



National Transportation Safety Board

Weather Related Accident Investigations and Lessons Learned

Paul Suffern

NTSB Meteorologist Investigator

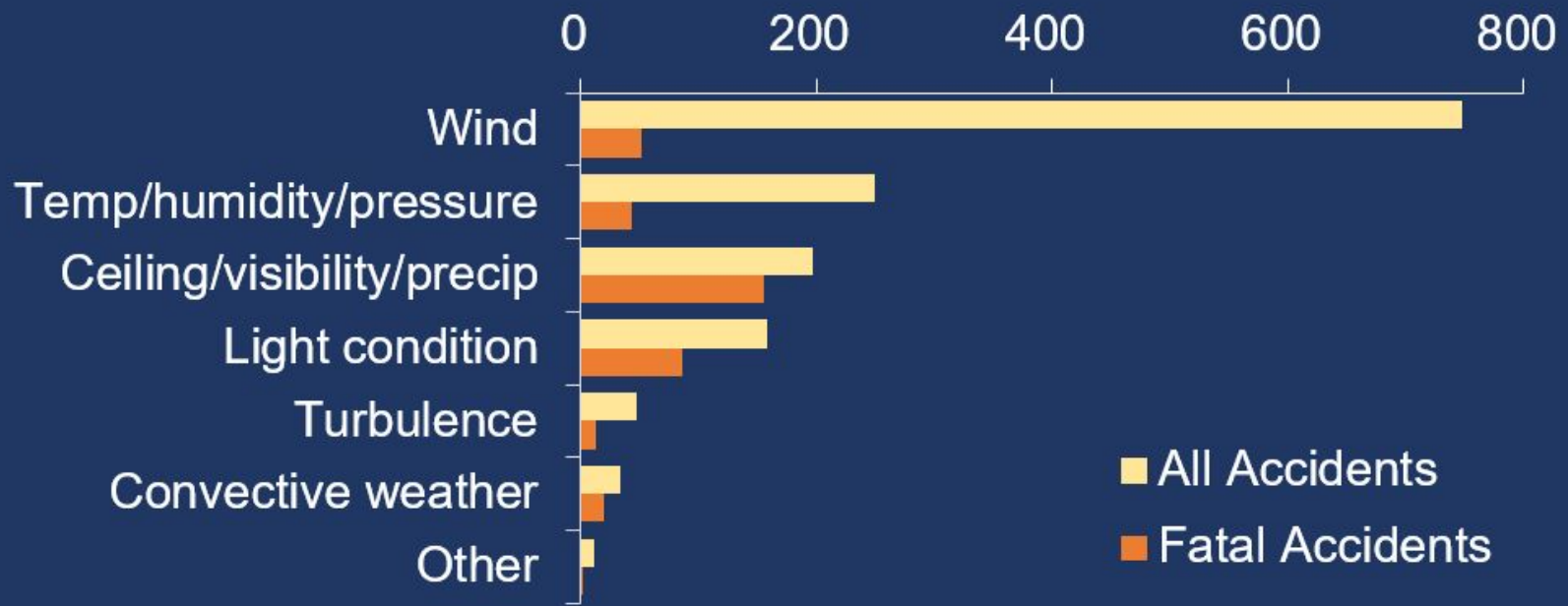


photo courtesy VansAirForce.net

Part 91 General Aviation Accidents 2012-2016

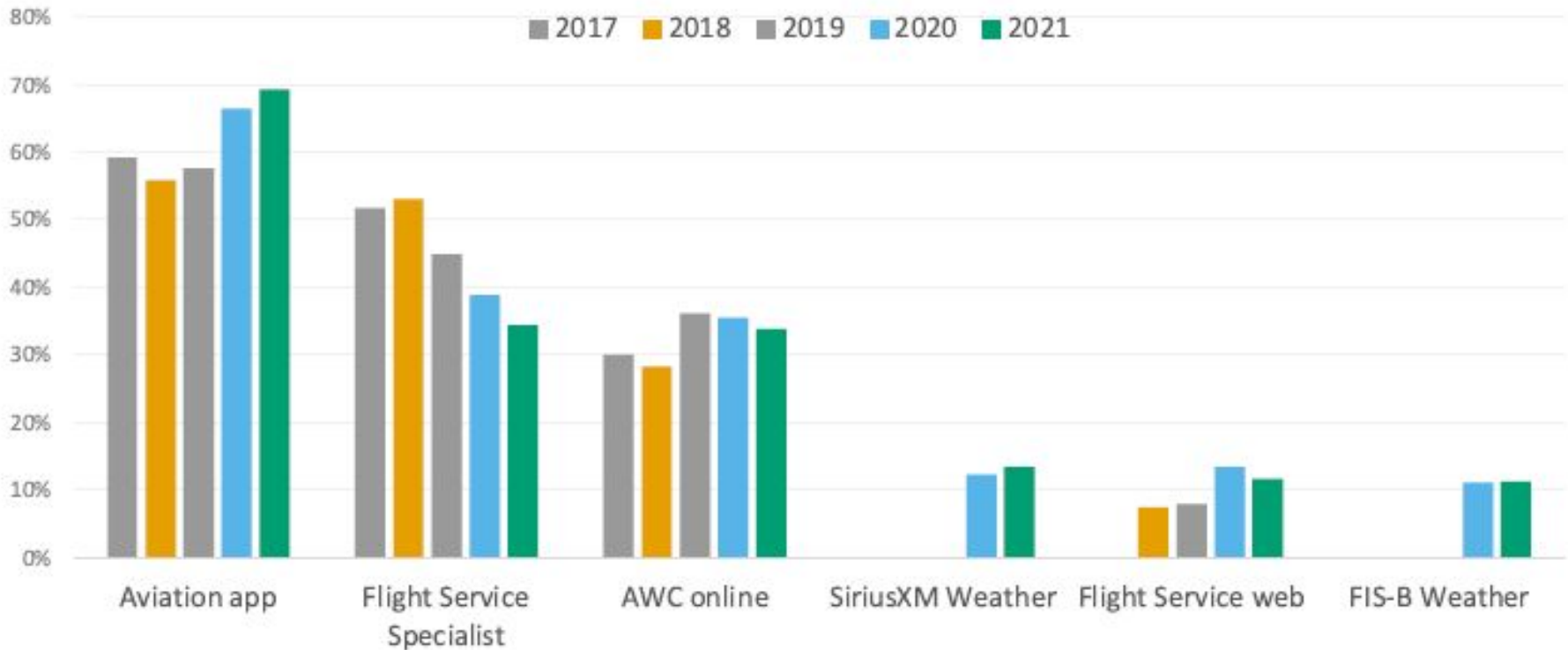
	Weather-Related	Non Weather Related	Total	Weather Related
Accidents	1,349	4,492	5,841	23%
Fatal Accidents	315	715	1,066	30%

Part 91 Accidents by Weather-Related Finding Category, 2012-2016



2021 AOPA Weather Survey

All Sources Used Immediately Prior to Flight (Select All)
CONUS, Change Over Time



WPR19FA077

Rockwell 112, N1332J

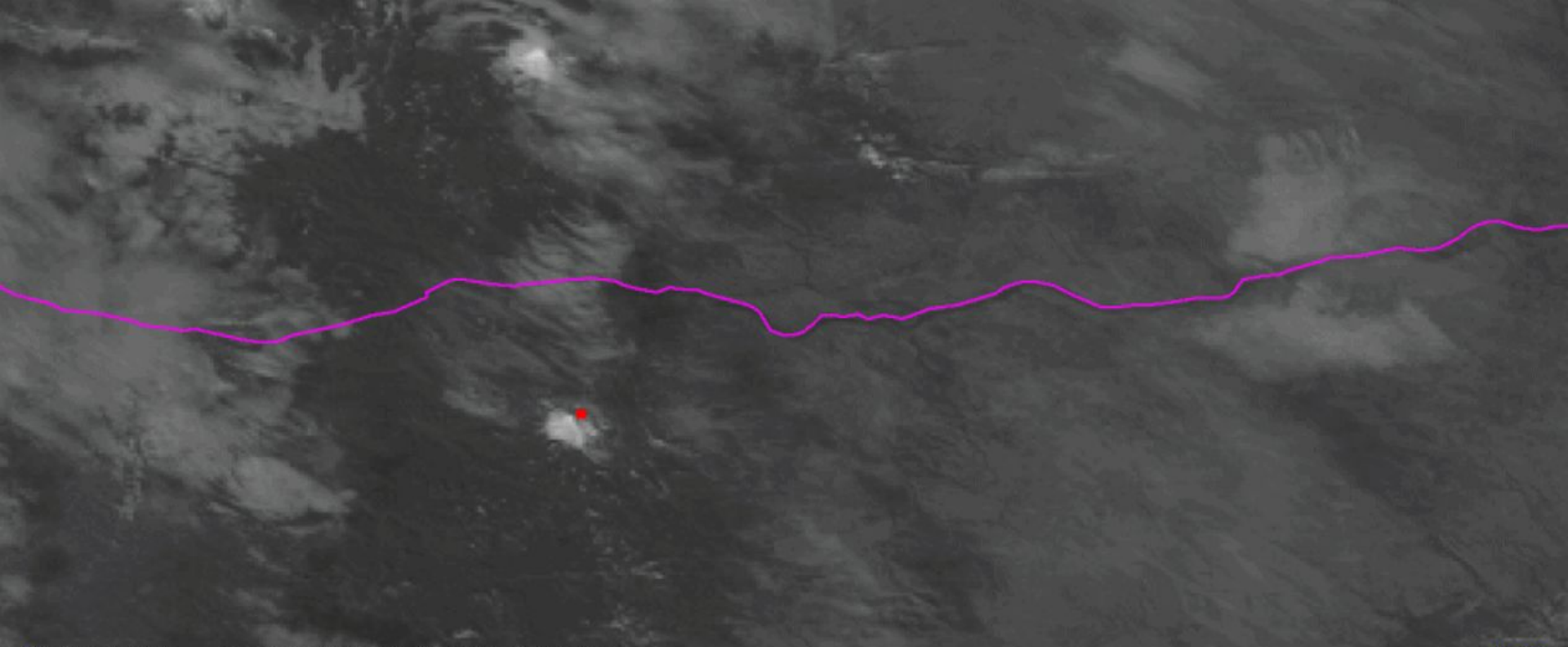
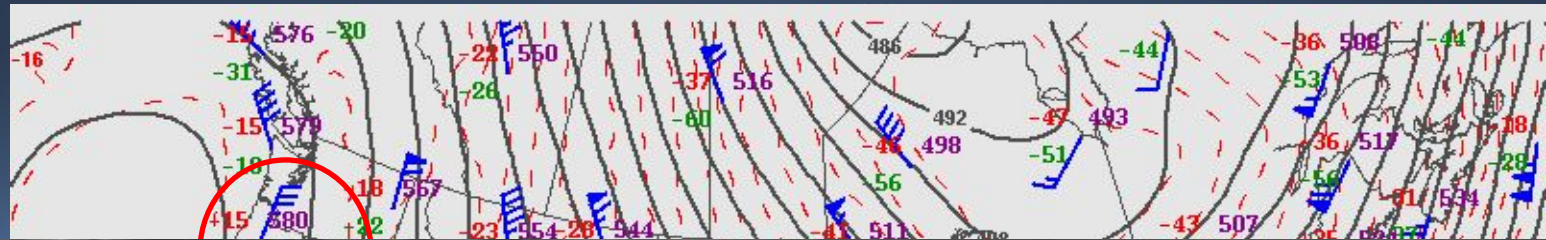
Mt. Hood, Oregon

