AOSC201: Weather and Climate Lab

Week 11: Urban Heat Island Effect

Section 103/105

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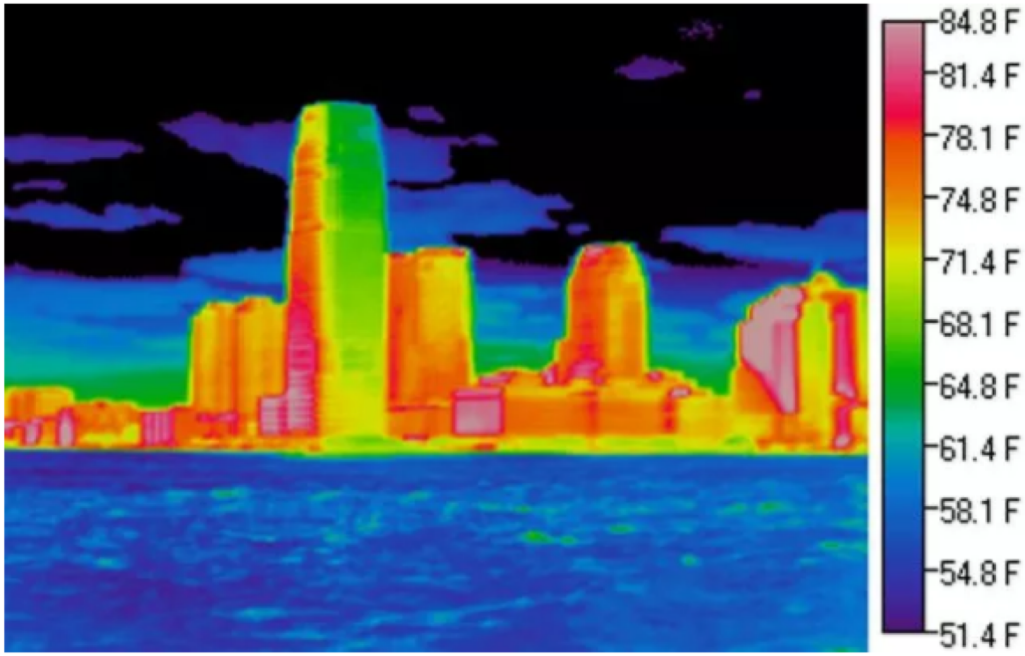
Week 11 Lab: *Urban Heat Island Effect*

- Lab#3 of Lab Manual (pages 15-19)
- 50 points in total (+ 1 bonus point available)

- GROUP Work: Qsn#1, 2, 4 and 6; INDIVIDUAL Work: for the rest

Urban Heat Island Effect

- Metropolitan area that is warmer than its surroundings
- City structure reduces air flow, traps heat
- Example: city with a million residents
  - → Mean air temperature: 1-3 °C warmer
  - → Evening air temperature: 6-12 °C warmer



