



# A Preliminary Study Thermal Storage Effect with Heat Island in Urban Environment

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# Urban Heat Island

An **Urban Heat Island (UHI)** is a metropolitan area which is significantly warmer than its surroundings.

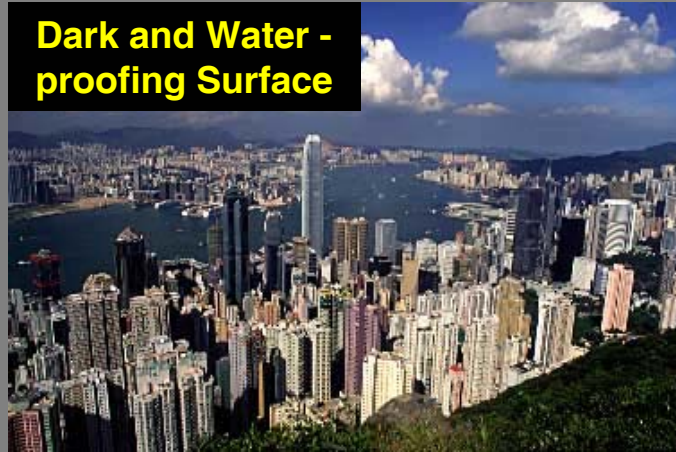


A view of “**Concrete Jungle**” (Hong Kong Island and Kowloon) from the peak

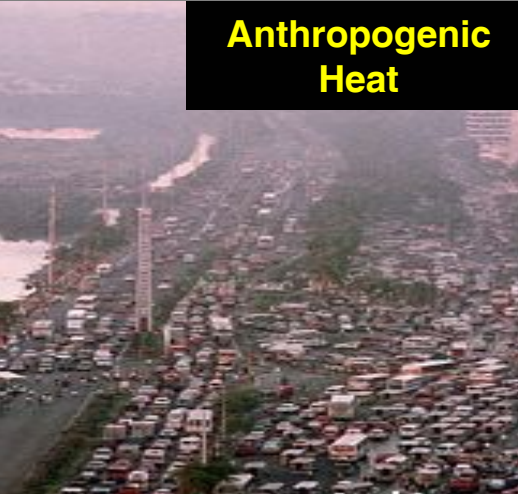
# Causes of Urban Heat Island



**Dark and Water -  
proofing Surface**

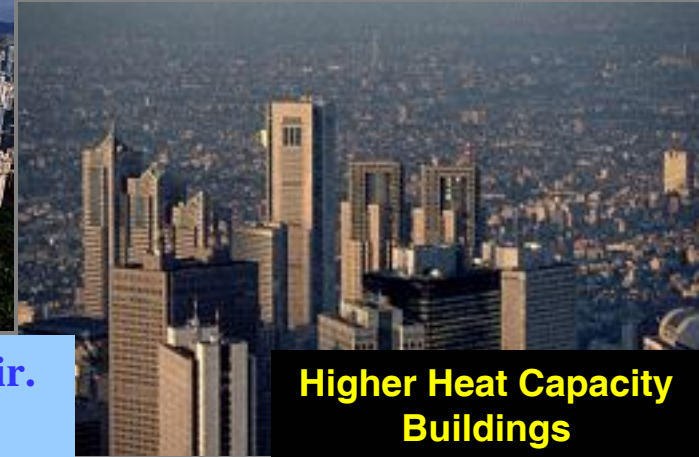


**Anthropogenic  
Heat**



- Human heat sources all warm the air.
- Pollution by exhausts, factories and other dusts absorb radiation.
- Dark surfaces have a low albedo; Water-proofing surfaces reduce latent heat loss by evaporation.
- Higher heat capacity surfaces increase sensible heat storage
- Limited sky view increase absorption of short-wave radiation and prevent heat loss during the night.

