Supercell Visualization

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Agenda

Supercell Overview

Virtual Reality & Our Application

Results & Demo

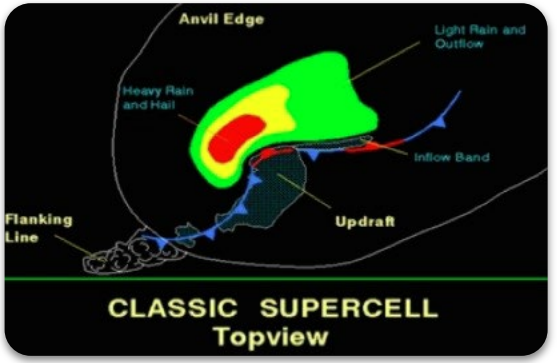
What is a Supercell Storm?

- A storm characterized by “its deep and persistent rotating updraft called a **mesocyclone**” (NOAA)
- Formed in environments with convective available potential energy (CAPE) and moderate/strong directional wind shear
- Least common type of thunderstorm
- Produces severe weather:
  - Heavy rain
  - Frequent lightning
  - Strong winds
  - Large hail
  - Occasionally weak to strong tornados

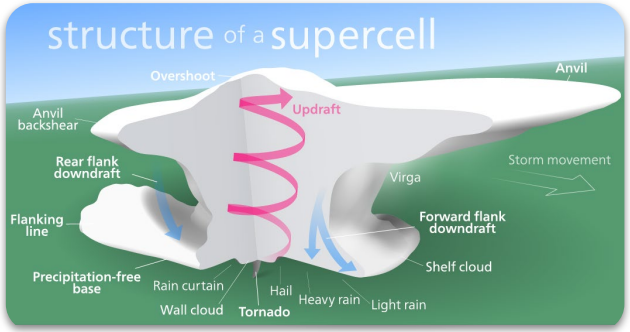
“A supercell with a hail core near Stratford, Texas on May 18, 2023.”
(Kyle Cutler, retrieved from Wikimedia Commons)

Structure of a Supercell

- Types: **Classic**, High precipitation (HP), Low precipitation (LP), and Miniature
- Components: **mesocyclone**, wall cloud, anvil, rain free base, rear flank downdraft, forward flank downdraft, gust front
    - Mesocyclone is the rotating updraft of air, which distinguishes the supercell
    - Wall cloud: rotating isolated cloud beneath the main updraft (visible from the ground)
    - Rain-free base



(NOAA)



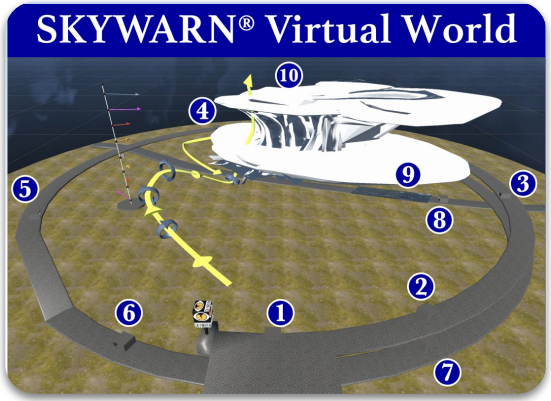
(Kelvin Ma via Wikimedia, CC BY-SA 3.0)

Why Virtual Reality (VR)?

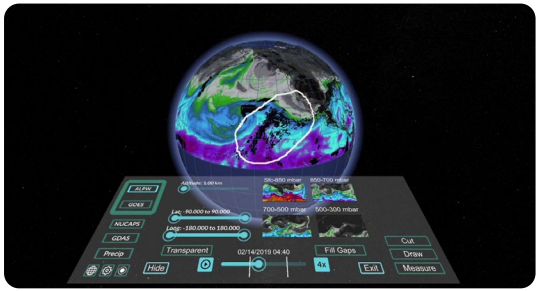
- Enables the intuitive visualization of the complex 3D structures/features of supercell storms
  - Can enable meteorologists to better identify, monitor, and predict supercells using a variety of data
- The Unity game engine and developing standards like OpenXR make it easy to build **highly-portable** virtual-reality applications
- Companies like **Apple**, **Meta**, and **Google** are working towards advancing the technology and making it more affordable

