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

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By FURUNO ELECTRIC CO., LTD
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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.
One of the smallest lightest Weather Radar (as of June 2013)
Features are High speed and High resolution 3D monitoring.

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<th>Specifications</th>
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Example of installation.

Installed by two people.

Easy to carry by car.

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.

Observation around Osaka Bay area 18:30 to 19:00 JST, August 6, 2013

- PPI Scan
- RHI Scan

Map of Osaka Bay area with color-coded rainfall intensity and location of radar stations.
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

Geospatial Information Authority of Japan Map
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

Fitting Model equation
\[ V_{\text{obs}} = u \sin \theta + v \cos \theta \]

u, v: Cartesian wind components
\( \theta \): Azimuth angle

Example of simulation
Arrow shows result of estimation

<Good point>
- 2D wind information by single radar

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\[ V_{\text{obs}} = u \sin \theta + v \cos \theta \]

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Example of simulation
Arrow shows result of estimation


Geospatial Information Authority of Japan Map
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.

- Acute angle and obtuse angle is not suitable for estimation
- Recommended angle of the radar 1 and radar 2 is 30~150deg.
Estimation of Wind Field using Single Doppler Radar

<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(max 6.7) [m/sec] north west

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

**Good Results**
Wide & Smooth
Cross-Beam
Lo S/N & Complex

**Not precise**

**Error Results**
Estimation of Wind Field using Dual Doppler Radars

<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 (max 6.7) [m/sec] north west

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Estimation of Wind Field using Dual Doppler Radars

<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 200[m]

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

Geospatial Information Authority of Japan Map
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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