2024 National Ambient Air Monitoring Conference

Status Update on the Unified Ceilometer Network

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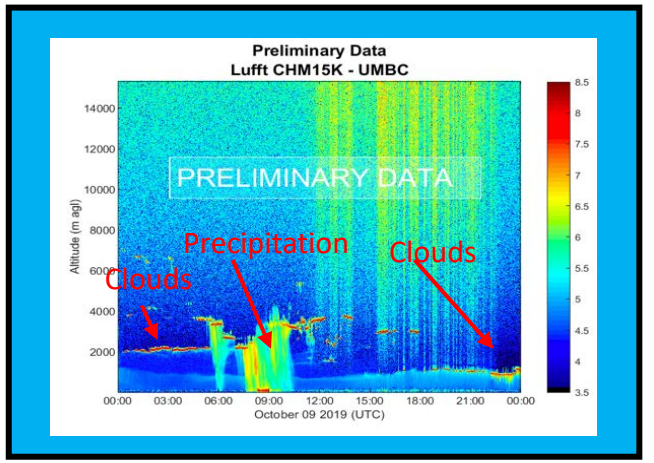
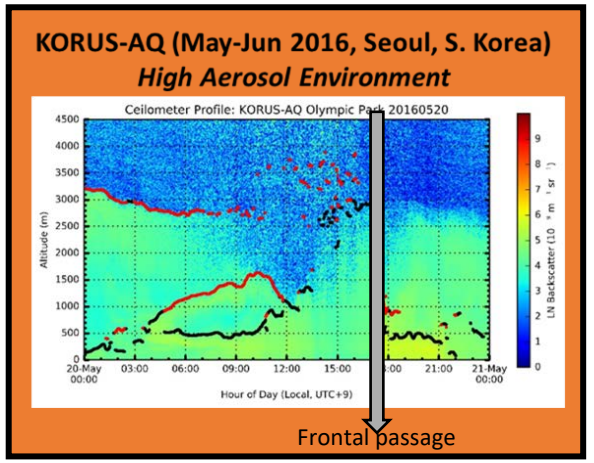
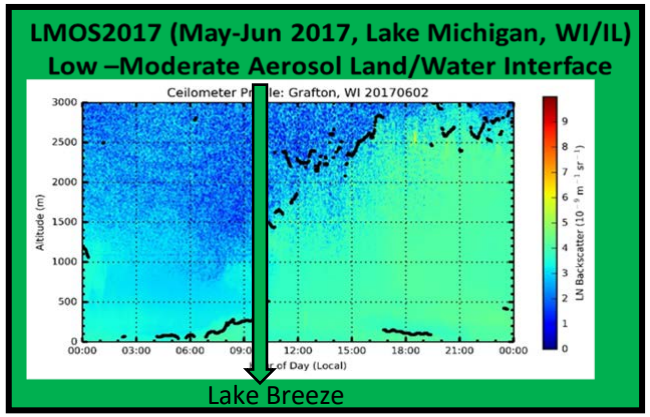
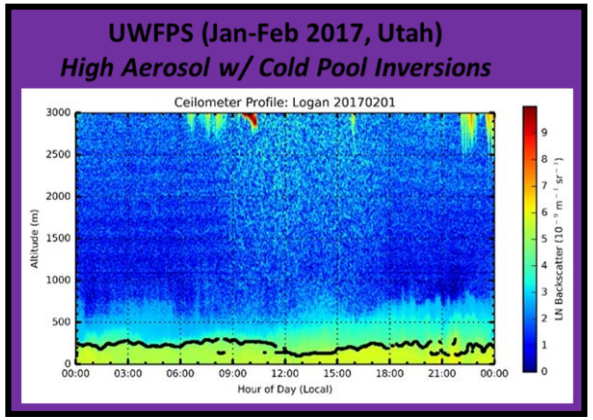
Monitoring the Planetary Boundary Layer

- ORD Research in collaboration with Hampton Univ and UMBC demonstrated ceilometers as a low cost option to monitor:
  - **Clouds and precipitation**
  - **PBL stratification**: residual layers, nocturnal boundary layers (NBL), lofted aerosol layers, mixed layer height (MLH), etc.
  - **Synoptic changes influencing PBL dynamics**
  - **Impact of local circulation (bay/sea/lake/land breeze)**
  - **Strong shallow inversions**



