The University of British Columbia
Christen / GEOB 300 / October 11, 2013

Midterm 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 8 pages. Make sure you have all. Marks are indicated in square brackets. Total possible marks are 100 (Part A: 32, Part B: 28, Part C: 40). Time allowed - 50 min.

Part A: Multiple choice questions

Solve all multiple choice questions. Check only one box per question. If you check none or multiple boxes, your answer will be invalid.

1. Name the part of the atmosphere that does not experience a diurnal variation in temperature, humidity and stability. [4]

   ○ Boundary-layer ○ Troposphere ○ Free atmosphere ○ Mixed layer

2. Assume that all of the following surfaces receive the same incoming radiative fluxes. Which surface will experience the highest amplitude in surface temperature T_0 over the course of a day? [4]

   ○ White concrete ○ Black styrofoam ○ Black concrete ○ White styrofoam

3. Which thermal property has the units $\mathrm{W\,m^{-1}\,K^{-1}}$? [4]

   ○ Thermal diffusivity ○ Thermal conductivity ○ Thermal admittance ○ Thermal capacity

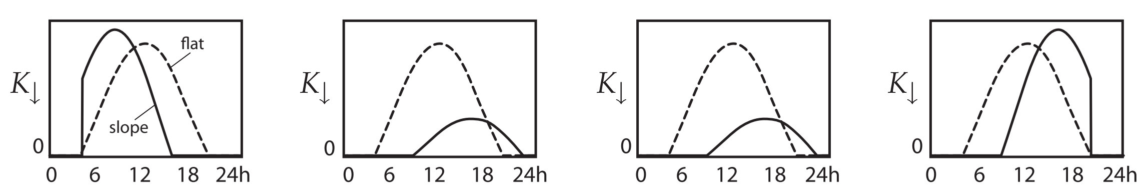
4. Which process is not relevant for energy transfer in micrometeorology and microclimatology? [4]

   ○ Interference ○ Convection ○ Radiation ○ Conduction

5. Where do you expect the ratio $S/K_{\downarrow}$ (i.e. of direct-beam irradiance S to total irradiance $K_{\downarrow}$) to be highest [4]?

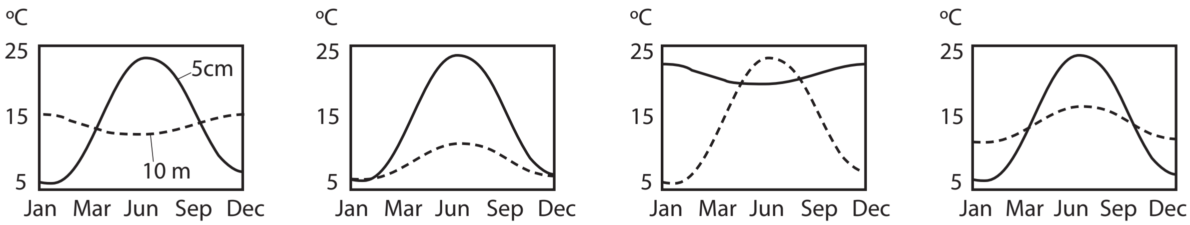
   ○ South East Asia ○ Coastal BC ○ Sahara desert ○ On the Moon

6. Assume a clear-sky day in Vancouver. How do you expect short-wave irradiance $K_{\downarrow}$ on a West-facing slope (45° slope angle) to change over the course of a day relative to $K_{\downarrow}$ on flat surface (dashed line)? [4]



   ○ ○ ○ ○

7. Which of the following graphs show realistic soil temperature traces at a depth of 5 cm (full line) and at a depth of 10 m (dashed line) over the year in a typical soil in Coastal British Columbia? [4]



○ ○ ○ ○

8. Which of the following tables show realistic annual totals of the radiation flux densities for a grassland site in Vancouver (e.g. Totem Field on UBC campus)? [4]

