

Surface temperatures in New York City: Geospatial data enables the accurate prediction of radiative heat transfer

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PROBLEM

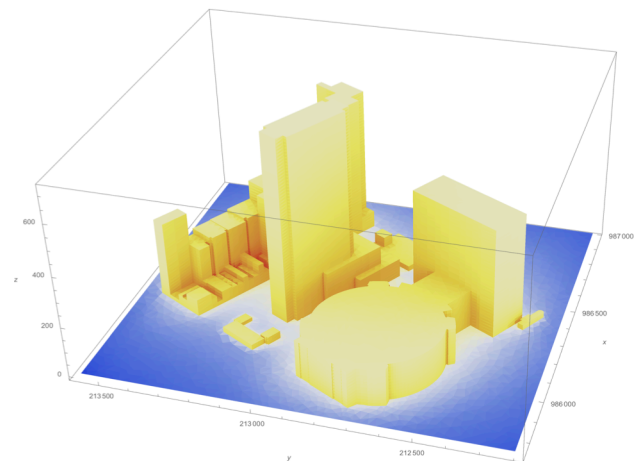
Cities are home to the majority of the world's population and thus contribute significantly to global energy consumption, waste, and pollution. The dynamics of an urban energy budget, especially the thermal exchange between densely built infrastructure and the surrounding environment, are not well understood. This is largely because the component of the energy budget associated with energy storage has been unattainable. The significance of this gap was highlighted in the early 1990's by a number of researchers working on the derivation of the urban energy budget. Although their research, which included work on urban heat island, radiative heat transfer and stored energy, was subsequently expanded to incorporate urban scale climate models that included the application of satellite remote sensing (resulting in better understanding of the thermal dynamic responses of the urban environments), the quantitative analysis of the thermal storage component is still elusive due to the large number of unknowns in the urban space equations of heat transfer. Time resolved analysis of the urban surface temperature appears to be the most effective avenue for closing this knowledge gap. Advancing the understanding of the energy budget will lead to improvements in several areas: models of urban meteorology and air quality, models that forecast energy demand and consumption, technological innovations in building materials, heating and cooling technologies, as well as climate control systems and urban design, all of which seek to enable energy efficiency at the building level and at city scale, while improving human health and the quality of the environment.

APPROACH

Researchers mapped surface radiations from nearly 100 blocks of Manhattans West Side in New York City. This includes measurements using a hyperspectral-imaging instrument and a theoretical radiosity model for calculating the measured radiation. The model results were subsequently compared with the measured values. This work benefits from a legacy of applications of spectroscopic imaging in earth sciences and remote sensing, including surface radiography and plume detection. In the majority of those applications, imaging systems are deployed in a "downward-looking" configuration, mounted on moving platforms such as aircraft and satellites. In contrast, when considering urban energy research, stationary ground based imaging offers the advantage of persistence and a desirable field of view.

FINDINGS

The close comparison of temperature values derived from measurements and the computed surface temperatures implies that our geospatial, thermodynamic model applied to urban structures is promising for accurate and high-resolution analysis of urban surface temperatures. The next step is to evaluate the assumption made in the calculation, followed by a time dependent analysis.



Surface temperatures from colder (blue) to warmer (red) for the area of Penn Plaza, New York City

WHY DOES THIS RESEARCH MATTER?

- Researchers developed a heat transfer model for precise prediction of urban surface temperatures that considers actual urban morphology obtained from GIS data and is validated by hyperspectral imaging.
- The model, which has many applications (energy budget, health) and extensions (time dependence, convection), may help close the knowledge gap regarding an understanding of the Earth's energy budget.