Water vapor estimation using digital terrestrial broadcasting waves

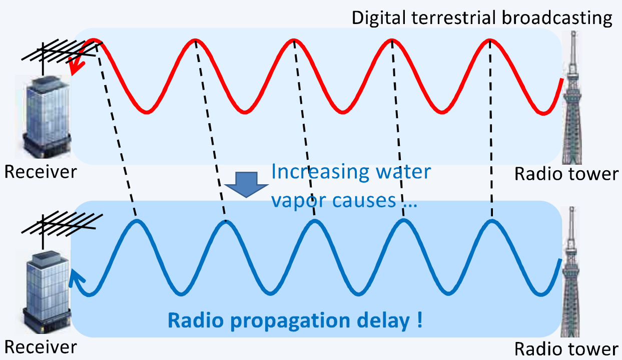
NICT 国立研究開発法人 情報通信研究機構 National Institute of Information and Communications Technology

Abstract

A method of estimating water vapor using digital terrestrial broadcasting waves is developed. Our target is to improve the accuracy of numerical weather forecast for severe weather phenomena such as localized heavy rainstorms in urban areas through data assimilation. In this method, we estimate water vapor near a ground surface from the propagation delay of digital terrestrial broadcasting waves. Developing a system that monitors water vapor near the ground surface would improve the accuracy of the numerical weather forecast of localized severe weather phenomena.

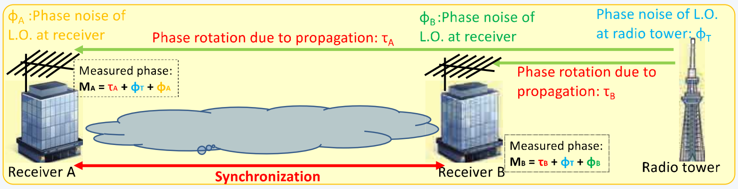
Principles and Methods

Radio waves are delayed due to water vapor through propagation. If we measure the propagation delay very precisely (picoseconds order), the information of water vapor can be retrieved.



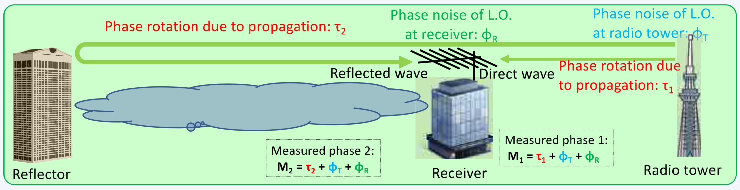
Principles for Estimating Water Vapor

Method to synchronize two local oscillators



Suitable for the deployed measurement system because reflectors are not required.

Method to use reflected waves

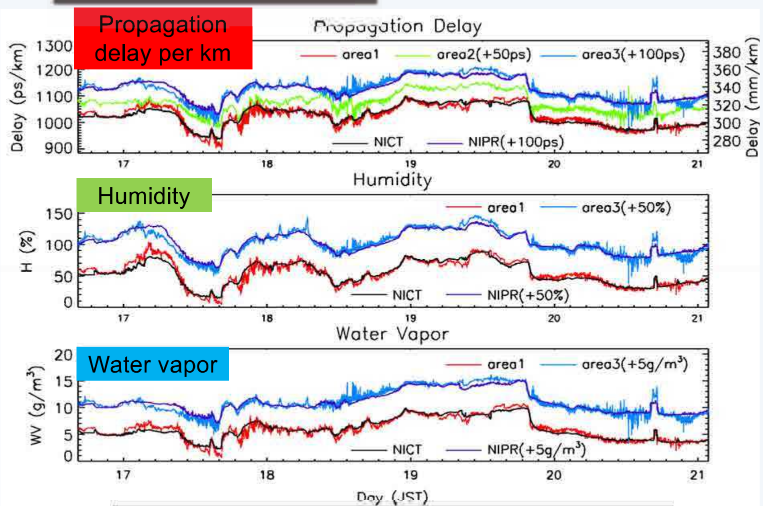


Observations can be performed without the synchronization of the local oscillators.