**Higher Heat Capacity  
Buildings**



**Factory & Other  
Pollution**

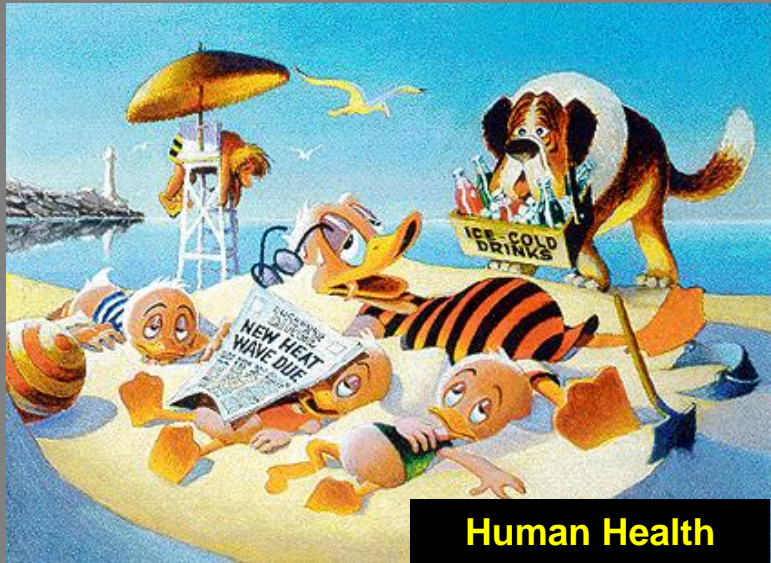


**Limited Sky View**





# Significance of Urban Heat Island



**Human Health**



**Energy Demand**



**Ozone Pollution**

# Urban Open Space

A general definition of open space includes any land or water surface that is not occupied by buildings.



Very limited open spaces in Hong Kong



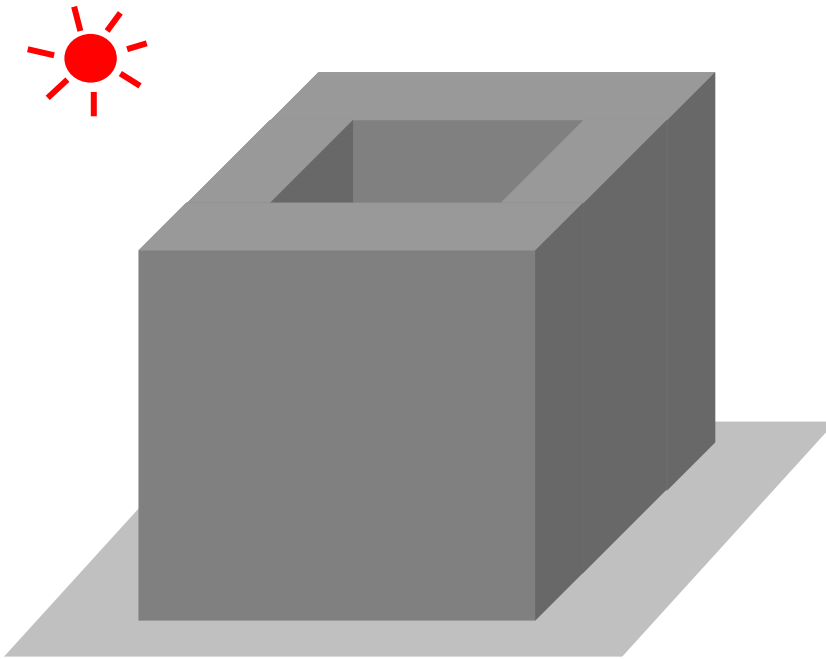
# The Questions are . . .

How much does the urban thermal mass contribute to the heat island ?

