Aviation Weather Forecasting With Satellites

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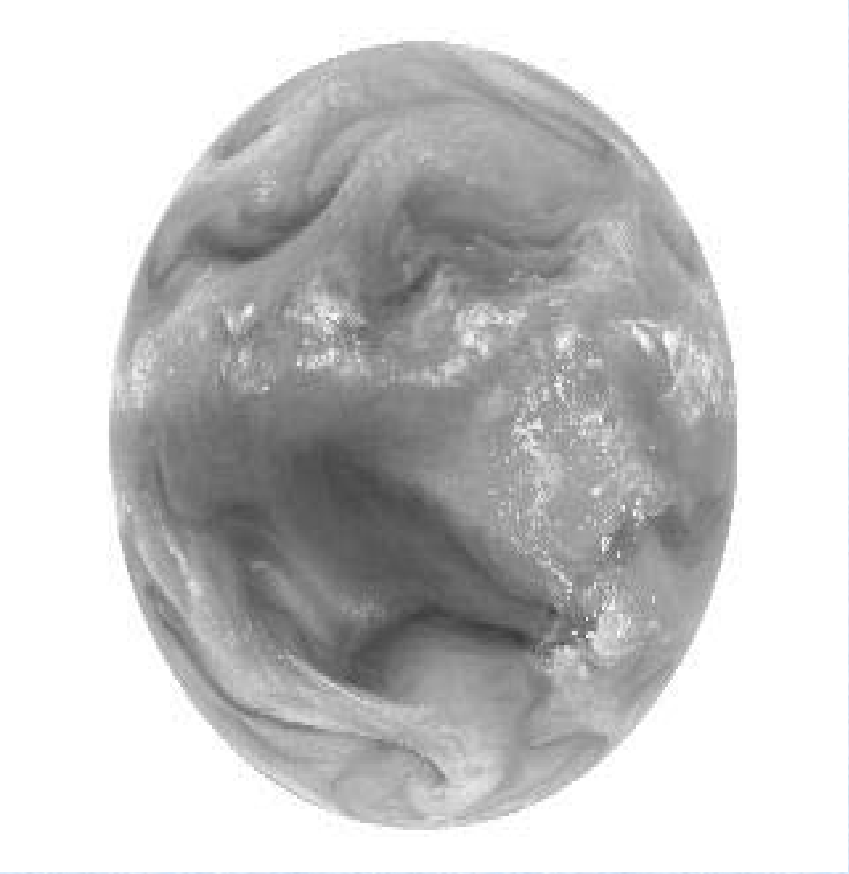
Overview

- Images from geostationary satellites (GOES) can be applied to detect and forecast aviation weather hazards including:
  - Icing
  - Volcanic ash clouds
  - Turbulence
  - Thunderstorm winds

What is a geostationary satellite?

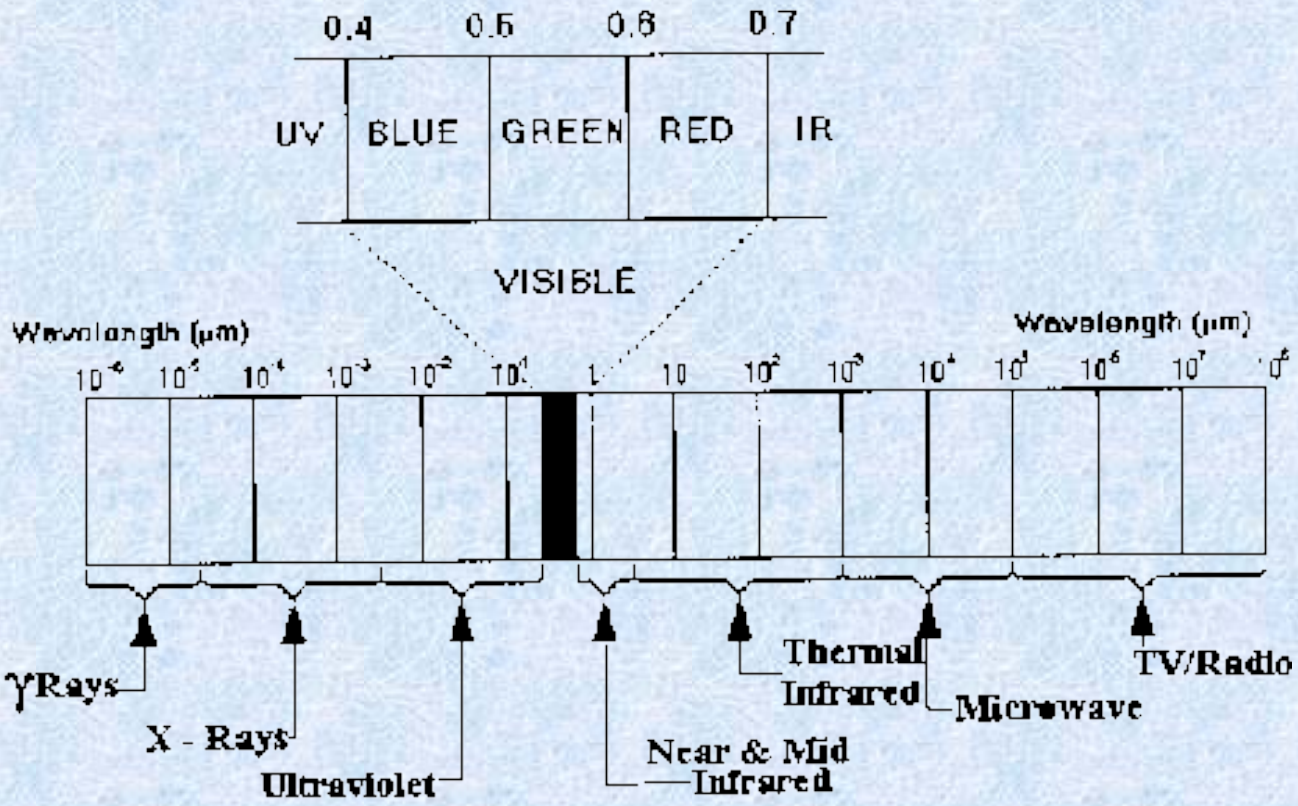
- Located 36,000 km above the earth, the GOES (Geostationary Operational Environmental Satellite) continuously observes the same region (the western hemisphere).
- Why 36,000 km?



GOES Aviation Products

- The GOES aviation forecast products are based on energy measured in different wavelength bands:
  - formulas that add or subtract satellite measured temperatures to show regions of high risk to aircraft.
- Cloud characteristics:
  - Composition
  - Morphology: form and structure and change with time

Electromagnetic Spectrum



GOES Channels

Band	Wavelength (μm)	Use
1 (Visible)	0.52-0.77	Cloud detection and identification
2 (Shortwave IR)	3.76-4.03	Fog identification, water vs. ice clouds
3 (Water Vapor)	5.77-7.33	Moisture content
4 (Longwave IR)	10.2-11.2	Cloud top temperature
5 (Longwave IR)	11.5-12.5	Low-level moisture
6 (Longwave IR)	12.96-13.72	Cloud characteristics

Quiz

- What is a geostationary satellite?
- What generates energy received by the satellite in the visible band?
- What generates energy received by the satellite in the infrared bands?
- Name 3 weather hazards to aviation.

Aviation Weather

Considerations:

- Aircraft characteristics:
  - Size
  - Design
  - Instruments
- Pilot experience

Aircraft Instruments

- Most aircraft are equipped with a standard set of **flight instruments** which give the pilot information about the aircraft's attitude, airspeed, and altitude.
- **Most aircraft have these six basic flight instruments**:
- Altimeter
- Airspeed indicator
- Magnetic compass
- Heading indicator
- Turn and bank indicator
- Vertical speed indicator

Aircraft Icing

- In-flight icing is the accretion of supercooled liquid water (SLW) on the airframe. This SLW can be in the form of cloud droplets or freezing rain/drizzle.

