



New Bird, New Challenges: The Calibration and Testing of the Airborne Gamma Snow Survey King Air 350CER

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NWS/OWP/NWC



AMS 2022

National Snow Analysis

To support the National Weather Service's mission by producing the best estimate of snow water equivalent, using all available data including satellite, airborne, and in-situ observations for the protection of life and property and enhancement of the national economy.

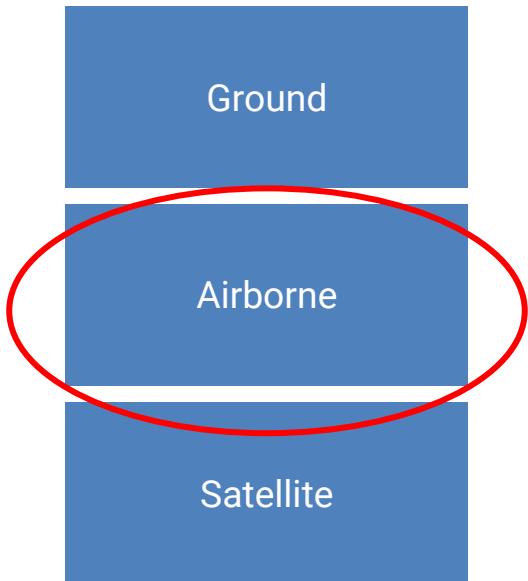


Operational mission collecting SWE and soil moisture measurements since 1980

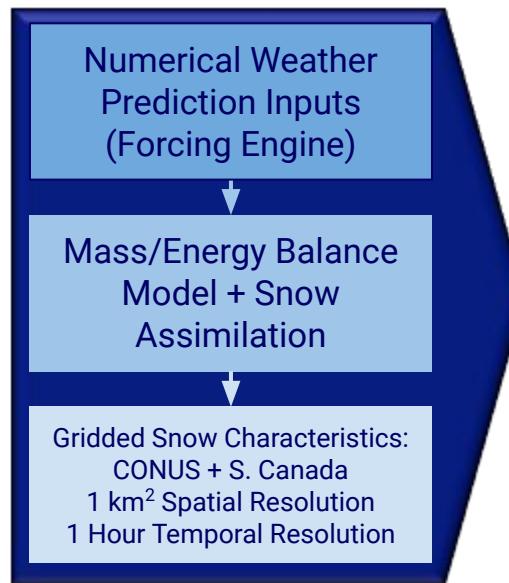


National Snow Analysis

Multisensor Snow Observations



Snow Modeling and Data Assimilation (SNODAS)



Snow Information (Products)

- Downloadable Maps
- Interactive Mapping
- Text Products
- Gridded Binary Files
- Time Series Plots
- Text Discussions



