# Demonstrating the utility of the Mesoscale Model Evaluation Testbed (MMET)

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National Center for Atmospheric Research
Research Applications Laboratory and Developmental Testbed Center

# DTC Mission

- The fundamental purpose of the DTC is to facilitate the interaction & transition of NWP technology between research & operations

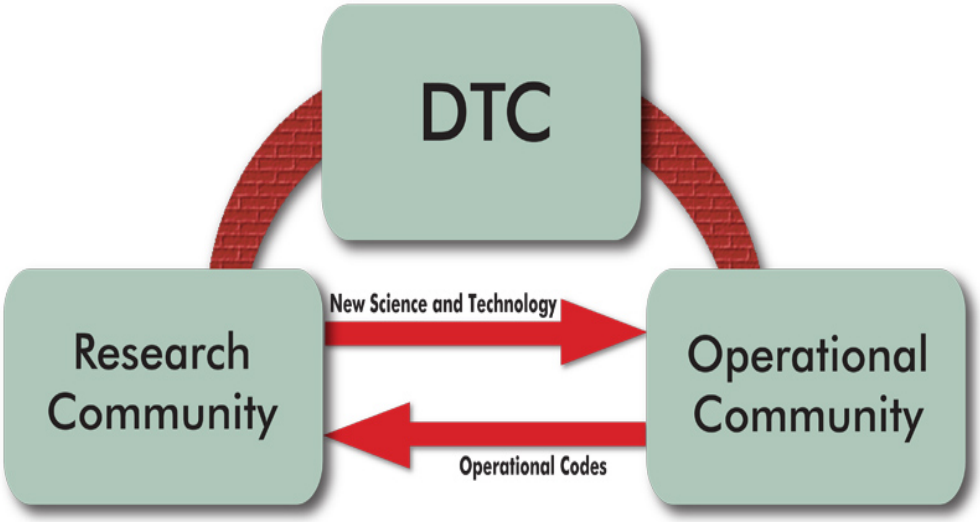
  DTC facilitates:

  - O2R transition by making the operational NWP systems available to the research community & providing community user support
  - R2O transition by performing testing & evaluation of new NWP innovations in a functionally similar operational environment over an extended period
  - Interaction between research & operational NWP communities through the organization of community workshops/meetings on important topics of interest to the NWP community & hosting a DTC Visitor Program

*DTC strives to be an **effective** and **efficient** community facility for the transition of innovations in NWP between research and operations.*

# Testing Protocol Motivation

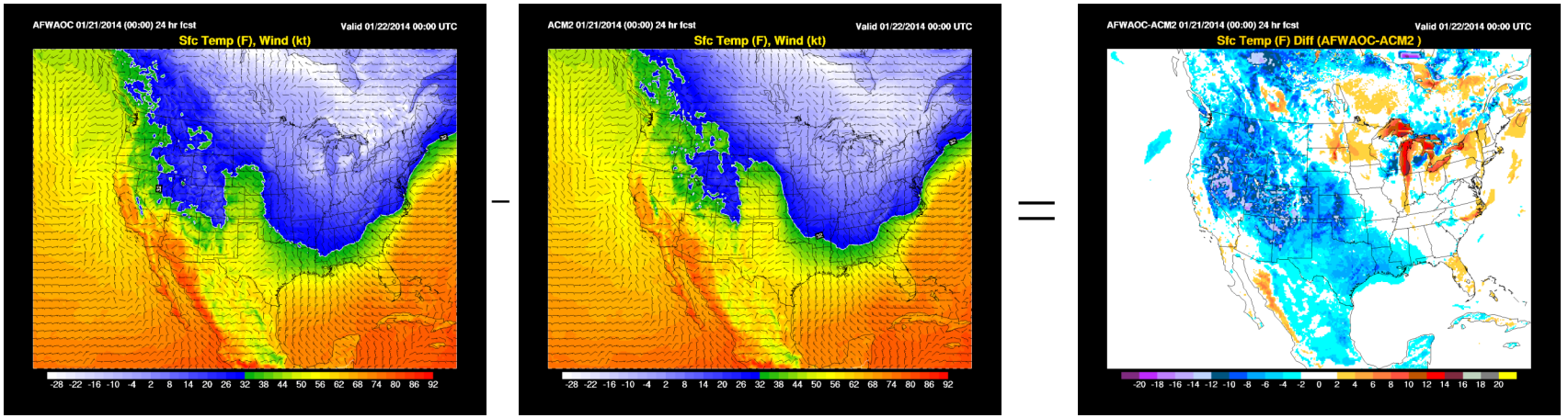
- Wide range of NWP science innovations under development in the research community
- Testing protocol imperative to advance new innovations through the research to operations (R2O) process *efficiently* and *effectively*
  - Three stage process:
    1) Proving ground for research community
    2) Comprehensive T&E performed by the DTC
    3) Pre-Implementation testing at Operational Centers



# Testing Protocol – Stage I

## Proving ground for research community

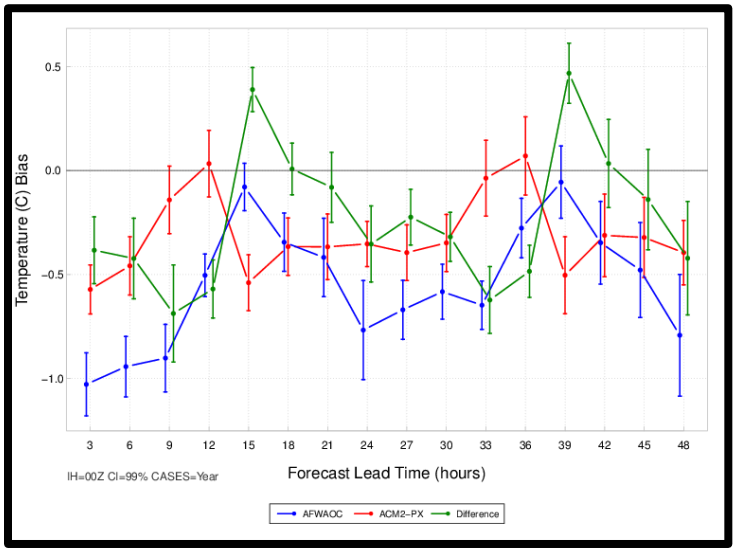
- Code development; Initial stage of testing
- Mesoscale Model Evaluation Testbed (MMET)
- Communicate results to the DTC; Nominate for Stage II testing
- Contribution of new technique into repository encouraged
  - Work with model developers committee
  - Apply for DTC Visitor Program support (see: http://www.dtcenter.org/visitors)

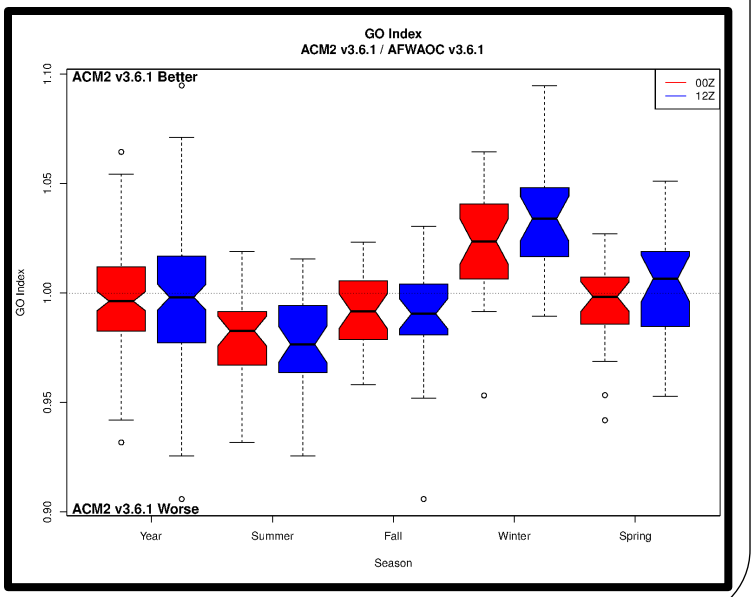


# Testing Protocol – Stage II

## Comprehensive T&E performed by the DTC

- Maintain a neutral position in order to provide a trusted, unbiased assessment
- Conduct comprehensive testing for a broad range of weather regimes
  - Run end-to-end system composed of community codes
  - Functionally similar to operational environment
- Evaluate based on extensive objective verification statistics
  - Traditional scores
  - New, relevant verification techniques (e.g., spatial methods)
  - Statistical significance assessment



# Testing Protocol – Stage III

## Pre-Implementation testing at Operational Centers

- Ultimate decision to proceed with pre-implementation testing is made by the Operational Centers and is based on a variety of factors, including:
  - Forecast performance
  - Computational requirements
- Testing specifics depend on the target production configuration, but may include:
  - Complex data assimilation testing
  - Initial condition diversity testing for ensemble members

# Mesoscale Model Evaluation Testbed (MMET)

**Why:** Assist the research community in efficiently demonstrating the merits of a new development

- Provide a common framework for testing; allow for direct comparisons

**What:** Mechanism to efficiently *assist* research community *with initial stage of testing*

- Provide model input and observational datasets to utilize for testing
- Establish and publicize baseline results for select operational models

**Where:** Hosted by the DTC; served through **R**epository for **A**rchiving, **M**anaging and **A**ccessing **D**iverse **DA**ta (RAMADDA)


http://www.dtcenter.org/eval/meso_mod/mmet/index.php

# Operational Baselines

- Baseline results for select Operational Configurations (OC) using:
  - Weather Research and Forecasting - Advanced Research WRF (WRF-ARW)
    - Air Force OC
    - **Coming soon: RAP/HRRR OC**
  - NOAA Environmental Modeling System – Nonhydrostatic Multiscale Model on the B-grid (NEMS-NMMB)
    - North American Mesoscale Forecast System (NAM) OC

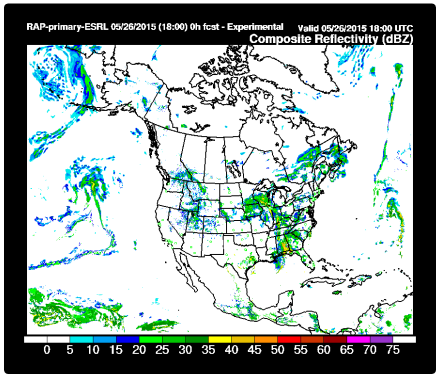
| Physics Suite | WRF-ARW Air Force OC | WRF-ARW RAP/HRRR OC | NEMS-NMMB NAM OC |
|---|---|---|---|
| Microphysics | WRF Single-Moment 5 | Thompson | Ferrier-Hires |
| Radiation (LW/SW) | RRTM/Dudhia | RRTMG/RRTMG | GFDL/GFDL |
| Surface Layer | Monin-Obukhov similarity theory | MYNN | Mellor-Yamada-Janjic |
| LSM | Noah | RUC | Noah |
| PBL | Yonsei University | MYNN 2.5 | Mellor-Yamada-Janjic |
| Convection | Kain-Fritsch | Grell-Freitas (RAP) | Betts-Miller-Janjic |

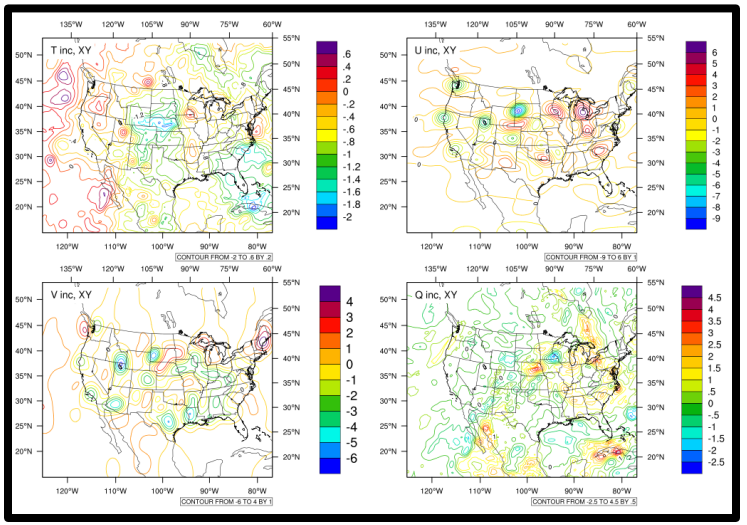
# MMET – Case Inventory

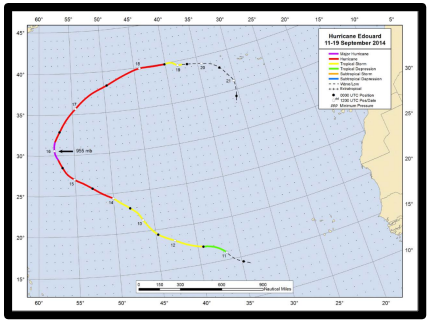
| Date(s) | Meteorological Scenario |
|---|---|
| **20090228** | Mid-Atlantic *snow storm* -NAM high QPF shifted too far north |
| **20090311** | *High dew point* predictions by NAM over the upper Midwest and in areas of snow |
| **20091007** | *HIRESW* runs *underperformed* compared to coarser NAM model |
| **20091217** | "*Snowpocalypse '09*" |
| **20100428-0504** | Historic Tennessee *flooding* associated w/ an atmospheric river |
| **20110404** | Record breaking *severe* report day |
| **20110518-26** | Extended *severe weather* outbreak covering much of the Midwest and into the eastern states |
| **20111128** | *Cutoff low* over SW US |
| **20120203-05** | *Snow storm* over Colorado, Nebraska, etc. |
| **20120628** | *Derecho* event that began in Iowa and traveled eastward through the Mid-Atlantic states |
| **20130729** | *Mesoscale convective system* (MCS) over SE Kansas |
| **20130908-14** | Historic Colorado *flooding* associated w/ long duration and warm rain processes |
| **20140105** | *Arctic air outbreak* impacting much of the United States east of the Rockies |
| **20110214-17** | *Atmospheric river* impacting the West Coast |

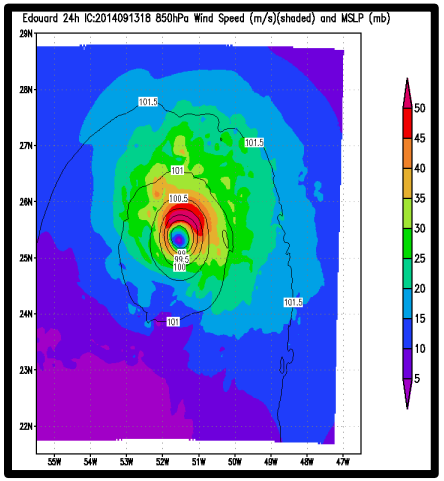
# New Features in MMET

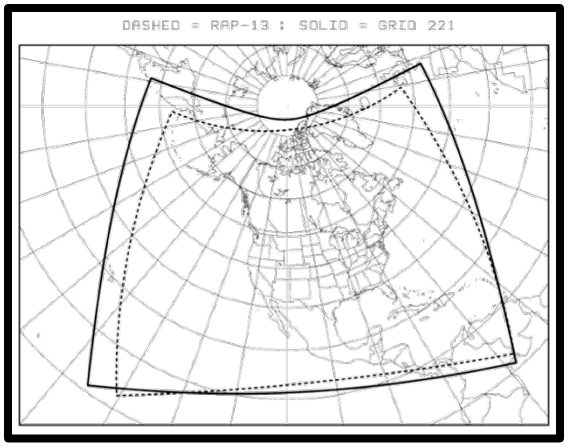
- New WRF-ARW operational baselines using RAP and HRRR physics suite configurations
- Addition option of operational RAP dataset for initialization
- Implementation of Gridpoint Statistical Interpolation (GSI) data assimilation
- Automated re-gridding capability within MET
- Addition of a hurricane case using the Hurricane WRF (HWRF)