Aircraft Icing Hazards

- Icing can adversely affect the flight characteristics of an aircraft. Icing can increase drag, decrease lift, and cause control problems.
- Recent icing-related accident: Canadair jet, Montrose, Colorado, 28 November 2004.
  - Six occupants on board: 3 dead, 3 seriously injured

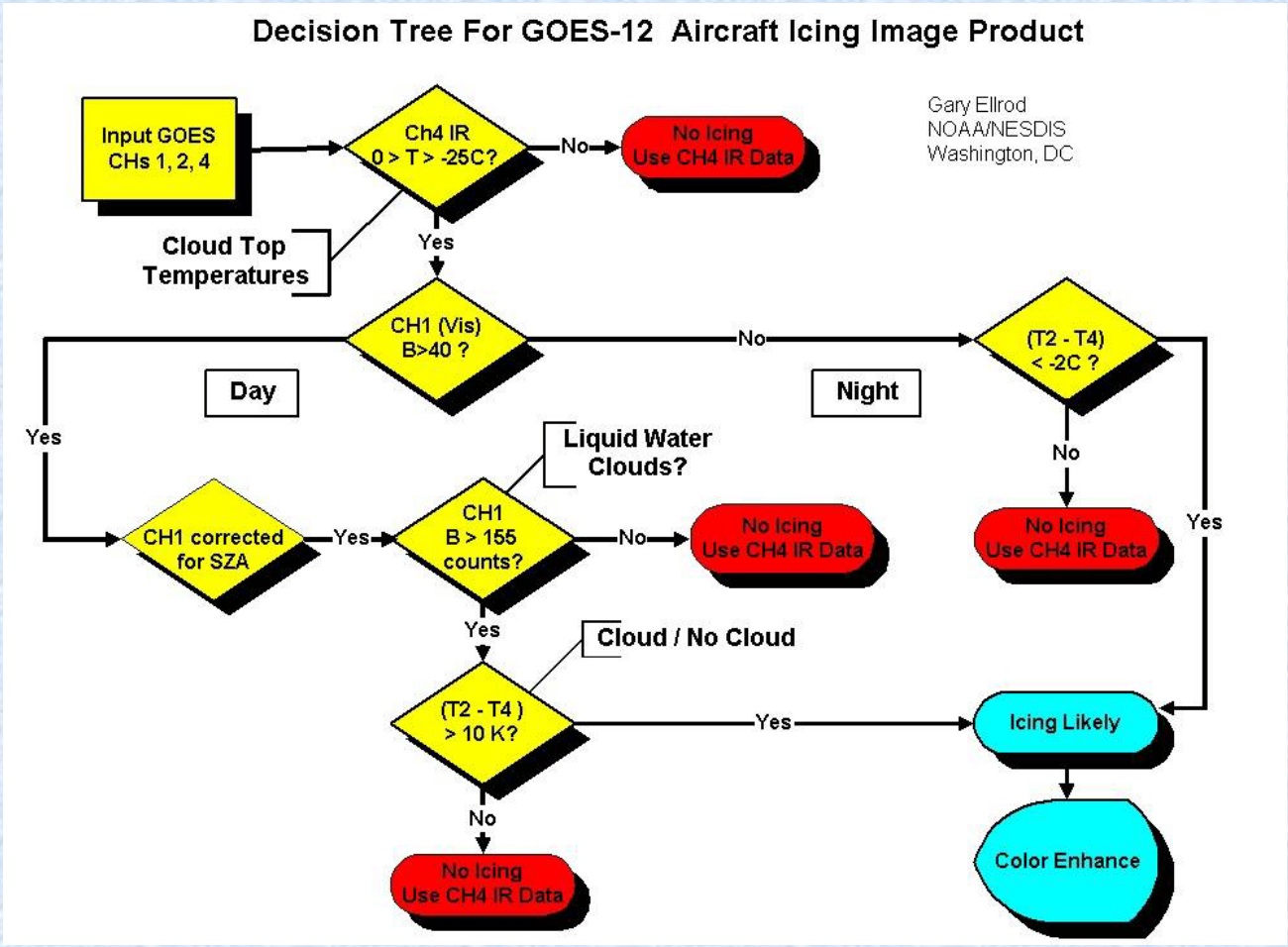
Aircraft Icing

- Weather conditions related to aircraft icing:
  - liquid clouds with temperatures in the 0 to -20 C range
  - large water drop sizes
  - large liquid water content
  - thick, extensive cloud systems resulting in long exposure to icing conditions during flight.

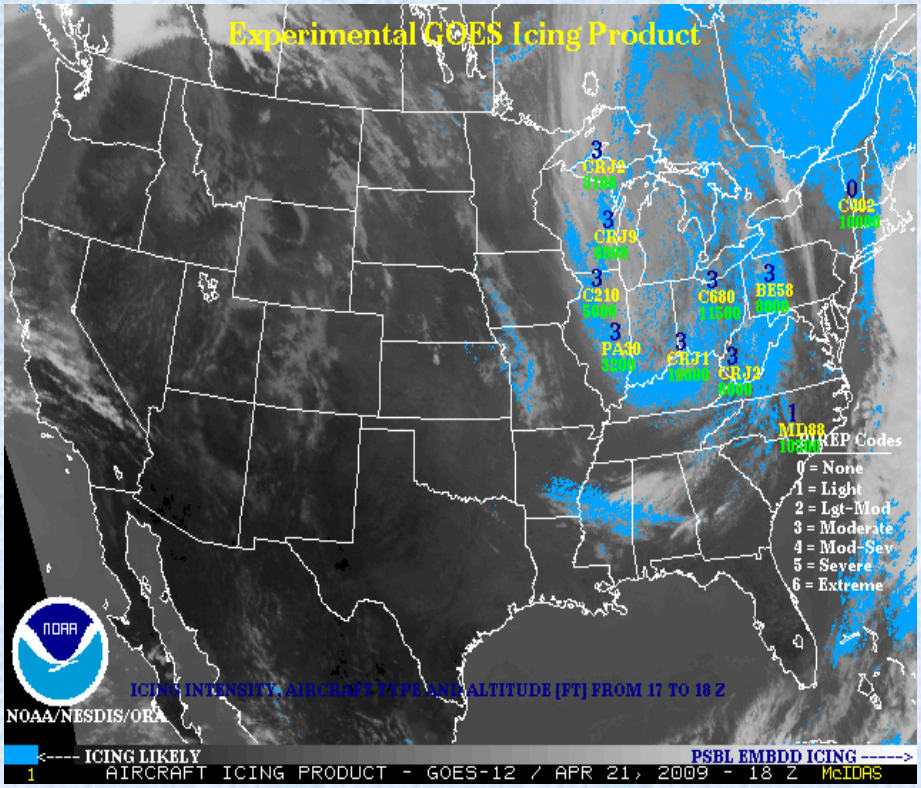
Icing Intensity

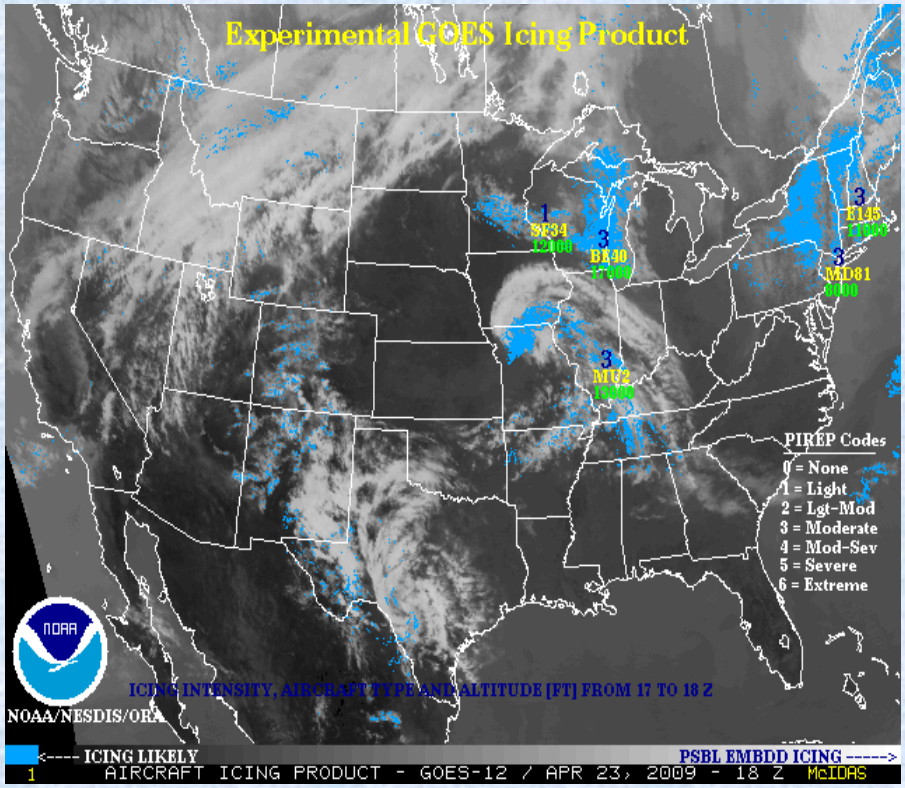
- LIGHT: The rate of accumulation may create a problem if flight is prolonged in this environment (over one hour).
- MODERATE: The rate of accumulation is such that even short encounters become potentially hazardous and use of deicing/anti-icing equipment or diversion is necessary.
- SEVERE: The rate of accumulation is such that deicing/anti-icing equipment fails to reduce or control the hazard. Immediate diversion is necessary.

