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ASSESSMENT OF THE DOPPLER RADAR FOR AIRPORT WEATHER (DRAW) SYSTEM IN JAPAN AS A RESEARCH TOOL FOR STUDYING TYPHOON

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1. INTRODUCTION

The Doppler Radar for Airport Weather (DRAW) system, which started its operation in 1995 as a wind shear detection and warning platform (Ishihara and Hata 1995), has been installed at eight major airports in Japan (Fig. 1). It has a 120-km observation range, a 0.7º azimuth resolution, and a pulse length of 1.0 micro-sec providing independent data points every 150 m in range. A volume scan update rate of 6 min and a 75-s time series of PPI scan of the lowest elevation, 0.8º, can be obtained (Table 1).

DRAWs have resulted in successive and high-resolution radar observations of convective weather phenomena not only for operational use but for research applications. Prior to the installation of DRAWs, high-resolution Doppler velocity data could be obtained only from research radars employed during limited field programs. For typhoon studies, all of the DRAWs are located less than 30km from shore, therefore, they can provide mesoscale details of wind and precipitation structure at landfall, which is of great importance because most typhoon damage occurs in the coastal zone. Although the above useful features, the typhoon observations with DRAW are limited by the range of 120km and much shorter ranges to the detailed typhoon boundary layer in addition to the large expanses in radar coverage.

In this study, I particularly aim at assessing opportunity for detecting typhoon circulations and precipitations with DRAWs as a research tool for studying typhoon. The purposes of this study are twofold: 1) to list all past tropical cyclone (TC*) cases observed

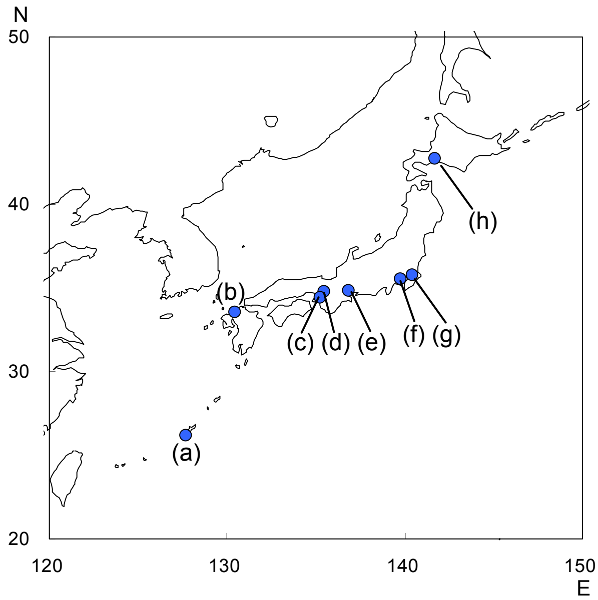

FIG.1 Locations of DRAW radar sites (circles). (a) Naha, (b) Fukuoka, (c) Kansai, (d) Osaka, (e) Chubu, (f) Haneda, (g) Narita, and (h) Shin-Chitose.

TABLE 1. Characteristics of the DRAW system.

Frequency	5290 MHz
Observation range	120km
Antenna Rotation rate	4 RPM
Pulse length	1.0μs
Range resolution	150m
Azimuth resolution	0.7°
Scan	Multiple-PPI Scan Elevations: 15 update rate: 6 minutes

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TC*: Strictly speaking, TC and extratropical cyclone transitioned from TC.

with the DRAWs, and 2) to estimate the probability of TC observations with the DRAWs. To simplify, radar data from the DRAWs are not referred but best-track archives are used to determine TC observation cases with DRAWs.

2. DATA

Best-track data of tropical cyclones (bounded by 20-50N and 120-150E) for the period 1977-2005 of the Japan Meteorological Agency are used. Furthermore, 1 hour center positions, cyclone status, and radii of storm winds are provided from an interpolation of the best-track data.

