WIND GUST AND STORM EVOLUTIONS OBSERVED DURING THE SHONAI AREA RAILROAD WEATHER PROJECT: A PRELIMINARY SURVEY

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I. INTRODUCTION

On Japan railroads, wind conditions affect operating efficiency, infrastructure, and safe passage of people and freight. For instance, strong and gusty winds cause regional delays or shutdowns, and especially hazardous crosswinds may lead to overturn of railcars. Since propeller-vane/cup anemometers densely cover on the railroads for operations through some wind speed thresholds (e.g., winds in excess of 25 ms^{-1}), small-scale but strong gusty winds are difficult to detect with the present system. The Shonai area railroad weather project will investigate fine-scale structure of wind gust dynamics and kinetics such as tornadoes, downbursts, and gustfronts. The ultimate goal of the project is to develop an automatic strong gust detection system for railroads, which the decision to warn is generally based upon information from a single-Doppler radar at low elevation angles. In this presentation, we will introduce an overview of the project as well as highlights from the planned field campaign and some initial results in the first winter of the project (1 October 2007 to 31 January 2008) will be presented.

II. THE GOALS OF THE PROJECT

In order to develop an automatic strong gust detection system for railroads using a single-Doppler radar wind observation, the following steps will be implemented:

1) Research on fine-scale structure of strong gust and associated storm dynamics and kinetics.
2) Assessment of radar performance for strong gust detection.
3) Prototype implementation for future strong gust detection system for railroads.

III. THE FIELD CAMPAIGN

In the first phase of the project 1), fine-scale structure of strong gusts over the Shonai Plain have been explored using the field campaigns and mesoscale simulations.

a. The study area

The high-resolution observations of strong gust phenomena have been performed over the Shonai area (Yamagata Pref., Japan). Primarily, over the Sea of Japan side, severe storms such as tornadoes and gust-generating cold fronts occur frequency in winter season. The Shonai area would provide an ideal setting for studying these phenomena (Kusunoki et al. 2007).

b. Instrumentations

Major observing facilities for this project included the two X-band Doppler radars and the network of automated weather station sites.

1) JR EAST X-band Doppler radar

JR EAST X-band Doppler radar was installed at the Amarume station in Shonai Town since March 2007. Since it is needed to observe wind gusts successfully, the radar is operated in a single PPI mode at the lowest elevation angle possible to provide the reflectivity and Doppler velocities as close to the ground. The single elevation angle is 3.0 degree and the scans are taken every 30sec (Kato et al. 2007).

2) MRI portable X-band Doppler radar

MRI portable X-band Doppler radar (X-POD: X-band, POrtable Doppler radar) have been installed on the roof of Shonai Airport building since late December 2007 (Kusunoki and Ichiyama, 2007). The radar, in combination with other devices such as the JR EAST X-band Doppler radar, has been used to obtain detailed meteorological data in the Shonai area. The distance between these radars is 10km and dual-Doppler scanning was conducted. The X-POD had a 2.5 minute-volume scan which was regularly interrupted by the RHI scans at the azimuth angles of 135 and 315degrees.

3) Surface network of automated weather station sites

In order to characterize and validate these structures near the surface, the surface weather stations were distributed in the study area. We have installed 26 weather transmitter (WXT520; Vaisala) at intervals of 4 kilometers in the area around the Shonai plain. Each device as been mounted on the top of a steel pole as high as 5 meters. The observation intervals are 1 second for wind direction and wind speed, and 10 seconds for temperature, humidity and pressure. The observation data are to be sent to the computer in the Institute via the Internet. These observations provide a detailed, high quality dataset with which to compare the simulation results. In addition to the above instruments, 60 GPS sondes were launched within 1-3 hours interval in the study area in December 2008 to recognize the vertical structures of strong gust conditions. The sonde soundings in the study area will be performed in this winter.

IV. INITIAL RESULTS

Wind gust events were selected based on surface wind speed data from the surface observation network. The following wind gust identification criteria were used at each surface wind data:

(1)Vpeak >= 25ms^{-1}, (2)DV >= 15ms^{-1}, and (3) DT<=3minutes, where Vpeak is the peak wind speed, DV is defined as the difference between Vpeak and the average wind prior to the gust, and DT is the difference between the time of the peak wind speed and the beginning of increase of wind speed. Because it is not easy to determine the values of DV and Dt from the surface wind speeds which contains turbulent fluctuations, the criteria 2 and 3 were manually identified. The resultant wind gust dataset (ten cases) is described in Table 1.

