OWLeS Project Outline and Update

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Personnel

- Jeff Frame
  - Clinical Assistant Professor (PI)
- Christopher Johnston
  - MS Graduate student
- Undergraduate students:
  - Dustin Conrad
  - Ben Marsh
  - Christian Sutter
  - Nick Zelasko

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A Preliminary Examination of Data Obtained during the Ontario Winter Lake-Effect Systems Project

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University of Illinois - Urbana, Illinois[A] SUNY Oswego - Oswego, New York[B] Center for Severe Weather Research - Boulder, Colorado[C]

Introduction

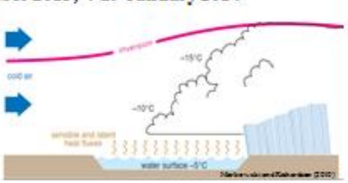
The OWLeS project is a comprehensive study of the cloud microphysics and dynamics of lake-effect systems (LeS), with the ultimate objective of improving Quantitative Precipitation Estimates (QPE) and Quantitative Precipitation Forecasts of LeS snowfall.

LeS may include cells, singular bands and mesoscale vortices. Communities neighboring the Great Lakes are often inundated with heavy lake-effect snowfalls each winter season, which can cripple aviation, ground transportation, and industry.

The OWLeS project has seven specific objectives, which are:

1. Understanding the development and evolution of the boundary layer as LeS move over one or more relatively warm bodies of water and intervening land surfaces.
2. Examining how LeS circulations and snowfall are altered by the New York Finger Lakes.
3. Examining how surface fluxes, lake-scale circulations, cloud microphysics, and radiative processes affect the formation, structure, and downstream evolution of LeS.
4. Understanding how long-fetch LeS intensify and evolve downwind of Lake Ontario.
5. Understanding cloud and dynamical processes contributing to the occasional lightning observed in long-fetch LeS cells.
6. Examining how dual-polarimetric radar variables reveal precipitation processes in LeS, and how well dual-polarimetric particle identification and QPE algorithms perform in LeS.
7. Examine the evolution of LeS over elevated terrain, such as the Tug Hill Plateau.

Project Dates: 4-21 December 2013; 4-29 January 2014



Acknowledgements

We are grateful to all of the volunteers who assisted with the data collection. Support from NSF Grant No. AGS 12-59257 is also acknowledged.

Instrumentation

Doppler on Wheels

The Doppler On Wheels (DOWs) are mobile X-band radars which are able to collect much higher resolution data than conventional WSR-88D radars. For this project, two dual-polarization DOWs and one rapid-scan DOW were utilized.

University of Wyoming King Air

The University of Wyoming King Air aircraft is equipped with a W-band cloud radar, downward facing lidar, microphysical probes, basic meteorological sensors, and radiometers.

Pods and Mesonets

Pods (left) and mesonets (right) measure wind speed, temperature, atmospheric moisture, and pressure. The mesonets perform transects through LeS to provide mobile in-situ data of basic meteorological variables. Pods can be deployed to provide up to ten additional stationary observations.

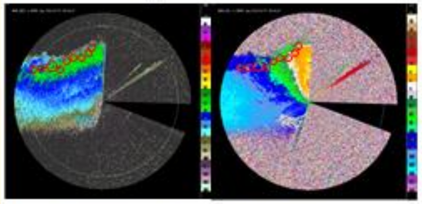
Mobile Integrated Profiling System

The Mobile Integrated Profiling System (MIPS) consists of a wind profiler (915 MHz), X-band profiling radar, profiling radiometer, lidar ceilometer, electric field mill, snowflake imager, and standard meteorological instrumentation.

Other instrumentation includes: Mobile rawinsondes, Millersville University Profiling System (MUPS), University of Utah snowfall gauges, hotplate, and snow depth sensor, and Millersville tethersonde.

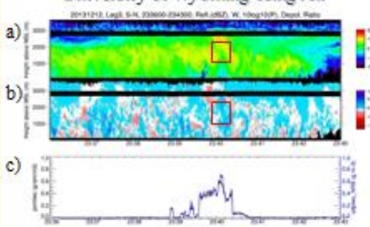
Preliminary Data

Doppler on Wheels



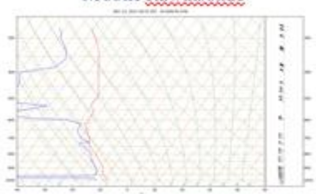
7 January 2014
0504 UTC
Reflectivity (left) and radial velocity (right) of a long-lake-axis-parallel (LLAP) snowband over Lake Ontario. Several vortices are visible on the northern edge of the band (red circles).

University of Wyoming King Air



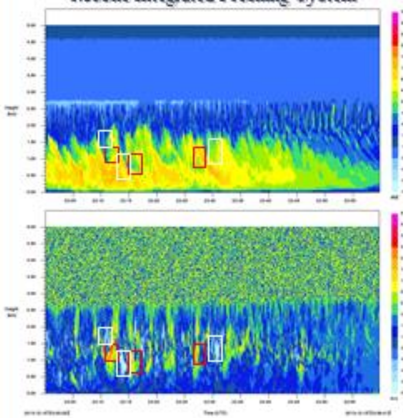
12 December 2336-2343 UTC
South to north vertical cross-section through an LLAP band near Sandy Creek, NY. a) Wyoming Cloud Radar reflectivity, b) vertical velocity, and c) liquid water content. Red box denotes the most intense updraft and bounded weak echo region.

Mobile Rawinsonde



12 December 2315 UTC
Mobile rawinsonde data launched by Millersville University at Sandy Creek, NY. Note deep conditionally unstable moist layer extending up to 615 mb.

Mobile Integrated Profiling System



15 December 2300-2359 UTC
X-band profiling radar reflectivity (top) and vertical velocity (bottom) within a long-lake-axis-parallel snowband over Sandy Creek, NY. Regions of strongest updraft are boxed in red and regions of strongest downdraft are boxed in white. Note that there are several convective cells embedded within the band.

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Student Presentations

- Preceding poster was presented at AMS Student Conference in Atlanta, GA, on February 1-2
- Poster was also presented at University of Illinois School of Earth, Society, and Environment Research Review
- Two undergraduate students (Dustin Conrad, Nick Zelasko) presented a talk at the Great Lakes Meteorology Conference hosted by Valparaiso University on March 22

Since OWLeS…

- I taught three classes during spring 2014 semester
- Chris is putting finishing touches on dual-pol LLAP paper
- Undergraduates took full course load
  - Advised to put off capstone research course until next year
- I do not have any instruments or data of my own
  - Data availability
  - Need to coordinate cases
- Since classes ended
  - Field studies of convection course (4 weeks on the Great Plains forecasting and observing severe convection)
  - In other words: WEDGES

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LLAP Science Objectives

- To understand the development of and interactions between internal layers within the boundary layer (BL) as LeS move over one or more relatively warm bodies of water and intervening land surfaces;
- To examine how LeS circulations and snowfall are altered by relatively small bodies of open water such as the New York Finger Lakes;
- To examine how surface fluxes, lake-scale circulations, cloud microphysics and radiative processes affect the formation, structure, and downstream evolution of LeS;
- To understand how long-fetch LeS (i.e. those aligned with Lake Ontario) intensify and evolve downwind of the lake;
- To understand cloud and dynamical processes contributing to the occasional lightning observed in long-fetch LeS cells, which may be only a quarter the depth of typical thunderstorms;
- To examine how radar dual-pol variables at X- and S-band reveal precipitation processes in LeS, and how well dual-pol particle identification and QPE algorithms perform in LeS;
- To examine the evolution of LeS over elevated terrain.

