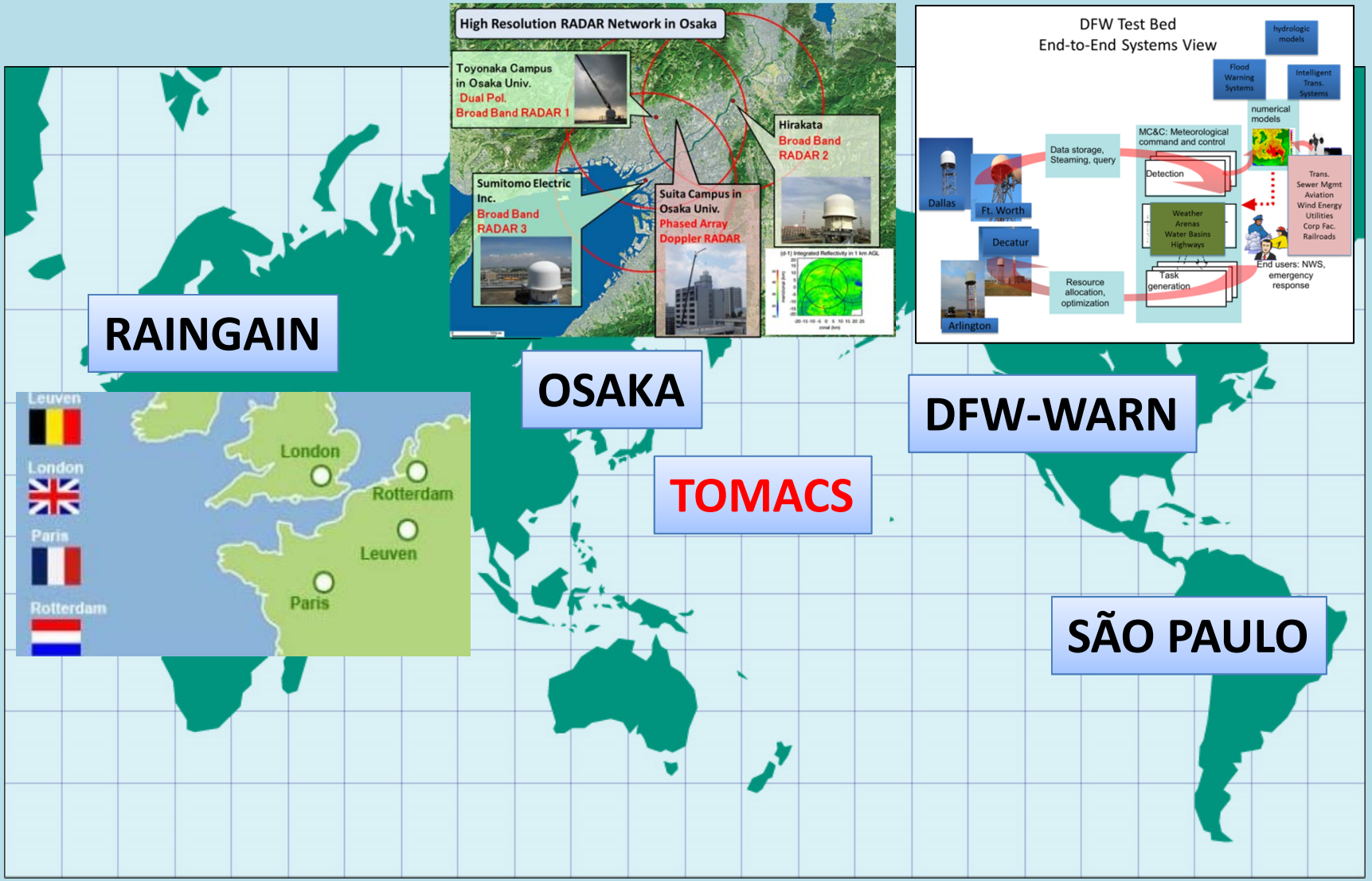
RESEARCH PROJECTS USING X-BAND POLARIMETRIC RADAR

Research Projects on Urban Floods using X-band Polarimetric Radar Network



BACK GROUND OF TOMACS

Change in Flood Damage Type

After WWII | 1960

- Most of damages were caused by typhoon
- 1945: Makurazaki (3,756), 1947: Kathleen (1,930), 1954: Toyamaru (1,761), 1964: Isewan (5,098)

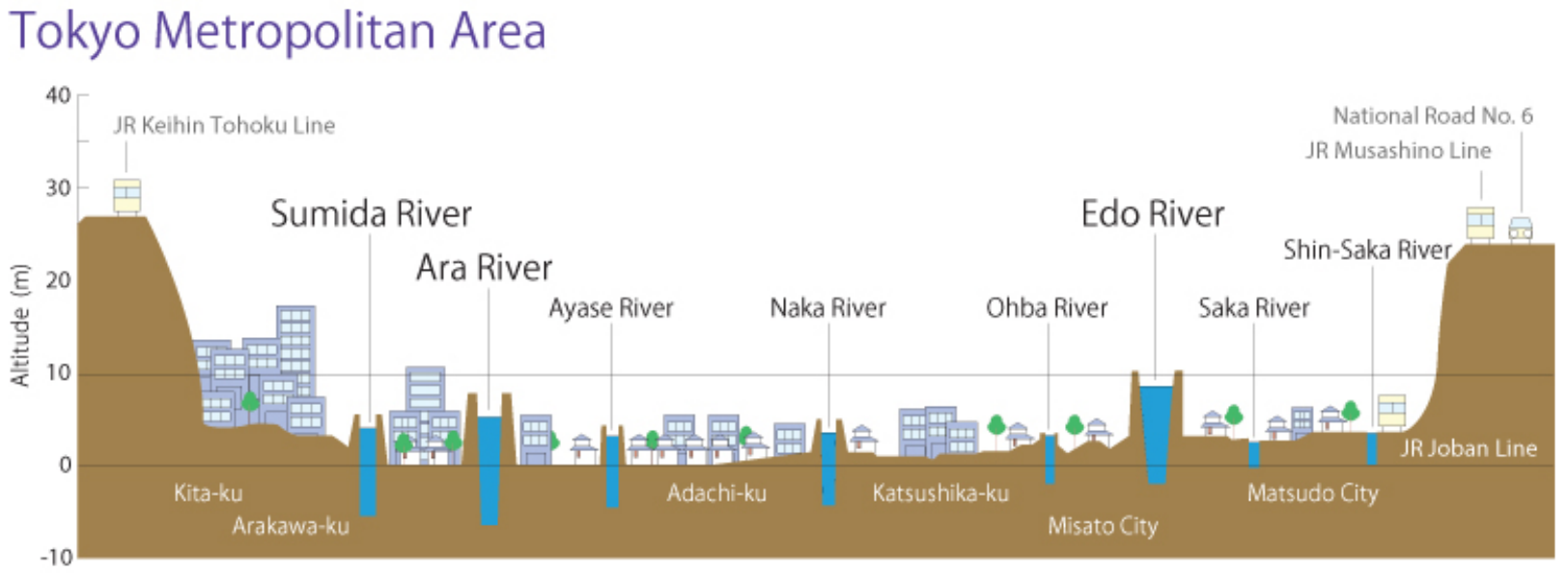
Rapid economic growth

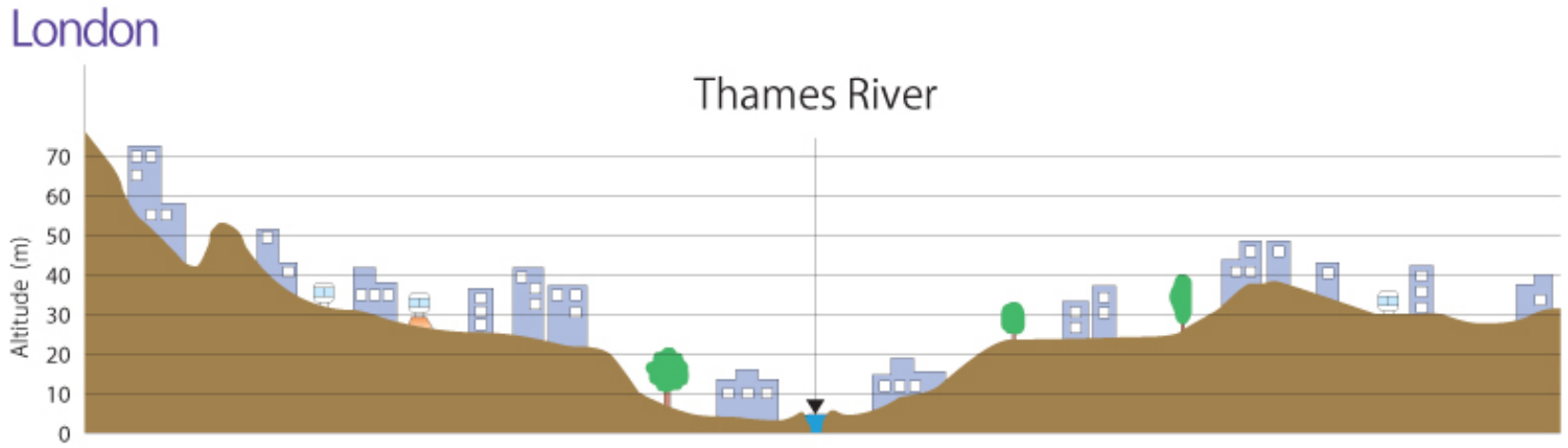
- Decrease in typhoon damage owing to C-band radar network, river development, flood control dam, etc.
- Urbanization, residents area in lower lands

