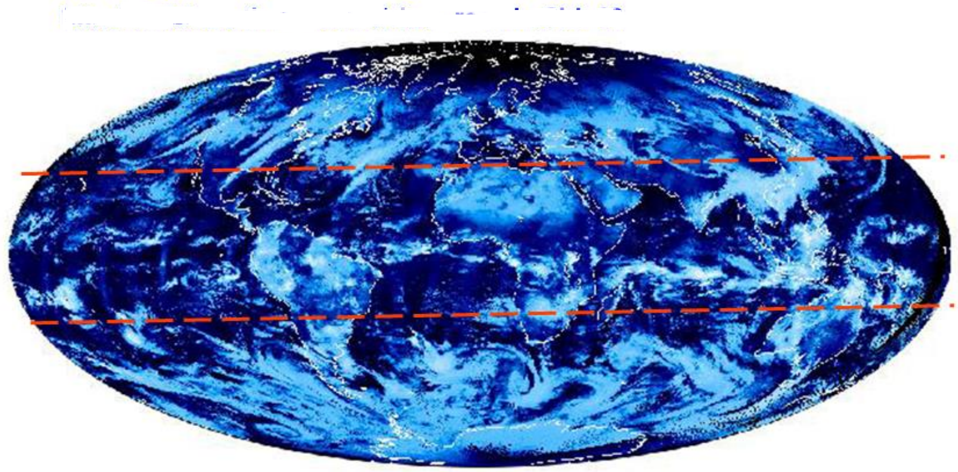
Name: Ian Hinds (19OCT2020)

GEOG 133 - Tropical Meteorology

Lab 1

Reflected Solar Radiance on The top of the Atmosphere on February 26, 2000 (24 hours – North Pole to South Pole)



https://visibleearth.nasa.gov/view.php?id=53857

Q1: Examine the image above and search for regions with high reflectivity in **tropical areas**. Discuss what you think are the main features responsible for high reflectance of solar Radiation. Use your best knowledge of geography and meteorology to answer this question. (4 points)

- **Cloud Coverage: Clouds absorb solar radiation, and are scattered throughout the tropics, especially over the ocean and rainforests (South America)**
- **Dry desert lands: The light-colored sand/surface reflects more sunlight than the ocean would, the Sahara Desert is the best example in this image**
- **Greenhouse Gases: These atmospheric gases absorb outgoing Longwave radiation and may result in higher reflectivity readings in some regions**

Q2: What are the main features that are responsible for high reflectance (albedo) of solar radiation in **high latitudes**? (4)

- **Glacier/Ice Coverage: This image is during Southern Hemispheric Summer, and a lot of solar reflectance is seen from Antarctica.**
- **Solar Declination: Overall there is more light ray spreading in the high latitudes during summer, this spreading contributes to high radiation reflectance in higher latitudes (Antarctica in this image)**

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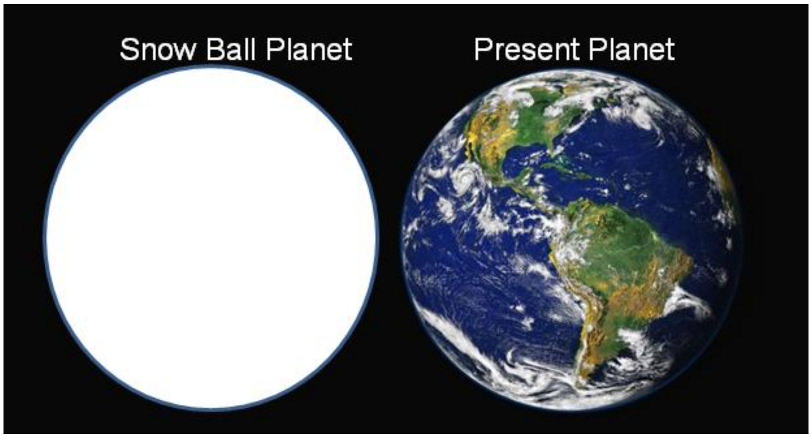