Virtual-Reality (VR) Weather Visualization

- Many virtual-reality weather visualization applications are emerging
  - SKYWARN
  - Envision XR
  - Embodied Weather
- Tend to be simulated models for educational purposes
- Our application is built upon MeteoVis, which visualized atmospheric phenomena



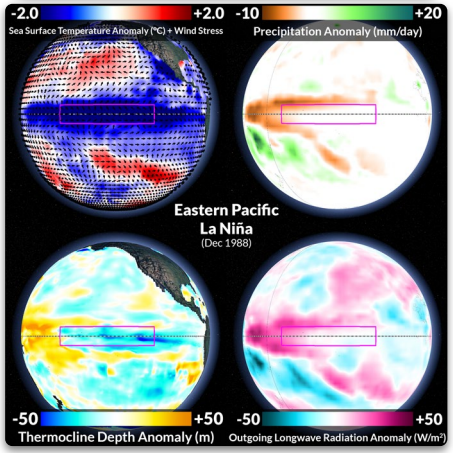
(Armani Cassel, Ross Forsyth, Stephen Foskey)



(David Li, Eric Lee, et. al.)

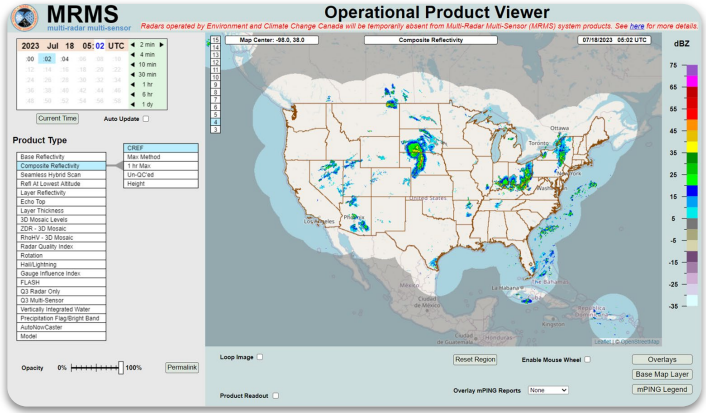
Our Application

- Built using the Unity game engine
- Showcasing weather phenomena through generalizable visualizations
  - Last summer we visualized the El Niño and La Niña phenomenon
- Support a wider variety of headsets using OpenXR
  - Can be streamed over the internet with applications such as Virtual Desktop
- Strive to make our application intuitive and easy to use