January 2019



- VFR Part 91 flight
- Pilot, ~1,350 hrs
- Portland, Oregon (TTD) to Camas, Washington (1W1)
- No known weather briefing
- 1-Fatal

***METAR K4S2 252255Z AUTO 35004KT 10SM CLR 10/03 A3043
RMK AO2=***



10001 6-17 IMG 2 25 JAN 19025 224538 02237 12994 00 33

McIDRS

National Weather Service
Storm Prediction Center

190126/0000 500 MB UA OBS, HGHTS, and TEMPS

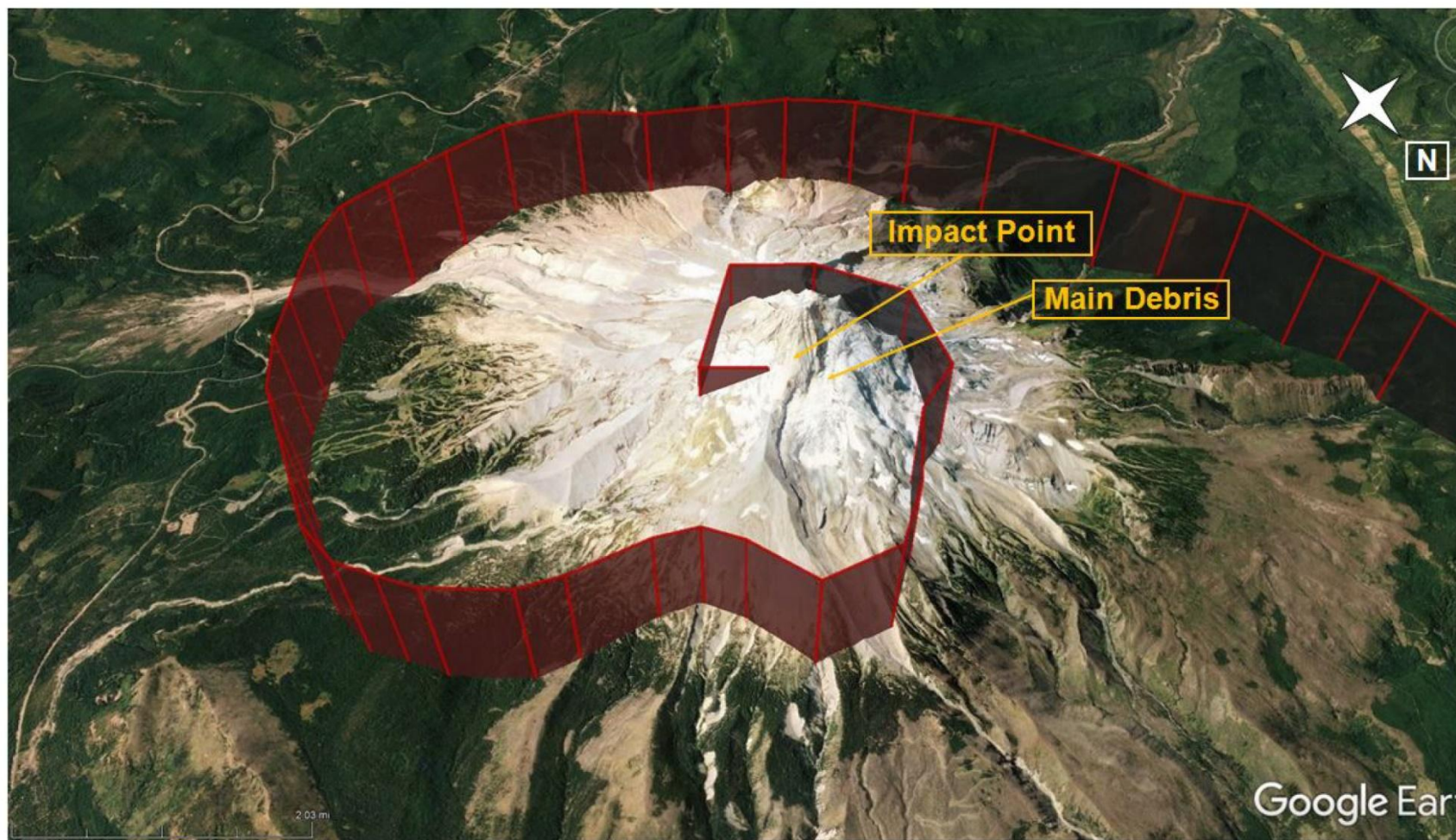


Photo 1 – Radar-Derived Flight Path

1000's OF FEET

60
50
40
30
20
10
0

STRATOSPHERE

TROPOPAUSE

TROPOSPHERE

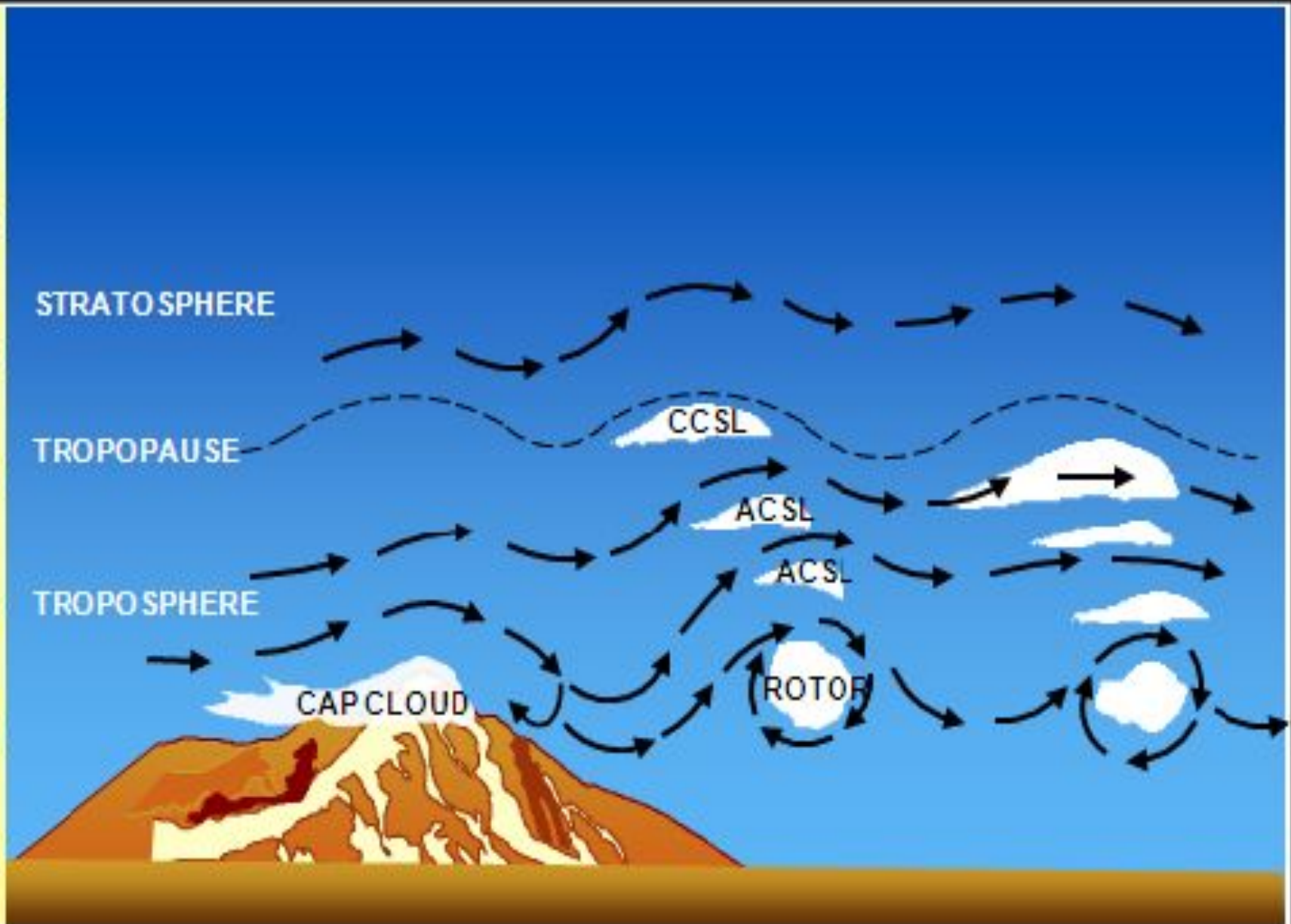
CAP CLOUD

CCSL

ACSL

ACSL

ROTOR



N Vertical Velocity 2019-01-25_23:00:00 S

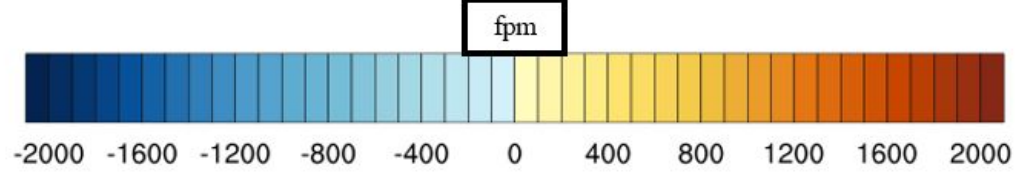
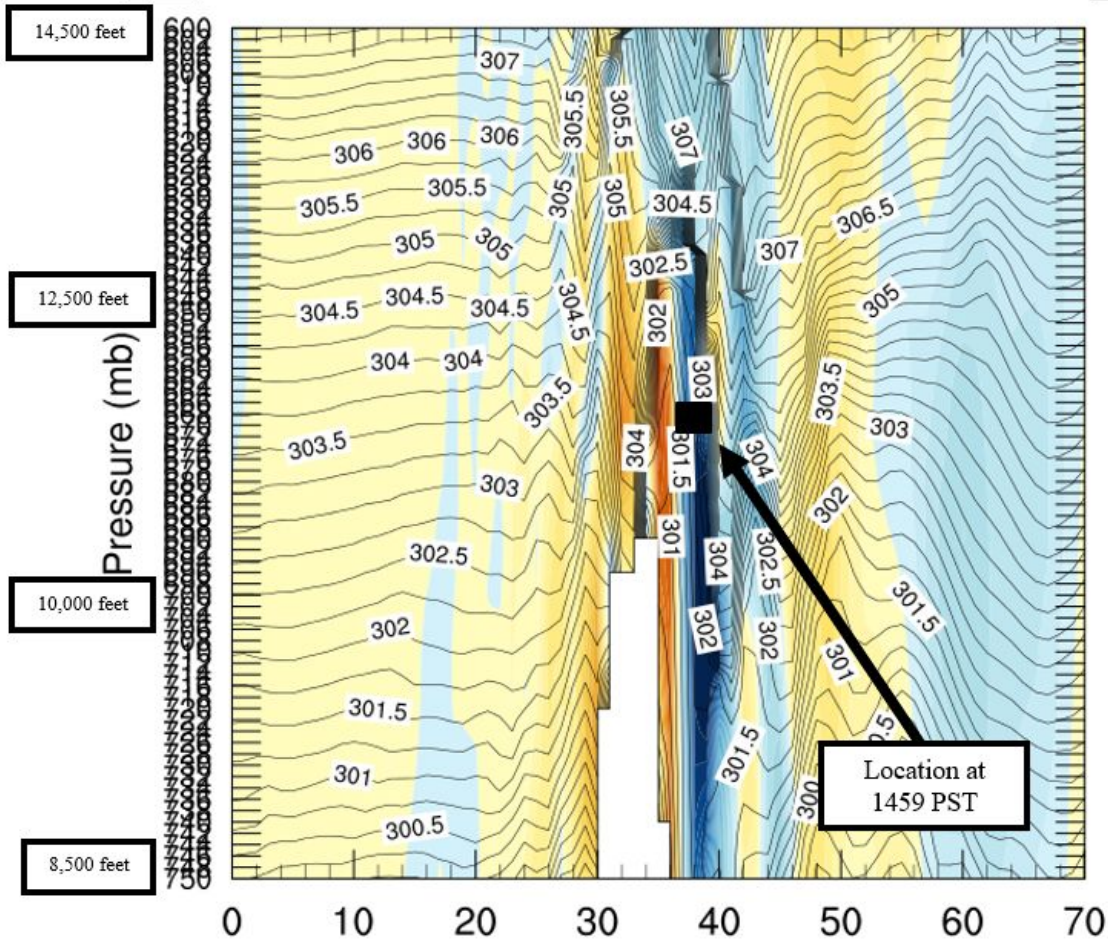


