Unholy connect: Aerosols and desertification

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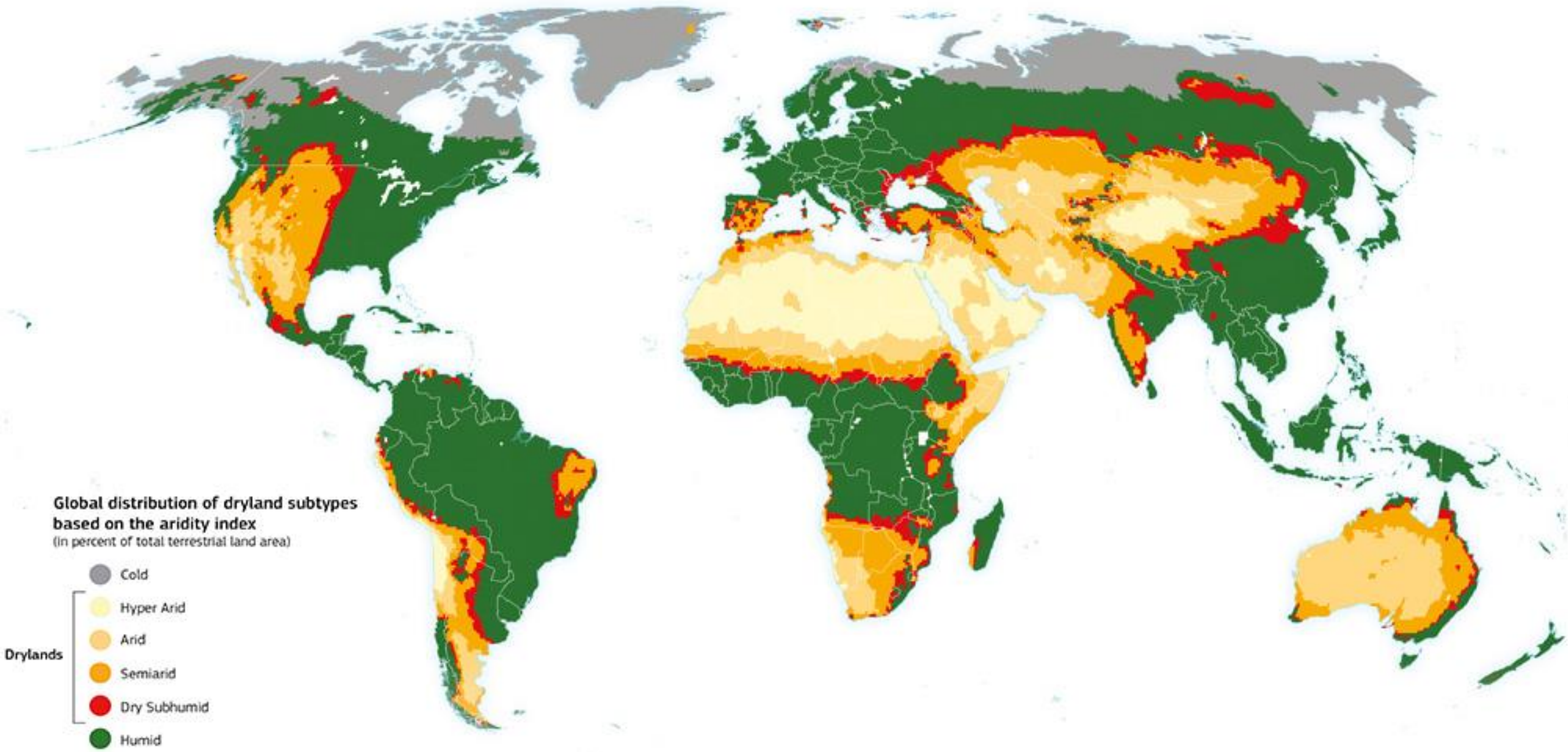
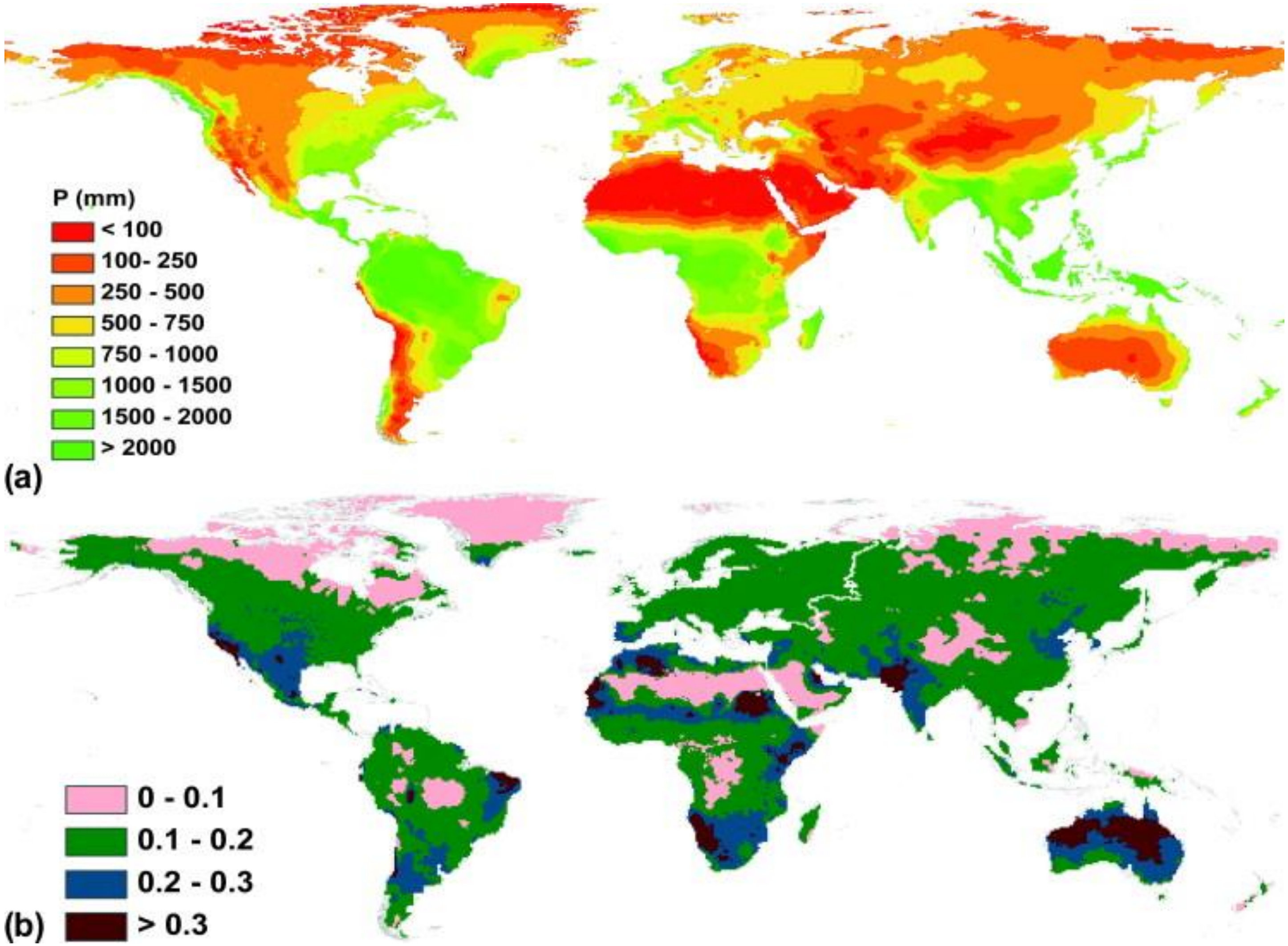


