# FNSB Model Update Overview and Timeline

This overview accompanies the full modeling technical report for Phase 1, for more details on the process, results, and background of the fine particulate matter (PM 2.5) State Implementation Plan (SIP) modeling update Phase 1 effort, please refer to the modeling technical report.

After the 2020 Amendment to the FNSB Serious Area SIP and its modeling was complete, it was clear that the data underlying the model was no longer as relevant for future use. The 2020 Amendment model was based on data from 2008, used data from the Fairbanks monitors and did not have any data from the North Pole monitor at Hurst Road that was installed in spring 2012. The Hurst Road monitor is the violating monitor, and it is important that the model update incorporate information from both areas. The process of updating the modeling platform is complex, costly and time consuming. Typically, a full model update, which DEC is undertaking, will take a few years to complete. This overview provides the basic framework, timeline, steps involved and the basic process.

**Phase 1 Update Existing Model to new software version of CMAQ; Build/Update new environment**

Phase 1 of the modeling update consists of updating the software that the air quality model uses and the base Linux system that DEC uses to run the model. The air quality model is called the Community Multi-scale Air Quality model or (CMAQ) and the software version changed from 4.7.1 to 5.3.2. Due to the intense processing times required to run the new version of CMAQ an upgrade to the computer system was needed. DEC set up the CMAQ model to run on a virtual Linux framework. The updated virtual machine was built with multiple processers (16) and will have the ability to run an air quality simulation in 5-8 days (previously the model took up to 30 days per run). In order to accommodate future SIP modeling runs and the amount of computing time one model run takes, a duplicate system was built with the same software update with a DEC contractor. The duplicate system was tested running the same scenario as the DEC system and a comparison was made between the two systems for accuracy. The details regarding the tests between the two systems may be found in the modeling platform technical report.[1]

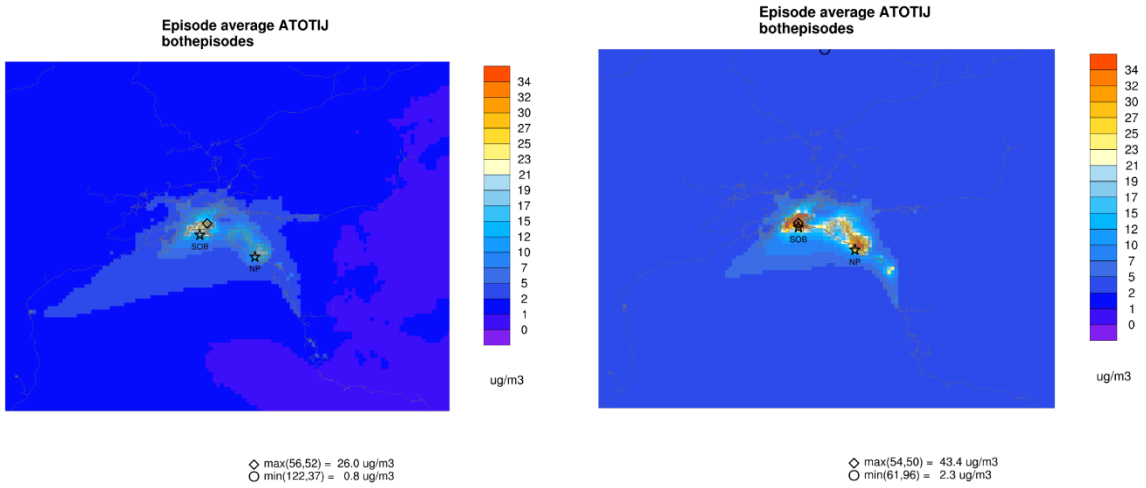
In addition to the updated software and computer systems, another Phase 1 goal was to understand how the new software version 5.3.2 affects organic matter (largest component of PM2.5 in Fairbanks), sulfate and precursor gases (SO2, NOX, VOC and NH4). In order to understand the differences between the two software versions the same data was used in both. The only data available for Phase 1 is the older 2008 meteorology and 2019 emission inventory from the Serious Area SIP. Using this old data allowed DEC to compare previous modeling efforts using the earlier software version with the same data using the new software version. Version CMAQ 5.3.2 has upgraded chemistry, speciation profiles and meteorological inputs. There are many other changes to the new version of CMAQ 5.3.2 and those are outlined in the technical modeling report. After completing this portion of Phase 1, DEC has a better understanding of how CMAQ 5.3.2 is operating.

