QPF Verification Comparison between the GFS and NAM Operational Models

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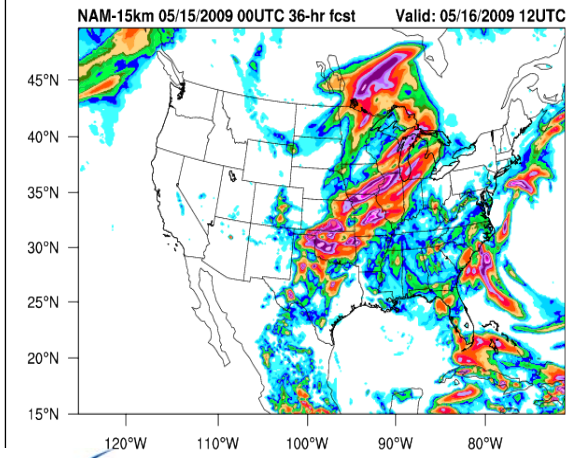
Overview

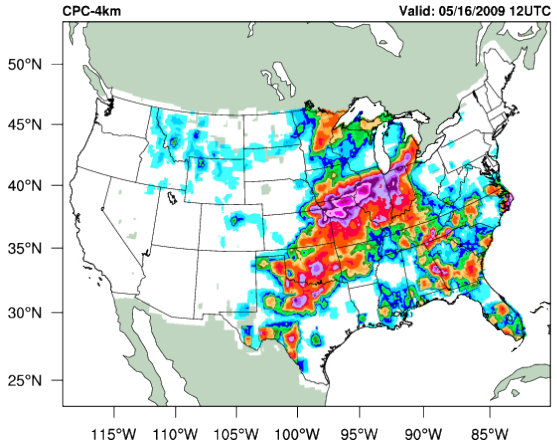
- Goal: Assess the performance of the Global Forecast System (GFS) and North American Mesoscale (NAM) operational models, which differ significantly in horizontal resolution
  - Secondary goal: Demonstrate the utility of, and the attributes available from, new spatial verification techniques

24-h Accumulated Total Precipitation (in)

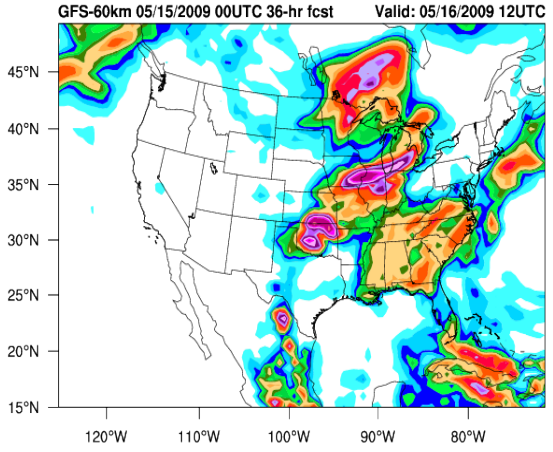
NAM (higher resolution)

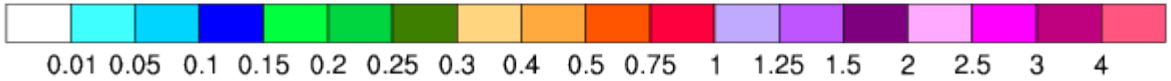


Observations



GFS (coarser resolution)



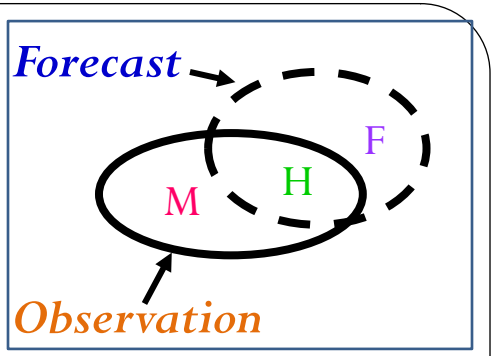


Experiment Design

- Native forecast datasets
  - GFS: global Gaussian grid (half-degree resolution)
  - NAM: E-grid domain (~12-km resolution)
- Native observation datasets
  - NCEP Stage II analyses: 3-h observed precip accum (4-km resolution)
  - NCEP/CPC analyses: 24-h observed precip accum (1/8-degree resolution)
- Test Period: 18 Dec 2008 – 15 Dec 2009
- Retrospective forecasts: 00 UTC daily initializations out to 84 h (with output available every 3 h)
- Common grid: 4-km, 15-km, 60-km CONUS
- Verification: Model Evaluation Tools v3.0

