

## Is the “Faustian Bargain” Coming Due?

### Sources and Resources for this Study

October 2024 Temperature Update - Berkeley Earth

[Why a two-year surge in global warmth is worrying scientists](#)

[Has Reducing Ship Emissions Brought Forward Global Warming? - Gettelman - 2024](#)

[Decline of Reflective Low Clouds May Have Contributed to Recent Record Heat - Inside Climate News](#)

[Recent global temperature surge intensified by record-low planetary albedo | Science](#)

Hansen 1990: [Pubs.GISS: Hansen and Lacis 1990: Sun and dust versus greenhouse gases: An assessment of their relative roles in...](#)

[The Rate of Global Warming During Next 25 Years Could Be Double What It Was in the Previous 50, a Renowned Climate Scientist Warns](#)

(July 2021): [July Temperature Update: Faustian Payment Comes Due](#)

<https://www.columbia.edu/~jeh1/Li.2022.Aerosols.NatRev.pdf>

<https://academic.oup.com/oacc/article/3/1/kgad008/7335889?searchresult=1&login=false> (Hansen et al: Nov 2023: Global Warming in the Pipeline)

The High Variability of Global Albedo:

<https://www.youtube.com/watch?v=O0B8Yi7AZvQ&t=7s>

<https://youtu.be/SYeFrudialM?si=Qp8-EmDB2ZS119DF>

[Why has it been even hotter than expected recently? Research points to diminishing cloud cover](#)

[Recent global temperature surge intensified by record-low planetary albedo | Science](#)

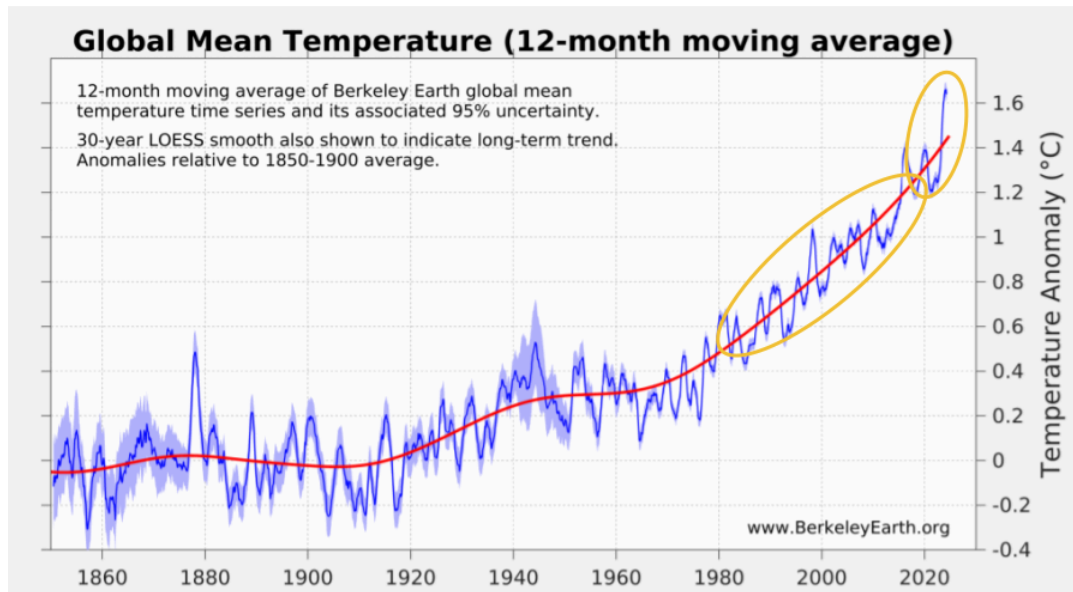


Dr. Faustus contemplates his bargain with Mephistopheles.

The term refers to the [legend](#) of [Faust](#) (or Faustus, or Doctor Faustus), a character in German [folklore](#) and [literature](#), who agrees to surrender his soul to an evil spirit (in some treatments, [Mephistopheles](#), or Mephisto, a representative of [Satan](#)) after a certain period of time in exchange for otherwise unattainable knowledge and magical powers that give him access to all the world's pleasures.

