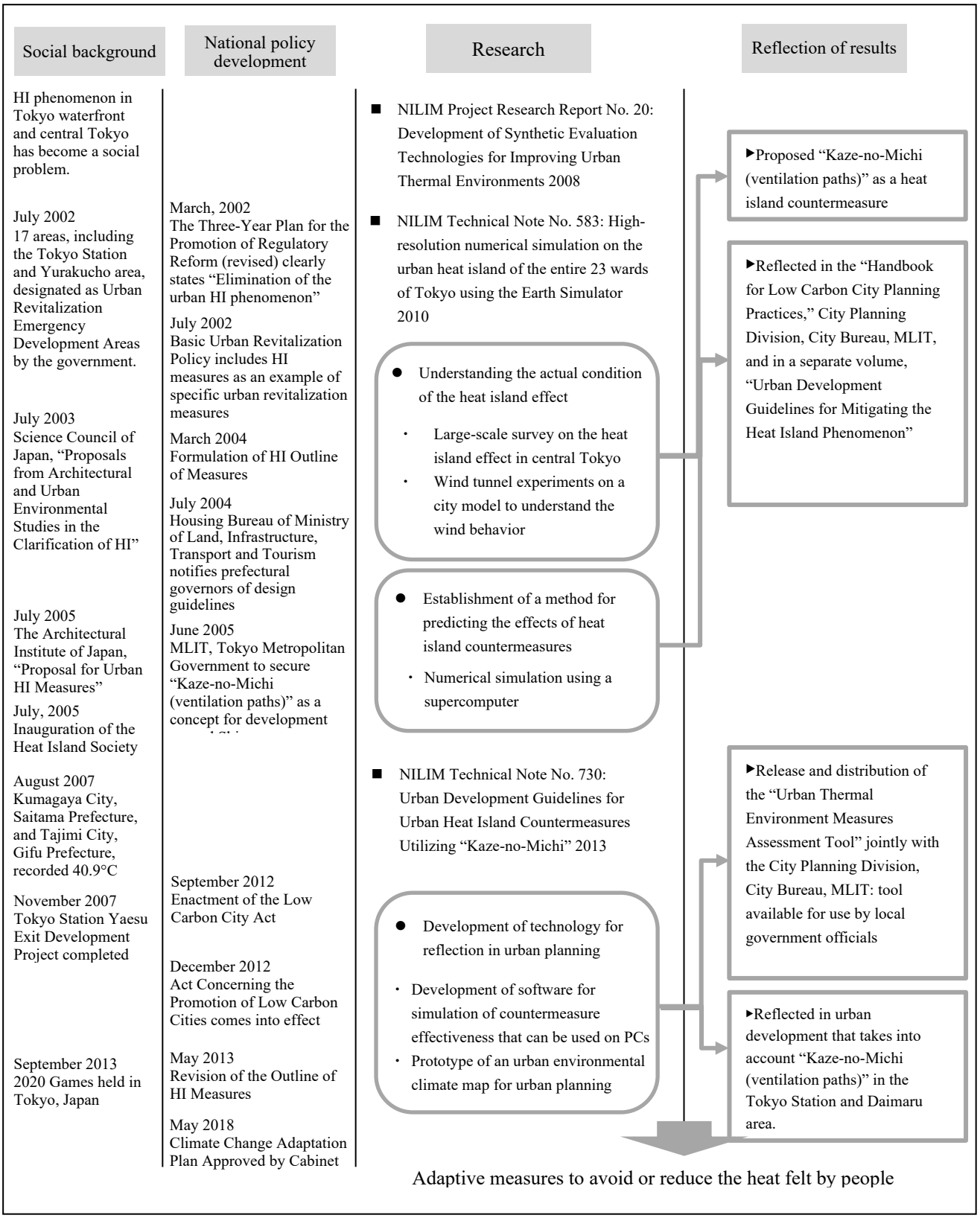
Urban heat island countermeasures

1. Outline of Studies and Activities



- The heat island effect is a phenomenon in which urban temperatures rise, resulting in increased living discomfort and health hazards such as heat stroke, as well as changes in the ecosystem. Currently, related ministries and agencies are working together to promote heat island countermeasures based on the "Outline of Heat Island Countermeasures" (formulated in 2004 and revised in 2013), which was prepared by the Liaison Conference of Related Ministries and Agencies for Heat Island Countermeasures.
- NILIM has been working to elucidate the causes of the heat island phenomenon and develop quantitative evaluation methods for heat island countermeasures for effective implementation in urban planning.
- It is widely known that the study of "Kaze-no-Michi (ventilation paths)" originated in Europe and was put into urban planning practice in Stuttgart, Germany. In Japan, too, " Kaze-no-Michi" research has long been carried out in the fields of geography, weather/climate, urban planning, and architecture. In introducing wind road planning in Japan, scientific studies on "Kaze-no-Michi" were conducted in a comprehensive technology development project of MLIT in order to acquire urban planning solution technology focusing on "sea breezes" unique to Japan and different from those in the West, taking into consideration the bay location of large cities and the regional climate characteristics.

