Recent Updates to Analyses and Data Assimilation Systems for High Resolution Nowcasting and Forecasting

Keith A. Brewster[1]
Kevin W. Thomas[1], Derek R. Stratman[1,3] and Frederick H. Carr[2]

[1]Center for Analysis and Prediction of Storms
[2]School of Meteorology
University of Oklahoma
[3]NRC Post-doc NOAA/NSSL

kbrewster@ou.edu

AMS NWP Conference Jan, 2017 6A.4

CAPS Real-Time Analysis and Data Assimilation

Analyses: 3DVAR and Complex Cloud Analysis used in

- Dallas Ft Worth Urban Testbed (Δx = 400m)
- Hazardous Weather Testbed and Hydrometeorological Testbed (Δx = 3 km)
  Initialization of CONUS Ensemble Forecasts

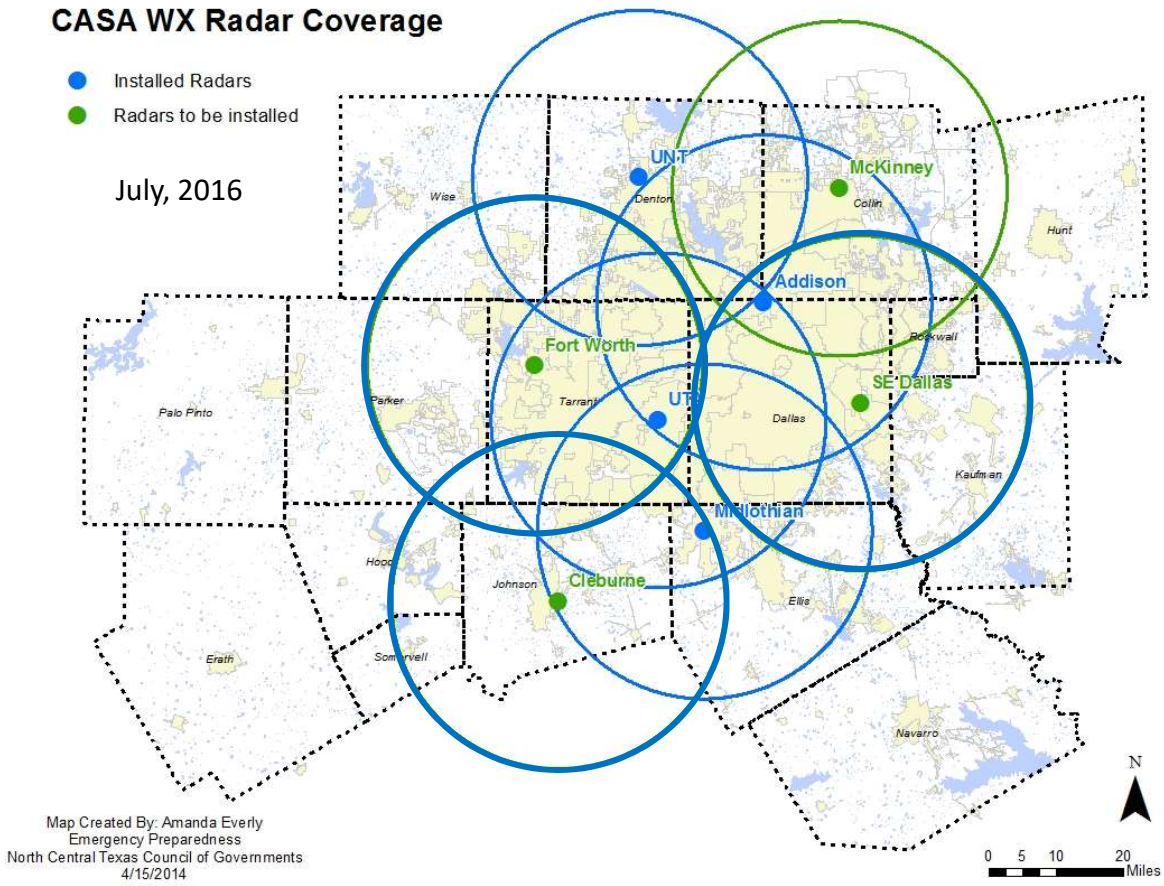
Data Assimilation: Incremental Analysis Updating (IAU) with increments from 3DVAR and Complex Cloud Analysis used in

- Dallas Ft Worth Urban Testbed (Δx = 1 km)
  0-2 h low-latency nowcasts and forecasts

Separately CAPS also using EnKF and Hybrid GSI EnKF

CASA Dallas-Fort Worth Urban Testbed

- Population ~ 6.5 million (4th largest city in U.S.)
- Severe weather – Floods, tornadoes, hail, severe winds, droughts
- Weather sensitive industries – transportation hubs (ground, air, rail), sporting venues
- Network of Networks approach
- Primary focus is severe weather and urban flood

