# Application of MET for the Validation of Satellite Precipitation Estimates

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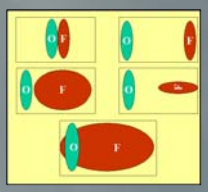
## Introduction:

• The goal of this study is to demonstrate the usefulness of the NCAR Model Evaluation Tools (MET) applied to the validation of high-resolution satellite rainfall estimates.
• MET was originally developed to support the Developmental Testbed Center (DTC) at NCAR and has been integrated into the Weather Research and Forecasting (WRF) system primarily for forecast verification applications. It provides tools that can be applied to spatial precipitation fields:
  • Grid-to-point validation
  • Grid-to-grid validation
  • Advanced spatial validation techniques



• Most validation studies rely on the use of standard validation measures (mean error, bias, mean absolute error, and root mean squared error, etc.) to quantify the quality of the precipitation estimates.
• Traditional are often not able to account for small-scale variability or discriminate types of errors such as displacement in time and/or space (location, intensity, and orientation errors, etc.) in the precipitation estimates.

• This initial analysis is a demonstration of MET. For the study, we have used MET applied to the TRMM Multi-satellite precipitation analysis (TMPA) and to the NRL-Blended satellite products at the 0.25° spatial and 3-h temporal resolution.

• Observation Dataset: SPC Spring 2005 Project
  • Time Period:18 April – 4 June 2005
  • 9 cases selected for extensive study
  • Study Domain: United States, Rocky Mountains (west) to Appalachian Mountains (east)
  • Stage II multi-sensor (radar-estimated rainfall combined with rain gauges) hourly accumulated precipitation on a 4-km grid
  • Precipitation was accumulated for the 3-h period and averaged to the same 0.25° grid of the satellite products.

## Spatial validation Technique:

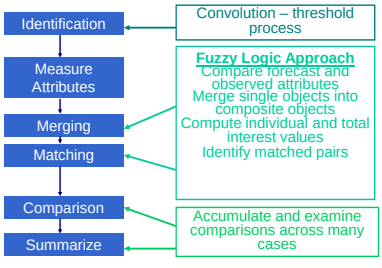
• MODE was developed at NCAR for forecast (e.g., WRF) evaluation.

• MODE Definitions
  *Merging*: Associating objects in the same field
  *Matching*: Associating objects between fields
  *Attributes*: Used for matching, merging, and evaluation

Example single attributes:
- Location
- Size (area)
- Orientation angle
- Intensity (0.10, 0.25,0.50, 0.75, 0.90 quantiles)

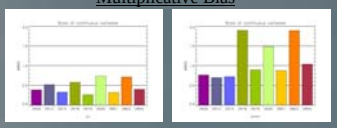
Example paired attributes:
- Centroid/boundary distance
- Size ratio
- Angle difference
- Intensity differences

Method for Object-based Diagnostic Evaluation (MODE): Object-based Approach

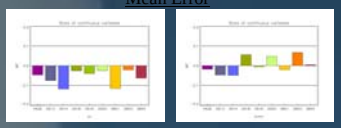



## Standard Statistical Analysis:

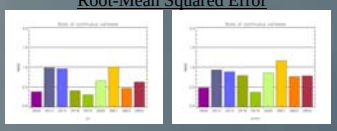
Multiplicative Bias



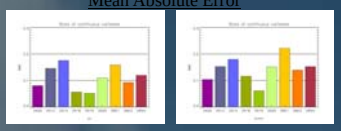
Mean Error



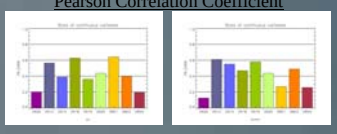
Root-Mean Squared Error



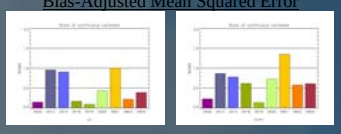
Mean Absolute Error



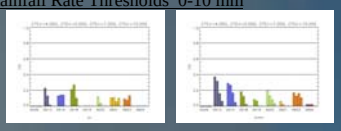
Pearson Correlation Coefficient



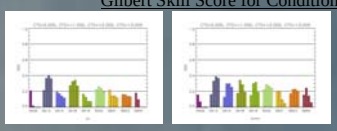
Bias-Adjusted Mean Squared Error

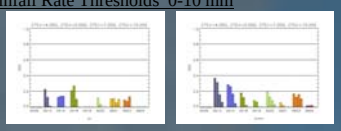


Critical Success Index for Conditional Rainfall Rate Thresholds 0-10 mm

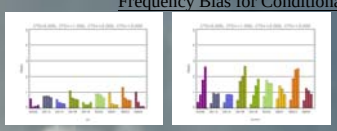


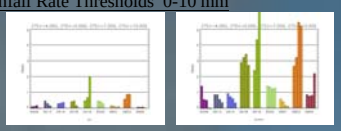
Gilbert Skill Score for Conditional Rainfall Rate Thresholds 0-10 mm





