臺灣海域三維海流系集同化系統建置

Development of a Three-Dimensional Ocean Current Ensemble Data Assimilation System for the Taiwan Region.

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摘　要

中央氣象局署三維海流作業化預報模式CWA-OCM(Central Weather Administration Ocean Current Model)使用RTOFS及HYCOM全球預報模式初始場及邊界場，以類資料同化方式每日修正模式。目前尚未納入資料同化功能，則對於模式結果修正有限，因此開發臺灣海域三維海流系集同化系統(以下簡稱CWA-OCM-DA)是有所必要。CWA-OCM-DA選用平行化資料同化系統PDAF(Parallel Data Assimilation Framework)做為資料同化演算模組，而採用地球系統模式框架(以下簡稱ESMF耦合器)作為模組交換資料框架，其為少數擁有非結構式網格模式，且能在不更改原始程式碼並以動態函式庫之方式引入。CWA-OCM-DA非採用傳統方式，直接對模式本身進行大幅修改，而是利用ESMF架構(Earth System Modeling Framework)作為主要控制系集計算工具，將原有SCHISM模式程式碼修改至符合ESMF規範，則ESMF為主架構能與其他程式耦合，其ESMF、SCHISM、PDAF皆以函式庫(library)的方式進行對應功能呼叫。未來在三者於版本更新時，CWA-OCM-DA無須更改，可分別直接以各自最新版本進行編譯及計算三者的模式發展各自獨立，各模式發展者專注發展並不相互影響，也不受限版本更新影響，皆以函式庫(library)的方式進行對應功能呼叫，可直接以最新版本進行編譯與計算。本文研究臺灣海域三維海流系集同化系統，以2015年蘇迪勒颱風為案例進行案例測試，使用公開之衛星資料及Argo剖面資料進行資料同化，修正計算結果，得到模式預報之分析場，提供予預報作為初始場進行預報。模式範圍為臺灣周邊海域進行計算產出預報結果，與未同化、衛星資料分析預報第一天之海表面溫度，發現同化後之海表面溫度與衛星資料均方根誤差(RMSE)較小，表示資料同化有效修正模式，提高預報精確度。

關鍵字：非結構式海流模式、海流系集、資料同化

Abstract

The Central Weather Administration Ocean Current Model (CWA-OCM) is a three-dimensional operational forecasting system for ocean currents that uses initial and boundary conditions from global models such as RTOFS and HYCOM. Although the model output is currently adjusted daily using a pseudo data assimilation approach, the absence of a true data assimilation system limits the accuracy of forecast corrections. To address this gap, the development of a dedicated data assimilation system—referred to as the CWA-OCM-DA—is essential.

CWA-OCM-DA integrates the Parallel Data Assimilation Framework (PDAF) as its data assimilation module and adopts the Earth System Modeling Framework (ESMF) as the data exchange interface. ESMF is one of the few frameworks capable of supporting unstructured grid models and allows integration without modifying the original source code, relying instead on dynamic libraries.

Unlike traditional approaches that require extensive modifications to the model code, CWA-OCM-DA utilizes ESMF to control ensemble computations. The SCHISM model code is adapted to comply with ESMF specifications,

enabling seamless coupling with other components. All modules—ESMF, SCHISM, and PDAF—are treated as independent libraries, allowing each to be updated and compiled separately without interfering with one another. This modular design ensures long-term maintainability and compatibility across future versions.

This study applies the CWA-OCM-DA system to simulate Typhoon Soudelor (2015) as a case study. Publicly available satellite data and Argo profile observations are assimilated to correct model outputs and generate analysis fields that serve as improved initial conditions for forecasts. The model domain covers the waters surrounding Taiwan. Results show that the assimilated sea surface temperature (SST) forecasts exhibit reduced root mean square error (RMSE) when compared with satellite observations on the first forecast day, demonstrating the effectiveness of the data assimilation system in improving forecast accuracy.

Key words : Unstructured Ocean Current Model, Ocean Current Ensemble, Data Assimilation