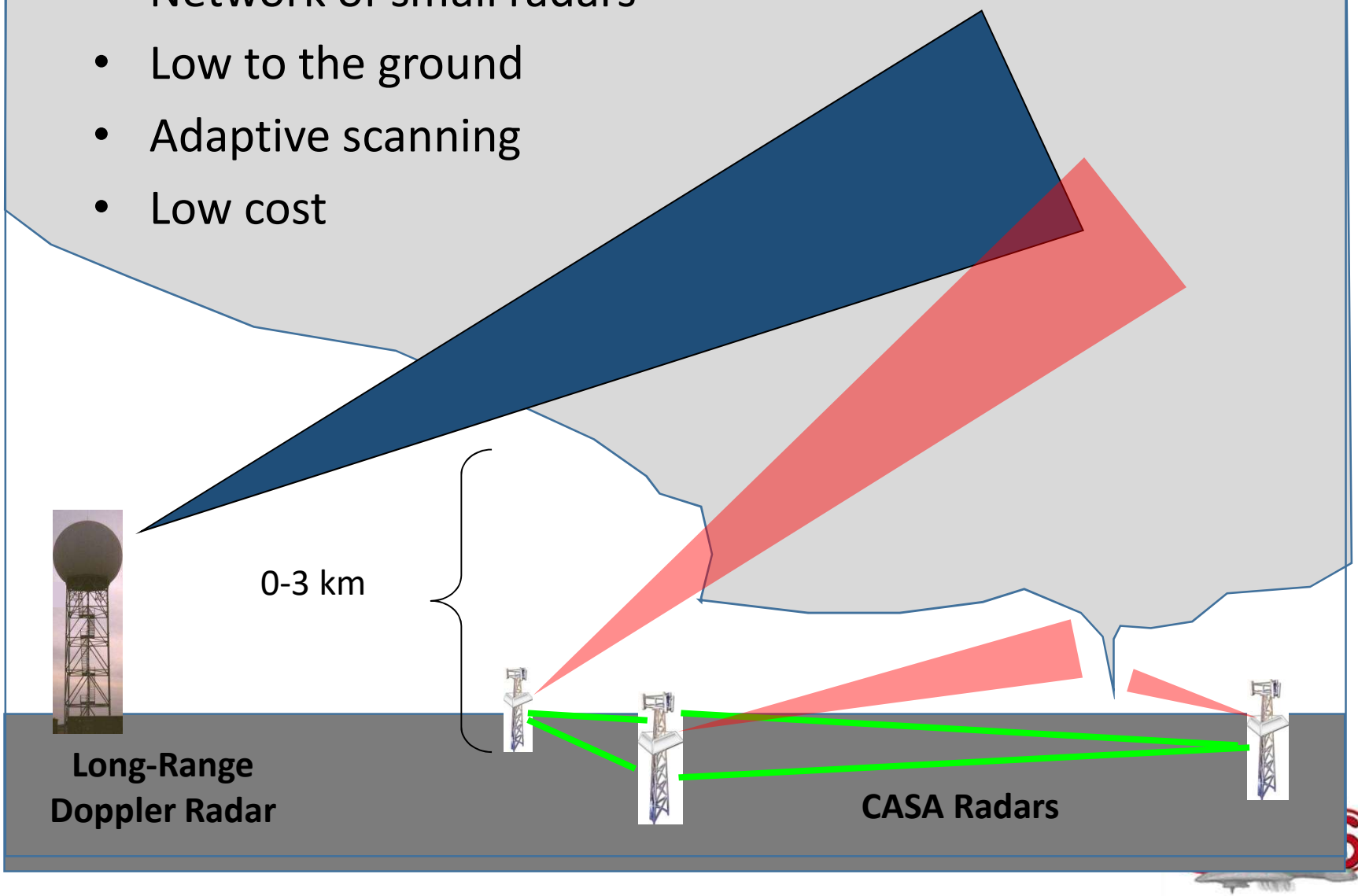


Poster 1027, Wednesday

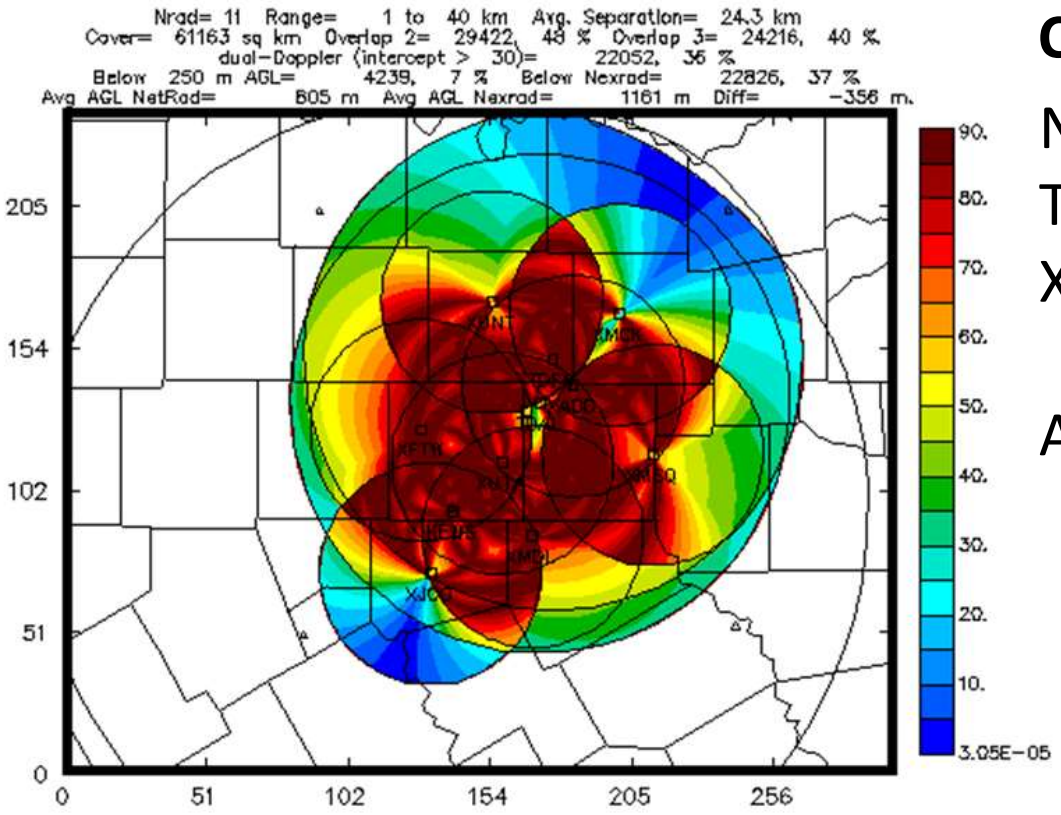
The CASA Concept

Collaborative **A**daptive **S**ensing of the **A**tmosphere

- Network of small radars
- Low to the ground
- Adaptive scanning
- Low cost



Building the Radar Network
Dual-Doppler Angle Analysis



Combined Network

NEXRAD: KFWS

TDWR: TDAL, TDFW

X-Band Network: 8 Radars

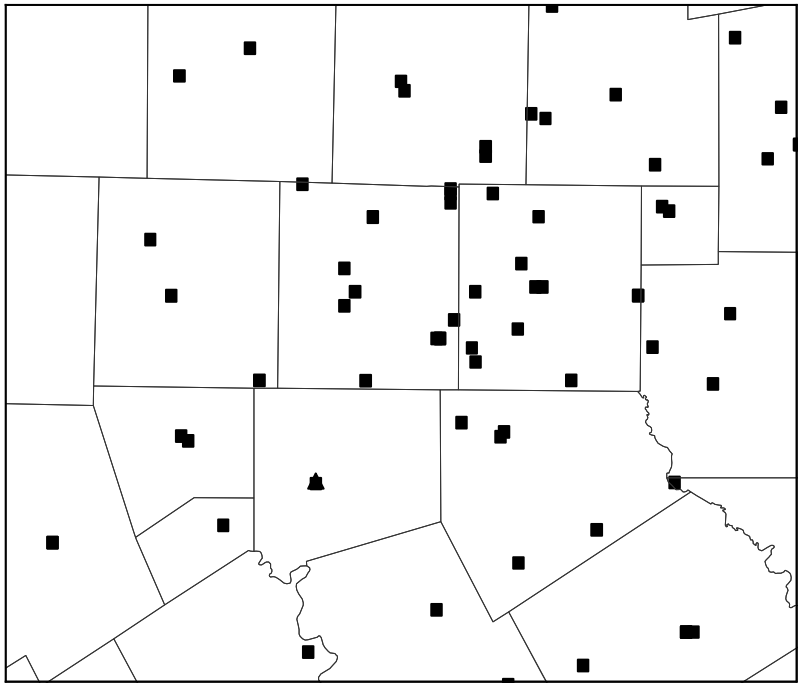
Avg Beam Height: 600 m

Observation Summary

Conventional Observations	Non-Conventional Observations
ASOS	EarthNetworks (WxBug)
AWOS	CWOP
	GST MoPED, Understory
	Oklahoma & W Texas Mesonets
S-band WSR-88D Radars	X-band Radars
	C-band TDWR Radars
Radiosondes	SODARs
	Radiometers
Aircraft MDCRS	Aircraft TAMDAR

