SCIT Rapid Update

and the "Virtues of Virtual Volumes"

NEXRAD TAC Information Briefing

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Summary

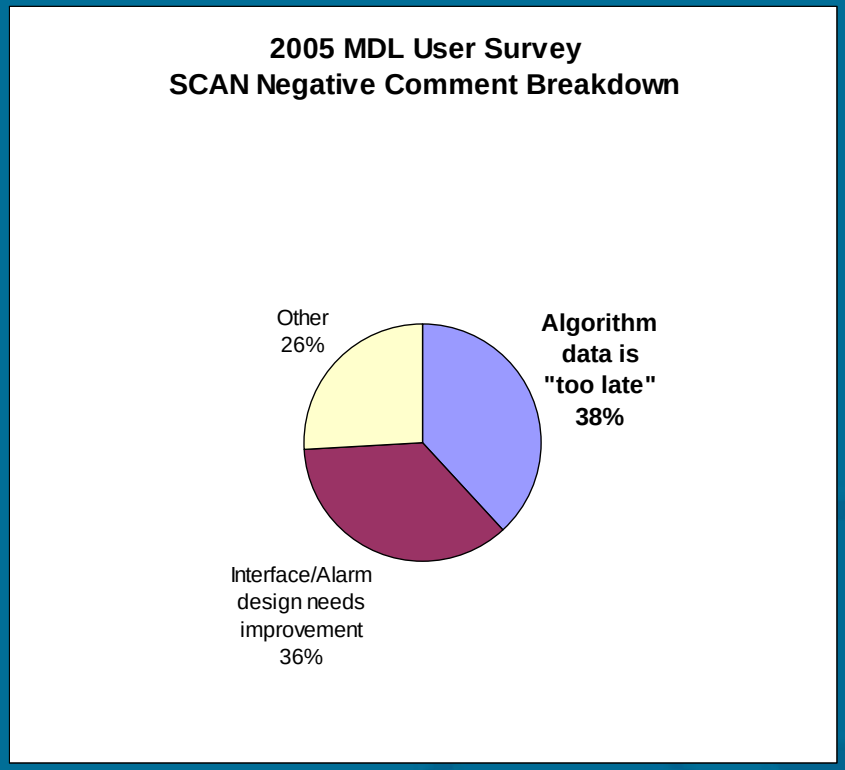
- Issues:
  - Only MDA and TDA Rapid Update have been implemented
    - Supports GPRA goal of increasing Tornado Warning Lead Time
  - SCIT and HDA RU are unfinished.
    - There may not be GPRA goals for downbursts, but these are the #1 severe weather concern in many WFOs, especially Western Region.
    - There are other benefits, which will be summarized later.
  - Rapid Update method for MDA and TDA is somewhat convoluted, providing somewhat confusing output.
- Proposed Solution:
  - Complete implementation of SCIT (and HDA) Rapid Update.
  - Use a "Virtual Volume" technique, which is simpler to implement and more elegant for users to understand.

History

- TAC Dec 2001 – Norman WFO Briefing suggested “Rapid Update” and “Virtual Volumes”
- TAC Fall 2002 – Rapid Update Decision Briefing
  - TAC recommends implementation of rapid-update concepts for SCIT, HDA, MDA, and TDA.
    - **TN-30 Status**: Development of the Rapid Update System continues to show great promise in identifying severe weather features prior to the end of a volume scan of radar data. This capability will allow users access to critical severe weather information in a more timely fashion.
- TAC Fall 2003 – WDSSII Multi-Radar/Sensor Algorithm Info Briefing
  - Virtual Volume processing has already been part of WDSSII for over 4 years

Needs Assessment

- 2005: There is still user dissatisfaction of latency for all algorithm products
  - Turns users off to the algorithm guidance.
- MDL/DAB wishes to respond to this by implementing "RapidSCAN"
  - All major algorithms (SCIT, HDA, MDA, TDA)
  - Eventually spatial fields (Digital VIL, gridded HDA, etc)



System for Convective Analysis and Nowcasting (SCAN)

- Recent activity to develop “RapidSCAN”
  - OB5: Already handles DMD data (rapid update)
    - 2D and 3D output available after each elevation scan
  - Requests to interface DMD with SCIT for Tables and Time-Height trends.
  - Initial requirement was for a SCIT 2D feature product.
  - Currently, SCIT IDs are only assigned at the end of the volume scan.
    - This means that SCIT information can only be tagged to DMD information at the end of a volume scan.
    - SCIT Time-Height trends would be delayed until the end of the volume scan – not good for rapid core evolution.
  - SCIT Rapid Update would allow the IDs to be available earlier, at the end of elevation scans.

