Precipitation and Boundary Layer Studies Using UHF Wind Profiler Radar /ISS, and TEAM- Radar in Taiwan

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ABSTRACT

The NCU(National Central University) ISS(Integrated Sounding System) was deployed in the southwestern area of Taiwan during May 15 to June 30, 2008 for the Terrain Induced Monsoon Rainfall Experiment(TiMREX). This 915 MHz wind profiler radar had been deployed in Dongsha island during May 5 to June 25, 1998 for the SCSMEX and deployed in the southeastern coast of Taiwan(Cheng-Kung station) during May 5 to June 30,2001 for the GIMEX. It was also deployed in the southern part of Taiwan in the past three years' fall seasons for air pollution meteorology observation. A wide variety of convective systems were observed during TiMREX, SCSMEX and GIMEX. The primary goal of these deployments were to measure the mesoscale structure of convective weather system and detail kinematic and thermodynamic structure change of the boundary layer flow and the local circulations. The detail boundary layer structure associated with several major convective events and severe air pollution episods will be discussed and compared in this investigation.

The Tawian Experimental Atmospheric Mobile-Radar (TEAM-R) is Taiwan's first mobile meteorolgical radar. Its construction was supported under a joint project issued to three institutes in Taiwan, including National Central University, National Taiwan University, and Chinese Culture University. TEAM-R is a X-band dual-polarimetric radar. After completing its construction in March, 2008, TEAM-R participated the SouthWest Monsoon Experiment, also known as Terrain-influenced Monsoon Rainfall Experiment (SoWMEX/TiMREX), conducted from May to June, 2008 in southern Taiwan. TEAM-R stationed at four different sites in the field for 50 consecutive days. The accumulated operational time was approximately 620 hours. At the early stage of the field experiment, TEAM-R was deployed at the same location with NCAR S-POL. This paper demonstrates a few cases of the TEAM-R measurements during SoWMEX/TiMREX, and shows the results of the attenuation correction using S-POL data sets.

1. INTRODUCTION:

In Taiwan, nine ground-based weather radars (six Doppler radars and three dual-polarimetric radars) constitute a dense radar network on this island where the area (~ 36,000 sq. km) is only slightly bigger than the state of Maryland. The data collected by these radar systems are used by the local radar meteorology community to conduct research related to QPE/QPF, terrain effect on severe precipitation, hydro-meteorology, and the application of radar data to prevent or mitigate the natural disasters.

2. The construction of TEAM-R:

The Central Mountain Range (CMR), with a maximum peak reaching about 4000 m and complex terrain on Taiwan poses serious difficulties to the observations by ground-based radar network. In October, 2006, a proposal was approved by the National Science Council to construct Taiwan's first mobile meteorological radar, named Taiwan Experimental Atmospheric Mobile-Radar, or TEAM-R. TEAM-R is a X-band dual-polarimetric radar. Its basic specifications are listed in Table 1. The construction of TEAM-R was completed in March, 2008. A picture of TEAM-R is depicted in Fig. 1.

3. TEAM-R measurements during 2008 SoWMEX/TiMREX:

The SoWMEX/TiMREX field experiment was conducted from May to June, 2008 in the southwestern part of Taiwan. Its scientific purpose is to understand the mechanisms that trigger the heavy precipitations in South China Sea and Taiwan during Asian summer monsoon season, so as to improve the accuracy of the quantitative precipation forecast in this area. Figure 2 illustrates the deployments of the radar systems. After completing its construction in March, 2008, TEAM-R also participated SoWMEX/TiMREX, stationed at four different sites in the field for 50 consecutive days. The accumulated operational time was approximately 620 hours. Figure 3 gives one example of the TEAM-R observations. At the early stage of the field experiment, TEAM-R was deployed at the same location with NCAR S-POL. The data collected during that period of time were

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used for calibrations.

4. TEAM-R data QC:

The issues regarding the TEAM-R dual-polarimetric measurements (DPMs) quality control (QC) mainly are the system bias, attenuation correction of the reflectivity (Z_{HH}) and the differential reflectivity (Z_{DR}). The Z_{HH} and Z_{DR} can be written in the forms of:

$$Z_{HHobs} = Z_{HH} + Z_{HHbias} + A_H$$

$$Z_{DRobs} = Z_{DR} + Z_{DRbias} + A_{HV}$$

The Z_{DR} system bias of TEAM-R was derived by analyzing the vertical pointing (VP) data. During the SoWMEX/TiMREX, there were 46 available VP data performed under the stratiform precipitation by TEAM-R.

