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3D Wind Field Estimation with Higher Spatial Resolution Using Multi Compact X-Band Weather Radars

Masahiro Minowa[1] , Toshiaki Takaki[1] , Satoru Oishi[2] , Eiichi Nakakita[3] 1 FURUNO ELECTRIC CO., LTD., Japan, 2 Kobe University, 3 Kyoto University

1.Introduction

Wind shear in a localized region usually causes a serious damage on transport systems. Real-time observation of wind field with dual polarimetric Doppler weather radars give us the most effective solution for preventing the damage caused by wind.

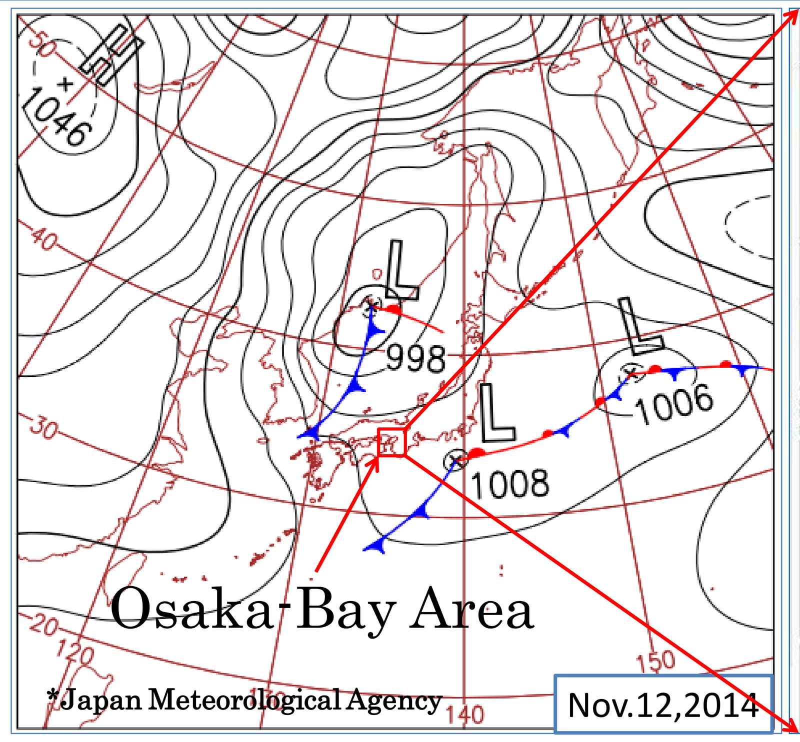

Fig 1 : Weather Map

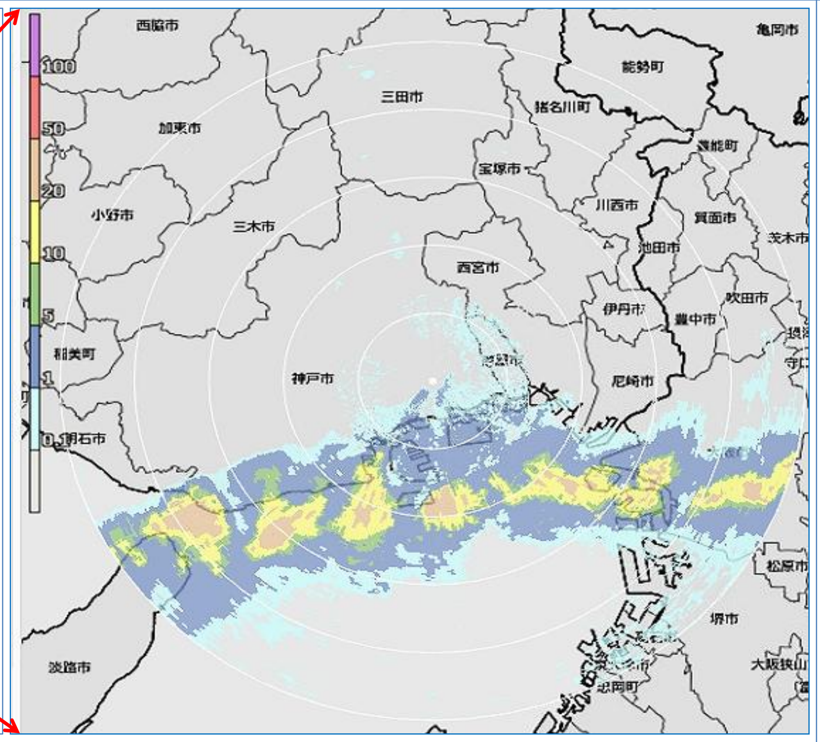

Fig 2 : Rain Distribution

Fig 1 shows weather map of Japan on Nov. 12, 2014. Cold front came from west and severe weather hit Osaka-Bay area. Around the Osaka-Bay area, three Doppler radars are deployed and observed heavy rain distribution at ※7:20 p.m. is shown Fig 2.
A case study for estimation of 3D wind field using the triple-Doppler analysis is presented here.