Many other benefits to AWIPS and SCAN

1. SCIT RU will provide DMD storm information before the end of the volume scan - more accurate extrapolation, earlier reporting, earlier storm ID association, more accurate meso type determination (e.g., low-topped mesos)

2. Rapidly updating SCIT output for diagnosing storm evolution (rapid core ascent or descent)

3. SCIT Time-height trends of reflectivity (eventually convergence/divergence), especially useful for severe downburst diagnosis.

4. SCIT RU will lead to Rapidly Updating Hail Detection Algorithm output as well.

5. New SCIT overlay graphics for depicting storm area and leading edge forecasts.

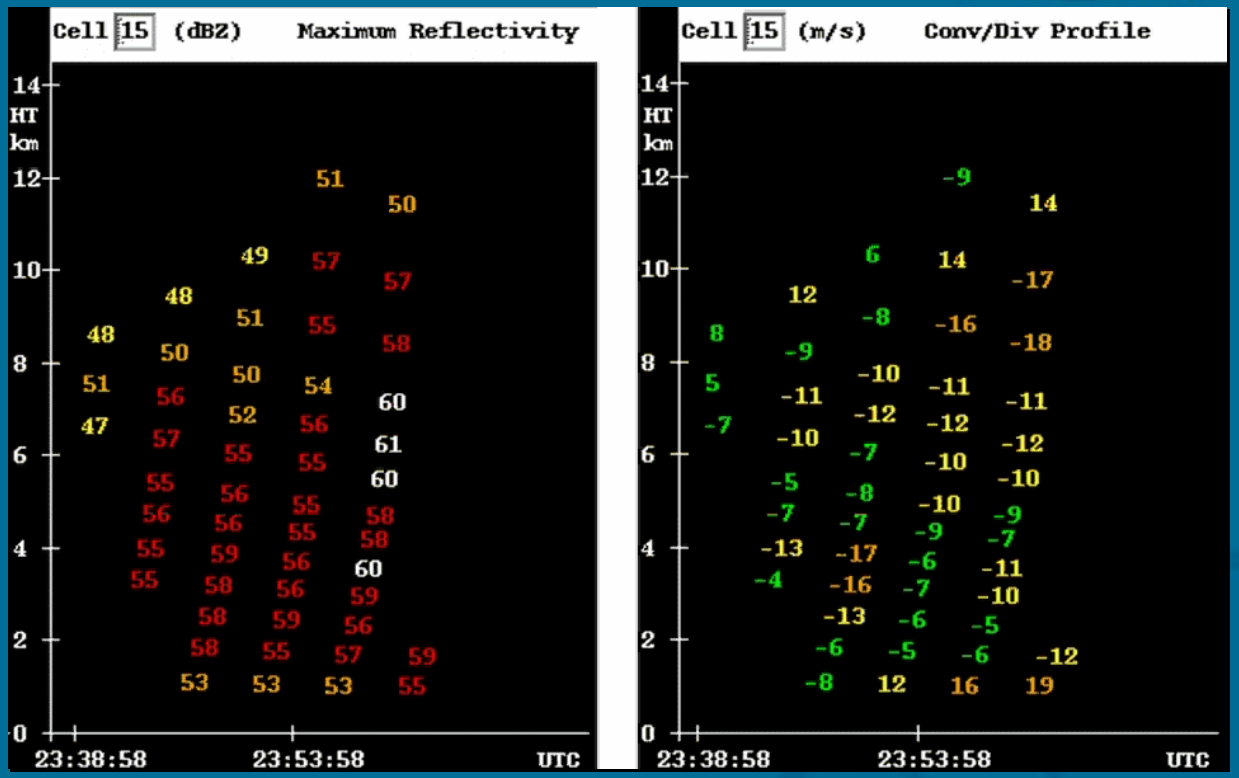
6. Integration of SCIT 2D feature "area" and "volume" information with lightning sensor data (NLDN CG data, and 3D data from the Lightning Mapping Arrays and space-borne systems) for new rapid-update lightning warning guidance products.

7. Integration of SCIT 2D feature "area" and "volume" information (azimuthal and range extents) with geospatial grids (VIL, Echo Tops, LRMs); can provide scatter plot of values (uncertainty).

8. Multiple-radar SCIT, combining 2D SCIT features from multiple radars into for improved accuracy and lead time.

Time-Height Trends

- Time-ht trends of Reflectivity important for storm core evolution
  - Rapid ascent useful for severe
  - Rapid descent useful for downburst
  - Very short time scales dictate rapid update output
- If Linear Least Square Derivative (LLSD) products are developed:
  - Can also create time-height trends of convergence and divergence ties to SCIT cells
  - Very important for downburst evolution



Progress

- SCIT RU Functional description written.
- Submitted Needs Identification Document.
- OS&T/SEC started implementation of SCIT RU in Spring 2005 for ORPG9 or ORPG10.
  - Utilized some NSSL WDSSII source code
- Coordination work with MDL/DAB, several Design Approach Reviews.
  - Already carried out some risk analysis (resource use, etc)
- Software implementation was 35-40% completed.
- Work put on back burner due to other priorities. Still “quasi-ORPG10”.
- Saffle recommended TAC briefing to bolster priority.
  - May also need OSIP
- Concerned about push to ORPG12!

