2D Wind Field Estimation with Higher Spatial Resolution Using Dual Compact X-Band Weather Radars

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By FURUNO ELECTRIC CO.,LTD January 5th , 2015

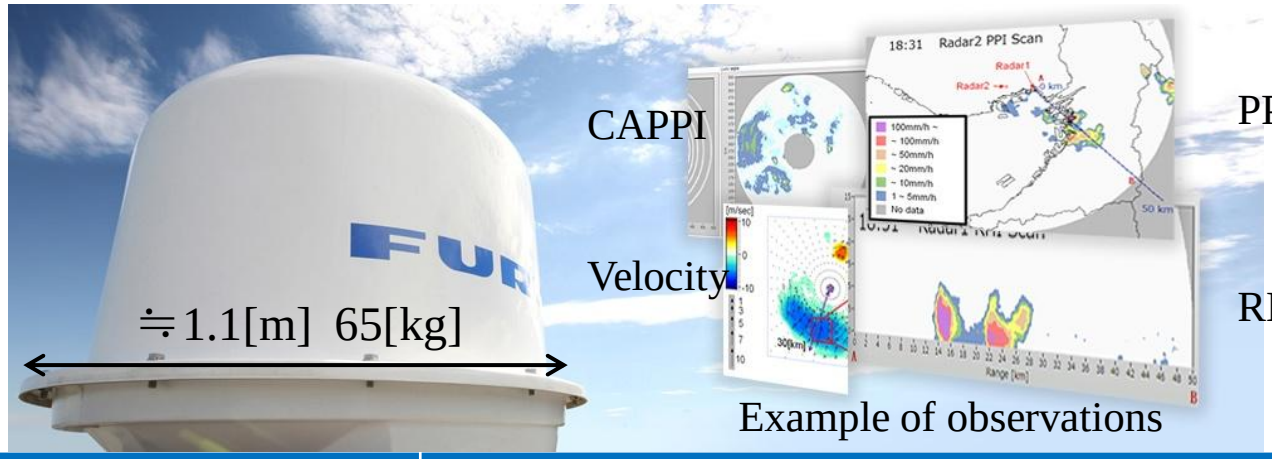
Contents

Introdution_1

- Backgrounds & Motivations
  - In worldwide, disasters are increasing due to localized weather.
    - Heavy rain, Tornado, Sudden strong wind.
  - It is difficult to observe detail by conventional large scale of radar.
  - We developed high resolution compact X-band radar to observe localized weather.
  - We succeeded to observe distribution of localized precipitation and wind field.
  - We believe it is useful for early-warning and prediction.

Introduction_2

- One of the smallest lightest Weather Radar（as of June 2013）
- Features are High speed and High resolution 3D monitoring.



	Specifications
Operating Frequency	X-band (9GHz band) Dual-Polarization
Beam Width	2.7 degrees (both horizontal and vertical beams)
Peak Output Power	100 W (solid-state, both horizontal and vertical beams)
Antenna Rotation Speed	16 rpm max. (adjustable)
Maximum Range	Approx. 30 km
Scan Modes	PPI, CAPPI, RHI
Power Supply	100-240 VAC, single phase, 50/60 Hz
Power Consumption	650 W max.

Introduction_3

◆ Example of installation.