Verification domain

Model Verification



- Traditional Verification Metrics
  - **Gilbert Skill Score (GSS)**: Fraction of obs and/or fcst events that were correctly predicted

$$\frac{\#\text{Hits} - \#\text{Hits}_{\text{rand}}}{\#\text{Hits} + \#\text{Misses} + \#\text{False Alarm} - \#\text{Hits}_{\text{rand}}}$$

$$\#\text{Hits}_{\text{rand}} = \frac{(\text{Total Fcst Area})(\text{Total Obs Area})}{\text{Total Area}}$$

Range: -0.33 to 1. Perfect: 1

  - **Frequency Bias**: Ratio of the frequency of forecast events to the frequency of observed events

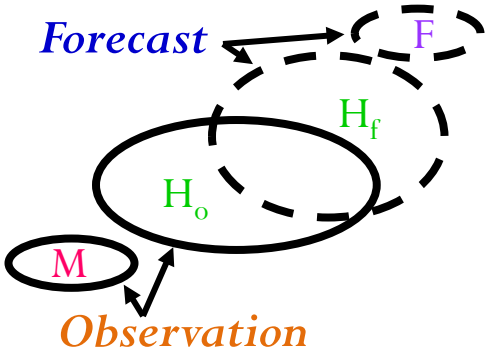
$$\frac{\#\text{Hits} + \#\text{False Alarm}}{\#\text{Hits} + \#\text{Misses}} \quad \text{-or-} \quad \frac{\text{Total Fcst Area}}{\text{Total Obs Area}}$$

Range: 0 to ∞. Perfect: 1 (Under-forecast<1, Over-forecast>1)

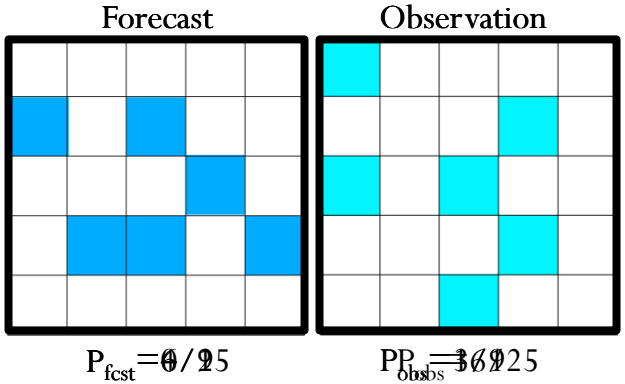
- Computed confidence intervals (CIs) at the 99% level, using a bootstrapping technique
- Identified statistically significant (SS) differences between scores

Model Verification, Cont.

- Spatial Verification Techniques
  - **Method for Object-based Diagnostic Evaluation (MODE)**: *Identify*, *merge* and *match* objects in forecast and observed fields
    - Example attributes:
      - centroid distance, boundary distance, angle difference, area ratio, percent coverage, intersection area ratio, etc.



  - **Fractional Skill Score (FSS)**: Obtain a measure of how forecast skill varies with spatial scale

