UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

OCT 18 2018

MEMORANDUM

SUBJECT: Concurrence Request for Approval of Alternative Model: BLP/AERMOD Hybrid Approach for Modeling Fugitive Emissions from Coke Oven Batteries at the AK Steel – Mountain State Carbon facility located in Follansbee, Brooke County, West Virginia

FROM: Timothy A. Leon Guerrero, Meteorologist
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THRU: Alice Chow, Associate Director
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TO: George Bridgers, Director of Model Clearinghouse
Air Quality Modeling Group, Office of Air Quality Planning and Standards

EPA Region III is seeking concurrence from the Model Clearinghouse on an alternative modeling approach using a combination of the Buoyant Line and Point Source model (BLP) and the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) to represent fugitive emissions from four (4) coke oven batteries at the AK Steel - Mountain State Carbon facility located along the Ohio River in Brooke County, Follansbee, West Virginia (WV). EPA Region 3 is seeking concurrence under 40 CFR Part 51, Appendix W- Guideline on Air Quality Models, paragraph 3.2.2(b)(2), to use this alternative model. The modeling demonstration using this alternative model approach was included in West Virginia's 1-hour SO_2 State Implementation Plan or SIP that was submitted to EPA on April 25, 2016 and deemed administratively complete on October 2, 2016.

EPA Region III is seeking Model Clearinghouse concurrence with this alternative model approval based on the Model Clearinghouse's recent action for using the BLP/AERMOD Hybrid technique for U. S. Steel Corporation's Clairton Plant located in the City of Clairton, Allegheny County, Pennsylvania (PA). Both facilities utilized similar alternative model approaches to simulate their coke oven fugitive emissions. Additionally, coking operations at both facilities are nearly identical, both facilities are located in similar terrain settings and both facilities are subject to complex terrain-induced wind patterns. These similarities are the basis for this concurrence request. A short technical analysis is included for your consideration. Please feel free to contact Alice Chow at (215) 814-2144 or myself at (215) 814-2192 if you have questions regarding our concurrence request.

Attachment.

EPA Region III Technical Review of the BLP/AERMOD Hybrid Approach Used in the West Virginia Attainment Demonstration

1. Regulatory Background

On June 22, 2010, the Environmental Protection Agency (EPA) promulgated a new 1-hour primary SO_2 National Ambient Air Quality Standard (NAAQS) of 75 parts per billion (ppb), which is met at an ambient air quality monitoring site when the 3-year average of the annual 99^{th} percentile of 1-hour daily maximum concentrations does not exceed 75 ppb, as determined in accordance with appendix T of 40 CFR part 50. (2010 SO_2 NAAQS). *See* 75 FR 35520. On August 5, 2013, EPA designated a first set of 29 areas of the country as nonattainment for the 2010 SO_2 NAAQS, including the Steubenville, Ohio-West Virginia (Steubenville, OH-WV) multi-state area, based on measured violations of the standard (*See* 78 FR 47191). The designations were effective on October 4, 2013. As a result of this designation, Ohio and West Virginia were required to develop State Implementation Plan (SIP) revisions to demonstrate attainment of the NAAQS within 18 months of the effective date of designation. The SIP revisions were due on April 4, 2015. On March 18, 2016, EPA found that West Virginia had failed to make this submittal *See* 81 FR 14736, effective April 18, 2016.

During the development of its attainment plan, West Virginia used the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD), the preferred model for most near-field regulatory applications, for all sources except the fugitive emissions emanating from the coke oven batteries. West Virginia used the Buoyant Line and Point Source Model (BLP) to characterize these fugitive emissions. In its approach, West Virginia generated hourly varying release heights using BLP and then calculated initial dispersion coefficients. Fugitive emissions were then included in EPA's preferred dispersion model, AERMOD, using multiple hourly varying volume sources with the hourly varying release heights determined from the BLP and these calculated initial dispersion coefficients.

