WeatherExtreme

How to Avoid Becoming the Subject of a Forensic Meteorological Investigation

Paul Fremeau, M.S.

IWAWS 2022

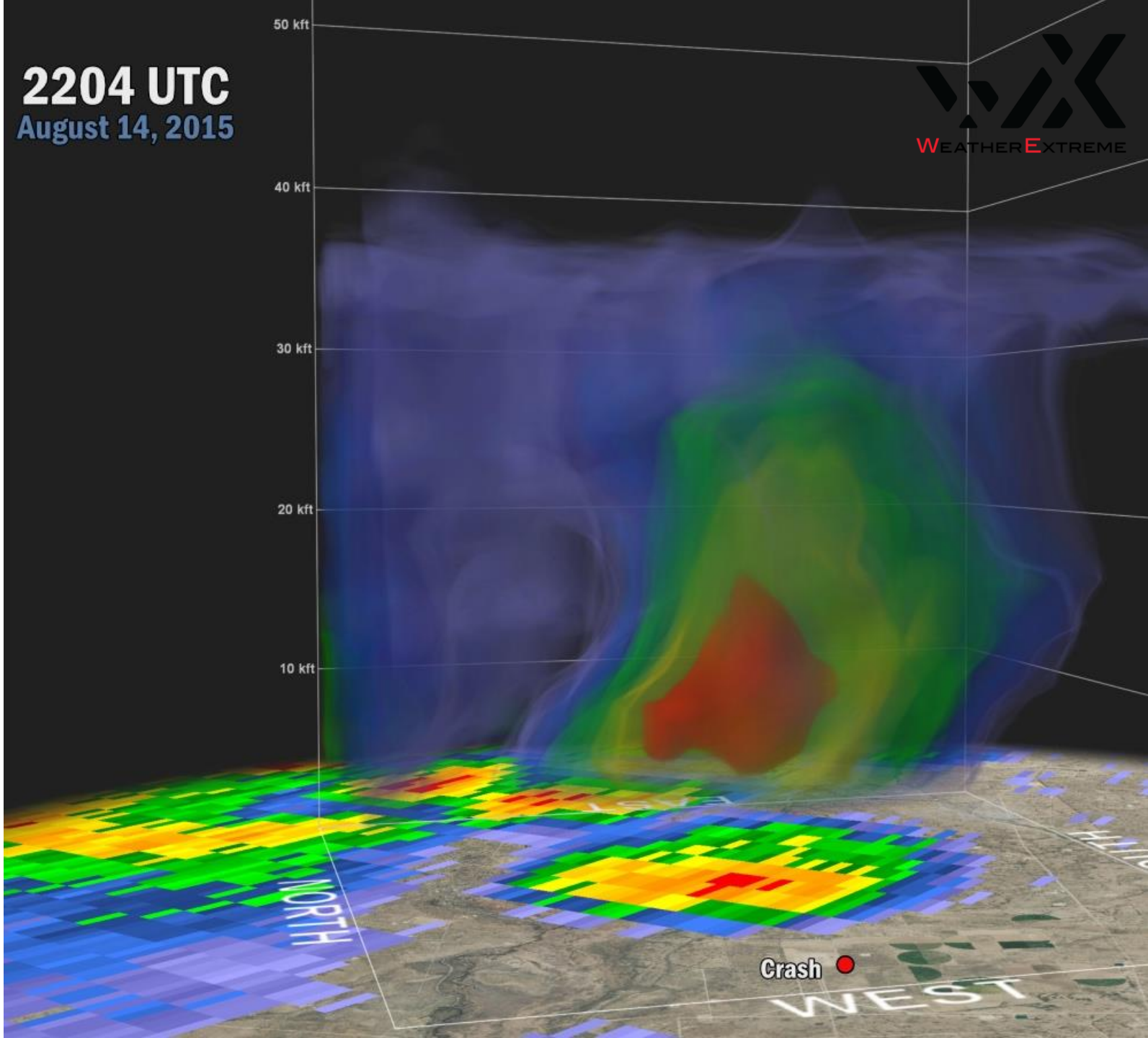
AMBASSADOR™ WRN WEATHER-READY NATION

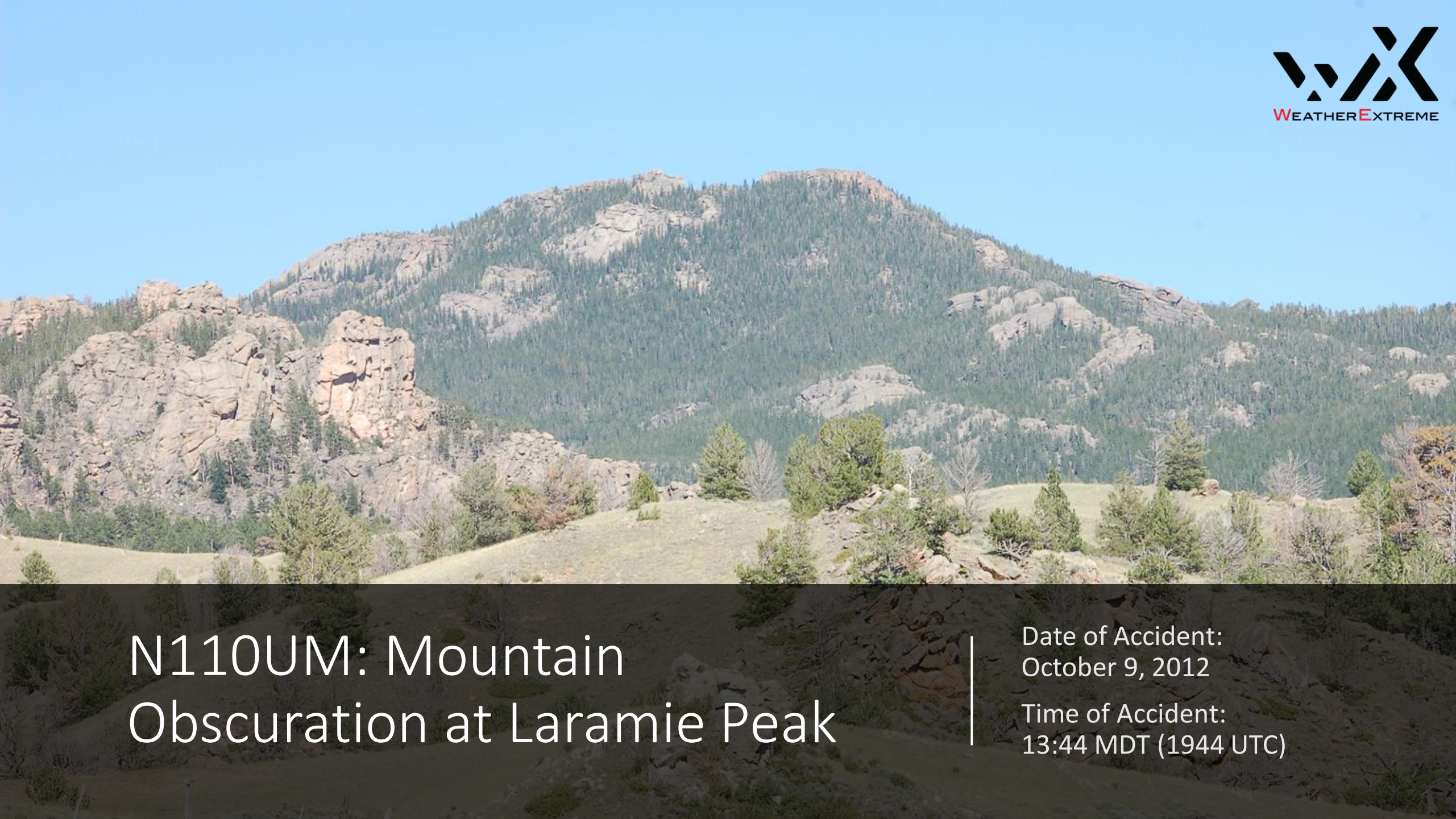
Agenda

- INTRODUCTION TO THE WORLD OF FORENSIC METEOROLOGY
- CASE 1: **MOUNTAIN OBSCURATION AT LARAMIE PEAK, WY**
- CASE 2: **STRUCTURAL ICING OVER YAMPA VALLEY, CO**
- CASE 3: **SEVERE TURBULENCE DURING DESCENT TO DENVER, CO**
- QUESTIONS

What is Forensic Meteorology?

- Reconstruction of Past Weather Events
- Often Supports Litigation/Lawsuits
- Involves Analyzing Historic Weather Data
- Often Requires *ex post facto* High-Resolution Modeling

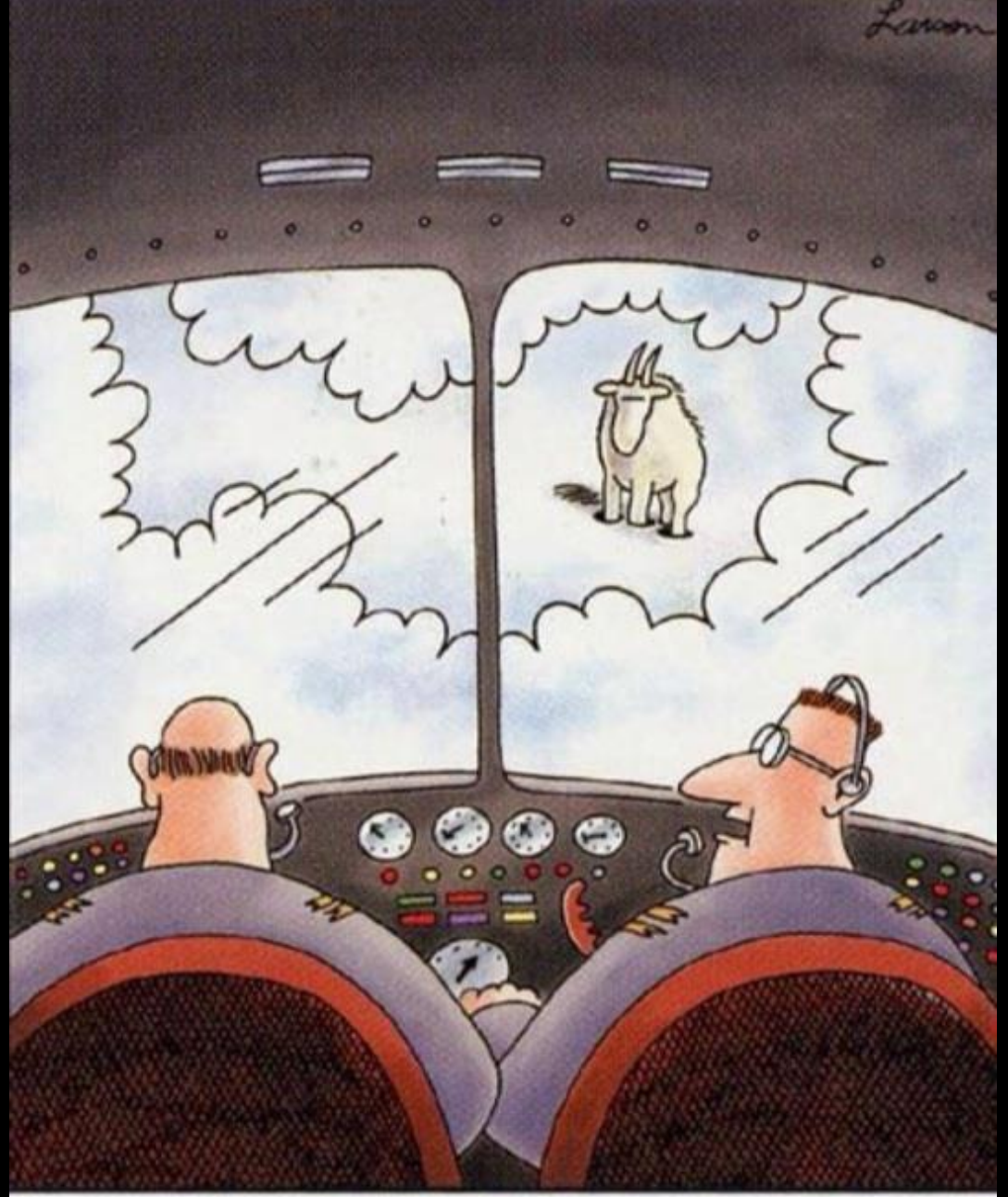




N110UM: Mountain Obscuration at Laramie Peak

Date of Accident:
October 9, 2012

Time of Accident:
13:44 MDT (1944 UTC)



"Say … what's a mountain goat doing
way up here in a cloud bank?"

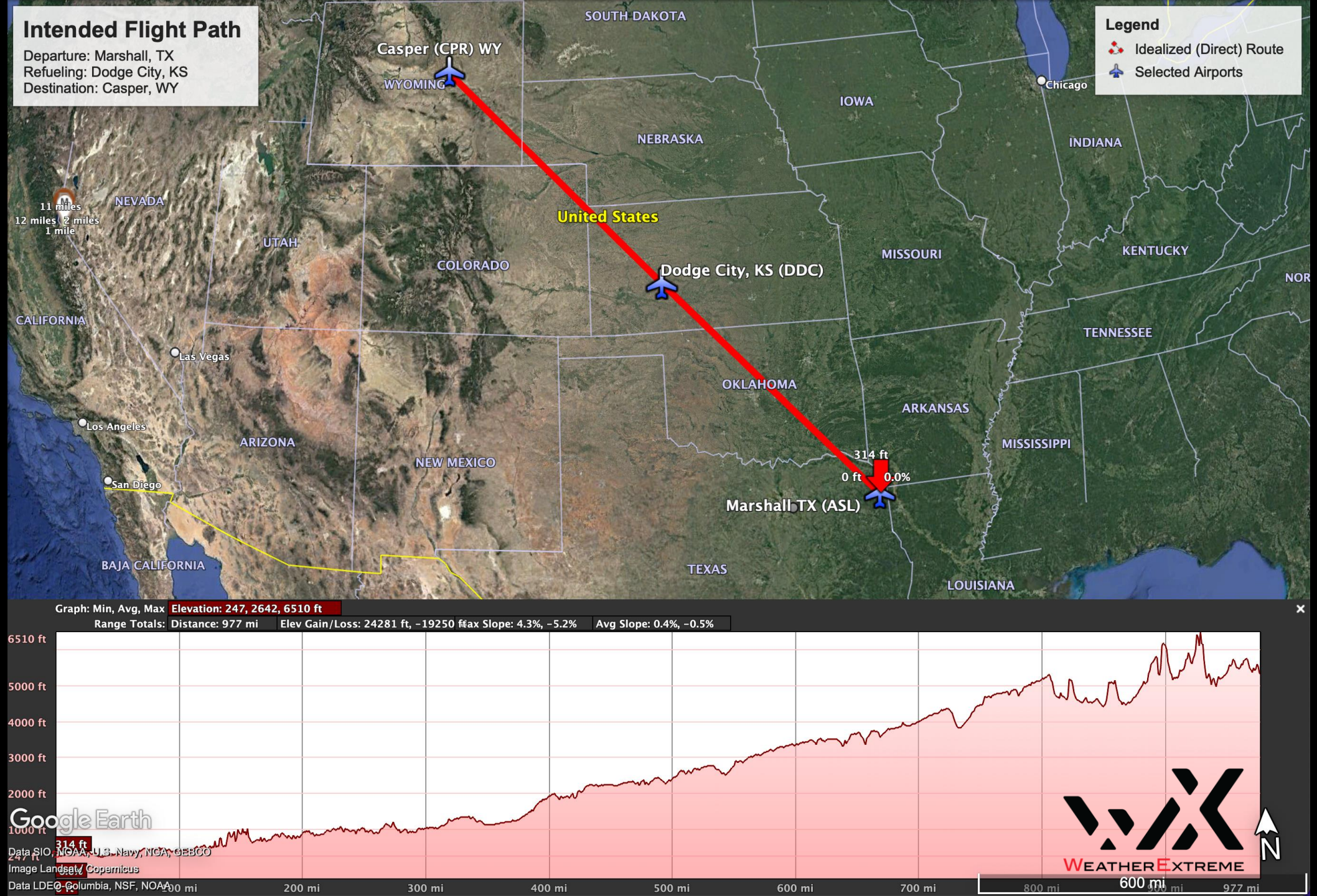
Case Background

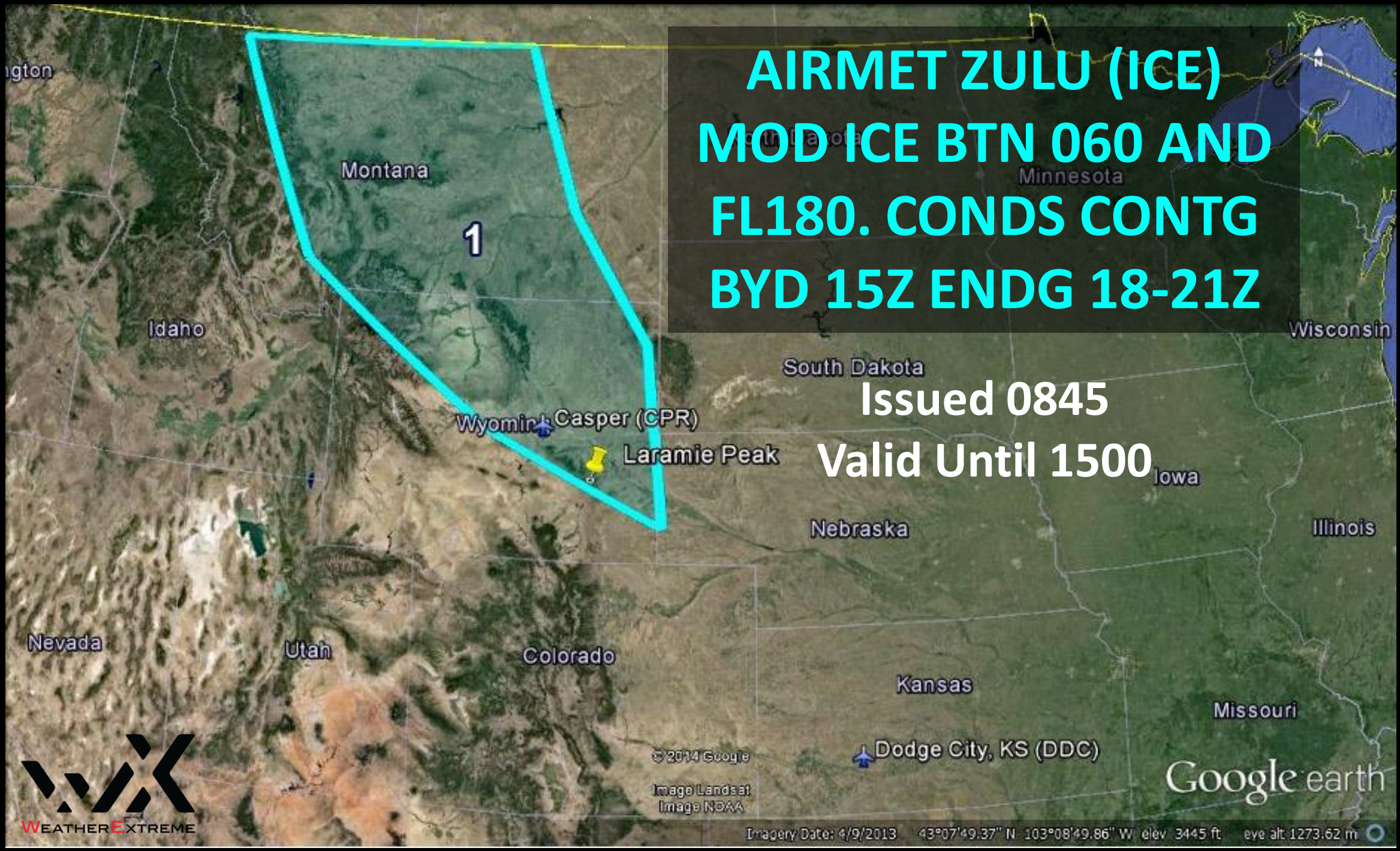
- Aircraft: Piper PA-32R-301T Saratoga II
- Registration: N110UM

