Monitoring and Prediction of Torrential Rainfall for Extreme Weather Resilient Cities

Masayuki Maki[1] (maki@bosai.go.jp), R. Misimi[1], T. Kobayashi[2], I. Nakamura[3], and collaborators*

[1]*National Research Institute for Earth Science and Disaster Prevention, Japan*
[2]*Meteorological Research Institute, Japan*
[3]*Toyo University, Japan*

Core Research Institutes:
- National Research Institute for Earth Science and Disaster Prevention (NIED)
- Meteorological Research Institute (MRI)
- Toyo University

Collaborated with 23 organizations:
- Universities and research institutes
  NILIM, Japan Weather Association, NICT, ENRI, Hokkaido Univ., DPRI/Kyoto Univ., Osaka Univ., Yamanashi Univ., Chuo Univ., Nihon Univ., National Defense Academy, TMRI, CRIEP, Pukyong National Univ., Corolado State Univ.
- Local government and private companies
  Tokyo Fire Department, Yokohama City, Fujisawa City, Edogawa-Ku/Tokyo, JR-EAST, JR-CENTRAL, Obayashi Co., Toshiba Co.,

Project Outline

It is recognized that large cities with a population of several million people are inherently vulnerable to severe weathers such as torrential rainfall, lightning, and tornados. Increase in the number of occurrences of torrential rainfall and giant typhoon, which may be due to the global warming, can bring extensive damages in large cities. Thus, the developments of monitoring and prediction system of extreme weather are urgent. The present research project aims to understand the process and mechanism of extreme weather using dense meteorological observation networks designed in the Tokyo metropolitan district, to develop the monitoring and predicting system of extreme phenomena (MPSEP), and to implement social experiments on extreme weather resilient cities in collaboration with the related government institutions, local governments, private companies, and residents.

Targeting Deep Convections Causing Local Heavy Rainfall and Flash Flood in Urban Areas

to Overcome Difficulties of Extreme Weather Forecast

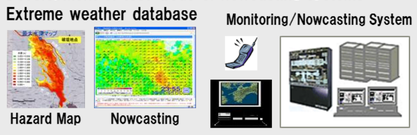
Theme 1: Field Experiments TOMACS

【Meteorology】
To obtain new insight on mechanisms of extreme weather
(1) Development of new technologies
(2) Field campaign in the Tokyo area (3) Statistical analysis

to Issue More Accurate and Adequate Warning

Theme 2: Monitoring and Very-short Forecasting System

【Engineering】
Developments collaborating with end users
(1) Extreme weather nowcasting methods
(2) Development of test-beds of nowcasting systems
(3) Extreme weather database

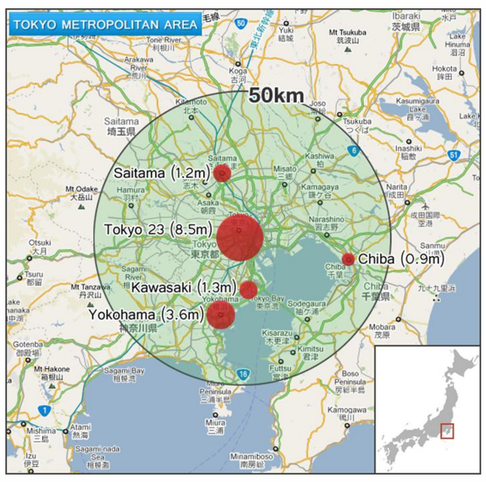


to Evaluate and to Adapt the Nowcasting Systems

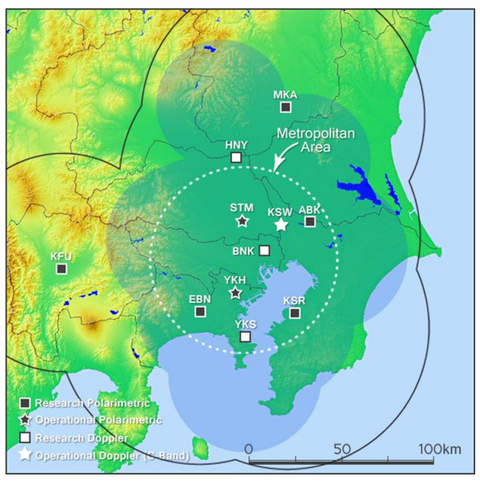
Theme 3: Social Experiments

【Sociology】
Evaluation and adaption the developed nowcasting system
(1) Social experiments in rescue services, risk management, infrastructure and education
(2) Recommendations for extreme weather resilient cities

