中央氣象局全球波譜模式2時次動力架構發展現況

The development of a two-time-level Semi-Lagrangian scheme in the Central Weather Bureau Global Spectral Model

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摘 要

中央氣象局於民國107年起開始建置新一代高解析度全球天氣模式CWBGFS TCo639L72，此模式採用半拉格朗日法(Semi-Lagrangian)動力架構以及歐洲中期天氣預報中心(European Centre for Medium-Range Weather Forecasts, ECMWF)整合預報系統(Integrated Forecast System, IFS)所使用的八面體網格系統，進一步提升模式積分之穩定度及效能。現階段此模式已有搭配之資料同化系統，目前採以平行作業的方式持續提供最佳之數值預報初始場，並藉此評估此全球預報系統上線作業之可能性。

CWBGFS TCo639L72現今積分時步策略仍採用跳蛙法(Leapfrog method)，亦是所謂的3時次(3 time level)，為了持續提升模式積分之效率，故規劃將時間積分策略更改為2時次，嘗試採用更長之積分時步，以提升積分效率。然而，2時次最大的挑戰便是如何估計正確及穩定的中間時間點(t+1/2)風場以提供計算平流貢獻所使用。我們嘗試透過計算動量方程式取代僅採用線性外插的方式來求得中間時間點的風場。首先，透過現在(t)及過去(t-1)時間的風場外插出中間(t+1/2)時間點的風場，用來將動量方程式中的平流項、氣壓梯度力項及科氏力項由現在時間平流至未來(t+1)。接著，完成前述估計後，我們可以得到未來時間的風場，透過與現在風場相加取平均後，便可得到中間時間點之水平風場。最終，便可再透過連續方程式計算出中間時間點的垂直風場，並藉此進一步對動量方程式、熱力方程式及傳送方程式進行估算而得到未來時間點氣象要素的預報場。2時次的動力架構雖然得額外耗費時間進行中間時間點風場之計算，但其積分時步可以較3時次放大兩倍，且可節省約20%的運算時間。後續除了持續針對動力架構進行改進外，亦將配合提升雲微物理參數化，並評估未來上線作業之可能性。

關鍵字：全球波譜模式、半拉格朗日法、二時次

Abstract

Since 2018, Central Weather Bureau devoted to developing the next generation high resolution global spectral model so called CWBGFS TCo639L72. The model dynamic core already be upgraded to Semi-Lagrangian by using Non-iteration Dimensional-split Semi-Lagrangian (NDSL) method and applied Octahedral reduced Gaussian grid as the grid system. This is not only reducing the utilization of computational resource, but also providing more stable results. Now, our own data assimilation system be used for TCo639L72 to provide the most suitable initial condition in near real time and trying to improve the performance of next generation global ensemble prediction system.

Considering the improvement of efficiency of model, two-time-level time scheme should be applied for more longer time step to replace leapfrog scheme (three-time-level time scheme) which TCo639L72 is using now. However, the biggest challenge of two-time-level scheme is how to estimate the mid-point (t+1/2) wind field correctly to maintain the accuracy and stability of forecast result. We try to estimate mid-point wind field via calculate the momentum equation instead of extrapolating from present (t) and past (t-1) wind field only. First, estimating mid-point wind field from present and past wind field by extrapolated, which are used for estimating the advection term, also advect the pressure gradient and Coriolis force term from present to future (t+1) in momentum equation. Second, we can have future wind field once completed the estimation of momentum equation and estimating the mid-point wind field by averaging present and future wind field. Finally, estimating vertical wind field via continuity equation, and calculating the momentum, thermal and transport equations to complete the integration. Two-time-level scheme takes more time to find mid-point wind field, but it still can save about 20% computational wall time than leapfrog scheme, because of two times longer time step be used. In the future, we will keep improving the dynamic core and upgrade the cloud microphysics for better performance.

Key words: Global Spectral Model, Semi-Lagrangian, two-time-level scheme