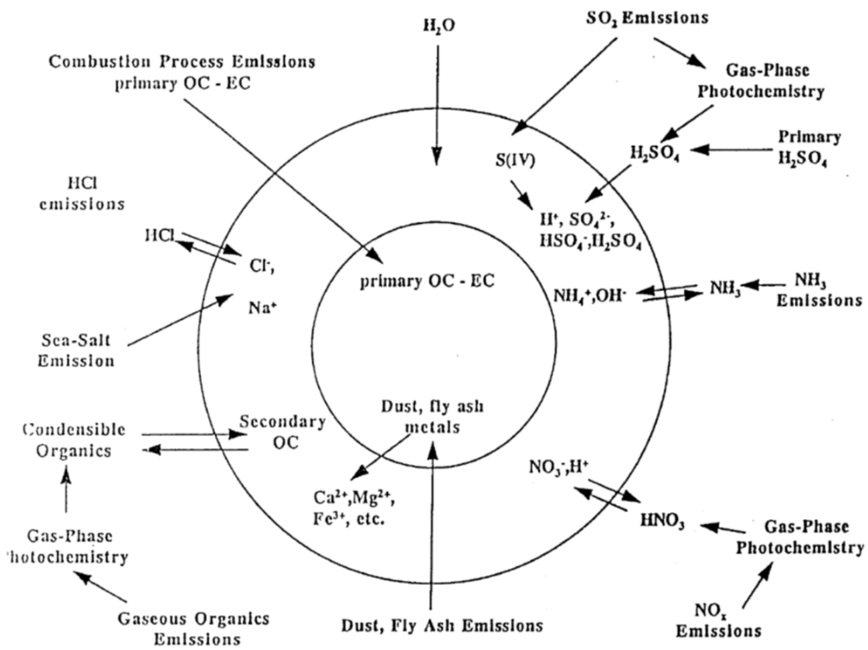
Typical Chemical Composition of Atmospheric Aerosols



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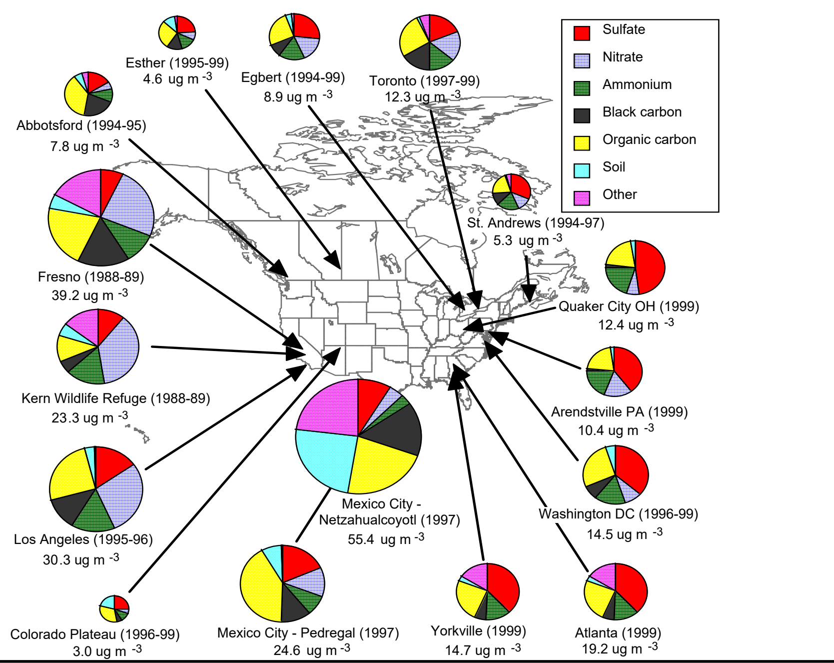
COMPOSITION OF PM2.5 (NARSTO PM ASSESSMENT)



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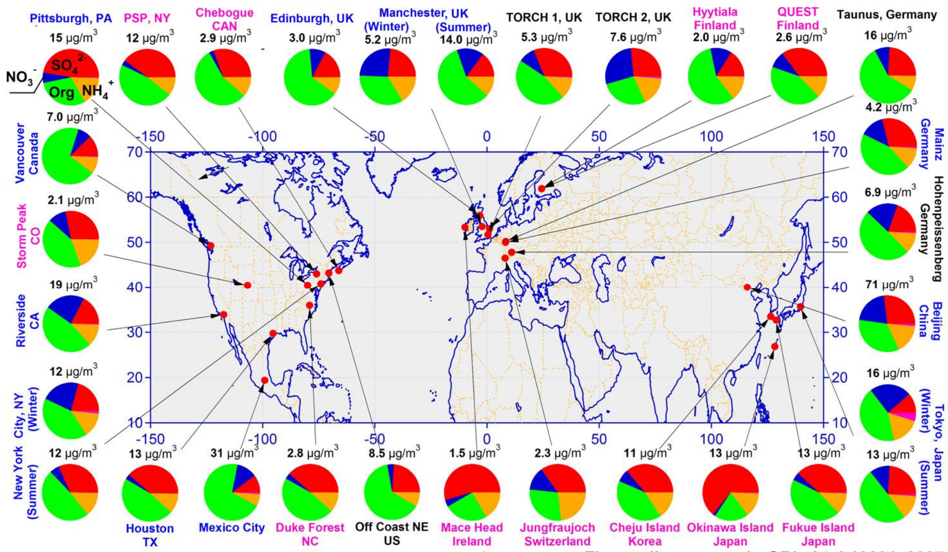

Zhang, Jimenez et al., *GRL*, 34, L13801, 2007

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II. Importance of atmospheric aerosols

1. Particles and health
2. Effects of aerosols on chemistry, radiation, cloud, climate and weather
3. Other emerging research topics related to particles

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1. Health Impacts of Atmospheric Aerosols

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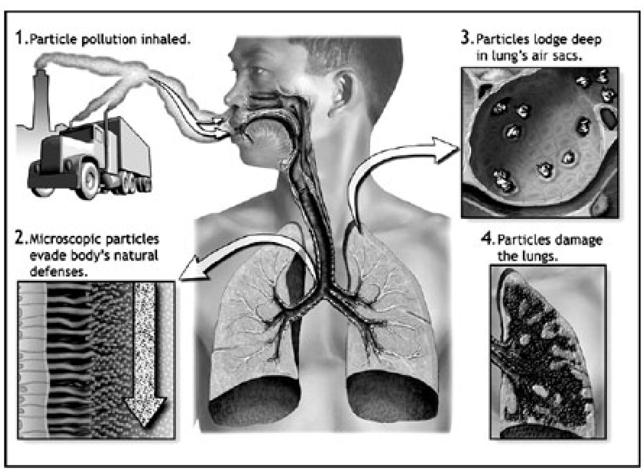

Because of its very small size, particle pollution gets right through the nasal passage, past the trachea and deep into the lungs. The smallest of the particles can even enter the bloodstream via the lungs.

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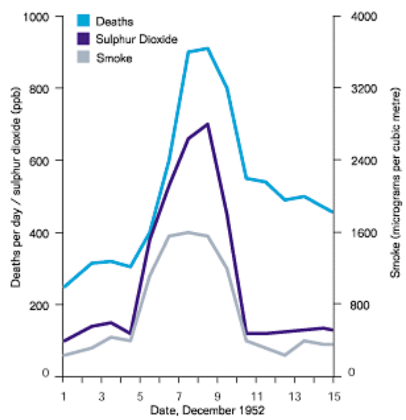
Air pollution and human health

1952: the "London smog disaster"

Air pollution
O_3, CO, NO_2, SO_2
aerosol



1950s: Los Angeles smog

Buildings in Los Angeles' Civic Center are barely visible from 1st and Olive Street on September 14, 1955. (Los Angeles Times via Getty Images)

A woman takes advantage of a "fresh air task force" supplying air from outside Los Angeles in 1958. (Bettmann Archive via Getty Images)

As many as 6,000 people attended a meeting to protest smog levels in Pasadena in 1954. (Allan Grant/The Life Picture Collection via

1950s-1960s: **New York City smog**

The 1966 smog wasn't the first time that New Yorkers were forced to brave dangerous smog. The infamous smog emergency of 1953 also took place in

A photo of the 1966 New York City smog as seen from the Empire State Building on November 24, 1966 at 8:30 a.m. The photo, taken by Neal Boenzi, was published on the front page of *The New York Times*.

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Air Pollution Linked to 1.2 Million Premature Deaths in China in 2010

Aly Song/Reuters

Shanghai in January. Researchers said the toll from China's pollution meant the loss of 25 million healthy years in 2010.

