

(3) Match the equation to its name.

\_A\_ Planck function

a) 
$$B_{\lambda}(T) = \frac{2hc^2/\lambda^5}{e^{hc/\lambda kT} - 1}$$

\_C\_ Wien's law

b)  $j^* = \sigma T^4$

\_B\_ Stefan-Boltzmann Law

c)  $\lambda_{\max} = b/T$

(2) What is the key difference between active and passive sensors?

*Need to say that active sensors emit radiation.*

*Active emit radiation to detect what bounces back, passive sensors just detect what is reflected from the object already.*

(1) What is the most common source of radiation detected by passive sensors?

- a) Infrared
- b) Reflected sunlight (\*)
- c) Sunlight
- d) Radio waves

(1) A radiometer is....

- a) A device which measures detects and analyzes spectral content of incident radiation
- b) A device that emits EM radiation and measures backscatter
- c) An instrument which measures EM intensity in a band of wavelengths (\*)
- d) None of the above

(1) LiDAR stands for....?

- a) Light Detection and Ranging (\*)
- b) Light Deflection and Ranging
- c) Light Detection and Reception
- d) Light Deflection and Receiving

(2) How does LiDAR work?

*Must mention using a laser to transmit light pulse, and a receiver to measure reflected/backscattered light.*

(4) Label each type of sensing with active (A) or passive (P)

A\_\_\_Radar altimetry

A\_\_\_LiDAR

A\_\_\_Precipitation radar

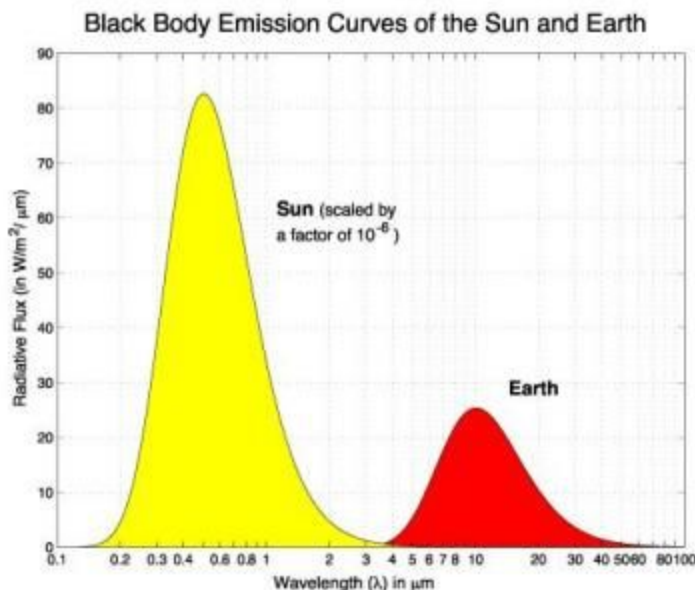
P\_\_\_Radiometer

(2) What is beam attenuation?

*Lessening in intensity of beam as it passes through matter*

(6) Why are the blackbody radiation curves for the Earth and the Sun so different? Draw a graph of the two curves.

*Must mention Stefan-Boltzmann Law & differences in temperature for the two bodies, with a thorough explanation of why that causes the different curves. Graph needs to show a much higher intensity and lower wavelength peak for sun than earth, axes labeled for full credit.*



What scattering mechanism is responsible for the sky's blue color?

- a) Brillouin
- b) Debye
- c) Raman
- d) Thompson
- e) None of the above (\*)

Is the scattering elastic or inelastic?

I\_\_\_ Brillouin

I) inelastic

E) elastic

E\_\_\_ Debye

I\_\_\_ Raman

E\_\_\_ Thompson

I\_\_\_ Compton

E\_\_\_ Rayleigh

Match the scattering to the phenomenon/application.

C\_\_\_ Rayleigh

a) x-ray photographs

B\_\_\_ Raman

b) spectroscopy

D\_\_\_ Debye

c) blue sky

A\_\_\_ Compton

d) white clouds

Where is the atmospheric refraction for a star the lowest?

*The zenith, or highest point above the earth*

List and define the four types of optical remote sensing systems.

