MITRE Safety of Flight Challenge: Reducing the Impact of Turbulence

Friends and Partners of Aviation Weather
Fall Meeting

October 8, 2025

Source: The Sunday Times, August 25, 2024
Singapore Airlines B777-312ER from London, UK to Singapore (May 21, 2024)

Public Release;
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Public Release Case Number 25-2435

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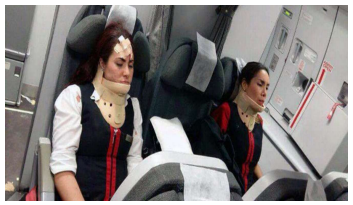
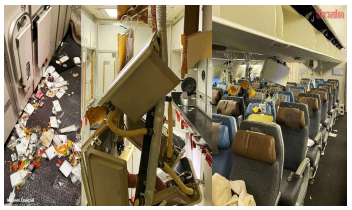
Why Turbulence?

Source: Arise News



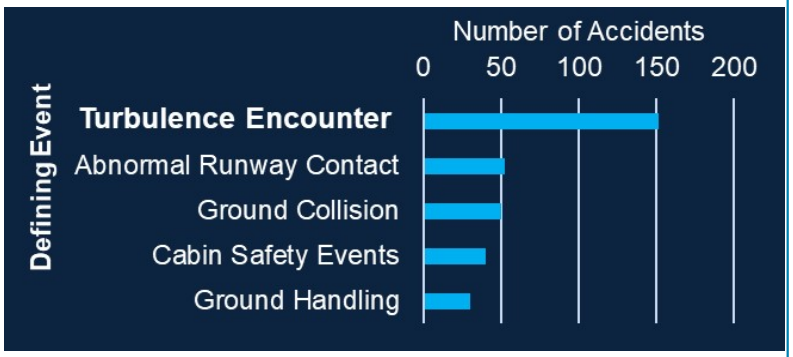
Source: Sharman & Lane (2016)