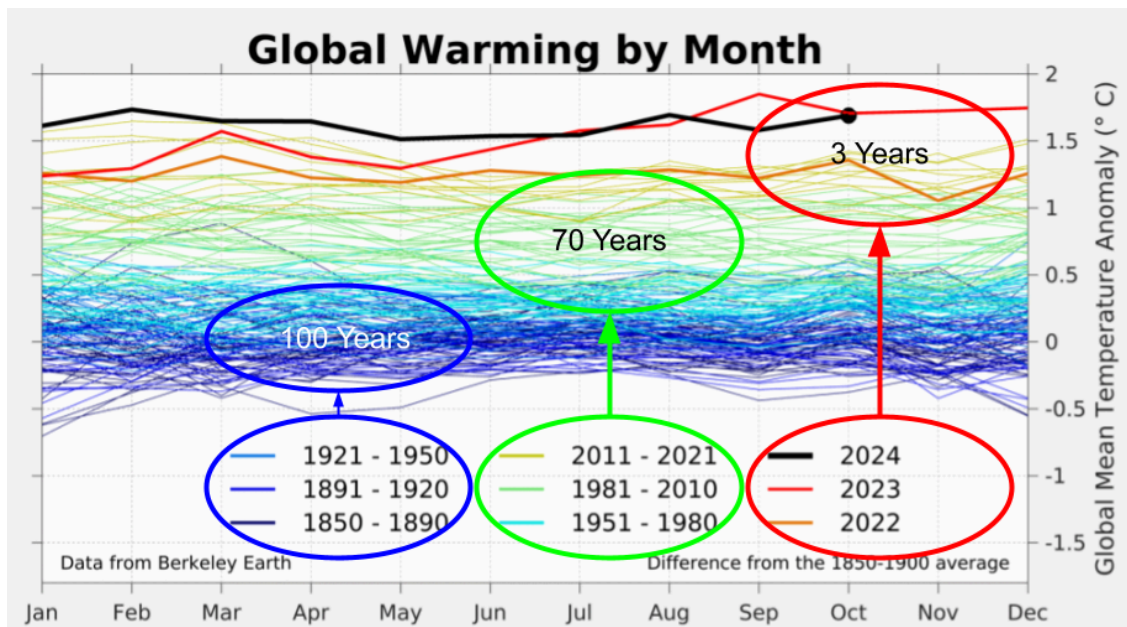
In just the last couple of months, many articles and studies have been exclaiming about the possibility that the Earth may have entered into a new phase - maybe something deeply different from the past is happening.

Let's look first at the data through October, 2024, in the context of the last 170 years:



Clearly, the last couple of years seem to be leaping even further upward, maybe in an accelerated fashion, compared to the last 40 years.

Another way this information is presented is the global temperature over each year, from January through December:



As noted in the Washington Post:

As 2023 came to a close, scientists had hoped that a stretch of record heat that emerged across the planet might finally begin to subside this year. It seemed likely that temporary conditions, including an El Niño climate pattern that has always been known to boost average global temperatures, would give way to let Earth cool down.

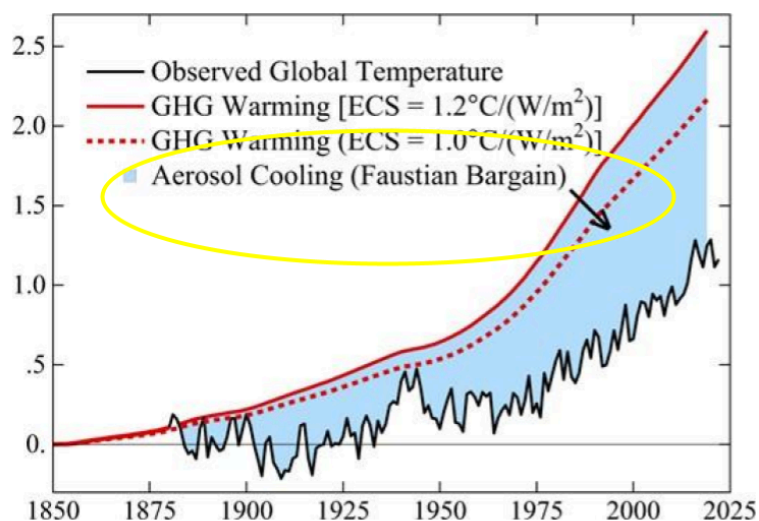
That didn't happen.