# What does MMET provide?

Initialization datasets

Pre-processing datasets

Model configurations

Post-processing scripts

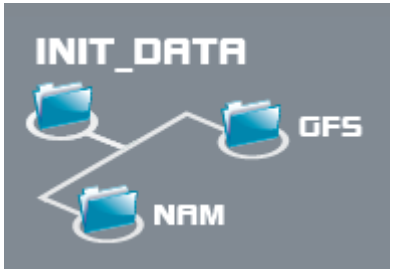
Graphics of model output and scripts

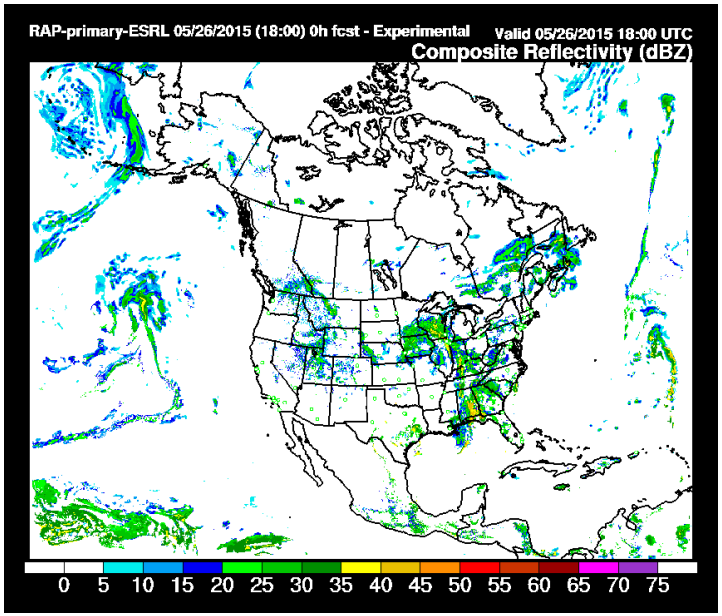
Observation datasets

Verification output and scripts

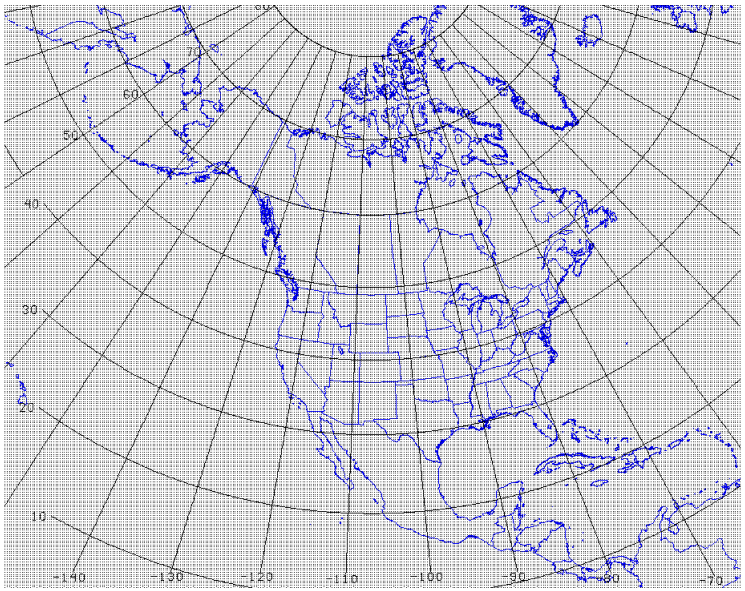
# Initialization Datasets

- NAM on NCEP Grid 221 (~32-km North American domain)
- GFS on 0.5° grid
- Coming soon:
  - Providing 13-km RAP data on North American domain
  - Implementing GSI in testing framework
    - ✓ Necessary files for running GSI will be included in repository

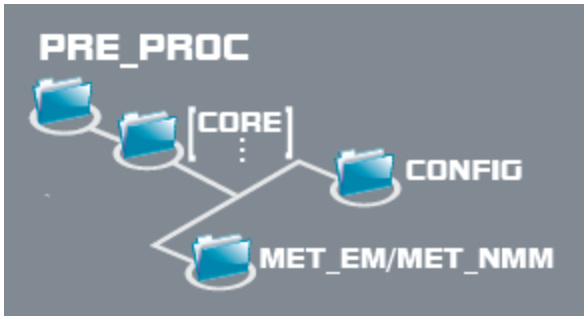



NCEP Grid 221



# Pre-processing




- namelist.wps and namelist.nps
- met_em* files and met_nmb* files

```
&share
 wrf_core = 'ARW',
 max_dom = 2,
 start_date = '2009-12-17_12:00:00', '2009-12-17_12:00:00',
 end_date   = '2009-12-21_00:00:00', '2009-12-21_00:00:00',
 interval_seconds = 10800,
 io_form_geogrid = 2,
/

&geogrid
 parent_id         = 1, 1,
 parent_grid_ratio = 1, 4,
 i_parent_start    = 1, 242,
 j_parent_start    = 1, 135,
 e_we          = 505, 805,
 e_sn          = 380, 629,
 geog_data_res = '2m', '30s',
 dx = 12000,
 dy = 12000,
 map_proj =  'lambert',
 ref_lat   = 38.60,
 ref_lon   = -98.90,
 truelat1  = 38.60,
 truelat2  = 38.60,
 stand_lon = -98.90,
 geog_data_path = '/path/to/geog',
 opt_geogrid_tbl_path = '/path/to/geogrid',
/

&ungrib
 out_format = 'WPS',
 prefix = 'NAM',
/

&metgrid
 constants_name='',
 fg_name = 'NAM',
 io_form_metgrid = 2,
 opt_metgrid_tbl_path = '/path/to/metgrid',
/
```

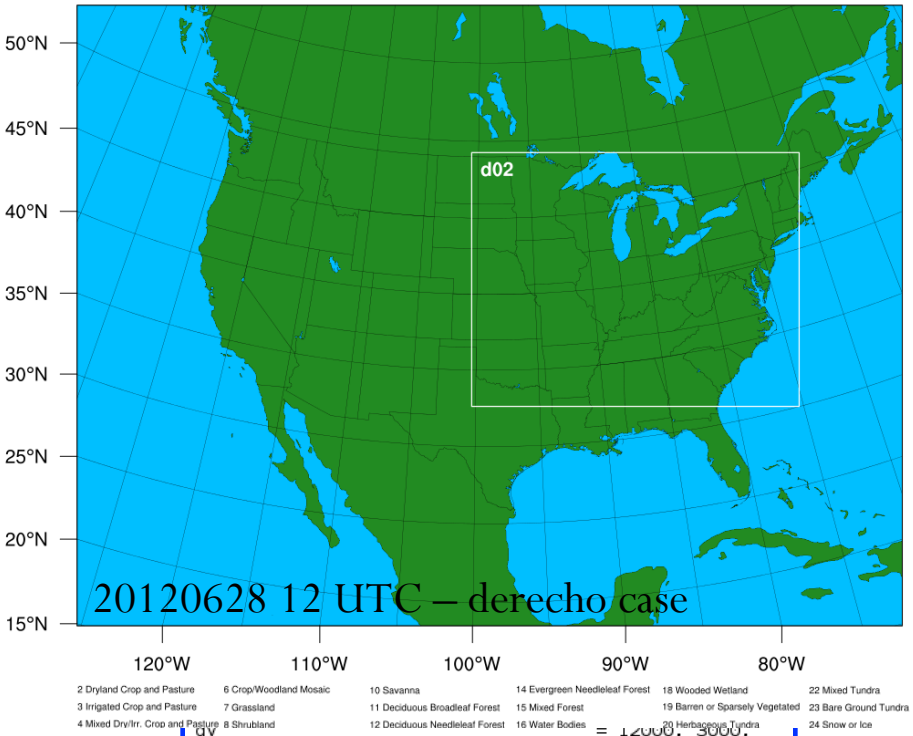
# Model

- Domain: 15-km CONUS grid
- Transitioning to a 12-km CONUS grid with 3-km nest over area of interest
- namelist.input and configure_file

**WRF-ARW namelist**

```
&time_control
run_days                            = 0,
run_hours                           = 84,
run_minutes                         = 0,
run_seconds                         = 0,
start_year                          = 2009, 2009,
start_month                         = 12, 12,
start_day                           = 17, 17,
...
dy
grid_id                             = 1, 2,
parent_id                           = 0, 1,
i_parent_start                      = 0, 242,
j_parent_start                      = 0, 135,
parent_grid_ratio                   = 1, 4,
parent_time_step_ratio              = 1, 4,
feedback                            = 1,
smooth_option                       = 0,
p_top_requested                     = 1000,
interp_type                         = 1,
lowest_lev_from_sfc                 = .false.,
...
...
...
```

**Model domain**



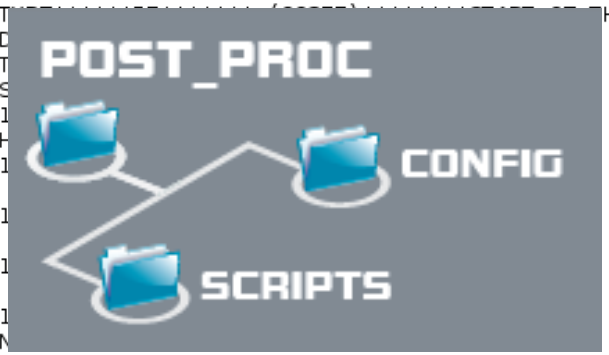

**NMMB configure file**

```
######## Model Core ###########
###############################

core: nmm                   # The dynamic core options:
                              # nmm
                              # gfs
                              # fim
                              # arw
###############################
##### Grid Specifications #####
###############################

im:  450                  # I gridpoints
jm:  400                  # J gridpoints
lm:  60                   # Number of atmospheric layers

tph0d:  38.600              # Central geographic latitude of grid (degrees)
tlm0d:  -98.900             # Central geographic longitude of grid (degrees, positive east)

wbd:  -28.287             # Grid's western boundary (rotated degrees)
sbd:  -21.546             # Grid's southern boundary (rotated degrees)

###############################
##### Grid Decomposition #####
###############################

inpes:  16                  # Number of compute tasks in the I direction
jnpes:  18                  # Number of compute tasks in the J direction

###############################
#### Specify the I/O tasks ####
###############################

quilting:              true    # Do you want asynchronous quilting/history writes?
read_groups:           0
read_tasks_per_group:  0
write_groups:          1
write_tasks_per_group: 16

#########################################
##### Fundamental Timestep (seconds) #####
#########################################

dt_int: 26          # Integer seconds
dt_num: 2           # Numerator of fractional second
dt_den: 3           # Denominator of fractional second

filt_dt_int: 26           # Integer seconds
filt_dt_num: 2            # Numerator of fractional second
filt_dt_den: 3            # Denominator of fractional second
...
...
...
```

For more information on the Unified Post Processor (UPP):
http://www.dtcenter.org/upp/users/

# Post-processing

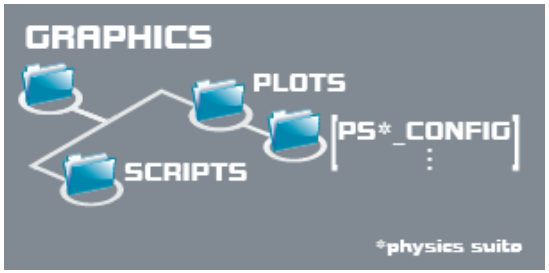
- run_unipost script
- wrf_cntrl.parm and nmb_cntrl.parm



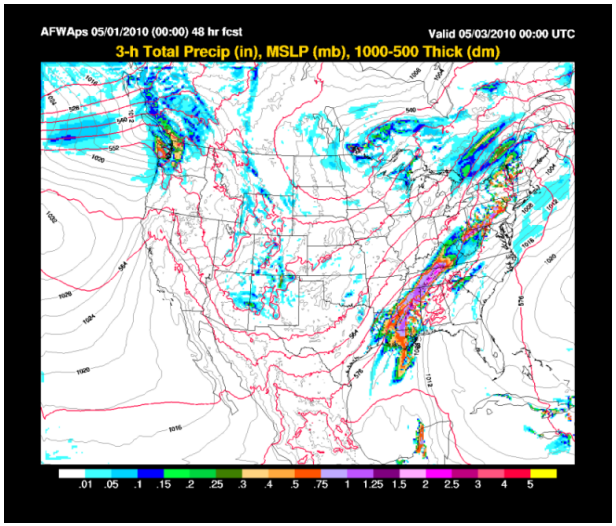

```
   KGT                                                    HIS OUTP
   IMD
   DAT
(PRESS
L=(111                                                    11111 1
(HEIGH
L=(111                                                    11111 1
(TEMP
L=(111                                                    11111 1
(DWPT
L=(111                                                    11111 1
(SPEC
L=(111                                                    11111 1
(U WIN
L=(11111 11111 11111 11111 11111 11111 11111 11111 11111 1
(V WIND ON MDL SFCS  ) SCAL=( 4.0)
L=(11111 11111 11111 11111 11111 11111 11111 11111 11111 1
(OMEGA ON MDL SFCS   ) SCAL=( 5.0)
L=(11111 11111 11111 11111 11111 11111 11111 11111 11111 1
(CLD WTR ON MDL SFCS ) SCAL=( 3.0)
L=(11111 11111 11111 11111 11111 11111 11111 11111 11111 1
(CLD ICE ON MDL SFCS ) SCAL=( 3.0)
L=(11111 11111 11111 11111 11111 11111 11111 11111 11111 1
(RAIN ON MDL SFCS    ) SCAL=( 3.0)
L=(11111 11111 11111 11111 11111 11111 11111 11111 11111 1
(SNOW ON MDL SFCS    ) SCAL=( 3.0)
L=(11111 11111 11111 11111 11111 11111 11111 11111 11111 1
(RADAR ECHO TOP      ) SCAL=( 4.0)
L=(10000 00000 00000 00000 00000 00000 00000 00000 00000 0
(RADAR REFL AGL      ) SCAL=( 4.0)
L=(11000 00000 00000 00000 00000 00000 00000 00000 00000 0
***DONE WITH THIS GRID***
```