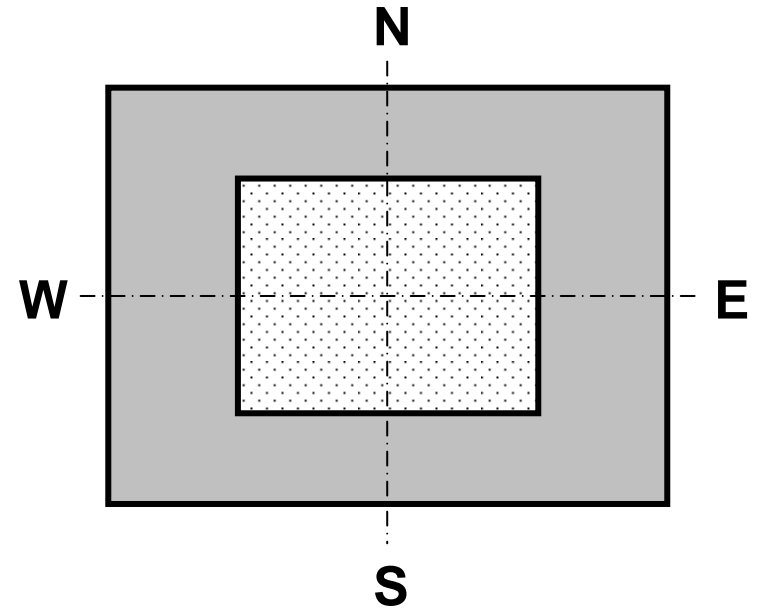
How does the thermal mass affect the thermal environment around the buildings ?

How to utilize open spaces to mitigate urban heat island?