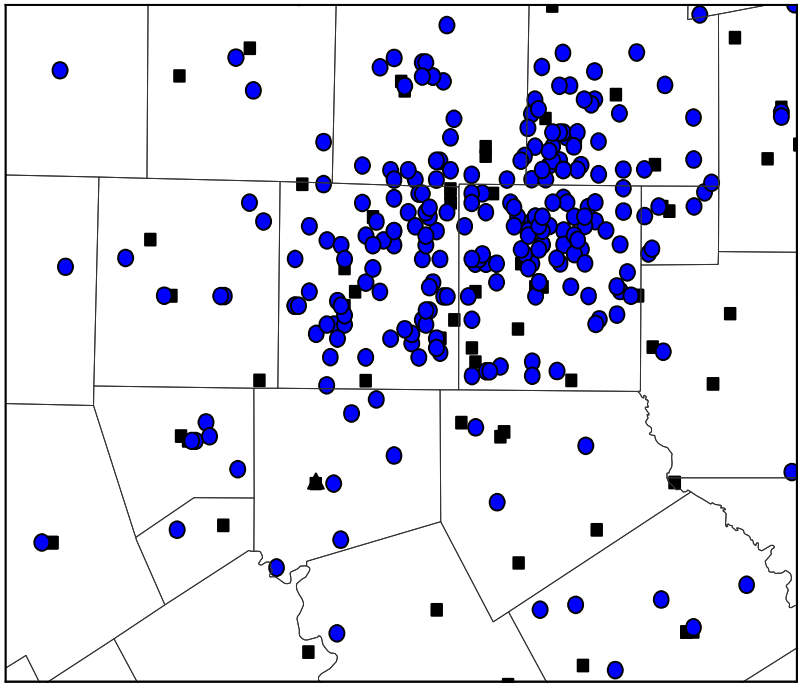
Surface Observations

Conventional Observations



AWOS & ASOS

Conventional & Non-conventional Observations



WxBUG & CWOP

Operational Configuration

OSCER Schooner
Xeon64 Haswell 2x10 Core Chips

- Analyses at 400 m Resolution Dedicated Queue
  - 3DVAR and Cloud Analysis
  - Sfc, Profilers, VAD, Radar Wind and Reflectivity
  - 5-minute Interval
  - 400-m grid spacing Grid Size 453 x 483 x 28
  - Processors: 20
  - Obs Processing & Analysis Wallclock ~8 min
- Assimilation/Forecasts On-Demand
  - 3DVAR and ARPS with 10-min IAU
  - Sfc, Profilers, VAD, Radar Wind and Reflectivity Assimilation
  - 2-hour Forward Forecast
  - 15 minute interval
  - 1-km grid spacing Grid Size 363 x 323 x 53
  - Processors: 4 x 40 = 160
  - Obs Processing + Analysis + Forecast Wallclock ~20-25 min