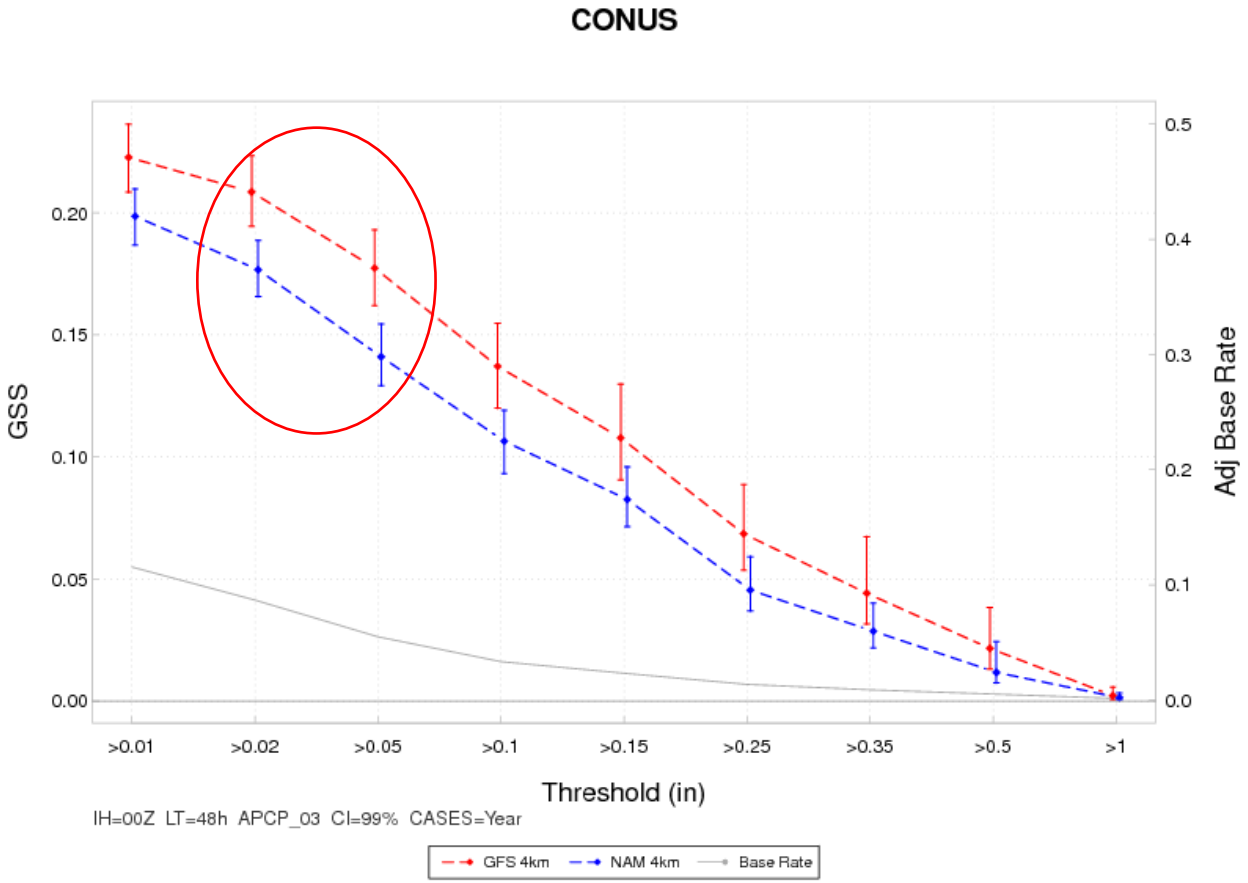


Courtesy: Mittermaier

Verification Results

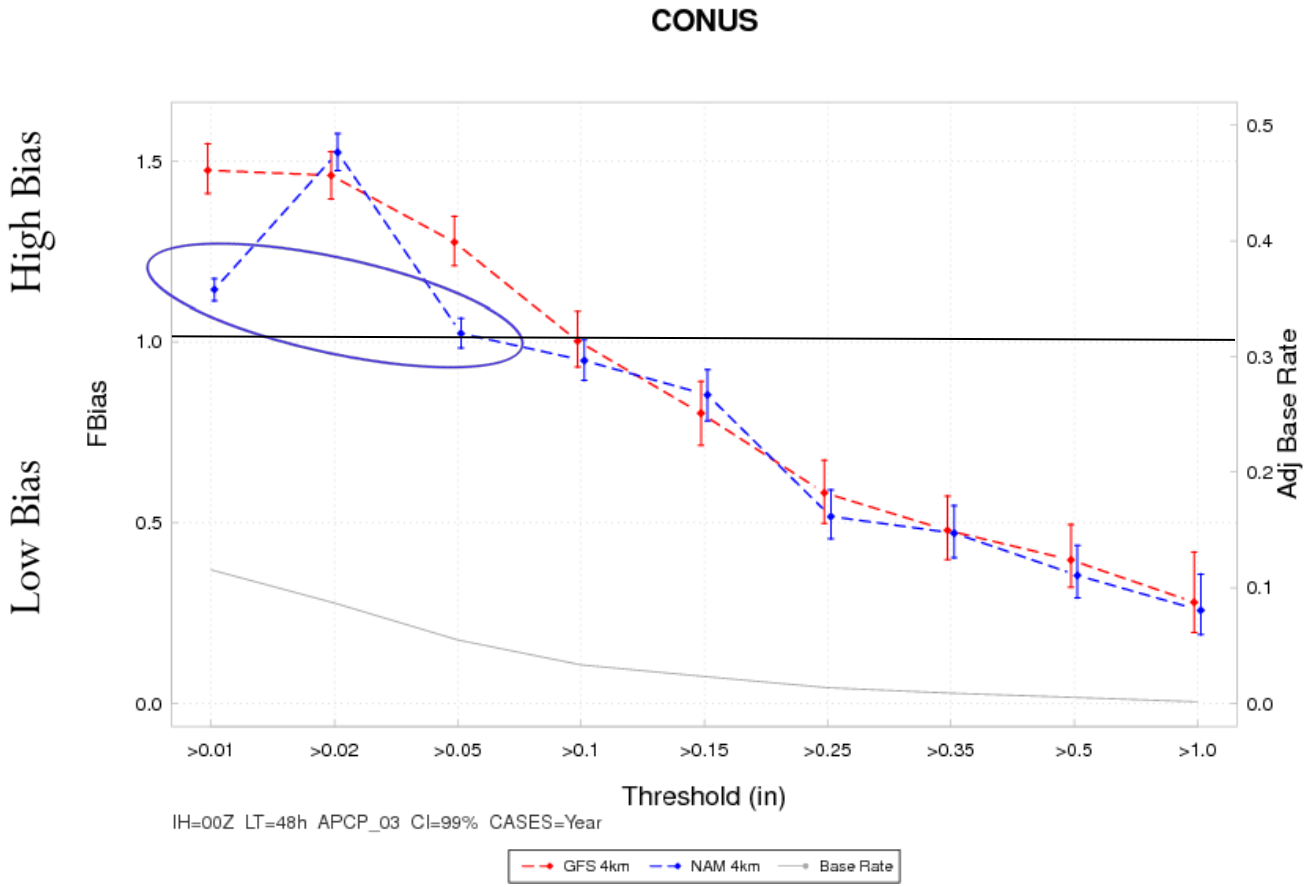
Traditional Verification:
Gilbert Skill Score (GSS)