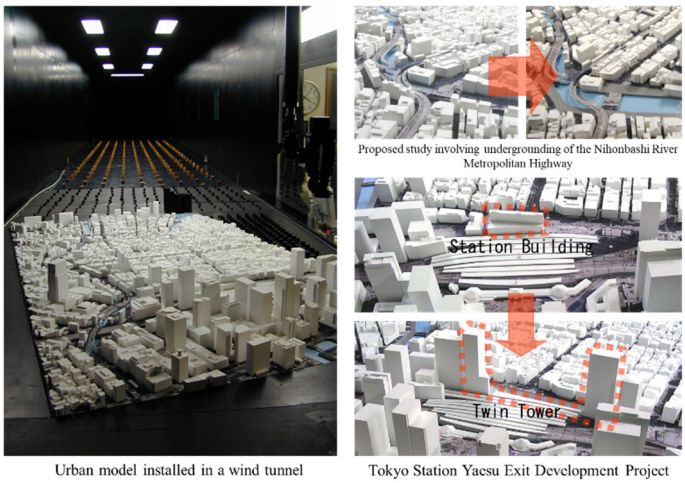
(1) Background Events

In the 2000s, buildings in central Tokyo began to rise in height and become overcrowded at an accelerating rate, and the heat island phenomenon in the area became a serious social problem. This was covered by many media outlets, and the heat island phenomenon was widely recognized as a new urban environmental problem. The "Three-Year Plan for the Promotion of Regulatory Reform (Revised)" (approved by the Cabinet in 2002) clearly stated the need for heat island countermeasures, and the "Outline of Heat Island Countermeasures" was formulated. However, the factors of the heat island phenomenon are complicated and the mechanisms are not fully understood, and there is not enough scientific knowledge to implement countermeasures.

(From left to right: Shiodome, Otemachi, Osaki, around Nihonbashi)
Figure-1 Overview of a large-scale meteorological observation survey

(2) Research and Development Tasks

- Research on evaluation and countermeasure technology for the thermal environment of urban space (MLIT General Technology Development Project, FY2004-2006)
- Research on the quantitative evaluation of the effect of the urban form on the thermal environment (funded by the Ministry of the Environment, 2004-2006)



Urban model installed in a wind tunnel
Tokyo Station Yaesu Exit Development Project
Figure-2 Wind tunnel test using an urban district model

(3) Outline of Research and Activities

We proposed "Kaze-no-Michi (ventilation paths)" as one of the measures to combat the heat island phenomenon in the Tokyo waterfront and city center areas, which was regarded as a social problem. We conducted large-scale

meteorological observations at 190 locations along the streets and on the rooftops of buildings in these areas (Figure-1), and wind tunnel experiments using an urban model of the Tokyo Station and Nihonbashi River area (Figure-2). Based on the results, we verified the effectiveness of the countermeasures, including the "Kaze-no-Michi," using a wide-area numerical simulation on a supercomputer. As an example, the effect of a plan that considered the "Kaze-no-Michi" in a large-scale redevelopment project around Tokyo Station at that time was predicted to improve the air ventilation over a wide area and lower the temperature by 2°C at maximum.

In undertaking the above research and development, NILIM, the Geospatial Information Authority of Japan, the Building Research Institute serving as the secretariat, and a study group was established to obtain advice from academic experts, with the participation of relevant divisions of MLIT, the Japan Meteorological Agency, the Ministry of the Environment, the Tokyo Metropolitan Government, and others.

2. Main Research Results

The research results were used in the city planning guidelines and heat island countermeasure plans of the Tokyo Metropolitan Government, Chiyoda Ward, and other local governments, as well as in the future vision of the Tokyo Station and Nihonbashi River area by the local community planning councils, and were also reflected in actual urban development. In addition, the basic policy of the "Act Concerning the Promotion of Low Carbon Cities (Eco-City Act)" (December 2012) and the "Low Carbon City Planning Practice Handbook" (City Planning Division, City Bureau, MLIT, December 2013) also showed how to utilize this law.