Proposed two configurations for water vapor measurement

Propagation delay is measured using the phase of digital terrestrial broadcasting waves. Because phase noises of local oscillators at radio towers and receivers are major error factors, two configurations are proposed to cancelled them out.

Observed Results



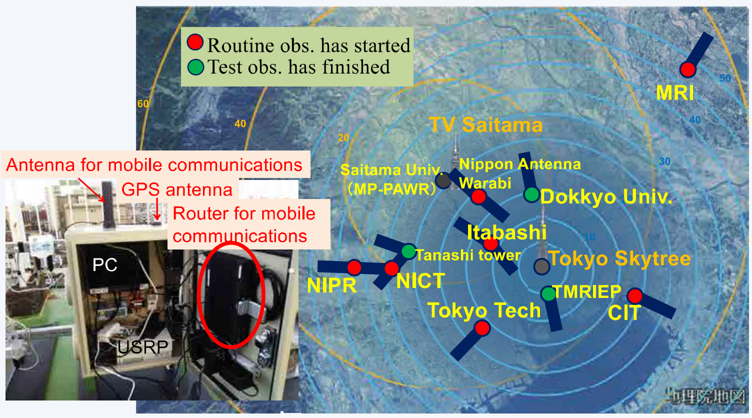
Observed data taken from 16 to 21 March 2016.

Positional relationship of the experiments.

Above figures show an example of observed results using reflected waves at NICT. Red, green, and blue lines are correspond to the results in areas 1, 2, and 3, respectively.

Observation Network

Real time phase measurement system is developed with a software-defined radio (SDR) technique. We deploy these measurement systems at Tokyo Metropolitan Area. Observed data are used to investigate the impact toward numerical weather forecast through data assimilation.



Present status of observation network in Tokyo Metropolitan Area.

Remote Sensing Laboratory

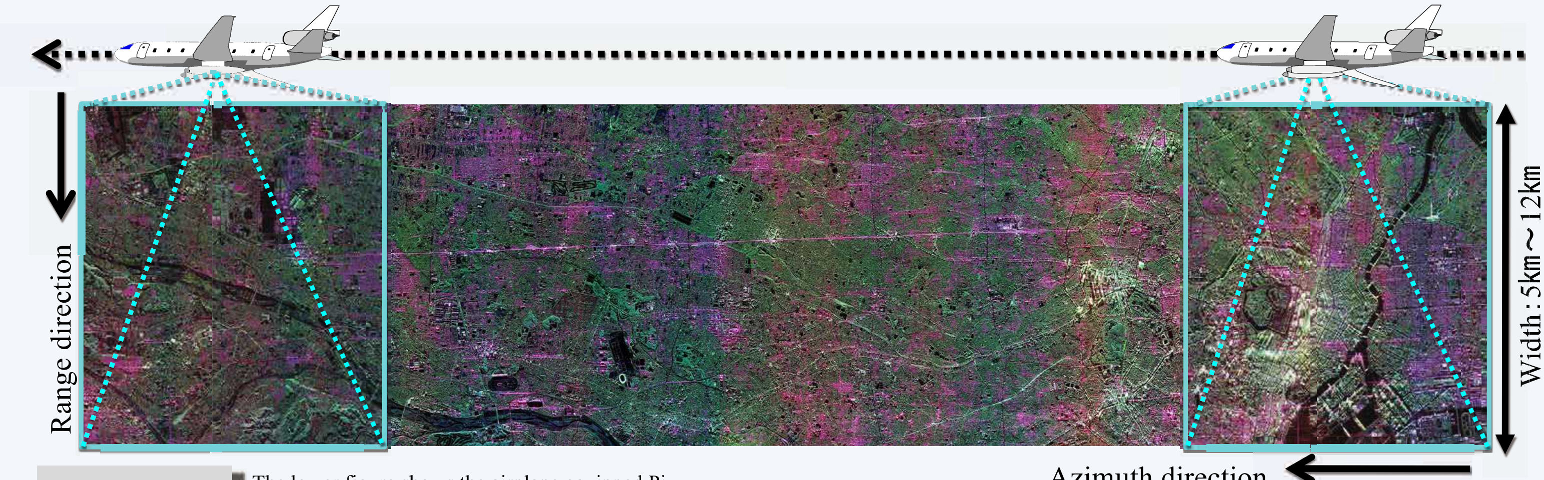
AERI 電磁波研究所 Applied Electromagnetic Research Institute

