ZAPYTAJ FIZYKA

KLIMAT ZŁOŻONY I PROSTY – NOBEL 2021

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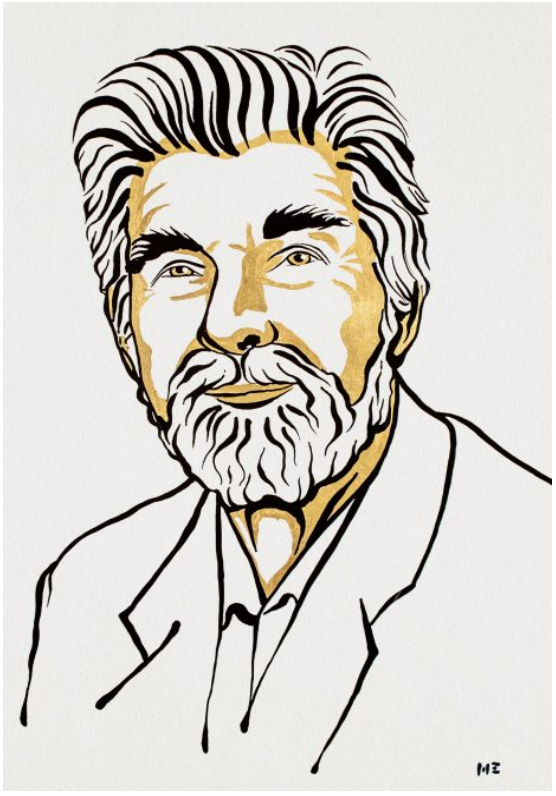
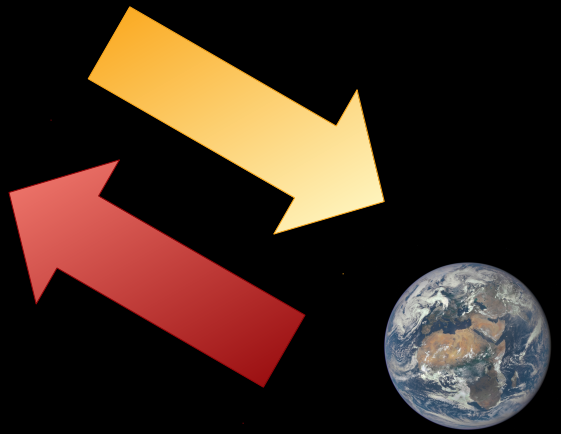


Niklas Elmehed (Nobel Prize Outreach)

NASA



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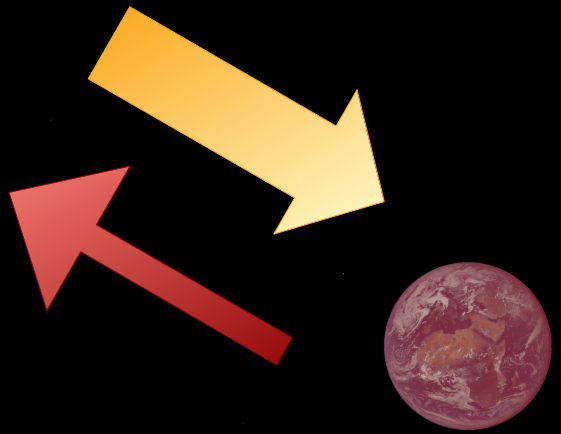

