

ATMO 336 -- Exam 3 120 total points including take-home essay

Name _____

The following equations and relationships may prove useful.

$$F_{d1} = F_{d2} \left(d_1^2 / d_2^2 \right) \text{ (Inverse Square law);}$$

$$\lambda_{\text{MAX}} = \frac{0.29 \times 10^4 \mu\text{mK}}{T} \text{ (Wien's Displacement law);}$$

$$E = \sigma T^4 \text{ (Stefan-Boltzmann law);}$$

$$T_{\text{SFC}} = \sqrt[4]{\frac{(1 - A) S_o}{4\sigma(1 - \epsilon/2)}} \text{ (one-level atmosphere, climate model);}$$

where d is distance, T is temperature, S_o = solar radiant flux (1368 Wm^{-2}), A=albedo, ϵ =emissivity and $\sigma = 5.67 \times 10^{-8} \text{ Wm}^{-2}\text{K}^{-4}$.

Multiple Choice Questions (Answer All 28 Questions) -- 3 Points Each

1. Our simple, one-layer atmospheric climate model was constructed from which combination of assumptions and laws?
(a) Radiative equilibrium and the Stefan-Boltzmann Law
(b) Convective equilibrium and Wien's Displacement Law
(c) Conservation of energy and the Inverse Square law
(d) Conservation of mass and Newton's Laws
2. The simple, one-layer atmospheric climate model indicates that surface warming would be caused by _____.
(a) increasing the albedo and decreasing the solar radiance while the atmospheric emissivity remains constant
(b) increasing the albedo and increasing the solar radiance while the atmospheric emissivity remains constant
(c) decreasing the albedo and increasing the atmospheric emissivity while the solar radiance remains constant
(d) decreasing the atmospheric emissivity and increasing the solar radiation while the albedo remains constant
3. The average distance between the Earth and the Sun is 150 million km. The average distance between Venus and the Sun is 108 million km. The solar radiant flux at the top of Earth's atmosphere is approximately _____ than the solar radiant flux on Venus.
(a) 2X smaller (b) 1.4X smaller (c) 1.4X larger (d) 2X larger

4. Which two gases are the greatest contributors to the greenhouse effect?
(a) carbon dioxide and methane (c) carbon dioxide and ozone
(b) carbon dioxide and CFCs (d) carbon dioxide and water vapor
5. Which process removes CO₂ from the atmosphere?
(a) photosynthesis (b) respiration/decay (c) burning fossil fuels (d) deforestation
6. The source of essentially all atmospheric O₂ on Earth is _____.
(a) volcanic emissions (c) disassociation of water
(b) photosynthesis (d) disassociation of stratospheric ozone
7. About half of all the sun's radiation energy that hits the planet Earth is absorbed by the oceans and objects on land.
(a) True (b) False
8. Most of the radiation energy that escapes from the planet Earth to outer space is emitted by _____.
(a) the Earth's surface (b) the Earth's interior (c) gases and clouds in the atmosphere
9. Which region on Earth emits the most radiation energy to space per square kilometer of surface area?
(a) Polar regions (b) Mid-latitude regions (c) Tropical regions
10. Most climate models predict that by the year 2100, the Earth's global average temperature will increase somewhere in the range of _____.
(a) (1 – 4)° C (b) (6 – 10)° C (c) (10 – 15)° C (d) (40 - 50)° C
11. As the global temperatures warm, sea surface temperatures will _____ and hurricanes should _____ in both frequency and intensity.
(a) cool; increase (b) cool; decrease (c) warm; increase (d) warm; decrease
12. If we assume that global warming does occur, the outcome (of the choices given) that we are most certain will occur is _____.
(a) the number of hurricanes will increase
(b) farming production in the U.S. will decline (too hot), but harvests in Canada and Russia will increase (longer growing season).
(c) tropical diseases will spread farther away from the equator
(d) sea level will rise

13. Since 1900, the global average surface temperature has _____.
(a) risen steadily to be about 0.6° C warmer today
(b) fluctuated up and down, but overall it is about 0.6° C warmer today
(c) fluctuated up and down, but overall it is about the same today
(d) declined steadily to be about 0.6° C cooler today
14. The most recent ice age cycles on Earth (over the last two million years) were most likely triggered by _____.
(a) changes in the positions of the continents
(b) decreases in the energy output of the Sun
(c) volcanic eruptions that eject massive amounts of aerosols into the atmosphere
(d) variations in Earth's orbit around the Sun
15. Ice core samples from Antarctica are used to estimate changes in surface temperatures and the atmospheric concentrations of carbon dioxide and methane. The data indicate that when temperatures are relatively warm, levels of carbon dioxide and methane are _____.
(a) relatively high (positive correlation)
(b) relatively low (negative correlation)
(c) sometimes high, sometimes low (no correlation)
16. A land bridge connecting Asia and Alaska formed during an _____ when sea levels were _____.
(a) interglacial warm period ; much lower than today
(b) interglacial warm period ; much higher than today
(c) ice age ; much lower than today
(d) ice age ; much higher than today
17. Which condition appears to be the most important seasonal factor that initiated Pleistocene glacial periods in the Northern Hemisphere?
(a) cooler summers (b) cooler winters (c) warmer summers (d) warmer winters
18. The last “snowball earth” episode is believed to have occurred around _____ years ago.
(a) 60,000 (b) 600,000 (c) 6 million (d) 600 million
19. The onset of snowball earth episodes and ice age glacial periods is an example of the _____ feedback.
(a) icehouse-greenhouse (b) ice-albedo (c) wind-evaporation (d) clouds-temperature