The observed distribution of different aridity levels, based on data for 1981-2010. Shading colour indicates regions defined as cold (grey), humid (green), dry subhumid (red), semiarid (dark orange), arid (pale orange) and hyperarid (pale yellow). Map produced by the European Commission's Joint Research Unit.

D'Odorico et al. (2013)



(a) Global mean precipitation. (b) Coefficient of variation (NA refers to areas where no data were available). Based on the CRU TS 3.1 data, a gridded data set developed by the Tyndall Centre for Climate Change Research and the Climate Research Unit (CRU) of the University of West Anglia [125] interpolating station data with the anomaly approach [138], [139]. The maps are based on data for the period 1901–2009, calculated for 0.5° by 0.5° grid.

D'Odorico et al. (2013)

IPCC SRCCL

- *The range and intensity of desertification have increased in some dryland areas over the past several decades (**high confidence**).*
- *Desertification hotspots, as identified by a decline in vegetation productivity between 1980s and 2000s, extended to about 9.2% of drylands (±0.5%), affecting about 500 (±120) million people in 2015. The highest numbers of people affected are in South and East Asia, North Africa and Middle East (**low confidence**).*

IPCC SRCCL

- *Climate change will exacerbate several desertification processes (**medium confidence**).*
- *Desertification exacerbates climate change through several mechanisms such as changes in vegetation cover, sand and dust aerosols and greenhouse gas fluxes (**high confidence**).*
- *Although CO2-fertilisation effect is enhancing vegetation productivity in drylands (high confidence), decreases in water availability have a larger effect than CO2-fertilisation in many dryland areas. There is high confidence that aridity will increase in some places, but no evidence for a projected global trend in dryland aridity (**medium confidence**).*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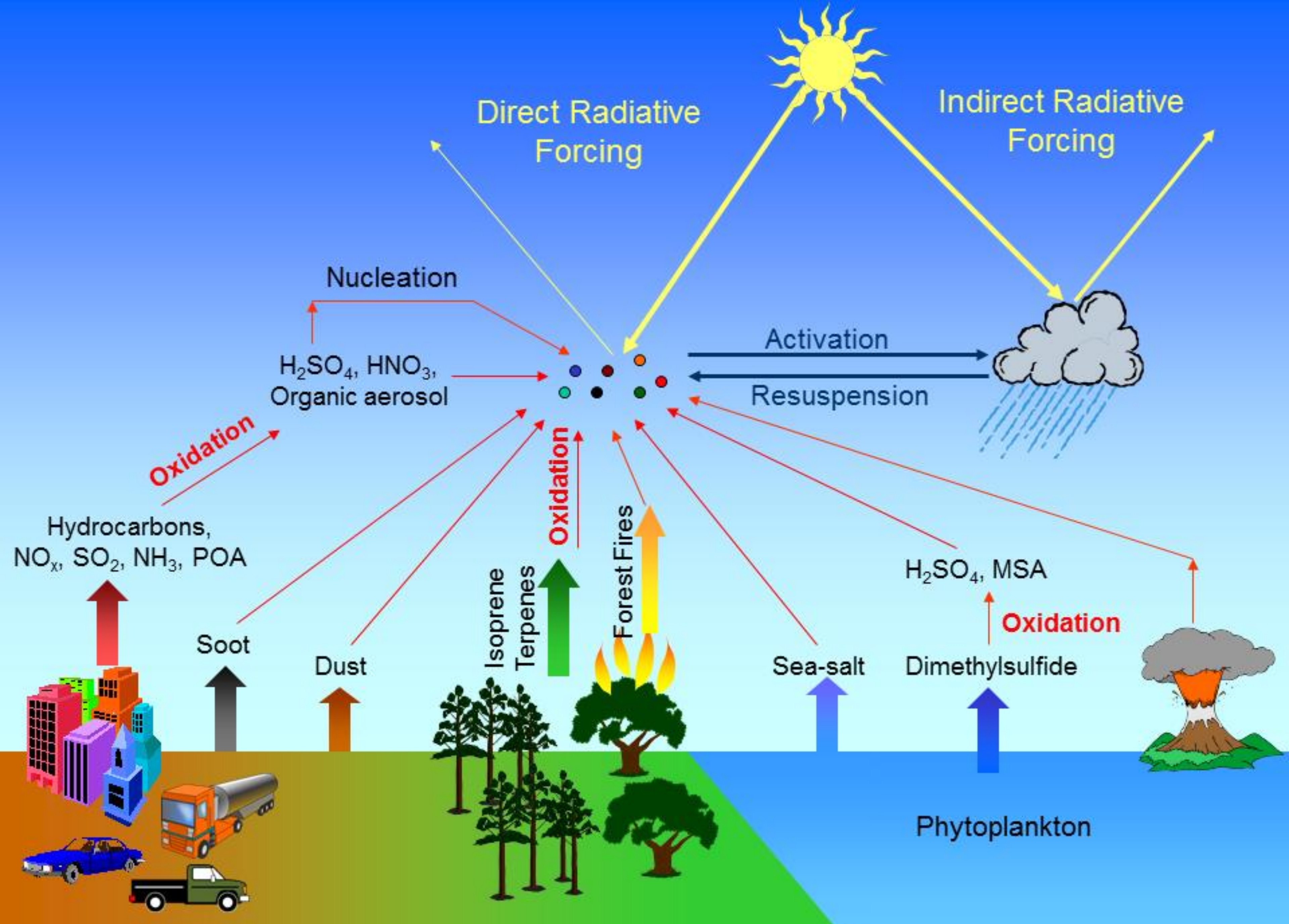
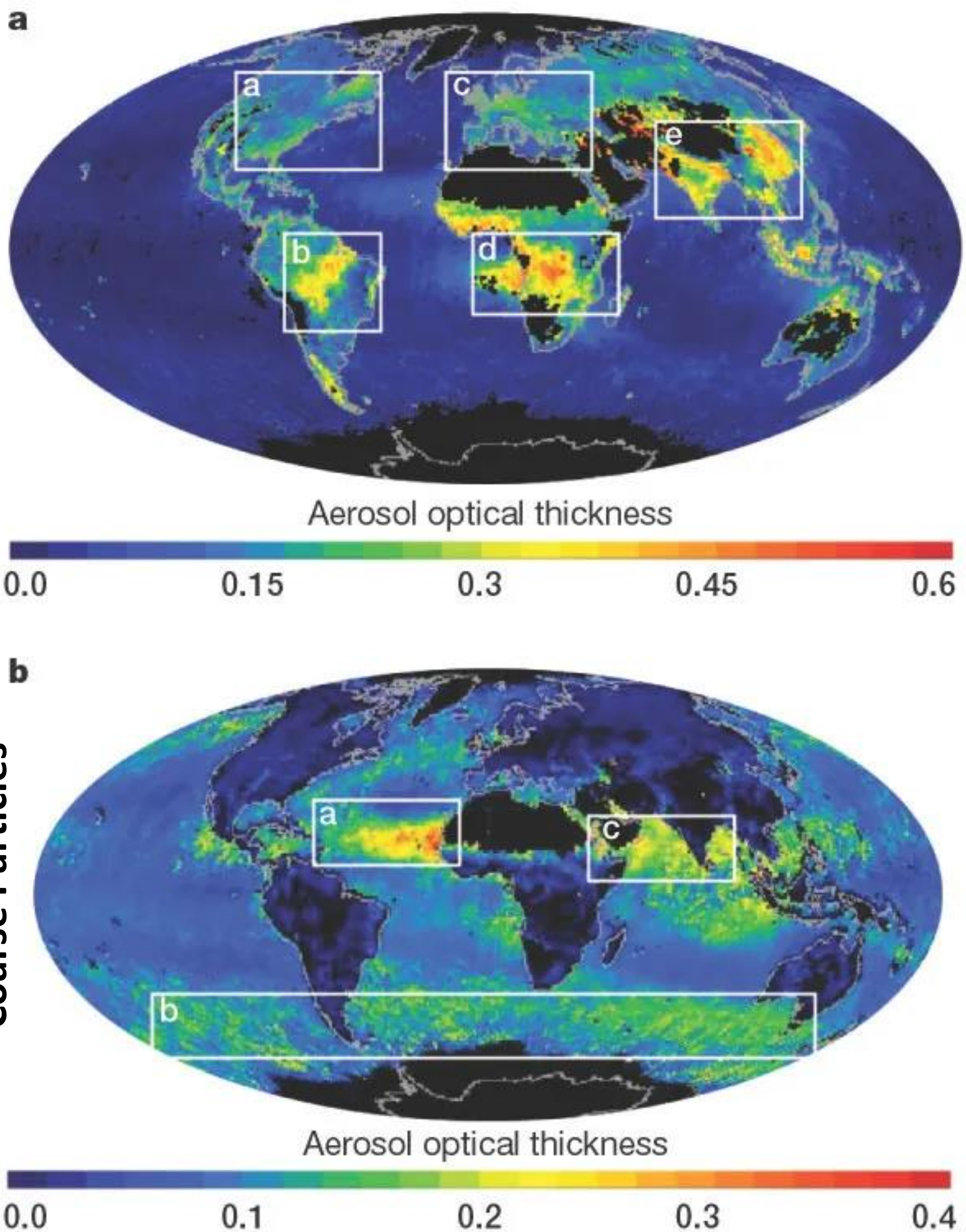
Picture courtesy by Dr. Peter Raven