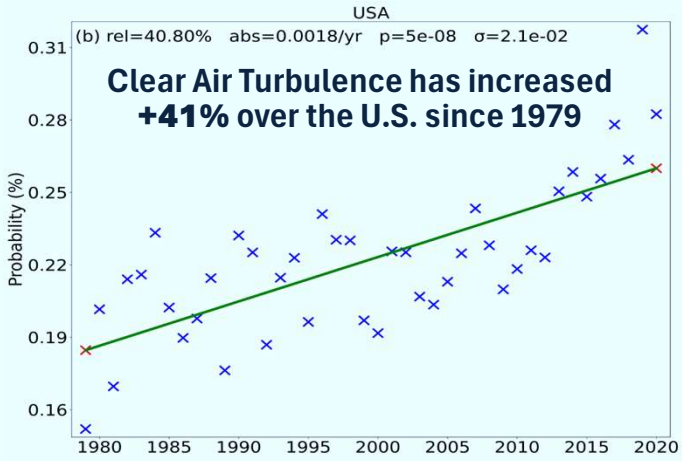
Source: WKMG Channel 6



Source: Khaosod English

NTSB Part 121 Top 5 Accident Defining Events 2003-2024





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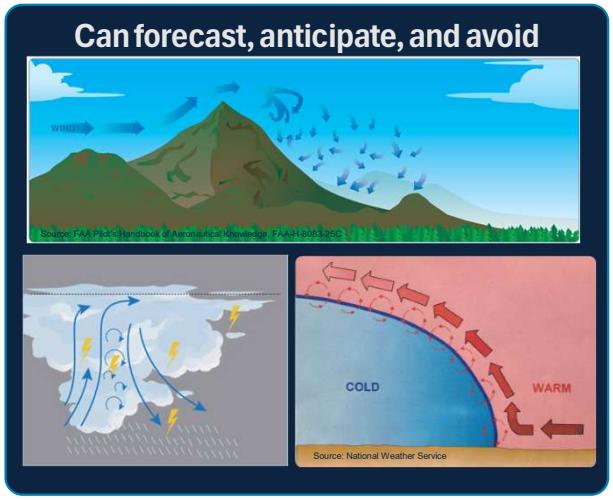
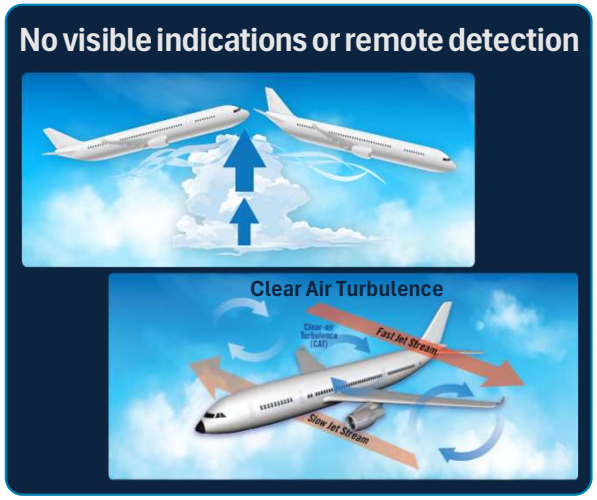
Where are the Gaps?

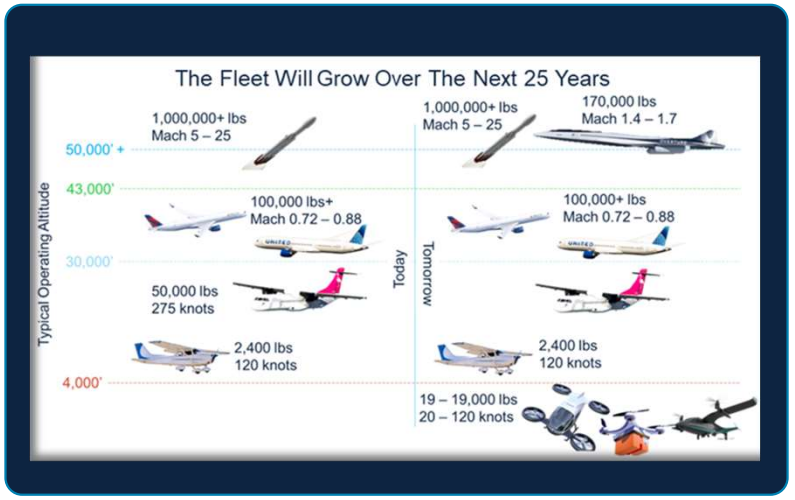
The only way to observe turbulence is to encounter it. CN1

For some forms of turbulence, its location can be predicted. Once it has been reported, airspace remains closed for a long time since there is no way to know that it has cleared.

Injuries resulting from turbulence encounters are the result of unexpected encounters where people and/or objects in the cabin are not secured.







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Slide 3

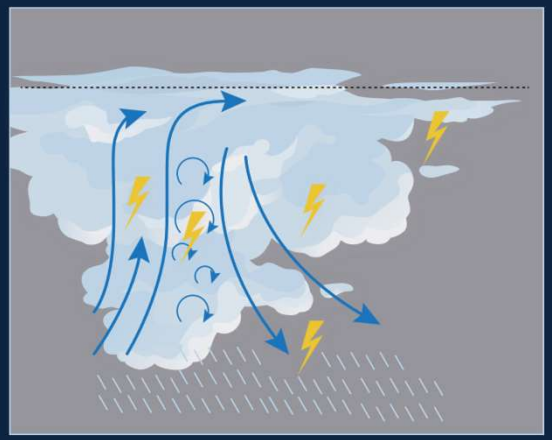
CN1 Is this an overly-general statement? Are there some forms of turbulence (ie associated with thunderstorms) that can be detected & avoided either by seeing the big thunderhead or by weather radar? I think the point is that for some turbulence, you don't know it till you hit it, but this makes it sound like turbulence is always a surprise unless its been reported by someone who experienced it.