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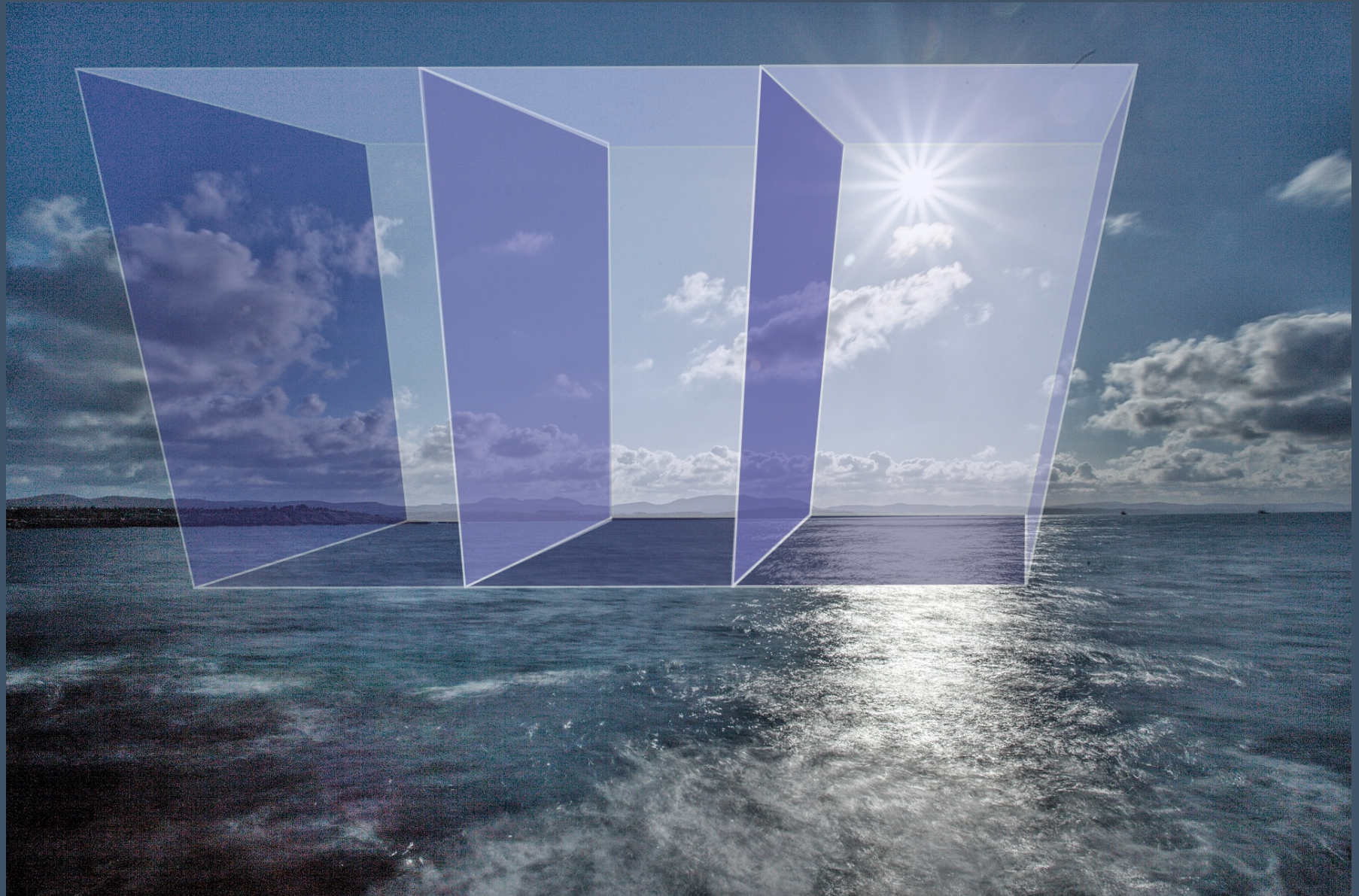
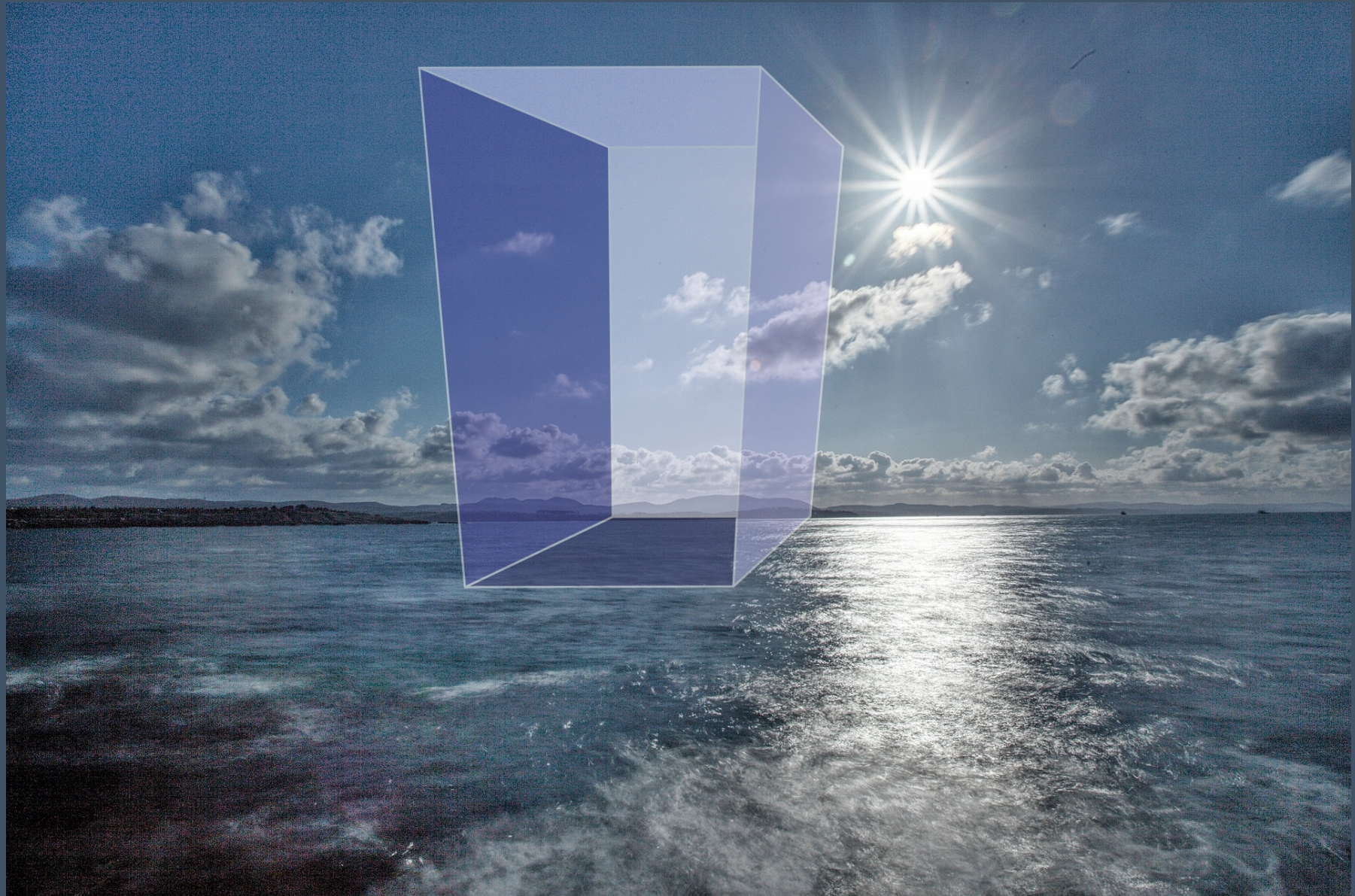
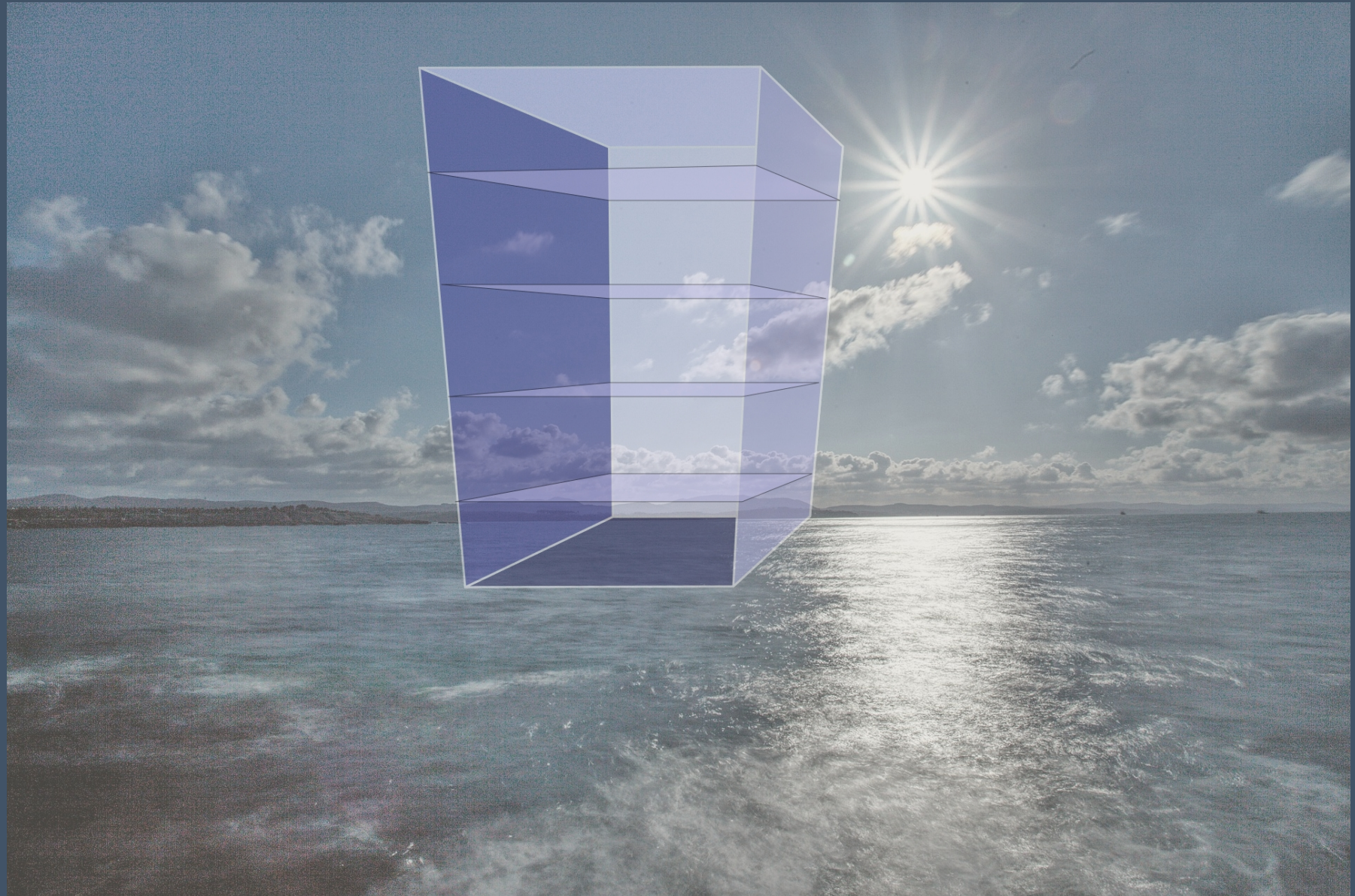
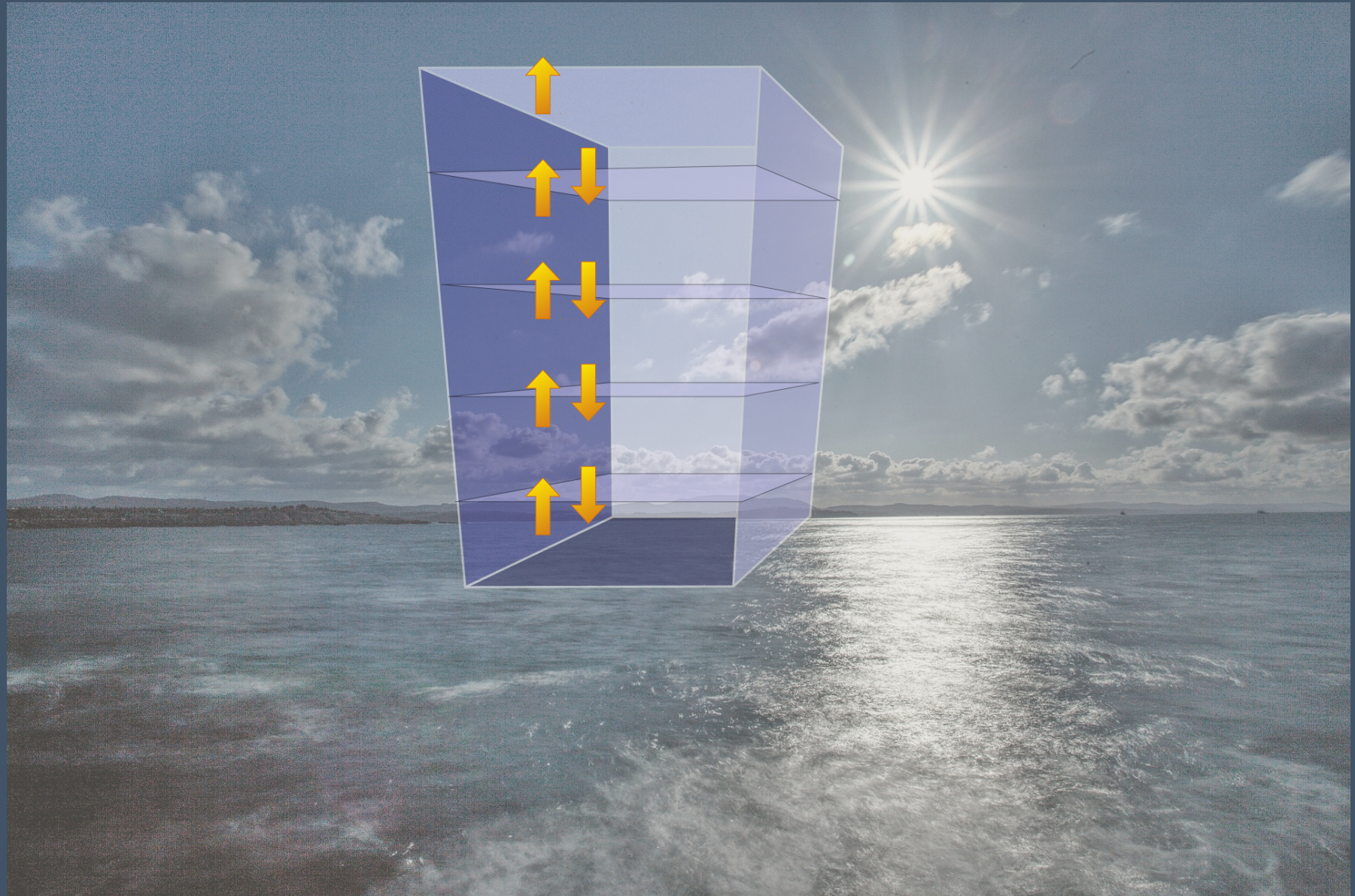
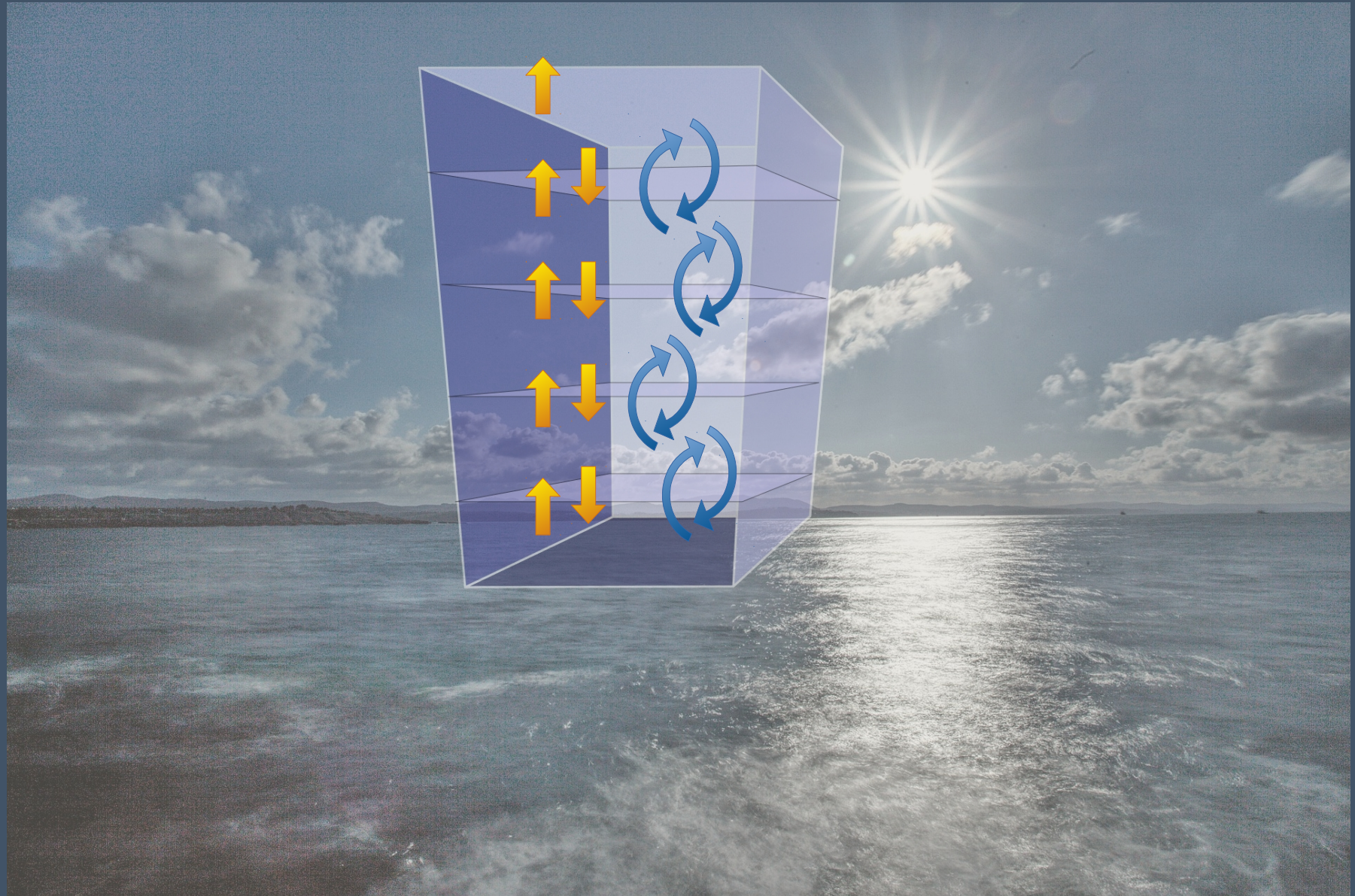
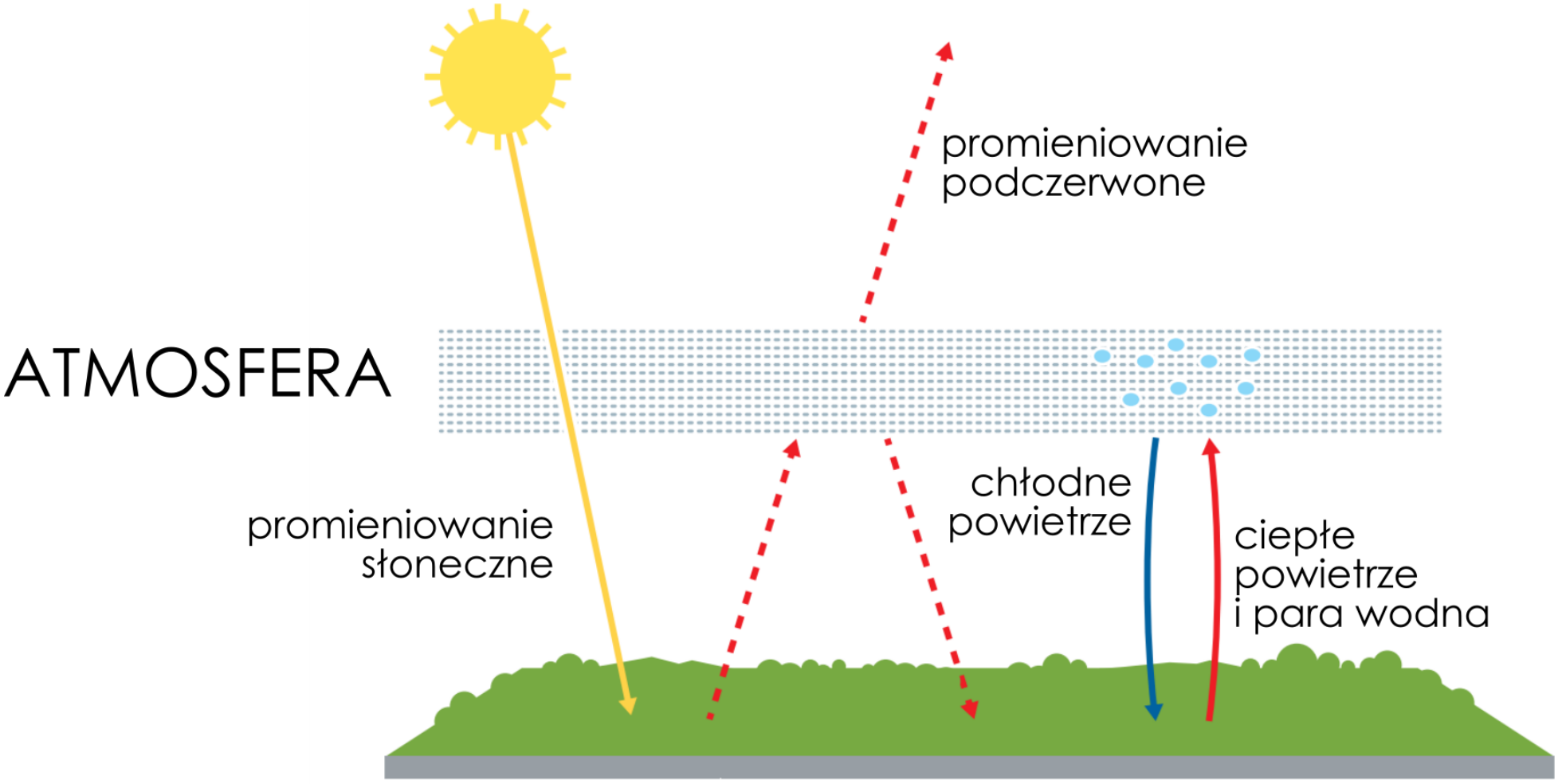