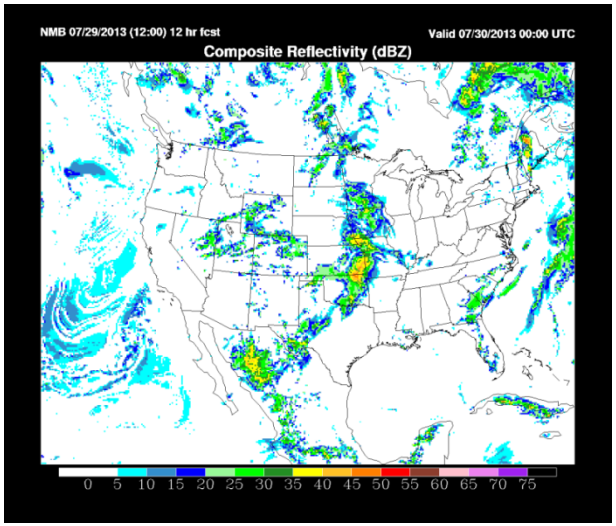
```
...
...
...
# Begin looping through domains list
# ie. for domain in d01 d02 d03
for domain in ${domain_list}
do

# Create model file name (inFileName)
dom_id=`echo "${domain}" | cut -d 'd' -f 2`
if [[ ${dyncore} == "ARW" || ${dyncore} == "NMM" ]]; then
  inFileName=${modelDataPath}/wrfout_d${dom_id}_${YY}-${MM}-${DD}_${HH}:00:00
elif [ ${dyncore} == "NMB" ]; then
  inFileName=${modelDataPath}/nmmb_hst_${dom_id}_nio_00${fhr}h_00m_00.00s
fi

# Check if that file exists
if [[ ! -e ${inFileName} ]]; then
  echo "ERROR: Can't find 'inFileName': ${inFileName}. Directory or file does not exist.  Exiting..."
  echo "ERROR: Check if 'modelDataPath': ${modelDataPath} exists."
  if [[ ${dyncore} == "ARW" || ${dyncore} == "NMM" ]]; then
     echo "ERROR: Check if file: 'wrfout_d${dom_id}_${YY}-${MM}-${DD}_${HH}:00:00' exists in modelDataPath."
  elif [ ${dyncore} == "NMB" ]; then
     echo "ERROR: Check if file: 'nmmb_hst_${dom_id}_nio_00${fhr}h_00m_00.00s' exists in modelDataPath."
  fi
  exit 1
fi

# Create itag based on user provided info.
# Output format now set by user so if-block below uses this
# to generate the correct itag.

if [[ ${outFormat} == "grib" ]]; then

cat > itag <<EOF
${inFileName}
${inFormat}
${YY}-${MM}-${DD}_${HH}:00:00
${tag}
EOF

elif [[ ${outFormat} == "grib2" ]]; then

cat > itag <<EOF
${inFileName}
${inFormat}
${outFormat}
${YY}-${MM}-${DD}_${HH}:00:00
${tag}
EOF

else
echo "ERROR: output format 'outFormat=${outFormat}' not supported, must choose 'grib' or 'grib2'. Exiting..."
exit 1
fi

#-----------------------------------------------------------------------
#   Run unipost.
#-----------------------------------------------------------------------
rm fort.*

ln -sf ${paramFile} fort.14

#-----------------------------------------------------------------------
# There are two environment variables tmmark and COMSP
# RUN the unipost.exe executable.
#-----------------------------------------------------------------------

${RUN_COMMAND} > unipost_${domain}.${fhr}.out 2>&1
...
...
...
```

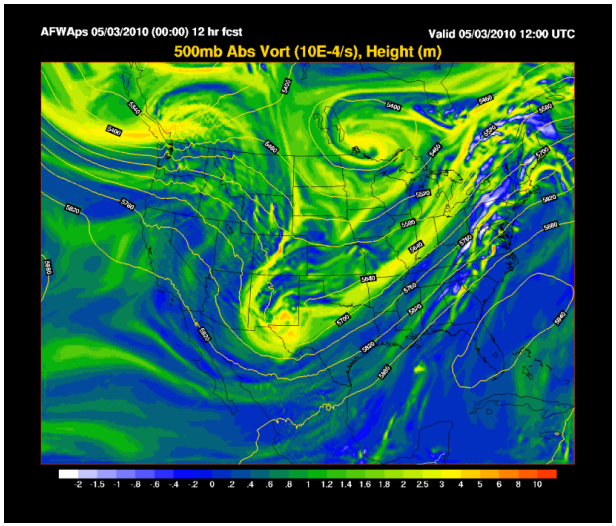
# Graphics




- NCL scripts and plots for a number of variables:
  - Surface and upper air fields (e.g., temperature, wind, and moisture fields)
  - Accumulated precipitation, composite reflectivity, CAPE, vorticity, etc.

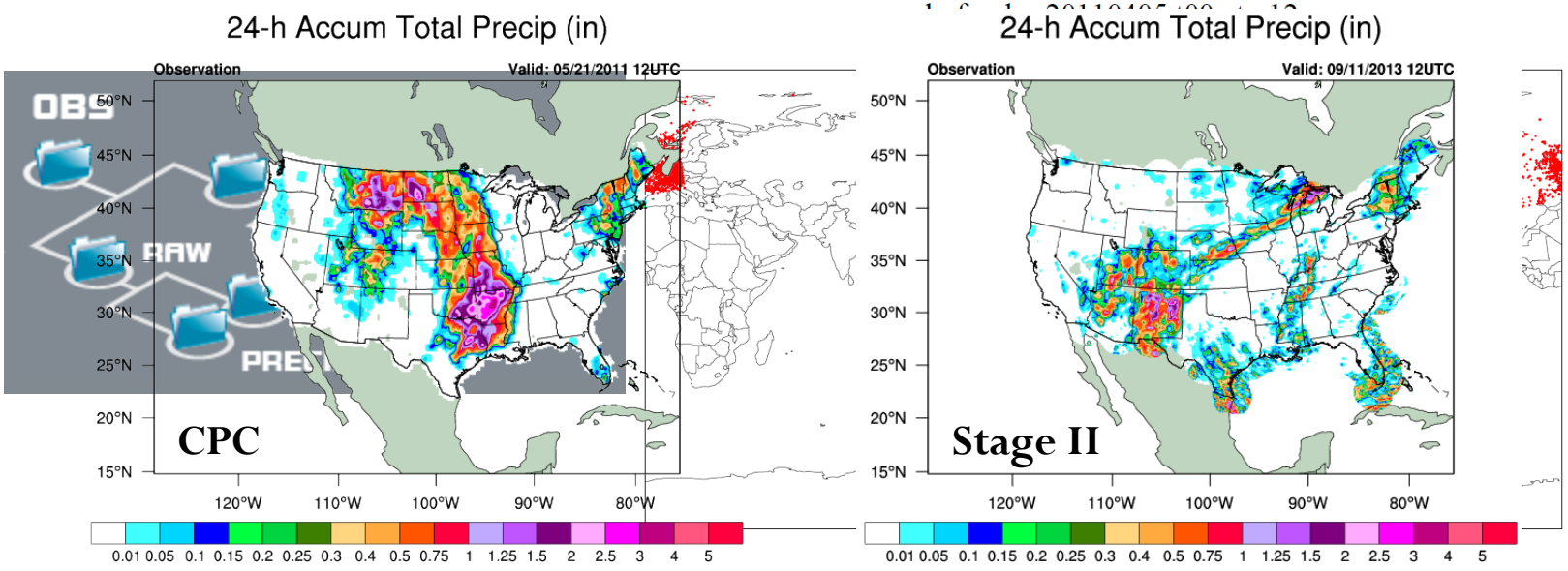


# Observation Datasets

- Raw and processed North American Data Assimilation System (NDAS) prepbufr files for point observations
- Raw and processed observations (regridded and in 3- and 24-h accumulations)
  - Climate Prediction Center Unified Gauge-Based Analysis (CPC)
  - Stage II
  - Stage IV (currently only available for the 20110213-16 atmospheric river case)
- NCL scripts and plots for accumulated observed precipitation



# Verification

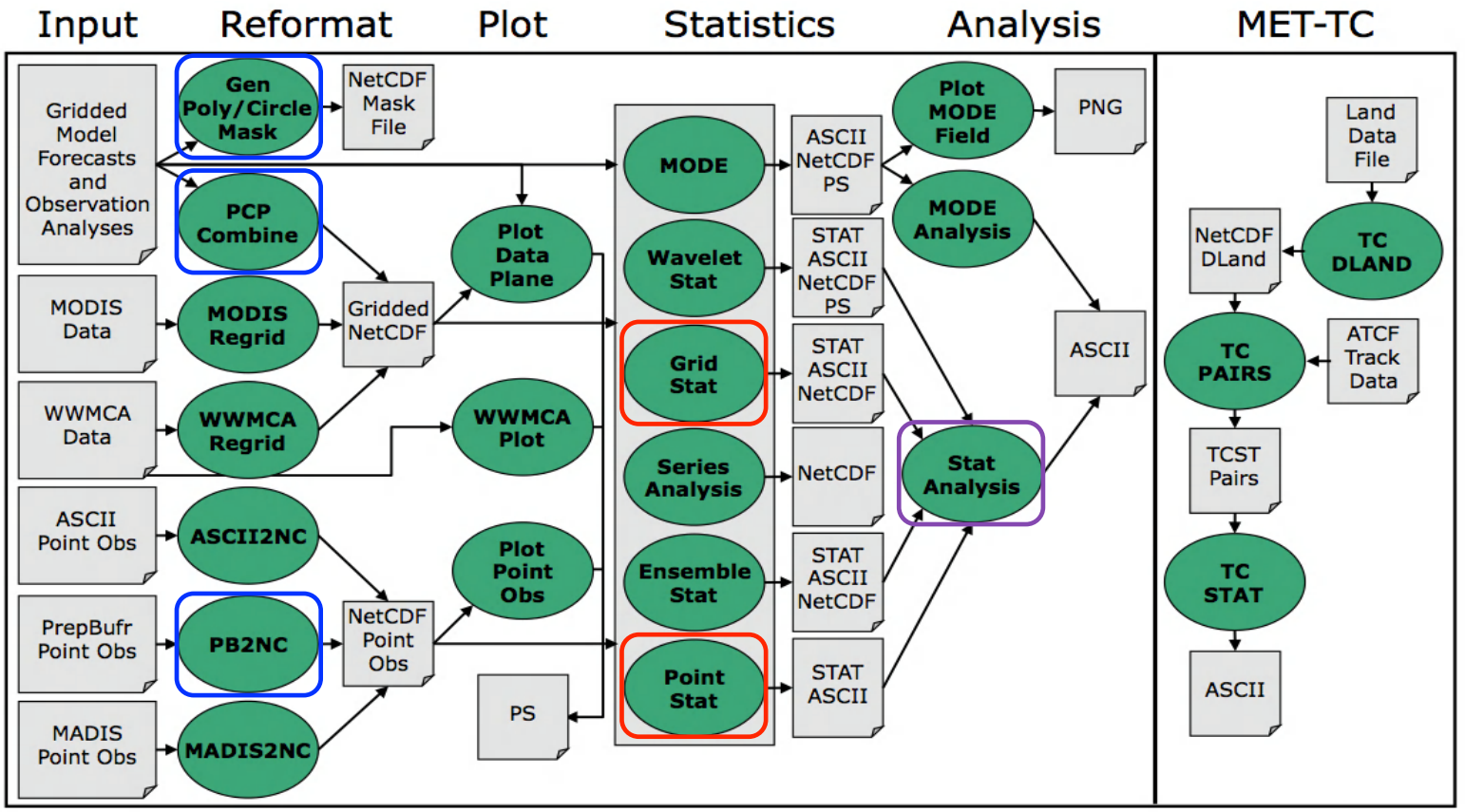
**Adapted from presentations by MET team, including Tara Jensen, Tressa Fowler, John Halley Gotway, and Kathryn Newman!**

- Why verify your forecasts??
  - Identify forecast strengths and weaknesses; use information to improve model
  - Help users and model developers interpret forecasts
  - Assist operational forecasters in understanding model biases and applying knowledge to forecasts
  - Monitor performance of model and/or configuration
  - Use information for enhanced decision making (e.g., emergency managers, wind energy)
  - Provides a standardized evaluation platform for cross-institution comparisons
- MET is freely available community code supported by the DTC **(must register to download)**
  - State-of-the-art suite of verification tools
  - Approximately 2750 registered users spanning ~120 countries
  - Users from universities, government, private companies, and non-profits
- MET provides a number of tools for evaluating model performance:
  - Full suite of standard statistics with non-traditional statistics regularly added
  - Neighborhood and object-based methods
  - Scale decompositions
  - Tropical cyclone verification

# Verification
## MET capabilities

MET has a number of tools for:

- reformatting
- plotting
- calculating statistics
- statistical analysis
- tropical cyclone verification



# Verification
## MET data formats & tools

MET components highly-configurable:
- Verify over specified fields and/or levels
- Apply thresholds
- Apply various interpolation methods
- Verify over user-specified regions

| Data | MET Tool |
|---|---|
| Gridded Forecasts<br>Gridded Observations<br>*(Grib1 / Grib2 / NetCDF with grid specifications included; next release to include reading GSI diagnostic file)* | Grid Stat (traditional or neighborhood)<br>Ensemble Stat<br>Wavelet Stat<br>MODE<br>Series Analysis |
| Gridded Forecasts<br>Point Observations<br>*(ASCII / PrepBufr / MADIS / littleR)* | Point Stat<br>Ensemble Stat<br>Series Analysis |
| Point Forecasts<br>Point Observations<br>*(ATCF file format)* | TC Pairs<br>TC Stat |

# Verification
## MET basics for MMET

- **Point-stat (grid-to-point verification)**
  - Input files:
    - Gridded forecast file (e.g., Grib1, Grib2, NetCDF)
    - Point observation file in NetCDF format (e.g., output of PB2NC, MADIS2NC, or ASCII2NC )
    - Configuration file
  - Output files:
    - ASCII statistics file(s) containing all of requested line types
  - Basic usage command:

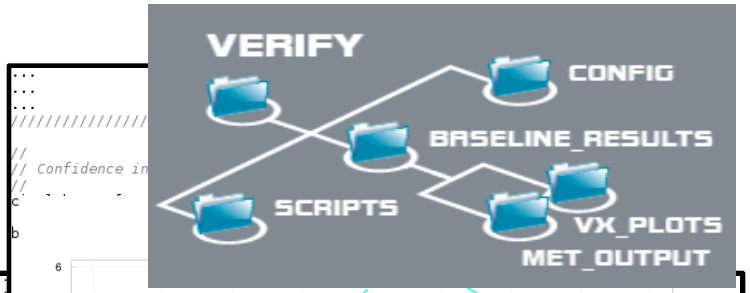
```
met-5.0/bin/point_stat \
   wrfprs_d01_03.tm00 \
   prepbufr.ndas.20110405.t03z.tm09.nc \
   PointStatConfig_ADPSFC \
   -outdir . \
   -log point_stat_ADPSFC.log \
   -v 2
```