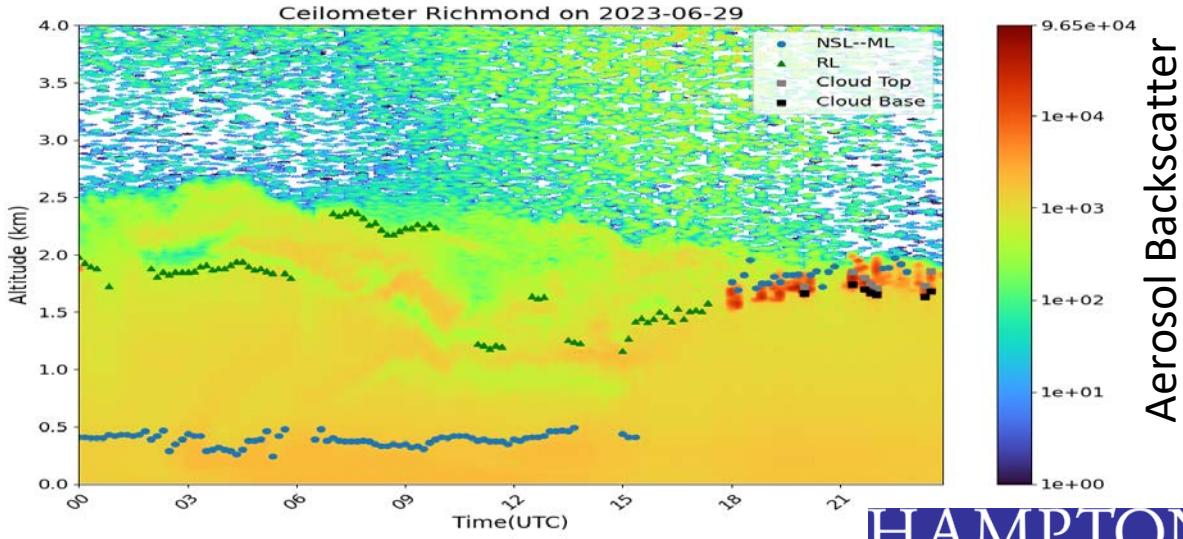




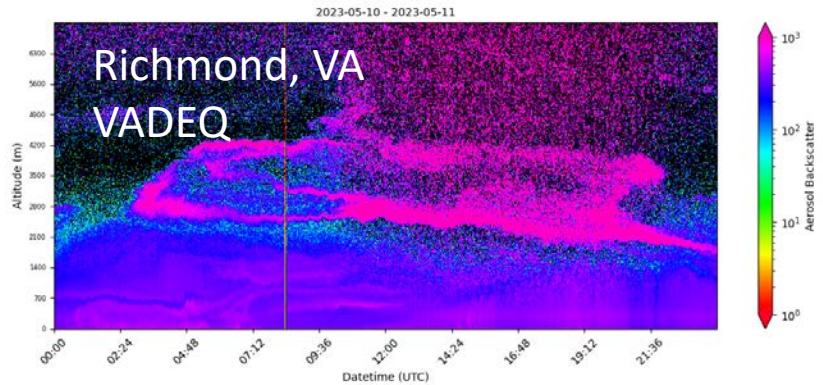


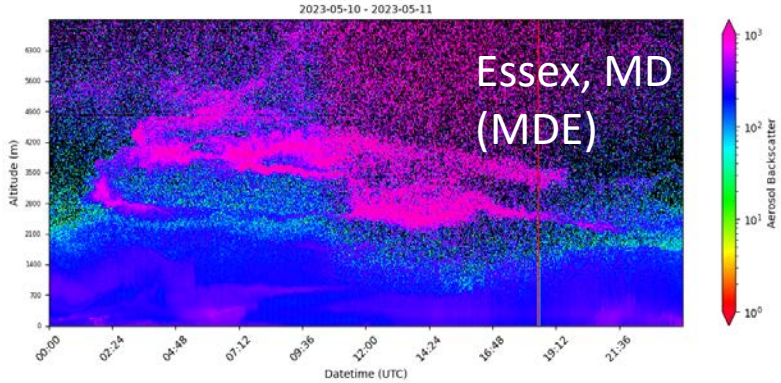
Aerosol Backscatter

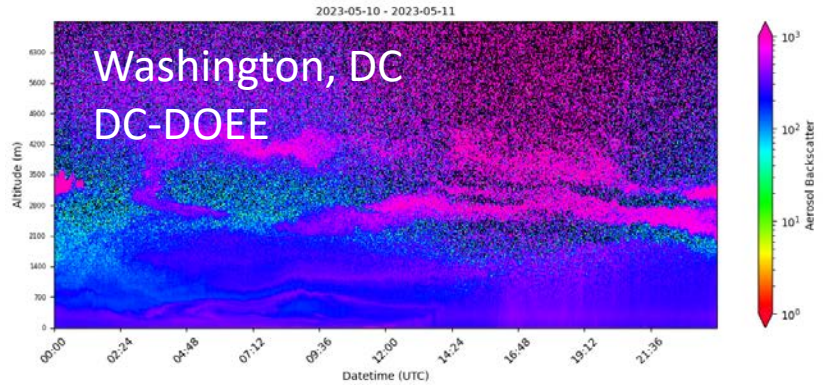
- PBL Height Temporal Evolution for Evaluation of Models
  - Accumulation and Dispersion of Pollutants and Vertical Distribution of Aerosols
- Fire Weather
  - Smoke Intrusion → AQ/Public Health Alert and Exceptional Events Analysis
- Improve Remote Sensing Retrievals: reduce uncertainty
- Optical/Physical Properties of Particles (Aerosols, Smoke, Dust)
  - AOD, Polarization, Color Ratio
- Validation Satellite Products
  - Aerosol Layer Height
- Volcanic Ash
  - Air Traffic

