Appendix K

Recommended Improvements

The Regional Haze Rule requires states to conduct a mid course review in 2012 of progress toward reasonable progress goals for 2018. There are several technical improvements that are recommended in the emissions inventory and air quality models that are used to support regulatory decisions for regional haze. These technical improvements are also important for states' efforts to demonste attainment of the ozone and PM2.5 health standards.

1) *Emissions inventory* We need to continue to improve emission inventories for regulatory sources, particularly emissions profiles for the composition of PM2.5 emissions.

2) Continued improvements are needed in the integrated *one-atmosphere air quality models* that are used to project air quality responses to emissions reductions. The interactions among primary and secondary pollutants in the atmosphere affect the levels of ozone, PM2.5, and haze in the atmosphere. As our understanding of partitioning between gaseous and aerosol phases improves, this understanding needs to be reflected in the models.

3) *Sulfate performance* for the CMAQ regional air quality model is good overall. Sulfate deposition is frequently overestimated in the models, particularly in the summer months. Overestimation of precipitation volume from convective storms is one possible explanation. Improvements in treatment of convective systems in the meteorological models would improve projections of pollutant deposition concentrations. At the coastal sites, when winds are blowing from the Gulf of Mexico or Atlantic Ocean, CMAQ under estimates measured sulfate at the monitors. Improvements to emissions inventories for commercial shipping in the Gulf and Atlantic were made in 2006; additional refinements to emissions estimates are needed. As well CMAQ's processes should be reviewed for sulfate formation over water, including availability of precursor species (hydrogen peroxide and ozone), dispersal patterns for moving and fixed SO2 emission sources, and vertical and horizontal within clouds over water. The accuracy of meteorological modeling of flux at the land-water interface is also an area for additional attention.

4) *Nitrate* is overestimated by the CMAQ model in the winter and underestimated in the summer, although summer monitored values of nitrate are very low. In the southeastern US, nitrate formation is driven largely by level of ammonia available in the atmosphere. Our understanding of seasonal variation in ammonia emissions from agricultural sources has improved; additional improvements in seasonal allocation of annual inventories would improve model estimates of ammonium nitrate formation.

5) *Organic carbon* is generally underestimated in the CMAQ in the summer months. Improvement in the characterization of primary carbon emissions and partitioning between gas and aerosol phase and formation of secondary organic aerosols is needed.

6) We need better tools for *organic carbon source apportionment*. In aged aerosol most of primary aerosol has reacted to form some secondary organic aerosol. Improved emissions profiles and stable molecular makers for anthropogenic and biogenic sources and fossil and modern carbon are critical.

7) Consistent measurement techniques are needed between rural and urban monitoring networks so that concentrations of organic carbon and elemental carbon can be compared between sites.

8) To improve our understanding of the contribution of fire from natural forest fires, prescribed burning, land clearing, and agricultural burning, states need to improve record keeping. Records should include acres burned, dates, location (latitude/longitude), fuel type, and intensity of burn.

9) Additional improvements to ***international emissions*** inventory are needed to improve our understanding of boundary conditions for our modeling domain and of the contributions from international emissions to pollutant concentrations at the VISTAS Class I areas. Currently monthly average inventories are used for non-US sources. Even when highly resolved meteorological data are used, these monthly average inventories do not reflect the episodic variation in emissions, particularly for fire events, that are important at the receptors. In the current modeling we cannot distinguish US from non-US sources of pollutant concentrations at the boundaries of the model domain. We need to improve our ability to trace emissions that originate within US as they are transported outside our modeling grid so that when they re-circulate back into the modeling domain they retain their identify as US emissions rather than non-US boundary conditions.

10) The effect of meteorological model performance on air quality model performance needs additional attention.

11) We need to capture the value of the continuous monitoring by evaluating model for the diurnal and spatial patterns seen in the monitored data.

12) We need to improve confidence in trajectory model for periods greater than 72 hours. Currently trajectories of longer duration have such large bands of uncertainty as to reduce any conclusions than can be drawn for transport greater than 72 hours.