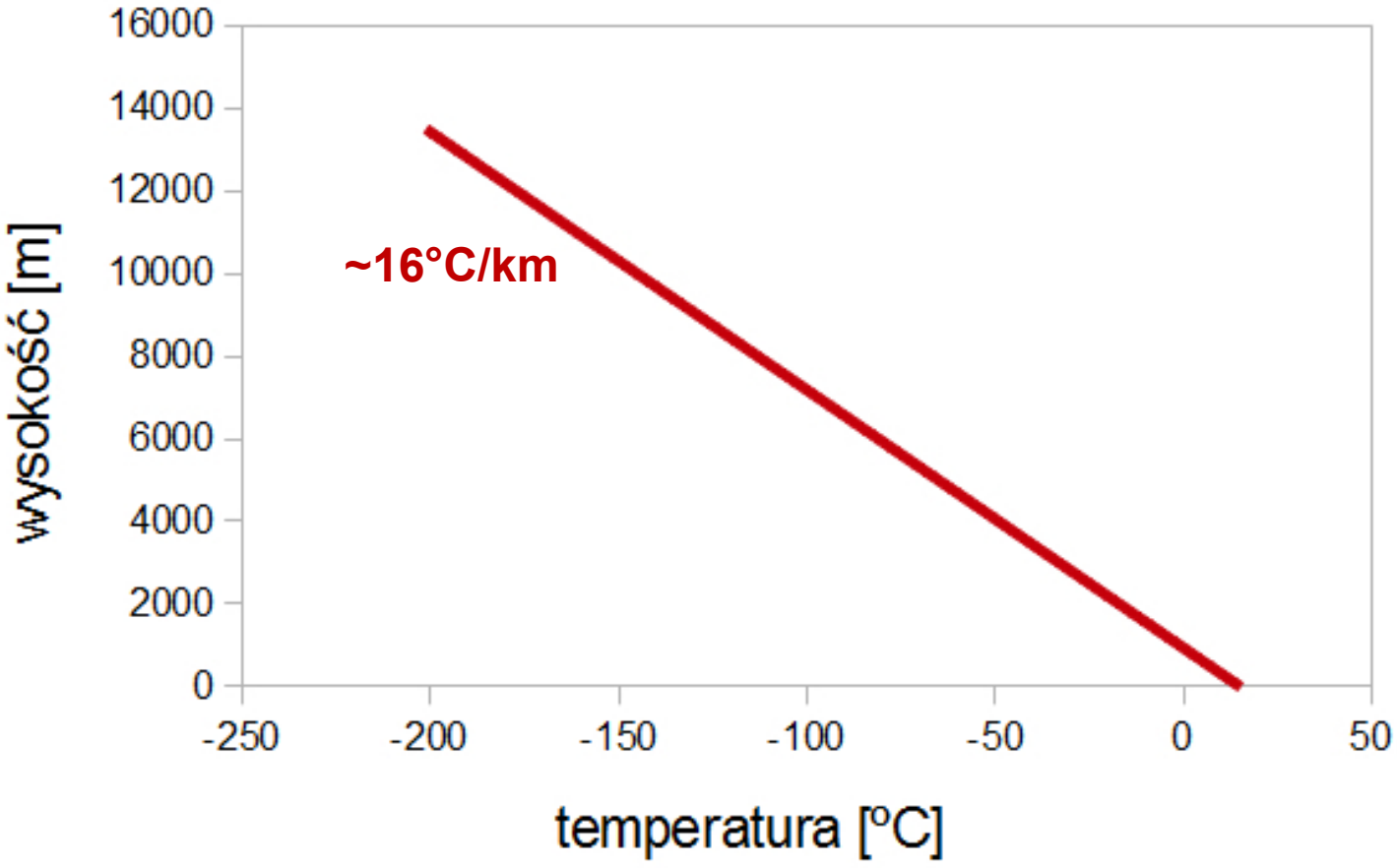




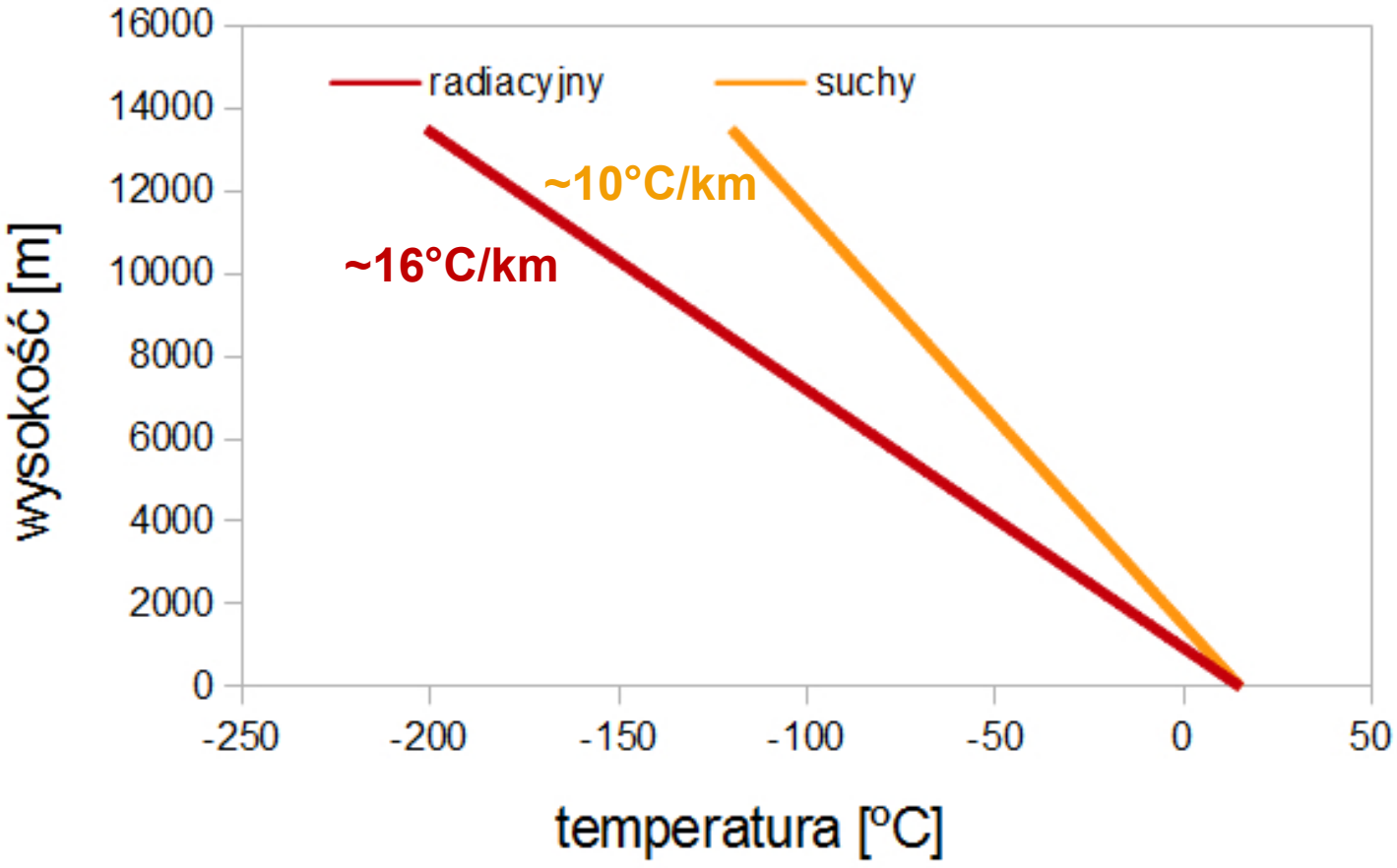




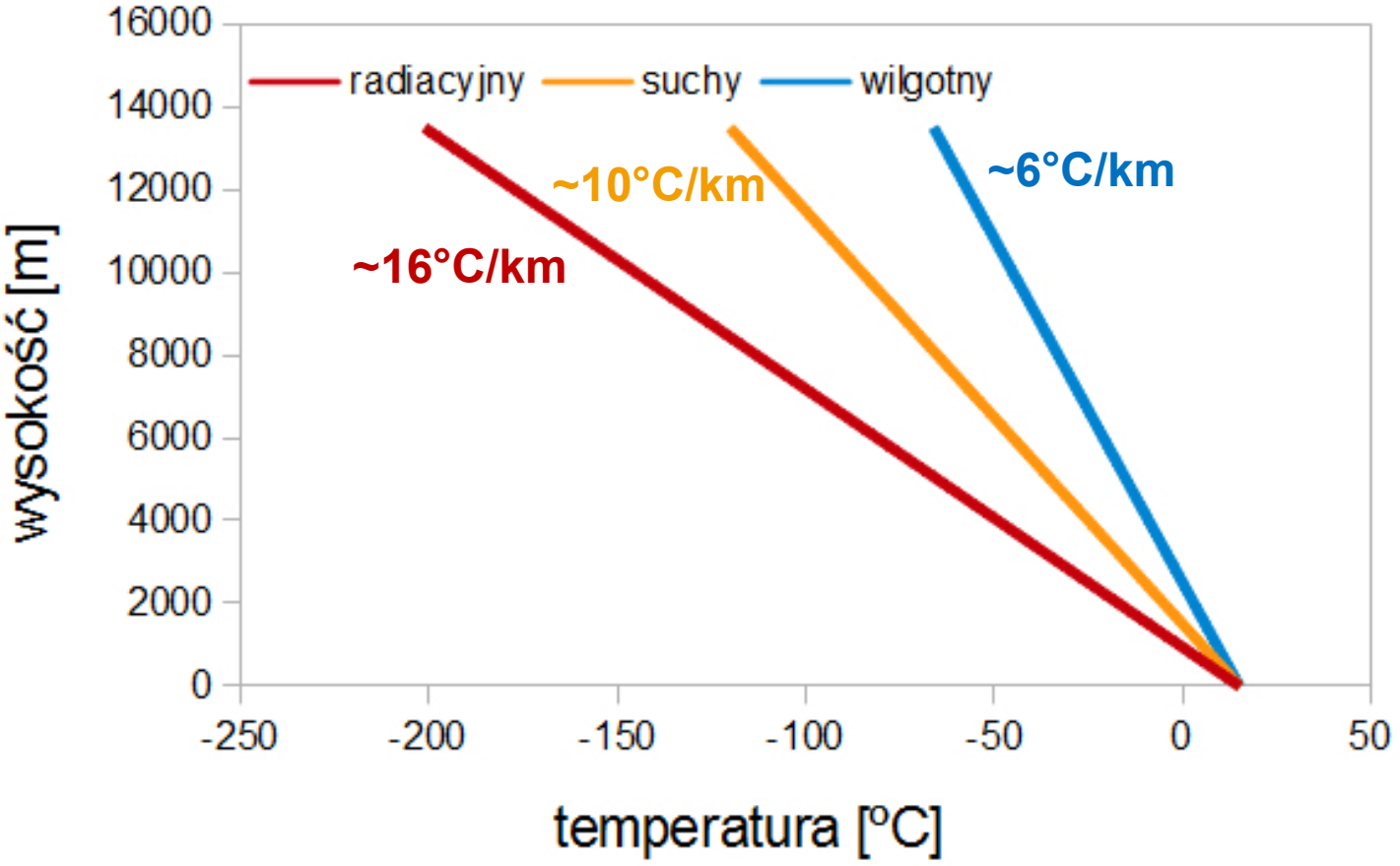
Gdyby energię transportowało wyłącznie promieniowanie…

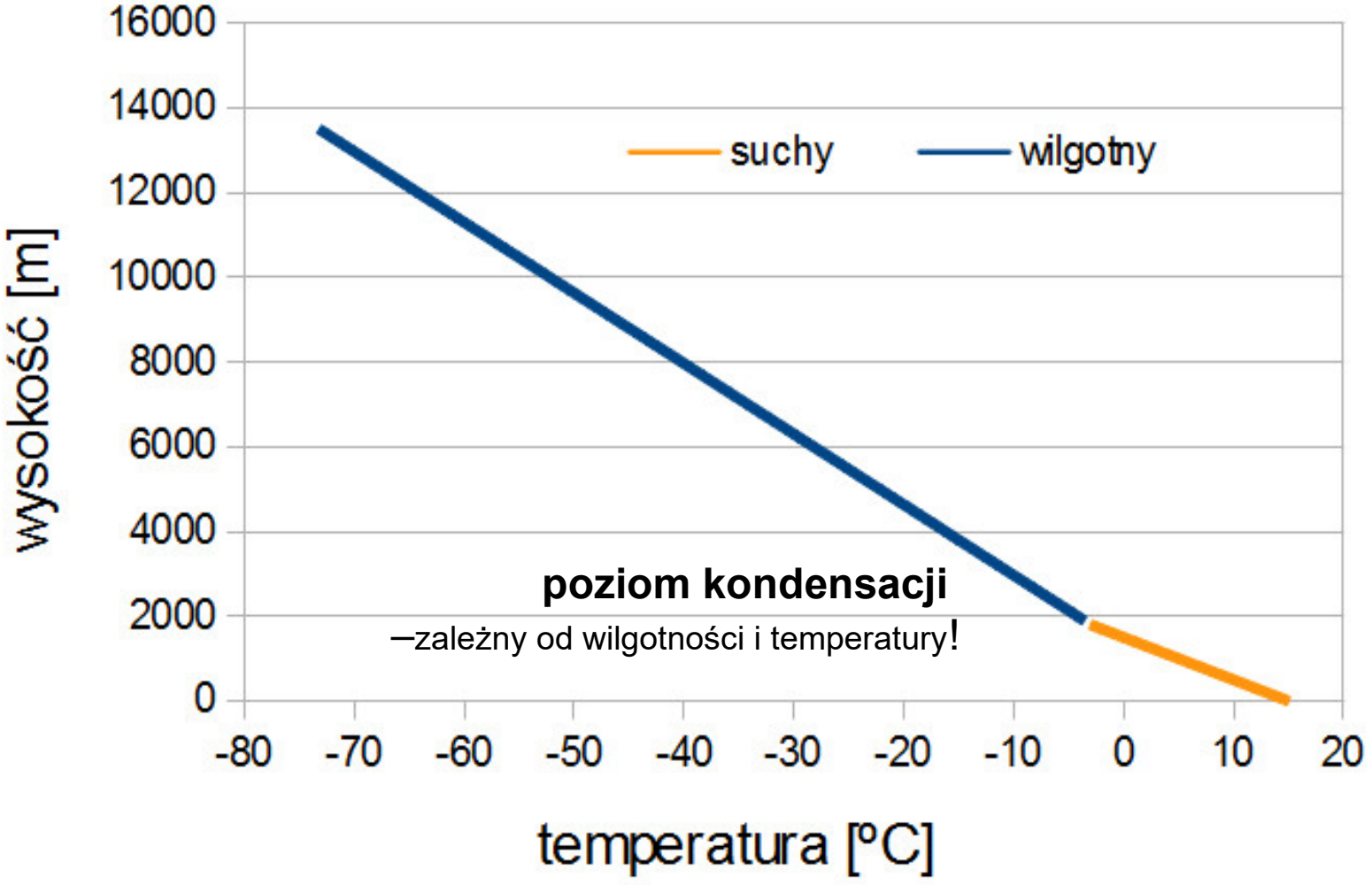


Ale mamy też ruchy powietrza (konwekcję)...



