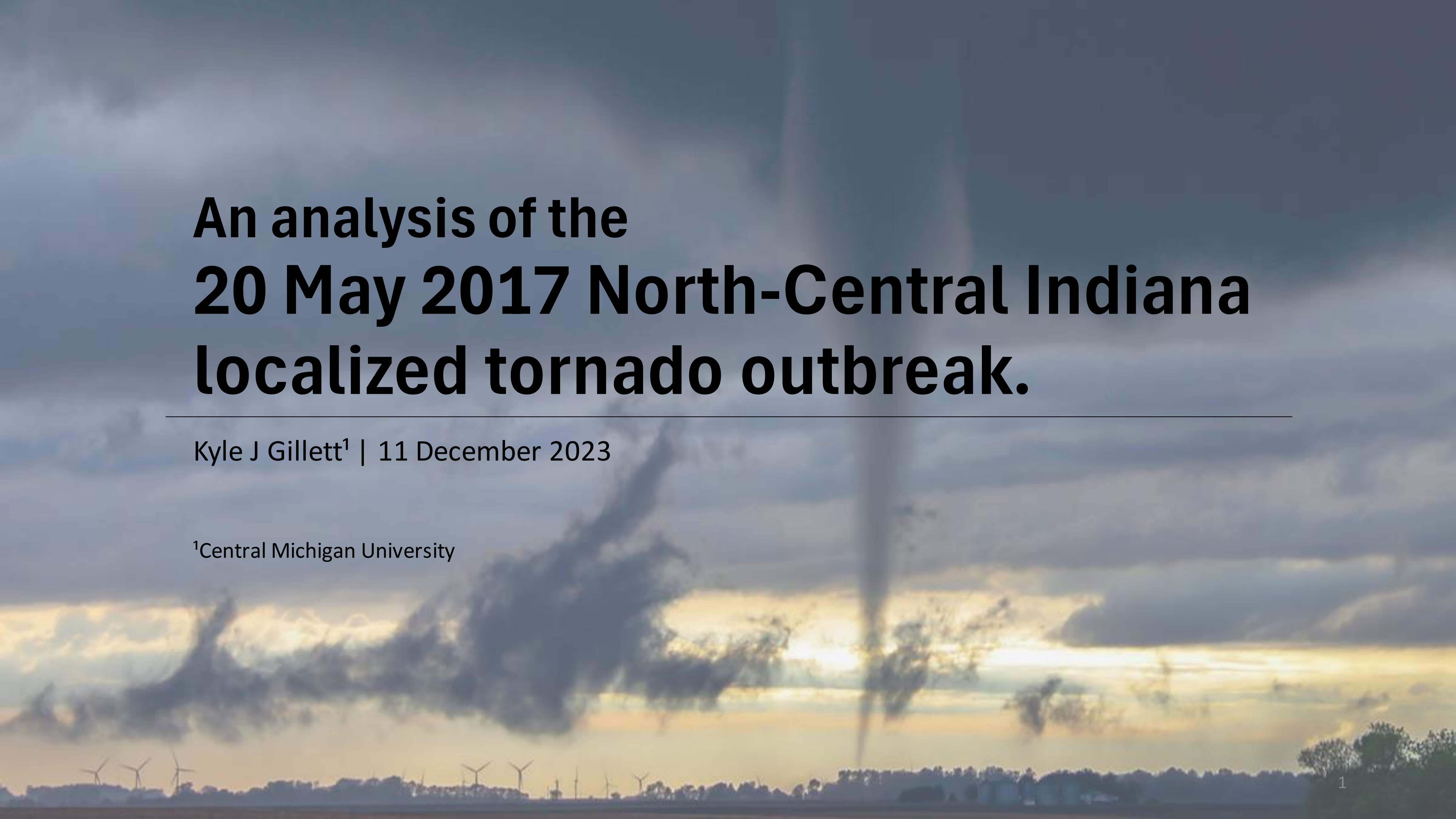


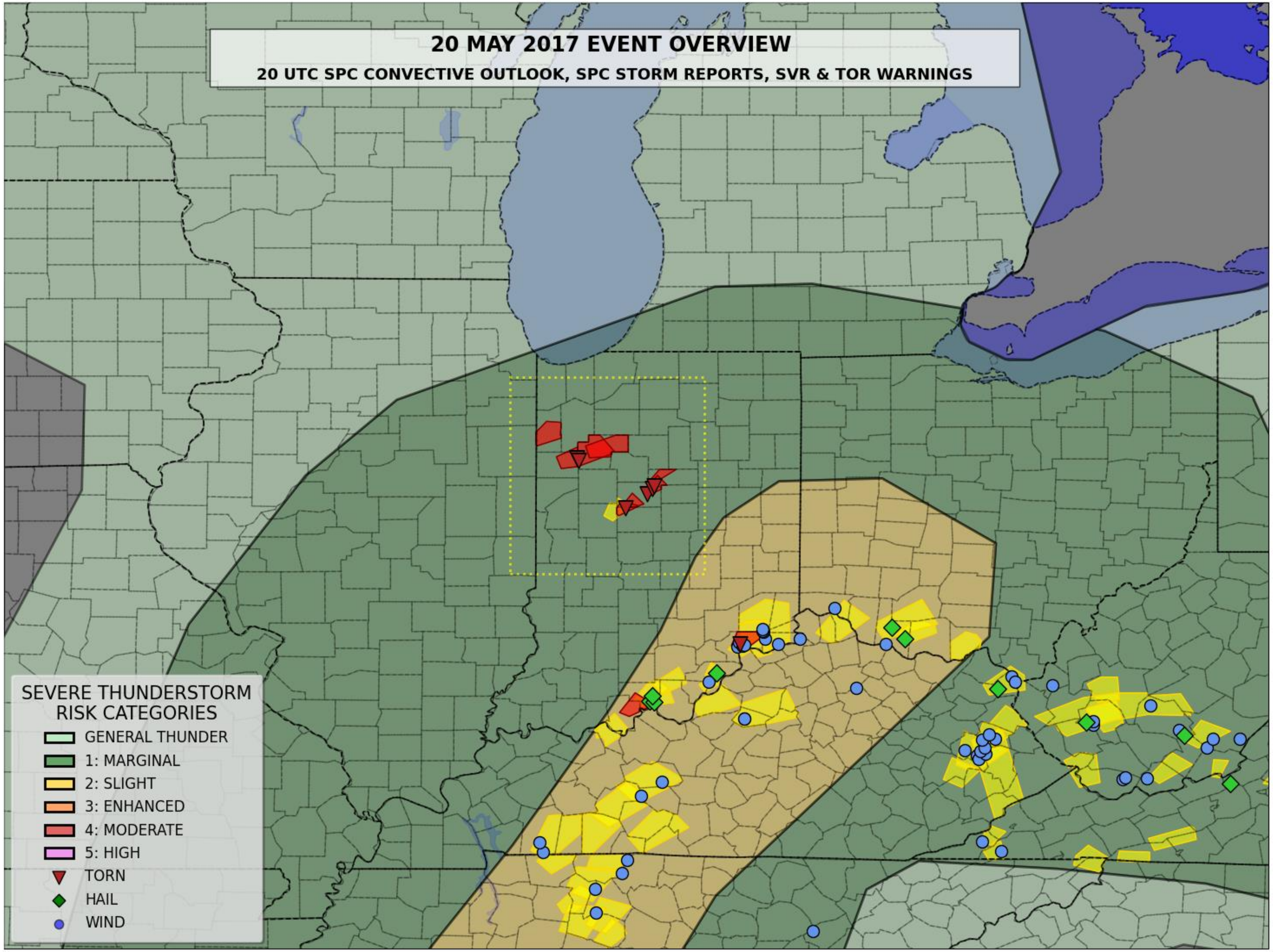
An analysis of the 20 May 2017 North-Central Indiana localized tornado outbreak.

Kyle J Gillett[1] | 11 December 2023

[1]Central Michigan University

CONTENTS

a. EVENT OVERVIEW

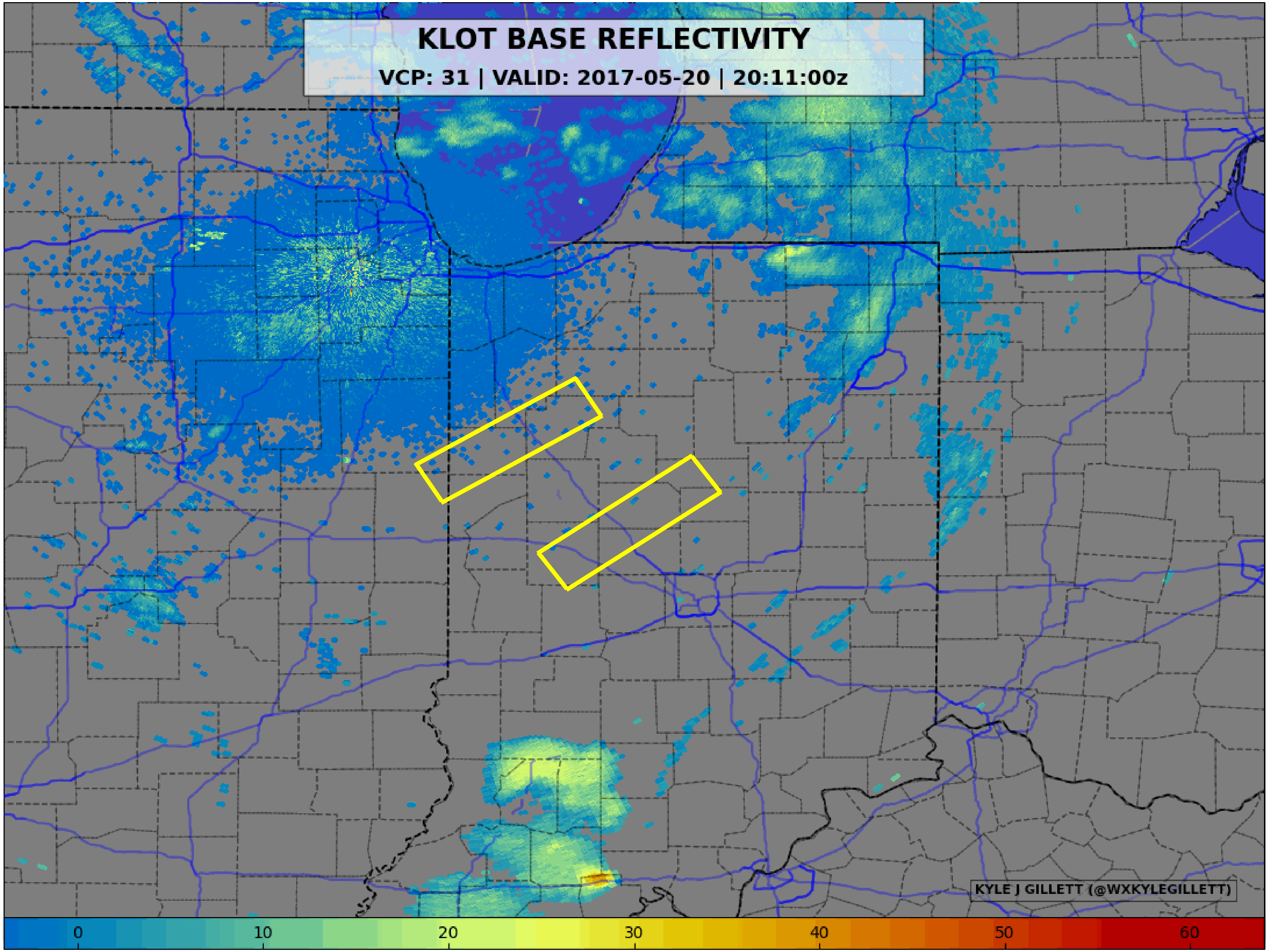


EVENT OVERVIEW

SPC 2000 UTC 20 May 2017 Day 1 Categorical Convective Outlook

SPC 20 May 2017 Storm Reports

20 May 2017 (ET) NWS Tornado & Severe Thunderstorm Warnings



EVENT OVERVIEW

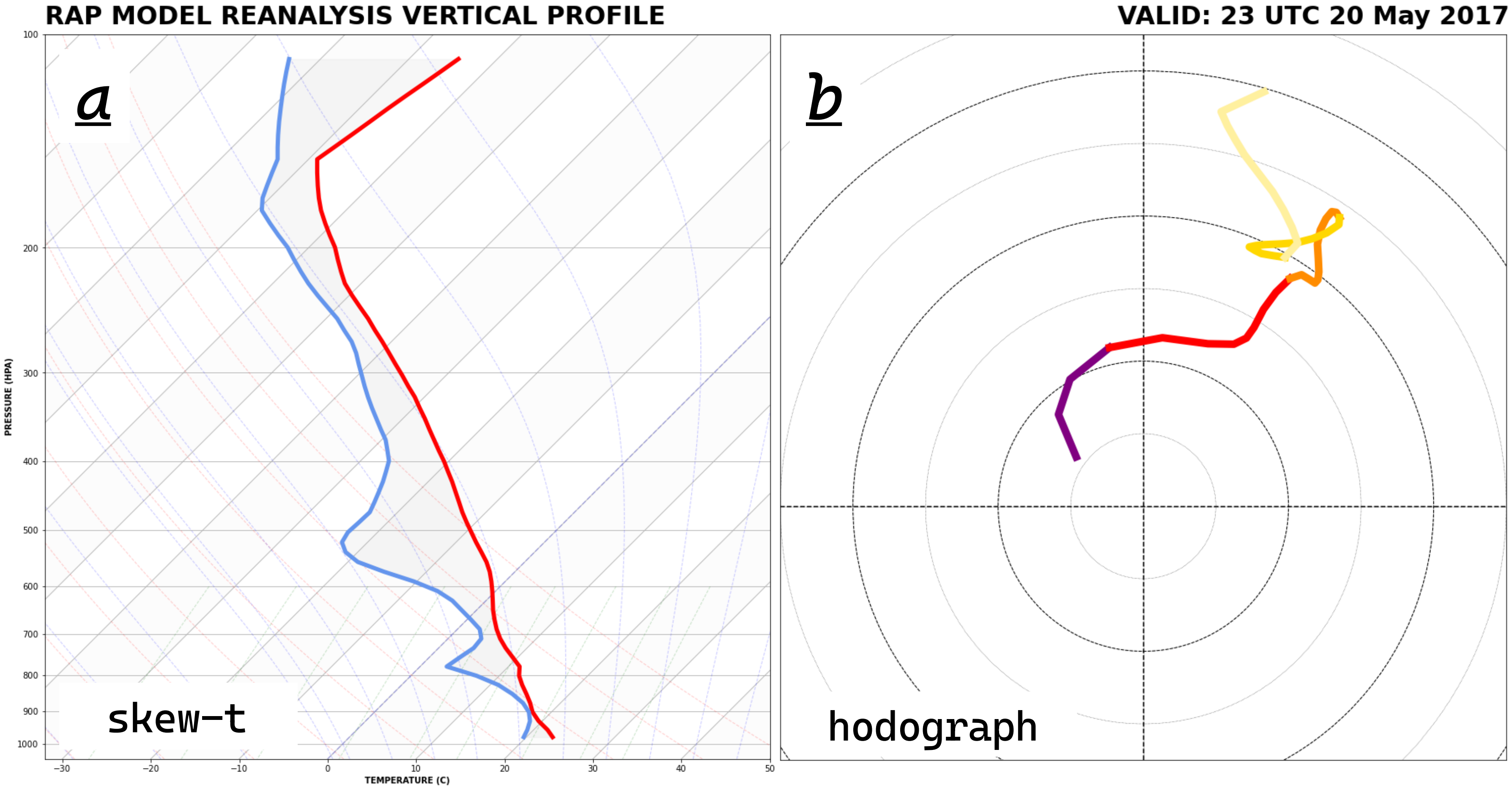
KLOT Base Reflectivity Loop

20 UTC 20 May to
01 UTC 21 May

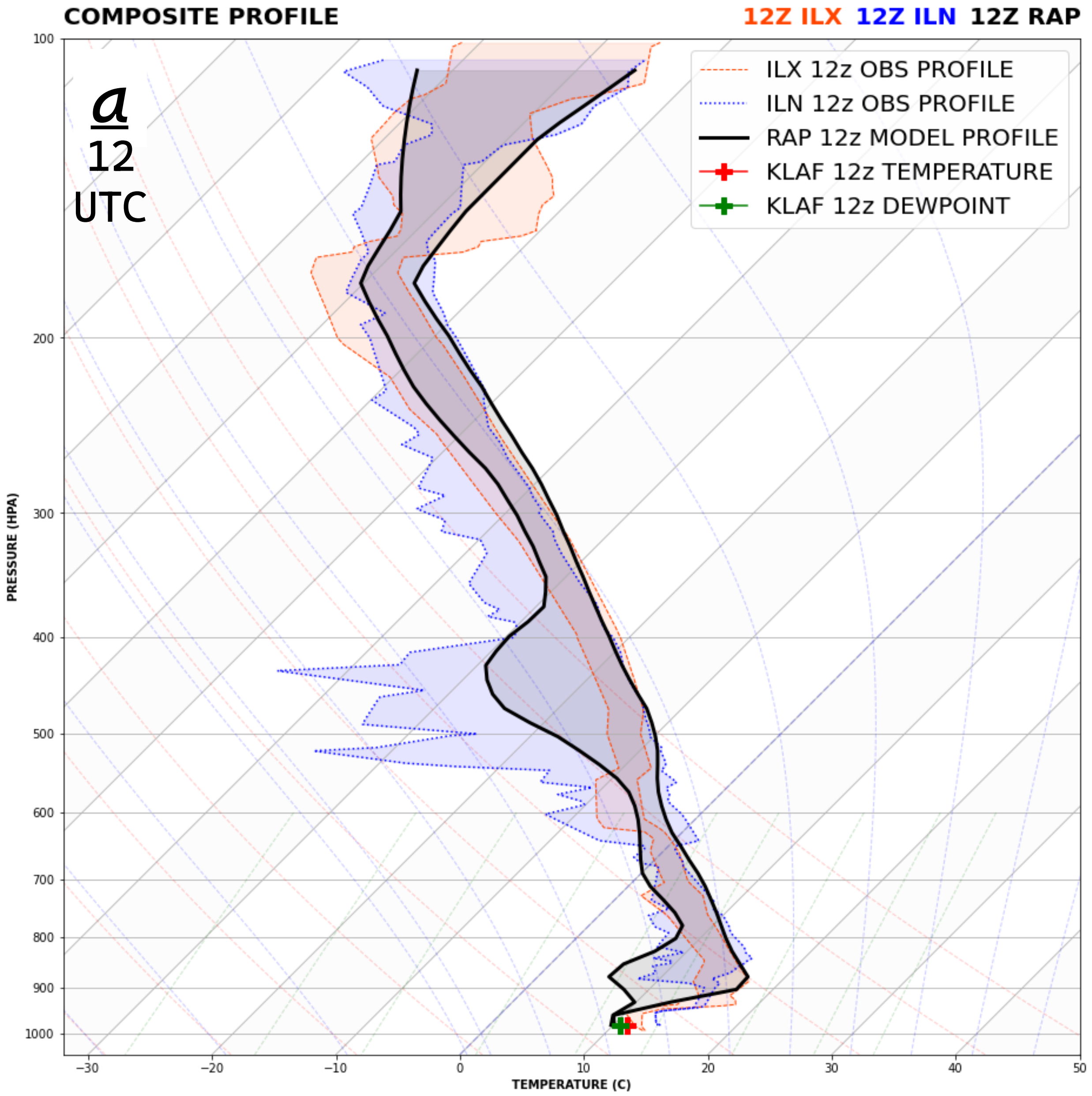
1. Highly localized outbreak of "mini-supercells" and weak tornadoes in north-central Indiana

