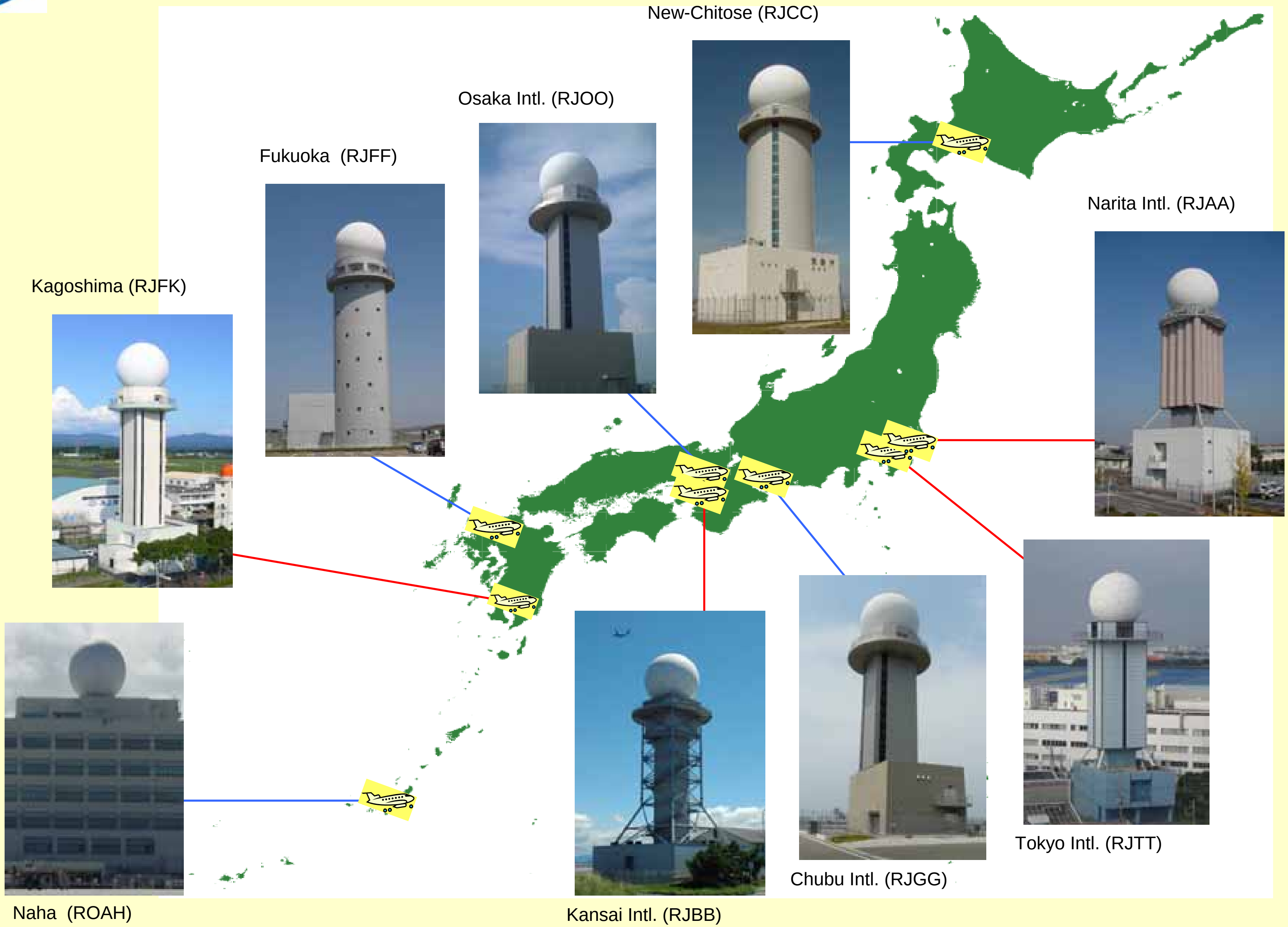
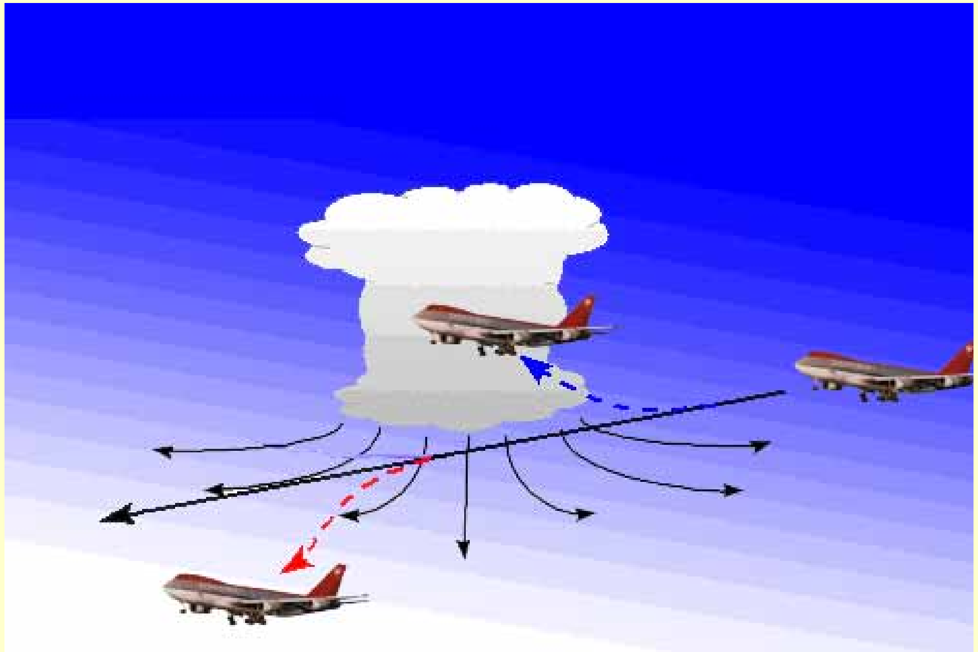
DRAW: Doppler Radar for Airport Weather



DRAW: Purpose



The wind shear (microburst and shear lines) in particular a dangerous phenomenon that has an extremely serious influence the safe flight management, especially the landing and taking off of aircraft.

- Monitoring the precipitation and air currents in areas surrounding airports and flight routes
- Automatic detection of precipitation distribution and low level wind shears form the obtained data.
- Providing the results to the airport weather service and air traffic control.

DRAW: Specification and Requirements

Radar specification

- Azimuth Resolution : 0.64° (Antenna Diameter 7.1m)
- Range Resolution : 150m
- Elevation : 0.7° ～45.9°
- Observation Range : 120km

Functional requirements

- To detect the microburst of a diameter of 500m within 10km from a radar.
- To detect the microburst within 20km from a radar every around 1 minute, and display a result after the detection within 30 seconds.
- To detect the shear line within 60km from a radar every six minutes.
- To observe the three-dimensional distribution of echo intensity within 100km from a radar.
- To use the two observation modes by climatic condition around the airport.

DRAW: Observation Mode

Aerial mode (normal weather condition)

- Observe the rainfall within 120km from a radar.
- Detect the microburst within 20km from a radar every 6 minutes.
- Detect the shear line within 60km from a radar every 6 minutes.

Airport mode (adverse weather condition)

- Observe the rainfall within 120km from a radar.
- Detect the microburst within 20km from a radar every 1.2 minutes.
- Detect the shear line within 60km from a radar every 6 minutes.

