EUMETSAT/15TH AMS SATELLITE CONFERENCE

Toward An Objective Enhanced-V Detection Algorithm

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Introduction

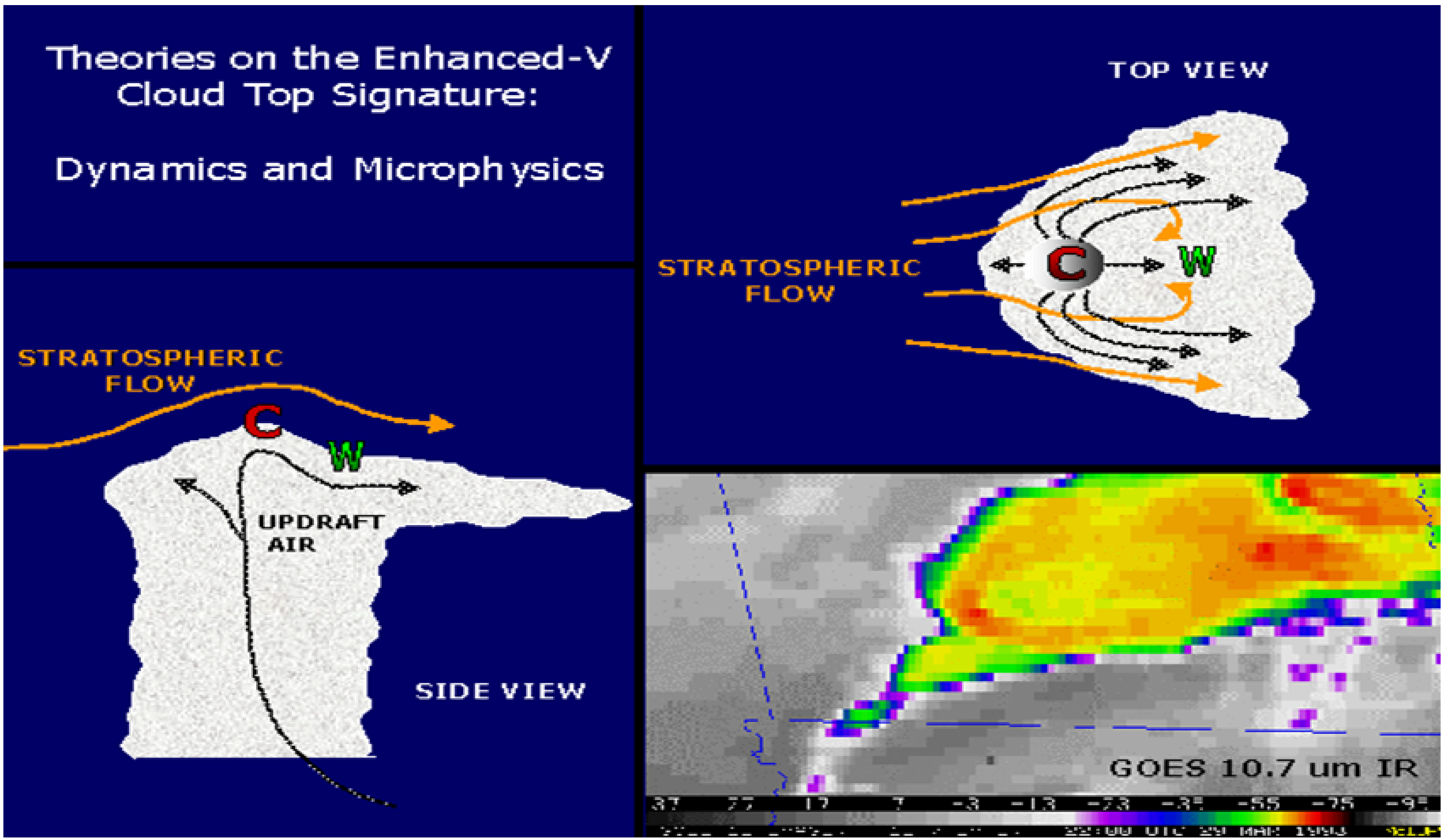
- Many studies have observed and analyzed the enhanced-V feature (McCann 1983; Negri 1982; Heymsfield et al. 1983a, 1983b; Heymsfield and Blackmer 1988; Adler et al. 1985; Brunner et al. 2007)

- Enhanced longwave InfraRed (IR) satellite imagery of deep convection sometimes display this cloud-top V-shaped feature, in which an equivalent blackbody temperature (BT) region of a storm is enclosed by a V-shaped region of colder BT

