CAPS Storm-Scale Ensemble Forecasts for the NOAA 2012 HWT Spring Experiment: New Features and QPF Verification

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In collaboration with: SPC, NSSL, NICS, NESDIS, CIRA, CIMSS

13th WRF Users Workshop, June 25-29, Boulder, CO
Outline

• History
• 2012 configuration highlight
• QPF verification
• Simulated synthetic GOES brightness temperature products
• SKEB in convection-allowing resolution
# CAPS SSEF history

<table>
<thead>
<tr>
<th></th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Member</strong></td>
<td>10</td>
<td>10</td>
<td>20</td>
<td>26</td>
<td>51</td>
<td>28</td>
</tr>
<tr>
<td><strong>Domain (grid spacing)</strong></td>
<td>2/3 CONUS (4 km)</td>
<td>3/4 CONUS (4 km)</td>
<td>3/4 CONUS (4 km)</td>
<td>Full CONUS (4 km)</td>
<td>Full CONUS (4 km)</td>
<td>Full CONUS (4 km)</td>
</tr>
<tr>
<td><strong>Forecast</strong></td>
<td>33 h</td>
<td>30 h</td>
<td>30 h</td>
<td>30 h</td>
<td>36 h</td>
<td>36 h</td>
</tr>
<tr>
<td><strong>NWP Model</strong></td>
<td>WRF-ARW (v2.2)</td>
<td>WRF-NMM, ARW (v3.0.1.1) ARPS</td>
<td>ARW, NMM (v3.1.1) ARPS</td>
<td>ARW, NMM (v3.2.1) ARPS</td>
<td>ARW, NMM (v3.3.1) ARPS, COAMPS</td>
<td></td>
</tr>
<tr>
<td><strong>Radar DA</strong></td>
<td>No radar</td>
<td>Radial wind &amp; reflectivity</td>
<td>Radial wind &amp; reflectivity</td>
<td>Radial wind &amp; reflectivity</td>
<td>Radial wind &amp; reflectivity</td>
<td></td>
</tr>
</tbody>
</table>

*Funded primarily by the NOAA CSTAR program, and leveraged by other NSF, NOAA and ONR grants*
Major changes from 2011

- **WRF version 3.3.1** is used for 2012 season. (ARPS v5.3)
- Total **28** SSEF members (4 km grid spacing) at 0000 UTC, running on *Kraken* at NICS
- Added **3** COAMPS members, including one with the new 2-moment Milbrandt-Yau microphysics CAPS just added into COAMPS
- **Upgraded** CI and Lightning Threat algorithm (in ARW members)
- **Native reflectivity algorithm** from each microphysics scheme
- **Synthetic GOES satellite IR** radiance and BTs (for GOES-R Proving Ground)
- A 5-member sub-ensemble with WRF-ARW newly available stochastic kinetic energy backscatter (**SKEB**) perturbation (Berner et al. 2011)
- A new **1200 UTC** initiated SSEF (15-member), running on local computer system (new OSCER *Boomer* – unable to fulfill due to hardware not fully in place)
2012 CAPS SSEF highlight

- 28 ensemble members (4-km grid spacing)
  - 23 WRF-ARW members (with a parallel 5-member with SKEB)
  - 1 WRF-NMM members
  - 1 ARPS member
  - 3 COAMPS member (experimental)
- 36h forecast, starting 00 UTC Mon-Fri
- Run on NICS Kraken (~9000 cores, 7 h)
- April 23 – June 8 (HWT: May 7 - June 8)
2012 Spring Experiment Domains

3DVAR
1200x780

ARW, ARPS, COAMPS & verification
1160x720

51 vertical levels

NMM
790x999
2012 ARW member configuration (23)

