

# Weather conditions and time intervals to reduce the potential for off-target movement of spray due to temperature inversions – An Update

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# The Problem

Spraying must not occur where there is upward air movement or where a temperature inversion prevents the spray cloud settling within the treated area (FAO, 2001).

- Temperature inversions are associated with **STABLE** atmospheric conditions
- Close to the ground, atmospheric stability changes diurnally between **STABLE, NEUTRAL, & UNSTABLE**

105 foot temperature monitoring tower



← 105' 38°F

← 64' 40°F

← 32' 40°F

← 16' 41°F

← 8' 41°F

Cloud of 5-25 u oil droplets generated under unstable conditions

OK to SPRAY!

AM 9:15:42

## Temperature Profile

105' 35°F

64' 30°F

32' 29°F

16' 28°F

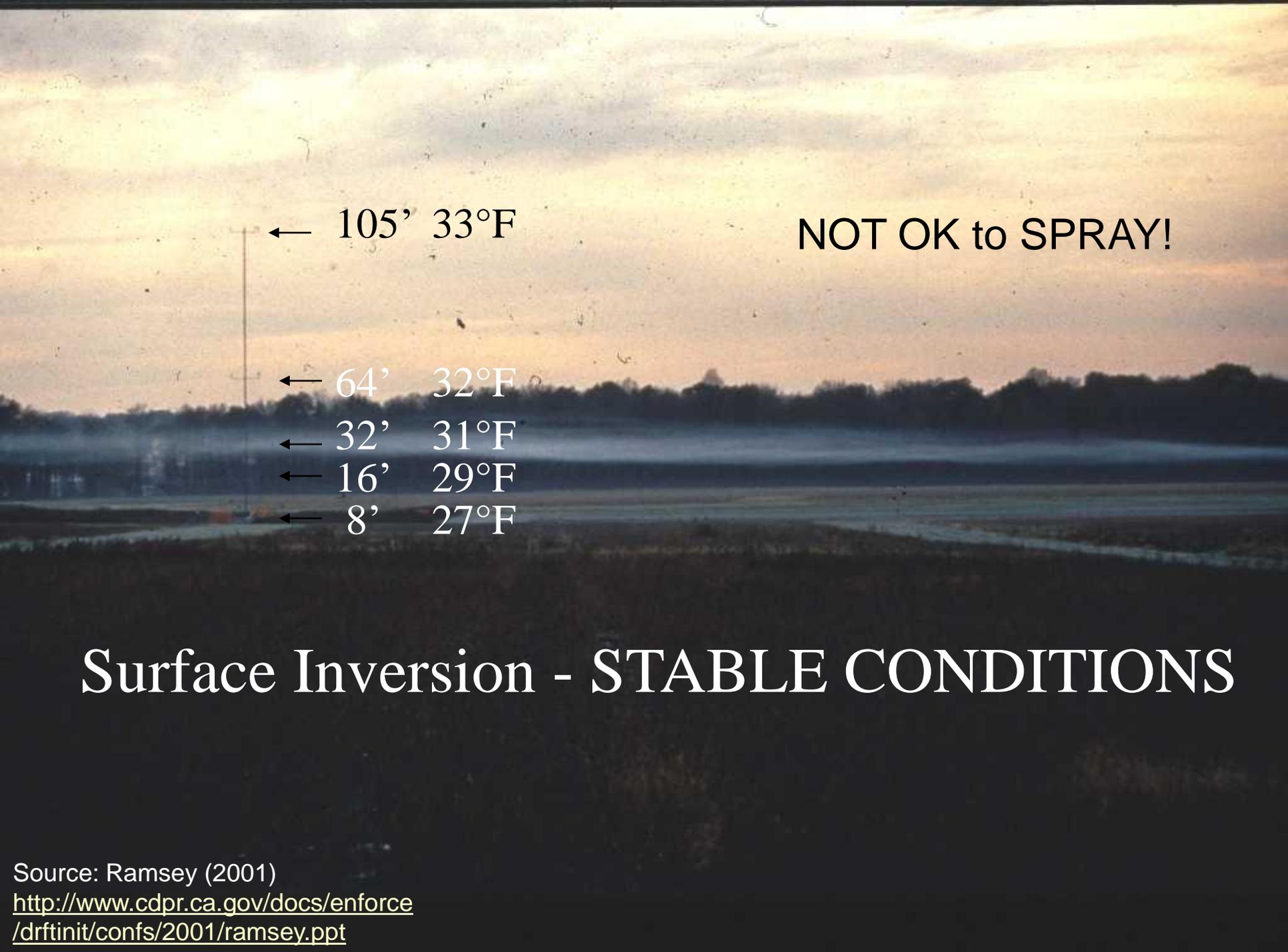
8' 26°F

Surface Inversion - STABLE CONDITIONS

AM 6:57:44

Source: Ramsey (2001)

