Using regional-scale OSSEs to explore the impact of infrared brightness temperature observations

Jason Otkin
UW-Madison/CIMSS

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Data Assimilation System

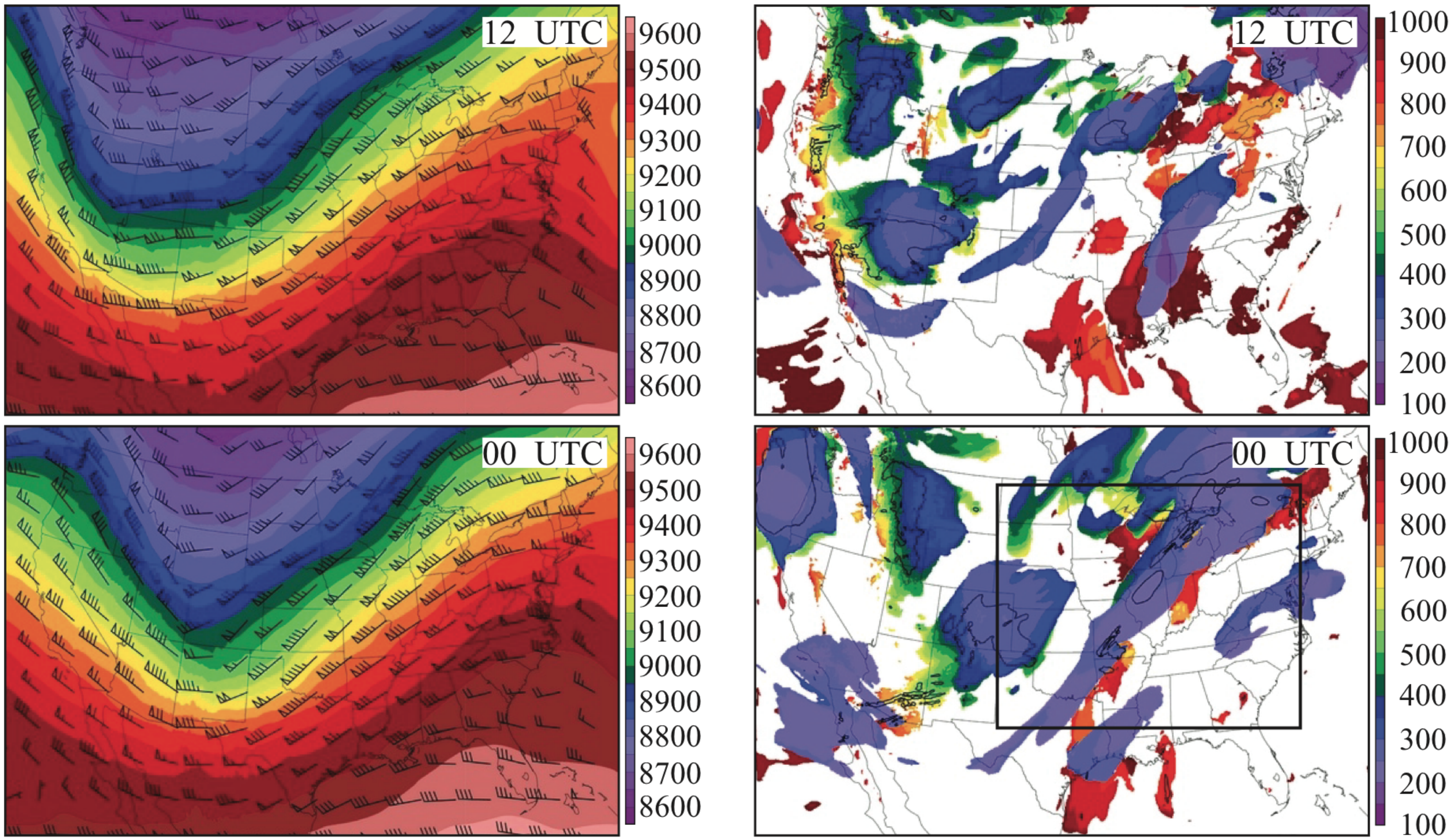
- Impact of infrared brightness temperature assimilation examined using a Regional-scale Observing System Simulation Experiment (OSSE) approach
    - Horizontal covariance localization radius employed used during the assimilation step
    - Impact of water vapor sensitive infrared bands on precipitation forecasts during a high impact weather event
- Assimilation experiments were performed using the WRF-ARW model and the parallel EAKF algorithm implemented in the DART data assimilation system
- Successive Order of Interaction (SOI) forward radiative transfer model was implemented within the DART framework
    - Simulated fields used by the forward model include T, q_v, T_{skin}, 10-m wind speed, and the mixing ratios and effective diameters for five hydrometeor species (cloud water, rain water, ice, snow, and graupel)