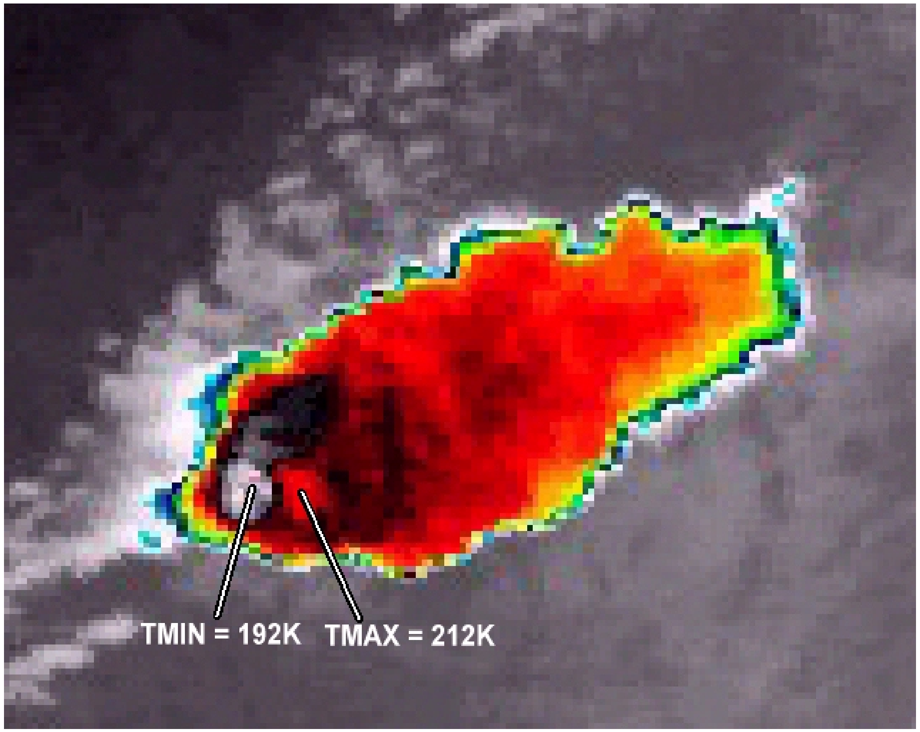
- Enhanced-V important for severe weather warning decision-making because it is associated with severe weather (McCann 1983, Brunner et al. 2007). Presence of enhanced-V features signifies strong tropospheric shear and intense updrafts, both of which are also essential for severe thunderstorms (Heymsfield and Blackmer 1988)

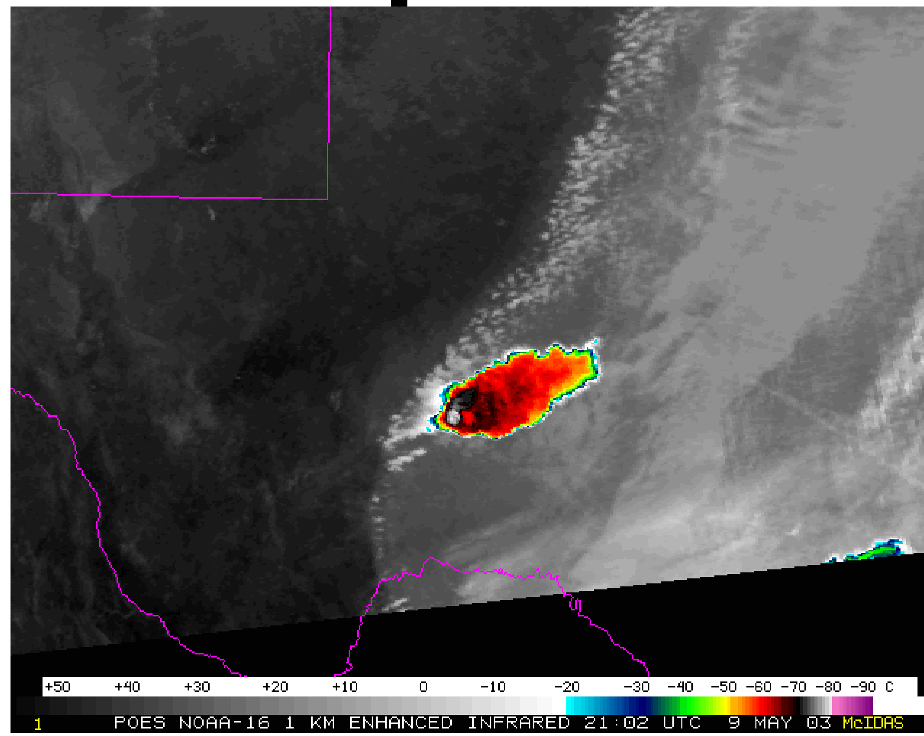
Background of the Enhanced-V

* Enhanced-V develops when a strong updraft penetrates into the lower stratosphere, resulting in an overshooting thunderstorm top