Instead, global temperatures remain at near-record levels. After [2023 ended up the warmest year in human history by far](#), 2024 is [almost certain to be even warmer](#). Now, some scientists say this could indicate fundamental changes are happening to the global climate that are raising temperatures faster than anticipated. “This shifts the odds towards probably more warming in the pipeline,” said Helge Goessling, a climate physicist at the Alfred Wegener Institute in Germany.

What is behind this sharp increase in heating? Hansen, et al made a strong case for reduction in shipping and other aerosols in **1990**, periodically through July of 2021, and as recently as a year ago in their *Warming in the Pipeline* paper.

**The idea is that we’ve had a “Faustian Bargain” in burning fossil fuels: The Earth is warmed by the CO<sub>2</sub>, but we’ve been hiding some of the warming by reflecting incoming sunlight, particularly from low clouds formed with the aerosols emitted during the fossil fuel burning. If we clean up that pollution (which kills millions annually), more heating will be unmasked.**

Hansen in 2021: “The Faustian payment that we noted in 1990 and is discussed in detail elsewhere is now due. Dr. Faustus had to pay the debt himself. We have willed it to our children and grandchildren.”

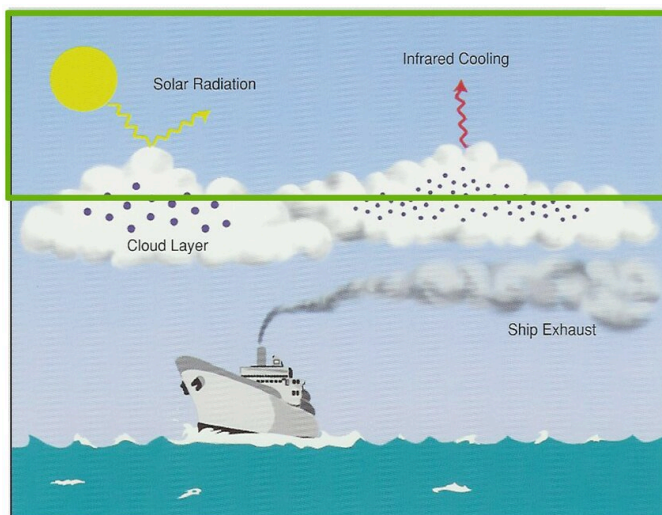


**Figure 13.** Observed global surface temperature (black line) and expected GHG warming with two choices for ECS. The blue area is the estimated aerosol cooling effect.