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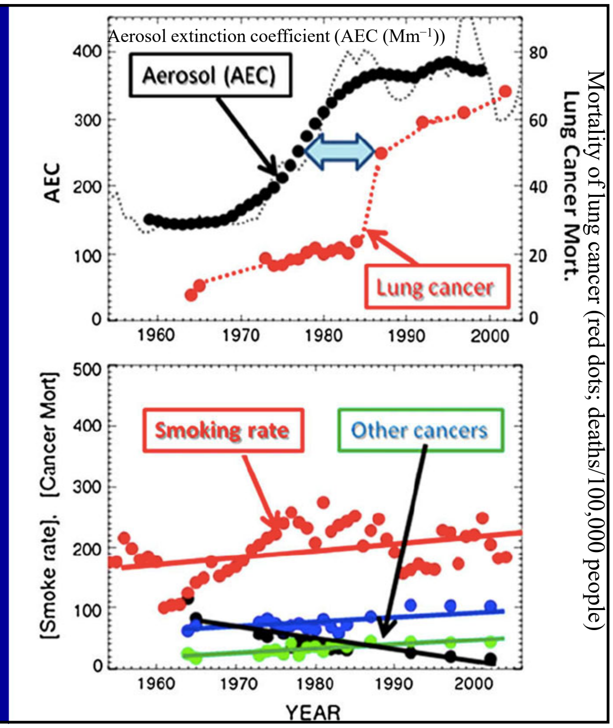
Tie, Wu, and Brasseur,
Atmos. Environ., 2009

“the dramatic increase in the occurrence of air pollution events between 1954 and 2006 has been followed by a large enhancement in the incidence of lung cancer”



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Association between size-segregated particles in ambient air and acute respiratory inflammation

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Science of the Total Environment 565 (2016) 412–419

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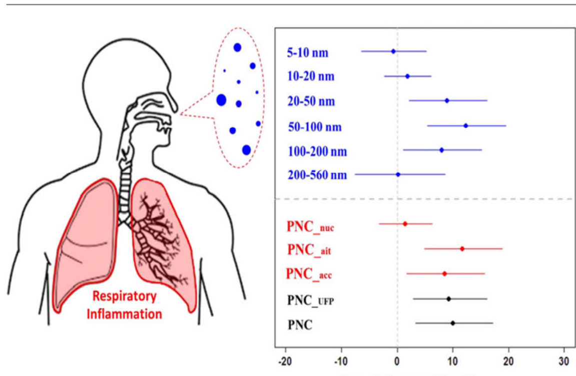
HIGHLIGHTS

- FE_{NO}, a biomarker of respiratory inflammation, was positively associated with almost all ambient air pollutants.
- The significant associations occurred within hours.
- The association between FE_{NO} and fine particulates depended on particle size, Aitken-mode particles have the most robust association.

GRAPHICAL ABSTRACT



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Science of the Total Environment 542 (2016) 841–844

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Short communication

Association of urban particle numbers and sources with lung function among children with asthma or allergies

Ya-Ru Li [a,1], Li-Ting Feng [b,1], Bing-Yu Chen [c,d], Ho Kim [e,f], Seung-Muk Yi [e,f], Yue Leon Guo [a,c,d,*], Chang-Fu Wu [a,b,g,**]

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HIGHLIGHTS

- Particle numbers and sources were used for examining particle-induced health effects.
- Secondary particle is most responsible for deterioration in childhood lung function.
- Analyses that rely on only particle number may underestimate risks of particles.

GRAPHICAL ABSTRACT

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Trees et al., Annals of the American Thoracic Society, 2024

Ultrafine Particles and Hospital Visits for Chronic Lower Respiratory Diseases in New York State

Ian Trees[1], Fangqun Yu[3], Xinlei Deng[1], Gan Luo[3], Wangjian Zhang[4], and Shao Lin[1,2]

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Abstract

Rationale: Exposure to particulate matter is associated with various adverse health outcomes. Ultrafine particles (UFPs; diameter <0.1 μm) are a unique public health challenge because of their size. However, limited studies have examined their impacts on human health, especially across seasons and demographic characteristics.

Objectives: To evaluate the effect of UFP exposure on the risk of visiting the emergency department (ED) for a chronic lower respiratory disease (CLRD) in New York State in 2013–2018.

Methods: We used a case-crossover design and conditional logistic regression to estimate how UFP exposure led to CLRD-related ED visits. GEOS-Chem Advanced Particle Microphysics, a state-of-the-art chemical transport model with a size-resolved particle microphysics model, generated air pollution simulation data. We then matched UFP exposure estimates to geocoded health records for asthma, bronchiectasis, chronic bronchitis, emphysema, unspecified bronchitis, and other chronic airway obstructions in New York State from 2013 through 2018. In addition, we assessed interactions with age, ethnicity, race, sex, meteorological factors, and season.

Results: Each 1-(interquartile range [IQR]) increase in UFP exposure led to a 0.37% increased risk of a respiratory-related ED visit on lag 0–0, or the day of the ED visits, (95% confidence interval [CI], 0.23–0.52%) and a 1.81% increase on lag 0–6, or 6 days before the ED visit, (95% CI, 1.58–2.03%). The highest risk was in the emphysema subtype (lag 0–5, 4.18%; 95% CI, 0.16–8.37%), followed by asthma (lag 0–6, 2.00%), chronic bronchitis (lag 0–6, 1.78%), other chronic airway obstructions (lag 0–6, 1.60%), and unspecified bronchitis (lag 0–6, 1.49%). We also found significant interactions between UFP health impacts and season (Fall, 3.29%), temperature (<90th percentile, 2.27%), relative humidity (>90th percentile, 4.63%), age (children aged <18 yr, 3.19%), and sex (men, 2.06%) on lag 0–6.

Conclusions: In this study, UFP exposure increased CLRD-related ED visits across all seasons and demographic characteristics, yet these associations varied according to various factors, which requires more research.

Keywords: air pollution; particulate matter; COPD; asthma

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Trees et al., Annals of the American Thoracic Society, 2024

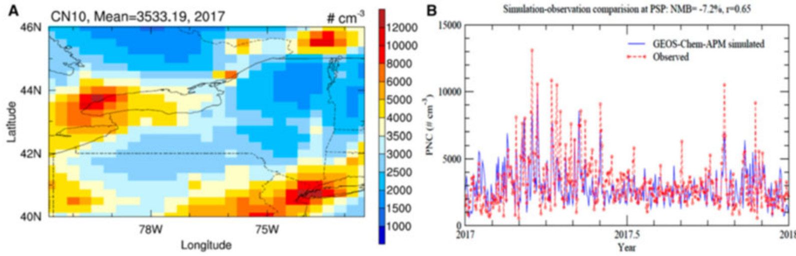

Figure 1. (*A*) Annual mean horizontal distributions of number concentrations of condensation nuclei >10 nm over New York State in 2017 simulated with GESO-Chem Advanced Particle Microphysics model with 0.3125° × 0.25° horizontal resolution. (*B*) Comparisons of simulated total particle number concentration versus those observed at the Pinnacle State Park site (77.21°W, 42.10°N). The observed and simulated values are for those >7 nm (62). APM = advanced particle microphysics; CN_{10} = condensation nuclei >10 nm; NMB = normalized mean bias; PNC = particle number concentration; PSP = Pinnacle State Park.

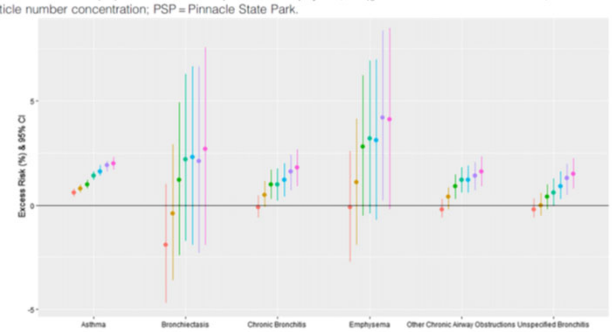

Figure 2. Ultrafine particle exposure and excess risk for a chronic lower respiratory disease subtype-related emergency department visit in New York State, lag 0-0 to lag 0-6, 2013-2018. CI = confidence interval.