I jeszcze kondensującą parę wodną!




16000
14000
12000
10000
8000
6000
4000
2000
0
wysokość [m]
suchy
wilgotny
poziom kondensacji
–zależny od wilgotności i temperatury!
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20
temperatura [ºC]

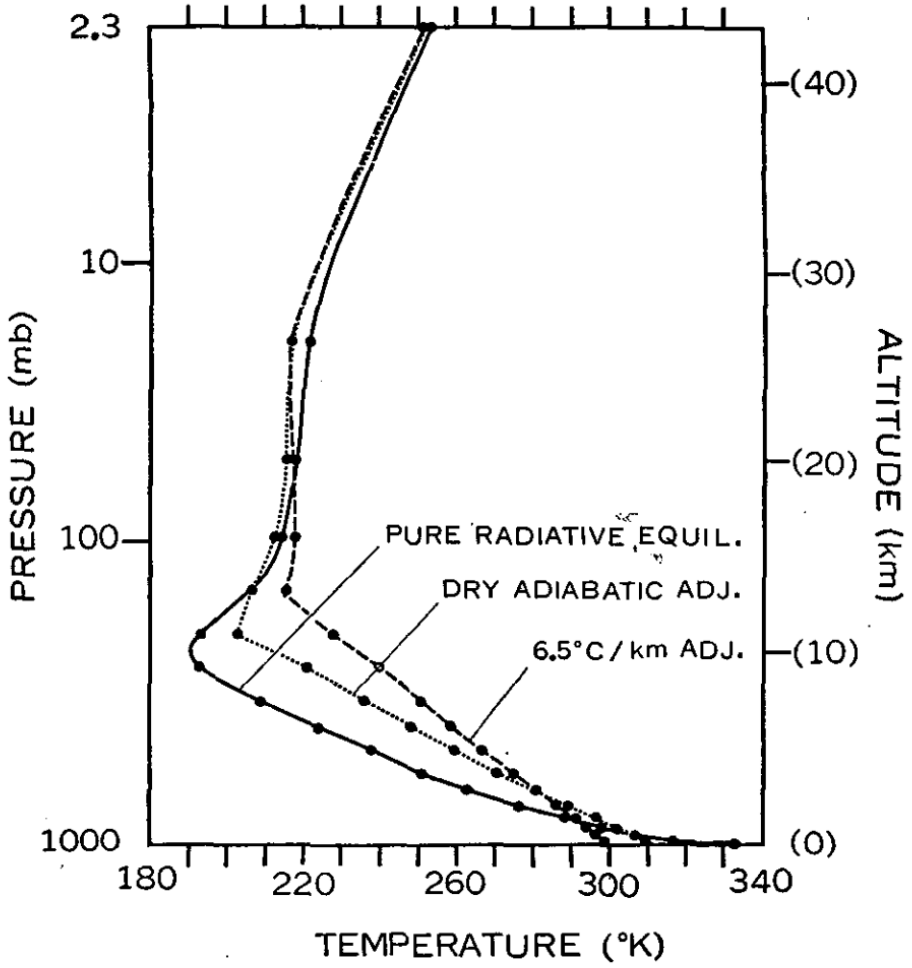


FIG. 4. The dashed, dotted, and solid lines show the thermal equilibrium with a critical lapse rate of 6.5 deg km^{-1}, a dry-adiabatic critical lapse rate (10 deg km^{-1}), and pure radiative equilibrium.

Thermal Equilibrium of the Atmosphere with a Convective Adjustment

SYUKURO MANABE AND ROBERT F. STRICKLER

General Circulation Research Laboratory, U. S. Weather Bureau, Washington, D. C.

(Manuscript received 19 December 1963, in revised form 13 April 1964)

Niklas Elmehed (Nobel Prize Outreach)

Ozone layer → stratosphere

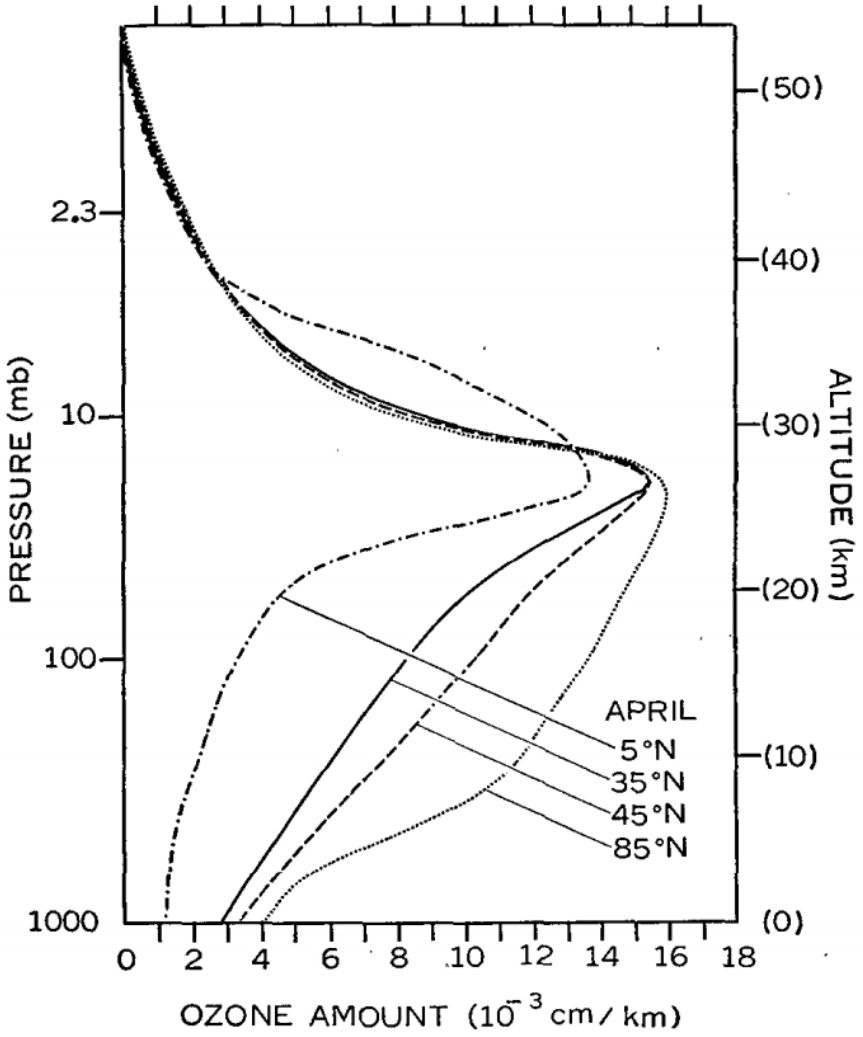


FIG. 5b. Examples of vertical distribution of ozone adopted for our computations.

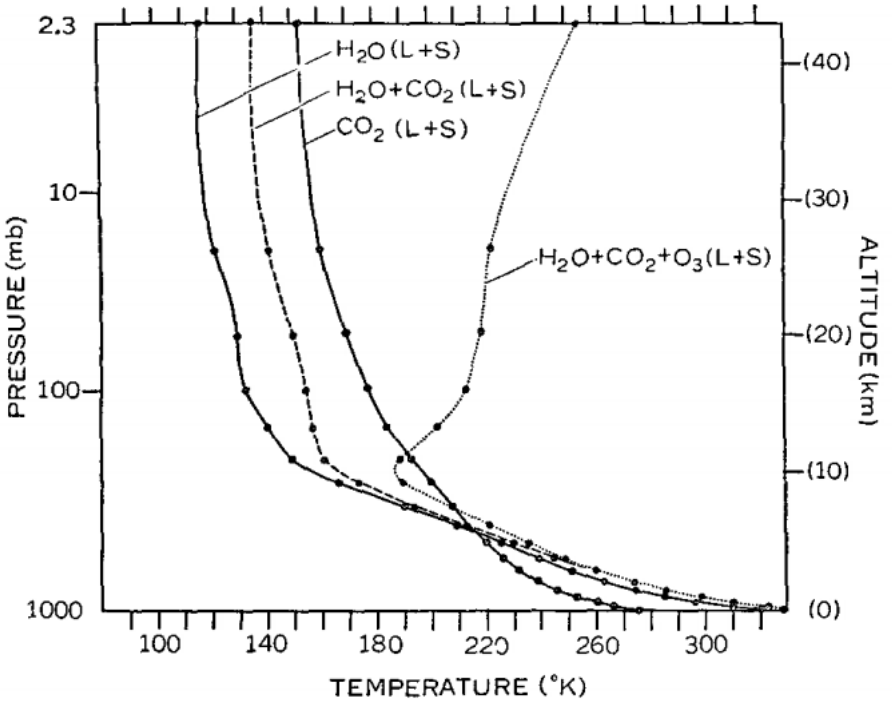
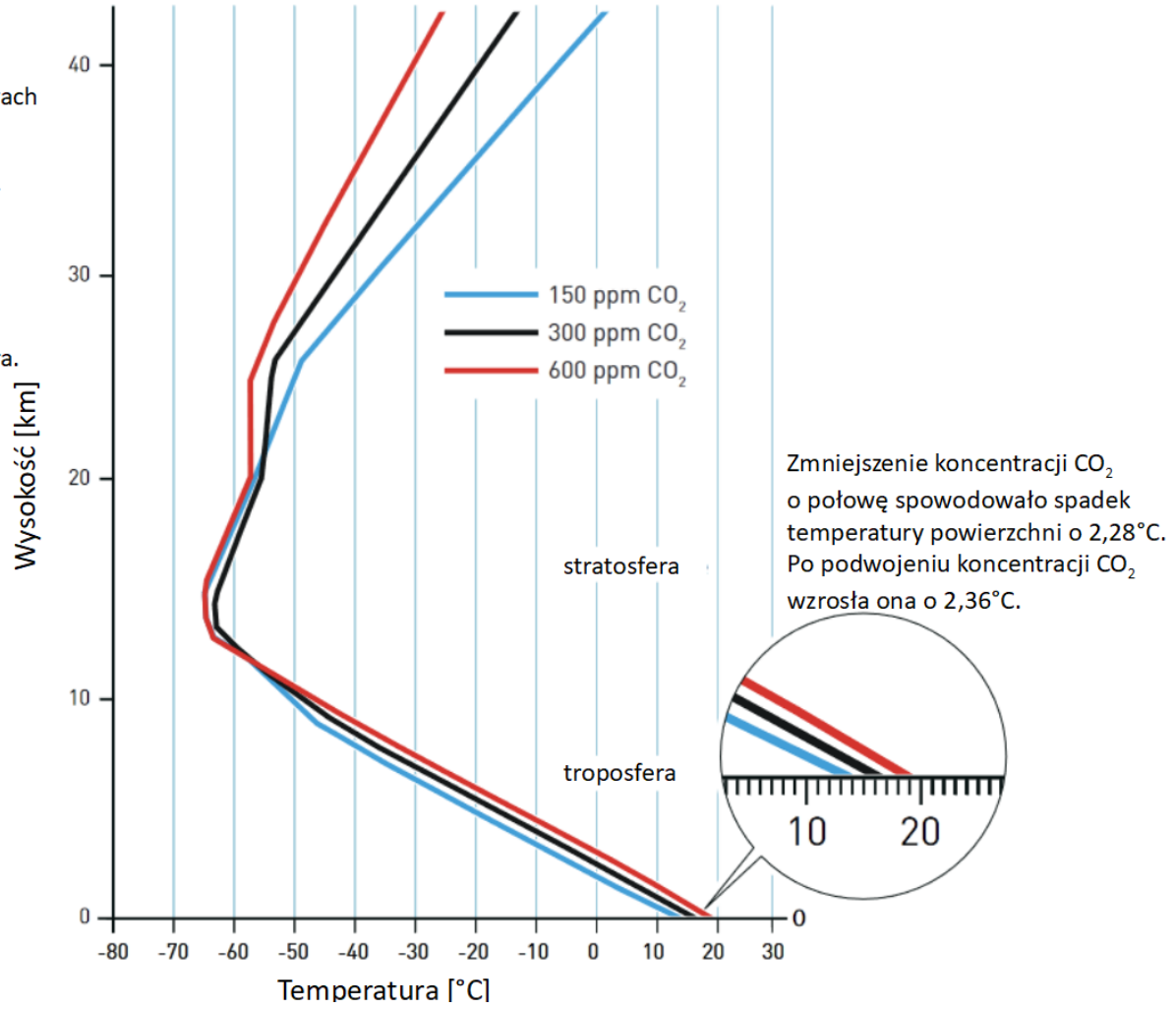


