Appendix D - Specification of aircraft and wildfire emissions in CALPUFF modeling

Most of emission sources in CALPUFF modeling were specified as point, line, and area sources with given release heights and other release parameters. There were two exceptions: aircraft and wildfire emissions.

Piston engine aircraft is a major source of lead in the atmosphere. Emissions in taxiing and takeoff/landing were treated differently. When the aircraft was high above the ground, the emissions from aircraft didn't contribute much to the ground-level concentration so they were neglected in the present study.

Following the method presented in U.S. EPA (2010), initial lateral diffusion parameter (s_{yi}) was specified as source separation distance divided by 2.15 and the initial vertical diffusion parameter (s_{zi}) was given by[1]

$$\sigma_{zi} = \left[1.8 + 0.11\left(\frac{W2}{U}\right)\right]\left(\frac{60}{30}\right)^{0.2} \quad (1)$$

Where W2 is half width of the runway (m) for taxiing operations and half of aircraft wingspan for takeoff/landing operations, U is the average wind speed (m/s) over the modeling period.

Different sets of initial diffusion parameters were used for taxiing and takeoff/landing operations.

For taxiing operations, use equation (1) to calculate initial vertical diffusion parameters with W2=12.2 m (half width of the runway), and annual average wind speed U = 2 m/s. Initial lateral diffusion parameter was calculated with

$$\sigma_{yi} = \frac{D}{2.15} \quad (2)$$

Where D is the horizontal separation distance between source centers which was set to 50 m. The release height was set to 1 m above the ground.

For Takeoff/Approach/Landing/Climb-out, use equation (1) to calculate initial vertical diffusion parameter with W2 = 21 m (half of aircraft wingspan) and the annual average wind speed U = 2 m/s. The initial lateral diffusion parameter remained the same for the taxiing operations. The takeoff/landing path was divided equally into a number of short segments so that the height difference of the two ends of each segment did not exceed 10 m, and the release height was set to the average height of each segment plus 1 m.

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[1] A correction has been made to this equation so that it is consistent with the one presented in CALINE3 user's guide.

The other emission source category that needed special treatment was wildfire. Due to the buoyancy generated by combustion of biofuel, elemental carbon emissions from wildfires could extend substantially in the vertical direction. Because plume rise was strongly affected by meteorological conditions such as vertical profiles of wind speed and temperature, plume rise calculations were carried out off-line and the calculation results were used to assign emissions in different vertical layers.

All wildfire emissions were characterized as 1 km x 1 km area sources. To disable the in-line plume-rise calculations, the plume of wildfire emissions was assumed to be a pseudo stack of the following release parameters: exit temperature = 200 K, and exit velocity = 0 m/s. The majority of the wildfire plumes were assigned to layers separated by the following heights: 0.0, 32.0, 71.0, 118.0, 174.0, 241.0, 322.0, 419.0, 534.0, 673.0, 839.0, 1038.0, 1276.0, 1561.0, 1900.0, 2307.0, 2791.0, 3368.0, 4055.0, 4873.0, 5845.0, all in meters. The first layer was between 0 and 32 m, and the second layer was between 32 and 71 m, and so on. The release heights used for all layer emissions were the average heights of the layers (for example, it was 16 m for the first layer), and the initial vertical diffusion parameters were the depths of the layer divided by 2.15 (for the first layer) or 4.3 (for all other layers).

The layers' configuration didn't change from basin to basin, but different upper bounds were used for different air basins, for example, 6 km for the Bay Area and South Coast, 4 km for the Imperial, 13 km for San Diego, and 15 km for Sacramento Valley.

References

U.S. EPA, 2010, Development and Evaluation of an Air Quality Modeling Approach for Lead Emissions from Piston-Engine Aircraft Operating on Leaded Aviation Gasoline, EPA-420-R-10-007.