※Local time

2.Triple-Doppler Analysis

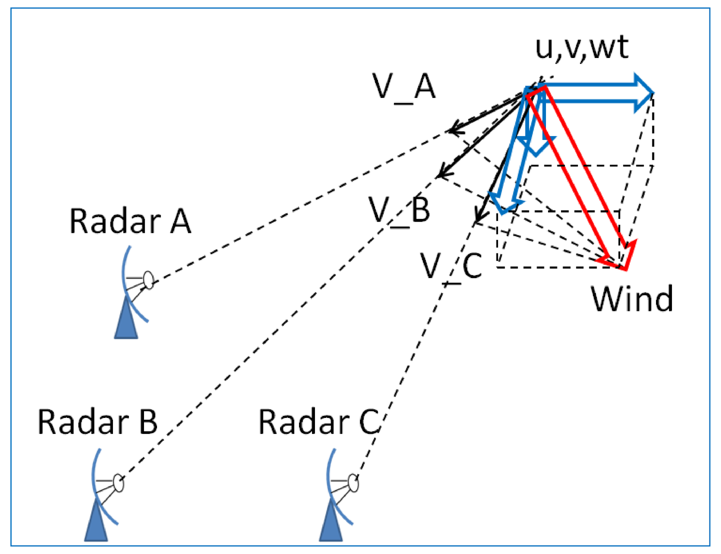

Fig 3: 3-Radar Observation

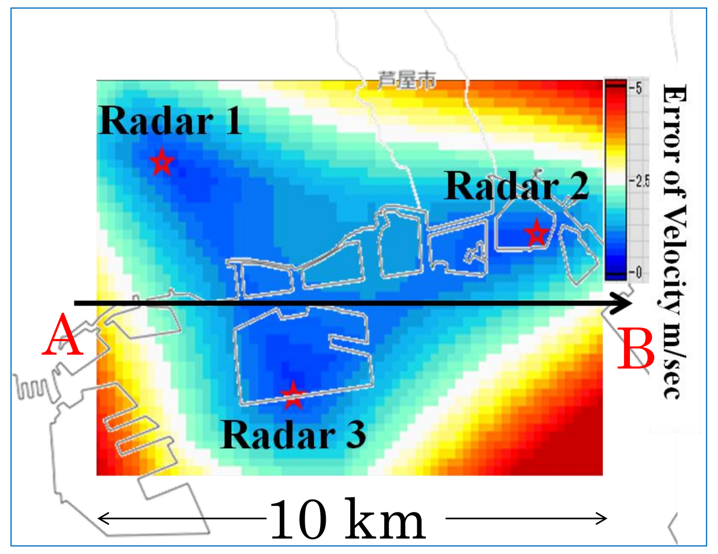

Fig 4: Low-error area

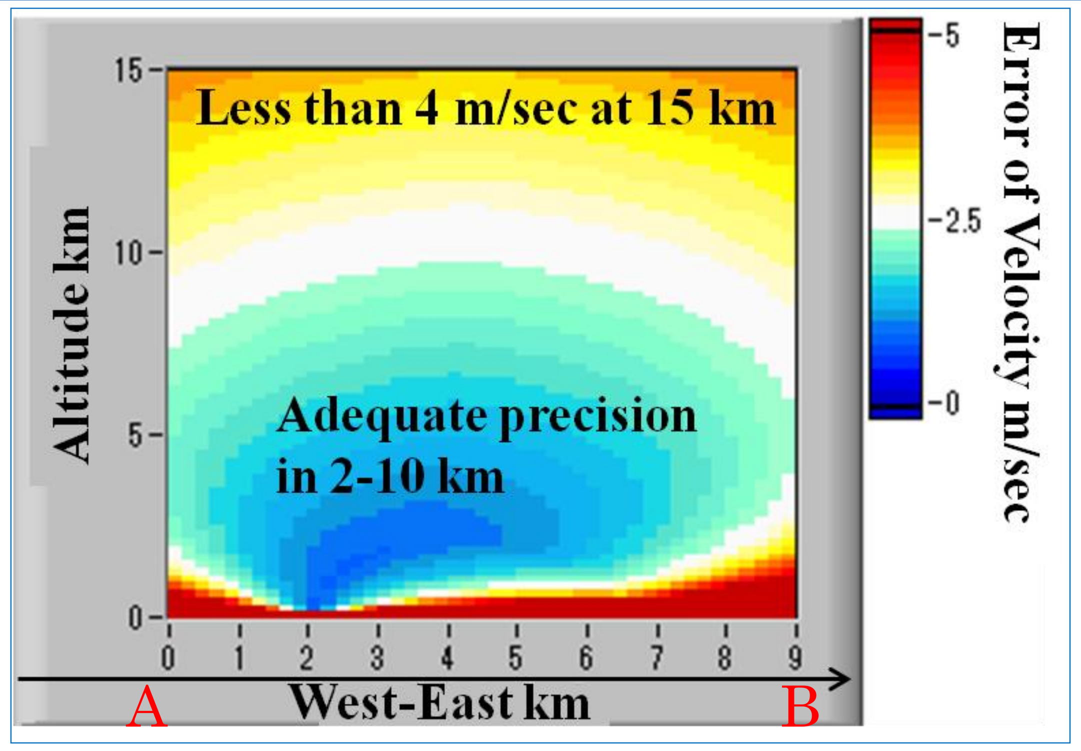

Fig 5: Cross-section in A

By deploying the three radars within 10 km range, vertical wind field can be directly estimated by the triple-Doppler analysis as shown Fig 3. Fig 4 and 5 show the probable error of a vertical wind field based on a simulation. Blue color shows high precision area to estimate 3D wind field. The wind field around the Osaka-Bay is observed in real time using the Multi-Radar System.

3.Wind field at 600 m altitude

The interesting case study on Nov.12, 2014 is presented when a cold front has passed through the Osaka Prefecture. In Fig 6, arrows show the horizontal wind field and colors show the vertical wind at 600 m altitude. The estimated horizontal wind field within 10-20 km range is precise and reliable. But horizontal and vertical wind vectors out of 20 km range were too large and they were not reliable quantitatively. This result shows triple-Doppler analysis is reliable in the area close to there radars.

