



# Assessing the Impact of Shared Ground Generators across the Bear River and Upper Snake Basins in Idaho

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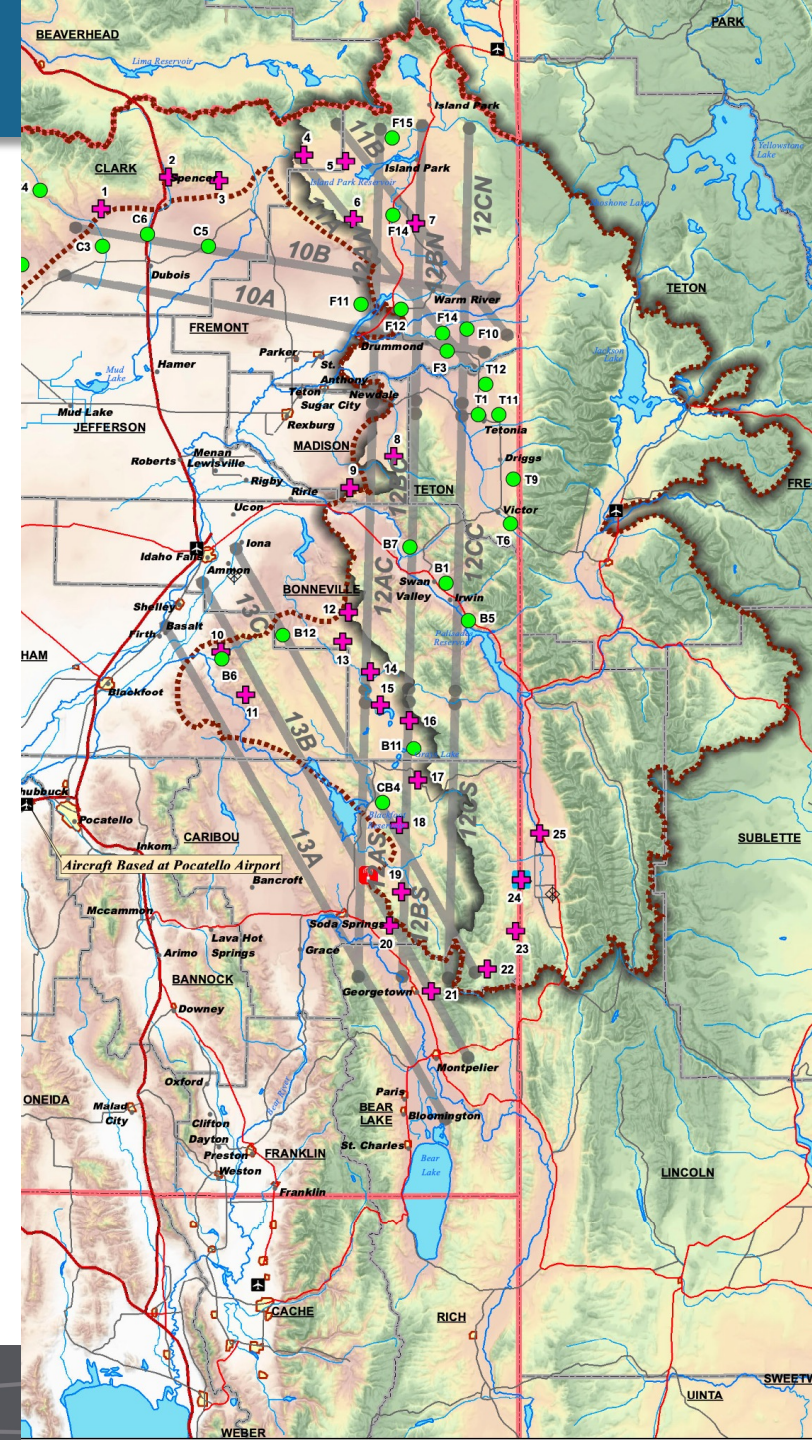
WMA, April 2023

# Background

The State of Idaho and Idaho Power Company (IPC) both have shared interests in operating cloud seeding programs to enhance precipitation in the state.

IPC, [in partnership with Idaho Water Resource Board](#) have been operating cloud seeding in selected basins, including the Upper Snake River Basin, to increase the State's water supply.

Given the proximity of the Bear River Basin and the Upper Snake Basin, there may be opportunities for these two regions to share infrastructure, such as weather instrumentation and cloud seeding facilities.

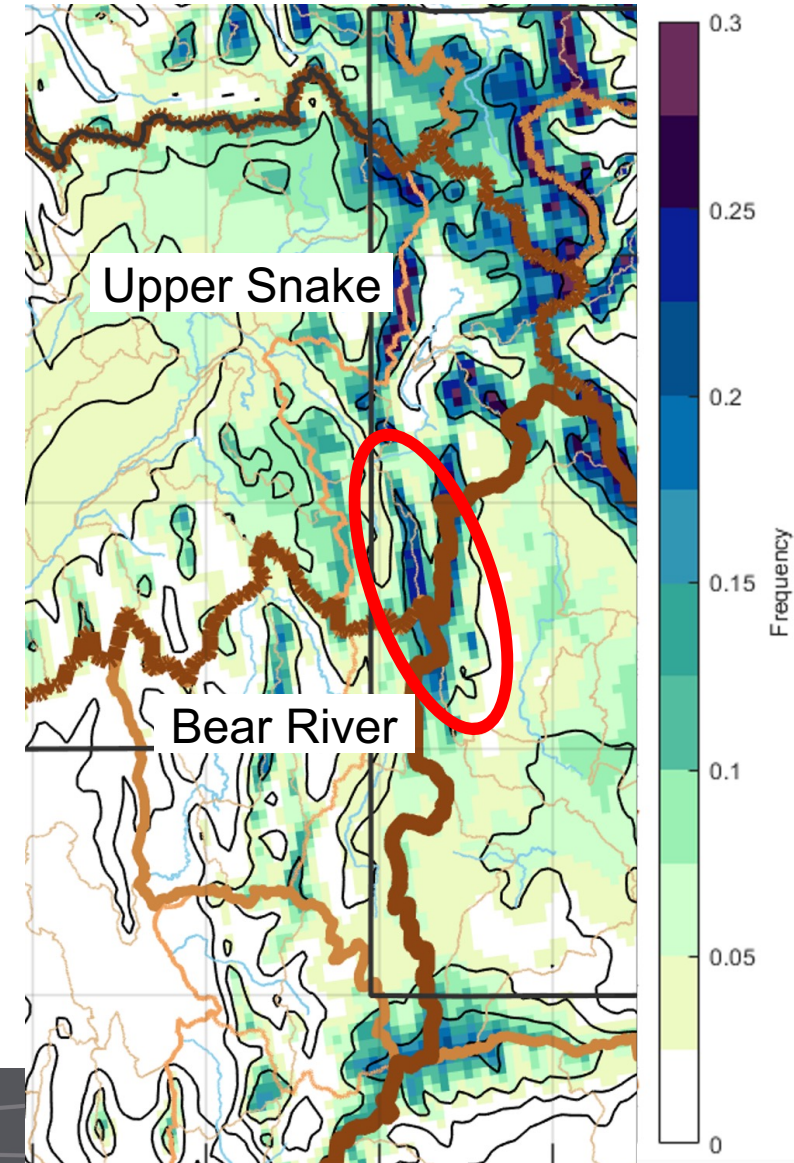


# Bear River Basin Feasibility Study (2022)

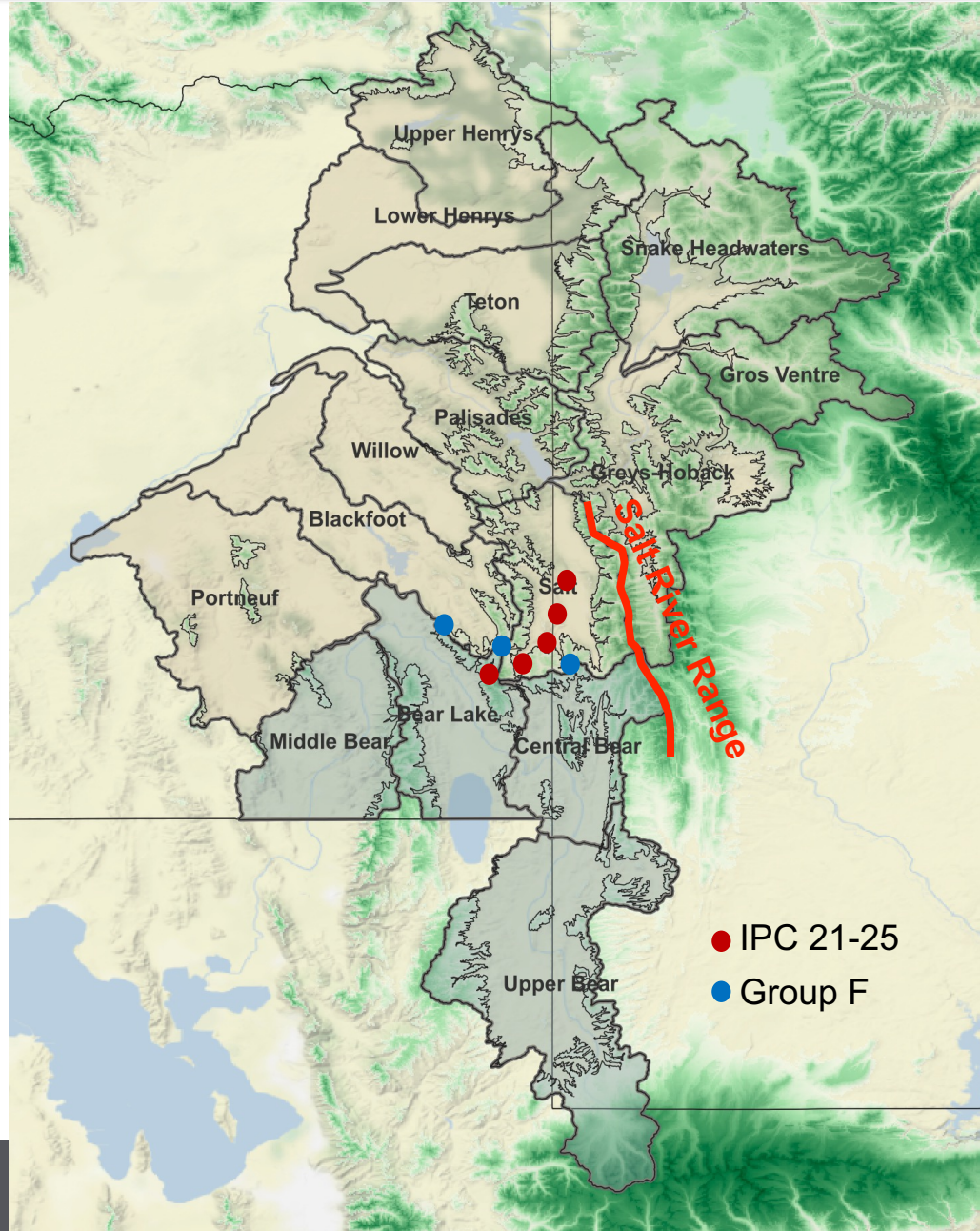
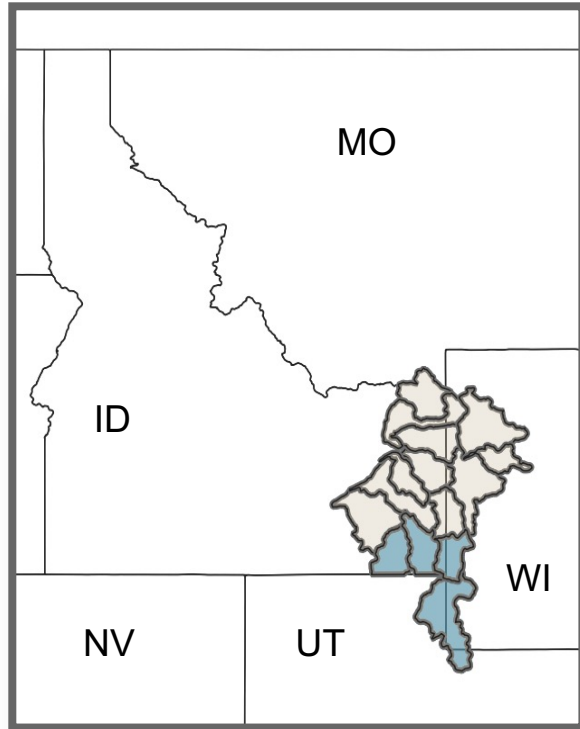
A preliminary cloud-seeding program designed to target the Bear River Basin