The main conclusion from the completed phase one of the modeling update is that CMAQ version 5.3.2 is operational on a new virtual computing framework with faster processing times. The new model version produced similar and reasonable modeling results for the non-attainment area, including increased organic carbon in North Pole and slightly increased sulfate. Figure 1 shows the PM 2.5 max cell at 26 ug/m3 for the old version and 43.4 ug/m3 for the new version and ATOTIJ (aerosol total PM 2.5 in size fraction I and j) is the modeling variable name. The increase in the PM 2.5 is from increased organic carbon from the updated chemistry and speciation profiles include in the software update.

[1] DEC modeling platform update technical report

These changes are detailed in section 2.3 and 2.4 of the technical modeling report. The EPA Region 10 reviewed the Phase 1 modeling work, provided comments, and those comments were incorporated into the technical report.

**Figure 1. The PM 2.5 (ATOTIJ) from the model version 4.7.1 (left) and the model version 5.3.2 (right)**



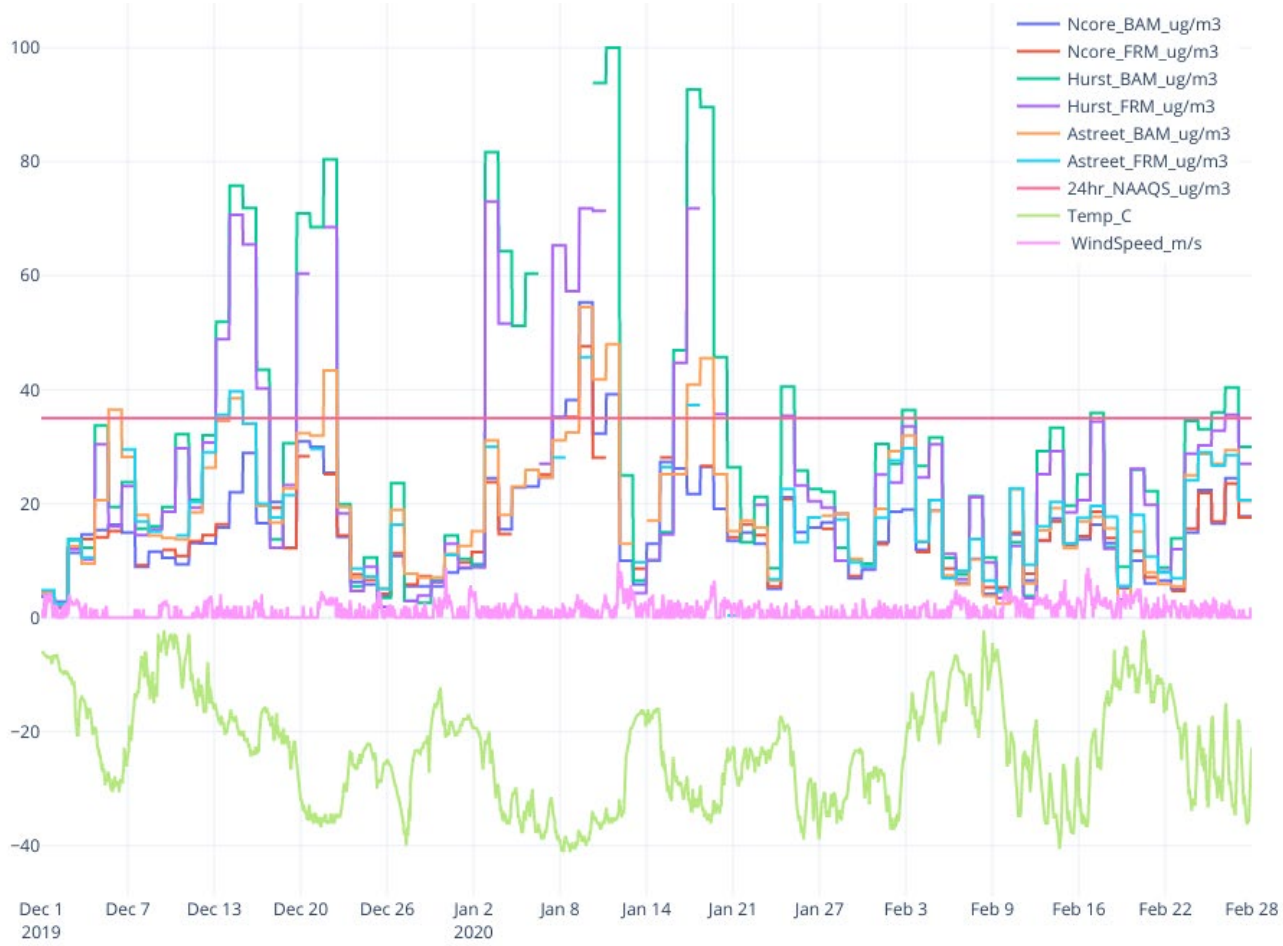

**Unfortunately, with the completion of Phase 1, the model is not usable for actual regulatory modelling and predicting future attainment. Only with the completion of the next two phases will DEC have the full capability needed to complete these types of analyses.**