Enhanced-V Quantitative Parameters Description

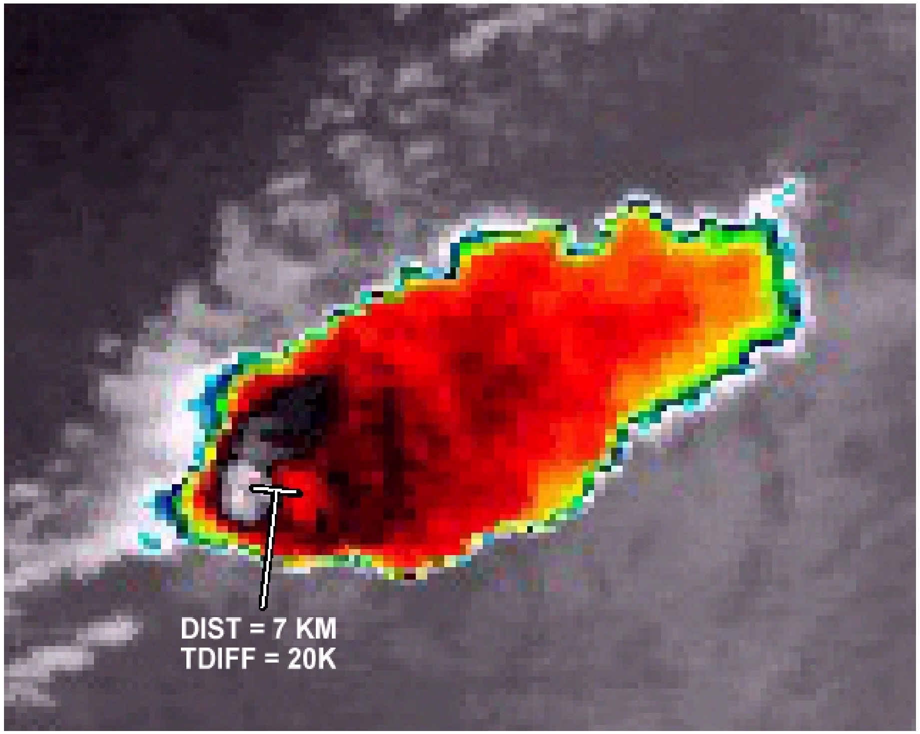


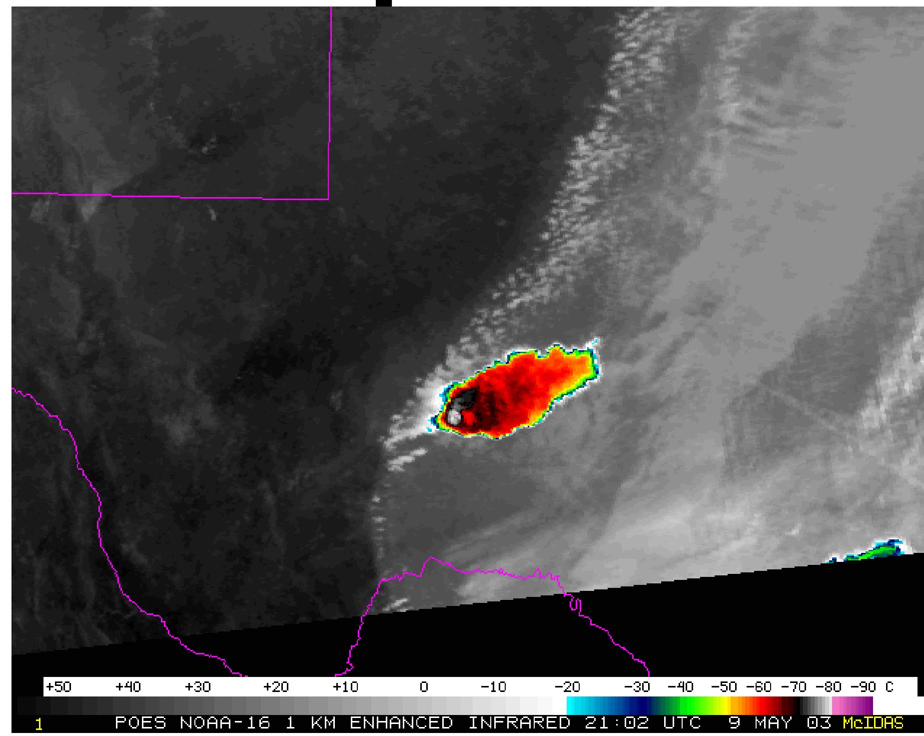


- <u>TMIN</u> - Minimum cloud top BT observed in the overshooting top region

- <u>TMAX</u> – Maximum cloud top BT detected within an embedded warm area downwind of TMIN

Enhanced-V Quantitative Parameters Description





- <u>TDIFF</u> – Difference in cloud top BTs between TMIN and TMAX which forms a cold-warm couplet