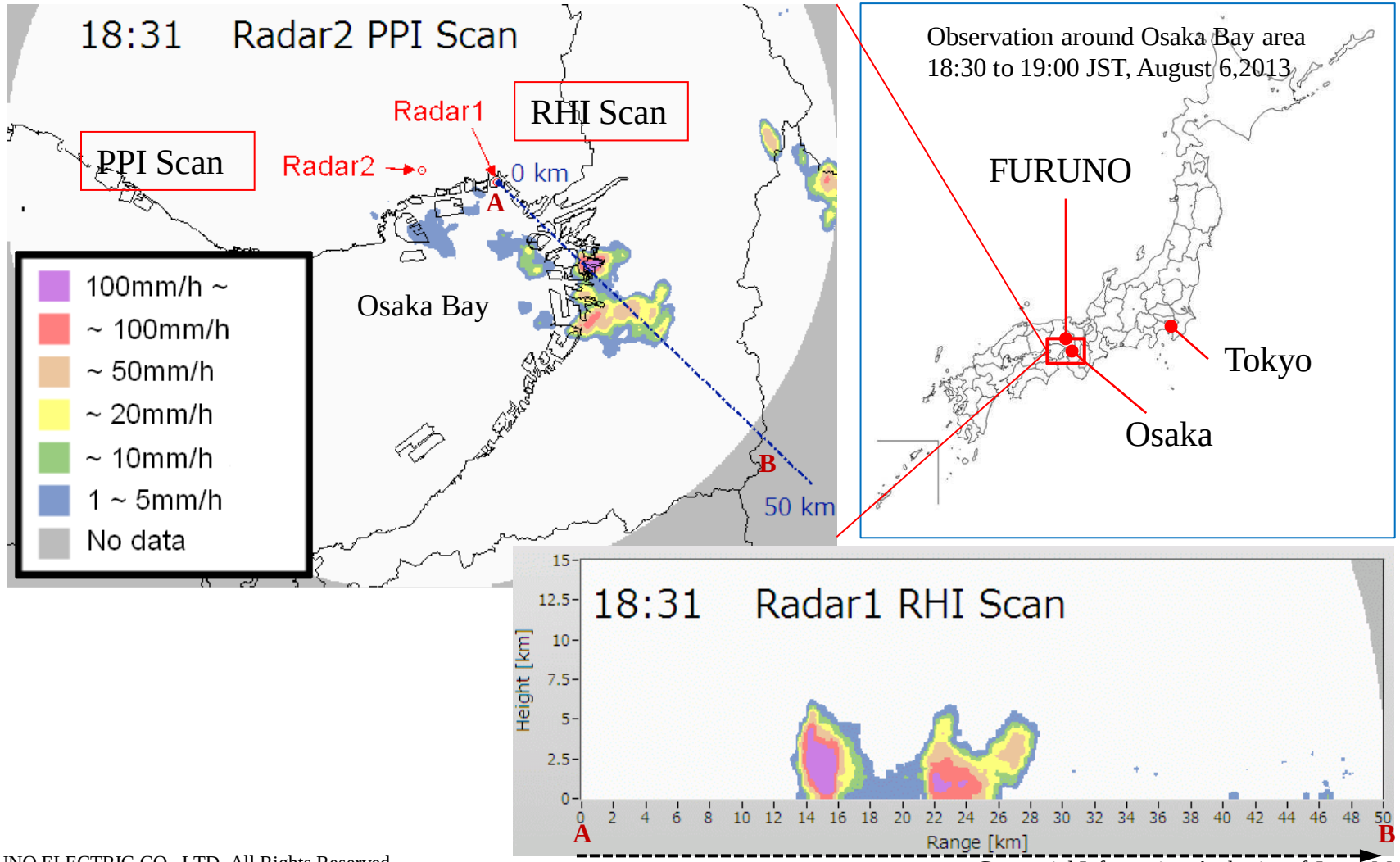
◆ Easy to carry by car.

◆ Installed by two people.

◆ View from the radar.

Observation by Two Radars

- PPI scan is suitable for observing the growth of a cumulonimbus.
- RHI scan is good at monitoring of cumulonimbus structure.



