

ACCELERATION OF CLIMATE CHANGE AND A FAUSTIAN BARGAIN



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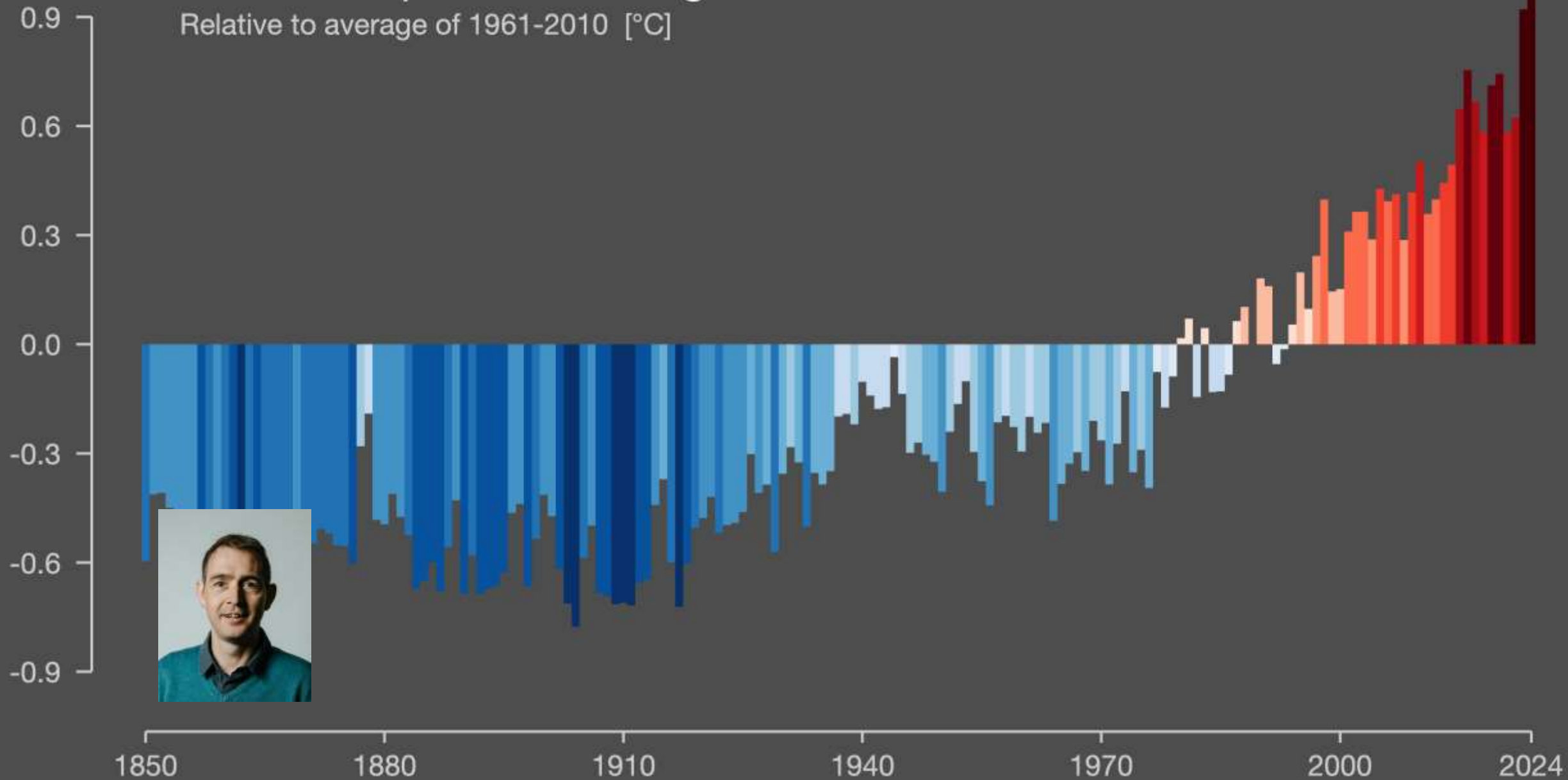
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Weather & Climate Discussions 21st February 2025



Global temperature change

Relative to average of 1961-2010 [°C]





**Global Warming Has Accelerated:
Are the United Nations and the
Public Well-Informed?
[Spoilers: No]**

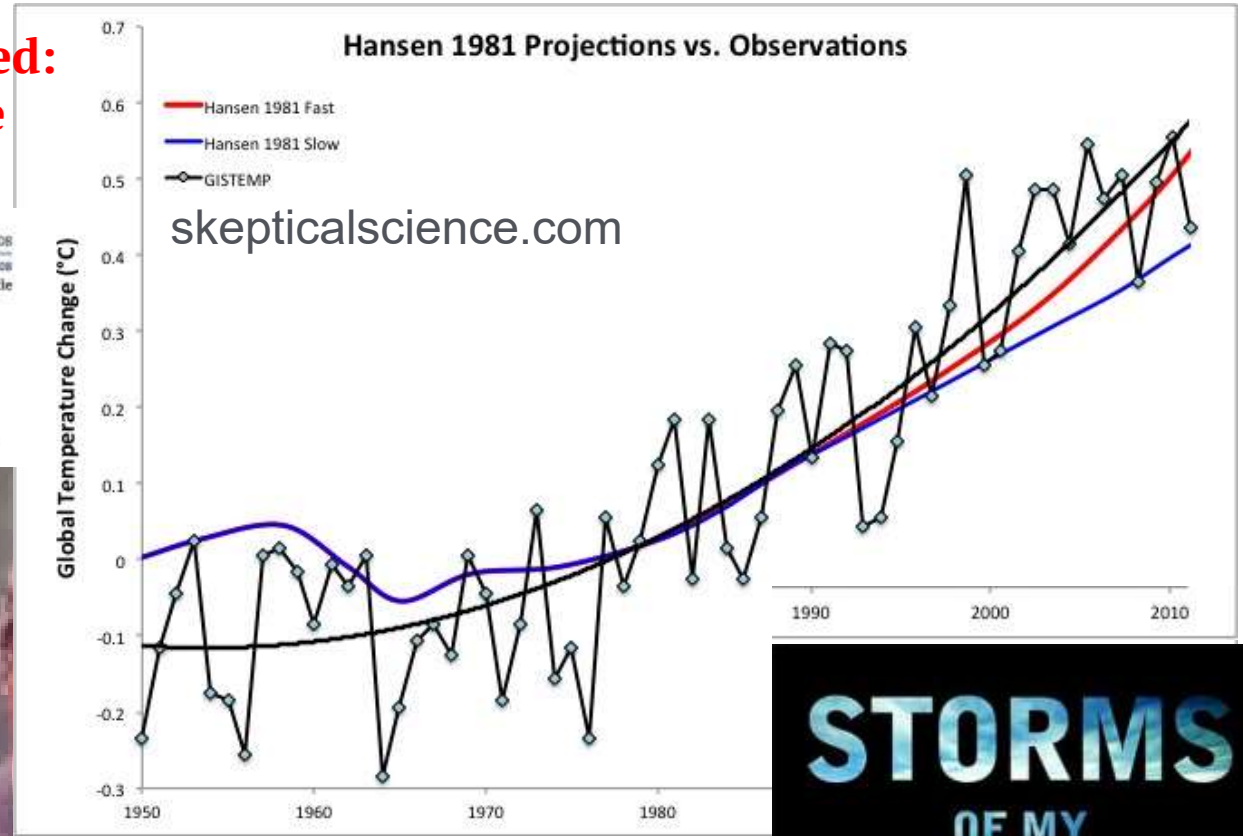
Global warming in the pipeline

James E. Hansen^{1,*}, Makiko Sato², Leon Simons², Larissa S. Nazarenko^{3,4}, Isabelle Sangha², Fushker Kharecha², James C. Zachos⁵, Karina von Schuckmann⁶, Norman G. Loeb⁷, Matthew B. Osman⁸, Qinqian Jin⁹, George Tselioudis², Eunbi Jeong¹⁰, Andrew Lacis¹¹, Reto Ruedy¹¹, Gary Russell¹², Junji Cao¹³, Jing Li¹⁴

