TOP TEN THINGS TO STUDY FOR TEST #3

Test #3 is on Monday Nov 9, 2015

A Test #3 Study Session will be held on Wed Nov 4 @ 3:30 - ~5:00 pm in Bannister Tree-Ring Building, Room 110
Like Test #1, Test #2 will consist of 10 multiple choice questions. Some questions will be slight variations of the RQ questions, but other questions will be a bit harder than those in the RQ's and they will cover the material in class presentations, in addition to the reading you've been doing for the RQ's.

FOLLOWING ARE THE TOPICS & READINGS COVERED IN TEST #3 *(also see the D2L Checklist)*

- **Test #3 will cover Topics #8 through #11**
- The readings that accompany these topics are in **Chapters 2, (parts of Chapter 3) , Chapter 4, and 15 (pp 295-301) in the SGC-E-text,** (with a few additional pages in *Dire Predictions* listed on the weekly Checklist & Textbook Reading Schedule)
- **Self Check& Readiness Quizzes RQ-5 & RQ-6** will help you to focus on the concepts of these readings that are most important for you to know and understand.

Following are a few more pointers on things to be sure you have read or understood:

- **The Global Energy Balance Material in Class Notes** -- Review this all- important topic in Class Notes (pp 45 -51 and 107- top of 109) -- including the parts we covered just before the Midterm Exam (see Class Follow Up on Oct 12th). Be sure you understand the *right side of the equation:* **H+LE+G** in addition to the left side. We will address pp 50 + 51 in Class on Nov 4th.
- **Chapter 2** in SGC-E-Text on **Topic #9 Systems & Feedbacks** -- focus on the first part of the chapter and the items emphasized in Self-Test & RQ-5.
- **Chapter 3** in SGC-E-Text - section on **Climate Feedbacks** (pp 53-55)
- **Chapter 4** in SGC-E-Text goes into more detail than was covered in the presentations on **Topic #10 How Climate Works** but the items in the Top Ten below will help you focus on the main points for our class. Be sure you understand Figs 4-1, 4-2, 4-3, & have a good grasp of Earth-Sun Relationships and the seasonal climate differences, as in Fig 4-15 and 4-16.
- For **Ocean Circulation,** see the points emphasized in the lecture on Topic #10 and in RQ-6. The figure in the middle of Class Notes on p 64 that depicts Poleward Heat Transport is a key one.
- In **Chapter 15** in SGC focus on the first part that deals with climate changes of the past, pp 295-301.
- For **Topic #11 Natural Climatic Forcing:** review **astronomical forcing** and **solar forcing**, as addressed in the Topic #11 class, the corresponding Class Notes pages, and in Self Test and RQ-6. Also know the basics of **volcanism** that were covered in your reading and **Lesson 2 of the I-2 Tutorial Assignment.** (We'll cover more in Class on Nov 4th.) The I-2 Tutorial provides a good summary of Natural Climate Forcing .

ASSIGNMENTS:
G-3 Applying the Energy Balance Terms (p 53 in Class Notes)
I-1 Lesson 1 on CO_2 & the GH Effect (you should review it) and
I-2 Lesson 2 on Mother Nature's Influence <== a good Test #3 study aid!

ANIMATIONS: The following **animations** *(which are also linked in your D2L Checklist)* may be useful aids for enhancing your understanding of some of the processes you've been learning about

Animation of Earth-Sun Relationships that Define the Seasons Earth-Sun Relationships
Animations of Global Energy Balance Map Patterns *(these were shown during the Topic #10 presentations)*
Incoming Shortwave Radiation Outgoing Longwave Radiation Net Radiation (R net) Air Temperature

AND NOW THE TOP TEN:

On the TOPIC #8 - THE GLOBAL ENERGY BALANCE:

1. ENERGY BALANCE EQUATION: Know what each term (and symbol) in the equation balance equation means and what processes they represent, (e.g., **direct SW, diffuse SW, albedo, H, LE G,** etc. **Understand the overview of The Energy Balance and general "pathways" of SW and LW radiation summarized on p 47 in CLASS NOTES.** Have a good idea of how <u>much</u> relative energy is in each of the component pathways of the Global Energy Balance? To figure out how much energy is in a pathway see the <u>*width of the arrows*</u> in the diagram on p 45 in CLASS NOTES. (You should now have this page labeled with the proper symbols based on our Topic #8 class whiteboard activities.) Could you label the pathways in this figure with the symbol they represent as we did in class?

