The National Weather Service Ceilometer Planetary Boundary Layer Project

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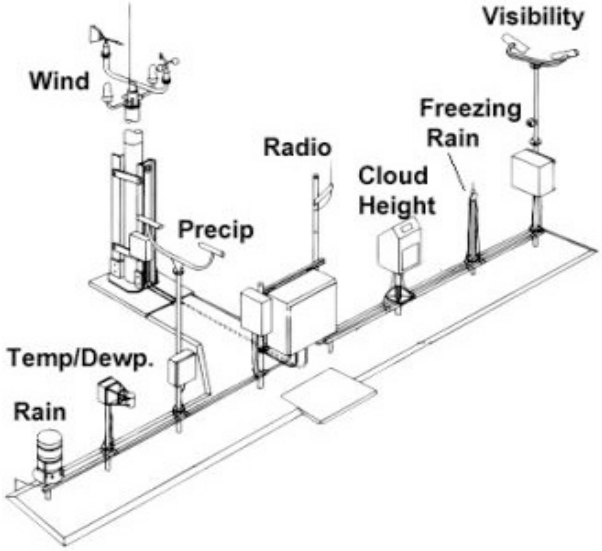
Outline

- Background
- Objective
- Methodology
- Preliminary Results
- Implementation Plan

Background

- NRC Study: Observing Weather and Climate from the Ground Up: A Nationwide Network of Networks (*http://www.nap.edu/catalog.php?record_id=12540*)
  - Identified national priorities for mesoscale atmospheric and related environmental observations
- The NWS along with ASOS (Automated Surface Observing System) partners are upgrading communication hardware capabilities of the ASOS network
  - This upgrade will allow increased throughput capabilities

Background



- Vaisala Model CL31 Ceilometer – ASOS since 2009
- All-weather instrument
- Operates at 910 ± 10 nm with a InGaAs diode laser pulse of 110 ns, 1.62µJ/pulse
- Uses a silicon avalanche photodiode detector from 0 to 25,000 ft range

Objective

- The CL31 PBL Project initiated in 2012 by the ASOS Product Improvement Program (now managed by NWS/STI) in response to NRC