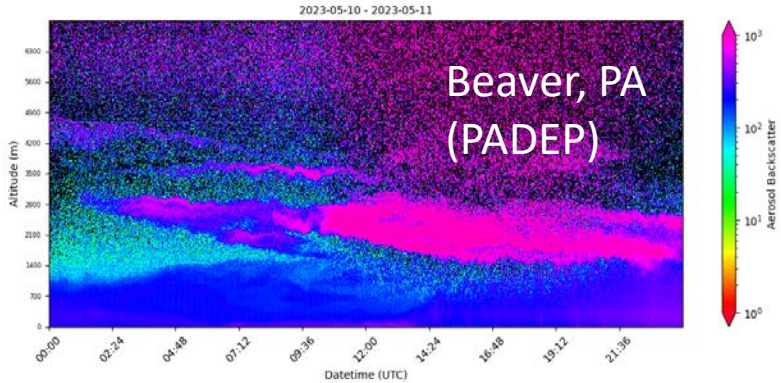


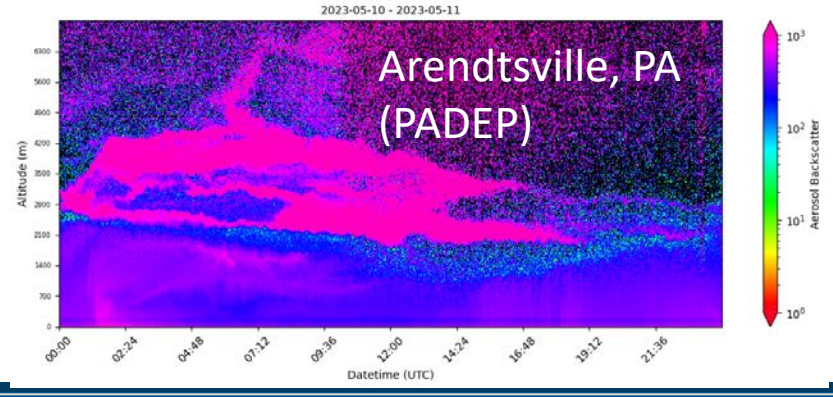
May 10, 2023: Canadian Wildfires (Alberta)

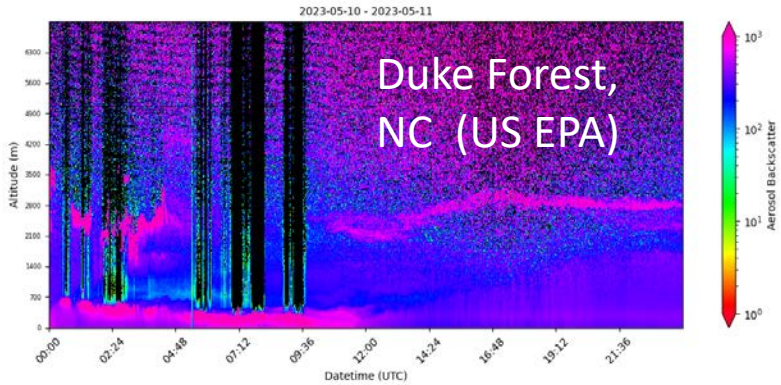








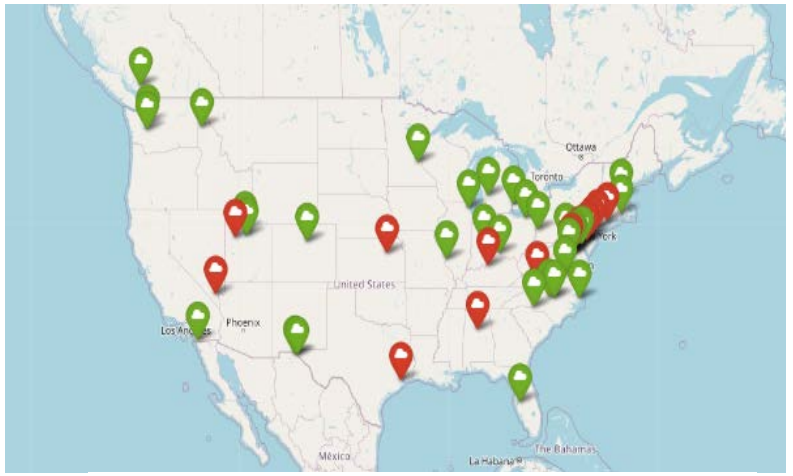




Objectives of the UCN

Challenge:

- Performance of current algorithms (research and commercial) not well documented across commercially available ceilometers.



UCN was established to:

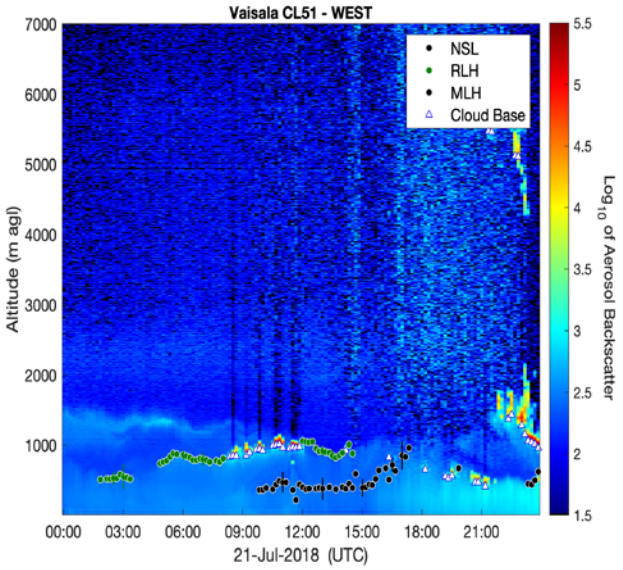
- Develop and implement a common MLH algorithm consistently across a developing heterogeneous network of ceilometer to avoid inconsistencies in data products and increases confidence in use of data for model evaluation (Caicedo et al. (2020) - https://doi.org/10.1175/JTECH-D-20-0050.1

- Develop and implement a centralized data archive of ceilometer 3-dimensional backscatter profiles align with standardized data outputs and retrievals.

