Developing time-variant filter for meso-scale surface temperature prediction

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Abstract

Many urban areas are vulnerable to heat-induced hazards. In the so-called Urban Heat Island (UHI), trapped heat flux within the building canopy increases the surface temperature of cities, and it is revealed that UHI has a non-linear synergy with extreme heatwaves. Therefore, fast/accurate temperature prediction is essential to mitigate the risk, improving the community's resilience. In this paper, we introduce a probabilistic model to forecast the meso-scale surface temperature, at a relatively low computational cost. The proposed model is developed to reduce the computational cost of the Numerical Weather Prediction (NWP) models. We calibrate the proposed model by processing the outcomes of an NWP model (i.e., the Princeton Urban Canopy Model coupled to the Weather Research and Forecast; WRF-PUCM) that reanalyzes historical temperature. The calibrated model is integrated into a Kalman-Filter scheme to update the predictions with the collected data.

Keywords: probabilistic modeling; surface temperature; hidden Markov model; dimension reduction; Kalman-filter.

1 Introduction

Surface temperature has a remarkable influence on the comfort of urban dwellers, as well as on human health and various social activities. Also, heat stressors can have a high impact on because of their high population. The trapped heat within building canopies isolates the cities' heat profile from the surrounding environments, this is the so-called Urban Heat Island effect (UHI), and it has a non-linear synergy with extreme heatwaves [1]. Therefore, predicting surface temperature is essential for risk management, and the fast and accurate forecast systems will enable the cities to operate infrastructure sustainably, enhancing urban resilience.

1.1 Numerical weather prediction model

Approaches based on Numerical Weather Prediction (NWP) are state-of-the-art for current weather forecasts and analysis [2]. NWP is a numerical model that solves partial differential equations for atmospheric fluid dynamics and other physical processes, including radiation transfer and cloud process. With the current growth of computing power, NWP has improved its accuracy so that highly reliable weather forecasts have been achieved. For instance, the Princeton Urban Canopy Model (PUCM) is able to predict complex heat patterns in an urban area, with a

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