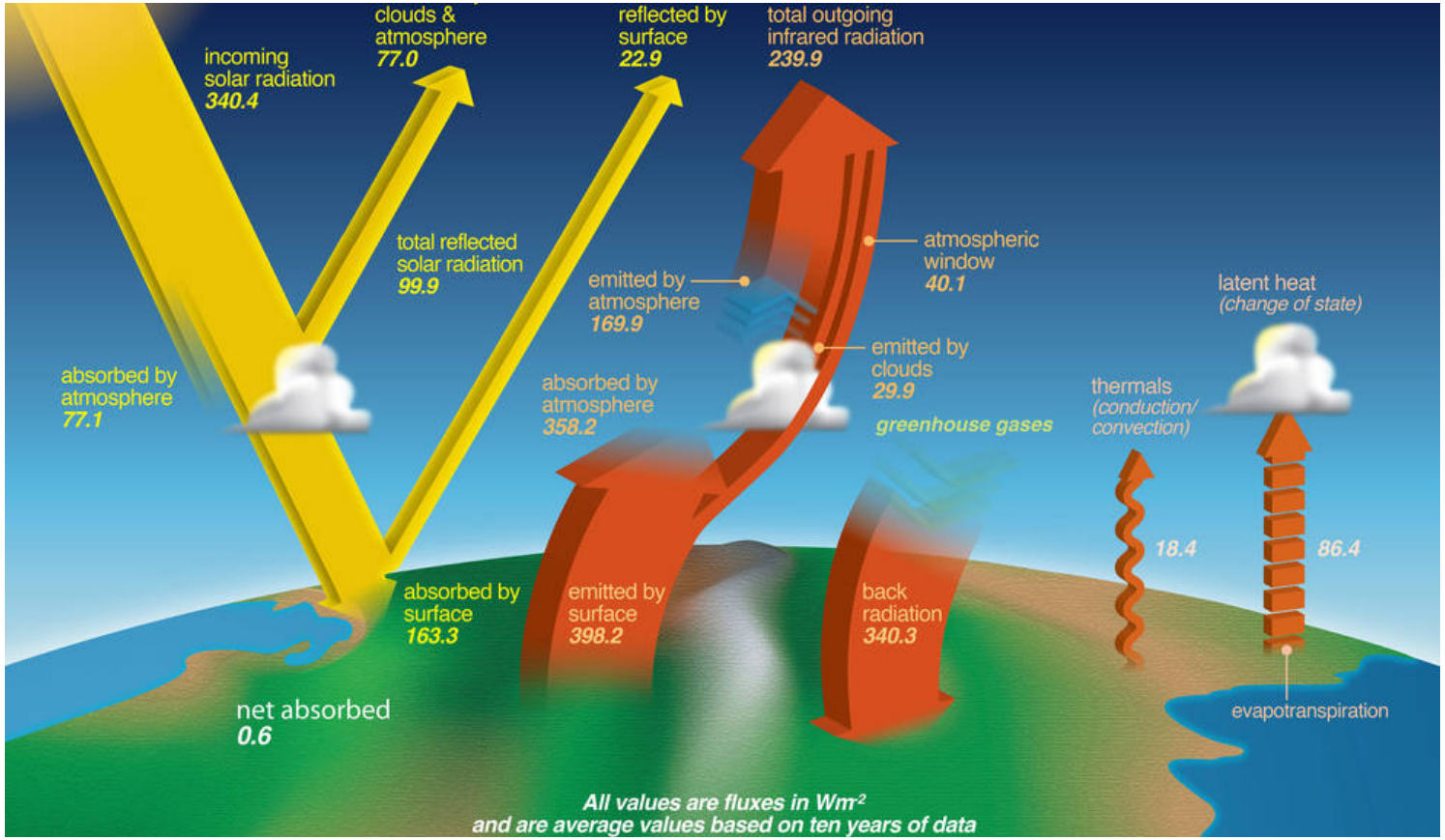
What are Urban Heat Islands?

Cities have much warmer temperatures than nearby rural areas.