- Increase the science and application uses of data products by leveraging PAMS and non-PAMS ceilometers in one central local

- Provide an option for back process of ceilometer data archive and algorithms improve with more robust data products

- Serve as a reporting option for the U.S. EPA PAMS program (Technical Note - Participation in the Unified Ceilometer Network, August 30, 2021)



Note: MLH term used to describe the day-time convective boundary layer. Ceilometer can measure day and night; we use Planetary Boundary Layer Height (PBLH) instead of MLH as we are using ceilometer measurements to characterize boundary layer through the entire day.

UCN Data Products to be covered in QAPP

Measurement /Retrieved Parameter	**Analysis Method**	**Derived parameter**	**Sampling Frequency**	**QC Check**
Mixing Layer Height	Haar wavelet algorithm	PAMS -Hourly Mixing Layer Height	10 min average MLH generated as common sample frequency	Visual check of data and products using aerosol backscatter and MLH
Residual height layer	Haar wavelet algorithm	PAMS - Hourly residual Layer Height	10 min average MLH generated as common sample frequency	Visual check of data and products using aerosol backscatter and MLH
Aerosol Backscatter	measured	**Non-PAMS derived parameter**	Varies by ceilometer 15-36 seconds	Visual check of data and instrument diagnostics monitoring
Aerosol layers	Haar wavelet algorithm	**Non-PAMS derived parameter**	10 min average generated as common sample frequency	Visual check of data and uncertainty evaluations
Cloud heights	Haar wavelet algorithm	**Non-PAMS derived parameter**	10 min average generated as common sample frequency	Visual check of data and products using aerosol backscatter
Precipitation	Haar wavelet algorithm (measure properties of image regions)	**Non-PAMS derived parameter**	10 min average MLH generated as common sample frequency	Visual check of data and products using aerosol backscatter

Current UCN Timeline

- Distribution of New Data Transfer Executables and Scripts (July-August 2024)
  - ***Priority is PAMS sites which have never received an executable for data transfer***
  - Data Transfer to NEW Hampton University Processing Server
  - Agencies should Inform via email all UCN and EPA contacts the date that you installed to assist and monitor data transfer

- Migration of Data Transfer from Old to NEW Processing Server (August-September 2024)
  - Transfer of Sites Displaying Data in https://ucn-portal.org

- New Webpage (October-November 2024)
  - Aerosol Backscatter Visualization (All Sites) and New Download* Features

- Mixing Layer Height Visualizations (December 2024)
  - Aerosol Backscatter with derived data products

* All Raw and Standardization Data Files are currently available for download by selecting site in http://cas.hamptonu.edu/~mcnabb/ucn/ceilometer_data.php

UCN Data Migration

Secure Data Transfer

Migration of data transfers from Univ. Maryland Baltimore County server to Hampton University server:

A new executable has been created for every PAMS site. Sites current not reporting to UCN are priority sites.

1- To coordinate migration, we are verifying and updating agency/organization contact person for each site. Important for Email Alert System.
Contact persons for each site can be found here:
https://www.ucn-portal.org/sites

2- Site information can be updated at any time, in addition to request to joining network UCN Google Form:
https://forms.gle/jBNypgacZc3FHs597

3- Email: Ruben Delgado (ruben.delgado@hamptonu.edu),
John McNabb (john.mcnabb@hamptonu.edu)
UCN (portal.ucn@gmail.com)
EPA (szykman.jim@epa.gov or james.j.szykman@nasa.gov)

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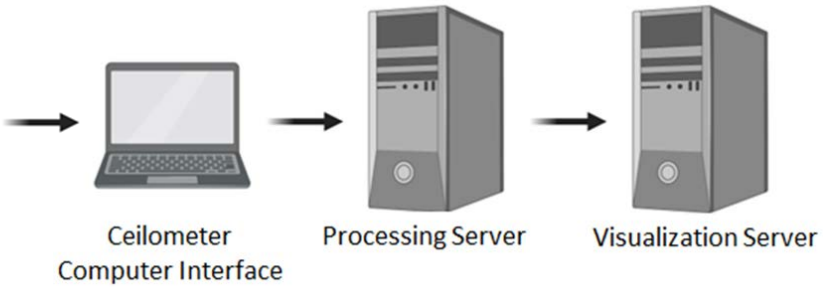
UCN Automated Data Transfer