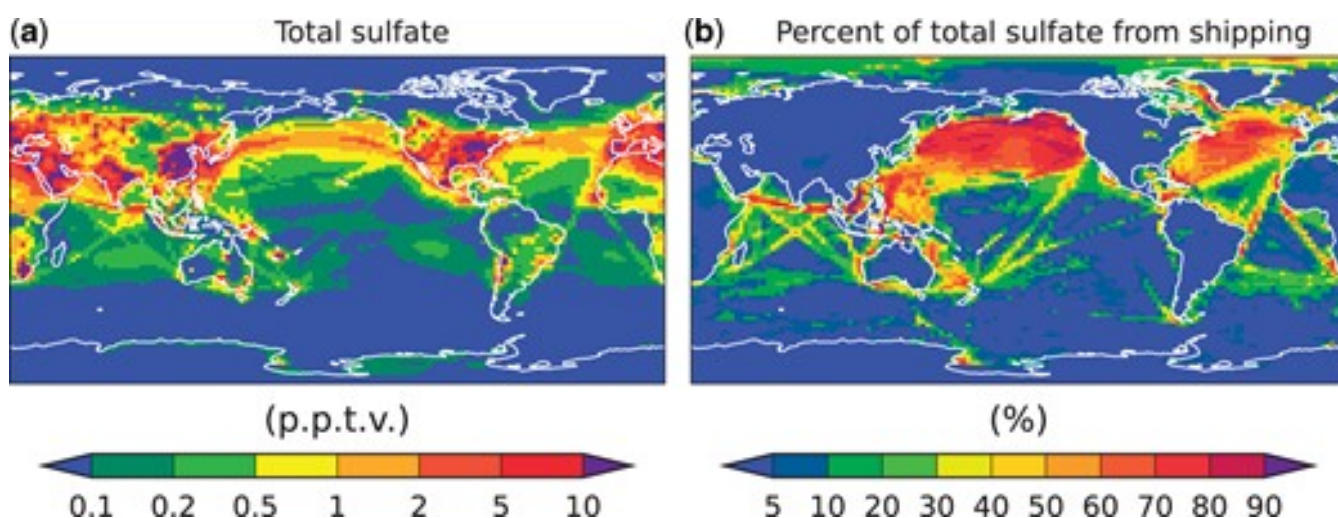


## MAYBE CLEANING UP SHIPPING FUELS IS HELPING THINGS HEAT UP

Here’s how aerosols from shipping exhaust can artificially cool, particularly by reflection from the low, densely white, clouds. Some warming does occur, especially in thinner high-altitude clouds (not shown here).

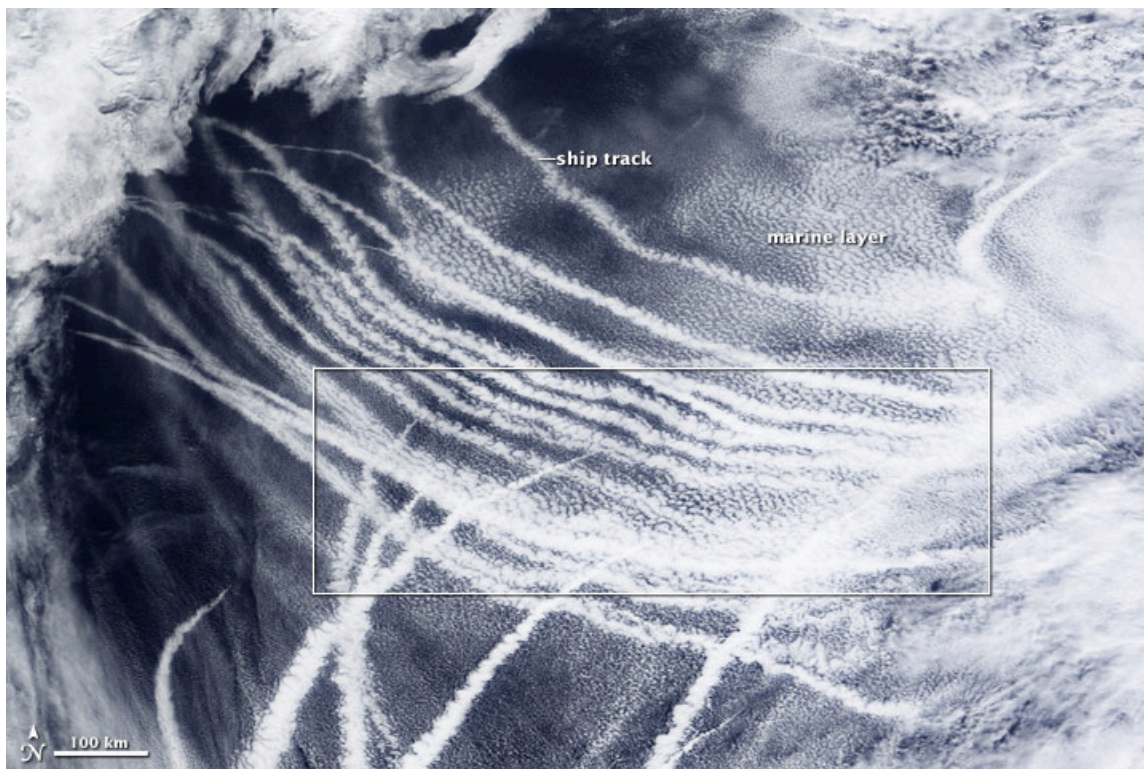


Hansen et al pointed out the major changes to the northern oceans from aerosol sulfates. As China has been reducing its particulate pollution (see darker region), this has increased its heating. Over the northern oceans, there has been a little less pollution, but getting rid of it (by cleaning up shipping fuels) has meant exposing the dark surface of the ocean, a very good energy absorber.