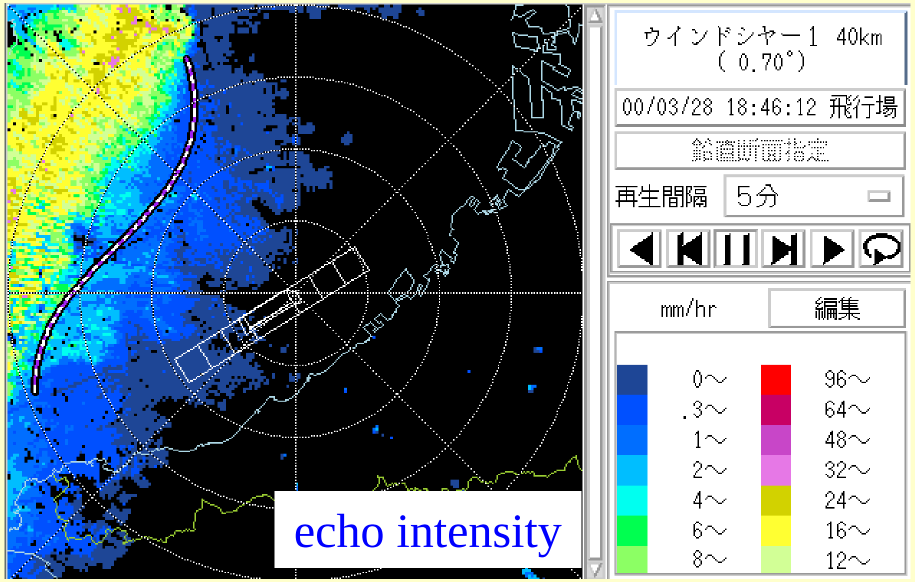
The standard of the change of the mode (aerial → airport)

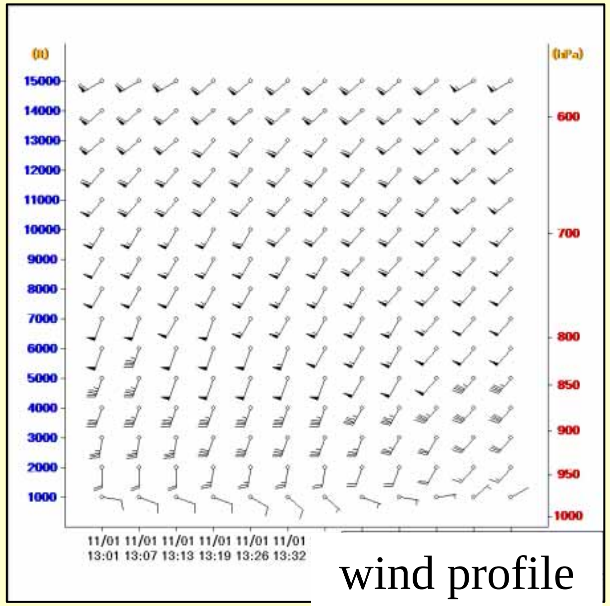
- Either of the two following conditions are satisfied, DRAW changes the observation mode.

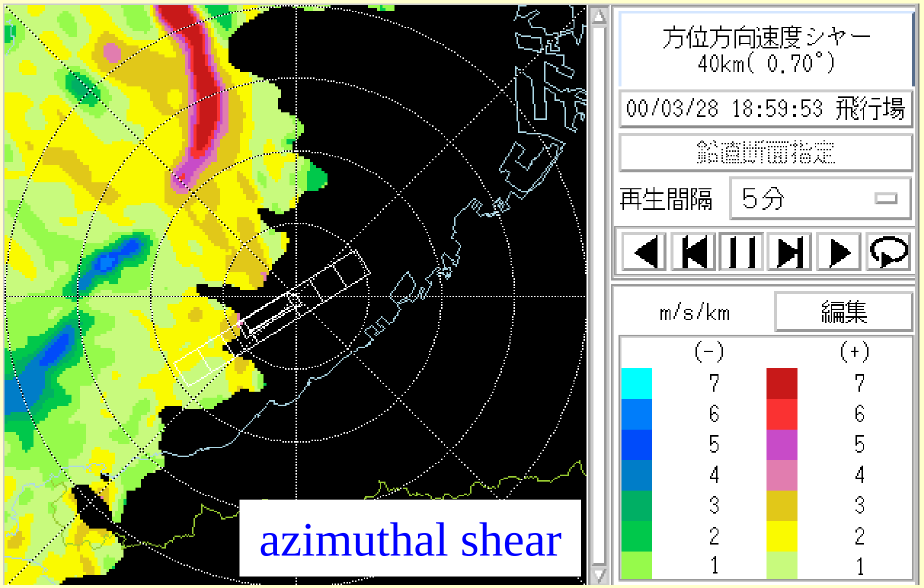
① When the rainfall domain (VIL > 2mm) is more than $100km^2$.

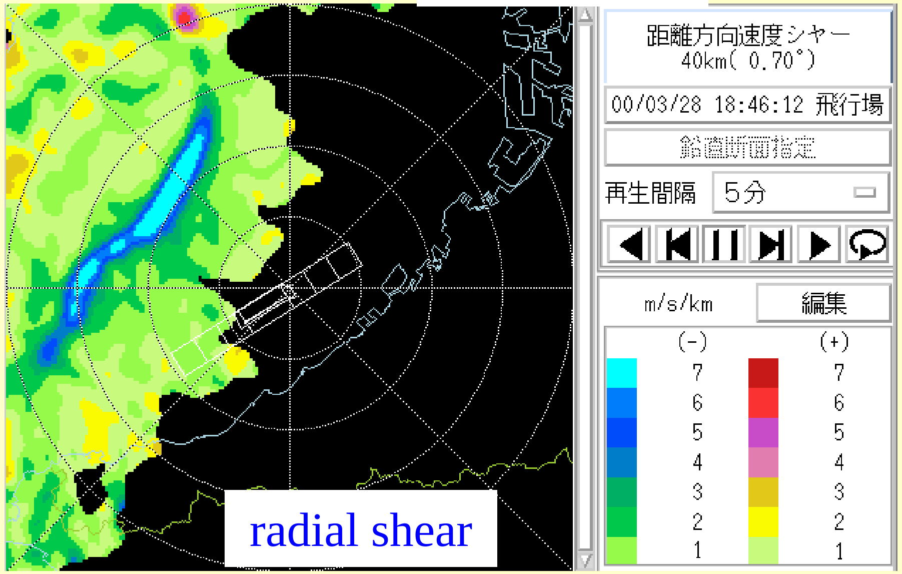
② When a microburst or a shear line is detected.