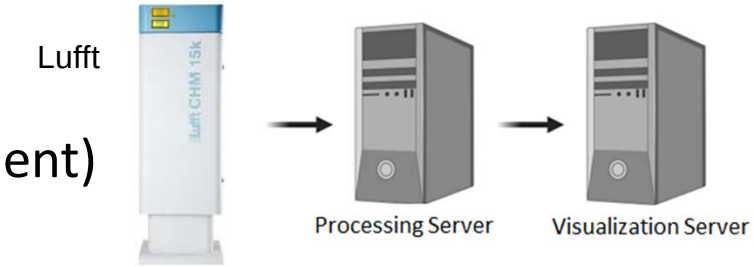
Minimum system requirements to join UCN:



Vaisala/BL-View (UCN data transfer executable)

- Windows 10 OS (Computer provided with CL51)
- Ability to send/receive data over at port 80/443
- Working internet connection
- Weblink to download executable emailed to Site Contact
- Administrator rights or the ability to obtain one for the ceilometer computer interface
- Executable will transfer all existing (archived) data

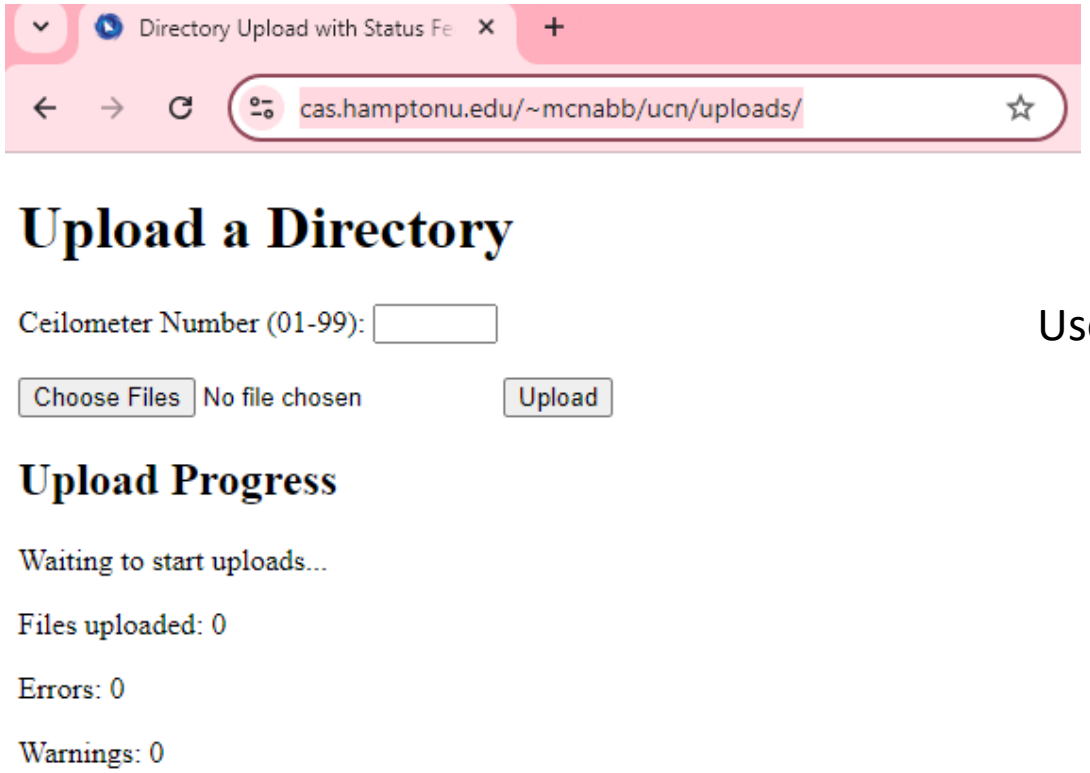
Lufft (UCN data transfer script)



- Working internet connection (need to have ability to assign IP to instrument)
- UCN Data transfer script needs to be uploaded directly to instrument
- If NO ability to assign IP, a computer with internet access can serve as data transfer interface
- Existing data needs to be transferred manually (next slide)

New UCN Manual Data Upload (Vaisala and Lufft)

http://cas.hamptonu.edu/~mcnabb/ucn/ceilometer_data.php



Users need to know the UCN Ceilometer Identifier for your PAMS site

UCN Ceilometer Identifier (CEILO-XX) can be found here:

http://cas.hamptonu.edu/~mcnabb/ucn/ceilometer_data.php

New UCN Manual Data Upload (Vaisala and Lufft)