Higher skill



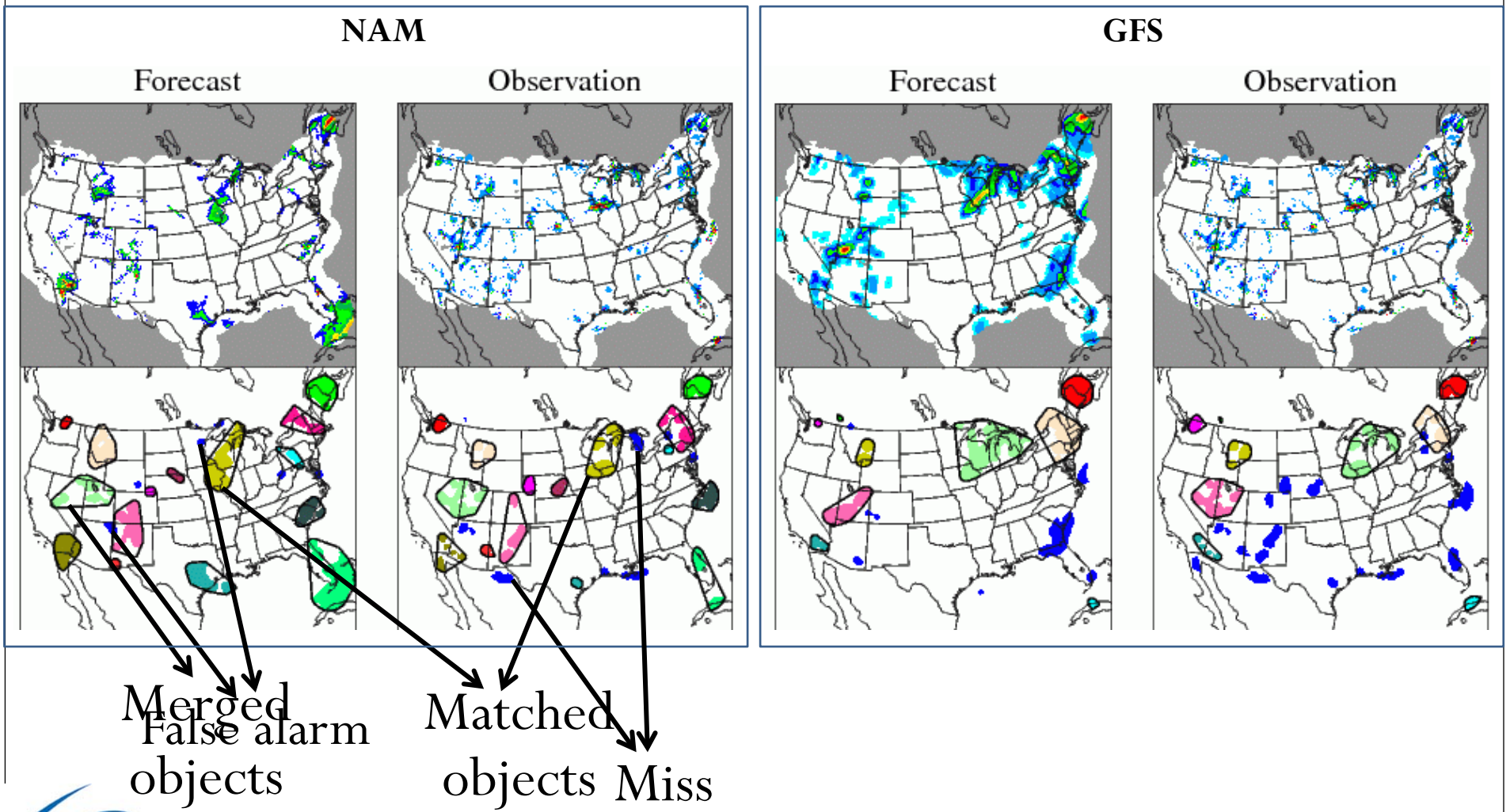
- With two exceptions, the scores are not statistically different when measuring performance based on this traditional metric