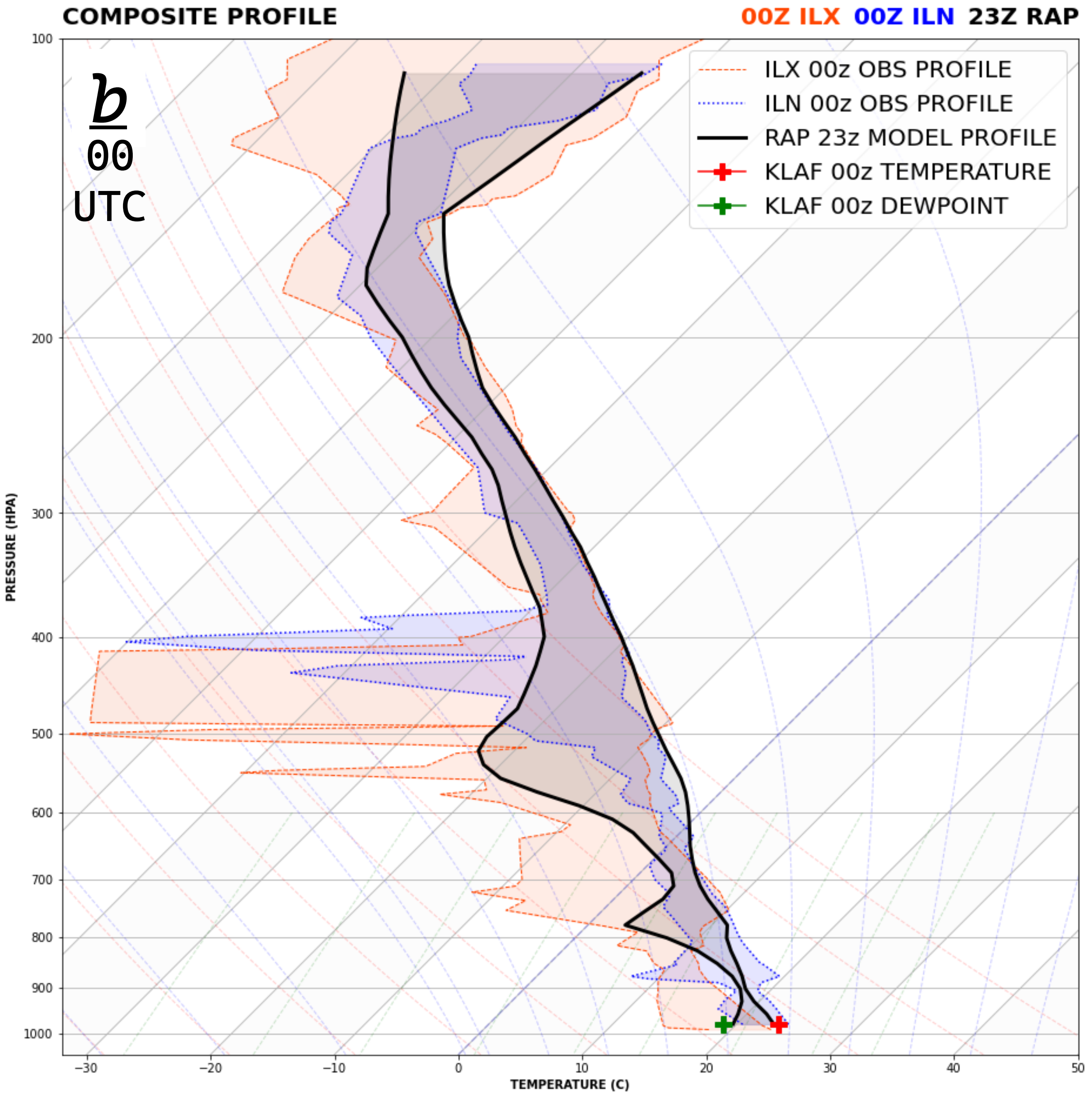
b. REANALYSIS METHODOLOGY

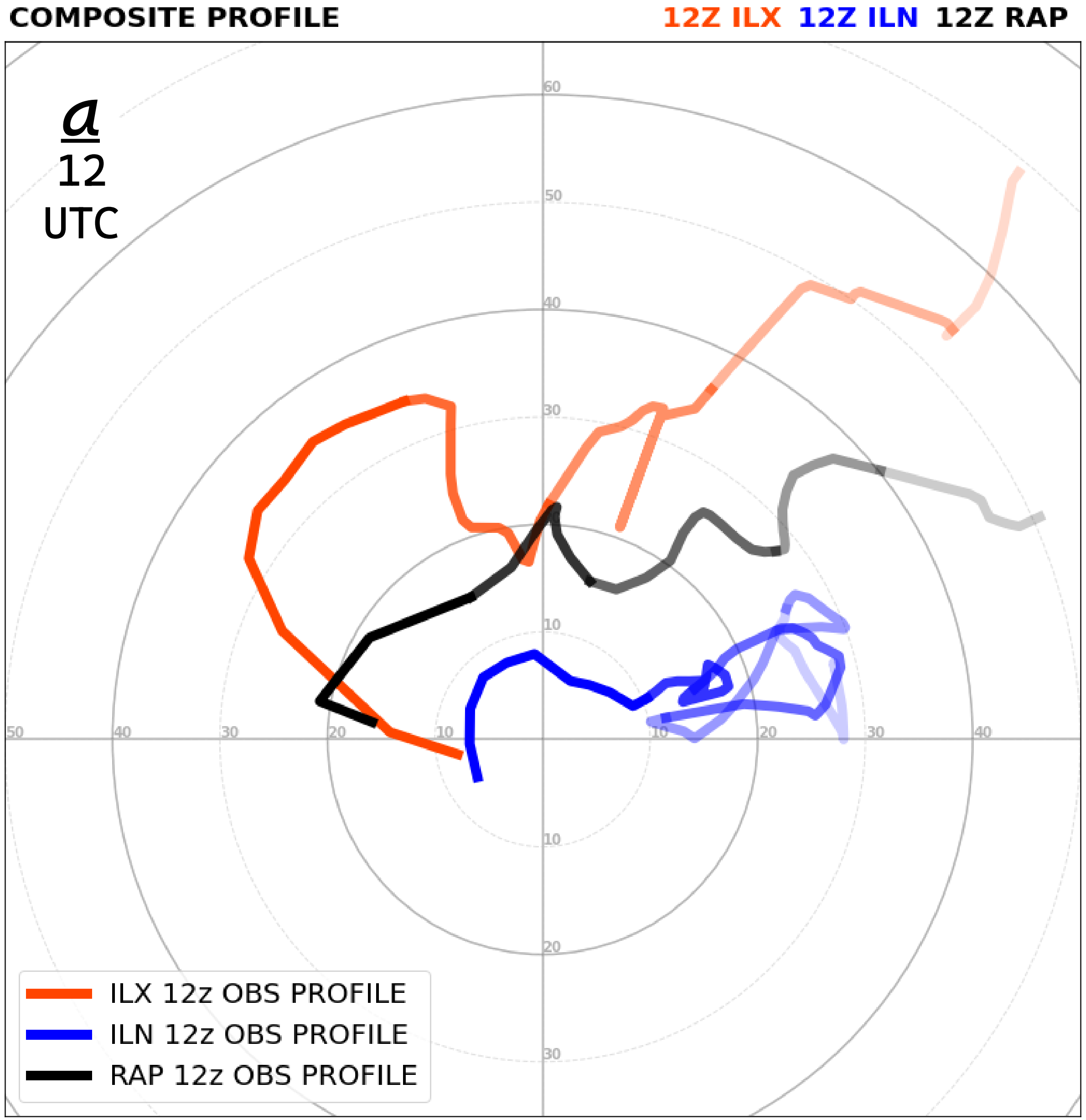
Reanalysis Data



RAP model reanalysis used to represent the near-storm vertical environment as no near-by *representative* observations are available


COMPOSITE PROFILE
12Z ILX 12Z ILN 12Z RAP
a
12
UTC
ILX 12z OBS PROFILE
ILN 12z OBS PROFILE
RAP 12z MODEL PROFILE
KLAF 12z TEMPERATURE
KLAF 12z DEWPOINT
PRESSURE (HPA)
TEMPERATURE (C)


COMPOSITE PROFILE
00Z ILX 00Z ILN 23Z RAP
b
00
UTC
ILX 00z OBS PROFILE
ILN 00z OBS PROFILE
RAP 23z MODEL PROFILE
KLAF 00z TEMPERATURE
KLAF 00z DEWPOINT
PRESSURE (HPA)
TEMPERATURE (C)


COMPOSITE PROFILE
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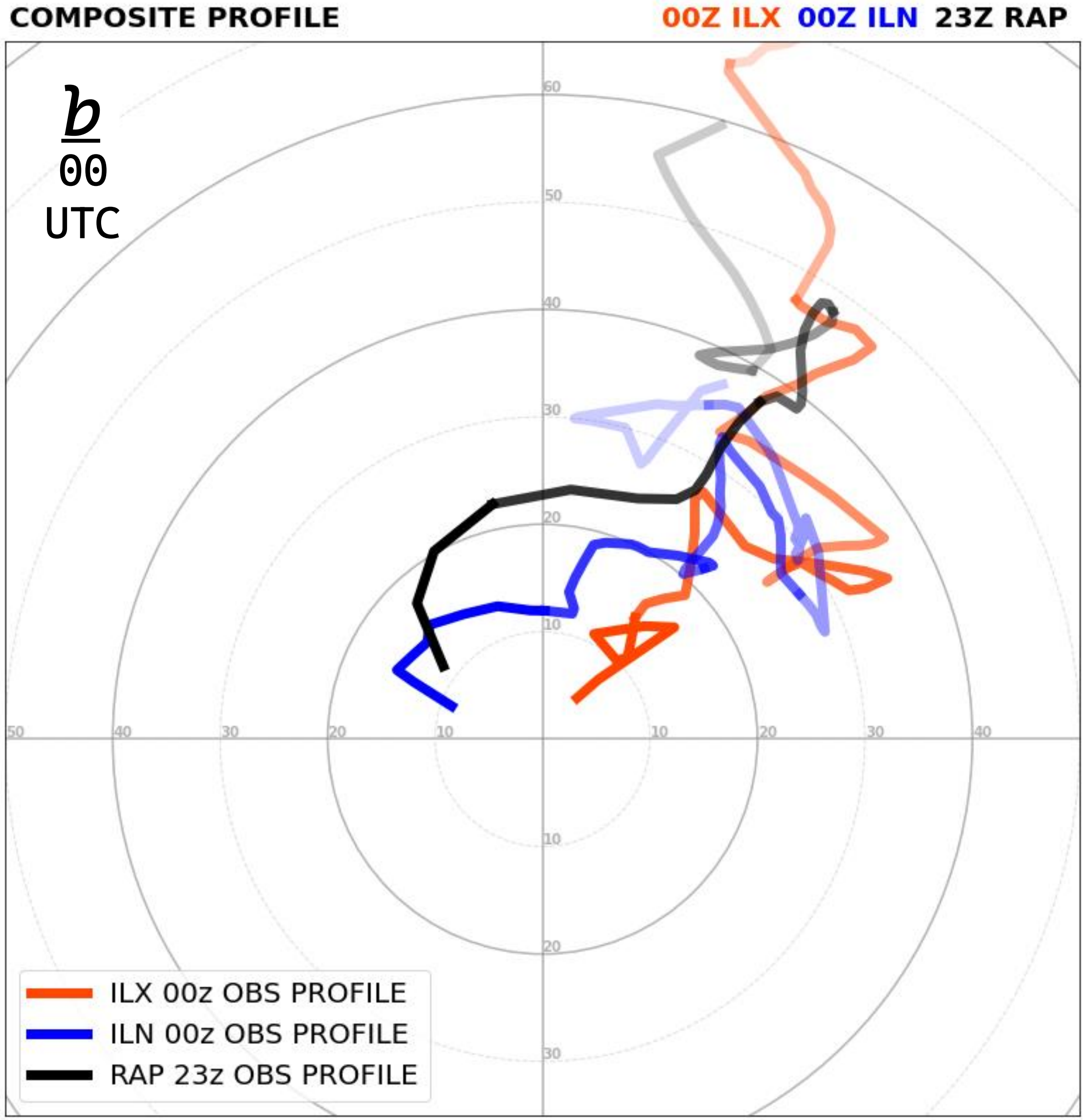
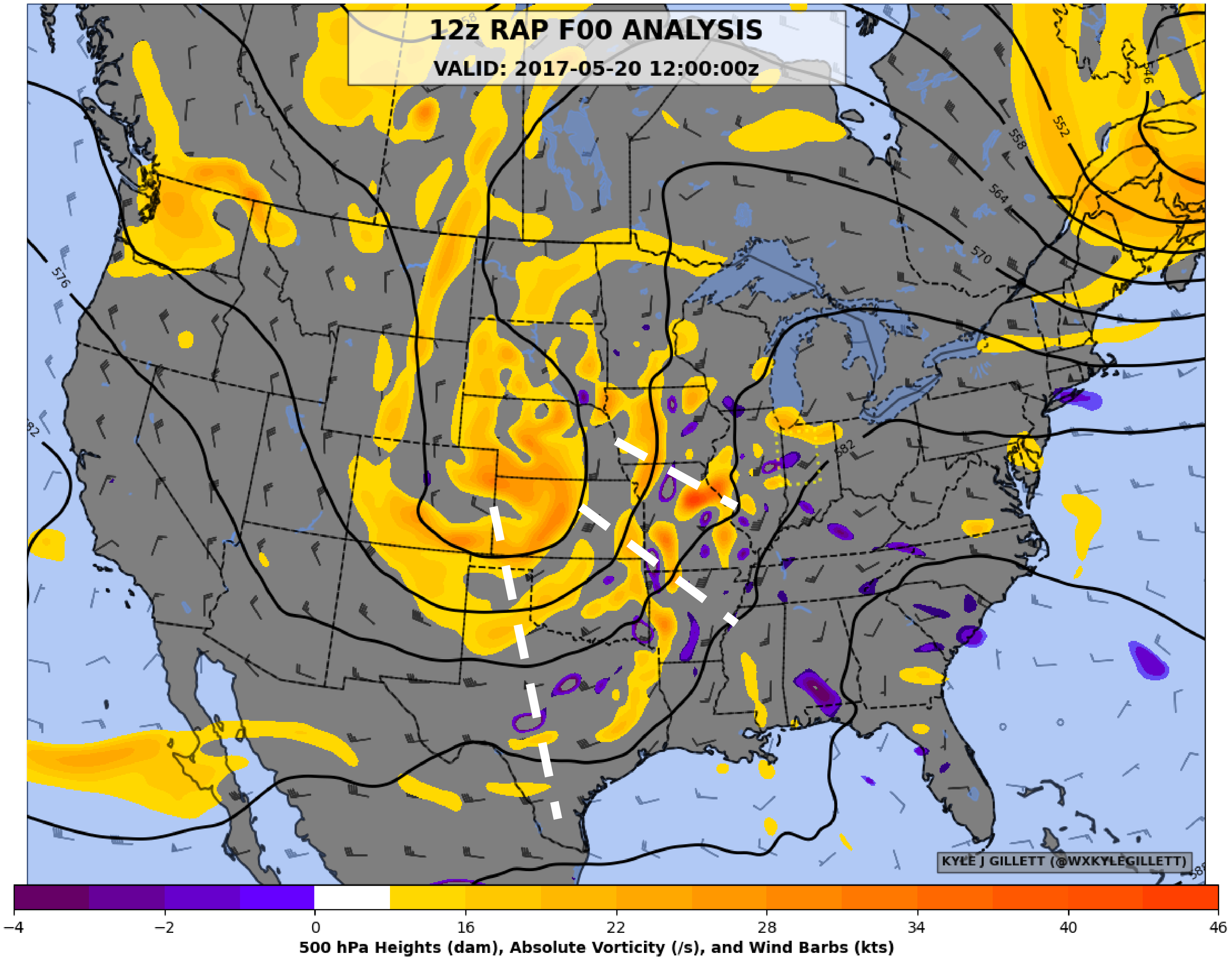
UTC
ILX 12z OBS PROFILE
ILN 12z OBS PROFILE
RAP 12z OBS PROFILE


COMPOSITE PROFILE
00Z ILX 00Z ILN 23Z RAP
b
00
UTC
ILX 00z OBS PROFILE
ILN 00z OBS PROFILE
RAP 23z OBS PROFILE

c. ENVIRONMENT ANALYSIS

1. SYNOPTIC



MESOANALYSIS

12 UTC 20 May 2017 RAP

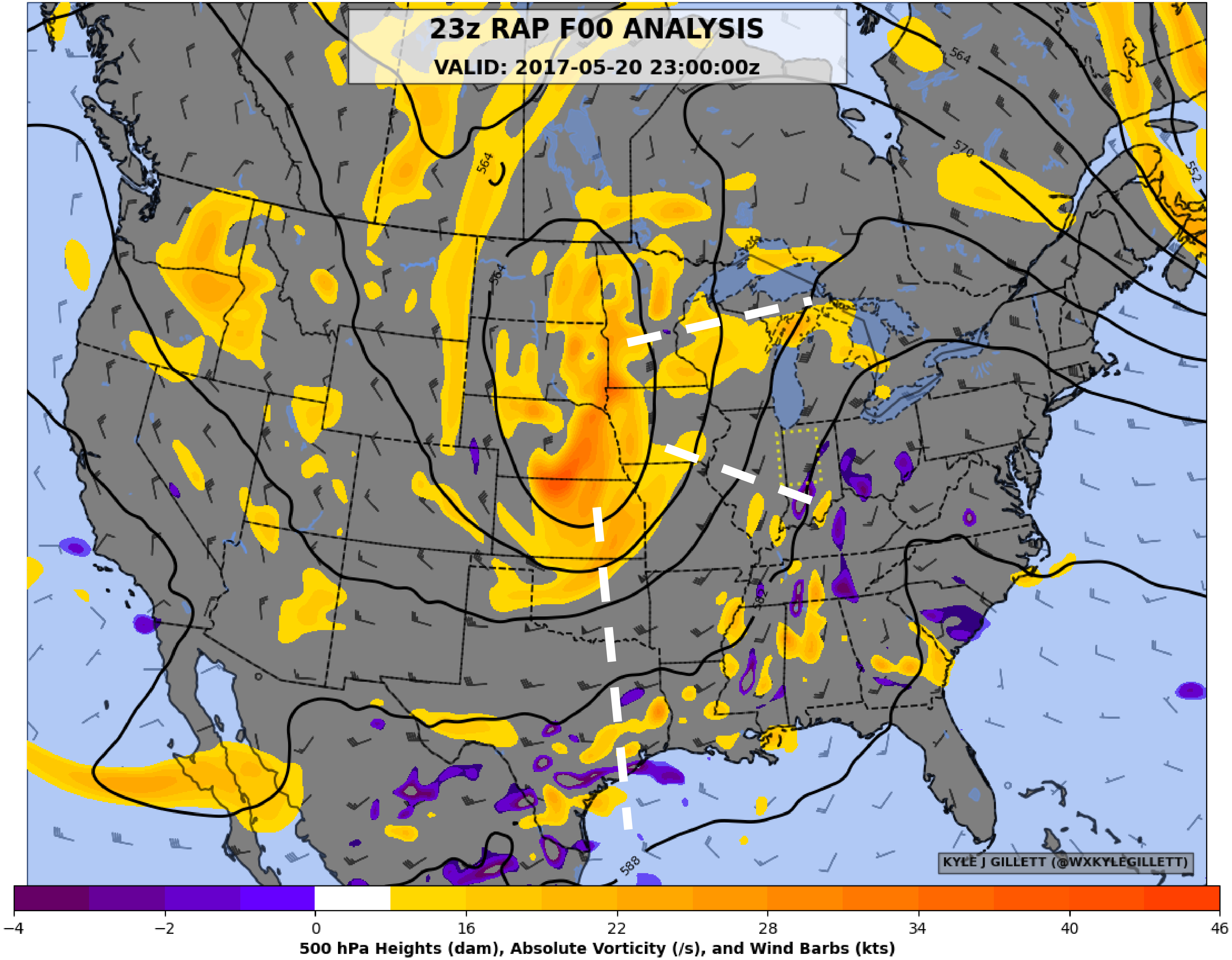
500 hPa Heights (black)

Absolute Vorticity (fill)

Wind (barbs)

Trough-of-interest axis (dash)

1. Large neutral-negatively-titled trough over the central & southern Plains
2. Several subtle shortwaves through ARLATX - Mississippi Valley



MESOANALYSIS

23 UTC 20 May 2017 RAP

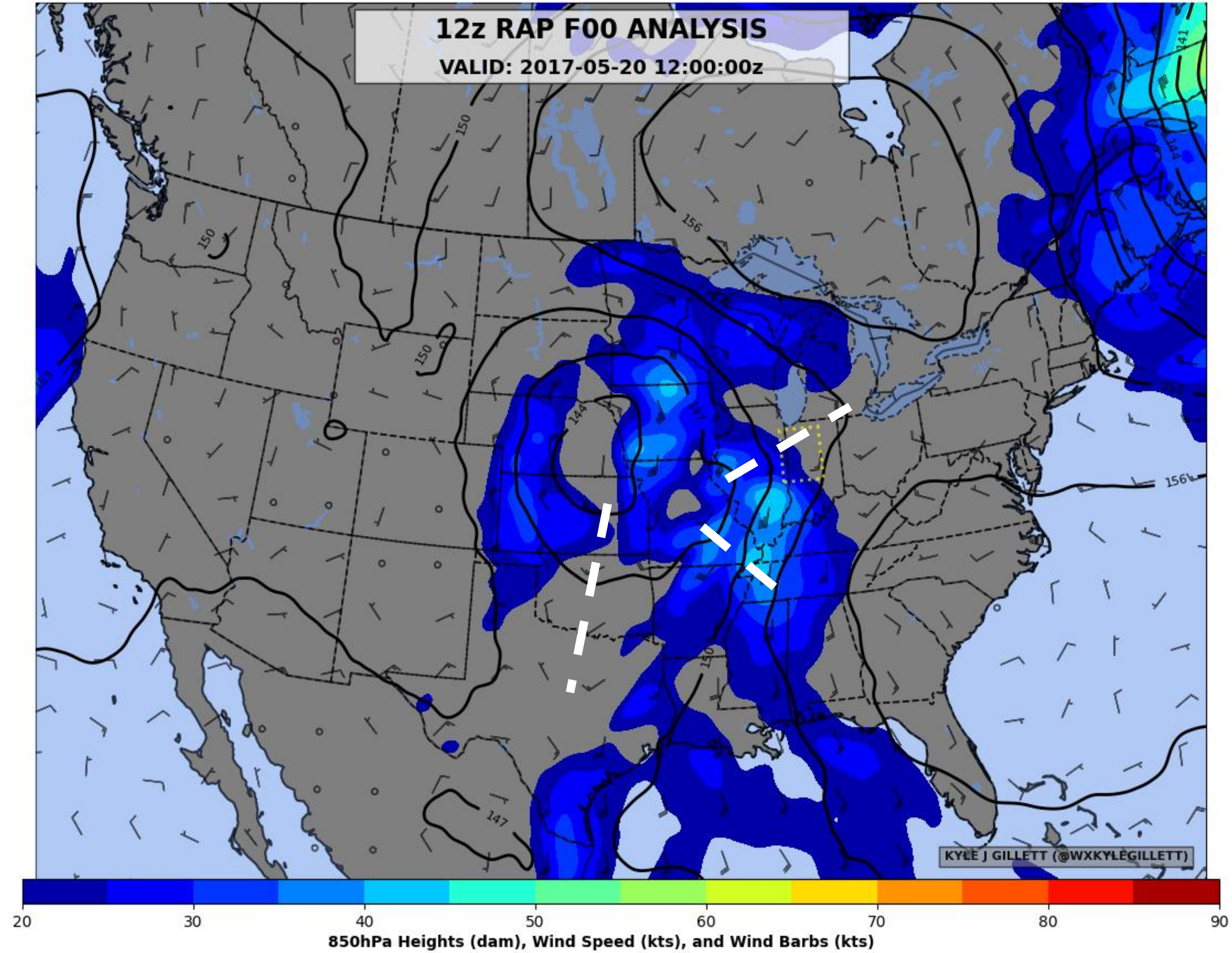
500 hPa Heights (black)

Absolute Vorticity (fill)

