

Cloud conditions for low atmospheric electricity during disturbed period after the Fukushima nuclear accident

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Abstract

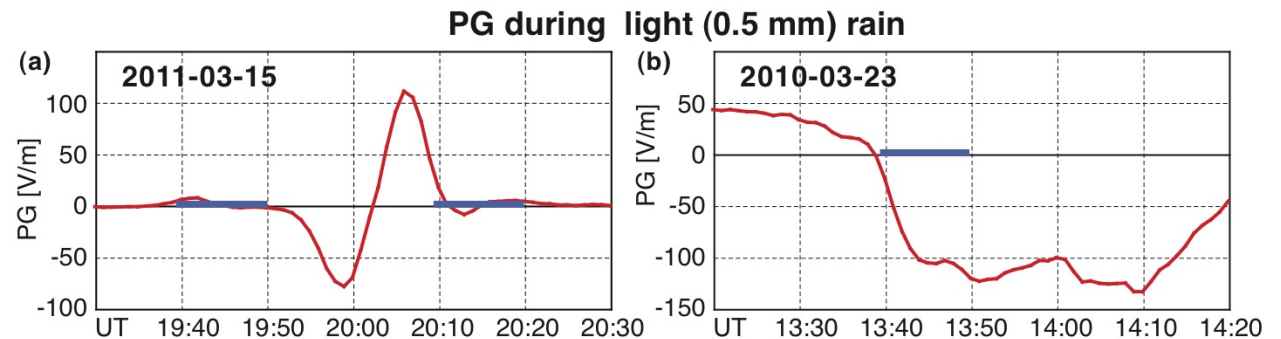
The atmospheric electric field data at Kakioka, 150 km southwest of the Fukushima Dai-ichi Nuclear Power Plant (FNPP1) suggested that electric charges are somewhat shielded when the radioactive dust was floating in the air, but the relation between the weather and this modification is not yet clear. Unfortunately the detailed weather data was not available above Kakioka (only the precipitation data was available).

To estimate the cloud condition from various meteorological information, including radar data, a link-database is set up (<http://www.chikyu.ac.jp/akiyo/firis/>). Here we present various radar images that we have prepared for March 2011.

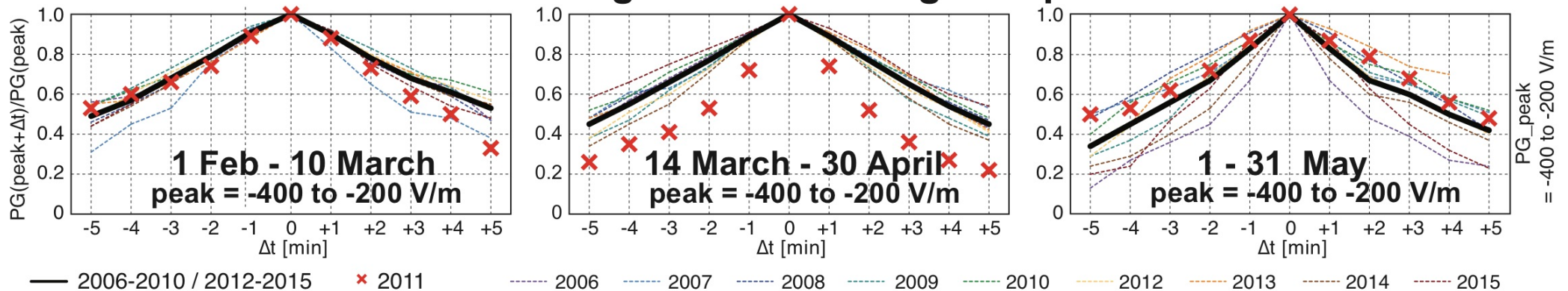
- (1) We prepared 3-D radar reflectivity data of JMA's C-band radars at Tokyo and Sendai, both including Fukushima, over several hundred km area, every 10 min.
- (2) We have released images of each altitude (1km interval) for 15-16 and 21 March (<http://sc-web.nict.go.jp/fukushima/>). => The vertical structure of the rainfall is almost the same between 4km height with the surface, and a sporadic high precipitation is observed at 6 km height for 15-16 March. On 21 March, the precipitation pattern at 5km height was similar to that of the surface.
- (3) An X-band radar centered at Fukushima university is also used to know more localized raindrop patterns at zenith angle of 4° . We prepared 10-minutes/120m mesh precipitation patterns for March 15-18, and 20-23 March. => Quantitative estimate is difficult from this X-band radar, but localized structure, especially for the rain-band along Nakadori (middle valley in Fukushima prefecture), that is considered to determine the highly contaminated zone, is observed with only this X-band radar in the mid-night (JST) of 15 March.

Motivation

Rain clouds = electrified $\Rightarrow$
 Atmospheric electric field vertical
 component (PG: potential gradient)
 shows short spikes on $-100 \sim -4000$
 (right figures).

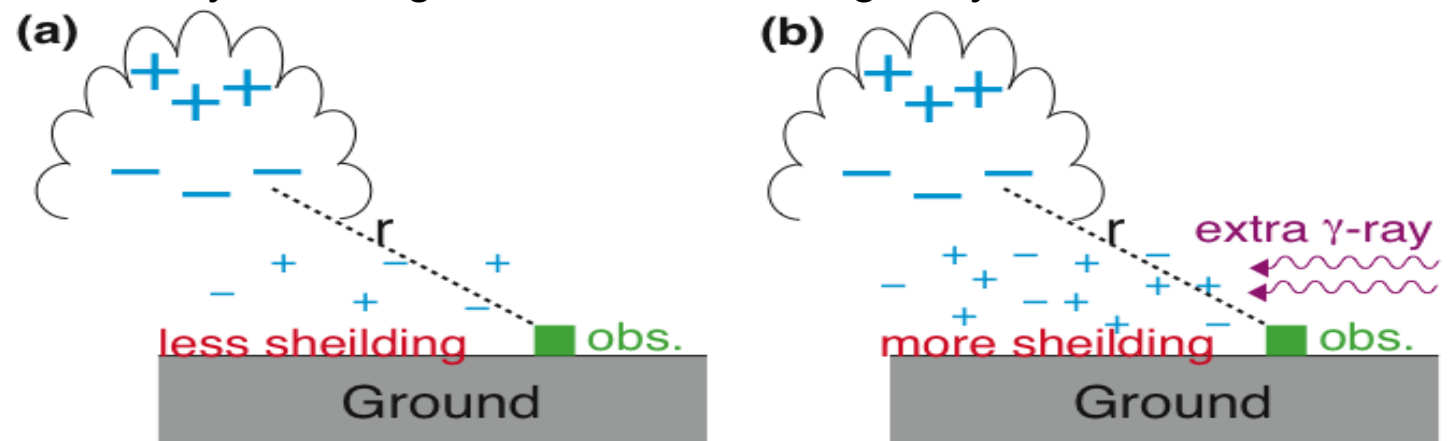


PG change from/to its negative peaks



Observation during shows that PG values near its peak is reduced due to the floating radionuclide (above figure). $\Rightarrow$ Probably shielding effect of cloud charges by the increased ions.

