

Undetectable by collision avoidance systems

Undetectable by the flight crew

### Meteorological Quality Control for the Calculation of Altimetry System Error

Undetectable by air traffic control



**Federal Aviation  
Administration**

# Overview

- Areas where meteorological quality control applies
- Assigning meteorological quality control scores to regions
- Meteorological parameter descriptions
- Methodology and data flow for alert reports

# Areas of Meteorological Quality Control

- NOAA model
  - ✦ Past work reviewed (NOAA product evaluation)
  - ✦ Data variables height and temperature
- Detection of atmospheric activity and instability
- FAA model
  - ✦ Evaluate flight estimation errors (model error)
  - ✦ Evaluate NOAA grid and vertical resolutions

# NOAA Model (Past Work Review)

- Tasked to switch from grib1 to grib2 format
- Data file evaluation performed on NOAA GFS (Global Forecast System) products
  - ✦ FAA WAFS (World Area Forecast System) – custom WAFS file produced by NOAA for FAA Separation Standards work (grib1)
  - ✦ WAFC (World Area Forecast Centers) – a NOAA production file with enhanced vertical resolution (grib2)
  - ✦ GDAS (Global Data Assimilation System) – A NOAA production file with enhanced horizontal, vertical and time resolutions and analysis data for times [00, 06, 12, 18] Z (grib2)
- GDAS chosen to replace FAA WAFS and currently in production for the calculation of ASE

# NOAA Model

- Quality control factors
  - ✦ Model initialization for height and temperature
  - ✦ Data gaps specific to a region
  - ✦ Accuracy
- Quality control checks
  - ✦ NOAA report
  - ✦ Catalog missing observations
  - ✦ Switch out data sets
  - ✦ Example use WAFS London instead of GDAS
  - ✦ Compare analysis and re-analysis differences
  - ✦ Compare ensemble aircraft height estimates of a flight level for a region and for a given time period against modeled flight level heights



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# Atmospheric Activity and Instability

- Types of activity and instability considered
  - ✦ Clear Air Turbulence
  - ✦ Mountain Wave Activity
  - ✦ Icing
  - ✦ Troughs and Ridges
  - ✦ Convection (Storms)
- Quality control checks
  - ✦ Score parameter by intensity and review
  - ✦ Correlate atmospheric activity and instability with ASE

# Atmospheric Activity and Instability

- Types of activity and instability pending consideration
  - ✦ In-cloud turbulence
  - ✦ Vorticity
  - ✦ Height gradient at a mb level (part of troughs and ridges)
  - ✦ Pressure gradient (part of troughs and ridges)

# FAA Model

- Quality control factors
  - ✦ Equations that model flight level height
  - ✦ Data resolution
  - ✦ Tropopause placement
- Quality control checks
  - ✦ Enhance equations ; use different equations
  - ✦ Use higher resolution data sets
  - ✦ Compare empirical and estimated tropopause placement



# Assign Quality Control Scores

	0 None; mv Missing Value	1 Light	2 Moderate	3 Severe	4 Extreme
NOAA Init					
NOAA Gaps					
CAT					
Mnt Wave					
Icing					
Trough/Rdge					
Storms					

# Quality Control Score Assignment

Parameters	Units	0 None; mv Missing Value	1 Light	2 Moderate	3 Severe	4 Extreme
NOAA Init	index	NIT=0	NIT=1	NIT=2	NIT=3	NIT=4
NOAA Gaps	index	NGP=0	NGP=1	NGP=2	NGP=3	NGP=4
CAT	index, [%]	CAT=0	CAT=1	CAT=2	CAT=3	CAT=4
CAT	edr (m <sup>2</sup> /3 s-1)	CAT=0	CAT<30	30<=CAT<55	55<=CAT<90	CAT>=90
Mnt Wave	index	MWV=0	MWV=1	MWV=2	MWV=3	MWV=4
Mnt Wave	edr (m <sup>2</sup> /3 s-1)	MWV=0	MWV<30	30<=MWV<55	55<=MWV<90	MWV>=90
Icing	index, [%]	ICE=0	ICE=1	ICE=2	3<=ICE<=4	ICE=5
Trough/Rdge	index	TRG=0	TRG=1	TRG=2	TRG=3	TRG=4
Storms	index	CNV=0	CNV=1	CNV=2	CNV=3	CNV=4
Storms	dbz	CNV=0	CNV<30	30<= CNV < 40	40 <= CNV < 50	CNV >= 50

# Quality Control File Description

- Coverage

- ✦ Continental US area
- ✦ Latitude 60 N -> 20 N
- ✦ Longitude -130 W -> -60 W
- ✦ 1.25 x 1.25 degrees (qc score file)
- ✦ 10 x 10 degrees (qc alert report, 35 regions)

- MB Levels

- ✦ 400, 300, 250, 200, 150, 100

- Parameter Definition

- ✦ NIT = NOAA Initialization
- ✦ NGP = NOAA Gaps
- ✦ CAT = Clear Air Turbulence
- ✦ MWV = Mountain Wave
- ✦ ICE = Icing
- ✦ TRG = Troughs and Ridges
- ✦ CNV = Convection

# Parameter Definition Tables

GRIB2 Code Table 4.207 (ICING)

Code Figure	Meaning
0	None
1	Light
2	Moderate
3	Severe
4	Trace
5	Heavy
6-191	Reserved
192-254	Reserved for Local Use
255	Missing

GRIB2 Code Table 4.208 (TURBULENCE)

Code Figure	Meaning
0	None
1	Light
2	Moderate
3	Severe
4	Extreme
5-191	Reserved
192-254	Reserved for Local Use
255	Missing



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# QC Score File Format

```
POS=60 N -130 W, DATE=20170925, HOUR=00, MB=400, NIT=,NGP=,CAT=,MWV=,ICE=,TRG=,CNV=  
POS=60 N -120 W, DATE=20170925, HOUR=00, MB=400, NIT=,NGP=,CAT=,MWV=,ICE=,TRG=,CNV=  
POS=60 N -110 W, DATE=20170925, HOUR=00, MB=400, NIT=,NGP=,CAT=,MWV=,ICE=,TRG=,CNV=  
POS=60 N -100 W, DATE=20170925, HOUR=00, MB=400, NIT=,NGP=,CAT=,MWV=,ICE=,TRG=,CNV=  
POS=60 N -090 W, DATE=20170925, HOUR=00, MB=400, NIT=,NGP=,CAT=,MWV=,ICE=,TRG=,CNV=  
POS=60 N -080 W, DATE=20170925, HOUR=00, MB=400, NIT=,NGP=,CAT=,MWV=,ICE=,TRG=,CNV=  
POS=60 N -070 W, DATE=20170925, HOUR=00, MB=400, NIT=,NGP=,CAT=,MWV=,ICE=,TRG=,CNV=  
POS=60 N -060 W, DATE=20170925, HOUR=00, MB=400, NIT=,NGP=,CAT=,MWV=,ICE=,TRG=,CNV=
```



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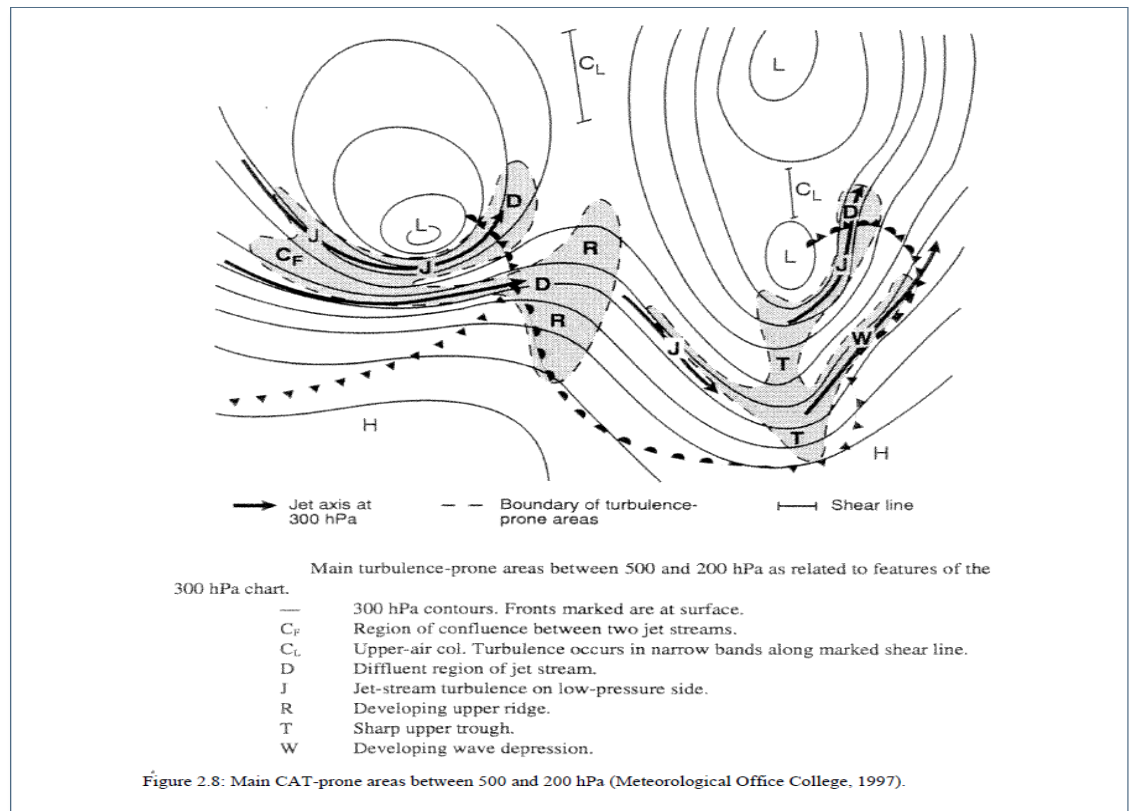