Oxford Open Climate Change, 2023, 3(1), kgad008
<https://doi.org/10.1093/oxfclm/kgad008>
Perspective article



Dr. James Hansen testifying before Congress in 1988



1 August 1981, Volume 213, Number 4511

SCIENCE

Climate Impact of Increasing Atmospheric Carbon Dioxide

J. Hansen, D. Johnson, A. Lacis, S. Lebedeff
P. Lee, D. Rind, G. Russell

Greenhouse Effect

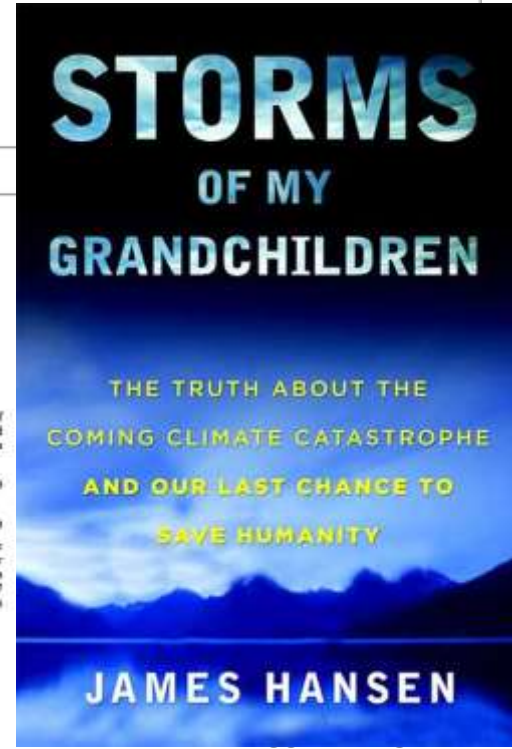
The effective radiating temperature of the earth, T_e , is determined by the need for infrared emissions from the planet to balance absorbed solar radiation:

$$\sigma R^2(1 - A)S_0 = 4\sigma R^2 T_e^4 \quad (1)$$

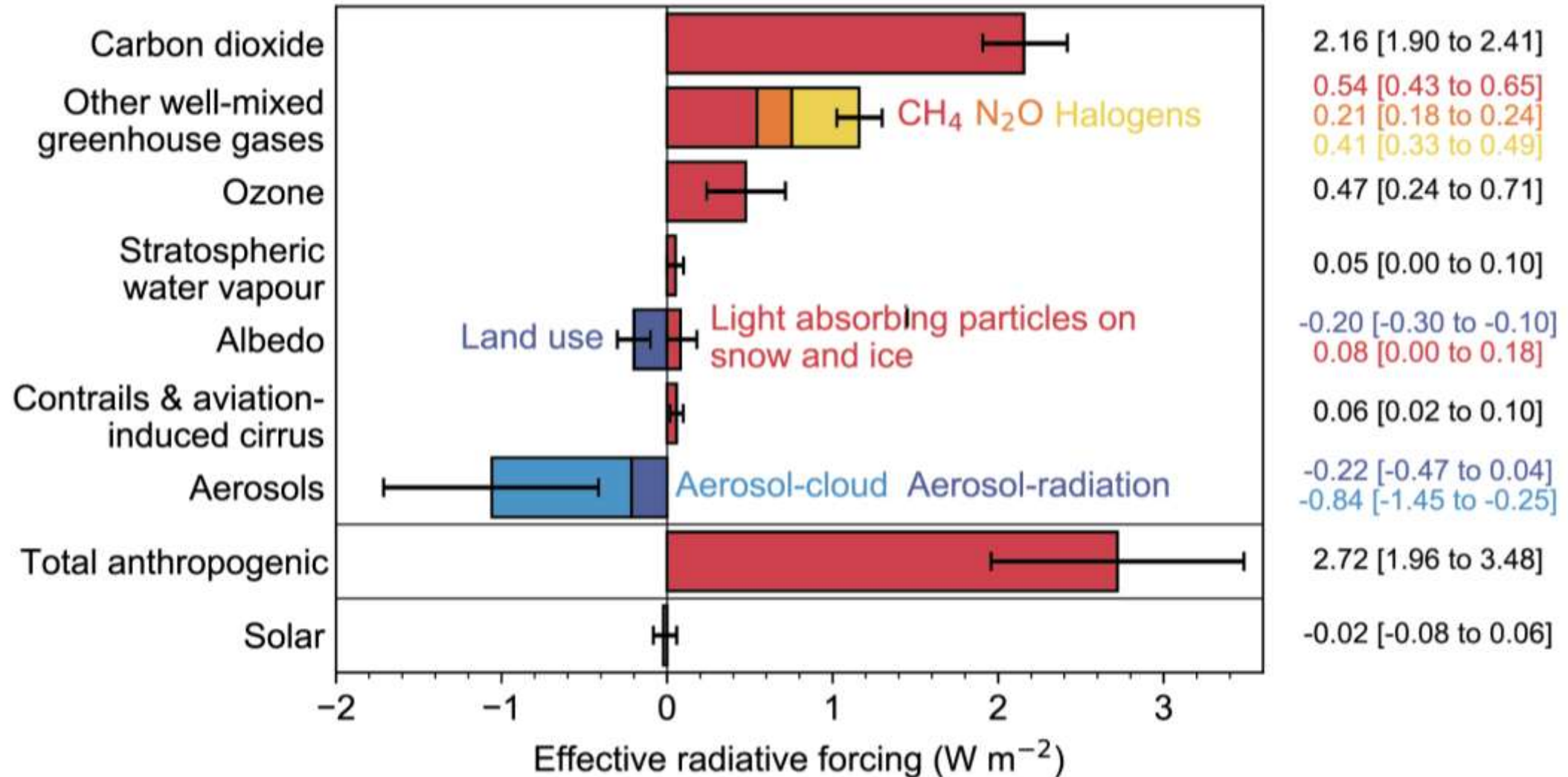
or

$$T_e = [3\sigma(1 - A)S_0]^{1/4} \quad (2)$$

where R is the radius of the earth, A the albedo of the earth, S_0 the flux of solar radiation, and σ the Stefan-Boltzmann constant. For $A = 0.3$ and $S_0 = 1367$ watts per square meter, this yields