Satellite Icing Detection



GOES Icing Product





Aircraft Icing Quiz

- What is Icing?
- Why is icing a hazard to aircraft in flight?
- Why is icing important to detect and forecast?

Turbulence

Turbulence

- Definition:
  - Irregular motion in the atmosphere, can be observed as gusts and lulls in the wind.
- Causes:
  - Vertical wind shear
  - Convection

Causes of Turbulence

Clear-air Turbulence (CAT)

Mountain wave Turbulence (MWT)

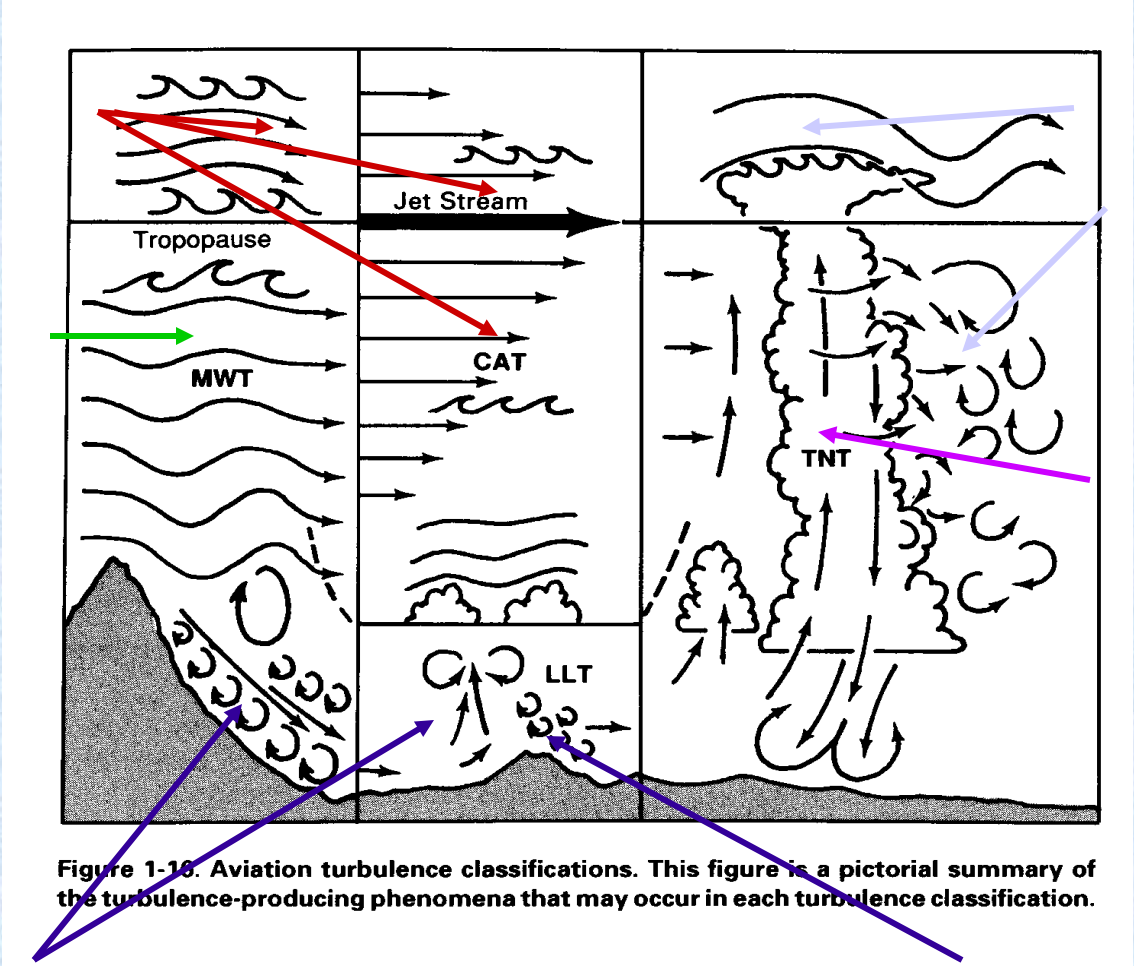


Figure 1-10. Aviation turbulence classifications. This figure is a pictorial summary of the turbulence-producing phenomena that may occur in each turbulence classification.

Cloud-induced or Convectively-induced Turbulence (CIT)

In-cloud turbulence

Low level Terrain-induced Turbulence (LLT)

Convective boundary Layer turbulence

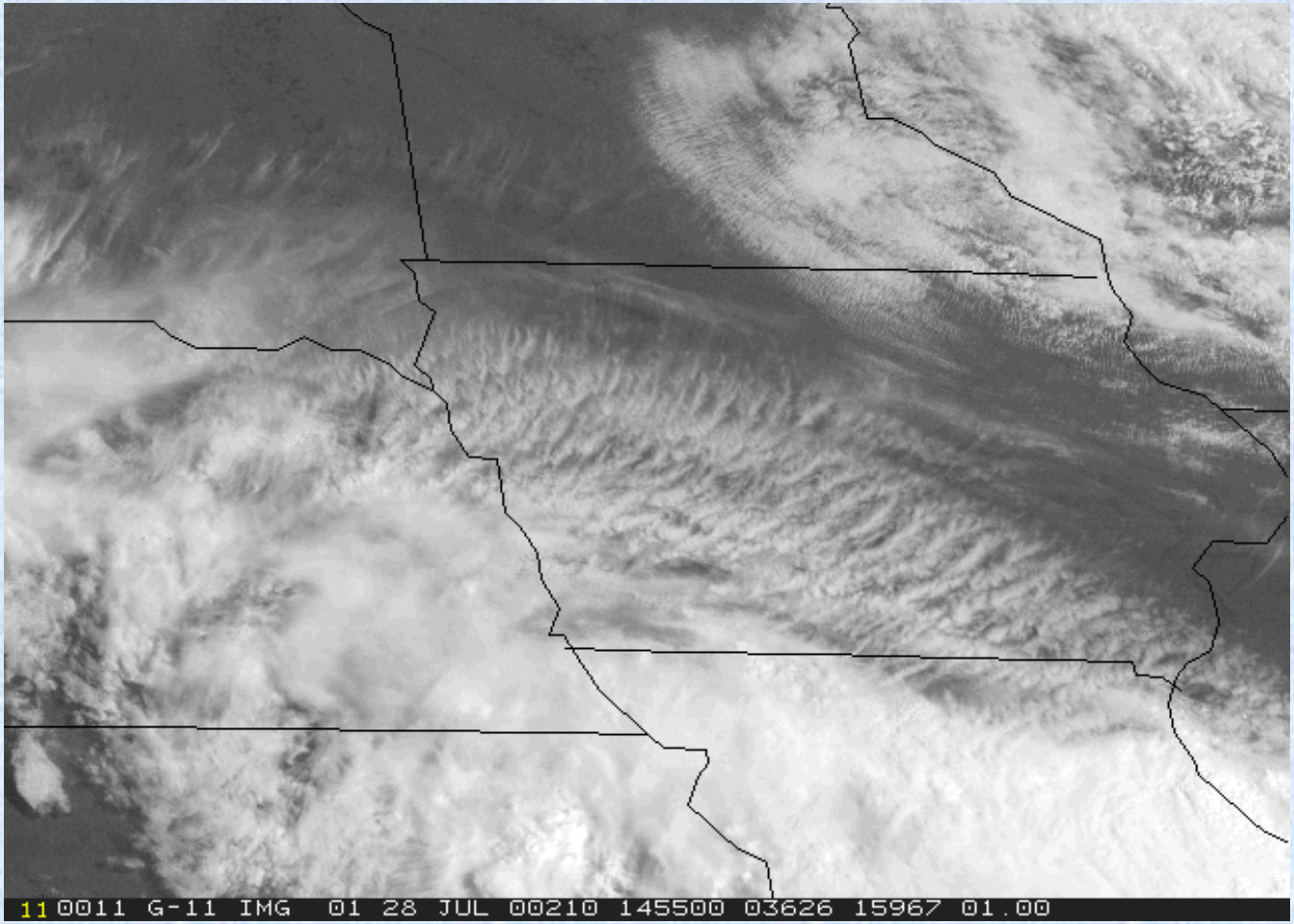
Source: P. Lester, "Turbulence – A new perspective for pilots," Jeppesen, 1994