<http://www.cdpr.ca.gov/docs/enforce/drftinit/confs/2001/ramsey.ppt>



← 105' 33°F

NOT OK to SPRAY!

← 64' 32°F

← 32' 31°F

← 16' 29°F

← 8' 27°F

## Surface Inversion - STABLE CONDITIONS

Source: Ramsey (2001)

<http://www.cdpr.ca.gov/docs/enforce/drftinit/confs/2001/ramsey.ppt>

# Stability Ratio

- Is a function of temperature at two heights and windspeed
- When temperature increases with height and this is combined with low enough windspeed, the stability ratio may indicate STABLE atmosphere.
- Application should not be made under these conditions

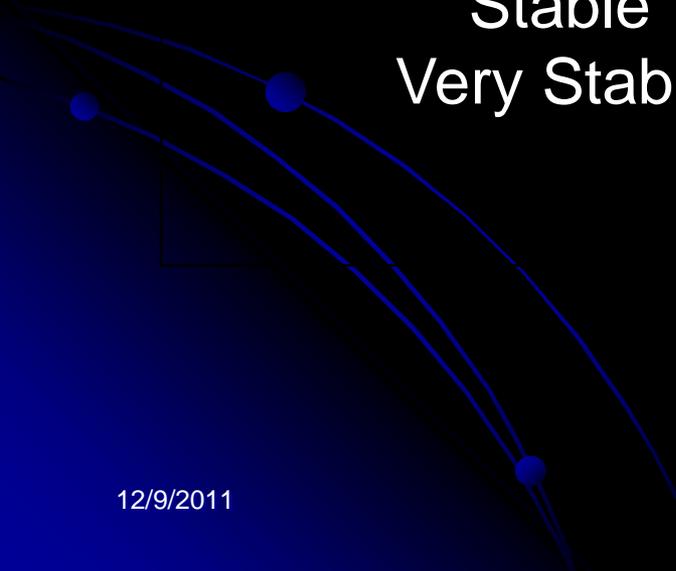
## Atmospheric Stability Category

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## SR Result

→ Unstable	-1.7 to -0.1
→ Neutral	-0.1 to 0.1
Stable	0.1 to 1.2
Very Stable	1.2 to 4.9

OK to spray



# Example - Arkansas Plant Board

- Enhanced regulations because of numerous spray drift complaints
- The detrimental effects on cotton of spraying 2, 4-D to rice or pastures under conditions of a temperature inversion have been documented (Bennett, 2006).
- Total complaints (due to spraying under temperature inversions, high wind, wrong wind direction, bad setup, etc) were 50/50 aerial and ground – Ford Baldwin

# Published criteria on when to avoid spraying

- Arkansas Agricultural Aviation Association, May 2007 Newsletter

Arkansas State Plant Board- Mike Thompson, Pesticide Division Director & Susie Nichols – Enforcement, were on hand to answer questions as well as handout such Command aerial application label, Glyphosate regulation and 2-4-D Regulation. Nichols noted that:

- the Propanil manufactures required by EPA to conduct an exposure study. There are five states participating, it is voluntary and that 60 in Arkansas had been chosen. (note: This is not through the ASPB) Hazard Evaluation and Regulatory Affairs Company (HERAC) of Greensboro, North Carolina was contracted to do this survey.
- the Command by Air 24 c – everything is the same as last year except that it is good for 5 years.
- the Glyphosate Regulations - applies to products packaged in containers one gallon or larger, labeled for agriculture use in row crops and rice production; applies to commercial right-of-way treatments; does not apply to pasture usage; may not be applied in a wind speed greater than 10 mph; may not be applied until there has been a 3 degree temperature increase from the morning low and may not be applied after a 5 degree temperature decrease from the afternoon high; civil penalty including a Warning Letter will be \$1,000.00 for each violation; for civil penalty assessment, glyphosate will be considered a restricted-use product.
- The 2-4-D Regulations - these conditions apply from April 15 – September 15 – no air or ground applications of 2-4-D in Clay, Greene, Craighead, Poinsett, Cross, Crittenden, St. Francis, Lee, Phillips and Mississippi counties. This means No pasture applications in these counties during this time period. If a producer can provide acceptable

