Mesoscale Boundaries and Convective Storm Development in Southwestern Ontario

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- ELBOW 2001 Project
- Boundary Identification
- Previous Studies
- Cell Initiation and their Association with Mesoscale Boundaries
- Cell Identification
- Distance to the Closest Boundary
- Results
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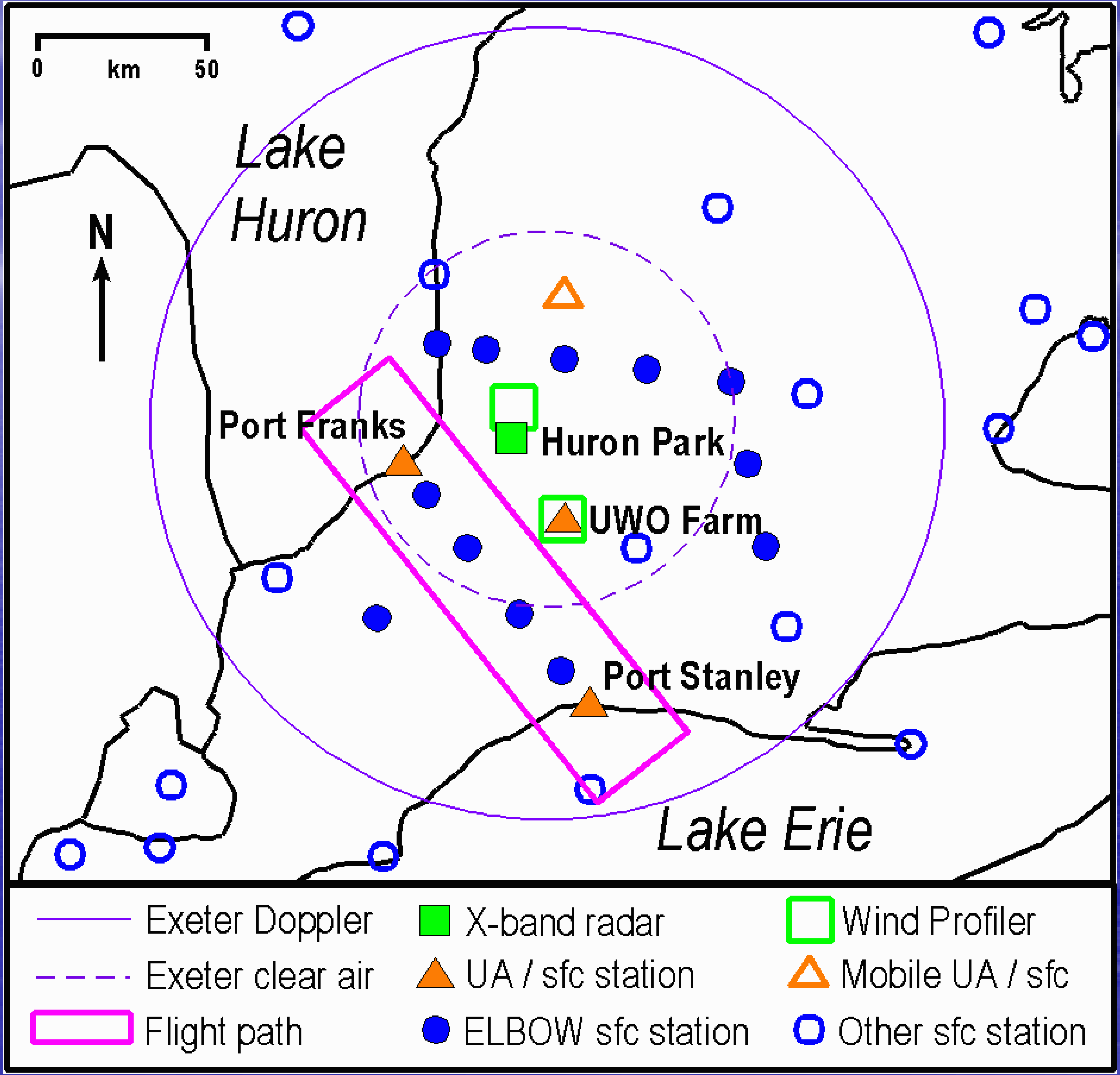
Mesoscale Boundaries

Southwestern Ontario presents a unique area in which to observe and study mesoscale boundaries. Common types include:

- Lake Breeze Fronts
- Land Breeze Fronts
- Outflow boundaries (storm gust front)
- Combinations of boundaries interacting

ELBOW 2001 Project



Alexander et al. (2018)

Dave Sills, Pat King, ECCC, Peter Taylor (York U. with CFCAS support).

Boundary Identification

Mesoscale boundaries identified included:

- Lake Breeze Fronts
- Gust Fronts
- 'Merged' Boundaries (the result of two lake breeze fronts interacting)
- 'Hybrid' Boundaries (the result of a lake breeze front interacting with another boundary type)
- 'Joined' Boundaries (the ends of two boundaries become linked together)
- 'Other' Boundaries (this included synoptic –scale fronts ,well developed horizontal convective rolls and boundaries in which the origin was unknown)

Semi-objective criteria were used to identify the boundaries in each analysis. Boundaries were identified for each hour of each day of summer 2001. The boundary analysis domain was given a range of approximately 150 km of the Exeter radar.

