1. Title Slide

Title: Improving Satellite QPEs by Incorporating Deep Convective Cloud Optical Depth

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Topics:

Hydrology and Precipitation/QPE

Program:

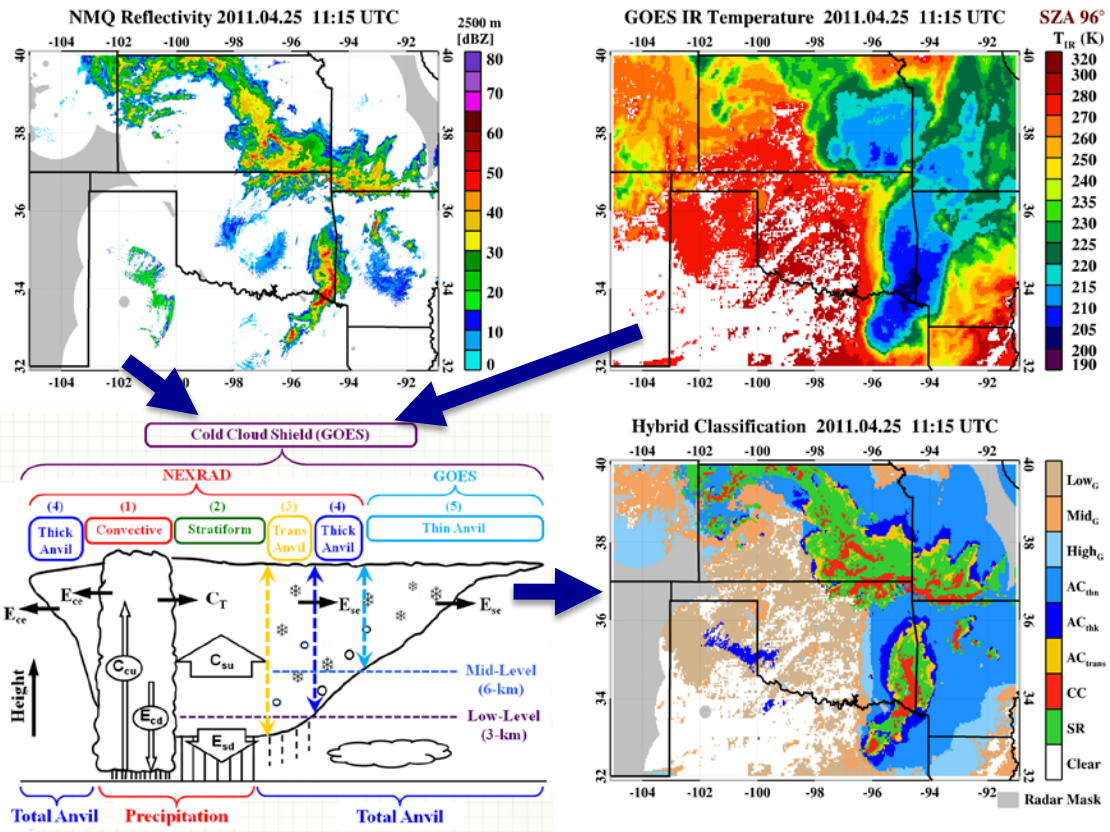
GOES-R3

2. Introduction

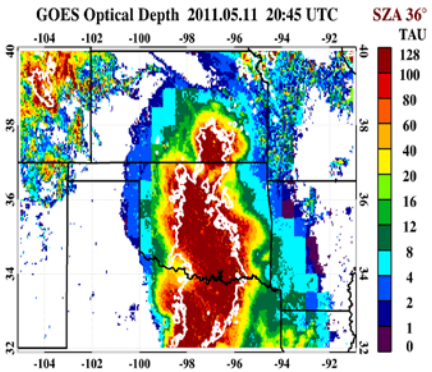
- **In our previous studies (Xiquan Dong's presentation/poster in 2011 and 2012 GOES-R3 meetings), we found that GOES-R SCaMPR precipitation retrievals underestimate for DCS rain cores and overestimate for anvil regions when compared to NEXRAD Q2 precipitation estimates.**
- **These problems with the GOES-R precipitation estimates arise because the estimates are primarily based on cloud-top IR brightness temperatures, which can be the same for both convective cores and non-precipitating anvil clouds.**
- **SCaMPR (Kuligowski 2002) and NEXRAD Q2 precipitation estimates have been compared to a dense precipitation gauge network (OK MESONET) to quantitatively evaluate the quality of these estimates and identify potential biases (Stenz et al. 2014). Additionally, an improved rain estimation algorithm has been developed that utilizes retrieved cloud optical depth to address the shortcomings of the SCaMPR algorithm (Stenz et al. 2014).**