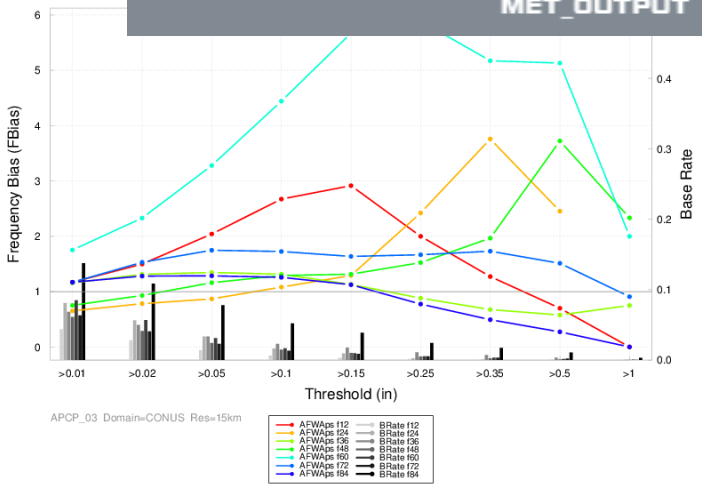
- **Grid-stat (grid-to-grid verification)**
  - Input files:
    - Gridded forecast file (Grib1, Grib2, NetCDF)
    - Gridded observation file (Grib1, Grib2, NetCDF)
    - Configuration file
  - Output files:
    - ASCII statistics file(s) containing all of requested line types
    - Optional NetCDF file with matched pairs
  - Basic usage command:

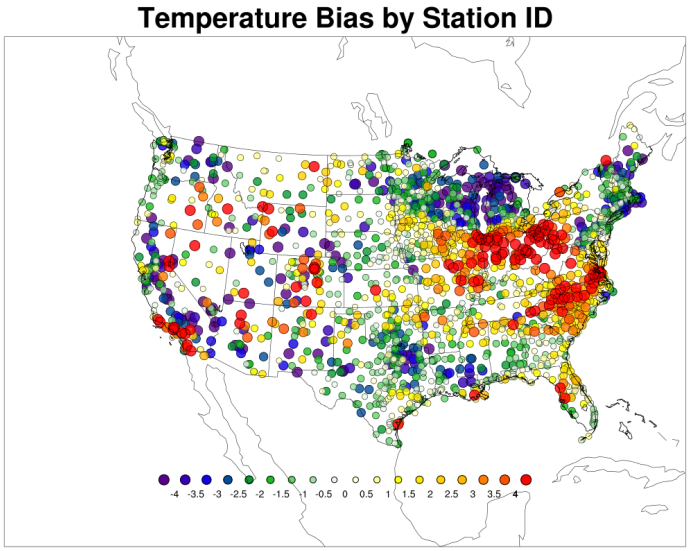
```
met-5.0/bin/grid_stat \
   wrfpcp_d01_03_03.nc \
   ST2ml.2011040503.grb \
   GridStatConfig_03h \
   -outdir . \
   -log grid_stat_03h.log \
   -v 2
```

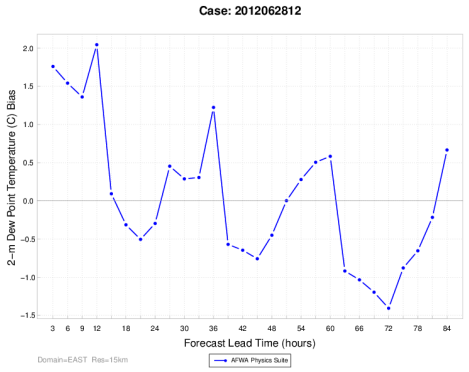
# Verification

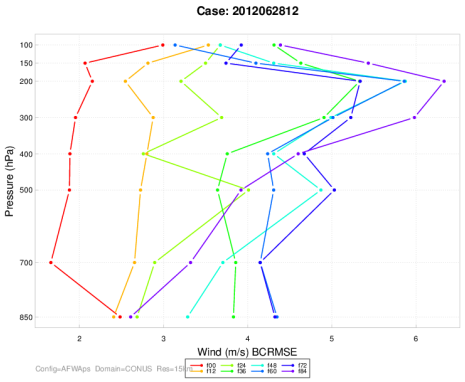
- Scripts to run MET (point-to-grid and grid-to-grid vx)
- MET configuration files
- Baseline results
  - Objective verification:
    - Surface and upper air [(BC)RMSE, bias] – temperature, dew point temperature, wind speed
    - Precipitation [Gilbert skill score, frequency bias] – 3- and 24-h accumulations
    - Over CONUS domain and 14 sub-regions to *identify spatial differences* and *perform focused impact studies*



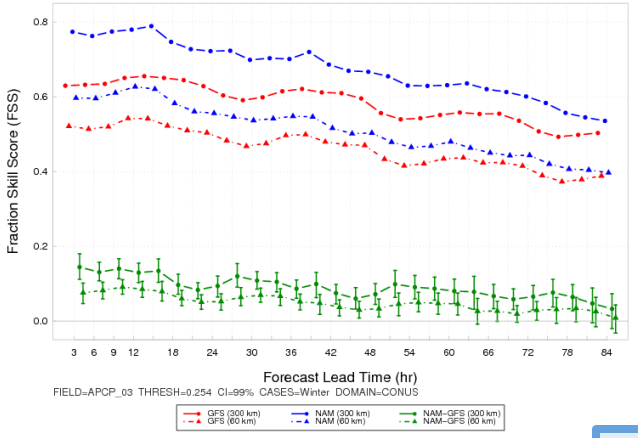



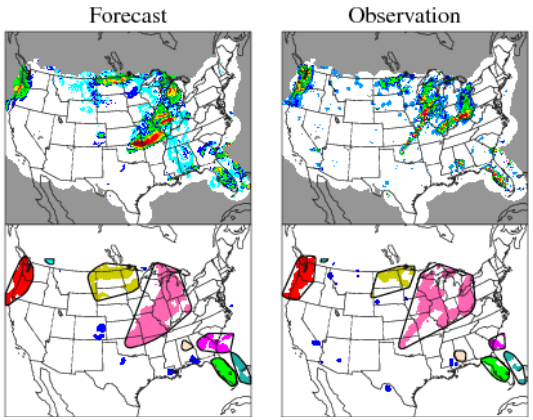



# Verification

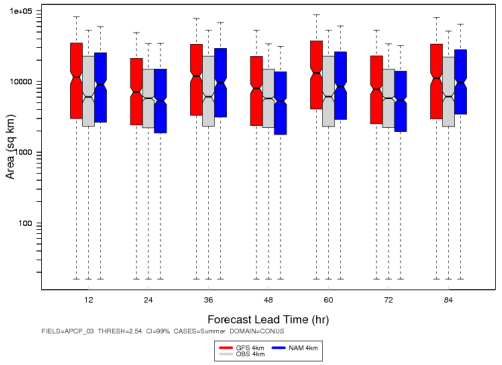
## Beyond the basics in MET

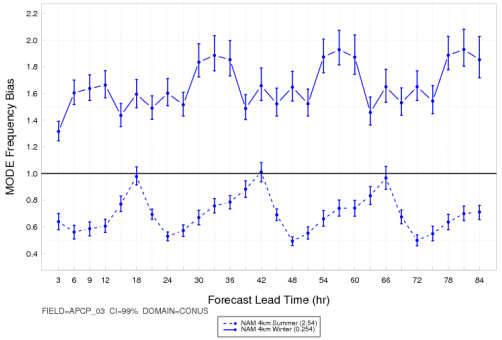
### Neighborhood Methods




### Object-based Methods



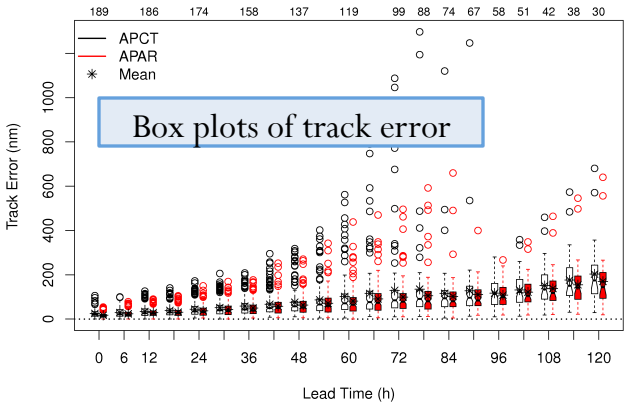




### Ensemble Verification

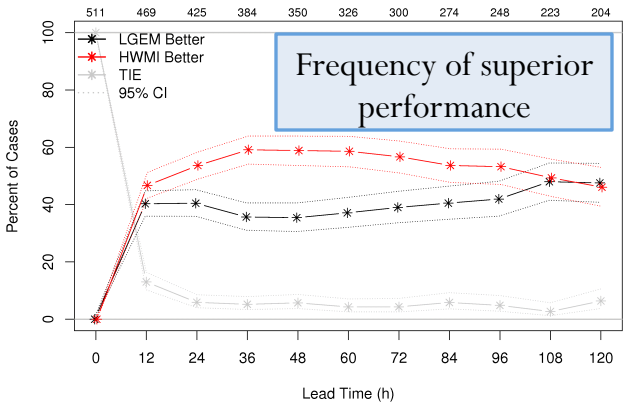
- Ensemble means
- Probability fields
- Rank histograms
- Spread-skill calculation
- Brier score
- Reliability diagrams
- Receiver Operating Characteristic Diagram + Area Under the Curve

### Tropical Cyclone Verification

**Track Error**
**Atlantic Basin (Land and Water)**




**Absolute Intensity Error Difference >=1 kt**
**Atlantic Basin (Land and Water)**



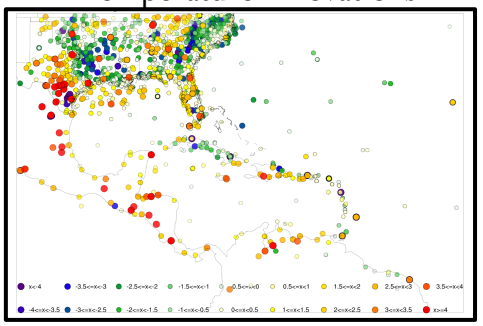
# Verification

## METv5.1 – Upcoming Advances

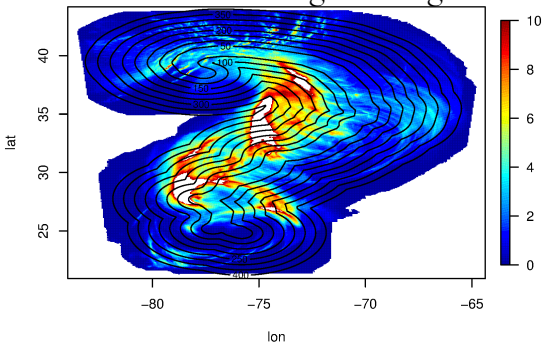

**New features being added to METv5.1:**

- Automated regridding
- Set thresholds for conditional verification of continuous variables
- Extract background error & innovations for conventional & radiance data from GSI diagnostic files
- Flexible definition of rapid intensification / rapid weakening events; categorical statistics then calculated from definition
- Storm-following masking with range rings
- MODE-Time Domain
  - 2D objects → 3D space-time objects
  - Applications: *Forecast consistency and evolution with high-temporal resolution data; timing, velocity, and duration errors; initiation and dissipation*

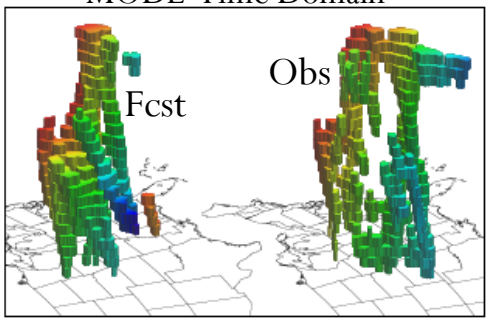
Temperature Innovations



Storm-following masking

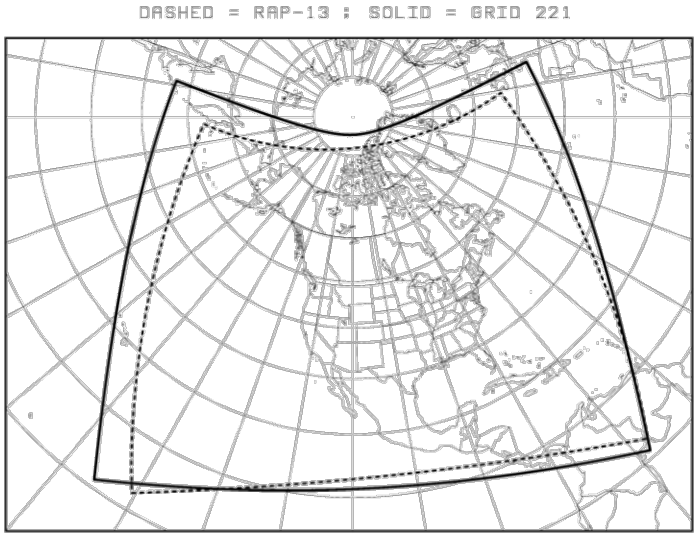



MODE-Time Domain



# Verification
## METv5.1 – Regridding


**Basic capability for automated regridding**




**Interpolation options:**

- Unweighted mean
- Distance-weighted mean
- Min, max, median
- Least squares
- Bilinear
- Budget

**Regridding options:**

- To forecast grid
- To observation grid
- To pre-defined grid (e.g. NCEP G221, user generated)
- To a grid specification (similar concept to UPP *copygb*)

***ALSO: Stand-alone tool available for regridding outside statistical tools***

# Verification
## Helpful MET resources

**MET website:** http://www.dtcenter.org/met/users/

- Download code (current version 5.0)
- Documentation: user's guide and tutorial presentations
- Online practical tutorials
- Related links for verification resources
- Questions regarding MET?