Wind (barbs)

Trough-of-interest axis (dash)

1. Trough closes off and ejects northeast into Northern Plains-Midwest
2. Subtle shortwaves move northward w/main trough, one centered just outside of case-domain



MESOANALYSIS

12 UTC 20 May 2017 RAP

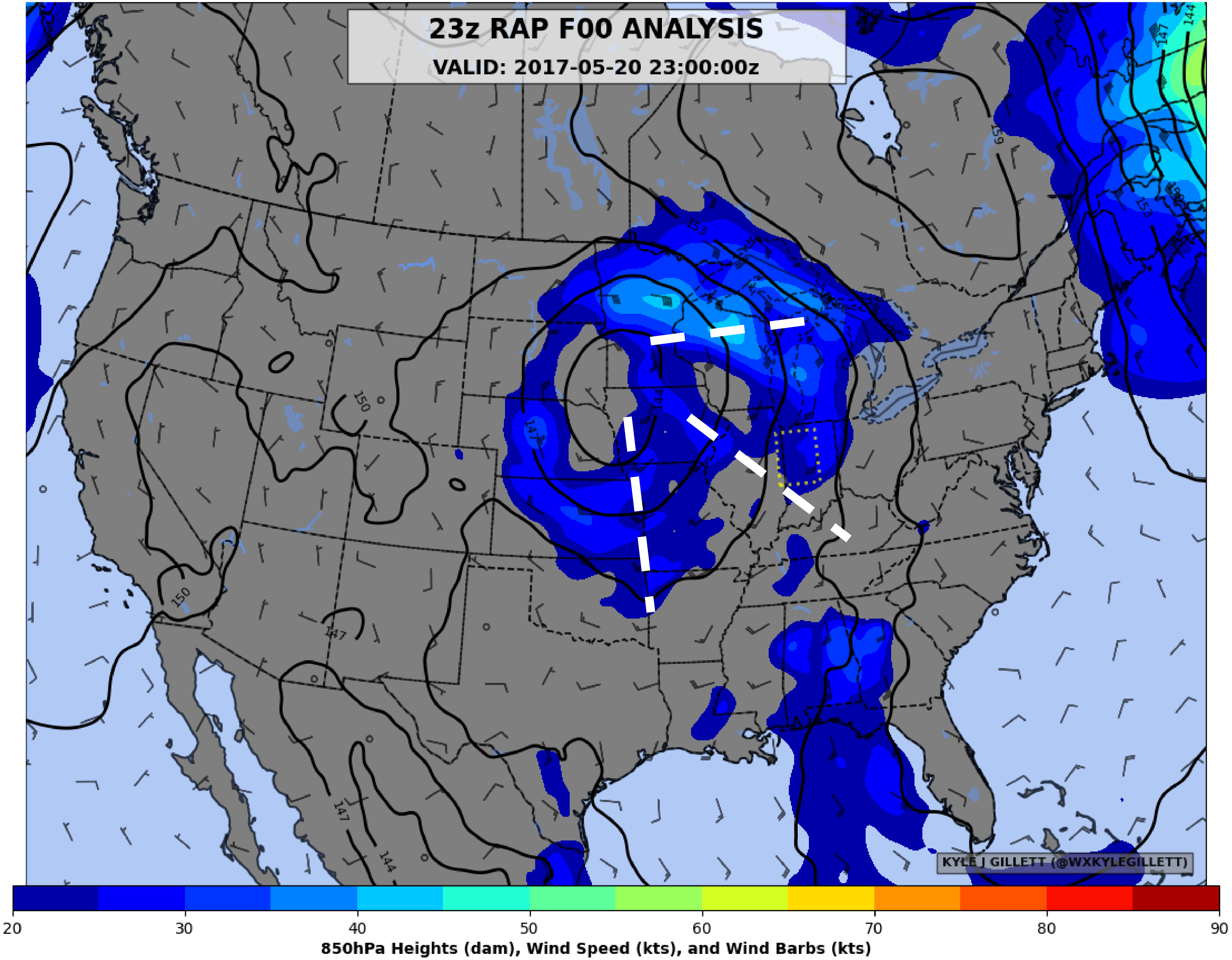
850 hPa Heights (black)

Wind (fill)

Wind (barbs)

Trough-of-interest axis (dash)

1. Moderate low-level jet through IL (30-40kts)
2. Shortwaves swinging around main low centered over the Central Plains



MESOANALYSIS

23 UTC 20 May 2017 RAP

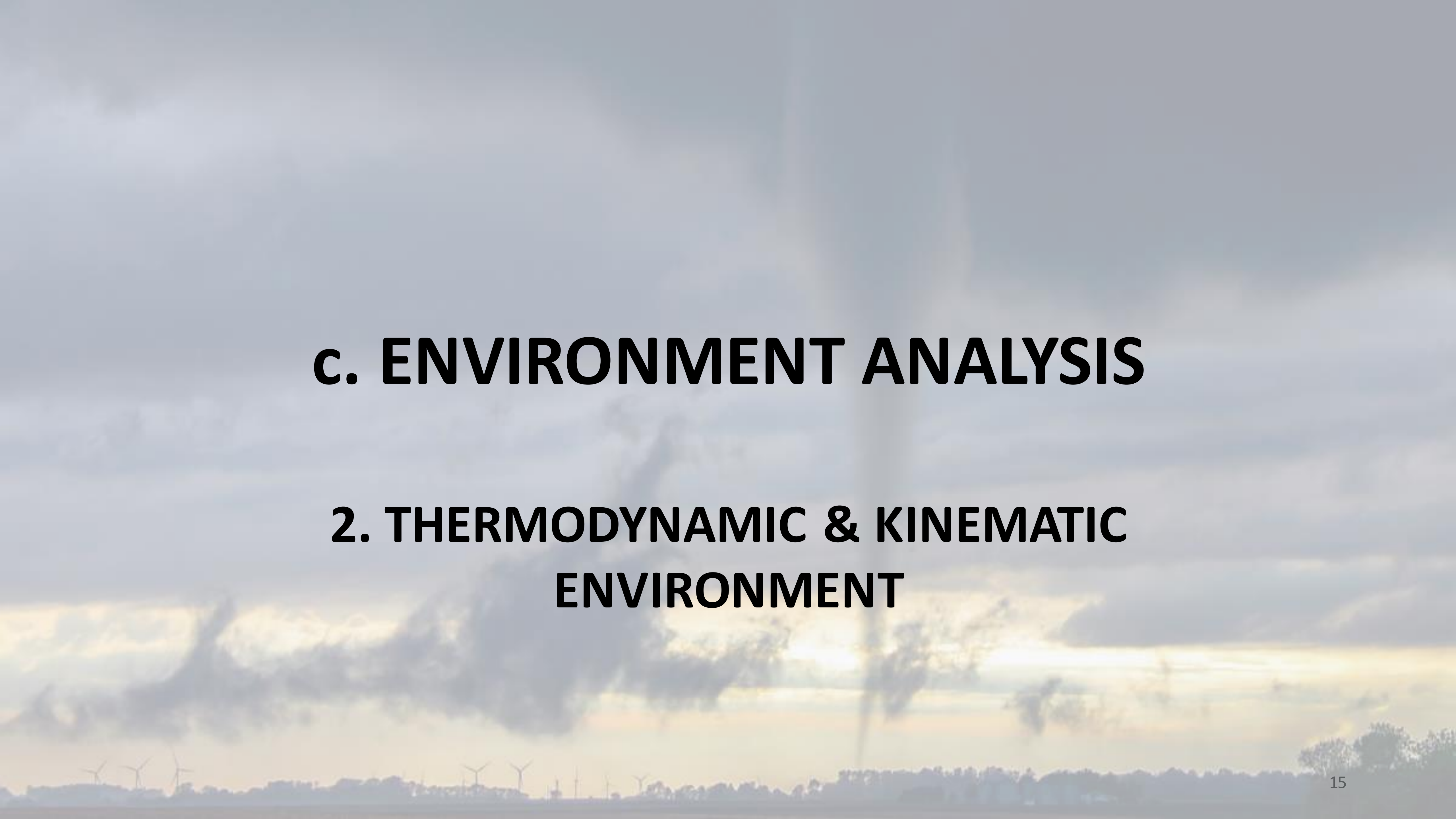
850 hPa Heights (black)

Wind (fill)

Wind (barbs)

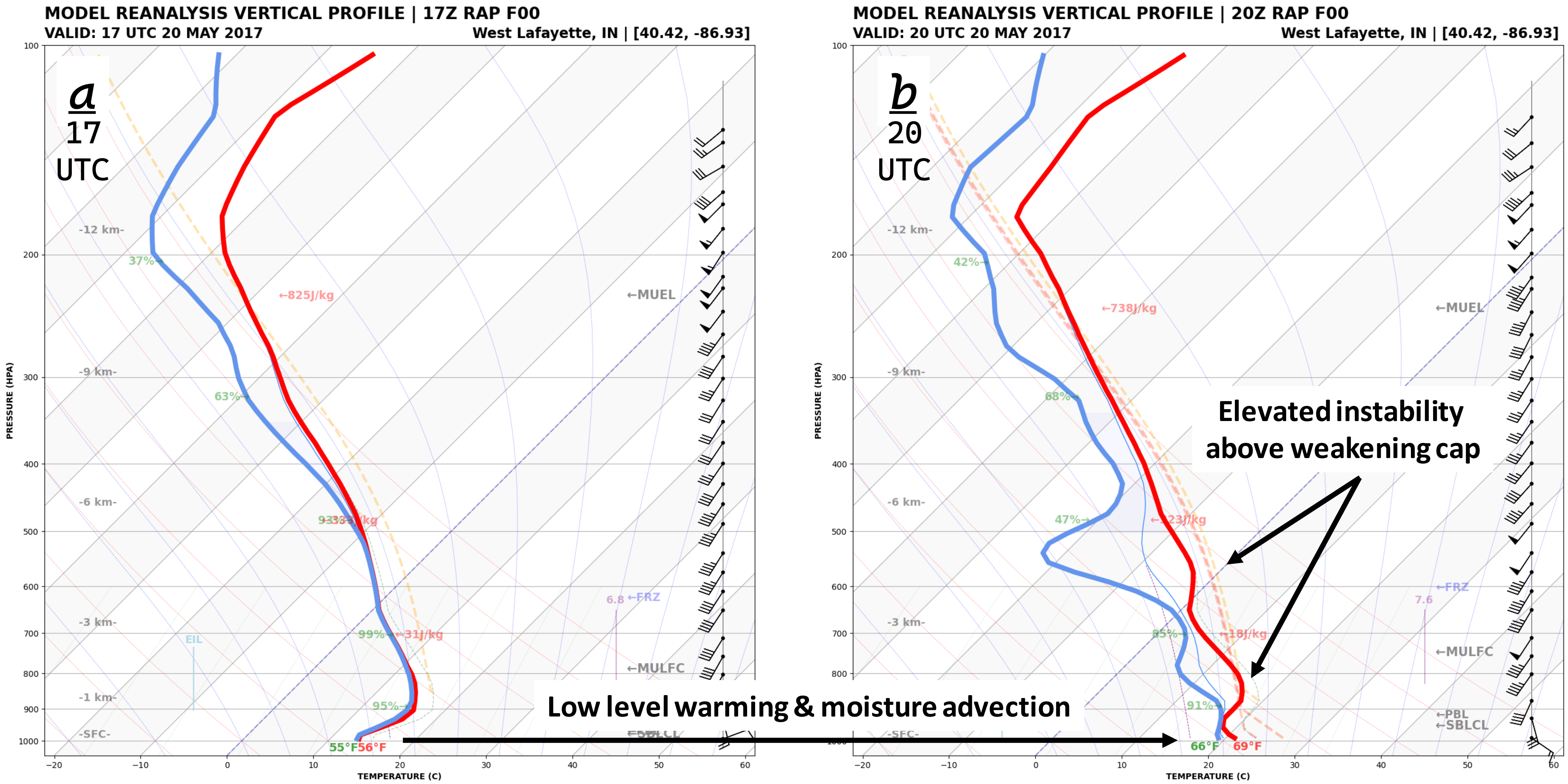
Trough-of-interest axis (dash)

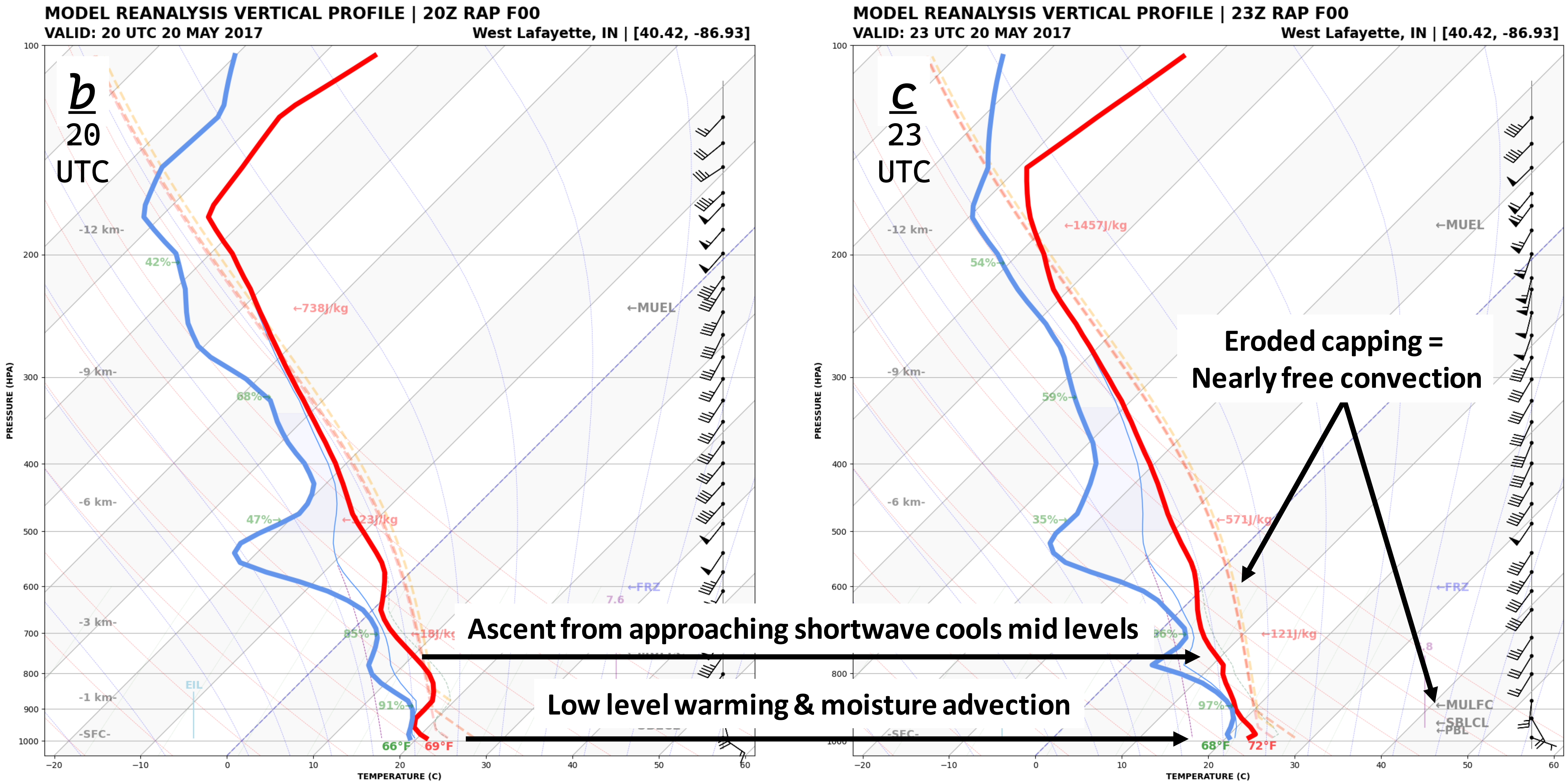
1. Low level jet weakens but still exists in central-northern case-domain.
2. Subtle shortwave over central IL and western IN



c. ENVIRONMENT ANALYSIS

2. THERMODYNAMIC & KINEMATIC ENVIRONMENT


MODEL REANALYSIS VERTICAL PROFILE | 17Z RAP F00
VALID: 17 UTC 20 MAY 2017
West Lafayette, IN | [40.42, -86.93]
a
17
UTC
MODEL REANALYSIS VERTICAL PROFILE | 20Z RAP F00
VALID: 20 UTC 20 MAY 2017
West Lafayette, IN | [40.42, -86.93]
b
20
UTC
PRESSURE (HPA)
TEMPERATURE (C)
←825J/kg
←738J/kg
←MUEL
←FRZ
←MULFC
←PBL
←SBLCL
55°F
56°F
66°F
69°F
Elevated instability above weakening cap
Low level warming & moisture advection

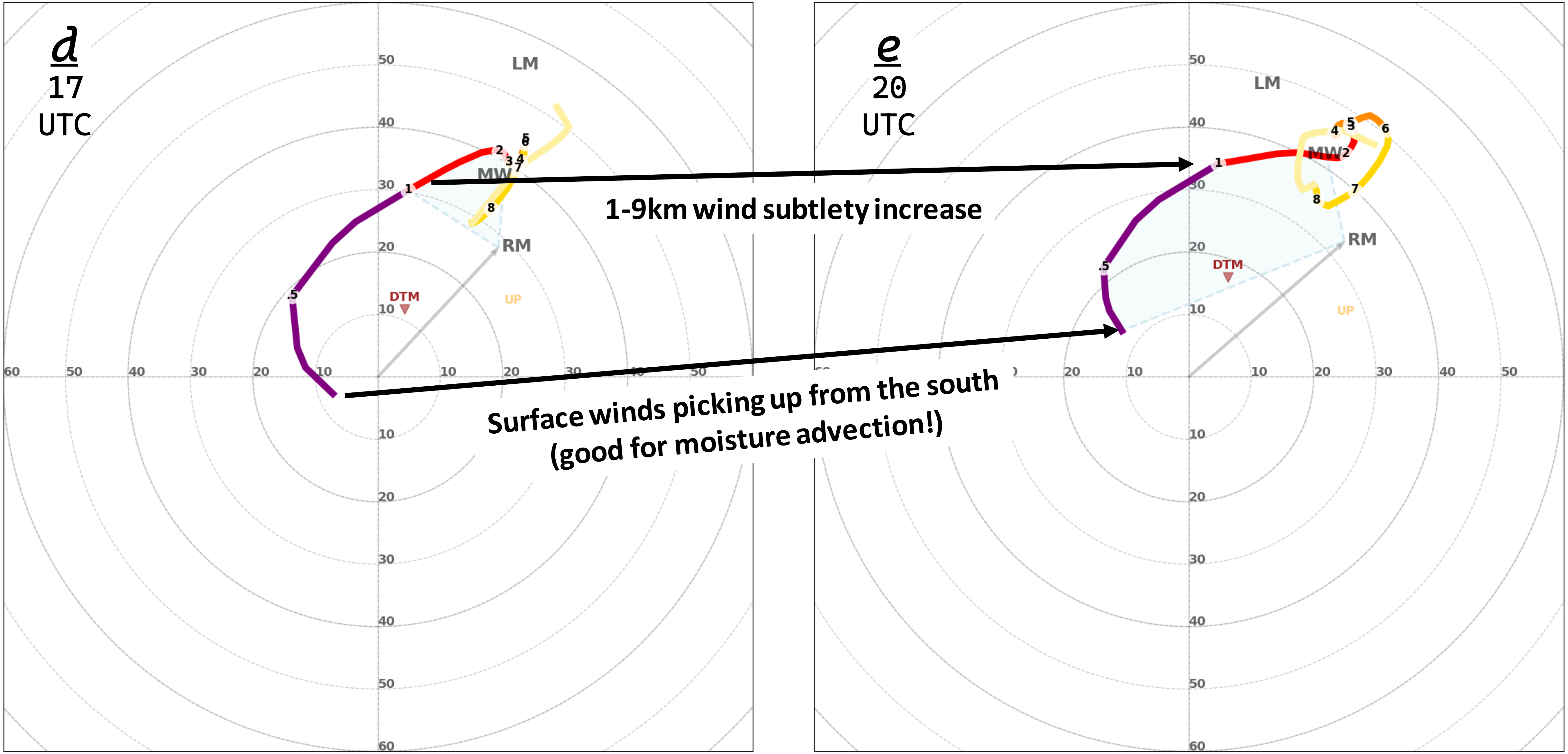

MODEL REANALYSIS VERTICAL PROFILE | 20Z RAP F00
VALID: 20 UTC 20 MAY 2017
West Lafayette, IN | [40.42, -86.93]
b
20 UTC
MODEL REANALYSIS VERTICAL PROFILE | 23Z RAP F00
VALID: 23 UTC 20 MAY 2017
West Lafayette, IN | [40.42, -86.93]
c
23 UTC
PRESSURE (HPA)
TEMPERATURE (C)
←738J/kg
←MUEL
←FRZ
66°F
69°F
←1457J/kg
←571J/kg
←121J/kg
←MULFC
←SBLCL
←PBL
68°F
72°F
Eroded capping =
Nearly free convection
Ascent from approaching shortwave cools mid levels
Low level warming & moisture advection

