# Applications of High-Resolution Wind Estimates in Storms from 1-Minute GOES-16 Imagery Using an Optical Flow Technique.

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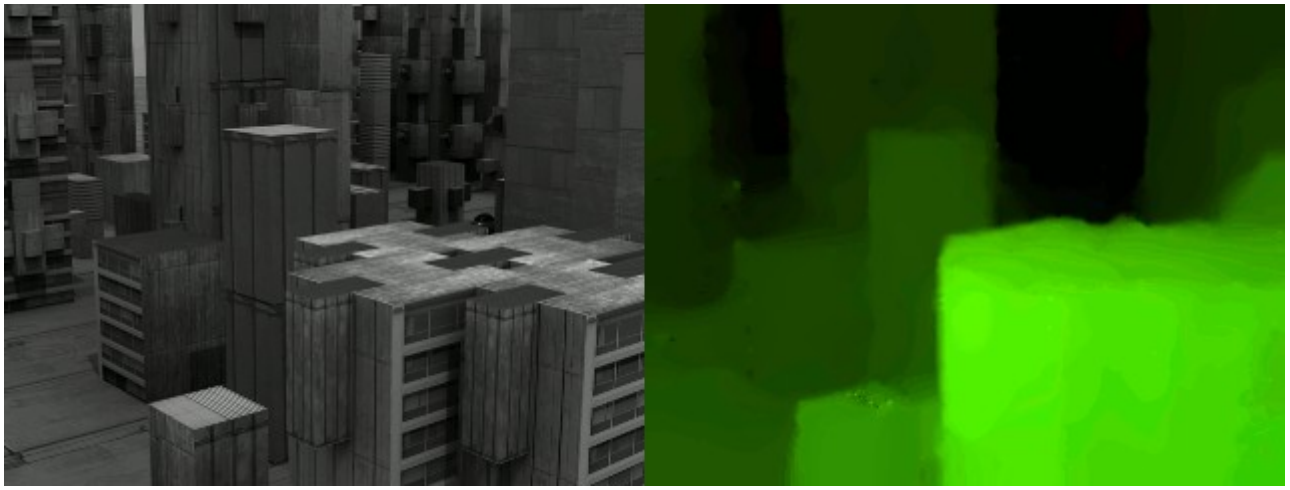
# *Dense* Optical Flow: What is it?

**Dense optical flow compares two images to estimate the apparent motion of each pixel in the one of the images.**



**Colorized optical flow. Color is direction and intensity is magnitude.**

# High Accuracy Optical Flow Estimation Based on a Theory for Warping

*T. Brox, A. Bruhn, Nils Papenberg, J. Weickert*
*Saarland University , Saarbrucken, Germany*

*Proc. 8th European Conference on Computer Vision, Prague CR, 2004*

-Variational Model

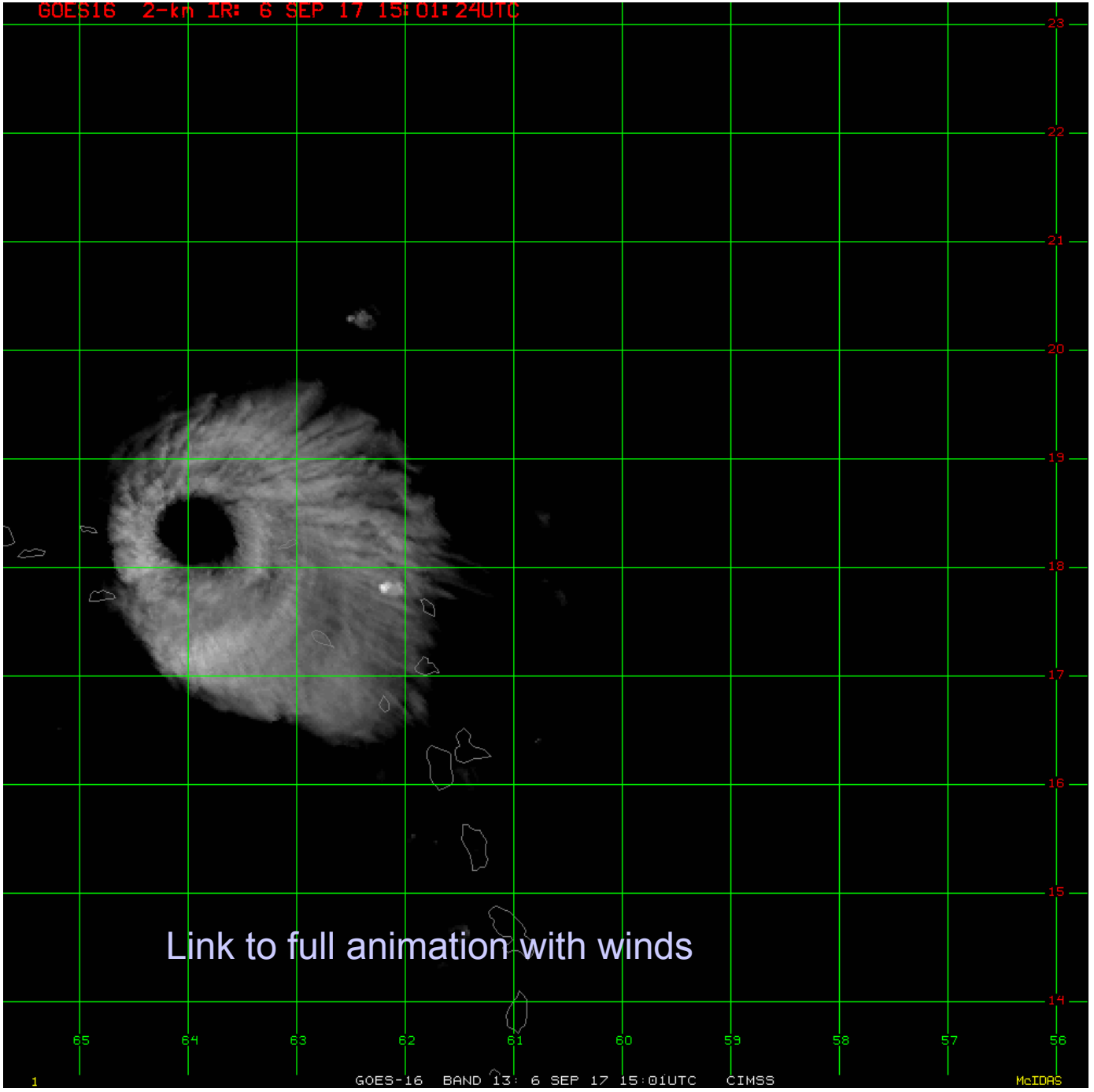
-Assumptions:
- Grey value constancy
- Gradient constancy
- Smoothness

-Multiscale approach (allows for large displacements)

-Small angular errors
-Insensitive to parameter variations
-Excellent robustness under noise
-Computationally Efficient