# Alert Report Format

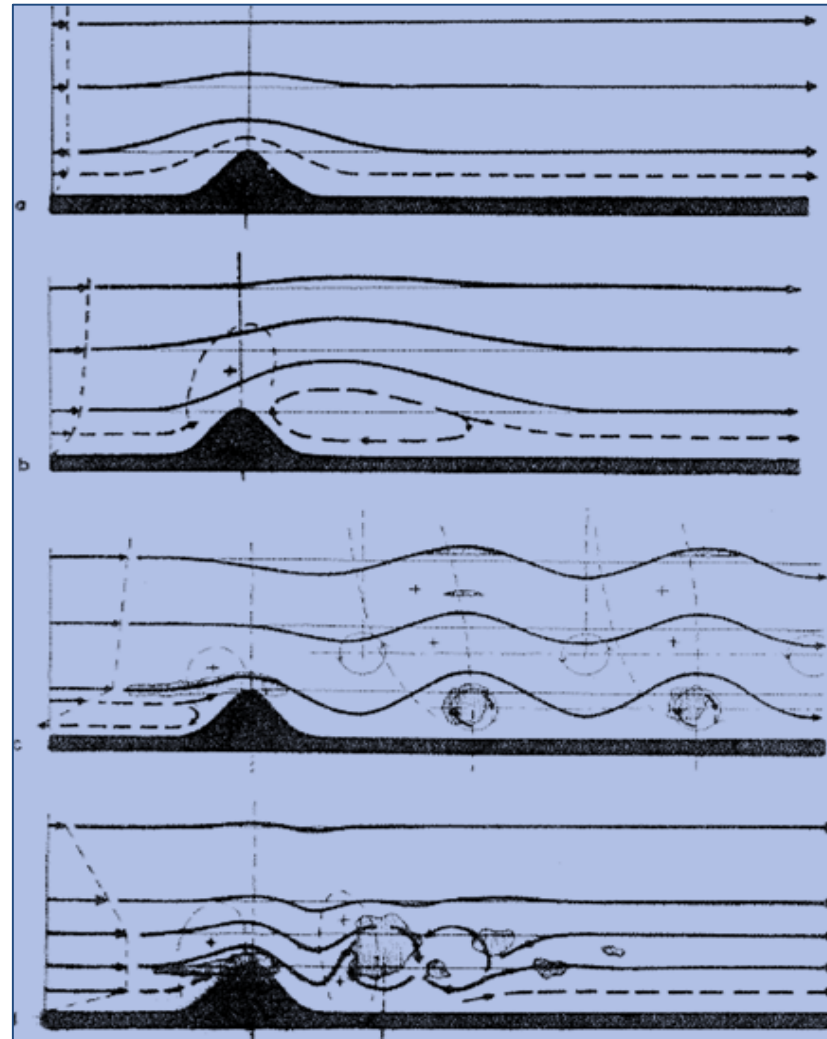
- Records containing scores  $\geq 3$
- Parameter plots; data sources for parameter plots mostly from AWC (Aviation Weather Center) → Used to check scores and display weather
  - ✦ GDAS (Global Data Assimilation System)
  - ✦ WAFS (World Area Forecast System)
  - ✦ RAP / HRRR (Rapid Refresh / High Resolution Rapid Refresh)
  - ✦ Sigmet / Airmet (Significant Meteorological Information / Airmen's Meteorological Information)
  - ✦ Pirep / Airrep (Pilot Report / Aircraft Report)

# Clear Air Turbulence

- Clear-air turbulence (CAT) is the turbulent movement of air masses in the absence of any visual clues such as clouds, and is caused when bodies of air moving at widely different speeds meet.
- The atmospheric region most susceptible to CAT is the high troposphere at altitudes of around 7,000–12,000 meters (23,000–39,000 ft.) as it meets the tropopause.
- Here CAT is most frequently encountered in the regions of jet streams. At lower altitudes it may also occur near mountain ranges.



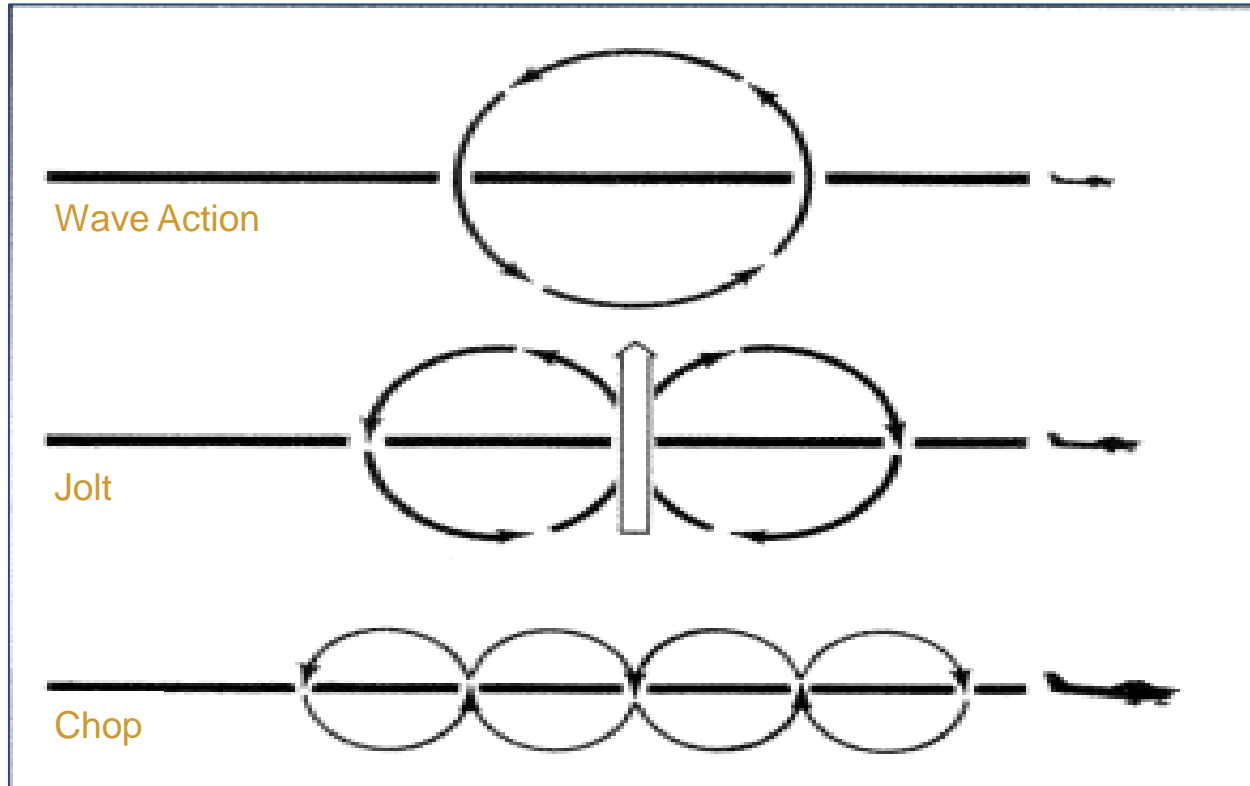
# Turbulence induced by mountain waves.



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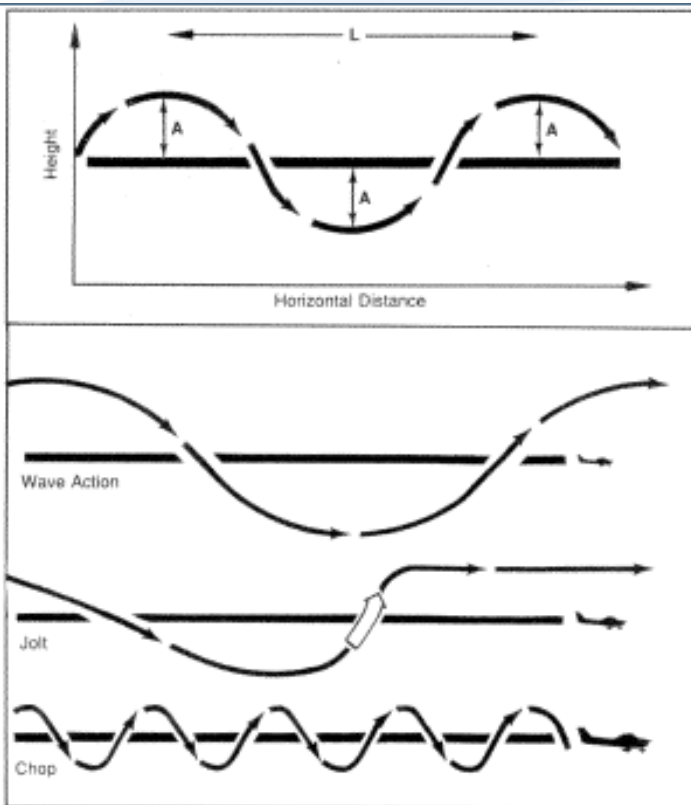


# Turbulence Eddy Dissipation Rates



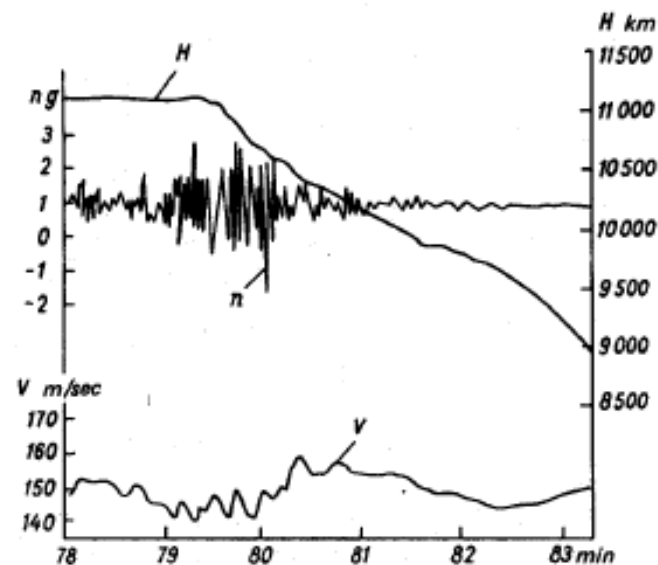
Effect of eddies with varying sizes

# Turbulence Effects



Effect of different wave motions

Oscillogram of flight of Boeing-720B in a clear-air turbulent zone.



An aircraft encountering clear-air turbulence  $V$  is the air speed,  $H$  the height, and  $n$  the vertical acceleration of the aircraft plus the acceleration of gravity.

