Lecture 1 – Exercises

Exercise 1: Urban characteristics

Satellite images of two districts of Lausanne are shown in Fig. 1. Based on the visual information provided, address the following questions:

1. Evaluate roughly the fraction of the urban cover of buildings (λ_b), vegetation (λ_v), and impervious ground (=roads) (λ_i) for both districts. Which district is expected to *have higher air temperatures*?
2. Evaluate building dimensions (H and W), building spacing (D) and canyon aspect ratio (λ) whenever applicable.
3. Evaluate the ratio of the living floor area to the overall surface (λ_{floor}) for both districts (consider that the height of one floor is 3 m). Compare the numbers.
4. Which district has the highest sky view factor?

** you can estimate various dimensions from pictures using a ruler and the scale indicated*

Fig. 1(a): Overview of the district of Chauderon (most of the buildings are 5-story)

Fig. 1(b): Overview of the district of Bellerive (most of the buildings are 3-story)

Exercise 2: Local Climate Zone and Urban Energy Balance

Consider the city of **Basel** (Fig.2) and the city of **Tokyo** (Fig. 3). Both cities are located in the Northern Hemisphere (Basel - 47.5596° N, 7.5886° E; Tokyo - 35.6762° N, 139.6503° E). Graphs in Fig. 4 illustrate estimated hourly heat flux densities in the summertime for each city. The mean anthropogenic heat flux (Q_F) for Basel is $8\ W/m^2$ and for Tokyo - $30\ W/m^2$.

1. Determine what **landscape types** (the local climate zones LCZ) of Basel and Tokyo are based on their images in Fig. 2-3.
2. Evaluate the energy balance using the data from Fig. 4 for each city **at noon**. Estimate the heat flux convected (Q_A) reading out the heat flux values from the graphs.
3. Compare **specific heat fluxes between two cities** shown in Fig. 4 and comment on them with respect to their landscape types:
   (a) Anthropogenic heat flux
   (b) Radiation heat flux
   (c) Sensible and evaporative heat flux

Figure 2: City view - Basel (Switzerland)

Figure 3: City view - Tokyo (Japan)

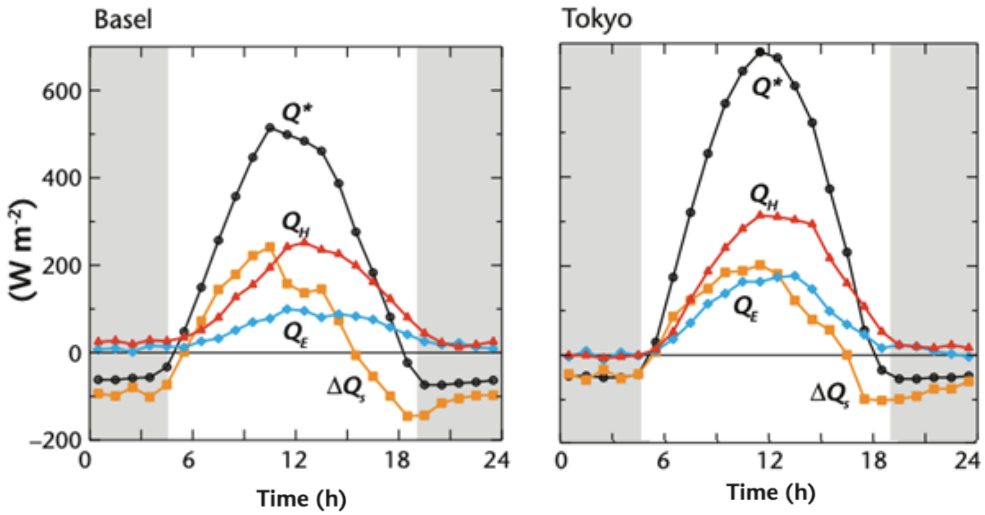


Figure 4: Hourly estimation of heat fluxes over a summer day in Basel (left) and Tokyo (right): Q^*- net allwave radiation, Q_H – sensible heat flux, Q_E – latent heat flux, ΔQ_S – heat storage change