Traditional Verification:
Frequency Bias

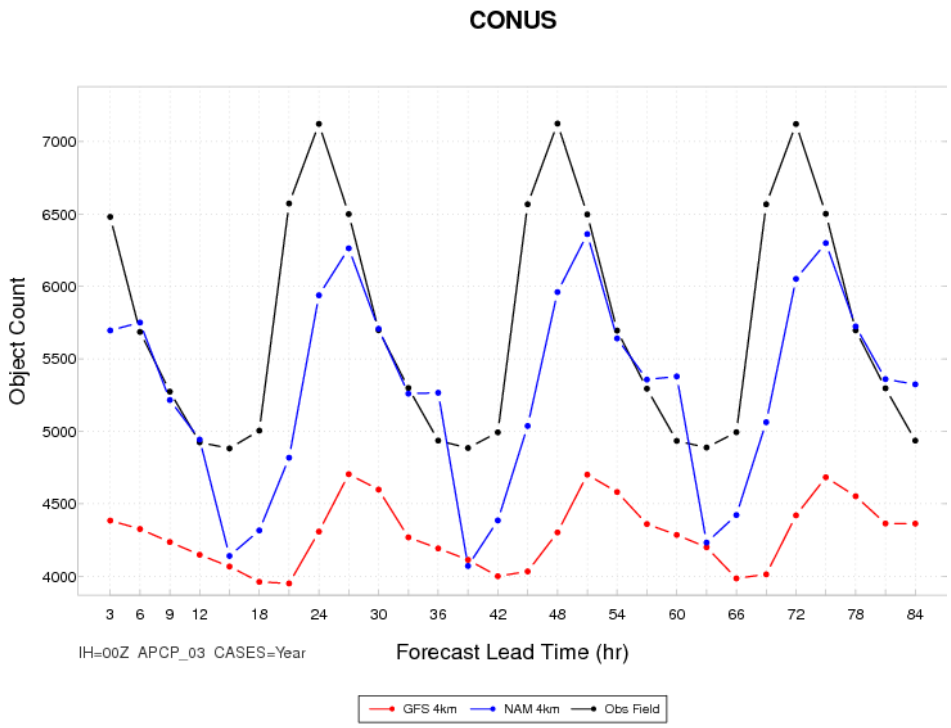


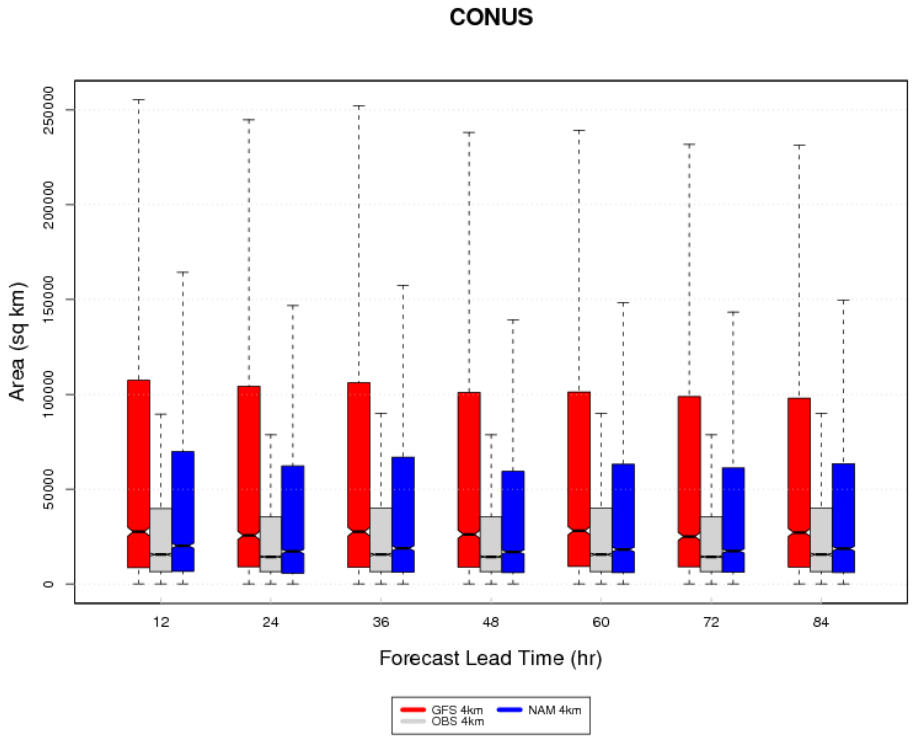
- Again, with two exceptions, the scores are not statistically different when measuring performance based on this traditional metric