3. RESULTS

As an example, Table 2 shows that a data list of cyclone tracks and status in case that center of TCs passed within ranges of DRAWs. It is estimated that 322 hours of data (61cases) had been collected with the eight DRAWs over past 30 TCs (Fig. 2). The maximum number of observations is in 2004 (i.e., 96 hours of 21cases from 8 TCs). One notable example in 2004 is Typhoon TOKAGE that the center passed near six DRAW sites and the extratropical transition process was observed with the Narita and Haneda DRAWs.

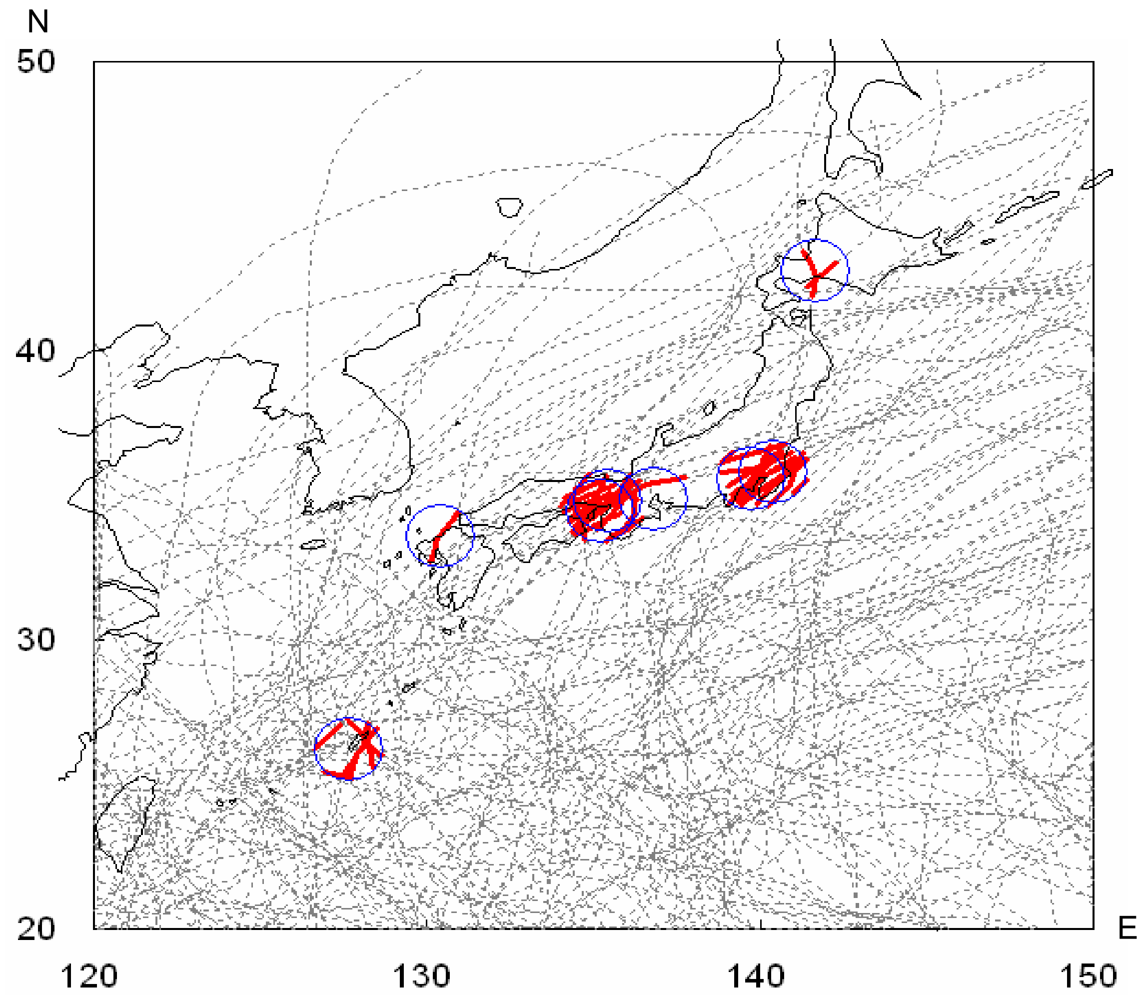

FIG. 2 Typhoon (Tropical cyclone) tracks from 1995 (thin dashed lines). The locations (tracks) of the TCs which centers within DRAW ranges are marked by solid red lines.

