PIBAL OBSERVATIONS TO ENHANCE THE JEFFERSON COUNTY SMOKE MANAGEMENT PROGRAM, 1999

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Abstract

Helium filled weather pilot balloons (pibals) were sent up at two locations within Jefferson County (Culver and COARC). Generally, five balloons were released each day between 8:30 a.m. and 3:30 p.m. Wind speeds and directions for different elevations above ground were calculated from vertical and horizontal degree readings. These data were analyzed to determine the extent and timing of weather variations within Jefferson County and to assess the reliability of local weather forecasts.

There were no consistent differences in the wind directions or speeds between the Culver and COARC locations. Wind direction did vary with time of day and elevation. Changes in wind directions occurred most often at the lower elevations, especially when inversions were present. Wind changes frequently occurred by 11:30 a.m. but could also occur late in the afternoon. With the exception of temperature predictions, the Jefferson County burn forecasts correlated well with the weather events of the day.

Introduction

For the past 10 years, the Jefferson County smoke management team has relied solely on air temperature readings taken by daily airplane excursions to predict local weather patterns. Air temperature readings show the location of inversions but do not provide wind speed or wind direction information.

The Observation Theodolite System provides wind speed and wind direction from the ground up to 10,000 ft elevations above ground in addition to determining potential inversion layers. Other smoke management programs have used the Theodolite successfully for forecasting local weather. In an effort to take advantage of monies paid to the state and to improve local smoke management, Jefferson County growers requested that a project be conducted to evaluate the use of the Theodolite System as part of Jefferson County smoke management.

The objectives of this study were to provide real time wind patterns to the Jefferson County smoke management team, determine if wind speeds and wind directions varied with location in Jefferson County and/or with time of day, and evaluate the accuracy of daily burn forecasts.

Materials and Methods

Wind directions and wind speeds were determined at one-minute intervals for a period of 10 minutes during each session using'an Observation Theodolite System and 26-inch diameter helium filled pibals. Each minute corresponds to the following above ground level elevations in feet: 709, 1,358, 2,008, 2,628, 3,248, 3,839, 4,429, 5,020, 5,610, and 6,201. Sessions generally were conducted five times each day at one of two locations within Jefferson County. The locations were (1) Central Oregon Agricultural Research Center (COARC) Dogwood Lane, Madras, OR, and (2) Benson Farms on the south side of Highland Lane in Culver, OR. Pibals generally were released at 8:30 a.m., 12:30 p.m. and 3:30 p.m. at COARC and at 11:30 a.m. and 2:30 p.m. at Culver.

The 8:30 a.m. pibal wind directions and wind speeds were sent via e-mail to Iry Tillung (Oregon State Department of Agriculture meteorologist), who then supplied Jefferson County with a bum forecast for the day. The burn forecast was based on the pibal data, airplane temperatures, and a variety of computerized weather models. A copy of the 8:30 a.m. pibal data was sent via fax to Doris Schledewitz (Jefferson County Smoke Management Coordinator) along with maximum and minimum temperatures for the previous day and the current Oregon Climate Service forecast for Central Oregon. The results from the 11:30 a.m. and 12:30 p.m. pibal releases were given to Doris Schledewitz via the phone to assist with the afternoon update to the burning plan.

Surface wind speeds, wind directions, humidities, dew points, and air temperatures were taken from the AgriMet weather station located at COARC. The weather station records data every 15 minutes with the exception of wind speeds which are recorded on an hourly basis.

Results and Discussion

Burn forecast accuracy was evaluated by summarizing the predicted Jefferson County weather and burn forecasts with actual daily occurrences. Weather comparisons focused on the 2,000-ft transport winds, surface winds, and the inversion elimination times/temperatures. Data for the table were taken from the field burning advisory reports, AgriMet weather printouts, and the pibal observations. Predicted weather for transport winds and surface winds correlated well with the pibal data. However, about 50 percent of the time, surface air temperature prediction curves developed by Iry Tillung were slower (from one to two hours) than the actual AgriMet temperature curves. Surface air temperature predictions were based on information from Redmond, Oregon, which is 500 ft greater in elevation than the Madras AgriMet weather station. Since Redmond generally reports temperatures a few degrees colder than Madras, this explains the slower temperature curves.

