# Dual-Doppler Radar Analysis for a Case Study during Southwesterly Flow Experiment (SoWFEX 2006)

**Chih-Hsien Wei** （魏志憲）
**Department of Military Meteorology, Air Force Institute of Technology**

**Tai-Hwa Hor** （何台華）
**General Education Center, Lunghwa University of Science and Technology**

## Abstract

Several remarkable convective systems associated with the Mei-yu frontal rainband were approaching the southern Taiwan area on 9-10 June 2006 during Southwesterly Flow Experiment (SoWFEX 2006). These systems brought torrential rainfall over the southwestern plain of Taiwan. The plan position indicators of CWB Chiku Doppler weather radar illustrate that the intense echoes had developed into convective lines with bulge, which are often referred to quasi-linear convective systems (QLCS). The constant altitude plan position indicators of Chiku radar show that there existed a significant weak echo channel in rear of the apex, splitting intense echoes (> 40 dBZ) into two parts. The radial velocity reveals that a cyclonic shear was located on the northern part of the linear system between 2 to 5 km levels in altitude. One of the QLCS was observed by both Kenting and Chiku Doppler weather radars. Due to the good quality of collecting dataset, it is useful for Dual-Doppler wind synthesis. The synthesized wind fields delineate the existence of peak updraft in 8 m $s^{-1}$and affirm the shearing circulation with maximum vertical vorticity over 3 $\times 10^{-3}$ $s^{-1}$ within the northern intense echo on the 3 km level. It also demonstrates an anticyclonic circulation embedded within the southern intense echo. The downdraft, which had a maximum of 5 m $s^{-1}$, was collocated with the weak echo channel. It suggests that the formation of weak echo channel was related to the existence of the descending air.

## Introduction

The completion of the Doppler weather radar network around the Taiwan island in 2002 has provided the capability to monitor the evolutions and structures of the MCSs capable of producing heavy rainfall and occasional strong surface wind over the Taiwan Strait in the Mei-yu season. By analyzing both Chiku and Kenting Doppler weather radar data collected on 7 June 2003, Wei et al. (2006) documented that these MCSs often exhibited a leading quasi-linear convective system (QLCS, Weisman and Trapp, 2003) structure with embedded echo distortion and/or bow-shaped segments and a trailing stratiform precipitation region. This is the first study documenting such a system by Doppler radar observations over the subtropical, oceanic region in East Asia. Wei and Hor (2006) presented an overall depiction for the QLCS embedded within MCSs also by applying the Taiwan radar network collected during the Southwesterly Flow Experiment in 2006 (SoWFEX, 2006), revealing the feature of QLCS was not unique in the area. Actually, several remarkable convective systems associated with the Mei-yu frontal rainbands were approaching the southern Taiwan area on 9-10 June 2006. The 3-D wind fields synthesized by Chiku and Kenting Doppler wind data are attempted to elucidate the characteristics of the QLCS.

## Environmental Conditions

The synoptic surface chart shows that a front was propagating Taiwan from 9 to 10 June 2006 and appeared quasi-stationary in central Taiwan area. By 1200 UTC 10 June 2006, the lower atmospheric wind field (below 700 hPa level) revealed a strong southwesterly flow possessing intense wind speed that exceeded 20 $ms^{-1}$. This indicates that the southern Taiwan area is favorable for developing severe weather systems. The convective available potential energy (CAPE) estimated from Tainan sounding data at the same time was about 1150 J $kg^{-1}$, which is comparable with the environment for the development of tropical squall line (Jorgensen et al. 1997) However, it is only a moderate intensity for the triggering of severe convections in midlatitutes.

## Evolution and Characteristic of the QLCS

The plan position indicators (PPIs) of Chiku Doppler weather radar illustrated that the intense echoes had developed into convective lines with bulge, which are often referred to line echo wave pattern (LEWP, Nolen 1959). By 0031 and 0041 UTC on 10 June 2003, the constant altitude plan position indicators (CAPPIs, Fig 1a, 1b) at 3 km level of Chiku radar show that there existed a significant weak echo channel in rear of the apex, splitting intense echoes (> 40 dBZ) into two parts. The radial velocity reveals that a cyclonic shear was located on the northern part of the linear system between 2 to 5 km levels in altitude. It is also well defined while the system propagated inland, featuring the bulge pattern.