*Panchromatic: single channel detector sensitive to radiation in a broad range.*

*Multispectral: multichannel detector with a few spectral bands*

*Superspectral: many spectral bands (>10), narrow ranges in bands*

*Hyperspectral: lots of contiguous spectral bands, >100.*

What range of EM waves do optical sensors detect?

- a) Visible light spectrum
- b) Infrared
- c) Microwaves
- d) A & B (\*)
- e) B & C
- f) None of the above

Assuming a constant atmospheric refractive index of  $n=1.003$ , for a ray of light incident perpendicular to the atmosphere/vacuum interface, what is the angle of refraction?

$$\begin{array}{ll} n_{\text{vacuum}}=1.0 & n_{\text{air}}=1.003 \\ \theta_{\text{vacuum}}=90 & \theta_{\text{air}}=? \end{array}$$

$$1.0(\sin(90))= 1.003(\sin\theta)$$

$$1.0/1.003=\sin\theta$$

$$\sin^{-1}(1.0/1.003)=\theta$$

$$\theta= 85.57$$

Fill in the blank (1 pt each)

A surface with a high albedo absorbs less light than a surface with low albedo.

Nitrous oxide has a greater global warming potential than carbon dioxide.

Are these carbon sinks part of the long-term (L), short-term (S) carbon cycle or both (B)?

S\_\_\_Plants

L\_\_\_Fossil fuels

S\_\_\_Oceans

S\_\_\_Animals

L\_\_\_Limestone

Which of these is not a greenhouse gas?

- a) Ozone
- b) Carbon dioxide
- c) Molecular nitrogen (\*)
- d) Nitrogen oxides
- e) None of the above

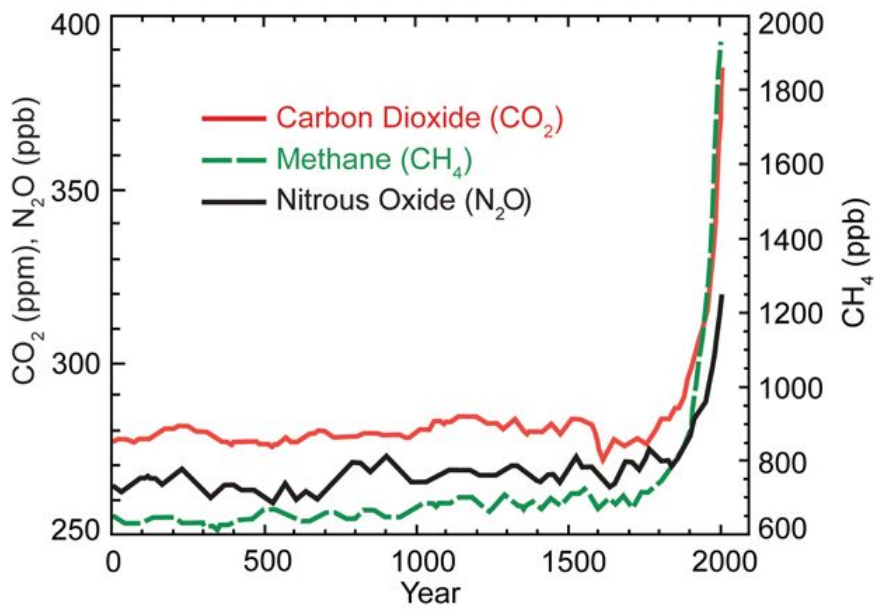
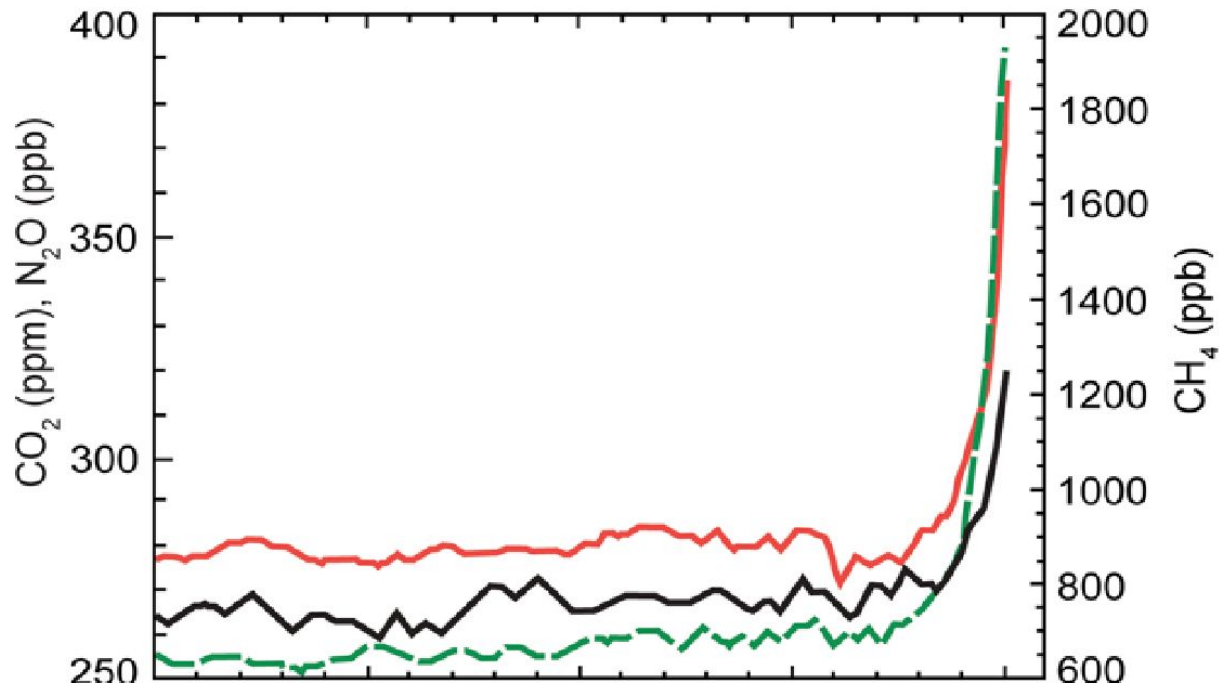
Order the following greenhouse gases from least to greatest abundance in the atmosphere: carbon dioxide, ozone, methane, nitrous oxide, chlorofluorocarbons, hydrofluorocarbons, and water vapor.