Boundary Identification

Lake Breeze Front Identification Criteria

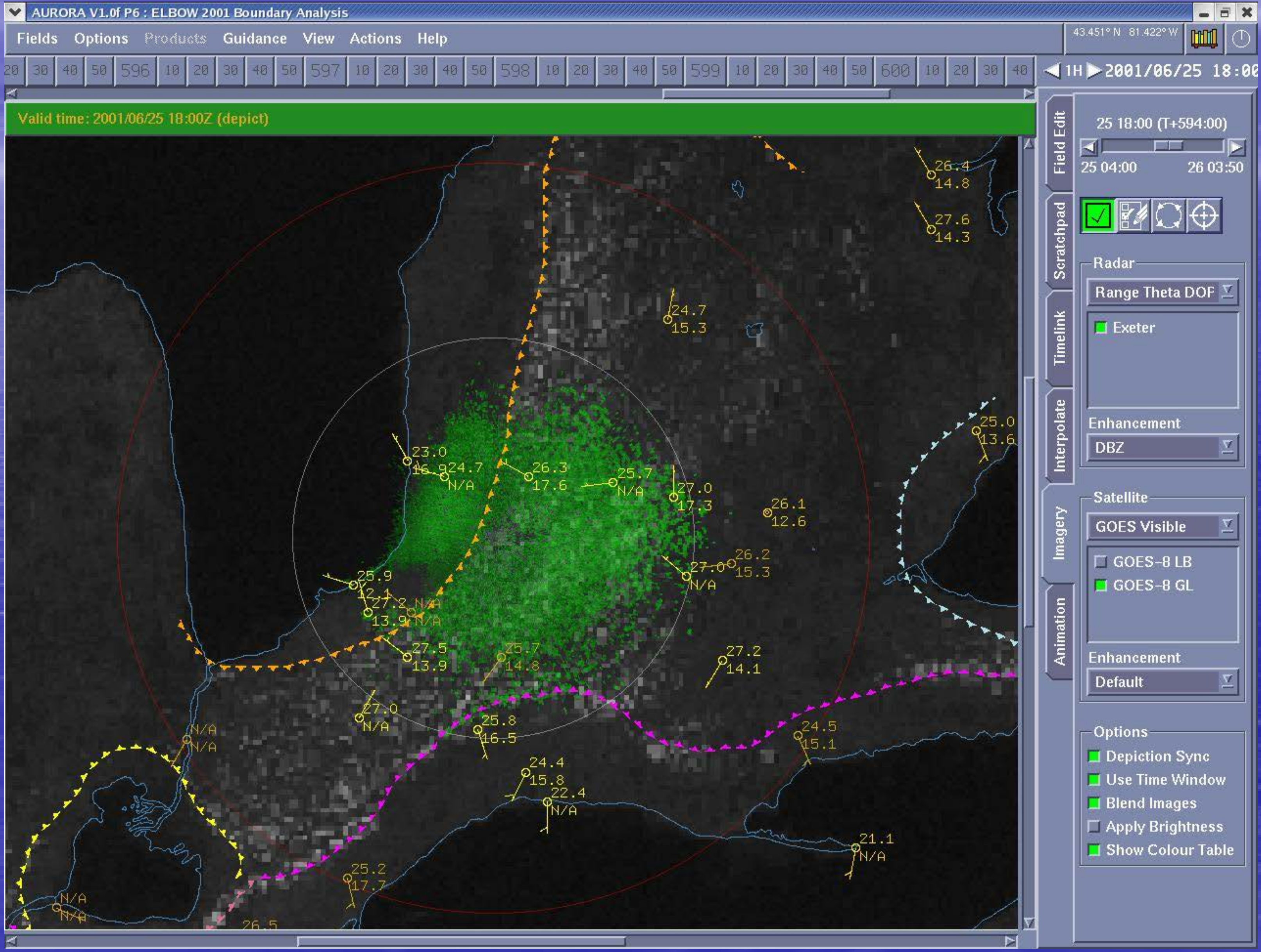
Platform	Positive Factors	Negative Factors	Ambiguous
Satellite (visible)	▶ line of cumulus clouds or sharp gradient in cumulus cloudiness quasi-parallel to shoreline ▶ gradual inland penetration of above	▶ persistent thick cloudiness over most or all of lake ▶ gradual change in the depth of cumulus clouds inland from lake (gradually deepening CBL)	▶ no cloud visible ▶ thin cirrostratus or broken mid-level clouds prevents seeing cumulus clouds
Radar (LogZ, Vr)	▶ fine line or sharp gradient in clear air reflectivity quasi-parallel to the shoreline ▶ shift in radial velocity along fine line ▶ gradual inland penetration of above	▶ large area of persistent precipitation over region	▶ no clear air echoes ▶ fine line or gradient in clear air echoes not well defined
Surface (Stn plots, time series)	▶ rapid shift in wind direction to onshore wind (may be accompanied by rapid change in wind speed, sharp decrease in temperature and sharp change in dew point within ~20 km of shore), ▶ gradual inland penetration of onshore winds ▶ elongated area of convergence quasi-parallel to shoreline Note: an area of broad divergence over the lake and the adjacent lake shore indicates a lake breeze circulation is present and may be used to support the presence of a lake breeze front	▶ Offshore winds	▶ often very subtle surface gradients at boundaries in moderate / high low-level wind regimes

As seen in Table 1 in Alexander et al. (2018)

Identification criteria for other boundary types can be found in Alexander (2012)

Boundary Identification

The Aurora research workstation (Greaves et al. 2001) was used to look at multiple images/data sets in order to identify mesoscale boundaries