Airborne Synthetic Aperture Radar (Pi-SAR X2)

国立研究開発法人 情報通信研究機構
National Institute of Information and Communications Technology

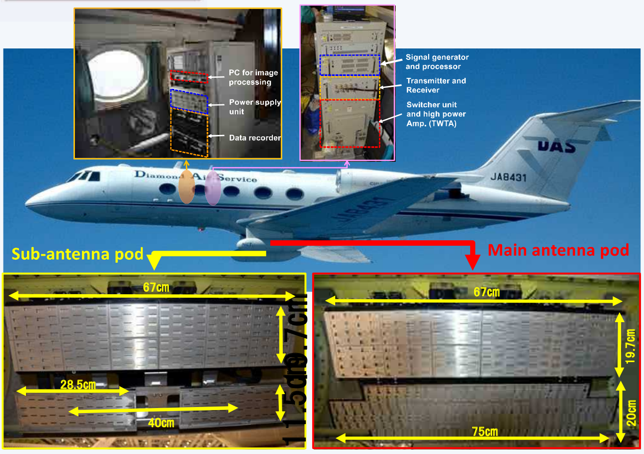
Abstract

SAR transmits radio waves to the ground surface and receives the backscattered echoes. SAR can take surface images independently of the time of the day or the atmospheric conditions because SAR uses microwaves. Pi-SAR X2 can also estimate surface elevations by interferometric observation. SAR uses the relative motion between the antenna and the target region to obtain finer spatial resolution than conventional real aperture radar. Backscattered echoes received successively and coherently at different antenna positions are stored and post-processed to realize high resolution. The spatial resolution in Pi-SAR X2 is 30cm.



Pi-SAR X2

The lower figure shows the airplane equipped Pi-SAR X2 device and the antenna pods.

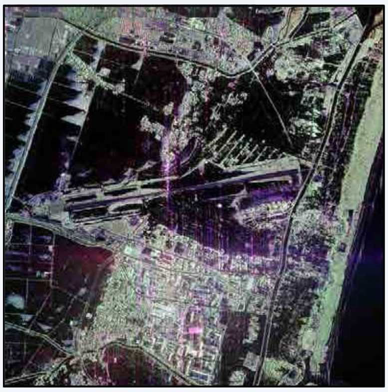


The top antenna is for cross-track interferometry, and the bottom one is for along-track interferometry.

The top antenna is a V polarization slotted waveguide antenna. The bottom one is an H polarization slotted waveguide antenna.

Observation

Left figure shows Sendai Airport observed by Pi-SAR2 on March 12, 2011. Right figure shows landslide observed by Pi-SAR2 on April 17, 2016.

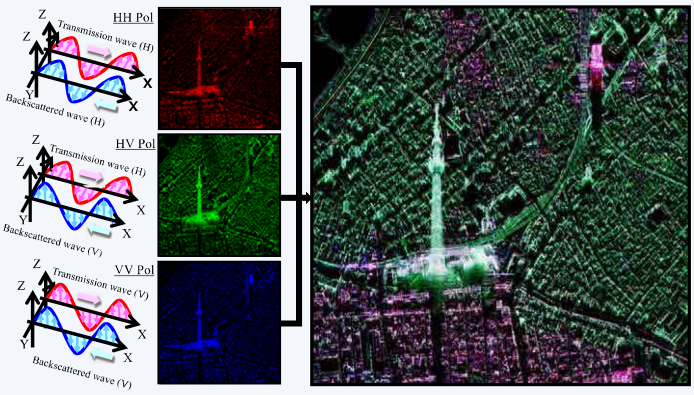


The run-up height of Tsunami is 5.7m at Sendai Airport. The black color shows the flooded areas. The rubble can be seen there. Tsunami reached about 5.5km inland from coastline.

