Física Da Poluição do Ar
Antropoceno

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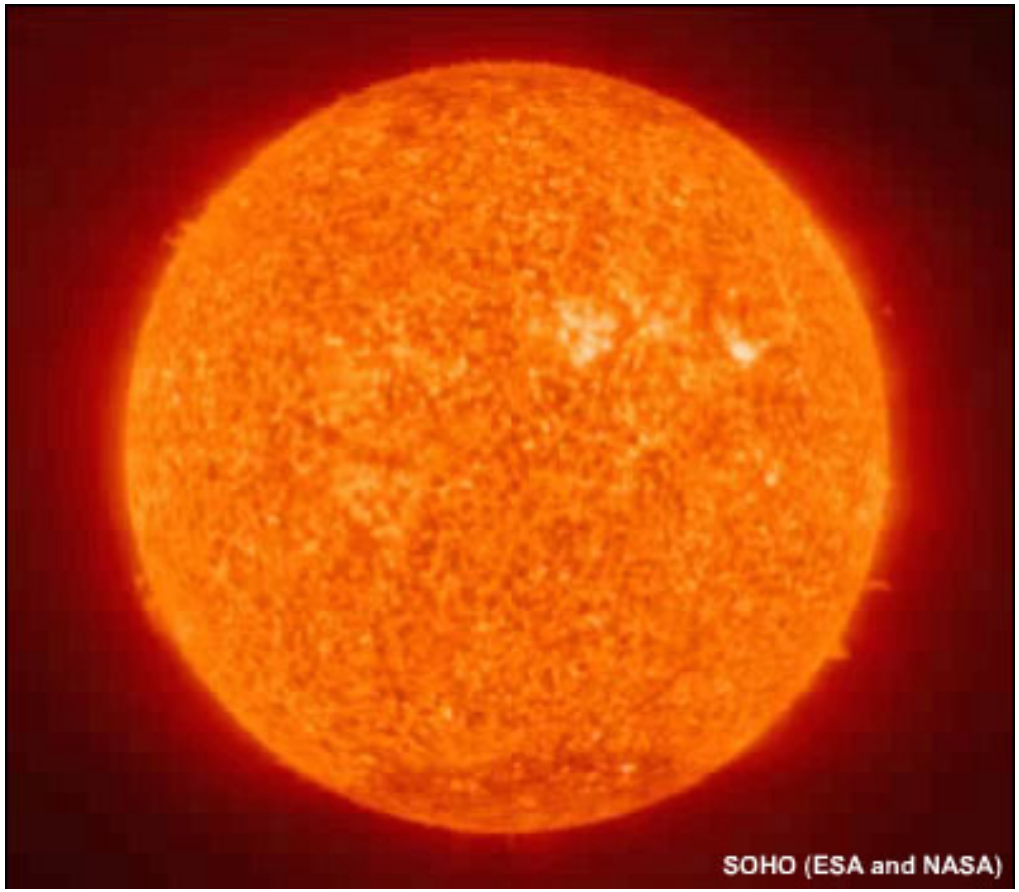
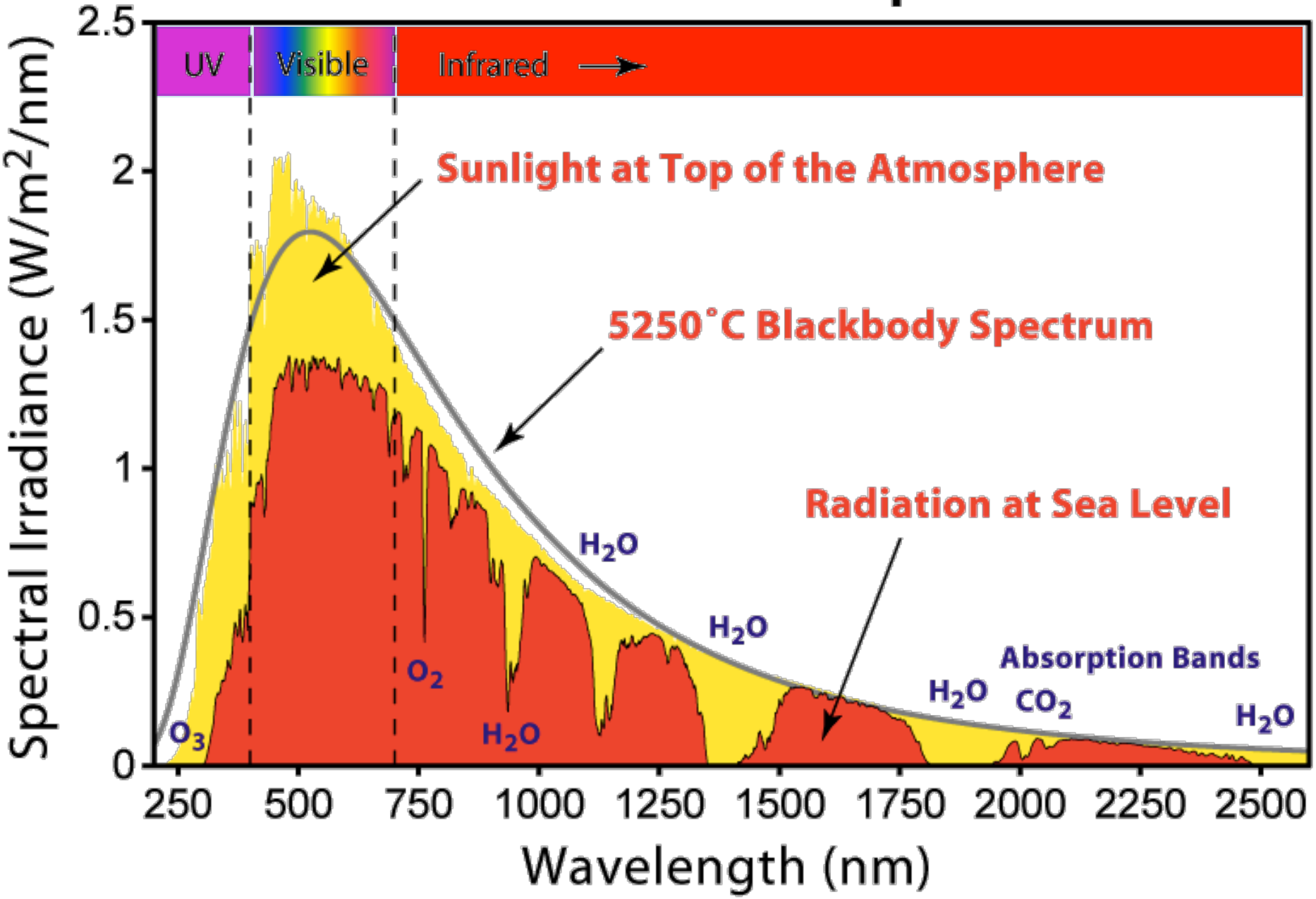
O Sol é a nossa fonte de energia

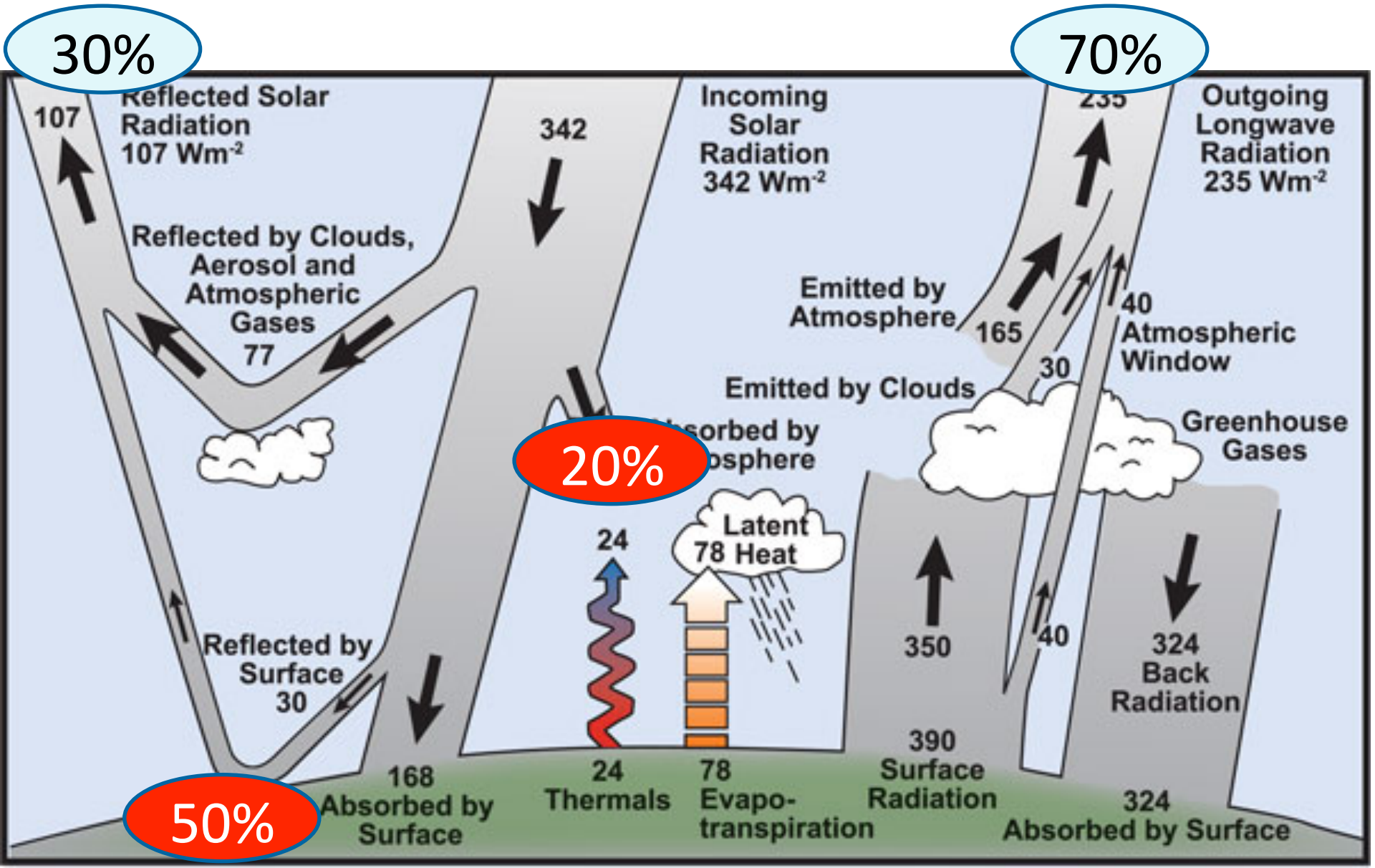


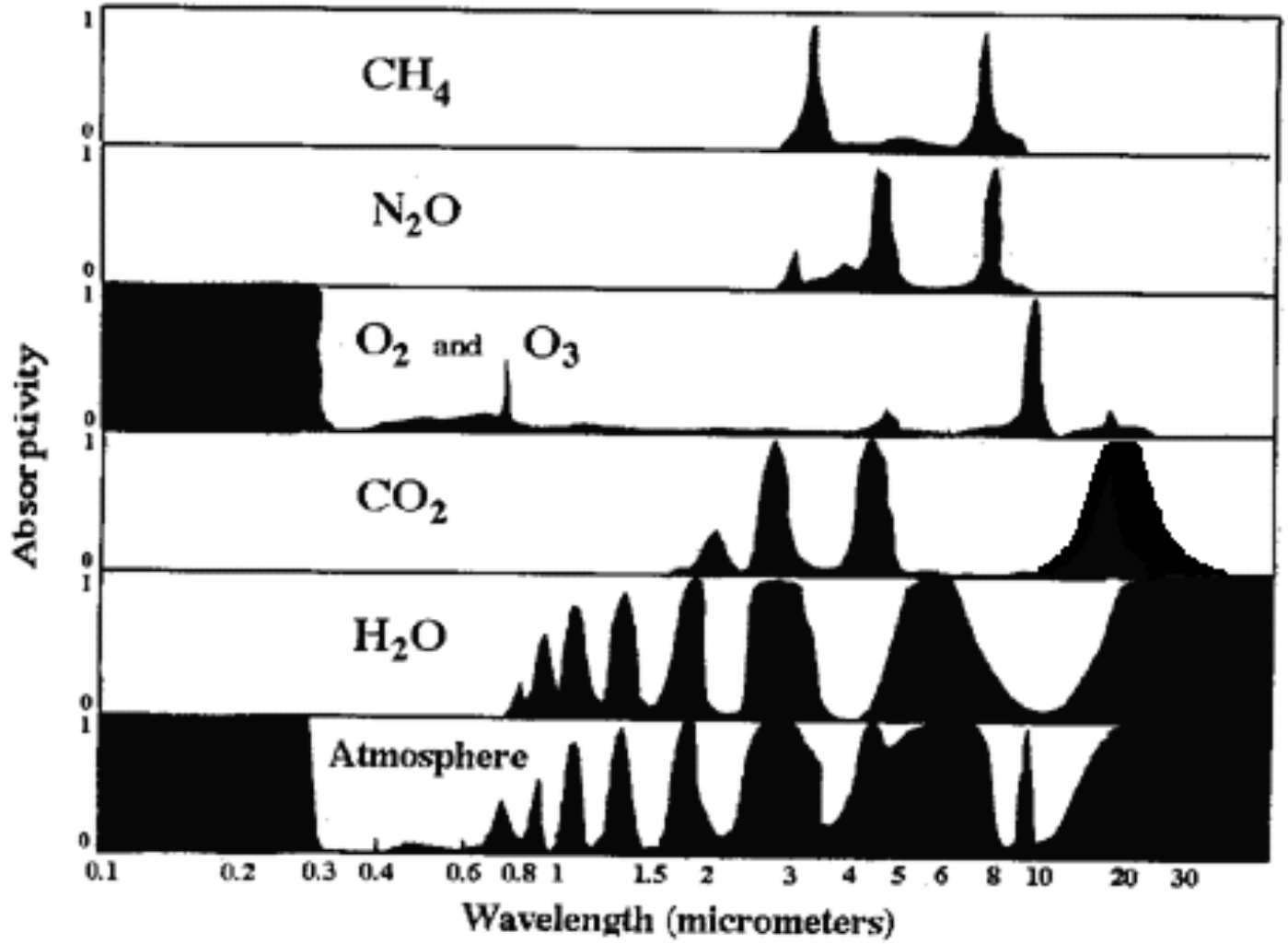
Sem o Sol, a temperatura na Terra seria -270^{o}C

Solar Radiation Spectrum

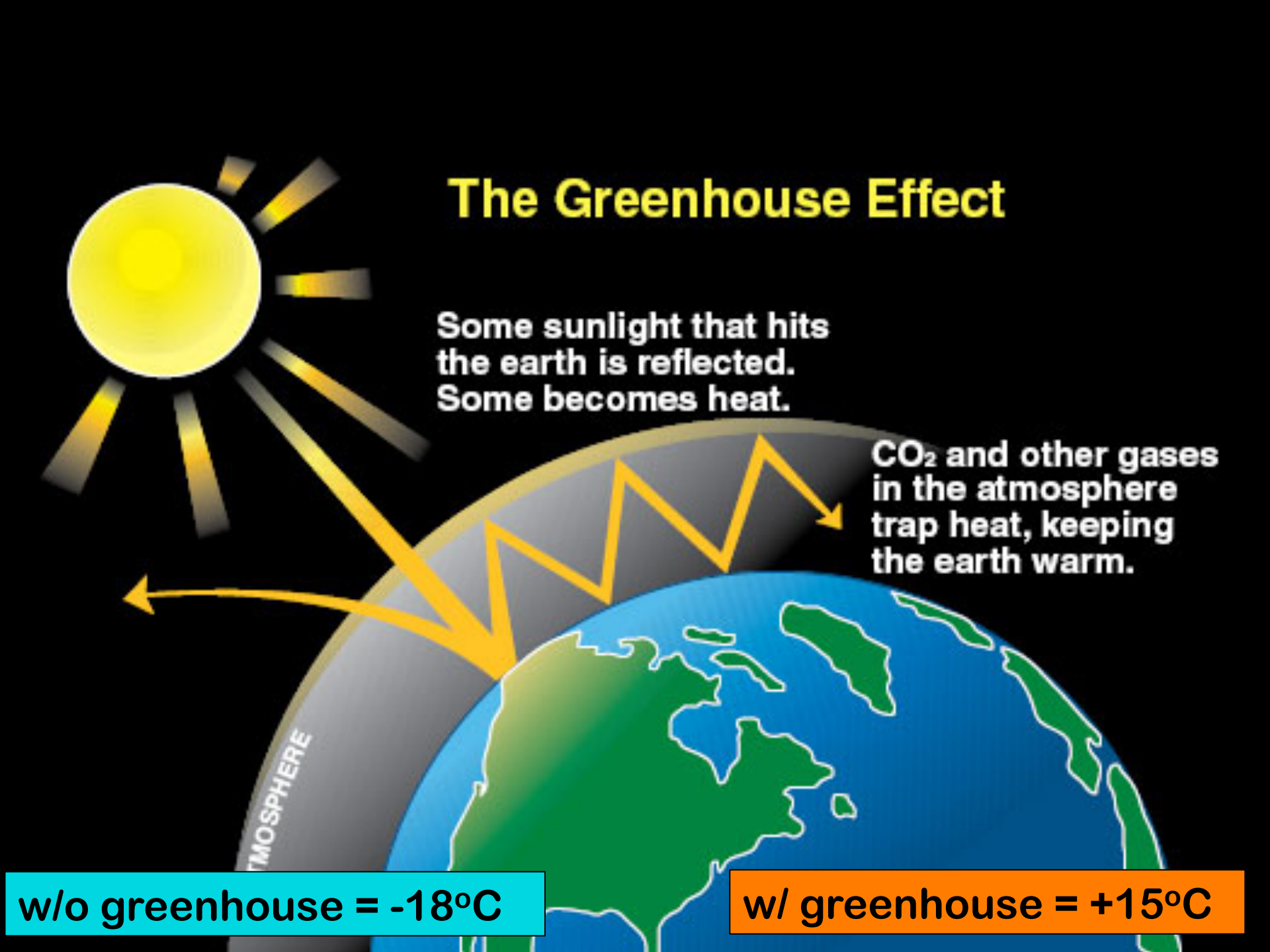


Atmospheric Energy Balance



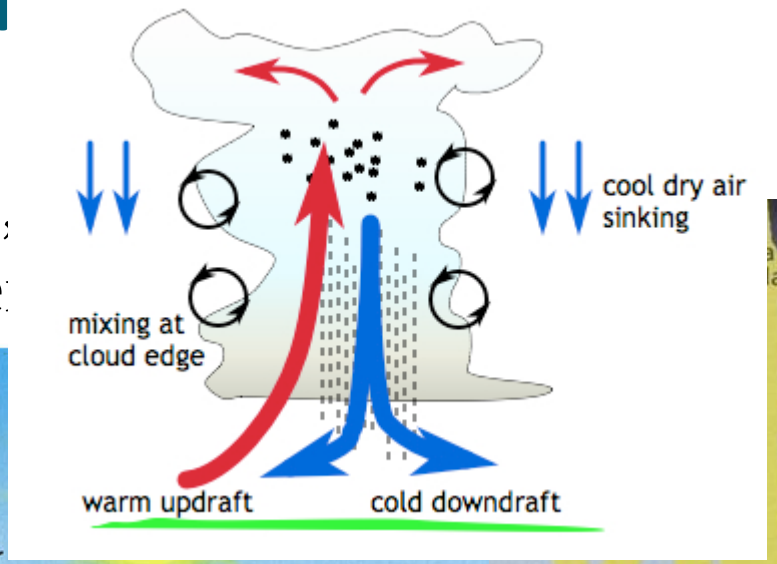


Absorptivity of various gases of the atmosphere and the atmosphere as a whole as a function of the wavelength of radiation. An absorptivity of zero means no absorption while a value of one means complete absorption. The dominant absorbers of infrared radiation are water vapor (H_2O) and carbon dioxide (CO_2). Oxygen (O_2) and ozone (O_3) absorb much of the sun's ultraviolet radiation.

