氣象局新一代全球天氣預報模式FV3GFS加入隨機擾動物理參數趨勢法之應用

Application of stochastic physics method in new generation global weather prediction system (FV3GFS) at CWB

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摘　　要

中央氣象局之新一代全球預報系統FV3GFS使用混成系集變分資料同化（hybrid EnVar）系統產製模式初始場，其背景誤差協方差是由靜態背景誤差協方差和系集卡爾曼濾波器（EnKF）提供的流場相依（flow-dependent）背景誤差協方差組合而成，共同決定分析場。因此EnKF中系集離散度使否恰當，為決定資料同化系統整體表現的重要因素之一。

然而，我們在建置與測試氣象局FV3GFS之資料同化系統過程中，發現EnKF的系集離散度和背景場均方根誤差相比有明顯偏小的現象。我們推測此離散度不足的原因是因為目前系統中僅使用Relaxation to Prior Spread（RTPS）方法做covariance inflation，而單用此方法可能不足以獲得適當系集離散度。對照本局目前作業的CWBGFS系統，其額外使用了additive inflation的方法來維持足夠的系集離散度，但此方法需要事先建立大量的系集擾動（perturbation）資料庫，執行起來較不方便。因此在FV3GFS中，我們嘗試使用隨機物理參數趨勢法（Stochastic physics）來提供額外的系集離散度，補足原additive inflation的效果。初步結果顯示，在FV3GFS之EnKF系統中使用隨機物理參數趨勢法後，溫度場及風場之系集離散度皆顯著增加，可提供更合適的動態背景誤差協方差，但考量此調整在混成資料同化系統中對於整理預報結果的影響是非常複雜的，需要進行更多資料同化實驗才可以決定隨機物理參數趨勢法之最佳設定及影響。

Abstract

A hybrid ensemble-variational data assimilation (EnVar) system is used to provide initial condition in Central Weather Bureau (CWB)'s new-generation global forecast system, FV3GFS. In the hybrid EnVar, the background error covariance is a combination of the static component and the flow-dependent component computed from an ensemble Kalman filter (EnKF). Therefore, the optimality of the ensemble spread in the EnKF is one of the important factors that determines the overall performance of the data assimilation system.

However, in the development and testing of CWB's FV3GFS system, we have found that the ensemble spread in the EnKF is obviously too small compared to the root-mean-square error of the background field. We think that this insufficient spread would be caused by the inability of the Relaxation to Prior Spread (RTPS) scheme, which is currently the only covariance inflation method used in the FV3GFS, to maintain an optimal ensemble spread. As a reference, the current operational CWBGFS additionally uses an additive inflation method to maintain a sufficient ensemble spread, but it requires a pre-prepared large ensemble perturbation database, which makes it not easy in the

implementation. Therefore, we try to use stochastic physics schemes to provide additional ensemble spread in order to complement the effect by the original additive inflation. Preliminary results show that the ensemble spreads of both temperature and wind fields are significantly increased by enabling the stochastic physics, which should provide more appropriate flow-dependent background error covariance in the data assimilation. Considering that the impact of the changes of the EnKF spread on the overall forecast performance of a hybrid data assimilation system is very complicated, further data assimilation experiments and verifications are needed to determine the optimal configurations of the stochastic physics schemes and their impacts.