**Phase 2 Develop Modeling Platform using latest CMAQ software version (5.3.2) and NEW data**

The modeling platform update is now complete, and we have CMAQ 5.3.2 up and running using a new 74 day episode of WRF (weather research and forecast) meteorological model inputs for a newer meteorological episode from winter 2019/2020 that represents both Fairbanks and North Pole wintertime conditions that create PM 2.5 exceedances. Figure 2 shows the meteorological episode that was considered and the corresponding PM 2.5 monitor data that is available during the same time period, the final meteorological episode is December 1 , 2019 to February 12$^{th}$ , 2020..

The new episode is 74days compared to the two- two-week episodes used in the Moderate and Serious SIPs. It is important to select an episode that includes inversions that happen in both warmer temperatures and colder temperatures. The colder temperatures represent the PM 2.5 non-attainment days and the warmer temperatures' have lower PM 2.5 and this helps with the spin up phase of the model so it can properly build emissions and check that the model is working accurately at low PM 2.5 levels. Figure 2 shows the monitored data from three monitors: the Hurst Rd monitor in North Pole, A street and NCORE in Fairbanks. The monitored PM 2.5 is plotted with the local Fairbanks Airport temperature and wind speed at the same time. The high PM 2.5 days coincide with the colder temperatures and low wind speeds. These are the conditions that combined with local emissions create high PM 2.5 in the Fairbanks area and that are captured within the 74 days. Phase 2 uses these 74 days of data (monitored and meteorology) with the model to customize the modeling for the communities' conditions.

Figure 2. Observed PM2.5 (µg/m³), Temperature (°C) and Wind Speed (m/s) in the Fairbanks area




The second important step in Phase 2 is incorporating the latest pollutant species data obtained from the air monitoring filters. The North Pole air monitoring site at Hurst Rd and the NCORE air monitoring site in Fairbanks both have speciation samplers that collect samples on filters on a 1- and 3-day schedule. Speciation samples are collected in addition to the routine Federal Reference Method (FRM) and BAM (Beta Attenuation Monitor) PM 2.5 monitors. This means that out of the 74-day episode there will be 23 days with actual speciation filter data that can be used to check model performance. In other words, the local speciation monitored data and the local meteorology allow the model to be tested for performance against real data. Figure 3 represents the total PM 2.5 from the filters and sulfate speciation available on the same days, the sulfate will be used for model performance in additions to other speciation components.