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Lin et al., Environmental Pollution, 2022

Check for updates

Particle surface area, ultrafine particle number concentration, and cardiovascular hospitalizations☆

Shao Lin [a,b,*], Ian Ryan [a], Sanchita Paul [c], Xinlei Deng [a], Wangjian Zhang [d], Gan Luo [e], Guang-Hui Dong [f], Arshad Nair [e], Fangqun Yu [e,**] fyu@albany.edu

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ARTICLE INFO

Keywords:
Ultrafine particles
Particle surface area
Air pollution exposure
Cardiovascular admission
Lag effect
Vulnerable population
Seasonality

ABSTRACT

While the health impacts of larger particulate matter, such as PM_{10} and $PM_{2.5}$, have been studied extensively, research regarding ultrafine particles (UFPs or $PM_{0.1}$) and particle surface area concentration (PSC) is lacking. This case-crossover study assessed the associations between exposure to PSC and UFP number concentration (UFPnc) and hospital admissions for cardiovascular diseases (CVDs) in New York State (NYS), 2013–2018. We used a time-stratified case-crossover design to compare the PSC and UFPnc levels between hospitalization days and control days (similar days without admissions) for each CVD case. We utilized NYS hospital discharge data to identify all CVD cases who resided in NYS. UFP simulation data from GEOS-Chem-APM, a state-of-the-art chemical transport model, was used to define PSC and UFPnc. Using a multi-pollutant model and conditional logistic regression, we assessed excess risk (ER)% per inter-quartile change of PSC and UFPnc after controlling for meteorological factors, co-pollutants, and time-varying variables. We found immediate and lasting associations between PSC and overall CVDs (lag0–lag0-6: ERs% (95% CI%) ranges: 0.4 (0.1,0.7) - 0.9 (0.7–1.2), and delayed and prolonged ERs%: 0.1–0.3 (95% CIs: 0.1–0.5) between UFPnc and CVDs (lag0-3–lag0-6). Exposure to larger PSC was associated with immediate ER increases in stroke, hypertension, and ischemic heart diseases (1.1%, 0.7%, 0.8%, respectively, all $p < 0.05$). The adverse effects of PSC on CVDs were highest among children (5–17 years old), in the fall and winter, and during cold temperatures. In conclusion, we found an immediate, lasting effects of PSC on overall CVDs and a delayed, prolonged impact of UFPnc. PSC was a more sensitive indicator than UFPnc. The PSC effects were higher among certain CVD subtypes, in children, in certain seasons, and during cold days. Further studies are needed to validate our findings and evaluate the long-term effects.

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Nair et al., Environmental Research, 2023

Environmental exposure disparities in ultrafine particles and $PM_{2.5}$ by urbanicity and socio-demographics in New York state, 2013–2020

Check for updates

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A R T I C L E I N F O

Keywords:
Air quality
Aerosols
Fine particulate matter
Ultrafine particles
Environmental justice
Public health inequalities

A B S T R A C T

Background: The spatiotemporal and demographic disparities in exposure to ultrafine particles (UFP; number concentrations of particulate matter (PM) with diameter $\leq$0.1 μm), a key subcomponent of fine aerosols ($PM_{2.5}$; mass concentrations of PM $\leq$ 2.5 μm), have not been well studied.

Objective: To quantify and compare the aerosol pollutant exposure disparities for UFP and $PM_{2.5}$ by socio-demographic factors in New York State (NYS).

Methods: Ambient atmospheric UFP and $PM_{2.5}$ were quantified using a global three-dimensional model of chemical transport with state-of-the-science aerosol microphysical processes validated extensively with observations. We matched these to U.S. census demographic data for varied spatial scales (state, county, county subdivision) and derived population-weighted aerosol exposure estimates. Aerosol exposure disparities for each demographic and socioeconomic (SES) indicator, with a focus on race-ethnicity and income, were quantified for the period 2013–2020.

Results: The average NYS resident was exposed to 4451 #·cm^{-3} UFP and 7.87 μg·m^{-3} $PM_{2.5}$ in 2013–2020, but minority race-ethnicity groups were invariably exposed to greater daily aerosol pollution (UFP: +75.0% & $PM_{2.5}$: +16.2%). UFP has increased since 2017 and is temporally and seasonally out-of-phase with $PM_{2.5}$. Race-ethnicity exposure disparities for $PM_{2.5}$ have declined over time; by −6% from 2013 to 2017 and plateaued thereafter despite its decreasing concentrations. In contrast, these disparities have increased (+12.5–13.5%) for UFP. The aerosol pollution exposure disparities were the highest for low-income minorities and were more amplified for UFP than $PM_{2.5}$.

Discussion: We identified large disparities in aerosol pollution exposure by urbanization level and socio-demographics in NYS residents. Jurisdictions with higher proportions of race-ethnicity minorities, low-income residents, and greater urbanization were disproportionately exposed to higher concentrations of UFP and $PM_{2.5}$ than other NYS residents. These race-ethnicity exposure disparities were much larger, more disproportionate, and unabating over time for UFP compared to $PM_{2.5}$ across various income strata and levels of urbanicity.

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Qi et al., Journal of Hazardous Materials, 2024

Hidden danger: The long-term effect of ultrafine particles on mortality and its sociodemographic disparities in New York State

Quan Qi[a], Fangqun Yu[b], Arshad A. Nair[b], Sam S.S. Lau[c,d], Gan Luo[b], Imran Mithu[e], Wangjian Zhang[f], Sean Li[g], Shao Lin[h,i,*]

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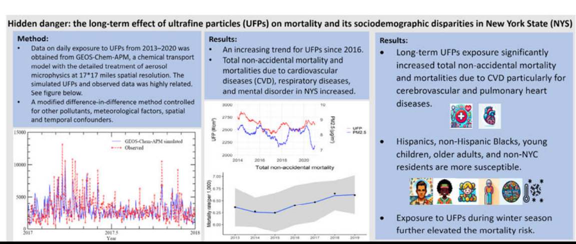
H I G H L I G H T S

- Long-term UFPs exposure significantly increased total non-accidental mortality.
- Mortalities for cardiovascular diseases were associated with UFP exposure.
- Hispanics and non-Hispanic Blacks experienced higher UFP-related mortalities.
- Young children, older adults, and non-NYC residents had higher UFP-Mortality risks.
- Exposure to UFPs during winter season further elevated the mortality risk.

G R A P H I C A L A B S T R A C T



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2. Effects of aerosols on chemistry, radiation, cloud, climate and weather

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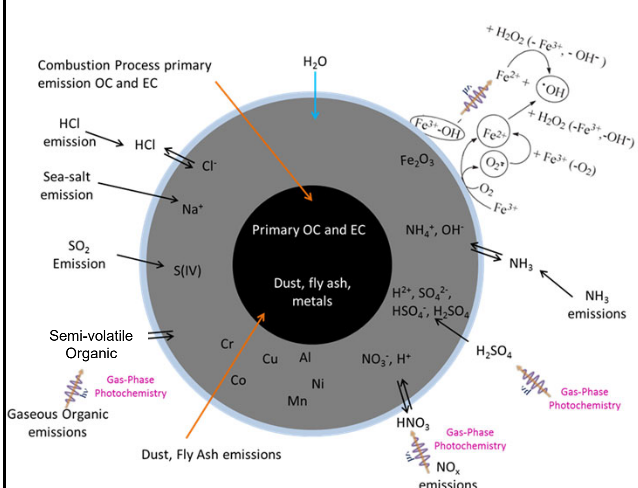
Chemical effects



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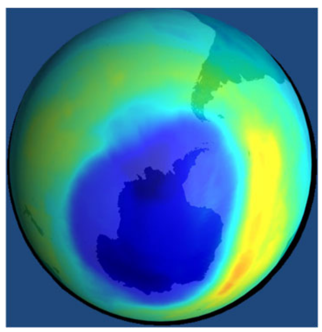
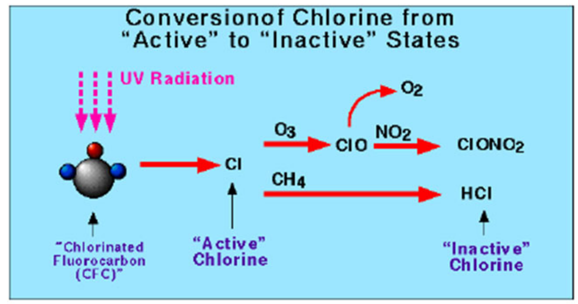
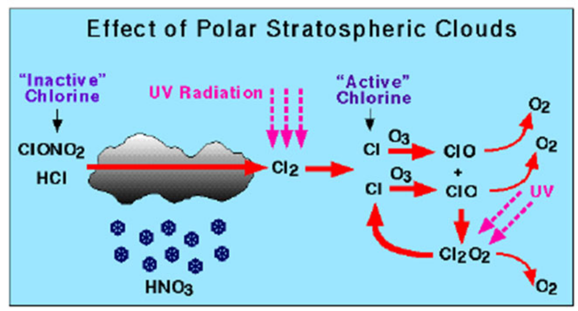
Polar Stratospheric Cloud (PSC) and Ozone Hole