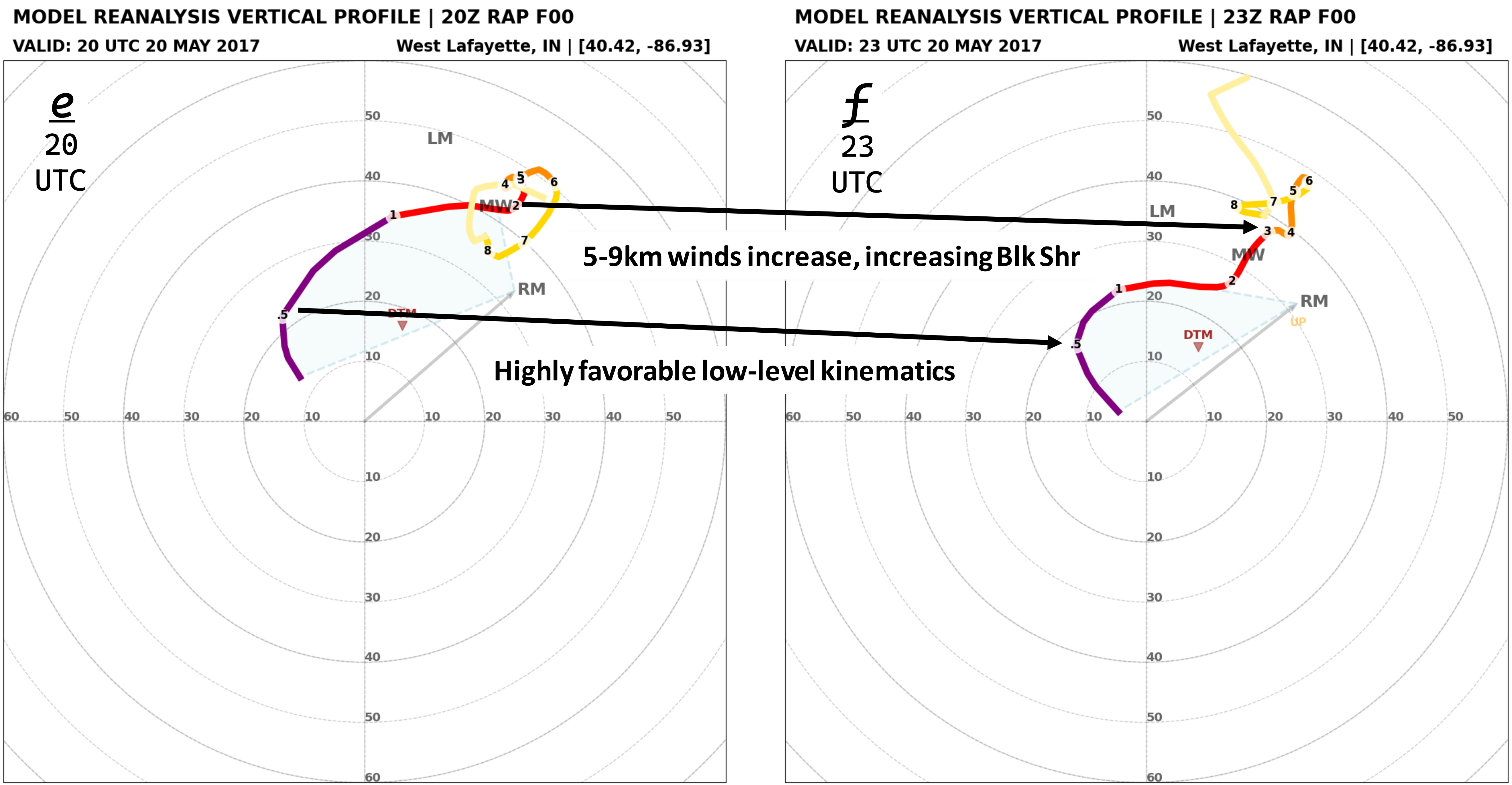
MODEL REANALYSIS VERTICAL PROFILE | 17Z RAP F00

VALID: 17 UTC 20 MAY 2017 West Lafayette, IN | [40.42, -86.93]

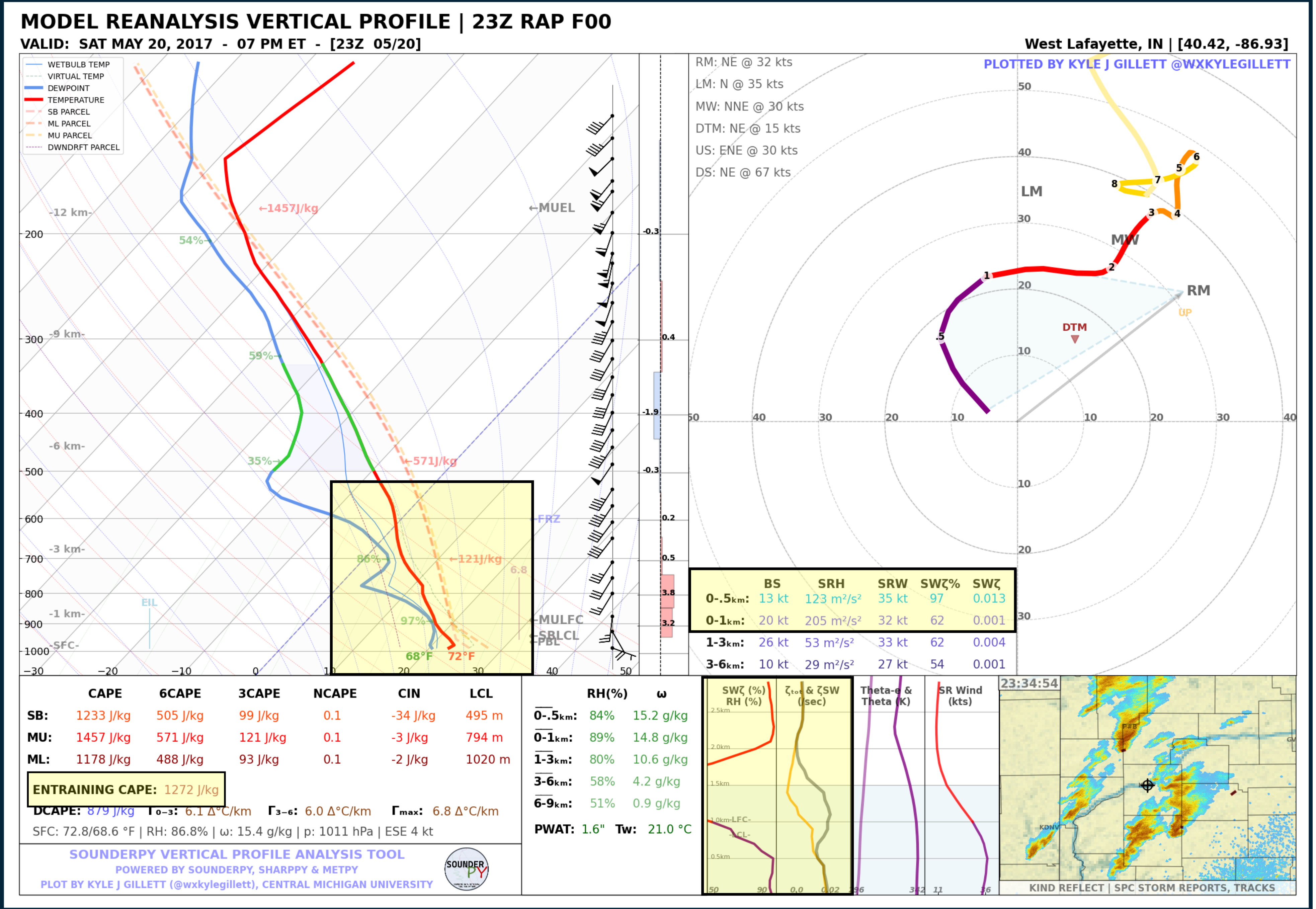
MODEL REANALYSIS VERTICAL PROFILE | 20Z RAP F00

VALID: 20 UTC 20 MAY 2017 West Lafayette, IN | [40.42, -86.93]





MODEL REANALYSIS VERTICAL PROFILE | 20Z RAP F00
VALID: 20 UTC 20 MAY 2017
West Lafayette, IN | [40.42, -86.93]
e
20 UTC
LM
MW
RM
DTM
MODEL REANALYSIS VERTICAL PROFILE | 23Z RAP F00
VALID: 23 UTC 20 MAY 2017
West Lafayette, IN | [40.42, -86.93]
f
23 UTC
LM
MW
RM
DTM
5-9km winds increase, increasing Blk Shr
Highly favorable low-level kinematics



RAP REANALYSIS FULL VERTICAL PROFILE

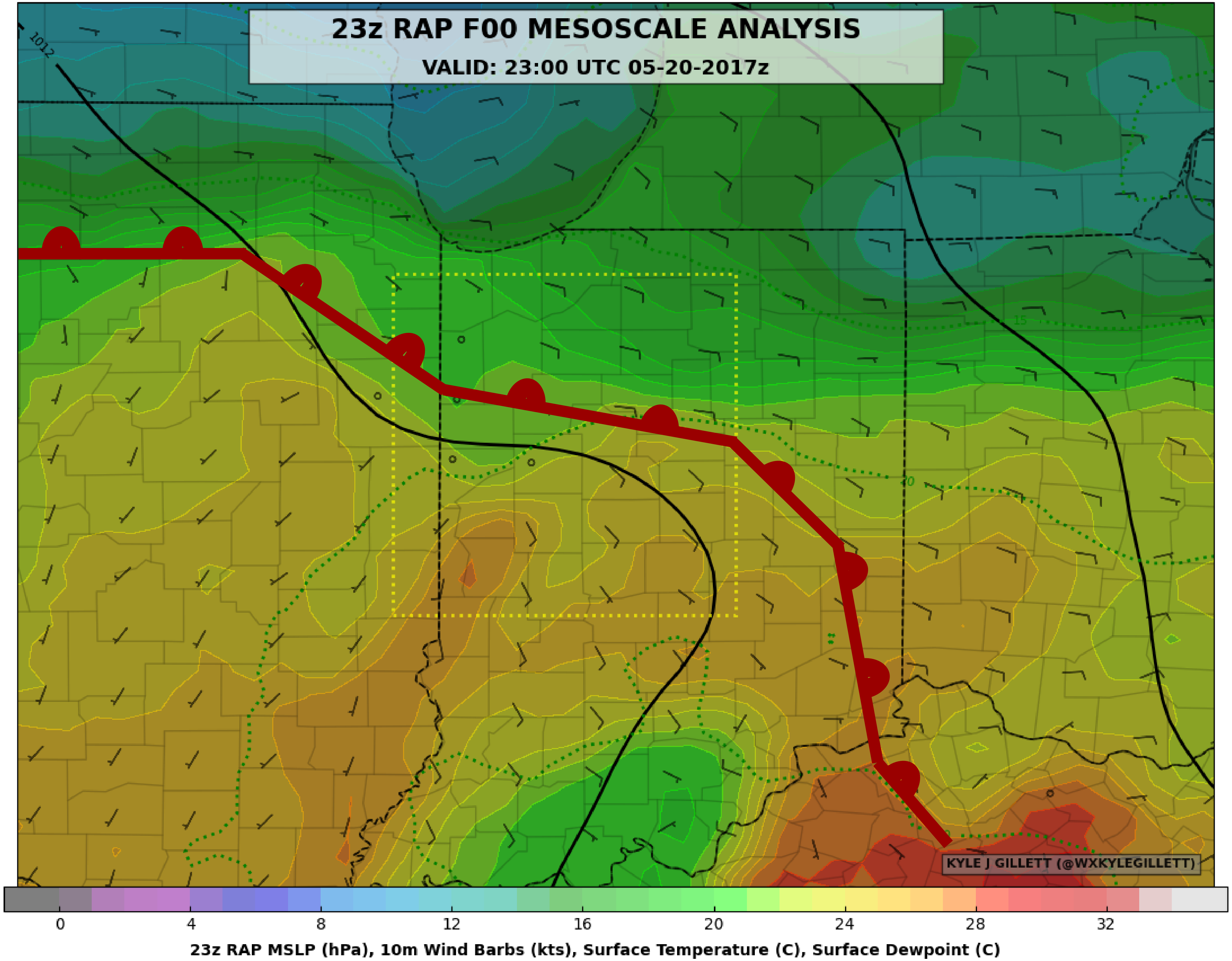
23 UTC 20 May 2017

KLAF – Lafayette, IN

1. Large Low-level instability
2. Moist low-mid levels
3. Moderate low-level horizontal vorticity
4. Large low-level storm relative wind
5. Overall, highly favorable kinematics and thermodynamics for the right storm.

c. ENVIRONMENT ANALYSIS

3. MESOSCALE ANALYSIS

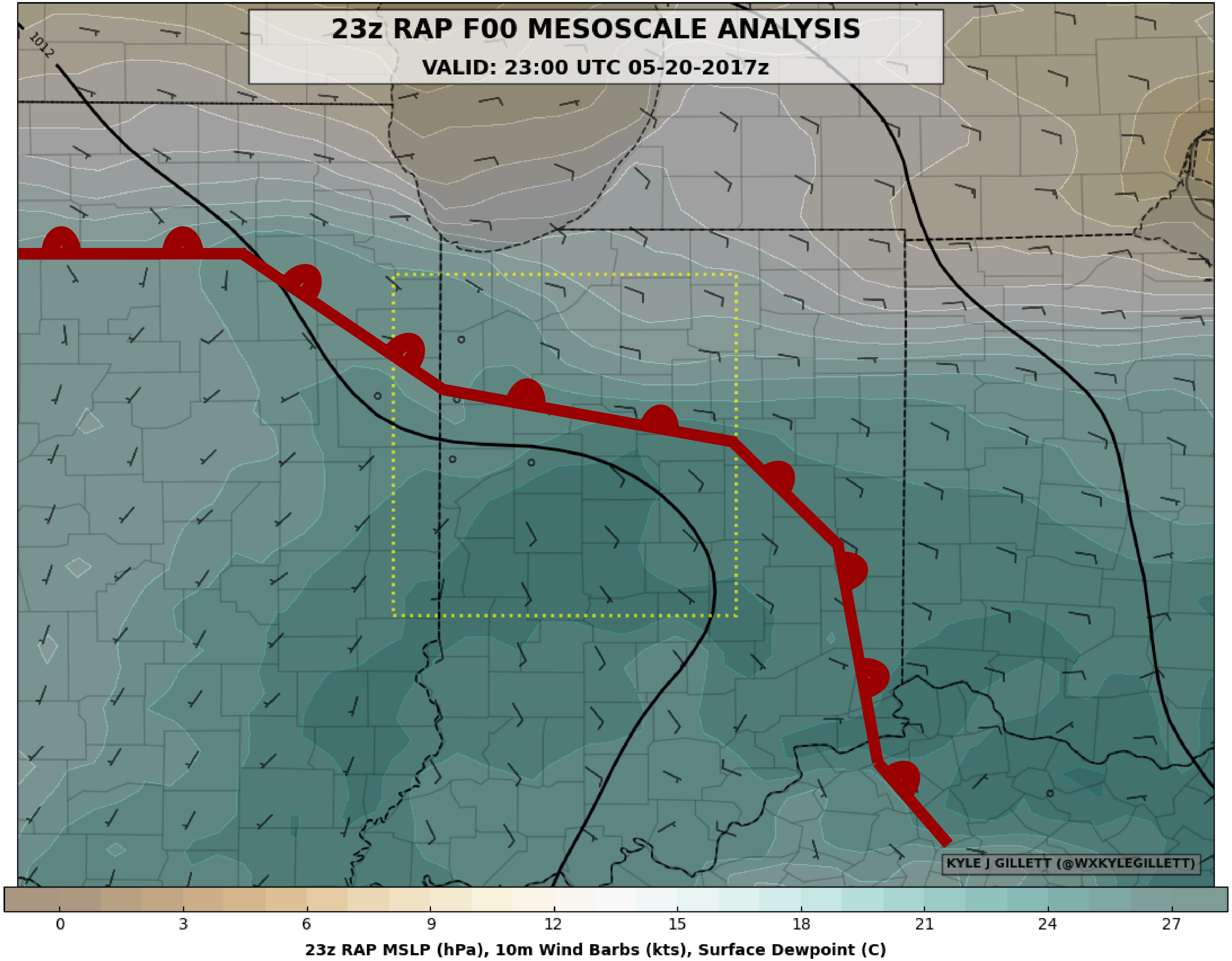


MESOANALYSIS

23 UTC 20 May 2017 RAP

MSLP
10m Wind Barbs
2m Temperature (fill)
2m Dewpoint (dash)

1. Warm front draped across central Indiana.
2. Backed low-level flow

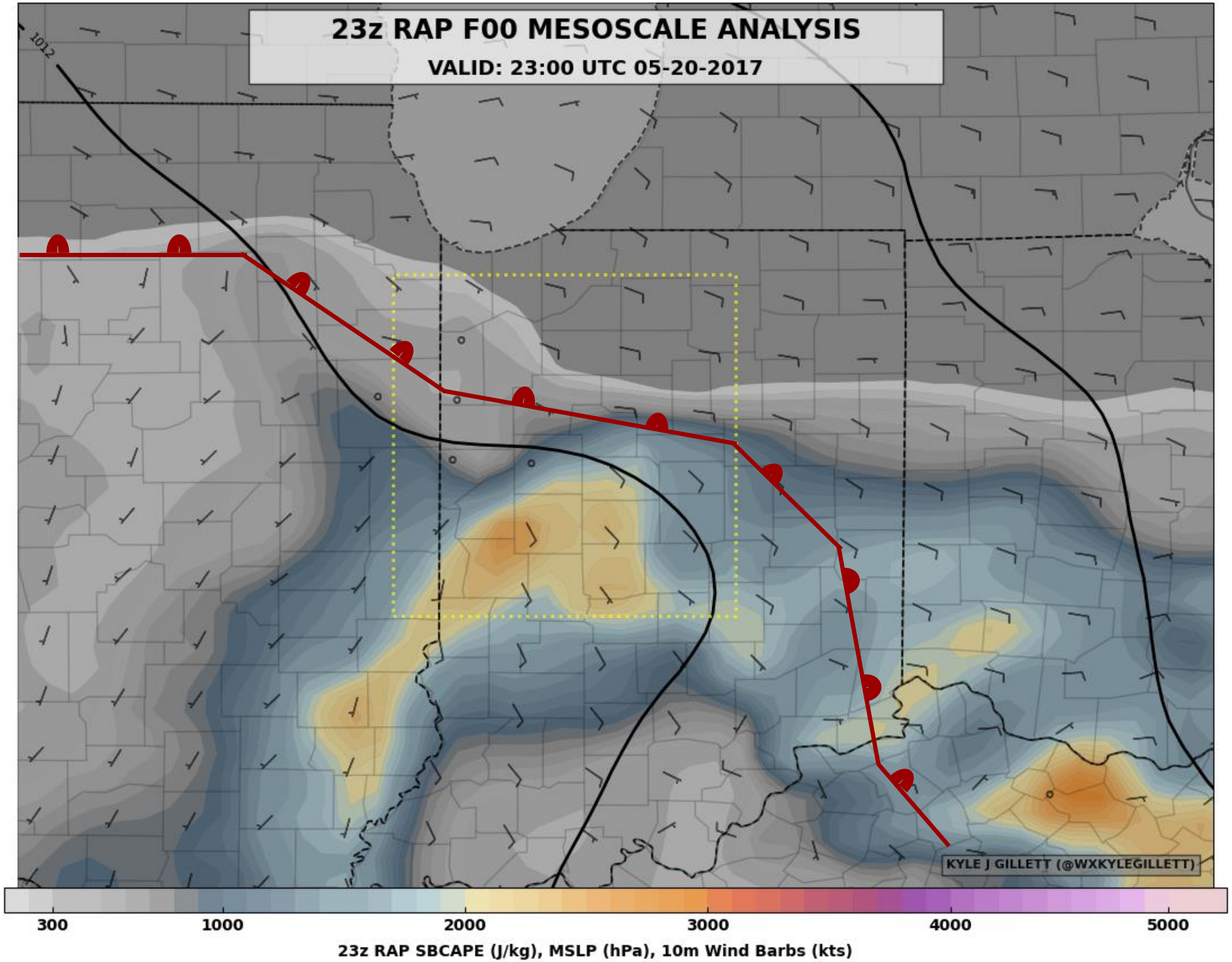


MESOANALYSIS

23 UTC 20 May 2017 RAP

MSLP
10m Wind Barbs
2m Dewpoint (fill)

1. Warm front draped across central Indiana.
2. Low-level moisture transport

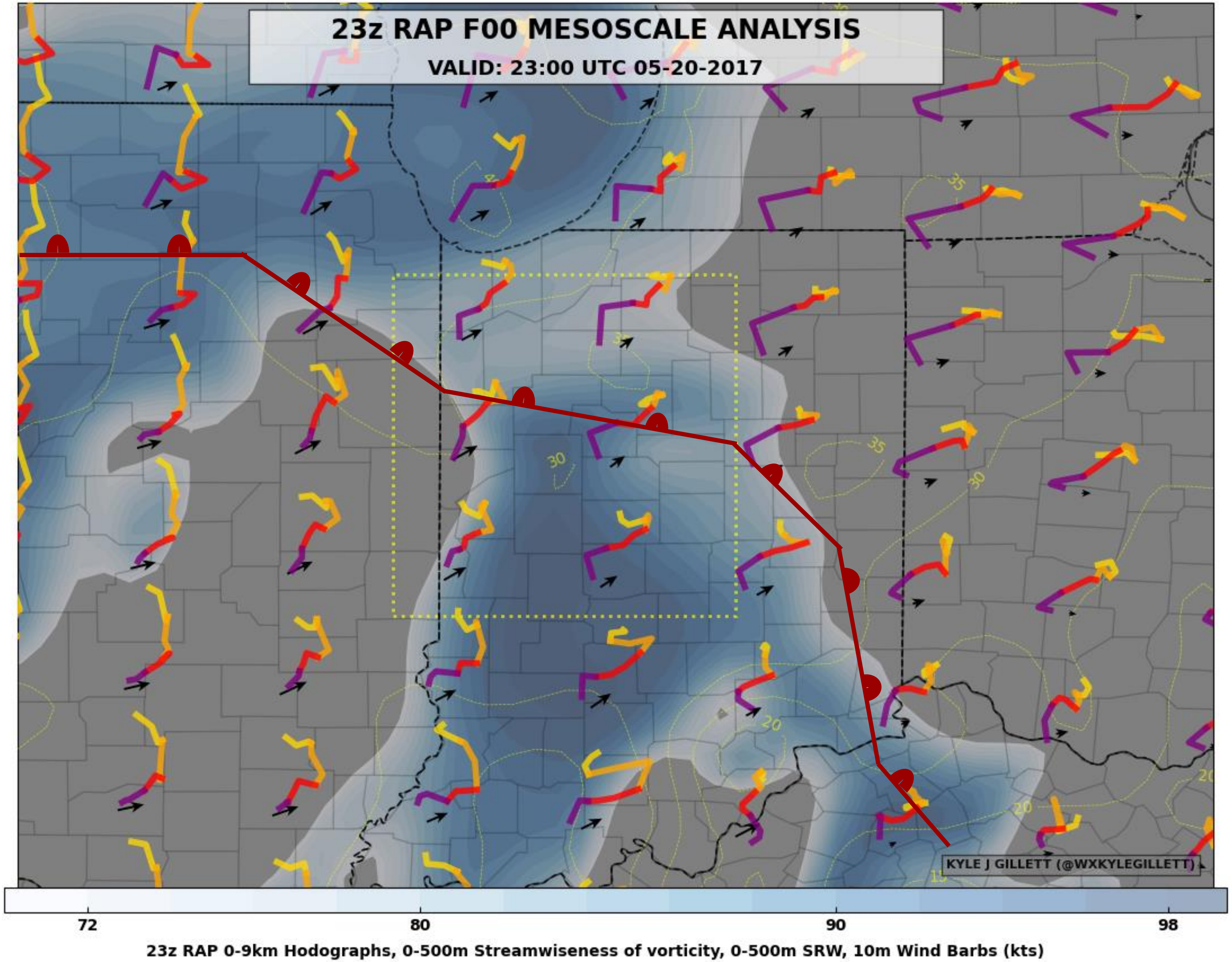


MESOANALYSIS

23 UTC 20 May 2017 RAP

MSLP
10m Wind Barbs
Surface-Based CAPE (fill)