- <u>DIST</u> – Distance between TMIN and TMAX

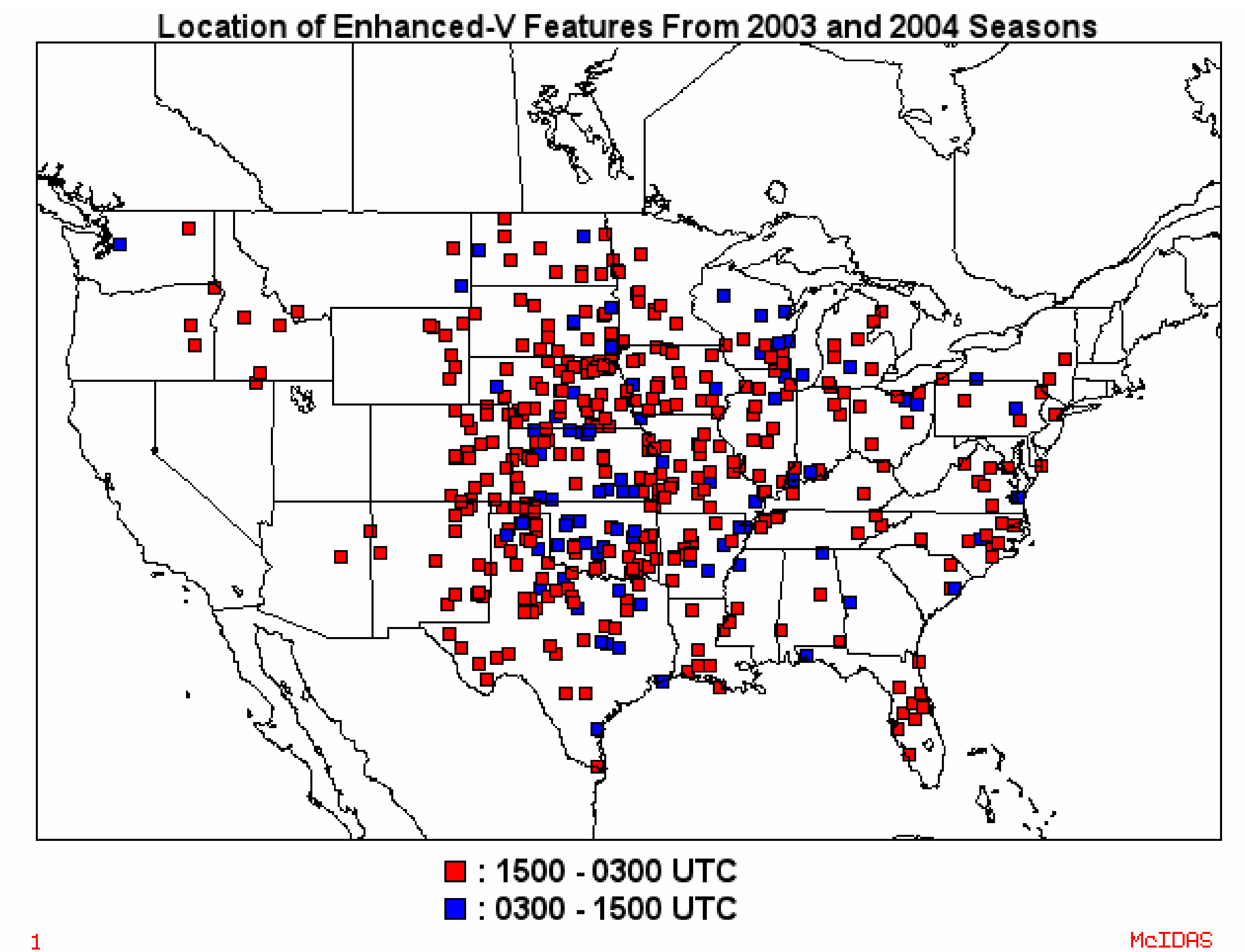
Description of Enhanced-V Datasets

• Two Low Earth Orbit (LEO) satellite datasets that included the 10.7, 10.8, and 11 micron IR channels were obtained over the continental United States for the enhanced-V study

→ 2003 Season: NOAA AVHRR and EOS MODIS AQUA and TERRA overpasses from 4 May 2003 to 5 July 2003 (209 enhanced-V cases)

→ 2004 Season: NOAA AVHRR and EOS MODIS AQUA and TERRA overpasses from 1 May 2004 to 1 July 2004 (241 enhanced-V cases)