Opportunities for sharing ground-based generators and/or aircraft with the Upper Snake seeding program, targeting the Salt River Range providing benefits to both basins

Frequency of GS LWC > 0.01 g kg<sup>-1</sup> & -18°C < GS T < -6°C  
CONUS-I Current Climate  
Nov-Apr Average

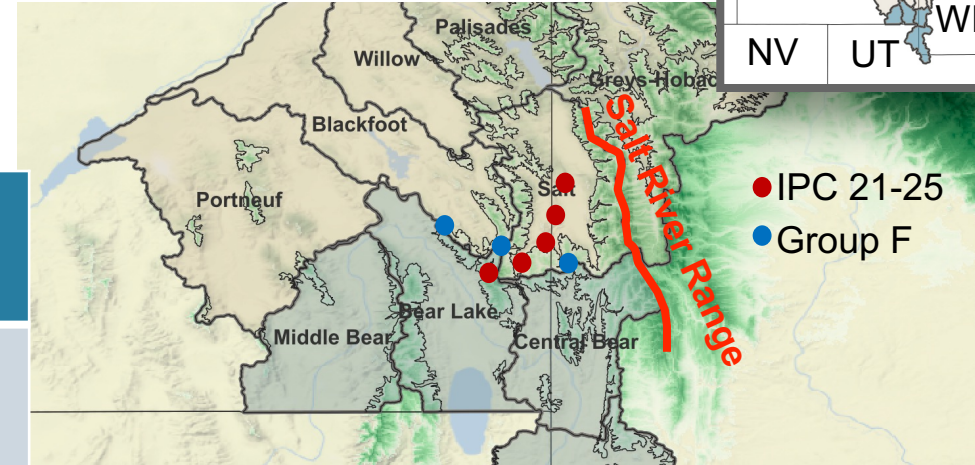
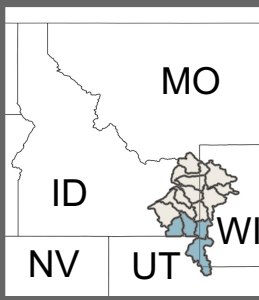


# Shared Generator Infrastructure

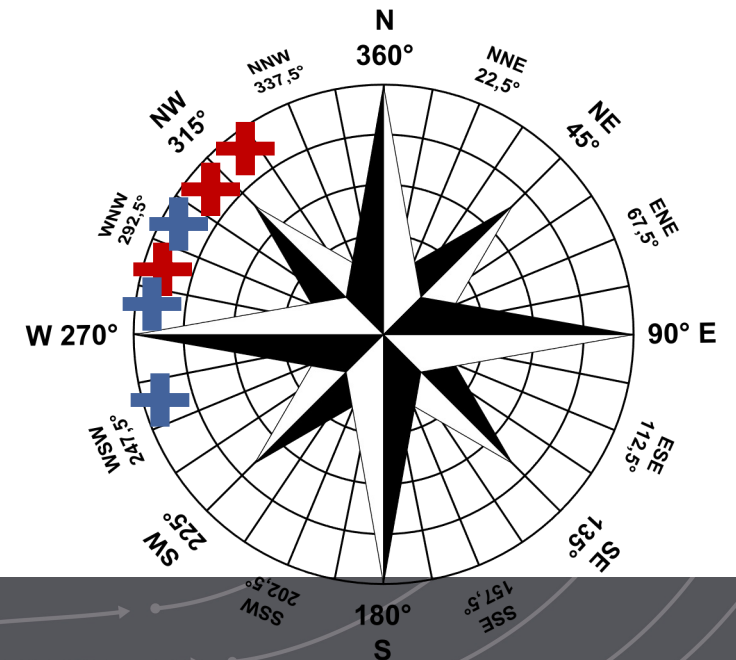


# Case Selection

Cases were selected based on winds and liquid water content over the Bear and Snake sides of the Salt River Range.



Start Time	Duration [h]	LWC [g/kg]	Precip Accum [mm]	Temp [°C]	WDir	WSpeed [m/s]	
2016-01-17 09:30Z	8.5	0.22	0.8	-9	297	8.7	Snake & Bear
2020-12-18 01:00Z	9	0.11	2.4	-9	323	7.7	
2021-01-17 21:15Z	7.75	0.19	0.6	-7	282	11.6	
2016-12-03 19:00Z	9	0.12	0	-11	280	9.3	Bear
2017-01-20 06:00	10	0.07	0.12	-10	293	4.4	
2018-02-25 04:00Z	7	0.05	1.6	-17	252	8.6	



# Opportunity Evaluation using WRF-WxMod

WRF-WxMod was used in six numerical experiments to investigate the contribution of:

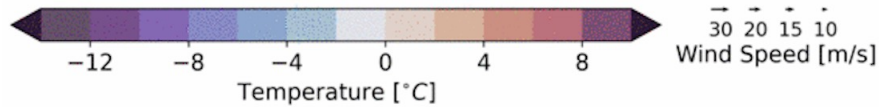
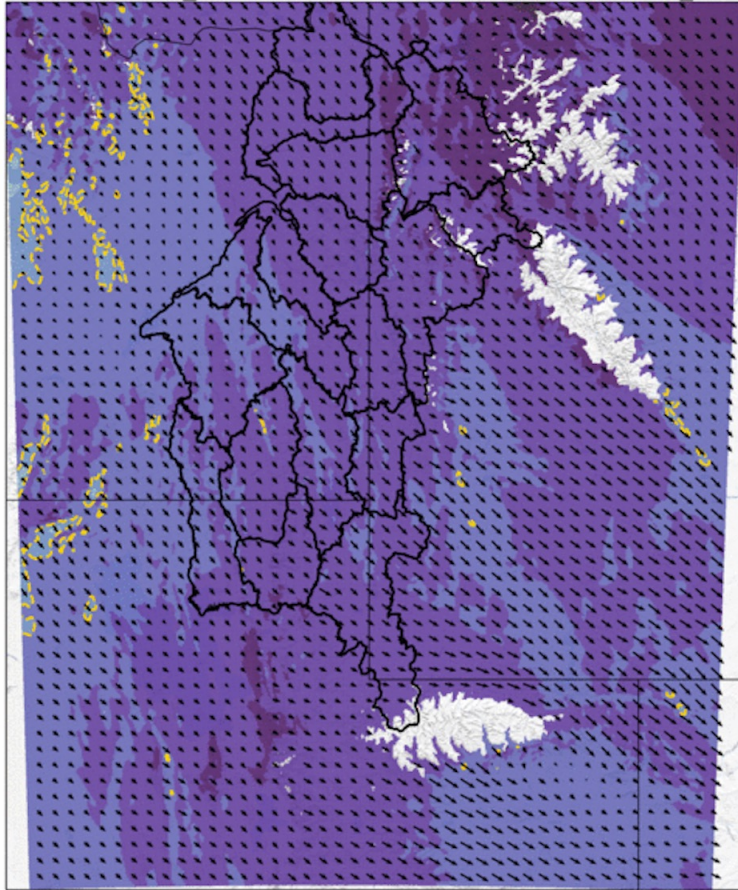
- 5 existing generators in the Upper Snake
- 3 hypothetical generators in the Bear River Basin



# Case 2016-01-17 00Z: Simulation Seeding Window 9:30 to 18Z

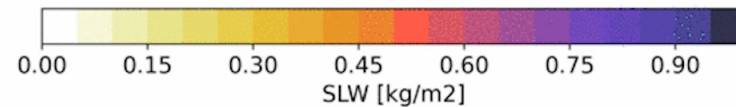
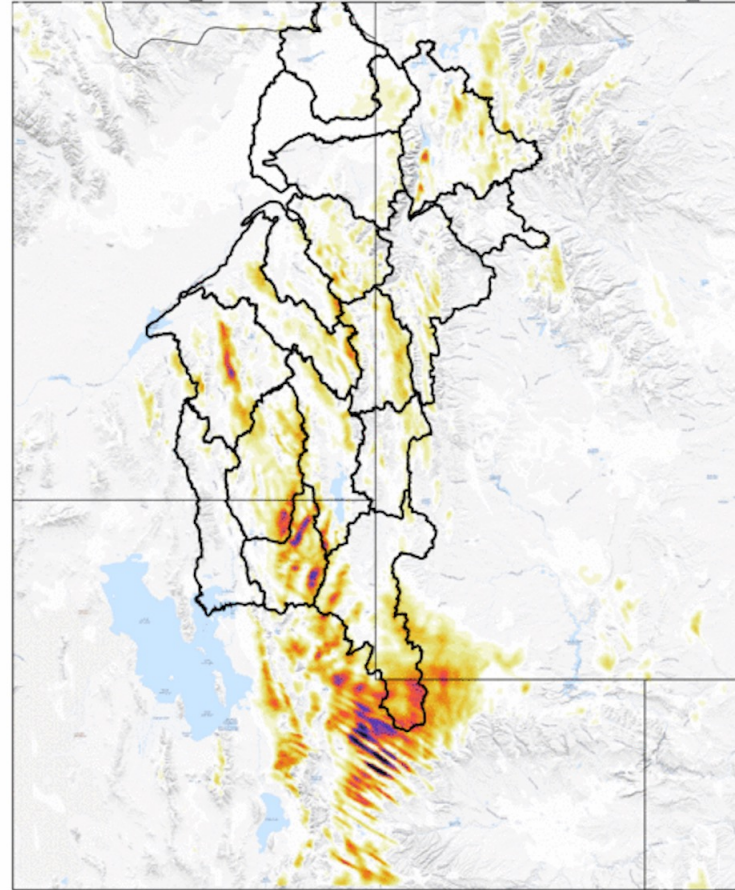
### Temperature and Wind Speed 700mb