**Figure 20.** Total sulfate (parts per trillion by volume) and percentage of total sulfate provided by shipping in simulations of Jin *et al.* [157] prior to IMO regulations on sulfur content of fuels.





[Has Reducing Ship Emissions Brought Forward Global Warming? - Gettelman - 2024](#) (August 2024)

## Key Points

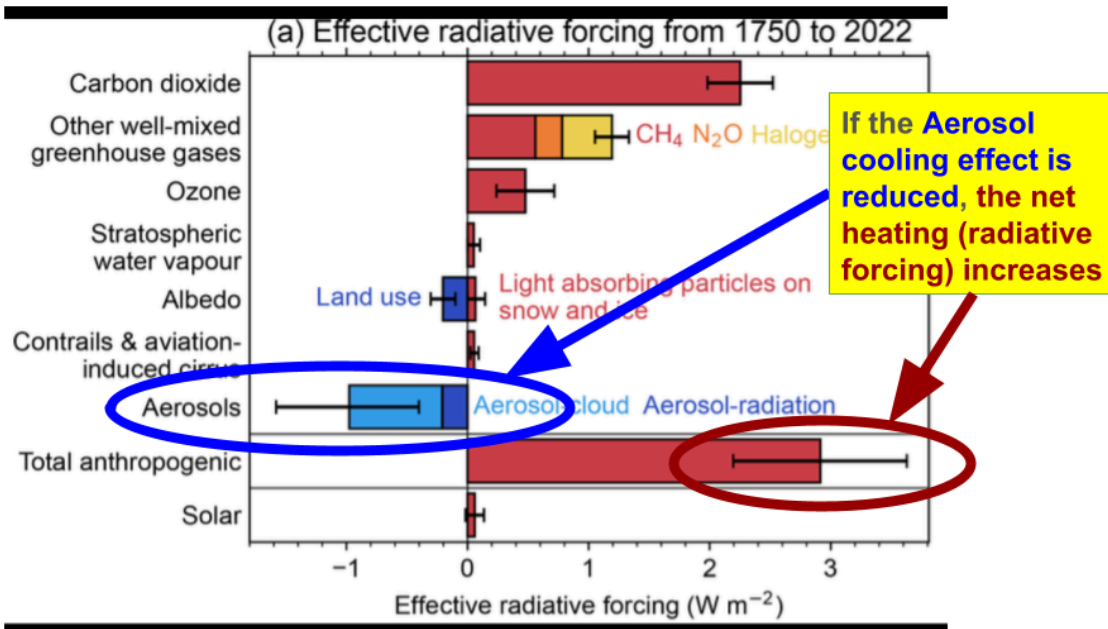
Recent regulations on ship sulfur emissions have decreased ship tracks and resulted in  $+0.12 \text{ Wm}^{-2}$  of radiative forcing

Observed cloud anomalies are correlated with observed ocean temperature anomalies and shipping radiative forcing

Reduced ship emissions may have accelerated global warming contributing to recent warm Northern Hemisphere surface temperatures

## Plain Language Summary

Ships have a unique climate effect due to brightening of low marine clouds, resulting in visible “ship tracks”. These ship tracks are due to clouds interacting with ship emissions, particularly sulfur. Recently, regulations have drastically reduced allowable ship sulfur emissions. This has resulted in a decrease in observable ship tracks. Modeling and observations indicate that the reduction in ship sulfur emissions could have slightly warmed the planet starting in 2020. These changes are remarkably co-incident with observed patterns of cloud changes and may have accelerated global warming.



So, that's the “Faustian Bargain”.

Perhaps, that's not all that's going on, though. It could be that heating itself may be disrupting how well the low-level clouds can even form. If this turns out to be the case, then loss of clouds may also be from an amplifying feedback, which might not stop when aerosols are cleaned up.