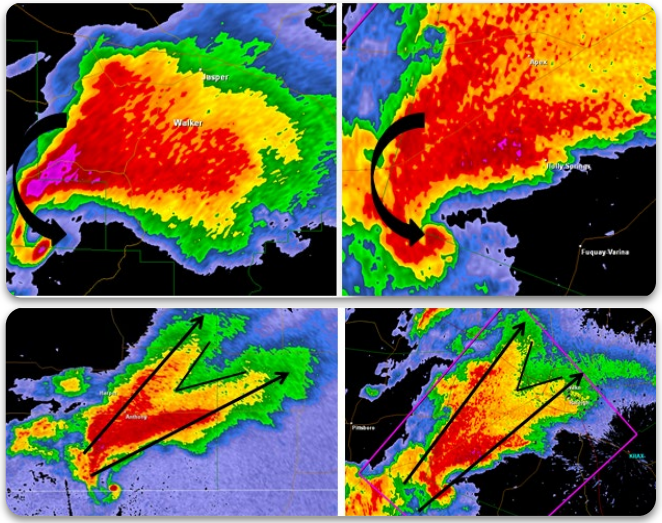
Getting Data

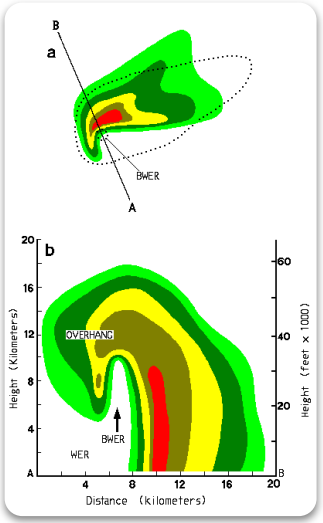
- Getting merged reflectivity data from the **Multi-Radar/Multi-Sensor System (MRMS)**
  - 3D Merged Reflectivity
  - Files in GRIB2 format
  - Resolution is 0.01° by 0.01°
- Data is resized to focus on supercell region
  - Saves on memory and processing time
- Custom C# readers for GRIB data
- Cloud coverage data from GOES*



Identifying a Supercell

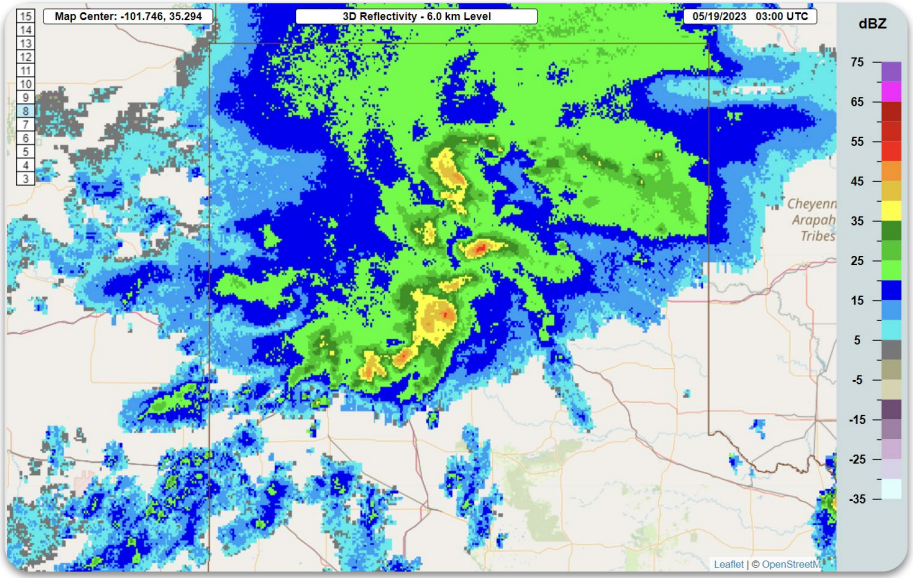
- Radar features:
  - **Hook echo**
  - Bounded weak echo region (BWER) / elephant trunk
  - V-notch / flying eagle
- **Goal:**
  - Identify the supercell using its radar features
  - Attempt to demonstrate features of its distinct 3D structure (anvil, overshoot, flanking line, etc.)