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Aerosol Direct and Indirect Climate Effects

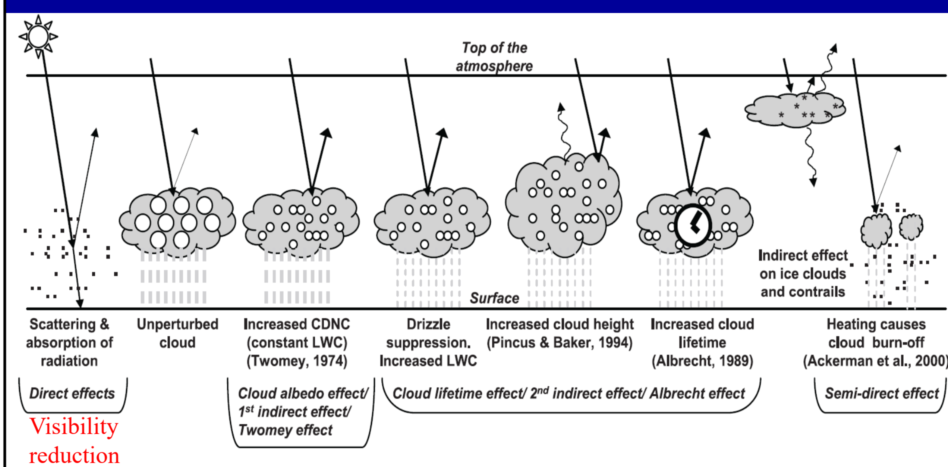

Figure 2.10. *Schematic diagram showing the various radiative mechanisms associated with cloud effects that have been identified as significant in relation to aerosols (modified from Haywood and Boucher, 2000). The small black dots represent aerosol particles; the larger open circles cloud droplets. Straight lines represent the incident and reflected solar radiation, and wavy lines represent terrestrial radiation. The filled white circles indicate cloud droplet number concentration (CDNC). The unperturbed cloud contains larger cloud drops as only natural aerosols are available as cloud condensation nuclei, while the perturbed cloud contains a greater number of smaller cloud drops as both natural and anthropogenic aerosols are available as cloud condensation nuclei (CCN). The vertical grey dashes represent rainfall, and LWC refers to the liquid water content.*

IPCC, 2007

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Mt. Pinatubo June 1991

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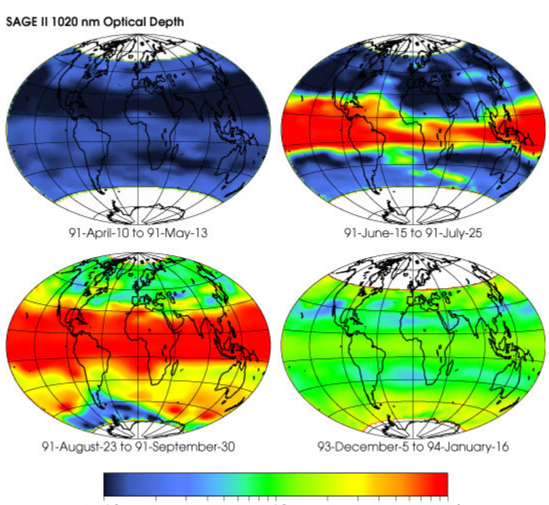
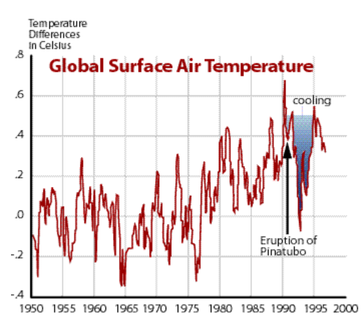
Impact of Pinatubo aerosols on average global surface air temperature: ~0.5 °C!



June 12, 1991 eruption



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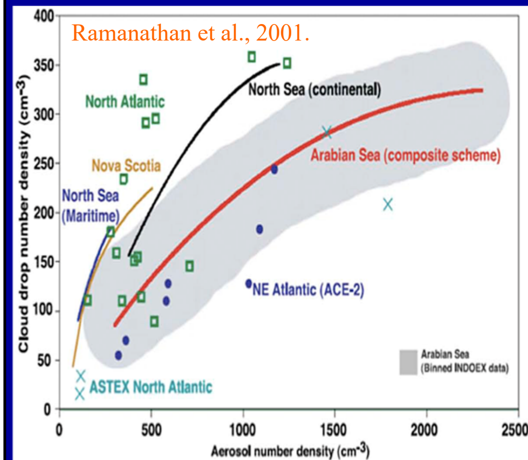
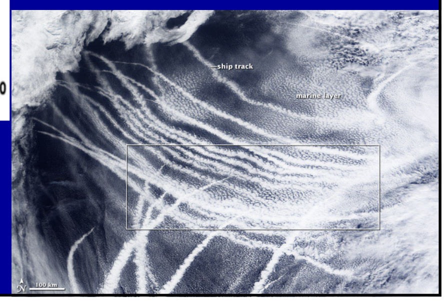
Aerosol Indirect Climate Effects





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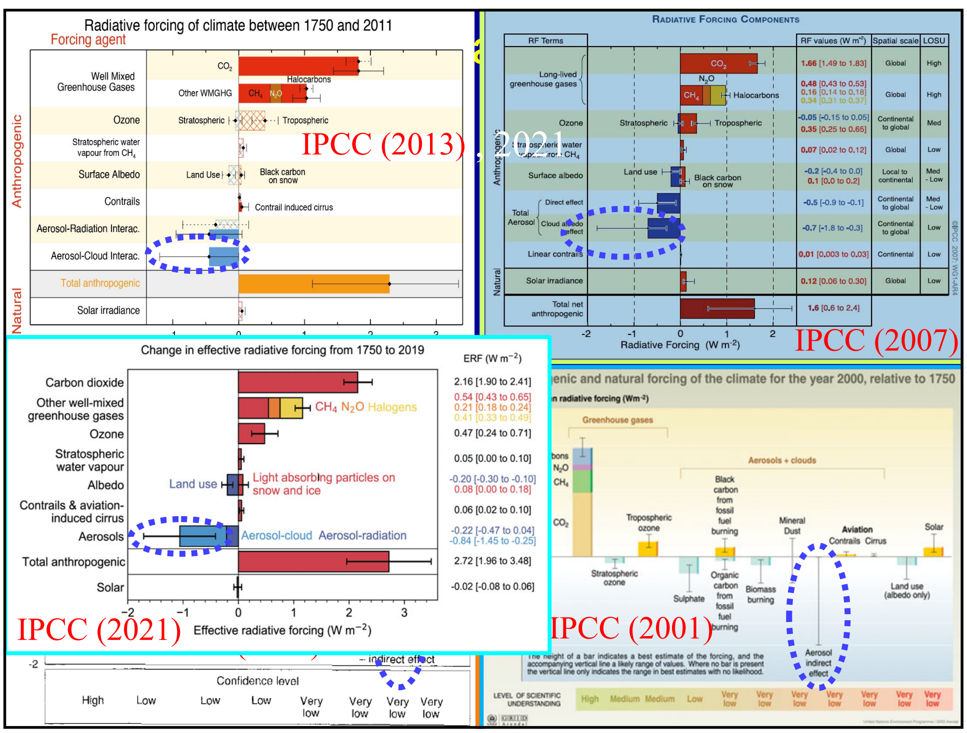

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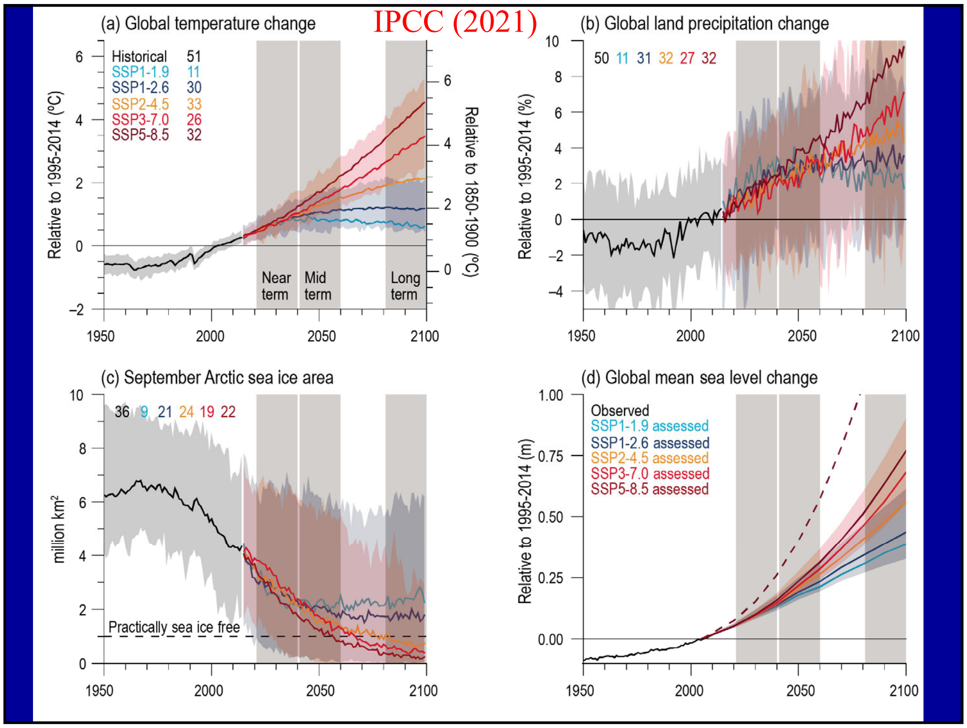