http://cas.hamptonu.edu/~mcnabb/ucn/ceilometer_data.php

UCN Data Overview

Not secure cas.hamptonu.edu/~mcnabb/ucn/ceilometer_data.php

New Chrome available

Ceilometer	Site Name	RAW First Date	RAW Last Date	STAND First Date	STAND Last Date
CEILO-01	Unknown	2021-10-09	2022-02-28	2021-06-09	2022-02-18
CEILO-04	Unknown	2022-05-24	2022-06-09	2088-05-24	2088-06-09
CEILO-05	Unknown	2021-10-19	2024-07-30	2021-10-19	2024-07-30
CEILO-07	Philadelphia, PA	2021-12-04	2022-01-30	2021-12-04	2022-01-30
CEILO-08	Richmond, VA	2021-10-19	2024-08-03	2021-10-19	2024-08-03
CEILO-09	Washington D.C.	2021-10-18	2024-08-03	2021-10-18	2024-08-03
CEILO-1	Unknown	2023-07-01	2023-07-03	2020-11-01	2020-11-03
CEILO-10	Las Vegas, NV	2021-11-14	2022-01-26	2021-11-14	2022-01-26
CEILO-11	Indianapolis, IN	2018-03-01	2024-08-03	2018-03-01	2024-08-03
CEILO-12	Providence, RI	2018-08-17	2023-10-19	2018-08-17	2023-10-19
CEILO-13	Manhattan, KS	2019-10-28	2020-01-28	2019-10-28	2020-01-28
CEILO-14	Salt Lake City, UT	2021-04-16	2022-08-17	2021-04-16	2022-08-17
CEILO-15	Londonderry, NH	2020-01-01	2024-08-03	2020-01-01	2024-08-03
CEILO-17	Utah Technical Center	2017-11-02	2024-08-03	2017-11-02	2024-08-03
CEILO-2	Unknown	2023-07-01	2023-07-08	2020-11-01	2020-11-08
CEILO-23	Ardenstville, PA	2020-03-25	2024-08-03	2020-03-25	2024-08-03
CEILO-25	Superior, CO	2017-10-25	2024-08-03	2017-10-25	2024-08-03
CEILO-27	Essex, MD	2021-09-09	2024-07-19	2021-09-09	2024-07-19
CEILO-28	St. Maries, ID	2020-08-13	2024-08-03	2020-08-13	2024-08-03
CEILO-29	Tacoma, WA	2020-08-04	2024-08-03	2020-08-04	2024-08-03
CEILO-30	Seattle, WA	2020-11-04	2024-06-02	2020-11-04	2024-05-29
CEILO-31	Cincinnati, OH	2020-07-15	2024-08-03	2020-07-15	2024-08-03
CEILO-33	Duke Forest,NC	2022-03-23	2024-08-03	2022-03-23	2024-08-03
CEILO-34	Blaine, MN	2020-12-16	2023-09-12	2020-12-16	2023-09-12
CEILO-36	Raleigh, NC	2021-04-13	2023-08-30	2021-04-13	2023-08-30
CEILO-37	Northbrook, IL	2022-02-26	2024-08-03	2022-02-26	2024-08-03

During site visits it is recommended that you add a quick check on data status from your site to any QA checklist.

Green: Data Up to Date
White: Partial Data Available

Yellow: Less Than Week Behind
Red: No Data Received

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QA/QC and Calibration/Validation

- U.S. EPA Quality Assurance Project Plan (QAPP)
  - Currently being updated to reflected changes occurring at Hampton University

- Quality Assurance Handbook for Air Pollution Measurement Systems; Volume IV: Meteorological Measurements Version 3.0 (Draft)
  - Updates include a subsection on ceilometers consistent with UCN QAPP, input provided by ORD and Hampton Univ.

- ASTM International
  - Draft Standard Guide for Mixing Layer Height from Laser Based Ceilometers (Yet to receive yes vote to move out of committee)

- Ad-hoc Ceilometer Experiment Study (ACES II)

  Summer 2025 Mid-Altantic: Lufft CHM15k, Vaisala CL51 and CL61

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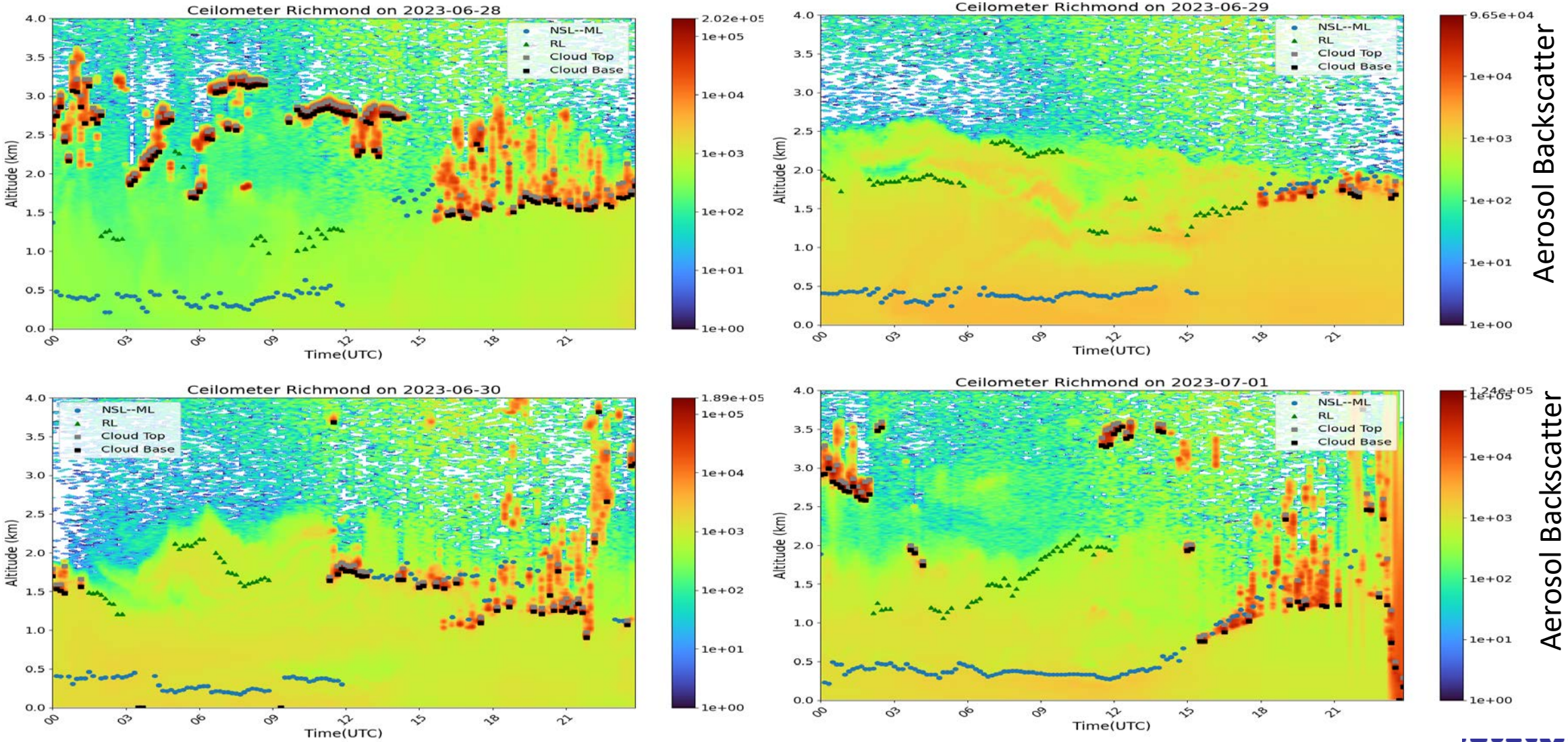
Goal for All PAMS sites reporting to the UCN
December 2024