DRAW: Products









DRAW: Wind Shear Detection

Shear line alert criteria

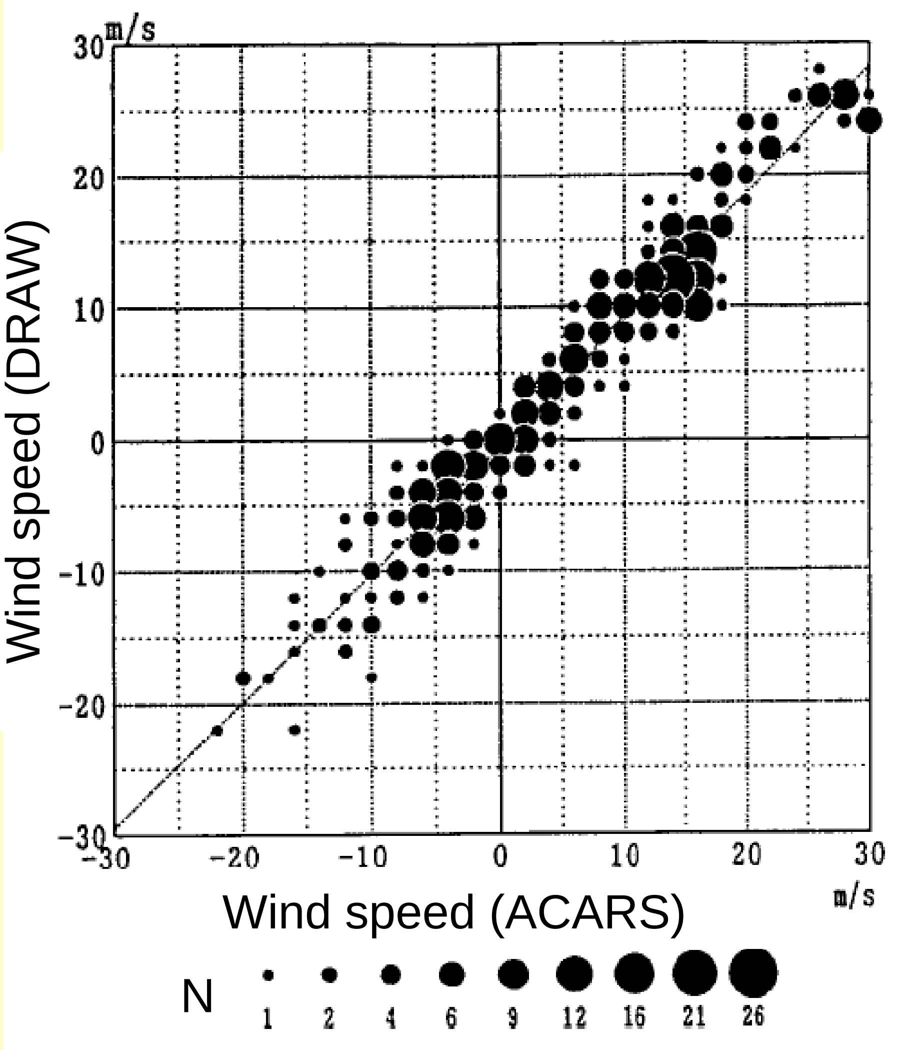
- The wind velocity difference of both sides of the shear line is more than 5m/s (about 9kt)
- The length of the shear line is more than 10km
- The maximum of radial shear is more than 2.0m/s/km

Microburst alert criteria

(three conditions are satisfied simultaneously)

- The maximum of the speed change is more than 8m/s (about 15kt)
- An area of the microburst more than $3km^2$
- The maximum rates of change of the Doppler velocity in the microburst is more than 5.6m/s/km

DRAW: Wind Accuracy and Performance for Shear line and Microburst Detection

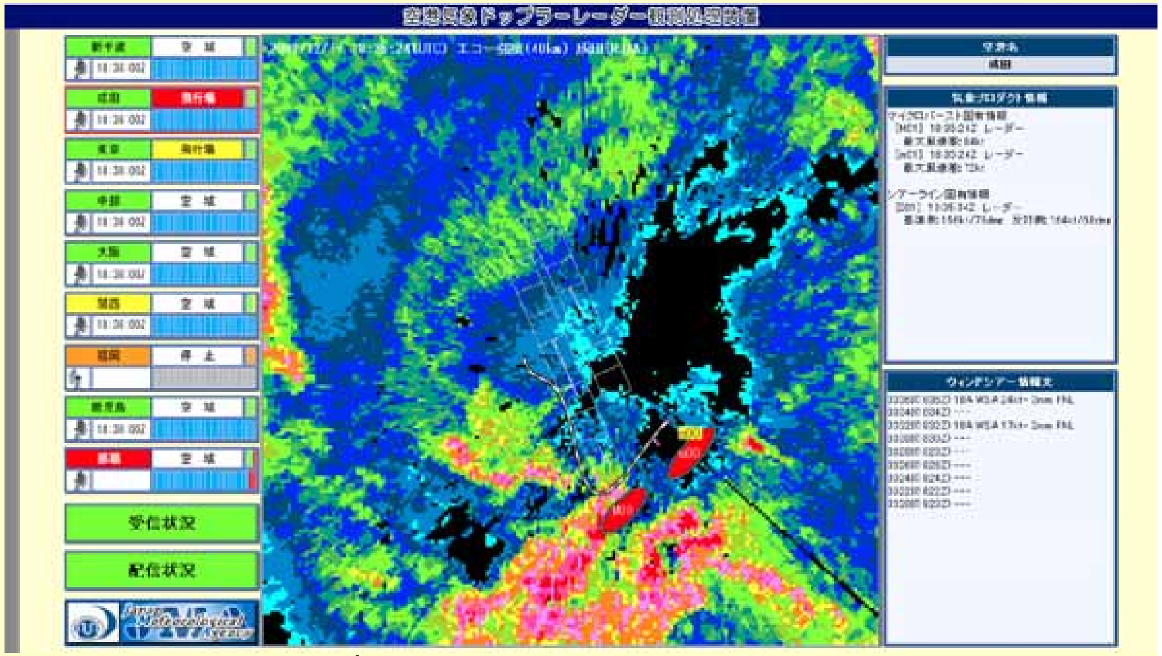


	ΔV_T (m/s)	Number (detected)	Number (observed)	POD (%)
Shear line	5	71	83	86
	10	53	56	95
	15	19	20	95
Microburst	8	257	297	87
	10	227	236	96
	15	83	84	99

DRAW performance evaluated from observation data during 1995-1998. (Akaeda, 2001)

DRAW: Recent Advances

- 2007 : LLWS (Low Level Wind Shear) Alert Service with DRAW and Lidar data (RJAA/RJTT)
- 2008 : Installation plan of DRAW was completed (Last installation was RJFK)
- 2009 : The collection of DRAW data to JMA headquarters