Appendix W of 40 CFR Part 51 identifies models which are preferred for regulatory application and which have undergone evaluation exercises including statistical measures of model performance (appendix A of Appendix W). Under 40 CFR 51.11 2(a)(2) and 40 CFR 51 Appendix W, section 3.2, if the preferred model is inappropriate for a particular application in a SIP, the model may be modified or another model substituted, provided that EPA approves the modification or substitution. Appendix W, section 3.2.2 (b) requires that an alternative model be "evaluated from both a theoretical and a performance perspective before it is selected for use," and outlines several conditions under which an alternative model can be approved. EPA Region 3 is seeking concurrence for the alternative BLP/AERMOD Hybrid approach under Appendix W, section 3.2.2 (b), condition (2), where "*a statistical performance evaluation has been conducted using measured air quality data, and the results of that evaluation indicate the alternative model performs better for the given application than a comparable model in appendix A.*" Unfortunately, monitoring data necessary to complete this statistical analysis is unavailable for the areas in which the regulatory version of AERMOD and the BLP/AERMOD Hybrid approach predict maximum impacts. EPA Region 3 is proposing to approve the use of the BLP/AERMOD Hybrid method based on a recently approved application of this methodology for the U. S. Steel Clairton Plant in Allegheny County, PA. We believe this approval is appropriate in this instance since both facilities are using a similar BLP/AERMOD Hybrid approach to simulate their buoyant fugitive coke oven emissions, both facilities are by-product coking plants with nearly identical coke production/handling methods, both facilities are located in similar terrain and both facilities appear to experience terrain-induced complex vertical wind patterns. The justification and concurrence for use

of the BLP/AERMOD Hybrid alternative model approach is outlined in a recent EPA Model Clearinghouse action (18-III-01). Allegheny County prepared a detailed analysis supporting its methodology entitled "*Alternative Modeling Technical Support Document: Buoyant Fugitives in Complex Terrain with a BLP/AERMOD Hybrid Approach*" dated July 27, 2018, which is available via the Model Clearinghouse Information Storage and Retrieval System[1].

2. Facility Location and Description

The AK Steel - Mountain State Carbon, LLC Follansbee Plant (Mountain State Carbon) is a by-product coke plant that produces metallurgical-grade coke along with foundry coke from coal for use at off-site steel and foundry facilities and for commercial sales. Coke is produced from coal at the facility's four (4) coke oven batteries. These batteries consist of one (1) 6-meter battery and three (3) 3-meter batteries; the battery dimensions are a reference to the coke oven battery heights. Coke oven battery heights are generally well correlated with a battery's age with taller ovens being more recently constructed than shorter ovens. Mountain State Carbon can produce in excess of one million tons of coke products per year (using slightly over 2,000,000 tons of coal). In addition, the facility operates a by-product plant that recovers usable products from the coking process and prepares coke oven gas (COG) for use as fuel for Mountain State Carbon's battery operations and on-site boilers. Other products produced at the by-product plant include light oil, ammonium sulfate, fuel gas, coal tar and sulfuric acid.

In 2017, Mountain State Carbon marked 100 years of coking operations at its Follansbee Plant. According to information in Mountain State Carbon's Title V permit[2], Batteries 1-3 were constructed in 1917 with major modifications occurring in 1953. Battery 8 is the most recently constructed battery and appears to have been brought online in 1976. At one time, coking operations were affiliated with a large steel mill complex located slightly down river near Mingo Junction in Jefferson County, OH. Operations at the former Wheeling-Pittsburgh Steel Electric Arc Furnace and Rolling Mill in Mingo Junction were suspended in 2009.