The system was observed by both Kenting and Chiku Doppler weather radars from 0030 UTC to 0100 UTC. Due to the good quality of collecting dataset, it is feasible for Dual-Doppler wind synthesis. The methodology and parameter setting for synthesizing 3-D wind fields are referred to Wei (2006). The synthesized wind fields delineate that the horizontal shear of southwesterly flow was significant along the system, generating intense vertical vorticity at mid-levels (3 ~ 5 km in altitude). By 0039 UTC, the shearing circulation with maximum vertical vorticity in $3 \times 10^{-3}$ $s^{-1}$ collocated with the northern intense echo at 3 km level, affirming the existence of cyclonic shear based on the single-Doppler analysis. It also demonstrated an anticyclonic circulation embedded within the southern intense echo with minimum vorticity of $-1.5\times10^{-3}$ $s^{-1}$. The peak updraft in 8 m $s^{-1}$ at the 3-km level also collocated with the northern intense echo. The downdraft, which had a maximum of 5 m $s^{-1}$, was collocated with the weak echo channel.

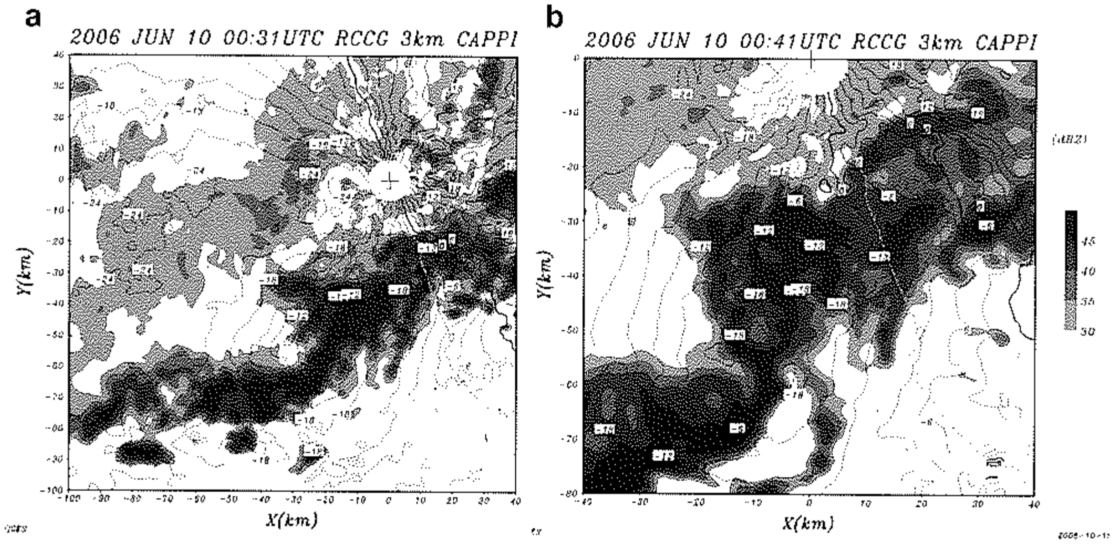


Figure 1. The composite CAPPI of reflectivity and Doppler wind field collected by Chiku Doppler weather radar at 3 km level at (a) 0031 UTC and (b) 0041 UTC on 10 June 2006.

The cross section across the apex of the system illustrates that the echo top could reach 14 km in altitude. The updraft located over 5 km in height is prominent for the development of the system. The front to rear flow is not apparent at lower levels but at higher levels, suggesting that two dimensional convergence occurs at mid-levels.

## References

Nolen, R. H., 1959: A radar pattern associated with tornadoes. *Bull. Amer. Meteor. Soc.*, **40**, 277-279.

Wei, C.H., T.H. Hor, M.H. Chang and W.C. Lee, 2006: Case study on the Characteristics of quasi-linear convective system off the southern coast of Taiwan in the 2003 Mei-yu season. *Atmos. Sci.*, **34**, 157-176. (In Chinese with English abstract)

Wei, C.H., 2006: Dual-Doppler radar analysis for the line echo wave pattern and mesoscale convective vortex over Taiwan area. Ph.D. thesis, 113pp. (In Chinese with English abstract)

Wei, C.H. and T.H. Hor, 2006: The preliminary analysis of linear convection in use of Doppler radar data during SOWFEX (2006). The 6th Conference on the recent development of Radar Meteorology. Taipei, Taiwan.