1990's | Present

- Increase of torrential rainfall frequency
- Increase of urban flood
- Increase of economical loss in urban area

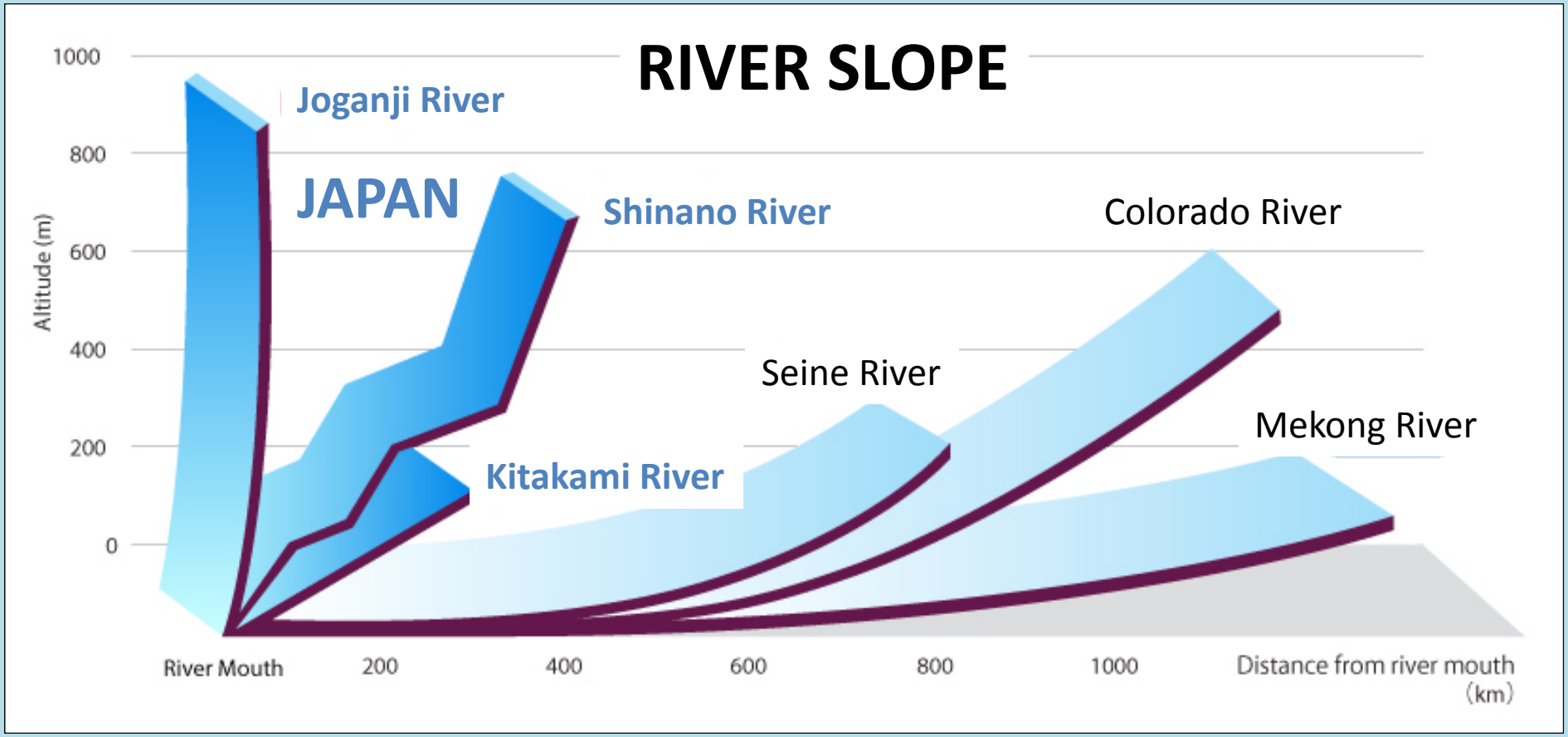
Geography of Tokyo Metropolitan Area





Geographical Feature of Rivers in Japan

Because Japanese river slope is steep, the time that reaches the maximum river level is immediately after the rainfall peak time. The flow charge at flooding time tends to increase according to urbanization



Urban Floods caused by Torrential Rain

Geographical Map of Japan

Characteristic

- Both accidents occurred within one hour after the rain began to start.

Togagawa:

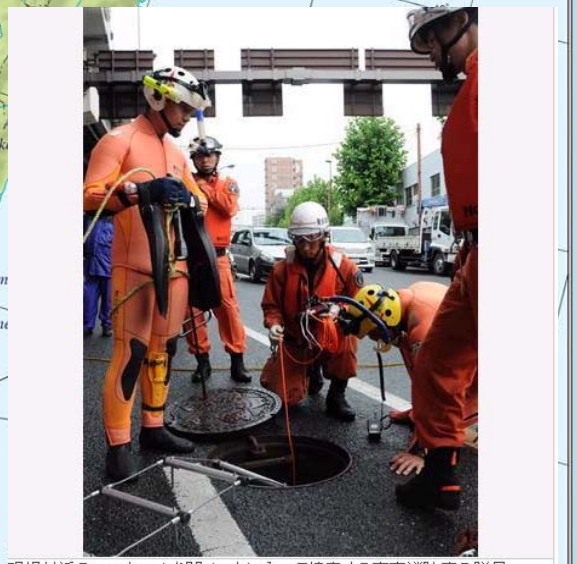
- Sudden increase of water level of Toga-river (1.3 m during 10 min).
- 20 people playing at a river side park were swept and 5 kids were killed

Zoshigaya:

- Sudden increase of water level in the sewage pipe.
- Five workers were swept downstream and drawn.

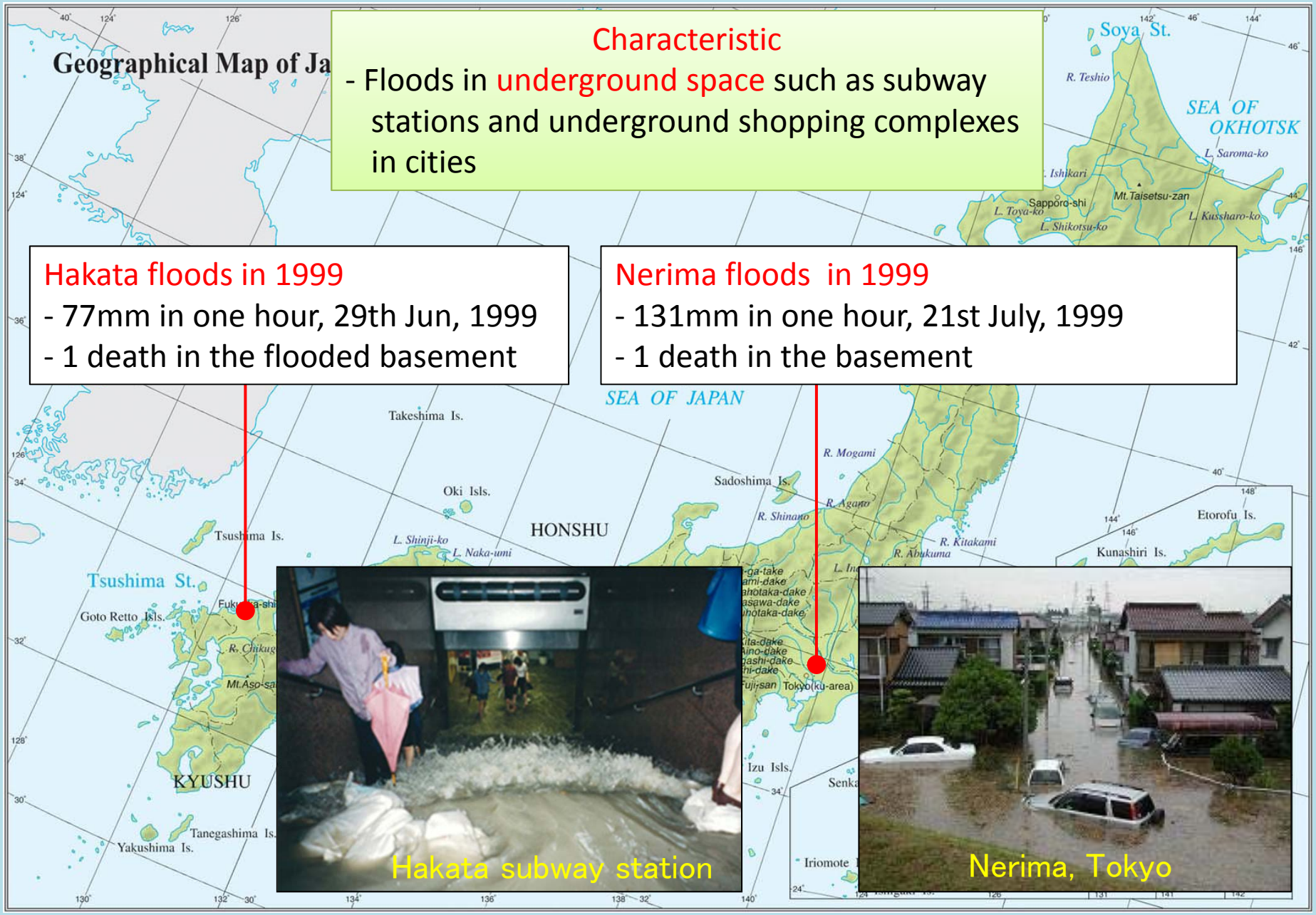
午後2時15分頃，現場から約150メートル上流の増水する前の都賀川。子供らが川遊びをしていた。