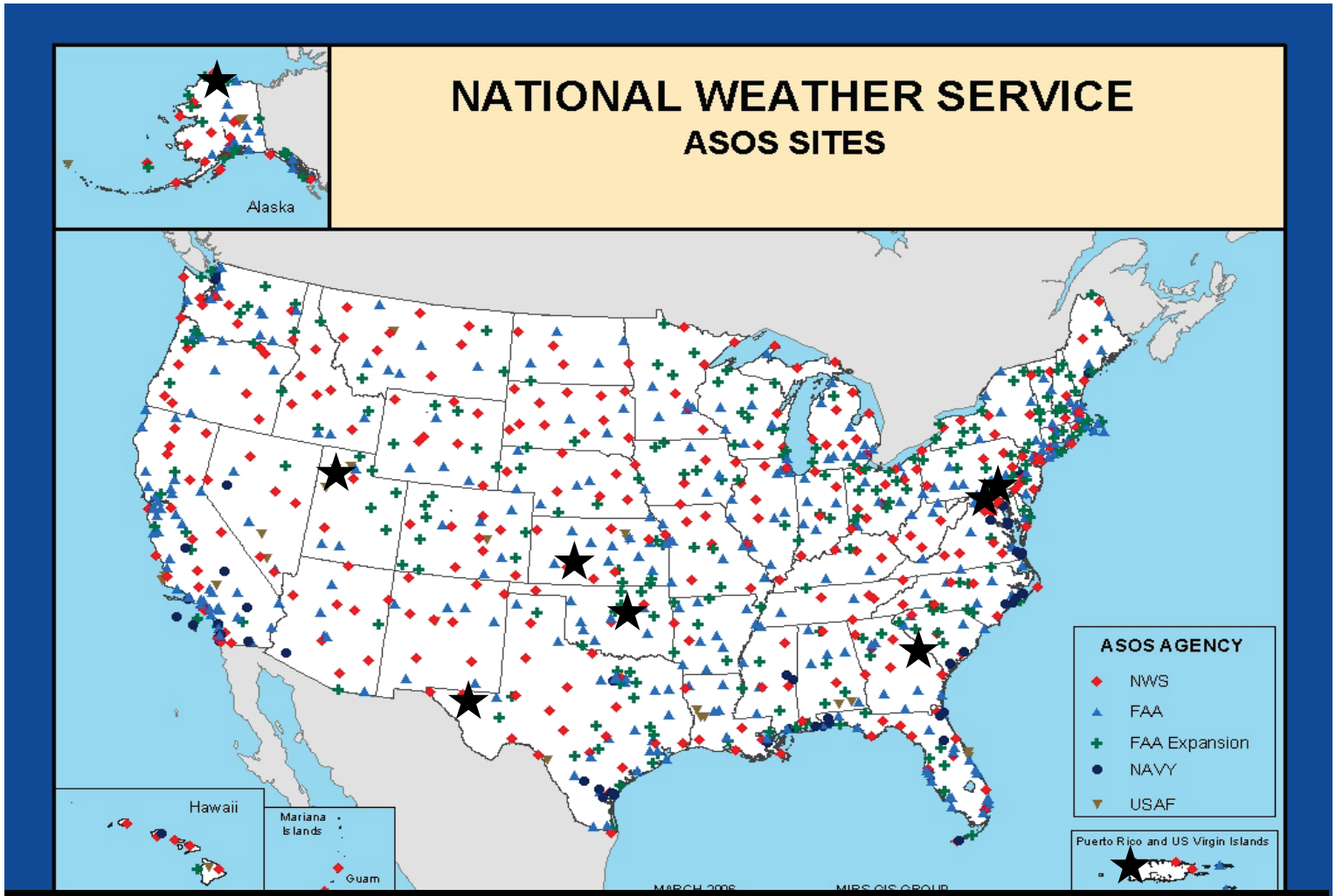
- GOAL: To show viability of ASOS ceilometer
  - ***detect mid level cloud bases above 12,000 ft***
  - ***archive vertical backscatter data***
  - ***monitor mixing heights and elevated aerosol layers***

Methodology

- Organize a small network of stand-alone CL31 ceilometers across the USA
- Archive data at a central repository at SFSC
- Report characteristics of data (i.e., data size and data quality)
- Optimize polling algorithm to minimize latency
- Evaluate mixing height algorithm
- Recommend implementation plan to ASOS Program Management Committee (APMC)