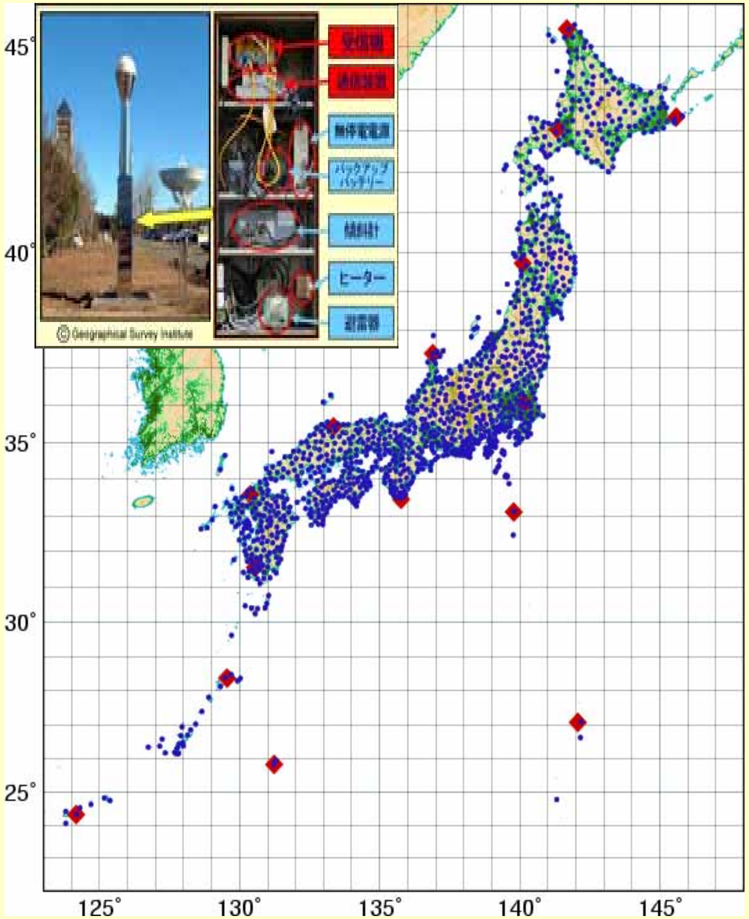


GPS Precipitable Water Monitoring

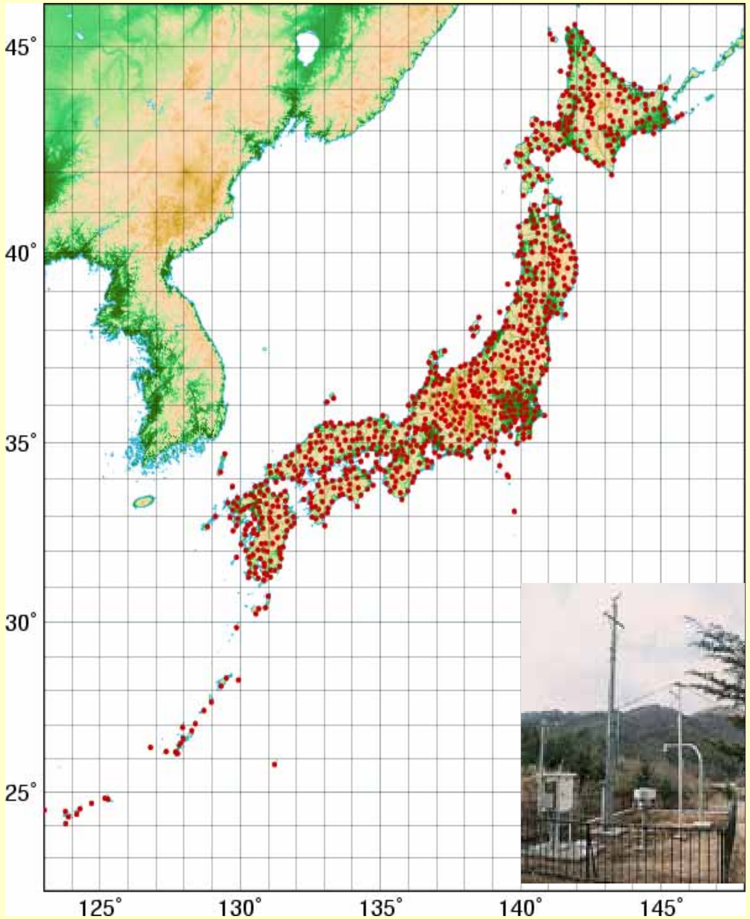
GPS PW: Observation Network in Japan

GEONET (GPS Earth Observation NETwork) is a GPS network operated by the Geographical Survey Institute, the Ministry of Land, infrastructure and transportation, Japan. Approximately 1,200 GPS receivers are located throughout Japan with a separation of 20 km in order to monitor crustal deformation of the earth.