Weekly Opportunities for Communication

Virtual Office Hours Thursdays 9:00 am-12:00 pm

- Q&A on UCN (data transfer, processing, downloads)
- Tutorial on Open Source tools for Visualization (Python, Panoply)
- Integrated Monitoring Systems for AQ events (surface, ceilometer/lidar and satellite)

To Make Appointment (if you need another besides Friday time, please ask):
Email:
ruben.delgado@hamptonu.edu and john.mcnabb@hamptonu.edu

Cell: Ruben Delgado (301-512-6638)

- Biweekly telecons with Berkley Hillis/Corey Mocka (OAQPS) and Jim Szykman (ORD) for monthly updates (progress/challenges)
- Monthly PAMS Telecom

Acknowledgements

Primary Contacts
Ruben Delgado (ruben.delgado@hamptonu.edu)
John McNabb (john.mcnabb@hamptonu.edu)
James Szykman (szykman.jim@epa.gov)

Background

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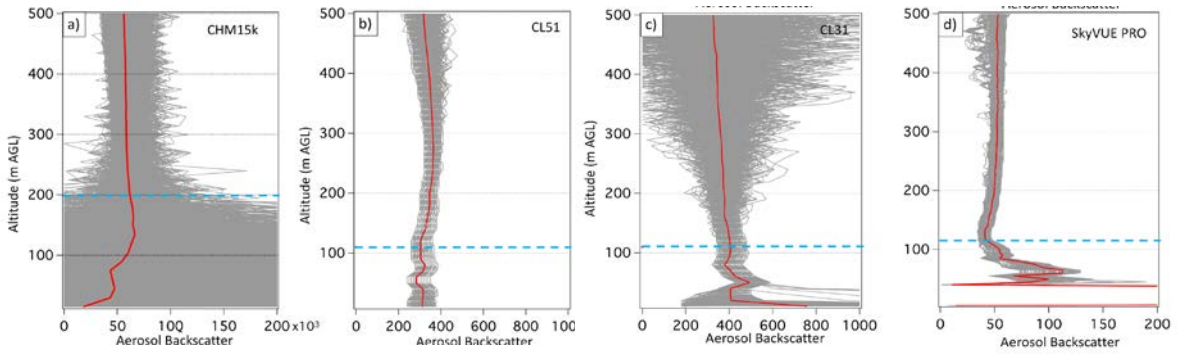
PAMS Hourly Mixing Layer Height Requirement

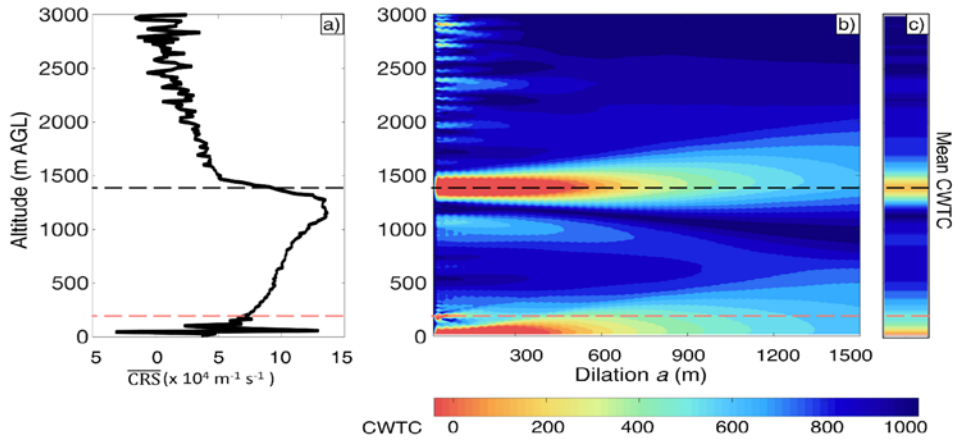
An Automated Common Algorithm for Planetary Boundary Layer Retrievals Using Aerosol Lidars in Support of the U.S. EPA Photochemical Assessment Monitoring Stations Program

Addresses instrumental signal quality (SNR, artifacts, overlap, etc.)



