Introduction to Wildland Fire Management

Fireline Safety 101: Keep informed on fire weather conditions and forecasts

REM 244: Introduction to Wildland Fire Management

3. Introduction to Fire Weather
   • Surface Temperatures
   • Wind
   • Wind Hazards
   • Relative Humidity
   • Atmospheric Stability

GEOG 301: Meteorology
Weather is a critical driver of fire behavior. One of the primary factors influencing the weather are day-to-day and site-to-site variations in the surface temperature. Surface temperature is influenced by:

1. Air moisture content and pollutants
   Water vapor and aerosols absorb radiation reducing amount of incoming solar radiation hitting the surface.

2. Solar Insolation
   The angle of the sun to the surface greatly affects the amount of radiation — i.e., seasons, aspect, time of day.

3. Lag between incoming and outgoing radiation
   When incoming radiation exceeds outgoing radiation (such as around noon or in summer) -> higher surface temperatures.

4. Surface properties of terrain and vegetation
   Dark surfaces absorb more radiation; water absorbs more heat than rock; evaporation provides cooling

Of weather’s components, wind has the greatest potential to impact the fire behavior by directly impacting rate of spread.

Definition: Wind is air motion with respect to the Earth’s surface. It is caused by temperature differences (pressure gradients).

Impacts of wind on fire behavior:
- Wind adds extra oxygen to the fire
- Wind helps preheating fuels by flattening and extending the flame lengths
- Wind affects direction of fire spread
- Wind increases the chance of spotting
- Fire-induced weather (heated air rises pulling other air in) also affects fire behavior
- Hot winds help preheating leading to higher intensity fires; cool air has more moisture leading to more smoldering fire fronts.
REM 244: The Importance of Wind

There are several types of wind that are important in the management of wildland fires.

General Winds affect large areas and are the "winds" reported in weather forecasts.

Local Winds are small-scale convective winds produced by features of terrain and vegetation.

Surface Winds are measured at 20 feet above the ground. Mid-flame Winds directly impact the direction of fire spread.

Source: Firefighters Handbook of Wildland Firefighting, TEIE (2005)

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REM 244: Examples of Local Winds

Local winds are highly dependent on terrain and land cover types. Examples include sea breezes and valley breezes.

Up-valley winds do not usually occur until most of the valley air is warm.

Aspect is a major driver in when these winds occur. Solar heating causes breezes on eastern slopes long before southern or western slopes.

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REM 244: Examples of Local Winds

Local winds are highly dependent on terrain and land cover types. Examples include sea breezes and valley breezes.
Certain wind conditions can be particularly hazardous in the management of wildland fires.

Cold Front Winds: As cold fronts approach wind speeds generally increase and when they pass they can cause wind direction to shift by 45° – 180°.!!

Foehn (Gravity Winds): Warm and dry winds that pass through passes and move downhill. Cause rapid drying of fuels and increased wind speeds. Other names include: Santa Ana Winds and Chinook Winds.

Thunderstorms: Very dangerous! Downdrafts (rapid decent of cold air at storm center) can be felt over 25 miles away and can cause havoc on fires. Mountains can funnel and accelerate these winds.

Firewhirls: These are miniature cyclones caused by strong convection currents and updrafts. What to watch for:
- Clear skies (unstable air)
- Light surface winds
- Strong solar heating
- Lee slope from prevailing winds
REM 244: Wind Hazards

Certain topographic features can affect wind speed and direction.

Directional Channeling: Wind direction changes and flows to mouth of a canyon.

Venturi Effect: Wind flows through a pass and accelerates.

Canyon Eddies: Localized eddies can form in late afternoons.

Source: Jenkins, Utah State University

REM 244: Relative Humidity (RH)

Definition: The % of water vapor in air relative to the greatest amount possible (i.e. saturation) at a given temperature.

Air moisture and thus RH has direct affects on fuel moisture and fire behavior.

Fires burn slower at night because the fine fuels absorb moisture from the damp night air.

RH and Temperature are linked:
- The dew point is the temperature at which the RH is 100%.
- For every 10°C temperature increase at 1000mb, RH drops by ~50%.

If you know dew point and temperature, you can predict RH.

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<th>Vapor (g) per Kilogram of Dry Air</th>
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Source: physicalgeography.net

REM 244: Relative Humidity (RH)

Aspect, elevation and cover type affect the relative humidity.

RH increases when temperature drops:
- North aspects are > 5° colder than south
- Temperatures decrease with increases in altitude
- At night, cool air flows down slope and collects in valleys >> inversion
- Dense vegetation is several degrees cooler than cleared / open areas
- Clouds reflect incoming solar radiation and can decrease surface temperature by 10-20°
- Wind reduces daytime temperatures

Source: Firefighters Handbook of Wildland Firefighting, TEIE (2005)
REM 244: Atmospheric Stability

**Definition:** The resistance of the atmosphere to vertical motion. Stable air resists vertical movement; unstable air encourages it.

- **Lapse rate** is the change in temperature with the change in altitude (and RH).
- As air dries (RH lowers) you get greater drops of T with elevation.
- If air cooler faster than 10° per 1000m there is vertical movement of air = unstable atmosphere.

Source: NASA

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**Unstable Air:**
- Increased chance of fire whirls
- Increased chance of sudden gusts in surface winds (can occur very quickly)
- Increased heights of convection columns >> higher intensity fires
- Increases chance of spotting

The Haines Index is used to gauge relative fire danger. It uses temperature and dew point at two altitudes and assigns a rating between 2 and 6.
- High Haines Index:
  - >> drier and more unstable atmosphere
  - >> high potential for large fire growth

Source: Jenkins, Utah State University

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**An inversion is a layer of stable air where temperature rises as altitude increases. A Thermal Belt is a “warm area” on a mountain slope associated with an inversion.**

- Inversions are common at night when a layer of warm air sits over one of cold air. Inversions weaken at sunrise as the sun heats the Earth’s surface.
- Fire behavior can have high intensities at night in thermal belts !!!!

Source: Firefighter Handbook of Wildland Firefighting, TEIE (2005); Jenkins, Utah State University
Visual indicators of Stable Air: Clouds in layers, stratus clouds, no vertical motion, smoke column does not rise, poor visibility in lower levels due to accumulation of haze and smoke, and fog layers.

Sources: Jenkins, Utah State University

Visual indicators of Unstable Air: Clouds grow vertically and smoke rises to great heights, cumulus type clouds, gusty winds, good visibility, and dust whirls.

Sources: Jenkins, Utah State University