CW3E Event Summary: Central Texas Floods

Center for Western Weather and Water Extremes
Scripps Institution of Oceanography
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Summary of the Central Texas floods in early July 2025

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https://x.com/TxDPS/status/1942700535171187163

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Intense convective storms produce extreme rainfall and catastrophic flooding in central Texas

- Extreme rainfall occurred over central Texas during 4–6 July 2025 in connection with repeated episodes of intense, widespread convective precipitation related to a slow-moving mesoscale convective vortex (MCV).
- Widespread rainfall totals of >5 inches were observed across central Texas, with embedded pockets of 10–20+ inches. Rainfall rates of 2–3 inches per hour were observed at many locations.
- The heavy rain caused rapid runoff leading to devastating flash flooding. Texas state officials have reported more than 100 fatalities associated with this event, with hundreds still missing.
- The extreme convective rainfall was caused by the interaction of persistent, moist low-level winds interacting with a slow-moving MCV within an environment characterized by weak synoptic-scale dynamical forcing. Deep, moist convection was supported by lifting associated with the MCV in the presence of extreme atmospheric water vapor content and elevated convective available potential energy.

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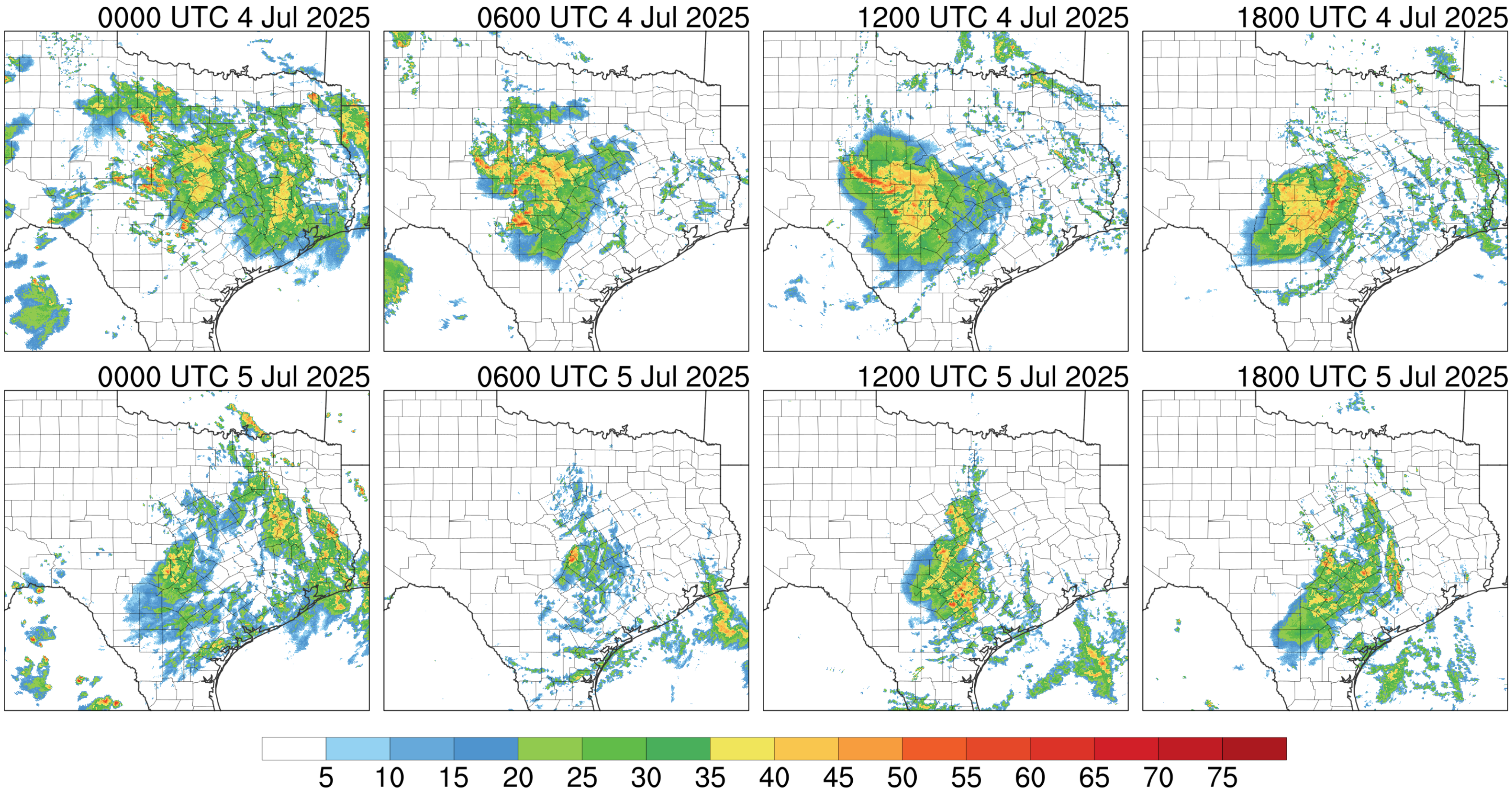
Radar observations for 4–5 July 2025



Composite radar reflectivity (dBZ). Data obtained from https://registry.opendata.aws/noaa-mrms-pds/

Widespread, slow-moving areas of heavy convective and stratiform rainfall (rates up to 2–3+ inches per hour) occurred on consecutive days between 3 and 7 July 2025 over central TX, with the location shifting slightly over the period.

The heaviest and most widespread rainfall, and the most severe flooding impacts, occurred in the early morning hours on 4 July.

