The University of British Columbia
Christen / GEOB 300, Section 101 / December 11, 2009
Microscale Weather and Climate

Sessional Examination

Name	Student #	
Signature	*for marking only* Score	Grade

Write answers directly into space provided. Additional pages are not allowed and will not be marked. There are 10 pages. Make sure you have all. Scores are indicated in square brackets. The total score is 100 (Part A: 24, Part B: 16, Part C: 20, Part D: 40). Read all instructions in the beginning of each part carefully. Time allowed: 90 min.

Rules governing formal examinations:

1. Each candidate must be prepared to produce, upon request, a UBCcard for identification;
2. Candidates are not permitted to ask questions of the invigilators, except in cases of supposed errors or ambiguities in examination questions;
3. No candidate shall be permitted to enter the examination room after the expiration of one-half hour from the scheduled starting time, or to leave during the first half hour of the examination;
4. Candidates suspected of any of the following, or similar, dishonest practices shall be immediately dismissed from the examination and shall be liable to disciplinary action;
    - Having at the place of writing any books, papers or memoranda, calculators, computers, sound or image players/recorders/transmitters (including telephones), or other memory aid devices, other than those authorized by the examiners;
    - Speaking or communicating with other candidates;
    - Purposely exposing written papers to the view of other candidates or imaging devices. The plea of accident or forgetfulness shall not be received;
5. Candidates must not destroy or mutilate any examination material; must hand in all examination papers; and must not take any examination material from the examination room without permission of the invigilator; and
6. Candidates must follow any additional examination rules or directions communicated by the instructor or invigilator.

Part A: Multiple choice questions

Solve <u>all</u> multiple choice questions. Check only one box per question. If you check none or multiple boxes, your answer will be invalid. Total: 24 marks (24% of exam).

1. Which term is part of the surface energy balance? [2]

   ◯ Ri ◯ Q_H ◯ NEE ◯ u_*

2. What is the most dominant heat transfer mechanism in the planetary boundary layer? [2]

   ◯ Conduction ◯ Coalescence ◯ Convection ◯ Convergence

3. What is the derived SI unit for a stress? [2]

   ◯ Pa ◯ $\mathrm{N\,m^{-2}\,s^{-1}}$ ◯ $\mathrm{W\,m^{-2}\,s^{-1}}$ ◯ $\mathrm{J\,m^{-2}}$

4. What Bowen ratio β do you expect for a surface that experiences the 'Oasis-effect'? [2]

   ◯ $\beta = 0$ ◯ $0 > \beta > 1$ ◯ $\beta > 1$ ◯ $\beta < 0$

5. Without performing a calculation, identify the most reasonable number that describes solar declination δ for today, noon (December 11, 2009, 12:00 PST)? [2]

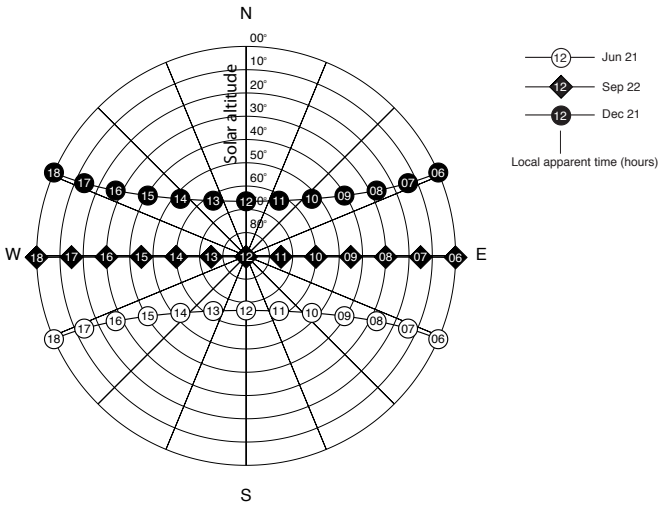
   ◯ $\delta = -22.9°$ ◯ $\delta = +23.5°$ ◯ $\delta = +56.4°$ ◯ $\delta = 0°$