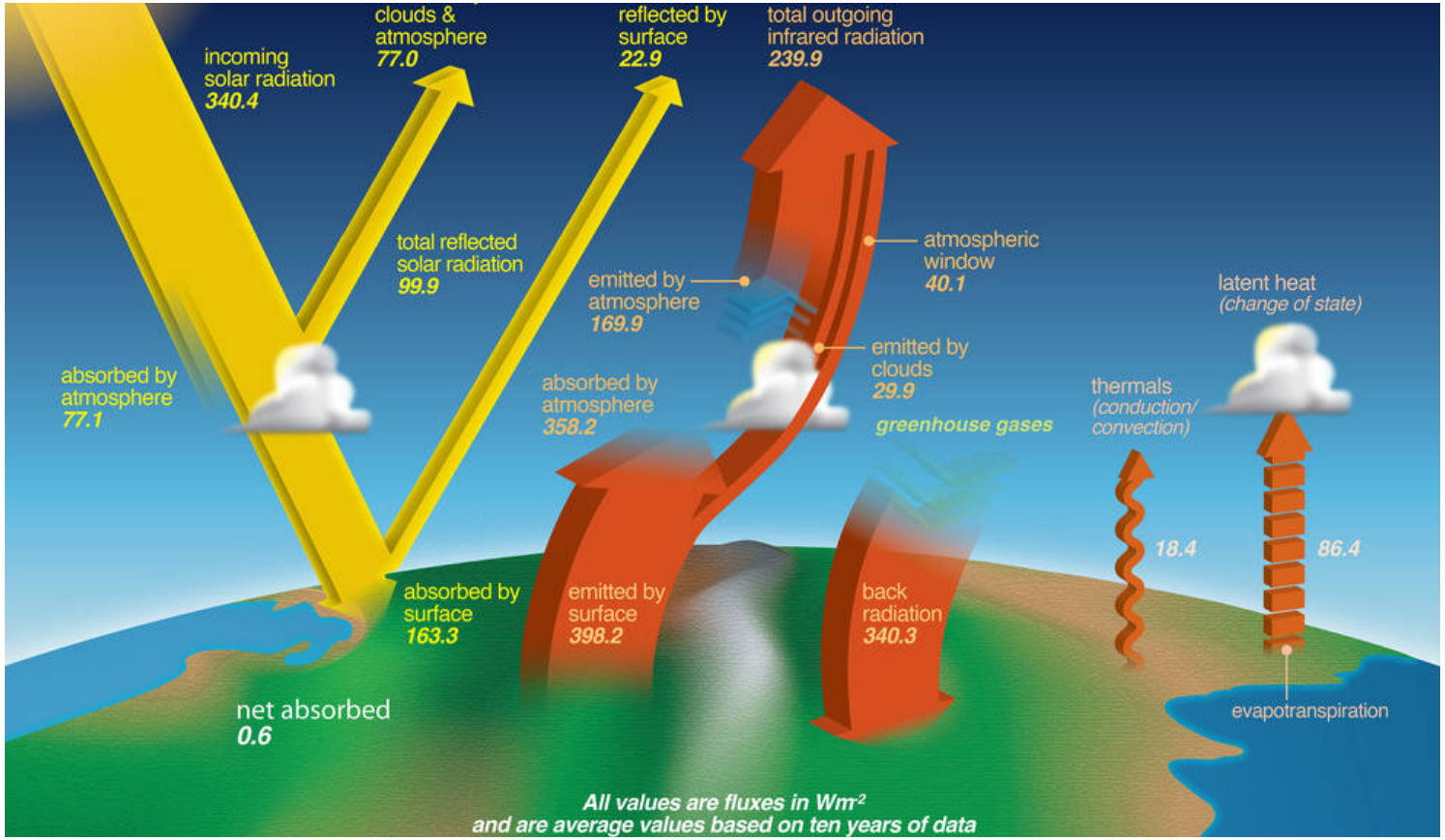
The sun's heat and light influence the city and the country differently.

The surfaces of different places **absorb** and **hold heat** differently, which is why there is a difference in temperature in the city and in the country.



