Mixing Heights & Smoke Dispersion

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Brief Introduction

- Fire Weather Program Manager
  - Liaison between the NWS Chicago office and local fire/land managers
- At Chicago since December 2000
  - Shreveport, LA
  - Northern Indiana

National Weather Service

- Federal Agency
  - NOAA (National Oceanic & Atmospheric Administration)
  - DOC (Department of Commerce)
- Mission, protection of life and property
- Staffed 24/7/365
- Fire weather forecasts vary by office, by season and by local user needs

Outline

- Mixing Heights/Soundings
- 1700 FT Forecast Mixing Temperature
- Seasonal Affects on Mixing Heights
- Transport Winds/Ventilation/Dispersion
- Afternoon dip in relative humidity
- Red Flag Warnings/Fire Weather Watches
- Surface Wind definition

Mixing Heights

- The height to which smoke will rise before spreading out (inversion = mixing height)
- Layer of stable air where temperatures warm with increasing height
- Acts as a lid, severely limiting amount of vertical motion

Mixing Heights

- Expressed in FT AGL (feet above ground level)
- Typically will be very low at night, usually less than 1000 ft, sometimes at the surface, due to surface cooling
- 1700 Feet
  - Minimum height most users want before burning
  - Depends on location, size, fuel type, etc., of burn site

Mixing Heights

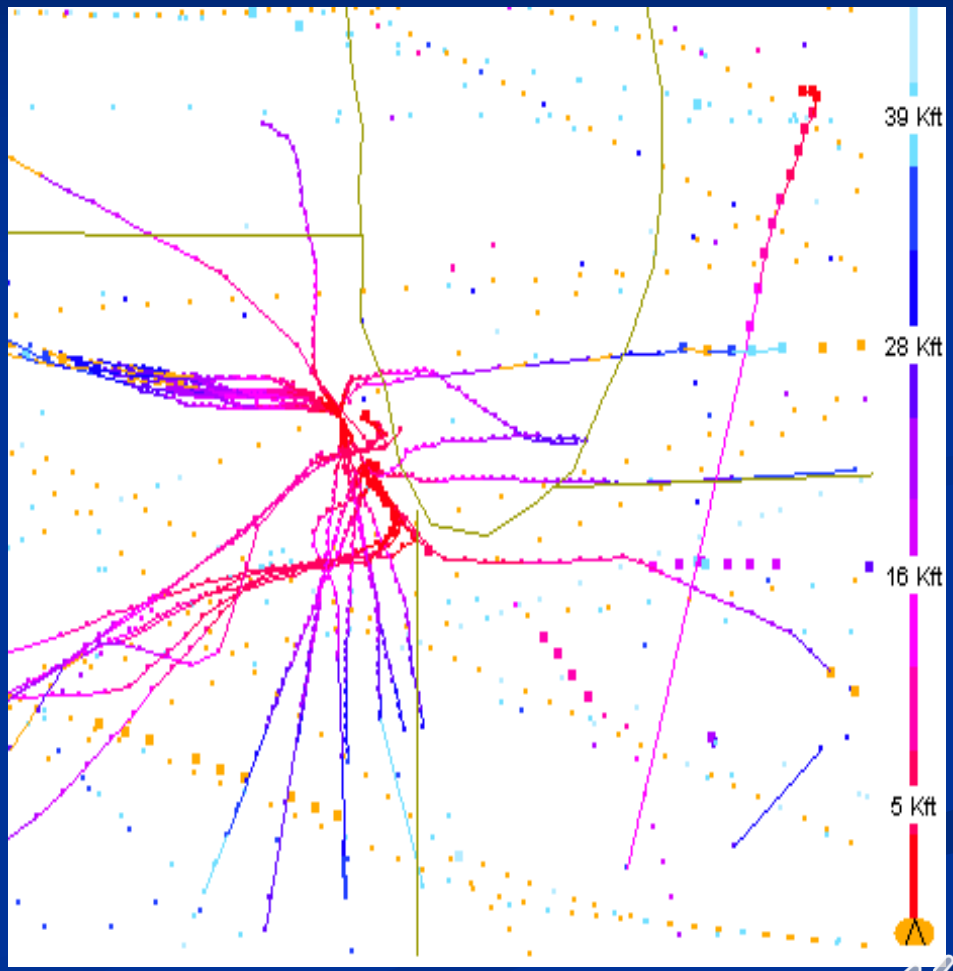
- Generally, an easy parameter to forecast, in terms of data availability
  - Multiple computer forecast models
  - Multiple forecasts levels & heights
  - Hourly forecast data available from some models
- Forecast accuracy dependent on many factors
  - Cloud cover and temperatures
- Data plotted and referred to as “soundings”

Difficult to Observe/Verify

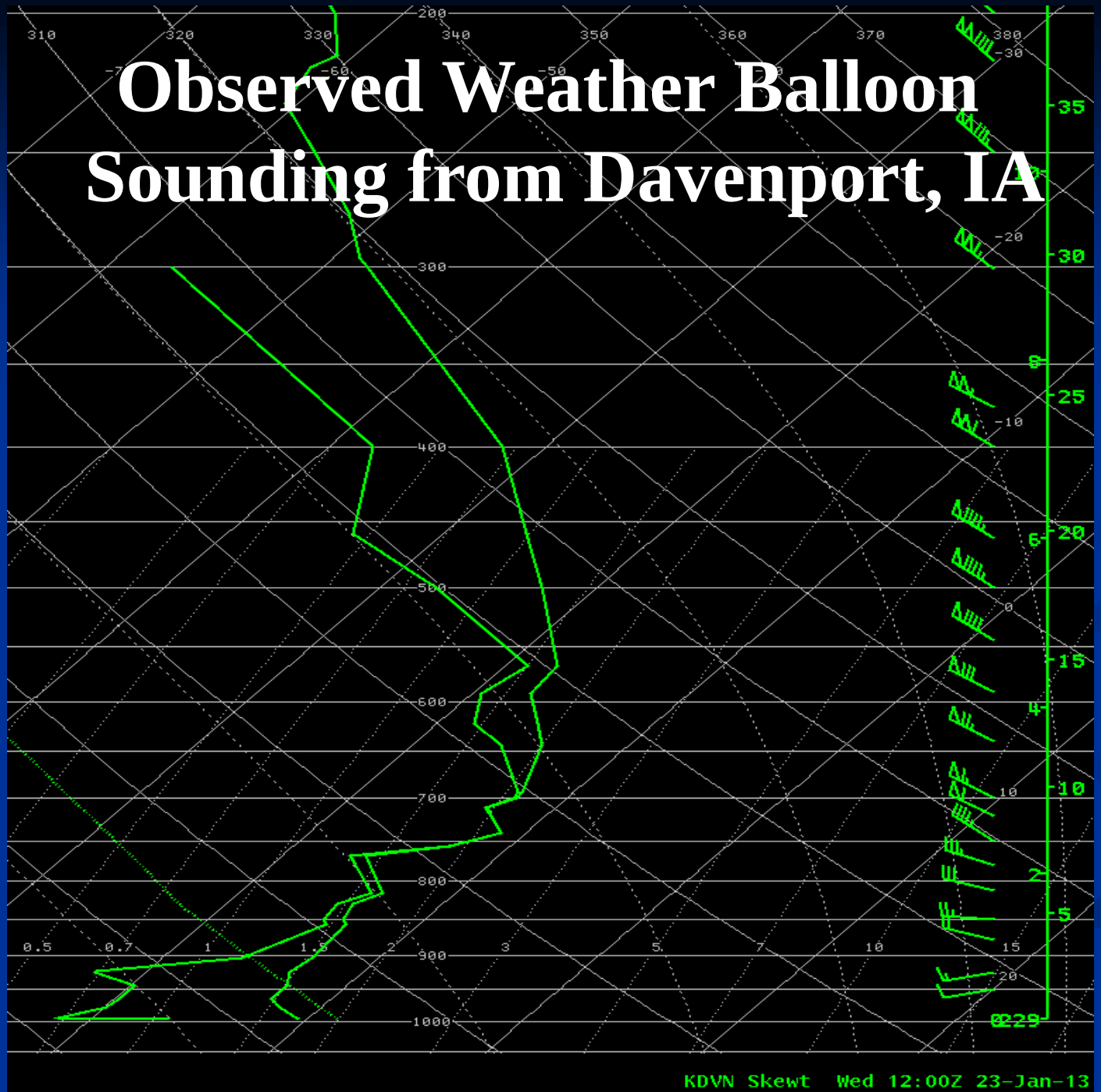
- Weather Balloons
  - Twice a day, early morning & early evening
  - Roughly 80 locations spread out across the country

