ANALYSIS OF NOCTURNAL COLD-AIR CURRENTS FORMED IN SATOYAMA (URBAN-NEIGHBORING HILLS AND FORESTS) USING AIRBORNE MSS DATA AND CFD SIMULATION

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1. INTRODUCTION

As urbanization progresses, housing development is sprawling to urban-neighboring areas. In order to make a good use of local natural energy, understanding of natural potential in the locations under consideration of urban development at the design stage is required. A klimaatlas including geographical information and climatic data is useful for understanding of natural potential. Aimed at developing a klimaatlas for understanding nocturnal cold-air currents that are formed in urban-neighboring hills/forests during summer nighttime and flow toward the neighboring urban areas, the present paper describes an attempt to use airborne MSS data as input data for simulating cold currents formed within a valley with forests during summer nighttime.

2. METHODOLOGY

An urban area surrounded by Satoyama (urban-neighboring hills and forests, suburban forests) was selected for analysis. The analysis was carried out according to the procedure indicated in Fig.1. The first step is to identify actual conditions of land covers in the selected urban and suburban areas using airborne MSS data, GIS data and aerial photographs. MSS data observed in Zushi city (Kanagawa Prefecture, Japan) at noon and night on a clear sky summer day was used in the analysis. Two types of the MSS data were used and their spatial resolutions were 6.3 m and 0.63 m, respectively. Vegetative cover distribution maps and thermographs of vegetative surface temperature were created from these data. At the second step, the relationship between topographic features and nocturnal temperature distribution of vegetative surface was analyzed in order to clarify the factors that have a great impact on formation of nocturnal cold currents. From the above analysis results, a valley in which a residential area is located and nocturnal cold currents might occur was selected for CFD (Computational Fluid Dynamics) simulation. The height from bottom to top of the selected valley is approximately 40 m. The width and length of the valley are 280 m and 625 m, respectively. 3D CAD models for CFD simulation were created based on MSS, GIS and DEM data (Fig.5).

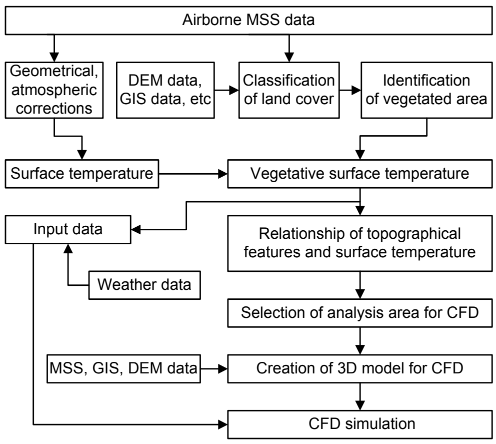

Fig.1 The analysis flowchart

3. RESULTS

From thermographs of surface temperature distribution (see Fig.3), it was found that surface temperatures of a valley slope with forests decrease from top to bottom. The surface temperature difference between the top and bottom of the valley reached 2°C. Surface temperatures from the MSS data were used in CFD simulation as input data (boundary conditions). Simulation results show that cold currents developed above the valley slopes flow down to the bottom of the valley. When wind blew at a velocity of 3 m/s from a direction perpendicular to the valley, the air above the slope on the windward side was 0.5°C cooler than that over the top of the valley, whereas the air temperature above the slope on the leeward side was nearly equal to that over the top of the valley (see the left graph of Fig.4). The cool air layer at a temperature of 1-2.5°C lower than ambient air temperature was formed from the bottom of the valley to a height of 20 m. Air temperature distribution within the valley can be quantified by using the proposed simulation method, and the cold current distribution can be visualized on a 3D color display (Fig.6).