Figure 23 – WRF cross section from 1500 PST of vertical velocity in fpm (color fill) and potential temperature in degrees Kelvin (black lines) from north to south across the terrain

Significantly exceeding the airplane's 200-fpm climb performance for that altitude.



The National Transportation Safety Board determines the probable cause(s) of this accident as follows:

The pilot's decision to fly the airplane in close proximity to mountainous terrain in an area of mountain wave activity that exceeded the performance capabilities of the airplane.

Contributing to the accident was the pilot's degraded decision making and performance due to his use of multiple sedating and impairing drugs.



Local Forecast



Local Forecast

Graphical Forecasts for Aviation - Turbulence

GFA Home

Info

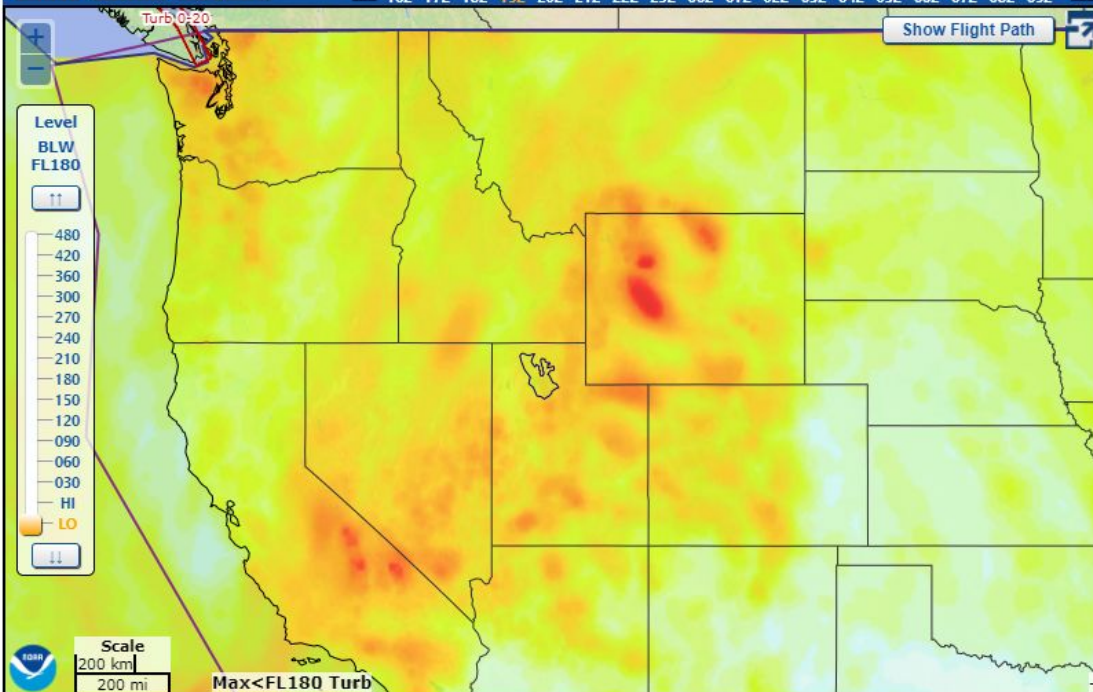
OUT USER

TAF CIG/MIS Clouds PCPN/WX TS Winds Turb Ice

+4hr 1900 UTC Mon 25 Oct 2021

Forecast Obs/Warn Map Options

16Z 17Z 18Z 19Z 20Z 21Z 22Z 23Z 00Z 01Z 02Z 03Z 04Z 05Z 06Z 07Z 08Z 09Z



Eddy Dissipation Rate	LGT	MOD	SEV	SEV	EXTRM	EXTRM	IE	Heavy	AIRMETS	Turb High	TurbHi	Turb Low	TurbLo	Below SFC			
	10	20	30	40	50	60	70	80	90	SIGMETS	Convective	Conv	Thunderstorm	TS	Trop Cyclone	TC	Turb

(m²s⁻¹ x 100) (Aircraft Weight)

Page loaded: 15:35 UTC | 08:35 AM Pacific | 09:35 AM Mountain | 10:35 AM Central | 11:35 AM Eastern

- ADVISORIES**
- SIGMET
 - G-AIRMET
 - Center Weather
- FORECASTS**
- Convection
 - Turbulence

- FORECASTS**
- Icing
 - Winds/Temps
 - Prog Charts
 - TAFs
 - Aviation Forecasts
 - WAFS Forecasts
 - Area Forecasts
 - Avn Forecast Disc (AFD)

- OBSERVATIONS**
- Aircraft Reps
 - METARs
 - Radar
 - Satellite

- USER TOOLS**
- Flightpath Tool
 - HEMS Tool
 - Text Data Server
 - Flight Folder
 - Decision Support
 - PIREP Submit
 - Standard Briefing
 - Aviation Testbed
 - Aviation Links

- ABOUT US**
- AWC
 - Help
 - FAQ
 - Contact Us



US Dept of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Centers for Environmental Prediction
Aviation Weather Center
7220 NW 101st Terrace
Kansas City, MO 64153-2371

Disclaimer
Information Quality
Glossary
About Us
Contact AWC

Privacy Policy
Freedom of Information Act (FOIA)
Career Opportunities
Server: IDP-BLDR:79
Version: v21.09

SB

• What about ForeFlight, FIS-B, Windy, etc....?

DAY/THREAT	Mon	Tue	Wed
Turbulence/LLWS	Red	Red	Green
Thunderstorms	Yellow (Central CA)	Green	Green
ICING	Red	Yellow (N AZ/UT)	Green
Low CIGS/VIS or East Winds	Red	Green	Green

	Likely – High Confidence
	Chance - Med Confidence
	Slight - Low Confidence
	No Threat

**ZLA AM Outlook
Impact Threat Matrix
Oct 24, 2021**



- RADAR/PIREPs
- 6 Hr Fcst
- 12 Hr Fcst
- Ntl Radar Loop
- FL360 Winds
- SIGMET CWA
- G-AIRMET High Turb (3hr fcst)
- G-AIRMET Low Turb (3hr fcst)
- G-AIRMET LLWS (3hr Fcst)
- G-AIRMET Icing (3hr Fcst)
- Flight Category Obs
- G-AIRMET IFR and MTN OBSCN (3hr Fcst)
- ZDV Radar West
- ZDV Radar East
- 2 HR TSTM PROB
- TCF 4HR FCST
- TCF 6HR FCST
- TCF 8HR FCST
- KDEN TAF
- Solicit PIREPS
- Advance Slides

AWC Radar: 314803z
1803z 31-May-2017

PermaLink Legend Refresh/Update



CEN19FA022

Mustang II, N287BM

Broomfield, Colorado

November 2018

- VFR Part 91 flight
- Pilot, ~1,100 hrs
- Local flight Erie, Colorado (EIK)
- No known weather briefing
- 2-Fatal



***METAR KBJC 021750Z 27026G35KT 50SM FEW080
FEW200 17/M01 A2992=***



Figure 3. Google Earth overlay of the entire accident flight.