Turbulence Hazards

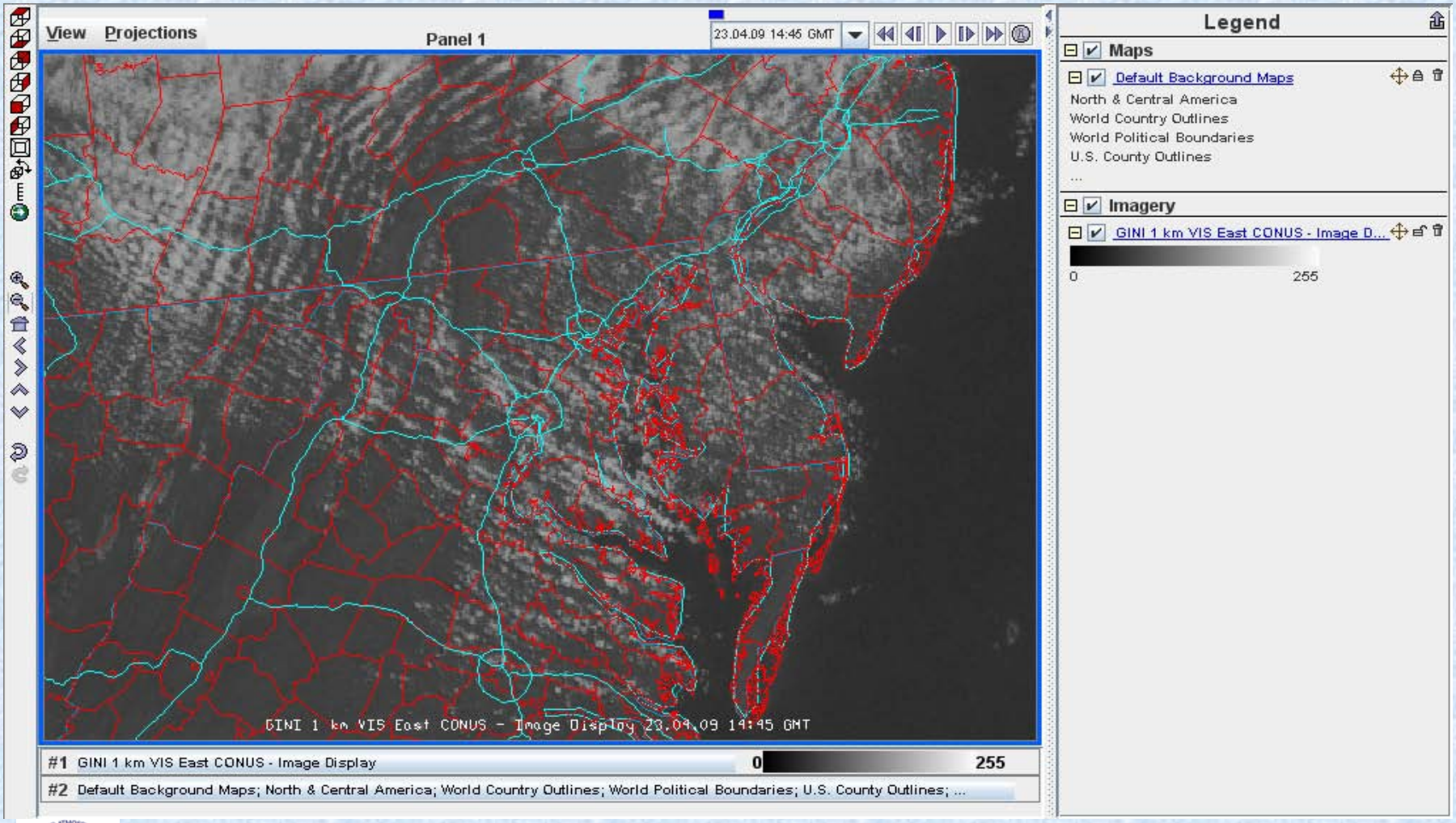
- Why is turbulence a hazard to aircraft?
  - **Structural Damage:** Results from encountering severe clear air turbulence. In extreme cases, this can lead to the break up of the aircraft. In even moderate turbulence, damage can occur to fittings within the aircraft especially as a result of collision with unrestrained items of cargo or passenger luggage. Prolonged exposure to turbulence will shorten the fatigue life of the aircraft.
  - **Physical Injury to Crew/Passengers:** Passengers and crew walking around the aircraft cabin can be injured.
  - 1997: United Airlines B747 encountered CAT over the Pacific ocean. Several passengers and crew were severely injured, one death.

- Why is it important to forecast turbulence?
  - Aircraft can avoid regions of severe turbulence.