<table>
<thead>
<tr>
<th>Member</th>
<th>IC</th>
<th>BC</th>
<th>Radar data</th>
<th>Microphy</th>
<th>LSM</th>
<th>PBL</th>
</tr>
</thead>
<tbody>
<tr>
<td>arw_cn ▲</td>
<td>00Z ARPSa</td>
<td>00Z NAMf</td>
<td>yes</td>
<td>Thompson</td>
<td>Noah</td>
<td>MYJ</td>
</tr>
<tr>
<td>arw_c0 (18h)</td>
<td>00Z ARPSa</td>
<td>00Z NAMf</td>
<td>no</td>
<td>Thompson</td>
<td>Noah</td>
<td>MYJ</td>
</tr>
<tr>
<td>arw_m3 ▲</td>
<td>arw_cn + em-p1_pert</td>
<td>21Z SREF em-p1</td>
<td>yes</td>
<td>Morrison</td>
<td>RUC</td>
<td>YSU</td>
</tr>
<tr>
<td>arw_m4</td>
<td>arw_cn + nmm-n2_pert</td>
<td>21Z SREF nmm-n2</td>
<td>yes</td>
<td>Morrison</td>
<td>Noah</td>
<td>MYJ</td>
</tr>
<tr>
<td>arw_m5</td>
<td>arw_cn + em-n2_pert</td>
<td>21Z SREF em-n2</td>
<td>yes</td>
<td>Thompson</td>
<td>Noah</td>
<td>ACM2</td>
</tr>
<tr>
<td>arw_m6 ▲</td>
<td>arw_cn + rsm-n2_pert</td>
<td>21Z SREF rsm-n2</td>
<td>yes</td>
<td>M-Y</td>
<td>RUC</td>
<td>ACM2</td>
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<td>arw_m7</td>
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<td>WDM6</td>
<td>Noah</td>
<td>MYNN</td>
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<td>arw_m8 ▲</td>
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<td>RUC</td>
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<td>arw_m9</td>
<td>arw_cn + etaKF-p1_pert</td>
<td>21Z SREF etaKF-p1</td>
<td>yes</td>
<td>M-Y</td>
<td>RUC</td>
<td>YSU</td>
</tr>
<tr>
<td>arw_m10 ▲</td>
<td>arw_cn + etaKF-n1_pert</td>
<td>21Z SREF etaKF-n1</td>
<td>yes</td>
<td>WDM6</td>
<td>Noah</td>
<td>QNSE</td>
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<tr>
<td>arw_m11</td>
<td>arw_cn + etaBMJ-p1_pert</td>
<td>21Z SREF etaBMJ-p1</td>
<td>yes</td>
<td>M-Y</td>
<td>Noah</td>
<td>MYNN</td>
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<tr>
<td>arw_m12</td>
<td>00Z ARPSa</td>
<td>00Z NAMf</td>
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<td>Thompson</td>
<td>Noah</td>
<td>MYNN</td>
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<td>arw_m13</td>
<td>00Z ARPSa</td>
<td>00Z NAMf</td>
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<td>Thompson</td>
<td>Noah</td>
<td>ACM2</td>
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<td>arw_m14</td>
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<td>M-Y</td>
<td>Noah</td>
<td>MYJ</td>
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<td>arw_m15</td>
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<td>Morrison</td>
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<td>MYJ</td>
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<tr>
<td>arw_m16</td>
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<tr>
<td>arw_m17</td>
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<td>00Z NAMf</td>
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<td>Thompson</td>
<td>Noah</td>
<td>YSU</td>
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<td>arw_m19*</td>
<td>00Z ARPSa</td>
<td>00Z NAMf</td>
<td>yes</td>
<td>Thompson</td>
<td>Noah</td>
<td>MYJ</td>
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<tr>
<td>arw_m20*</td>
<td>arw_cn + em-p1_pert</td>
<td>21Z SREF em-p1</td>
<td>yes</td>
<td>Morrison</td>
<td>RUC</td>
<td>YSU</td>
</tr>
<tr>
<td>arw_m21*</td>
<td>arw_cn + rsm-n2_pert</td>
<td>21Z SREF rsm-n2</td>
<td>yes</td>
<td>M-Y</td>
<td>RUC</td>
<td>ACM2</td>
</tr>
<tr>
<td>arw_m22*</td>
<td>arw_cn + rsm-p1_pert</td>
<td>21Z SREF rsm-p1</td>
<td>yes</td>
<td>WDM6</td>
<td>RUC</td>
<td>MYJ</td>
</tr>
<tr>
<td>arw_m23*</td>
<td>arw_cn + etaKF-n1_pert</td>
<td>21Z SREF etaKF-n1</td>
<td>yes</td>
<td>WDM6</td>
<td>Noah</td>
<td>QNSE</td>
</tr>
</tbody>
</table>

For all ARW members: ra_lwPhysics = RRTM; ra_swPhysics = Goddard; cuPhysics = none

SKEB
### 2012 NMM member configuration (1)

<table>
<thead>
<tr>
<th>member</th>
<th>IC</th>
<th>BC</th>
<th>Radar data</th>
<th>mp_phy</th>
<th>lw_phy</th>
<th>sw-phy</th>
<th>sf_phy</th>
</tr>
</thead>
<tbody>
<tr>
<td>nmm_cn</td>
<td>00Z ARPSa</td>
<td>00Z NAMf</td>
<td>yes</td>
<td>Ferrier</td>
<td>GFDL</td>
<td>GFDL</td>
<td>Noah</td>
</tr>
</tbody>
</table>