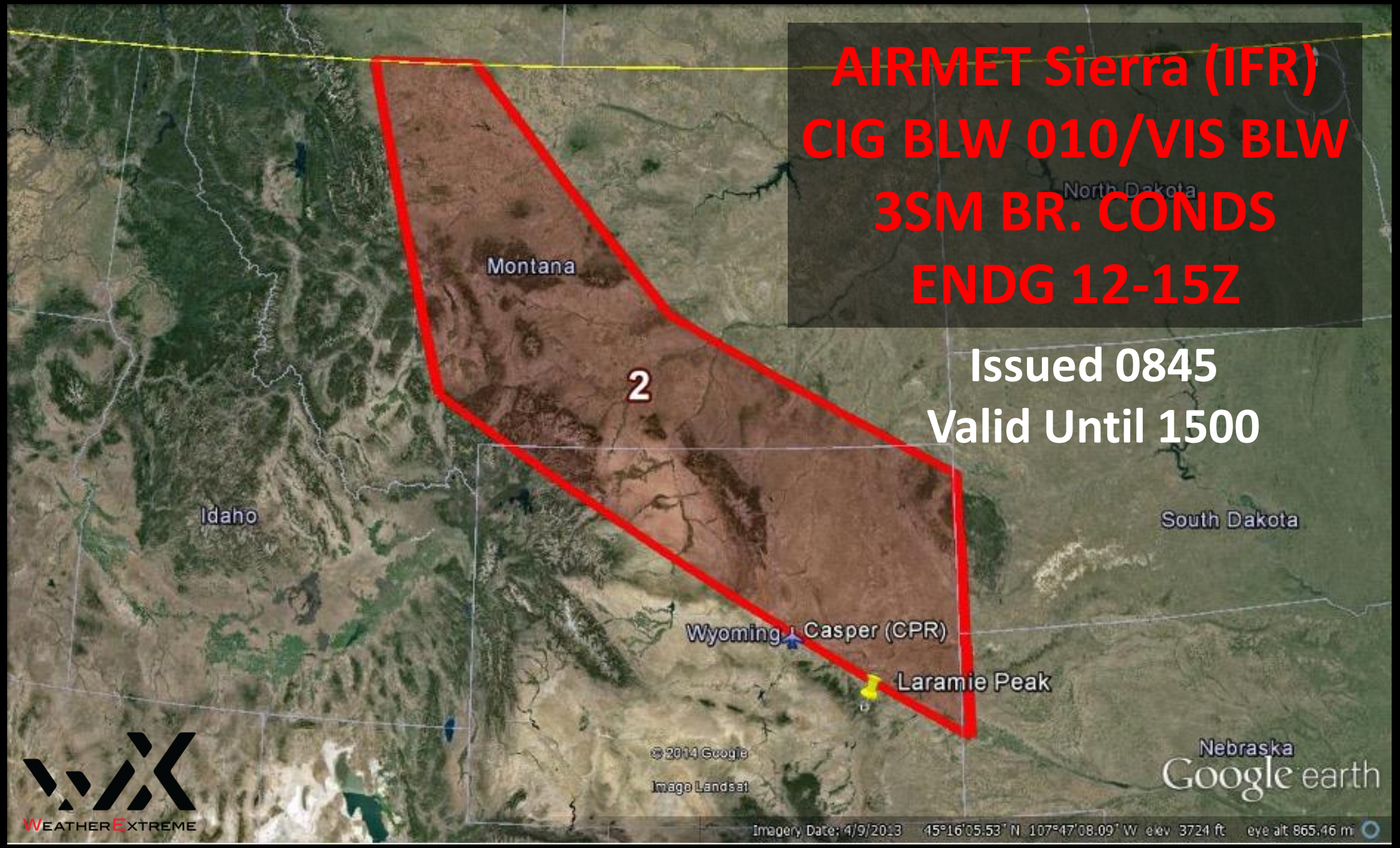
- Date of Accident: October 9, 2012
- Time of Accident: 13:44 MDT (1944 UTC)

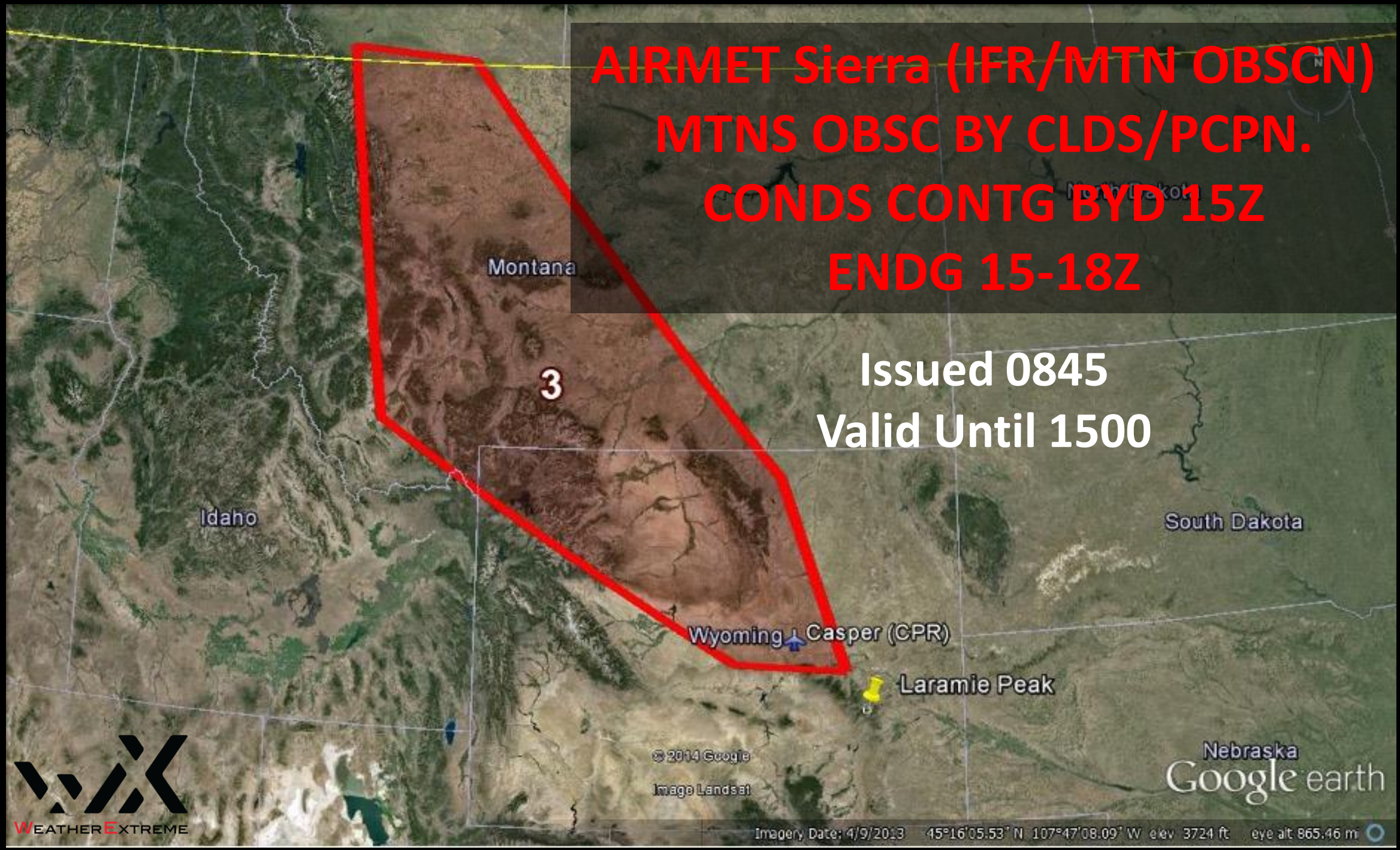
- Souls Onboard: 1 Pilot + 3 Passengers

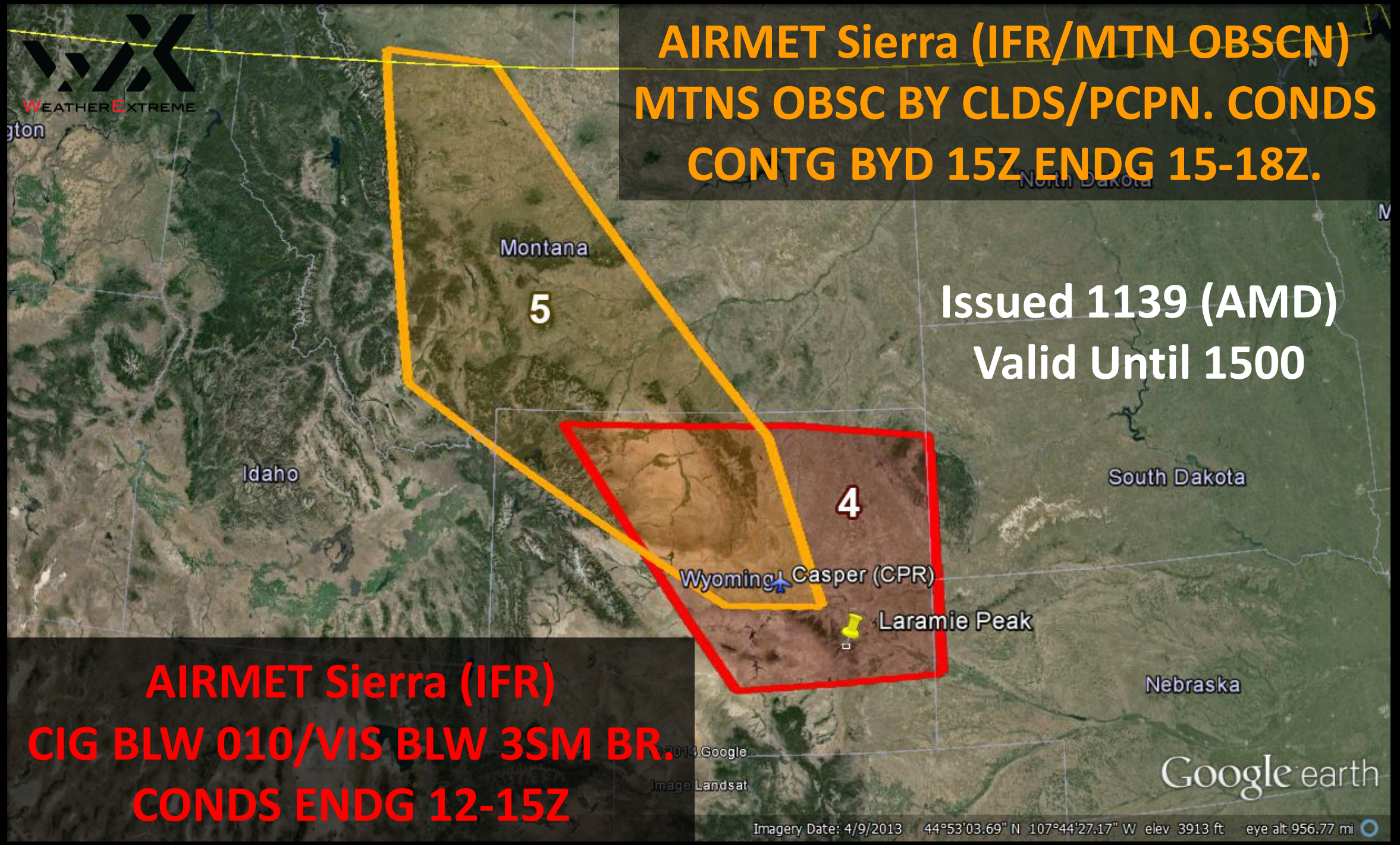
- Defining Event: VFR Encounter with IMC + CFIT

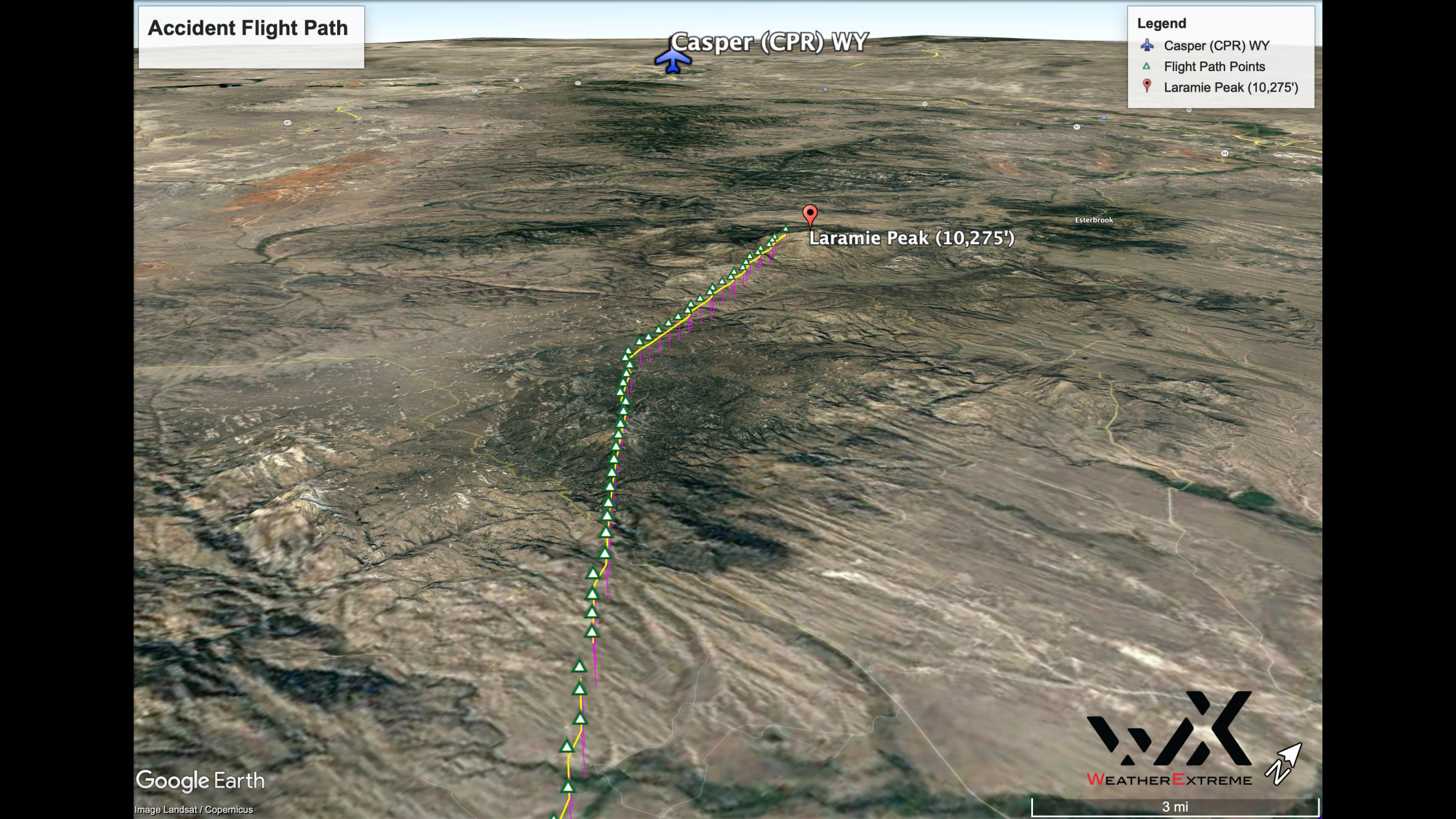

Intended Flight Path
Departure: Marshall, TX
Refueling: Dodge City, KS
Destination: Casper, WY
Legend
Idealized (Direct) Route
Selected Airports
Casper (CPR) WY
Dodge City, KS (DDC)
Marshall TX (ASL)
314 ft
0 ft
0.0%
United States
SOUTH DAKOTA
WYOMING
NEBRASKA
IOWA
Chicago
INDIANA
NEVADA
UTAH
COLORADO
MISSOURI
KENTUCKY
CALIFORNIA
Las Vegas
Los Angeles
San Diego
ARIZONA
NEW MEXICO
OKLAHOMA
ARKANSAS
MISSISSIPPI
TENNESSEE
TEXAS
LOUISIANA
BAJA CALIFORNIA
11 miles
12 miles
2 miles
1 mile
Graph: Min, Avg, Max Elevation: 247, 2642, 6510 ft
Range Totals: Distance: 977 mi Elev Gain/Loss: 24281 ft, -19250 ft Max Slope: 4.3%, -5.2% Avg Slope: 0.4%, -0.5%
6510 ft
5000 ft
4000 ft
3000 ft
2000 ft
1000 ft
314 ft
100 mi
200 mi
300 mi
400 mi
500 mi
600 mi
700 mi
800 mi
977 mi
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
Data LDEO-Columbia, NSF, NOAA
WeatherExtreme
N
600 mi