# Model - An Open Space Surrounded by Buildings



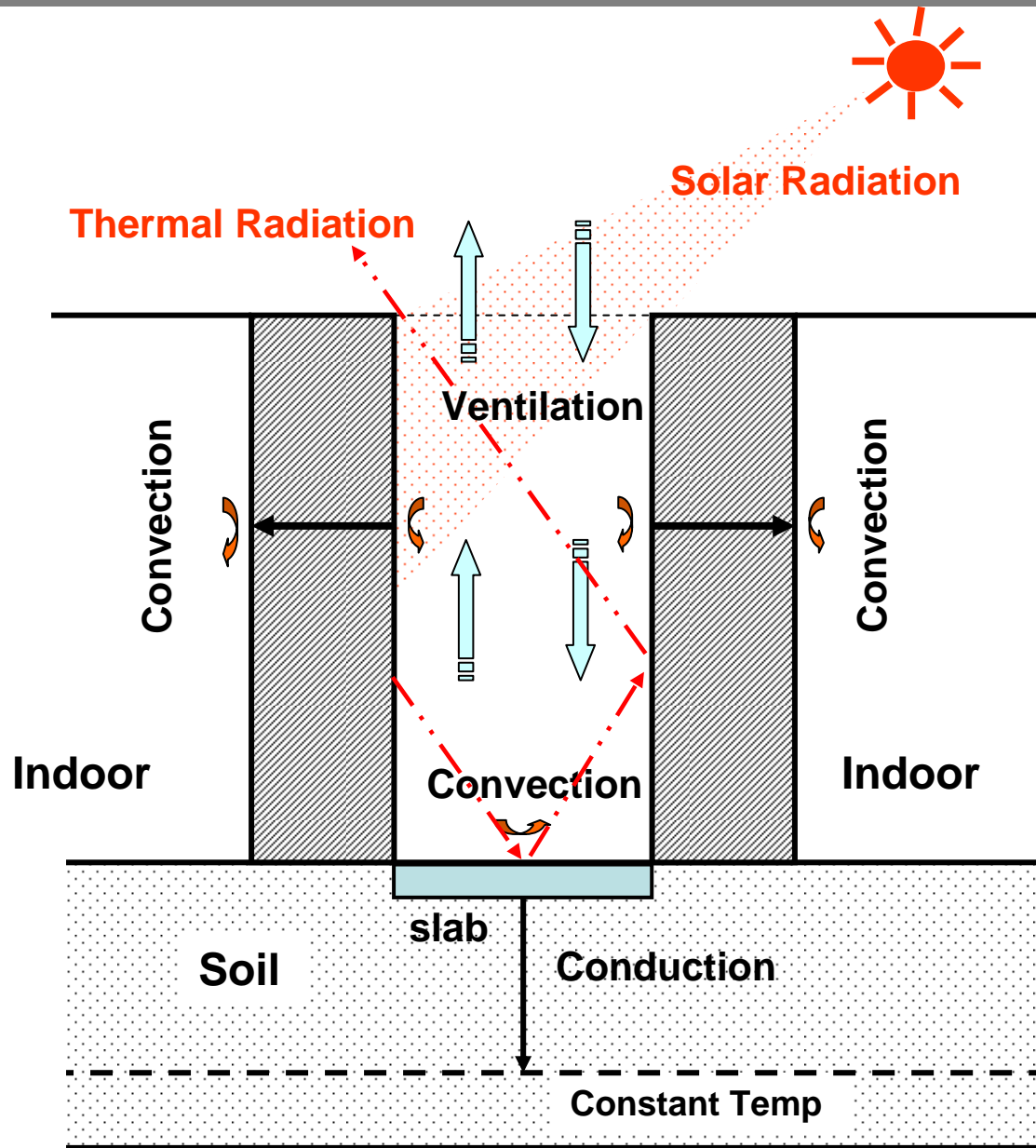
Model Geometry



- Building
- Open Space

Model Plan

# Heat Transfer







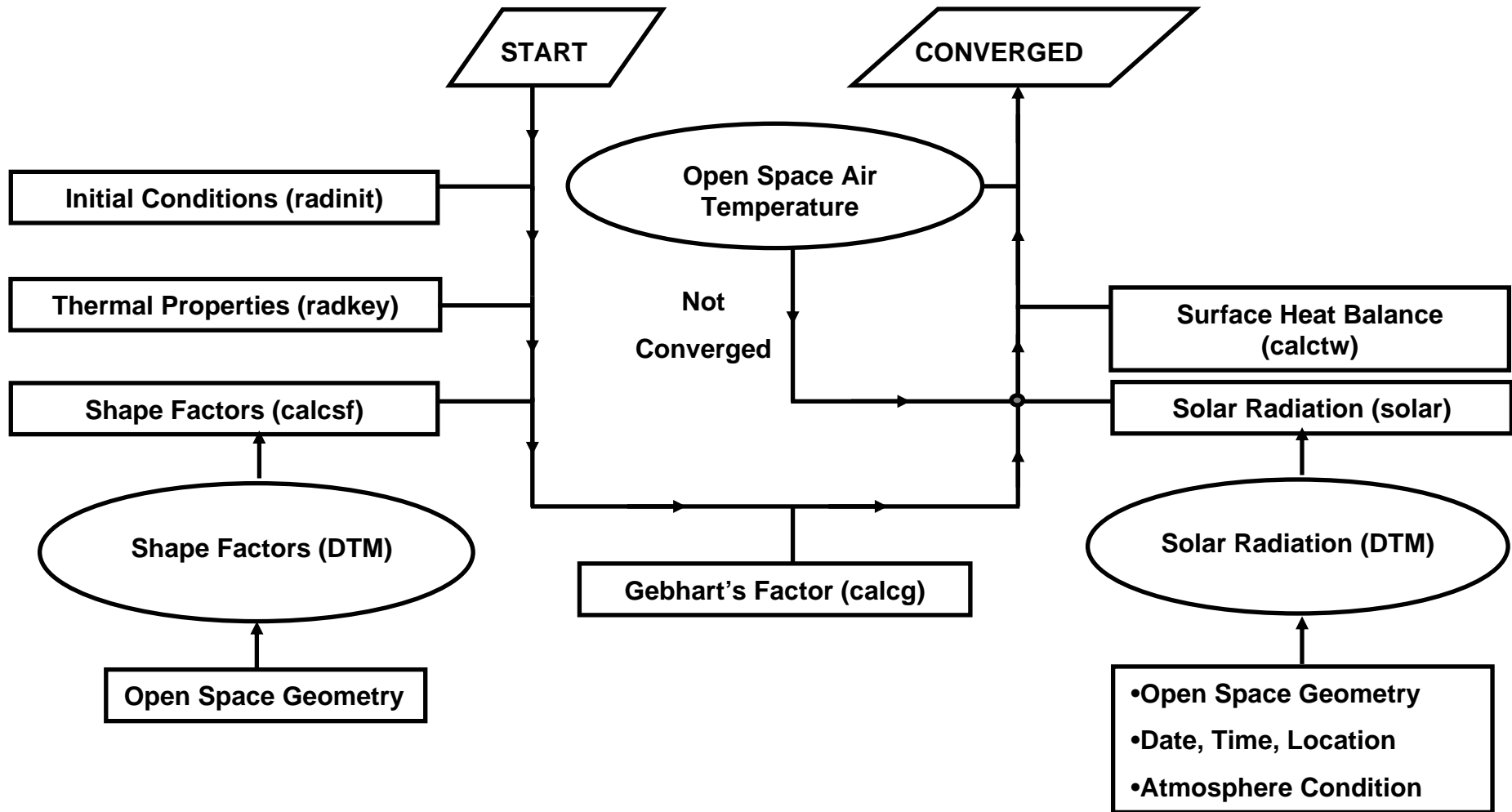
# Model Assumptions

- The air in the open space is assumed uniform;
- The vertical ventilation is assumed to be a constant value.
- The indoor air temperature is assumed to be constant, 22 °C.
