Millersville / Penn State Goals, Methods and Cases

Rich Clark, George Young,

Todd Sikora, Daniel Eipper:

Millersville University and Penn State

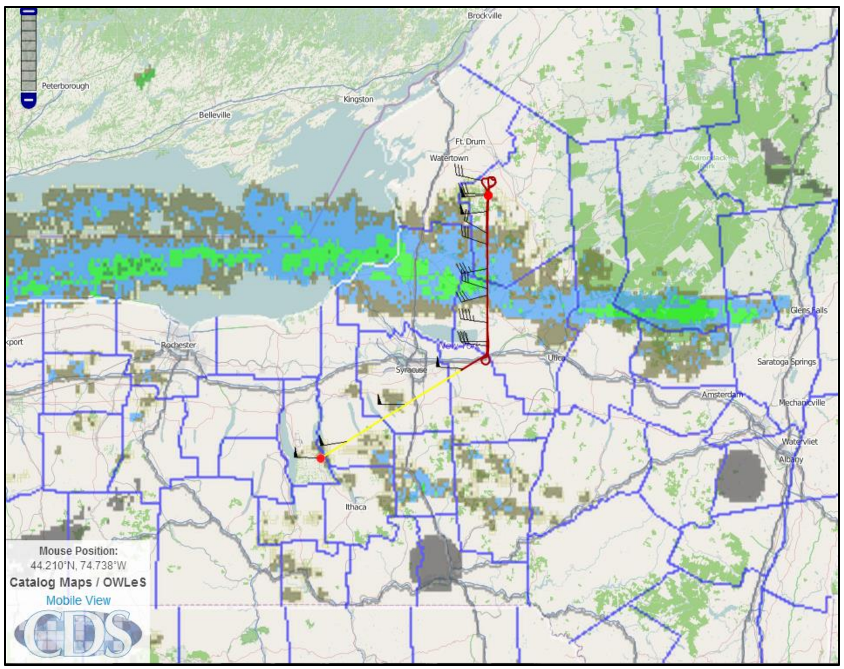
Goals

- Inland Penetration of Long-Lake-Axis Parallel Bands (InPen LLAP)
  - Why does inland penetration of LLAP bands vary so greatly? – It's not *just* the advection of a warmed, moistened boundary layer inland.

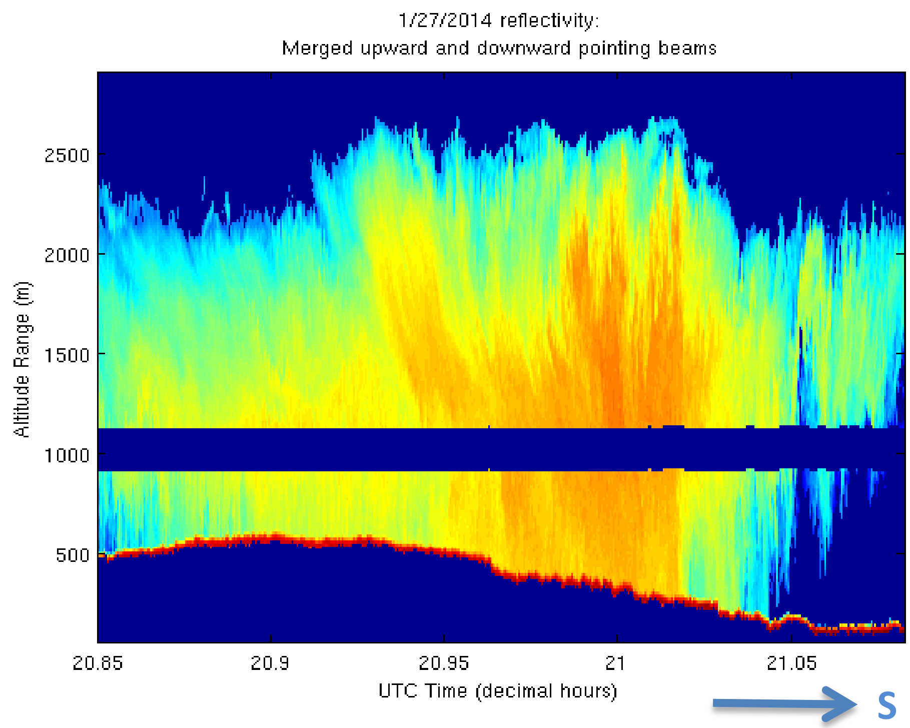
- Overland Convection within the Lake Aggregate Plume (OvCon LAP)
  - Why does diurnal convection form overland within the lake aggregate plume? Why some days and not others?