EFFECTIVE RADIATIVE FORCING 1750-2019

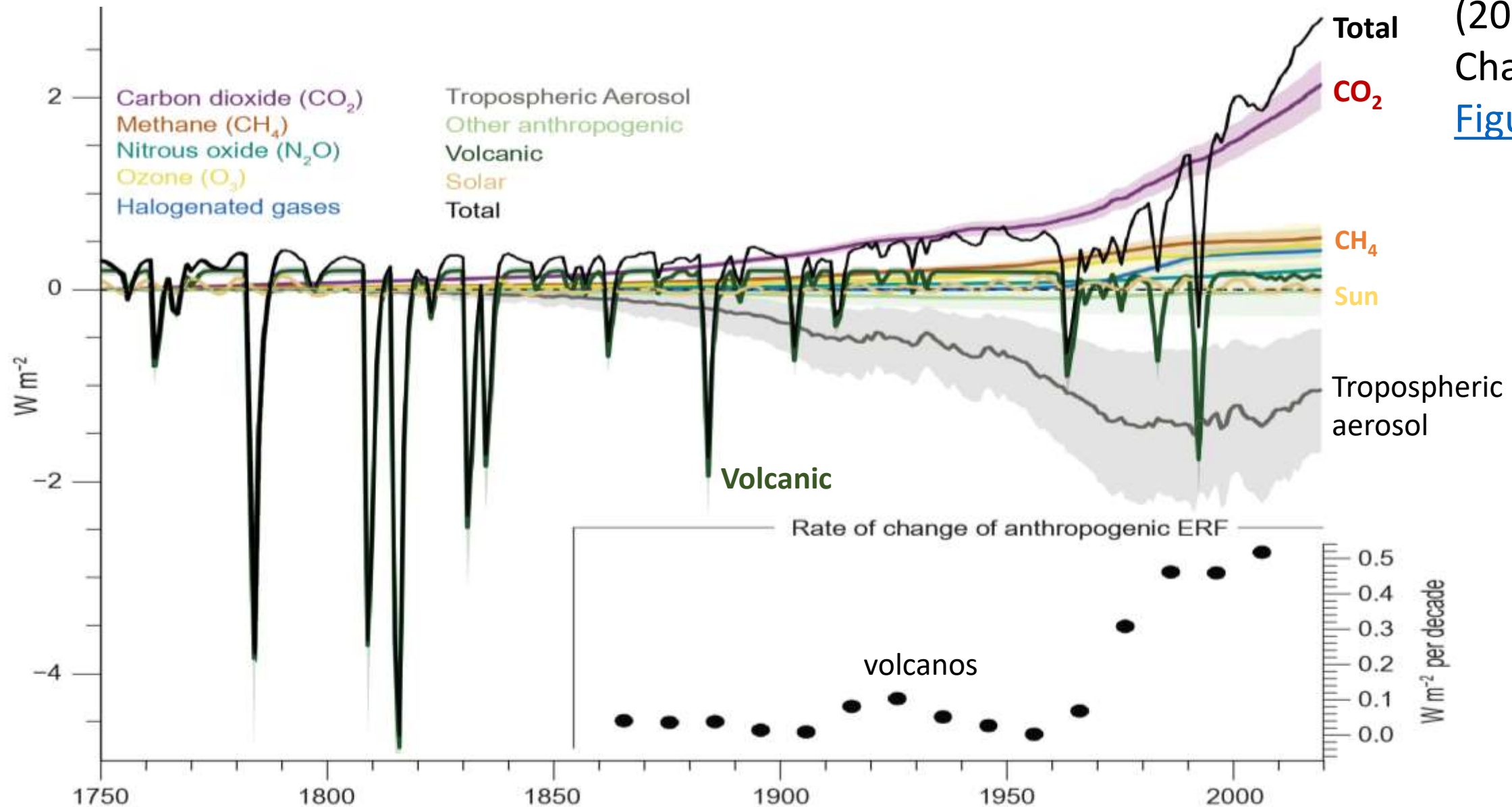


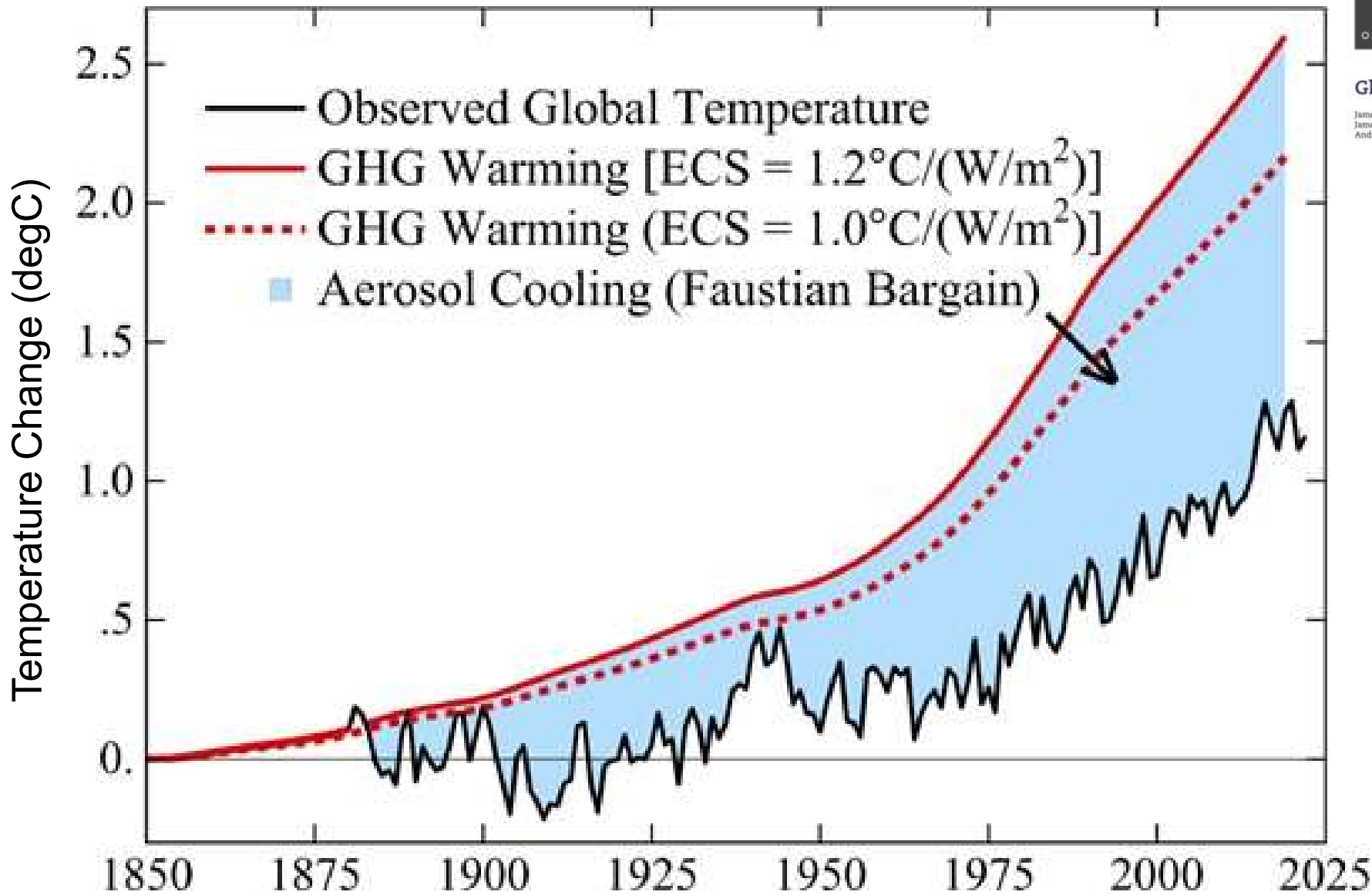
MODIS onboard NASA's Aqua satellite
on July 3, 2010 [science.nasa.gov]