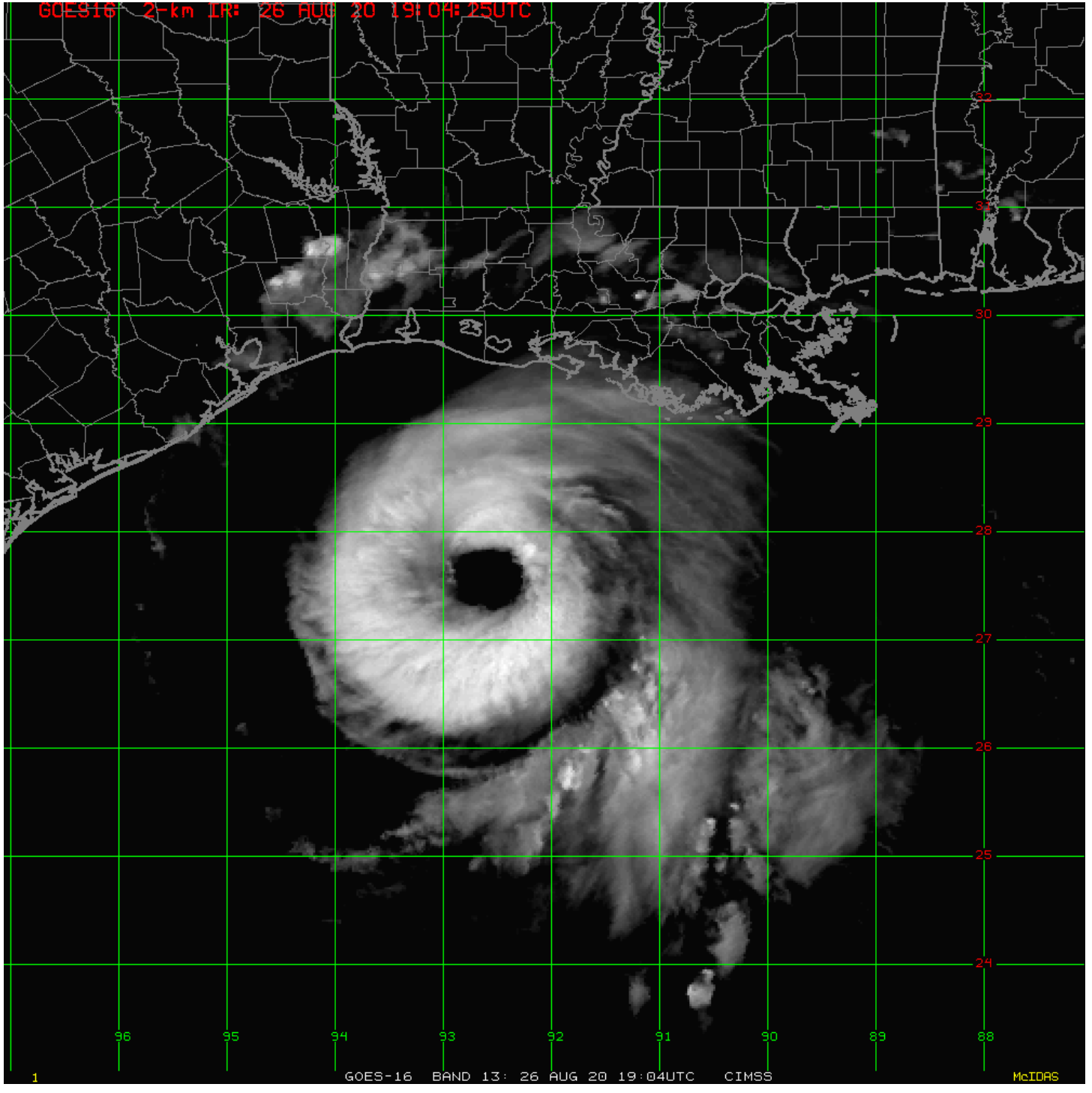
# Hurricane Irma

## "Super enhanced" IR (ABI band 13): 06 Sep 17: 1501-1515 UTC

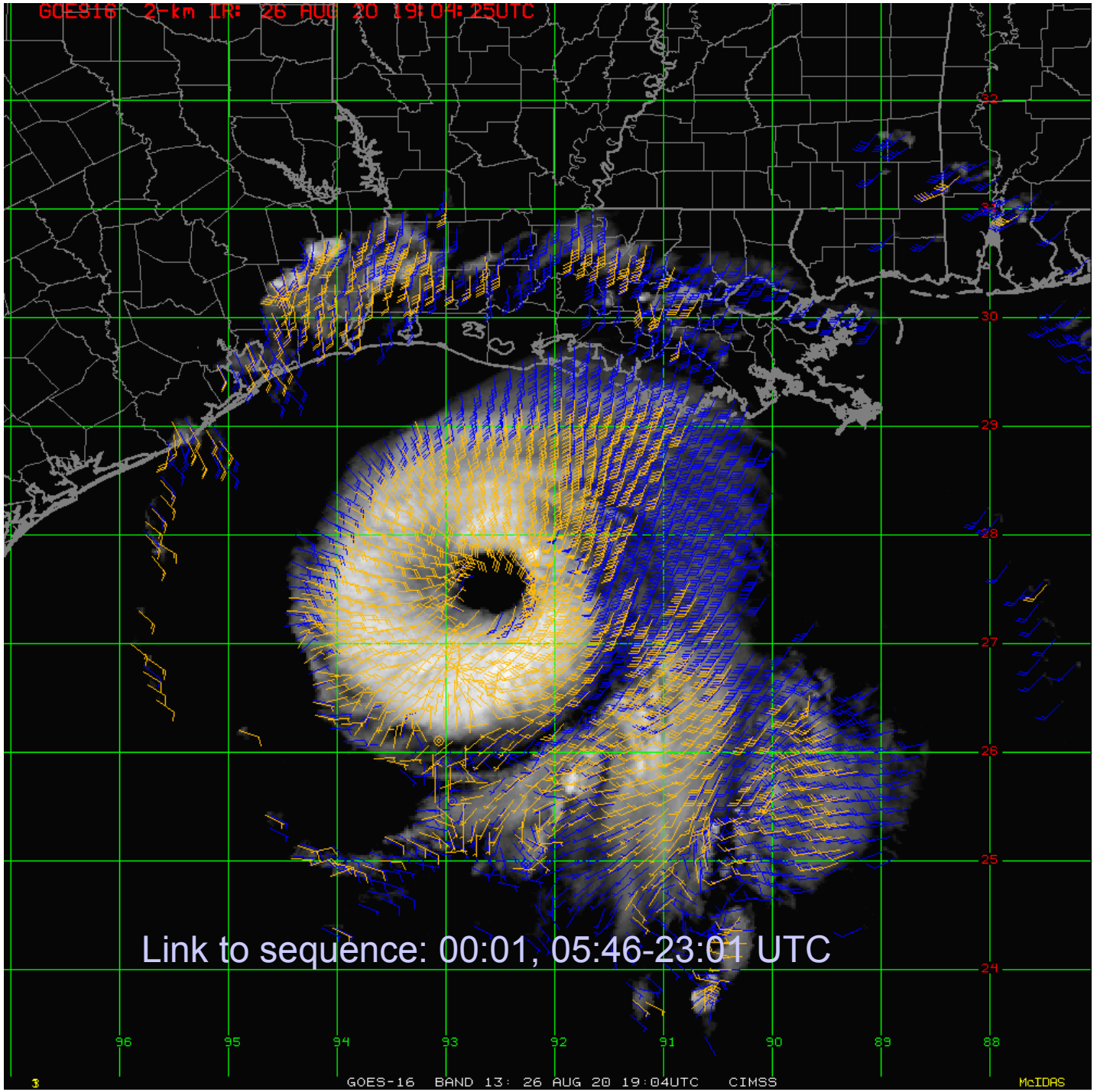


# Hurricane Laura

## “Super enhanced” IR (ABI band 13): 26 Aug 20: 19:04 UTC

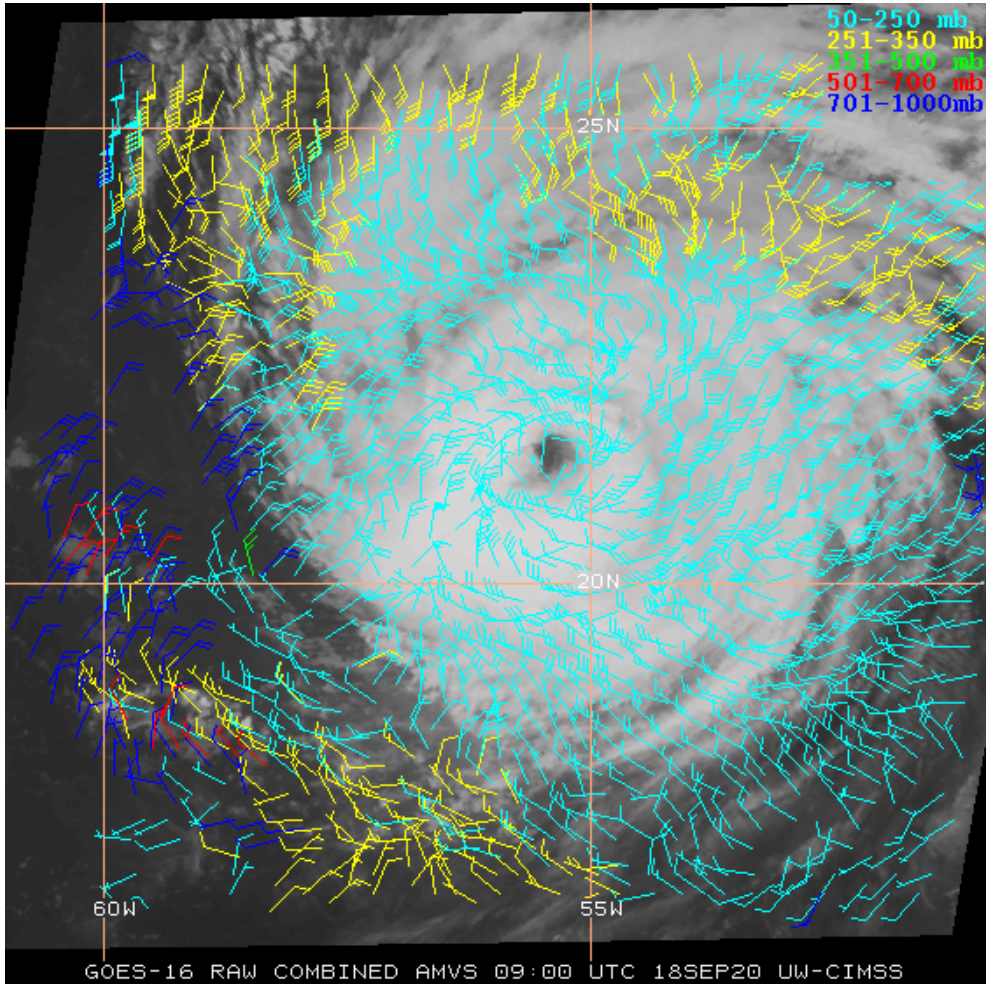


# Hurricane Laura
# Super enhanced" IR (ABI band 13): 26 Aug 