Mountain State Carbon resides in the Allegheny Plateau province of the Appalachian Mountain system. This area is made up of complex river valley terrain and includes rural land, densely populated neighborhoods and some industrial facilities. Besides the coke plant and shuttered steel mill, the nonattainment area also includes the Cardinal Power Plant, a coal-fired electric generating plant located approximately ten (10) km south of Mountain State Carbon near Brilliant, OH. Another large steel manufacturing complex, Weirton Steel, is located approximately ten (10) km north of Mountain State Carbon in neighboring Hancock County, WV, just outside the nonattainment area. This facility's SO_2 emissions, however, are less than two (2) tons per year (tpy) due to production changes that occurred a decade ago.

Coke products at Mountain State Carbon are made by heating coal to extremely high temperatures (over 1,800° F) in an oxygen deficient atmosphere. This concentrates the carbon and removes any impurities. The coke produced is subsequently used as fuel in iron and steel production and foundry operations because it generates very high heat with less smoke than coal. The production of the coke itself, however, produces significant amounts of reduced sulfur compounds due to sulfur in the raw coal being liberated in the coke oven batteries. Sulfur dioxide is produced when COG is burned in the ovens,

[1] https://cfpub.epa.gov/oarweb/MCHISRS/index.cfm?fuseaction=main.search
[2] See Section 1.1 of Mountain State Carbon's Title V permit documentation: https://dep.wv.gov/daq/permitting/titlevpermits/Documents/August%202015/Mt.%20State%20Carbon%20Final.pdf

boilers and flares. In 2013, Mountain State Carbon emitted 467.94 tons of SO_2[3]. Total combined SO_2 SIP modeled emissions for Mountain State Carbon were 2,229.7 tpy.

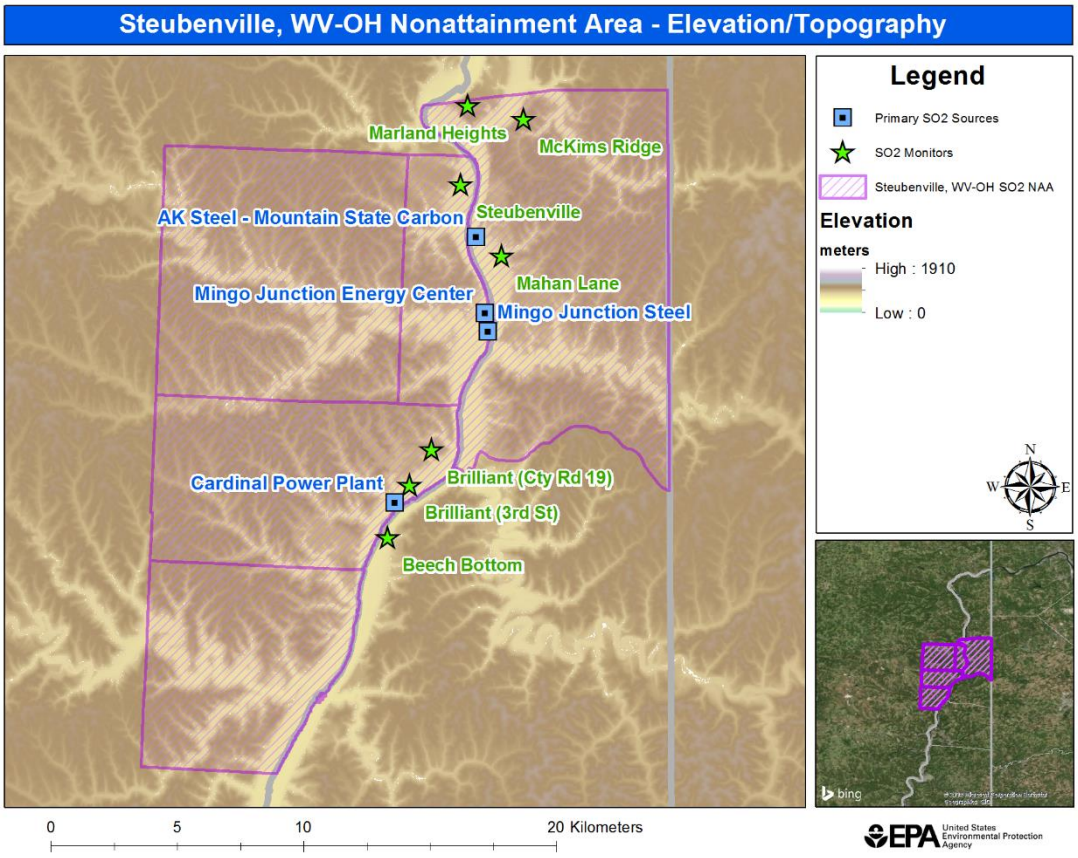
Coking facilities are complex emission sources with multiple emission points and include numerous structures where building downwash can impact pollutant dispersion. As noted previously, sulfur is driven off during the coking process producing reduced sulfur compounds, primarily hydrogen sulfide (H_2S). SO_2 is produced when reduced sulfur compounds are oxidized (or burned). Material/product handling processes generate numerous individual particulate emission sources while the coke production processing itself generates combustible COG that contributes to particulates and SO_2 emissions when burned. COG derived from the Mountain State Carbon's coking process is collected from the ovens and sent via pipeline to the facility's by-product (acid) plant to recover usable products including COG. Operations at Mountain Stare Carbon's acid plant effectively reduce the COG's sulfur content prior to combustion. Treated COG is then sent back to the coke ovens for combustion to heat the ovens, is used in on-site boilers for steam generation or is flared. Off-site transport of COG is no longer permitted in accordance with a Consent Order in the West Virginia portion of the Steubenville, OH-WV 1-hour SO_2 SIP.