  ***met_help@ucar.edu***

# Examples of Community Use

"Snowpocalypse" (17 Dec 2009) – *Gary Lackmann*

Flooding in TN (28 Apr – 4 May 2010) – *Pedro Jimenez & Jimy Dudhia*

Flooding in TN (1 – 3 May 2010) – *Kelly Mahoney*

Derecho Event (28 June 2012) – *Anthony Torres*

# MMET – Community Use
# User Cases – Gary Lackmann

**Case Details: 17 Dec 2009** **"Snowpocalypse"**

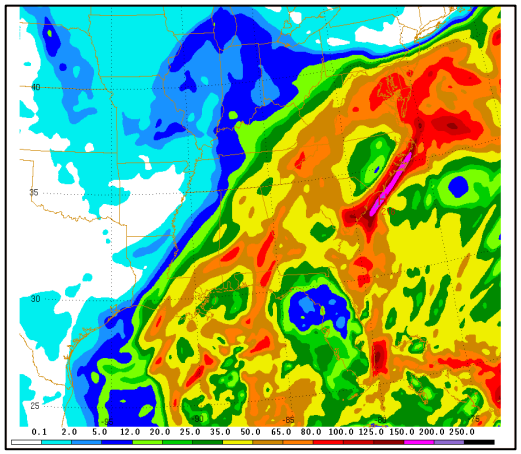
*Forecasts:* All simulations: 15-km grid length

1. WRF v3.4 ARW baseline (MMET Baseline Configuration w/ *WSM5* microphysics)
2. WRF v3.4 ARW namelist w/ *Milbrandt-Yau* microphysics

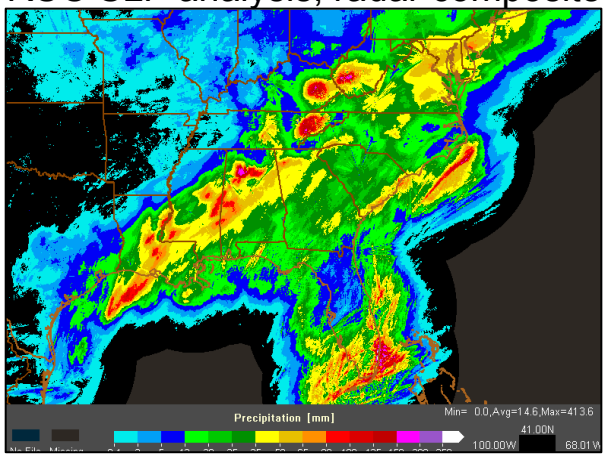
*Model Initialization:* 12 UTC 17 Dec, utilized IC/BC files from DTC

## 72-h Accumulated Precipitation & Analysis

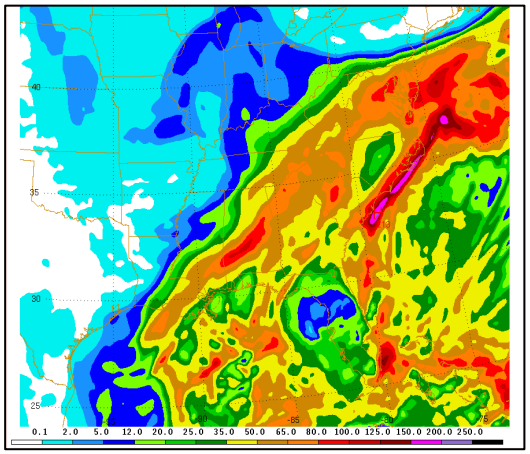
MMET Baseline – WSM5




RUC SLP analysis, radar composite




Milbrandt-Yau




**Case Summary**

- Both forecasts captured main features:
  - Axis of precipitation over coastal Carolinas and VA
  - Precipitation minimum over FL
- Significant over-prediction over NC, SC, and VA and issues with precipitation cessation

# MMET – Community Use

## User Cases – Pedro Jimenez & Jimy Dudhia

**Case Details: 28 Apr – 4 May 2010** **Flooding in TN**

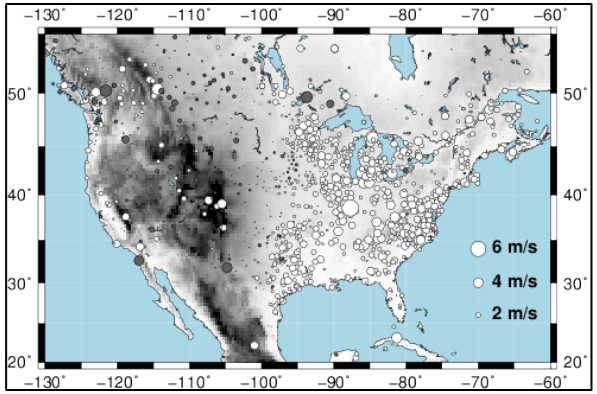
*Forecasts:* All simulations:15-km grid length

1. WRF v3.4 ARW baseline (MMET Baseline Configuration w/ *YSU* PBL)
2. WRF v3.4 ARW namelist w/ *topo_wind=1* activated w/ *YSU* PBL

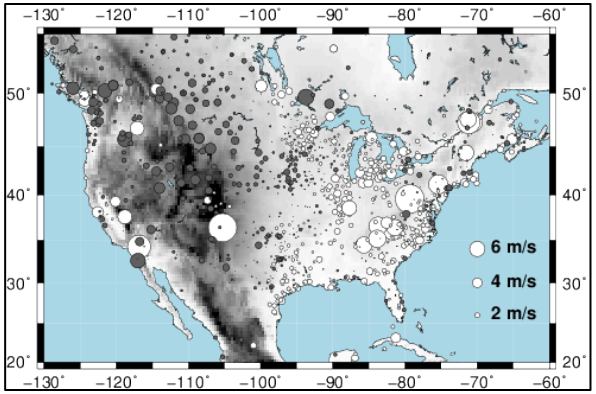
*Model Initialization:* Utilized IC/BC files from DTC

*Verification:* Utilized observation files provided by DTC

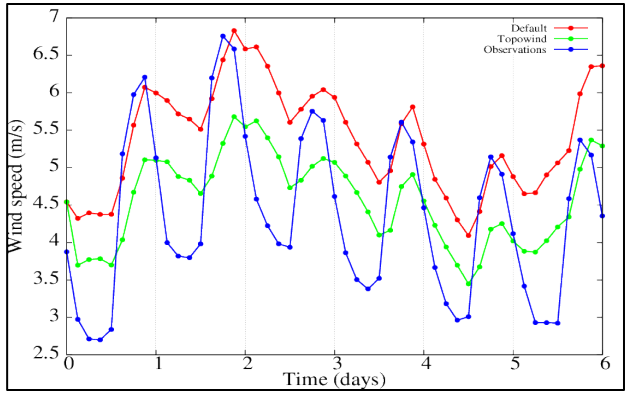
MMET Baseline




topo_wind=1




Wind Speed 6-day Average Error




**Case Summary**

- *topo_wind=1* – smaller errors over plains but larger errors over higher terrain
- Overall 6-day domain average with *topo_wind=1* smaller than default
- Reduces diurnal mean bias but does not capture full diurnal amplitude

# MMET – Community Use
# User Cases – Kelly Mahoney

**Case Details: 1 – 3 May 2010** **Flooding in TN**

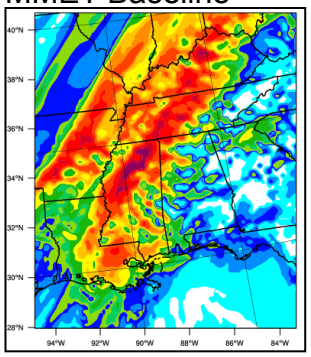
*Forecasts:* Simulations #1-3: 15-km grid length; Simulation #4: 4-km grid length/1.3-km inner nest

1. WRF v3.5 ARW baseline (MMET Baseline Configuration w/ *WSM5*)
2. WRF v3.5 ARW namelist w/ *Thompson* microphysics
3. WRF v3.5 ARW namelist w/ *Thompson* microphysics and *no CP scheme*
4. WRF v3.5 ARW namelist w/ *#3 physics* and *4-km/1.3-km grid length*

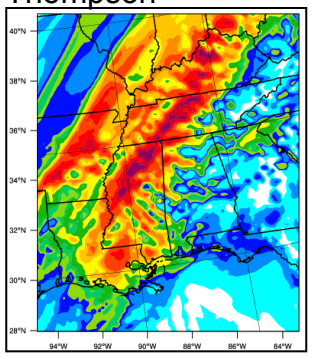
*Model Initialization:* Utilized IC/BC files from DTC for simulations #1–3, NAM 00 UTC 20100501 forecast from DTC to produce IC/BCs for #4

## 48-h Total Precipitation Accumulation

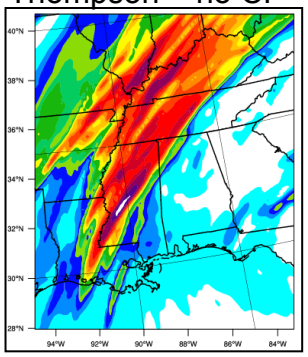
MMET Baseline



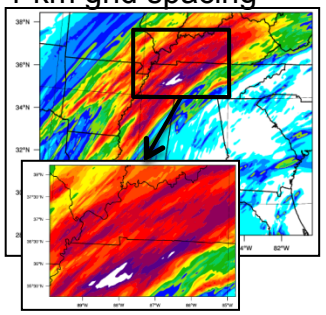
Thompson



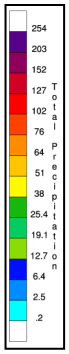
Thompson + no CP



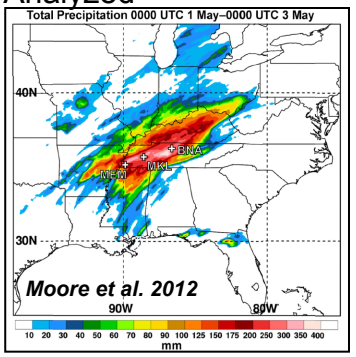
4-km grid spacing



1.3-km grid spacing




Analyzed

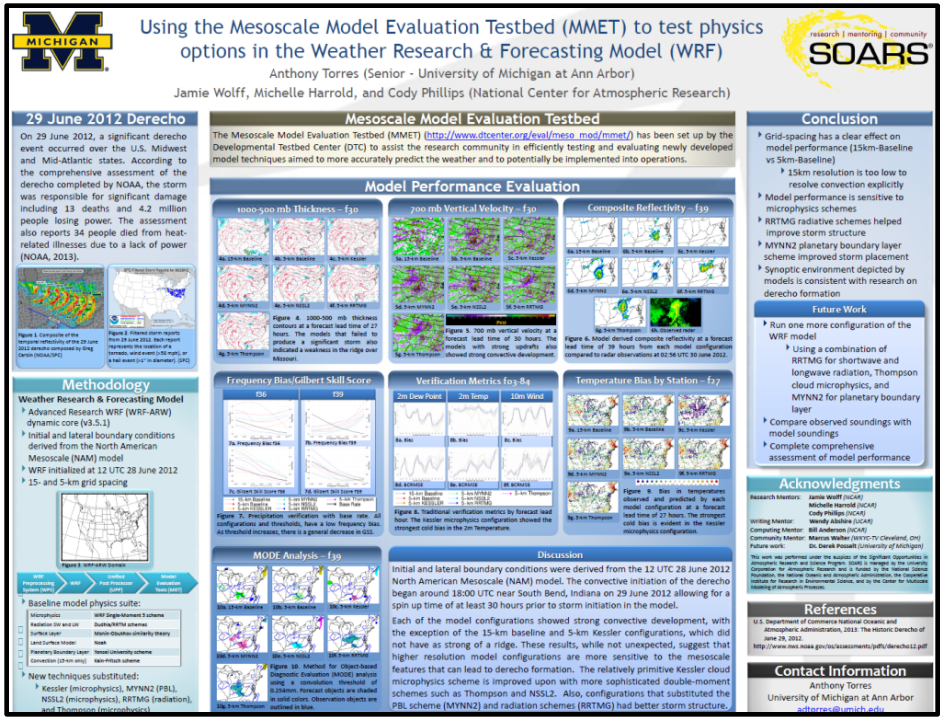



**Case Summary**

- Strong synoptic-scale dynamical forcing; all simulations generate precipitation maxima > 150 mm
- Significant over-forecast of precip found in LA and AR in all runs; timing error vs. location error?
- KF CP scheme generates NW-SE-oriented precip banding not seen in explicit convection runs
- Increased horizontal resolution increases precipitation maxima

# MMET – Community Use
# User Cases – Anthony Torres

- SOARS Protégé in Summer 2014 from University of Michigan
- Used MMET to investigate significant derecho event on 29 June 2012
- Tested several WRF-ARW configurations:
  - **Baseline physics suite** – 15-km & 5-km
  - **Kessler** (microphysics), **MYNN2** (PBL), **NSSL2** (microphysics), **RRTMG** (radiation), and **Thompson** (microphysics), and **Thompson w/ MYNN2** (microphysics/ radiation) – 5-km
- Performed traditional and spatial verification using MET



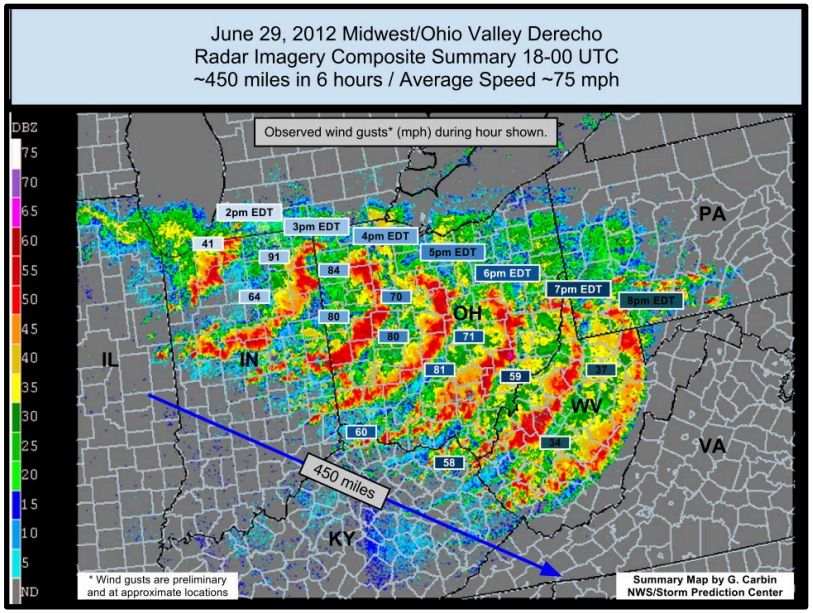
# 28 June 2012 Case

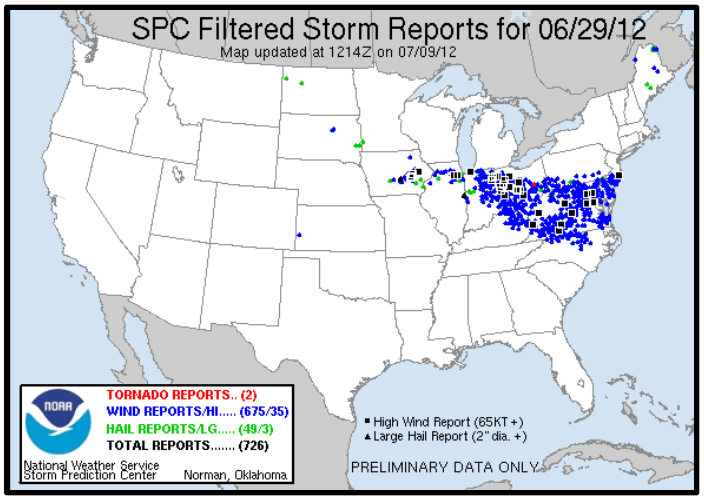
**Initialized 28 June 2012 at 12 UTC**

AF Operational Configuration w/ WRF-ARW (AF OC)
NAM Operational Configuration w/ NEMS-NMMB (NAM OC)