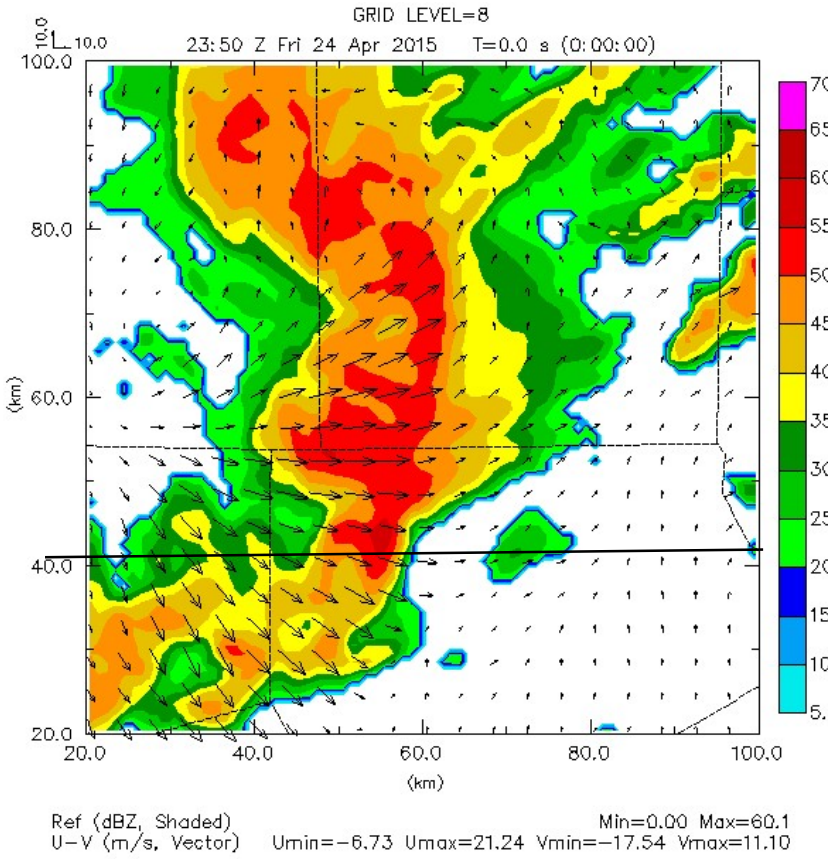
Recent Improvements

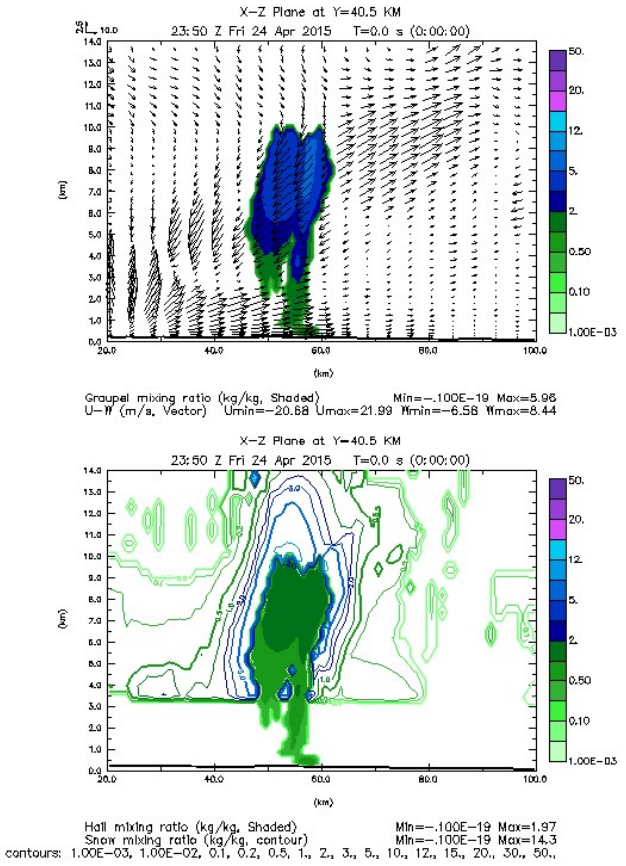
- Updated the cloud analyses handling of reflectivity to be exactly reversible to reflectivity plotting algorithms for all microphysics options in ARPS and WRF.

  2015 NWP Conference paper

- Cloud analysis no longer saturates air in rainy downdrafts
- Introduced IAU with Variable Dependent Timing
- Updated IAU processing to better handle multi-moment microphysics.
- Tuned scripts to further reduce latency.