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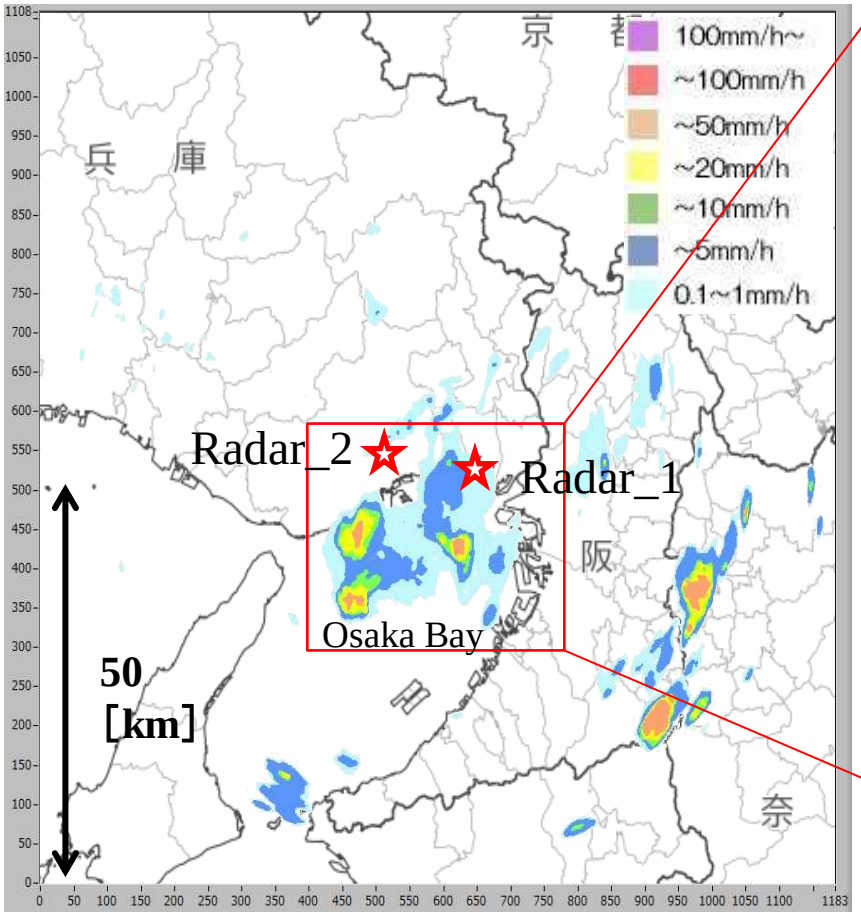
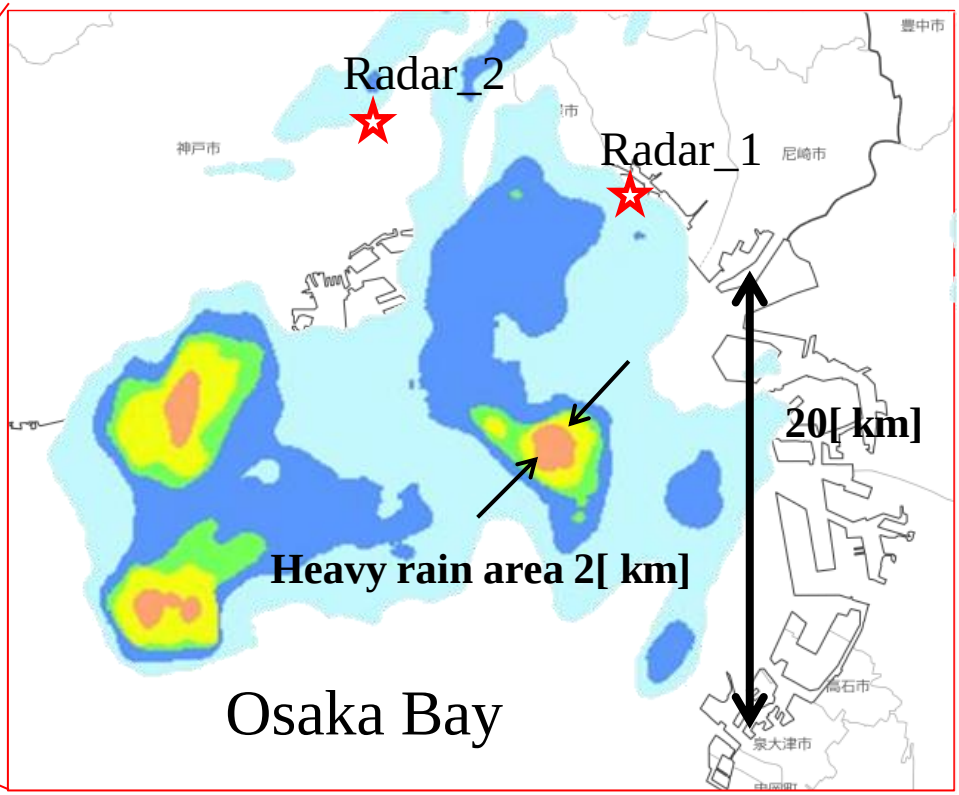
Observation by Two Radars

Combined result of the Radar_1 data & Radar_2 data.