Given the air temperature profile from ground level to 5,000 ft above ground, it is possible to determine what the surface temperature needs to be to break the inversion. Therefore, surface temperature prediction curves are important in forecasting when inversions will be eliminated. Elimination of inversions allows lower level air currents to mix with upper level transport winds, removing smoke farther away from the ground surface and away from the immediate vicinity. Jefferson County smoke management generally started burning earlier than the burn forecast recommended, likely causing greater low-level smoke concentrations. However, because surface heating generally occurred faster than predicted, mixing potentials were probably better than expected.

Balloon release data were compared between Culver and COARC to determine the similarities and differences in conditions across the Jefferson County smoke management region. The releases were timed one hour apart. Most of the direction differences between locations occurred before 12:30 p.m. and were at elevations below 2,000 ft. Of the 20 days where there was at least one complete location comparison, consistent differences in wind directions between the two locations were apparent on only three days (August 18, 26, and 31).

Changes in wind direction occurred on all 17 days where data was collected through 3:30 p.m. Changes in wind direction also occurred on 12 of the additional 14 days where at least two balloons were released on the same day. Most of these changes were below the 2,500 ft elevation level and occurred by 11:30 a.m.

Differences in wind direction often were caused by surface winds that generally changed from a southerly flow early in the morning to a northerly flow later in the day as ground temperatures increased. In addition, at times the presence of slow air currents caused changes in wind directions that were not really significant.

Average wind speeds were calculated for all 10 elevation readings for each balloon release, and then the averages were averaged. There were no differences in wind speeds between the Culver and COARC locations (8.7 mph vs. 8.4 mph, respectively). When separated by time, the Culver site showed slightly faster wind speeds at 12:00 p.m. than the COARC site (9.5 mph vs. 8.8 mph, respectively). The opposite occurred at 3:00 p.m., with Culver showing somewhat slower wind speeds than COARC (7.2 mph vs. 7.8 mph, respectively).

To evaluate the possibility of location differences at lower elevations, wind speeds from the 709-ft, 1,358-ft, and 2,008-ft elevations were averaged and compared. Low elevation wind speed averages were not greatly different between locations (5.8 mph vs. 5.5 mph for the Culver and COARC locations, respectively). When separated by time, the trends were similar to those exhibited by the overall average, but more pronounced (5.7 mph vs. 4.6 mph at 12:00 p.m. and 6.0 mph vs. 7.1 at 3:00 p.m., for Culver and COARC locations, respectively).

The effect of time of day on wind speeds was assessed by comparing the 8:30 a.m. readings to the 3:30 p.m. readings. Comparisons of wind speeds were made for the 709-ft elevations and for an average of all elevations. Wind speeds at the 709-ft elevation were greater at 3:30 p.m. for 14 of 18 comparisons. Generally, AgriMet surface winds also increased with time and, for most of the burn season, ranged from one to five miles per hour. In contrast, only seven of the 18 comparisons for average wind speeds were greater at 3:30 p.m. Although wind speeds were generally greater at the end of the day, there were three days when wind speeds at the 709 ft elevation slowed down with time and several occasions when wind speeds varied up and down throughout the day.

Wind direction, wind speed, and the existence of inversions directly effects smoke dispersion. For example, strong winds (6 mph at the surface and 10 mph at 709 ft) on August 25, 1999 kept the smoke column moving horizontally to the ground, creating poor road visibility and hazardous driving conditions. On August 26, 1999, slower wind speeds (3 mph at the surface and 9 mph at 709 ft) allowed for vertical smoke movement up to 2,600 ft before hitting an inversion. The effect of inversions (areas where wind speeds are slow and air temperatures do not change) is to keep the smoke trapped near the ground rather than allowing it to rise and move out of the area, as occurred on September 24, 1999. On the 24th at 11:45 a.m., an inversion layer about 2,500 ft above the ground prevented smoke from breaking into the 15-to-20 mph upper westerly transport winds. Then, as the inversion started to break, low elevation winds picked up from the southeast and spread the smoke column back towards the ground (12:15 and 12:45 p.m.). In contrast, on September 23 the absence of an inversion and low elevation wind speeds of 6 to 7 mph dispersed smoke upwards and to the northeast. Thirty minutes later, little trace of visible smoke remained.

Recommendations

After evaluating results from the first year of this two-year project, the following recommendations are suggested for the second year.

1. Continue to release two to five pilot balloons daily to provide better understanding of changes in wind speed and direction.
2. Release morning balloons as late as possible to obtain wind speeds and directions more closely related to those occurring at the time field burning starts.
3. Release balloons at sensitive areas just prior to burning.
4. Take pictures of smoke dispersion with each balloon release.