20: 19:04 UTC

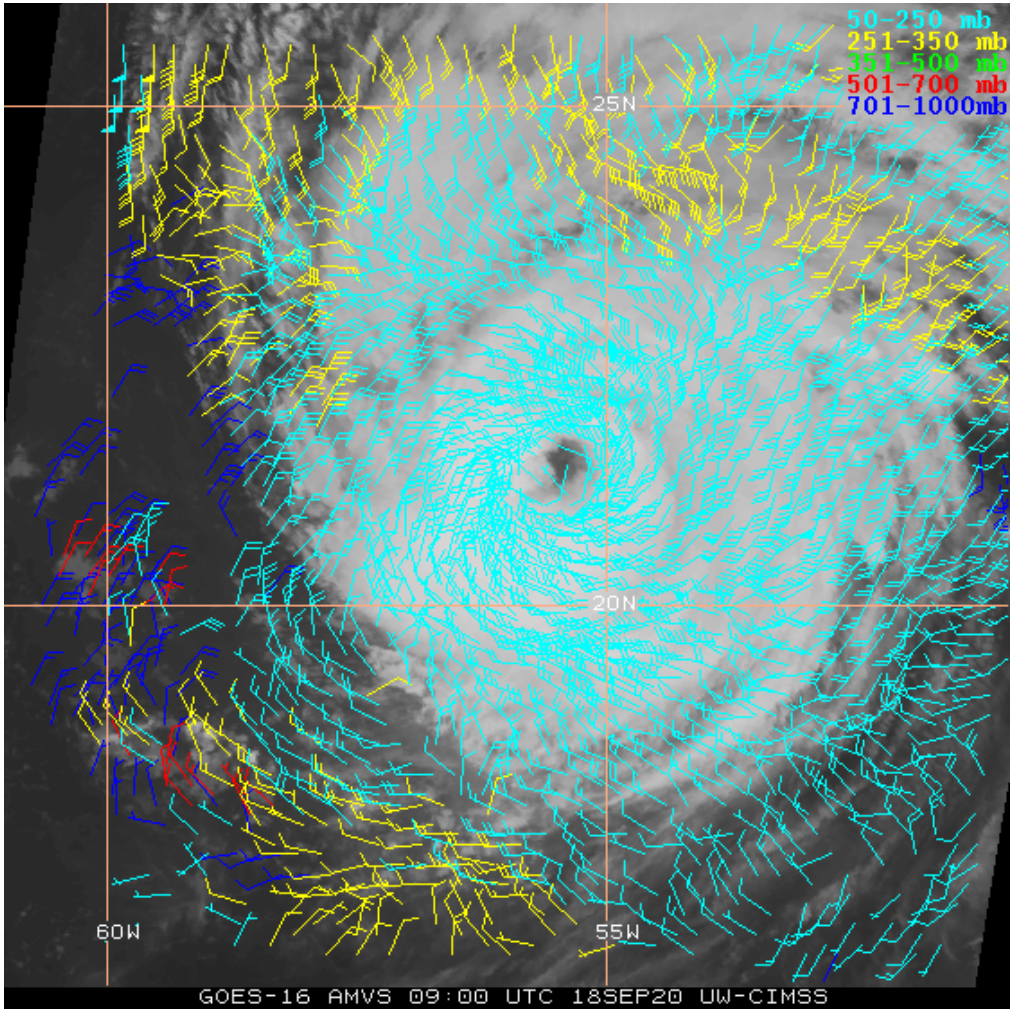


# Combined Optical Flow and AMV

# Hurricane Teddy
# 18 Sep 20 09:00 UTC

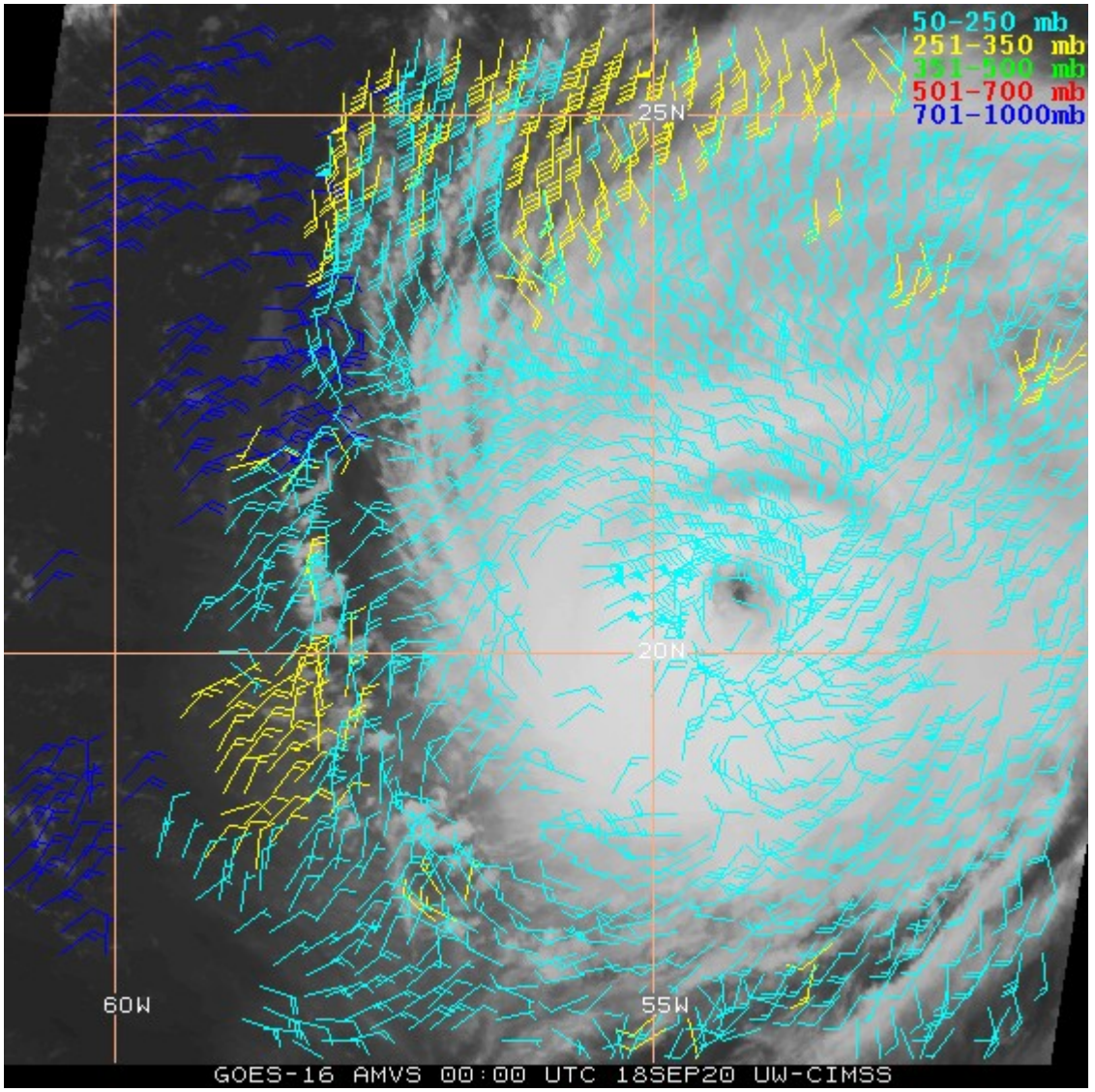



**AMV only**

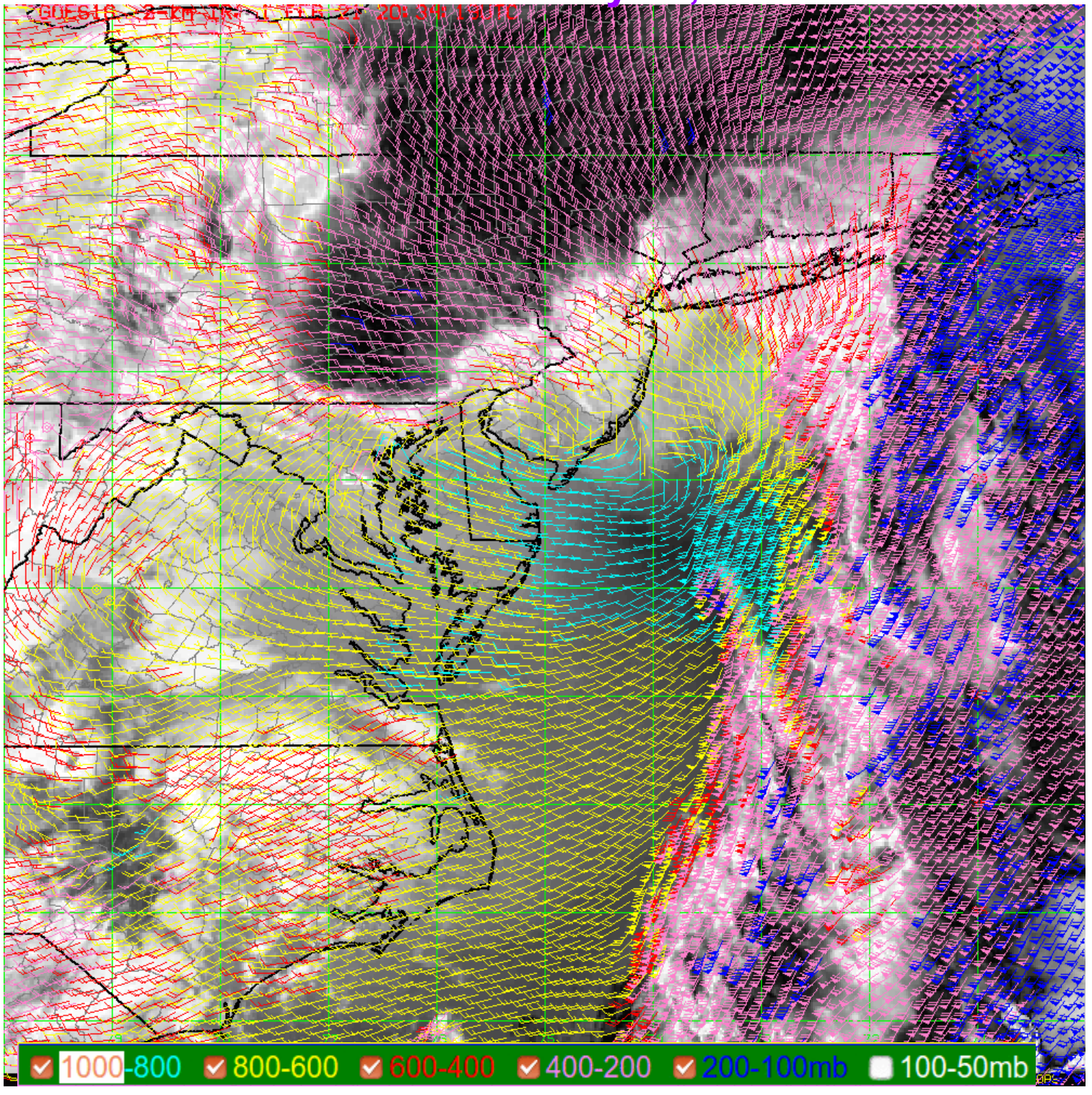



**AMV + Optical Flow**

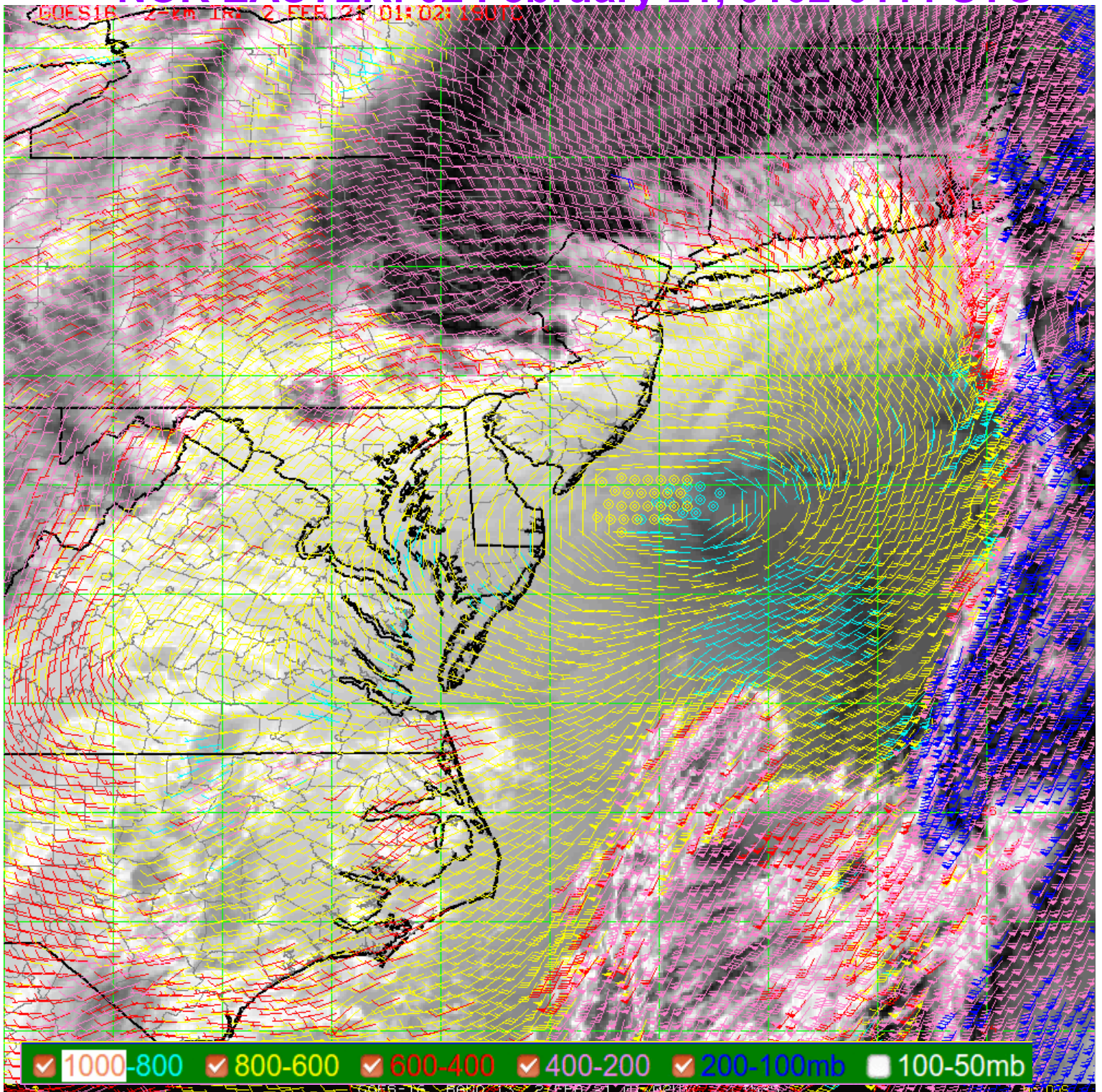
# Hurricane Teddy:
# 18 Sep20 00:00-23:45 UTC



