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Title(English)	A LARGE-EDDY SIMULATION STUDY OF 3D-SENSIBLE HEAT FLUX ON TURBULENT ORGANIZED STRUCTURES WITHIN AND ABOVE A REALISTIC URBAN AREA
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（博士課程）
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論 文 要 約

THESIS OUTLINE

専攻： Department of	International Development Engineering 専攻	申請学位（専攻分野）： Academic Degree Requested	博士 (Engineering) Doctor of
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要 約
Thesis Outline

This dissertation examines the thermal effect on turbulent flow within and above a realistic urban area using parallelized large-eddy simulation model (PALM). PALM model was coupled with microscale energy-balance model and was improved with the implementation of 3-D high resolution heterogeneous sensible heat fluxes from building facades and urban surfaces. Initial boundary condition of the energy balance model was provided from the mesoscale climate model (WRF) which was improved with new aerodynamic parameterization and global datasets.

The scope of this study is threefold. First, to improve mesoscale weather model by applying new urban parameterization. Second, to use the outputs of this mesoscale model to feed the 3D-City Irradiance Model which is used particularly in architectural field. Finally, to assign calculated 3-D heat flux to the building facades of large-eddy simulation model with the addition of realistic inflow conditions and realistic urban roughness. Within this scope, the thesis outline is composed of seven chapters.

Chapter One (Introduction) provides a framework to the research problem. The chapter is subdivided into five parts. Part One surveys the current state of the literature on realistic urban area representation in both for mesoscale and microscale models. This part points out that recent studies which have proven the need for realistic urban geometry for surface roughness in numerical weather prediction models and large-eddy simulation (LES) models, thereby referring simulations which have been conducted for smooth and homogeneous surfaces. Part Two defines the research problem about simplified urban geometry and thermal characteristics for boundary-layer development. Part Three describes the objective of the study to represent this layer accurately assigning realistic urban geometry and three-dimensional heating from the building surfaces. The scope of the study is discussed in Part Four. Part Five gives a summary of the Chapter One.

Chapter Two (Theoretical Background) gives the structure to support the theory of the study. Part One is the introduction. Part Two defines the basic terminology related to the turbulence and turbulent organised structures. Part Three explains the mathematical models to describe the turbulent flow field. Turbulent organised structures in boundary layer for neutral and unstable conditions are described in Part Four. Part Five presents the

boundary-layer turbulence generated by urban surfaces.

Chapter Three (Model Description and Simulation Setup) consists of four parts, each of them dealing with structure of the main large-eddy simulation (PALM) from regional to building scale. Part One summarizes the conceptual framework of the research methodology. Part Two focuses on Weather Research and Forecasting (WRF) Model which is a mesoscale numerical weather prediction system. Simulation setup for default and modified WRF model and is described in this part. Furthermore, case studies with various combination of urban surface parameters are presented. Part Three illustrates energy balance model which calculates heat transfer within urban canopies. Part Four deals with large-eddy simulation model(PALM). Description of the cases used in the simulation with realistic and idealistic urban surfaces for heating and no heating conditions are also given in this part.

Chapter Four (Weather Modelling Using Detailed Urban Parameters Derived from Global Datasets) highlights the improvements of urban representations in weather models using global datasets and explains the estimation of urban surface parameters, sea surface temperature, anthropogenic heat emission and urban cover of a specific example, the city of Istanbul. Utilization of global datasets as surface boundary inputs for urban areas and the sea in a weather model was validated with this study. Results implied that global datasets can be used as alternate to real building data. Due to Istanbul's geographical location, the SST input was found to influence the simulated air temperature. 4-km sea surface temperature data improved the accuracy of simulated air temperature and boundary layer. Along with the urban surface parameters, the inclusion of a 1-km global AHE and urban cover enhanced the UHI especially over the eastern side of Istanbul.

Chapter Five (Coupling Mesoscale Outputs with 3-D Irradiance Model) describes how the outputs of the WRF simulation were treated as initial boundary conditions of the 3D-City Irradiance Model. A Central business district with high-rise buildings close to the old city center of Istanbul was selected as a simulation domain. Domain divided into 16 patches and each patch was calculated separately in the energy balance model. Results indicated that %74 of the sensible heat flux emitted via ground and roof surfaces which were directly exposed to the solar radiation. %19 of the sensible heat flux was from south facades of the buildings. Although, the distribution of the values was same for north and east facades of the buildings (%2), west façade showed slightly higher values (%3).

Chapter Six (Boundary-layer Modelling with Buoyancy-driven Flows Over a Realistic Urban Area) explains the findings of coupling 3D-City Irradiance and PALM and validation of the model with the field experiments, wind-tunnel studies, and numerical simulations. 3-D sensible heat flux values extracted from the energy balance model were assigned to the building surfaces in large-eddy simulation. Results revealed that turbulent organised structures formed by local shear above urban area are smaller and elongated through the streamwise direction. With the addition of the heat flux, the size of the structures becomes larger plum-shaped structures due to the strong thermal mixing. Moreover, heterogeneity in the building height distribution of realistic cases also altered the size and the continuity of the turbulent structures. This alteration is important since the size of the structures determine the boundary-layer thickness.

Vertical and horizontal velocity variances indicated quiet good match with empirical equations. The chapter is also pointed out the correlation between turbulent structures within and above the canopy. Idealized building array with constant heat flux revealed highly correlated results (0.8) due to the ideal street array since the structures do not encounter any obstacles through the flow direction. With substituting realistic building distribution, correlation decreased to 0.5 due to the obstructed structures by buildings and dead end. Above the canopy, despite the slight differences, values reached to 0.6 for ideal case and 0.4 for realistic cases. Another finding in this chapter is that local flow structures within the canopy depends on the distributed heat fluxes from the building facets.

Conclusions are drawn in Chapter Seven (Concluding Remarks) which reviews the research findings and highlights the practical applications of the study. It is noted that

- Global datasets can be used as an alternate to real building morphological data to estimate the urban parameters.
- Global SST, AHE & urban parameters improved the accuracy of simulated air temperature and wind speed.
- LES model can be employed for distributing heat flux to the building surfaces realistically.
- Spatial development of the boundary-layer thickness can be defined by the level at which mean wind speed was 99% of the scalar concentration.
- There is a correlation between turbulent organized structures within and above the canopy.

With these findings, this research will contribute to future research on thermal turbulent structures in urban boundary-layer topic.