$\Rightarrow$ What kind of cloud condition (mist or rain) is the most sensitive to the radionuclide?

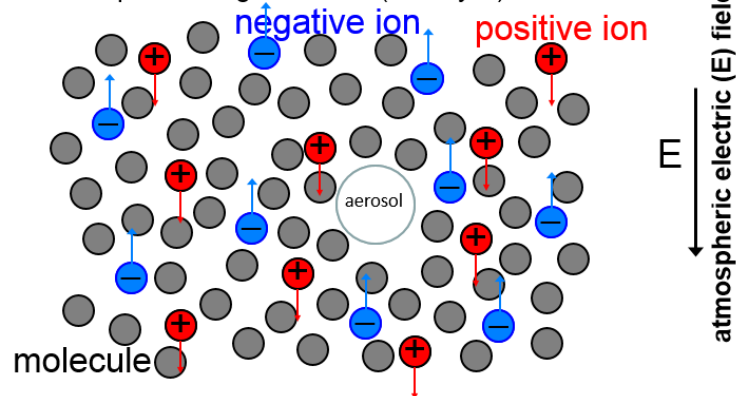


Ion density n : $\frac{dn}{dt} = q - \alpha n^2 - \beta nN$

q : production (by cosmic ray, radon, and γ -ray)

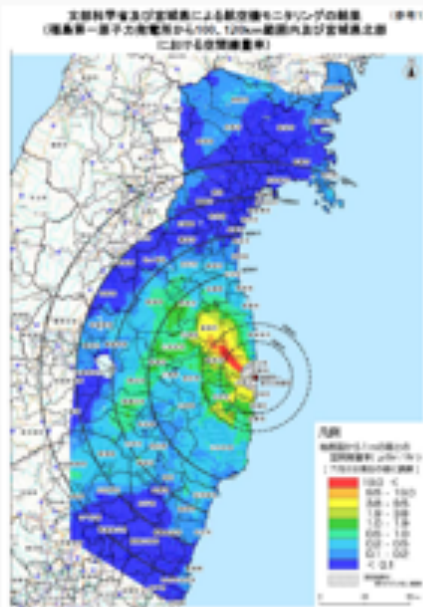
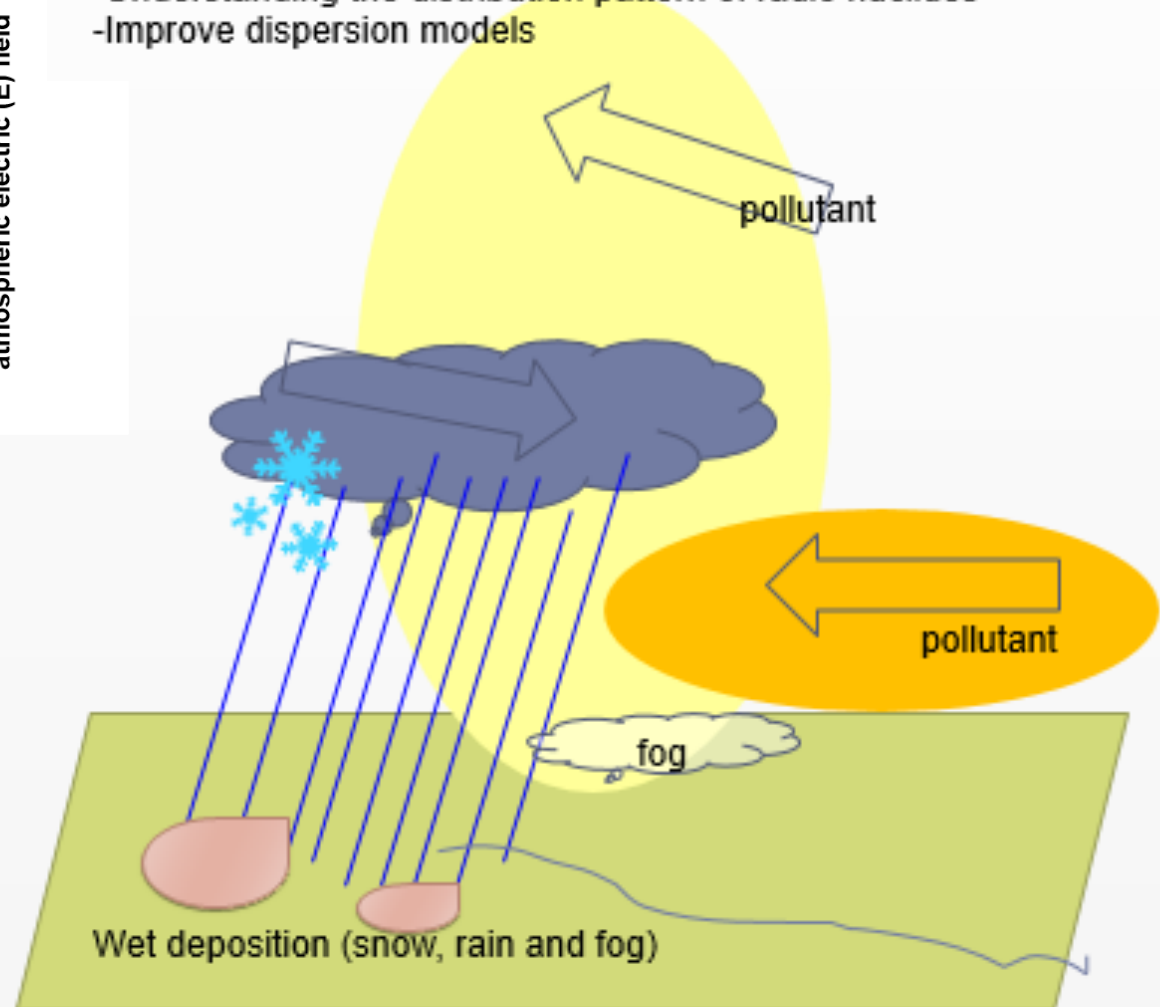
α : neutralization

β : attaching to aerosol (density N)



It is important to know the vertical level of precipitation and precipitation type for

- Understanding the distribution pattern of radio nuclides
- Improve dispersion models



Need 3D information on **rain drop and fog** to understand **wet deposition processes & precipitation type**, but initial drizzle is difficult to be measured by the tipping bucket-type rain gauges

Method:

- Collect meteorological data to understand wet/dry deposition process of the radio nuclides from Fukushima Daiichi NPP in March 2011.