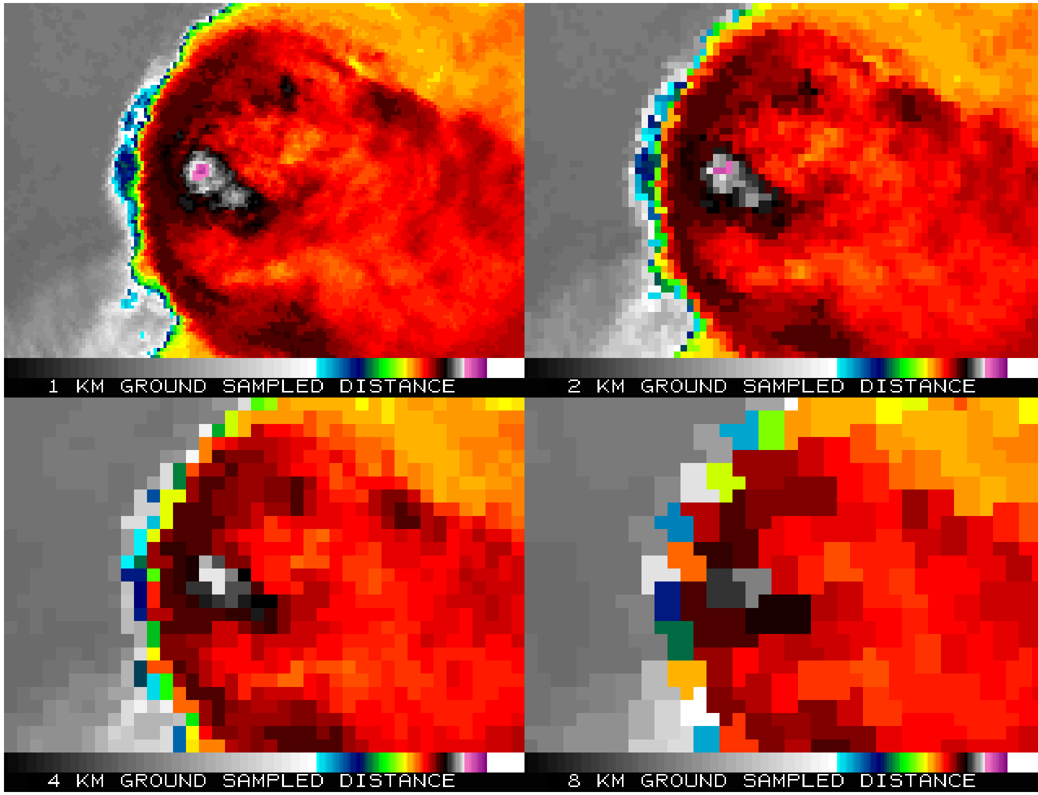
Map of Enhanced-V Cases (450 Total) from 2003 and 2004 Seasons: Geographic and Daytime Versus Nighttime Distributions



Enhanced-V Quantitative Parameters Results

2003 SEASON:	**209 CASES**			
PARAMETER	**MEAN**	**MEDIAN**	**MAXIMUM**	**MINIMUM**
TMIN (K)	201	200	222	184
TMAX (K)	217	217	246	205
TDIFF (K)	16	16	35	5
DIST (km)	11	10	43	3
2004 SEASON:	**241 CASES**			
PARAMETER	**MEAN**	**MEDIAN**	**MAXIMUM**	**MINIMUM**
TMIN (K)	201	201	220	181
TMAX (K)	217	217	232	206
TDIFF (K)	16	15	41	5
DIST (km)	10	9	41	3

