Assimilation of Satellite Infrared Brightness Temperatures and Doppler Radar Observations in a High-Resolution OSSE

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The assimilation experiments were performed on the NOAA/NESDIS/STAR "S4" supercomputer at the University of Wisconsin–Madison

Brightness Temperature Assimilation at Convective Scales

- Assimilation experiments performed using the WRF model, the DART ensemble data assimilation system, and the Community Radiative Transfer Model (CRTM)

- Synthetic satellite and radar observations created using output from a 2-km resolution truth simulation of a severe thunderstorm event

- Assimilation experiments were performed using a 50-member ensemble containing 4-km resolution and 52 vertical levels

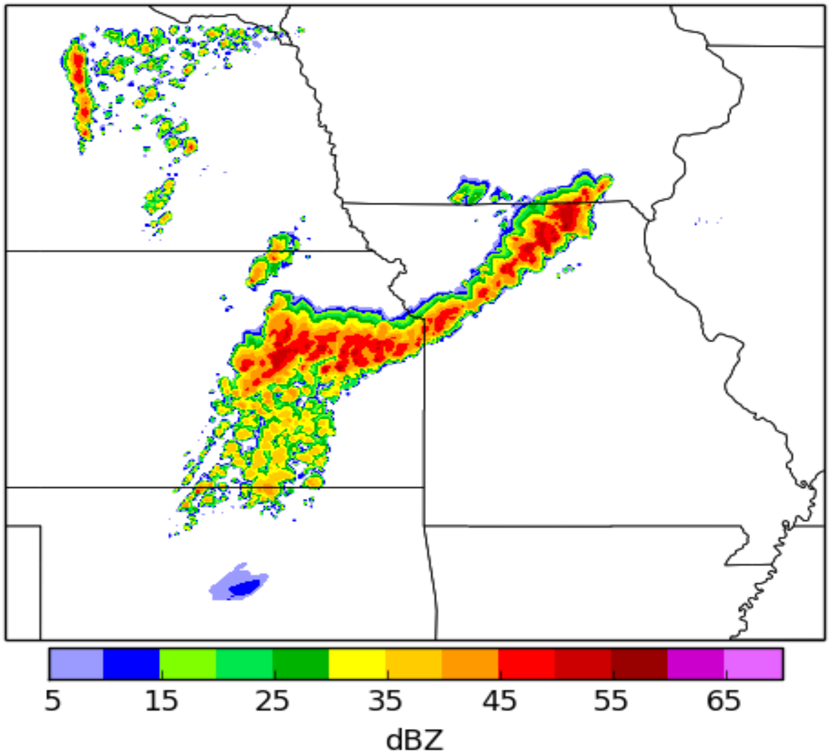
- GOES-R Advanced Baseline Imager and Doppler radar observations were assimilated every 5 minutes during a 2-hour assimilation period

    - Clear and cloudy sky 6.95 μm brightness temperatures sensitive to clouds and water vapor in the middle and upper troposphere

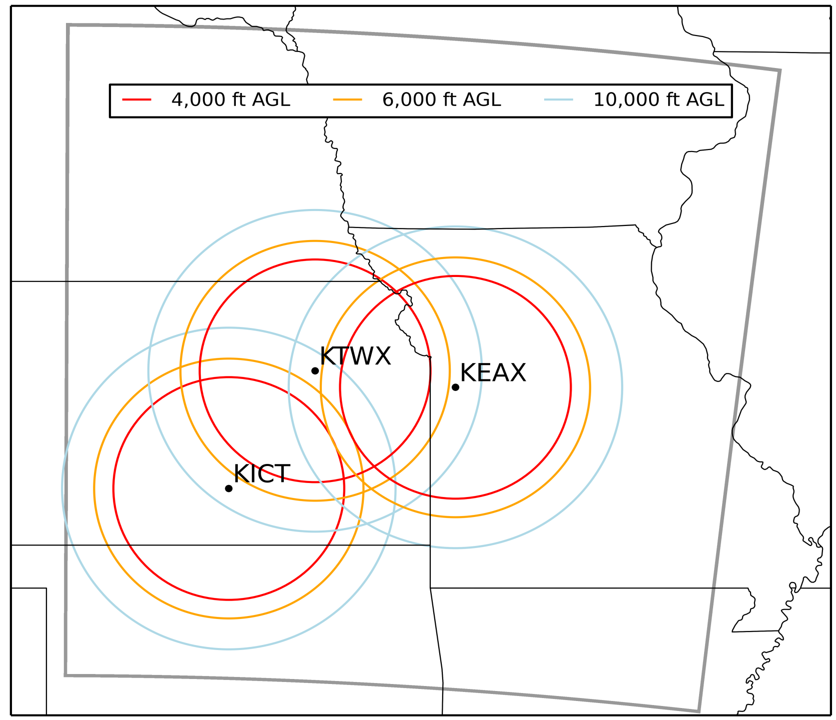
    - Provides a spatially continuous 2-dimensional view of cloud and water vapor fields across entire model domain