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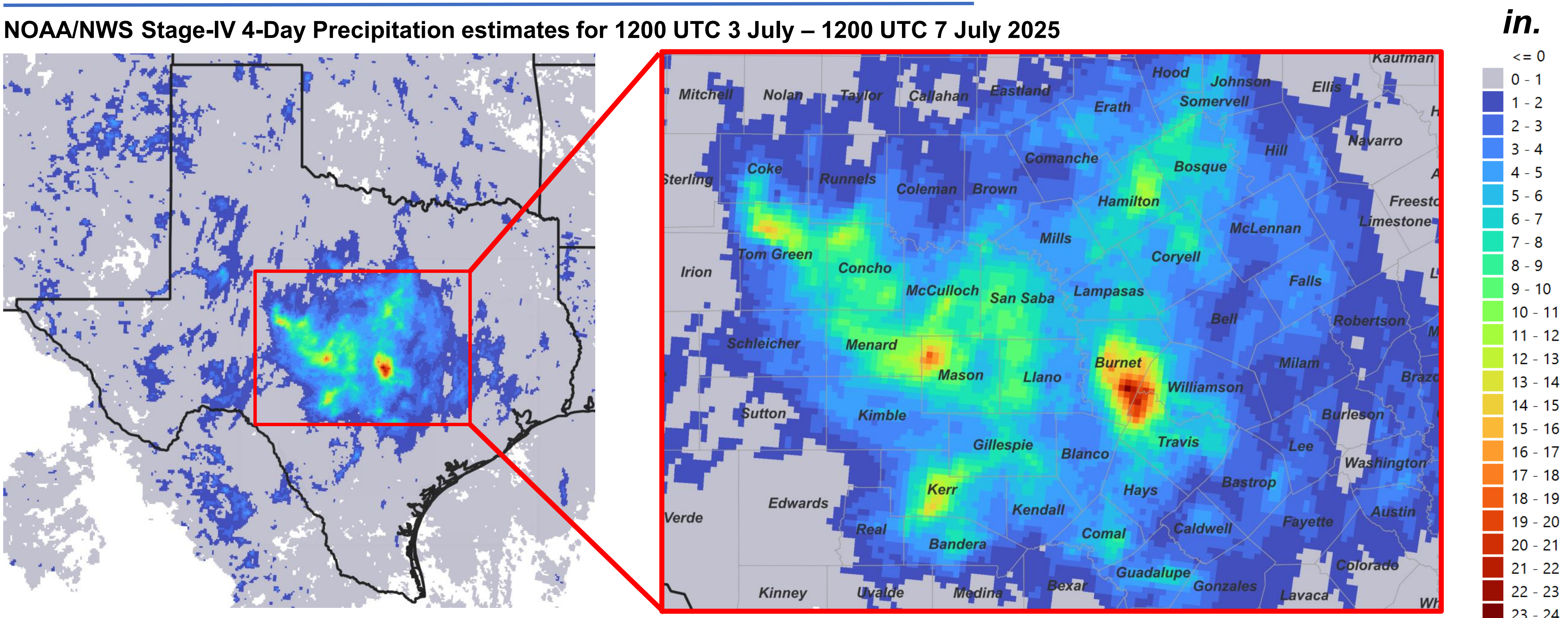
NOAA/NWS Stage-IV 4-Day Precipitation estimates for 1200 UTC 3 July – 1200 UTC 7 July 2025



*NWS Stage IV 4-Day Precipitation Totals accessed online via https://water.noaa.gov/resources/downloads/precip/stageIV. Texas counties names labeled in **bold.***

- Widespread rainfall totals of >5 inches were observed across central Texas.
- Areas of >10-inch totals were observed in a number of counties.
- Totals exceeded 20 inches near the border of Burnet, Williamson, and Travis counties.

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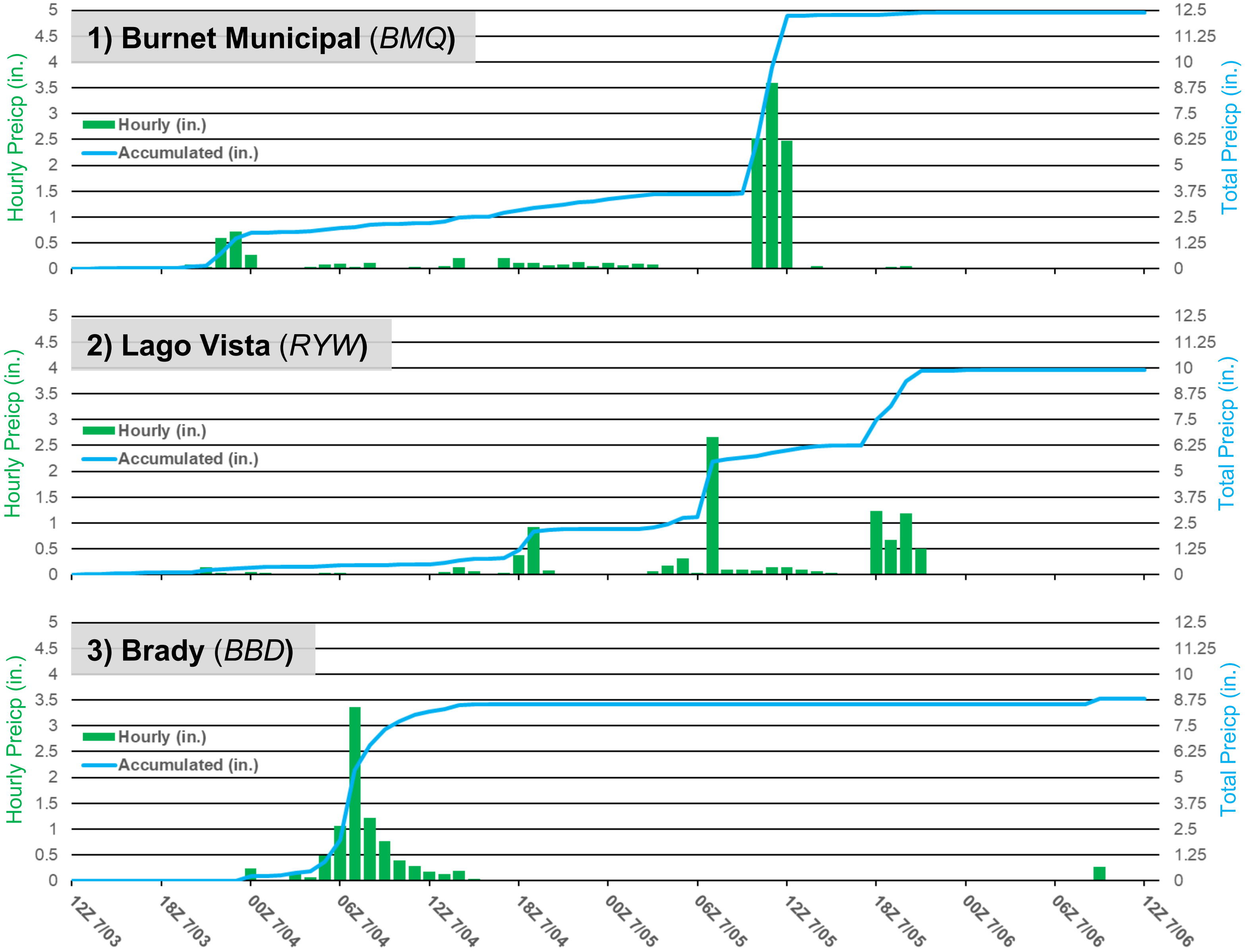
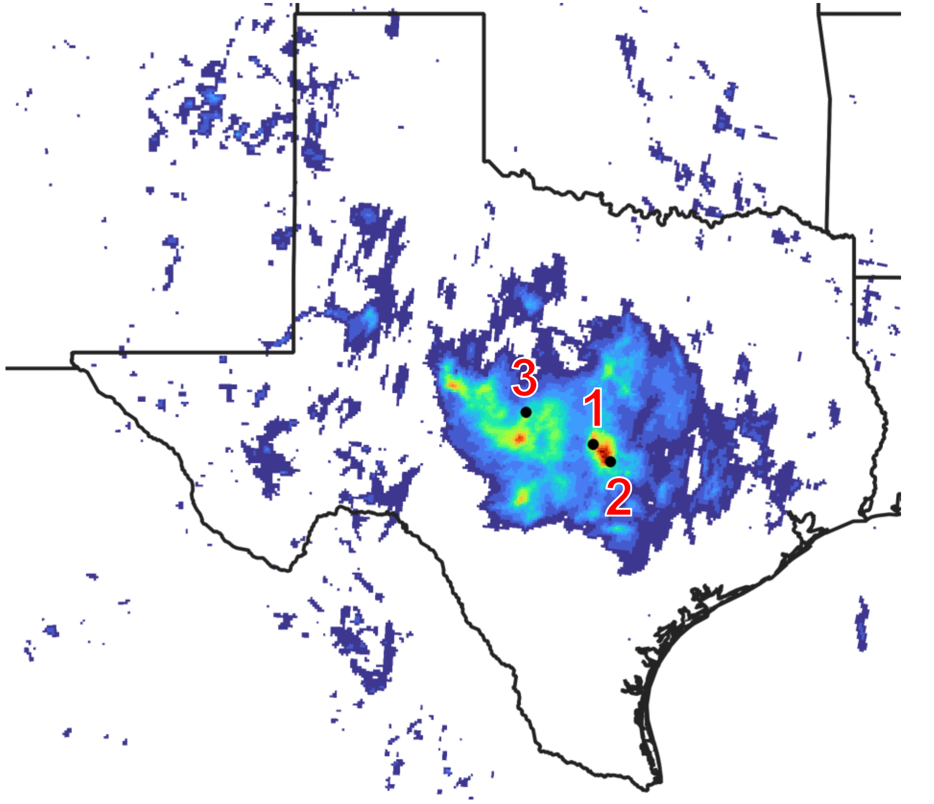
Charts & map valid: 1200 UTC 3 Jul – 1200 UTC 6 Jul 2025