(Figure for Q3-Q5)

Q3: It has been hypothesized that Earth's surface might have been covered with ice and snow 950 million years ago. Paleomagnetic evidence suggests that there were few if any continents at high latitudes 600-700 million years ago. When most continents are close to the equator, the Earth is deprived of a mechanism that keeps the amount of carbon dioxide in the atmosphere above a critical level. If carbon dioxide in the atmosphere slowly dropped over millions of years due to a slow reduction in volcanic activity, global temperatures would drop and glaciers would cover low latitude continents. Discuss the snow ball theory using the concept of albedo and positive feedback. (4)

With an absence or extreme limitation of atmospheric Carbon Dioxide, terrestrial cooling experiences a positive feedback loop, and continues to cool because of the lack of CO2. As Ice coverage grows, Earth's albedo raises, and less solar radiation is absorbed by the surface, feeding the cooling positive feedback loop. The loop would be broken by a large increase of atmospheric CO2, from volcanic activity protruding through/heating the ice.

More on the snowball theory: http://math.ucr.edu/home/baez/earth.html

Q4: In which situation (snow ball planet or present planet) would an individual viewing Earth from space (with eyes similar to ours) see our planet brighter and why? (2)

- **Snowball earth would be much brighter, due to the extreme amounts of solar reflectance. Present earth absorbs more solar radiation.**

Q5: Global warming may cause droughts in one region and more rainfall in another. What could be the impact on the Earth's albedo if more convective clouds begin to form in the tropics? (4)

- **If more convective clouds form in the tropics, more solar radiation will be reflected out of the atmosphere than absorbed by the surface, cooling the tropics, due to the decrease of direct solar radiation. After some time, the convective cloud coverage would decrease because there would be cooler air near the surface of the tropics.**