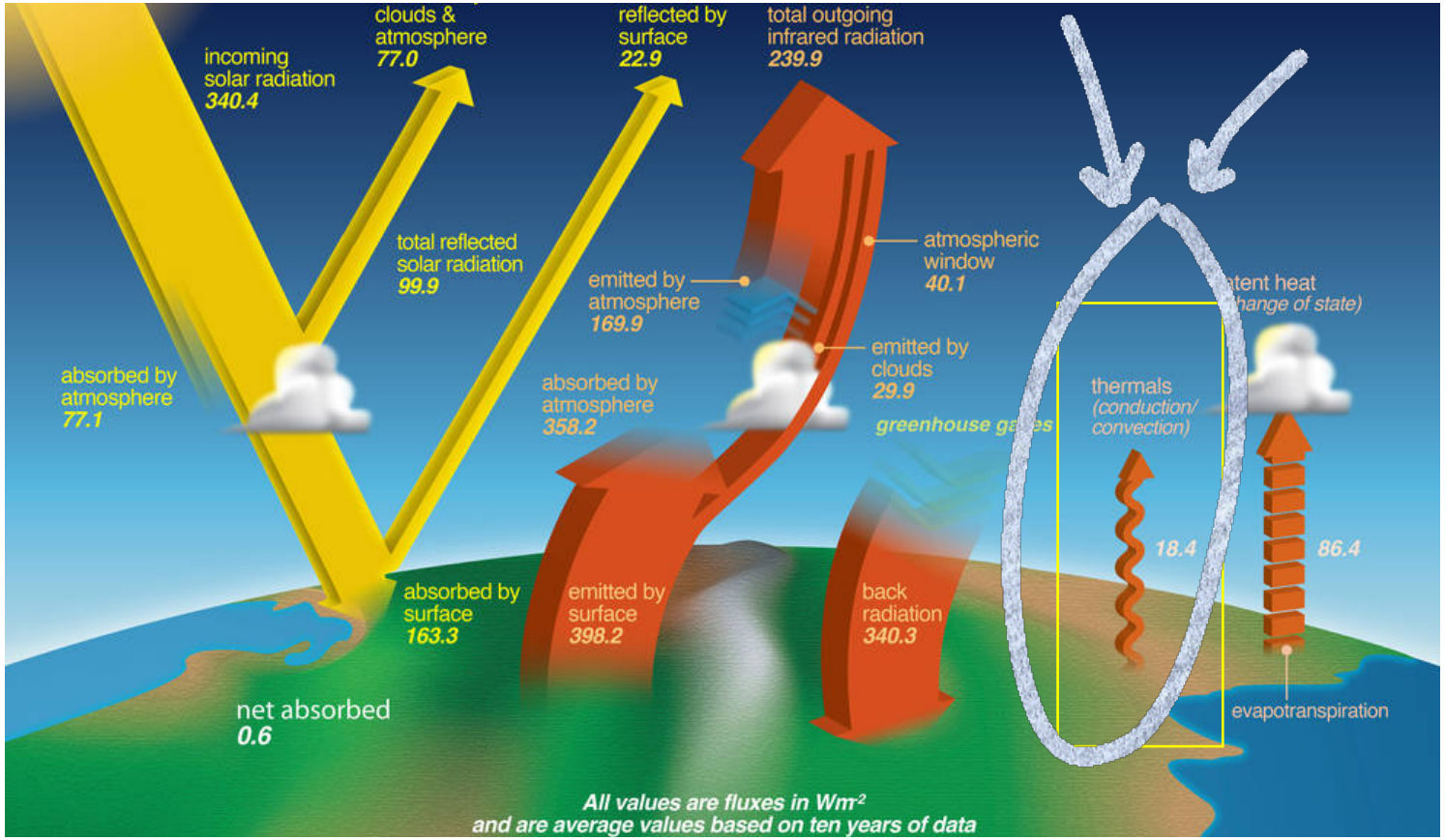
What is the 'Earth's Energy Budget'?