1. Low level diurnal heating and low-level moisture advection support large CAPE along warm front.



MESOANALYSIS

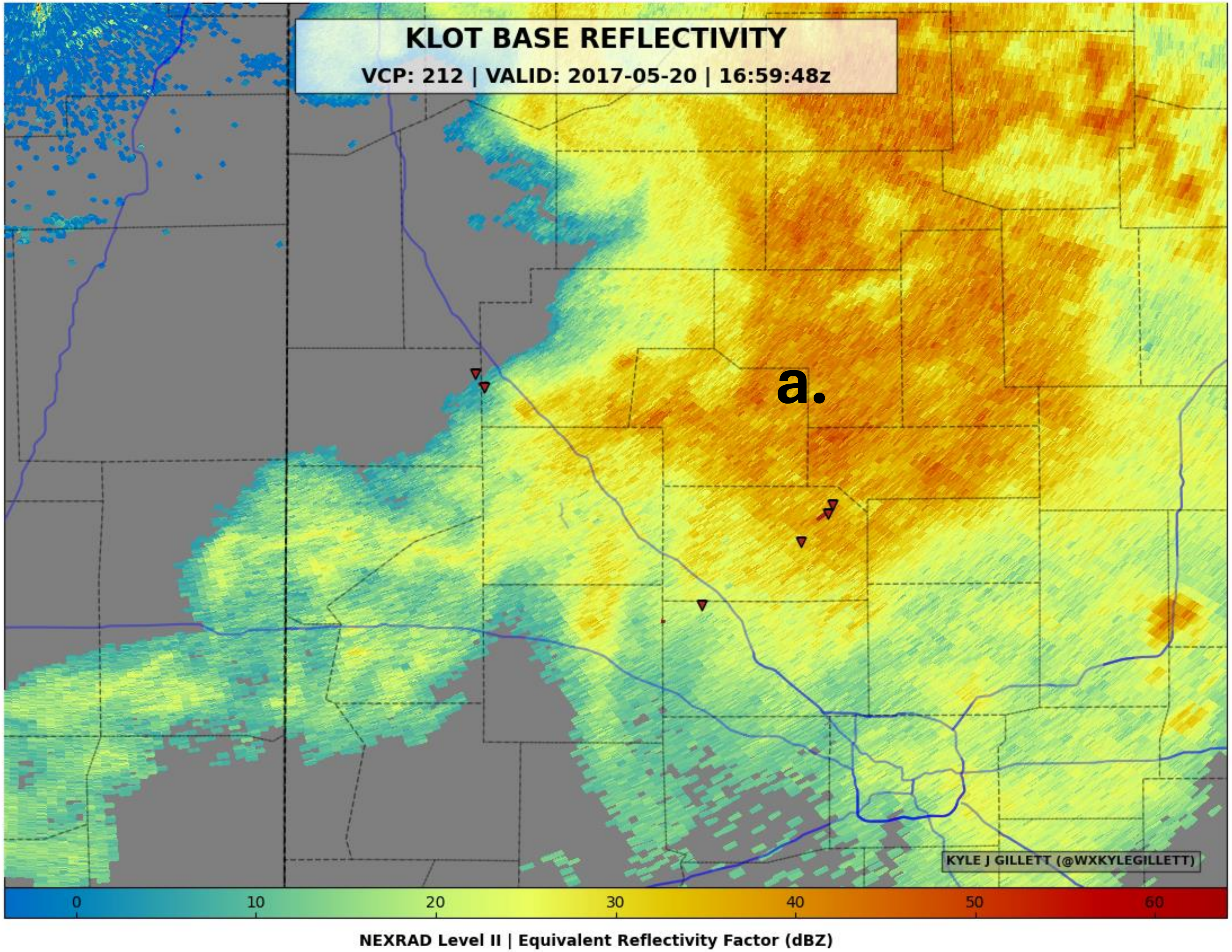
23 UTC 20 May 2017 RAP

0-9km Hodographs
0-500m Streamwiseness (fill)
0-500m Storm Relative Wind (contour)

1. Enlarged hodographs near the warm front
2. Large low-level streamwiseness
3. Large low-level storm relative wind.

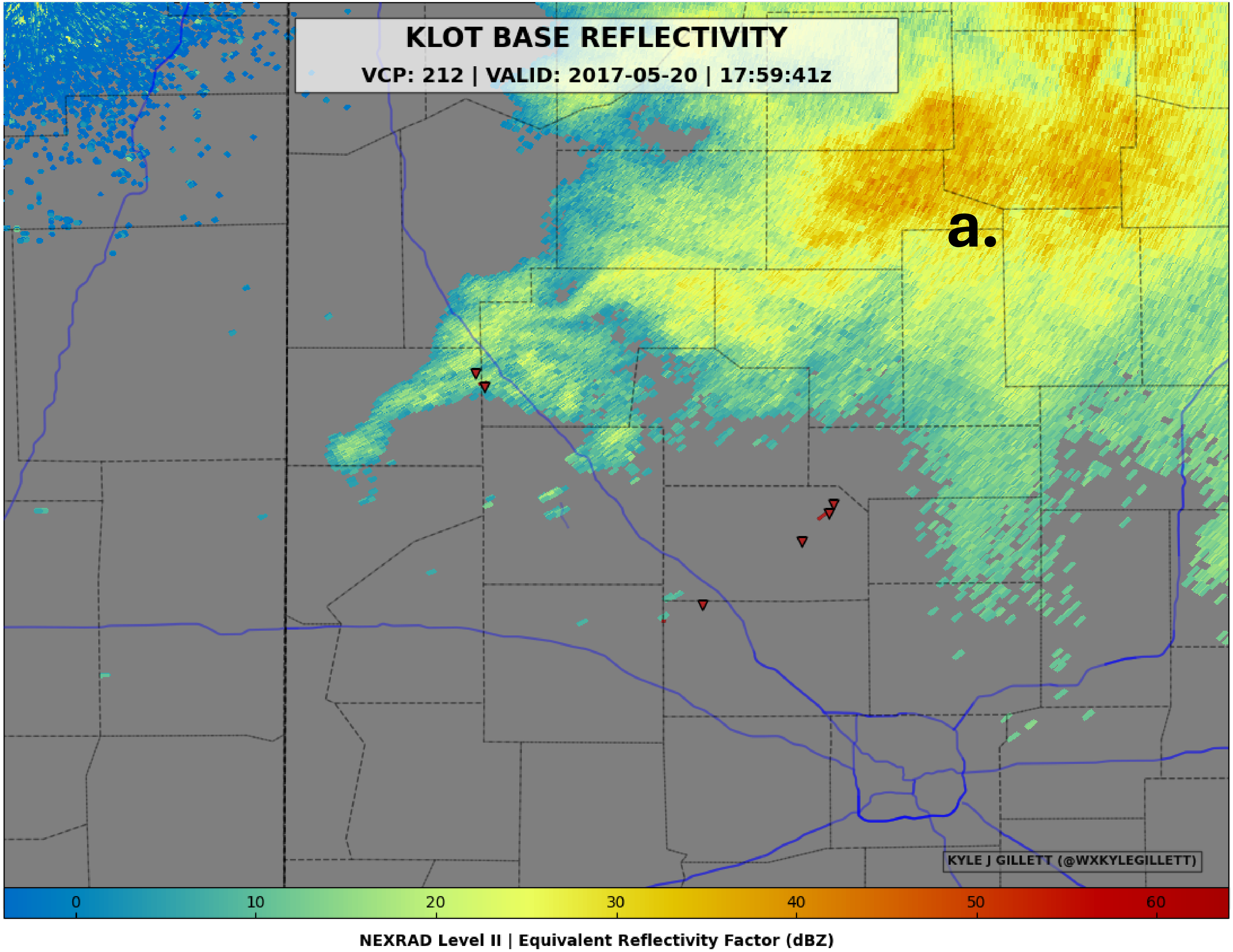
0-1km 1-3km 3-6km 6-9km

d. RADAR EVOLUTION



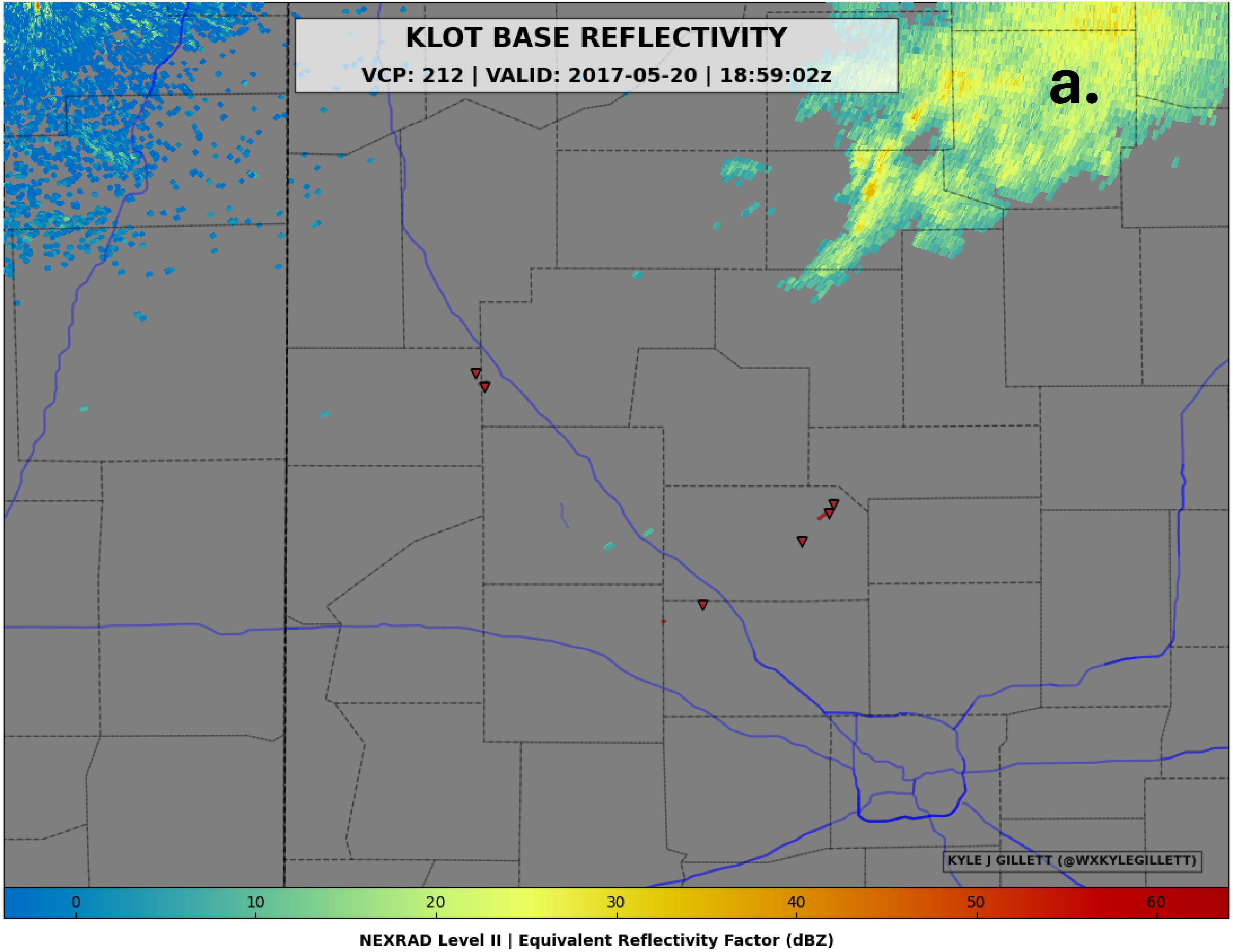
17 UTC 20 May

1. Pt. a: stratiform rain left behind by morning convection



18 UTC 20 May

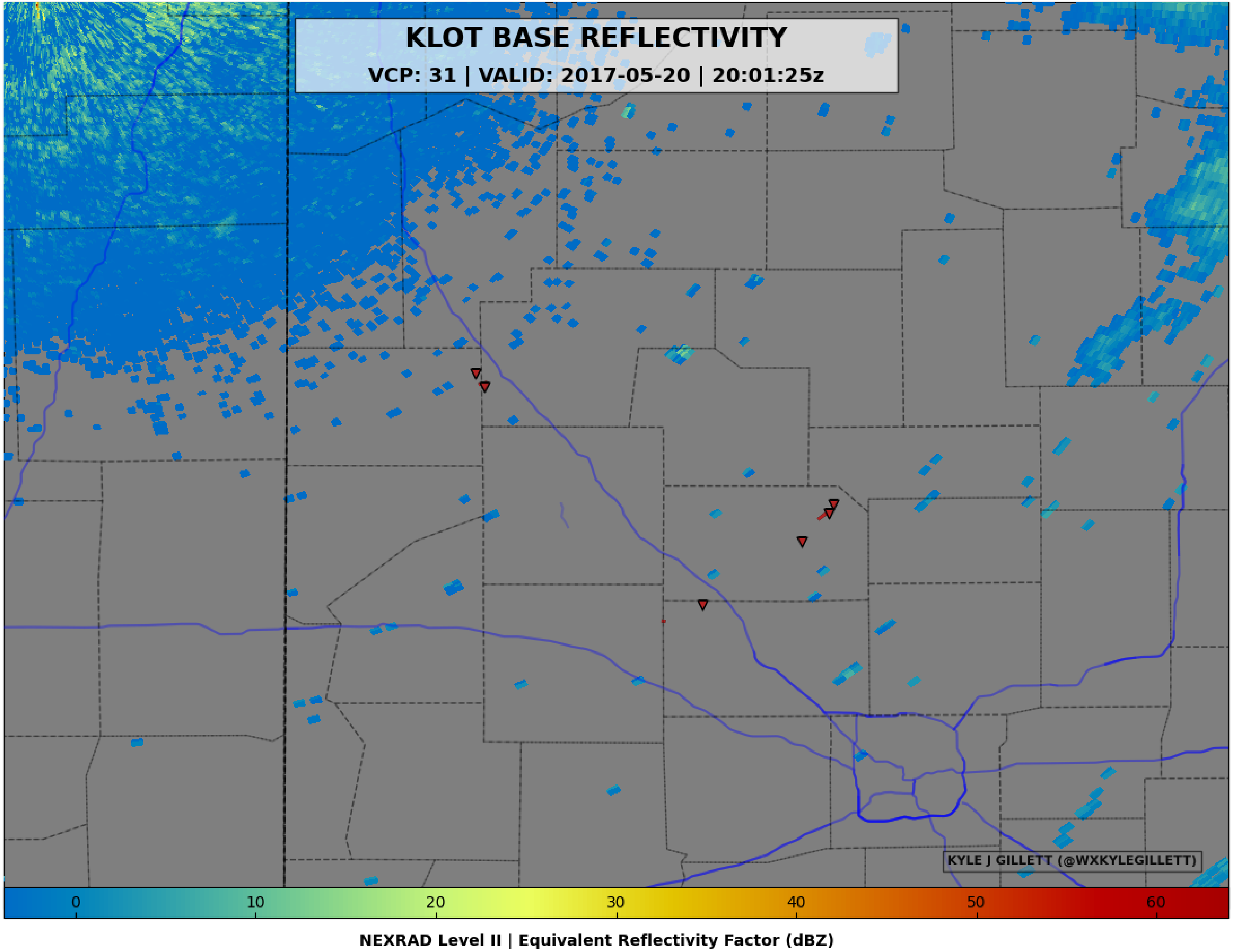
1. Pt. a: stratiform rain left behind by morning convection



19 UTC 20 May

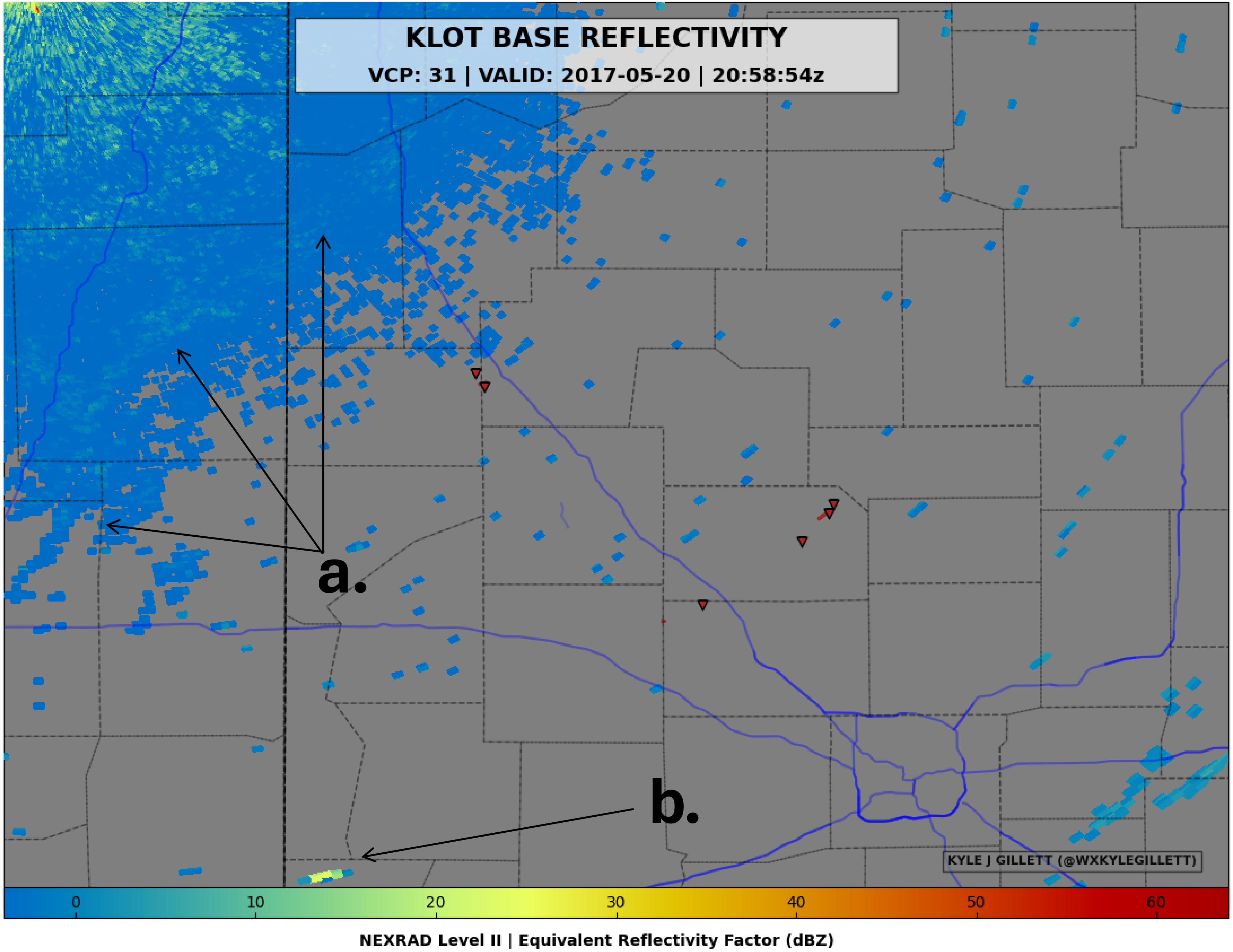
1. Pt. a: stratiform rain left behind by morning convection

