Evaluation of the Performance of Satellite Precipitation Estimates against a Radar Gauge Product: Case Studies for Tornadoes

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Abstract

Determining satellite precipitation estimates (SPEs) from Geostationary Operational Environmental Satellites (GOES) can be challenging, as SPEs are indirect way of measuring precipitation. One of the weaknesses of SPEs may be location error occurring in highly sheared environments. Location errors in SPEs may occur in highly sheared environments as the hydrometeors don't fall straight down and so the surface rainfall is displaced from the coldest cloud tops. When it comes to estimating rainfall, ground based radar is more reliable than GOES satellites. As a result, this project's goal is to evaluate the performance of NOAA STAR's SPEs in "Tornado Alley" specifically in Oklahoma, Kansas, and Nebraska in May 2010. For this study, we used three SPEs, Hydro-Estimator (HE), QMorph (QM) & Self Calibrating Multivariate Precipitation Retrieval (SCaMPR), and the ground-radar gauge product, Stage-IV (ST-IV). We investigated 41 cases of Tornadoes. Evaluation parameters such as correlation coefficient (CC) and root-mean-square error (RMSE) between the SPEs and the Stage-IV satellite are calculated. SCaMPR performed better than the other two SPEs in 41 number of cases. Further analysis is needed to evaluate the location error between SPEs and ST-IV.

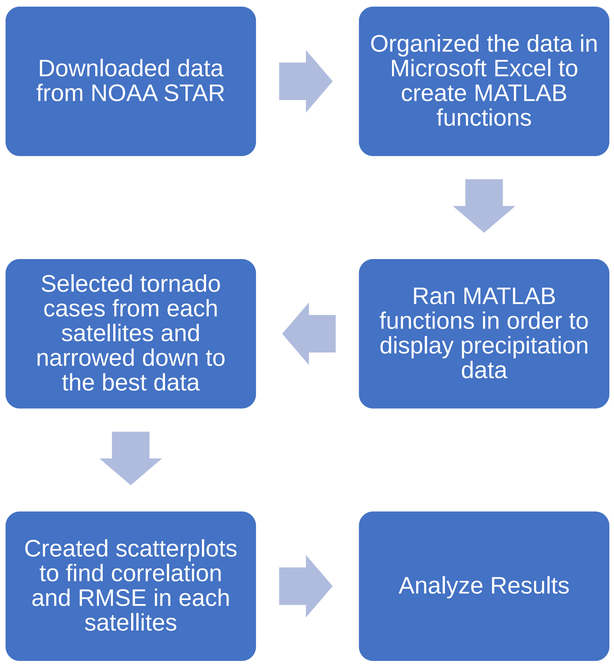
Introduction

A priority with GOES satellites is to improve SPE accuracy to provide reliable readings at a fine time scale. Inaccuracies can be determined by comparing the SPEs to ground radar, which proves to be the most accurate. HE relies on infrared readings to produce hourly precipitation estimates, using GOES band 3 (10.7 μm wavelength). QMorph creates hourly IR estimates then MW estimates every three hours. Lastly, SCaMPR utilizes both IR and MW in bands 3 & 4 (wavelengths 6.7 μm and 10.7 μm) of GOES to approximate rainfall data. Using Matrix Laboratory (MATLAB) the most accurate SPE was determined through a calculation of their RMSE & CC and analyzed to see which is closest to ST-IV CC.

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$$

Correlation Coefficient Formula
Determines strength between two variables (Ex: HE and ST-IV)

Methods



Results

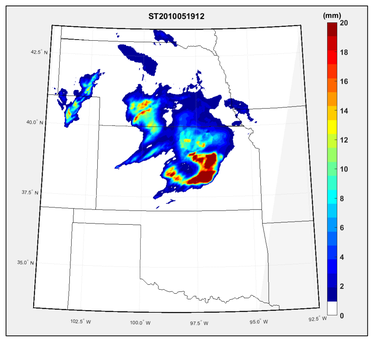


Fig 1: Stage-IV Radar Gauge Product (ST-IV)