The Z_{HH} system bias of TEAM-R was derived via the self-consistency approach suggested by Vivekanandan et al. (2003) [1]. The self-consistency of the DPMs of TEAM-R can be expressed as:

$$K_{DP} = 10^{-3.9506} Z_{HH} Z_{DR}^{-2.293}.$$

The K_{DP} is immune to the system bias and the attenuation effect, and the Z_{DR} system bias has already obtained from the VP data. After the Φ_{DP} based single-coefficient attenuation correction for the Z_{HH} and Z_{DR}, the last unknown is the Z_{HH} system bias. The attenuation correction parameters were derived for 5yrs DSD in northern Taiwan. Therefore, the Z_{HH} system bias was derived by the calculation of the difference between the attenuation corrected observed Z_{HH} and the self-consistency derived Z_{HH} (from K_{DP} and corrected Z_{DR}). The mean Z_{HH} bias on Jun. 5th, 2008 was about -2.0 dB. In Fig. 4, the raw data and corrected Z_{HH} and Z_{DR} from TEAM-R were demonstrated. It can be seen that the bias-attenuation corrected Z_{HH} and Z_{DR} showed more reasonable values compared to the raw measurements. The values of the Z_{DR} measurements in stratifrom region (15~70km) were about 0.0 dB after the bias-attenuation correction. The attenuation correction algorithm was single-coefficient Φ_{DP}-based attenuation correction.

The observation uncertainty of Z_{DR} can be derived from the VP data in a light stratiform rain. The standard derivation of Z_{DR} in stratiform VP data was 0.18 dB. The Φ_{DP} observation uncertainty was computed using measurements from a light stratiform rain region where there was nearly no Φ_{DP} increment with distance. In the absence of a Φ_{DP} increment, the fluctuations in observed Φ_{DP} were directly related to standard deviation. The standard deviation of Φ_{DP} is about 2.4 degrees.

REFERENCE

[1] Vivekanandan, J., G. Zhang, S. M. Ellis, D. Rajopadhyaya, and S. K. Avery, 2003: Radar reflectivity calibration using differential propagation phase measurement. /Radio Sci., /*38*, 8049, doi: 10.1029/2002RS002676.

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Fig. 1: Taiwan Experimental Atmospheric Mobile-Radar (TEAM-R)

Fig. 2: The radar deployments during 2008 SoWMEX/TiMREX. S-POL is from NCAR, and JP stands for a Japanese radar provided by Nagoya University. The Integrated Sounding System, a vertical pointing radar, was operated by NCU.