Impact of Spatial Resolution on Enhanced-V Temperature Parameters

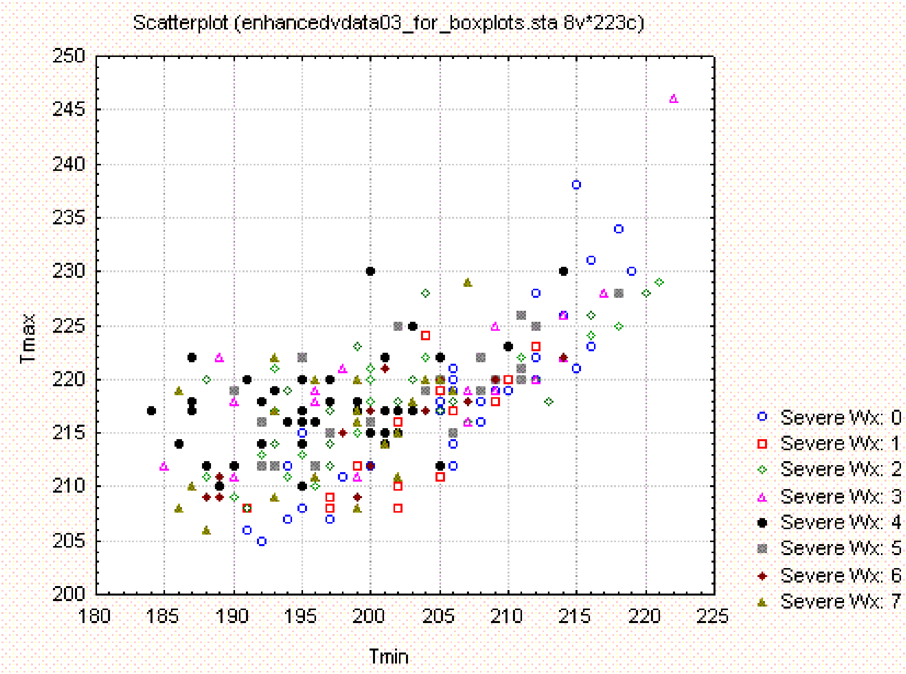


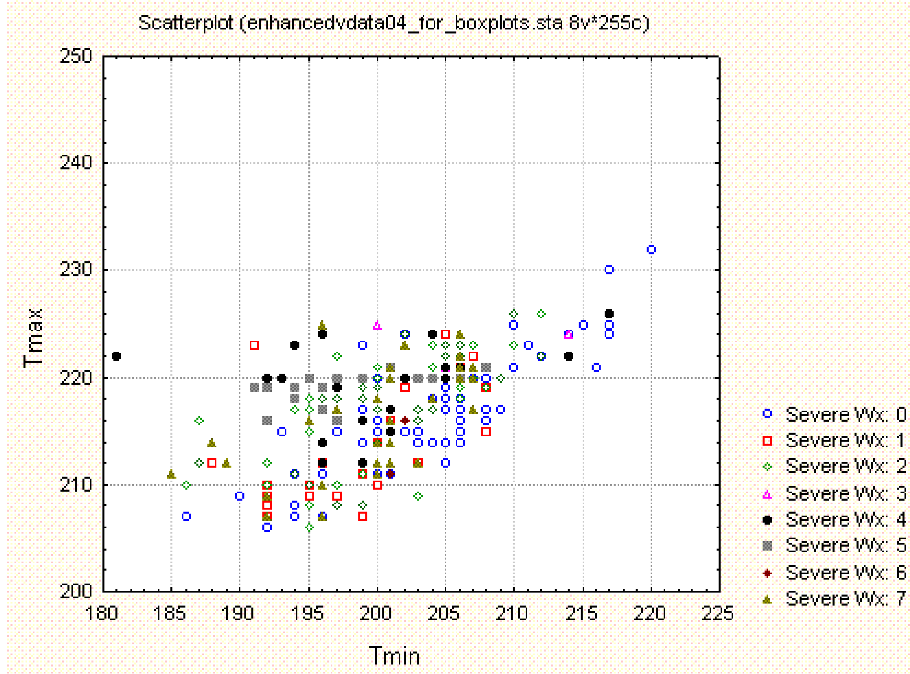
Example MODIS Case Study

	1 km	2 km	4 km	8 km
TMIN	186 K	188 K	193 K	197 K
TMAX	219 K	218 K	216 K	215 K
TDIFF	33 K	30 K	23 K	18 K

- TMIN changes the most (11 K), while TMAX does not change much (only 4 K) when going from finer (1 km) to coarser (8 km) spatial resolution
- TDIFF changed significantly, mainly because of TMIN

2003 and 2004 Seasons TMIN VS TMAX 2D Scatter Plots





- **2-Dimensional scatter plots of TMIN (K) VS TMAX (K) for all enhanced-V cases in the 2003 and 2004 seasons**

- **Each enhanced-V case was assigned to one of eight different categories**

  - Blue circle (category 0) indicates false detection of severe weather

  - All other cases (categories 1-7) indicate severe weather

Table of 2003 and 2004 TMIN VS TMAX 2D Scatter Plot Results (For TMIN < 205 K and TMAX >= 212 K)

Severe Weather Category	2003 Season	2004 Season
Tornado	54/103 (52%)	33/113 (29%)
Hail	82/103 (80%)	95/113 (84%)
Wind	54/103 (52%)	54/113 (48%)
Any of three severe types	99/103 (96%)	99/113 (88%)

Flow Chart for Overshooting Top/Temperature Couplet Algorithm

Thresholds for MODIS Cases

INPUT

- ❖BT(6.7)
- ❖BT(11)
- ❖Upper Left Image Line/Elem

OUTPUT

- ❖ Cold Pixel Latitude/Longitude Location and Value
- ❖ Warm Pixel Latitude/Longitude Location and Value
- ❖ Temperature Couplet Value
- ❖ Temperature Couplet Orientation