Examples – InPen LLAP

NEXRAD 3D Mosaic 6 kft image for 1/27/2014, 21:30 UTC, along with flight track.



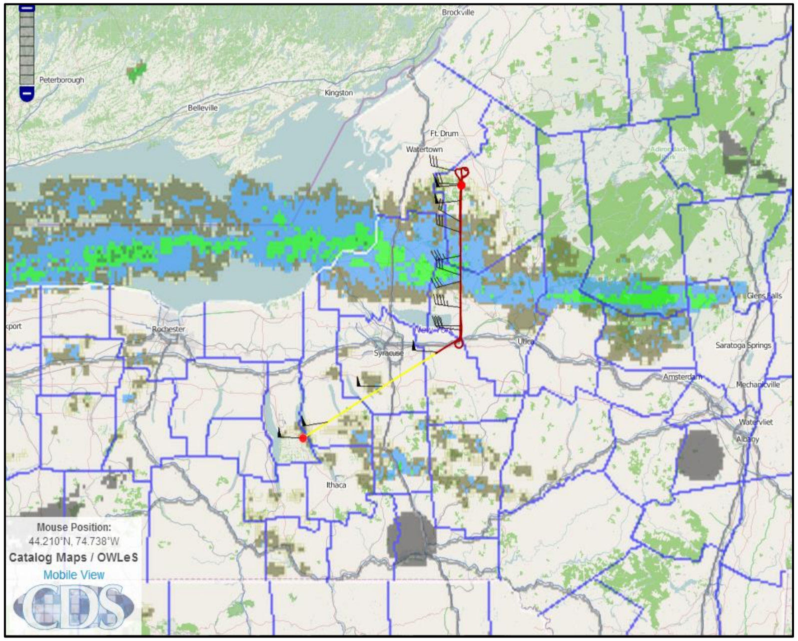
WCR Level II: Reflectivity transect for 1/27/2014



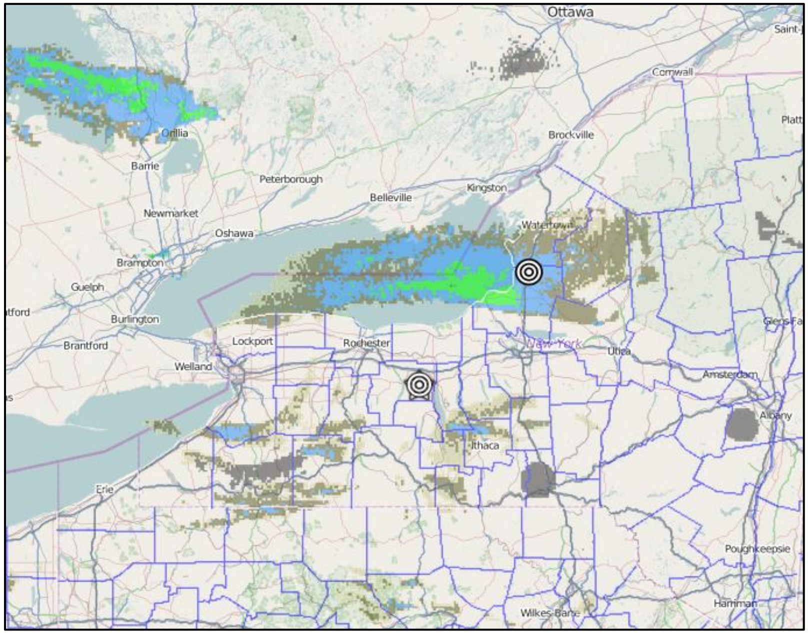
Thoughts on InPen LLAP

At times LLAP bands penetrate over 200 km inland. At other times the convection dies soon after landfall. Why is this?