Jet Stream Turbulence



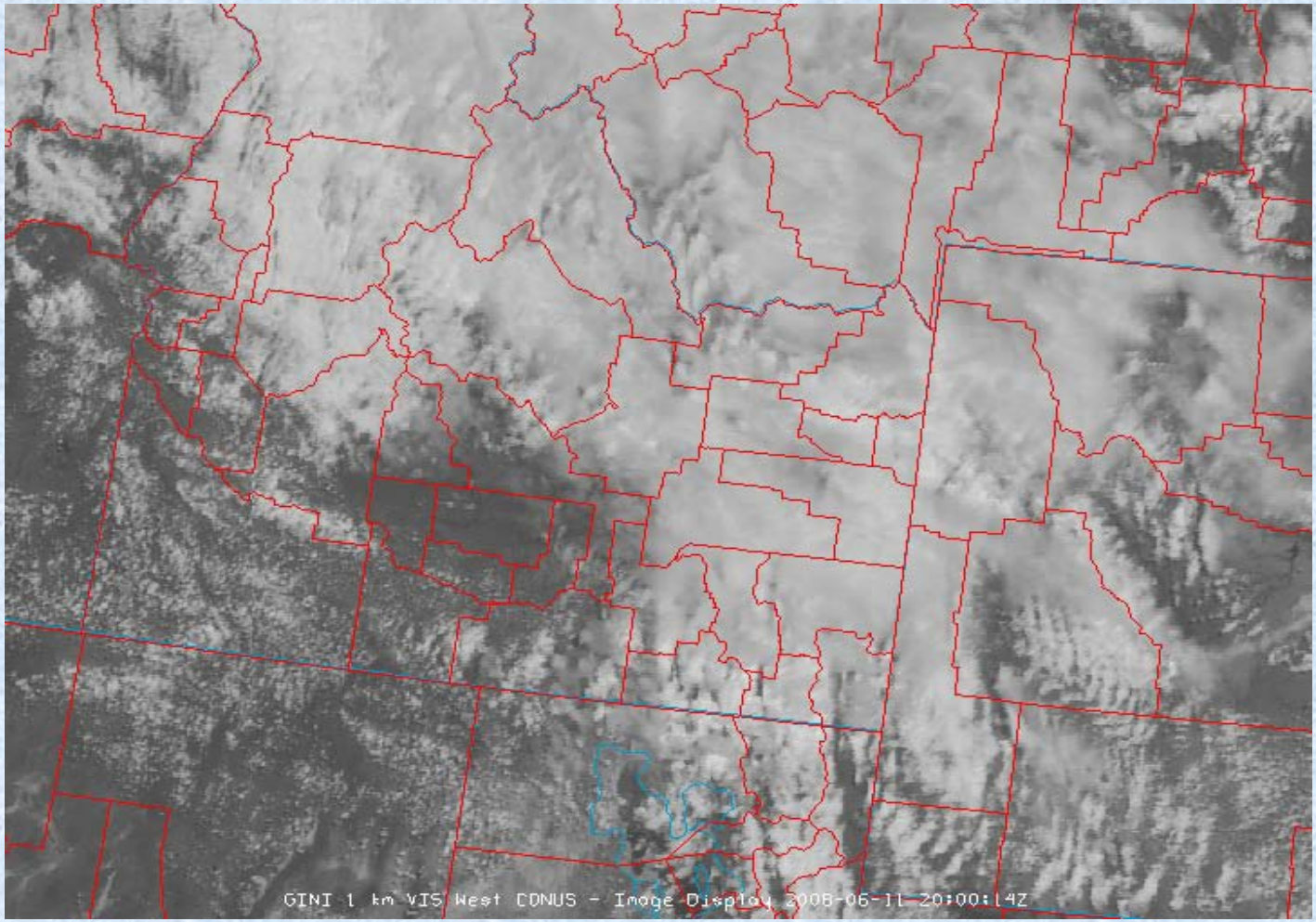
Low-level Turbulence



Turbulence Quiz

- What is turbulence?
- What are different types of turbulence?
- Why is turbulence a hazard to aircraft?
- Why is it important to forecast turbulence?
- Where can turbulence occur?

Turbulence Quiz



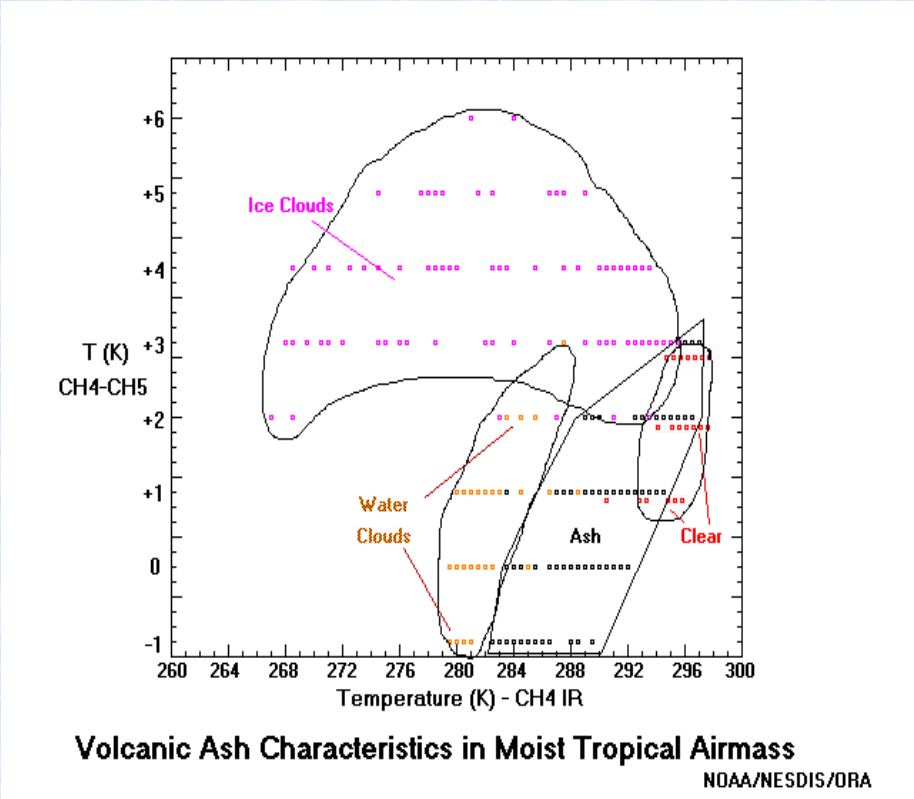
Volcanic Ash Hazards

- In addition to damaging the leading edge surfaces of aircraft, ash ingested into jet engines results in loss of performance, and possibly complete shutdown.

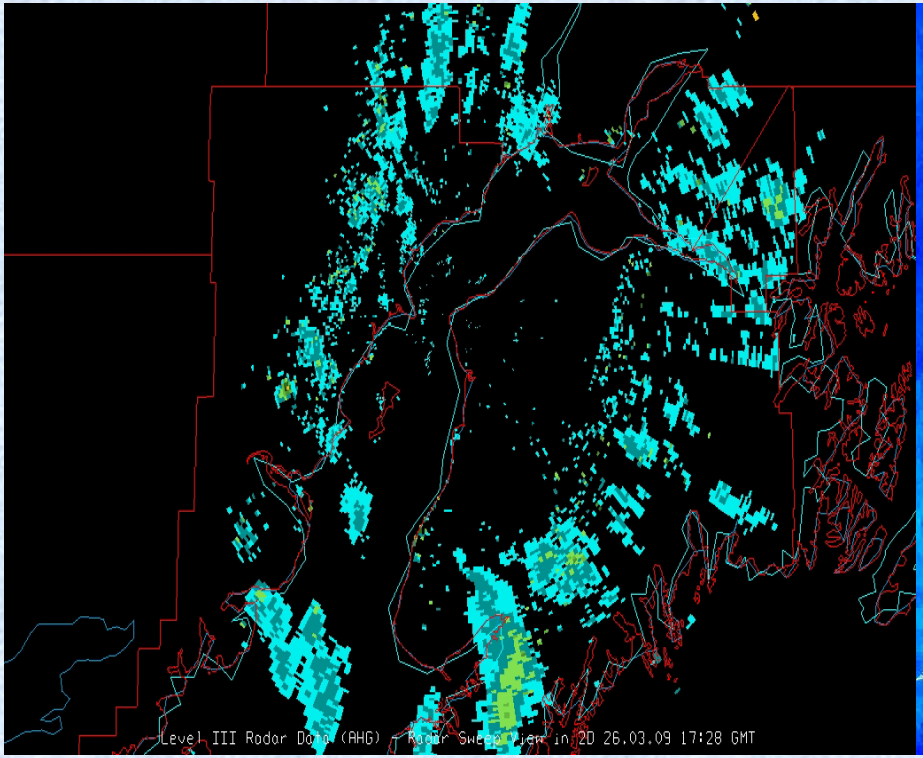
Mt. Redoubt, AK 1750 UTC 26 March 2009
Taken from Diamond Ridge near Homer, AK

Satellite Volcanic Ash Detection

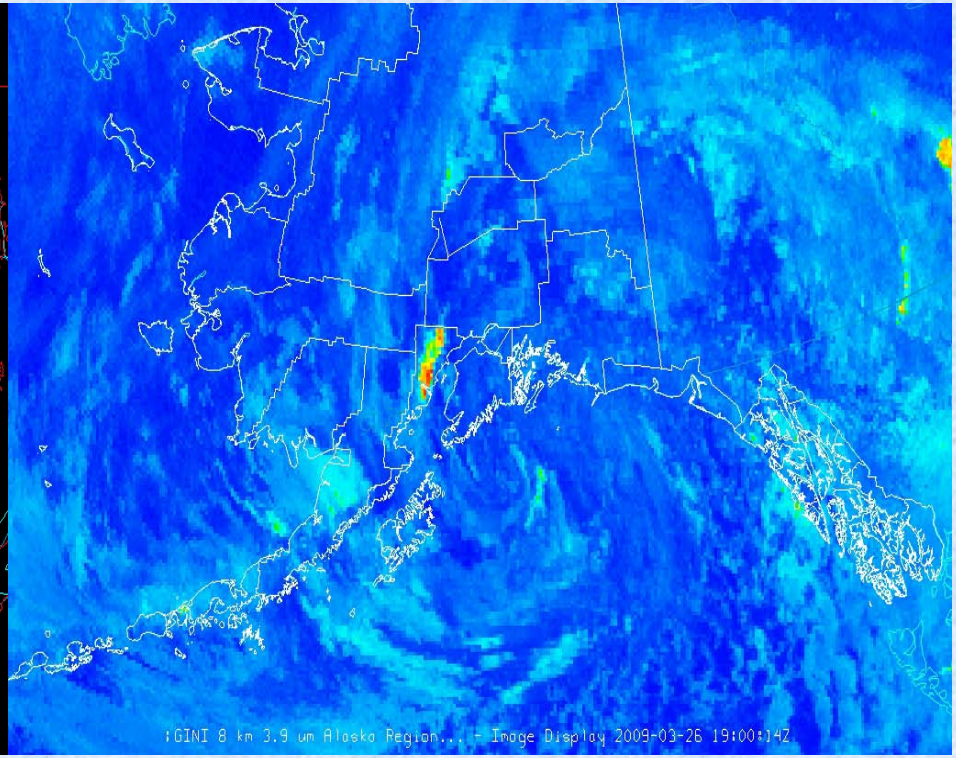
- Combine information from the shortwave IR (CH 2), with two longwave IR channels (4 and 5).
- Temperature differences in Bands 4 and 5 can help identify areas of volcanic ash due to unique energy properties.