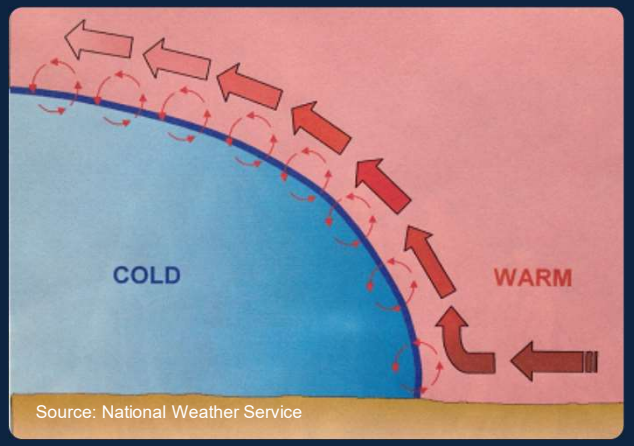
Dr. Chris Niessen, 2025-08-27T22:37:56.533

Where are the Gaps?

Can forecast, anticipate, and avoid

Source: FAA Pilot's Handbook of Aeronautical Knowledge, FAA-H-8083-25C

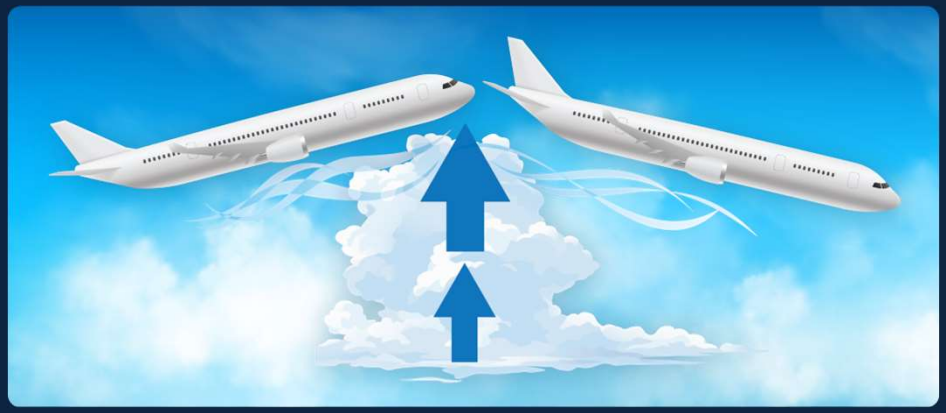




Source: National Weather Service

Where are the Gaps?