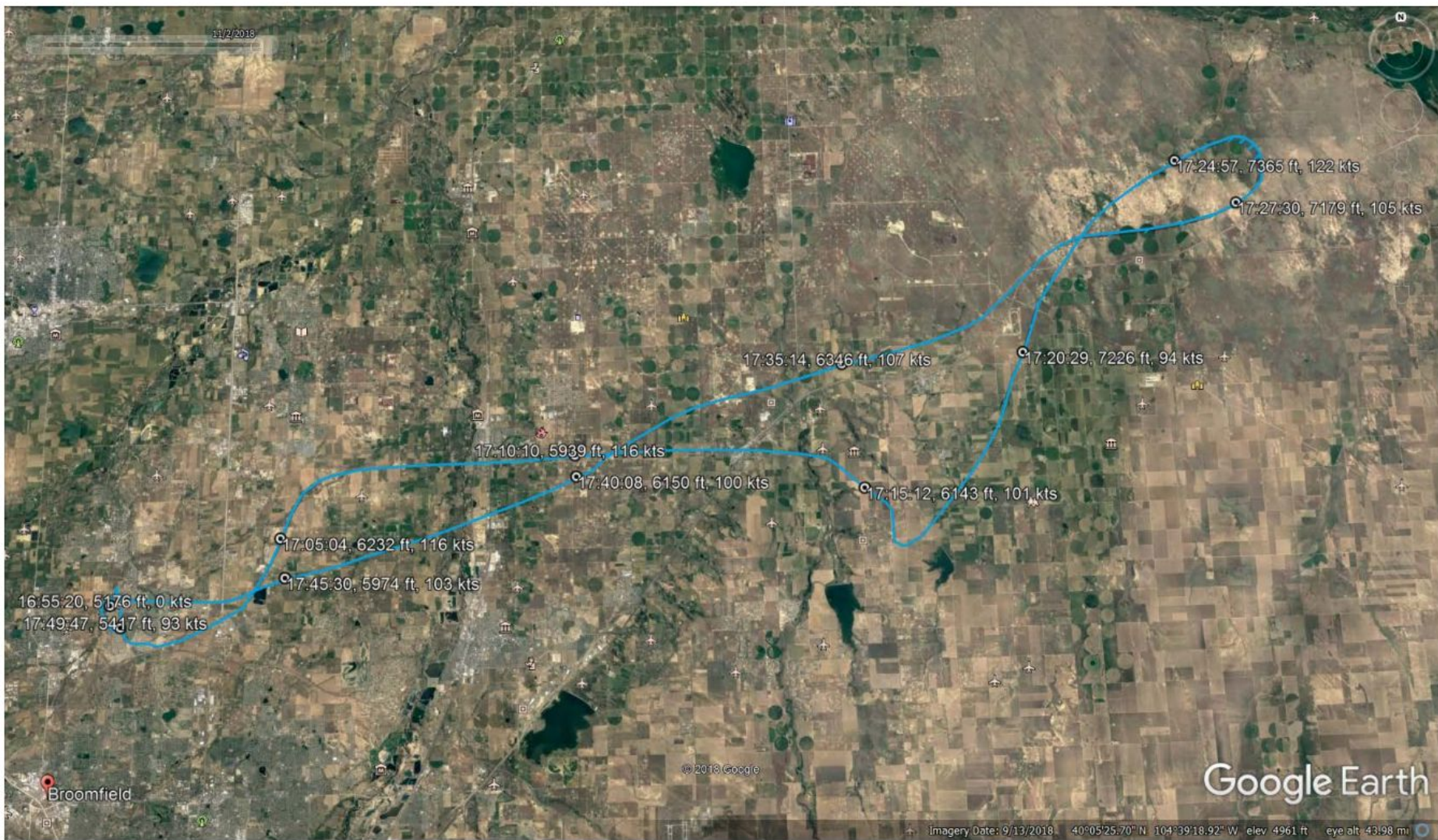
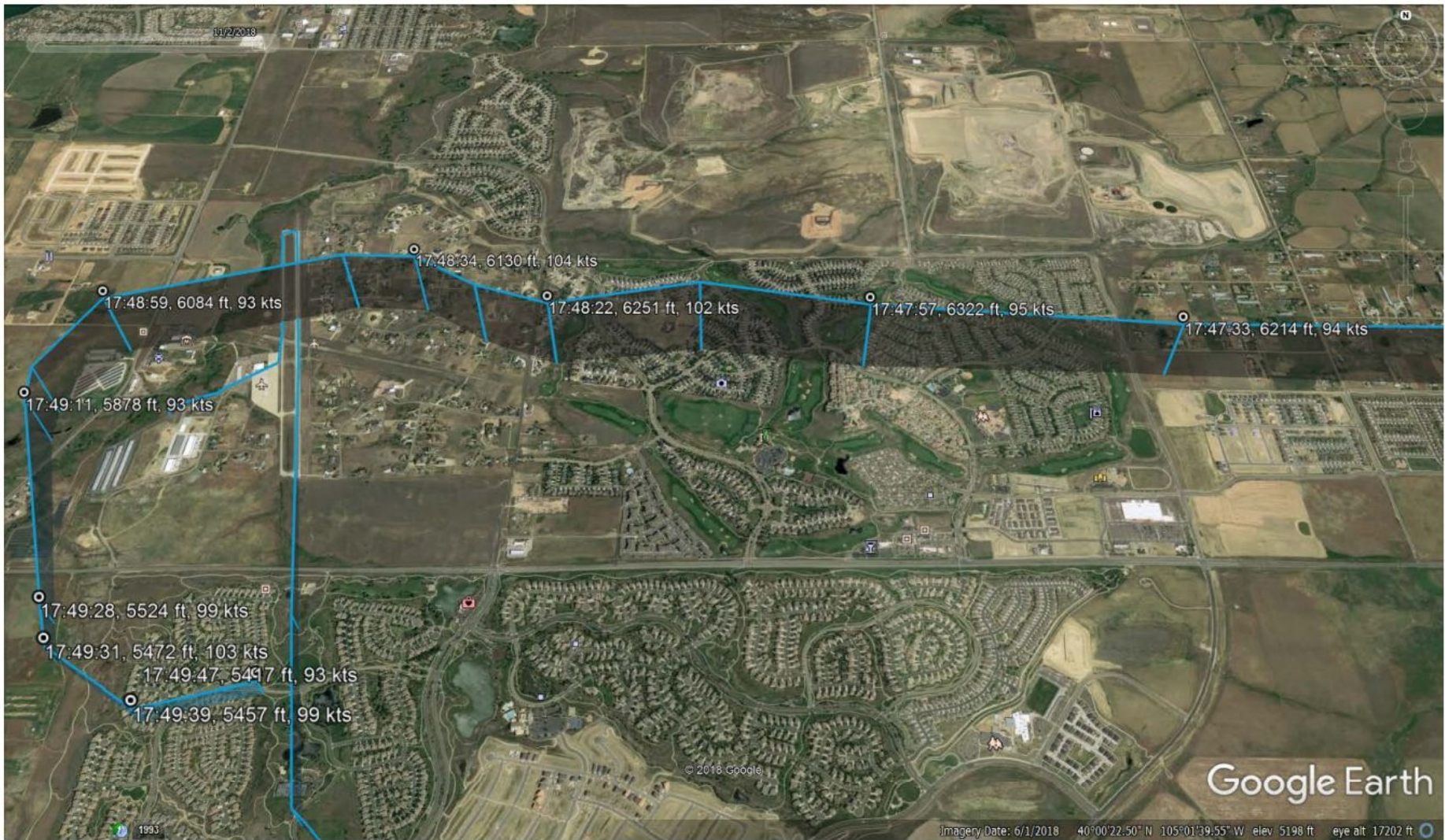
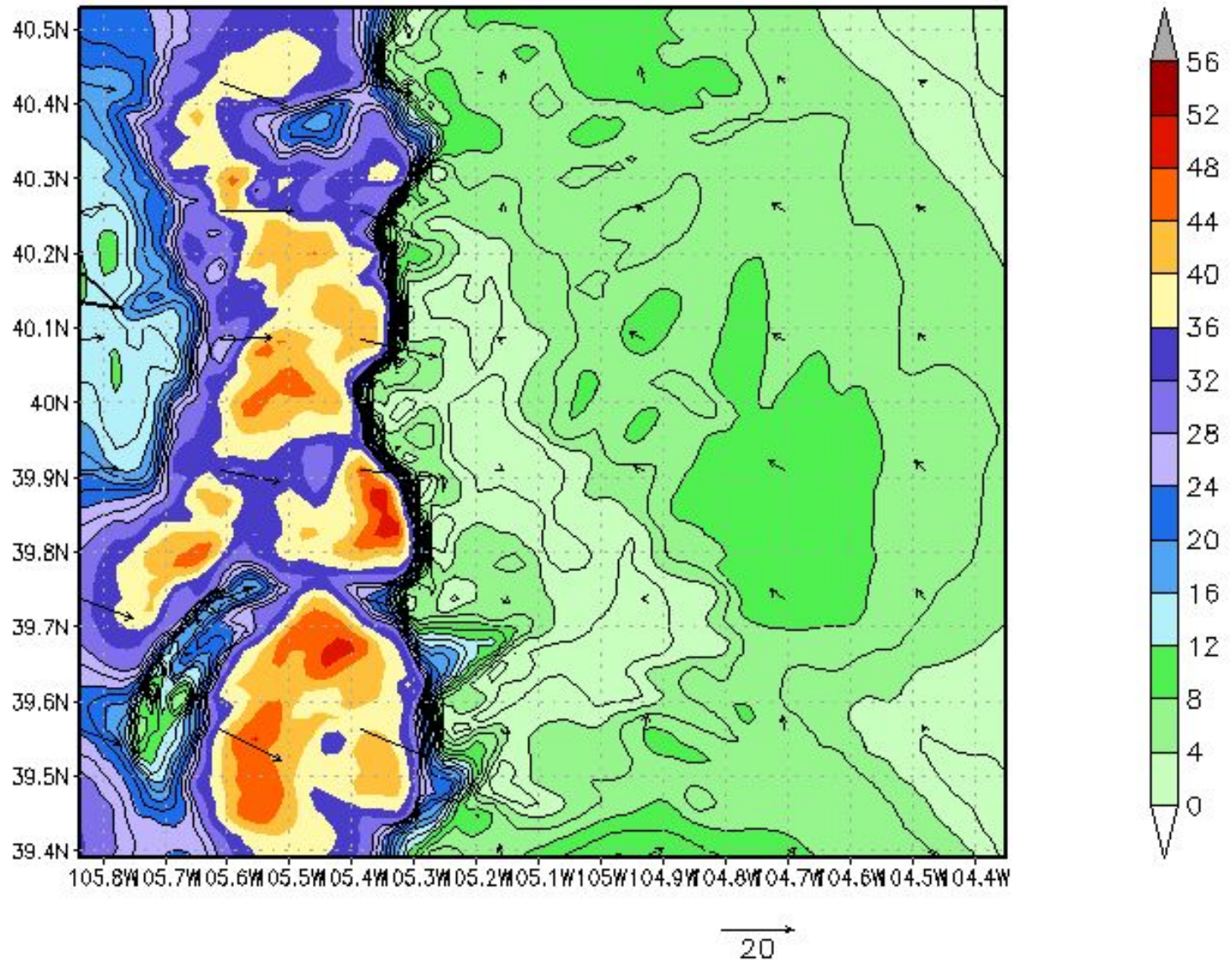


Figure 4. Google Earth overlay at the end of the accident flight.



840 mb Winds (KT)
Forecast Valid 08:30Z02NOV2018





The National Transportation Safety Board determines the probable cause(s) of this accident as follows:

The pilot's inability to maintain airplane control following an encounter with mountain wave turbulence

Preflight Planning

TABLE 1
Pilots' Usage of 15 Aviation Weather Products for Three Different Types of Flight

<i>VFR Local</i>			<i>VFR Cross-Country</i>			<i>IFR</i>		
<i>Product</i>	<i>Usually or Always</i>		<i>Product</i>	<i>Usually or Always</i>		<i>Product</i>	<i>Usually or Always</i>	
	<i>Self</i>	<i>All</i>		<i>Self</i>	<i>All</i>		<i>Self</i>	<i>All</i>
METAR	72%	78%	RADAR	87%	82%	RADAR	83%	85%
RADAR	72%	70%	TAF	81%	81%	TAF	83%	81%
TAF	70%	71%	METAR	72%	80%	METAR	77%	82%
Surf anl chart	45%	41%	Winds aloft	72%	77%	Winds aloft	70%	79%
Satellite	43%	45%	Surf anl chart	68%	61%	Surf anl chart	70%	69%
PIREP	43%	38%	Satellite	55%	60%	PIREP	66%	65%
Winds aloft	43%	45%	PIREP	53%	46%	Satellite	62%	67%
Area forecast	34%	36%	Area forecast	51%	58%	AIR/SIGMET	58%	64%
AIR/SIGMET	34%	43%	AIR/SIGMET	47%	57%	Area forecast	55%	62%
Conv. outlook	25%	20%	Winds aloft-Gr.	41%	41%	Sig. weather chart	51%	56%
Winds aloft-Gr.	22%	22%	Conv. outlook	38%	39%	Current icing	51%	57%
Sig. weather chart	21%	26%	Sig. weather chart	33%	44%	Winds aloft-Gr.	50%	50%
NCWF	17%	17%	Current icing	32%	25%	Conv. outlook	43%	51%
Current icing	11%	11%	NCWF	23%	30%	NCWF	38%	38%
Frz level graphic	6%	7%	Frz level graphic	21%	18%	Frz level graphic	30%	40%

Note. VFR = visual flight rules; IFR = instrument flight rules; PIREP = Pilot Weather Report; NCWF = National Convective Weather Forecast.