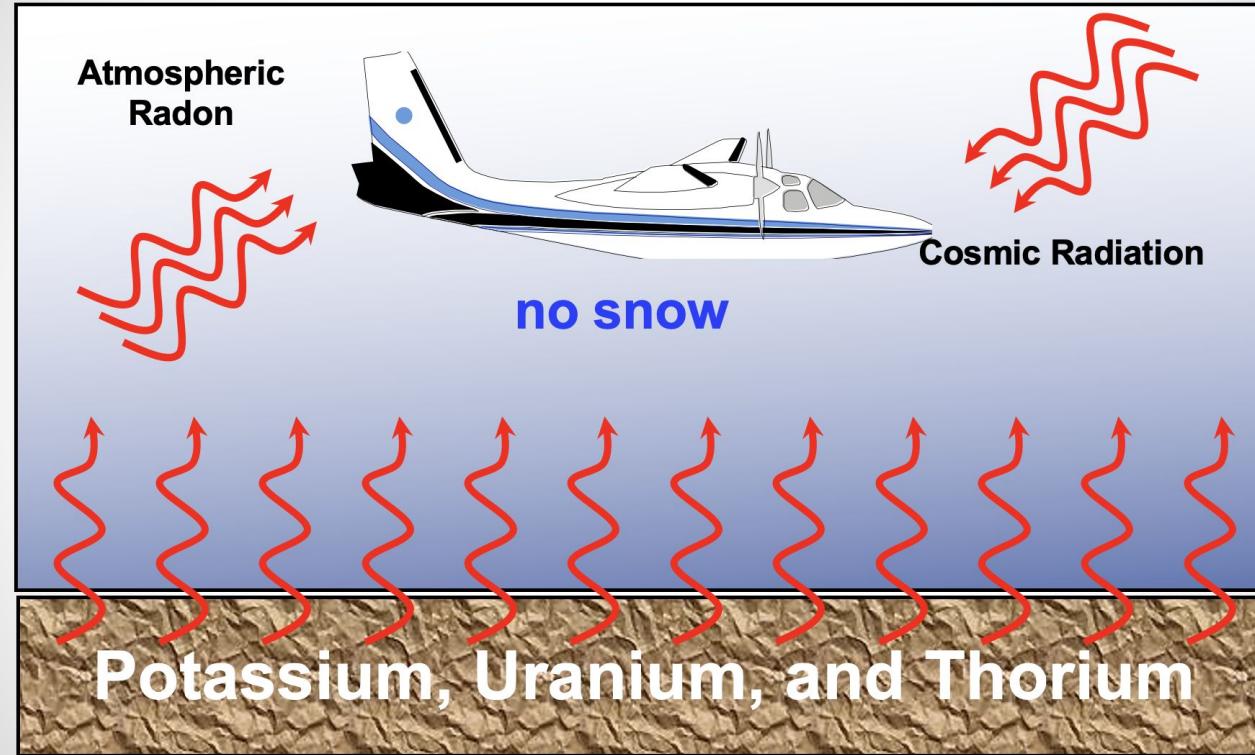
Importance of Airborne Gamma Data

- Used by the National Weather Service Weather Forecast and River Forecast Offices as critical inputs to river and flood forecasts, water supply forecasts, and spring flood outlooks.
- These observations are incorporated in OWP's SNODAS model
- Federal, state and local agencies use airborne snow water equivalent observations in their decision support operations.
- In many remote areas of the United States where vulnerable and underserved communities exist, the airborne observations are the only reliable SWE observations available.

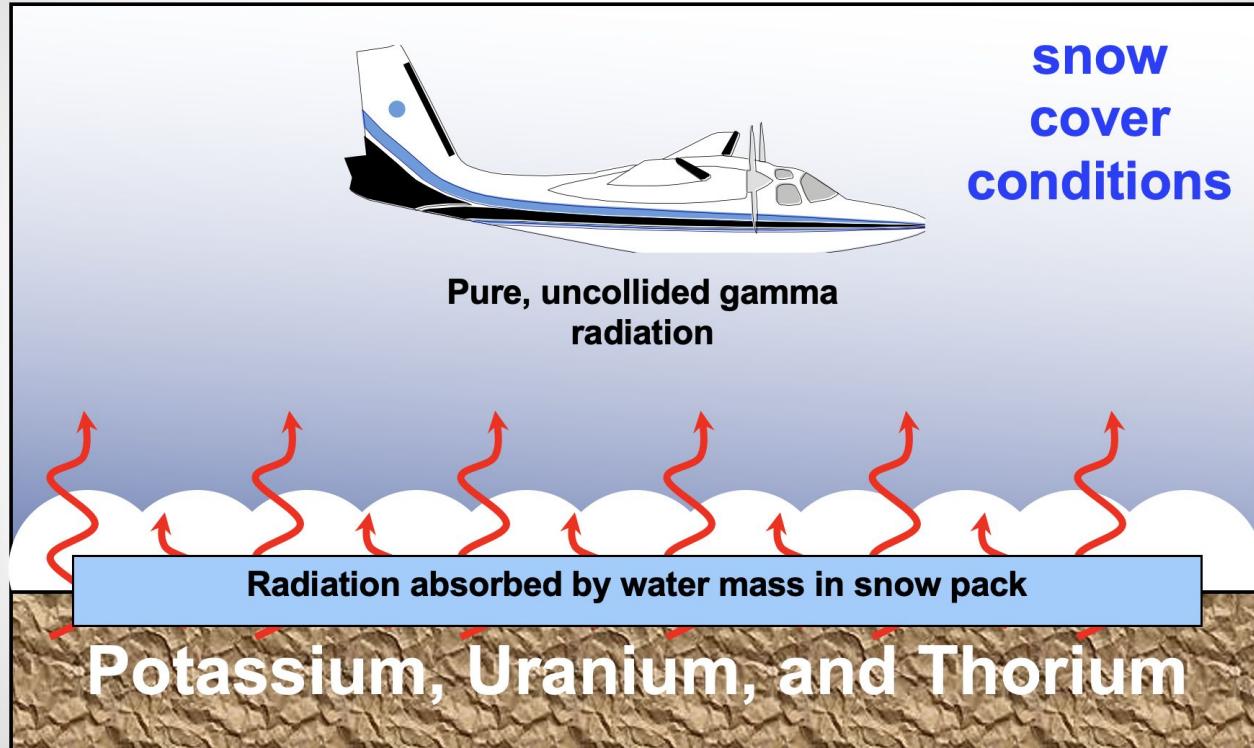


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Natural Terrestrial Gamma Radiation



Natural Terrestrial Gamma Radiation



Changes over time ...



Changes for the future



Feasibility Study FY18

Initial testing November 2017

27% Gross Down Counts (GDC) in N68RF

Determined N68RF was NOT a suitable replacement

6% attenuation on clean new King Air

Suitable starting point.



