Air Quality Impact of the NARA Aviation Biofuel Refinery

Bailey Tebou[1], Vikram Ravi[2] and Brian K. Lamb[2]

[1]North Carolina State University, Department of Engineering, Chemical Engineering and Paper Science and Engineering

[2]Washington State University, Department of Civil and Environmental Engineering, Laboratory for Atmospheric Research

Introduction

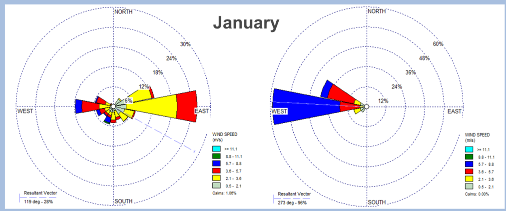
Current methods of removing woody biomass residue from logging operations are wasting a potential biofuel resource and, due to slash burns of these residues, are negatively impacting the environment. The establishment of a biofuel supply chain to convert woody biomass into usable biofuel would benefit the environment and create less pollution. Through the Northwest Advanced Renewables Alliance (NARA) project, plans have been developed to use woody biomass residue as a feedstock for aviation biofuel. This will involve bio-processing of the residue at a refinery, which in turn, will have the potential for emission of air pollutants, including various air toxic compounds. Here we assess the impact of the NARA bio-refinery on local air quality as part of an overall sustainability assessment of the biofuel supply chain in the Pacific Northwest.

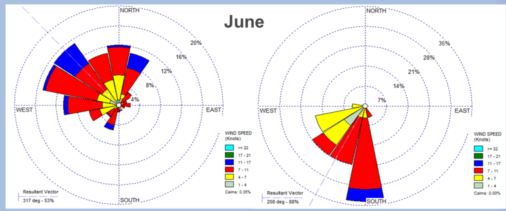
Objectives

- To use the Gaussian dispersion modeling software AERMOD to determine the concentrations of SO_2 and NO_2 at specified distances from the stacks.
- To generate time series plots and contour plots of the concentrations and compare it with National Ambient Air Quality Standards (NAAQS).