NEXRAD 3D Mosaic 6 kft images



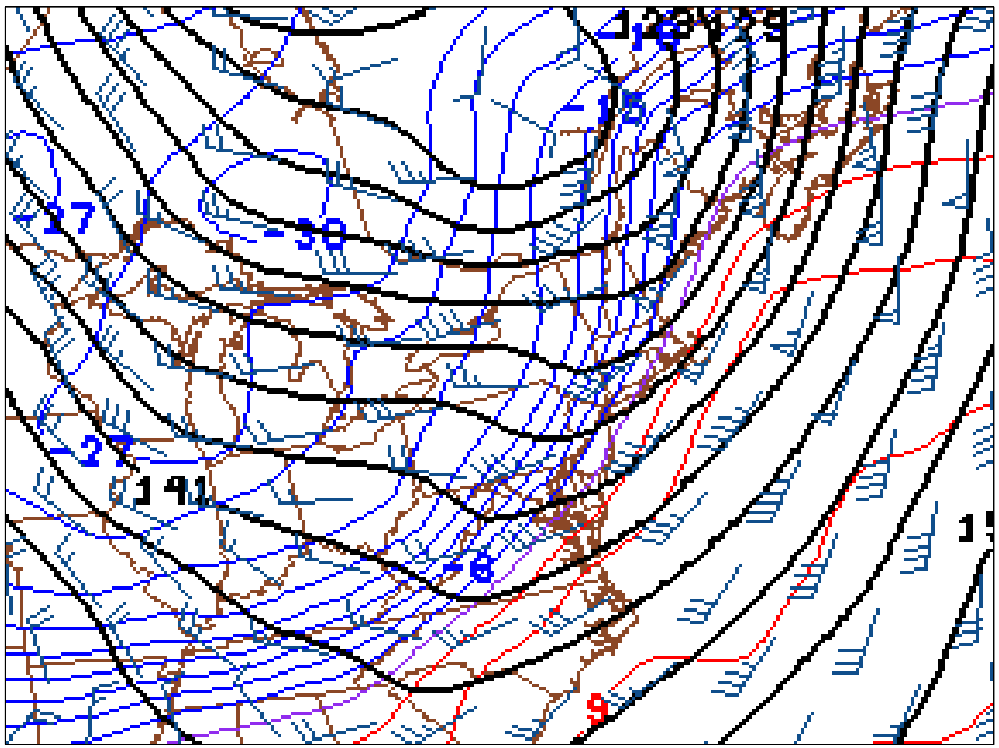
1/27/14, 21:30 UTC



1/28/14, 5:45 UTC

Thoughts on InPen LLAP

Preliminary evidence that times with strong CAA are preferred over times that are merely cold and windy.



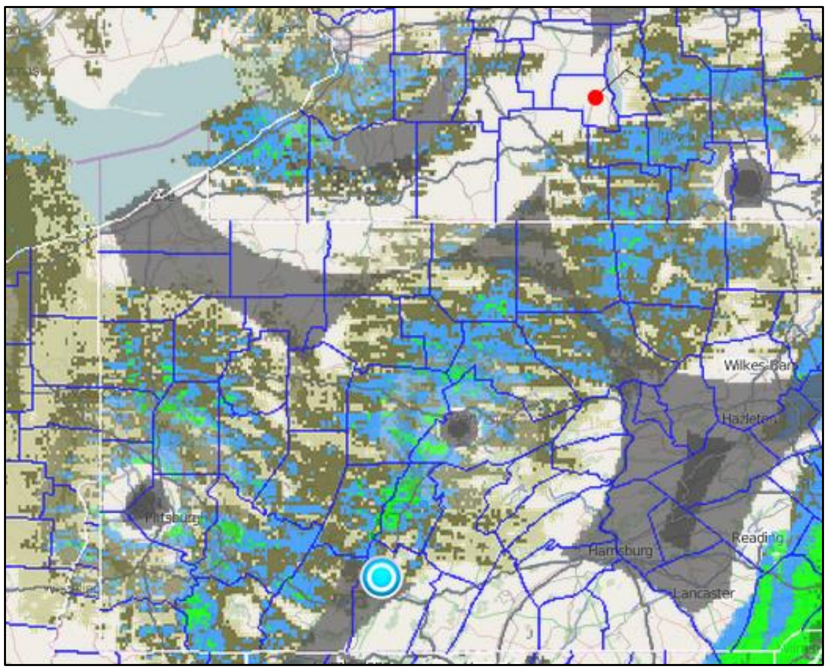
GFS 850 hPa Heights and Temps; valid on 1/27/14, 18:00 UTC

