Evaluation of a Scale Separation Technique for Assessing WRF Forecasts of Radar Reflectivity

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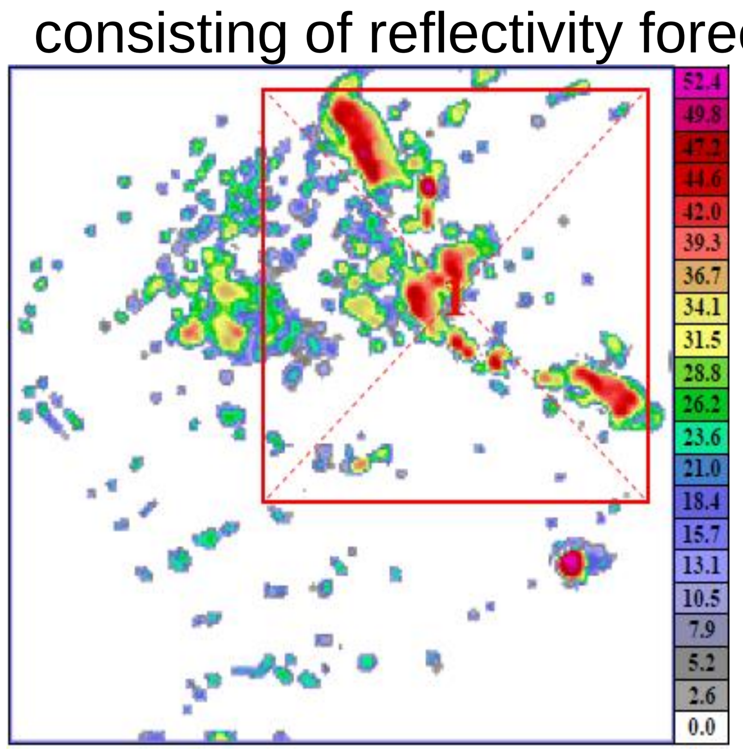
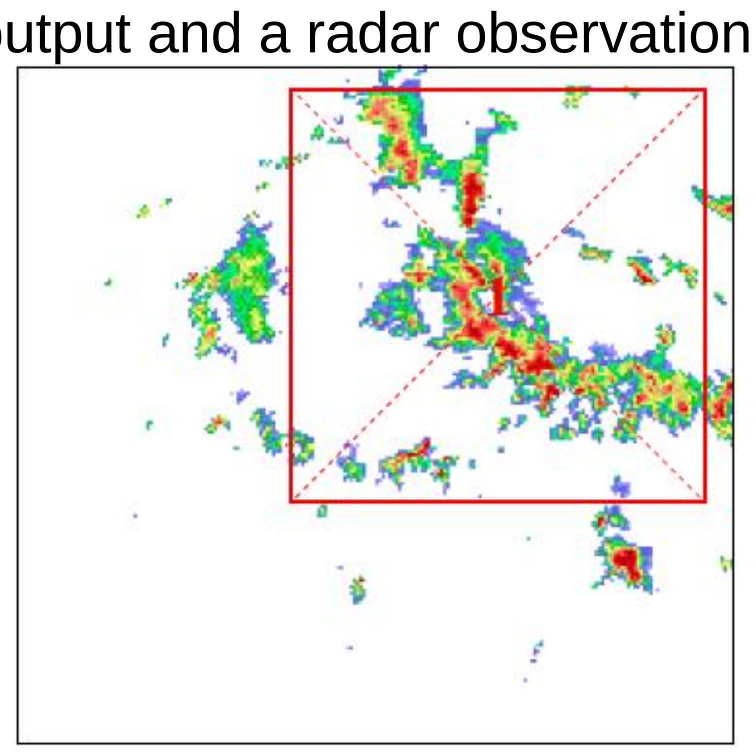
Objectives

- Determine the utility of a scale separation technique for assessment of WRF radar reflectivity forecasts that assimilate radar observations
  - Accomplish this by applying this technique to a case study dataset consisting of reflectivity forecast output and a radar observation