- The diagram that you see displays the earth's Energy Balance.
- The yellow arrows represent the radiation emitted by the sun.
- Radiation from the sun can be absorbed or reflected.
- That is why some of the yellow arrows point right back to space. This shows reflection.
- About 50% of the radiation from the sun that reaches the earth is absorbed by the surface.
- The surface absorbs the sun's radiation and **gains energy**, warming the surface. The surface eventually releases some of this energy to the atmosphere above.



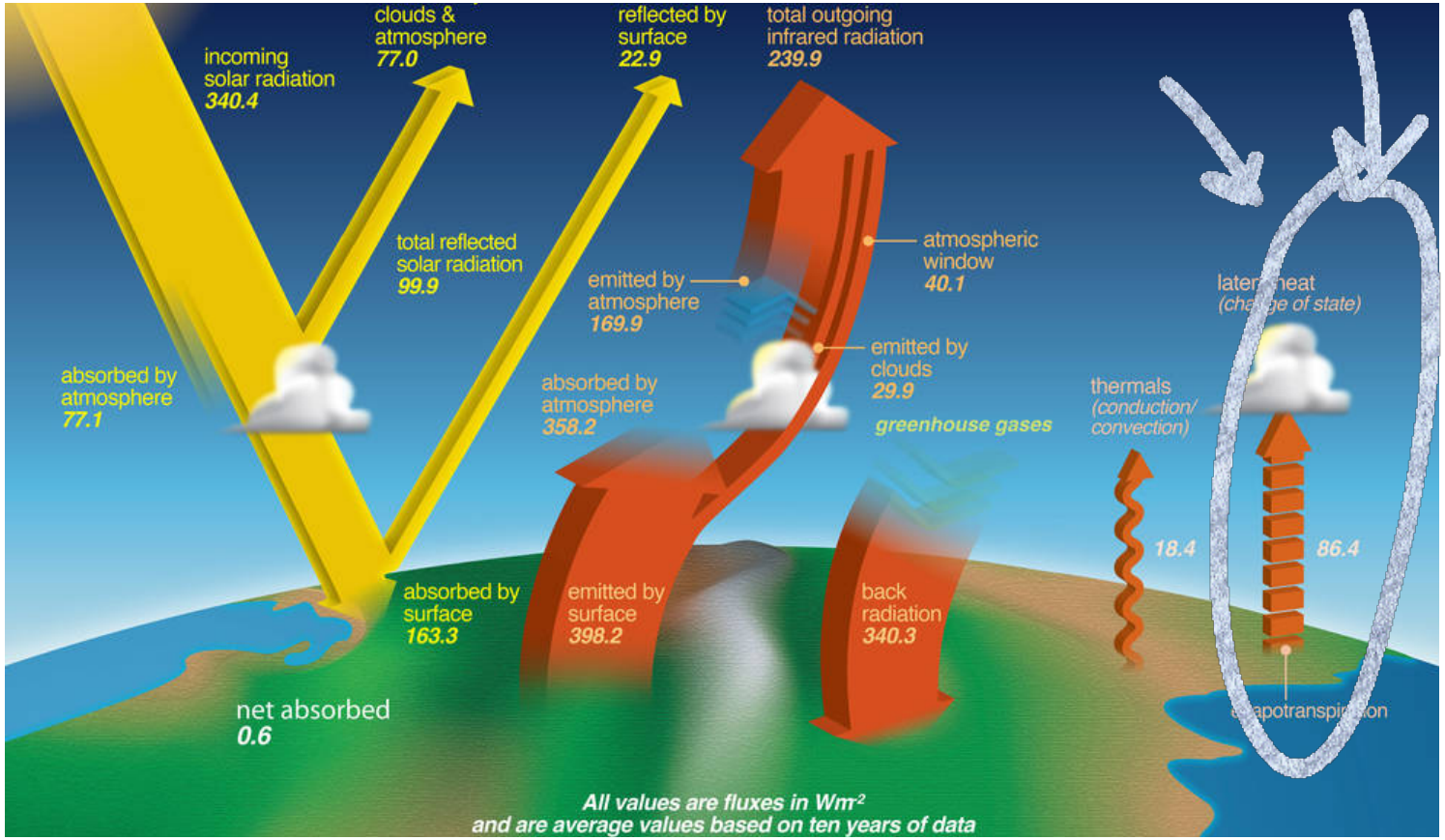
What is the 'Earth's Energy Budget'?