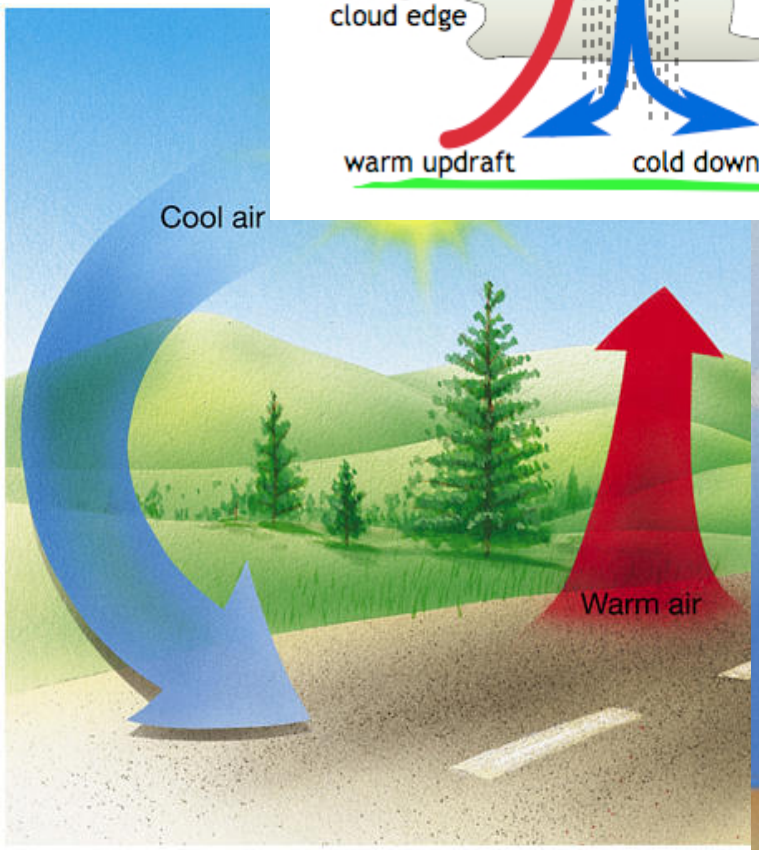

The Greenhouse Effect
Some sunlight that hits the earth is reflected. Some becomes heat.
CO_2 and other gases in the atmosphere trap heat, keeping the earth warm.
w/o greenhouse = -18°C
w/ greenhouse = +15°C

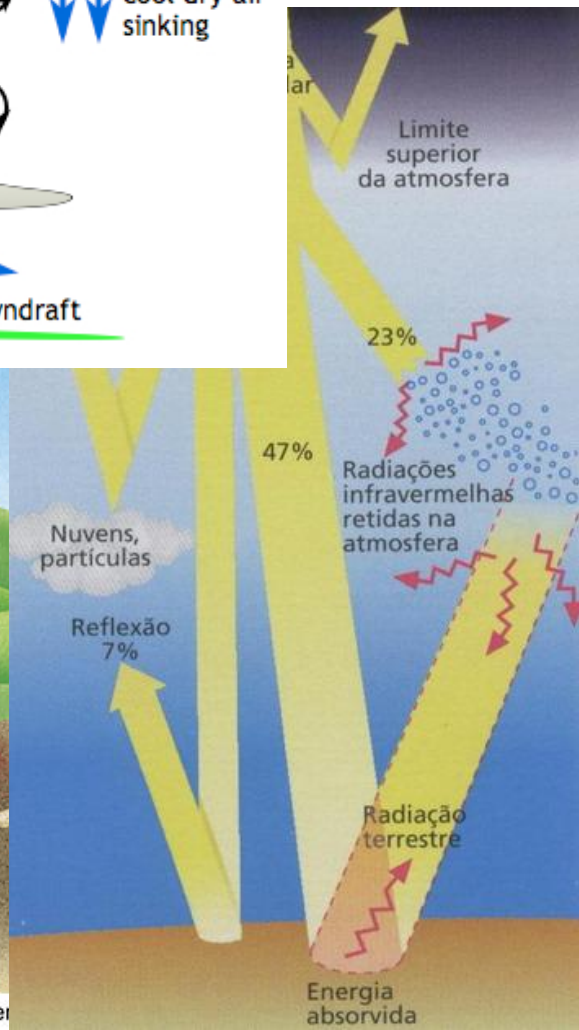
Convecção e Nu

- Como a maior parte da
absorvida na superfície,
esquentando a atmosfe



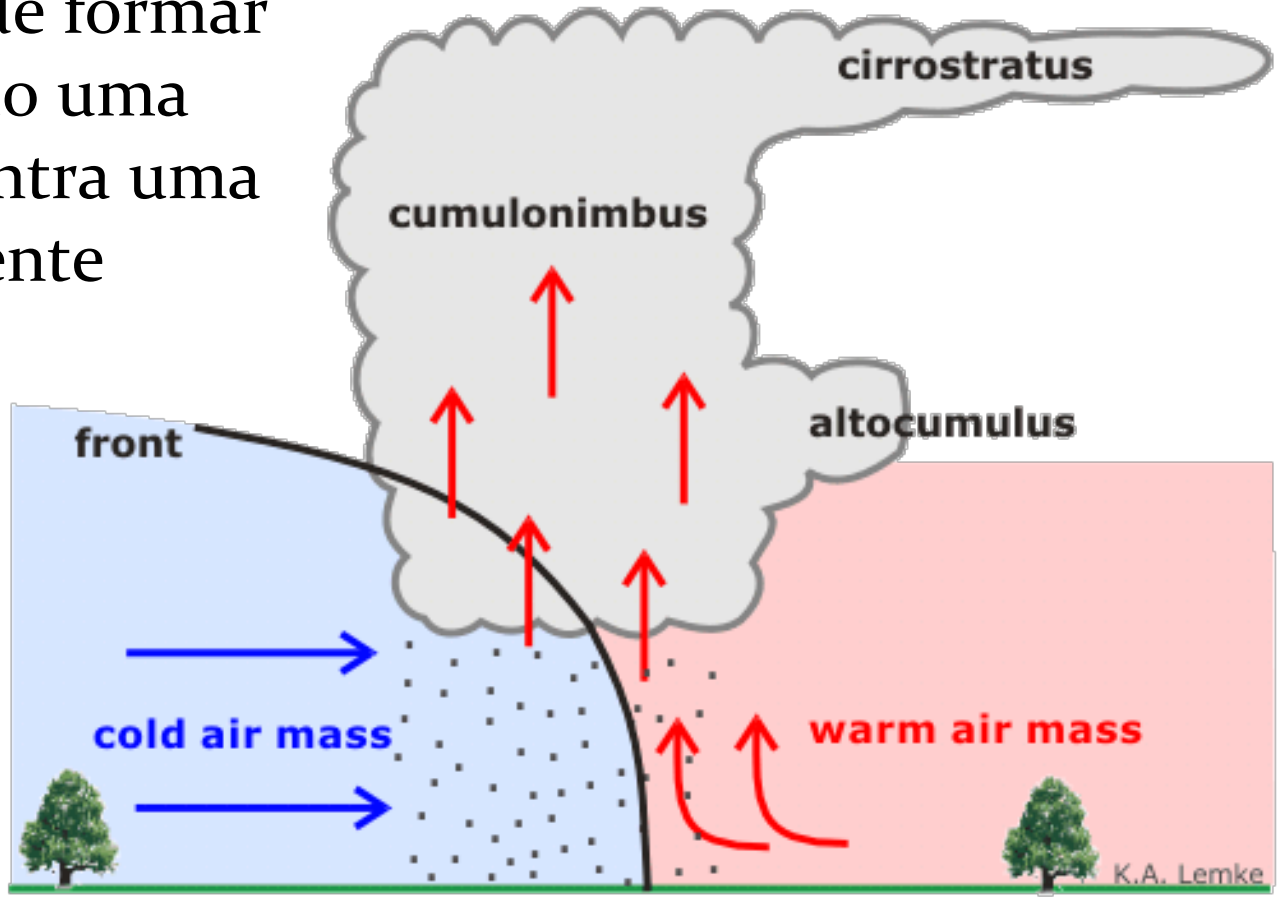
O ar quente é menos denso e sobe, pois o ar frio que está em cima é mais pesado.





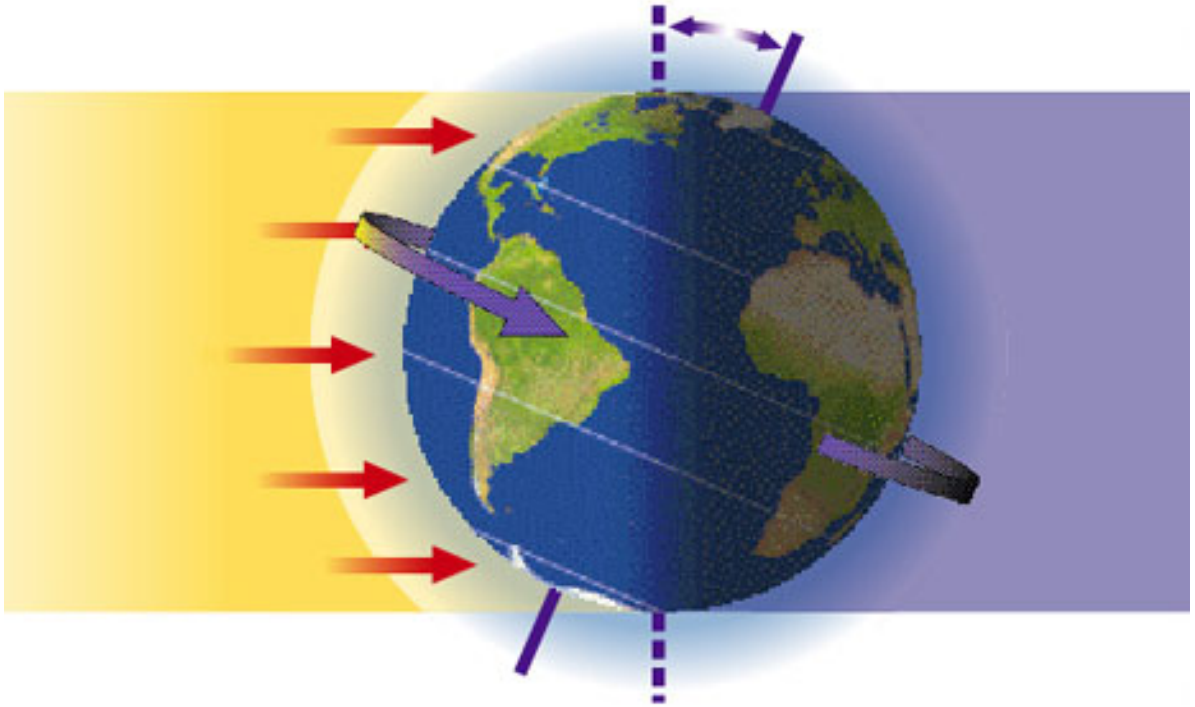
Nuvens e Frentes

- Uma outra maneira muito comum de formar nuvens é quando uma frente fria encontra uma massa de ar quente

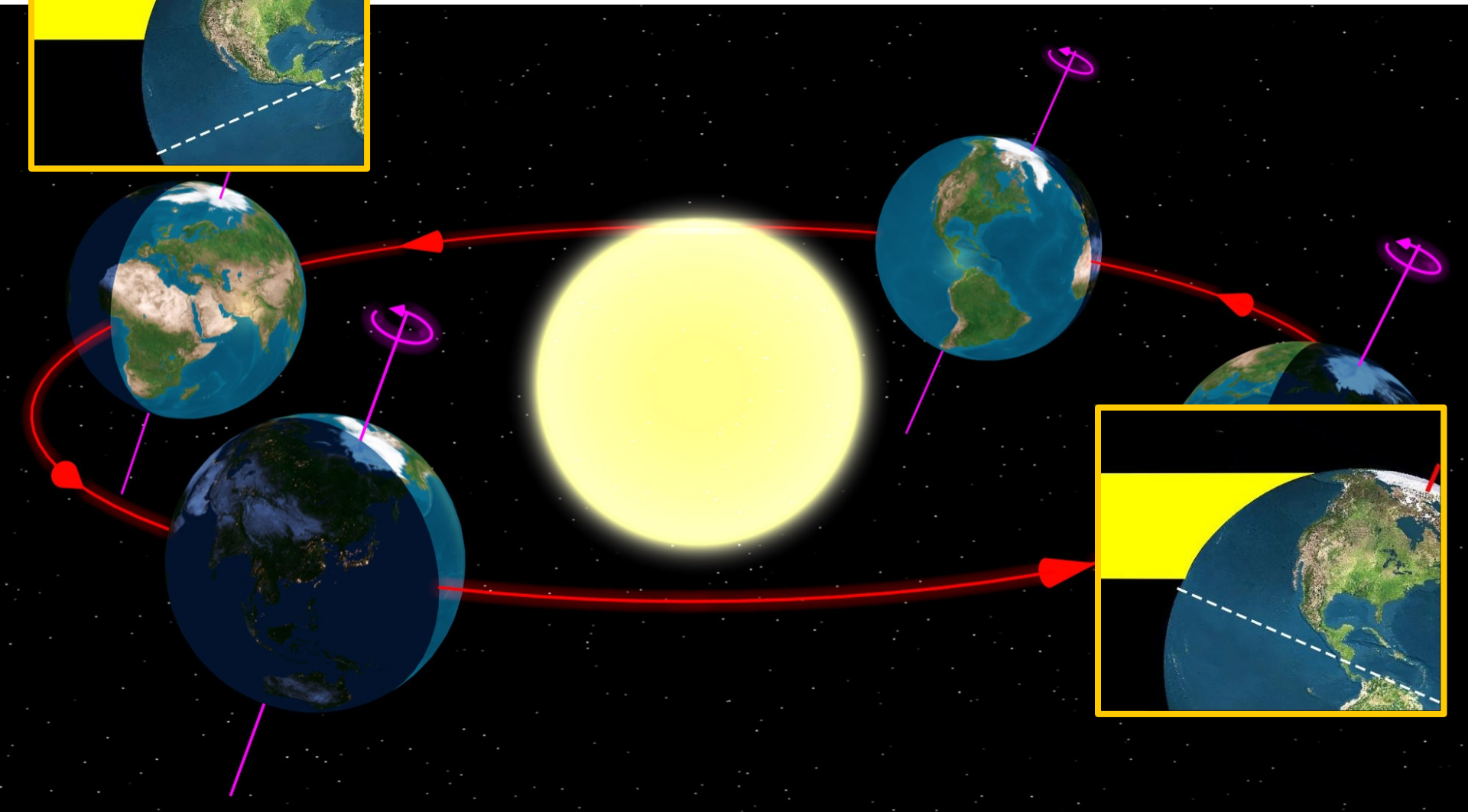


Dia e Noite

- A energia que recebemos do Sol também não é distribuída igualmente pela superfície do planeta!
  - Giro em torno do próprio eixo
  - O eixo é inclinado em relação a órbita em torno do Sol



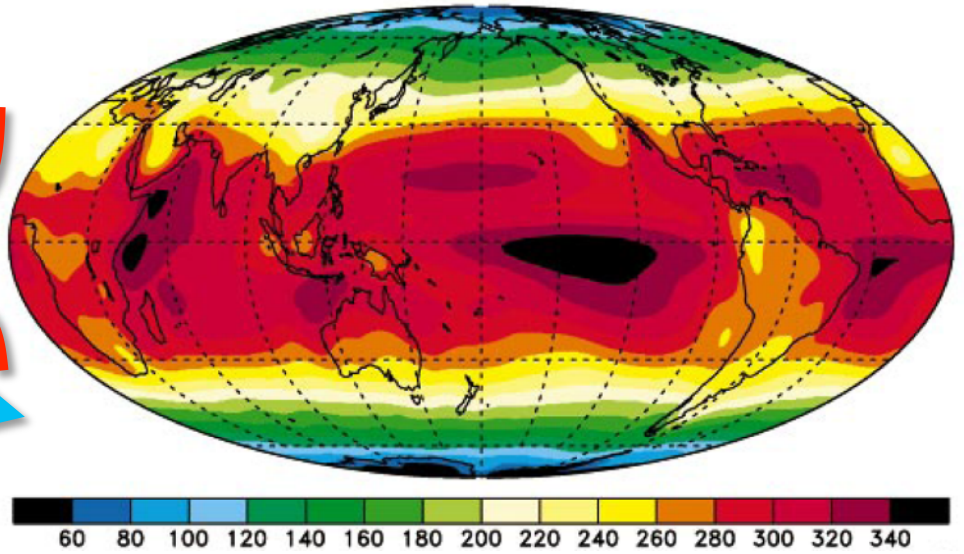
Estações do ano



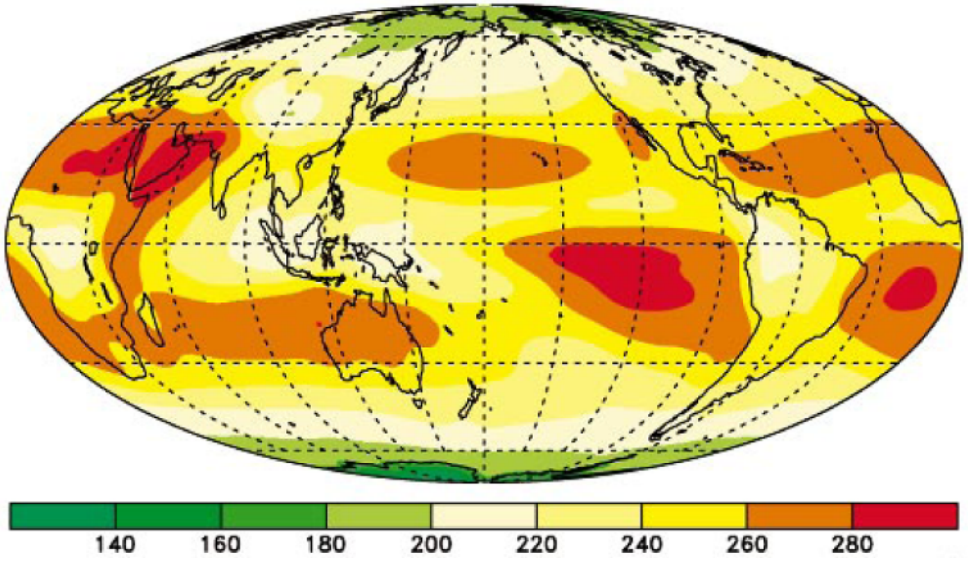
Distribution on the Earth

Hot air rises at the equator

Cold dry air decendes at high latitudes



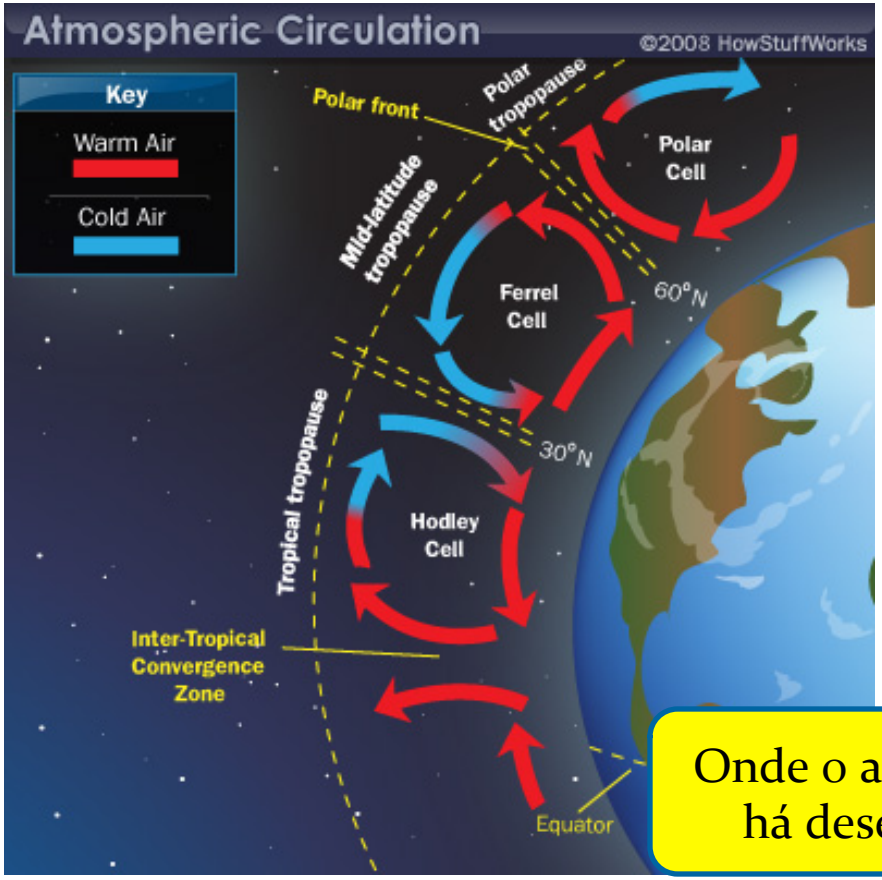
Annual mean solar radiation budget at top (W/m2)