NWS ASOS hourly precipitation observations (green, in.) and 3-day accumulated precipitation (blue, in.). Accessed via: https://mesonet.agron.iastate.edu/request/download.phtml

Intense hourly precipitation rates of 2–3+ inches per hour were reported at multiple locations across central TX during the event.

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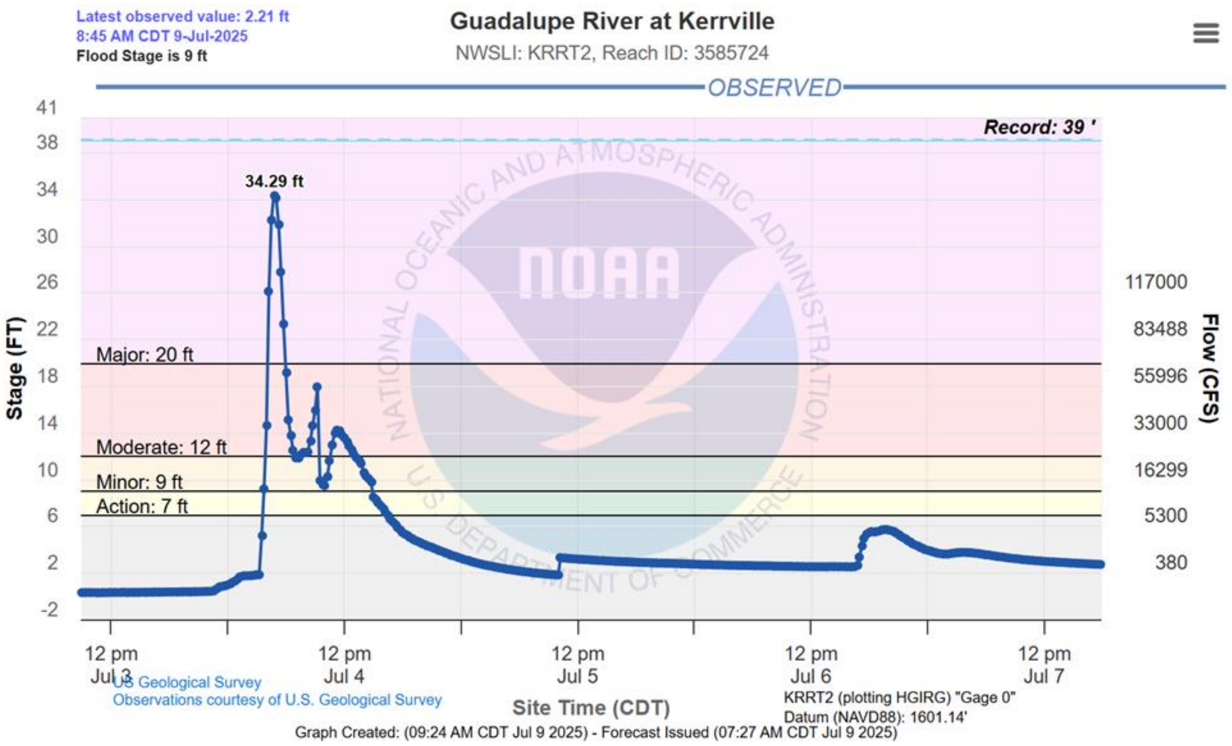

