Characterization of the Dryline in Alberta: Observations from UNSTABLE 2008

Neil M. Taylor[1], David M. L. Sills[2], John M. Hanesiak[3], Craig D. Smith[4], and Julian C. Brimelow[1]

Contact: Neil.Taylor@canada.ca

1. Introduction

- In the summer of 2008, the authors conducted a field study to investigate thunderstorm initiation (TI) and severe weather in the foothills region of Alberta (Taylor et al., 2011; *Bull. Amer. Meteor. Soc.*, **92**, 739-763).
- The Understanding Severe Thunderstorms and Alberta Boundary Layers Experiment (UNSTABLE) intensive observation period ran during 9-23 July.
- Fixed and mobile instrumentation were deployed to examine near-surface and upper-air processes associated with TI.
- A stated goal was to improve our understanding of the dryline in this region and the role it may play in local TI and severe weather.
- **With an appropriate conceptual model, forecasters are better equipped to anticipate dryline development/evolution and subsequent influences on (severe) thunderstorm forecast and alerting decisions.**

2. Dryline Locations

- Typical dryline distances from radars in Alberta preclude identification via reflectivity fine lines so dryline identification relied on surface observations.
- Drylines were subjectively analysed based on mixing ratio (q_v) and/or dew point (T_d; for stations not reporting pressure) discontinuities across boundaries that were not associated with fronts or cold pools (Fig. 1). Gradient thresholds of $q_v \geq 0.03$ g kg^{-1} km^{-1} and $T_d \geq 0.08$ °C km^{-1} were used to identify 154 dryline positions on 9 days during the IOP (Table 1).

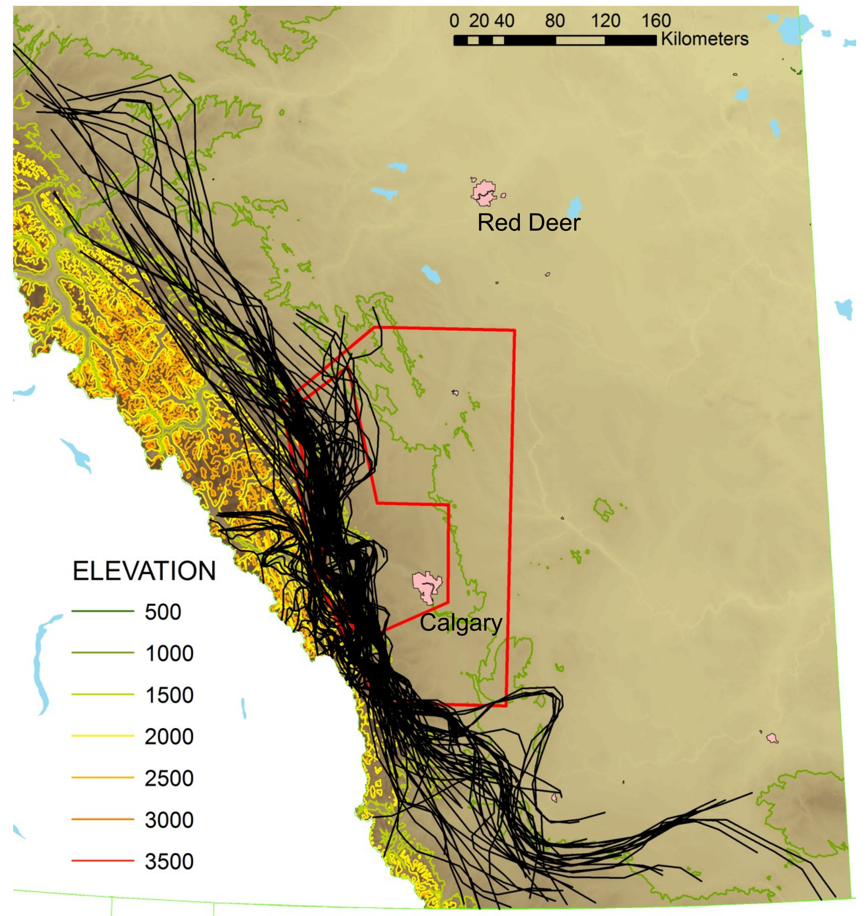


Table 1: Days and start-end times when drylines were observed.

Day (July)	Analyses (UTC)
9	15-05
12	14-06
13	14-05
14	14-05
16	16-03
17	13-04
19	14-08
20	14-11
21	12-07

Fig. 1: Analyzed positions of the dryline for the times in Table 1. Red lines define the UNSTABLE study area. Elevation is in metres and larger cities are noted.