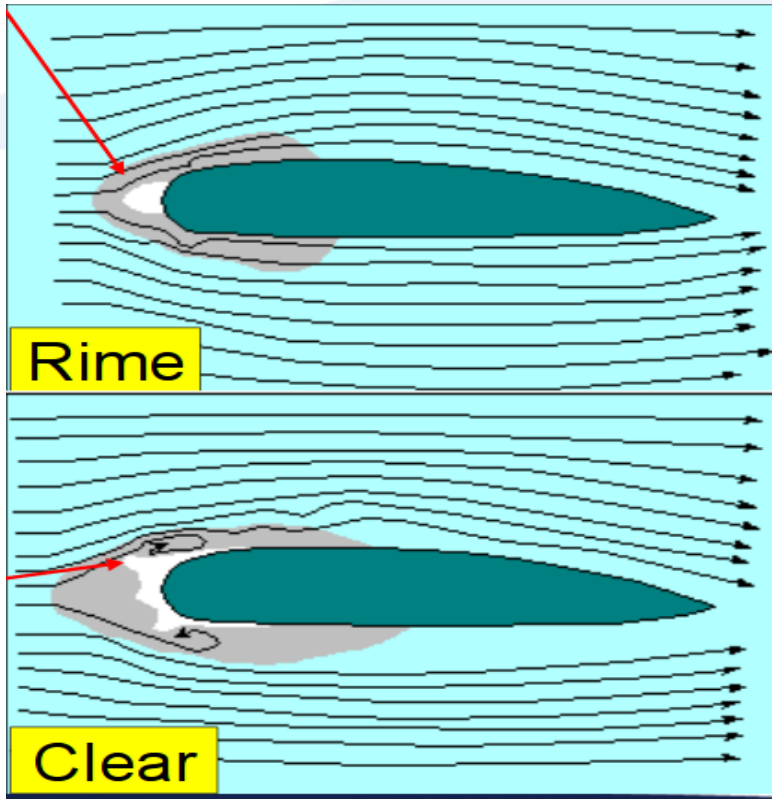


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# Icing

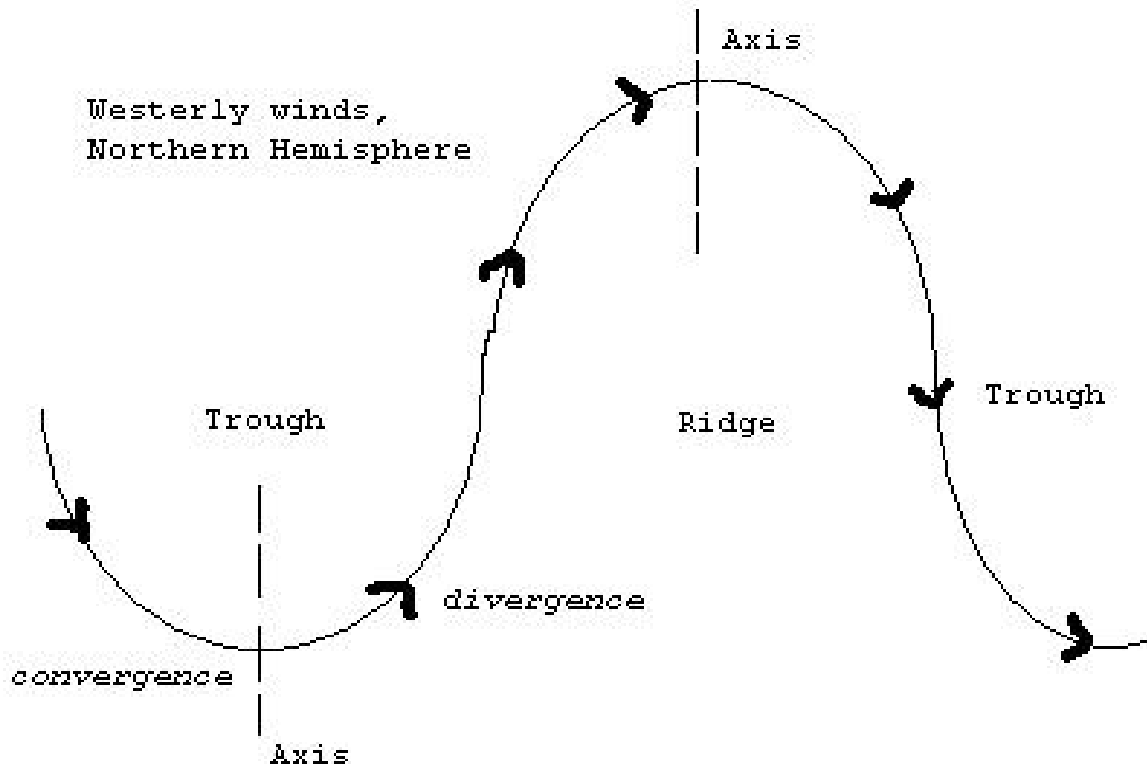
In aviation, icing conditions are those atmospheric conditions that can lead to the formation of water ice on the surfaces of an aircraft, or within the engine as carburetor icing.



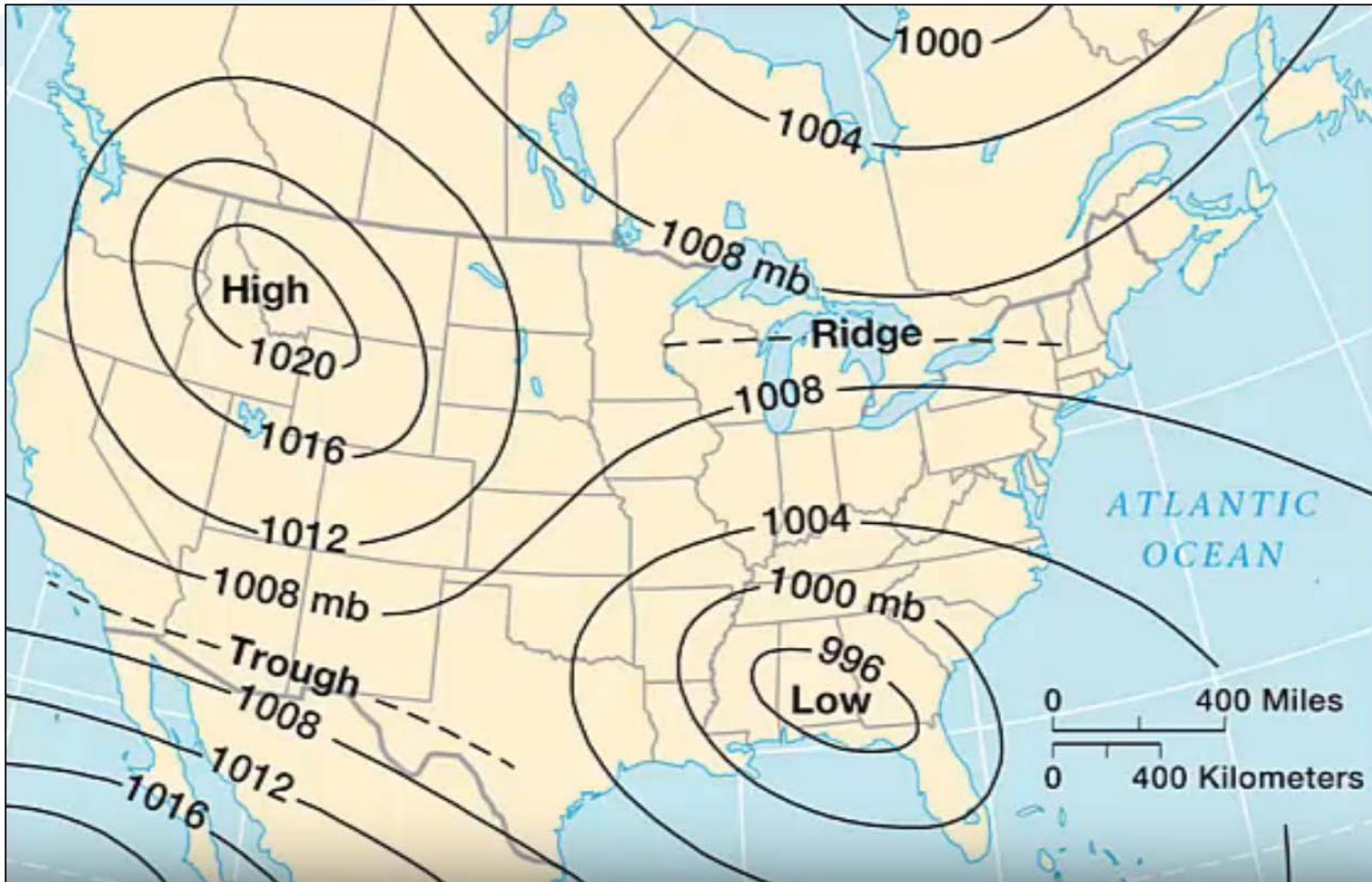
Inlet icing is another engine-related danger, often occurring in jet aircraft. These icing phenomena do not necessarily occur together. Many aircraft, especially general aviation aircraft, are not certified for flight into known icing—icing conditions certain or likely to exist, based on pilot reports, observations, and forecasts.

# Troughs and Ridges

A trough is an elongated area of relatively low pressure extending from the center of a region of low pressure. A ridge is an elongated area of relatively high pressure extending from the center of a high-pressure region.