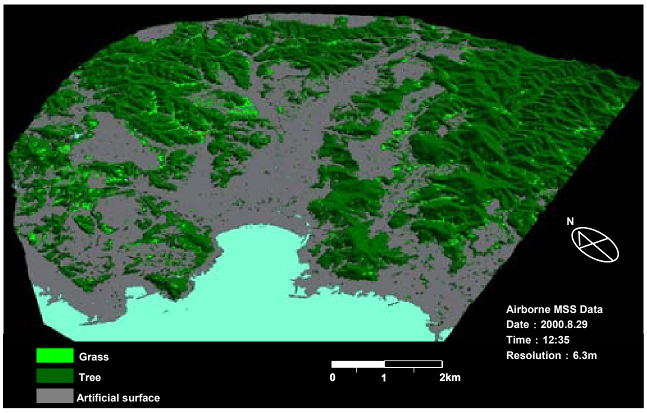

Fig.2 Vegetative surface distribution in the analyzed area

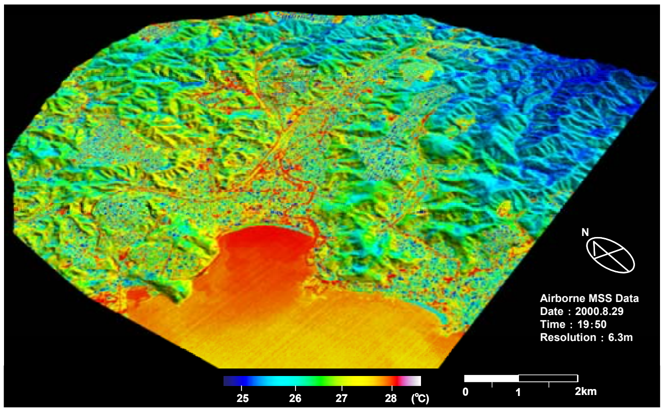

Fig.3 Nighttime surface temperature distribution

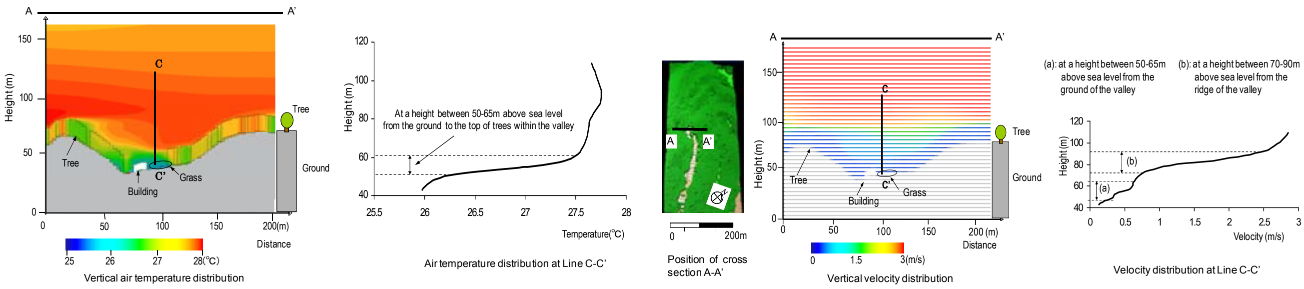

Fig.4 Vertical air temperature (left) and velocity (right) distributions in the selected valley

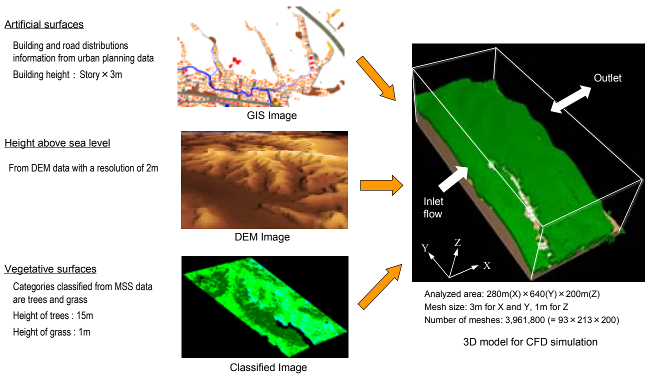

Fig.5 3D CAD model of the valley for the CFD simulation

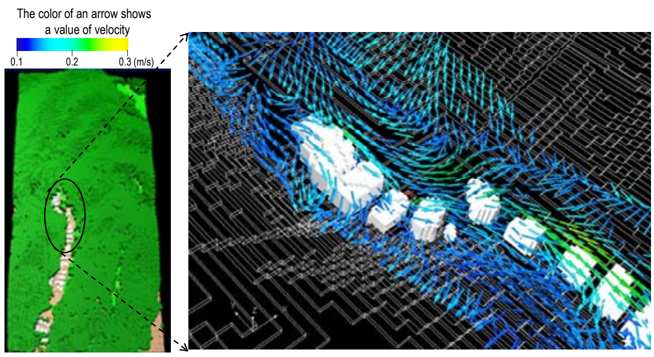

Fig.6 Velocity and vector distributions near the valley bottom

4. REFERENCES

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