GEOG 272 Lab 4 Convective Heat Flux Density

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Theory:

1) Available Energy
   - Provides energy for Q_H
   - Provides energy to increase ground surface temperature and the surface to air temperature gradient.
   - The greater the available energy, then greater the Q_H
2) Air Temperature
   - Forms a temperature gradient between the surface and air
   - The lower the air temperature, the greater the gradient, and the greater the Q_H
3) Surface Roughness
   - Wind interacting with a rough surface, creates turbulence that rapidly moves heat away from surface.
   - The rougher the surface, the more turbulence, the higher the Q_H
4) Wind Speed (2 main parts to this)
   - In the thin laminar boundary layer, airflow is parallel to the surface, there is no vertical mixing and vertical heat transfer is only via conduction.
   - In the deep turbulent boundary layer (above the laminar layer), vertical heat flow is via rapid turbulent eddies
   - Stronger winds decrease the depth of the laminar boundary layer and create more turbulence, speeding up the transfer of heat in the turbulent boundary layer
   - Higher wind speed means a higher Q_H

Data:

Dry Bulb air Temperature at waist height

Site	Temperature
Quad Site	18.2℃
Pavement Site	16.2℃

Wind Speed

Sites	Wind Speed
Quad Site	1.8km/hr
Pavement Site	1.5km/hr

Net all-wave radiation (Q*)

Sites	Net all-wave radiation (Q*)
Quad Site	229.36 W/m^2
Pavement Site	38.052 W/m^2

Ground Heat Flux Density (Q_G) and Evaporative Heat Flux Density (Q_E)

Sites	Ground Heat Flux Density (Q_G)	Evaporative Heat Flux Density (Q_E)
Quad Site	27 W/m^2	208.62 W/m^2
Pavement Site	11.42 W/m^2	0 W/m^2

Roughness of each surface and general weather conditions

Quad Site: The site is relatively smooth, but uneven little bumps throughout the site.

There are grass covering the whole site and the ground is very wet and muddy. It is slightly cloudy to North and has direct sunlight. Cloudy towards the west of the site.
Pavement Site: This site has a really smooth surface that is covered in pavement. The ground is very warm and dry. There are scattered thin clouds in the sky and the site is also receiving direct sunlight. However, trees and shadows are blocking some radiation.

Case Study:

1) a) **Q*:** The net all wave radiation for the Quad site is 229.36 W/m^2. The Pavement site has a net all wave radiation of 38.052 W/m^2. The net all wave radiation difference for both sites is 191.308 W/m^2. Therefore, the Quad site has a higher net all wave radiation and is receiving 191.308 W/m^2 more radiation.
   b) **Q_G:** The ground heat flux density for the Quad site is 27 W/m^2. The Pavement site has a ground heat flux density of 11.42 W/m^2. The ground heat flux density difference for both site is 15.58 W/m^2. Therefore, the Quad site has a higher ground heat flux density.
   c) **Q_E:** The Quad site has an evaporative heat flux density of 208.62 W/m^2. The evaporative heat flux density for the Pavement site is 0 W/m^2. The evaporative heat flux density difference is 208.62W/m^2. Therefore, the Quad site has a higher evaporative heat flux density.

   Summary: At the Quad site there is a higher amount of all wave radiation than the pavement site. There is a lot of radiation being used as evaporation process at the Quad site because there is a high evaporative heat flux density (208.62 W/m^2). Due to the moist ground, not a lot of solar radiation can perform work to heat the ground. Most of the available energy at Quad is being used up by evaporative heat flux density; therefore, there is not a lot of available energy at this site. At the Pavement site, there is no evaporation process-taking place because the ground is very dry (no available water to be evaporated). The ground heat flux density for Pavement site is relatively low because pavement has a high albedo that can reflect huge amount of solar radiation. Therefore, the Pavement site should have a higher available energy because less energy being used by ground heat flux density and evaporative heat flux density.
2) a) **Available energy**: Based on the applicable controls of available energy, the Pavement site has a higher available energy than the Quad site. Therefore, the Pavement site should have a greater QH because there is greater amount of available energy.
   b) **Air Temperature:** The air temperature at the Quad site is 18.2℃ and the air temperature at the Pavement site is 16.2℃. Based on the theory, the lower the air temperature will lead to a greater gradient difference and therefore, the greater Q_H. In conclusion, the Pavement site has a higher QH because it has a lower air temperature.
   c) **Surface Roughness:** The Quad site is relatively smooth, but uneven little bumps throughout the site. The Pavement site has a really smooth surface that is covered in pavement. In conclusion, the Quad site has a rougher ground surface than the Pavement site. Rougher the ground surface, more turbulence are created and less radiation being reflected. Therefore, the Quad site should have a higher QH. However, the assumption from this theory is opposite of our result.
   d) **Wind Speed:** The Quad site has a wind speed of 1.8km/hr. The Pavement site has a wind speed of 1.5km/hr. The Quad site is receiving a higher wind speed than the Pavement site. Therefore, the stronger wind at Quad site creates more turbulence and speeds up the transfer of heat. Based on the result, the Quad site has higher wind speed and that means the site has a higher QH.

   Summary: The convective flux density for the Quad site is -6.26W/m^2. The Pavement site has a convective flux density of 26.63 W/m^2. Based on the

calculation, the Pavement site has a higher convective flux density that the Quad site.
Judging from the applicable controls of available energy, the Pavement site has a higher available energy than the Quad site, this means the greater the available energy, the greater the QH. Therefore, Pavement site has a higher convective heat flux density.
Looking at the air temperature data we collected, we can draw the conclusion that the Pavement site has a higher Q_H based on the theory we learned in class. The Pavement site has a high albedo this means that the solar radiation is being reflected. The pavement itself is preventing the heat to travel further into the ground; this means the ground is relatively cold. Therefore, the pavement site has a higher gradient differences and therefore, a greater the Q_H.
The Quad site has a rougher ground surface than the Pavement site. Rougher the ground surface, more turbulence are created, and less radiation being reflected. Therefore, the Quad site should have a higher QH. However, the assumption from this theory is opposite of our result. This is probably because there is a lot of cold air at the surface of the Quad site due to evaporation, the turbulence than brings up cold air into atmosphere.
The Quad site is receiving a higher wind speed than the Pavement site. Therefore, the stronger wind at Quad site creates more turbulence and speeds up the transfer of heat. Based on our result, the Quad site has higher wind speed and that means the site has a higher QH.
In conclusion, based on the theory and our results, the Pavement site has a higher convective heat flux density.