Methods - InPen LLAP

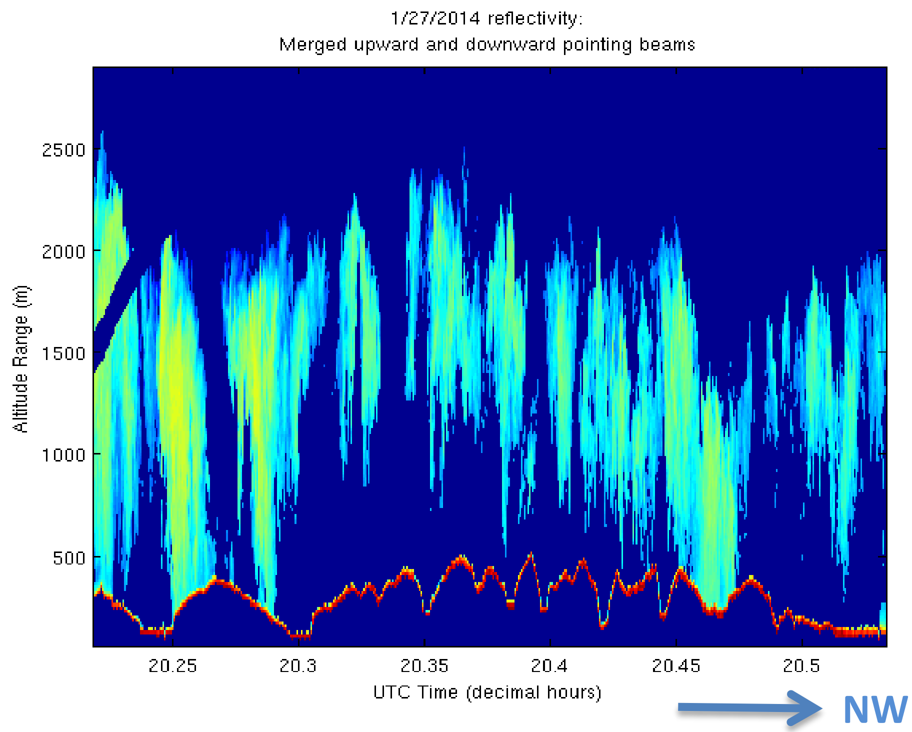
- Observations used
  - Kingair *in situ*, cloud radar, and cloud lidar data
  - MU Flux tower, SODAR, and LIDAR data
  - Rawinsondes from multiple sources
  - DOW radar
- Questions asked
  - Why does significant inland penetration occur some days and not others?
  - What causes LLAP bands to strengthen/weaken inland?