This image shows landslides that occurred after a huge earthquake. The red circle shows landslide area.

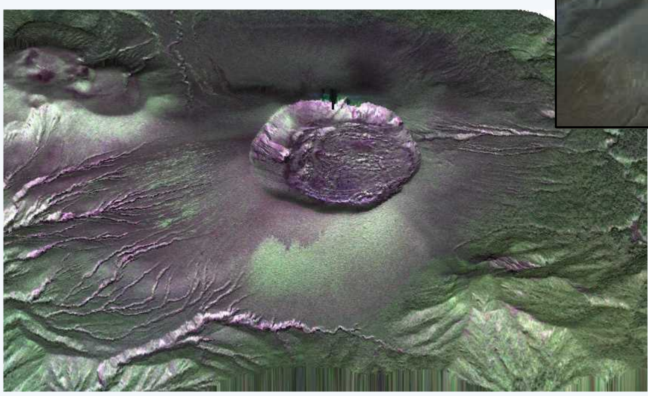
Color image

Pi-SAR2 can observe a ground or sea surface by using vertically and horizontally polarized waves. The lower-right figure shows the color composite image around Tokyo Sky-tree.



3D image

The lower figure shows 3D image around Mt. Shinmoe. This image is created from the elevation data and color composite SAR image.



- Observation day Jan. 11, 2013
- Altitude:8,800m
- Color composition
  R : HH
  G : HV
  B : VV

Remote Sensing Laboratory

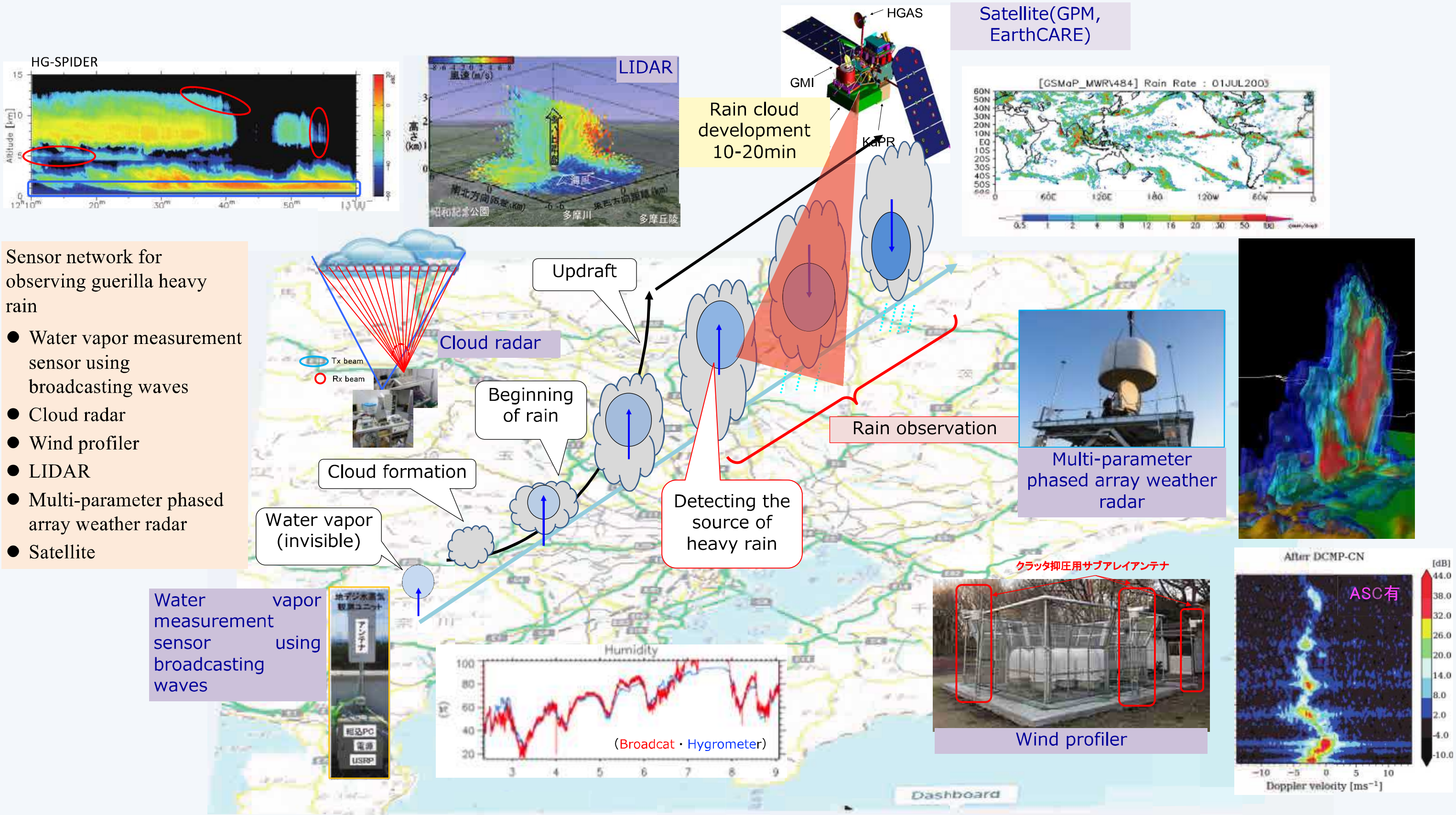
AERI 電磁波研究所 Applied Electromagnetic Research Institute

