同化地基觀測改善北台午後熱對流預報：2019年07月22日個案研究

Improving the afternoon thunderstorm prediction with assimilation of the ground-based observations in Taiwan: a case study on 22 July 2019

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摘　要

臺灣地區擁有高解析度的地基觀測網絡，其中包含118個GNSS接收站以及435個地表氣象測站。GNSS接收站能提供大氣對於GNSS衛星訊號在傳播過程中造成的路徑延遲資訊，而天頂方向的延遲量則稱為天頂向總延遲(Zenith total delay, ZTD)。ZTD資料擁有高時間解析度的優勢，能夠即時提供快速變化的水氣資訊。而地表氣象測站直接觀測地表風等變數，能提供近地面的輻合輻散場資訊。本篇研究探討同化ZTD資料及地表氣象測站資料對於2019年07月22日發生在臺灣北部之短延時強降雨午後熱對流事件的影響，該個案於兩小時內在臺北市的公館雨量站降下了117mm的致災性豪雨，其中在第一小時降雨量就達到92.9mm。

本篇研究的同化實驗使用WRF-LETKF資料同化系統，其中ZTD資料的同化區間為每半小時，地表氣象測站的同化區間為每小時。實驗結果顯示同化ZTD資料在北臺灣離岸到岸邊皆提供了有效的水氣與溫度修正，並且加強了臺北盆地周遭的低層入流，北臺灣大量的水氣輻合通量使得模式能夠建立短時間的強對流降雨。同化過程中加入地表氣象測站的風場資料後，更能改善對於發生於臺北市的強對流位置的預報。另外，實驗結果也顯示了水平局地化尺度的選擇對於是否能提供正確的同化修正量是重要的，ZTD資料能提供大尺度的水氣修正，這建立了有利對流發展的大環境，而ZTD資料與地表氣象測站資料在於小尺度的風場修正則對強對流發生的位置有著關鍵的影響。無論是水氣或風場的修正，對於午後熱對流的預報初始化及預報對流的發展皆是不可或缺的。

Abstract

A network with dense ground-based observation stations has been established in Taiwan, including 118 stations of the GNSS receivers and 435 surface weather stations. The ground-based GNSS receiver measures the delay in the path in receiving a signal from a GNSS satellite, and zenith total delay (ZTD) expresses this delay as the excess path length along the zenith direction. The ZTD data are available at a high temporal frequency and can provide the fast-changing moisture information at near real time. The surface station data directly observe the surface wind and can provide information about the near surface convergence fields. This study investigates the impact of assimilating the GNSS-ZTD data and surface station data on short-term heavy rainfall prediction associated with an afternoon thunderstorm over northern Taiwan on 22 July 2019. This event is characterized by very intense rainfall rate (92.9 mm h-1) at Gongguan and an accumulated rainfall of 117 mm in 2hr.

Data assimilation experiments are conducted with the WRF-LETKF system, which assimilates the ZTD data every 30 minutes and surface wind data every hour. Results suggest that assimilating the ZTD data provides effective moisture and temperature adjustment from offshore to coastal area of Taiwan and enhances the low-level inflow into the Taipei basin. With the great amount of moisture convergence flux over northern Taiwan, the model generates strong convections, and the heavy precipitation takes place in a short time. Coupling with the surface wind data, the

location of the strongest convection is better predicted. In particular, results suggest the choice of horizontal localization scale is important for deriving the effective correction. The large-scale moisture correction from ZTD data provides the critical precondition of convection development while the small-scale wind correction from both the ZTD and station data is decisive for the heavy rainfall location over northern Taiwan. Without enough moisture and wind correction, the thermodynamics instability cannot be established and thus mechanism for heavy rainfall cannot be triggered in the forecast.