1. National Lab-West, Meteorological Service of Canada, Environment and Climate Change Canada (ECCC)
2. Cloud Physics and Severe Weather Research Section, ECCC
3. Centre for Earth Observation Science, University of Manitoba
4. Climate Processes Section, ECCC

Environment and Climate Change Canada
Environnement et Changement climatique Canada
Canada

3. Fixed Observations

- We identified 1234 surface observation pairs across the observed drylines.
- Temperature (T) variability across the dryline is small but dew point (T_d) is markedly higher on the moist side (Fig. 2).
- Air density (Fig. 2; calculated where pressure data available) contrasts across the dryline are small with the moist air tending to be slightly more dense.

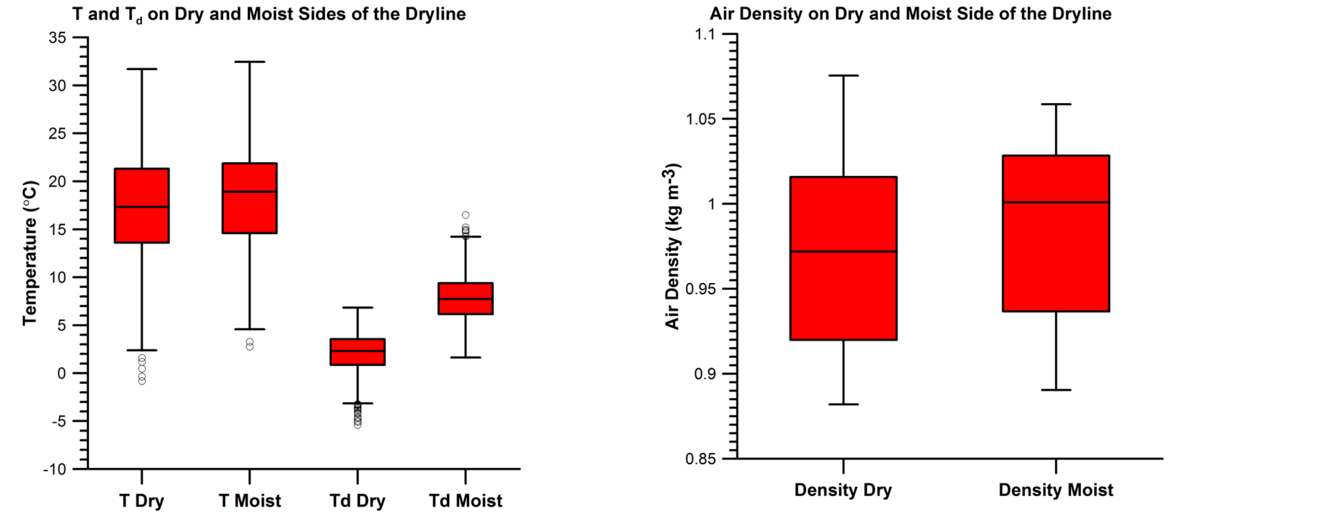


Fig. 2: Boxplots of all available observation pairs across the dryline for temperature (T) and dew point (T_d) [left] and air density [right]. Whiskers extend to ± 1.5x the interquartile range and outliers are indicated by open circles.

- Dryline intensity (Fig. 3; as indicated by gradients in mixing ratio [q_v]) varies during the day with maximum gradients in the late afternoon/early evening.