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Research Proposals

- Undergraduate Team A: Dual-Doppler analysis
- Undergraduate Team B: Dual-polarimetric analysis
- Chris Johnston (MS): Generating cells within lake-effect convection

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Research Outline – Undergraduate Team A

- Perform dual-Doppler analysis of LLAP case from OWLeS
  - Edit data, objectively analyze data, perform dual-Doppler wind synthesis
  - Vorticity budgets, origins/observations of vortices, updraft strength
  - Prove some of the conclusions reached in Steiger et al. (2014)
  - Are vortices found preferentially on one side of a band or another relative to the mean boundary layer wind?
- Possible candidates include:
  - December 10-12, 2013
  - December 12-13, 2013
  - December 18-19, 2013 (no UWKA)
  - January 6-7, 2014
  - Other possible candidates??
- I want to decide case at this meeting because I really want to avoid duplicate cases!
- Have held off on requesting any data for this reason

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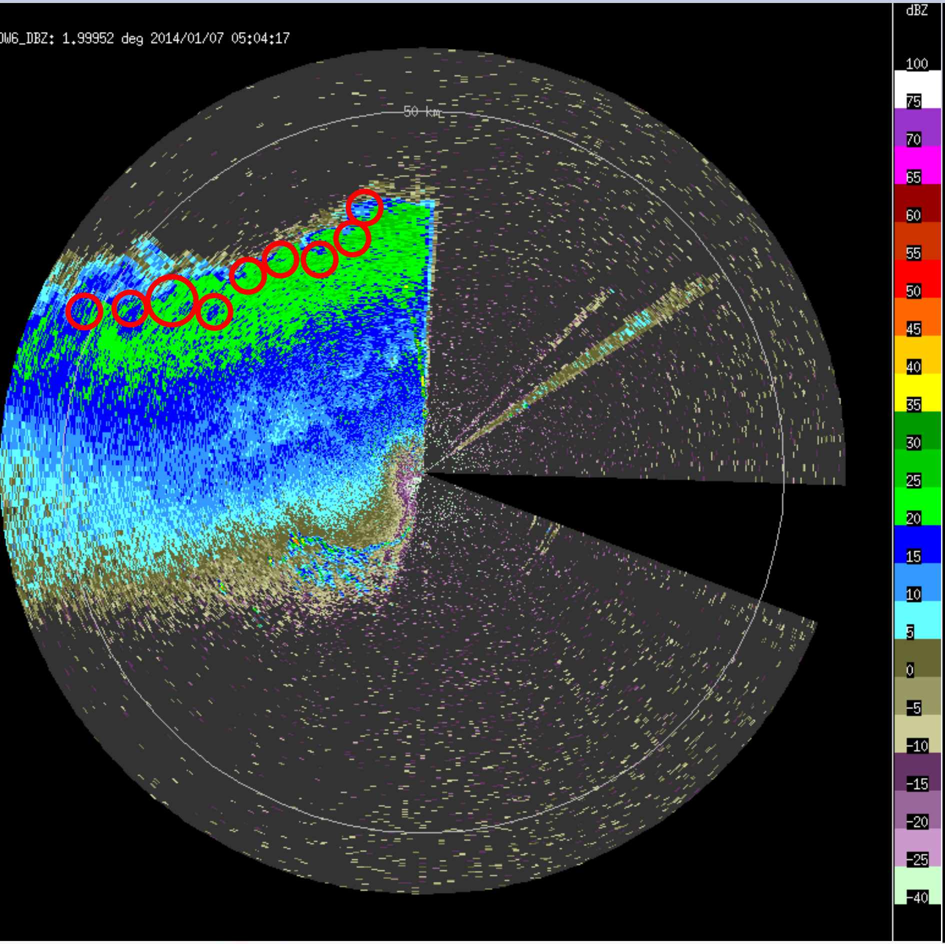
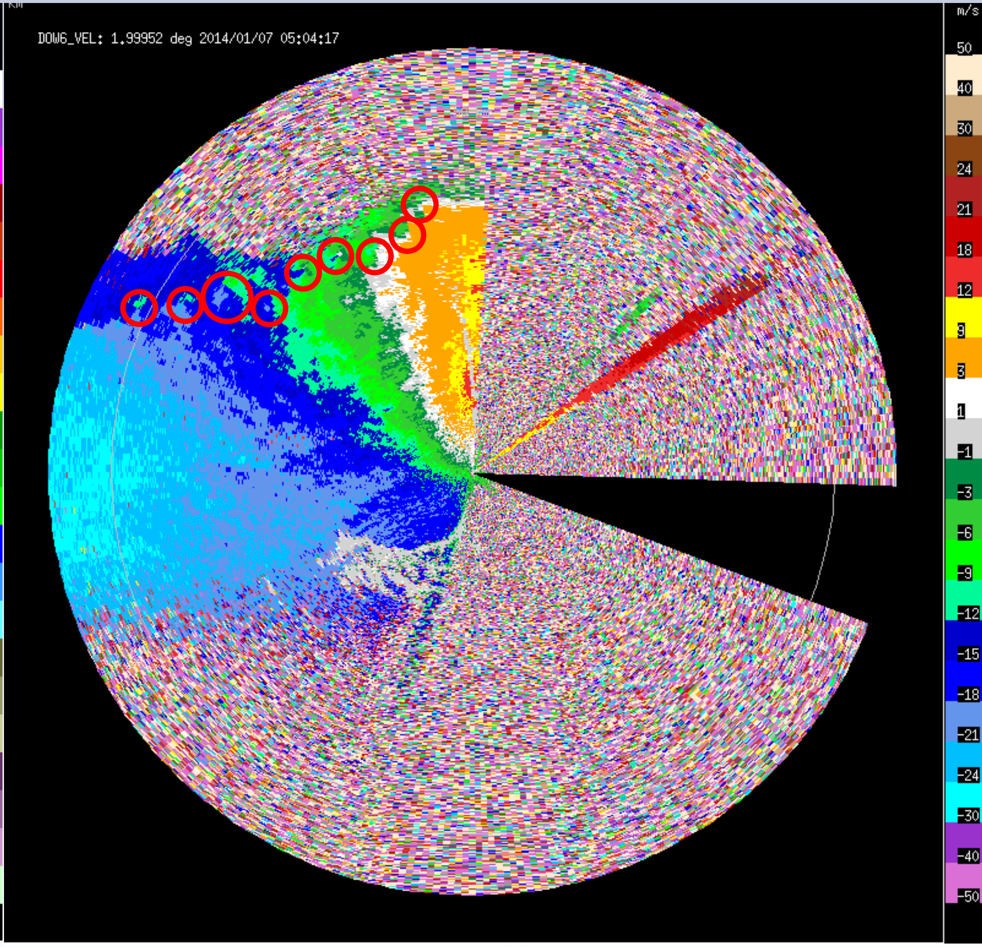
Example: 0507 UTC January 7, 2014





Data Required – Undergraduate Team A

- DOW radar data
  - Form crux of dual-Doppler
- Possibly UWKA data (if flying on case day)
  - Particularly WCR data
- Mobile soundings
- Surface observations

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Science Objectives – Undergraduate Team A

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Research Outline – Undergraduate Team B

- Identify cases in which dual-polarimetric DOW radar data were collected over surface observing sites
  - Oswego, Utah, others(?)
- Edit and objectively analyze data centered on surface observing sites
- Using MATLAB software, identify values of dual-polarimetric variables related to each precipitation type
  - Is there a difference in X-band dual-pol signatures between types?
  - Do results substantiate preliminary LLAP results?