Regional OSSE Advantages

- The ABI sensor will provide detailed observations of the atmospheric state over the same geographic domain with very high spatial (< 2 km) and temporal (5 minute) resolution
  - These observations will be very useful for improving the structure of fine-scale features in atmospheric analyses used to initialize high-resolution numerical models
  - Regional-scale OSSEs provide an ideal way to demonstrate the future impact of the ABI sensor since their higher spatial resolution and more frequent updates more closely match its capabilities
- Assess the impact of infrared observations on the cloud field
  - Clouds are poorly sampled by in-situ conventional observations
  - It is very helpful to have an exact measure of the characteristics of the cloud field, such as the cloud distribution and optical depth, from the truth simulation

OSSE Truth Simulation

07-08 January 2009



- Large trough (ridge) across western (eastern) U.S. with numerous cloudy areas within and immediately downstream of the trough

OSSE Configuration

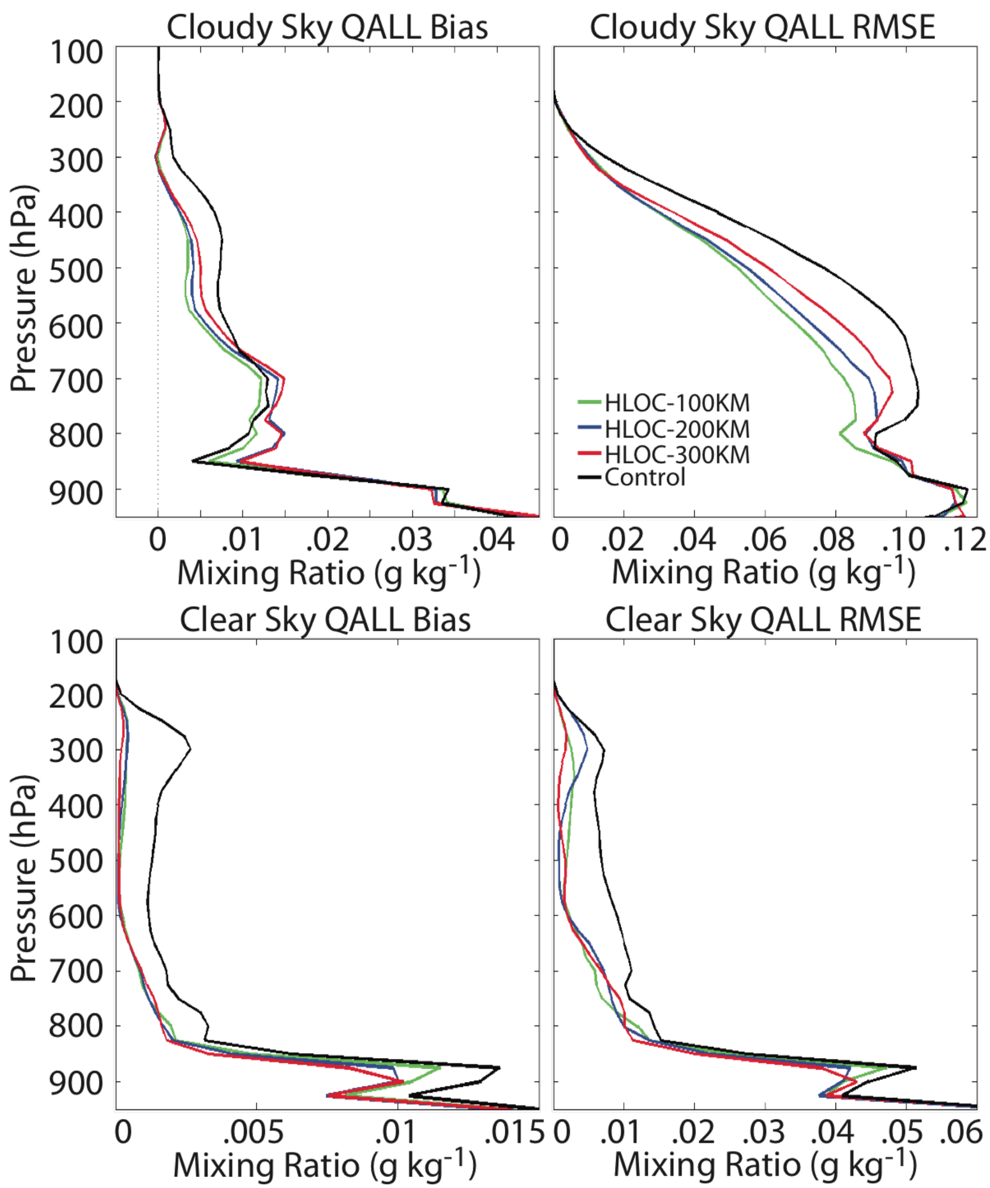
Four assimilation experiments were performed:

- Control – conventional observations only
- HLOC-100KM – conventional + ABI 8.5 μm T_b (100 km loc. radius)
- HLOC-200KM – conventional + ABI 8.5 μm T_b (200 km loc. radius)
- HLOC-300KM – conventional + ABI 8.5 μm T_b (300 km loc. radius)

- Assimilation experiments were performed using an 80-member ensemble containing 18-km horizontal resolution and 37 vertical levels
- Observations were assimilated once per hour during 12-hr period
- Both clear and cloudy sky ABI 8.5 μm brightness temperatures were assimilated

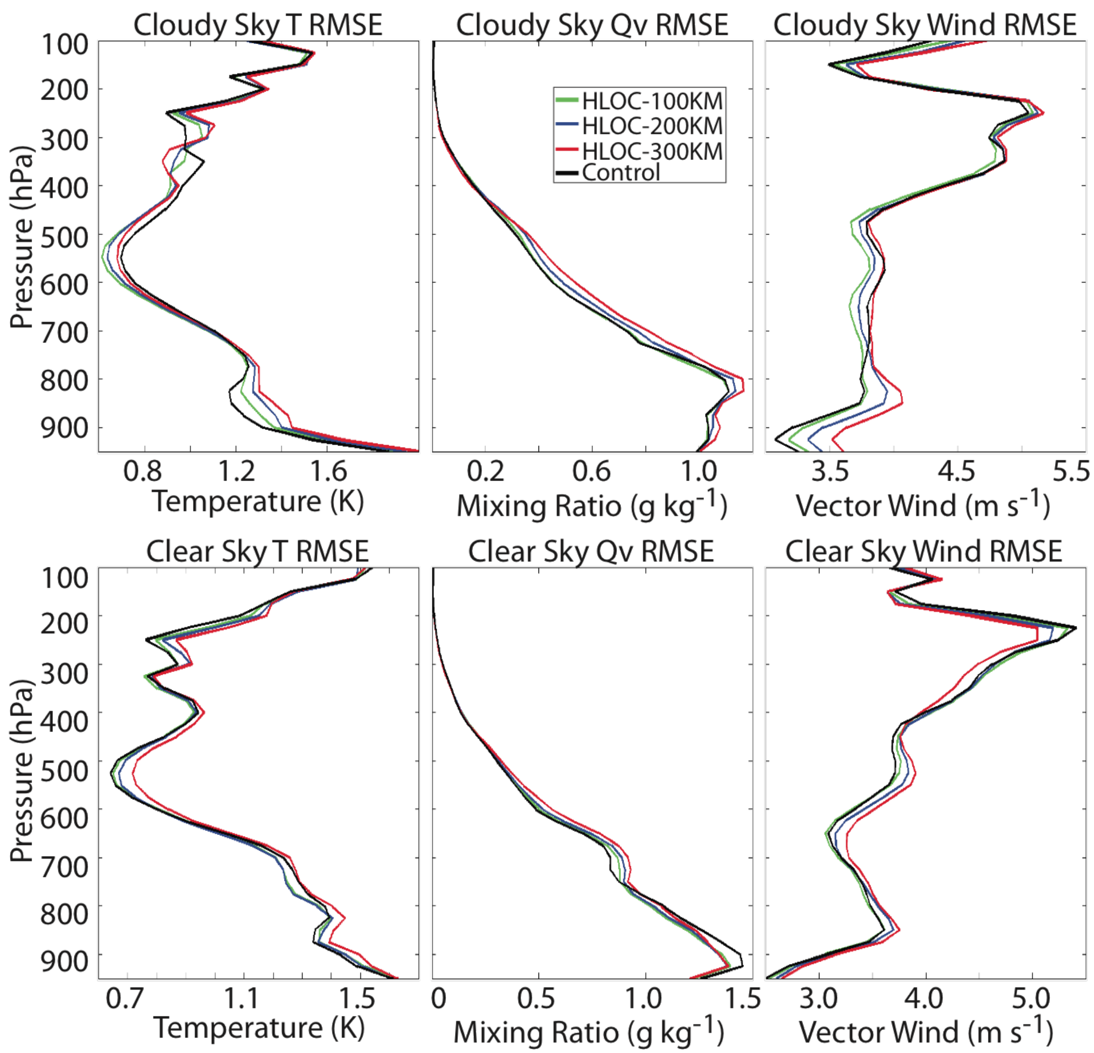
- Manuscript published in *Monthly Weather Review* earlier this year