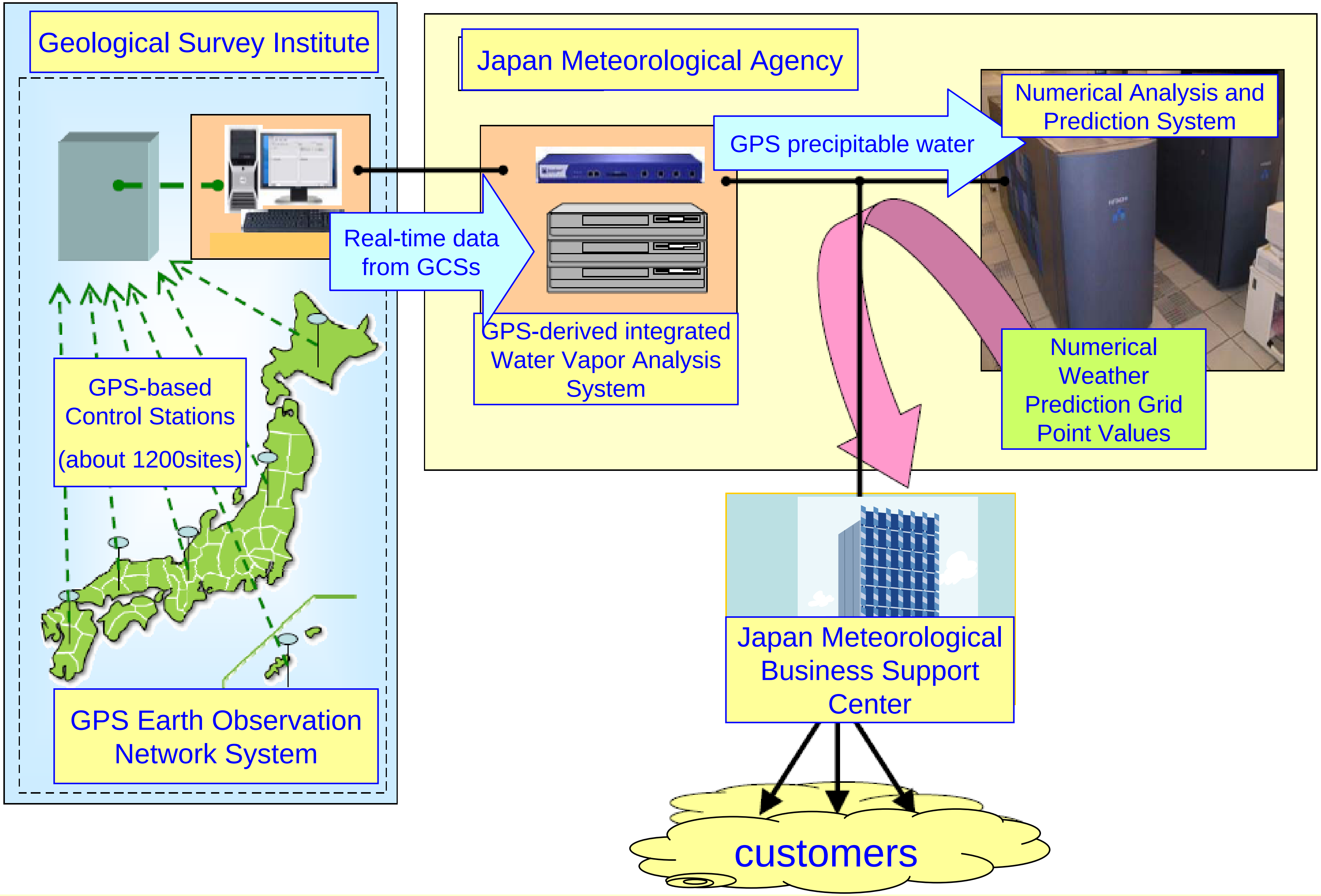
GEONET



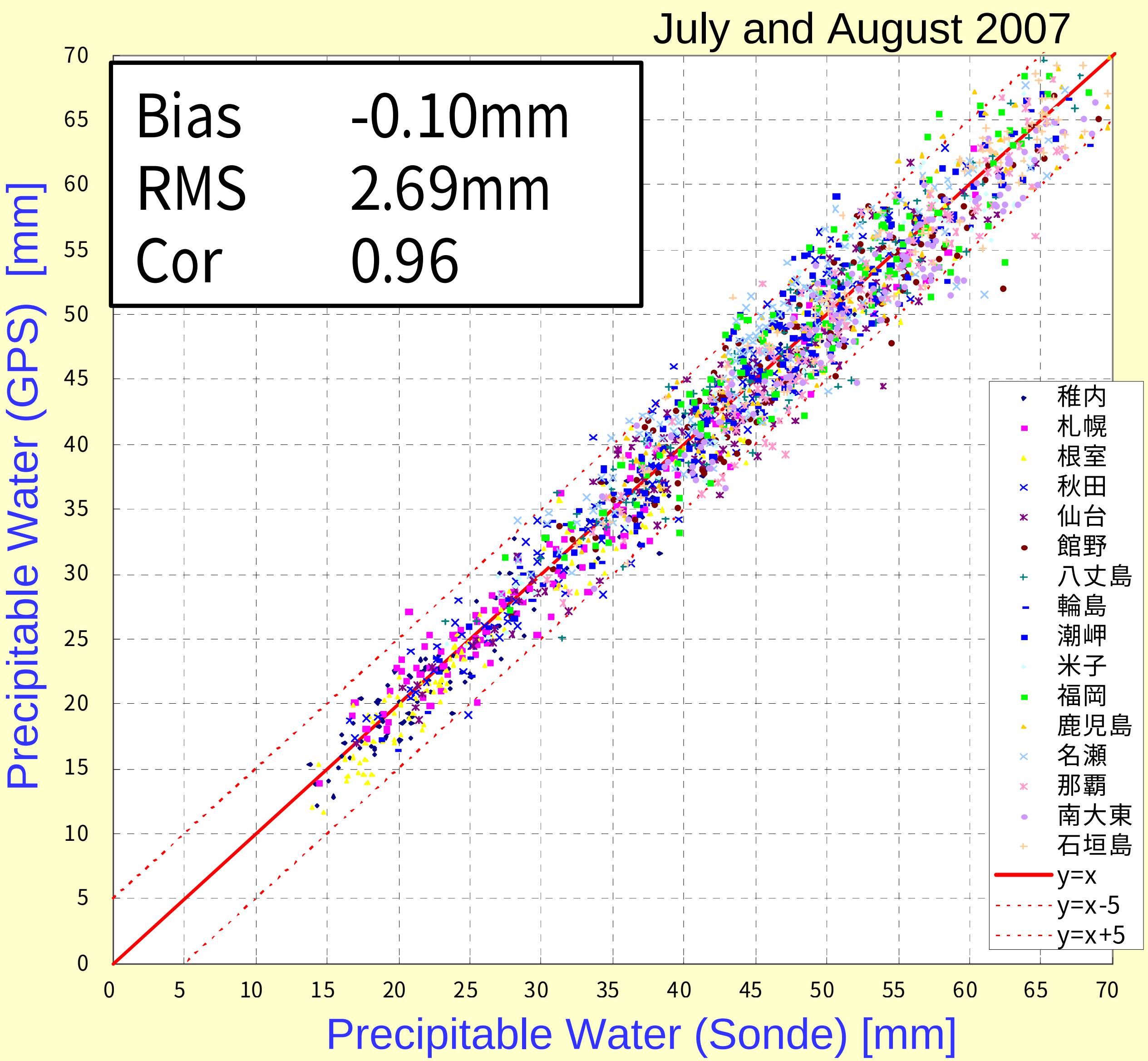
AMeDAS



GPS PW: Data flow



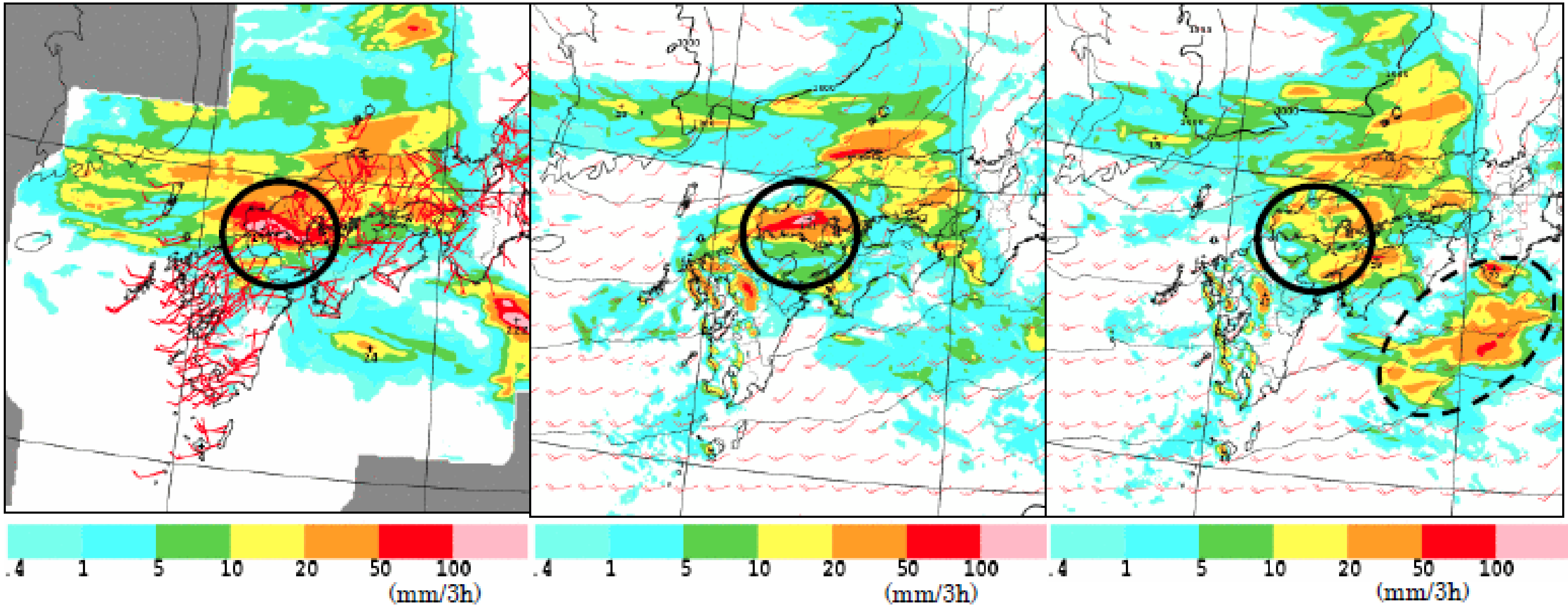
GPS PW: Accuracy



Impacts of GPS PW on Numerical Prediction

The precipitable water, which was obtained from GPS processing, was assimilated into the meso-scale 4-dimensional variational data assimilation system of the JMA.

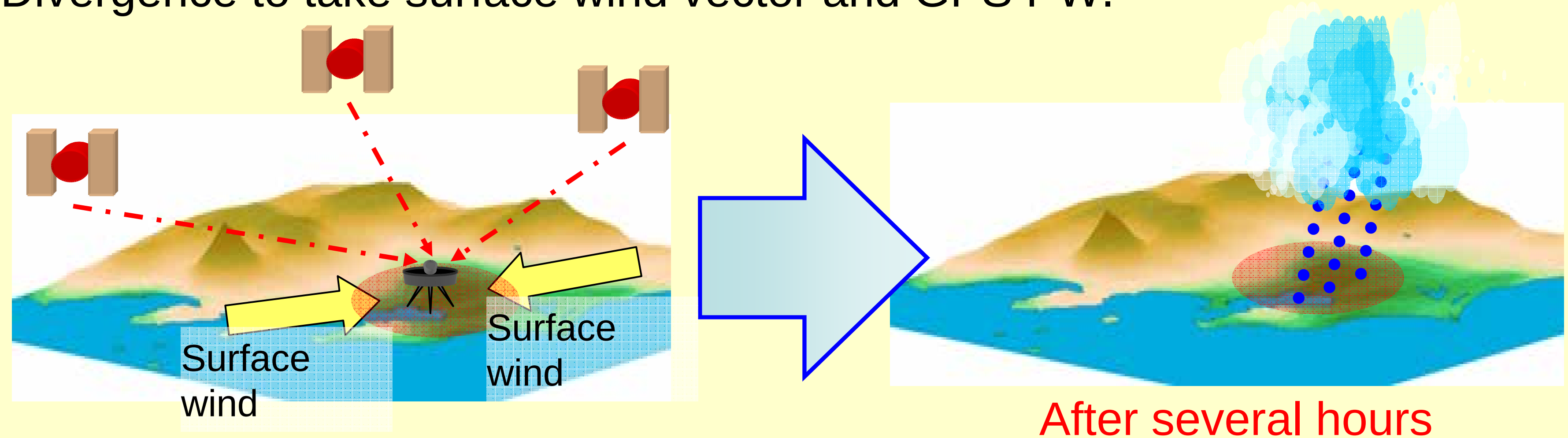
Precipitation | with GPS PW | without GPS PW



Rainfall amount during 6JST to 9JST forecast hours from the initial condition of 6JST on 15 July 2009.