Examples – OvCon LAP

NEXRAD 3D mosaic 4 kft and 6 kft composite image for 1/6/2014,   16:30 UTC

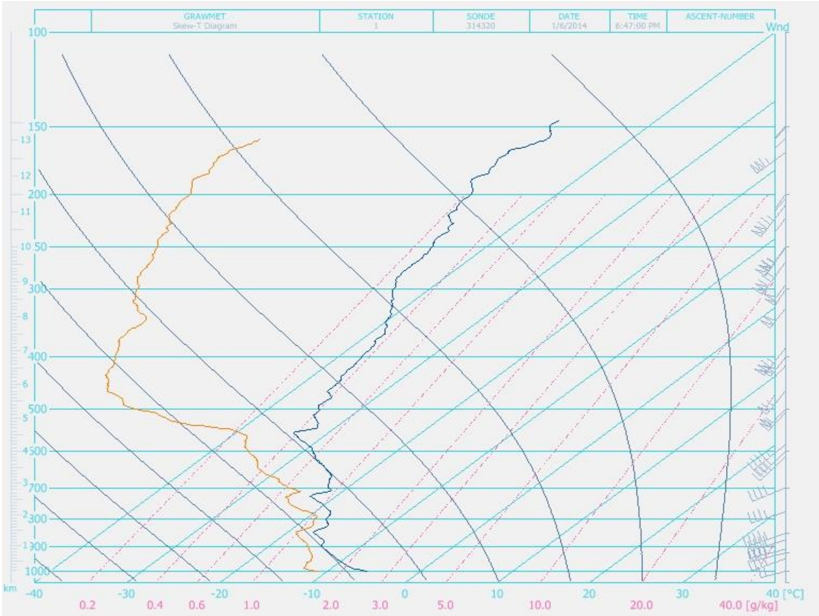


WCR Level II: Reflectivity transect for 1/27/2014



Thoughts on OvCon LAP

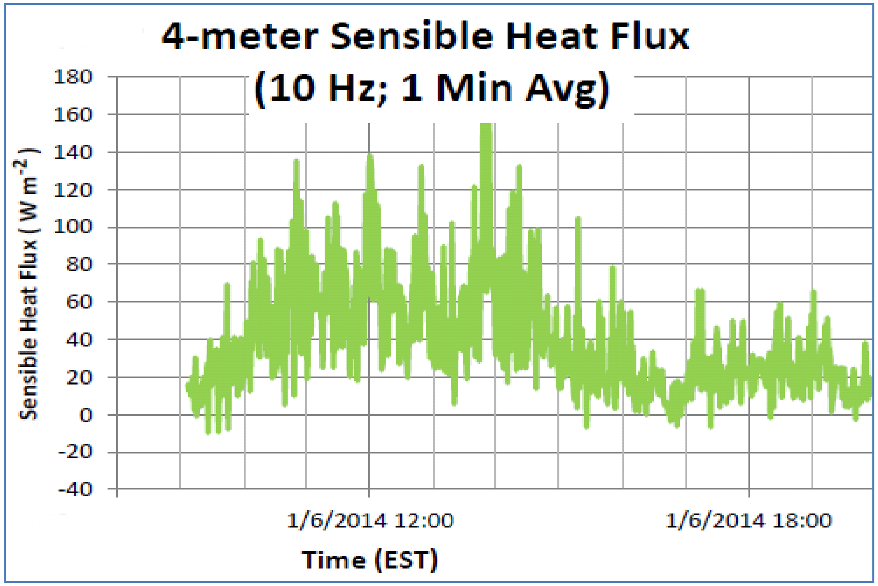
Post-cold front lake-aggregate plume develops: Surface fluxes lead to a the development of a ~1 km deep, relatively moist, well mixed boundary layer of meso-alpha width (i.e., something that looks a lot like a maritime tropical boundary layer in terms of stability and humidity profiles) and that plume advects downwind.



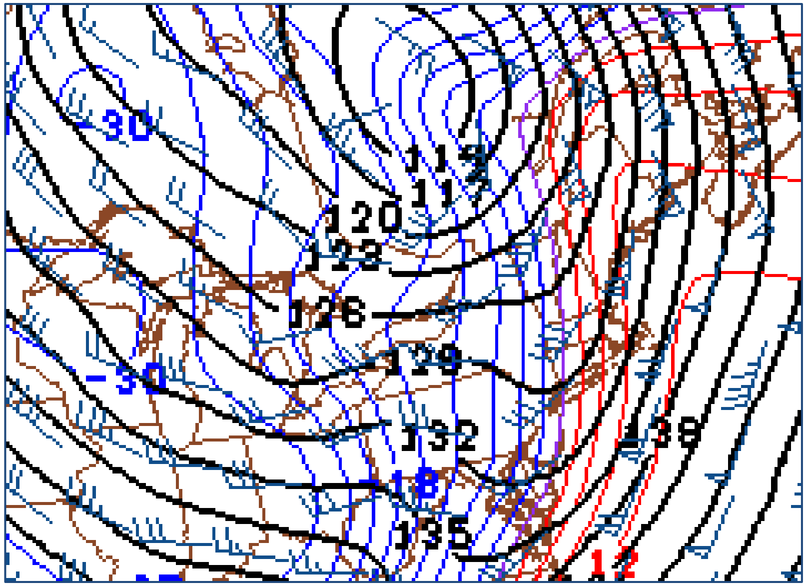
HWS, Medina, NY, 1/6/14, ~ 7:00 pm

Thoughts on OvCon LAP

Overland, moist boundary layer convection develops diurnally in this setting – days with some surface heat fluxes and (*differential?*) CAA are preferred.



