應用CorrDiff於ECMWF-SEAS5短期氣候預報之AI降尺度評估

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摘　　要

隨著氣候變遷加劇，跨領域單位（如農漁林業、水利署、能源及防災部門）對於氣候資訊的空間精細度與預報長度需求日益提升，亟需更具在地化與多時空特性的預報產品以作為決策輔助。近年國際研究顯示，深度學習降尺度技術能有效將低解析度的氣象資料轉換為高解析度的在地化資訊，因此氣象署與NVIDIA 合作開發生成式擴散模型（CorrDiff），利用深度學習架構重建局部環流與氣象變化。

本研究旨在延續前期針對模型架構與不同氣象變數的敏感度研究成果，進一步將 CorrDiff 模型應用於歐洲中期天氣預報中心（ECMWF）的短期氣候模式（SEAS5），評估其在臺灣區域的降尺度可行性與預報能力。為滿足實務上不同情境的決策需求，本研究將評估不同時間尺度的CorrDiff模型表現：一方面透過「日 CorrDiff 模型」評估極端天氣事件（如寒害、豪大雨）的極致空間細節捕捉能力；另一方面透過「月 CorrDiff 模型」評估其在長期氣候變率與空間趨勢的掌握度，藉此建立一套具作業化潛力的多種應用場合的 AI 降尺度流程，以提升在地化氣候服務品質。

關鍵字：短期氣候模式, 降尺度

Assessing AI-based Downscaling (CorrDiff) on ECMWF-SEAS5 Seasonal Forecast

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Abstract

With the intensification of climate change, cross-sectoral agencies (e.g., agriculture, fisheries and forestry, the Water Resources Agency, energy, and disaster management) are placing increasing demands on the spatial resolution and lead times of climate information, and urgently require forecast products with stronger localization and multi-temporal–spatial characteristics to support decision-making. Recent international studies have shown that deep-learning downscaling techniques can effectively transform low-resolution meteorological data into high-resolution localized information. In response, the Central Weather Administration (CWA), in collaboration with NVIDIA, developed a generative diffusion model (CorrDiff) that leverages deep-learning architectures to reconstruct local circulation and meteorological variability.

This study builds on prior work examining model architecture and the sensitivity of different meteorological variables, and further applies the CorrDiff model to the European Centre for Medium-Range Weather Forecasts (ECMWF) short-term climate system (SEAS5) to evaluate its downscaling feasibility and forecast skill over Taiwan. To meet diverse practical decision-making scenarios, we assess CorrDiff's performance at multiple temporal scales: a "daily CorrDiff model" is used to evaluate the model's ability to resolve fine-scale spatial details of extreme weather events (e.g., cold surge and intense heavy rainfall), while a "monthly CorrDiff model" is used to assess its capacity to capture longer-term climate variability and spatial trends. Through these evaluations, we aim to establish an operationally viable, multi-application AI downscaling workflow to improve the quality of localized climate services.

Key Words：Seasonal Forecast Model, Downscaling