### *Arkansas Agricultural Aviation Association*

Glyphosate...”may not be applied until there has been a 3 degree temperature increase from the morning low and may not be applied after a 5 degree temperature decrease from the afternoon high”

- Arkansas Pesticide Use and Application Act – Regulations (Rev. 2008)
  - Chapter 20 - PESTS AND PESTICIDES, SUBCHAPTER I, GENERAL PROVISIONS

- All subsequent verification documentation must be provided to the Flight Board prior to use of the setup.
- (B) The spray boom height at the time of product release shall not exceed 15 feet above the crop canopy. Where obstructions in or adjacent to the field of application will not safely allow application at the 15 foot level, a higher elevation may be used in the vicinity of such obstructions. However, where the product label imposes more restrictive application elevations, those elevations must be complied with.
  - (C) Herbicide applications may not be made under conditions where the spray may possibly be entrained in an inversion layer. As an indicator that an inversion is unlikely to exist, the applicator shall record the ambient temperature measured at the airstrip from which he/she is working for each application. Inversions are much less likely to exist if the temperature has increased three (3) degrees Fahrenheit from the morning low at the time of application for applications made before noon or has not decreased more than three (3) degrees Fahrenheit from the afternoon high for applications made after noon. The applicator should also use other legal means available to him/her to verify that an inversion does not exist.
  - (D) All spray nozzle discharges must be pointed toward the rear of the aircraft and a minimum of ten (10) inches below the trailing edge of the wing.
  - (E) The spray boom length divided by the wing span shall not be greater than 0.7 for fixed wing aircraft and 0.8 for rotary wing aircraft.
  - (F) The wind shear angle of the spray nozzle discharge may not exceed thirty (30) degrees. However, the spray classification category requirements of paragraph (1)(i) below must be met.
  - (G) Drift reduction nozzles such as Eagle Jet, CD drift reduction tips, narrow angle (65 degrees or less) flat fans

“Inversions are much less likely to exist if the temperature has increased three (3) degrees Fahrenheit from the morning low at the time of application for applications made before noon or has not decreased more than three (3) degrees Fahrenheit from the afternoon high for applications made after noon.”

- Do these temperature criteria make sense?
- What are wind speeds below which temperature inversions occur?
- Does any of this depend on time of year?

- We took temperature and wind data on weather towers to answer these questions

# Procedures

- We logged temperature and wind data from a weather tower using high precision thermistors and wind sensors
- Heights of data acquisition were
  - 15, 30, 45, 60, 75, 90 feet for temperature
  - 15, 40, 65, and 90 feet for wind