# NOR'EASTER: 01 February 21, 2034-2046 UTC



# NOR'EASTER: 02 February 21, 0102-0114 UTC



# Lawrence, KS 28 May 2019

## Tornadoes

### Tornado - Douglas/Leavenworth County

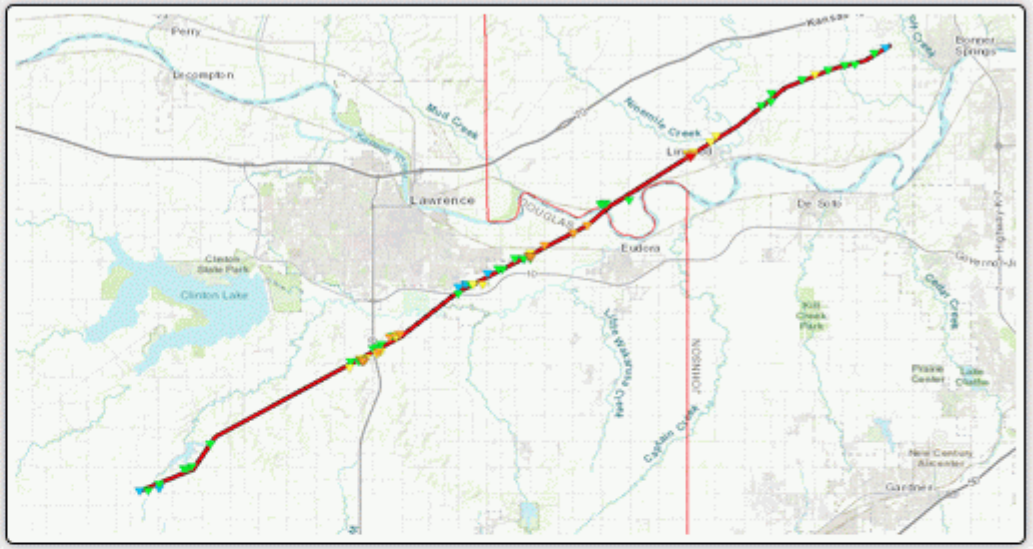
Douglas and Leavenworth Counties

| | |
|---|---|
| **Date** | 28 May 2019 |
| **Time (Local)** | 06:05 PM CDT |
| **EF Rating** | EF - 4 |
| **Est. Peak Winds** | 170 MPH |
| **Path Length** | 31.82 Miles |
| **Max Width** | 1 mile |
| **Injuries/Deaths** | 18 injuries; 0 fatalities |

**Summary:**

The tornado developed in southwestern Douglas county Kansas and tracked to the east-northeast while strengthening. EF-3 damage occurred in northeastern Douglas county, then the storm gained strength and produced EF-4 damage in southern Leavenworth county Kansas.

