資料驅動天氣推估技術於防災預警作業之落實與應用

Implementation and Application of Data-Driven Weather Prediction Technology in Disaster Warning Operations

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摘　　要

為落實資料驅動天氣推估(DWP)技術於防救災實務應用，本中心引進國際最新的 AI 全球模型並進行在地化調整，同時測試與建置新一代區域數值模式(MPAS Regional)，透過數值模擬(NWP)與 AI 降尺度技術的整合，建立更穩健的氣象預警架構。目前系統已成功建立每日更新 2 次的自動化作業，整合 Google GraphCast、NVIDIA FourCastNet2、ECMWF AIFS、微軟 Aurora 等 11 組國際先進 AI 全球模型，提供未來 15-90 天大尺度環流與天氣系統發展趨勢。同時，研發多尺度殘差網路(MSRN)技術，透過兩階段逐步放大策略，產出(0.0125°)高解析度雨量產品，並依校驗表現動態配置權重整合傳統 NWP，產出最佳化之系集雨量等加值產品。

此外，本研究運用卷積神經自動編碼器(CNN-AutoEncoder)擷取 18 個關鍵變數之高維度空間拓撲特徵，並結合機器學習演算法建置客觀判釋模組，用以定義汛期天氣類型，進而藉由相似度指標動態推估全臺降雨空間分布與致災熱區情境。

關鍵字：多尺度殘差網路技術、天氣判識

Abstract

To implement Data-driven Weather Prediction (DWP) technology into disaster mitigation, this center integrates numerical weather prediction (NWP) with AI downscaling techniques by developing a next-generation regional model (MPAS Regional) alongside international AI global models tailored for localized operations. The system features an automated workflow updated twice daily, integrating 11 advanced AI models, including Google GraphCast, NVIDIA FourCastNet2, ECMWF AIFS, and Microsoft Aurora, to project large-scale circulation and weather system trends for the next 15 to 90 days. Concurrently, a Multi-Scale Residual Network (MSRN) utilizes a two-stage progressive downscaling strategy to produce high-resolution (0.0125°) rainfall products, dynamically adjusting model weights

based on validation performance to output optimized ensemble precipitation products integrated with traditional NWP.

Furthermore, a CNN-AutoEncoder extracts high-dimensional spatial topological features from 18 key variables, combining with machine learning to construct an objective module that defines flood-season weather types and dynamically projects Taiwan's rainfall distribution and disaster hot zones via similarity indices. This integrated architecture significantly enhances warning lead times and spatial granularity for resilient disaster response.

Keywords: Multi-Scale Residual Network Technology, Weather Recognition