# Procedures

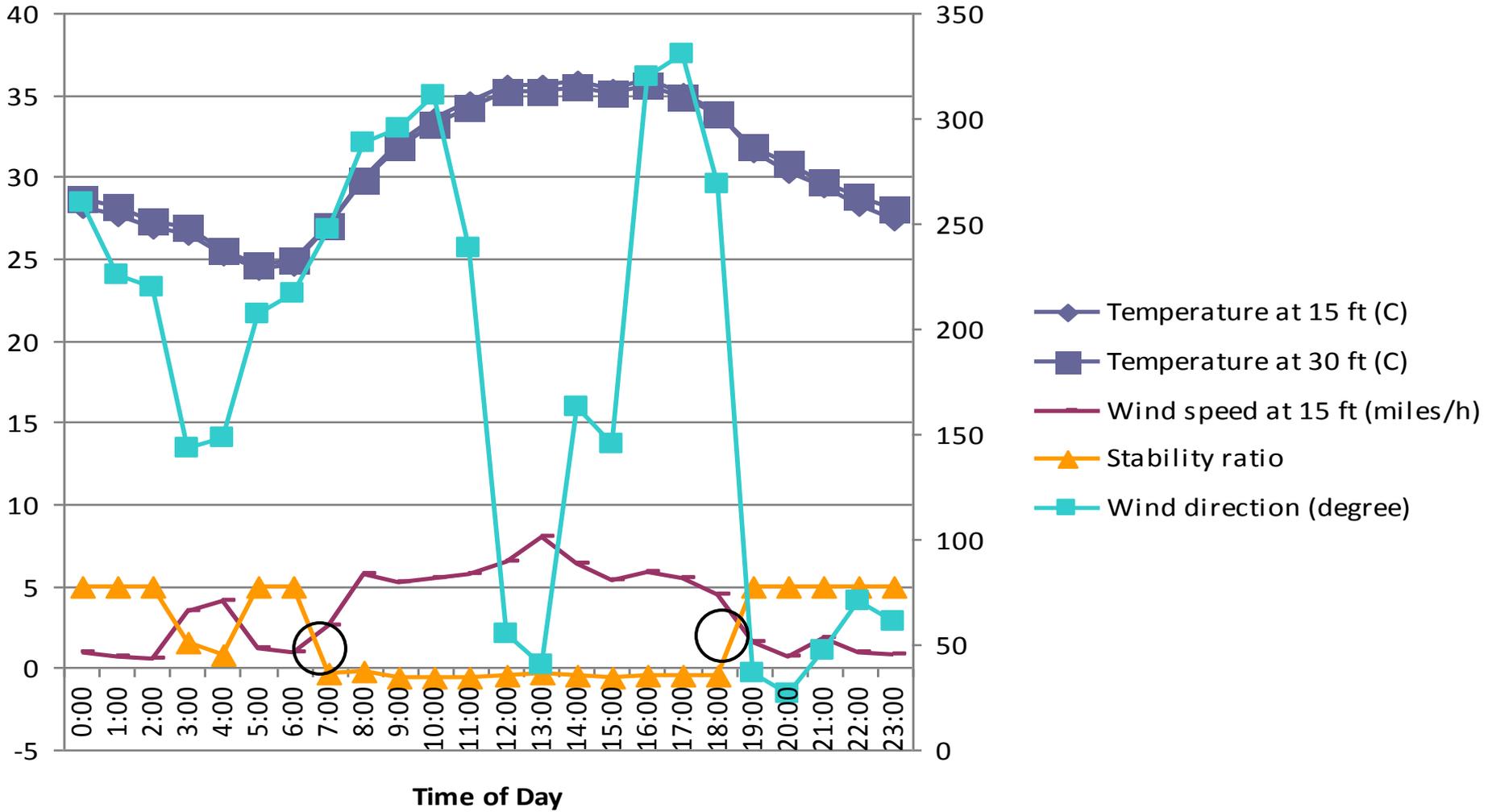
- Data were analyzed to determine when inversions typically occurred, and when stability ratios indicated STABLE conditions where spraying is NOT advised.

# Results

## Summer months

12/9/2011

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15 July, 2004

# 15 July 2004

- “Safe to spray” began sometime between 6:00 and 7:00 AM and continued to between 6:00 and 7:00 PM