- We assume that the ambient temperature can be expressed as

$$T_o = 30 + 5 \times \sin(\omega t - 2\pi/3)$$

$\omega$  is the frequency of the outdoor temperature fluctuation with a value of  $2\pi / 24 \text{ h}^{-1}$

# Model Program

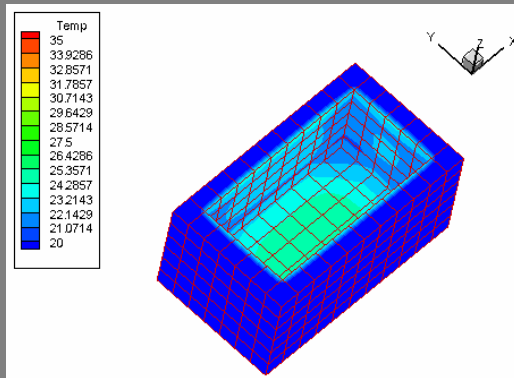




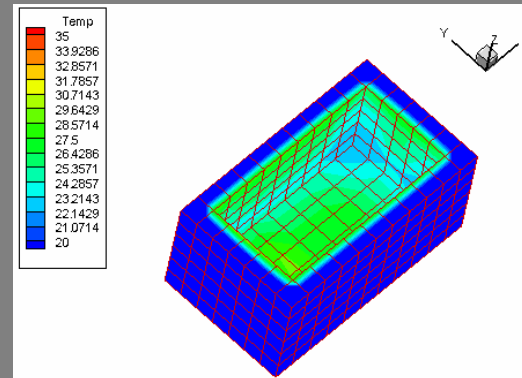
# Model Test

Beijing (120° Longitude, 40° Latitude)