ASOS Ceilometer Sites

Stand-Alone CL31 sites depicted by black stars



Chet Schmitt (OBS 3): ASOS Ceilometer Workshop, NWS/Sterling, VA. March 22, 2012

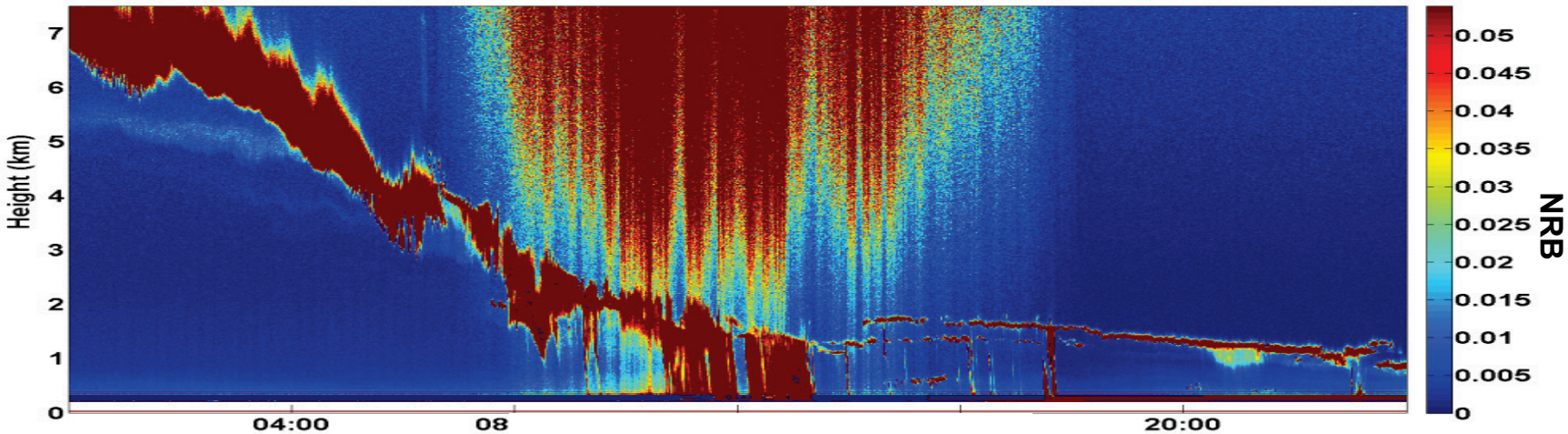
Data Analysis

- **Data quality**
  - Examine error characteristic of retrieved aerosol backscatter profiles for various sky cover and climate conditions
  - Compare to Reference Lidars
    - Raman Lidar (ARM SGP and HU/NCAS Beltsville, MD)
    - Micro-Pulse Lidar (MPL) (ARM SGP and NWS/SFSC)
    - Elastic Lidar Facility (ELF) (UMBC)
- **Mixing Height Algorithms**
  - UMBC Method (Compton et al. 2013)
  - Hybrid-Lowest Method (Hicks et al. 2015)
  - Vaisala BL-View technique
  - Radiosonde
    - Bulk Richardson Method (Seidel et al. 2012)

