# NWS Aviation Operations and Forecasting

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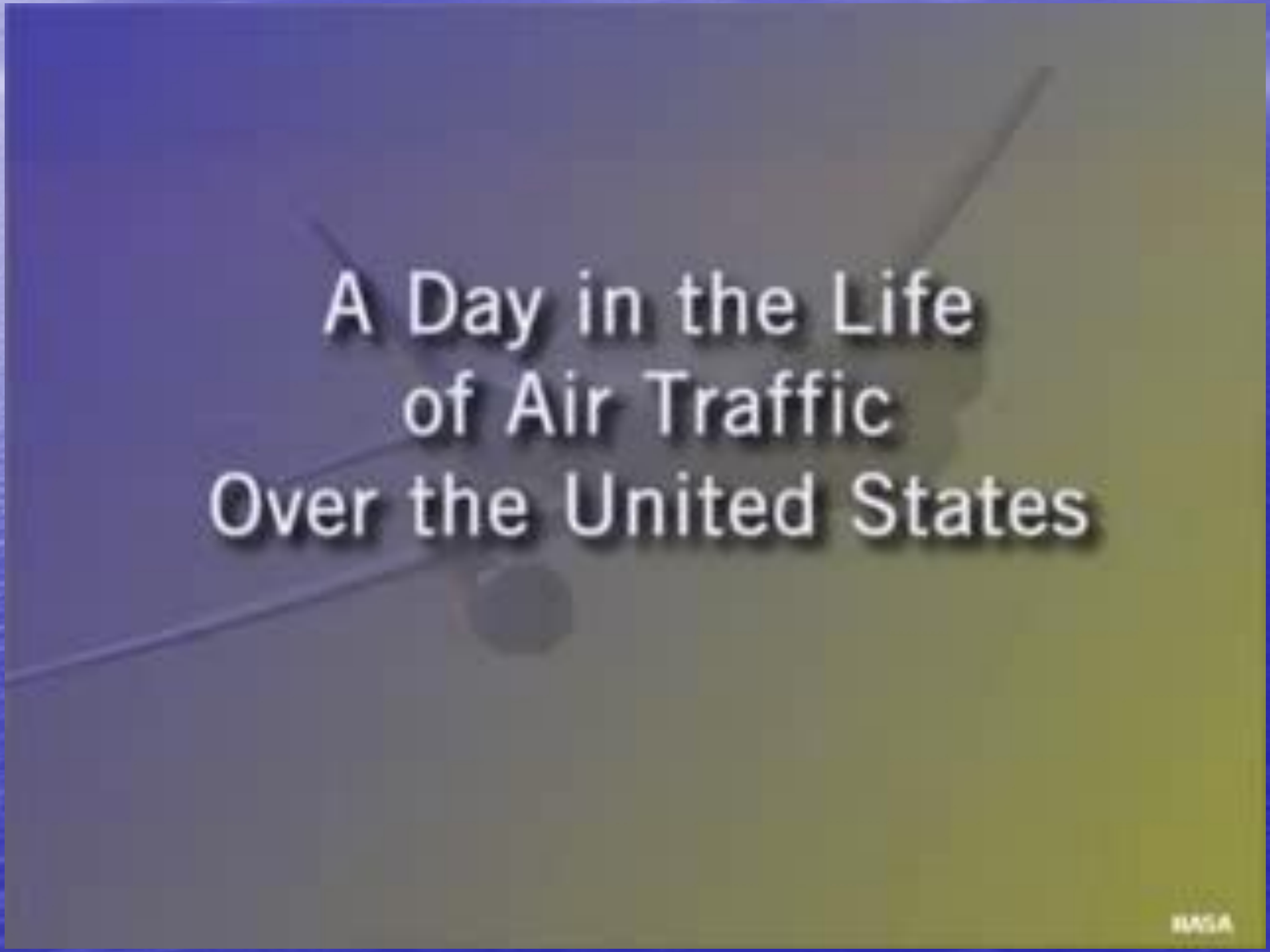
# NWS and the National Airspace System (NAS)

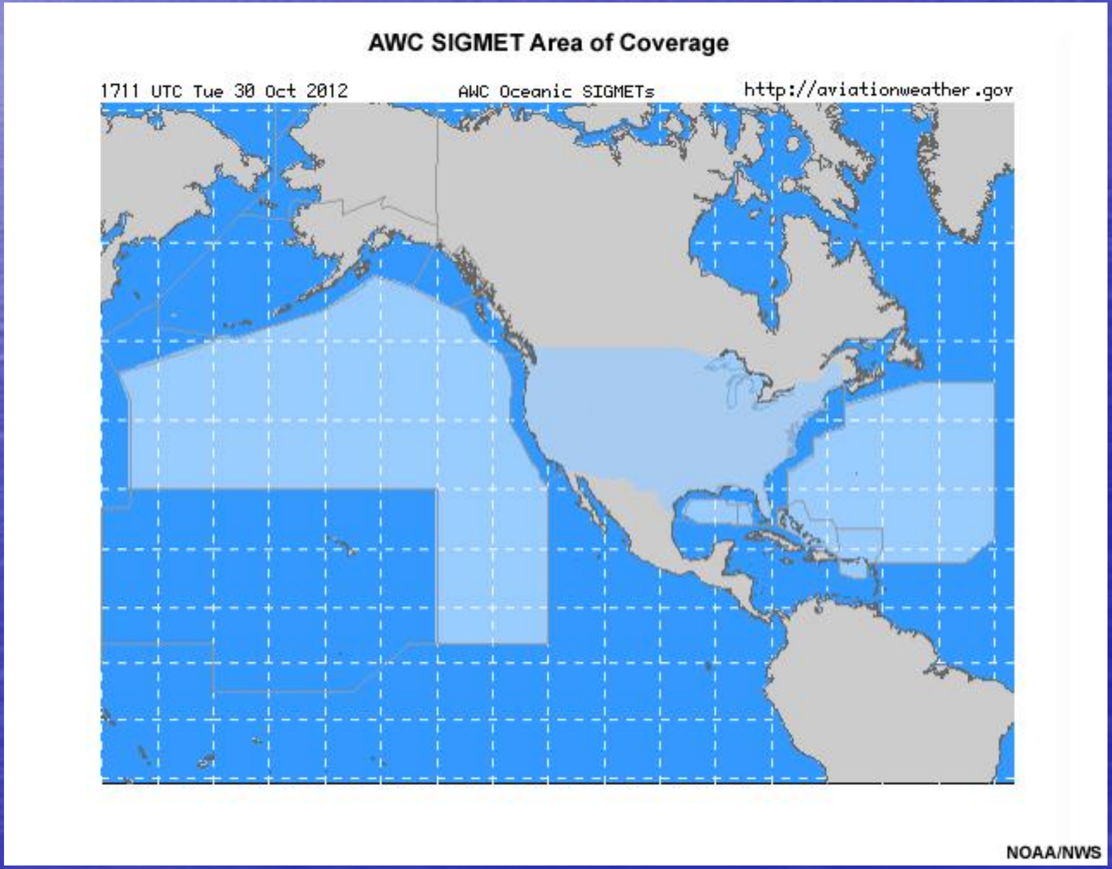
- NAS - complex set of facilities, procedures, aircraft, and people that create an environment for the safe operation of all types of aircraft.
  - The Federal Aviation Administration (FAA) is responsible for the air traffic flow management and control. Its mission is to provide the safest, most efficient airspace in the world.
- NWS Role – supports NAS through its operations via various centers:
  - Aviation Weather Center (AWC)
  - Center Weather Service Units (CWSU’s)
  - WFO’s (Weather Forecast Offices)
  - Alaska Aviation Weather Unit (AAWU)
  - Air Traffic Control System Command Center (ATCSCC) meteorologists