# Troughs and Ridges (labeled)

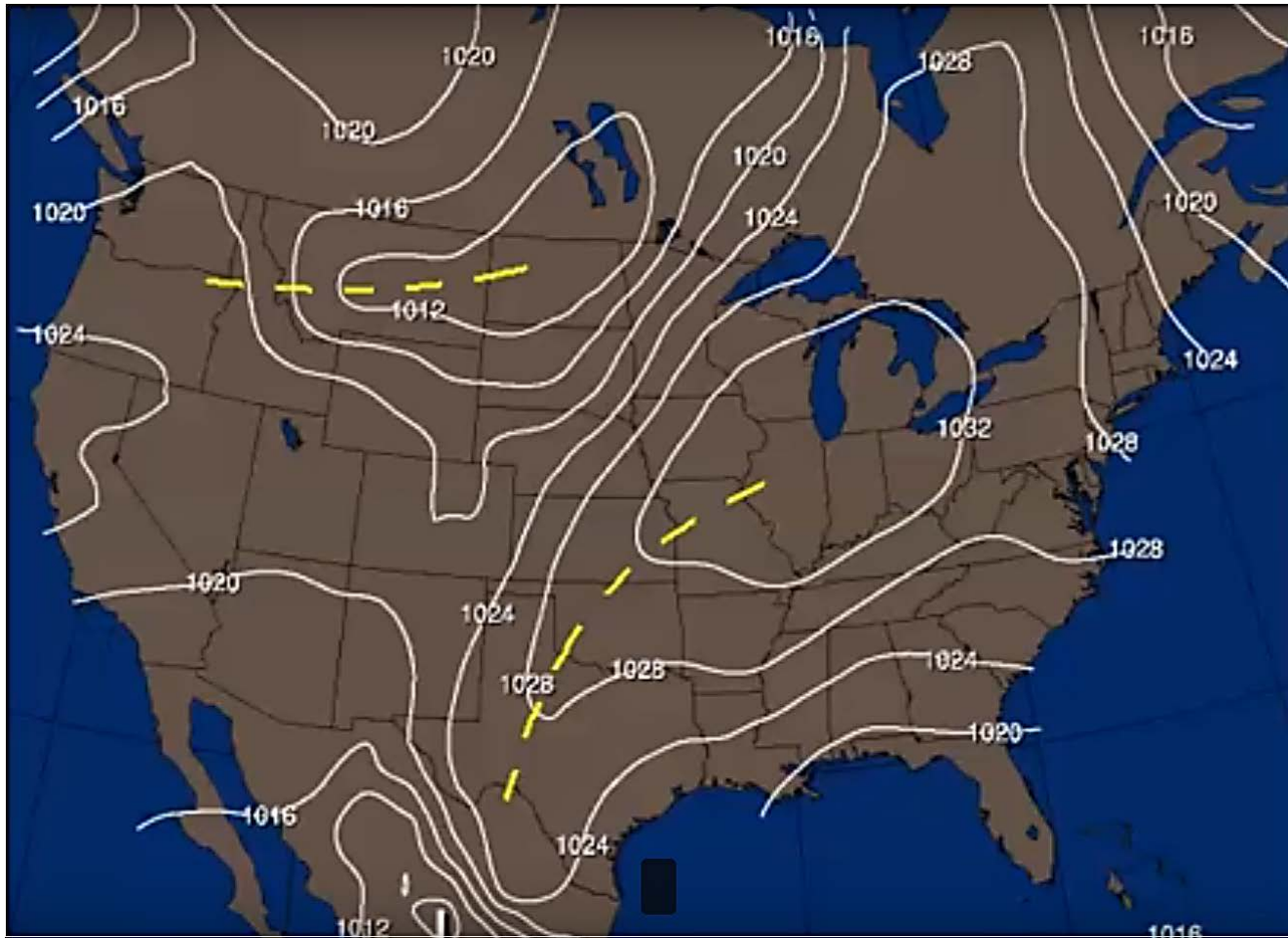


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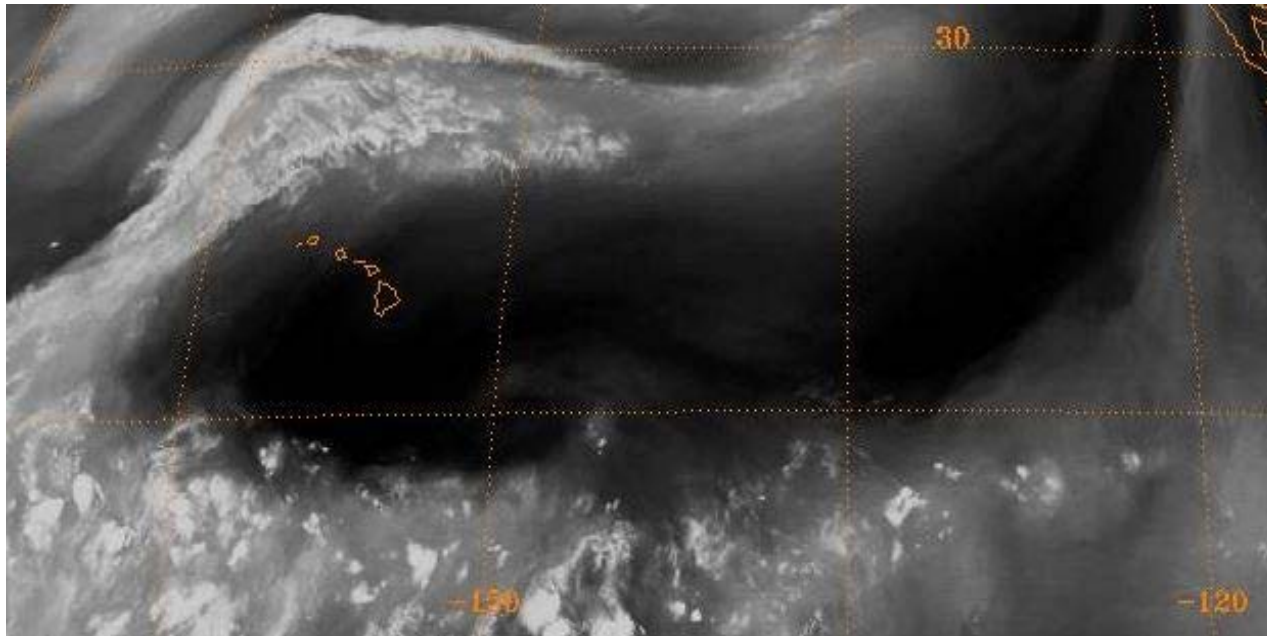
# Troughs and Ridges



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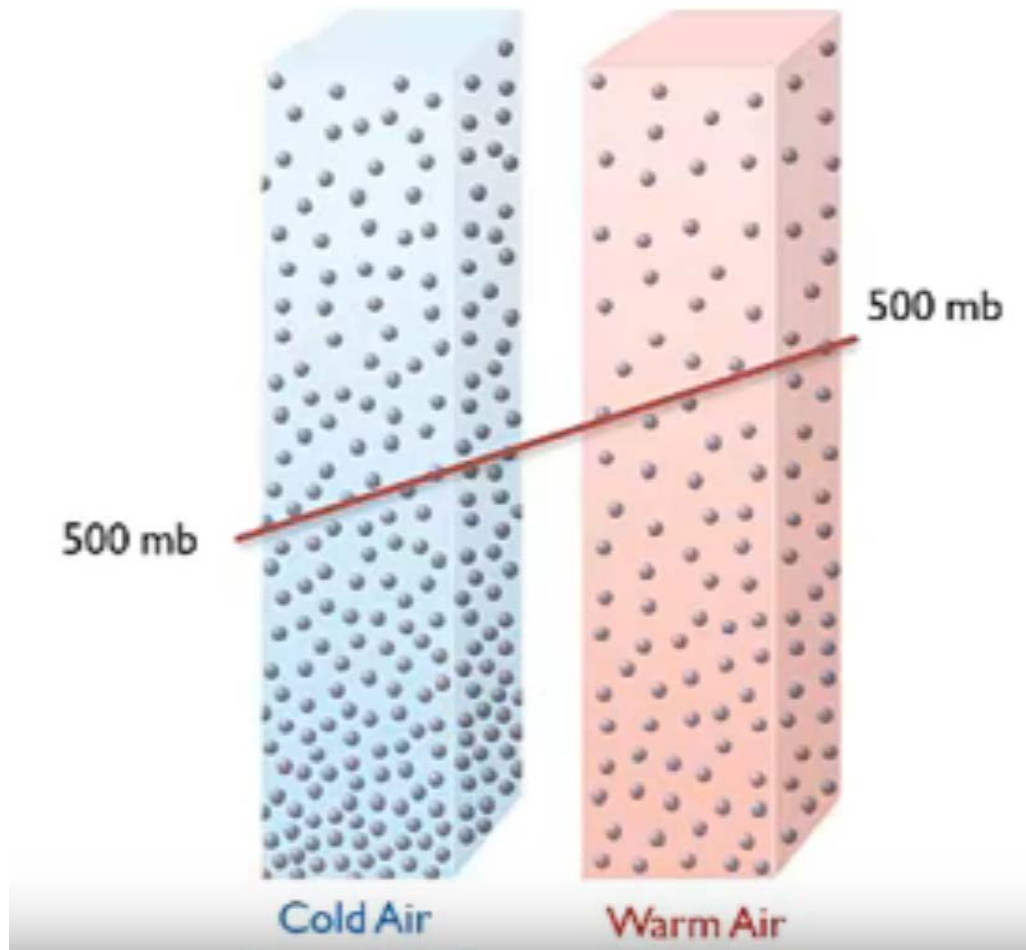
# Trough or Ridge?