No visible indications or remote detection



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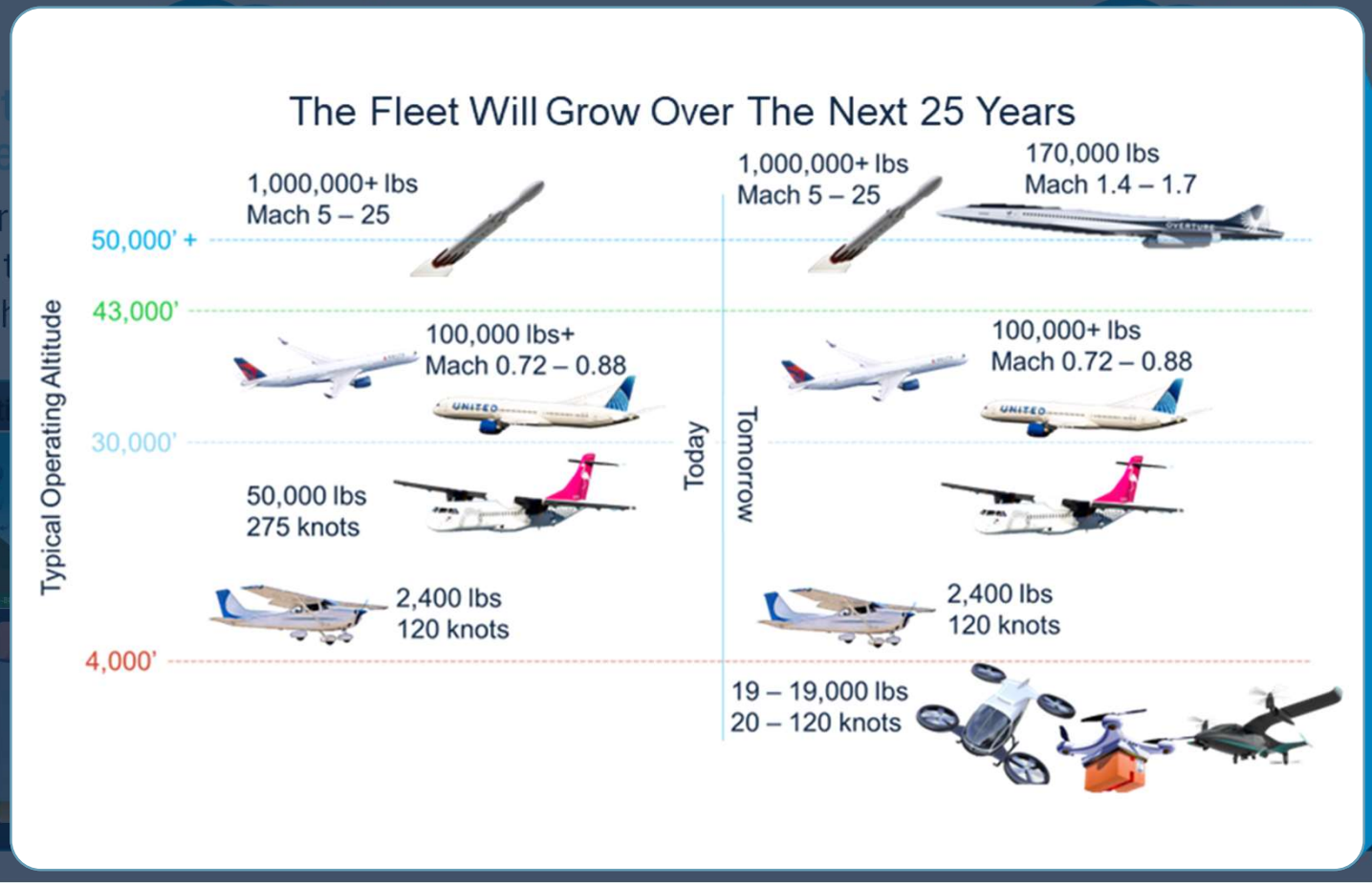
Where are the Gaps?



Holistic Solution

Vision: Radical safety of flight improvement in the presence of increasing turbulence

Remote Detection and Forecasting

Cabin Safety Enhancements

Impact on Emerging Air Vehicles

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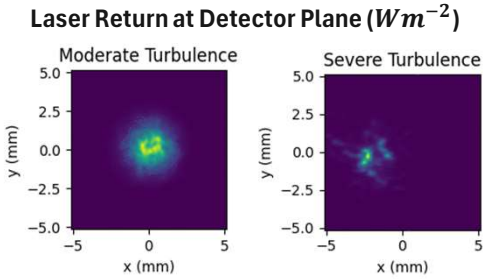
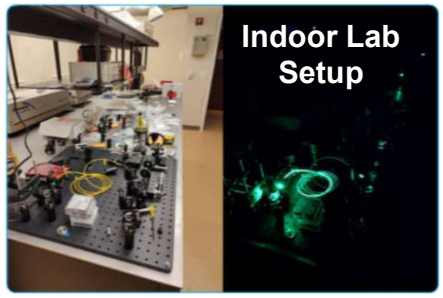
On Board Remote Detection

Goal: Two to five minutes of warning, enough time to avoid turbulence and/or fully secure the cabin, including any service carts, passengers in lavatory, etc.