**Track Map**

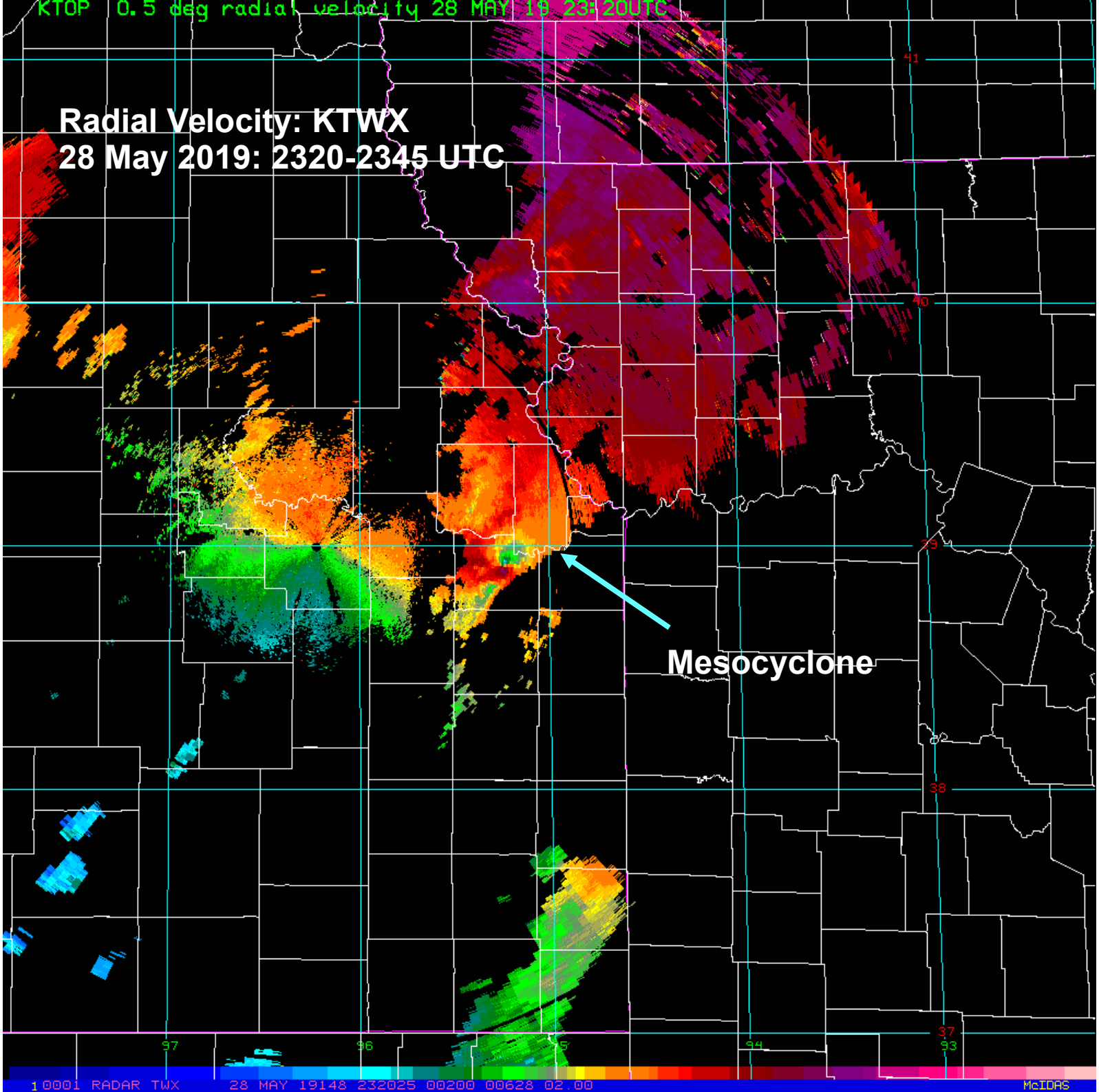


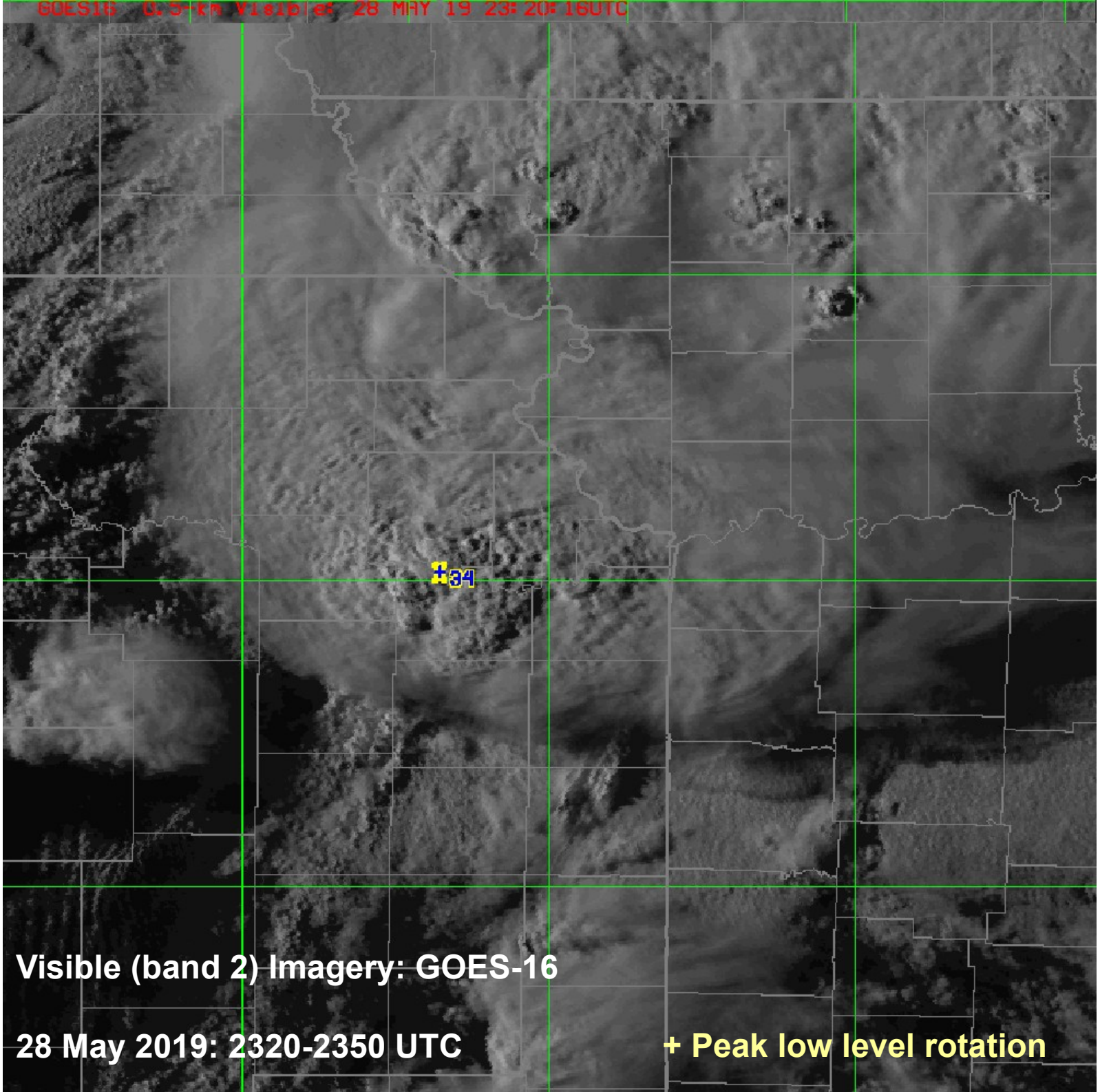

EF0 EF1 EF2 EF3 EF4 EF5 TSTM UKN

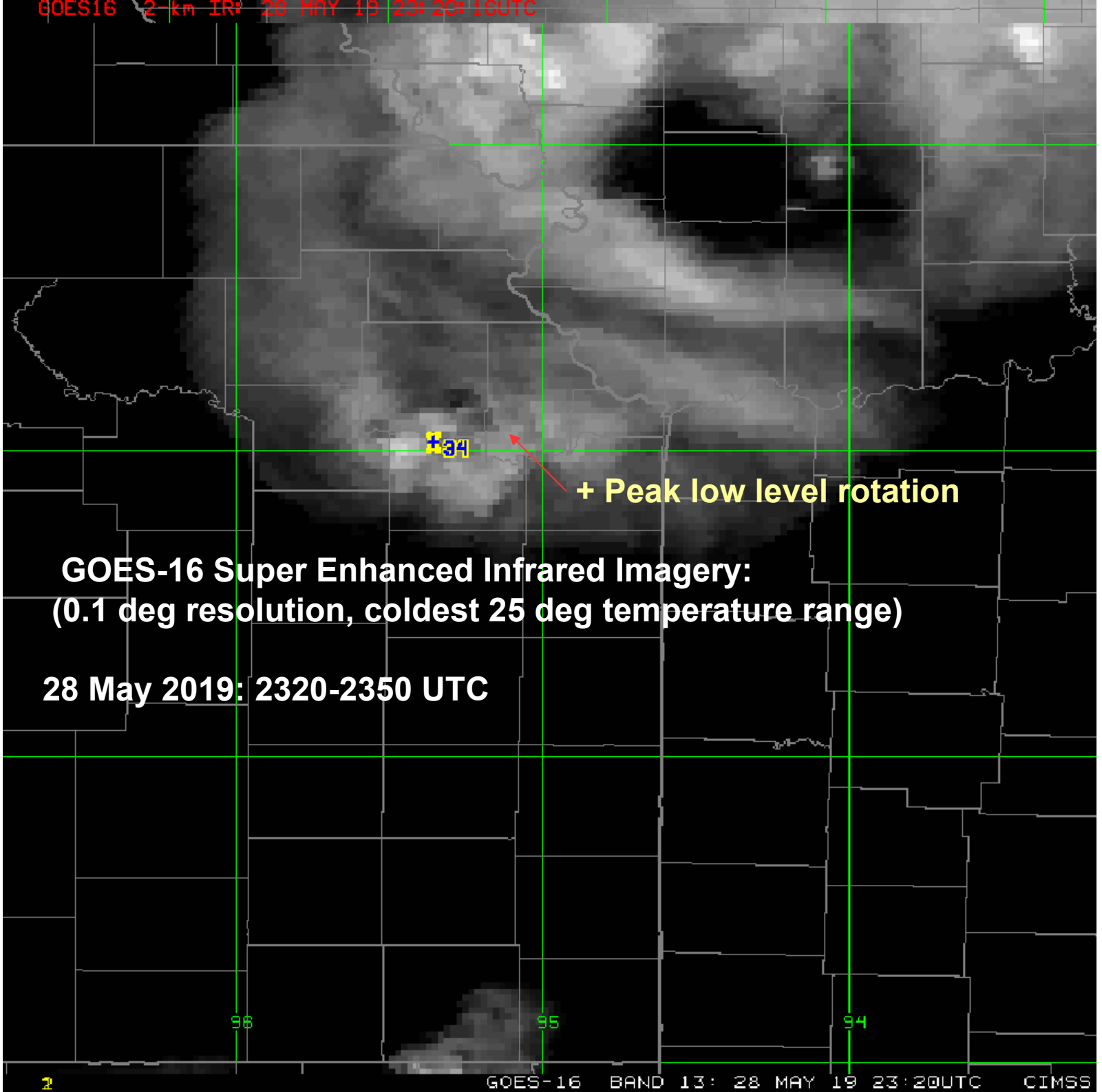
Downloadable KMZ File

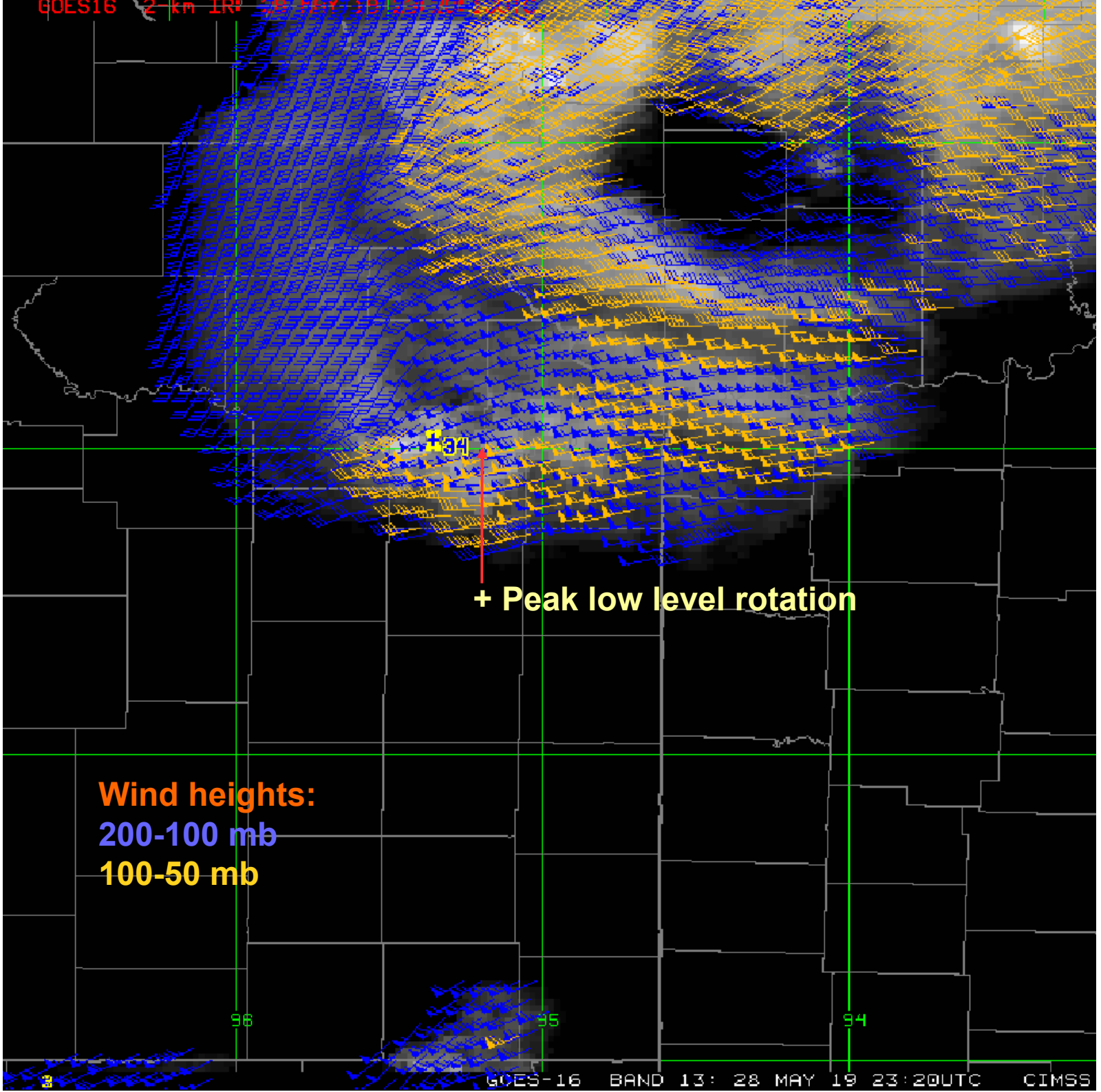
EF-4 damage to a home near Linwood, KS (NWS Survey).

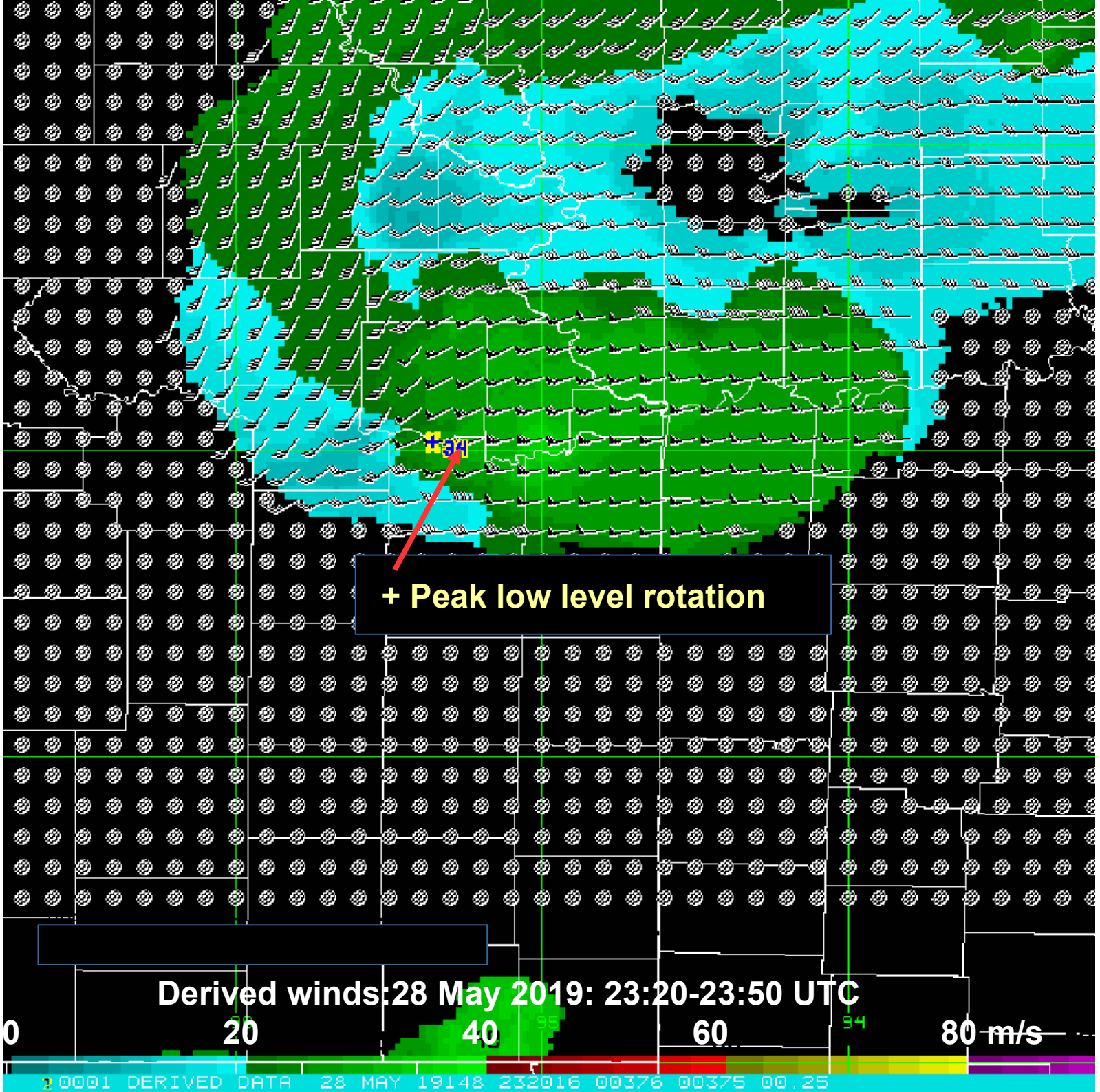
EF-3 damage to a home near Linwood, KS (NWS Survey).


