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

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Introduction

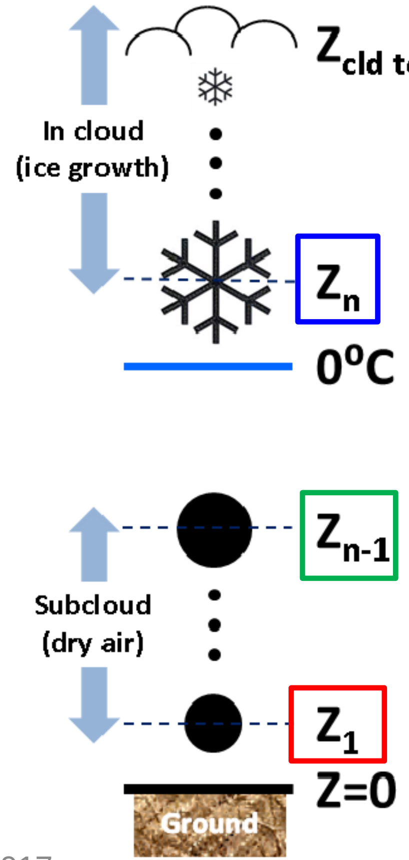
- **The new F-A scheme is part of the version 4 North American Modeling (NAMv4) upgrade (February 2017 implementation)**
- **Results will be shown only from 3-km NMMB runs**
- **Only a subset of the microphysics changes will be described**

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

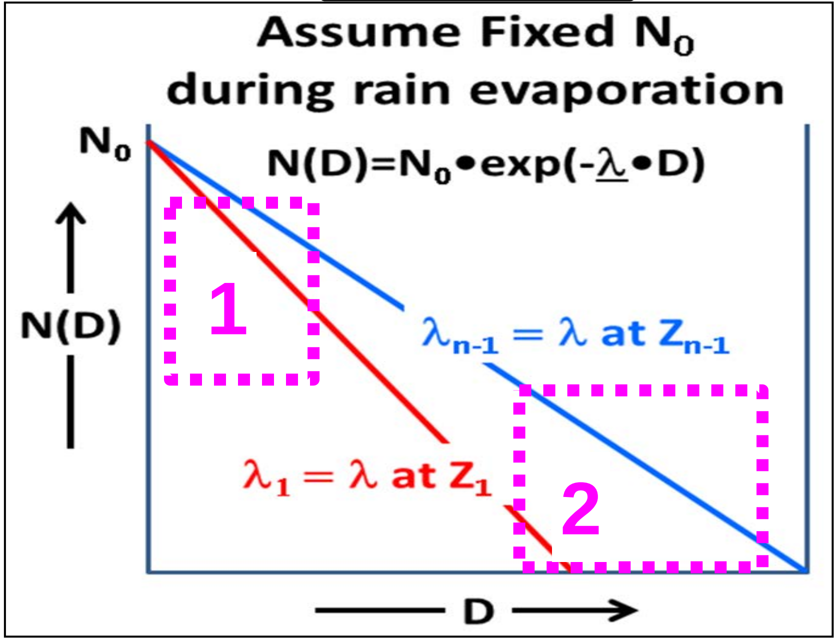
Stratiform Rain Parameterization (1 of 2)



- $\boxed{Z_n}$ is the first (lowest) model level where T < 0^oC
- $\boxed{Z_{n-1}}$ is where ice melts to form rain at >0^oC
- Drops evaporate in dry air below cloud base until reaching $\boxed{Z_1}$ (1^{st} model level above the surface)
- Two different assumptions for drop size spectra:
  1. OLD: Fixed intercept (N_{0r}), variable mean diameter $(\overline{D_r})$ that *decreases* as rain falls towards the ground ... vs ...
  2. NEW: Fixed mean diameter $(\overline{D_r})$, variable intercept (N_{0r}) that *decreases* as rain falls towards the ground