Courtesy: Phys.org

Fine Particles

Coarse Particles



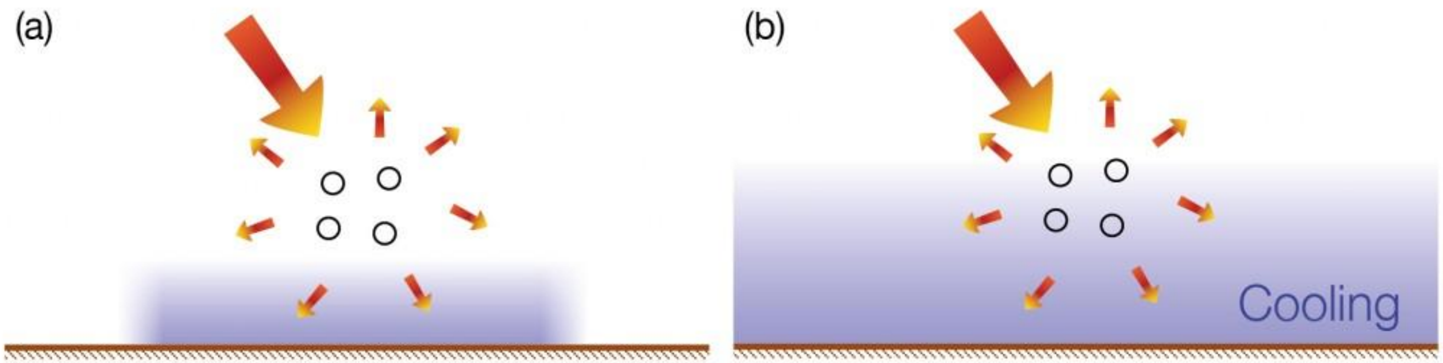
AOT is a measure of the aerosol column concentration and is represented by the colour scale at a wavelength of 0.55 µm. Black regions have surface properties inappropriate for MODIS aerosol retrievals or very low solar elevations. The white boxes indicate regions with high aerosol concentrations. a, Distribution of fine AOT. The image shows fine particles in pollution from North America and Europe (regions a and c), vegetation fires in South America and southern Africa (regions b and d) and pollution in south and east Asia (region e). b, Distribution of coarse AOT. Coarse dust from Africa (region a), salt particles in the windy Southern Hemisphere (region b) and desert dust (region c).

Kaufman, Y. J., D. Tanré, and O. Boucher, 2002: A satellite view of aerosols in the climate system. Nature, 419, 215–223, doi:10.1038/nature01091. https://doi.org/10.1038/nature01091.