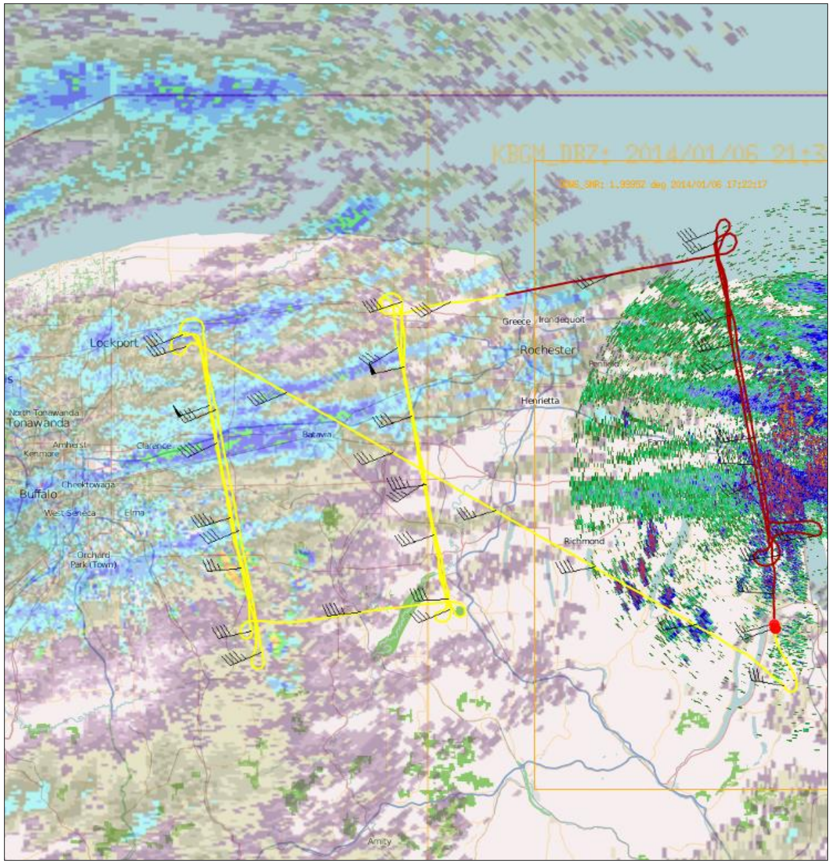
MU, Stanley, NY



01/06/2014, 1800 UTC, 850 hPa
NAM Analysis

Thoughts on OvCon LAP

Wind shear can act to organize convection. If so, it acts as an additional energy source (LeMone). Latent heat release may enhance the convective rolls or cells.