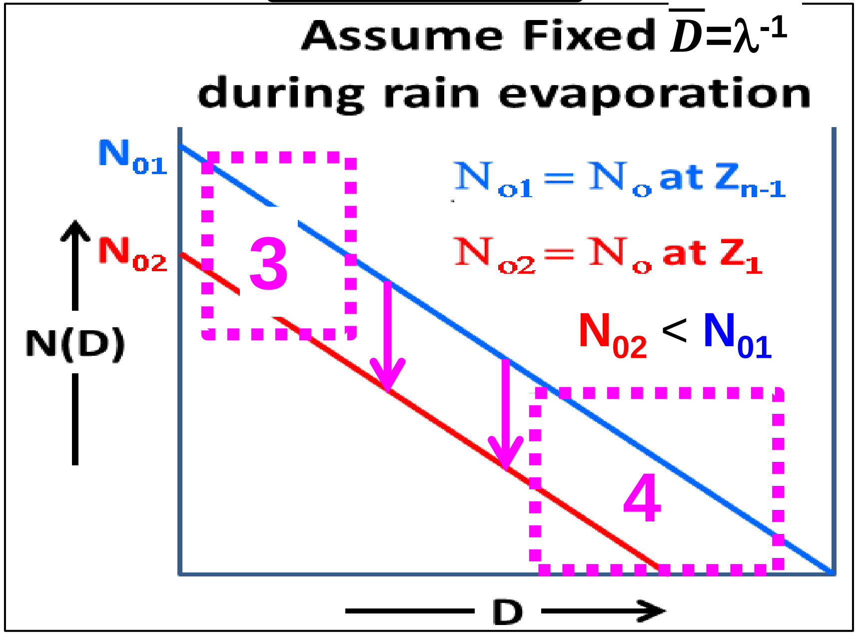
Stratiform Rain Parameterization (2 of 2)

