Convectively Induced Turbulence on 1 July 2015 – What, Where and Why?

climate extremes
ARC centre of excellence

Aircraft encounters with turbulence are a crucial safety and operational hazard affecting the aviation industry, costing millions worldwide each year.

Understanding ***where*** and ***why*** does connectively induced turbulence occur is important.

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What - Background

- Turbulence is nonlinear and irregular motion it mixes out the instability, diffusive nature
- Occur in 3-dimensions, and energy cascading through the dissipation of turbulence
- Turbulence associated with convective system is the convectively induced turbulence (CIT)
- Mechanisms for CIT (Sharman and Trier, 2019):
  - **Gravity waves** propagating and breaking away from cloud
  - Enhanced **shears** and/or **instabilities** in duced by outflow at extensive anvil, and overshooting tops

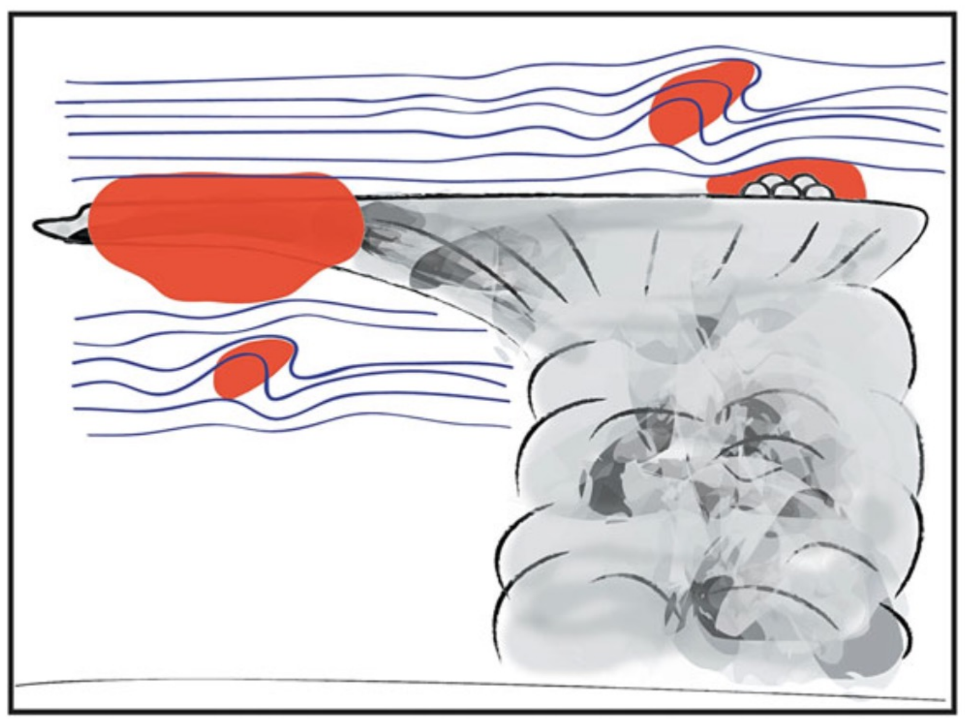

Figure 1 - A schematic representation of the CIT generating regions (red areas).
Grey area is the cloud, black lines represent the physical cloud boundary and blue lines are isentropes.
(Sharman and Lane, 2016, based on Lester, 1993)

1 July 2015

- Intensive Observation Period 17, 1 July 2015, Plains Elevated Convection at Night (PECAN)
- 10 hours
- Over north-western Missouri and south-eastern Nebraska
- Nocturnal mesoscale convection
- Strong low-level jet and cluster-like mesoscale convective system (MCS)

Data

- Radiosonde
- Mesonet
- Weather radar maintained by GridRad, measured hourly
- Commercial aircraft data
- ERA5 Reanalysis

Key Questions

- Where is convectively induced turbulence (CIT) in the atmosphere, relative to the convective system?
- Why there is CIT at this part of the convective system?
- What are the meteorological processes lead to observations of severe turbulence in this case?