Changes in Effective Radiative Forcing

Forster et al.
(2021) IPCC
Chapter 2,
[Figure 2.10](#)





Global warming in the pipeline

James E. Hansen^{1*}, Makiko Sato², Leon Simons³, Larissa S. Nazarenko^{4,5}, Isabelle Sangha⁶, Pushker Kharecha⁷,
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 Andrew Lacis², Reto Ruedy^{3,11}, Gary Russell², Junji Cao¹², Jing Li¹³

← Hansen et al. (2023)
 “Global warming in the pipeline”
 Oxford Open Climate Change
 [33 pages]

*“Aerosol offset of
 greenhouse gas warming
 is a Faustian bargain...
 providing present benefit
 without regard to future
 consequences.”*

[Hansen et al. (2024)
 Environment: Science and
 Policy for Sustainable
 Development, 39 pages]

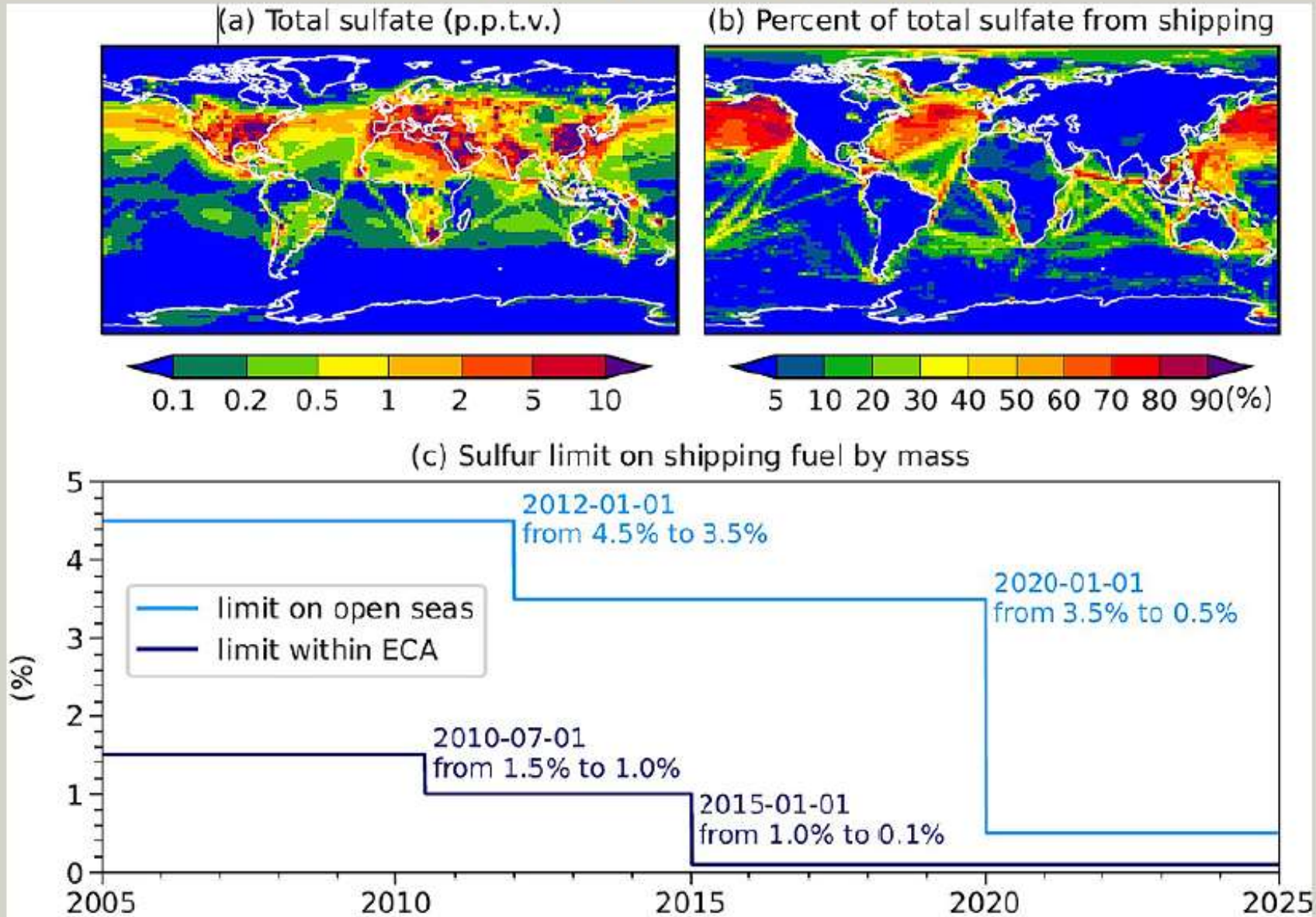
Figure 2. Faustus contemplates bargain with Mephistopheles, who offers him his present desire at the cost of future detriment, much like the cooling benefit of aerosols, which extract a cost in rapidly increased global warming once society no longer tolerates unhealthy air pollution.⁸



Hansen et al. (2024)
Environment: Science and
Policy for Sustainable
Development



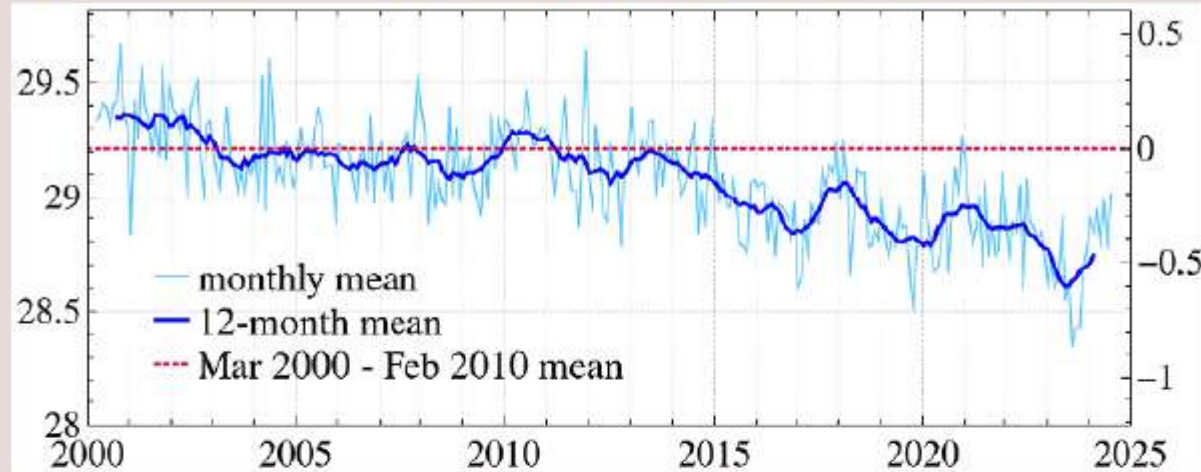
Figure S5. Sulfate aerosols and sulfur limit on emissions,
p.p.t.v. = parts per trillion by volume.**



CLEANER SHIP FUEL

“...aerosols emitted into polluted air have much less effect on clouds than aerosols emitted into a pristine atmosphere...”

