Howard University Beltsville Campus (HUBC): Involvement, Contribution, and Impact in Atmospheric Sciences Research

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1. Introduction:

Howard University, in partnership with NOAA, NASA, and several other federal agencies, has built a rigorous research program in atmospheric sciences at the Howard University Beltsville Campus (HUBC). Atmospheric sciences research at HUBC is helping the nation and the international community to understand and develop innovative strategies to improve weather forecasts, effectively mitigate climate change, and better understand and predict air quality.

2. Site and Instrumentation

HUBC is located approximately 12 miles northeast of downtown Washington, DC, on 110 acres in suburban Maryland (figure 1). The campus is in a suburban/rural setting. HUBC contains minimal development with not more than 5 percent of the land area occupied by building structures, making it an ideal environment for studying a range of surface-atmospheric interaction processes.

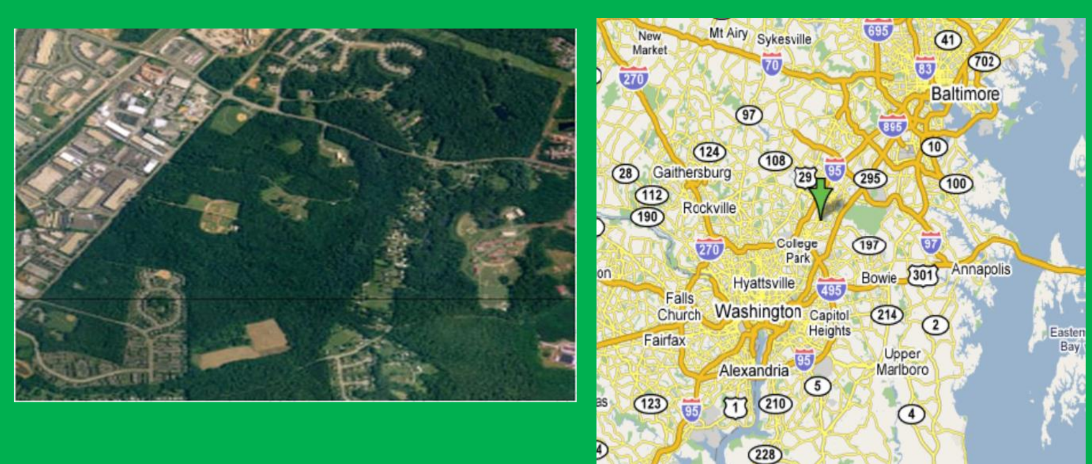

Figure 1: Aerial view of HUBC (left), and HUBC location (right).

A comprehensive set of instruments have been deployed including water vapor Raman lidar, micro wave radiometer (MWR), upper air sounding systems, spectral and broadband radiometers, 31 m flux and meteorological tower, gas analyzers and particle samplers, as well as low-cost sensors (figure 2). These instruments are calibrated to international standards, and their measurements properly archived and disseminated for a variety of scientific research activities and applications.

Figure 2: Aerial view with locations of some of the major observing systems at HUBC. Not shown is the main building on the north side of the site that houses ALVICE, Micro-wave Radiometer, laboratories and office space in 13600 Sq. Ft.

3. Air Quality:

Atmospheric pollutants such as ozone and fine particle matter (PM) are recognized as harmful substances to human health. HUBC in partnership with Maryland Department of the Environment (MDE) has been monitoring trace gases and aerosols (PM) since 2004. Since then, HUBC has been launching ozonesondes during high ozone episodes, and it hosts one of the most complete air quality stations in the MDE network (figure 2). Figure 3 shows a case study when HUBC lidar (ceilometer) detected smoke plume from fires originated in Canada, this smoke provoked a widespread high ozone event over the mid-Atlantic on June 11, 2015.