- Development of a database of the collected data => **FUKUSHIMA-IRIS**

Radar (C-band, X-band)

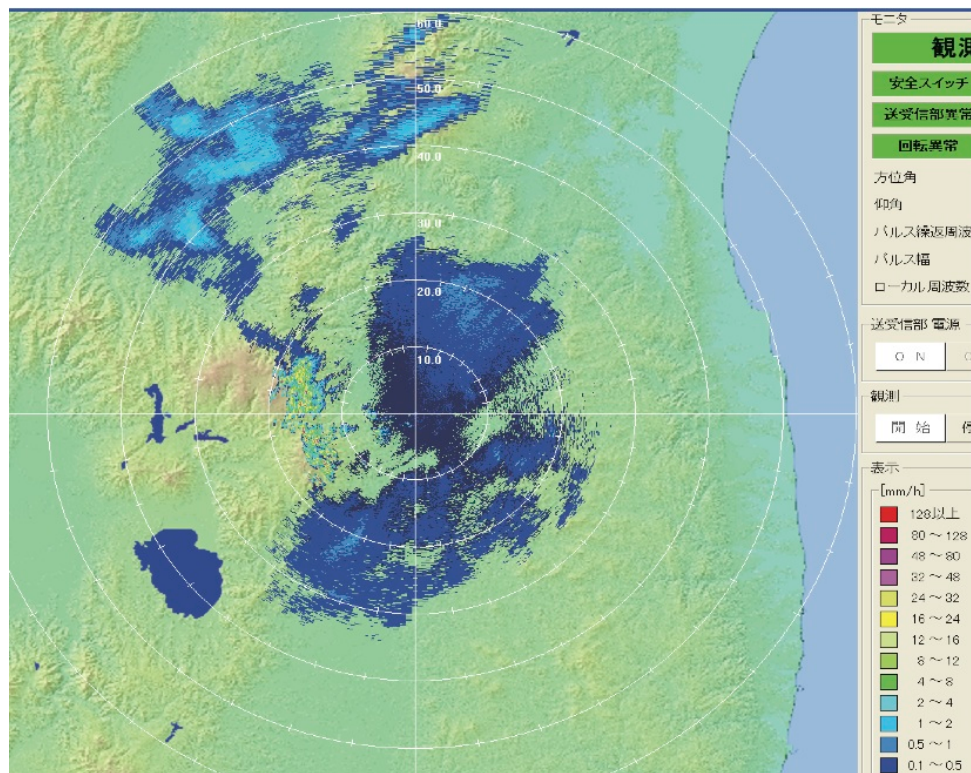
Local meteorological data

Satellites

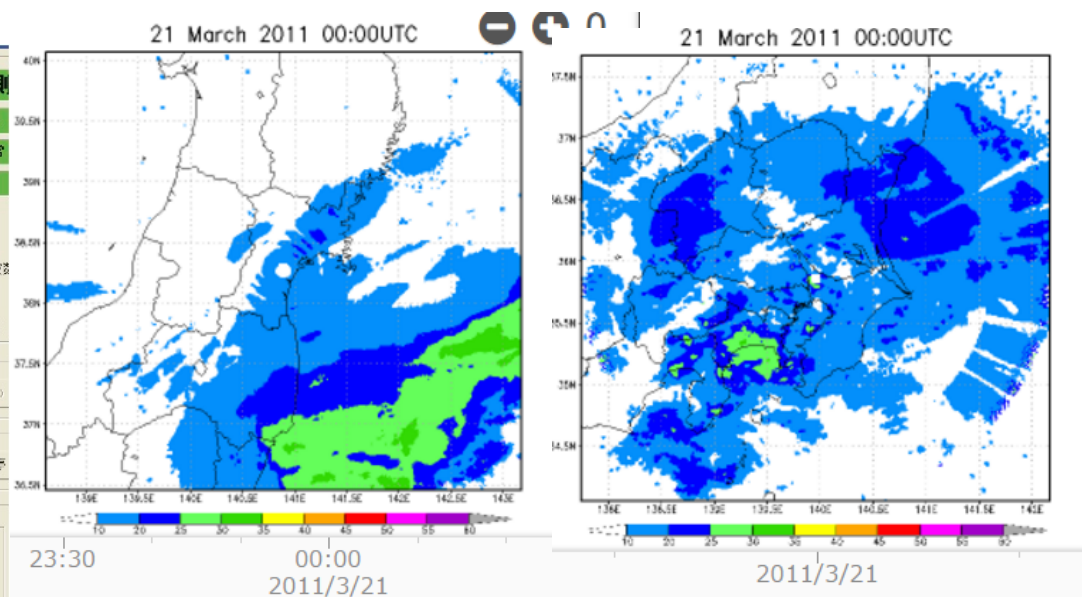
Others (Atmospheric Electricity)

<http://www.chikyu.ac.jp/akiyo/firis/index.html>

<http://www.st.hirosaki-u.ac.jp/~yatagai/firis/index.html>



X-band Radar@Fukushima U.