Difficult to Observe/Verify

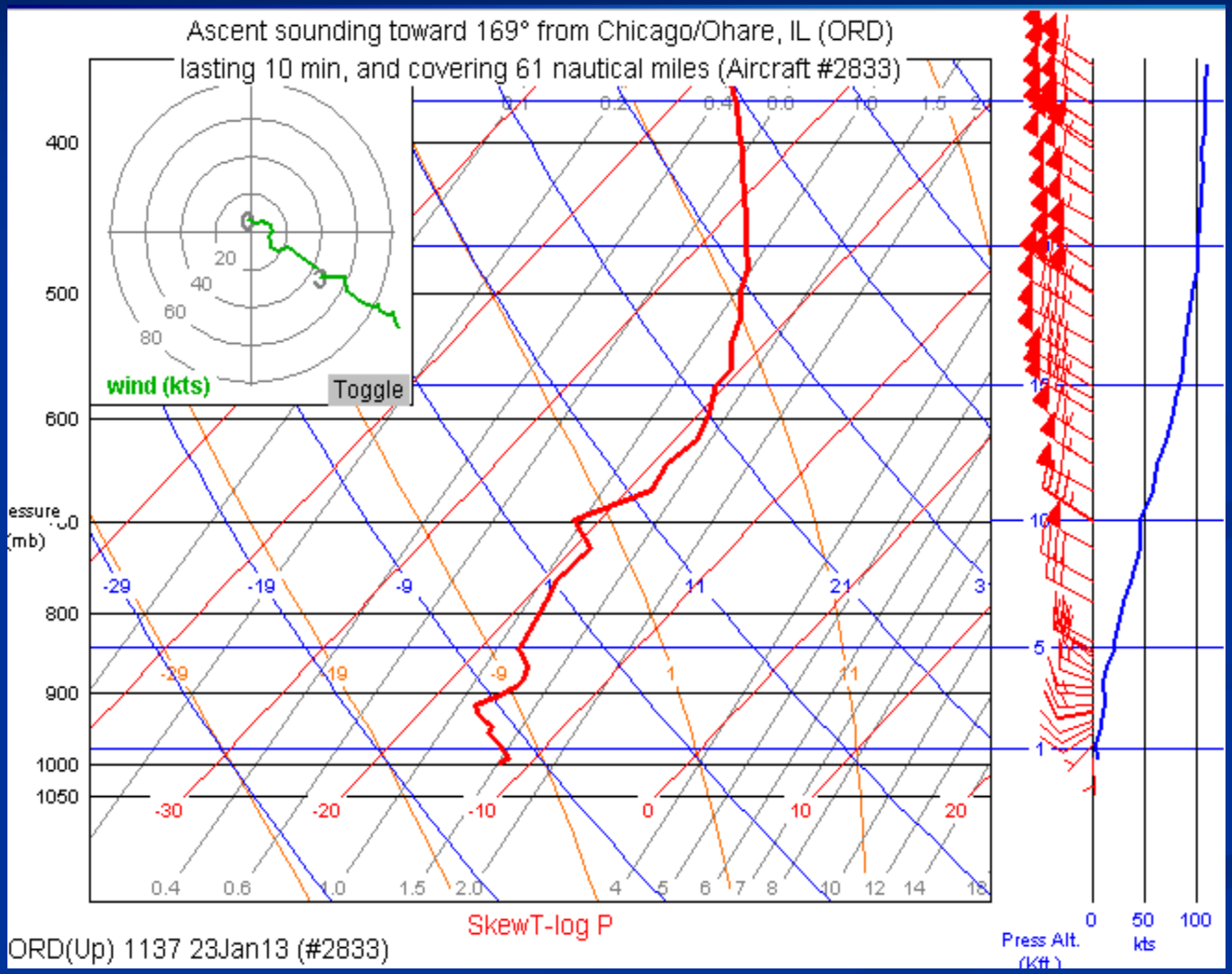
- Weather sensors on aircraft
  - Clustered around large airports/metro areas
  - Only available to federal agencies



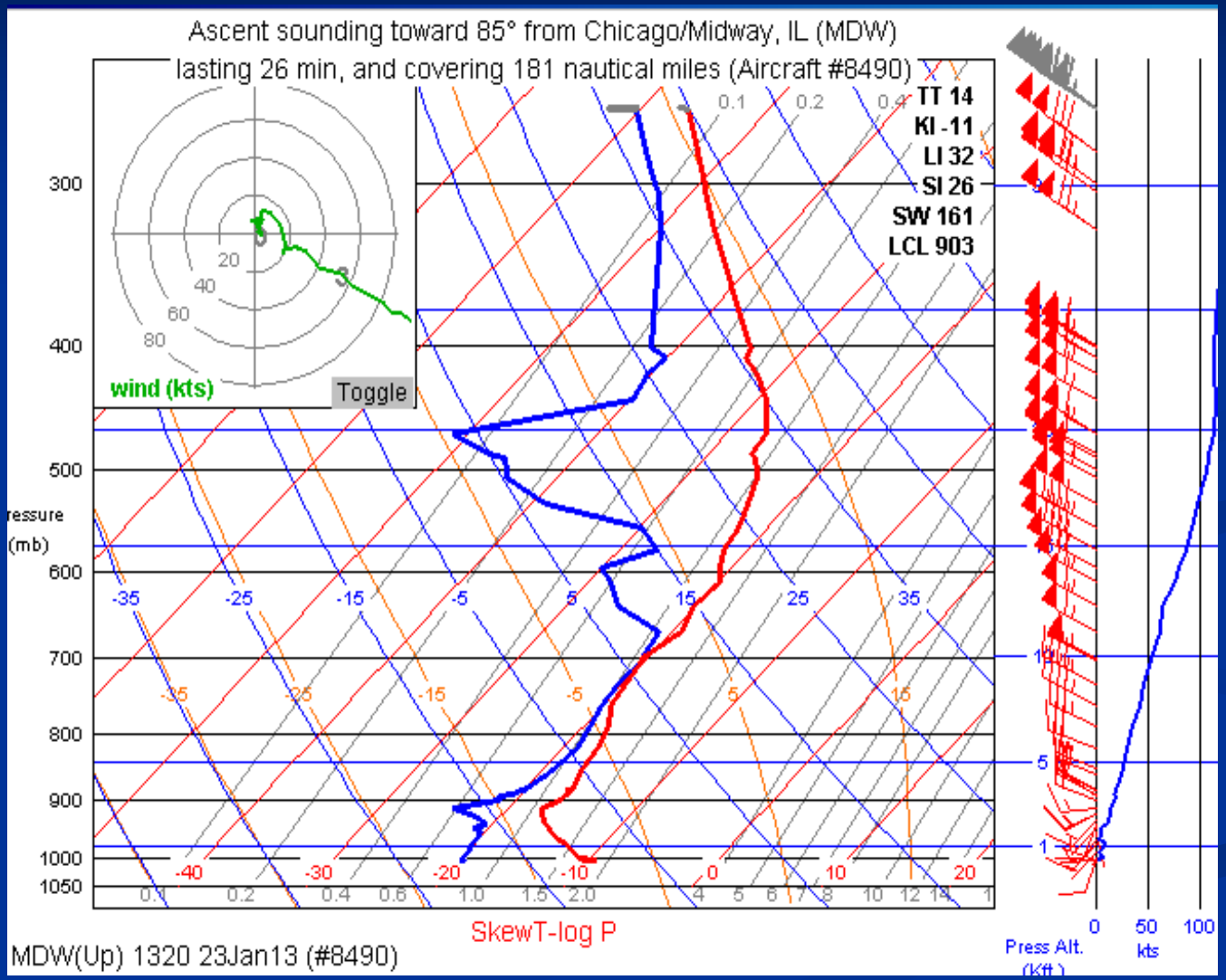
Observed Weather Balloon Sounding from Davenport, IA