$K_\downarrow = 4.6$ GJ m^{-2} y^{-1}	$K_\downarrow = 11.4$ GJ m^{-2} y^{-1}	$K_\downarrow = 10.1$ GJ m^{-2} y^{-1}	$K_\downarrow = 4.6$ GJ m^{-2} y^{-1}
$K_\uparrow = 0.8$ GJ m^{-2} y^{-1}	$K_\uparrow = 0.8$ GJ m^{-2} y^{-1}	$K_\uparrow = 11.4$ GJ m^{-2} y^{-1}	$K_\uparrow = 0.8$ GJ m^{-2} y^{-1}
$L_\downarrow = 11.4$ GJ m^{-2} y^{-1}	$L_\downarrow = 10.1$ GJ m^{-2} y^{-1}	$L_\downarrow = 0.8$ GJ m^{-2} y^{-1}	$L_\downarrow = 10.1$ GJ m^{-2} y^{-1}
$L_\uparrow = 10.1$ GJ m^{-2} y^{-1}	$L_\uparrow = 4.6$ GJ m^{-2} y^{-1}	$L_\uparrow = 4.6$ GJ m^{-2} y^{-1}	$L_\uparrow = 11.4$ GJ m^{-2} y^{-1}
○	○	○	○

Part B: Short answer questions.

Answer only four out of these five short answer questions. Note: 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.

1. Briefly explain the difference between *near infrared radiation* (NIR) and *thermal infrared radiation* (TIR). [7]

2. Briefly explain the difference between *heat capacity* and *heat flux density*. [7]

3. Briefly explain the difference between *Beer's law* and *Fourier's law* in a homogeneous medium. [7]

4. Briefly explain the difference between *solar declination* δ and *solar altitude* β. [7]

5. Assume a homogeneous layer of soil between the surface and 10 cm depth. At a given time, Q_G at the surface is 120 W m^{-2} while at 10 cm depth $Q_G = 20$ W m^{-2}. The soil layer has a heat capacity of $C = 1\,\mathrm{MJ\,m^{-3}\,K^{-1}}$. Assuming those conditions remain the same, in how many seconds has is the soil layer warmed up by 1 K? [7]

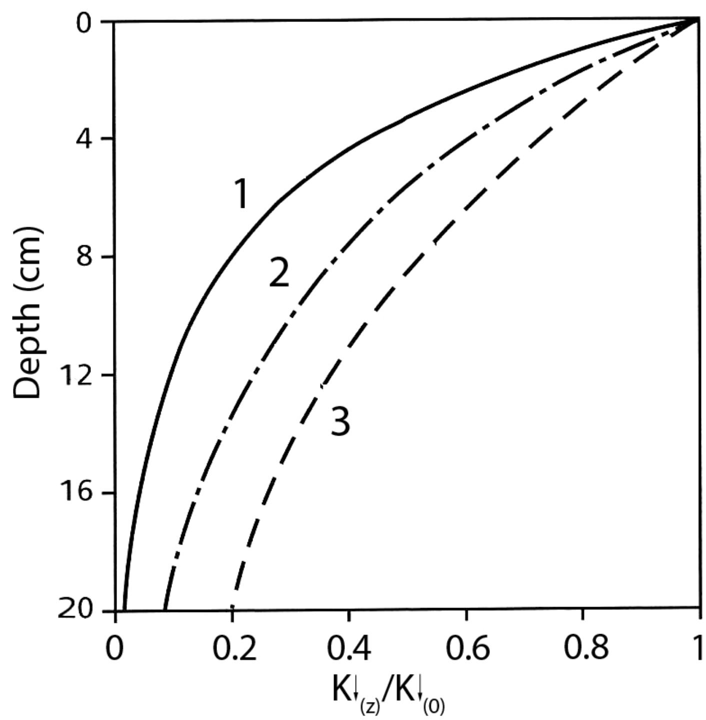
Part C: Problem questions

Answer <u>only four</u> out of the following six questions. 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.

1. The lines in the graph below show measured vertical profiles of $K_\downarrow$ as a function of depth z in three different snow packs: A fresh snow pack, a mid-winter snow-pack, and an old snow pack in late spring.