2. Introduction

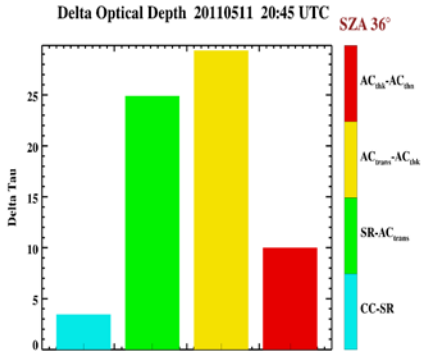
Hybrid Classification Algorithm (Feng et al.2011)



GOES Optical Depth



Optical Depth Difference



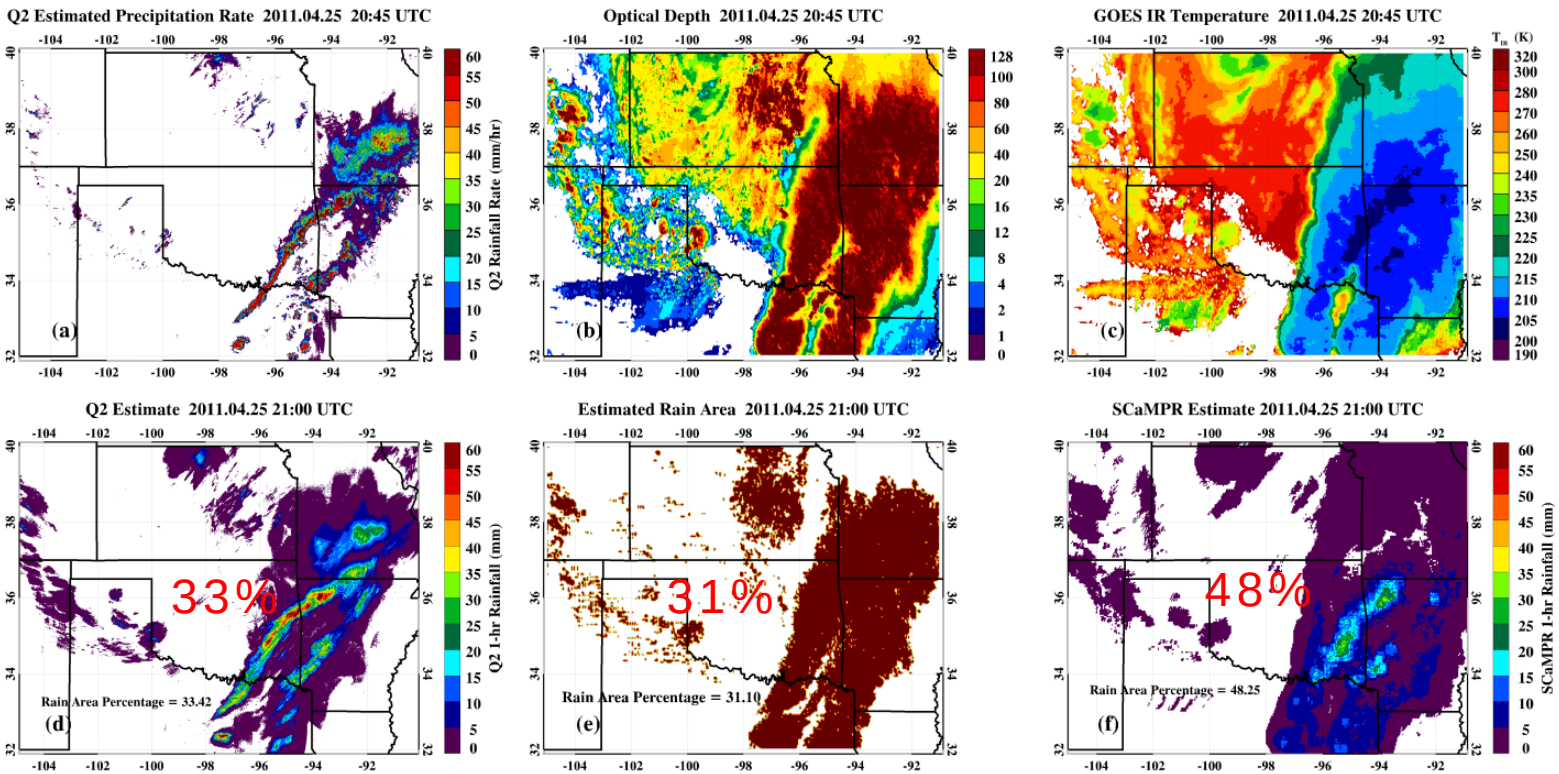
1) Use Hybrid Classification Algorithm to Analyze Errors (left)
2) Use Optical Depth Characteristics (Large difference in Tau between Stratiform and Anvil regions) to Improve Satellite QPEs (right)

