

# 隨機物理參數擾動（SPP）方法於YSU邊界層參數化方案之應用研究

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## 摘要

臺灣中央氣象署營運中的區域系集預報系統 WEPS (WRF Ensemble Prediction System)，是建構於WRF模式之上的系統，透過多物理參數組合、初始場擾動與側邊界條件擾動產生 20 組系集成員。然而，多物理方案的使用可能導致預報結果聚集 (clustering) 及系統維護上的困難。因此，未來的目標為逐步以單一物理方案結合隨機物理參數擾動法 (SPP) 來取代多物理設定。SPP 是目前許多作業模式常用的擾動方法，透過對特定物理參數或變數加入隨機擾動，依據物理特性引入隨機變異，進而提升系集離散度。

本研究首先將 SPP 方法應用於 YSU 行星邊界層 (PBL) 參數化方案，對其內部數個參數進行擾動，包括用於 PBL 擴散的 K 理論公式參數、以及與混合與穩定度相關的常數。我們分析了對單一或多個 YSU 變數擾動後，對 WEPS 預報離散度所產生的影響。結果顯示，相較於未應用 SPP 的系集預報，加入 SPP 後能有效提升預報準確度與離散度，並改善誤差離散關係。此成果顯示，未來有望以單一邊界層方案結合 SPP，簡化目前複雜的多物理組態結構。

**關鍵詞：**系集預報；隨機物理參數擾動 (SPP)；YSU 邊界層方案

## Application of Stochastic Parameter Perturbation (SPP) Scheme in the YSU PBL Parameterization

### Abstract

The Taiwan Central Weather Administration's operational WRF-model based regional ensemble, the WRF Ensemble Prediction System (WEPS), generates 20 ensemble members using multiple physics schemes, initial condition perturbations, and lateral boundary condition perturbations. However, the use of multiple physics schemes can lead to forecast clustering and maintenance challenges. Therefore, the future plan aims to gradually replace the multiple physics schemes with a single physical parameterization suite combined with Stochastically Perturbed Parametrizations (SPP), a commonly used perturbation method in operational models. SPP introduces random perturbations to specific physical parameters or variables, creating stochastic variability based on changes in physical characteristics, thereby increasing the ensemble spread.

We initially applied SPP to the Yonsei University (YSU) planetary boundary layer (PBL) scheme. Various physical parameters within the YSU scheme were perturbed, including those in the K-theory formula for PBL, as well as

constants related to PBL mixing and stability. The impact of perturbing individual and combinations of YSU PBL variables on the spread of WEPS forecasts was assessed. The results show that introducing SPP perturbations to the YSU scheme indeed improves both forecast accuracy and spread compared to corresponding ensemble forecasts without SPP, leading to an improved spread–error relationship. These findings are promising and suggest it may be possible to eventually simplify the complex structure of the multi-physics WEPS configurations with a single PBL scheme and SPP.

**KEYWORDS:** Ensembles; Stochastically Perturbed Parametrizations (SPP); YSU PBL Scheme