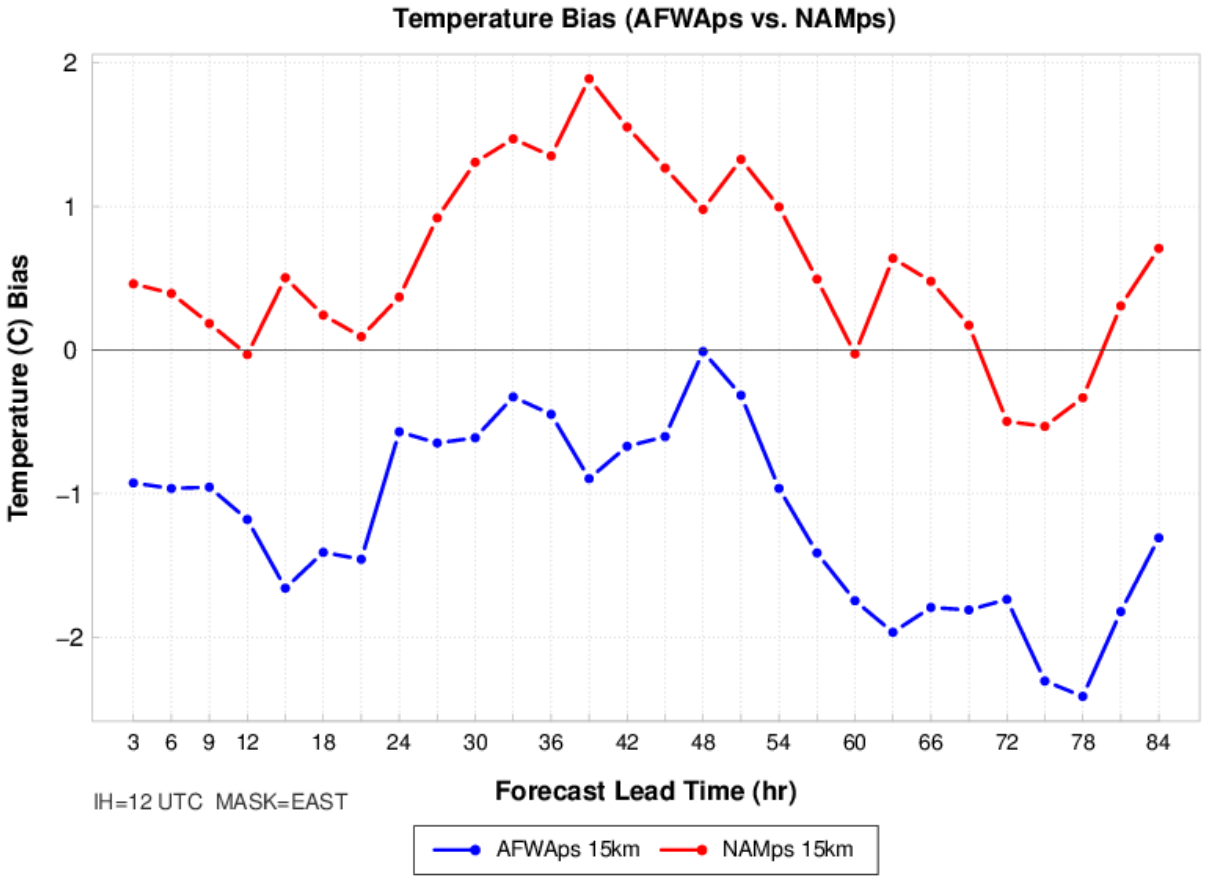
# Event Background

- Progressive derecho originated in Midwest, moved ESE across the Ohio Valley into the Mid-Atlantic
  - Traversed over 700 miles over 10 states
  - 13 deaths directly associated with storm
  - 4 million lost power
- Operational forecast guidance:
  - GFS and NAM did not provide much forecast assistance more than 24 hours out from the event
  - High-Resolution Rapid Refresh (HRRR) model forecast an MCS to move through impacted area on morning of 29 June 2012 → *however, previous performance by HRRR did not allow for much confidence in forecast*
- Case evaluation:
  - Objective verification
  - Subjective assessment of performance
  - Grid-spacing impact → *does higher resolution improve forecast?*



# East 2-m Temperature Bias
## Time Series (03 – 84 h)




- Both AF OC and NAM OC have similar distribution in temperature bias curve with lower biases at the beginning and end of the forecast period and higher relative biases during the middle of the forecast period
- AF OC has a cold bias at most forecast lead times

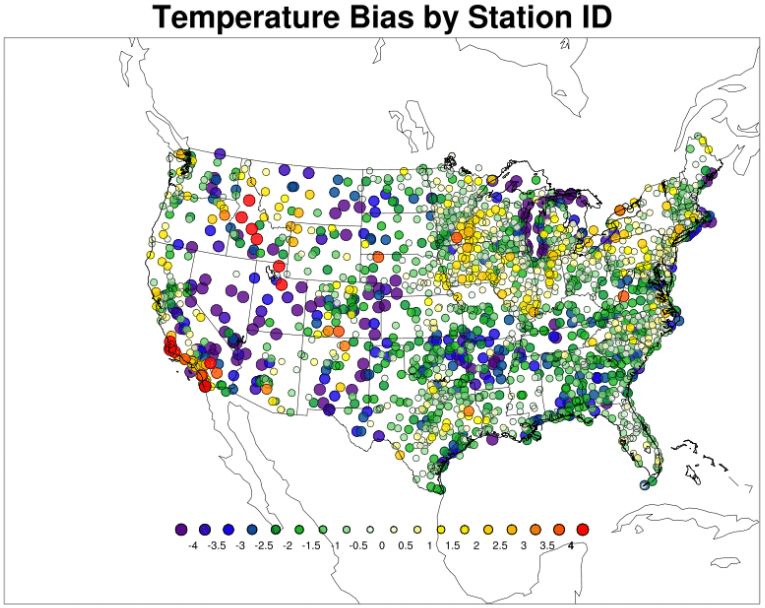
# Point Verification

## 2-m Temperature Bias (84-h forecast)

Fcst Hr: 03

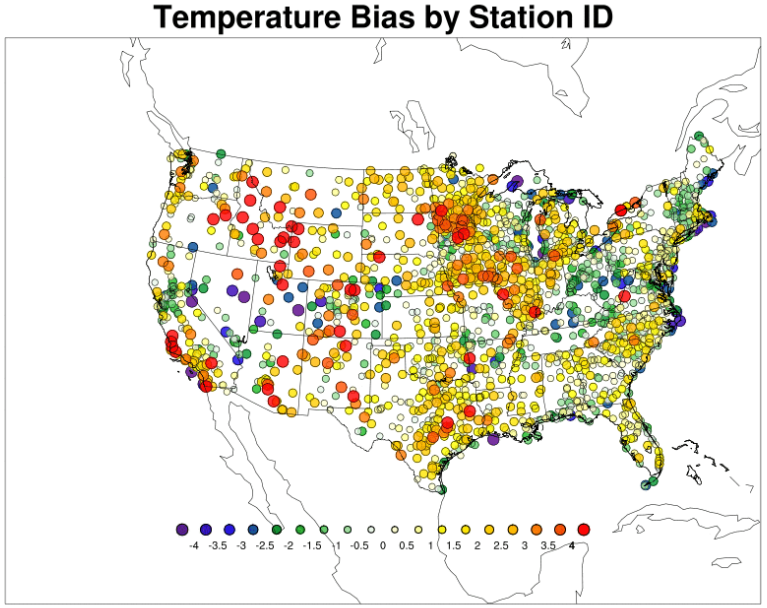
Valid: 15 UTC

**AF OC**



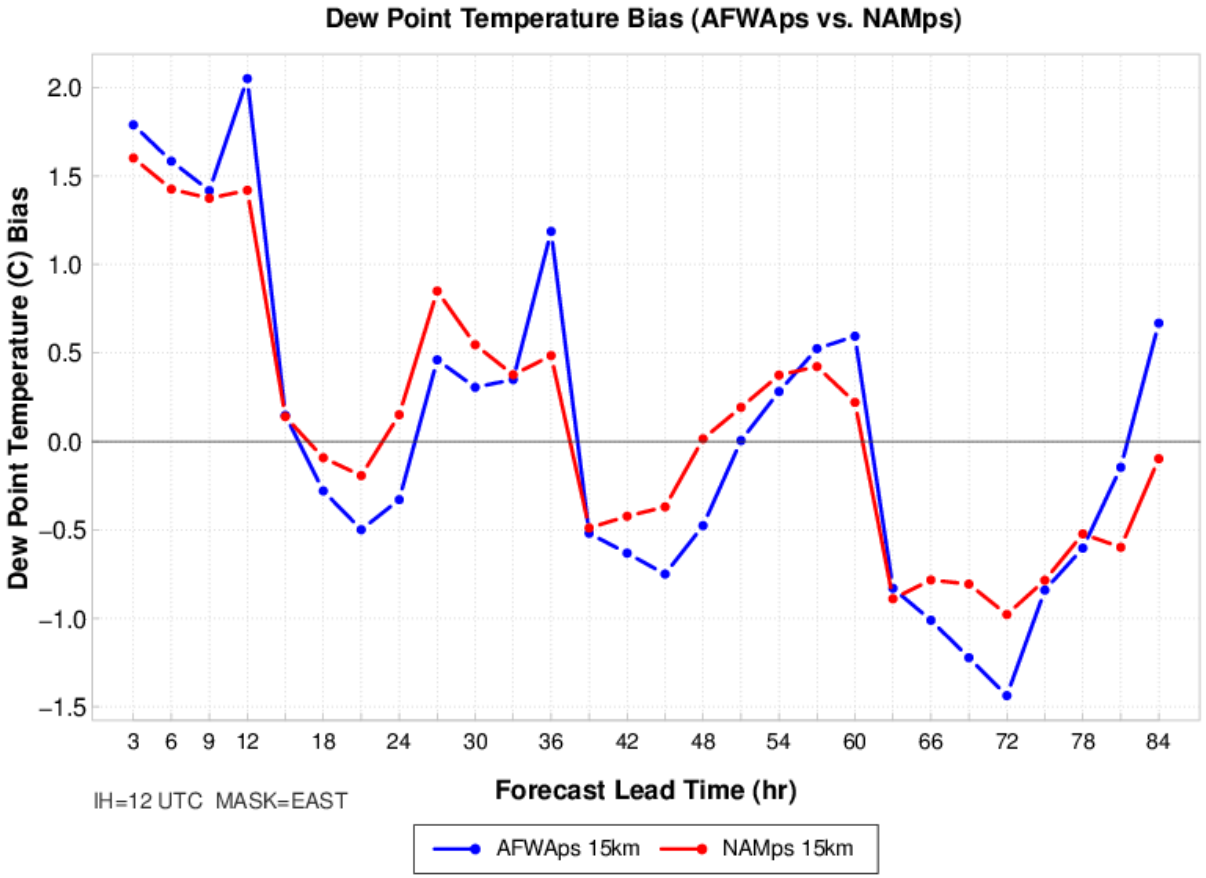

Config=AFWAps Grid Spacing=15km Date=20120628 Init=12UTC Fcst Hr=03h

**NAM OC**



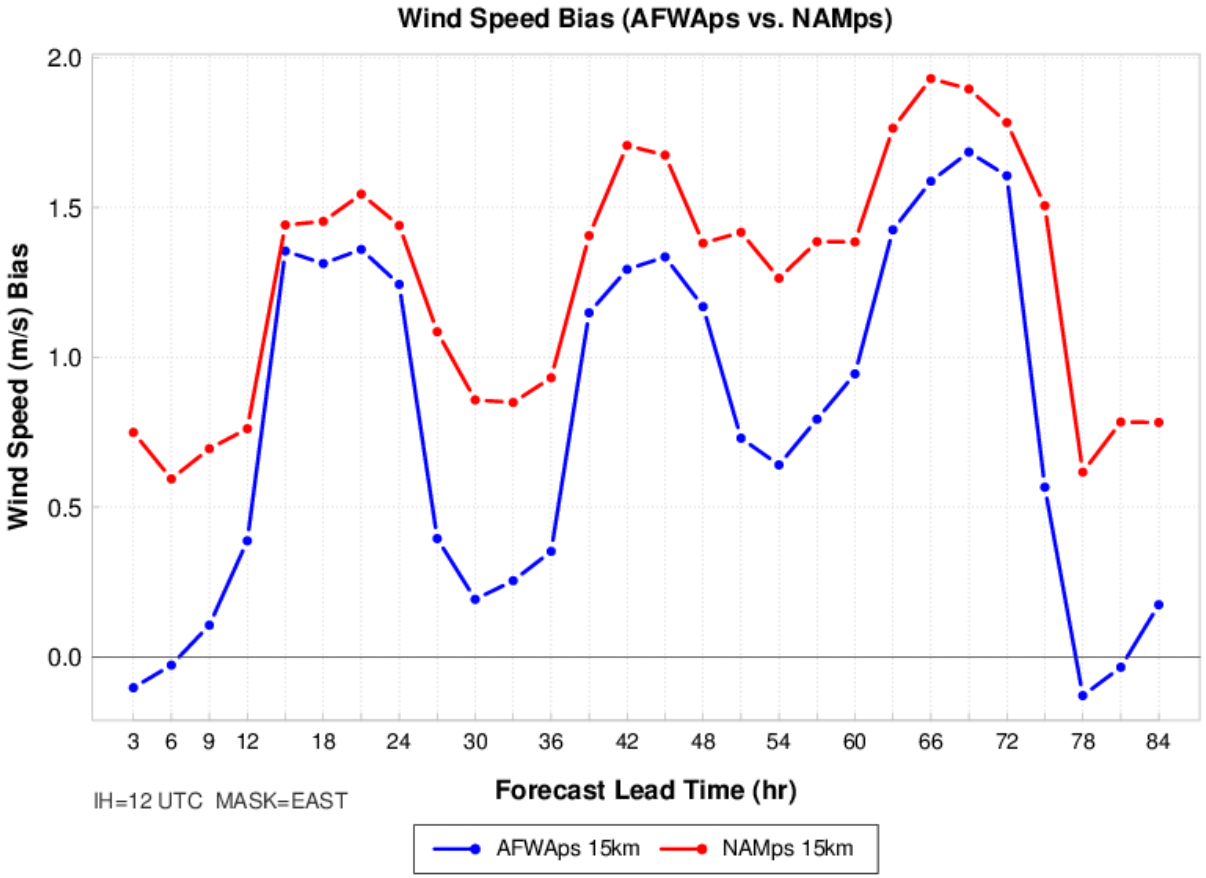

Config=NAMps Grid Spacing=15km Date=20120628 Init=12UTC Fcst Hr=03h

# East 2-m Dew Point Temperature Bias Time Series (03 – 84 h)




- Both AF OC and NAM OC have similar diurnal signals with both configurations showing a general drying trend throughout the forecast period
- AF OC typically has lower median biases than NAM OC at valid times from 06 – 18 UTC