Calibration Plan

Aircraft delivery and modification

Install and Testing of Equipment

Evaluation of Fuel Effects

Develop Aircraft Coefficients

Cosmic

High and Low Altitude flights

Verify Coefficients

Evaluate Aircraft capabilities - repeatability

Evaluate Platform in Survey Scenarios

Snow Free Conditions

Upper Midwest / Northern Plain

Northeast / hills / mountains

Alaska



Initial Scan of Aircraft

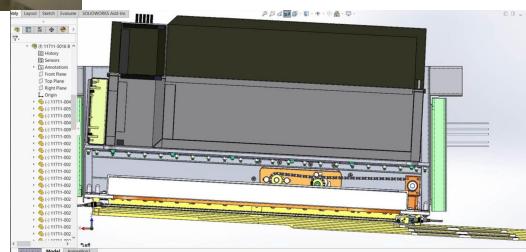
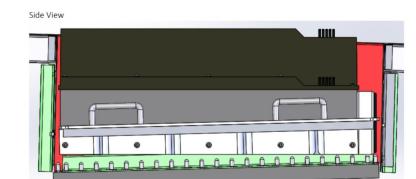
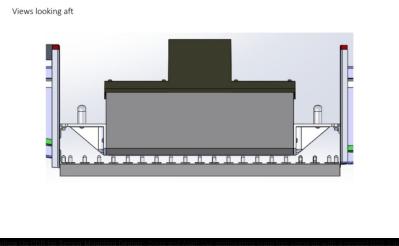
Attenuation of gross down counts (GDC) in the aft camera port position was **13%** and **19%** for potassium.

Attenuation of GDC in the forward position was **19%** and **27%** for potassium

N68RF attention is 27% GDC and 34% Potassium



Aircraft Modifications



Scan of Aircraft after Mods

Attenuation of gross down counts (GDC) in the aft camera port position after modifications were reduced from 13% to **7%** and from 19% to **10 %** for potassium.

Attenuation of GDC in the forward position after modifications were reduced from 19% to **8%** and from 27% to **10%** for potassium

N68RF attention is 27% GDC and 34% Potassium



Acceptance Team - Nov 2020



How to declare success?

- Current Gamma SWE is within +/- 1 cm of water.
- RFC's need SWE within 1-2 cm for the plains snowpack.
- How many lines are we going to be unable to fly?
- So many unknowns, requested a year of overlap

Airborne Snow Water Equivalent *Measurement Error (cm)*

	Agri.	Forest
Root Mean Square Error	0.81	2.31
Average Absolute Error	0.75	1.87
Average Bias	0.54	0.15
Percent Bias	12.10	1.28
N (flight lines)	23	70



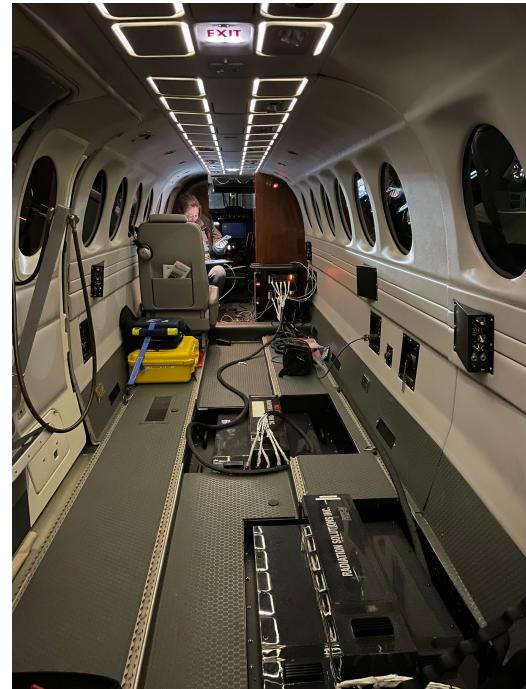
Challenges

- Delayed Acceptance of Aircraft
- Accelerated timeline
- Cracked Crystal
- Weather
- Aircraft feeds - Radar Altimeter offset
- Dual system configuration
- RadAssist Software
- Radon
- Potassium in PMT
- Operational Snow Survey Requirement - Go Time
- Positive Covid-19 case