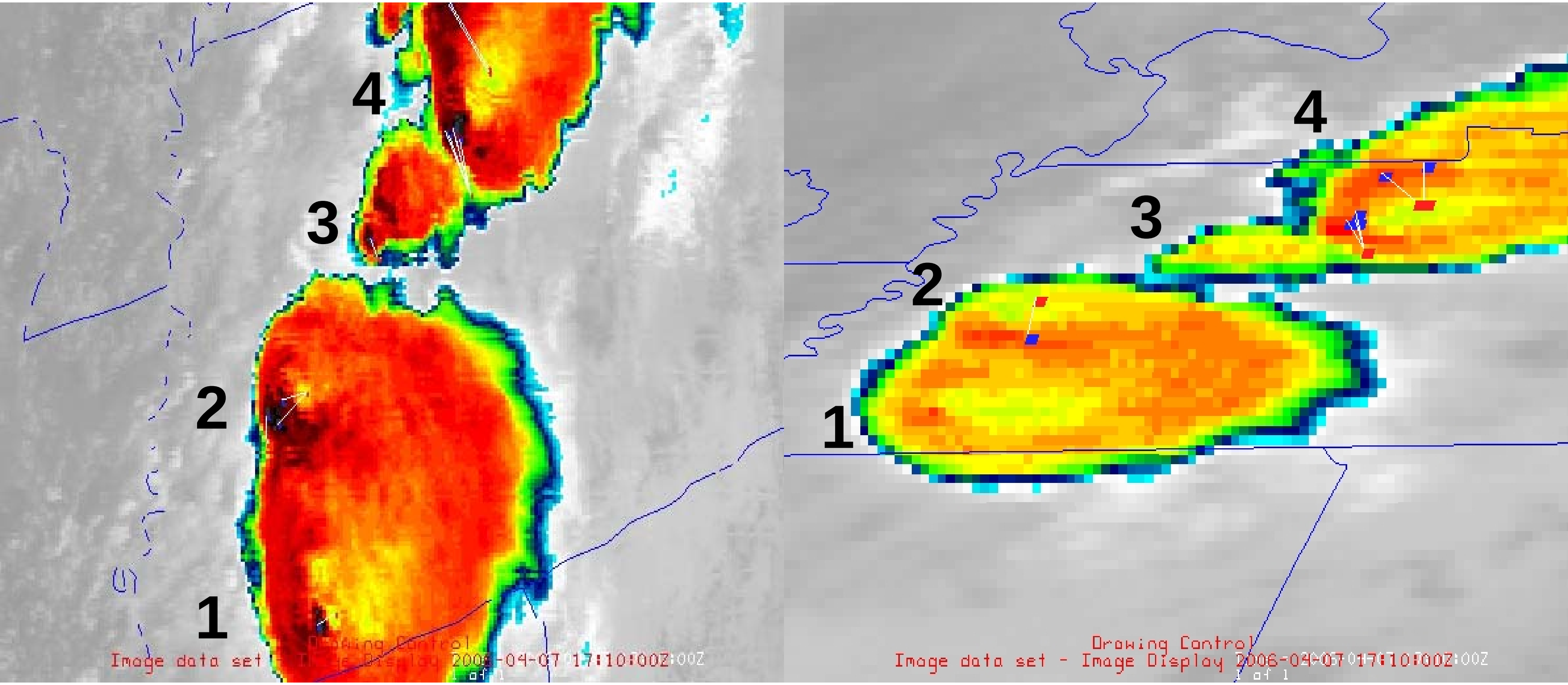
STEP 1

Overshooting Top Algorithm
To Isolate
Overshooting Top Pixels;
[BT(6.7) – BT(11) ≥ 6K]

STEP 2

Temperature Couplet Algorithm
For Each Identified Overshooting Top Pixel;
Distance And Temperature/Temperature Difference Threshold Checks Performed):
***** Distance ≤ 20km
***** BT(11) Difference ≥ 15K And ≤ 35K
***** BT(6.7) – BT(11) ≥ 0K Of Potential Warm Pixel
***** BT(11) ≤ 205K Of Cold Pixel
***** Warm pixel location has to be in eastern 180 degree quadrant compared to cold pixel location
* Additionally, Magnitude And Angle Orientation Of Detected Temperature Couplet Is Calculated.