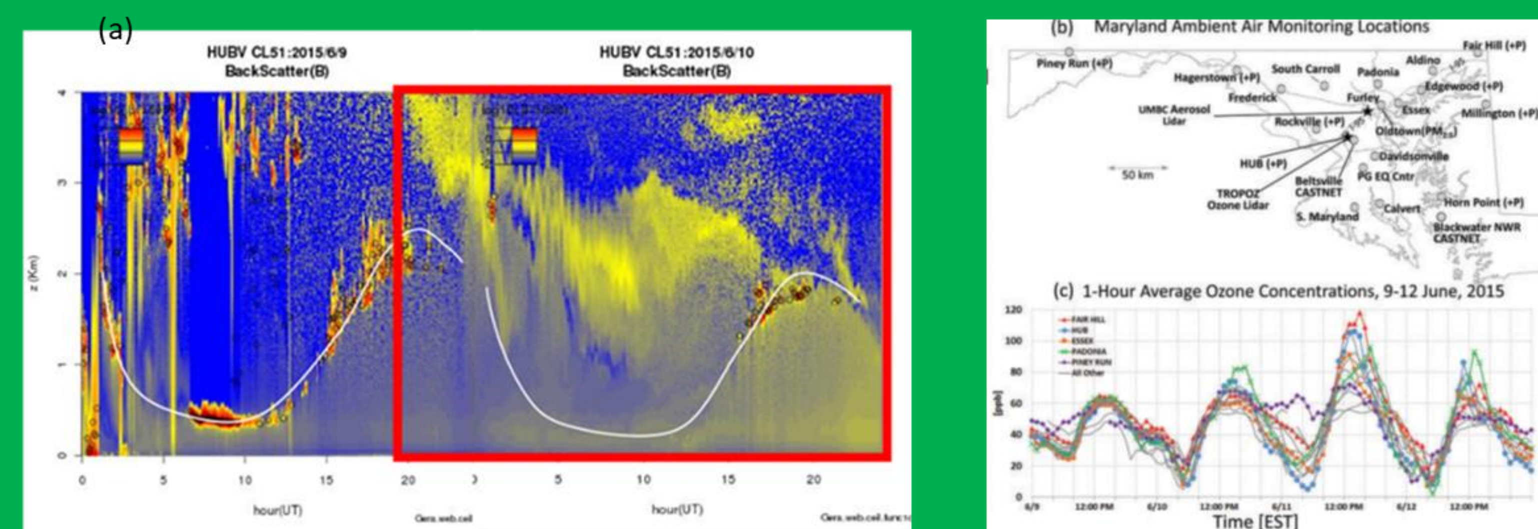

Figure 3: (a) CL51 ceilometer backscatter time series on June 9 and 10, 2015 at HU-Beltsville, MD. The planetary boundary layer height is shown as a white curve. Smoke plume is associated with moderate high backscatter values (bright yellow) on 6/9 20:00 UT till 6/10, 10:00 UT. (b) Location of the Maryland Department of Environment air quality stations, (c) and the hourly ozone concentration observed during the smoke plume event (from Dreessen et al, 2016).

4. Climate: GRUAN Network & Satellite

Established in 2008, under World Meteorological Organization GCOS (Global Climate Observational System) reference upper-air observing network (GRUAN – figure 4a) will provide long-term, high-quality climate data records from the surface, through the troposphere, and into the stratosphere. Howard University is a GRUAN site in collaboration with NWS, NASA, NOAA/JPSS/STAR group, and the only academic intuition in the GRUAN network.

A method has been developed selecting a single satellite retrieval profile using the atmospheric variability of scalars (e.g. water vapor and temperature) determined by in situ ground based remote sensing instruments for site state best estimate (SASBE). Satellite products from NOAA Unique Combined Atmospheric Processing System (NUCAPS) are collocated and compared with HUBC site results (figure 4b). NUCAPS profiles are within a 20% agreement of the radiosonde/HURL for water vapor mixing ratio values, with a dry bias of 3 g/kg in the lower troposphere (figure 4c).