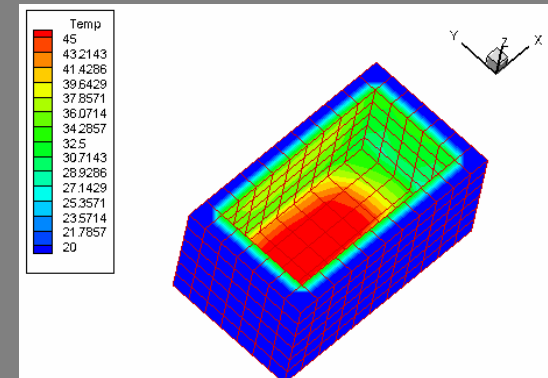
Date: 2006, July 1st



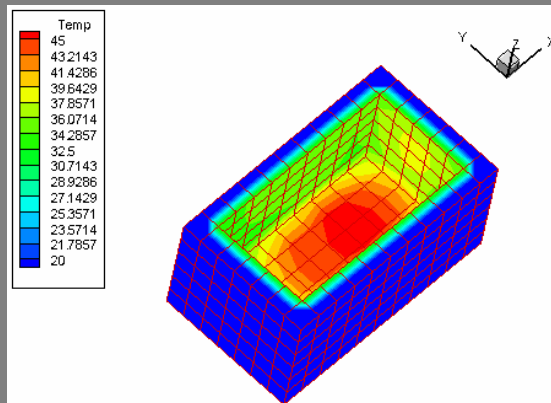
4:00 am



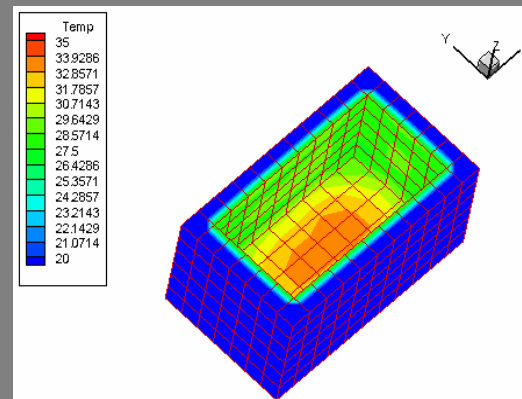
8:00 am



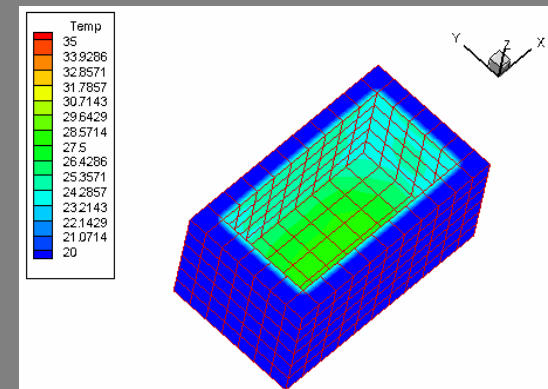