Aerosol Direct Effects

Aerosol-radiation interactions

Scattering aerosols

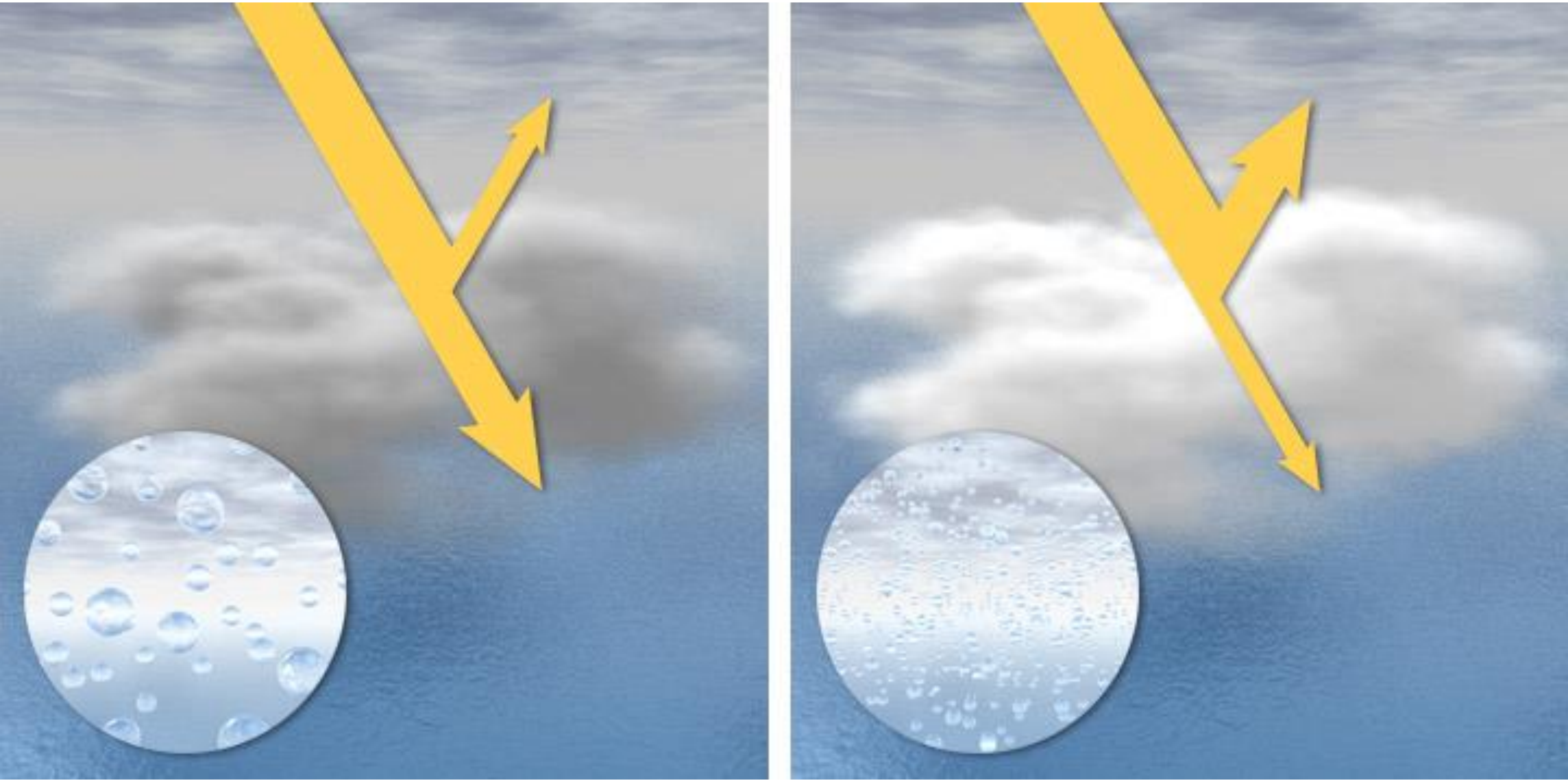


Aerosols scatter solar radiation. Less solar radiation reaches the surface, which leads to a localised cooling.

The atmospheric circulation and mixing processes spread the cooling regionally and in the vertical.

Source: IPCC AR5

Aerosol Indirect Effect



Clouds in clean air are composed of a relatively small number of large droplets (left). As a consequence, the clouds are somewhat dark and translucent. In air with high concentrations of aerosols, water can easily condense on the particles, creating a large number of small droplets (right). These clouds are dense, very reflective, and bright white. This influence of aerosols on clouds is called the “indirect effect,” and is a large source of uncertainty in projections of climate change. (NASA image by Robert Simmon.) ***Source: https://earthobservatory.nasa.gov/features/Aerosols***

Anthropogenic Aerosols and the Weakening of the South Asian Summer Monsoon

Massimo A. Bollasina,[1] Yi Ming,[2]* V. Ramaswamy[2]

Observations show that South Asia underwent a widespread summertime drying during the second half of the 20th century, but it is unclear whether this trend was due to natural variations or human activities. We used a series of climate model experiments to investigate the South Asian monsoon response to natural and anthropogenic forcings. We find that the observed precipitation decrease can be attributed mainly to human-influenced aerosol emissions. The drying is a robust outcome of a slowdown of the tropical meridional overturning circulation, which compensates for the aerosol-induced energy imbalance between the Northern and Southern Hemispheres. These results provide compelling evidence of the prominent role of aerosols in shaping regional climate change over South Asia.

Bollasina, M., Y. Ming, and V. Ramaswamy, 2011: Anthropogenic Aerosols and the Weakening of the South Asian Summer Monsoon. Science (80-.)., 334, 502–505,

AGU PUBLICATIONS

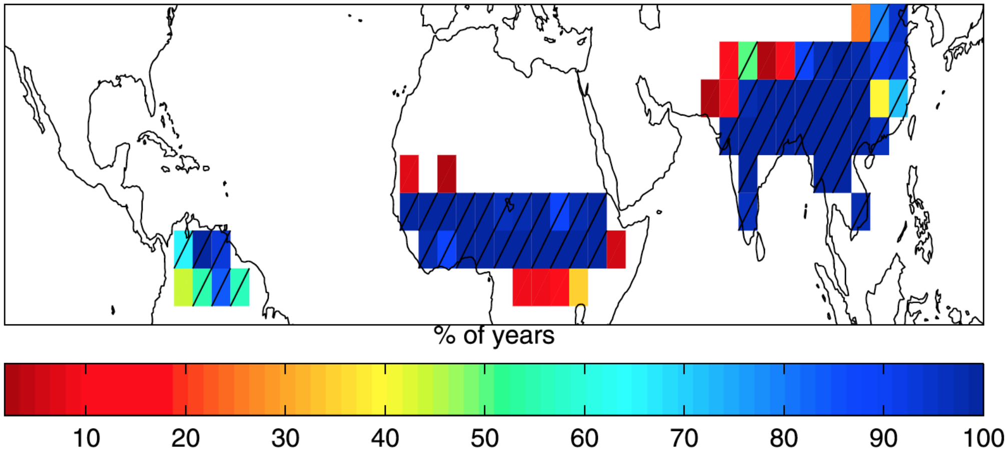
Geophysical Research Letters

RESEARCH LETTER
10.1002/2014GL060811

Decreased monsoon precipitation in the Northern Hemisphere due to anthropogenic aerosols