WSR-88D Radar Observations

Truth Comp. Reflectivity

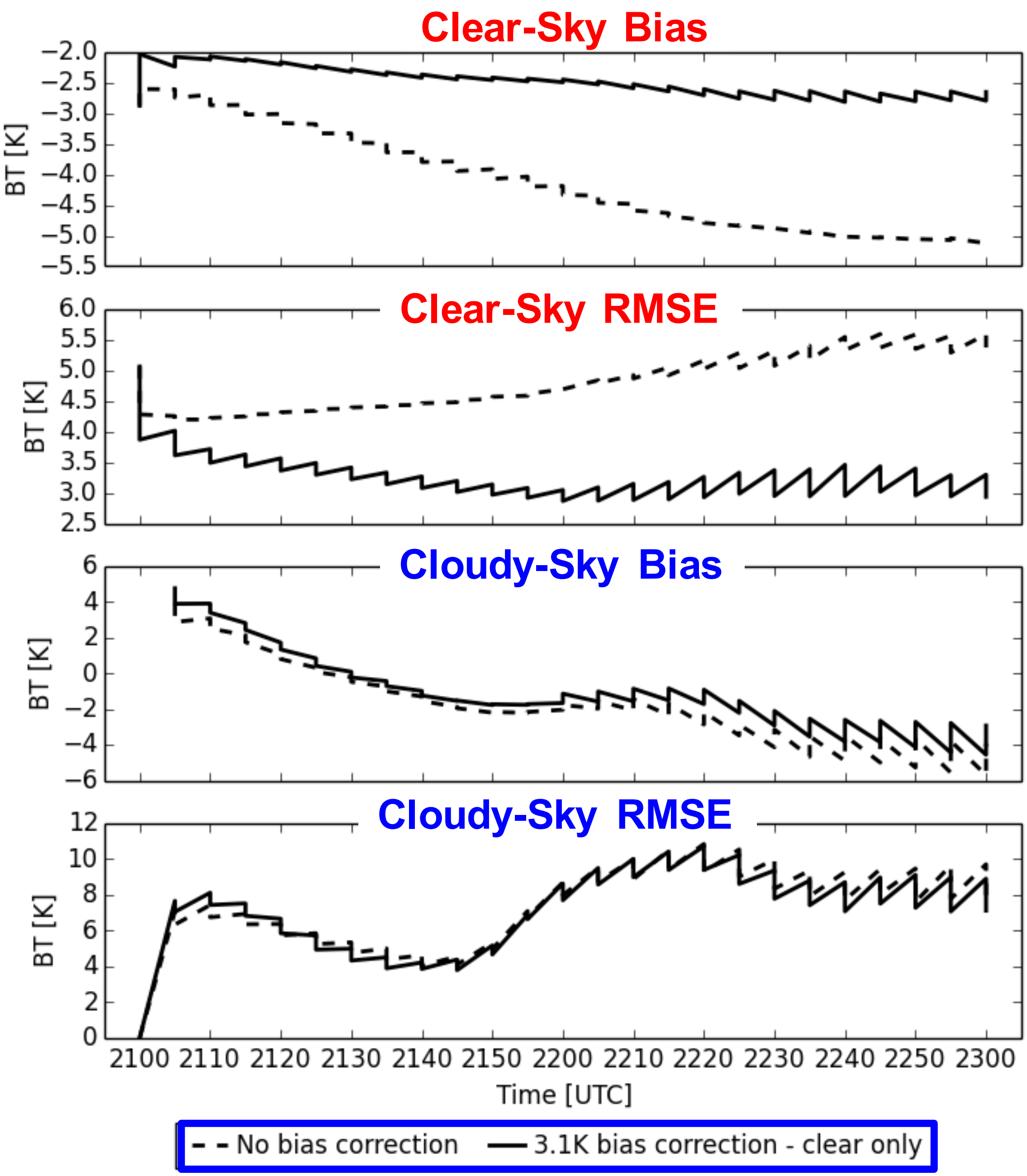


Radar Scan Coverage



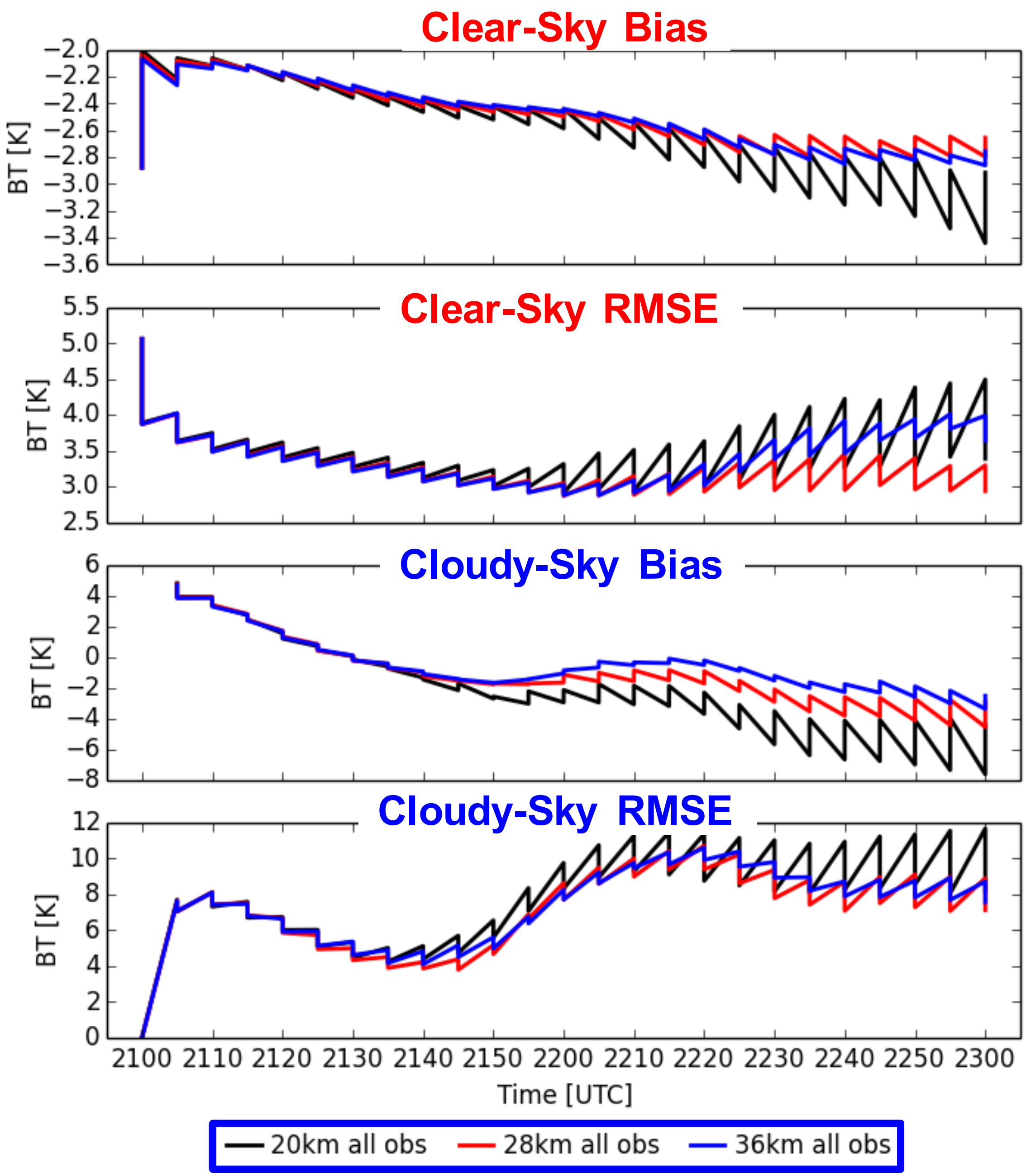
- Simulated WSR-88D radar reflectivity and radial velocity obs were produced for the Wichita, Topeka, and Kansas City radars
- Provide dense 3D coverage where there are large cloud particles
- VCP-21 scanning strategy used with 9 elevation angles
- Clear-sky observations (< 10 dBZ) were not assimilated