Where - Preliminary Result

- At 0800 UTC, concentrated turbulence records between 2 convective regions – closest distance to convection is 13km
- Most of the radiosonde locations are near convection, adequate for further analysis
- Reanalysis data help understanding the background meteorological process, where could be favourable to CIT generation

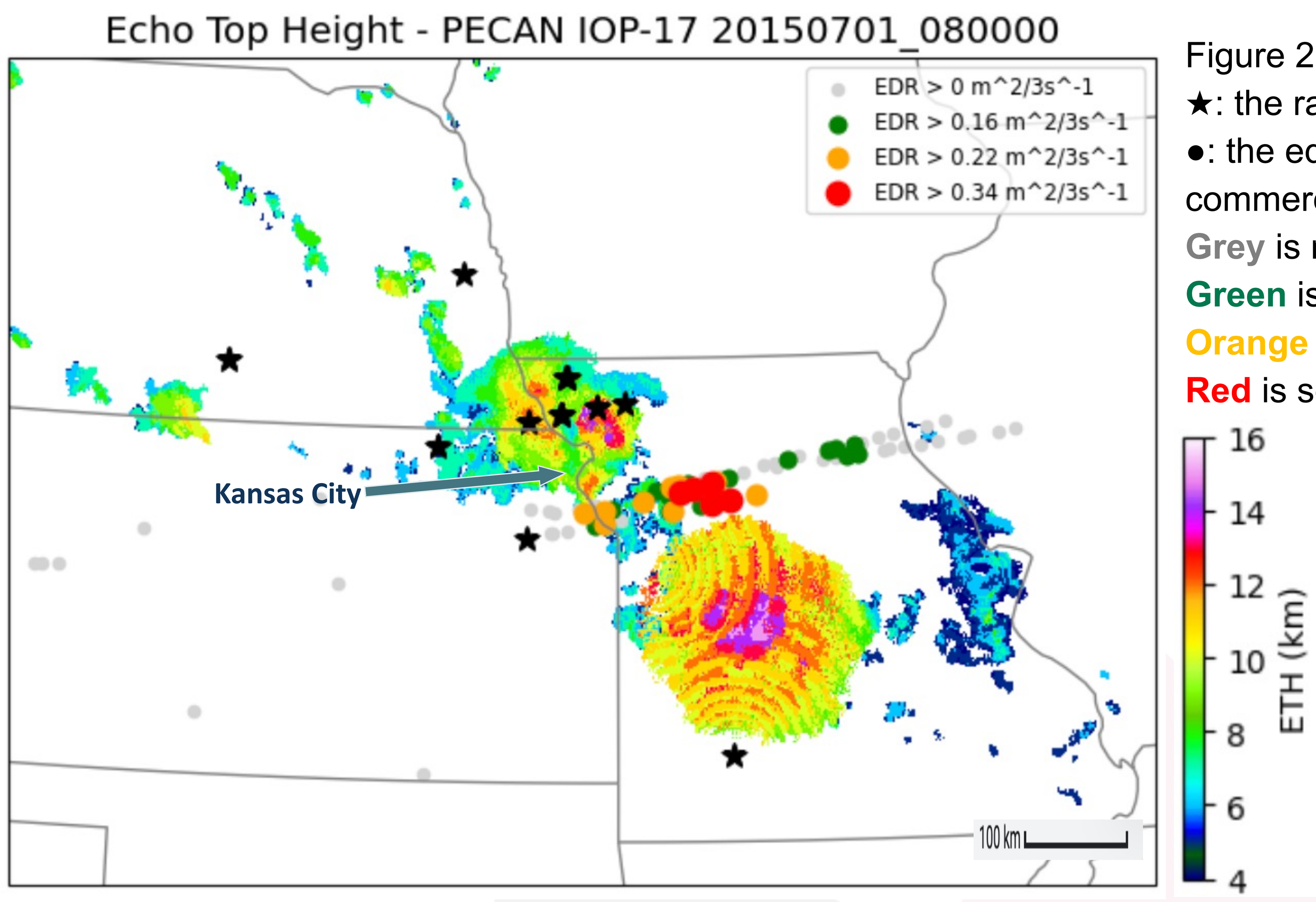

Figure 2 - Echo Top Height plot (ETH) at 0800UTC
★: the radiosonde location
●: the eddy dissipation rate (EDR) record from commercial aircraft data;
Grey is non turbulence event
Green is light turbulence event
Orange is moderate turbulence even
Red is severe turbulence