April 24, 2015 Hail Case

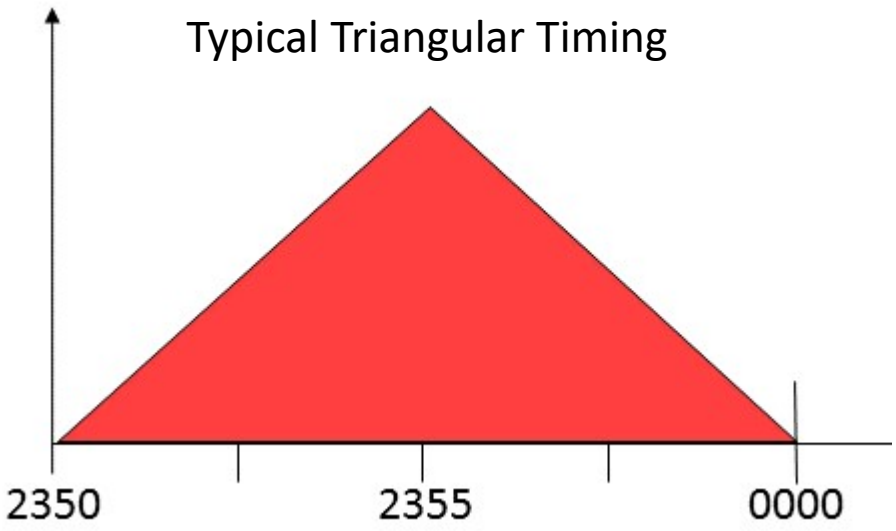


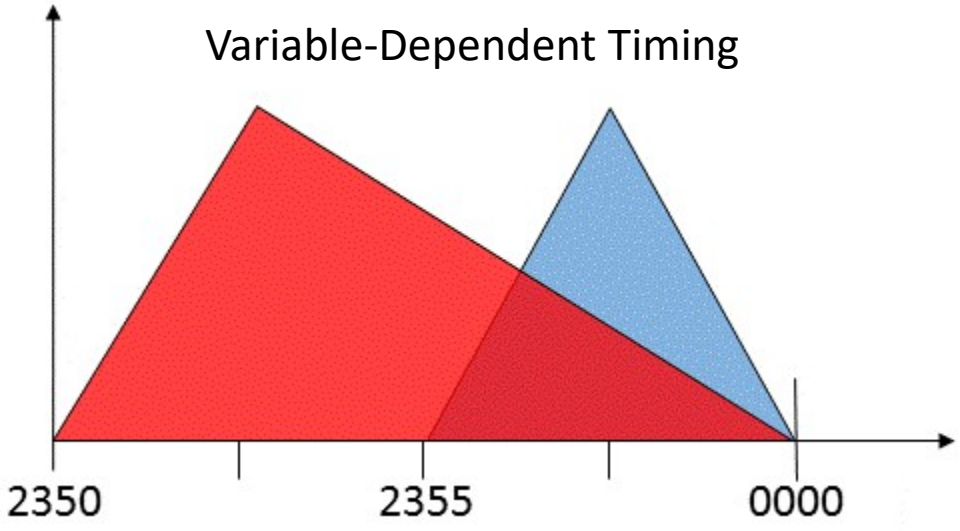


Test Using Milbrant & Yau Single-Moment Microphysics

Updated IAU Scheme

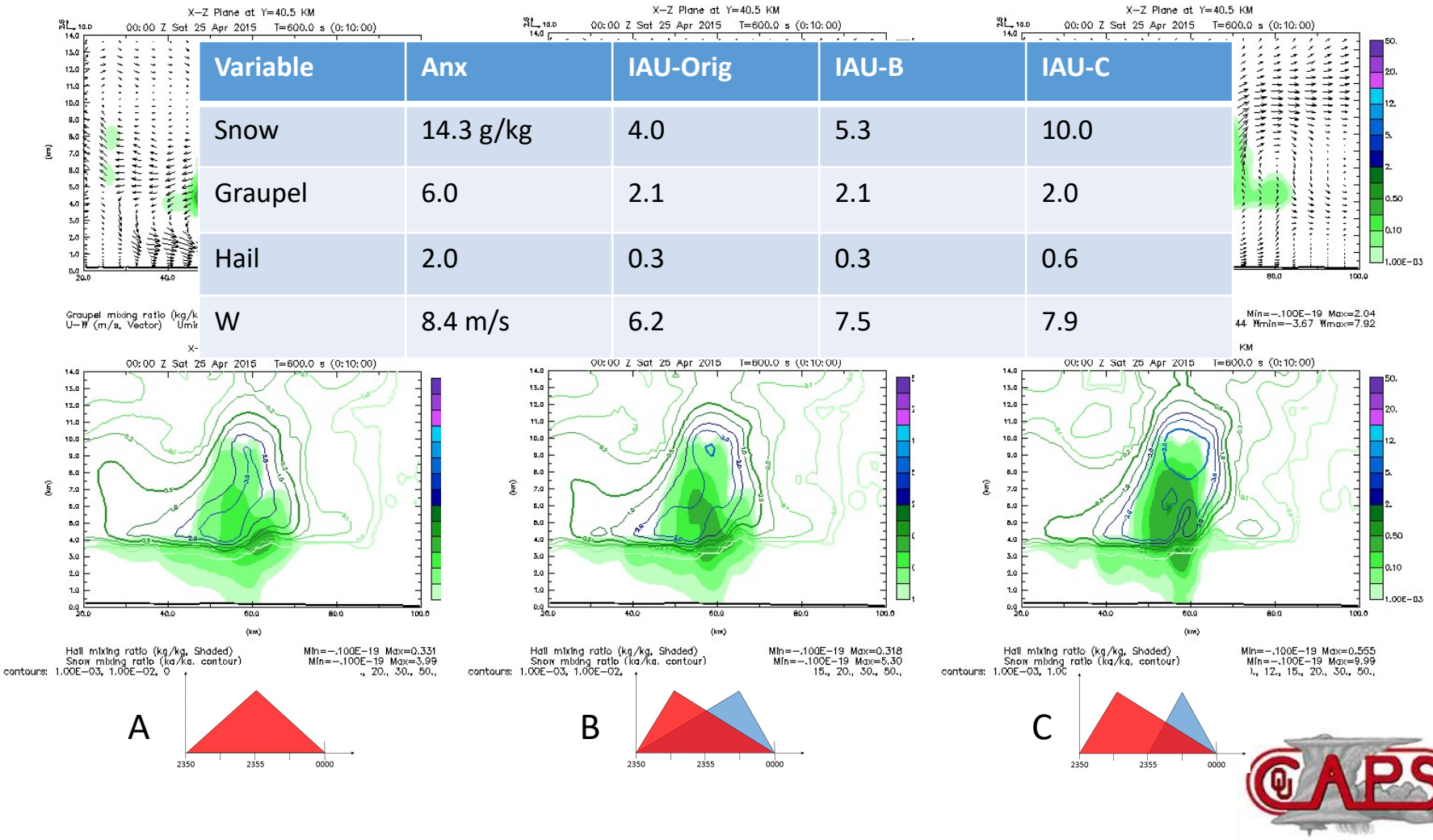
- Variable-Dependent IAU Timing