Fcst: 2016-01-17\_00:00Z +09.00h Valid at 2016-01-17\_09:00Z

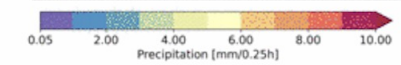
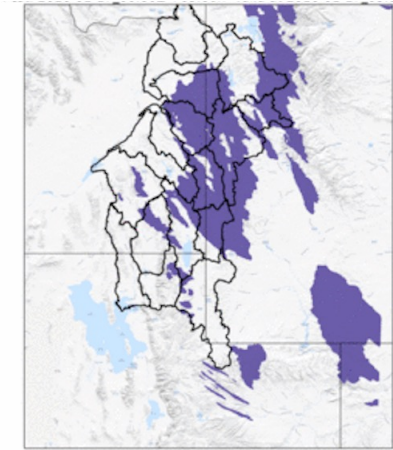


### Supercooled Liquid Water Path $T \leq -6^\circ\text{C}$

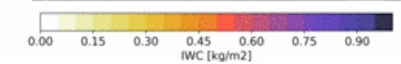
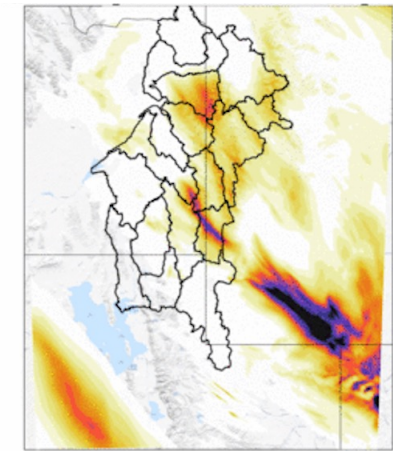
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### Precip Rate



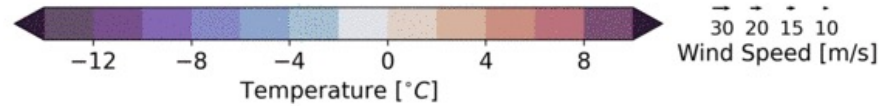
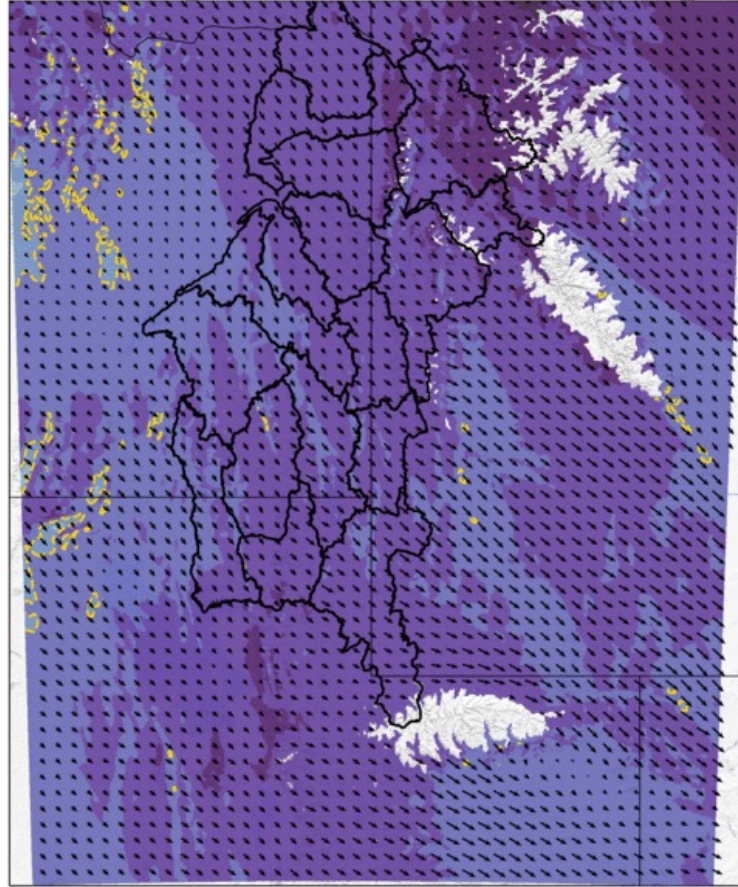
### Ice Path



# Case 2016-01-17 00Z: Simulation Seeding Window 9:30 to 18Z

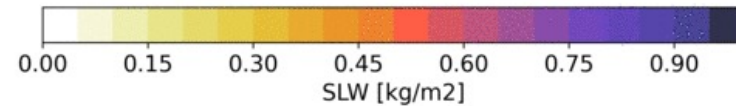
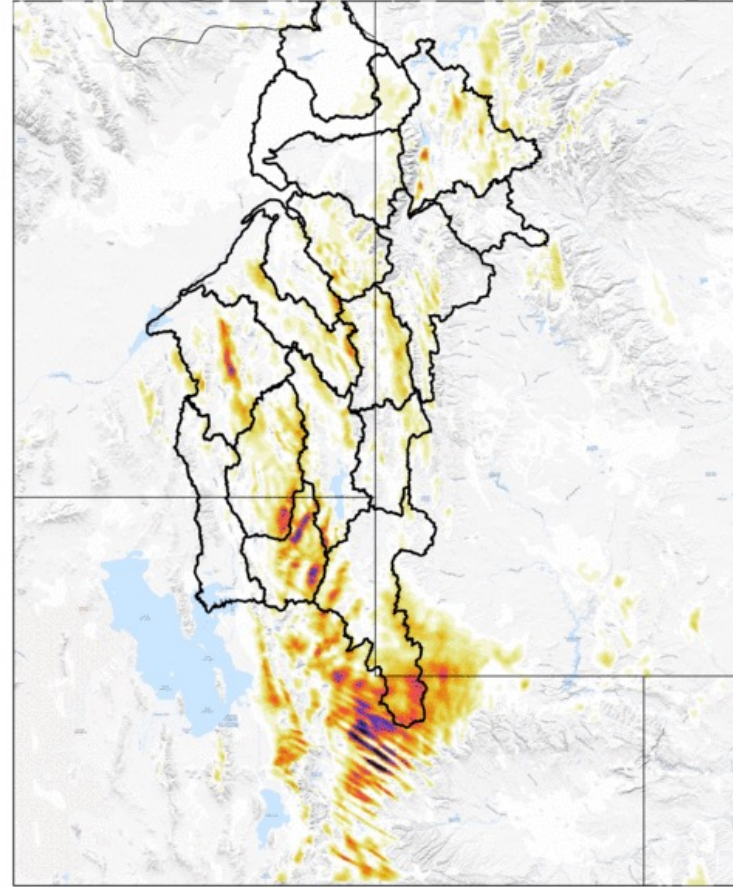
### Temperature and Wind Speed 700mb

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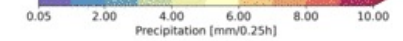
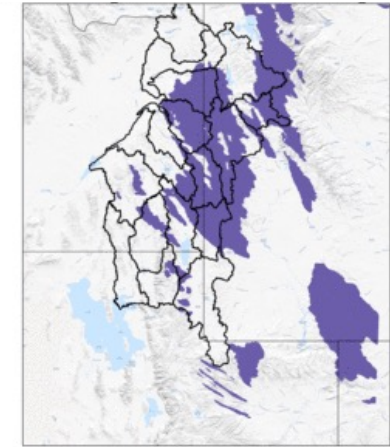


### Supercooled Liquid Water Path $T \leq -6^\circ\text{C}$

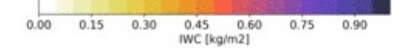
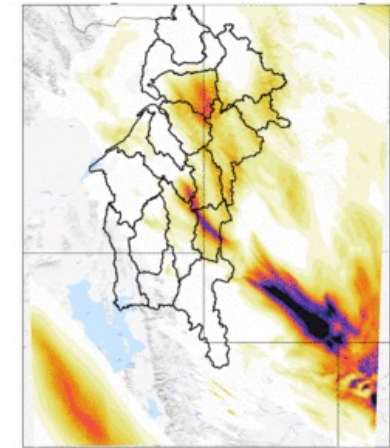
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### Precip Rate