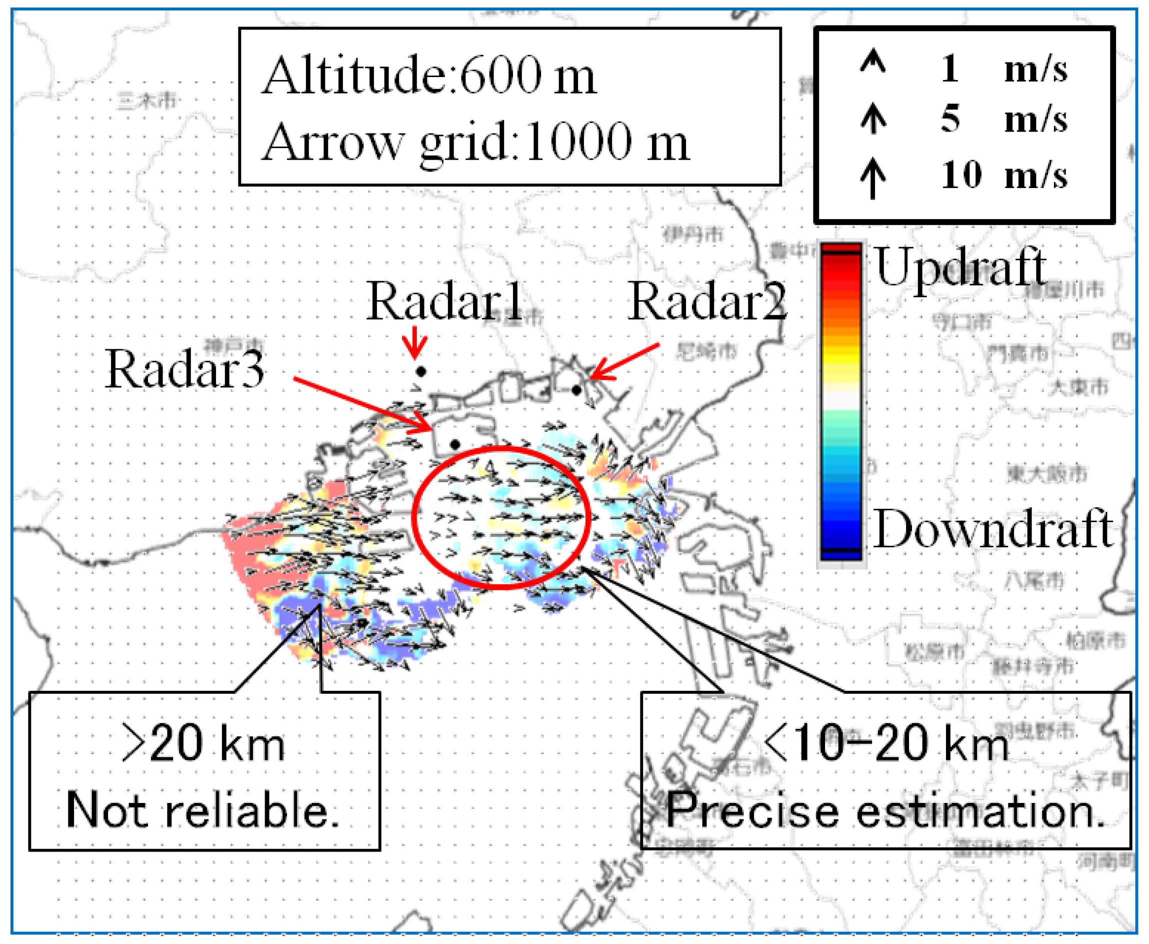

Fig 6: Wind field at 600 m

4.Shear line at 1500 m

Fig 7 shows horizontal and vertical wind field at 1500 m altitude. The meanings of arrows and colors are same as Fig 6. We can see remarkable shear line as shown red line Fig 7. Updrafts are observed in the south side and downdrafts are observed in the north side. It supports the fact that the shear line is associated with the cold front. Though these wind arrows are slight far from three radars, overall trend of horizontal wind is approximately correct, west to south.