# Example – Traffic in NAS



# NWS Role - supporting NAS

- Aviation Weather Center – issues nationally-based products (broader-scale aviation hazards such as turbulence, convection, volcanic ash).

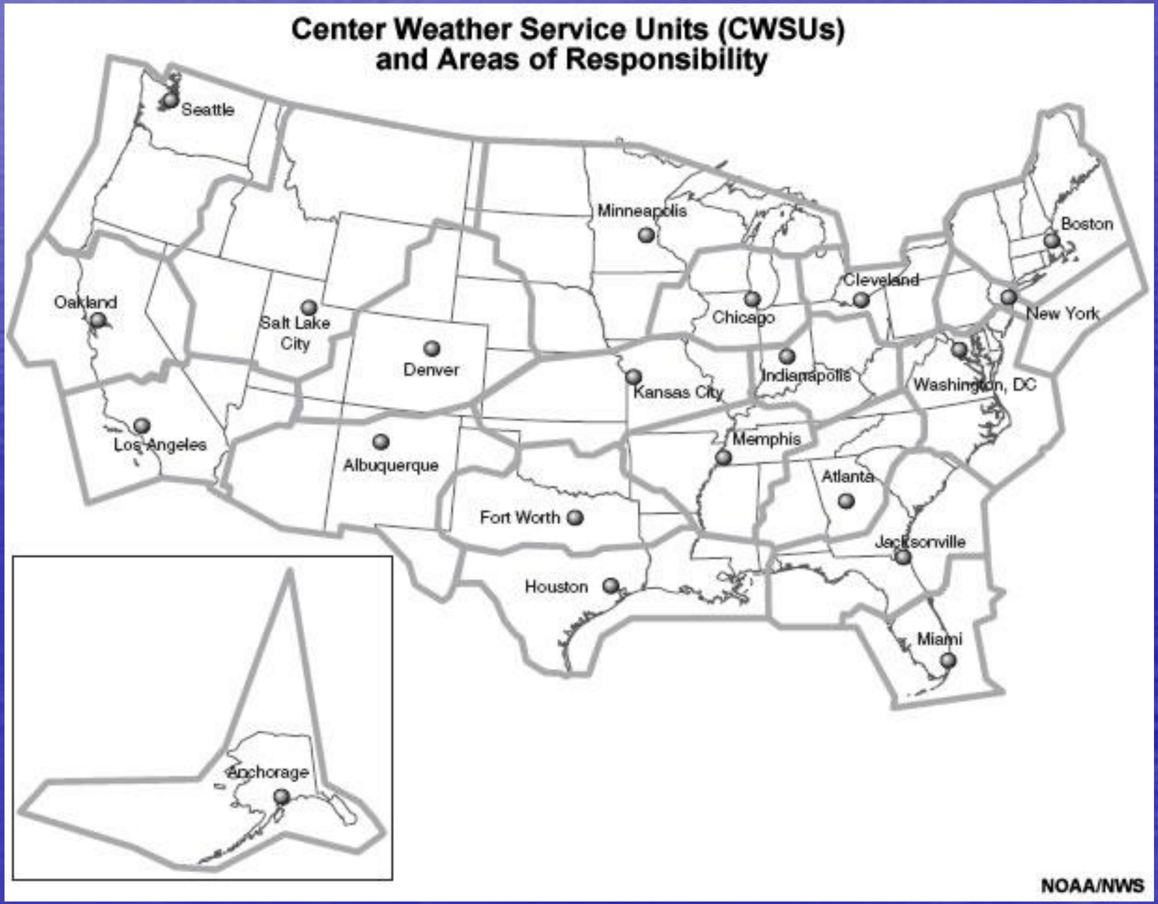


# NWS Role - supporting NAS

- Center Weather Service Units (CWSUs) –
  - Are located at Air Route Traffic Control Centers (ARTCC - where en route flights are managed).
  - Work with ARTCC and TRACON (Terminal Radar Approach Control Facilities) traffic management coordinators and deliver in-person briefings to facilitate weather impact planning.
  - Provide ongoing weather updates to ARTCC Area supervisors and terminal facility personnel.
  - Produce forecasts on icing, turbulence, convection.

# NWS Role - supporting NAS

- Center Weather Service Units (CWSUs) –
  - 21 Nationwide



# NWS Role - supporting NAS

- <u>Weather Forecast Offices</u> –
  - Produce forecasts (TAFs) – time and site specific forecasts which apply to an area within a 5 mile radius of center of runway complex. These cover a 24-30 hour period, are issued 4 to 8 times/day, and are amended as necessary.