Frequency Bias for Conditional Rainfall Rate Thresholds 0-10 mm

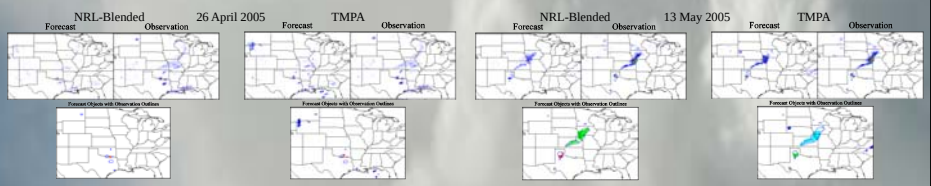




## Evaluation Cases:

• Note: For each case, the "Forecast" is the satellite rainfall estimate and the "Observation" is the surface rainfall estimate.

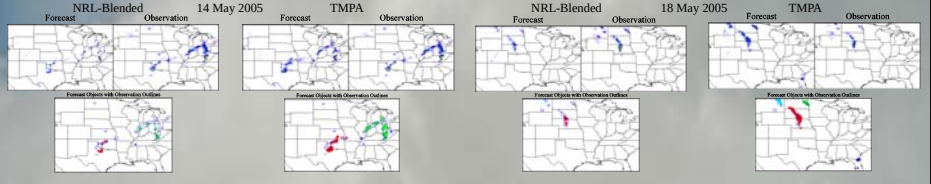
NRL-Blended 26 April 2005 TMPA



NRL-Blended 13 May 2005 TMPA



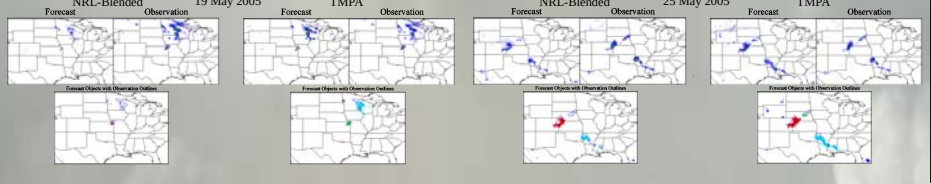
NRL-Blended 14 May 2005 TMPA



NRL-Blended 18 May 2005 TMPA



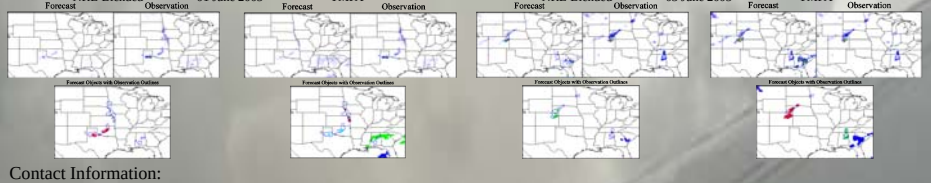
NRL-Blended 19 May 2005 TMPA



NRL-Blended 25 May 2005 TMPA



NRL-Blended 01 June 2005 TMPA

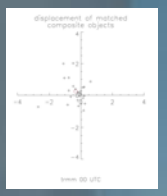


NRL-Blended 03 June 2005 TMPA



NRL-Blended 04 June 2005 TMPA

## Spatial Analysis:



## Summary:

• The analysis indicates that NRL-blended product underestimated the rainfall for the 9 cases. The TMPA product was in much better agreement with the Stage II product
• Other statistical measures (ME, MAE, RME, Correlation, CSI, GSS) show that the two products performed very similar to each other for the 9 cases
• Spatial analysis indicates that both products observed the structure of the more intense precipitation regions, but missed the light precipitation areas. Displacement analysis indicates that the NRL-blended precipitation is slightly biased north, which is not observed in the TMPA
• The MET is a useful application for computation of standard statistical validation measures and provide information about the spatial variability between the surface and satellite precipitation estimates
• The study is in the process of being expanded to evaluate the other high-resolution satellite precipitation products
• Once the initial configuration of MET is complete, it can be used for routine analysis at other validation locations (Europe, West Africa, etc.)
• The object analysis will be expanded to evaluate other errors such as intensity, orientation, and temporal displacement

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