CEN17FA354

Cirrus SR-22, N462SR

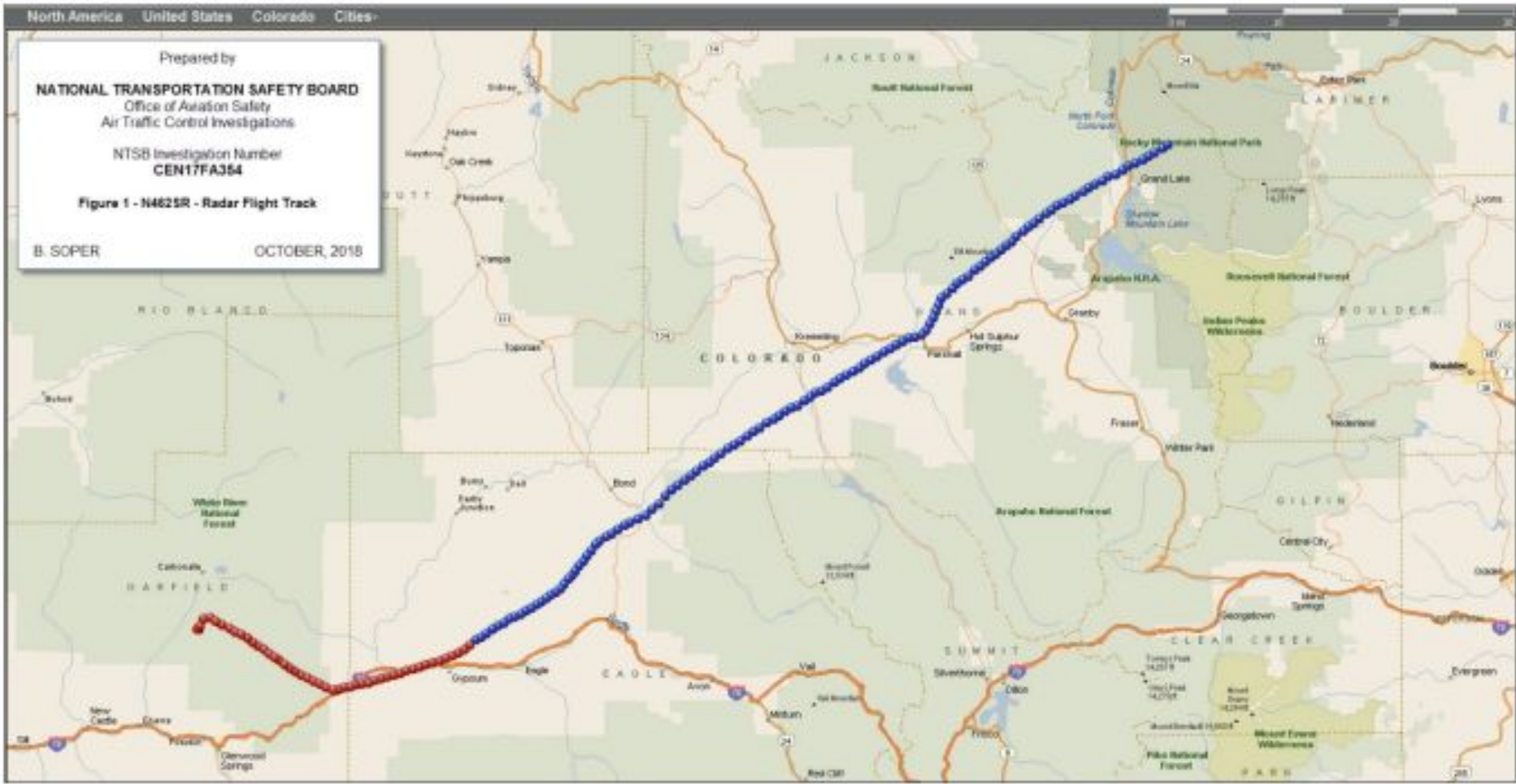
Glenwood Springs, Colorado

September 2017



- VFR flight following part 91 flight
- Pilot, ~300 hrs, 2.4 hours in simulated IMC
- Fort Collins, Colorado (FNL) to Moab, Utah (CNY)
- No record of weather briefing request
- 4-Fatal

***METAR KRIL 160153Z AUTO 30005KT 10SM BKN075 OVC095
12/08 A3004 RMK AO2 LTG DSNT S RAE48 TSE05 SLP139
P0002 T01220083=***



***METAR KJMM 100251Z AUTO 24012G24M1 100V 500 1 1/4SM
-RA OVC002 02/01 A3024 RMK AO2 LTG DSNT E=***

Pilot departed around 1920 and later than was planning

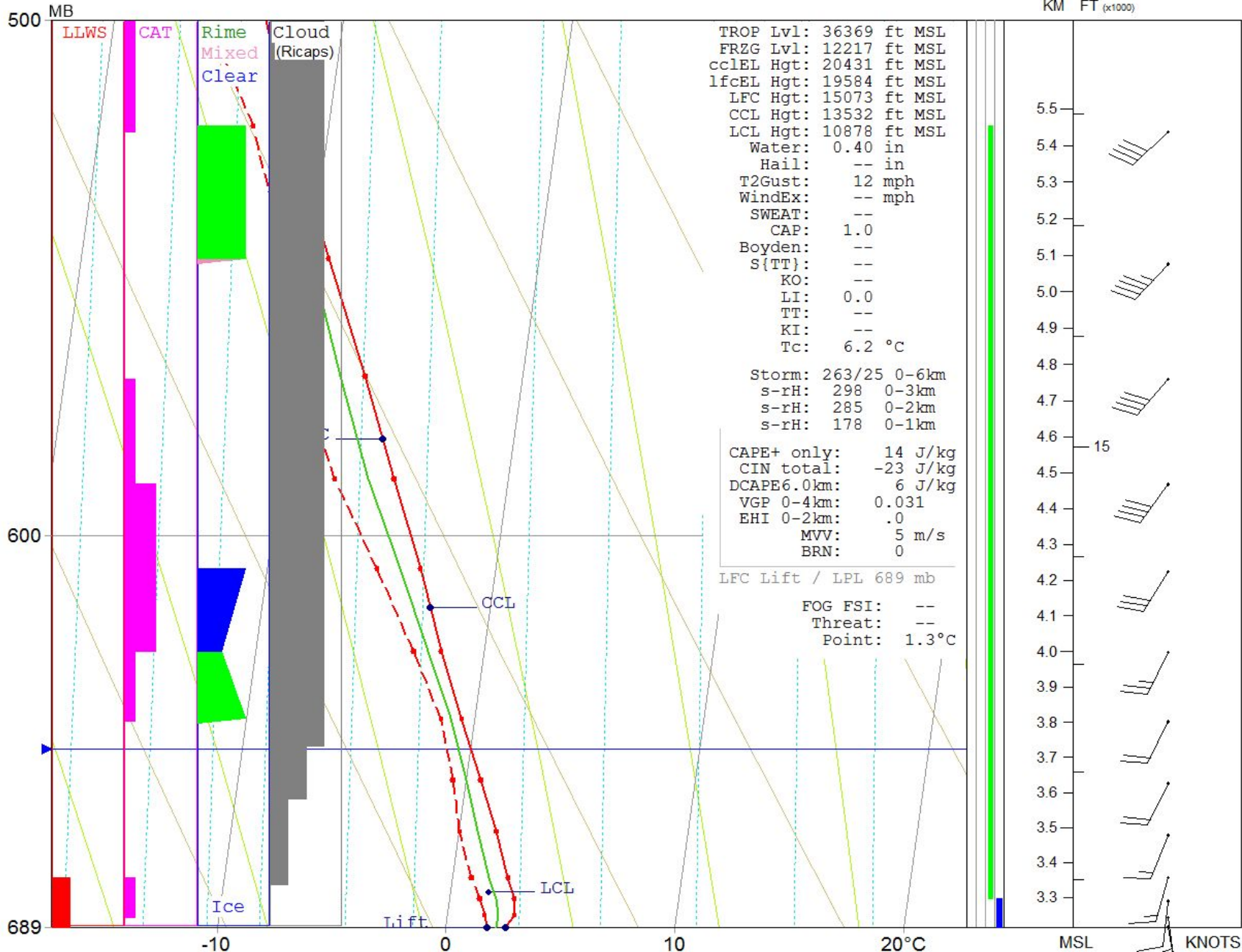
The pilot was receiving VFR flight-following services during the flight

At 1925, the pilot stated to the controller that he was going to climb the airplane to 15,000 ft msl to "get over the mountains and then back down."

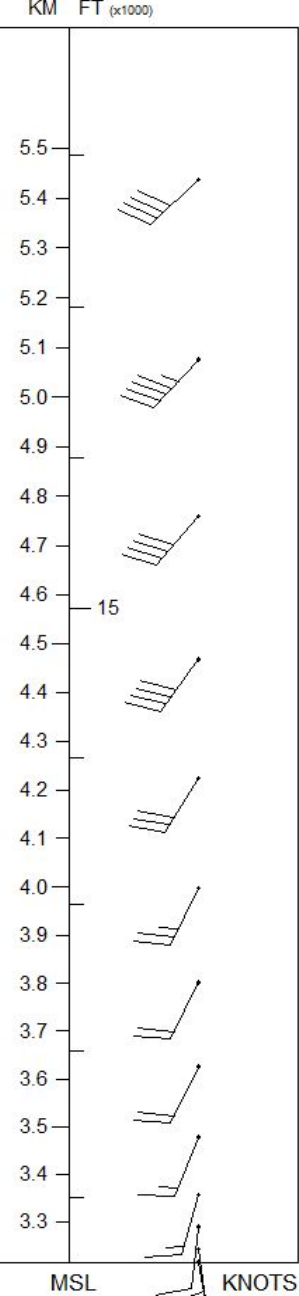
At 1928, the airplane turned to a southwesterly direct heading to CNY at an indicated altitude about 10,700 ft msl.