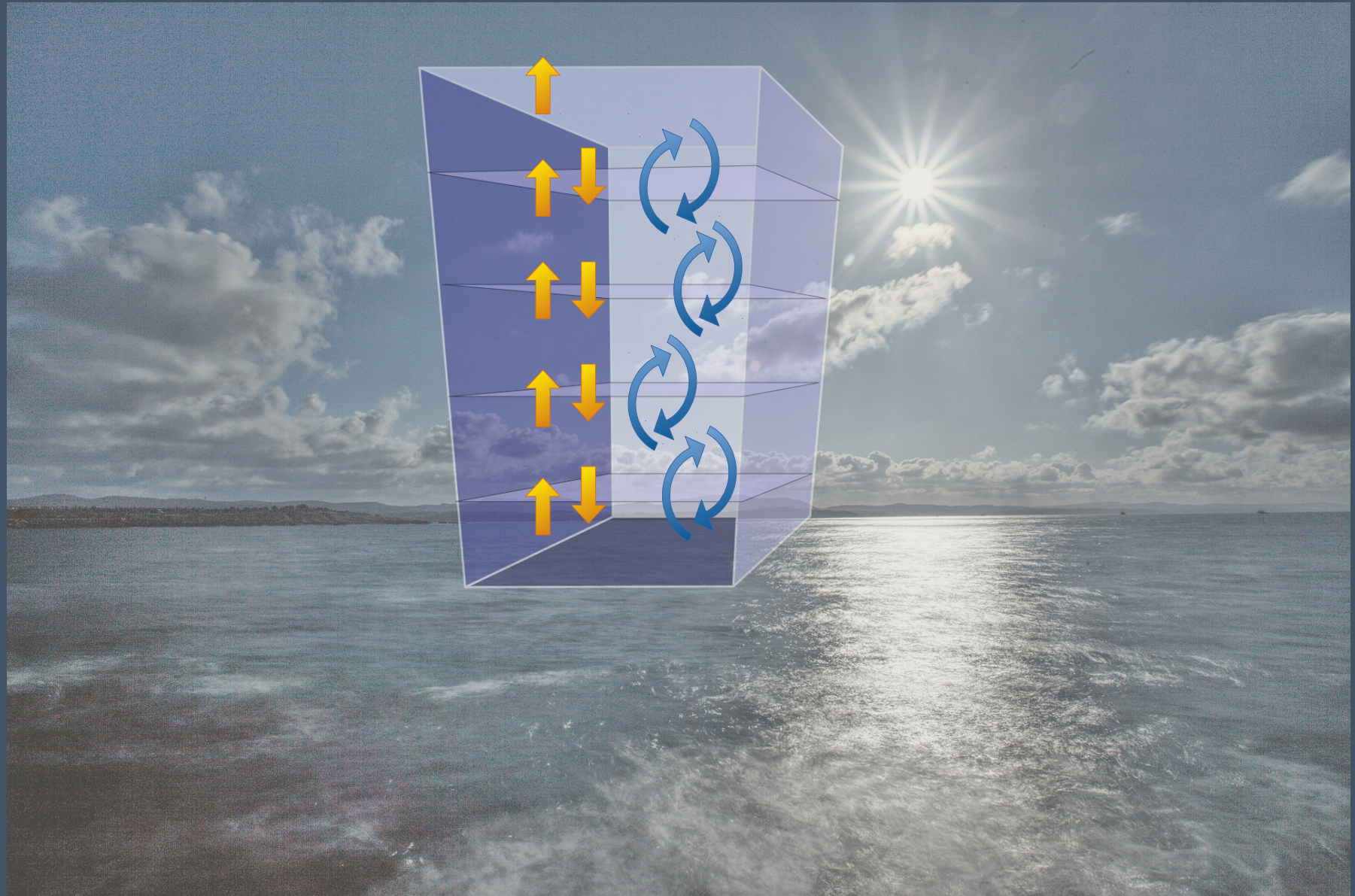
FIG. 6a. Pure radiative equilibrium for various atmospheric absorbers. The distribution of gaseous absorbers at 35N in April are used. $S_c=2$ ly min^{-1}, $\cos\bar{\zeta}=0.5$, $r=0.5$. No clouds. (L+S) means that the effects of both long wave radiation and solar radiation are included.

Dwutlenek węgla ogrzewa atmosferę

Podwyższona koncentracja CO_2 prowadzi do wzrostu temperatury w dolnych warstwach atmosfery oraz do ochłodzenia górnej atmosfery.
Manabe potwierdził, że zmiany temperatury są związane ze wzrostem koncentracji CO_2; gdyby przyczyną był wzrost aktywności słonecznej, nagrzewałaby się cała atmosfera.

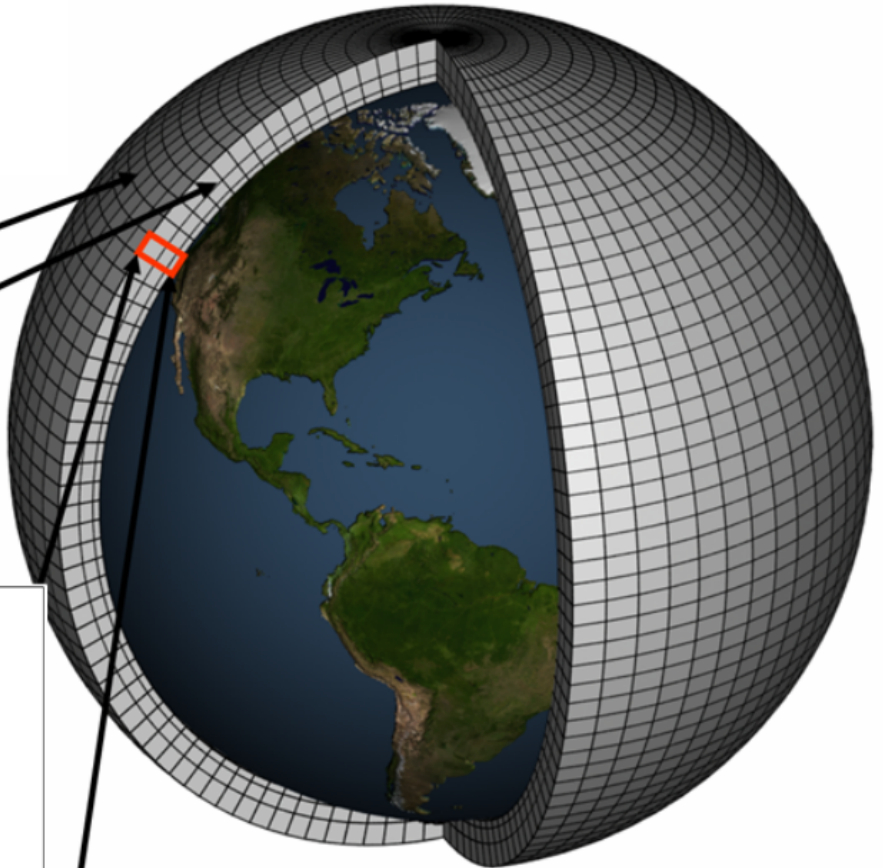


Johan Jarnestad (The Royal Swedish Academy of Sciences), na podstawie Manabe i Wetherald (1967)

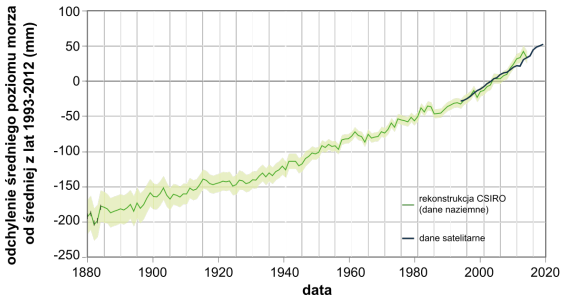


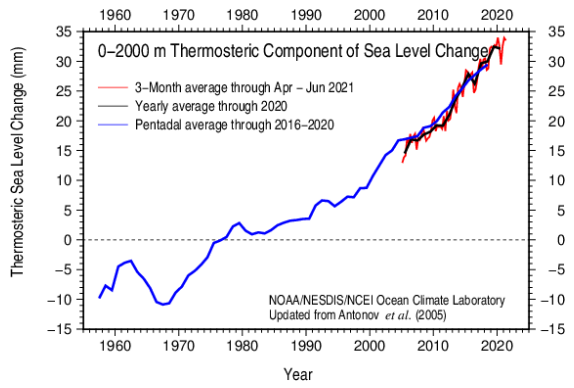
siatka pozioma
(szerokości i długości geograficzne)

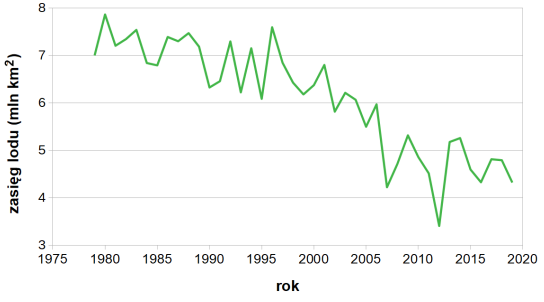
siatka pionowa
(wysokość lub ciśnienie)



Na podst. ilustracji NOAA



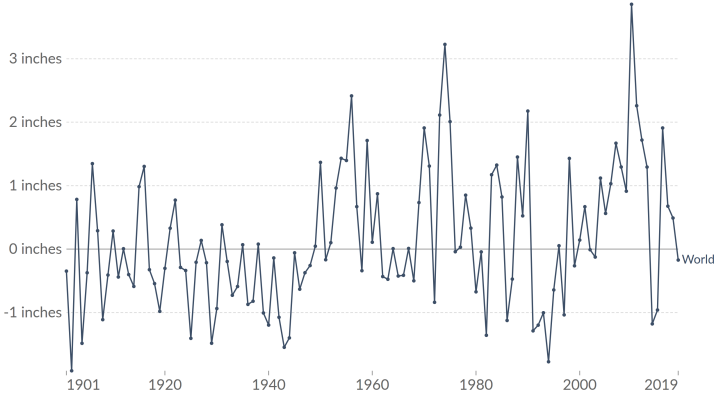




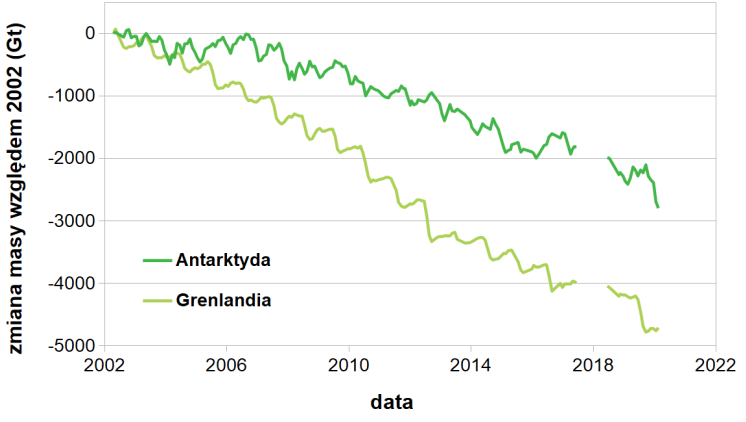
Global precipitation anomaly

This indicator shows annual anomalies compared with the average precipitation from 1901 to 2000 based on rainfall and snowfall measurements from land-based weather stations worldwide.

Our World in Data



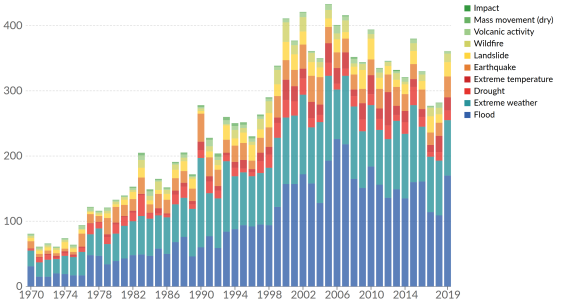
Source: National Oceanic & Atmospheric Administration (NOAA) via the US EPA — OurWorldInData.org/natural-disasters • CC BY
Note: Global anomalies have been determined by dividing the world into a grid, averaging the data for each cell of the grid, and then averaging the grid cells together.



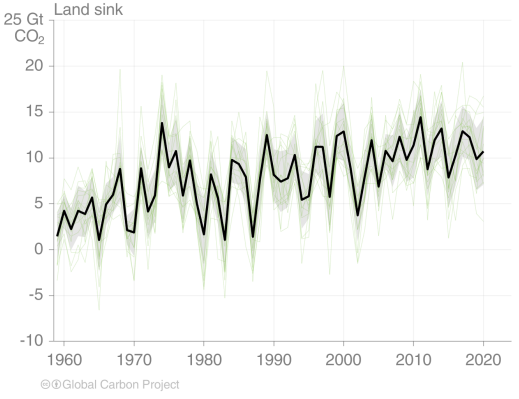
Global reported natural disasters by type, 1970 to 2019

The annual reported number of natural disasters, categorised by type. This includes both weather and non-weather related disasters.