12:00 pm



16:00 pm

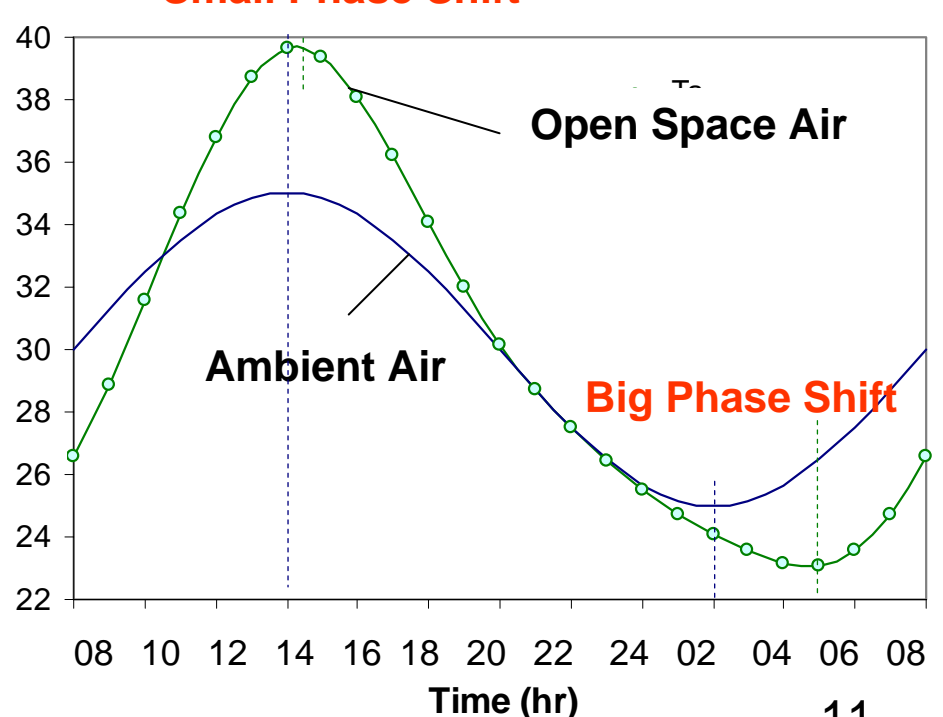
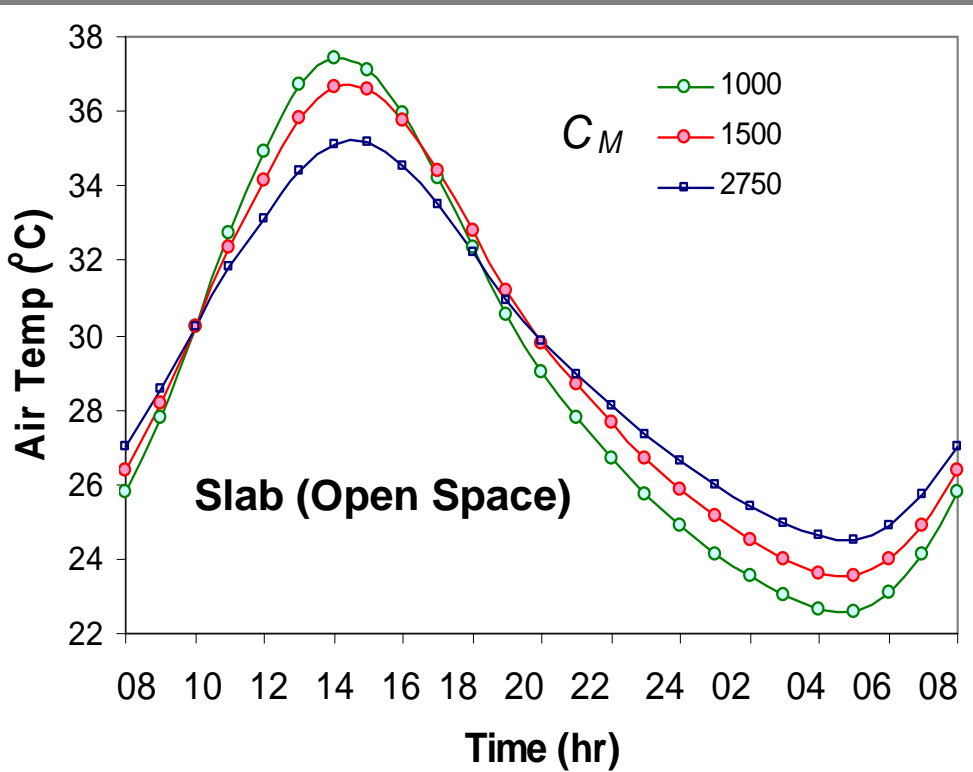


20:00 pm



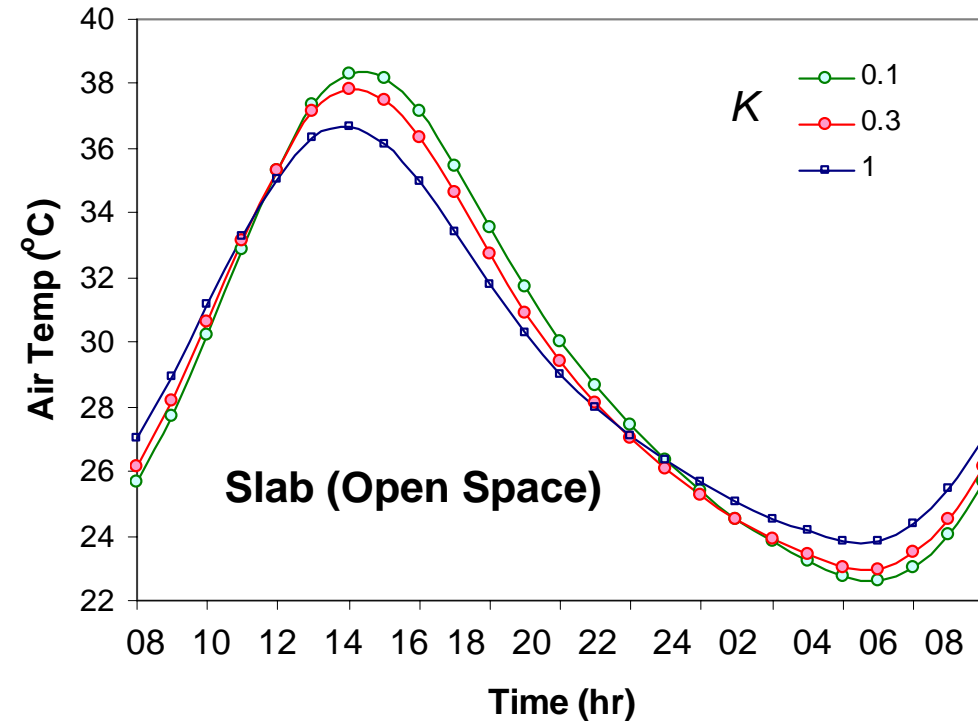
0:00 am  
(Next day)