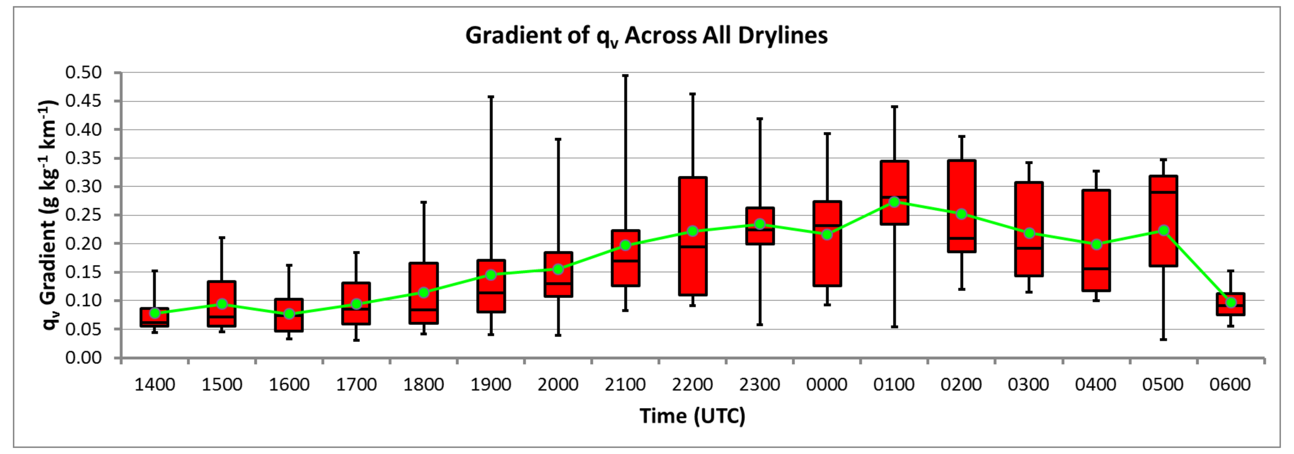


Fig. 3: Boxplots showing gradients in q_v (g kg^{-1} km^{-1}) across the dryline from 1400 UTC (0800 LT) to 0600 UTC (0000 LT). Averages are plotted in green. Black lines in the boxes are median values. Whiskers extend to the max. and min. of the distribution.

- Wind direction (Fig. 4) in the dry air tends to be from the WSW or W; in the moist air direction is variable but with a preferred easterly component.
- Differences in the u component of the wind (Fig. 4) indicate the majority of paired observations are associated with convergence.

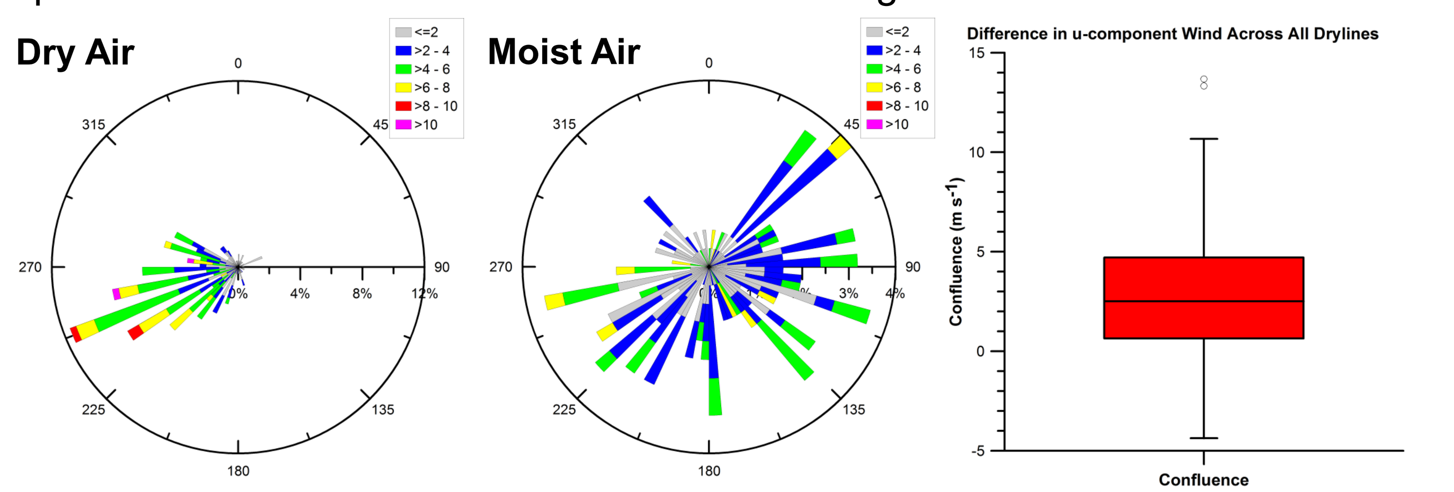


Fig. 4: Wind observations for all drylines. Polar plots of speed (m s^{-1}) and direction in the dry and moist air [left] and boxplot of the difference (dry-moist) in (map-relative) u-component wind across all drylines [right]. Whiskers and outliers as in Fig. 2.

4. Mobile Observations

- Mobile surface observations were collected primarily with the Automated Mobile Meteorological Observation System (AMMOS; Fig. 5).
- We sampled drylines 11 times on four separate days. Fig. 5 shows examples of q_v across the dryline on two different roads from 13 July 2008. Average results from all dryline transects are shown in Table 2 below.