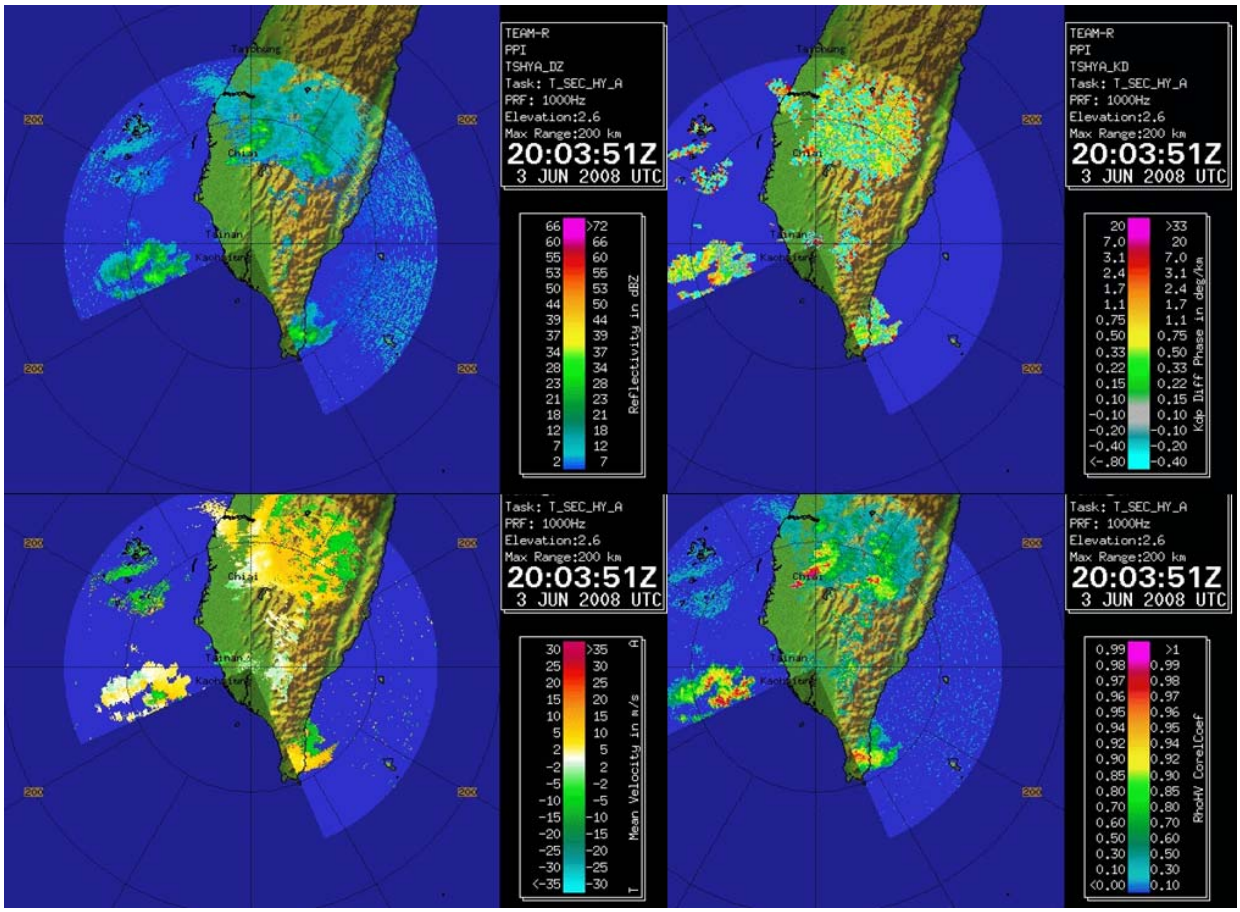

Fig. 3, One example of TEAM-R observations during SoWMEX/TiMRX on June 3, 2008. The parameters shown are: radar reflectivity (uppler left), K_{DP} (upper right), radial wind (lower left), ρ_{HV} (lower right). The southwest sector was blocked by the cabinet on the truck platform, but the observations can be compensated by other radars such as S-POL.

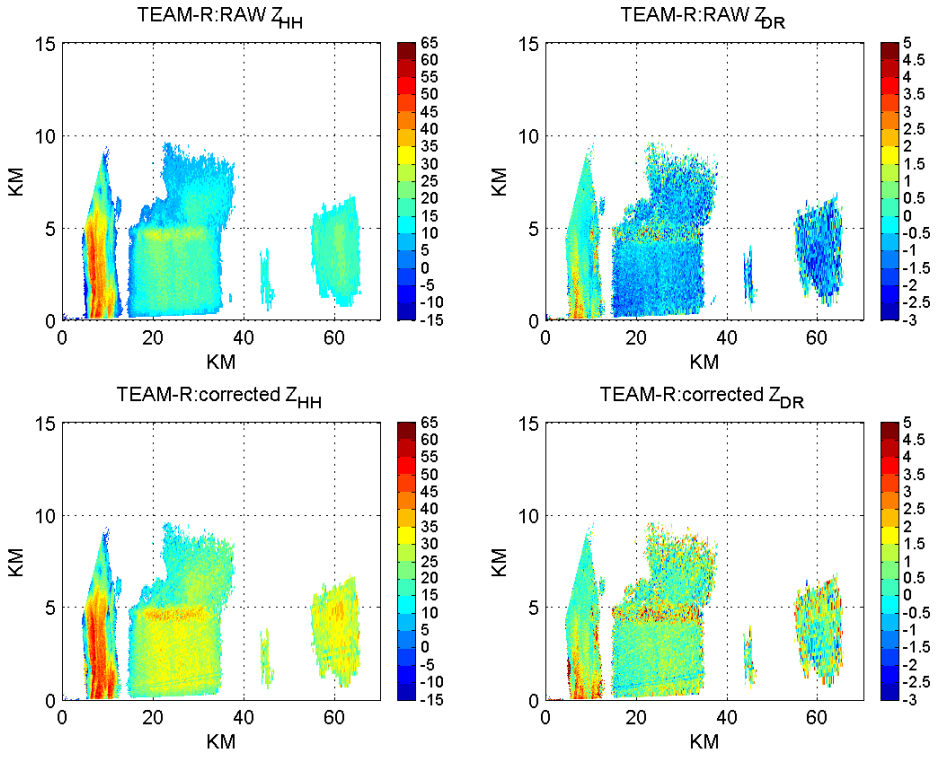

Figure 4: The raw measurements and bias-attenuation corrected Z_{HH} and Z_{DR} from TEAM-R.

Table 1: Specification of TEAM-R

Operated by	NCU, Taiwan
Platform	Mobile, flatbed truck
Transmitter	Klystron
Transmitter frequency	9.620 GHz
Transmitter Wavelength	3.12 cm (X-band)
Transmitter Peak Power	50 kW
Transmitter Pulse Width	1μ, 1.5μ, 2μ
Pulse Repetition Frequency	3000 Hz (max)
Polarization Diversity	H, V
Transmitted Pulse Package	Up to 4 pulse width
Antenna Type	Parabolic reflector
Antenna Diameter	1.8 m
Antenna Beam Width	1.4 deg
Antenna Gain	42 dB
Antenna Scan Rate	Max : 20 deg/sec
Receiver band width	10 MHz
Receiver dynamic range	92~102 dB
Measurement Range	100 km