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WINTER AERIAL OPERATIONS 2021-2022

WYOMING WEATHER MODIFICATION

MEDICINE BOW & SIERRA MADRE MOUNTAINS

with extension in over Colorado's Never Summer Mountains

Final Operations Summary prepared for the Wyoming Water Development Office

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Airborne Cloud Seeding Operations
2021-2022 Winter Operations Report

For the

Sierra Madre and Medicine Bow Mountain Ranges, Wyoming
Never Summer Mountain Range, Colorado

Prepared By

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EXECUTIVE SUMMARY

This report summarizes the aerial cloud seeding activities conducted by Weather Modification LLC, dba Weather Modification International (WMI) during the 2021-2022 winter operational season from 1 November 2021 through 15 April 2022. The program, facilitated by the Wyoming Water Development Office (WWDO), utilized a WMI seeding aircraft to increase snowfall in the mountains in the Upper North Platte River and Colorado River Basins for additional runoff. This was the 4th season Weather Modification International has provided pilot and aircraft services to conduct aerial cloud seeding operations for the State of Wyoming and the Jackson County Water Conservancy District. During this time WMI has flown 552 hours over 119 missions for the program!

Primary funding for the project was provided by the Wyoming Water Development Commission (WWDC), with funds appropriated by the Wyoming Legislature, in the amount of $722,959.52. Additional funding was provided by the Board of Public Utilities (BOPU) of the City of Cheyenne, in the amount of $50,000. The Jackson County Water Conservancy District (JCWCD) provided an additional $83,906.12 for operations conducted for the Never Summer Mountains within the State of Colorado, primarily through a grant from the Colorado Water Conservation Board (CWCB).

The target area was defined by the client as the Medicine Bow and Sierra Madre Mountain Ranges (MBSM) located within the North Platte and Little Snake River Basins (western flanks of the Sierra Madre) in south-central Wyoming, and the Never Summer Mountain Range (NS) located in north-central Colorado. WMI's meteorological team provided operational guidance and was responsible for detailing seeding mission parameters, forecasting, and determining when flights were undertaken. More about these two target areas is provided in Section 1.0 of this report.

A WMI-modified Beechcraft King Air C90 seeding aircraft (US FAA registration N6111V, replaced by a King Air C90 with US registration N518TS on 31 March 2022) was equipped with two wing-mounted burn-in-place flare racks and three belly-mounted ejectable flare racks for glaciogenic seeding. The aircraft also featured a data-logging computer system that recorded telemetry seeding occurrences and provided the capability to receive in-flight weather and radar updates.

Experienced WMI flight crewmembers (pilot-in-command and first officer) operated the aircraft during seeding missions, handled the seeding agent, and performed seeding equipment maintenance as needed. The aircraft and crew were based in Cheyenne, Wyoming. This location was selected to expedite safe and speedy aircraft climbs to the seeding tracks, and because Cheyenne has an instrument approach and adequate hangar and maintenance facilities.

Flight operations were conducted according to basic guidelines established by WMI and the WWDO. The seeding method used on the 2021-2022 project was glaciogenic (or "cold cloud") seeding - treating clouds with nuclei composed of a silver-iodide (AgI) compound to induce freezing and accelerate precipitation formation. Seeding was conducted when weather conditions were determined to be suitable, employing standard winter storm broadcast

seeding track techniques. The WMI project personnel discussed relevant weather information daily to determine the best mission timing, altitudes, and seeding tracks based on winds and temperatures at flight altitudes.

The project aircraft arrived on site 29 October 2021. The first mission of the 2021-2022 season took place in the Never Summer range on 2 November 2022. The last seeding event of the 2021-2022 season occurred in the Medicine Bow range on 15 April 2022. The program ended the same day, on 15 April 2022. A grand total of 202.85 hours were flown, 511 burn-in-place flares were burned, and 6,530 ejectable flares were fired throughout the project season.

In the Medicine Bow and Sierra Madre ranges 39 flights were conducted for a total of 152.44 flight hours, consisting of thirty-five (35) seeding and four (4) reconnaissance missions. Of the 152.44 flight hours, 106.92 hours were conducted for the Medicine Bow range and 45.52 were conducted for the Sierra Madre range. A total of 168,730 grams of seeding agent were dispensed via 5,174 ejectable flares (20 grams each) and 435 burn-in-place flares (150 grams each).

When seeding opportunities were not present in Wyoming but existed over the Never Summer range of Colorado, seeding operations were conducted in Colorado on behalf of the Jackson County Water Conservancy District. Additional details regarding seeding priorities were provided in an MOU between the Wyoming Water Development Commission (WWDC) and the Jackson County Water Conservancy District (JCWCD).

In the Never Summer Mountain Range of Colorado, fifteen (15) flights were conducted for a total of 50.4 flight hours. Of these 15 flights, 12 were seeding missions, and 3 were reconnaissance missions. A total of 38,520 grams of seeding agent were dispensed via 1356 ejectable flares (20 grams each) and 76 burn-in-place flares (150 grams each).

The WMI team is proud to have been a part of the 2021-2022 Wyoming Weather Modification Program with extension over Colorado's Never Summer Mountains; we look forward to future seasons!

Figure 1. Captain Alex Sailsbury snaps a picture through the clouds while flying on Medicine Bow Track 4. 235 EJs were used on this mission over 4 hours and 51 minutes.

ACKNOWLEDGMENTS

The 2021-2022 project had multiple partners whom WMI here acknowledges. In addition, the project ran smoothly, effectively, and safely because of the diligence of many people, and we appreciate all of them.

Funding for all operations in the Medicine Bow and Sierra Madre target areas within Wyoming was largely made possible by the Legislature of the State of Wyoming, through the Wyoming Water Development Commission. The project budget for the Medicine Bow and Sierra Madre target area was enhanced by the City of Cheyenne Board of Public Utilities. Seeding flights that targeted the Never Summer Mountain Range in Colorado were made possible by the Jackson County Water Conservancy District, primarily through a grant from the Colorado Water Conservation Board.

Project guidance and direction on behalf of the State of Wyoming was provided by Program Manager Ms. Julie Gondzar, and Mr. Barry Lawrence of the Wyoming Water Development Office. The WMI seeding aircraft crew was comprised of captain Brian Kindrat, who was replaced by captain Alex Sailsbury in late January 2022, and copilot Ryan Starkey. Meteorological services, which included forecasting, weather monitoring (for seeding conditions), and direction of operations were provided primarily by Mr. Daniel Gilbert. Numerical weather prediction services and a meteorological web interface for the project was provided by Mr. Adam Brainard. Additional meteorological support was provided by Mr. Jason Goehring. Mr. Bruce Boe, Vice President of Meteorology, provided scientific program oversight.

From the Fargo corporate office, logistical and technical support for the airborne seeding equipment was provided by Mr. Dennis Afseth. Mr. Jake Van Ornum and Ms. Erin Fischer (Client Services) provided administrative and recordkeeping support, with the assistance of Ms. Ramona Adams and Ms. Cindy Dobbs. Aircraft maintenance and servicing were coordinated by Mr. Mike Clancy in cooperation with Mr. Jody Fischer, who managed the flight operations team.

Seeding agent, in the form of glaciogenic pyrotechnics, were provided by Ice Crystal Engineering LLC. We here acknowledge the excellent performance of these flares, and thank ICE Manager, Mr. Charlie Harper, and his entire manufacturing team.

The Jackson County Water Conservancy District board was very supportive and helpful throughout, especially Mr. Jim Baller and Mr. Ty Wattenberg. The support and assistance of the Colorado Water Conservation Board and the Colorado Department of Natural Resources, namely Mr. Andrew Rickert, were also greatly appreciated.

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1 BACKGROUND & TARGET AREA

Atmospheric water transformed to precipitation is one of the primary sources of fresh water in the world. However, a large amount of water present in clouds never is converted into precipitation that makes it to the ground. This has prompted scientists and engineers to develop the means to augment water supplies through cloud seeding. The Wyoming Weather Modification Program, with extension over Colorado's Never Summer Mountains, is designed to augment snowfall over select portions of the North Platte River Basin and the Little Snake River Basin (western flanks of the Sierra Madres). By increasing the snowpack and resultant spring runoff, subsequent water supplies downstream are increased. In addition to easing the necessity for other more costly means of non-hydroelectric generation, cloud seeding increases the water availability for municipal, recreational, and environmental interests.

The program conducted aerial cloud seeding operations, as described herein. A modified Beechcraft King Air C90 aircraft owned and operated by WMI released silver iodide-based ice nuclei using pyrotechnics. These artificial ice nuclei cause additional snow to form and precipitate in the target area.

The target area included portions of South-Central Wyoming and North-Central Colorado, as defined:

- Medicine Bow and Sierra Madre (MBSM) – Portions of the Medicine Bow and Sierra Madre Mountain Ranges located in Carbon and Albany County Wyoming. The ranges run mostly north to south. The Continental Divide extends along the high points of the Sierra Madre Mountains, with runoff from the western slopes draining into the Colorado River Basin and the eastern slopes draining to the North Platte River Basin. Runoff from the Medicine Bow Mountains drains into the North Platte Basin.
- Never Summer range (NS) – Located in north-central Colorado, the Never Summer Mountain Range lies within the Upper North Platte River Basin and includes Jackson, Grand, and Larimer Counties. Only portions within Jackson County were targeted in the 2021-2022 program.

Standard winter broadcast-seeding techniques were employed. Seeding of winter storms was conducted whenever WMI meteorologists determined conditions were suitable. The meteorology team issued daily forecasts and updated the project pilots on a frequent basis. The wind direction determined which "set" of seeding tracks would be used, temperature and cloud depth determined the seeding altitude, and the wind speeds at that altitude determined the distance flown upwind from the target. WMI, in cooperation with the WWDO and the CWCB, established the tracks prior to the field program. Generally, the WMI meteorologists attempted to provide the flight crew a 2-hour advance notice prior to the desired commencement of seeding operations.

Table 1 lists the exact location of each track's endpoints and wind speed limits for their use. The WMI crew can modify the seeding tracks in response to actual storm conditions encountered during flight to optimize targeting. This past season flight tracks were shortened and/or extended on multiple missions due to actual weather conditions. This illustrates the versatility of the aircraft and crew in ensuring effective targeting.

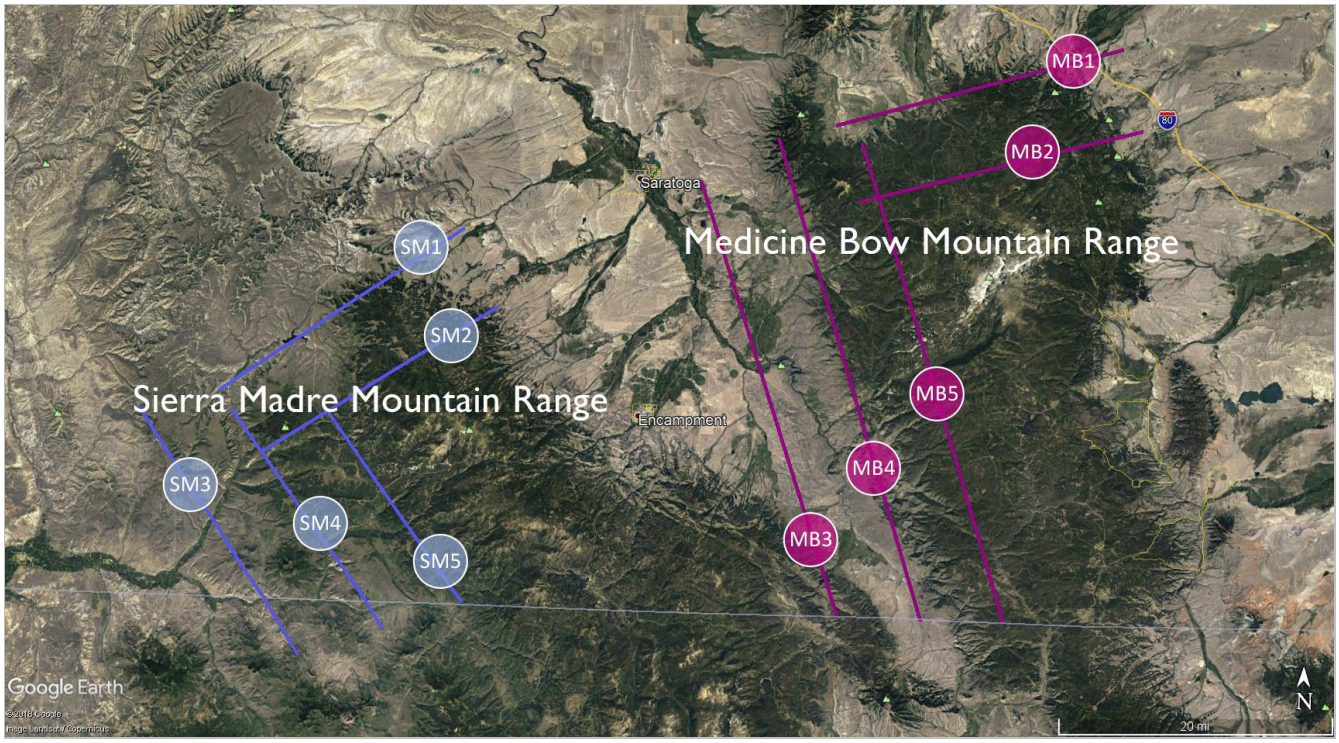


Figure 2. Medicine Bow and Sierra Madre Target Areas located in the State of Wyoming. The predetermined flight tracks are visible in lavender (Sierra Madre Mountain Range) and magenta (Medicine Bow Mountain Range).

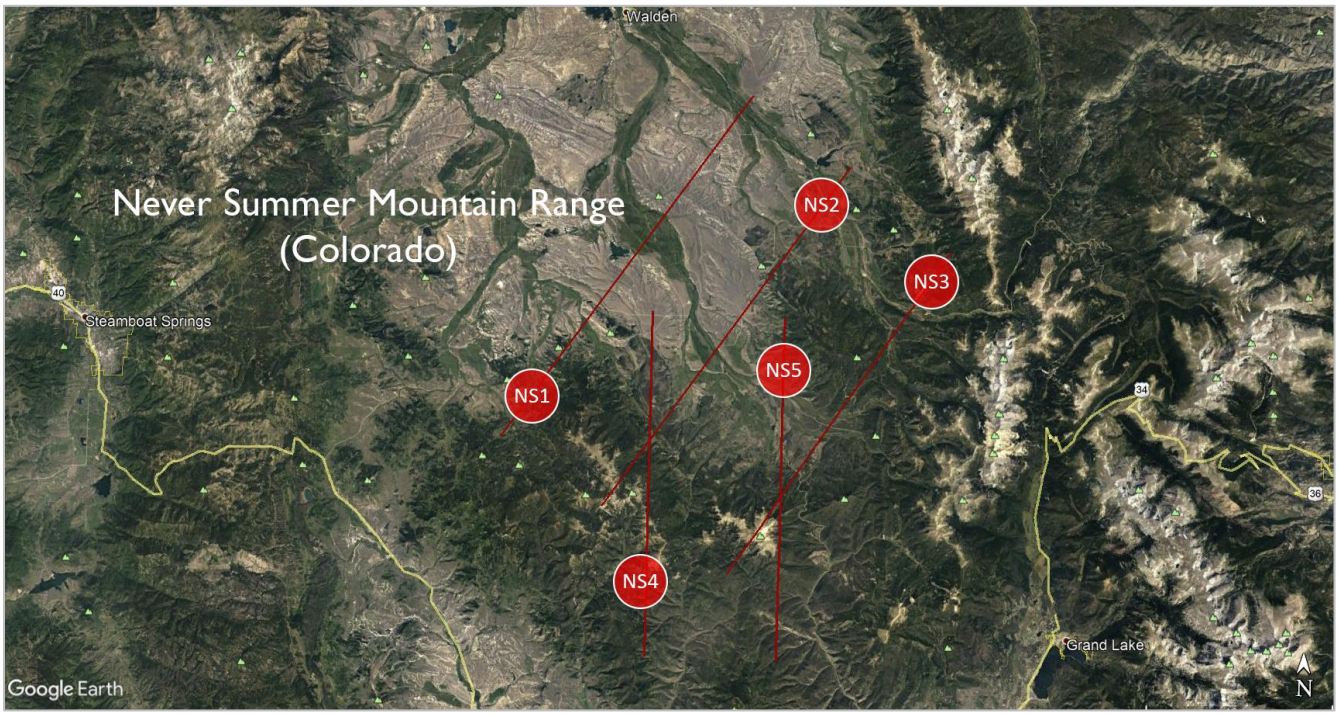


Figure 3. Never Summer Target Area located in the State of Colorado. The predetermined flight tracks are visible in red.

Table 1. The locations of each track's endpoints and wind speed limits are given.

MEDICINE BOW			
TRACK	WAYPOINT	VOR/RADIAL/DME	WIND SPEED LOWEST ALT
MB1	MB1E	LAR/296/025	30 - 55 KTS 14,000 ft
	MB1W	LAR/272/038	
MB2	MB2E	LAR/288/021	< 30 KTS 14,000 ft
	MB2W	LAR/265/036	
MB3	MB3N	LAR/265/046	55+ KTS 14,000 ft
	MB3S	LAR/226/041	
MB4	MB4N	LAR/270/041	30 - 55 KTS 14,000 ft
	MB4S	LAR/222/037	
MB5	MB5N	LAR/271/036	< 30 KTS 14,000 ft
	MB5S	LAR/217/033	

SIERRA MADRE			
TRACK	WAYPOINT	VOR/RADIAL/DME	WIND SPEED LOWEST ALT
SM1	SM1E	CKW/116/032	30 - 55 KTS 13,000 ft
	SM1W	CKW/150/033	
SM2	SM2E	CKW/120/037	< 30 KTS 13,000 ft
	SM2W	CKW/147/038	
SM3	SM3N	CKW/159/033	55+ KTS 13,000 ft
	SM3S	CKW/147/053	
SM4	SM4N	CKW/149/035	30 - 55 KTS 13,000 ft
	SM4S	CKW/142/052	
SM5	SM5N	CKW/139/037	< 30 KTS 13,000 ft
	SM5S	CKW/136/051	

NEVER SUMMER			
TRACK	WAYPOINT	VOR/RADIAL/DME	WIND SPEED LOWEST ALT
NS1	NS1N	RLG/004/042	30 - 55 KTS 15,000 ft
	NS1S	RLG/350/024	
NS2	NS2N	RLG/012/041	< 30 KTS 15,000 ft
	NS2S	RLG/004/022	
NS3	NS3N	RLG/020/040	55+ KTS 15,000 ft
	NS3S	RLG/020/022	
NS4	NS4N	RLG/002/031	30 - 55 KTS 15,000 ft
	NS4S	RLG/019/016	
NS5	NS5N	RLG/012/033	< 30 KTS 15,000 ft
	NS5S	RLG/034/020	

WMI utilizes National Weather Service NEXRAD radar data, GOES-R satellite data, and in-house high-resolution numerical weather prediction to identify suitable times for seeding. The modeling tools predict periods when and where seedable clouds are likely (based on winds, temperatures, and liquid water content). When models forecast seedable cloud conditions, project pilots and meteorologists work in tandem, continuously monitoring radar, satellite, and cloud conditions. When real-time observations indicate the likely presence of suitable targets, a flight is launched. Upon reaching seeding tracks, pilots check temperatures, winds, and supercooled water content. If conditions are indeed suitable, seeding commences and continues until conditions deteriorate or the aircraft runs low on fuel or flares. If suitable conditions are not encountered during a flight, no seeding will occur, and the aircraft returns to base having conducted "reconnaissance". After a seeding or reconnaissance flight ends, flight crews and meteorologists immediately prepare for another flight if additional flights may be warranted and crew rest permits.

General cloud seeding criteria established for the Wyoming/Colorado project were:

<u>Requirements to initiate a flight:</u>

- WMI models indicate supercooled liquid water (SLW), wind speed and direction, and temperature profiles suitable for targeting clouds in the -5° to -15°C range.
- The range selected is based on which will likely have the greatest SLW. Because the aircraft can be flown lower, down to 13,000 feet, on the Sierra Madre, that range may be chosen in certain temperature profiles or cloud depths.
- Seeding altitude varies between 13,000 to 16,000 feet, depending on temperature profile, cloud depth, and observed supercooled liquid water (icing rate).
- In daytime hours webcams and visible satellite imagery provide information on cloud depth and coverage.
- At night, infrared and water-vapor satellite imagery provide sufficient cloud coverage information.
- The ground conditions at the Cheyenne Airport (KCYS) must be safe for departure and be forecasted to be suitable for return at end of flight. This is mostly taken from the TAFs (Terminal Area Forecasts) and occasionally PIREPS (Pilot Reports), AIRMETS (Airman's Meteorological Information), and SIGMETS (Significant Meteorological Information).
- Radar echoes over the Medicine Bow range (the only range covered by radar, and only partially) are not required. We have observed that cloud SLW is often marginal when echoes are present over the Medicine Bow range.

<u>Procedures en route to seeding track:</u>

- The aircraft will climb above the expected altitude of the icing layer (over the targeted range) while in transit. This avoids beginning seeding with ice already on the airframe. Altitude decisions are influenced by Numerical Weather Prediction cross-sections of SLW and temperature.
- The pilot will note 0°C, -5°C, and -10°C levels and report to meteorologist, along with overall cloud conditions and winds/icing conditions.
- The pilot will communicate with the meteorologist to confirm/adjust seeding track and altitude based on observed conditions.

Required to begin seeding once on track:

- When the seeding track is approached, the aircraft will carefully descend into the target layer from above, to be sure not to accumulate rapid airframe icing. If severe icing is encountered, the aircraft may immediately climb out of it and contact the meteorologist. Depending on temperature and observed cloud conditions, it may be determined that seeding should occur immediately above the cloud layer with ejectable flares.
- SLW must be present in the -5°C to -15°C layer at an altitude targetable by ejectable flares, burn-in-place flares, or both. It is preferred that the seeding be conducted below the -10°C level whenever possible, but ejectables may be dropped from as cold as -15°C once the existence of SLW is confirmed below. The presence of SLW below should be confirmed before beginning seeding. It should be checked at least hourly.
- The targetable SLW must be present (at seedable temperatures) at reasonable horizontal distance from the target area to allow for fallout of precipitation in the target (20-30 min upwind).

2 PROJECT PERSONNEL

WMI provided an experienced flight crew for the winter cloud seeding season, which consisted of one pilot in-command (PIC) and one copilot (first officer). WMI employs copilots on seeding flights to enhance flight safety and targeting, as cockpit workload and recordkeeping responsibilities can be shared.

The Cheyenne team consisted of Captain Brian Kindrat (replaced in late January 2022 by Captain Alex Sailsbury), and first officer Ryan Starkey. This was Kindrat's sixth and final winter season with WMI. Previously, Kindrat had flown multiple winter seasons on WMI's Idaho project, and many summer seasons in Alberta. This was Sailsbury's fourth winter season with WMI. His previous winter experience includes projects in California, Idaho, and North Dakota. This was Starkey's first winter season with WMI, with previous experience on WMI's summertime North Dakota project as an intern and captain.

Aircrew training was conducted in Fargo, ND prior to the start of the season by Jody Fischer, Vice President of Operations. Fischer is a Weather Modification Association (WMA) Certified Operator. This was Fischer's nineteenth winter season; he has several hundred hours of flight experience in Wyoming mountainous terrain. Training was also conducted by Kirk Hamilton, Chief Pilot. Hamilton had six wintertime seasons' experience, including extensive flying on previous seasons in Wyoming.

Figure 4. The 2021-2022 flight crew from left to right - Ryan Starkey and Alex Sailsbury stand in front of N6111V) in the Legend AeroServe hangar in Cheyenne, WY. Photo submitted by Captain Alex Sailsbury.

Figure 5. Ryan Starkey on the tug, pulling the aircraft out of the hangar for a night mission over all three mountain ranges served by the project. Photo by Captain Alex Sailsbury.

Daniel Gilbert, Chief Meteorologist; Jason Goehring, Field Meteorologist; and Adam Brainard, Meteorological Systems Lead, formed WMI's meteorology team. This was Gilbert's eighteenth and final year of winter seeding operations and forecasting. This was Goehring's seventeenth year of Wyoming seeding operations and forecasting, in addition to his working six summers of airborne seeding operations in Alberta, Canada. Gilbert and Goehring have worked together for twelve consecutive seasons on Wyoming programs dating back to the Wyoming Weather Modification Pilot Project. Brainard has been involved with the Wyoming seeding programs since the 2016-2017 season, providing forecasting, operations, and numerical weather prediction support. Brainard has also completed nine years of summer seeding operations in North Dakota, Alberta, and Saudi Arabia. Bruce Boe, WMI Vice President of Meteorology, provided overall management of the meteorology team during its day-to-day operations. Gilbert, Goehring, and Brainard are all Weather Modification Association Certified Operators.

Additional project coordination and administrative support was provided by WMI headquarters in Fargo, ND.

Figure 6. The WMI Forecasting team from left to right – Dan Gilbert (Chief Meteorologist), Jason Goehring (Field Meteorologist), and Adam Brainard (Meteorological Systems Lead). Goehring is based in Long Lake, SD, and Gilbert in Fort Dodge, IA. Brainard resided in Pinedale, WY during the winter season to forecast and assist with the Wyoming Wind River ground operations program. Photos by Gilbert, Goehring, and Brainard.

2.1 Pre-Project Ground School

A pre-project ground school was held remotely via GoToMeeting with the flight crew, meteorology team, client, and key WMI staff on 25 October 2021. All WMI project employees attended. The meeting topics included forecasting, modeling, media protocol, overview of the project, reporting pre- and post-flight, aerial cloud seeding operations, and safety. WMI administrators – Bruce Boe, Vice President of Meteorology; Jody Fischer, Vice President of Operations; and Erin Fischer, Director of Client Services, and Jake Van Ornum, Client Services Assistant, also attended the kickoff meeting. The meeting allowed both groups to share information which improved communication, program efficiency, and contributed to the overall success of the program.

3 EQUIPMENT

3.1 Beechcraft King Air C90

WMI Beechcraft King Air C90, U.S. FAA registration N6111V, arrived on site 29 October 2021 It was ferried by Captain Kirk Hamilton. N6111V was dedicated for full-time use on the program and its crew provided 24 hours-a-day, 7-days-a-week support for cloud seeding activities. The aircraft and crews were based at the Cheyenne Regional Airport. Hangar, deicing, maintenance, and fueling services were obtained from Legend AeroServe at the Cheyenne airport. N6111V was replaced on 31 March 2022, by WMI's Beechcraft King Air C90 N518TS.

Figure 7. WMI Beechcraft King Air C90, N6111V rests on the ramp at the Cheyenne Regional Airport. Photo by Kirk Hamilton.

The Beechcraft King Air platform is a high-performance twin-engine turboprop aircraft that has proven itself with numerous operators in a wide variety of weather research and cloud seeding operations. Standard equipment includes full dual VFR/IFR instrumentation, an FAA instrument-approach certified GPS navigation system, on board digital weather radar, pressurized cabin, and emergency oxygen.

The high performance of the turbine-powered King Air provides the power needed to climb safely above the dangerous icing zone (-10°C to -15°C) when required, even after accumulation of significant ice on the airframe. The endurance of this aircraft allowed coverage of the entire project area from the Cheyenne base of operation with a maximum time-on-station of approximately 5hours in ideal conditions.

All WMI aircraft are equipped and certified for instrument flight (IFR), day and night. This equipment includes VHF communication and navigation radios, GPS navigation, onboard weather radar system, and an emergency locator beacon system. In addition to pressurization, an oxygen system is installed in the event of a loss in cabin pressure.

There were multiple crew seats available in the aircraft; however, WMI aircraft are operated in U.S. Federal Aviation Administration "Restricted" category when in seeding configuration and so only project personnel are allowed on board per FAA regulations.

A total of 12,099 gallons of Jet -A fuel was consumed on the project (9,478 gallons for the MBSM and 2,620 gallons for the NS target area), an average of 59.65 gallons per aircraft flight hour. All project fuel was purchased by WMI at the aircraft base location. Fuel costs went up significantly during the project, from $4.17 to $5.96 per/gallon with an average of $4.94 per/gallon. This was $1.70 per/gallon higher than during the 2020-2021 winter season.

Two aircraft issues were encountered during the season:

- 20 November 2021- An altimeter in N6111V failed enroute to the seeding tracks. Due to the mountainous terrain and weather in the seeding area, the crew decided it was unsafe to continue the mission with the instrument failed. The flight was subsequently cancelled, and the crew safely returned to the airport. N6111V was ferried back to Fargo on 22 November, and the altimeter was replaced. The aircraft returned to Cheyenne and was operational the next day.
- 31 March 2022- N6111V became due for routine maintenance inspections due to the high number of hours flown and was replaced by C90 N518TS. No operations were missed.

The WMI flight crew was directed by ATC to change altitude on several missions this season. One incident worth noting was on 29 March 2022, when ATC directed the crew to climb from 19,000ft to 20,000ft due to another aircraft passing under the seeding track. The passing aircraft reported significant amounts of snow and ice crystals in the seeding area, and a rapid increase in Supercooled Liquid Water as the aircraft passed out of the seeding area. This observation is consistent with expectations that the introduction of glaciogenic seeding agent into supercooled liquid water would result in a localized increase in snow and ice particles.

3.1.1 Flight in Known Icing Conditions

The C90 is FAA-certified and equipped for flight into "known icing" conditions with pneumatic deicing boots on the wings, horizontal and vertical stabilizers, exhaust-heated engine inlets, electrically-heated propeller blades, pitot/static ports, heated windshields, and lights to illuminate the leading edges of the wings for inspection during flight. WMI pilots are trained prior to any project on weather recognition, proper seeding procedures, flight operations in icing conditions, crew coordination, flight safety, and judgment. Our policy of two-pilot crews helps

ensure that proper attention can be paid to sometimes rapidly-changing flight and seeding conditions as they occur. WMI has an exemplary safety record and takes extremely seriously the safety of the general public, WWDO employees, and its company personnel.

Known-icing certification should in no way be interpreted to mean that the aircraft's manufacturer expected it to fly for extended periods within icing conditions. Such certification means that the U.S. FAA has certified that the aircraft is equipped with the necessary deicing equipment and has the required power to safely transit (climb or descent through) layers of icing. This capability will always be kept in mind during operations, ensuring the flight crew can deal safely with winter storm conditions.

In the Wyoming area, there are no lower terrain areas nearby to which the aircraft can escape severe icing encounters and melt off airframe icing, and usually the only option is to return for an instrument approach to the Cheyenne airport. However, with the use of ejectable flares, such descents are even less frequent (Tessendorf *et al.*, 2015).

Occasionally seeding flights are forced to divert during winter missions due to excessive airframe icing. During the 2021-2022 season, only one flight was impacted this severely by icing. On 4 January 2022, the crew in N6111V were forced to return to Cheyenne while enroute to the Sierra Madre's due to the rapid buildup of airframe icing. The crew made their decision in the interest of safety, and returned to the Cheyenne airport without further incident

Figure 8. Images of airframe icing from 2021-2022 winter season. Left Ryan Starkey holds a piece of ice off the propeller spinner while posing next to the remains of ice buildup on the leading edge of the wing. Right – Ice buildup on the nose and propeller spinner. Both images were taken after a 5-hour mission over the Medicine Bow range on 22 March 2022. Photos by Captain Alex Sailsbury.

3.1.2 Weather Availability In-Flight

As an enhancement to safety, all WMI seeding aircraft are also equipped with a GPS-based terrain mapping and warning system, which displays surrounding terrain features and aviation navigation graphics. The system also provides real-time colored (yellow and red) terrain warnings based upon its database and GPS aircraft position during missions. This system enabled thorough and accurate positional and terrain awareness during instrument and night flights, and allowed decisive action whenever heavy icing conditions dictated flight diversions.

WMI flight crews were also equipped with ADS-B real-time weather and traffic information on a company-issued iPad. Real-time weather and radar data are overlaid on a moving map of the target area. The ability to visualize weather conditions upstream allowed the pilots to make effective real-time seeding decisions and optimize use of their fuel and flares.

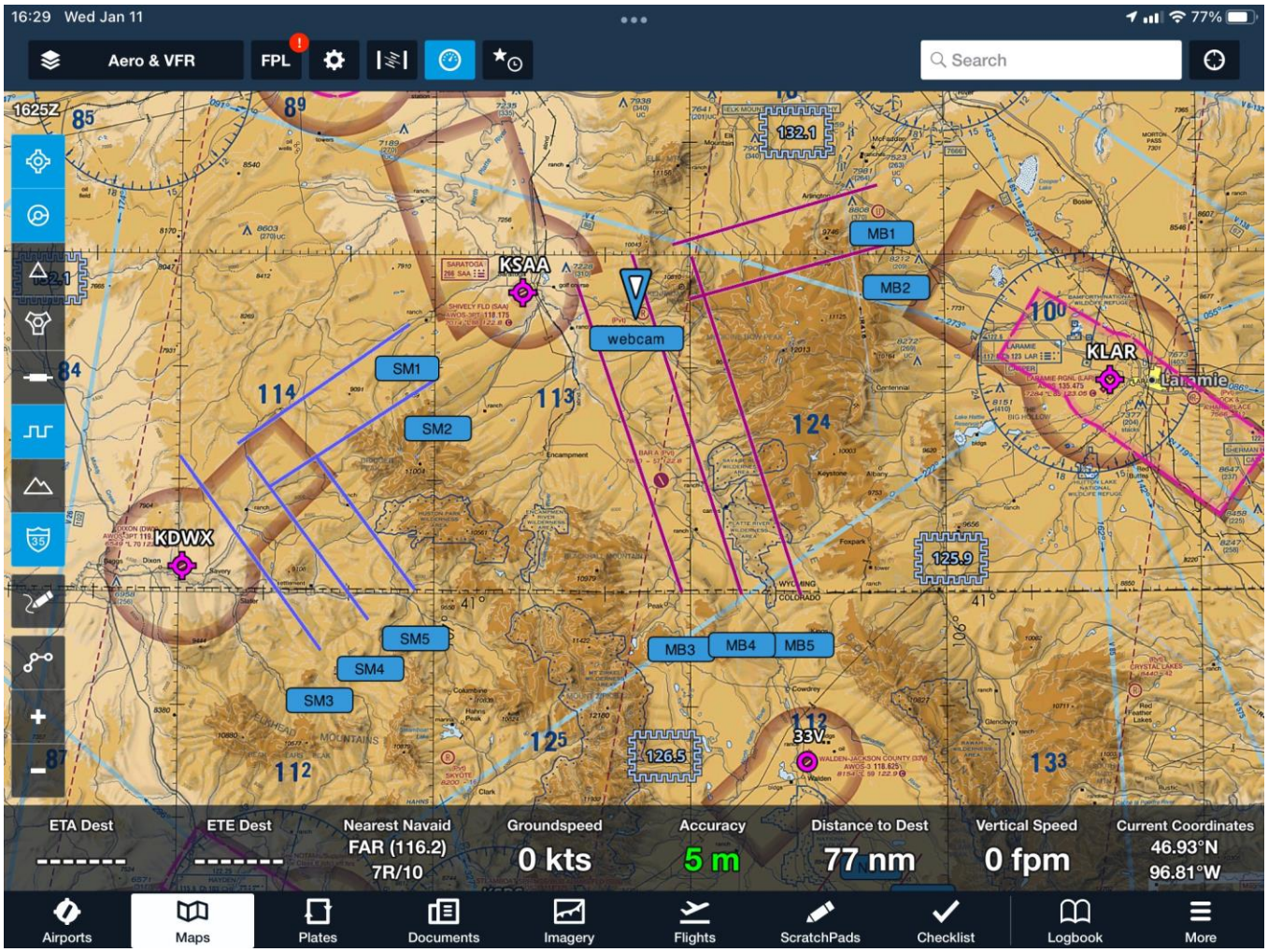


Figure 9. Image from a WMI iPad showing ADS-B weather information visible to the cloud seeding pilot while conducting operations. The Medicine Bow and Sierra Madre target areas in Wyoming overlay is shown on the ForeFlight application. The target area at the time of this photo was void of weather.

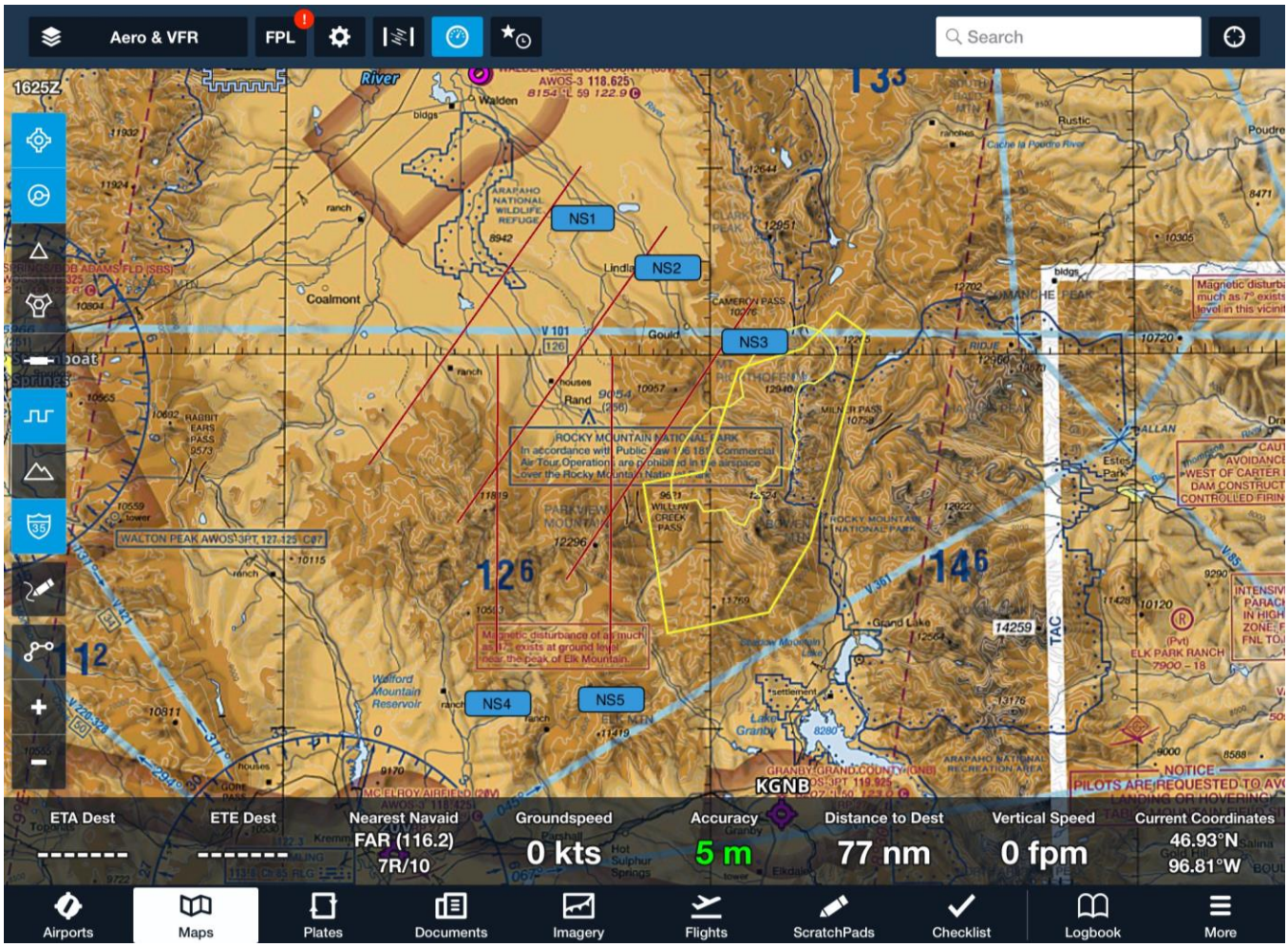


Figure 10. Like Figure 9, the overlay for the Never Summer Mountain Range target area (red tracks) in Colorado is shown on the ForeFlight application. The target area at the time of this photo was void of weather.

3.2 In-Flight Communications

In-flight communications took place using cellular phones and messaging services such as WhatsApp. Communication between the flight crew and meteorologists consisted of text messages and photo images of relevant weather conditions. This link allowed the flight crew to communicate with the meteorology team to make the best decisions about seeding locations and rates. This link also gave the flight crew an invaluable resource to use at times when the weather and surface conditions at the Cheyenne airport required close monitoring during missions. This empowered the flight crew to make safe decisions regarding how much fuel was required to make the flight to a safe airport, and how long the crew was able to spend on track, seeding.

3.3 Seeding Equipment and Agents

The project aircraft was modified with two wing-mounted burn-in-place flare racks and three ejectable flare racks. Seeding equipment was fabricated and installed by WMI in accordance with U.S. Federal Aviation Administration approvals (U.S. FAA Form 337), and seeding data were ingested along with GPS position information into a WMI "Datalogger" computer.

3.3.1 Burn-in-place (ICE-BIP®) Flares

Burn-in-Place flares were burned whenever especially large amounts of supercooled liquid water (SLW) or bands of embedded cumuliform clouds were encountered during seeding operations. In wintertime operations, seeding is usually performed using tracks upwind of the target areas, as was done on this program. This is called *broadcast seeding*, with the idea being that the seeding crystals produced by the flares will mix with the available cloud mass and activate when they encounter SLW, thus resulting in snow downwind in the target area.

Each burn-in-place flare rack was mounted to the wing such that the flares themselves are positioned aft of the trailing edge. Each rack held 24 flares, for a full capacity of 48. The flares can be burned in any quantity throughout the flight, one at a time or in multiples. These glaciogenic flares yield 150 grams of seeding material and burn for about 4+ minutes each. The flare formulation has been tested for nucleus yield at Colorado State University.

Figure 11. N6111V carried two dual burn-in-place flare racks. The flares shown are 150g ICE-EB® Ice Crystal Engineering LLC glaciogenic flares. A total of 511 ICE-EB™ flares were expended during the 2021-2022 season. Photo by Kirk Hamilton.

3.3.2 Ejectable (ICE-EJ®) Flares

Ejectable flares are ignited and burn as they fall away from the aircraft about 2500 ft (in the absence of up- or down-drafts). These flares are used when there is sufficiently thick cloud mass in the seeding zone and enable storms to be effectively treated while the aircraft remains above the peak aircraft icing altitude, thus increasing on-station time. The seeding aircraft was equipped with three belly-mounted ejectable flare racks. Each rack holds 102 flares, for a full capacity of 306 ejectable flares. The rack is designed with removable baskets which hold the 20 mm diameter flare cartridges. This allows quick reloading of flares between missions.

The seeding equipment controls are mounted in the cockpit for pilot or copilot operation. WMI owns and manufactures the seeding equipment. All equipment construction is aircraft-quality, and systems are easily accessed for routine maintenance. Equipment installation was completed and flight-tested at WMI's maintenance facility in Fargo, North Dakota, prior to project start. The pilots regularly checked all the equipment to ensure functionality. All WMI aircraft modifications and equipment installations are U.S. FAA-approved.

Figure 12. Ejectable flare belly racks installed on the project aircraft. Each ejectable flare yields 20g. The project aircraft was equipped as pictured with 306 ejectable flares. A total of 6,530 ICE-EJ® were expended during the 2021-2022 season. Photo by Kirk Hamilton.

All glaciogenic seeding materials used were manufactured by Ice Crystal Engineering LLC (ICE) of Kindred, North Dakota. ICE pyrotechnic output, as a function of cloud temperature, has been established at the Colorado State University (CSU) Cloud Simulation and Aerosol Laboratory (SimLab), in Fort Collins, Colorado (DeMott 1999). ICE pyrotechnics have established an excellent record in the field and are well known for their extremely low failure rate. All ICE products are ISO9001:2015 certified. This ensures that strict manufacturing standards and processes are followed, including suppliers, customer service, and quality control. For more information on ICE Crystal Engineering please visit: www.iceflares.com.

A total of 435 burn-in-place and 5174 ejectable flares were expended during this winter season for the Medicine Bow and Sierra Madre Mountain Ranges in Wyoming. In the Upper North Platte River Basin of Colorado, 76 burn-in-place and 1356 ejectable flares were expended for the Never Summer range.

Figure 13. The empty ejectable casings after a successful season. The casings are taken to a local metal recycling facility at the conclusion of the project. Photo by Captain Alex Sailsbury.

3.3.3 Flight Data and Recording

The aircraft carried a WMI Datalogger system, which recorded and displayed selected flight data. The core of the system is a purpose-built computer that records all parameters during each flight. The Datalogger ingested GPS position, altitude, groundspeed, and cloud water inertial probe (CWIP, see Sec. 3.3.4) data. Each seeding event (firing of a burn-in-place flare or ejectable flare) was also recorded. The flight file was then archived and replayed on a ground-based computer using WMI's *AirLink II* software to create a complete flight track of the mission, as shown later in this report. Such plots also contain a basic map of the target area and terrain, see Section 6.0.

The WMI flight crew also kept paper records of the flight notes and regular seeding agent inventories. The flight forms were recorded and transmitted to the client, as requested.

3.3.4 Cloud Water Inertial Probe (CWIP)

The WMI King Air C90 featured a Cloud Water Inertial Probe (CWIP). The CWIP measured and recorded GPS altitude, wind speed and direction, temperature, humidity, airspeed, angle of attack, updraft speed, and liquid water content. Data from the instrument was displayed on an iPad for cockpit access during operations. Data were reviewed post-mission by WMI's Instrument technicians and archived for the WWDO.

Figure 14. Cloud Water Inertial Probe (CWIP) installed under the aircraft wing. Photo by WMI.

Figure 15. A screenshot of the CWIP iPad. This screen shows the primary CWIP display used by the crew in flight to monitor seeding conditions. Its display includes horizontal wind, seed score, temperature, liquid water content (LWC), relative humidity (RH), and vertical speed (VS). Seed score is a mathematically calculation based on several of these measurements. Although interesting to see, it should be noted that it is only as good as the measurement it is taking and should be interpreted with caution. For example, if the aircraft is seeding above the cloud layer using ejectable flares, the seed score is inaccurate as the instrument is in clear air and is not sampling what is being seeded below the aircraft (ejectables fall downward) and downwind. Screenshot by Captain Alex Sailsbury.

4 METEOROLOGICAL SERVICES

WMI meteorologists provided support for the airborne operations. Weather systems deemed to have seeding potential were monitored on a 24-hours-per-day, 7 days-per-week basis (24/7). The meteorologists provided the project pilots with forecasts and relevant weather information throughout the season. They routinely discussed with the flight crew the weather situation as it evolved. These discussions included anticipated cloud conditions, temperatures, upper-level winds, and the timing of upcoming opportunities.

Dan Gilbert (WMI Chief Meteorologist), Adam Brainard (WMI Meteorological Systems Lead) and Jason Goehring (WMI Field Meteorologist) alternated duties, preparing the project forecasts and, along with the flight crews, monitoring opportunities for operations.

The standard reference time chosen for the project field operations was "universal time coordinates" (UTC). This time, also called Greenwich Mean Time (GMT) or Coordinated Universal Time (CUT), is the accepted international standard of time for general aviation and meteorological observations, reporting, and communication. The shorthand notation for UTC is the letter Z, so 1800 UTC can also be written 1800Z or 18Z.

4.1 Suspension of Cloud Seeding Operations

Cloud seeding operations may be suspended as part of the standard operating procedures of the program. There are circumstances where additional precipitation could pose a potential threat to life or property. The public may perceive (rightly or wrongly) that seeding activities pose or increase such a threat. For these reasons, seeding suspension criteria have been established and are strictly adhered to by the operators in accordance with industry standards. Suspension criteria were monitored by WMI's meteorology team in close partnership with the WWDO and JCWCD.

4.1.1 2021-2022 Suspension Criteria

Snowfall histories are used to determine the Historic Range of Natural Variability (HRNV) for a given SNOTEL facility. These historic snow-water equivalents are then combined and a 'median' is established for a period of time, usually 30 years. This 'median' is then used to set the HRNV by the day or month of any recorded year.

Thresholds at which cloud seeding will be suspended for this operation are identified below. These criteria were implemented to govern all seeding decisions.

Cloud seeding will be suspended if any of the criteria listed below are met:

1. Seeding shall be suspended in any target area if and when range-wide snow water equivalents (SWE) indicated by designated NRCS SNOTEL sites exceed a percentage of the long-term median defined by a linear upper limit of 85% of the thirty-year (1981-2010) median April 1 SWE for the site on November 15 (normal program start), and increasing to 140% of the median April 1 SWE as of April 1[1].
2. Insufficient reservoir storage for flood control, based upon hydrologic estimates of total snowpack using all available data.
3. Potential for significant rain events above 8,500 feet MSL. The area of risk would not be targeted until the risk had passed. This is very rare at the latitude of the target area (rain in winter is uncommon.)
4. Severe winter weather events, as forecast by the National Weather Service office having responsibility for the target. For Never Summer operations, this is the Boulder Weather Service Office. The area forecast to be affected would not be targeted until the risk had passed.
5. Extreme avalanche risk in a specific target area, as indicated by the Colorado Avalanche Information Center (CAIC). The area of risk would not be targeted until the risk had passed.
6. If a significant wildfire occurs within the watersheds of the target area, the Forest Service shall be consulted prior to the next cloud seeding season to determine if there is need for suspension(s) that account(s) for the newly burned areas.
7. Care will be taken to avoid targeting major highways to avoid impact on transportation corridors. In the case of the Never Summer range, there are no major highways in immediate proximity to the target area.
8. Seeding may be suspended at any time in the Never Summer target area, upon direction from the Colorado Water Conservation Board or the Jackson County Water Conservancy District.
9. Seeding may be suspended at any time in the Medicine Bow and/or Sierra Madre target area, upon direction from the Wyoming Water Development Office.

To facilitate the monitoring of SWE at SNOTELs in and near the project target areas, graphics were generated daily from the on-line SNOTEL data, and made available to project personnel and sponsors. The web link allowed SWE conditions to be assessed with a simple click of a mouse. An example of this graphic is shown below in Fig. 16.

[1]During the Wyoming Weather Modification Pilot Project, a research program, the upper limit was conservatively set at 120% of the 1971-2000 mean SWE. However, when the 1981-2010 thirty-year period of record became available, the Natural Resources Conservation Service (NRCS), which operates the SNOTELs, decided to publish (on the NRCS SNOTEL web sites) the long-term median, rather than the mean, as they determined the medians were more indicative of typical values. Thus, the operational criteria now use medians rather than means, and also the 1991-2020 period of record. The upper limit was raised from 120% to 140% because this corresponds approximately to one standard deviation above the long-term medians, meaning that snowpack at this level would still be well within the limits of natural variability. We note that the *lowest* SWE suspension threshold currently employed in the western United States is 140%, including programs in Idaho, Utah, Nevada, and California.

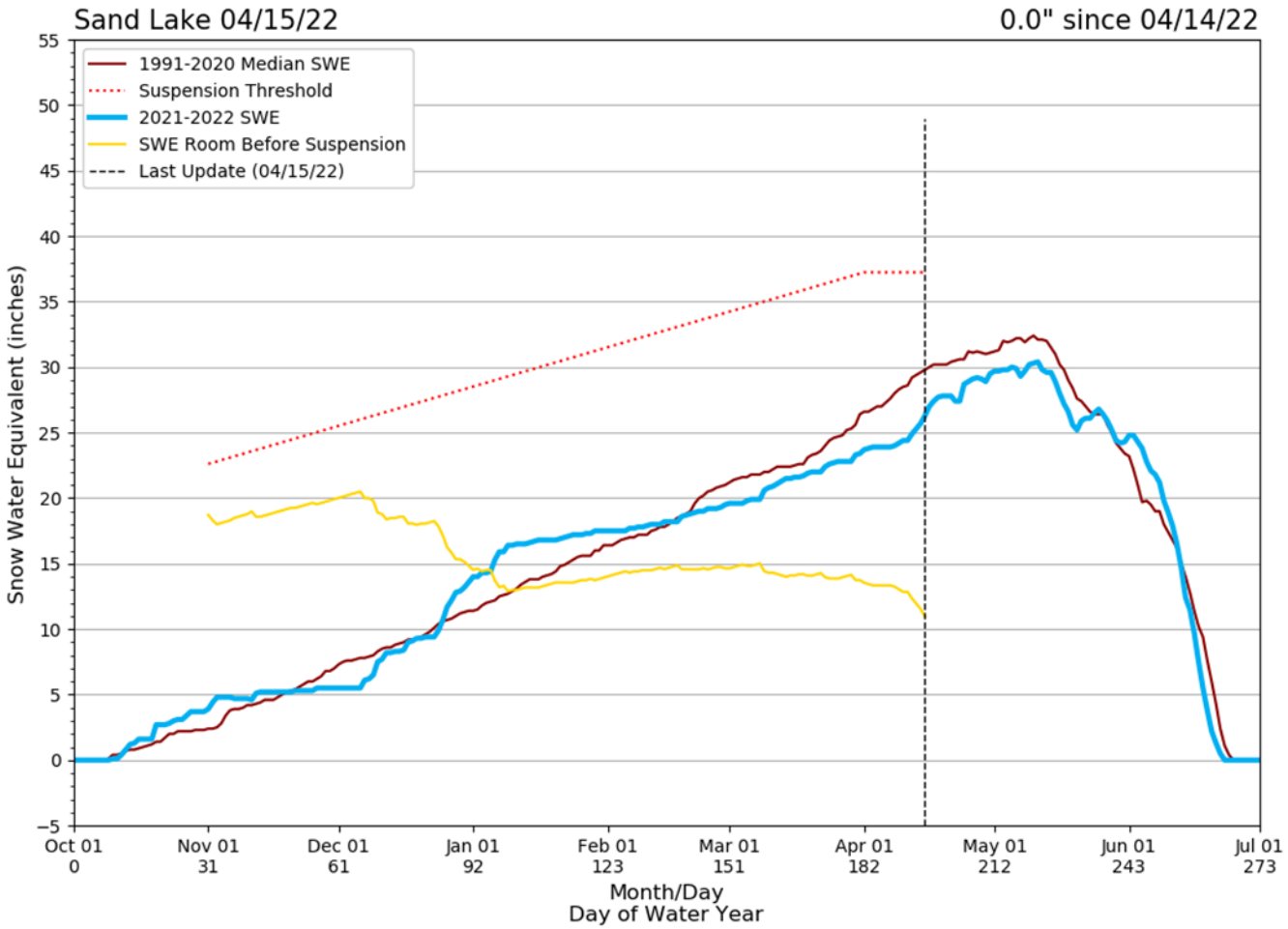


Figure 16. The accumulation of snow water equivalent (SWE, broad blue trace) measured at the Big Sandy Opening SNOTEL within the target area on the western flank of the Wind River Mountains is shown. The thirty-year median is shown in red. The suspension threshold is shown by the fine dotted line. The yellow line indicates the amount of additional SWE needed to reach the suspension threshold, in other words, the difference between the suspension threshold and the 2021-2022 SWE. This graphic is available on the WMI project site for all relevant SNOTELs, throughout the season.