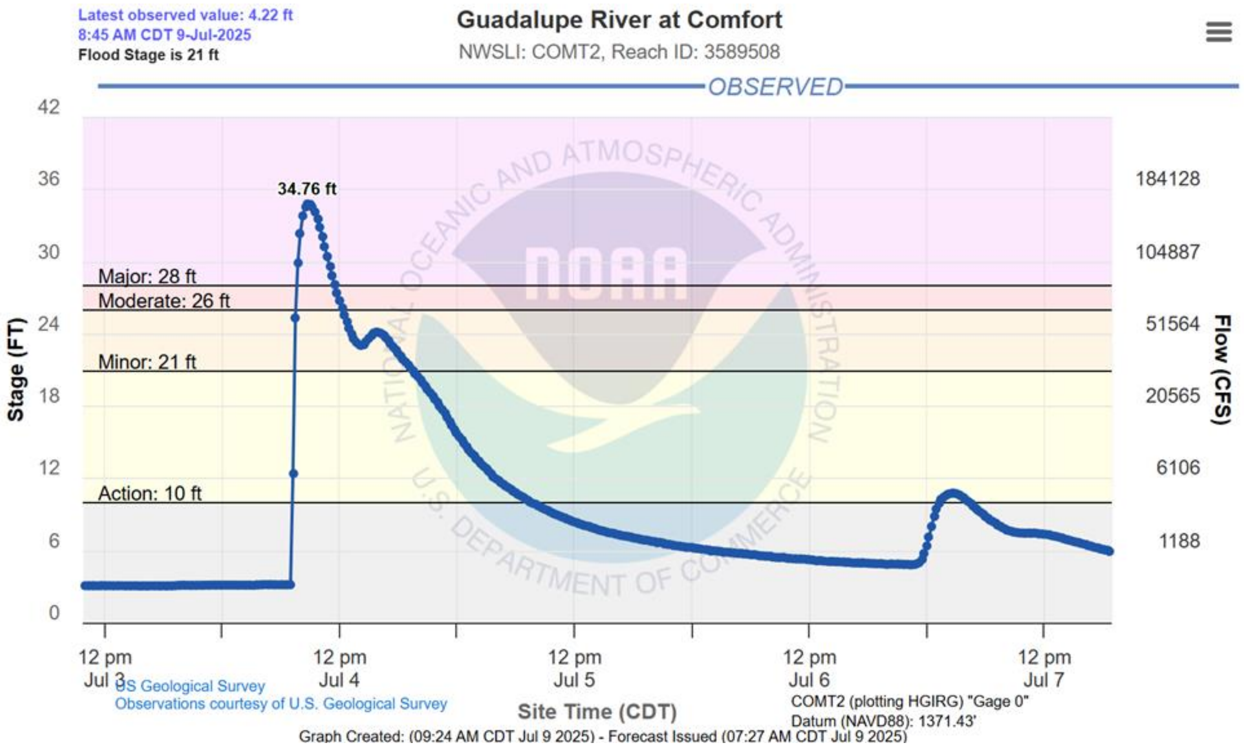

Stream gage plots from the Guadalupe River at Kerrville, TX, (left) and Comfort, TX, (right) between 3–7 July 2025. Accessed via water.weather.gov

- The high rain rates during the event, especially on 4 July, led to extraordinarily large and rapid rises in streamflow that resulted in major flash flooding.
- The Guadalupe River at Kerrville, TX (left) rose ~32 feet in just 1.5 hours (5:15 a.m. – 6:45 a.m. CDT on 4 July).
- The Guadalupe River at Comfort, TX (right) rose ~32 feet in 1.75 h (9:00 a.m. – 10:45 a.m. CDT on 4 July).

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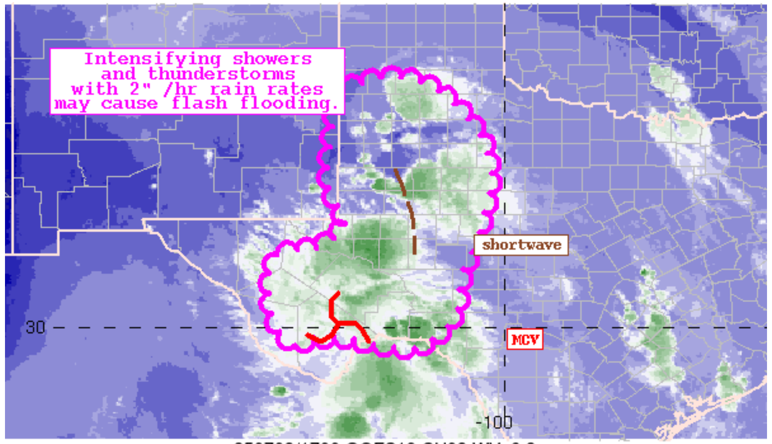
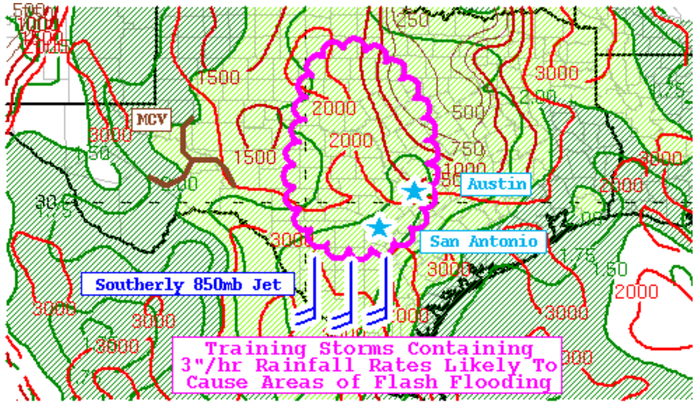
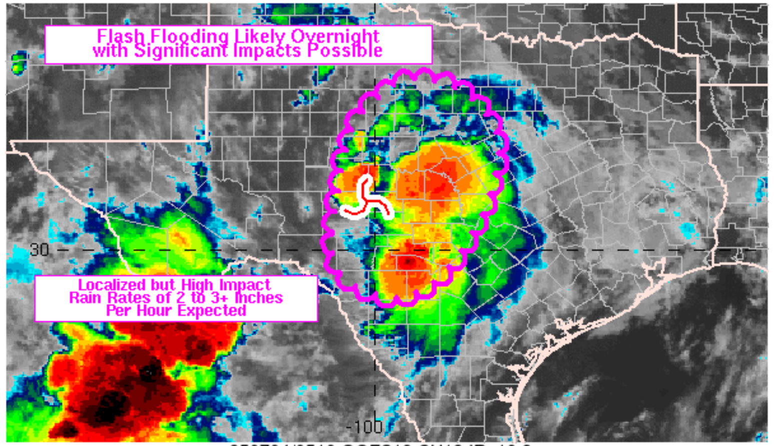
NWS Weather Prediction Center: Mesoscale Precipitation Discussions



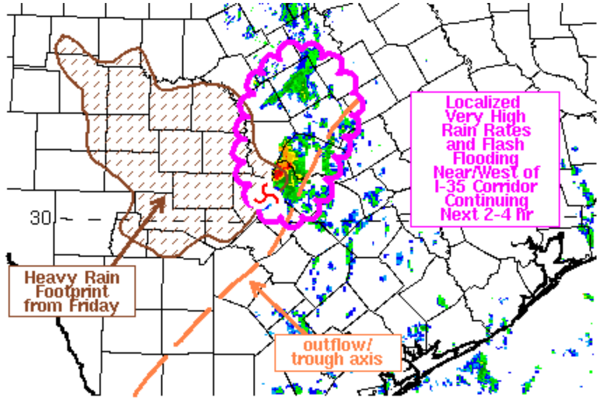
250703/1700 GOES19 CH08 WV_6.2
WPC MPD #0580



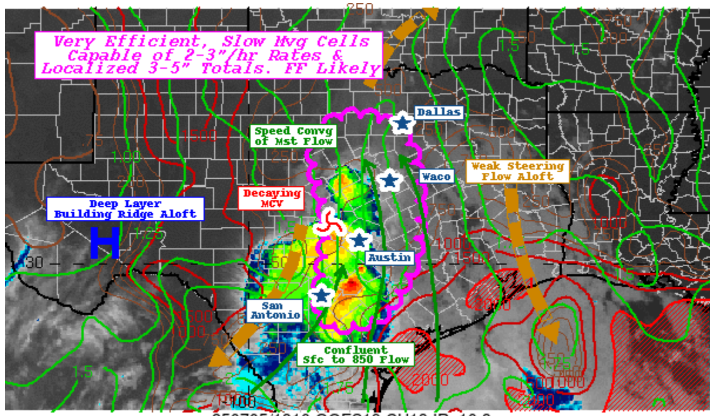
RAP32 PRECIP WATER 250703/2100f004
RAP32 MU CAPE 250703/2100f004
WPC MPD #0582