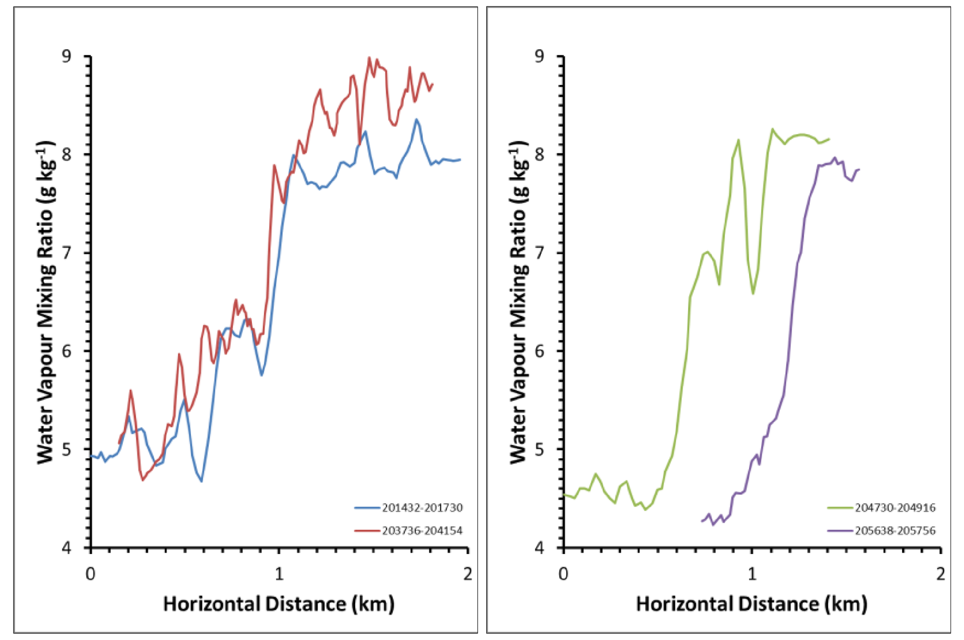
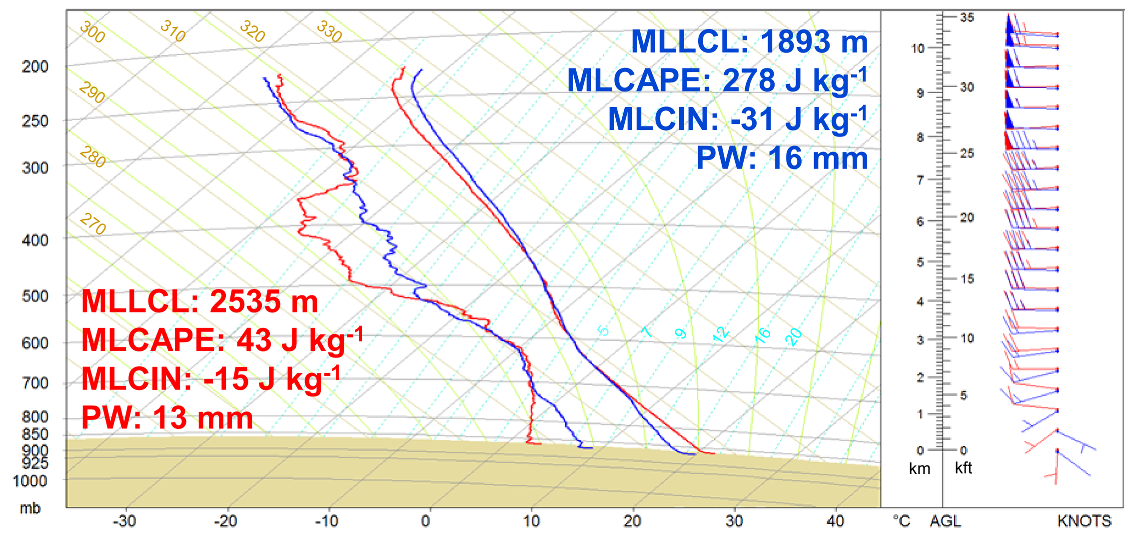


Fig. 5: AMMOS [left] and 2-s q_v obs. across the dryline on 13 July [right]. Distances are relative to the westernmost data point in the dry air. Curves identified as HHMMSS (UTC).

Table 2: Mean differences and gradients of various parameters across the dryline.