- **Radar_1:FURUNO INT Center　　Radar_2:Kobe University**
- **2014/06/12_18:00**
- **Pulse Width 50[μ sec] → Pulse Compression 1[μ sec]**
- **Freq Modulation 2[MHz]**
- **Elevation 4[deg] PPI Scan**

＜Advantage of two radar observation＞

- Prevent attenuation problem
- Prevent shadowing problem
- Estimation of wind field with high accuracy
  → Dual-Doppler method
  → cf. VVP method

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Estimation method by single radar

<VVP method>

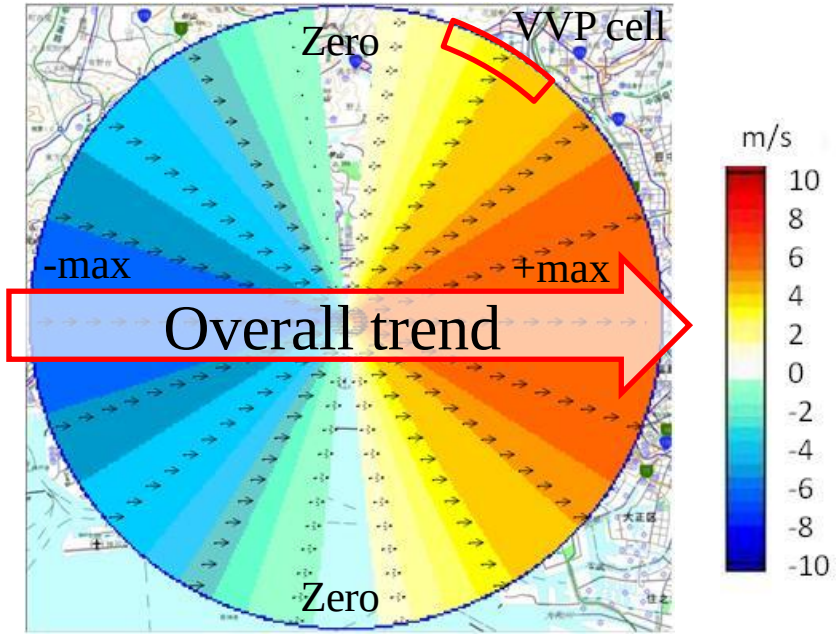
- Estimate 2D wind field using change of Doppler velocity distribution by Single Doppler radar
- VVP grid area is assumed to be uniform wind field

<Good point>

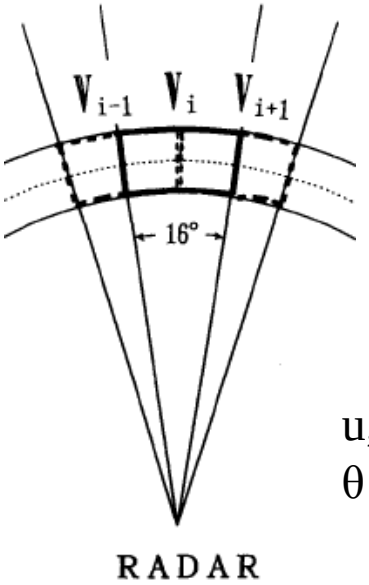
- 2D wind information by single radar

<Bad point>

- Difficult to estimate localized wind field
- Wide and smooth distribution is necessary



Example of simulation
Arrow shows result of estimation



Fitting Model equation

$$V_{obs} = u \sin\theta + v \cos\theta$$

u, v: Cartesian wind components
θ : Azimuth angle

<Simplified VVP method> Ryozo Tatehira, and Osamu Suzuki, 1994: Accuracy in Estimation of Wind Velocity from Single Doppler Radar (in Japanese). Tenki, 41, 761-764.

Estimation by two radars

<Dual-Doppler method>

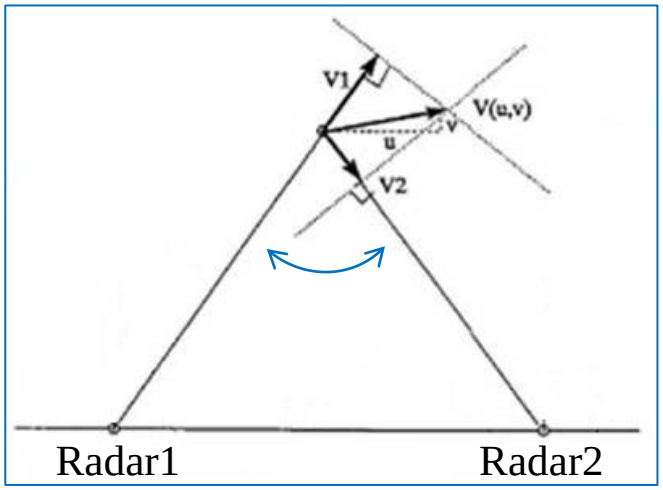
- Estimate wind field directly by two Doppler radars
- Two wind vectors are composed