Urban Heat Island effect on NYC skyscrapers

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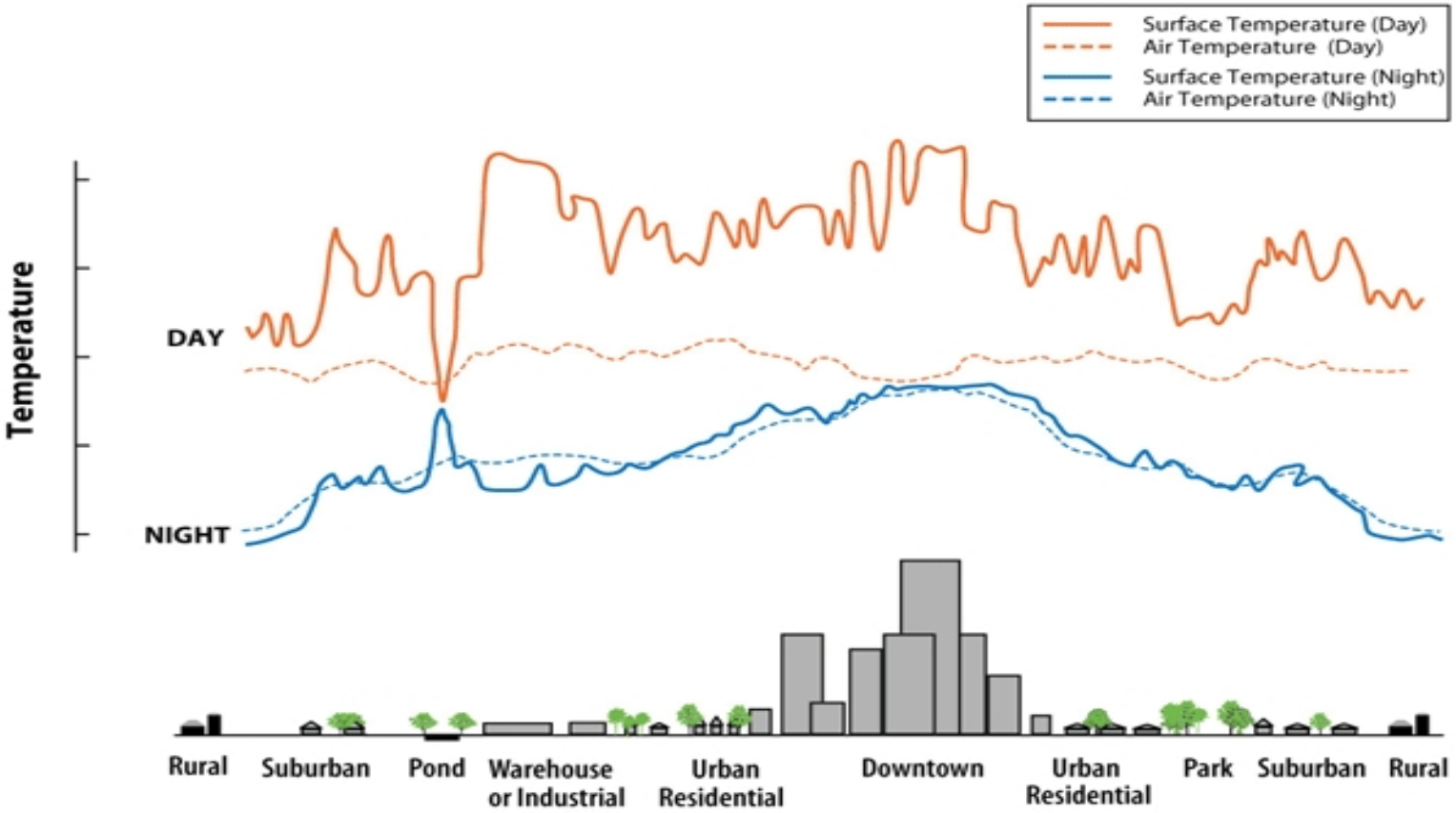
Urban Heat Island Effect



- Formed from urbanization through paved roads, concrete structures, and reduced vegetation
- Evapotranspiration – evaporation from soil and plants
  - *"earth's natural air conditioning"*
  - able to cool air 2-8 °C

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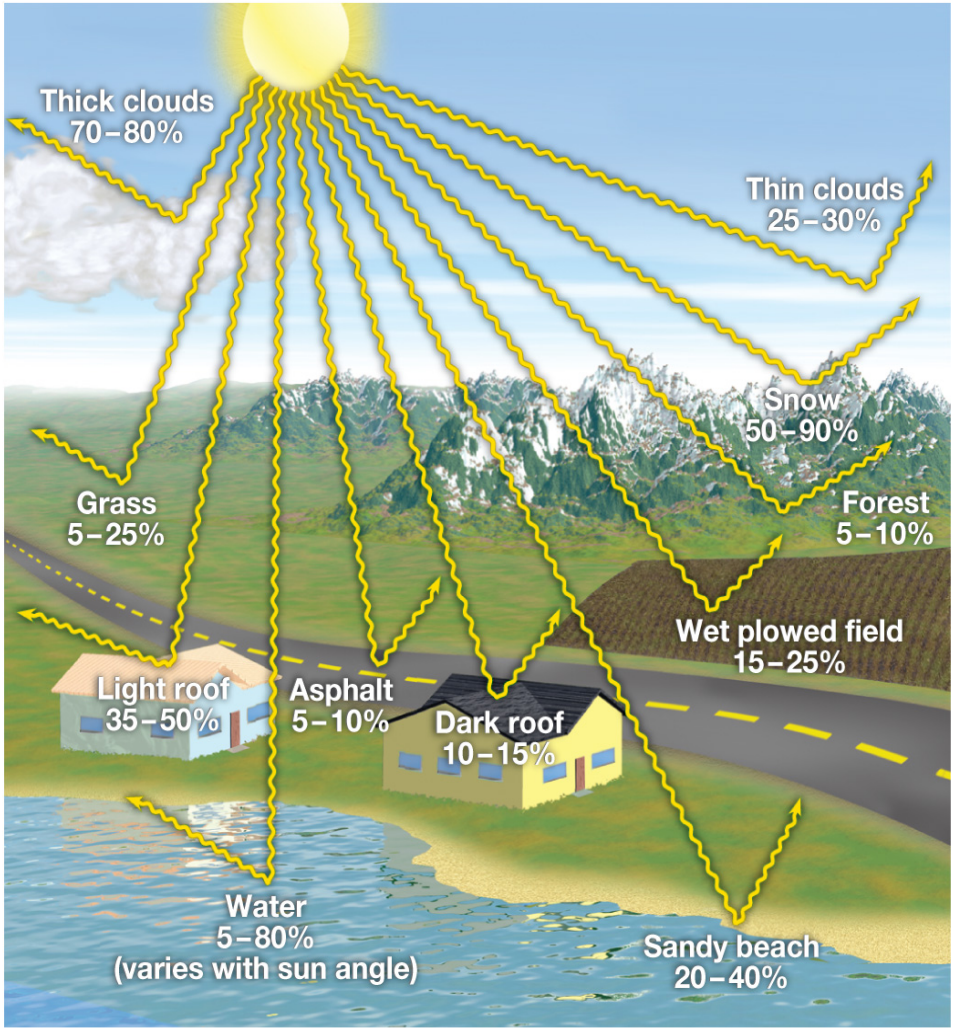
Albedo