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# Height Gradient

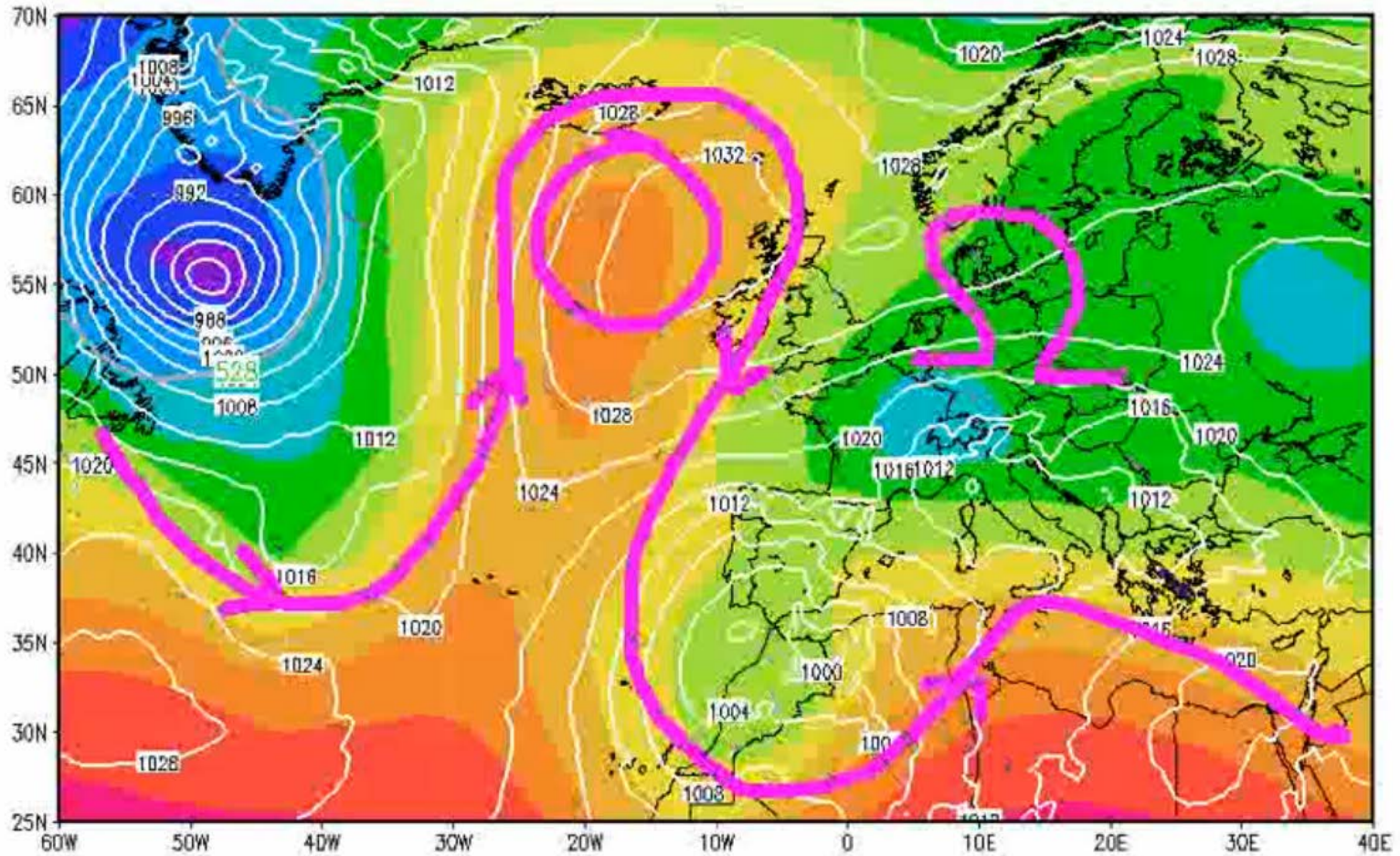


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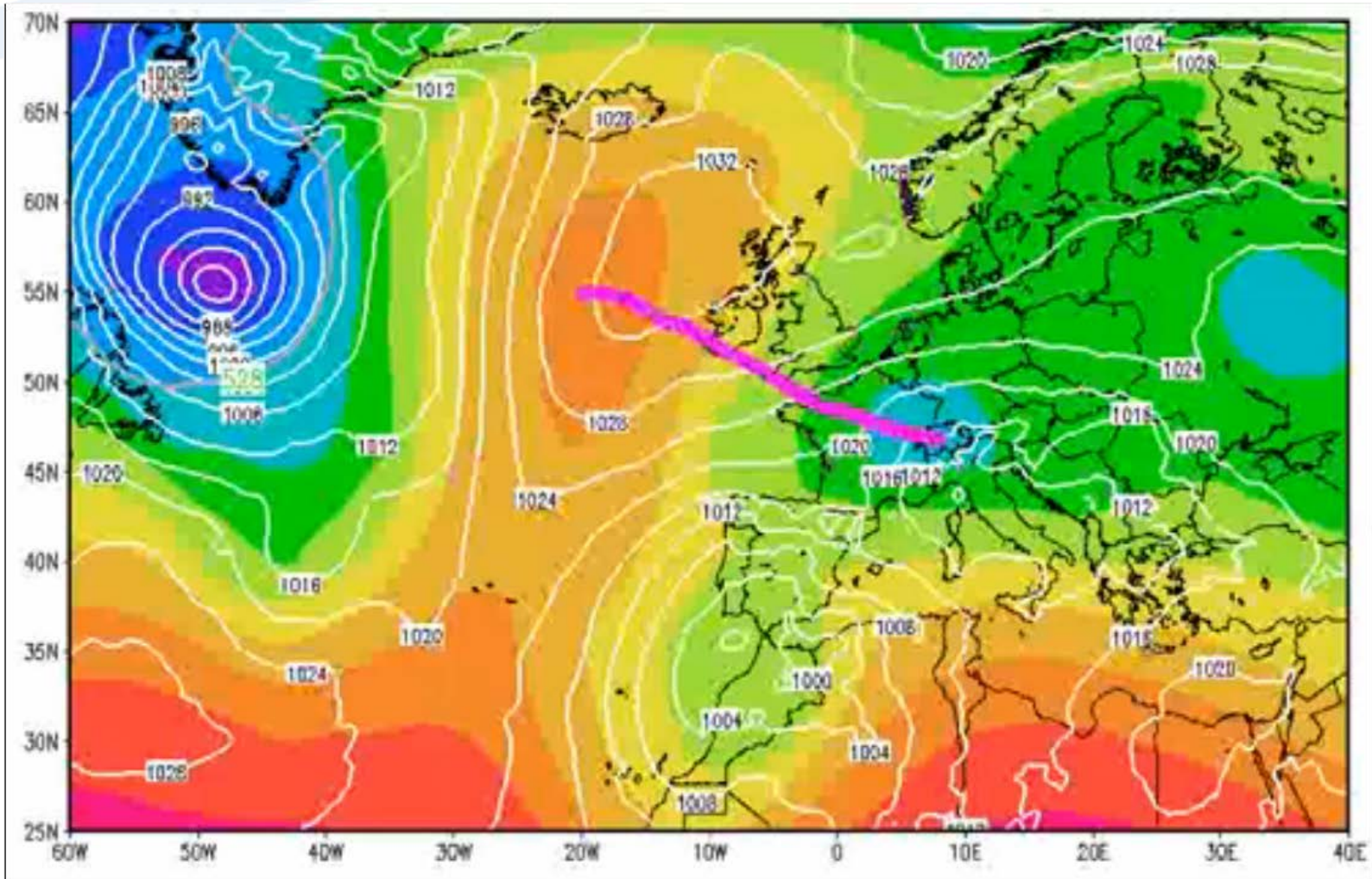
# Ridge and Height Gradient (part 1)



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# Ridge and Height Gradient (part 2)

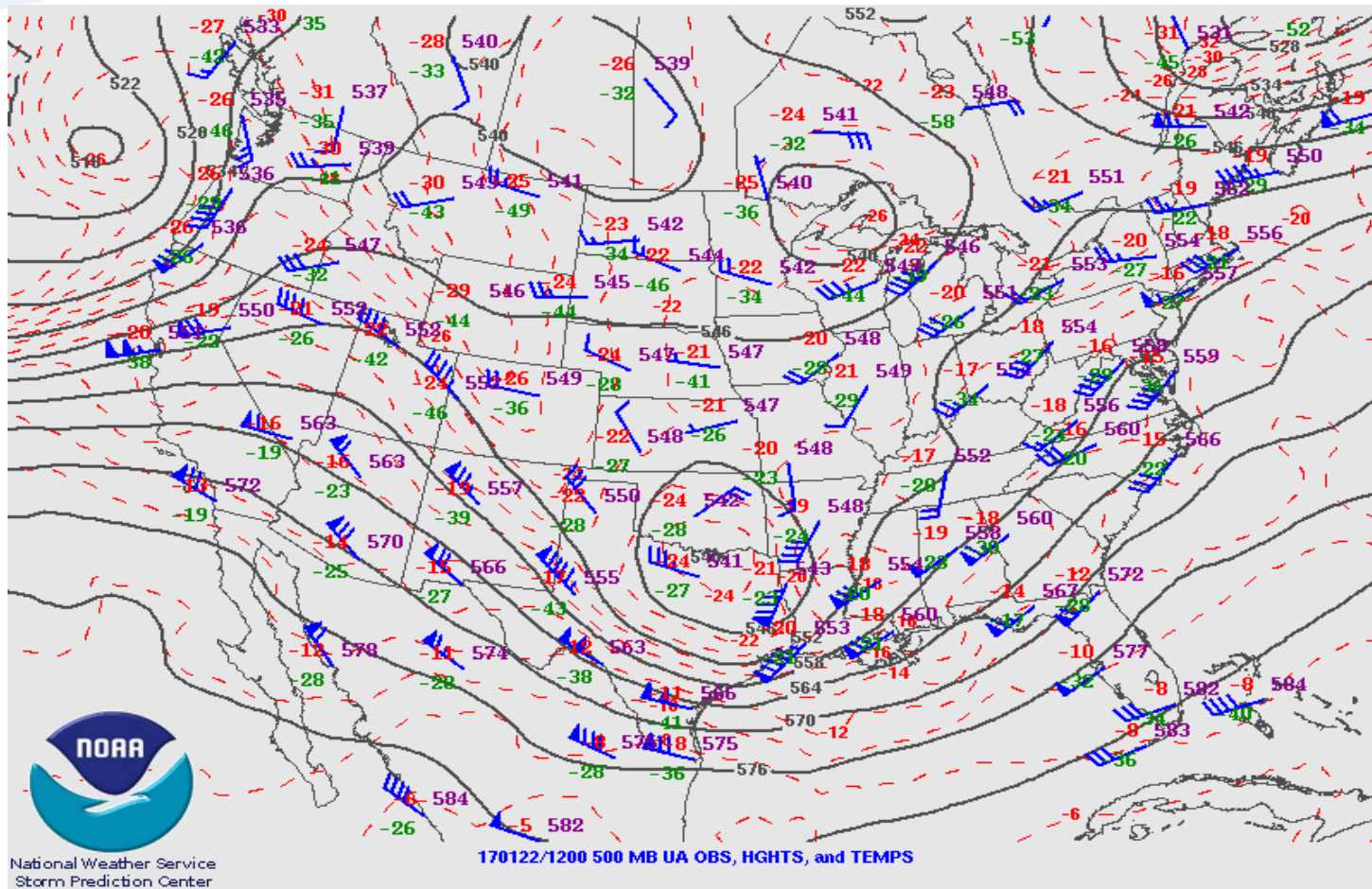


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# Upper Level Contours Trough and Height Gradient