20. The most rapid rise increase in the concentration of carbon dioxide in the atmosphere occurred during which period?
(a) 1860-1900 (b) 1900 – 1940 (c) 1940 – 1980 (d) 1980 – today
21. The atmospheric greenhouse effect exists because _____.
(a) the atmosphere is opaque to both incoming solar radiation and outgoing infrared radiation
(b) the atmosphere is transparent to both incoming solar radiation and outgoing infrared radiation
(c) the atmosphere is transparent to incoming solar radiation but opaque to outgoing infrared radiation
(d) the atmosphere is opaque to incoming solar radiation but transparent to outgoing infrared radiation
22. The globally averaged albedo of the earth is presently closest to what value?
(a) 10% (b) 30% (c) 50% (d) 70%
23. All of the climate changes listed below have been observed over the past century EXCEPT which one.
(a) Sea level has risen between 4 and 10 inches
(b) The number of hurricanes worldwide has increased two fold
(c) Mountain glaciers have retreated worldwide
(d) The Northern Hemisphere growing season has lengthened at high latitudes
24. The warmest winters would be associated with _____.
(a) high obliquity (large axis tilt) and winter occurring at perihelion (earth closest to the sun)
(b) high obliquity (large axis tilt) and winter occurring at aphelion (earth farthest to the sun)
(c) low obliquity (small axis tilt) and winter occurring at aphelion (earth farthest to the sun)
(d) low obliquity (small axis tilt) and winter occurring at perihelion (earth closest to the sun)
25. The sun appears reddish orange at sunset instead of light yellow as at high noon because sunlight must travel a _____ distance through the atmosphere, which in turn leads to more selective scattering of _____ light.
(a) longer; blue (b) longer; red (c) shorter; blue (d) shorter; red
26. According to the NOVA video “Dimming of the Sun”, the atmospheric pollution layer can cut down the amount of sunlight that hits the Earth’s surface by approximately _____.
(a) 1% (b) 10% (c) 30% (d) 50%

27. According to the NOVA video “Dimming of the Sun”, the empirical evidence collected during the three days of grounded commercial flights that followed 9/11 show that **the absence of** jet contrails have _____.

- (a) a warming impact on maximum surface temperatures
- (b) a cooling impact on minimum surface temperatures
- (c) both a warming impact on maximum temperatures and a cooling impact on minimum temperatures
- (d) no significant impact on either maximum or minimum surface temperature

BECAUSE NONE OF THE ABOVE ANSWERS ARE CORRECT FOR THE ORIGINAL MISWORDED QUESTION, CREDIT WILL BE GIVEN FOR ALL ANSWERS

28. According to the NOVA video “Dimming of the Sun”, if we continue to decrease the level of particle pollutants while pumping more greenhouse gases into the atmosphere, temperatures could rise another _____ over current projections by mid-century (2050).

- (a) 0-1° C
- (b) **2-3° C**
- (c) 4-5° C
- (d) 6-7° C

Short Answer Questions (Answer 1 of the 3 questions) -- 6 Points Each

1. **Why are there seasons on Earth?** During the yearly seasonal cycle, the amount of solar radiation energy that strikes a given location on Earth changes each day. **List the two factors that determine the amount of solar radiation received at a given latitudinal location on a given day of the year.** (NOTE: The answer is not latitude; seasonal changes for the two factors are observed at all latitudes).

The tilt of the earth's rotation axis, so-called *obliquity*, is why there are seasons. Obliquity affects two factors that determine the total daily of radiation received at a location: the solar zenith angle (how high in the sky the sun is) and the length of daylight hours. These factors vary by calendar date.

2. In Tucson, the average high temperature on the spring equinox is 74° F, while the average high temperature on the fall equinox is 93° F. **Explain why the average high temperature is so much warmer on the fall equinox compared to the spring equinox. In your answer, make sure to compare and contrast the solar heating in Tucson on these two days.**

Both cities receive the same amount of daily incoming solar radiation at the spring and fall equinoxes. The difference in average high temperatures is related to differences in ground temperatures and temperatures aloft (high above the 2 m thermometer level). At the spring (fall) equinox, the ground and upper air temperature are cold (warm) as winter (summer) has just ending. Thus more (less) of solar radiation that is absorbed by the surface is needed to warm the ground and air aloft via convective heat transport.

3. Consider two cities located at the same latitude -- Bluetown and Redtown. Each city has the same "normal" low temperature of 28° F for the winter season. **What does "normal" mean?** Over the last 100 years, Bluetown recorded 500 winter days with low temperatures below 0° F, while Redtown recorded only 7 such days. **How can this be possible? What additional information about the two cities does this last piece of information tell you?**

Normal refers to the *average* daily low temperature for the winter, where the average is computed over many winters. Since Bluetown has the most below zero days, it must also have more days with minimums well above the normal value of 28°F. Redtown is different, with few days with minimum temperatures that are well above the normal. Bluetown's climate is highly variable from day to day and typifies a continental location far inland from any ocean; Redtown's climate exhibits little daily variability and typifies a coastal location close to an ocean.