Comparison of Rapid Update Techniques

- MDA RU/TDA RU
  - Match 3D detection from the last complete volume scan with the one at the current elevation scan.
  - Update the low-level information
  - Extrapolate the unmatched detections.

- Virtual Volume (VV)
  - Virtual volume just means the vertical and time association are repeatedly run at the end of each elevation using the latest data from all elevation scans. As an elevation scan updates, it simply replaces the data from the previous time, and you always have a complete virtual volume.

Virtual Volumes

- Why not implemented in the past?
  - Concerns about “interface” between oldest and latest elevation scan data
    - Storm motion – 2D features would not properly align
    - Storm Evolution – can’t really avoid this unless we have Smart VCPs (e.g., interlaced, but then VV will still work!)
- Solution – leverage off activity to bring Near-Storm Environment (NSE) grids from AWIPS OB7 to ORPG9, and use background storm motion vector to help perform time-to-space correction for 2D feature positions.

Leverage new NSE data requirement

- For AWIPS OB7, ORPG9:
  - Send Near-Storm Environment (NSE) data from AWIPS to ORPG
    - T, T_d, **u, v**
    - Within 200 nm of RDA
    - RUC analysis field (or 1 h forecast)
    - If model data unavailable, use nearest rawinsonde

Virtual Volumes

- Was implemented in WDSSII system in 2002, but for a multi-radar SCIT
  - Virtual Volumes are inherent to multiple-radar; still works when only one radar available.
- We think that this is much easier to implement, and more elegant for users to understand, than present Rapid Update scheme.
  - Concept will work for interlaced VCPs like TDWR, Phased Array Radar, and multi-radar
  - Concept will work for gridded products (single and multi-radar), such as VIL, gridded HDA, etc.

Virtual Volumes

NEXRAD
VCP 12

19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5
15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6
12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