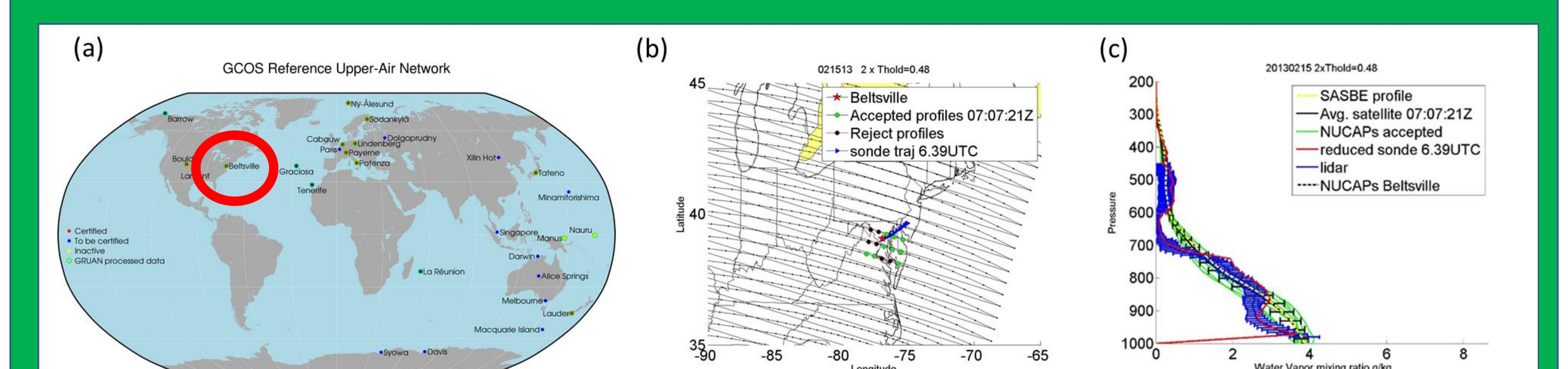

Figure 4: (a) GRUAN network locations. HUBC is highlighted in the red circle. (b) Lines represent the SUOMI NPP satellite trajectories , red and green dots are the profile locations of the NUCAPS products (red rejected profiles, green accepted profiles), blue dots are the radidosonde trajectory. (c) Site Atmospheric State Best Estimate using Raman Lidar (HURL), radiosonde, and NUCAPS products.

5. Weather:

Howard University with conjunction with University Maryland Baltimore County and Morgan State University are developing an upper-air meteorological network for nowcasting (short term weather forecast – 2 to 6 hours).

One motivation was the derecho system that passed through the region on June 29, 2012. This derecho left a path of destruction stretching more than 600 miles from the Upper Midwest to the Mid-Atlantic coast (Figure 5a). This resulted in massive tree damage and power outages leaving nearly 4 million residents without power, extensive damage to transmission lines, power poles, and substations, and left 500,000 without power for nearly a week. For this event, observations from the MWR convey atmospheric destabilization as early as 15 hours in advance of the approaching storm in the Mid-Atlantic (figure 5b). This coupled with record heating at the surface resulted in abnormally high convective instability indices beginning near 15Z (10 am), more than 10 hours in advance of the derecho (10 pm, figure 5c). On the other hand, forecasters were unaware of the exact state of the atmosphere until the analysis of the 00Z radiosonde launch (8 pm LT).