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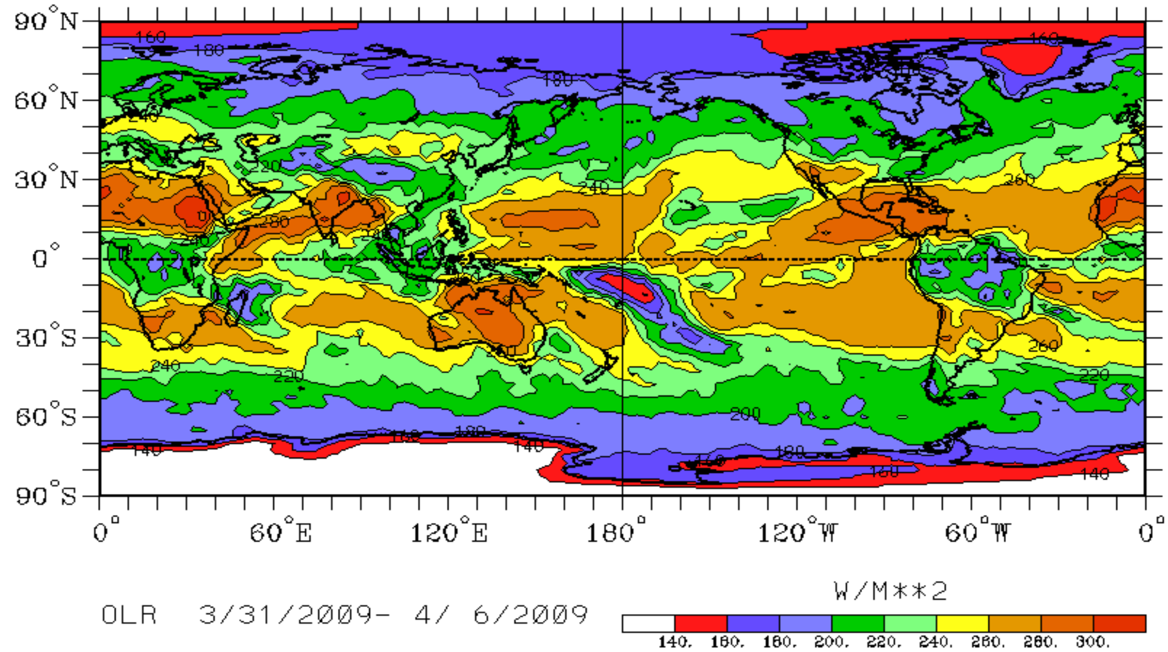
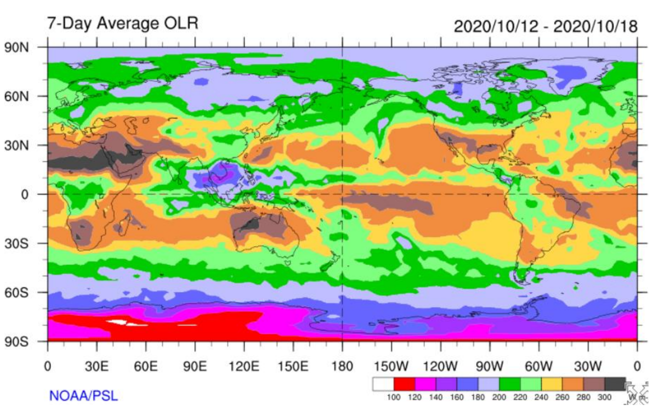
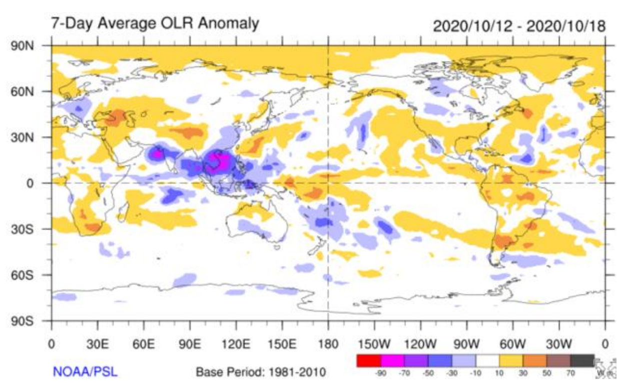


Q6: The figure above shows a map with average outgoing longwave radiation (OLR) emitted by Earth during March 31-April 6, 2009 and obtained by satellite sensors. Examine this map in tropical areas and discuss where convective activity was more intense. Likewise, indicate where it was suppressed or less intense. Base your answer on the concept of earth emission and the relationship between OLR and temperature. See PowerPoint titled "LECTURE 2 RADIATION" on GauchoSpace. (6)

In this figure, the majority of OLR is emitted from the tropical region. Areas with OLR measurements of greater than 200Wm^-2 represent convective cloud coverage or light-colored landscape (in this case desert regions). Convective activity is most intense in North Africa (Sahara Desert), Australia, The Indian Ocean, Gulf of Mexico, and Eastern Pacific. These regions are having extremes of drought and moisture, and emit surface-based OLR, and deep convective cloud OLR.

Q7: Go to the website: http://www.cdc.noaa.gov/map/clim/olr.shtml and download the most recent map of OLR (weekly) and the map of anomalies for the same week. Interpret the observed patterns on tropical regions. (4)
In Southeast Asia and the South Pacific, there is a much lower than average OLR measurement and is depicted by dark pink and purple colors. There are relatively higher than average measurements in desert and warmer than normal regions.