Clear Sky Bias Correction During 2-Hour Assimilation Period



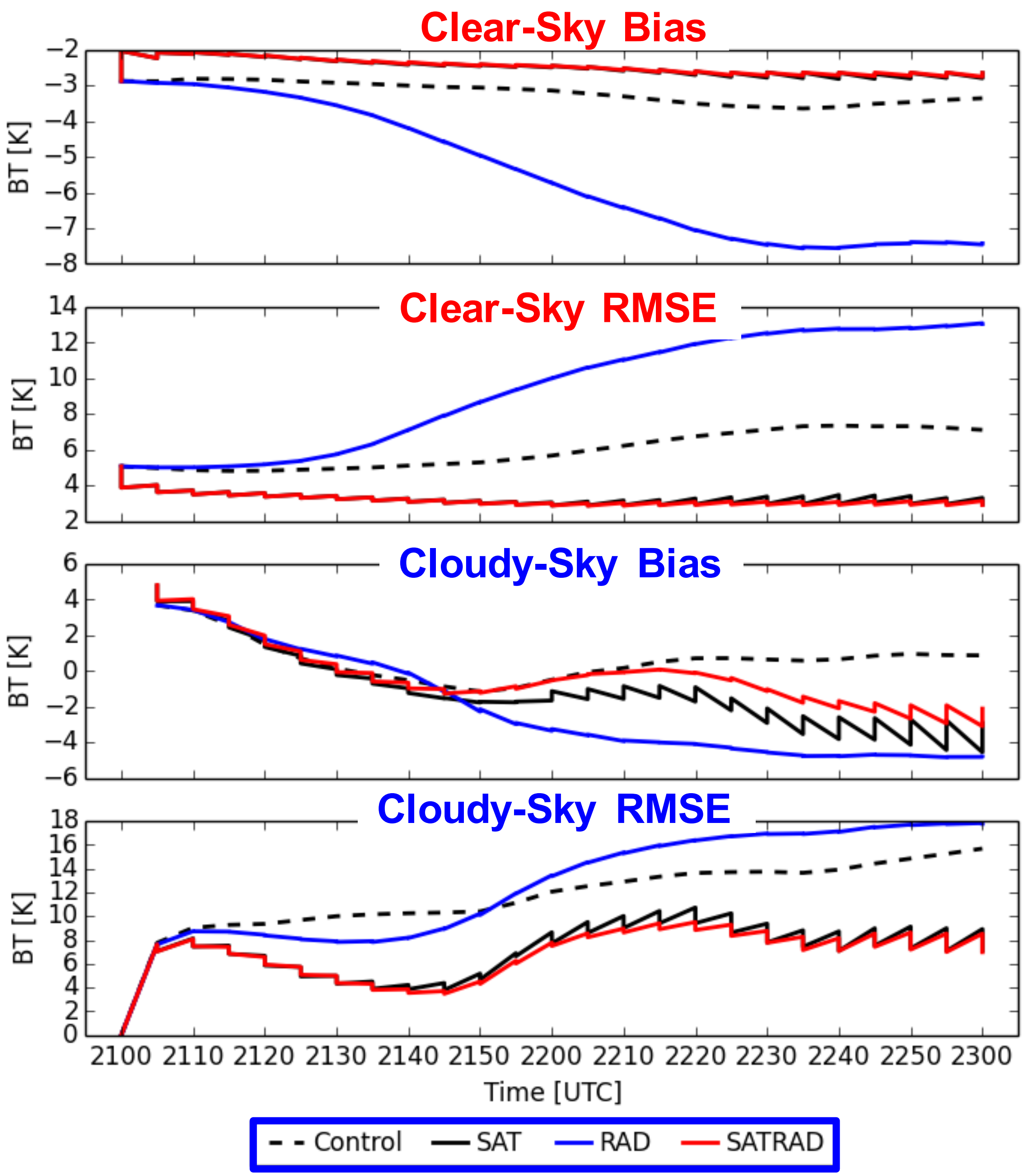
- Large negative brightness temperature bias due to the use of different initialization datasets in the truth (NAM) and assimilation (GFS) experiments
- Added 3.1 K to the clear sky observations
- Cloudy observations were not bias-corrected
- Bias and RMSE greatly reduced in clear areas of the model domain
- Cloudy-sky statistics were also slightly improved