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New System Configuration



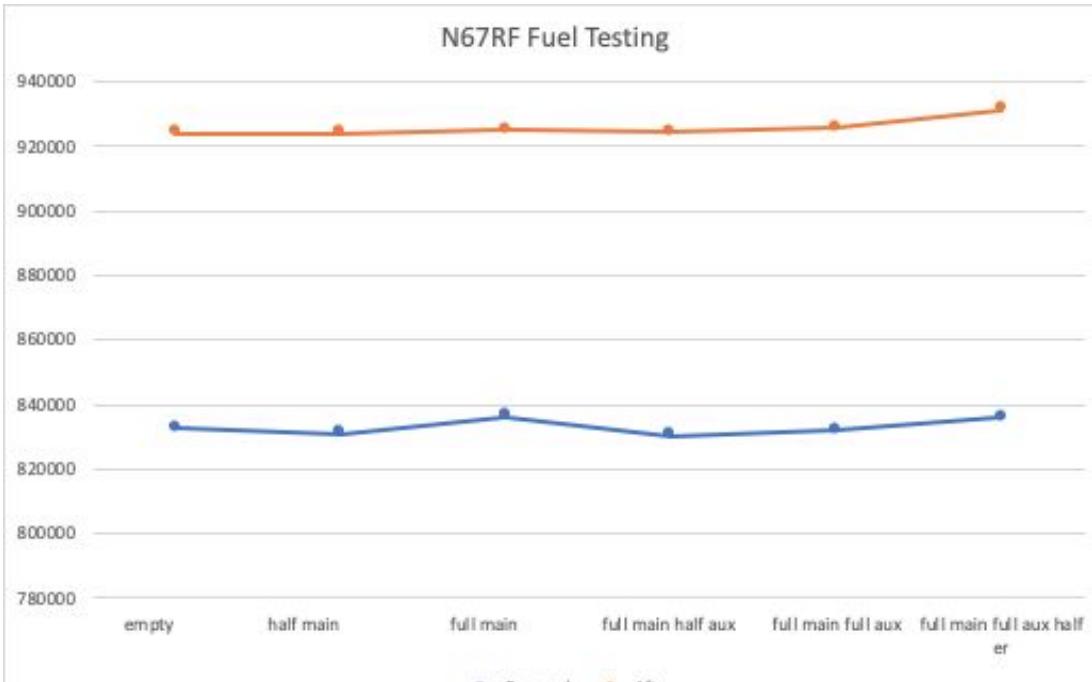
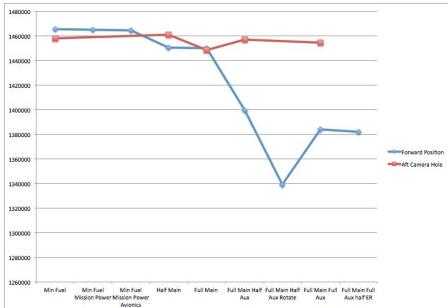
N67RF Fuel Testing

Total Counts Channel 10-1020

Attenuation of Empty to Full Main
Full Aux Half ER

0.38% Forward
0.78% Aft

N68RF Fuel Attenuation was
~6%



Repeatability and Fuel Testing

Altitude

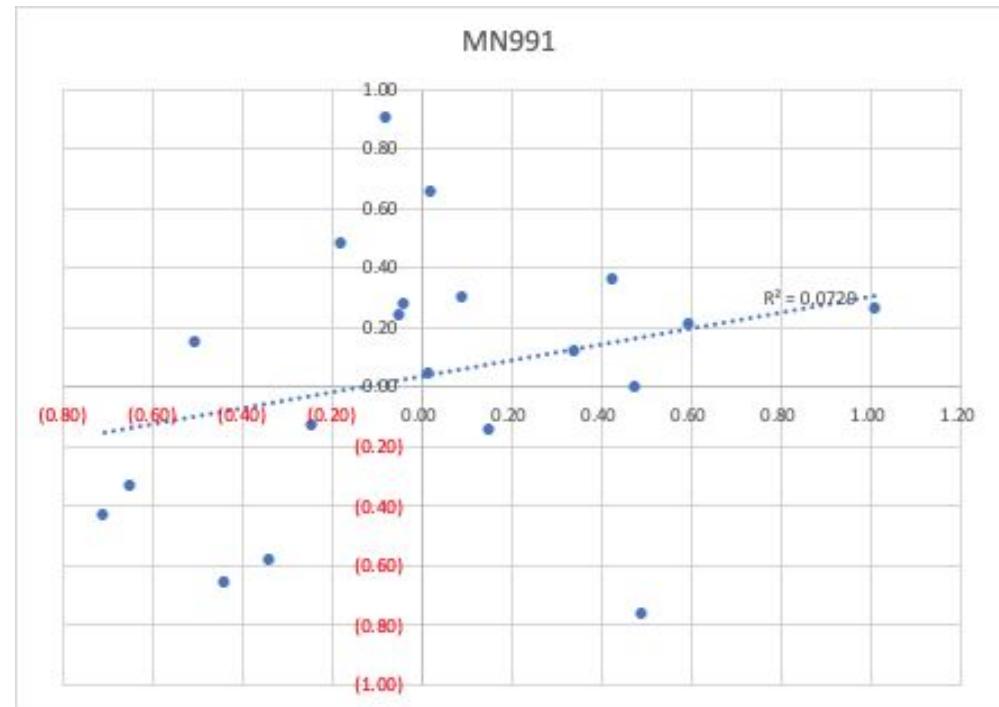
X/Y deviation from line

Speed

Fuel

Sensor

Speed



MN991 Repeatability

		GCDR	GCUR	LR	KR	UR	TR	CDR	CUR	Altitude	AcqTime	SWE
Forward -RSI1	Average	24449	2737	10040	3324	1150	829	795	166	488	320.8	4.4
	StDev	312	43	130	45	30	13	6	3	4	3	0.3
Aft - RSI2	Average	23477	2591	9647	2897	1145	805	800	170			6.5
	StDev	256	34	114	41	23	16	6	2			0.3

N=20

Average Counts in Regions of Interest (ROI) and STDEV - small

What does it mean?