<u>*Specific Hints:*</u> (Several of them on this important topic!)

- Do you understand the concept of **albedo**? Which symbol is used for it? What kinds of surfaces on Earth have high albedos and what have low albedos? - Do you know which symbol (or symbols) refer to the **Greenhouse Effect** ? Which symbol represents incoming solar radiation on a **cloudy day?** Which symbol represents the way the Earth 'cools itself' by sending out to space **through the IR atmospheric window?**

Do you understand what the difference is between the LEFT side of the equation (the electromagnetic radiation balance part) and the RIGHT side of the equation (the thermal energy balance part, i.e. H, LE, & G). - Do you understand the difference between **Sensible Heat (H) and Latent Heat /(Energy (LE)** ?

Do you understand the **difference between these two terms??** $\sum_{LW}$ **vs.** **H**

<u>*This may help:*</u> *IR is electromagnetic radiation, it is not heat. Heat can only be sensed after IR is absorbed by the atoms and molecules in a substance and the atoms move faster. H represents the fast-moving atoms and molecules (like a warm wind, a rising current of hot air, or a warm ocean current like air or water). H can be sensed with a thermometer but IR cannot.*

Do you understand which segments of the phase change graph of H2O (from solid => liquid => gas) represent **Sensible Heat** and which represent **Latent Energy** ? (Class Notes p 48)

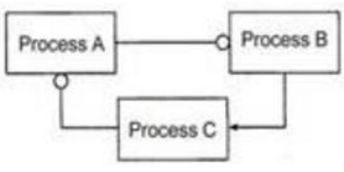
On TOPIC # 9 - SYSTEMS & FEEDBACKS

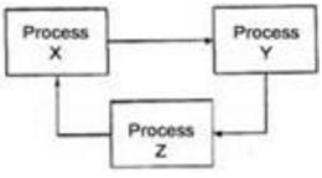
2. Understand the **concept of a SYSTEM,** including **COUPLINGS, FEEDBACK LOOPS** (both positive & negative feedback loops). Know how to recognize whether a coupling diagram is a **positive** or **negative coupling** and whether a **feedback loop** is a **positive or negative loop**. Understand that a negative feedback loop is "**self regulating"** and a positive feedback loop is **"self-amplifying."**

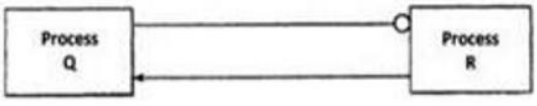
<u>*Specific Hint:*</u> Know which type of loop (positive or negative) is associated with a **STABLE equilibrium state** and which type is associated with an **UNSTABLE equilibrium state** and know which of these states is of greatest concern with respect to perturbations and forcings leading to global climate change.

Test your understanding:

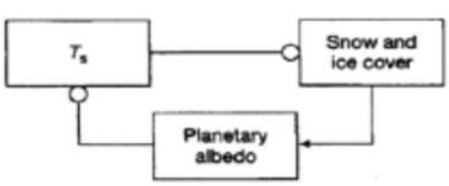
- Coupling A-B is negative, Coupling B-C is positive, the complete A-B-C Feedback Loop is positive. **Why?**
- The X-Y-Z Feedback Loop is also positive, even though it looks different than the A-B-C Loop. **Why?**
- Feedback Loop Q-R is negative and is also the only diagram shown having a stable equilibrium state. **Why?**

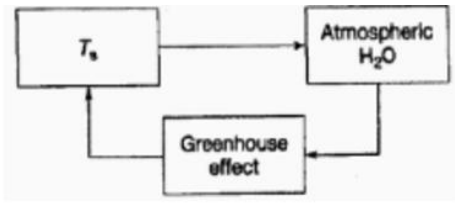


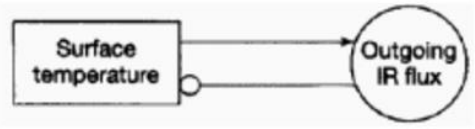




3**.** Over and above being able to identify the type of feedback or coupling by its diagram, be able to **reason your way through the actual physical processes** that are coupled together in the feedback loops shown below (and on pp 27 and 53-54 in SGC) to explain how they work.