- The red arrows show the energy that is released. The name of this energy is infrared radiation and is detected as **heat**, like the warmth you feel from a fire.
- As the temperature of a surface warms, it will release more infrared radiation (more heat), regardless of what materials make up the object.



What is the 'Earth's Energy Budget'?

- The curvy arrow shows another way that energy is released from the surface through **conduction** and **convection**.
- **Conduction** transfers heat to cooler air that directly touched the host surface.
- **Convection** occurs when air warmed by the surface rises upward, moving heat away from the surface. *Convection from the hot pavement is the reason that the air above a hot road on a summer day appears to shimmer.*
- Both convection and conduction remove energy from the surface faster when the surface is much warmer than the air above



What is the 'Earth's Energy Budget'?

A third way by which energy is transferred from earth's surface is through **evaporation**, which is shown by the **dashed arrow**.

Evaporation is the changing of liquid water to an invisible gas called water vapor. This change requires energy, and evaporation is the reason that you cool off when you sweat. The surface of the earth also "sweats". When water evaporates from the earth's surface, it transfers energy away from the surface, keeping it cool.

Why "budget"?

We call this energy 'budget' or 'balance'. Why? Because the earth is releasing the same amount of energy that it is gaining.

The processes of conduction, convection, infrared radiation, and evaporation that you previously read are responsible for this **balance**.

When something happens that destabilizes this, then one of these things responds to balance again. It is like a math problem that always must result to zero.

So, the more energy the earth is gaining, the more energy it has to release!

Albedo!

- Have you ever noticed that you feel it gets warmer outside in the summer when you wear black, and you feel cooler when you wear white? This is the effect of albedo!
- Why? Because, as mentioned before, some materials reflect more sunlight than others.
- Albedo shows how much of the incoming sunlight is reflected by a surface.
- The less albedo a surface has, the more energy is getting absorbed.

→ This means that the less albedo a surface has, the warmer it feels!

→ The more it reflects (higher albedo) the cooler it feels!

What do plants do?

- Plants take up water from the ground through their roots. Then, they store the water in their stems and leaves. The water eventually travels to small holes on the underside of the leaves. There, the liquid water turns into water vapor and is released into the air. This process is called **transpiration**.
- By releasing water, plants cool themselves and the surrounding environment. Like how sweat cools the human body, energy is absorbed and transported away from a warm object by the evaporation of water. When solar energy is absorbed by plants, much of the energy is released by transpiration instead of warming the plant and increasing convection and infrared radiation release. Also, over a forest canopy or a vast expanse of grassland, large amounts of transpiration can greatly increase water vapor in the atmosphere, causing more precipitation and cloud cover in an area. The additional cloud cover often reinforces the cooling by blocking sunlight.