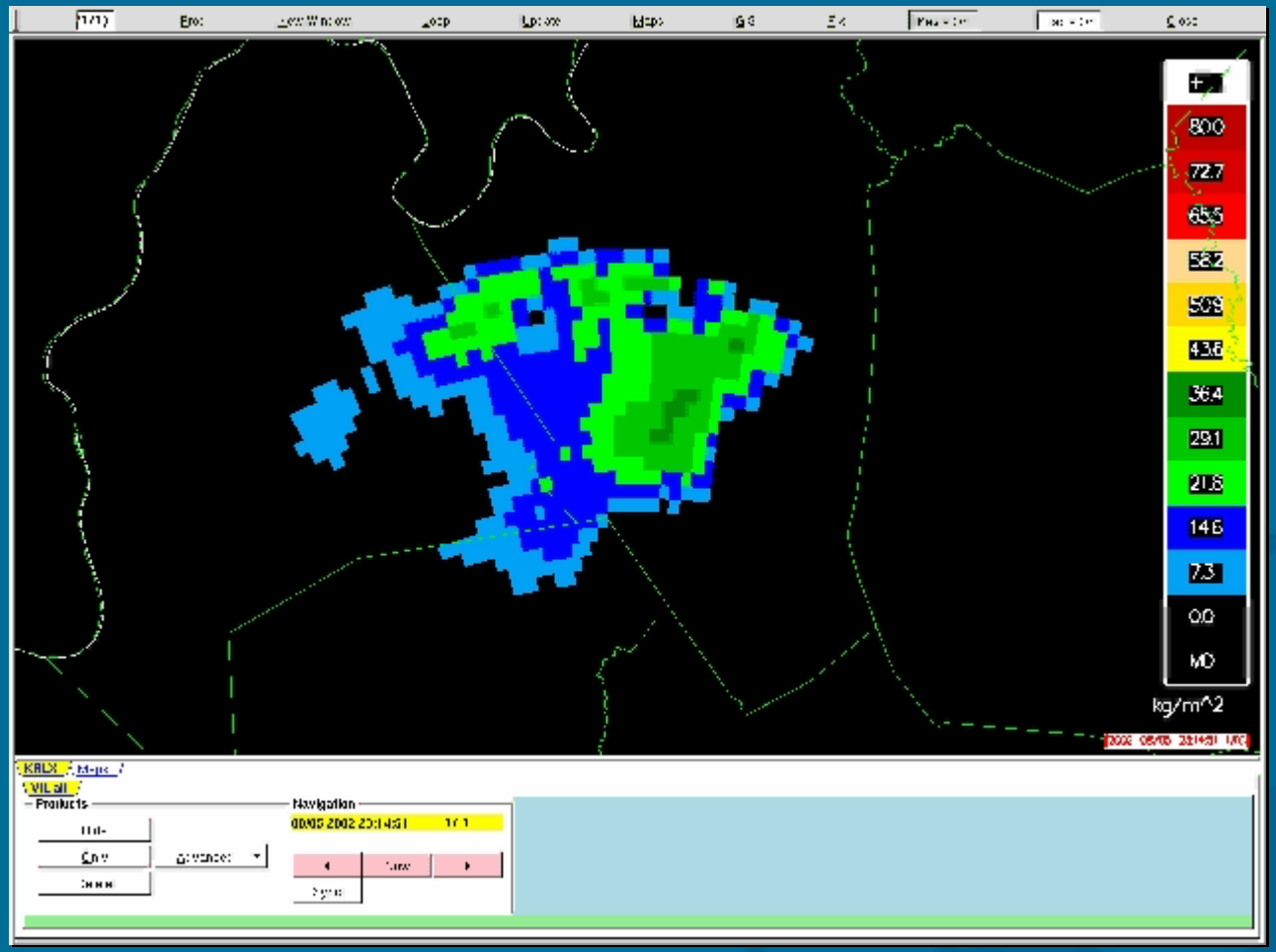
Virtual Volumes

TDWR

31.8	31.8	31.8	31.8	31.8	31.8	31.8	31.8	31.8	31.8	31.8	**31.8**	
24.9	24.9	24.9	24.9	24.9	24.9	24.9	24.9	24.9	24.9	**24.9**	24.9	
0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	**0.3**	0.3	0.3	**31.8**
19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	**19.2**	19.2	19.2	19.2	**24.9**
14.6	14.6	14.6	14.6	14.6	14.6	14.6	**14.6**	14.6	14.6	14.6	14.6	**19.2**
1.0	1.0	1.0	1.0	1.0	1.0	**1.0**	1.0	1.0	1.0	1.0	1.0	**14.6**
0.3	0.3	0.3	0.3	0.3	**0.3**	0.3	0.3	0.3	0.3	0.3	0.3	**11.2**
11.2	11.2	11.2	11.2	**11.2**	11.2	11.2	11.2	11.2	11.2	11.2	11.2	**7.5**
7.5	7.5	7.5	**7.5**	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	**3.8**
3.8	3.8	**3.8**	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	**1.0**
0.6	**0.6**	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	**0.6**
0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	**0.3**

