SOUTHERN Fire Exchange
Uniting Fire Science and Natural Resource Management
JOINT FIRE SCIENCE PROGRAM

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Smoke Prediction with VSMOKE

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WHAT IS VSMOKE?

VSMOKE is a computer-based model for predicting concentrations of fine particulate matter and cross-plume visibility from prescribed fires. It is used extensively in the Southeast by state and federal agencies. The model was originally developed in the 1990's by Leonidas Lavdas (USDA Forest Service Southern Research Station) and was subsequently modified by Bill Jackson (USDA Forest Service, North Carolina) for ArcGIS and ArcMap outputs (http://webcam.srs.fs.fed.us/tools/vsmoke/download.shtml). VSMOKE is now also available in a web-based version (http://weather.gfc.state.ga.us/GoogleVsmoke/vsmoke-Good2.html). VSMOKE-Web is the easiest of the three versions to use as a simple planning tool; it provides satellite image or map-based projections of downwind smoke concentrations for your prescribed burn plan.

WHEN IS IT APPLICABLE?

VSMOKE is based on weather conditions and smoke-related problems found in the eastern United States, generally in flat or rolling topography. It was designed for single, low-to-moderate intensity surface fires and dry weather visibility impacts. Dry weather visibility generally means daytime use rather than at night when humidity levels rise.

VSmoke can assist with your prescribed burn plan by providing important projections of downwind smoke concentrations.
PHOTO BY LEDA KOBZIAR.

WHAT ARE ITS LIMITATIONS?

The smoke concentration and sightline characteristic estimates can be applied cautiously in rugged terrain, but the spatial variability of windflow over rugged terrain limits the plume model's effectiveness. Estimates of sightline visibility are also limited when relative humidity is above 70 percent. Lavdas' *Program VSMOKE-Users Manual* (https://www.fs.usda.gov/treesearch/pubs/1561) published in 1996 is a lengthy description of the derivation and mathematical basis of VSMOKE[1]. The manual includes various constraints on model use for those who want to delve into applications with greater detail.

INPUTS AND OUTPUTS

VSMOKE is a weather-driven model that incorporates emissions information from other models. Burn location is identified by a pointer on a map (VSMOKE-Web) or by entering latitude and longitude. Weather forecast inputs include: wind direction (uniform) and speed (steady), mixing height, and atmospheric stability. Additional burn parameter inputs—fuel type (12 classes), fuel moisture condition (wet, damp, dry, very dry), fuel loading, burn unit size, and ignition method—are processed via a VSMOKE link to the Fire Emissions Production Simulator (FEPS). Fuel loads (tons/acre) are automatically input for each fuel type, although burn managers can revise the fuel load if they have more accurate information. The resulting fuel consumption and emissions information is used by VSMOKE to produce the smoke plume characteristics described in the model outputs.

VSMOKE estimates downwind peak hourly concentrations of particulate matter (PM 2.5) and carbon monoxide (CO) at 31 fixed distances, from 0.1 to 62 miles from the fire. It also estimates those concentrations at each fixed point, perpendicular to the smoke plume direction (both vertically and horizontally), illustrating how far and well a person may see through the smoke at each distance. The results in the VSMOKE model are presented in tables, with seven plume characteristics at each of the 31 points. A report and tables displaying the results are prepared by the VSMOKE model and can be copied into a written report for burn managers to include in their files.

In the ArcGIS and Web versions, results are displayed as smoke plume overlays on a map or satellite image (Figure 1). In VSMOKE-Web, each color overlay represents expected downwind ground-level PM 2.5 concentrations that reflect the threshold values (e.g., moderate, unhealthy, hazardous) of the national Air Quality Index. VSMOKE-Web currently does not produce the cross-plume visibility estimates or the table outputs available in the PC-version. Researchers anticipate future updates to the web-version to provide those outputs.

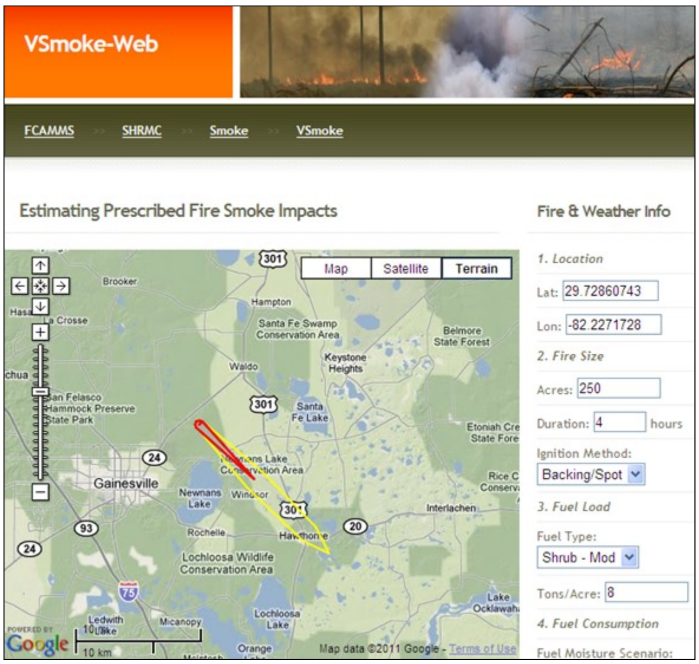

Figure 1. VSmoke-Web produces smoke plume overlays on a map or satellite image.

INTERPRETING THE OUTPUT

The map-based cones in the ArcGIS and Web output indicate possible areas of hazardous smoke impacts for highways, residential areas, or other smoke sensitive locations. As with other smoke management tools, such potential impacts could be mitigated by adjusting burn plans for smaller burns, different wind directions, atmospheric stability conditions, or ignition patterns. If the results indicate a risk of hazardous visibility conditions during daytime, it might be advisable to further investigate the potential for additional nighttime problems. PB-Piedmont (https://piedmont.dri.edu//) is a model for predicting nighttime smoke movement. Most state smoke management guides and prescribed burner training materials discuss strategies for avoiding these nighttime problems.

WHERE CAN I GET MORE INFORMATION ABOUT SMOKE PREDICTION MODELS?

Predicting smoke dispersion and concentration has been the focus of research and modeling for over 50 years. The 1976 *Southern Forestry Smoke Management Guidebook* provided detailed procedures and tables for evaluating smoke concerns. Today, work is carried on by multiple agency collaborations, such as the US Forest Service AirFire program (http://www.airfire.org) and the US Forest Service Fire and Environmental Research Applications Team in the Pacific Northwest (http://www.fs.fed.us/pnw/fera). Both websites are entry points for learning more about both simple and complex models that are currently available.

REFERENCES

[1]Lavdas, L. G. (1996). Program VSMOKE—User's Manual. General Technical Report SRS-6. Asheville, NC: USDA Forest Service, Southern Research Station. Available for download https://www.fs.usda.gov/treesearch/pubs/1561 .

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