Exercise 3: Urban heat island (UHI) effect

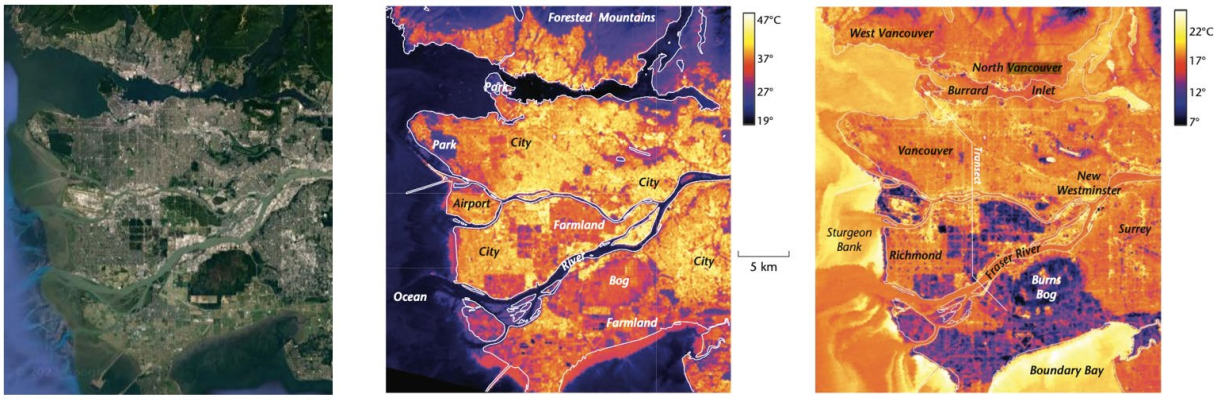
Satellite and infrared landsat (IR) images of the surface of the Vancouver area are shown in Fig. 6. The *daytime* IR image at 12:24 is shown in Fig. 6(a), and the *nighttime* IR image at 23:10 is shown in Fig. 6(b). In addition, air temperature variations in *urban* and *rural* areas of Vancouver over 24h are shown in Fig. 7.

Based on the information given in Fig. 6, address the following questions:

1. What is the correlation between *daytime* temperatures and the type of surfaces?
2. Evaluate the highest value of the *surface* urban heat island magnitude (UHI_{mag}) at *daytime*
3. Evaluate the highest value of the *surface* urban heat island magnitude (UHI_{mag}) at *night*
4. Comment about differences in surface temperatures between *daytime* and *night*

Based on the information given in Fig. 7, address the following questions:

5. Calculate the maximum *air* heat island magnitude (UHI_{mag}) during the day and night. When did the maximum occur? Comment on the difference with the *surface* heat island magnitude calculated in (2)-(3).
6. Estimate the *night air* heat island magnitude (UHI_{mag}) considering the Vancouver population as 1.65 million inhabitants in 1992. Compare the value determined with the value calculated in (5).



(a) Satellite image of Vancouver (b) IR image (03.09.2010 @ 12:24) (c) IR image (03.09.2010 @ 23:10)

Figure 6: Surface images of the Vancouver area [Oke, Urban climates, p. 207]

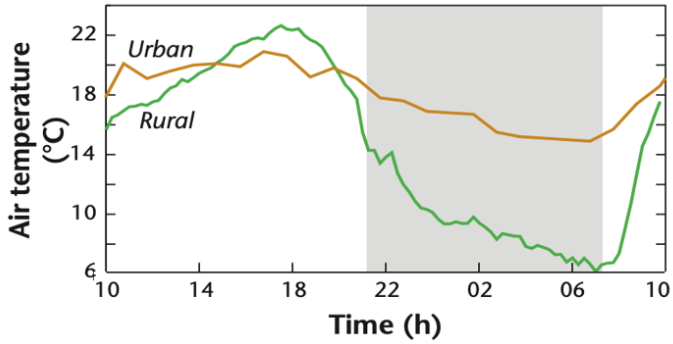


Figure 7: Air temperature variation of urban and rural areas in Vancouver on 10-11 Aug. 1992 [Oke, Urban Climates, p. 217]

Exercise 4: UHI causes and mitigation

London is a city of high *air* heat island magnitude with a monthly-averaged value of 2.9°C. The image shown in Fig. 8 was taken on the Deptford high street of London. Based on the image, address the following questions:

1. Identify the possible causes of the UHI.
2. For each cause, identify potential solutions to mitigate the UHI effect.

Figure 8: Urban scene - Deptford high street of London