For all NMM members: *pbl_physics=MYJ; cu_physics=none*

### 2012 ARPS member configuration (1)

<table>
<thead>
<tr>
<th>member</th>
<th>IC</th>
<th>BC</th>
<th>Radar data</th>
<th>Microphy.</th>
<th>radiation</th>
<th>sf_phy</th>
</tr>
</thead>
<tbody>
<tr>
<td>arps_cn</td>
<td>00Z ARPSa</td>
<td>00Z NAMf</td>
<td>yes</td>
<td>Lin</td>
<td>Chou/Suarez</td>
<td>Force-restore</td>
</tr>
</tbody>
</table>

For all ARPS members: no cumulus parameterization

### 2012 COAMPS member configuration (3)

<table>
<thead>
<tr>
<th>member</th>
<th>IC</th>
<th>BC</th>
<th>Radar data</th>
<th>Microphy.</th>
<th>radiation</th>
<th>sf_phy</th>
</tr>
</thead>
<tbody>
<tr>
<td>cmps_cn</td>
<td>00Z ARPSa</td>
<td>00Z NAMf</td>
<td>yes</td>
<td>Hobbs-Rutledge</td>
<td>-</td>
<td>-</td>
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<tr>
<td>cmps_c1</td>
<td>00Z ARPSa</td>
<td>00Z NAMf</td>
<td>yes</td>
<td>M-Y</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>cmps_c0</td>
<td>00Z NAMa</td>
<td>00Z NAMf</td>
<td>no</td>
<td>Hobbs-Rutledge</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Members in red contribute to the **12-member baseline ensemble** for post-processing
Spaghetti of cref = 35 dBZ
(24-h fcst, valid 00Z May 30, 2012)
QPF verification
ETS for 3-h accumulated precipitation
(2011 data)
ETS of 3-h accumulated precipitation ≥ 0.1 in

NAM-12 driven

SREF driven (IC pert/LBCs)
ETS of 3-h accumulated precipitation $\geq 0.5$ in
ETS of 3-h accumulated precipitation

≥ 0.1 in

≥ 0.5 in
BIAS of 3-h accumulated precipitation

≥ 0.1 in

≥ 0.5 in
ETS of 3-h accumulated precipitation
-- microphysics impact

≥ 0.01 in

≥ 0.1 in

≥ 0.5 in
ETS of 3-h accumulated precipitation -- PBL scheme impact

- ≥ 0.1 in
- ≥ 0.5 in
- ≥ 0.01 in
Synthetic satellite IR imagery

• Three radiative transfer models (RTMs)
  – CRTM, CIRA RTM, CIMSS RTM
• Support various sensors, mainly GOES IR imagers
• Programmed into CAPS post-processing module
• Run in realtime using MPI with direct reading of tiled (split) MWP model output
• Apply to all members, with ensemble probability generated
CRTM synthetic GOES-R IR imagery
4/27/2011 case (25 h forecast)
Simulated GOES-13 10.7µm BT products
(24 h forecast valid 5/1/2012 00 UTC)

**ARW_CN**
00:00Z Tue 1 May 2012  T=86400.0 s (24:00:00)

**MEAN**
00:00Z Tue 1 May 2012  T=86400.0 s (24:00:00)

**Probability BT≤-32C**
00:00Z Tue 1 May 2012  T=86400.0 s (24:00:00)

**Probability BT≤-52C**
00:00Z Tue 1 May 2012  T=86400.0 s (24:00:00)
Probability of 10.7 µm BT ≤ -32°C
(TS Beryl -- 00 UTC May 27 initiation)

01:00Z Sun 27 May 2012  T=3600.0 s (1:00:00)

btn32p(%, Shaded)  Min=0.00  Max=100.
Simulated GOES-13 10.7μm BT products
(24 h forecast valid 6/7/2012 00 UTC)
SKEB impact at storm-scale

- **SKEB1**: 5-member sub-ensemble with SKEB `default` perturbation turned on
  (arw_m19 ~ arw_m23)
- **SKEB2, SKEB4**: 2x, 4x default perturbation amplitude
- **NOSKEB**: 5-member without SKEB
  (arw_cn, arw_m3, arw_m6, arw_m8, arw_m10)
- Ensemble spread and mean rmse evaluated for the case of June 7, 2012
500 hPa height

10-m U

1-h acc. precipitation

Poster P87 (Zhu et al.)
Thanks!