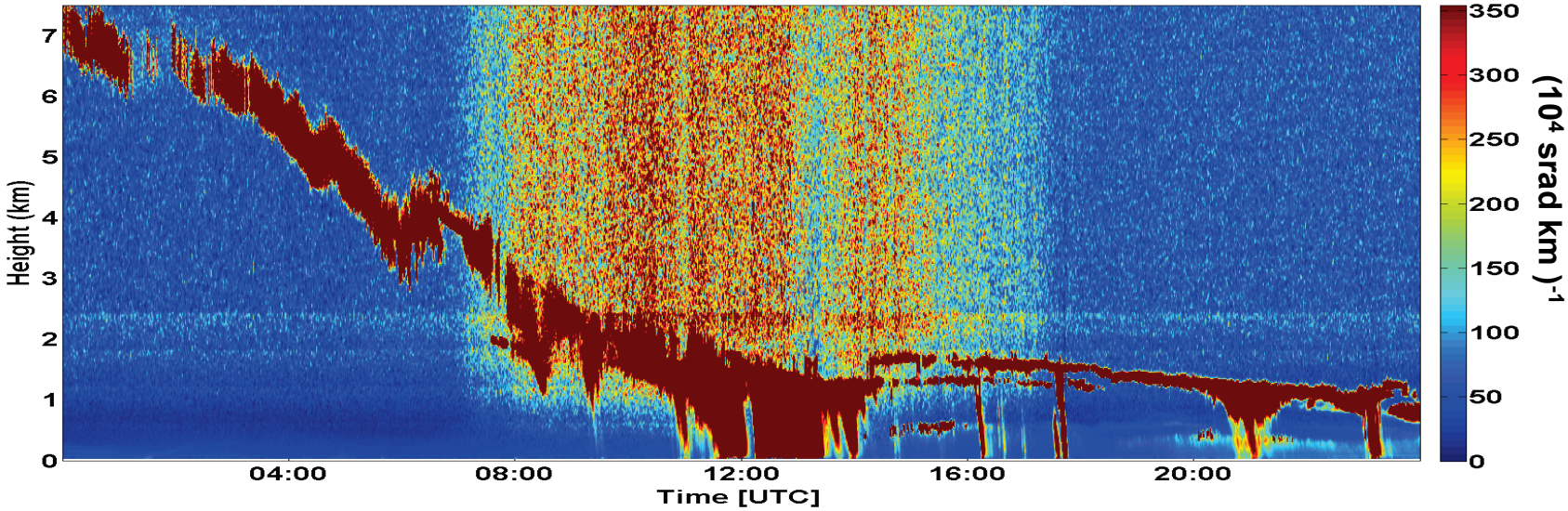
Track air pollution & Nowcast

Data Quality

MPL (25 mW output)



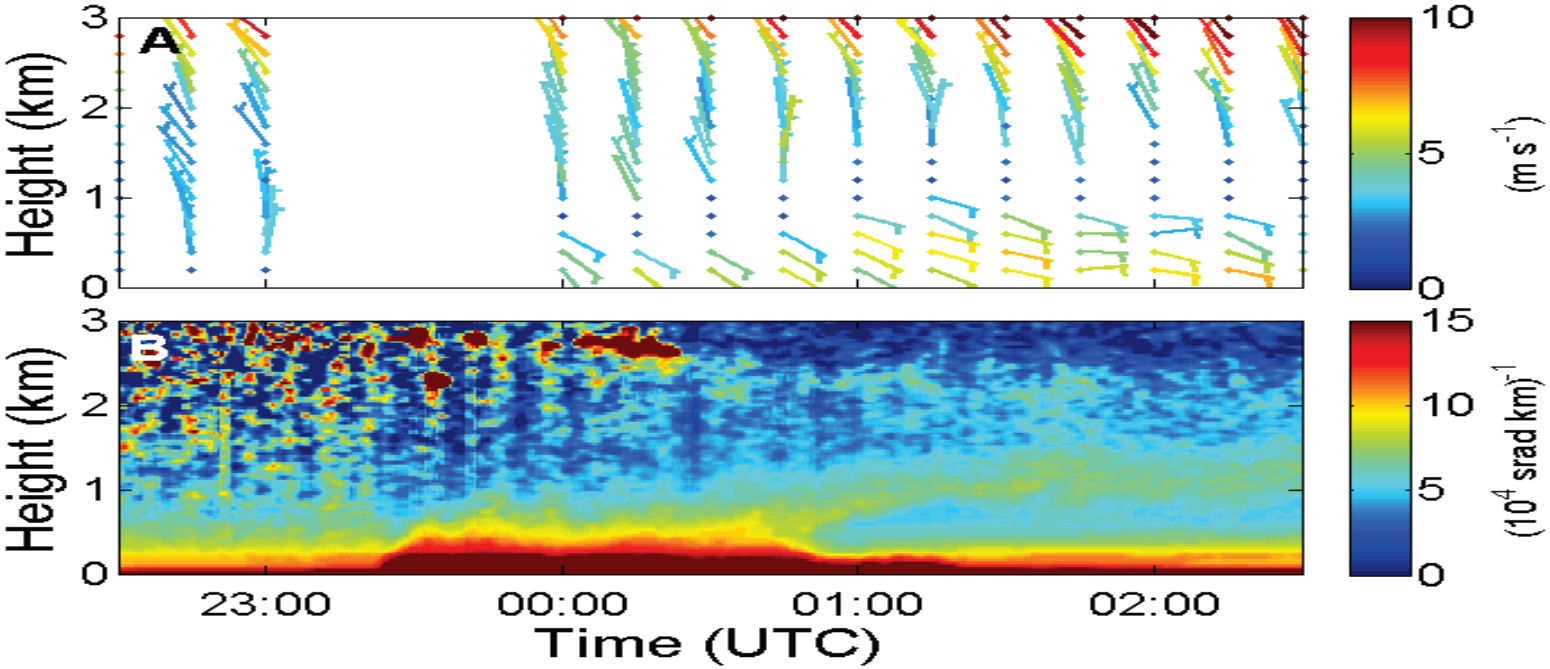
CL31 (1 mW output)