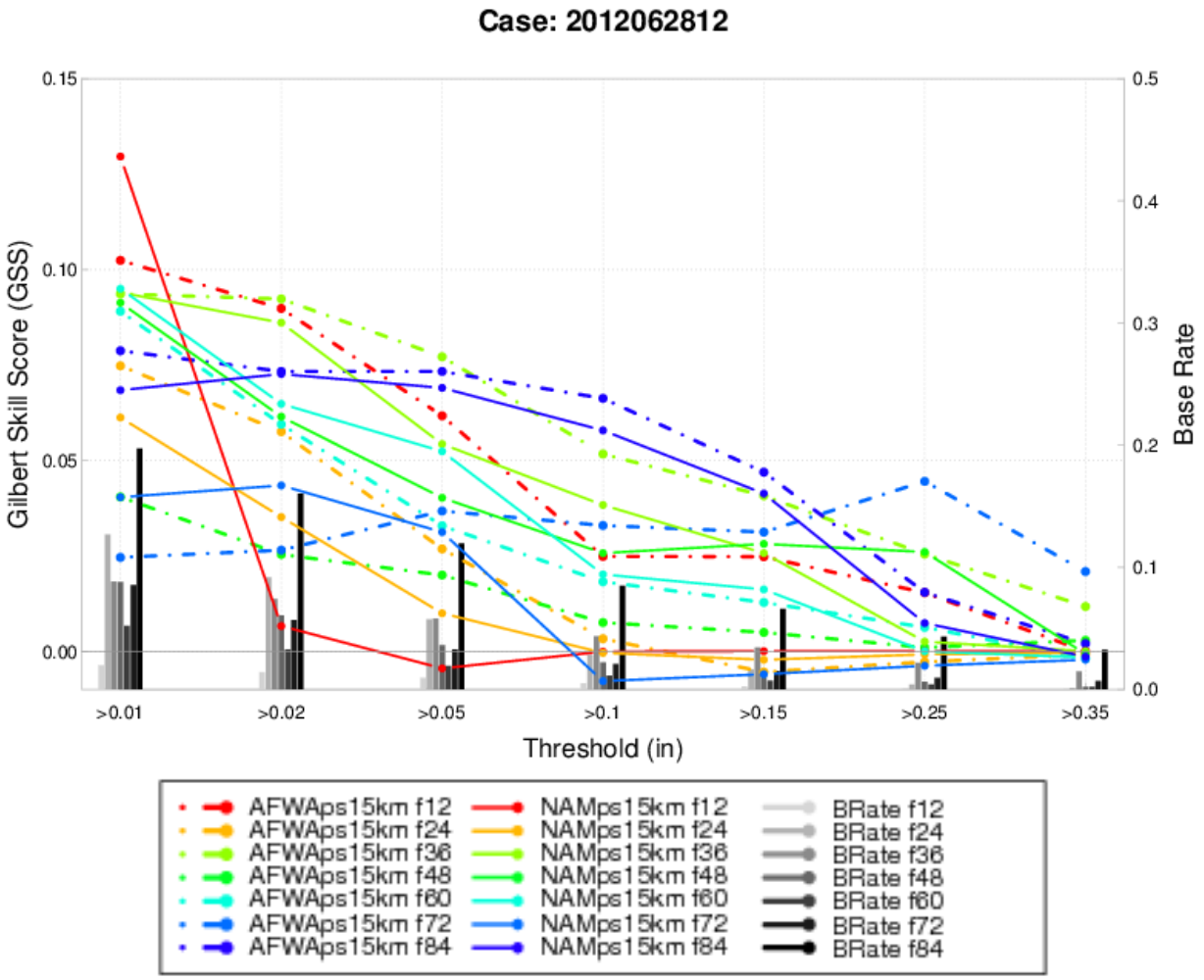
# East 10-m Wind Speed Bias Time Series (03 – 84 h)




- Both AF OC and NAM OC have similar diurnal signals with lower relative biases during the day and high biases during the evening into overnight periods
- AF OC has lower median biases than NAM OC at all forecast lead times

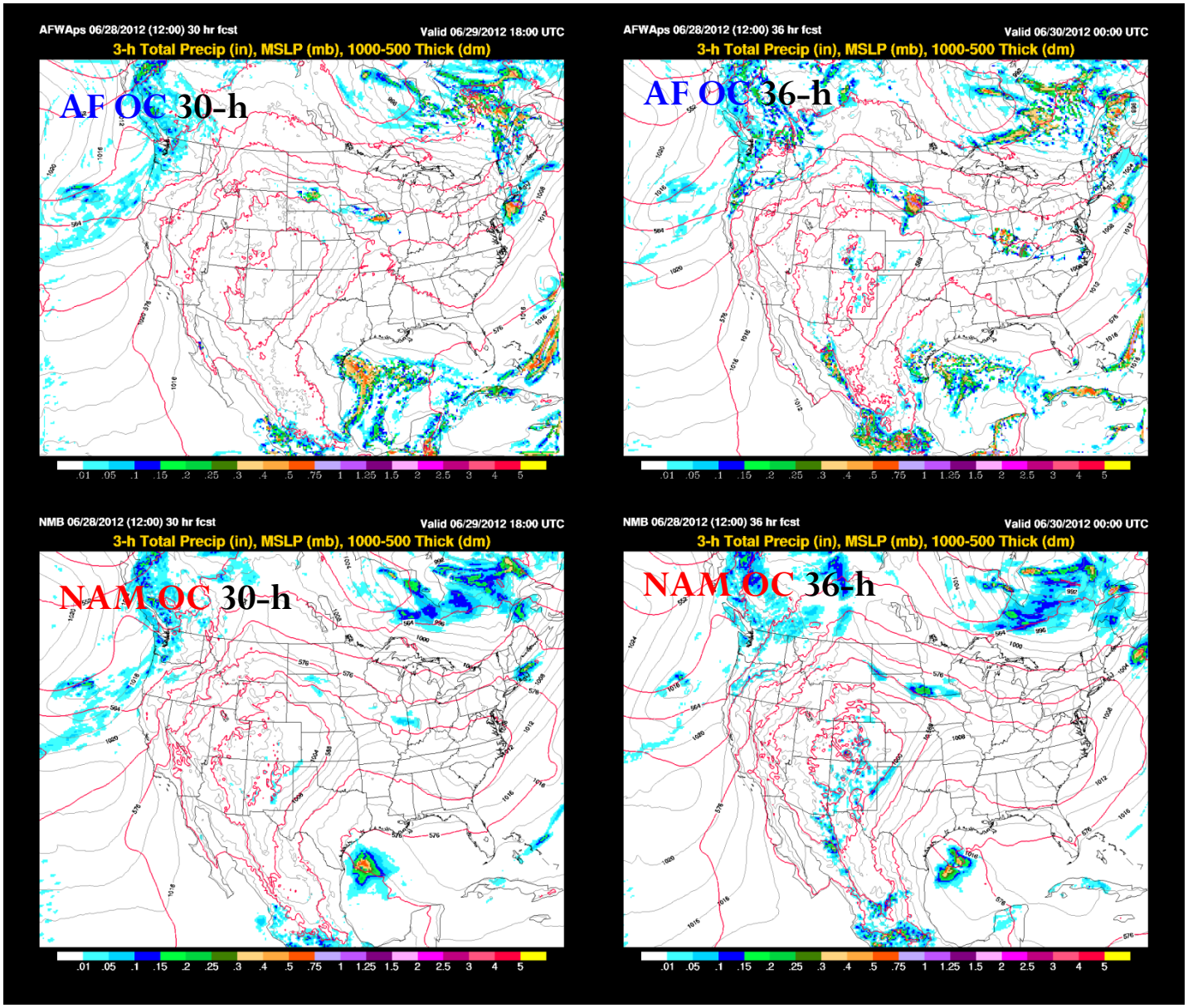
# East 3-h Precipitation Verification

## Gilbert Skill Score (GSS) by threshold




- Description:
  - AF OC dot-dash
  - NAM OC solid
  - Cooler colors with increasing forecast lead time
  - Base rate = relative frequency of occurrence of the event
- Both configurations show a general decrease in skill and base rate with increasing threshold

# 3-h Accumulated Precipitation

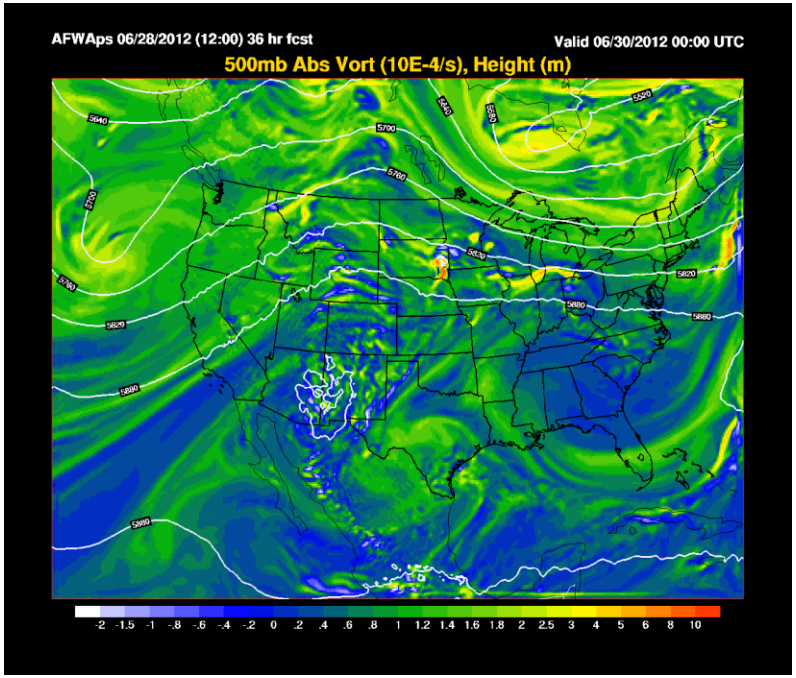



- AF OC produces precipitation in area of interest but not indicative of high-impact event
- NAM OC has minimal precipitation at the 30-h forecast lead time and no signal at the 36-h forecast lead time

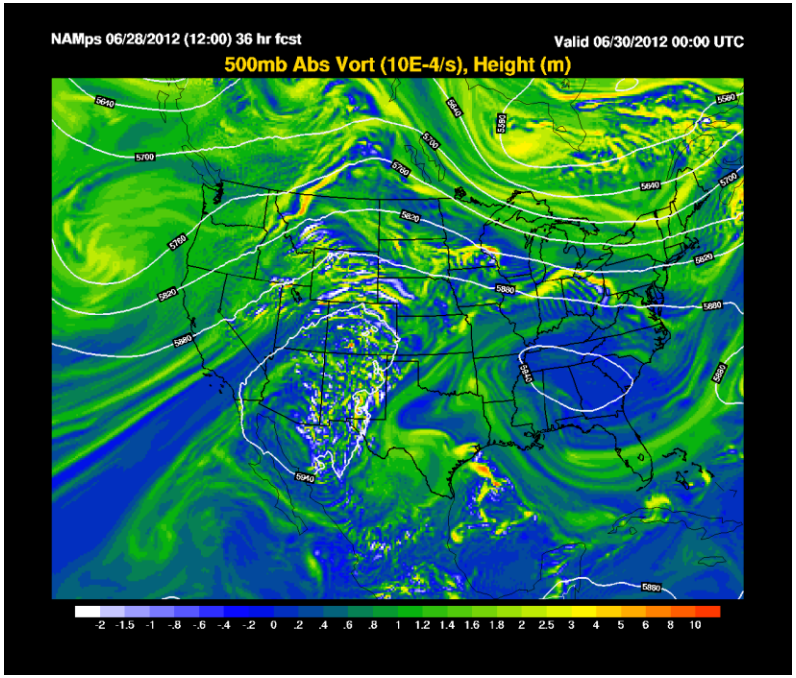
# Absolute Vorticity

## 36-h forecast

**AF OC**



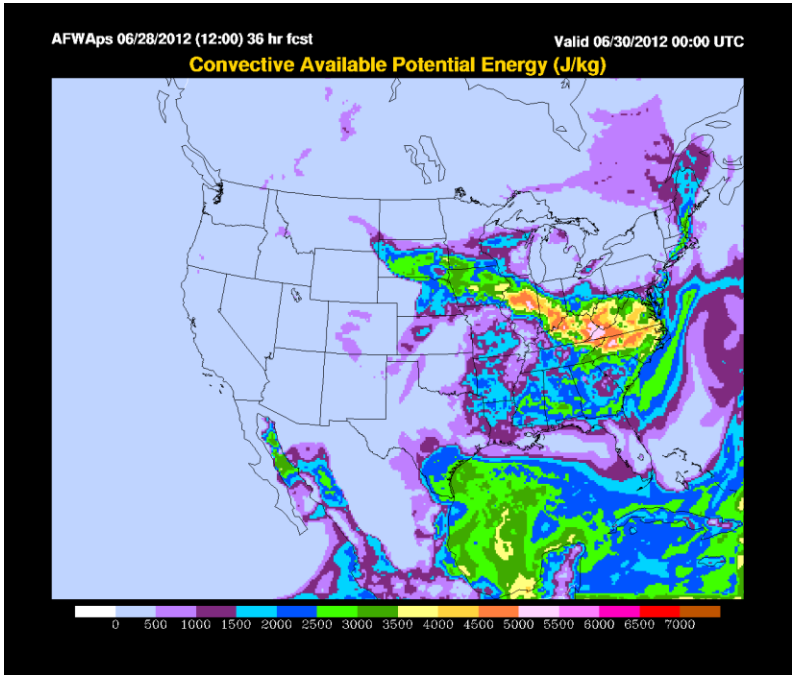

**NAM OC**



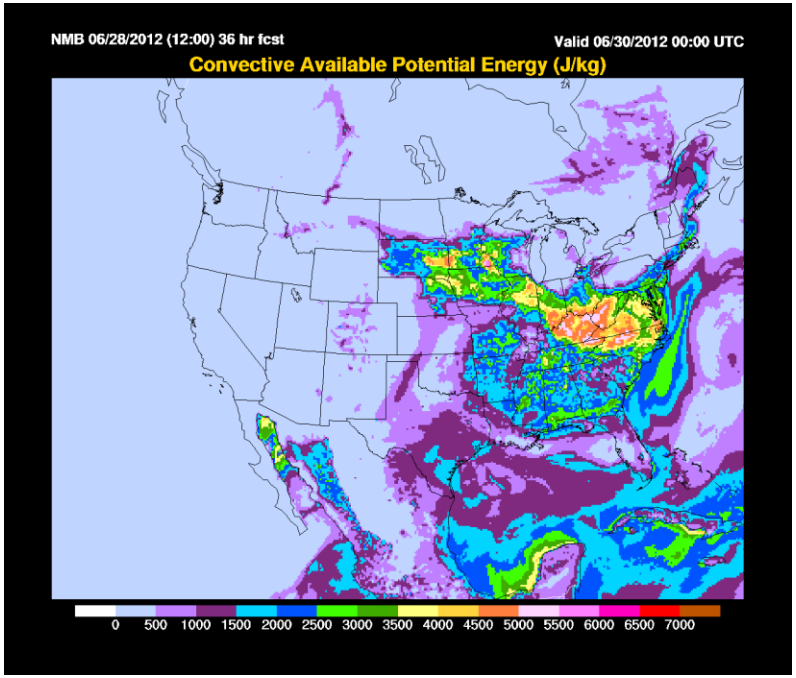

- Large-scale pattern characterized by high pressure in mid-levels over SE and zonal flow over the east and north