Mountain State Carbon periodically shuts down its acid (by-product) plant for regularly scheduled maintenance; two ten-day periods, one ten-day period in the spring and one ten-day period in the fall. During these "outage" periods there is no means to reduce the COG's sulfur content and plantwide SO_2 emissions increase substantially. This practice is common for other by-product coking operations in Region 3 that do not have redundant COG treatment systems. Non-recovery type coke plants, by design, have no means of removing reduced sulfur compounds prior to COG combustion and therefore have much higher SO_2 emissions.

As noted previously, Mountain State Carbon is located along the Ohio River. This part of the northern panhandle of West Virginia resides in the Allegheny Plateau physiographic province of the Appalachian Mountain system. This area is marked by dendritic rivers systems imbedded within steep valleys were terrain rises approximately 120 meters above the (river) valley floors (Figure 1).

[3] See WV DEP Title V documents available at: https://dep.wv.gov/daq/permitting/titlevpermits/Pages/default.aspx

Figure 1. Steubenville, WV-OH 1-Hour SO_2 Nonattainment Area



3. BLP/AERMOD Hybrid Approach-Technical Basis

Generating metallurgical and foundry coke from coal involves prodigious amounts of heat. Coke ovens themselves operate at temperatures that can exceed 1,800° F. While emissions from coking operations can be well controlled at times, the nature of the production process generates opportunities for fugitive emissions that must be accounted for in any modeling demonstration. Fugitive SO_2 emissions are generated from leaks in the COG collection system (from stand pipes, manhole covers or flue ducts that can be caused by system upsets that generate brief episodes of positive pressure in the collection system that damage air-flow seals), from coke oven charging events, from leaks from malfunctioning and/or imperfect coke oven door seals, from coke oven door opening events, from coke oven pushing events, from hot-car transportation, from coke handling operations and from coke quenching activities**.** Fugitive emissions are reported as part of EPA's National Emission Inventory (NEI). According to the 2014 NEI, Mountain State Carbon's fugitive SO_2 emissions accounted for approximately 1% of the total plant-wide SO_2 emissions. This fraction represents a small percentage of the annual emissions from Mountain State Carbon. Fugitive SO_2 emissions represent a much smaller fraction of Mountain State Carbon's total hourly emissions during periods when the acid plant is offline (outage periods) when plant-wide hourly emissions increase substantially. These outages, according to West Virginia's SIP modeling demonstration, are generally the controlling periods and are the largest contributors to the SIP simulation's final modeled design value.