Track air pollution & Nowcast

Data Quality

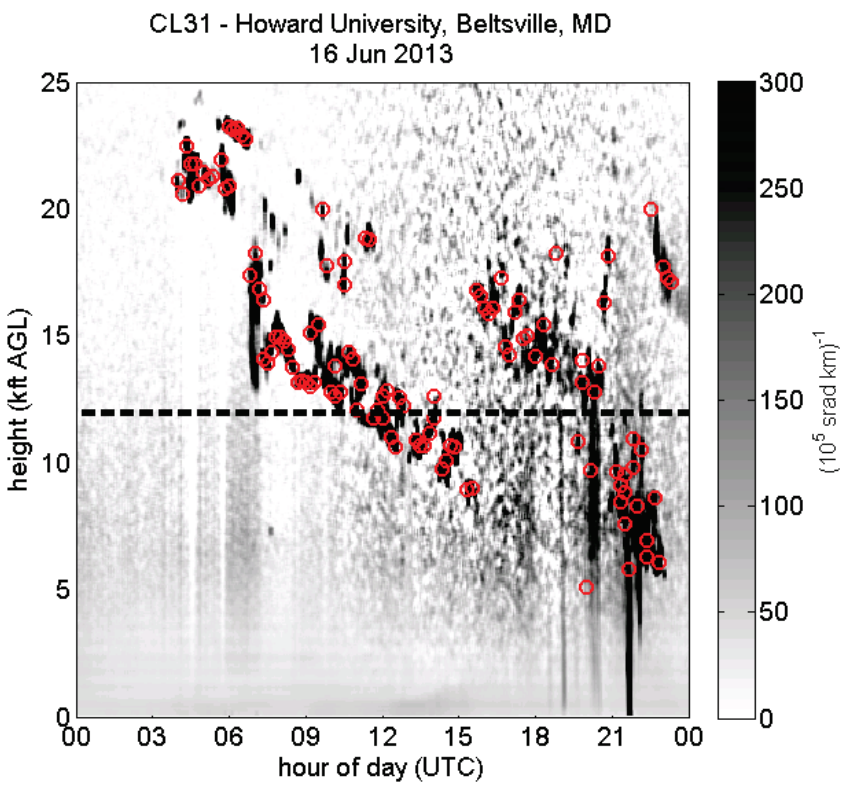
915 MHz Wind Profiler and CL31 ceilometer at Beltsville, MD

