Research Brief
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Quantifying Climate Impacts of Surface Albedo

PROBLEM

The atmosphere is a dynamic system. Any changes that occur in one place due to factors such as wind speed, temperature, and surface albedo (the measure of the fraction of solar energy reflected by the Earth's surface) can impact the system as a whole. Atmospheric models give researchers the ability to simulate various scenarios and project changes to the climate and atmospheric system under various conditions. We used such models to study the impact of surface albedo on the climate.

APPROACH

Initial condition ensemble is a statistical method used to investigate variations that exist in a natural environment (in this case, an atmospheric system). This method is useful in estimating the *signal* of surface albedo impact on the atmospheric system as distinct from the *noise* of natural variability. In this study, the initial condition ensemble was conducted using the Weather Research and Forecasting model (WRF) for year 2005 over the entire continental United States at 50 km horizontal resolution. We ran two scenarios: (1) a control run in which all urban surface albedos are 0.15, and (2) a run with elevated urban surface albedos of 0.40 (a number chosen because it appears as the upper range of pavement albedo in several existing studies). A higher surface albedo indicates higher reflectivity, typically associated with lighter colored surfaces. Each scenario generated four simulations with the same atmospheric physics but different start dates (Dec. 1, Dec. 2, Dec. 3, and Dec. 4, 2004).

FINDINGS

In this study, the change in surface albedo only applies to rooftops, pavements, and walls of urban land cover grid cells. The two groups of simulations (low and high albedo) were compared to determine the impacts of elevating urban surface albedo and to account for the uncertainty in the errors or noise introduced by the slightly different initial conditions. The results are represented as the differences in surface temperature between the two scenarios when urban surface albedos are elevated from 0.15 to 0.40. The ensemble mean of all potential outcomes as a whole, instead of individual initial conditions, shows that during the summer season of 2005 the elevating urban surface albedo has an overall cooling effect at both local and regional scales, such as the consistent cooling over mid-US and east coast shown in Figure 1.

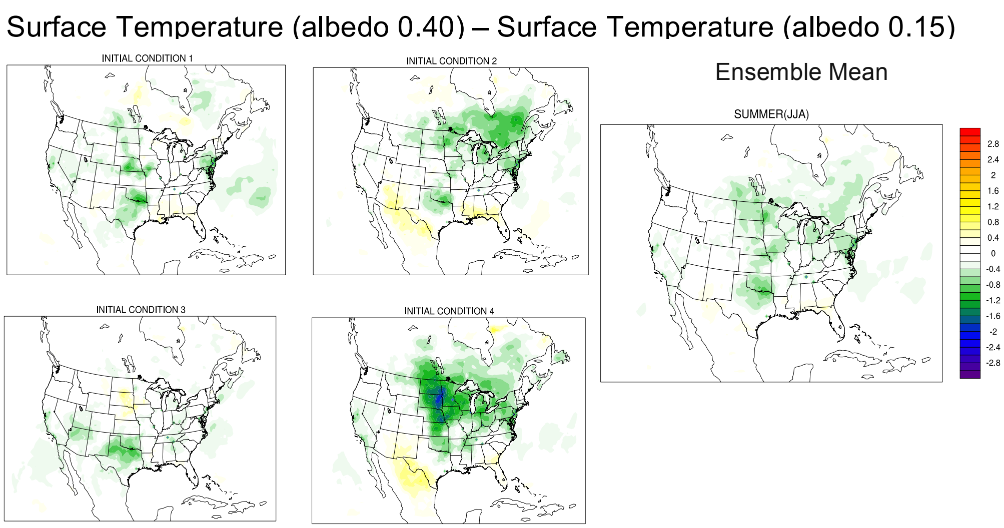

Figure 1. The changes in surface temperature from elevating urban surface albedo during summer of 2005. The four initial conditions have starting dates of Dec. 1 to Dec. 4, 2004, respectively, while the Ensemble Mean is the average of the four initial conditions. Green color represents cooling from decrease in surface temperature due to elevating albedo, while yellow represents warming.

IMPACT

Climate models can be linked to environmental impact analyses of infrastructure to determine the impacts of surface albedo on the climate. After an analysis to remove natural variability, the model results show that the impact of elevating surface albedo has a cooling effect that is robust at both local and regional scales during the summer season. More refined analyses of urban areas will provide insights on surface albedo impacts in specific regions. Future analyses may address changes in CO_2 equivalence.

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