Alexander (2012)

Previous Studies

Wilson and Schreiber (1986)

- Studied convective initiation in proximity to convergence lines in Colorado (East of the Rocky Mountains)
- Study period was May to August, 1984
- Boundary layer convergence lines were identified through Doppler radar
- Cells which reached a 30 dBZ level (at 1 km altitude) were identified and the distance from the cell to the closest boundary layer convergence line was measured
- moving boundary: 0 – 20 km behind
- stationary boundary: 0 – 15 km
- colliding boundary: 0 – 5 km

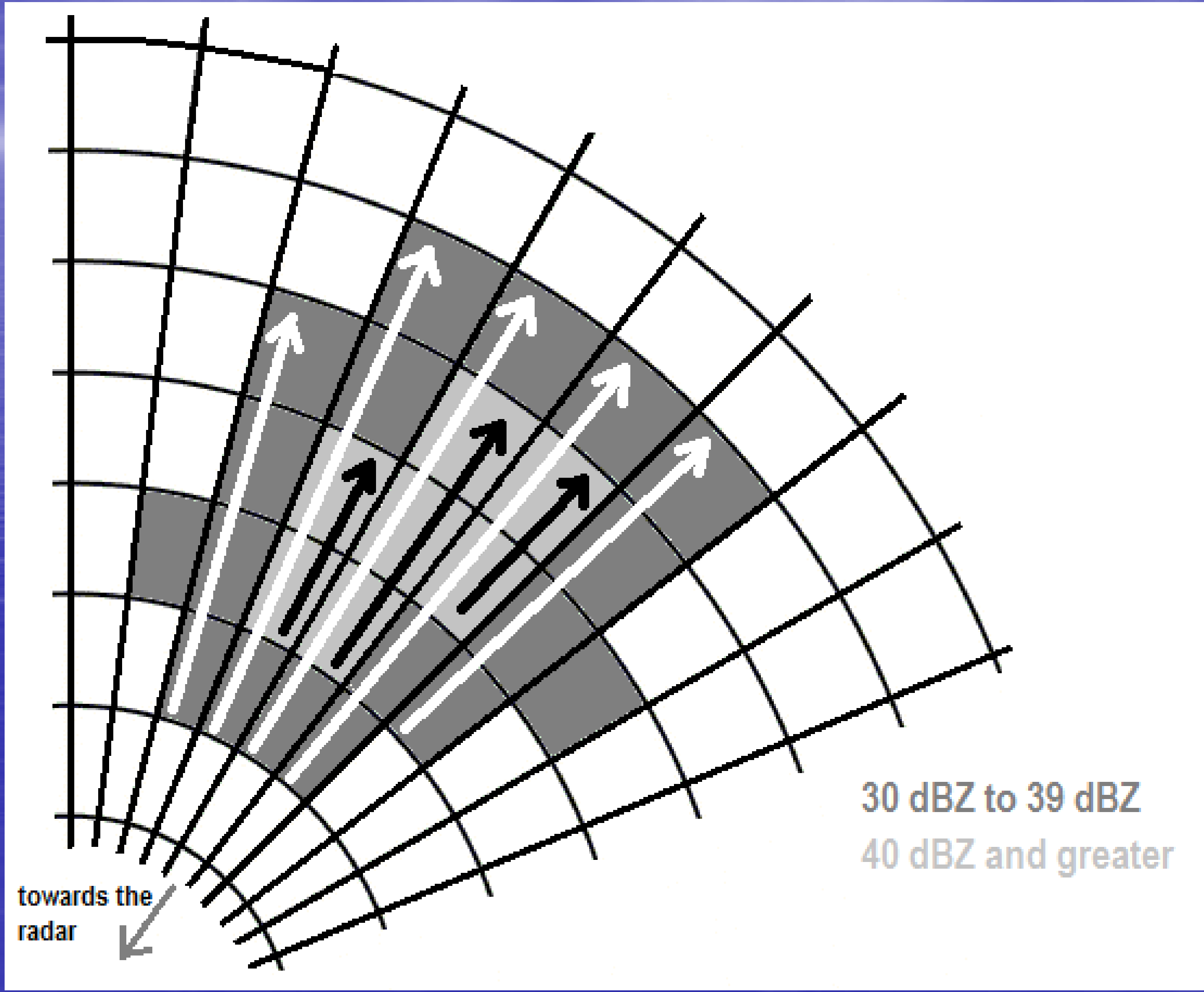
Cell Initiation and their Association with Mesoscale Boundaries

- Looked at 1 km CAPPI and 1 km MAXR products from Exeter radar
- Considered cells reaching 40 dBZ which were identified by a Unified Radar Processor (URP) cell identification algorithm
- Since boundaries were identified hourly, cells reaching 40 dBZ on the hour and 10 min after were considered. The time frame this was done for was 1600 to 0000 UTC (or 1200 to 2000 EDT)
- Cells identified within 80 km of the Exeter radar were considered, to ensure good boundary coverage
- Days with warm front influence in the region were not considered.
- Used URP cell tracking data as a suggestion. Tracks were analyzed visually.
- These 40 dBZ cells had their distance to the closest low-level mesoscale boundary measured