Fugitive coke oven emissions are not easily characterized using the standard emission characterizations available in current air-dispersion models, such as the POINT, VOLUME and AREA source characterizations used in AERMOD, because coke ovens involve super-heated materials that generate emissions that are very buoyant with respect to normal ambient temperatures. Historically in Region 3, coke oven fugitive emissions have been modeled using a technique that accounts for these emissions' initial buoyancy. Previous PM_{10} SIPs for Allegheny County and Steubenville-Weirton, OH-WV have used a technique that used EPA's Buoyant Line and Point Source (BLP) model. More specifically, the modeling used emission source estimates of temperature and vertical velocity as input into BLP to yield estimated plume rise and the calculated initial dispersion coefficients, then treating emissions as (hourly varying) VOLUME sources within the air-dispersion model. Memos discussing this characterization are referenced as 91-III-12, 93-III-06, and 94-III-02 in the Model Clearinghouse Information Storage and Retrieval System[4]. A similar approach was used in EPA's *Risk Assessment Document for Coke Oven MACT Residual Risk*[5]. More recently, this approach was used to model buoyant fugitive coke oven emissions from the U. S. Steel Corporation's Clairton Plant in Allegheny County, Pennsylvania, by the Allegheny County Health Department for its current $PM_{2.5}$ SIP modeling platform and previously in its 1-hour SO_2 SIP modeling demonstration[6]. A comprehensive analysis by the Allegheny County Health Department[7] using several source characterization methods and AERMOD's regulatory BUOYLINE source characterization determined that the BLP/AERMOD Hybrid approach "…*is currently the best available method for modeling buoyant line sources in the complex terrain*…". Given the similarities in terrain and source type, EPA Region 3 believes it is appropriate to use this approach for Mountain State Carbon's buoyant coke oven fugitive emissions.

4. Approval Basis for the Alternative BLP/AERMOD Hybrid Approach for Mountain State Carbon

The basis for approval of West Virginia's use of the alternative BLP/AERMOD Hybrid approach is predicated on the Allegheny County Health Department's alternative model demonstration, which recently received alternative model approval and concurrence. A full statistical analysis for Mountain State Carbon's coke oven fugitive emissions was unable to be performed due to the lack of monitoring data near the area of the modeled predicted peak concentrations. Coke oven fugitive emissions from Mountain State Carbon and U. S. Steel's Clairton Plant are both simulated using a similar approach. An extensive analysis by Allegheny County fully demonstrates that the alternative BLP/AERMOD Hybrid approach provides better model performance over the current regulatory (BUOYLINE source characterization) version of AERMOD. Similarities in buoyant fugitive emission sources, terrain and complex wind flows between these two (2) facilities, in EPA Region 3's opinion, are sufficient for an alternative model concurrence from the Model Clearinghouse.