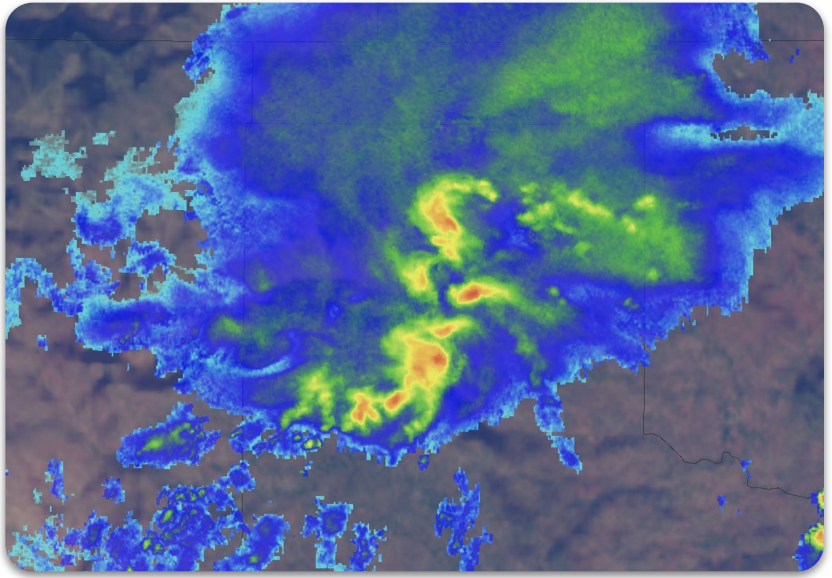


(US Tornado and Wikimedia)