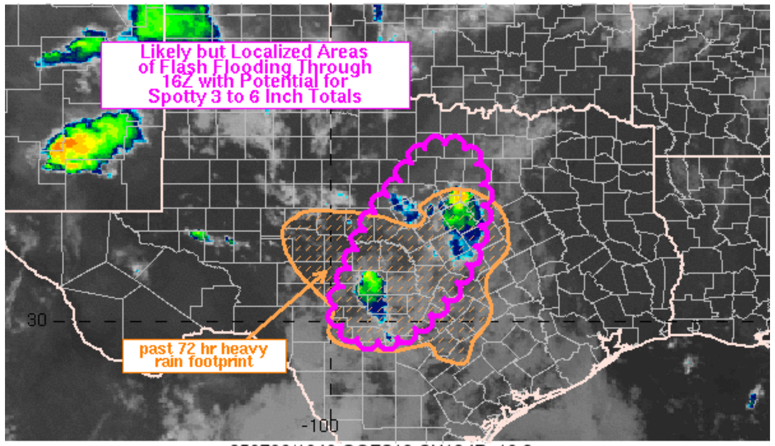
250704/0510 GOES19 CH13 IR_10.3
WPC MPD #0584



250705/0536 NATL 1 KM COMP REFL 1.00
WPC MPD #0592



250705/1310 GOES19 CH13 IR_10.3
RAP32 ML CAPE (lowest 90MB) j/kg 250705/1200f002
RAP32 PRECIP WATER 250705/1200f002
WPC MPD #0596



250706/1040 GOES19 CH13 IR_10.3
WPC MPD #0601

The NWS Weather Prediction Center issued numerous mesoscale precipitation discussions during 3–5 July for this event, each highlighting the meteorological ingredients associated with short-duration, high-intensity precipitation over central TX and the areas at risk for flash flooding.
(Pictured above are a small selection of the MPDs issued during this period; see https://www.wpc.ncep.noaa.gov/metwatch/metwatch_mpd.php).

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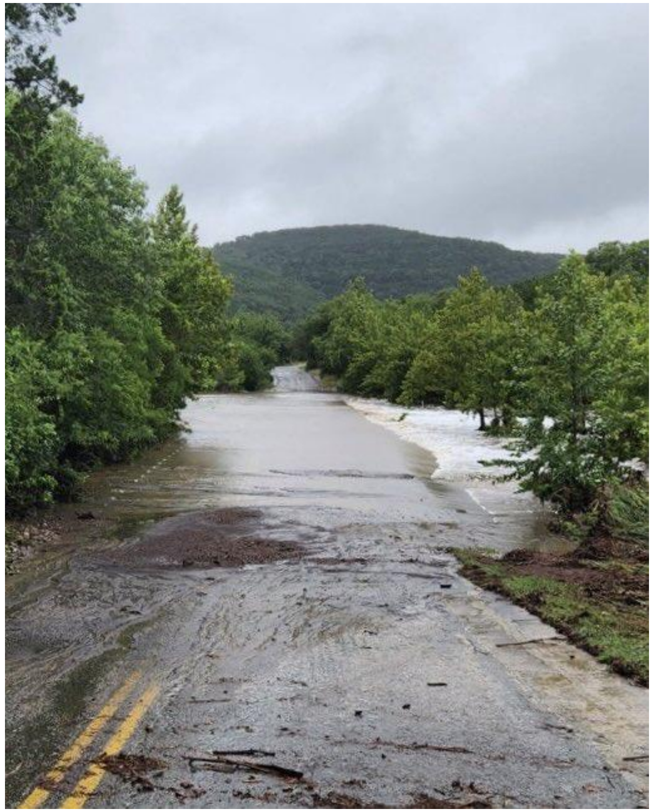
https://x.com/TxDOTSanAntonio/status/1941165320959603179

https://x.com/TxDPS/status/1942700535171187163



https://x.com/TPWDparks/status/1941532113268060440

https://x.com/TxDPS/status/1942700535171187163

Flooding occurred along rivers and streams across central Texas, with water exceeding banks and flowing over bridges in the region.

Hundreds of people were rescued and evacuated from flood zones by local, state, and federal agencies using air, water, and land assets.

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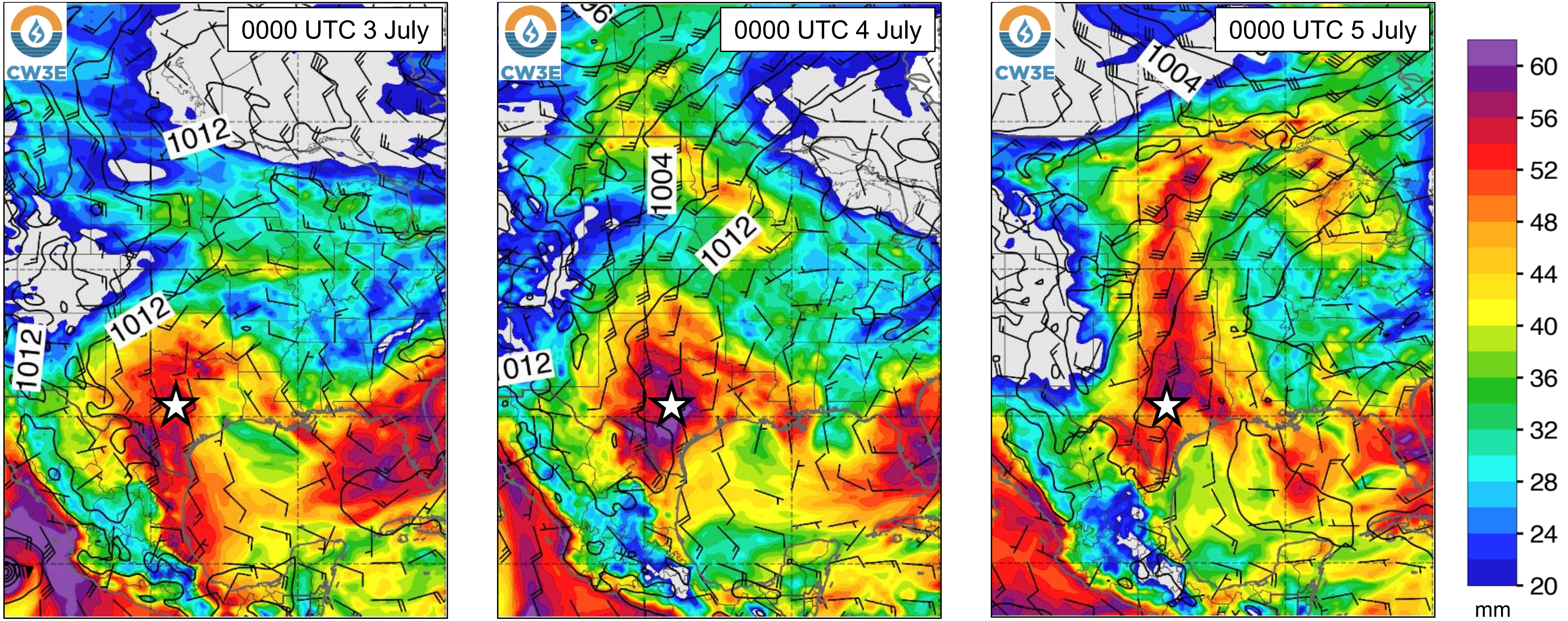

