FEWG – A WORKING GROUP FOR NCDFR MTM

NC SMP Technote 11 – December 27th, 2008

Mixing Height and Transport Wind Calculations and Absolute Minimums for Burning under the NC Smoke Management Program

These minimums apply when solely using the NC SMP Ventilation Index System. The Operational Research Evaluation Burns Project (OREBS) has established an alternative means to evaluate burning conditions whereby lower transport wind speeds are permissible. This is through the use of an accepted atmospheric dispersion model (ADM). However, the established minimum for mixing height will remain the same for VIS or ADM.

Each individual state has the responsibility through federal legislation to maintain air quality according to the provisions outlined in the Clear Air Act. Forestry and other ecosystems management and protection in NC participate and assist in maintaining air quality through the use of the NC Smoke Management Program. The goal of the NC's voluntary smoke management program is to advise when the burning of forest or ecosystems residues under meteorological conditions is good for smoke dispersion and to advise to refrain from burning when unfavorable meteorological conditions would result in smoke intrusions.

Participating agencies, entities or individual landowners under the current NC SMP use the combination of meteorology, fuel loading, and distance to smoke sensitive areas to keep visibility and air quality impacts of smoke within acceptable limits. Burning under favorable weather conditions with a variety of prescribed fire techniques can keep smoke emissions to a minimum and adequately disperse smoke. Adequate dispersion depends on three characteristics of the atmosphere; atmospheric stability, mixing heights, and transport winds. Burning during good vertical dispersion with the pre-determined amount of fuels that can be consumed within the "burning window", will properly dilute smoke.

NC SMP is based on a ventilation index based system (VIS). Ventilation Index is the product of the mixing height and the transport wind speed. Winds and atmospheric stability are the two most important meteorological factors in an effective NC SMP. The National Weather Service is the strategic partner that assists the state by issuing Smoke Management Forecasts. These forecasts include guidance on air mass stability, mixing heights of surface-based air, and transport or free air winds within the mixing layer.

Mixing Height Calculations

Mixing heights represent the top of the layer through which relatively vigorous mixing will take place. It is the height at which smoke will lose its buoyancy and stop rising. A well mixed layer is a layer in the atmosphere in which the lapse rate is roughly dry adiabatic (5.5 degree Fahrenheit per 1,000 ft). Mixing heights commonly go through large diurnal variations and seasonal variations.

Good smoke dispersion

An estimate of the afternoon's mixing depth can be obtained by finding the height above the surface of the dry adiabatic intersection of today's forecast maximum temperature with today's 1200 UTC upper air sounding. However, daily forecasts of afternoon mixing heights using 1200 UTC soundings can introduce errors into the mixing height calculations since 1200 UTC soundings are not always conservative into the afternoon hours.

Modifications to the 1200 UTC sounding need to take into account processes that tend to modify atmospheric temperature and moisture profiles such as 1) low-level heating or cooling, 2) synoptic-scale lift or subsidence, and 3) mid-level temperature and moisture advection. A more accurate approach to predicting late afternoon mixing heights is to use "**forecast soundings valid for 0000 UTC"**. Forecast soundings valid for 0000 UTC will (should) take into account the various processes mentioned above that modify morning upper air soundings. Mixing height forecast is only going to be as good as the model's forecast max temperature.

Therefore, model forecasts of mixing height are usually 1st reviewed either from the gridded data mixing height fields or through Bufkit (tool) soundings. These methods and models vary from forecaster to forecaster. Thus the art of forecasting by the fire weather forecaster is critical and knowing the weather's uniqueness attributable to the local forecasting area. Mixing height is determined from a forecast sounding and modified through forecasting skill for the forecasted max temperature. From there the mixing height is determined. When preparing the 9AM Smoke Management Forecast the fire weather forecaster will review the observed 12Z soundings to determine if the earlier forecasted mixing height forecast requires an update as specified under the NC NWS Fire Weather Annual Operating Plan.

For prescribed burning mixing height represents the top of the atmospheric volume available for dispersion. High mixing heights imply that large volumes of air are available for smoke dispersion. Thus, with higher mixing heights, smoke concentrations will be less and especially at long distances from the fire. **Mixing heights less than 500 meters or ~ 1700 ft. are associated with air pollution episodes. This is a "no Burn Day" unless an ADM is being used.**

Transport Wind Speed Calculations

There is another major factor affecting smoke transport and dispersion besides vertical plume rise and dispersion by physical forces such as atmospheric mixing. It is the horizontal movement or advection on an azimuth determined by transport wind direction and speed. Wind speeds usually increase with height, except where funneling takes place near the ground (as through a mountain saddle or opening in the forest). Transport wind speed is the arithmetic average of all wind speeds within the mixing layer, including surface wind speed. Smoke concentrations usually decrease as transport wind speeds increase. Transport wind speeds of less than **4 meters per second or ~ 9 mph are indicators of stagnant conditions which often result in air pollution episodes and again represent a "no Burn Day" unless using atmospheric dispersion models.**

Prescribed fire or wildfire during stagnant conditions can lead to the collection of smoke in drainages and can seriously degrade visibility conditions on roadways. This places in peril the safety and welfare of pedestrians and persons traveling in vehicles on our roadways.

Poor smoke dispersion on NC Roadways from wildfires.

This technical note was made possible and prepared from information obtained from NOAA NWS John Werth, and Ron Steve, USFS-SHRMC Scott Goodrick and General Technical Reports SE-I0 December 1976 SOUTHERN FORESTRY SMOKE MANAGEMENT GUIDEBOOK, and NCDFR FE Branch OREBS Project.