Plan of the Field Observation in the Tokyo Metropolitan Area: Lifecycle of Cumulonimbus Experiment (LCbEx)

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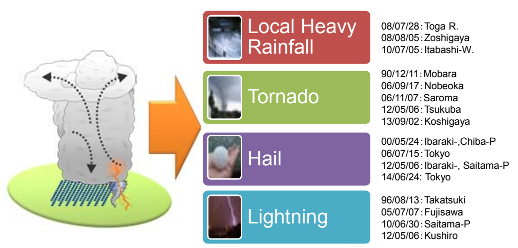
INTRODUCTION

Disasters caused by local heavy rainfall, tornadoes, hail, and lightning are serious social problems especially in urban areas in Japan. It is known that these phenomena are associated with developed cumulonimbi (Cb). The understanding of development mechanism and development of prediction method are needed for the reduction of these disasters.

Extreme Weather is caused by Developed Cumulonimbus (Cb)

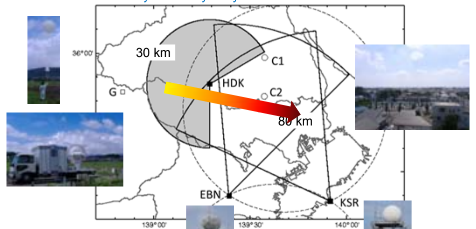


LCbEx-I (2011-13)

National Research Institute for Earth Science and Disaster Prevention (NIED), Japan started field observation of lifecycle of Cb (Lifecycle of Cb Experiment: LCbEx-I) in the Tokyo Metropolitan Area from 2011 using a Ka-band Doppler radar, two X-band polarimetric radars, and stereo photography, etc. A case study of early development stage of Cb was carried out with Ka-band Doppler radar data (Sakurai et al. 2012) and the thermodynamical retrieval using sector volume scan data by two X-band polarimetric radars at 1 to 2 min interval. Furthermore it was shown that the data assimilation of cloud liquid water content (latent heat) and potential temperature deviation had important effects to prediction of Cb development using cloud resolving model.

LCbEx-I (August, 2011-13)

Prediction of local heavy rainfall by early detection of cloud and data assimilation



■ : Radar site
HDK = Ka-band radar (shade: 30km range), sounding, camera, surface obs, MWR
EBN, KSR = X-band polarimetric radar (80km range)
Sector (solid line): area of typical sector scan
Circle (broken line): area of dual Doppler synthesis
○ : Stereo photograph

NEW REMOTE SENSORS

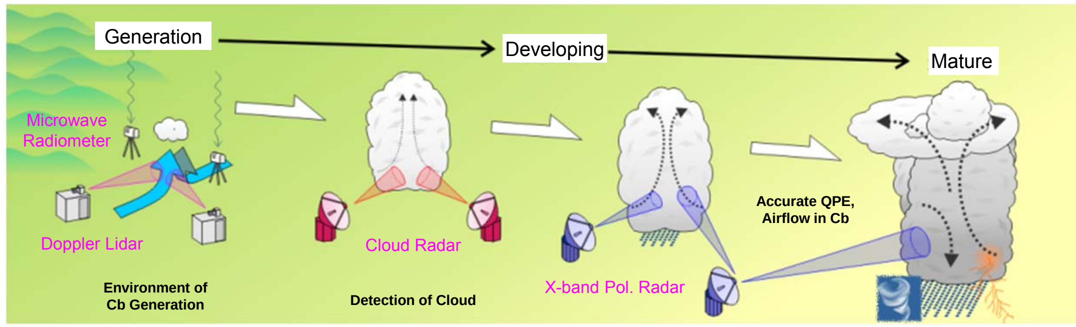
In 2013 and 2014, ten microwave radiometers, three Doppler lidars, and five Ka-band radars were additionally set up in the Tokyo Metropolitan Area covered by the X-band polarimetric radars for the observation of environment of cumulus (Cu) initiation and Cb development, and cloud before precipitation. We can get information on water vapor, wind field in the clear air, and non-precipitating cloud, respectively. All data can be collected and processed in real-time in the NIED.