AIRMET ZULU (ICE)
MOD ICE BTN 060 AND
FL180. CONDS CONTG
BYD 15Z ENDG 18-21Z
Issued 0845
Valid Until 1500
1
Montana
Idaho
Wyomin
Casper (CPR)
Laramie Peak
South Dakota
Minnesota
Wisconsin
Iowa
Nebraska
Illinois
Nevada
Utah
Colorado
Kansas
Missouri
Dodge City, KS (DDC)
© 2014 Google
Image Landsat
Image NOAA
Google earth
WEATHEREXTREME
Imagery Date: 4/9/2013 43°07'49.37" N 103°08'49.86" W elev 3445 ft eye alt 1273.62 m


AIRMET Sierra (IFR)
CIG BLW 010/VIS BLW
3SM BR. CONDS
ENDG 12-15Z
Issued 0845
Valid Until 1500
Montana
2
North Dakota
Idaho
South Dakota
Wyoming
Casper (CPR)
Laramie Peak
Nebraska
© 2014 Google
Image Landsat
Google earth
WeatherExtreme
Imagery Date: 4/9/2013 45°16'05.53" N 107°47'08.09" W elev 3724 ft eye alt 865.46 mi


AIRMET Sierra (IFR/MTN OBSCN)
MTNS OBSC BY CLDS/PCPN.
CONDS CONTG BYD 15Z
ENDG 15-18Z
Issued 0845
Valid Until 1500
3
Montana
Idaho
South Dakota
Wyoming
Casper (CPR)
Laramie Peak
Nebraska
© 2014 Google
Image Landsat
Google earth
WeatherExtreme
Imagery Date: 4/9/2013 45°16'05.53" N 107°47'08.09" W elev 3724 ft eye alt 865.46 mi


WeatherExtreme
AIRMET Sierra (IFR/MTN OBSCN)
MTNS OBSC BY CLDS/PCPN. CONDS
CONTG BYD 15Z ENDG 15-18Z.
Montana
5
Issued 1139 (AMD)
Valid Until 1500
Idaho
South Dakota
4
Wyoming
Casper (CPR)
Laramie Peak
Nebraska
AIRMET Sierra (IFR)
CIG BLW 010/VIS BLW 3SM BR.
CONDS ENDG 12-15Z
Image Landsat
Google earth
Imagery Date: 4/9/2013 44°53'03.69" N 107°44'27.17" W elev 3913 ft eye alt 956.77 mi


Accident Flight Path
Casper (CPR) WY
Legend
Casper (CPR) WY
Flight Path Points
Laramie Peak (10,275')
Laramie Peak (10,275')
Esterbrook
Google Earth
Image Landsat / Copernicus
WeatherExtreme
3 mi


WeatherExtreme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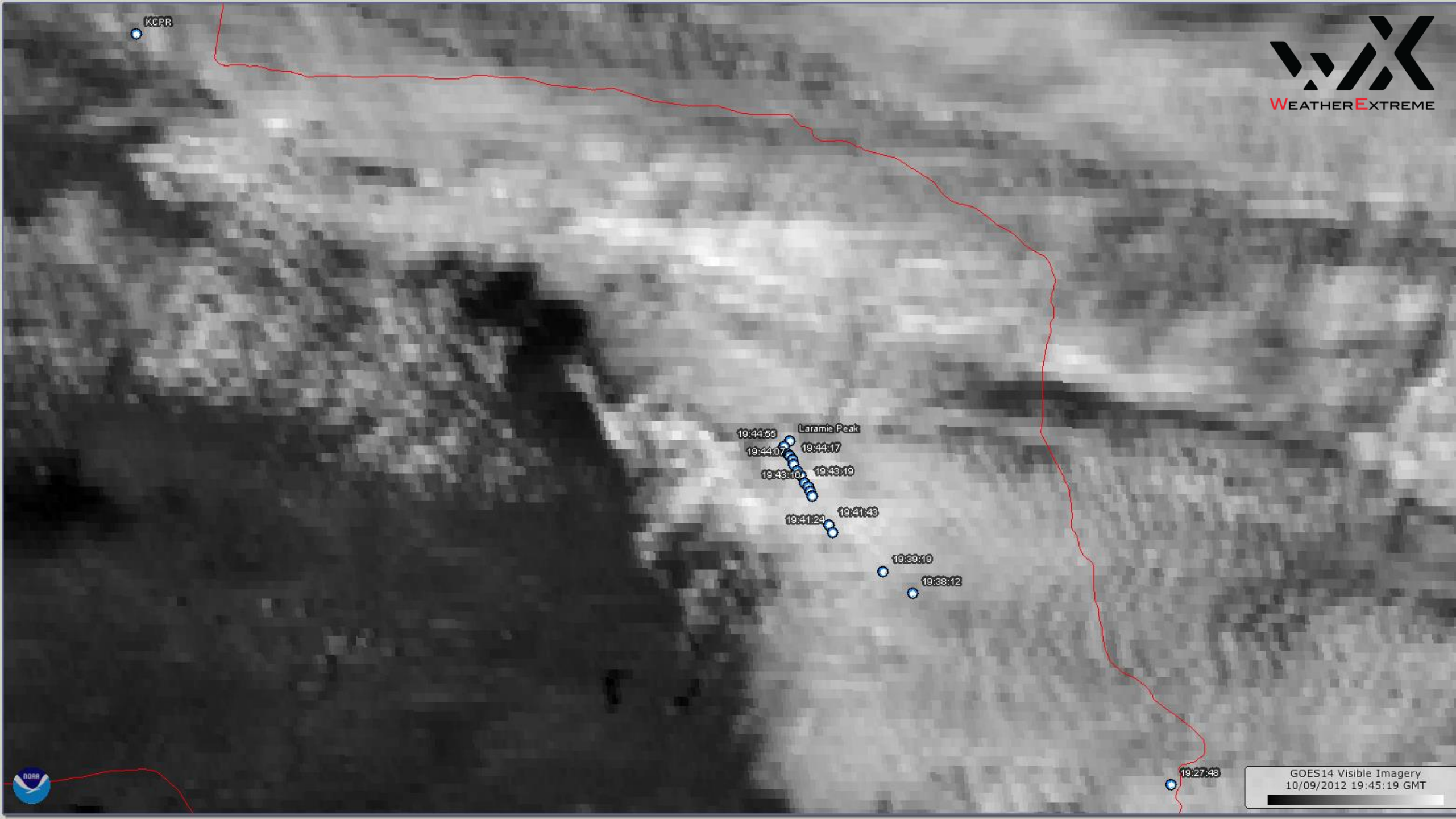
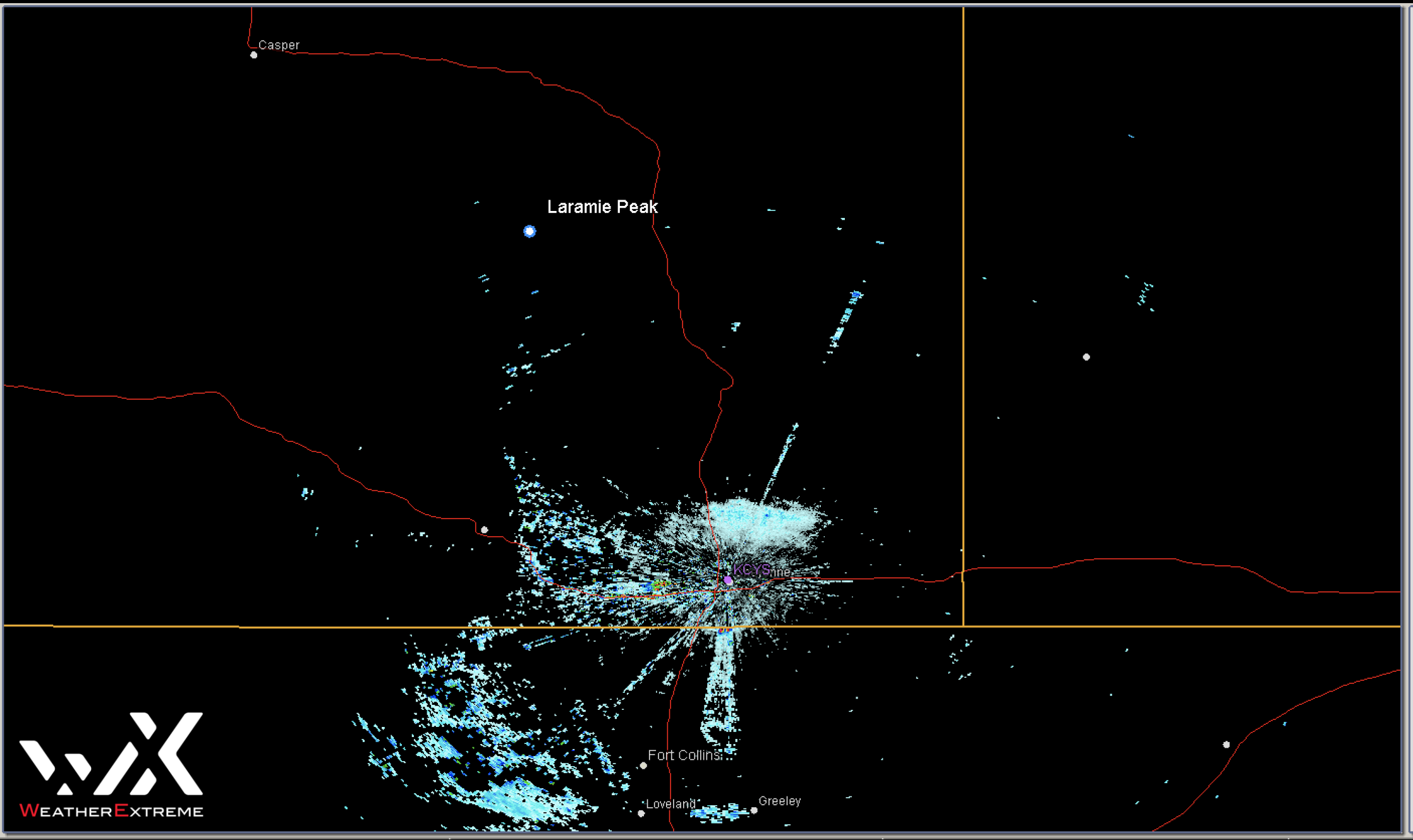

KCPR
Laramie Peak
19:44:55
19:44:17
19:44:07
19:43:19
19:43:10
19:41:43
19:41:24
19:39:19
19:38:12
19:27:48
WeatherExtreme
GOES14 Visible Imagery
10/09/2012 19:45:19 GMT



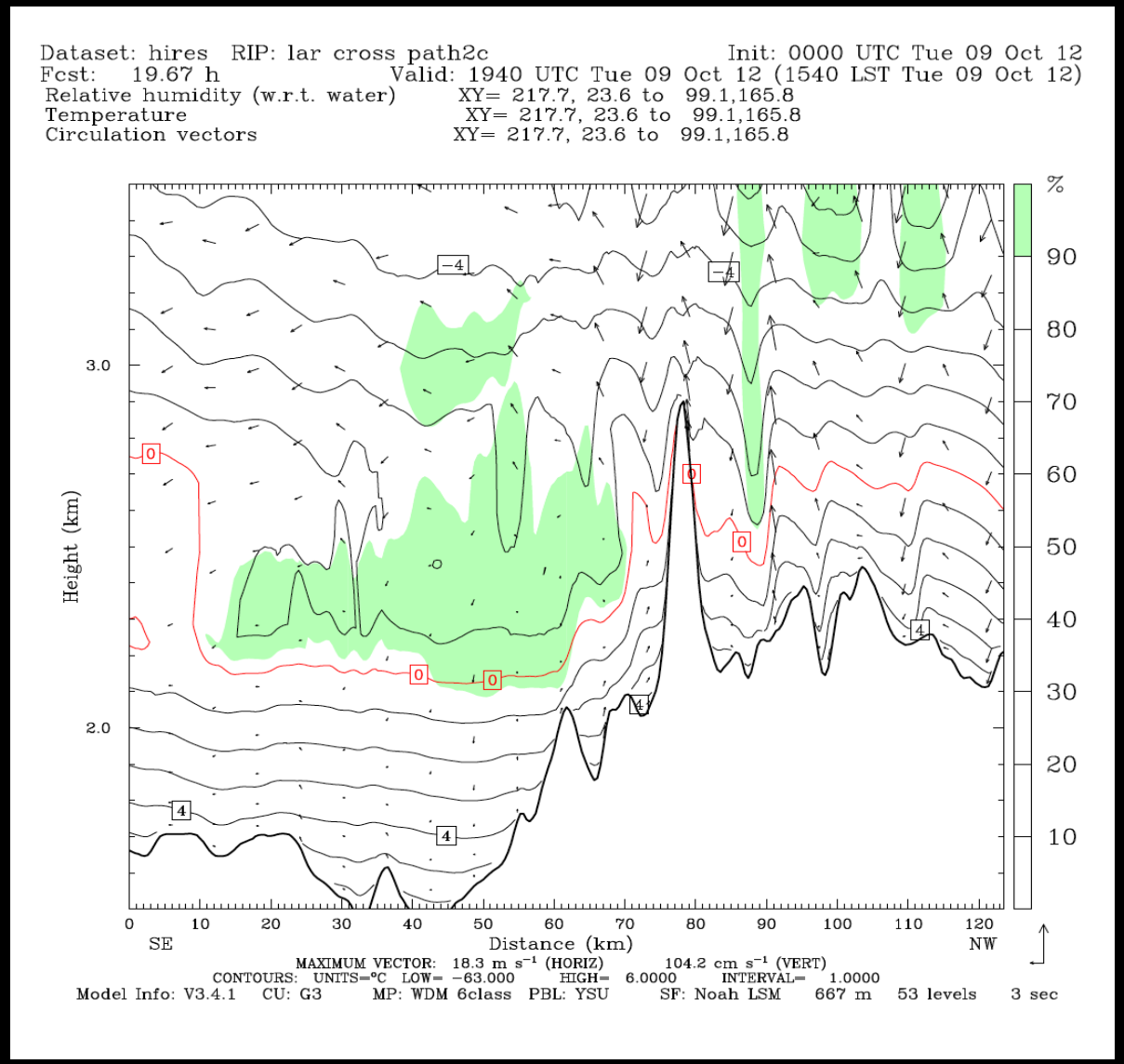
NEXRAD LEVEL-II
KCYS - CHEYENNE, WY
10/09/2012 19:46:58 Z
LAT: 41/09/06 N
LON: 104/48/21 W
ELEV: 6128 FT
VCP: 32