6. Which term describes the standard deviation of the wind component u? [2]

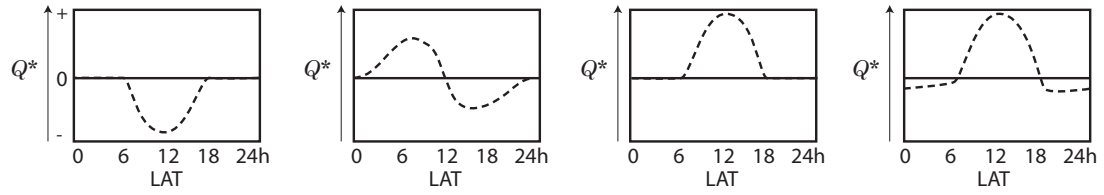
   ◯ $\overline{\left(\sqrt{u'}\right)}$ ◯ $\sqrt{\overline{u'^2}}$ ◯ $\sqrt{\overline{u'}^2}$ ◯ $\sqrt{\overline{u}^2}$

7. Determine the latitude where the sun-path diagram shown below is valid for. [2]

   ◯ 90°N ◯ 23.5°S ◯ 0°N/S ◯ 66.5°S

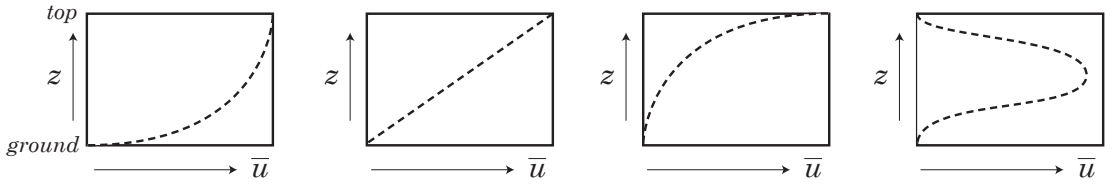


8. How does net all-wave radiation Q^* change with time over a 24h period? Assume clear skies and a grass surface on UBC Totem Field during our first field visit. [2]



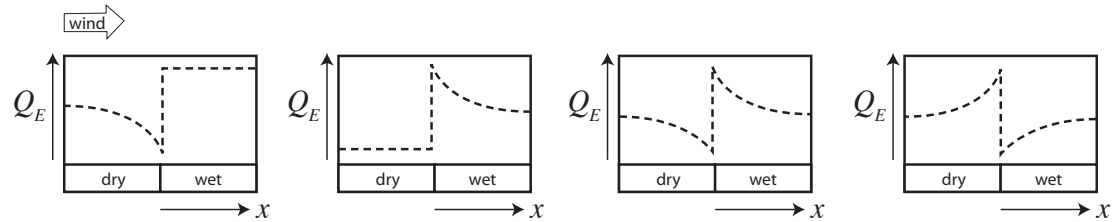
○ ○ ○ ○

9. How does mean wind speed $\overline{u}$ change with height z within an ideal, uniform crop canopy? *top* refers to the top of the crop canopy. [2]



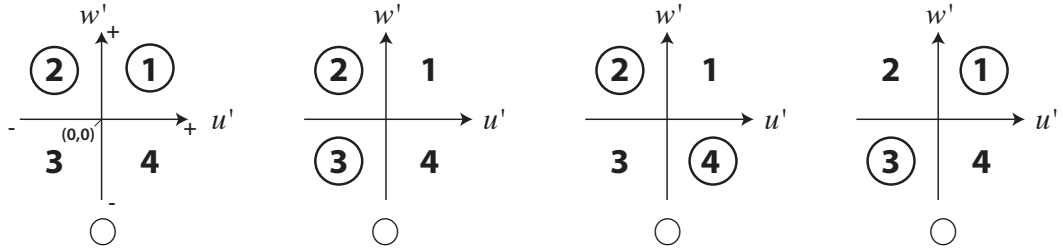
○ ○ ○ ○

10. How does Q_E at a given height above the surface change as an air mass flows first over a dry patch then over a wet patch? Wind is blowing from left to right, and x is the 'fectch'. [2]



○ ○ ○ ○

11. In the surface layer, which two quadrants (combinations) of the joint probability distribution between u' and w' are the two most likely ones to occur? [2]



○ ○ ○ ○

12. Which statement on turbulent kinetic energy (TKE) is generally true in the surface layer, if everything else is kept constant? [2]

○ TKE decreases with increasing wind speed.
○ TKE decreases with increasing surface roughness.
○ TKE decreases with increasing net all-wave radiation.
○ TKE decreases with increasing stability.