午後2時50分，急激に増水した都賀川。10分間で1.3mの水位上昇。5名が流されて犠牲。



現場付近のマンホールを開け、中に入って捜索する東京消防庁の隊員＝5日午後2時、東京都豊島区雑司が谷（植村光貴撮影）

Urban Floods caused by Torrential Rain



Characteristic

- Floods in underground space such as subway stations and underground shopping complexes in cities

Hakata floods in 1999

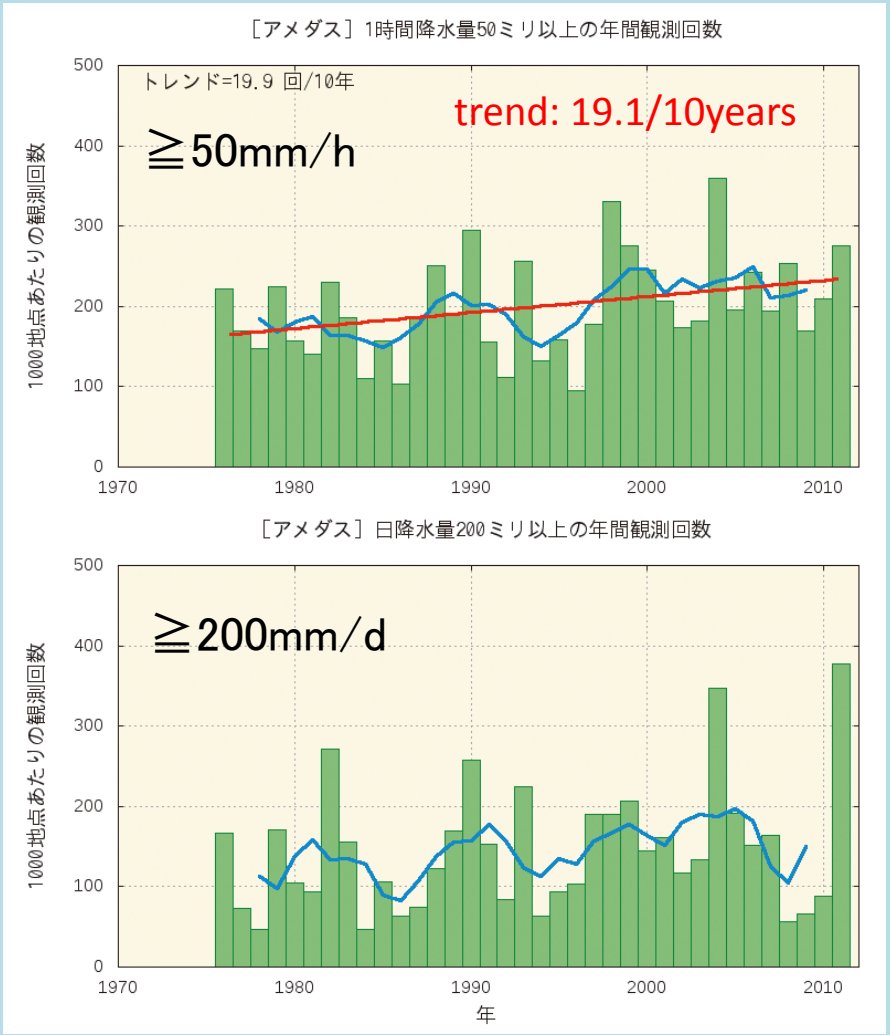
- 77mm in one hour, 29th Jun, 1999
- 1 death in the flooded basement

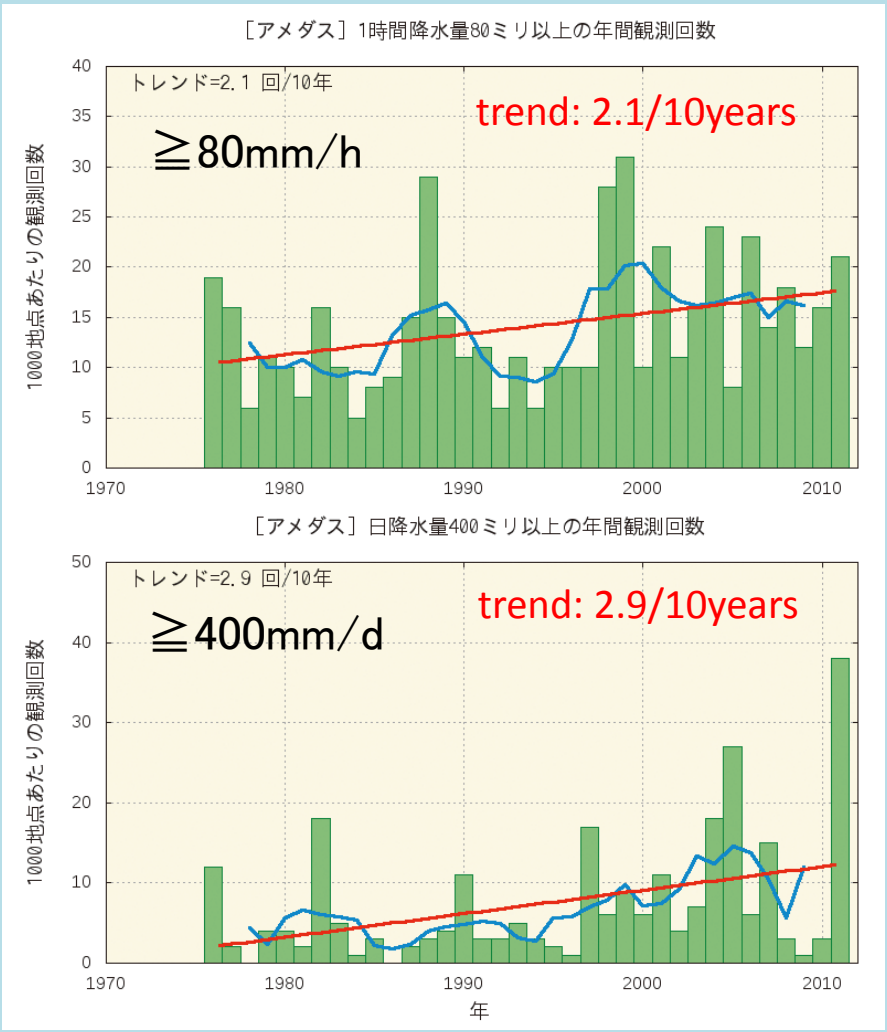
Nerima floods in 1999

- 131mm in one hour, 21st July, 1999
- 1 death in the basement

Number of Occurrence of Localized Heavy Rainfall

According to the rain gauge data of AMeDAS (since 1976), the number of occurrence of hourly rainfall exceeded 50 mm/h, 80 mm/h, and 400mm/day tend to increase (JMA, 2011).





Windstorm and Tornado Damages

" Social System Reformation Program for Adaption to Climate Change"
Strategic Funds for the Promotion of Science and Technology (JST/MEXT)

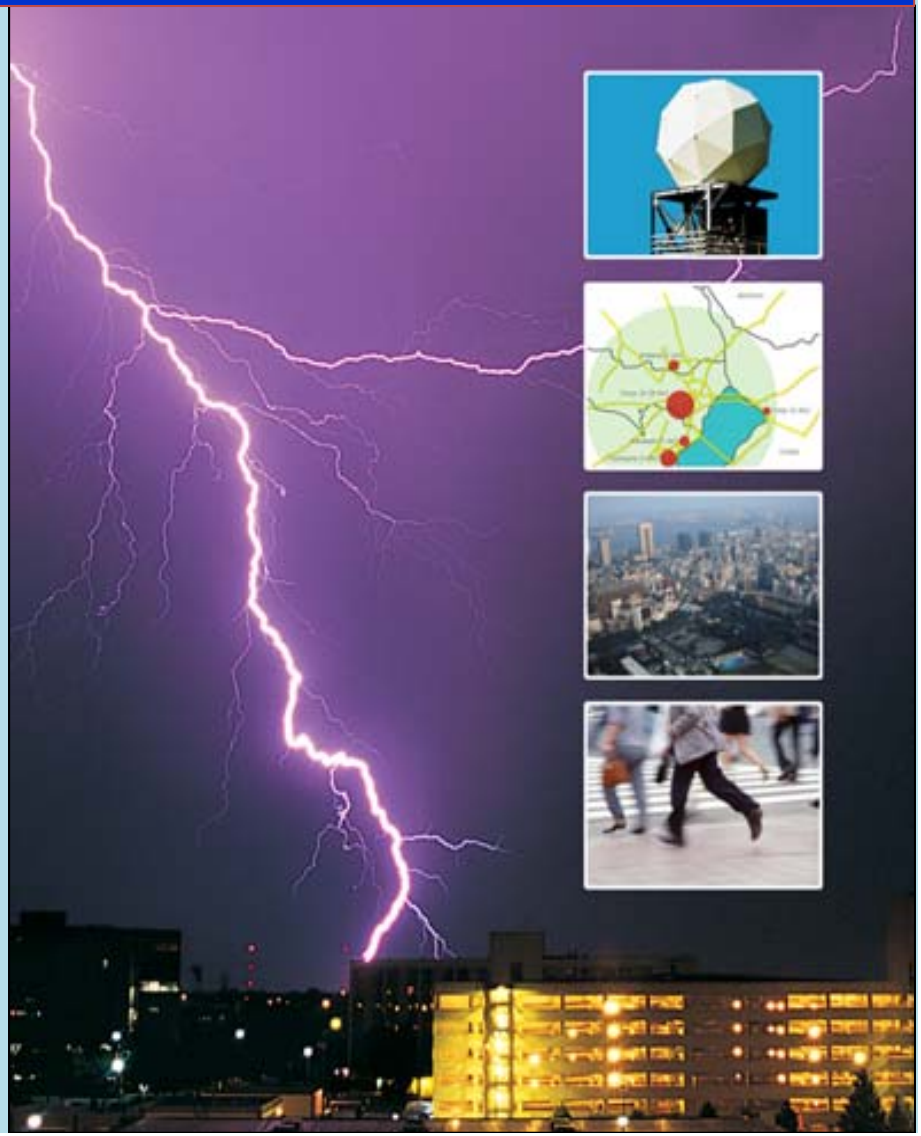
Tokyo Metropolitan Area Convection Studies for Extreme Weather Resilient Cities (TOMACS)