GPS PW: Flux Divergence

It is necessary to grasp the place where water vapor converges, which predict local rainfall phenomenon. Therefore, this study made GPS PW Flux Divergence to take surface wind vector and GPS PW.



$$\frac{1}{g}\int\left[\frac{\partial}{\partial x}(\overline{uq})+\frac{\partial}{\partial y}(\overline{vq})\right]dp \approx \frac{1}{g}\int_{Surface}^{middle}\nabla\cdot\mathbf{v}qdp \approx -\overline{M},$$

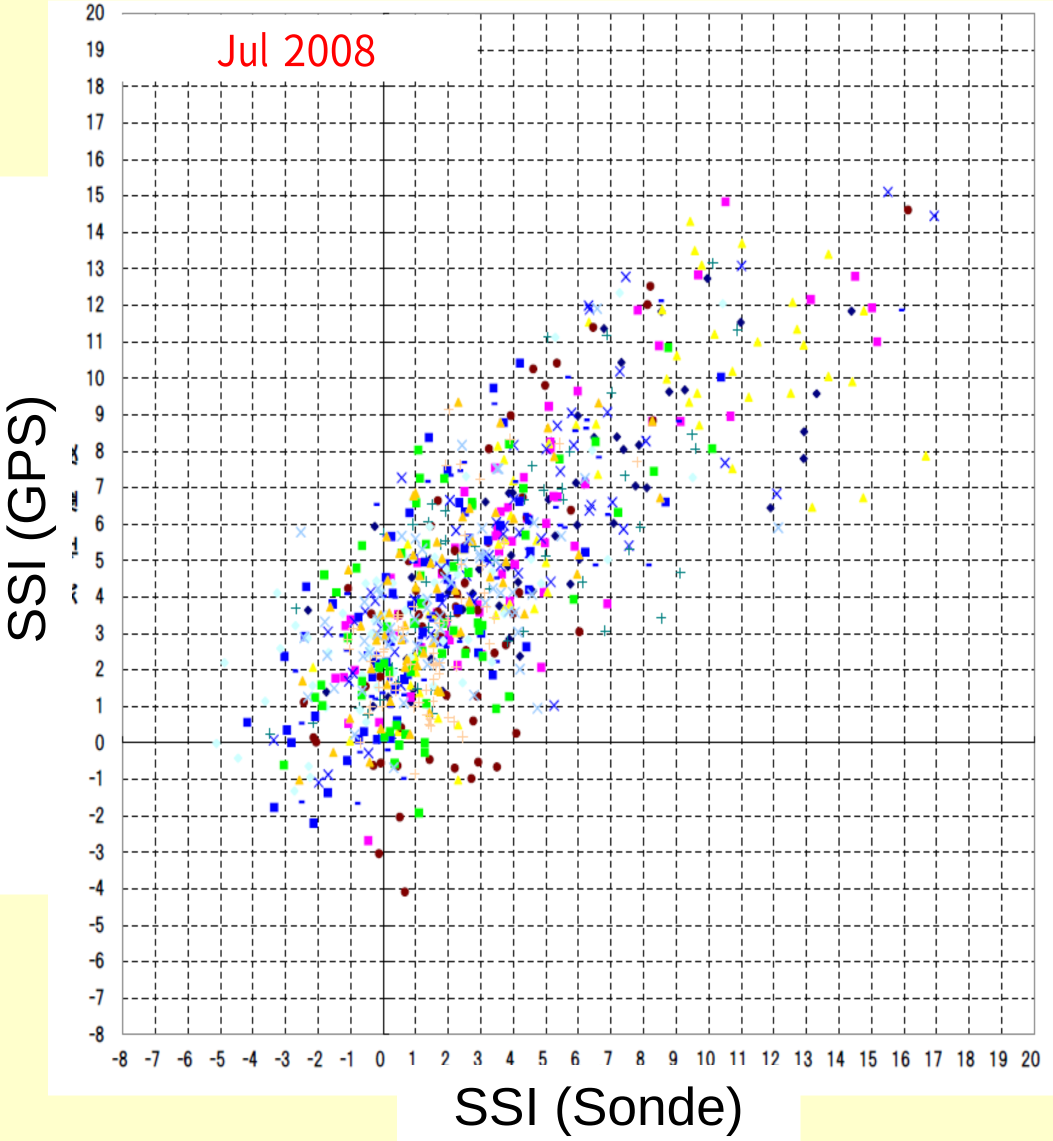
Low level water vapor Flux Divergence Column condensation rate

$$\text{GPS PW Flux Div.} = \nabla\cdot(\mathbf{v}'\times PW) = \frac{\partial(u'\times PW)}{\partial x}+\frac{\partial(v'\times PW)}{\partial y},$$

$$\text{unit}: \frac{\text{m}}{\text{s}}\times\frac{\text{kg}}{\text{m}^2}\times\frac{1}{\text{m}} = \text{kgm}^{-2}\text{s}^{-1},$$

u', v' : surface wind components from AWS network, AMeDAS.

GPS PW: Showalter's Stability Index (SSI)



SSI = T500 – Tparcel

- T500: Temperature at 500 hPa
- Tparcel: Temperature at 500 hPa of a parcel lifted from 850 hPa
- 850hPa humidity   Column
- HumidityThe Column humidity defines it for a ratio of GPS PW for saturation PW.

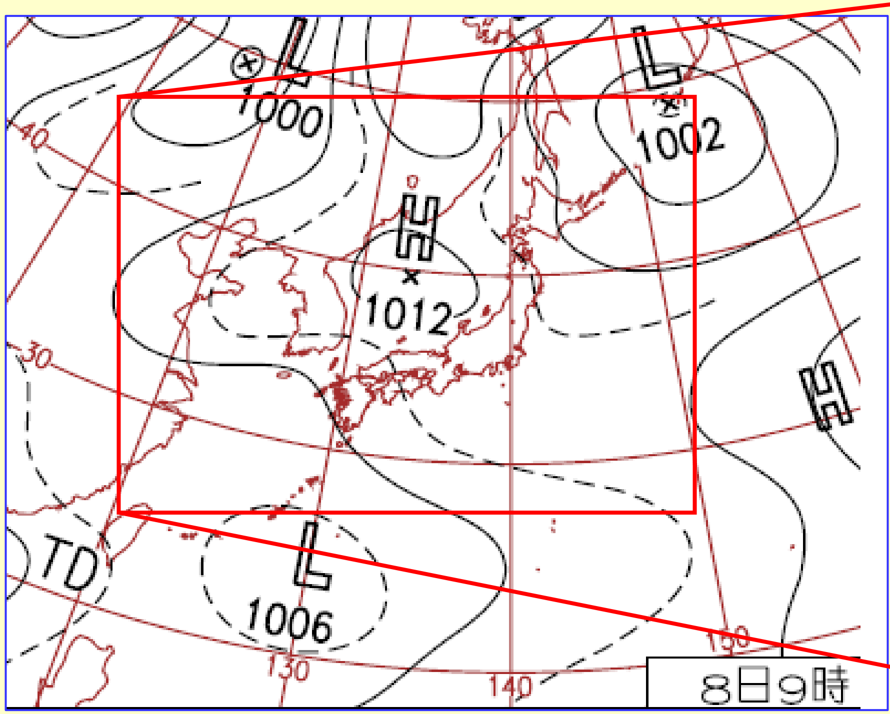
Column humidity = GPS_PW / Saturation PW

- Column humidity shows that it is very likely that it rains in a case beyond 60% (Niimura et al.,2000).