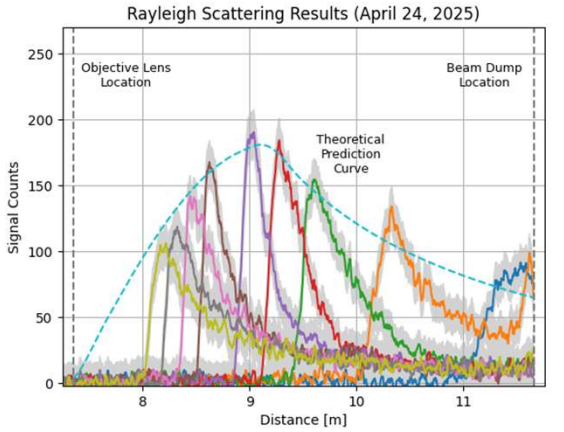
Theory



Experiment



Preliminary Lab Results



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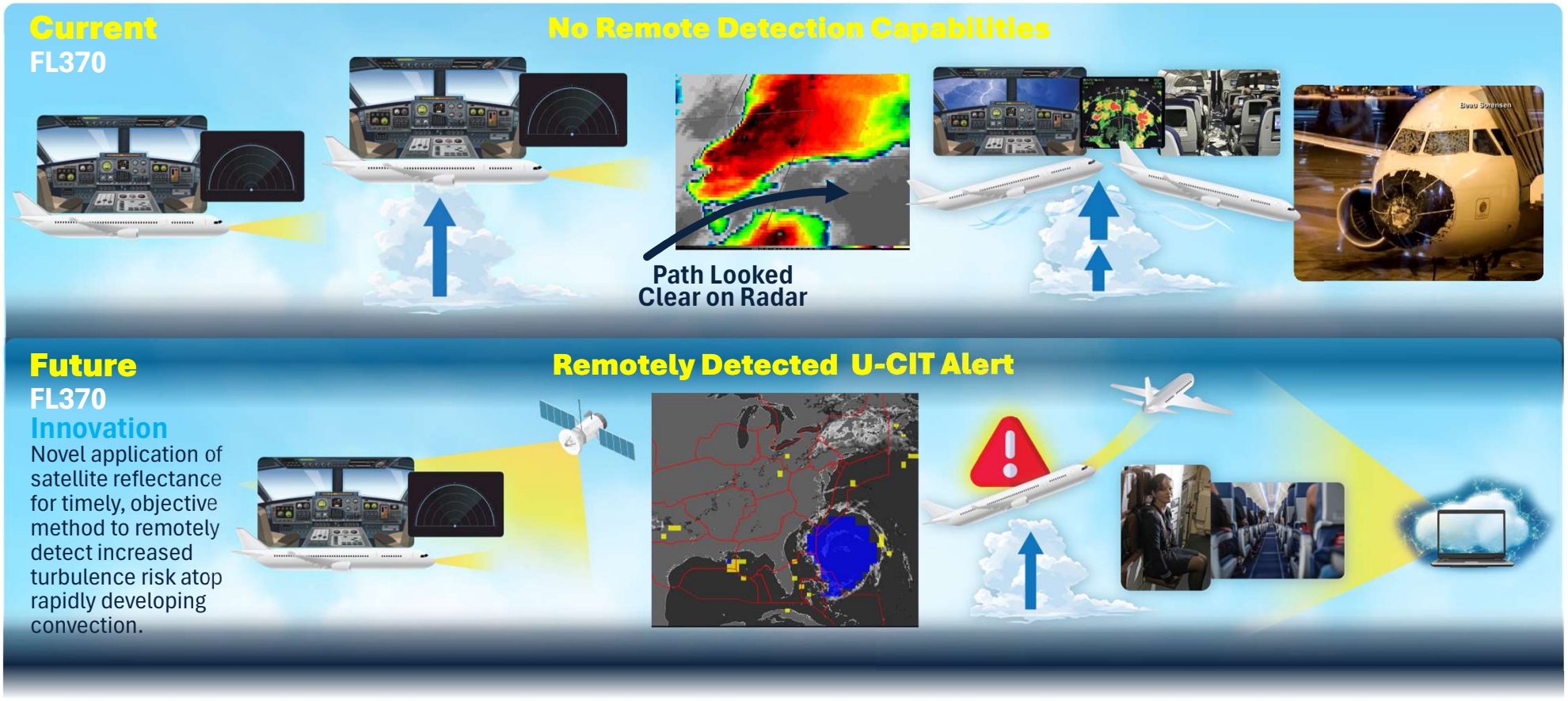
Upgrowth Convective Induced Turbulence (U-CIT) Satellite Remote Detection

Goal: *Apply weather satellite data to detect and alert for turbulence above growing convection*