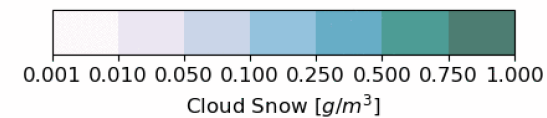
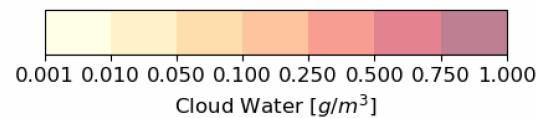
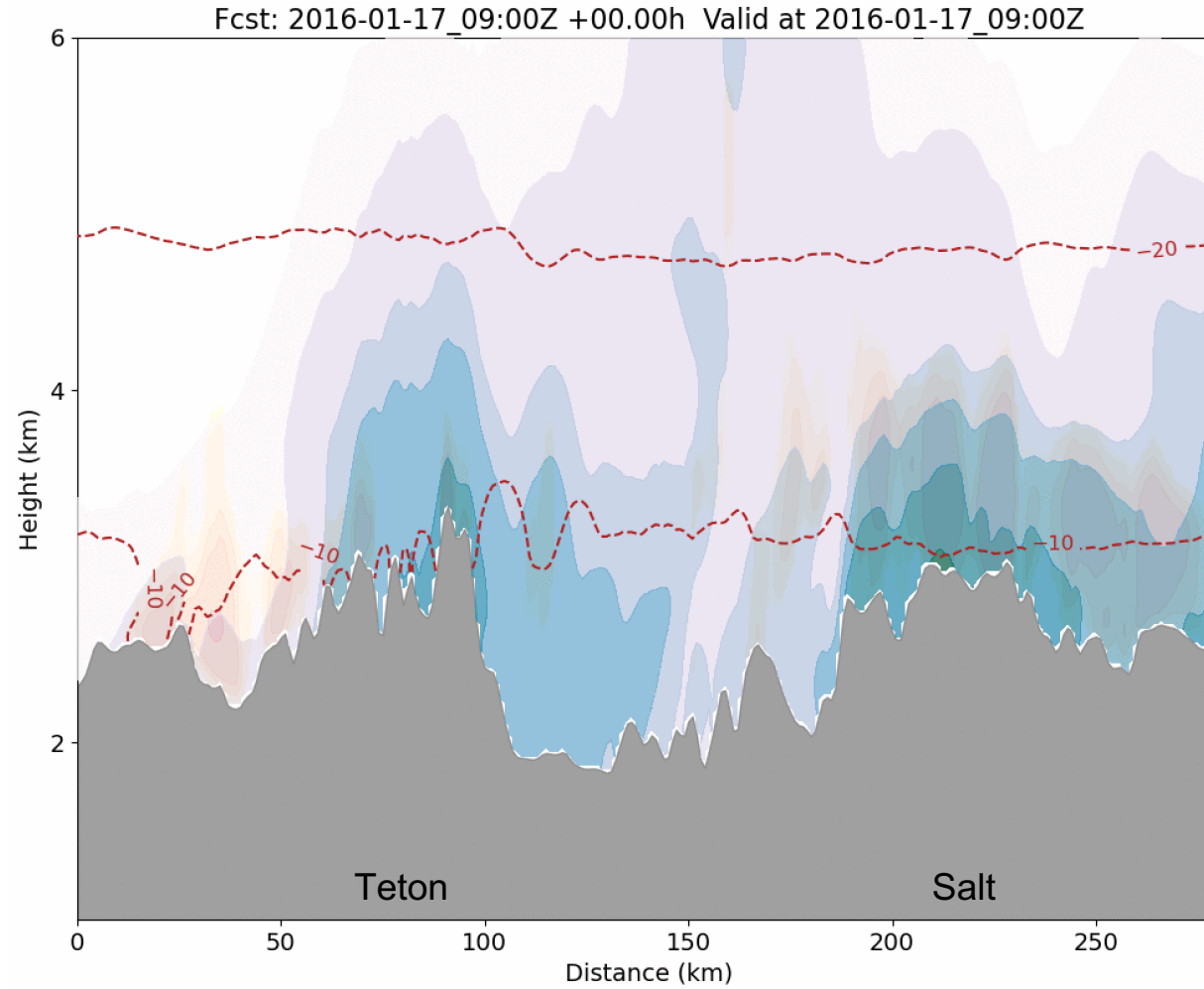
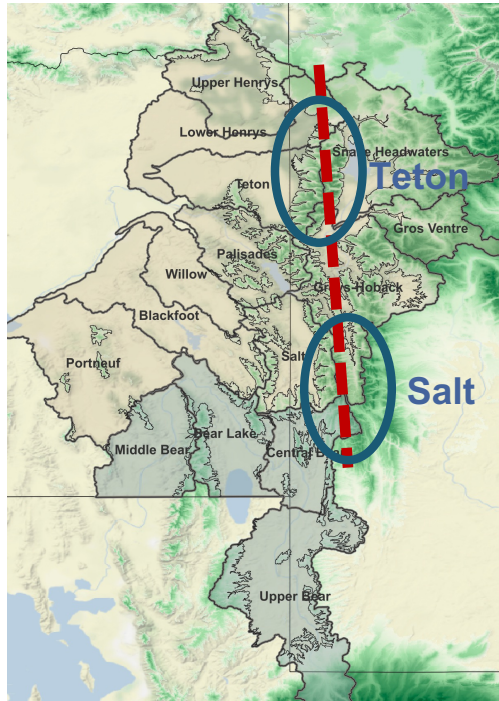


### Ice Path

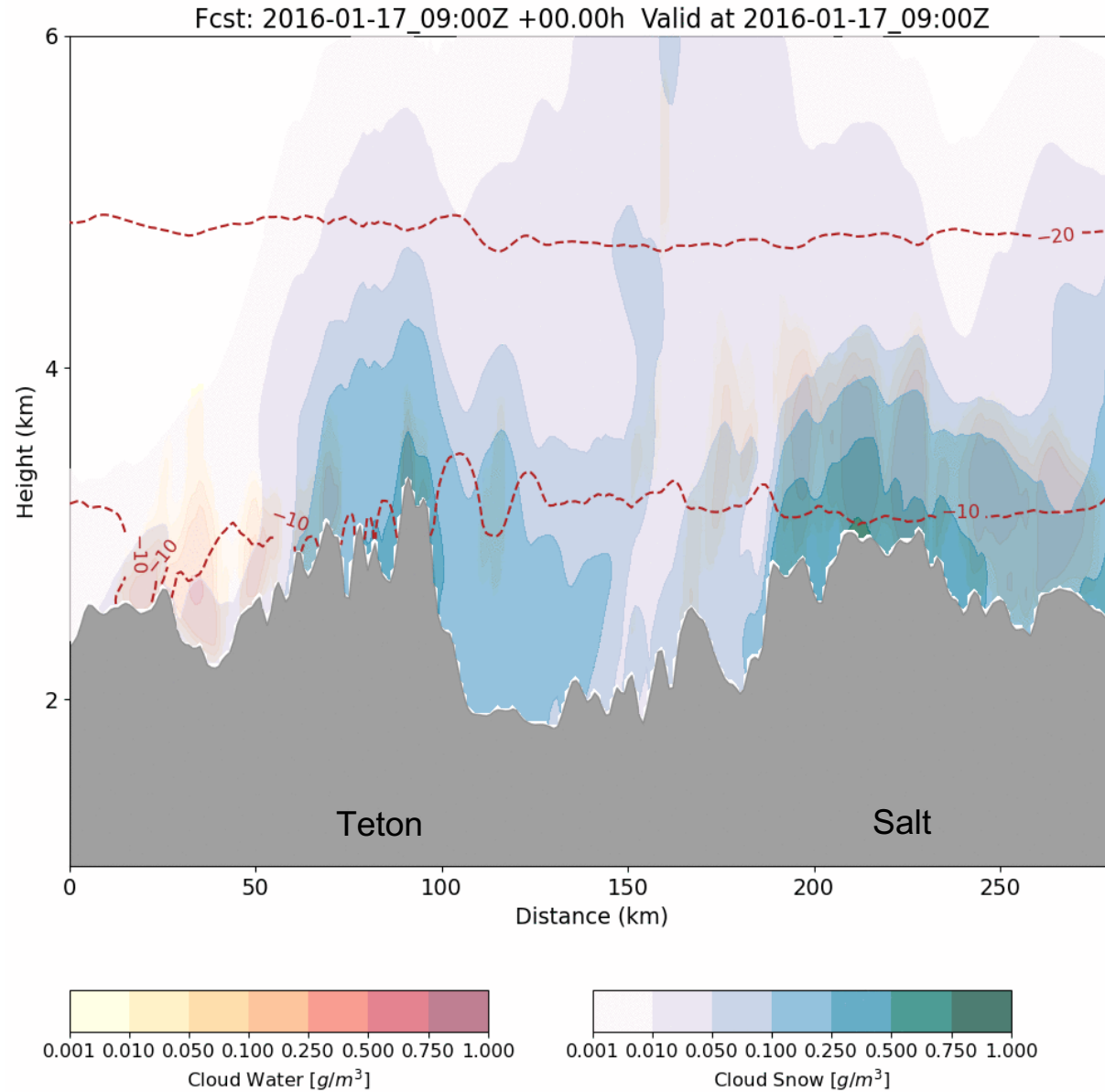




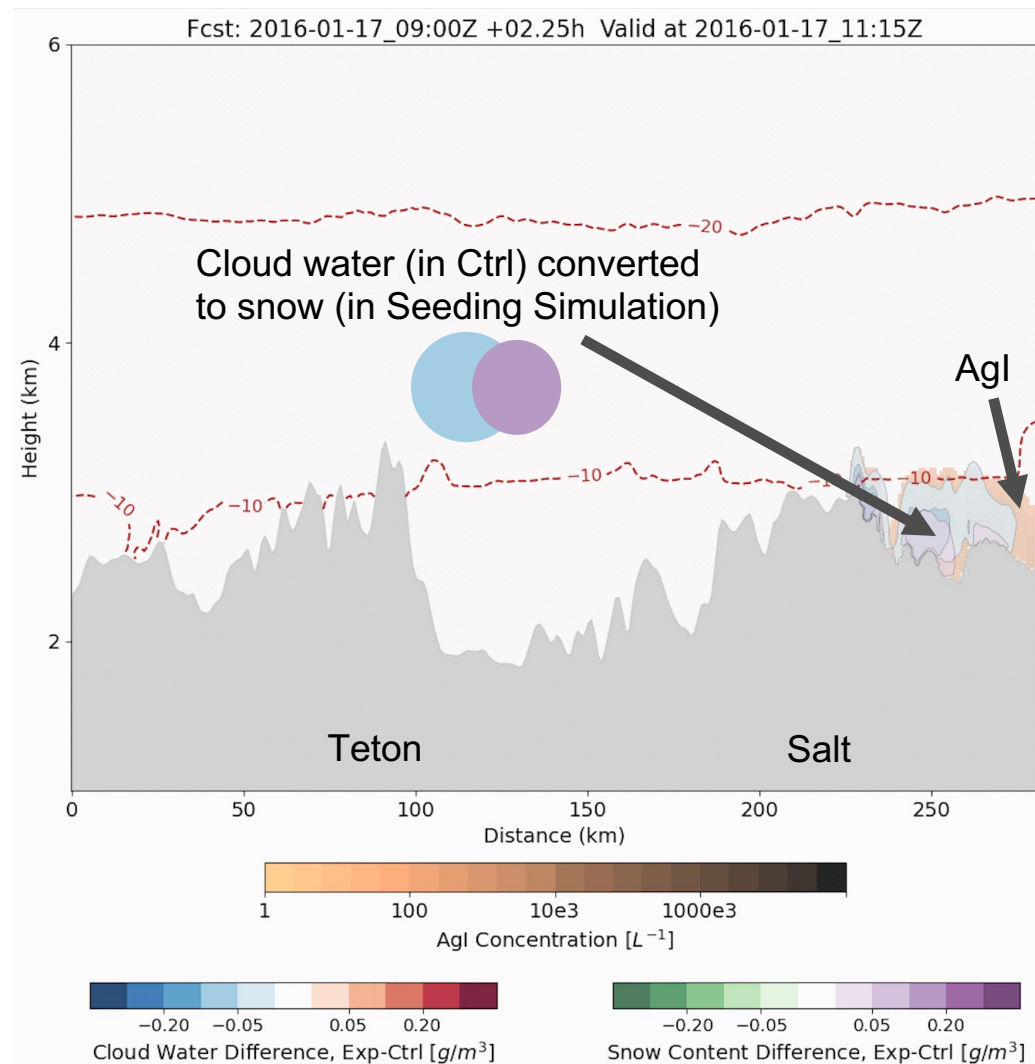
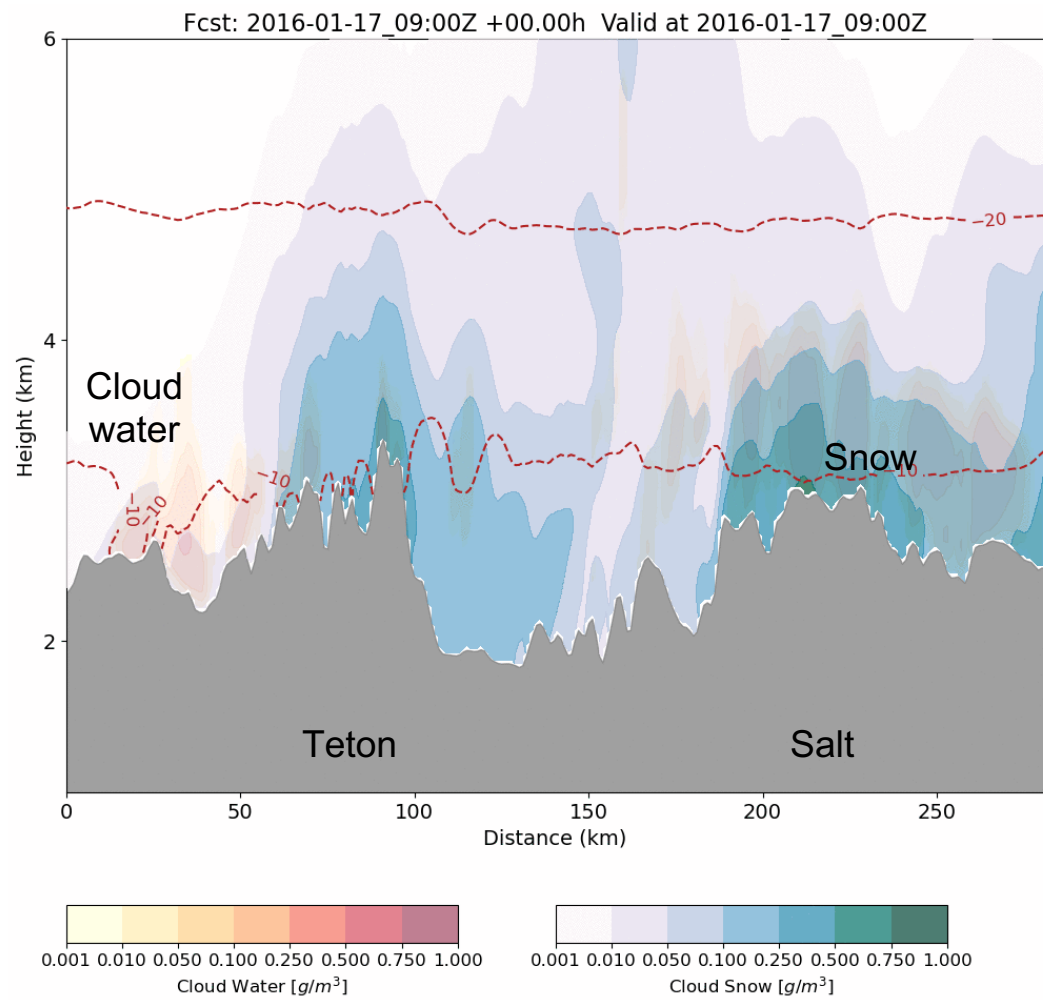
# Case 2016-01-17 00Z: Simulated Vertical Cross-Section