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Q8: The figure below shows the total solar radiation received at the top of the atmosphere in cal cm^{-2} day^{-1} for each latitude (vertical axis) and month of the year (horizontal axis). Using this figure compare the approximate solar radiation received at the top of the atmosphere in the city and on the month you were born (approximate latitude and month). Compare with the approximate solar radiation received at the top of the atmosphere on the same month at 10°S, the equator, 80°N and 80°S. (4)

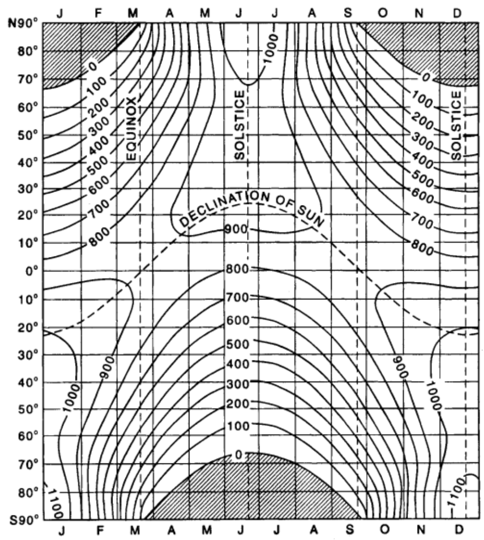

Figure 3.4 Total solar radiation received at the top of the atmosphere in cal cm^{-2} day^{-1}. Shaded areas indicate continuous darkness. Declination of sun indicates the location where the sun is in the zenith. From List (1958). Reproduced by permission of Smithsonian Institute Press, Boston

During the month of April, In southern California, there was approximately 900 cal cm^-2 day^-1 of solar radiation. At 10° S and the equator, there was less radiation, approximately 800 cal cm^-2 day^-1. At 80°N, there was much less radiation, a mean of 450 cal cm^-2 day^-1. At 80°S there was mostly an absence of solar radiation, because April is the close to the fall equinox in the southern hemisphere.

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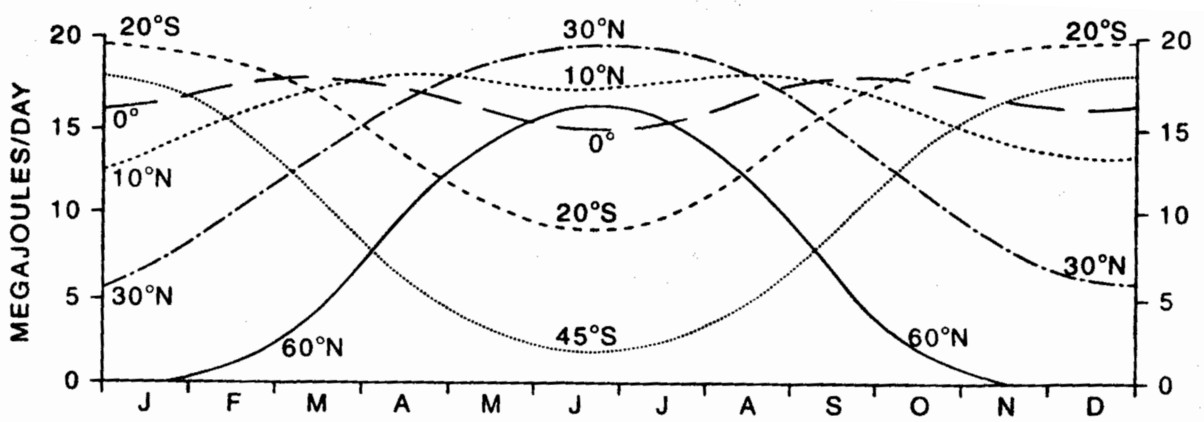

Figure 3.5 Solar radiation received at the earth's surface assuming an atmospheric transmission coefficient of 0.60. Source: List (1958, p. 421). Reproduced by permission of Smithsonian Institution Press.

Q9. The figure above shows the solar radiation received **AT EARTH'S SURFACE**, assuming a transmission coefficient (a coefficient that takes into account the extinction of the solar radiation through the atmosphere until it reaches the surface) of 0.60. Based on these curves discuss why "tropical latitudes, while never receiving the high daily maxima reached near the poles, receive relatively large amounts of insolation throughout the year". Hint: Use the concept that the total yearly radiation can be estimated by the integral below these curves (total area below the curves from January to December). (2)

Since the earth's sits on a tilted axis, the tropics remain in a more constant insolation region year-round. The poles will be tilted away from the sun in respective solstices; however, the tropics remain impacted by the sun's light rays year-round. The poles receive the maxima when a pole is tilted towards the sun and is relatively closer compared to other latitudes.