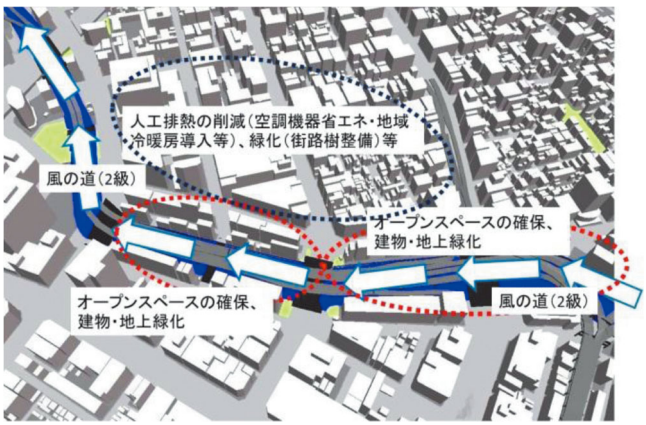
(1) Development and release of evaluation tools for urban thermal environment measures, etc. (released jointly with the City Planning Division, City Bureau, MLIT)

- The simulation technology for the heat island countermeasure effects using the Earth Simulator was developed as a tool[4] etc. that can be used by local government officials and business operators (Figure-3).
- It is possible to comprehensively predict the effects of temperature reductions through consideration of "Kaze-no-Michi" as a heat island countermeasure, as well as the effects of greening, energy-saving air conditioning equipment, water-retaining pavement, and district heating and cooling, etc.
- Furthermore, in order to effectively promote the creation of low-carbon cities as well as urban heat island countermeasures, we also developed an evaluation tool that can predict the CO_2 emission reduction effects in addition to the temperature reduction effects of heat island countermeasures.

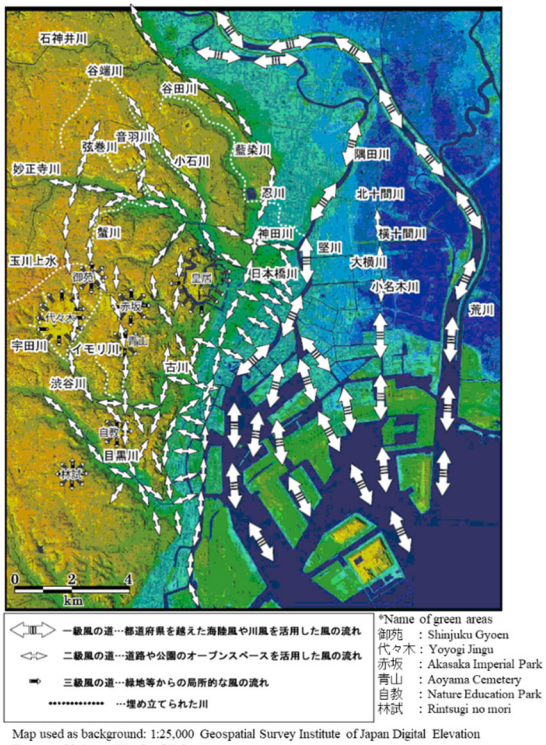
Figure-3 Images of the PC software for assessment of UHI countermeasures

(2) Heat island control maps and guidelines

- For residents and businesses seeking to improve the comfort of outdoor spaces, the "Guidelines for Urban Development Utilizing Kaze-no-Michi"[3] were prepared for urban planners and environmental planners of local governments to consider the cool breezes that flow through each city and take effective measures that suit the regional characteristics of each city.



Policy map of district scale measures



Policy map of city scale measures

Figure-4 Draft of the "Kaze-no-Michi" measures in the Tokyo waterfront and central Tokyo

- To enable local governments to implement heat island countermeasures as part of urban planning, the aforementioned evaluation tools were used to study “Kaze-no-Michi” and other countermeasure policies based on the actual temperature and wind flow conditions, as shown in the “heat island countermeasure map” (Figure-4).

3. List of Related Reports and Technical Documents

(1) NILIM Project Research Report No. 20 Development of Synthetic Evaluation Technologies for Improving Urban Thermal Environments
http://www.nilim.go.jp/lab/bcg/siryou/kpr/prn0020.htm

(2) NILIM Technical Note No. 583 High-resolution heat island numerical analysis for the entire 23 wards of Tokyo using the Earth Simulator
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn0583.htm

(3) NILIM Technical Note No. 730 Urban Development Guidelines for Urban Heat Island Countermeasures Utilizing “Kaze-no-Michi”
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn0730.htm

(4) Urban Thermal Environment Assessment Tool - CFD in Excel
http://www.nilim.go.jp/lab/icg/hyouka-tool.htm

4. Future Outlook

Added to the “Outline of Heat Island Countermeasures” (revised in 2013) was the promotion of adaptation measures to reduce the impact on human health, etc. In addition, the “Climate Change Adaptation Plan” (approved by the Cabinet in 2018) clearly states “Impacts of heat on people’s lives” in “the field of national and urban life,” etc. In recent years, there has been a growing demand for adaptation measures to avoid or reduce the heat that people experience. In order to study the effects of heat on people’s lives, we plan to combine population flow data, thermal simulators, and 3D urban models, and develop research activities to support urban policy through analysis technology utilizing IoT and big data.