Annual mean outgoing long wave radiation at top (W/m2)

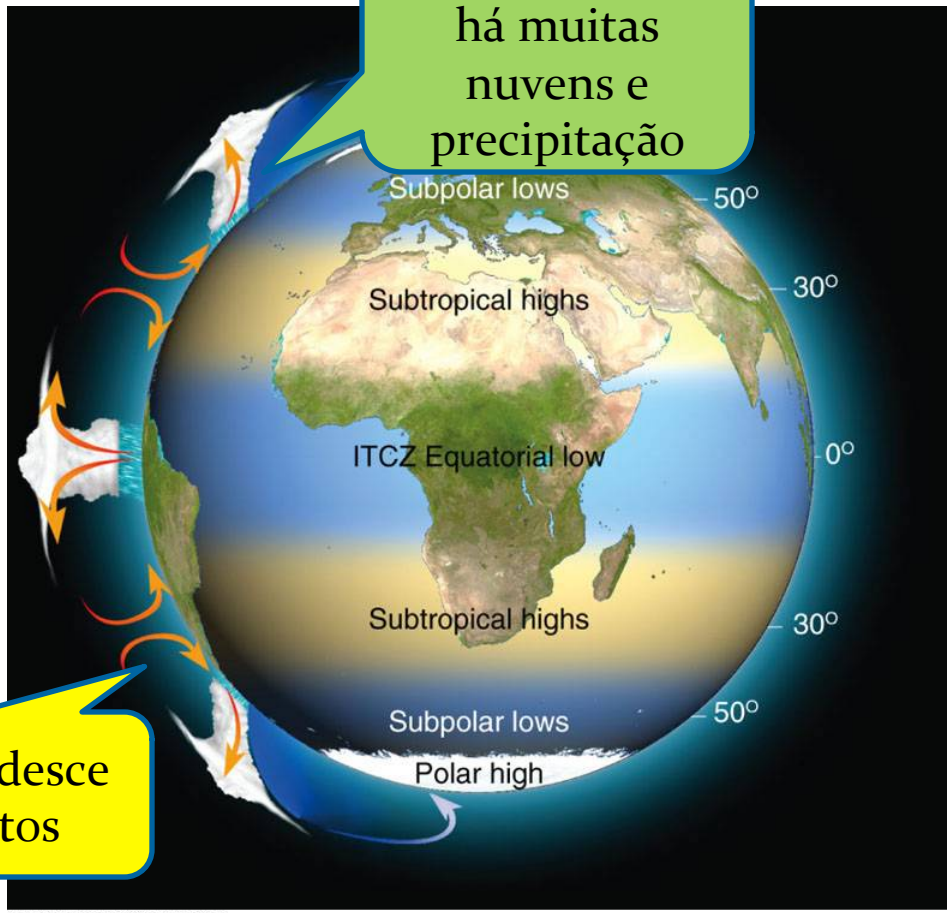
Trenberth and Stepaniak, J. Clim. (2003)

Circulação de grande escala



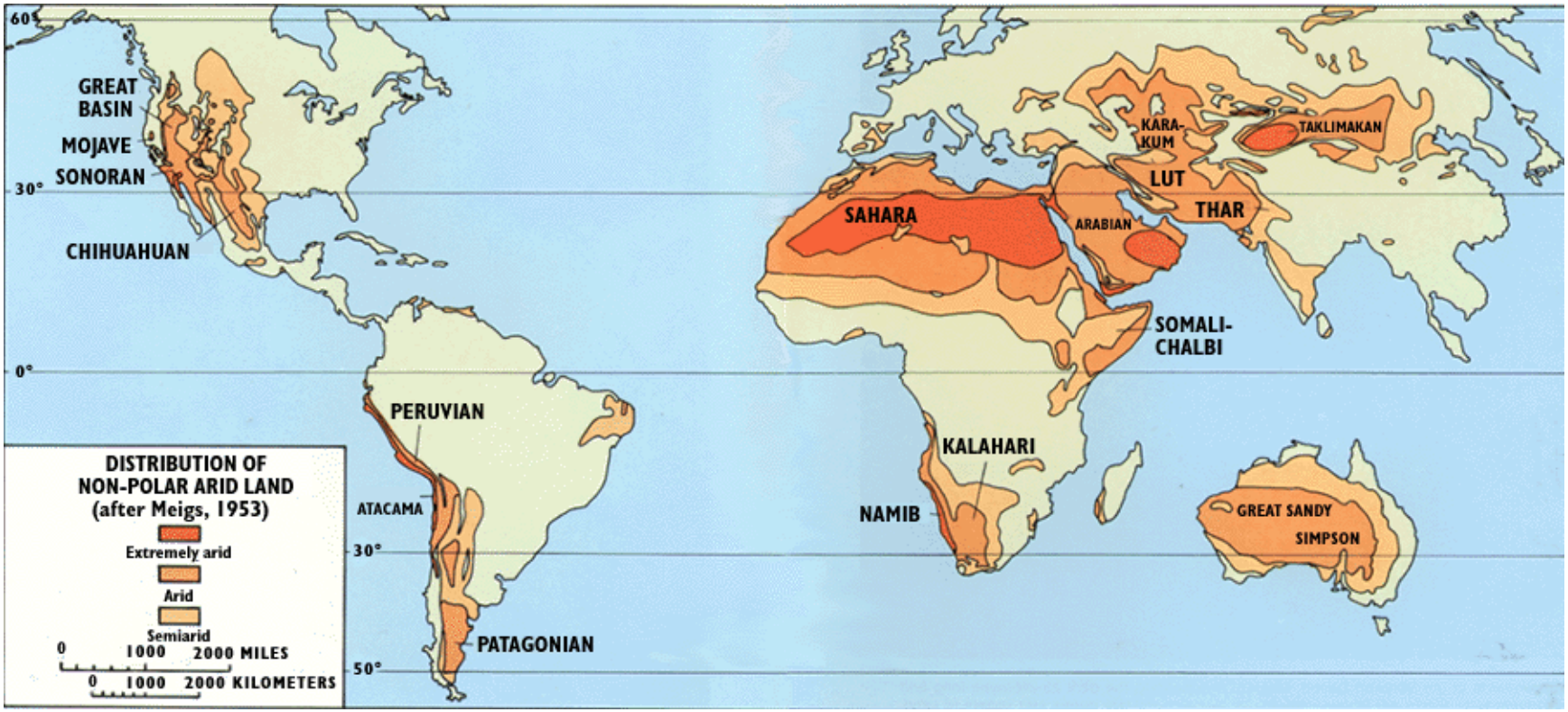
Onde o ar desce há desertos

Onde o ar sobe há muitas nuvens e precipitação



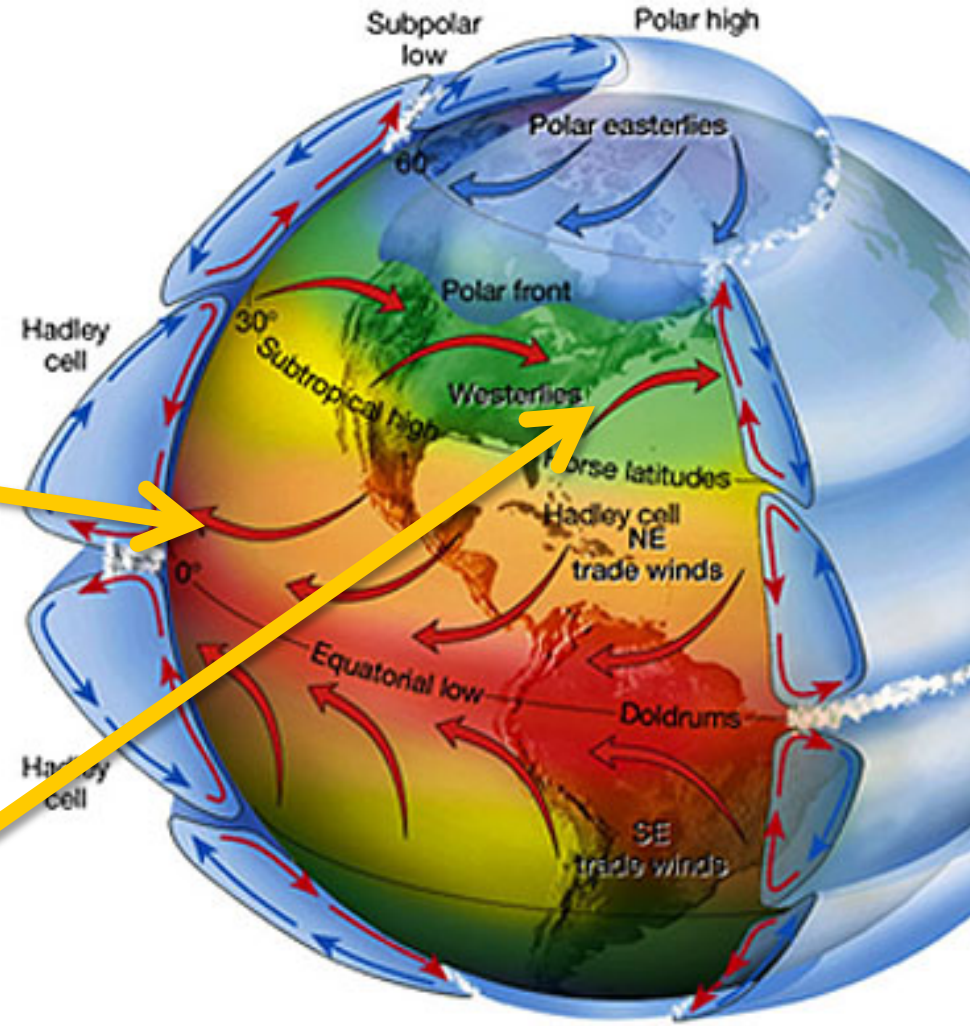
Localização dos grandes desertos

- Nas latitudes onde o ar desce seco e frio, há precipitação é pouco e as regiões são desérticas.



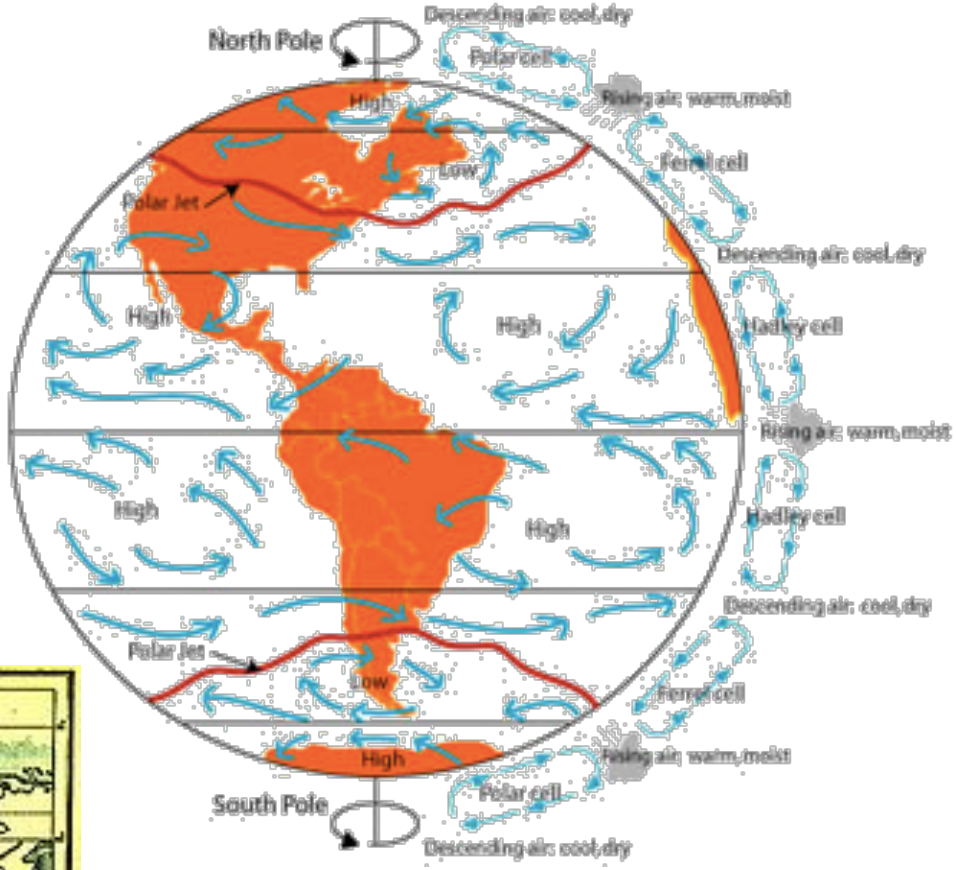
Circulação global

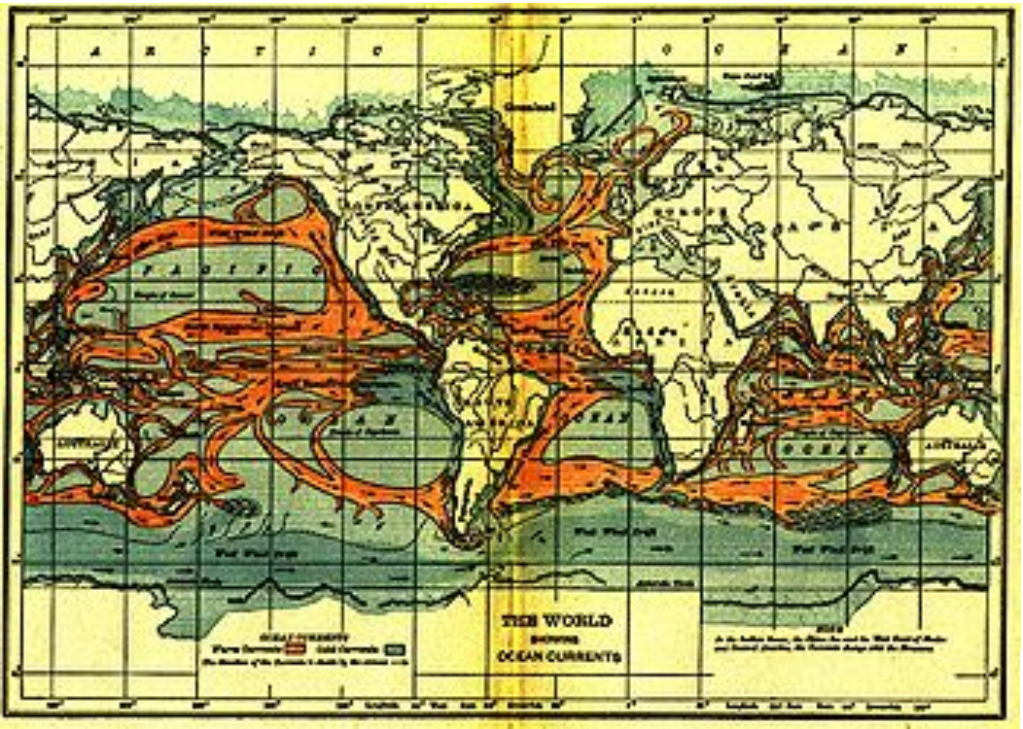
- Como a terra gira, por inércia, a atmosfera acaba ficando para traz.
  - A célula de Hadley fica inclinada no equador, formando os **Alísios**.
  - Já o ar que desce em latitudes mais altas está girando mais rápido que a chão (ele estava no EQ), e a circulação é ao contrário