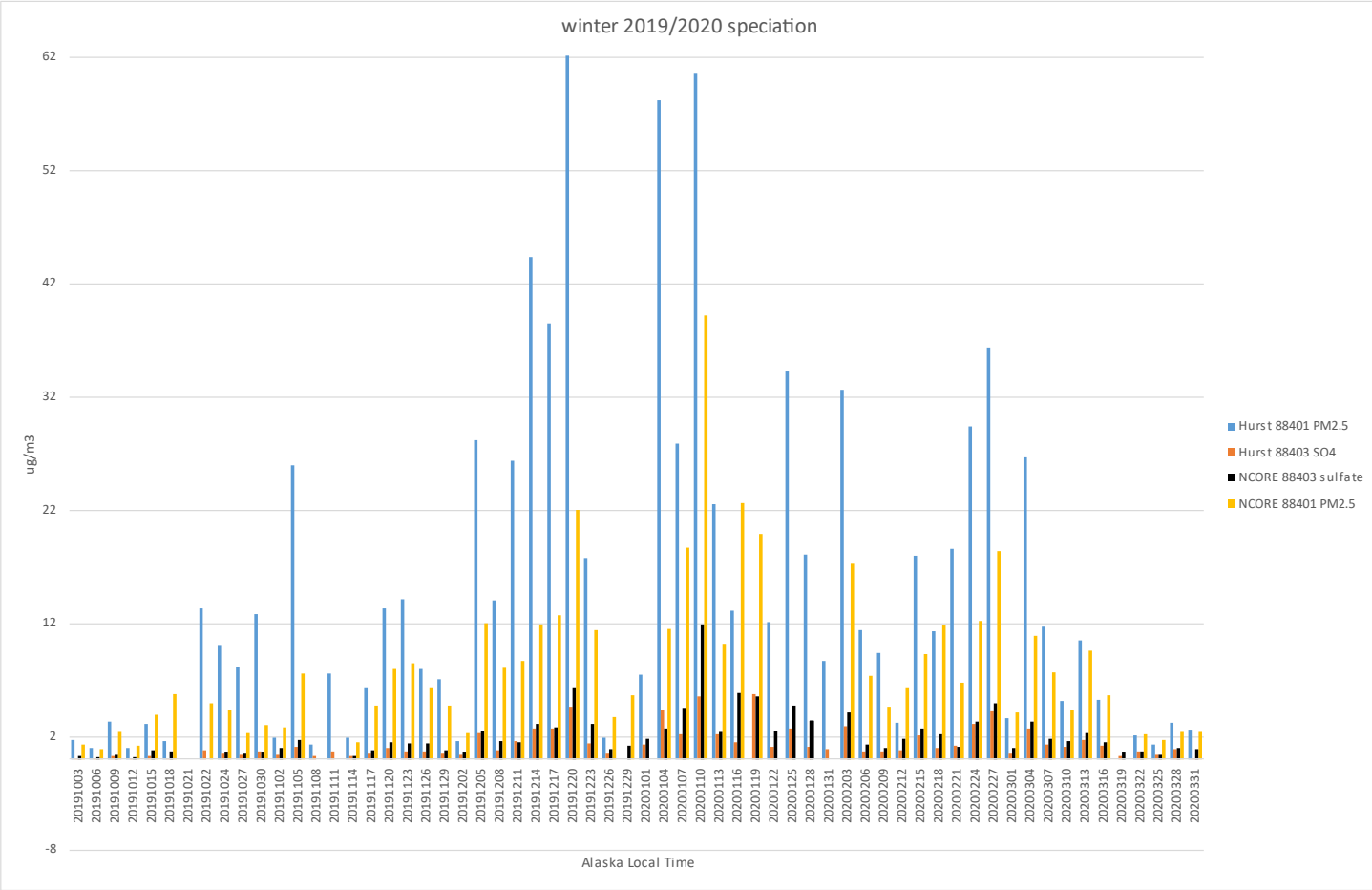



Figure 3. PM 2.5 and sulfate from the speciation filters at Hurst Road in North Pole and NCORE monitors.

The model performance is assessed for PM 2.5, organic matter, sulfate, nitrate, ammonium, PM other (soils and crustal material), NOx and SO2 (for comparison to NCORE gas measurements). The raw CMAQ model outputs are compared to daily FRM measurements for PM 2.5 and speciation when available. The final model performance plots as well as other required metrics are reviewed and approved by the EPA for SIP work.

The model requires emission inputs that will be coupled with the meteorology from the 74-day episode. During Phase 2, DEC worked with its contractors to develop the most up-to-date wood stove emissions, hourly point source emissions and emission estimates from all other sectors for input into the model. Details on the emission inventory will ultimately be found in the technical modeling report, Phase 2. The emissions inventory for the 74-day episode is complete and is being run through SMOKE (Sparse Matrix Operator Kernel Emissions Model), the preprocessor of emissions to make model-ready emissions inputs for the CMAQ model. The report for Phase 2 of the model update is not yet completed and the technical report will be updated as the timetable sections below (Table1) are completed. The Phase 2 full estimated timeline is below and can be found in the technical report. The WRF meteorological model inputs for running the CMAQ model were completed in November of 2021. Point source hourly data has been collected and emission were run through SMOKE, a model run is complete with only the point source emissions, the model run will serve as a zero out run (zero other emissions) and will be re-evaluated after model performance is complete. DEC anticipates model evaluation will be completed end of the summer of 2022 with EPA approval by fall. DEC is expecting it will take EPA from 2-3 months to complete their evaluation.

**Phase 3 PM2.5 Model for regulatory purposes**

Phase 3 of the modeling platform update is using the new model (completed from Phase 2) for regulatory work including SIP updates and precursor demonstrations. There are mandatory steps that must be completed before a model may be used for regulatory purposes. These mandatory steps have been documented previously in the Moderate and Serious SIPs. Briefly, these steps include development of a new 5-yr modeling design value with concurrence from EPA; selection of a new base year and the development of a new emissions inventory. These items require updating due to the time that has passed since the last regulatory modelling was conducted.