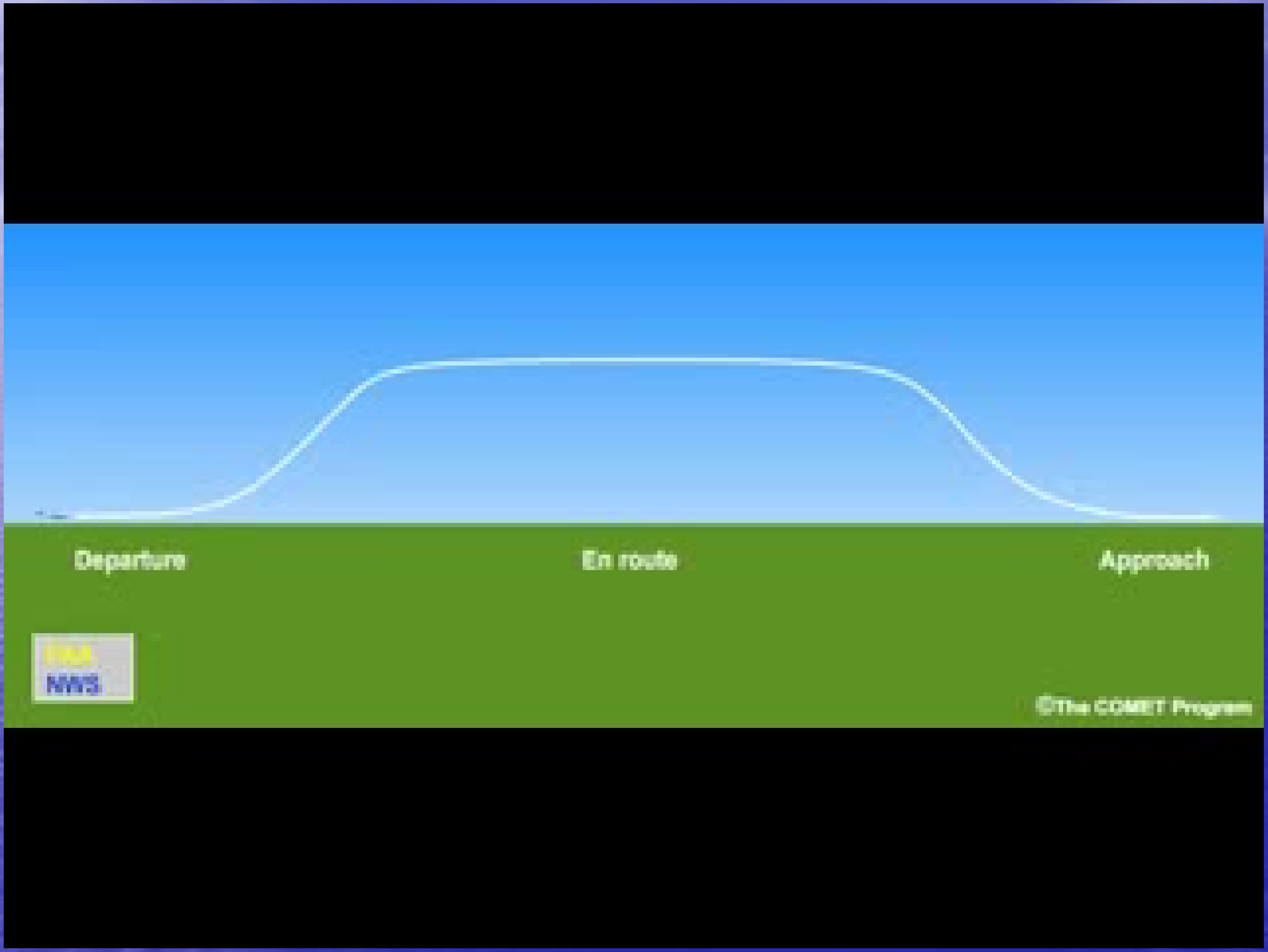
# NWS Role - supporting NAS

- <u>Air Traffic Control System Command Center Meteorologists (ATCSCC)</u> –
  - NWS National Aviation Meteorologists (NAMs) synthesize weather info from various NWS sources into a consistent message to directly support weather operations at the ATCSCC.
  - The ATCSCC regulates air traffic when weather, equipment, runway closures, or other impacting conditions place stress on the NAS. In these instances, Traffic Management Personnel at the ATCSCC take actions to modify traffic demands in order to remain within system capacity.

# Phases of Flight

- TERMINAL - the aircraft is cleared and takes off from the assigned runway.
- DEPARTURE - the aircraft departs local air space.
- EN-ROUTE - flight between the terminals.
- APPROACH - approach and descent towards the terminal.
- TERMINAL- landing on assigned runway and taxi to terminal.

# Phases of Flight




Video Source: COMET course “Weather Decision Support for the National Airspace System”

# Phases of Flight

**Phase of Flight and Weather Impacts**

| Terminal | Departure | En Route | Approach | Terminal |
|---|---|---|---|---|
|  |  |  |  |  |
| Freezing or frozen precipitation and any thunderstorm hazard, including lightning or strong winds, may impact ramp and taxiway operations. | Wind, wind shear, microbursts, turbulence, icing, and thunderstorms may impact departure operations. | Jet stream winds, mountain waves, turbulence, icing, thunderstorms, and volcanic ash may impact en route operations. | Wind, wind shear, microbursts, turbulence, icing, and thunderstorms may impact arrival and approach operations. | Freezing or frozen precipitation and any thunderstorm hazard, including lightning or strong winds, may impact ramp and taxiway operations. |
| Wind, wind shear, low ceiling, and/or visibility may impact terminal runway operations. | | | Ceilings and visibilities determine the type of approach (visual vs. instrument) | Wind, wind shear, low ceiling, and/or visibility may impact terminal runway operations. |

# Phases of Flight – Terminal Ops

**Arrival Demand > Airport Acceptance Rate**

FAA control facilities must work together to reduce arrival demand. This situation will require additional human resources. Delays will occur.

**Arrival Demand = Airport Acceptance Rate**

This situation will be monitored closely by FAA controllers. High situational awareness must be retained, resulting in staff fatigue. How long will it last?

**Arrival Demand < Airport Acceptance Rate**

Smooth operations with a lower need for situational awareness. Overhead is available for unexpected events.

# Phases of Flight – Terminal Ops

- Icing (accumulations of frost, snow, freezing rain/drizzle on aircraft and runway surfaces).
- Convective hazards (thunderstorms, lightning, microbursts, hail).
- Non-convective low-level wind shear.
- Precipitation (runway conditions—braking action, snow/ice removal).
- Wind direction and speed.
- Cloud ceiling heights.
- Visibility (tower, field, and Runway Visual Range).
- High density altitude (associated with high temperatures) affecting lift.

# Phases of Flight – Terminal Ops

Example of Weather Impact on AAR:

- Aircraft must land via an Instrument Flight Rules (IFR) approach when ceilings or visibilities are below Visual Flight Rules (VFR) conditions. An IFR approach spaces the aircraft farther apart as they land via an Instrument Landing System (ILS), which *reduces the AAR*.