Figures 3 and 4 show the expected frequencies of TC observations with DRAWs. In order to reduce the bias in year-to-year variations of tracks and numbers of TCs, the best-track data for the period 1977-2005 are used, which includes years before installing the DRAWs. For centers of TCs, on average, about one TC will be observed with each DRAW site (Fig. 3a). The Naha DRAW (the southernmost DRAW site) will provide the most frequent observations and each observed center would remain in radar range for periods between 4 and 11 hours (Fig. 3b). Furthermore, observation of TC formation processes is expected only with the Naha DRAW. The Shin-Chitose DRAW (the northernmost site) will make much fewer TC observations than other sites, however, will be favorable for extratropical cyclone characteristics transitioned from TC.

As another example, observations of boundary layers of outer rainbands are examined. The lowest elevation angle of 0.8º at a 120-km distance exceeds 2500m. In order to investigate detailed TC boundary layer structures, much shorter range observations are required (from the surface to 300m AGL, corresponding to 21km radar range). In this study, the outer wind fields (i.e., the spatial extent of larger radii of 50-kt surface winds) are considered as an index of horizontal scale of outer rainbands. The results in Fig. 4 can be found as approximately similar patterns as in Fig. 3 for centers of TCs.

4. SUMMARY

In this study, it is shown that many TC cases will be collected with DRAW and new algorithms for them would be worth developing. DRAWs will play an increasing role to understand detailed TC structures and life cycles (e.g., eyewall replacement, polygonal eyewall, extratropical transition, aymmetric structure) , and in the future, to improve TC intensity forecasts.

REFERENCES

Ishihara, M., and K. Hata, 1995: Operational Doppler weather radar for airport in Japan. Preprints, *27th Conf. on Radar Meteorology*, Amer. Meteor. Soc., 723-724.