When conducting regulatory modeling there are several steps in additional to those identified above. For example, the raw model outputs from the updated CMAQ model are run through SMAT (speciated model attainment testing) to identify a baseline design value and a future design value. Future modeling runs and different scenarios are identified and run through the model based on things like current regulations and control programs in place and input from stakeholder groups, community members, FNSB, DEC and EPA. Then future year model runs are conducted to assess controls and precursors. It can take multiple model runs to assess various control measures, typically 2-5 runs. Phase 3 of the modeling update has not started yet, except to identify elements that need to be updated and that have significant lead time. Model runs to support pollutant-specific precursor demonstrations may only be conducted at the end of Phase 3 when all the mandatory steps are completed.

**Schedule and Status**

**Table 1. Phase 1 ,2 and 3 of the technical updates to the modeling platform and estimated timeline**

**Phase 1 Development of the CMAQ 5.3.1 system using existing emissions and meteorology**

| Section in Report | Component/Step | Status/Estimated Timeline | Notes/Responsible Party |
|---|---|---|---|
| 2.1 | MCIP5 (using original 2008 WRF meteorology) | completed 7/20/20 | EPA OAR as part of the FY20 RARE grant |
| 2.2a | CMAQ 5.3.2 compile | completed 8/20/20 | Compiled on the DEC Linux server using MPI and the benchmark simulation |
| 2.2b | CMAQ 5.3.2 compile and comparison (5.3.2 released in October of 2020 and contained significant updates to woodstoves) | completed | DEC/Contractor |
| 2.3 | Upgrade to SMOKE 4.7 using Serious SIP 2019 EI | Completed 1/ 2021 | Contractor |
| 2.4 | CMAQ 5.3.2- 2019 EI and 2008 WRF (MCIP5) | completed 7/2021 | DEC – Initial comparison modeling run on the original 2008 met and emissions |
| | **EPA review of phase one report, concurrent with DEC review** | **completed 10/2021** | **EPA/DEC** |

**Phase 2 Development of the CMAQ 5.3.2 system with new emissions and meteorology**

| Section | Component | Estimated Timeline | Notes |
|---|---|---|---|
| 2.5 | WRF Meteorology simulations for new episode winter 2019/2020 | Completed November 2021 | Contractor |

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|---|---|---|---|
| 2.6 | MCIP5- 2019-2020 | Completed November 2021 | Contractor |
| 2.7 | North Pole Speciation Data analysis of entire winter and SMAT | Completed March 2022 | DEC |
| 2.8 | Inventory Step A Emission Inventory Revisions (2019):<br>-Day/Hour-specific point sources<br>- Episodic temperature dependence for other sectors | Completed January 2022s | Contractor |
| 2.9 | Inventory Step B Emission Inventory Revisions (All Applicable Years):<br>- Updated space heating survey<br>- Integration of MOVES202X<br>-Data for mandatory fuel switch starting 12/1/2022 | 2023 | Contractor / DEC |
| 2.10 | SMOKE 4.7 2019/2020 New episode | Completed for point sector March 2022 All other sectors April 2022 | Contractor |
| 2.11 | CMAQ 5.3.2 model performance | August 2022 | DEC/Contractor |
| 2.12 | EPA review of CMAQ 5.3.2 model performance | 2-3 months? | EPA |
| 2.13 | CMAQ 5.3.2 model run with new 2019 emissions and meteorology<br>*timing subject to new activity data if collected for 2019 | Completed and running model for point source sector emissions.<br>Post model evaluation pending EPA approval.<br>1-2 months of effort | DEC / Contractor – fully updated QA/QC and model performance version of CMAQ 5.3.2 |

**Phase 3 Modeling for Regulatory Purposes**

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|---|---|---|---|
| 2.14 | 5-year modeling design value | After EPA approves model performance 2022 -2023 | DEC/EPA |
| 2.15 | Updated Emissions Inventory with new base year | After EPA approves model performance 2022 -2023 | DEC/Contractor |
| 2.16 | SMAT /Sandwich | Jan/Feb 2022 | DEC |
| 2.17 | CMAQ Future control runs (2-5 model runs) | After EPA approves model performance 2022 -2023 | DEC |
| 2.18 | New Precursor Demonstration | After EPA approves model performance 2022 -2023<br>AND/IF sulfate performance has improved | DEC |