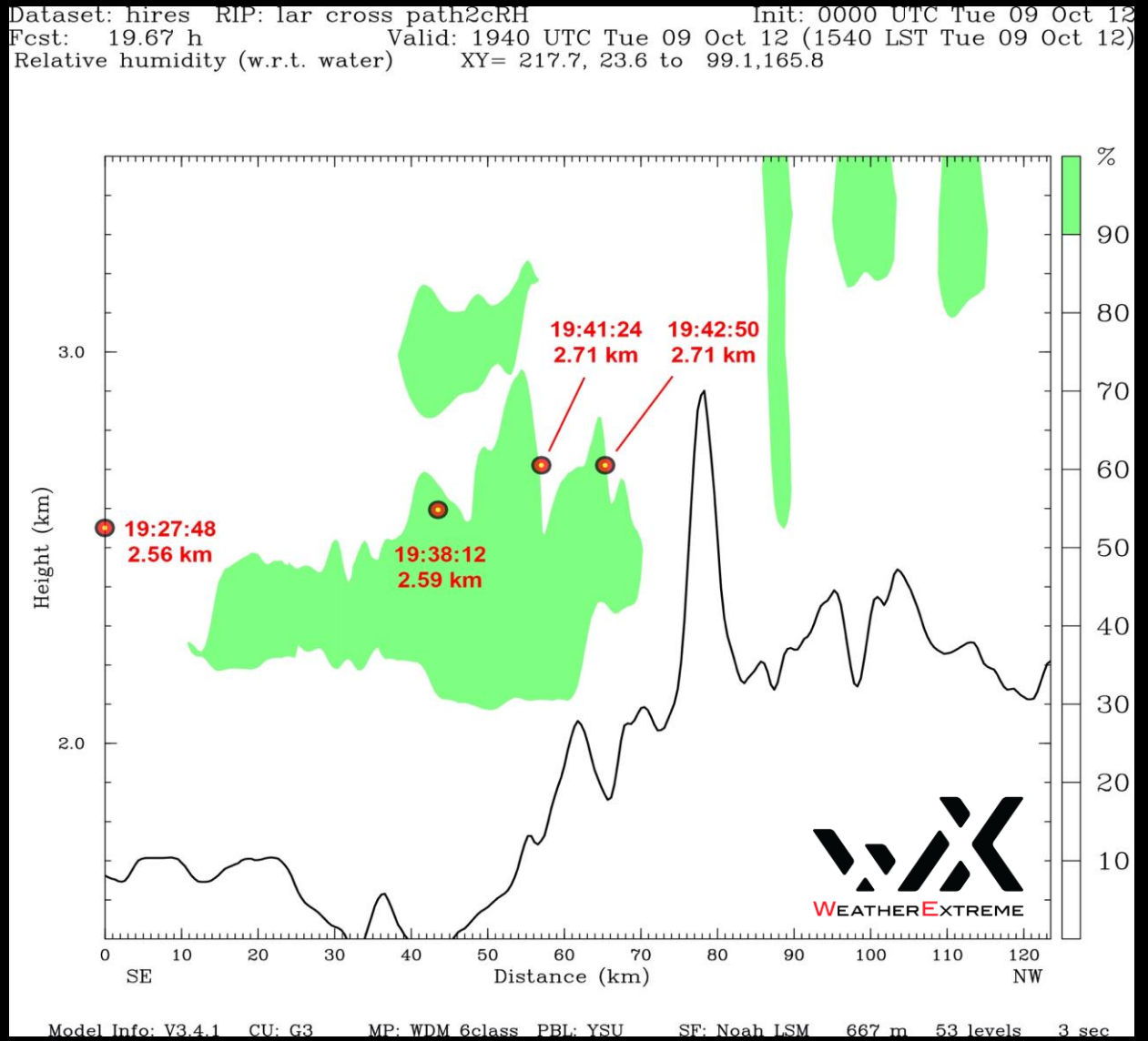
REFLECTIVITY
ELEV ANGLE: 0.54
SWEEP TIME: 19:47:32 Z

Legend: dBZ

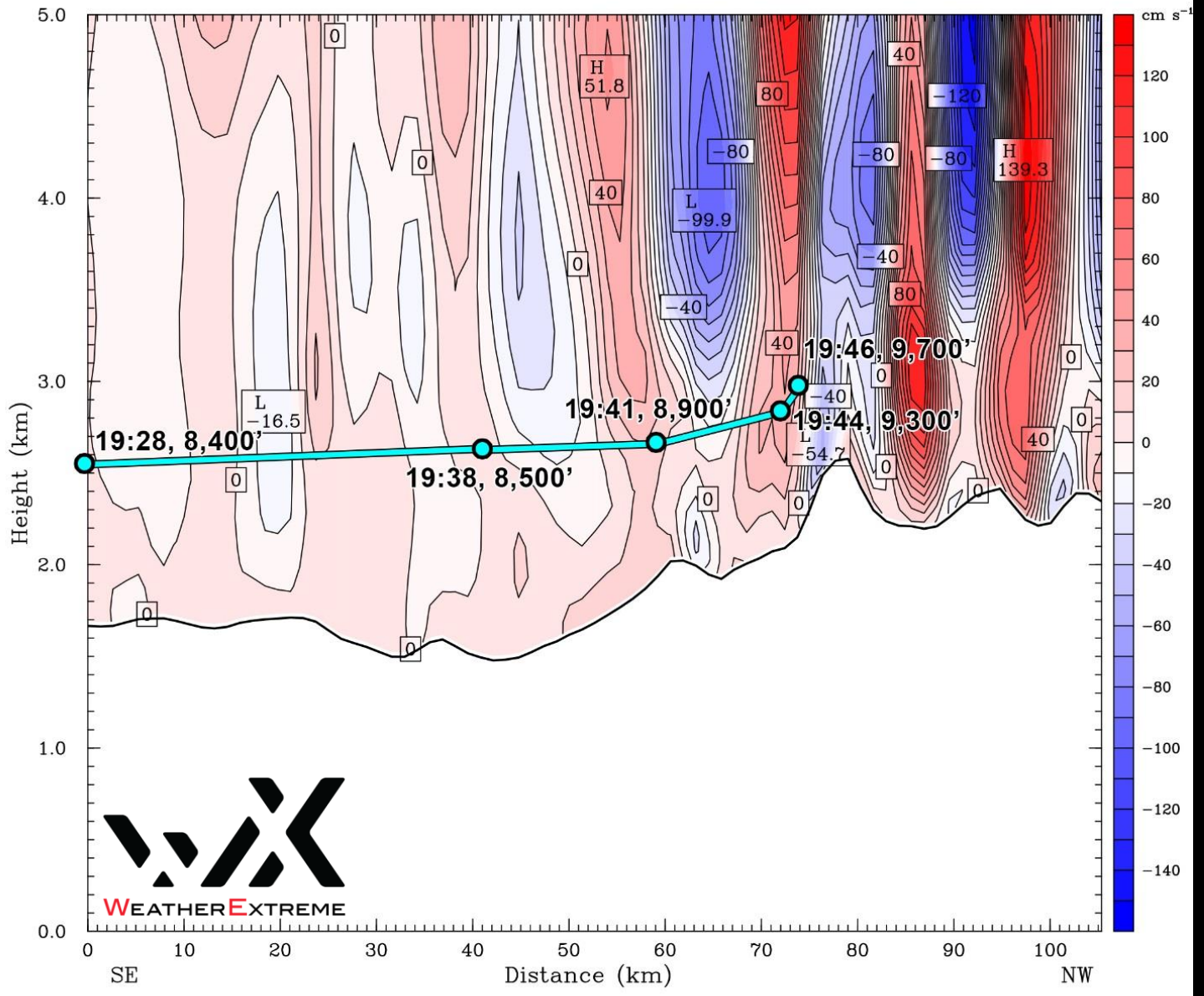
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25

RF


Dataset: hires RIP: lar cross path2c Init: 0000 UTC Tue 09 Oct 12
Fcst: 19.67 h Valid: 1940 UTC Tue 09 Oct 12 (1540 LST Tue 09 Oct 12)
Relative humidity (w.r.t. water) XY= 217.7, 23.6 to 99.1,165.8
Temperature XY= 217.7, 23.6 to 99.1,165.8
Circulation vectors XY= 217.7, 23.6 to 99.1,165.8
Height (km)
3.0
2.0
0 10 20 30 40 50 60 70 80 90 100 110 120
SE
Distance (km)
NW
%
90 80 70 60 50 40 30 20 10
MAXIMUM VECTOR: 18.3 m s⁻¹ (HORIZ) 104.2 cm s⁻¹ (VERT)
CONTOURS: UNITS=°C LOW= -63.000 HIGH= 6.0000 INTERVAL= 1.0000
Model Info: V3.4.1 CU: G3 MP: WDM 6class PBL: YSU SF: Noah LSM 667 m 53 levels 3 sec


Dataset: hires RIP: lar cross path2cRH Init: 0000 UTC Tue 09 Oct 12
Fcst: 19.67 h Valid: 1940 UTC Tue 09 Oct 12 (1540 LST Tue 09 Oct 12)
Relative humidity (w.r.t. water) XY= 217.7, 23.6 to 99.1,165.8
19:41:24
2.71 km
19:42:50
2.71 km
19:27:48
2.56 km
19:38:12
2.59 km
Height (km)
3.0
2.0
0 10 20 30 40 50 60 70 80 90 100 110 120
SE
Distance (km)
NW
%
90 80 70 60 50 40 30 20 10
WEATHEREXTREME
Model Info: V3.4.1 CU: G3 MP: WDM 6class PBL: YSU SF: Noah LSM 667 m 53 levels 3 sec

Dataset: larnarr RIP: lar cross path xy Init: 0000 UTC Tue 09 Oct 12
Fcst: 19.75 h Valid: 1945 UTC Tue 09 Oct 12 (1545 LST Tue 09 Oct 12)
Vertical velocity XY= 174.2, 74.5 to 140.0,114.6



CONTOURS: UNITS=cm s^{-1} LOW= −150.00 HIGH= 130.00 INTERVAL= 10.000
Model Info: V3.4.1 CU: G3 MP: WDM 6class PBL: YSU SF: Noah LSM 2.0 km 53 levels 10 sec

Takeaways

- Not Instrument-rated? Avoid IMC Religiously.
- File a flight plan
- Know along-route weather & Terrain
- Respect mountain meteorology

N41WE: Structural Icing over Yampa Valley

Date of Accident:
January 11, 2005

Time of Accident:
21:45 MST
(0445 UTC 1.12.2005)

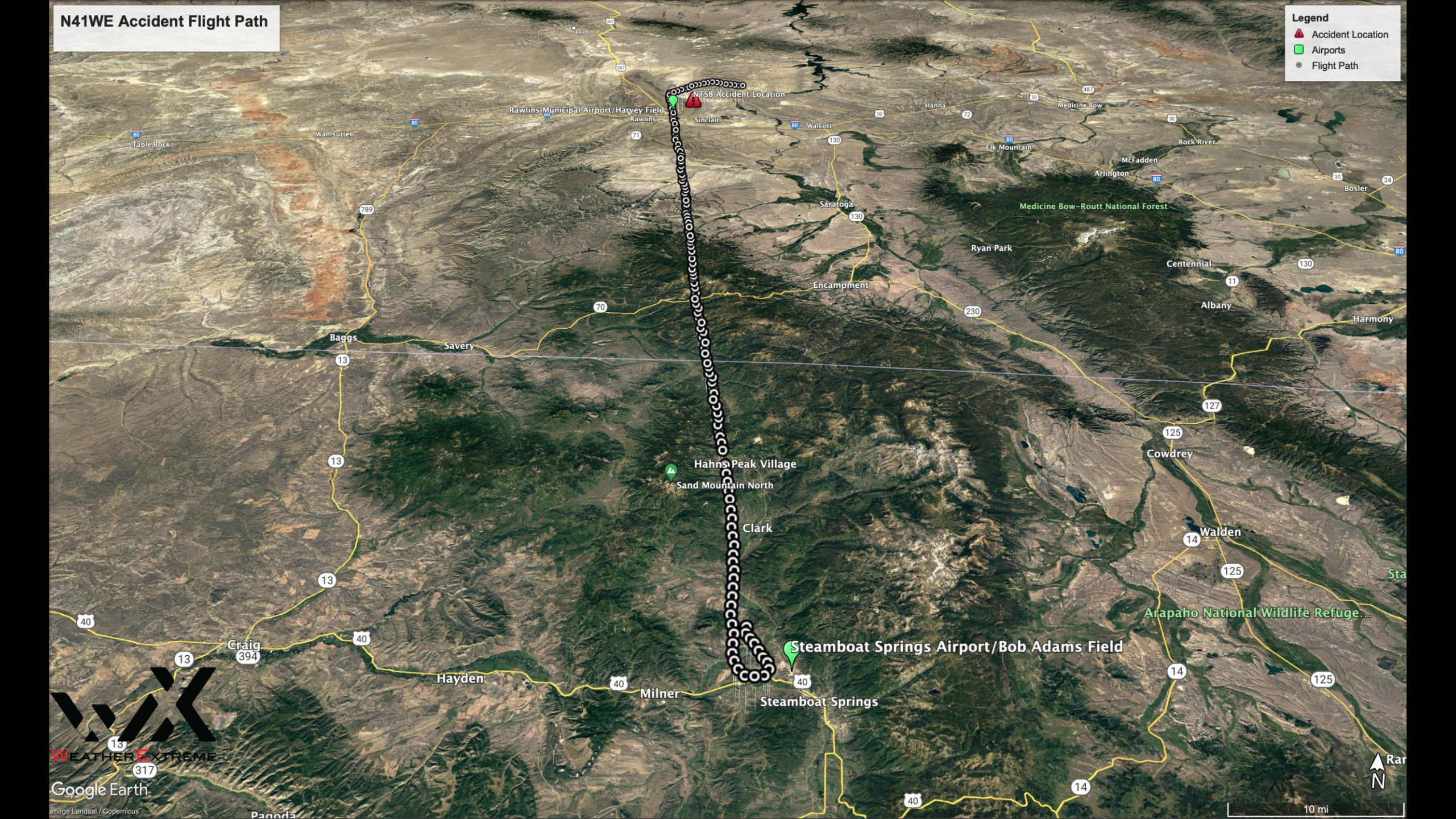
Case Background

- Aircraft: Beech BE-90 King Air
- Registration: N41WE

- Date of Accident: January 11, 2012
- Time of Accident: 21:45 MST (0445 UTC 1/12/2012)

- Souls Onboard: 1 Pilot + 3 Passengers

- Defining Event: Inadvertent Flight into Severe Icing Conditions; Aerodynamic Stall


N41WE Accident Flight Path
Legend
Accident Location
Airports
Flight Path
NTSB Accident Location
Rawlins Municipal Airport/Harvey Field
Rawlins
Sinclair
Wamsutter
Table Rock
Walcott
Hanna
Medicine Bow
Elk Mountain
Rock River
McFadden
Arlington
Bosler
Saratoga
Medicine Bow-Routt National Forest
Ryan Park
Centennial
Encampment
Albany
Harmony
Baggs
Savery
Hahns Peak Village
Sand Mountain North
Clark
Cowdrey
Walden
Arapaho National Wildlife Refuge...
Steamboat Springs Airport/Bob Adams Field
Steamboat Springs
Craig
Hayden
Milner
WEATHEREXTREME
Google Earth
Image Landsat / Copernicus
N
10 mi

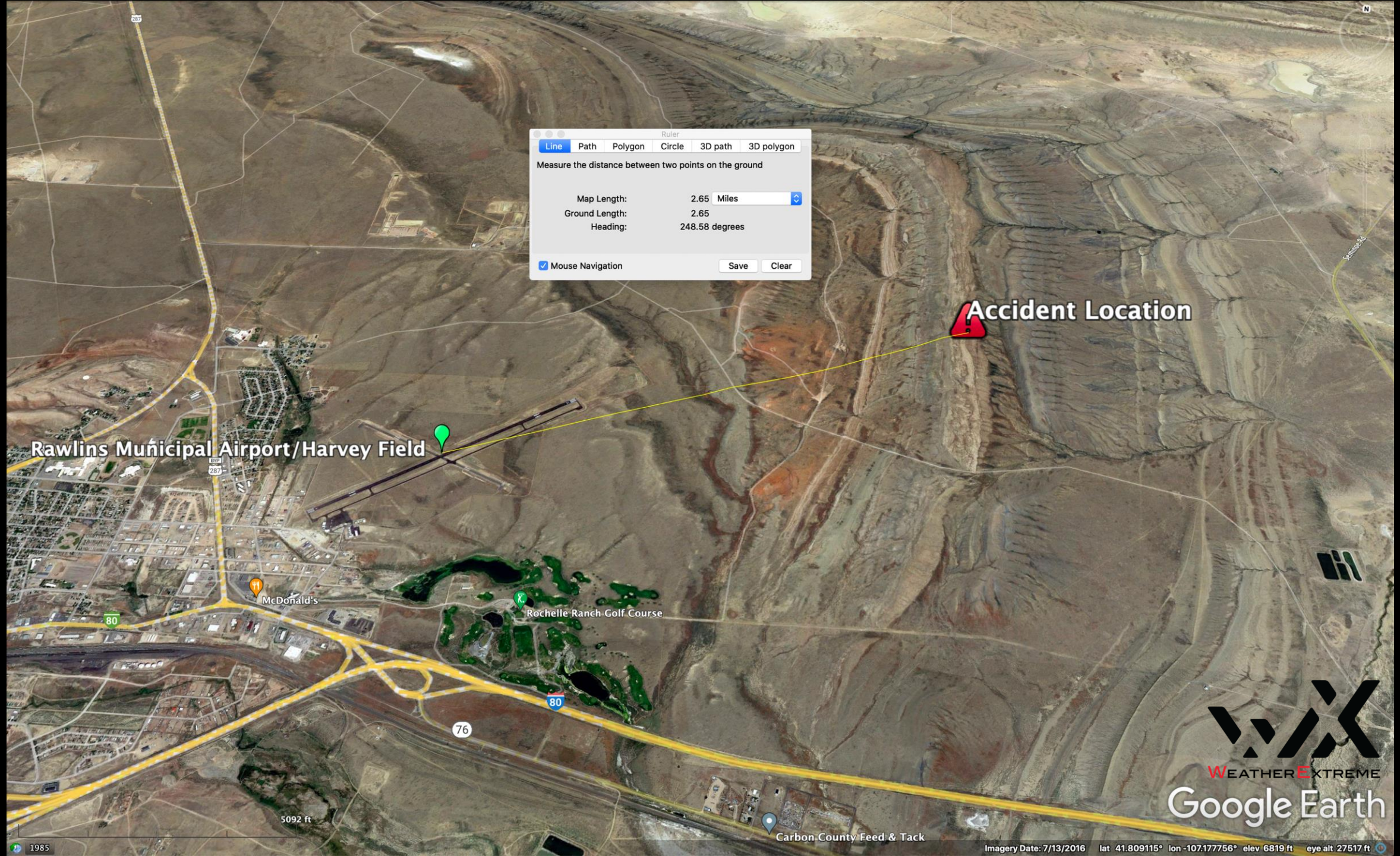

Ruler
Line
Path
Polygon
Circle
3D path
3D polygon
Measure the distance between two points on the ground
Map Length: 2.65 Miles
Ground Length: 2.65
Heading: 248.58 degrees
Mouse Navigation
Save
Clear
Accident Location
Rawlins Municipal Airport/Harvey Field
McDonald's
Rochelle Ranch Golf Course
Carbon County Feed & Tack
5092 ft
80
76
287
Seminoe Rd
WEATHEREXTREME
Google Earth
1985
Imagery Date: 7/13/2016 lat 41.809115° lon -107.177756° elev 6819 ft eye alt 27517 ft

Figure 19. AIRMET Zulu for ice and freezing level issued at 0245Z January 12, 2005, and valid until 0900Z on January 12, 2005.