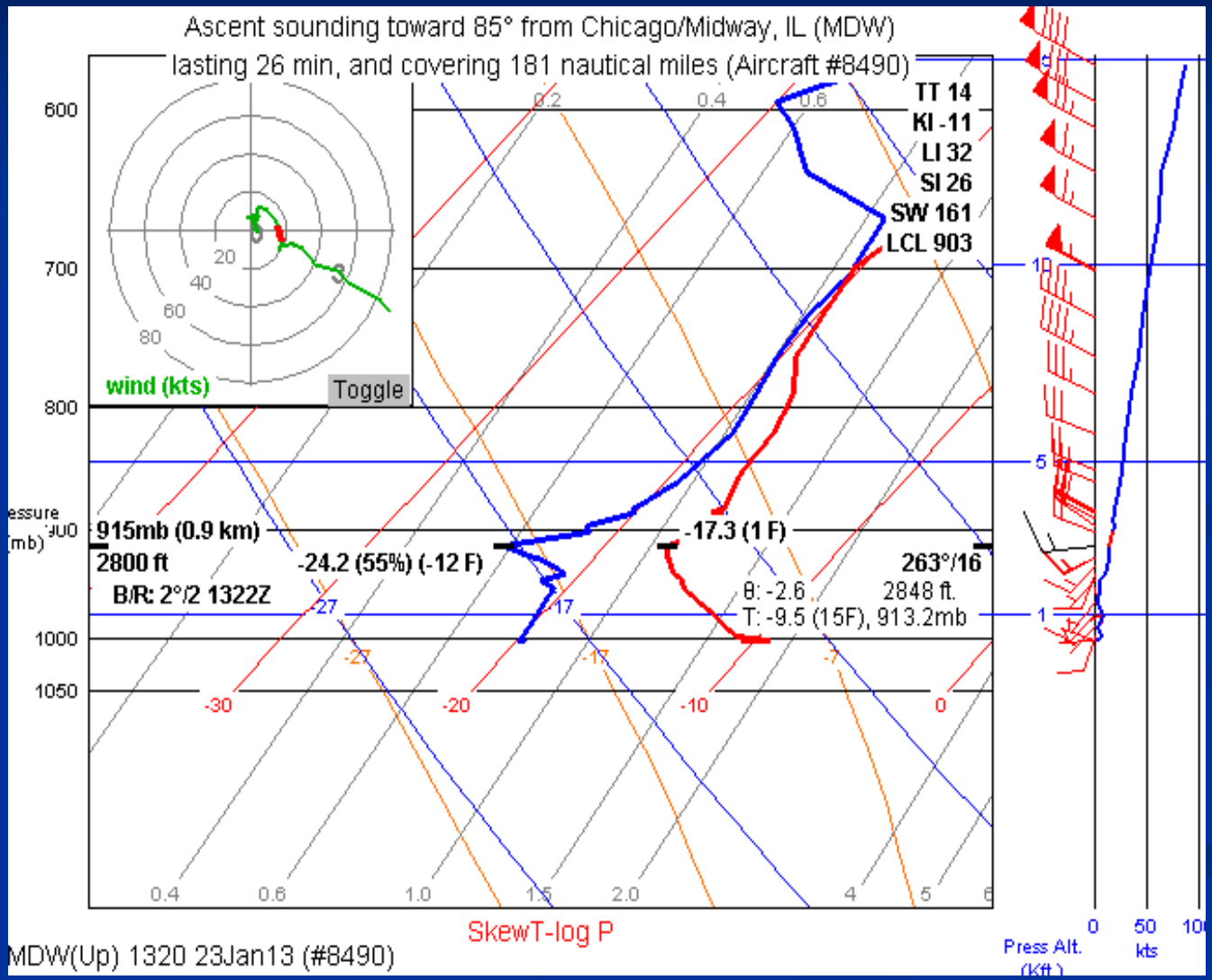
Observed Aircraft Sounding

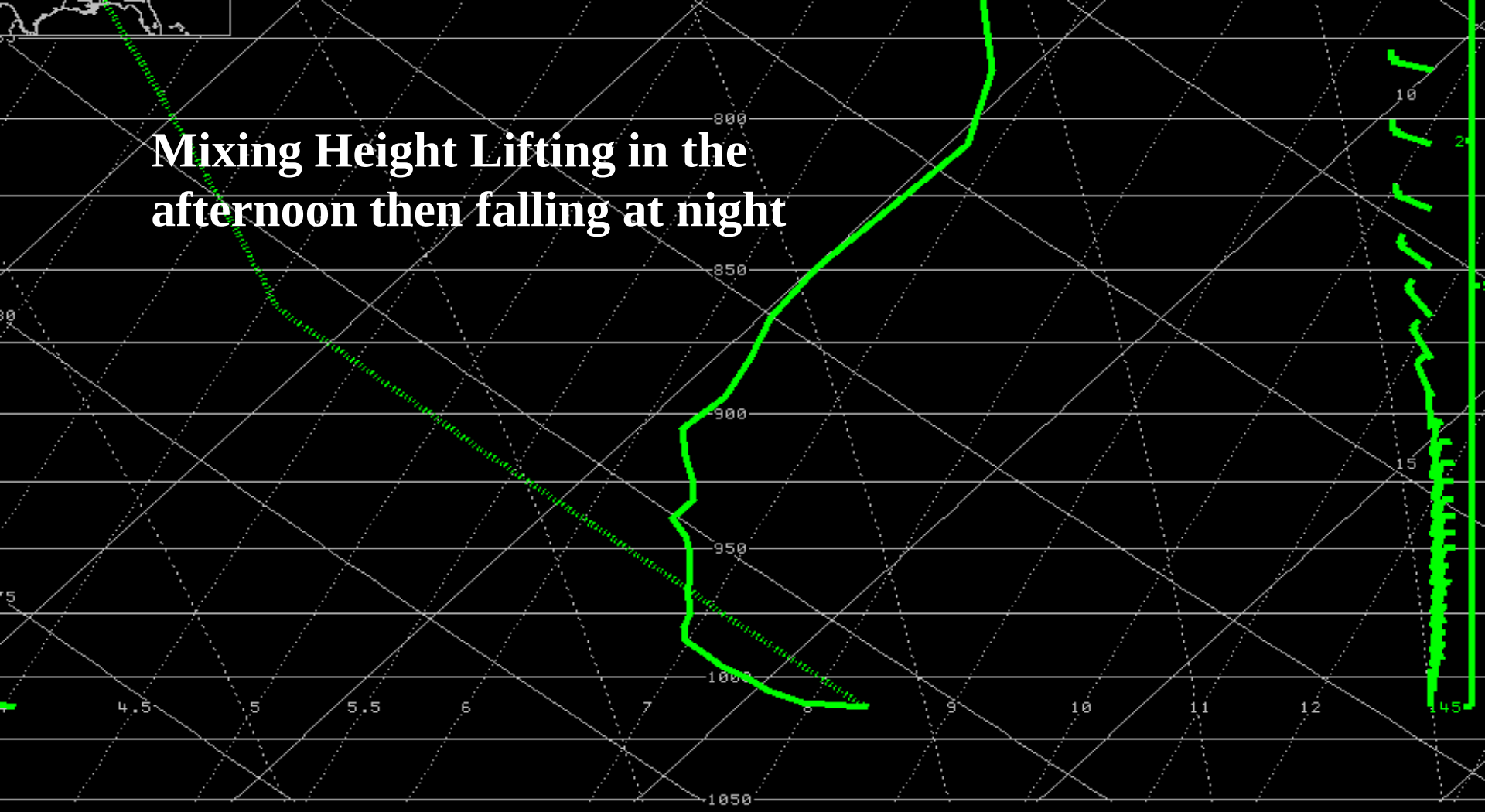


Observed Sounding with Dewpoint



Lowest Levels





Mixing Height Lifting in the afternoon then falling at night

1700 FT Mixing Temperature

- When the ***observed*** surface temperature equals the 1700 FT ***forecast*** mixing temperature, it can be ***estimated*** that the mixing height is now near or passing through 1700 feet.
- Used as a rough estimate by field personnel
- Local conditions such as bodies of water, terrain, rural vs. urban areas, may have impacts