Radar Comparison



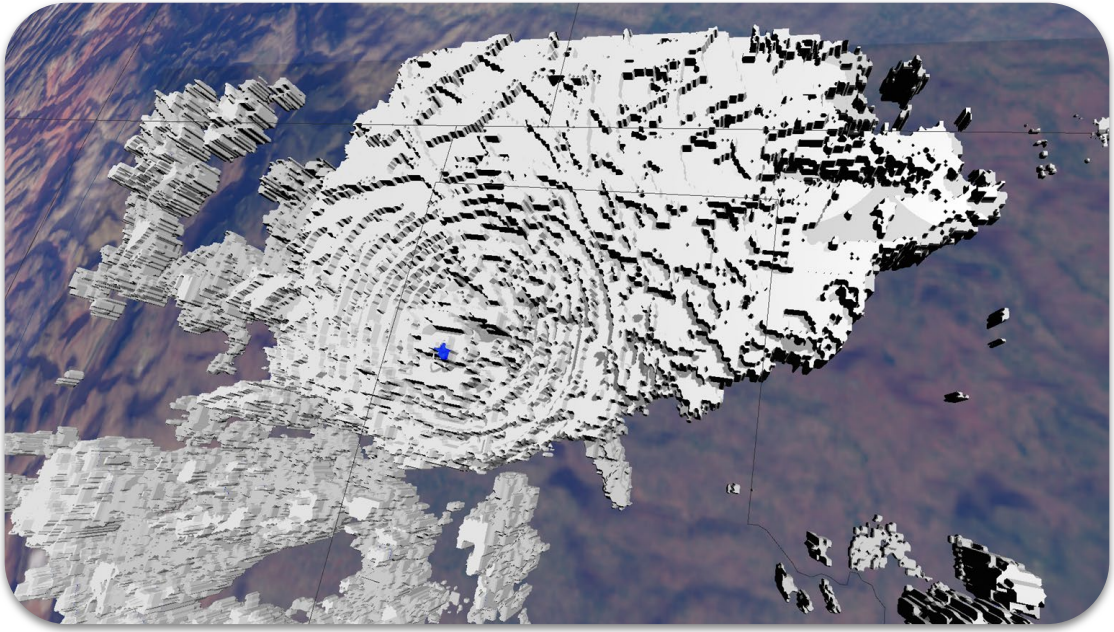
MRMS Product Viewer



Our Application

MRMS Merged Reflectivity @ 6km, 5/19/2023 03:00 UTC

3D Mesh Reconstruction



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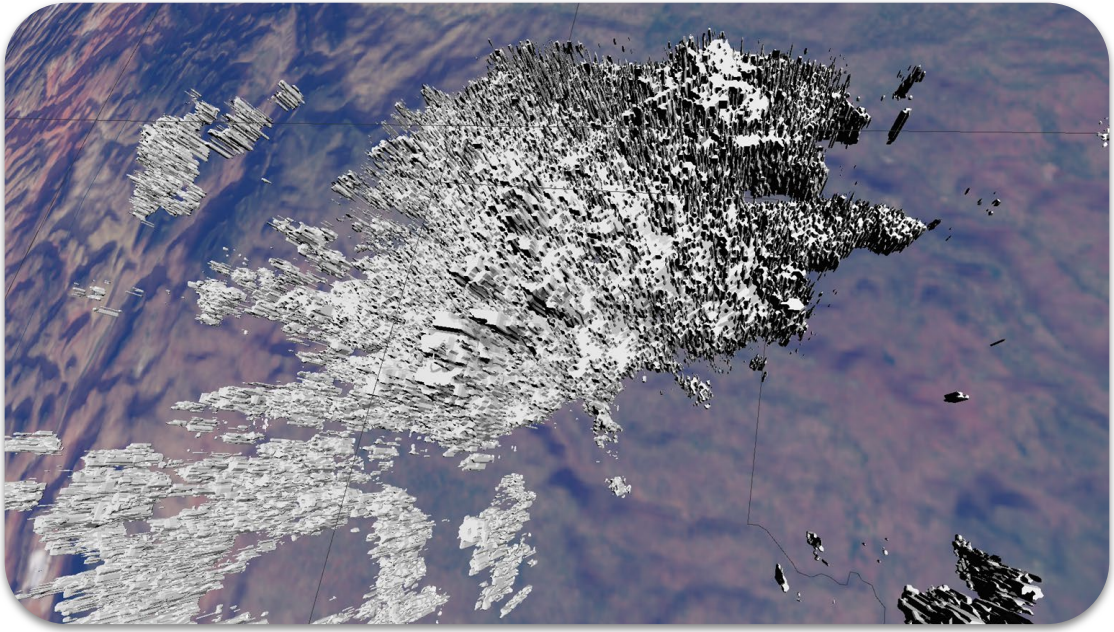
MRMS Merged Reflectivity, 5/19/2023 03:00 UTC

3D Mesh Reconstruction



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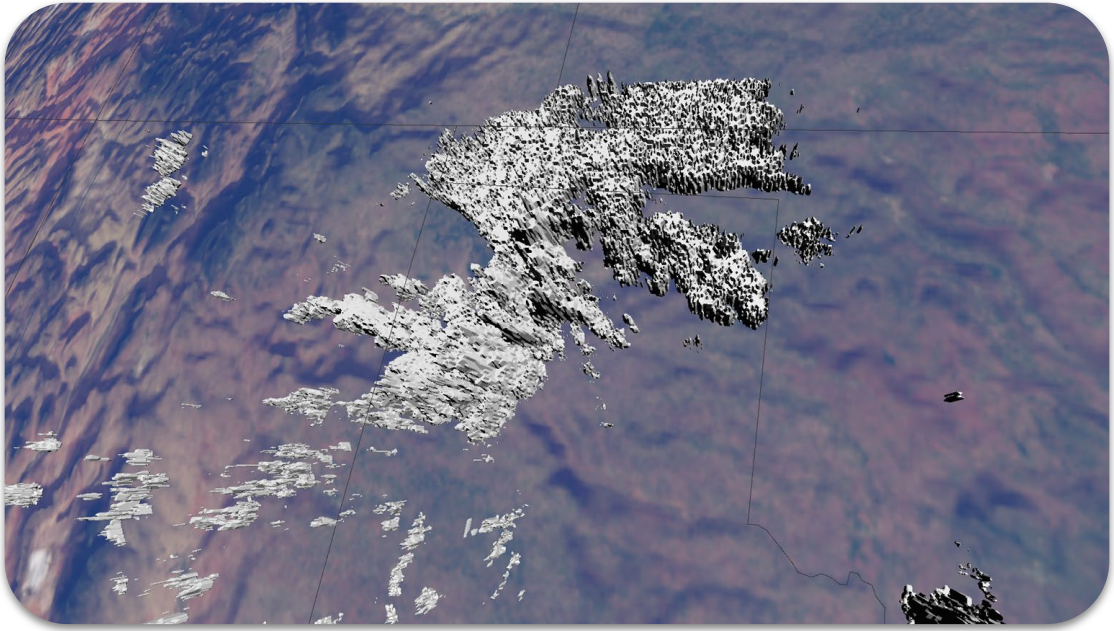
3D Mesh Reconstruction