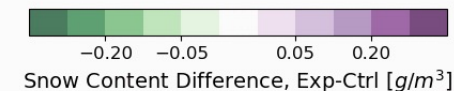
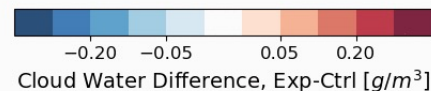
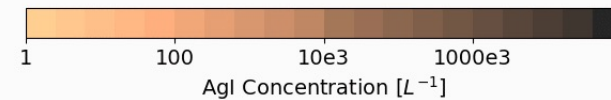
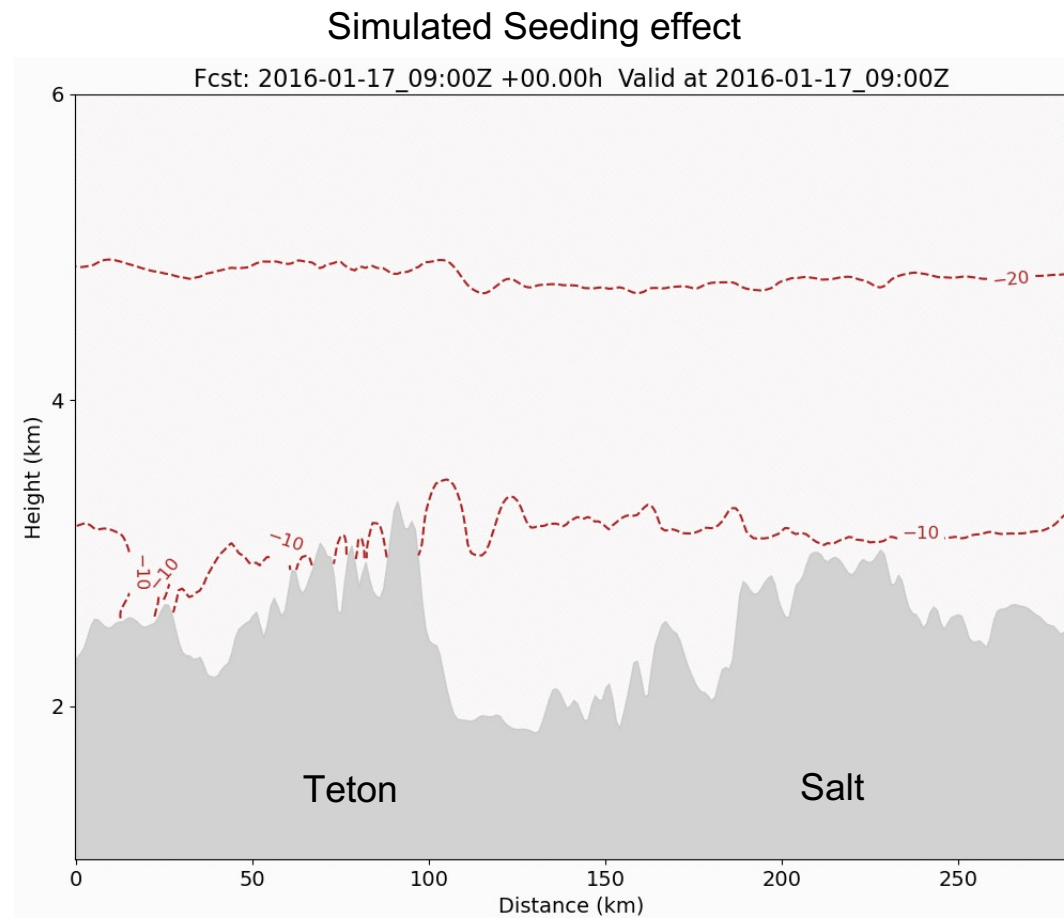
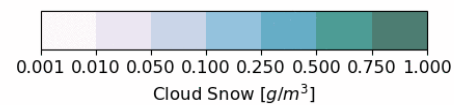
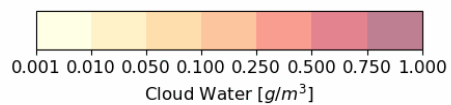
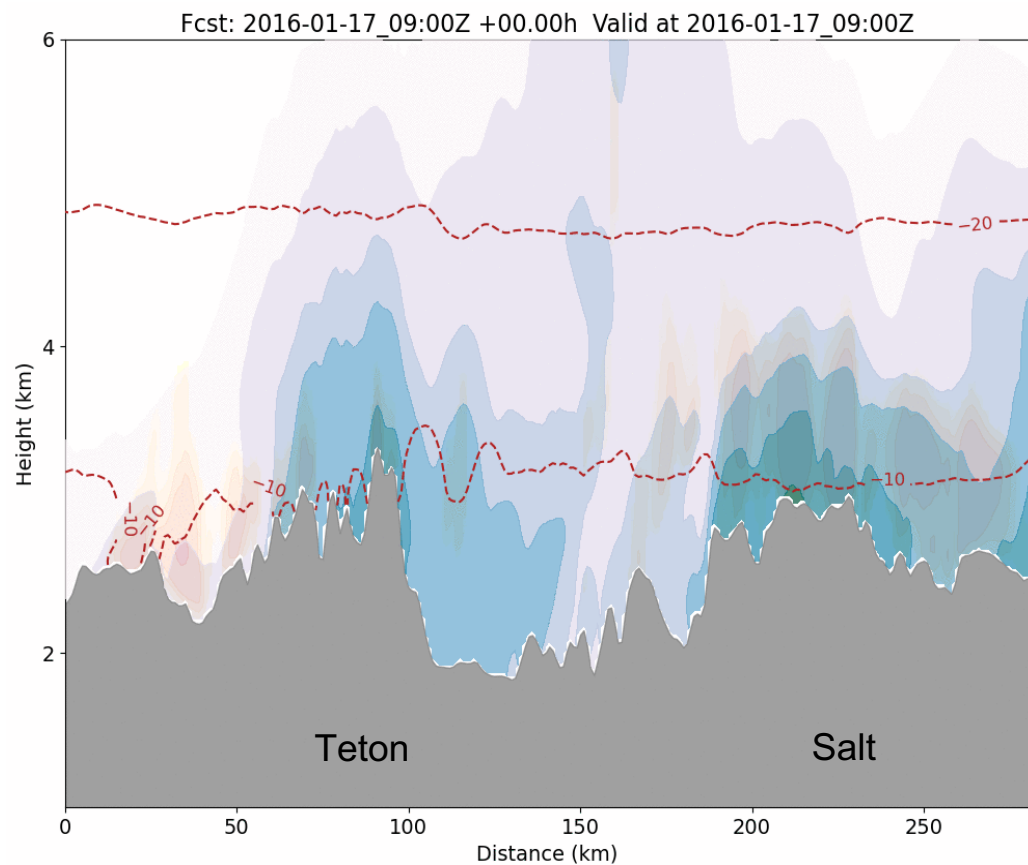
# Case 2016-01-17 00Z: Simulated Vertical Cross-Section