Satellite Volcanic Ash Detection

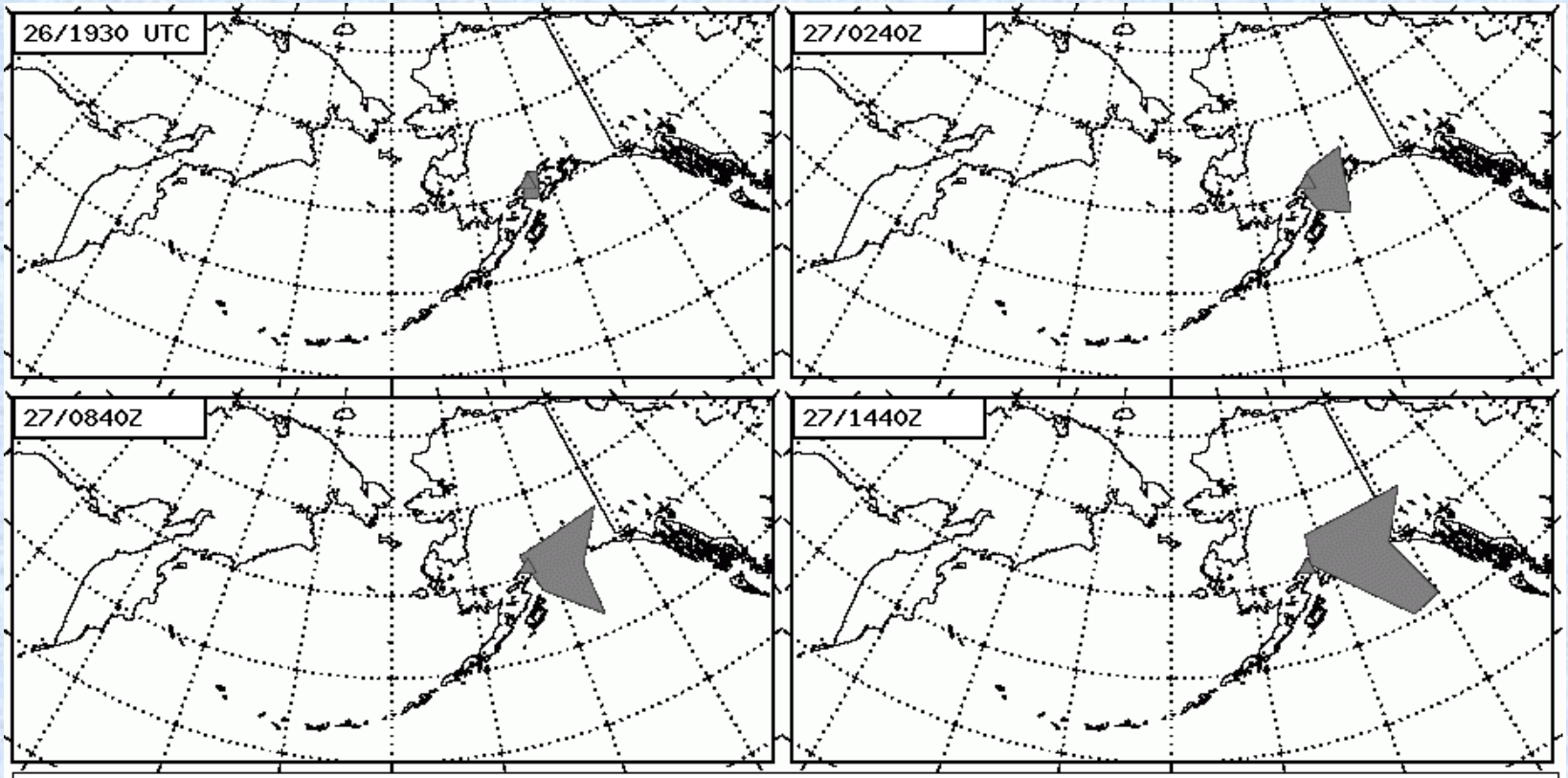


Anchorage Radar



GOES Volcanic Ash Product

Satellite Volcanic Ash Detection



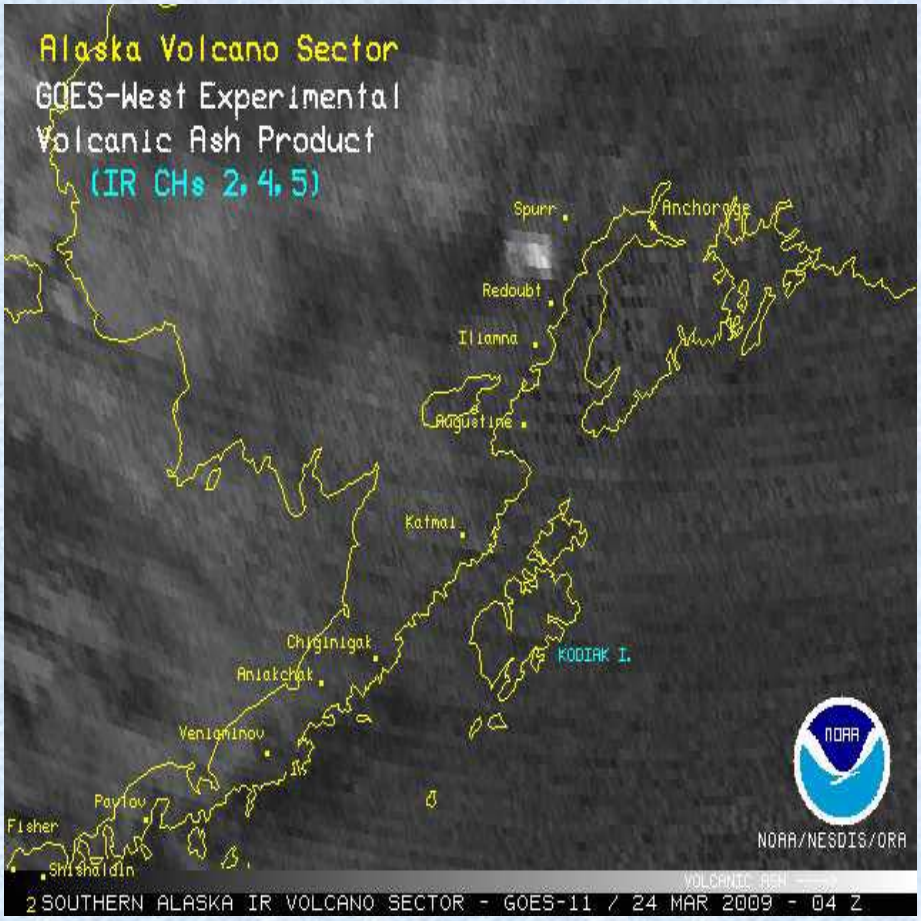
VOLCANIC ASH ADVISORY
DTG: 20090326/2040
VAAC: ANCHORAGE
VOLCANO: REDOUBT 1103-03
AREA: SOUTH CENTRAL ALASKA
SUMMIT ELEV: 10198ft (3109m)
ADVISORY NUM: 2009-18