M. Maki[1], R. Misumi[1], T. Nakatani[1], S. Suzuki[1], T. Kobayashi[2], Y. Yamada[2], A. Adachi[2], I. Nakamura[3], M. Ishihara[8],
and TOMACS members*

* T. Maesaka[1], A. Kato[1], T. Kayahara[1], S. Shimizu[1], T. Wakatsuki[1], Y. Shusse[1], K. Hirano[1], K. Iwanami[1], N. Sakurai[1], D.-S. Kim[1], O. Suzuki[2], Y. Shoji[2], K. Kusunoki[2], H. Yamauchi[2], N. Seino[2], H. Seko[2], E. Sato[2], H. Inoue[2], C. Fujiwara[2], S. Saito[2], N. Nagumo[2], T. Kawabata[2], S. Origuchi[2], F. Fujibe[2], S. Tsuchiya[4], A. Yamaji[5], M. Yasui[6], Y. Fujiyoshi[7], Y. Suzuki[8], T. Ushio[9], K. Sunada[10], T. Yamada[11], H. Nakamori[12], F. Kobayashi[13], H. Sugawara[13], H. Yokoyama[14], H. Hirakuchi[15], T. Sato[16], M. Yoshii[16], A. Togari[17], D. Tsuji[18], K. Otsuka[19], T. Murano[20], D.-I. Lee[21], V. Chandrasekar[22]

[1]NIED, [2]MRI, [3]Toyo University, [4]NILIM, [5]JWA, [6]NICT ,[7]Hokkaido Univ., [8]DPRI/Kyoto Univ. [9]Osaka Univ., [10]Univ. of Yamanashi, [11]Chuo Univ., [12]Nihon Univ., [13]National Defense Academy, [14]TMRIEP, [15]CRIEPI, [16]Tokyo Fire Dep., [17]JR-EAST, [18]JR-CENTRAL, [19]Obayashi Co., [20]Toshiba Co., [21]PKNU, [22]CSU

http://www.mpsep.jp/ZENTAI/Brochure/TOMACS_E-J.pdf



PARTICIPANTS

- **Core research institutes:**
  - ***Natl. Res. Inst. for Earth Sci. and Disast. Prevention (NIED)***
  - ***Meteorol. Res. Inst. (MRI)***
  - ***Toyo University***
- **More than 100 participants**
- **Collaboration with 25 organizations:**
  - **16 Research Institutes and Universities**

    NILIM, JWA, NICT, ENRI, TMRI, CRIEP,
    Hokkaido Univ., DPRI/Kyoto Univ., Osaka Univ., Yamanashi Univ.,
    Nagasaki Univ., Chuo Univ., Nihon Univ., NDA, PKNU, CSU
  - **5 Local Governments**

    Tokyo Fire Department, Yokohama City, Fujisawa City,
    Edogawa-Ku/Tokyo, Minami-Ashigara City,
  - **4 Private Companies**

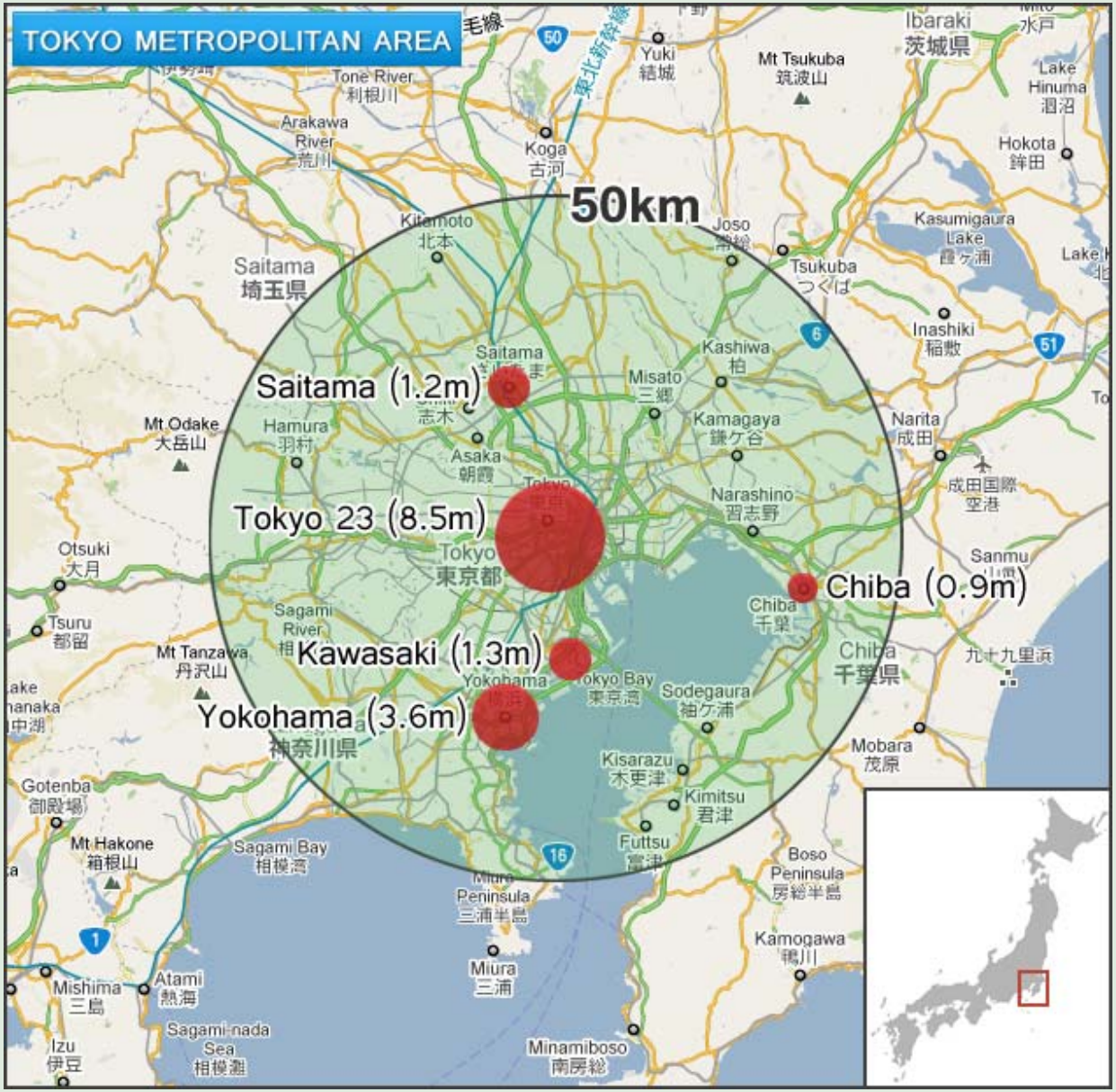
    JR-EAST, JR-CENTRAL, Obayashi Co., Toshiba Co.

Test Bed

Target area of TOMACS is the Tokyo metropolitan area which is defined an area within a 50km radius of the Tokyo Metropolitan Gov. Office.

There are five mega cities shown by red circles. (Number shows population in million)

About 30 million people live in the area, which corresponds to the population of Canada.