Virtual Volumes

- Digital VIL
  - 10-minute loop
  - Update after each elevation scan



Functional Description

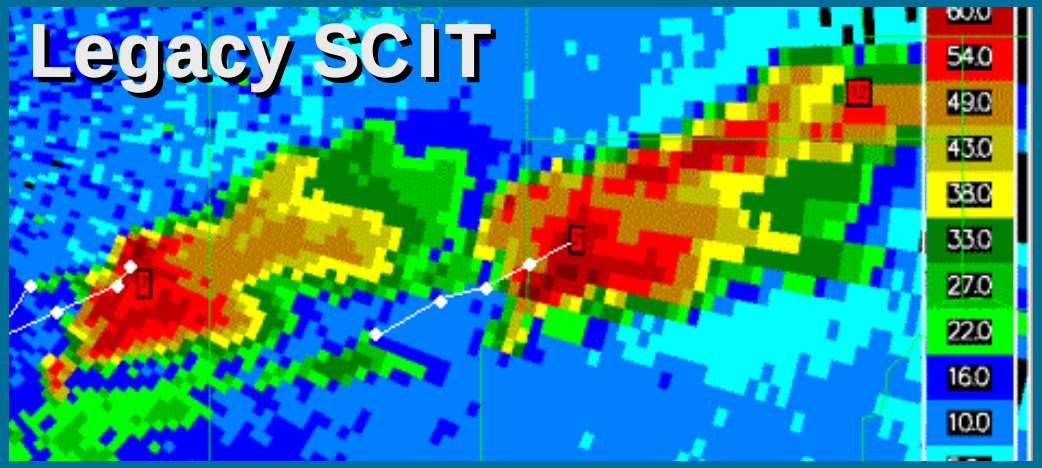
- **2D Feature Collector**
  - Group all 2D feature from current “virtual volume”; sort by elevation angle
    - Special conditions are available for VCP changes and data gaps
- **Position Correction**
  - Combination of background motion field from Near-Storm Environment (NSE) grids (AWIPS input into ORPG), and current storm motion
  - Motion vector of immature cells is weighted more toward the background motion field, and as cells become more mature, the drift motion is weighted more toward the actual storm motion. Once a cell is “fully mature” (e.g., 20 minutes), the actual storm motion is wholly used to drift the 2D features.
  - This method accounts for cells that are moving deviant from the mean wind.
  - Background motion field candidates: Mean 0-6 km (u, v), Bunkers

