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Estimating Stability Class in the Field

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Abstract

A simple and easily remembered method is described for estimating cloud ceiling height in the field. Estimating ceiling height provides the means to estimate stability class, a parameter used to help determine Dispersion Index and Low Visibility Occurrence Risk Index, indices used as smoke management aids. Stability class is also used as an input to VSMOKE, an atmospheric dispersion model used to estimate prescribed fire smoke effects on air quality and visibility.

Keywords: Cloud ceiling height, Dispersion Index, dispersion models, Low Visibility Occurrence Risk Index, prescribed burning, stability class.

Introduction

Land managers must be able to assess whether a prescribed fire will reduce visibility and increase driving hazards. In the last 20 years, researchers have developed and improved numerical indices and dispersion models that give those responsible for prescribed burning this ability. Stability class is one of three meteorological parameters used to characterize atmospheric dispersion, both alone (Lavdas 1986) and within models that estimate smoke concentrations from prescribed burning (Lavdas 1996b, Southern Forest Fire Laboratory Personnel 1976). Unlike the other two parameters, mixing height and transport windspeed, estimates or forecasts of stability class are not generally available from the National Weather Service. Without stability class, field personnel cannot calculate Dispersion Index (Lavdas 1986) or Low Visibility Occurrence Risk Index (LVORI) (Lavdas 1996a), or use dispersion models such as INPUFF (Petersen and Lavdas 1986), VSMOKE (Lavdas 1996b), or VSMOKE-GIS (Jackson and others, in press). This inability to obtain stability class operationally is in spite of the availability of algorithms for estimating stability class from other commonly available meteorological parameters (Turner 1964) (summarized by Lavdas 1986). Stability class may be determined from opaque cloud cover, cloud ceiling height, surface (20 feet) windspeed, and solar elevation angle. Cloud cover and windspeed are routinely given in weather reports and forecasts. Moreover, both may be estimated in the field after minimal instruction. Lavdas (1976) (summarized by Southern Forest Fire Laboratory Personnel 1976) developed a convenient way to determine solar elevation angle from the length of shadows cast. Cloud ceiling height is not given in National Weather Service forecasts or observations routinely distributed to the general public. No formula exists for translating ceiling height into parameters accurately observable by field personnel. This single parameter has remained an obstacle to field determination of stability class.

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Cloud Ceiling Height

Cloud ceiling height helps determine the incoming or outgoing radiation which heats or cools the ground surface—thereby heating or cooling the layer of atmosphere nearest the ground. Accordingly, cloud influence on radiation can be categorized by the action of particular clouds on the sun's visible light. Cloud height categories are related to cloud light transmission characteristics by the following scheme:

Cloud height category	Cloud height	Cloud light transmission
High	>16,000 ft	High
Middle	7,000 - <16,000 ft	Medium
Low	< 7,000 ft	Low

Cloud light transmission characteristics may be estimated for individual cloud elements (or groups of similar elements) by estimating the appearance of the sun or cast shadows that would result if the sun were shining through that particular cloud element. The following scheme may be used:

Solar/cast shadow appearance	Cloud light transmission
Sun is bright, casts distinct shadows.	High
No distinct shadows, sun visible as a faint disk or bright area with its location in the sky closely determinable.	Medium
Sun not visible, cloud or cloud shadow is medium gray to dark.	Low

This method can be mastered by remembering three phrases: "There's the shadow"—high; "There's the sun"—medium; and "There's no sun"—low.

The Turner stability class determination method specifies cloud ceiling height—the lowest altitude for which opaque clouds cover more than one-half of the sky. Field personnel should determine if more than one-half of the sky is covered by clouds of low light transmission, then medium, then high. For example, if three-tenths of the sky is covered by low clouds, three-tenths by medium (six-tenths low and medium), and three-tenths by high (nine-tenths low, medium, and high), then the ceiling is medium.

Estimates of cloud light transmission should be made as if the sun were directly behind the cloud and fairly high in the sky (i.e., a shadow cast by the sun in that position in the sky should be no more than three times the height of the object). Clouds, sun, or both lower in the sky should be included in the analysis, but regarded as if they were higher in the sky.

Puffy cumulus clouds appear dazzling white if in direct sunlight but dark on the shadow side. Because cloud light transmission is estimated as if the sun is attempting to shine through the cloud, the appearance of a cumulus cloud's shadow side should be used. These clouds normally yield low light transmission.

Estimating cloud light transmission at night is more difficult but can be accomplished by using a full moon as a benchmark:

Full moon's appearance	Cloud light transmission
Full moon "man in the moon" features evident.	High
Full moon "watery," blurry, barely visible, or only apparent as a light blotch.	Medium
Full moon not visible.	Low

The nighttime method may be mastered by remembering: "There's the man in the moon"—high; "There's the moon"—medium; and "There's no moon"—low.

Implications

Once fire personnel have obtained mixing height, transport windspeed, opaque cloud cover, and surface windspeed from the National Weather Service and calculated solar elevation angle and cloud ceiling height in the field, they can estimate stability class on site. With this information, they can calculate Dispersion Index and LVORI in the field. In addition, they can use this information to run more complex dispersion models.

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