1700 FT Mixing Temperature

- If the 1700 FT ***forecast*** mixing temperature is ***equal to or less than*** the forecast high/maximum temperature, then the mixing height is forecast to reach 1700 feet or higher
  - Max temp forecast, 65 degrees
  - Max mixing height forecast, 4500 ft
  - 1700 ft forecast mixing temperature, 58 degrees
  - When your surface temperature reaches 58 degrees, the mixing height is ***forecast*** to be near 1700 ft

1700 FT Mixing Temperature

- If the 1700 FT ***forecast*** mixing temperature is ***higher/warmer than*** the forecast high/maximum temperature, then the mixing height is **NOT** forecast to reach 1700 feet
  - Max temp forecast, 55 degrees
  - Max mixing height, 1500 ft
  - 1700 ft forecast mixing temperature, 58 degrees
  - Your surface temperature would have to reach 58 degrees for a 1700 ft mixing height, but the forecast high temperature is only 55 degrees

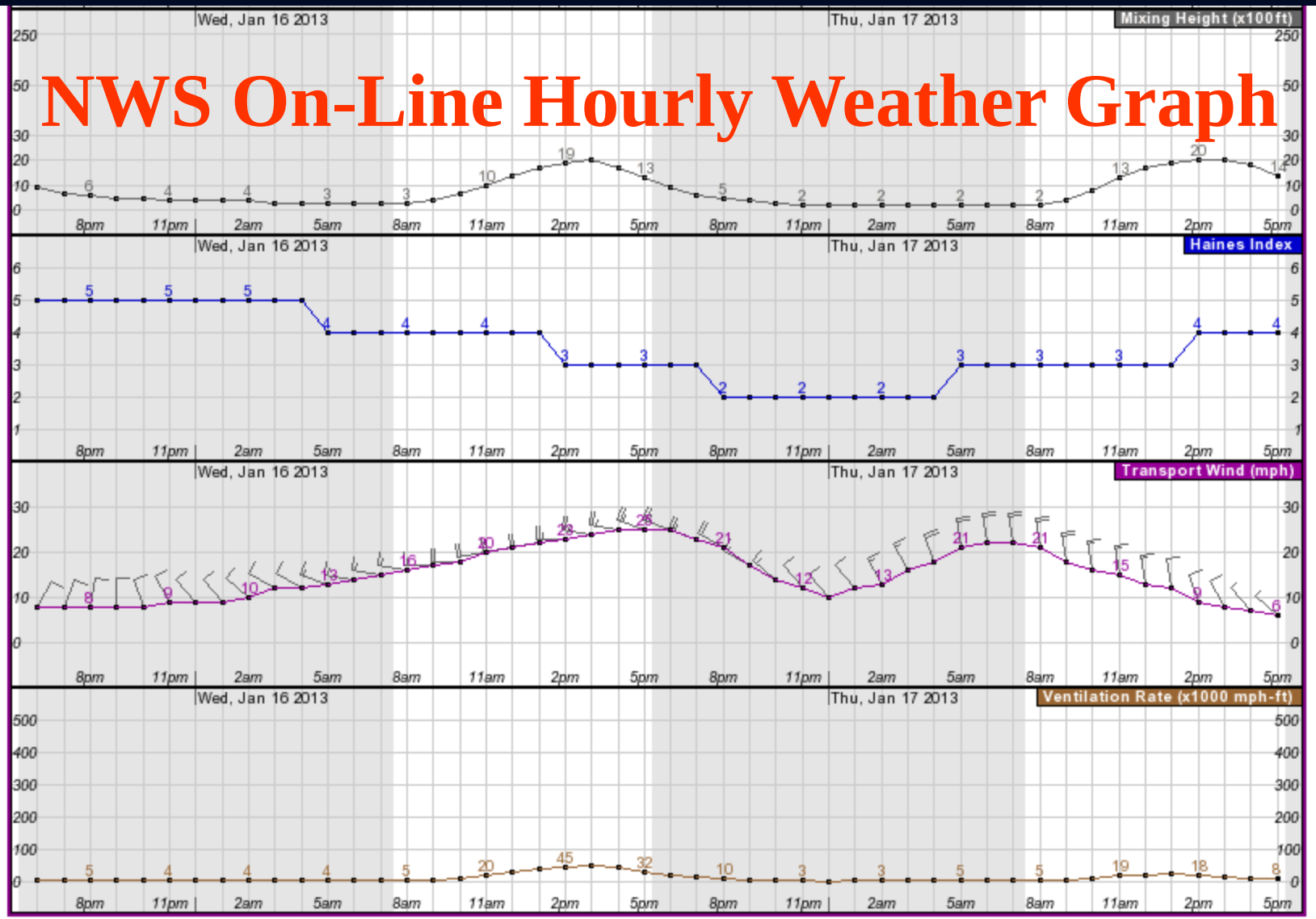
1700 FT Mixing Temperature

- IMPORTANT! This is only a forecast! Forecasts can and do change!
  - Unexpected cloud cover could keep temperatures lower than expected and thus not reach the 1700 ft mixing temperature or even the expected max/high temperature. **Result: Much lower mixing heights**
  - Temperatures may warm to or above the 1700 ft forecast mixing temperature, pushing the mixing height well above 1700 ft. **Result: Much higher mixing heights**

1700 FT Mixing Temperature

- Hourly weather graphs of mixing heights available on-line from many NWS offices, which will show height in feet vs. time
- Provides detailed information for specific grid points
- 1700 ft forecast mixing temperature still an important tool/parameter in the field and can help determine whether mixing height graphs are on track