<Good point>

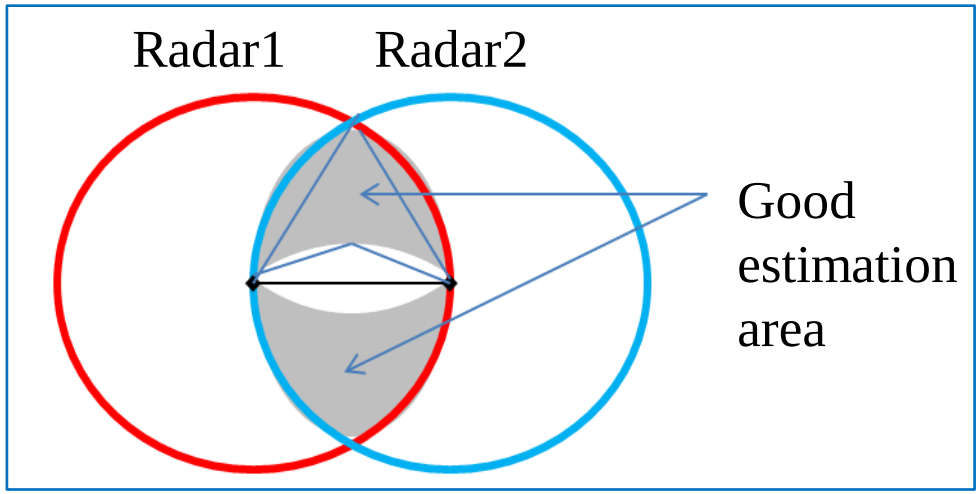
- Big advantage in accuracy
- Easy to estimate localized wind field

<Bad point>

- Area that we can calculate is limited.



Observation angle



Estimation area

- Acute angle and obtuse angle is not suitable for estimation
- Recommended angle of the radar1 and radar2 is 30~150deg.