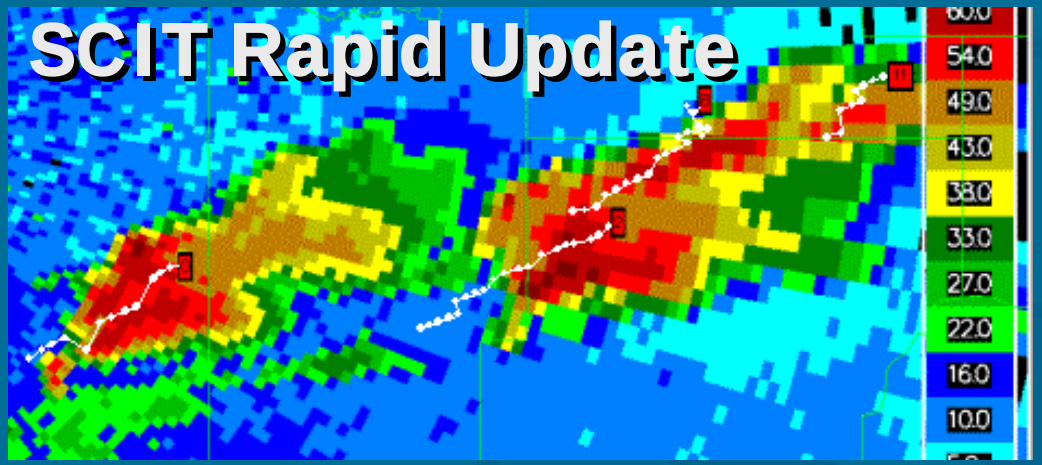
Functional Description

- **Vertical and Time Association**
  - Procedures are identical to current SCIT
  - However, performed after every Elevation Scan
  - Since time association is performed at much smaller intervals, there is less chance of cell tracks being broken.
- **Cell Diagnosis**
  - Also remains identical to current SCIT; cell attributes updated rapidly
  - Hail Detection Algorithm (HDA) would also be updated rapidly

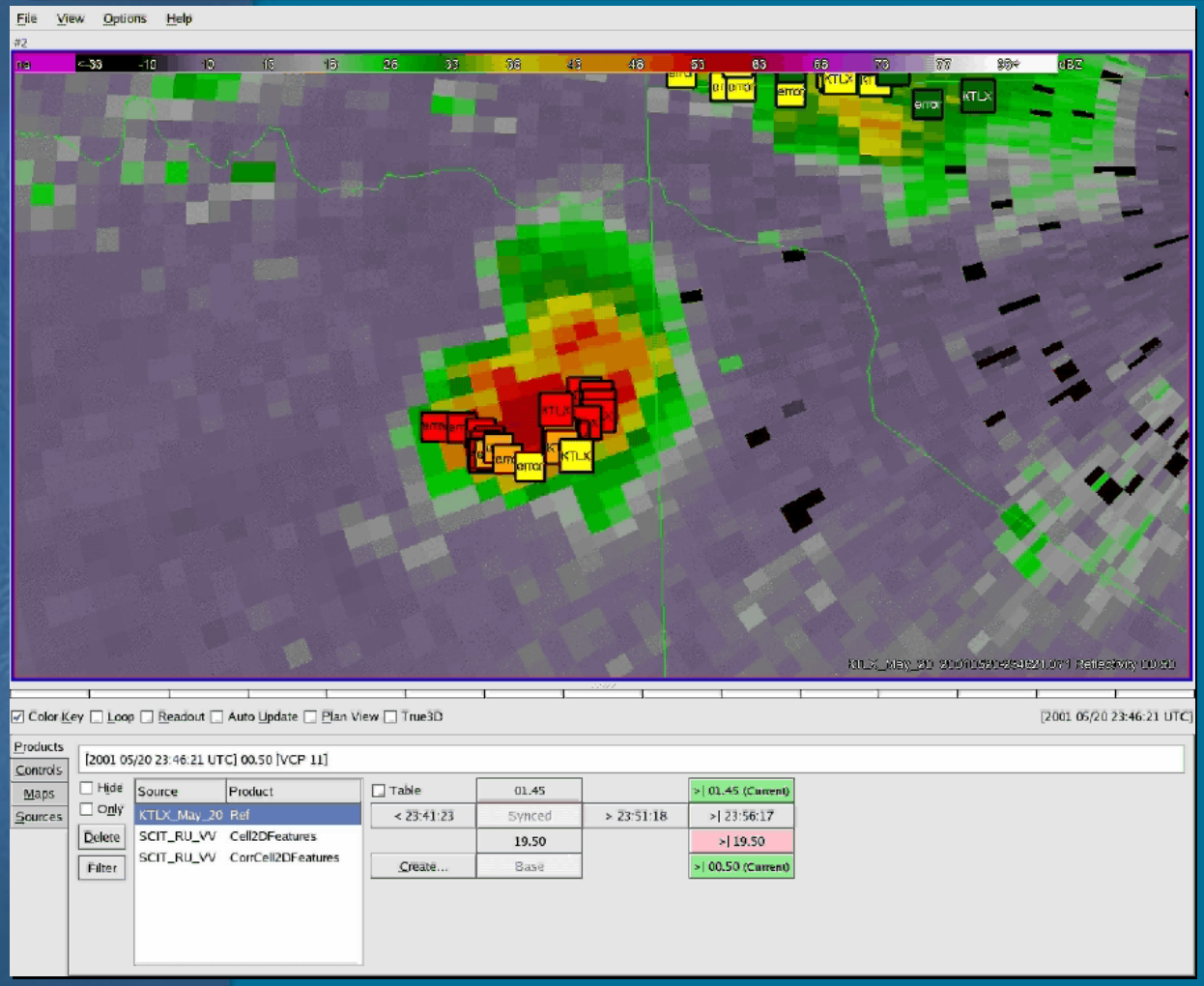
Comparison of Position Updates and Tracks