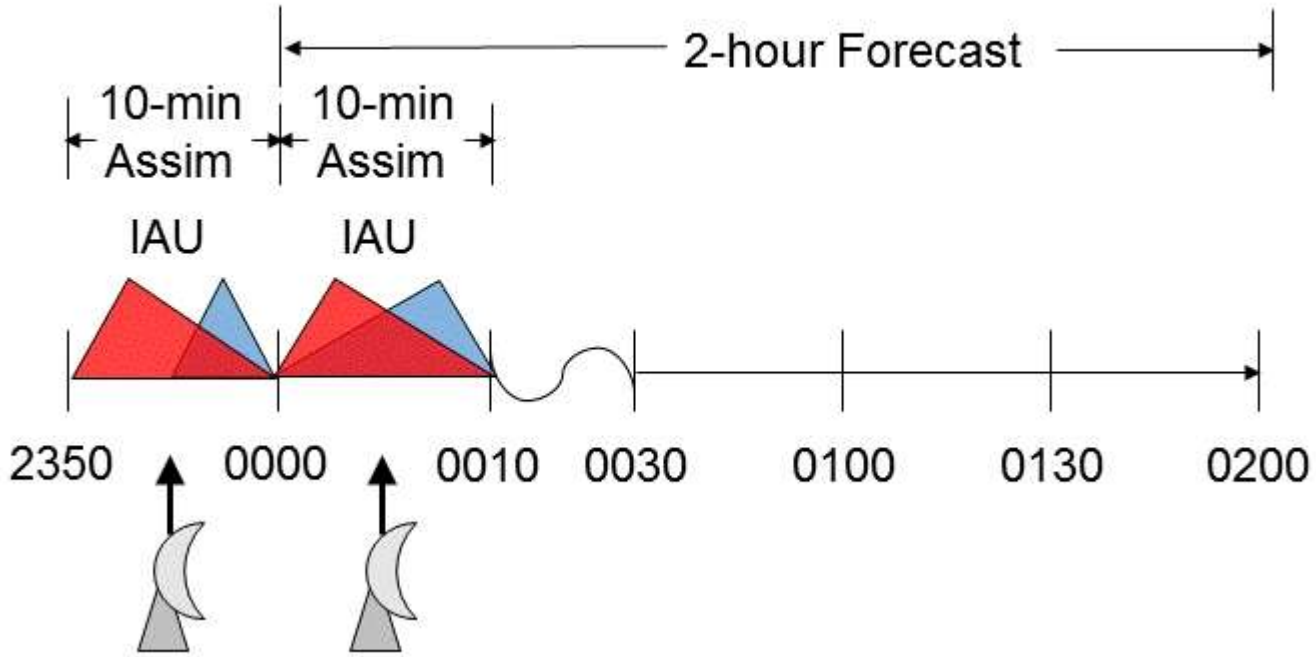


After 10 Minutes IAU

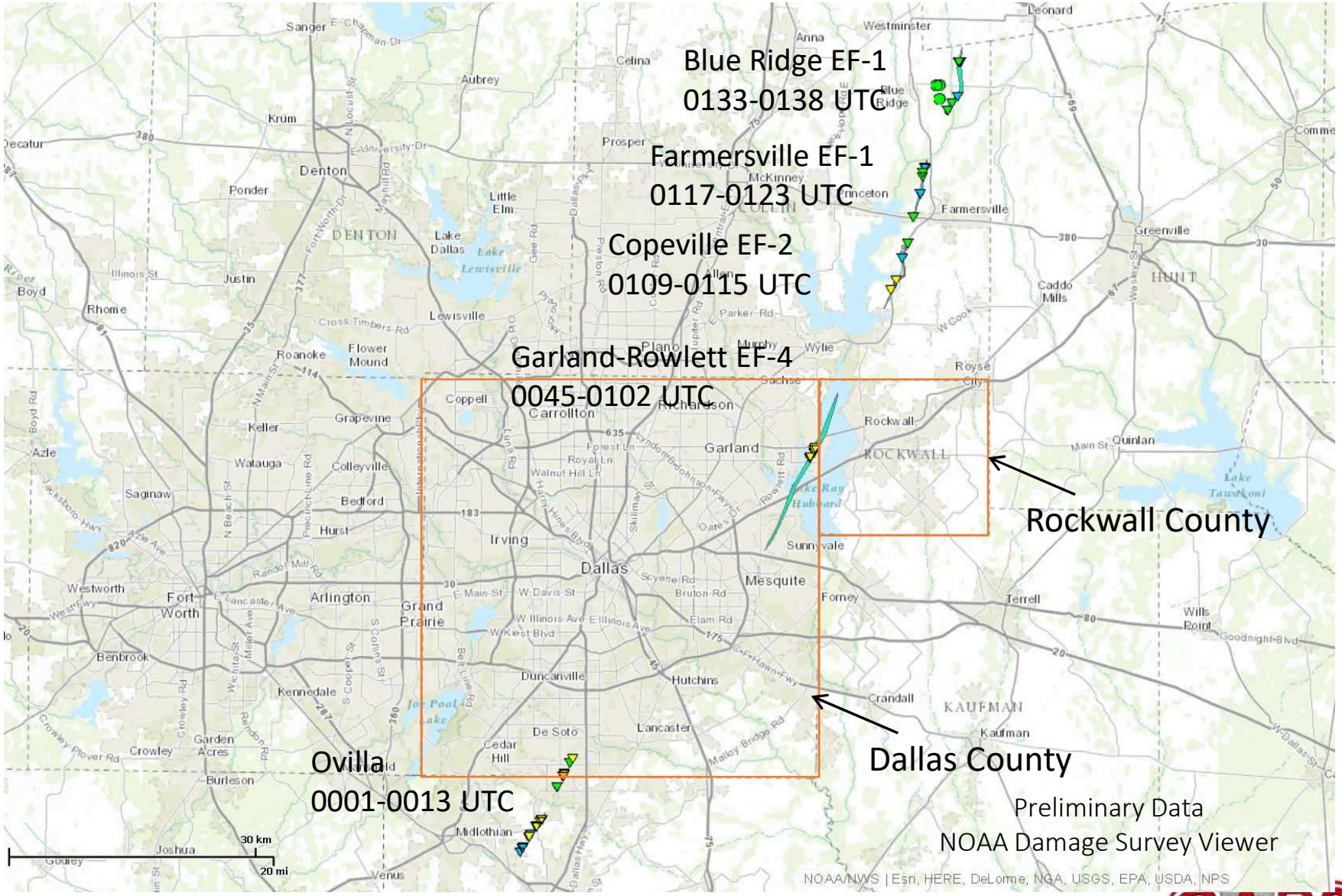
Variable	Anx	IAU-Orig	IAU-B	IAU-C
Snow	14.3 g/kg	4.0	5.3	10.0
Graupel	6.0	2.1	2.1	2.0
Hail	2.0	0.3	0.3	0.6
W	8.4 m/s	6.2	7.5	7.9



