Unified Ceilometer Network

Ruben Delgado\textsuperscript{1,2}, V. Caicedo\textsuperscript{1}, K. Taguba\textsuperscript{1}, D. Taylor\textsuperscript{1}, P. Maniktala\textsuperscript{1}, A. Rathod\textsuperscript{1}, B. B. Demoz\textsuperscript{1,2}, R. K. Sakai\textsuperscript{3}, F. Moshary\textsuperscript{2,4}, E.J. Welton\textsuperscript{5}, B. L. Lefer\textsuperscript{6}, M. Woodman\textsuperscript{7}, D. Krask\textsuperscript{7}, J. Szykman\textsuperscript{8}, K. Cavender\textsuperscript{8}

\textsuperscript{1}University of Maryland, Baltimore County
\textsuperscript{2}NOAA Center for Earth System Sciences and Remote Sensing Technologies
\textsuperscript{3}Howard University, \textsuperscript{4}City College of New York
\textsuperscript{5}NASA Goddard Space Flight Center, \textsuperscript{6}NASA Headquarters
\textsuperscript{7}Maryland Department of the Environment
\textsuperscript{8}U.S. Environmental Protection Agency

2020 MARAMA Air Monitoring Training Committee Workshop
December 8-10, 2020
• State and local air quality agencies to measure hourly MLH at the national PAMS, as is set forth in 40 CFR Part 58 driven by the state’s State Implementation Plan (SIP) modeling data needs.

• MLH requirement not limited to a particular technology (i.e. ceilometers, lidars, Doppler wind lidars and radar wind profilers).

• Need to develop a common MLH algorithm that can be implemented across a heterogeneous network.

• Develop centralized standardization of data outputs and retrievals.
2019 MARAMA Workshop

EPAMS Network Testbed

Testbed: 6 ceilometer sites in MD and NY

2020 MARAMA Workshop

Unified Ceilometer Network

Network: 28 sites across US and Canada
The UCN began with evaluation studies (Ad-Hoc Ceilometer Evaluation Study) and prototype networks (EPAMS Network Testbed) since December 2016.

Collaboration between UMBC, U.S. EPA, NASA (synergy with MPLNET) and NOAA on a ground-based ceilometer network to support of redesigned PAMS network. UCN: unique State/Federal/International/Academic collaboration allows for extensive observational coverage of the PBL in North America.

The UCN network will host, process, display, and distribute ceilometer data and products in near-real time. Ceilometer aerosol backscatter profiles are used to determine the PBL height with continuous 10-minute temporal resolution (Caicedo et al. 2020).

Mixing layer aerosol layer, and cloud base heights will be released online in the Spring 2021. Caicedo et al. (2020) https://doi.org/10.1175/JTECH-D-20-0050.1
• Instrumentation:
  • Ceilometer, PANDORA, Auto GC
  • Ambient air database (met, PM$_{2.5}$, O$_3$, NO$_2$, NOx, speciated VOCs)
• Validation/verification satellite products and meteorological/air quality forecasts.
Real-Time Visualizations and Data Archive

PBL Automated Outputs:

- Cloud-base heights
- Precipitation flags
- Filtered PBL heights (NSL, RL, MLH)
- Uncertainties for PBL heights

Caicedo et al. (2020)

www.alg.umbc.edu/real-time-data-info/  www.alg.umbc.edu/archives/
Current Features:

- Display of 15-minute data
- Notification of data transfer interruption
- Real-time diagnostic parameters
- Archiving all ‘raw’ data from all sites
- Displaying archive images for all sites


Common retrieval algorithm for heterogeneous network with proper QA applied to develop a data product for use for the modeling community.
Development of standardized retrieval algorithms for heterogeneous network

Automatically screens for clouds and precipitation

- Derive cloud layer heights using the Haar wavelet retrieval methodology

Layer attribution for the PBL height is supported with the use of continuation and time-tracking parameters
QA/QC and Calibration/Validation

• ASTM International
  — Standard Guide for Measurement of Aerosol, Cloud, and Particle Pollution by Ceilometers
    • Summary of the fundamentals of lidar, a description of the methodology and equipment used, factors to consider during site selection and equipment installation, and recommended procedures for acquiring valid and relevant data.