Toward early detection of heavy rain which develops in a short time

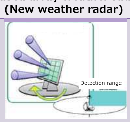
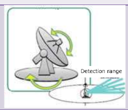
国立研究開発法人 情報通信研究機構 National Institute of Information and Communications Technology

Abstract

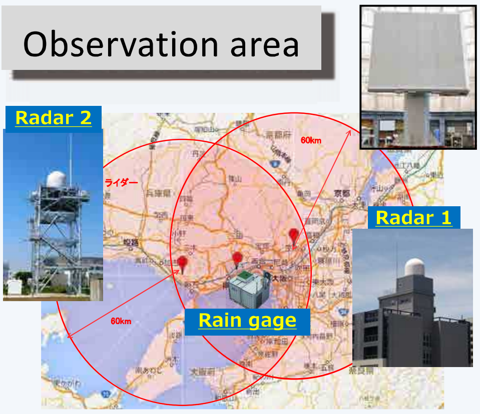
The lower figures shows the physical process until guerilla heavy rain occurs and NICT sensor network to measure water vapor, cloud, rain and wind. NICT aims to contribute to society such as early detection of disasters using the sensor network.



New weather radar

	Phased array weather radar (New weather radar)	XRAIN (Conventional weather radar)
		
Antenna Type	Planar antenna (128 element waveguide slot antenna)	Parabolic antenna (diameter 2.2 m)
Transmitter	Semiconductor device	Klystron[1] or Semiconductor device[2]
Power	430W	100kW[1] or 200W[2]
Observation range	60km	80km
Polarized wave	Horizontally polarized wave	Horizontally and vertically polarized wave
Observation time	30s (100 elevation angle)	300s(15 elevation angle)
Observation items	Radar Reflection Factor, Doppler Speed	Radar Reflection Factor, Doppler Speed, Polarization wave radar reflection factor ratio , phase difference

Observation area



New radar systems were installed at Osaka area. Radar 1 was installed on the top of the building at Osaka Univ.. Radar 2 was installed on the top of the tower at NICT Kansai branch.

Observation results

The lower figures show the time series of the local heavy rain caused by solitary cumulonimbus clouds observed with the new weather radar. Look at the three-dimensional structure of rainfall near the Kyotanabe-shi in the southern part of Kyoto Prefecture from the northeast direction (lattice spacing 100 m).