Circulação Global

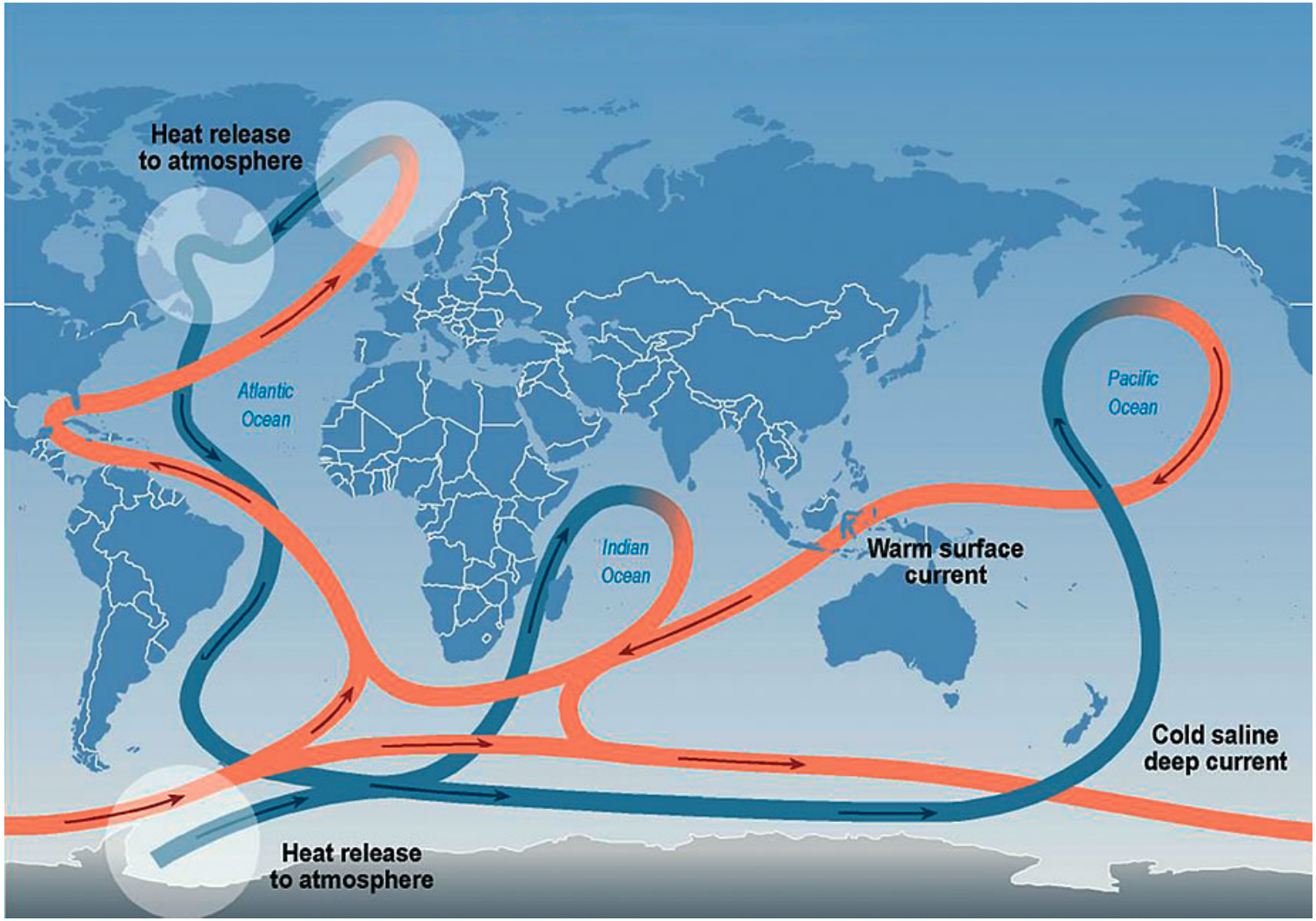
- Os ventos próximos da superfície forçam o surgimento de correntes oceânicas





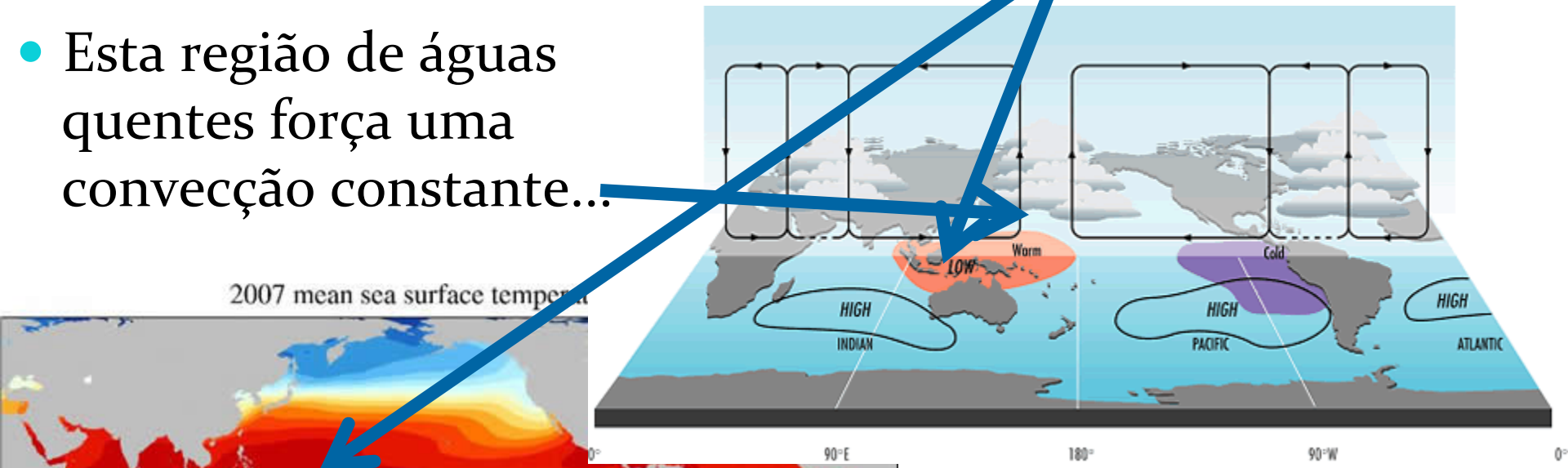
1911

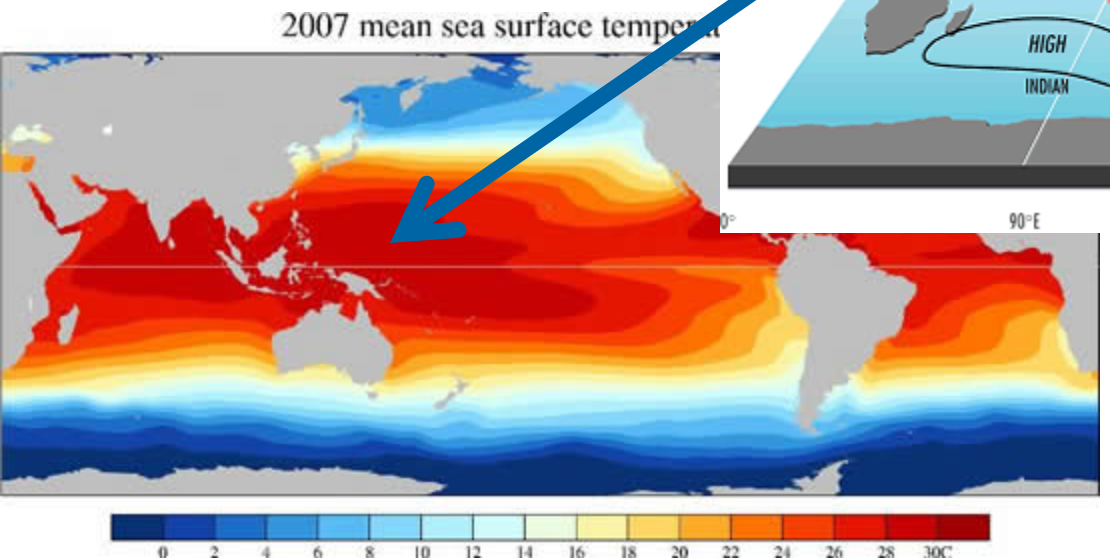
Oceanic circulation



Circulação de Walker

- Devido a presença constante dos ventos alísios, a água mais quente vai sendo empurrada para oeste.
- Esta região de águas quentes força uma convecção constante...

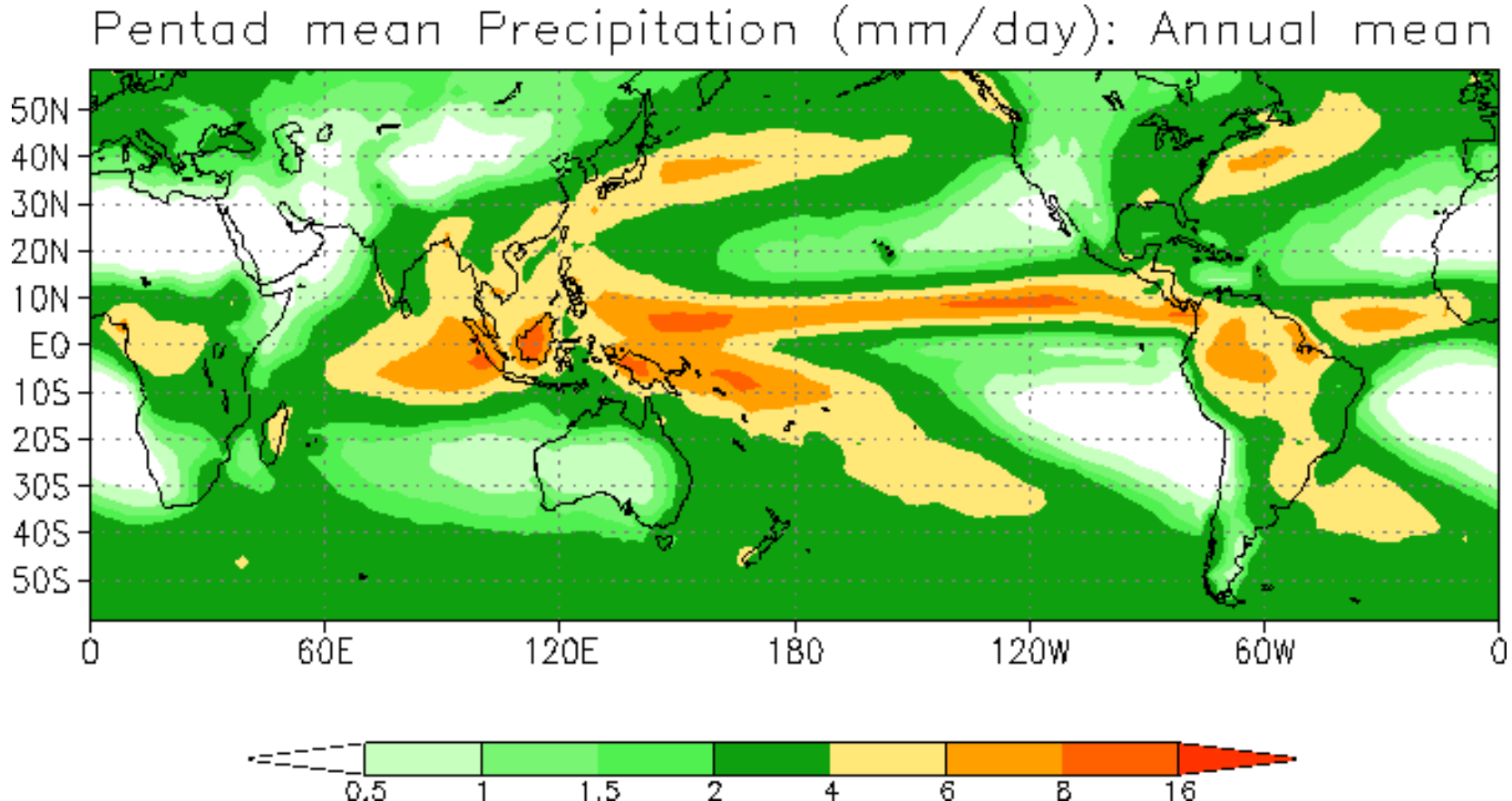




- Estas células formam a circulação de Walker.

Precipitação

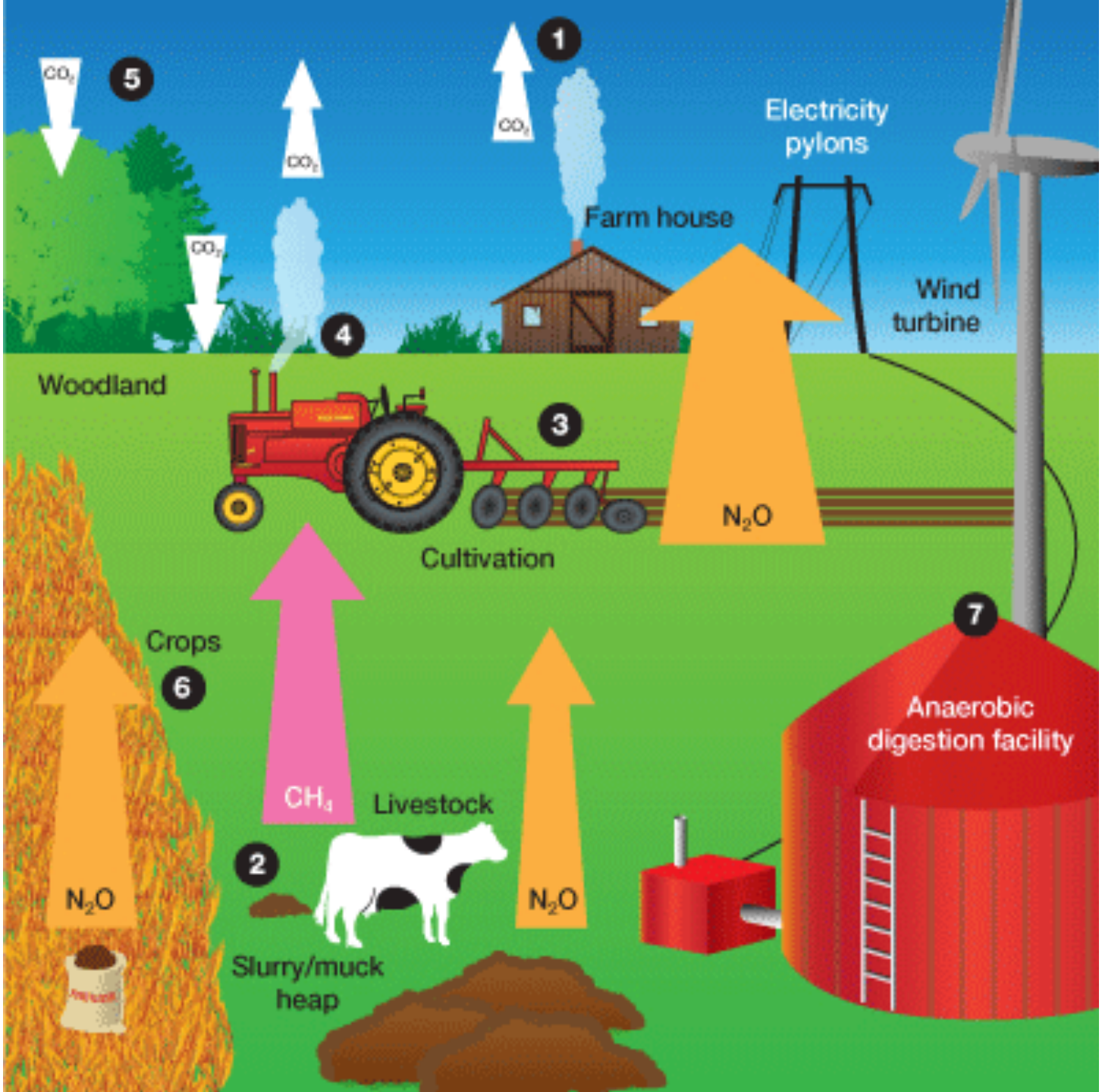
- A distribuição global dos ventos, e principalmente de onde eles sobem e descem, determinam em grande parte a distribuição da precipitação



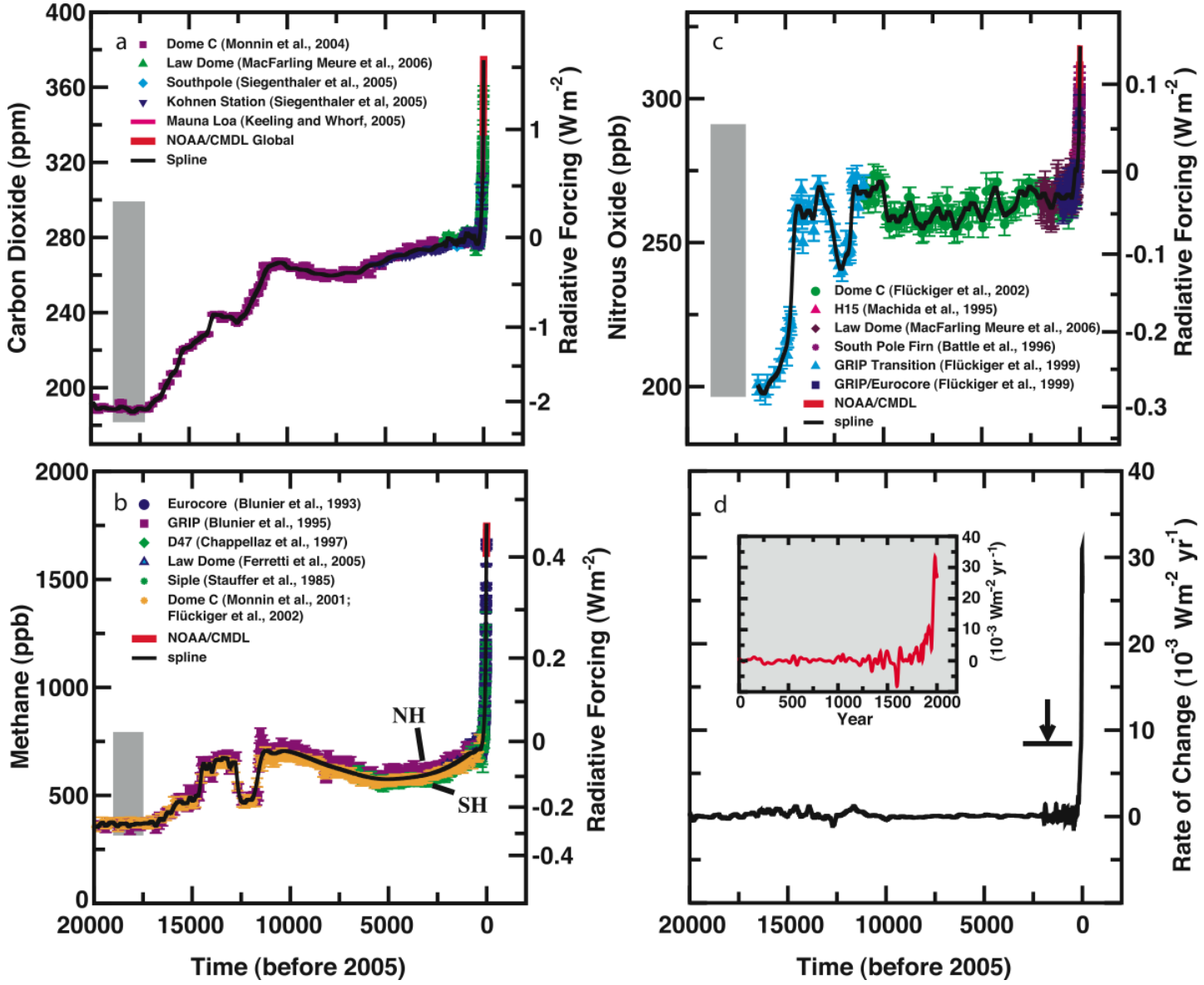
Circulação da Atmosfera

- A terra recebe energia do sol, a maior parte chega na região tropical e é absorvida na superfície.
- Esse aquecimento desigual força o surgimento de ventos na atmosfera e de correntes no oceano.
- Esta circulação redistribui a energia

A teoria que explica o movimentos dos fluídos é chamada de dinâmica dos fluídos.