Using the same Aircraft Coefficients for the two systems we calculated SWE.

MN991 Repeatability - New Questions

Why are the two systems getting different results?

Why is there a potassium bias?

Fuel testing didn't show any issues.

Initial scan didn't show anything.

While on the ground, there are more counts, so the difference is masked.

Reached out to manufacturer.

The PMT (Photomultiplier Tube) - Changed manufacturers. The newer systems have less potassium.

A dark blue background featuring several white, glowing COVID-19 virus particles. One large, sharp-edged virus is prominent in the center-right, while smaller, more rounded viruses are scattered across the left and top edges.

COVID-19

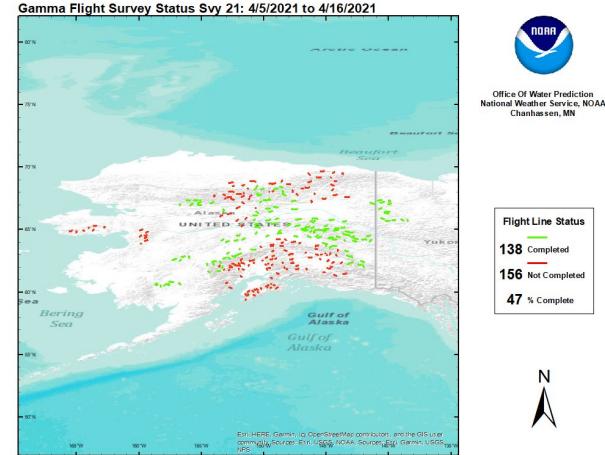
Alaska

Airborne data is some of the only data collected to support Alaska region.

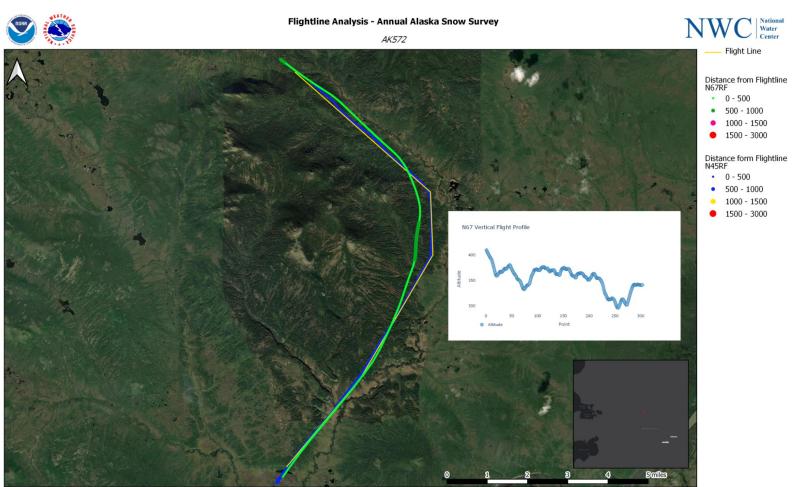
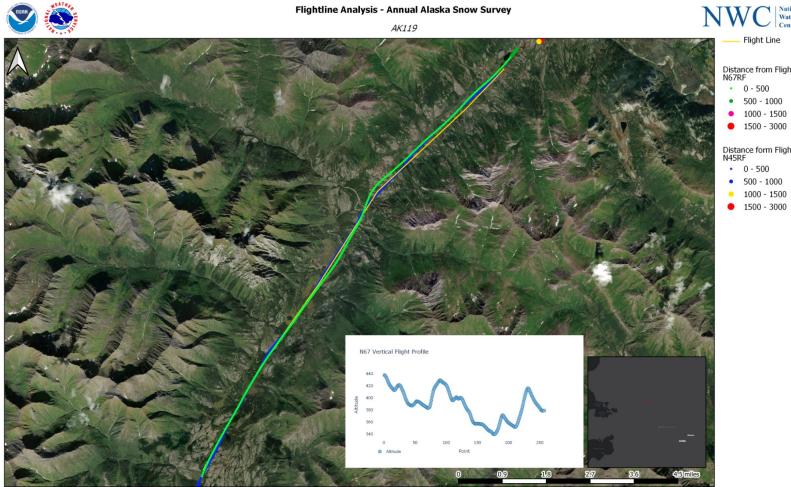
Some lines were unable to be flown, greatest challenges were along ridge lines.

Having extended range (ER) tanks were a benefit for longer endurance.

Results - less counts / greater variability in deeper snowpack. Not as critical in deepest snowpack.