NWS On-Line Hourly Weather Graph

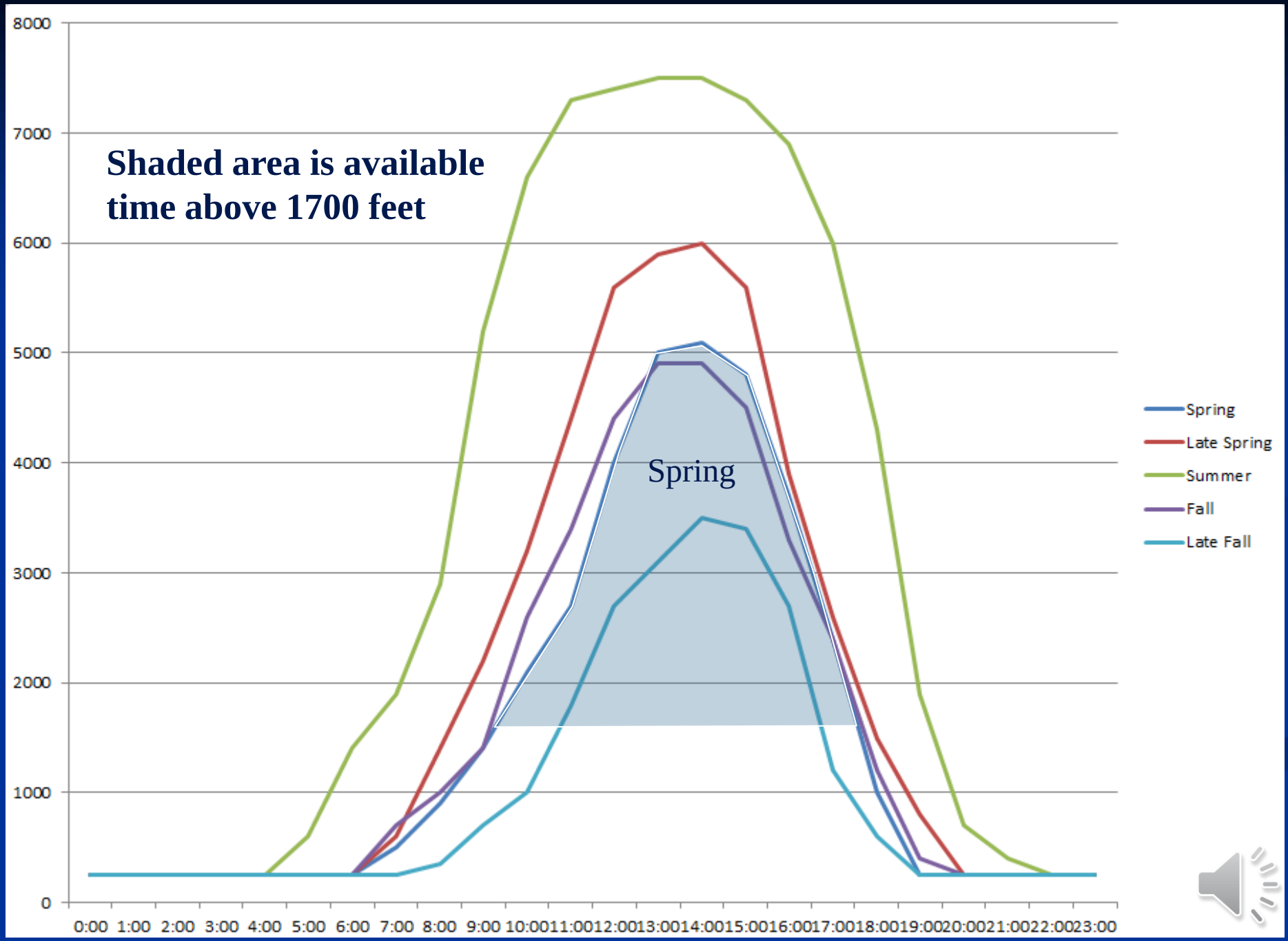


Wednesday, January 16 at 3pm

Temperature: 41 °F Dewpoint: 18 °F Wind Chill: 36 °F Surface Wind: W 9mph
Sky Cover: 11% Precipitation Potential: 2% Relative Humidity: 39%
Thunder: <10% Rain: <10% Snow: <10% Freezing Rain: <10% Sleet: <10%
Mixing Height: 2000ft Haines Index: 3 Ventilation Rate: 48000mph-ft
Transport Wind: W 24mph

Mixing Heights

- Seasonal Affects
  - Duration of sunlight
  - Mixing heights reach 1700 FT earlier and stay above 1700 FT longer
  - Potential for mixing heights to reach higher, several thousand feet
- At the same time, vegetation is greening up