- Not all runways at an airport are ILS-equipped, which further reduces the AAR. IFR or Low IFR (LIFR) conditions, combined with different types of arriving airplanes, add stress to the system and may even require some airports to close.

# Phases of Flight – Approach/Departure Ops

- **Ceilings/Visibilities**
- **Thunderstorms**
- **Wind Shear**
- **Microbursts**
- **Icing**
- **Turbulence**

# Phases of Flight – En-Route Ops

- Thunderstorms
- Severe turbulence and mountain waves
- Jet stream winds
- Icing
- Volcanic ash
- Space weather

# Terminal Aerodrome Forecasts (TAFs)

- Forecasts for a 5SM radius from the center of a runway complex which include the following weather elements:
  - Wind direction, sustained speed and gusts
  - Prevailing Visibility (SM) and Ceilings (AGL)
    - Tall Tower Airports – report LOWER of either Tower or Surface Vis.
    - "Ceiling:" First broken or overcast layer going upward
  - Weather which restricts visibility (including intensity)
  - Low level wind shear (within 2000 FT AGL)

# Terminal Aerodrome Forecasts (TAFs)

- Issued at least 4 times/day, every 6 hours (00 UTC, 06 UTC, 12 UTC, 18 UTC) but some higher volume terminals have 8 times/day.
- Forecast extends out to AT LEAST 24 hours, although some can extend out to 30 hours.
- First 6 hours – most important ("Critical TAF period"), greatest detail.

# Terminal Aerodrome Forecasts (TAFs)

```
FTUS41 KALY 271724
TAFALB
TAF
KALB 271724Z 2718/2818 09005KT P6SM VCSH OVC050
     FM272000 10005KT 1 1/2SM -SN BR OVC015
      TEMPO 2800/2804 1/2SM SN FZFG VV008
     FM280900 32007KT 3SM -SHSN BR SCT015 OVC025
     FM281400 31009KT P6SM VCSH SCT020 BKN040=
```

# Flight Categories

| Category | Designation | Ceiling | Visibility |
|---|---|---|---|
| 9 | VFR | None | Greater than 6 miles |
| 8 | VFR | 6500 - 12000 | |
| 7 | VFR | 3000 - 6000 | 6 |
| 6 | MVFR | 2000 - 3000 | 3 -5 |
| 5 | MVFR | 1000 - 1900 | |
| 4 | IFR | 500 - 900 | 2.0 - 2 3/4 |
| 3 | IFR | | 1.0 - 1 3/4 |
| 2 | LIFR | 200 - 400 | 1/2 or 3/4 |
| 1 | VLIFR | Lower than 200 Feet | Lower than 1/2 mile |

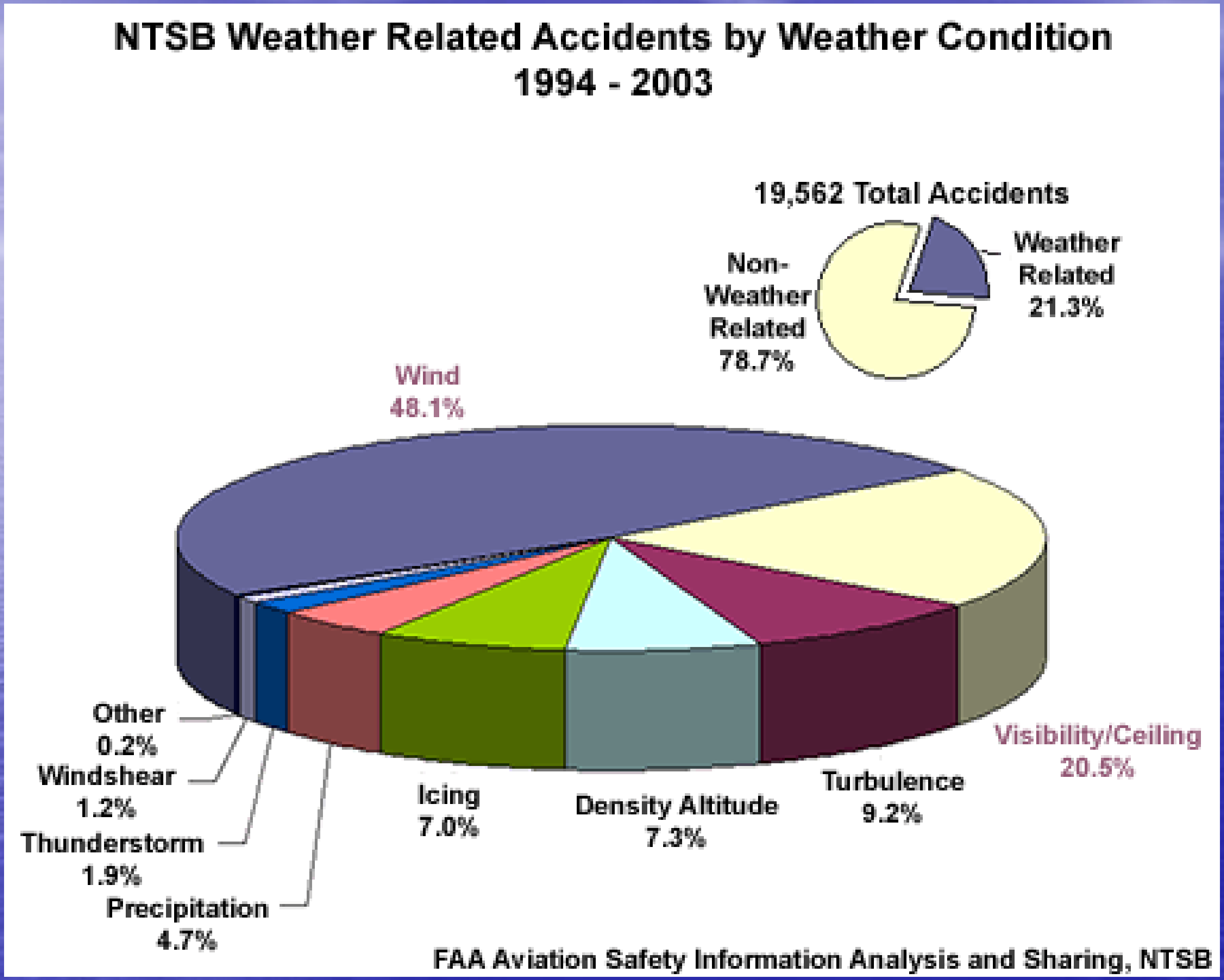
FAA

VFR=Visual flight rules; MVFR=Modified visual flight rules; IFR=Instrument Flight Rules; LIFR=Low instrument flight rules; VLIFR=Very low instrument flight rules

# Flight Categories

- Lower Flight Categories (sub-VFR) – require pilots to rely more on the Instrument Flight Panel.
- Also requires more spacing between aircraft and lower Airport Acceptance Rate.