Part B: One-word questions

Answer all of the following short answer questions in one or a few words, or provide a formula. Total: 16 marks (16% of exam).

1. What is the name of the ratio $K_{\uparrow}/K_{\downarrow}$? [2]

2. List a parameter / number of your choice that can be used to describe dynamic stability of the atmopshere. [2]

3. What is the name of the process where large mixed-layer thermals penetrate some distance up into the stable atmosphere aloft the inversion that caps the mixed layer, where they are repelled and returned (which results in a downward flux of Q_H)? [2]

4. Name the approach that we used to directly measure the sensible heat flux density Q_H by tracking vertical wind fluctuations w' and fluctuations of temperature T' on UBC Totem Field. [2]

5. Name an approach or instrument to measure transpiration of a tree. [2]

6. Name the region half-way up the slopes in a valley that show typically the highest temperatures during night? [2]

7. What do we call the precipitation in a forest or crop canopy that remains on the surface of the plant (leaves etc.) and that does not reach the ground? [2]

8. What do we call the energy needed to warm up one kilogram of a material by one Kelvin? [2]

Part C: Short answer questions

Answer only four out of these six short answer questions. Note: the first five questions with any answer written into the space provided will be marked, hence solving more than four questions is not to your advantage. Total: 20 marks (20% of exam).

1. Briefly explain the difference between a *black body* and a *grey body* in the context of radiative theory. [5]

2. Briefly explain the difference between *water deficit* and *potential evapotranspiration.* [5]

3. Briefly explain the difference between a *sweep* and an *ejection.* [5]

4. Briefly explain the difference between an *autotrophic respiration* and a *heterotrophic respiration.*[5]

5. Briefly explain the difference between a *histogram* and a *hysteresis*. [5]

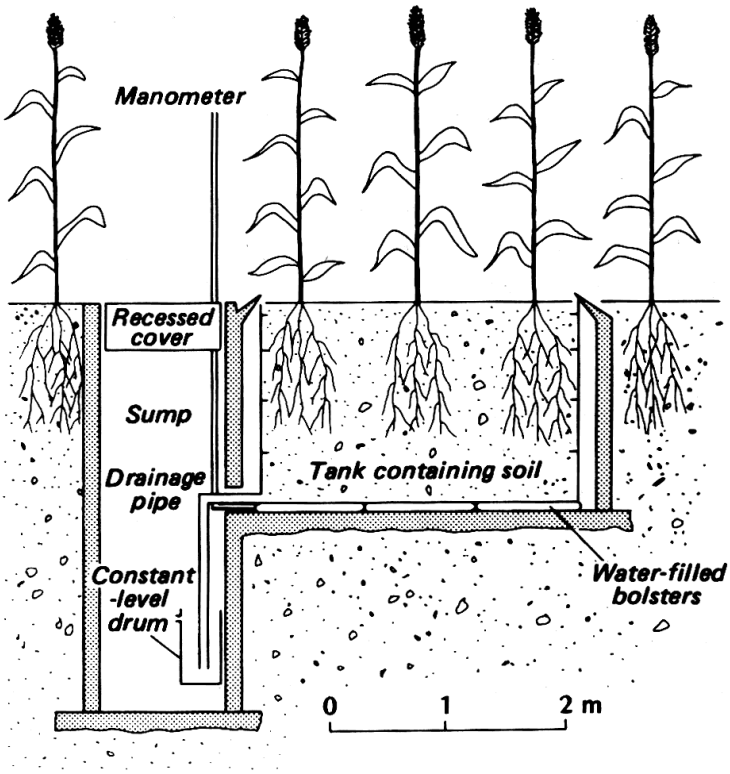
6. Briefly explain the difference between the *roughness length* z_0 and the *mixing length* ℓ. [5]