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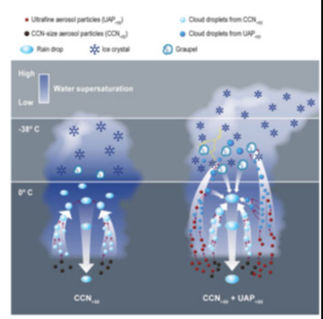
Fan *et al.*, *Science* **359**, 411–418 (2018) 26 January 2018

RESEARCH ARTICLE

ATMOSPHERIC PHYSICS

Substantial convection and precipitation enhancements by ultrafine aerosol particles

Jiwen Fan,[1*] Daniel Rosenfeld,[2] Yuwei Zhang,[1,3] Scott E. Giangrande,[4] Zhanqing Li,[3,5] Luiz A. T. Machado,[6] Scot T. Martin,[7] Yan Yang,[1,8] Jian Wang,[4] Paulo Artaxo,[9] Henrique M. J. Barbosa,[9,10] Ramon C. Braga,[6] Jennifer M. Comstock,[1] Zhe Feng,[1] Wenhua Gao,[1,11] Helber B. Gomes,[12] Fan Mei,[1] Christopher Pöhlker,[13] Mira L. Pöhlker,[13] Ulrich Pöschl,[13,14] Rodrigo A. F. de Souza[15]



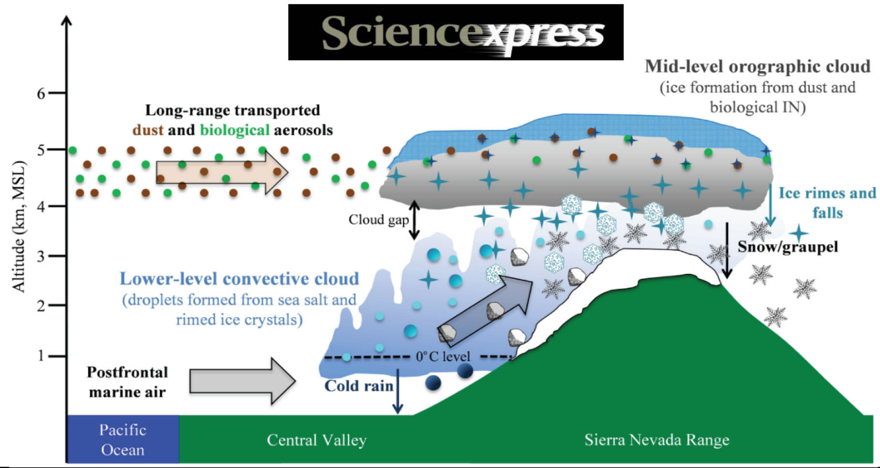
Aerosol-cloud interactions remain the largest uncertainty in climate projections. Ultrafine aerosol particles smaller than 50 nanometers ($UAP_{<50}$) can be abundant in the troposphere but are conventionally considered too small to affect cloud formation. Observational evidence and numerical simulations of deep convective clouds (DCCs) over the Amazon show that DCCs forming in a low-aerosol environment can develop very large vapor supersaturation because fast droplet coalescence reduces integrated droplet surface area and subsequent condensation. $UAP_{<50}$ from pollution plumes that are ingested into such clouds can be activated to form additional cloud droplets on which excess supersaturation condenses and forms additional cloud water and latent heating, thus intensifying convective strength. This mechanism suggests a strong anthropogenic invigoration of DCCs in previously pristine regions of the world.

38

Creamean, et al.
Science, 2013

Dust and Biological Aerosols from the Sahara and Asia Influence Precipitation in the Western U.S.

Sciencexpress



CalWater-2011 field observations showed days with dust and bioparticles experienced extensive snowfall

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High resolution WRF simulations of Hurricane Irene: Sensitivity to aerosols and choice of microphysical schemes

A. Khain *, B. Lynn, J. Shpund

Department of Atmospheric Sciences, The Hebrew University of Jerusalem, Jerusalem 91904, Israel

Atmospheric Research 167 (2016) 129–145

A B S T R A C T

Recent studies have pointed to the possible sensitivity of hurricanes to aerosols via aerosol effects on microphysical and thermodynamic processes in clouds. Hurricane Irene, occurring in August 2011, is an excellent case study for investigating aerosol effects on tropical cyclone (TC) structure and intensity: it moved northward along the eastern coast of the United States, and weakened much faster than was predicted by the National Hurricane Center. Moreover, the minimum pressure in Irene occurred, atypically, about 40 h later than the time of maximum wind speed. In this study, we simulate Hurricane Irene with 1-km grid spacing using Spectral Bin Microphysics (SBM) and various bulk microphysical schemes in WRF. Simulations with SBM showed that aerosols penetrating the eyewall of Irene from the Saharan Air Layer (SAL) led to an intensification of convection at Irene's eyewall and to a deepening of the hurricane. When Irene moved along the eastern coast of the United States, continental aerosols led to an intensification of convection at Irene's periphery, which interfered with the re-forming of the inner eyewall and to Irene weakening. Sensitivity tests using different “bulk” microphysics schemes indicated a large dispersion of simulated minimum pressure and maximum wind between different simulations. This showed that the simulated hurricane intensity was very sensitive to microphysical processes. Moreover, in consequence,

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Geophysical Research Letters

RESEARCH LETTER
10.1002/2015GL064479

Key Points:
- Aerosols contribute to flooding by "aerosol-enhanced conditional instability"
- Reducing pollution (particularly BC) in the Sichuan Basin mitigates floods
- Coupling aerosols with meteorology may improve weather forecasts

Substantial contribution of anthropogenic air pollution to catastrophic floods in Southwest China

Jiwen Fan[1], Daniel Rosenfeld[2], Yan Yang[1,3], Chun Zhao[1], L. Ruby Leung[1], and Zhanqing Li[4,5]

[1]Atmospheric Sciences and Global Change Division, Pacific Northwest National Laboratory, Richland, Washington, USA, [2]Institute of Earth Sciences, Hebrew University of Jerusalem, Jerusalem, Israel, [3]Chinese Academy of Meteorological Sciences, Beijing, China, [4]Department of Atmospheric and Oceanic Science and ESSIC, University of Maryland, College Park, Maryland, USA, [5]State Key Laboratory of Earth Surface Processes and Resource Ecology and Joint Center for Global Change Studies, Beijing Normal University, Beijing, China

Key Points:
- Aerosols contribute to flooding by "aerosol-enhanced conditional instability"
- Reducing pollution (particularly BC) in the Sichuan Basin mitigates floods
- Coupling aerosols with meteorology may improve weather forecasts

41

J Atmos Chem
DOI 10.1007/s10874-015-9300-x 2015

Sensitivity of convection to observed variation in aerosol size distributions and composition at a rural site in the southeastern United States

T. L. O'Halloran · J. D. Fuentes · W. K. Tao · X. Li

aerosol composition over short time scales. Variations in the aerosol size distribution and composition resulted in substantial variation in the total number of cloud condensation nuclei (CCN) produced in the four case studies. Cases with high CCN concentrations developed larger, more vigorous clouds with more precipitation generated by both warm and cold rain processes. Greater numbers of drops were propelled aloft and formed an extensive ice anvil that produced a large area of stratiform rain. Convection was enhanced by increasing aerosols despite decreases in precipitation efficiency. In contrast, lower CCN concentrations developed smaller clouds with suppressed cold rain processes and less total precipitation. The relatively

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SCIENCE ADVANCES | RESEARCH ARTICLE 2022

ATMOSPHERIC SCIENCE

Substantial global influence of anthropogenic aerosols on tropical cyclones over the past 40 years

Hiroyuki Murakami[1,2]*

Over the past 40 years, anthropogenic aerosols have been substantially decreasing over Europe and the United States owing to pollution control measures, whereas they have increased in South and East Asia because of the economic and industrial growth in these regions. However, it is not yet clear how the changes in anthropogenic aerosols have altered global tropical cyclone (TC) activity. In this study, we reveal that the decreases in aerosols over Europe and the United States have contributed to significant decreases in TCs over the Southern Hemisphere as well as increases in TCs over the North Atlantic, whereas the increases in aerosols in South and East Asia have exerted substantial decreases in TCs over the western North Pacific. These results suggest that how society controls future emissions of anthropogenic aerosols will exert a substantial impact on the world's TC activity.