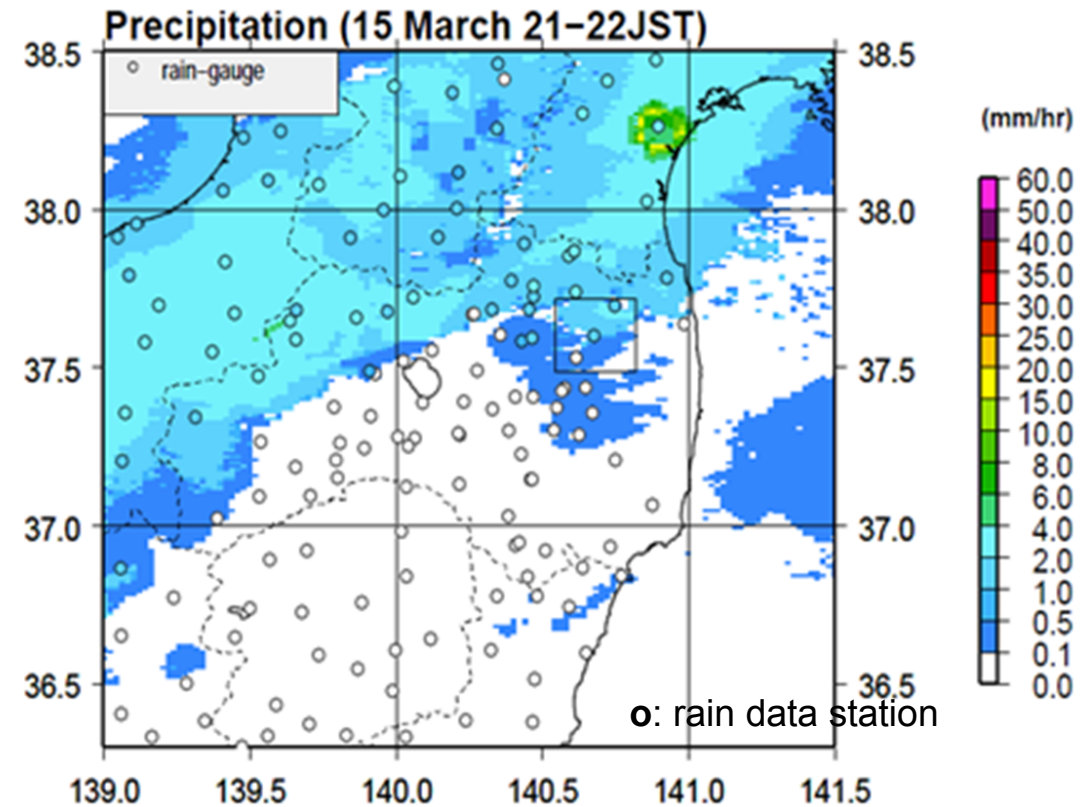
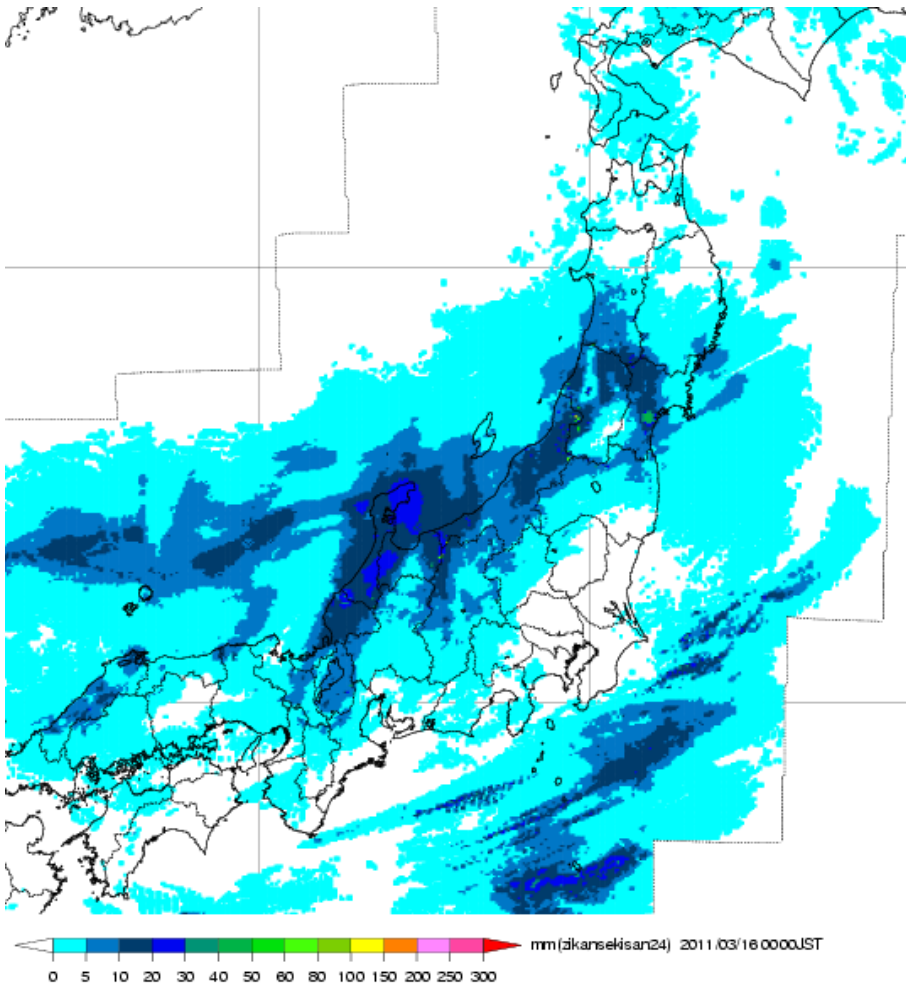