Project Structure and Organizations

Social Experiments Strategy Committee /Cabinet Office

Principal investigator → Representative

Liaison Council
- Periodical meeting with all participants
- Observation WG
- Nowcasting WG
- Social experiment WG

Steering Committee
- Evaluations on research plan
- Progress review
- Recommendation to the Cabinet Office

Theme 1: Studies on Extreme Weather with Dense Meteorological Observations

【New insights for the mechanism of extreme weather】

(1) Development of new technologies
（MRI, NICT, Osaka Univ., Toshiba Co.)
(2) Field campaign in the Tokyo area
（MRI, Hokkaido Univ., NICT, NIED, NDA, Yamanashi Univ., Chuo Univ., CRIEP, JWA）
(3) Statistical analysis （MRI）

Real time obs. data ⇓ ⇑ Demand on data

Enlightenment of science technologies

Scientific Interest

Demand on System

MPSEP outputs

Theme 2: Development of Extreme Weather Early Detection & Prediction System

【Collaborative developments with end users】

(1) Extreme weather nowcasting and forecasting （NIED・MRI・NILIM）
(2) Monitoring and Prediction System of Extreme Weather (MPSEP)
（NIED・JWA・Kyoto Univ.）
(3) Extreme weather data base (NIED）

Theme 3: Social Experiments on Extreme Weather Resilient Cities

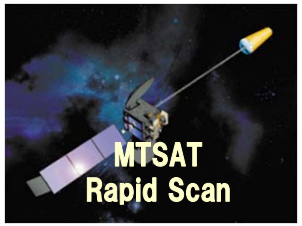
【Evaluation and adaptation of MPSEP】

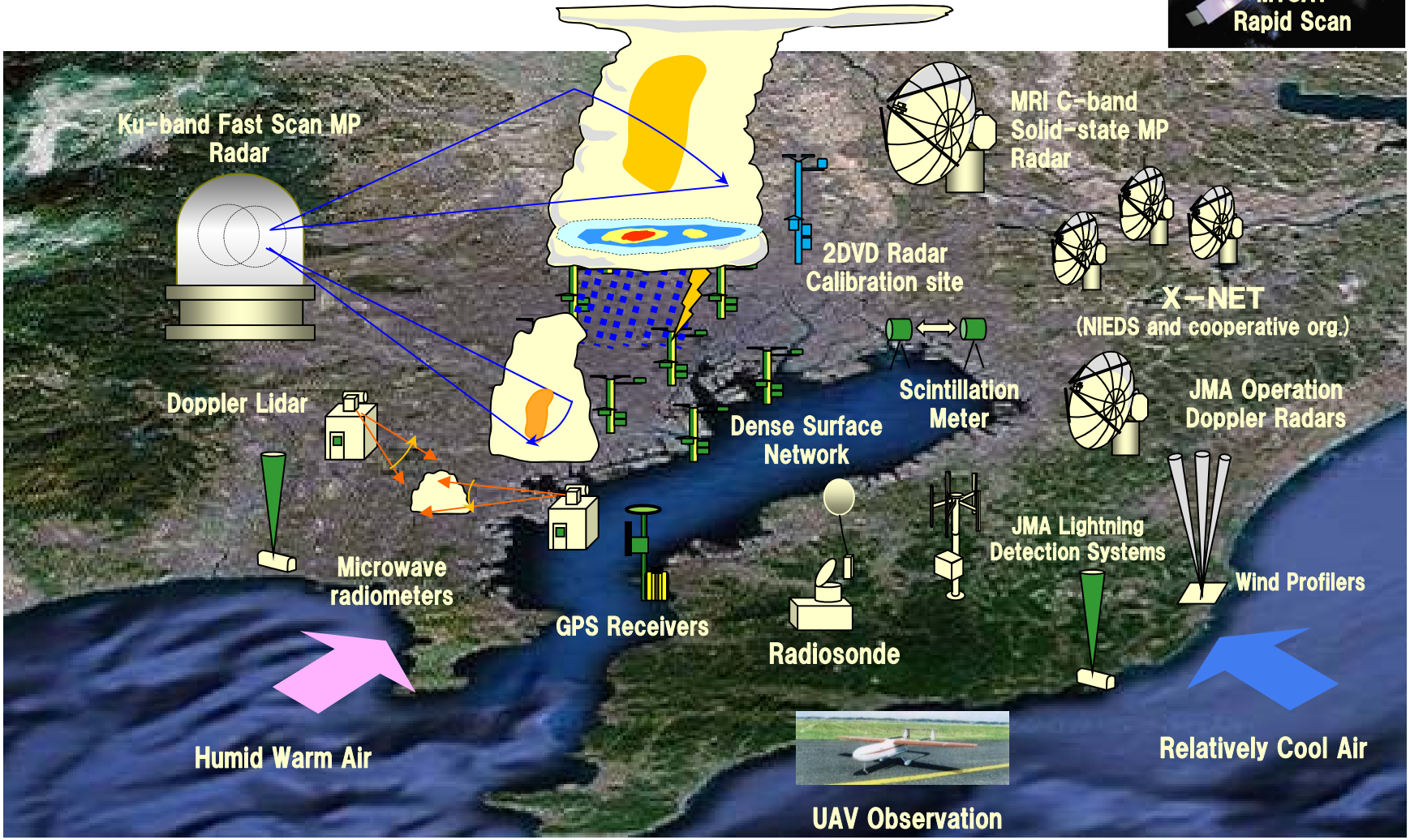
(1) Social experiments in four fields
(NIED, Toyo Univ., TMRIEP)
① Rescue service (Tokyo Fire Dept.)
② Risk managements (Local governments)
③ Infrastructure (JR East, JR Central, Obayashi)
④ Education (High school)
(2) Analysis of experiments (Toyo, Nihon Univ.)

- To understand the mechanisms of localized convective storms and related extreme weather.

Theme 1: Studies on Extreme Weather with Dense Meteorological Observations

Observations of convective precipitations with a dense meteorological instruments are conducted by MRI, NIED and 12 research groups in the summers of 2011-2013 in the Tokyo Metropolitan Area.





X-NET in the Tokyo Metropolitan Area

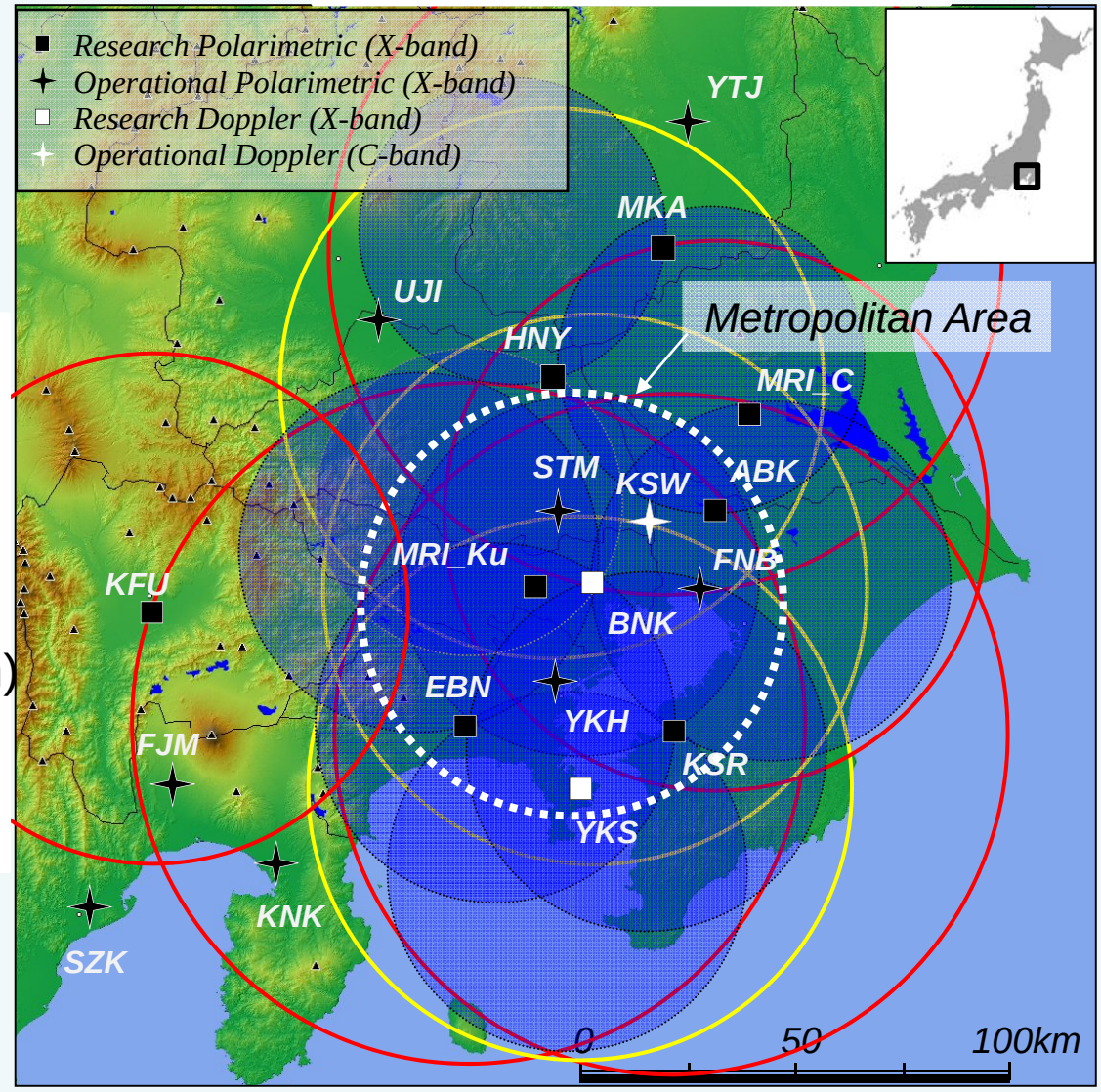
Figure shows the locations of research radars of X-NET and MLIT operational radars; ten X-band polarimetric radars and four Doppler radars are used. Almost all radar data are sent to NIED and processed in real time .