4.2 WMI Numerical Weather Prediction

WMI meteorologists monitor and evaluate a host of real-time and prognostic products to conduct efficient seeding operations. Data included in real-time monitoring and forecasting this season consisted of the following: live radar data from the National Weather Service network of WSR-88D radars, satellite imagery, surface observations, webcam imagery, aviation weather sites (for icing products and observations), a variety of publicly-available numerical models (NAM, GFS, HRRR etc.), and unique in-house modeling tools specially developed for the program. When weather conditions deviate from those forecast or rapidly changing conditions otherwise warrant, weather updates were initiated by the meteorologist.

For the 2021-2022 season, WMI operated a variable nested limited area domain of the Weather Research and Forecasting (WRF) model. During quiet weather periods, an inner high-resolution nest covering both the Wind River Range ground-based generator program and this aerial project was used. When weather was more active, and operations were either possible or ongoing (aka IOP mode), individual nests for the two programs were implemented. The high-resolution inner nest(s), whose boundaries are shown with a thick black border(s) on the plots below, was initialized from the High Resolution Rapid Refresh (HRRR) model, and was given the North American Model (NAM) forecast for boundary conditions at 3-hour intervals. The outer domain grid spacing was 7.5 km and the inner higher-resolution nest grid spacing was 2.5 km during quiet periods, 7.5km and 1.5km in IOP mode. The model was routinely run twice per day, with a 60-hour forecast duration for the 12 UTC model cycle and a 72-hour forecast duration for the 00 UTC model cycle. When IOP mode was activated, model integrations from 06 and 18 UTC initial condition datasets were also executed. Information provided by these customized WRF runs provided very specific tools that greatly improved targeting and effectiveness of seeding, such as the explicit forecasting of supercooled water content over the flight tracks, and winds/temps aloft at a high spatiotemporal resolution. A large number of graphical outputs were developed specifically to aid the cloud seeding decision-making. Examples of some of the meteorologists' favorites are shown in the following figures.

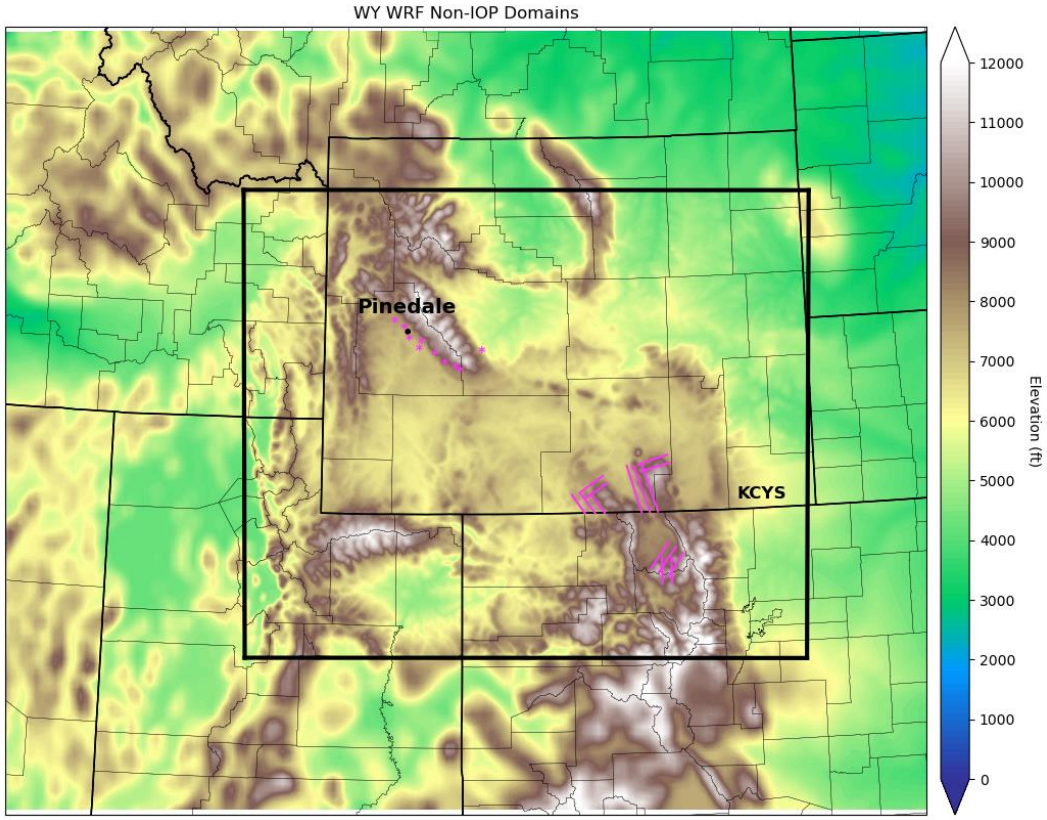


Figure 17. WMI Wyoming Nested 2.5km WRF Domain in quiet weather periods. Solid pink lines show the established aerial seeding tracks, selected from or modified based on the meteorological conditions present during each seeding event. Pink dotes indicate the location of WMI ground-based cloud seeding generators, operated as part of a separate Wyoming program for the Wind River range. Graphical output and BUFKIT format model soundings from WMI's Wyoming WRF domain were published to http://wmiradar.com/wy as soon as the data was available.

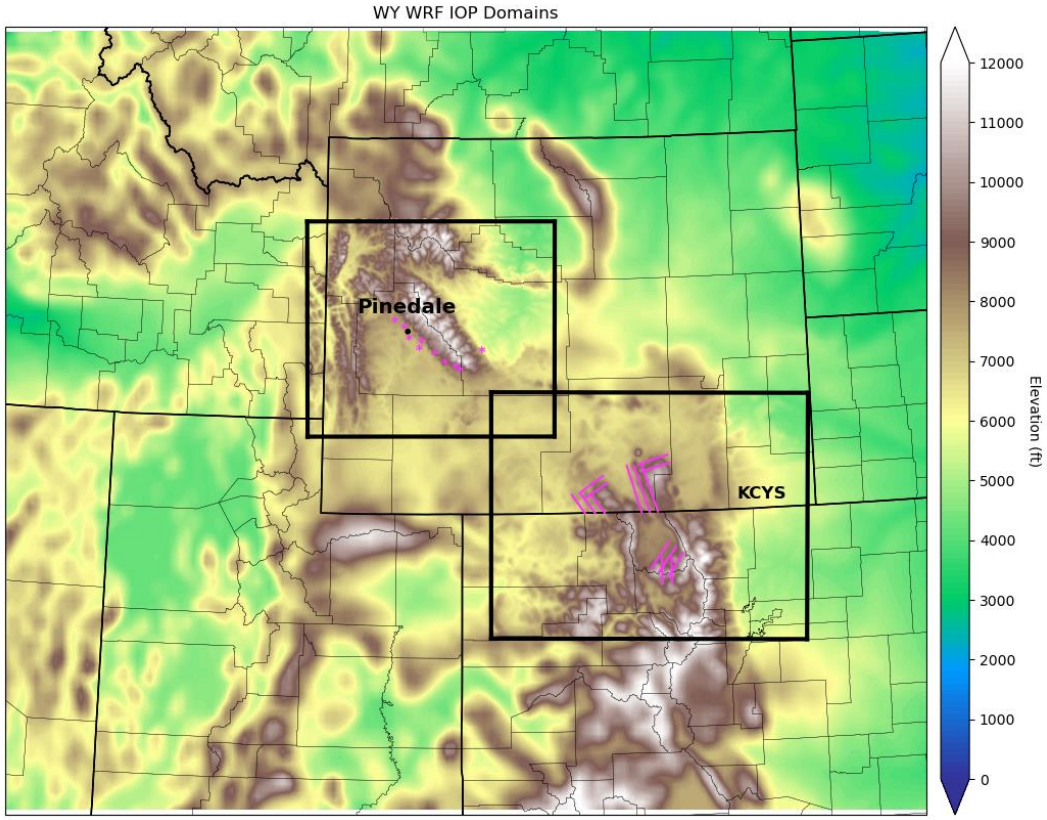


Figure 18. WMI Wyoming Nested WRF Domains during Intensive Operations Periods (IOP mode).

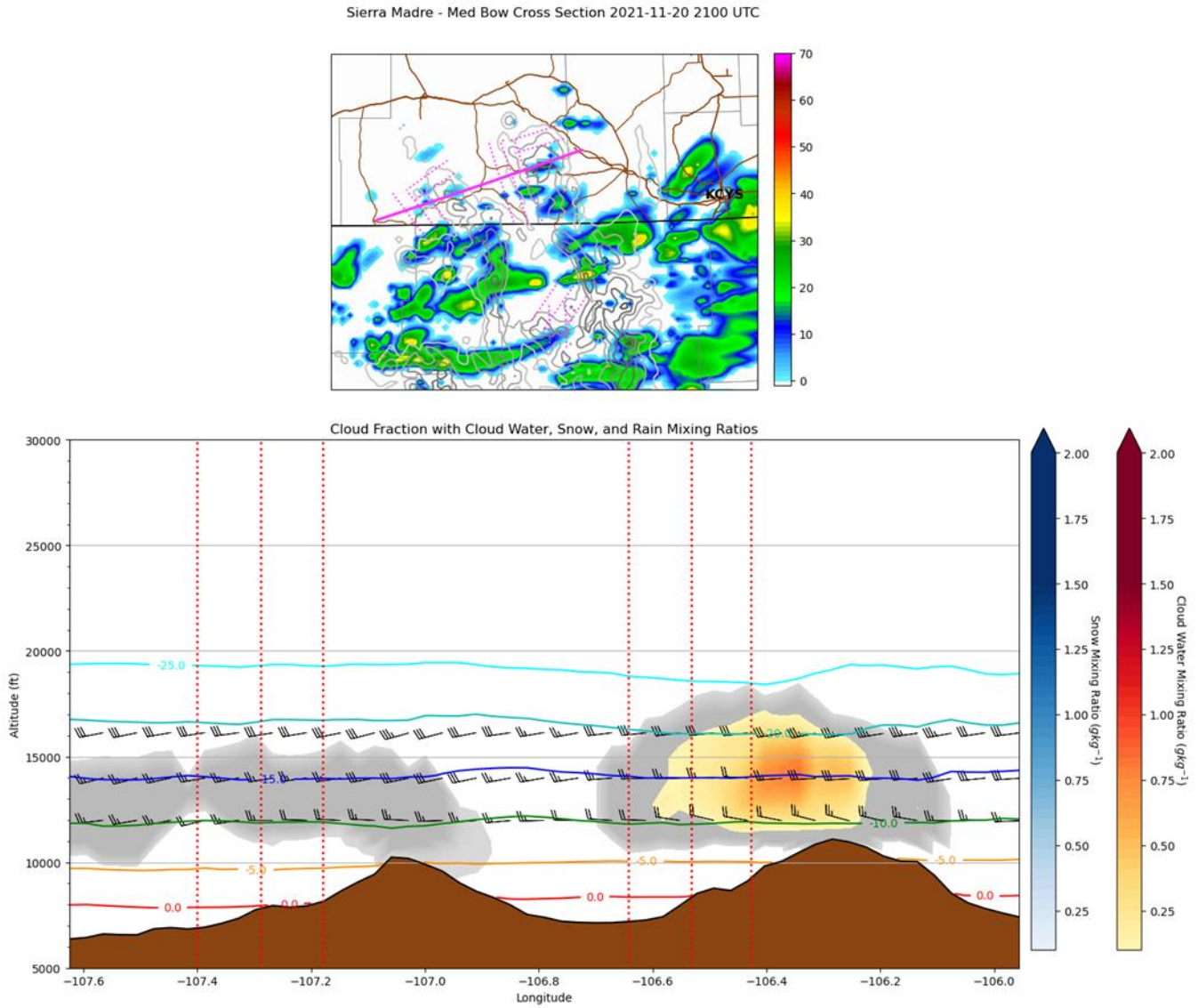


Figure 19. Plot of model simulated composite reflectivity is shown at the top, with a vertical cross section in the bottom half spanning the western flight tracks of the Sierra Madre and Medicine Bow range. The plot is mode for 21:00 UTC on 20 November 2021, or 2 PM MST. See text for interpretation and discussion.

Figure 19, designed specifically to show an overview of weather in the Sierra Madre and Medicine Bow ranges, shows a vertical cross section from southwest to northeast along the pink track in the composite reflectivity plot above. Horizontal distance, denoted by lines of longitude, is depicted along the x-axis, while vertical depth from the model surface (brown fill) up to 30,000 ft MSL is shown on the y-axis. This cross section intersects six project flight tracks at the vertical red dotted lines. Depicted on the cross section are a number of atmospheric variables. 3-dimensional model-simulated clouds are shown in a gray fill, model-predicted liquid cloud water (SLW when colder than freezing) is shown in warm (orange/red) colors, and model-predicted snow is shown in blue. Plot fill priority is given to cloud water, followed by snow, then cloud fraction. Isotherm contours at -25°C, -20°C, -15°C, -10°C, -5°C,

and 0°C are shown in cyan, teal, blue, green, orange, and red respectively, and horizontal wind barbs at various heights at or near common seeding aircraft altitudes are also depicted (northwest winds around 40 kts are shown in this example).

Figure 20, much like Figure 19, shows a vertical cross section along the solid pink line in the composite reflectivity plot in the top half of the figure. This cross section, spanning from the western Never Summer flight tracks to the KCYS airport, again shows horizontal distance denoted by lines of longitude on the x-axis and vertical depth from the model surface (brown fill) up to 40,000 ft MSL on the y-axis. The cross section depicts isotherms, cloud fraction, cloud water, and snow in the same manner as Figure 19. In contrast to the previous figure, however, horizontal wind barbs are withheld, and the cross section is drawn over a broader distance from the seeding tracks to the base airport. This cross section is an example of a plot adapted from input from pilots, who appreciated the meteorological-focused meteograms like in Figure 18, but desired a cleaner design, and with the entire flight path between the seeding tracks and KCYS depicted.

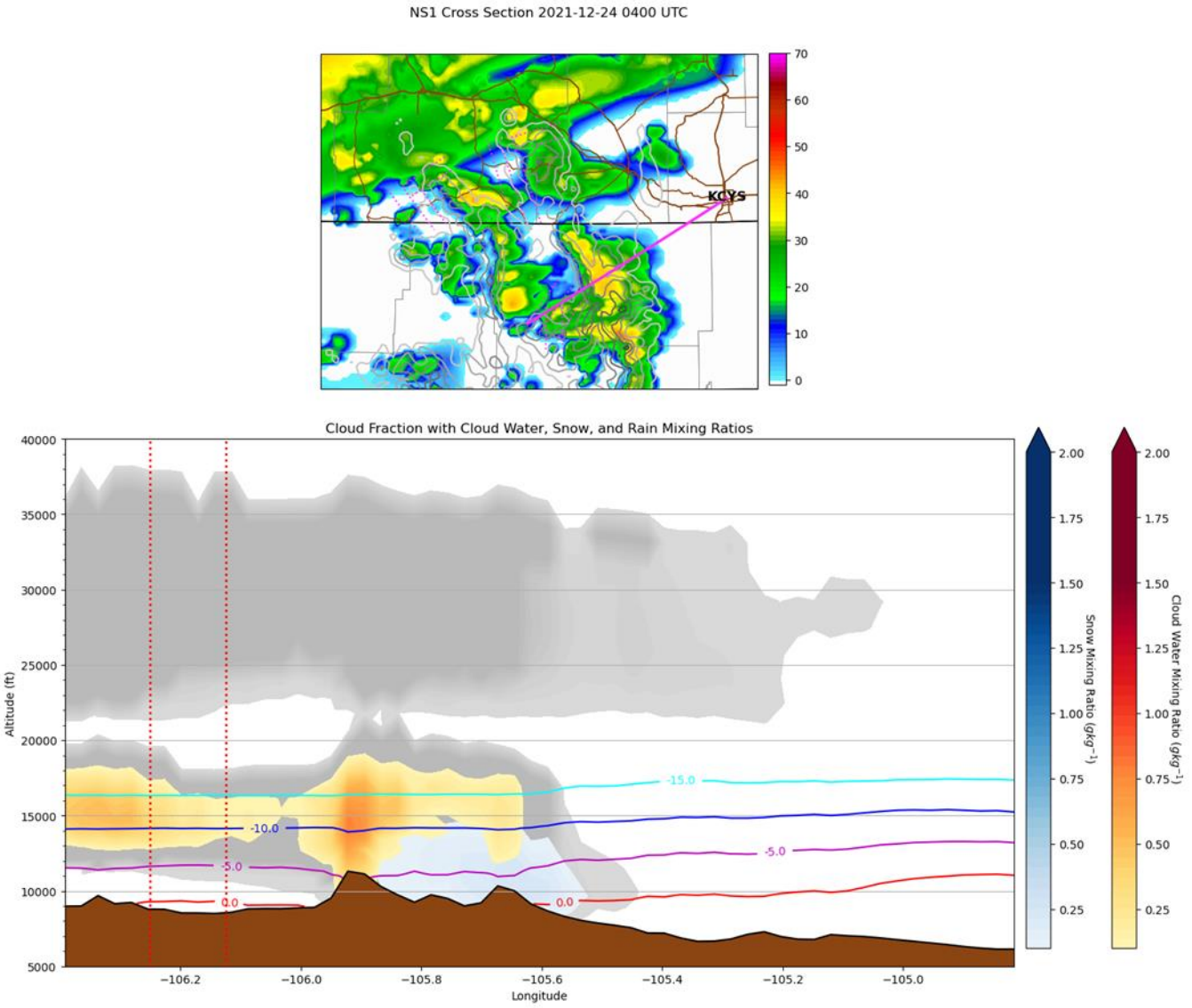


Figure 20. This plot, like Figure 19, shows model composite reflectivity in the top portion with a vertical cross section beneath. The cross section is drawn from the western most Never Summer range flight track to the Cheyenne Airport. The plot is mode for 04:00 UTC on 24 December 2021, or 10 PM MST 23 December 2021. See text for interpretation and discussion.

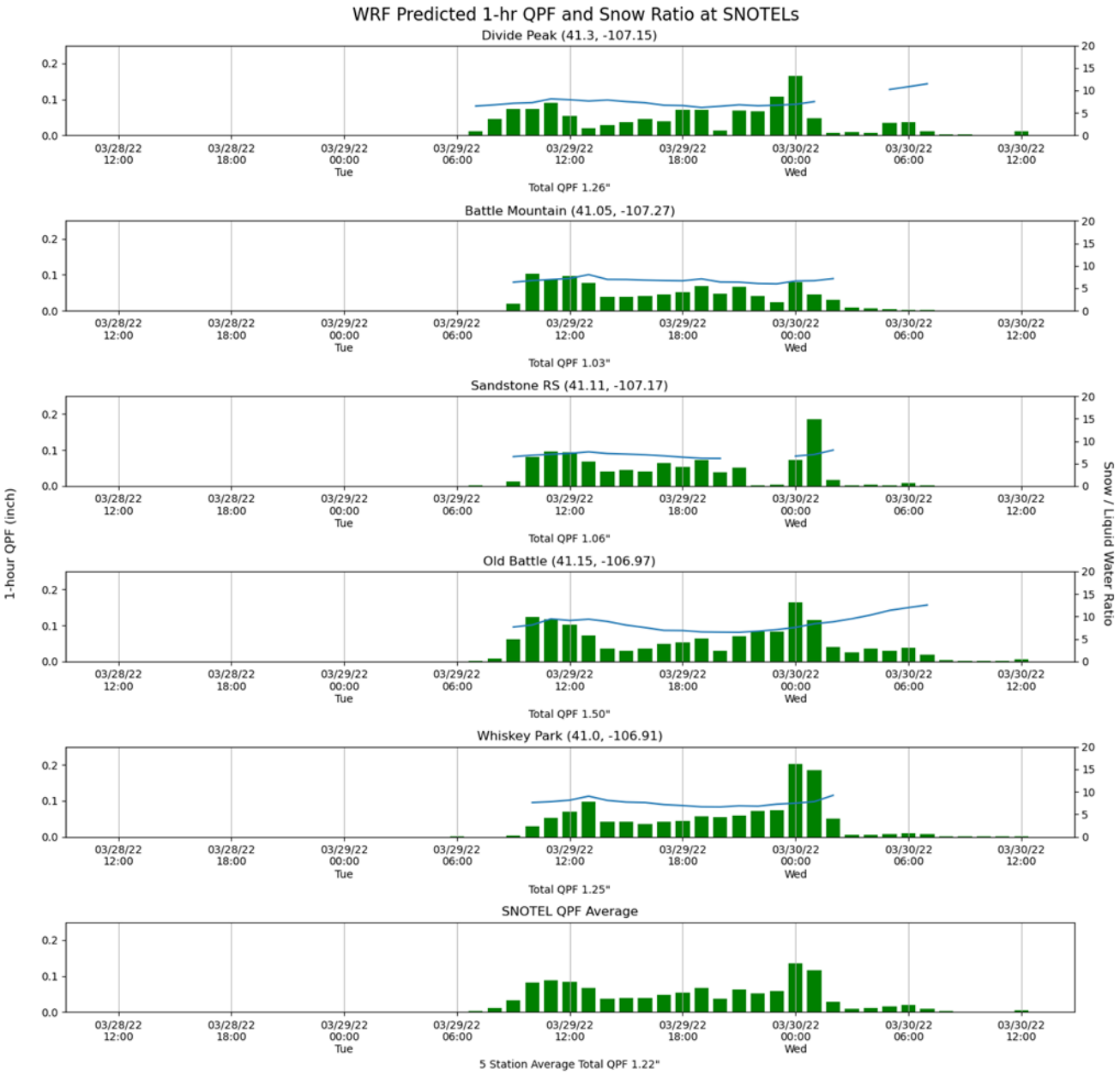


Figure 21. This plot shows hourly quantified precipitation forecast (QPF) outputs for five different SNOTEL locations in the Sierra Madre range. A five-station average is shown in the bottom plot.

In Figure 21, a meteogram showing hourly model-predicted precipitation (a.k.a quantitative precipitation forecast, or QPF) at predefined locations, outputs are chosen based on the existing locations of SNOTEL sites. This type of meteogram was made for all three target ranges for each model cycle, with this plot showing an example for the Sierra Madre range from the 12 UTC WRF run on 28 March 2022. A double y-axis is used to show model predicted snow-liquid water ratios on the right. The meteogram duration is 60-hours, the same as the model duration of the high-resolution nest.

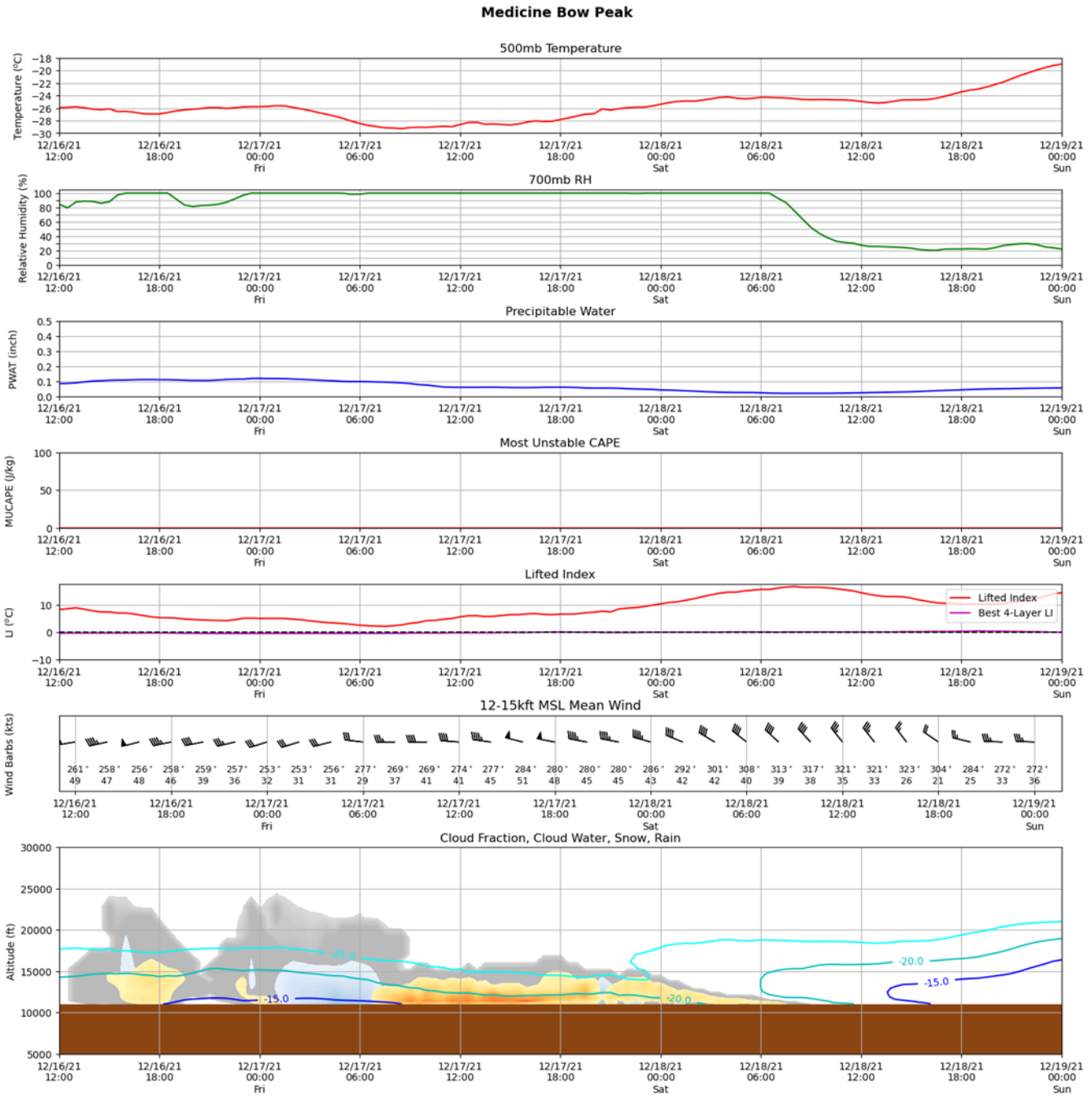


Figure 22. This figure, another meteogram, shows the forecasted evolution of a selection of mid-tropospheric, convective, and precipitation variables through time. The location is fixed at Medicine Bow Peak. Further explanation is provided in the text below.

One final plot example is Figure 22. This multi-variable meteogram shows the forecasted progression of 500 mb temperature, 700 mb relative humidity (RH), precipitable water, most unstable convective available potential energy (CAPE), lifted index, 12,000-15,000 foot altitude average wind direction and speed, and a time-height cross section of isotherms, cloud fraction, cloud water, and snow. 500 mb temperature and 700 mb relative humidity are important lower troposphere tracers to monitor for warm/cold air advection and the presence of moisture in the air that can be lifted along the upwind side of the mountains. Precipitable water depicts the overall evolution of tropospheric moisture, while most unstable CAPE and lifted index are used to monitor the potential for convection accompanying precipitation, which may be hazardous to seeding operations. An average 12 kft -15 kft wind speed and direction is predicted and displayed as a wind barb every two hours, as this block of altitude is frequently utilized by our aircraft during seeding operations. Finally, the time-height cross section shows a breakdown of the model simulated cloud, cloud water, and snow expected throughout the identified time period. Location is held constant, in this case on the grid point nearest Medicine Bow in the Medicine Bow range, for all variables, though adjacent valley locations are used for lower tropospheric variables and precipitable water to provide a better free-atmosphere approximation of these model values.

4.3 Use of Weather Radar Data

While evaluating timely radar information has always been an aspect of the meteorological services involved in this cloud seeding program, WMI began ingesting live radar data from the nationwide network of NOAA NEXRAD radars this project season. Using radar software called TITAN, Thunderstorm Identification Tracking Analysis and Nowcasting, a mosaic of NEXRAD radars was created, and customizable overlays of aerial flight tracks and select geopolitical features (e.g., counties, interstates) were added for context. Further, timely aircraft position information was added, allowing a real-time fusion of radar information with seeding aircraft position. Web images of both a regional radar mosaic and a closer view of any airborne seeding/patrol operations were created and published in real-time on the project operations webpage when potentially seedable weather occurred.

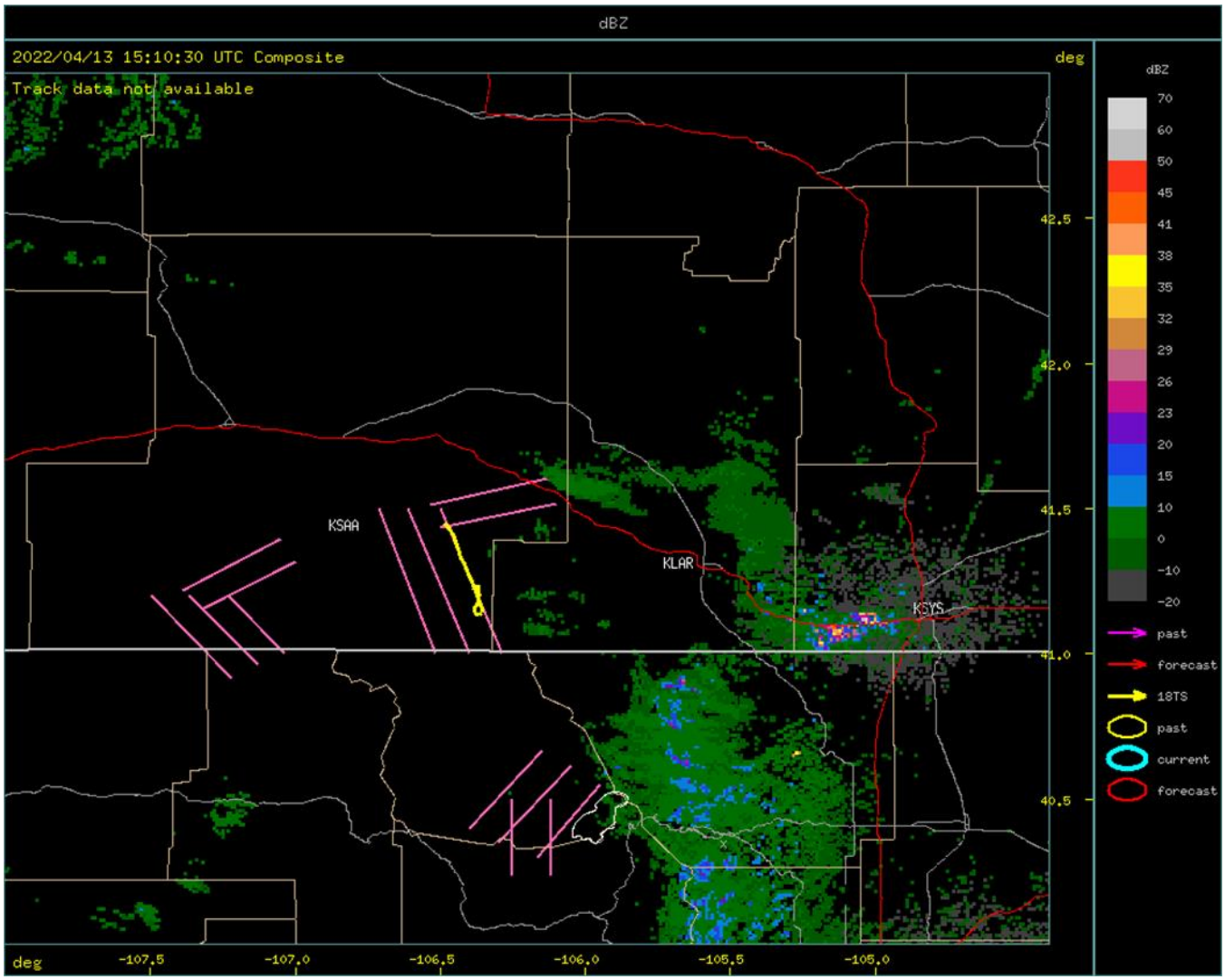


Figure 23. This is a mosaic of composite reflectivity from NOAA NEXRAD radars located in Riverton, WY, Cheyenne, WY, and Denver, CO. Aerial seeding track lines are shown in pink, while the aircraft flight track is shown in yellow.

4.4 WMI Forecast Sheet

Today's ODC: +2

SYNOPSIS

Jet level charts show a westerly jet streak over our region and Colorado today while an incoming trough from the northwest meanders into the Rockies from the PACNW. This will be a cooler system with relatively light moisture as it pushes through today and tomorrow. PWAT will peak around 0.25 inches this evening and then slowly drop off tonight and tomorrow while the 500mb temps drop from around -26C this evening to around -29C tomorrow. While these temps aloft are typically on the cold side for seeding operations, our models are indicating some periods of light (but persistent) SLW this evening through midday tomorrow. Seeding level winds will be moderate, around 30-40 knots tonight and tomorrow, yet sufficient for orographic snow/SLW. Low level RH plummets tomorrow evening with a flat ridge moving in, bringing dry weather Friday night through at least Tuesday. Another round of active weather arrives Wednesday when a powerful Pacific system off the California coast finally moves onshore.

FORECAST

By chance, we currently have a third pilot in CYS, so we have the option to do three consecutive flights on this system if conditions warrant. Orographic clouds and snowfall will improve through this afternoon and evening, and then light continuous mountain snow is expected late this evening through tomorrow afternoon. Temps are certainly on the cold side for seeding, but models continue to indicate marginally targetable SLW this evening through midday tomorrow. SLW does not appear to be overly deep, but it is targetable with ejectables if models verify. A seeding flight is scheduled for 3Z (8pm MST) this evening for the NS4 tracks. Following that flight, a second flight on the MB/SM is expected. If conditions are good on the second flight, a third flight may be possible on the MB/SM tomorrow from mid morning to early afternoon. With temps as cold as they are at midlevels, it will not be surprising if we find the models to be incorrect and SLW to be too scarce to continue. However, we will plan for three flights and hope it works out. Dry conditions return Friday evening through Tuesday while a massive low plants itself off the coast. This system will finally kick inland around midweek bringing another chance of seeding Wednesday-Thursday.

ACTION: NS4 flight scheduled for 3Z this evening. A MB/SM flight will likely follow late tonight. If that second flight is productive with enough SLW, a third flight will be possible midday tomorrow. No seeding tomorrow evening through Tuesday.

Day 2 Outlook ODC: 0

WRF MODEL SOUNDING	
SAA	00Z, 17 December
0 °C level	n/a
-5 °C level	7.3 kft
-10 °C level	10.1 kft
-20 °C level	15.2 kft
Precipitable Water	0.20 inches
14 kft T/wind	-17.8°C 254@31 kts
16 kft T/wind	-21.7°C 251@40 kts
700 mb T/wind	-9.1°C 244@26 kts
500 mb T/wind	-26.1°C 246@44 kts

YESTERDAY'S WEATHER **Observed ODC: +1**

Temps Max/Min: Saratoga 43/12 Cheyenne 42/20 Walden 37/12

Weather Summary: Deep orographic clouds with light intermittent SLW were present through the afternoon with snow showers, particularly in the NS range. A seeding flight probably would have been attempted in the afternoon, but extremely gusty winds at CYS (hurricane force wind gusts) precluded any flight operations. Partial clearing occurred in the evening with only patchy thin orographic clouds lingering into the late night hours. Late in the period, overcast layers overspread the MB/SM, and orographic clouds began to deepen ahead of the next incoming trough.

Flights: None

Orographic Day Category (ODC)		
-3	No Seeding	Clear skies, or clear with isolated upper-level cloudiness.
-2	No Seeding	Occasionally clear, with cirrus, cirrostratus, altostratus; cloud bases above mountains.
-1	No Seeding	Limited coverage or short-lived orographic clouds, not enough temporal or spatial extent to warrant seeding activities.
0	Possible Seeding	Some orographic clouds/stratus over mountain tops. SLW/Winds/Temps marginal or uncertain. Operations possible, but not likely.
+1	Seeding Likely	Orographic clouds and/or stratus deck enshrouding mountain tops, Supercooled Liquid Water/Winds/Temps favorable for seeding.
+2	Extensive Seeding	Persistent orographic clouds and/or stratiform cloud deck enshrouding mountain tops, Supercooled Liquid Water/Winds/Temps favorable for extended seeding operations.

Figure 24. A WMI forecast sheet from 17 December 2021; all forecasts were submitted to the client via email daily.

5 PROJECT FLIGHT DATA

The first 2021-2022 winter mission was flown 2 November 2021 for the Never Summer Mountain Range. A map of each seeding event is provided. The pre-established flight tracks are shown in blue and actual aircraft tracks are shown in black. Yellow dots denote where ejectable flares were fired, and blue triangles denote where burn-in-place flares were ignited. The table beneath each map details the mission and includes fight data (engine on/off, total time), flares used, pilot(s) observations, a description of observed weather conditions, and area forecast relevant to that mission. Maintenance and training flights conducted at the contractor's expense are not included in the list.

All flights for the Wyoming target areas are summarized in Table 2. Those flown for the Never Summer range in Colorado are given in Table 3.

Figure 25. N6111V's instrument panel on a night mission over the Medicine Bow range. Photo by Captain Alex Sailsbury

Table 2. Flight operations for the Medicine Bow and Sierra Madre Mountain Ranges are summarized.

2021-22 WYOMING N6111V & N518TS FLIGHT SUMMARY

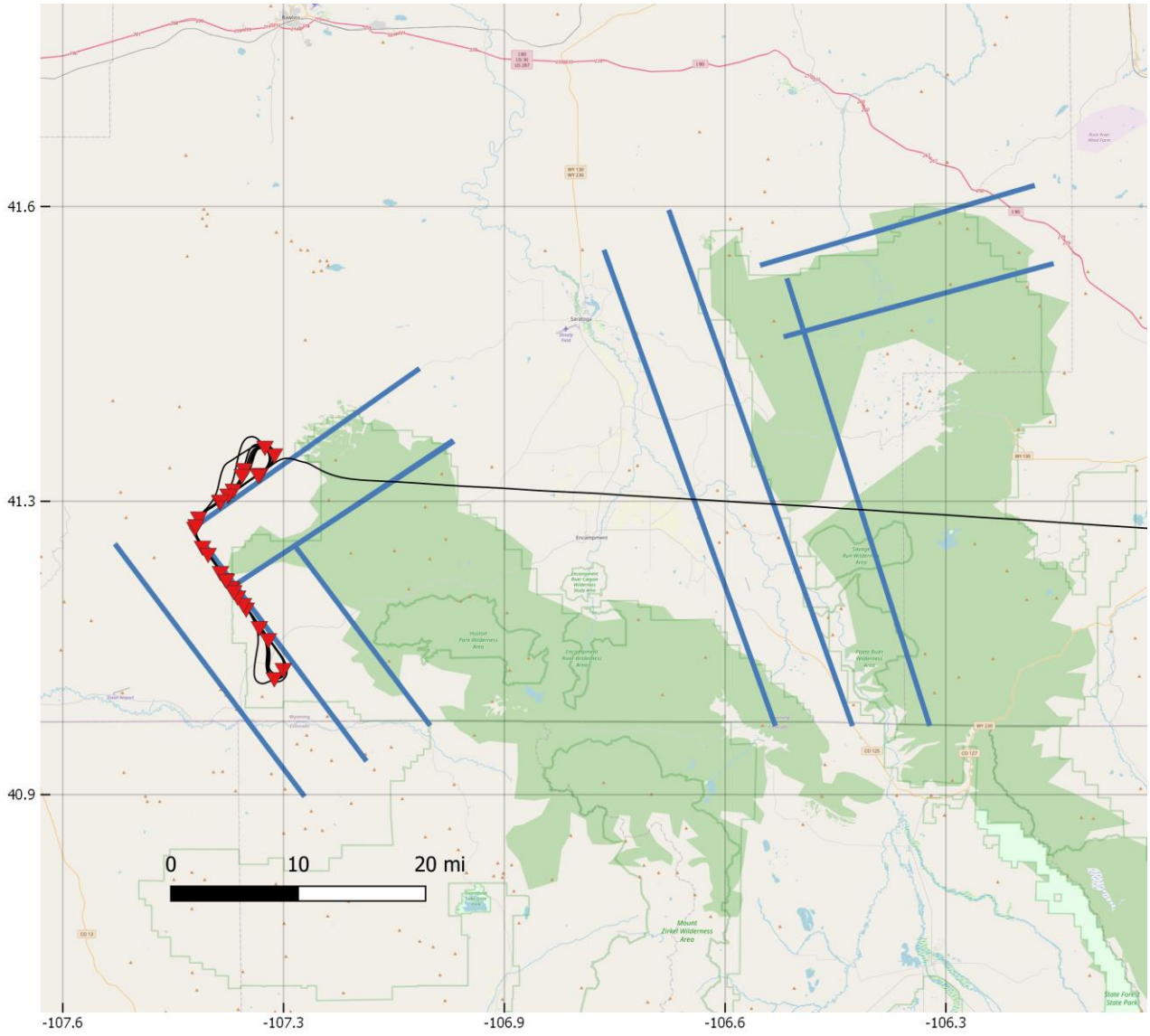
	SNOW	RECON	REPO	WMI OTHER	BILLABLE TOTAL	MX FLIGHTS	BIP	EJ	TRACK(S)	TARGET AREA	CREW	Flight #
DATE	35	4	0									
11/10/2021	4.75				4.75	0.00	38		SM4, Modified Track	MBSM	BKRS	1
11/11/2021	4.95				9.70	0.00	34	241	MB4, Modified Track	MBSM	BKRS	2
11/12/2021	5.05				14.75	0.00	26	201	Modified Track	MBSM	BKRS	3
11/20/2021	5.18				19.93	0.00		279	MB4	MBSM	BKRS	4
11/22/2021				2.75	19.93	2.75						
11/23/2021				3.12	19.93	5.87						
11/24/2021	3.88				23.81	5.87		174	MB1, MB2	MBSM	BKRS	5
12/9/2021	4.68				28.49	5.87	9	248	SM4, SM5	MBSM	BKRS	6
12/9/2021	5.15				33.64	5.87	40	212	MB4	MBSM	BKRS	7
12/15/2021	1.95				35.59	5.87	8		MB4, MB5, SM4	MBSM	ASRS	8
12/17/2021	4.25				39.84	5.87		129	MB4, MB5	MBSM	ASRS	9
12/17/2021	5.40				45.24	5.87		218	MB4	MBSM	ASRS	10
12/23/2021	5.18				50.42	5.87	38		SM3	MBSM	BKRS	11
12/25/2021	4.15				54.57	5.87	1	192	SM4, SM3, MB3	MBSM	BKRS	12
12/26/2021	1.52				56.09	5.87		3	SM3	MBSM	BKRS	13
12/30/2021	2.00				58.09	5.87	2	4	SM4	MBSM	BKRS	14
12/30/2021	2.95				61.04	5.87	22		SM4	MBSM	BKRS	15
1/4/2022	2.38				63.42	5.87	4	25	MB3	MBSM	BKRS	16
1/4/2022	3.92				67.34	5.87		195	MB1	MBSM	BKRS	17
1/6/2022		1.25			68.59	5.87				MBSM	BKRS	18
1/8/2022	4.72				73.31	5.87		149	SM3	MBSM	BKRS	19
1/14/2022	3.52				76.83	5.87	9	109	MB1	MBSM	BKRS	20
2/7/2022				1.15	76.83	7.02					ASRS	
2/10/2022	3.62				80.45	7.02		292	MB1	MBSM	ASRS	21
2/11/2022	4.85				85.30	7.02		235	MB4	MBSM	ASRS	22
2/21/2022	4.58				89.88	7.02	35	19	MB5, MB4	MBSM	ASRS	23
2/24/2022		1.97			91.85	7.02			SM5	MBSM	ASRS	24
3/5/2022	4.58				96.43	7.02	3	300	SM5	MBSM	ASRS	25
3/9/2022	4.87				101.30	7.02		101	MB4	MBSM	ASRS	26
3/13/2022	3.15				104.45	7.02		227	MB5, MB4	MBSM	ASRS	27
3/16/2022	5.08				109.53	7.02	38		MB4	MBSM	ASRS	28
3/17/2022	2.85				112.38	7.02		91	SM2	MBSM	ASRS	29
3/21/2022	5.02				117.40	7.02	2	269	MB5	MBSM	ASRS	30
3/22/2022	5.15				122.55	7.02	43	302	MB1, MB2	MBSM	ASRS	31
3/29/2022	5.07				127.62	7.02	40		SM5	MBSM	ASRS	32
3/29/2022	4.95				132.57	7.02	5	302	MB5, MB2	MBSM	ASRS	33
4/1/2022	1.97				134.54	7.02		17	SM5, MB5	MBSM	ASRS	34
4/5/2022	4.47				139.01	7.02	35	204	MB3	MBSM	ASRS	35
4/12/2022		1.50			140.51	7.02			SM3, MB3	MBSM	ASRS	36
4/12/2022		1.25			141.76	7.02			SM4	MBSM	ASRS	37
4/13/2022	5.23				146.99	7.02	3	134	SM5, MB5	MBSM	ASRS	38
4/15/2022	5.45				152.44	7.02		302	MB4, MB3	MBSM	ASRS	39
TOTALS	146.47	5.97	0.00	7.02	152.44	7.02	435	5174				

Table 3. Flight operations for the Never Summer Mountain Range are summarized.

2021-22 COLORADO N6111V & N518TS FLIGHT SUMMARY

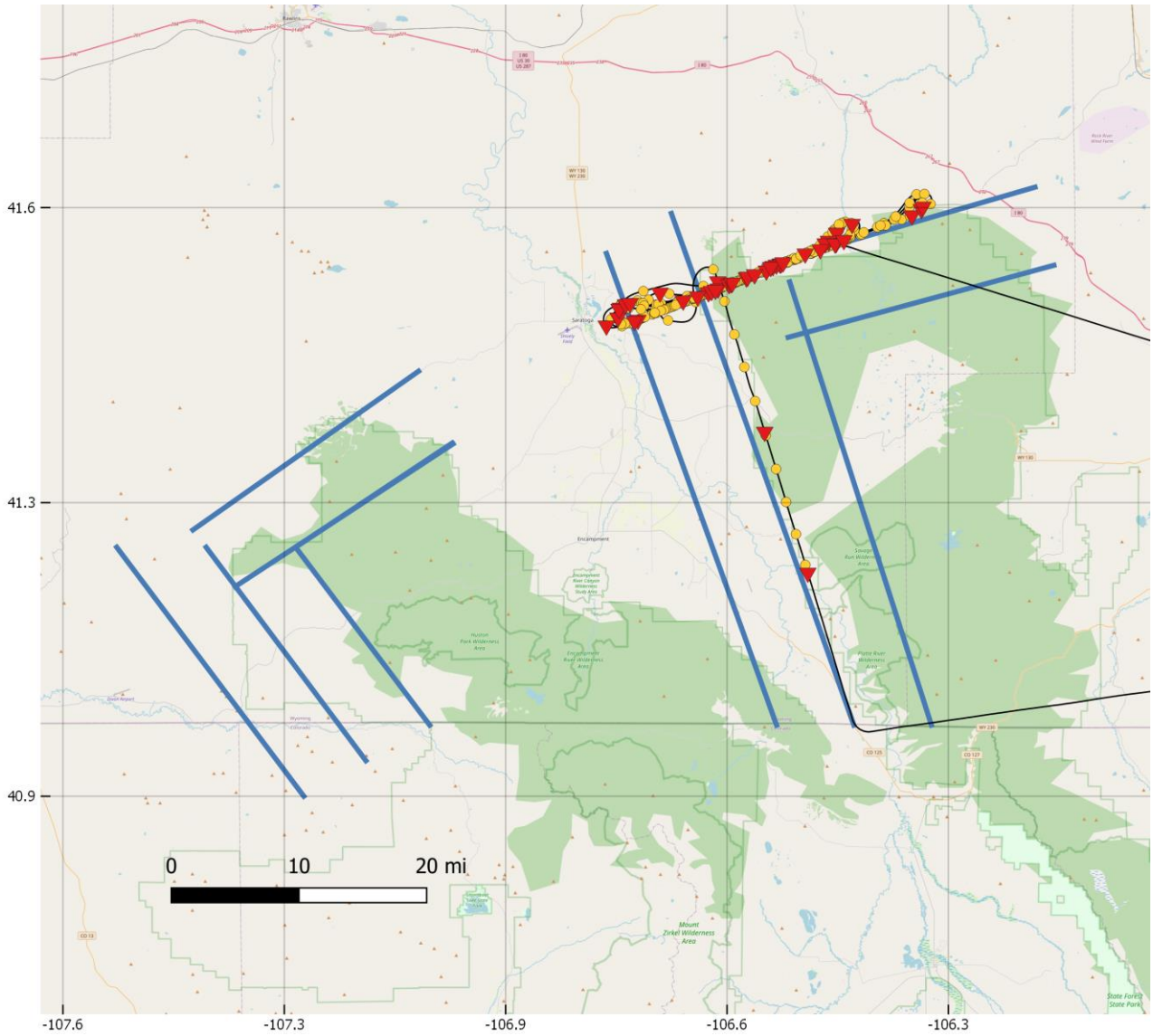
	SNOW	RECON	REPO	WMI OTHER	BILLABLE TOTAL	MX FLIGHTS	BIP	EJ	TRACK(S)	TARGET AREA	CREW	Flight #
DATE	**12**	**3**	**0**									
11/2/2021	3.93				**3.93**	**0.00**	29		NS3	NS	BKRS	1
12/15/2021	1.70				**5.63**	**0.00**		19	NS4	NS	ASRS	2
12/23/2021	4.60				**10.23**	**0.00**	2	172	NS4, NS1	NS	BKRS	3
12/24/2021		2.22			**12.45**	**0.00**			NS4, NS2, NS3	NS	BKRS	4
12/26/2021	3.47				**15.92**	**0.00**		99	Modified, NS4	NS	BKRS	5
12/27/2022	4.68				**20.60**	**0.00**		162	NS4	NS	BKRS	6
1/4/2022		0.95			**21.55**	**0.00**			NS1	NS	BKRS	7
3/13/2022		1.80			**23.35**	**0.00**			NS2, NS5	NS	ASRS	8
3/16/2022	4.80				**28.15**	**0.00**	43		NS5	NS	ASRS	9
3/17/2022	2.05				**30.20**	**0.00**		33	NS3, Modified	NS	ASRS	10
4/1/2022	2.63				**32.83**	**0.00**		166	NS3	NS	ASRS	11
4/5/2022	5.00				**37.83**	**0.00**		240	Modified	NS	ASRS	12
4/10/2022	5.15				**42.98**	**0.00**	1	161	NS5, NS4	NS	ASRS	13
4/12/2022	3.50				**46.48**	**0.00**		32	NS4	NS	ASRS	14
4/12/2022	3.93				**50.41**	**0.00**	1	272	NS4	NS	ASRS	15
TOTALS	**45.44**	**4.97**	**0.00**	**0.00**	**50.41**	**0.00**	**76**	**1356**				

5.1 Mission Flight Tracks – Medicine Bow and Sierra Madre Mountain Ranges, WY



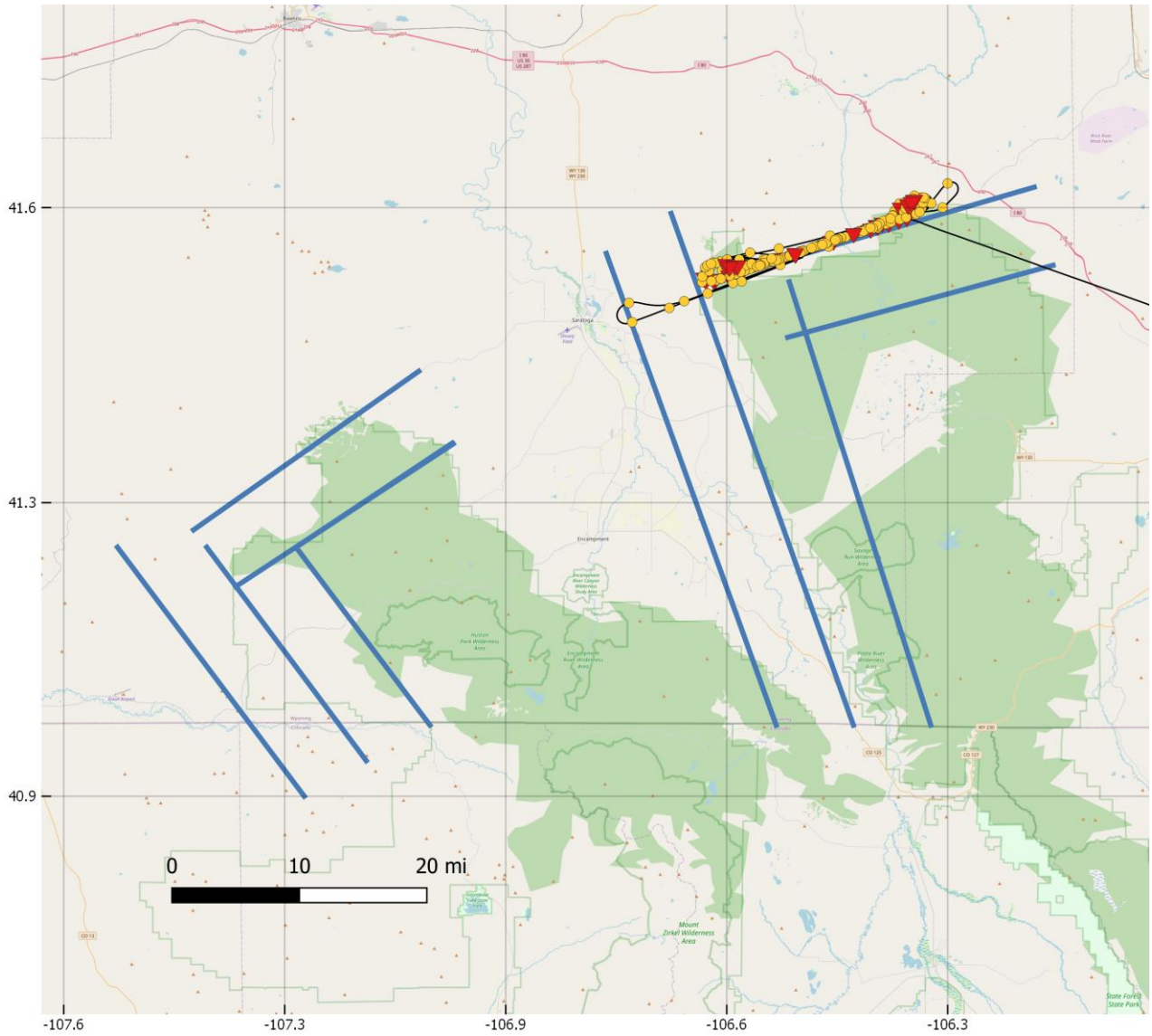
N6111V	OPS #:	01			SEED
	Track(s)/Basin:		SM-4, Modified		
UTC Date:	November 10, 2021		MST Date:	November 9, 2021	
UTC Engines ON:	02:51		MST Engines ON:	7:51 pm	
UTC Engines OFF:	07:36		MST Engines OFF:	12:36 am	
Total Time:	4:45	4.75hr	Flares Used:	38 BIP	0 EJECT
Pilot's Flight Summary:	Departed CYS for SM-4 at 14kft. Once on track found no liquid water to start, but good conditions reported lower so we seeded using BIPs at 13kft. Later in the flight, liquid water was present at our altitude in patches, but not enough to cause icing problems so we continued seeding. During the mission, winds shifted favoring the top 1/3 of				

	track 4 and the bottom 1/3 of track 1. At the end, some convection moved in when we were nearing our time for needing fuel and we returned to CYS.
Synoptic Analysis:	Upper-level charts show a shortwave ridge exiting the region this afternoon to be replaced by a trough sweeping through the Rockies this evening into tonight. This will be a relatively short-lived event, but we will see decent moisture for a few hours this evening until it drops off sharply on the back side of the trough. PWAT will peak above 0.40 inches just before midnight. Seeding level winds will be southwesterly around 30 knots until the trough axis passes through around midnight and they will shift to northwest. Moisture becomes insufficient for ops after around 8z tonight, but it will increase again Wednesday night. Thursday and Friday look to see excellent moisture in place along with northwest flow in a setup favorable for persistent orographic clouds and mountain snowfall. Moisture lingers into Saturday, but it looks to drop for Sunday. Drier conditions return Sunday through the middle of next week, but we remain in strong WNW flow.
Area Forecast:	As the trough moves through this evening, we will see a narrow seeding window between 3z and 8z. Conditions look to be best in the SM where the heaviest accumulation is expected. The SM should see 3-5 inches of snow accumulation during this brief event, but the MB will see less, perhaps 2-3 inches of snowfall. The NS range will see the lightest snowfall with only an inch or two. SLW and cloud depth look somewhat shallow with this system, but temps are cold enough that we should be able to target this layer in the SM from 13kft with ejectables. We will tentatively schedule a flight on the SM4 track this evening to be on track at 4z, ending by 8z. Winds will be shifting from SW to NW throughout the flight, so we will likely need to adjust our track as the mission progresses. Shallow orographic clouds and snow showers linger through the night and tomorrow, but SLW looks insufficient for additional flights. Deep excellent SLW is forecast Thursday through early Saturday. Extensive seeding operations are expected during this timeframe. We will see a break in the action Saturday night and Sunday, and early next week looks drier with a long gradual warm up.
Flight occurred in the evening hours of the 9th; weather information is from Nov. 9th.	