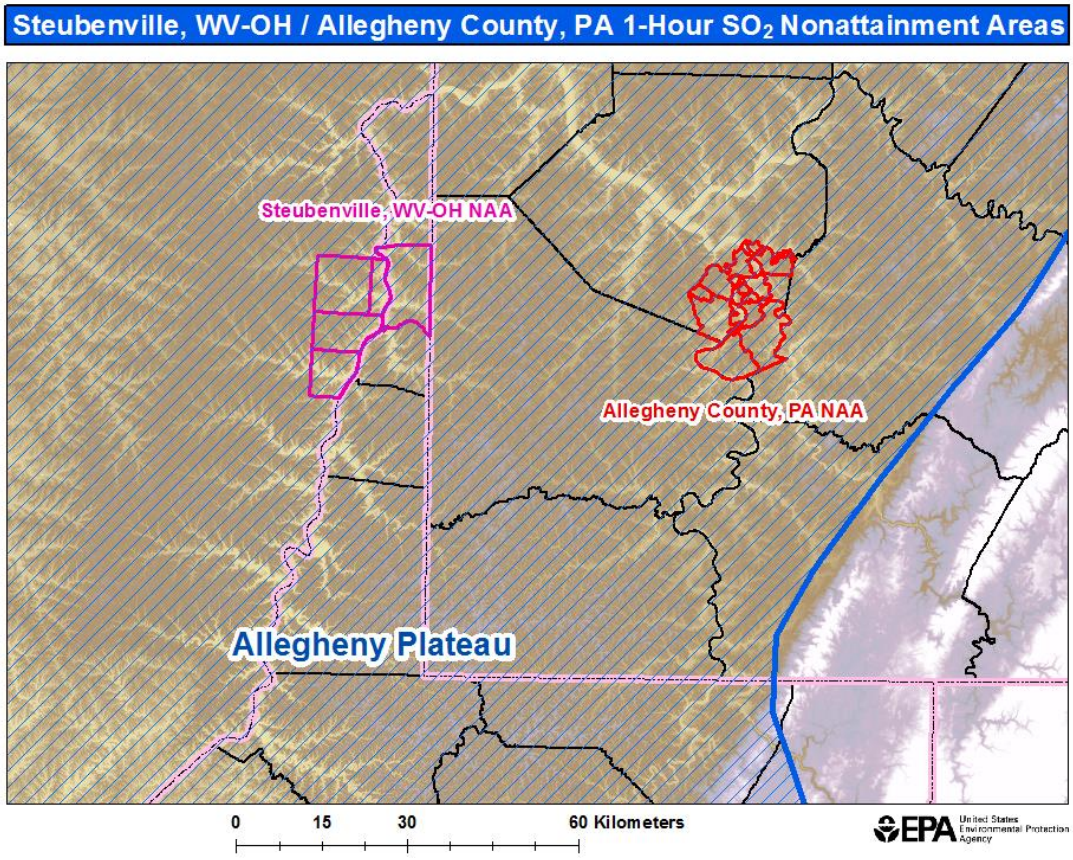
While there are some differences in feed coal, coke oven age and COG by-product plant operations, the fugitive coke oven emissions from both Mountain State Carbon and U. S. Steel's Clairton Plant are essentially the same in that they are initially very buoyant due to the substantial heating involved in the coke making process. Based on Allegheny County's recent alternative model analysis, utilizing the

[4] https://cfpub.epa.gov/oarweb/MCHISRS/index.cfm?fuseaction=main.search
[5] Report dated December 22, 2003, and available at: https://www.epa.gov/sites/production/files/2016-01/documents/coke_rra.pdf
[6] https://www.alleghenycounty.us/Health-Department/Programs/Air-Quality/Regulations-and-SIPs.aspx
[7] https://www3.epa.gov/ttn/scram/guidance/mch/new_mch/ACHD_Alternative_Demo_Buoyant_Fugitives_Final.pdf

BLP/AERMOD Hybrid approach provides better model performance for these very hot (buoyant) fugitive emission sources than the regulatory version of AERMOD.

Mountain State Carbon and U. S. Steel's Clairton Plant are both located in similar terrain settings since they reside in the same physiographic province; the Allegheny Plateau province of the Appalachian Mountain system. Both plants lie in river valleys, the Monongahela and Ohio rivers, that make up a larger regional pattern of incised dendritic valleys within an overall elevated plateau (see Figure 2). Elevation differences between the valley floor and surrounding elevated terrain for both facilities are approximately 120 meters (m). Actual distances between the two (2) facilities are modest. Mountain State Carbon is located approximately 60 km west of U. S. Steel's Clairton Plant. Given the similarities in terrain between the coke plants we would expect each facility's buoyant fugitive emissions to behave similarly and therefore be better simulated using the alternative BLP/AERMOD Hybrid approach.