KTOP 0.5 deg radial velocity 28 MAY 19 23:20UTC
Radial Velocity: KTWX
28 May 2019: 2320-2345 UTC
Mesocyclone
41
40
39
38
37
97
96
95
94
93
1 0001 RADAR TWX 28 MAY 19148 232025 00200 00628 02.00
McIDAS

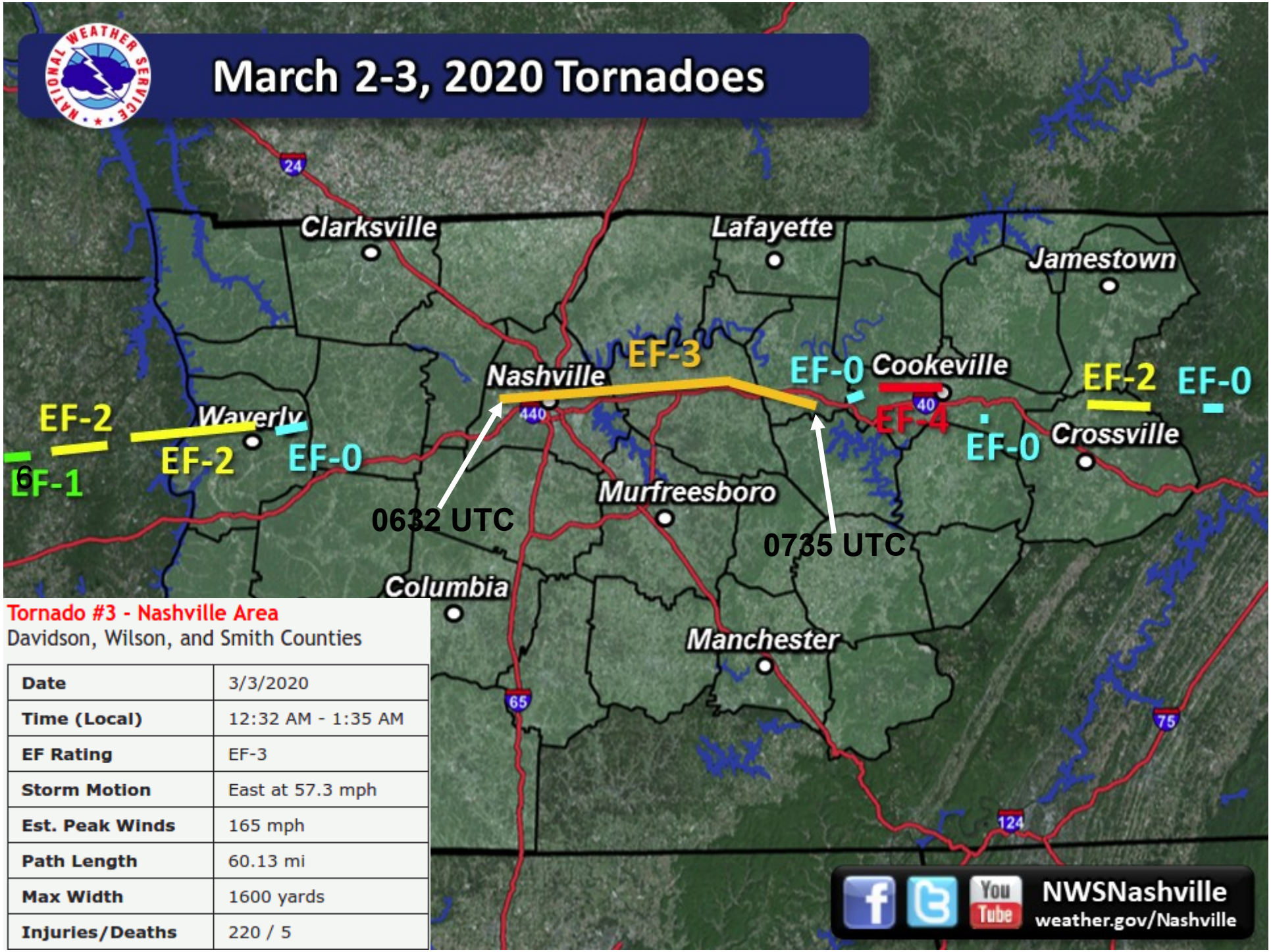

GOES16 0.5 km Visible 28 MAY 19 2320 16UTC
34
Visible (band 2) Imagery: GOES-16
28 May 2019: 2320-2350 UTC
+ Peak low level rotation


GOES16 2-km IR: 28 MAY 19 23:20:16UTC
34
+ Peak low level rotation
GOES-16 Super Enhanced Infrared Imagery:
(0.1 deg resolution, coldest 25 deg temperature range)
28 May 2019: 2320-2350 UTC
96
95
94
GOES-16 BAND 13: 28 MAY 19 23:20UTC CIMSS


GOES16 2-km IR
34
+ Peak low level rotation
Wind heights:
200-100 mb
100-50 mb
96
95
94
GOES-16 BAND 13: 28 MAY 19 23:20UTC CIMSS


+ Peak low level rotation
Derived winds:28 May 2019: 23:20-23:50 UTC
0
20
40
60
80 m/s
0001 DERIVED DATA 28 MAY 19148 232016 00376 00375 00.25

# Middle Tennessee storms

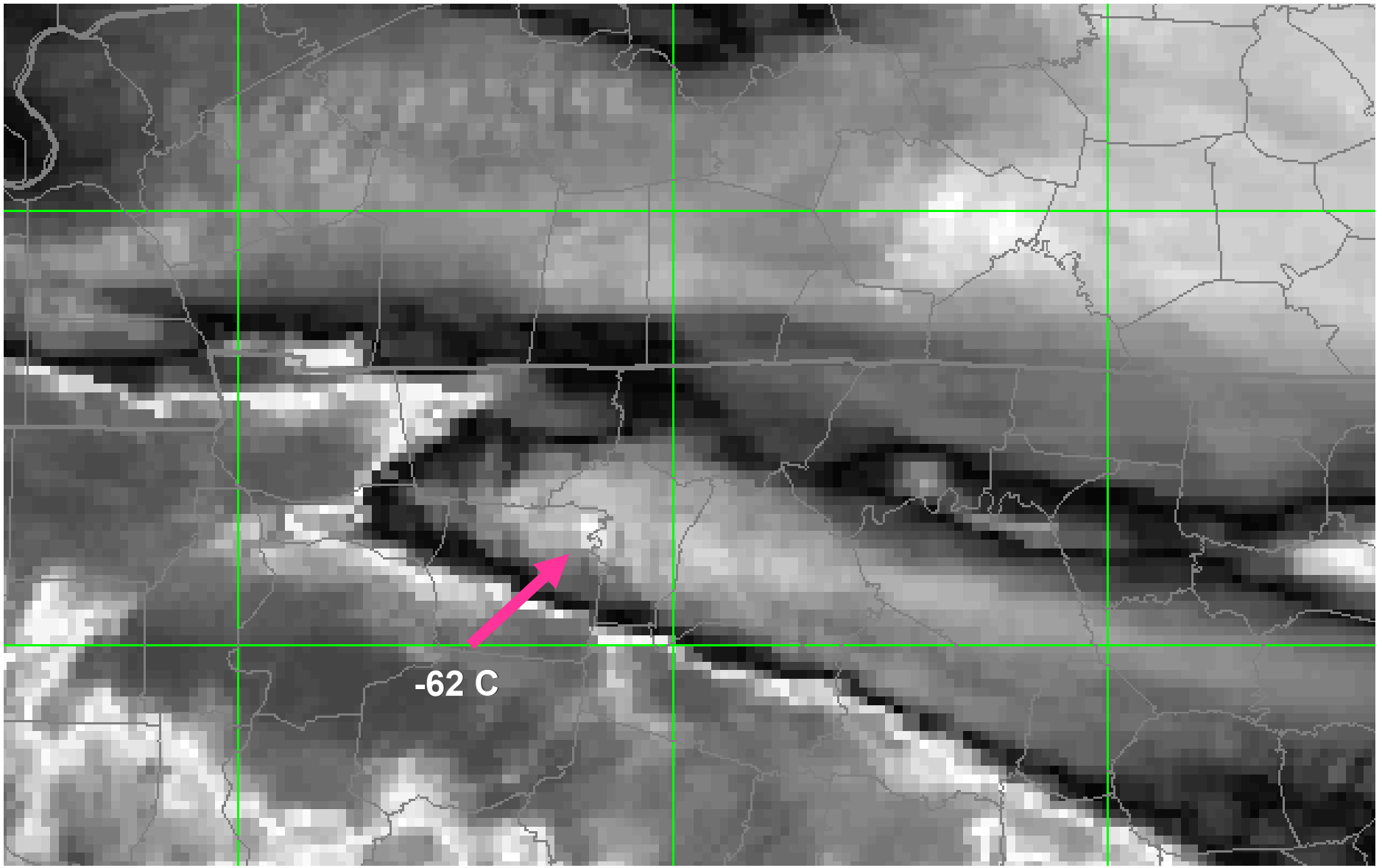



Tornado #3 - Nashville Area
Davidson, Wilson, and Smith Counties

| | |
|---|---|
| **Date** | 3/3/2020 |
| **Time (Local)** | 12:32 AM - 1:35 AM |
| **EF Rating** | EF-3 |
| **Storm Motion** | East at 57.3 mph |
| **Est. Peak Winds** | 165 mph |
| **Path Length** | 60.13 mi |
| **Max Width** | 1600 yards |
| **Injuries/Deaths** | 220 / 5 |