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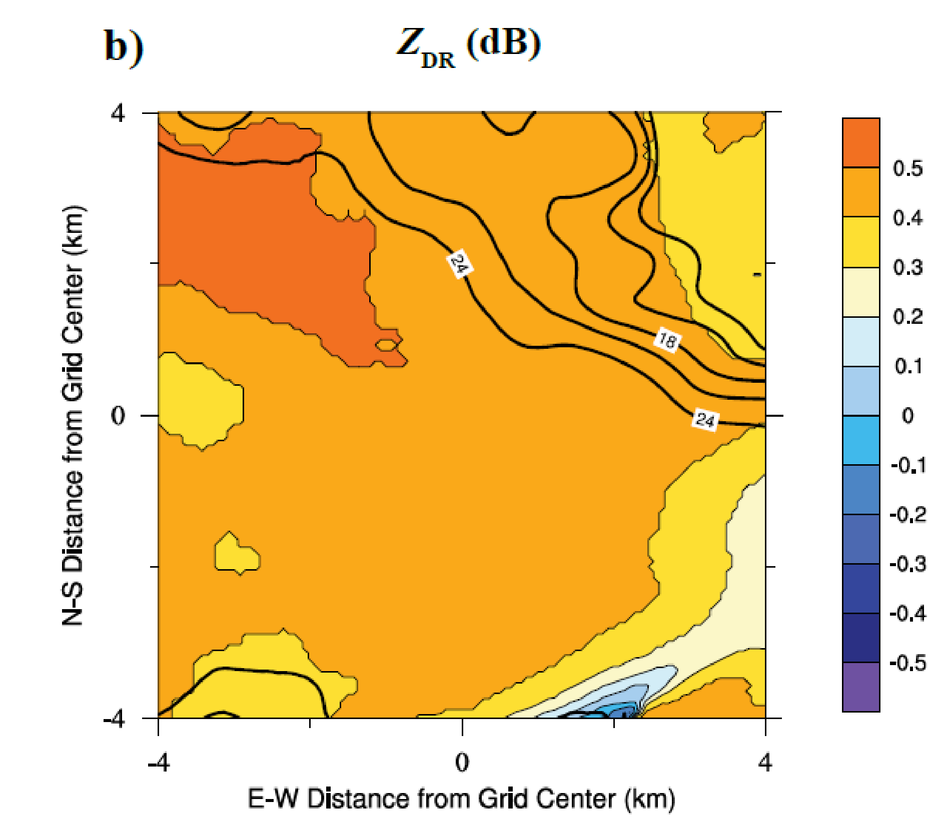
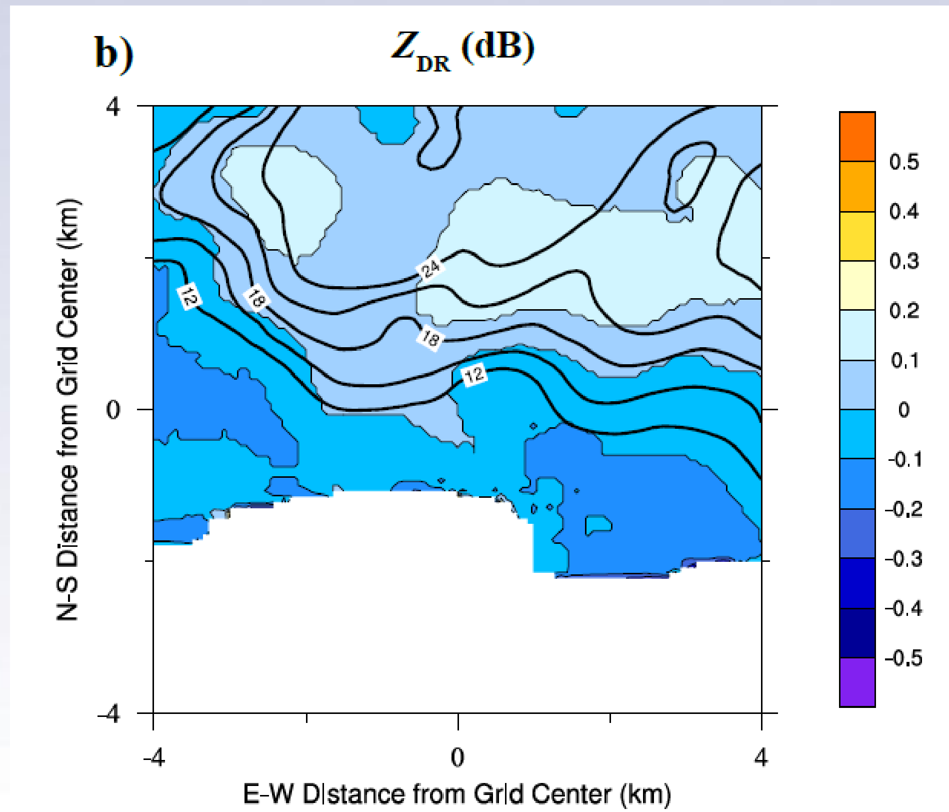
Z_{DR}



Aggregates

Snow Pellets



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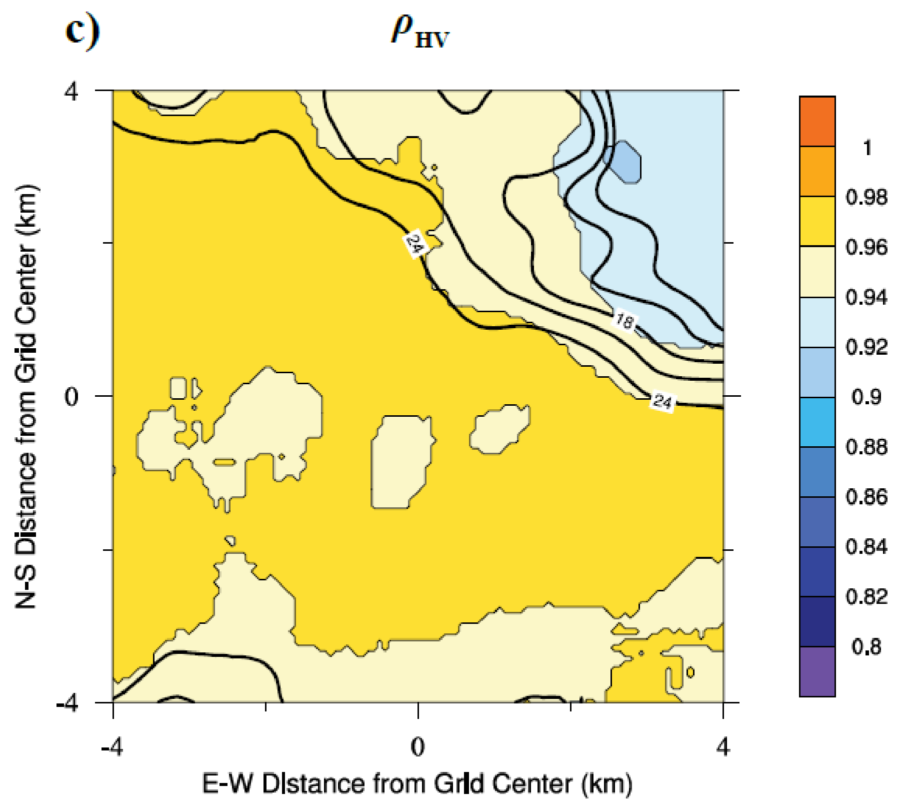
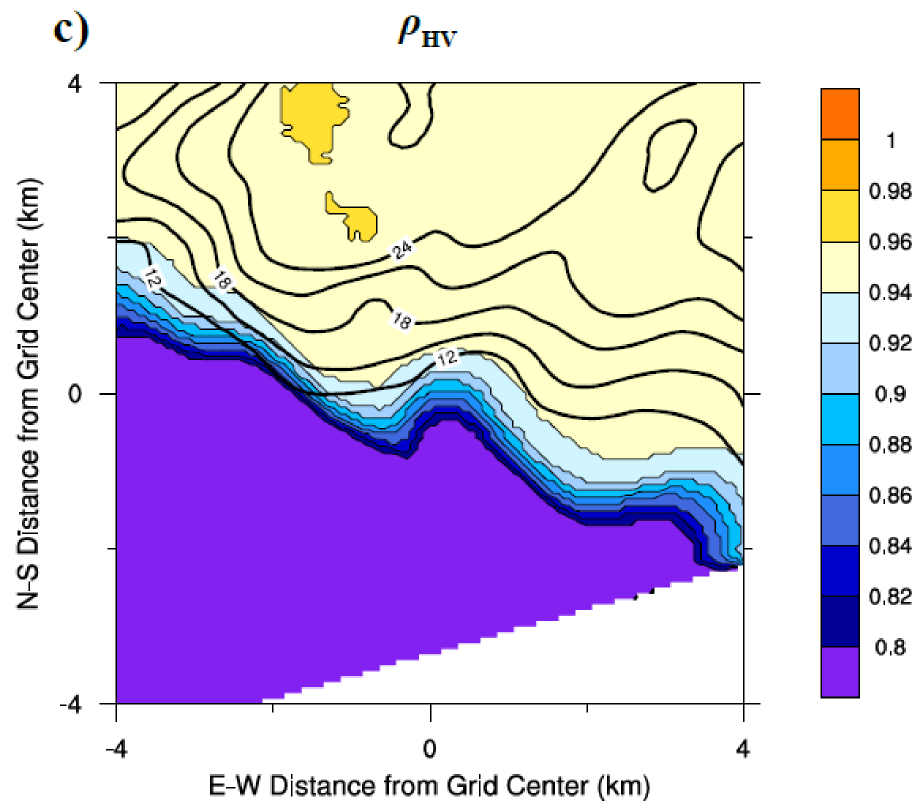
ρ_{HV}