Research Radars

- C-band polarization radar (1)
- X-NET (8)
- Ka-band Doppler (1, not shown)
- Ku-band rapid scan radar (1)
- Doppler Lidar (2, not shown)

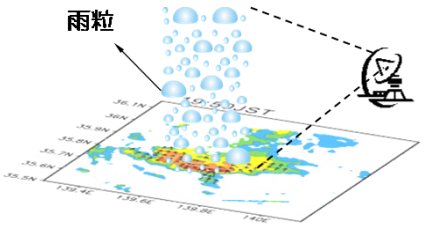
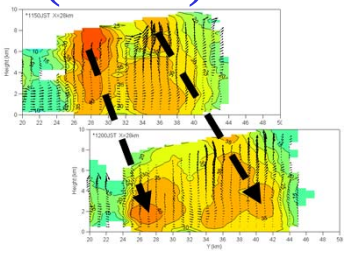
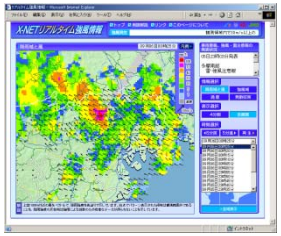
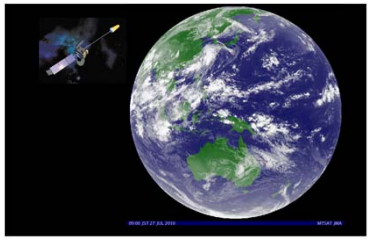
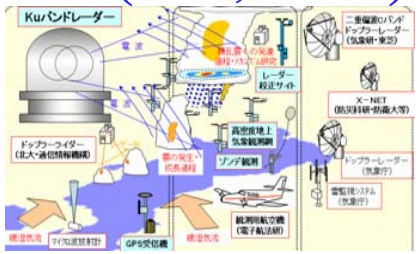
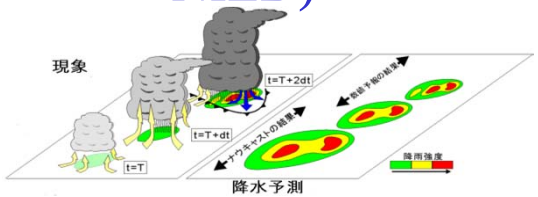
Operational Radars

- MLIT X-band pol (8)
- JMA C-band Doppler (1)
- Doppler lidar (1, not shown)



- To improve an early detection and prediction algorithm of extreme weather in collaboration with end users.

Theme 2: Development of Extreme Weather Early Detection & Prediction System

Early detection (~5 minute)	Use of VIL (NIED) 	Precipitation core tracking (NIED) 
Nowcasting (~1 hour)	Nowcasting of strong wind (Kyoto Univ., NIED, JWA) 	Use of “rapid scan” of MTSAT (JMA, MRI) 
Data assimilation and numerical forecast (~6 hours)	Assimilation of TOMACS data (MRI, NIED) 	Improvement of numerical forecast (MRI, NIED) 

- To put the method into practical use through social experiments.

Social Experiment on Emergency Deployments

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

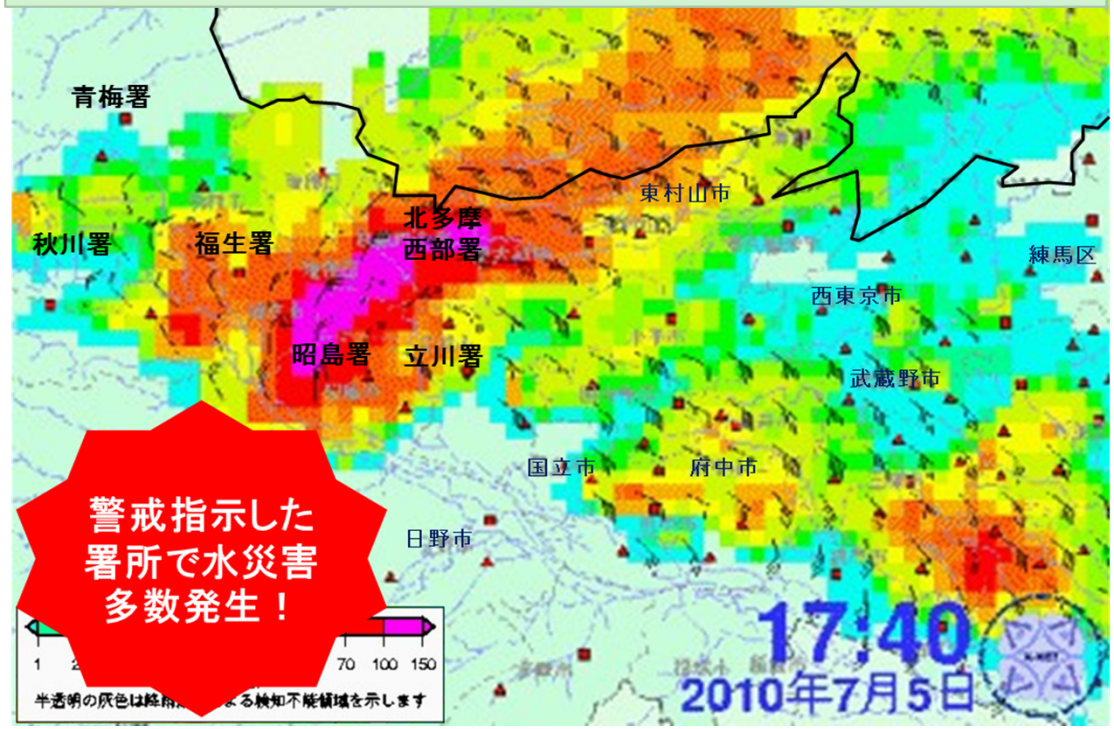
16:02
- Thunderstorm advisory
- Start watching X-NET products

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



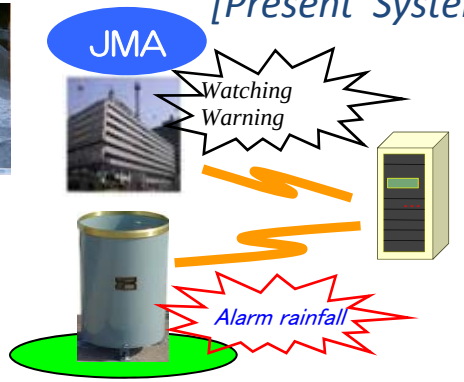
Rainfall and wind distributions in Tama region in Tokyo at 17:40 JST, July 5, 2011. Rectangle and triangle show locations of branch and sub-branch stations, respectively.

Social Experiment on River Managements

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)

[Present System]



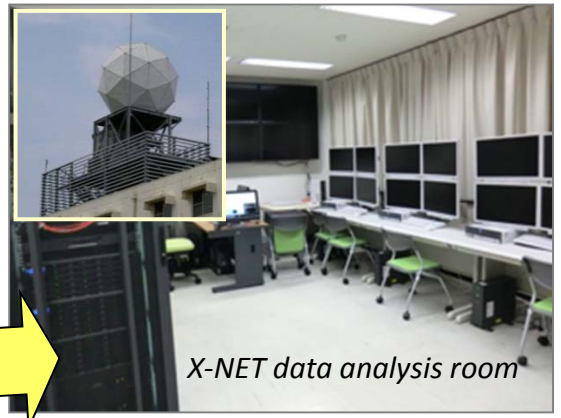
- Warning for rapid increase of water level
- Warning lamp and announcement
- Automated operation

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

Information	Lead time	Evaluation
Rain gauge (on site)	No lead time for evacuation	×
Rain gauge (near site)	Some lead time if there is enough number of rain gauges 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 now cast (accuracy ?) Accuracy or delay of warning	○
X-NET products	**5-15min with high accuracy**	**under examination**

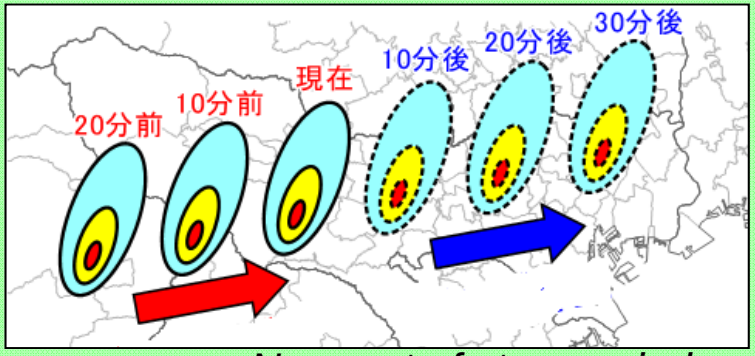
[Future System]

Add X-NET products to the present system
- *rainfall amount I watershed*
- *QPE and QPF*



Social Experiment on Infrastructures

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

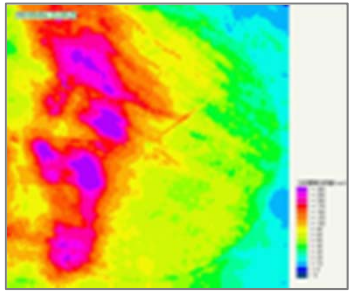


Nowcast of strong winds

Damaged crane

Tokyo Sky Tree (634m)