Variable	Difference	Gradient
Temperature	-0.2 °C	-0.2 °C km^{-1}
Dewpoint	7.2 °C	12.0 °C km^{-1}
Mixing Ratio	2.9 g kg^{-1}	4.9 g kg^{-1} km^{-1}
Potential Temperature	-0.2 K	-0.1 K km^{-1}
Virtual Pot. Temperature	0.4 K	0.8 K km^{-1}
Density	1.2 x10^{-3} kg m^{-3}	3.1 x10^{-3} kg m^{-3} km^{-1}
Estimated Width	790 m	

- 2-hourly soundings between 1600 and 0000 UTC were obtained on operations days. Composite profiles and average layer characteristics are shown in Figs. 6 and 7 for "dry" and "moist" soundings within 40 km of the dryline.



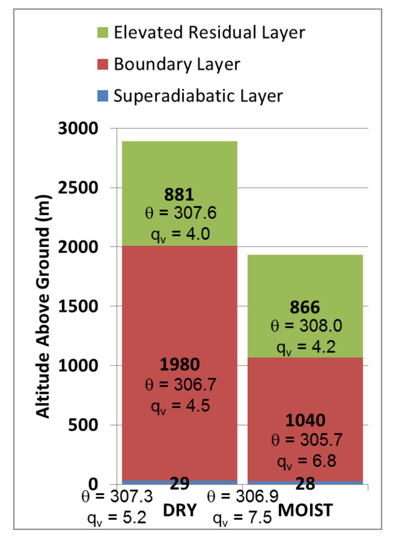


Fig. 6: [Above Left] Composite sounding data (average values every 5 m in vertical) for 12 dry (red) and 34 moist (blue) soundings within 40 km of the dryline. Average values for selected parameters from the respective sounding datasets also shown.

Fig. 7: [Above Right] Average depth (m), potential temperature (θ; K), and mixing ratio (q_v; g kg^{-1}) for various layers from the sounding datasets used in Fig. 6.

5. A Dryline Cross-Section

- Limited aircraft observations were available for UNSTABLE but the dryline of 13 July was well sampled. When combined with surface observations and sounding data a vertical cross-section illustrates the 2D structure of the dryline.