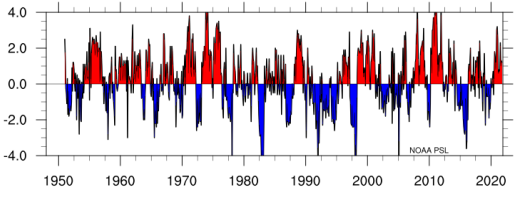
Our World in Data

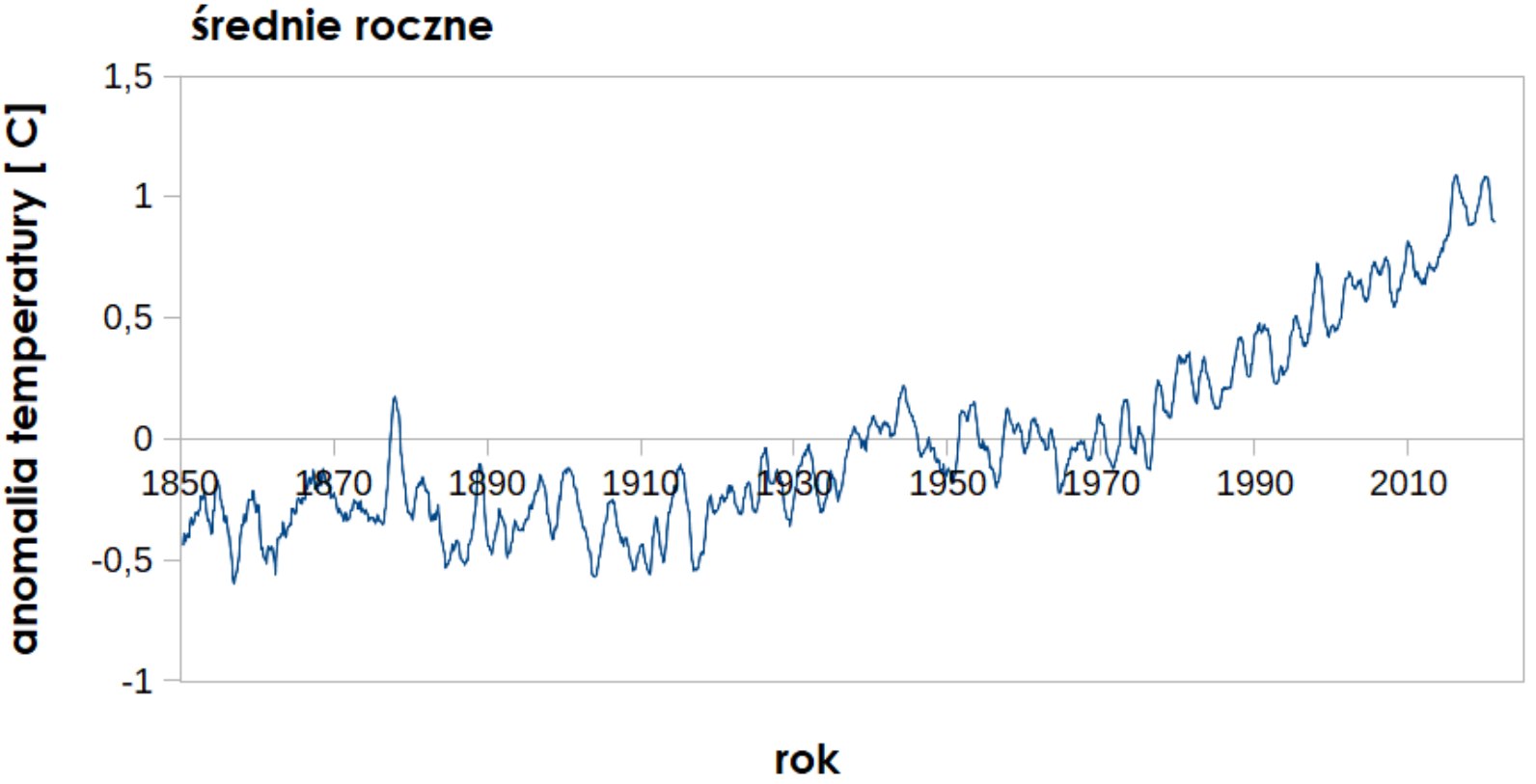


Source: EMDAT (2020): OFDA/CRED International Disaster Database, Université catholique de Louvain – Brussels – Belgium
OurWorldInData.org/natural-disasters • CC BY



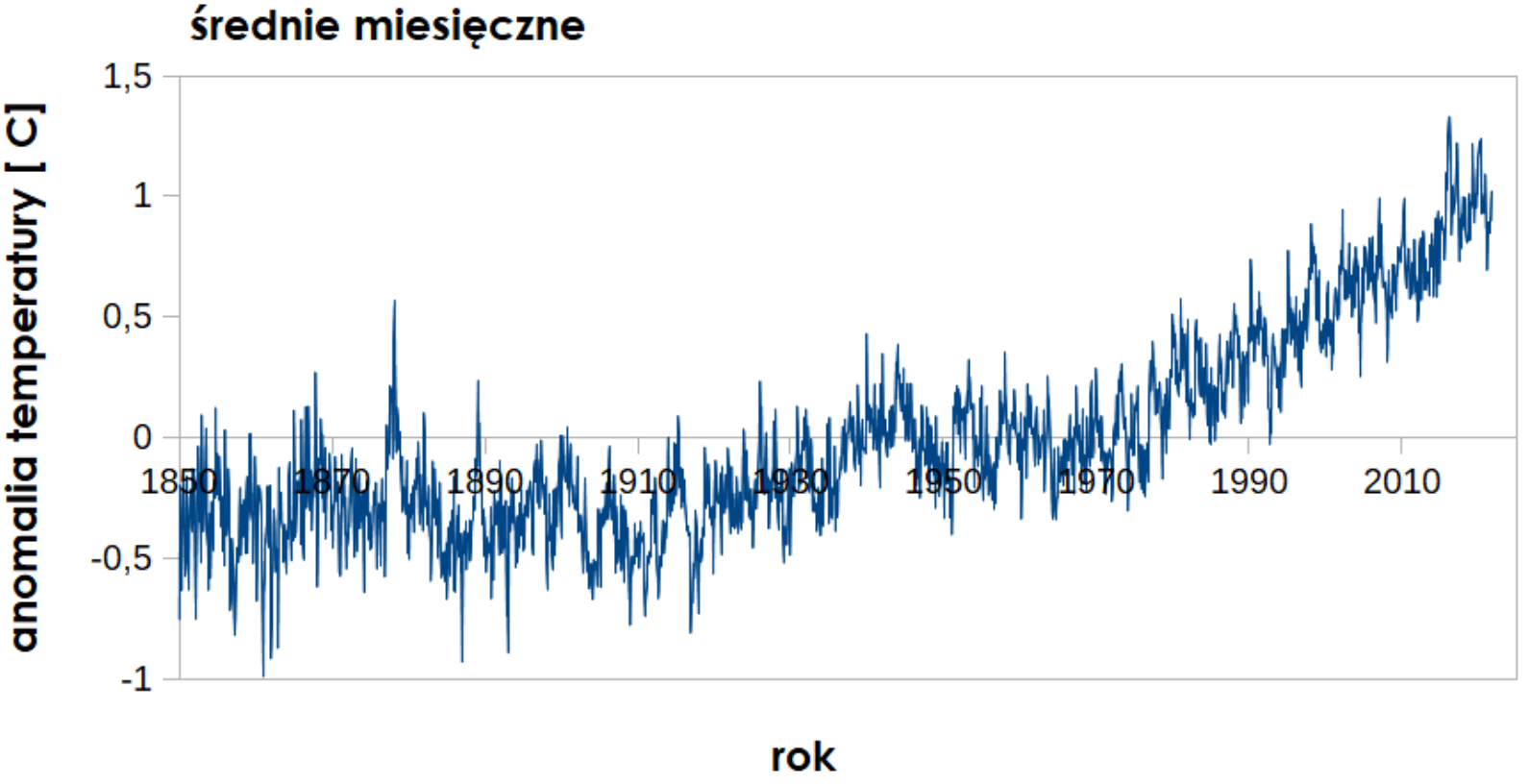
SOI





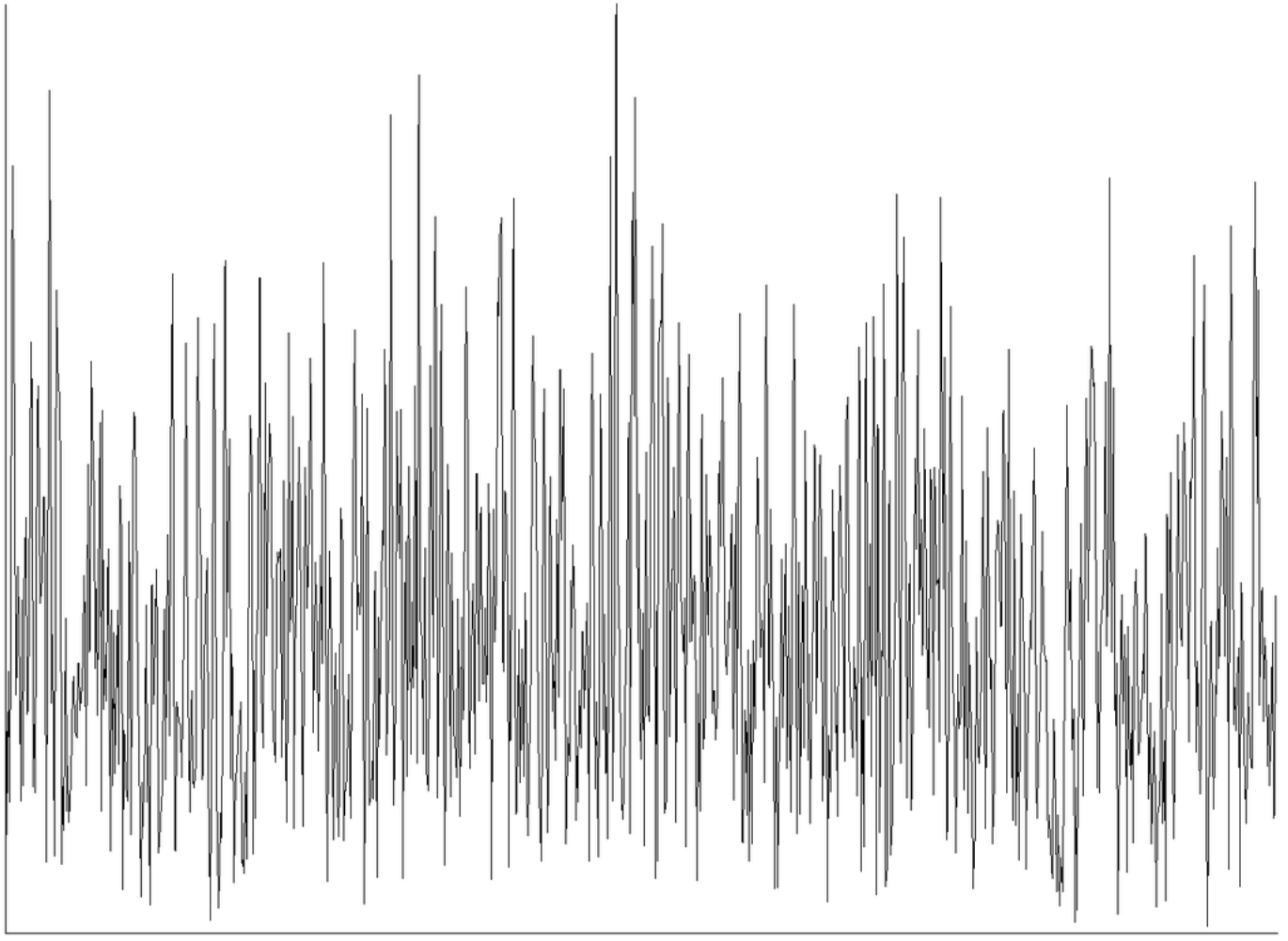
Okres referencyjny: 1951-1980

Dane: Berkeley Earth



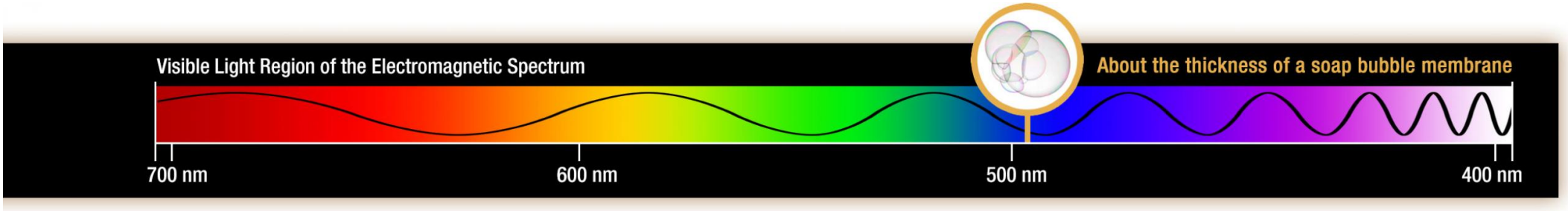
Okres referencyjny: 1951-1980

Dane: Berkeley Earth



biały szum

Ilustracja: Bautsch



białe światło – fale o wszystkich długościach

czerwone światło – głównie fale dłuższe

Ilustracja: NASA

Stochastic climate models

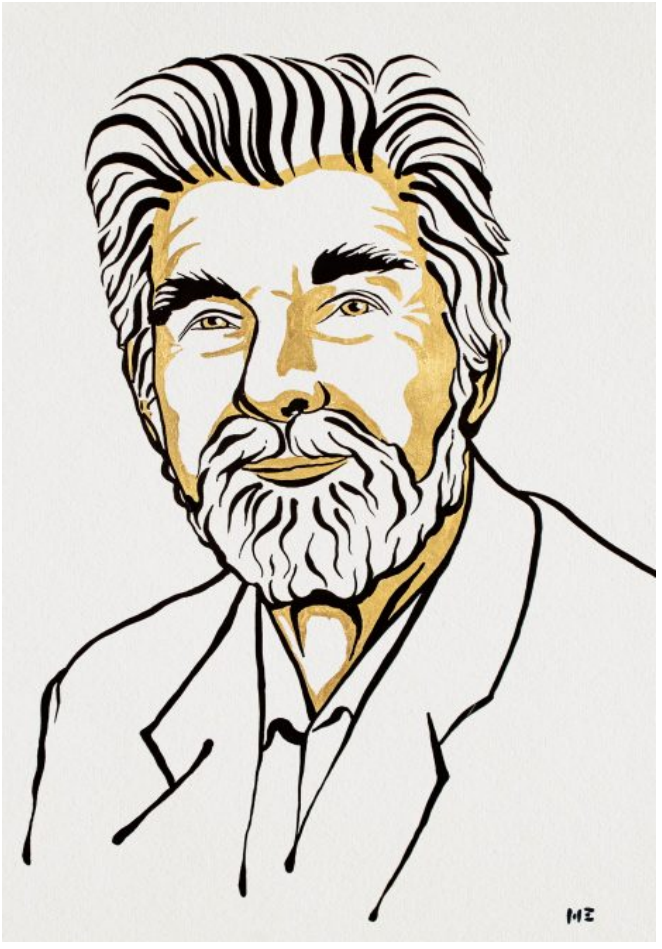
Part I. Theory

By K. HASSELMANN, *Max-Planck-Institut für Meteorologie, Hamburg, FRG*

(Manuscript received January 19; in final form April 5, 1976)