Horizontal Localization During 2-Hour Assimilation Period



- Tested impact of horiz. covariance localization radius when assimilating satellite T_b observations
- 28 km radius resulted in the smallest errors by end of assimilation period
- 20 km radius led to much larger analysis increments, but largest errors; unable to remove clouds from clear areas of domain
- 36 km radius degraded cloud analysis and caused erroneous thunderstorms

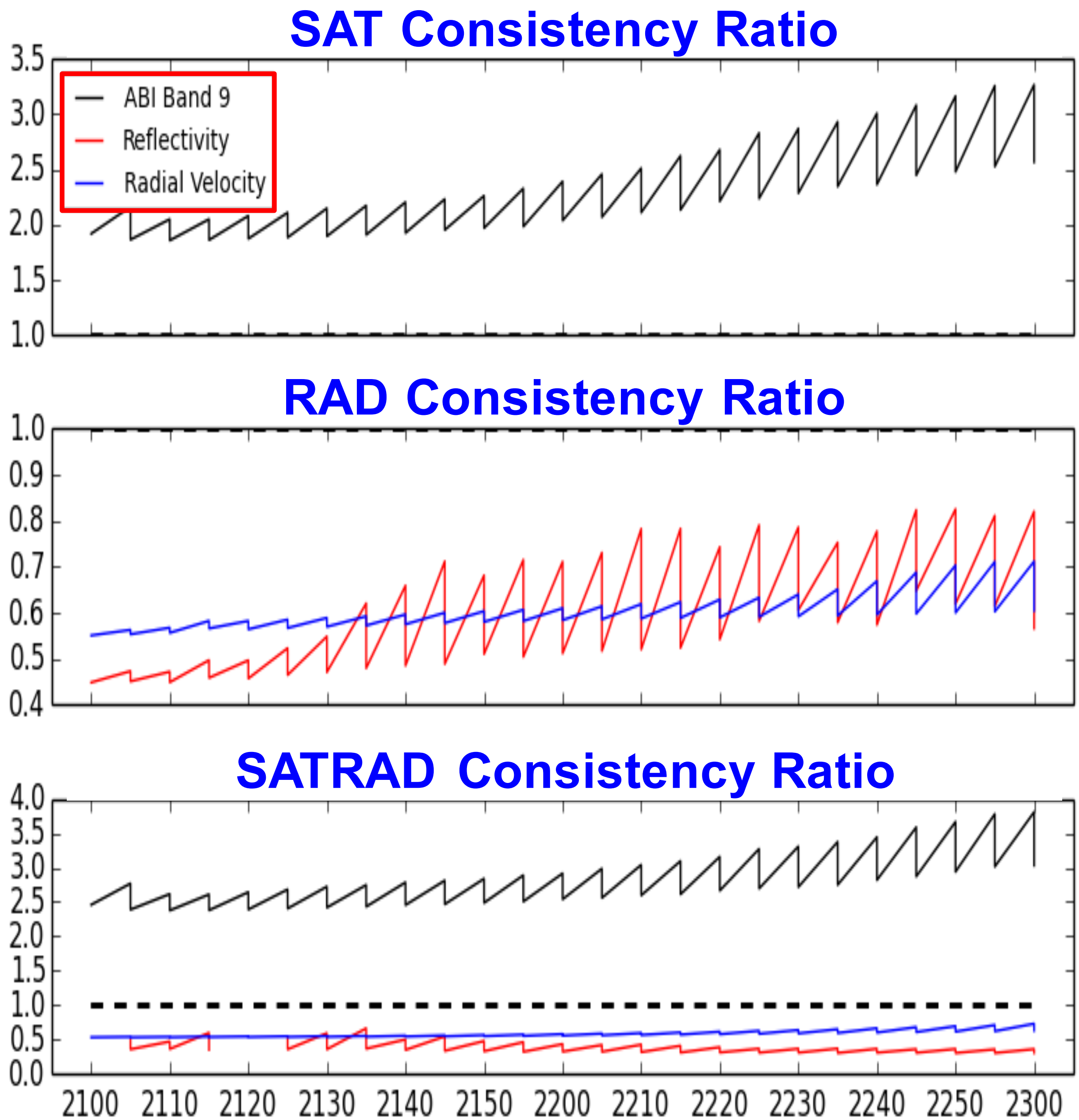
6.95 μm T_b Analysis Errors During Assimilation Period