Cloud Errors After Last Assimilation Cycle



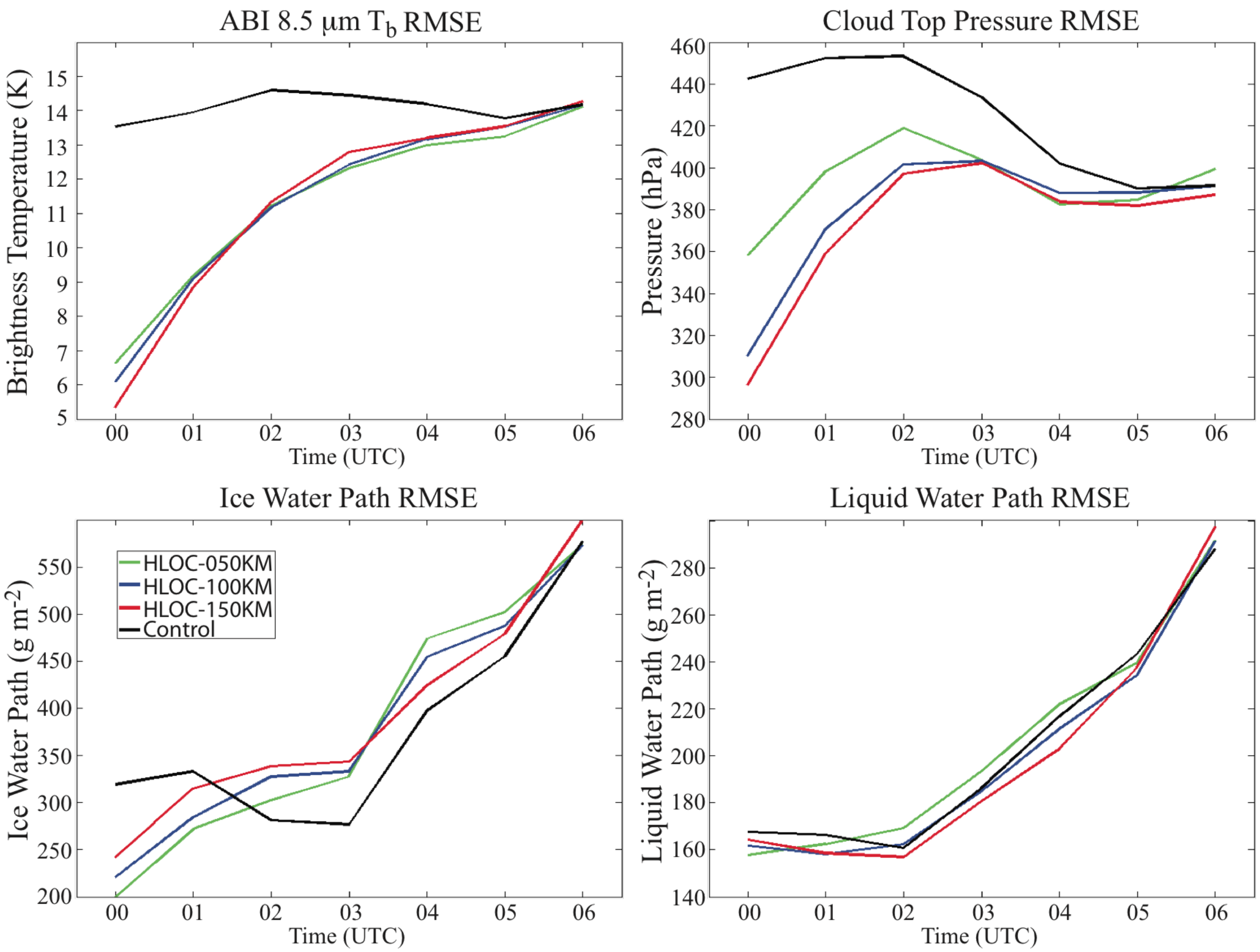
- Total cloud condensate (QALL) errors over the entire model domain after the last assimilation cycle
- Similar errors occurred for the clear sky grid points
- Errors consistently decreased with decreasing localization radius for the cloudy grid points
- Suggests different loc. radii should be used for clear and cloudy observations