Sendai & Tokyo C-band Radar @JMA

We also show some case studies using FUKUSHIMA-IRIS

Radar AMeDAS precipitation and JMA C-band radar reflectivity

24-hr Radar Rainfall Amount 16 March 2011

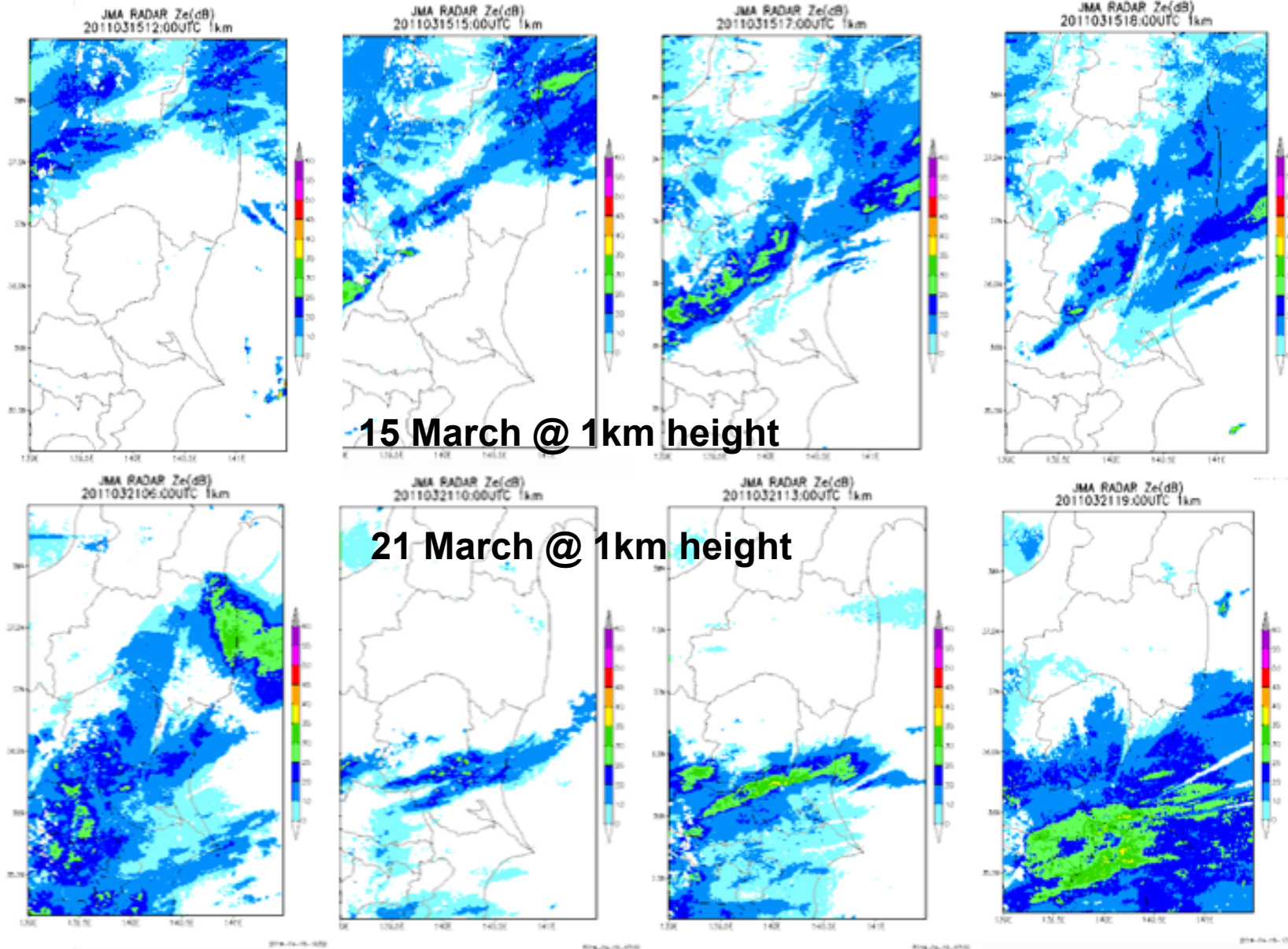


JMA Radar AMeDAS precipitation is estimated from the JMA C-band CAPPI and AMeDAS rain-gauges.

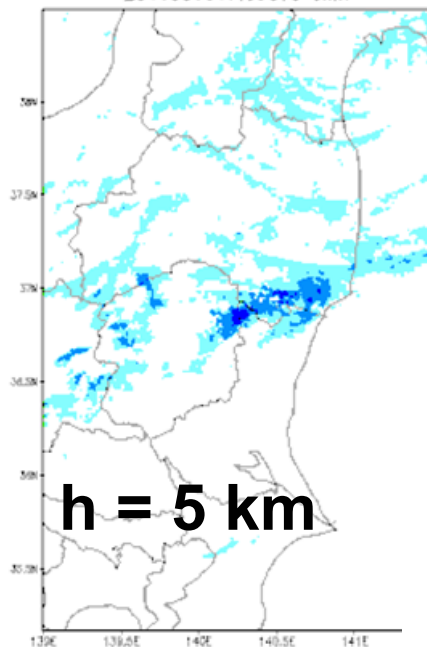
3-dimensional radar reflectivity

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Examples of radar reflectivity.
A $0.0125^\circ \times 0.00833^\circ \times 1\text{km}$ data
is available every 10 minutes.