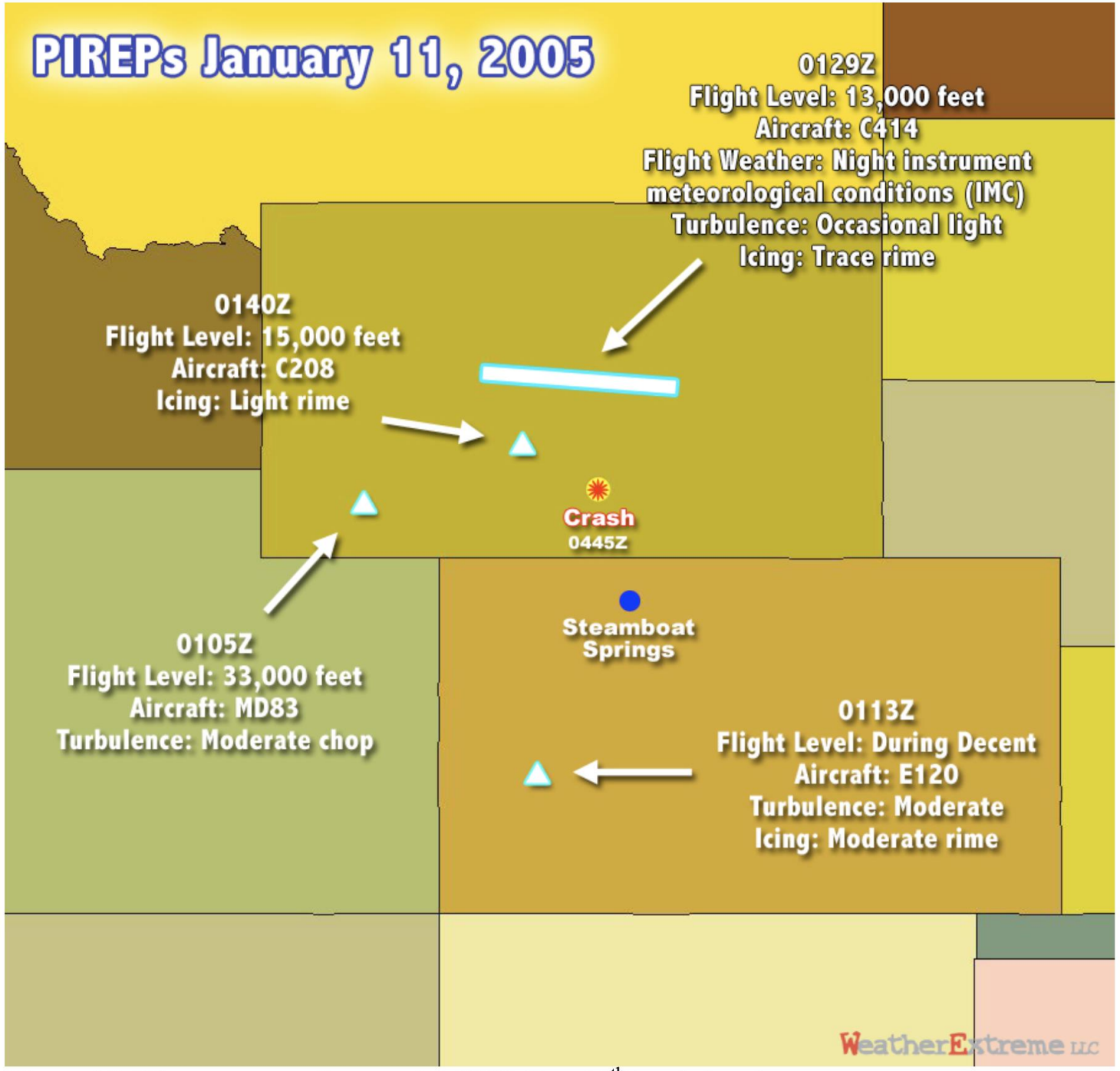


Figure 18. Pilot reports on January 12, 2005 (Jan. 11th local times).

NASA TM 107423

Fig. 24. Ice Growth Pattern Showing LEWICE Calculation Time Steps of Run 123.

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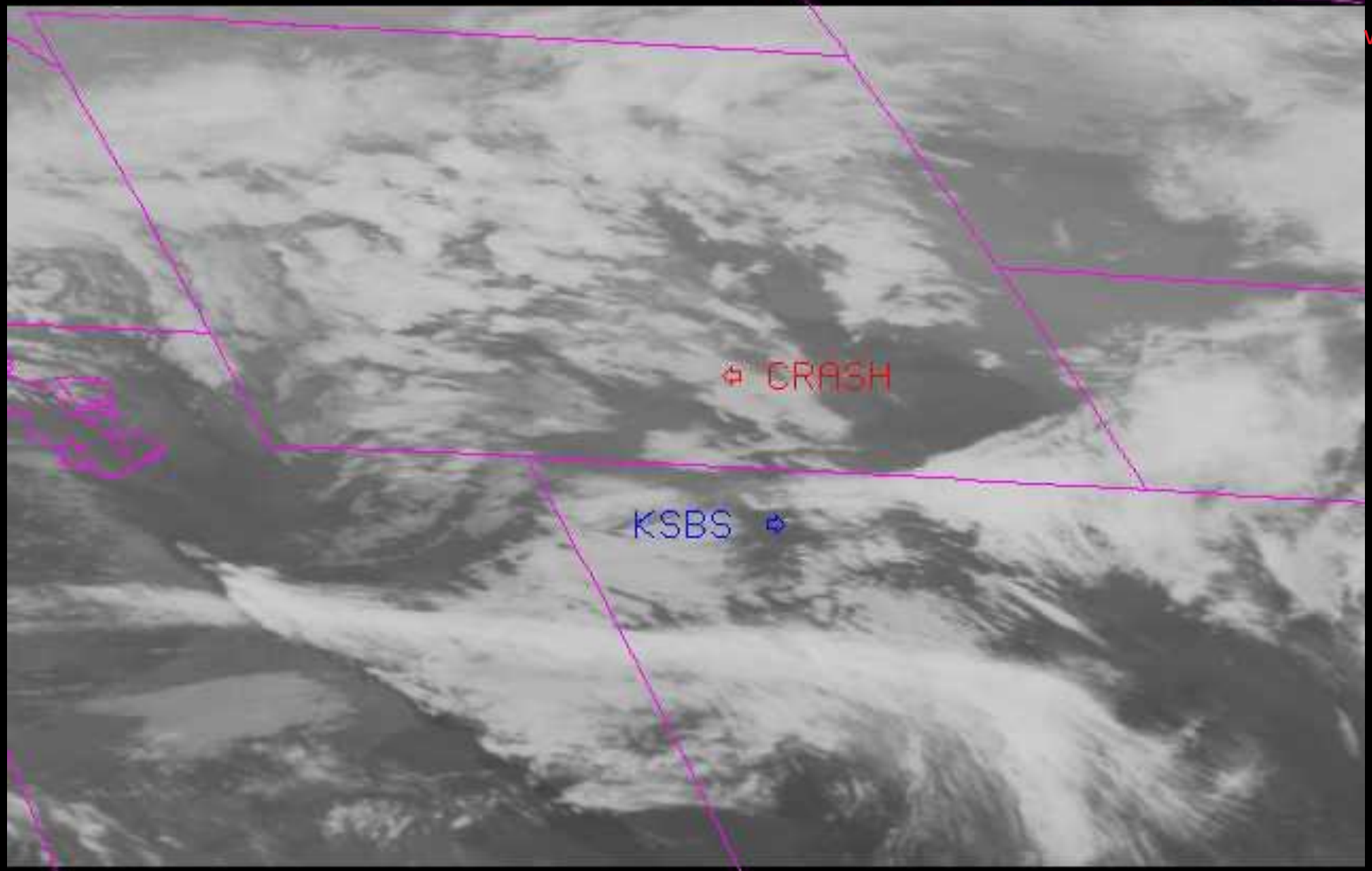
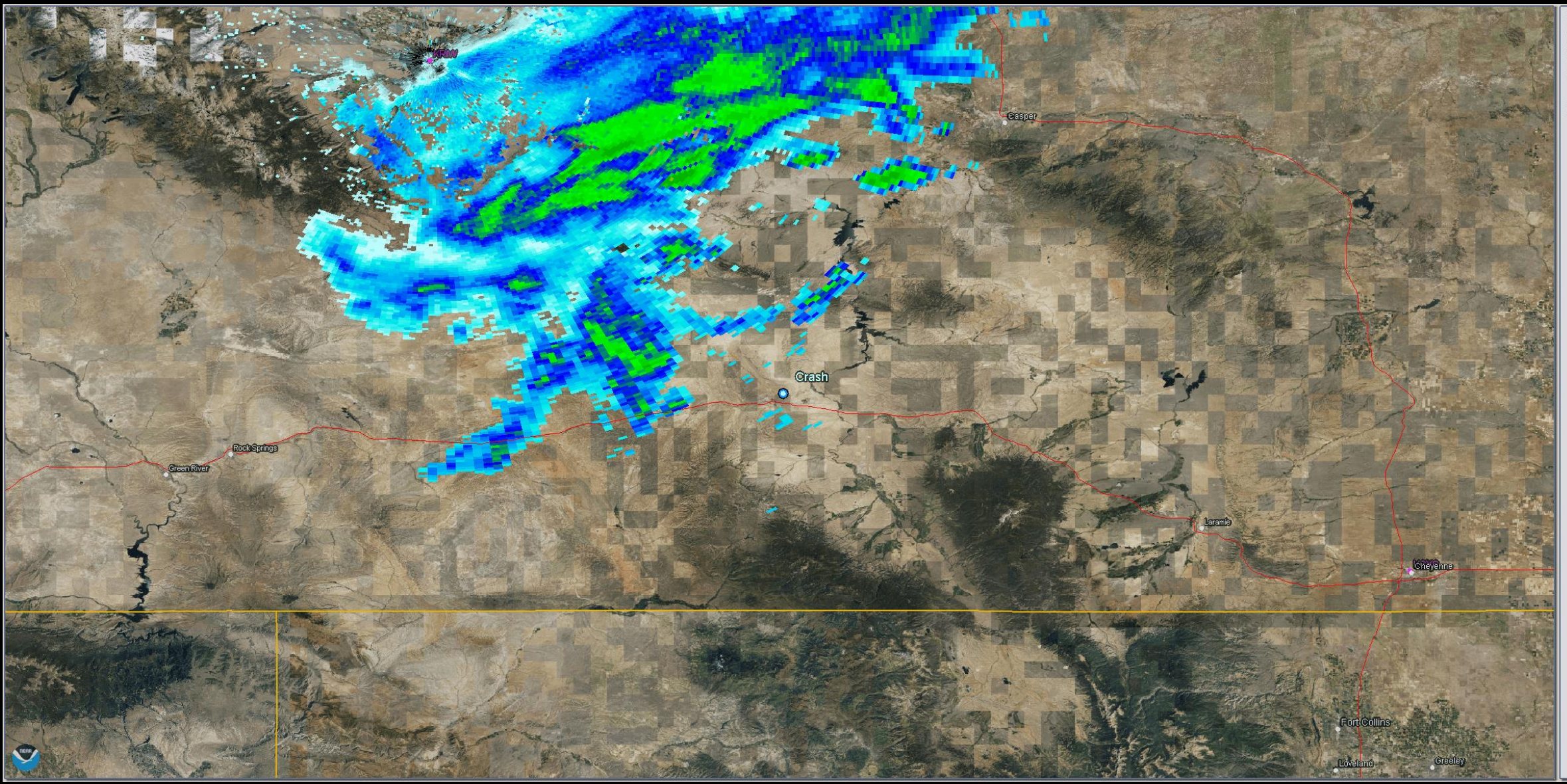
WeatherExtreme

WeatherExtreme

WEATHER EXTREME


HARTZELL


CRASH
KSBS
4 0004 G-10 IMG 4 12 JAN 05012 000000 03497 17981 04.00



NEXRAD LEVEL-II
KRIW - RIVERTON, WY
01/12/2005 04:25:46 Z
LAT: 43/03/57 N
LON: 108/28/36 W
ELEV: 5568 FT
VCP: 21

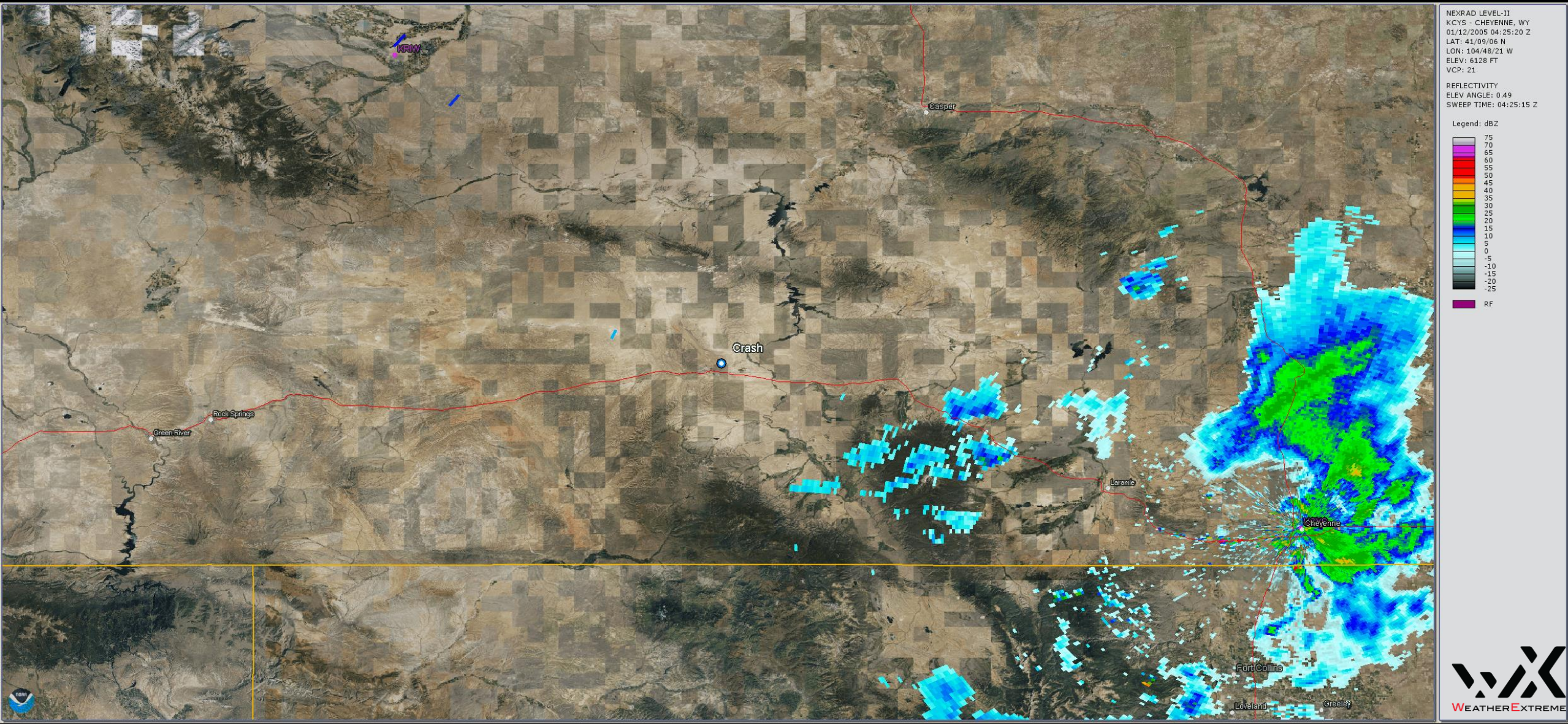
REFLECTIVITY
ELEV ANGLE: 0.47
SWEEP TIME: 04:25:44 Z

