4B.4 - The New Ferrier-Aligo (F-A) Microphysics in the 3-km NAM CONUS Nest

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Introduction

• The new F-A scheme is part of the version 4 North American Modeling (NAMv4) upgrade (February 2017 implementation)

• Results will be shown only from 3-km NMMB runs

• Only a subset of the microphysics changes will be described
Primary Microphysics Changes

• Increased the area of stratiform anvils & reduced high reflectivity biases at upper levels
  ✓ Larger # conc. of snow ($N_s$) at cold temperatures away from convection
• Improved vertical structure of stratiform radar reflectivity
  ✓ Assumed mean drop sizes ($\overline{D_r}$) fixed with height below melting layers
• Reduced widespread light reflectivity from shallow PBL clouds
  ✓ Added a drizzle scheme for low clouds where warm-rain processes dominate

✓ Changes based on comparing with Thompson microphysics runs
• $Z_n$ is the first (lowest) model level where $T < 0^\circ C$
• $Z_{n-1}$ is where ice melts to form rain at $>0^\circ C$
• Drops evaporate in dry air below cloud base until reaching $Z_1$ (1st model level above the surface)
• Two different assumptions for drop size spectra:
  1. OLD: Fixed intercept ($N_{0r}$), variable mean diameter ($\bar{D}_r$) that decreases as rain falls towards the ground ... vs ...
  2. NEW: Fixed mean diameter ($\bar{D}_r$), variable intercept ($N_{0r}$) that decreases as rain falls towards the ground
Stratiform Rain Parameterization (2 of 2)

OLD F-A

NEW F-A

Assume Fixed $N_0$ during rain evaporation

1. Smallest change in # of small drops
2. Largest change in # of large drops

Assume Fixed $\overline{D} = \lambda^{-1}$ during rain evaporation

3. Fewer small drops, less rain evaporates
4. Similar change in # of drops of all sizes

$N(D) = N_0 \cdot \exp(-\lambda \cdot D)$

$\lambda_{n-1} = \lambda$ at $Z_{n-1}$

$\lambda_1 = \lambda$ at $Z_1$

$N_{01} = N_0$ at $Z_{n-1}$

$N_{02} = N_0$ at $Z_1$

$N_{02} < N_{01}$
6-h Valid at 21Z 29 June 2012 Derecho (1 of 2)

A - Larger Ns reduced snow reflectivity aloft in stratiform anvils
B - Stratiform rain scheme increased rain reflectivity & rainfall below anvils
Drizzle Parameterization (1 of 2)

- Drizzle forms from low-level liquid clouds at \(>0^\circ C\)
- It is completely disconnected from rain formed from melting ice
- Assumes smaller, more numerous drops
- Parameterized by *increasing* \(N_{0r}\) (opposite of stratiform rain)
Drizzle Parameterization (2 of 2)

- Drizzle is limited to rain contents \( Q_r = \rho \cdot q_r < 0.5 \) g m\(^{-3}\)
- \( N_{0r} \) increases with decreasing \( Q_r \)

\[
N_{0r} = \begin{cases} 
10^9 \text{ m}^{-4}, & Q_r \leq 0.02 \text{ g m}^{-3} \\
8 \times 10^6 \text{ m}^{-4} \times (0.5 \text{ g m}^{-3}/Q_r)^{1.5}, & 0.02 \text{ g m}^{-3} < Q_r < 0.5 \text{ g m}^{-3} \\
8 \times 10^6 \text{ m}^{-4}, & Q_r \geq 0.5 \text{ g m}^{-3} 
\end{cases}
\]

\( (N_L = N_0 \) for exponential distributions)
Improved Composite Reflectivity from Drizzle

OLD F-A

Echoes from small raindrops formed in thin PBL clouds.

12-h valid 12Z on 23 June 2016

NEW F-A

Reduced areas of < 20 dBZ due to new drizzle scheme
Real-Time Composite Reflectivity Statistics

1 June – 20 Sept 2016 (06 h – 60 h @6h)

Critical Success Index (CSI)

- 12-km NAM
- 12-km NAMX
- 4-km Nest
- 3-km NestX

NEW F-A => OLD F-A
=> NEW F-A

Frequency Bias = \frac{FCST}{OBS}

Bias = 1

1/24/2017
28th WAF/24th NWP Conf
Real-Time 1-km AGL Reflectivity Statistics

1 June – 20 Sept 2016 (06 h – 60 h @6h)

Critical Success Index (CSI)

Frequency Bias = \frac{FCST}{OBS}

Bias = 1

1/24/2017

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Reduced High QPF Biases (Warm Season)

- Improved data assimilation methods described in 3B.4 (Rogers et al.), Poster 1204 (Carley et al.), & Session 9.5 of IOAS Conf (Liu et al.)
- Other model changes also described in Poster 1205 (Ferrier et al.)

0-12h Rainfall from 19 July 2016

Observations

4-km Ops Nest

3-km Parallel Nest

3 inches

15 inches

(Old F-A)

(New F-A)

4 inches
Precipitation Scores

19 July – 29 August 2016
(0-24 h + 12-36 h + 24-48 h + 36-60 h)

Old
New

Bias = 1 (perfect)
Summary

• The F-A microphysics changes played a part of the NAMv4 upgrade, resulting in
  – Improved composite and 1-km AGL radar reflectivity (and vertical radar reflectivity structure)
  – Improved (reduced) high QPF biases in the current 4-km ops NAM CONUS nest

• These changes will be most noticeable during the warm season
Future Work

• Evaluate multiple microphysics packages (F-A, Thompson, WSM6) in regional 3-km FV3 runs as part of the regional NAMv4 CONUS nest physics suite