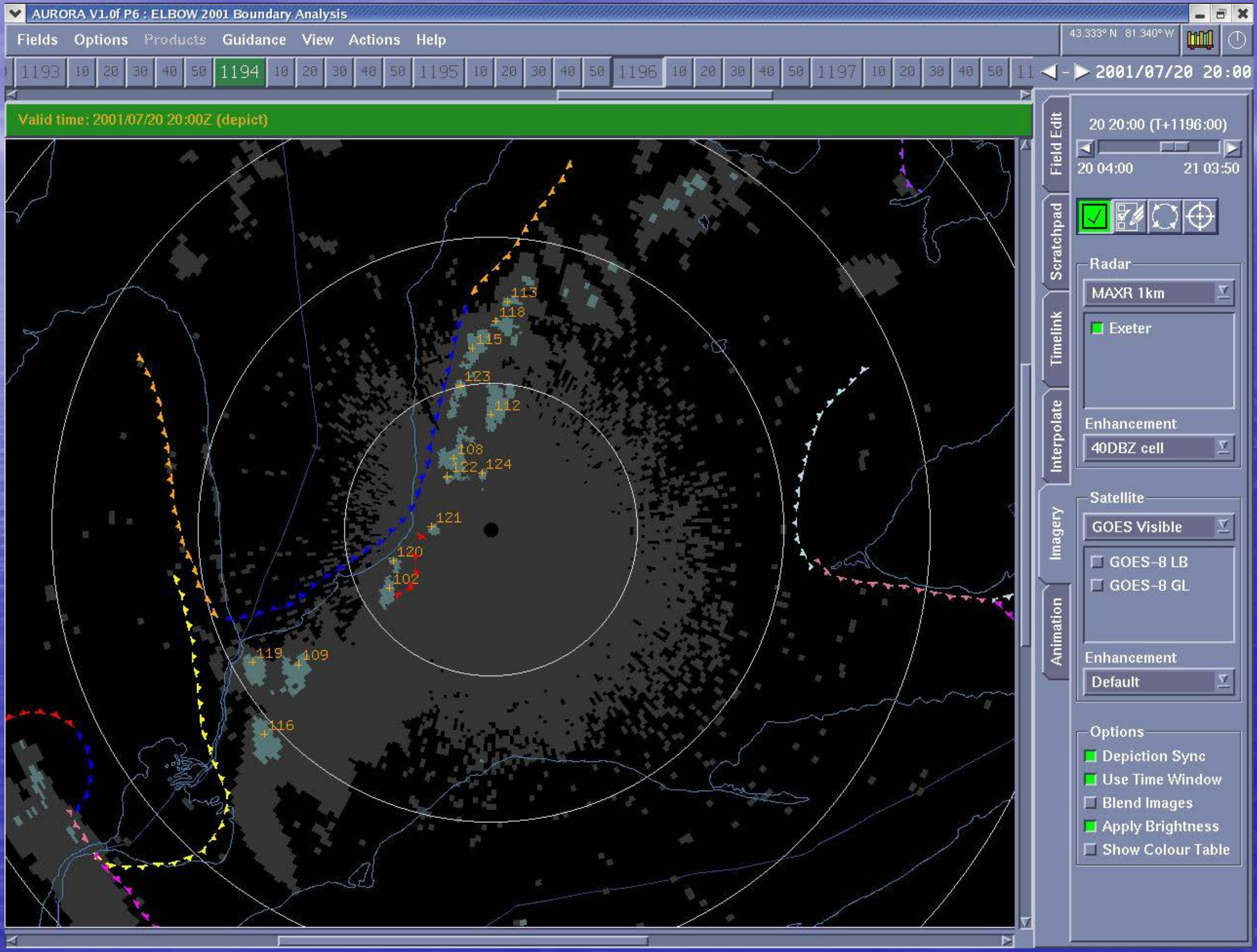
Cell Identification

The URP cell identification algorithm was based on the concepts and methods employed in the TITAN algorithm (Dixon and Wiener 1993)

Alexander et al. (2018)

