群集分析技術於颱風系集定量降水預報系統之應用

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摘要

數值天氣預報存在可預報度的限制，中央氣象署發展系集預報系統(WEPS)，主要是以WRF區域模式為基礎，巢狀網格解析度分別為15公里跟3公里，透過初始隨機擾動、邊界擾動和物理參數法擾動等，產生20組系集預報成員，旨在涵蓋預報的不確定性。然而，如何從系集預報系統所提供的龐大預報資料中取得有用的資訊，並確實掌握預報的不確定性，是WEPS在天氣預報應用的重要關鍵。

WEPS各系集成員的預報雖然存在差異，但成員之間常有相近的特徵，這可能與模式大氣的環境條件或是系集成員的模式組態有關，即所謂分群現象，這也可能反映了未來預報可能的情境。在過去研究中，氣象署利用類神經網路之自組織映射圖網路(self-organizing map, SOM)群集分析技術，針對梅雨鋒面降水個案，將WEPS模式的定量降水預報分為四個群集，進行分群特性分析，並進一步針對綜觀診斷變數之分群，提供降水情境下大氣環境的詮釋與論述。

颱風在臺灣的降雨及風速預報與颱風中心和臺灣地形的相對位置密切關係，因此本研究期望透由分群方法，產製不同情形之颱風路徑預報，提供防災決策參考。此外，本署為提供預報及防災單位在颱風臨臺期間預報指引，建立以系集模式為基礎的系集模式颱風定量降水預報 (Ensemble Typhoon Quantitative Precipitation Forecast, ETQPF)，此系統可透過指定颱風路徑，配合系集預報系統產生之大量定量降雨數據，產製出該路徑之定量降雨預報，因此，分群後的颱風路徑，可搭配ETQPF系統，產製對應之定量降水域報。

關鍵字：系集預報、群集分析、颱風定量降水預報

The application of cluster analysis techniques for Ensemble Typhoon Quantitative precipitation forecast system

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Abstract

Numerical weather prediction has its limitations in predictability. The Central Weather Administration (CWA) has developed the Weather Research and Forecasting Ensemble Prediction System (WEPS), primarily based on the WRF regional model with nested grid resolutions of 15 kilometers and 3 kilometers. Through techniques like initial perturbations, boundary perturbations, and multi-physic parameters, WEPS generates 20 ensemble forecast members aimed at covering forecast uncertainties. However, extracting useful information from the extensive forecast data provided by the ensemble prediction system and effectively managing forecast uncertainty are critical challenges in the application of WEPS to weather forecasting.

While forecasts from individual members of WEPS exhibit differences, there are often similar characteristics among members, which may be related to atmospheric conditions or the configuration of model ensemble members—a phenomenon known as clustering. This clustering may also reflect potential future forecast scenarios. Previous studies by the meteorological bureau have utilized self-organizing map (SOM) cluster analysis techniques with neural networks to categorize quantitative precipitation forecasts from the WEPS model into four clusters for cases of Mei-Yu frontal precipitation. This approach allows for cluster-specific analysis of synoptic diagnostic variables, providing interpretations and discussions on atmospheric conditions during precipitation events.

The prediction of rainfall and wind speeds associated with typhoons in Taiwan closely correlates with the relative positions of typhoon centers and Taiwan's terrain. Therefore, this study aims to use cluster analysis techniques to generate typhoon track forecasts under different scenarios, providing references for disaster prevention decisions. Furthermore, to support forecasting and disaster prevention agencies during typhoon events, CWA has established the Ensemble Typhoon Quantitative Precipitation Forecast (ETQPF) based on the ensemble model. This system utilizes specified typhoon tracks and vast quantitative rainfall data generated by the ensemble prediction system to produce quantitative precipitation forecasts along these tracks. Thus, clustered typhoon tracks can be paired with the ETQPF system to produce corresponding quantitative precipitation area forecasts.

Key words: Ensemble Forecast, Cluster analysis, Typhoon Quantitative Precipitation Forecast