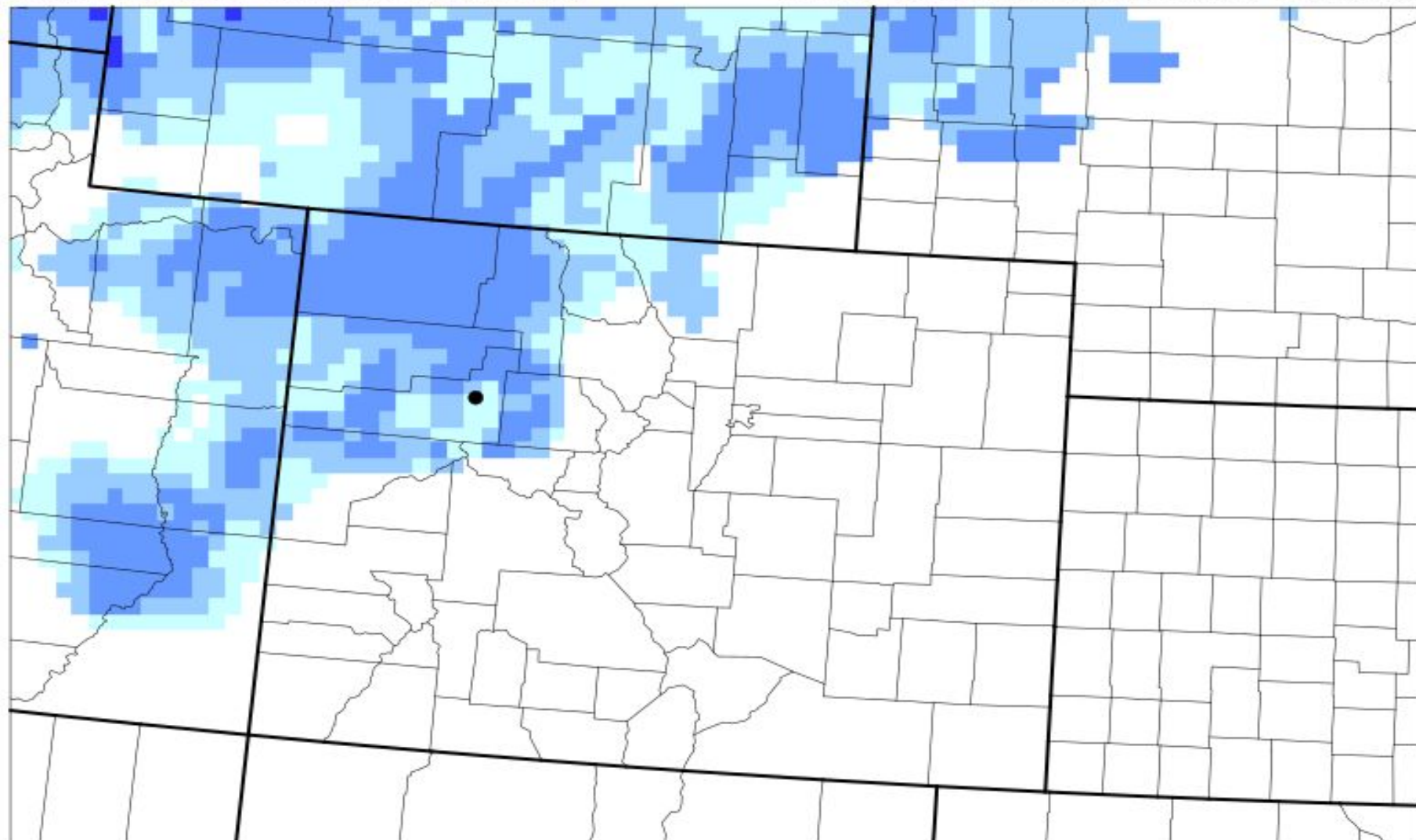
By 1932, the airplane had climbed to 13,200 ft and stopped climbing. From 1940 to 2000, radar data showed the airplane on a southwest heading with a series of altitude changes between 13,200 ft and 10,500 ft

At 2008, a passenger sent a text message to her mother, "Taking the long way around, lots of weather, keep you posted."



TROP Lvl:	36369 ft	MSL
FRZG Lvl:	12217 ft	MSL
cc1EL Hgt:	20431 ft	MSL
lfcEL Hgt:	19584 ft	MSL
LFC Hgt:	15073 ft	MSL
CCL Hgt:	13532 ft	MSL
LCL Hgt:	10878 ft	MSL
Water:	0.40	in
Hail:	--	in
T2Gust:	12	mph
WindEx:	--	mph
SWEAT:	--	
CAP:	1.0	
Boyden:	--	
S{TT}:	--	
KO:	--	
LI:	0.0	
TT:	--	
KI:	--	
Tc:	6.2	°C
Storm:	263/25	0-6km
s-rH:	298	0-3km
s-rH:	285	0-2km
s-rH:	178	0-1km
CAPE+ only:	14	J/kg
CIN total:	-23	J/kg
DCAPE6.0km:	6	J/kg
VGP 0-4km:	0.031	
EHI 0-2km:	.0	
MVV:	5	m/s
BRN:	0	
LFC Lift / LPL	689	mb
FOG FSI:	--	
Threat:	--	
Point:	1.3	°C





None

Trace

Light

Moderate

Heavy

Severity Category

Flt Cat: ● MVFR ● IFR ● LIFR | PIREP Turb: ▲ LGT ▲ MOD ▲ SEV | PIREP Ice: ☘ LGT ☘ MOD ☘ SEV

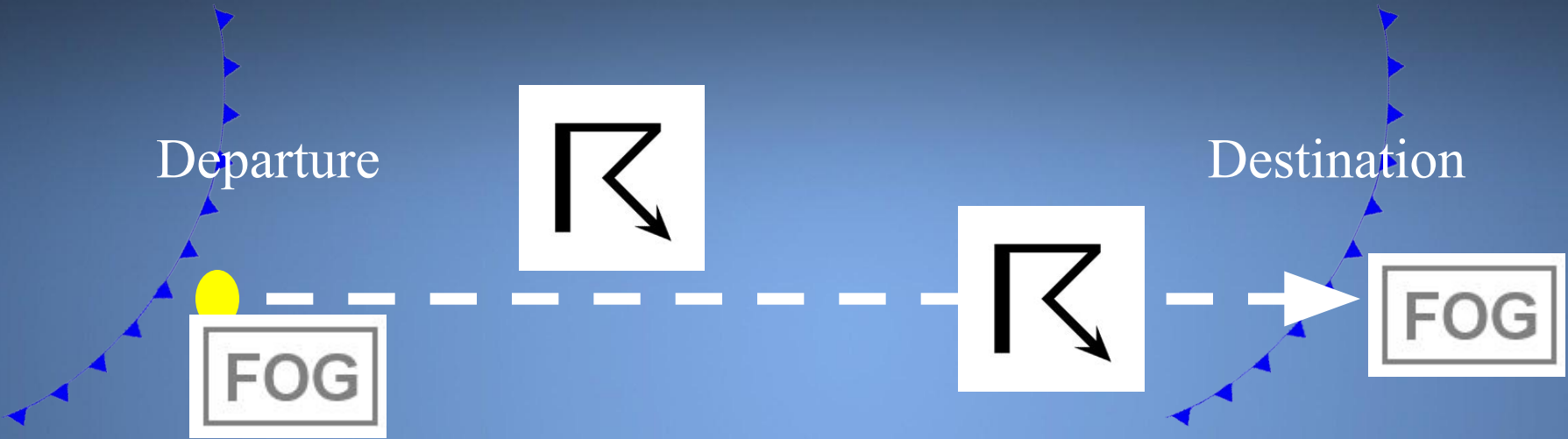
Disclaimer: International SIGMET locations approximated. Please refer to SIGMET text for full details



The National Transportation Safety Board determines the probable cause(s) of this accident as follows:

The non-instrument-rated pilot's inadequate preflight weather planning, his decision to depart into forecast instrument meteorological conditions along the route of flight, and his continued visual flight into instrument meteorological conditions, which resulted in spatial disorientation and a subsequent loss of airplane control.

Weather considerations surrounding accidents



- What about the en route conditions?
- When was the forecast issued?
- Any adverse weather predicted?
- What's in the surrounding area?

What about FAA AC 91-92:

7 GENERAL OPERATING PRACTICES.

7.1 Preflight Actions. As part of the preflight familiarization with all available information concerning a flight, each pilot should review all appropriate sources (including but not limited to Chart Supplements, the AIM, and NOTAMs), for pertinent information on current traffic patterns at the departure and arrival airports, airport environment, routing, departure and approach procedures, NOTAMs, weather, GNSS availability (if required), crew duties, standard cockpit procedures (e.g., transferring aircraft control), protected phrases, potential emergencies and their remedies, alternates and alternative mission options, fuel and timing, and Take Off and Landing Data (TOLD) speeds. Preflight

actions are a rehearsal of the whole flight with contingencies added. Pilots should use a checklist to ensure they do not miss any area of the operation (see Appendix [B](#) for a sample preflight checklist). For many GA pilots, the Flight Service Station (FSS) remains an important source of comprehensive weather and aeronautical information. However, most pilots have become more accustomed to performing a self-briefing than calling an FSS. The FAA considers that a self-briefing may be compliant with current Federal aviation regulations. By self-briefing, pilots can often improve their knowledge of weather and aeronautical information. Flight Service personnel are available should a pilot need assistance.

What about FAA AC 91-92?

8 SAFETY-RELATED DO'S AND DON'TS.

8.1 Do:

1. Establish personal minimums that reflect your level of proficiency.
2. Plan ahead and obtain an outlook briefing.
3. Obtain a standard briefing as close to your departure time as possible.
4. Obtain an abbreviated briefing just before takeoff if your standard briefing is 1 hour or more old or if the weather is questionable.
5. Allow more margin for weather at night. Clouds and the horizon may be difficult or impossible to see on dark nights. Always stay above the highest terrain until a safe landing is assured.
6. Check PIREPs, NOTAMs, AIRMETs, and SIGMETs.
7. Consider VFR flight following (ATC workload permitting).
8. Consider filing a VFR flight plan.

14

3/15/21

AC 91-92

9. Have a contingency plan for alternates if unexpected circumstances arise.
10. Be familiar with any applicable disclaimers related to the accuracy of the information provided by the subscribed commercial service.

8.2 Don't:

1. Plan flights that exceed your personal minimums or level of proficiency.
2. Plan flights in or near current or forecast convective activity.
3. Fly in or near thunderstorms. Scattered thunderstorms may be safely circumnavigated, but do not try to fly through or under one or closer than 20 nm) from one.
4. Continue VFR into IMC. Instead, wait it out or turn around if you find en route weather lowering below your personal limits.