In each case, surface wind and surface pressure observations confirmed the passage of a storm-scale vortex over the surface observation site. There was a suggestion of storm-scale vortices within parent storms seen in the radar reflectivity and Doppler velocity data from the JR-East radar. Figure 1 shows examples of wind gust characteristics. In the case of 5 December 2007, surface observation site C4 confirmed a maximum wind of 28.2 ms^{-1}. Over the same time, the wind direction changed from the west-southwest to the northwest and the surface pressure dropped about 2hPa. Almost simultaneously, JR-E radar revealed that the existence of mesoscale vortices and hook echoes.

Date	Surface observation site	Time (LST)	Wind speed (ms^{-1})	Parent storm type
15 November 2007	A1	10:46:29	26.2	CL
18 November 2007	E1	8:12:48	27.5	T
19 November 2007	SAK	5:06:30	25.6	T->L
19 November 2007	A1	5:46:49	25.8	T->L
05 December 2007	C4	8:42:04	28.2	C
30 December 2007	B1	18:57:53	26.1	T
31 December 2007	B1	4:05:50	25	T
1 January 2008	B1	13:27:28	29	T->L
17 January 2008	B1	11:34:52	25.1	C
25 January 2008	C2	5:27:41	31.3	L
25 January 2008	SHO	5:28:42	28.8	L

TABLE 1. Wind gust dataset during the first winter of the project (1 October 2007 to 31 January 2008). T, L, CL, and C refer to parent storm of transverse (wind-normal) cloud bands, longitudinal (wind-parallel) cloud bands, convective line and cell, respectively.

V. CONCLUSIONS AND FUTURE WORK

In this presentation, we briefly present some initial results from the gust wind dataset during in the first winter of the project (1 October 2007 to 31 January 2008). High-resolution observations obtained with the JR-E radar revealed that the existence of mesoscale vortices and hook echoes. Surface observation network confirmed wind gusts associated with the passage of these vortices. On wind gust detection, one of the paramount features is a tornado and/or a larger circulation within which tornadoes are expected to occur. Therefore, these results are noticeable and will assess of Doppler radar performance for gust wind detection. Because it is premature to extrapolate our results from this one winter season, additional gust cases are needed to confirm this preliminary study.

VI. AKNOWLEDGMENTS

This study was supported by the Program for Promoting Fundamental Transport Technology Research from the Japan Railway Construction, Transport and Technology Agency (JRTT).

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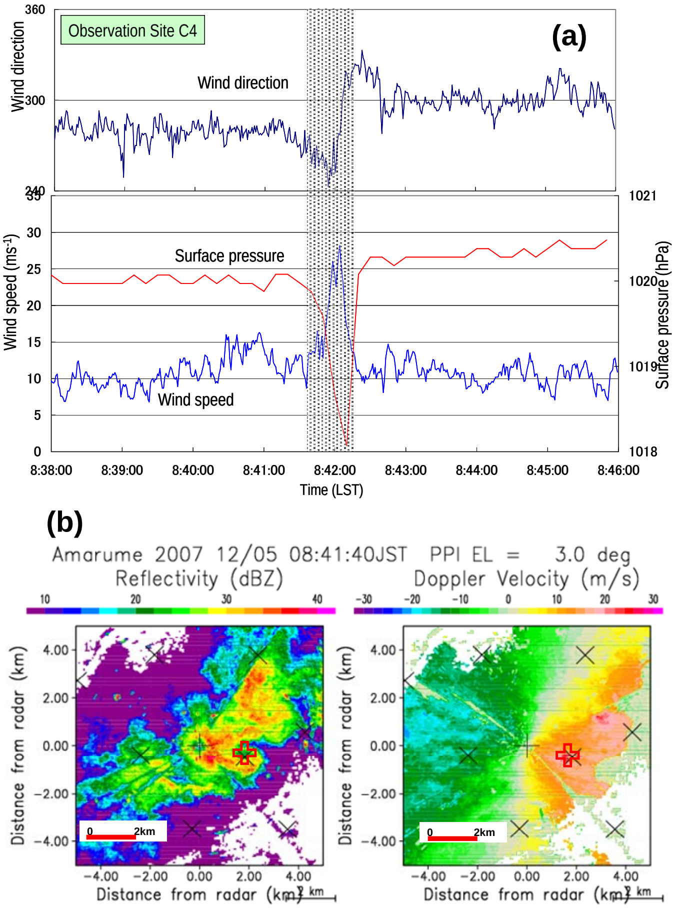

FIG. 1 Examples of wind gust characteristics observed during the project. (a) Surface wind speeds, directions, and surface pressures at the surface observation site C4. The vertical hatch is indicated by the radar scanning period of (b). (b) Radar reflectivity on 5 December 2007, at 08:41:40 LST just before the passage of a radar vortex pattern over the surface observation site C4. Data were collected by the JR-East X-band radar. The surface observation site C4 is indicated with a plus sign.