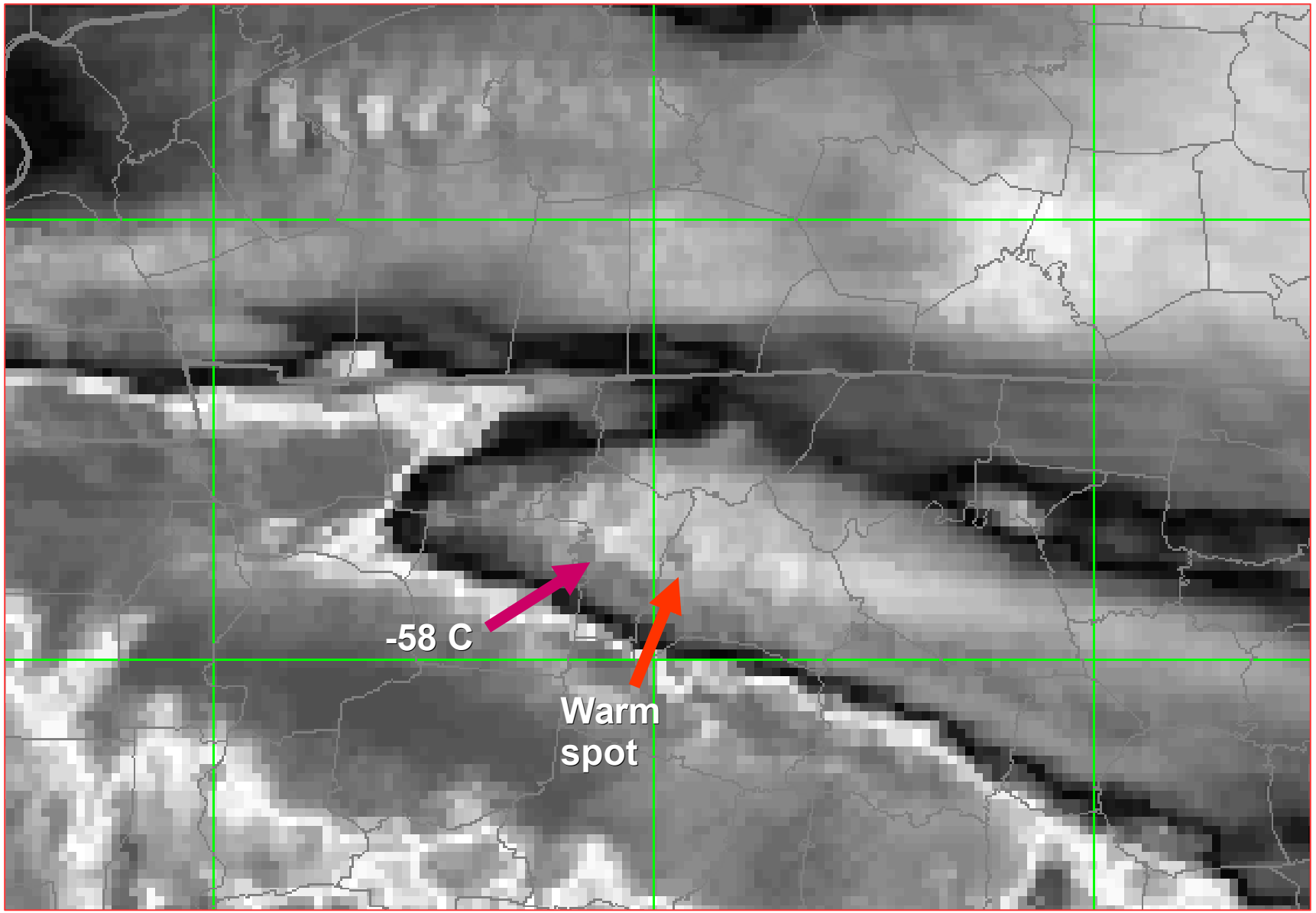
# Super Enhanced Infrared Imagery: GOES-16