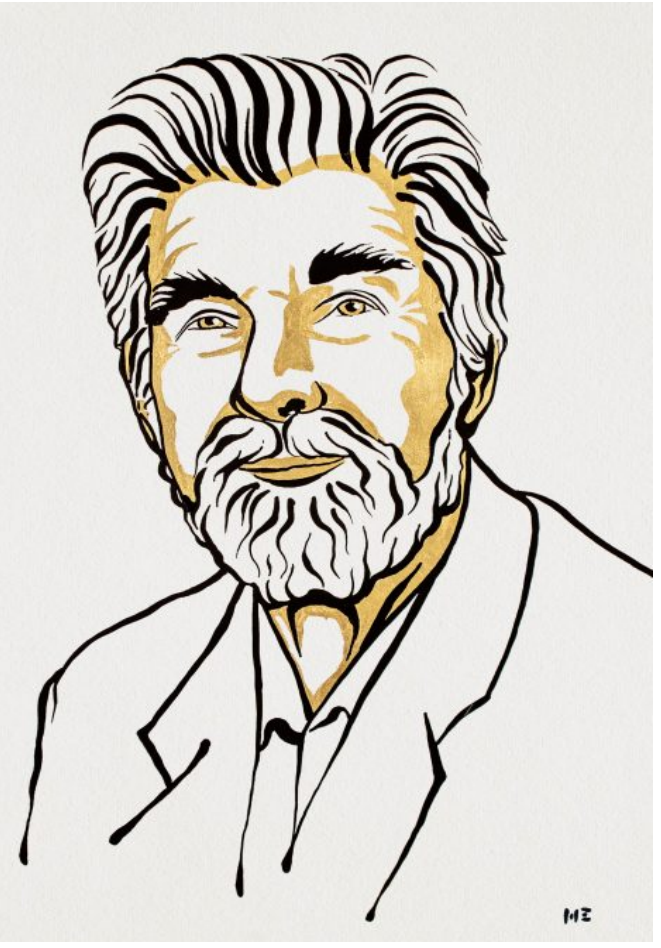
ABSTRACT

A stochastic model of climate variability is considered in which slow changes of climate are explained as the integral response to continuous random excitation by short period "weather" disturbances. The coupled ocean–atmosphere–cryosphere–land system is divided into a rapidly varying "weather" system (essentially the atmosphere) and a slowly responding "climate" system (the ocean, cryosphere, land vegetation, etc.). In the usual Statistical Dynamical Model (SDM) only the average transport effects of the rapidly varying weather components are parameterised in the climate system. The resultant prognostic equations are deterministic, and climate variability can normally arise only through variable external conditions. The essential feature of stochastic climate models is that the non-averaged "weather" components are also retained. They appear formally as random forcing terms. The climate system, acting as an integrator of this short-period excitation, exhibits the same random-walk response characteristics as large particles interacting with an ensemble of much smaller particles in the analogous Brownian motion problem. The model predicts "red" variance spectra, in qualitative agreement with observations. The evolution of the climate probability distribution is described by a Fokker-Planck equation, in which the effect of the random weather excitation is represented by diffusion terms. Without stabilising feedback, the model predicts a continuous increase in climate variability, in analogy with the continuous, unbounded dispersion of particles in Brownian motion (or in a homogeneous turbulent fluid). Stabilising feedback yields a statistically stationary climate probability distribution. Feedback also results in a finite degree of climate predictability, but for a stationary climate the predictability is limited to maximal skill parameters of order 0.5.



Niklas Elmehed, Nobel Prize Outreach

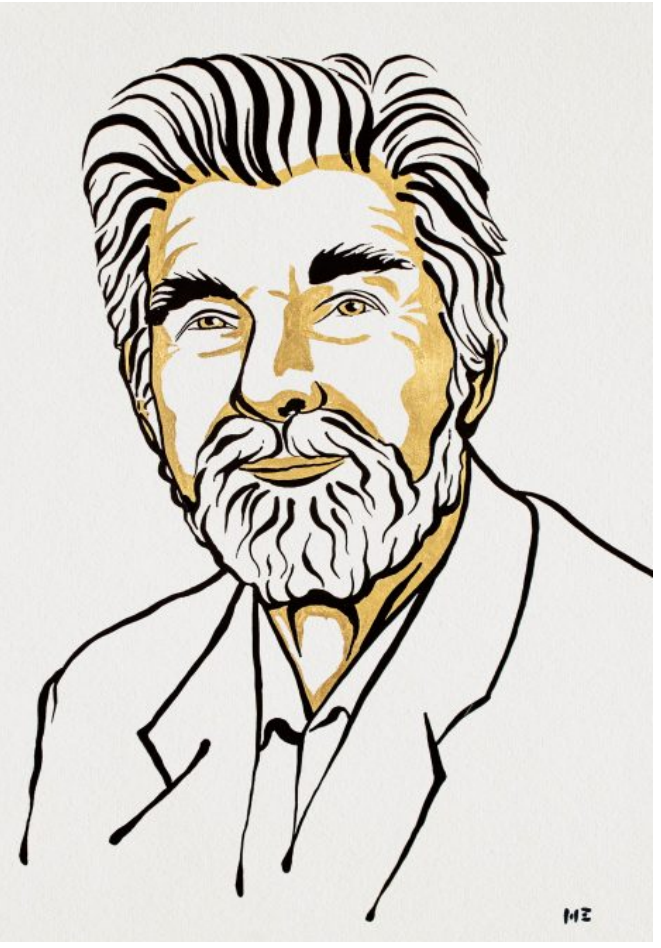
System klimatyczny ma pamięć.



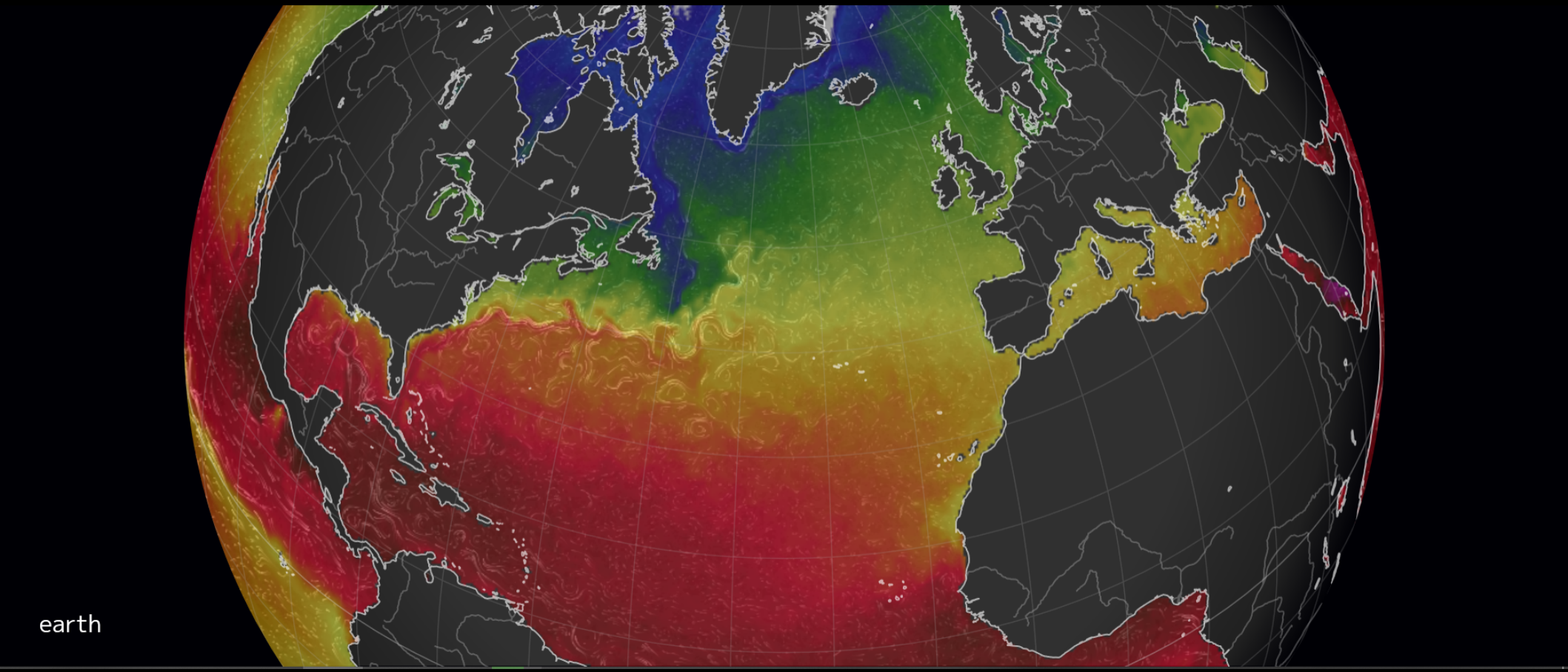
Niklas Elmehed, Nobel Prize Outreach

System klimatyczny ma pamięć.

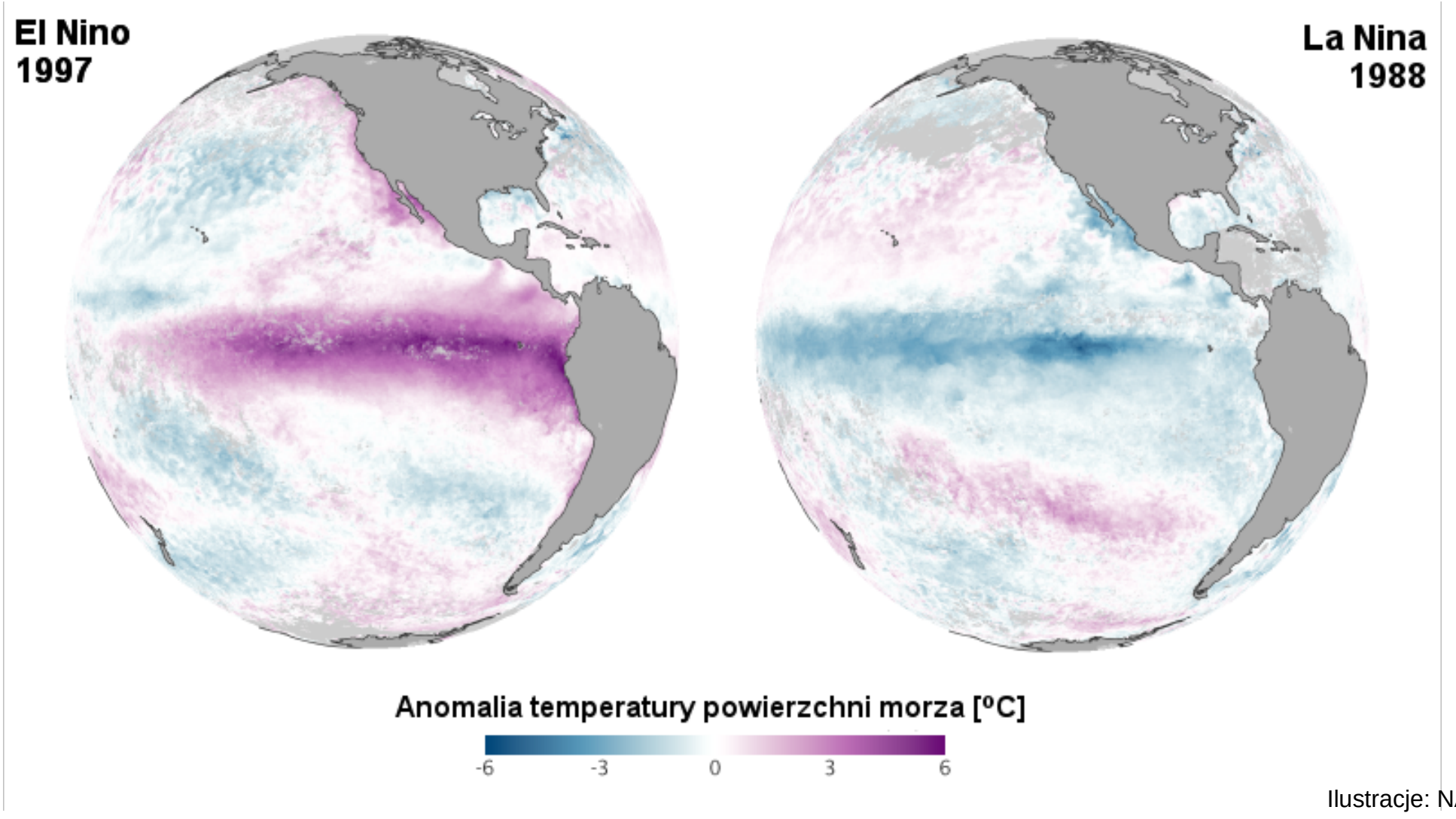
Tą pamięcią jest ocean.