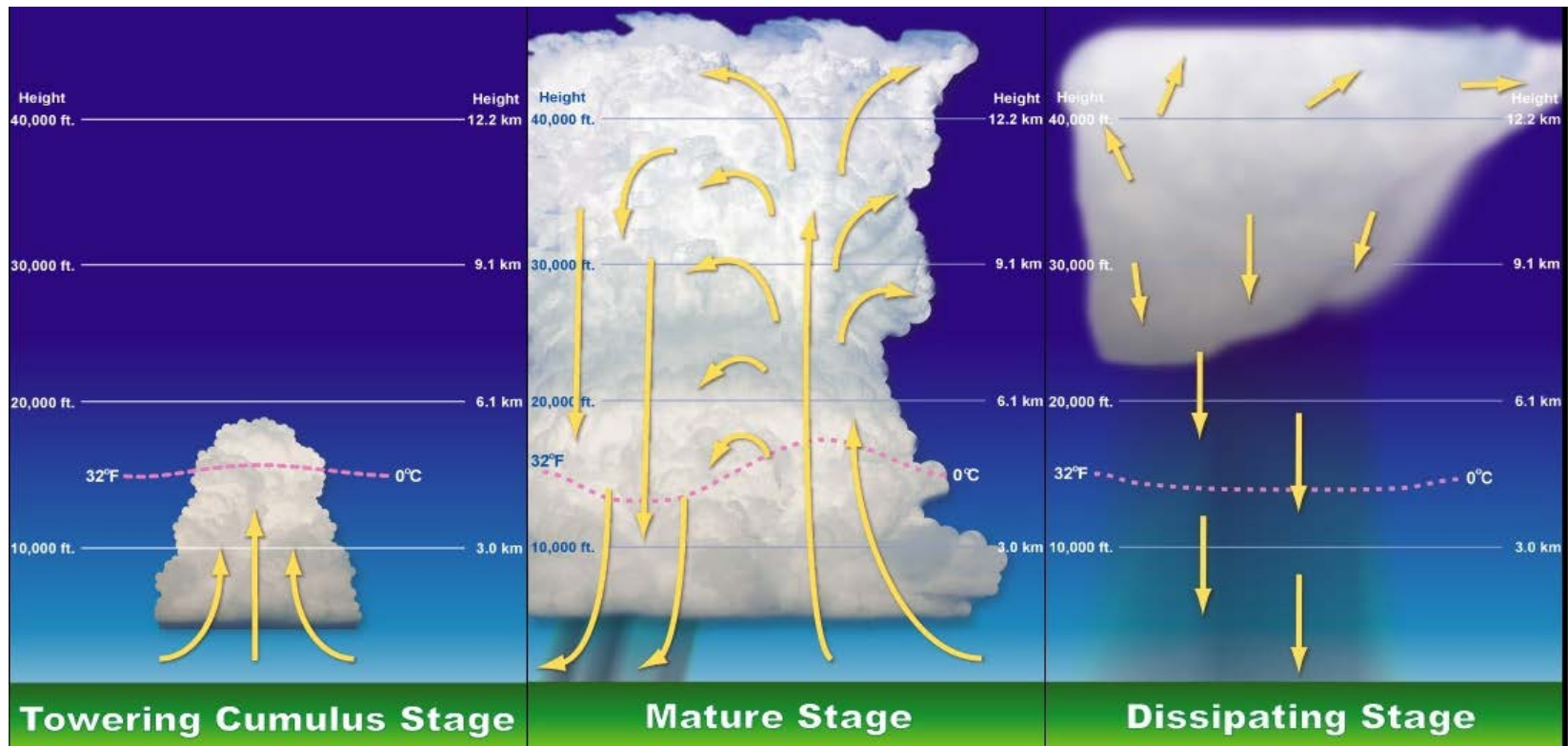


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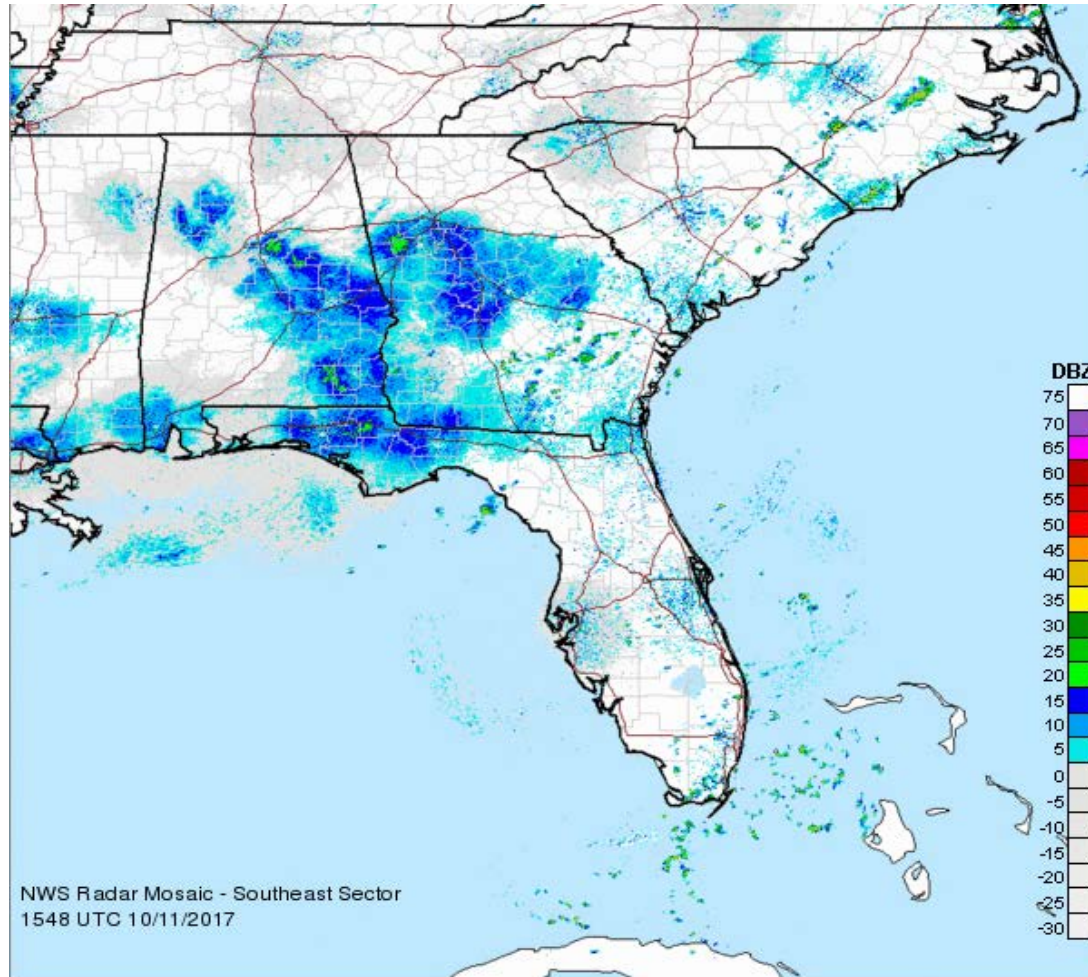
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# Convection

The vertical movement of heat or other properties by massive motion within the atmosphere



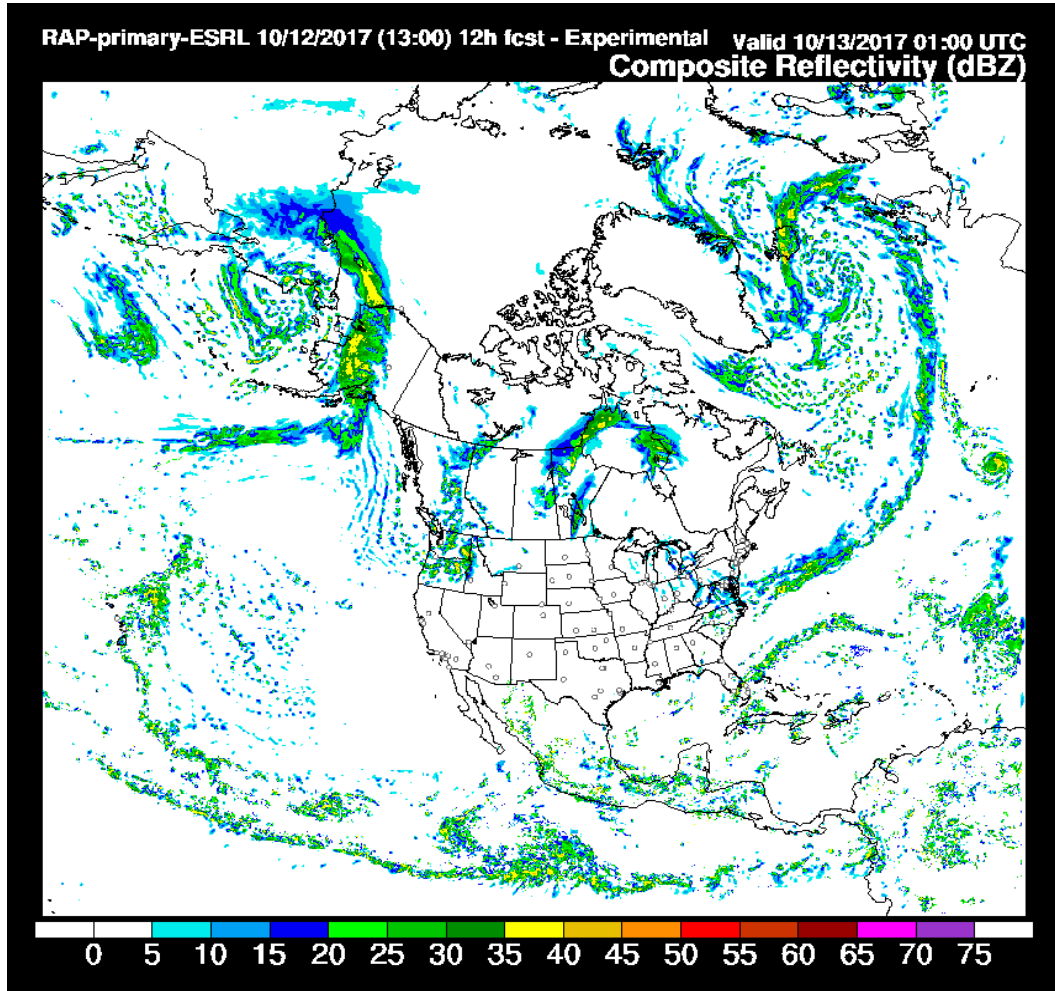
# Convection (AWC)