- 20 May 2001
- Output “Throttled” to every 60 seconds.
- Note that storm position has moved ahead of 0.5 elevation location.



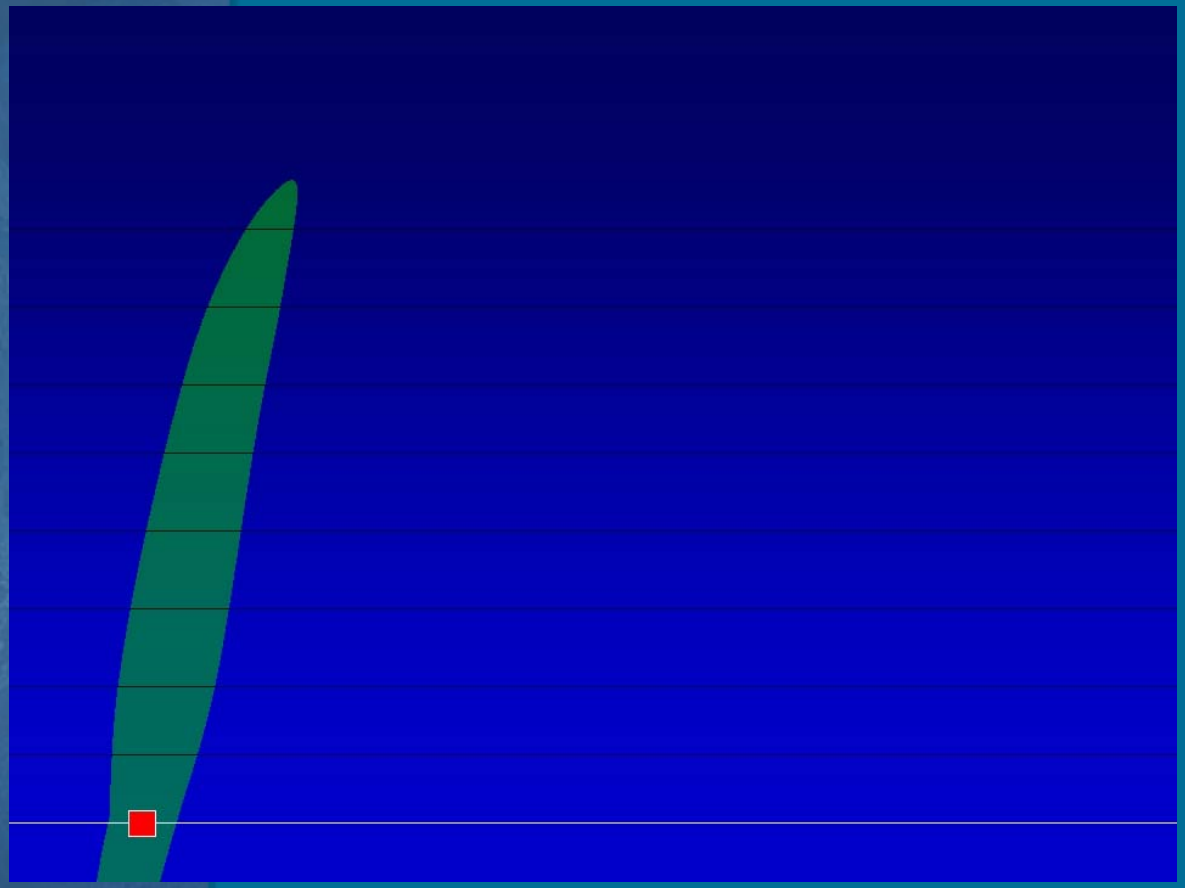


2D Feature Drift Example



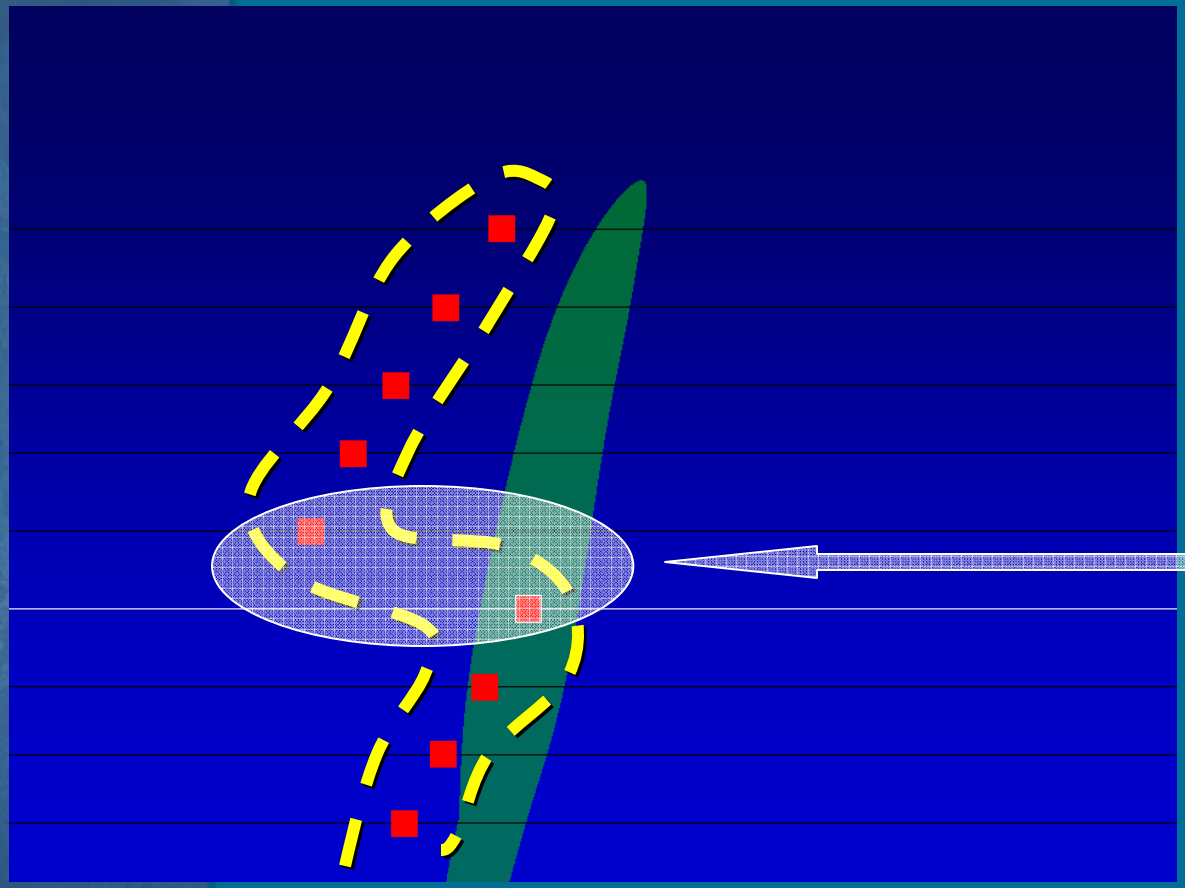
- 20 May 2001
- Plotted in 3D space using WDSSII
- Smaller icons (labeled “error”) are without drift
- Larger icons (labeled “KTLX”) are with drift applied