Can you do the two feedback loops we did in groups on your own? (see the slides in the Class Follow Ups for Oct 28th and Nov 2nd (also p 57 in Class Notes).

On TOPIC # 10 - HOW CLIMATE WORKS *HINT: many of the points in the items below are succinctly summarized in the CHAPTER SUMMARY on SGC-E-Text (p. 82).*

4. Variations in Energy from the Sun (due to Seasons & the Earth-Sun Relationships) -- Understand what **causes the seasons** and know what the following terms mean: **solstice, equinox, axis tilt (obliquity), aphelion, perihelion (*see pp 59-60 in Class Notes*)** Understand how latitudinal differences in **solar insolation** arise due to Earth-Sun relationships and how the combination of solar **intensity** (depends on sun angle) and **duration** (depends on length of day) leads to seasonal and latitudinal differences in how much incoming shortwave solar radiation is received by the Earth (see SGC-E pp 68-70).

5. Global Latitudinal Energy Distribution and Net Radiation -- Understand why more solar energy is received and absorbed by the Earth's surface in the low latitudes (near the equator) and less in the high latitudes (near the poles.) Understand **Figure 4-2** in SGC (p 61) and p 61 in CLASS NOTES and be able to link it to the concepts of incoming solar shortwave radiation and outgoing terrestrial longwave radiation and how this leads to energy surpluses and deficits at different latitudes.

Specific Hint: Understand how the figure on the bottom of CLASS NOTES p 62 depicts **ways in which energy is transported poleward from surplus to deficit areas of the globe** and the **role that Hadley Cells, Rossby waves** and the transfer of energy from **H => LE => H through H_2O phase changes** plays in this transport of energy.

6. Atmospheric Circulation – Here are the basics to know on this topic: Due to the surplus of energy in the low latitudes, temperatures are warmer and the hot air at these latitudes **rises** (**convection).** The hot air holds lots of water vapor which leads to rainfall in the warm, humid tropical low latitudes. The convection that starts near the equator is part of a large convection cell (**Hadley Cell**). In the subtropics, around **30° N & S latitude,** the Hadley Cell circulates air back down to the surface as **subsidence** (sinking air) occur. Figure 4-3 in SGC p 61 illustrates this. The Hadley Cells are not able to transport surplus energy all the way to the cold, high latitudes of the polar regions. Instead, **Rossby Waves** circulate warm and cold air in the mid and high latitudes to balance out surplus and deficit regions (as in the "dishpan experiment").

Specific Hints:

-- On the small map on p 68 in Class Notes, be able to explain what climates A, B, C & D are like and how they are linked to different parts of the general circulation of the atmosphere.

-- One of the **indicators of a warming world** is *rising humidity in the atmosphere*.(see diagram on p 119 of Class Notes). Can you explain how this indicator is linked to Fig 4-25 in the SGC E-Text (Figure is also shown on p 65 in Class Notes)? See also **I-1 Lesson 1 Tutorial Slide 10 on Water Vapor**. Can you tie this into the **Water Vapor Feedback Loop** on p 53 in Chapt 3 of SGC (and also on p 55 in Class Notes? *Hopefully you have filled in the blank boxes in the Water Vapor Feedback Loop on p 55 with words when we covered this together in class! If not, do it now based on p 53 in SGC.*

7. Ocean Circulation *(based on how much we cover in class on Wednesday Nov 4th)* -- Understand how the *General Circulation of the Atmosphere* (Fig 4-11) drives the **circulation of the warm and cool surface ocean currents** (bottom of p. 64 in CLASS NOTES), especially via the large gyres in the oceans that are steered by winds. Know where the El Niño and La Niña ocean circulations occur and which one tends to be related to warmer temperatures worldwide when it dominates. (covered in the **I-2 Lesson 2 Tutorial on Mother Nature' Influence, Slide 16**.)