JMA RADAR Ze(dB)
2011031517:00UTC 5km



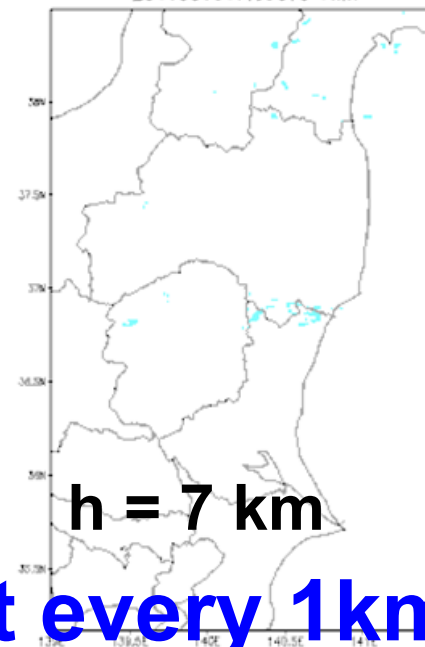
h = 5 km

JMA RADAR Ze(dB)
2011031517:00UTC 6km



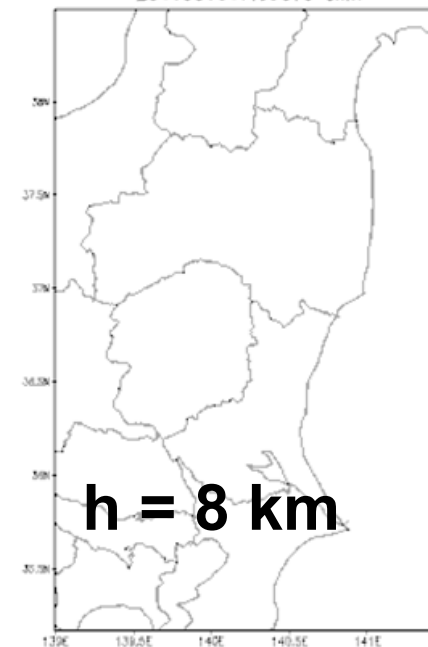
h = 6 km

JMA RADAR Ze(dB)
2011031517:00UTC 7km



h = 7 km

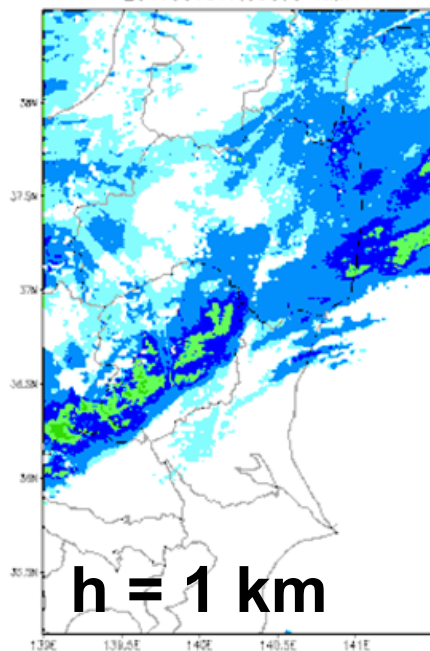
JMA RADAR Ze(dB)
2011031517:00UTC 8km



h = 8 km

Available at every 1km

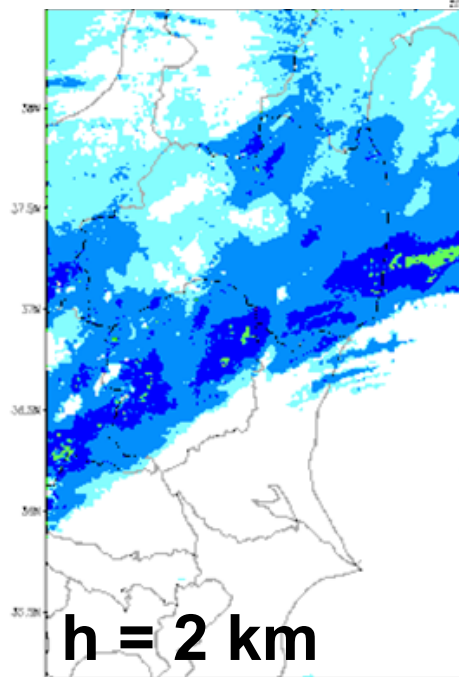
JMA RADAR Ze(dB)
2011031517:00UTC 1km



h = 1 km

2014-0

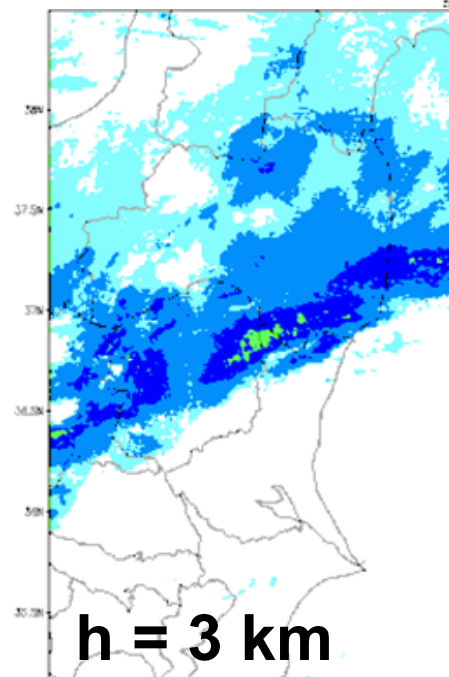
2014-04-10-01



h = 2 km

2014-04-

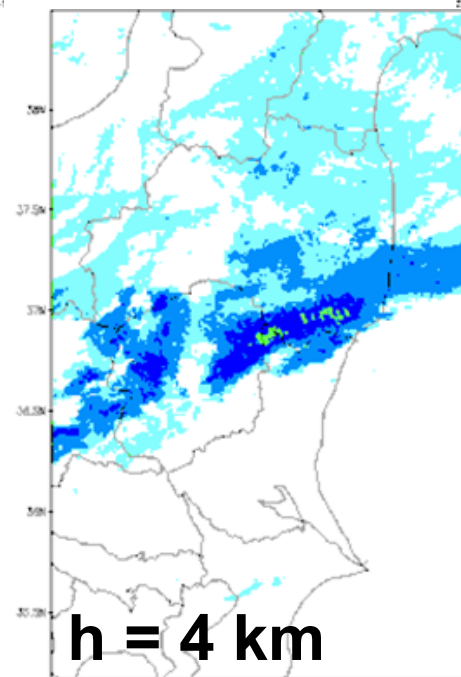
2014-04-10-01



h = 3 km

2014

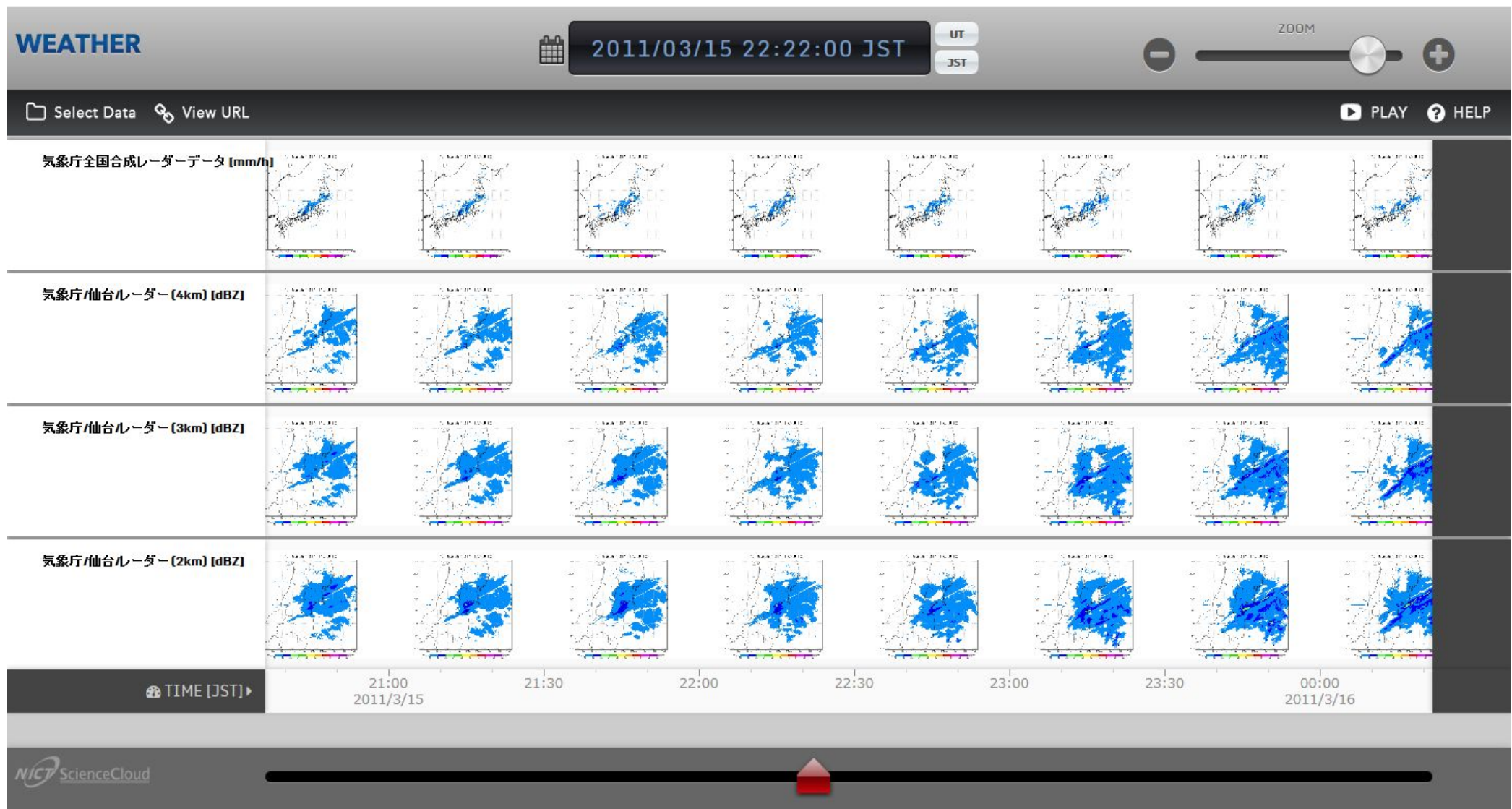
2014-04-10-0030



h = 4 km

2014-04-10-0030

C-band radar reflectivity 3D-maps (Sendai and Tokyo) are available



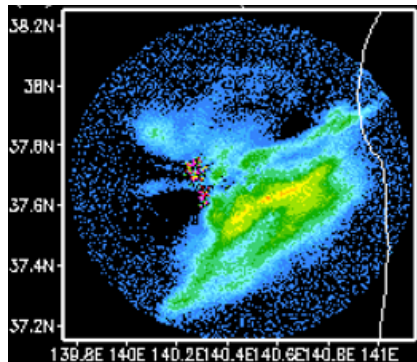
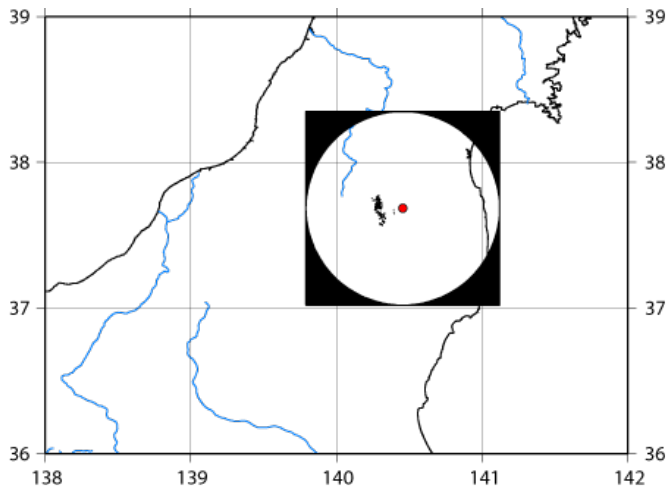
A sample snapshot of the JMA Raingauge-calibrated Radar precipitation at 2-km height over Japan (top panels) and C-band radar reflectivity at 2, 3 and 4km heights [20:30-24:00 JST 15 March] shown by NICT STARStouch [<http://sc-web.nict.go.jp/fukushima/>].