2. Clearing conditions behind departing rain heading into peak afternoon heating



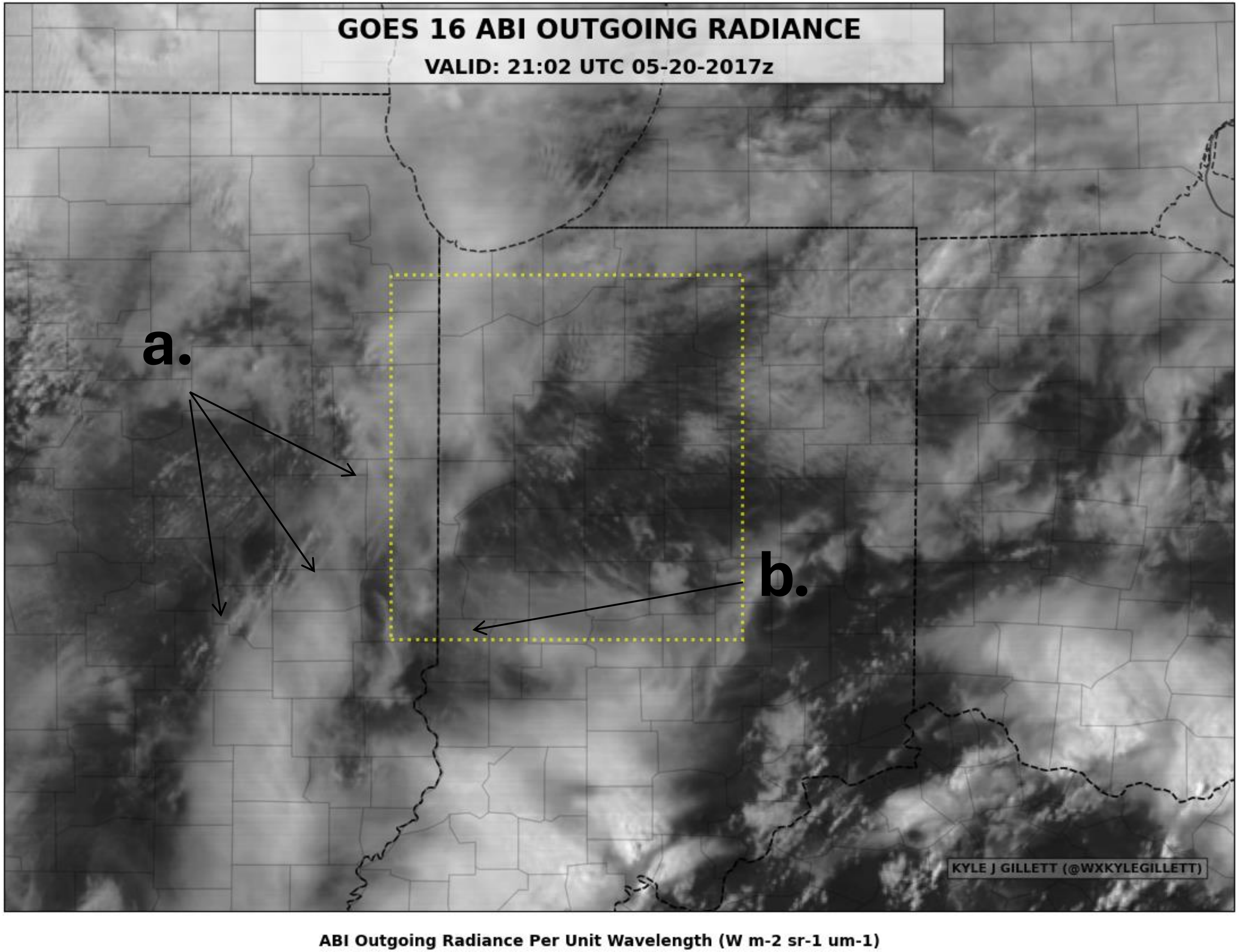
20 UTC 20 May

1. Clear conditions during peak afternoon heating
2. VCP Change to 31



21 UTC 20 May

1. Pt. a: Subtle boundary draped from NNE to SSW across eastern IL & NW IN.
2. Clear conditions during peak afternoon heating
3. Pt. b: first indications of CI attempts WSW of Indianapolis

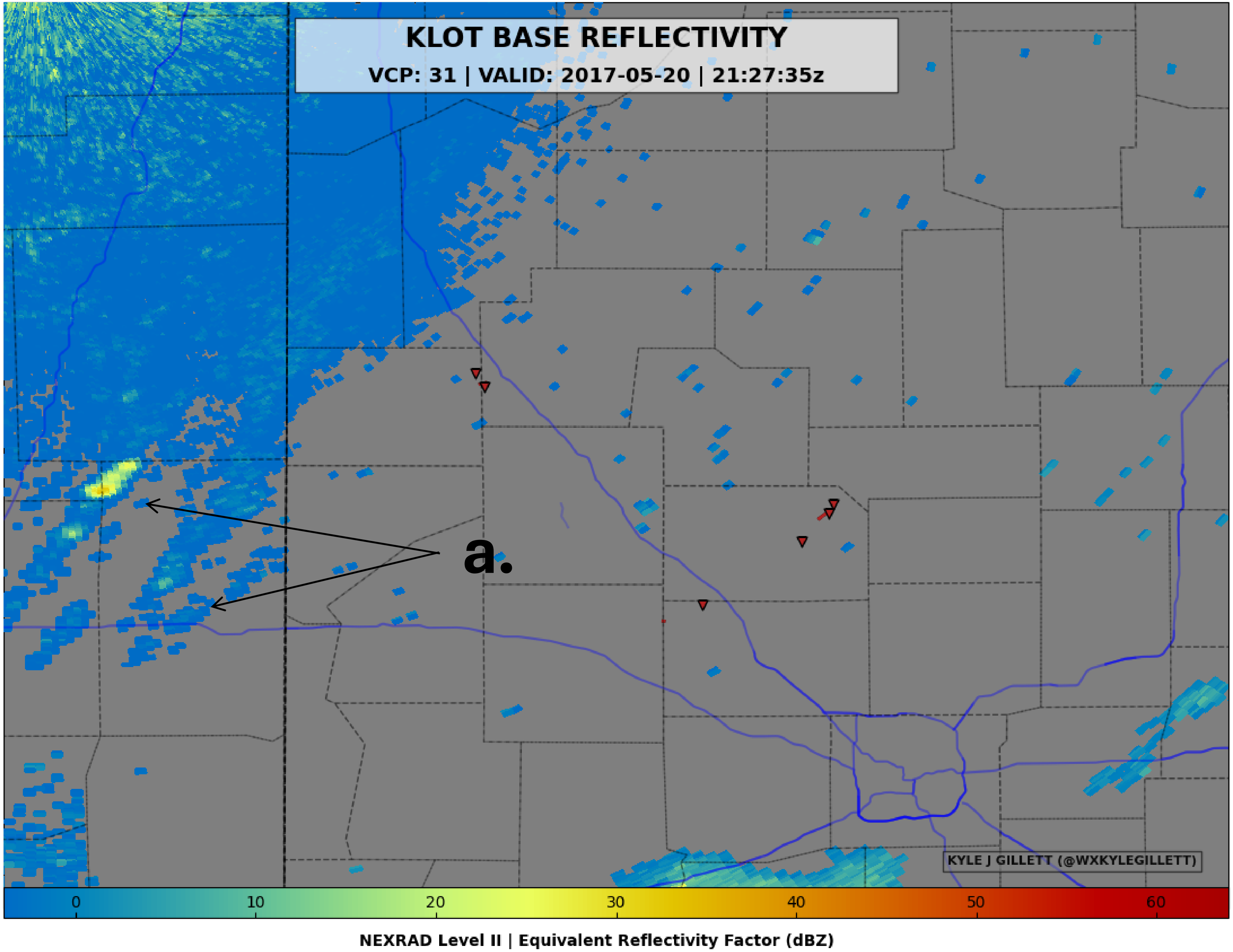


21 UTC 20 May

1. Pt. a: Subtle boundary draped from NNE to SSW across eastern IL & NW IN.

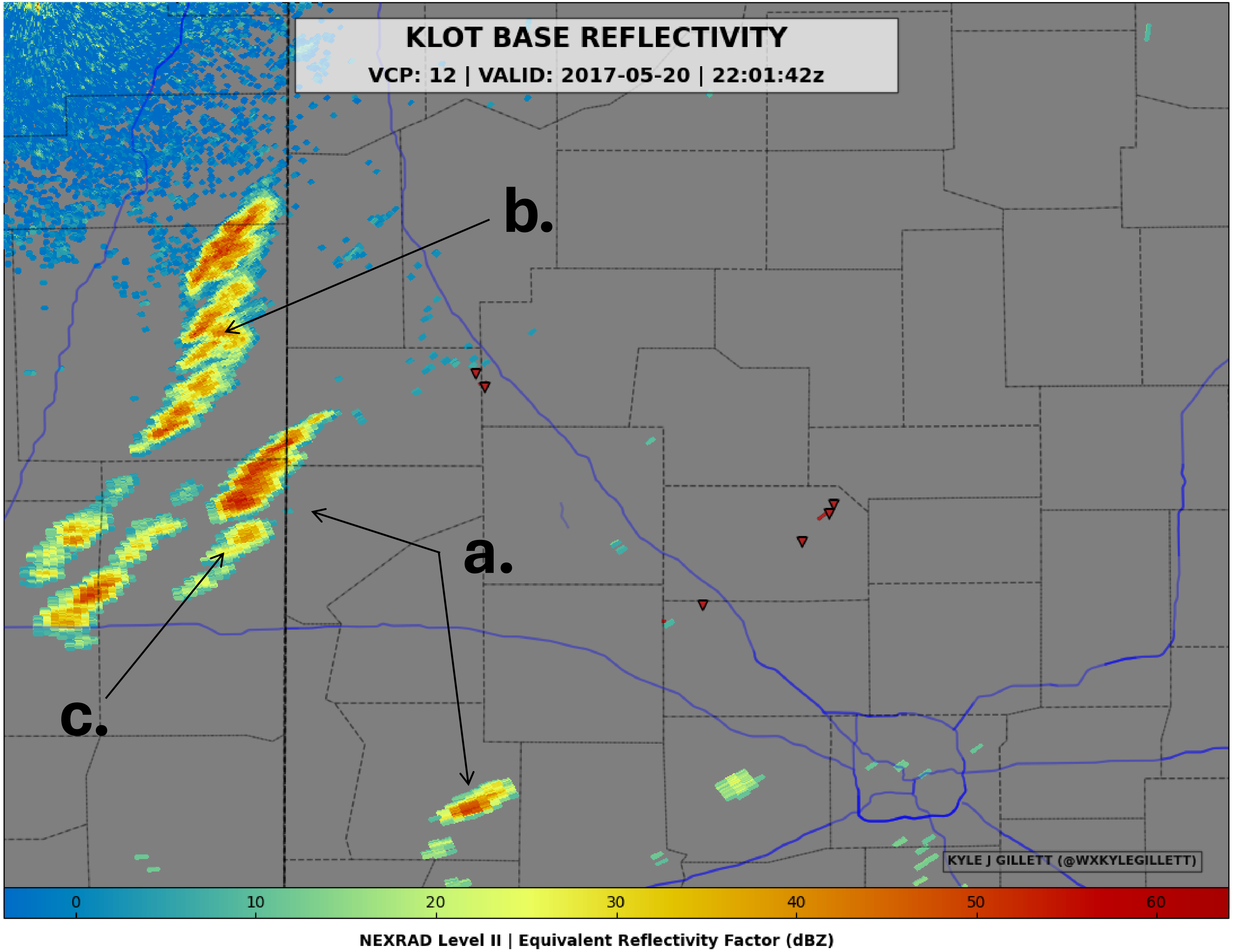
2. Clear conditions during peak afternoon heating

3. Pt. b: first indications of CI attempts WSW of Indianapolis



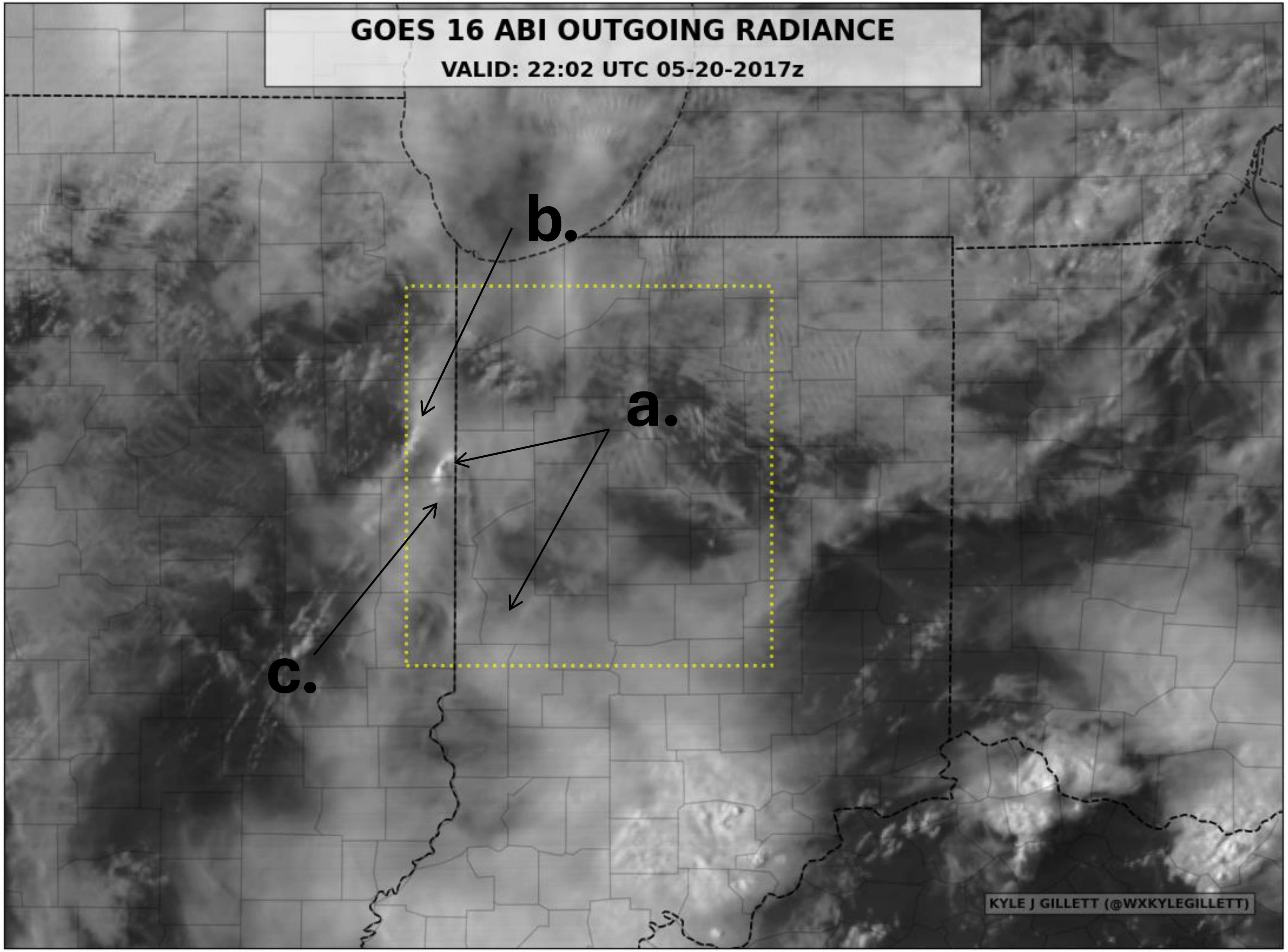
21:30 UTC 20 May

1. Pt. a: First indications of CI WSW of Indianapolis
2. Clear conditions during peak afternoon heating



22 UTC 20 May

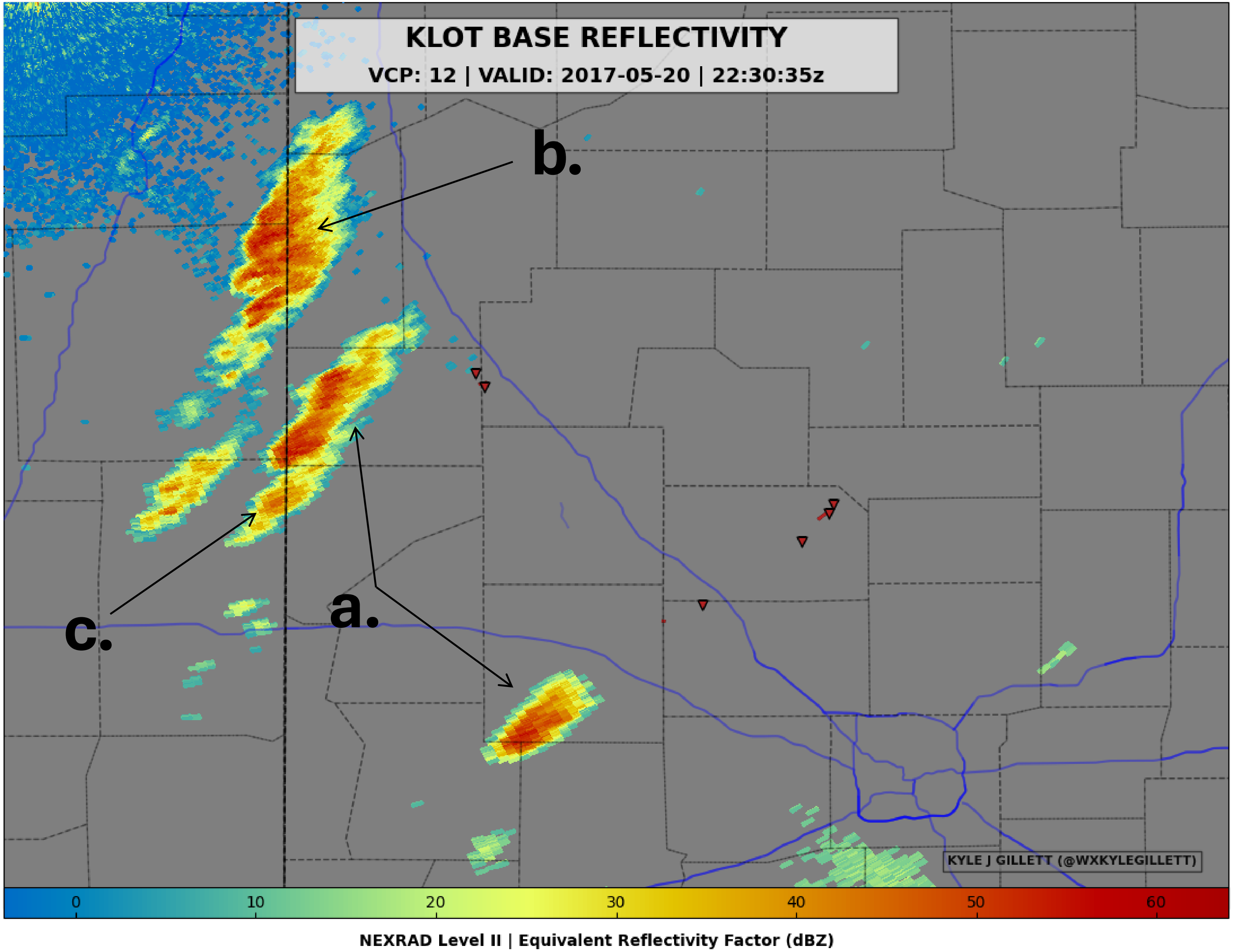
1. VCP change to 12
2. <u>Pt. a</u>: Two main discrete development areas with "open warm sector access"
3. <u>Pt. b</u>: more linear, clustered convection along cold front.
4. <u>Pt. c</u>: Possibly favorable future rear-flank merger into northern supercell



ABI Outgoing Radiance Per Unit Wavelength (W m-2 sr-1 um-1)

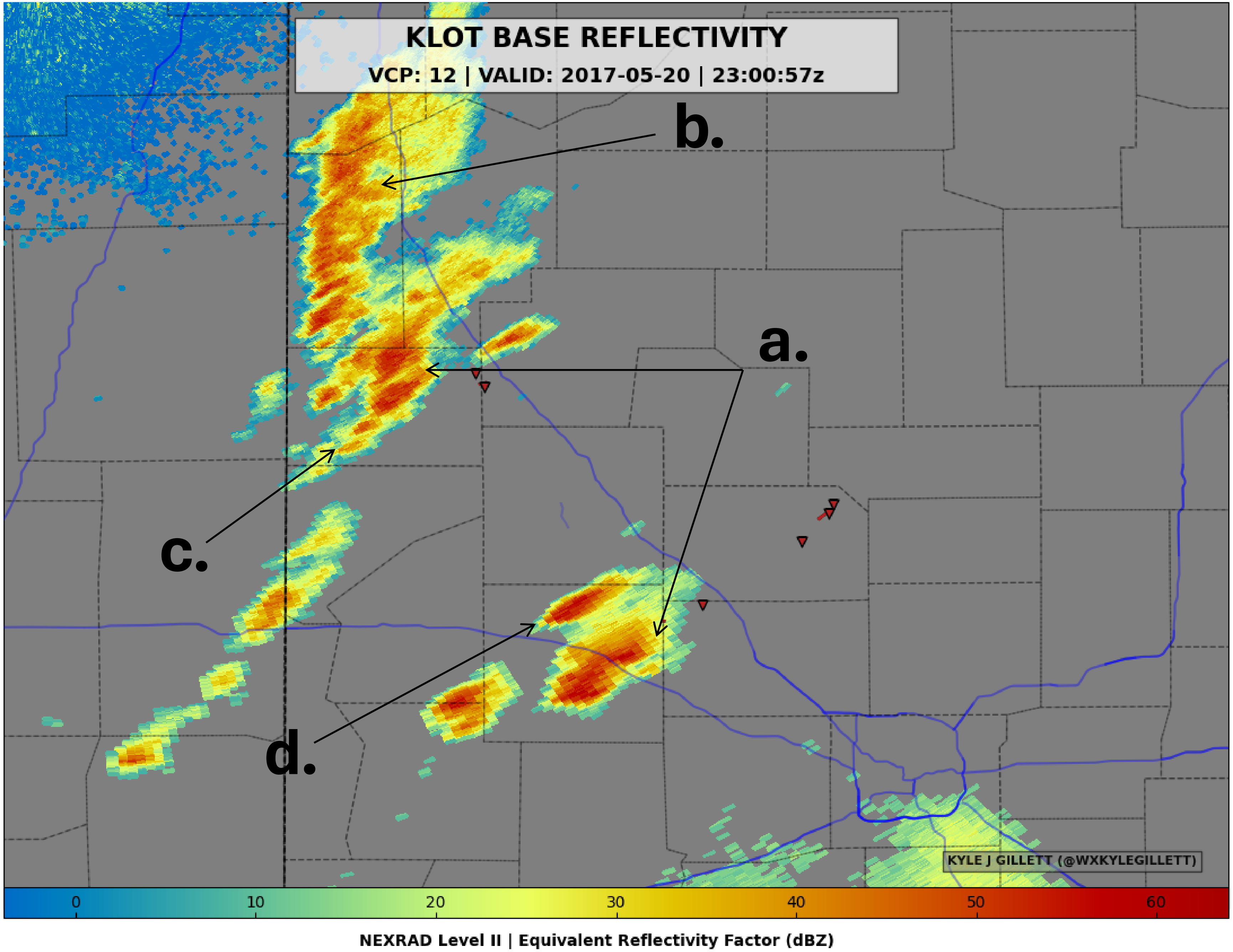
22 UTC 20 May

1. VCP change to 12
2. Pt. a: Two main discrete development areas with "open warm sector access"
3. Pt. b: more linear, clustered convection along cold front.
4. Pt. c: Possibly favorable future rear-flank merger into northern supercell