Vertical X-Section
NO DRIFT CASE



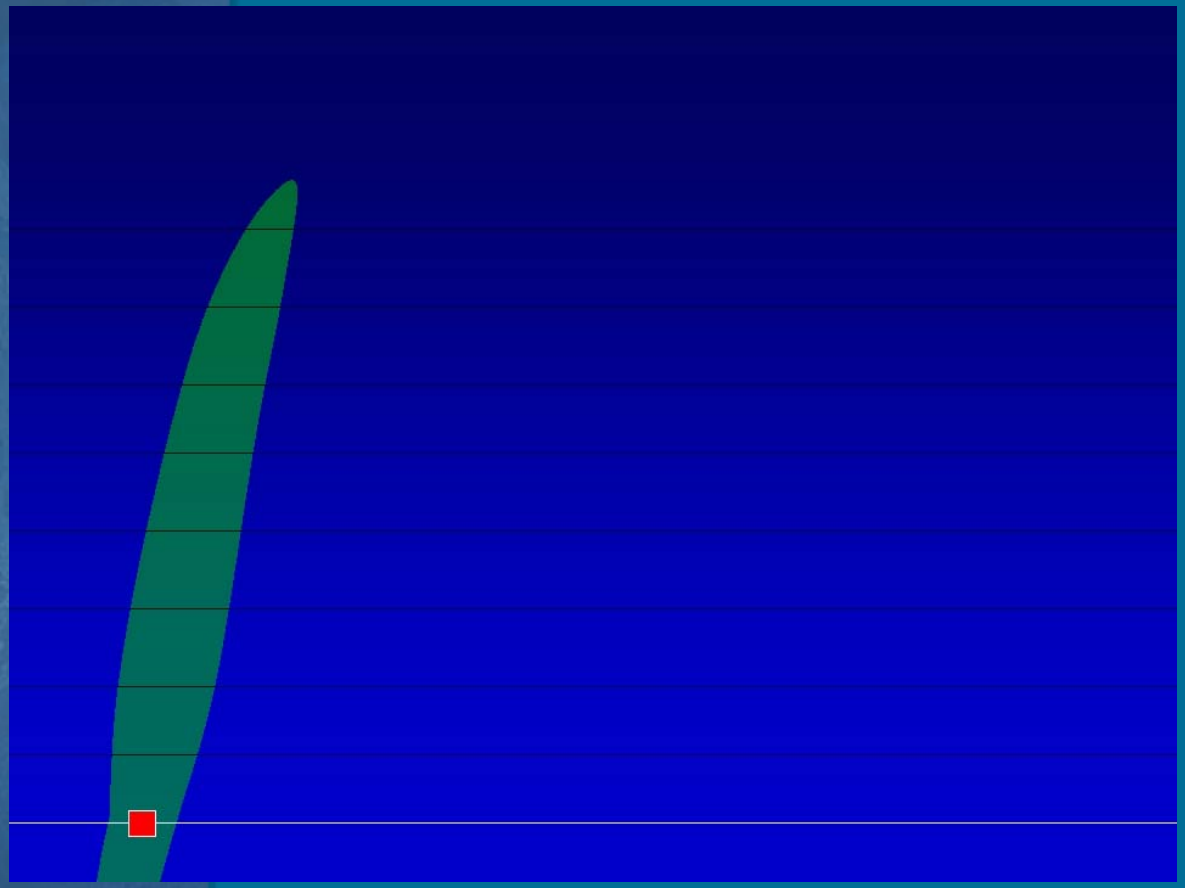
- Green: Hypothetical vertical storm core
- White: Current elevation scan altitude
- Red: 2D feature centroid plotted in vertical

Vertical X-Section
NO DRIFT CASE



- Green: Hypothetical vertical storm core
- White: Current elevation scan altitude
- Red: 2D feature centroid plotted in vertical
- Spatial discontinuity at interface of oldest and newest elevation scans.

Vertical X-Section
DRIFT CASE



- Green: Hypothetical vertical storm core
- White: Current elevation scan altitude
- Faded Red: 2D feature centroid plotted in vertical
- Red: 2D feature location **with drift applied**

Vertical X-Section
DRIFT CASE

- Green: Hypothetical vertical storm core
- White: Current elevation scan altitude
- Faded Red: 2D feature centroid plotted in vertical
- Red: 2D feature location with drift applied
- **More realistic location of vertical storm core**

Concept of Operations

- Virtual Volume output is essentially “live”
  - No more “waiting out” the end of the volume scan
  - Time-height trends will update each time new elevation scan updates
  - Will immediately be able to assess important signatures such as core ascent and descent
    - Important severe weather and downburst signatures can evolve within a volume scan update time.
  - No “new types” of detections (e.g., extrapolated detections), as they all look and behave the same

Recommendation

- MDL recommends continuing the implementation of SCIT Rapid Update Virtual Volume technique for ORPG Build 10.
- Looking for TAC recommendation of:
  - Implementing SCIT Rapid Update as soon as possible, and
  - Use the Virtual Volume concept for SCIT RU, and eventually other applications
    - Natural segue to multiple-radar/sensor applications which only work in a “virtual volume” world

Backup Slides

Comparison to previous technique

	MDA RU (old method)	SCIT RU Virtual Volume
Save 2D features in memory	No	Yes (max 1 MB, 0.3MB in FL)
Save 3D features in memory	Yes (7KB)	No
Vertical association at each elevation scan	Up to the current elevation	Through whole virtual volume
Feature matching	Yes (different logics for the lowest elevation and others)	No
Feature extrapolation	Yes	No
Check if features are topped	Yes	No
Position correction of 2D features using NSE	No	Yes

Comparison to previous technique

- Memory
  - VV takes more memory than RU.
  - But the difference will be less than 1MB
- CPU
  - Both are close
    - MRU/TRU spends CPU on feature matching.
    - VV spends CPU on the position correction
- Implementation
  - VV is relatively easier to implement than MRU/TRU.