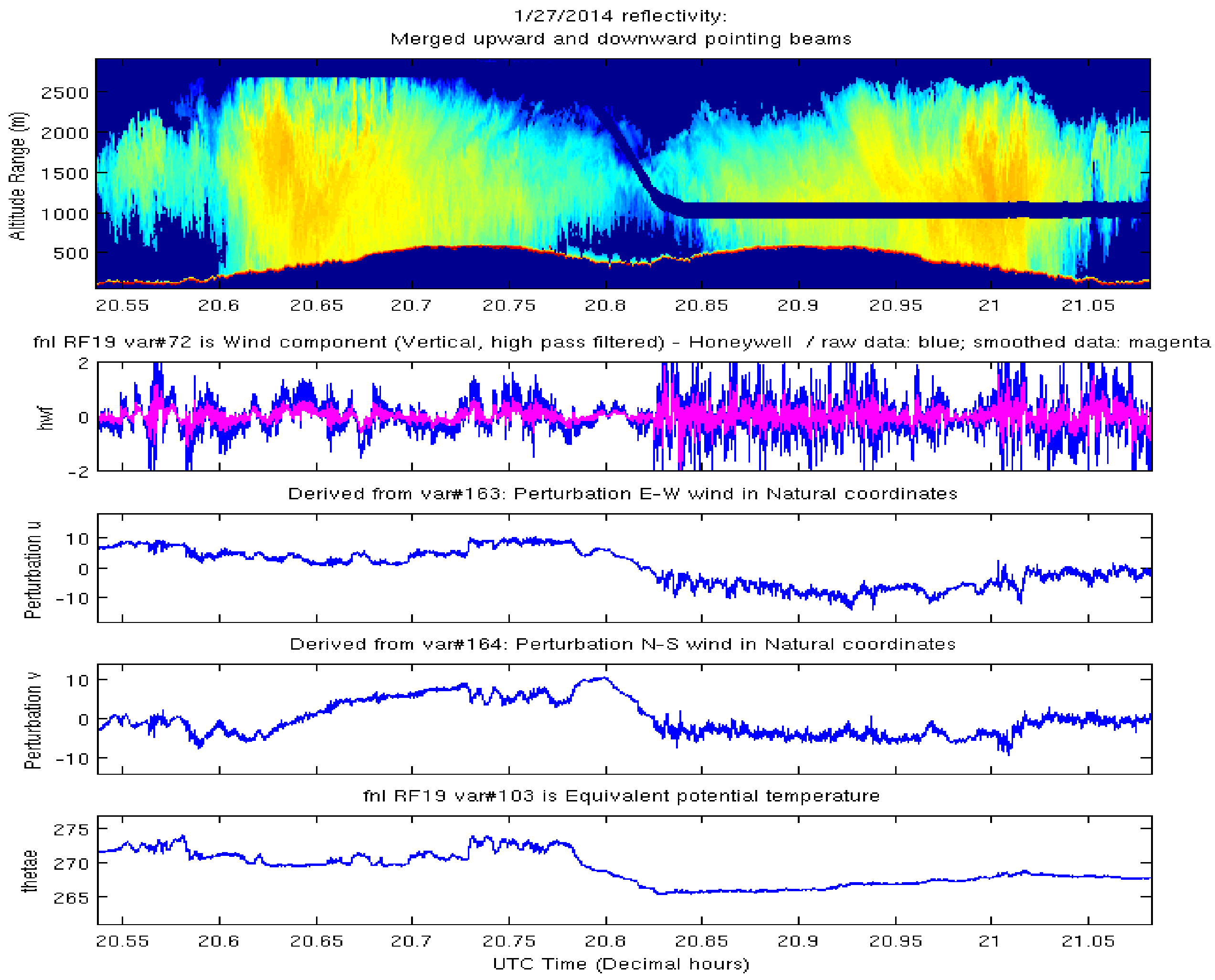


Composite WSR-88D / DOW radar (~5:30 pm) with UWKA flight track

Methods – OvCon LAP

- Observations used
  - Kingair *in situ*, cloud radar, and cloud lidar data
  - MU Flux tower, SODAR, and LIDAR data
  - Rawinsondes from multiple sources
  - DOW radar
- Questions asked
  - What is the role of surface heat flux?
  - What are the roles of CAA and dCAA/dz?
  - What role does surface friction play in these?
  - Is latent heat release just along for the ride?

Analysis Tools



Greybush Collaboration

- Professor Steven Greybush – Penn State
- Goals
  - Develop ensemble assimilation methods suited to regions with strong mesoscale surface forcing
  - Explore ensemble predictability in such cases
- Dr. Greybush Contributions
  - Surface forcing, CAA and dCAA/dz fields for our studies of the dynamics of InPen LLAP and OvCon LAP

Cases for which Dr. Young was flight scientist

Date	Inland Penetration of LLAP	Overland Convection LAP
12/10/2013 (IOP 2a)	175 km (off Lake Erie)	Modest
01/06/2014 (IOP 6)	100 km (off Lake Erie)	Extensive
01/08/2014 (IOP 9)	60 km (off Lake Ontario)	Little or none
01/20/2014 (IOP 16)	175 km (off Lake Erie)	Moderate
01/27/2014 (IOP 21)	210 km (off Lake Ontario)	Extensive


Questions?

Ensemble Data Assimilation, Modeling, and Predictability for Lake Effect Snow

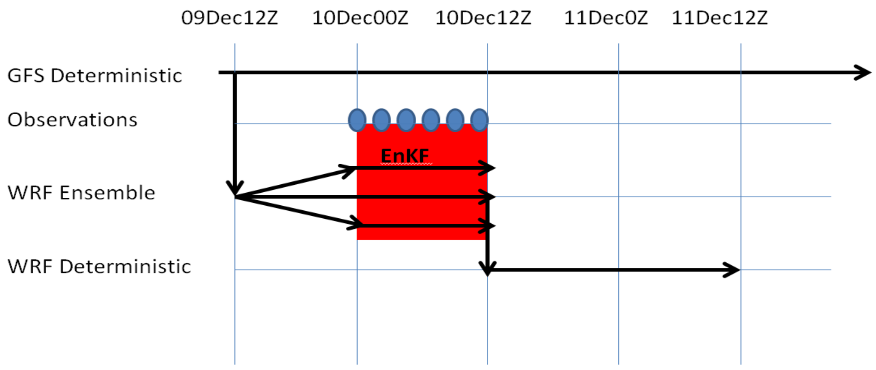
Steven J. Greybush
Assistant Professor of Meteorology
Fellow of the Institute for CyberScience
Penn State University

OWLeS Science Meeting
Oswego, NY; June 25, 2014

OWLeS as Assimilation Testbed

Why OWLeS?

