Impact of urban expansion and warming climate on sea-breeze circulations: A numerical study in the Greater Houston Metropolitan Area

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The Building Effect Parameterization + Building Energy Model (BEP+BEM) with a detailed urban parameterization coupled with the Weather Research and Forecasting (WRF) model is used to simulate the summertime local circulation in the Houston, Texas metropolitan area. Six numerical model simulations at 3km horizontal resolutions (within the nested parent domain of 9km) are performed using land use data representative of 2010, and 2100. They include:

(a) Control Simulation (with 2010 land use with current and future climate)

(b) same as (a) but with less aggressive urban expansion

(c) same as (a) but with more aggressive urban expansion

For future climate simulation, CCSM4 data (RCP8.5 scenario) were used to generate the climate perturbation, which was then applied to the current forcing data (NCEP final analyses) used for the numerical model simulations. Validation is based on comparison between model simulations and observations and it shows reasonably good model performance. Numerical simulations show an important interaction between the sea breeze and the urban heat island (UHI) circulation. The UHI forms a strong convergence zone in the center of the city and accelerates the sea-breeze front toward it. This phenomenon raises several questions. (1) With urban expansion, how is the sea breeze penetration modified? What is its impact on energy consumption in the city during the summer season, (2) After the dissipation of the UHI, how does the penetration of sea breeze change? (3) How is the speed of the sea breeze modified with climate change and/or urban expansion? We will discuss our approach and present our results that help answer these questions.