*Least abundant* → Hydrofluorocarbons, chlorofluorocarbons, ozone, nitrous oxide, methane, carbon dioxide, water vapor → *most abundant*

What is the most abundant trace gas in the atmosphere?

- a) Carbon dioxide
- b) Water vapor
- c) Argon (\*)
- d) Nitrogen
- e) None of the above

(6) Label the chart with the correct greenhouse gas for each data plot.



Which greenhouse gas has the most variable spatial distribution?

- a) Nitrous oxide
- b) Carbon dioxide
- c) Water vapor (\*)
- d) CFCs
- e) None of the above

What type of cloud is most likely to cool the earth's surface via interaction with solar radiation?

- a) Cirrus
- b) Stratus
- c) Cumulonimbus
- d) Stratocumulus (\*)
- e) None of the above

Which is the most significant natural source of aerosols?

- a) The ocean (\*)
- b) Volcanoes
- c) Wind
- d) Wildfire
- e) None of the above

What would be the overall climate impact of a large volcanic explosion?

- a) Short period of warming (a few years)
- b) Long period of warming (20-50 years)
- c) Short period of cooling (a few years) (\*)
- d) Long period of cooling (20-50 years)
- e) None of the above

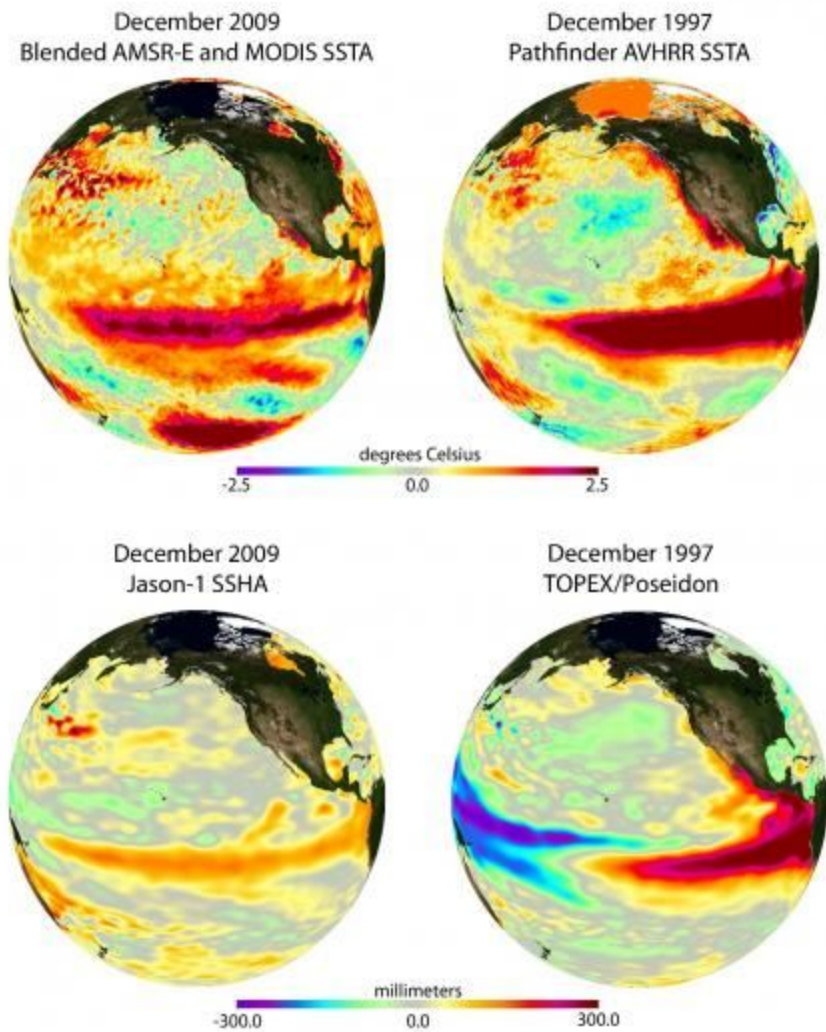
Is the impact of aerosols uniform across the planet?

*No, aerosol concentration varies temporally but typically has greater impact on areas with high fossil fuel use. (Need to have explanation for credit. Partial credit if the answer is correct but explanation is wrong.)*

What is the theorized impact of increased aerosols on clouds and heat transfer?

*Smaller droplets but more of them. This creates a brighter cloud from greater light scattering across more surfaces. This then increases the albedo of the clouds and increases the amount of reflected radiation, resulting in a cooling effect.*

### Monthly Averaged Sea Surface Temperature and Height Relative to Normal



What phenomenon does the above series of images depict?