GFS model IWV analyses: *Integrated water vapor (mm; shaded), sea level pressure (contoured), and 850-hPa wind (barbs) for 3–5 July 2025.*

Between 3 and 6 July, a persistent corridor of southerly/southeasterly lower-tropospheric winds (i.e., a low-level jet) extending from the western Gulf of Mexico provided a sustained supply of very moist air (IWV >50 mm; **shown above**) over Texas in conjunction with elevated IVT (>400 kg m^{-1} s^{-1}; see next slide). These conditions were maintained in an environment characterized by weak upper-level winds and an absence of strong synoptic-scale dynamical forcing. IWV values were largest (>60 mm) on 4 July, favoring especially high rainfall rates.

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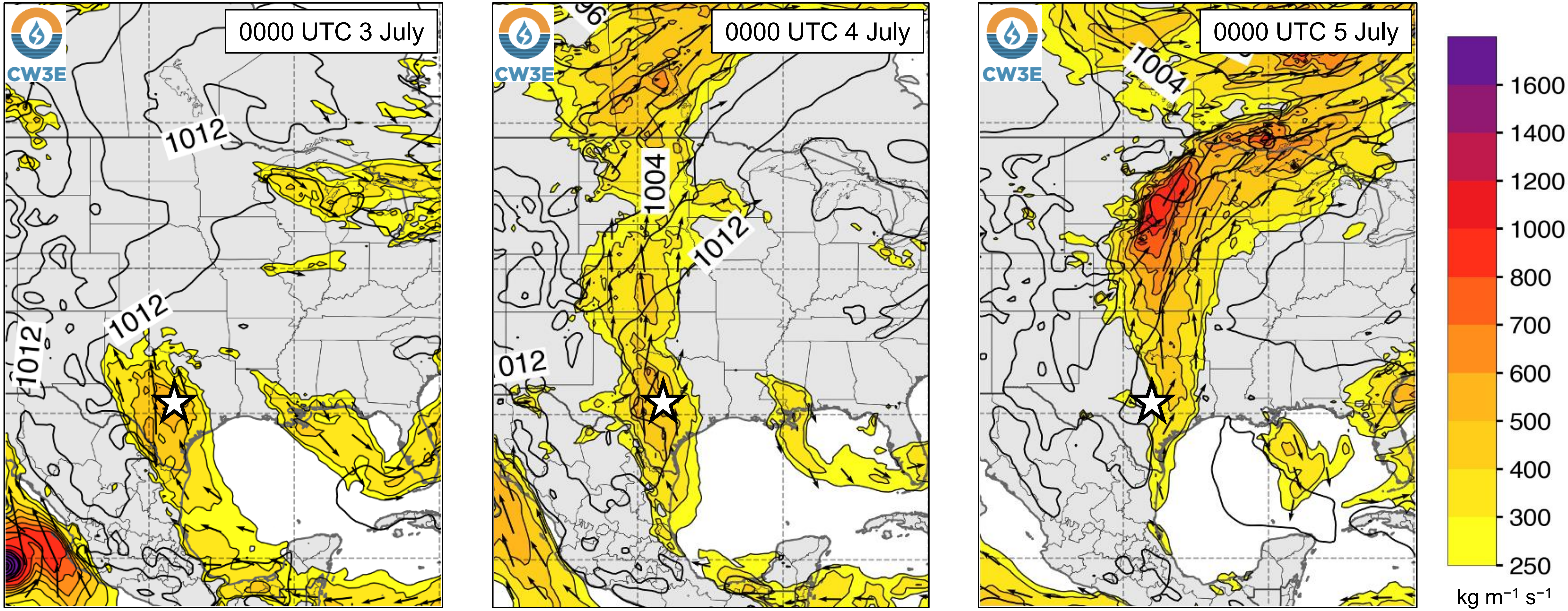

***GFS model IVT analyses:** Integrated water vapor transport (kg m^{-1} s^{-1}; shaded & vectors) with sea level pressure (contoured) for 3–5 July 2025.*

Between 3 and 6 July, a persistent corridor of southerly/southeasterly lower-tropospheric winds (i.e., a low-level jet) extending from the western Gulf of Mexico provided a sustained supply of very moist air (IWV >50 mm; see previous slide) over Texas in conjunction with elevated IVT (>400 kg $m^{-1}s^{-1}$; **shown above**). These conditions were maintained in an environment characterized by weak upper-level winds and an absence of strong synoptic-scale dynamical forcing. IWV values were largest (>60 mm) on 4 July, favoring especially high rainfall rates.