Radar name	Observation Period	TC name	Cyclone status		Locations
Shin-Chitose	2002 Oct. 1 20UTC - 2002 Oct. 1 23UTC	(HIGOS)	STS	(†)	(141.6 ,41.9 -141.3 ,43.5)
	2004 Sept. 0 4UTC - 2004 Sept. 0 5UTC	(CHABA)	STS		(141.4 ,42.2 -142.3 ,43.1)
Narita	1996 Sept. 22 6UTC - 1996 Sept. 22 7UTC	(VIOLET)	TY		(141.0 ,35.1 -141.4 ,35.5)
	1998 Sept. 15 23UTC - 1998 Sept. 16 1UTC	(STELLA)	STS		(139.5 ,35.7 -140.3 ,36.7)
	1999 Sept. 15 9UTC - 1999 Sept. 15 11UTC	(ZIA)	TD		(139.5 ,36.4 -140.8 ,36.8)
	2000 Jul. 7 20UTC - 2000 Jul. 8 0UTC	(KIROGI)	TY-STS		(140.6 ,35.0 -141.3 ,36.5)
	2001 Aug. 22 5UTC - 2001 Aug. 22 9UTC	(PABUK)	TS		(139.5 ,35.3 -140.6 ,36.5)
	2001 Sept. 11 0UTC - 2001 Sept. 11 7UTC	(DANAS)	STS		(139.5 ,35.2 -140.6 ,36.6)
	2002 Jul. 10 15UTC - 2002 Jul. 10 18UTC	(CHATAAN)	STS		(139.7 ,34.9 -141.1 ,36.1)
	2002 Jul. 16 2UTC - 2002 Jul. 16 4UTC	(HALONG)	STS		(140.0 ,35.2 -141.1 ,36.0)
	2002 Oct. 1 11UTC - 2002 Oct. 1 13UTC	(HIGOS)	TY		(139.6 ,35.3 -140.3 ,36.7)
	2004 Oct. 9 8UTC - 2004 Oct. 9 11UTC	(MA-ON)	TY-STS		(139.4 ,35.2 -141.1 ,36.3)
	2004 Oct. 20 17UTC - 2004 Oct. 20 20UTC	(TOKAGE)	STS-L		(139.3 ,35.8 -141.0 ,36.5)
	2005 Jul. 26 11UTC - 2005 Jul. 26 15UTC	(BANYAN)	TS		(140.2 ,35.1 -141.4 ,36.2)
	2005 Aug. 25 17UTC - 2005 Aug. 26 2UTC	(MAWAR)	TY-STS		(139.5 ,35.1 -141.4 ,36.2)
Haneda	1997 Jun. 20 6UTC - 1997 Jun. 20 7UTC	(VIOLET)	STS		(138.8 ,36.1 -139.2 ,36.5)
	1998 Sept. 15 22UTC - 1998 Sept. 16 0UTC	(STELLA)	STS		(139.0 ,35.3 -140.0 ,36.0)
	1999 Sept. 15 8UTC - 1999 Sept. 15 10UTC	(ZIA)	TD		(138.9 ,36.1 -140.1 ,36.6)
	2000 Jul. 7 19UTC - 2000 Jul. 7 22UTC	(KIROGI)	TY		(140.2 ,34.6 -141.0 ,35.8)
	2001 Aug. 22 4UTC - 2001 Aug. 22 8UTC	(PABUK)	TS		(139.2 ,35.1 -140.3 ,36.2)
	2001 Sept. 10 21UTC - 2001 Sept. 11 6UTC	(DANAS)	STS		(139.0 ,34.7 -140.3 ,36.3)
	2002 Jul. 10 14UTC - 2002 Jul. 10 17UTC	(CHATAAN)	STS		(139.4 ,34.7 -140.6 ,35.7)
	2002 Jul. 16 1UTC - 2002 Jul. 16 3UTC	(HALONG)	STS		(139.3 ,34.8 -140.6 ,35.6)
	2002 Oct. 1 10UTC - 2002 Oct. 1 12UTC	(HIGOS)	TY		(139.3 ,34.9 -140.0 ,35.9)
	2004 Oct. 9 8UTC - 2004 Oct. 9 10UTC	(MA-ON)	TY-STS		(139.4 ,35.2 -140.5 ,36.0)
	2004 Oct. 20 16UTC - 2004 Oct. 20 19UTC	(TOKAGE)	STS-L		(138.8 ,35.8 -140.4 ,36.2)
	2005 Jul. 26 10UTC - 2005 Jul. 26 13UTC	(BANYAN)	TS		(139.9 ,34.7 -140.7 ,35.7)
	2005 Aug. 25 15UTC - 2005 Aug. 25 23UTC	(MAWAR)	TY-STS		(139.2 ,34.8 -140.8 ,36.0)
Chubu	2004 Sept. 29 13UTC - 2004 Sept. 29 14UTC	(MEARI)	STS		(135.8 ,35.3 -136.1 ,35.7)