OLD F-A



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

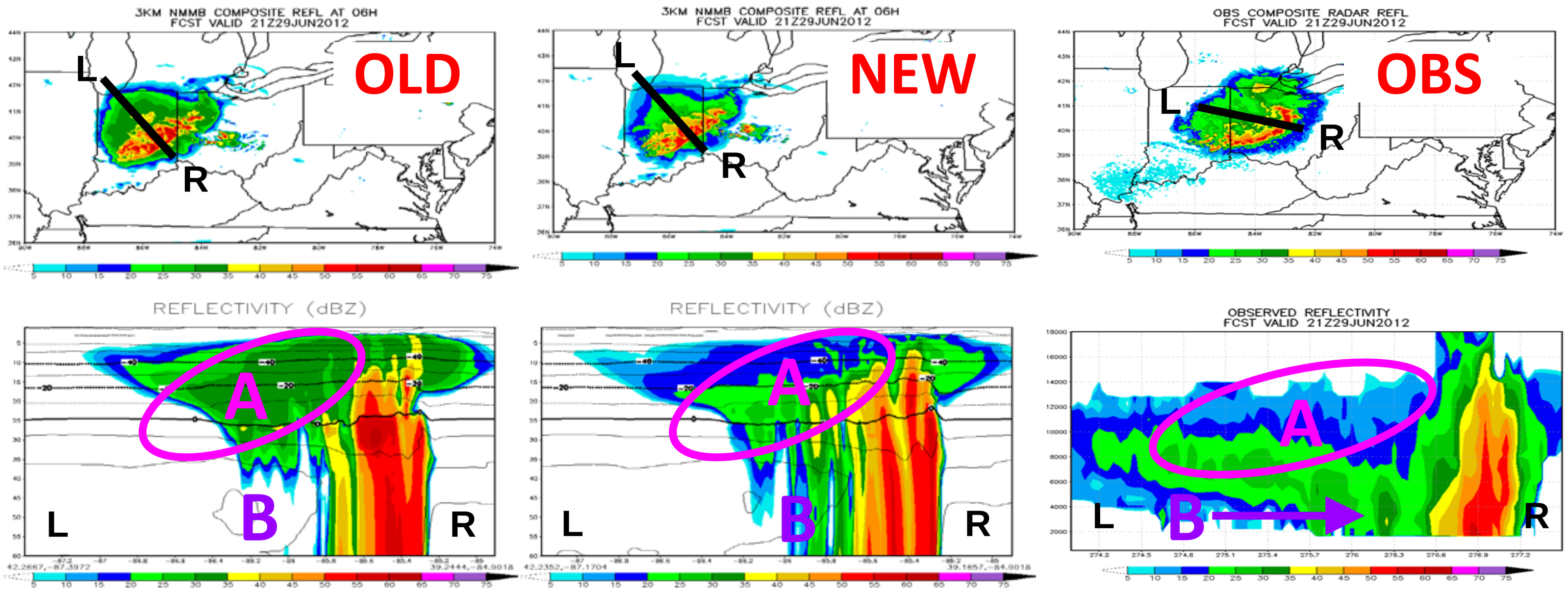
NEW F-A



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

6-h Valid at 21Z 29 June 2012 Derecho (1 of 2)

(Forecasts - stretched vertical coordinate)



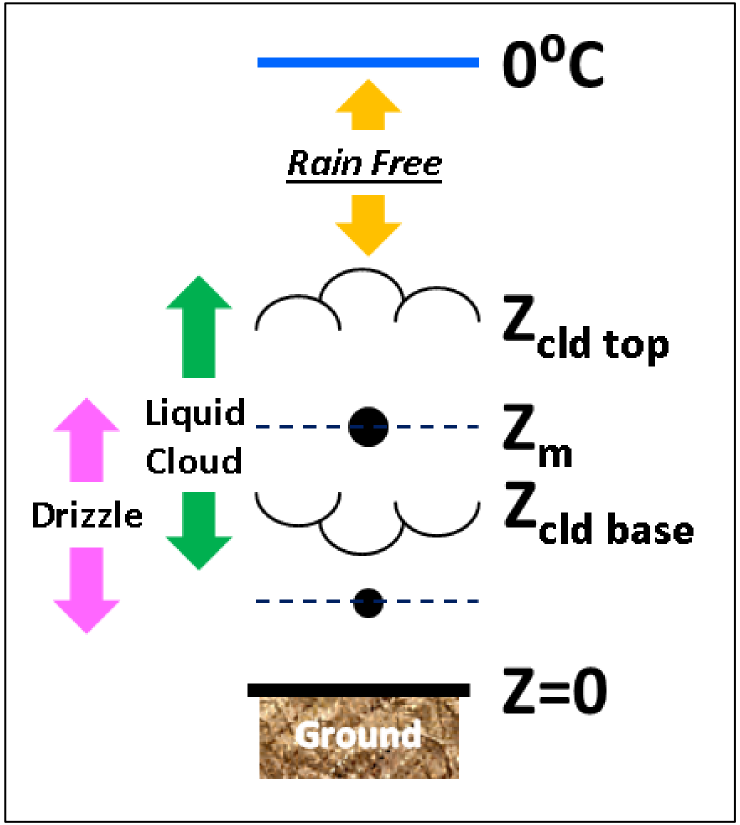
(Observations - linear height coordinate)

A - Larger N_s 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°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)



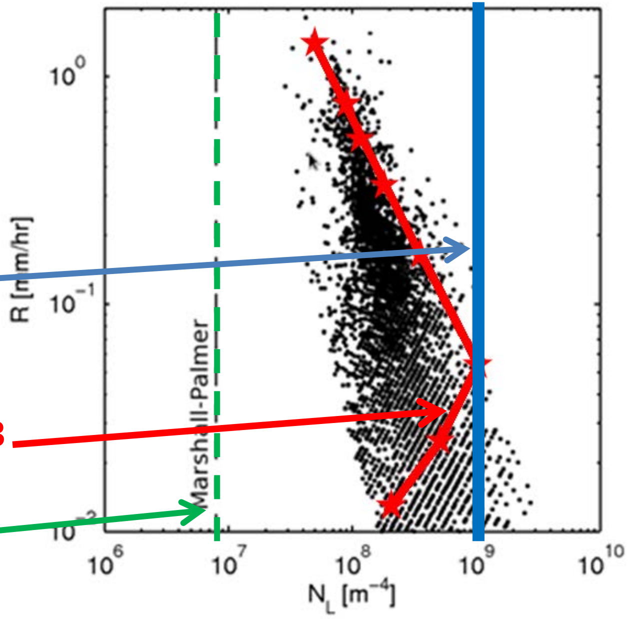
Drizzle Parameterization (2 of 2)

