CIVL1210

Homework 4

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A CIVL1210 Homework Assignment

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Problem 1

1. LCZ1 (Compact high-rise) has the highest trapping effect. It is because they have deeper canyons in between buildings, and radiation is trapped inside due to more reflection of radiation in the deep canyons. The dense environment and tall structure reduce airflow and trap heat radiation, leading to trapping effect.

2. Spatial and temporal scale measure the air pollution across the space and temperature respectively. In spatial scale, air quality are measure across different locations, with a large time scales. But in temporal scale air quality is measured in different temperature.

3. We can reduce vegetation and surface moisture, perturbs the hydrologic cycle. We can also increase roughness slowing the air flow.

4. In city, there are more walls that are virtually snow-free and cities physically remove snows from major roads, snow surfaces are also soiled by urban aerosols, tire tracks, resulting in a low snow content, leading to be a higher albedo in urban area than rural area. Hence, urban have a higher urban warmth and the snow melt faster than rural, which has a low albedo.

Problem 2

1. A,B,C,D
2. A,B,D
3. B
4. B,D
5. A,B,C
6. A,B,E
7. C

Problem 3

Consider the case where canyon is flat.

$$\alpha = \frac{W\alpha_g + H\alpha_{w1} + H\alpha_{w2}}{W + 2H} = \frac{10 \times 0.2 + 40 \times 0.25 + 40 \times 0.4}{10 + 2 \times 40} = 0.311$$

Now Consider the case where canyon is not flat.

$$
\begin{aligned}
\psi_{G\to S} &= \sqrt{1+\left(\frac{H}{W}\right)^2} - \frac{H}{W} = \sqrt{1+\left(\frac{40}{10}\right)^2} - \frac{40}{10} = 0.123 \\
\psi_{G\to W} &= \frac{(1-\psi_{G\to S})}{2} = \frac{(1-0.123)}{2} = 0.438 \\
\psi_{W\to W} &= 1 - 2\times\psi_{G\to W} = 1 - 2\times 0.438 = 0.123 \\
S_G &= D_{\text{sky}} \times (1-\alpha_G) \times (\psi_{G\to S} + \psi_{W\to S}\alpha_{WL}\psi_{G\to W} + \psi_{W\to S}\alpha_{WR}\psi_{G\to W}) \\
&= D_{\text{sky}} \times (1-0.2) \times (0.123 + 0.438\times 0.25\times 0.438 + 0.438\times 0.4\times 0.123) \\
&= 0.154 D_{\text{sky}} \\
S_{\text{LW}} &= D_{\text{sky}} \times (1-\alpha_{WL}) \times (\psi_{W\to S} + \psi_{G\to S}\alpha_G\psi_{W\to G} + \psi_{W\to S}\alpha_{WR}\psi_{W\to W}) \\
&= D_{\text{sky}} \times (1-0.25) \times (0.438 + 0.123\times 0.2\times 0.438 + 0.438\times 0.4\times 0.123) \\
&= 0.353 D_{\text{sky}} \\
S_{\text{RW}} &= D_{\text{sky}} \times (1-\alpha_{WR}) \times (\psi_{W\to S} + \psi_{G\to S}\alpha_G\psi_{W\to G} + \psi_{W\to S}\alpha_{WL}\psi_{W\to W}) \\
&= D_{\text{sky}} \times (1-0.4) \times (0.438 + 0.123\times 0.2\times 0.438 + 0.438\times 0.25\times 0.123) \\
&= 0.277 D_{\text{sky}} \\
\alpha_{\text{canyon}} &= 1 - S_G - S_{\text{LW}} - S_{\text{RW}} = 0.216
\end{aligned}
$$

The change in effective albedo = 0.311 − 0.216 = 0.095

It will increase by 0.095.

Problem 4

1.

$$
\begin{aligned}
Q* &= K\downarrow - K\uparrow + L\downarrow - L\uparrow \\
&= (1-\alpha)K\downarrow + \varepsilon L\downarrow - \varepsilon\sigma T^4 \\
&= (1-0.25)\times 900\frac{W}{m^2} + 0.9\times 200\frac{W}{m^2} - 0.9\times 5.67\times 10^{-8}\frac{W}{m^2K^4}\times((30+273)K)^4 \\
&= 425\frac{W}{m^2}
\end{aligned}
$$

2.

$$
\begin{aligned}
\text{Sensible heat flux } \mathrm{Q_H} &= -\rho_a c_p K_H \frac{\vartheta T}{\vartheta Z} = \rho_a c_p K_H \frac{T_S - T_A}{H} \\
&= 1.2\frac{kg}{m^3} \times 1.0\frac{m}{s} \times 1005\frac{J}{kgK} \times \frac{(30-26)K}{6m} \\
&= 804\frac{W}{m^2} \\
\text{Ground heat flux } \mathrm{Q_G} &= -k\frac{dT}{dz} = k \times \frac{T_s - T_m}{d} \\
&= 1.6\frac{W}{mK} \times \frac{(30-25)K}{0.05m} \\
&= 160\frac{W}{m^2}
\end{aligned}
$$

Let surface temperature that balance the net radiation by $\mathrm{T_s}$

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\begin{aligned}
Q* &= Q_S + Q_H \\
Q* &= \rho_a c_p K_H \frac{T_S - T_A}{H} + k \times \frac{T_s - T_m}{d} \\
425\frac{W}{m^2} &= 1.2\frac{kg}{m^3} \times 1.0\frac{m}{s} \times 1005\frac{J}{kgK} \times \frac{T_s - 26K}{6m} + 1.6\frac{W}{mK} \times \frac{T_s - 25K}{0.05m} \\
425 &= 233T_s - 6026 \\
T_s &= 27.7^\circ C
\end{aligned}
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