多都卜勒氣象雷達三維風場合成技術(WISSDOM)介紹及作業化應用結果說明

廖宇慶 [1]　馮智勇 [2]　吳奕亨 [2]　簡佑穎 [2]　鄧詠霖 [1]　楊伯謙 [1]　王溫和 [3]　方偉庭 [3]

國立中央大學大氣科學系 [1]　多采科技有限公司 [2]　中央氣象局氣象衛星中心 [3]

摘　要

本研究將中央大學大氣科學系發展之多都卜勒氣象雷達三維風場合成技術(WISSDOM; WInd Synthesis System used to DOppler Measurement)以作業化的方式應用於涵蓋全臺灣的天氣監測分析。WISSDOM 利用變分法進行多都卜勒氣象雷達之三維風場合成，流程設定為由數個約束條件組成的價值函數，包含徑向風投影關係式、背景風場、非彈性連續方程、垂直渦度方程、地面氣象測站觀測資料以及 Laplacian 平滑項，再以 Immersed Boundary Method (IBM) 處理下邊界條件，以變分進行極小化，反演得到複雜地形上的三維風場。

為了滿足逐 10 分鐘產製全臺灣水平解析度 1 公里、垂直解析度 500 公尺、共 360*560*10 個格點的三維風場需求，本研究使用 CPU 及 GPU 平行計算技術優化程式計算效能，並建置即時介接各類觀測資料流程，將計算時間縮短至 10 分鐘內自動完成。

反演所需的觀測資料如下：(1)8 部雷達的徑向風觀測，包括七股（RCCG）、清泉崗機場（RCCK）、綠島（RCGI）、花蓮（RCHL）、墾丁（RCKT）、馬公（RCMK）、五分山雷達（RCWF）及五分山 C-POL(RCMD) ；(2)STMAS 數值模式；(3)探空；(4)地面站。例行作業化的主要設定包含：(1)每 10 分鐘進行一次反演，因考慮觀測資料上傳需要時間，因此程式執行時間與進行反演的時間相差 20 分鐘; (2)背景風場的選取方式為每半小時(整點與 30 分)使用數值模式分析場，其餘時間點則使用前一次風場反演結果。(3)風場反演會依據雷達資料量多寡(亦即判斷是否有天氣系統)決定是否啟動反演，目前的判據為在反演區域內有雷達資料的格點數佔總格點數的 3.2% 為門檻值(亦即雷達數目乘上 0.4%)，其目的為允許每個雷達皆有雜訊容錯空間，若低於此門檻則不進行反演，輸出背景風場。

本報告亦會討論未來可以對 WISSDOM 做進一步優化的研究方向以及可能的應用。

關鍵字：都卜勒氣象雷達、三維風場合成、CPU/GPU 平行計算、線上作業化

Introduction of WISSDOM and its operational application

Yu-Chieng Liou[1], Chih-Yung Feng[2], Yi-Heng Wu[2], Yu-Ying Chien[2], Yung-Lin Teng[1]

Po-Chien Yang[1], Wen-Ho Wang[3], Wei-Ting Fang[3]

[1]Department of Atmospheric Sciences, National Central University

[2]Manysplendid InfoTech

[3]Meteorological Satellite Center, Central Weather Bureau

Abstract

In this research the multiple-Doppler radar wind synthesis method (WISSDOM) developed by NCU is applied at an operational mode with the domain size covering the entire Taiwan and vicinity area. In WISSDOM a cost function is formulated in which several constraints are implemented. They include the geometric relation between radar radial wind and the Cartesian winds, background wind field, the anelastic continuity equation, the vertical vorticity equation, surface station data assimilation, and a smoothing term. The Immersed Boundary Method (IBM) is applied to deal with the bottom boundary condition. The variational minimization technique is adopted, yielding a set of three-dimensional wind field over complex terrain.

The operational WISSDOM contains 360x560x10 grid points, with a horizontal and vertical spatial resolution reaching 1.0 km and 0.5 km, respectively. By using CPU and GPU parallel computing technique, the computational time can be reduced to less than 10 minutes. The data injected to operational WISSDOM include (1) radial winds from 8 radars (RCCG, RCCK, RCGI, RCHL, RCKT, RCMK, RCWF, RCMD); (2) STMAS model outputs; (3) Sounding; (4) Surface stations. The background wind field is updated every 30 minutes. It is provided by the model outputs to fill in the radar data-void regions. Due to the time needed to collect all the necessary data, the retrieved wind field is 20 minutes behind the actual time. The ratio between the number of the grid points with radar data and the total grids is used to determine whether or not to initiate the operational WISSDOM retrieval. Currently a threshold value of 3.2% is given.

In our presentation future plans for further optimizing WISSDOM and its potential applications will also be addressed.

Key words: Doppler weather radar, three-dimensional wind synthesis, CPU/GPU parallel computation, operation.