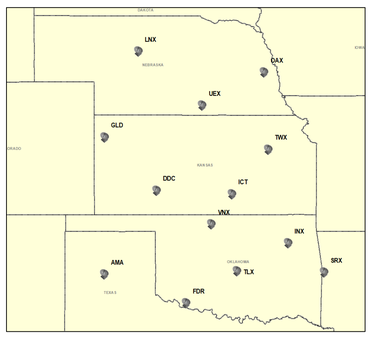


Fig 2: Ground Radars within Study Area

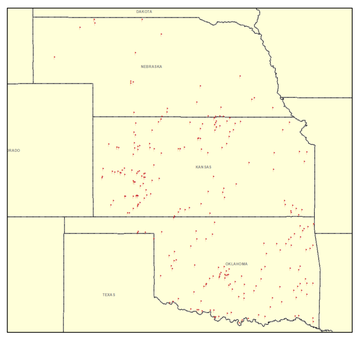


Fig 3: May 2010 tornado causes within study area

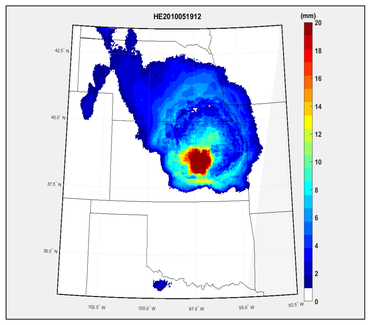


Fig 4: Sample Hydro-Estimator (HE)

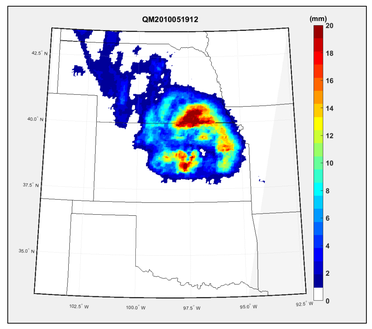


Fig 5: Sample QMorph (QM)

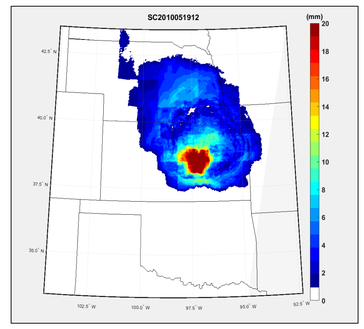


Fig 6:Sample Self Calibrating Multivariate Precipitation Retrieval (SCaMPR)

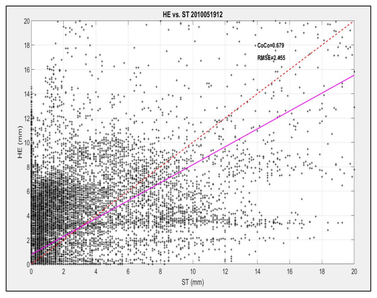


Fig 7: Hydro-Estimator against ST-IV

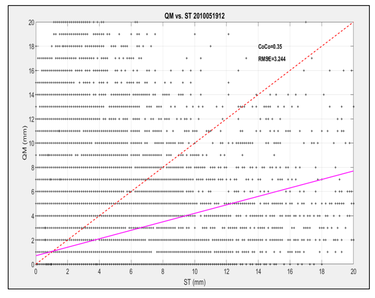


Fig 8: Qmorph against ST-IV

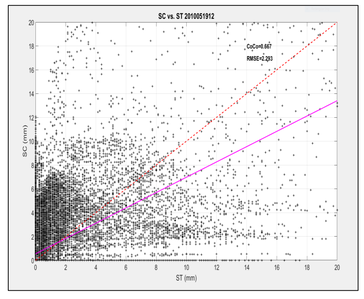


Fig 9: SCaMPR against ST-IV

May 2010	Total Precip. (mm x 10^6)	Avg. Correlation	Avg. RMSE
ST – IV	0.526	N/A	N/A
HE	1.340	0.4139	1.4002
Qmorph	1.057	0.3771	1.426
SCaMPR	0.907	0.4403	1.1794

Table 1: Summary of Comparison between SPEs and ST – IV

Conclusion

Overall, for a majority of the cases, the Self Calibrating Multivariate Precipitation Retrieval (SCaMPR), had the strongest correlation when being compared to Stage-IV (ST-IV) while QMorph had the weakest correlation. Threfore, SCaMPR would be the most reliable SPE to use for estimating rainfall data. However, all SPEs require increased accuracy to provide concise reports of storms to ensure no civilians are in danger. Qmorph specifically would need more accuracy due to its weak correlation with the Stage-IV ground satellite. More research will be required to report further inaccuracies of SPEs when viewing tornadoes and non-tornado events.

References

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