Figure 2. Steubenville, WV-OH and Allegheny County Nonattainment Areas



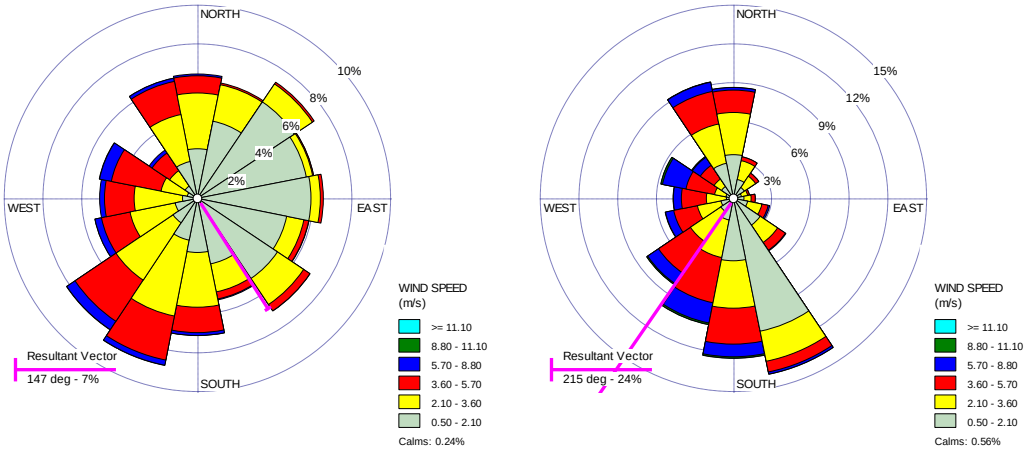
Another common feature shared between Mountain State Carbon and U. S. Steel's Clairton Plant is the presence of complex wind fields created by the surrounding terrain. Both areas experience nocturnal inversions that impact overnight wind field patterns. Allegheny County conducted a thorough analysis of the impacts of local terrain induced meteorological patterns using a prognostic meteorological model to more accurately reproduce the wind flows that impact local air dispersion. Given the similar terrain setting surrounding Mountain State Carbon, it should similarly be subject to complex wind flow patterns, especially during the overnight hours. West Virginia used meteorological data from a 50-m

tower (Follansbee Met Tower) located just south of Mountain State Carbon in its 1-hour SO_2 SIP modeling analysis. Winds were collected at 10-m and 50-m for three years (2007-09). Figure 3 shows wind roses for the Follansbee Met Tower and the prognostic Weather Research Forecast or WRF model used to simulate winds near U. S. Steel's Clairton Coke Plant. Wind roses and predominant wind field vectors represent the 10-m and 50-m levels at both facilities and show that wind fields vary with height at both locations. Wind directions differ between the two (2) sites due to differences in valley orientations between Mountain State Carbon and U. S. Steel Clairton. While there are differences in each area's wind fields, both areas experience similar complex (vertical) wind patterns that impact dispersion.

Figure 3. Follansbee Met Tower and U. S. Steel's Clairton Plant Prognostic Wind Roses