Specific Hint: Understand the **relative roles that ocean and atmospheric circulation play in transporting heat poleward** in the Northern Hemisphere to balance areas of energy surplus with areas of energy deficit. The question that will be asked will be related to how ocean circulation fits into either the figure on the bottom of **p 68** (sensible and latent heat transport) or the figure in the middle of **p 67** in CLASS NOTES (poleward transport in the N. Hemisphere).

On TOPIC # 11 - NATURAL CLIMATIC FORCING

8**. Astronomical Forcing** *(based on how much we cover in class on Wed Nov 4th)*-- Review the principles that govern the amount of solar energy received by the Earth due to Earth-Sun Orbital Relationships over long periods of geologic time (how much the Earth's axis tilts, how elliptical the shape of the Earth's orbit is, and the variation in the time of year when the Earth is closest to the Sun). **NOTE: Astronomical Forcing and the Milankovitch Cycles are covered in the I-2 Tutorial: Lesson 2 "Mother Nature's' Influence" Slides 8-12 <= be sure you study this tutorial!**

Specific Hint: Know that at present, the **Earth is farthest from the Sun in July** (not January) (as in Figure X & Y below -- shown also on p 67 in Class Notes) and what implications this has for the amount of solar insolation received by the Northern Hemisphere during its summer (Jun-Aug) compared to the Southern Hemisphere during *its* summer (Dec - Feb) . How might the climate of the Northern Hemisphere have been different in the past with the opposite configuration, i.e., when the Earth was farthest from the Sun during the *Southern Hemisphere's* summer and therefore closest during the Northern Hemisphere's summer (depicted in Figure Z below)?

Figure X

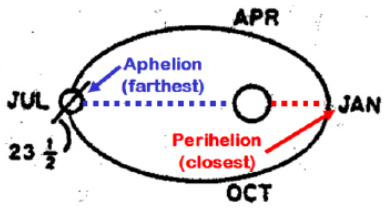


Figure Y

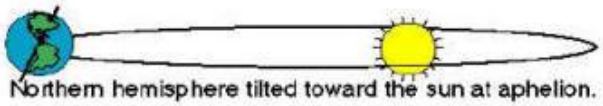
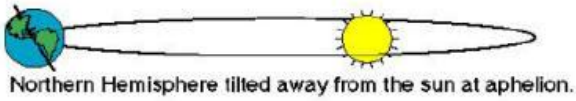


Figure Z



9. Solar Variability -- Know that periods of MORE sunspots = GREATER solar brightness and periods of FEWER sunspots = LESS solar brightness. Know where we are on the sunspot "cycle" right now (maximum or minimum). Know why the "Maunder Minimum" period is significant. (answer = dearth of sunspots and a possible factor in the Little Ice Age -- although there were also a lot of volcanic eruptions then). Know also that linking solar variability to temperature trends on Earth has been inconclusive and can't account for all of recent 20th century warming.

Specific Hint: Be able to present a reasoned response to the argument which states that the observed global warming of recent decades (e.g. since the1970s) -- is primarily due to natural solar variability, and is not human-caused. (See **Slides 21-26 in the Lesson 2 Tutorial)**

10. Volcanism and Climate -- Know **how volcanic eruptions can affect climate**, understand the process whereby this effect takes place and what the importance of **sulfate aerosols** is. Know how temperature at different levels in the atmosphere is affected by an eruption. **(See I-2 Tutorial: Lesson 2 "Mother Nature's' Influence" Slides 13-15 and Slide 18)** *(also to be covered in G-5 in class on Wednesday Nov 4th)*

Specific Hint: **Be able to tie all this into the ENERGY BALANCE equation (esp. incoming SW, and albedo).**