Part D: Problem questions

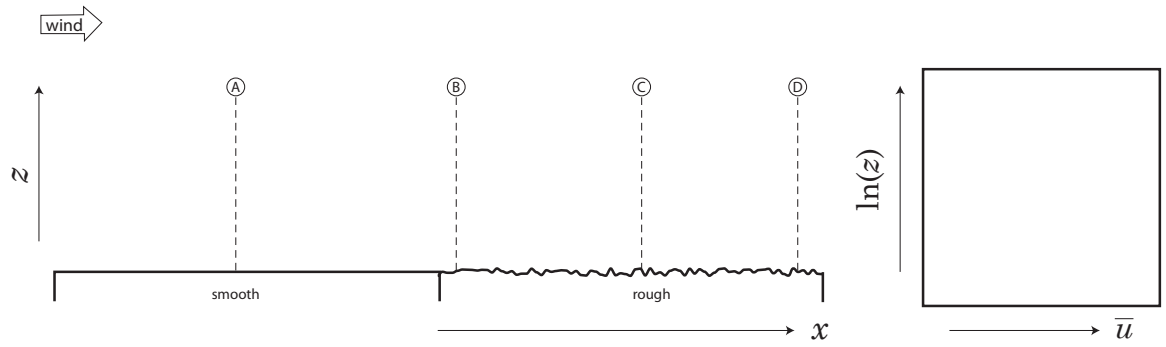
Answer only four out of the following six questions and provide explanations of your interpretation steps. Again: the first four questions with any answer written into the space provided will be marked, hence solving more than four questions is not to your advantage. Total: 40 marks (40% of exam).

1. Under the same atmospheric conditions, above which surface do you expect to measure a higher net all-wave radiation Q^* during day: (1) irrigated crop-field *or* (2) dry bare soil. Provide at least two arguments that support your answer. [10]

2. The figure below shows a schematic cross-section through an instrument that is commonly used in agrometeorological research. (a) What is the name of this instrument? (b) What is it designed for? (c) Explain its operating principle. [10]

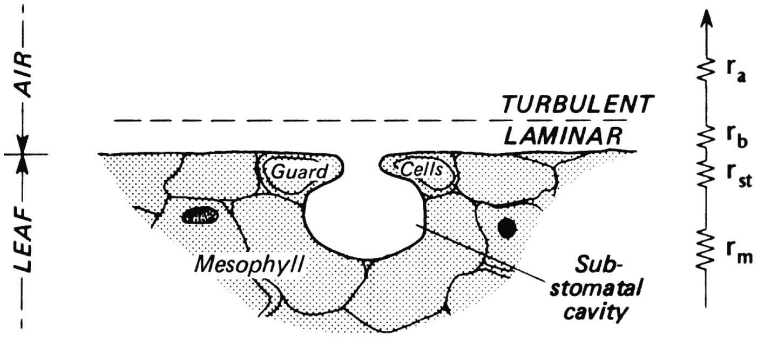


3. Assume a condition where wind blows from left to right from a smooth to a rough surface patch. (a) Where (A, B, C, or D) do you expect surface shear-stress τ_0 to be largest? Explain why. (b) Sketch into the schematic cross-section how you would expect the depth of the internal boundary layer over the rough patch δ to grow with fetch x. (c) Draw and label the vertical profiles of mean wind speed $\overline{u}$ at positions A, B, C and D into the graph to the right. Note that the y-axis is given as the logarithm of the height above surface z. [10]



4. Turbulence is an important feature of the atmospheric flow near the surface. Give an account of all processes that create turbulence (production) in the lower atmosphere. Name the process that leads to a decay of turbulent motions, and explain what happens to the kinetic energy of the turbulent flow in this process? [10]

5. The following figure shows a schematic cross-section through the underside of a leaf. (a) Name r_a, r_b, r_{st} and r_m. (b) Separately determine in the table (i.e. check boxes) which of r_a, r_b, r_{st} and r_m are relevant for the exchange of sensible heat, water and carbon-dioxide between leaf and atmosphere. (c) Comment on the direction of the carbon-dioxide flux and the water vapour flux between leaf and atmosphere for a typical daytime situation. [10]



	r_a	r_b	r_{st}	r_m
Sensible heat	☐	☐	☐	☐
Water vapour	☐	☐	☐	☐
Carbon-dioxide	☐	☐	☐	☐

6. The satellite image shown below illustrates the arrangement of boundary-layer clouds in 'streets' and/or regular spacing over Southeast Australia during day (Image Source: Aqua - MODIS platform, NASA). Explain why those regular patterns emerge. You might draw a sketch to support your argumentation. [10]

[End of Exam - 10 pages]