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

$$N_{0r} = \begin{cases} 10^9 \text{ m}^{-4}, & Q_r \leq 0.02 \text{ g m}^{-3} \\ 8\times10^6 \text{ m}^{-4} * (0.5 \text{ g m}^{-3}/Q_r)^{1.5}, & 0.02 \text{ g m}^{-3} < Q_r < 0.5 \text{ g m}^{-3} \\ 8\times10^6 \text{ m}^{-4}, & Q_r \geq 0.5 \text{ g m}^{-3} \end{cases}$$

(default value in old F-A)

Fig. 12 from Westbrook *et al.* (2010, *Atmos. Meas. Tech.*)

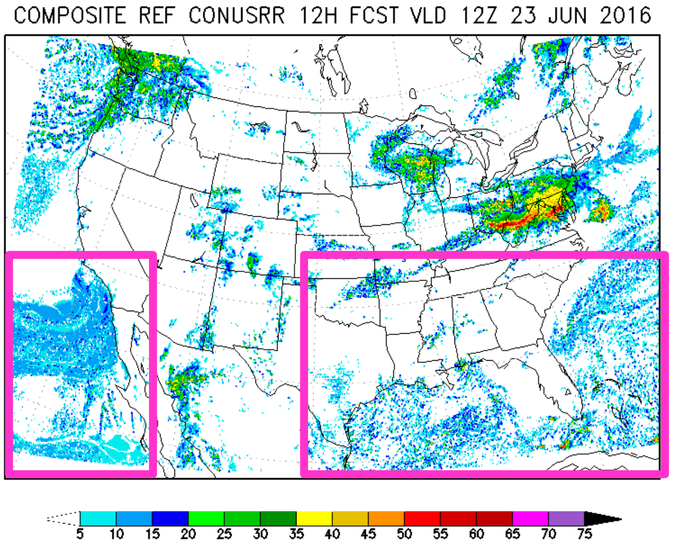


($N_L = N_0$ for exponential distributions)

Improved Composite Reflectivity from Drizzle

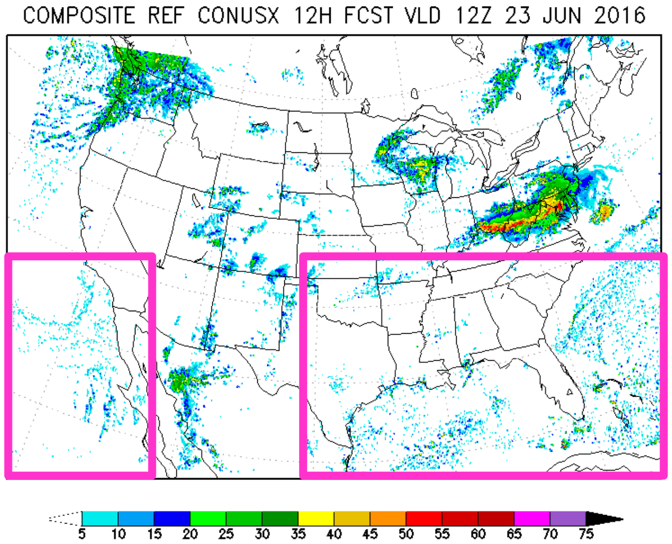
12-h valid
12Z on 23 June 2016

OLD F-A



Echoes from small raindrops formed in thin PBL clouds.