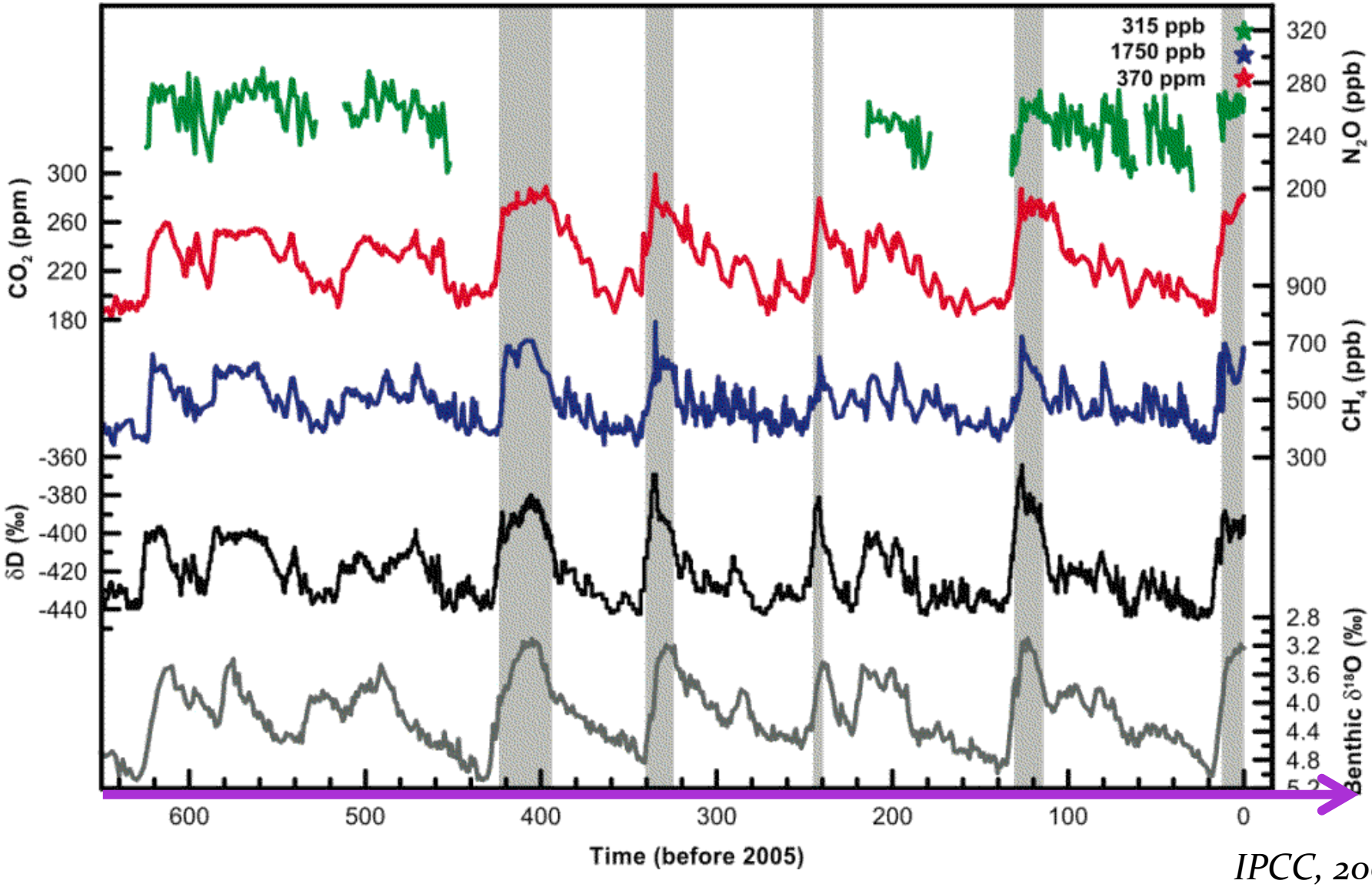

1
CO_2
5
CO_2
CO_2
Electricity pylons
Farm house
Wind turbine
4
Woodland
3
N_2O
Cultivation
Crops
6
7
Anaerobic digestion facility
CH_4
Livestock
2
N_2O
N_2O
Slurry/muck heap

Antropogenic? Yes!



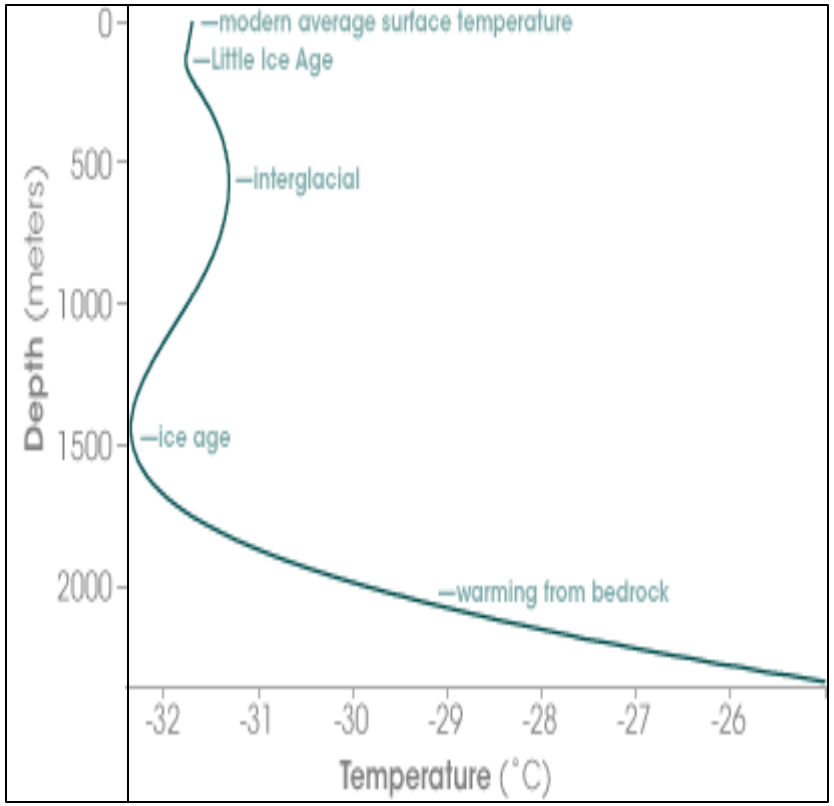
IPCC, 2007

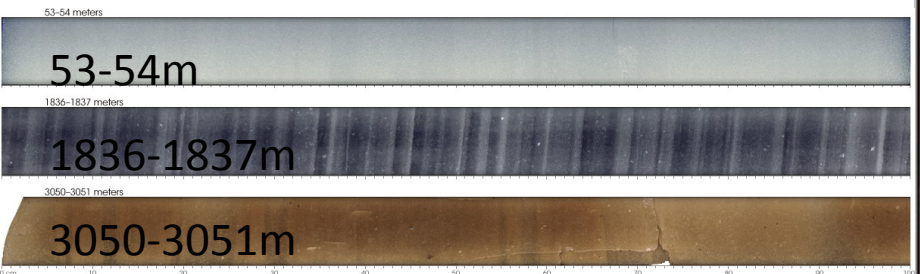
Vostok (650ky)

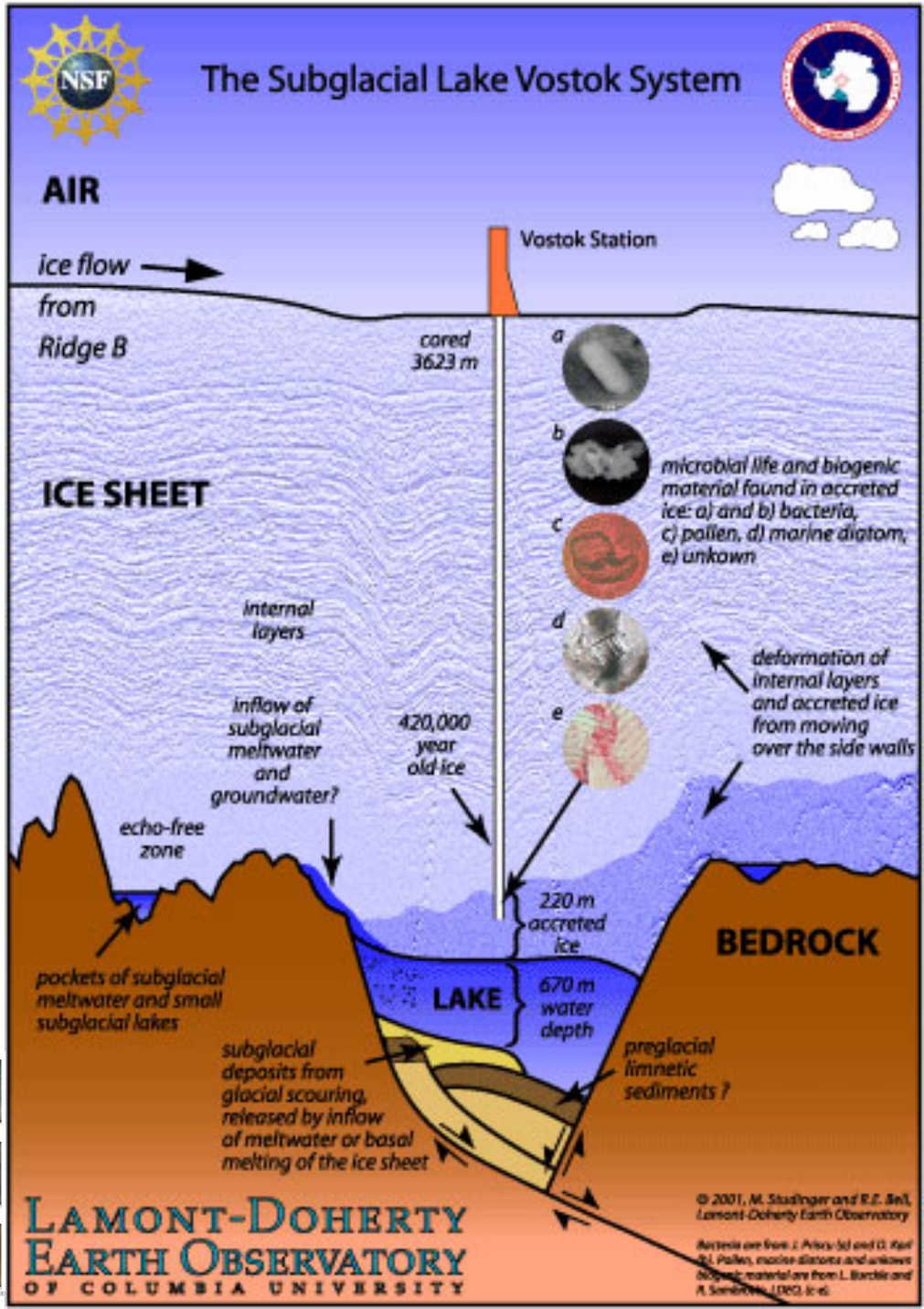


IPCC, 2007

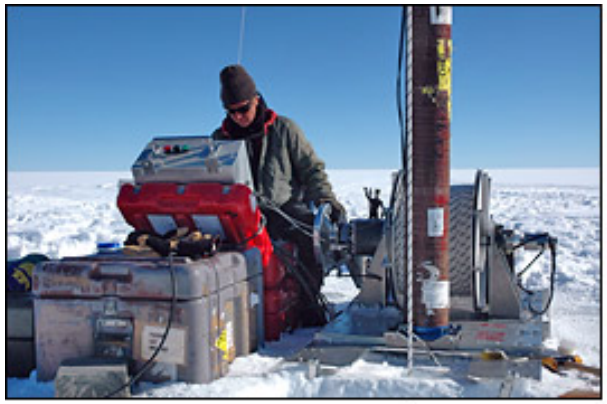
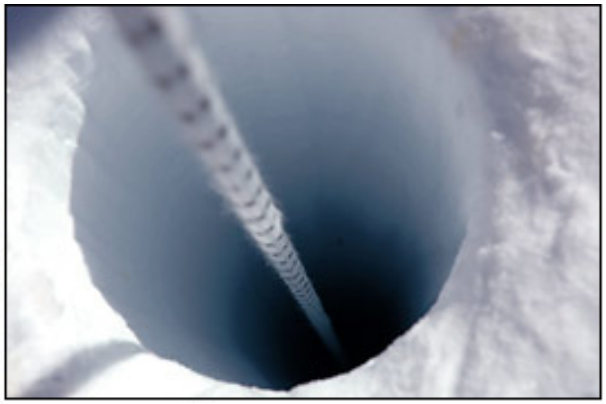
Ice Cores


modern average surface temperature
Little Ice Age
interglacial
ice age
warming from bedrock
Depth (meters)
0
500
1000
1500
2000
-32
-31
-30
-29
-28
-27
-26
Temperature (°C)


53-54 meters
53-54m
1836-1837 meters
1836-1837m
3050-3051 meters
3050-3051m


The Subglacial Lake Vostok System
AIR
Vostok Station
ice flow from Ridge B
cored 3623 m
ICE SHEET
microbial life and biogenic material found in accreted ice: a) and b) bacteria, c) pollen, d) marine diatom, e) unkown
internal layers
deformation of internal layers and accreted ice from moving over the side walls
inflow of subglacial meltwater and groundwater?
420,000 year old ice
echo-free zone
220 m accreted ice
BEDROCK
pockets of subglacial meltwater and small subglacial lakes
LAKE
670 m water depth
subglacial deposits from glacial scouring, released by inflow of meltwater or basal melting of the ice sheet
preglacial limnetic sediments ?
LAMONT-DOHERTY EARTH OBSERVATORY
OF COLUMBIA UNIVERSITY

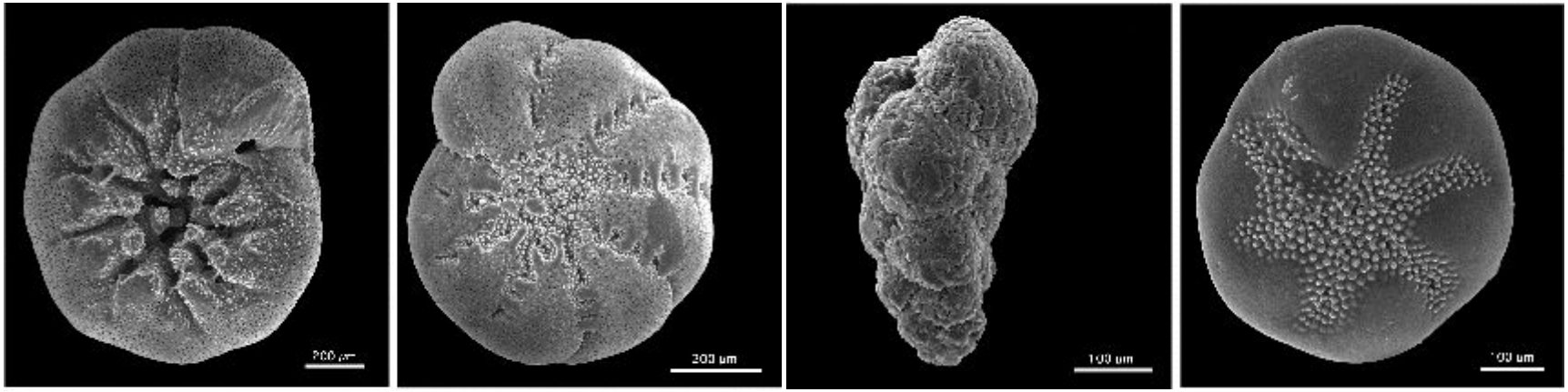
Ice Cores

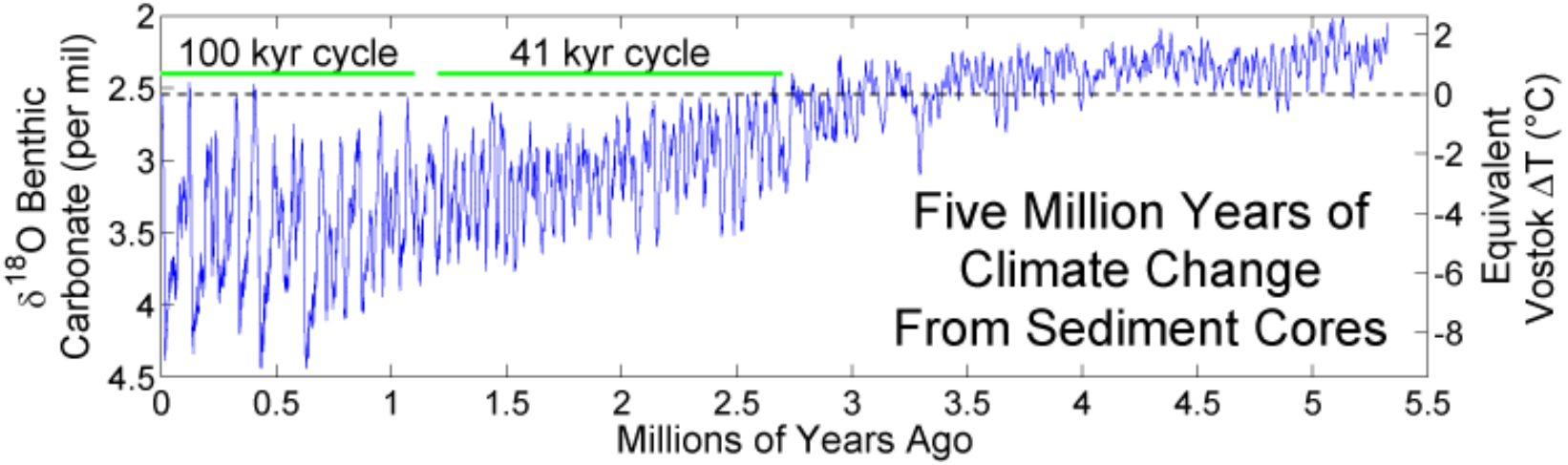






Same thing now on ocean sediments

Shell of Foraminifera's is made of $CaCO_3$

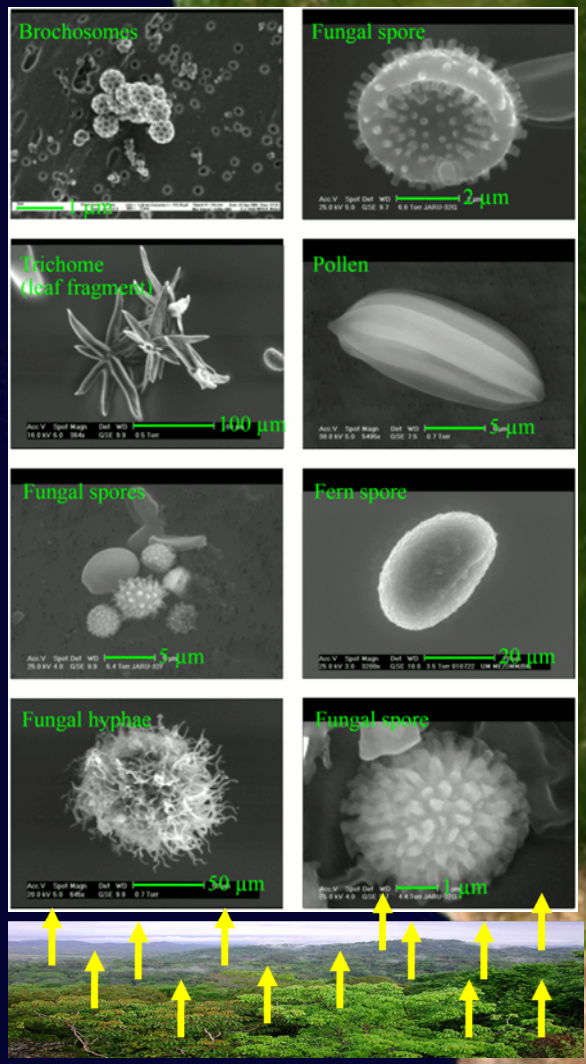




Lisiecki and Raymo (Paleoceanography, 2005).