- Control – no assimilation
- SAT – satellite only
- RAD – radar only
- SATRAD – both satellite and radar observations

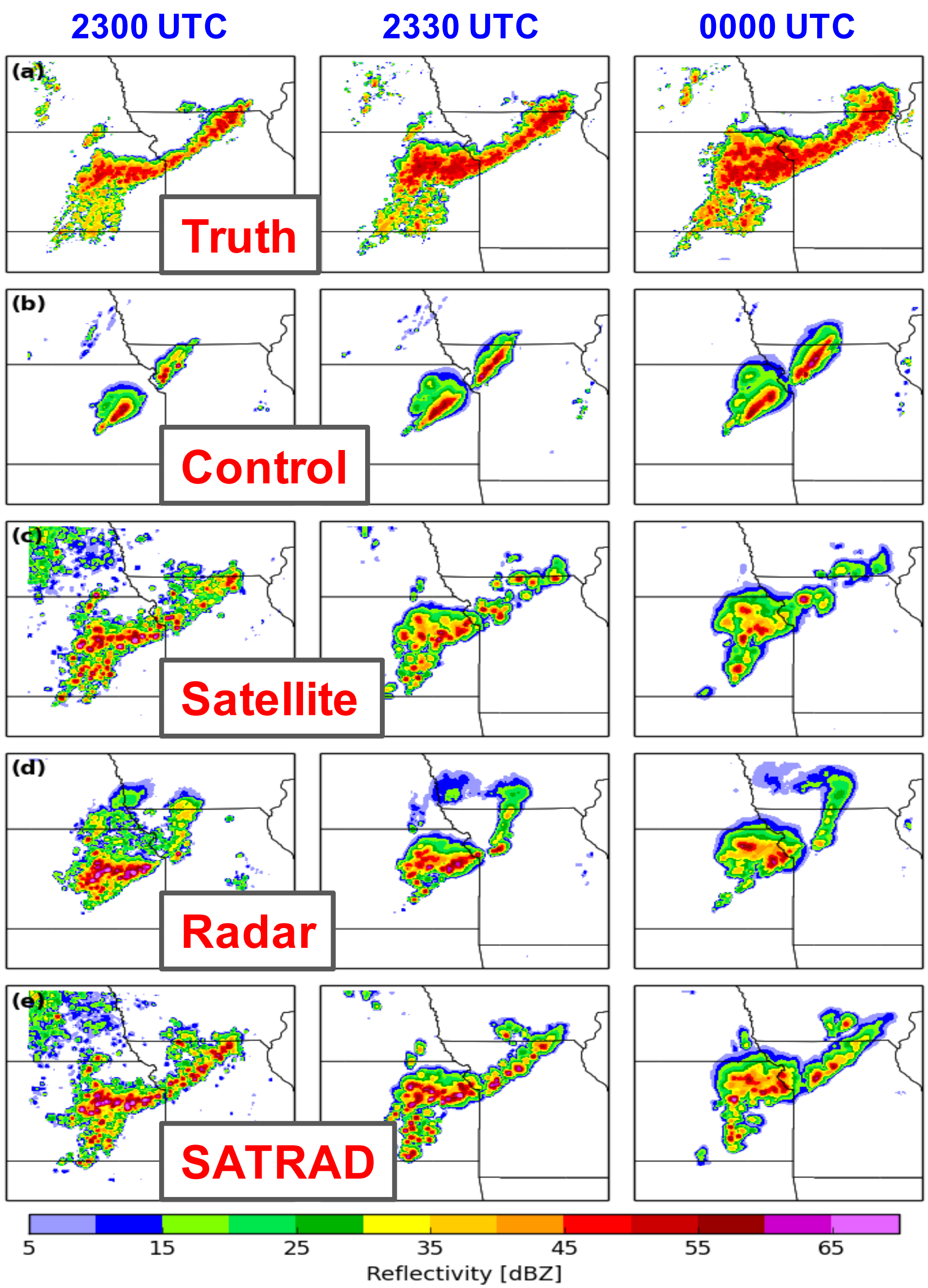
- Satellite observations had large positive impact on the cloud and moisture fields
- Radar data assimilation led to larger errors due to lower sensitivity to moisture and poor domain coverage
- Best results obtained during the SATRAD case