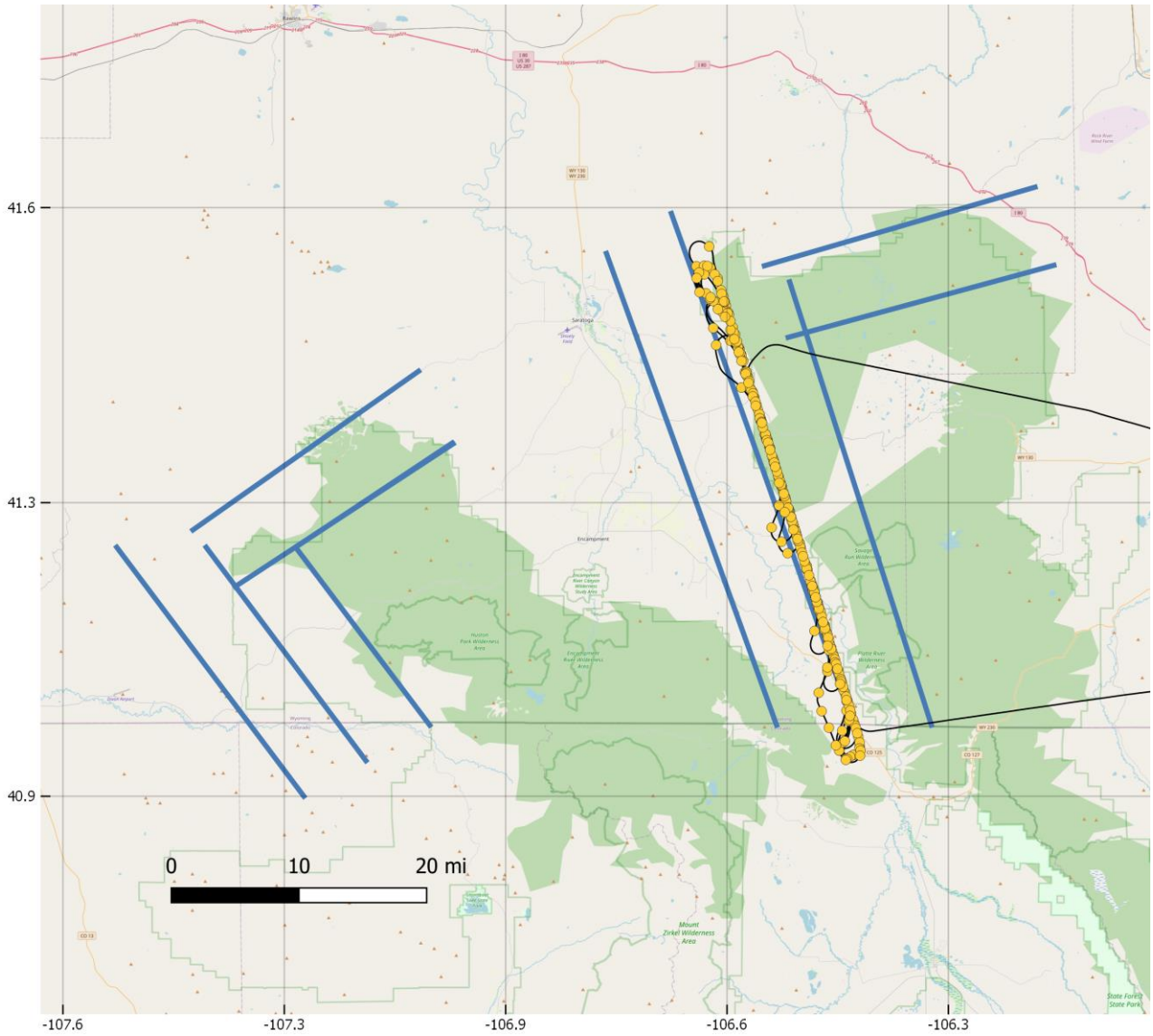
N6111V	OPS #:	02			SEED
	Track(s)/Basin:		MB-4, Modified		
UTC Date:	November 11, 2021		MST Date:	November 11, 2021	
UTC Engines ON:	19:04		MST Engines ON:	12:04 pm	
UTC Engines OFF:	00:01		MST Engines OFF:	5:01 pm	
Total Time:	4:57	4.95hr	Flares Used:	34 BIP	241 EJECT
Pilot's Flight Summary:	Departed CYS for MB-4 at 20kft. Once on track, we found LWC up to 0.40 and was instructed by radar to fire EJs and BIPS. Shortly after reporting winds, radar modified our track to using MB-1 modified to extend southwest to the north point of MB-3 track. As clouds began to drop, we stopped firing BIPs and increased using EJs every 30 seconds. As the flight continued, we descended with the cloud tops. Stopping our				

	descent at 17kft, we started to use BIPs with EJs until we were running low on fuel and returned to CYS.
Synoptic Analysis:	As the trough exits to the east, WY develops strong northwest flow today. A jet streak noses into the region this afternoon from the PACNW. As a ridge over the coast amplifies, the strong flow over our area will shift more northerly by Friday. Moisture has tapered off for today, and low level RH will not be sufficient for deep orographic development through morning. However, good low level moisture advection will occur tomorrow. PWAT will rise above 0.30 inches by tomorrow evening. Strong northwest winds of 50 knots coupled with good low level moisture will create a very good setup for deep juicy orographic clouds tomorrow afternoon through late evening. With minimal midlevel forcing or midlevel cloud to provide natural seeder/feeder nuclei from above, SLW content should be quite high with this purely orographic mountain snow event. This setup continues Friday into early Saturday with more northerly winds, and then moisture wanes Sunday through early next week.
Area Forecast:	Marginal low and orographic clouds are all that is expected today and tonight, nothing adequate for seeding throughout the period. Partial clearing is expected late in the day. Orographic clouds will deepen gradually tonight and tomorrow morning becoming thick enough for operations by midafternoon tomorrow. Two seeding flights are expected tomorrow afternoon through late evening, probably on the MB range. WMI models are indicating heavy SLW tomorrow, and ejectables will likely be our preferred seeding method while skimming cloud tops to avoid heavy airframe icing. Additional flights are expected Friday with continued orographic snow, and there will be a slight chance for ops early Saturday depending on timing and crew rest requirements. No seeding is expected Sunday. This storm will be confined to the mountains as it is purely orographic in nature. Conditions at CYS should remain excellent for operations through Saturday with no concerns regarding ceilings/visibility/mist etc.
Flight occurred in the afternoon hours of the 11th; weather information is from Nov. 10th.	



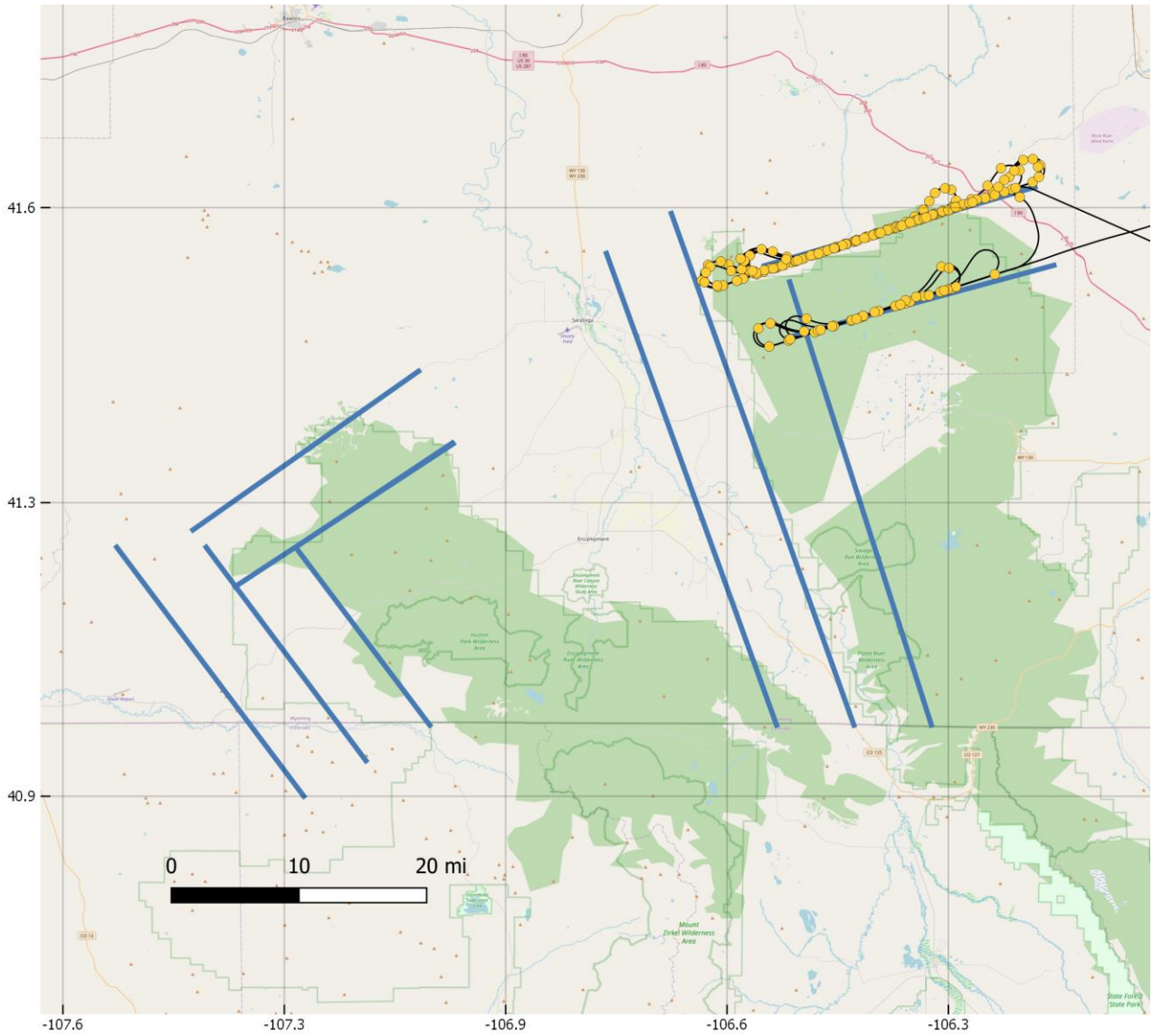
N6111V	OPS #:	03			SEED
	Track(s)/Basin:		Modified		
UTC Date:	November 12, 2021		MST Date:	November 11, 2021	
UTC Engines ON:	02:25		MST Engines ON:	7:25 pm	
UTC Engines OFF:	07:28		MST Engines OFF:	12:28 am	
Total Time:	5:03	5.05hr	Flares Used:	26 BIP	201 EJECT
Pilot's Flight Summary:	Departed CYS for MB-1 Modified to extend the southwest point to the northwest point of MB-3, shortly changed to MB-4 with EJs fired once a minute. Throughout the flight, cloud tops periodically descended, as did we with them. Once we descended to 16kft, sufficient LWC was found and radar instructed us to continue with EJs along with BIPs back to back. We did this until the end of the flight when we were instructed to only fire EJs on the last couple laps on track before needing to return to CYS for fuel.				

Synoptic Analysis:	A potent northwesterly jet streak is in place over the ranges which will become more northerly tonight as a west coast ridge builds. A massive low pressure system is in place over the Upper Midwest. Good low level moisture moves in this afternoon with PWAT approaching 0.40 inches by 00z before dropping overnight and then climbing again tomorrow. Low level winds are very strong from the NW, and orographic lift is excellent which is creating significant orographic clouds and snowfall today. Wind speeds will be a bit lighter tomorrow which will mean shallower orographic clouds and much lighter snow accumulation. This event looks confined to the mountains, as midlevel dynamics are weak. Moisture drops off Saturday and looks insufficient for ops through midweek.
Area Forecast:	A flight is underway this afternoon for the MB range on a modified track designed to fit the strong NW winds. Wind speeds have been around 60-70 knots, and plenty of SLW has been reported, and heavy mountain snowfall is evident on radar. Excellent seeding conditions will continue through late evening. After the aircraft returns to CYS and is refueled/flared, a second flight will be launched immediately, probably for the MB range again. Cloud depth is insufficient for seeding overnight. Tomorrow, orographic cloud is shallower, but we may be able to get a flight on the SM range where we are able to fly lower down to 13kft. This is not certain at this time, but we will say there is a fair chance and reassess in the morning. Weekend operations are looking unlikely, and nothing seedable is forecast through about Wednesday. More active weather moves in late next week.
Flight occurred in the evening hours of the 11th; weather information is from Nov. 11th.	



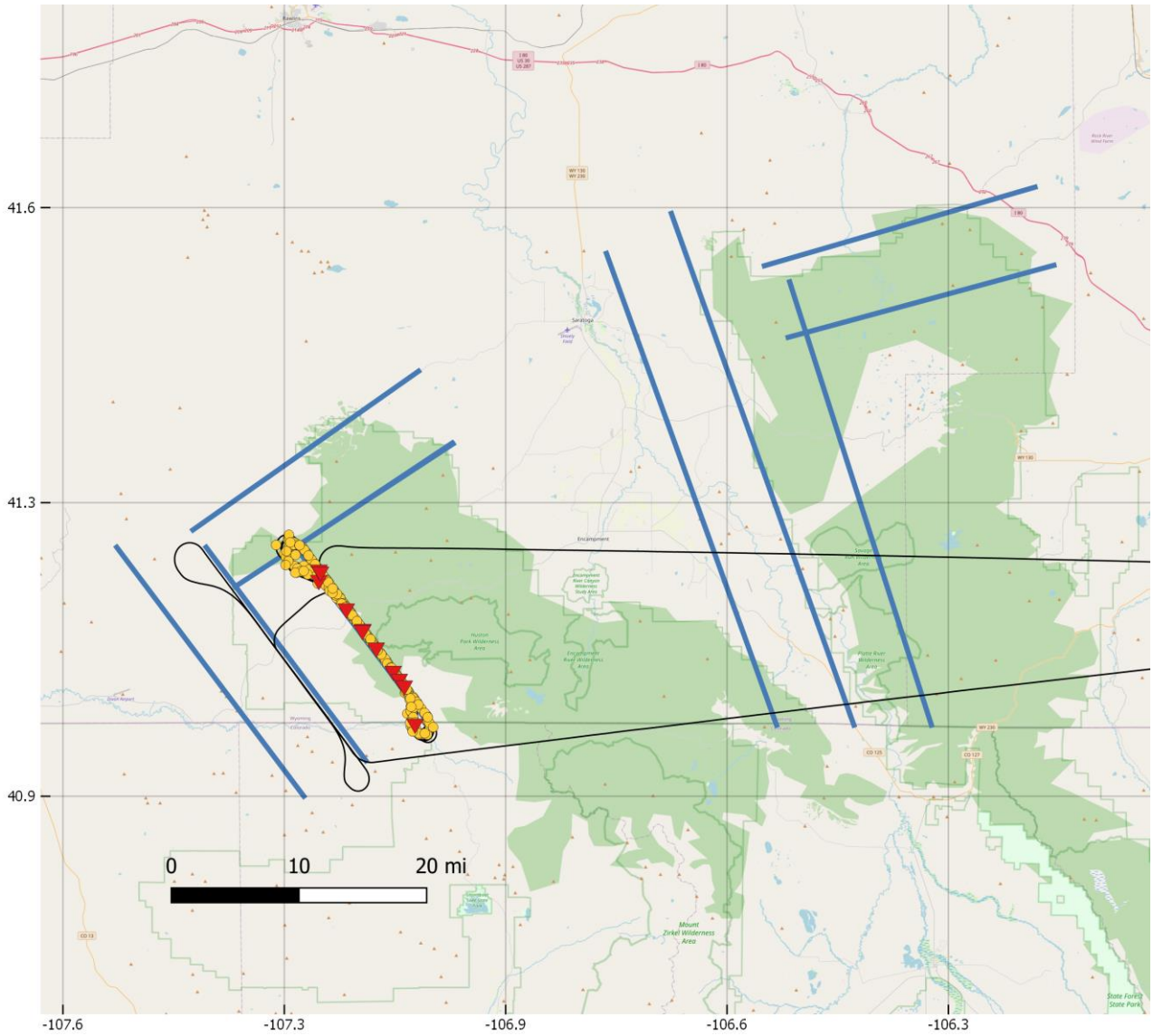
N6111V	OPS #:	04			SEED
	Track(s)/Basin:		MB-4		
UTC Date:	November 20, 2021		MST Date:	November 19, 2021	
UTC Engines ON:	04:27		MST Engines ON:	9:27 pm	
UTC Engines OFF:	09:38		MST Engines OFF:	2:38 am	
Total Time:	5:11	5.18hr	Flares Used:	0 BIP	279 EJECT
Pilot's Flight Summary:	Departed CYS for MB-4 @ 20kft. Once on track, flew a lap to find what LWC was present and found 19.5kft optimal for seeding. Firing EJs twice a minute in the good LWC found at the south end of the track, and one EJ a minute at the north end with slightly less LWC. Throughout the flight, cloud tops dropped slightly, so we adjusted our seeding altitude. Towards the last third of the flight, conditions showed significant SLW				

	in the northern portion of the track and finished seeding with EJs every 30 seconds. We returned to CYS due to low fuel and all EJs spent.
Synoptic Analysis:	Quasi-zonal flow is in place at upper levels this morning with a jet streak over the Great Basin nosing into Colorado. A shortwave trough will push through our region late tonight and tomorrow morning. A cold front pushes through the region tomorrow morning. PWAT has improved overnight, and we should see values between 0.30 and 0.40 inches through tomorrow evening before dry air returns. Low level (700mb) RH lags, however, and dry low levels will delay the development of significant orographic clouds until late this evening. Seeding level winds will be around 35 kts this evening and tonight from the west. Mid and low level temps will be dropping steadily through tomorrow evening, and then significant warming will occur tomorrow night through Monday as ridging returns. The next active weather will arrive around the middle of next week when the next trough pushes through the Rockies.
Area Forecast:	WMI models are showing much better SLW in today's runs with less natural ice crystals, and a MB flight looks promising overnight. A flight is scheduled to begin seeding around 11pm local time for the MB4 track. There looks to be a lull in activity tomorrow morning, and then there will be a slight chance for another flight tomorrow afternoon or early evening in either the MB or NS. The SM does not appear to be worthwhile throughout this event due to shallow SLW. Conditions at CYS appear favorable for overnight operations with no precipitation or low ceiling/visibility issues. Storm total QPF will be on the lighter side with this event, averaging 3-5 inches of snow accumulation by late Saturday. Colder air invades Saturday behind the cold front. Dry warmer conditions return Sunday and Monday, and then the next batch of moisture will start to reach WY Tuesday into Wednesday. Longer range models are suggesting a potential seeding window on Wednesday, but this will surely evolve in coming days.
Flight occurred in the evening hours of the 19th; weather information is from Nov. 19th.	



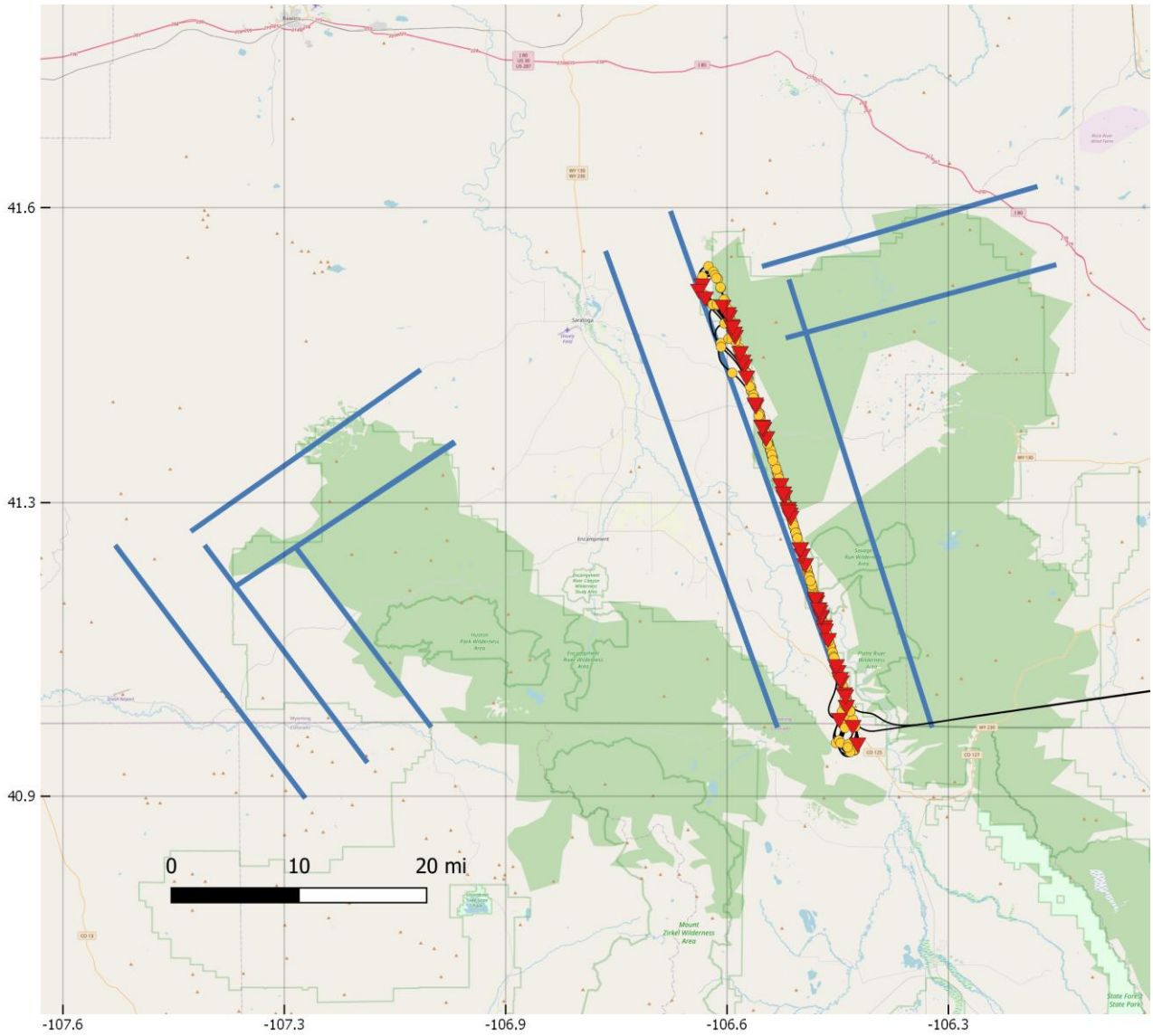
N6111V	OPS #:	05			SEED
	Track(s)/Basin:		MB-1, MB-2		
UTC Date:	November 24, 2021		MST Date:	November 24, 2021	
UTC Engines ON:	14:53		MST Engines ON:	7:53 am	
UTC Engines OFF:	18:46		MST Engines OFF:	11:46 am	
Total Time:	3:53	3.88hr	Flares Used:	0 BIP	174 EJECT
Pilot's Flight Summary:	Departed CYS for MB-1 @ 15kft. Once on track, tops were between 14k & 15kft. We found sufficient SLW. Radar instructed us to start firing EJs at two per minute. Later in the flight clouds started to separate and we started to see holes to the ground. Radar instructed us to fly down to track MB-2 and see what we could find. We reported SLW and solid cloud tops and continued to fire EJs at one per minute. Once clouds started to				

	break up and liquid water was less than sufficient, we reported what we had and were instructed to RTB.
Synoptic Analysis:	Upper level charts show the ridge exiting to the east and moderate southwest flow over our region. A trough moves into the northern Rockies tonight and tomorrow bringing decent vorticity advection. An associated cold front pushes southeast through our region this evening after sunset. This will be a moisture-starved system, and PWAT struggles to climb above 0.20 inches throughout the event. WMI models indicate SLW will remain too shallow for ops in the NS range throughout this storm. It will be too shallow for ops in the MS/SM through dawn, but we may see a narrow window of adequate SLW starting just after sunrise tomorrow morning through noon. By tomorrow evening, we will be behind the trough axis with cool northwest flow and drier air sets in. Ridging returns Thursday. We then look to remain in dry warm weather through the weekend and through next week under a persistent ridge.
Area Forecast:	Low and orographic cloud cover will continue to increase through this evening along with upper level cloud layers. The cold front sweeps through this evening, and then the trough moves through tonight and tomorrow. Moisture is insufficient for deep targetable SLW through tonight, but light mountain snowfall will occur after midnight. Snowfall rates increase around dawn as clouds deepen, and we have a slight chance for seeding around sunrise tomorrow morning until about noon. The best chance for operations appears to be in the MB range tomorrow morning. There appear to be no chances for seeding in the NS range, and the SM cloud depth is not as good as the MB tomorrow. The MB will see a few inches of snow accumulation by tomorrow afternoon. Snowfall ends tomorrow around sunset, and then cold northwest flow will bring cool temps tomorrow night behind the trough. Thursday will see a warmup as ridging returns, and then we enter a long period of doldrums with dry warm conditions. Long range models show nothing remotely adequate for seeding this weekend through next week with unseasonably warm temperatures.
Flight occurred in the morning hours of the 24th; weather information is from Nov. 23rd.	



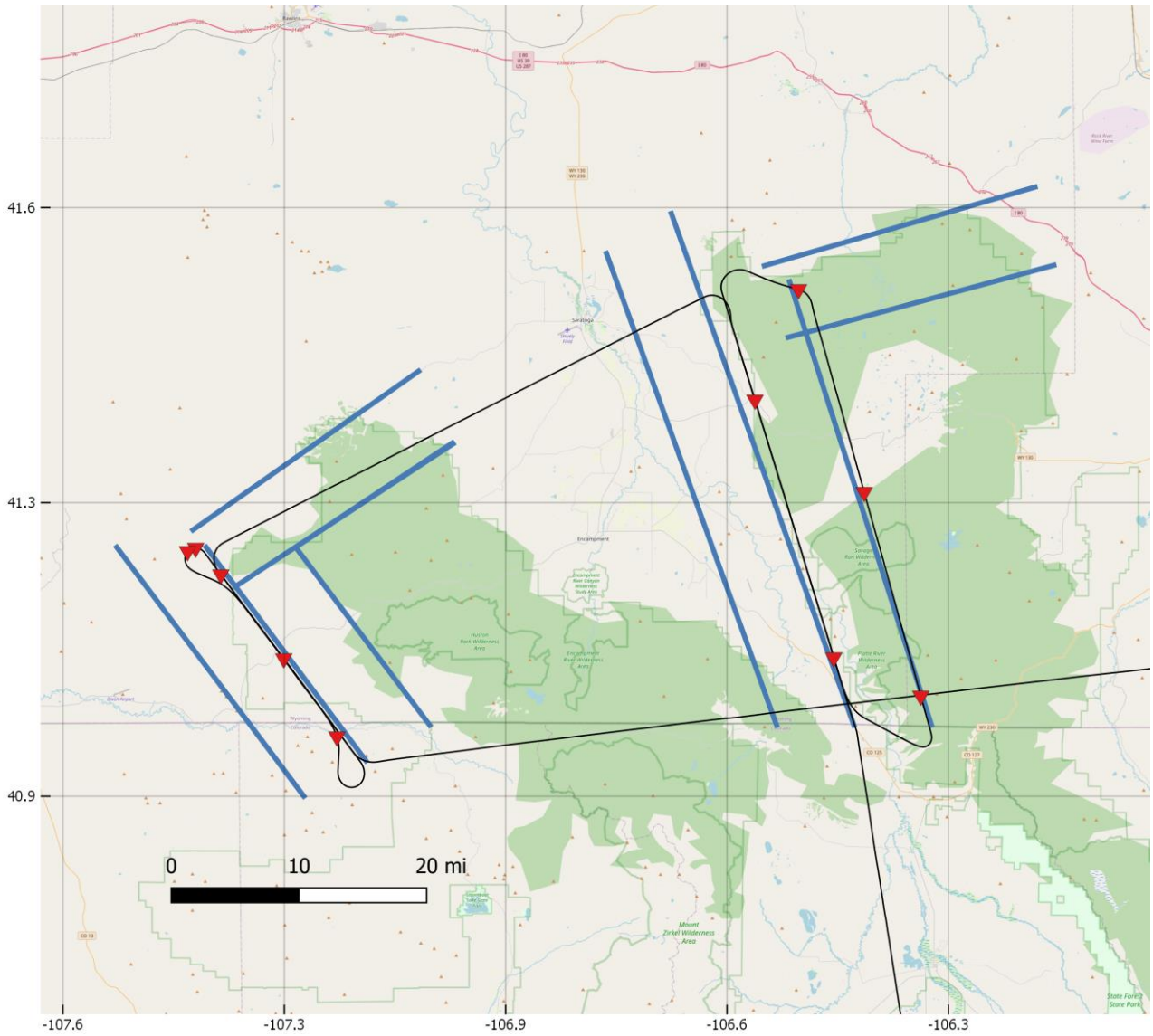
N6111V	OPS #:	06			SEED
	Track(s)/Basin:		SM-4, SM-5		
UTC Date:	December 9, 2021		MST Date:	December 8, 2021	
UTC Engines ON:	00:56		MST Engines ON:	5:56 pm	
UTC Engines OFF:	05:37		MST Engines OFF:	10:37 pm	
Total Time:	4:41	4.68hr	Flares Used:	9 BIP	248 EJECT
Pilot's Flight Summary:	Departed CYS for SM-4 starting at 13kft. shortly changed to SM-5 for better conditions and LWC proved to be much higher. Throughout the flight, cloud tops ascended, and we adjusted our altitude as required to stay just above the majority of the cloud tops, occasionally entering cloud tops to check LWC. LWC proved to be plentiful until the end of the flight when radar instructed us to RTB to rechem, refuel, and be ready to go for another wave of great LWC.				

Synoptic Analysis:	The small ridge is exiting to the east, and a major winter storm approaches from the west as a large upper trough. This system will bring heavy snow accumulation to the ranges this evening through Friday. Waves of vorticity will impact the ranges this evening through Friday evening, but the best dynamics will be later tomorrow and Friday as the main trough axis pushes through. The cold front arrives Thursday morning. The best seeding conditions appear to be this evening and tonight in the early prefrontal hours of the system as moisture advection, warmer temperatures, and stronger orographic enhancement create deep targetable SLW with less midlevel cloud. Seeding conditions appear excellent through morning, and then deep midlevel cloud moves in tomorrow and Friday depleting SLW and creating poor conditions at the CYS airport Thursday afternoon and Friday. Dry cold conditions are expected Friday night, and then dry warmer conditions are expected for the weekend and Monday as ridging returns. The next system arrives Tuesday/Wednesday.
Area Forecast:	Shallow orographic clouds are in place at forecast time, but they will improve throughout the afternoon becoming seedable around sunset. Deep targetable SLW is expected this evening and tonight, and at least one (probably two) seeding flights are anticipated. Seeding level winds will be westerly around 50 knots tonight, and the SM4/MB4 tracks appear favorable with a mix of EJs and BIPs. Seedable conditions are also expected in the NS range, but the WY ranges will take priority throughout this storm, and NS seeding is not expected. Pilots will need to rest tomorrow morning, and then conditions at CYS will deteriorate around noon tomorrow with low ceilings/snow/poor visibility while SLW over the ranges drops below seeding threshold. Seeding appears unlikely tomorrow and Friday. Winter Storm Warnings have been issued for this system with 1 to 2 feet of snow likely in the highest terrain by Friday. WMI models indicate scant SLW Thursday and Friday. While operations will probably be impossible due to poor airport conditions, it appears will not be missing any good SLW tomorrow or Friday. Dry conditions are likely Saturday through Monday as another ridge pushes through, and then another potent system arrives Tuesday into Wednesday bringing another chance for seeding.
Flight occurred in the evening hours of the 8th; weather information is from Dec. 8th.	



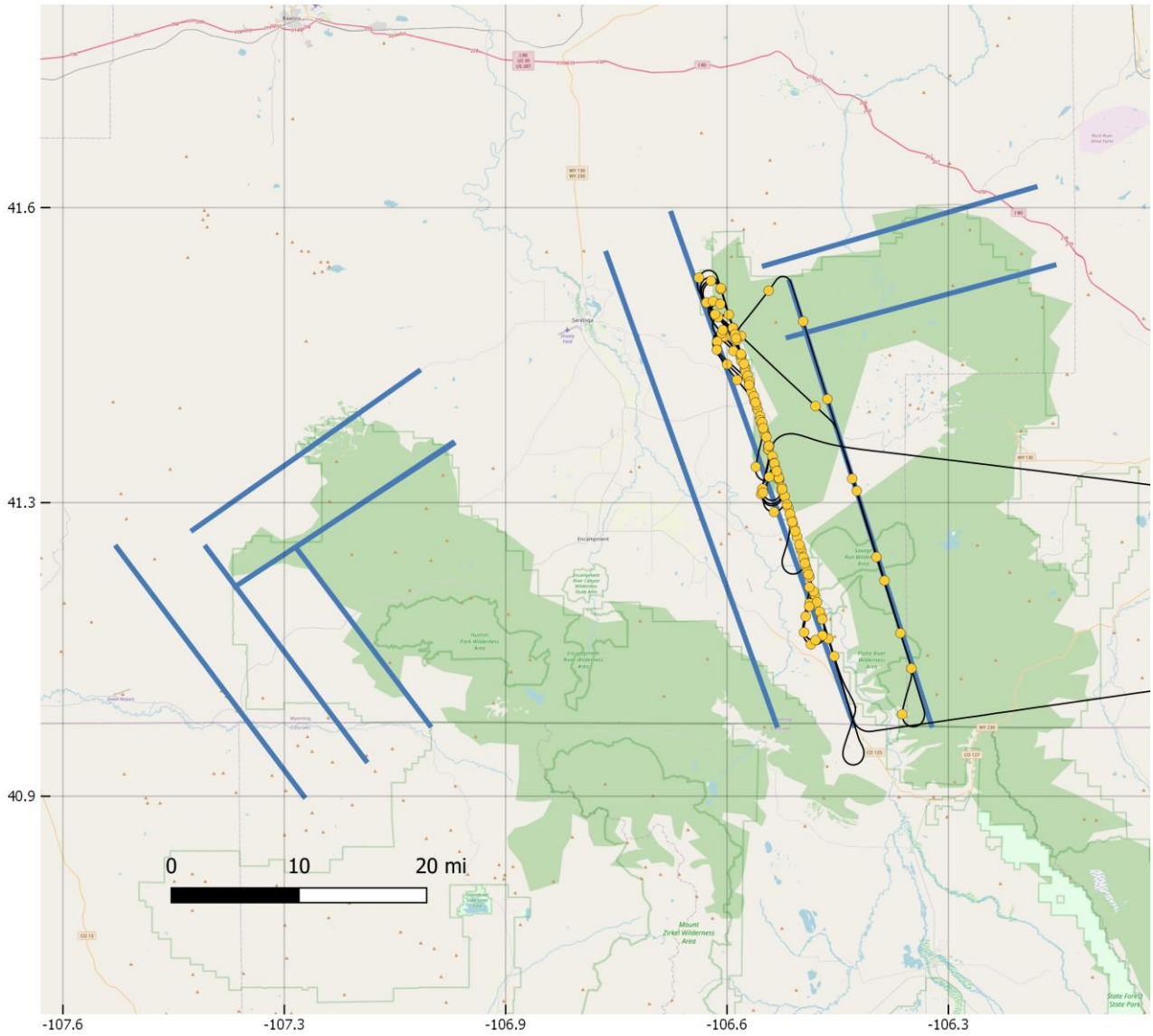
N6111V	OPS #:	07			SEED
	Track(s)/Basin:		MB-4		
UTC Date:	December 9, 2021		MST Date:	December 8, 2021	
UTC Engines ON:	06:46		MST Engines ON:	11:46 pm	
UTC Engines OFF:	11:55		MST Engines OFF:	4:55 am	
Total Time:	5:09	5.15hr	Flares Used:	40 BIP	212 EJECT
Pilot's Flight Summary:	Departed CYS for MB-4 started @ 16kft. and descended with the cloud tops as required. LWC was sufficient for BIPs and EJs as instructed by radar. Seedable clouds were lacking at the very north and south ends, so cutting off a couple miles was occasionally necessary. Seeding conditions were great for the entire flight until needing to return to CYS for fuel and crew rest.				

Flight occurred in the evening hours of the 8th; weather information remains the same as MBSM Ops #6.



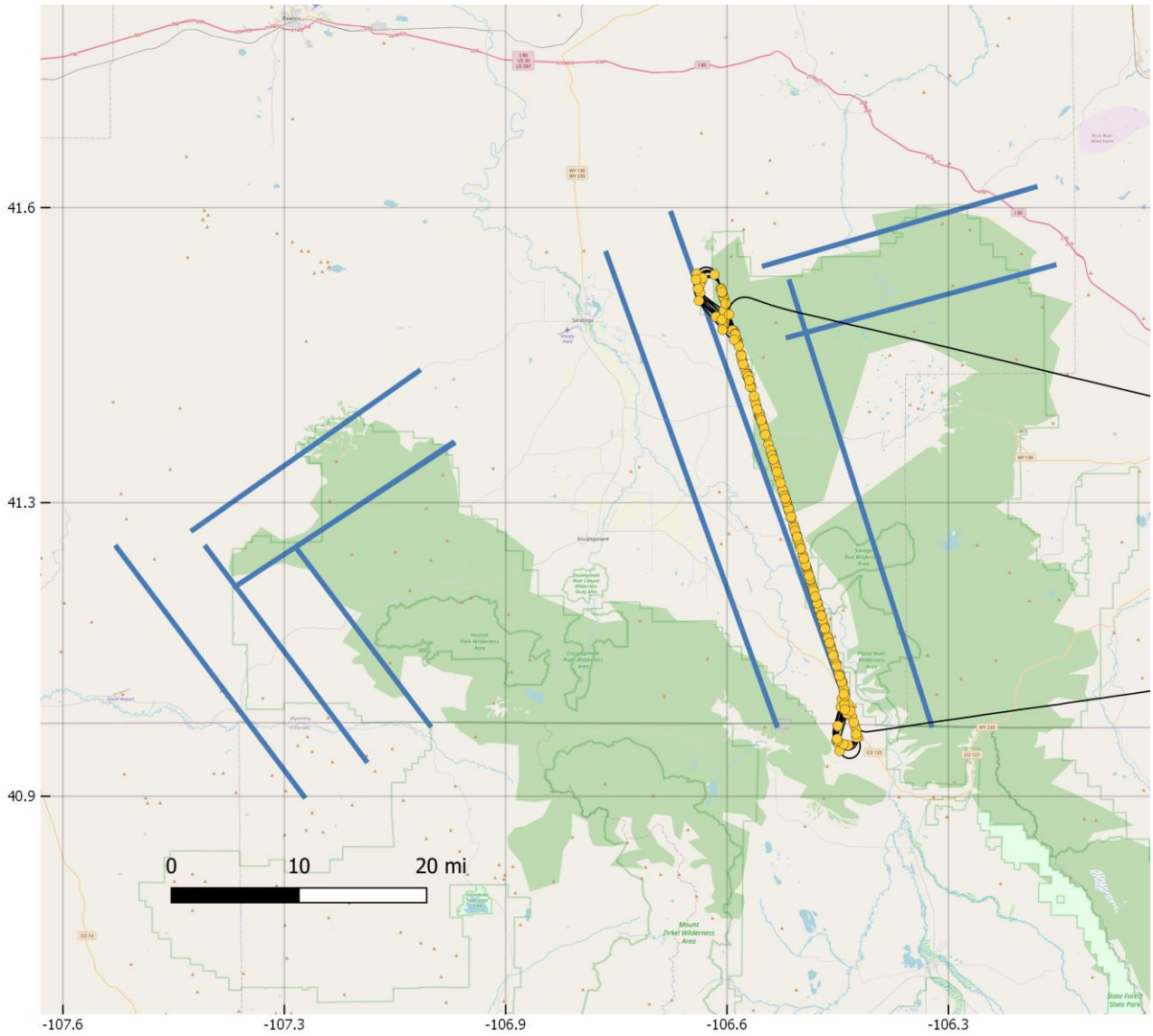
N6111V	OPS #:	08			SEED
	Track(s)/Basin:		MB-4, MB-5, SM-4		
UTC Date:	December 15, 2021		MST Date:	December 15, 2021	
UTC Engines ON:	14:48		MST Engines ON:	7:48 am	
UTC Engines OFF:	16:45		MST Engines OFF:	9:45 am	
Total Time:	1:57	1.95hr	Flares Used:	8 BIP	0 EJECT
Pilot's Flight Summary:	Departed CYS for the NS Range @ 14kft. Once on track, we did not find liquid water, but models showed LWC below our position. The project mets instructed us to start firing EJs once a minute. With conditions not improving and only flying in ice crystals, the mets instructed us to stop seeding and move to the MB Range. We found high LWC on the way to MB, but nothing found on track. The mets instructed us to light BIPs continuously for broadcast seeding. The mets then instructed us to check conditions on the track east of MB-4 (MB-5) to see if there was a presence of LWC. No conditions				

	existed for seeding, so the mets instructed us to stop seeding and fly to the SM Range. Conditions were checked at 13kft but no LWC was found. The mets instructed us to continue using BIPs for broadcast seeding. The mets directed us to RTB to rechem and refuel for potential ops later today.
Synoptic Analysis:	A deep trough along the coast continues to draw impressive amounts of Pacific moisture onshore with an Atmospheric River setup. A southwesterly upper jet is in place over our region. The coastal trough moves inland today, reaching WY late tonight through tomorrow afternoon. The best dynamics still look to stay south of our ranges, but all target ranges will see some accumulating snow tomorrow morning and afternoon. This will be a relatively warm wet system with PWAT around 0.35 to 0.4 inches. As midlevel temps fall with the approaching trough axis tomorrow, instability is likely in the morning, particularly with the passage of the leading cold front in the morning. Convective snow squalls will be possible. The high winds with steep lapse rates could present operational challenges with turbulence tomorrow morning, but it will also increase targetable SLW. A very small shortwave ridge pushes through tomorrow evening/night, and then another (colder/drier) trough moves through Thursday into Friday bringing more seeding chances.
Area Forecast:	Overcast layers and thin orographic clouds are expected to diminish through sunset with a few hours of clearing this evening/tonight. Areas prone to downslope winds will see extremely gusty winds today with CYS potentially experiencing gusts up to 75 mph. These winds will moderate overnight. Deep low cloud moves in before dawn with the approach of the cold front. Deep overcast layers and thick orographically enhanced low clouds are expected from around dawn to sunset tomorrow. The best seeding conditions will be from sunrise to midafternoon. All ranges will see around 3 to 6 inches of snowfall by sunset tomorrow. Two flights are possible tomorrow. This fast-moving system exits by tomorrow evening giving us a break in the action tomorrow evening/overnight. We look to have another longer seeding window Thursday through early Friday with the next incoming trough from the northwest. This will be a colder system with less moisture, but WMI models are hinting at decent orographic clouds and SLW Thursday-early Friday. Transient ridging will bring dry conditions Saturday, and then another progressive trough arrives Sunday with cool air and light moisture providing another potential seeding window. Next week looks to remain active with a possible major system midweek.
Flight occurred in the morning hours of the 15th; weather information is from Dec. 14th.	



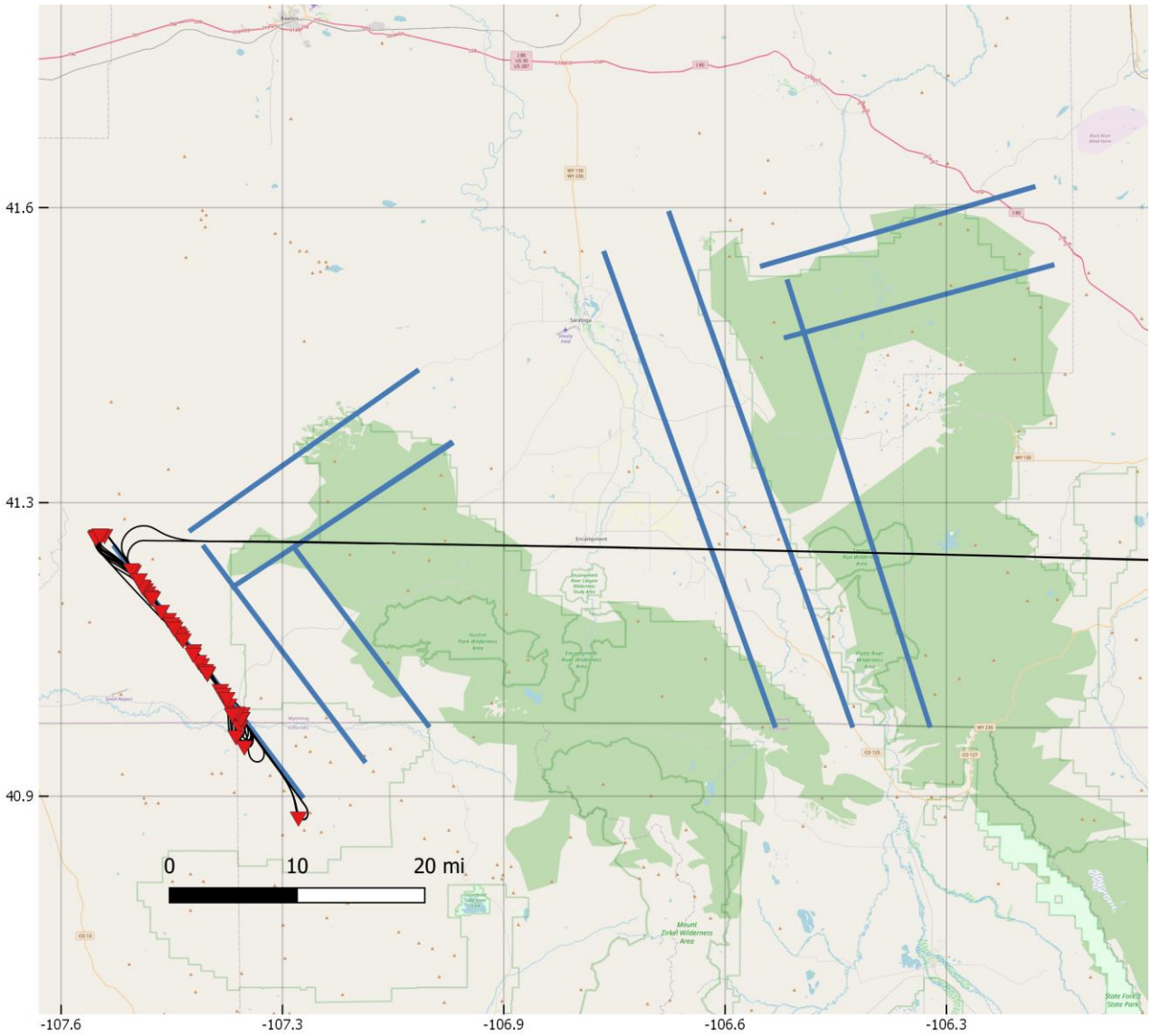
N6111V	OPS #:	09			SEED
	Track(s)/Basin:		MB-4, MB-5		
UTC Date:	December 17, 2021		MST Date:	December 16, 2021	
UTC Engines ON:	05:04		MST Engines ON:	10:04 pm	
UTC Engines OFF:	09:19		MST Engines OFF:	2:19 am	
Total Time:	4:15	4.25hr	Flares Used:	0 BIP	129 EJECT
Pilot's Flight Summary:	Departed CYS for the MB range (MB-4) @ 14kft. Good LWC was found at the beginning of the flight and was forecasted to get better. As we flew the track, the south half started to clear out and we were instructed to stay on the northern half of the track. Models showed LWC downwind of our track and the mets requested us to fly the MB-5 track to see what we could find for LWC. Good LWC was found at the north end of MB-5 and the mets had us return to the MB-4 track due to higher winds. Seeding continued				

	until conditions started to clear out downwind of our seeding track. The mets instructed us to RTB once conditions downwind started to clear out.
Synoptic Analysis:	Jet level charts show a westerly jet streak over our region and Colorado today while an incoming trough from the northwest meanders into the Rockies from the PACNW. This will be a cooler system with relatively light moisture as it pushes through today and tomorrow. PWAT will peak around 0.25 inches this evening and then slowly drop off tonight and tomorrow while the 500mb temps drop from around -26C this evening to around -29C tomorrow. While these temps aloft are typically on the cold side for seeding operations, our models are indicating some periods of light (but persistent) SLW this evening through midday tomorrow. Seeding level winds will be moderate, around 30-40 knots tonight and tomorrow, yet sufficient for orographic snow/SLW. Low level RH plummets tomorrow evening with a flat ridge moving in, bringing dry weather Friday night through at least Tuesday. Another round of active weather arrives Wednesday when a powerful Pacific system off the California coast finally moves onshore.
Area Forecast:	By chance, we currently have a third pilot in CYS, so we have the option to do three consecutive flights on this system if conditions warrant. Orographic clouds and snowfall will improve through this afternoon and evening, and then light continuous mountain snow is expected late this evening through tomorrow afternoon. Temps are certainly on the cold side for seeding, but models continue to indicate marginally targetable SLW this evening through midday tomorrow. SLW does not appear to be overly deep, but it is targetable with ejectables if models verify. A seeding flight is scheduled for 3Z (8pm MST) this evening for the NS4 tracks. Following that flight, a second flight on the MB/SM is expected. If conditions are good on the second flight, a third flight may be possible on the MB/SM tomorrow from mid morning to early afternoon. With temps as cold as they are at midlevels, it will not be surprising if we find the models to be incorrect and SLW to be too scarce to continue. However, we will plan for three flights and hope it works out. Dry conditions return Friday evening through Tuesday while a massive low plants itself off the coast. This system will finally kick inland around midweek bringing another chance of seeding Wednesday-Thursday.
Flight occurred in the evening hours of the 16th; weather information is from Dec. 16th.	



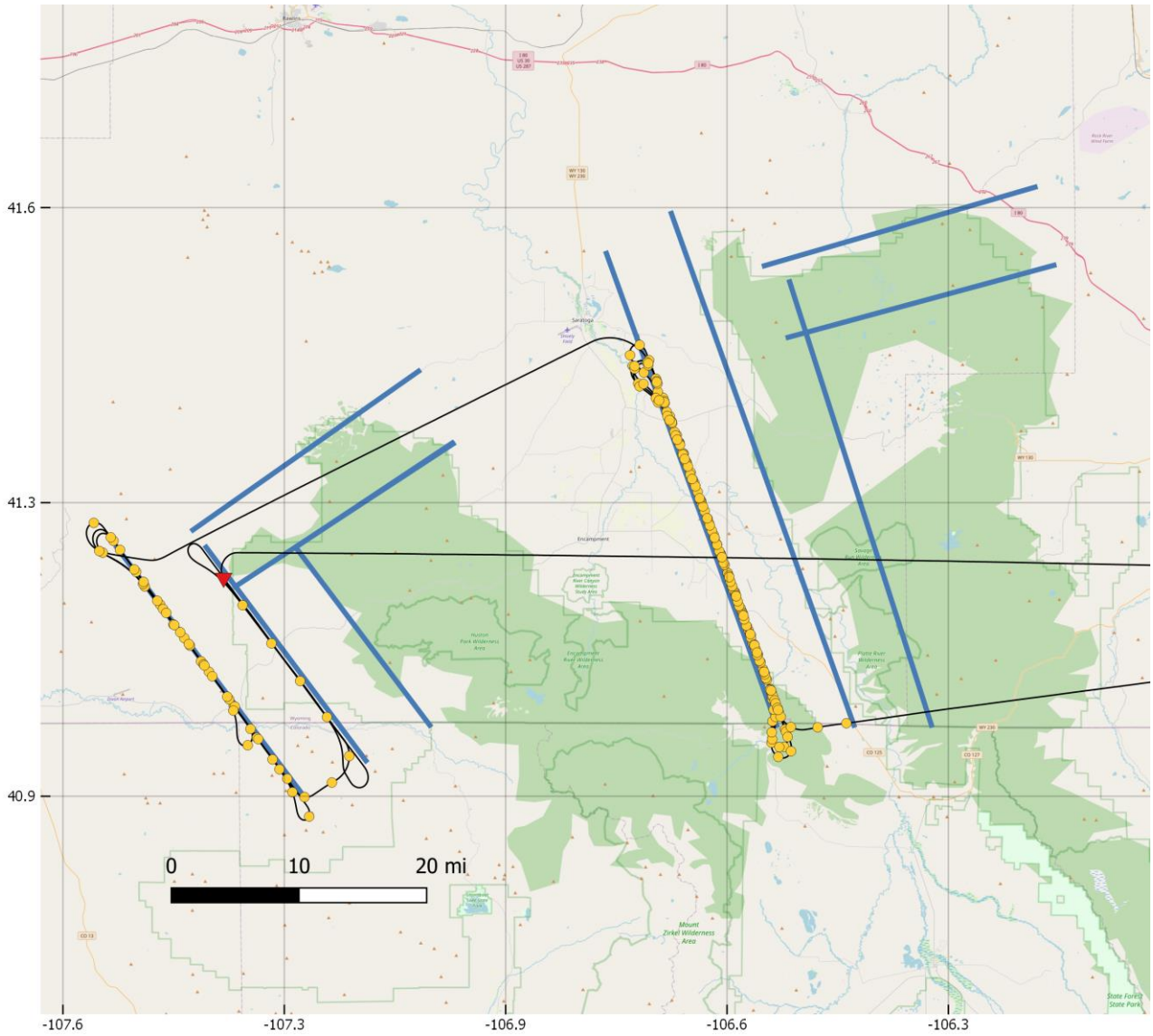
N6111V	OPS #:	10			SEED
	Track(s)/Basin:		MB-4		
UTC Date:	December 17, 2021		MST Date:	December 17, 2021	
UTC Engines ON:	14:07		MST Engines ON:	7:07 am	
UTC Engines OFF:	19:31		MST Engines OFF:	12:31 am	
Total Time:	5:24	5.4hr	Flares Used:	0 BIP	218 EJECT
Pilot's Flight Summary:	Departed CYS for MB-4 track @ 14kft. We found good LWC on the way to the track and found up to .2 LWC on track. The mets instructed us to start with broadcast seeding firing EJs once a minute, while conditions were forecasted to improve throughout the flight. Shortly after initial broadcast seeding, pockets of higher LWC were found and the mets instructed us to fire extra EJs in the pockets of LWC. once running low on fuel, we RTB.				