Forecast reflectivity feature



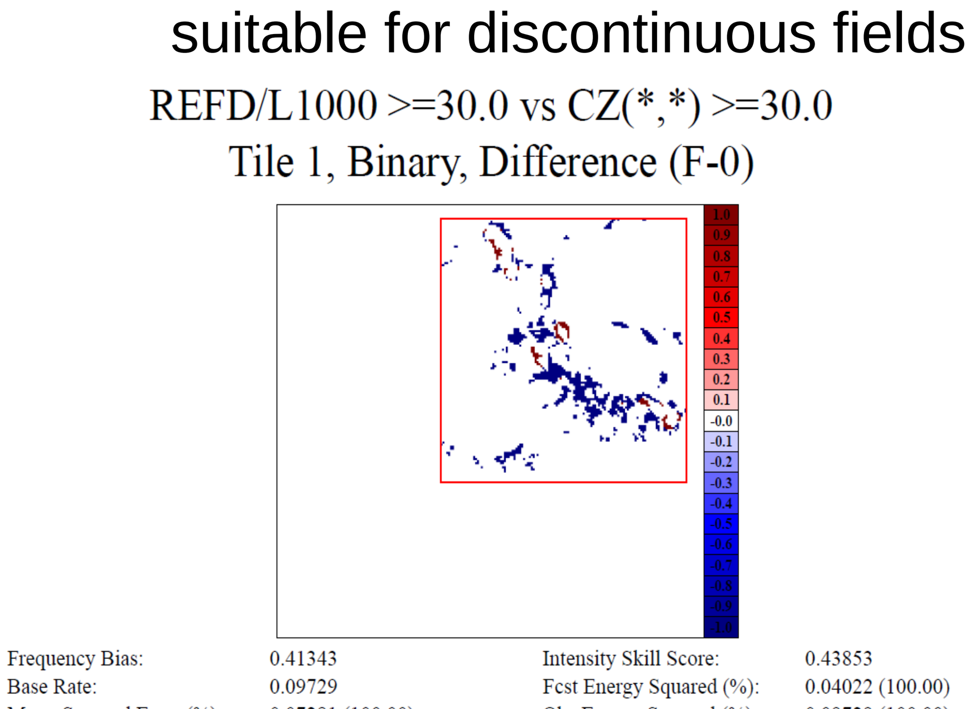
Observed reflectivity feature

Challenges

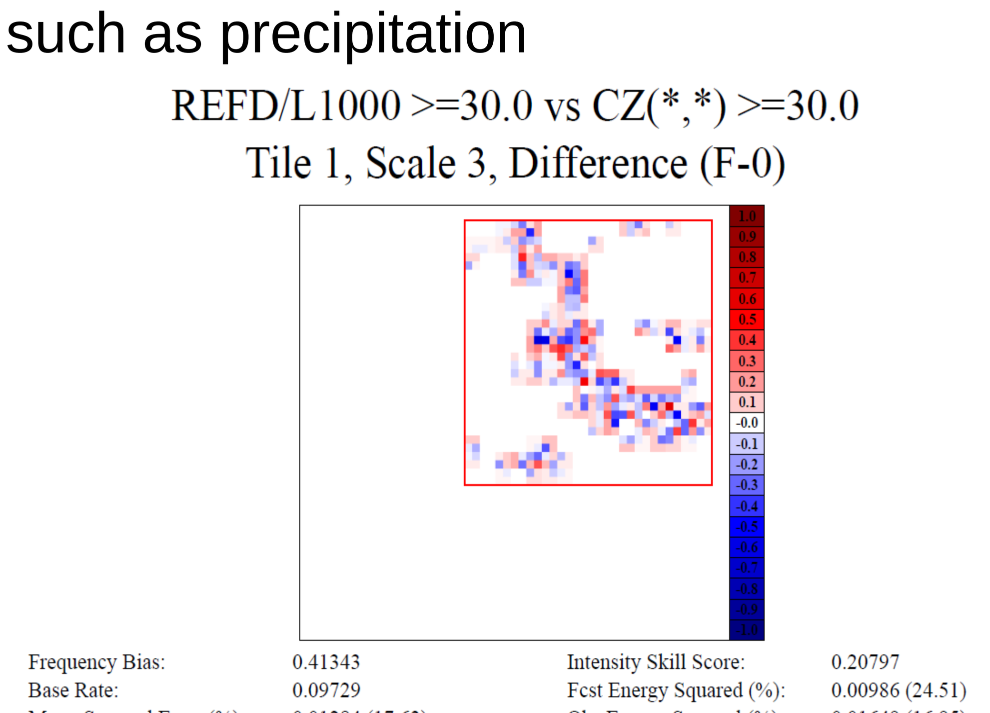
- Need a verification technique which will give credit for the skill of high resolution reflectivity forecasts without being unduly influenced by errors resulting from a near-miss forecast
- Spatial verification using neighborhood methods assess skill in terms of neighborhood size, but does not assess skill at specific scales

Approach

- Use the MET Wavelet-Stat tool to apply the scale separation technique to the case study dataset
  - 1-km resolution forecast output from the Army Weather Running Estimate-Nowcast (WRE-N) which uses the WRF-ARW
  - WRE-N modified to assimilate radar reflectivity observations from Kwajalein Atoll Ballistic Missile Defense Test Site
  - Use 1-km radar observations from Kwajalein Atoll radar as ground truth
- MET Wavelet-Stat uses the Intensity-Scale approach developed by Casati et al. (2004):
  - Focus assessment on forecast reflectivity object of interest
  - Performs verification on different error spatial scales
  - Uses single band spatial filter wavelets to evaluate performance independently at separate scales
  - Evaluates the forecast error and skill as a function of reflectivity intensity and the spatial scale of the error
  - Scale components obtained by applying 2-D Haar wavelet filter suitable for discontinuous fields such as precipitation