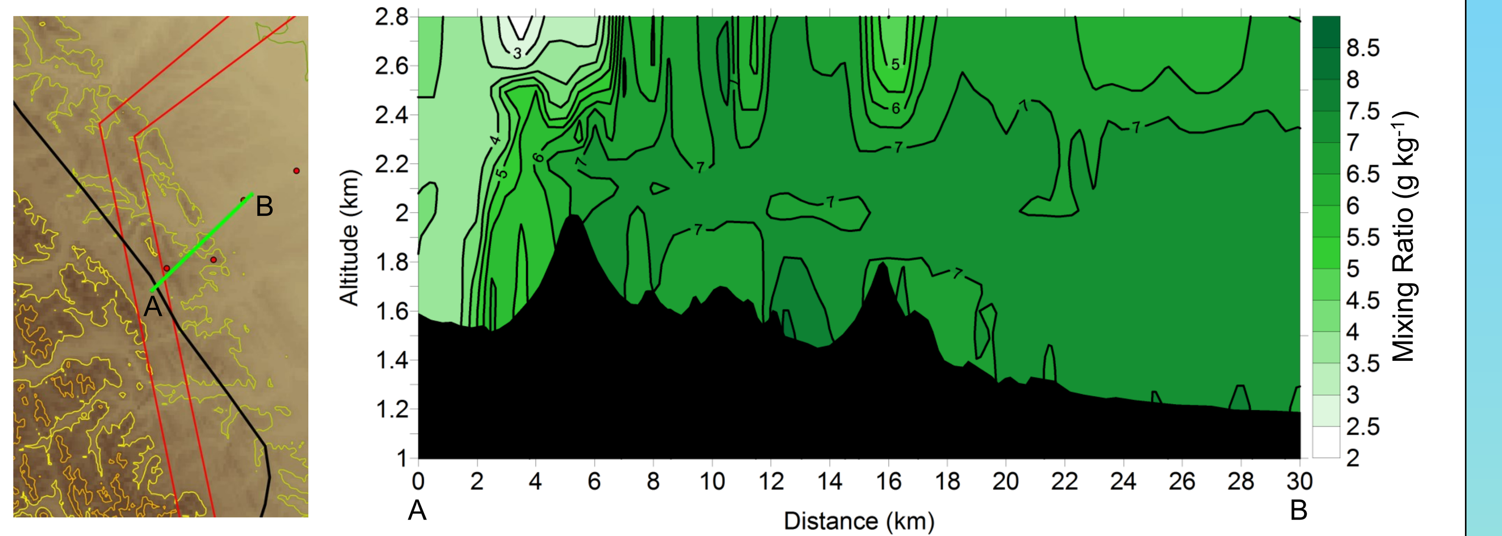


Fig. 8: [Left] Aircraft cross-section (green line) and 1900 UTC dryline position (black line). [Right] Plot of q_v (g kg^{-1}) via aircraft and other obs. on 13 July (1755-1930 UTC).

6. Conceptual Model

- Observations from UNSTABLE are treated collectively to refine our conceptual model for the dryline in Alberta.
- The dryline was observed to undergo limited advancement towards the plains except for southern AB. More significant dryline "bulging" has been observed during periods outside of the UNSTABLE IOP (see Fig. 9).
- Dryline intensity appears to peak near 0100 UTC (1900 LT) although overall density differences across the dryline appear to be small.
- Wind observations indicate that the dryline is associated with convergence.
- From mobile observations, average dryline width was estimated to be ~ 800 m with gradients of q_v in the 2-8 g kg^{-1} km^{-1} range (mean = 4.9 g kg^{-1} km^{-1}).
- Soundings show a moist boundary layer on the "east" side of the dryline that is "capped" by an elevated residual layer originating from the dry air.

Convergence at the dryline, a moist unstable environment to the east, and westerly winds aloft to advect incipient cells over the moist boundary layer are consistent with the dryline acting as a mechanism for thunderstorm initiation in Alberta.

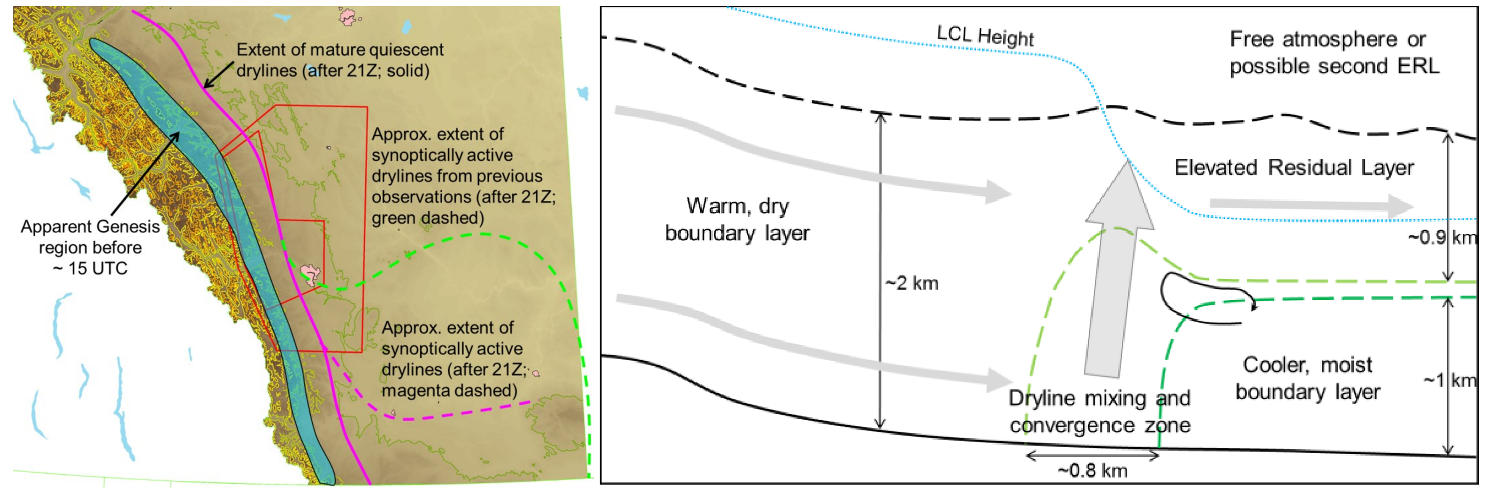


Fig. 9: Plan-view [left] and cross-section [right] conceptual diagrams for the dryline in AB based on observations from UNSTABLE. The cross-section characterizes a mature dryline (adapted from Ziegler and Rasmussen [1998; *Wea. Forecasting*, **13**, 1106-1131]).