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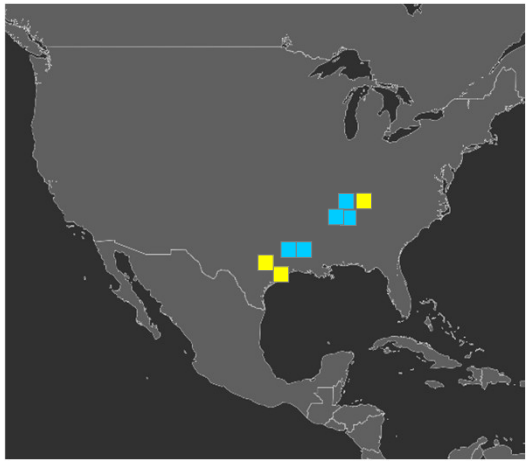
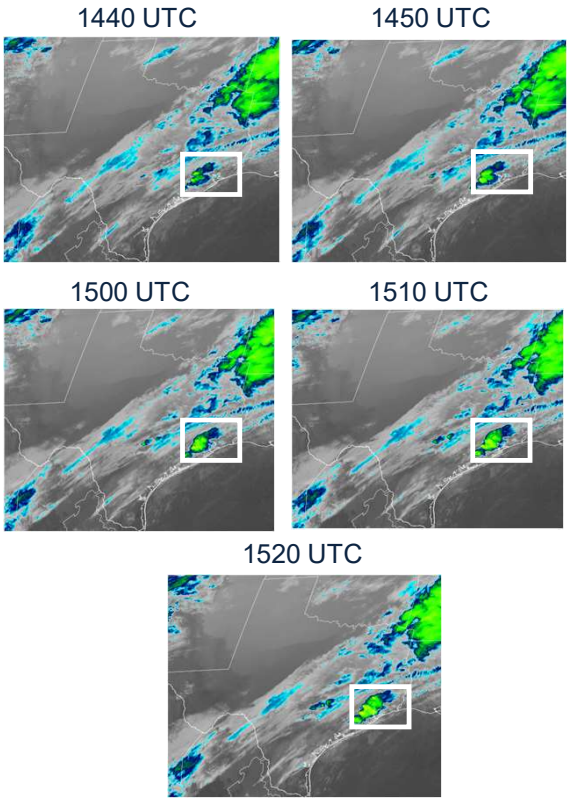
MITRE | U-CIT Upgrowth-Convectively Induced Turbulence

Goal: Apply weather satellite data to detect and alert for turbulence above growing convection.

U-CIT™ Alert Concept of Operations

- Leveraging Rapid updating geostationary satellite (GOES-19)
- Infrared cooling rate to identify potential rapid development and vertical growth for both Day and Night
- U-CIT™ alerts for elevated risk potential
  - 100 km x 100 km grid cell alerts
  - Allows for uncertainty
  - Conceptual Model:
    - Yellow U-CIT™ alert: No visible convection at or above FL300, however lower altitude and/or adjacent convection is creating a CIT risk above FL300
    - Blue: Mature convection above FL300 that is visible to pilot and on radar where CIT would normally be expected. Presented for situational awareness
- Georeferenced data allows for straightforward adaptation of alerts (e.g., along track or airspace)