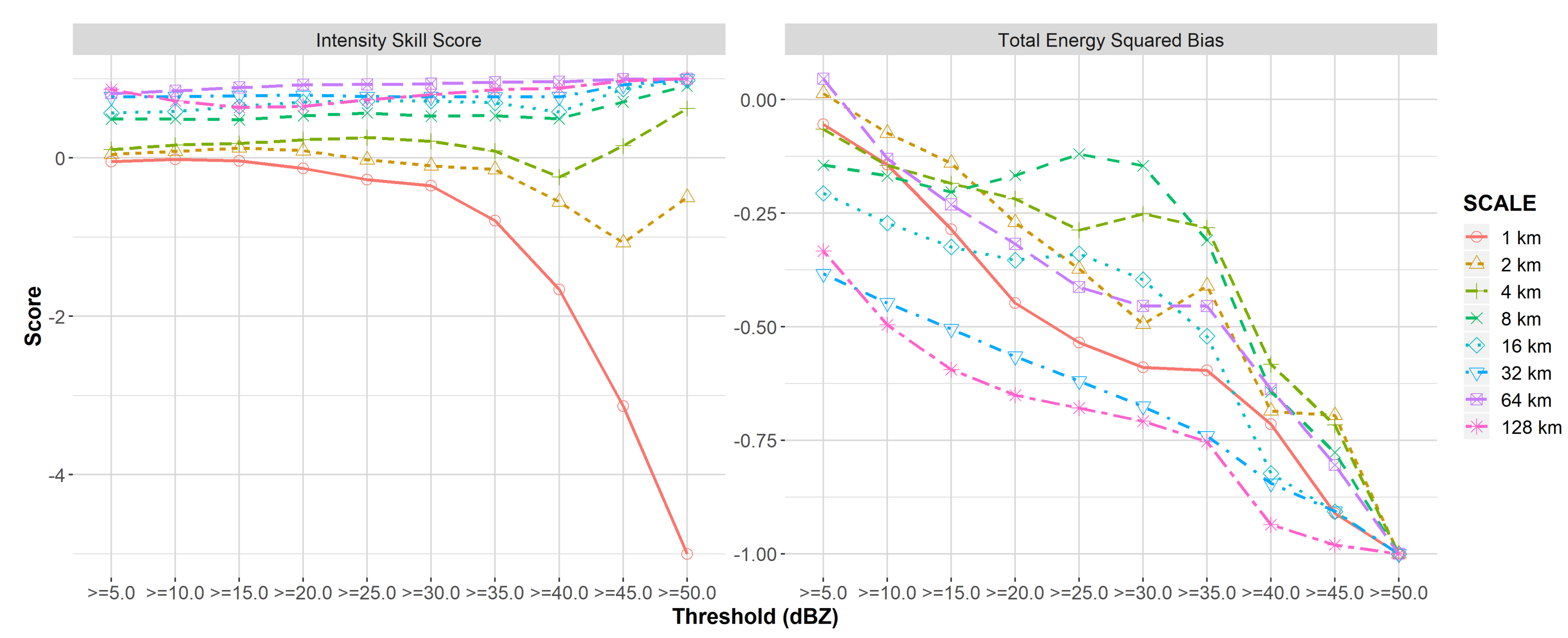
1-km binary difference field Threshold = 30 dBZ



Error at spatial scale 3 = 4-km Threshold = 30 dBZ

Results

- Ran MET Wavelet-Stat using a tiling option to create a 32X32 grid square tile over the reflectivity feature of interest
- Wavelet-Stat computed the difference between the binary forecast field and the binary observed field to generate a binary difference field
- Wavelet-Stat produced frequency bias (FBIAS), Intensity Skill Score (ISS), mean squared error (MSE), forecast and observed energy squared (En2) as a function of scale and threshold value



ISS and En2 bias scores for all thresholds and error scales

- Used output to derive additional metrics needed for analysis such as mean squared error percent (MSE%), forecast and observed energy squared percent (En2%), En2 bias

Discussion & Conclusions

- Scale separation provides:
  - Assessment of model skill and errors as a function of threshold and scale
  - A way to separate the larger displacement errors from the smaller scale errors attributable to mishandling of smaller scale processes
  - A method to determine bias at specific scales and thresholds
  - Analysis of the distribution of forecast and observed squared energy which gives insight into how the model is performing for large scale organized convection and small scale convective showers

Path Forward

- Test scale separation technique on additional cases which will contrast good performance with bad performance in order to see how this is manifested in the scores and error statistics
- Automate generation of plots, tables and derived metrics from Wavelet-Stat output

References

- Casati, B., Ross, G., and Stephenson, D. 2004: A new intensity-scale approach for the verification of spatial precipitation forecasts. *Meteorol. Appl.* 11, 141-154, https://doi.org/10.1017/S1350482704001239. 5.
- National Center for Atmospheric Research. Model Evaluation Tools version 5.2 (METv5.2), User's Guide 5.2. Boulder (CO); 2016 Aug.

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