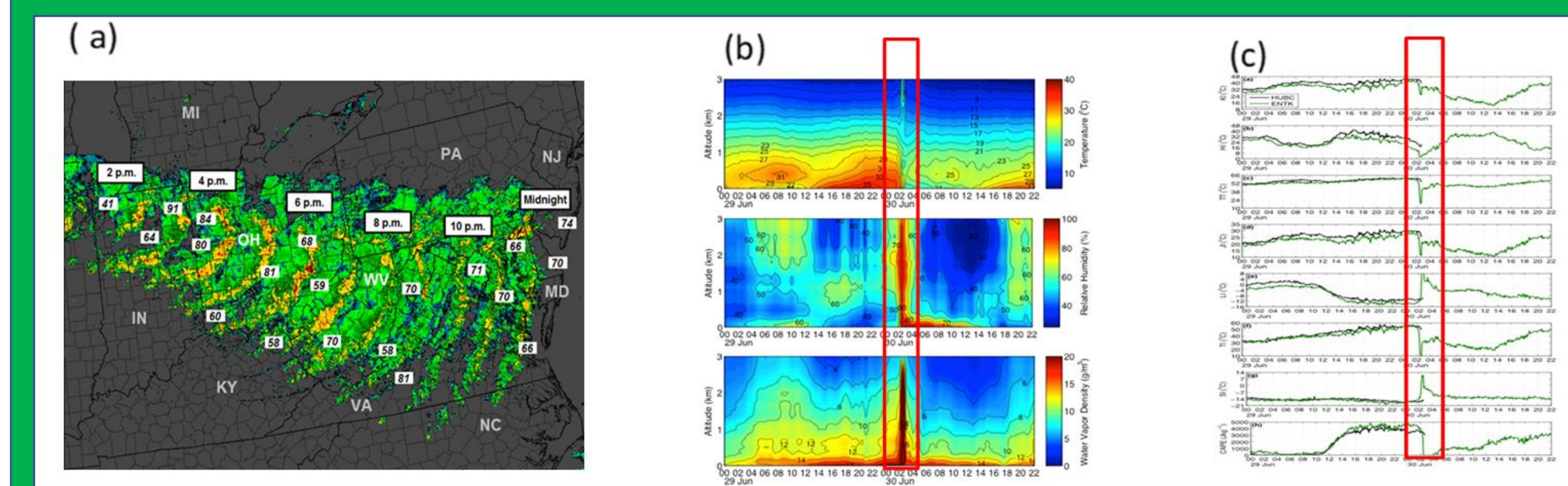

Figure 5:: (a) Radar image composite summary of derecho with highest reported wind gusts (*Furgione*, 2013). (b) MWR contoured observations of (top) temperature, (middle) relative humidity, (bottom) and water vapor density in the lower troposphere during the derecho episode (highlighted in the red rectangle) (c) MWR derived instability indices from top to bottom of KI, HI, TT, JI, LI, TI, SI, and CAPE, derecho passage highlighted in red rectangle.

6. OWLETS-2:

The Ozone Water-Land Environmental Transition Study-2 (OWLETS-2) is a follow-on study to better understand the behavior of ozone and related trace gases across the water land transition zone in the upper portion of the Chesapeake Bay. OWLETS-2 used a unique combination of measurements during summer 2018 (June 6 to July 6) to more fully characterize the behavior of ozone in the Baltimore region. This included two ozone lidar systems, multiple wind and aerosol lidars, ozonesondes, UAVs, research aircraft, and a host of in-situ measurements at the University of Maryland Baltimore County (UMBC), Hart-Miller island (HMI) and HUBC to obtain measurements simultaneously over land and water (Figure 6).

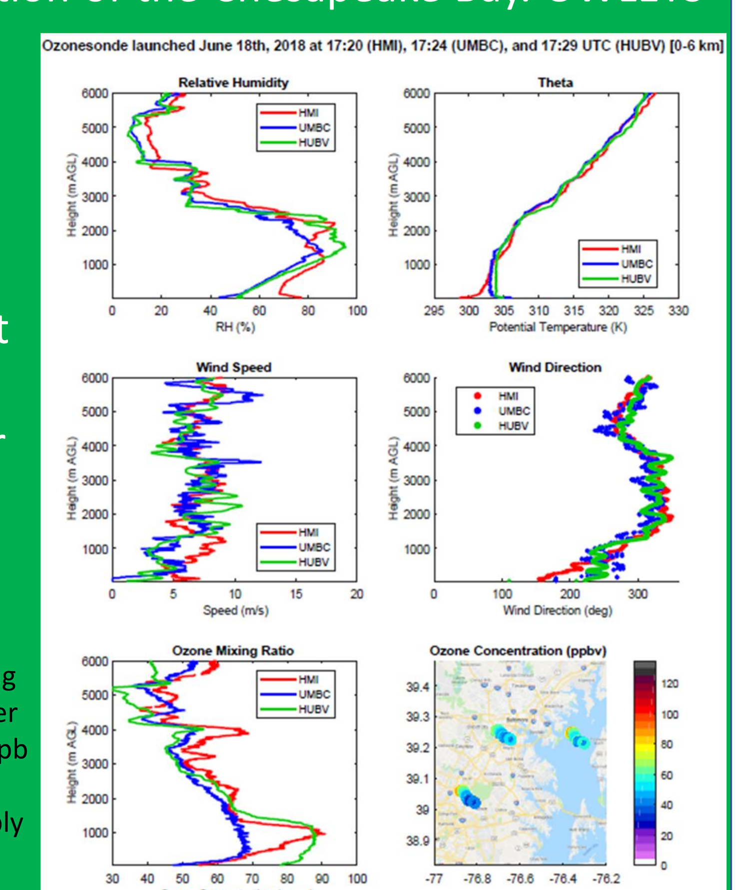

Figure 6 represents the triple coordinated launch for HUBC, UMBC, and HMI on June 18, 2018, at approximately 17:20 UTC with initial wind blowing from the south. There is a deep layer of elevated ozone over water and over HUBC from 500-1500 m. At its peak at around 1000 m, there is over a 20 ppb difference between UMBC and the other two sites. Boundary layer heights over land look to be about 1200-1500 m. Below 300 m, ozone values sharply decrease from 70 ppb to about 50-55 ppb over HMI and UMBC, but not at HUBC.