Review report on the Proposal 2000201 entitled “Analysis Planetary Boundary Layer Processes from an Incipient Surface/Upper Air Mesonet Network in the Washington DC-Baltimore MD region” submitted by Drs. Sakai and Demoz.

The region between Washington, D.C. and Baltimore, MD as well as surrounding areas covers multiple types of land-use and land cover including urban, suburban, rural, forest, bay, and their mix. It is an ideal target region to conduct an investigation for better understanding the processes that govern the planetary boundary layer (PBL) development and the PBL height (PBLH) variation over a complex land surface. The well-designed meso network consisting of multiple ceilometers and microwave radiometers (MWR) as proposed is well-suited to achieve the objectives. The applicants raise two scientific questions in this proposal. Is it feasible to use MWR/ceilometer network measurements to quantify the contributions of local and non-local driving forces to the PBL development and PBLH variation over a complex landscape? Can the elevated mixing layer (EML) be developed over a region with a large landscape contrast? These are two interesting topics to the boundary-layer meteorology community and other relevant fields such as air quality and numerical weather predictions. The findings are expected to deepen our understanding of the driving forces that are used to support the PBL development over the complex landscape, improve the PBL parameterization schemes, and eventually benefit numerical weather and air quality predictions.

The first topic may advance our knowledge and understanding on how the PBLH varies from one to another types of surface with a big thermal contrast between them from the perspective of three-dimensional observations. It is interesting but could be a big challenge when mesonet observational data are utilized to quality the contributions of local and non-local driving force to the PBL development and evolution. The proposal suggests using eddy covariance (EC) measurements and one-dimensional model to estimate the local and non-local contributions to the development of the PBL. The former is understandable since surface heat flux is the key driving force for the PBL development when local contribution is dominant, but the proposal does not present clearly on what 1-D model will be used and how the model can be used to quantify the non-local contribution.

Regarding the EML, it was first observed over a large topographic region with a scale greater than km2 such as the Colorado Plateau (> km2, Arritt et al. 1992), or steep mountainous terrain like the Swiss Alps (Steinbacher et al., 2004), then Freedman and Fitzjarrald (2017) observed an EML structure on a spatial scale of less than 5000km2 over the Hudson Valley New York State. For those EMLs, topography plays a critical role. In contrast, the terrain selected by this study is relatively flat and the study area is much smaller. I am not sure the thermal-induced circulation is sufficient to support the development of an EML on such a small spatial scale with the large thermal contrast between bay and urban, or between urban and suburban or forest areas (see Hypothesis 2 in the proposal). But it is worth to explore since the mesonet may provide very high quality vertical profiles with high temporal and spatial resolutions.

Overall, the proposal represents a great interest to the boundary-layer meteorology, air quality, and other relevant communities and has a high potential to optimize the PBL parametrization schemes and then improve numerical weather and air quality (e.g., particulate matter with aerodynamic diameter of 2.5 micrometer or less, PM2.5) predictions on a regional scale. It also may provide a good chance to minority undergraduates from three Hist Black universities to learn how to use the advanced instruments like MWR and ceilometers to probe the PBL structures and how to use the observational data to address the scientific questions. The whole team including PI, Co-PI, and Co-Is are well quantified with rich experience of operating and maintaining the instruments, strong skills of analyzing observational data, and capability of using the data to address their scientific questions. The MWR/ceilometer network with stationary and rover lidars and MWRs could be sufficient to monitor the three-dimensional structures of the PBL and their evolution over the heterogeneous surface with varying physical properties. Therefore, I would suggest the NSF considers this proposal as one of candidates for their support given the intellectual merit and broad impacts that the proposal has and will have.

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Strengths: The proposal is expected to deepen our understanding of the processes governing the planetary boundary layer (PBL) and the elevated mixing layer (EML) development which are critical to air quality and weather predictions. It is pretty new that the applicants propose to use a meso-network to monitor the contributions of local and non-local driving forces to the PBL development since most of the related studies are limited to modeling work. It is the first time that people propose that the EML can be developed over a transition region with a large thermal contrast and then use the ceilometer or lidar-observed aerosol backscatter profiles to detect the EML. The plan for conducting the proposed activities is well-organized. The team is well quantified since they have rich experience of operating and maintaining the instruments (e.g., ceilometer and microwave radiometer, MWR), strong skills of analyzing observational data, and capability of using the data to address their scientific questions. The PI, Co-PIs, and Cs and their universities have adequate resources to complete the proposed activities.

Weaknesses: The applicants propose to use one-dimensional (1D) model to estimate non-local contribution to the PBL development, but what 1D model will be used and how the relative contributions of local and non-local factors to the PBL developments are quantified need to be strengthened. I am not sure that the EML can be developed on so small spatial scale due to thermal-induced circulation since the EMLs were observed on the regions with much larger scale and complex terrain in the past. In addition, there are a well-designed with high-density network monitoring surface particulate matter with aerodynamic diameter of 2.5 micrometers or less (PM2.5) nationwide operated by US EPA. It will be more useful if this study may shed more lights on the retrieval of vertical profiles rather than surface PM2.5 only (see Section 3.2).

Strengths: I believe that the findings of this study will benefit optimization of the PBL parameterization schemes and eventually numerical weather and air quality predictions on regional scale at NOAA and EPA. The proposal will provide a very good opportunity to minority undergraduate and master students from three Hist Black universities on learning how to use the advanced instruments like MWR and ceilometers for probing the PBL structures and how to use the observational data to address the scientific questions. The team is well quantified. Both team and their universities have adequate resources to reach the goals as proposed.

Weakness: It may need some specific plans of getting more minority undergraduates to participate in the activities proposed. In Section 4.5, the papers’ submission need more detailed information with suggested topics although there is some information given in Section 4.4.

Overall, the proposal represents a great interest to the boundary-layer meteorology, numerical weather and air quality predictions, and other relevant fields. The outcomes of this proposal are expected to have a high potential to benefit optimization of the PBL parametrization schemes and improve numerical weather and air quality (e.g., PM2.5) predictions on a regional scale. It will benefit minority undergraduates from three Hist Black universities to learn how to use the advanced instruments like MWR and ceilometers to probe the PBL structures as well as their research. The whole team including PI, Co-PI, and Co-Is are well quantified. The meso-network with stationary and rover systems (MWR/ceilometer) that they have is a valuable resource to monitor the three-dimensional structures of the PBL and their evolution over the heterogeneous surface with varying physical properties. All these will guarantee all the proposed activities to be completed. Therefore, I would suggest the NSF considers this proposal as one of good candidates for support given the intellectual merit and broad impacts that the proposal has and will have.