Figure 6. Earth's albedo (reflectivity, in percent), seasonality removed.**

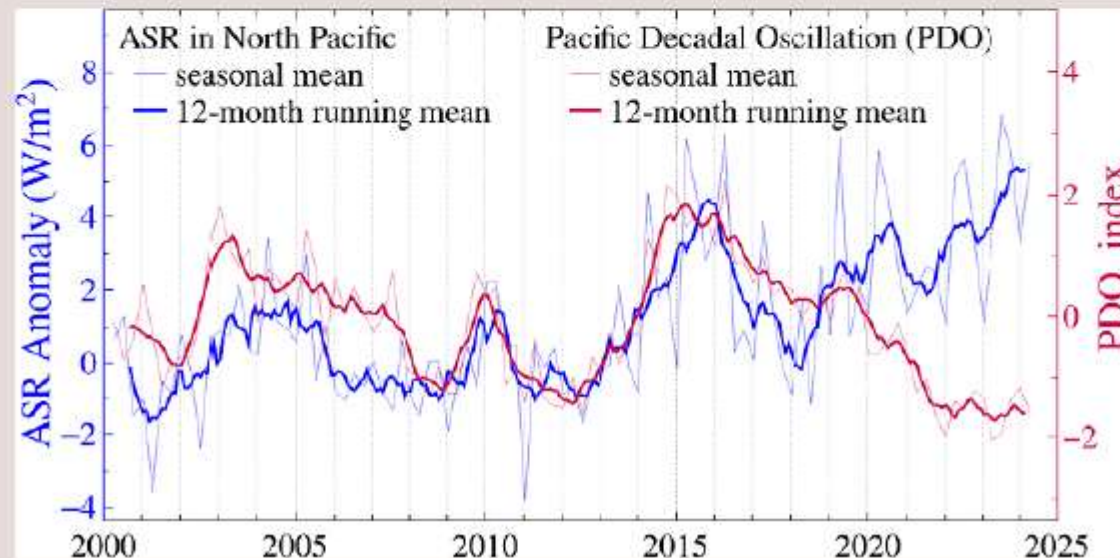


“Earth’s albedo decreased about 0.5% (of 340 W/m²), which is 1.7 W/m² additional heating of Earth since 2010!”

- Some of this is feedback by ice/snow and cloud, some is ship fuel aerosol decline.
- But how much and why does it not correlate with shipping regulations?

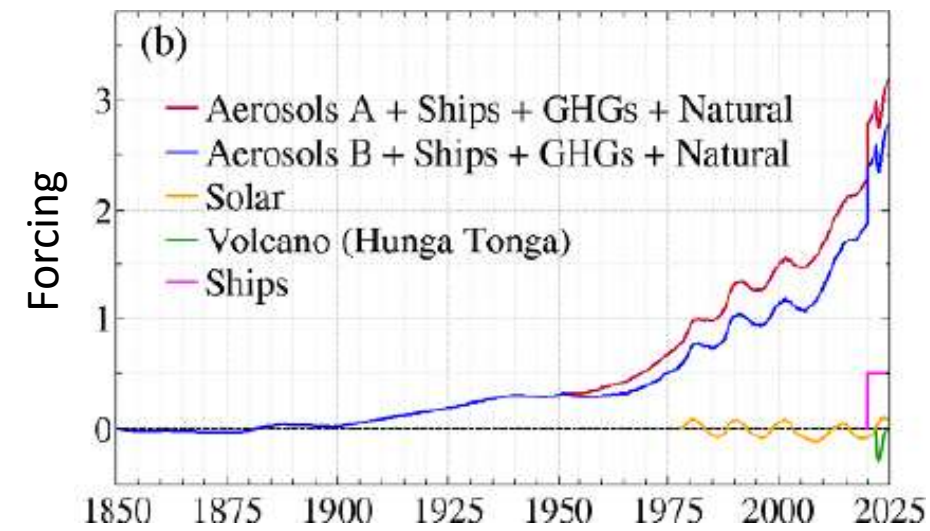
“...strong decline of the Pacific Decadal Oscillation (PDO) in 2020-22... temporarily hid the ship aerosol effect on global temperature.”

Figure 7. Absorbed Solar Radiation (ASR) and Pacific Decadal Oscillation (PDO).**



Global Warming Has Accelerated: Are the United Nations and the Public Well-Informed?

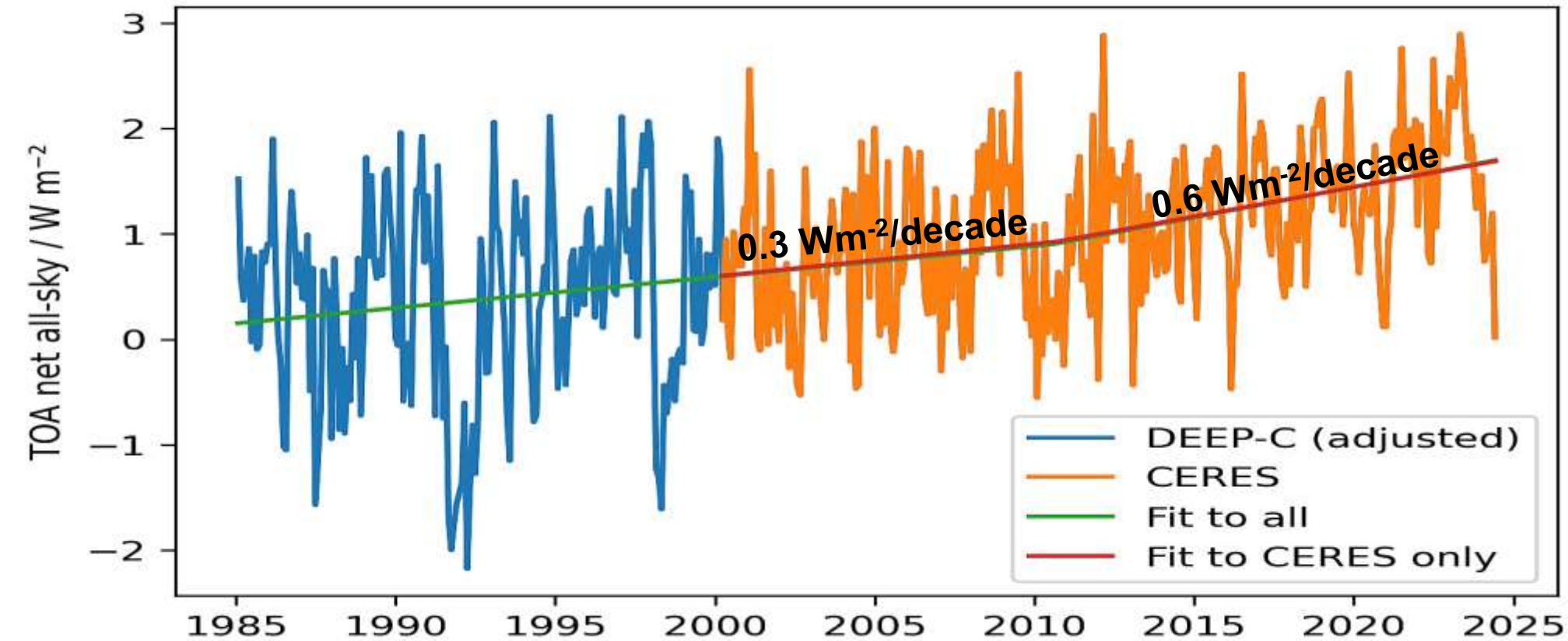
Hansen et al. (2024) Environment: Science and Policy for Sustainable Development [39 pages]