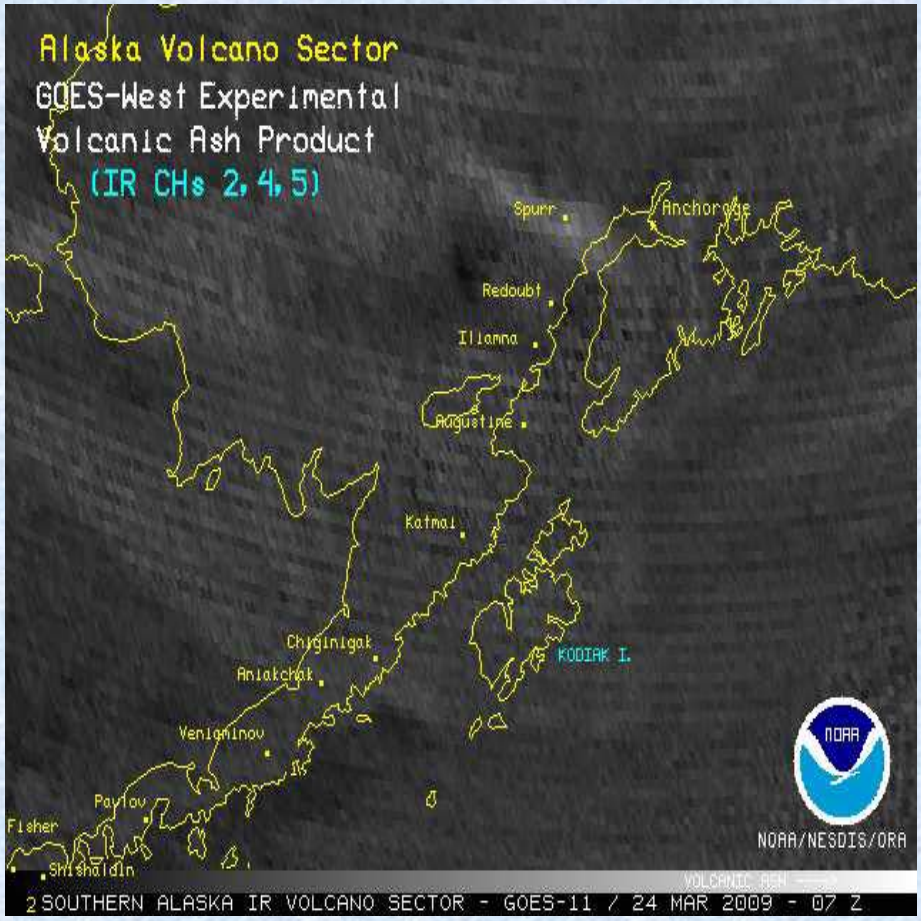
INFO SOURCE: POES/GOES/AVO/PILOT REPORT/RADAR
ERUPTION DEAILS: EXPLOSIVE ERUPTION AT 26/1724 UTC
REMARKS: LIGHT ASHFALL REPORTED AT HOMER BY TRUSTED OBSERVER.
NEXT ADVISORY: 20090327/0240Z

Volcanic Ash Quiz

- Why is volcanic ash a hazard to aircraft in flight?
- Why is volcanic ash important to detect and forecast?

Volcanic Ash Quiz



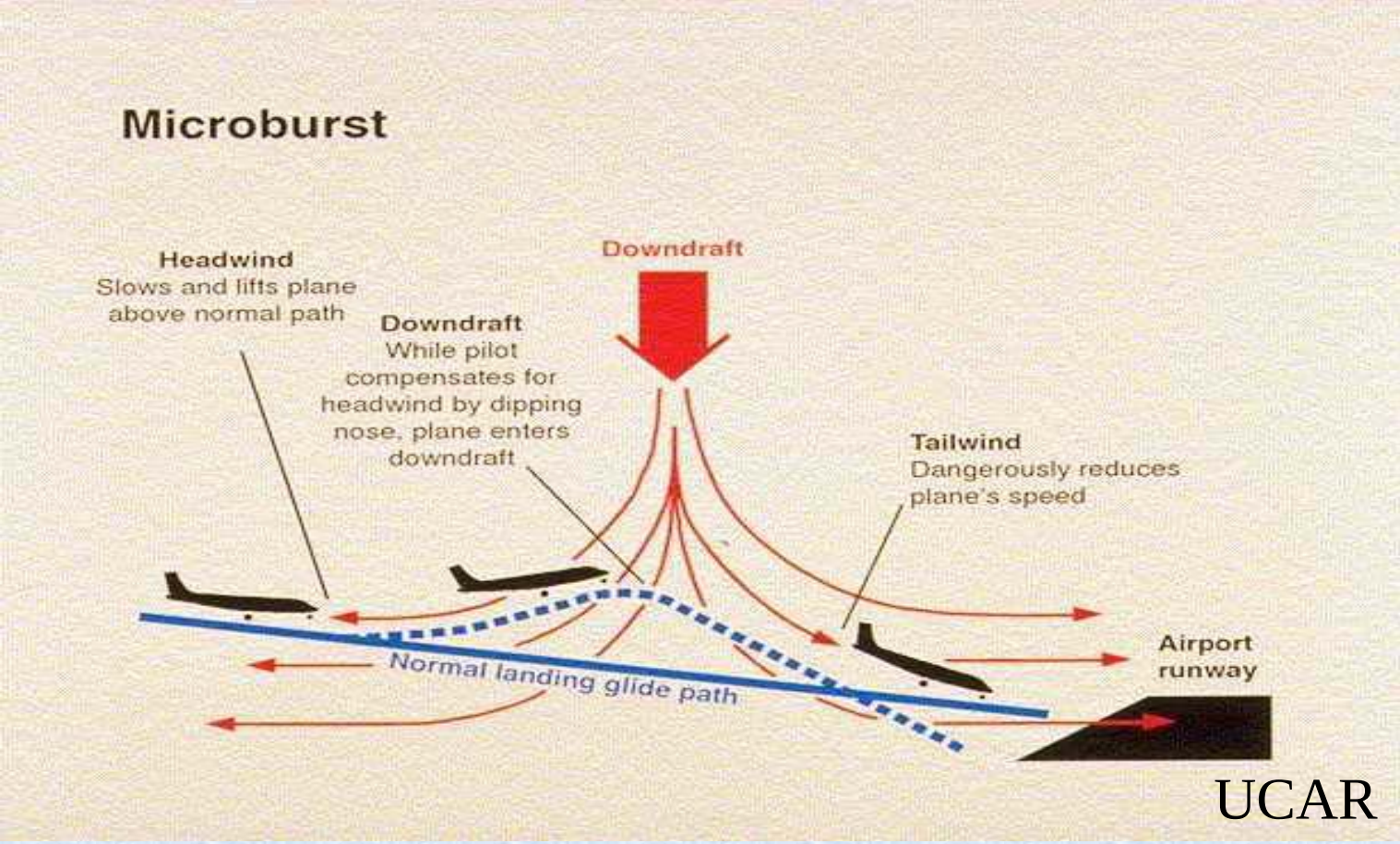


Downburst and Microburst

- Strong downdraft produced by a convective storm (or thunderstorm) that causes **damaging winds** on or near the ground.
- Due to the resulting **intense wind shear**, downbursts are a **hazard to aircraft** in flight, especially during takeoff and landing.