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JGR Atmospheres

RESEARCH ARTICLE
10.1029/2024JD041600

Investigation of the Sensitivity of Tropical Cyclogenesis to Aerosol Intervention

Thao Linh Tran[1,2], Jiwen Fan[3], Daniel Rosenfeld[4], Yuwei Zhang[5], Helen Cleugh[1], Andrew McC Hogg[2], and Roslyn Prinsley[1]

[1]Institute for Climate, Energy and Disaster Solutions, Australian National University, Canberra, ACT, Australia, [2]Research School of Earth Sciences, Australian National University, Canberra, ACT, Australia, [3]Environmental Science Division, Argonne National Laboratory, Lemont, IL, USA, [4]The Fredy & Nadin Herrman Institute of Earth Sciences, The Hebrew University of Jerusalem, Jerusalem, Israel, [5]Atmospheric Sciences and Global Change Division, Pacific Northwest National Laboratory, Richland, WA, USA

Key Points:

- Aerosols of different sizes and concentrations have contrasting effects on microphysics and wind intensities of a developing vortex
- Coarse aerosols initially dampen vortex acceleration; fine/ultrafine aerosols boost it first but later weaken it more than coarse aerosols
- All aerosols hold promise for intervention, but technological limits impede the generation of the necessary volume of coarse aerosols

Supporting Information:

Supporting Information may be found in the online version of this article.

Correspondence to:

T. L. Tran,
thaolinh.tran@anu.edu.au

Citation:

Tran, T. L., Fan, J., Rosenfeld, D., Zhang, Y., Cleugh, H., Hogg, A. M., & Prinsley, R. (2025). Investigation of the sensitivity of tropical cyclogenesis to aerosol intervention. *Journal of Geophysical Research: Atmospheres, 130*, e2024JD041600. https://doi.org/10.1029/

Abstract As risks from tropical cyclones (TCs) are fueled by climate change escalation, there is an urgent need for transformational solutions to complement traditional approaches. Seeding TCs using aerosols can be a promising method to reduce cyclone intensity, supported by theoretical understanding of the microphysical effects of aerosols on TC clouds. The ideal time to intervene effectively in TCs is likely during their initial stage, before TC wind speeds reach their peak. However, studies exploring potential aerosol effects on TC formation remain scarce. This study investigates how a TC embryo responds to the addition of aerosols of varying sizes using the Weather Research & Forecasting (WRF) model coupled with a spectral-bin microphysics model. We found that aerosols of different sizes and concentrations distinctively affect the pre-TC vortex's microstructure and dynamics. Fine and ultrafine aerosols enhance the latent heat of condensation, freezing, deposition, and riming, initially intensifying the vortex. However, this results in enhancement of the cold pool, thereby reducing inflow and surface fluxes, subsequently weakening the vortex. Coarse aerosols produce the opposite effect to that of fine and ultrafine aerosols. Coarse aerosols lead to a slower initial acceleration owing to enhanced warm rain. However, the resulting weaker cold pool is insufficient to effectively reduce the strength of the vortex at the later stage. This study provides critical insights into how aerosols of varying sizes and concentrations modulate the energy cascade and impact the evolution of a TC embryo, laying the groundwork for further research on TC risk management through aerosol intervention.

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3. Other emerging research topics related to particles

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Climate-busting plane pollution revealed by new EU study

By Sam Morgan | EURACTIV.com   Nov 25, 2020 (updated: Dec 6, 2020)

Plane contrails are among the non-CO2 climate effects of aviation. [Photo: Shutterstock]

Print

The European Commission published new findings on Tuesday (24 November) that confirm aviation's non-CO2 climate impact is substantial, as the EU executive mulls how to regulate plane travel in the decades to come.

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CLEAN AVIATION

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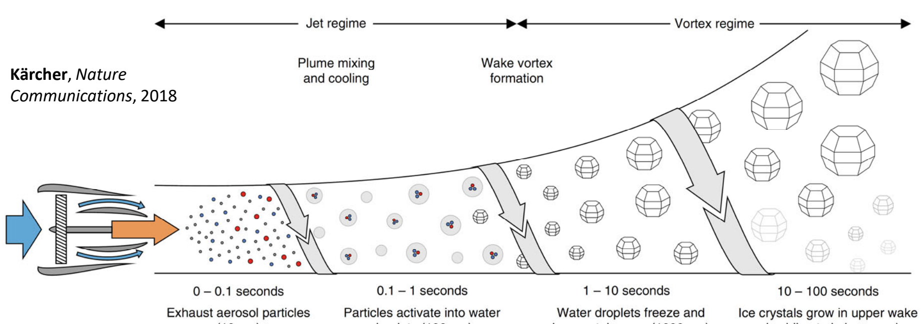
Formation and Evolution of Aerosols and Contrails in Aircraft Wakes

Kärcher, *Nature Communications*, 2018



48

Hydrogen flight and contrails

MODERN FLYING

Airbus, GE Aviation, Safran to Develop Hydrogen Flight Test Demonstrator

Airbus aims to use a modified A380 equipped with hydrogen fuel tanks as a test platform.

By Thom Patterson — February 22, 2022

Airbus unveiled an artist's rendering Tuesday of its A380 hydrogen test demonstrator. [Courtesy: Airbus]

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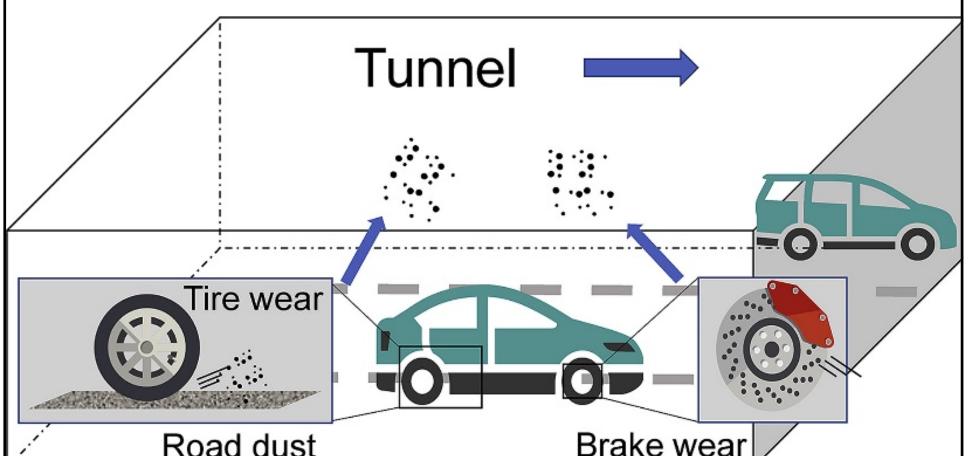
Non-tailpipe emissions



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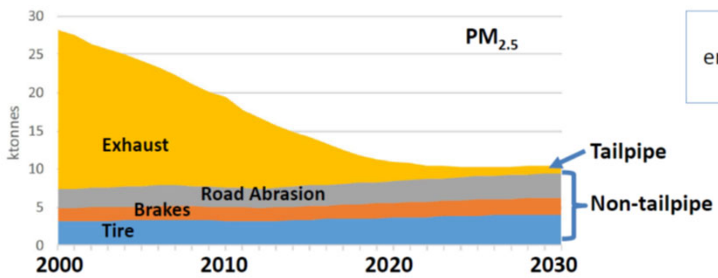
Non-tailpipe emissions now exceed tailpipe emissions?



On-road vehicle emissions in United Kingdom

Could be even more skewed is very substantial electrification of the fleet.

https://uk-air.defra.gov.uk/assets/documents/reports/cat09/1907101151_20190709_Non_Exhaust_Emissions_typeset_Final.pdf

Are non-tailpipe emissions more toxic than other types of PM?