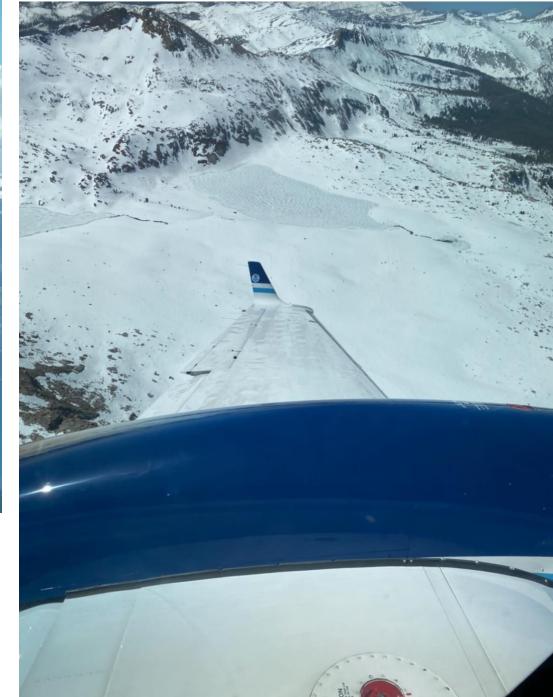
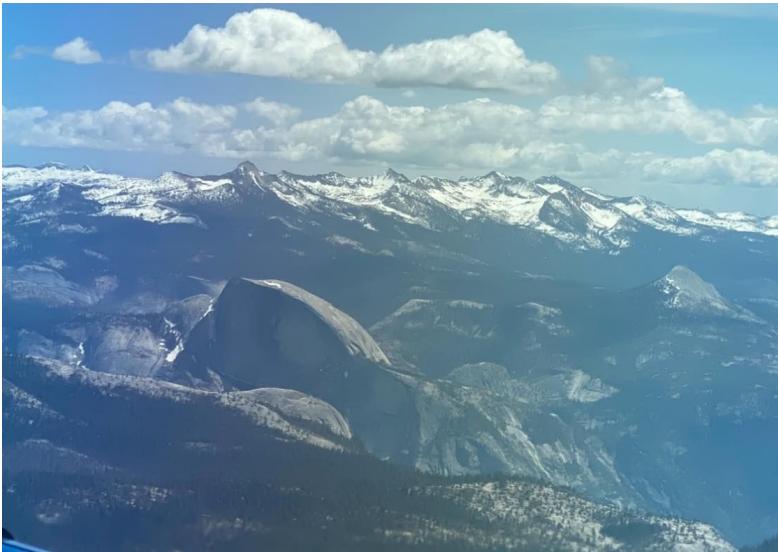


Mountain Flying



Pilot proficiency and "chasing" of altitude improved over time.

Mountain Flying



Results



A compressed timeline of just 4 months, and numerous challenges and limitations to collect sufficient data sets, barring unforeseen factors and untested scenarios, OWP believes the King Air 350 CER (N67RF) can adequately support the Airborne Gamma Mission.



Results

King Air Sensor 1	n=226	Acquire Time (seconds)	Snow Water Equivalent (cm)	Soil Moisture (%)
Average Difference N45RF-N67RF Sensor 134		34.47	0.00	-5.23
Standard Deviation		13.45	1.70	31.75

Table 1. Calculation of the average difference and standard deviation of the acquire time, snow water equivalent and soil moisture between Jetprop Commander N45RF minus Sensor 134 in King Air 350 CER N67RF where n is the number of flightlines used in the calculation



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Results

King Air Sensor 2	n=226	Acquire Time (seconds)	Snow Water Equivalent (cm)	Soil Moisture (%)
Average Difference N45RF - N67RF Sensor 135		34.39	0.05	-2.58
Standard Deviation		14.00	1.30	20.31

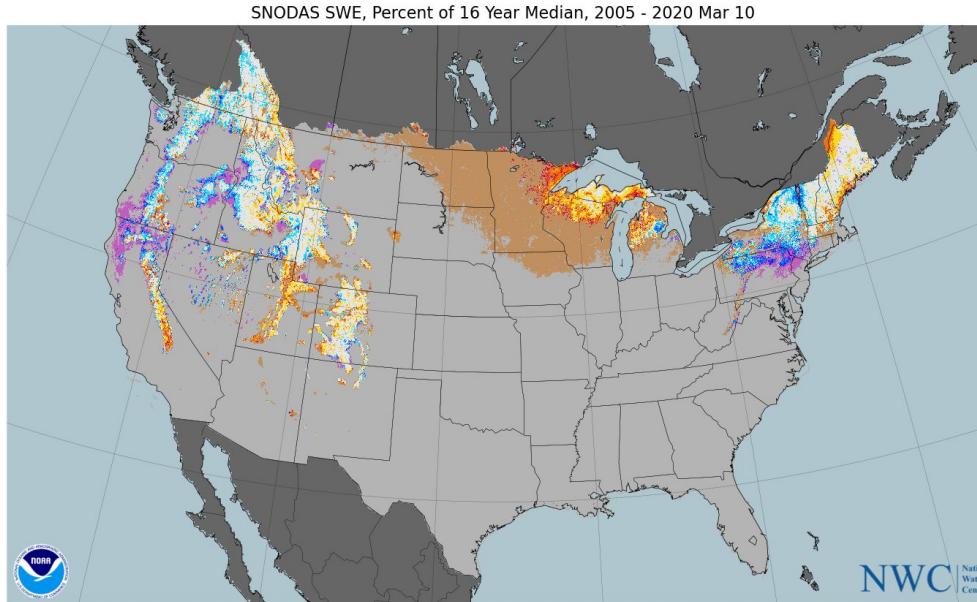
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Results