Estimation of Wind Field using Single Doppler Radar

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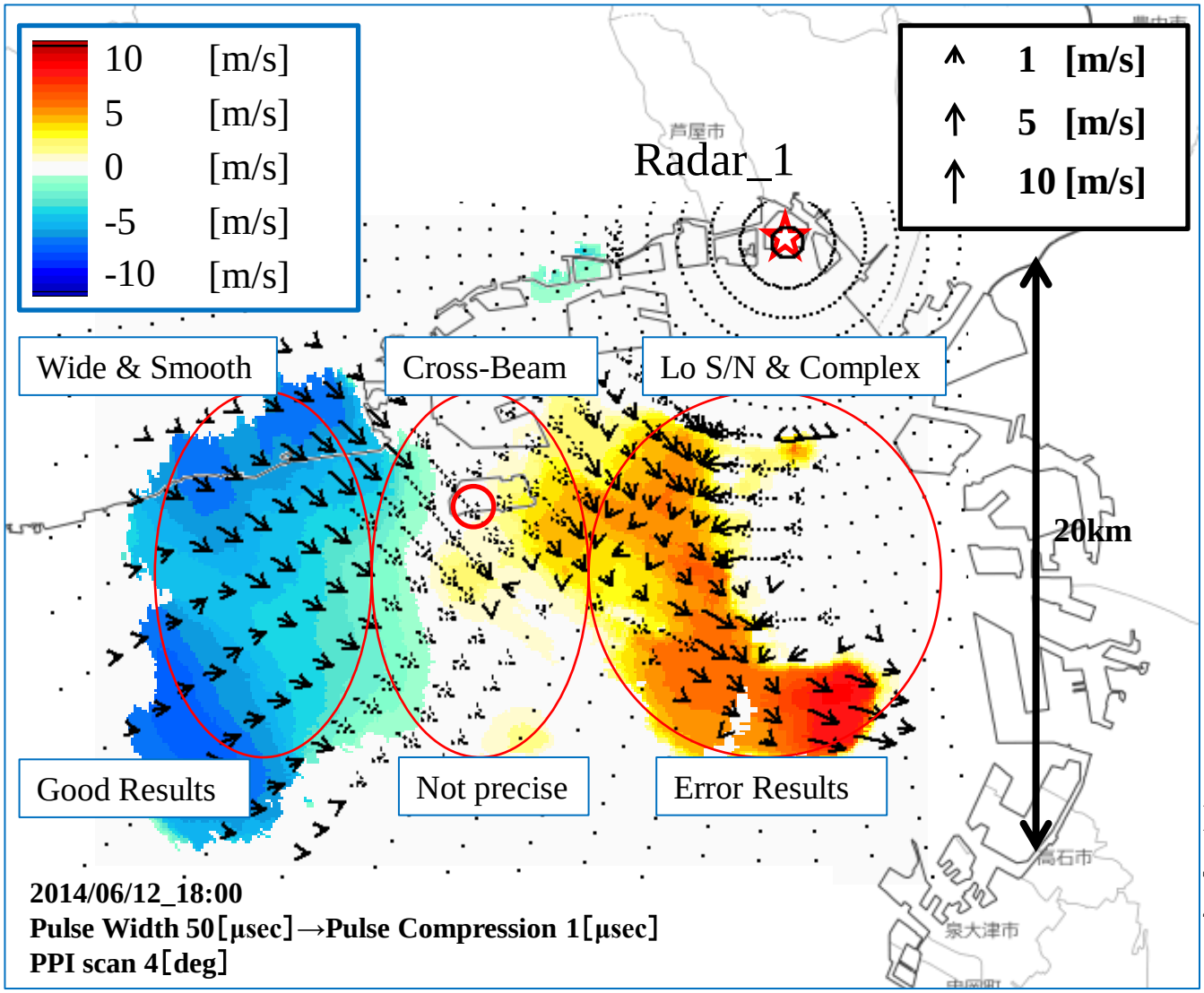
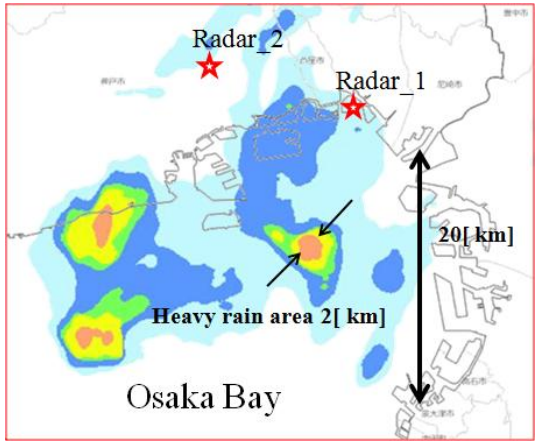
＜Estimated by Simplified VVP method Radar_1 ：FURUNO INT Center＞





＜input data, resolution＞
- Precipitation 0.5deg,100m
- Wind velocity 0.5deg,100m

＜output data, resolution＞
- 2D wind grid 5deg,1km

KOBE Airport Wind gauge
Japan Meteorological Agency
4.2(max6.7) [m/sec] north west

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Estimation of Wind Field using Dual Doppler Radars