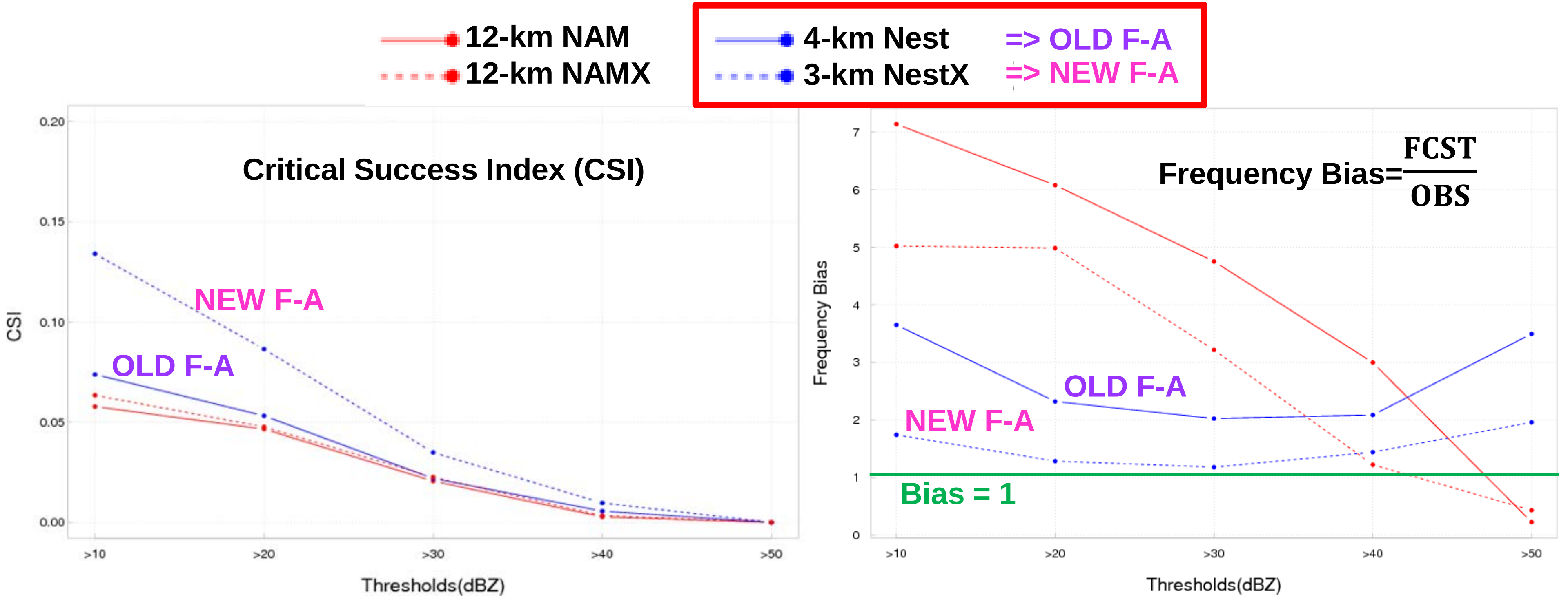
NEW F-A



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)