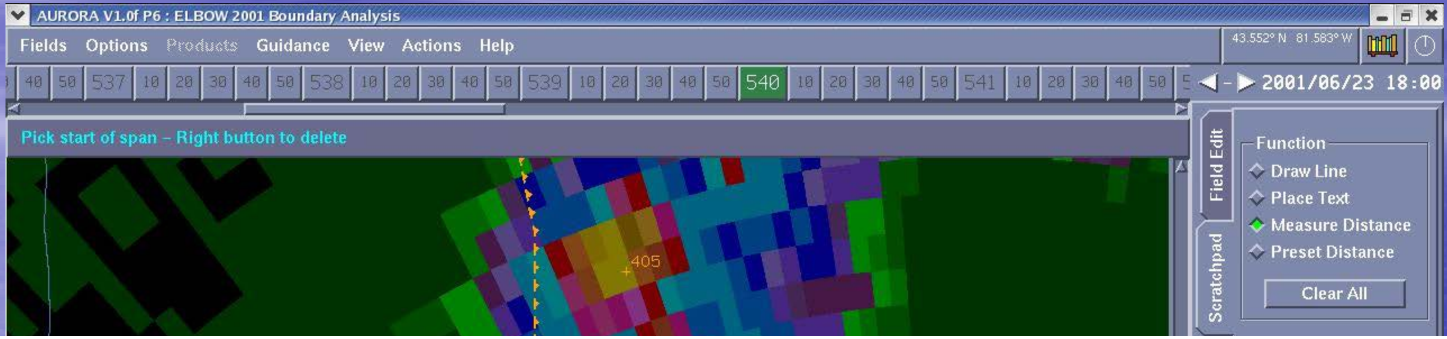


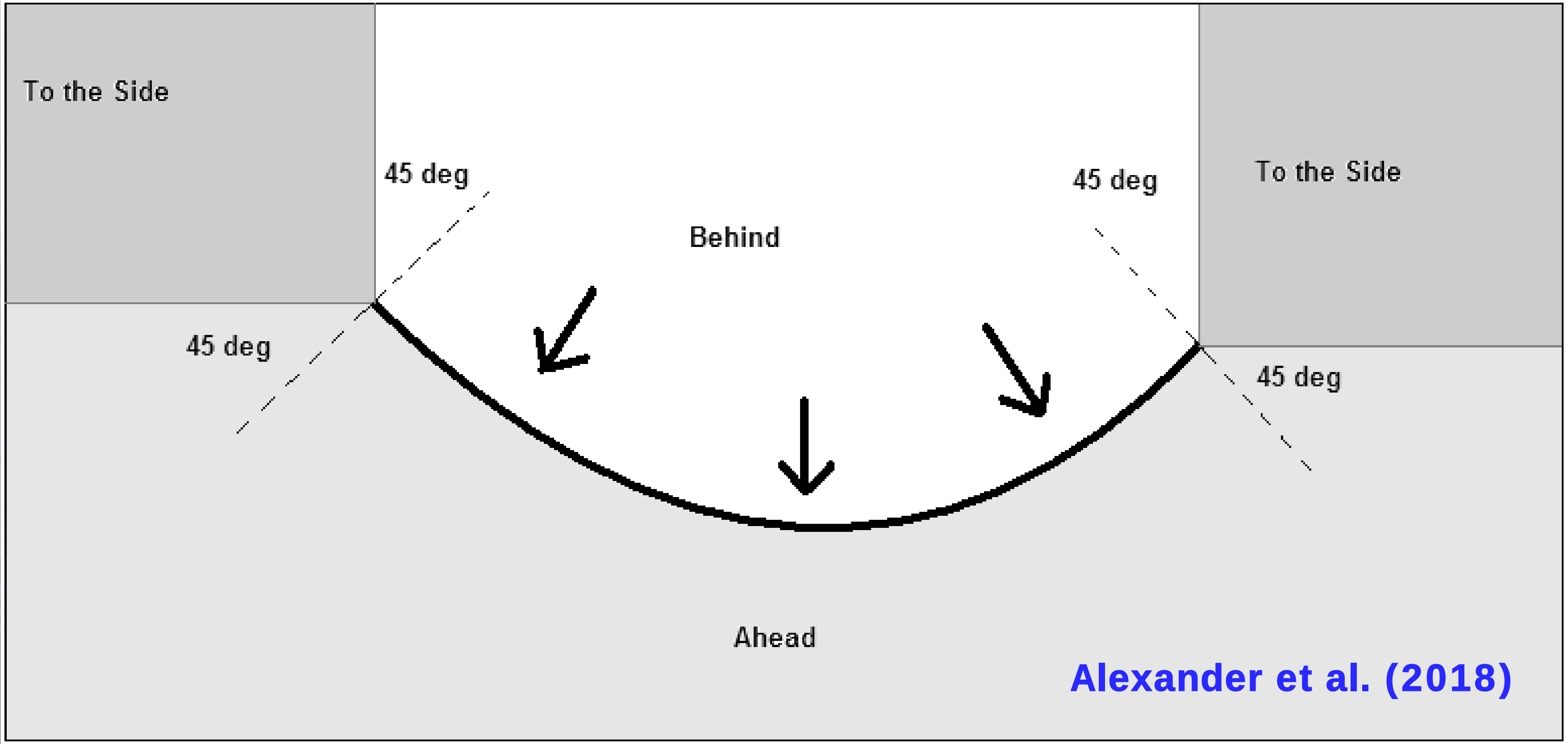
Cell Identification



Figures from Alexander (2012) and Alexander et al. (2018)