Spatial Verification:
Method for Objection-based Diagnostic Evaluation (MODE)



MODE:
Object Counts and Areas

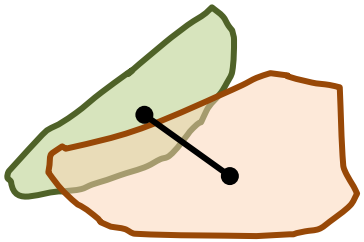


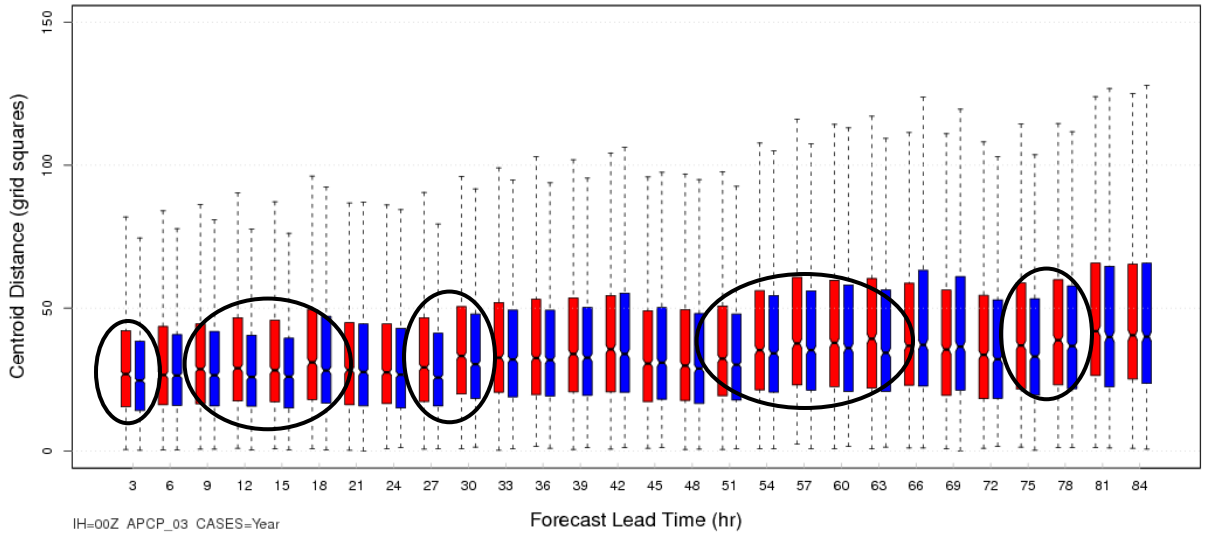


- Counts and size distribution for objects defined within the **NAM4** forecast are more consistent with the obs field than the **GFS4** forecast

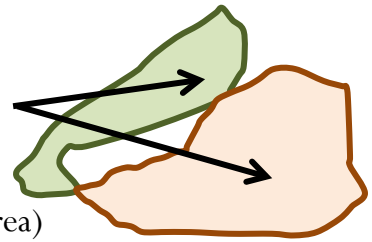
MODE Attributes (matched objects):