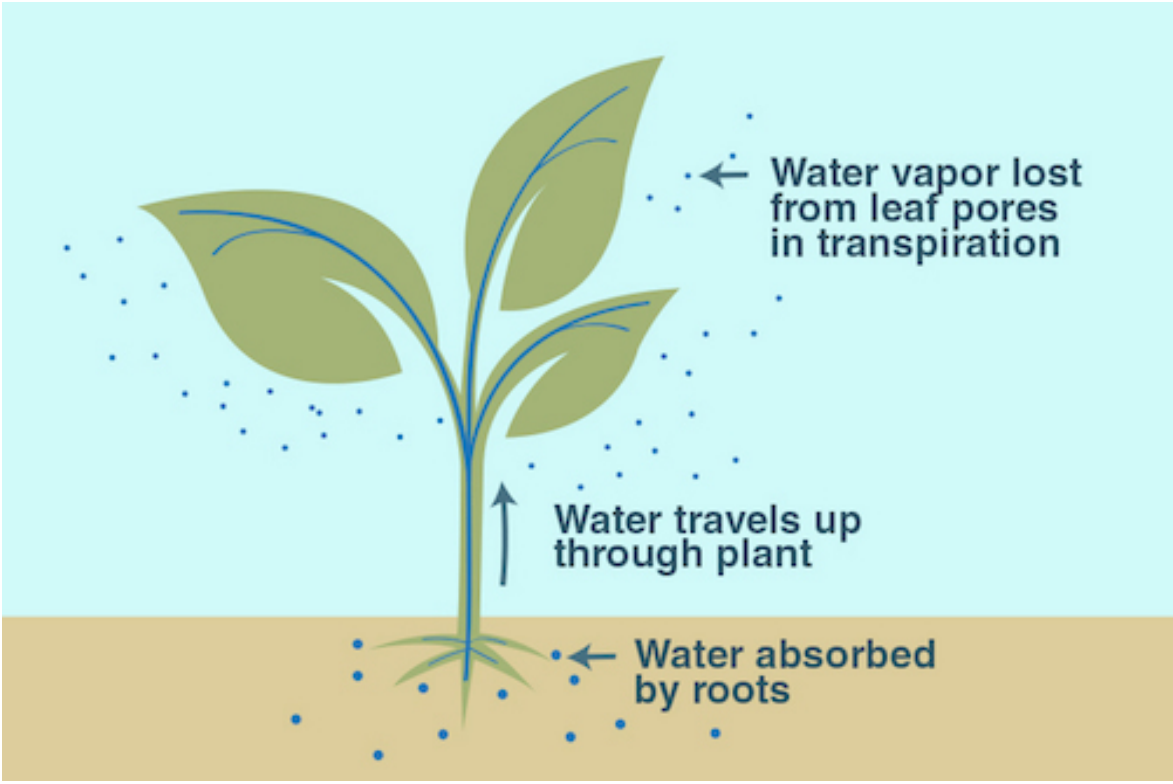
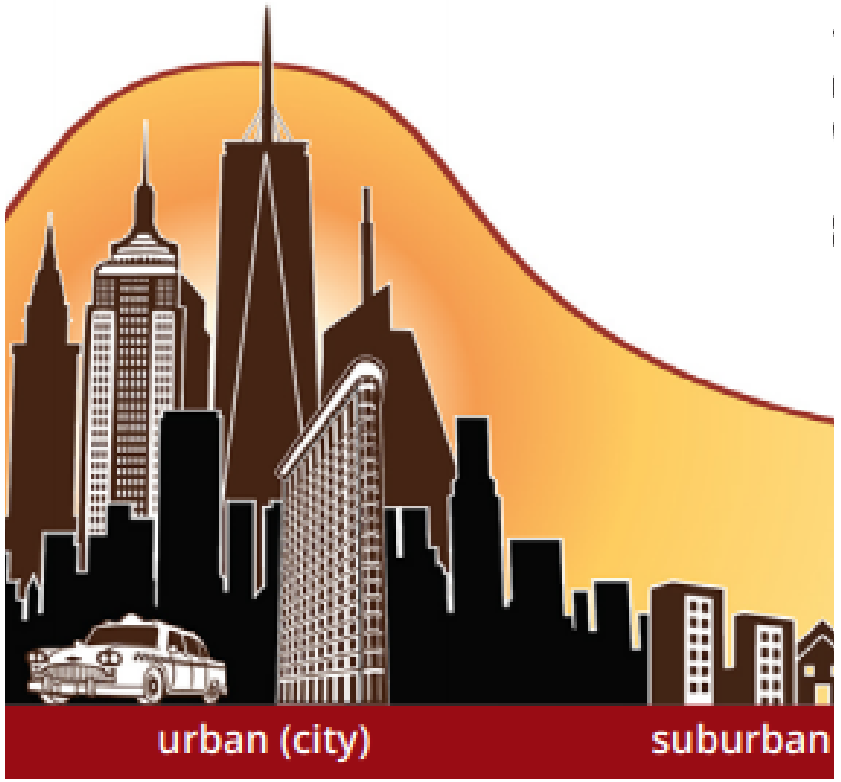