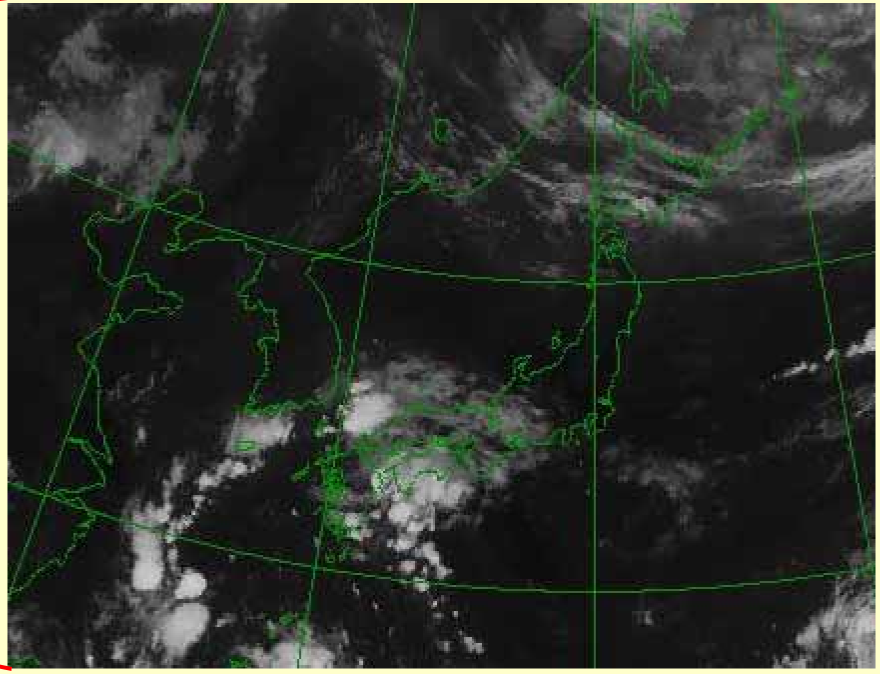
GPS PW: A Heavy Rain Case on 8 August 2008

Heavy rainfall and thunderstorms observed over the western part of Japan and Nansei Islands on 8 August 2008 resulted from the unstable condition of the atmosphere.

Heavy rain and flood warnings were issued at 1504JST and 1532JST for Chikugo and Fukuoka area in Fukuoka prefecture, respectively.