   (a) Attribute the various snow-packs to the curves 1 to 3 to and justify your choice. [3]
   (b) The graphs show broadband $K_\downarrow$. However specific wavelengths (λ) might behave differently. Sketch directly into the graph expected profiles for radiation at $\lambda \approx 400$ nm and for $\lambda \approx 1000$ nm (for a fresh snow pack). [4]
   (c) Which law describes the curves you have drawn (name the law) [3].

   Note: $K_{\downarrow(0)}$ is the shortwave irradiance above the snow-pack, i.e. at $z = 0$ cm.



2. The thermal admittance of a soil (μ_s) is the thermal property that governs soil surface climates.

   (a) Give an example of a soil that has a particularly low μ_s and one that has a particularly high μ_s. [4]
   (b) Sketch graphs of the expected surface temperatures T_0 for both soils separately over the course of a clear-sky day (i.e. draw time of day on the x-axis, and T_0 on the y-axis). [3]
   (c) Which of your two soils might be better suited for agriculture? Justify. [3]

   In all cases assume a soil in a flat area in BC's Lower Mainland.

3. A recent study published in *Nature Climate Change (Vol 2, 613 - 618, 2012)* reports 'changes in plant growth in an area of around 100'000 km^2, known as the northwestern Eurasian tundra, stretching from western Siberia to Finland. Surveys of the vegetation, using data from satellite imaging, and fieldwork [...] showed that in 8-15% of the area willow and alder plants have grown from shallow shrubs into trees over 2 metres in height in the last 30-40 years'. The study concludes that this 'change from shrubs to forest is important as it alters the albedo (α) effect.'

   (a) Does the annual α increase or decrease as a result of the plant growth? [2]
   (b) List the two most important reasons why α changes. [4]
   (c) Briefly speculate, what is the effect of the altered α effect on soil temperatures and near-surface air temperatures, and the consequence on plant growth. Explain why. [4]

4. This equation describes $L_\uparrow$ of a flat land-surface.

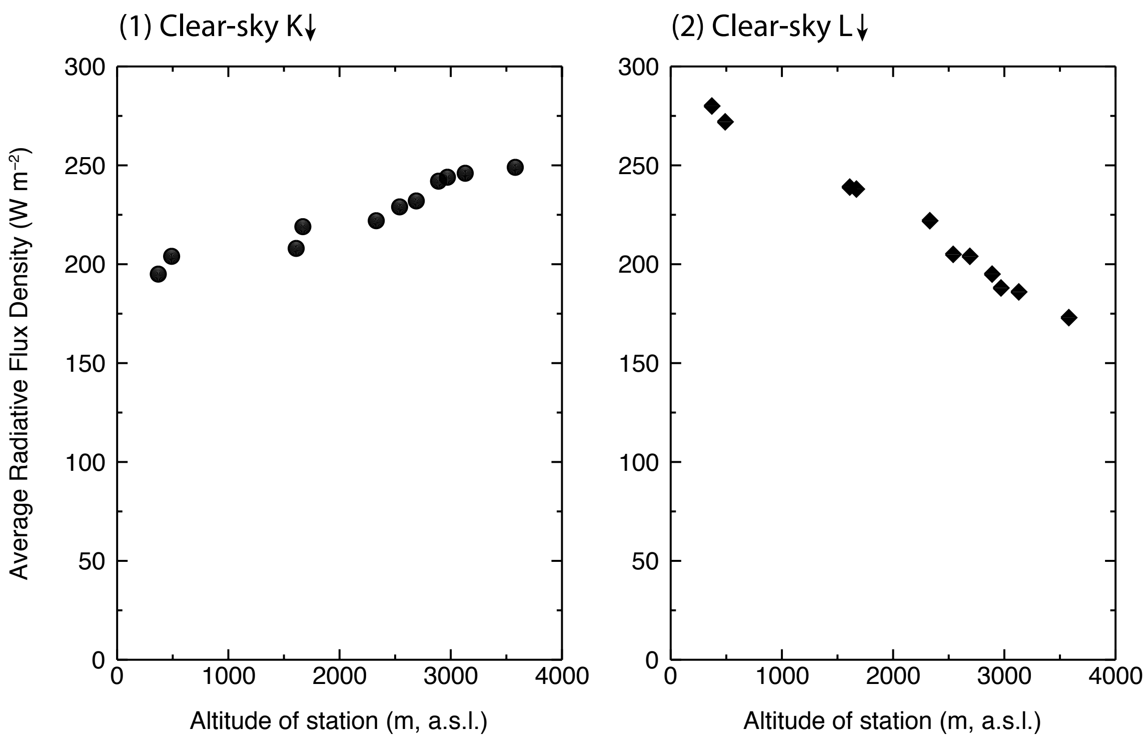
   (a) What are the radiative processes captured in each of term I and term II? [4]
   (b) Which law forms the basis for term I (provide name)? [2]
   (c) Why do we use ε to describe the process in term II? [4]