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



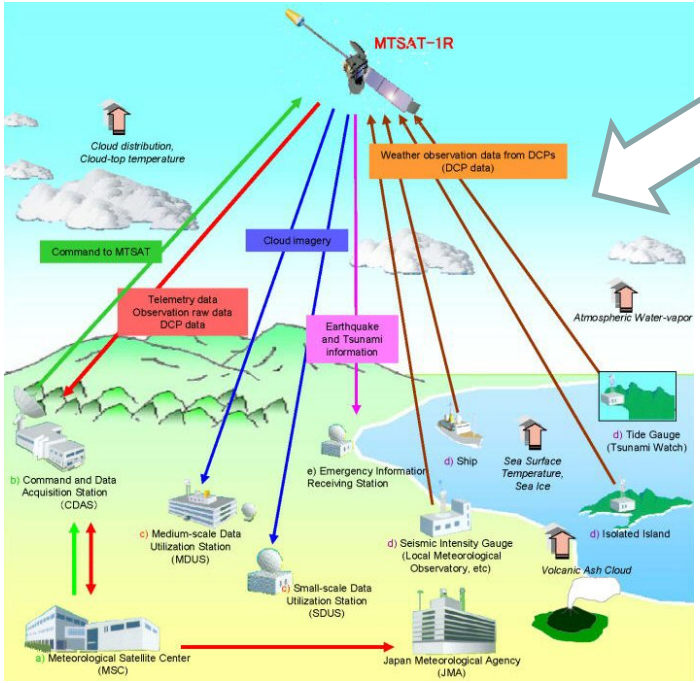
72 hour effective rain

Transport operation control system

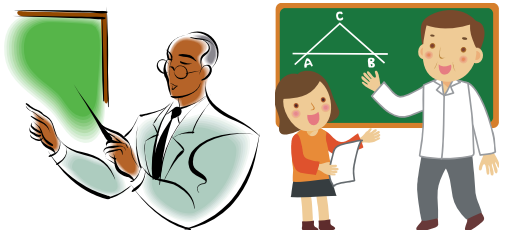
Shinkansen, JR-EAST

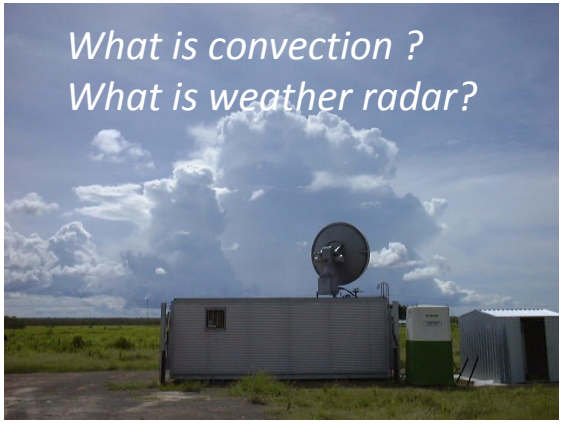
Social Experiment on Educations

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.



Measurements of atmosphere



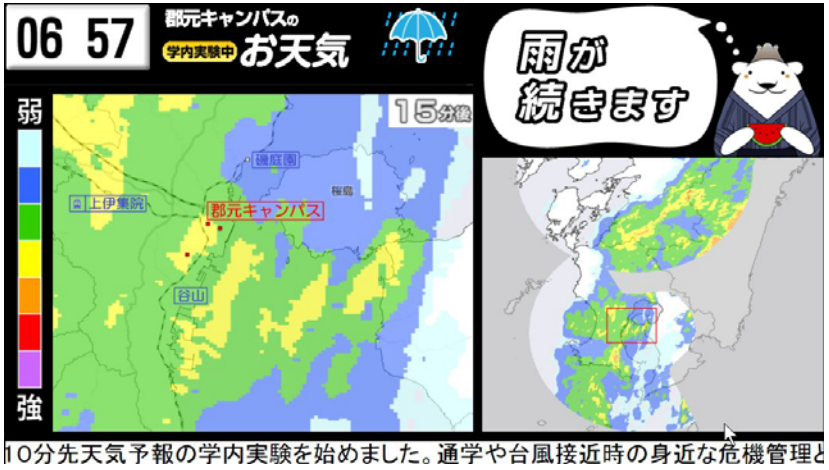


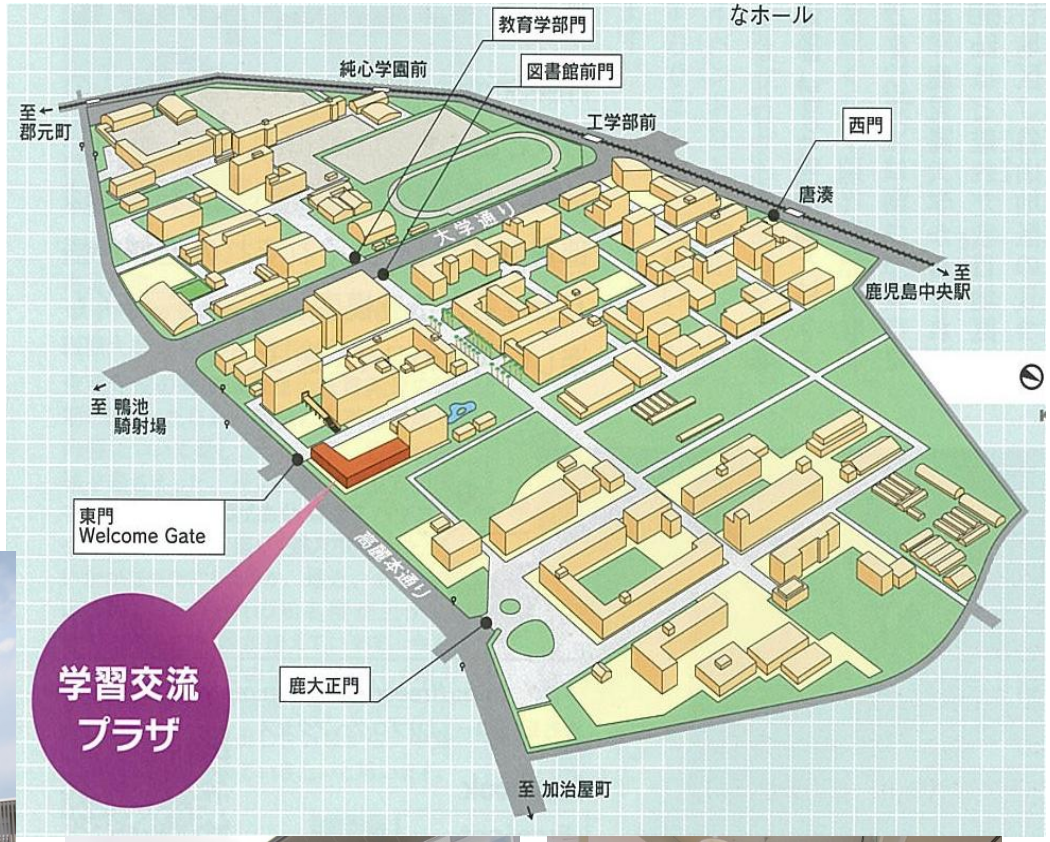
Doppler radar (NIED)

X-NET monitor display

Campus Weather in Kagoshima Univ.

http://micos-sa.jwa.or.jp/metro/mpsep/Campusweather/kagoshima_PC/movie/index.htm





TOMACS OVER VIEW

(1) TOMACS

- Target: Extreme weather
- Provision of high resolution rainfall and wind data
- Organization: 25 institutes 100 participants
- Interactive research activities with end-users

(2) Observations

- Tokyo metropolitan area
- Dense meteorological instruments
- Start in 2010 and full-scale experiments in 2011-2013
- Selected as one of RDP/WWR/WMO

(3) Social experiments

- QPF based on the extrapolation and data assimilation
- Application to variety of end users

- What is next ?

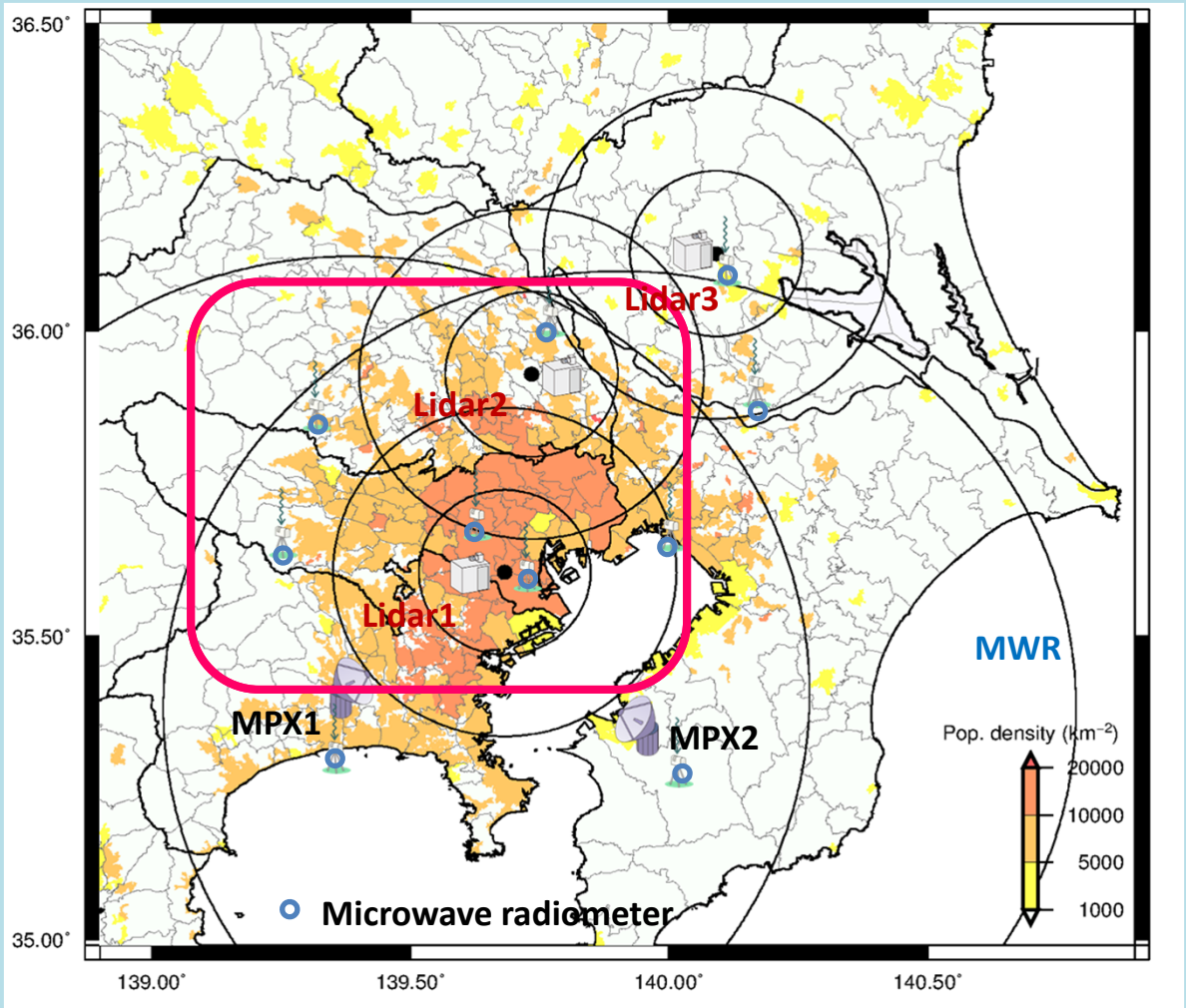
Multi-sensing of Convective Storm (NIED, NICT)