D. Polson[1], M. Bollasina[1], G. C. Hegerl[1], and L. J. Wilcox[2]

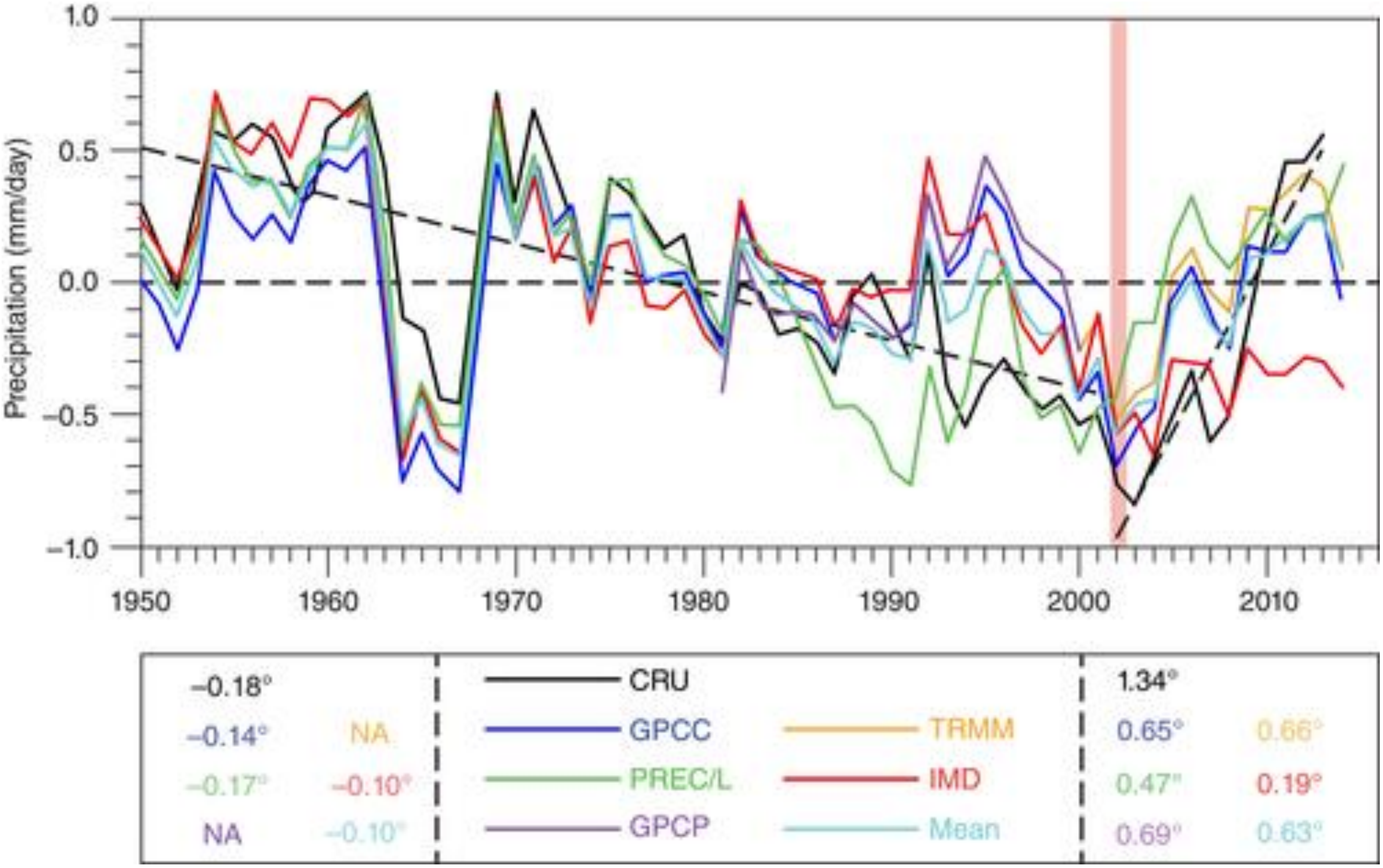
[1]School of GeoSciences, Grant Institute, University of Edinburgh, Edinburgh, UK, [2]National Centre for Atmospheric Science (Climate), Department of Meteorology, University of Reading, Reading, UK



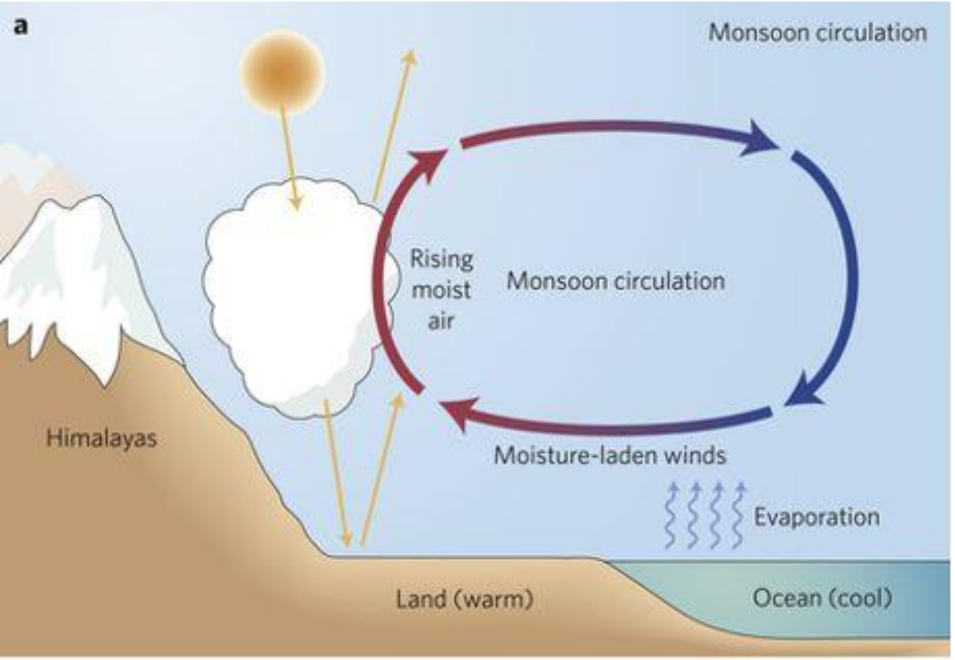
Key Points:

- Monsoon precipitation decrease over the second half of the twentieth century
- Decrease in precipitation can only be explained by anthropogenic aerosol
- This result is consistent across all Northern Hemisphere monsoon regions