Shaded area is available time above 1700 feet
Spring
Spring
Late Spring
Summer
Fall
Late Fall
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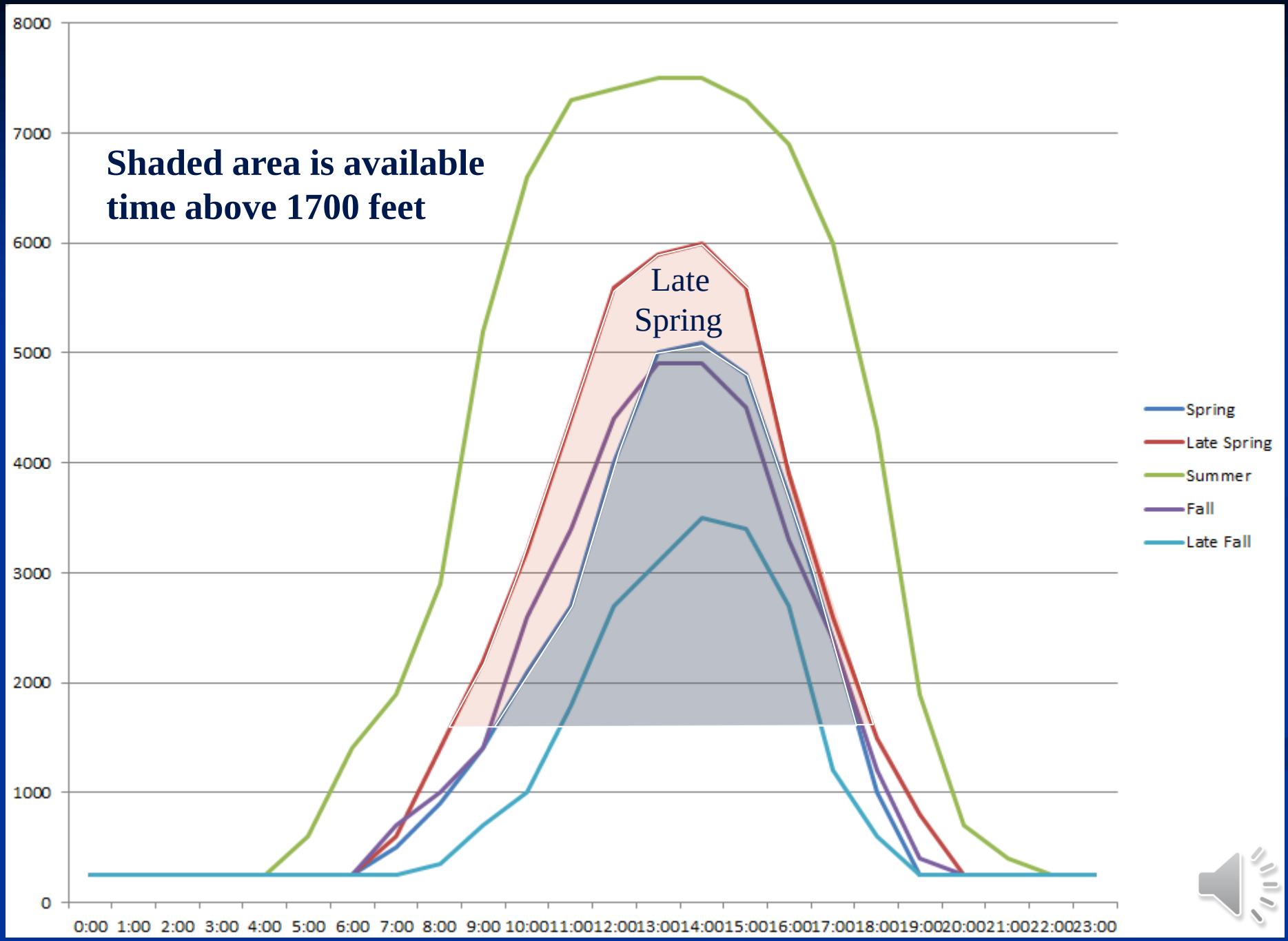
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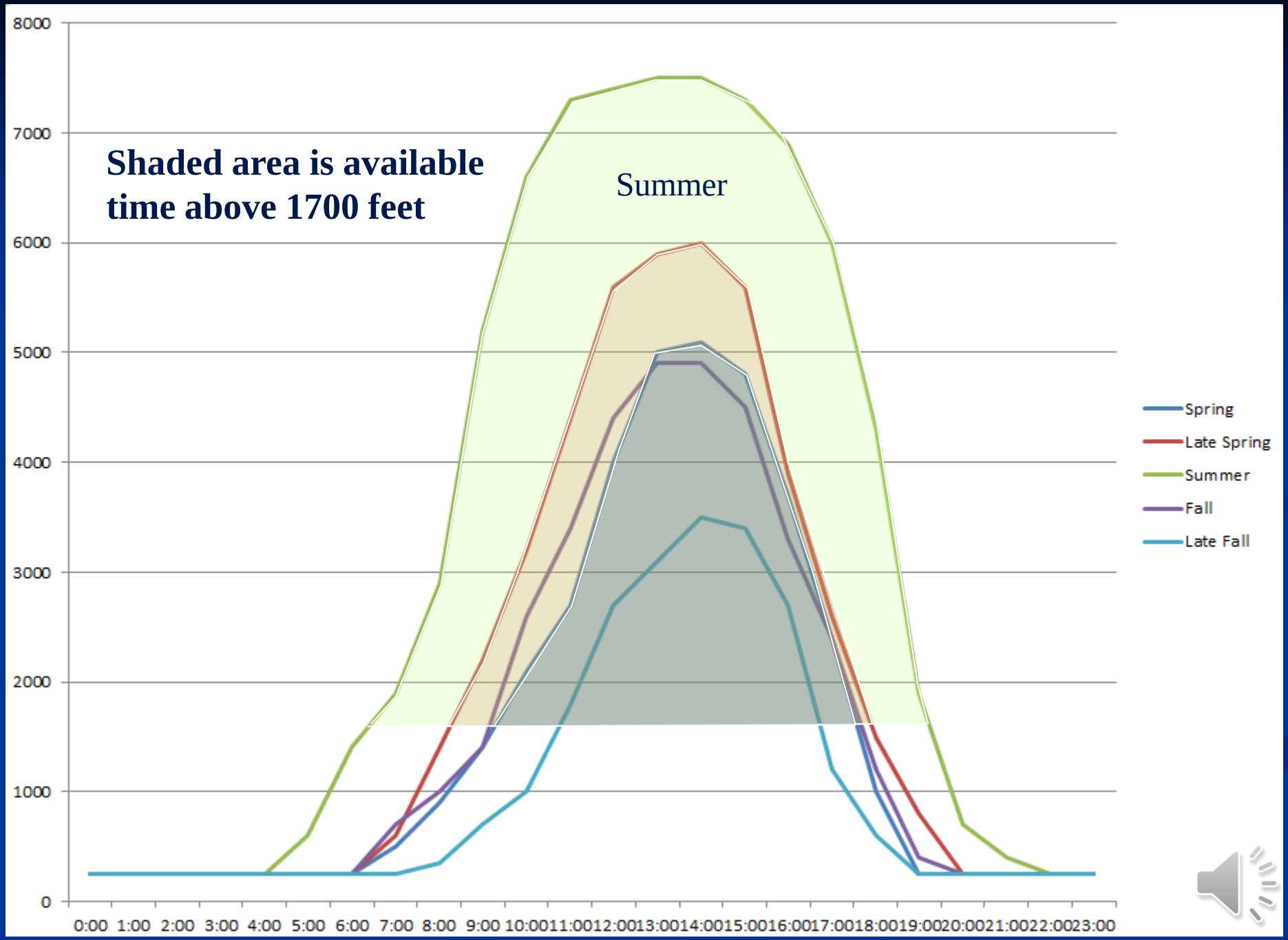