Image: An illustration of the process of transpiration
Credit: NASA JPL/Caltech

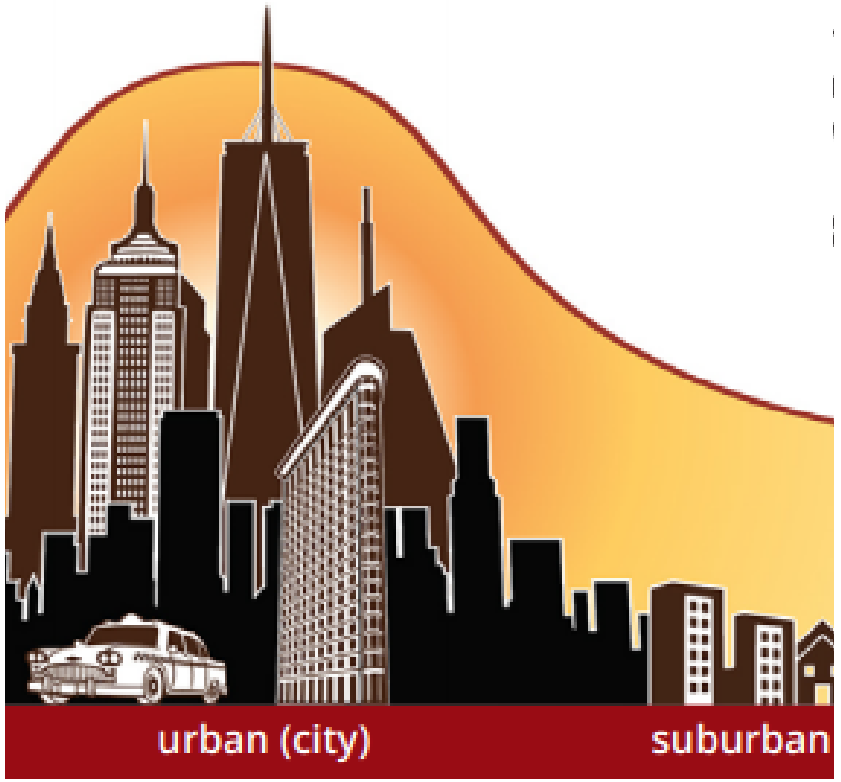
Where Do Urban Heat Islands Form?

- The hottest places on earth are full of rock and stone, they do not have a lot of water, plants, or trees, and they are full of dark colors.
- Cities are full of these rocky surfaces — asphalt, brick, and concrete —that absorb heat by day and release it at night. These materials are used to make the sidewalks, parking lots, roads, and basketball courts of urban areas. **Urban heat islands form because humans replace cooler surfaces with rocky surfaces**.
- These hard and dark-colored surfaces contribute to the urban heat island effect in two ways. **First**, these surfaces have a **low albedo**, which increases the amount of energy from solar radiation they absorb. **Second**, these surfaces **do not contain much water to evaporate**, meaning that less of the absorbed energy evaporates water, and more goes into warming the surface and releasing energy by conduction, convection, or radiation. <u>The combination of these factors means that cities and other highly developed areas are hotter than the plant-covered countryside.</u>



Where Do Urban Heat Islands Form?

- Urban areas often see temperatures rise 6°C (10°F) hotter than the surrounding suburbs and rural areas. Cities tend to be hotter than their surrounding areas at all times of the day and at all times of the year. However, a variety of factors influence the urban heat island. Bigger cities tend to have stronger heat-trapping capacities than smaller cities. Cities surrounded by forests have more pronounced heat islands than do cities in arid environments, since replacing forests with paved surfaces in urban areas has much more of a warming effect than replacing dry sand and rock with the pavement.



Why are Urban Heat Islands a Problem?

- Urban heat islands are one of the easiest ways to see how human impact can change our planet. Sidewalks, parking lots and skyscrapers wouldn’t exist if humans weren’t there to build them. And although these structures are essential to city living, the heat islands they create can be dangerous for humans.
- In the summer, New York City is about 7°F (4°C) hotter than its surrounding areas. That doesn’t seem like much, but these higher temperatures can cause people to become dehydrated or suffer from heat exhaustion. The hot temps also require more energy to operate fans and air conditioners. This can lead to power outages and a serious danger to public health.