Aggregates

Snow Pellets



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Research Outline – Undergraduate Team B (Cont.)

- Compare X-band polarimetric variables (DOWs) to S-band (WSR-88Ds)
  - Do relationships (e.g., higher/lower ZDR for certain p-types) agree or disagree between bands
  - Compare to WSR-88D p-type algorithm results
- Investigate how polarimetric signatures vary with altitude and precipitation type
  - Compare UWKA microphysical data to surface precipitation type
  - How do polarimetric signatures change as the precipitation type changes?

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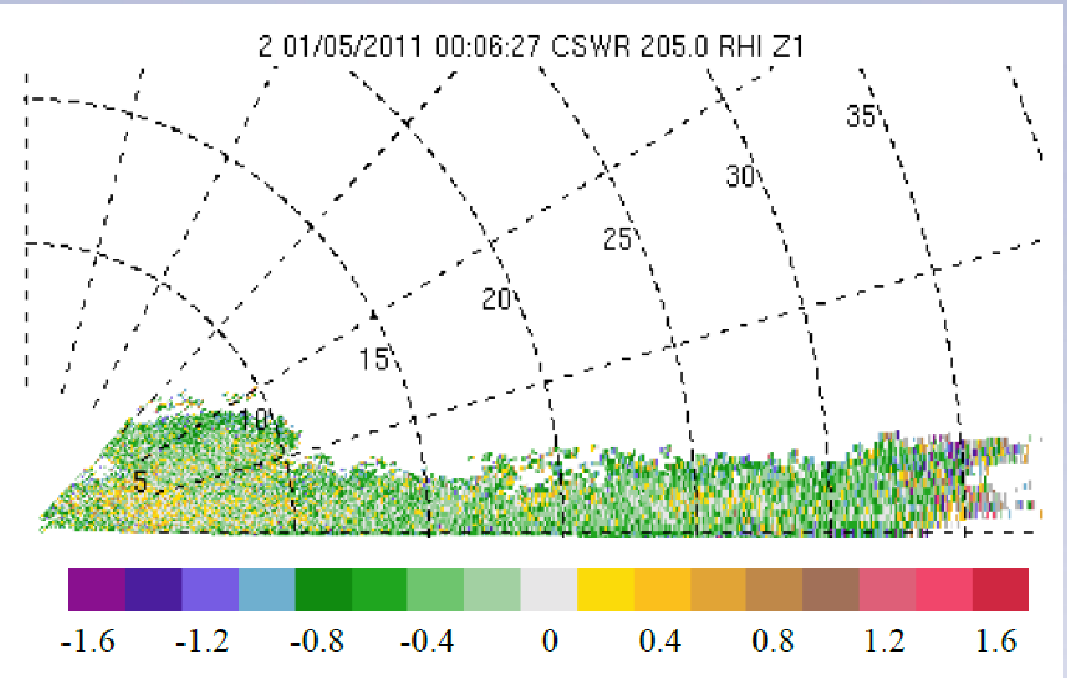
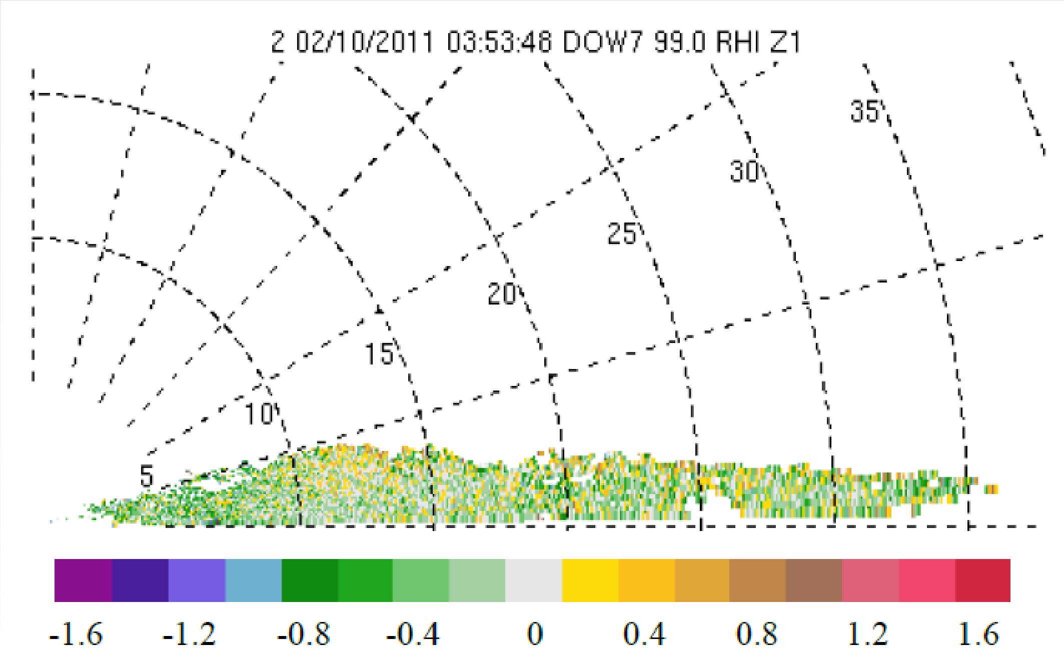
Z_{DR} and Height





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Data Required – Undergraduate Team B

- DOW radar data
- Surface snow observations
- WSR-88D data
  - Dual-pol?
- UWKA data
  - Microphysical data most important
- Mobile soundings
- Surface observations

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Science Objectives – Undergraduate Team B

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Snow Generating Cells Observed during OWLeS

