Supplemental Information

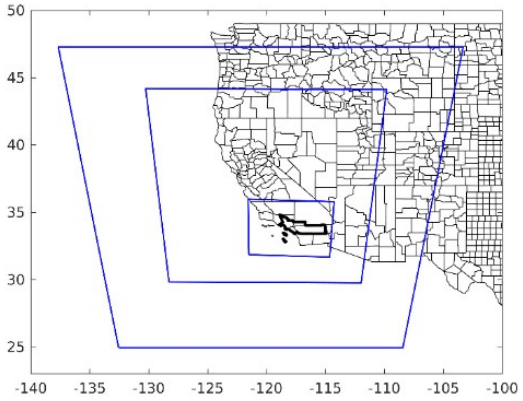

Figure S1. Map of the study region, with the target area of the South Coast Air Quality Management District of California in thick black lines.

Eddy diffusivity from similarity theory and local Richardson Number

In this study, we use eddy viscosity (K-theory) to compute vertical mixing. The eddy diffusivity (K_z) in CMAQ is based on two different models. K_z computed for vertical mixing within the PBL is derived from Hostlag and Boville (Holtslag and Boville, 1993), while K_z computed for both below and above the PBL is based on the local Richardson number and vertical shear (Liu and Carroll, 1996). Below the PBL, K_z is defined as

$$K_z = \frac{k u_* z}{\phi_H\left(\frac{z}{L}\right)} \#(S1)$$

where $k = 0.4$ is the von Karman constant, u_* is the friction velocity, z is the vertical height, $\phi_H\left(\frac{z}{L}\right)$ is the Monin-Obukhov similarity function, and L is the Monin-Obukhov length. The similarity function varies with the PBL conditions. During the stable condition, $\phi_H\left(\frac{z}{L}\right) = \left(1 - 16\frac{z}{L}\right)^{-\frac{1}{2}}$, and during unstable condition, $\phi_H\left(\frac{z}{L}\right) = \left(1 - 1.6\,PBL\frac{z}{L}\right)^{-\frac{1}{2}}$, where the stable boundary layer is driven by the friction velocity, and the unstable conditions occur when the sensible heat flux is upward.

CMAQ also computes eddy diffusivity using the local Richardson number, defined as

$$K_z = l^2 s\left(1 - \frac{Ri}{Ri_c}\right)^2 \#(S2)$$

and

$$R_i = \frac{\frac{g}{T_v}\frac{\partial \theta_v}{\partial z}}{\frac{\partial u^2 + \partial v^2}{\partial z^2}}$$

where θ_v is the virtual potential temperature, T_v is the virtual temperature, l is the mixing length, g is gravitational constant, and $Ri_c = 0.25$ is the critical Richardson number.

Outside of the PBL, CMAQ uses eddy diffusivity from local Richardson number (Eq. S2). However, inside the PBL, eddy diffusivity is the greater value between Eq. S1 and Eq. S2.

Supplemental References

Holtslag AAM, Boville BA. Local Versus Nonlocal Boundary-Layer Diffusion in a Global Climate Model. J Climate. 1993; 6(10):1825–42. Available from: http://journals.ametsoc.org/doi/10.1175/1520-0442(1993)006<1825:LVNBLD>2.0.CO;2

Liu M, Carroll JJ. A High-Resolution Air Pollution Model Suitable for Dispersion Studies in Complex Terrain. Mon Wea Rev. 1996; 124(10):2396–409. Available from: http://journals.ametsoc.org/doi/10.1175/1520-0493(1996)124<2396:AHRAPM>2.0.CO;2