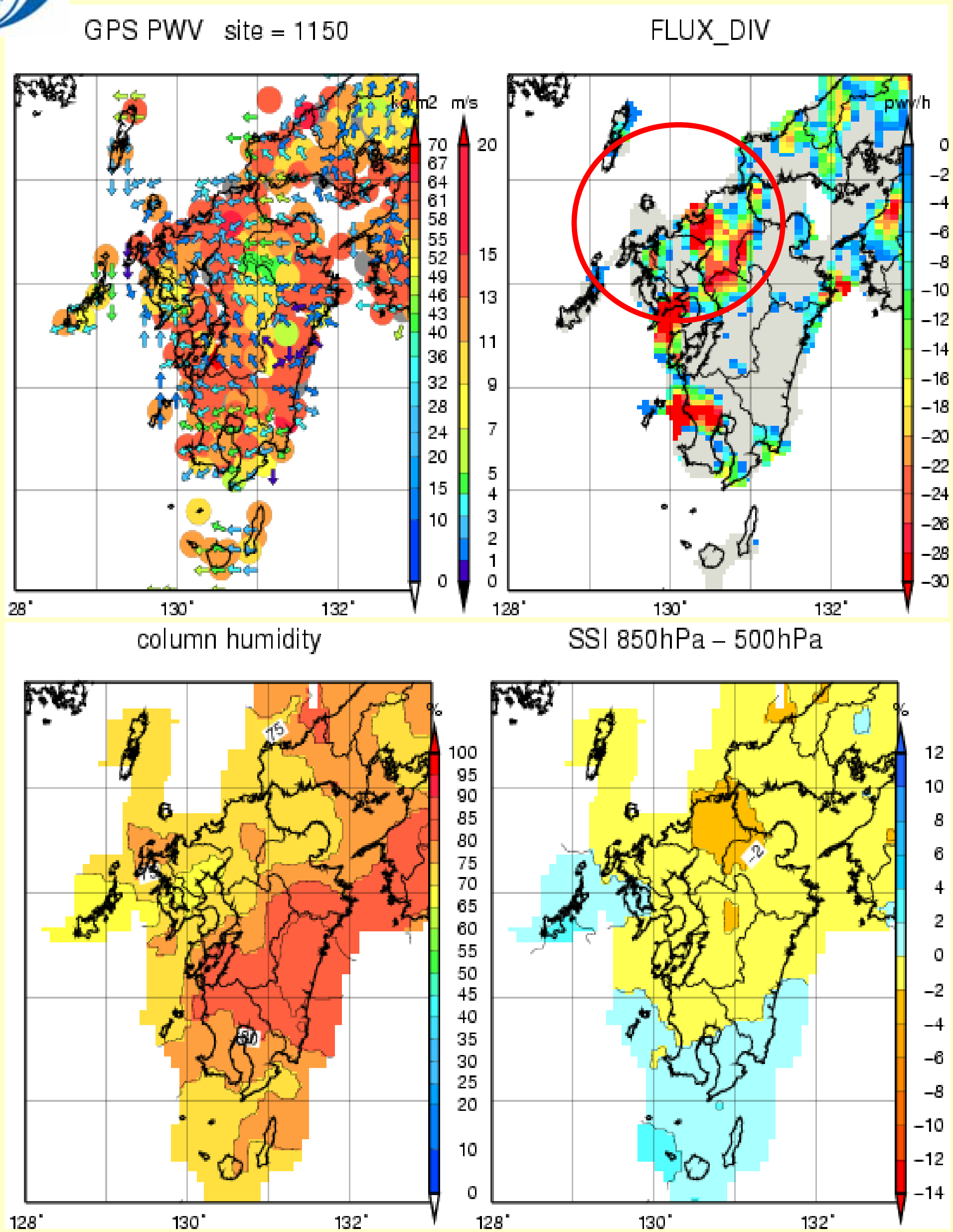


Surface（09JST, 8 AUG 2008）

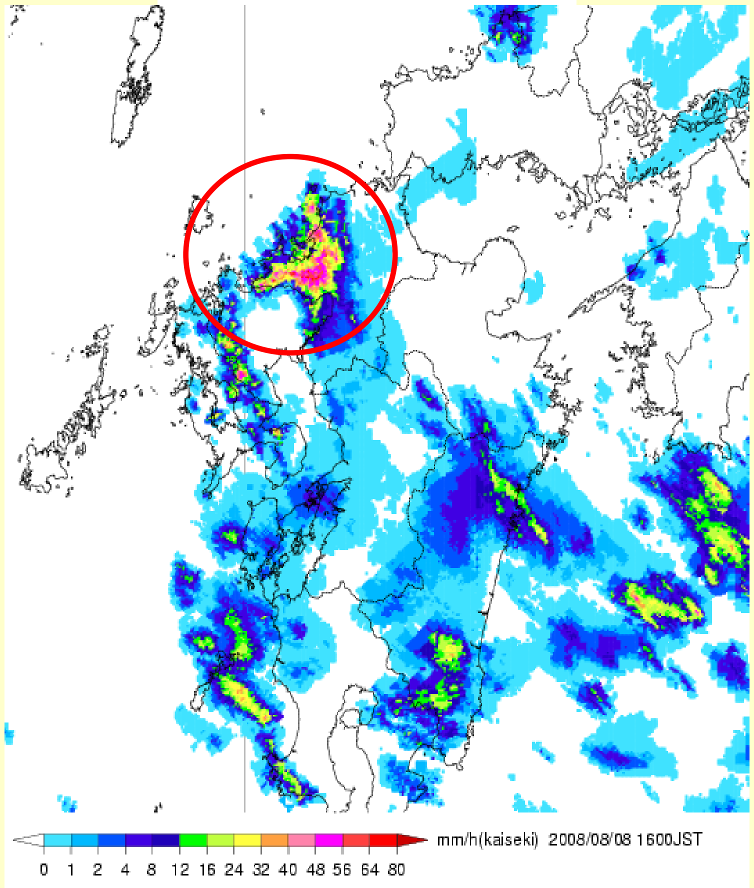


MTSAT-IR（09JST, 8 AUG 2008）

GPS PW: A Heavy Rain Case on 8 August 2008

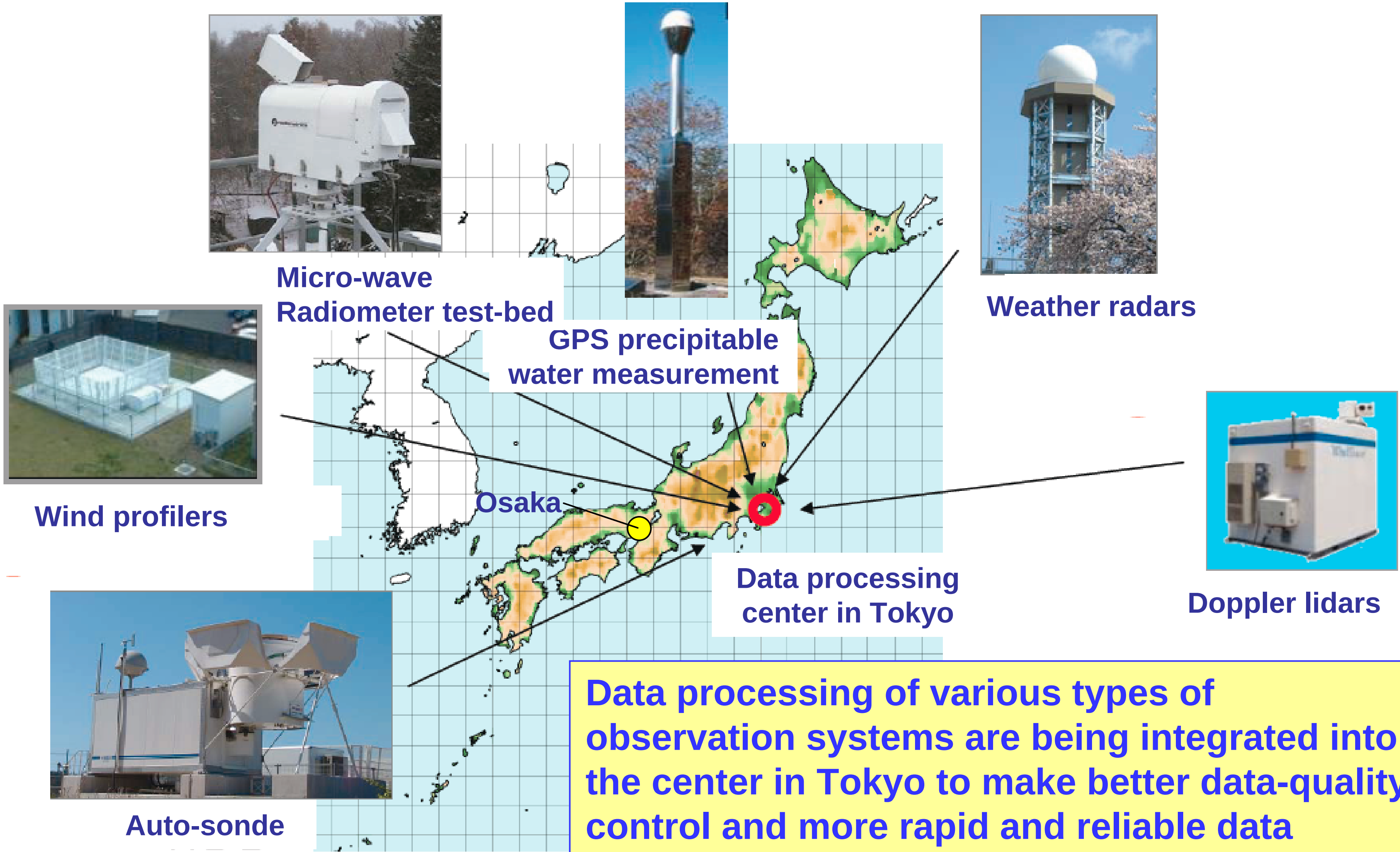


16:00 JST



Aug 8 , 2008

System Integration of Observation and Data-processing



Data processing of various types of observation systems are being integrated into the center in Tokyo to make better data-quality control and more rapid and reliable data processing.

Comparison of surface based remote sensors

	Radar	Wind profiler	GPS receiver
Weather condition	Rainy (snowy) weather	All-weather	All-weather
Variables	Echo intensity Doppler velocity	Wind(u, v, w) S/N ratio	Precipitable water (PW)
Accuracy	Wind < 2m/s	Wind <2 m/s	PW < 3 kg/m^2
Maximum height (km)	15 (depends on weather conditions)	3〜9 (depends on weather conditions)	
Vertical resolution (km)	1 〜2	0.3	
Horizontal spacing (km)	1	120	20km
Time between observations (h)	0.17	0.17	1
Delay in delivery to user (h)	0.3 〜0.5	0.3〜1.3	0.5
Application	Data assimilation Monitoring	Data assimilation Monitoring	Data assimilation Monitoring

Assimilation of surface remote sensor data into NWP

	Radar	Wind profiler	GPS receiver
Variables	Doppler velocity, 1-houhr Precipitation (Radar-Raingauge Analyzed Precipitation data)	Wind	Precipitable water (PW)
Horizontal spacing (km)	1	120	20km
Analysis scheme	4D-Var (4-dimensional variational data assimilation)	4D-Var	4D-Var
NWP model (assimilation window)	MSM* (3-hour)	MSM* (3-hour) GSM** (6-hour)	MSM* (3hour)
Date	December 2006 (general weather radar)	June 2001	October 2009

*MSM: Meso-scale model , **GSM: Global spectral model.

Summary

•At present JMA operates observation networks with surface based remote sensors (20 general weather radars, 9 Doppler radars for aviation service, 31 wind profilers, etc.) and utilizes GPS precipitable water estimated from GEONET data.

•20 general weather radars and 9 Doppler radars for aviation have the capabilities of observing three-dimensional precipitation and wind field to detect severe weather and low-level wind shears which are often hazardous to aircraft.

•Data from surface based remote sensors contributes to improve accuracy of the NWP with data assimilation and also to monitor atmospheric conditions.

Current issues and future plan

- Conventional radar replacement to Doppler radar for general weather radars.
- Replacement of the radar observation processing system to realize high-reliability, high-accuracy, high-resolution in space and extendibility of radar products.
- Development of integrated monitoring system with various remote sensing and surface observations to improve our atmosphere monitoring ability.