CEN18FA101

Socata TBM 700, N700VX

Evanston, Wyoming

February 2018



- IFR Part 91 flight
- Pilot, ~ 4,150 hrs, 100 hours make and model
- Tulsa, Oklahoma (TUL) to Evanston, Wyoming (EVW)
- ForeFlight weather briefing request the evening before
- 2-Fatal

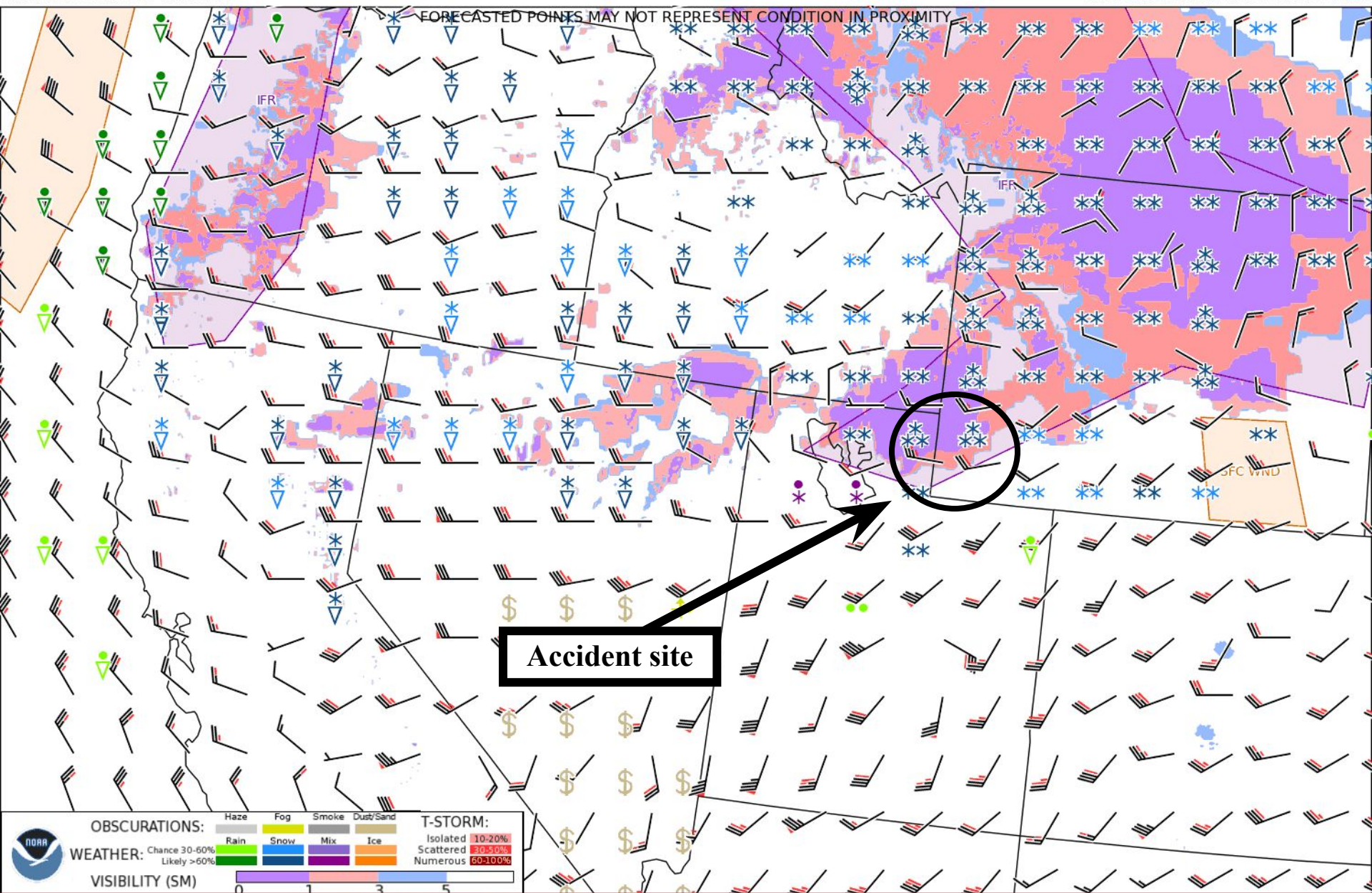
***METAR KEVW 182153Z AUTO 34013KT 1/4SM SN FZFG
VV008 M03/M03 A2947 RMK AO2 PK WND 26032/2101 SLP961
P0000 T10281033=***

Pilot requested and received ForeFlight weather briefing package around 2034 the evening before (departure ~1200)

The commercial pilot was conducting an instrument approach following a 3.5-hour cross-country instrument flight rules (IFR) flight. About 1.6 miles from the runway threshold, the airplane began a climb consistent with the published missed approach procedure

Rather than completing the slight left climbing turn toward the designated holding point, the airplane continued in an approximate 270° left turn, during which the airplane's altitude varied, before entering a descending right turn and impacting terrain

Experiencing avionics malfunction several months before the accident...used iPad as back up



AIRMETS, GFA, TAF, MIS calling for IFR to LIFR... in addition “Winter Storm Warning” for heavy snow issued before departure



The National Transportation Safety Board determines the probable cause(s) of this accident as follows:

The pilot's loss of control due to spatial disorientation.

What about New Mexico cases?



WPR19FA103, CEN18LA077, GAA18CA036, GAA15CA133,
CEN14FA369, CEN13FA183

Flying in Mountainous Terrain

- Continued updates on weather
- Give yourself plenty of safety margin near mountainous terrain and clouds
- If wind is blowing perpendicular to a mountain range always expect turbulence
- Consistent communication between ATC and Pilots
- When making safety conscious decision before takeoff, follow through with that decision even if weather looks “better”

Current NTSB Products

- Numerous safety recommendations and safety alerts
 - Pilot in-cockpit NEXRAD latency
[In-Cockpit NEXRAD Mosaic Imagery \(ntsb.gov\)](#)
 - Mastering Mountain Flying:
[Mastering Mountain Flying \(ntsb.gov\)](#)
 - Flight in Snow:
[NTSB Safety Alert 82 / Flight in Snow](#)
 - PIREPs:
[Pilot Weather Reports \(PIREPs\): Pay It Forward \(ntsb.gov\)](#)

Current NTSB Products

- Numerous safety recommendations and safety alerts
 - Provide controllers with automated PIREP data-collection tools
 - Require air carriers to disseminate all turbulence observations to the NAS as a condition of EWINS approval
 - Issue AIRMETs with higher granularity
 - Distribute AIRMETs, SIGMETs, CWAs, total lightning, and hail information to controllers as selectable layers radar displays, and train controllers on their use
 - Operationalize a turbulence nowcast such as GTGN
 - Incorporate ADS-B Wx

Importance of Clear Communication



Any Questions?

Email: paul.suffern@ntsb.gov



National Transportation Safety Board

Aviation Icing Resources

<https://aviationweather.gov/icing>

AVIATION WEATHER CENTER
NATIONAL WEATHER SERVICE

ADVISORIES FORECASTS OBSERVATIONS TOOLS NEWS SEARCH ABOUT USER

ADDS Icing

Current Icing Sigmets



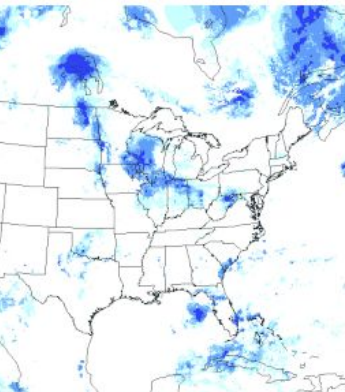
Click on image to access plots

Current Icing Aircraft Reports



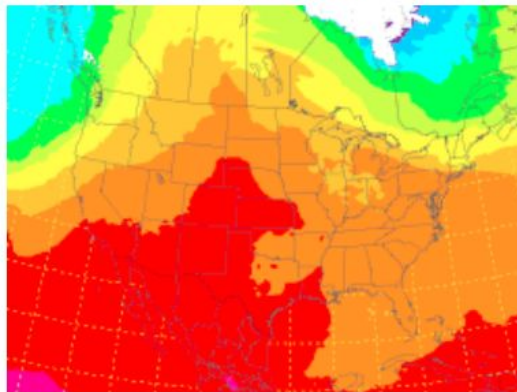
Click on region names to access plots

Forecast Icing



Click on image to access plots

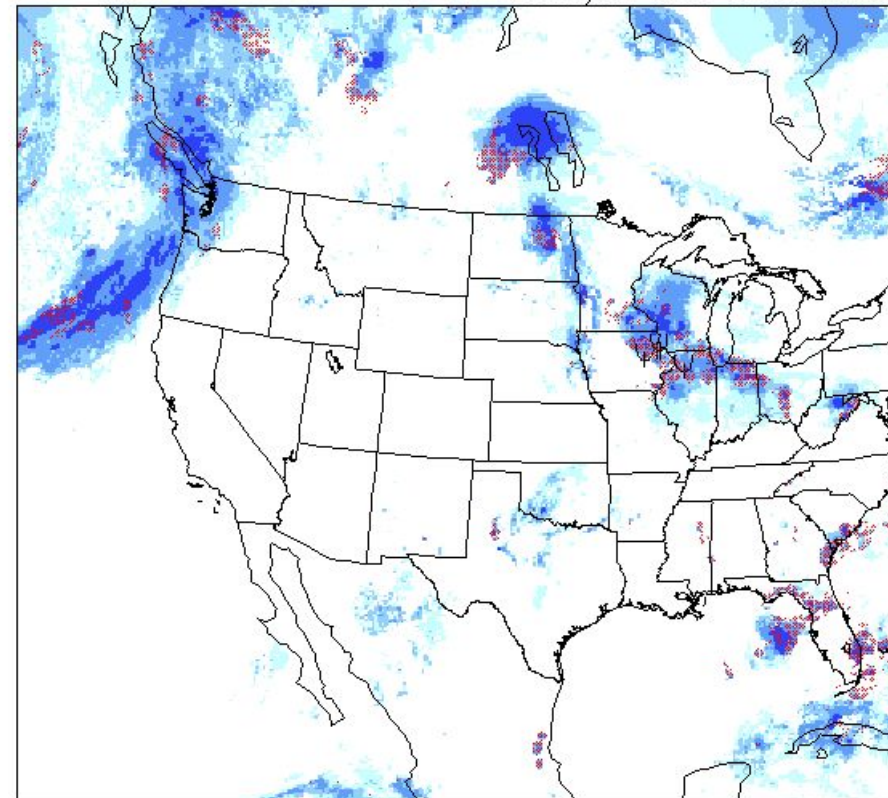
Freezing Level



Click on image to access plots

Maximum icing severity (1000 ft. MSL to FL300)