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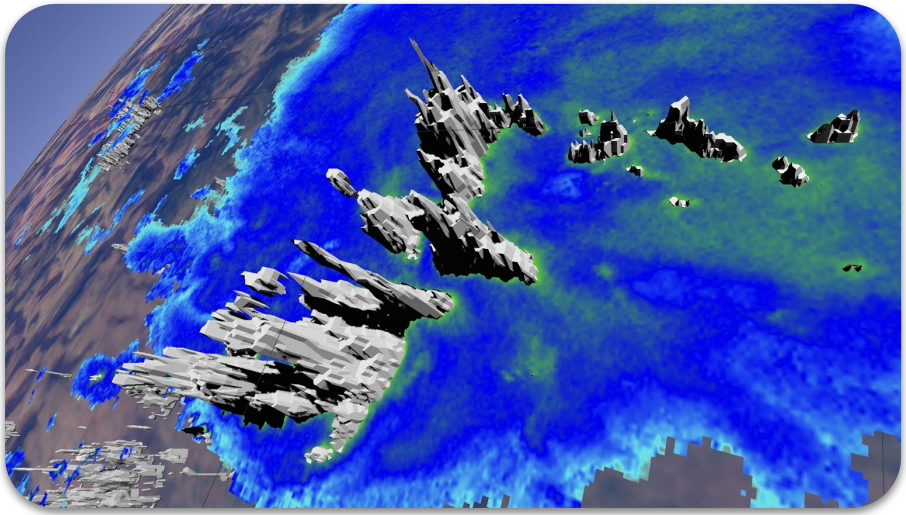
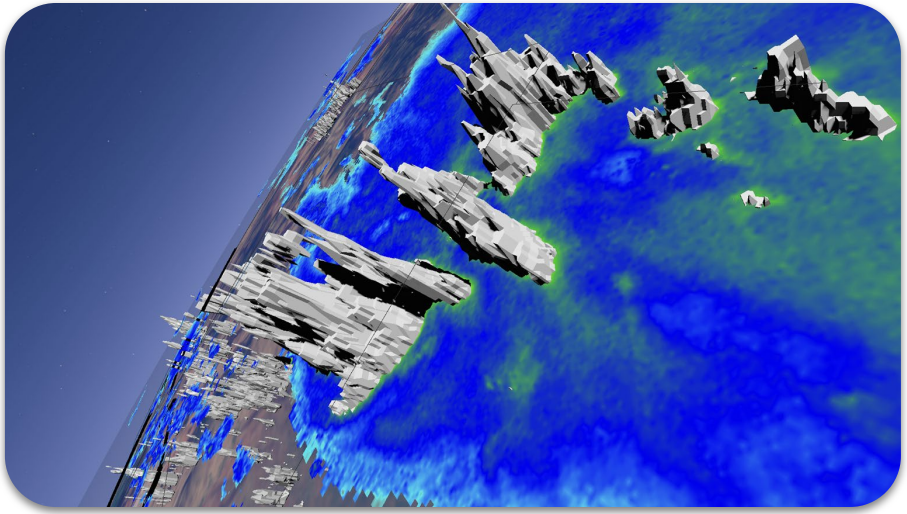
MRMS Merged Reflectivity, 5/19/2023 03:00 UTC