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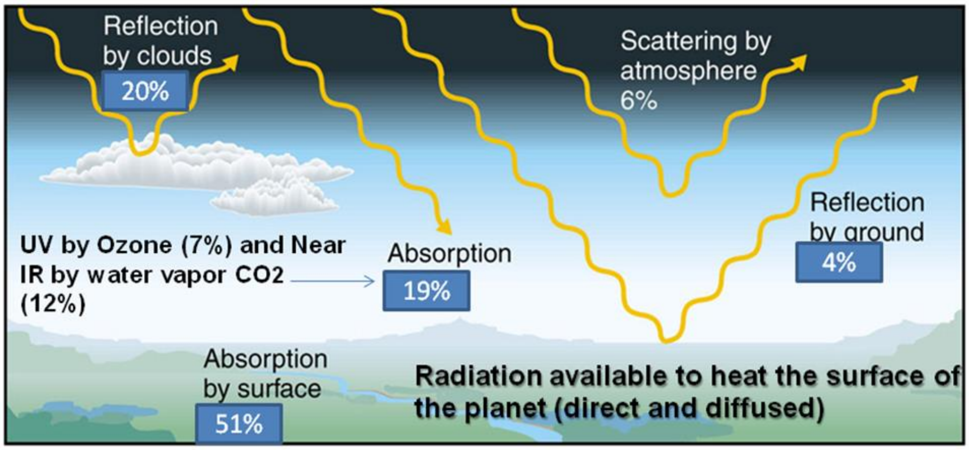

Q10. The diagram above shows the percentage of the solar radiation that is reflected by clouds, scattered and absorbed by the atmosphere, and reflected by the ground. This diagram represents the average values for the entire planet. Locally, the fractions shown above can be quite different. Using this diagram, qualitatively discuss what would be relative importance of each component for the total radiation available to heat the **SURFACE** over a) the Sahara desert, b) the Amazon forest during the wet season, c) the tropical South Pacific and d) the Amazon during the dry season during which large scale forest burning occurs. (8)

a) **The Sahara Desert, due to its light-colored surface, reflects more sunlight than it absorbs, and contributes to the 4% of radiation reflected by the ground. Due to a large amount of insolation, there is still percentages of energy that contribute to surface heating.**

b) **The Amazon forest, during the wet season, contributes to the 20% of cloud reflection, due to constant cloud coverage. There is more surface heating during this time because the clouds are reflecting OLR and IR to the surface.**

c) **The Amazon forest, during the dry season, contributes to the 51% radiation absorption by the surface. The vast extent of vegetation absorbs large amounts of solar energy. This example contributes to a large amount of surface heating.**

d) **When large scale burning in the Amazon occurs, large amounts of CO_2 are added into the atmosphere, contributing to the 19% of radiation absorption from greenhouse gases. Additionally, the smoke coverage contributes to the 20% of cloud-based reflection. Overall, this contributes to a positive feedback loop for surface heating.**

