Improving Air–Sea Consistency through Weakly Coupled Atmosphere–Ocean Data Assimilation in the KIM (Korean Integrated Model) Coupled Earth System

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Abstract

Weakly coupled data assimilation (WCDA) has been proposed as an effective approach for improving consistency between atmosphere and ocean analyses while maintaining separate data assimilation systems. In this study, a WCDA system was developed and evaluated within the Korean Integrated Model (KIM) coupled Earth system and compared with a conventional uncoupled data assimilation (UCDA) configuration during the summer of 2022.

The WCDA framework exchanges surface boundary information between atmospheric and oceanic components during the assimilation cycle, enabling improved cross-component consistency at the air–sea interface. Compared to UCDA, WCDA reduces discrepancies between near-surface air temperature and sea surface temperature, indicating improved atmosphere–ocean coupling consistency and providing more physically consistent coupled initial conditions.

In the ocean, WCDA enhances temperature and salinity analyses and forecasts, particularly in the Northern Hemisphere subsurface ocean. In the atmosphere, WCDA improves near-surface analyses by reducing errors in temperature, specific humidity, and wind speed, with benefits extending to 5-day forecasts.

Overall, these results demonstrate that WCDA improves both atmospheric and oceanic forecast performance while enhancing physical consistency at the air–sea interface. This study highlights the importance of atmosphere–ocean consistency in coupled data assimilation and supports the future development of fully coupled Earth system prediction within KIM.