Physical Climatology: Applied (GEO 4221-3)

Boundary Layer Climates

Final Exam: 17 December 1996

The final exam has four different sections:

- Specific questions on chapters 3, 4, 9, and Appendix 2 — 12 points
- Short answer questions (facts) — 6 points
- Process oriented questions to describe a phenomena — 12 points

Questions on simple non-vegetated and vegetated surfaces

1. *Climates of snow, ice*
   a) The albedo of wet snow is much lower than dry snow: how much and why?
   b) The net radiation maximum of a snow over is not at the surface, explain why.
   c) Describe all the surface energy balance terms of a wet snow pack during melt.

2. *Climates of desert and water*
   a) Characterize the energy balance of a sandy desert.
   b) What is the short-wave penetration depth for a tropical ocean: law & make graph.
   c) What percentage of Q* is dissipated in Q_E, Q_H and Q_A for an ocean surface (annual)?

3. *Climates of vegetation*
   a) What is zero-plane displacement? If h is the height of the top of a vegetation canopy, approximately what is the height of the zero-plane?
   b) What is a stomata and how does it control the energy and water balance of a leaf? Draw a simple diagram of the components of the radiation budget of a leaf.
   c) How and why does the climate beneath a forest canopy differ from that of a nearby area without vegetation?

4 *Air pollution in the boundary layer*
   a) What are the major processes in the life cycle of pollutants?
   b) Define lofting, fumigation, and fanning and describe the stability conditions in which they occur.
   c) During which times of the day and seasons of the year would we expect pollutant-trapping inversions to occur in Boulder or Denver? Why?

Short answer questions

5. What is the most important physical law you have learned in the lecture, describe.
6. How does wind speed increase with height under neutral atmospheric conditions.
7. Divide the total study hours you spend during this course by the total lecture hours; assume this ratio to be the Bowen ratio - what kind of climate does it describe (wet or dry)?
8. What is the SI-units for radiative flux density.
9. What is the value of the solar flux density (solar constant) at the top of the atmosphere.
10. What is the roughness lengths? Give values for snow, water, grass and forest.

Process oriented question

11. *Global Warming*

Lets assume all the sea ice cover in the Arctic and around Antarctica is vanished due to an increase in solar radiation in summer. Speculate how this would effect the global climate in general, and the climate in the polar regions in particular.

12. *Earth-atmosphere interaction*

Lets assume an increase in temperature by 5° C on an annual basis. Speculate on the resulting climate change for Boulder due to the temperature increase, including cloudiness, storm frequencies, snow amount in the Rocky Mountains, and resulting vegetation change. The graph below shows the mean monthly temperature and precipitation for Boulder based on a 30-year time series. Discuss your speculative climate change in relation to the values given in the graph.