3D Mesh Reconstruction

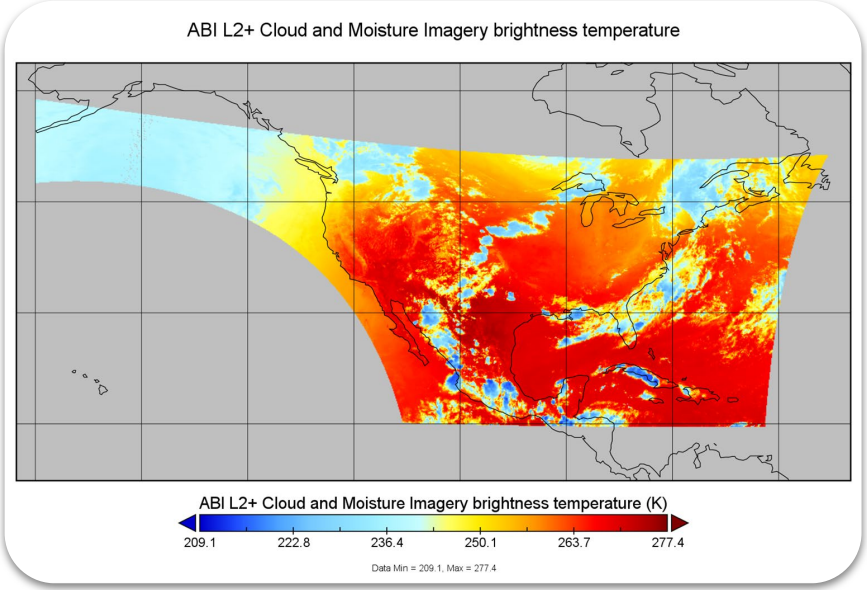


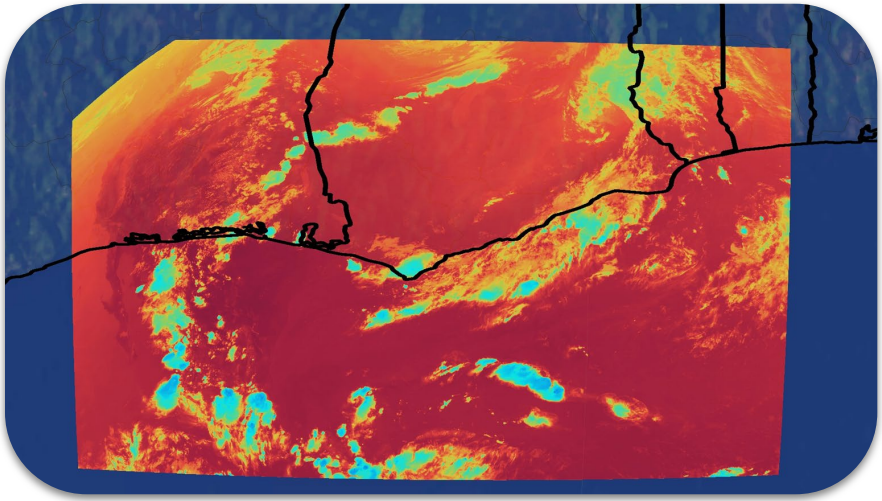


> 25 dBZ

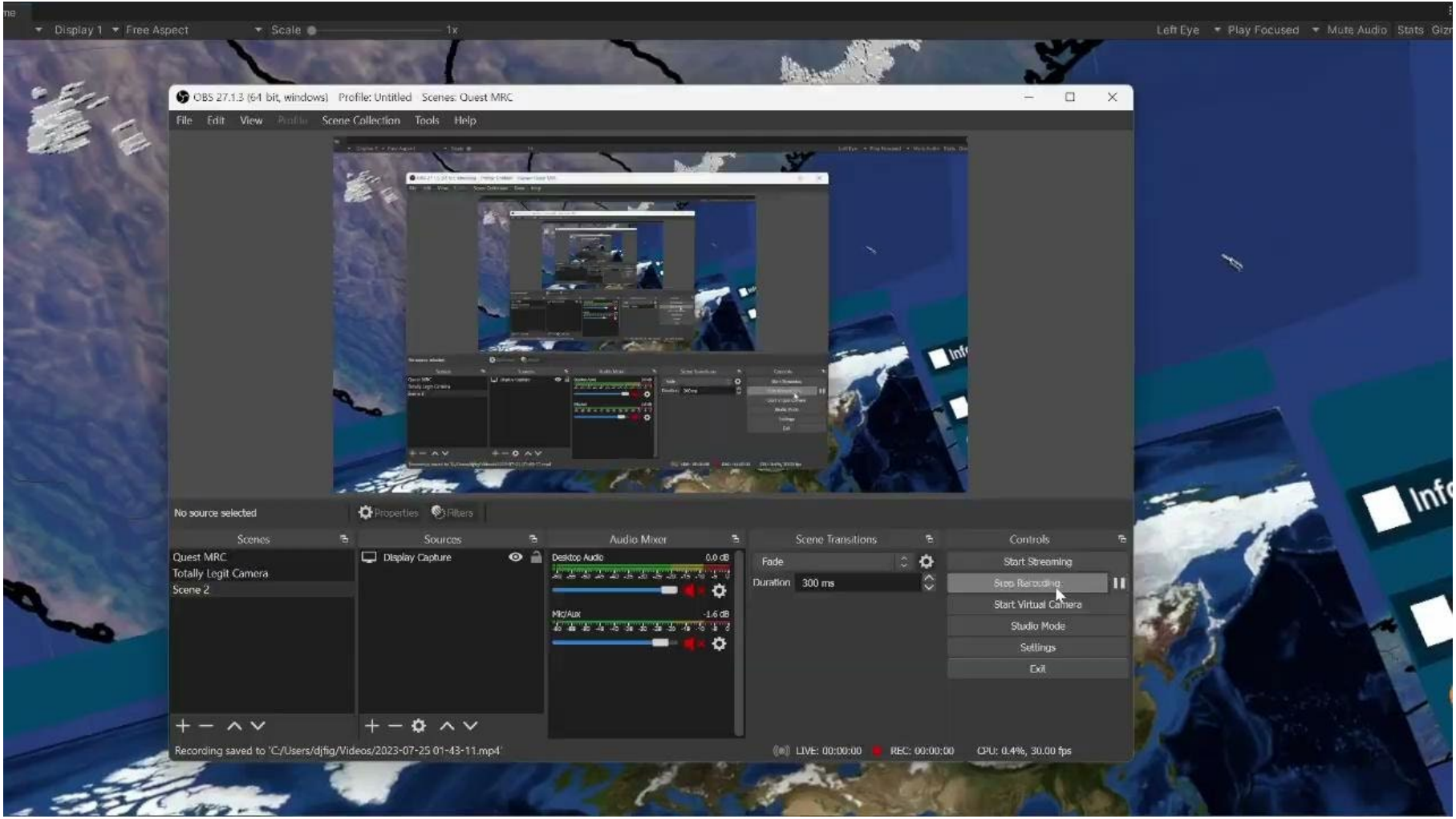
MRMS Merged Reflectivity, 5/19/2023 03:00 UTC

GOES





ABI L2+ Cloud and Moisture Imagery brightness temperature, 07/10/2023 12:22 UTC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Totally Legit Camera
Scene 2
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Audio Mixer
Desktop Audio 0.0 dB
Mic/Aux -1.6 dB
Scene Transitions
Fade
Duration 300 ms
Controls
Start Streaming
Stop Recording
Start Virtual Camera
Studio Mode
Settings
Exit
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LIVE: 00:00:00
REC: 00:00:00
CPU: 0.4%, 30.00 fps

Future Supercell Work

- Vertical cross section
  - Easier to identify BWER
- Optimize memory management
  - Better memory usage = more data visible
- Properly project GOES data over U.S.
- Identify more concrete supercell cases
- Overlay textbook model of supercell
- Incorporation of other data sources?

More Future Work

- Visualize other types of weather phenomena
- Develop **mixed-reality (MR)** and **augmented-reality (AR)** support
  - Meta Quest
  - HTC XR Elite
  - Apple Vision Pro
- Bring application to mobile devices like the iPad and iPhone
- Enable multi-user support to better facilitate mentor and student interactions

Thank you!

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