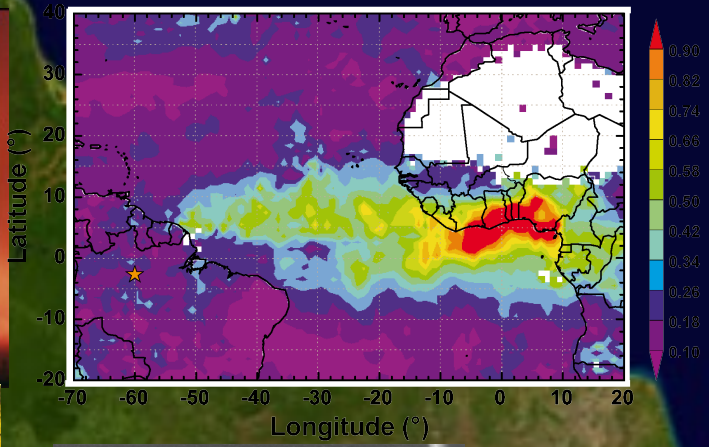
Amazonia: 3 different types of aerosols

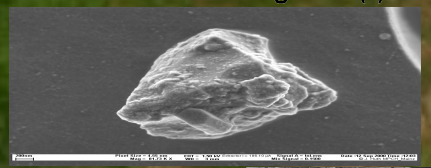
Biogenic (primary and SOA)

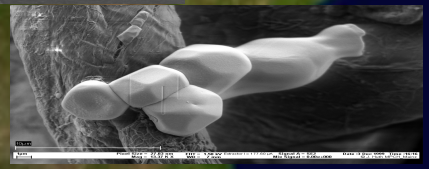


Biomass Burning

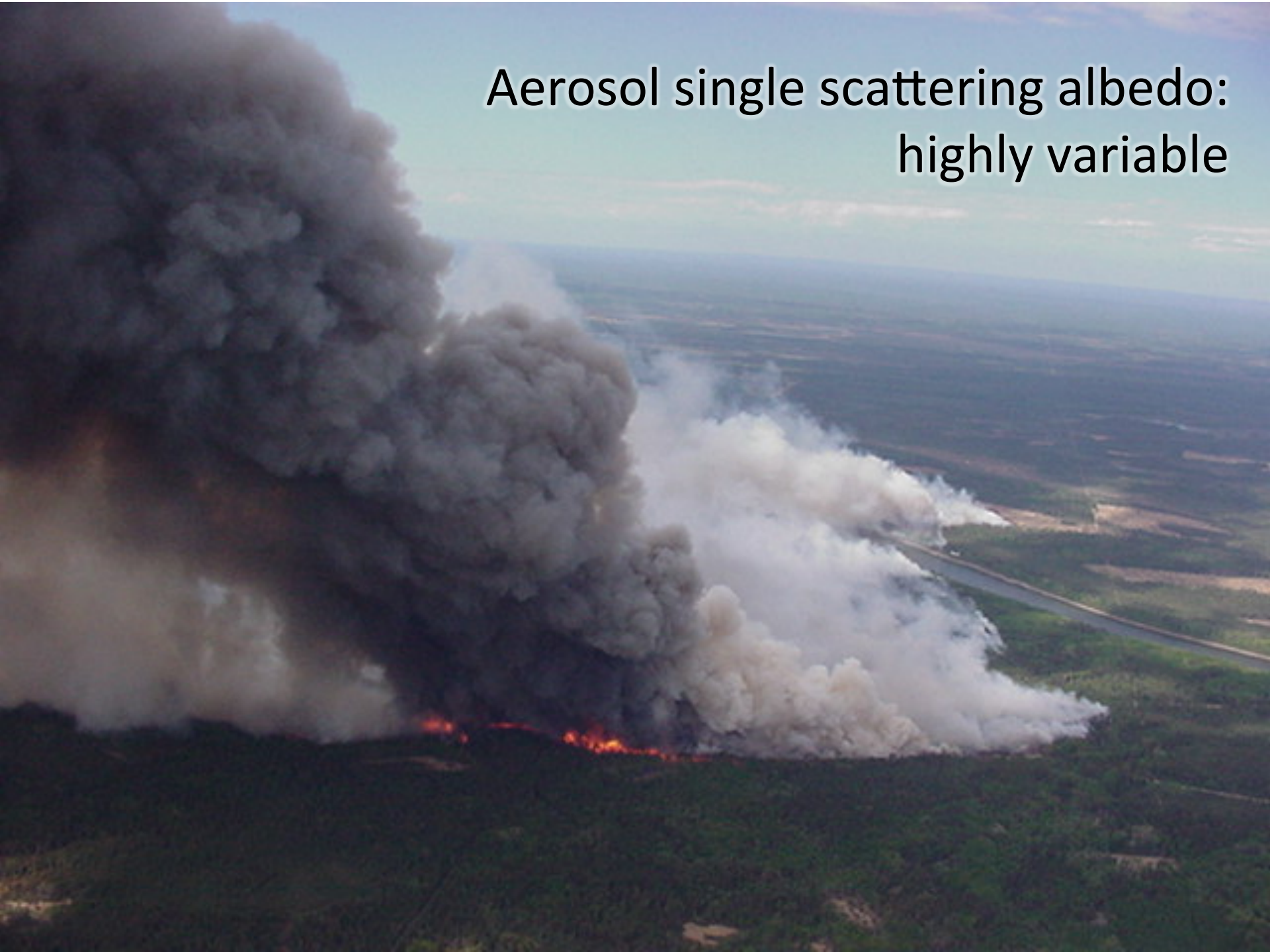
Dust from Sahara





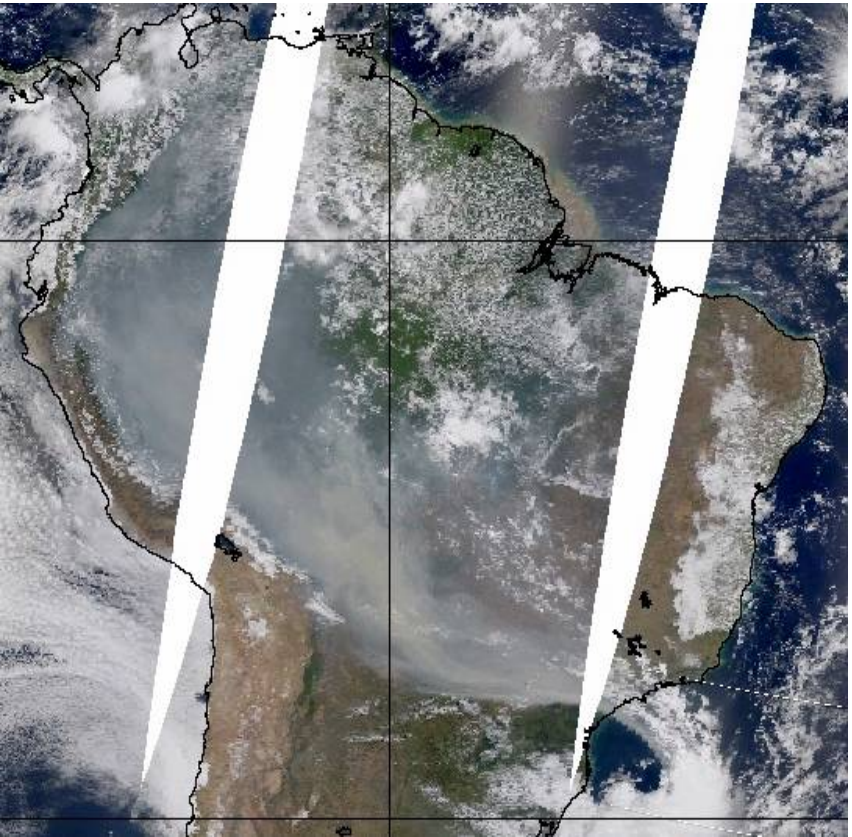


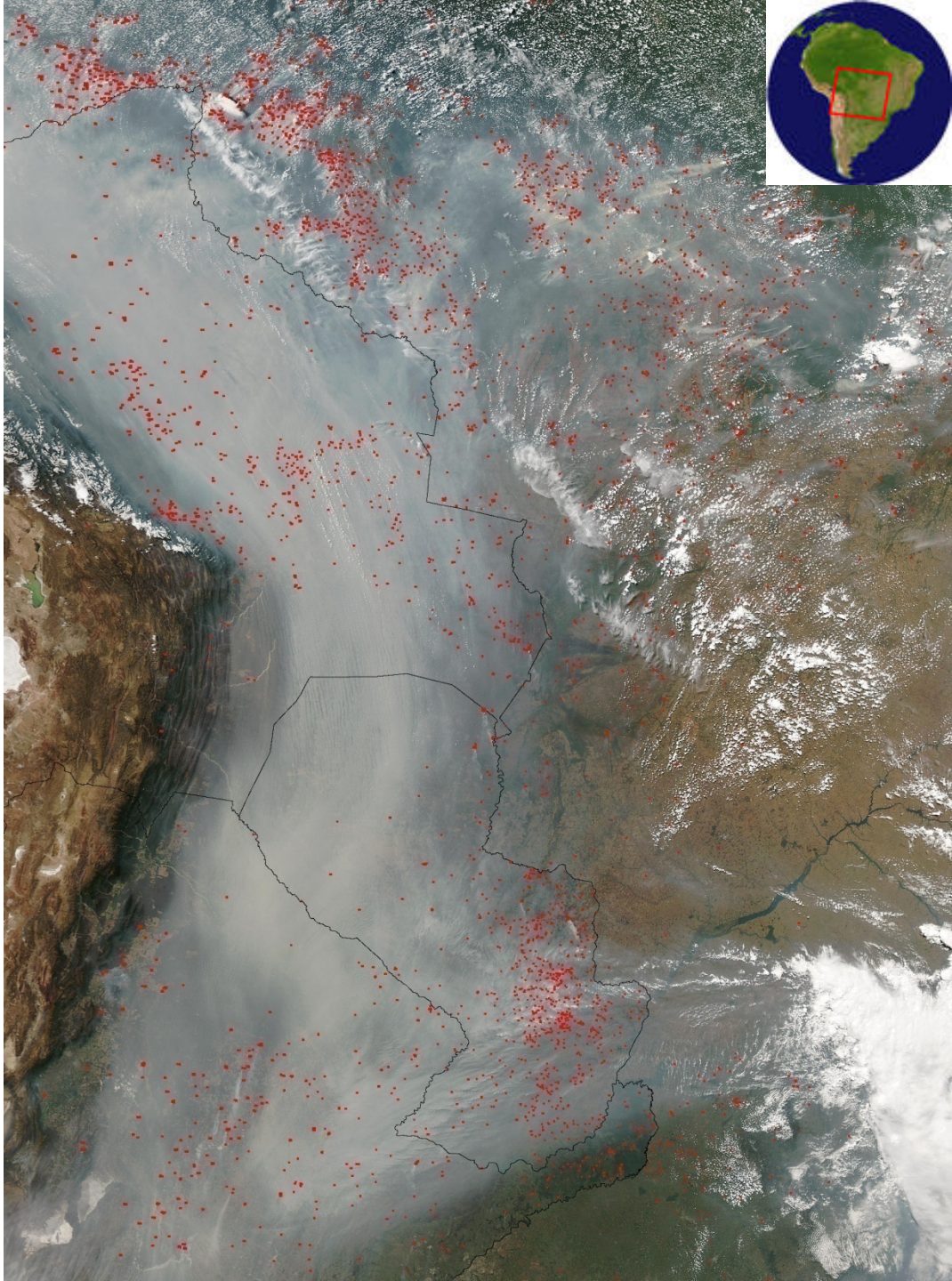
Each with VERY different properties and impacts


Aerosol single scattering albedo:
highly variable

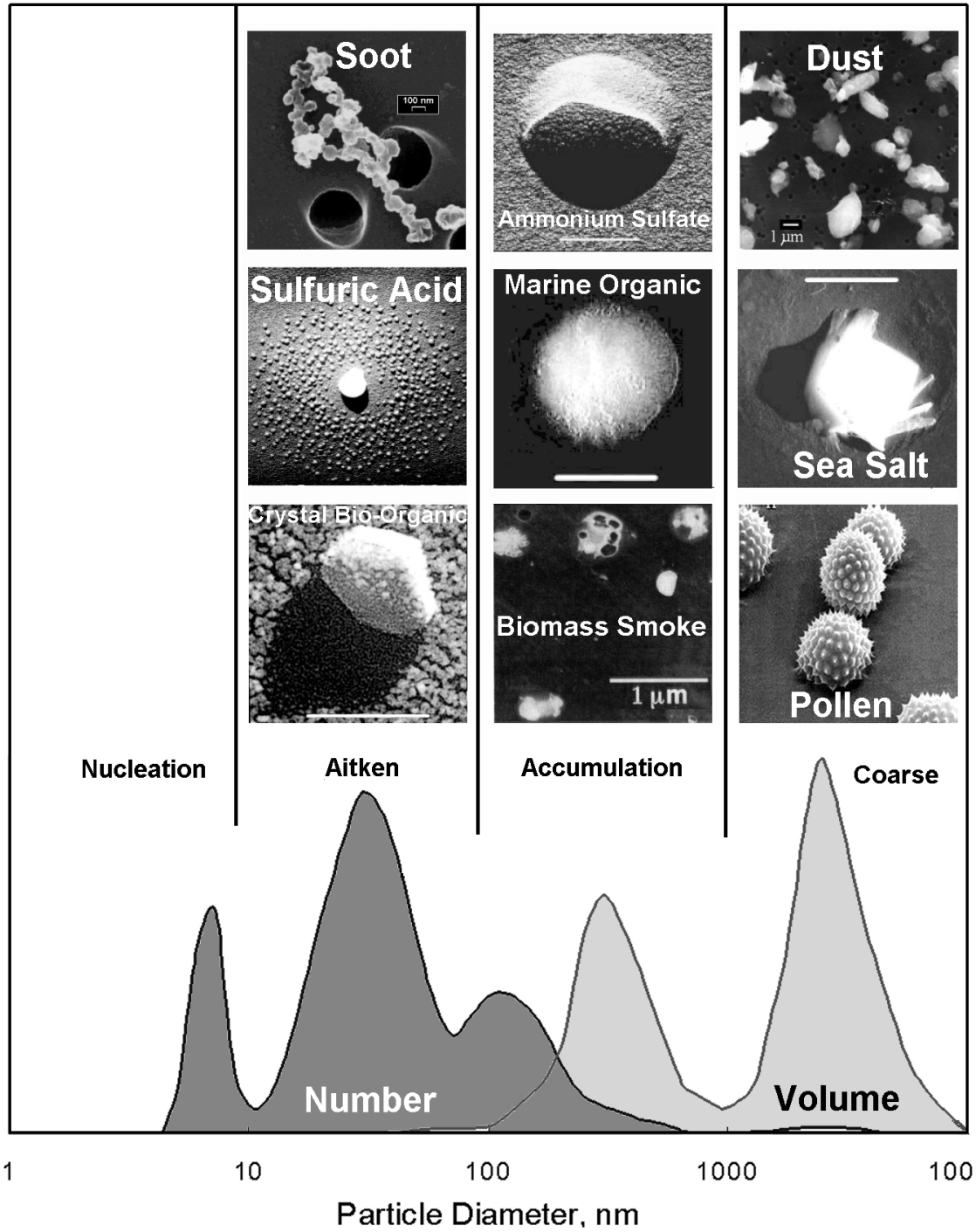
Large scale aerosol distribution in Amazonia

- Severe health effects on the Amazonian population (about 20 million people)
- Climatic effects, with strong effects on cloud physics and radiation balance.
- Changes in carbon uptake and ecosystem functioning



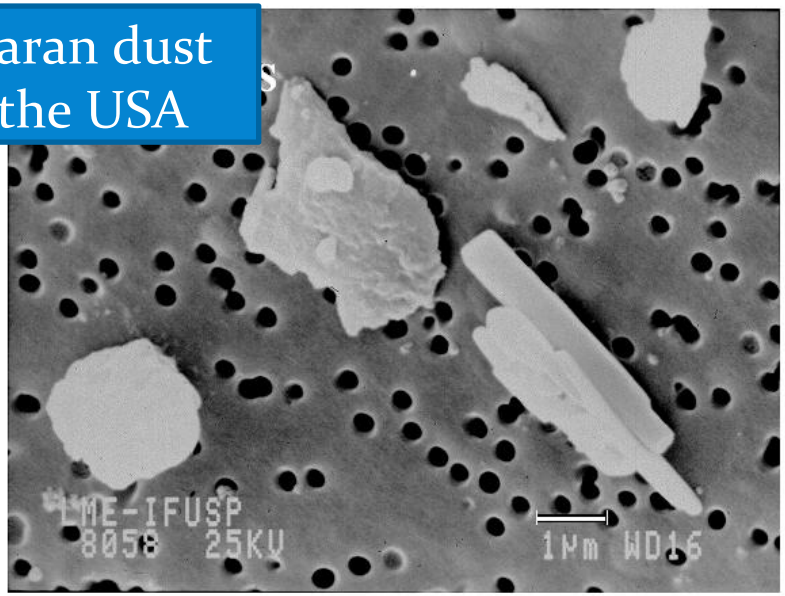


- Interaction of the aerosol with the radiation field depends:
  - Size
  - Shape
  - Surface properties