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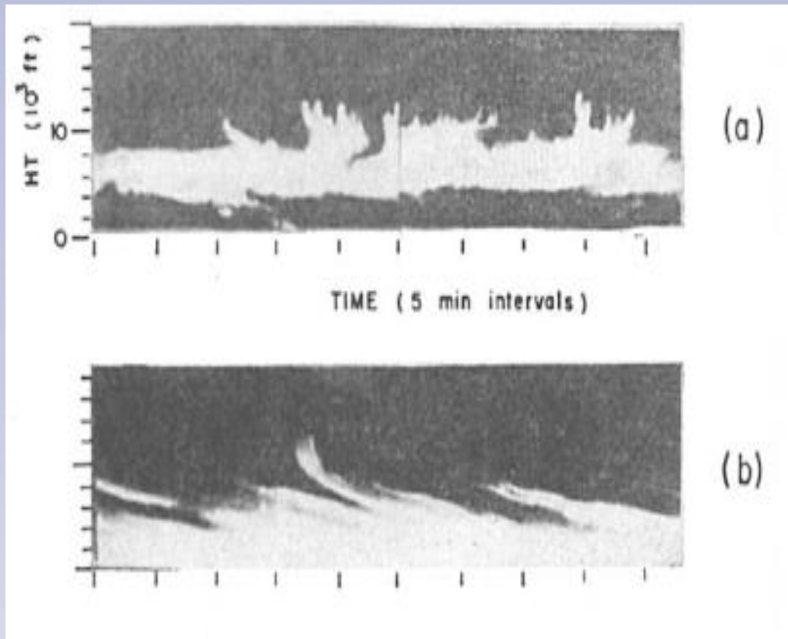
Previous Research

- Previous research conducted by
  - Douglas et al. (1957), Hobbs and Locatelli (1978), Herzegh and Hobbs (1980), Houze et al. (1981), Rosenow et al. (2013), and Rauber et al. (2014), suggest the presence of cloud top generating cells within extratropical cyclones
  - Kumjian et al. (2014) details the existence of cloud top generating cells within orographic winter storms along Colorado's Front Range



Douglas et al. (1957)

Vertically erect turrets near echo top

- ~1-2 km horizontal and vertical extent
- ~1-2 m s^{-1} vertical velocities

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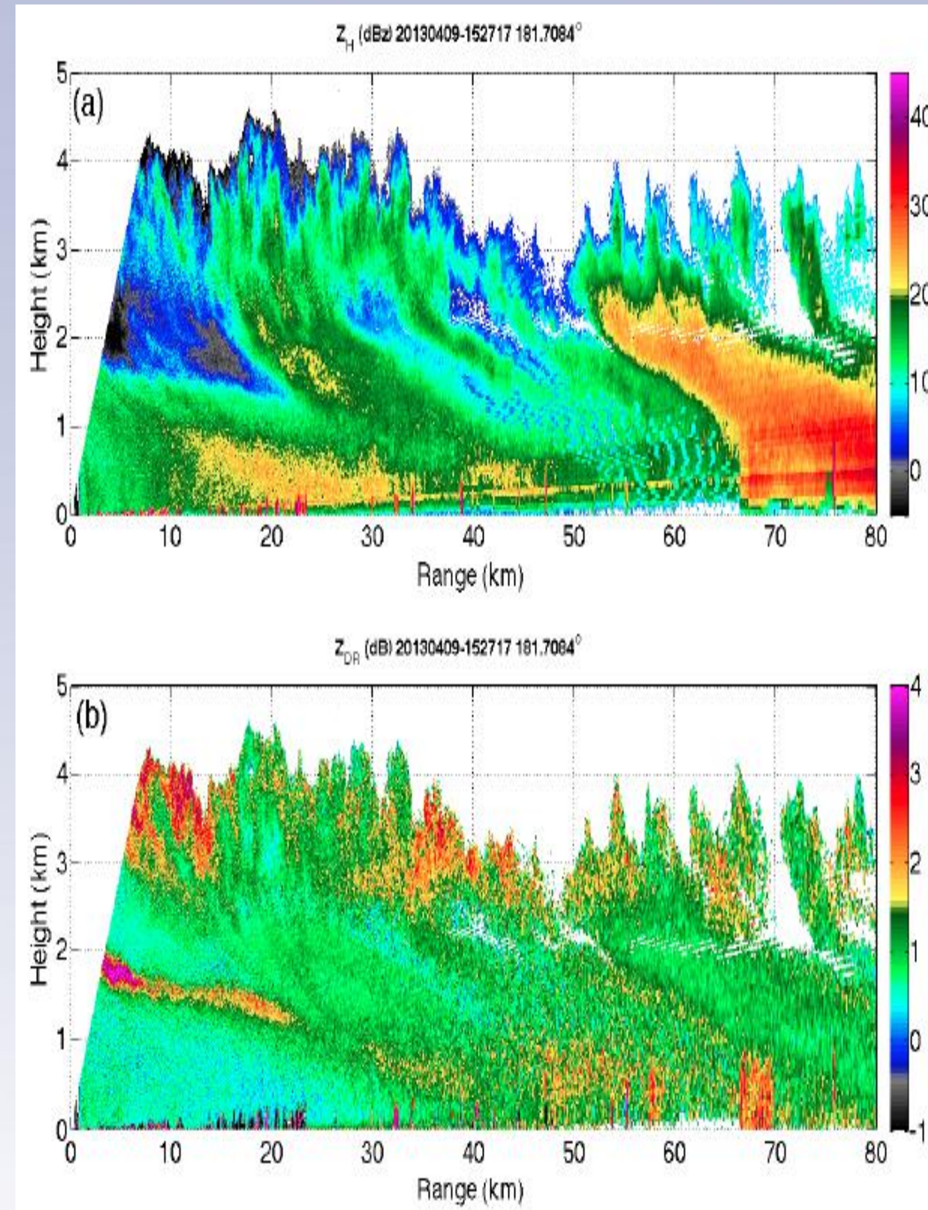
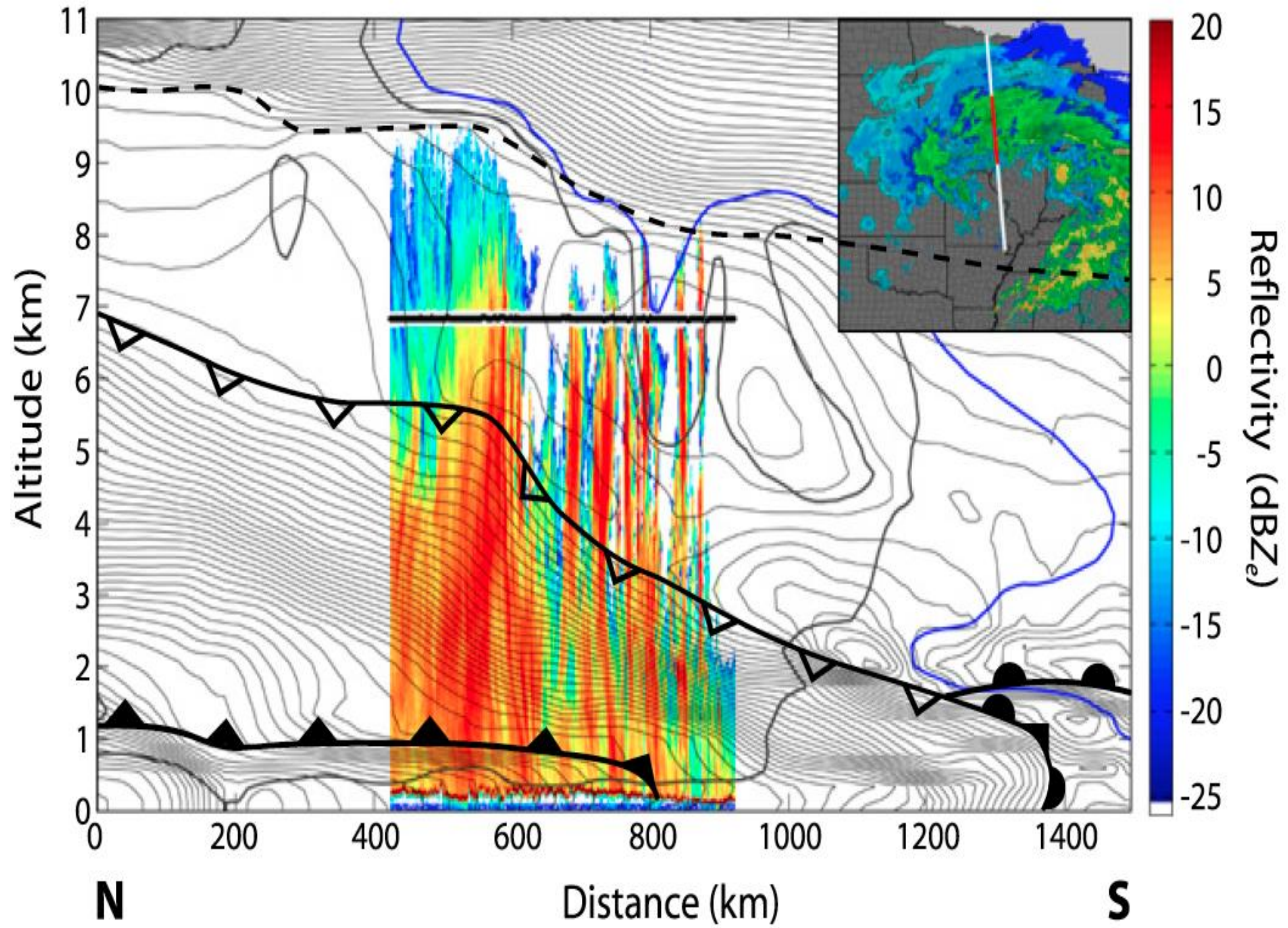