Test bed and X-NET

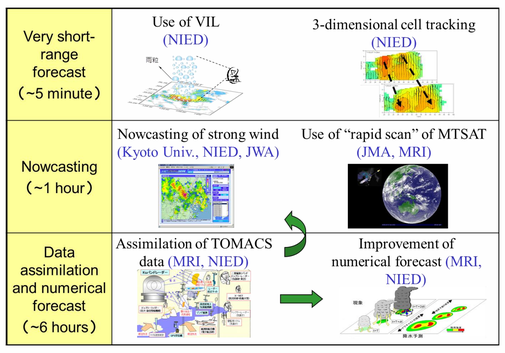


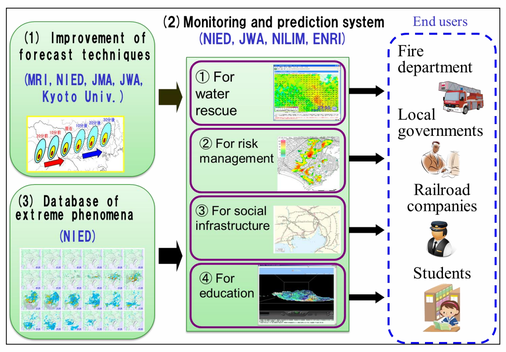
Target area of X-NET. About 30 million people live in the Tokyo metropolitan area which is defined an area within a 50km radius of the Tokyo Metropolitan Government office. Numbers show population in million.



X-NET radar observation area (outer black circle line) and topography. The translucent blue color shows wind retrieval area with multiple-Doppler radar analysis.

Monitoring and Prediction System



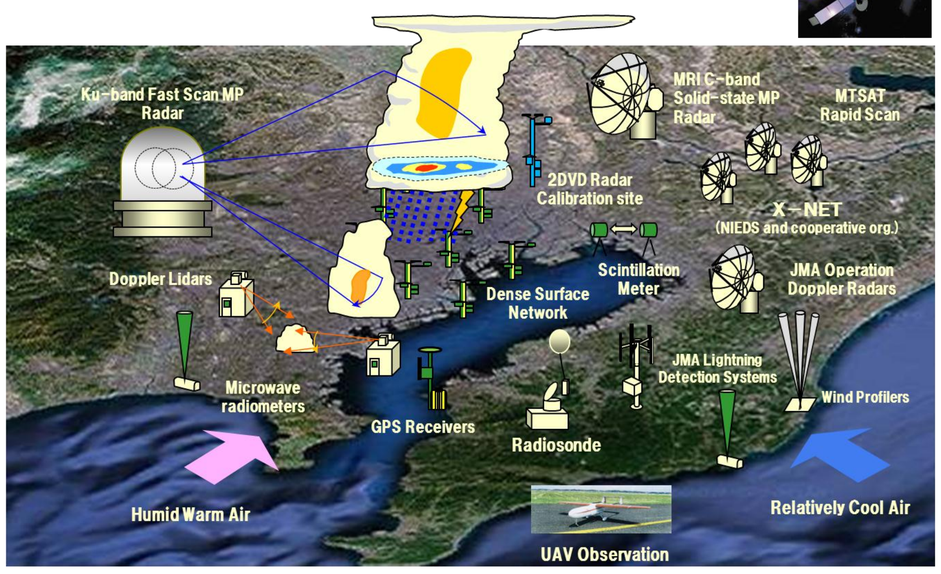


The aim of the second research subject is to establish the "Monitoring and Prediction System of Extreme Phenomena (MPSEP)" which can process real-time data of the dense meteorological observation networks and predict localized heavy rainfalls and strong winds. Information from the MPSEP is utilized in social experiments described in the third research subject. It is also an aim of the research subject to establish database of the extreme weather which is useful for planning disaster countermeasures.

Tokyo Metropolitan Area Convection Study

To understand the initiation, development, and dissipation processes of convective precipitation, and to clarify the mechanism of localized heavy rainfall which potentially causes natural disasters such as flooding and land slide, a variety of cumulus activities are studied by dense research and operational meteorological observation networks in the Tokyo Metropolitan Area, numerical experiments, and statistical analysis of environmental conditions preferable for extreme weather.

TOMACS (Tokyo Metropolitan Area Convection Study) with a dense observation network by MRI, NIED and 12 research groups in the summers of 2011-2013, as testbed for deep convection.



The network of dense meteorological instruments used in the project.