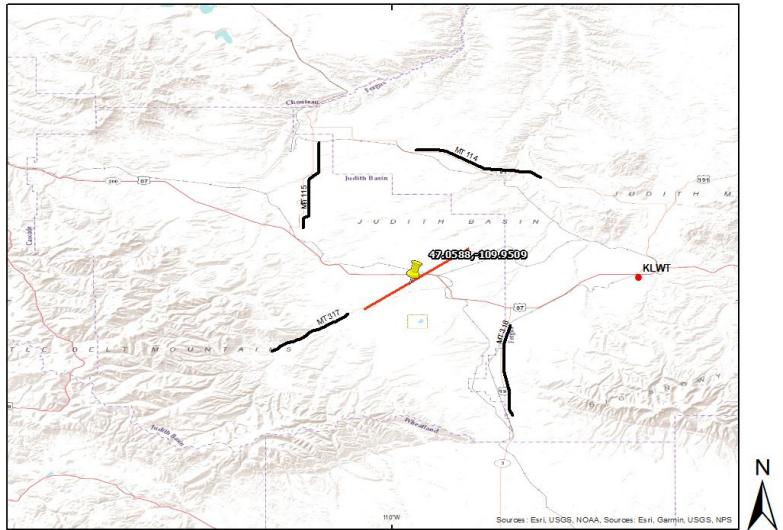


Limited wet soil moisture conditions, or deep snowpack, due to the minimal snowpack in the Upper Midwest, Northern Plains, and Northeast this past snow season.



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SnowEx 2021 and King Air



 Office Of Water Prediction
National Weather Service, NOAA
Chanhassen, MN

SnowEx 2021 Judith Basin

0 5 10 20 Nautical Miles



SnowEx 2021 MT Feb 24, 2021

Suppose to be ground data verification. Had crews to collect samples.





SPLASH

Study of Precipitation, the Lower Atmosphere and Surface for Hydrometeorology

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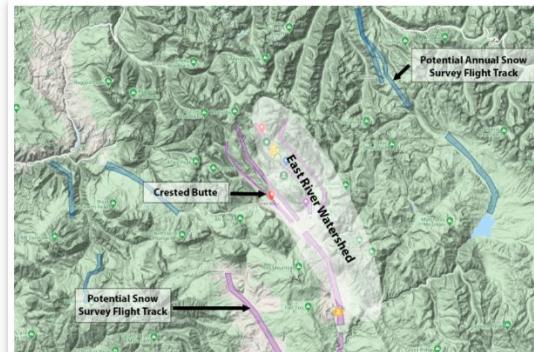
About