Thermodynamic Errors After Last Assimilation Cycle



- Thermodynamic and moisture errors after the last assimilation cycle
- Greater degradation tended to occur when a larger radius was used
- These results show that a smaller radius is necessary to maintain accuracy relative to Control case

Short-Range Forecast Impact



- Overall, the initially large positive impact of the infrared observations decreases rapidly with time

- Results show that without improvements in the thermodynamic and moisture fields, it is difficult to preserve initial improvements in the cloud field

Impact of ABI Water Vapor Bands

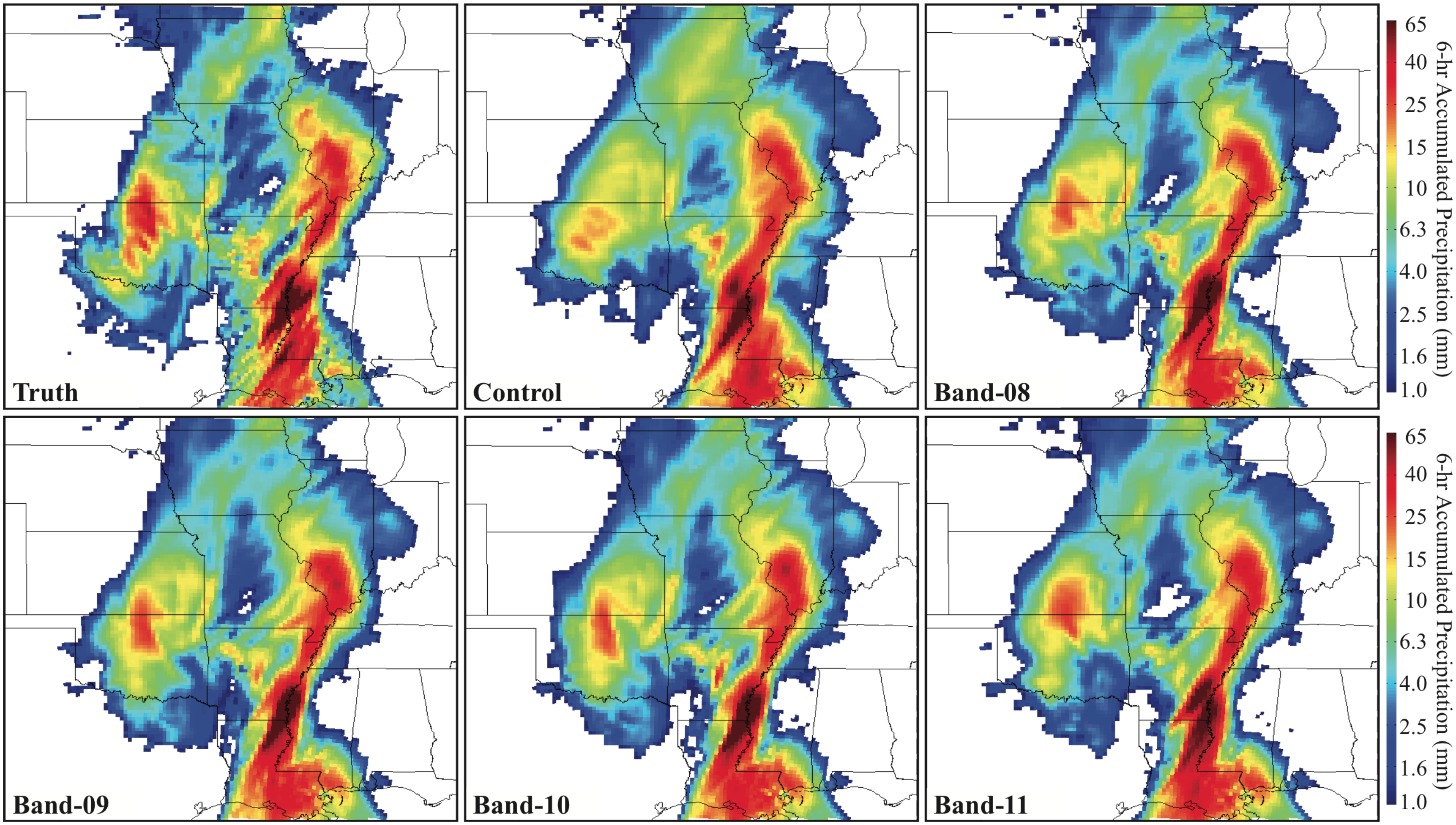
- A regional-scale OSSE was used to evaluate the impact of the water vapor sensitive ABI bands on the analysis and forecast accuracy during a high impact weather event

- Five assimilation experiments were performed:
  - Control – conventional observations only
  - Band-08 -- conventional + ABI 6.19 μm T_b (upper-level WV)
  - Band-09 -- conventional + ABI 6.95 μm T_b (mid-level WV)
  - Band-10 -- conventional + ABI 7.34 μm T_b (lower-level WV)
  - Band-11 -- conventional + ABI 8.5 μm T_b (window)

- Assimilation experiments were performed using a 60-member ensemble containing 15-km horizontal resolution and 37 vertical levels
- Observations were assimilated every 30 minutes during a 6-hr period

- Manuscript accepted last month for publication in the *Journal of Geophysical Research*

6-hr Accumulated Precipitation Forecasts



• Precipitation forecasts were more accurate during the brightness temperature assimilation cases.

Precipitation Forecast Skill

	6-hr Accumulated Precipitation Thresholds (mm)				
EXP	**>0.25**	**>2.54**	**>6.35**	**>12.7**	**>25.4**
Total Events	10,749	5,946	3,152	1,599	580
Control	0.724	0.663	0.573	0.558	0.387
Band-08	**0.758**	**0.702**	0.604	0.575	0.439
Band-09	**0.756**	0.679	0.601	**0.595**	**0.450**
Band-10	0.739	0.667	**0.609**	**0.599**	0.429
Band-11	0.742	0.671	**0.608**	0.552	0.434

- Infrared brightness temperature assimilation improved the forecast skill for all precipitation thresholds
- Relative improvements increased for the higher precipitation thresholds