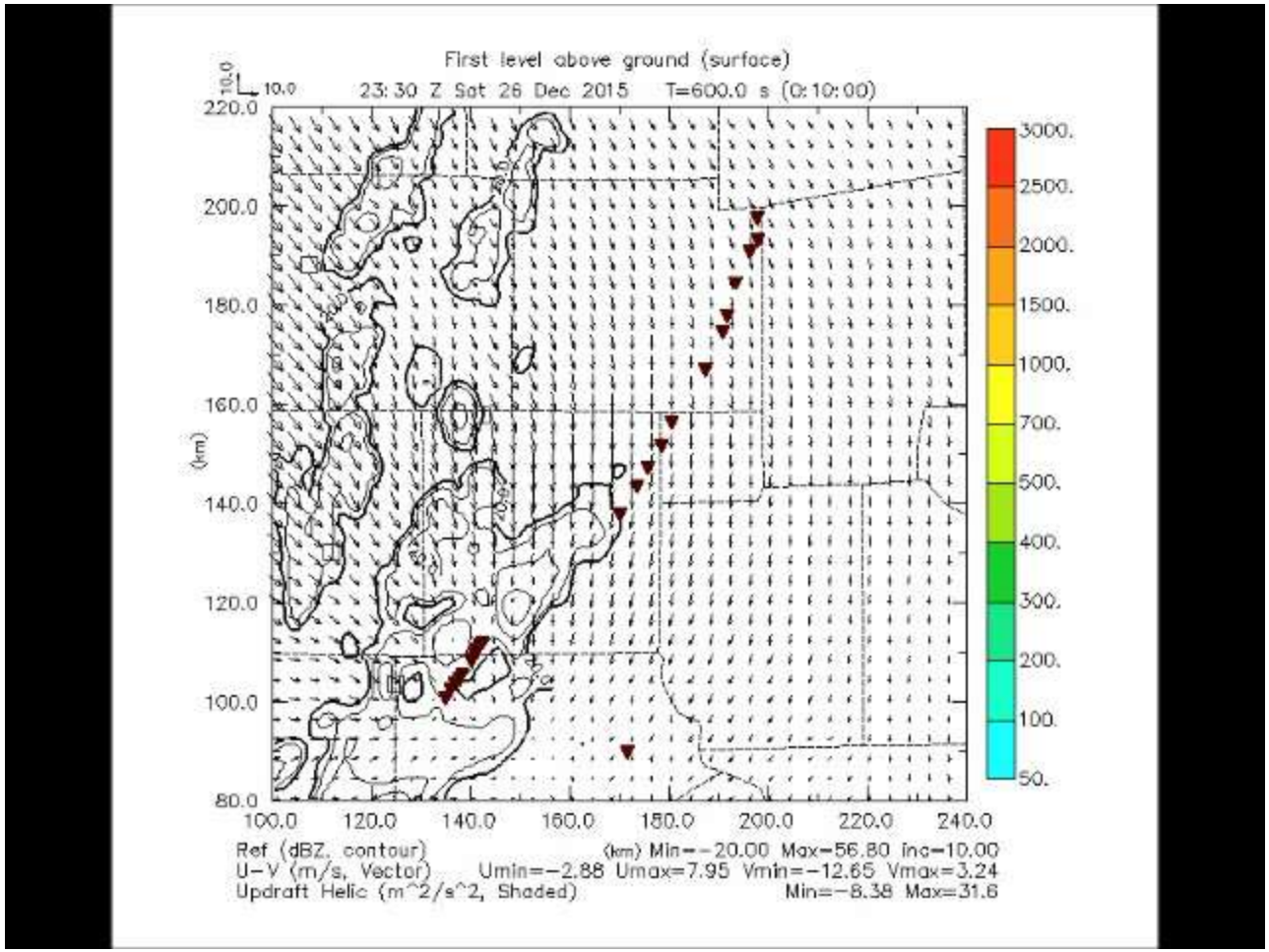
Operational Cycled IAU



D/FW Metro Tornado Tracks, 26 Dec 2015

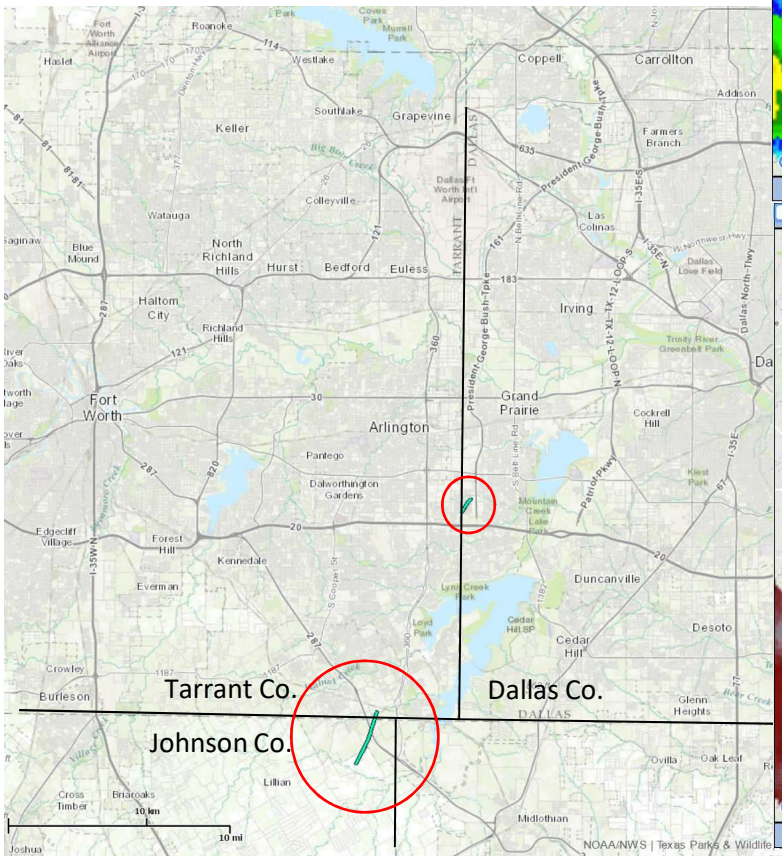


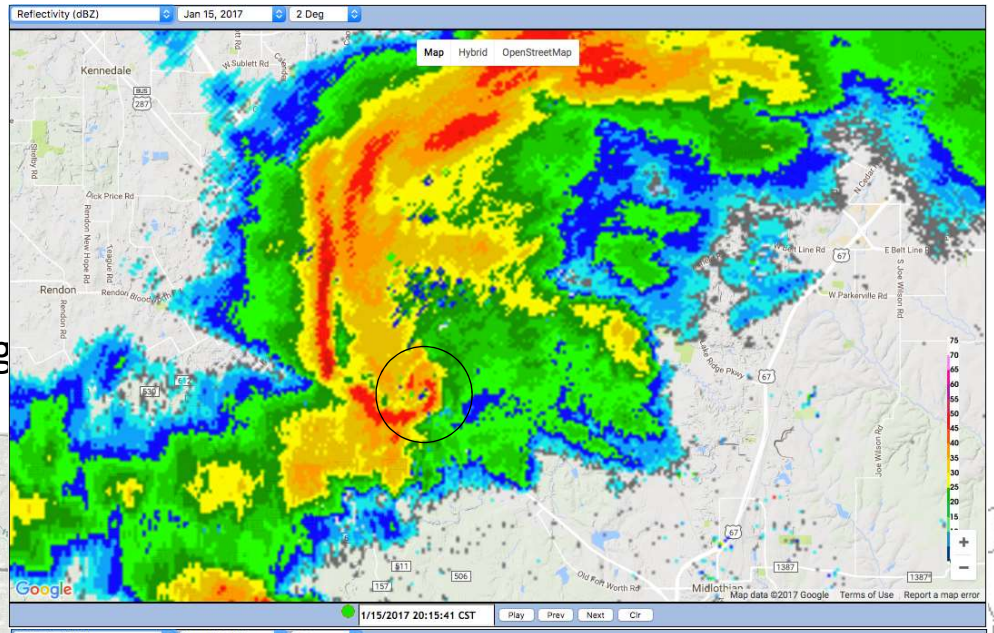
1-km Forecast Initialized 2330 UTC 26-Dec-2015