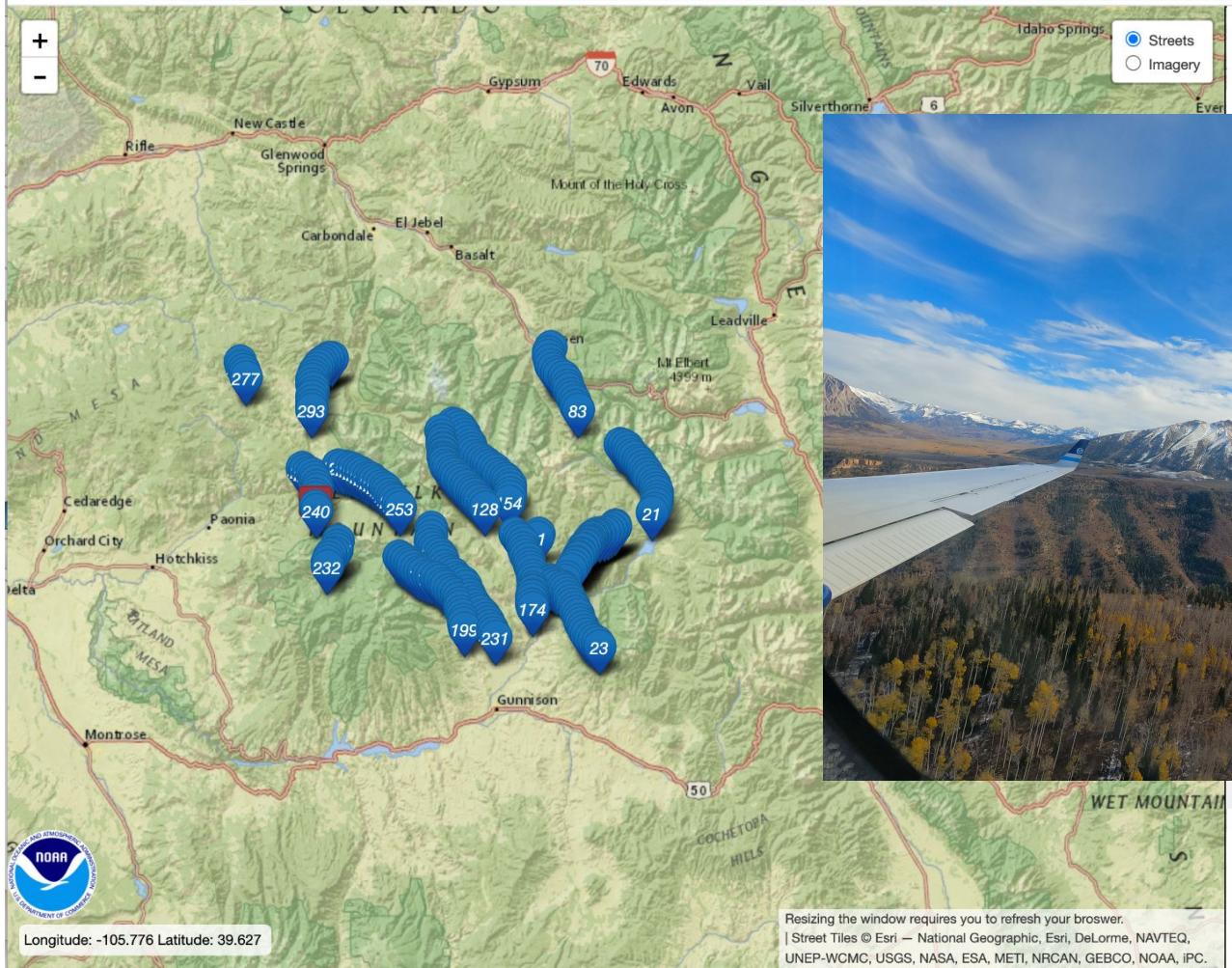
From fall 2021 to summer 2022, NOAA and research partners will participate in the **Study of Precipitation, the Lower Atmosphere and Surface for Hydrometeorology (SPLASH)**.

This field study will install a comprehensive, state-of-the-art observing network in the East River watershed of the Colorado mountains with a goal of advancing weather and water prediction capabilities in areas with complex terrain.

Anticipated Benefits

In combination with scientific analysis of the resulting datasets, research will apply SPLASH observations and the resulting enhanced process-understanding to evaluate and improve NOAA's latest suite of modeling tools, including the Unified Forecast System, Rapid Refresh Forecast System, and National Water Model. The ultimate goal of this





Soil Moisture Survey
NWS Office of Water Prediction
Colorado SPLASH Soil Moisture
October 2021



Date: 2021-10-21 Time: 12:48:21

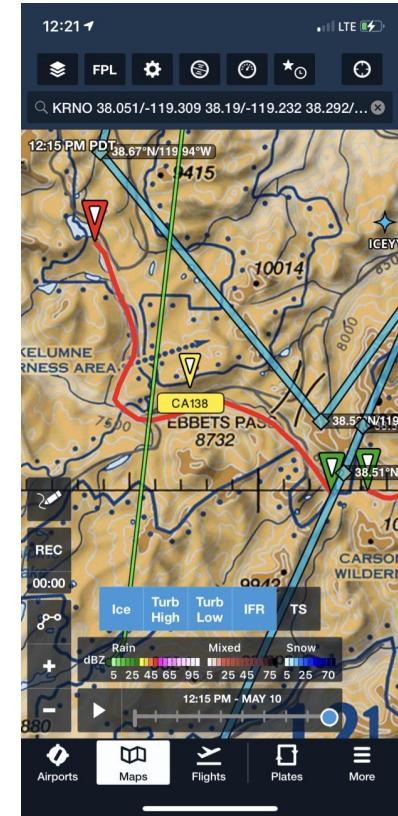
Challenges

Aircraft Performance -

Higher speeds, larger turning radius ~ 10% of current flightlines will need to be removed or relocated.

Most pronounced on lines that follow ridge tops.

For example 3 of the 47 lines flown in the Sierra Nevada will need to be relocated.



Challenges

Weather Minimums -

Higher minimum survey speed will result in more conservative weather calls.

Moderate turbulence is greater factor, especially with operator in back.

May take additional days to collect survey then what has been done historically.





Conclusion

OWP believes the King Air 350 CER (N67RF) can adequately support the Airborne Gamma Mission, barring unforeseen factors and untested scenarios

The King Air 350CER was able to replicate SWE data collected by retired platform within 0.05cm with a standard deviation of 1.3cm

The acquisition, modification, and operationalizing a new platform can be challenging but can open door for innovation.

One system will be flown operationally, leaving an open additional port.



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Thank You!



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