# 15 July 2004

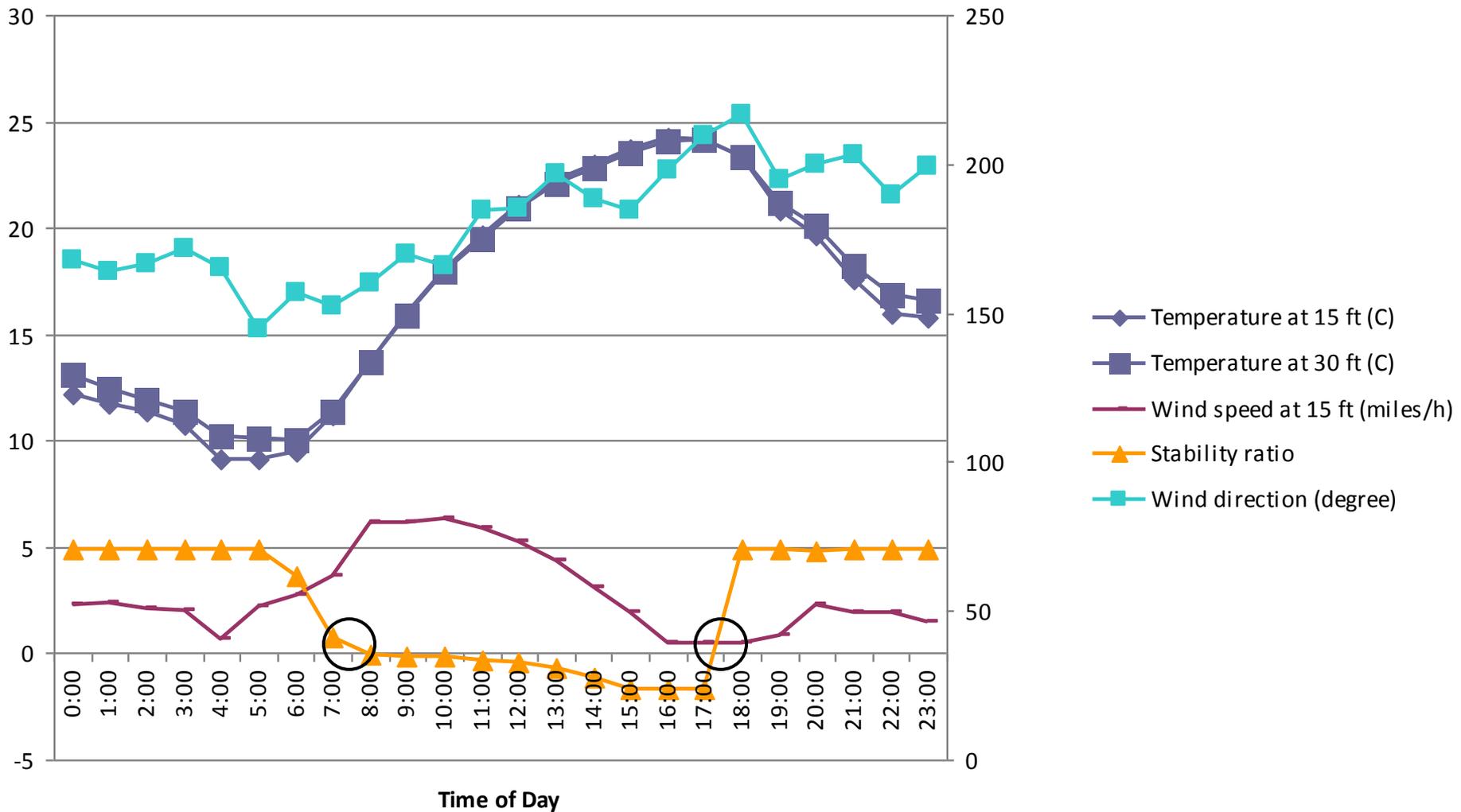
- Morning temperature rise was  $0.3^{\circ}\text{F}$  (6:00) and  $4.8^{\circ}\text{F}$  (7:00) AM.
  - Wind speed went from 0.9 to 2.6 mph

# 15 July 2004

- Evening temperature reduction was 3.5° F at 6:00 and 7.8°F at 7:00 PM
  - Wind speed went from 4.4 to 1.5 mph
- Recommendation for 3 degree temperature reduction after which 'no spray' was conservative