Flight occurred in the evening hours of the 16th; weather information remains the same as MBSM Ops #9.



N6111V	OPS #:	11			SEED
	Track(s)/Basin:		SM-3		
UTC Date:	December 23, 2021		MST Date:	December 23, 2021	
UTC Engines ON:	23:47		MST Engines ON:	4:47 pm	
UTC Engines OFF:	04:58		MST Engines OFF:	9:58 pm	
Total Time:	5:11	5.18hr	Flares Used:	0 BIP	38 EJECT
Pilot's Flight Summary:	Departed CYS for SM-3 @ 14kft. Once on track, clouds were patchy below the track line, but looked good to the east for seeding. The mets instructed us to start using BIPs continuously for broadcast seeding. Due to winds, we shortened the southern part of the track. Conditions remained the same for the remainder of the flight and BIPs were used for all seeding. Due to high winds on the way to the SM-3 track, and on track, we were running low on fuel before using all of the BIPs. RTB @ 4:20Z.				

Synoptic Analysis:	An intense westerly jet streak is in place over our region, and a deep system off the west coast continues to pump copious moisture inland as an Atmospheric River event unfolds for the west coast. With strong low level winds and abundant moisture over our ranges, orographic clouds have been excellent throughout the day with aircraft reporting moderate to heavy SLW. Similar conditions are likely through tomorrow. A bit of a lull is anticipated Saturday as the remnants of the Pacific system move east through the Four Corners. Another reinforcing digging through moves down the coast toward Vancouver over the weekend, keeping us in a similar pattern through much of the coming week with a Pacific moisture tap from a coastal low. Winter Storm Warnings are in effect project wide, and an avalanche watch has also been issued. No suspension criteria have been met so far.
Area Forecast:	The aircraft is currently being fueled and flared in preparation for a second flight later today. Deep SLW and excellent seeding conditions are anticipated on this flight according to WMI models. Good conditions will persist through the night, but pilot duty day will cause a break in operations tonight. Seeding will begin again tomorrow morning, and two more flights are expected during the day tomorrow. Conditions at CYS will be less favorable tomorrow with snow/rain. However, afternoon high temperatures should be warm enough that we can continue to operate during the warmer part of the day without any trouble. No seeding will occur Saturday. More seedable clouds appear likely Sunday, and then the longer range forecast is for numerous potential seeding windows throughout next week as we remain in a wet pattern.
Flight occurred in the evening hours of the 23rd; weather information is from Dec. 23rd.	

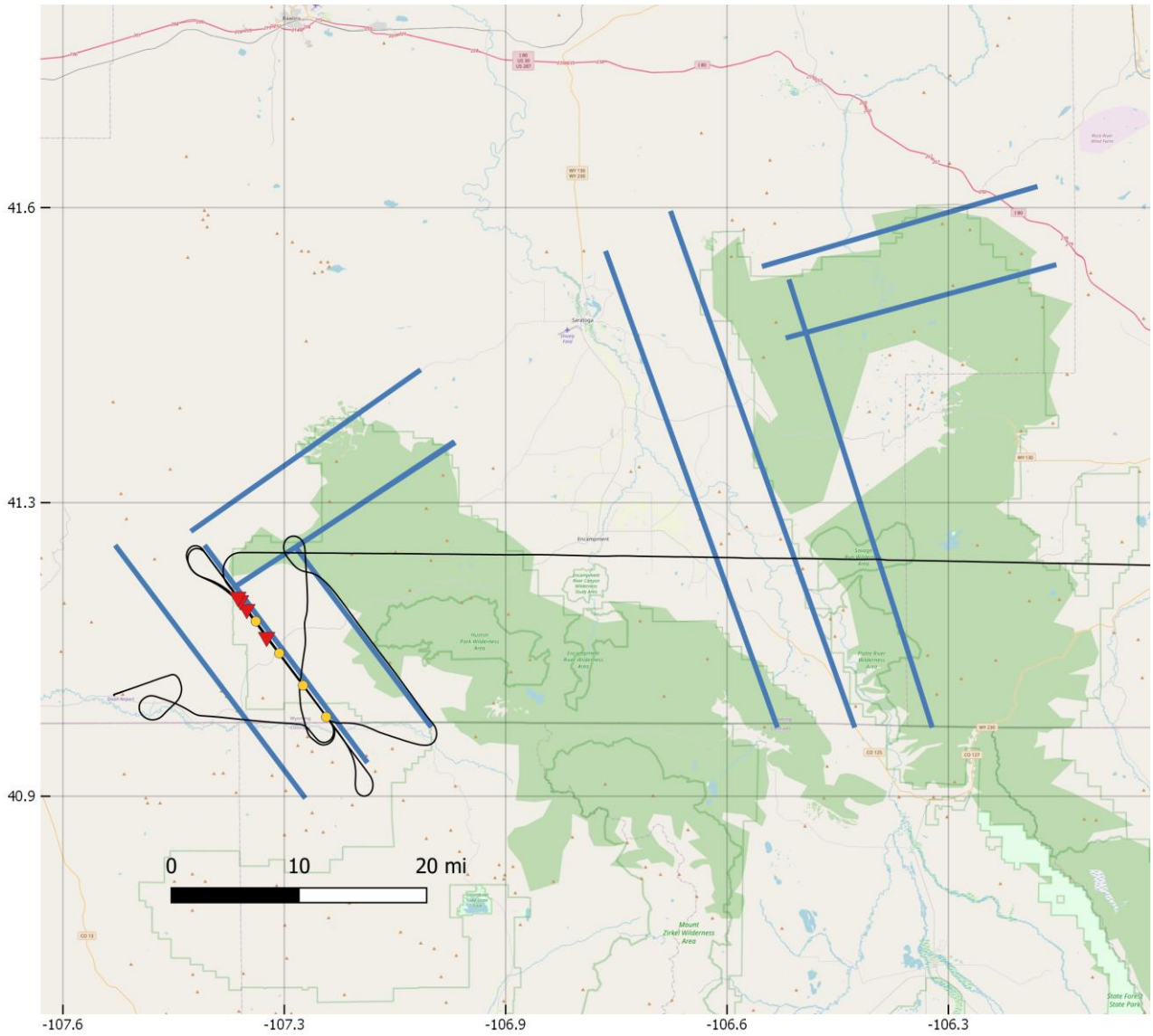


N6111V	OPS #:	12			SEED
	Track(s)/Basin:		SM-4, SM-3, MB-3		
UTC Date:	December 25, 2021		MST Date:	December 24, 2021	
UTC Engines ON:	03:07		MST Engines ON:	8:07 pm	
UTC Engines OFF:	07:16		MST Engines OFF:	12:16 am	
Total Time:	4:09	4.15hr	Flares Used:	1 BIP	192 EJECT
Pilot's Flight Summary:	Departed CYS for SM-4 @ 14kft. Good LWC was found on the way to the track. Once on track, we were in the clouds and were instructed to use BIPs. Shortly after we were in and out of cloud tops and instructed to use EJs once a minute. With winds changing, we moved to SM-3. Once convection moved in, the mets instructed us to pause seeding and move to the MB-				

	3 track. Moving over to MB-3, we picked up icing and ascended to 15kft. Once on track, LWC was still good, and started with EJs once every 30 seconds and due to winds and conditions, we cut off the north 4 miles of the track. Due to the storms approaching Laramie and quickly moving to CYS, we stopped seeding and RTB.
Synoptic Analysis:	The strong upper level jet that was over WY has moved eastward this morning, with the main jet stream now to the south. The midlevel pattern remains mostly unchanged; nearly zonal flow with a lot of scattered vorticity over a good portion of the western US. Moisture continues to flow into the area though it will not be quite as much as it was before. A weak cold front is expected to come through the area this evening, but it will not have a major effect. This flow of moisture into the area looks to continue through Monday.
Area Forecast:	Orographic cloud will remain over the range throughout the period. The cloud will be thickest with the most snowfall and SLW during the afternoon. After the front moves through this evening, the cloud will become shallower and snowfall and SLW will drop even through a strong cross barrier flow continues. The cloud strengthens again after midnight and snowfall will increase, but SLW will remain fairly shallow. The 700 mb temperature is steady around -7C through mid evening, then drops off tonight. Decent snowfall occurs tomorrow morning and afternoon, then the cloud becomes shallower by evening and only light scattered snowfall is expected in the evening and night. More snowfall is expected Sunday morning and afternoon. SLW will be shallow, but strong cross barrier flow is expected.
Flight occurred in the evening hours of the 24th; weather information is from Dec. 24th.	

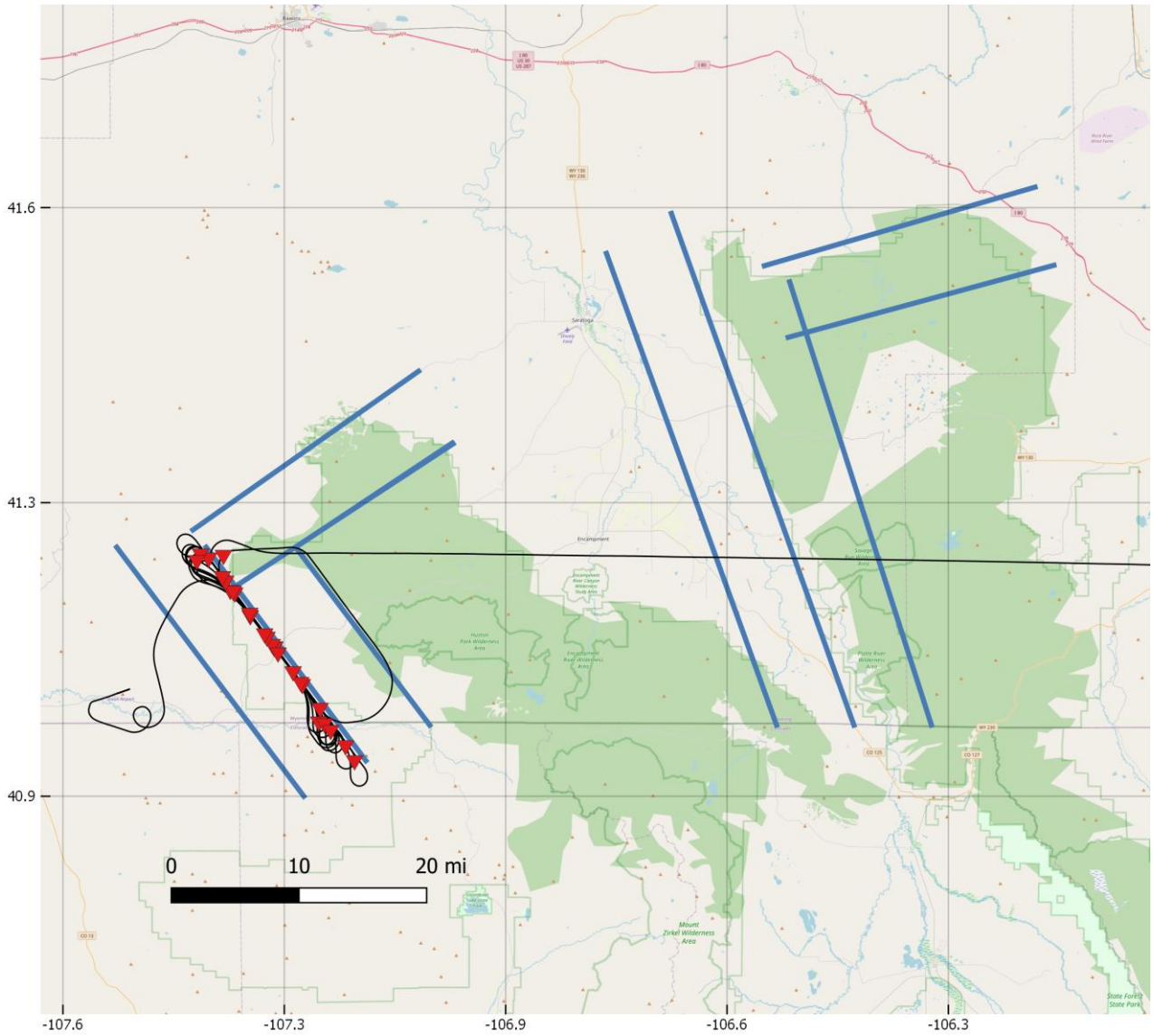
Flight track unavailable for this mission.

N6111V	OPS #:	13			SEED
	Track(s)/Basin:		SM-3		
UTC Date:	December 26, 2021		MST Date:	December 26, 2021	
UTC Engines ON:	16:33		MST Engines ON:	9:33 am	
UTC Engines OFF:	18:04		MST Engines OFF:	11:04 am	
Total Time:	1:31	1.52hr	Flares Used:	0 BIP	3 EJECT
Full flight summary continued in the table for Never Summer Ops #5.					



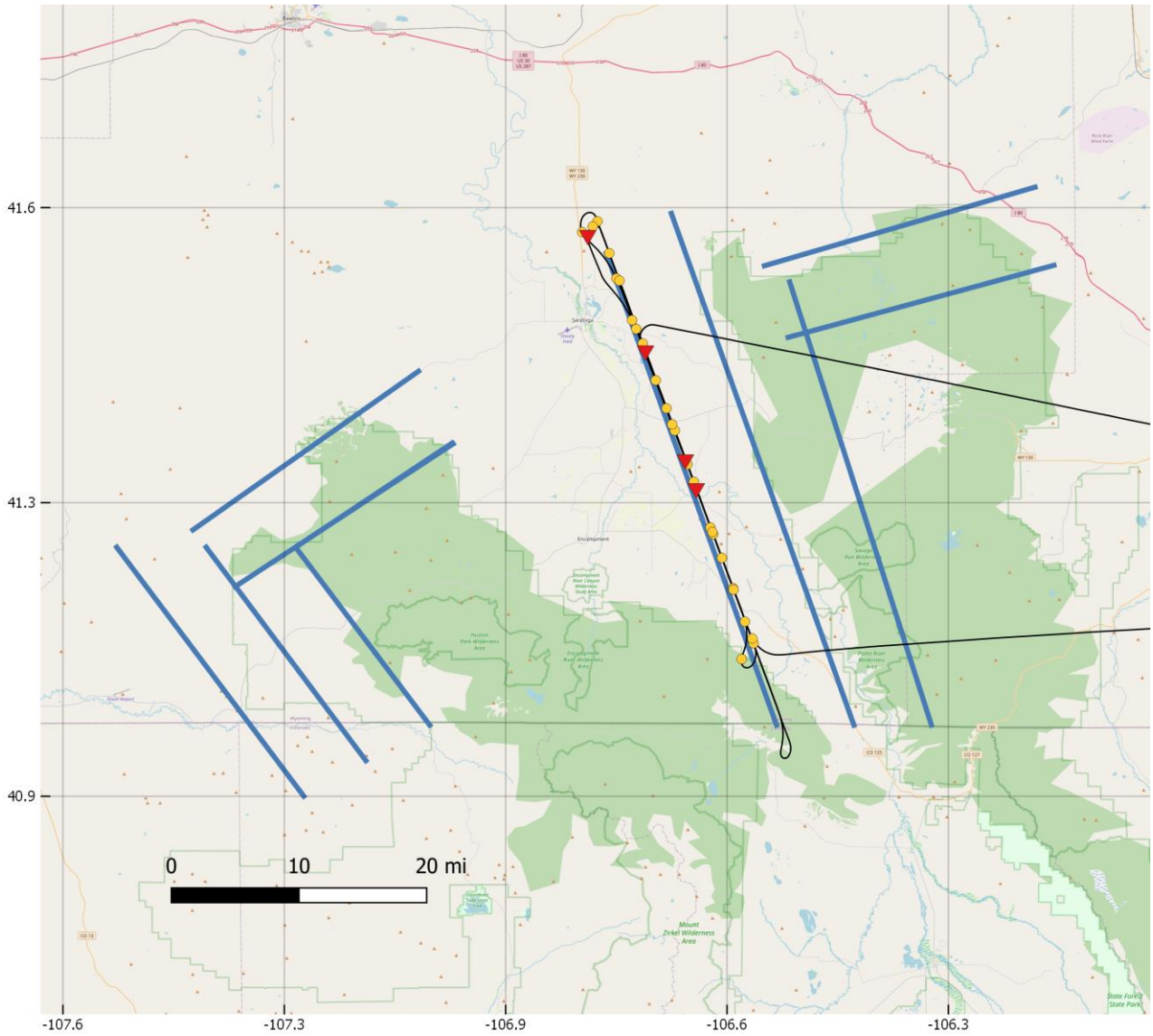
N6111V	OPS #:	14			SEED
	Track(s)/Basin:		SM-4		
UTC Date:	December 30, 2021		MST Date:	December 30, 2021	
UTC Engines ON:	13:23		MST Engines ON:	6:23 am	
UTC Engines OFF:	15:23		MST Engines OFF:	8:23 am	
Total Time:	2:00	2hr	Flares Used:	2 BIP	4 EJECT
Pilot's Flight Summary:	Departed CYS for SM-4 @ 13kft. Picked up LWC ranging up to .56 on the way to track, found .1-.2 on track and flying mostly on top of the cloud layer. The meteorologists instructed to start seeding with EJs, and shortly after conditions changed, so we switched to BIPs. Shortly after, starting BIPs, we had an urgent crew request to divert to Dixon airport (DWX) for a short bathroom break.				

Synoptic Analysis:	The blocked trough pattern persists over the Rockies with the upper jet to the south of the target ranges today. The jet will lift north into CO tonight creating stronger W flow by morning. A cold air mass remains in place with 500mb temps lingering around -28°C through morning. Temps aloft will start to warm slightly tomorrow morning. PWAT will be below 0.20 inches today, increasing slightly for tonight and tomorrow to around 0.20 inches. Lobes of vorticity will be pushing through the region today through Friday as several shortwave troughs pass through the region. As wind speeds, moisture, and stability improve overnight, SLW will return and deepen through morning providing potential for seeding early tomorrow morning starting before dawn. Seedable conditions are possible through tomorrow evening, and then SLW disappears again Friday and Saturday. Significant ridging will occur Sunday through the middle of next week.
Area Forecast:	Light snow showers will occur this afternoon and evening with shallow SLW and nothing seedable. SLW depth and snowfall rates improve slowly overnight, and targetable orographic clouds appear likely around dawn. Decent SLW looks to persist through tomorrow afternoon and into the evening which will likely provide an opportunity for two flights tomorrow. Late tomorrow night, SLW wanes as the system becomes naturally efficient with abundant midlevel snowfall. Light snowfall continues Friday and early Saturday, but seedable SLW appears unlikely. A very cold air mass will be in place for most of Saturday, and then ridging returns Sunday through the middle of next week with no chance for seeding through at least Tuesday. Another significant system appears to be on tap later next week as another large low moves down the BC coast from the Gulf of Alaska, ejecting vorticity and pumping moisture into our region.
Flight occurred in the morning hours of the 30th; weather information is from Dec. 29th.	



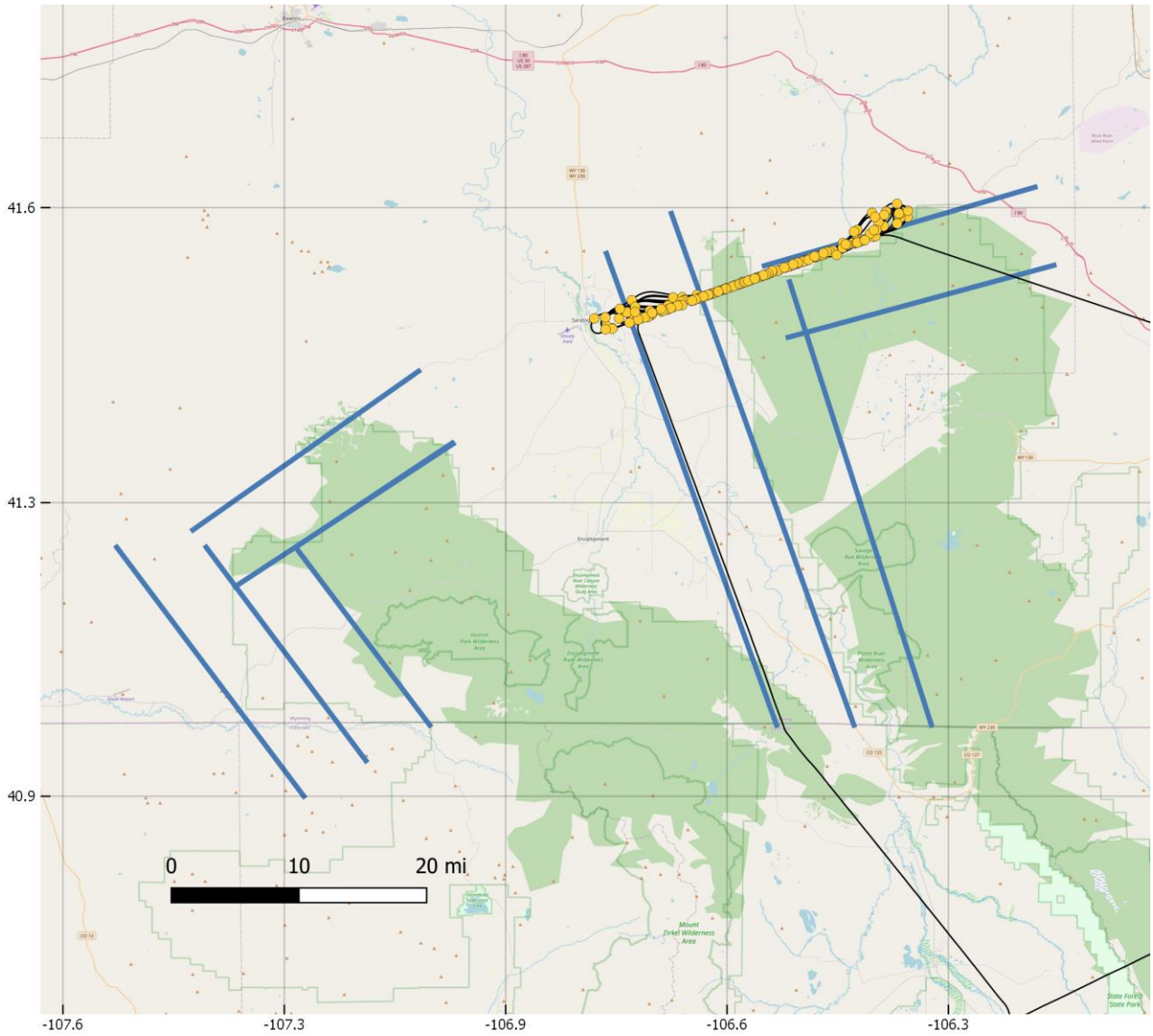
N6111V	OPS #:	15			SEED
	Track(s)/Basin:		SM-4		
UTC Date:	December 30, 2021		MST Date:	December 30, 2021	
UTC Engines ON:	15:37		MST Engines ON:	8:37 am	
UTC Engines OFF:	18:34		MST Engines OFF:	11:34 am	
Total Time:	2:57	2.95hr	Flares Used:	22 BIP	0 EJECT
Pilot's Flight Summary:	Departed DWX for SM-4 @ 13kft. Once on track, we resumed seeding with the same weather conditions on the previous flight form. Seeding occurred with BIPs and continued until LWC downwind started to diminish. At radar request and due to low fuel, we returned to CYS.				

Flight occurred in the morning hours of the 30th; weather information remains the same as MBSM Ops #14



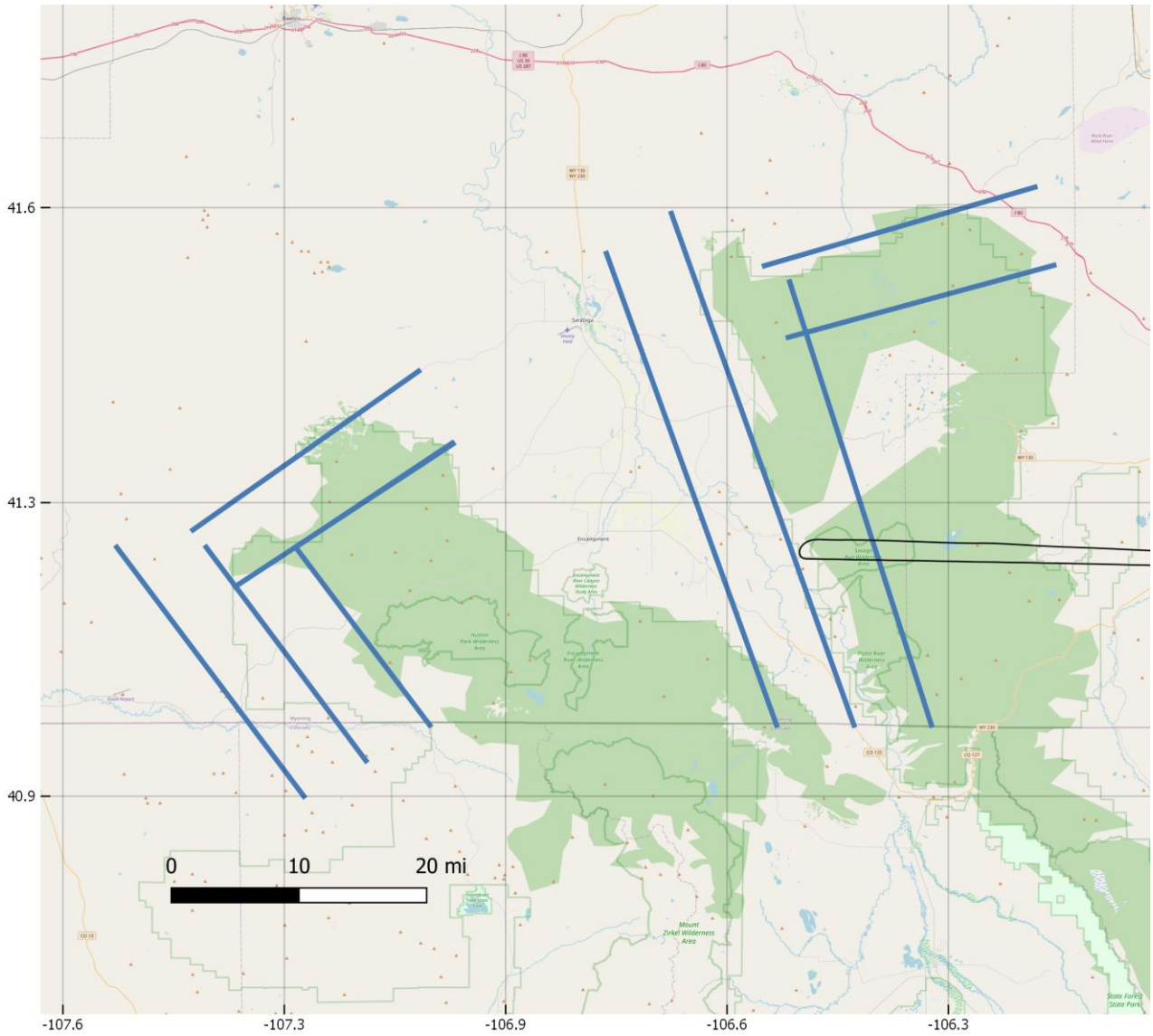
N6111V	OPS #:	16			SEED
	Track(s)/Basin:		MB-3		
UTC Date:	January 4, 2022		MST Date:	January 4, 2022	
UTC Engines ON:	16:37		MST Engines ON:	9:37 am	
UTC Engines OFF:	19:00		MST Engines OFF:	12:00 pm	
Total Time:	2:23	2.38hr	Flares Used:	4 BIP	25 EJECT
Pilot's Flight Summary:	Departed CYS for MB-3 @ 15kft. Once on track, we modified the track due to winds. We started seeding with EJs and BIPs. Due to airframe icing, we had to end seeding early and RTB.				
Synoptic Analysis:	The ridge over the Rockies will keep dry conditions in place through tonight, and then the incoming trough will start to impact our region around dawn. The incoming trough is currently rounding the south side of the coastal British Columbia low. A powerful				

	northwesterly jet is off the coast nosing into the PACNW and Montana. A strong northwesterly jet will move into our region by dawn. Midlevels show multiple lobes of vorticity moving through our area tomorrow morning through Wednesday. Low levels are quite dry today through most of tonight, becoming saturated around dawn. Moisture then looks to continue streaming into our region through Thursday evening with PWAT peaking above 0.40 inches Thursday. PWAT will steadily increase Tuesday through Thursday evening. We will see a break in the active weather Friday with a shot of dry air, and then another moisture-starved disturbance pushes through for the weekend.
Area Forecast:	Dry conditions continue today with no seeding before dawn. Three days of active weather and operations appears to be on tap starting tomorrow morning after dawn. According to latest WMI models, we will likely see two daytime seeding flights tomorrow, again on Wednesday, and at least one on Thursday. Seeding level winds will be quite strong tomorrow, around 70 knots at times. Orographic lift will be impressive, and we should see abundant deep targetable SLW throughout the period. After two flights tomorrow, we will take a break for pilot rest and then pick up operations Wednesday morning when able. Wednesday looks to have potential for very deep heavy SLW, and we will have to be extra aware of airframe icing concerns. As midlevels cool Wednesday, we will see some light instability, and we could have embedded convection Wednesday afternoon. After pilot rest Wednesday night, we will start again Thursday morning. If timing works out, we could squeeze in two flights on Thursday as well, but this will be dependent on when the dry air arrives later in the day Thursday. Heavy snow accumulation is expected in all ranges by Thursday evening with potential for 1.5 inches of SWE and over 2 feet of snow accumulation in the high country.
Flight occurred in the morning hours of the 4th; weather information is from Jan. 3rd.	



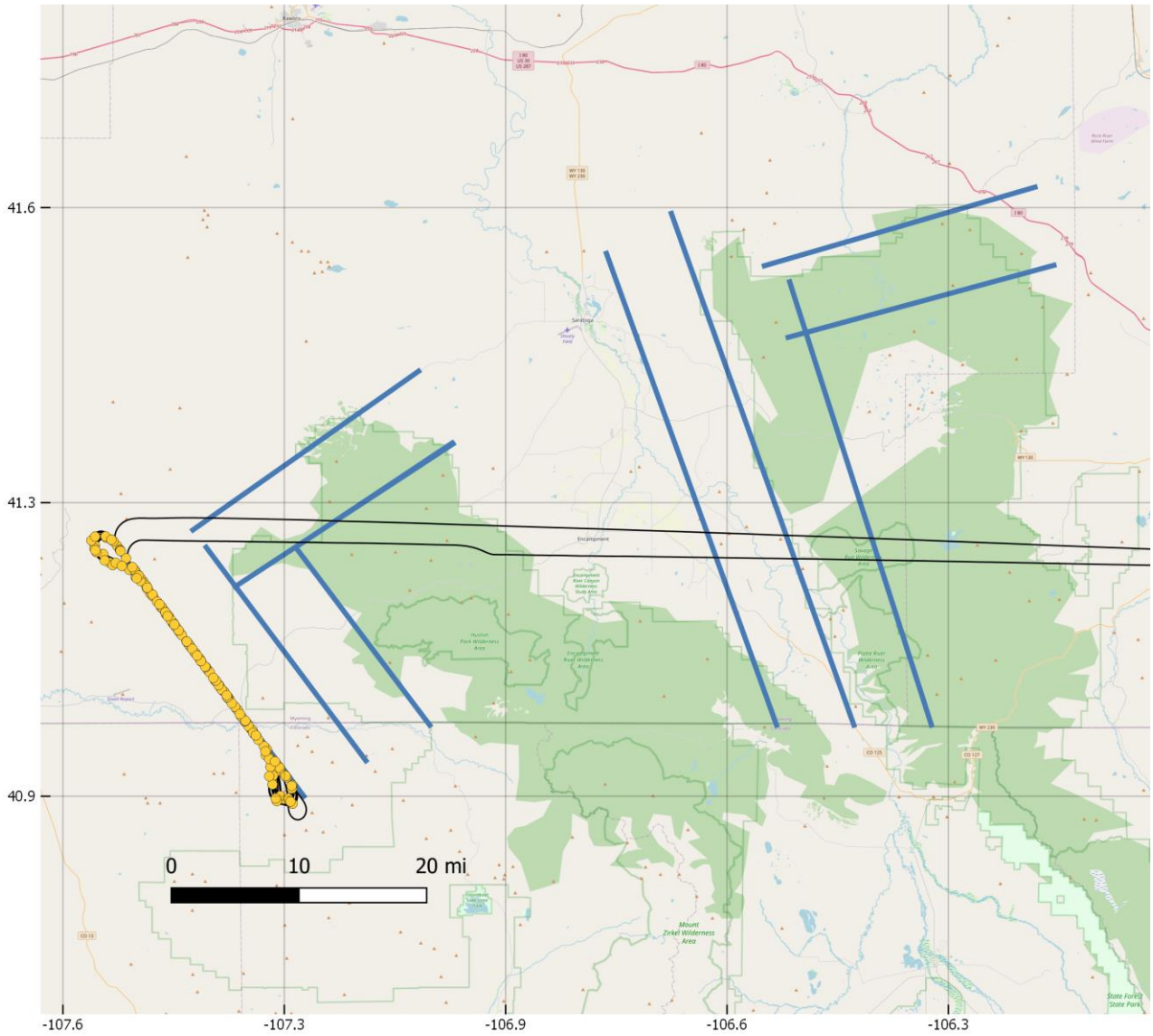
N6111V	OPS #:	17			SEED
	Track(s)/Basin:		MB-1		
UTC Date:	January 4, 2022		MST Date:	January 4, 2022	
UTC Engines ON:	23:43		MST Engines ON:	4:43 pm	
UTC Engines OFF:	03:38		MST Engines OFF:	8:38 pm	
Total Time:	3:55	3.92hr	Flares Used:	0 BIP	195 EJECT
Pilot's Flight Summary:	Departed CYS for the NS Range @ 19kft. Once on track, the conditions were not sufficient for seeding and the mets instructed us to fly up to the MB range. Once on track MB-3, winds were favoring MB-1, extending to the west. Seeding occurred with EJs only due to winds and conditions. As the flight continued, the cloud deck and tops continued to rise, making us raise our seeding altitude. We continuously found good LWC in the cloud tops and RTB when low on fuel.				

Synoptic Analysis:	Upper-level charts continue to show a strong northwesterly jet streak over the region. Seeding level winds are quite strong today, upwards of 70 knots on tracks. We look to remain in very strong northwest flow through Thursday with lobes of midlevel vorticity pushing through the region. A plume of moisture will continue flowing into the ranges through Thursday, and PWAT will steadily climb through the next 24 hours. With strong winds and good moisture, orographic clouds and SLW are impressive through Thursday. We will see a brief lull in moisture Friday with a weak ridge pushing quickly through the region, and then another impulse arrives Saturday with light moisture and light SLW. Beyond the weekend, we look to have a high amplitude ridge setting up over the Rockies early next week with a less active pattern indicated later next week.
Area Forecast:	Deep orographic clouds and heavy snowfall will continue throughout the period. Heavy SLW was observed on the first flight this morning, and this may be a limiting factor for additional operations later today. A second flight is planned for this afternoon on the MB3 track. Due to the heavy icing conditions observed earlier today, seeding will likely be attempted from relatively cold (higher altitudes) temperatures to reduce airframe icing concerns. Ejectable flares will be favored. Pilots will rest overnight, and then we will have good SLW again tomorrow with potential for two more flights during the day. Weak instability is still in the cards for tomorrow, but it does not look to be intense. Thursday will see continued seedable deep SLW, but icing conditions appear slightly lighter than today/tomorrow. We will have a break in operations Friday, and then another round of seeding appears possible for Saturday. Models have trended wetter for Saturday's system, so this is trending toward being a seedable system. Heavy snow accumulation is expected through the next 48 hours with some models indicating over 2 inches of SWE in the higher terrain by Thursday with 2 to 3 feet of snow accumulation. A Winter Storm Warning remains in effect.
Flight occurred in the afternoon hours of the 4th; weather information is from Jan. 4th.	



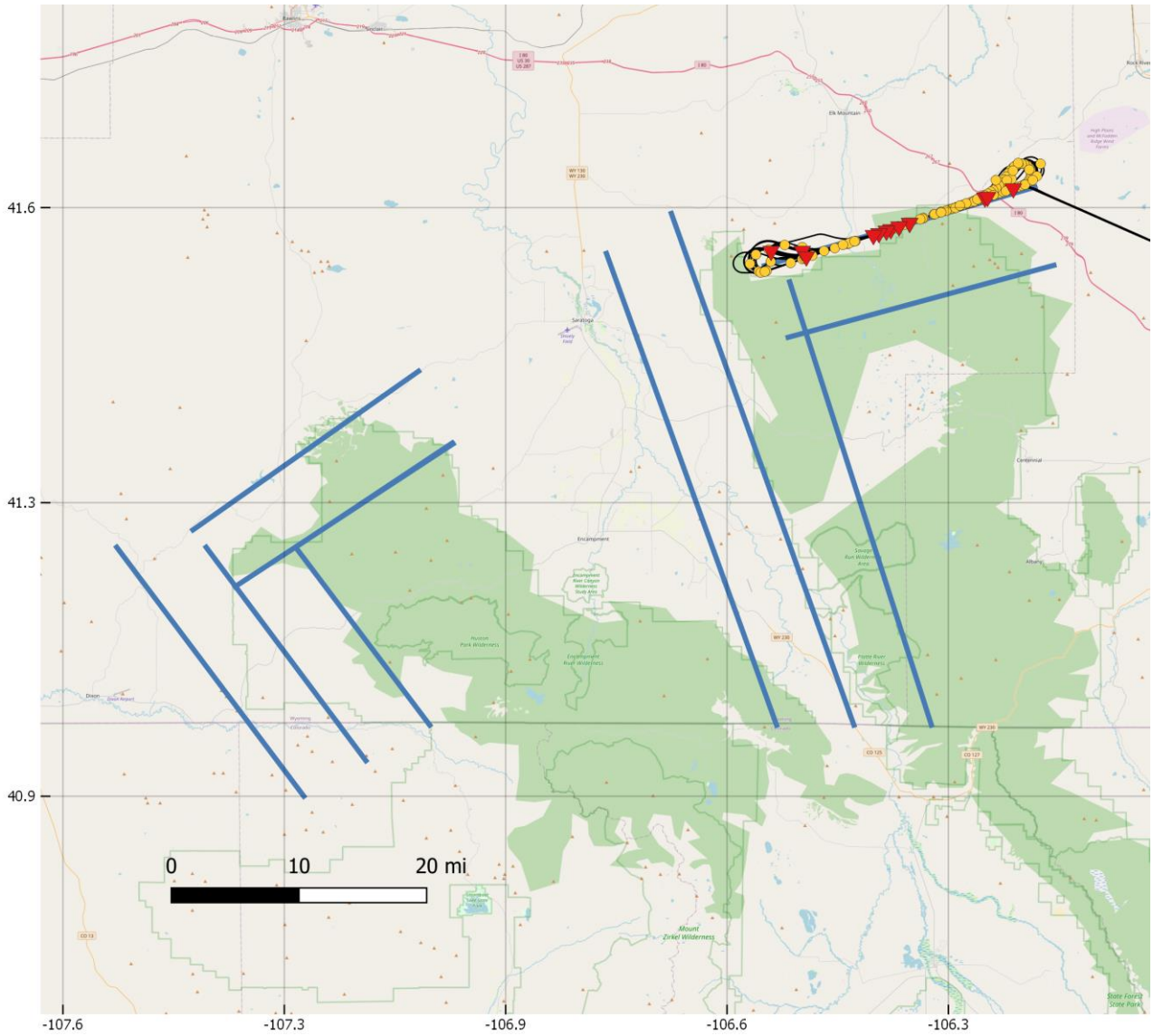
N6111V	OPS #:	18			RECON
	Track(s)/Basin:				
UTC Date:	January 6, 2022		MST Date:	January 6, 2022	
UTC Engines ON:	19:19		MST Engines ON:	12:19 pm	
UTC Engines OFF:	20:34		MST Engines OFF:	1:34 pm	
Total Time:	1:15	1.25hr	Flares Used:	0 BIP	0 EJECT
Pilot's Flight Summary:	Departed CYS for the SM Range, but due to heavy airframe icing on the way to the track, we had to abort the mission and RTB.				
Synoptic Analysis:	A large trough pattern continues over the Plains, and our region is under a potent jet streak with very strong NW flow aloft through tomorrow. At midlevels, lobes of vorticity continue pushing through the region through tonight. A stream of moisture will be flowing through the region through tomorrow. PWAT will peak around 0.3 inches today				

	and then peak around 0.45 inches tomorrow afternoon (impressive for this time of year). Midlevel warming will occur this evening through tomorrow as this warm moist air advects into the region. Today's model runs are showing much less convective potential for tomorrow. However, with such strong seeding level winds and very high moisture content, we will probably see very heavy SLW tomorrow (potentially severe). A transient ridge pushes through Friday bringing drier air and a lull in precipitation. A shortwave then pushes through Saturday with light moisture, but this looks to be a fairly minor system.
Area Forecast:	Heavy snow accumulation continues through tomorrow evening, finally tapering off tomorrow night. Impressively deep juicy orographic clouds will persist through tomorrow evening. SLW will be quite heavy at times, and clouds will be seedable throughout the next 36 hours. Unfortunately, airport conditions at CYS are not safe for flight operations today or tonight. This will preclude any flights until tomorrow afternoon when freezing mist, low ceilings, and poor visibility improve. We will likely see at least one flight tomorrow afternoon/evening. Model cross sections are indicating very heavy SLW tomorrow, so we will need to be aware of potential for severe rapid airframe icing. Friday will see about 12 hours of clearing as the transient ridge zips through. A weaker system arrives Friday night or Saturday morning. This system will have much lighter moisture, but early indications are for marginally seedable SLW. Beyond Saturday, we look to enter a drier pattern for next week as a high amplitude ridge develops over the Rockies and the western states.
Flight occurred in the afternoon hours of the 6th; weather information is from Jan. 5th.	



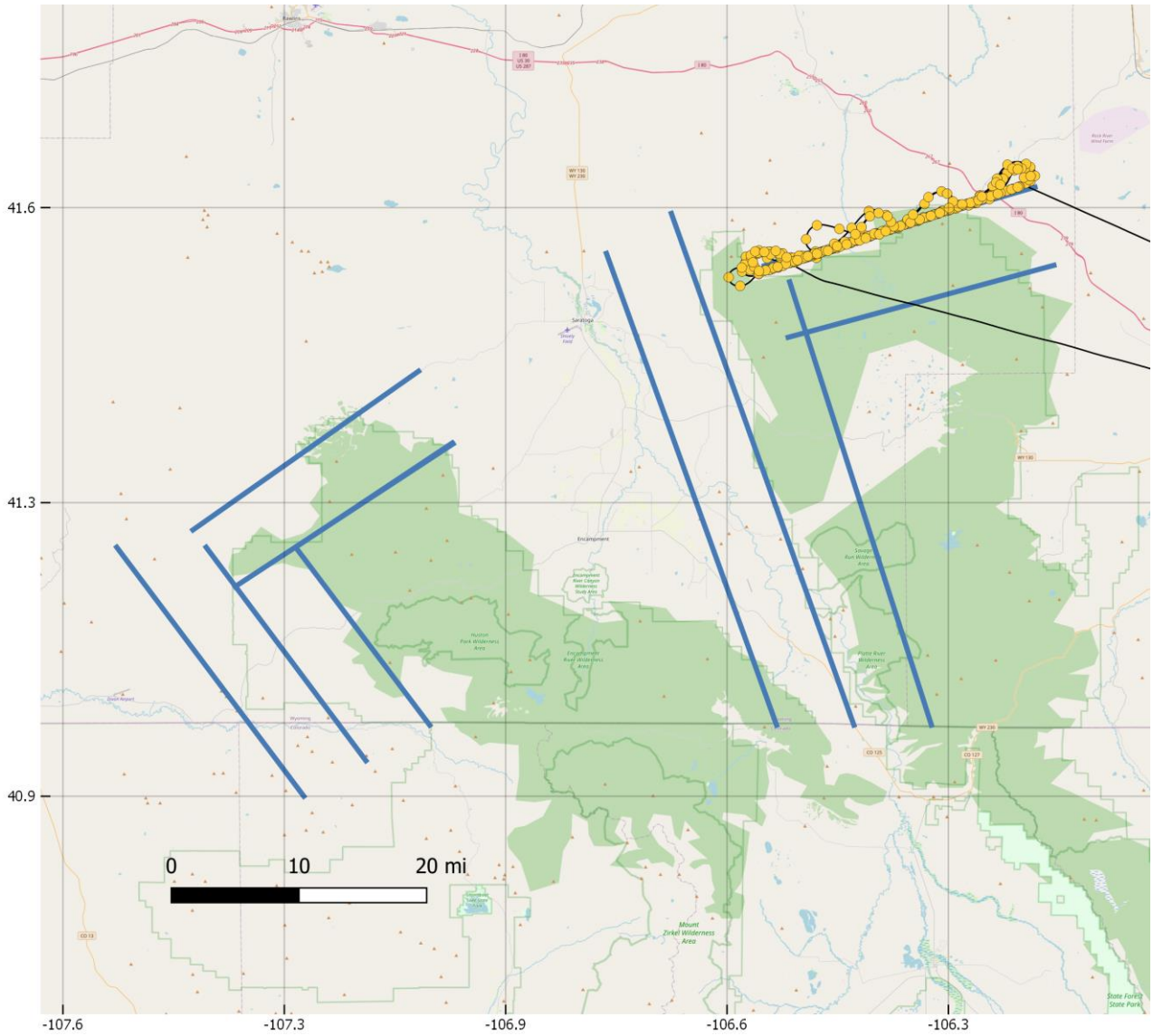
N6111V	OPS #:	19			SEED
	Track(s)/Basin:		SM-3		
UTC Date:	January 8, 2022		MST Date:	January 8, 2022	
UTC Engines ON:	07:07		MST Engines ON:	12:07 am	
UTC Engines OFF:	11:50		MST Engines OFF:	4:50 am	
Total Time:	4:43	4.72hr	Flares Used:	0 BIP	149 EJECT
Pilot's Flight Summary:	Departed CYS @19kft for SM-3. Once on track, we descended to 15.1kft due to cloud tops. Throughout the flight, cloud tops continued to rise, but were mostly ice crystals. Some cloud tops contained LWC reported up to 0.8. Once the LWC was confirmed, we increased the seeding rate to one EJ per minute. Once low on fuel, we finished seeding and RTB.				

Synoptic Analysis:	At the upper-levels, a fast moving transient ridge is in place over the region this afternoon. The ridge has shifted the upper jet north of our region, and wind speeds aloft have diminished. By this evening, the ridge will be exiting as the jet returns bringing stronger southwest flow. A broad trough stretching from the Gulf of Alaska to the Upper Plains will impact the region late this evening through tomorrow morning. PVA from the trough is expected overnight, and a rather brief wave of moisture will pass through from midnight to dawn. Low level RH will be modest tonight, yet sufficient for orographic clouds and SLW. Seeding level winds look to be moderate as well, around 35-40 knots. WMI models are predicting about six hours of targetable SLW in the MB/SM tonight. The system will arrive later for the NS range, moving through tomorrow morning with shallower clouds (not targetable). Strong ridging will occur Sunday through most of next week.
Area Forecast:	Mostly clear skies early in the period will give way to partly cloudy skies this evening as the ridge quickly exits and the incoming trough approaches. A wave of seedable clouds will be in place for the MB and SM ranges starting around midnight to 1 AM MST timeframe. Conditions appear to remain favorable through around sunrise, and then moisture and precipitation will taper off tomorrow morning for the WY ranges and end by noon. Shallow SLW and lighter snowfall are expected in the NS range from around 5 AM MST through early afternoon tomorrow. The NS looks to see only an inch or two of accumulation, while the MB/SM will see twice that. One seeding flight is expected for the SM range overnight, and then seeding will end by dawn. Starting Sunday, we enter a dry warmer pattern for the coming week as a high amplitude ridge brings high pressure and subsidence through at least Thursday. The GFS model is suggesting light moisture will return Friday, but there are currently no major storm systems on the horizon for the next ten days.
Flight occurred in the morning hours of the 8th; weather information is from Jan. 7th.	



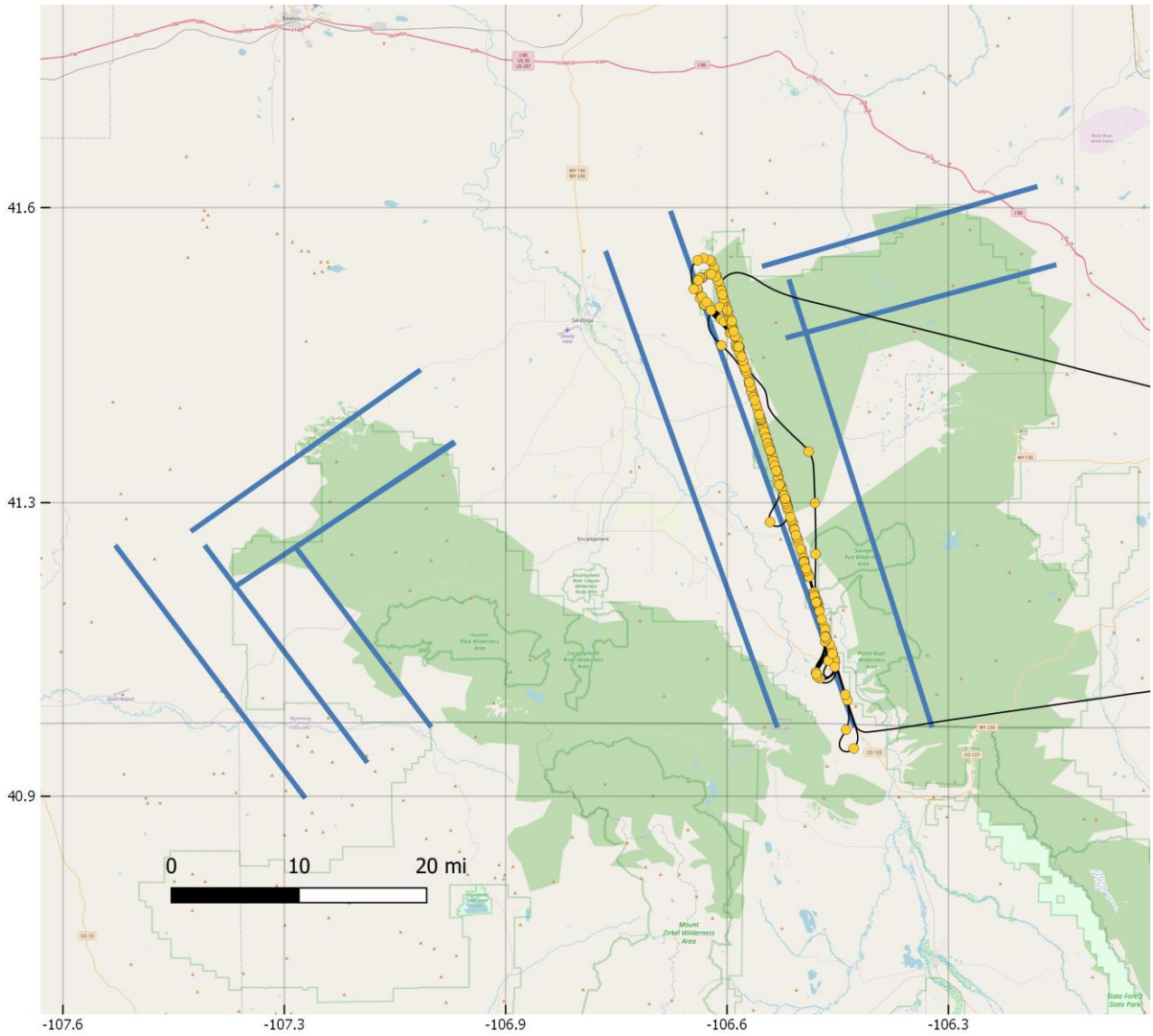
N6111V	OPS #:	20			SEED
	Track(s)/Basin:		MB-1		
UTC Date:	January 14, 2022		MST Date:	January 14, 2022	
UTC Engines ON:	17:24		MST Engines ON:	10:24 am	
UTC Engines OFF:	20:55		MST Engines OFF:	1:55 pm	
Total Time:	3:31	3.52hr	Flares Used:	9 BIP	109 EJECT
Pilot's Flight Summary:	Departed CYS for MB-1 @ 15kft. Once on track, we found LWC reporting up to 0.32 and decided to climb up to 16.5kft to avoid airframe icing. Throughout the first half of the flight, cloud tops ascended causing up to ascend while seeding. Towards the end, cloud tops started to drop allowing us to descend with them. While seeding above the conditions, the mets instructed us to use EJs. Once the conditions moved down wind, they instructed us to switch to BIPs. Due to winds, we were able to utilize the entire				

	track for seeding the range. Once conditions started to deteriorate for seeding, the mets instructed us to RTB.
Synoptic Analysis:	Upper-level charts show a ridge axis passing through our region this afternoon while a potent shortwave approaches from the west. Moderate northwest flow aloft this morning will become stronger westerly flow by evening. Midlevel moisture moves in today and tonight, but low levels look to remain dry until around dawn tomorrow morning. As low levels finally saturate tomorrow morning, we will see fair orographic development through the morning/afternoon Friday. Seeding level winds will be northerly for most of the day. PWAT peaks around 0.30 inches for a few hours in the late morning and then drops through the rest of the day. Low level RH remains saturated through late evening, dropping sharply after midnight Friday night. Behind the trough, a high amplitude ridge quickly transitions the region back to clear dry conditions for the weekend. Dry air and ridging dominate through Tuesday, and then the next minor disturbance arrives Wednesday.
Area Forecast:	The ranges will see significant high and midlevel cloud layers throughout the afternoon and evening. Clouds erode after midnight bringing partial clearing for a few hours before the main frontal wave arrives around 12z tomorrow morning. Deep overcast layers are expected early tomorrow morning through midnight tomorrow night with fair orographic clouds through the afternoon. Clouds rapidly diminish tomorrow night behind the shortwave as strong ridging returns. Tomorrow's system will be borderline for seeding operations, but latest models are showing a window of targetable SLW from morning through the midafternoon hours in northerly flow. The MB range appears to be the best option at this time, and we will tentatively plan a MB flight for the northern tracks to begin sometime between dawn and noon. We will pin this down later tonight after the 00z models are in. Snow is expected from dawn through early evening, and then flurries persist through midnight before clouds clear out tomorrow night. Dry mild conditions are likely Sunday through Tuesday. Another modest system arrives Wednesday with limited moisture. Seeding chances for Wednesday are uncertain at this time, but we could see another marginal narrow window for a flight.
Flight occurred in the morning to afternoon hours of the 14th; weather information is from Jan. 13th.	