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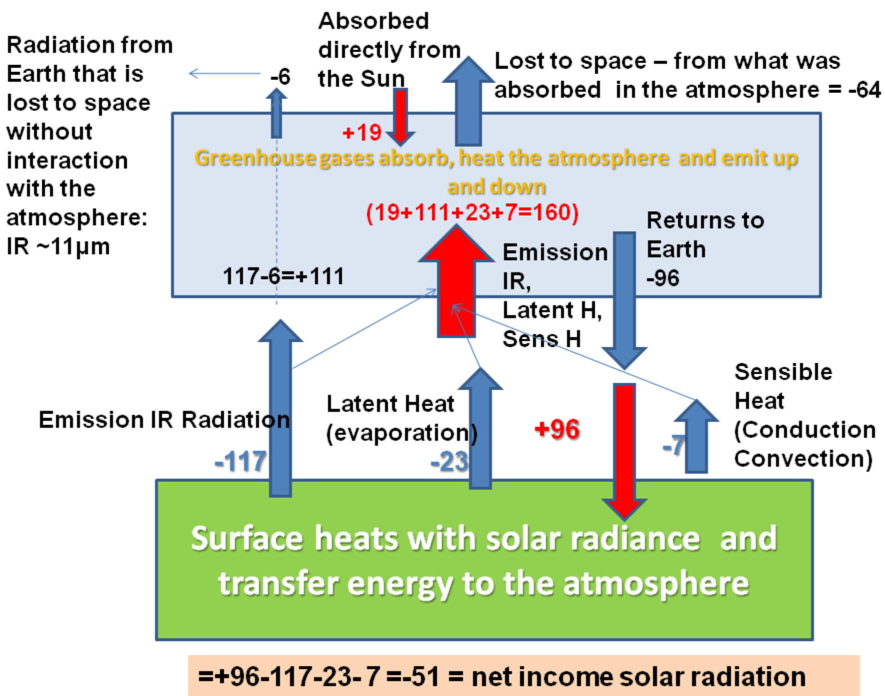

Q11. Use the diagram above and qualitatively discuss what would be the relative importance of each component of the budget over the surface to heat the **ATMOSPHERE** over a) the Sahara desert, b) the Amazon forest during the wet season, c) the tropical South Pacific and d) the Amazon during the dry season with large scale forest burning. (8)

a) **The Sahara desert emits a large amount of OLR, and largely contributes to the amount of OLR in the atmosphere.**

b) **The Amazon forest during a wet season contributes to a large amount of atmospheric heating to the cloud absorption of IR radiation.**

c) **The South pacific would contribute to atmospheric heating due to both cloud coverage (IR absorption), and water vapor emittance (greenhouse gas).**

d) **The Amazon forest during large scale burning emits large amounts of CO_2 into the atmosphere, which is a greenhouse gas that directly relates to IR heat storage in the atmosphere.**

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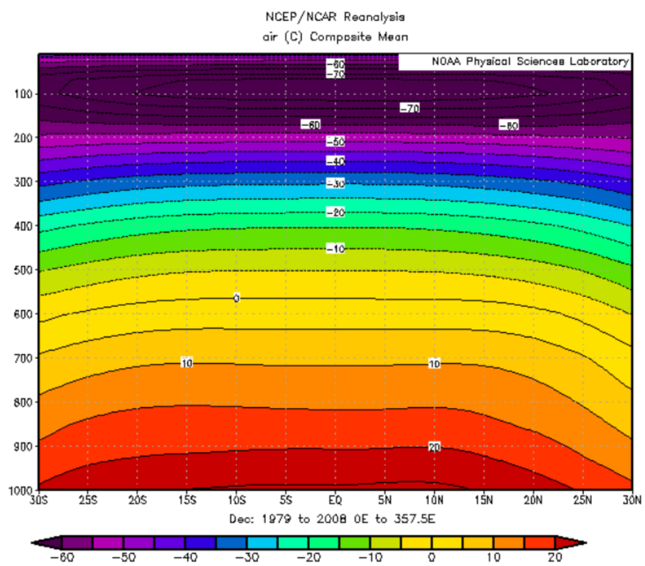
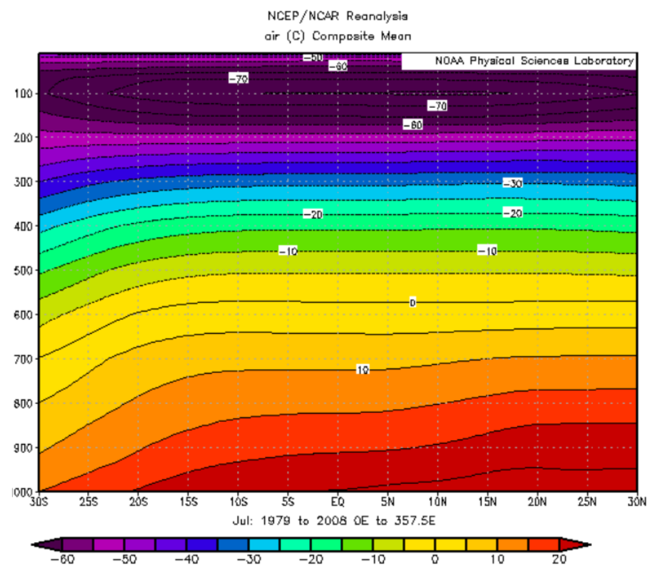
Q12. The objective of this exercise is to observe differences in surface temperature in low latitudes around the globe and compare with high latitudes. (8)