CASE 1: 7 APRIL 2006 1710 UTC MODIS AND GOES OVER TENNESSEE



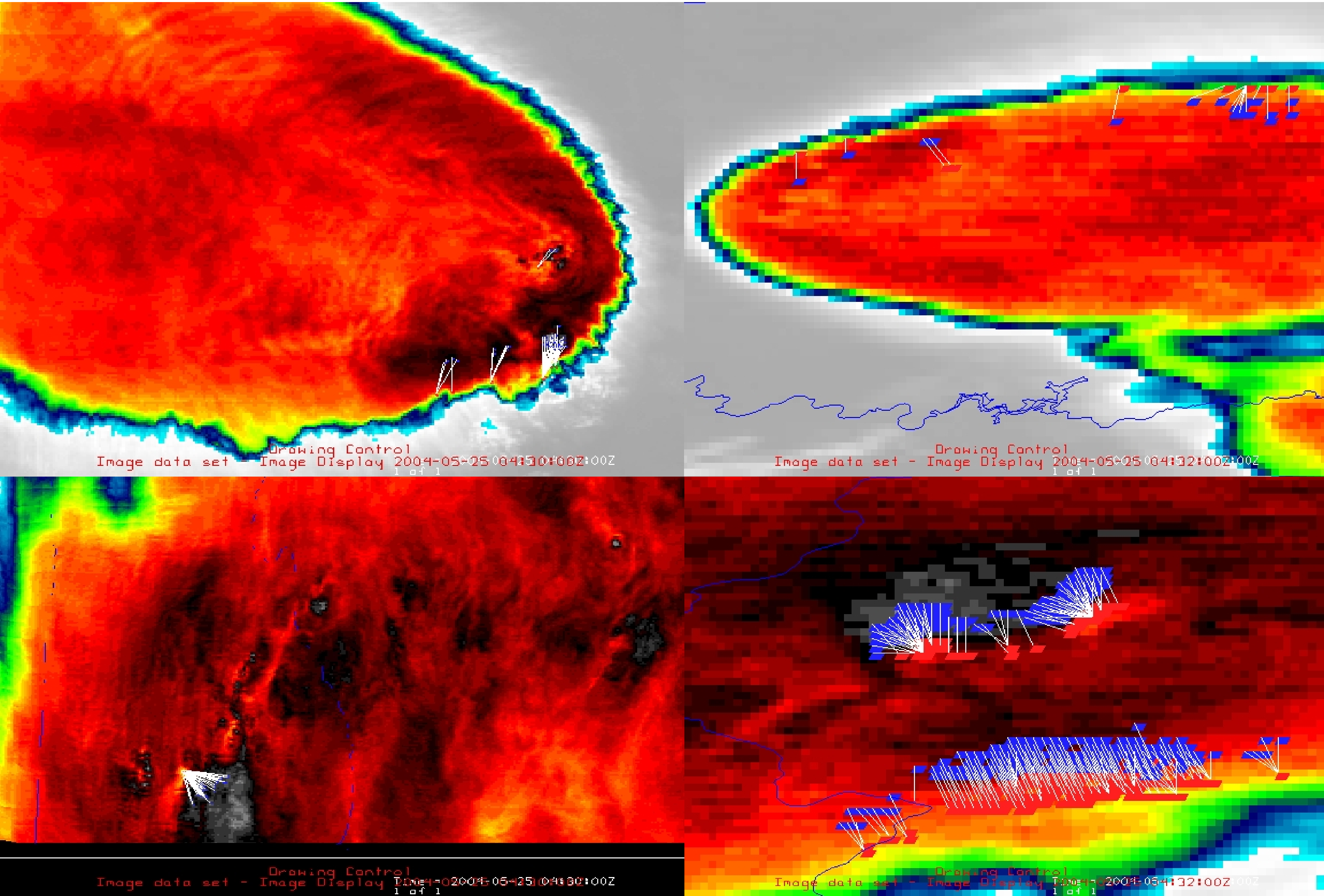
MODIS THRESHOLDS:

* BT(6.7) – BT(11) ≥ 6K Of Overshooting Pixel
* BT(11) ≤ 205K Of Cold Pixel
* BT(11) Difference ≥ 15K And ≤ 35K
* BT(6.7) – BT(11) ≥ 0K Of Warm Pixel
* Distance ≤ 20 km

GOES THRESHOLDS:

* BT(6.5) – BT(10.7) ≥ 0K Of Overshooting Pixel
* BT(10.7) ≤ 215K Of Cold Pixel
* BT(10.7) Difference ≥ 6K And ≤ 25K
* BT(6.5) – BT(10.7) ≥ -2K Of Warm Pixel
* Distance ≤ 20 km

CASE 2: 25 MAY 2004 0430 UTC MODIS/0432 UTC GOES OVER OKLAHOMA AND ILLINOIS



Flow Chart For Next Step: Enhanced-V Algorithm

INPUT

- BT(6.7)
- BT(11)
- Upper Left Image Line/Elem

STEP 1

Overshooting Top Algorithm

STEP 2

Temperature Couplet Algorithm

STEP 3

Enhanced-V Cross-Correlation Algorithm
Search For Enhanced-V Features Around Temperature Couplet Regions:

- Orient Enhanced-V Fabricated Matrix In Direction Of Temperature Couplet Angle Orientation
- Search 50x50 Pixel Box Around Overshooting Top Pixel Location Associated With Temperature Couplet

OUTPUT

- Latitude/Longitude Location of Enhanced-V
- Ranking of Enhanced-V

Future Work

• Revise overshooting top/temperature couplet algorithm to minimize false detection of temperature couplets and to detect more temperature couplets

• Develop enhanced-V cross-correlation algorithm by searching in the region of temperature couplets for correlations between the enhanced-V and the enhanced-V fabricated matrix

• Test overshooting top/temperature couplet/enhanced-V algorithm on several years of cases

• Main goal is for algorithm to be useful for operations with future sensors, such as GOES-R