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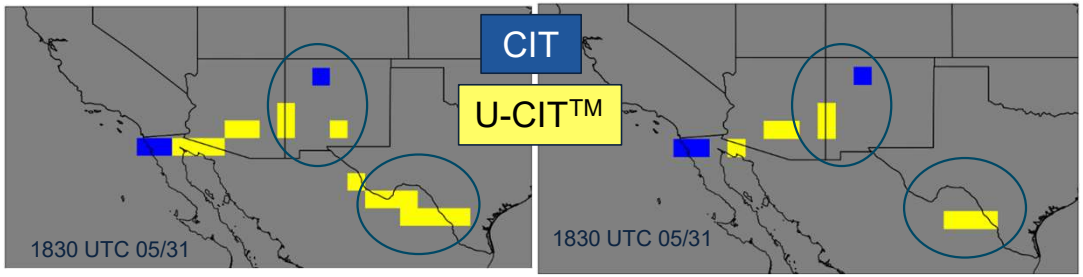
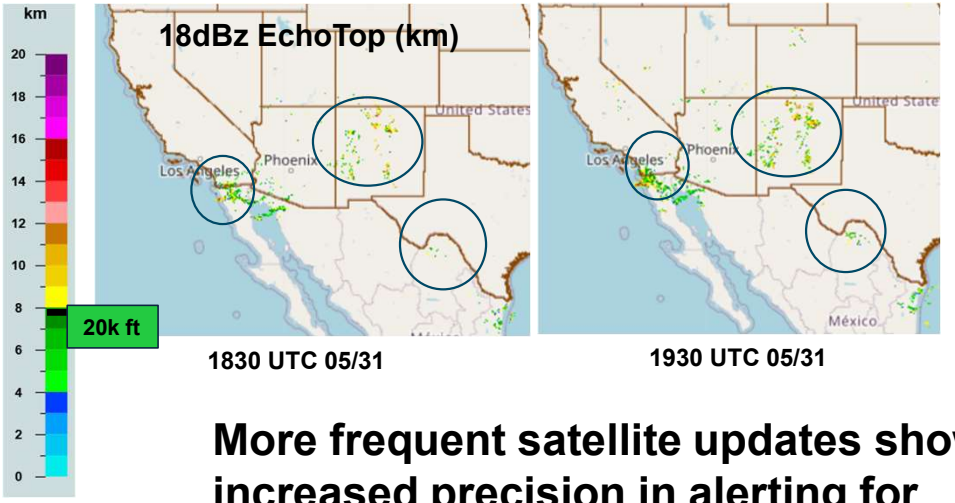
MITRE | U-CIT Upgrowth-Convectively Induced Turbulence

Goal: Apply weather satellite data to detect and alert for turbulence above growing convection.

15-min Cooling Rate

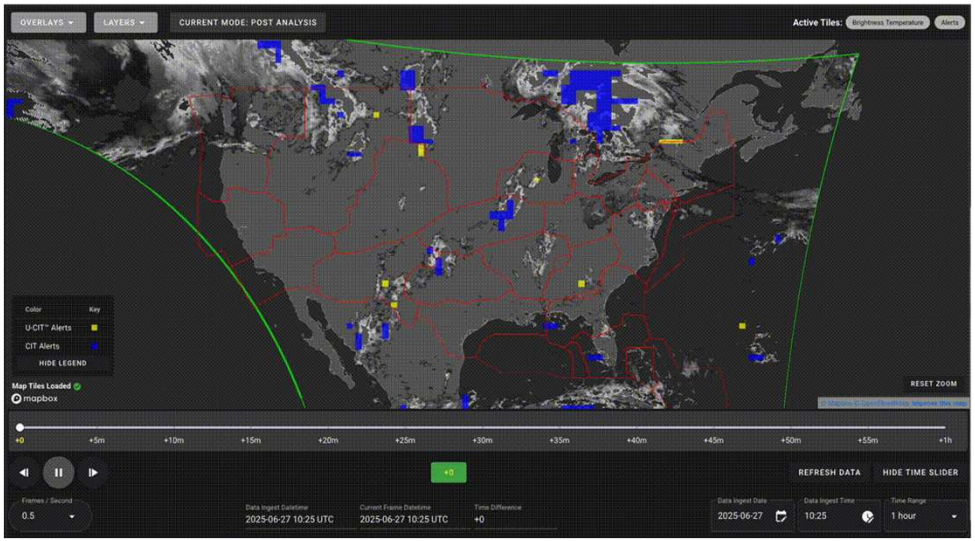
5-min Cooling Rate





1830 UTC 05/31

1930 UTC 05/31



More frequent satellite updates show increased precision in alerting for potential U-CIT

User Interface to visualize impacts to airspace

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Next Steps

Refinement of the algorithm is ongoing based on validation against observed EDR and echo tops

Plans to adapt anticipated EDR intensity associated with U-CIT™ alerts

Feedback and collaboration on the approach welcome

Notice

This work was supported by the MITRE Independent Research and Development Program.