# Case 2016-01-17 00Z: Differences between Seeding and Ctrl Simulations

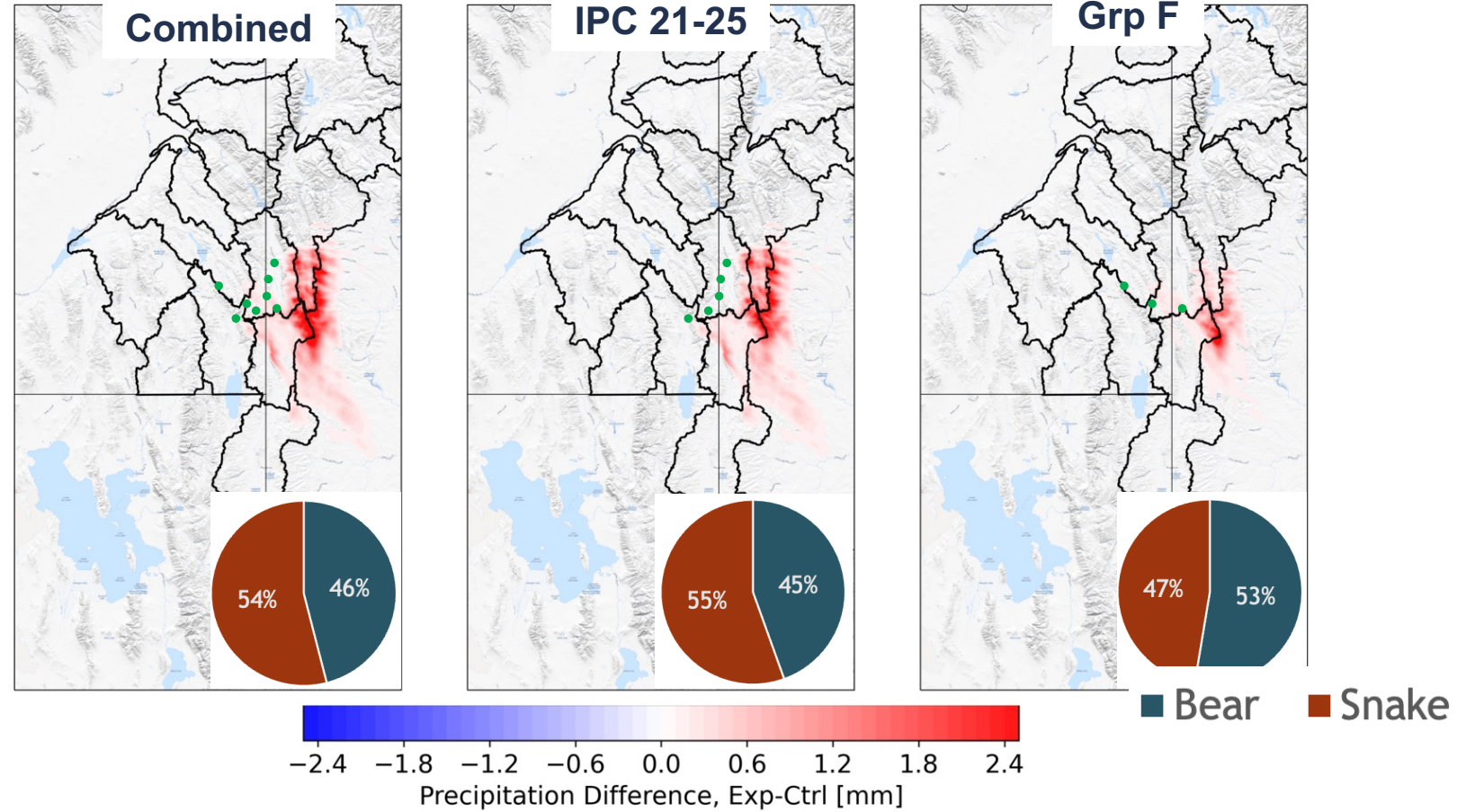


# Case 2016-01-17 00Z: Differences between Seeding and Ctrl Simulations



# Simulated Seeding Effect for Case 1

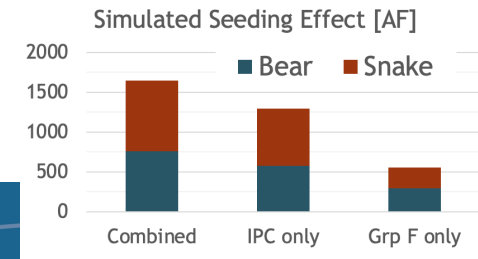
Simulated Seeding  
Effect =  $P_{Exp} - P_{Ctrl}$



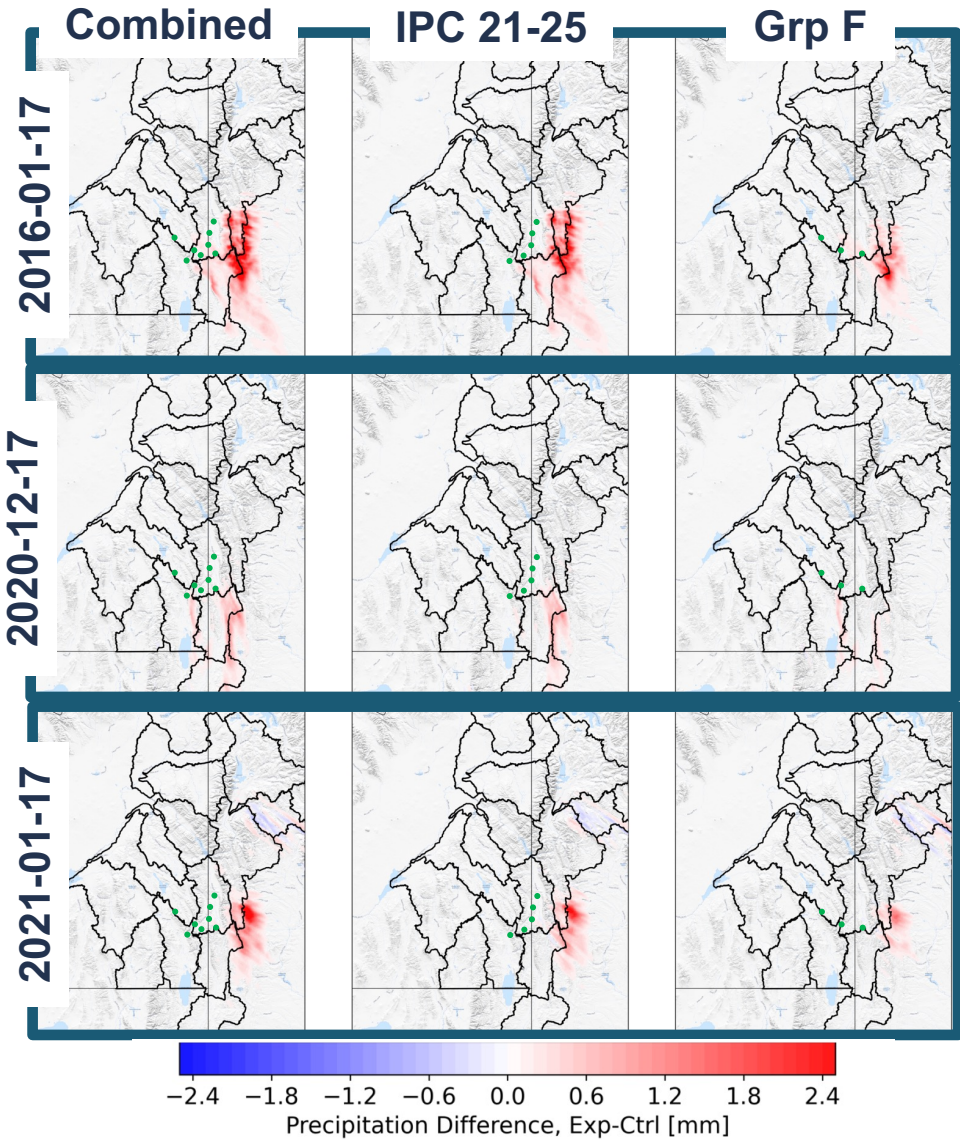
Decrease  
Simulated  
Precipitation

Increase  
Simulated  
Precipitation

Simulated Seeding Effect [AF]			
	Combined	IPC only	Grp F only
<b>Total</b>	<b>1645</b>	<b>1292</b>	<b>550</b>
Bear	757	575	290
Snake	888	717	261



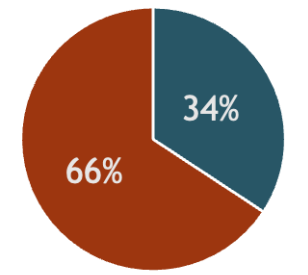
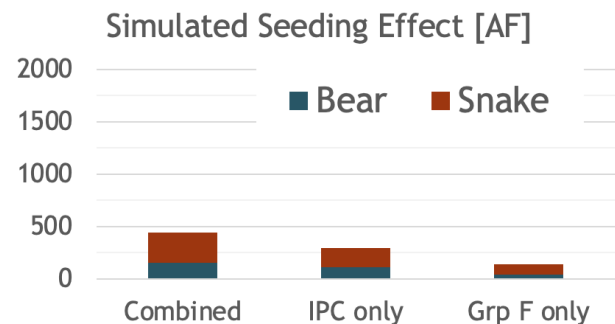
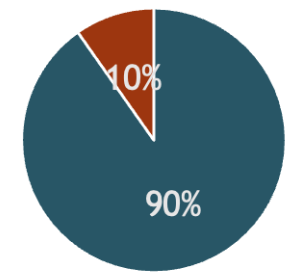
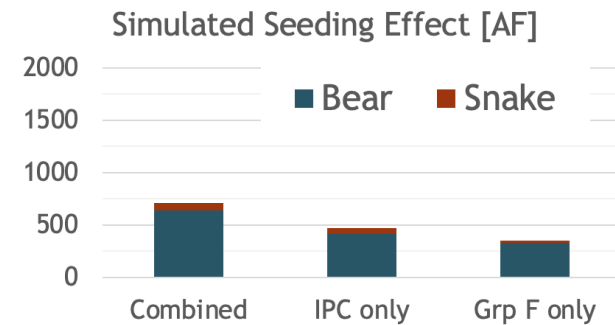
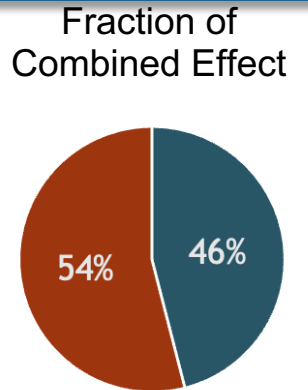
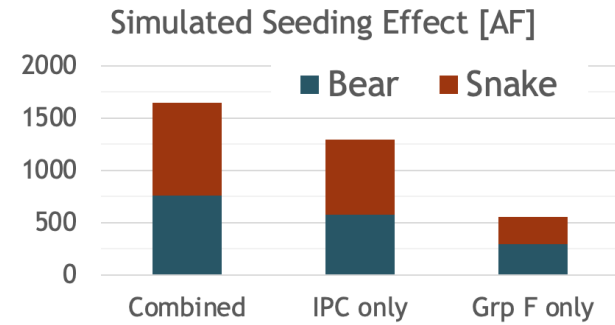
# Simulated Seeding Effect for Bear and Snake Basins



