ATM 211 **Climate and Climate Change** **Fall, 2003**

Homework 3 assigned: Thurs Oct 23 due: Mon Nov 3

Readings for Energy balance theory of climate change:
KKC Chap 3(finish),
Climate Modeling Chapter (Chap 6 from KKC 2003) - available on class website
Lorius ice-core article - available on class website

KKC Chap 3:

1. *Greenhouse Effect:* (a) What is the main greenhouse gas in the atmosphere? (A greenhouse gas traps heat by absorbing infrared radiation emitted from the surface. What atmospheric gas does the most heat-trapping?) [2 pts] (b) Clouds are a major contributor to the greenhouse effect on Earth – true or false? [2 pts] (c) Clouds are a major contributor to the albedo of the Earth – true or false? [2 pts]

2. *Climate feedbacks:* State the three major feedbacks that affect the Earth's climate sensitivity. (Do not include the temperature-IR feedback.) For each one, state whether it is thought to be a positive or negative feedback and state the confidence of this knowledge as "high", "medium", or "low". [9 pts]

Name of Feedback	Sign of Feedback	Confidence Level

3. *Lorius et al. article:* Using information in the article to answer the following. Be sure to give appropriate units for all answers. (a) How large is the climate forcing associated with doubled CO_2? (b) What is the surface temperature change for doubled CO_2 for the case of no feedbacks? (c) What is the range of temperature changes for recent general circulation model experiments forced with doubled CO_2? (d) Lorius et al. discuss climate sensitivity in terms of the feedback factor, f, which is defined as $f = \Delta T_s/\Delta T_e$, where ΔT_s is the global surface temperature change associated with greenhouse gas forcing as deduced from the ice-core record and ΔT_e is the global surface temperature change that would occur if the climate had no feedbacks. What value of the feedback factor, f, do Lorius et al. deduce from their analysis? (e) What are the feedbacks that contribute to climate sensitivity in the analysis of Lorius et al? (f) These feedbacks play out over a time scale of 10-100 years, according to the article (see page 133, paragraph 3), yet Lorius et al. refer to these as "fast feedbacks". Why are they considered "fast feedbacks" in the context of this study? [18 pts]

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4. Consider the three cloud types shown in the table below. (a) Which lets through the most solar energy? [2 pts] (b) Which does the most heat-trapping? [2 pts] (c) Which cloud top is the lowest (closest to the surface)? [2 pts] (d) Which, if any, of these clouds are definitely composed of liquid water droplets, rather than ice crystals? [2 pts] (e) For Type 2, calculate E_{IN} and E_{OUT} (both in units of W/m^2). State whether this cloud type has a warming or cooling effect on the planet. [6 pts]

Cloud	Albedo	Cloud-top temperature (K)
Type 1	0.2	220
Type 2	0.4	250
Type 3	0.6	280

Define the following terms in the context of this course [2 pts each]:
climate sensitivity, greenhouse effect, lapse rate

Extra credit: Do problem 5 of the Critical-Thinking Problems at the end of Chap 3. [5 extra credit points]