# Weather-Related Accidents

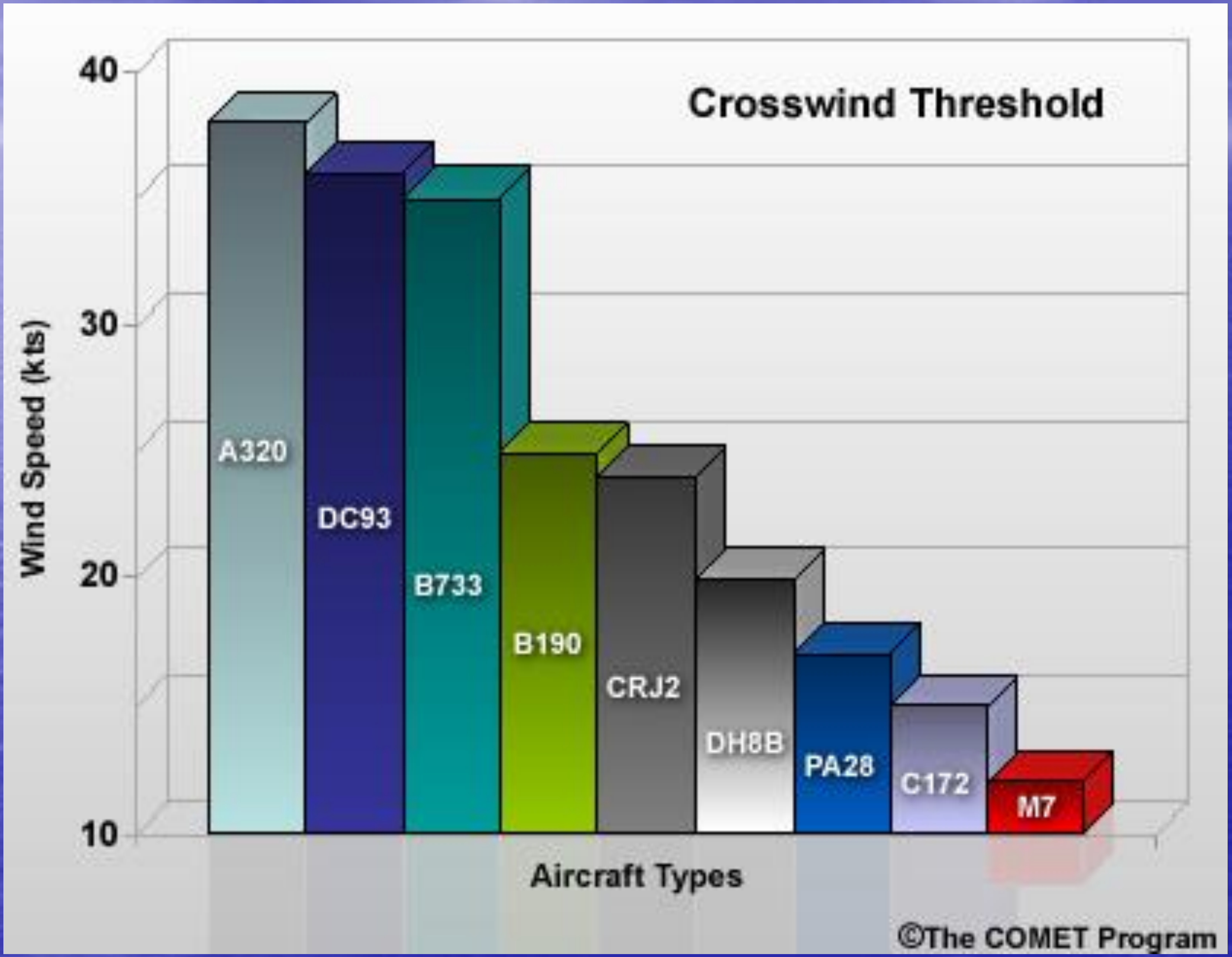



From: NASDAC Review of NTSB Weather-Related Accidents.
Data provided by the Federal Aviation Administration's Aviation Safety Information Analysis and Sharing (ASIAS) center using data from the NTSB Accident and Incident Data System.

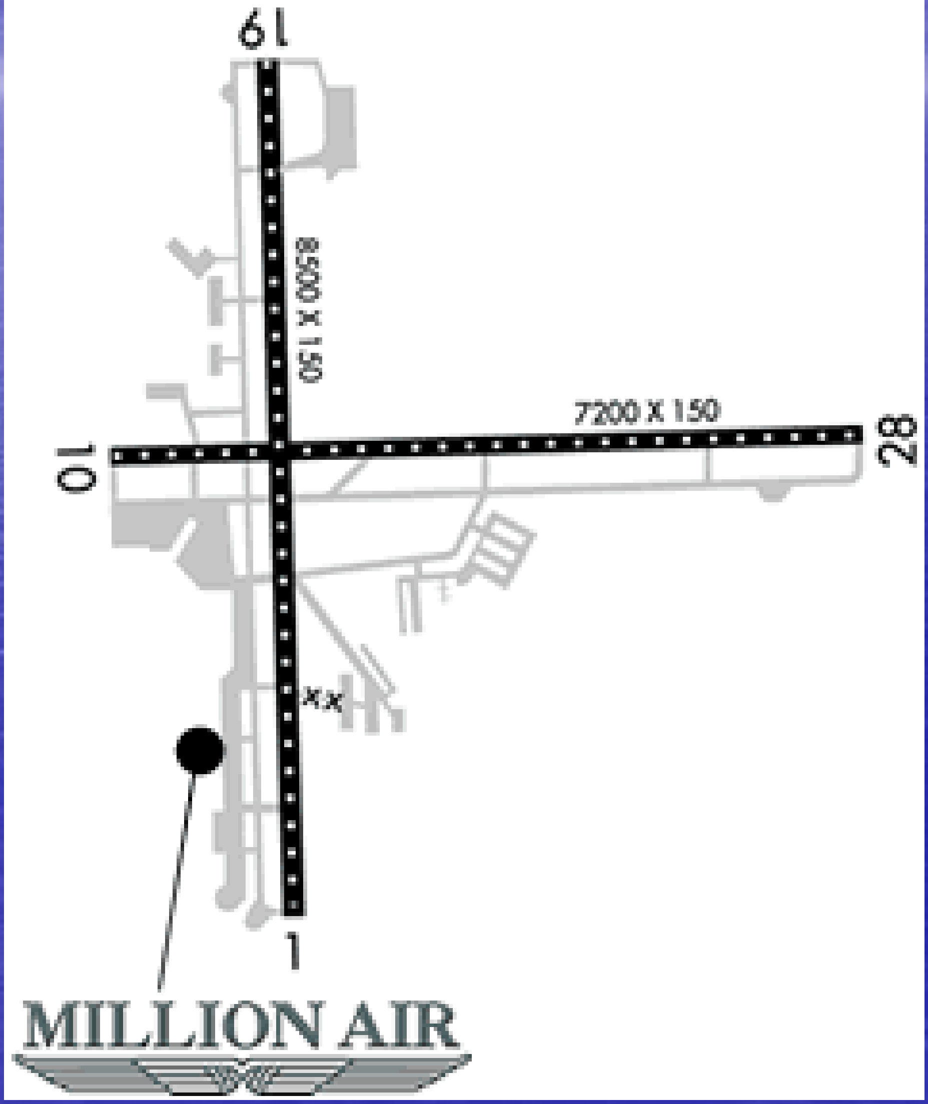
# Winds and Airplanes (near ground)