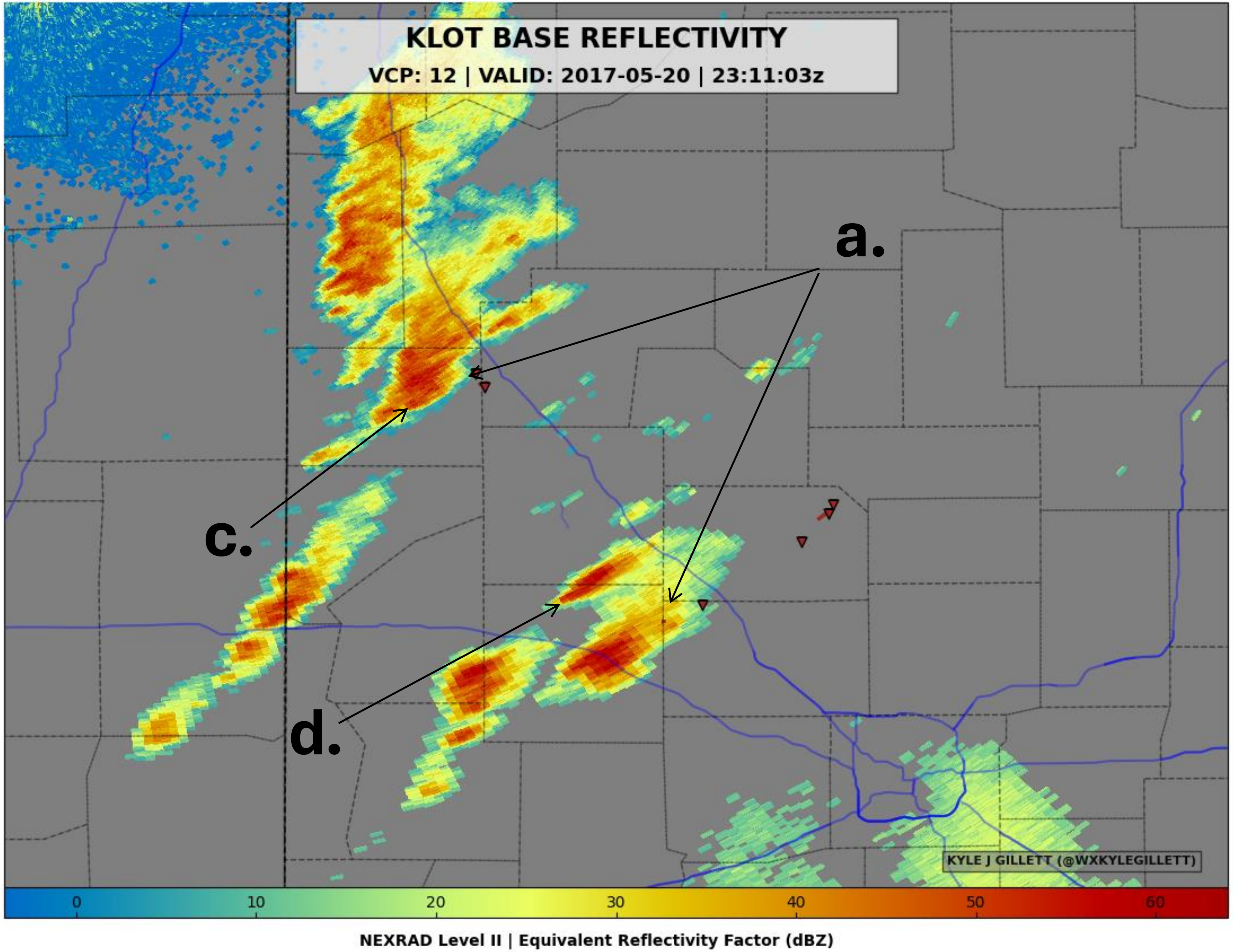
22:30 UTC 20 May

1. Pt. a: “main storms”
2. Pt. b: more linear, clustered convection along cold front.
3. Pt. c: Possibly favorable rear-flank merger into northern supercell



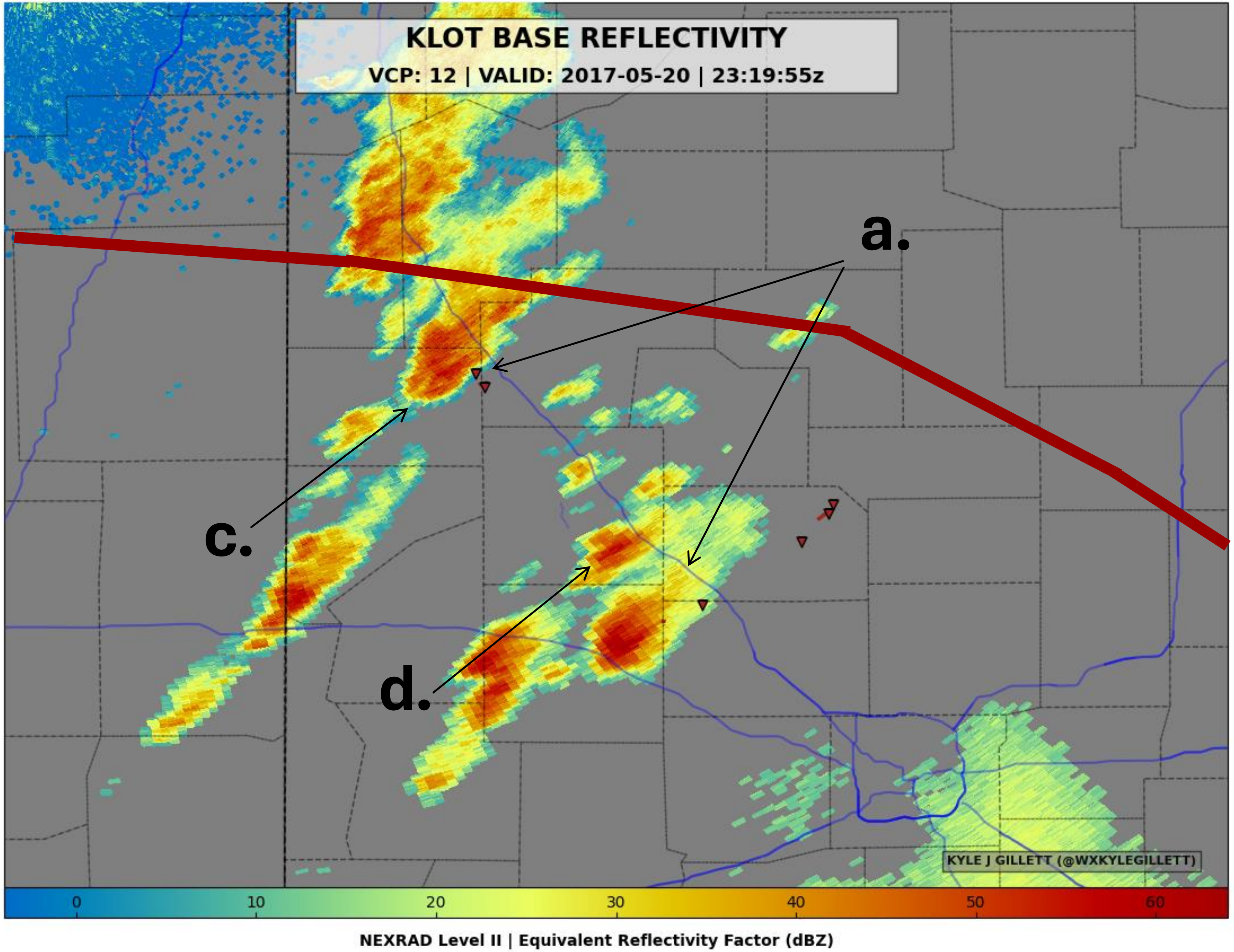
23 UTC 20 May

1. Pt. a: Two main supercells of interest
2. Pt. b: more linear, clustered convection along cold front.
3. Pt. c: Possibly favorable rear flank merger on northern supercell. Main cell briefly shrinks & becomes disorganized.
4. Pt. d: left split from the southern supercell



23:10 UTC 20 May

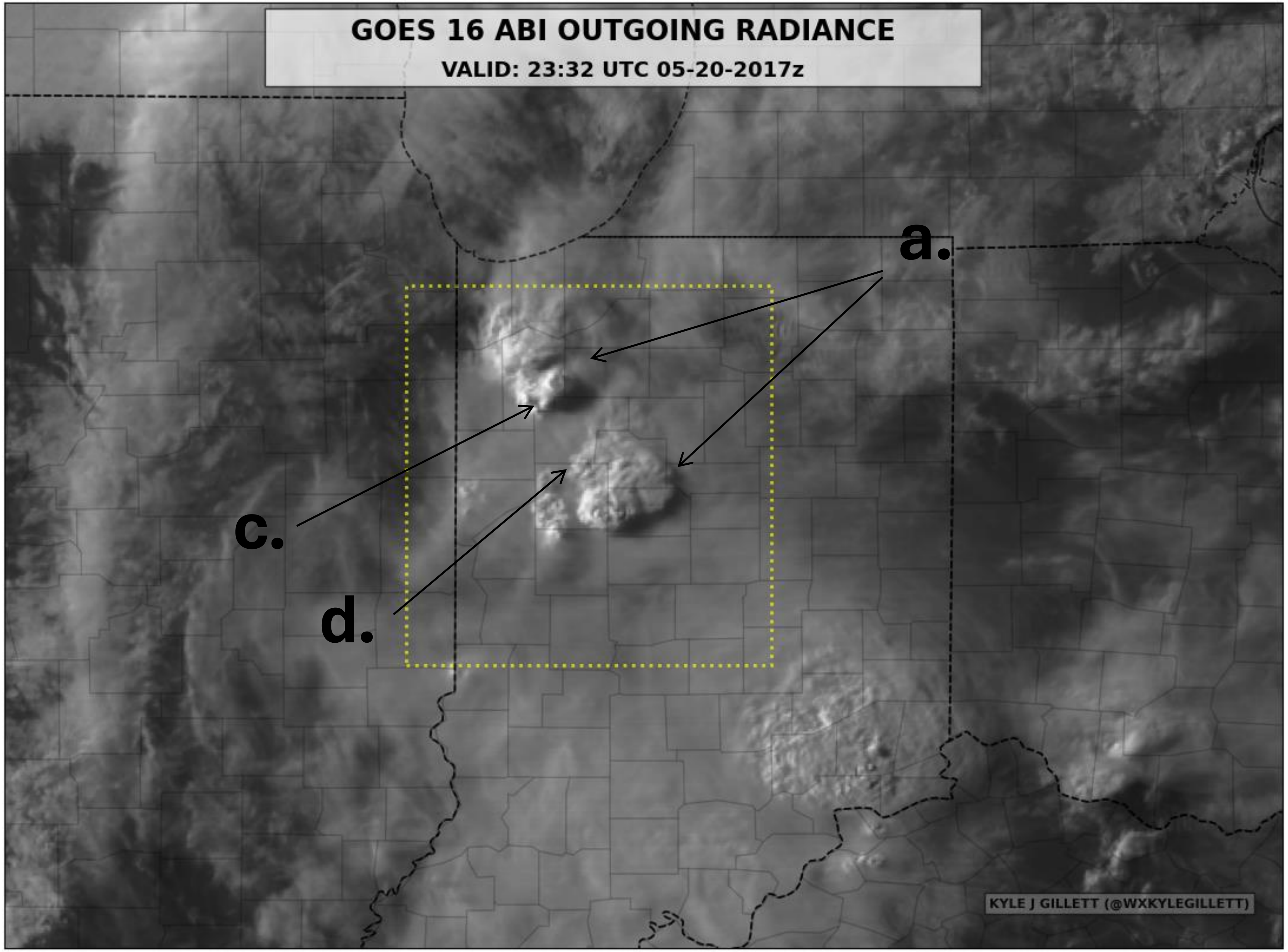
1. Pt. a: Two main supercells
2. Pt. c: Northern supercell ingests merging shower, begins to organize again
3. Pt.d: Left split from southern supercell



23:20 UTC 20 May

1. Pt. a: Two main supercells
2. Pt. c: Merger is complete & the northern supercell is at its strongest point
3. Pt.d: Left split from southern supercell

23z Warm Front Location

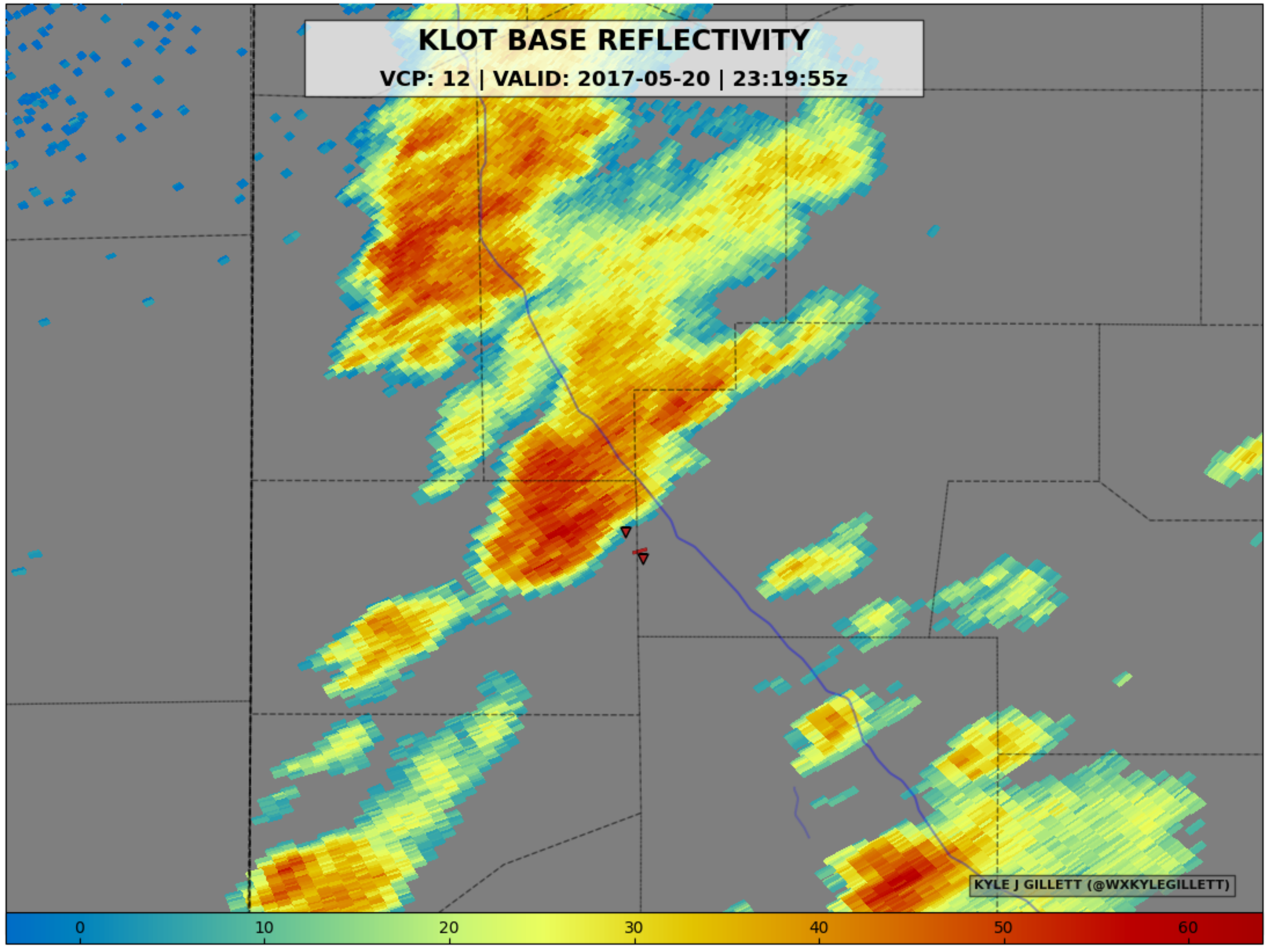


ABI Outgoing Radiance Per Unit Wavelength (W m-2 sr-1 um-1)

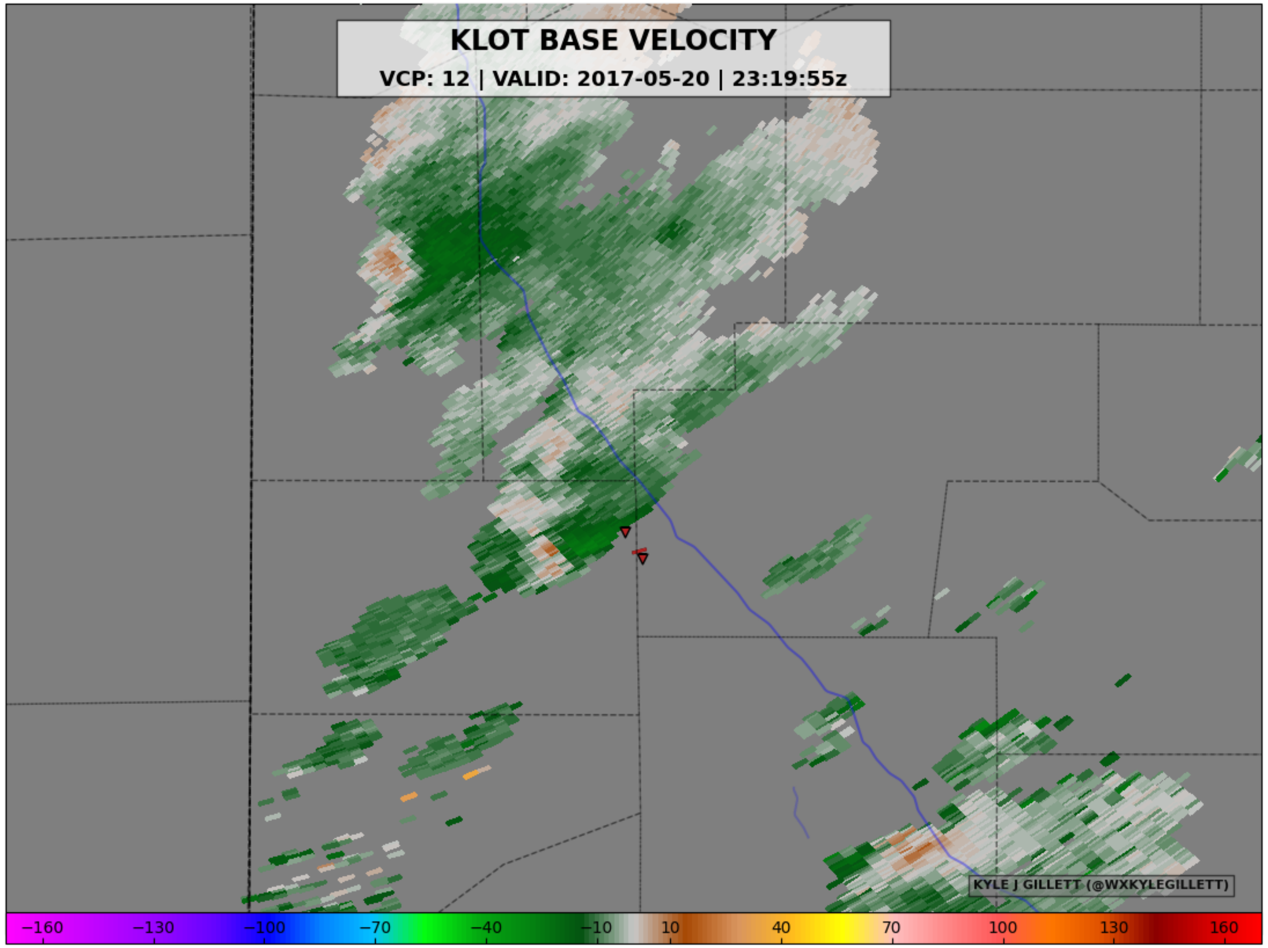
23:20 UTC 20 May

1. Pt. a: Two main supercells
2. Pt. c: Merger is complete & the northern supercell is at its strongest point
3. Pt.d: Left split from southern supercell