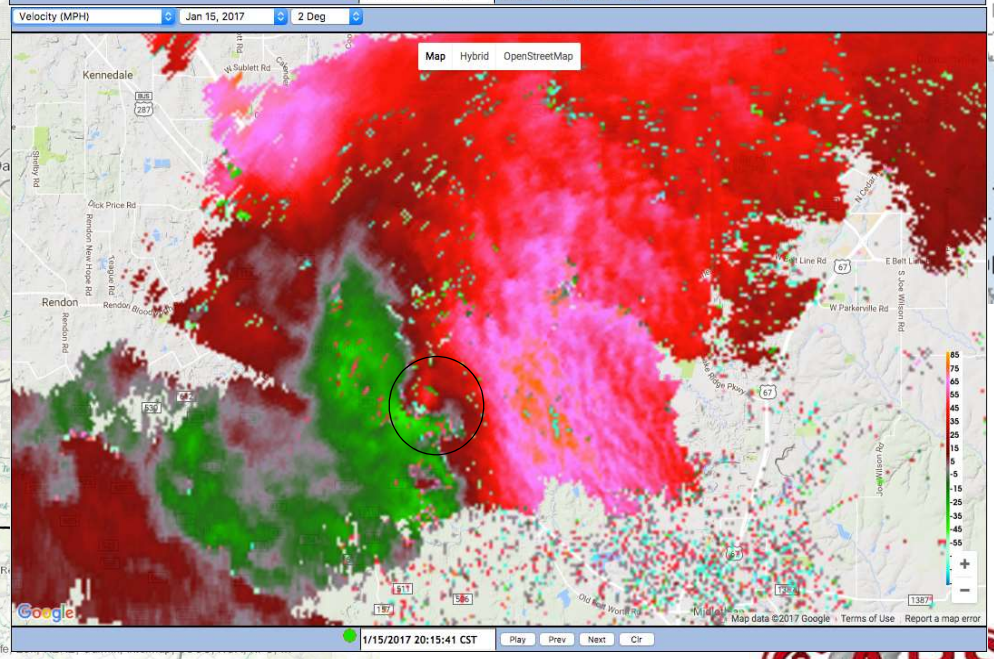


Evening of 15 January 2017

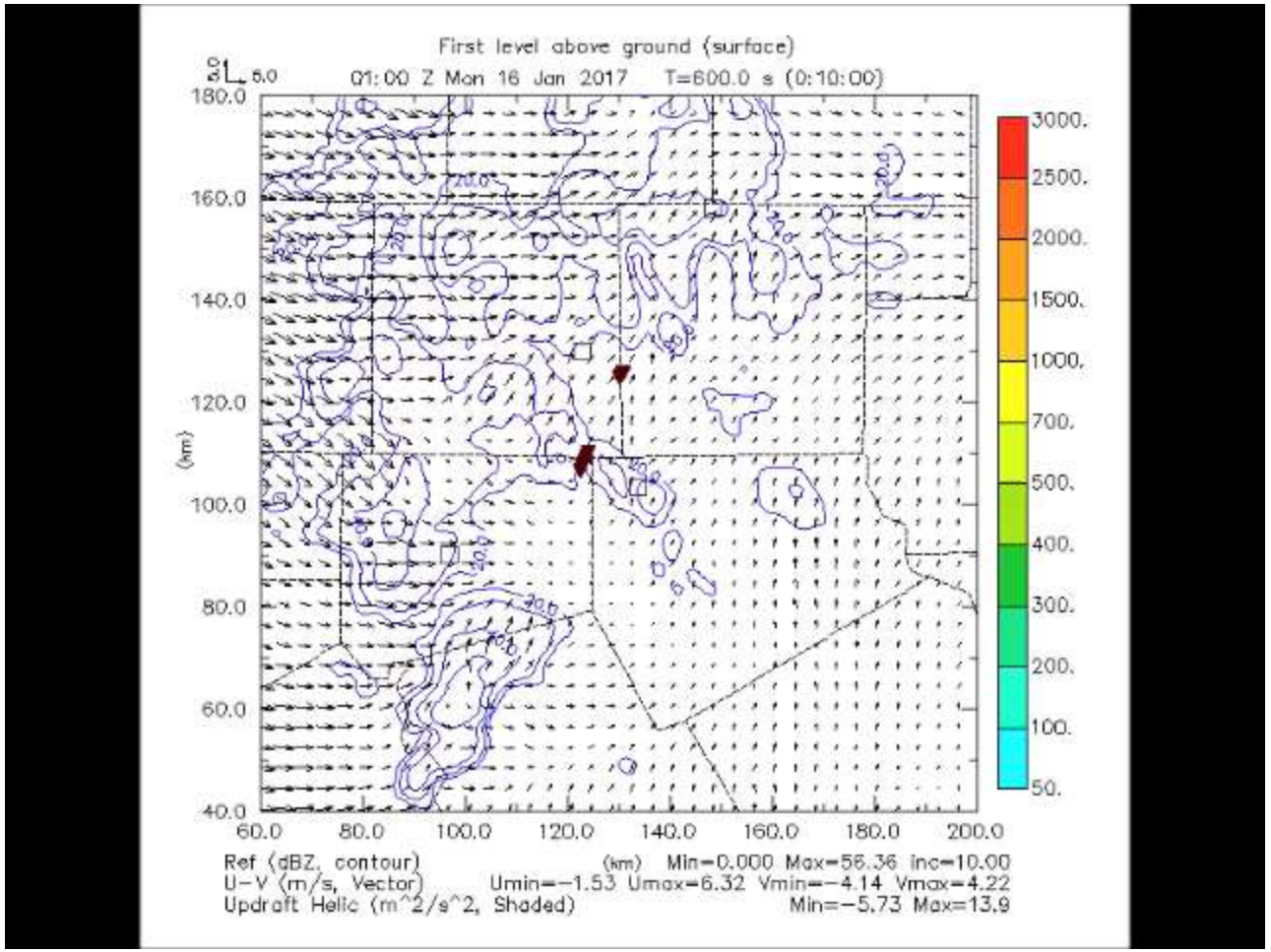
F0 Tornadoes in D/FW Metroplex
0211-0214 UTC Mansfield
0243-0244 UTC Grand Prairie
Plus other wind damage reports along







0100 UTC Forecast

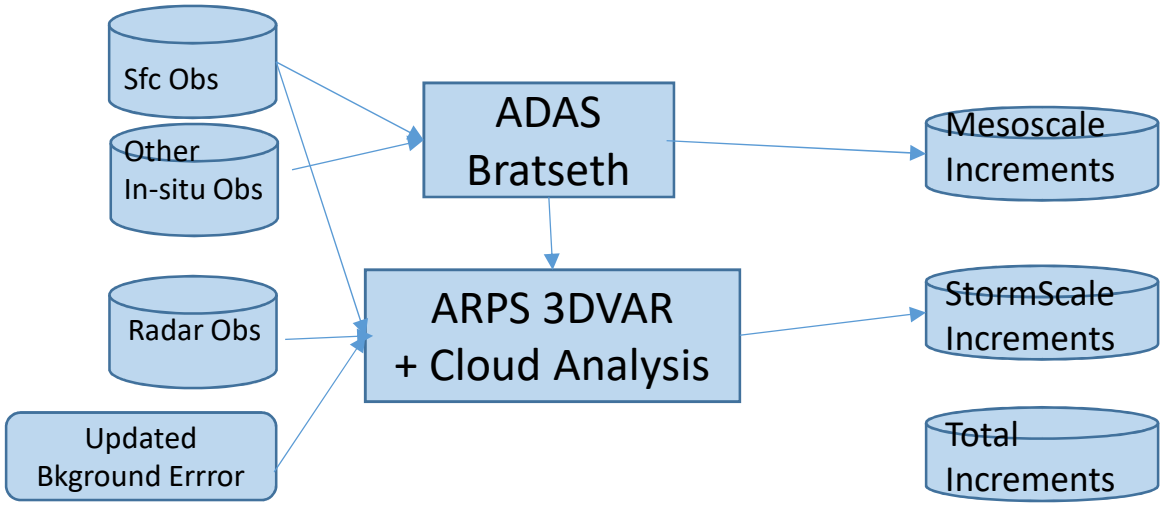


Ongoing Work and Future Plans

- Update real-time to Milbrandt-Yau microphysics
- Compute verification stats over month-long periods
- Continue with data denial experiments
  - Posters 656, 666, 667
- Experiment with a 3DVAR-Bratseth Hybrid Analysis Scheme

Proposed Hybrid Analysis Scheme

- 3DVAR implementations ignore ob-ob covariances
  - Problem for clustered observations
- 3DVAR with radar data can overwhelm surface observations due to sheer number of observations
- Bratseth Scheme in ADAS handles ob-ob covariances but can be slow with radar data due to number of data points & can't add equation constraints desired for final solution.
- Can introduce flow-dependence using isentropic distance function



Observations Lead the Way

- Data denial and observation impact experiments underway to gauge importance of deployed observation systems
- Regarding other observation needs:
  1. Network with complete profiling of the boundary layer Temperature, Humidity and Winds (0-3 km)
     - Automated Unmanned Aircraft System (UAS) or
     - Combination of Radiometers and Wind Profilers (SODAR or LIDAR)
  2. Improved density of surface observations in rural areas
     - Expansion of West Texas Mesonet, for example

In Closing…

- Real time Data Analyses and Forecasts Operating with Low Latency
- Updated Hydrometeor Retrieval for Multiple Microphysics Schemes
- Developed new IAU with Variable-Dependent Timing
- Additional Improvements on the Way

CAPS Forecasts Online
http://forecast.ou.edu

Thanks to:

- CASA Colleagues from UMass, CSU, participating cities, counties
- OSCER Staff
- Partial funding from NOAA National Mesonet Program & NOAA OS&T

Contact Info:
kbrewster@ou.edu