- Airplanes take off/land more efficiently when oriented *into* the wind because the aircraft's groundspeed is minimized, less runway is required to achieve lift, and the pilot has more time to make adjustments necessary for a smooth landing.
- As the wind turns more perpendicular to the runway, a gradual degradation of airplane performance occurs and the pilot must compensate. (Cross-Wind issues)
- Cross-Wind issues are particularly problematic during <u>landing</u> (portion of the Terminal Phase).

# Cross-Winds


Crosswind Threshold
Wind Speed (kts)
40
30
20
10
A320
DC93
B733
B190
CRJ2
DH8B
PA28
C172
M7
Aircraft Types
©The COMET Program

# Cross Winds – Runway Configuration at KALB



# Non-convective Low Level Wind Shear

- Wind shear can occur at any altitude; however, a sudden change in wind direction and/or speed within 2000 ft of the surface can be particularly hazardous. During this phase of flight, the aircraft is operating at relatively slow speeds, and a major change in wind velocity can lead to a loss of lift.
- A tailwind shear, the abrupt change from a headwind to a tailwind, is particularly dangerous because it can cause an airplane to stall or land short of the runway.

# Low Level Wind Shear Example - Landing

# Aviation Forecasting (for TAFs)

- Ceiling Forecasting:
  - Upstream observational data.
  - RAP13, HRRR, HREF, 3km and 12km NAM are most useful due to high spatial/vertical resolution in lower atmosphere and during near-term (“Critical TAF period”).
  - BUFKIT soundings (especially base of inversion).
  - Low level model RH and wind fields (especially 1000-900 mb, 925 mb, 850 mb).
  - MOS Data (LAV/MAV/MET).

# Aviation Forecasting (for TAFs)

- Visibility Forecasting:
  - Upstream observational data.
  - RAP13, HRRR, HREF, 3km and 12km NAM are most useful due to high spatial/vertical resolution in near-term ("Critical TAF period").
  - BUFKIT data (especially boundary layer evolution and inversion potential).
  - Low level model RH and wind fields (especially 1000 mb).
  - MOS Data (LAV/MAV/MET).
  - *Crossover temperature technique (UPS).

# Aviation Forecasting (for TAFs)

- <u>Crossover Temperature – Forecasting Radiational Fog:</u>
  - Dewpoint temperature at maximum air temperature for the day = "Crossover Temperature"
  - If nighttime low temperature drops 3 or more degrees (F) BELOW the "Crossover Temperature", the potential for IFR Visibility (due to radiational fog) significantly increases, *ASSUMING NO ADVECTION* of moisture
  - Not as helpful near bodies of water

# Aviation Forecasting (for TAFs)

- Crossover Temperature – Example

| Time | Temperature (F) | Dewpoint (F) |
|---|---|---|
| 2 PM | 84 | 67 |
| 3 PM | 85 | 66 |
| 4 PM | 87 | 64 |
| 5 PM | 88 | 63 |
| 6 PM | 86 | 65 |
| 7 PM | 82 | 68 |

**Crossover Temperature: 63 F**

# MOS Guidance

**Sample Message**

```
KDCA   NAM MOS GUIDANCE    1/24/2008  1200 UTC
DT /JAN  24/JAN  25                /JAN  26                /JAN  27
HR    18 21 00 03 06 09 12 15 18 21 00 03 06 09 12 15 18 21 00 06 12
N/X                     15          24          20          30    28
TMP   36 35 30 24 21 18 16 21 23 22 23 21 20 21 22 24 27 29 29 29 30
DPT   14  9  3  0 -2 -4 -3 -3 -2  2  8 12 15 17 19 22 24 25 25 24 21
CLD   CL CL FW FW SC SC BK OV OV OV OV OV OV OV OV OV OV OV OV BK FW
WDR   34 33 34 35 34 36 36 06 14 08 05 04 02 02 03 05 05 06 03 35 34
WSP   07 14 14 11 10 10 08 03 02 05 07 11 11 12 10 07 04 04 07 11 10
P06          0     0     0     0    55    76    60    34    36 13  9
P12                      0          58          86          48    25
Q06          0     0     0     0     1     1     1     0     1     0
Q12                      0           1           2           1     0
T06       0/ 0  0/ 9  0/ 1  1/ 0  3/ 0  0/ 0  0/ 1  0/ 0  3/ 0  0/ 0
T12             1/ 9        1/ 1        3/ 0        1/ 1     1/ 0
SNW                      0                       6                 0
CIG    6  8  8  8  8  7  7  7  7  4  4  3  2  3  3  2  2  1  1  2  8
VIS    7  7  4  5  5  5  6  7  7  7  7  7  7  7  7  7  7  7  7  6  5
OBV    N  N BR BR BR BR  N  N  N  N  N  N  N  N  N  N  N  N  N HZ BR
```