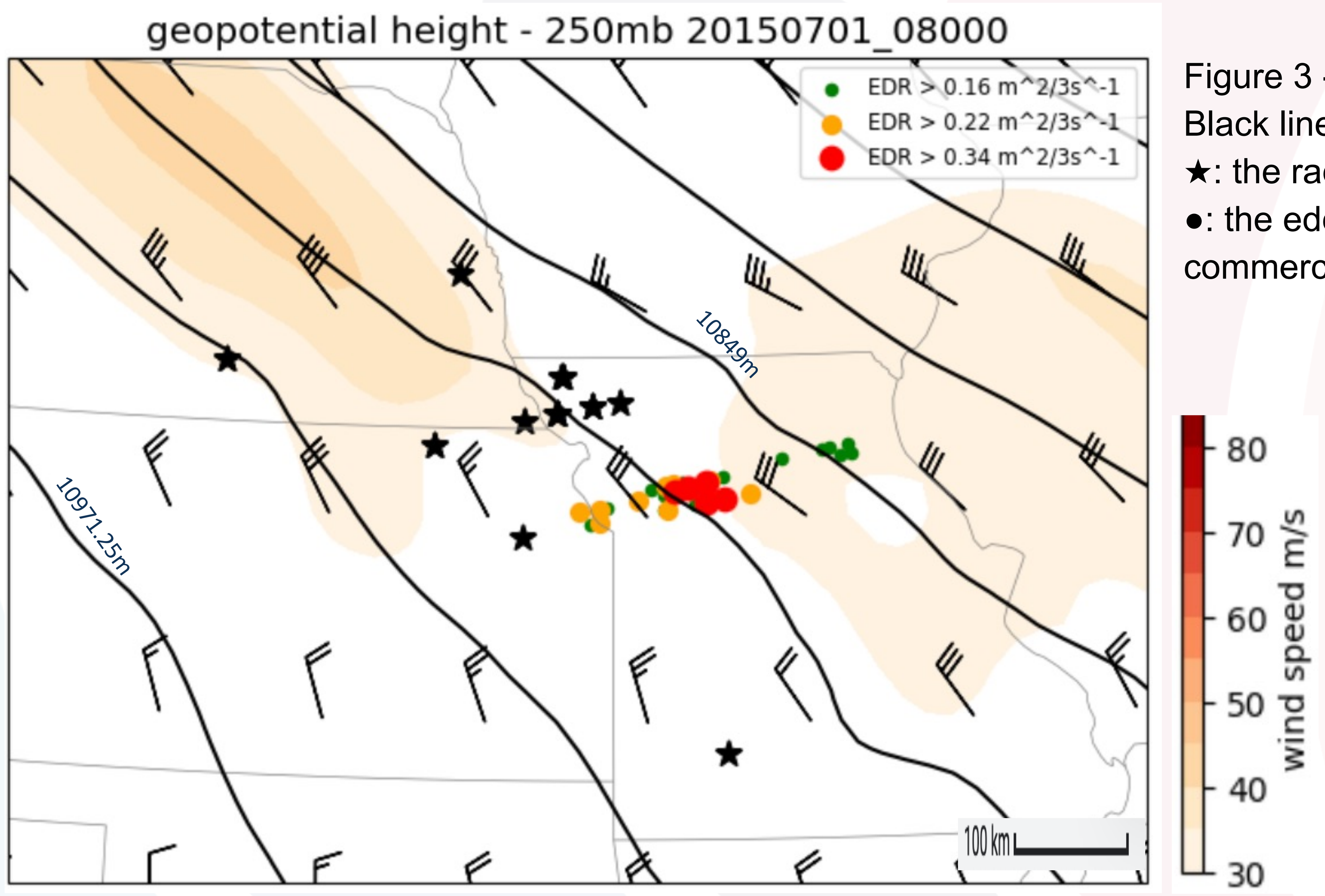

Figure 3 - Geopotential Height at 250mb at 0800UTC
Black line is the geopotential height
★: the radiosonde location
●: the eddy dissipation rate (EDR) record from commercial aircraft data; same as Figure 2

Why – Next Step

- Investigate the background meteorological process
- Use background environment (across different scales) to understand turbulence events
- Compare observations to reanalysis
- Use to reanalysis to fill in gaps in observations, to build a more completed picture of CIT on the investigating period
- Find the spatial pattern of CIT relative to this convection

Acknowledgement

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- GridRad Archive, Homeyer and Bowman
- ERA5

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