Legend: dBZ

75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25

RF

WeatherExtreme

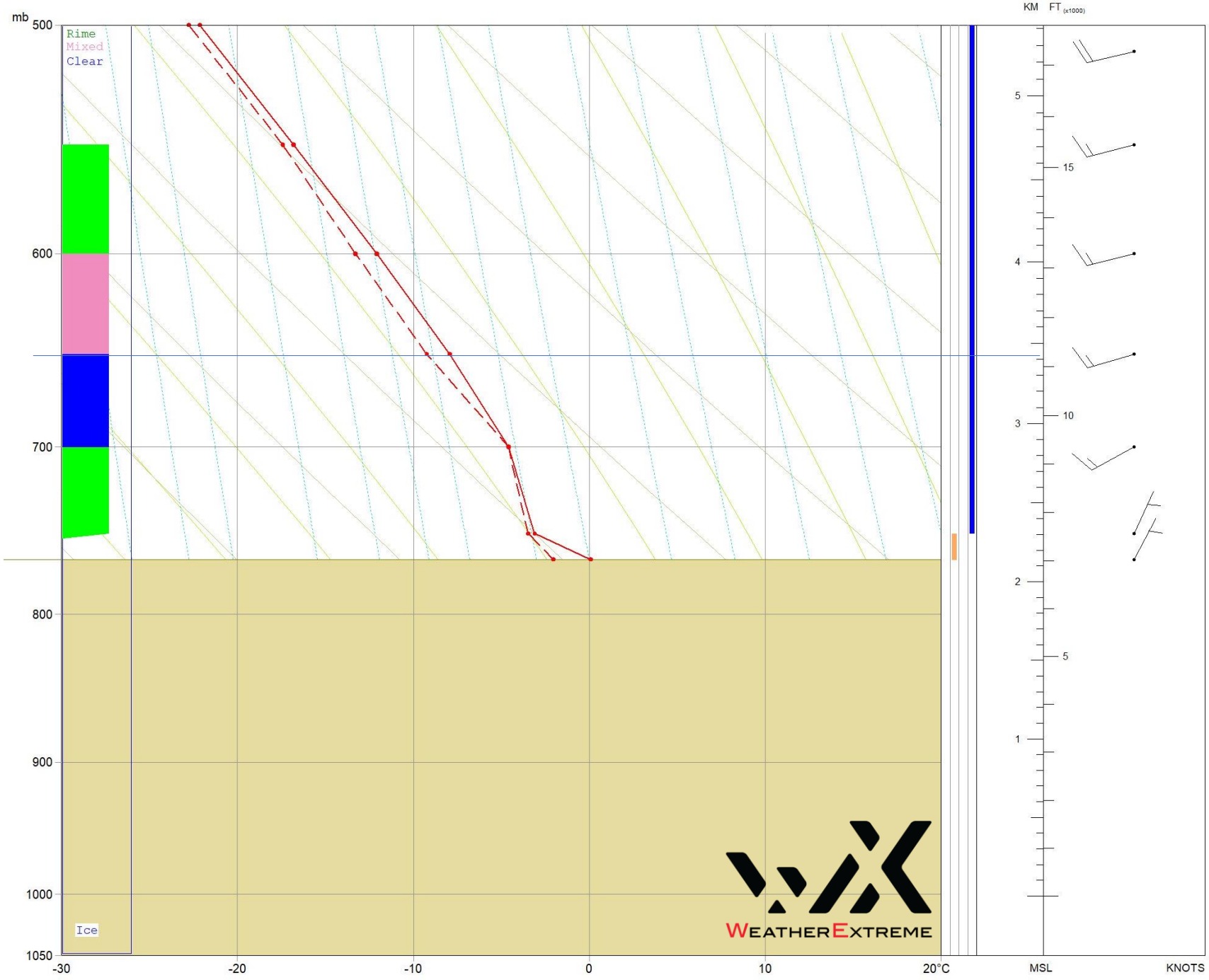

KRIW
Casper
Crash
Rock Springs
Green River
Laramie
Cheyenne
Fort Collins
Loveland
Greeley
NEXRAD LEVEL-II
KCYS - CHEYENNE, WY
01/12/2005 04:25:20 Z
LAT: 41/09/06 N
LON: 104/48/21 W
ELEV: 6128 FT
VCP: 21
REFLECTIVITY
ELEV ANGLE: 0.49
SWEEP TIME: 04:25:15 Z
Legend: dBZ
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
RF
WEATHEREXTREME

ERA-5 Reanalysis
05Z Model Sounding

Rime Ice
Moderate or Greater
500 ft AGL – 2,300 ft AGL AND
6,100 ft AGL – 8,500 ft AGL

Clear Ice
Moderate or Greater
2,300 ft AGL – 4,100 ft AGL

Mixed Ice
Moderate or Greater
4,100 ft AGL – 6,100 ft AGL



Graphic: Typical ASOS Installation

Accident Surface Obs

ASOS: KRWL

~2.5 miles Southwest of Accident

- Temp/Dew: 0°C/0°C
- Weather: Light Snow & Mist

- Sky Conditions:
  Few at 500’ (Few at 600’)
  Scattered at 900’ (Broken at 1,100’)
  Overcast at 1,500’ (Overcast at 1,700’)

*21:45 MST METAR (21:53 MST METAR)

Takeaways

- Avoid flight into adverse weather conditions when possible (especially solo)
- Think twice about landing while accumulating ice
- Underestimating weather & overestimating capability is a recipe for disaster

N110UM: Severe Turbulence During Descent to Denver Approach

Date of Incident:
April 14, 2012

Time of Incident:
23:49 MDT April 14, 2012
(0549 UTC 4.15.2012)

WeatherExtreme

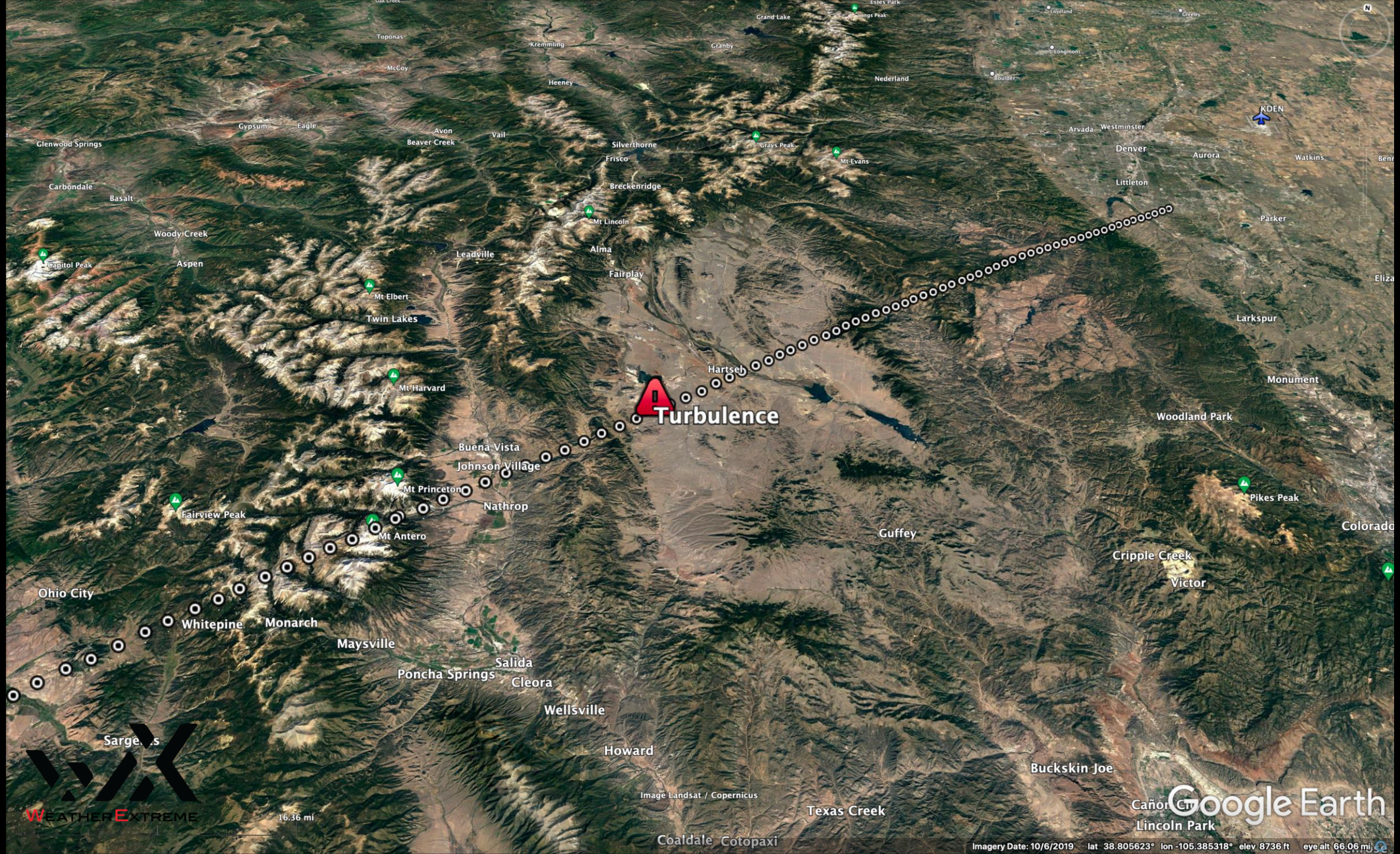
Case Background

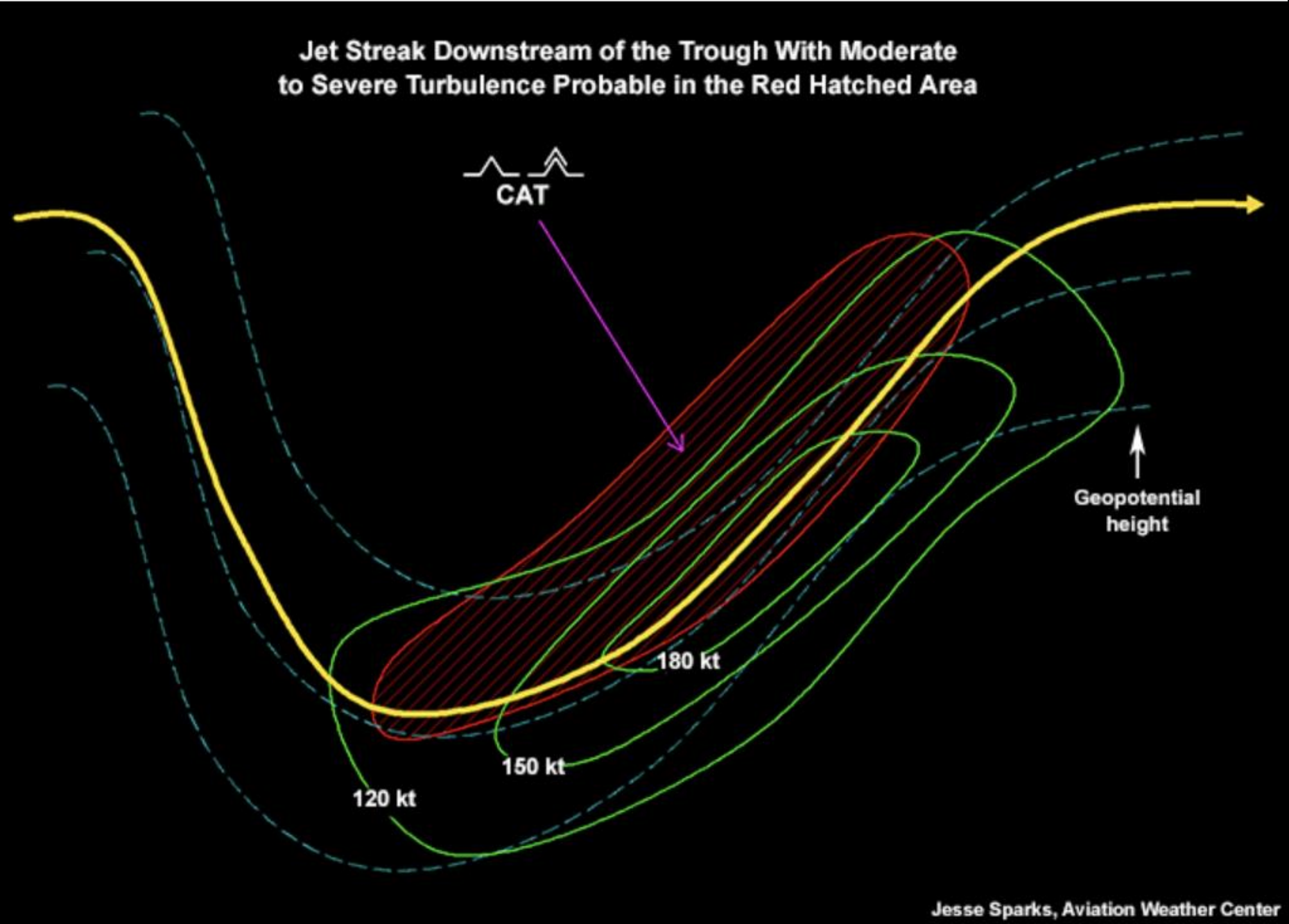
- Aircraft: Airbus A319-132
- Registration: N808AW

- Date of Accident: April 14, 2012
- Time of Accident: 23:49 MDT
  (0549 UTC 4/15/2012)

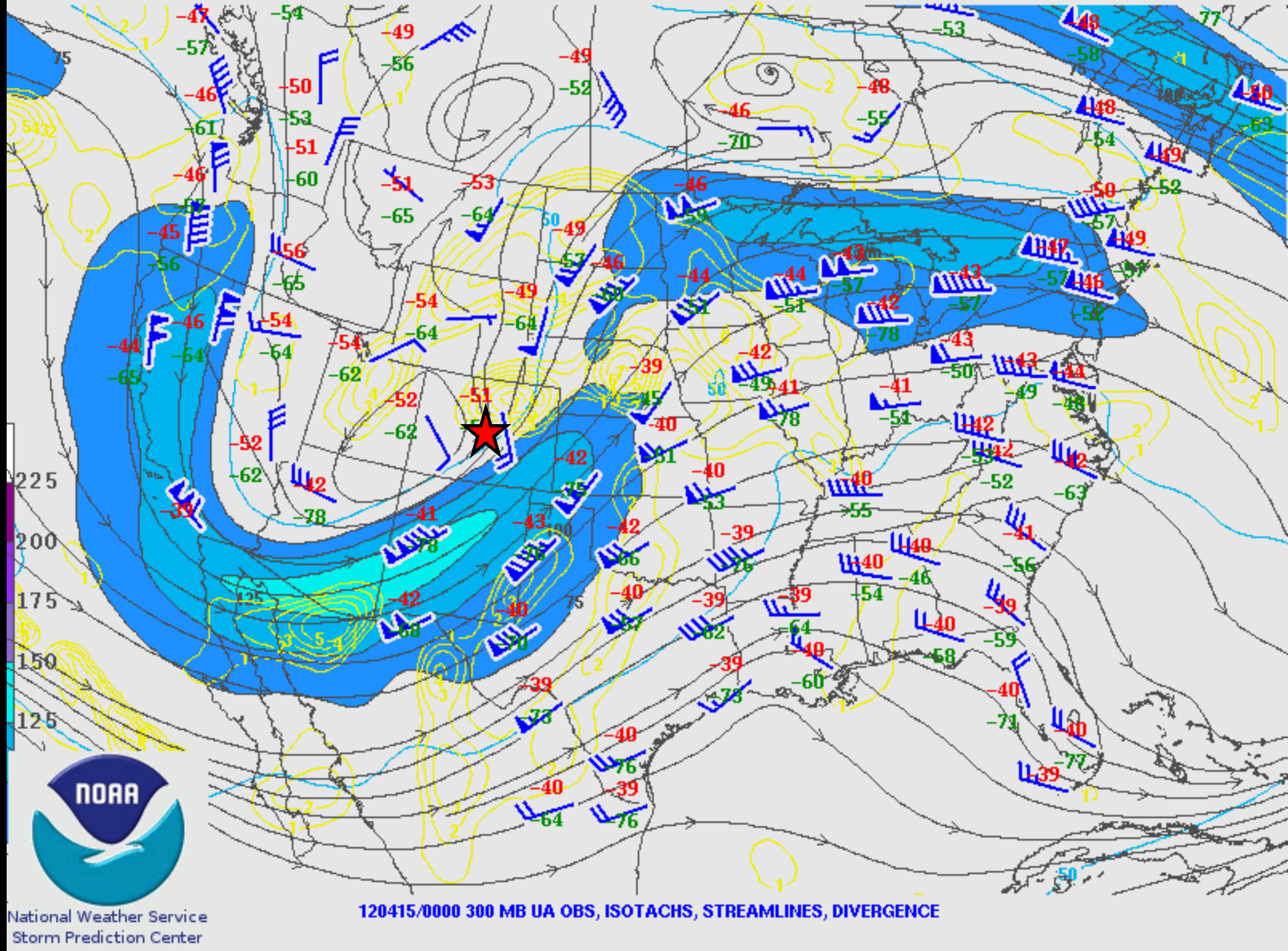
- Souls Onboard: 98

- Defining Event: Severe Turbulence


Turbulence
Grand Lake
Estes Park
Loveland
Greeley
Toponas
Kremmling
Granby
Longmont
McCoy
Heeney
Nederland
Boulder
KDEN
Gypsum
Eagle
Avon
Beaver Creek
Vail
Arvada
Westminster
Glenwood Springs
Silverthorne
Frisco
Grays Peak
Mt Evans
Denver
Aurora
Watkins
Carbondale
Basalt
Breckenridge
Littleton
Mt Lincoln
Parker
Woody Creek
Capitol Peak
Aspen
Leadville
Alma
Fairplay
Mt Elbert
Twin Lakes
Larkspur
Hartsel
Mt Harvard
Monument
Buena Vista
Woodland Park
Johnson Village
Mt Princeton
Pikes Peak
Nathrop
Fairview Peak
Mt Antero
Guffey
Colorado
Cripple Creek
Victor
Ohio City
Whitepine
Monarch
Maysville
Salida
Poncha Springs
Cleora
Wellsville
Howard
Buckskin Joe
Texas Creek
Lincoln Park
Coaldale
Cotopaxi
Image Landsat / Copernicus
Google Earth
16.36 mi
WeatherExtreme
Imagery Date: 10/6/2019 lat 38.805623° lon -105.385318° elev 8736 ft eye alt 66.06 mi