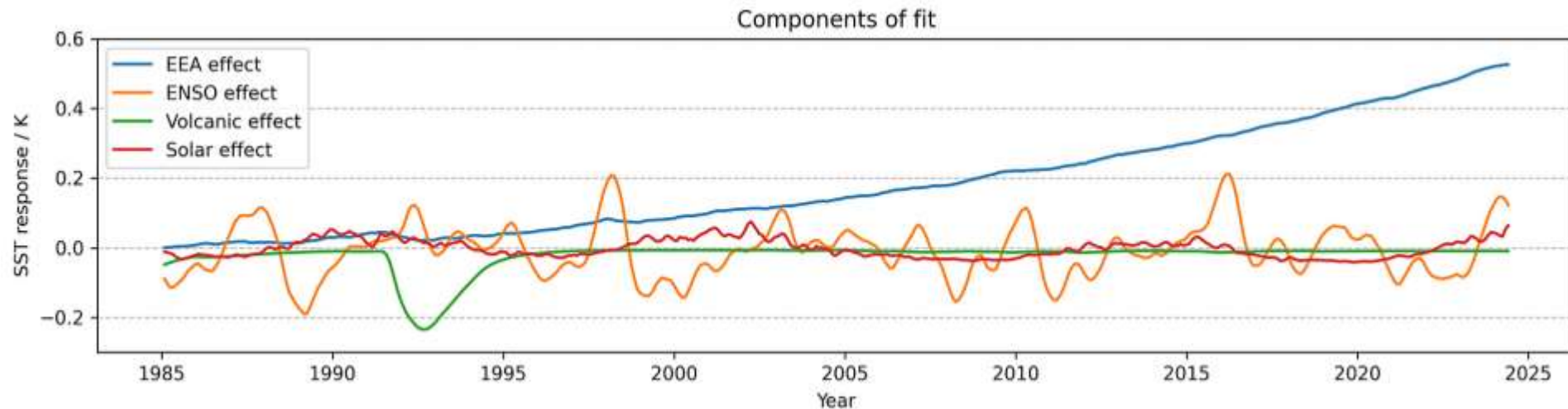
- “...aerosol forcing induced by International Maritime Organization restrictions on ships could be $\sim 0.5 \text{ W/m}^2$... much larger than aerosol forcing (0.079 W/m^2) estimated in IPCC formulation...”
...based on CERES 2020-23 anomaly in absorbed sunlight relative to 2000-2010: $+3.2 \text{ W/m}^2$ in N Pacific (10% of globe) & $+2.8 \text{ W/m}^2$ in N Atlantic (6% of globe): $3.2 \times 0.1 + 2.8 \times 0.06 = 0.5 \text{ W/m}^2$ [???
- “due to absence of global aerosol & cloud measurements needed to calculate the aerosol forcing accurately, aerosol forcing & climate sensitivity wedded in inappropriate shotgun marriage...”
- “...additional warming [in 2023] mainly the effect of reduced human-made aerosols, especially aerosols produced by ships. The ship aerosol effect is greatest in the North Pacific and North Atlantic because that is where ship-produced [sulphate] aerosols exceeded natural aerosols...”

Look at palaeo records, changes in sun, Hunga volcano, internal variability, feedbacks

Deseasonalised EEI



Observed
changes in
Earth's top of
atmosphere
energy budget



Merchant et al.
(2025) ERL

SPATIAL PATTERN OF IMBALANCE



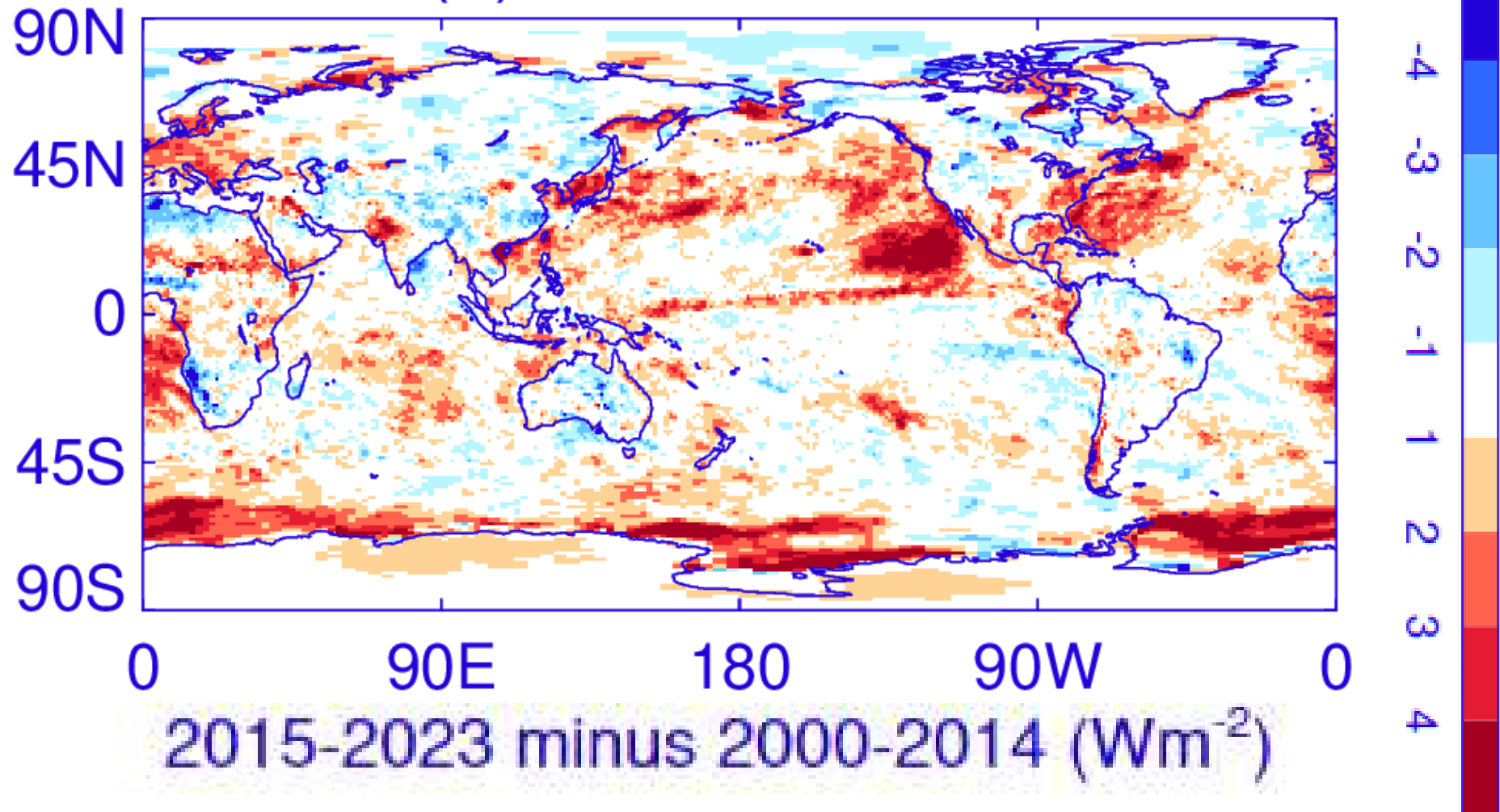
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(a) dNET, CERES