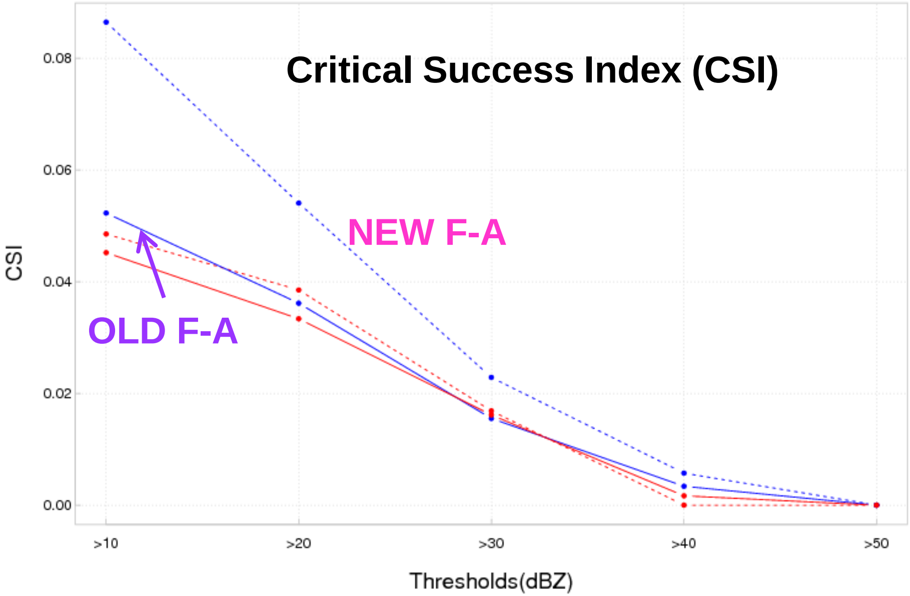


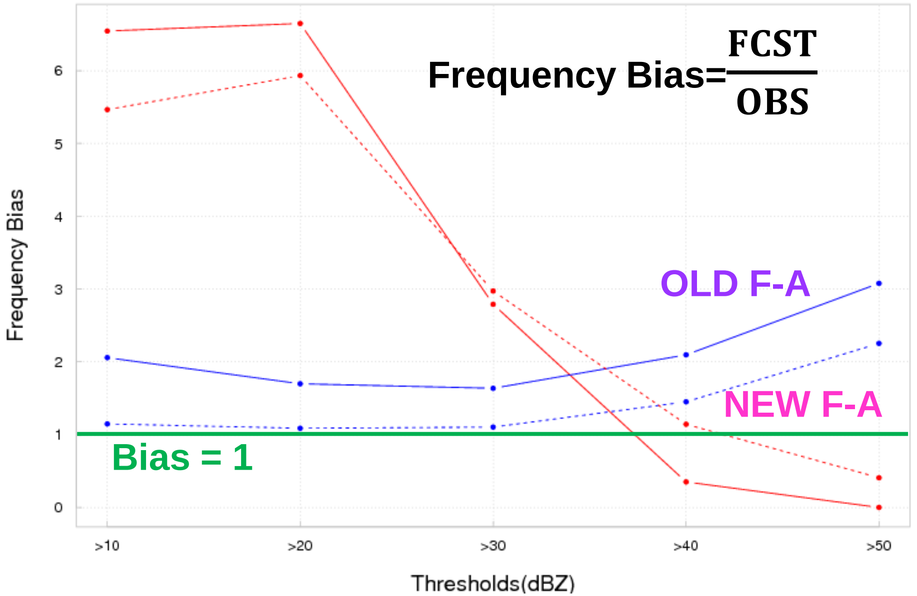
Real-Time 1-km AGL Reflectivity Statistics

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

12-km NAM
12-km NAMX

4-km Nest => OLD F-A
3-km NestX => NEW F-A



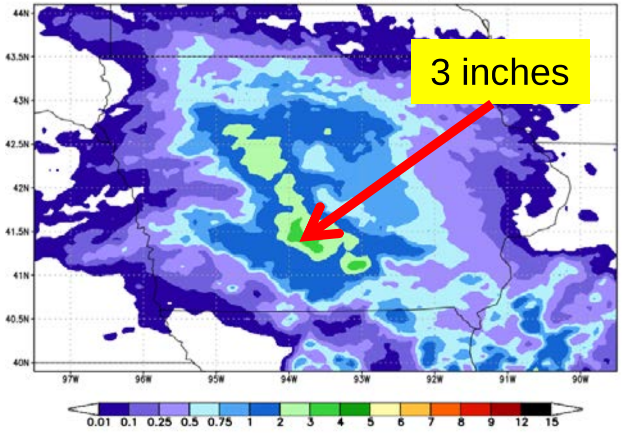


Reduced High QPF Biases (Warm Season)

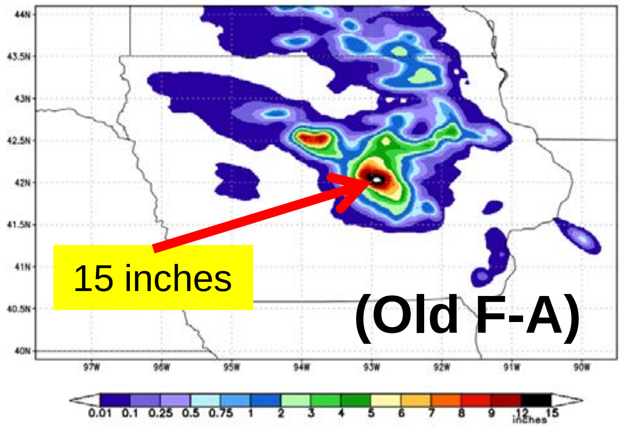
- **Improved data assimilation methods described in 3B.4 (Rogers *et al*.), Poster 1204 (Carley *et al*.), & Session 9.5 of IOAS Conf (Liu *et al*.)**
- **Other model changes also described in Poster 1205 (Ferrier *et al*.)**