# Convective Available Potential Energy
## 36-h forecast

**AF OC**




**NAM OC**

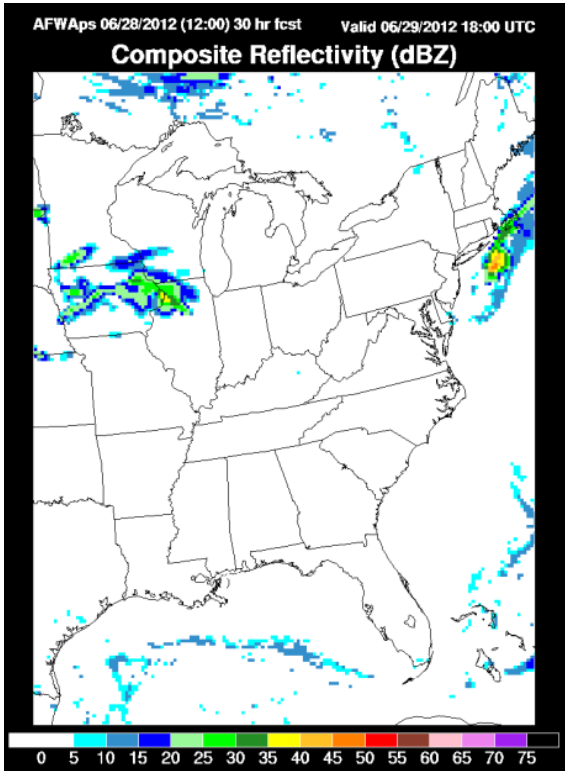



- CAPE axis aligns with elongated mid-level ridge
- Both AF OC and NAM OC have CAPE values indicative of a high-impact event with maximum values >5000 J/kg
- What factors are contributing to both models missing the event?

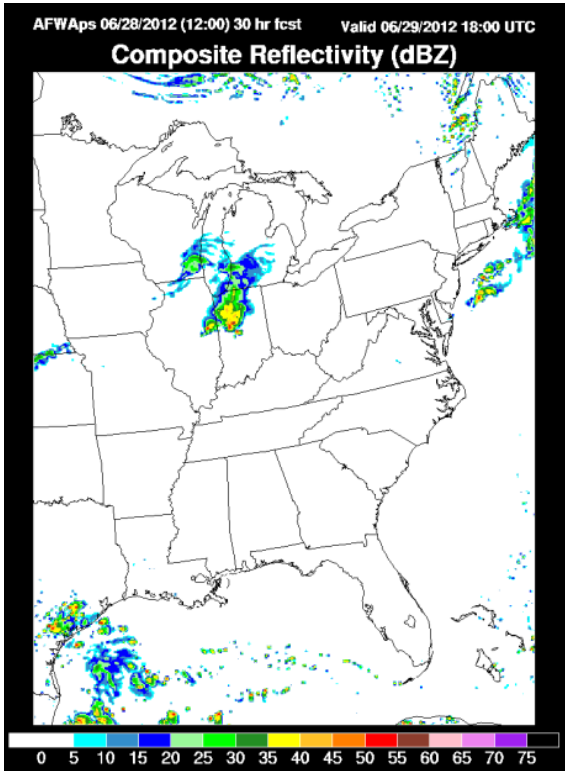
# Composite Reflectivity - AF OC

## 30-h forecast, valid at 18 UTC 29 June 2012

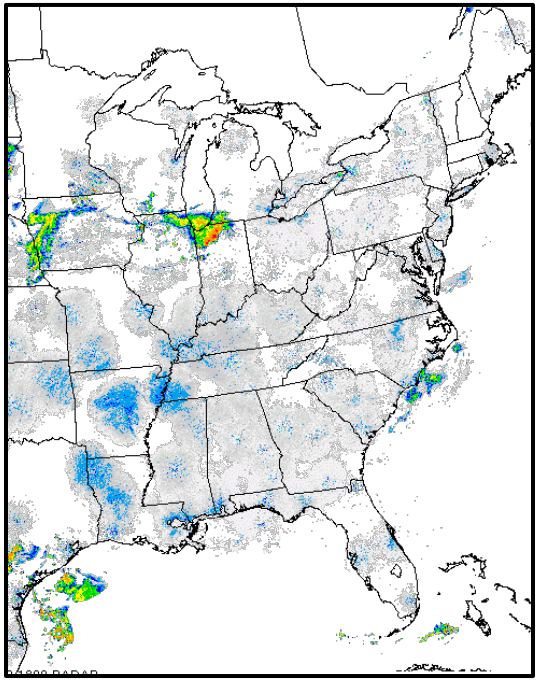
**15-km**




**5-km**



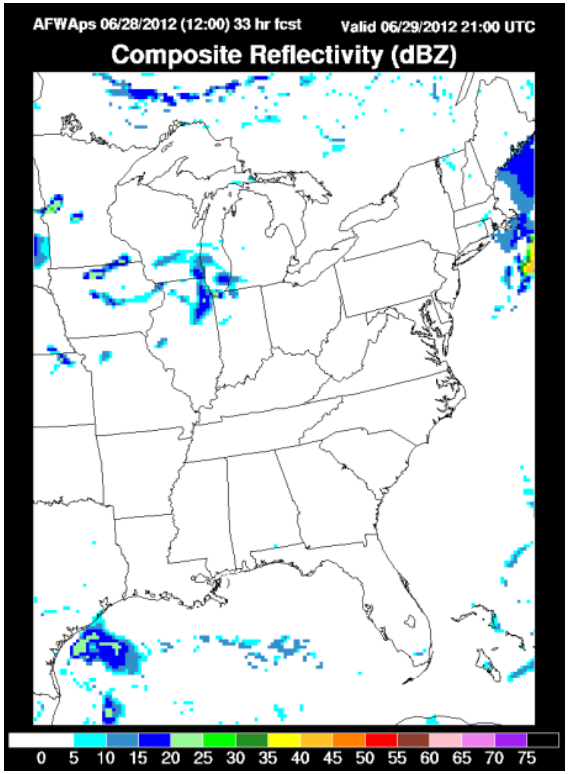

**Observation**



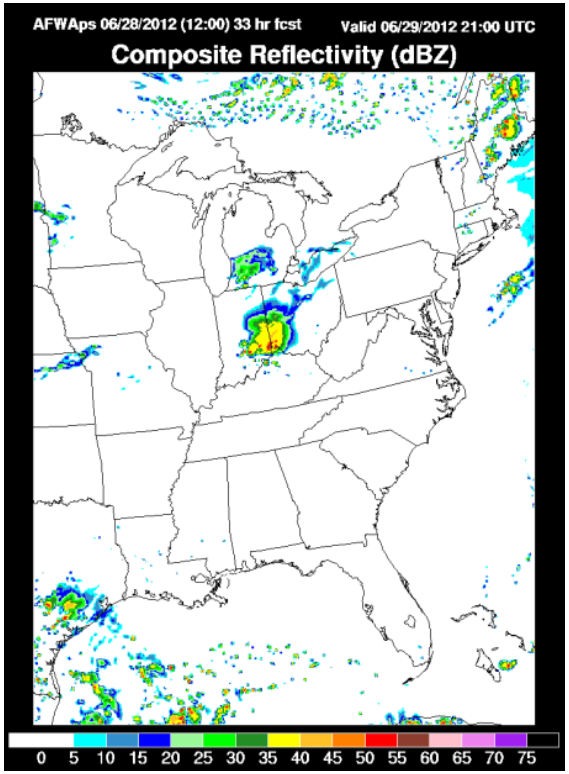
# Composite Reflectivity - AF OC

## 33-h forecast valid at 21 UTC 29 June 2012

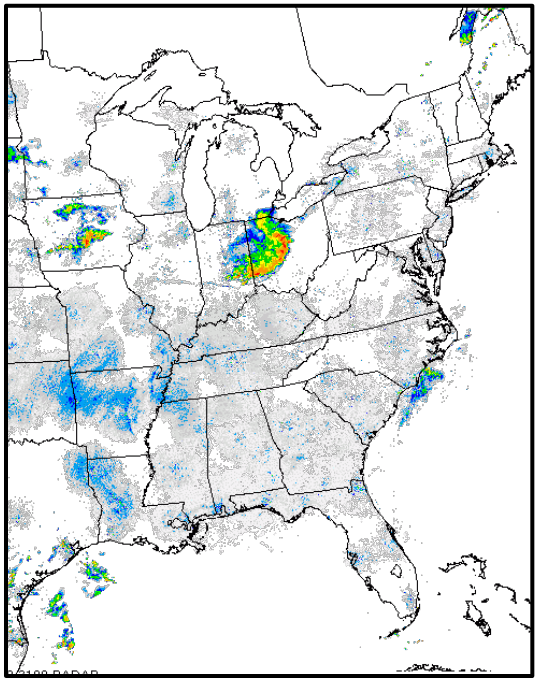
**15-km**




**5-km**



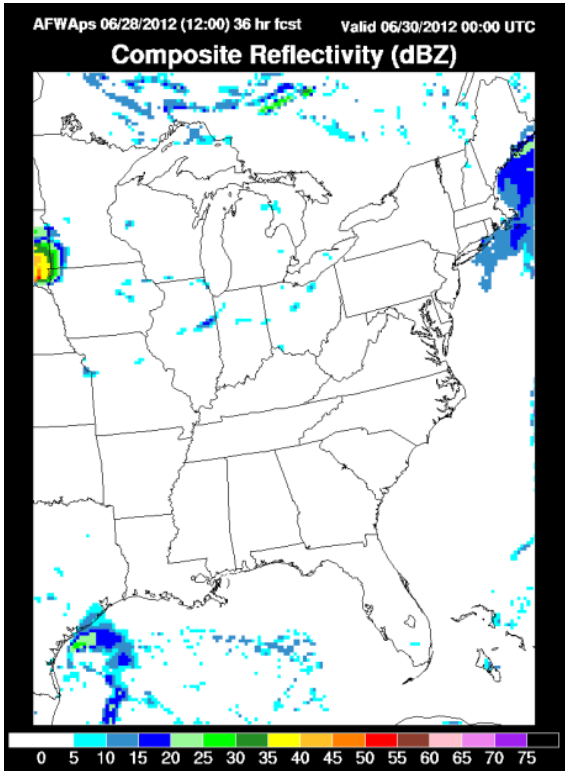

**Observation**



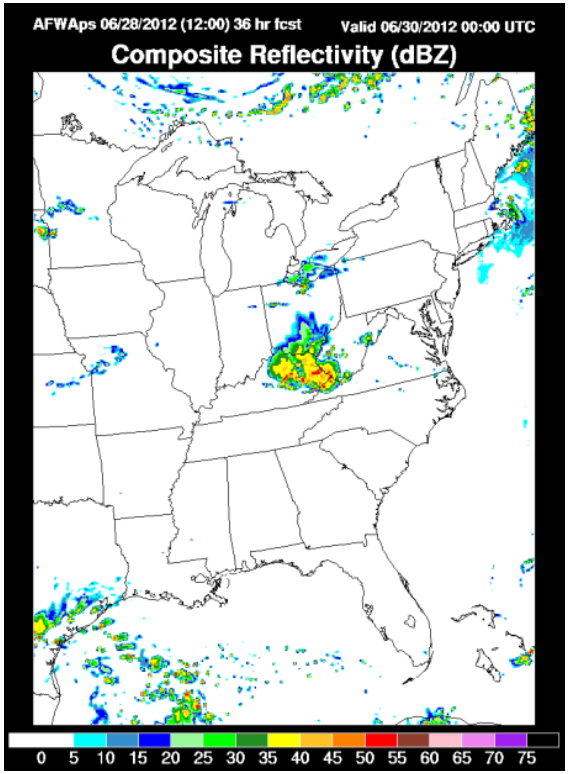
# Composite Reflectivity - AF OC

## 36-h forecast, valid at 00 UTC 30 June 2012

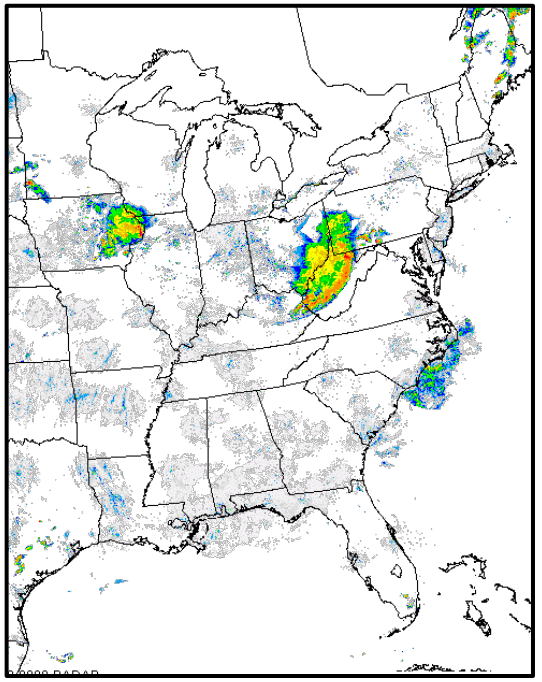
**15-km**




**5-km**




**Observation**



# How to…

**Links to MMET and related sites**

**Online tour of MMET data repository**

# MMET Online Links

MMET Website

- http://www.dtcenter.org/eval/meso_mod/mmet/index.php

R2O Testing Protocol Document

- http://www.dtcenter.org/eval/meso_mod/mmet/testing_protocol.pdf

Nomination form for new innovations

- http://www.dtcenter.org/eval/meso_mod/mmet/candidates/form_submission.php

Submission form for additional cases to be included in MMET

- http://www.dtcenter.org/eval/meso_mod/mmet/cases/form_submission.php

RAMADDA Data Repository

- http://www.dtcenter.org/repository

# Community Code Links

Weather Research and Forecasting Model (WRF)

- http://www.wrf-model.org/index.php

NOAA Earth Modeling System (NEMS)

- http://www.dtcenter.org/nems-nmmb/users/

Unified Post Processor (UPP)

- http://www.dtcenter.org/upp/users/

Model Evaluation Tools (MET)

- http://www.dtcenter.org/met/users/

Gridpoint Statistical Interpolation (GSI)

- http://www.dtcenter.org/com-GSI/users/

# Questions?

## Thank You!

### Contact information for MMET Team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