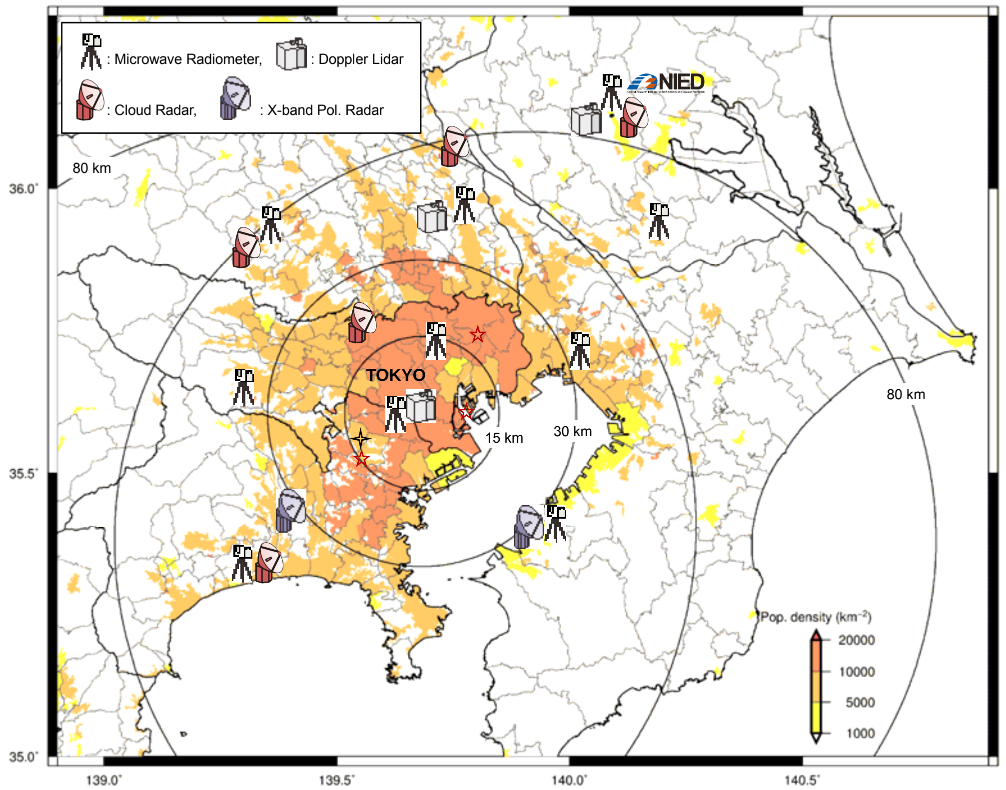
Development of estimation method not based on statistical methods of vertical profile of water vapor and other parameters is one of issues related to microwave radiometer measurements.

Three of the Ka-band radars have polarimetric capability that is thought to be useful for data quality control and detection of ice crystals. Precise estimation of cloud liquid water content is one of issues and the comparison with in-situ measurements is planned.

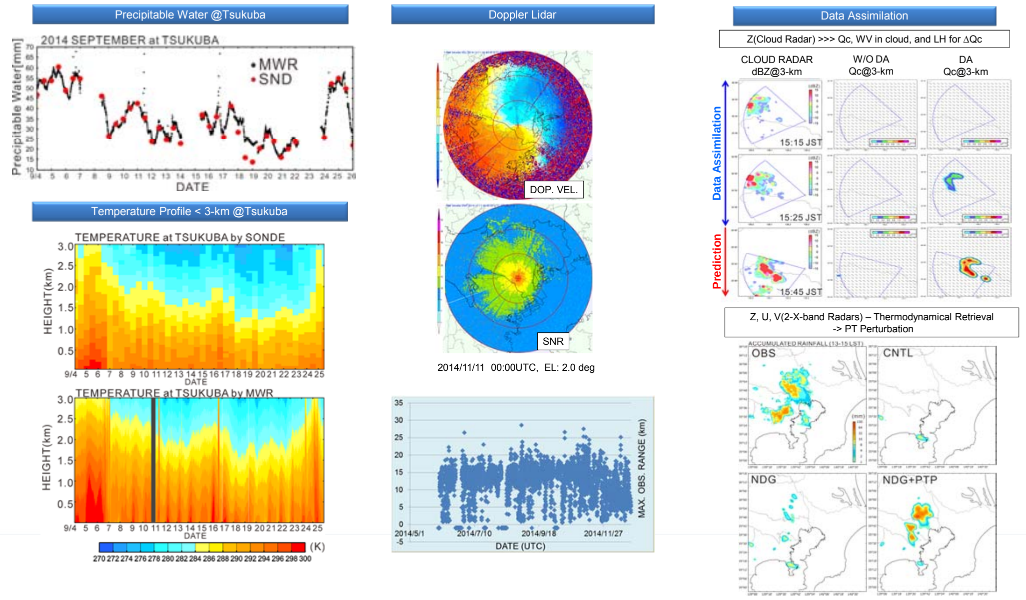
LCbEx-II

The field observation (LCbEx-II) using these new remote sensors is started from the summer season in 2015 for the understanding of development process including initiation of Cu and early stage of Cb development, precipitation formation process from cloud, and prediction of Cb development using an NWP model and data assimilation.