Go to the website:
http://www.esrl.noaa.gov/psd/cgi-bin/data/composites/printpage.pl

a)Plot a latitude-height climatology of surface temperature for December following the steps indicated below (see example shown on next page).

b) Repeat the same procedure but now for July. Click over figures and copy them to a document to help with the analysis. Compare plot (a) with (b) highlighting their main differences and similarities. Hint: look at a global map to identify the geographic features that are observed around the longitude chosen.





In Dec (left) and Jul (right) there is relatively similar air temperature variations overall. Both indicate a heating of the tropics since 1979. However, the differences in air temperature relative to latitude are inversed, which accounts for the 2 solstices, summer and winter. The Northern hemisphere would be warmer on average in July, and the Southern hemisphere would have lower heating values (the July image slopes upward to the right to indicate the heat variation per latitude).

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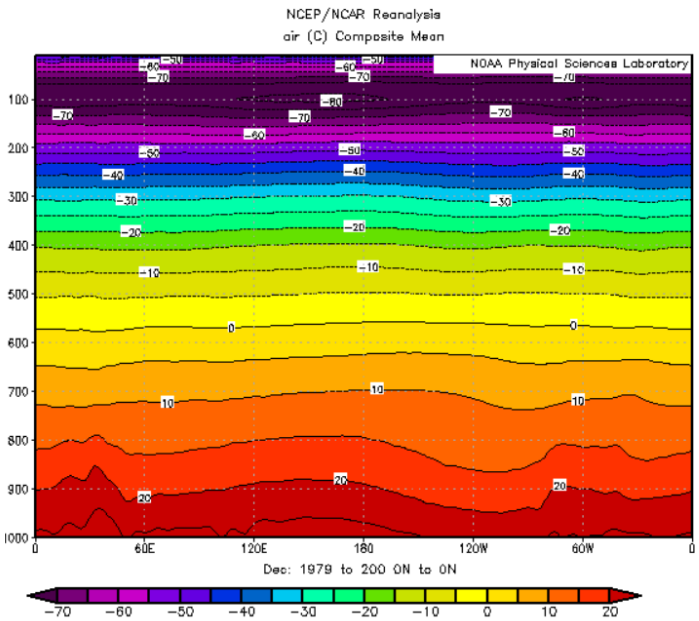
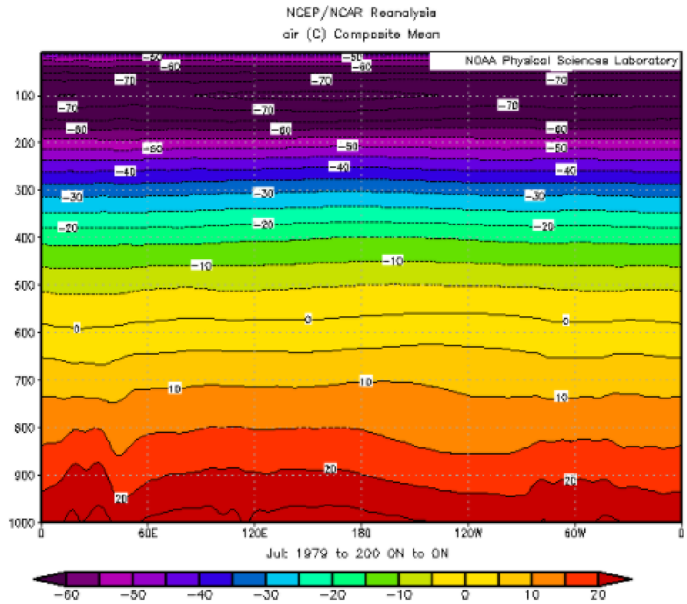
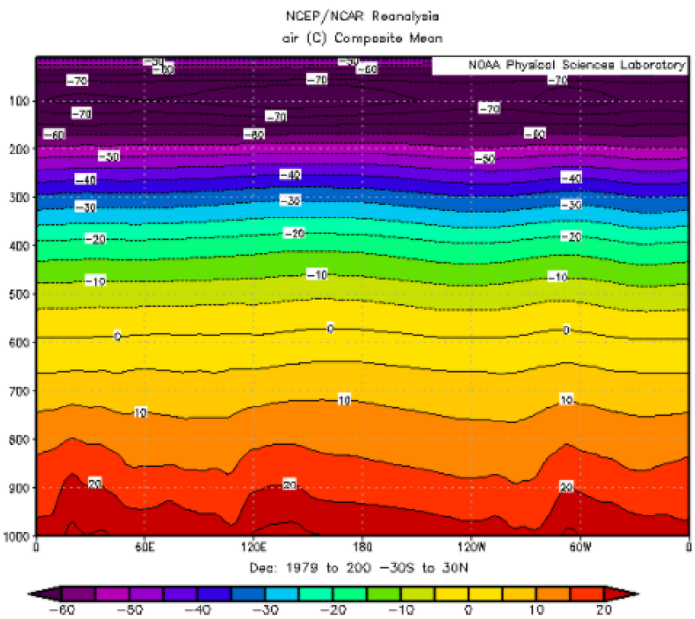
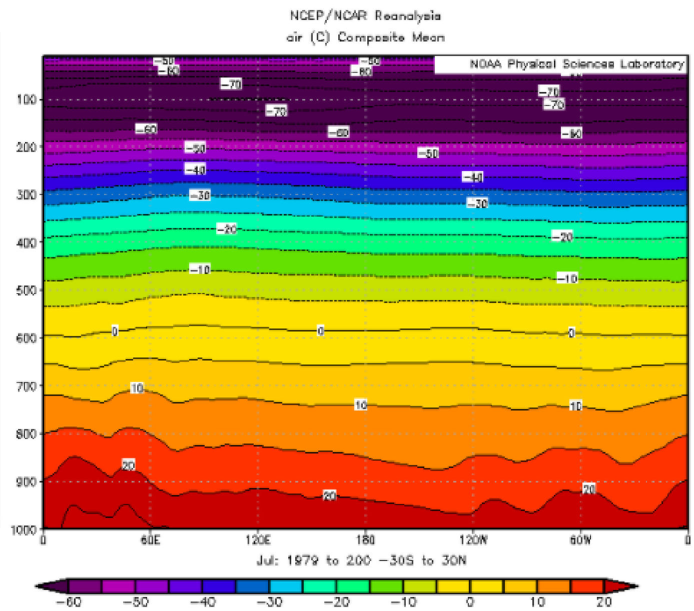
c) Repeat your plots (December and July) but now replacing “latitude by height” with “longitude by height”. Choose latitude 0º (equator).

e) Repeat the same procedure as in © but now choose a higher latitude (for example 30°N). Compare plot © with (d) and highlight the mean differences and similarities.









Plot C (top) has similar temperature variations per longitude throughout the year since the plots focus on the equator. Compared to Plot D (bottom), where there is more variation per longitude and per time of year. A similarity both plots share is that individual longitude values do not experience major fluctuations year-round.