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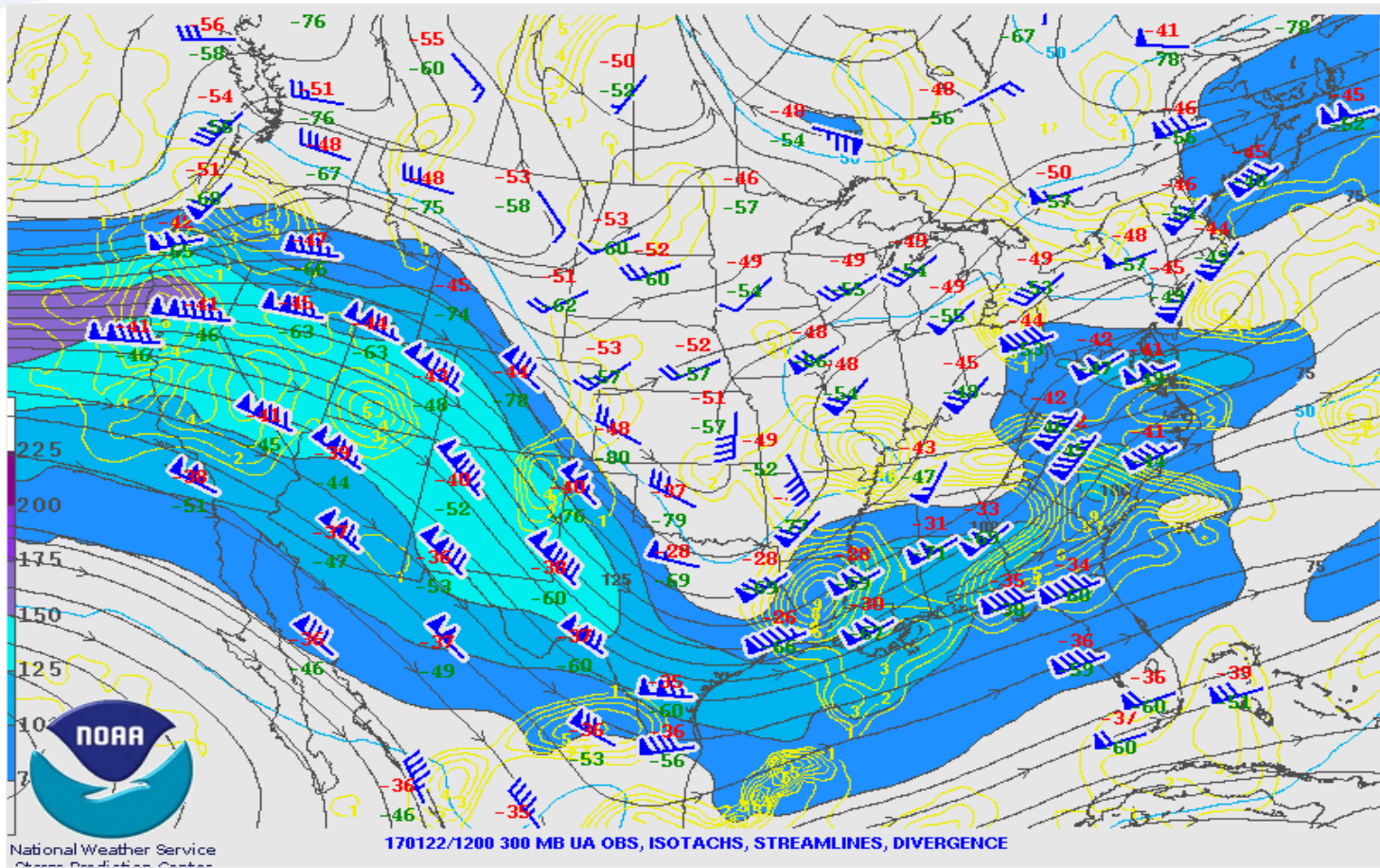
# Convection (RAP)



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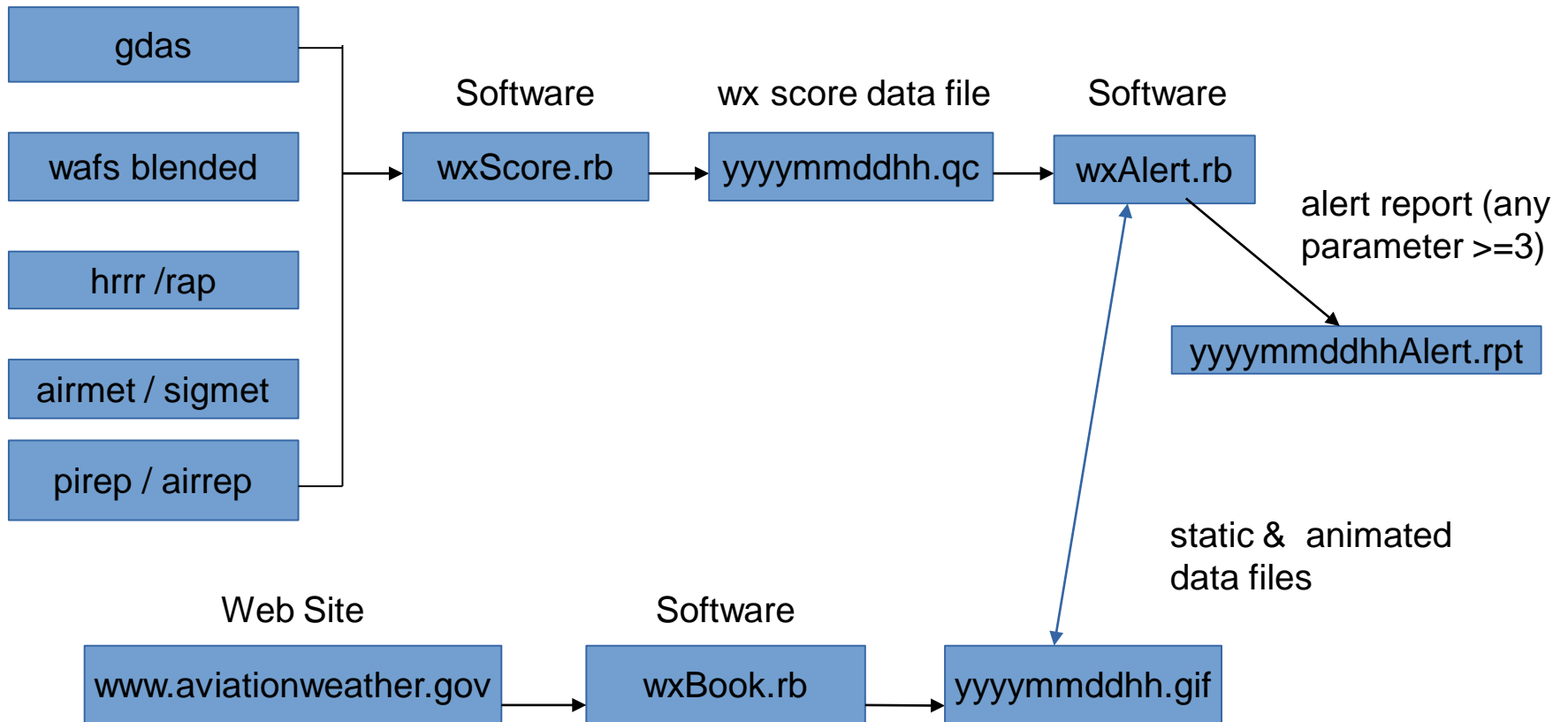
# Upper Level Contours (Storm Center)