51

nature COMMUNICATIONS

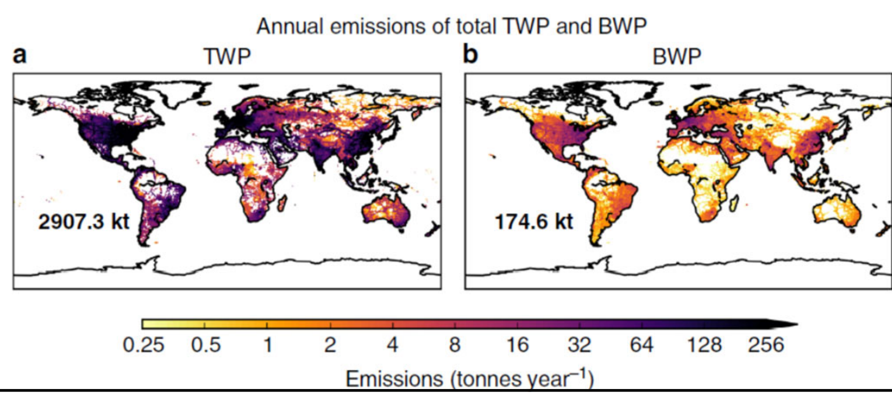
ARTICLE

https://doi.org/10.1038/s41467-020-17201-9

"Here, we present global simulations of atmospheric transport of microplastic particles produced by road traffic (TWPs – tire wear particles and BWPs – brake wear particles), a major source that can be quantified relatively well. We find a high transport efficiencies of these particles to remote regions."

Atmospheric transport is a major pathway of microplastics to remote regions

N. Evangeliou[1✉], H. Grythe[1], Z. Klimont[2], C. Heyes[2], S. Eckhardt[1], S. Lopez-Aparicio[1] & A. Stohl[1,3]



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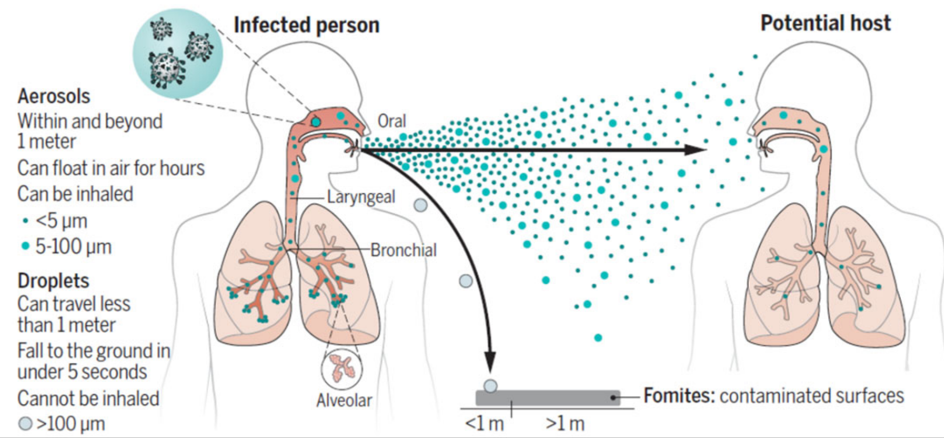
REVIEW SUMMARY

Wang *et al.*, *Science* **373**, 981 (2021)

CORONAVIRUS

Airborne transmission of respiratory viruses

Chia C. Wang*, Kimberly A. Prather*, Josué Sznitman, Jose L. Jimenez, Seema S. Lakdawala, Zeynep Tufekci, Linsey C. Marr



53

Maryland Today | UMD to Lead

https://today.umd.edu/umd-lead-15m-project-investigati

UNIVERSITY OF MARYLAND

WEDNESDAY, APRIL 27, 2022

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RESEARCH

UMD to Lead $15M Project Investigating the Role of Aerosols in Flu Transmission

Participants in NIH-funded Study to Play Pool, Cards, Video Games Together to Test How Flu Spreads

"The medical community doesn't yet fully understand aerosols and has been waiting for more evidence from a trial like this one," said Milton, who will lead the project. "My hope is that we can address this persistent controversy that has held up our ability to respond to respiratory pandemics."

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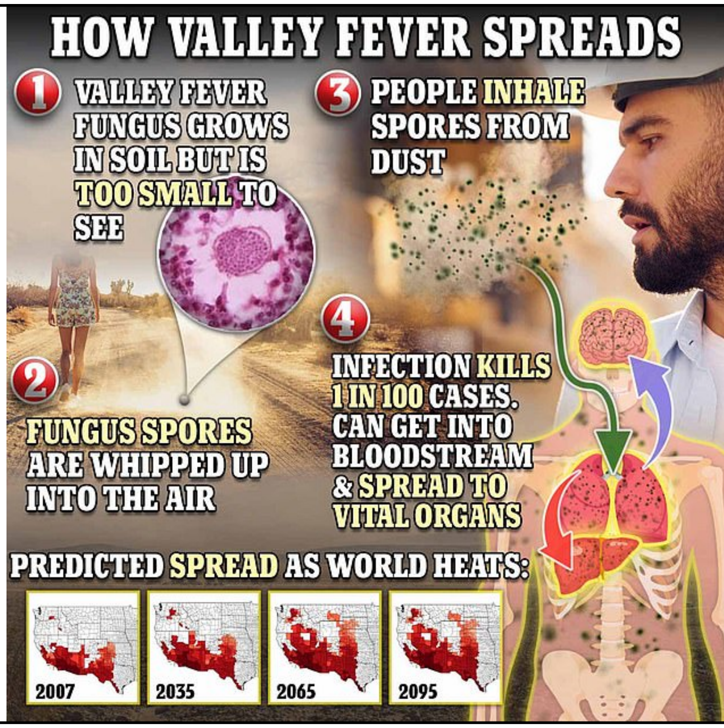
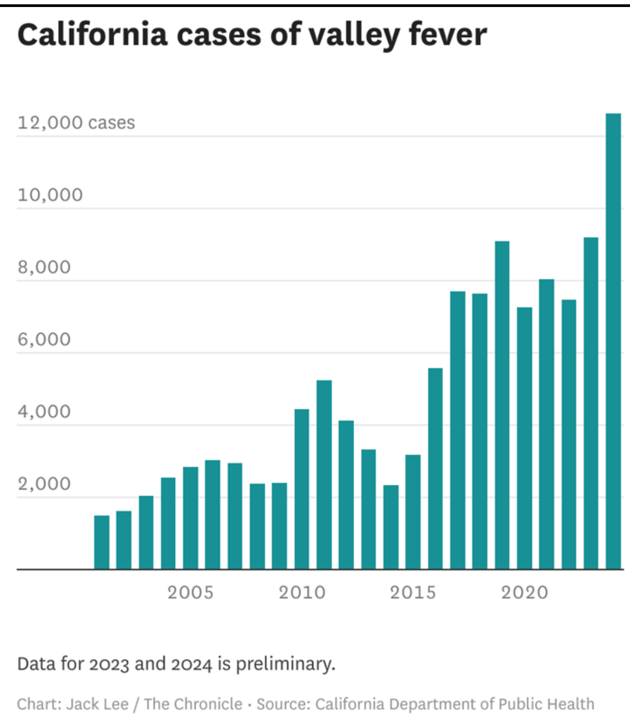

HOW VALLEY FEVER SPREADS
1 VALLEY FEVER FUNGUS GROWS IN SOIL BUT IS TOO SMALL TO SEE
2 FUNGUS SPORES ARE WHIPPED UP INTO THE AIR
3 PEOPLE INHALE SPORES FROM DUST
4 INFECTION KILLS 1 IN 100 CASES. CAN GET INTO BLOODSTREAM & SPREAD TO VITAL ORGANS
PREDICTED SPREAD AS WORLD HEATS:
2007
2035
2065
2095

55


California cases of valley fever
12,000 cases
10,000
8,000
6,000
4,000
2,000
2005
2010
2015
2020
Data for 2023 and 2024 is preliminary.
Chart: Jack Lee / The Chronicle · Source: California Department of Public Health

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Legionnaires' disease has been increasing but the reasons are unknown!