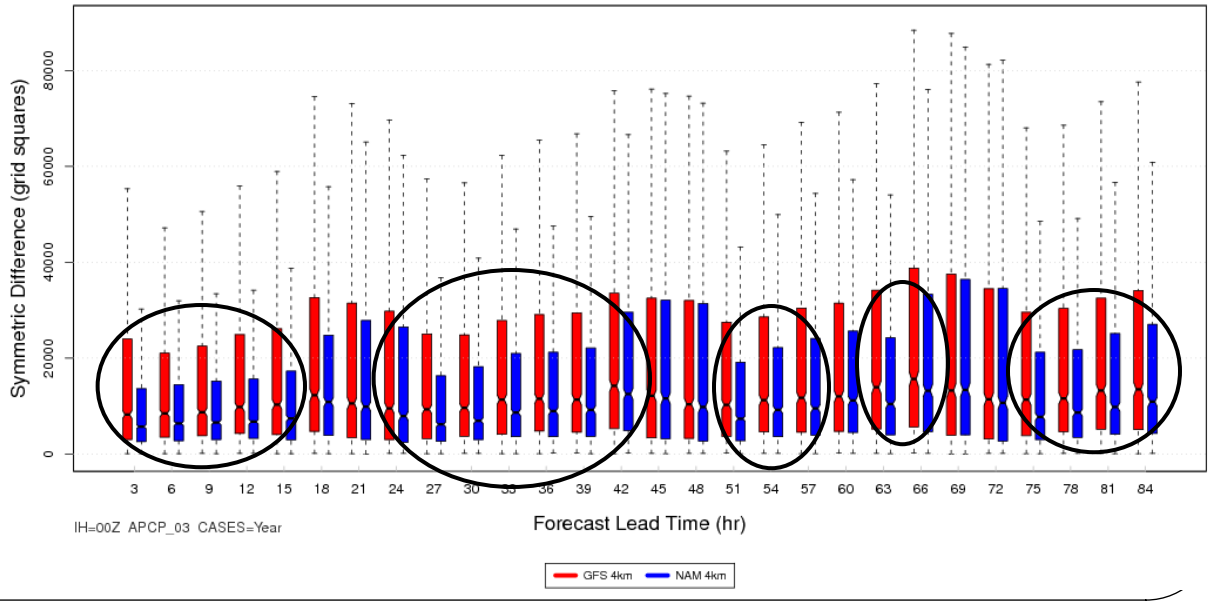
Example:
Centroid
Distance



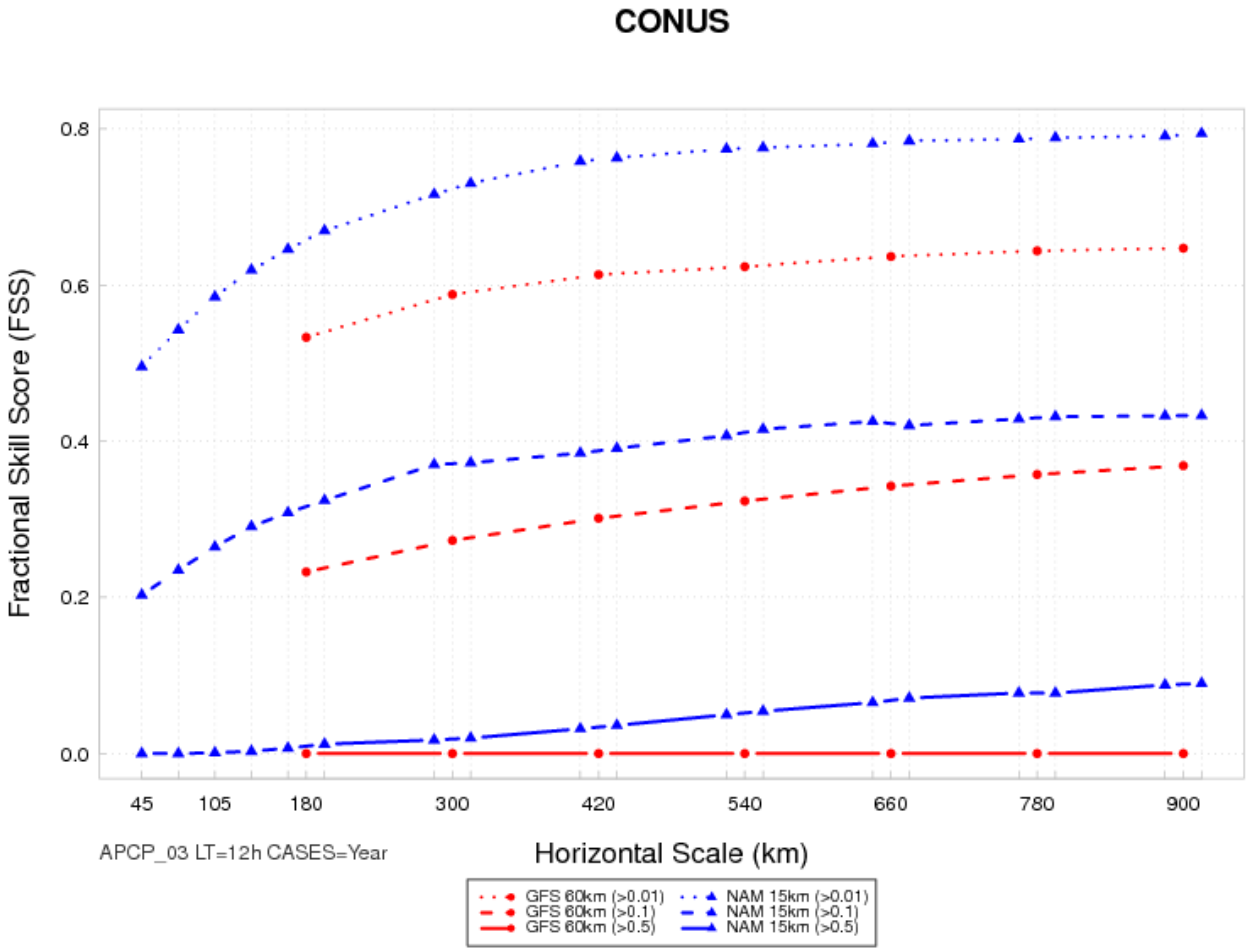


Example:
Symmetric
Difference
(non-intersecting area)