• U.S. EPA Methods Document/Quality Assurance Project Plan (QAPP)
  — Quality Assurance for Ground Based Ceilometers

• Ad-hoc Ceilometer Experiment Study (ACES) 2021
  — Evaluation of Lufft Cloud Simulator and Vaisala Termination Hood

• Educational Materials
  — Introduction to Ceilometer: Instrumentation and Data Interpretation
    • Available upon request

*Under preparation
Ceilometer networks typically established by national weather services around the globe primarily designed for detection of clouds.

Instrument capability of providing observations of the vertical structure of the boundary layer makes it a resourceful tool to study atmospheric phenomena.

The presence of particle pollution in the atmosphere and their extension on a given air mass can be determined from the ceilometer data.

Comprehensive three-dimensional assessment of the air quality
Surface Measurements – Ceilometer - Satellite
UCN is at the center of a re-invigorated effort to combine remote sensing and ground-based measurements of aerosol concentrations into a 3D-view of the atmosphere.

Designed to improve the accessibility of data for the air quality community across the U.S.

Serving two distinct audiences who need:

- Real-time tools that are used by forecasters for interpretation and guidance on the day of measurement
- Retrospective analysis tools for compliance assessment, analysis, and event interpretation
Verification/Validation of Models and Satellite Products

PBL Height:
Ceilometer vs NOAA FV3 and GFS model
(Loughner et al. 2019)

Smoke transport within PBL observed by ceilometers network
supplementing GOES-16/ABI AOD
(Huff et al. 2020)
New Data Portal

• Data Portal Under Construction

• Dynamic display of ceilometer data

• Data Downloads
  • Raw Data
  • Retrieval (MLH) Data
  • Data Export (ASCII, Netcdf)
  • Quicklooks (jpeg, png)

• Synergy of air quality monitor data and satellite observations
New Data Portal

- Site Information (Including AQS designation)
- 3D-Air Quality System (3D-AQS)
  - Integrates remote sensing observations from a variety of platforms into **air quality** decision support:
    - Graphical Display of:
      1- Ceilometer (Dynamic Interface)
      2- Satellite Images
      3- Surface Observations
  - Data Download
- Mixing Layer Height Requirement: Data Submission
  - UCN will follow guidance of U.S. EPA for data submission to AQS
December 2020-March 2021
• Implementation of dynamical web display and retrieval applications
• Prototype pre-operational phase (i.e. operational testing)

April-May 2021
• Virtual Workshop on Ceilometer (Measurements, Applications and Data Interpretation.

June 1, 2021
• Fully Operational Data Portal for U.S. EPA requirement
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Disclaimer: Although this work was reviewed by EPA and approved for publication, it may not necessarily reflect official Agency policy.
Extra Slides
Technical Guidance

• Definition and guidelines for data transfer to UMBC database
  • Assisted FTP/HTTPS transfers setup

• Recommended guidelines for regular maintenance
  • Real-time instrument diagnostic monitoring

• Definition and guidelines for data usage/download
  • Web portal documentation for data download and correct use of scientific data

• Guidance for the scientific use of data products
  • Detailed documentation for data products and methodologies

• Review and exchange of relevant technical and scientific information
Level 1a: Data archiving of ‘raw’ signals directly from instrumentation
Level 1b: Reformatted ‘raw signals’ into uniform Network Common Data Form (NetCDF) data files
Level 2: NetCDF data files of calibrated signals
Level 3: PBL and cloud products: 10-minute to hourly retrievals (NetCDF data files and/or ASCII files)
• Real-time and Retrospective Analysis of Air Quality Events
• Correlation of Surface Mass Concentrations to Column Measurements
  • Above/Below Mixing Layer Height
  • Aerosols: AOD-PM$_{2.5}$ Estimator (MODIS, VIIRS)
  • Ozone: TOLNET, PANDORA
• Verification/Validation of Satellite Products and Models
  • GOES 16/ABI: Smoke Plume Height Injection
  • TEMPO, MAIA