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Technical Note: Sensitivity of 1-D smoke plume rise models to the inclusion of environmental wind drag

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Abstract. Vegetation fires emit hot gases and particles which are rapidly transported upward by the positive buoyancy generated by the combustion process. In general, the final vertical height that the smoke plumes reach is controlled by the thermodynamic stability of the atmospheric environment and the surface heat flux released by the fire. However, the presence of a strong horizontal wind can enhance the lateral entrainment and induce additional drag, particularly for small fires, impacting the smoke injection height. In this paper, we revisit the parameterization of the vertical transport of hot gases and particles emitted from vegetation fires, described in Freitas et al. (2007), to include the effects of environmental wind on transport and dilution of the smoke plume at its scale. This process is quantitatively represented by introducing an additional entrainment term to account for organized inflow of a mass of cooler and drier ambient air into the plume and its drag by momentum transfer. An extended set of equations including the horizontal motion of the plume and the additional increase of the plume radius is solved to simulate the time evolution of the plume rise and the smoke injection height. One-dimensional (1-D) model results are presented for two deforestation fires in the Amazon basin with sizes of 10 and 50 ha under calm and windy atmospheric environments. The results are compared to corresponding simulations generated by the complex non-hydrostatic three-dimensional (3-D) Active Tracer High resolution Atmospheric Model (ATHAM). We show that the 1-D model results compare well with the full 3-D simulations. The 1-D model may thus be used in field situations where extensive computing facilities are not available, especially under conditions for which several optional cases must be studied.

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