- **Ratio of reflected solar radiation to the total incoming solar radiation**
- Higher albedo = higher reflectance
- Urban areas absorb more insolation
  - → Ambient temperatures rise
- Some cities employ techniques to increase albedo
  - Use more reflective paints
    - →Surfaces with a white coating (α = 0.72) were 45°C cooler than black coatings (α = 0.08)
  - Planting trees, canopies, or green roofs



Albedo of different surfaces

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Heat Capacity and Specific Heat

- What is Heat Capacity?
  - *a measurable physical quantity equal to the ratio of the heat added to (or removed from) an object to the resulting temperature change.*
- How is this different from specific heat?
  - *Specific Heat is heat capacity per unit mass* (how much energy it takes to raise the temperature of a 1 kg substance by 1 K)
- Water specific heat: **4185.5** J $kg^{-1}K^{-1}$
- Aluminum specific heat: **921.1** J $kg^{-1}K^{-1}$

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Question 1 (2 points) Directions:

- Measure the temperature of ice water with your IR thermometer.
- Go up to the board and record your value with Group #.
- **ACCURACY** = (Your Measurement of Temperature – Expected Temperature)
- **PRECISION** = (Class Average – Your Measurement of Temperature)
- WRITE proper units.

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Question 2 (5 points) Directions:

- IR Thermometers have been handed out.
- Measure and record the temperatures (*Observation #1 in °F*) of different materials set up in the display.
- Be specific in your description (*material, color, size*).
- Several materials are painted in different colors (e.g. black, grey, white)
- There are ~ 30 items in total.

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Question 2 (… continued; 5 points) Directions:

1. White tall building
2. Black tall building
3. White medium building
4. Black medium building
5. White small building
6. Black small building
7. White industrial complex
8. Black industrial complex
9. Sandy dirt (wet)
10. Sandy dirt (dry)
11. Soil (wet)
12. Soil (dry)
13. Red Brick
14. White Brick
15. Dark Rock
16. Light Rock
17. Film A – silver
18. Film A – white
19. Film A – black
20. Film B– silver
21. Film B – light grey
22. Film B – dark grey
23. Film B - white
24. Film B – black
25. Film C – silver
26. Film C – white
27. Film C – black
28. Film D – silver
29. Film D – white
30. Film D – black

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Question 3 (4 points) Directions:

- 2 containers with sandy dirt – 1 with water added, 1 is dry.
- 2 containers with soil – 1 with water added, 1 is dry.
- Which containers are cooler, the ones that are dry or the ones that have water added?
- Explain the reason for this difference in temperature between the wet and dry containers.

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Question 4 (8 points) Directions:

- Select 6 objects when you go outside.
- Note the "color" and the "material name" when you record your measurements.
- **One point extra credit** for the person, who is able to tell me the coldest object outside.
- Which one has the coldest temperature?
- Which one has the warmest temperature?

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Question 5 (4 points) Directions:

- Look at your temperature measurements of the objects outside (Question #4) and within the display (Observation #1 column, previous page).
- Do you notice a correlation between your temperature readings of different objects?
- If yes, what is the relationship?
- If no, describe why this might be the case.

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Question 6 (5 points) Directions:

- Measure and record the temperatures (*Observation #2 in °F*) of different materials set up in the display, *after it has been sufficiently heated from the heat source*.
- Add a change in temperature column to the right, Δt.
- Write down the difference in temperature between Observation#2 and Observation#1.

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Questions 7 and 8 (3 points each) Directions:

- Provide me THREE things for each question that experienced the largest and smallest change in temperature respectively.
- Hint: Look at the temperature difference (3rd column you added) on Page 17 of Lab Manual.

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Question 9 (4 points) Directions:

- Hint: Different objects have different masses and densities; also refer the definition of specific heat provided in the beginning of this class presentation.

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Question 10 (4 points) Directions:

- Write about the change in diurnal temperature (i.e. temperature variability) in a city compared to non-urban areas.

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Question 11 (4 points) Directions:

- "Shading the car" is not an acceptable answer.
- Think critically about what these canopies mean to the albedo of the asphalt surface (of the parking lot) and the urban heat island effect.

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Question 12 (4 points) Directions:

- Research for TWO things as low-cost solutions to the urban heat island problem.


Thank you


Questions ?