Geophysical Research Abstracts
Vol. 13, EGU2011-4870, 2011
EGU General Assembly 2011

A coupled energy and water transport model for urban surfaces

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Changes of surface landuse types, resulting from rapid global urbanization, have significant impacts on urban environmental and engineered systems including heat island formation and modification of the hydrological cycle and air quality. The last few decades have seen increasing efforts to capture and characterize the physics of flow and surface transport processes in the lower urban atmosphere; the representation of latent heat and water in these efforts however remains inadequate. In this work, we propose a new urban surface exchange scheme, coupling a single-layer town energy balance (TEB) model with a hydrological model for subsurface water transport and urban evapotranspiration. The energy transport model is developed based on the one used in the Weather Research and Forecasting (WRF) model. Improvements in this new urban surface exchange scheme include: (1) derivation and implementation of a spatially-analytical method that captures surface temperatures and conductive heat fluxes better; (2) statistical characterization of uncertainties in the surface input parameter space; and (3) coupling to a hydrological model to better parameterize the evaporation (and latent heat budget) from urban surfaces, for both engineered surfaces with water-holding capacity and vegetated surfaces. Intensive field measurements are also carried out through a large network of sensors deployed over the campus of Princeton University. Data collected from the sensor network are used to provide input parameters as well as to validate the proposed numerical scheme.