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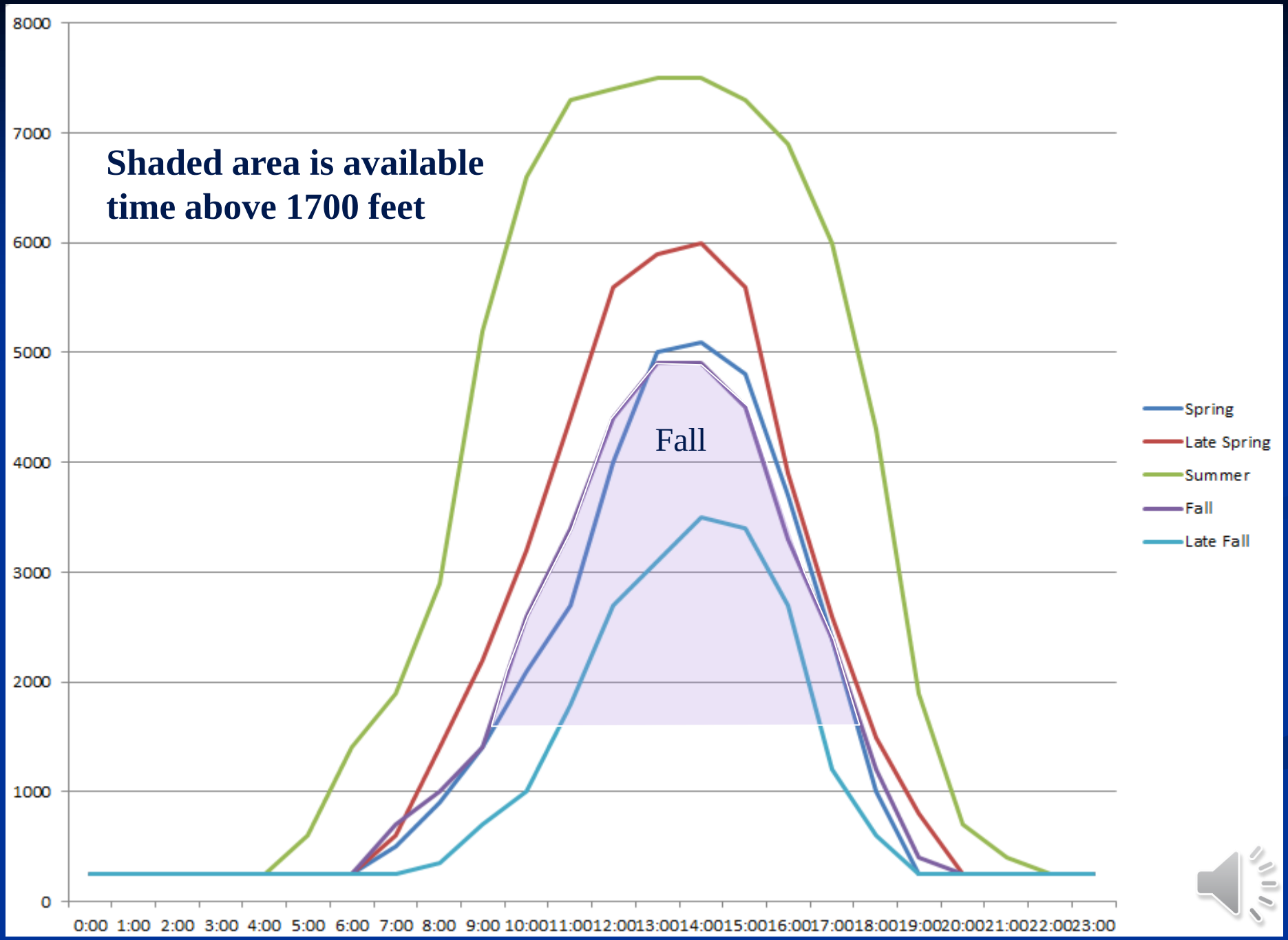
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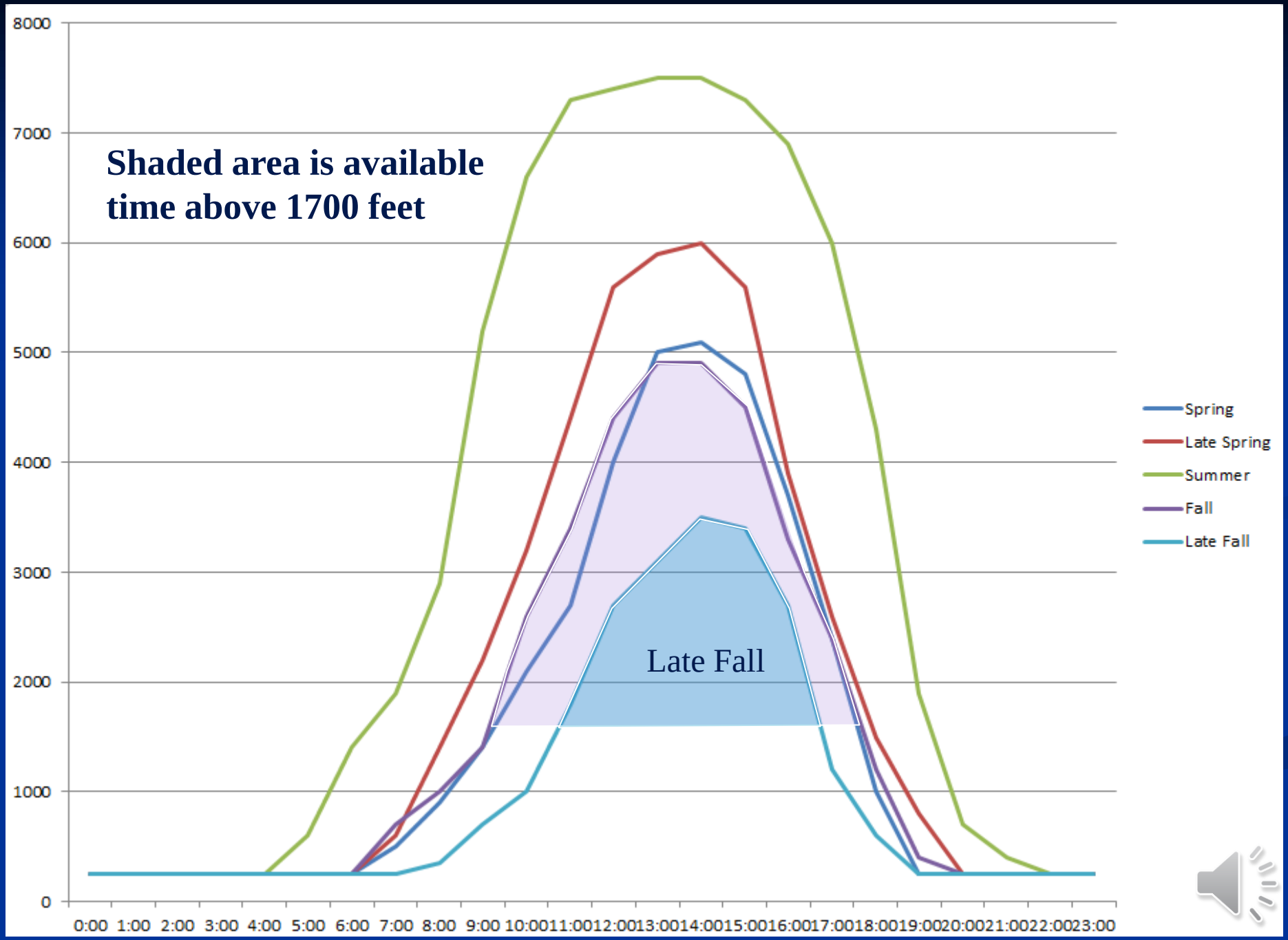
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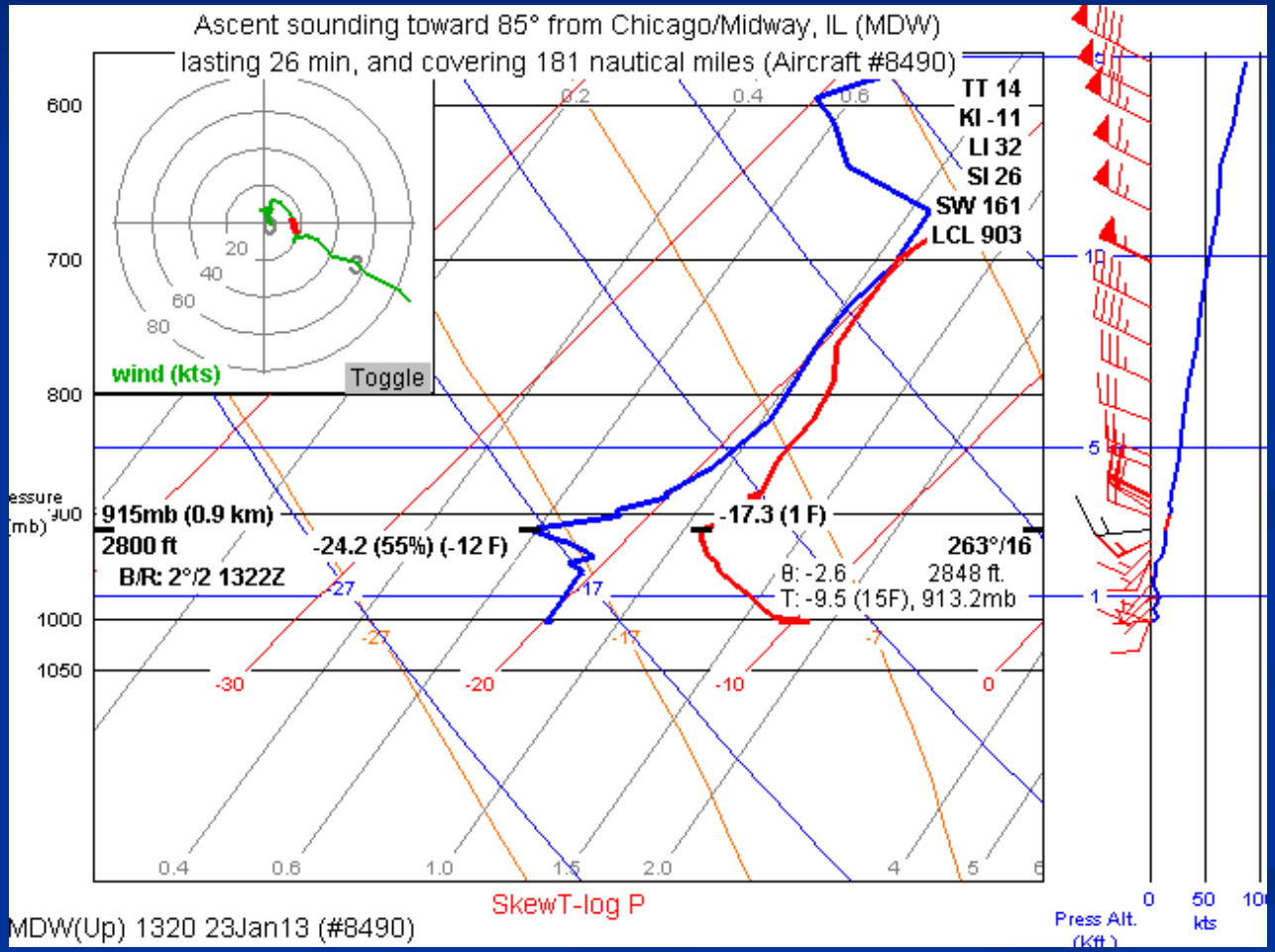
Transport Winds