Define minimum reliable signals and limitations

Haar step-function to detect changes in aerosol backscatter profiles using multiple dilations



QC/QA of Ceilometer Aerosol Backscatter Signal and Mixing Layer Height Determination

Caicedo et al. (2020)
https://doi.org/10.1175/JTECH-D-20-0050.1

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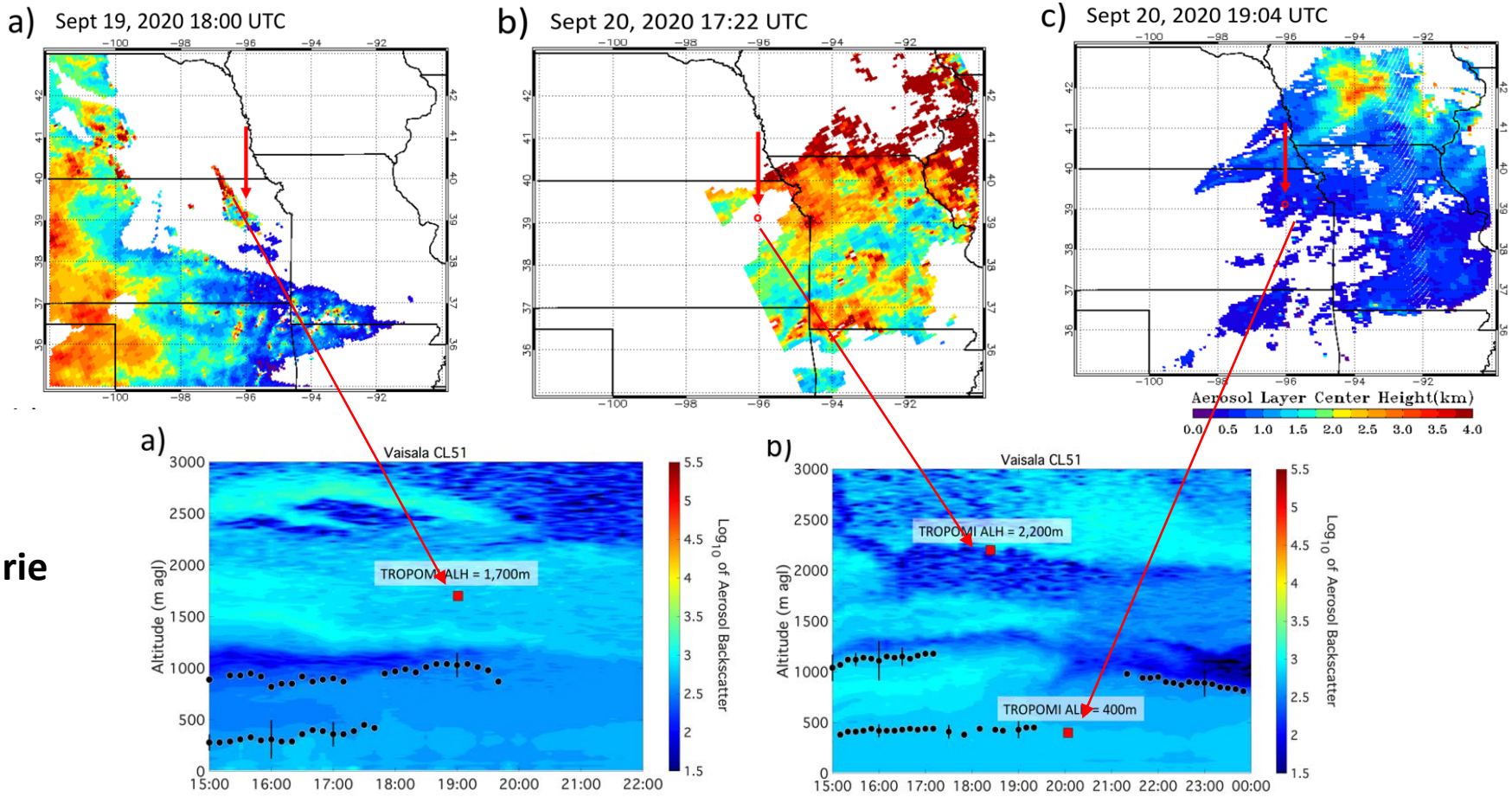
Satellite Validation of Aerosol Height Products

TROPOMI Aerosol Layer Heights

U.S. Region 7 CL51 at Konza Prairie Site



The UCN site in Konza Prairie, Kansas (EPA Region 7: 39.1022°N, 96.6096°W Bottom a-b) captured the evolution of the smoke plume transport. Ceilometer planetary boundary layer heights were calculated at the times of TROPOMI measurements and contrasted against TROPOMI ALH (Top a-c).

Source: Caicedo (CIRES)/Wang (Univ. Iowa)