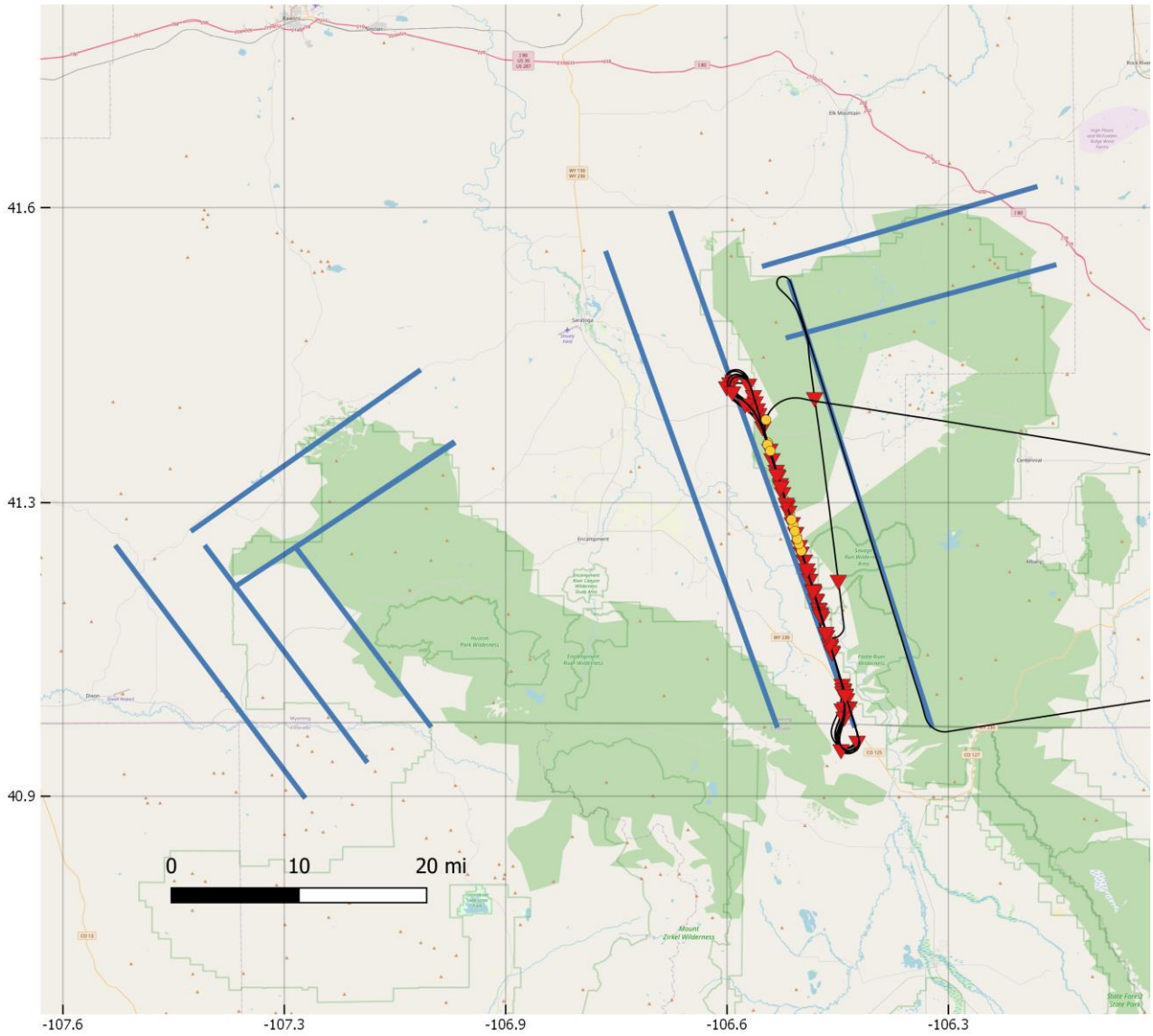
N6111V	OPS #:	21			SEED
	Track(s)/Basin:		MB-1		
UTC Date:	February 10, 2022		MST Date:	February 9, 2022	
UTC Engines ON:	02:16		MST Engines ON:	7:16 pm	
UTC Engines OFF:	05:53		MST Engines OFF:	10:53 pm	
Total Time:	3:37	3.62hr	Flares Used:	0 BIP	292 EJECT
Pilot's Flight Summary:	Departed CYS for MB-1 @ 16kft. Once on track, we found good LWC and started seeding with EJs once every 30 seconds. Due to airframe icing, we ascended to 17kft and continued seeding. Later in the flight, the eastern end of the track began to clear up and we started to focus more on the west end of the track. Cloud tops continue to provide good LWC for seeding and reported up to 0.65 towards the end of the flight. Once all the flares had been fired, we returned to CYS.				

Synoptic Analysis:	Upper-level charts show the nose of a northerly jet streak pushing into WY this evening. The western ridge remains strong while a large-scale trough spans the eastern half of the country. The Rockies are positioned between the ridge and trough. A small shortwave glances the region this evening, but the best vorticity advection looks to stay east of our ranges. Total moisture in this system is limited, and PWAT looks to peak around a quarter inch. Low level RH and wind speeds will be sufficient for a few hours of marginal orographic development after sunset. SWE estimates are quite low with perhaps an inch of snow accumulation in the MB between 8pm MST and midnight, confined to the mountains. No snow is forecast for the SM, and only flurries are expected in the NS. Another shortwave arrives Friday with another brief window of marginal SLW.
Area Forecast:	Low clouds will be present over the ranges for most of the period. The MB and NS ranges will see a brief wave of light snowfall between sunset and midnight with a couple hours of fair SLW likely on the north side of the MB starting around 8pm local time. A seeding flight has been scheduled to depart CYS at 7:30 pm MST for track MB1. We may only see a couple hours of targetable SLW, so this is not expected to be a full-length long flight. Marginal low clouds and flurries are possible after midnight, but nothing targetable. Shallow orographic clouds are possible tomorrow with a few flurries, but nothing worth seeding. Friday's shortwave will bring cold air aloft but slightly better low level RH, and we could see another brief seeding window with some light snow accumulation and patchy SLW. We could get another marginal seeding opportunity Friday. Dry conditions are likely over the weekend through early next week. A more potent system is apparent next Wednesday, but the storm track is not particularly promising for seeding chances. Models are still trying to determine the exact track of this low. Today's GFS runs push the low to our south and west which would bring easterly flow (not workable), but if it ends up taking a more northerly path, we might have a shot at operations Wednesday.
Flight occurred in the evening hours of the 9th; weather information is from Feb. 9th.	



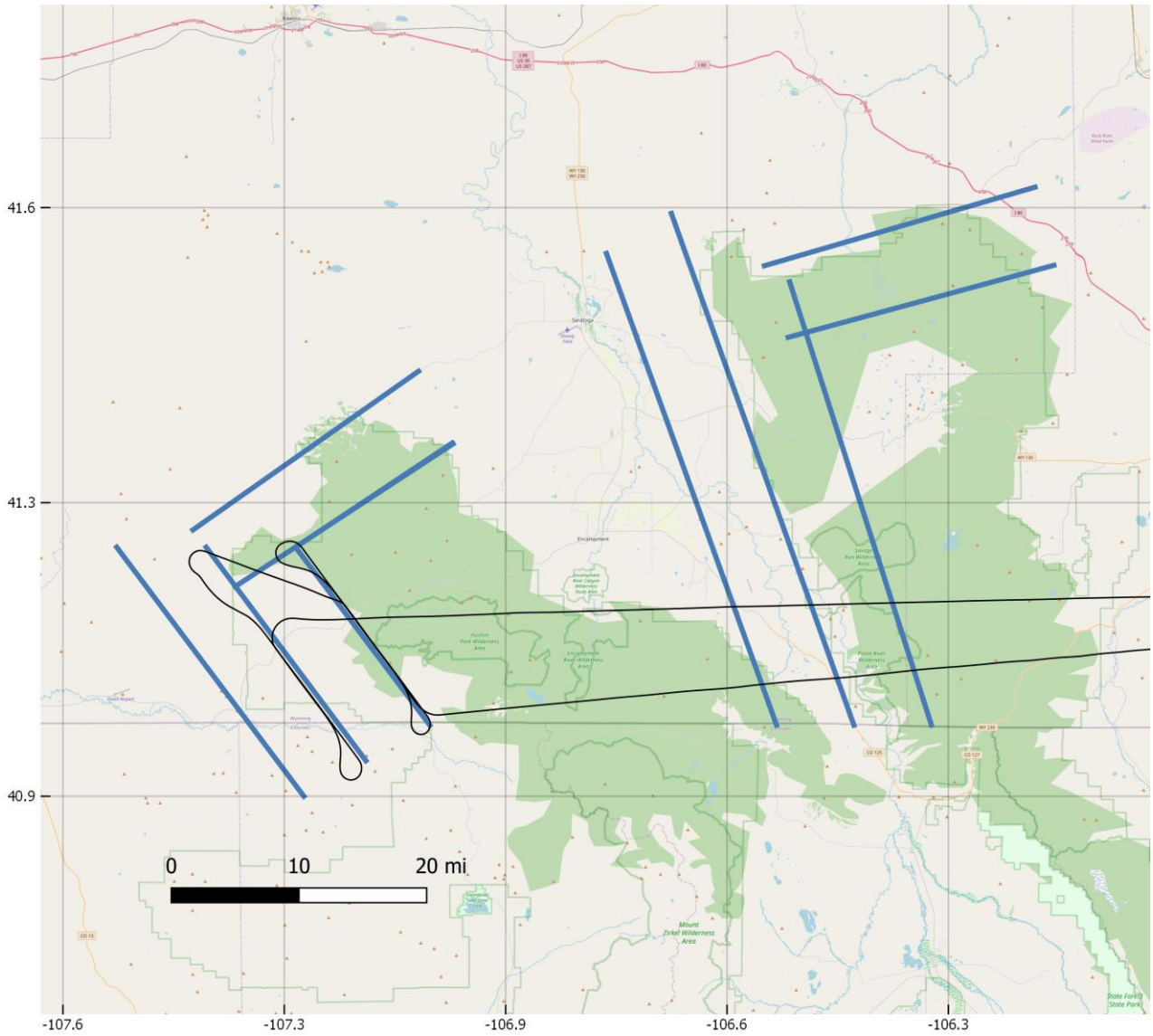
N6111V	OPS #:	22			SEED
	Track(s)/Basin:		MB-4		
UTC Date:	February 11, 2022		MST Date:	February 11, 2022	
UTC Engines ON:	13:51		MST Engines ON:	6:51 am	
UTC Engines OFF:	18:42		MST Engines OFF:	11:42 am	
Total Time:	4:51	4.85hr	Flares Used:	0 BIP	235 EJECT
Pilot's Flight Summary:	Departed CYS for MB-4 @ 16kft. Once on track, we descended to the lowest altitude ATC would allow, which was 14kft. Due to this altitude being just above the cloud tops, we could not sample the clouds for LWC, but the mets instructed us to start seeding with EJs once a minute. With the new models that came out during mission, the cloud tops were expected to rise. Later in the flight, cloud tops did start to rise and towers				

	started to develop with good LWC just above 0.6. Once we were running low on fuel, we RTB.
Synoptic Analysis:	The eastern portion of the large coastal ridge is pushing back into WY today, and the upper jet retreats to the north and east of our region for the daytime hours. We will see moderate northwest flow aloft today, but it will become much stronger overnight as the jet shifts south again into WY late in the period. Midlevel vorticity pushes through late in the period. The western portions of the trough to our east will dig southward through WY into CO. Decent PVA is likely tomorrow. Total moisture will remain unimpressive through tomorrow, dropping slowly through the next 36 hours. This lacking PWAT will limit precipitation totals. Dry air returns Saturday through Tuesday. The next incoming system will arrive late Wednesday when a robust low pressure system from the PACNW moves into the central/southern Rockies. The exact track of this system is still uncertain, but today's GFS still pushes this system south of us which would not provide good winds for operations.
Area Forecast:	Scattered low clouds and waves of upper-level clouds are all that is expected through late tonight. Just before sunrise, orographic clouds improve over the MB range becoming seedable. Targetable SLW appears possible through tomorrow morning, mainly in the MB range. A flight appears warranted. We will have to monitor the conditions/TAFs for CYS tomorrow morning, however. WMI models are indicating low ceilings and poor visibility from dawn through midmorning which could preclude operations. Seeding level winds at dawn will be from the northwest around 45 kts. Low level RH appears favorable, but PWAT values will be as low as 0.10 inches. This will not be a major snow accumulation event, particularly for the SM range. The MB will likely see a couple inches of snow at the highest elevations, while the NS records perhaps an inch of snow. The SM range can expect little more than flurries tomorrow. By noon, SLW will become too shallow and patchy for operations. Snow ends around midnight tomorrow evening. Dry conditions are likely Saturday through Tuesday, and then the next round of active weather arrives late Wednesday through Thursday. We should be planning for potential ops during this time, but the storm track of the low will dictate seedability based on wind direction. This is still uncertain.
Flight occurred in the morning hours of the 11th; weather information is from Feb. 10th.	



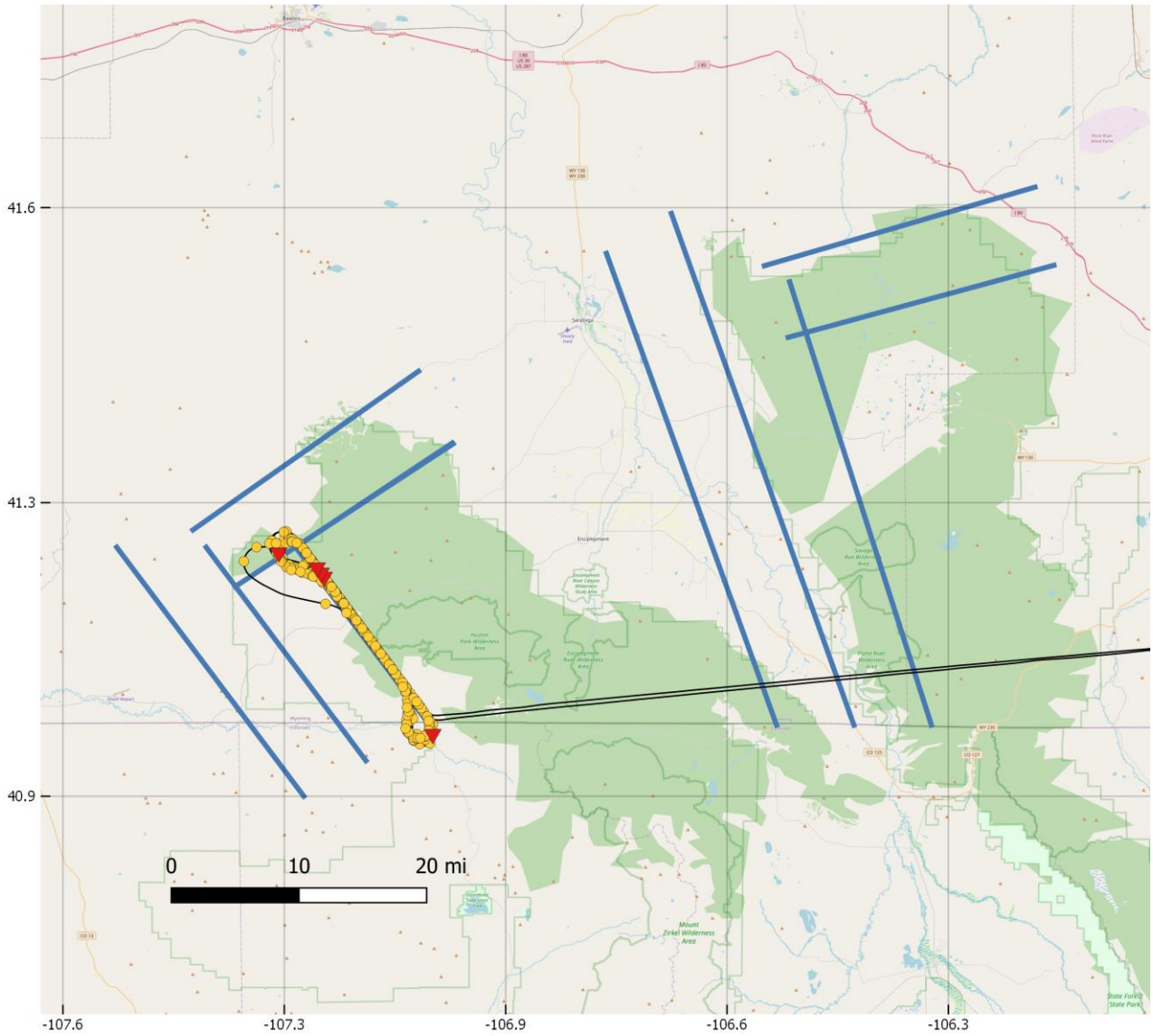
N6111V	OPS #:	23			SEED
	Track(s)/Basin:		MB-5, MB-4		
UTC Date:	February 21, 2022		MST Date:	February 21, 2022	
UTC Engines ON:	16:45		MST Engines ON:	9:45 am	
UTC Engines OFF:	21:20		MST Engines OFF:	2:20 pm	
Total Time:	4:35	4.58hr	Flares Used:	35 BIP	19 EJECT
Pilot's Flight Summary:	Departed CYS @ 16kft to MB-5. Winds were slightly higher on track than forecasted and was right on the border, so the mets instructed us to move to MB-4. LWC was found on MB-4 & 5, so the mets instructed us to start seeding with BIPs continuously. Once LWC started to pick up, the mets instructed us to start EJs in the strong pockets of LWC. Once we lit all of our BIPs, we RTB.				

Synoptic Analysis:	Upper-level charts show strong flow from the WSW today as the tail of a jet streak will be in place over our region. Flow aloft will become more southwesterly throughout the period as a digging trough over the coast pushes from Washington into the Great Basin by tomorrow. The trough continues digging and developing into California on Tuesday, and then it will push inland through the Four Corners on Wednesday. This system will provide decent moisture and PVA for our region tonight through Wednesday night. The trough axis finally exits the Rockies early Thursday morning. A massive cold front will slowly push southward through the region tomorrow morning bringing a polar airmass to much of the northern third of the country. Much of this multiday system will be naturally efficient with abundant ice crystals, but we will likely see some targetable SLW at times, particularly the early portion of the storm when PWAT peaks around 0.30 inches. Orographic lift will be excellent through Monday evening. Sky conditions at CYS will be a concern starting tomorrow
Area Forecast:	High and midlevel clouds will increase through this evening becoming overcast and much deeper by late evening. Around midnight, low clouds will start to blanket the ranges, and widespread snowfall will begin. Pockets of targetable SLW are expected after midnight, mostly in the MB range tonight. SLW appears targetable in the NS range tomorrow morning. However, conditions at CYS will become problematic by midday tomorrow due to potential for low IFR. Based on latest WMI modeling, we will need to be done with any seeding by noon tomorrow. There appears to be a good chance for a MB seeding flight around 2 AM MST. There is a fair chance for a second flight around dawn tomorrow morning in the NS range, but this could be impacted by the expected low ceilings and poor conditions in CYS, depending on timing. Seedable clouds are likely in the NS through tomorrow evening, though operations will likely be halted by tomorrow afternoon due to either pilot duty day limitations or CYS skies. Periods of heavy snow accumulation are likely in all ranges through early Thursday morning. The later portions of this system appear to have minimal SLW at this time, but we will continue watching for more seedable windows through Thursday morning. Dry cold conditions are likely Thursday, then more snow Friday.
Flight occurred in the morning hours of the 21st; weather information is from Feb. 20th.	



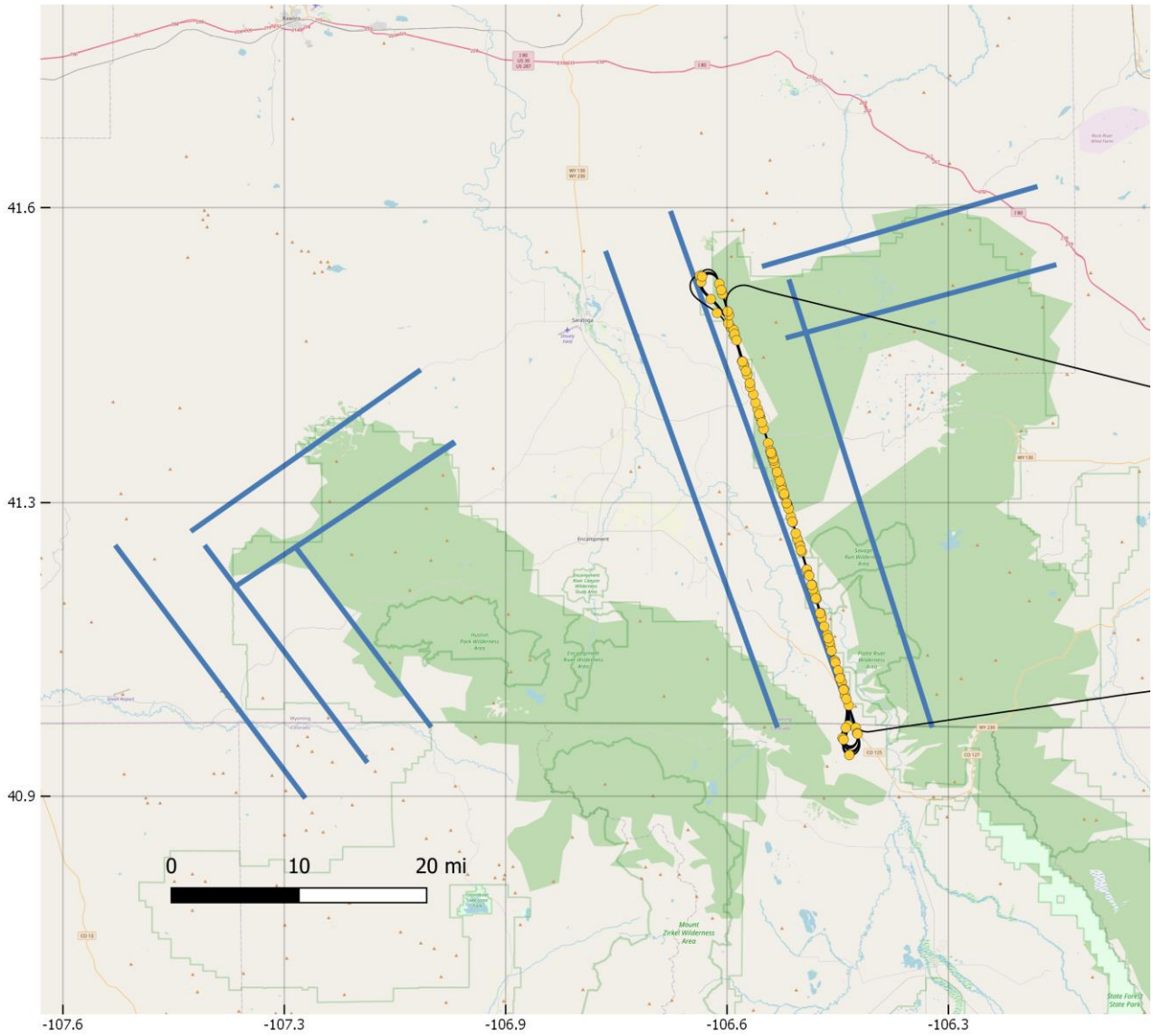
N6111V	OPS #:	24			RECON
	Track(s)/Basin:		SM-5, SM-4		
UTC Date:	February 24, 2022		MST Date:	February 23, 2022	
UTC Engines ON:	02:24		MST Engines ON:	7:24 pm	
UTC Engines OFF:	04:22		MST Engines OFF:	9:22 pm	
Total Time:	1:58	1.97hr	Flares Used:	0 BIP	0 EJECT
Pilot's Flight Summary:	Departed CYS for track SM-5. Track was clear with ground visible below. Moved to SM-4 at direction of meteorologist. No seedable conditions were found, and we RTB at meteorologist direction.				
Synoptic Analysis:	The large-scale trough pattern remains for the western US and Rockies today. The jet core has dropped south into the Four Corners region, but our area is under moderately strong southwest flow. Winds aloft are strongest in the NS further south. The trough				

	has continued to dig southward through California reaching the Mexico border, and it will now push inland through the Four Corners today through tomorrow morning. As the trough axis passes through tonight, we will eventually switch to northwest flow by morning. A second weaker trough moves through our region later Thursday into Friday in cold northwest flow with minimal moisture. Our 500 mb temps look to linger around -30°C through Friday afternoon, and then significant warming and dry air arrives Friday evening through the weekend as strong ridging returns to the Rockies. Ridging and dry air are likely through most of next week, according to the longer range models, though several minor shortwaves will push through Montana on Sunday and Thursday.
Area Forecast:	Low and midlevel cloud cover will persist over the region through dawn with occasional brief patches of partial clearing. We will see a short break in the cloud cover tomorrow morning as the southern trough exits, but then the second northwestern trough immediately follows. Cloud cover returns by tomorrow afternoon as the cold moisture starved northwesterly trough moves in with a dusting of snow and no significant SLW. Deep overcast clouds linger through Friday afternoon, and then skies will clear out Friday evening. Dry weather is then expected Friday evening through most of next week. Our only chance for a seeding window appears to be in the SM this evening, but it is a narrow window. Starting around 7 pm local time, the SM will see a few hours of marginal SLW below 13kft. We can fly lowest in the SM range, so this may be targetable with ejectables skimming tops. A flight is tentatively planned for the SM this evening to be on track around 7 pm. Conditions appear seedable for 2 or 3 hours. Other than this short window, the ranges appear to have insufficient SLW for operations. Winds at seeding levels will be southwesterly around 20 knots, favoring SM5 this evening.
Flight occurred in the evening hours of the 23rd; weather information is from Feb. 23rd.	



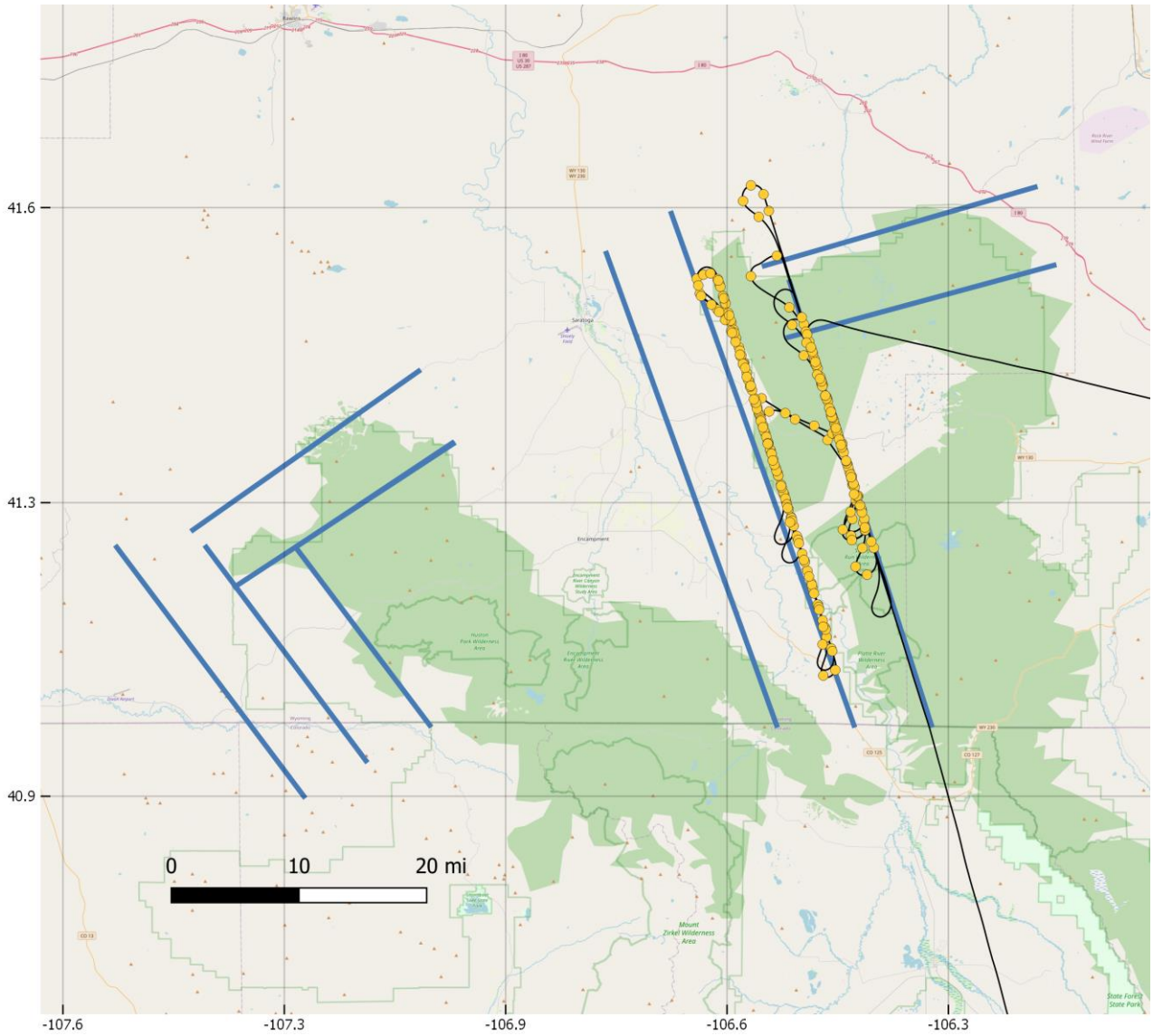
N6111V	OPS #:	25			SEED
	Track(s)/Basin:		SM-5		
UTC Date:	March 5, 2022		MST Date:	March 5, 2022	
UTC Engines ON:	09:08		MST Engines ON:	2:08 am	
UTC Engines OFF:	13:43		MST Engines OFF:	6:43 am	
Total Time:	4:35	4.58hr	Flares Used:	3 BIP	300 EJECT
Pilot's Flight Summary:	Departed CYS for track SM-5 @ 15kft. Once on track, we found LWC reporting above 0.3 and mets instructed us to start seeding with EJs once every 30 seconds. Due to airframe icing, we ascended just above the cloud tops @ 15.5kft. Throughout the flight, LWC increased above 0.5 as cloud tops started to ascend to our altitude. Once we expended all EJs onboard, the mets instructed us to start seeding with BIPs. Due to				

	deteriorating conditions in Cheyenne, we departed the track early in case we couldn't get into CYS and had to divert.
Synoptic Analysis:	The upper level winds are weak over the area today, with the main flow well to the south. The midlevel ridge is now over the eastern US with a large scale trough over CA making its way over the Rockies today. The first wave of PVA has moved into the area this afternoon already with a lot of scattered PVA around the region tonight and tomorrow morning. A strong push of midlevel moisture brought the thick cloud coverage this morning and afternoon. While low level moisture has been increasing too, the strongest flow will occur this evening through tomorrow afternoon. WY and CO will remain under a general trough pattern for the weekend and most of Monday, but moisture flow will be more in waves and not as continuous from Saturday night to Monday. Colder air is slowly making its way into the area but the 500 mb temperature will stay above -27C until Sunday evening. Drier air with NW flow is expected for late Monday and Tuesday before a broad trough comes through on Wednesday.
Area Forecast:	Thick midlevel clouds have been over the ranges, but bases have been generally above the peaks. Widespread precipitation will move into the area from the south after sunset. The beginning will be more convective and inconsistent conditions. After midnight, the clouds will become orographic with continuous snowfall. Decent SLW is expected just below flight level with SW wind between 25 and 30 kts, becoming westerly and lighter. The limiting factor will be continuous rain-snow mix at CYS from the mid evening and through the night. There could be heavier periods, and ceilings will mainly be very low. Snowfall at CYS will be letting up tomorrow morning but will not end until around noon. After that, the weather should not be an issue at CYS, but it will be much colder than today. No SLW is expected tomorrow morning as the snowfall rates will be quite high. The widespread snowfall over the mountains will be ending tomorrow early afternoon as well, then only scattered showers during the afternoon and evening. Continuous snowfall will be forming tomorrow night through Sunday morning. Best chance for seeding with that period looks to be over the SM again during the night. The 500 mb temperature will be getting colder on Sunday, limiting any SLW.
Flight occurred in the morning hours of the 5th; weather information is from Mar. 4th.	



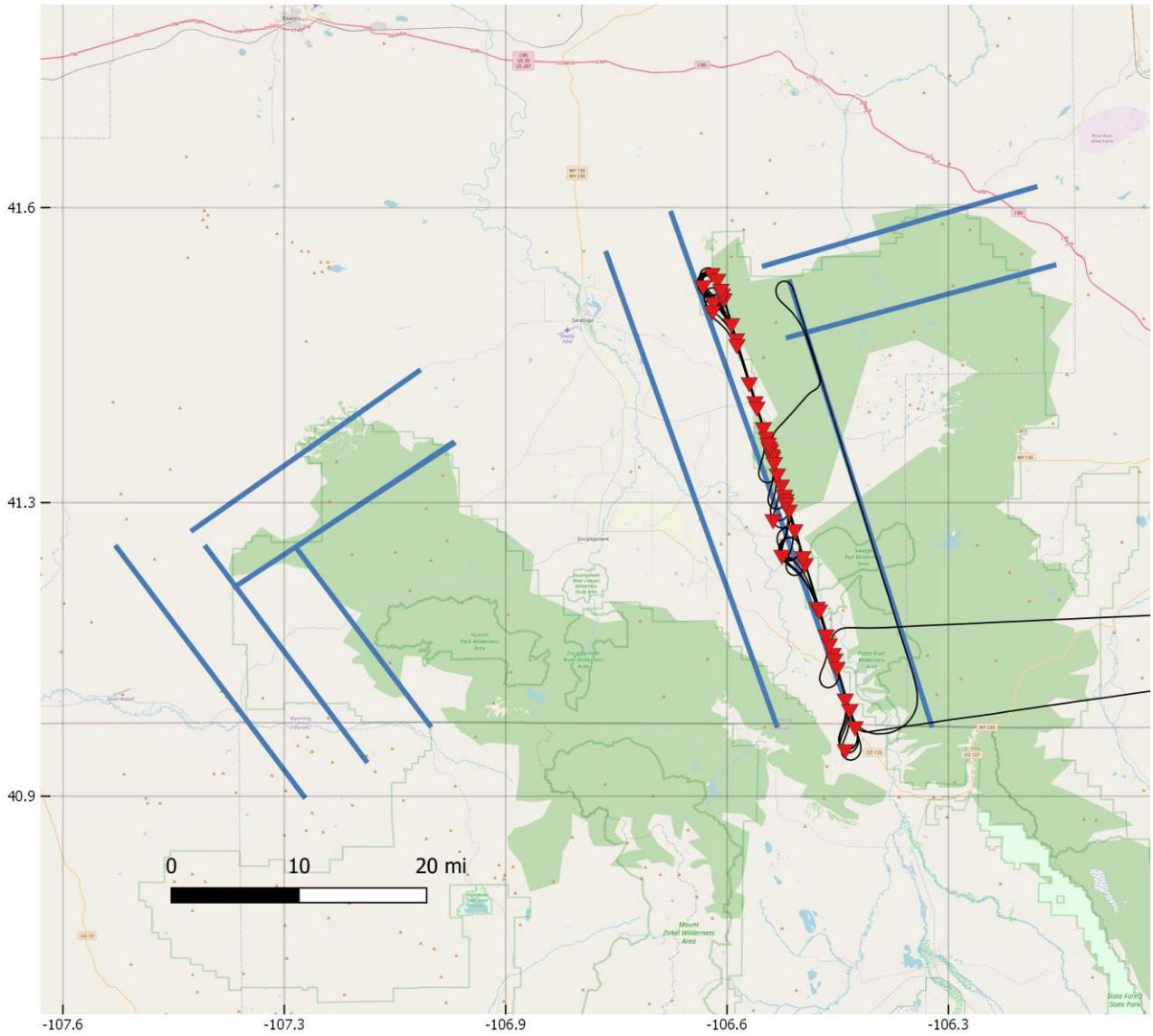
N6111V	OPS #:	26			SEED
	Track(s)/Basin:		MB-4		
UTC Date:	March 9, 2022		MST Date:	March 9, 2022	
UTC Engines ON:	07:45		MST Engines ON:	12:45 am	
UTC Engines OFF:	12:37		MST Engines OFF:	5:37 am	
Total Time:	4:52	4.87hr	Flares Used:	0 BIP	101 EJECT
Pilot's Flight Summary:	Departed CYS for MB-4 @ 16kft. Once on track, we were able to descend to 14kft. Throughout the flight, the CWIP reported LWC up to 0.4 and the mets instructed us to seed with EJs once every two minutes. Once conditions descended below 14kft, we could not get any LWC readings due to ATC restrictions. Due to no readings, the mets instructed us to RTB.				

Synoptic Analysis:	The upper level winds have been weak over the area. The speed will increase slightly but remain less than 70 kts as the main jet stream is to the south. A high amplitude ridge is over the eastern Pacific giving NW midlevel flow over the western US. A short-wave trough has been coming from Canada into western MT and WY this morning which gave the thin cloud coverage this morning. A broad trough region will start developing over the northern US Rockies this evening and then strengthening tomorrow. Low level moisture starts increasing this afternoon, then a stronger flow is expected this evening and night. The moisture starts to decrease tomorrow afternoon, then moves away tomorrow night even through the trough axis will not pass through until Thursday afternoon. The ridge then moves across the western US, bringing dry conditions for the end of the week until a small system comes through on Sunday.
Area Forecast:	The thin clouds this morning had mostly diminished, but low clouds are developing again over the MB and SM. Those clouds will continue to strengthen in the coming hours but will not form over the NS until this evening. Widespread low clouds will then around for the rest of the period and most of tomorrow. The main wind is westerly and 35 to 40 kts this afternoon and evening, then 40 to 50 kts tonight. Snowfall will become moderate to heavy in the SM and MB this evening and through the night but will be light to moderate in the NS. Despite the heavy snowfall, SLW is expected over the MB and SM during the night, but it will be more over the ranges and not as much upwind on the flight tracks. Still will probably be worthwhile for a flight. The NS does not look to get any SLW during the night, but a little does form tomorrow morning, as the SLW disappears from the MB and SM. Conditions at CYS will again be questionable and will need to be monitored before a flight. Light snowfall continues through tomorrow evening, but no SLW is expected after noon. The snowfall will end by midnight Wednesday night, but low clouds will hang around until midday Thursday. After that, Sunday will be the next chance for snowfall, but it looks to be a quick and light system.
Flight occurred in the morning hours of the 9th; weather information is from Mar. 8th.	



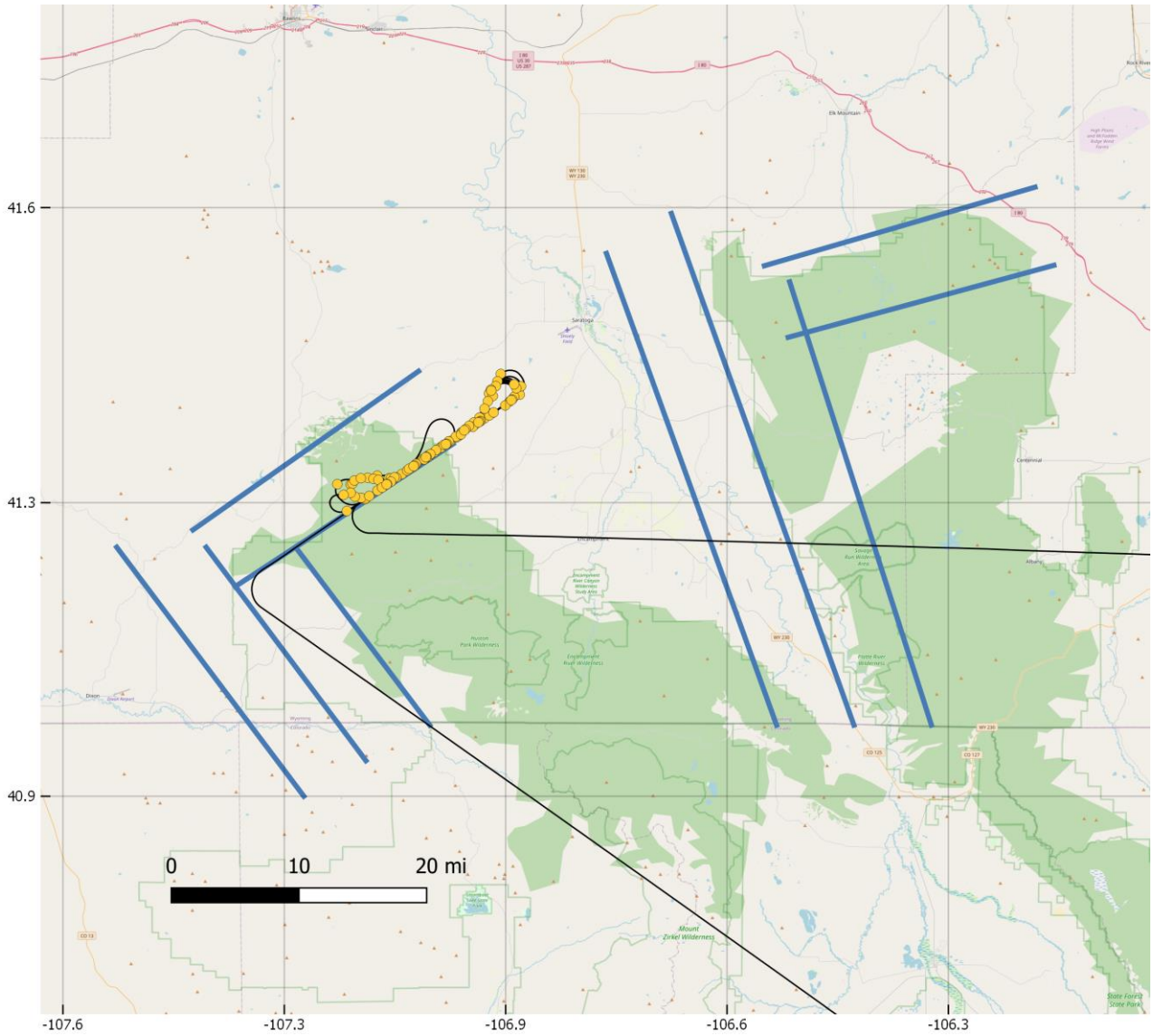
N6111V	OPS #:	27			SEED
	Track(s)/Basin:		MB-5, MB-4		
UTC Date:	March 14, 2022		MDT Date:	March 13, 2022	
UTC Engines ON:	01:28		MDT Engines ON:	6:28 pm	
UTC Engines OFF:	04:37		MDT Engines OFF:	9:37 pm	
Total Time:	3:09	3.15hr	Flares Used:	0 BIP	227 EJECT
Pilot's Flight Summary:	Took off from CYS for the NS Range @ 16kft. Once on track, we descended to 15kft, but no LWC was found. The mets decided that conditions in the MB would be better for seeding. Once on track at the MB, the CWIP started reporting LWC up to 0.4 and we were instructed to start seeding with EJs. Throughout our time on the MB, cloud tops started descending and LWC was still reporting up to 0.3/0.4. Towards the end of the seeding, cloud cover started moving east of track and clearing on the north and south				

	ends. Once cloud cover started clearing, the mets instructed us to finish our pass and RTB.
Synoptic Analysis:	Upper-level charts indicate moderate west southwesterly flow ahead of an incoming shortwave trough. The associated cold front is moving through this afternoon, and then the trough axis is expected to push through in the late evening. This is a fast-moving quick hitter and precipitation totals appear to be light, but we will see some brief periods of targetable SLW. Stronger colder northerly flow is expected on the back side of the system tonght, and then ridging returns tomorrow through Tuesday afternoon with a sharp rise in temps aloft. The next trough arrives early Wednesday through Thursday. This system does not appear to bring strong vorticity to WY, but we will see saturated low levels and moderate seeding level winds which will create some orographic snow and SLW. A shortwave ridge moves in Friday, and then a ridge amplifies over the Rockies Saturday while a trough digs down the west coast from the Gulf of Alaska potentially forming a cutoff low near Baja on Sunday or early next week. Timing and track of this system are still uncertain.
Area Forecast:	Deep overcast clouds have overspread the region at forecast time as the cold front approaches. Snowfall has begun, spreading from west to east across the region. WMI models indicate SLW to be poor in the initial hours of this system, but it is expected to improve this evening. A NS flight is likely after sunset, ending around midnight. Behind the trough axis, the midlevel clouds will clear out and we will see some shallow orographic clouds lingering over the ranges with some decent SLW. However, this layer currently looks to be too shallow for seeding. It is possible the evening models will show slightly deeper orographic clouds overnight, so we cannot completely rule out an overnight flight until we see the 00z runs. Dry conditions are likely tomorrow and most of Tuesday. The next chance for seeding will be early Wednesday through Thursday. We can expect dry weather Friday and Saturday, but then things get hazy for Sunday through early next week as we are expecting a deep low to move down the coast into California and deepen into a cutoff low. The timing of when and where this system will start moving east into the Rockies is very hard to pin down this far out, but there is a possibility of a low moving through early next week
Flight occurred in the evening hours of the 13th; weather information is from Mar. 13th.	



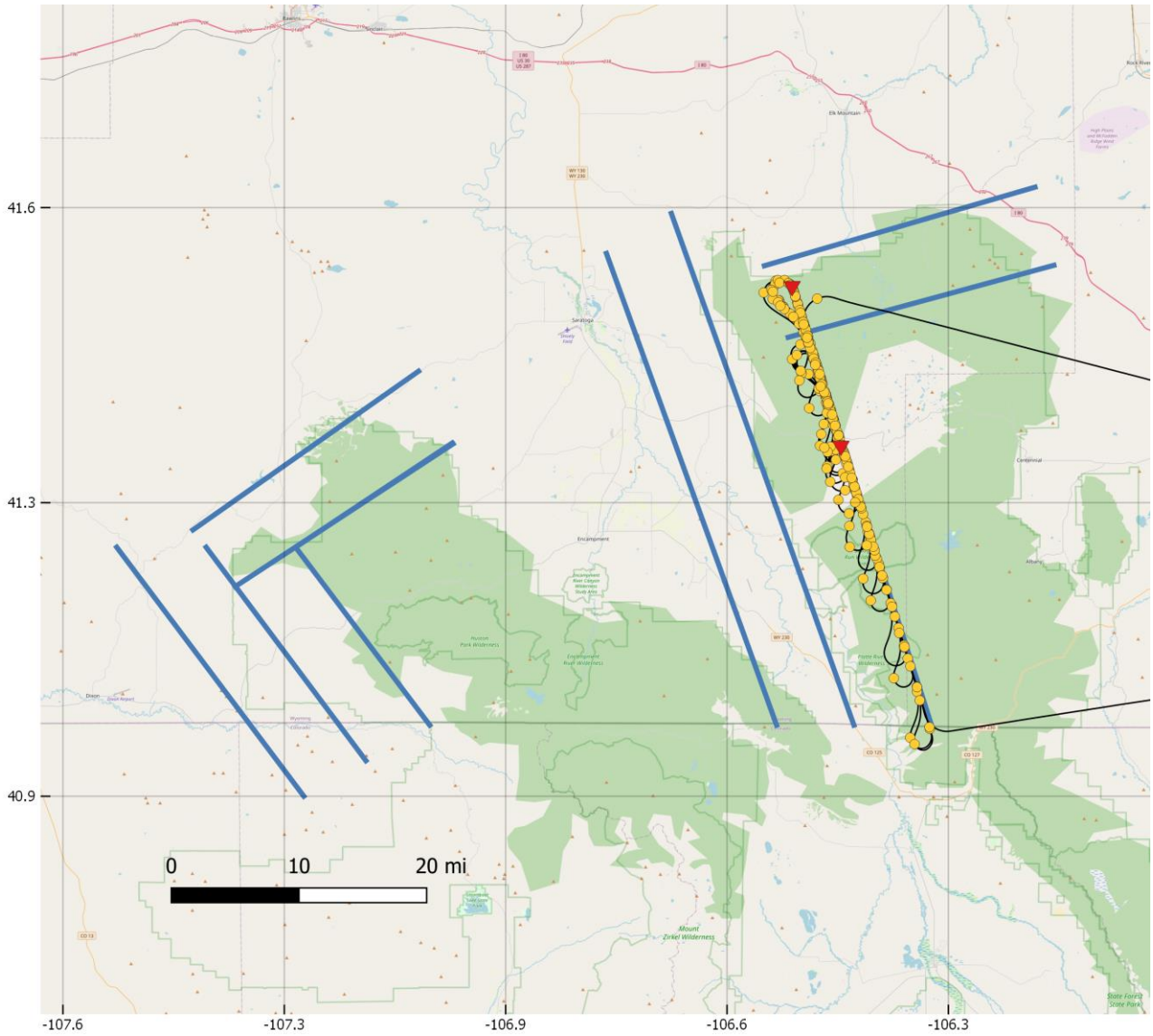
N6111V	OPS #:	28			SEED
	Track(s)/Basin:		MB-4, MB-5		
UTC Date:	March 16, 2022		MDT Date:	March 16, 2022	
UTC Engines ON:	07:12		MDT Engines ON:	1:12 am	
UTC Engines OFF:	12:17		MDT Engines OFF:	6:17 am	
Total Time:	5:05	5.08hr	Flares Used:	38 BIP	0 EJECT
Pilot's Flight Summary:	Departed CYS for MB-4 @ 15kft. Once on track, the CWIP started to report decent LWC and good seeding conditions for BIPs. Once we determined wind and what LWC was present on MB-4 & 5, the mets instructed us to start seeding with BIPs. LWC stayed fairly consistent throughout the majority of the flight. Towards the end of the flight, LWC peaked before declining as we started to run low on fuel. We returned to CYS after conditions on track were no longer suitable for seeding.				

Synoptic Analysis:	Weak upper level flow is over the region this afternoon but a small, SW jet will be crossing over WY tonight. The midlevel ridge is moving eastward and flattening to nearly zonal flow today, with a short-wave trough coming through the area tonight and tomorrow morning. A surface cold front will also be crossing the area tomorrow morning. Low level moisture will be increasing after midnight, with the strongest push expected around sunrise and continuing through the morning. After this short-wave trough passes the area, a slightly stronger and deeper trough system will be coming for Wednesday night and Thursday morning. The moisture with this trough will be more variable and the wind will be northerly. A strong, deep system is expected over the Rockies the beginning of next week. This could bring a high amount of snowfall to the area, mainly Sunday and Monday, but some continuing into Tuesday. Easterly wind direction and poor conditions at CYS could limit seeding opportunities from this system.
Area Forecast:	The sky has been mainly clear lately, except for high clouds and that will continue for the rest of the afternoon and most of the evening. Midlevel clouds will move in late in the evening. Low clouds will start forming over the SM first a little after midnight then over the MB by the middle of the night. Snowfall will be very light until just before sunrise, when it will be moderate over the MB and SM. Thick cloud and ice are expected up to 20 kft, but some SLW is forecast over the MB and SM in the hours right after sunrise. The snowfall will drop southward to NS during the morning and will end in the MB and SM by noon. The ice will not be as deep in the NS and more SLW is expected in the late morning and early afternoon. The snowfall in the NS will be ending by sunset Wednesday. CYS is not expected to get any precipitation until Wednesday evening and then will continue into Thursday morning. The second round of snowfall in the mountains will begin in the MB around midnight. It will be very light with little to no SLW expected and questionable wind flow. The NS will have shallow low clouds Thursday morning, but only flurries and clouds not expected to be thick enough for seeding operations. That system will be gone by noon on Thursday, then it will be dry until Sunday afternoon.
Flight occurred in the morning hours of the 16th; weather information is from Mar. 15th.	



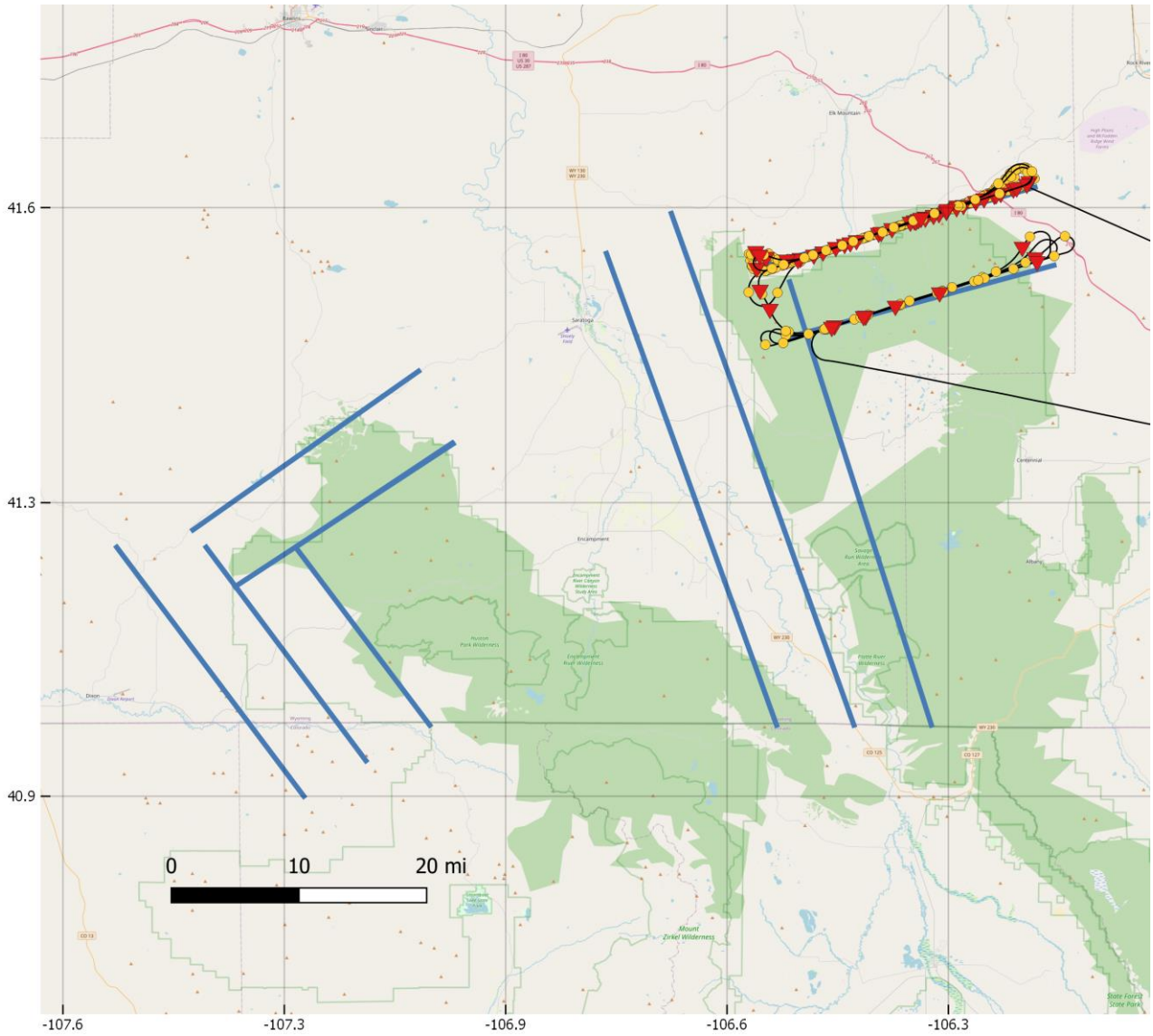
N6111V	OPS #:	29			SEED
	Track(s)/Basin:		SM-2		
UTC Date:	March 17, 2022		MDT Date:	March 17, 2022	
UTC Engines ON:	09:34		MDT Engines ON:	3:34 am	
UTC Engines OFF:	12:25		MDT Engines OFF:	6:25 am	
Total Time:	2:51	2.85hr	Flares Used:	0 BIP	91 EJECT
Pilot's Flight Summary:	Departed CYS for NS-3 @ 15kft. On the way to track, we picked up good LWC just northeast of the NS. Once on track, we estimated that the clouds were 500ft below our minimum flying altitude. We seeded with EJs until the updated models came out. With the updated models, the mets decided to move us to the SM range. Once on the SM-2 track, the CWIP picked LWC and the mets instructed us to start seeding with EJs. Once we were running low on fuel, we returned to CYS.				