Distance to the Closest Boundary

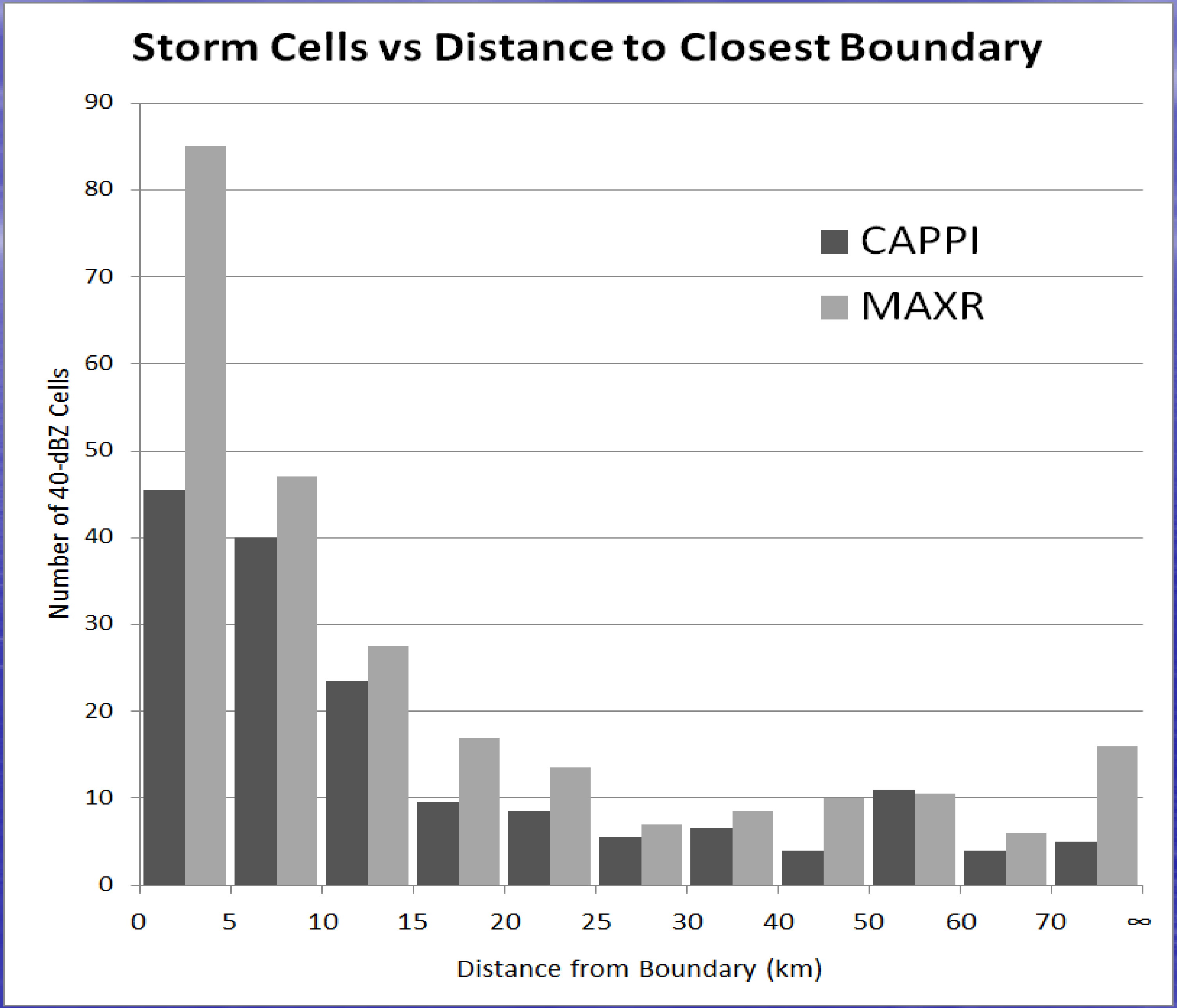




Results

78.4% of CAPPI cell initiations and 75.8% of MAXR cell initiations occurred within 30 km of a boundary.

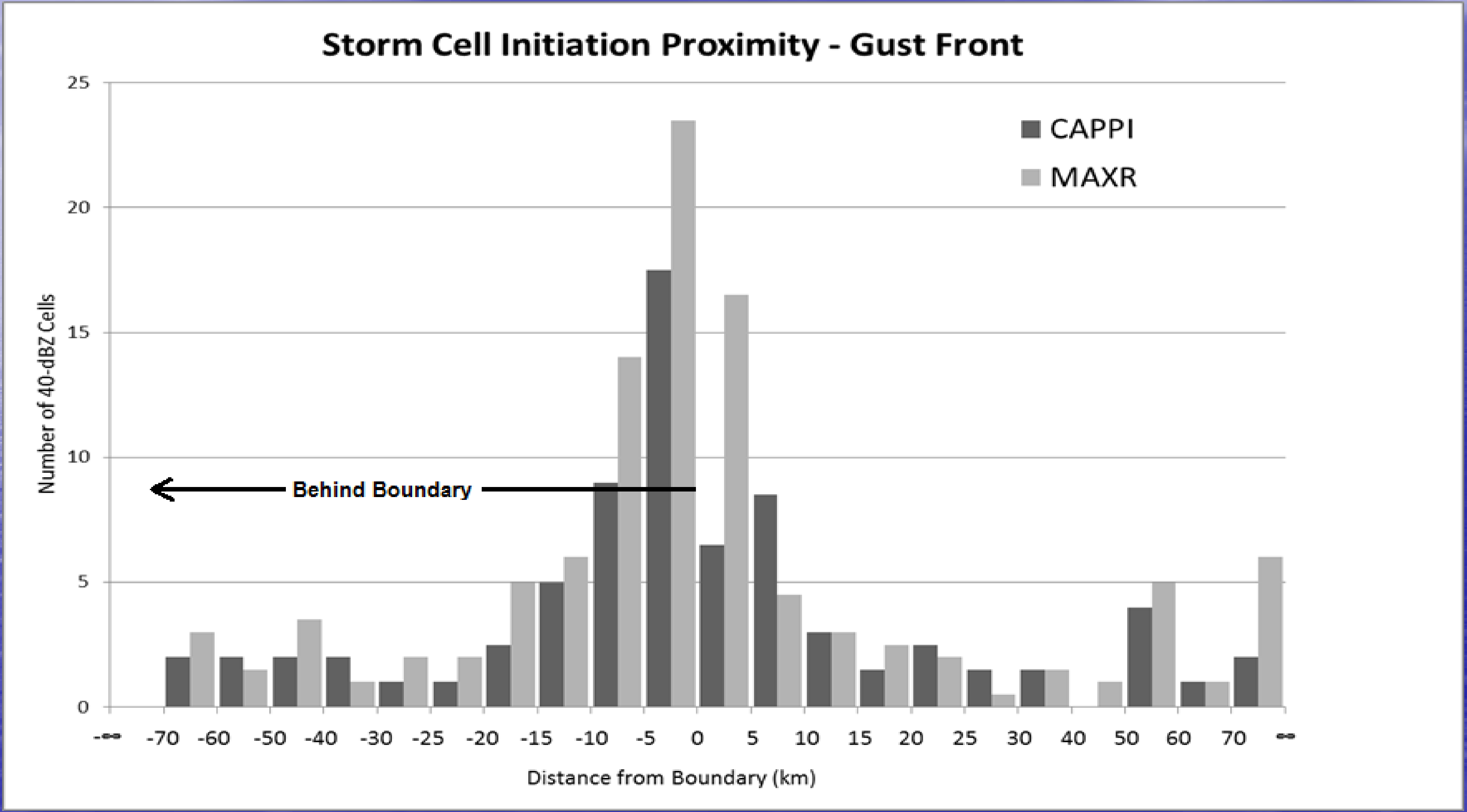
Alexander et al. (2018)