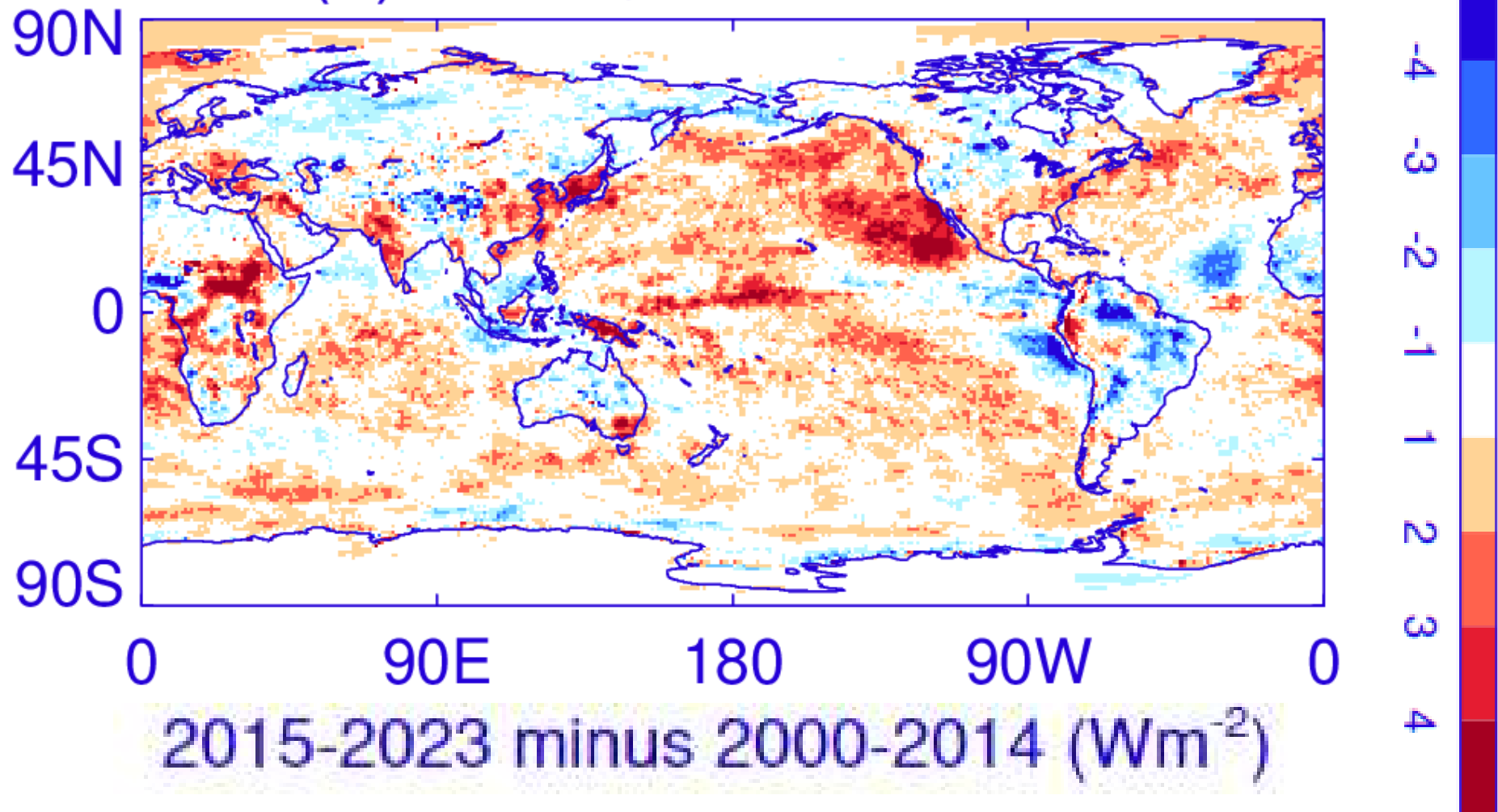
CERES Net
Imbalance Aug
2022-Jul 2023:
 1.9 Wm^{-2}
(+1.1 Wm^{-2}
larger than
2006-2020)