**Ceiling Height (CIG) Categories**

| | |
|---|---|
| 1 | < 200 feet |
| 2 | 200 - 400 feet |
| 3 | 500 - 900 feet |
| 4 | 1000 - 1900 feet |
| 5 | 2000 - 3000 feet |
| 6 | 3100 - 6500 feet |
| 7 | 6600 - 12,000 feet |
| 8 | > 12,000 feet |

**Visibility (VIS) Categories**

| | |
|---|---|
| 1 | < 1/2 miles |
| 2 | 1/2 - < 1 miles |
| 3 | 1 - < 2 miles |
| 4 | 2 - < 3 miles |
| 5 | 3 - 5 miles |
| 6 | 6 miles |
| 7 | > 6 miles |

**MAV Obstruction to Vision (OBV) Categories**

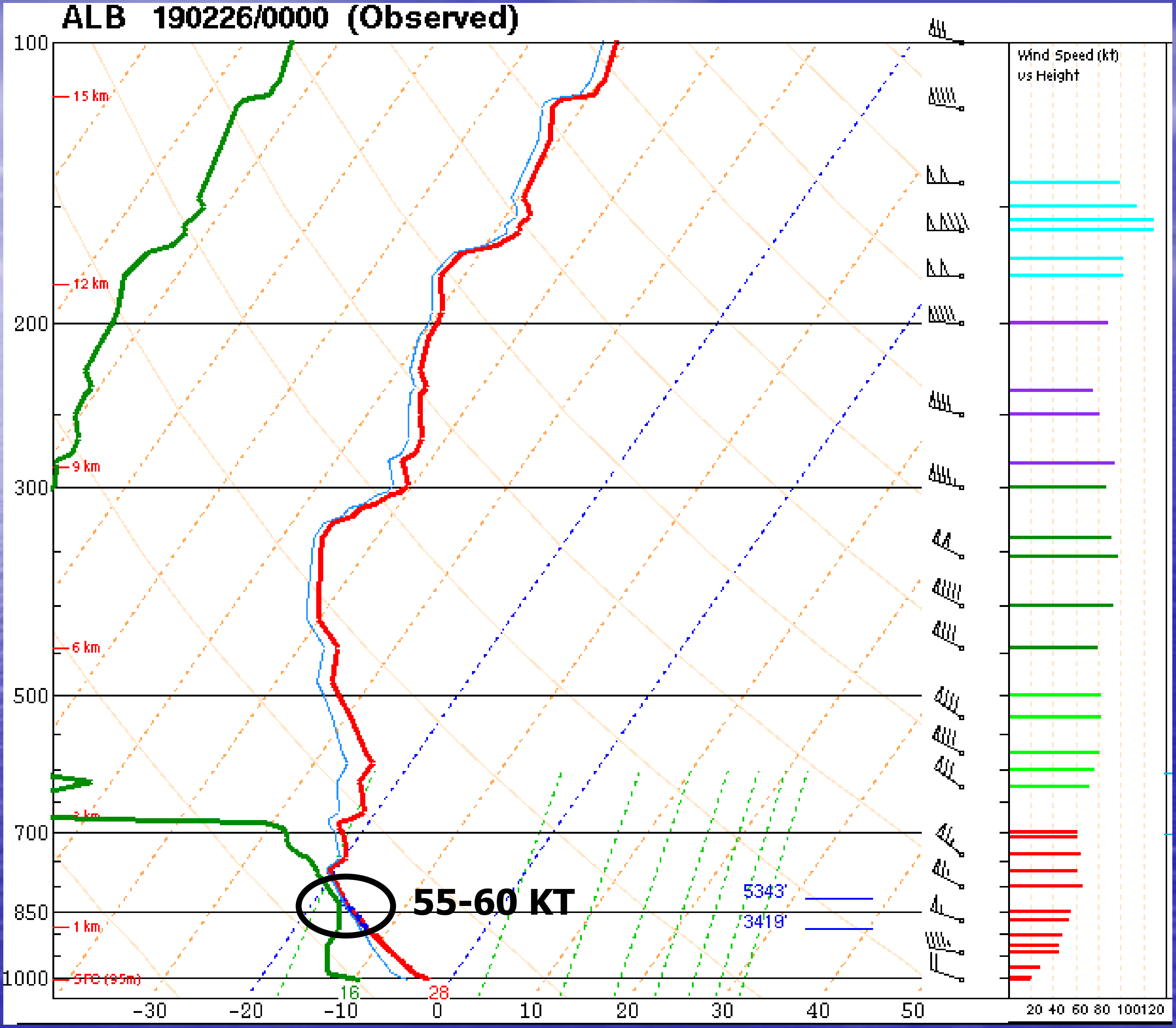
| | |
|---|---|
| N | none of the following |
| HZ | haze, smoke, dust |
| BR | mist (fog with visibility >= 5/8 mile) |
| FG | fog or ground fog (visibility < 5/8 mile) |
| BL | blowing dust, sand, snow |

**Cloud (CLD) Categories**

| | |
|---|---|
| CL | clear |
| FW | > 0 to 2 octas of total sky cover |
| SC | > 2 to 4 octas of total sky cover |
| BK | > 4 to < 8 octas of total sky cover |
| OV | 8 octas of total sky cover or totally obscured |

# Aviation Forecasting (for TAFs) - Winds

- Upstream observational data.
- RAP13, HRRR, HREF, 3km NAMNEST and 12km NAM are most useful due to high spatial/vertical resolution in near-term (“Critical TAF period”).
- BUFKIT data (especially winds at top of mixed layer for gust potential).
  - Downward momentum transfer.
  - ~ 80% of wind can transfer down from top of well mixed layer.
  - Maximum downward momentum transfer if winds align from similar direction through well-mixed layer.
- Low level model wind fields.
- MOS Data (LAV/MAV/MET) – especially for direction.