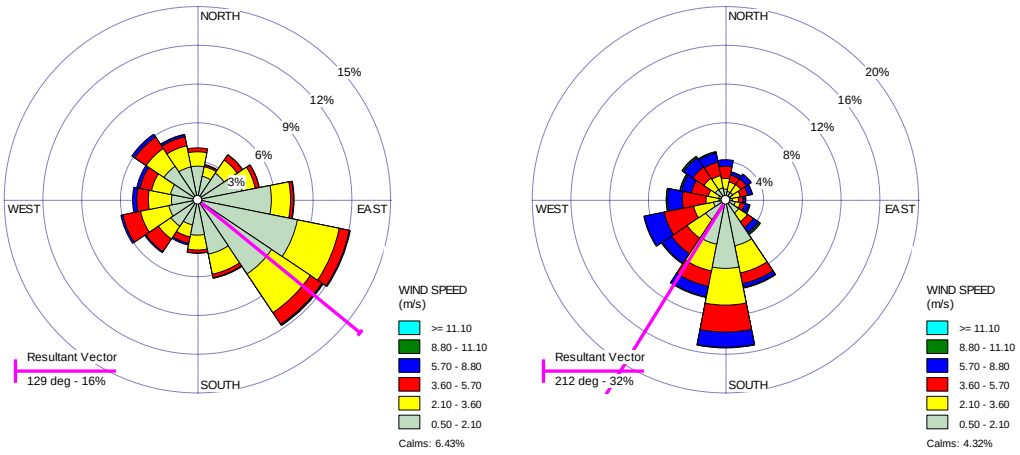
Follansbee, WV Met Tower

10-m Tower Wind Rose **50-m Tower Wind Rose**



US Steel – Clairton Plant 440-m Grid MMIF Data

10-m MMIF Wind Rose **50-m MMIF Wind Rose**



5. Conclusion

EPA Region 3 is seeking Model Clearinghouse concurrence of the alternative model approval for West Virginia's use of the BLP/AERMOD Hybrid approach to model Mountain State Carbon's buoyant fugitive coke oven emissions. A similar alternative model approach received Model Clearinghouse concurrence for a similar by-product coking plant in Allegheny County, Pennsylvania, as described in the previous sections.

While a complete statistical analysis under Appendix W section 3.2.2 (b)(2) was not possible for Mountain State Carbon due to the lack of monitoring data in the area of maximum model impact, EPA Region 3 proposes that an alternative model approval and Model Clearinghouse concurrence can still be granted based on the recent statistical analysis completed by the Allegheny County Department of Health and the similarities between Mountain State Carbon and U.S. Steel Clairton. This statistical analysis showed the BLP/AERMOD Hybrid approach provided better model performance than the regulatory version of AERMOD for these source types. These similarities between the two facilities include:

- Both coke plants used a similar approach, the BLP/AERMOD Hybrid approach, to model buoyant fugitive emissions from their coke oven operations
- Both coke plants have similar (fugitive) emission sources. Mountain State Carbon (Steubenville, OH-WV nonattainment area) and U. S. Steel's Clairton Plant are by-product coke plants with nearly identical coke-production processes, which release similar types of very hot (buoyant) fugitive SO_2 emissions.
- Both coke plants have similar topographic settings. Each plant is located in a major river valley with steep valley slopes that give way to higher plateau elevations. Elevation differences between the river valley floor and higher plateau areas at both plants are approximately 120 m. Similar topographic settings are due to the plants residing within the Allegheny Plateau physiographic province of the Appalachian Mountain system. Mountain State Carbon is roughly 60 km west of U. S. Steel's Clairton Plant.
- Both coke plants show evidence of complex (vertical) wind structures, which ultimately impact emission dispersion though differences in valley orientation yield different wind patterns between the two (2) sites.

Analysis recently submitted by the Allegheny County Health Department and reviewed by EPA indicates that the BLP/AERMOD Hybrid approach, also utilized by West Virginia for Mountain State Carbon, provides better model performance when simulating the impacts from the very hot (buoyant) coke oven fugitive emissions in complex terrain settings. This approach for modeling buoyant coke oven fugitive emissions has a long history of use in EPA Region 3 and ultimately received Model Clearinghouse concurrence (18-III-01) for use at the U. S. Clairton Plant on August 10, 2018. Due to similarities between Mountain State Carbon and U. S. Steel's Clairton Plant, we formally request Model Clearinghouse concurrence with our request to approve the BLP/AERMOD Hybrid approach, an alternative model under section 3.0 of Appendix W – Guideline on Air Quality Models, in West Virginia's 1-hour SO_2 SIP modeling demonstration.