Allan & Merchant (2025) ERL

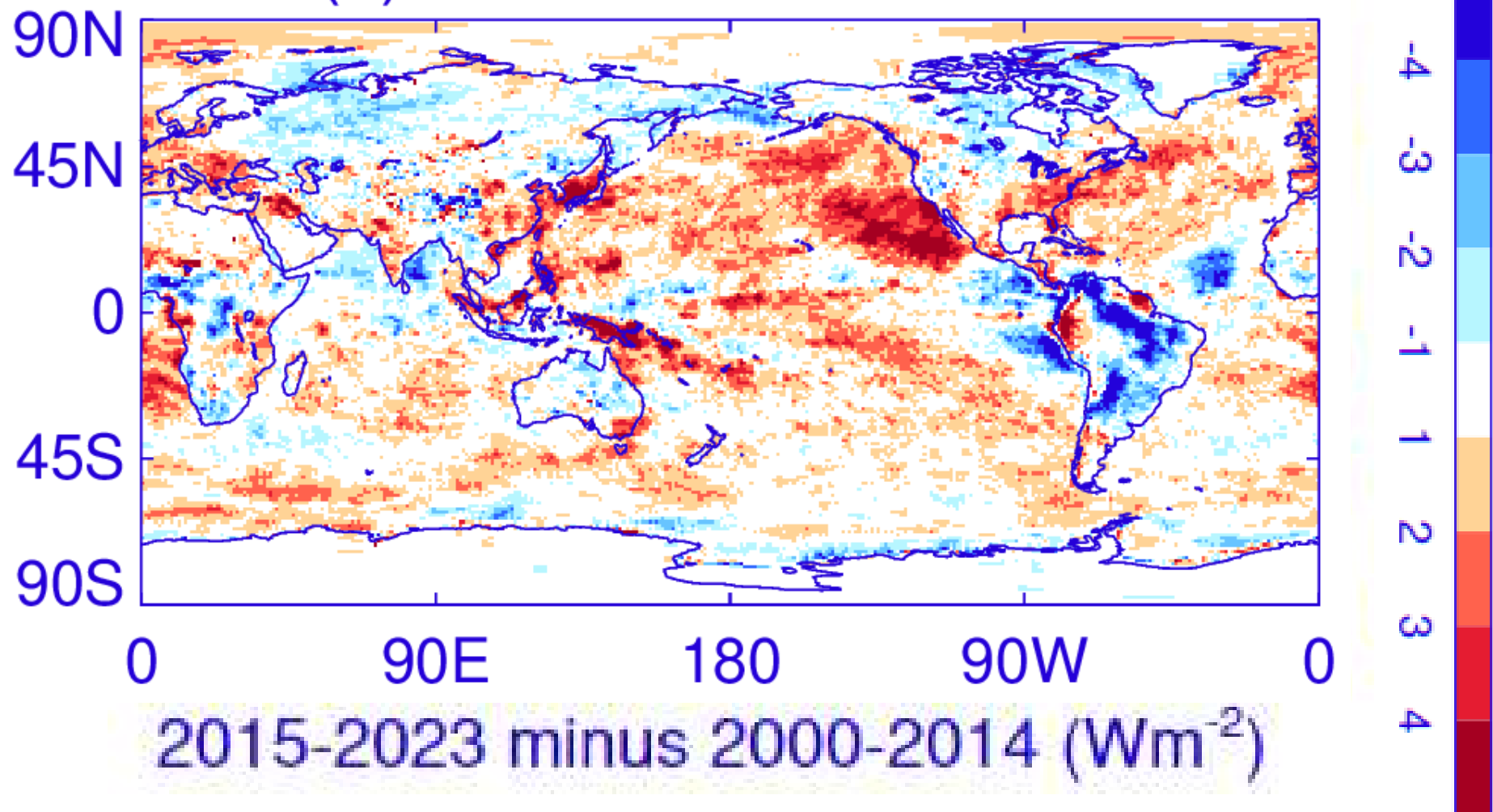
SPATIAL PATTERN OF IMBALANCE

(b) dNET, CERES-ERA5



ABSORBED SOLAR RADIATION

(c) dASR CERES-ERA5



ABSORBED SOLAR RADIATION (clear)

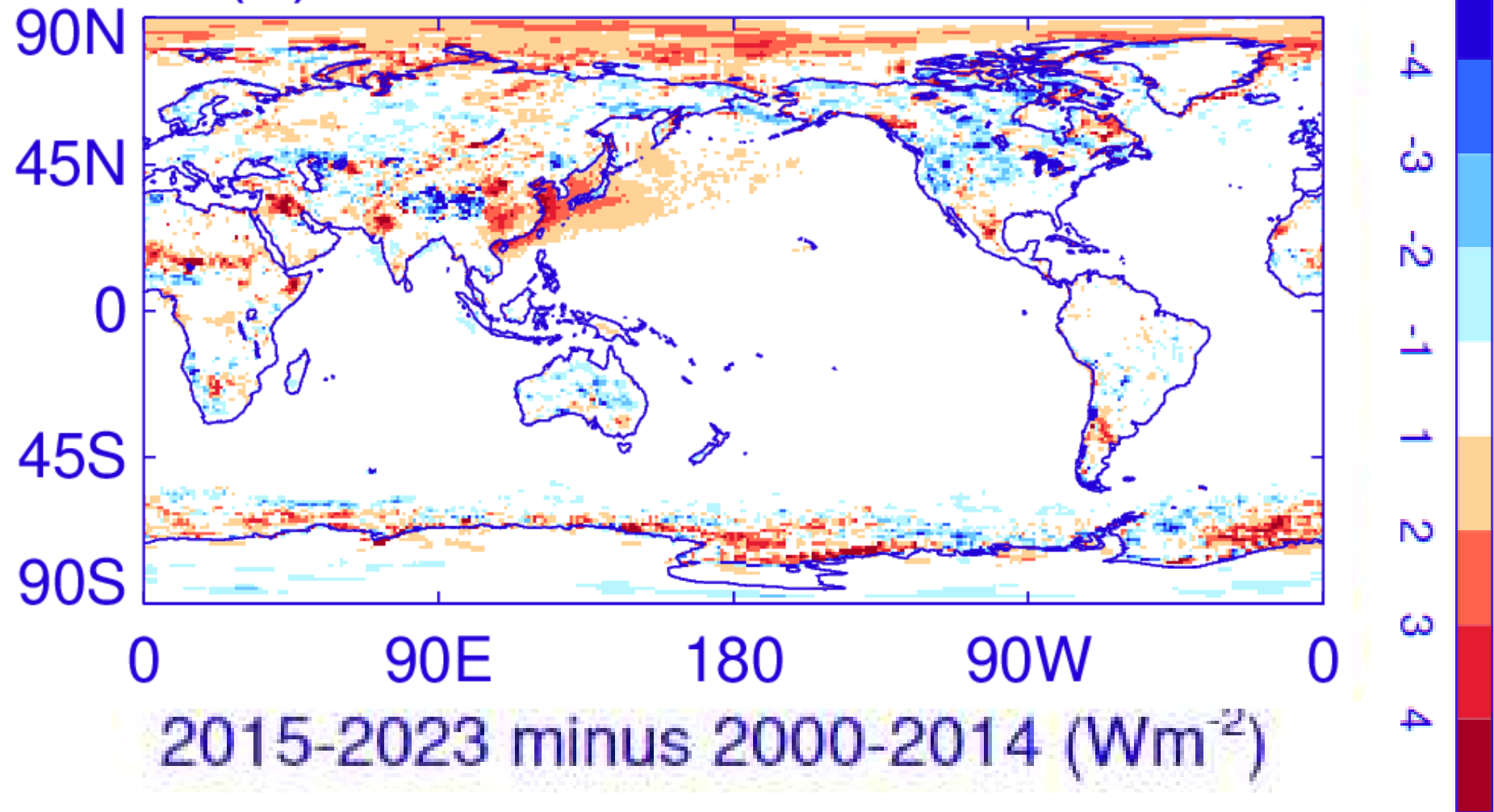


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(d) dASR clear CERES-ERA5



CONCLUSIONS



- Extensive report(s) by Hansen et al., aimed at “*broad audience*”:
 - masking of global warming by particle pollution has been underestimated
 - future climate change may be even worse than anticipated.
- Larger than expected effect of declining aerosol pollution on global warming?
- Arguments not new; though reasonable, overstate conclusions relative to IPCC
- “*The second half is a polemic, and not worth reading*” [Bill Collins, famous scientist]
- **But:** magnitude of increases in Earth’s heating rate & ocean surface warming mean scientific community keeping a close eye
- **UNCHANGED:** urgent need to cut greenhouse gas emissions and to properly account for the full economic cost of our actions on the planet and people.”