	2004 Oct. 20 9UTC - 2004 Oct. 20 14UTC	(TOKAGE)	TY-STS		(135.7 ,34.8 -137.7 ,35.6)
Osaka	2002 Jun. 11 4UTC - 2002 Jun. 11 6UTC	(NOGURI)	TD		(134.9 ,33.9 -135.8 ,34.4)
	2003 Jun. 0 5UTC - 2003 Jun. 0 10UTC	(LINFA)	L		(134.2 ,34.8 -134.9 ,35.7)
	2003 Aug. 8 17UTC - 2003 Aug. 9 0UTC	(ETAU)	STS-TS		(134.7 ,34.0 -136.1 ,35.5)
	2004 Jun. 11 9UTC - 2004 Jun. 11 12UTC	(CONSON)	L		(134.7 ,34.2 -136.4 ,35.5)
	2004 Jun. 21 3UTC - 2004 Jun. 21 6UTC	(DIANMU)	STS		(134.7 ,34.3 -135.4 ,35.7)
	2004 Aug. 4 14UTC - 2004 Aug. 4 17UTC	(MALOU)	TS		(134.6 ,34.1 -134.5 ,35.3)
	2004 Sept. 29 11UTC - 2004 Sept. 29 13UTC	(MEARI)	STS		(134.6 ,34.4 -135.8 ,35.3)
	2004 Oct. 20 8UTC - 2004 Oct. 20 11UTC	(TOKAGE)	TY		(134.8 ,34.1 -136.3 ,35.2)
Kansai	1996 Jul. 19 10UTC - 1996 Jul. 20 3UTC	(EVE)	TD		(134.1 ,34.5 -136.4 ,34.9)
	1997 Jun. 28 9UTC - 1997 Jun. 28 11UTC	(PETER)	STS		(134.4 ,34.8 -135.7 ,35.4)
	1997 Jul. 26 7UTC - 1997 Jul. 26 12UTC	(ROSIE)	TY-STS		(134.7 ,33.5 -134.2 ,34.8)
	1997 Sept. 16 16UTC - 1997 Sept. 16 19UTC	(OLIWA)	TS		(134.1 ,34.9 -135.2 ,35.5)
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	1999 Sept. 14 23UTC - 1999 Sept. 15 3UTC	(ZIA)	TS		(134.3 ,34.2 -135.5 ,35.1)
	2001 Aug. 21 9UTC - 2001 Aug. 21 18UTC	(PABUK)	STS		(135.4 ,33.4 -136.5 ,34.2)
	2002 Jun. 11 3UTC - 2002 Jun. 11 6UTC	(NOGURI)	TD		(134.5 ,33.6 -135.8 ,34.4)
	2003 Jun. 0 4UTC - 2003 Jun. 0 8UTC	(LINFA)	L		(134.0 ,34.6 -134.6 ,35.4)
	2003 Aug. 8 15UTC - 2003 Aug. 8 23UTC	(ETAU)	STS		(134.4 ,33.7 -135.9 ,35.2)
	2004 Jun. 11 8UTC - 2004 Jun. 11 11UTC	(CONSON)	TS-L		(134.4 ,33.8 -135.8 ,35.1)
	2004 Jun. 21 2UTC - 2004 Jun. 21 5UTC	(DIANMU)	TY-STS		(134.4 ,33.9 -135.2 ,35.2)
	2004 Aug. 4 13UTC - 2004 Aug. 4 17UTC	(MALOU)	TS		(134.7 ,33.6 -134.5 ,35.3)
	2004 Sept. 29 10UTC - 2004 Sept. 29 13UTC	(MEARI)	STS		(134.3 ,34.1 -135.8 ,35.3)
	2004 Oct. 20 7UTC - 2004 Oct. 20 10UTC	(TOKAGE)	TY		(134.4 ,33.8 -136.0 ,35.0)
Fukuoka	2005 Sept. 6 5UTC - 2005 Sept. 6 13UTC	(NABI)	TY		(130.1 ,32.7 -130.9 ,34.4)
Naha	2003 Aug. 6 19UTC - 2003 Aug. 7 3UTC	(ETAU)	TY		(128.4 ,25.5 -128.2 ,27.0)
	2003 Sept. 19 2UTC - 2003 Sept. 19 13UTC	(CHOI-WAN)	STS		(127.6 ,25.2 -128.2 ,27.1)
	2004 Jun. 10 2UTC - 2004 Jun. 10 6UTC	(CONSON)	TY		(126.6 ,26.2 -127.4 ,27.1)
	2004 Sept. 5 2UTC - 2004 Sept. 5 14UTC	(SONGDA)	TY		(128.7 ,26.0 -127.6 ,27.2)
	2004 Sept. 25 18UTC - 2004 Sept. 25 22UTC	(MEARI)	TY		(127.8 ,25.2 -126.9 ,25.4)
	2004 Oct. 19 3UTC - 2004 Oct. 19 10UTC	(TOKAGE)	TY		(127.5 ,25.3 -128.5 ,26.9)