Kumijan et al. (2014)



Rosenow et al. (2013)

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Background

- Ongoing analyses of several cases from OWLeS
  - On January 8, 2014, and on many other dates, generating cells were observed
- Literature review in progress
- Previous studies have shown the presence of generating cells in winter storms (extratropical cyclones and orographic systems)
  - Traditionally, it is taught that precipitation in these systems arises from the forced ascent of stable air
  - In contrast, lake-effect precipitation is primarily convectively induced (buoyant ascent)
  - Are generating cells important in the formation of precipitation in systems governed by buoyant ascent too?

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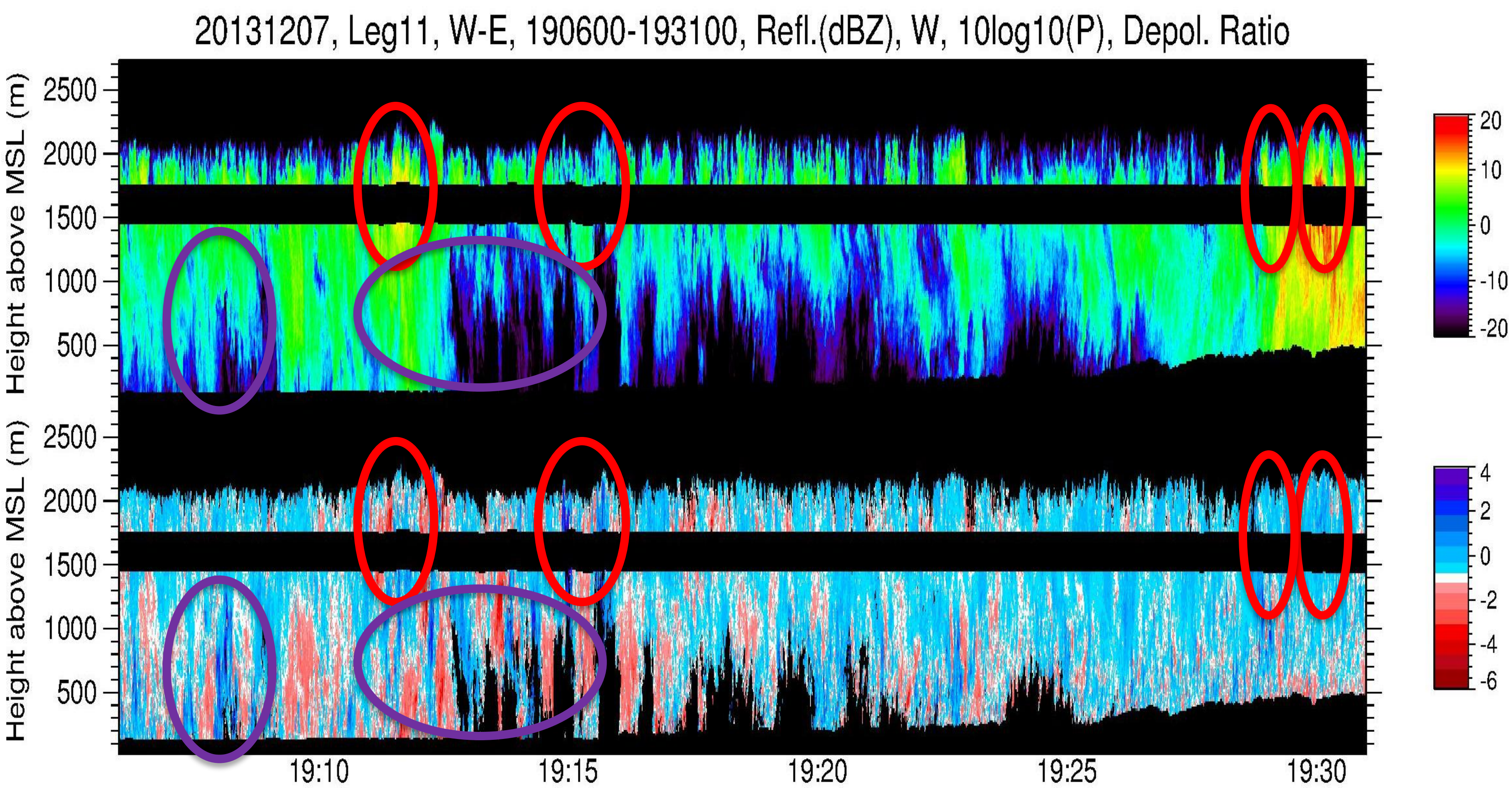
Generating Cell Example #1 (LLAP)