Synoptic Analysis:	Upper-level charts show a trough continues to push through the Rockies. Excellent moisture is in place today, and PWAT will peak near 0.40 inches this evening before slowly diminishing overnight. A closed circulation develops at 700 mb to our south tonight, and low level winds will be very light, eventually becoming northeasterly by morning. The midlevel trough axis passes through our ranges early tomorrow morning, and then weak shortwave ridging is expected Thursday afternoon/night. Flow flattens later tomorrow with a minor shortwave, but then a small ridge amplifies over the western states and moves into the Rockies Friday and Saturday. Meanwhile, a deep low in the Gulf of Alaska will eject a trough down the coast which will dig and deepen into a large low over the Great Basin by Sunday. This appears to mark the beginning of an active wet period for the region as multiple impulses appear to move through next week with good moisture.
Area Forecast:	Orographic lift will be poor throughout the period. However, moisture appears sufficiently deep that we may see a chance for seeding of a deep juicy stratus deck tonight with decent SLW enshrouding the ranges. The best chance for seeding appears to be the MB range, and any flights will occur on the tracks designed for light winds. SLW does not appear deep enough for seeding the NS tonight (minimum flight altitude 15 kft there). Widespread precipitation occurring over the region this afternoon has no targetable SLW, and pilots need to rest after two back-to-back flights last night and this morning, so no flights will be possible before midnight. We will have a look at the 00z models this evening before making final determination about an overnight flight in the MB. We should see a bit of a lull in precipitation this evening, and then another big wave moves through from midnight through tomorrow morning. By dawn, wind direction will become unworkable, so only one flight is possible. Clouds clear out around midday tomorrow, and then dry conditions are expected tomorrow afternoon through Saturday. The next chance for seeding arrives Sunday-Monday, and most of next week will see chances for precipitation in a wet active pattern.
Flight occurred in the morning hours of the 17th; weather information is from Mar. 16th.	



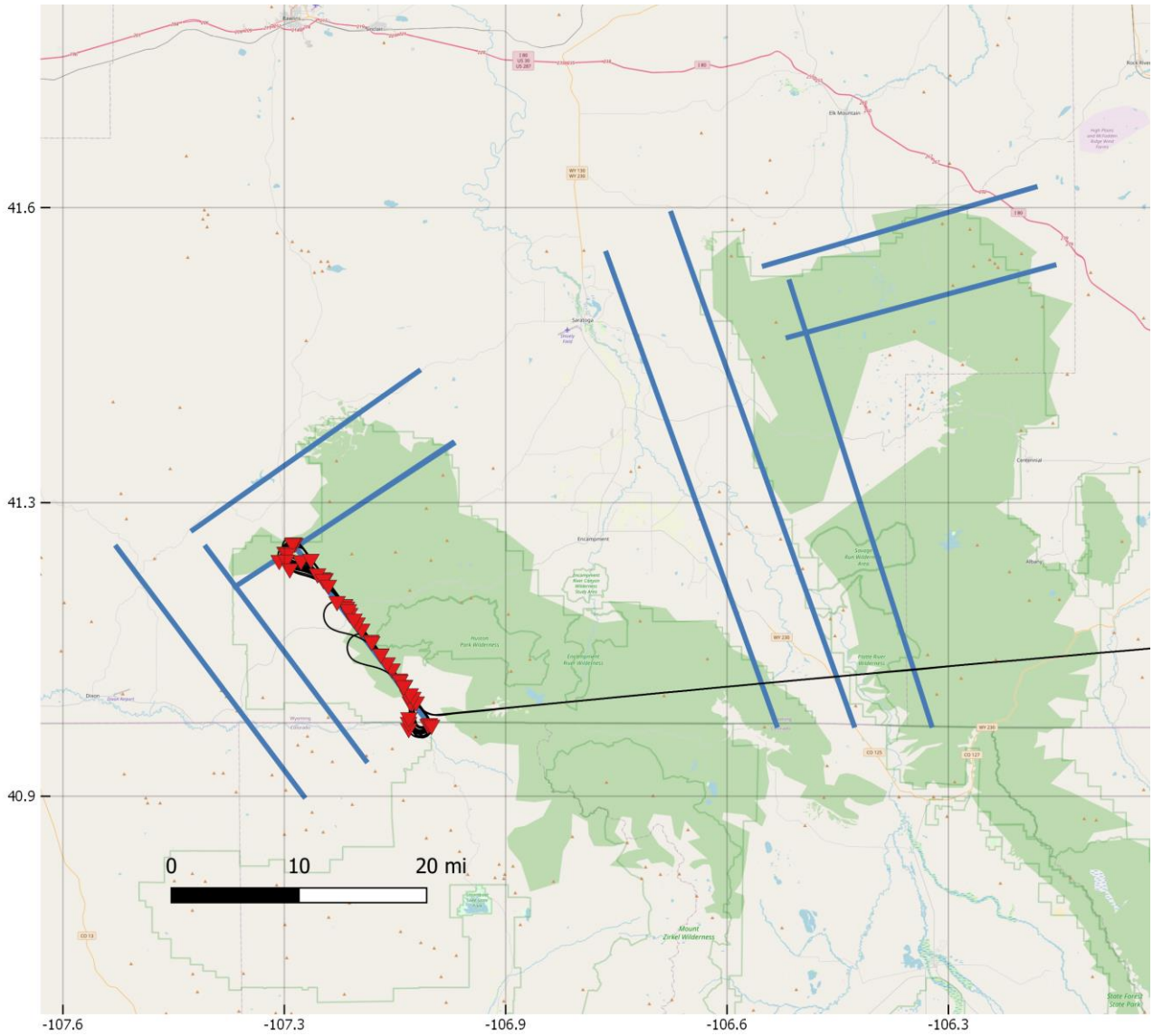
N6111V	OPS #:	30			SEED
	Track(s)/Basin:		MB-5		
UTC Date:	March 21, 2022		MDT Date:	March 21, 2022	
UTC Engines ON:	06:15		MDT Engines ON:	12:15 am	
UTC Engines OFF:	11:16		MDT Engines OFF:	5:16 am	
Total Time:	5:01	5.02hr	Flares Used:	2 BIP	269 EJECT
Pilot's Flight Summary:	Departed CYS @ 16kft for the MB-5 track. Once on track, we descended to the minimum altitude @ 14kft and the CWIP started reporting LWC up to 0.3. With forecasted LWC in the models and the reported LWC, they instructed us to start seeding with EJs once a minute and BIPs at pilot's discretion. Later in the flight, the cloud tops started to rise and the LWC started to increase. Due to seeding conditions				

	getting better, the mets instructed us to increase the seeding rate with EJs. Once low on fuel and the forecasted time frame was ending, we returned to CYS.
Synoptic Analysis:	Jet level charts indicate moderate southwest flow over the region with an approaching large trough expected to push through our ranges tonight through tomorrow. A strong northerly jet streak will be in place over the region by Tuesday on the back side of the trough. A cutoff low will develop to our south tonight and tomorrow, and low level winds will be very light tonight and tomorrow for the project region on the north side of this low. Latest model runs are no longer showing northeast wind direction, but orographic lift appears quite weak which is limiting SLW extent and depth. This system appears to have a lot of natural ice crystals. A cold front sweeps through the region in the early evening hours. There will be some weak instability through the early evening as well. As the trough moves through the Rockies, a strong ridge amplifies over the coast. We will see another batch of moisture move through Tuesday, but then the strong ridge will bring dry conditions Wednesday through the end of the work week.
Area Forecast:	Deep overcast cloud layers are expected throughout the period. Isolated showers are likely through sunset with some convective elements across the region. As the cold front moves in during the early evening, precipitation will become more widespread, and it will continue through the predawn hours. This system is a bit of a disappointment with low QPF and marginal seeding conditions. SLW appears quite sparse tonight with light winds and poor orographic lift. However, there are some intermittent patches of SLW in the MB that may be worthy of investigation shortly after midnight. Clouds will clear out during the day tomorrow, and then another wave of moisture moves through Tuesday in strong northerly flow. This wave will have better orographic lift, but temps aloft will be much colder on the back side of the trough. This Tuesday wave does not appear particularly promising for SLW, but we will not yet rule out a chance for another flight. Dry conditions are expected Wednesday through Saturday with the ridge, and then another shortwave pushes through late Sunday into Monday bringing another quick shot of precipitation to the region.
Flight occurred in the morning hours of the 21st; weather information is from Mar. 20th.	



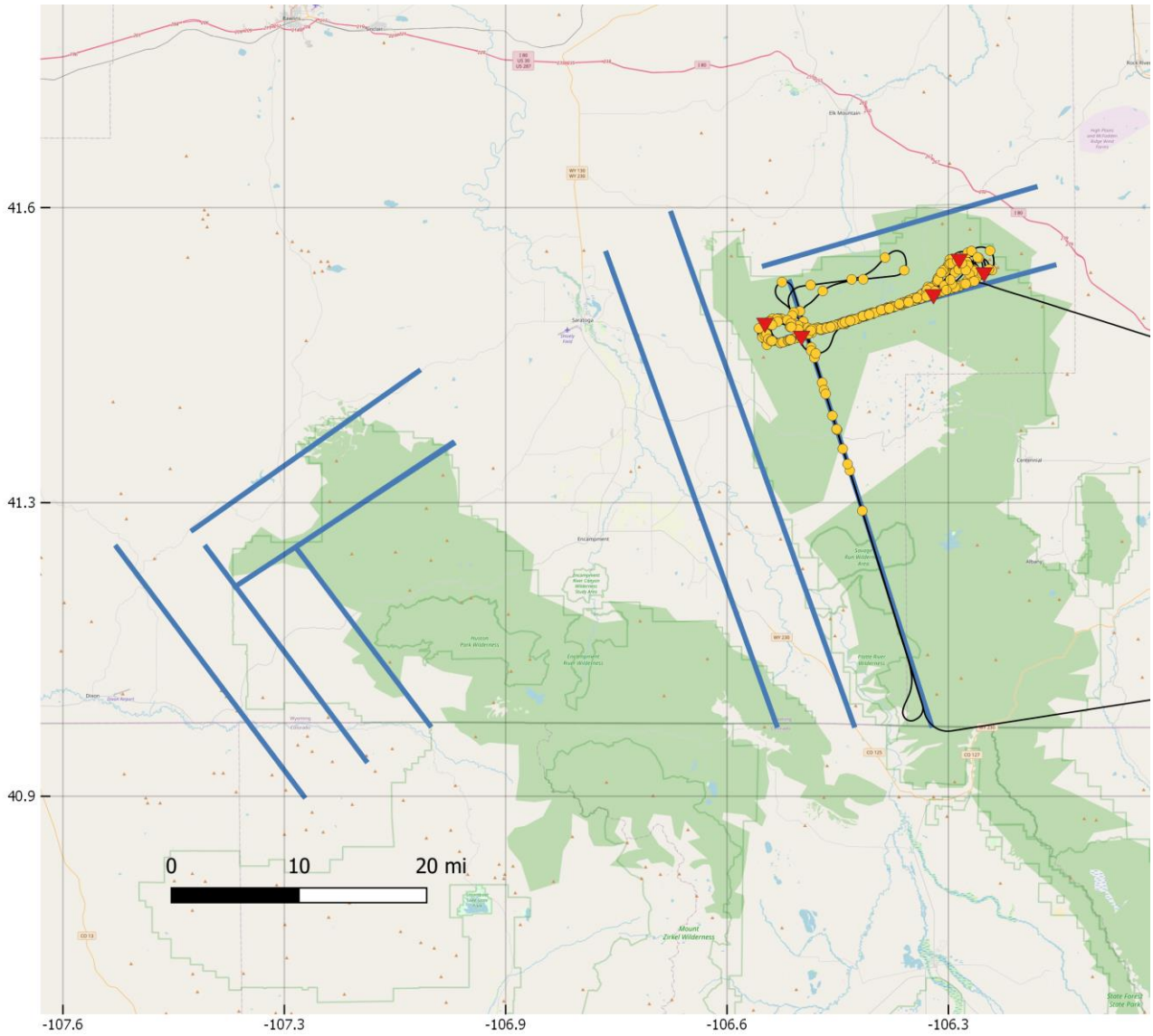
N6111V	OPS #:	31			SEED
	Track(s)/Basin:		MB-1, MB-2		
UTC Date:	March 22, 2022		MDT Date:	March 22, 2022	
UTC Engines ON:	13:37		MDT Engines ON:	7:37 am	
UTC Engines OFF:	18:46		MDT Engines OFF:	12:46 pm	
Total Time:	5:09	5.15hr	Flares Used:	43 BIP	302 EJECT
Pilot's Flight Summary:	Departed CYS for the MB-1 track @ 15kft. Once on track we were in and out of cloud tops where LWC was reporting 0.3-0.5. Due to the higher LWC and good seeding conditions, the mets instructed us to start seeding with EJs once every 30 seconds. Shortly after starting to seed, cloud tops became a little more frequent and the mets instructed us to start seeding with BIPs as well. Once we were about halfway through the third rack of EJs, the mets instructed us to slow our seeding rate with EJs to last the				

	rest of the flight. Once we were running low on flares and fuel, the seeding conditions started to decrease and the mets instructed us to finish seeding if conditions permitted and RTB when necessary.
Synoptic Analysis:	At the upper-levels, a low pressure system continues pushing through New Mexico today. Our region will be in northerly cold flow aloft with decreasing PWAT values through this evening. A northerly jet streak moves in late tonight. We will see a small batch of low level moisture moving in tomorrow morning through tomorrow evening. With stronger low level winds tomorrow, this moisture should be sufficient for some modest orographic development and widespread showers. Models are indicating potentially targetable SLW tomorrow morning through the early evening. QPF will be light. As the southern low exits, a high amplitude ridge will then push into the Rockies Wednesday through Saturday keeping a warmer dry air mass over the region. A shortwave pushes through Montana late Wednesday night, but this looks to ride the top of the ridge and remain well north of our ranges. The next chance for active weather appears to be next Monday with another potent Pacific trough from the west.
Area Forecast:	The scattered to broken low cloud layer over the ranges will continue to diminish throughout the day, giving way to mostly clear skies this evening and tonight. Low overcast returns around dawn, and then scattered showers are expected tomorrow morning through tomorrow evening. WMI models indicate somewhat shallow SLW tomorrow, but it may be just deep enough for seeding. Winds will be northerly and stronger tomorrow, and orographic lift will be better, particularly for the northern slopes. Precipitation ends by tomorrow night, and then dry conditions are expected through the weekend. The next incoming system looks to be a large trough moving in from the west with decent moisture and strong dynamics. Latest long range modeling suggests this system could take a southern track again, keeping the best dynamics to our south, but we will have to watch the evolution of this system throughout the week to see if that track and timing hold.
Flight occurred in the morning hours of the 22nd; weather information is from Mar. 21st.	



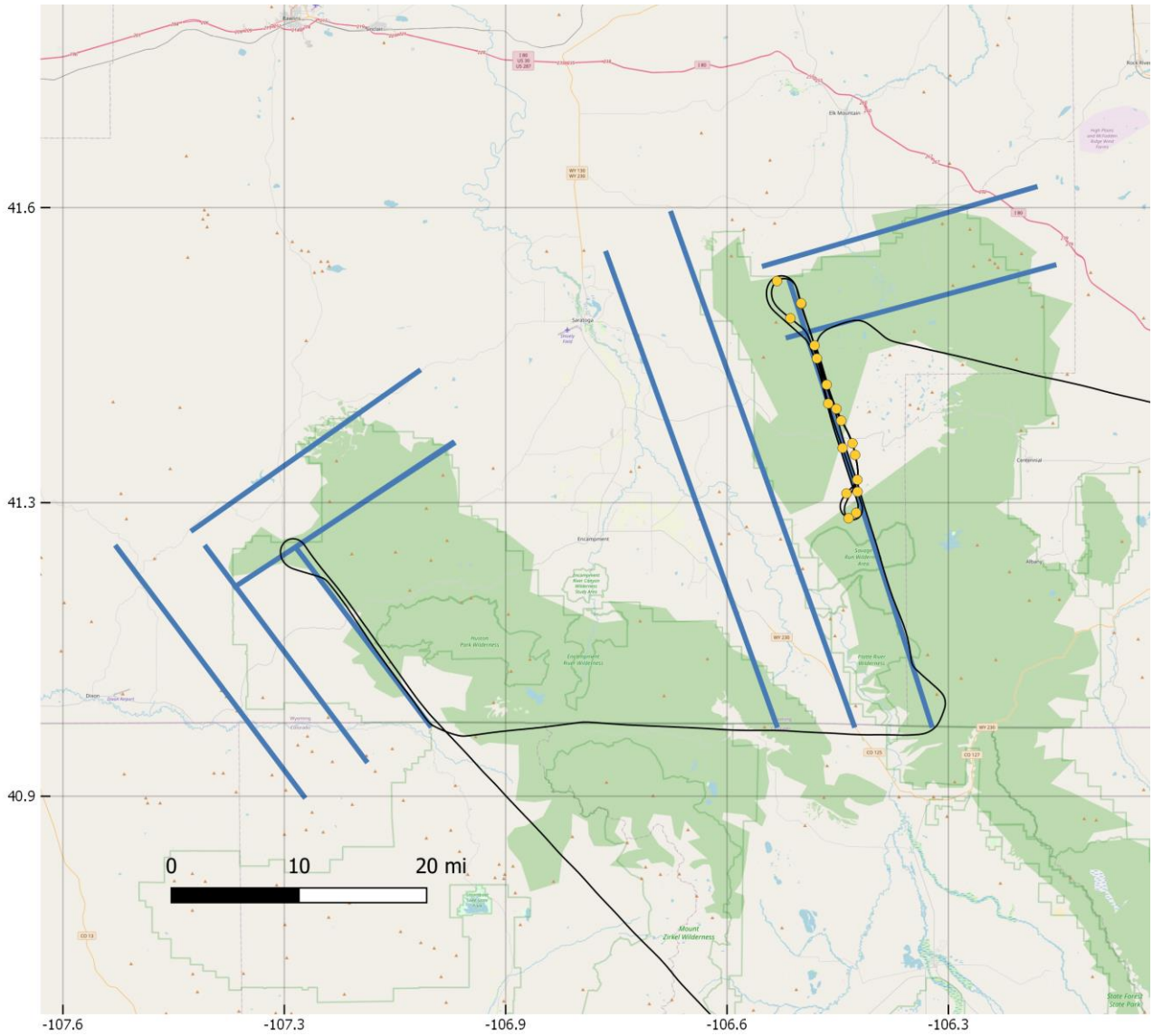
N6111V	OPS #:	32			SEED
	Track(s)/Basin:		SM-5		
UTC Date:	March 29, 2022		MDT Date:	March 29, 2022	
UTC Engines ON:	08:19		MDT Engines ON:	2:19 am	
UTC Engines OFF:	13:23		MDT Engines OFF:	7:23 am	
Total Time:	5:04	5.07hr	Flares Used:	40 BIP	0 EJECT
Pilot's Flight Summary:	Departed CYS for track SM-5 @ 13kft. Once on track, the CWIP reported fairly consistent LWC in cloud tops, and the mets instructed us to start seeding with BIPs. After the first hour of the flight: cloud tops, wind, LWC, and the seeding rate stayed steady. Towards the end of the flight, winds started to shift more west, northwesterly. Once low on fuel, we returned to CYS for a refuel and quick turn for the next flight.				

Synoptic Analysis:	A powerful low pressure system is moving onshore over California. Our region is now under moderate southwest flow aloft as the low approaches the Four Corners region. This system will draw copious moisture into our region tonight and tomorrow with PWAT rising well above 0.40 inches. The strongest dynamics will pass to our south tomorrow, and low level flow will switch to northwesterly by dawn tomorrow morning on the back side of the system. Low level winds appear to be modest tonight and tomorrow, around 20-25 knots. Orographic lift will be light, but there should be adequate SLW for seeding tonight and tomorrow. As midlevels cool tomorrow, afternoon instability will create widespread convection through the early evening. Moisture diminishes tomorrow evening. A shortwave trough pushes through in northwest flow early Wednesday morning with poor moisture, and then a small ridge moves in Wednesday night into Thursday. Yet another shortwave and cold front push through the region Thursday night into Friday from the west.
Area Forecast:	Cloud cover increases through this evening, and then heavy precipitation is expected to begin in all ranges by midnight tonight and continue through tomorrow evening. Around 6 to 9 inches of snow accumulation appears likely in the highest terrain by tomorrow evening. Conditions will likely be suitable for operations late tonight through most of tomorrow morning. As instability develops tomorrow afternoon, seeding will be halted. This should work out fine, as pilots will surely need rest after two flights anyway. Seeding appears unlikely tomorrow evening after the convective threat ends, as the last lingering bits of moisture will probably be insufficient for deep targetable clouds, and wind direction may be unworkable. Seeding level winds will be from the SW late this evening, shifting to NW by morning as the low passes through. Wednesday's minor shortwave does not appear seedable due to lacking moisture. After tonight, the next good chance of operations appears to be a frontal system Thursday night into Friday.
Flight occurred in the morning hours of the 29th; weather information is from Mar. 28th.	



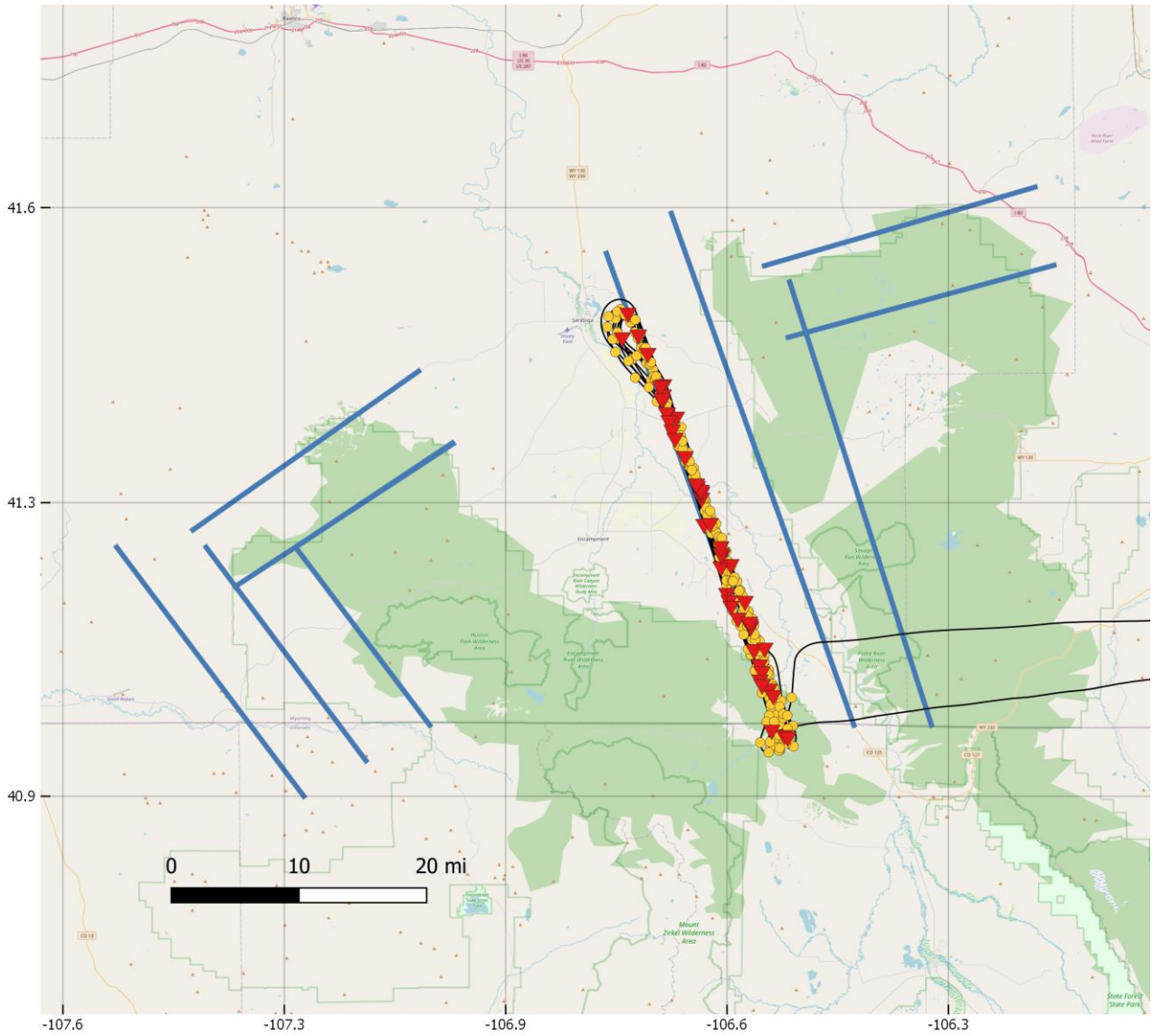
N6111V	OPS #:	33			SEED
	Track(s)/Basin:		MB-5, MB-2		
UTC Date:	March 29, 2022		MDT Date:	March 29, 2022	
UTC Engines ON:	13:37		MDT Engines ON:	7:37 am	
UTC Engines OFF:	18:34		MDT Engines OFF:	12:34 am	
Total Time:	4:57	4.95hr	Flares Used:	5 BIP	302 EJECT
Pilot's Flight Summary:	Departed CYS for the MB-5 track. Once on track, there was broken cloud cover on the south end of the track and reported 0.2 LWC on the north half of the track. Due to winds shifting and the models showing more northwesterly winds on the MB-2 track, they instructed us to fly over to MB-2 and report back. Once on track MB-2, we found abundant LWC that very quickly started an airframe icing problem. During our climb to get above the cloud tops, the mets instructed us to stay on this track and start seeding				

	with EJs. During the climb through the LWC, they also instructed us to seed with BIPs. Once on top, the cloud tops continued to rise throughout the flight. Due to consistently high LWC throughout the flight, we were instructed to increase the seeding rate with EJs to twice a minute. After expending all of the EJs on board, we descended back into the LWC and seeded with the remaining BIPs onboard. Once all the BIPs were expended, we were low on fuel and returned to CYS.
Flight occurred in the morning hours of the 29th; weather information remains the same as MBSM Ops #32.	



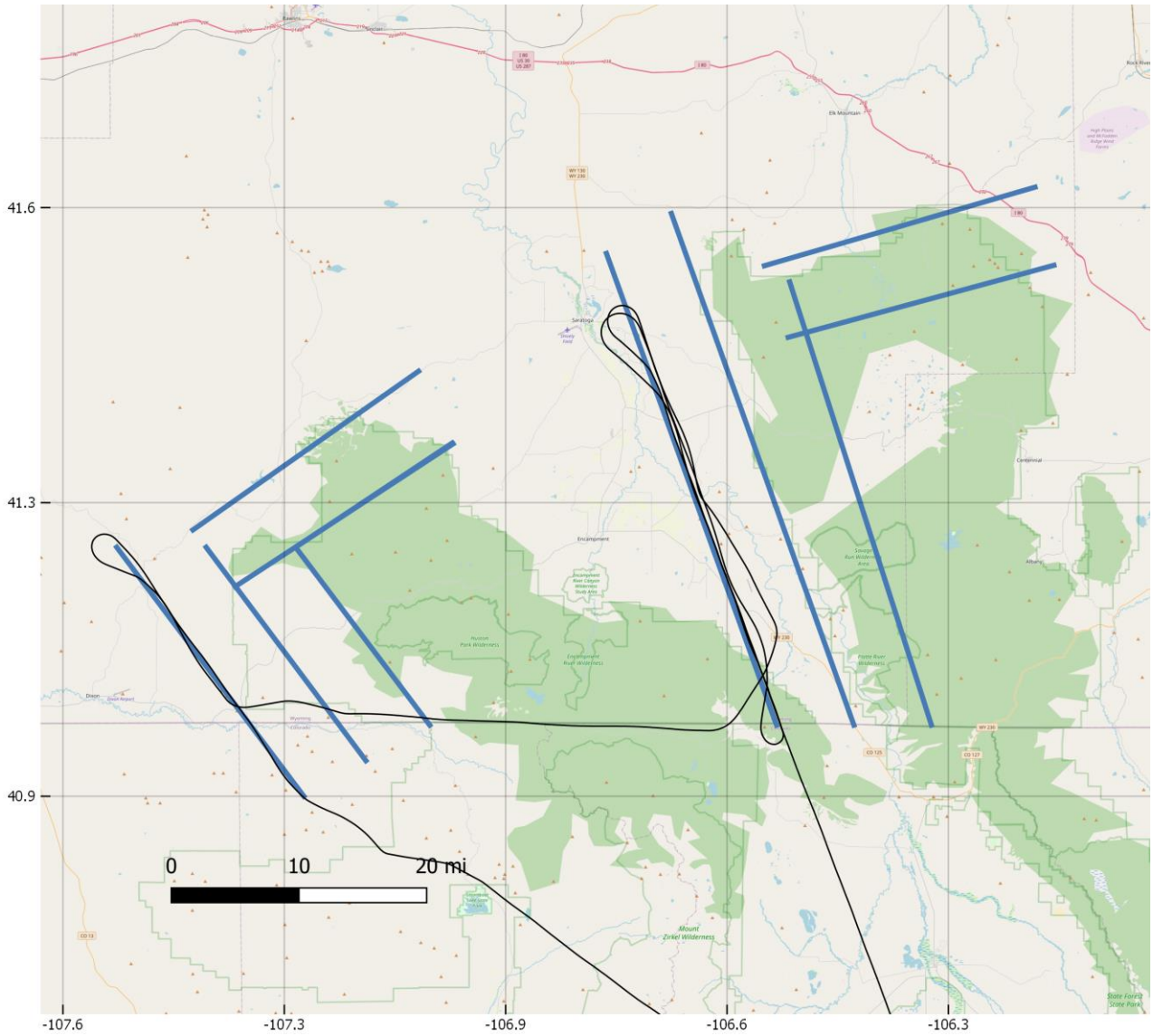
N518TS	OPS #:	34			SEED
	Track(s)/Basin:		SM-5, MB-5		
UTC Date:	April 1, 2022		MDT Date:	April 1, 2022	
UTC Engines ON:	09:05		MDT Engines ON:	3:05 am	
UTC Engines OFF:	11:03		MDT Engines OFF:	5:03 am	
Total Time:	1:58	1.97hr	Flares Used:	0 BIP	17 EJECT
Pilot's Flight Summary:	Departed CYS for NS-3 @ 16kft. Once on track, we descended to 15kft for sampling what LWC was present. LWC was reporting up to 0.56 and the mets instructed us to start seeding with EJs once every 30 seconds. Due to airframe icing, we climbed up to 16kft and continued seeding. About an hour after seeding, we descended to sample the LWC and it was reporting around 0.1, and the mets instructed us to slow our seeding rate. Shortly after, the mets instructed us to stop seeding and fly to the SM range. Once				

	on track SM-5, there were no seedable conditions present so the mets instructed us to fly to the MB range. Once on track MB-5, we found what appeared to be good cloud cover, but the clouds were too low to sample. The mets instructed us to start seeding with EJs once a minute. Shortly after, the mets instructed us to stop seeding and RTB CYS.
Synoptic Analysis:	Upper-level charts show a large defined trough pattern over most of the country stretching from Oregon to New England. Midlevel flow is more convoluted with a small ridge over WY today and a shortwave moving into the region this evening. The shortwave slowly exits by morning, and then another small ridge moves in tomorrow. Another little shortwave pushes through to our north Saturday night, but the system will be too far north to be much of a weather maker for our region. Another small progressive ridge pushes through Sunday, and then we begin a multi-day wet pattern Monday through Wednesday with very strong (and moist) northwest flow. A low is expected to form over Montana by Tuesday. Conditions appear excellent for deep orographic clouds and SLW from Monday night through Tuesday night, and seeding level winds will be from the WNW perhaps reaching 60 knots. Ridging returns next Thursday.
Area Forecast:	High and midlevel clouds will continue to increase through this evening as the trough approaches. Precipitation will begin to spread into our ranges shortly after sunset and increase through midnight. A few hours of targetable SLW appear likely around midnight as the midlevel snow band exits. Conditions appear marginally seedable in the MB and NS ranges around midnight. Seeding level winds will be from the west around 25-30 kts, and a modest layer of SLW is likely below 15 kft. A seeding flight has been scheduled for the NS3 track to depart shortly before midnight. Only one flight is expected tonight. High and midlevel clouds clear out by dawn, but a stratus deck lingers into tomorrow morning. Skies should clear by forecast time tomorrow. Dry conditions are expected tomorrow. The next chance for light snowfall will be late Saturday night, but this system appears very light and seeding chances are slim. Sunday through Monday morning will be dry, and then an active wet period is expected Monday evening through early Wednesday with an outstanding orographic setup. Longer range models are picking up on this event, indicating deep abundant targetable SLW, Monday night and Tuesday.
Flight occurred in the morning hours of the 1st; weather information is from Mar. 31st.	

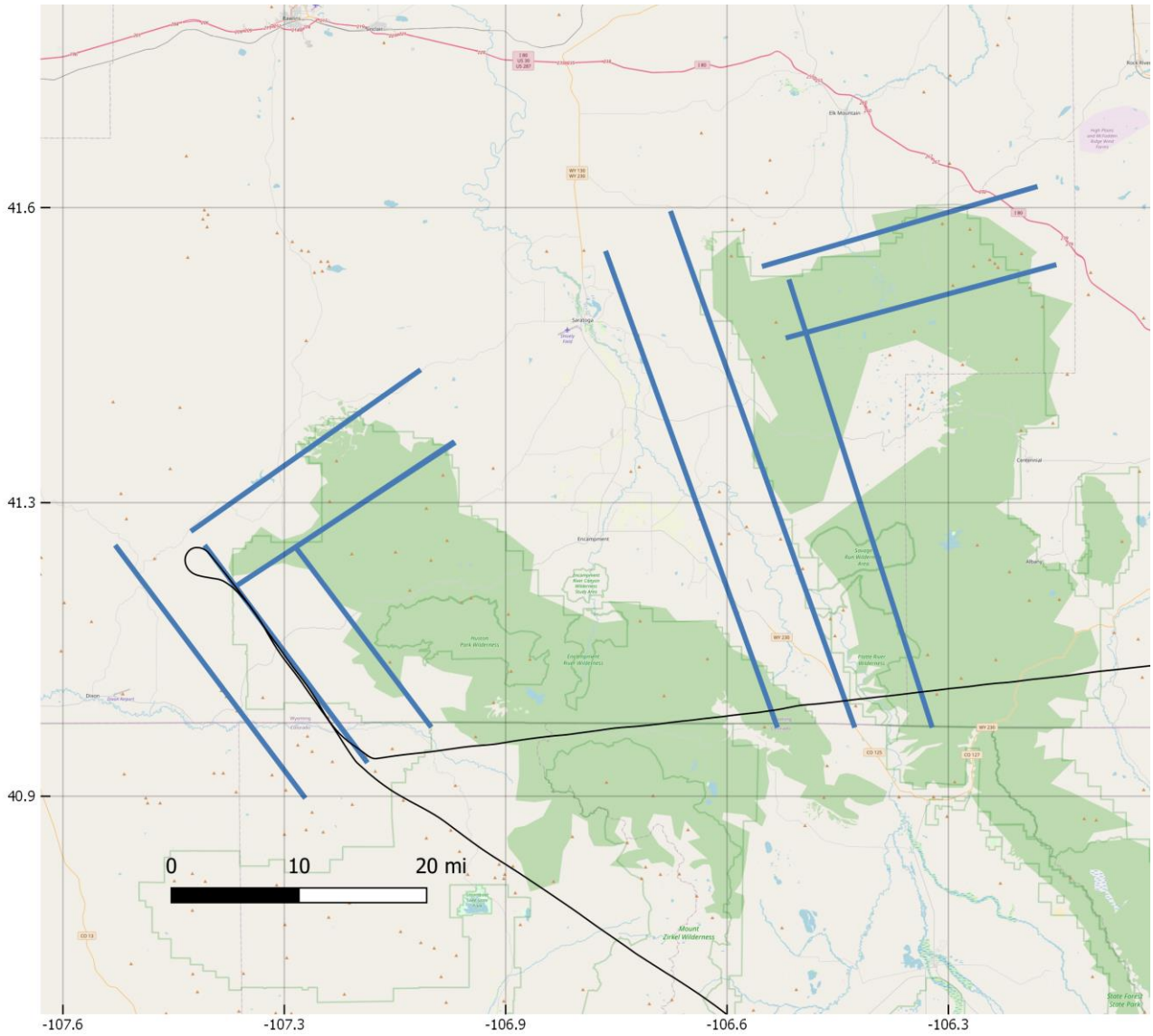


N518TS	OPS #:	35			SEED
	Track(s)/Basin:		MB-3		
UTC Date:	April 5, 2022		MDT Date:	April 5, 2022	
UTC Engines ON:	06:27		MDT Engines ON:	12:27 am	
UTC Engines OFF:	10:55		MDT Engines OFF:	4:55 am	
Total Time:	4:28	4.47hr	Flares Used:	35 BIP	204 EJECT
Pilot's Flight Summary:	Departed CYS for the MB-3 track @ 14kft. On the way to track, we found heavy LWC and once one track, the mets instructed us to start seeding with EJs and BIPs. This kept up for the entire flight until winds became too high for seeding into the target area. The mets instructed us to stop seeding and RTB.				
Synoptic Analysis:	A large powerful jet streak is nosing into the region from the PACNW today. The region will be under very strong northwest flow through tomorrow, and then the strong flow				

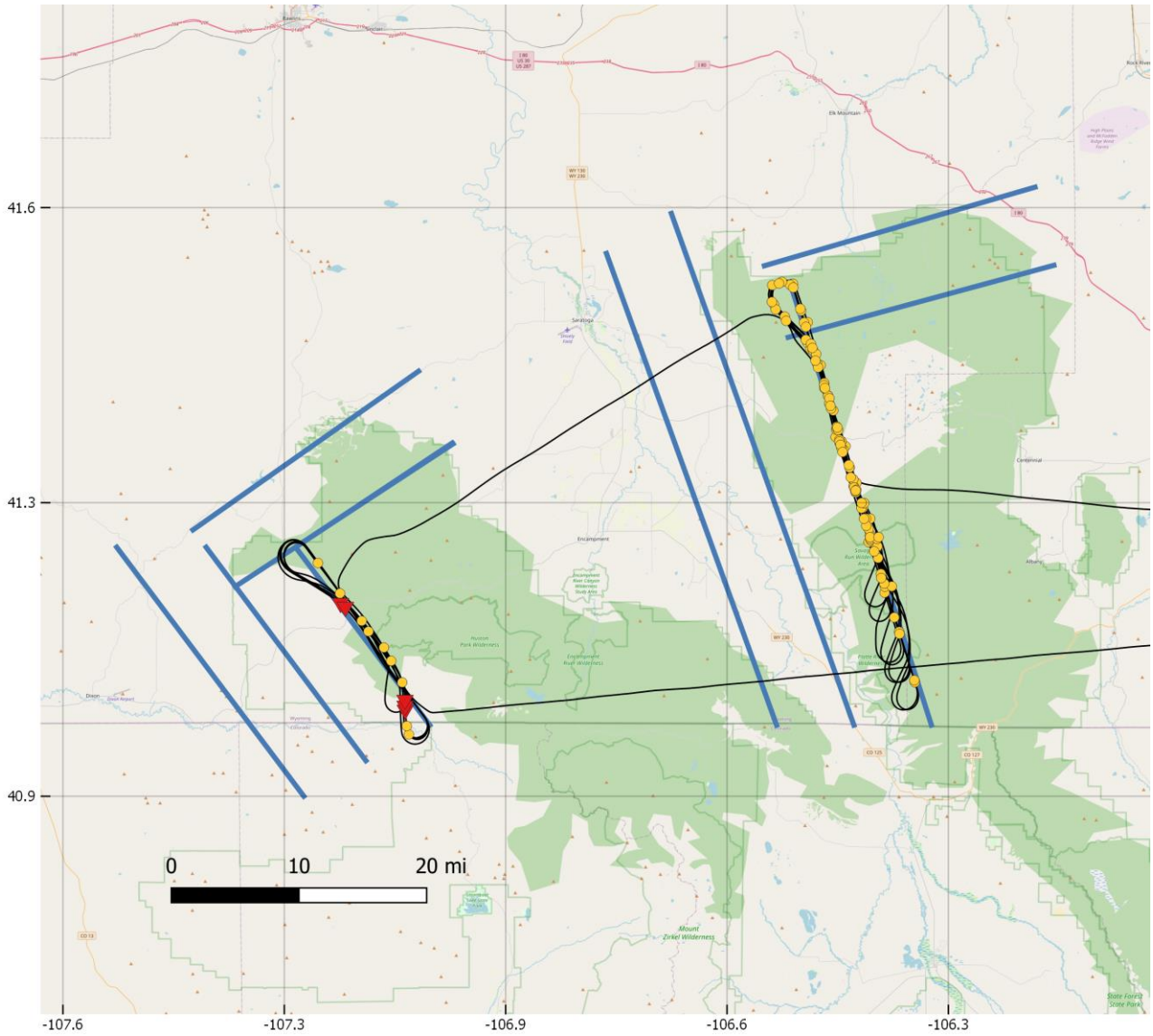
	aloft becomes more northerly by tomorrow night as a low develops to our north and a ridge amplifies over the coast. Copious moisture is flowing onshore over the PACNW, and this will reach the project region this evening. Excellent PWAT is expected this evening and tonight, peaking around 0.40 inches. A cold front sweeps through tonight. A much colder airmass is expected for tomorrow and Wednesday, and PWAT values will drop to around 0.10 inches. Very strong winds are expected this evening and tonight, perhaps topping 75 mph at seeding level. Wind speeds will moderate a bit tomorrow. Brief ridging is expected Thursday and Friday, and then another trough arrives from the northwest for the weekend.
Area Forecast:	The strong winds and excellent moisture will combine to create impressive orographic clouds and SLW tonight and tomorrow. Deep overcast clouds are expected through midnight while orographic clouds with very heavy SLW are expected from sunset through the end of the period. Low and midlevel clouds are likely tonight as well. Wind speeds will be unusually strong. This will force us to use the distant high-speed tracks for seeding. There will be several safety considerations impacting operations this evening and tonight. The first is the potential for severe icing conditions. All efforts will need to be made to avoid getting the aircraft into the heavy SLW on this storm. We will need to keep our distance and altitude tonight, broadcasting this system from well-upwind if necessary to avoid icing up the plane. Second, the very strong winds may create some challenges with mechanical turbulence. If this becomes too problematic, it could cut operations short, especially with about ten hours of seeding possible tonight. SLW appears targetable through noon tomorrow, and then conditions are probably not adequate for seeding tomorrow evening/night as moisture wanes and temps drop. Light snow continues through Wednesday evening. Dry conditions are likely Thursday and Friday.
Flight occurred in the morning hours of the 5th; weather information is from Apr. 4th.	



N518TS	OPS #:	36			RECON
	Track(s)/Basin:		SM-3, MB-3		
UTC Date:	April 12, 2022		MDT Date:	April 11, 2022	
UTC Engines ON:	02:59		MDT Engines ON:	8:59 pm	
UTC Engines OFF:	04:29		MDT Engines OFF:	10:29 pm	
Total Time:	1:30	1.5hr	Flares Used:	0 BIP	0 EJECT
Full flight summary continued in the table for Never Summer Ops #14.					

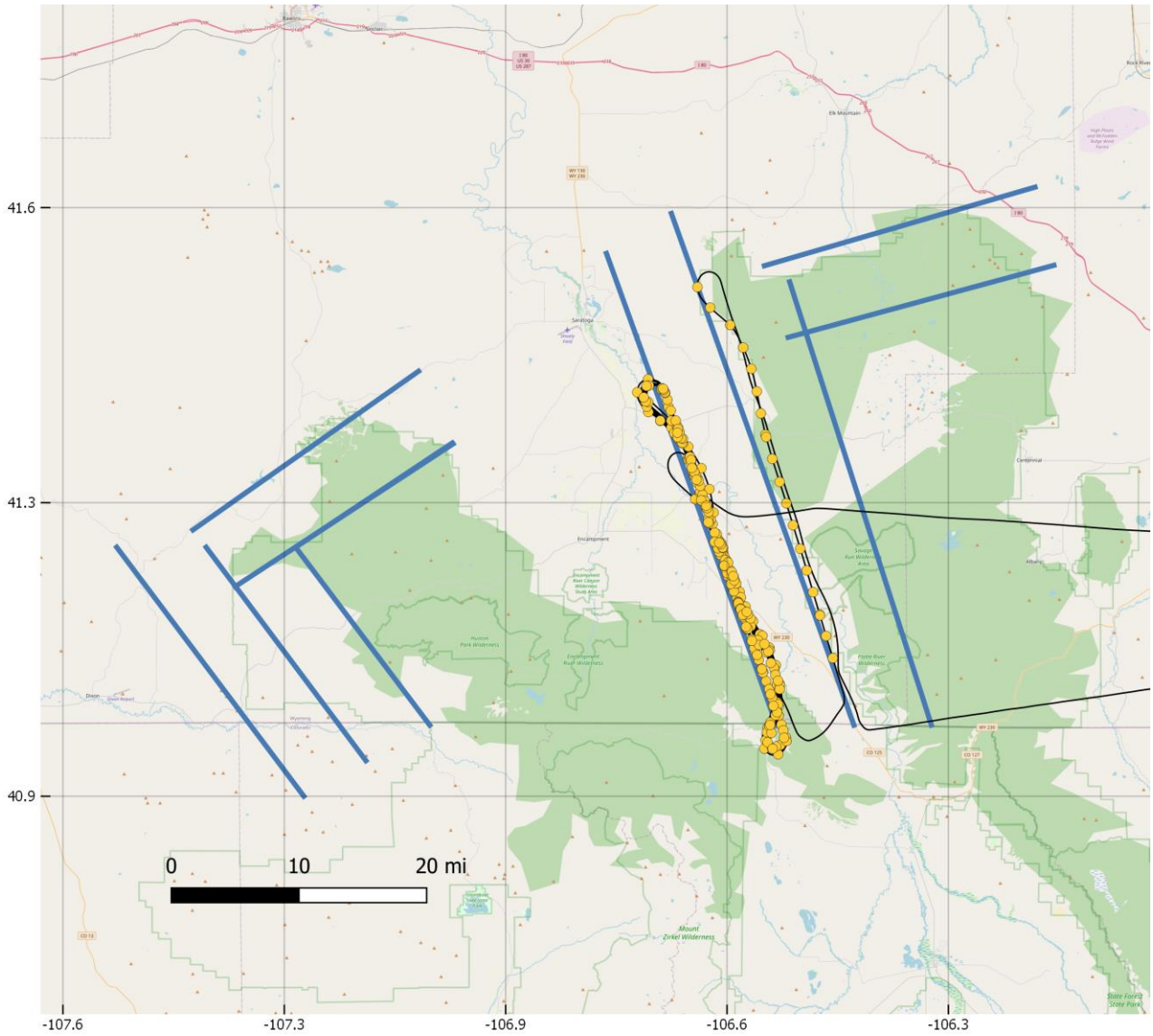


N518TS	OPS #:	37			RECON
	Track(s)/Basin:		SM-4		
UTC Date:	April 12, 2022		MDT Date:	April 12, 2022	
UTC Engines ON:	06:58		MDT Engines ON:	12:58 am	
UTC Engines OFF:	08:13		MDT Engines OFF:	2:13 am	
Total Time:	1:15	1.25hr	Flares Used:	0 BIP	0 EJECT
Full flight summary continued in the table for Never Summer Ops #15.					



N518TS	OPS #:	38			SEED
	Track(s)/Basin:		SM-5, MB-5		
UTC Date:	April 13, 2022		MDT Date:	April 13, 2022	
UTC Engines ON:	10:54		MDT Engines ON:	4:54 am	
UTC Engines OFF:	16:08		MDT Engines OFF:	10:08 am	
Total Time:	5:14	5.23hr	Flares Used:	3 BIP	134 EJECT
Pilot's Flight Summary:	Departed CYS for the SM-5 track @ 13kft. Once on track, we found cloud tops around 13k ft. and LWC in the cloud tops. We climbed just above cloud tops to avoid airframe icing and started seeding with EJs. Due to conditions, the mets instructed us to change to BIPs. Due to cloud cover diminishing and our prop heat failing, we stopped seeding and moved over to the MB range. Once on track @ 17kft, we started seeding with EJs, while staying just above cloud tops. Once we were running low on fuel, we RTB.				

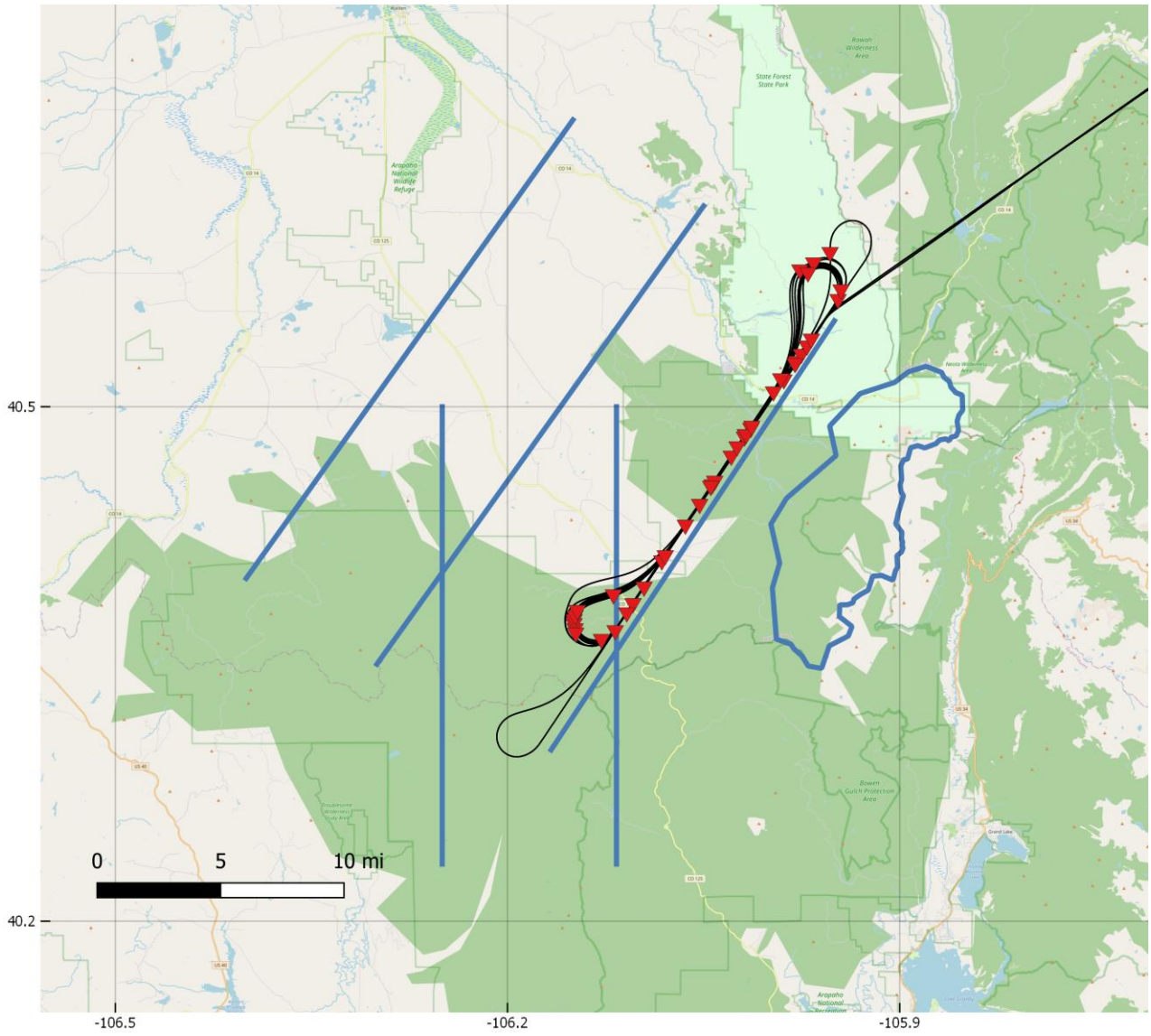
Synoptic Analysis:	The large-scale trough pattern persists over the northern Rockies and PACNW. Our region is under strong southwest flow aloft, and a cold air mass is in place throughout the period. The 500 mb temps are well below -30°C, and PWAT will linger just above 0.10 inches. At midlevels, a closed low is inching through northern WY, and potent vorticity advection is expected today. At lower levels, there is decent moisture, relative to the cold temps aloft. With the low centered just to our north, strong westerly winds are likely at seeding levels. This is a decent setup for orographic enhancement, mainly overnight. There will be some weak CAPE this afternoon into the late evening again as the cold temps aloft have steepened lapse rates. More instability is likely tomorrow afternoon. Strong westerly flow persists through Friday. Warmer moister air will return late Wednesday through Friday.
Area Forecast:	The rest of the week is trending wetter in today's model runs. Snow showers continue through this evening, but no targetable SLW is expected through midnight. Overnight, light SLW is indicated. A single flight is possible tonight after midnight in either the MB or SM. Seeding level winds will not be as strong as what we saw last night, which should make targeting easier. The cold air mass in place will make the SM more favorable for temps, as we can drop to 13kft into the warmer portion of the cloud. We make final decisions about overnight operations after the 00z model runs this evening. Activity wanes tomorrow morning/afternoon, and we will see daytime convection. After tonight, the next window for potential seeding looks to be Thursday morning around sunrise.
Flight occurred in the morning hours of the 13th; weather information is from Apr. 12th.	