3. Evaluation of Biases

Platform	Percentage of Rainfall in CC	Percentage of Rainfall in SR	Percentage of Rainfall in AC	Percentage of Rainfall in Unclassified/Thin Anvil Regions
MESONET	69.02	26.87	2.49	1.62
Q2	70.00	26.33	2.08	1.59
SCaMPR	12.77	30.84	36.80	19.59

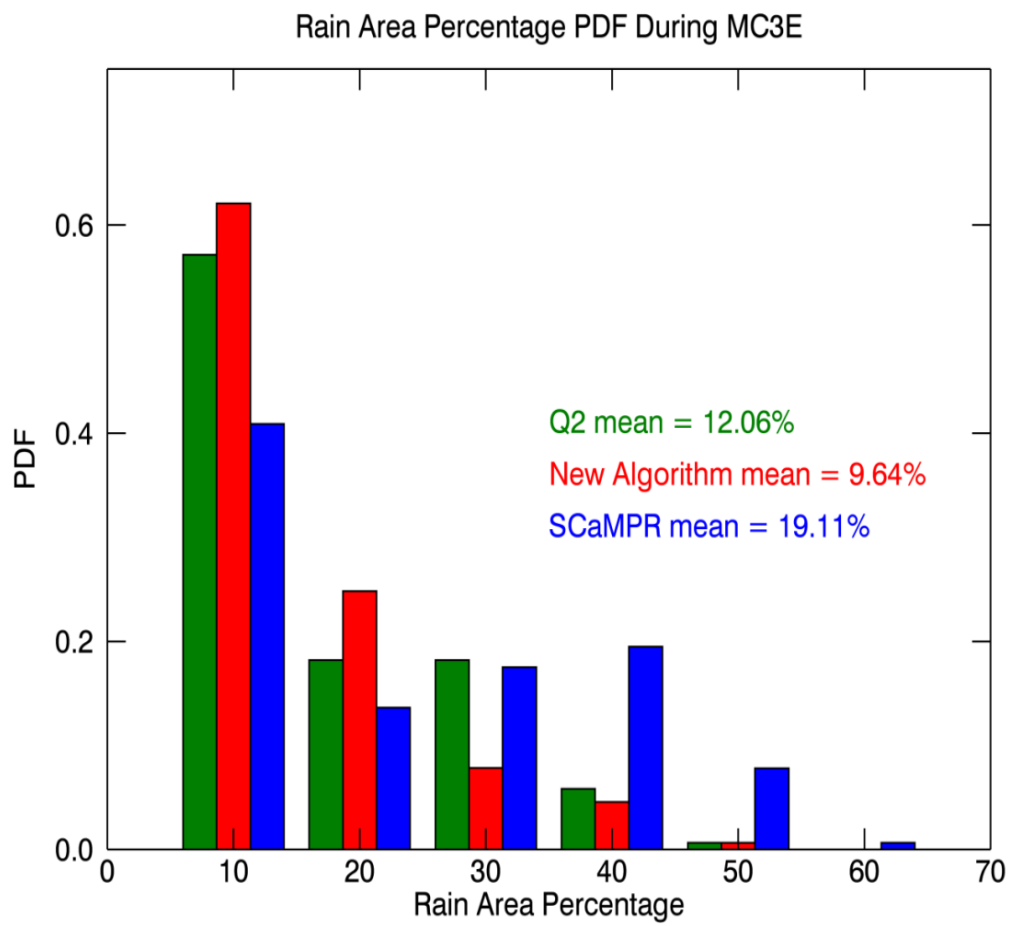
- **NEXRAD Q2 estimates are representative of ground truth (Can be used for validation/calibration of satellite QPEs such as SCaMPR)**
- **SCaMPR estimates show strong wet bias in anvil regions and a strong dry bias in rain core regions (Typical issue for other IR-based estimate algorithms)**
- **Incorporation of cloud optical depth can significantly reduce this discrepancy and produce a distribution with the majority of SCaMPR estimated precipitation in the rain core (CC + SR) region.**