# Results

Spring and Fall – cooler temperatures



15 April, 2004

# 15 April 2004

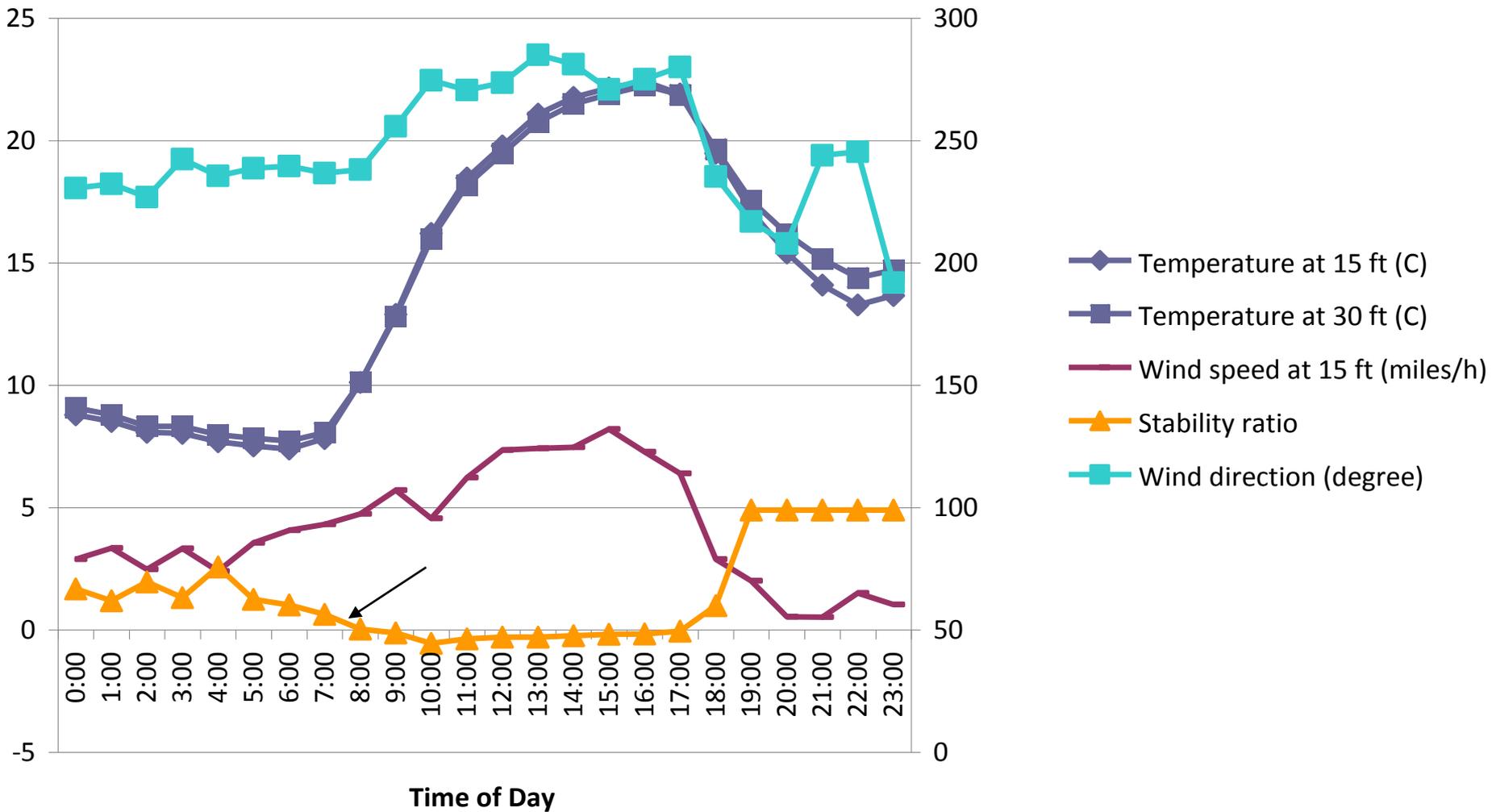
- “Safe to spray” began sometime between 7:00 and 8:00 AM to just after 5:00 PM

# 15 April 2004

- Morning temperature rise was 3.8° (7:00) and 8.3° F (8:00).
  - Wind speed went from 3.7 to 6.1 mph

# 15 April 2004

- Became unsafe to spray way before 3° temperature reduction was met in evening
  - Evening wind was calm



15 October, 2004

# 15 October 2004

- “Safe to spray” began sometime between 7:00 and 8:00 AM and continued to between 5:00 and 6:00 PM

# 15 October 2004

- Morning temperature rise was 0.8°F (7:00) and 4.9°F (8:00) AM.
  - Wind speed went from 4.3 to 4.7 mph

# 15 October 2004

- Evening temperature reduction was 0.9° at 5:00 PM and 4.8°F at 6:00 PM
  - Wind speed went from 6.4 to 2.9 mph

# Summary

- During hot summer months, guideline to wait for 3° F temperature rise in morning and not spray after a 5° decrease at dusk is valid by our data.
  - Wind speeds as low as 2.6 mph were “OK to Spray” only if these conditions existed.
- Previous data from Texas indicates similar times of day to avoid spraying (Fritz et al., 2008) as our Mississippi study for summer months

# Summary

- During spring and fall, surface heating took longer, so period where it was “Safe to Spray” occurred one hour later in the morning; to one hour earlier at dusk.
- Guideline to wait for 3° F temperature rise in morning and before a 5° decrease at dusk seemed to be the better choice.
- Neither guideline was a good indicator in the Spring when the wind was calm, especially in the afternoon.
  - Keeping wind speed greater than 4 mph was better insurance for spray safety.

# Acknowledgements

- Dr. Lowrey A. Smith (retired) for beginning the work on temperature inversions in 2003

# Thank You!

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