Analysis valid 1700 UTC Fri



SLD threat

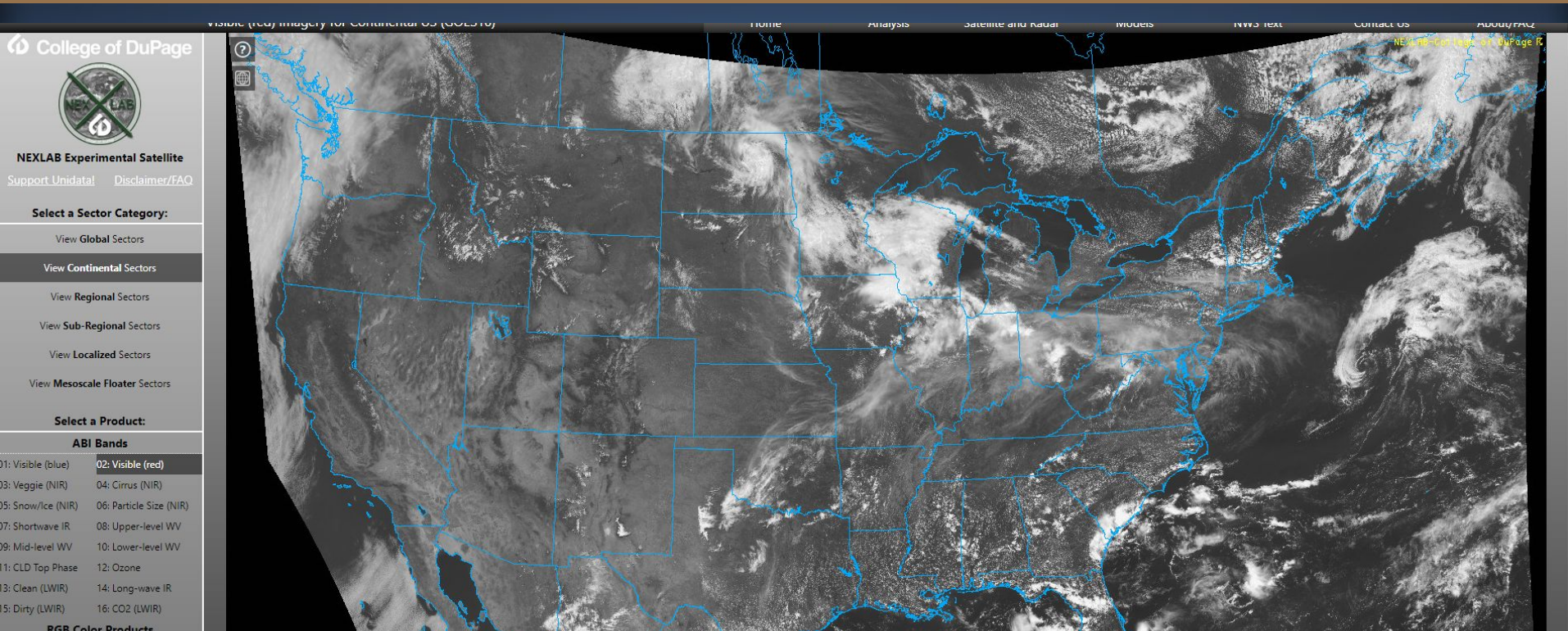
None Trace Light Moderate

⊖ Negative ⊘ Trace-Light ⊘ Light-Moderate ⊘ Moderate

⊘ Trace ⊘ Light ⊘ Moderate ⊘ Severe

Icing PIREP Symbols

<https://weather.cod.edu/satrad/#>



The screenshot shows the NEXLAB Experimental Satellite website. The main content is a satellite image of the United States with state boundaries outlined in blue. On the left side, there is a navigation menu with the following sections:

- College of DuPage
- NEXLAB Experimental Satellite
- Support Unidata! Disclaimer/FAQ
- Select a Sector Category:
 - View Global Sectors
 - View Continental Sectors
 - View Regional Sectors
 - View Sub-Regional Sectors
 - View Localized Sectors
 - View Mesoscale Floater Sectors
- Select a Product:
 - ABI Bands**
 - 01: Visible (blue)
 - 02: Visible (red)
 - 03: Veggie (NIR)
 - 04: Cirrus (NIR)
 - 05: Snow/Ice (NIR)
 - 06: Particle Size (NIR)
 - 07: Shortwave IR
 - 08: Upper-level WV
 - 09: Mid-level WV
 - 10: Lower-level WV
 - 11: CLD Top Phase
 - 12: Ozone
 - 13: Clean (LWIR)
 - 14: Long-wave IR
 - 15: Dirty (LWIR)
 - 16: CO2 (LWIR)
 - BGR Color Products

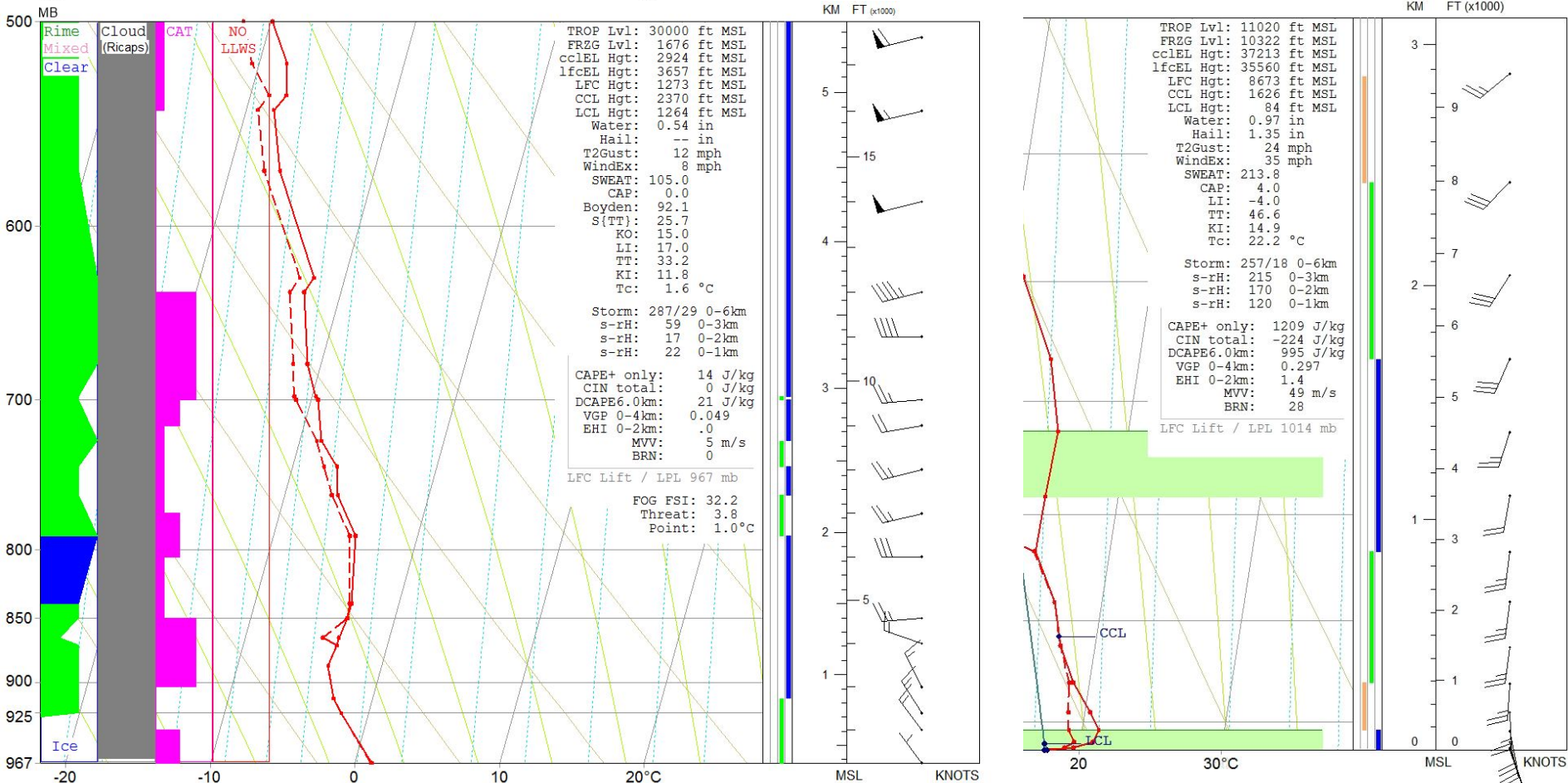
More satellite training available at:

<https://weather.msfc.nasa.gov/sport/training/>

Aviation Icing Resources

Upper air sounding

Moisture/clouds/icing/turbulence/ etc...



<http://weather.uwyo.edu/upperair/sounding.html>

University of Wyoming
College of Engineering
Department of Atmospheric Science

format

Region: North America | Type of plot: Text: List | Year: 2018 | Month: Jun | From: 08/12Z | To: 08/12Z | Station Number: 72672

Click on the image to request a sounding at that location or enter the station number above.

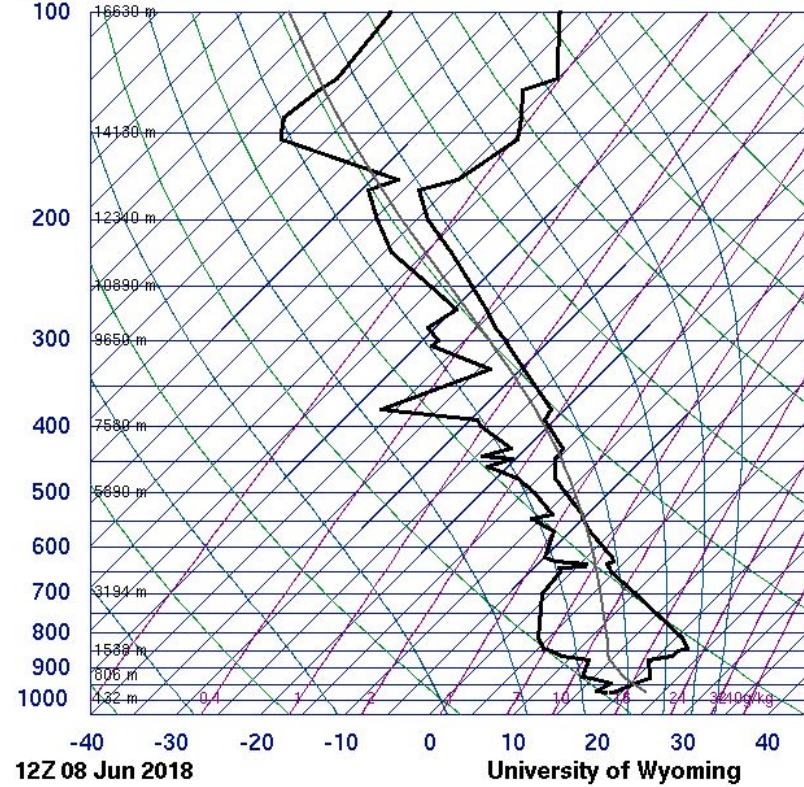


- Include frost point calculations.
- Recalculate Data

Interested in graduate studies in atmospheric science? Check out our program at the [Unive](#)

Questions about the weather data provided by this site can be addressed to [Larry Oolman \(lcoolman@uwyo.edu\)](mailto:Larry.Oolman@uwyo.edu)

72357 OUN Norman



SLAT	35.18
SLON	-97.44
SELV	345.0
SHOW	0.14
LFTV	-1.15
SWET	99.99
KINX	28.10
CTOT	17.10
VTOT	32.10
TOTL	49.20
CAPE	55.77
CAPV	70.81
CINS	-626.
CINV	-554.
EQLV	439.8
EGTV	437.4
LFCT	550.5
LFCV	564.3
BRCH	56.42
BRCV	71.63
LCLT	288.7
LCLP	892.8
MLTH	298.2
MLMR	12.68
THCK	5758.
PWAT	34.41

Description of the [sounding indices](#).

-

Interested in graduate studies in atmospheric science? Check out our program at the [University of Wyoming](#)

Questions about the weather data provided by this site can be addressed to [Larry Oolman \(lcoolman@uwyo.edu\)](mailto:Larry.Oolman@uwyo.edu)

Resources for upper air data understanding:

<http://www.theweatherprediction.com/rmo/parameters/>

http://www.atmos.millersville.edu/~lead/SkewT_HowTo.html