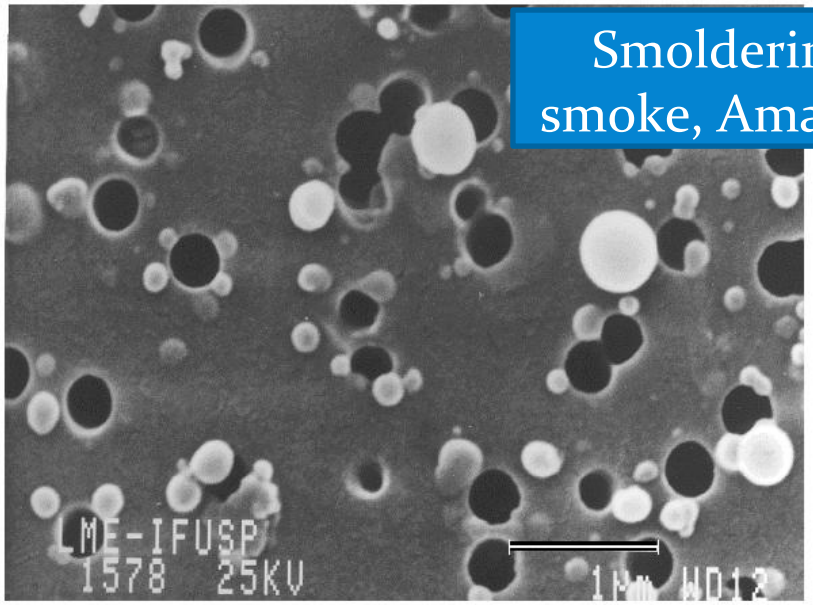


… Aerosols can be very different

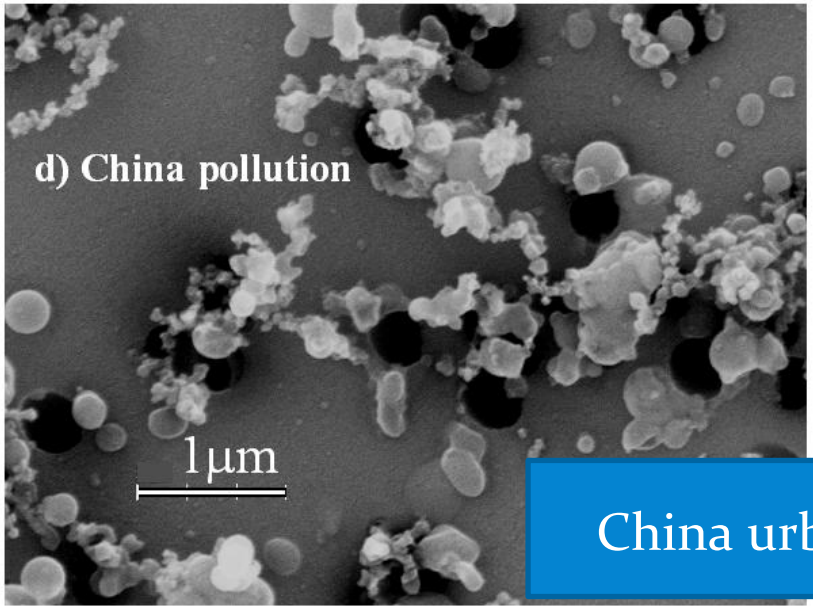
Saharan dust in the USA



Smoldering smoke, Amazon

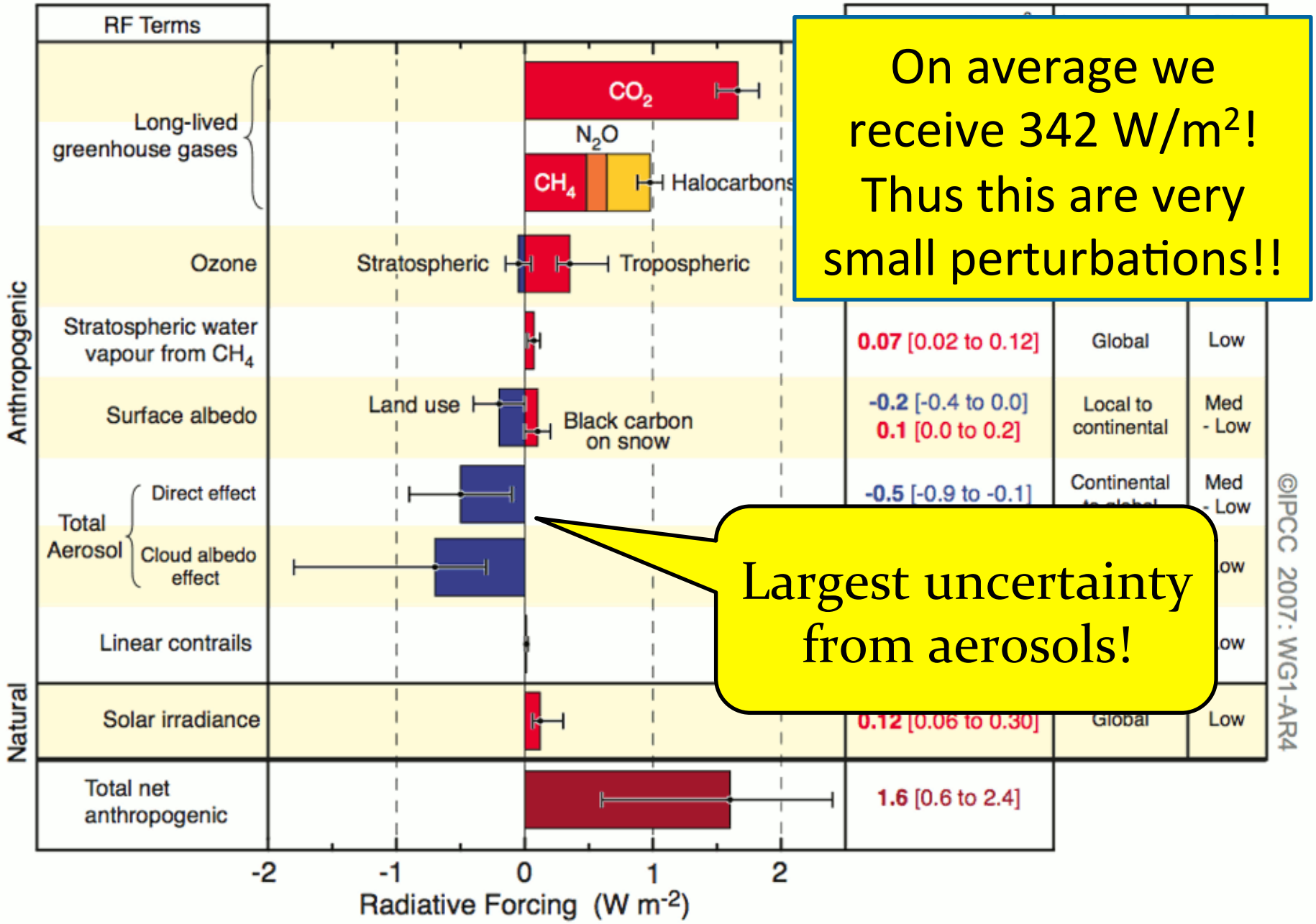


Flaming smoke, Amazon



China urban

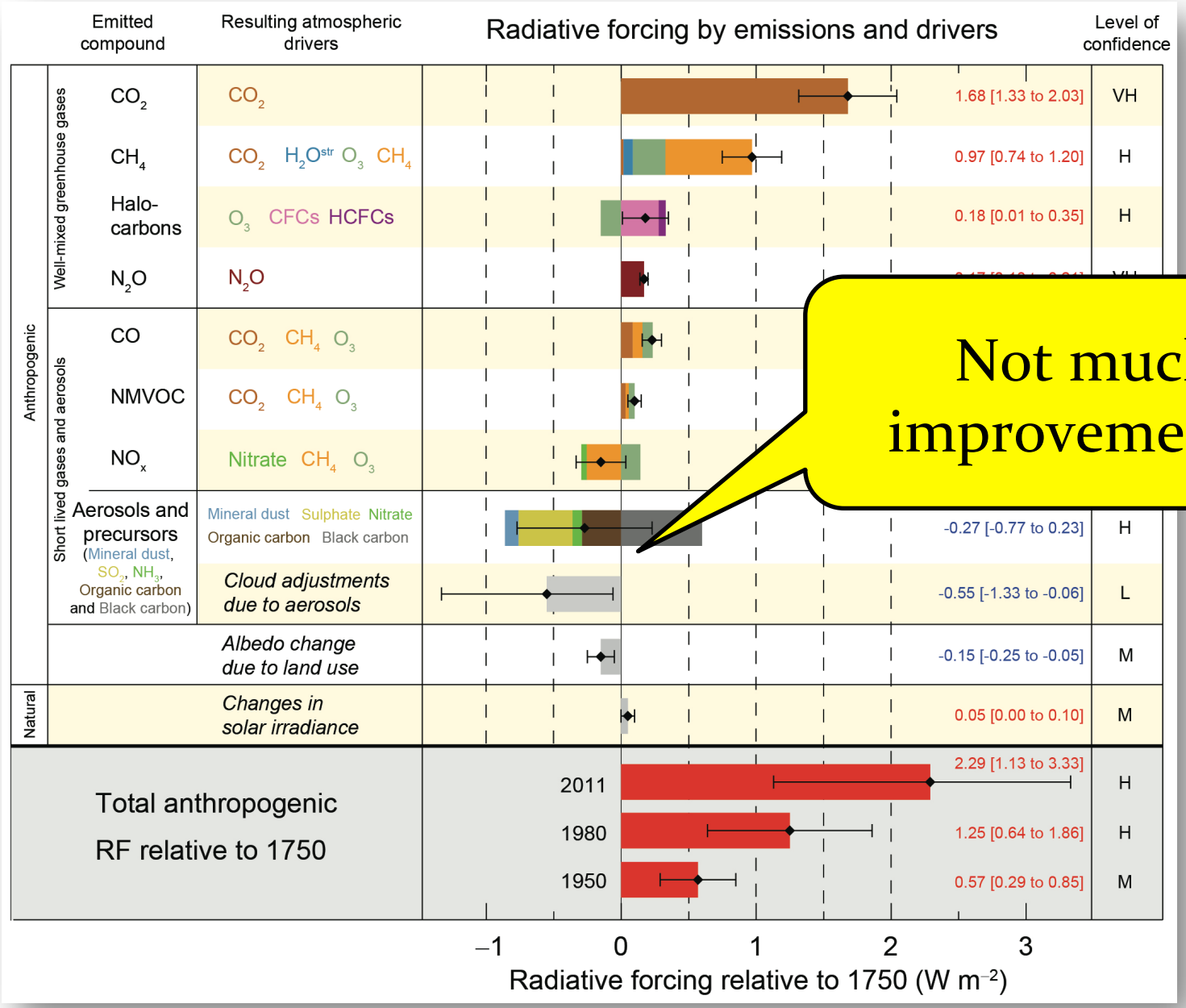
Radiative forcings of the global climate system IPCC 2007



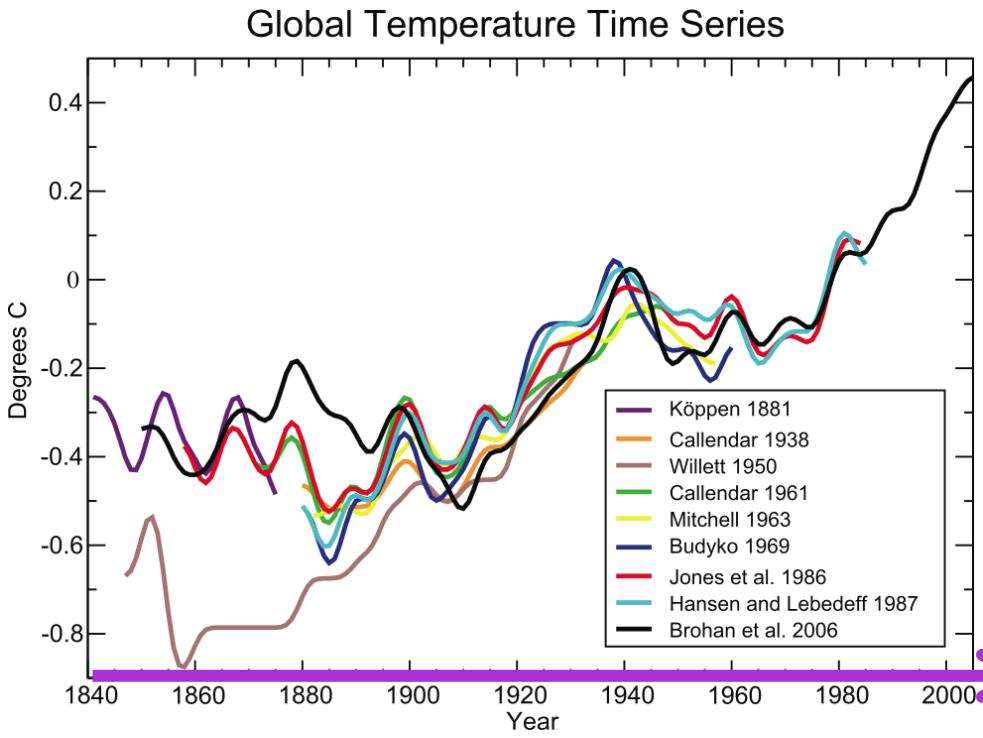
On average we receive 342 W/m^2! Thus this are very small perturbations!!

Largest uncertainty from aerosols!

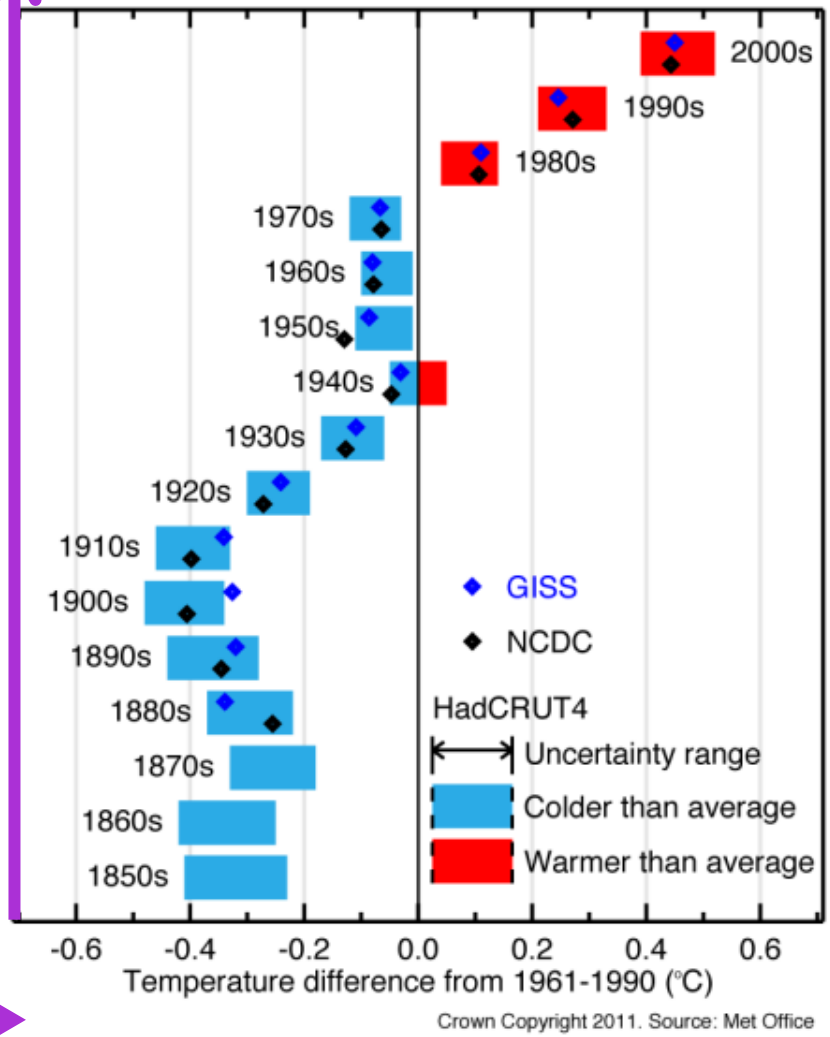
Forçante radiativa do sistema climático global (IPCC 2013)



