結合季節時序與天氣類型的客觀診斷應用於臺灣旱災預警

Integrating Objective Seasonal Progression and Weather Type Diagnosis for Drought Early Warning in Taiwan

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摘　要

乾旱的發生往往與次季節至季節尺度的降雨及大氣環流異常密切相關。發展次季節氣候監測的技術，對於提升旱災預警能力有其重要性。

本研究參考東亞季風區季節研究的相關文獻，建構一年六個次季節的架構，即為「季節曆」。本研究並運用 44 年高解析 CFSR 再分析資料，搭配深度學習演算法，發展出一套可客觀診斷季節時序進展的技術。此方法透過特徵擷取與相似度比對，判定當前大氣環流狀態所對應的季節階段，進而判定季節進展快慢。以過去 44 年臺灣梅雨季（南海季風）肇始日期為例，比對本技術與文獻定義，結果顯示差距位於合理範圍內，驗證此技術的合理性與適用性。

此外，本研究亦於季節曆架構下，結合東亞多變數環流場與台灣降雨型態，在機器學習演算法輔助之下發展天氣類型分類與辨識技術。此技術搭配季節時序診斷技術，有助我們綜合次季節與綜觀尺度環流特徵來診斷降雨的異常。本研究並以梅雨季為例，示範上述技術於提供旱災預警情資的應用。

目前季節診斷功能已完成自動化，天氣類型辨識自動化亦正進行中，這些產品都已經對外展示於旱災預警平台，提供即時監測服務。

關鍵字：季節時序、機器學習、天氣類型、旱災預警

Abstract

Droughts are often associated with precipitation and atmospheric circulation anomalies at the subseasonal-to-seasonal (S2S) timescale. Developing S2S climate monitoring techniques is therefore essential for enhancing drought early warning capabilities.

In this study, we established a "seasonal calendar" framework consisting of six sub-seasons annually, based on literature related to the East Asian monsoon studies. Using 44 years of high-resolution CFSR reanalysis data, we developed an objective method for diagnosing sub-seasonal progression through a deep learning approach. This method combines feature extraction and similarity comparison to determine which seasonal phase the current atmospheric circulation state best corresponds to and to assess whether the season is progressing earlier, later, or on time. A comparison between our diagnosed onset dates of the Taiwan Meiyu season (i.e., South China Sea monsoon) over the past 44 years and those defined in the literature shows good agreement, demonstrating the method's applicability.

Furthermore, under the seasonal calendar framework, we developed a machine learning–based weather type identification technique that incorporates not only multivariable East Asian circulation fields but also Taiwan's precipitation patterns. Integrating this technique with the seasonal progression diagnostics enables the interpretation of precipitation anomalies from both subseasonal and synoptic-scale perspectives. Using the Meiyu season as an example, we demonstrate the application of these techniques in supporting drought early warning information.

The seasonal progression monitoring procedure has been operationalized, and the weather type identificaiton system is currently being integrated. Both products have been incorporated into the drought early warning platform to provide real-time monitoring services.

Key words: seasonal progression, machine learning, weather type, drought early warning