0-12h Rainfall from 19 July 2016

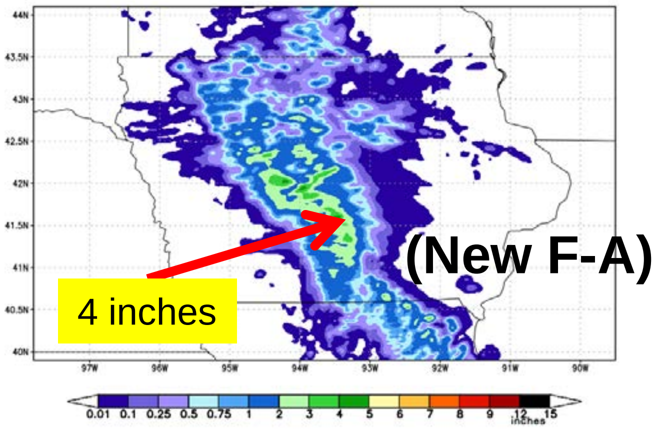
Observations



4-km Ops Nest



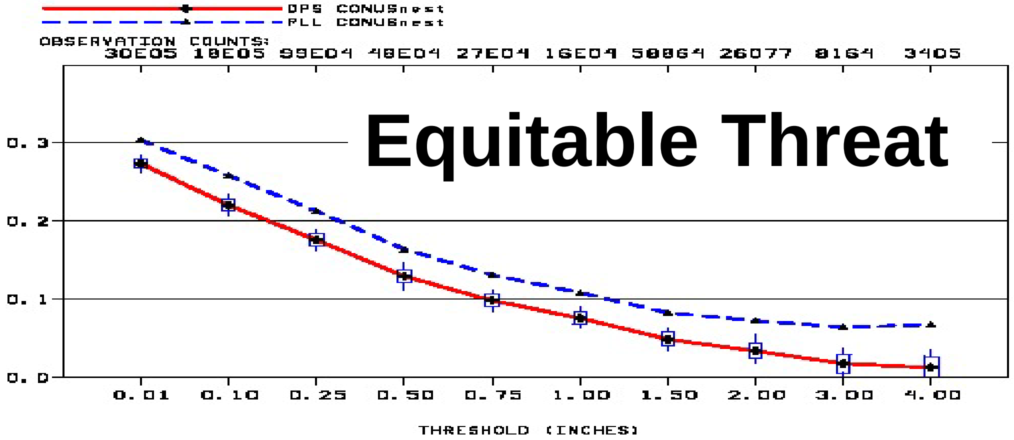
3-km Parallel Nest

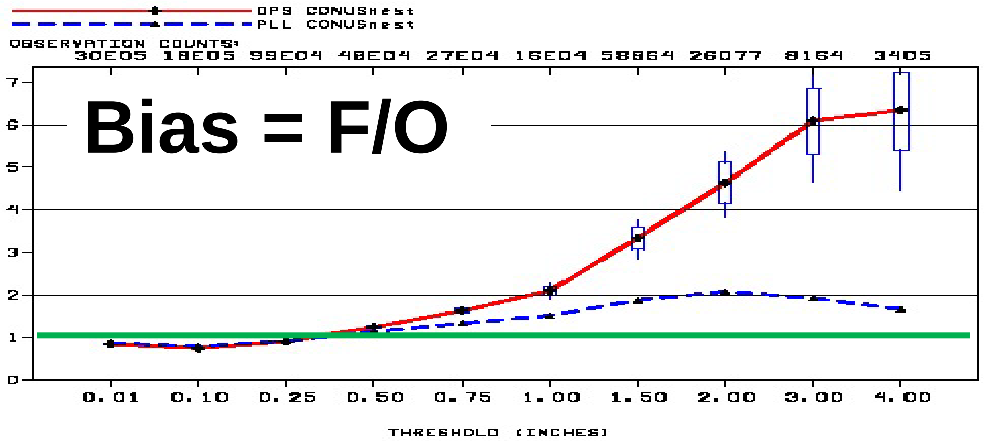


Precipitation Scores

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