Are non-hydrostatic dynamics necessary in climate simulations of Midwest convective systems?

Christopher J. Anderson, Iowa State University

Problem

Midwest mesoscale convective systems (MCSs) develop from non-hydrostatic processes as they self-organize from convective elements into a coherent, stable mesoscale circulation. Since MCSs produce most of the Midwest warm-season rainfall, it is natural to ask whether regional climate simulations of warm-season rainfall are improved when the climate model uses a non-hydrostatic dynamic core.

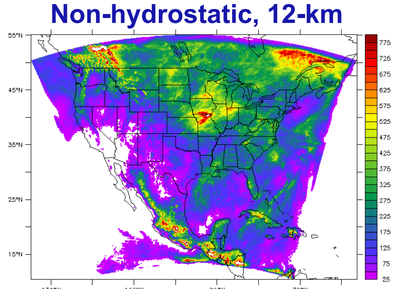
Experiment

A large number of MCSs occurred during the Midwest flood period of 1993 June-July, and their aggregate effect is evident in mean fields.

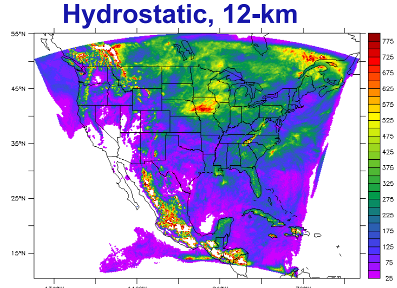
This period is simulated with the Weather Research and Forecast model using 12-km and 24-km grid spacing. For each grid spacing, two simulations are performed: one with and one without hydrostatic dynamics.

Results

Non-hydrostatic, 12-km



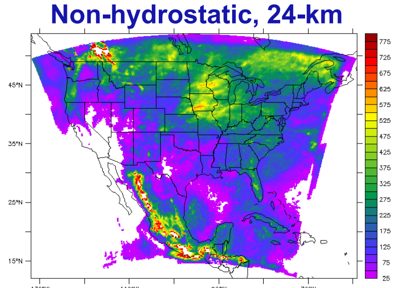
Hydrostatic, 12-km



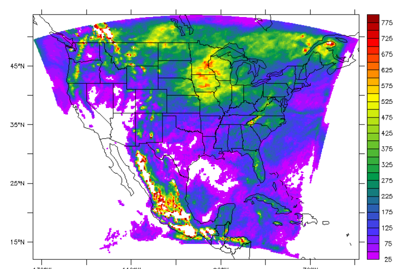
WRF Parameterization Settings

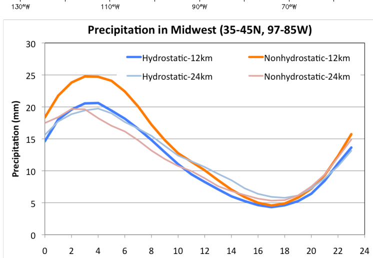
Modified Kain-Fritsch CPS
Thompson Microphysics
ETA Similarity Surface Layer
MYJ Boundary Layer
NOAH LSM
RRTMG Longwave
RRTMG Shortwave

Non-hydrostatic, 24-km



Hydrostatic, 24-km





Main Results

All simulations produce a region of rainfall within the Midwest exceeding 500 mm.

The region of maximum rainfall is considerably more focused in 12-km compared to 24-km simulation.

Peak hourly rainfall amount is similar among all simulations except the 12-km non-hydrostatic simulation.

Summary and Ongoing Work

Further diagnostics of convective heating profiles and position of rainfall relative to low-level fronts and low-level jets will elucidate whether non-hydrostatic dynamics improves coupling of mesoscale processes.

Non-hydrostatic dynamics have noticeable impacts at 12-km and less noticeable impacts at 24-km.

The question of whether non-hydrostatic dynamics improves warm-season rainfall is dependent on perspective. Non-hydrostatic dynamics appear less necessary for seasonal, regional anomaly than for hourly rainfall rate.