Observation Space Diagnostics – Consistency Ratio



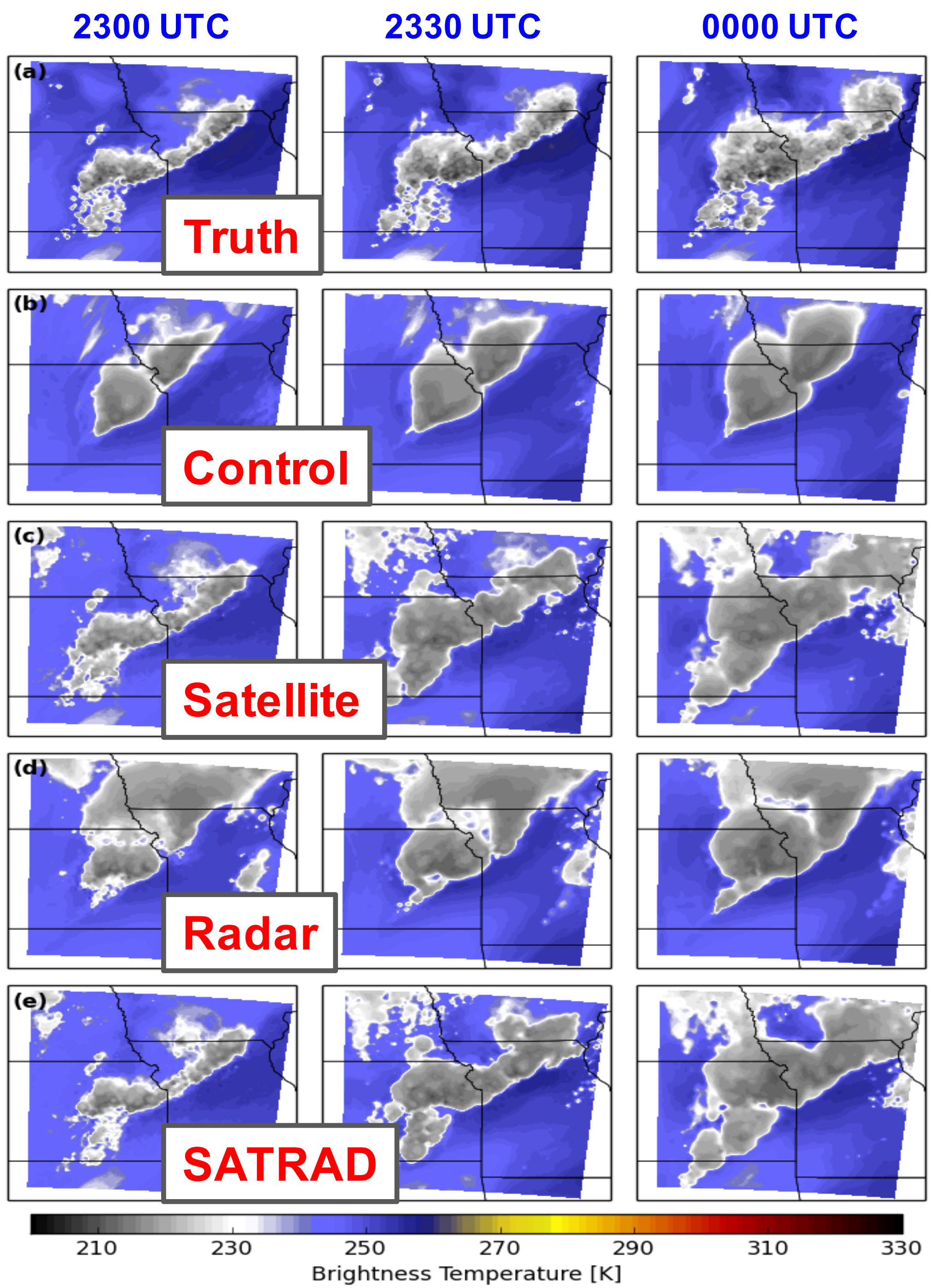
- Consistency ratio compares actual to optimal ensemble spread (should ideally be equal to 1)
- Ratio is too large for satellite observations – indicates too much ensemble spread or that the observation errors are too large
- Ratio is too small for radar observations – indicates deficient ensemble spread for cloud and wind fields