N518TS	OPS #:	39			SEED
	Track(s)/Basin:		MB-4, MB-3		
UTC Date:	April 15, 2022		MDT Date:	April 15, 2022	
UTC Engines ON:	16:20		MDT Engines ON:	10:20 am	
UTC Engines OFF:	21:47		MDT Engines OFF:	3:47 pm	
Total Time:	5:27	5.45hr	Flares Used:	0 BIP	302 EJECT
Pilot's Flight Summary:	Departed CYS for MB-4 @ 18kft. Once on track, we dipped down into the cloud top to verify LWC and then climbed back up just above the cloud top to avoid airframe icing. The mets instructed us to start EJs once a minute. After reporting the winds, the mets instructed us to move over to the MB-3 track and increase the rate of EJs to once every 30 seconds. As the flight went on, the conditions on track and downwind got better for seeding. Later in the flight, the mets instructed us to slow the rate of EJs to once a				

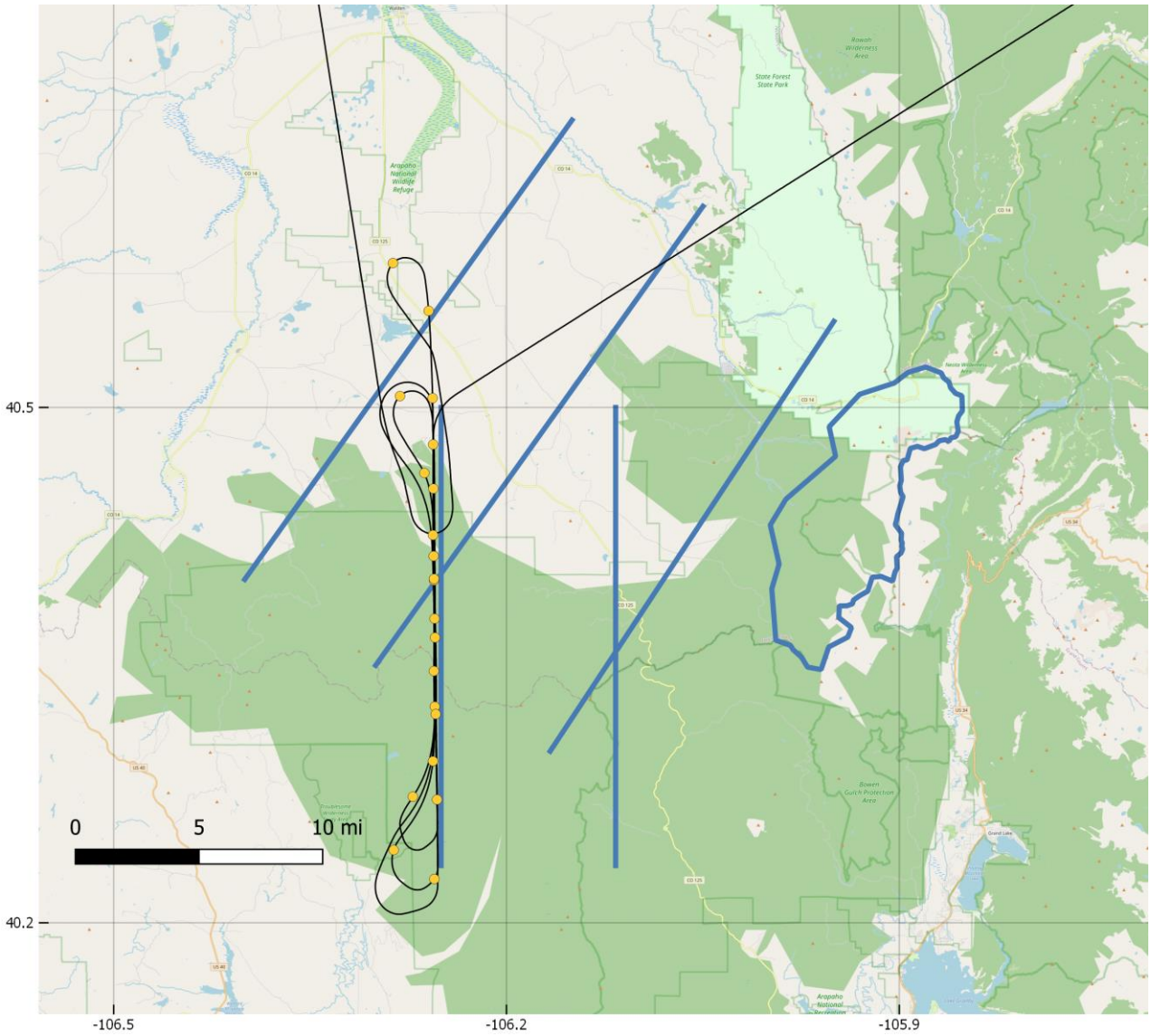
	minute to spread out the seeding material over the course of the flight. Once out of EJs and low on fuel, we RTB. This was our final flight of the season.
Synoptic Analysis:	A strong westerly upper level jet is stretched across CO today but will be drifting northward tomorrow. The midlevel flow is mainly zonal with a lot of scattered PVA passing through today and tomorrow morning. A small wave of moisture moved through this morning but is slowly waning this afternoon and evening. A stronger push of moisture will be coming tonight and continue until midday tomorrow. Moisture will then be decreasing tomorrow afternoon and evening as the project season comes to an end.
Area Forecast:	The clouds over the ranges this morning have started to thin and will slowly fade throughout the afternoon. By sunset the bases will be above the peaks of the ranges, and small clouds with elevated bases will remain through the evening. The clouds start thickening after midnight with continuous snowfall during the night and tomorrow morning. The best SLW at flight level with westerly winds will be over the MB from 09Z to 12Z, at which point a cold front moves through bringing stronger snowfall and less LW. Behind the front, the snowfall rate decreases and SLW returns a little after sunrise and favorable seeding conditions are expected over both the MB and SM tomorrow morning and early afternoon. There should not be any weather issues at CYS. The clouds will start diminishing tomorrow in the later afternoon and expected to be gone shortly after sunset. The sky will be clear for the late evening and early nighttime, and then high clouds filter in during the night.
Flight occurred in the morning to afternoon hours of the 15th; weather information is from Apr. 14th.	

5.2 Mission Flight Tracks – Never Summer range, CO

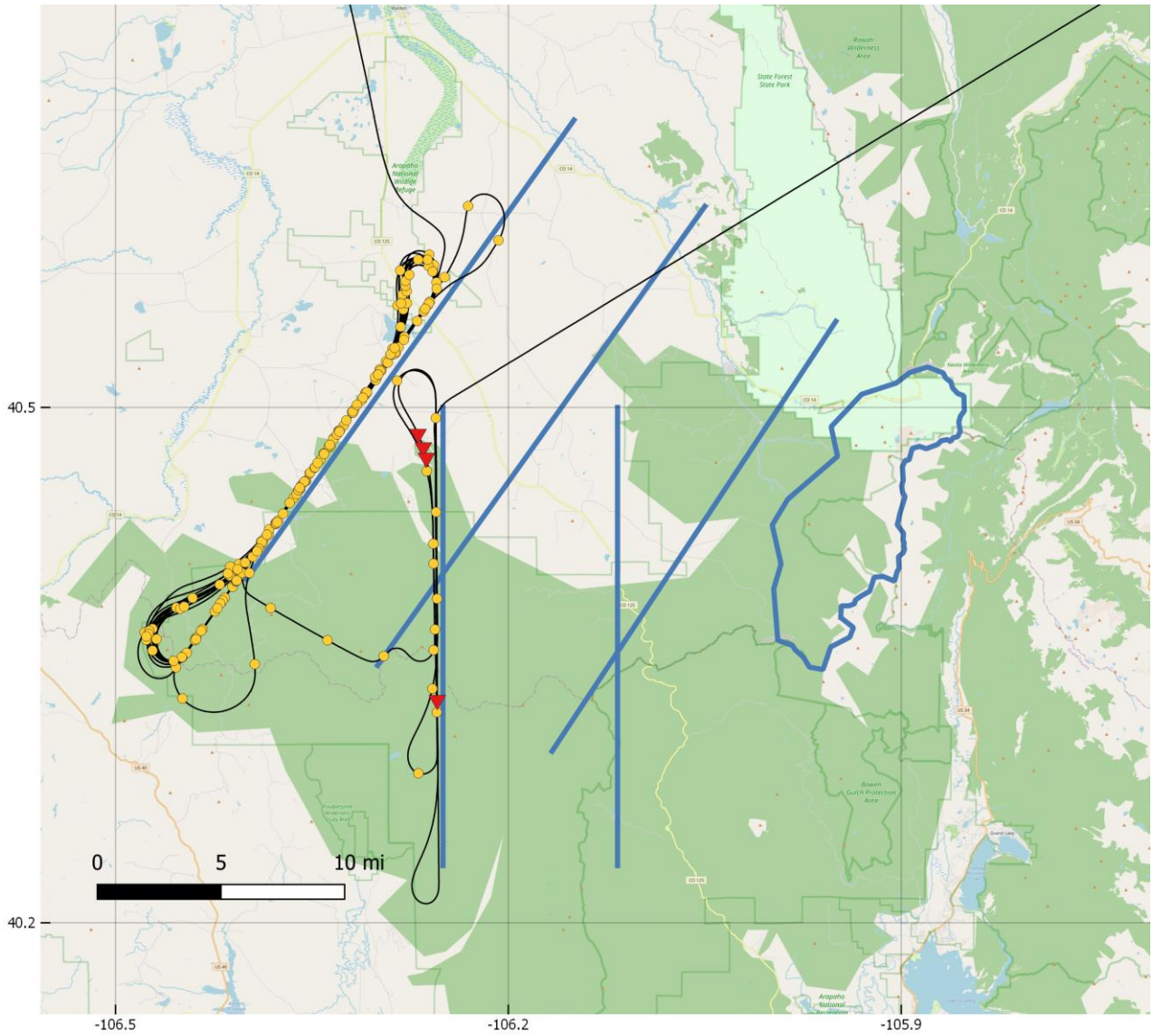


N6111V	OPS #:	01			SEED
	Track(s)/Basin:		NS-3		
UTC Date:	November 2, 2021		MDT Date:	November 2, 2021	
UTC Engines ON:	16:39		MDT Engines ON:	10:39 am	
UTC Engines OFF:	20:35		MDT Engines OFF:	2:35 pm	
Total Time:	3:56	3.93hr	Flares Used:	29 BIP	0 EJECT
Pilot's Flight Summary:	Departed CYS for NS-3 at 15kft. Once on track we found no liquid water to start, but good conditions reported lower so we seeded using BIPs. Later in the flight, liquid water was present at our altitude but not enough to cause icing problems, so we continued seeding until conditions deteriorated and we RTB.				

Synoptic Analysis:	Upper level charts indicate the jet core just east of the project ranges with moderate WNW flow. A high amplitude ridge is in place over the PACNW and British Columbia, while a potent shortwave trough off the Washington coast draws Pacific moisture onshore over Northern California and the PACNW. A slug of moisture lingers over WY through early Wednesday keeping low levels mostly saturated through tomorrow night. Ridging and drier air will then take hold Wednesday through the weekend. Deep moisture is in place over the region with PWAT values above 0.4 inches. Dynamics are fairly weak, and seeding level winds are relatively light. Dense low cloud cover blankets the region with very low ceilings in CYS through most of the seedable periods. Already warm midlevel temps will be warming steadily throughout the period with 500mb temps rising from around -19°C this morning to almost -16°C by morning. Seeding level winds will be mostly from the W around 25-30 knots.
Area Forecast:	Intermittent pockets of marginally seedable SLW (supercooled liquid water) will be present today through tomorrow. Showery activity is likely during the afternoon with the best precipitation occurring in the NS range. Widespread precipitation overspreads the entire region by midnight (including CYS) and continues through the night. The light low level winds and somewhat stagnant nature of this moisture are creating a setup for very low cloud bases across the region which will likely cause concerns for flight operations. The light winds are also not particularly favorable for deep SLW and orographic cloud over the peaks as SLW depth is only modest for such a warm system. This appears to be more of a widespread moisture advection precipitation event than a strictly orographic event. TAFs indicate ceilings ranging from 400 to 700 feet through midnight, and our models indicate this unlikely to improve much by midnight. Another complicating factor for operations will be the inoperative ILS at CYS this week. We would likely attempt a seeding flight tonight or perhaps tomorrow on some of this marginally deep SLW, but only if forecast ceilings improve enough that is no longer a safety issue.
Flight occurred in the morning hours of the 2nd; weather information is from Nov. 1st.	

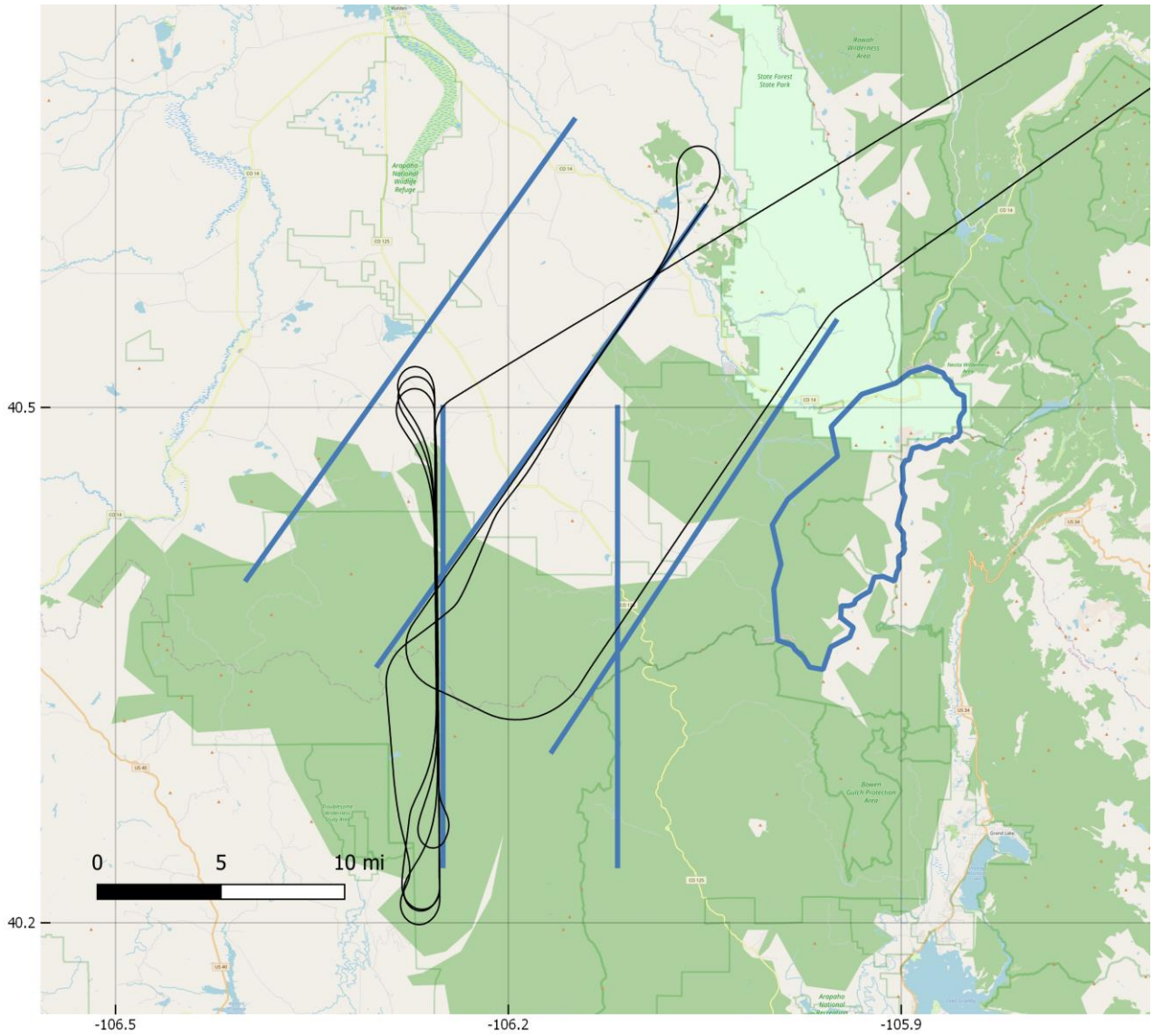


N6111V	OPS #:	02			SEED
	Track(s)/Basin:		NS-4		
UTC Date:	December 15, 2021		MST Date:	December 15, 2021	
UTC Engines ON:	13:06		MST Engines ON:	6:06 am	
UTC Engines OFF:	14:48		MST Engines OFF:	7:48 am	
Total Time:	1:42	1.7hr	Flares Used:	0 BIP	19 EJECT
Full flight summary continued in the table for Medicine Bow & Sierra Madre Ops #8.					



N6111V	OPS #:	03			SEED
	Track(s)/Basin:		NS-4, NS-1		
UTC Date:	December 23, 2021		MST Date:	December 23, 2021	
UTC Engines ON:	16:46		MST Engines ON:	9:46 am	
UTC Engines OFF:	21:22		MST Engines OFF:	2:22 pm	
Total Time:	4:36	4.6hr	Flares Used:	2 BIP	172 EJECT
Pilot's Flight Summary:	Departed CYS for NS-4 @ 17kft. Once on track, we found good LWC in the clouds and the mets instructed us to start seeding with BIPs. Not long after, we flew out of the clouds, and being just above the cloud tops, the mets instructed us to switch to seeding with EJs once a minute. Due to winds, we were instructed to cut off the south five miles of the track. Then due to wind changes, we were instructed to switch and use the south half of the track NS-1 and extend the southern point. Seeding conditions remained the				

	same for the remainder of the flight except for lowering cloud tops, which resulted in us lowering our seeding altitude. At radar request, we RTB.
Synoptic Analysis:	Upper-level charts show a very strong westerly jet streak over our region, especially late in the period. A ridge axis moves through the region this afternoon, and then we will be in a transitional period tonight through tomorrow morning as moisture begins to pour into the ranges. The long-advertised moisture plume from the Pacific cutoff low will arrive tomorrow morning creating heavy snow and excellent orographic clouds. Impressive PWAT values are expected tomorrow and Friday, and low level moisture will be excellent tomorrow morning through Friday night along with strong orographic lift with 700mb winds around 50 knots. A lull in moisture is expected on Saturday, and then it increases again Sunday evening. A Winter Storm Warning has been issued for the ranges with up to 3 feet of snow likely in the SM and 2 feet in the MB range by Saturday morning. Multiple impulses are expected next week as well, and we will remain in an active pattern through next weekend with multiple seeding windows.
Area Forecast:	Thin orographic clouds are expected off and on today and tonight, but nothing seedable. Deep moisture and targetable clouds arrive by midmorning tomorrow. Snowfall will begin around dawn, spreading from west to east. The first seeding flight for tomorrow will likely begin in the late morning hours, and there should be abundant deep SLW allowing for back-to-back flights during the day. We will likely take a break from ops tomorrow night to allow for pilot rest and then start operations again Friday morning with two more flights appearing likely. This first wave may see four seeding flights by Friday evening. No operations will occur Saturday. Another seeding window appears likely late Sunday into Monday. Additional seeding chances are expected next week as well, and the current GFS timing of these waves suggests seeding windows early Tuesday and again Thursday.
Flight occurred in the morning to afternoon hours of the 23rd; weather information is from Dec. 22nd.	

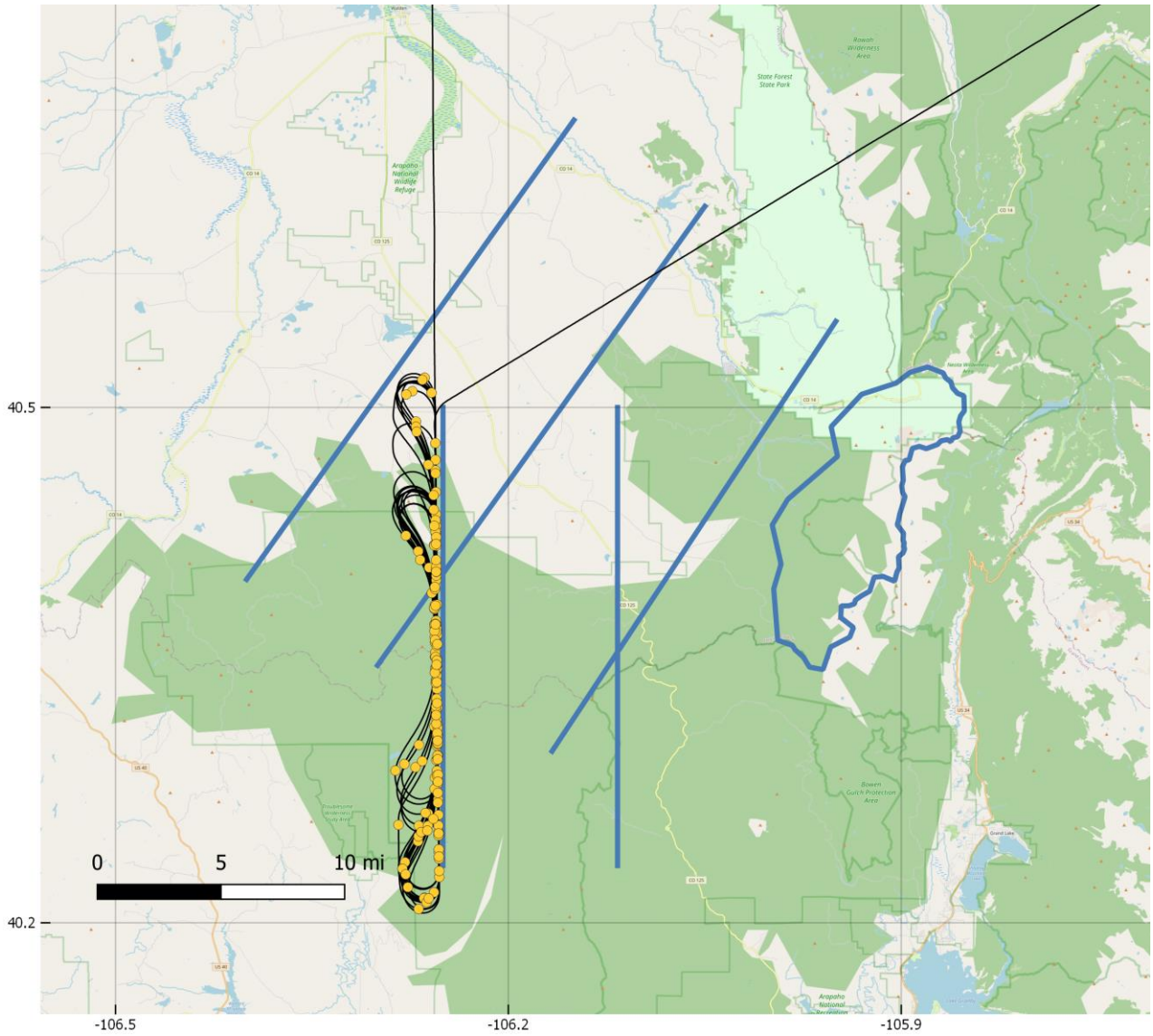


N6111V	OPS #:	04			RECON
	Track(s)/Basin:		NS-4, NS-2, NS-3		
UTC Date:	December 24, 2021		MST Date:	December 24, 2021	
UTC Engines ON:	19:13		MST Engines ON:	12:13 pm	
UTC Engines OFF:	21:26		MST Engines OFF:	2:26 pm	
Total Time:	2:13	2.22hr	Flares Used:	0 BIP	0 EJECT
Pilot's Flight Summary:	Departed CYS for NS-4 @ 15kft. No LWC on the way to track and nothing found on track, as flight progressed, visibility dropped and the mets were expecting seeding conditions to move in. The mets instructed us to check out conditions on NS-2 and when conditions did not improve for seeding, they requested us to check out NS-3. Conditions did not improve and we RTB.				

Flight occurred in the afternoon hours of the 24th; weather information remains the same as MBSM Ops #11.

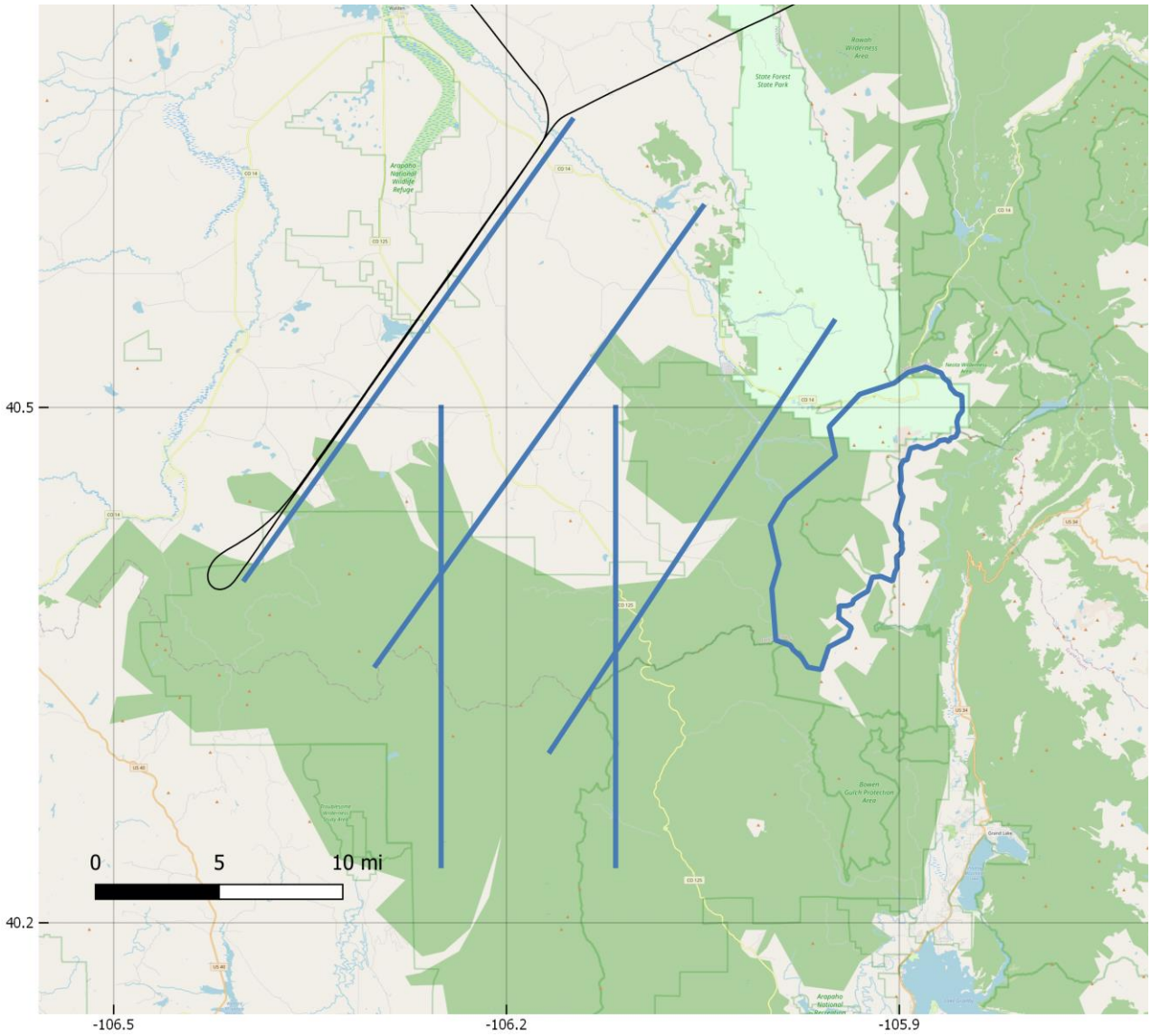
Flight track unavailable for this mission.

N6111V	OPS #:	05			SEED
	Track(s)/Basin:		SM-4, SM-3, MB-3		
UTC Date:	December 26, 2021		MST Date:	December 26, 2021	
UTC Engines ON:	18:04		MST Engines ON:	11:04 am	
UTC Engines OFF:	21:32		MST Engines OFF:	2:32 pm	
Total Time:	3:28	3.47hr	Flares Used:	0 BIP	99 EJECT
Pilot's Flight Summary:	Departed CYS for SM-3 @ 14.5kft. Once on track we found good LWC and were instructed by the mets to start seeding with EJs once a minute. Shortly after, seedable conditions moved east and were no longer suitable with the high winds. The mets instructed us to move to the NS-4 track. Once on track, winds were higher than expected and we established a parallel track about 7 miles west of NS-4 track. The mets instructed us to start seeding with EJs once a minute for broadcast seeding as waves of seedable conditions were expected to roll through. Throughout the mission seeding on the modified track, winds started to lower enough to move back to the NS-4 track and continued seeding until low on fuel. Once low on fuel, we RTB.				
Synoptic Analysis:	An omega block, centered by a large upper-level ridge in the East-Central Pacific, has left much of the western CONUS in a cold longwave trough. Moisture with this trough has brought waves of precipitation and occasional seeding opportunities to our target ranges the last several days, with the stagnant pattern continuing to bring periods of enhanced moisture and lift the next several days. At the surface, the midday surface analysis shows a low pressure center near South Pass, with a cold front moving east across southern Wyoming and Colorado. Banded orographically enhanced precipitation has been observed across southern WY and CO ahead of this front, with project aircraft finding areas of embedded SLW at the time of the forecast.				
Area Forecast:	Widespread snow showers will continue until the cold front overtakes the region from west to east this afternoon. Orographic clouds will continue behind the front, though moisture decreases, with no further seeding opportunities likely this evening or tonight. Overcast skies continue into Monday, and despite low precipitable water values, orographic cloud persists. NWP solutions show small quantities of potentially targetable liquid water over the peaks, with a marginal seeding opportunity possible, especially later in the day. This will be reassessed in subsequent NWP runs tonight and tomorrow. Looking further ahead, midlevel NVA will bring a short reprieve in orographic cloud and precipitation Tuesday, but a new system approaches from the southwest Wednesday with a new round of potentially seedable conditions.				
Flight occurred in the morning hours of the 26th; weather information is from Dec. 25th.					

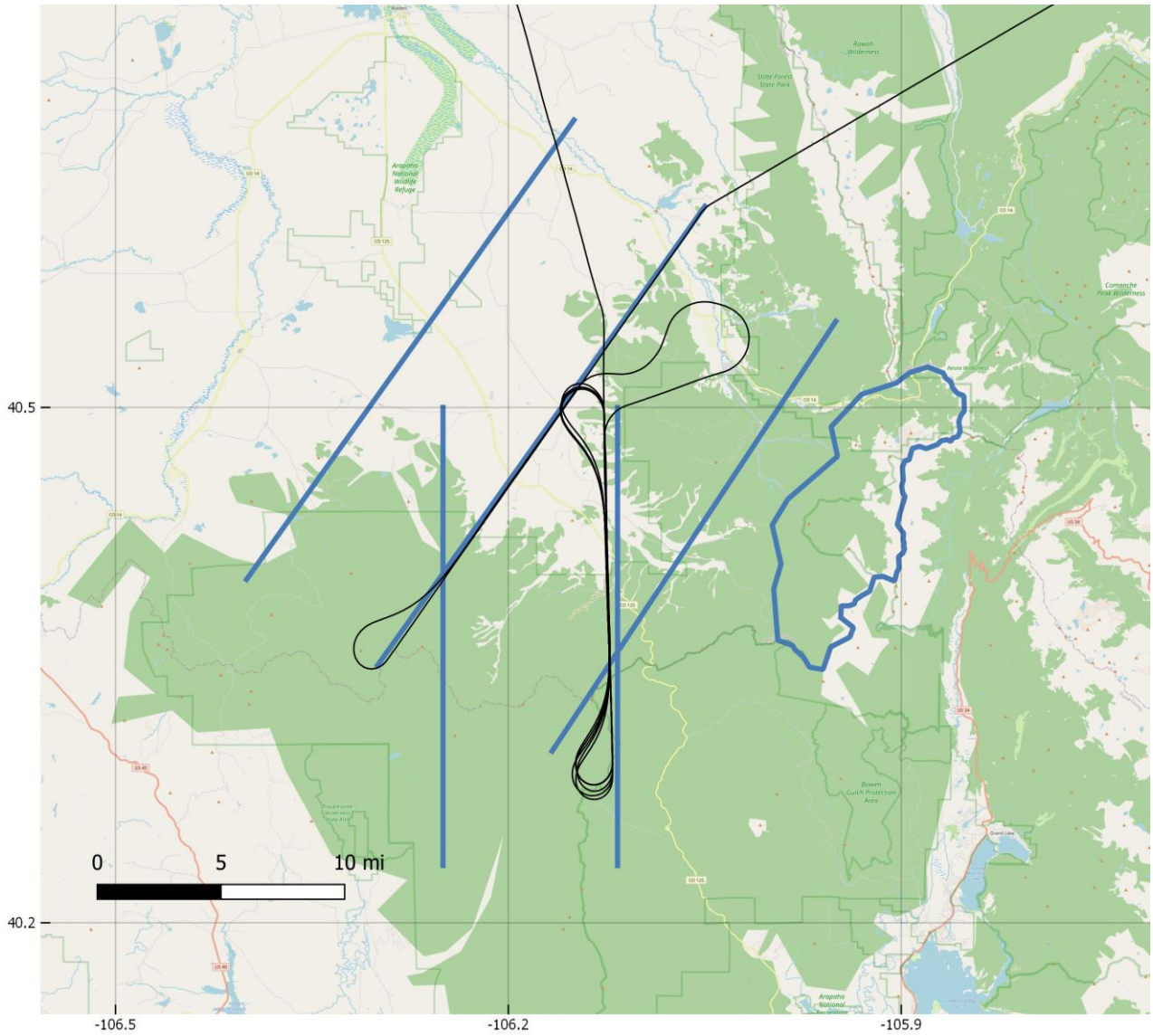


N6111V	OPS #:	06			SEED
	Track(s)/Basin:		NS-4		
UTC Date:	December 27, 2021		MST Date:	December 27, 2021	
UTC Engines ON:	18:29		MST Engines ON:	11:29 am	
UTC Engines OFF:	23:10		MST Engines OFF:	4:10 pm	
Total Time:	4:41	4.68hr	Flares Used:	0 BIP	162 EJECT
Pilot's Flight Summary:	Departed CYS for NS-4 @ 15kft. Once on track, we found consistent LWC for seeding in cloud tops, and the mets instructed us to start seeding with EJs once a minute. Due to wind, we shortened the north part of the track. Throughout the flight, patchy areas of cloud cover and convection moved through the track and we seeded as required. We paused seeding in the patchy areas and added an extra EJ if LWC was high enough. Throughout the flight, cloud tops and layers ascended, as did we to account for icing and convection. Due to wind changes later in the flight, we extended the north end to				

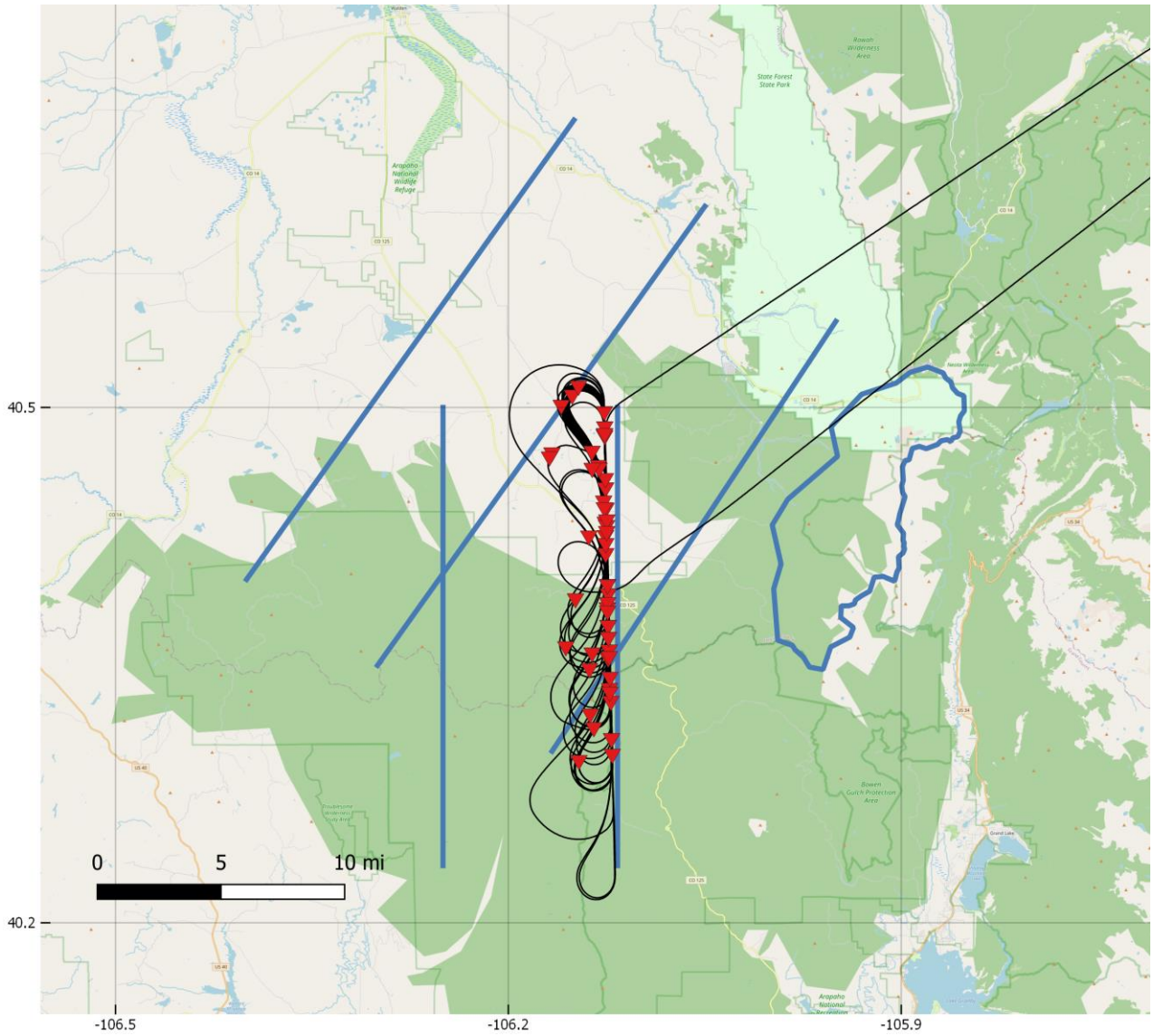
	normal length and shortened the south end of the track. At the end of seeding, there were multiple patchy areas with only a few areas with sufficient LWC to continue seeding. We informed the mets and they instructed us to stop seeding and RTB CYS.
Flight occurred in the morning to afternoon hours of the 27th; weather information remains the same as NS Ops #5.	



N6111V	OPS #:	07			RECON
	Track(s)/Basin:		NS-1		
UTC Date:	January 4, 2022		MST Date:	January 4, 2022	
UTC Engines ON:	22:46		MST Engines ON:	3:46 pm	
UTC Engines OFF:	23:43		MST Engines OFF:	4:43 pm	
Total Time:	0:57	0.95hr	Flares Used:	0 BIP	0 EJECT
Full flight summary continued in the table for Medicine Bow & Sierra Madre Ops #17.					

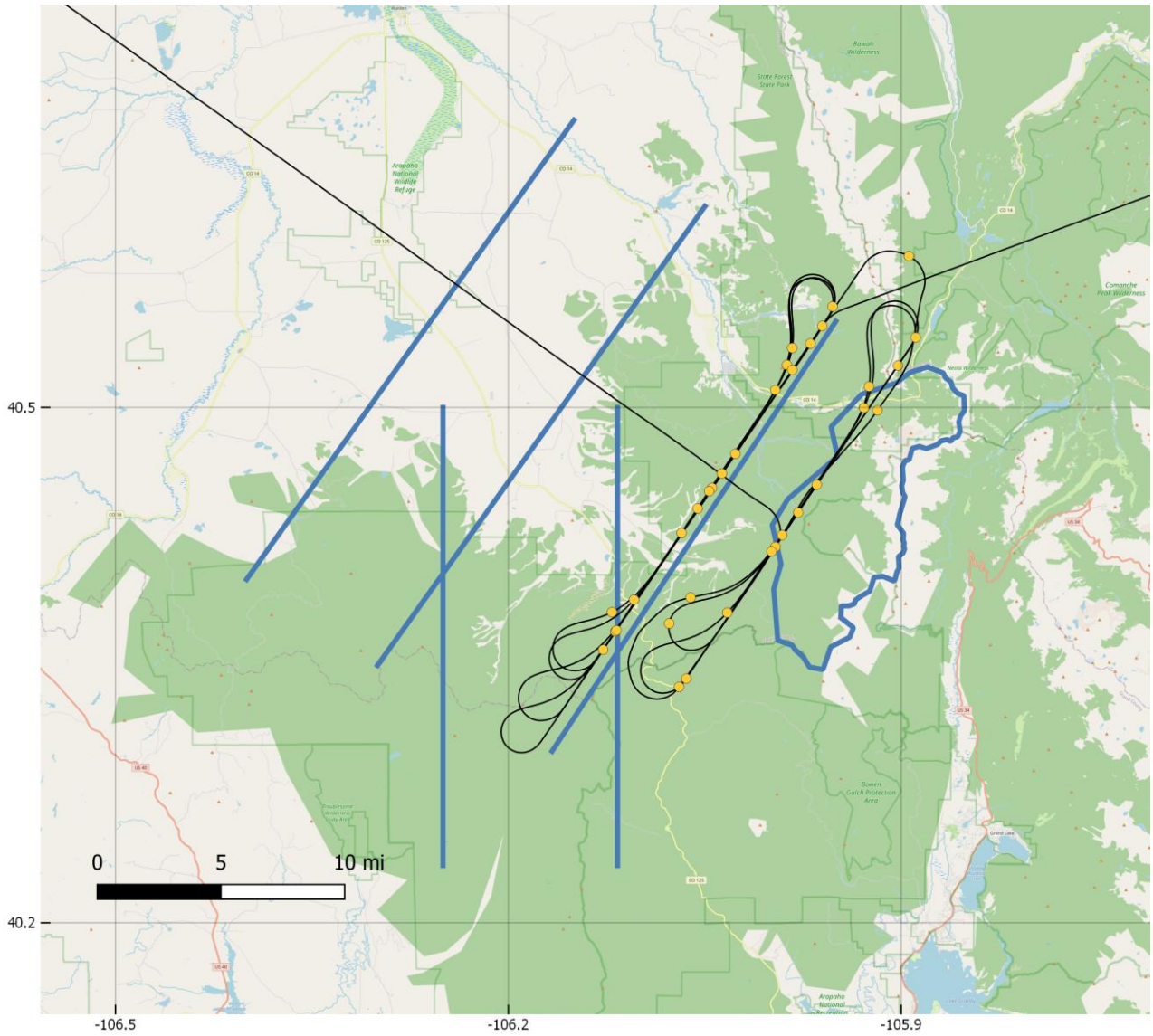


N6111V	OPS #:	08			RECON
	Track(s)/Basin:		NS-2, NS-5		
UTC Date:	March 13, 2022		MDT Date:	March 13, 2022	
UTC Engines ON:	23:40		MDT Engines ON:	5:40 pm	
UTC Engines OFF:	01:28		MDT Engines OFF:	7:28 pm	
Total Time:	1:48	1.8hr	Flares Used:	0 BIP	0 EJECT
Full flight summary continued in the table for Medicine Bow & Sierra Madre Ops #27.					

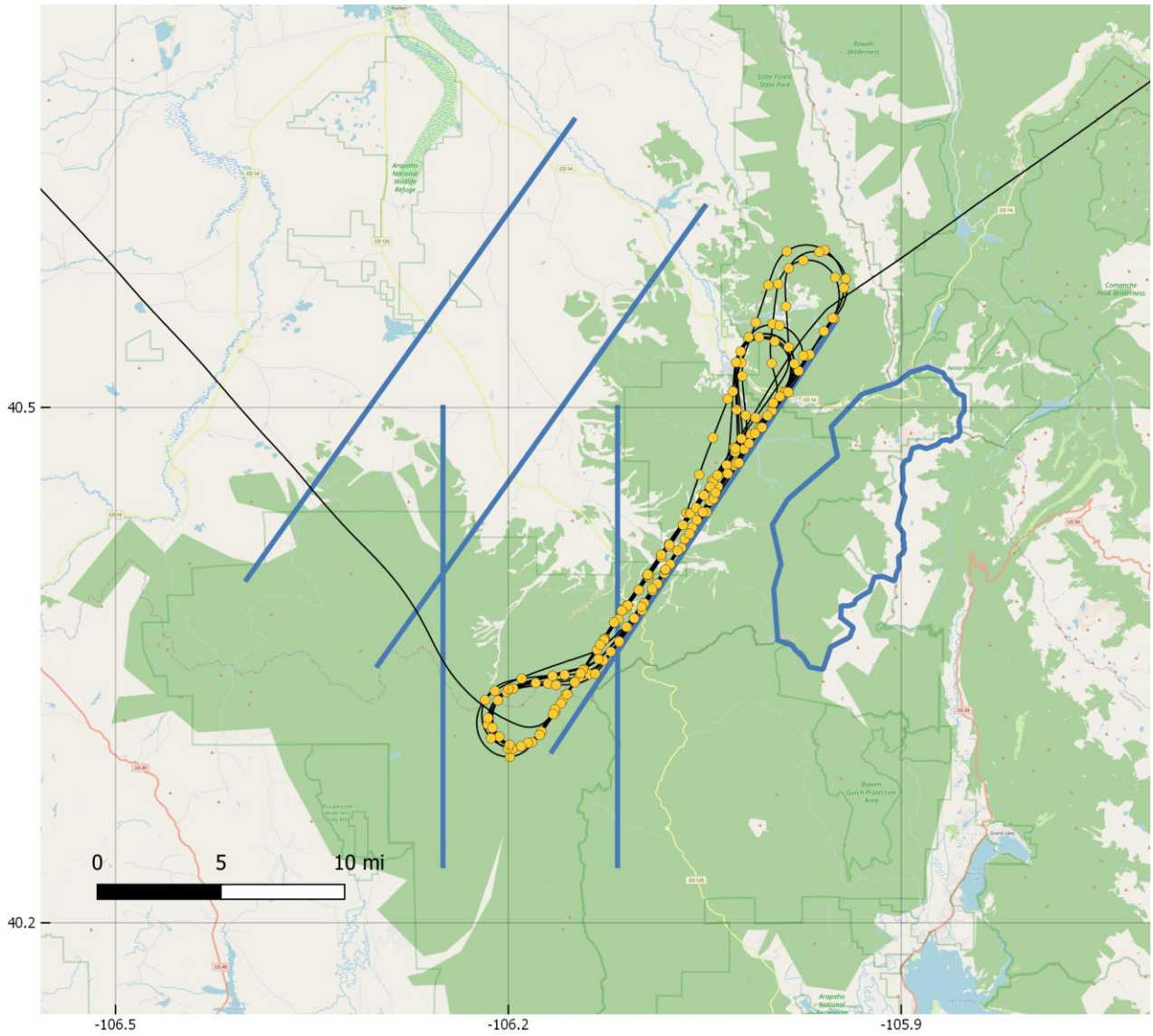


N6111V	OPS #:	09			SEED
	Track(s)/Basin:		NS-5		
UTC Date:	March 16, 2022		MDT Date:	March 16, 2022	
UTC Engines ON:	15:37		MDT Engines ON:	9:37 am	
UTC Engines OFF:	20:25		MDT Engines OFF:	2:25 pm	
Total Time:	4:48	4.8hr	Flares Used:	43 BIP	0 EJECT
Pilot's Flight Summary:	Departed CYS @ 15Kft for NS-5. Once on track, we found LWC and the mets instructed us to start seeding with BIPs. As the flight went on, conditions continued to improve and LWC continued to increase. Towards the end of the flight, conditions started to decline and LWC became patchier. Once all the BIPs were used for seeding, we RTB due to low fuel.				

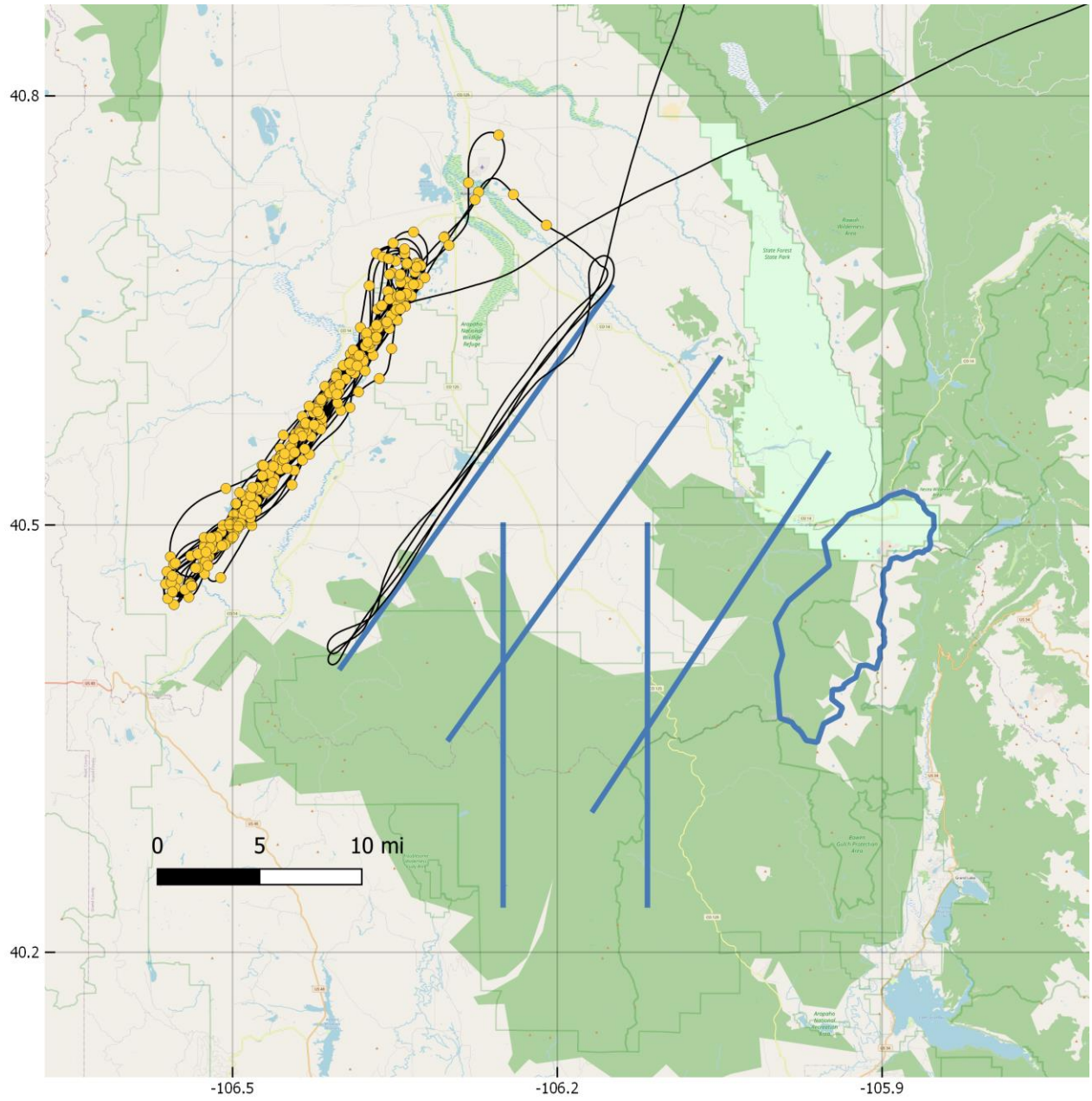
Flight occurred in the morning hours of the 16th; weather information remains the same as MBSM Ops #28.



N6111V	OPS #:	10			SEED
	Track(s)/Basin:		NS-3, Modified		
UTC Date:	March 17, 2022		MDT Date:	March 17, 2022	
UTC Engines ON:	07:31		MDT Engines ON:	1:31 am	
UTC Engines OFF:	09:34		MDT Engines OFF:	3:34 am	
Total Time:	2:03	2.05hr	Flares Used:	0 BIP	33 EJECT
Full flight summary continued in the table for Medicine Bow & Sierra Madre Ops #29.					

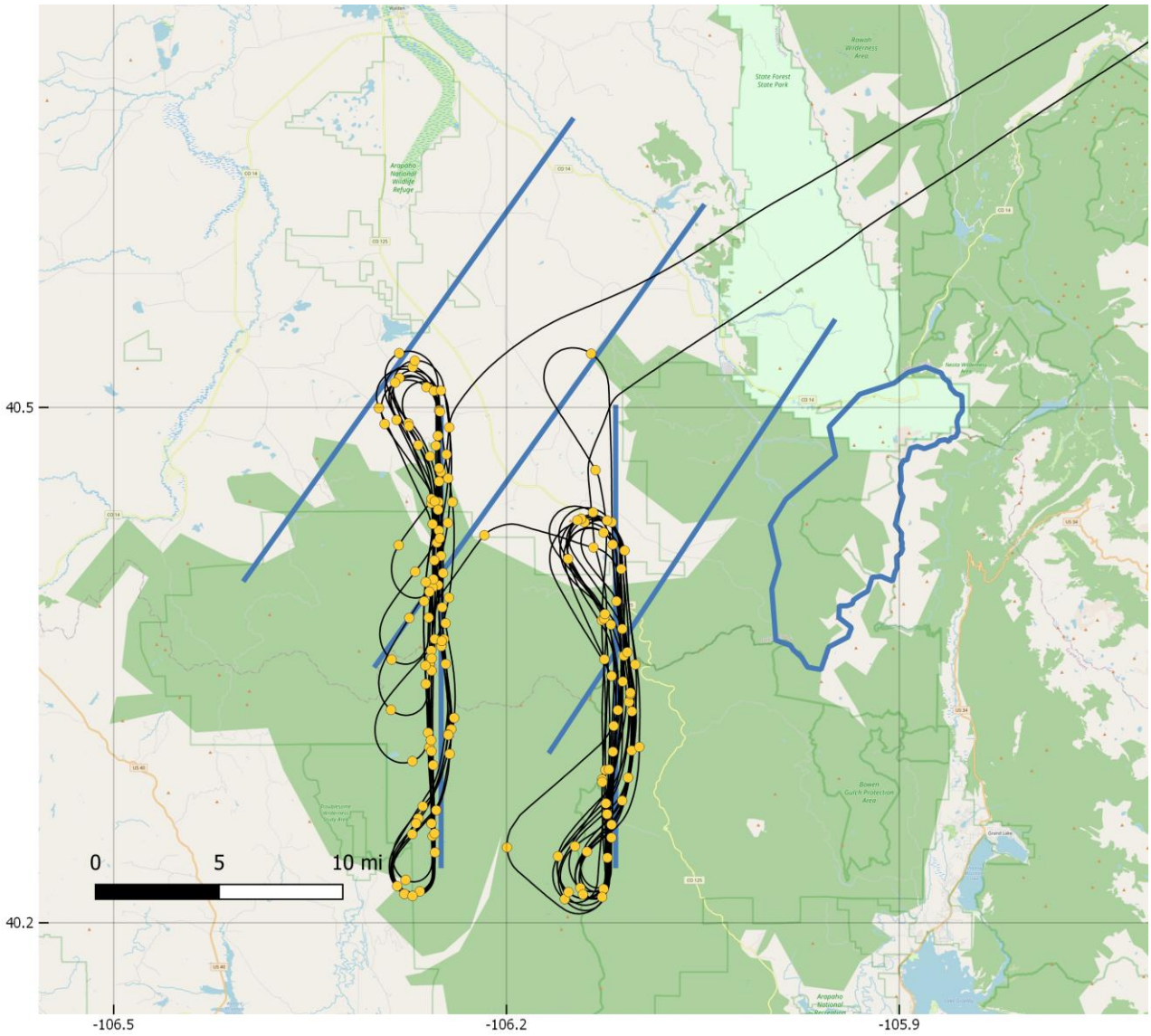


N518TS	OPS #:	11			SEED
	Track(s)/Basin:		NS-3		
UTC Date:	April 1, 2022		MDT Date:	April 1, 2022	
UTC Engines ON:	06:27		MDT Engines ON:	12:27 am	
UTC Engines OFF:	09:05		MDT Engines OFF:	3:05 am	
Total Time:	2:38	2.63hr	Flares Used:	0 BIP	166 EJECT
Full flight summary continued in the table for Medicine Bow & Sierra Madre Ops #34.					