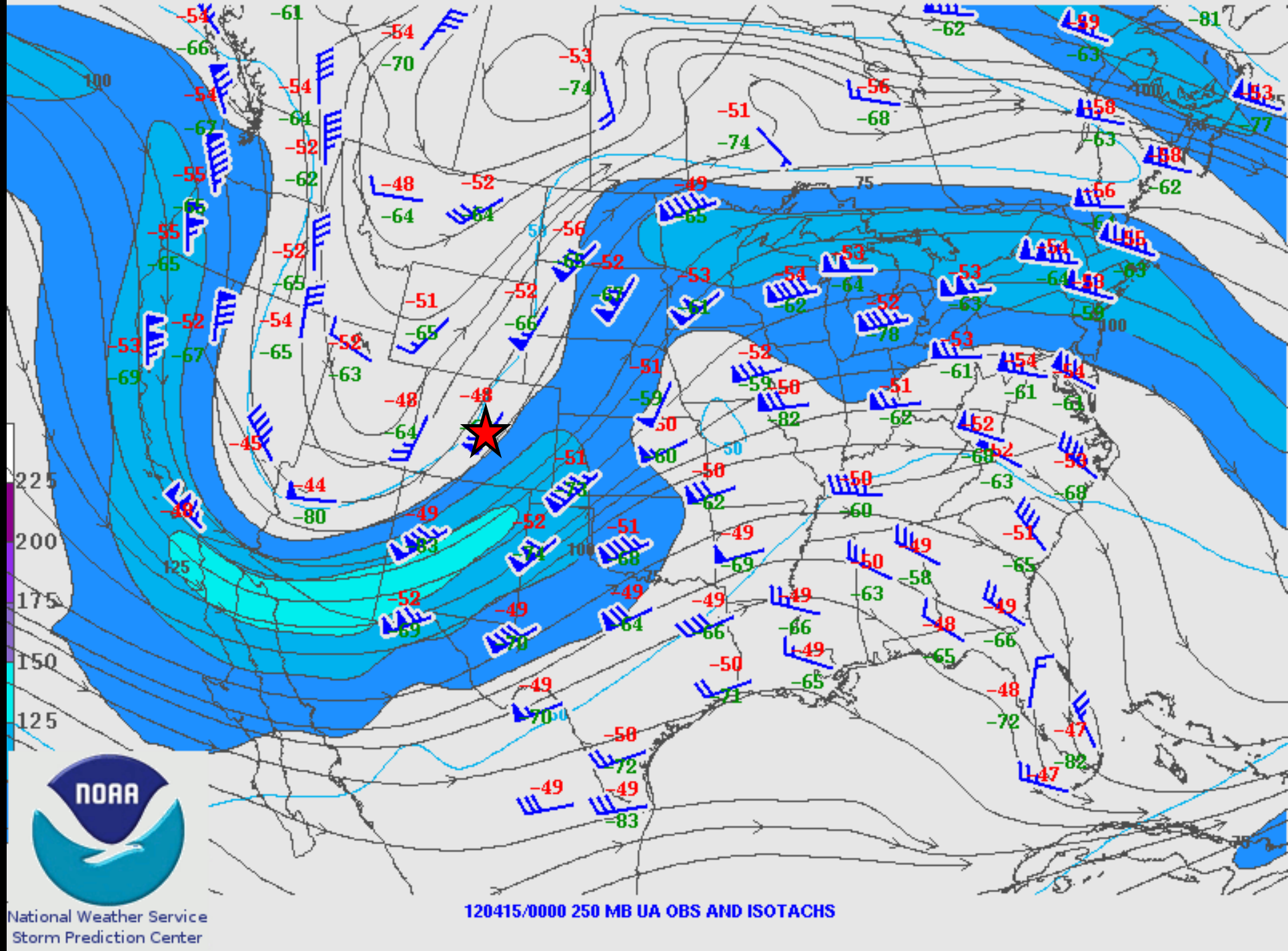

Jet Streak Downstream of the Trough With Moderate
to Severe Turbulence Probable in the Red Hatched Area
CAT
Geopotential
height
180 kt
150 kt
120 kt
Jesse Sparks, Aviation Weather Center

00 UTC
300mb

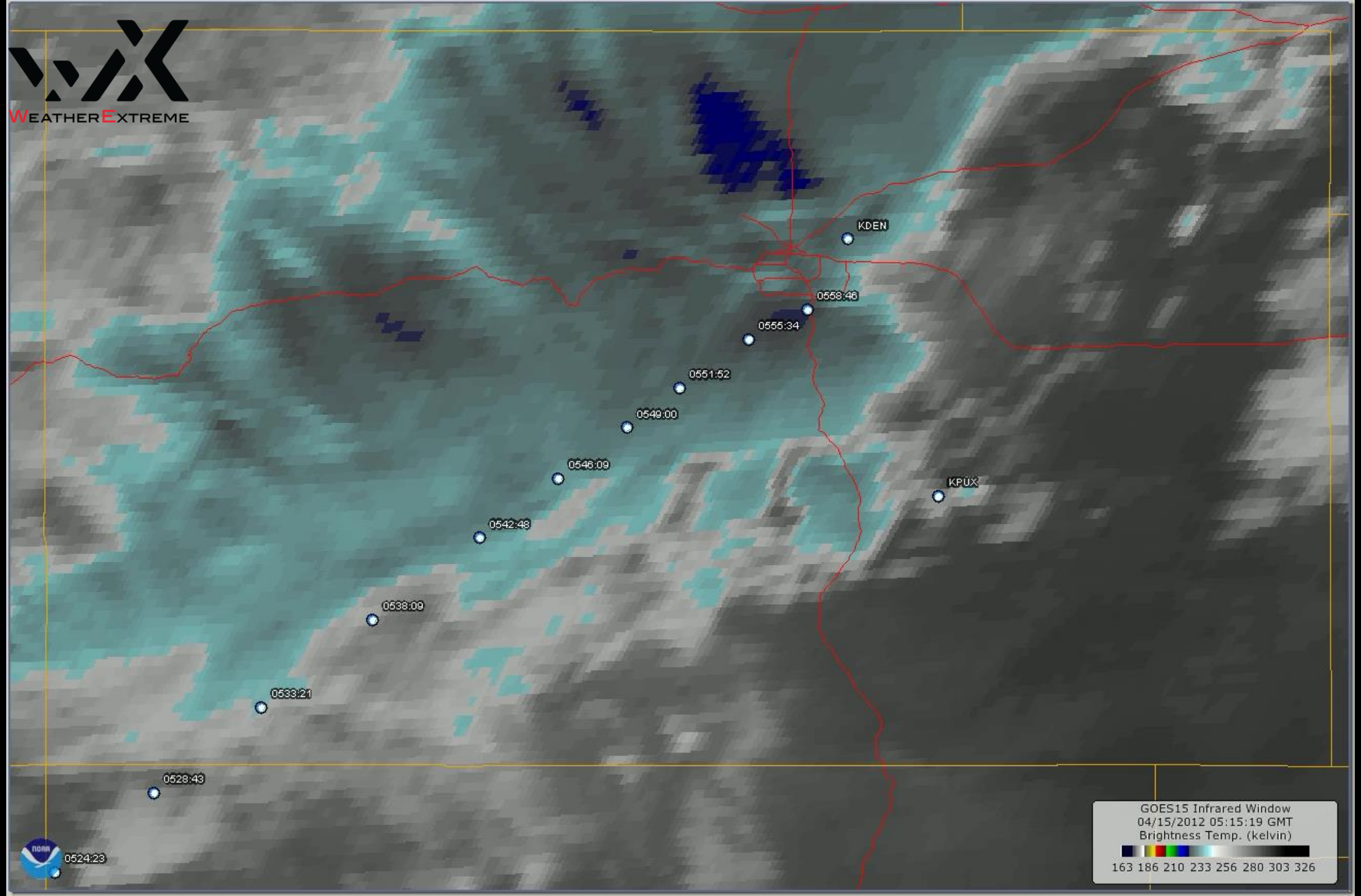


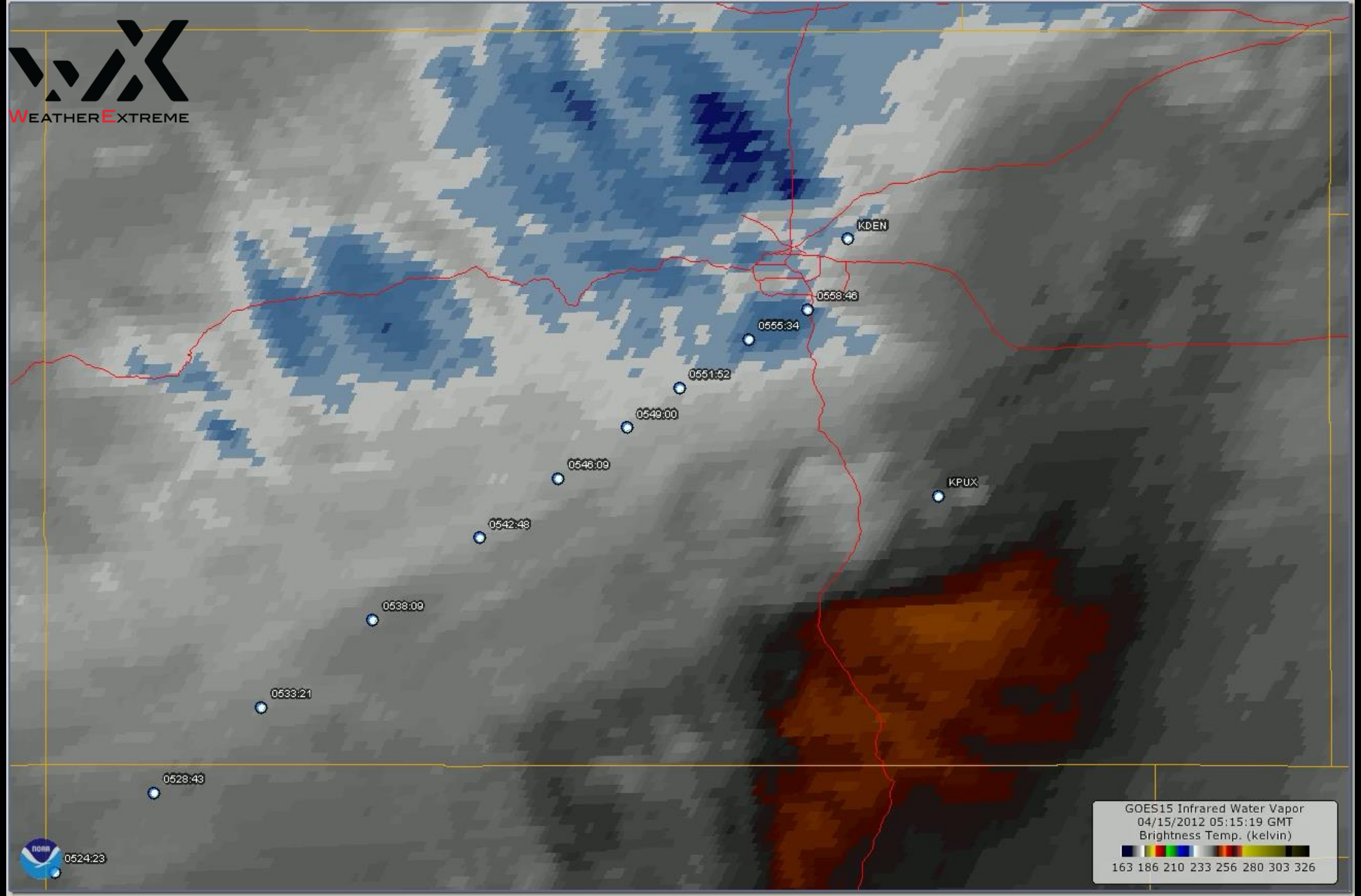
WeatherExtreme

00 UTC
250mb

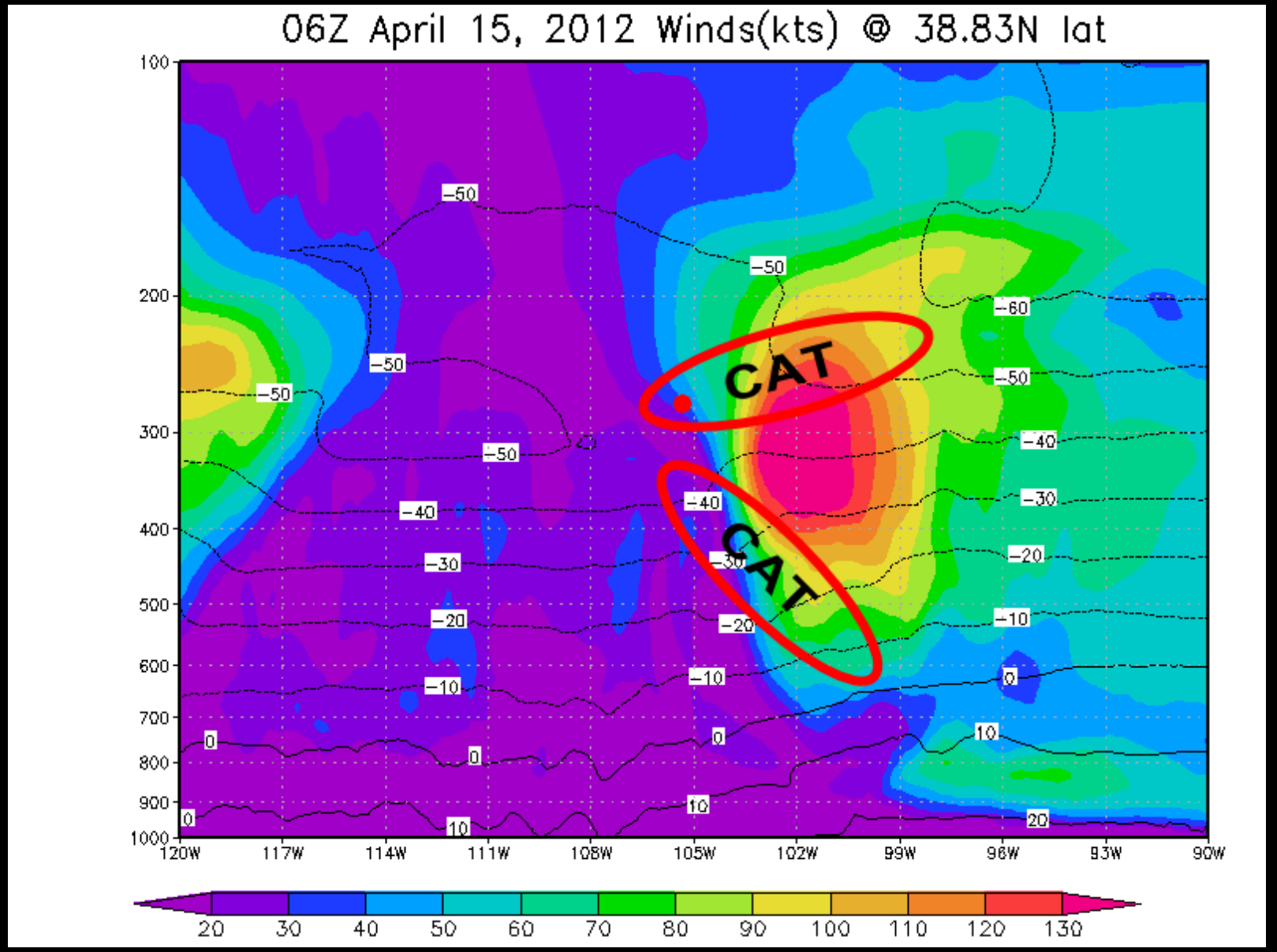


WeatherExtreme


WeatherExtreme
KDEN
0558:46
0555:34
0551:52
0549:00
0546:09
KPUX
0542:48
0538:09
0533:21
0528:43
0524:23
GOES15 Infrared Window
04/15/2012 05:15:19 GMT
Brightness Temp. (kelvin)
163 186 210 233 256 280 303 326