$$L_\uparrow = \underbrace{\varepsilon\,\sigma\,T_0^4}_{\text{Term I}} + \underbrace{(1-\varepsilon)L_\downarrow}_{\text{Term II}}$$

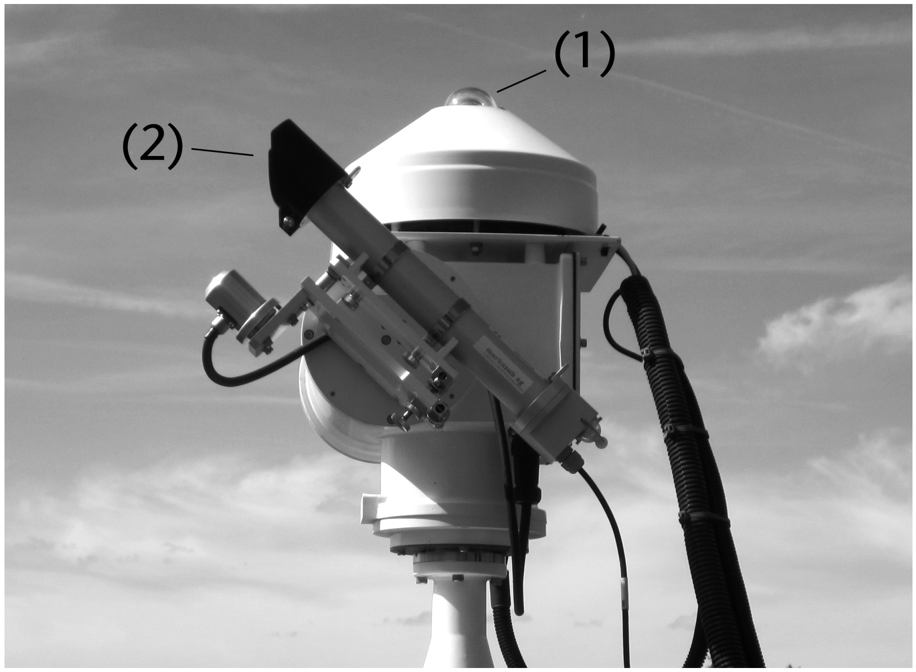
5. The graphs show measured radiative fluxes from a network of 11 stations located at various altitudes in the Swiss Alps. Each dot represents a site. The graphs show measured average $K_\downarrow$ and $L_\downarrow$ for clear-sky cases (i.e. simultaneously cloud-free at all sites). All sites measure fluxes on a horizontal surface and are located in open terrain with sky view factors close to 1.

   (a) For both, $K_\downarrow$ and $L_\downarrow$, describe the effect of altitude on flux densities. [2]

   (b) Provide a detailed physical explanation for the observed changes in flux density with altitude, separately for $K_\downarrow$ and $L_\downarrow$ [8]



6. The photo shows a set-up to measure solar radiation.
   (a) What is the name of the instruments labelled (1) and (2)? [4]
   (b) Which variables do they measure each? [4]
   (c) The platform that holds the two instruments can automatically adjust azimuth and tilt. Why? [2]



END OF EXAM