- ***Average*** wind speed and direction in the mixed layer
- The mixed layer is the surface to the mixing height
- Example, the mixing height is 2000 feet, and the transport winds are South at 15 mph. This means that the ***average*** wind speed between the surface and 2,000 feet is 15 mph FROM the south

Transport Winds/Mixed Layer



Ventilation Rate/Dispersion

- Multiplication of the ***mixing height*** in feet and the ***transport winds*** in knots
  - Units differ based on user needs
- The larger the number, the better the ventilation
- NWS forecasts typically display highest number or “Vent Rate Max” for a 12 hour period
- Important to remember this “Max” may only last a few hours

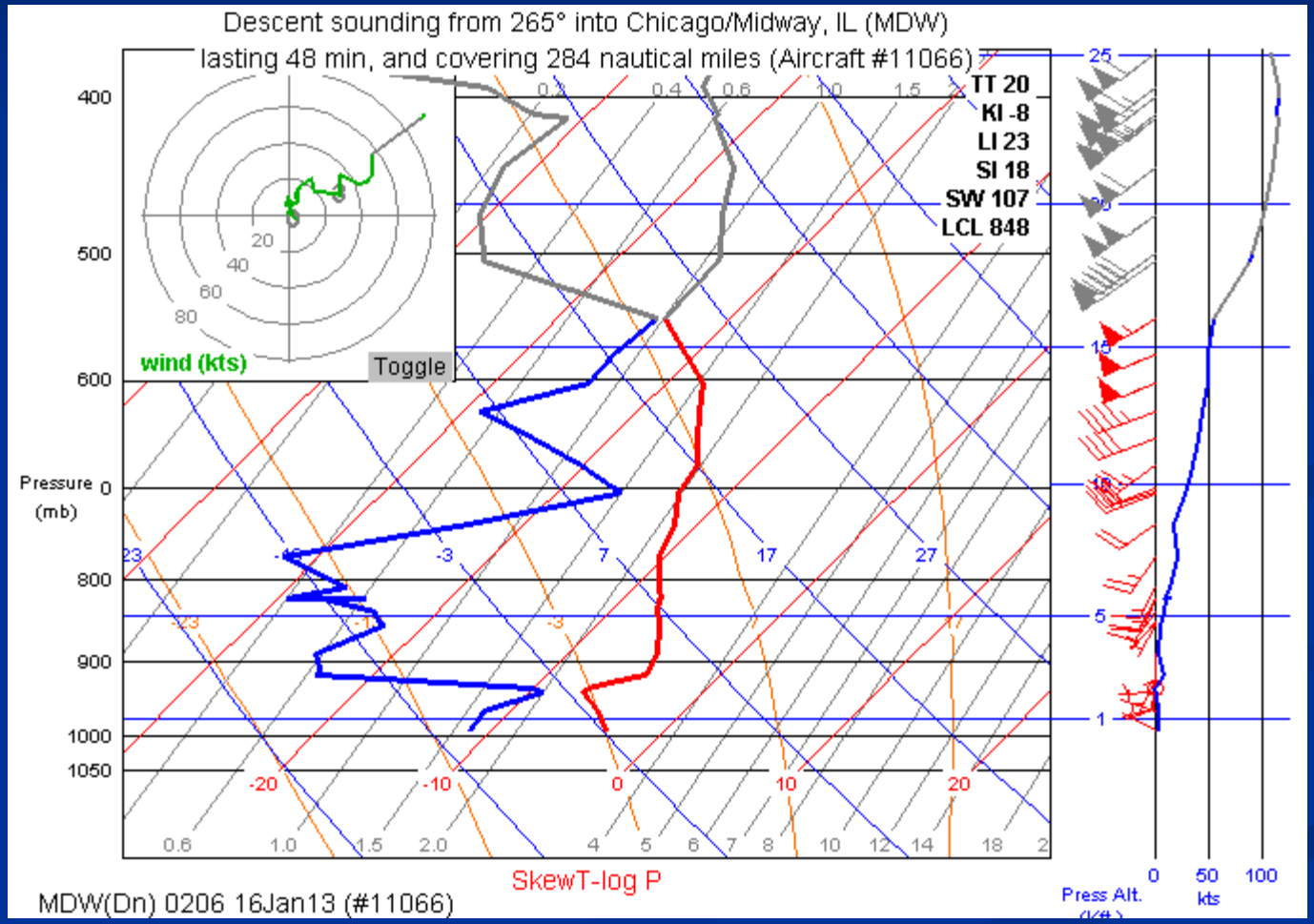
Ventilation Rate/Dispersion

- IMPORTANT, descriptors are determined by the users! Forecasters only provide/create the numbers. Range/descriptors below used by Chicago area fire/land managers
  - Poor, < 40,000 knot feet
  - Fair, 40,000 to 60,000 knot feet
  - Good, 60,000 to 100,000 knot feet
  - Very Good, 100,000 to 150,000 knot feet
  - Excellent, > 150,000 knot feet

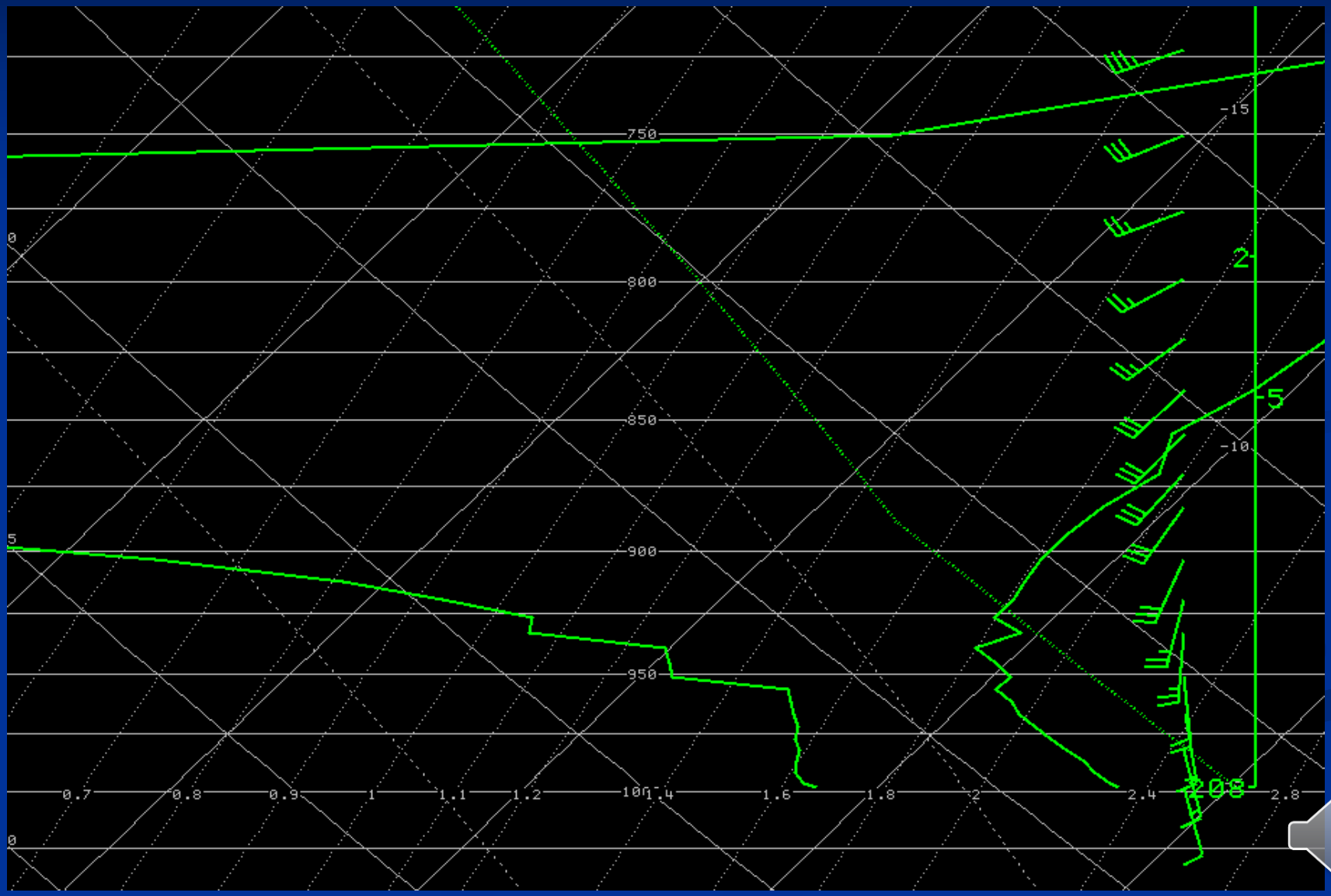
Ventilation Rate/Dispersion

- ***High*** mixing height with ***light*** transport winds
  - 8,000 feet with an east wind 10 knots, 80,000
  - Smoke column will go straight up
  - Tilted slightly by direction of light winds
- ***Low*** mixing height with ***strong*** transport winds
  - 2,000 feet with a south wind 35 knots, 70,000
  - Smoke column will not rise very high
  - Tilted strongly by direction of winds

Sudden Drop In Humidity



How Low will RH drop?



Fire Weather Watches/Red Flag Warnings

- A fire weather watch/red flag warning is issued when a combination of dry fuels and weather conditions create extreme fire danger and/or fire behavior
  - Watches issued in the 18 to 96 hour time frame
  - Warnings issued up to 48 hours
- Criteria differ by NWS office/local user needs
- NWS Chicago Criteria
  - Sustained 20 foot winds of 20 mph or higher
  - Afternoon relative humidity less than 25%
  - 10 hour fuel moisture at 8% or less for one day

Important note on Winds

- Surface winds in meteorology are defined as a 10 meter wind (roughly 33 feet)
- If the forecast doesn't specifically say, "20 foot" wind, then assume it is at 10 meters
- NWS Chicago uses a standard 20% reduction
  - 10 meter wind is 10 mph, 20 foot wind is 8 mph
  - Strong cold air advection could be less, 15%
  - Strong warm air advection, could be more, 25%

Thank you

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