Implementation of Terrain Resolving Component by Immersed Boundary Method for Variational Doppler Radar Analysis System (VDRAS)

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Introduction

A 4DVAR Doppler radar retrieval system for high-resolution and rapid updated analysis. Installed in more than 20 sites since 1999. (Sun and Crook, 1997)

Cloud model inside the system has no ability to resolve terrain.

Improve the accuracy of analysis even short-term Quantitative Precipitation Forecast (QPF) by implementing terrain resolving ability for VDRAS.

Ghost-cell immersed boundary method (GCIBM)

Tseng and Ferziger (2003)

Ghost-cell: first grid point under terrain surface (immersed boundary).

Imposing terrain boundary condition implicitly by updating ghost-cell value.

Update every time step in model integration. Terrain effect gradually obtained.

Variables updated: U, V, W, q, and qr.

2-D linear mountain wave simulation

Simulated for comparisons with the available analytic solution (Smith, 1980).

Isothermal atmosphere (dT/dz = 0), T = 250 K. Bell-shaped mountain.

Parameters: wind speed = 20 m s⁻¹, terrain half-width = 10 km, max. height = 1 m.

Model resolutions: ∆x = 2 km, ∆z = 200 m.

Parallel forecast with WRF model

Both models are initialized by the same sounding profile (squall line).

Pseudophysics scheme: Kessler (warm rain process).

Terrain: half-width = 10 km, maximum height = 2 km.

VDRAS cloud model resolutions: ∆x = 1 km, ∆z = 250 m. (161 x 141 x 50 grids)

OSSE: data assimilation experiment

Verification for adjoint model and assimilation scheme.

Virtual radial wind and rainwater mixing ratio from WRF are assimilated (full domain coverage).

Assimilation strategy and experiment design:

WRF forecast (Truth) VDRAS retrieval WRF forecast (Truth) VDRAS retrieval

WRF forecast VDRAS forecast

VDRAS cloud model with IBM could generate similar convection evolution as WRF model.

Cold pool propagation dominates convection development.

Summary and future work

Parallel forecast shown the terrain-resolving capability of modified forward model.

OSSE results display the surprising performance of assimilation scheme, and proved the completeness of modified adjoint model.

Application to real cases with terrain-interacted convections, which can provide convective-scale analysis and even short-term QPF.

References and acknowledgments


This research is sponsored by Central Weather Bureau of Taiwan, under Grant M0TC-CWB-103-M-06.