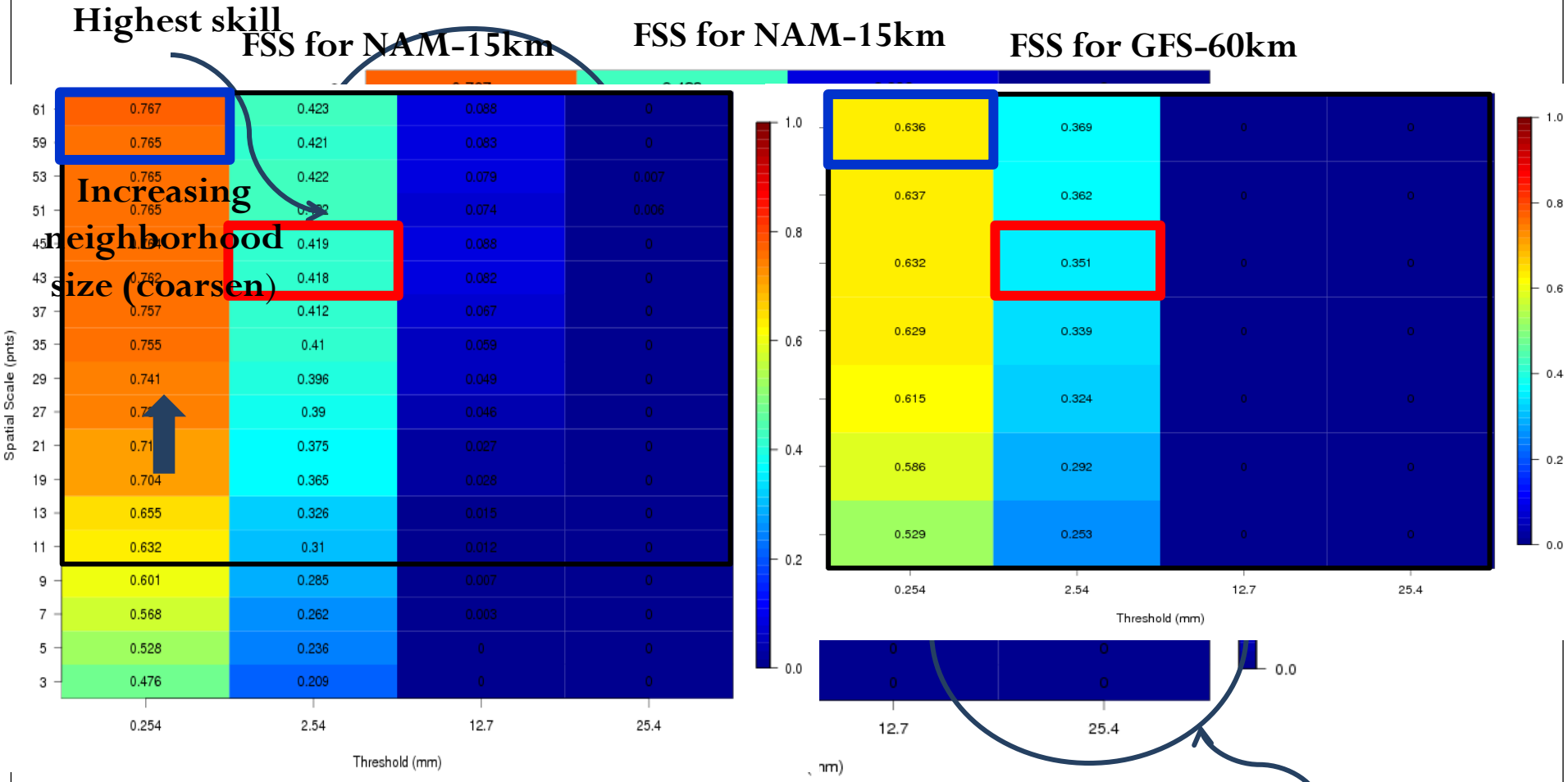


Spatial Verification:
Fractional Skill Score



- **NAM15** is consistently higher than the **GFS60** across all thresholds (12h lead time shown)

FSS: Quilt Plot



- FSS for **NAM15** forecast is consistently higher than the **GFS60** forecast regardless of spatial scale or threshold

Summary

- Even though, subjectively, the higher-resolution models can provide added benefit, traditional verification metrics show no notable, consistent improvement in scores
- Advanced spatial verification techniques can provide useful information on forecast skill for high-resolution models
  - MODE
    - NAM objects (counts and area) more closely reproduce those of the observation field
    - Example attributes of matched objects favor the NAM
  - FSS
    - NAM has consistently higher skill than the GFS at comparable spatial scales
- For more information, see:

http://verif.rap.ucar.edu/eval/gfs_nam_pcp/

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