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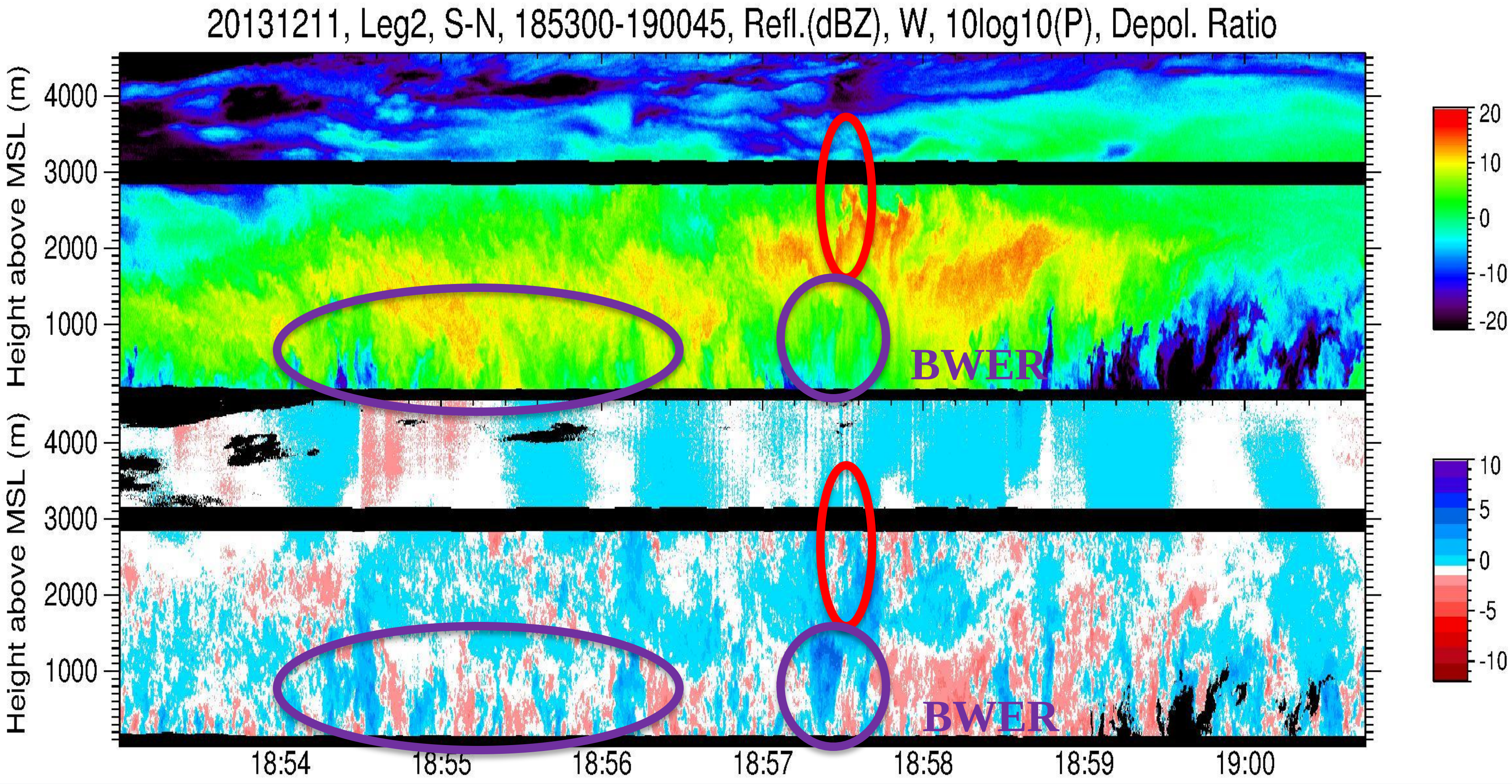
IOP 1: December 7, 2013, Wyoming Cloud Radar

Generating Cells   Surface-based Convection

Generating Cell Example #2 (LLAP)



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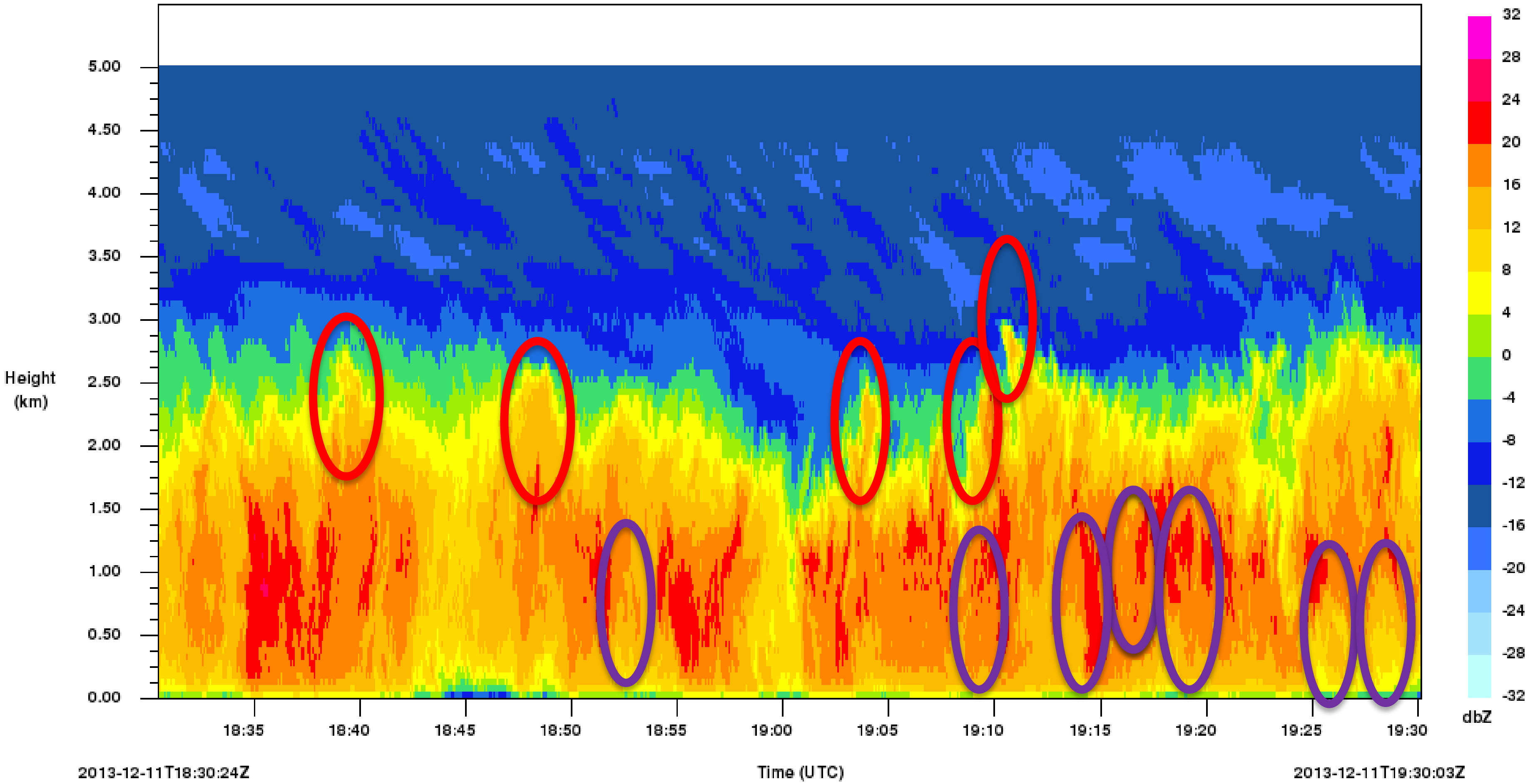
IOP 2b: December 11, 2013, Wyoming Cloud Radar

Generating Cell — Surface-based Convection

Generating Cell Example #2 (LLAP)