- Wintertime precipitation has not yet been a major focus of DA studies to date.
- For lake effect, both the synoptic scale environment and mesoscale details matter.
- Involves shallow rather than deep convection, strong surface forcing, and topography.
- OWLeS provides unprecedented field obs for verification.



- High resolution (3 km, then 1 km) WRF ensemble
- Assimilate observations every 30 minutes using PSU-EnKF.
- Ensemble *mean* represents best analysis estimate, ensemble *spread* characterizes uncertainty.

Project Goals

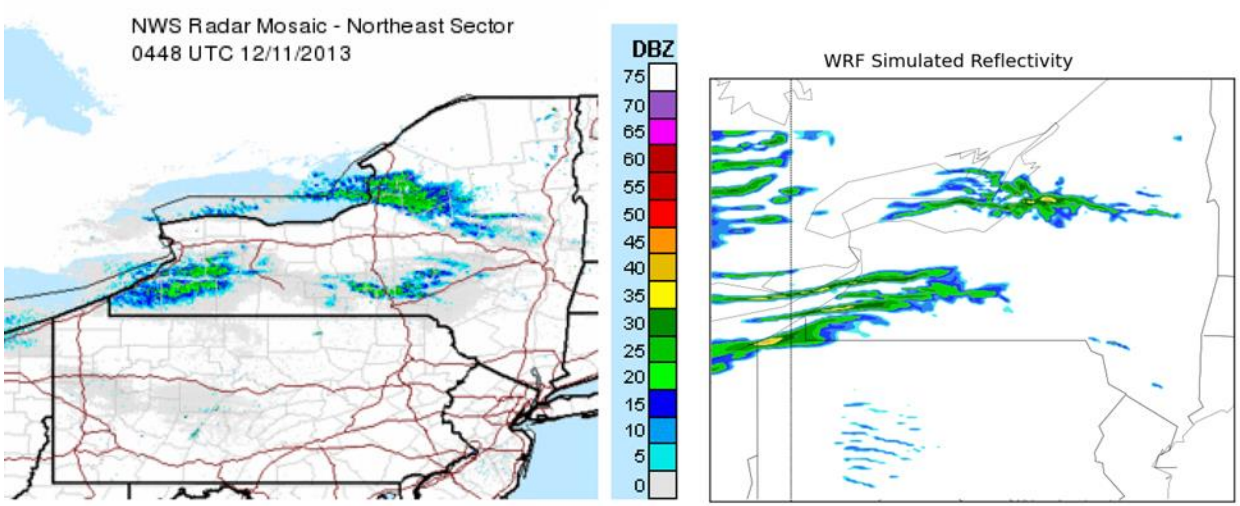
- **Assimilation**: Design an advanced WRF-based mesoscale ensemble data assimilation system for winter precipitation.
  - Evaluate latest techniques: EnKF, 4DEnsVar, E4d-var
  - Optimize assimilation of surface, upper air, and radar data.
  - Assimilate operational observations, validate with field campaign observations.
- **Predictability**: Explore ensemble predictability of lake-effect snow.
  - Compare the fundamental (dynamics-limited) versus the practical (model/obs limited) predictability.
  - Characterize the timescales for error growth and saturation.
  - Understand the relative contributions of initial condition, boundary condition, and model error.

Project Benefits

- With the newly-optimized data assimilation system, we will produce an **ensemble reanalysis** for cases of interest.

  (e.g. 3-D winds, temperatures, surface forcing, advection fields)

- Product will be available for interested OWLeS investigators.



Sample output of PSU-WRF-EnKF simulated radar compared to NWS composite radar. Forecast initiated from analysis that assimilates conventional observations only.