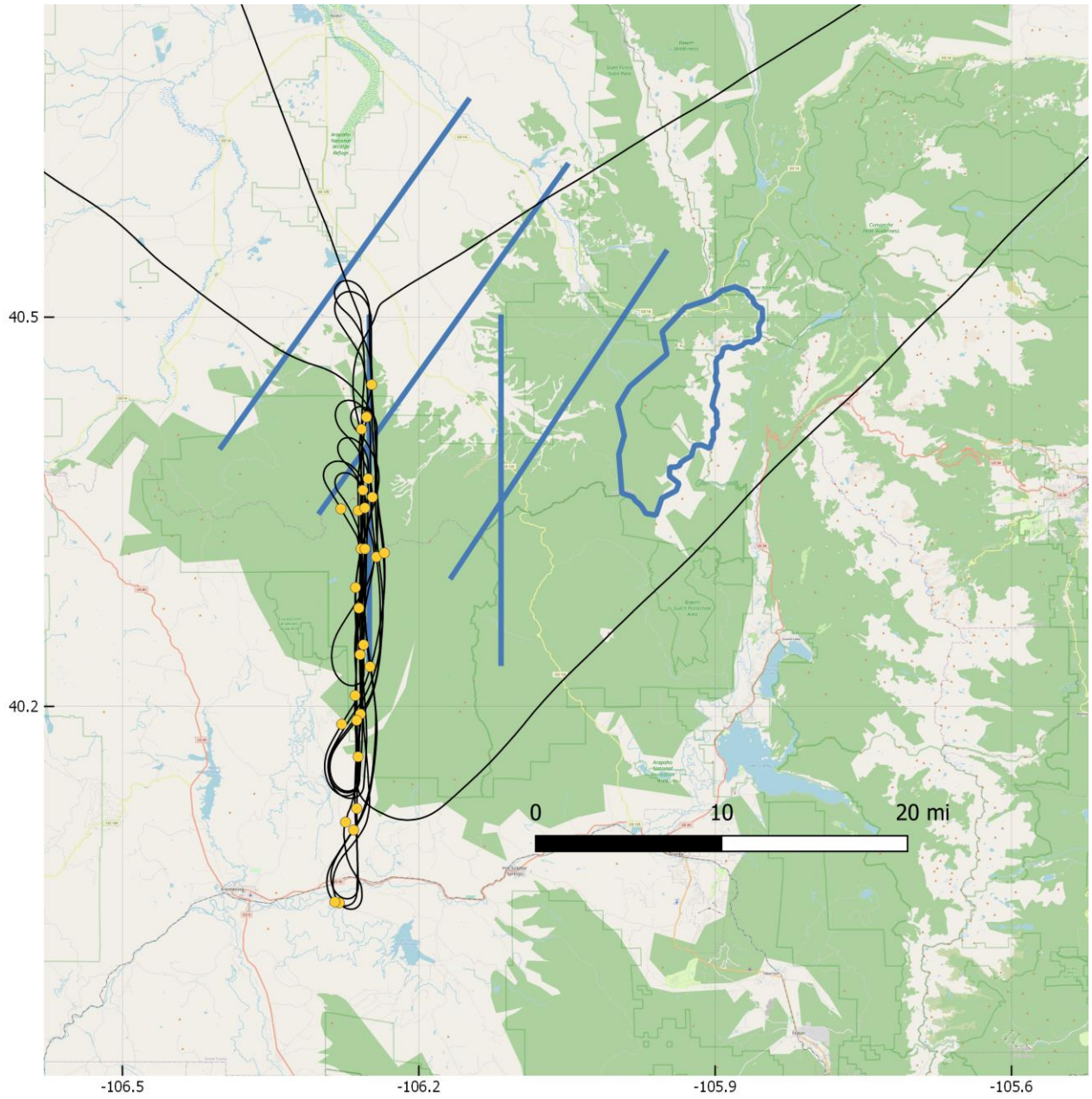
N518TS	OPS #:	12			SEED
	Track(s)/Basin:		NS-1, Modified		
UTC Date:	April 5, 2022		MDT Date:	April 5, 2022	
UTC Engines ON:	12:51		MDT Engines ON:	6:51 am	
UTC Engines OFF:	17:51		MDT Engines OFF:	11:51 pm	
Total Time:	5:00	5hr	Flares Used:	0 BIP	240 EJECT
Pilot's Flight Summary:	Departed CYS for the NS-1 track, due to high winds on track, we had to create a modified track 6 miles parallel to the northwest of NS-1. Once on the modified track, the mets instructed us to start seeding with EJs. Due to higher LWC on track, the mets				

	instructed us to increase the seeding rate to two EJs a minute. Once we began running low on fuel, we stopped seeding and RTB.
Flight occurred in the morning hours of the 5th; weather information remains the same as MBSM Ops #34	



N518TS	OPS #:	13			SEED
	Track(s)/Basin:		NS-5, NS-4		
UTC Date:	April 10, 2022		MDT Date:	April 9, 2022	
UTC Engines ON:	03:17		MDT Engines ON:	9:17 pm	
UTC Engines OFF:	08:26		MDT Engines OFF:	2:26 am	
Total Time:	5:09	5.15hr	Flares Used:	0 BIP	161 EJECT
Pilot's Flight Summary:	Departed CYS for the NS-5 track @ 15kft. Once on track, there was not much LWC present so we decided to climb to 17.5kft to search the area. We found occasional, 0.3 LWC and the mets instructed us to start seeding with EJs once every 2 minutes. Due to higher winds, the mets instructed us to move to the western track NS-4. We continued to check different altitudes to see if we could find better LWC, but eventually returned to 15kft due to forecasted LWC at that altitude. LWC started to show up and we were instructed to increase the rate depending on how much LWC we found. Towards the				

	end of the mission, LWC and cloud cover became a little less frequent on the south end of track, so we started to cut off those areas and focused on the north end of track. Once low on fuel, we stopped seeding and RTB.
Synoptic Analysis:	Upper-level charts indicate a large-scale trough approaching the Rockies from the west. PWAT will increase throughout the afternoon, peaking at 0.40 inches around sunset this evening. There is a layer of dry air in the low levels that will limit orographic development and SLW with this system, particularly in the MB/SM range. This is less pronounced in the NS. Instability is expected this afternoon until shortly after sunset, and scattered convection is likely across the region today. This is now looking to be a rather brief event with precipitation mostly ending around midnight and only flurries after that. A much colder air mass invades tonight, and 500 mb temps will drop below -30C by morning with PWAT dropping to 0.1 inches. Conditions rebound tomorrow with warming and moisture advection. Another trough pushes through late Monday bringing another round of light snow through Tuesday morning. Tuesday evening through Wednesday will be very cold aloft. Models are now showing another trough moving through on the final day of project.
Area Forecast:	Seeding conditions will not be as good as expected this evening due to a layer of dry air in the low levels. The best chance for targetable clouds will be in the NS range between sunset and midnight, and flight will likely occur to at least check for SLW. Clouds will not be adequate for seeding after around 9z tonight. Deep overcast is expected through 9z. Afternoon convection is expected which should end shortly after sunset. A NS seeding flight will likely occur late this evening, ending by 9z. Clearing is expected late tonight. High and midlevel clouds return tomorrow afternoon. Our next chance for seeding appears to be Monday evening/night. Light snow is also expected Tuesday and Wednesday, but temps aloft will be very cold and SLW looks to be too light for operations. Longer range models are now showing one final push from another shortwave trough moving through next Friday which could potentially provide one last chance for a seeding flight on the last day of project. This is a change from earlier models, so we will need to keep an eye on how it evolves in coming days.
Flight occurred in the evening hours of the 9th to the morning hours of the 10th; weather information is from Apr. 9th.	

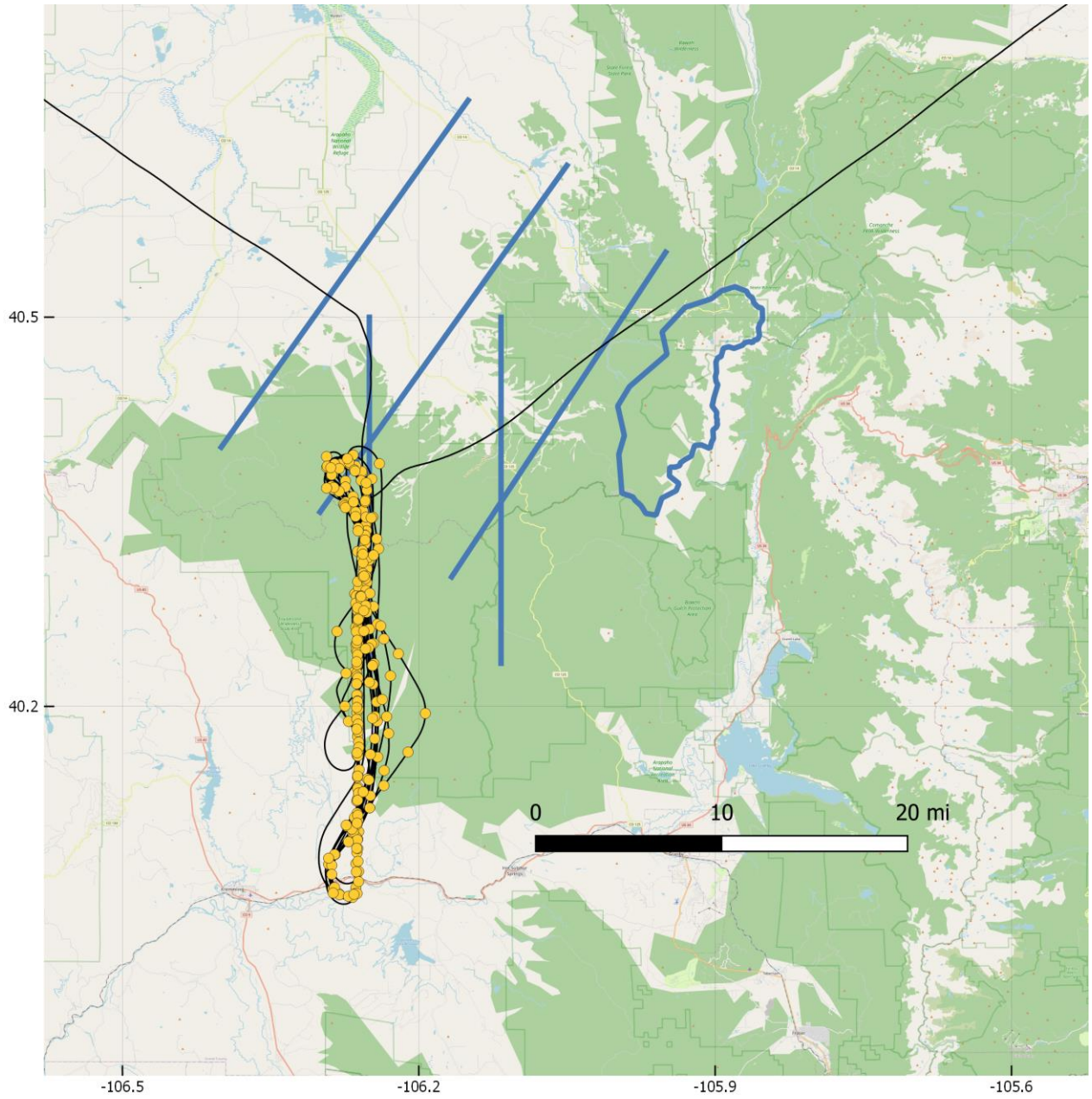


N518TS	OPS #:	14			SEED
	Track(s)/Basin:		NS-4		
UTC Date:	April 12, 2022		MDT Date:	April 11, 2022	
UTC Engines ON:	01:20		MDT Engines ON:	7:20 pm	
UTC Engines OFF:	02:59		MDT Engines OFF:	8:59 pm	
Total Time:	1:39	1.65hr	Flares Used:	0 BIP	3 EJECT
N6111V returned to Never Summer after moving to Medicine Bow. See next table.					

N518TS	OPS #:	14			SEED
	Track(s)/Basin:		NS-4		
UTC Date:	April 12, 2022		MDT Date:	April 11, 2022	
UTC Engines ON:	04:29		MDT Engines ON:	10:29 pm	
UTC Engines OFF:	06:20		MDT Engines OFF:	12:20 am	
Total Time:	1:51	1.85hr	Flares Used:	0 BIP	29 EJECT

Pilot's Flight Summary:	Departed CYS for the NS range @ 15kft. Once on track, there were patchy seedable conditions present, but the meteorologists said the models showed more LWC moving in shortly. We continued until conditions proved to not be improving at the time. The mets instructed us to move to the SM range to check out more forecasted LWC. We tried multiple altitudes on track SM-3, but we only found ice crystal and no LWC. The mets instructed us to then move to the MB-3 track, but only ice crystals were present at multiple altitudes in the MB range as well. The mets then had us move back to the NS-4 track. More favorable seeding conditions and LWC were present and the mets instructed us to start seeding again with EJs. Along with the mets, we agreed to end the flight slightly early to have enough time to get back to CYS, reflare and refuel, and get back to the NS track for abundant forecasted LWC.
Synoptic Analysis:	A large scale trough pattern remains in place across the region with a large upper low over western Canada. Strong westerly flow is expected throughout the period as a jet streak stretches from the PACNW coast through the Great Basin into the Midwest. At midlevels, a closed low approaching from the west pushes through WY tonight and tomorrow. Strong dynamics are associated with this system which will provide significant midlevel snow. Moisture will be excellent in the early stages of this storm with PWAT peaking above 0.40 inches around midnight. Temps aloft and PWAT gradually decrease through midday tomorrow, and 500 mb temps will be near -35°C by tomorrow afternoon. Instability is likely this evening with CAPE evident until midnight. Low level RH remains elevated in the colder air mass tomorrow, and clouds will have marginal low level SLW tomorrow night, particularly in the MB range. While the system will be naturally efficient, the strong orographic winds may provide just enough enhancement to be worthwhile for operations.
Area Forecast:	Seeding flights are expected this evening and tonight, probably in the NS and MB ranges. Evening convection may create some challenges this evening, but it does not look heavy enough to hinder seeding flight. The first flight of the evening will likely occur in the NS range starting around 8pm MDT, and then a subsequent overnight flight in the MB is likely. Winds will be strong from the SW, and high-speed tracks will be utilized once again. Latest NWS storm warnings indicate 8 to 16 inches of snow accumulation possible by tomorrow in the higher elevations with the heaviest accumulation expected in the SM range. Nothing targetable is expected during the day tomorrow, but SLW appears to be better tomorrow night in the MB range. If later model runs continue to show this trend, we may get another round of seeding on the colder part of this storm tomorrow night. We will have to reassess this tomorrow, as it is rather unusual to have deep SLW with 500mb temps near -35°C. We will see a lull in clouds/precip Wednesday night through midday Thursday, and then another batch of

	moisture Thursday evening through Friday bringing another potential seeding window for the end of project.
Flight occurred in the evening hours of the 11th to the morning hours of the 12th; weather information is from Apr. 11th.	



N518TS	OPS #:	15			SEED
	Track(s)/Basin:		NS-4		
UTC Date:	April 12, 2022		MDT Date:	April 12, 2022	
UTC Engines ON:	08:13		MDT Engines ON:	2:13 am	
UTC Engines OFF:	12:09		MDT Engines OFF:	6:09 am	
Total Time:	3:56	3.93hr	Flares Used:	1 BIP	273 EJECT
Pilot's Flight Summary:	Departed CYS for the SM range instead of the NS range, due to convection on range, @ 16kft. Once on track, we tried multiple altitudes similar to the previous flight, but only found ice crystals. The mets instructed us to fly down to the NS-4 track. Once on track,				

	we found LWC and light airframe icing. Due to winds, we extended the south part of the track by 5-10 miles depending on seedable cloud cover. We also cut off the north half of the standard track. About halfway through the NS part of the flight, LWC became more present and the mets instructed us to increase the seeding rate. Towards the end of the flight, LWC became even more present. Shortly after, we were running low on fuel and RTB.
Flight occurred in the morning hours of the 12th; weather information remains the same as NS Ops #14.	

5.3 2021-2022 All Missions Map

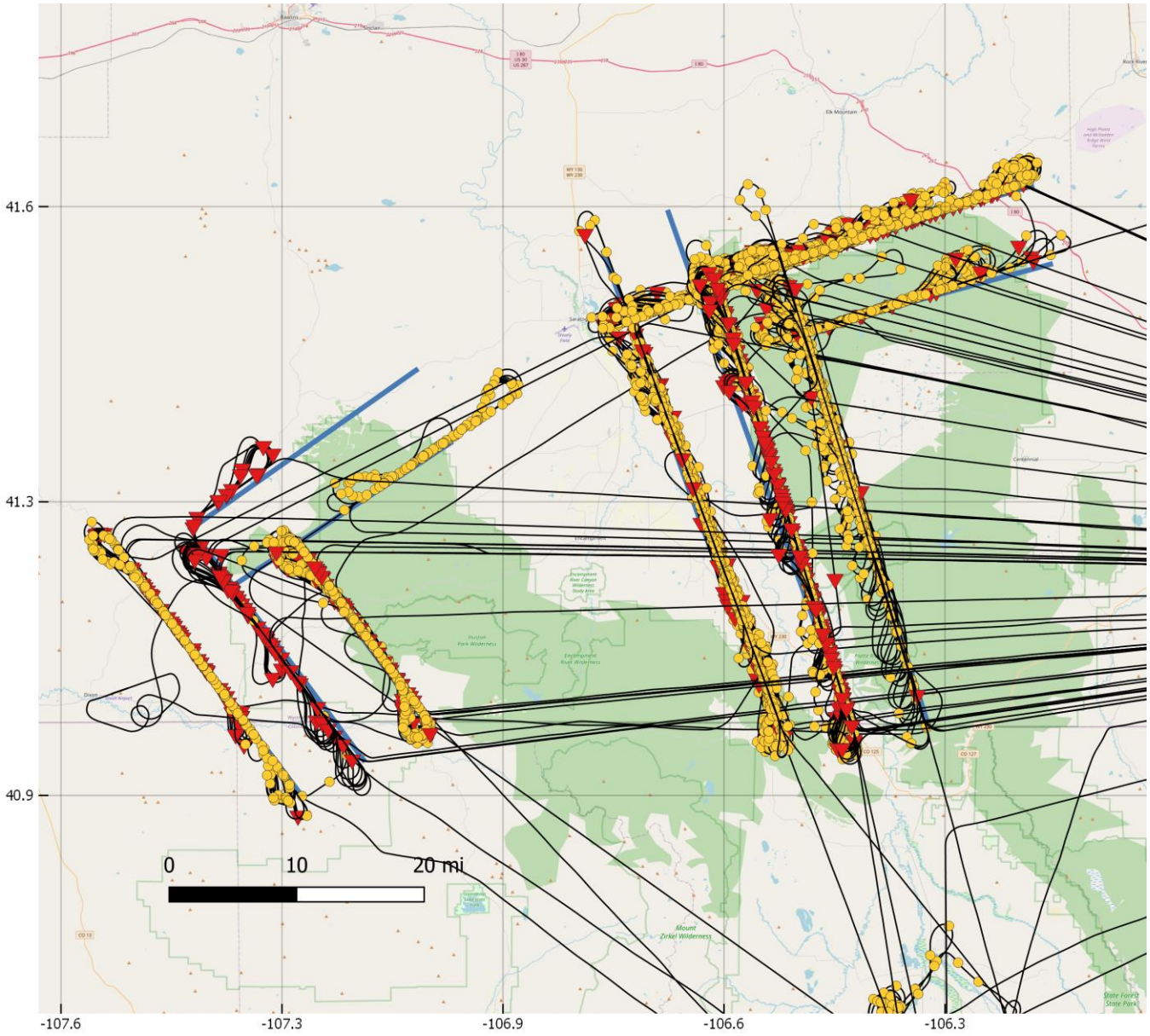


Figure 26. All flights conducted for the 2021-2022 winter season in the Medicine Bow and Sierra Madre mountain ranges of Wyoming.

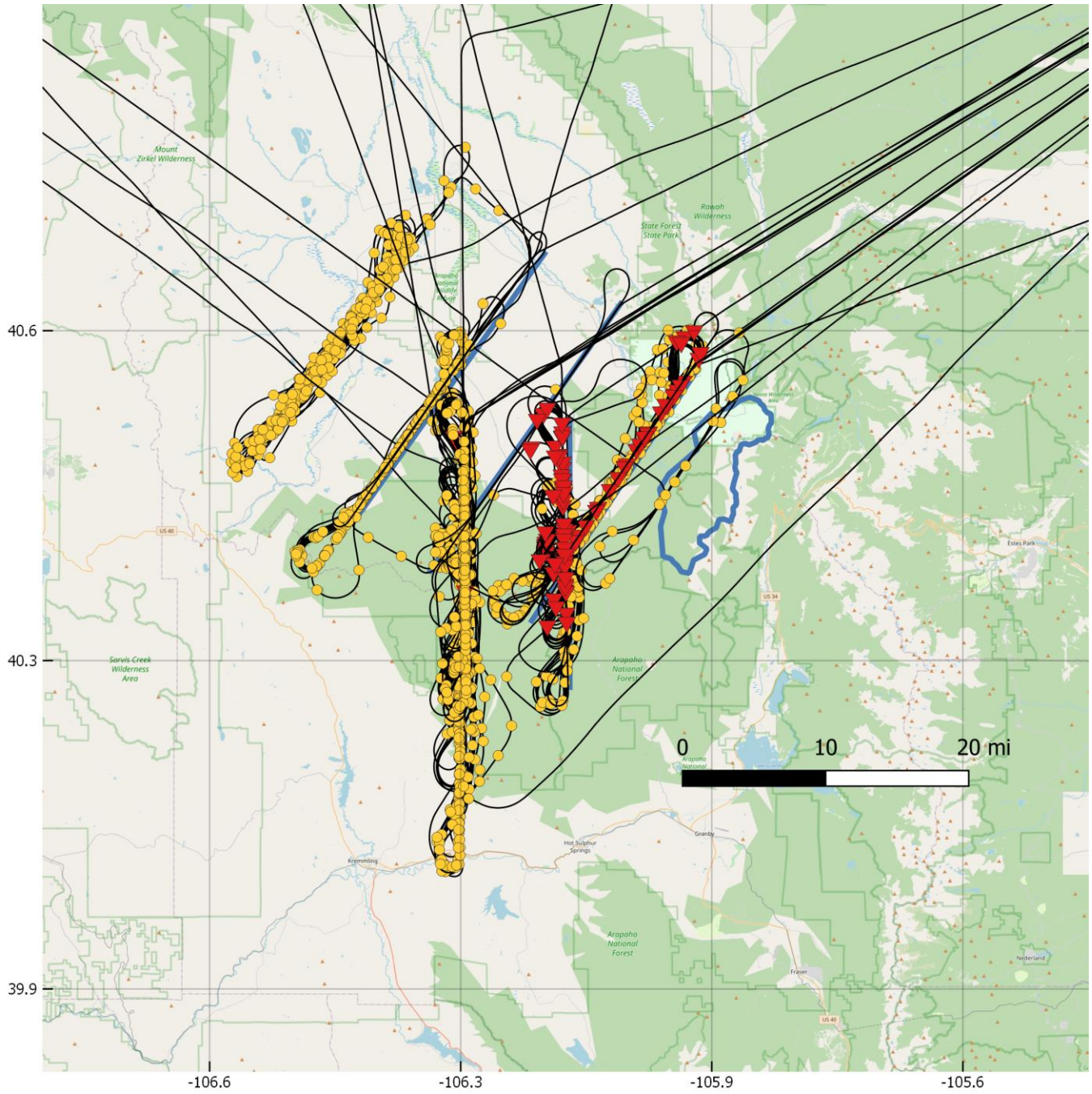


Figure 27. All flights conducted for the 2021-2022 winter season in Colorado's Never Summer Mountain Range.

6 2021-2022 OPERATIONS SUMMARY

Season flight operations are summarized in Table 4. Each flight is represented by its own column, so when there are two flights on a single day, for example, December 23 there are two columns. Project-billable flights include only seeding and reconnaissance (Recon), but non-billable flights (usually flown for maintenance reasons) are not listed.

A total of 43 project-billable flights were flown. Of these 43 missions, time was split between WY and CO on 7 flights:

- December 15: Flight split between Never Summer, Medicine Bow, and Sierra Madre ranges. 8 BIP and 2 EJs were used on the Medicine Bow and Sierra Madre ranges.
- December 26: Flight split between Sierra Madre and Never Summer. 3 EJs were dropped over the Sierra Madre, and 99 EJs were dropped over the Never Summer range.
- January 4: Flight split between Never Summer and Medicine Bow ranges. 195 EJs were dropped over the Medicine Bow range.
- March 13: Flight split between the Never Summer and Medicine Bow ranges. 227 EJs were dropped over the Medicine Bow range.
- March 17: Flight split between Never Summer and Sierra Madre ranges. 33 EJs were dropped over the Never Summer, and 91 EJs were dropped over the Sierra Madre range.
- April 1: Flight split between Never Summer, Sierra Madre, and Medicine Bow ranges. 166 EJs were dropped over the Never Summer range, and 17 were dropped over the Sierra Madre and Medicine Bow ranges.
- April 12: Flight was split between Sierra Madre, Medicine Bow, and Never Summer ranges. This flight saw multiple range changes. In summary, the flight departed Cheyenne, for the Never Summer, moved to the Sierra Madre, then the Medicine Bow, then the Never Summer again, finally ended after one more change to the Sierra Madre. 32 EJs were dropped over the ranges total, with 3 over the Never Summer and 29 over the Sierra Madre and Medicine Bow ranges.

December saw the highest activity by flight count, with 13 flights in one month. December also accounts for the month with the highest number of flight hours, with 51.7 seeding hours and 2.2 Reconnaissance hours. In contrast, February accounts for just 4 flights, including 1 non-project billable maintenance flight.

A little under 210 hours were flown this season. Of those, 7 hours were for maintenance, 10.9 were for reconnaissance, and an impressive 191.9 hours were for seeding.

WMI would like to thank all those involved with making the 2021-2022 season a success, and we look forward to many more such seasons in the future.

Table 4. Flight operations for the 2021-2022 season are summarized.

Wyoming Operations Summary (MBSM)

Date	Engine On (UTC)	Engine Off (UTC)	Duration (hrs)	Monthly Flight Hours	Flight Hours Season Total	Seeding Agent Released (kg)	Seeding Agent Monthly Total	Seeding Agent Season Total
11/2/2021								
11/10/2021	2:51	7:36	4:45	4:45	4:45	5.70	5.70	5.70
11/11/2021	19:04	0:01	4:57	9:42	9:42	9.92	15.62	15.62
11/12/2021	2:25	7:28	5:03	14:45	14:45	7.92	23.54	23.54
11/20/2021	4:27	9:38	5:11	19:56	19:56	5.58	29.12	29.12
11/22/2021								
11/23/2021								
11/24/2021	14:53	18:46	3:53	3:53	23:49	3.48	3.48	32.60
12/9/2021	0:56	5:37	4:41	8:34	28:30	6.31	9.79	38.91
12/9/2021	6:46	11:55	5:09	13:43	33:39	10.24	20.03	49.15
12/15/2021								
12/15/2021	14:48	16:45	1:57	15:40	35:36	1.20	21.23	50.35
12/17/2021	5:04	9:19	4:15	19:55	39:51	2.58	23.81	52.93
12/17/2021	14:07	19:31	5:24	25:19	45:15	4.36	28.17	57.29
12/23/2021								
12/23/2021	23:47	4:58	5:11	30:30	50:26	5.70	33.87	62.99
12/24/2021								
12/25/2021	3:07	7:16	4:09	34:39	54:35	3.99	37.86	66.98
12/26/2021	16:33	18:04	1:31	36:10	56:06	0.06	37.92	67.04
12/26/2021								
12/27/2021								
12/30/2021	13:23	15:23	2:00	38:10	58:06	0.38	38.30	67.42
12/30/2021	15:37	18:34	2:57	41:07	61:03	3.30	41.60	70.72
1/4/2022	16:37	19:00	2:23	2:23	63:26	1.10	1.10	71.82
1/4/2022								
1/4/2022	23:43	3:38	3:55	6:18	67:21	3.90	5.00	75.72
1/6/2022	19:19	20:34	1:15	7:33	68:36	0.00	5.00	75.72
1/8/2022	7:07	11:50	4:43	12:16	73:19	2.98	7.98	78.70
1/14/2022	17:24	20:55	3:31	15:47	76:50	3.53	11.51	82.23
2/7/2022								
2/10/2022	2:16	5:53	3:37	3:37	80:27	5.84	5.84	88.07
2/11/2022	13:51	18:42	4:51	8:28	85:18	4.70	10.54	92.77
2/21/2022	16:45	21:20	4:35	13:03	89:53	5.63	16.17	98.40
2/24/2022	2:24	4:22	1:58	15:01	91:51	0.00	16.17	98.40

MBSM summary is continued on the next page.

3/5/2022	9:08	13:43	4:35	4:35	96:26	6.45	6.45	104.85
3/9/2022	7:45	12:37	4:52	9:27	101:18	2.02	8.47	106.87
3/13/2022								
3/13/2022	1:28	4:37	3:09	12:36	104:27	4.54	13.01	111.41
3/16/2022	7:12	12:17	5:05	17:41	109:32	5.70	18.71	117.11
3/16/2022								
3/17/2022								
3/17/2022	9:34	12:25	2:51	20:32	112:23	1.82	20.53	118.93
3/21/2022	6:15	11:16	5:01	25:33	117:24	5.68	26.21	124.61
3/22/2022	13:37	18:46	5:09	30:42	122:33	12.49	38.70	137.10
3/29/2022	8:19	13:23	5:04	35:46	127:37	6.00	44.70	143.10
3/29/2022	13:37	18:34	4:57	40:43	132:34	6.79	51.49	149.89
4/1/2022								
4/1/2022	9:05	11:03	1:58	1:58	134:32	0.34	0.34	150.23
4/5/2022	6:27	10:55	4:28	6:26	139:00	9.33	9.67	159.56
4/5/2022								
4/10/2022								
4/12/2022								
4/12/2022	2:59	4:29	1:30	7:56	140:30	0.00	9.67	159.56
4/12/2022								
4/12/2022	6:58	8:13	1:15	9:11	141:45	0.00	9.67	159.56
4/12/2022								
4/13/2022	10:54	16:08	5:14	14:25	146:59	3.13	12.80	162.69
4/15/2022	16:20	21:47	5:27	19:52	152:26	6.04	18.84	168.73

Shaded rows indicate days on which flight(s) occurred in Colorado, but not Wyoming

Colorado Operations Summary (NS)

Date	Engine On (UTC)	Engine Off (UTC)	Duration (hrs)	Monthly Flight Hours	Flight Hours Season Total	Seeding Agent Released (kg)	Seeding Agent Monthly Total	Seeding Agent Season Total
11/2/2021	16:39	20:35	3:56	3:56	3:56	4.35	4.35	4.35
11/10/2021								
11/11/2021								
11/12/2021								
11/20/2021								
11/22/2021								
11/23/2021								
11/24/2021								
12/9/2021								
12/9/2021								
12/15/2021	13:06	14:48	1:42	1:42	5:38	0.38	0.38	4.73
12/15/2021								
12/17/2021								
12/17/2021								
12/23/2021	16:46	21:22	4:36	6:18	10:14	3.74	4.12	8.47
12/23/2021								
12/24/2021	19:13	21:26	2:13	8:31	12:27	0.00	4.12	8.47
12/25/2021								
12/26/2021								
12/26/2021	18:04	21:32	3:28	11:59	15:55	1.98	6.10	10.45
12/27/2021	18:29	23:10	4:41	16:40	20:36	3.24	9.34	13.69
12/30/2021								
12/30/2021								
1/4/2022								
1/4/2022	22:46	23:43	0:57	0:57	21:33	0.00	0.00	13.69
1/4/2022								
1/6/2022								
1/8/2022								
1/14/2022								
2/7/2022								
2/10/2022								
2/11/2022								
2/21/2022								
2/24/2022								

NS summary is continued on the next page.

3/5/2022								
3/9/2022								
3/13/2022	23:40	1:28	1:48	1:48	23:21	0.00	0.00	13.69
3/13/2022								
3/16/2022								
3/16/2022	15:37	20:25	4:48	6:36	28:09	6.45	6.45	20.14
3/17/2022	7:31	9:34	2:03	8:39	30:12	0.66	7.11	20.80
3/17/2022								
3/21/2022								
3/22/2022								
3/29/2022								
3/29/2022								
4/1/2022	6:27	9:05	2:38	2:38	32:50	3.32	3.32	24.12
4/1/2022								
4/5/2022								
4/5/2022	12:51	17:51	5:00	7:38	37:50	4.80	8.12	28.92
4/10/2022	3:17	8:26	5:09	12:47	42:59	3.37	11.49	32.29
4/12/2022	1:20	2:59	1:39	14:26	44:38	0.06	11.55	32.35
4/12/2022								
4/12/2022	4:29	6:20	1:51	16:17	46:29	0.58	12.13	32.93
4/12/2022								
4/12/2022	8:13	12:09	3:56	20:13	50:25	5.59	17.72	38.52
4/13/2022								
4/15/2022								

Shaded rows indicate days on which flight(s) occurred in Wyoming, but not Colorado

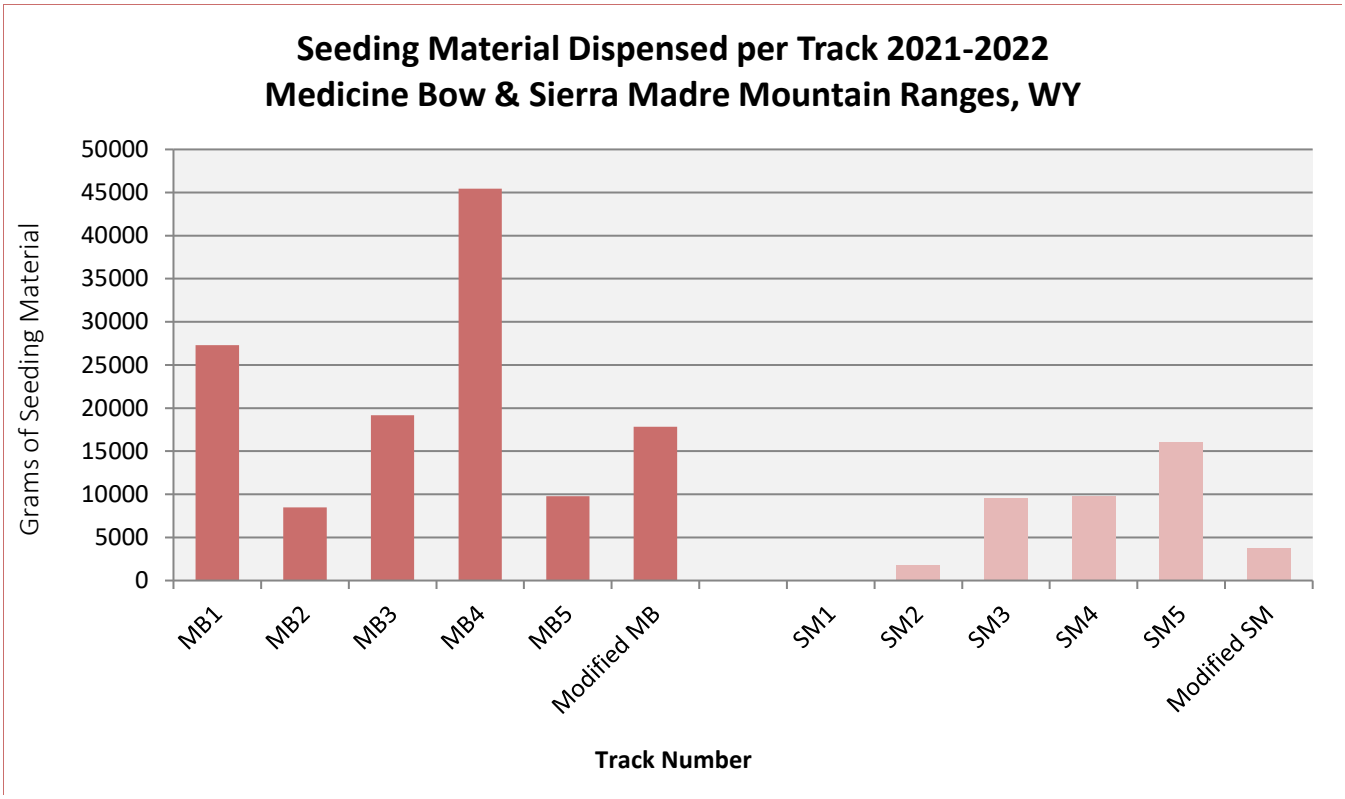


Figure 28. Grams of seeding material dispensed per track over the Medicine Bow and Sierra Madre Mountain Ranges in Wyoming.

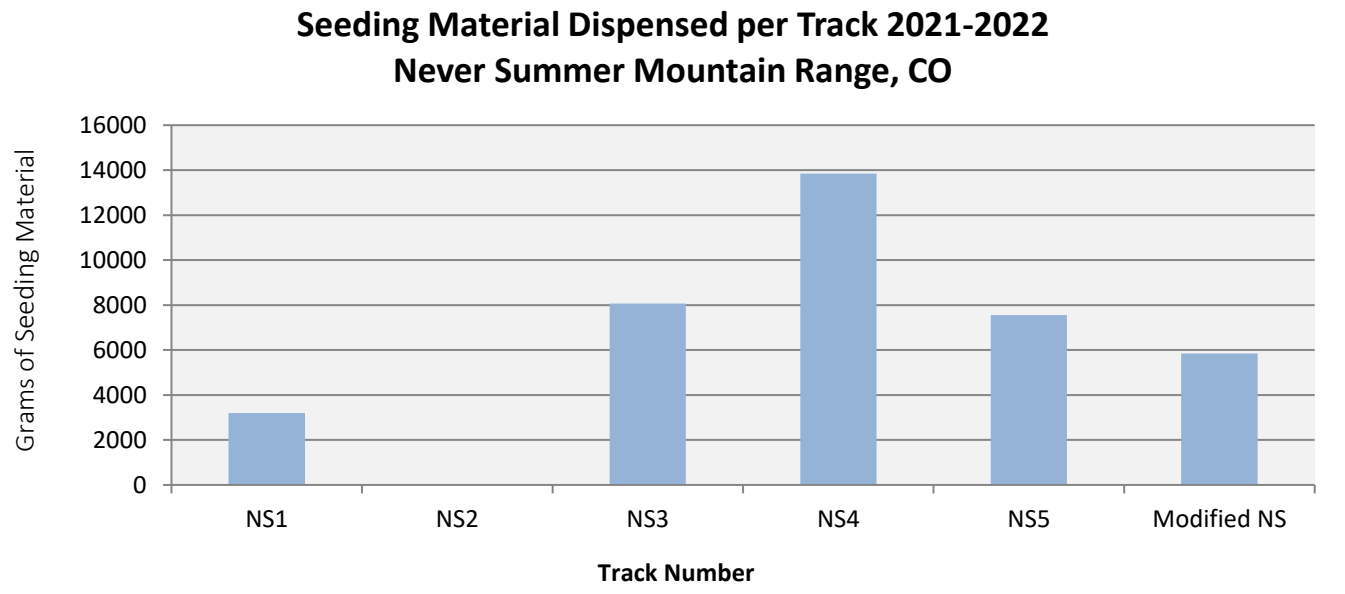


Figure 29. Grams of seeding material dispensed per track over the Never Summer Mountain Range in Colorado during the 2021-2022.

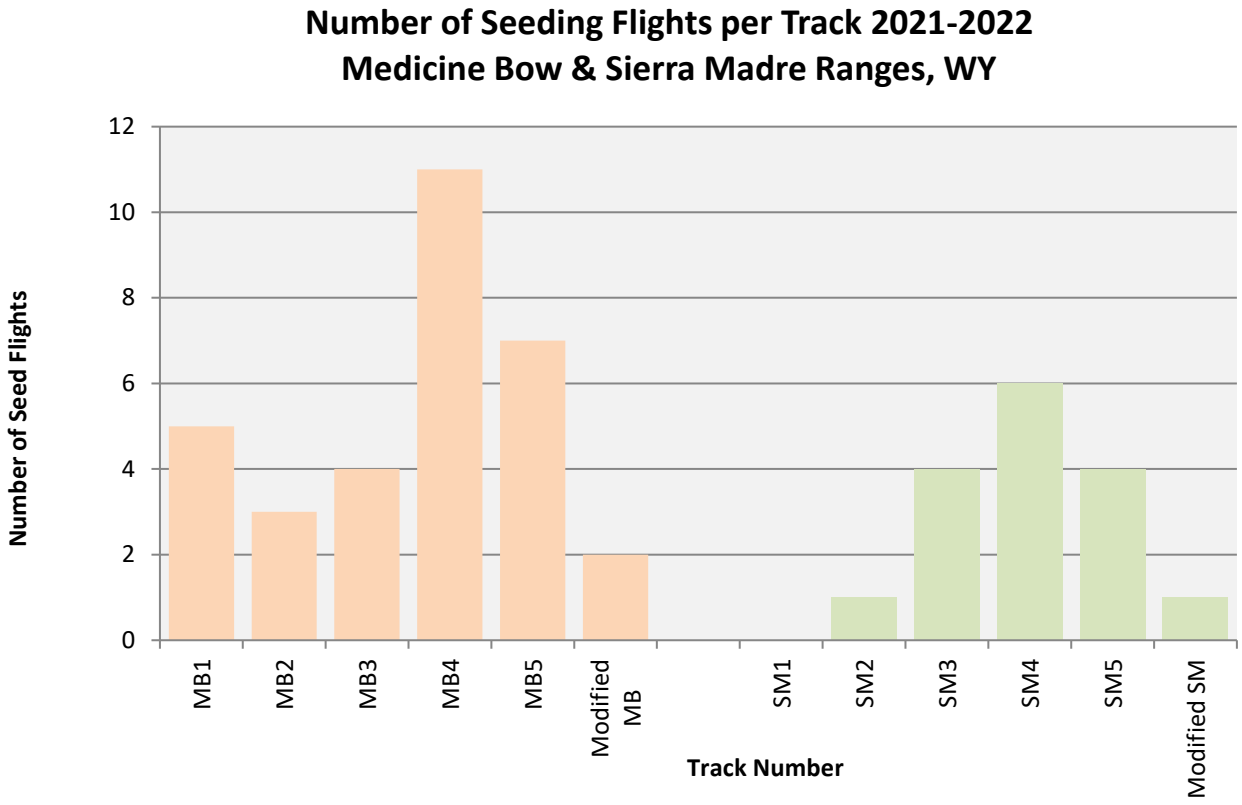


Figure 30. Number of seeding flights per track in the Medicine Bow and Sierra Madre Mountain Ranges in WY. Some flights may utilize multiple tracks.

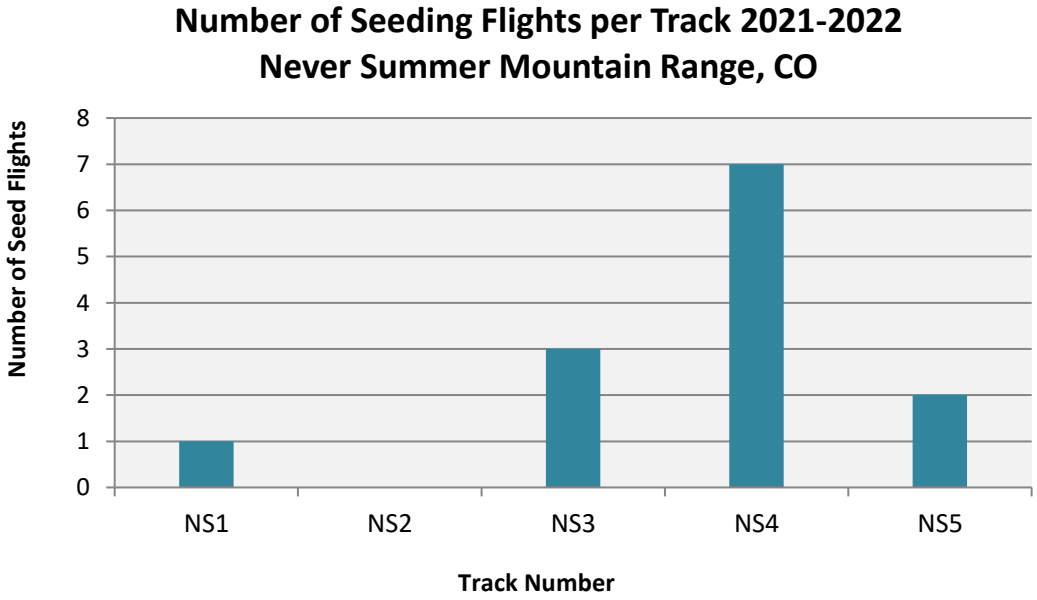


Figure 31. Number of seeding flights per track in the Never Summer Mountain Range in CO. Some flights may utilize multiple tracks.

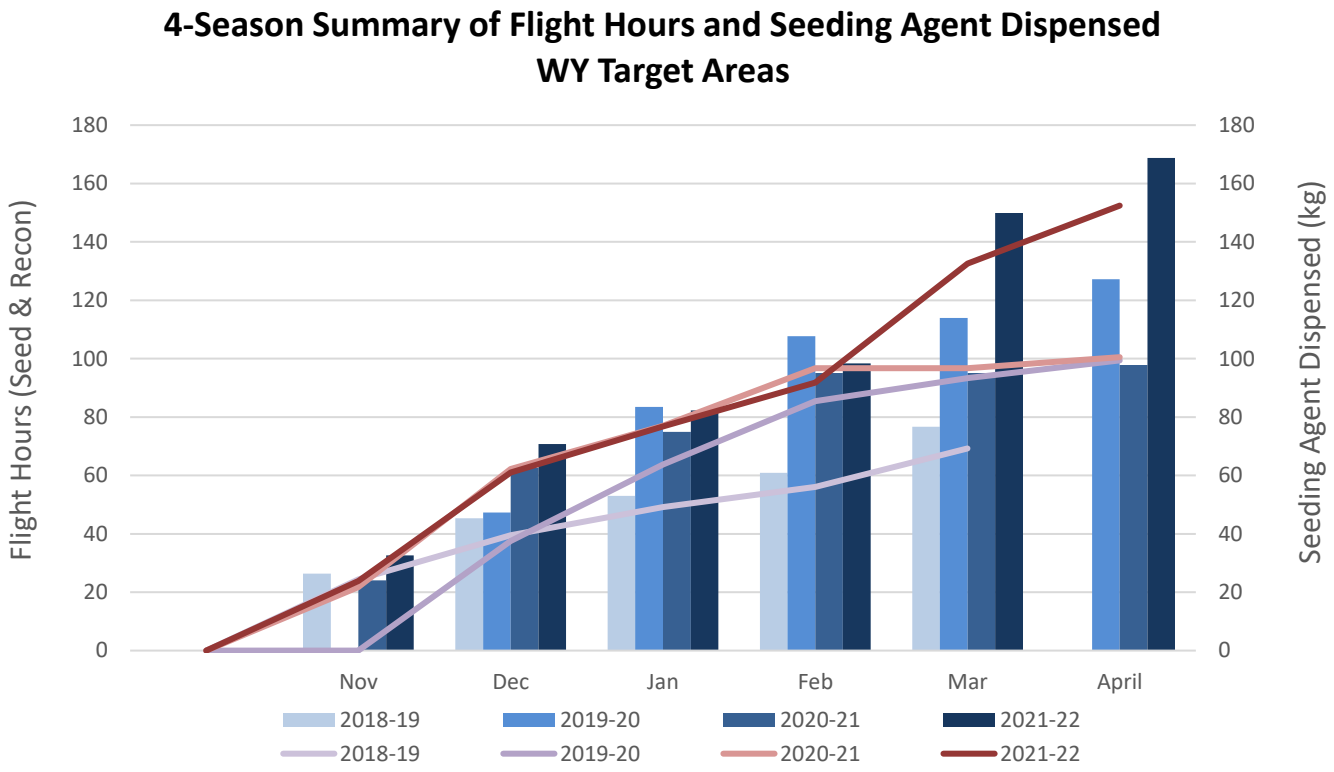


Figure 32. 4-Season Summary of Flight Hours and Seeding Agent Dispensed for the Wyoming Target Areas (Medicine Bow and Sierra Madre Mountain Ranges). Note: Laramie Mountain Range data is included from 15 November 2018 - 20 December 2020.

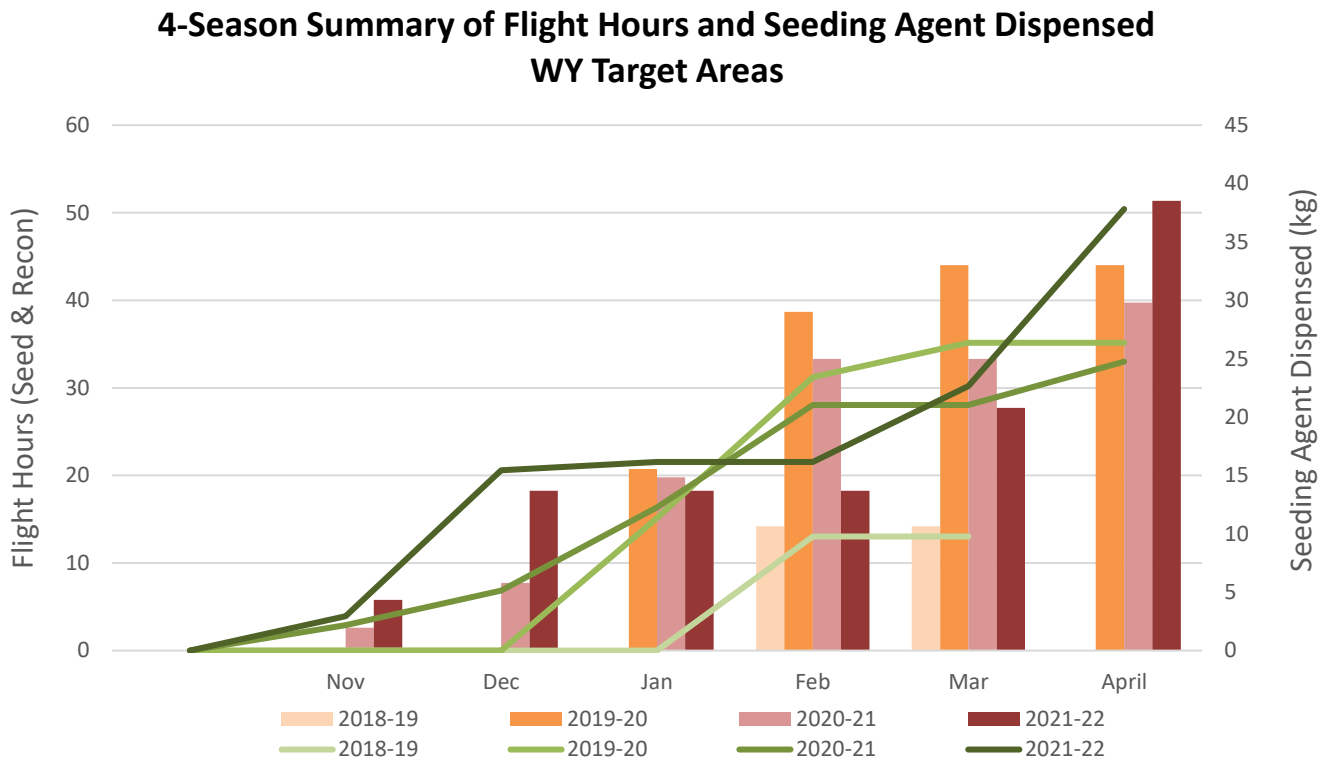


Figure 33. 4-Season Summary of Flight Hours and Seeding Agent Dispensed for the Colorado Target Area (Never Summer Mountain Range).

7 CONTRACTOR'S FINAL REMARKS

The 2021-2022 winter season was Weather Modification International's fourth winter season providing operational aerial cloud seeding and meteorological services for the Medicine Bow and Sierra Madre Mountain Ranges of Wyoming and the Never Summer Mountain Range in Colorado. The target ranges provided ample suitable seeding targets, and the terrain, base of operations, and Air Traffic Control allowed safe, effective operations.

The 2021-2022 season marked the busiest winter cloud seeding season in WMI history for a single aircraft flying a total of 202.85 hours. This is due to the increased budget for the season as well as numerous active weather patterns that presented an abundance of seeding opportunities for the Wyoming and Colorado ranges.

Annual snowpack for the region, at the time operations ended April 15, 2022, was slightly below normal. This suggests that the number of seeding opportunities observed this season was likely slightly less than what could be expected in a typical season. During the 2021-2022 season, meteorology and pilot staff focused efforts on utilizing project resources to target the most promising clouds in order to maximize the benefits of the program.

WMI invites comments from the WWDO and JCWCD regarding this winter's program. For more information regarding Weather Modification International please visit our website: www.weathermodification.com

Figure 34. The Cheyenne airport, as seen from Captain Alex Sailsbury's perspective while copilot Ryan Starkey makes the smooth landing.