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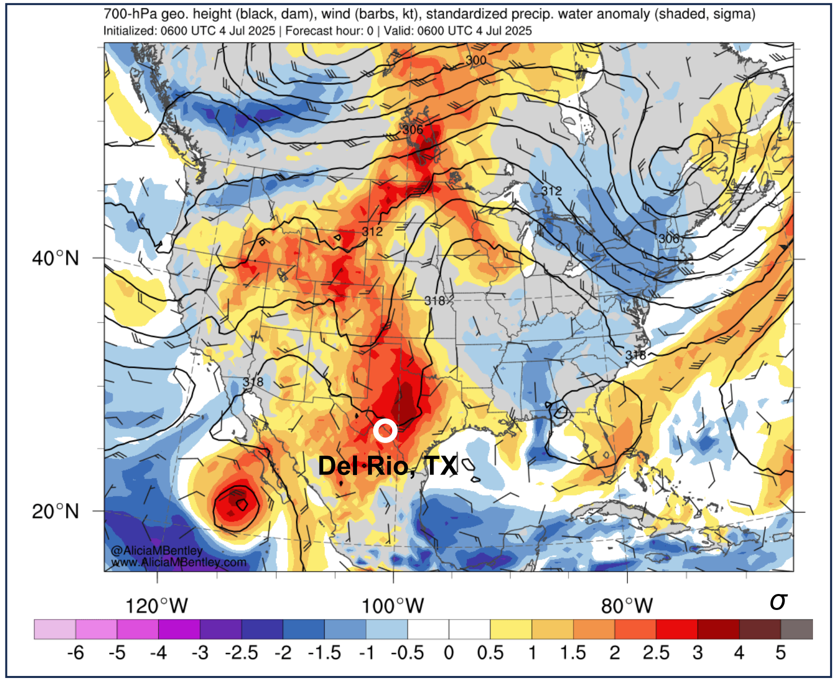
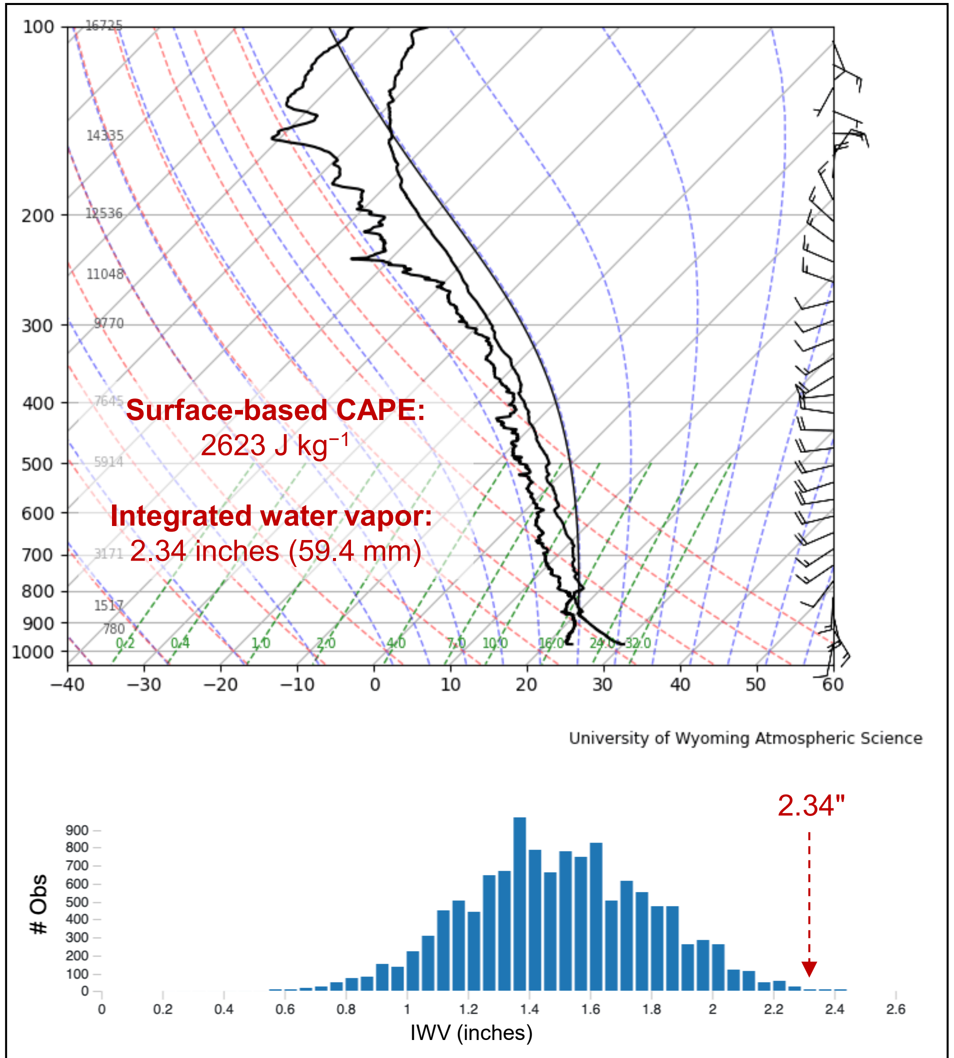
a. Water Vapor Anomaly (0000 UTC 4 July)



b. Del Rio Sounding (0000 UTC 4 July)



Historical distribution of IWV for June–Aug at Del Rio, TX

(a) Integrated water vapor standardized anomaly (σ, shaded) with 700-hPa geopotential height (contoured) at 0000 UTC 4 July 2025. Image constructed from GFS model data and obtained from: https://www.atmos.albany.edu/student/abentley/realtime/anom.php

(b) Radiosonde observations 0000 UTC 4 July at Del Rio, TX. Image obtained from https://weather.uwyo.edu/upperair/sounding.shtml with historical distribution for June – Aug; image obtained from: https://www.spc.noaa.gov/exper/soundingclimov2/

Moist, unstable conditions over Texas

- The extreme rainfall was supported by a combination of large IWV and high convective available potential energy.
- The observed IWV value on 4 July at Del Rio, TX, was extreme in the context of the historical summertime IWV distribution at that location.

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What is a mesoscale convective vortex (MCV)?

Definition: *"A midlevel, warm-core low pressure center that develops within the stratiform region of a mesoscale convective system (MCS) as a result of latent heat release over a multi-hour time period. The cyclonic vortex has a diameter ranging from 50 to 200 km (31 to 124 mi) and a depth from 2.5 to 5 km (1.5 to 3.1 mi).* ***An MCV can persist for 12 hours or more after its parent MCS has dissipated. A residual MCV may help initiate a subsequent episode of convection."***

– AMS Glossary of Meteorology (https://glossary.ametsoc.org/wiki/Mesoscale_convective_vortex)