TABLE 2 *(previous page).* TC observations with DRAWs, 1995-2005.

(†) TD: tropical depression, wind speed less than 34 kt. TS: tropical storm, wind speed 34-47 kt. STS: severe tropical storm, wind speed 48-63 kt. TY: typhoon, wind speed 64 kt or higher. L: extratropical cyclone.

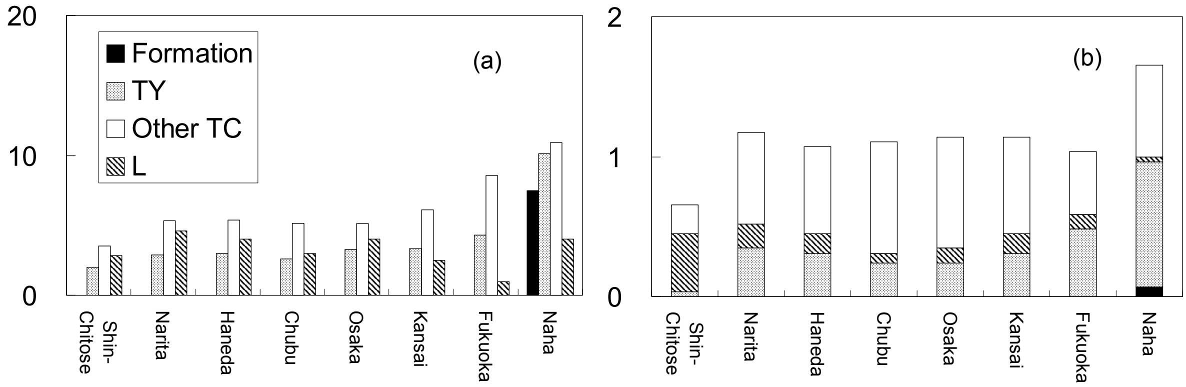

FIG. 3 Histograms of expected observations of TC centers with DRAWs. (a) frequencies. (b) observation periods for each TC center. DRAW site names are sorted from left to right corresponds to north to south.

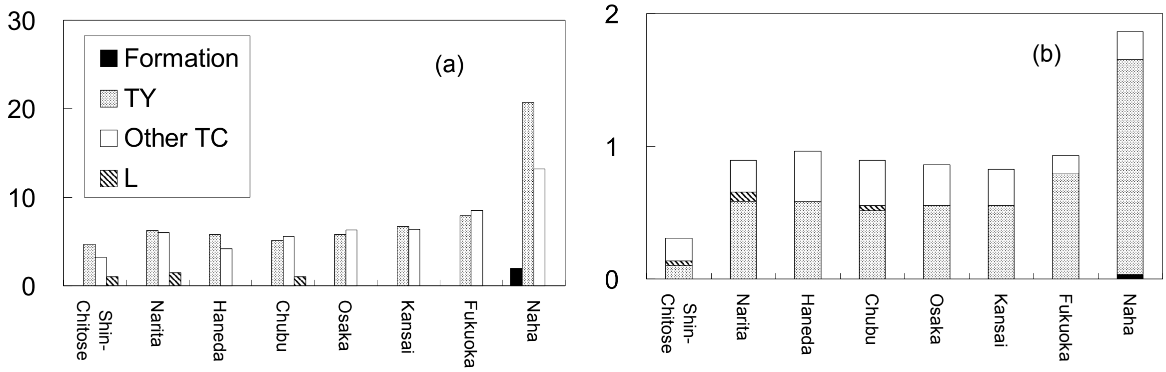

FIG. 4 Same as Fig.3 but for boundary layers of TC outer rainbands.