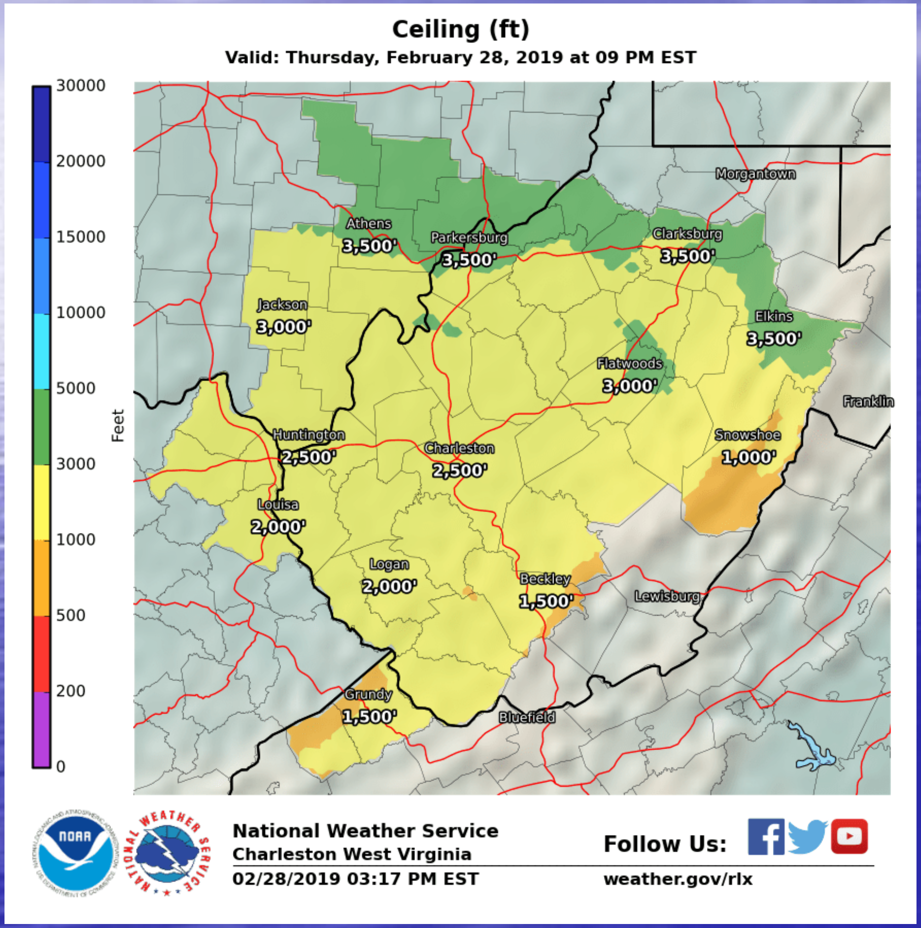


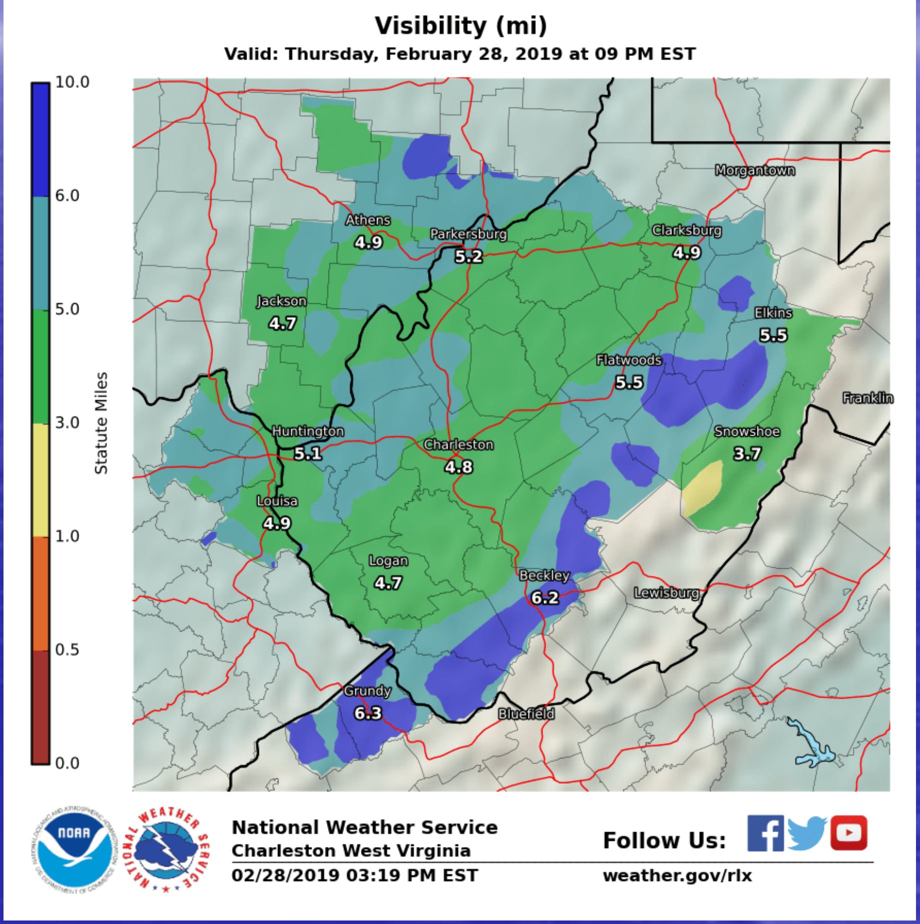
ALB 190226/0000 (Observed)
Wind Speed (kt) vs Height
55-60 KT
15 km
12 km
9 km
6 km
3 km
1 km
SFC (95m)
100
200
300
500
700
850
1000
5343'
3419'
16
28
-30
-20
-10
0
10
20
30
40
50
20 40 60 80 100 120

# Aviation Forecasting (for TAFs) – Low Level Wind Shear

- Observational Data – both upstream and in place.
  - WSR 88-D VAD Wind Profile/Mesonet Wind Profilers.
  - PIREPs (Pilot Reports).
- Forecast data
  - BUFKIT/Model soundings (strong low level inversion, low level jet).
  - Low level model wind fields (especially at and below 925 mb).
  - MOS data (surface winds – trending to light/calm with strong winds above).

# NWS Digital Aviation



# NWS Digital Aviation

- Advantages:
  - Promotes consistency among NWS gridded forecast elements.
  - Allows for greater spatial coverage of site specific forecasts, covering needs for a larger aviation customer base.
- Disadvantages:
  - Limited observational data availability could lead to unrepresentative forecast data.
  - Collaboration/consistency difficulties due to rapid weather element changes over small areas (sub-mesoscale effects).

# Resources

- NWS Directives at https://www.nws.noaa.gov/directives/010/010.php (under NDS 10-8 Aviation Weather Services)
- COMET/MetEd course "Weather Decision Support for the National Airspace System"
- COMET/MetEd course: "Writing TAFs for Ceilings and Visibilities"
- COMET/MetEd course "Distance Learning Aviation Course - DLAC 1: Forecasting Fog/Low Stratus for Aviation Operations"
- COMET/MetEd course "Writing TAFs for Winds and Low-Level Wind Shear"