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# Data Files

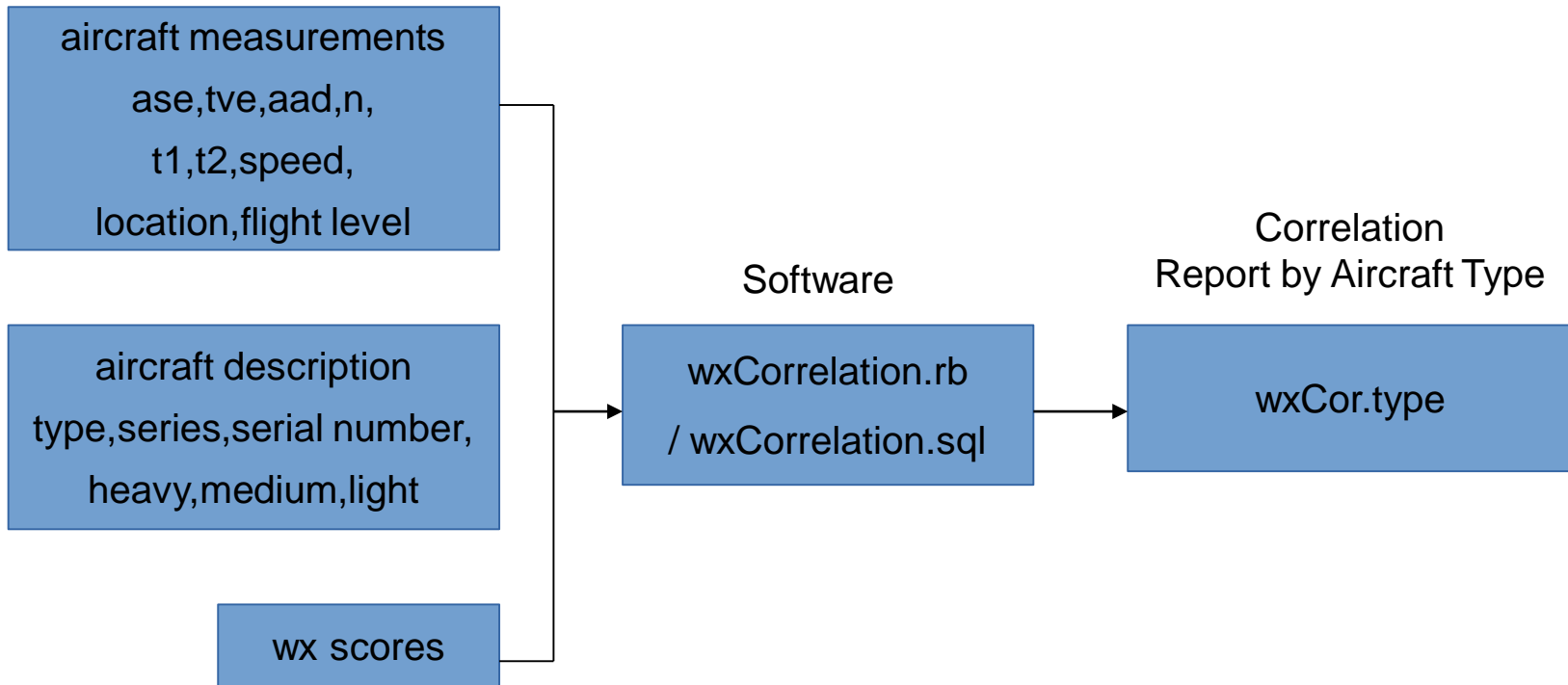
## NOAA Data Files



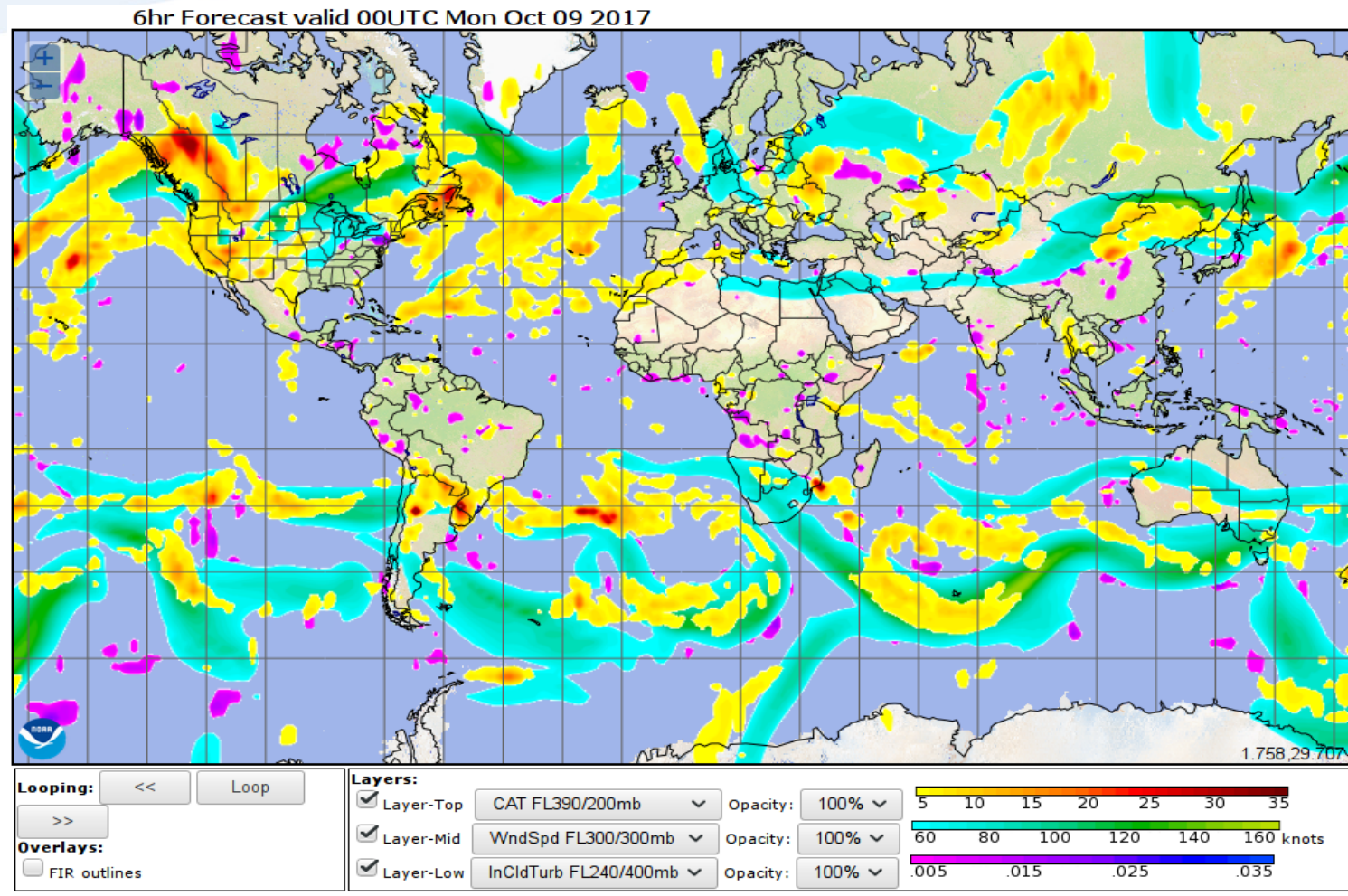


# Correlation Between Aircraft Performance and Weather

Data Files &/or  
Database Tables



# Alert Report Nevada (confirmed alert?)



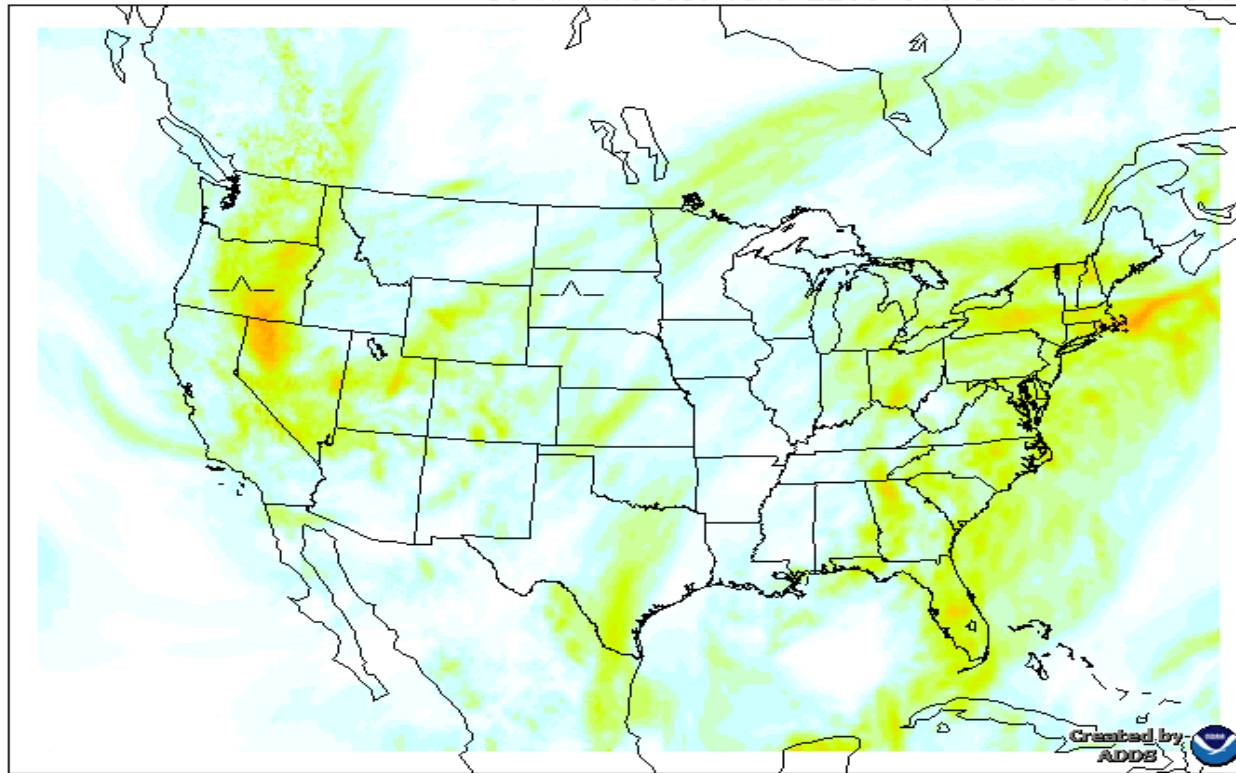
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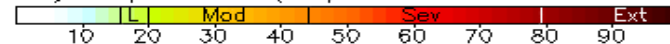
# Alert Report Nevada (confirmed alert?)

## GTG - Clear air turbulence at FL350

00 hr forecast valid 2200 UTC Sun 08 Oct 2017



Eddy Dissipation Rate (EDR)



Turb PIREP Symbols

- |                  |                  |                   |           |
|------------------|------------------|-------------------|-----------|
| ○ Smooth         | △ Light          | —△ Moderate       | —△ Severe |
| - - Smooth-Light | △ Light-Moderate | △ Moderate-Severe | △ Extreme |



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# Convection Forecast

Type: SIGMET Hazard: CONVECTIVE

WSUS32 KKCI 051855

SIGC

CONVECTIVE SIGMET 56C

VALID UNTIL 2055Z

MO KS NE

FROM 60NW PWE-30E PWE-60S PWE-60W PWE-60NW PWE

AREA EMBD TS MOV FROM 24025KT. TOPS TO FL440.

OUTLOOK VALID 052055-060055

FROM 50NW EAU-30NE COU-50SSE ICT-40SE CDS-40W

MRF-30SE DMN-60W

ALS-40ESE LAA-ANW-50NW EAU

WST ISSUANCES EXPD. REFER TO MOST RECENT ACUS01

KWNS FROM STORM

PREDICTION CENTER FOR SYNOPSIS AND

METEOROLOGICAL DETAILS.



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# Turbulence Forecast

Type: AIRMET Hazard: TURB

WAUS42 KKCI 051445

MIAT WA 051445

AIRMET TANGO UPDT 3 FOR TURB VALID UNTIL 052100

AIRMET TURB...NC SC GA NY LO PA OH LE WV MD DC VA

FROM 60NE BUF TO 20SW ETX TO 50E RDU TO 40ESE CAE  
TO 50SW PZD TO

GQO TO HNV TO HNN TO CVG TO FWA TO DXO TO 60NE BUF

MOD TURB BTN FL260 AND FL380. CONDS CONTG BYD 21Z  
THRU 03Z.

OTLK VALID 2100-0300Z...TURB NC SC GA NY LO PA OH LE  
WV MD DC DE

VA

BOUNDED BY 70SSW YOW-50ESE SYR-30NW SBY-20SW  
ORF-20NW ILM-50SW

PZD-GQO-HNV-HNN-CVG-FWA-DXO-70SSW YOW

MOD TURB BTN FL260 AND FL380. CONDS CONTG THRU 03Z.



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# Ice Forecast

Type: AIRMET Hazard: ICE

WAUS43 KPCI 051445

CHIZ WA 051445

AIRMET ZULU UPDT 2 FOR ICE AND FRZLVL VALID UNTIL 052100

AIRMET ICE...IL IN KY

FROM 30SW GIJ TO FWA TO CVG TO 40ENE PXV TO 30WNW TTH TO 20WNW

BVT TO 30SW GIJ

MOD ICE BTN 140 AND FL230. CONDS ENDG 18-21Z.

OTLK VALID 2100-0300Z

AREA 1...ICE SD NE MN IA MO WI IL

BOUNDED BY 40N RWF-50WSW ODI-30WNW DLL-40SSE DLL-40S JOT-20E

AXC-50W AXC-30SSE DBQ-90S FSD-20NNE FSD-40N RWF

MOD ICE BTN 140 AND FL200. CONDS CONTG THRU 03Z.

AREA 2...ICE KS MO OK TX AR

BOUNDED BY 30W COU-50SW FAM-40SW ARG-40SE RZC-40S TXO-40SE

TBE-50NNE MMB-50WNW ICT-50SE SLN-60NW OSW-30W COU

MOD ICE BTN 160 AND FL250. CONDS CONTG THRU 03Z.

FRZLVL...RANGING FROM 070-165 ACRS AREA

MULT FRZLVL 080-100 BOUNDED BY 20ENE MOT-80ESE MOT-50ESE BIS-

50WSW DIK-20WNW ISN-20ENE MOT

080 ALG 70SE YWG-70ESE INL-70NNE SAW

120 ALG 50WSW RAP-70SSE BIS-40NNE ABR-60SSE DLH-50E GRB-30SSW

YVV

160 ALG 20NW RZC-SGF-60E SGF-30WNW ARG



**FAA**



**END**



**FAA**

**NextGEN**