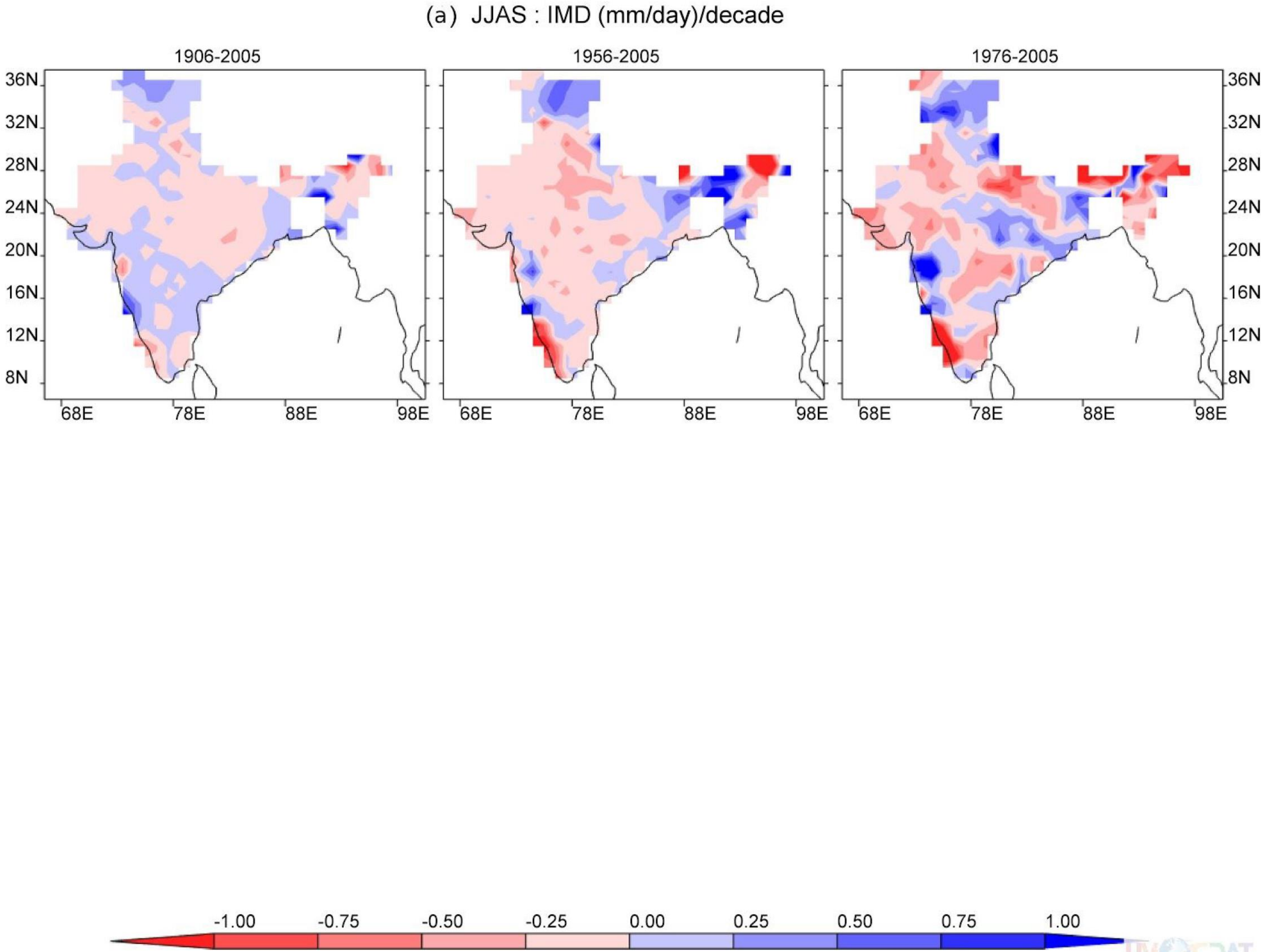
Trends in Indian Summer Monsoon Rainfall



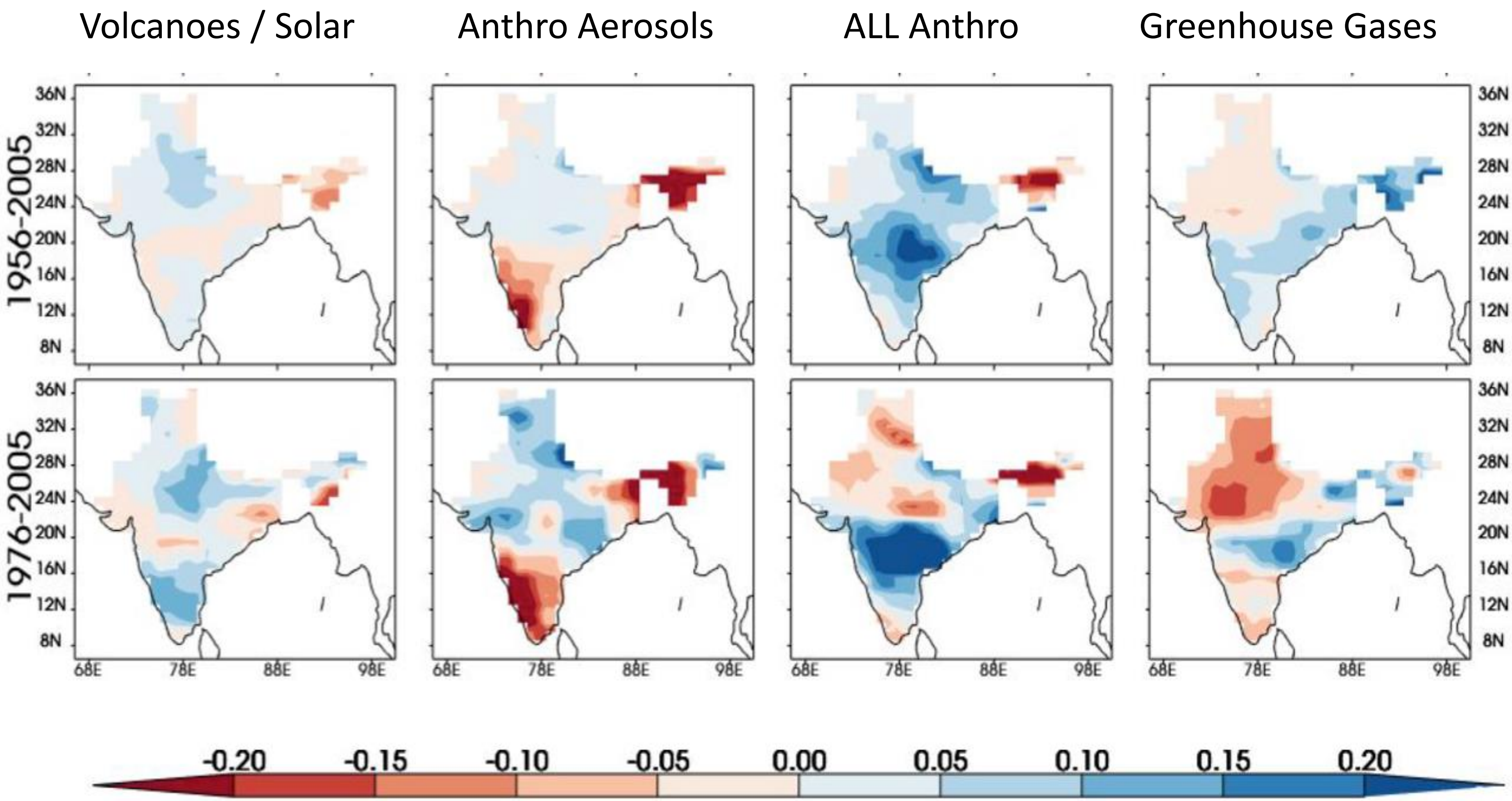
WIREs Clim Change, Volume: 10, Issue: 2, First published: 24 January 2019, DOI: (10.1002/wcc.571)