*An el Nino event*

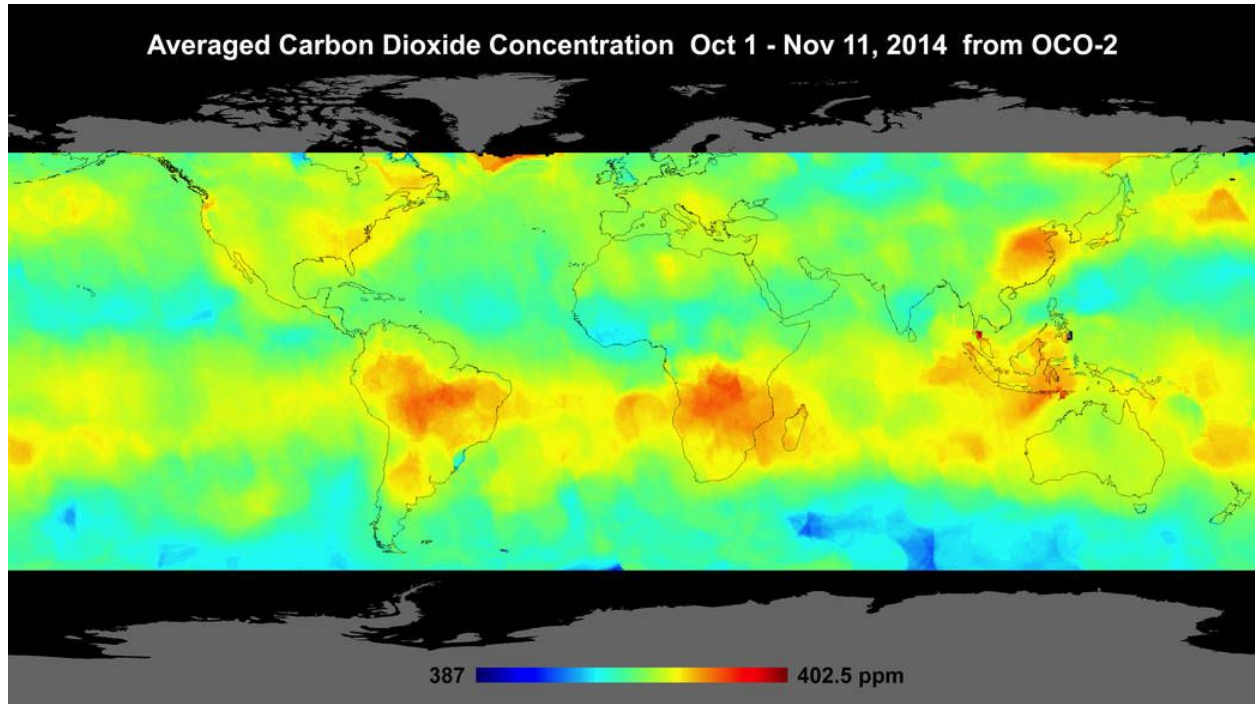


What do the colors in this image represent?

*Blue represents ice, white is clouds.*

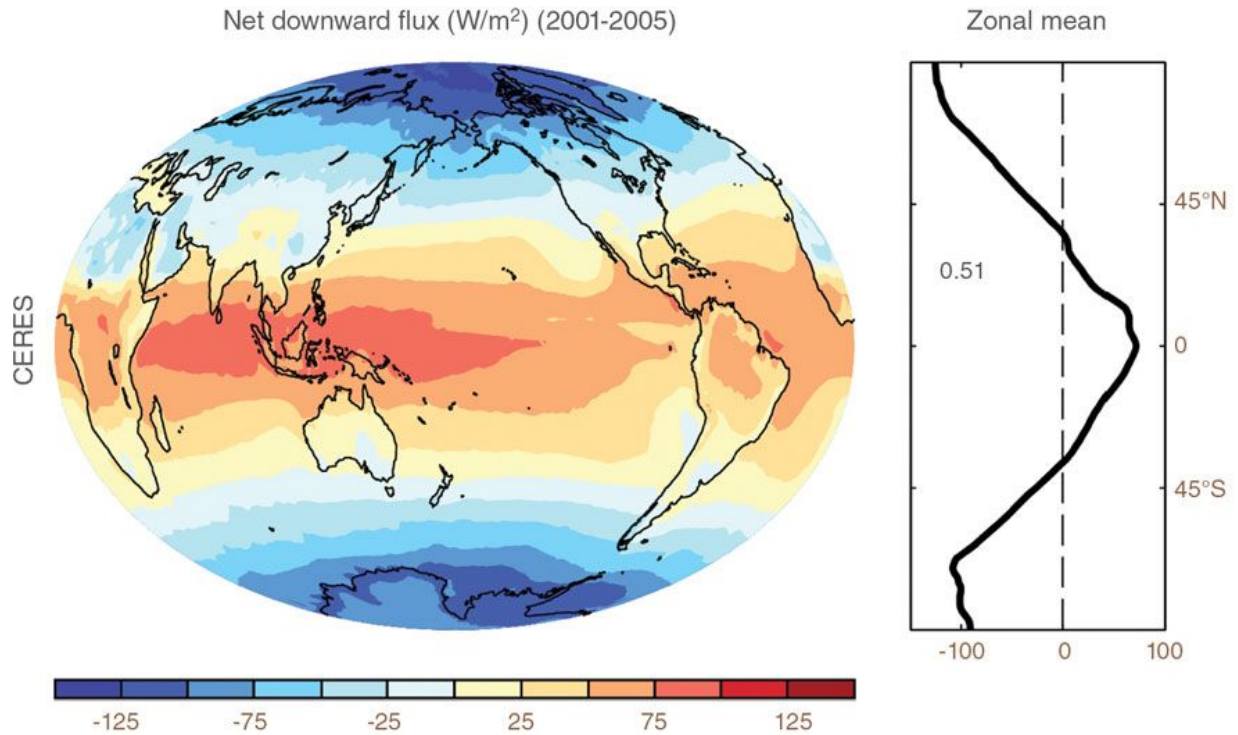
Why is Lake Erie unclouded, but not the other Great Lakes?