Microburst Hazards

Microburst Hazards



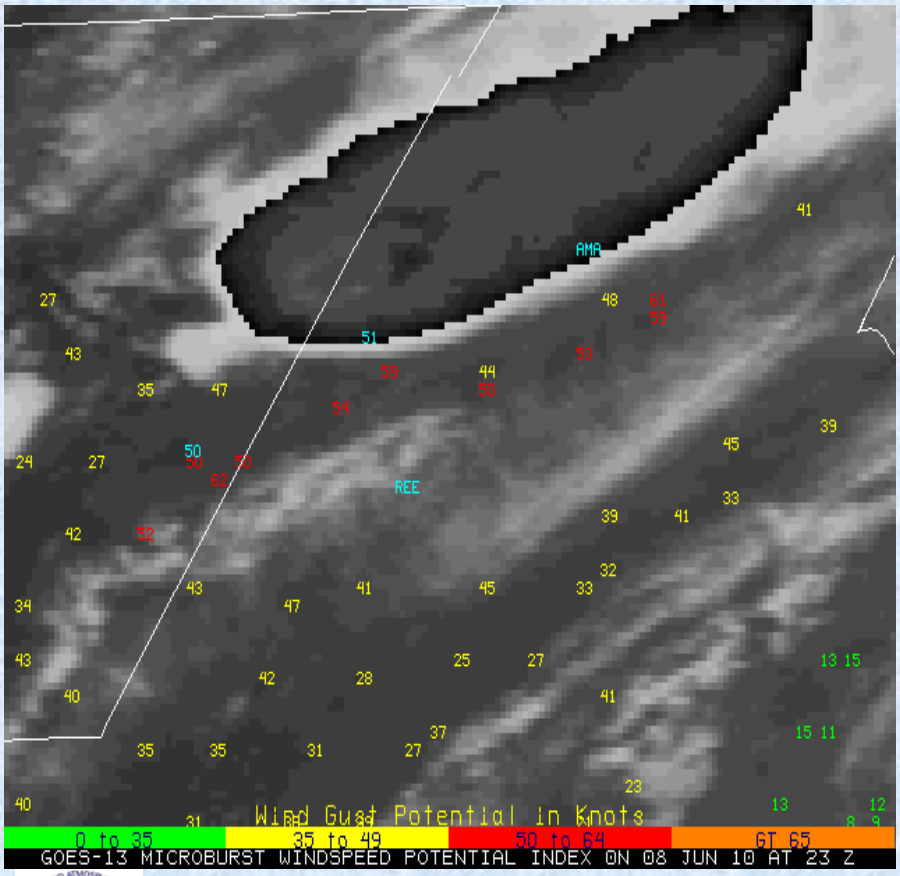
Historic Microburst-Related Airline Disasters

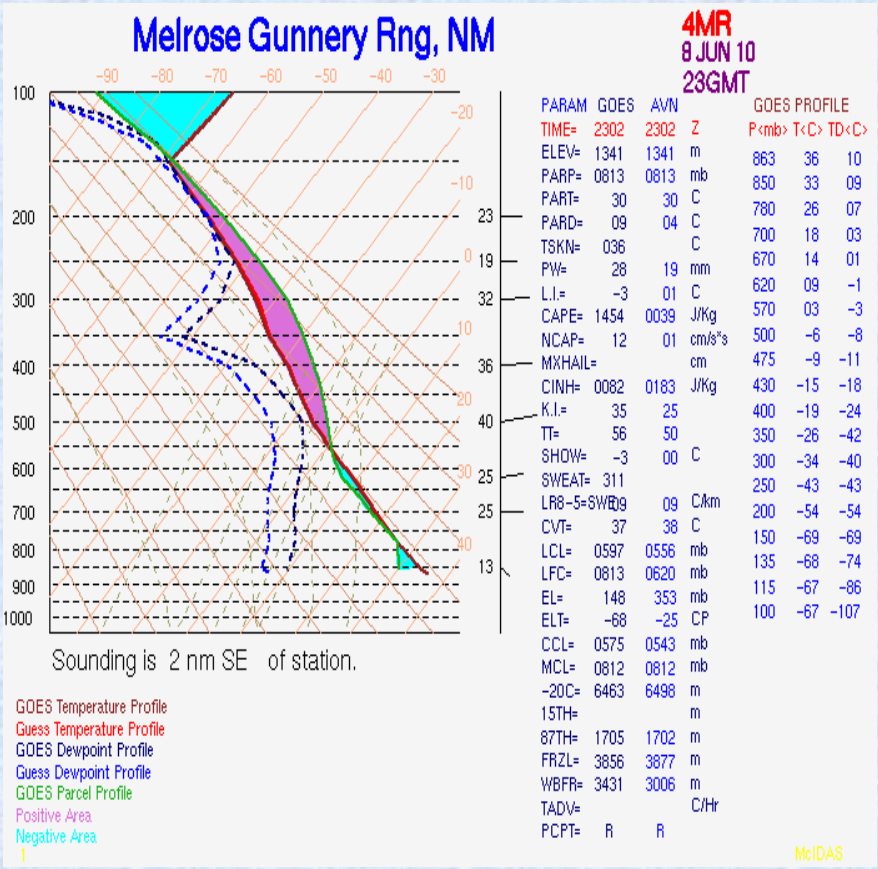
- Eastern 66, New York (JFK), June 1975
- Continental 426, Denver, August 1975
- Pan American 759, New Orleans, July 1982
- Delta 191, Dallas-Ft. Worth (DFW), August 1985
- USAIR, Charlotte (CLT), July 1994
- American Airlines, Little Rock (LIT), June 1999

Microburst Quiz

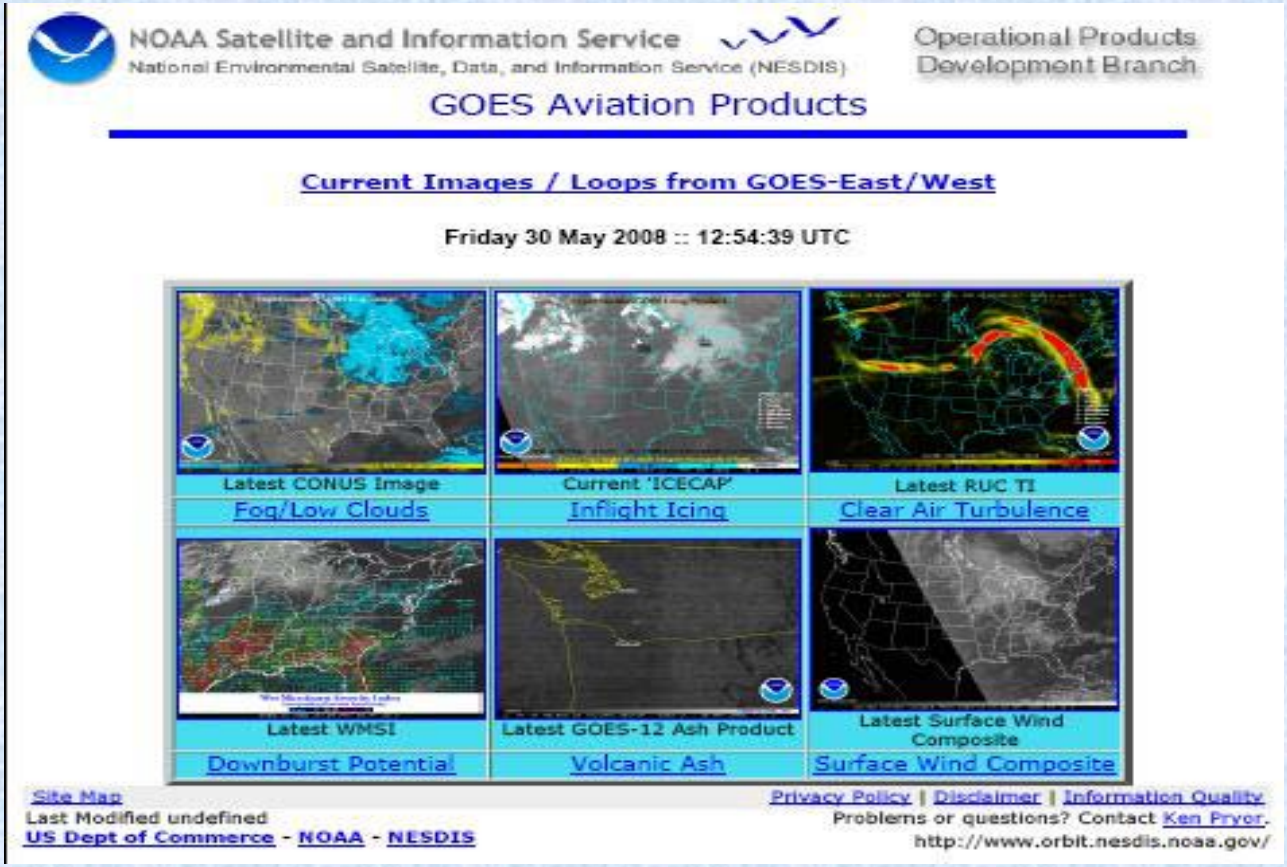
- What is a downburst/microburst?
- Why are microbursts a hazard to aircraft?
- Why is it important to forecast microbursts?
- Where do microbursts occur?

Microburst Quiz





GOES Aviation Products



http://www.star.nesdis.noaa.gov/smcd/opdb/aviation/aviation.html

Summary

- Aviation weather requires understanding:
- Aircraft characteristics
- Hazards
- Weather conditions
- Detection methods
- Satellite imagery interpretation
  - Identify meteorological features/hazards

Questions?

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