Niklas Elmehed, Nobel Prize Outreach

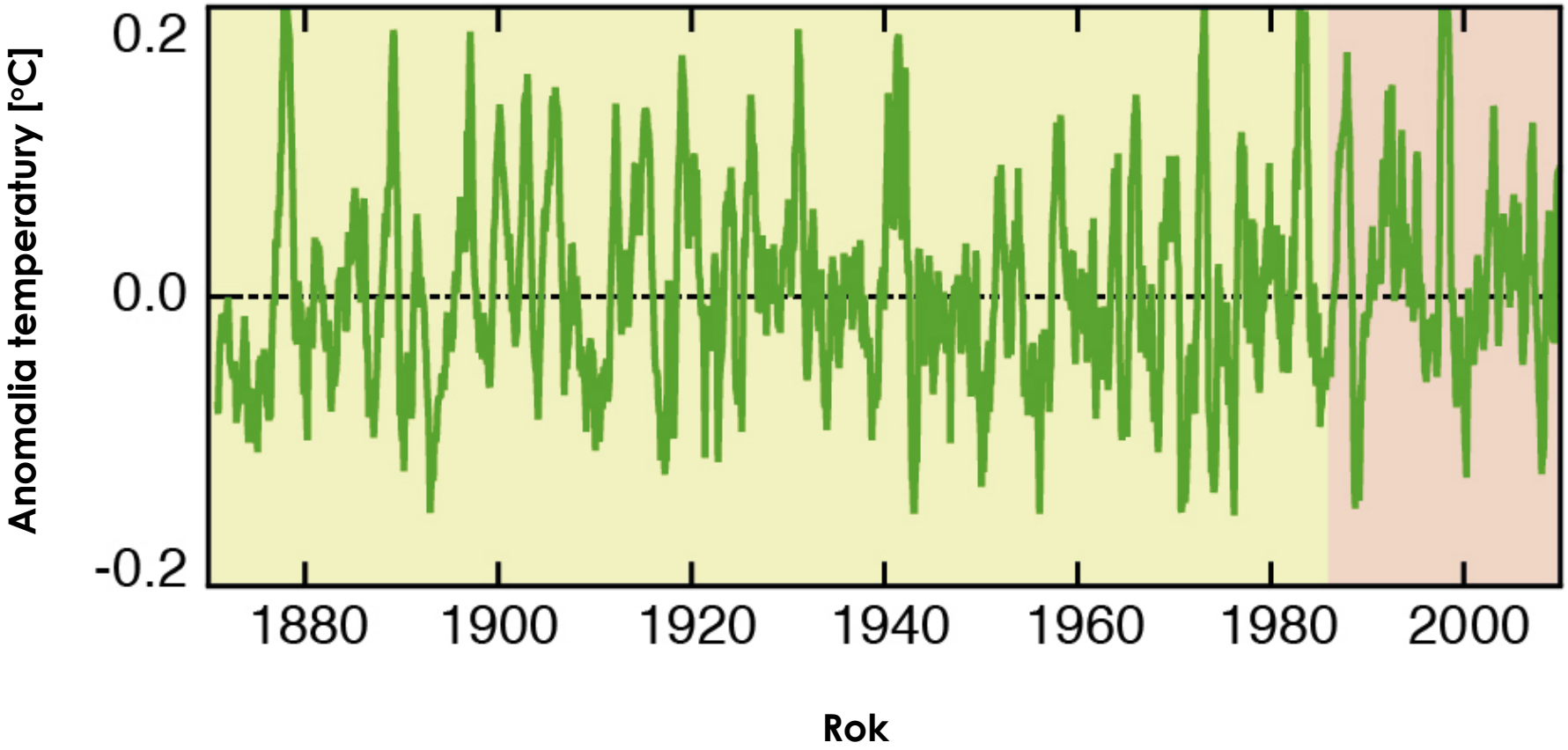


https://earth.nullschool.net



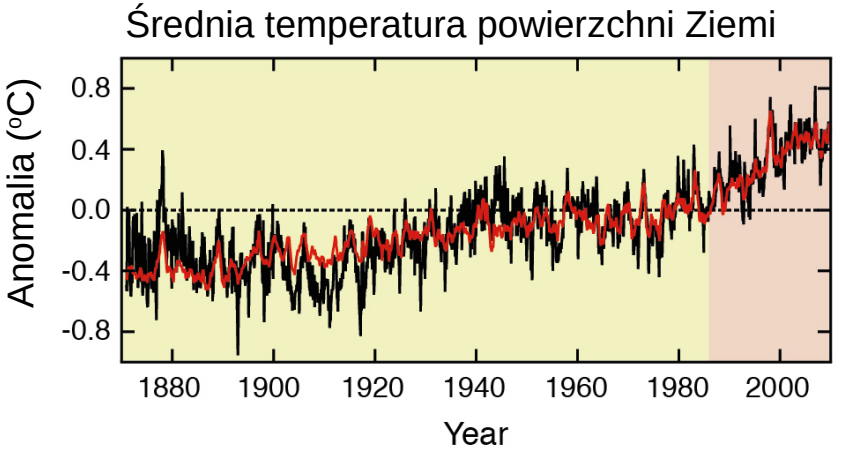
Ilustracje: NASA

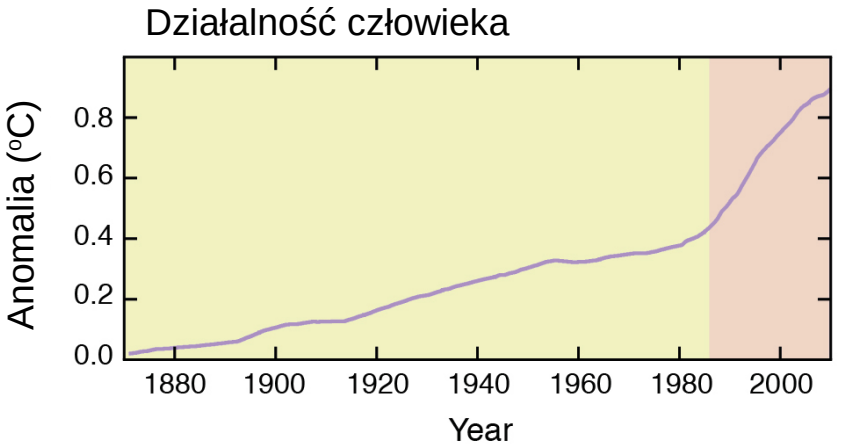
Wewnętrzna zmienność klimatu

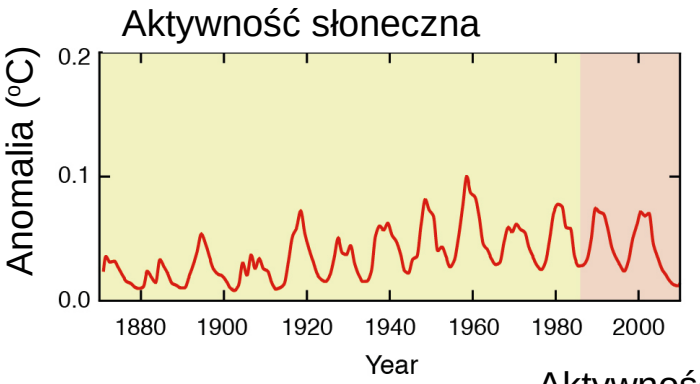


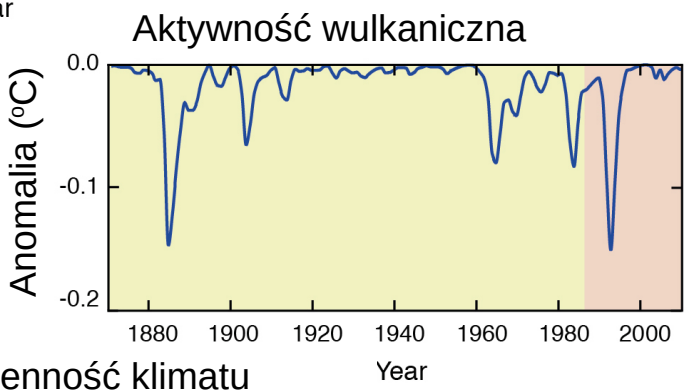
Szum czerwony

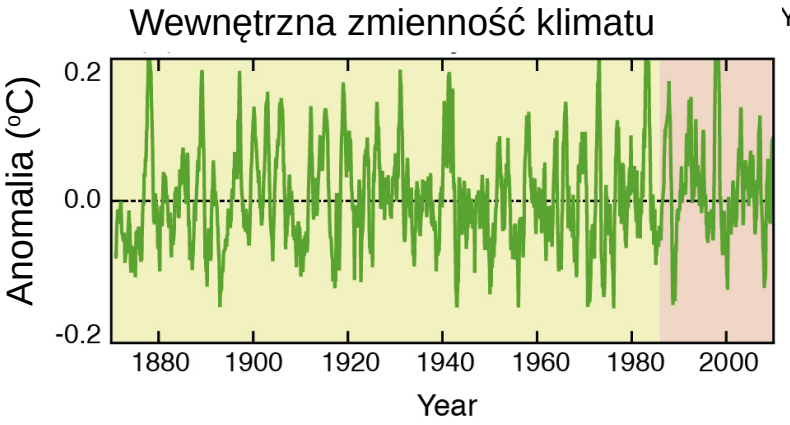
IPCC 2013 AR5, FAQ5.1







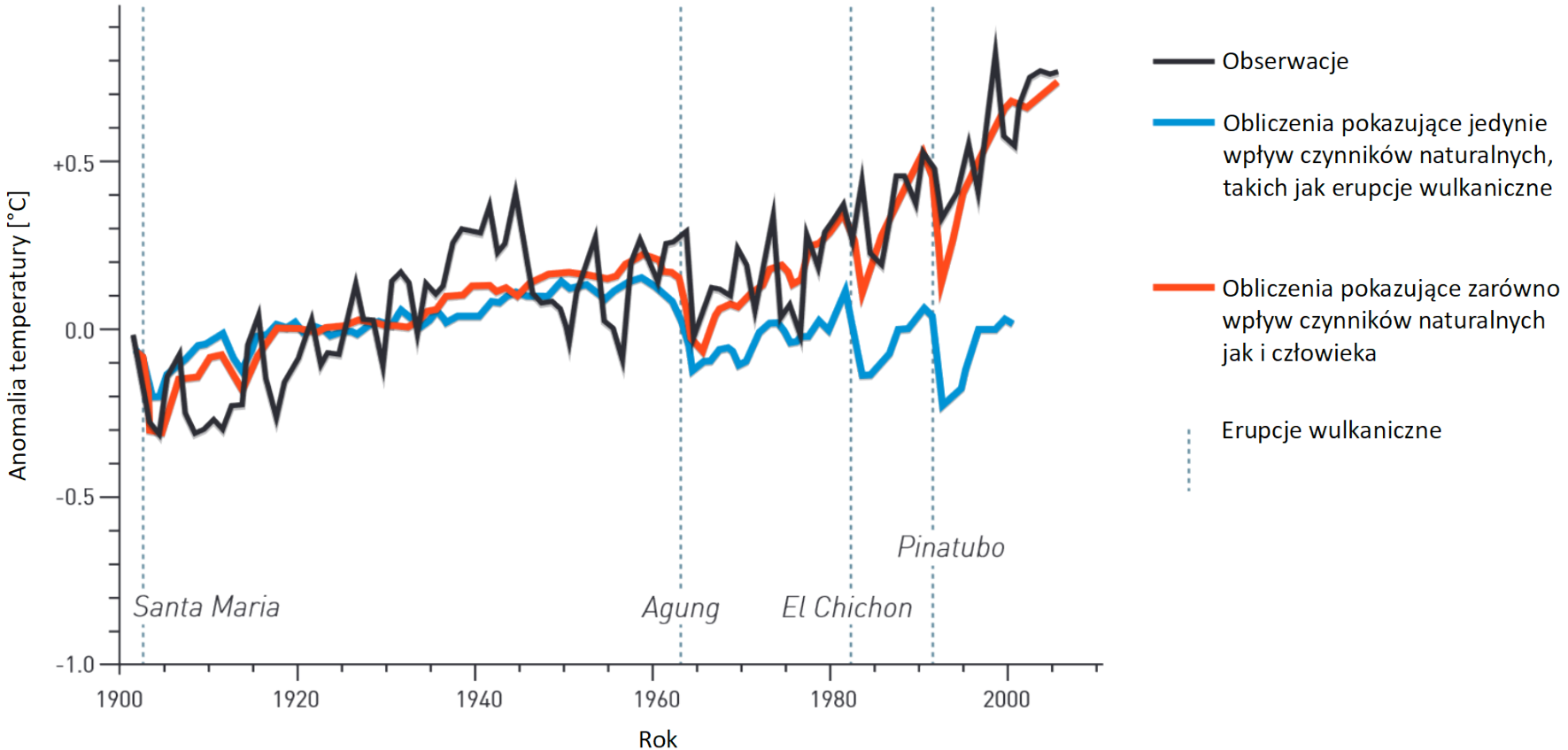




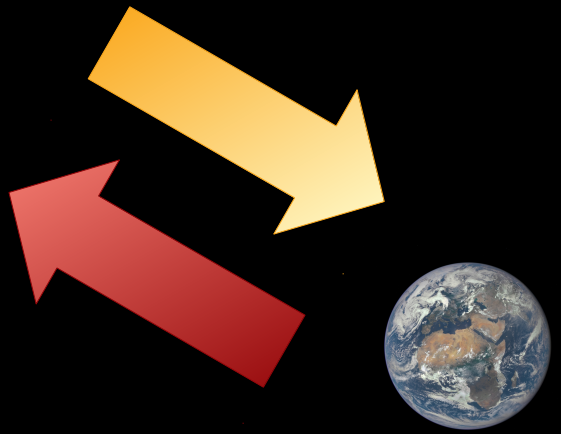
IPCC 2013 AR5, FAQ5.1

Identyfikacja przyczyn zmiany klimatu

Klaus Hasselmann opracował metody rozróżniania wpływu czynników naturalnych i antropogenicznych na ocieplenie atmosfery.
Porównanie zmian średniej temperatury względem lat 1901-1950 [°C].



Johan Jarnestad (The Royal Swedish Academy of Sciences), na podstawie Manabe i Wetherald (1967)



NASA