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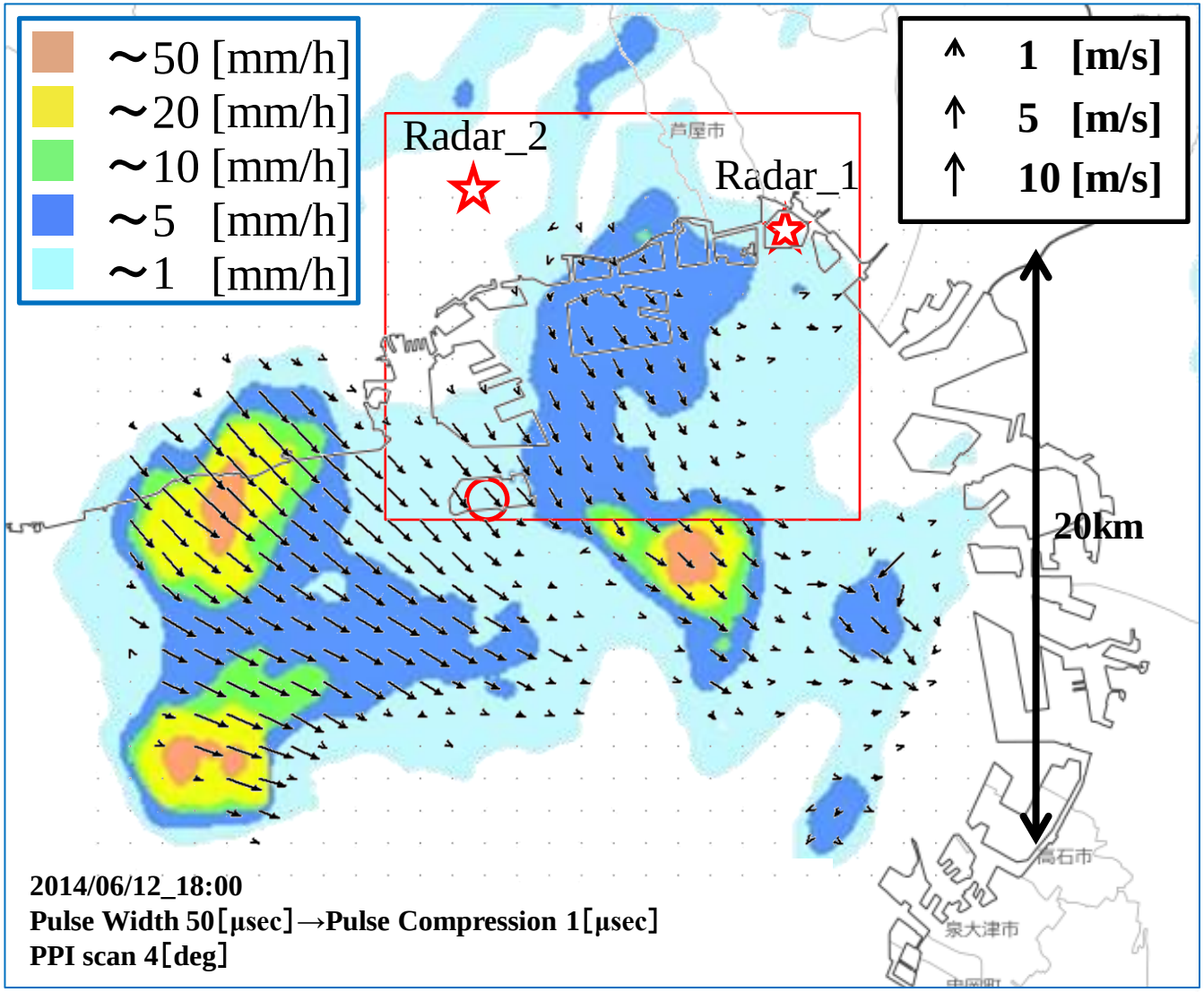
＜Estimation by Dual-Doppler method Radar_1:FURUNO INT Center Radar_2：Kobe University＞



＜Precipitation data＞
- Azimuth resolution 0.5[deg]
- Range resolution 100[m]

＜wind velocity data＞
- Azimuth resolution 0.5[deg]
- Range resolution 100[m]

＜Arrows＞
- Dual-Doppler Method
- Grid size 1[km]

KOBE Airport Wind gauge
Japan Meteorological Agency
4.2(max6.7) [m/sec] north west