- 3 Doppler Lidars, 10 Microwave radiometers
- Ka-band polarimetric Doppler radars (Dec. 2014)
- Development of phased array pol radar (by 2017)

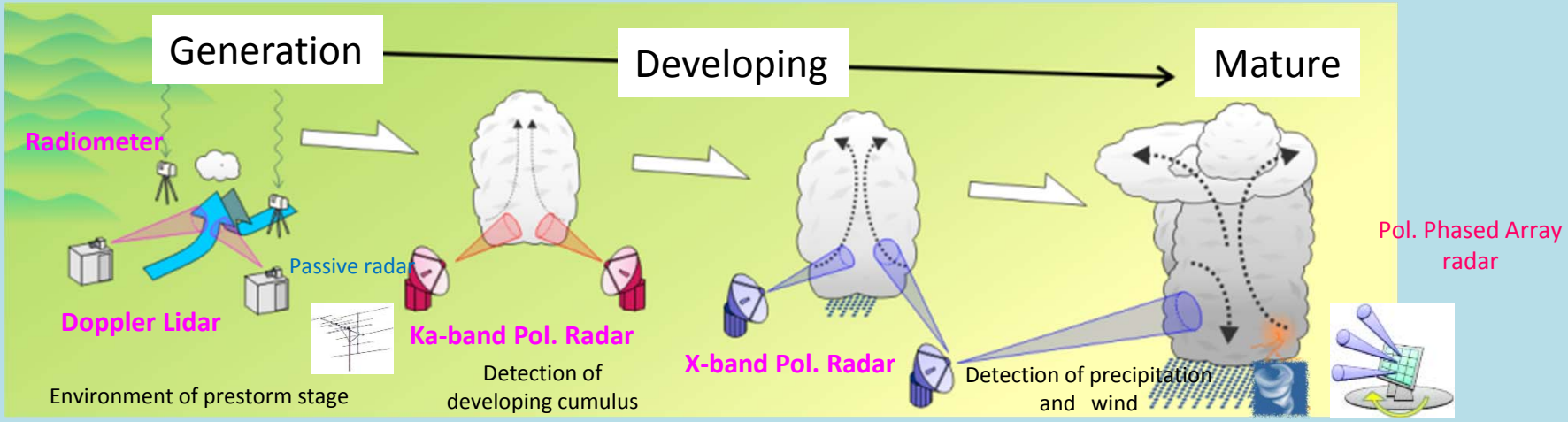
➢ Initiation of convective storm
➢ Forecasting with Data assimilation
➢ Tokyo Olympic 2020

Doppler Lidar

Microwave Radiometer

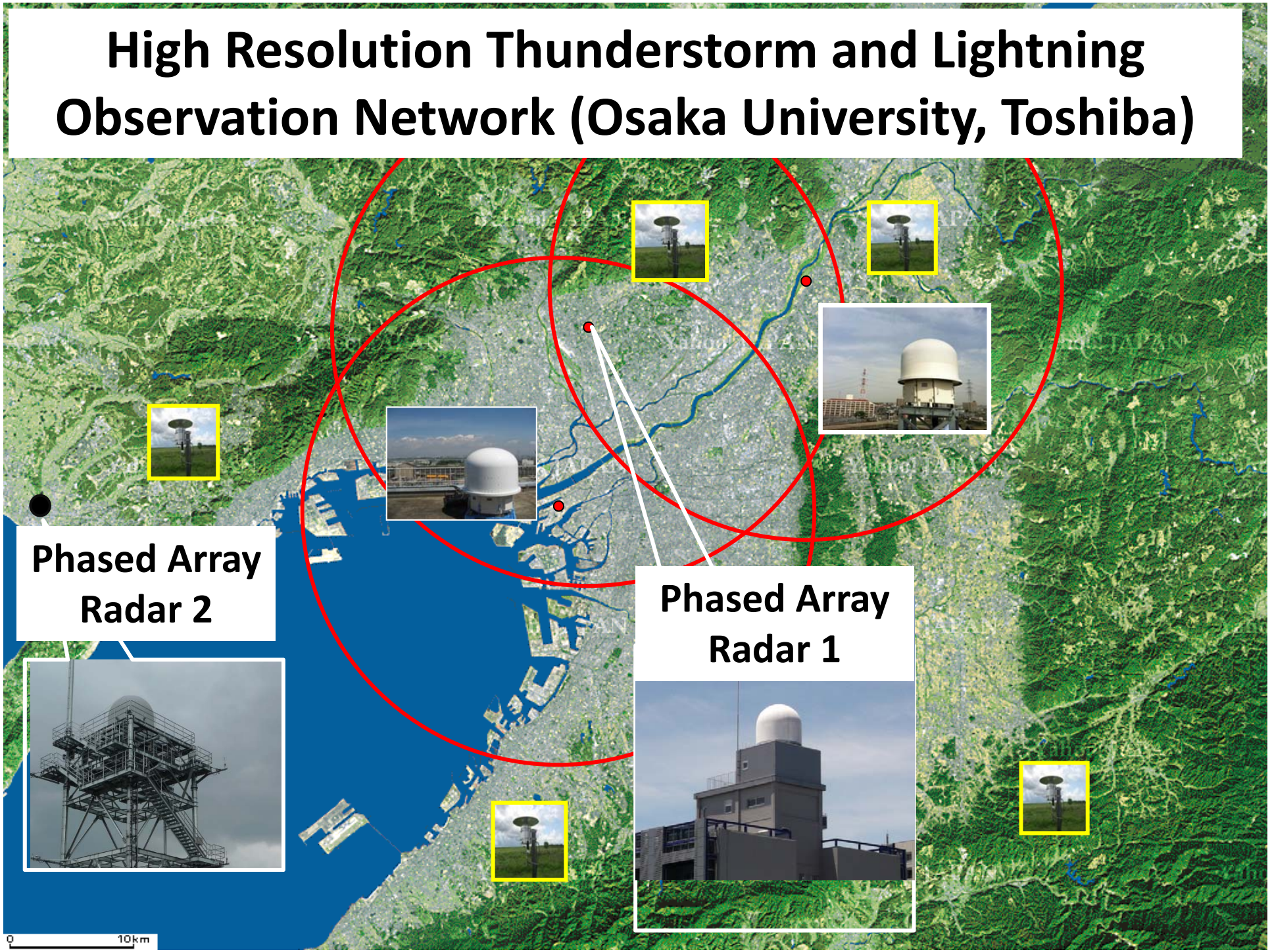


Multi-sensing of Convective Storm



Stage	Instruments	Organization	Retrieved Information
Pre-storm	MWR	NIED	Vertically integrated water vapor
	Passive antenna	NICT	Horizontal distribution of water vapor
	Doppler lidar	NIED	3-D distributions of aerosols & winds in clear atmosphere
Cloud	Ka-band pol. radar	NIED	3-D distributions of cloud droplets and winds
Rain	X-band Pol. radar (X-NET, XRAIN)	NIED, MLIT	3-D distribution of precipitation parameters & wind in convective storms
	Pol. phased array radar (MP-PAR)	NICT	Ibd. (within one minute)

High Resolution Thunderstorm and Lightning Observation Network (Osaka University, Toshiba)



SUMMARY

- It has been believed for long time that X-band wavelength was not adequate for QPE.
- Polarimetric technique changed this common sense drastically.
- Advantages of X-band pol radar now accelerate the monitoring and forecasting of extreme weathers in urban area.
- Multidisciplinary approach using X-bad pol radar network is now ongoing in the world.

Thank you for your attention