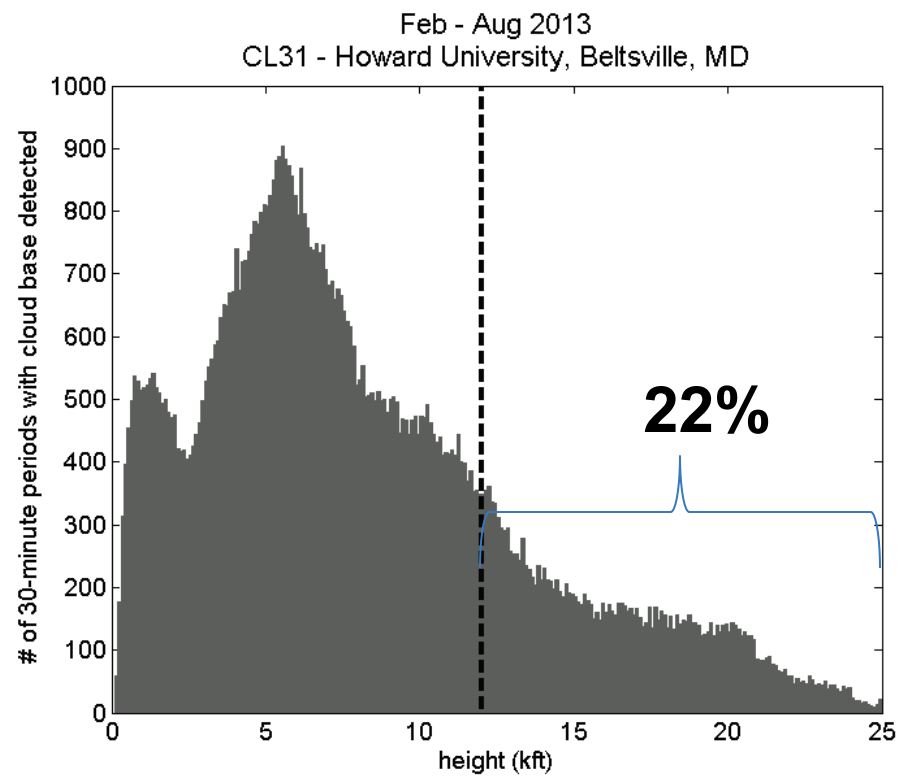


Passage of a bay breeze front from the Chesapeake Bay on 4-5 Aug 2007. The top panel shows the co-located radar wind profiler wind speed and direction

Track mid clouds
Data Quality

- Preliminary data statistics:



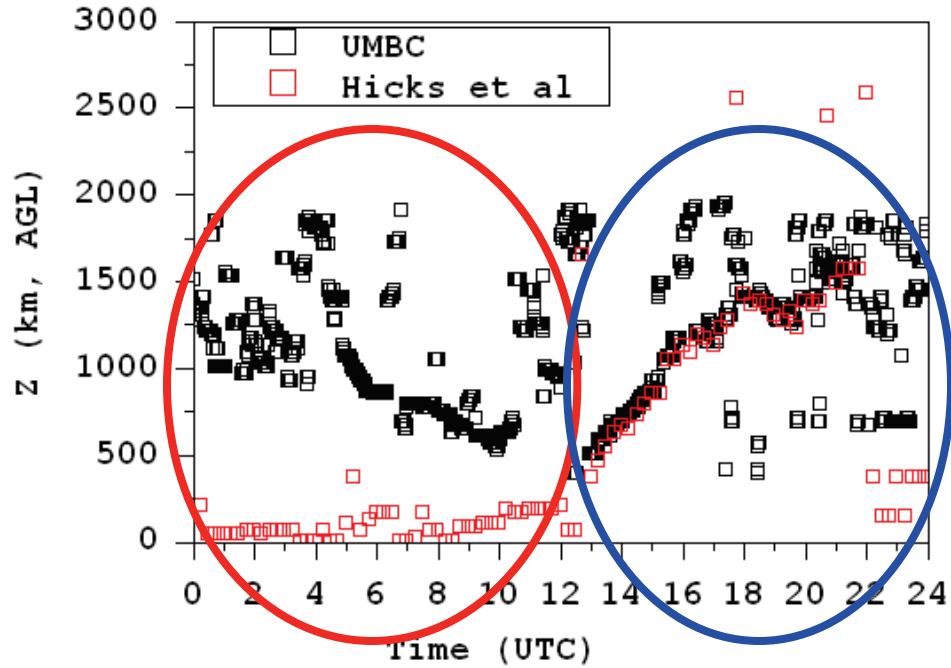


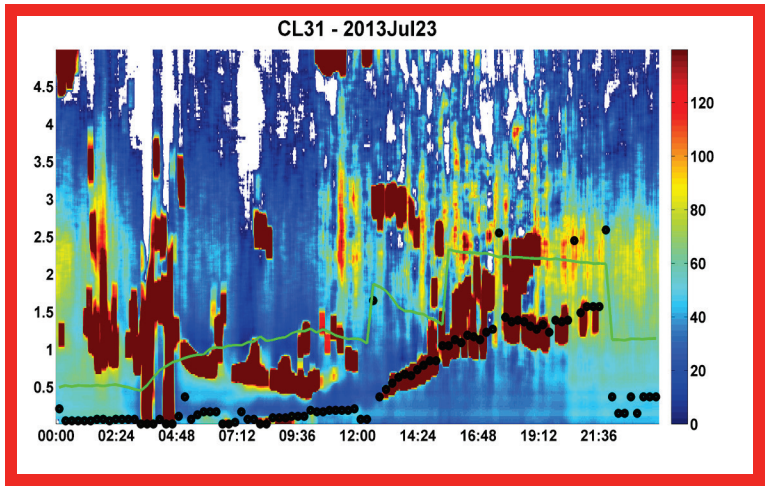
Monitor mixing heights:

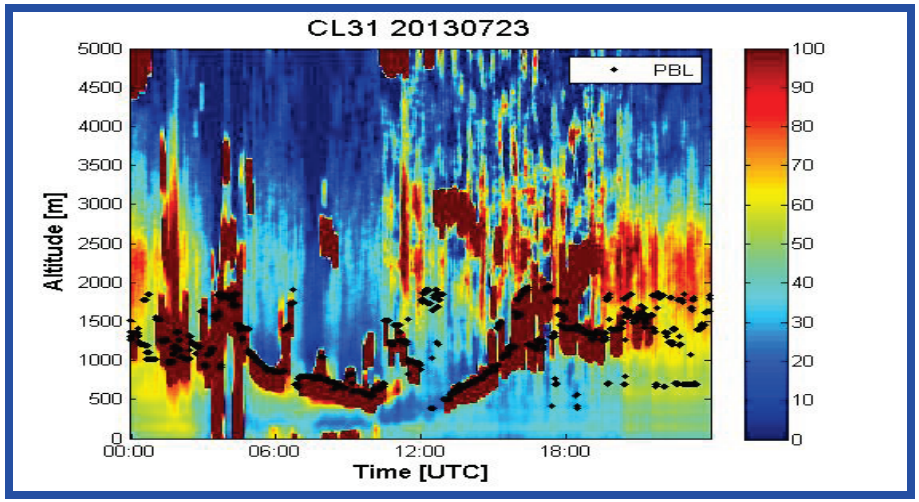
Mixing height algorithms

<u>Good Comparison Day:</u>

- Excellent morning PBL evolution
- LCL filter (Espy):
  - *removes day-night transitions*
- Elastic lidar challenges :
  - *day-night transitions*
- Similar in convective region







Monitor PBL heights:

PBL height algorithms

Preliminary Results for VA/DC/MD area, 2013 - 2015:

		BLView avg diff (m)	Hicks avg diff(m)	UMBC avg diff (m)
	Method			
STABLE	Liu Liang	710.327	12.066	1221.472
	RiB	770.776	173.336	1158.482
	Heffter	761.597	54.004	1243.862
	AVERAGE	768.476	123.15	1236.075
CONVECTIVE	Liu Liang	196.37	-604.388	****
	RiB	527.195	-175.566	****
	Heffter	-299.849	-1151.683	****
	AVERAGE	227.076	-732.185	****

Lidar-sonde differences:

- LL – gradient of theta
- RiB – Conv/mech (0.25)
- Heffter – lapse rate of theta

NB: PBLH comparisons under ideal conditions – revealed +/- 200m (IHOP2002)

Implementation Plan

- **Recommendations to APMC**
  - Do not change current sky condition algorithm w.r.t backscatter profile (poll twice a minute for cloud bases, ~30 sec)
  - Poll ceilometer once a minute (~45 sec) for backscatter profile
  - To avoid latency issues, up baud rate to 57,600 bps
    - Negligible data degradation
  - The Acquisition Control Unit (ACU) CPU should
    - Convert hex data to decimal
    - Down sample and save data into binary format
    - Make data available to users via NCEI, 3 to 6 hr lag
      - Data size is 145 KB to 1.5 MB with 10 min to 1 min and 20 m resolution for a daily file

CL31 PBL Project

Thank you

ACKNOWLEDGEMENTS

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