Estimation of Wind Field using Dual Doppler Radars

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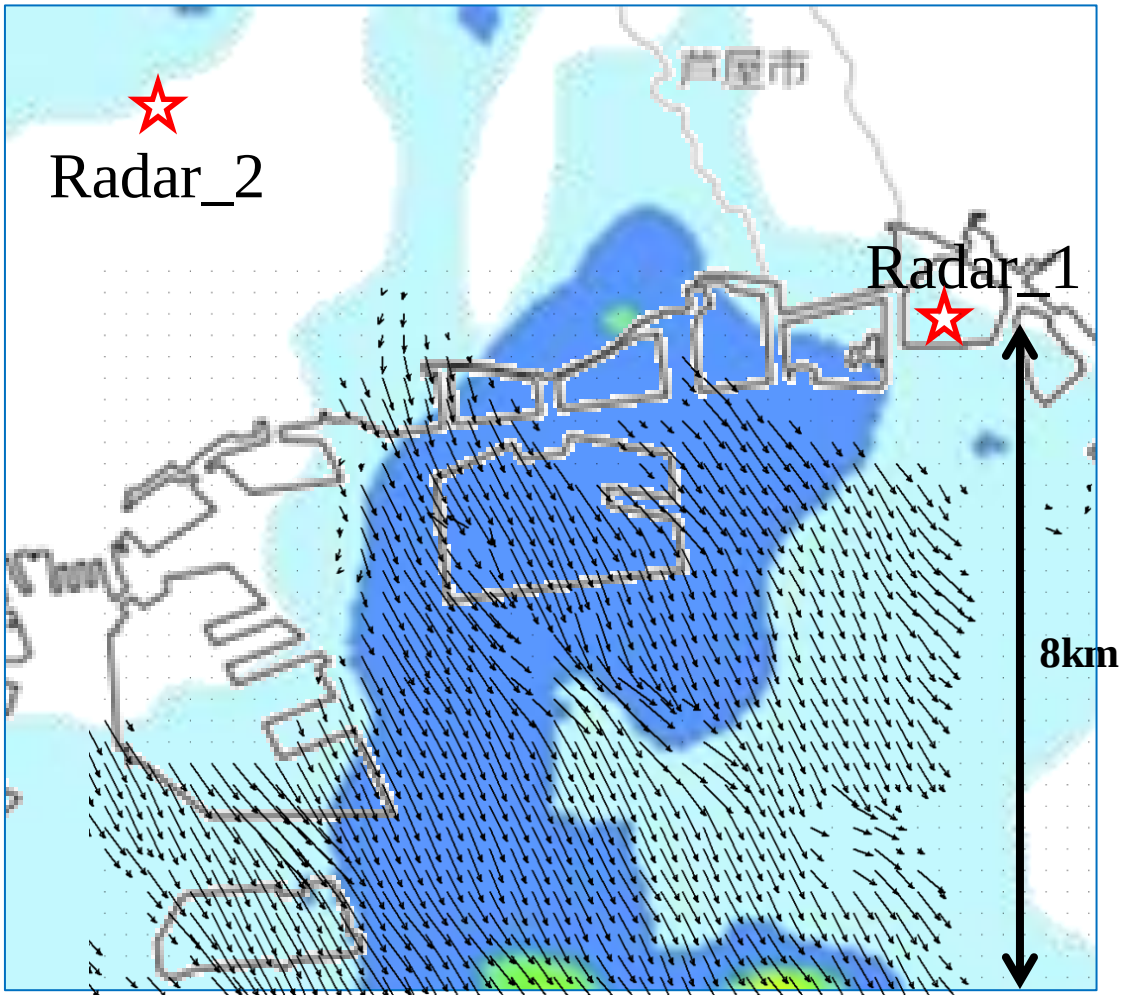
＜Estimation by Dual-Doppler method Radar_1:FURUNO INT Center Radar_2：Kobe University＞



2014/06/12_18:00
Pulse Width 50[μsec]→Pulse Compression 1[μsec]
PPI scan 4[deg]

＜Precipitation data＞
- Azimuth resolution 0.5[deg]
- Range resolution 100[m]

＜wind velocity data＞
- Azimuth resolution 0.5[deg]
- Range resolution 100[m]

＜Arrows＞
- Dual-Doppler Method
- Grid size 200[m]

1 [m/s]
5 [m/s]
10 [m/s]

～20 [mm/h]
～10 [mm/h]
～5 [mm/h]
～1 [mm/h]

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Conclusions

- Single-Doppler analysis by VVP method is suitable for estimation of the overall trend of wind field.
- Dual-Doppler analysis has big advantages in estimation of the local wind-field compared with VVP analysis.
- In addition, we succeeded to estimate the wind-field extremely small grid size 200[m].

Next step

- Evaluation of wind field
  - The wind field calculated by Dual-Doppler analysis seems to be correct compared to wind gauge in Kobe airport.
  - We have to evaluate more cases.
- Next plan
  - Evaluation with other reference data such as Lidar, wind profilers.
  - The best way of evaluation is a balloon observation

    …difficult in Kobe.

Acknowledgement

- The research project is supervised by Professor Eiichi Nakakita of Kyoto University and Professor Satoru Oishi of Kobe University.

Thank you for your attention ! ☺

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