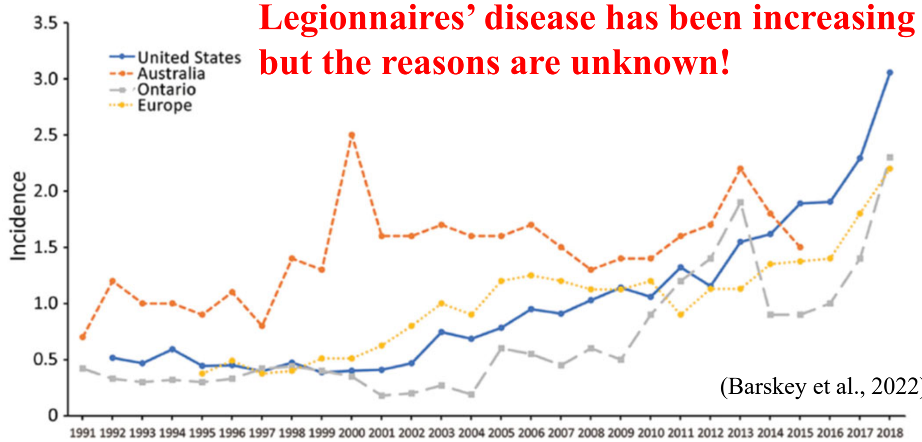
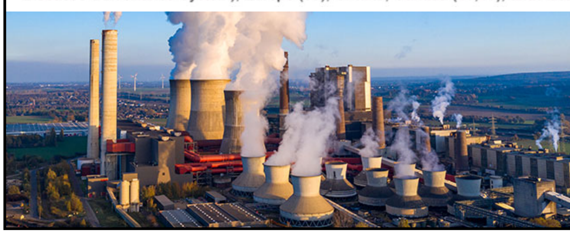


Figure 8. International crude incidence (cases/100,000 population) trends of Legionnaires' disease, United States (National Notifiable Diseases Surveillance System), Europe (*39*), Ontario, Canada (*40,41*), and Austra



Interactions of aerosolized droplets with weather and environments

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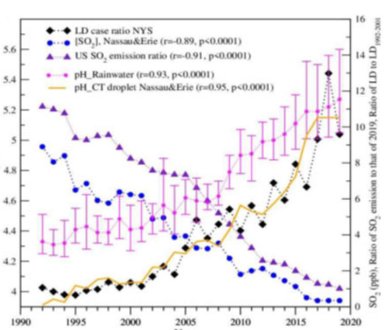
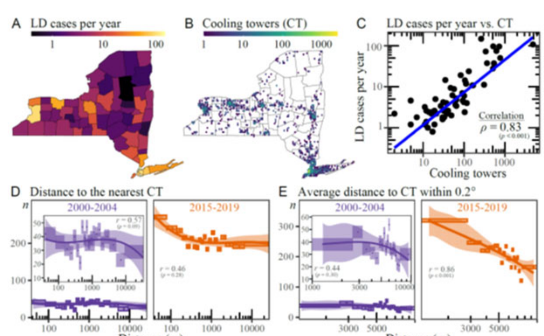
Mysteriously rapid rise in Legionnaires' disease incidence likely linked to declining sulfur dioxide

Yu et al., PNAS-Nexus, 2024.

Fangqun Yu[a,1,2], Arshad Arjunan Nair[a,1,2], Ursula Lauper[b], Gan Luo[a], Jason Herb[a], Matthew Morse[b], Braden Savage[b], Martin Zartarian[b], Meng Wang[c], and Shao Lin[d]

[a]Atmospheric Sciences Research Center, University at Albany, State University of New York, Albany, NY 12226; [b]Bureau of Water Supply Protection, New York State Department of Health, Albany, NY 12223; [c]School of Public Health and Health Professions, University at Buffalo, State University of New York, Buffalo, NY 14214; [d]School of Public Health, University at Albany, State University of New York, Albany, NY 12144





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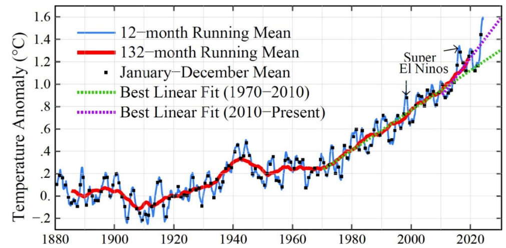
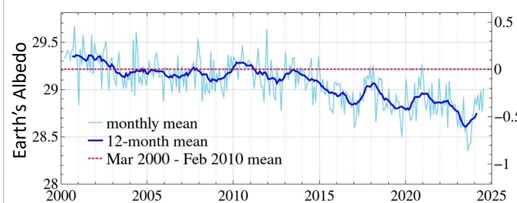
Claim '2 Degree Target Is Dead' Triggers Debate Over Climate Scenarios

ENVIRONMENT 06 February 2025 By ISSAM AHMED, AFP

Capping rising temperatures to 2 C by 2100 becoming increasingly unlikely. (Paul Souders/Getty Images)





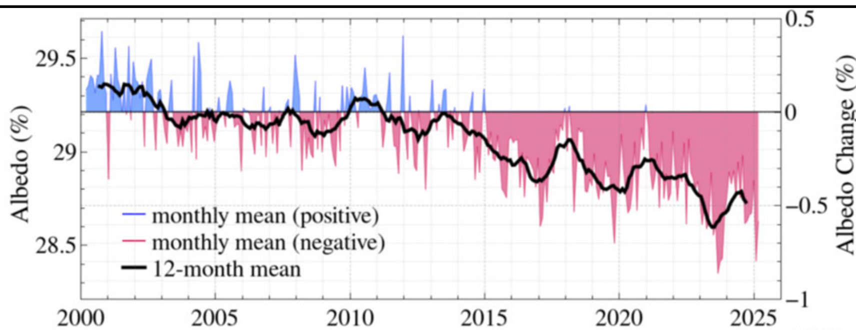


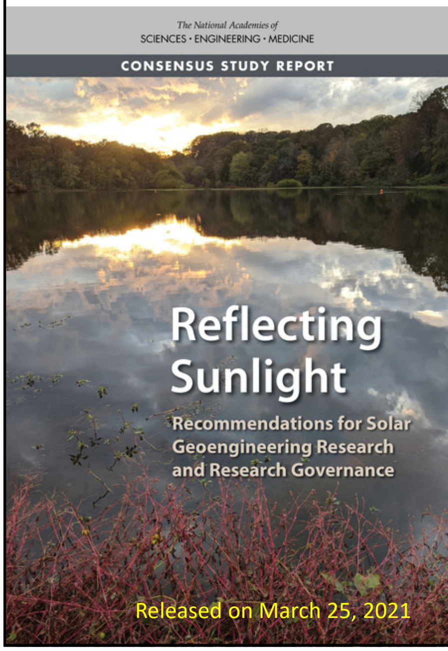
Fig. 1. Earth's albedo (reflectivity, in percent), seasonality removed[1,2,3,4]

Large Cloud Feedback Confirms High Climate Sensitivity

James Hansen and Pushker Kharecha 13 May 2025

Abstract. Earth's albedo (reflectivity) declined over the 25 years of precise satellite data, with the decline so large that this change must be mainly reduced reflection of sunlight by clouds. Part of the cloud change is caused by reduction of human-made atmospheric aerosols, which act as condensation nuclei for cloud formation, but most of the cloud change is cloud feedback that occurs with global warming. The observed albedo change proves that clouds provide a large, amplifying, climate feedback. This large cloud feedback confirms high climate sensitivity, consistent with paleoclimate data and with the rate of global warming in the past century.

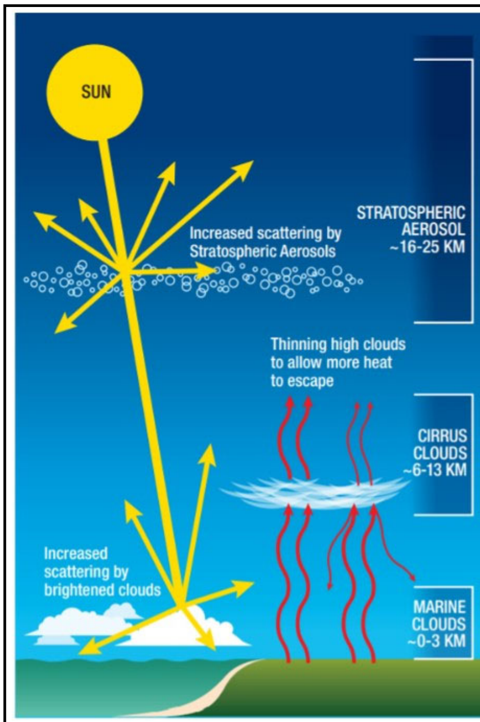
Geo-Engineering



"Given the urgency of the risks posed by climate change, the U.S. should pursue a research program for solar geoengineering — in coordination with other nations, subject to governance, and alongside a robust portfolio of climate mitigation and adaptation policies, says a new report from the National Academies of Sciences, Engineering, and Medicine. The report emphasizes that solar geoengineering is not a substitute for reducing greenhouse gas emissions."

"The report says the U.S. Global Change Research Program (USGCRP) should lead the effort to establish and coordinate a solar geoengineering research program across federal agencies and scientific disciplines, with funding in the range of \$100 million-\$200 million over the first five years."

61



Discussion:

The importance of understanding aerosols.

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