*Lake Erie is unclouded because it is covered in ice, and so air blowing over the lake doesn't pick up moisture like for the other lakes.*



Explain the elevated carbon dioxide levels in China.

*CO2 levels are elevated in China due to heavy use of fossil fuels.*



Interpret the information in the image and explain its impact on Earth's climate.

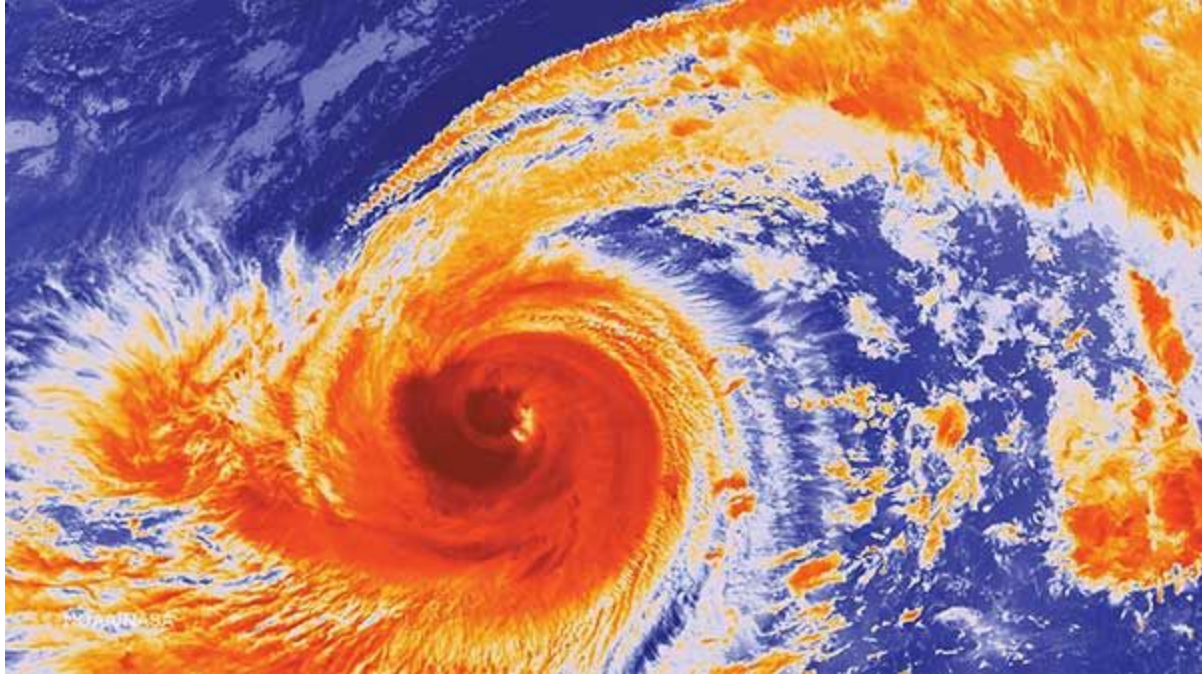
*Uneven heating of the earth*

*Transportation of heat from equator to poles by ocean ( $\frac{1}{3}$ ) and atmosphere ( $\frac{2}{3}$ )*