Simulated Radar Reflectivity During 1-Hour Forecast Period



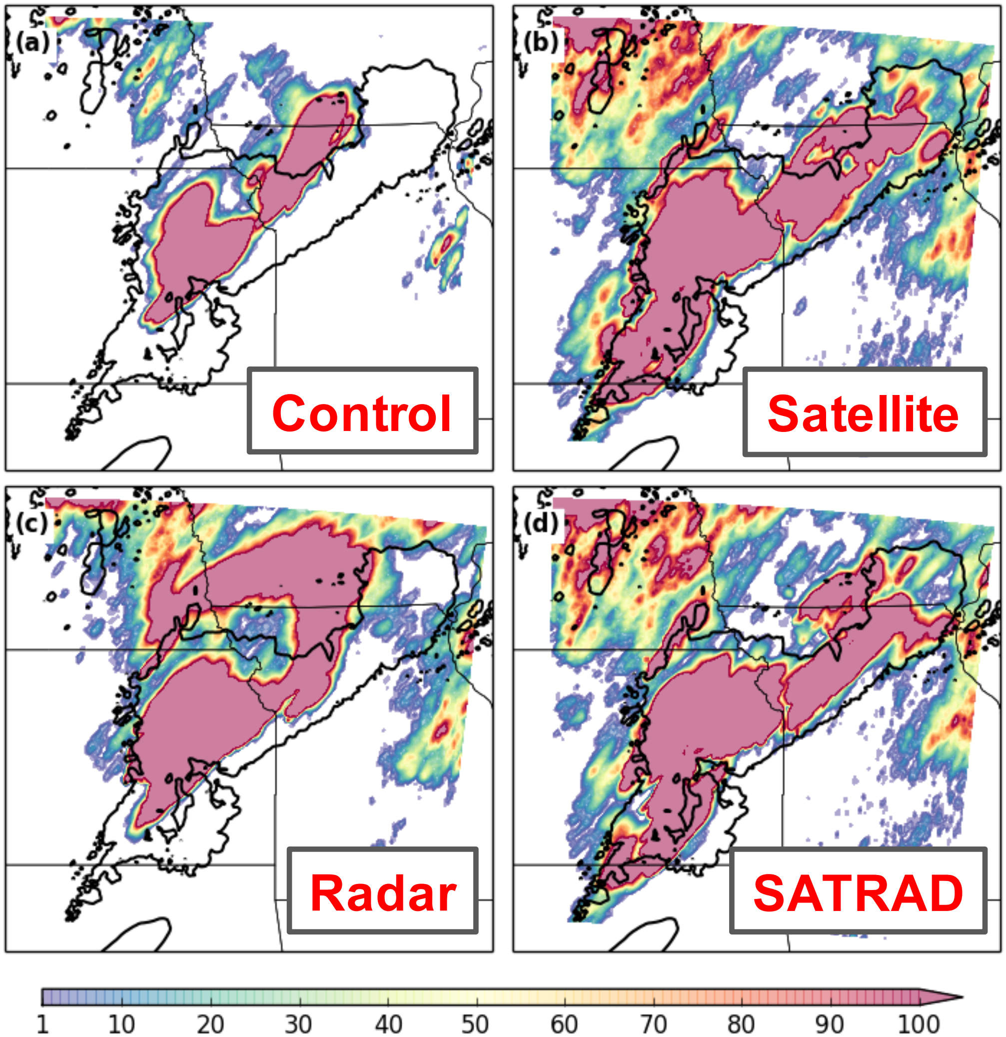
- Truth simulation had a long line of thunderstorms
- Control without satellite and radar assimilation is the least accurate
- Initial thunderstorm structure more accurate when satellite and radar observations were assimilated
- Best structure was obtained when both satellite and radar observations were assimilated
- Thunderstorms maintained organization longer during the SATRAD case

Simulated ABI 6.95 μm T_b During 1-Hour Forecast Period



- Truth simulation had a long line of thunderstorms
- Initial thunderstorm structure more accurate when satellite and radar observations were assimilated separately
- Best structure was obtained when both satellite and radar observations were assimilated
- Satellites can fill in data gaps even within data rich locations such as the central United States
- Results show that radar and satellite observations provide complementary information about the atmospheric state

Forecast 35 dBZ Composite Radar Reflectivity Probabilities



Probability of Composite Reflectivity > 35 dBZ

- 35 dBZ contour from truth simulation shown by black line
- Spatial coverage is too small during the Control case
- Assimilation of radar obs led to some improvements
- Much larger positive impact when satellite observations were assimilated, with better coverage across eastern Kansas and northern Missouri
- Best probabilistic forecast achieved during the combined SATRAD case

References

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