## Band 13: 03 March 2020 06:07 UTC

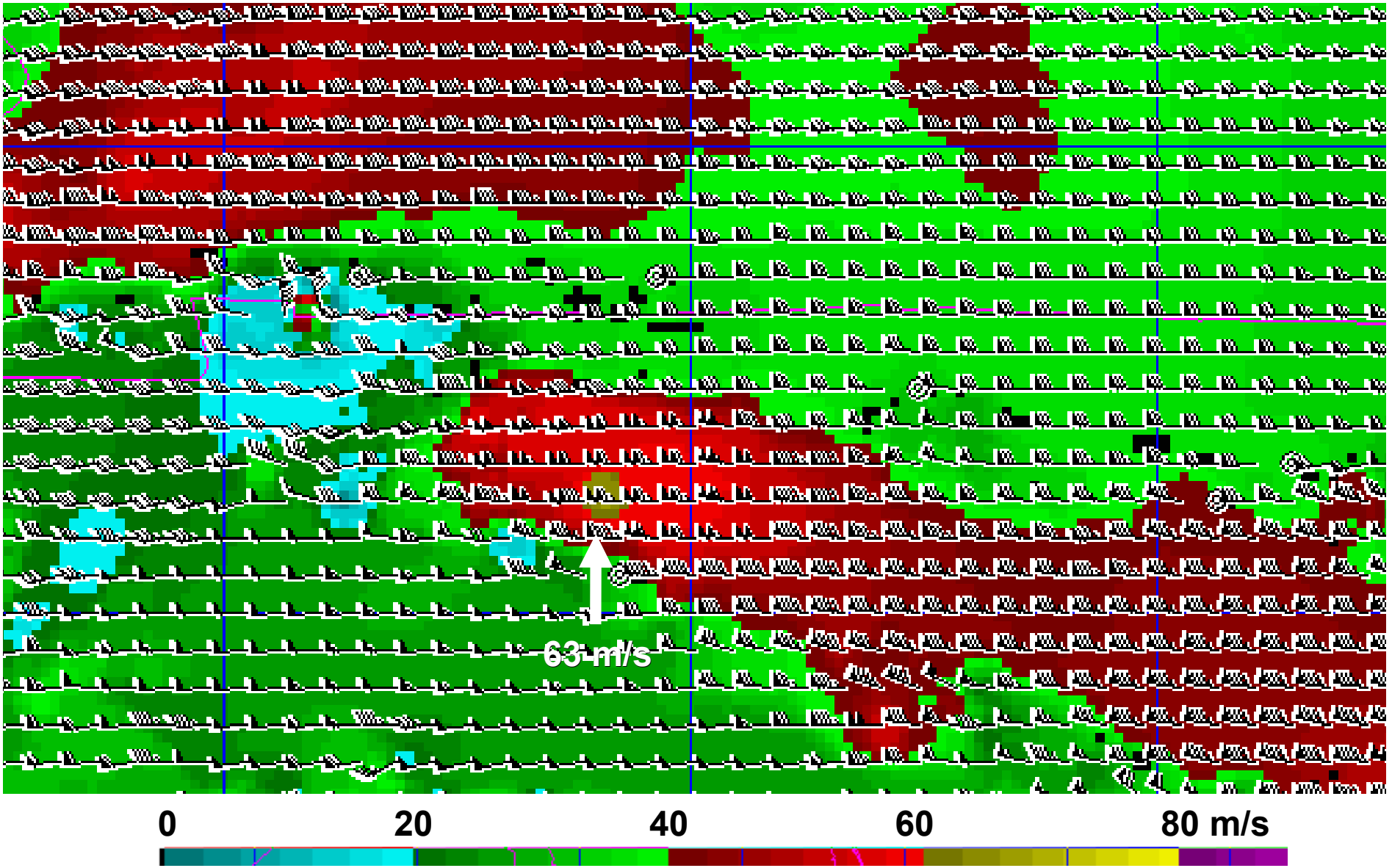


## Super Enhanced Infrared Imagery: GOES-16

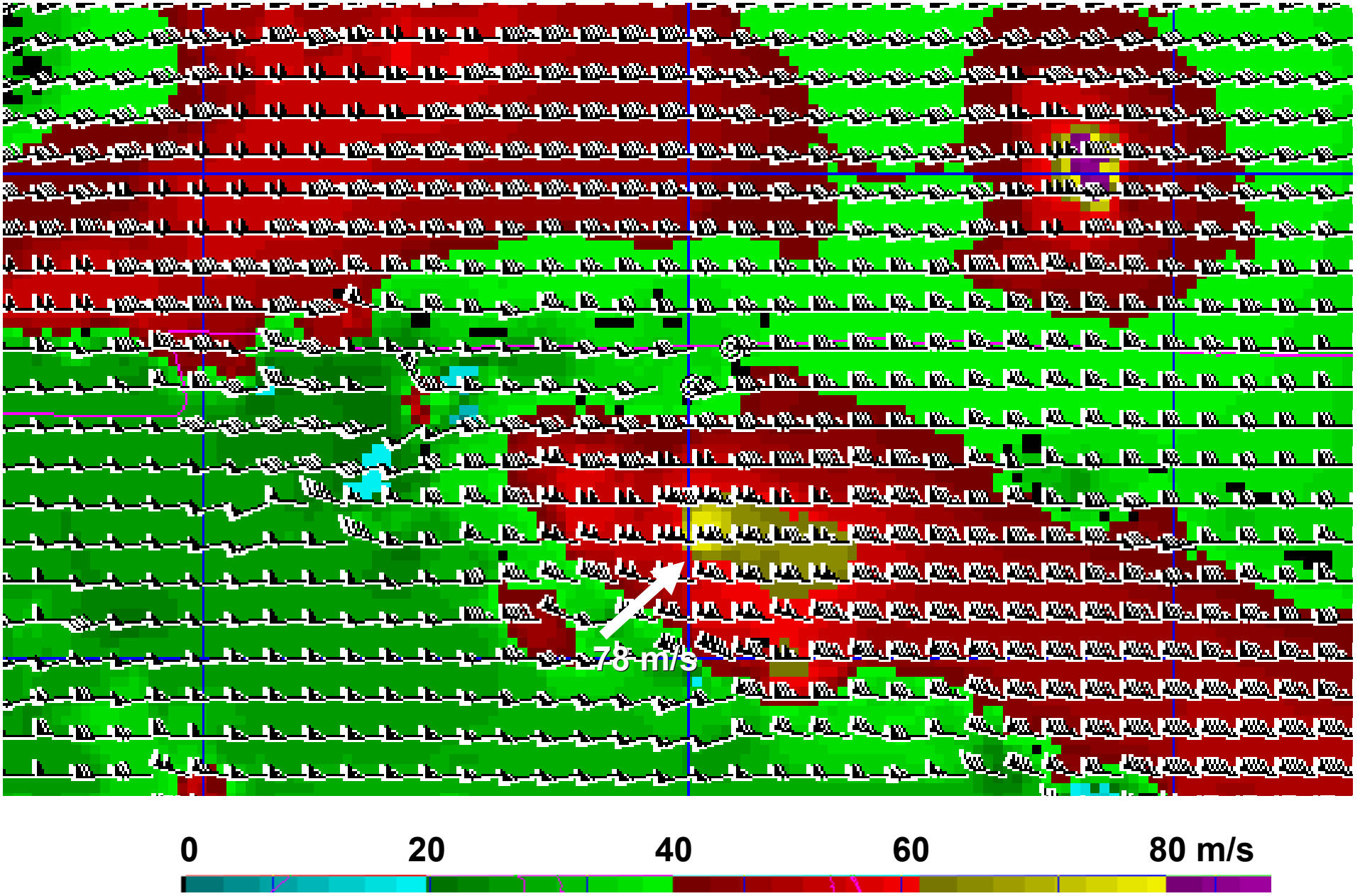
**Band 13: 03 March 2020 06:16 UTC**

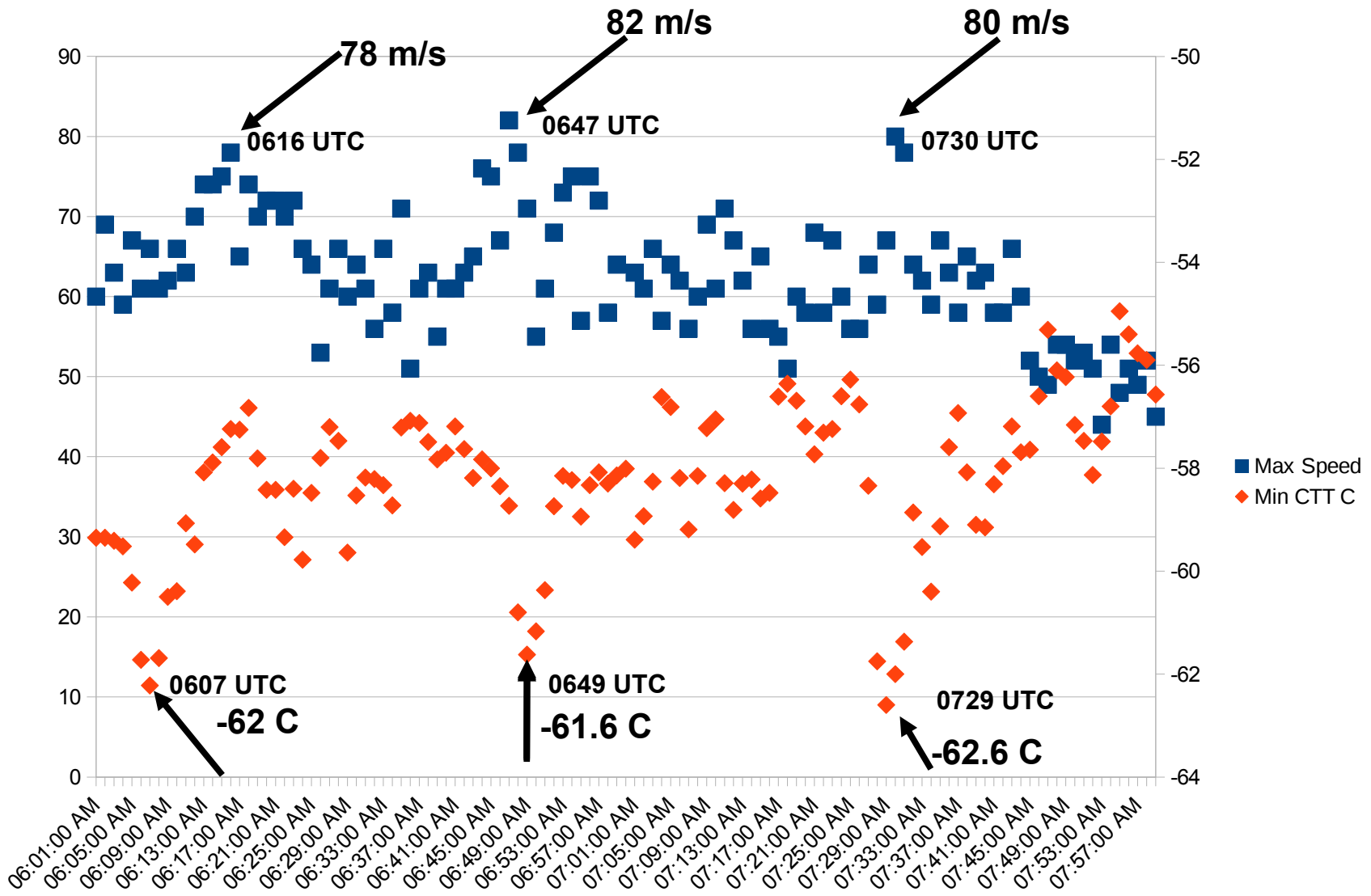


# GOES-16 derived wind speed: 03 March 2020 06:07 UTC

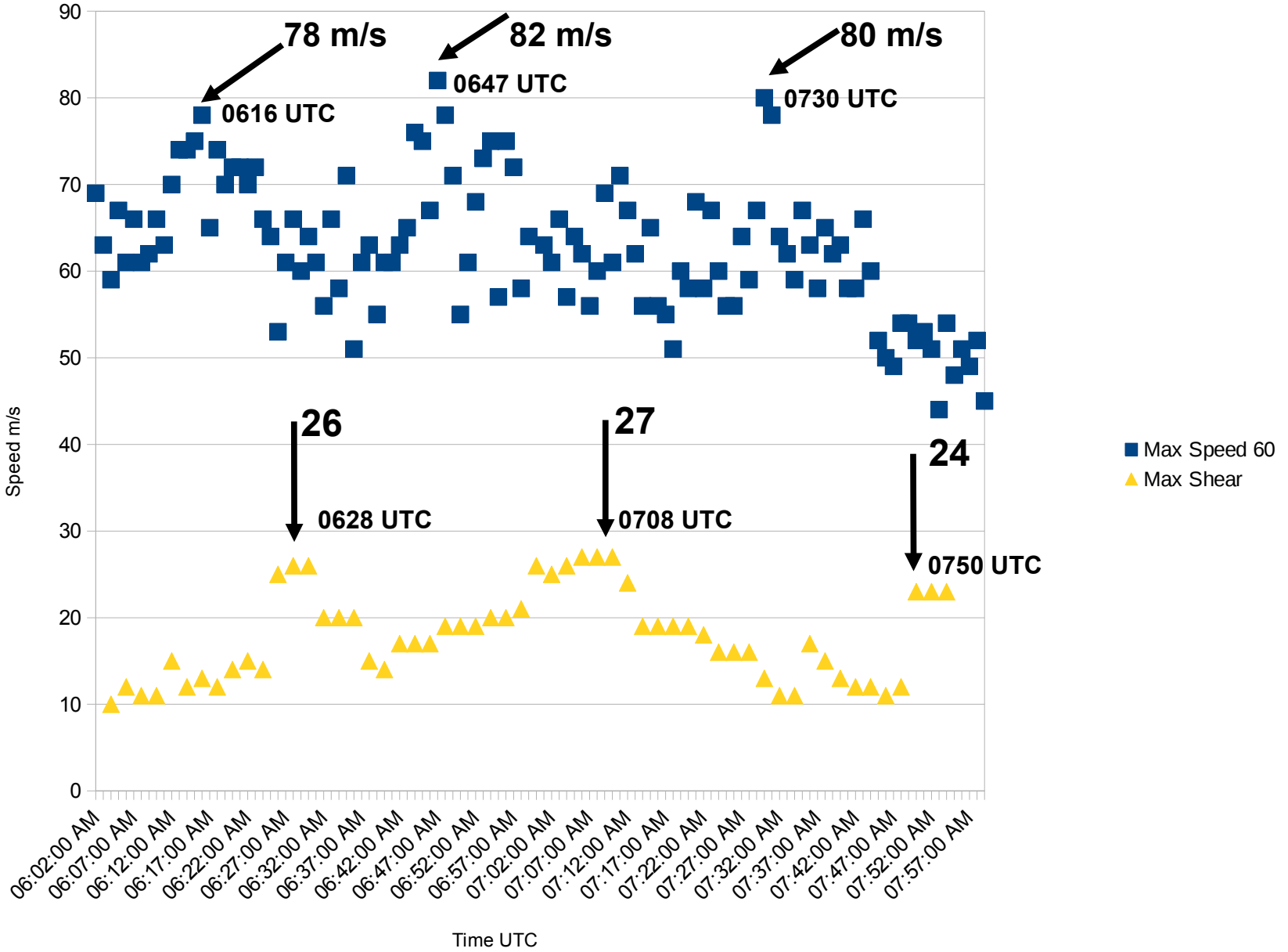


# GOES-16 derived wind speed: 03 March 2020 06:16 UTC




Maximum wind speed vs Minimum cloud top temperature
78 m/s
82 m/s
80 m/s
0616 UTC
0647 UTC
0730 UTC
0607 UTC
-62 C
0649 UTC
-61.6 C
0729 UTC
-62.6 C
90
80
70
60
50
40
30
20
10
0
-50
-52
-54
-56
-58
-60
-62
-64
Max Speed
Min CTT C
06:01:00 AM
06:05:00 AM
06:09:00 AM
06:13:00 AM
06:17:00 AM
06:21:00 AM
06:25:00 AM
06:29:00 AM
06:33:00 AM
06:37:00 AM
06:41:00 AM
06:45:00 AM
06:49:00 AM
06:53:00 AM
06:57:00 AM
07:01:00 AM
07:05:00 AM
07:09:00 AM
07:13:00 AM
07:17:00 AM
07:21:00 AM
07:25:00 AM
07:29:00 AM
07:33:00 AM
07:37:00 AM
07:41:00 AM
07:45:00 AM
07:49:00 AM
07:53:00 AM
07:57:00 AM

# Maximum wind speed vs Low-level rotation



# Summary

## Possible Applications:

- Optical Flow technique takes advantage of GOES-R 1-minute image interval in mesosectors

- Uses “Super image enhancement (IR 0.1 deg C)

- High density of cloud track winds (2 km for IR)

- Monitor intensity of thunderstorm updrafts

- Additional aid for situational awareness

## Uncertainties:

-Uncertainty in cloud top heights (resolution differences with IR)

-Validation needed

**Thank you!**

**T'áá íiyisíí ahéhee'** ***(Diné Bizaad)***

**Quyanaqpak!** ***(Inupiaq)***

**Miigwech (Ojibwe)**

**Link to archived and real-time imagery:**

https://www.ssec.wisc.edu/~rabin/winds/goes16/cases/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