Results

	CAPPI		MAXR	
	# of Cells (initially reaching 40 dBZ)	% of Total	# of Cells (initially reaching 40 dBZ)	% of Total
Total Cells	169		260	
Lake-Breeze Front	22	13.0	53	20.4
Gust Front	99	58.6	142	54.6
Merged	3	1.8	4	1.5
Hybrid	18	10.7	21	8.1
Joined	5	3.0	4	1.5
Other	16	9.5	24	9.2
No boundary to measure to	6	3.6	12	4.6

Results



Alexander et al. (2018)

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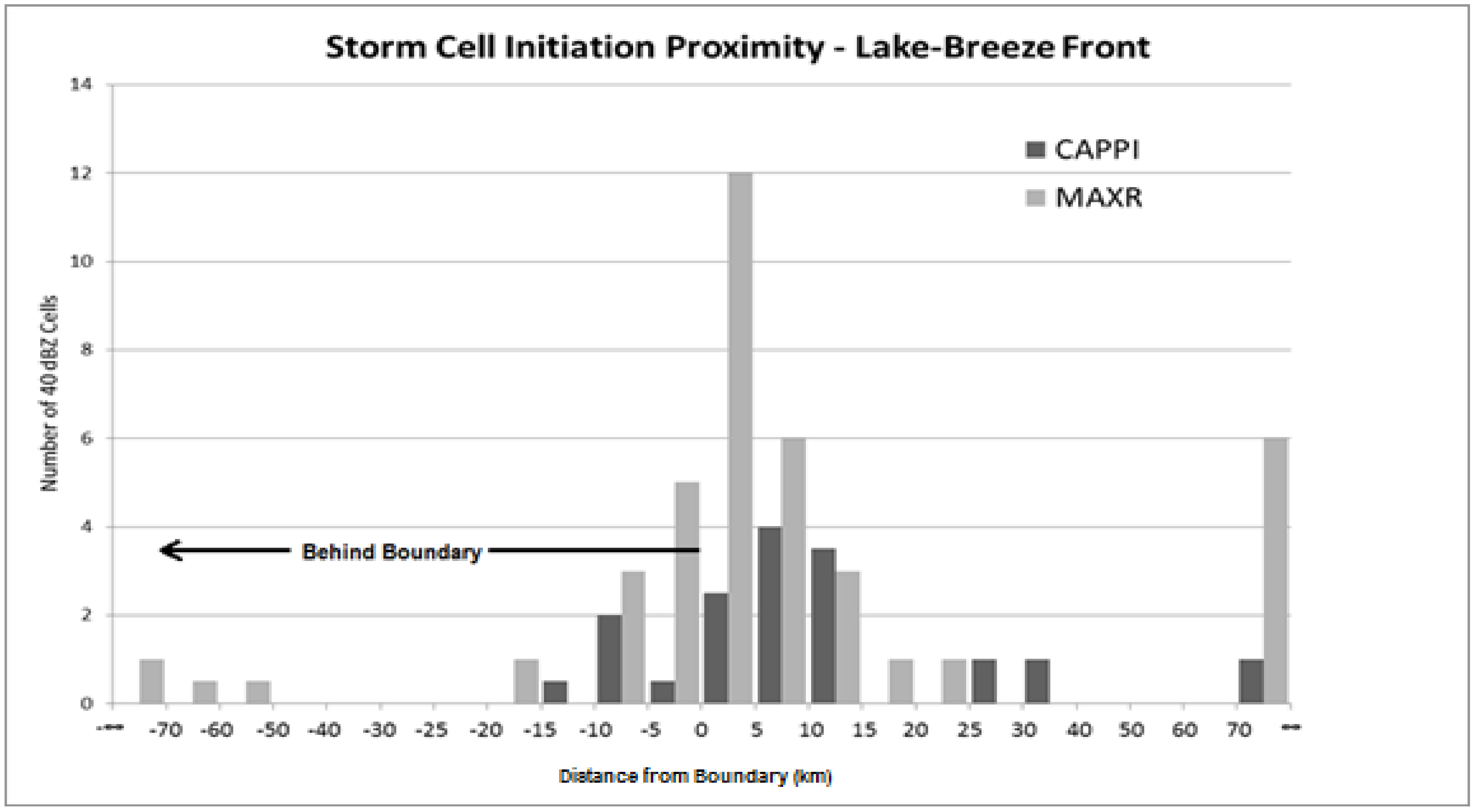

Alexander et al. (2018)