Current status and Next to do

- Some dataset is ready. Enhance the data
- Comparison between the PG (atmospheric electric field) data and Radar data (quick examination with C-band data (15, 16, and 21 March, 2011) shows a consistent cloud pattern with “fog can enhance shielding (because the ions are not cleaned off by the rain), but is far from conclusive.
- We keep examination with X-band data
- We need to enhance the dataset

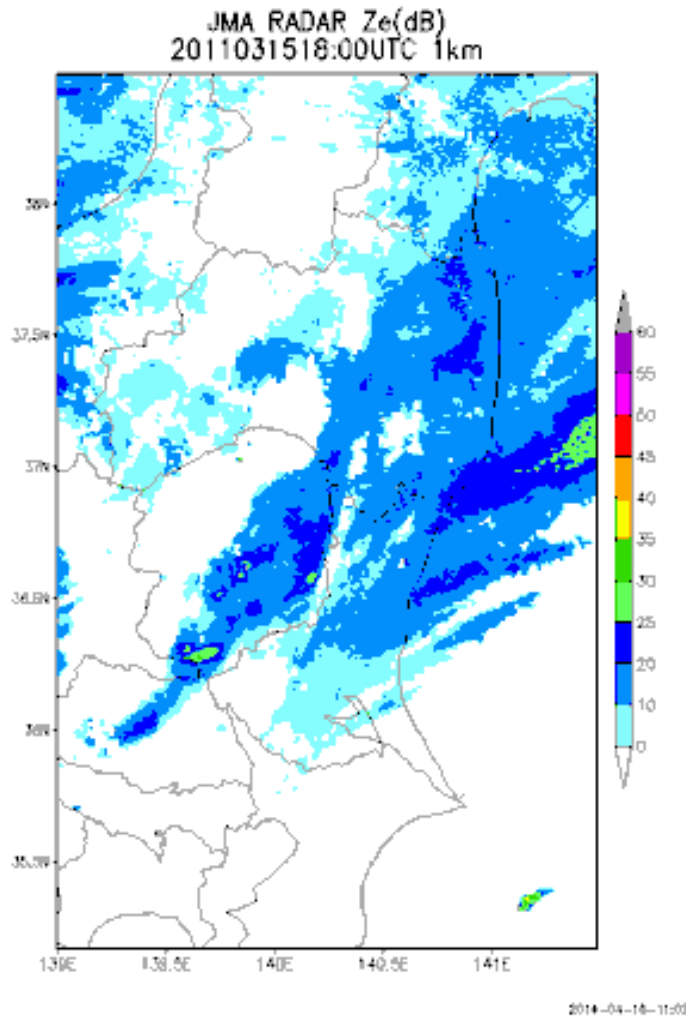


Fukushima University X-band radar (cf JMAC-band radars)



	X-band	C-band radar reflectivity
Coverage	$r = 60\text{km}$ (centered Fukushima)	Constant Altitude Plan Position Indicator (CAPPI) of a 400 km x 400 km square (centered Sendai and Tokyo)
Time Interval	30 sec $\rightarrow$ 10 min	10 min
Height	Fixed 4° elevation angle	1~10 km (every 1 km)
Horizontal Res.	120 m mesh	$0.0125\text{deg} \times 0.0083\text{deg}$

JMA C-band radar



Format

Binary (one plane/record)

GrADS ctl file

Mesh:

EW x 200

NS x 400

Height x 15

Resolution

EW 0.0125° longitude

NS 0.0083333° latitude

Altitude 1km

Time 10 minutes

Range

S-W edge: 139.0°, 35.167°

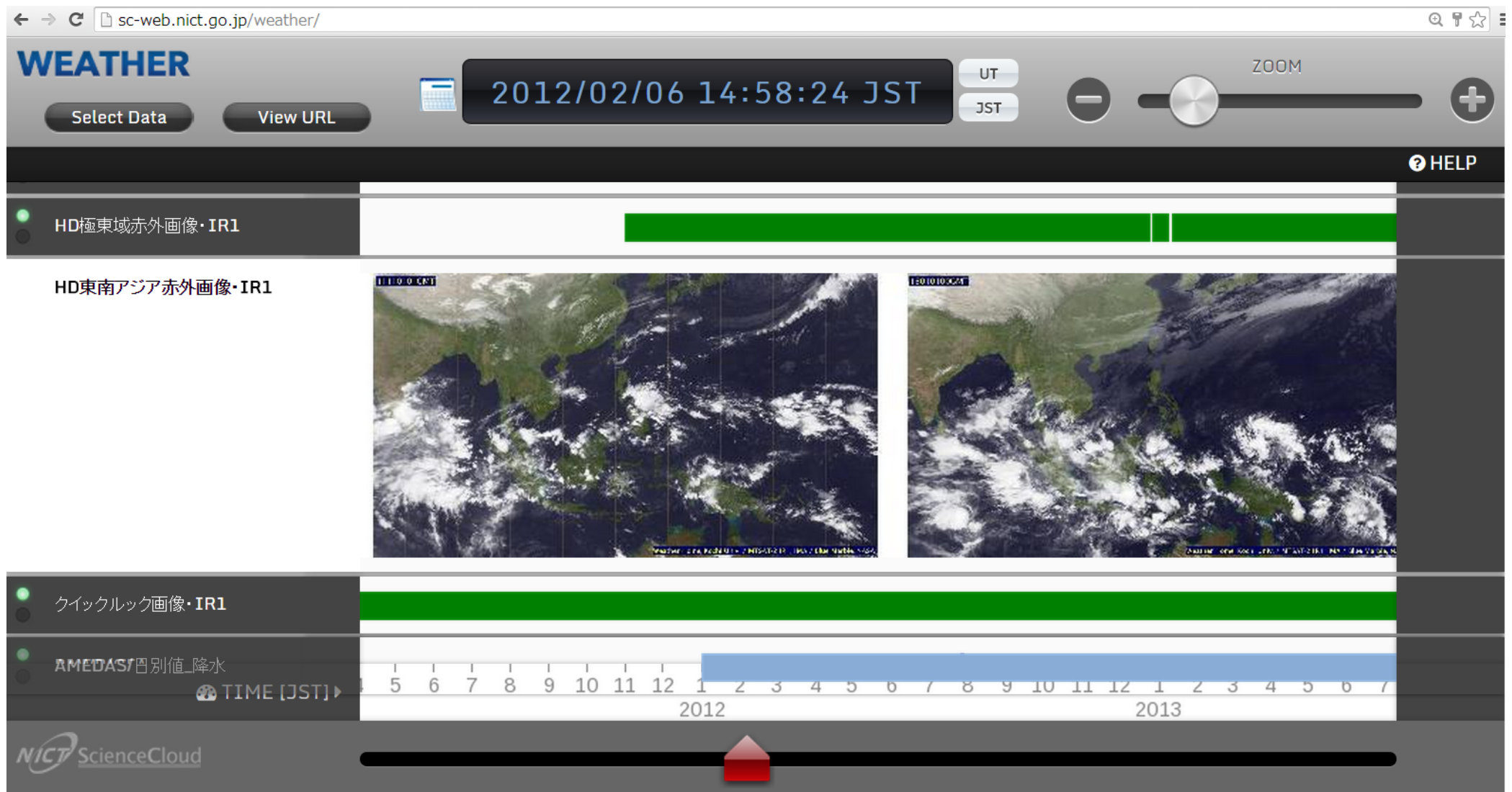
Data type

Equivalent reflection index

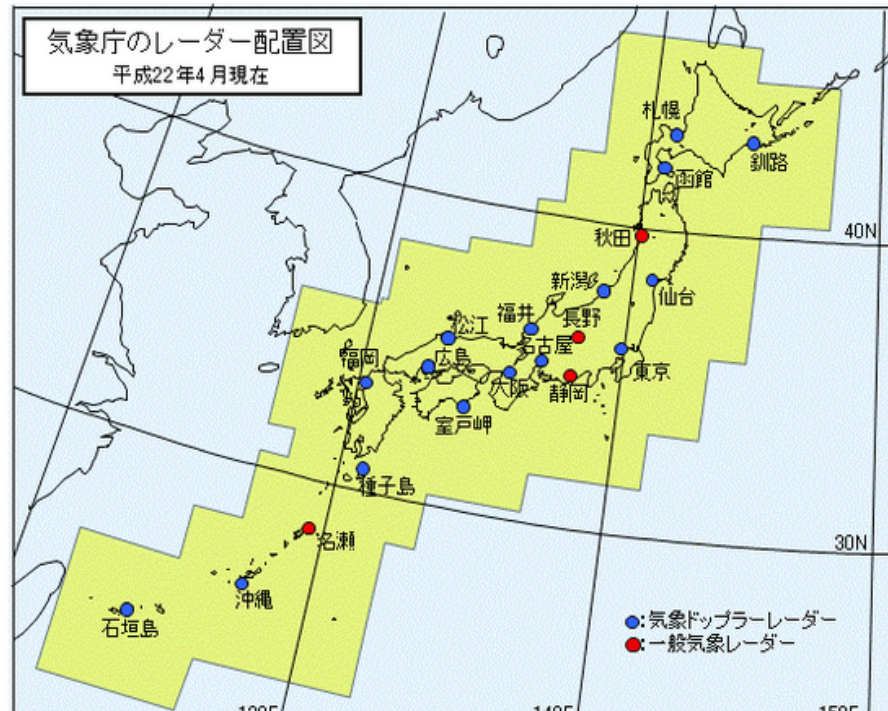
Unit: dBZ

**An example of C-band radar reflectivity of Japan
Meteorological Agency. [18UTC 15 March, 1km height].**

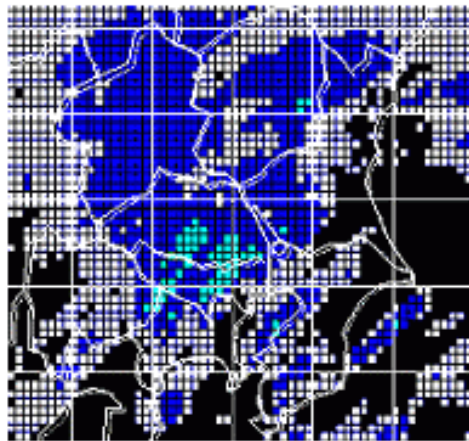
NICT science cloud STARS Touch (courtesy of Dr. Murata@NICT)



Radar AMeDAS

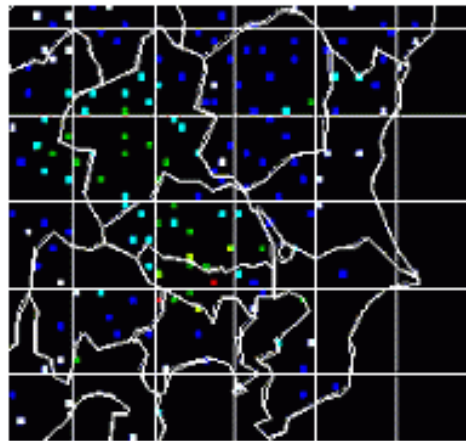


レーダーの1時間積算値



面的に得られる雨量

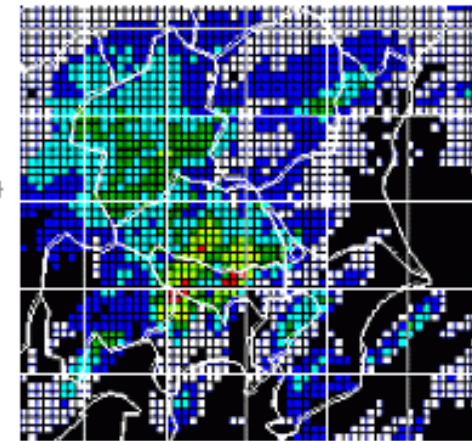
アメダスの1時間雨量



正確な雨量



解析雨量



面的で正確な雨量