*Hadley, Ferrel, & Polar cells transfer heat away from the equator*

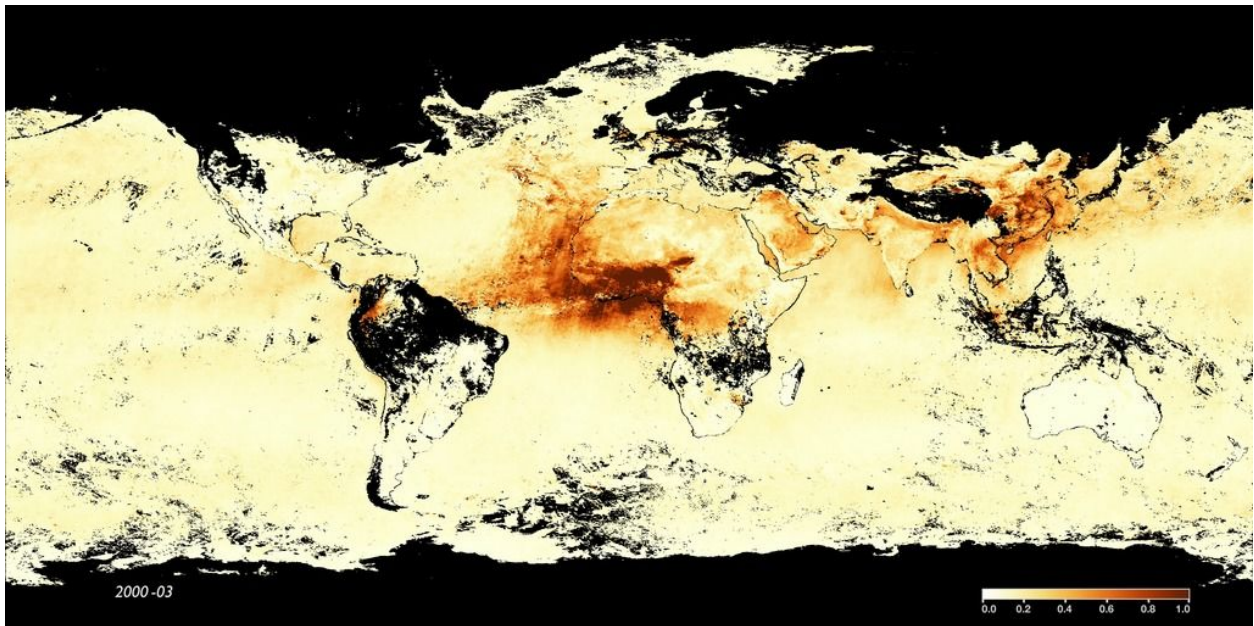
*Ocean current (ex Gulf Stream) heat transfer*





(tiebreaker) The above image, created from CrIS, shows what event off the coast of Japan?

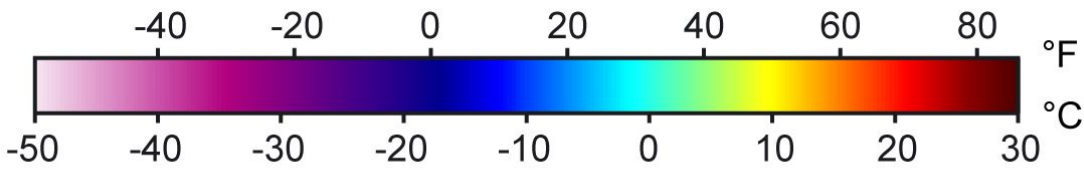
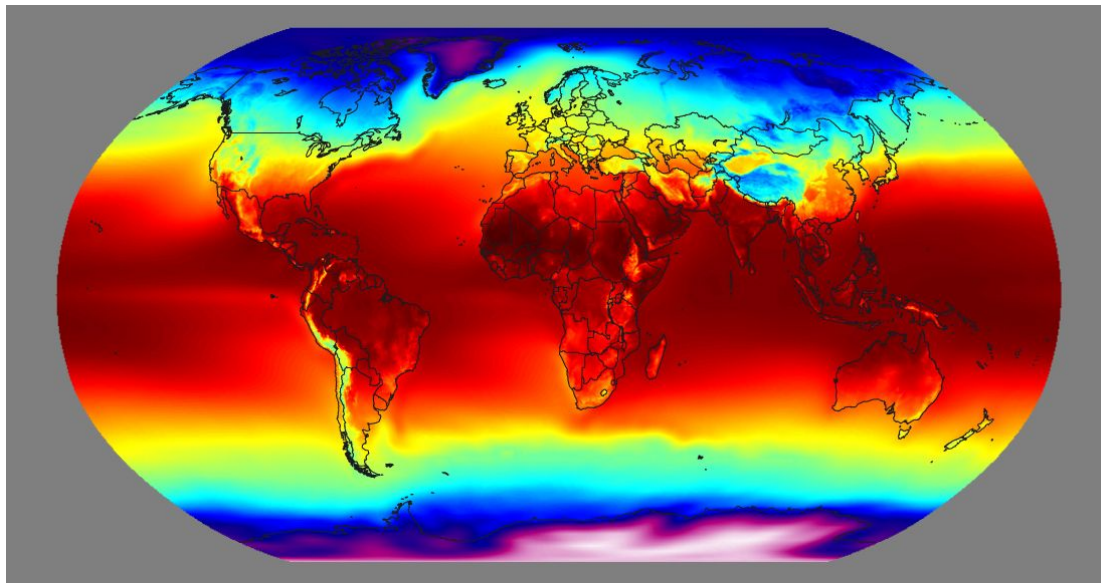
*Must say Typhoon. Not hurricane, as it is not in the Atlantic ocean.*



MODIS image of aerosol optical depth. Which regions will see the greatest health effects? What is indicated by the black pixels?