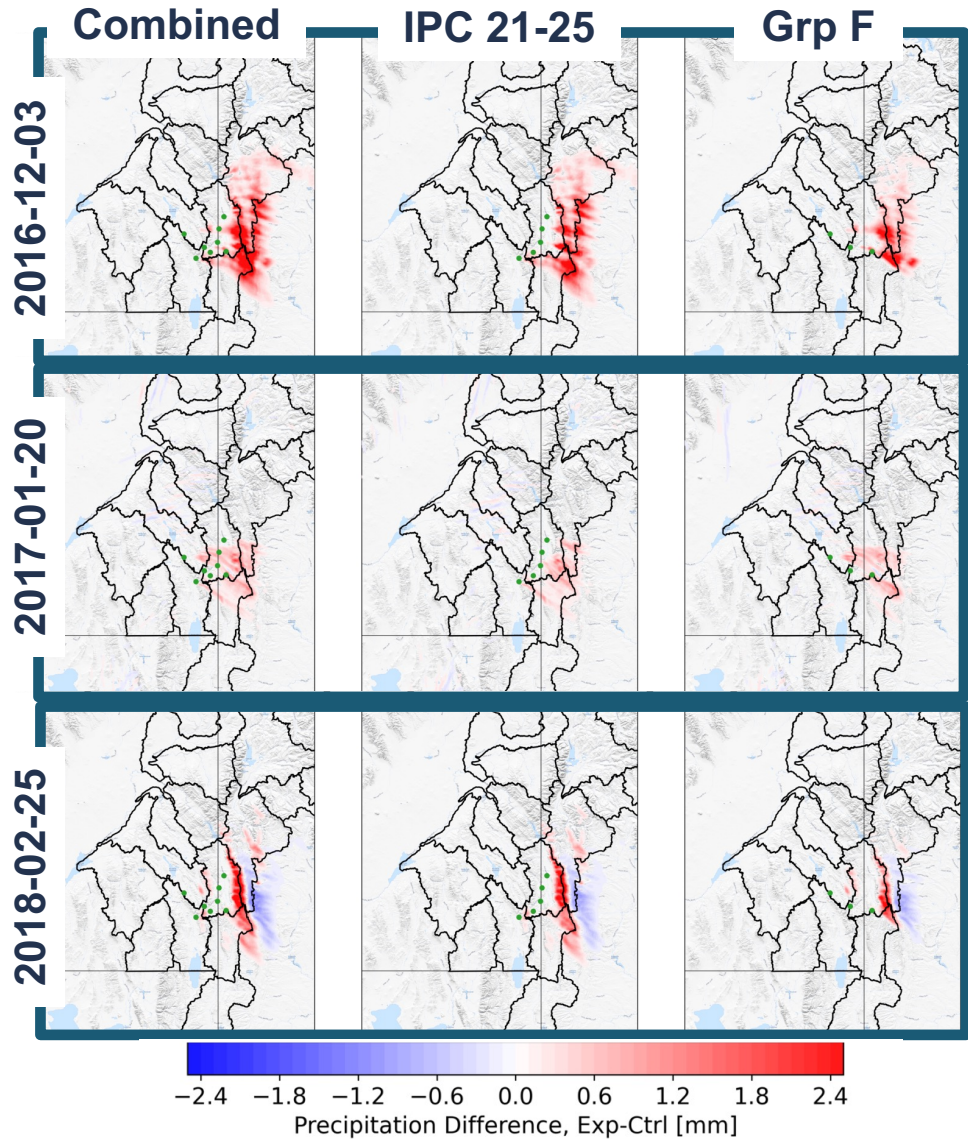
		Simulated Seeding Effect [AF]		
		Combined	IPC only	Grp F only
<b>Total</b>		<b>1645</b>	<b>1292</b>	<b>550</b>
Bear		757	575	290
Snake		888	717	261

		Simulated Seeding Effect [AF]		
		Combined	IPC only	Grp F only
<b>Total</b>		<b>709</b>	<b>466</b>	<b>347</b>
Bear		640	412	330
Snake		69	54	17

		Simulated Seeding Effect [AF]		
		Combined	IPC only	Grp F only
<b>Total</b>		<b>438</b>	<b>292</b>	<b>134</b>
Bear		150	112	39
Snake		288	180	95



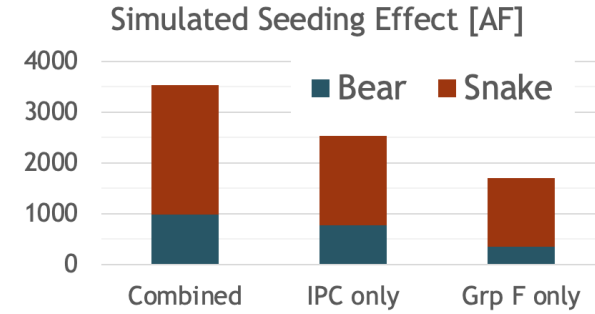
# Simulated Seeding Effect for targeting Bear River Basin



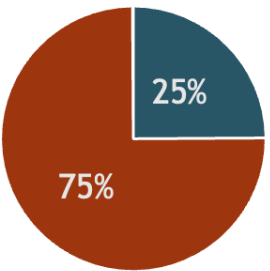
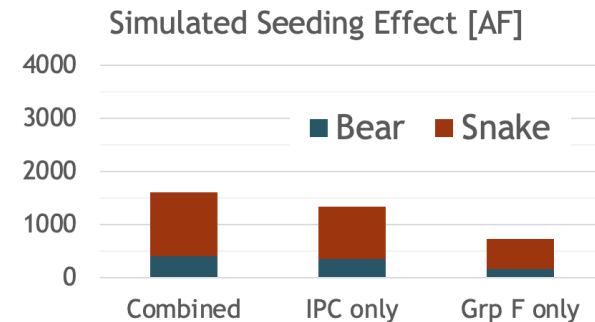
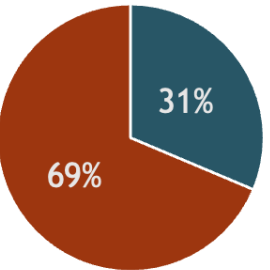
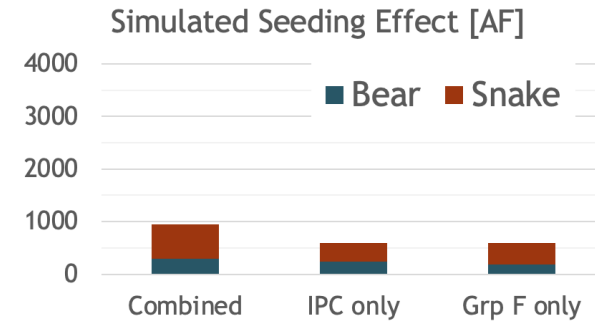
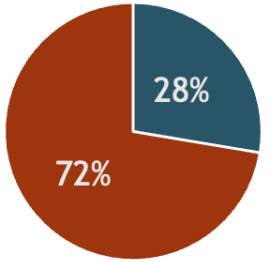
Simulated Seeding Effect [AF]			
	Combined	IPC only	Grp F only
<b>Total</b>	<b>3533</b>	<b>2529</b>	<b>1694</b>
Bear	977	770	340
Snake	2556	1759	1354

Simulated Seeding Effect [AF]			
	Combined	IPC only	Grp F only
<b>Total</b>	<b>942</b>	<b>596</b>	<b>598</b>
Bear	295	243	183
Snake	647	353	416

Simulated Seeding Effect [AF]			
	Combined	IPC only	Grp F only
<b>Total</b>	<b>1598</b>	<b>1339</b>	<b>725</b>
Bear	398	347	155
Snake	1200	992	570



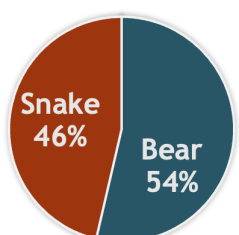
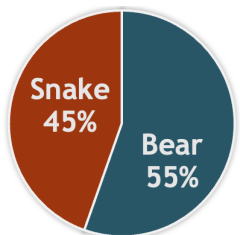
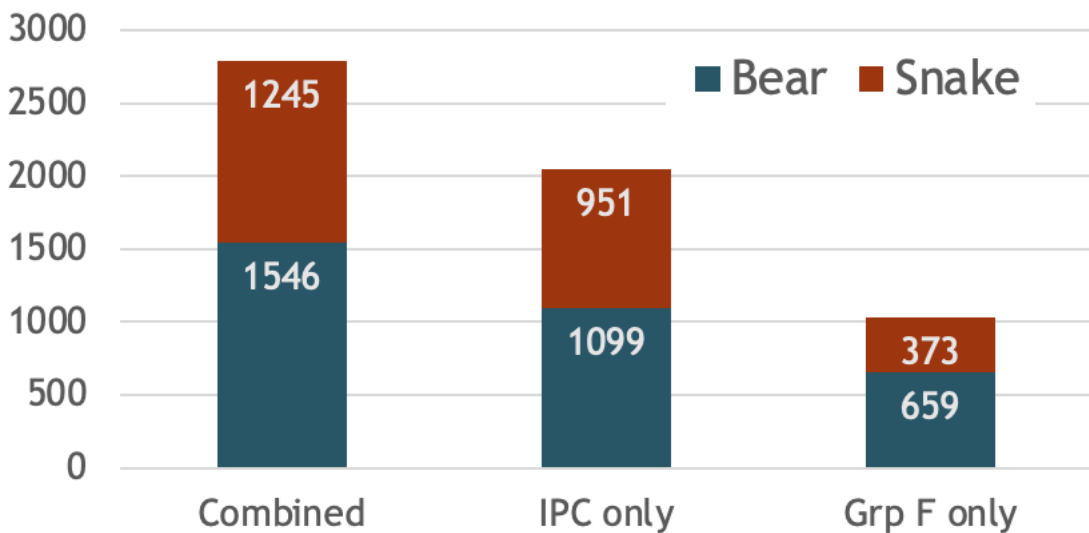
Fraction of Combined Effect