Observation of Temperature Increase

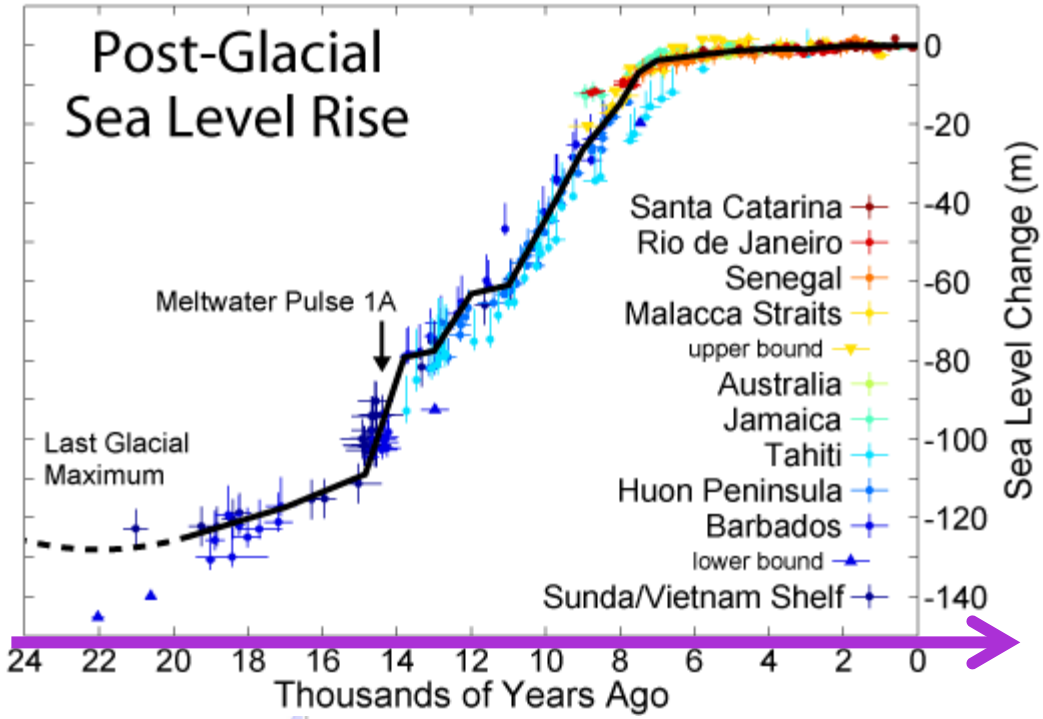


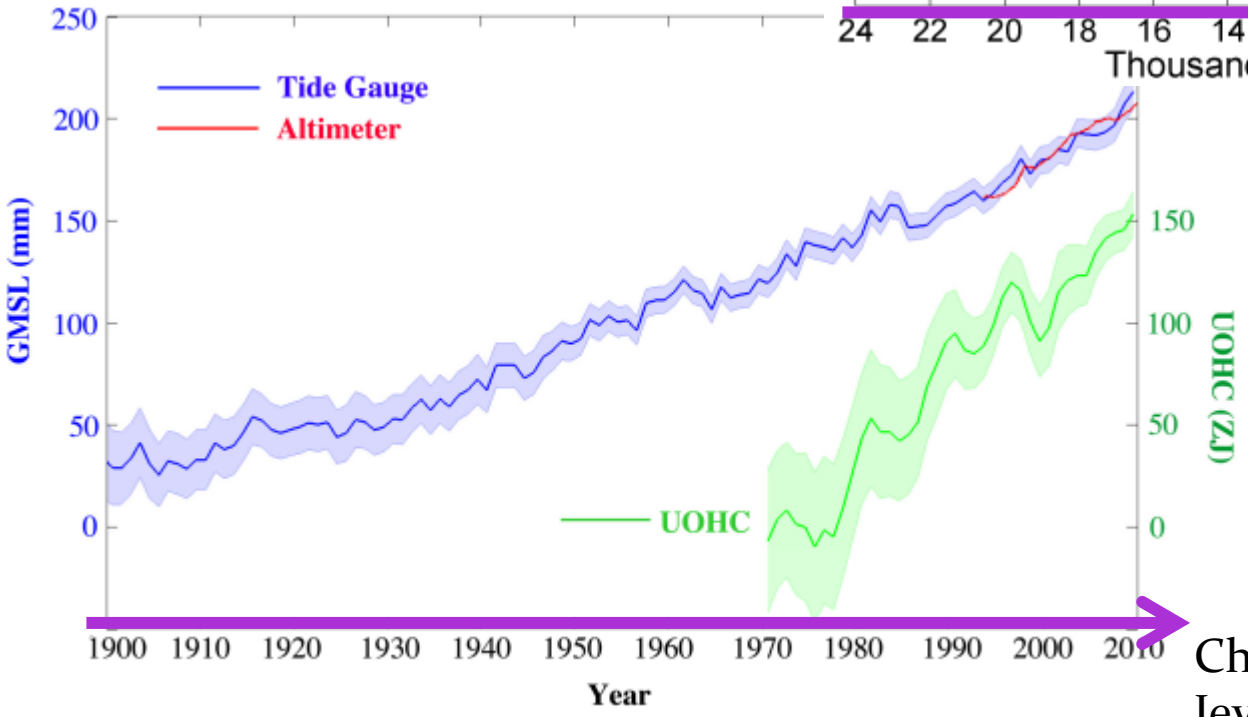
IPCC, AR4 2007



IPCC, AR5, 2013

(2) Sea level

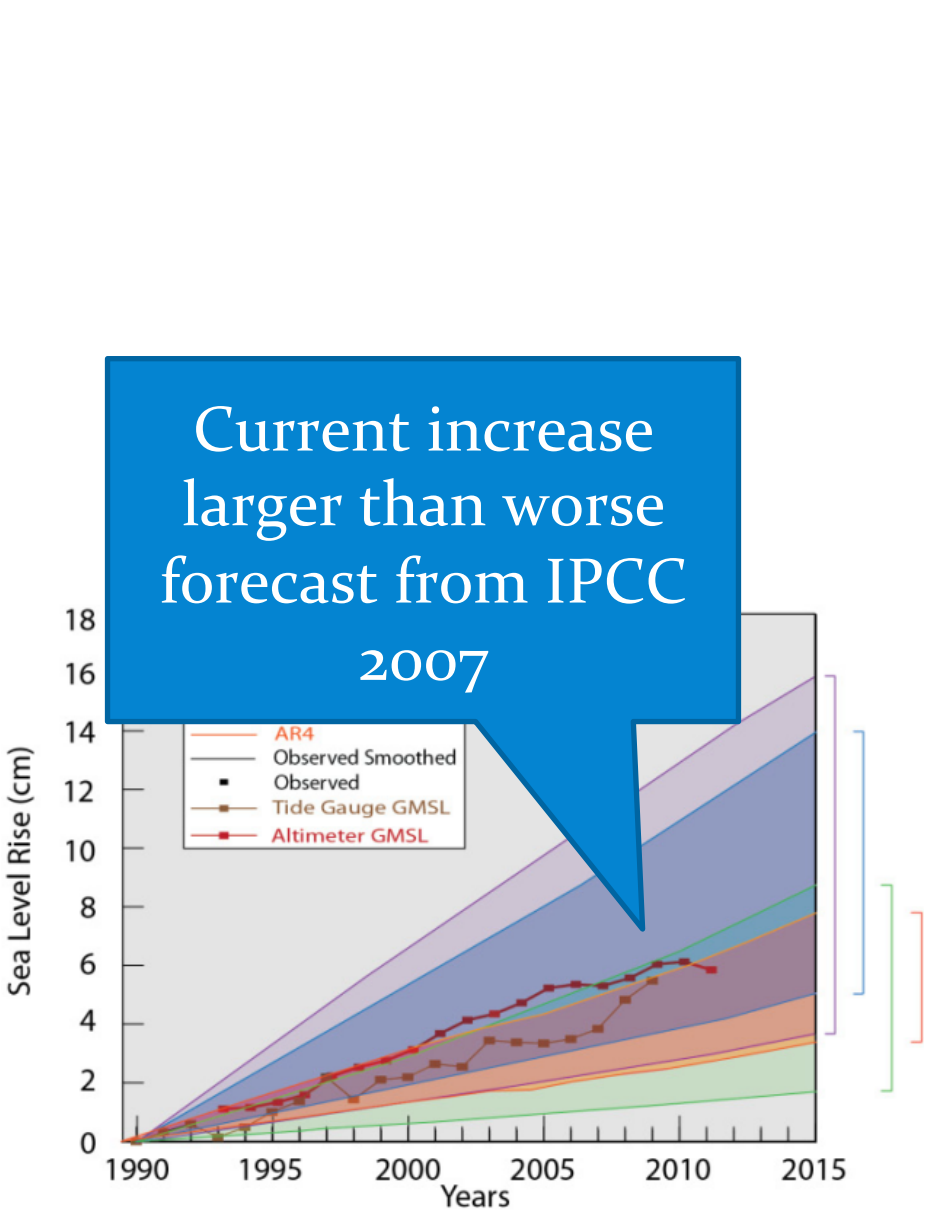


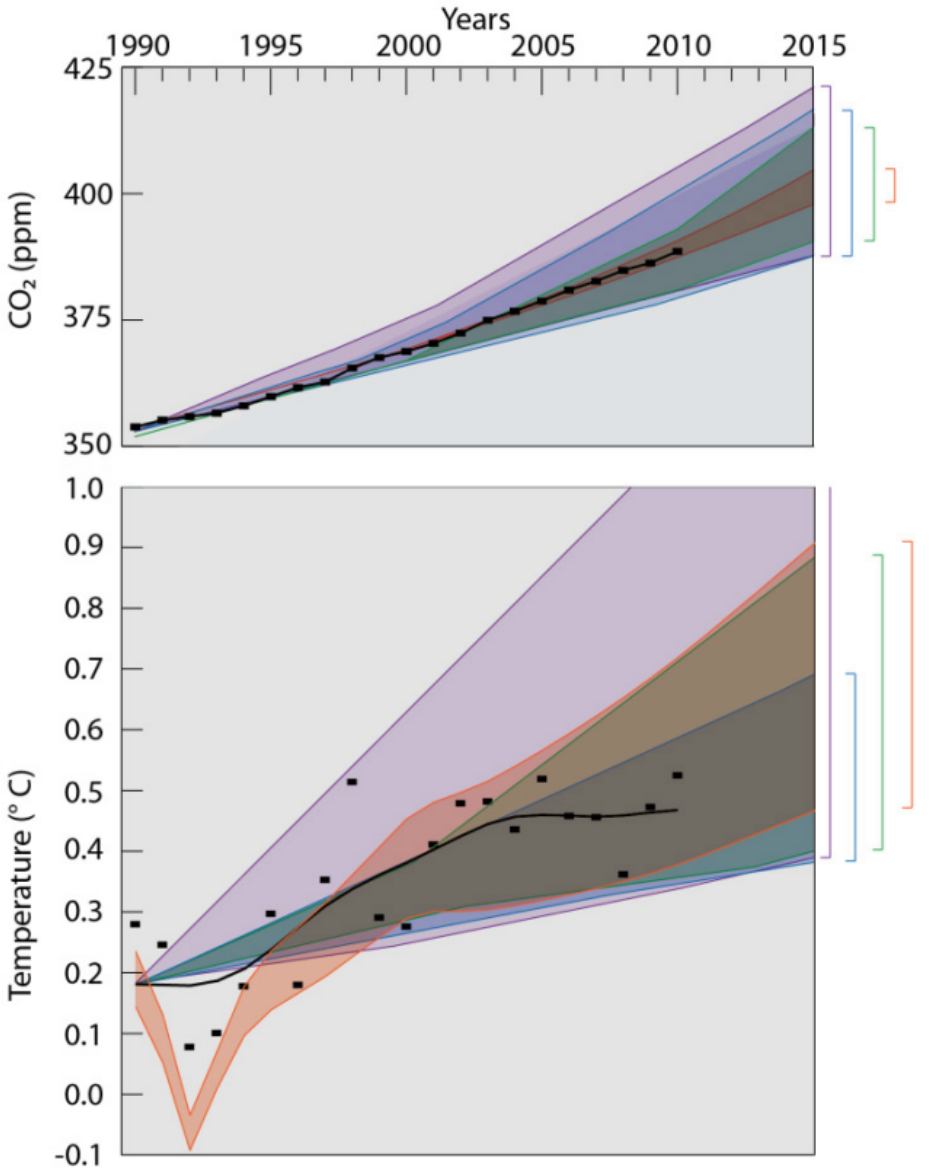


IPCC, AR5, 2013

Church and White, 2011;
Jevrejeva et al., 2008;
Nerem et al., 2010

Despite it all…

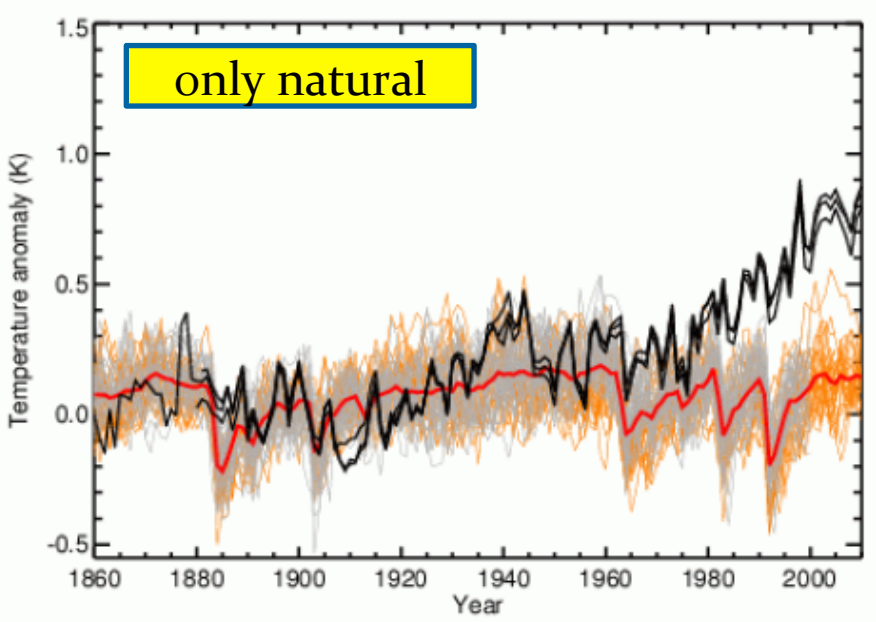


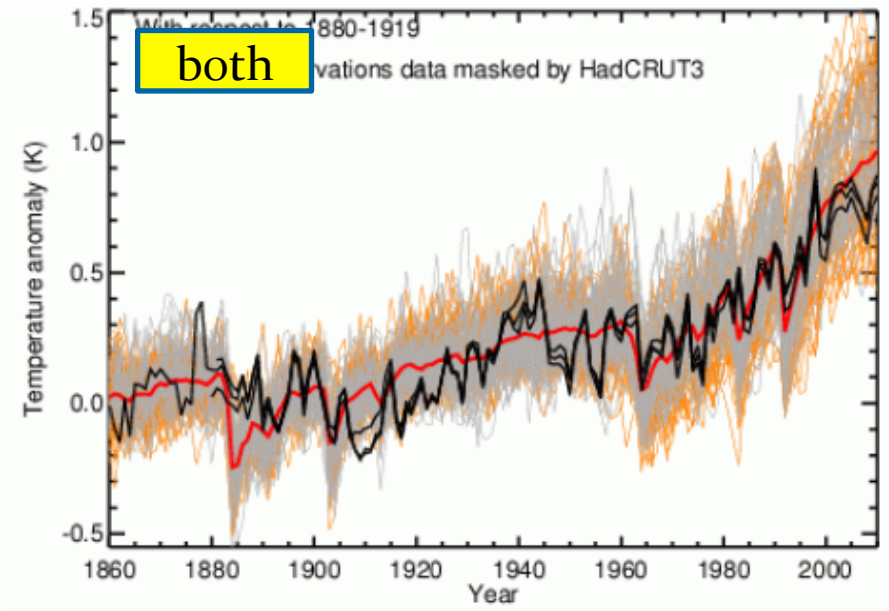


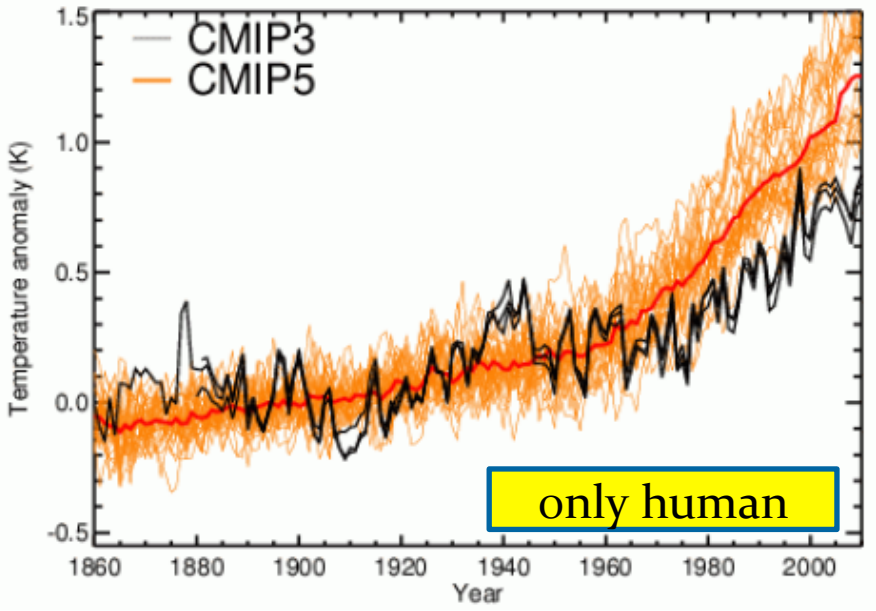
IPCC, AR5

Only explained by

- natural+antropogenic

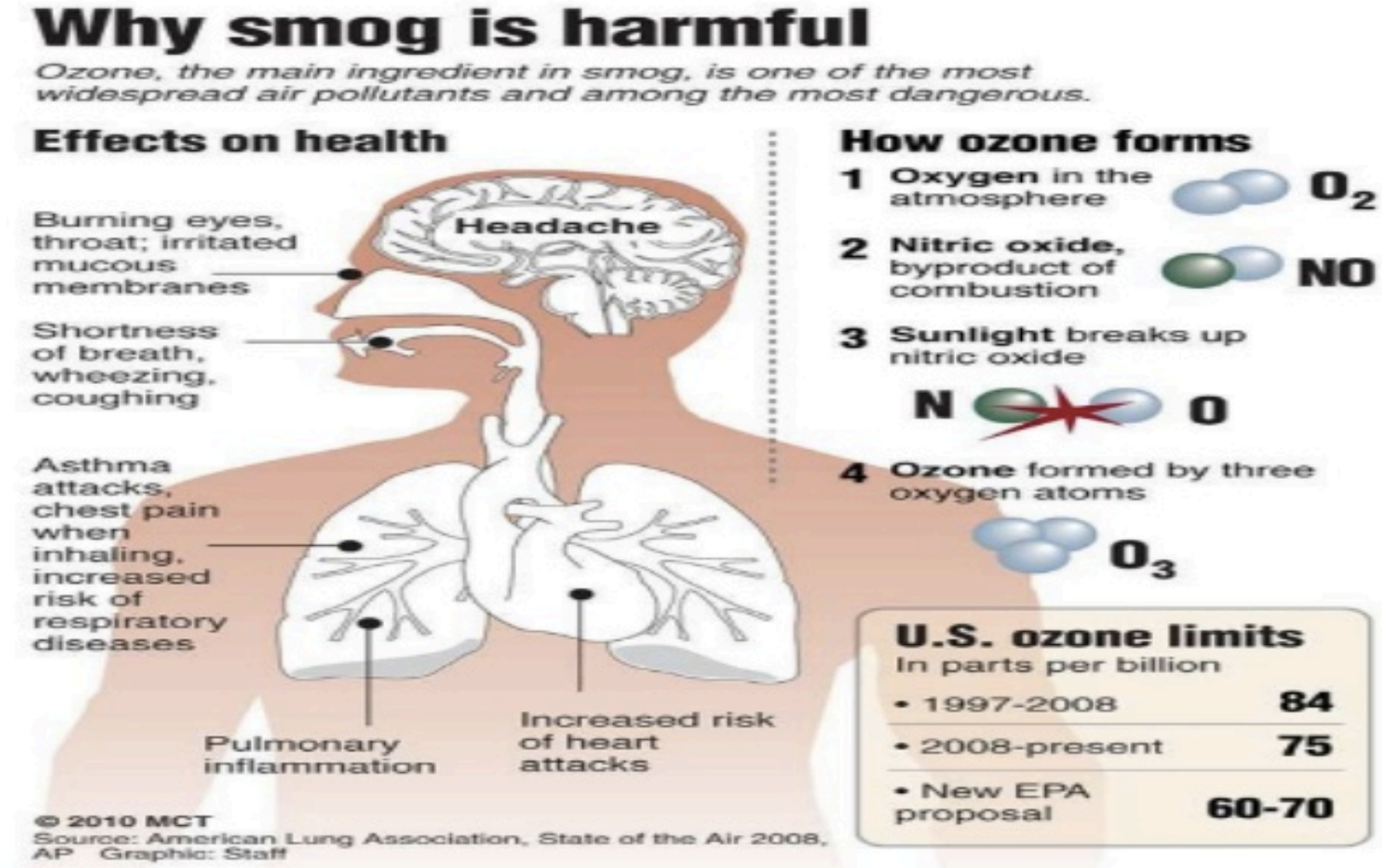


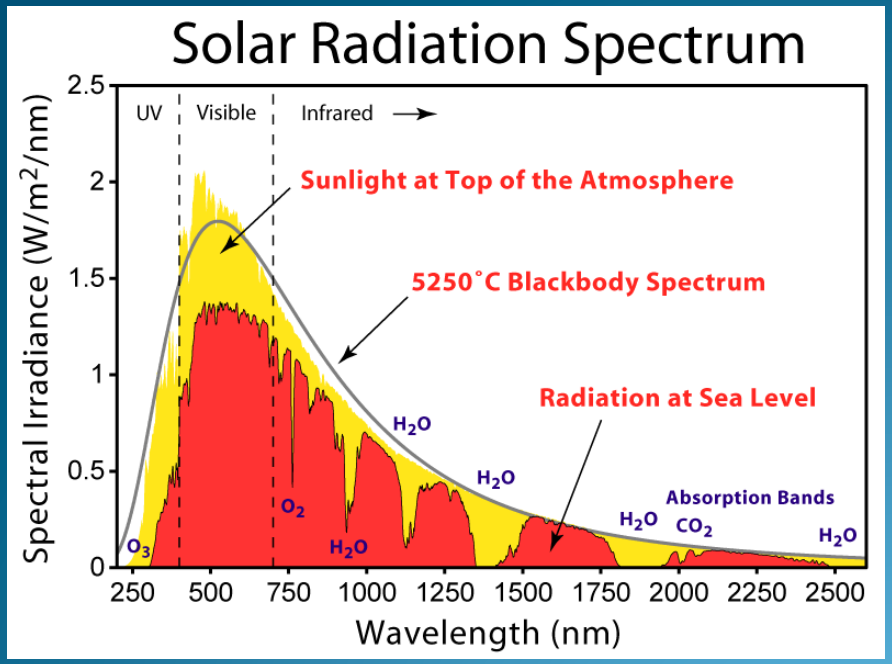




IPCC, AR5

EFFECTS OF SMOG





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