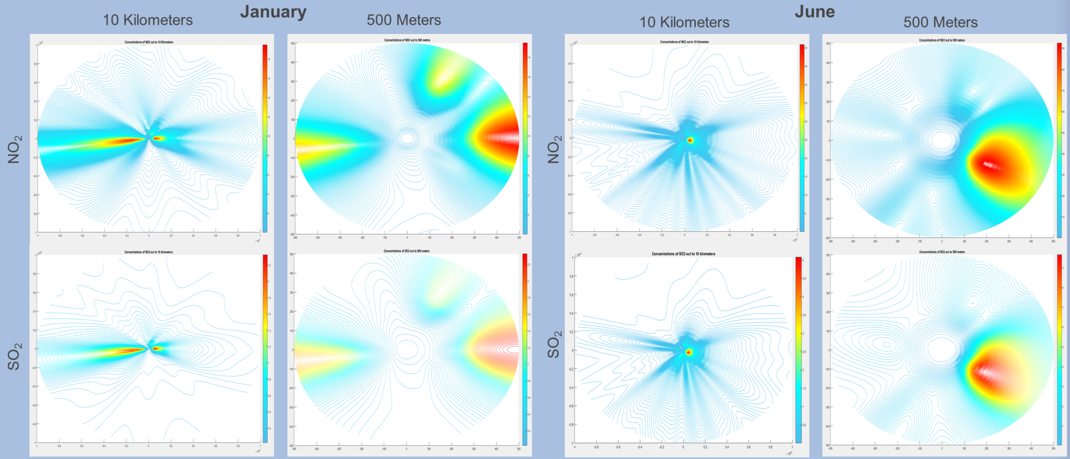
Methodology

- Biorefinery emissions and several other related inputs were obtained from the Techno-Economic Analysis group of the NARA project, and the Cosmo Specialty Fiber mill was used as a potential location and to obtain physical stack parameters for the biorefinery.
- Meteorological input data covering a summer and winter month (January, 2013 and June, 2013) were obtained from the Weather Research & Forecasting (WRF) numerical weather forecast system for the Pacific Northwest operated by University of Washington and processed using Mesoscale Model Interface Program (MMIF).
- Simulated SO_2 and NO_2 pollutant concentrations are presented in terms of receptor time series, contour maps of average and maximum downwind concentrations, and in tables of mean and maximum levels.
- Model simulations using the EPA's AERMOD model were used to predict concentrations for both months.
- Simulations were carried out for all directions as a whole, and for a 50 degree sector along the mean wind direction.
- MATLAB was used to create contour plots using AERMOD plotfiles as direct input.

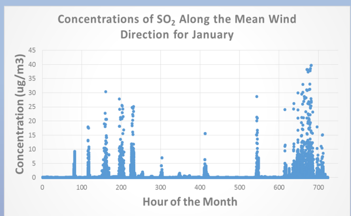


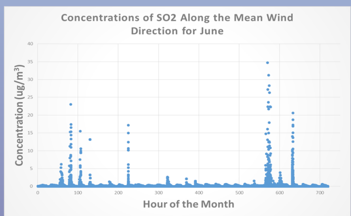


From left to right, the four wind roses display the wind rose plot for the month of January, the wind rose for January 28th, the wind rose for the month of June, and finally the wind rose for June 24th. The two wind roses for the entire month show where the mean wind direction lies. Two major wind directions are evident for the month of January but only one is evident for June. The individual days for both months were chosen by looking at the time series plots shown below and choosing the time of the maximum concentration along the mean wind direction. In both cases, the wind direction on that day almost directly opposes the mean wind direction.



The figures in the left column for each month depict the concentrations every 500 meters for distances of 0-10 kilometers. The concentrations listed on the plots is listed in units of ug/m^3. The figures in the right columns show a closer grid of contours from 0-500 meters to highlight the highest concentrations immediately downwind of the source. Two distinct wind directions are evident along the east and west wind directions. Maximum SO_2 concentrations of approximately 40 ug/m^3 for both months are well below the National Ambient Air Quality Standards (NAAQS) of 197 ug/m^3. The one-hour NAAQS level for NO_2 is 188 ug/m^3, and NO_2 concentrations peak at around 100 ug/m^3.





Day in January	Hour of Day (Hour of Month)	Concentration (ug/m^3)	Boundary Layer Height (m)	Wind Speed (m/s)	Wind Direction	Temperature (K)
28	22 (670)	40	910	7.02	272	280
23	16 (544)	29	679	4.31	281	280
7	17 (161)	30	682	4.95	277	281

Day in June	Hour of Day (Hour of Month)	Concentration (ug/m^3)	Boundary Layer Height	Wind Speed (m/s)	Wind Direction	Temperature (K)
24	18 (570)	35	513	5.6	176	285
4	10 (82)	23	306	4.07	112	297
10	9 (225)	17	538	0.53	196	292

Time series plots of the concentration of SO_2 for a grid of receptors lying along the 50 degree sector of the mean wind direction were used to determine when concentrations were peaking and to further analyze the meteorological conditions that led to the maximum concentrations. The three most distinct spikes in the month of January occurred on the 29th at hour 8, the 23rd at hour 16, and the 7th at hour 17. The column cluster around the largest spike occurring on the 29th reflects relatively high wind speeds which suggests a minimum in plume rise and a resulting high ground-level concentration. The mean wind direction on the 28th-29th almost directly opposes the mean wind direction for the month as a whole and reflects passage of a weather front with strong winds. This pattern occurs throughout the month of January with spikes occurring when winds are high and associated with passage of a weather front. This same pattern was observed in June. The first row in each table shows the highest peak of each month, and the next two rows show the next two highest peaks at distinct points during the month.

NARA

Northwest Advanced Renewables Alliance

This work, as part of the Northwest Advanced Renewables Alliance (NARA), was funded by the Agriculture and Food Research Initiative Competitive Grant no. 2011-68005-30416 from the USDA National Institute of Food and Agriculture.