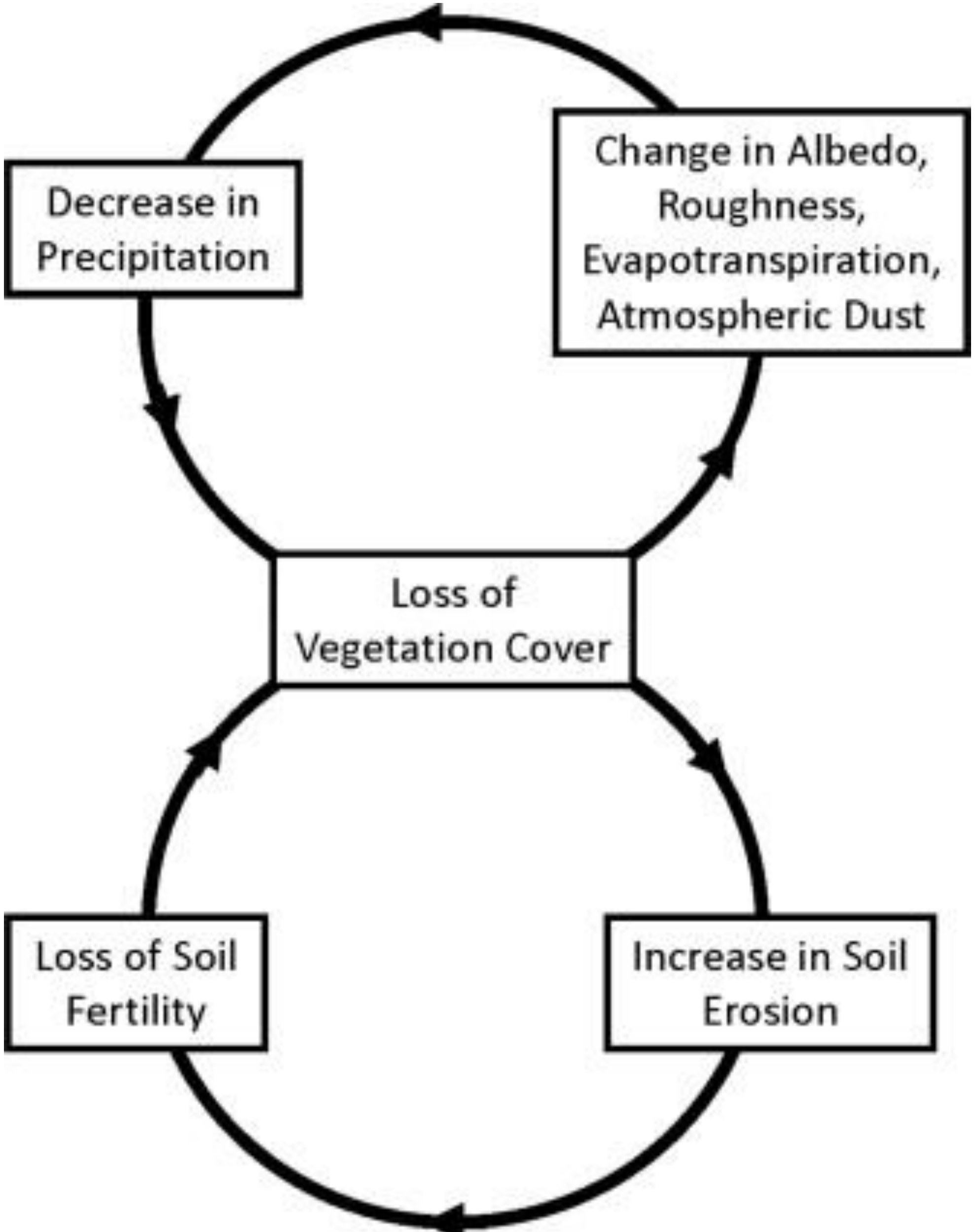
Singh, D., 2015: Tug of war on rainfall changes. Nat. Clim. Chang., 6, 20.



Dileepkumar & AchutaRao (In Preparation)



Dileepkumar & AchutaRao (In Preparation)



Examples of desertification feedbacks.

Bottom loop: the typical land degradation feedback. The exposure of the soil surface to wind and water erosion causes substantial losses of soil nutrients thereby preventing the re-establishment of vegetation. This type of feedback invokes the ability of vegetation to stabilize the soil surface as the mechanism that allows the system to persist either in a vegetated or in a bare soil state.

Top loop: vegetation-atmosphere feedbacks.

D'Odorico, P., A. Bhattachan, K. F. Davis, S. Ravi, and C. W. Runyan, 2013: Global desertification: Drivers and feedbacks. Adv. Water Resour., 51, 326–344,

