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)
- 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
Model Verification

- **Traditional Verification Metrics**
  - **Gilbert Skill Score (GSS):** Fraction of obs and/or fcst events that were correctly predicted
    \[
    \frac{\#\text{Hits} - \#\text{Hits}_{\text{rand}}}{\#\text{Hits} + \#\text{Misses} + \#\text{False Alarm} - \#\text{Hits}_{\text{rand}}} \]
    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 \(\infty\). 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
Verification Results
Traditional Verification: Gilbert Skill Score (GSS)

- 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 NAM-15km forecast is consistently higher than the GFS-60km forecast regardless of spatial scale or threshold.

Increasing neighborhood size (coarsen)
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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