23:20 UTC 20 May



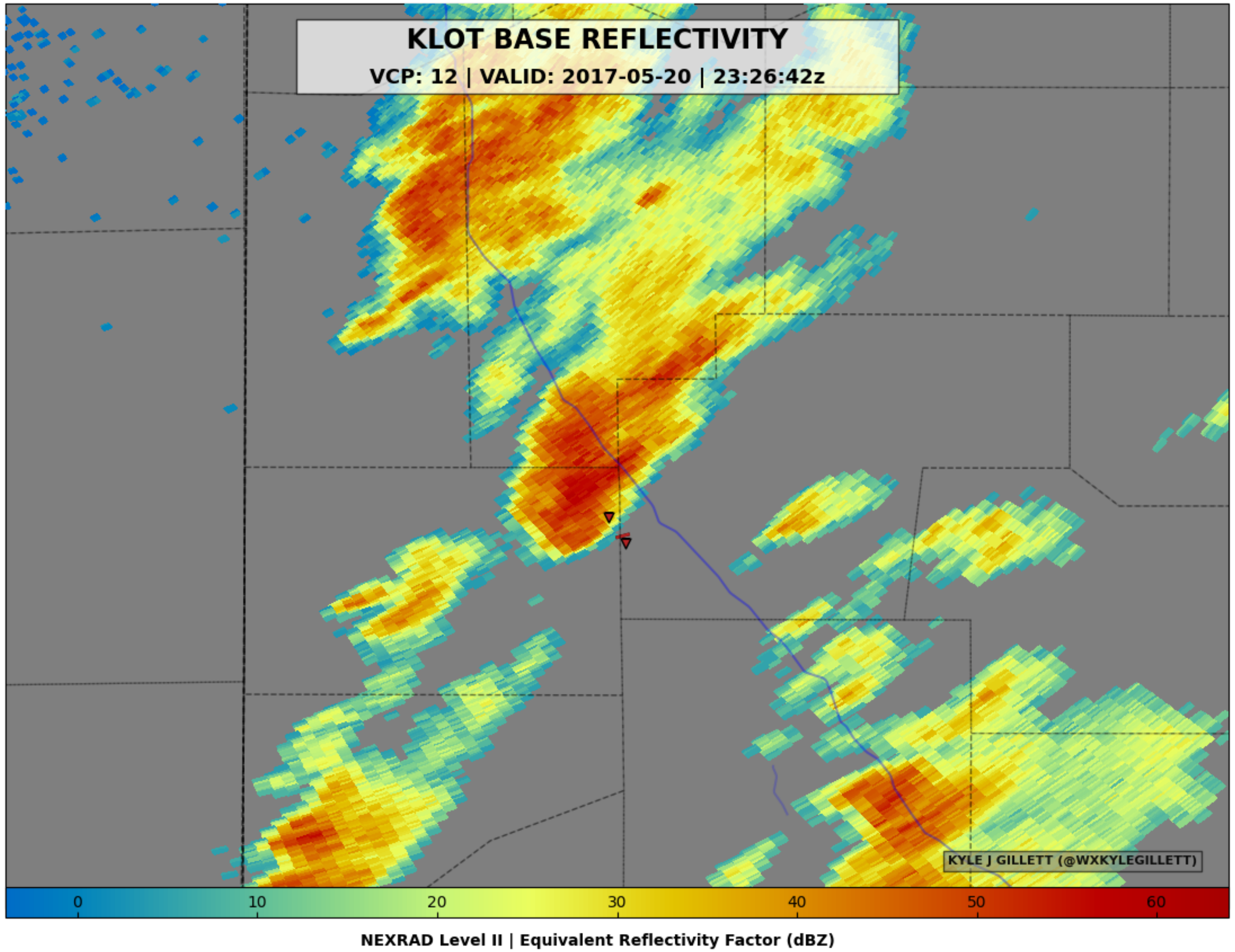
NEXRAD Level II | Equivalent Reflectivity Factor (dBZ)

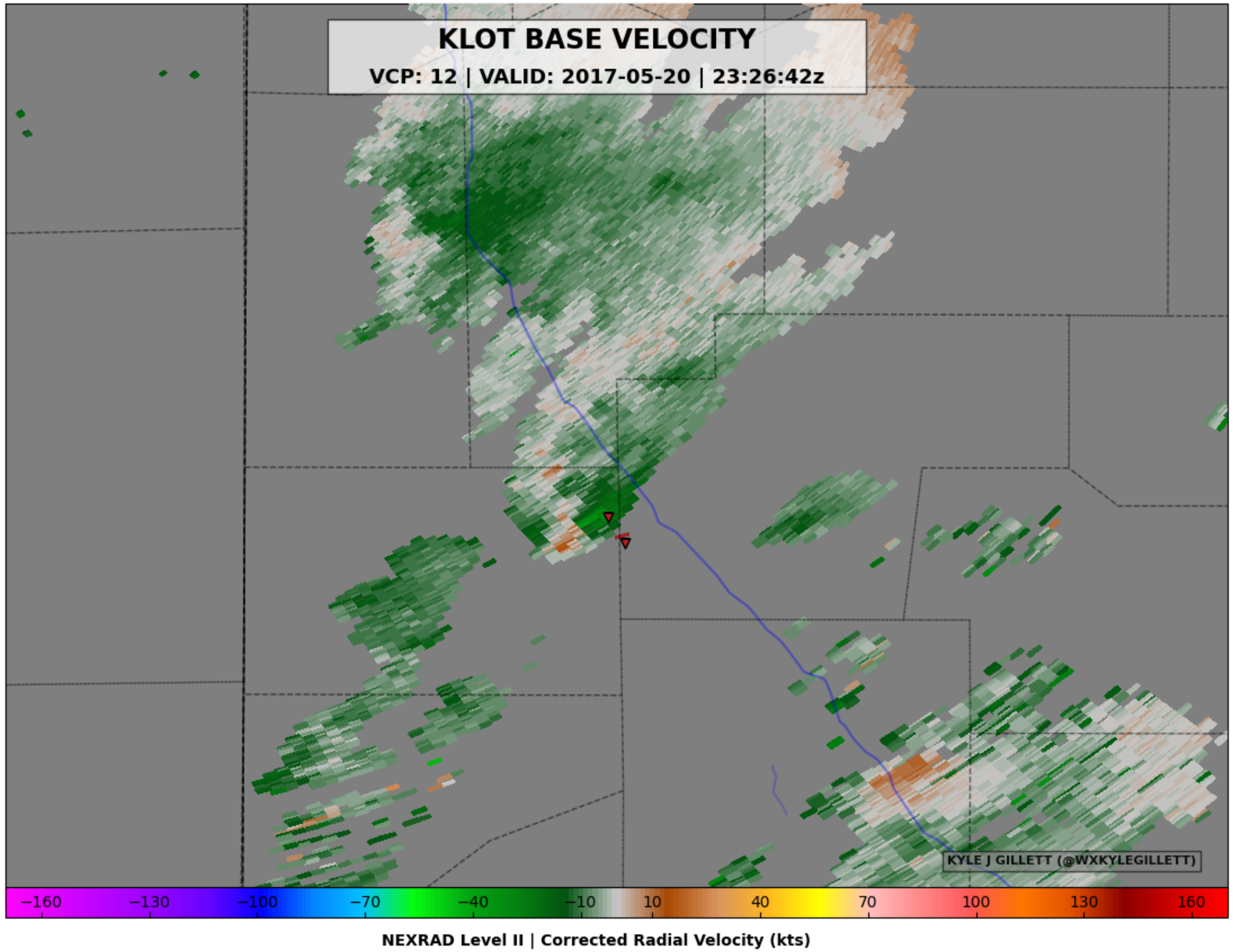


NEXRAD Level II | Corrected Radial Velocity (kts)

1. Far clearer supercell reflectivity structure
2. Broad inflow (2.1km beam height)
3. Velocity suggests lower-level mesocyclone developing (inbound + outbound flow)

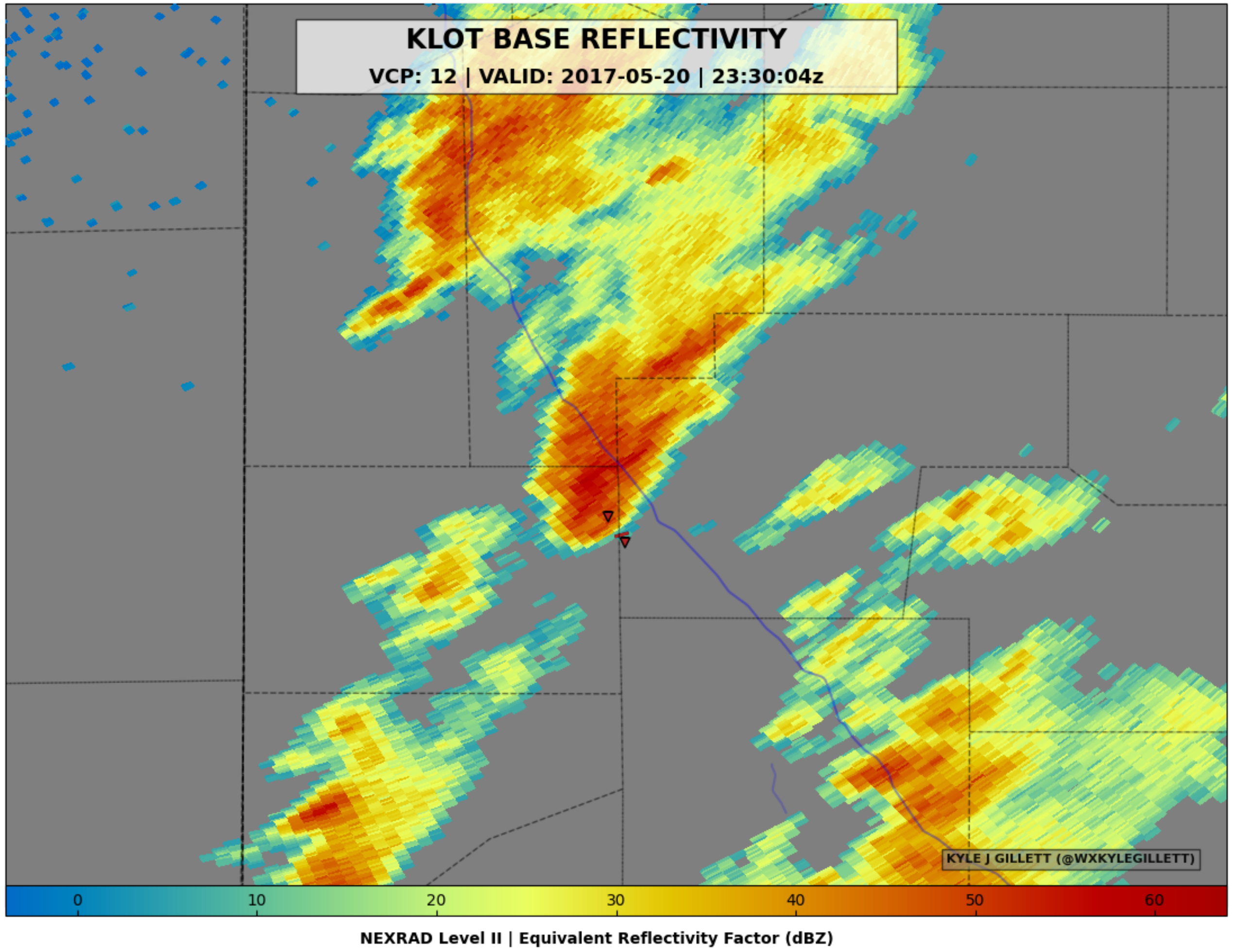
23:25 UTC 20 May

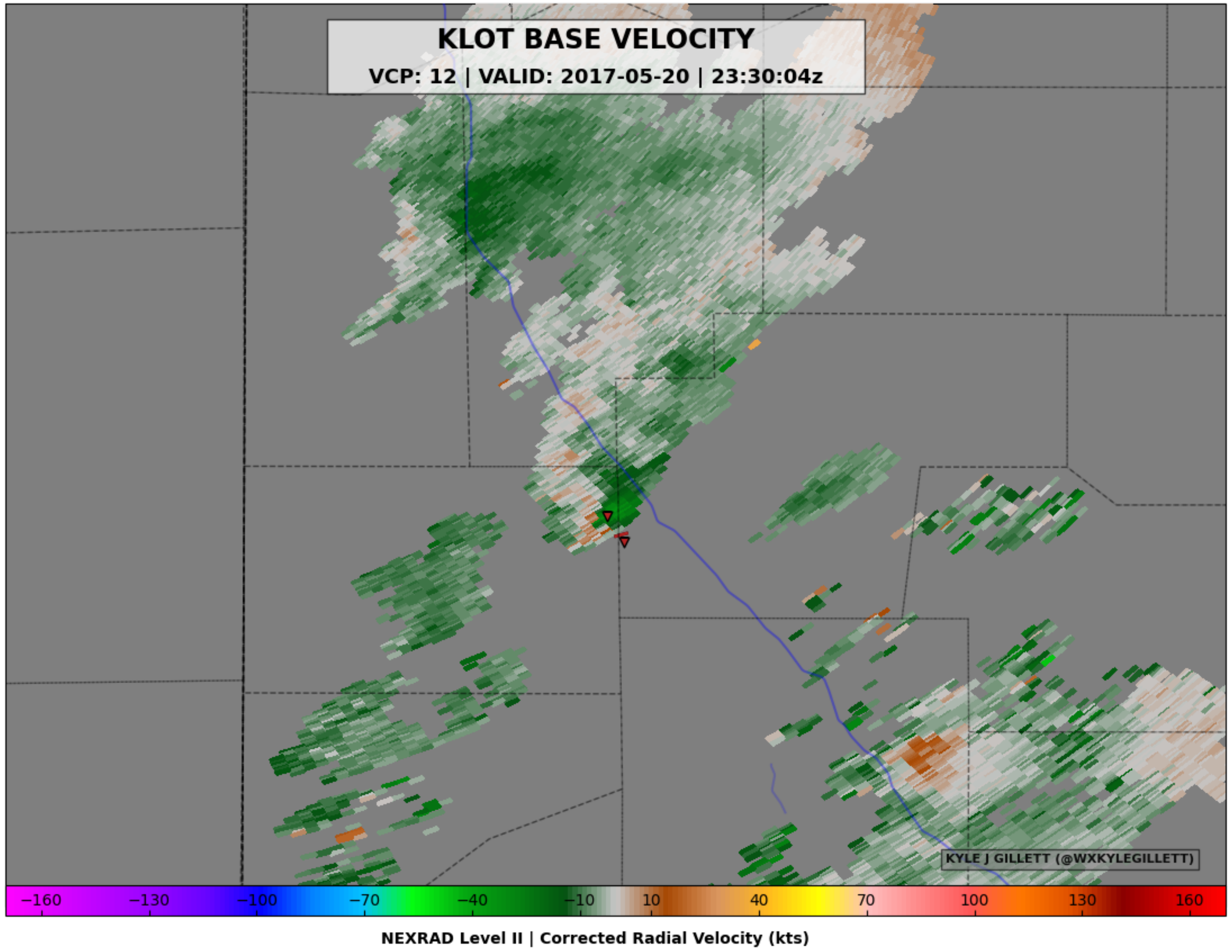




1. Supercell begins rightward deviation (increasing SWV ingestion & SRW)
2. Broad increase in inflow velocity
3. More prominent mesocyclone signature (psbl RFD surge signature)

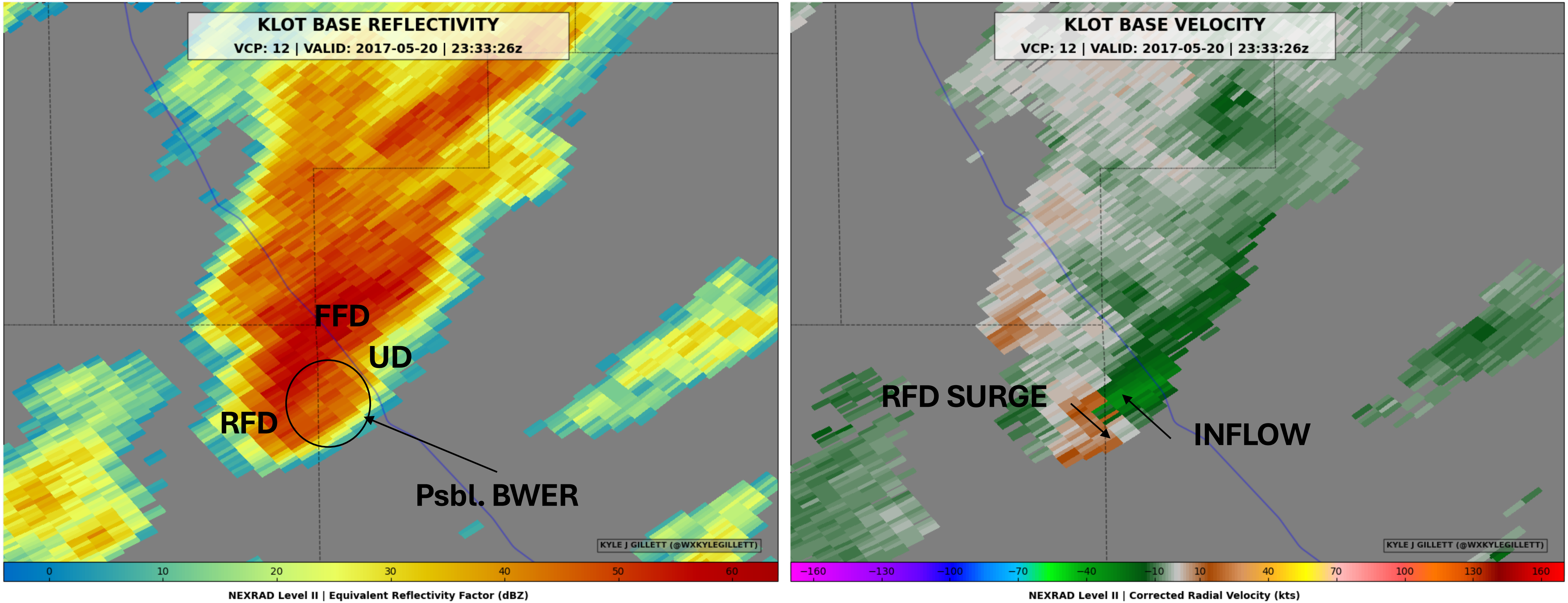
23:30 UTC 20 May



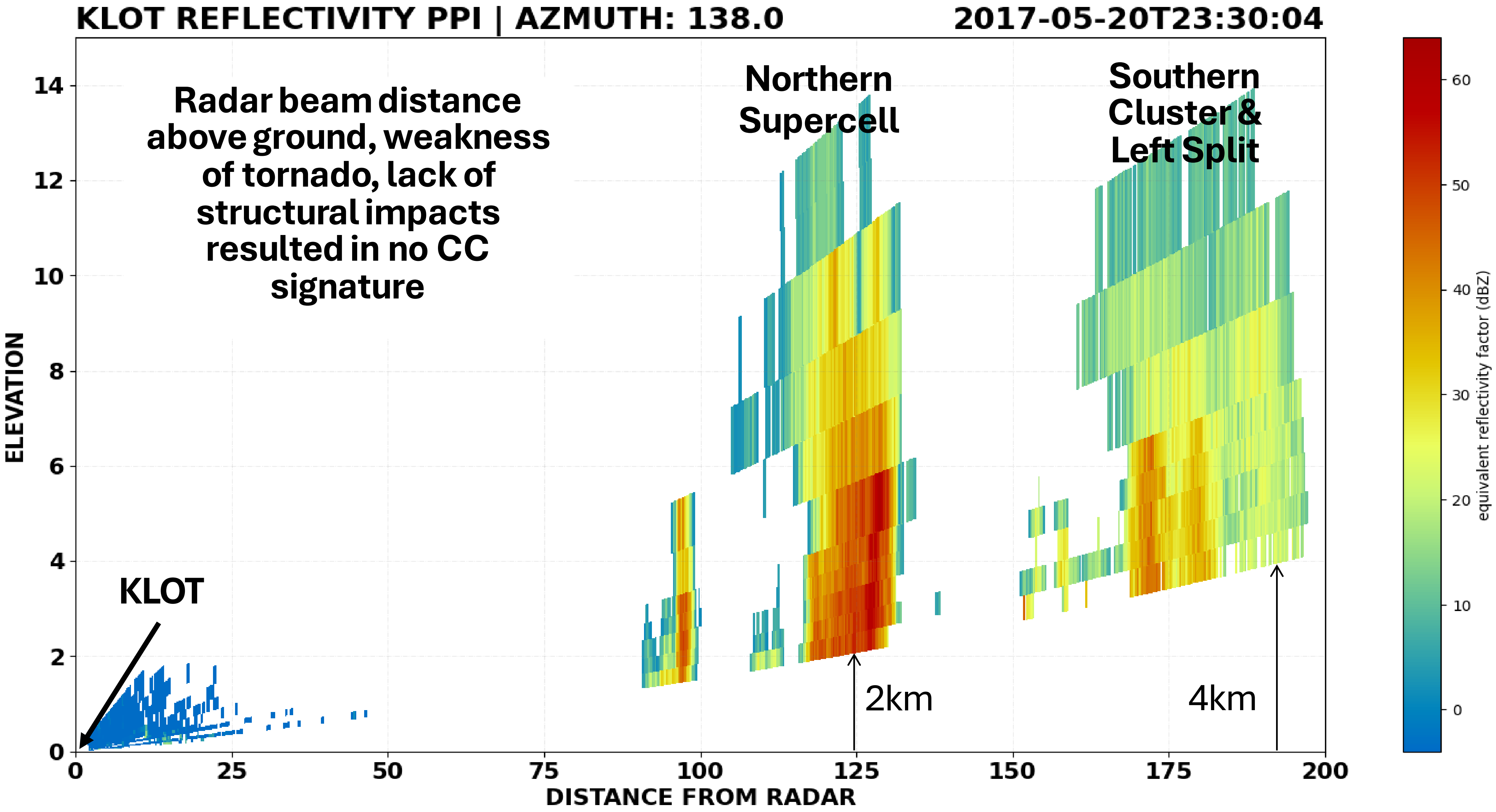


1. Tornado #1 develops
2. Tight couplet (2.1km beam height)
3. Inflow velocities increase & become more centralized.

23:33 UTC 20 May



1. Tornado #1 on the ground
2. Clear mesocyclone signature & tornadic couplet


KLOT REFLECTIVITY PPI | AZMUTH: 138.0
2017-05-20T23:30:04
Radar beam distance above ground, weakness of tornado, lack of structural impacts resulted in no CC signature
Northern Supercell
Southern Cluster & Left Split
KLOT
2km
4km
ELEVATION
DISTANCE FROM RADAR
equivalent reflectivity factor (dBZ)

e. CONCLUSIONS

FORECASTER TAKEWAYS

a. Subtle details were key

- Weak shortwave provided **upper-level lift** & adiabatic cooling of mid-level temperatures.
- Afternoon heating & low-level cyclonic **moisture advection** provided **destabilization.**
  - Warm, humid surface
  - Strong low-level destabilization (0-3km CAPE)
  - Moist profile limited CAPE-dilution via entrainment
- Cyclonic low-level flow via weak surface cyclone & a subtle warm front draped across the risk area provided favorable low-level **kinematics**
  - Ample low-level horizonal vorticity
  - High streamwiseness of horizontal vorticity
  - Strong storm relative wind (reduced CAPE-dilution via entrainment)
  - Ample bulk shear

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