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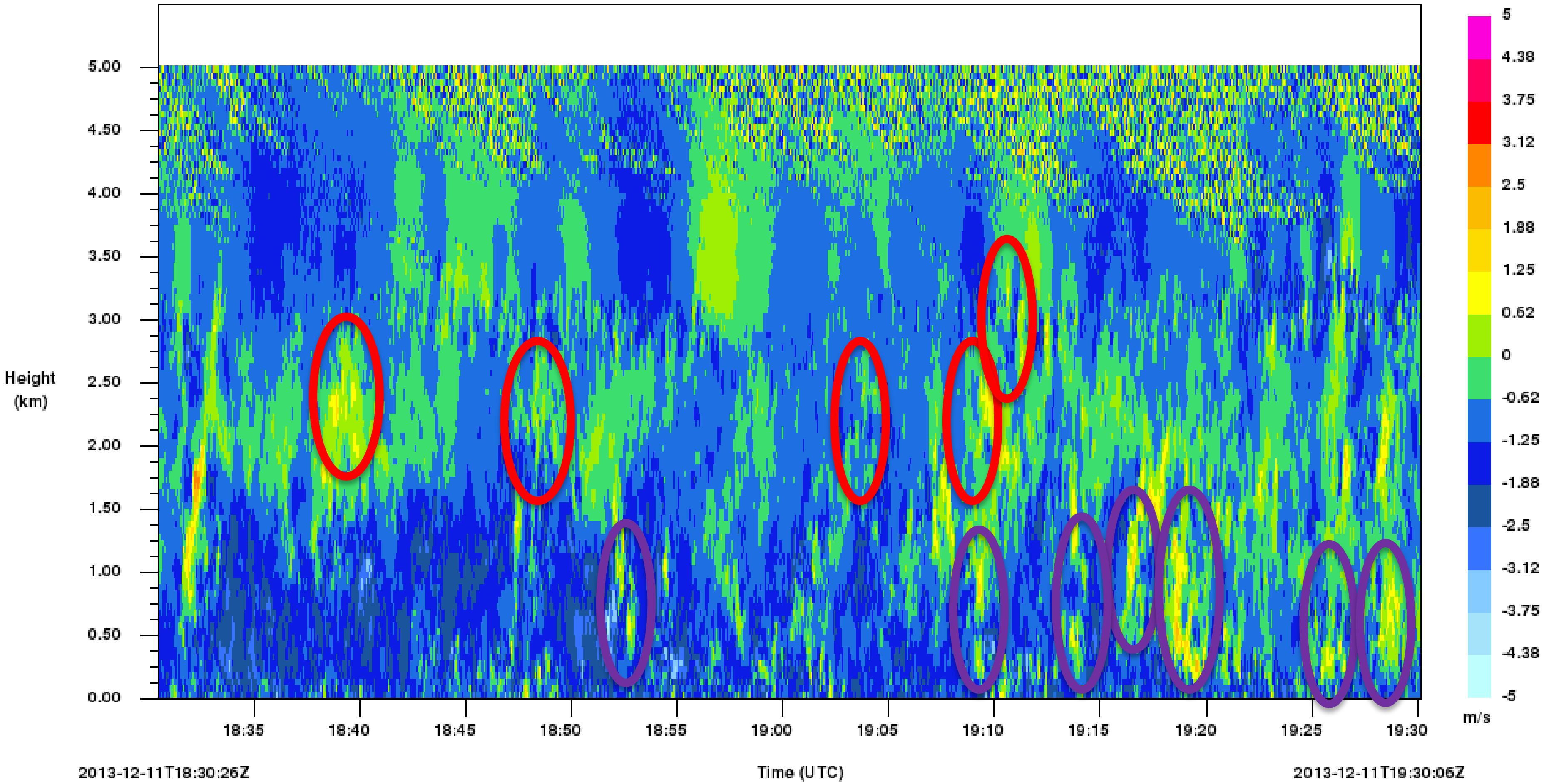
IOP 2b: December 11, 2013, UAH XPR Reflectivity

Generating Cells   Surface-based Convection

Generating Cell Example #2 (LLAP)



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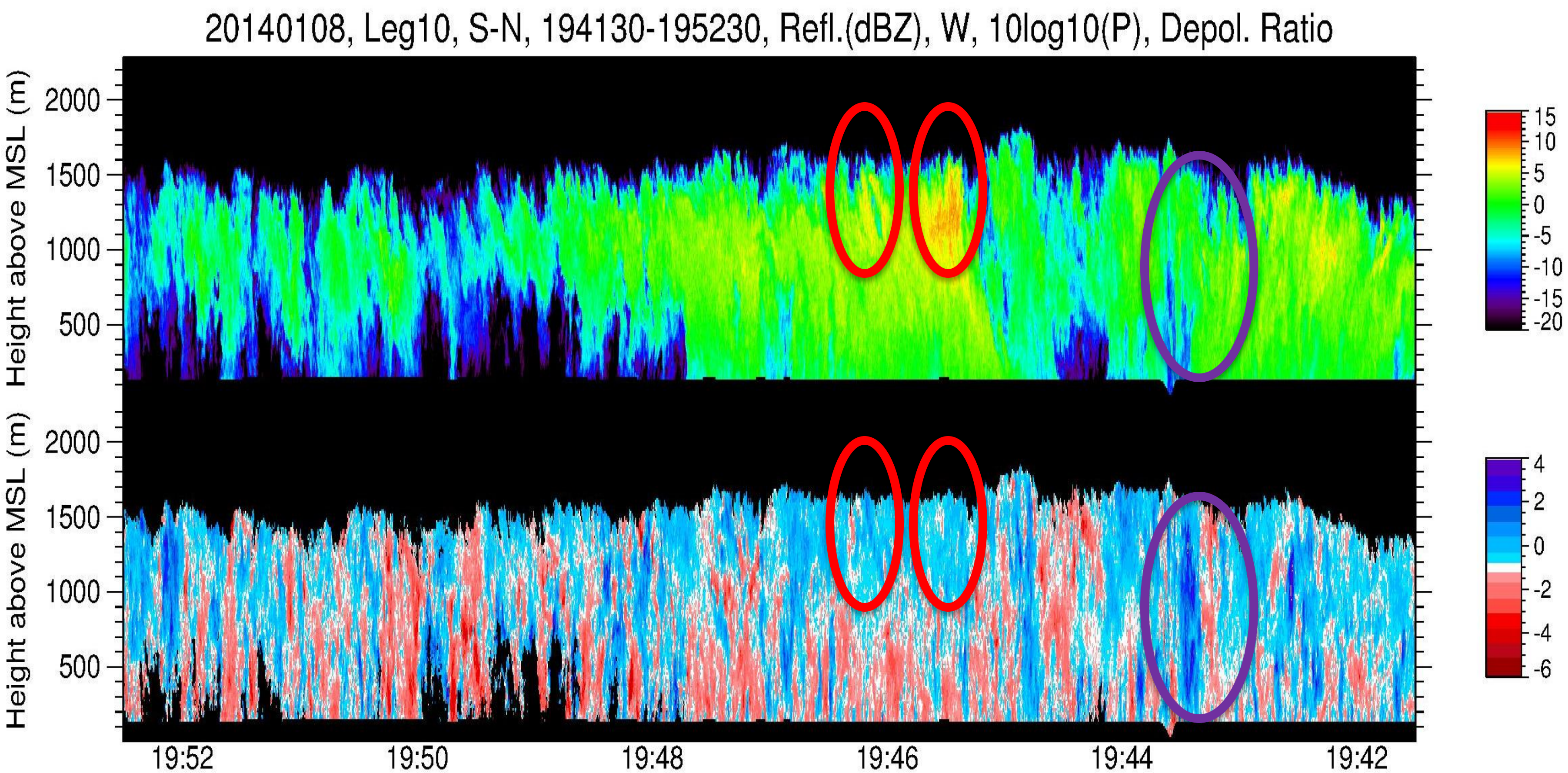
IOP 2b: December 11, 2013, UAH XPR Velocity

Generating Cells

Surface-based Convection

Generating Cell Example #3 (Upwind)



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IOP 8: January 8, 2014, Wyoming Cloud Radar

Generating Cells — Surface-based Convection

Scientific Questions

- Do these generating cells create areas of enhanced snowfall at the surface?
- What species of hydrometeors are associated with generating cells within lake-effect bands?
- When do these generating cells occur (night or day) and how common are they?
- Does their relative frequency depend on the synoptic or thermodynamic environment?
- Are they associated with smaller convective cells or are they associated with the larger mesoscale snow band?
- Do shortwave troughs affect the organization, intensity, and presence of generating cells? (Neil Laird and Nick Metz)

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Data Required

- DOW PPIs, RHIs, and any surveillance scans completed
- University of Wyoming King Air Cloud Radar/Lidar and in situ microphysical data
- University of Alabama at Huntsville MIPS
  - X-band Profiling Radar
- NCAR Super Cooled Liquid Water Sondes
- SUNY Oswego snow crystal observations and liquid water content
- University of Utah snow crystal observations and liquid water content
- Rawinsondes


QUESTIONS??