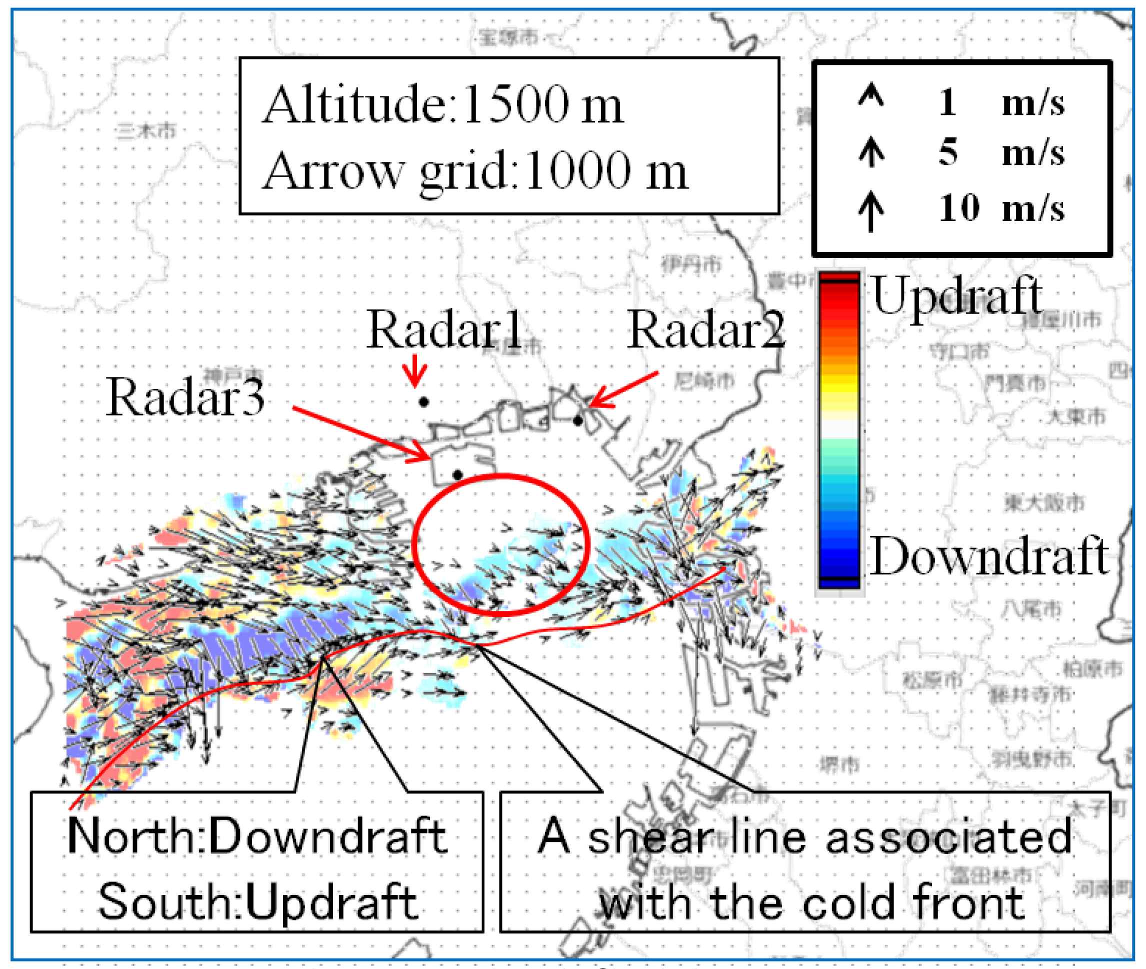

Fig 7: Wind field at 1500 m

5.Comparison with anemometer

Time	Anemometer at Kobe Airport . m/sec at every 10 min.			
	Averaged	Comes from	Maximum	Comes from
7:10 p.m.	4.4	W	6.2	W
7:20 p.m.	6.1	W	8.7	WSW
7:30 p.m.	5.0	W	7.7	W

※Local time

Fig 8 indicates the wind field at 750 m altitude and a position of Kobe Airport. The horizontal wind vectors at 750 m altitude within 10-20 km range are averaged, and compared with the anemometer which is placed in Kobe Airport. The results are as follows.
- Estimated wind field by radars;
  7.9 m/s, 216 deg, from west or west-southwest
- Observed wind field by anemometer;
  6.1 to 8.7 m/s, from west or west-southwest

The estimated horizontal wind field is reliable compared with the observation of anemometer.