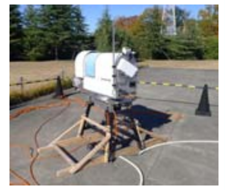


PRELIMINARY RESULTS



MICROWAVE RADIOMETERS (10)

HATPRO, RPG (10-sets)	
Measured values	14-ch, TB
Frequency	K-band (7ch; 22-30 GHz) V-band (7ch; 51-59 GHz)
Beam width	K-band: 3.5 deg V-band: 1.8 deg
Estimated parameters	PW, VICLW Vertical Profile of T, WV, CLW
Time resolution	~ 1-min (real-time)
Height resolution	50 m (z < 1.2 km) 200 m (z < 5 km) 400 m (z > 5 km)
Estimation accuracy	T: 0.25 K RH: 5 %



DOPPLER LIDARS (3)

MITSUBISHI (3-sets)	
Wavelength	1.55 μm (Eye safe)
Pulse width	500 ns
PRF	4 kHz
Pulse energy	≥ 1 mJ
Range resolution	30, 75, 150 m
No. range bin	200
Obs. range	400 m - 30 km in radius
Max wind speed (absolute value)	≥ 38 m/s
Velocity resolution	≤ 0.4 m/s
Scan range	Az: 0 - 360 deg El: −5 - 185 deg
Scan rate	1 - 20 deg/sec
Output	V, W, SNR, Doppler Spectra

CLOUD RADARS (5) >>> see POSTER #174

MITSUBISHI (5-sets)		
Type	Single (H) (2-sets)	Dual-pol (3-sets)
Polarization	H	H & V (H or V)
Sensitivity@20km	−20 dBZ	−17 dBZ
Frequency	Ka-band (35 GHz)	
Antenna, Beam width	Cassegrain, Circ. Parabola, ≤ 0.4 deg	
Gain, Isolation	≥ 52dB, ≥ 30 dB	
Transmitted power	EIK, 3 kW	
Pulse width	Short pulse: 0.5 or 1.0 μs, Long pulse: 30 - 100 μs	
PRF	2.5 kHz, max	
Doppler velocity	≥ 7 m/s (DPRF)	
Range bin	75 or 150 m	
Min detectable power	−109.5 dBm (LNA-input)	
Scan range (Max scan rate)	Az: 0 - 360 deg (36 deg/sec) El: −10 - 182 deg (12 deg/sec)	
Obs. range	30 km in radius	

X-BAND POLARIMETRIC RADARS (2)

	EBINA	KISARAZU
Frequency	9.4687/9.4712 GHz	9.415 GHz
Antenna type	2.0 mϕ Parabola	2.2 mϕ Parabola
Scan range (rate), Az: El:	Full Circle (≤ 36 °/s) -2° to +90° (≤ 12 °/s)	Full Circle (≤ 36 °/s) -2° to +182° (≤ 18 °/s)
Antenna gain	43.4 dB	≥ 43 dB
Beam width	1.2°	≤ 1.25°
Transmitter	Solid state device	Klystron
Peak power (Duty)	400 W x 2 (5 %)	50 kW (0.8%)
Pulse width	1.0/32 μs	0.5/1.0/2.0 μs
PRF	≤ 1500 Hz	≤ 1800 Hz
Polarization	H & V (SHV)	H & V (SHV)
Nyquist velocity	11.9 - 47.5 m/s	14.3 - 57.4 m/s
Noise figure	2.4 dB	≤ 2.0 dB
Min. detectable signal	−115/−130 dBm	≤ −110 dBm
Obs. range	80 km	≥ 80 km
Outputs	T, Z, V, W, Z_{DR}, ρ_{hv}, Φ_{DP}, K_{DP}, I/Q	T, Z, V, W, Z_{DR}, ρ_{hv}, Φ_{DP}, K_{DP}