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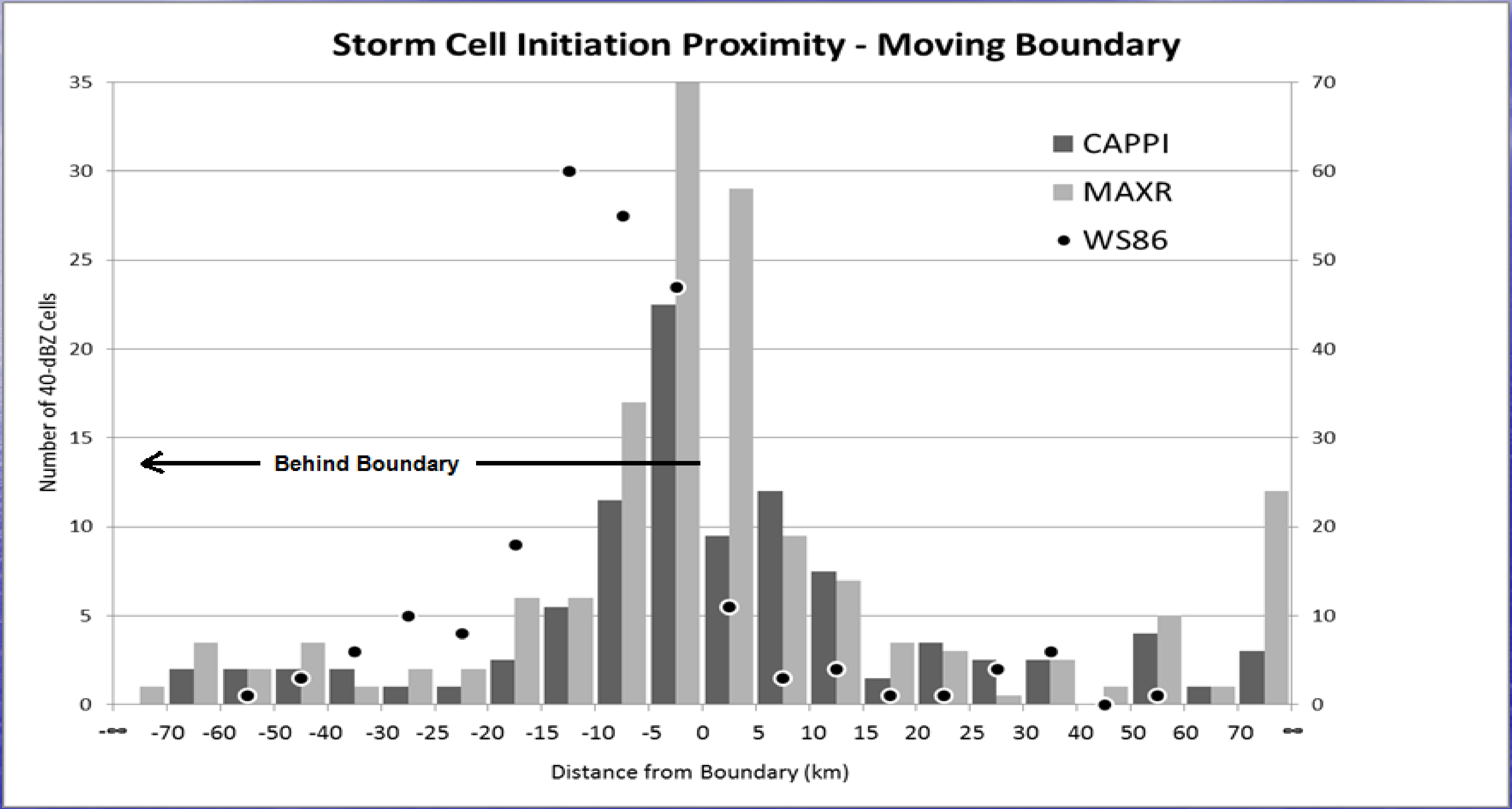

Alexander et al. (2018)

Results

- The CAPPI showed 10 days with initiations closest to a Gust Front or a boundary involving a Gust Front. Of these, 6 days showed the first cell initiation of the 8 hr analysis period closest to a Lake Breeze Front
- The MAXR showed 11 days with Gust Front initiation and 6 of these days showed the first cell of the day to initiate closest to a Lake Breeze Front
- This suggests Lake Breeze Fronts may often initiate the first storms of the day, which in turn generate Gust Fronts
- A study by Koch and Ray (1997) found the same results in North Carolina where first cells formed in association with Sea Breeze Fronts
- This may be more clear if every 10 min and the full day was studied

Summary

- 78.4% of CAPPI cell initiations and 75.8% of MAXR cell initiations occurred within 30 km of a boundary.
- Cell initiations occur most frequently 0 – 5 km ***behind*** Gust Fronts and Moving Boundaries and 0 – 5 km ***ahead*** of Lake Breeze Fronts.
- Lake Breeze Fronts may provide the lifting mechanism needed to initiate first convective storms on many days, however, Gust Fronts initiate the most convective storms.
- 1 km MAXR products appear to perform better than 1 km CAPPI products when detecting storm initiation along mesoscale boundaries.
- This study showed similar results to the study by Wilson and Schreiber (1986). Their results as well as the ones of this study may be applicable to any location where low-level mesoscale boundaries regularly occur.

Alexander et al. (2018)

References

Alexander, L. S., D. M. L. Sills and P. Taylor, 2018: Initiation of Convective Storms at Low-Level Mesoscale Boundaries in Southwestern Ontario. *Wea. Forecasting*, 33, 583-598, https://doi.org/10.1175/WAF-D-17-0086.1.

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