4. Improvements with a newly developed cloud-precipitation classification algorithm



- Precipitating Area of SCaMPR (bottom right) is significantly reduced by incorporating optical depth (bottom middle)
- Original SCaMPR areal coverage of precipitation was 48.3%, reduced to 31.1% by incorporating optical depth in the new algorithm
- Result is much closer to radar estimated (33.4% areal coverage)

4. Improvements with a newly developed cloud-precipitation classification algorithm



- Rain area percentages were evaluated from 14 selected DCS cases during the Midlatitude Continental Convective Clouds Experiment (MC3E) IOP.
- Including Optical Depth significantly reduced the areal coverage of satellite estimated precipitation
- A modified SCaMPR algorithm (includes optical depth) can greatly reduce erroneous retrievals of precipitation from anvil regions of DCSs

4. Improvements With GOES-R

- More IR bands to improve SCaMPR/modified SCaMPR algorithms
  - Current version utilizes two IR bands, with GOES-R, five IR bands will be utilized improving precipitation rate estimation
- Temporal Resolution Increase with GOES-R
  - GOES-R will provide images every 5 minutes (similar to the temporal resolution of WSR-88D volume scans)
  - Less interpolation of rates will be needed, providing more accurate estimates
  - Precipitation rate products will be available to NWS forecasters more quickly and more continuously

5. Possible Limitations

- Limited Optical Depth Differences Between Convective Core and Stratiform Regions
  - Effectively Separating rain core(CC and SR) from anvil regions is possible from satellite data alone, but further separating CC from SR regions remains a challenge
- Quality of cloud microphysics retrievals at night
  - Cloud optical depth retrievals at night are currently unreliable for this application
  - Incorporation of model/observational data, along with tracking algorithms can aid in nighttime precipitation estimates... but possibly not to the degree that optical depth retrievals do.

6. Pathway to Operations

1) Analysis of modified SCaMPR algorithm using the hybrid classification categories
2) Inclusion of empirical relationships between cloud microphysical properties and precipitation rate into the modified SCaMPR
3) Validation/Calibration using both NEXRAD Q2/Q3 and high quality rain gauge
4) Inclusion of topographic effects, synoptic conditions, tracking codes, model data, etc
5) Validation/calibration to produce final product

-- After step 3, preliminary products will be made available and user suggestions/needs will assessed and met through open communication from this stage onwards

7. Anticipated Results

1) Construct a short climatology of DCSs over the CONUS, examining potential regional differences in formation and precipitation characteristics
2) Provide a final precipitation estimation product that utilizes IR brightness temperatures and cloud microphysical properties to provide estimated precipitation rates over CONUS (every 5 minutes with GOES-R)
3) Use findings from (1) to further improve the precipitation estimation algorithm in (2)
4) The data archive in (1) and output from the precipitation rate estimation algorithm (2,3) can be used by modelers to improve forecasts of DCSs

8. Timeline for Critical Activities

1) Analysis of modified SCaMPR algorithm using the hybrid classification categories (2014)
2) Inclusion of empirical relationships between cloud microphysical properties and precipitation rate into the modified SCaMPR (2015)
3) Validation/Calibration using both NEXRAD Q2/Q3 and high quality rain gauge networks (2016)
4) Inclusion of topographic effects, synoptic conditions, tracking codes, model data, etc (2015)
5) Validation/calibration to produce final product (2016)

-- Preliminary product availability/correspondence with users anticipated by Spring 2015

9. Publication List

- References

- Zhang, J., et al. (2011), National Mosaic and Multi-Sensor OPEN MQ) System: Description, Results, and Future Plans, Bulletin of the American Meteorological Society, 92(10), 1321-1338.
- Kuligowski, R. J., 2002: A self-calibrating real-time GOES rainfall algorithm for short-term rainfall estimates. *J. Hydrometeor*, 3, 112–130.

- **Publications**

  Stenz, R., X. Dong, B. Xi, and Kuligowski, (2014): Assessment of SCaMPR and NEXRAD Q2 precipitation estimates using Oklahoma Mesonet observations. Accepted J. Hydrometeor