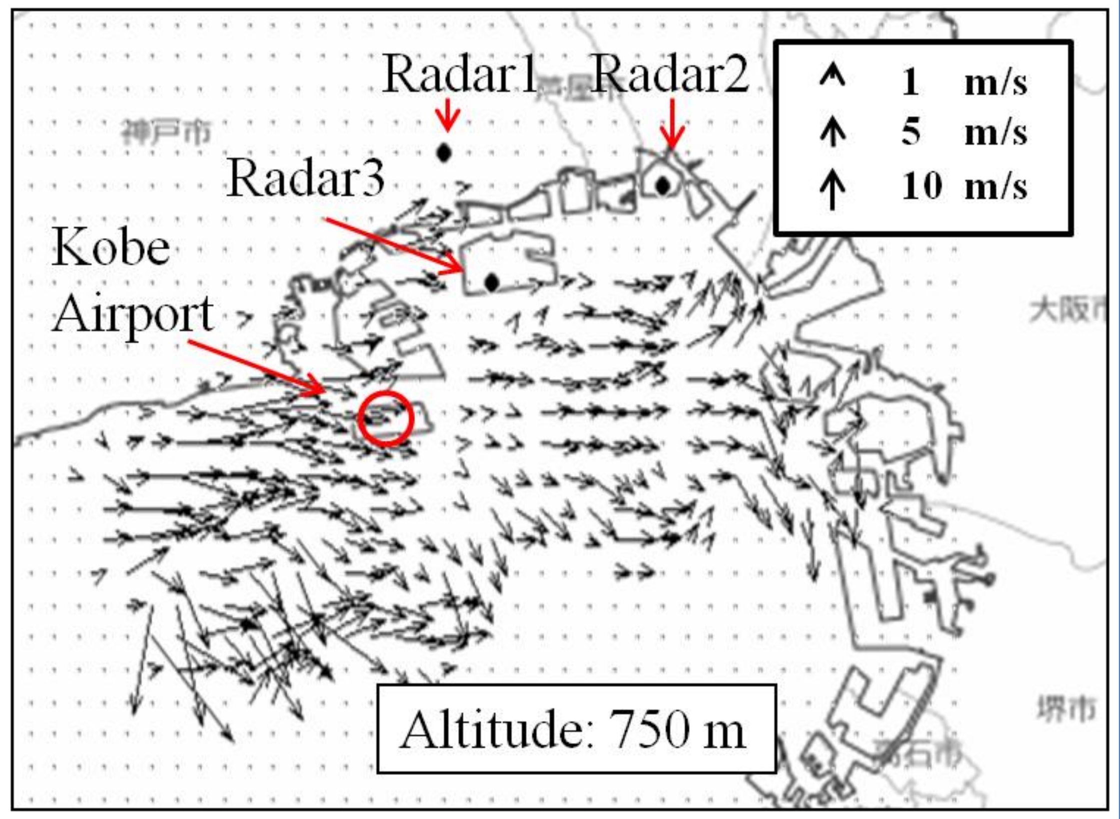

Fig 8: Wind field at 750 m

6.Conclusions

The Multi-Radar System has been developed and deployed around the Osaka-Bay area. Three Doppler radars are connected through the Internet. Wind field around the Osaka-Bay area is observed in real time on a regular basis. By deploying the three radars within 10 km range, vertical wind field can be directly estimated by the triple-Doppler analysis.

The interesting case study on 12th November 2014 is presented. The estimated horizontal wind field within 10-20 km range is precise and reliable, but horizontal and vertical wind field beyond 20 km range are not. At 1500 m altitude, a remarkable shear line was observed.

*Used the map of The Geospatial Information Authority of Japan Digital Japan Portal Web Site.

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