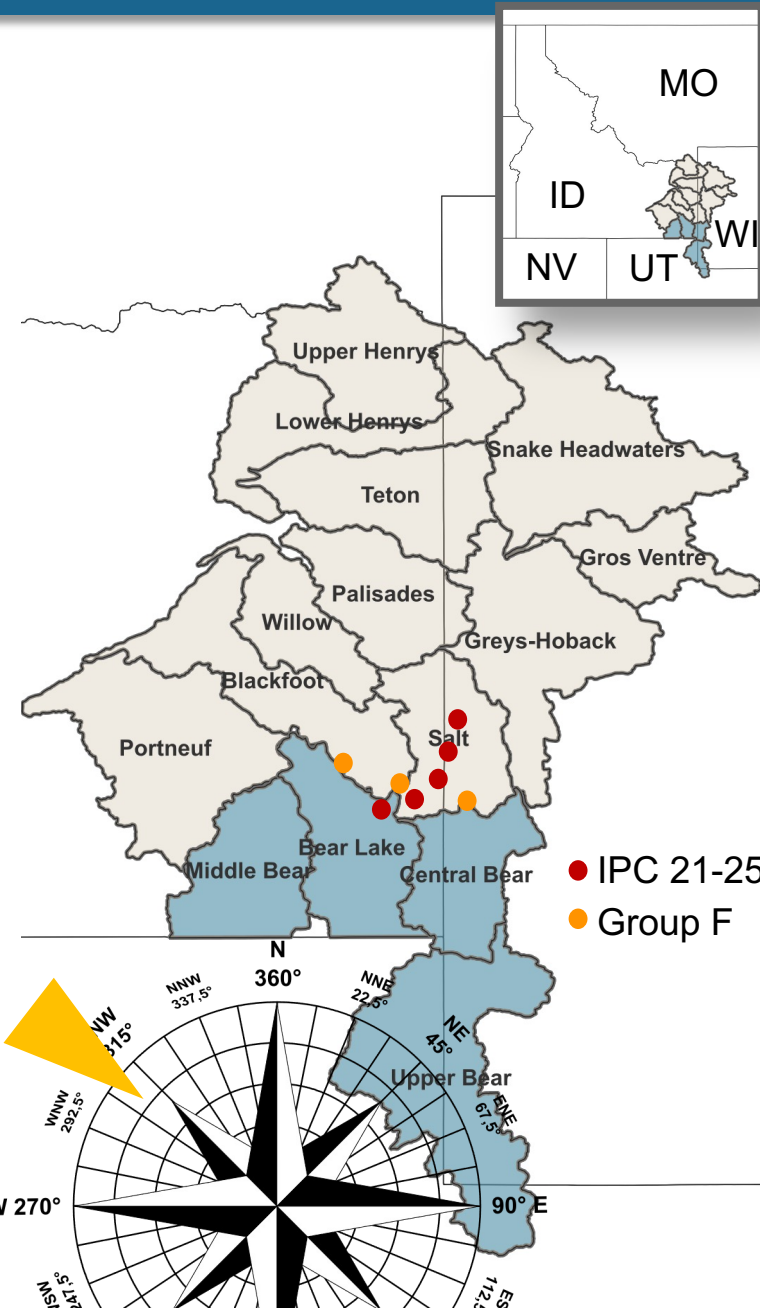
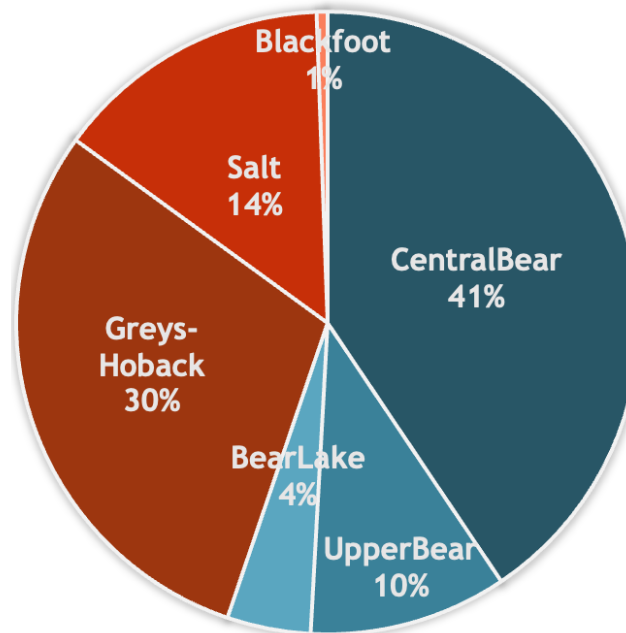
# Impact from Cases Selected for Shared Infrastructure Ground Seeding

Shared cases:  
 C1: 2016-01-17  
 C2: 2020-12-17  
 C3: 2021-01-17

### Simulated Seeding Effect [AF]



### FRACTION OF COMBINED SEEDING EFFECT





# Impact from Cases Selected for Bear River Basin Ground Seeding

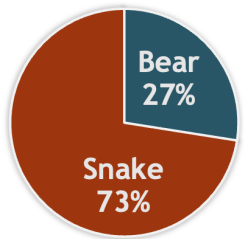
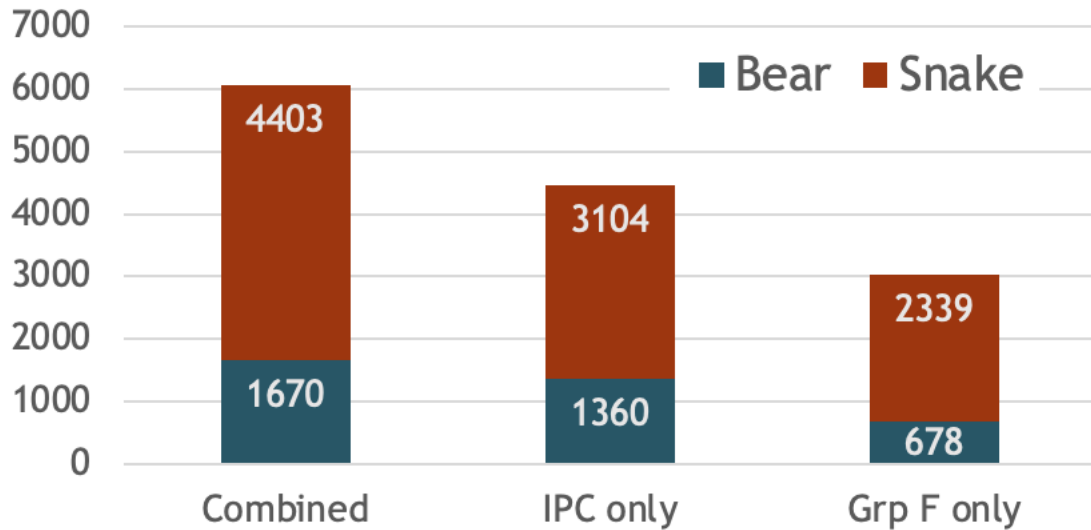
Bear River Basin cases:

C1: 2016-12-03

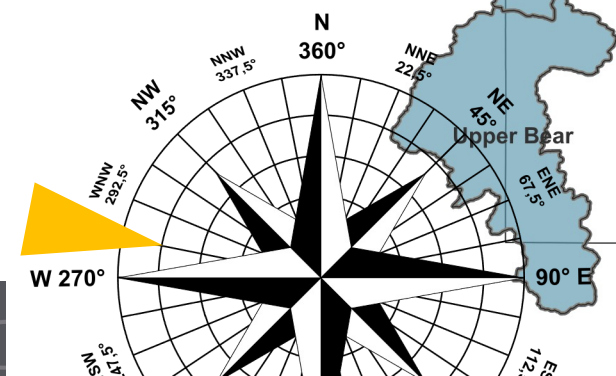
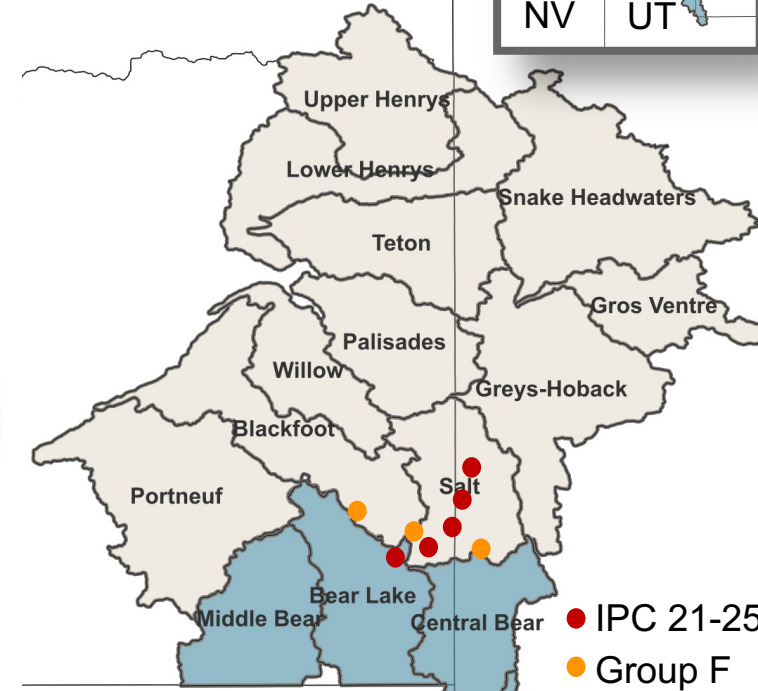
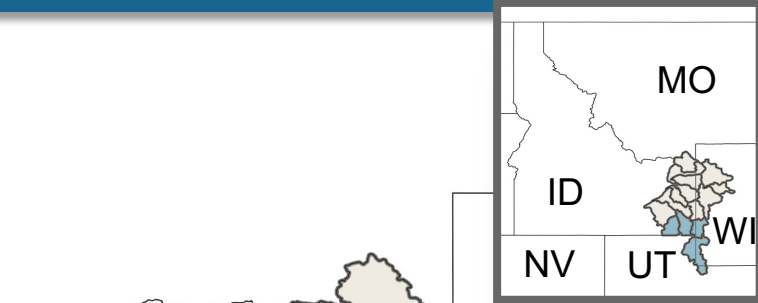
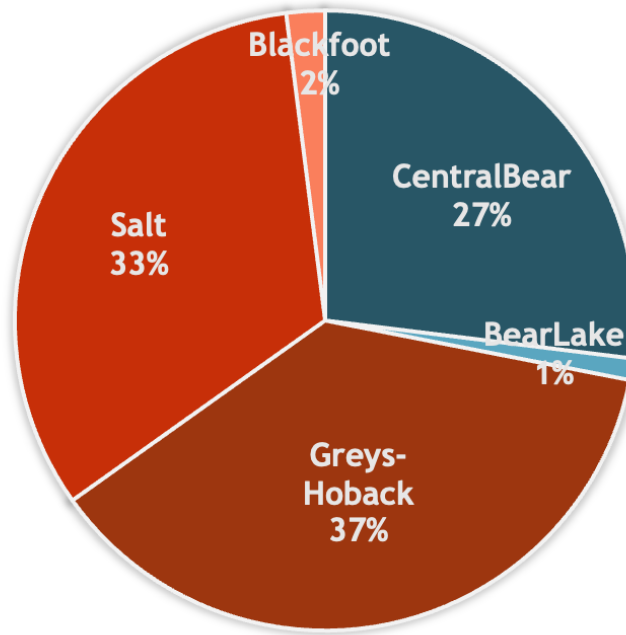
C2: 2017-01-20

C3: 2018-02-25

### Simulated Seeding Effect [AF]



### FRACTION OF COMBINED SEEDING EFFECT



# Summary

- This study used WRF-WxMod simulations to study the potential for sharing ground generators between the Upper Snake and Bear River Basins seeding programs
- The results of this study indicate that there is benefit to both basins with the shared ground generators
- For the configurations and cases studied in this analysis, the combined effect from the addition of the proposed Group F Bear River Basin generators was able to produce more precipitation than the existing IPC generators (21-25) alone in all simulated experiments