# Open Space Air Temp

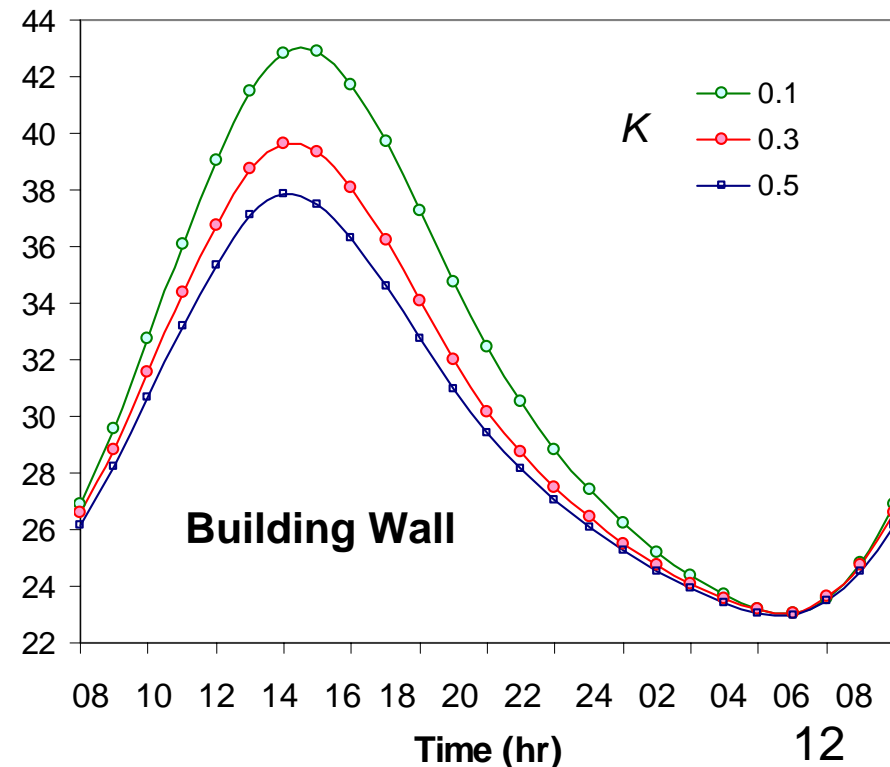


Bigger the thermal mass, lower the temperature at daytime while higher temperature at nighttime

# Different Surface Conductivity



Indoor air is constant, higher thermal conductivity can drive heat conduction into wall.



For bigger thermal mass, higher thermal conductivity can help heat through its body.



# Conclusions



- Through a simple model – an open space surrounded by buildings, the effect of urban thermal storage on urban heat island can be found.
- The simple model has been shown (although very preliminarily) to be useful to analyze the heat transfer behaviors in the structure.
- To simulate the complex microclimate in urban areas, CFD airflow code should be combined with the present model.
- Therefore, the model can be developed to evaluate the effect of different open space on the urban heat island and thermal environment. The results can be necessary for city planning and building design.



Thank you!