*West Africa, China.*

*Data could not be gathered by MODIS.*



## **Annual Mean Temperature**

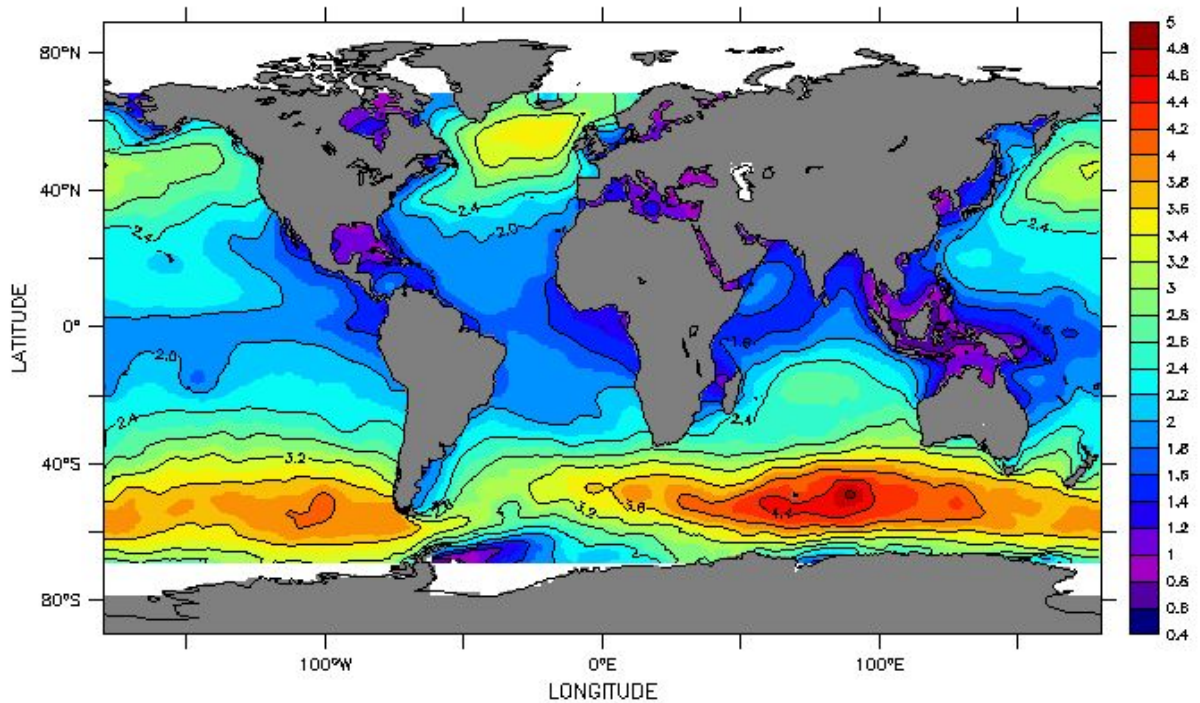
(tiebreaker) Why is Antarctica's average temperature colder than the Arctic?

*West Wind Drift current isolates Antarctica, Gulf Stream & North Atlantic current warm the Arctic. The size of the Antarctic continent vs the Arctic ocean, no mitigating temperature effects from ocean in the middle of Antarctica.*



AVISO

TIME : 12-FEB-2004 00 to 12-FEB-2005 00



Mean Significant wave height Jason-1 (m)

Which regions have the highest waves? What is the reason for this?

*Highest: Southern ocean, Northern Atlantic, Northern Pacific*

*Reason: West winds in southern ocean create strong current, long unobstructed path around earth (no continents in way) to impact waves. North Atlantic & Pacific location of the westerly wind belt.*