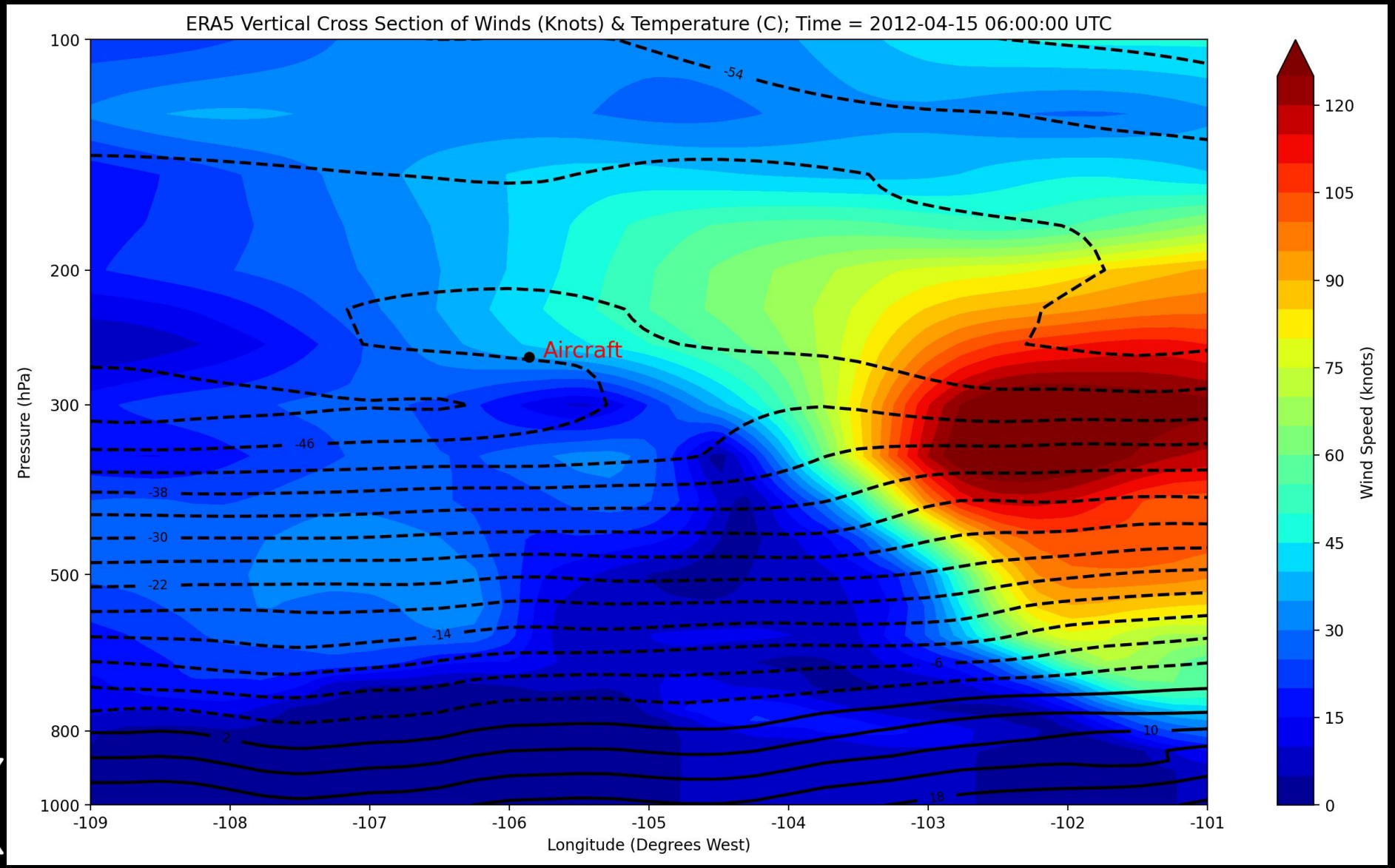

WeatherExtreme
KDEN
0558:46
0555:34
0551:52
0549:00
0546:09
KPUX
0542:48
0538:09
0533:21
0528:43
0524:23
GOES15 Infrared Water Vapor
04/15/2012 05:15:19 GMT
Brightness Temp. (kelvin)
163 186 210 233 256 280 303 326

North American Model (NAM): Jet Stream Cross-Section



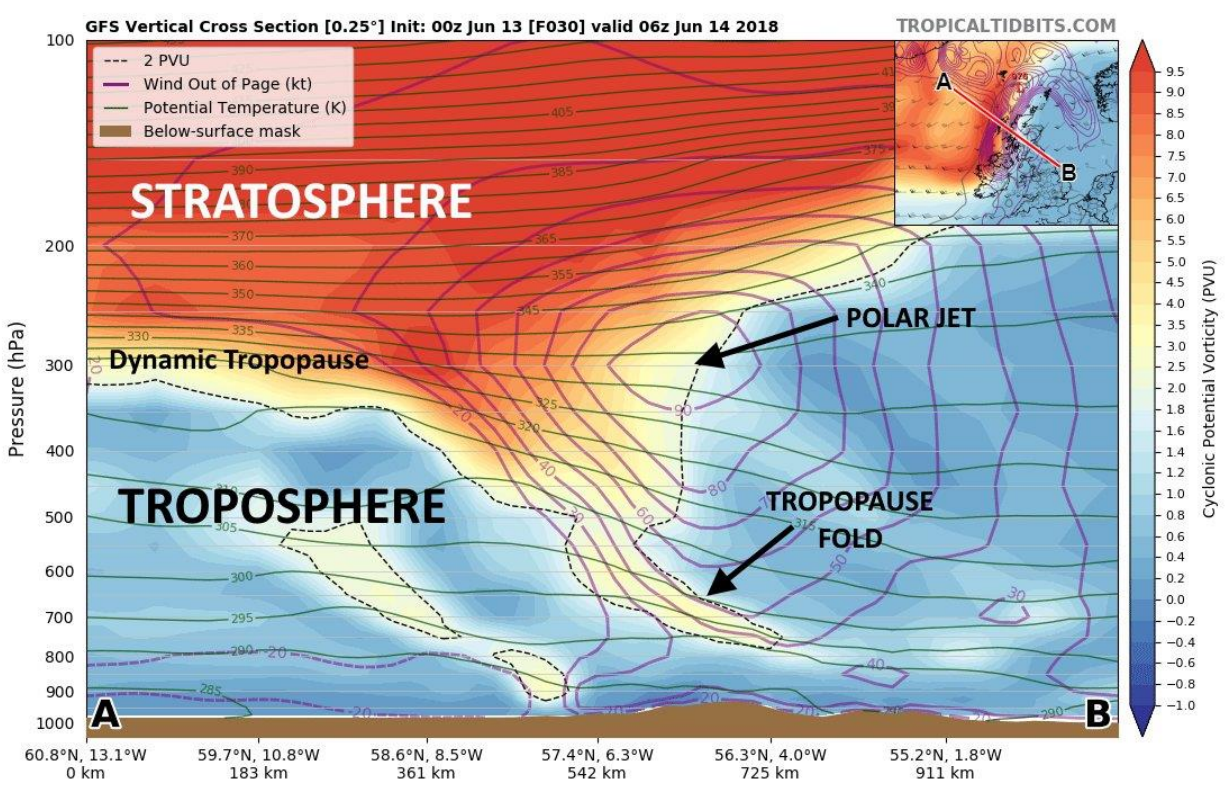
WeatherExtreme

ERA5 Reanalysis Data: Jet Stream Cross-Section



WeatherExtreme

Stratospheric Intrusion / Tropopause Fold

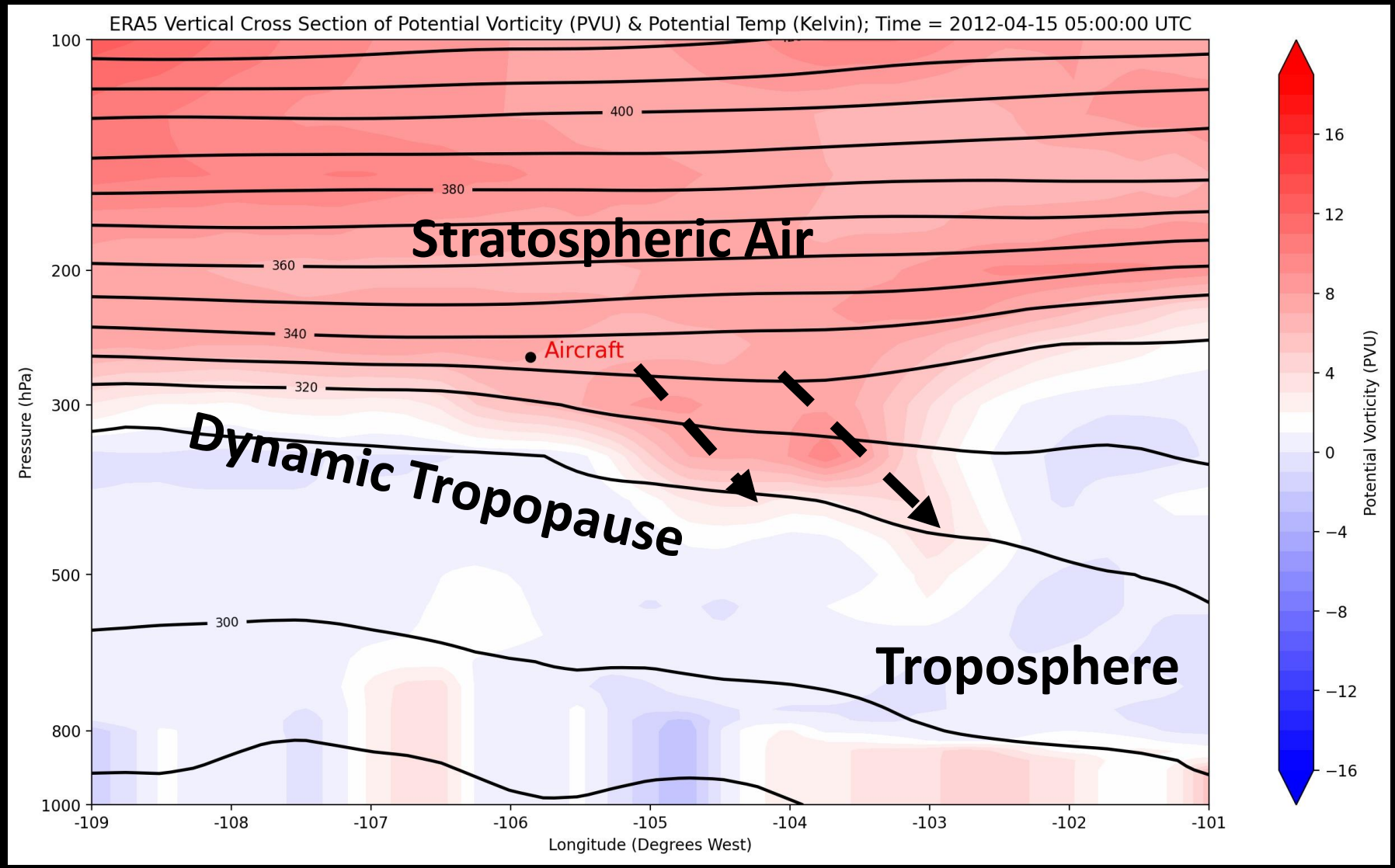


Dr Simon Lee
@SimonLeeWx

What's better than one stratosphere? Two stratospheres! GFS shows a tropopause fold over W Scotland early on Thursday associated with an unusually intense surface cyclone (~970 hPa). 'First' tropopause down to ~800 hPa.
Graphics via @TropicalTidbits.

WeatherExtreme

ERA5 Reanalysis Data: Tropopause Fold



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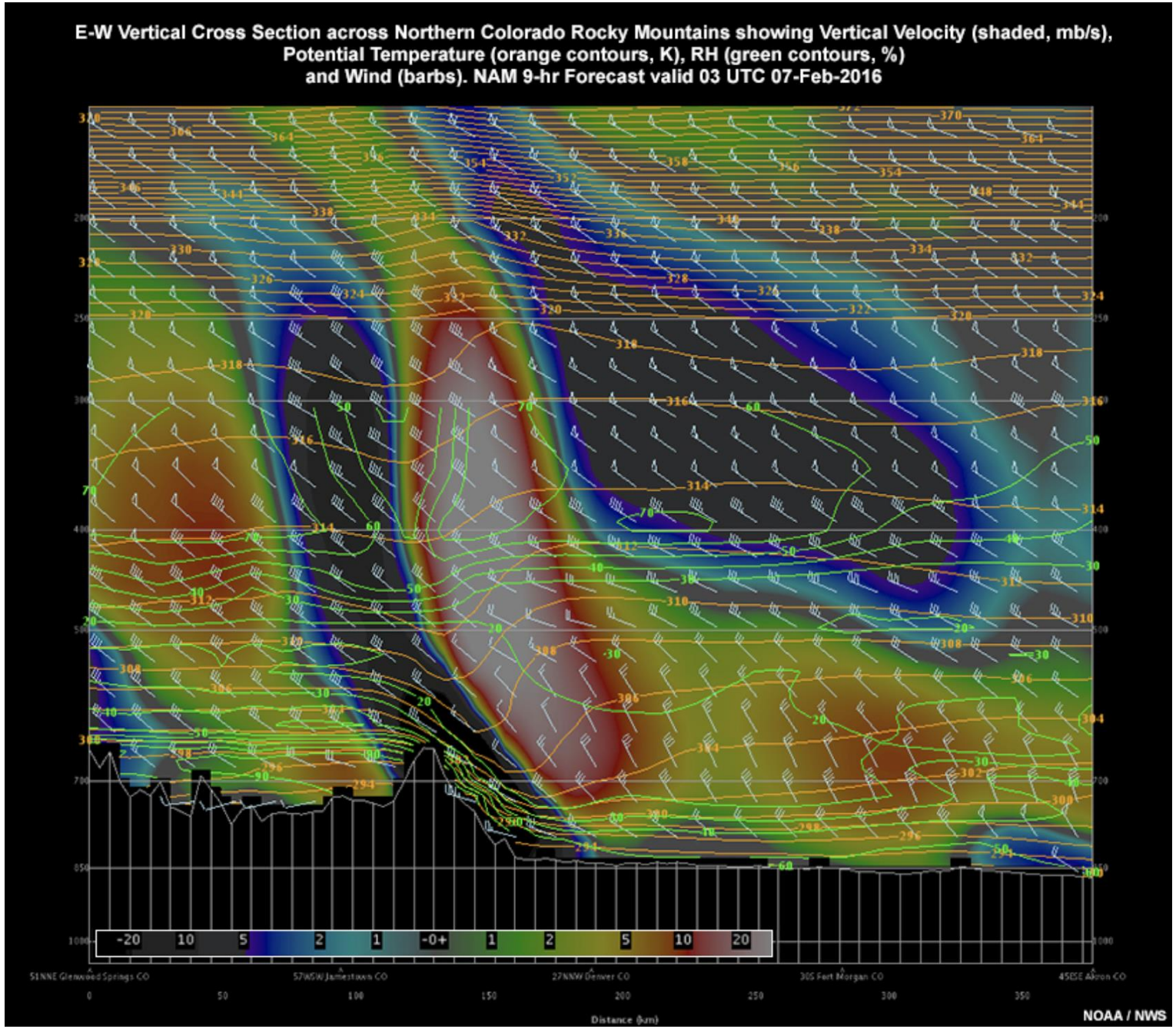
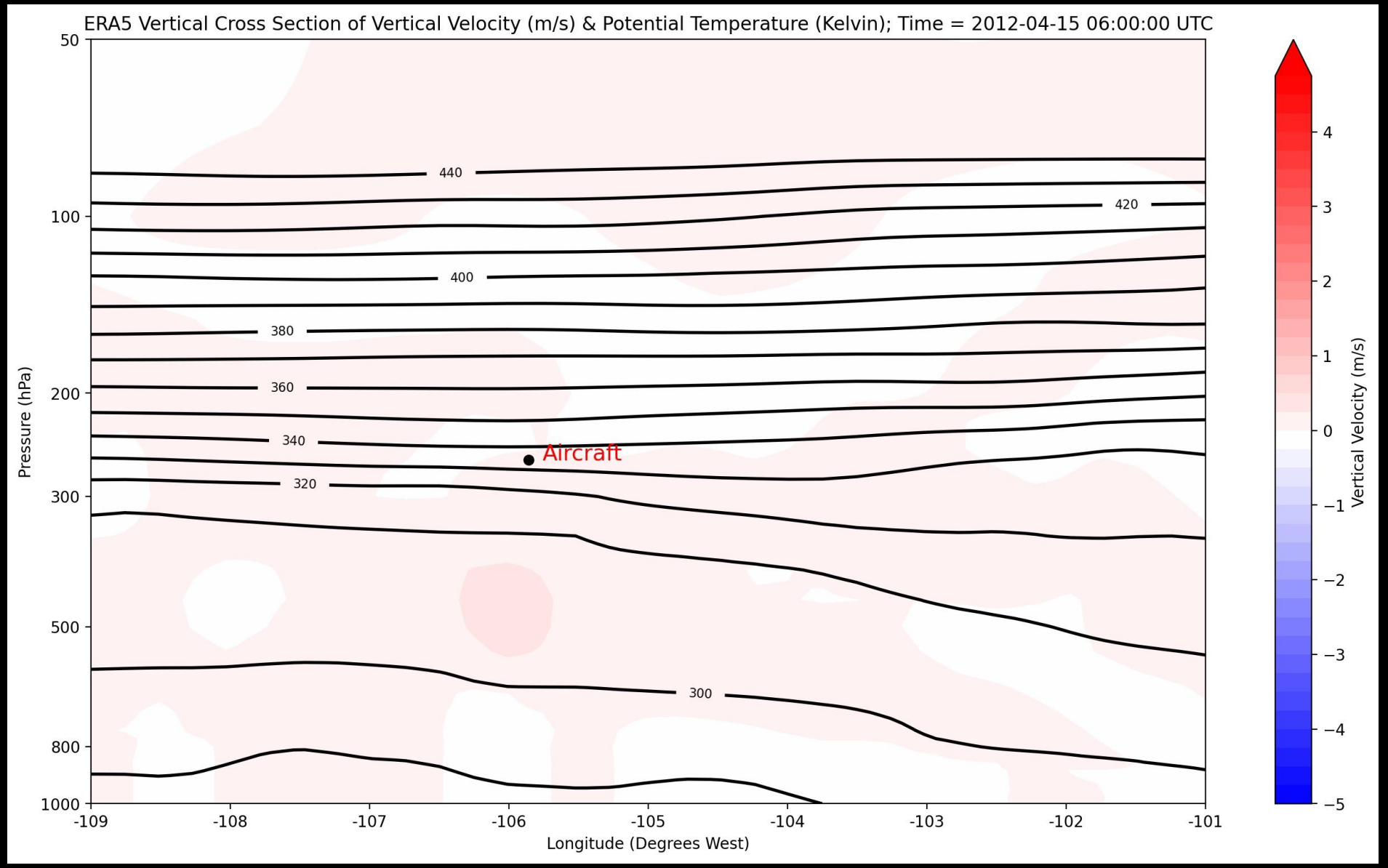
Compare to Mountain Wave Activity



ERA5 Reanalysis Data: Vertical Velocity



Takeaways

- **Anticipate Jetstream Turbulence (Especially near tropopause)**
- **Check for AIRMETs**
- **Monitor PIREPs**
- **Provide PIREPs**

Questions?

Get In Touch:

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