Thank you

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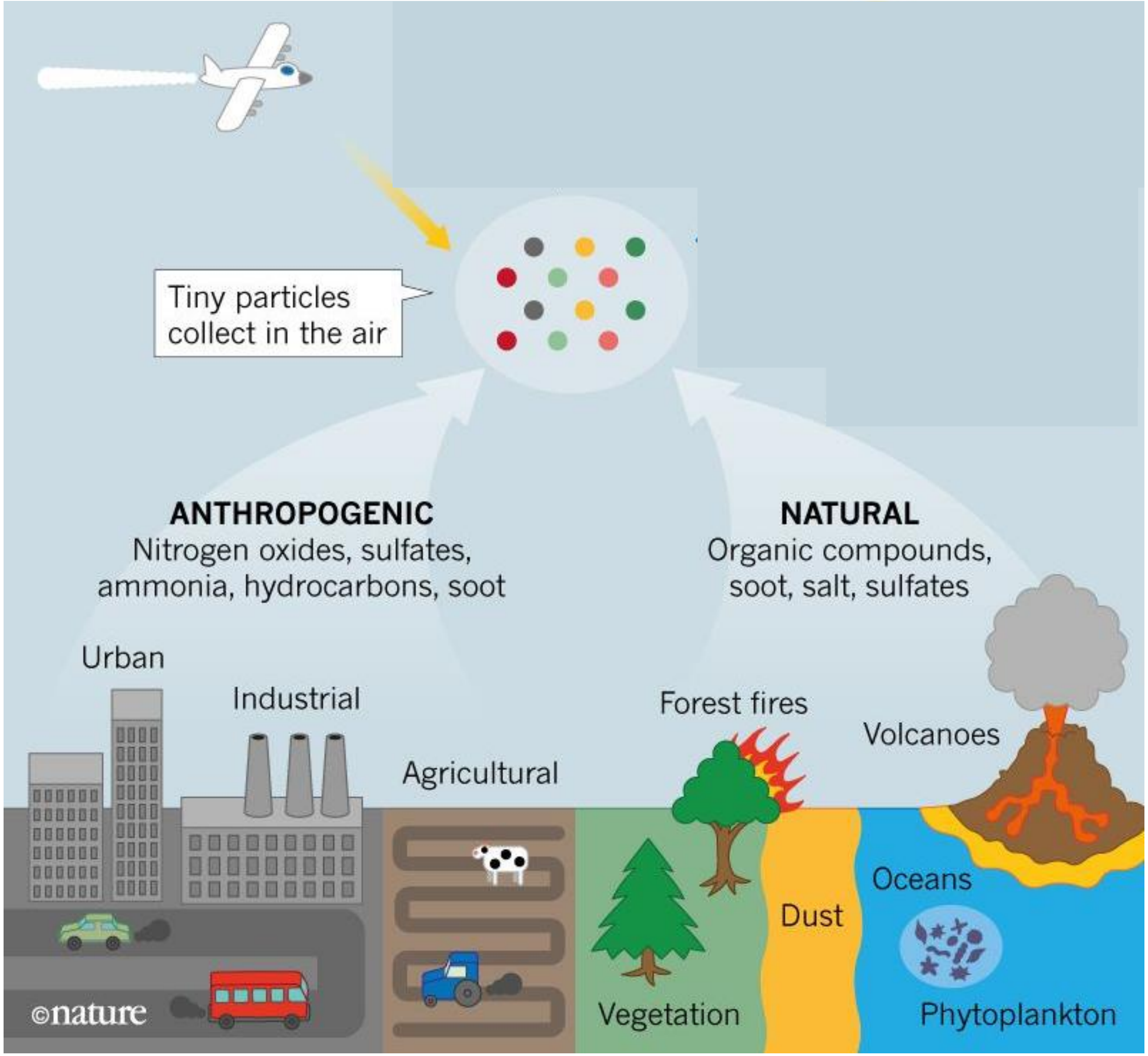
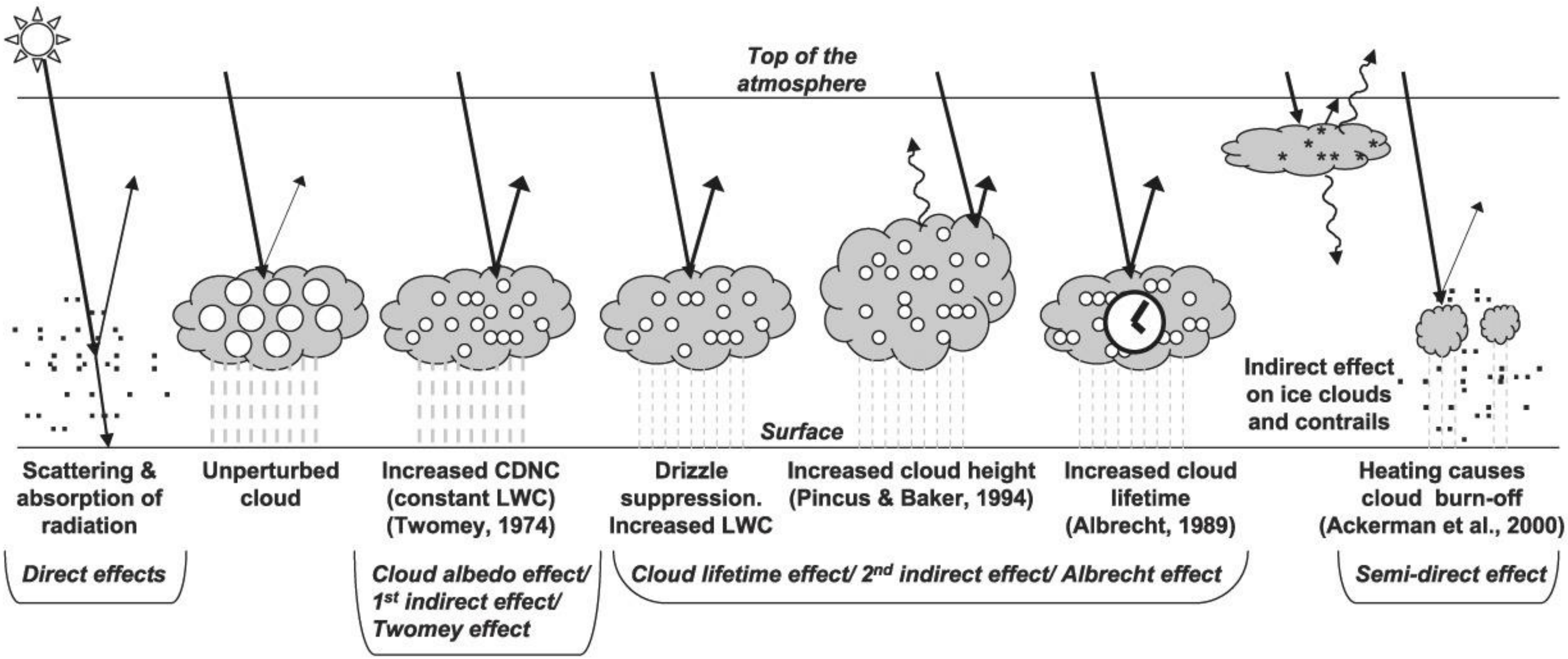

Tiny particles collect in the air
ANTHROPOGENIC
Nitrogen oxides, sulfates, ammonia, hydrocarbons, soot
NATURAL
Organic compounds, soot, salt, sulfates
Urban
Industrial
Agricultural
Forest fires
Volcanoes
Vegetation
Dust
Oceans
Phytoplankton
©nature

Aerosols: More Complicated Effects



The *direct effect* is the mechanism by which aerosols scatter and absorb shortwave and longwave radiation, thereby altering the radiative balance of the Earth-atmosphere system.

The *indirect effect* is the mechanism by which aerosols modify the microphysical and hence the radiative properties, amount and lifetime of clouds

Ash on Snow

Dark aerosols dramatically change the reflectivity of the Earth's surface when they land on snow. Black ash covered the summit of New Zealand's Mount Ruapehu after an eruption in 2007, but was soon covered by fresh snow. Long-term accumulation of black carbon aerosols in the Arctic and Himalaya is leading to increased melting of snow. (Photograph ©2007, New Zealand GeoNet.)) Source: https://earthobservatory.nasa.gov/features/Aerosols

Desert dust, volatile organic compounds from vegetation, smoke from forest fires, and volcanic ash are natural sources of aerosols. (Photographs copyright (left to right) Western Sahara Project, Jonathan Jessup, Vox, and Ludie Cochrane.)