Jorgensen, D. P., M. A. LeMone and S. B. Trier, 1997: Structure and evolution of the 22 February 1993 TOGA COARE squall line. Aircraft Observations of Precipitation, Circulation, and Surface Energy Fluxes. *J.*

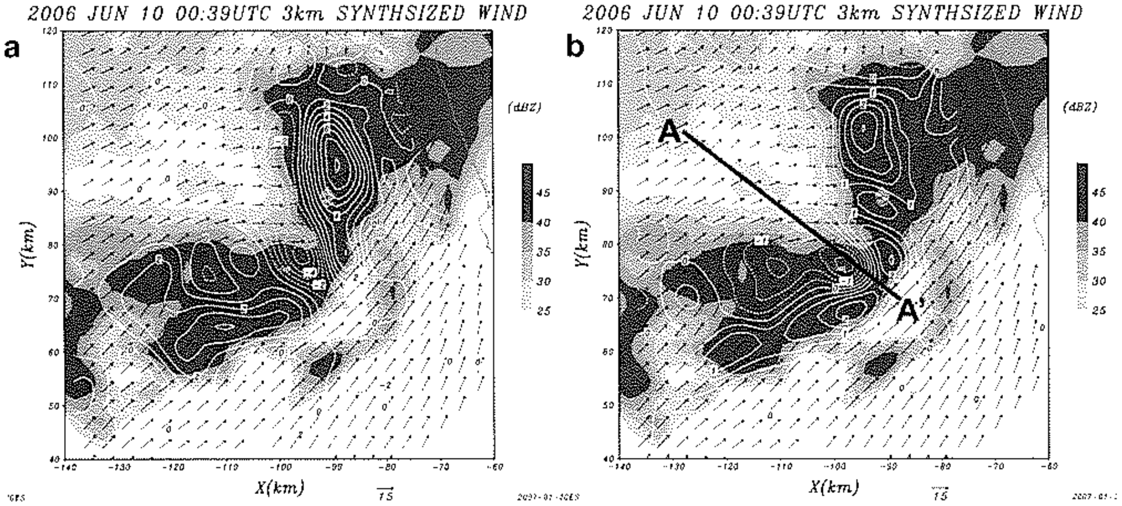


Figure 2. The synthesized wind fields (m $s^{-1}$) in u, v in the altitude of 3 km at 0039 UTC on 10 June 2006. The contours show the (a) vertical velocity (m $s^{-1}$) and (b) vorticity field ($s^{-1}$).

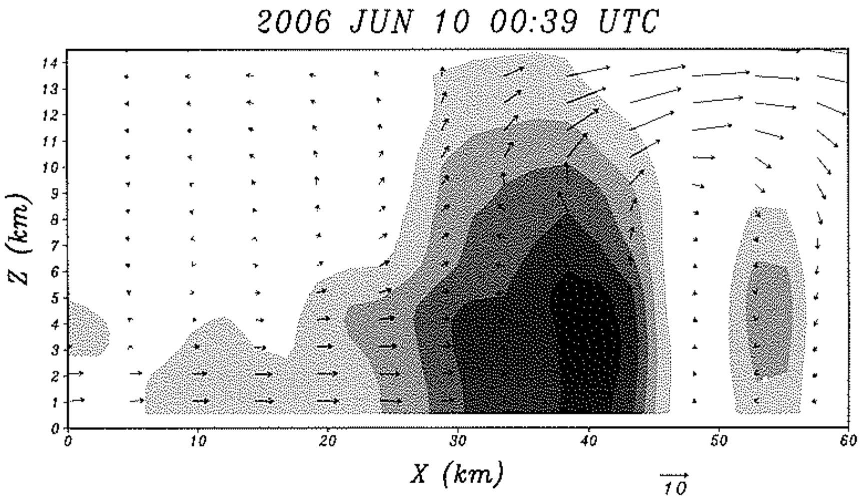


Figure 3. Vertical cross sections of reflectivity (dBZ) and wind field relative to system (across the A-A' line shown in Fig. 2b) at 0039 UTC 10 June 2006.