**ANOTHER QUESTION: MAYBE THE EARTH WON'T MAKE AS MANY REFLECTING CLOUDS AS IT HEATS UP**

There may be another, even more worrying effect: Maybe a warmer earth won't make as many **low-clouds!** [Recent global temperature surge intensified by record-low planetary albedo | Science](#)

Several factors are driving the decline of the Earth-cooling low marine cloud layers, including climate cycles like El Niño, as well as a drop of sulfate aerosol emissions from shipping and other industrial sources. But Gossling, the lead author, **was most worried that the study affirms other research showing that global warming itself is driving the loss of clouds by diffusing distinct layers of the atmosphere that promote the formation and persistence of low-elevation marine clouds.**

Here's the clouds from space:

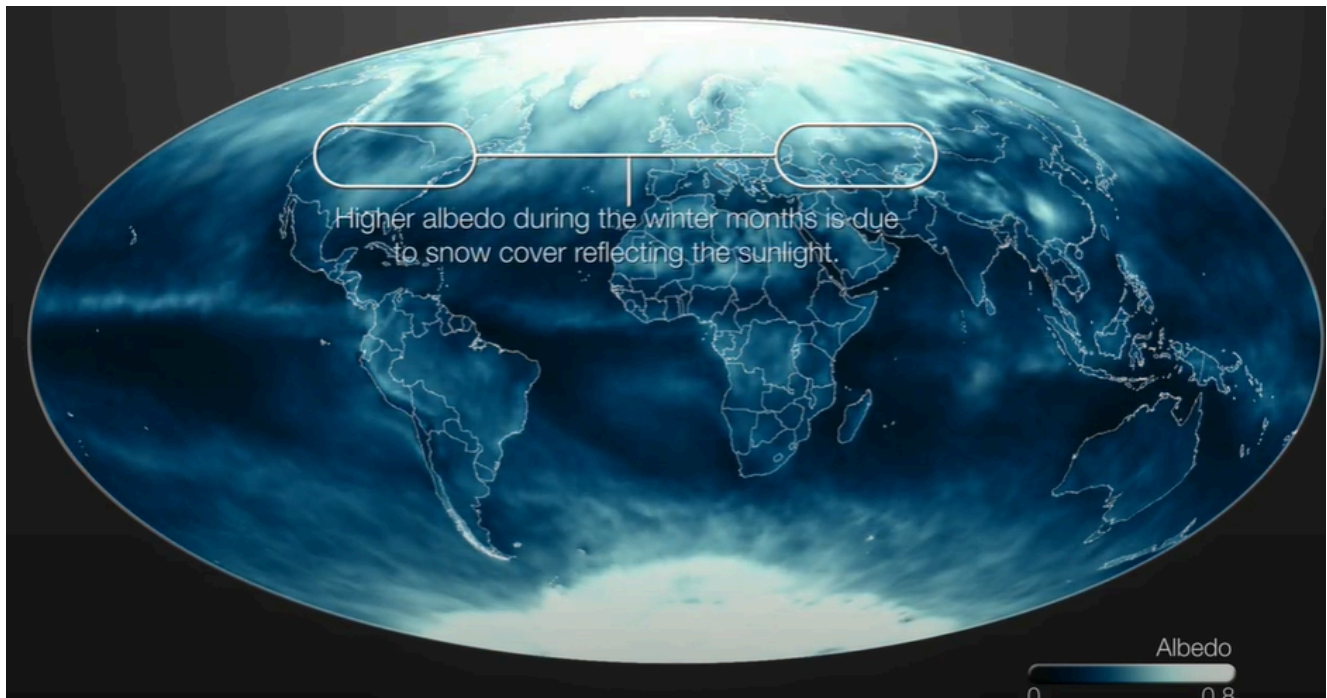


The new question, still to be sorted out, is whether the clouds which help cool us - the highly-reflecting low clouds - will have more trouble forming as the earth warms. Will the warmth cause more mixing from the surface up to the higher clouds, disrupting the lower level where these thick clouds form.



Note how the clouds high up are wispy and both 1) let the warming sunlight through and 2) are very cold so they can't get rid of heat to space very well. Because of these factors, the **high-altitude clouds keep heat in → warming.**





<https://www.youtube.com/watch?v=O0B8Yi7AZvQ&t=7s>

## ***PUNCHLINES***

- In the last few years, global warming is happening faster than expected.
- There is good evidence that reducing aerosols, particularly from requiring cleaner shipping fuels, is likely part of the reason. This is a result of a **Faustian Bargain** which cloaked some of the effects of burning fossil fuels with reflective particulates from that burning. As this pollution is cleaned up, to save millions of lives a year, warming is increasing.
- Studies are also looking for “amplifying feedbacks” which may be reducing the heat reflective low-level clouds by just heating them up and diffusing their atmospheric layers.