Meteorological facilities used in TOMACS

Target	Meteorological parameters	Instruments	
		Research facilities	Operational instruments
Pre-storm Environment	Temperature (middle and lower atmosphere)	UAV, Microwave radiometers	Radio sonde
	Water vapor (middle and lower atmosphere)		Radio sonde, GPS network
	Wind (middle and lower atmosphere)	UAV	Radio sonde, UHF Wind profilers
	Temperature, water vapor, wind (boundary layer)	Doppler Lidars	UHF Wind profilers, AMeDAS
	Surface T, wind, rain (partially Td, P)	High spatiotemporal surface meteorological network	AMeDAS, AEROS
Cumulus	Cumulus images (visible, infrared)	Web cameras	MTSAT rapid scan imager
Thunderstorms	High-spatiotemporal precipitation	Ku-band fast scan radar	–
	3D Precipitation field	X-NET(polarimetric, Doppler radars) MRI C-band polarimetric radar	MLIT X-band polarimetric radar network JMA C-band Doppler radar network
	3D wind field		
	Polarimetric parameters		MLIT X-band polarimetric radar
	Drop size distribution	Disdrometer network , Micro rain radar	–
	Rainfall amount	Disdrometer network	Raingauge networks (AMeDAS, MLIT, Local government)
	lightning	–	JMA LIDEN

Social Experiments

The aim of the third research project is to validate the effects of the MPSEP on disaster prevention and the reduction of damage in these situations trough field tests of the MPSEP in four different disciplines: Emergency deployments, river managements, infrastructures, and educations. Before implementing social experiments, surveys on appropriate information and effective means of transmitting information will be done in the each experimental field to make the MPSEP suitable for practical use.

The Tokyo Fire Department (TFD) examines X-NET information for prompt flood preparedness, emergency deployments of firemen, and efficient and safety rescue activities.

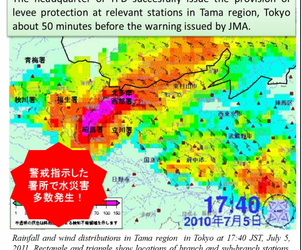
16:02
- Thunderstorm advisory
- Start watching X-NET products

16:49
- Heavy rainfall of 50~70mm/h at NW of Tama area
- Warning at relevant fire stations

16:50~17:10
- Issuance of levee protection at relevant stations

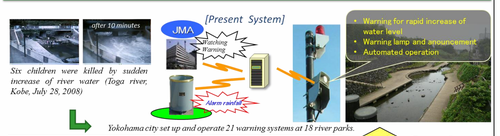
17:40
- A heavy rain and flood warning in Tama area (JMA)

The headquarter of TFD succesfully issue the provision of levee protection at relevant stations in Tama region, Tokyo about 50 minutes before the warning issued by JMA.



Rainfall and wind distributions in Tama region in Tokyo at 17:40 JST, July 5, 2011. Rectangle and triangle show locations of branch and sub-branch stations, respectively.

Yokohama City examines QPE and QPF for improvements of the flash flood warning system in urban water parks.



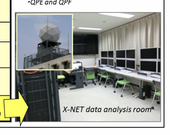
Six children were killed by sudden increase of river water (Toga river, Kobe, July 28, 2008)

Yokohama city set up and operate 21 warning systems at 18 river parks.

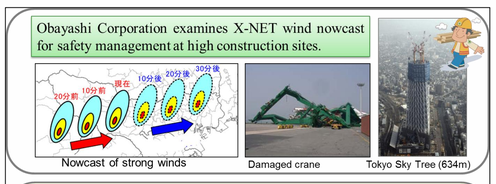
Information	Lead time	Evaluation
Raingaugel (on site)	No lead time for evacuation	×
Raingauge (near site)	Some lead time if there is enough number of raingauges near the site	○
River level (on site)	No lead time for evacuation	×
River level (upstream)	Insufficient lead time due to short river channel	×
Info. from JMA	60 minute lead time for nowcast (accuracy ?) Accuracy or delay of warning	○
X-NET products	5~15min with high accuracy	under examination

[Future System]

Add X-NET products to the present system
•rainfall amount / watershed
•QPE and QPF

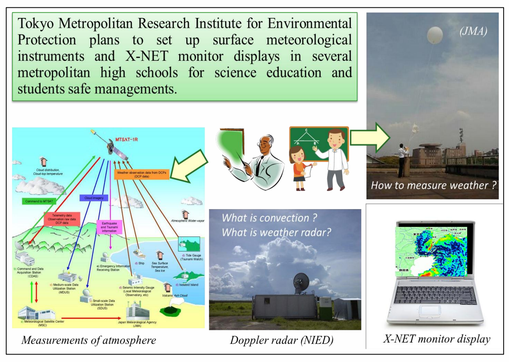


Obayashi Corporation examines X-NET wind nowcast for safety management at high construction sites.



East Japan Railway Company and Central Japan Railway Company examine X-NET QPE and QPF information for their computer-assisted traffic control system.

Tokyo Metropolitan Research Institute for Environmental Protection plans to set up surface meteorological instruments and X-NET monitor displays in several metropolitan high schools for science education and students safe managements.



National Research Institute for Earth Science and Disaster Prevention
3-1 Tennodai, Tsukuba, Ibaraki 305-0006, Japan

独立行政法人 防災科学技術研究所 NIED