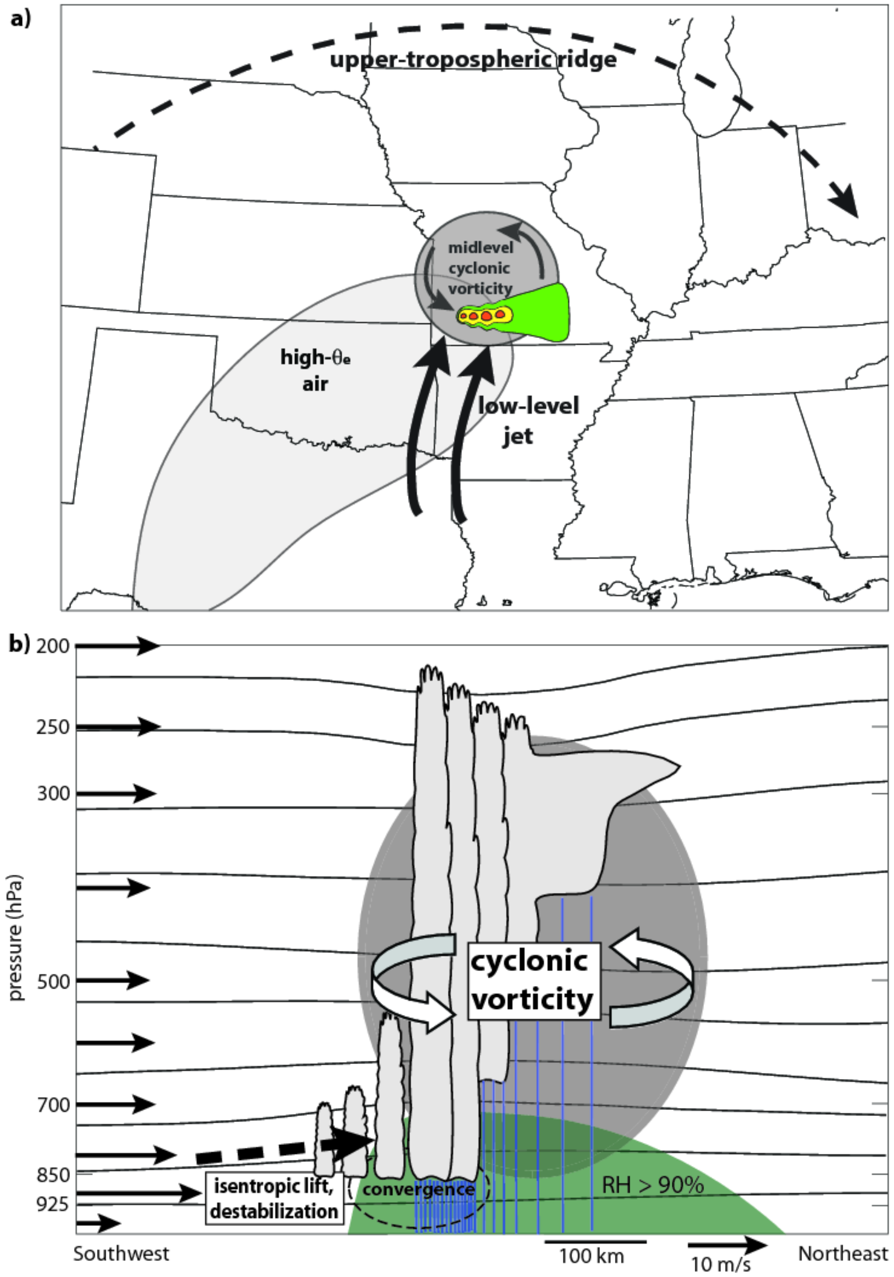

Fig. 13 from Schumacher and Johnson (2009, https://doi.org/10.1175/2008WAF2222173.1): *Schematic diagrams showing important processes in the development and maintenance of extreme-rain-producing convective systems associated with midlevel circulations. (a) Plan view. A schematic representation of the radar reflectivity structure of an MCS is shown in color, in relation to the location of a midlevel vorticity maximum (dark gray shading and curved arrows). The thick dashed curve indicates the flow in the upper troposphere (e.g., 250 hPa). Thick black arrows show the location of an LLJ, and the light gray shading shows the location of high-θe air at low levels (e.g., 925–800 hPa). (b) Southwest-to-northeast cross section. Representative isentropes (every 5 K) are shown by the thin black lines; the wind profile (including LLJ) is shown by the vectors on the left. A reference vector and length scale are shown at bottom. Green shading indicates areas with relative humidity >90%; gray shading indicates high values of absolute cyclonic vorticity. The thick dashed arrow shows air approaching the circulation from the southwest, which is undergoing isentropic upglide and destabilization.*

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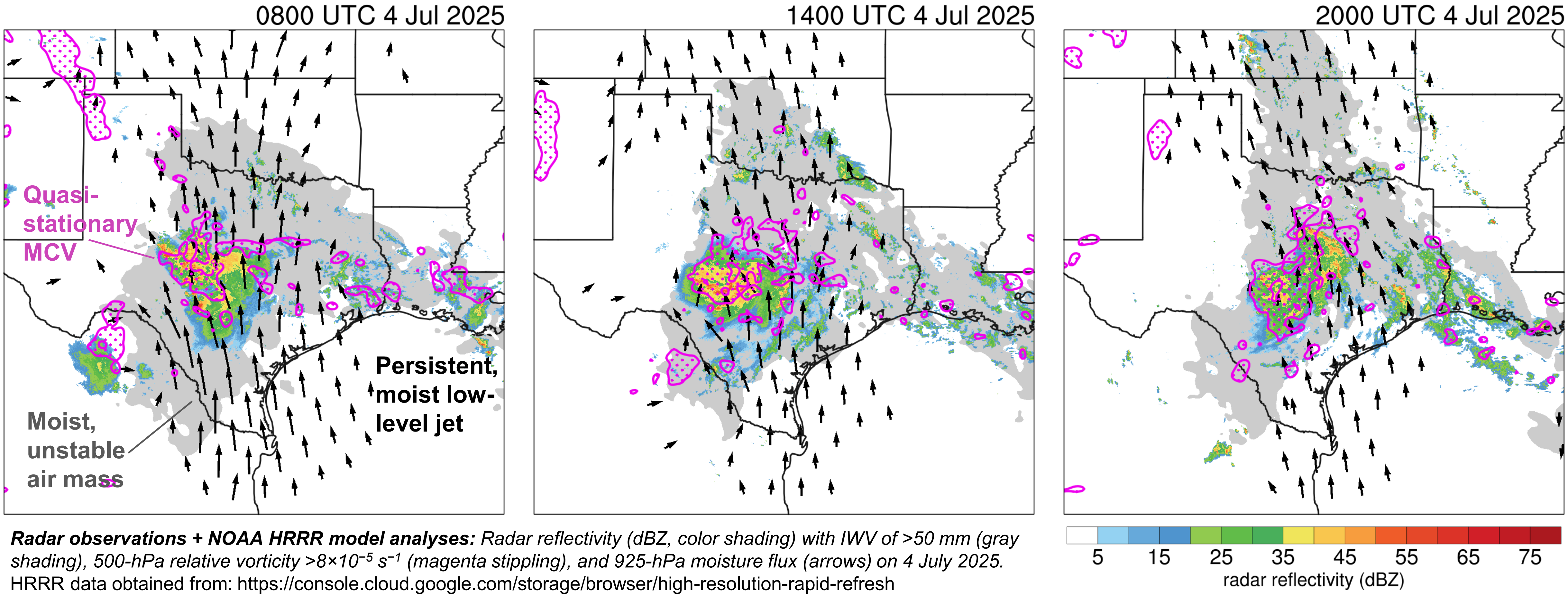

Radar observations + NOAA HRRR model analyses: *Radar reflectivity (dBZ, color shading) with IWV of >50 mm (gray shading), 500-hPa relative vorticity >8×10^{-5} s^{-1} (magenta stippling), and 925-hPa moisture flux (arrows) on 4 July 2025.*
HRRR data obtained from: https://console.cloud.google.com/storage/browser/high-resolution-rapid-refresh

Summary: Convection was triggered and maintained where a low-level jet and a concomitant moisture flux corridor interacted with a quasi-stationary MCV (visible in the 500-hPa relative vorticity). The requisite lifting to initiate deep convection likely occurred as the moist air ascended along sloping isentropic surfaces on the flanks of the MCV. The MCV was maintained by latent heat release in the convective storms and served to focus repeated episodes of convection on consecutive days.

IWV >50 mm
500-hPa relative vorticity >8×10^{-5} s^{-1}
200 × 10^{-3} m s^{-1} — 925-hPa moisture flux