## GOOD NEWS CORNER

[Reducing contrails could be a surprisingly effective climate solution - Cipher News](#)

It may be that a lot of heat-holding contrails (think of high-altitude clouds which tend to hold heat) can be avoided by minimal rerouting of airplanes



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Most human beings have an almost infinite capacity for taking things for granted.

Aldous Huxley

“

All is a miracle. So smile, breathe, and go slowly. Walk as if you were kissing the earth with your feet.

Thich Nhat Hanh



## Our Natural World Peaceful and/or Devastating



First came the 9.1 earthquake. Twenty minutes later, the first tsunami waves, as high as 167 feet, blasted this coast, uprooting a crescent of homes, business, trees, and people. (Look closely at before-and-after satellite images above Indonesia’s Sumatran coast.) The 2004 tsunami, the deadliest ever recorded, is the subject of a

new National Geographic documentary. See what a tsunami can do.

## Supplemental Materials

### Approximate “Cheat Sheet”:

1 meter → 3 feet      1 degree Celsius (°C) → 2 degree Fahrenheit (°F)  
 ppm = parts per million      CO<sub>2</sub> = Carbon Dioxide  
 1 tonne = 1000 kilograms = 2205 pounds      1 gigatonne (1 Gt) = 1 billion tonnes  
 1 trillion tonnes (1Tt) = 1000 gigatons

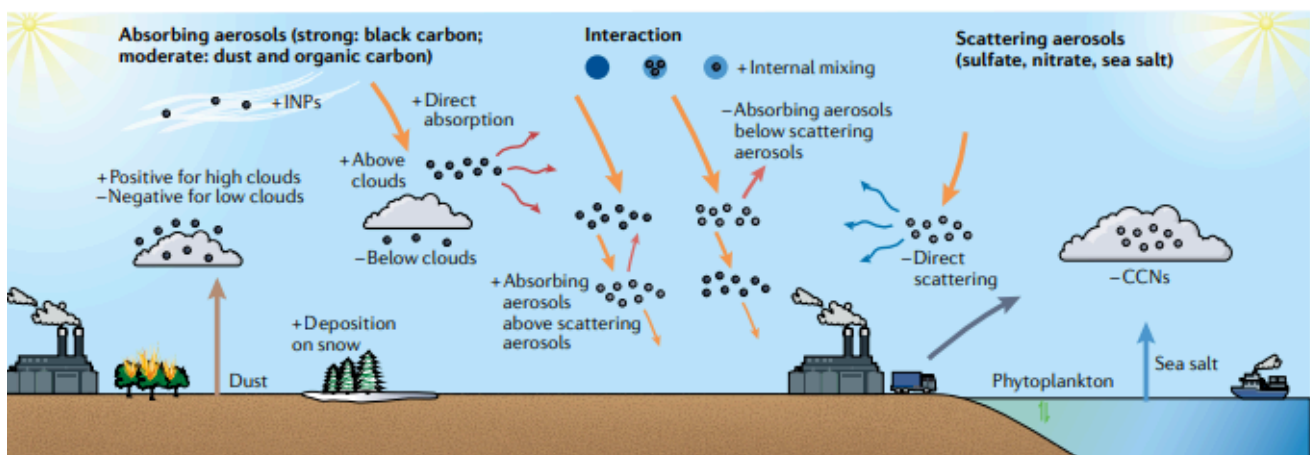


Fig. 2 | **The radiative effects of aerosols.** Schematic of radiative effects of absorbing (dark grey dots) and scattering aerosols (light grey dots), as well as their interactive effects. Scattering aerosols induce negative forcing (-) by directly reflecting sunlight and interacting with clouds; absorbing aerosols, in general, have a warming effect (+), although their interaction with clouds might produce slight cooling. The interaction between scattering and absorbing aerosols enhances the absorption and, thus, the warming effect. Light orange arrows represent incident sunlight; dark orange, scattered radiation by scattering aerosols; red, the radiation re-emitted by absorbing aerosols; and dark blue, scattered sunlight. CCN, cloud condensation nuclei; INPs, ice-nucleating particles.