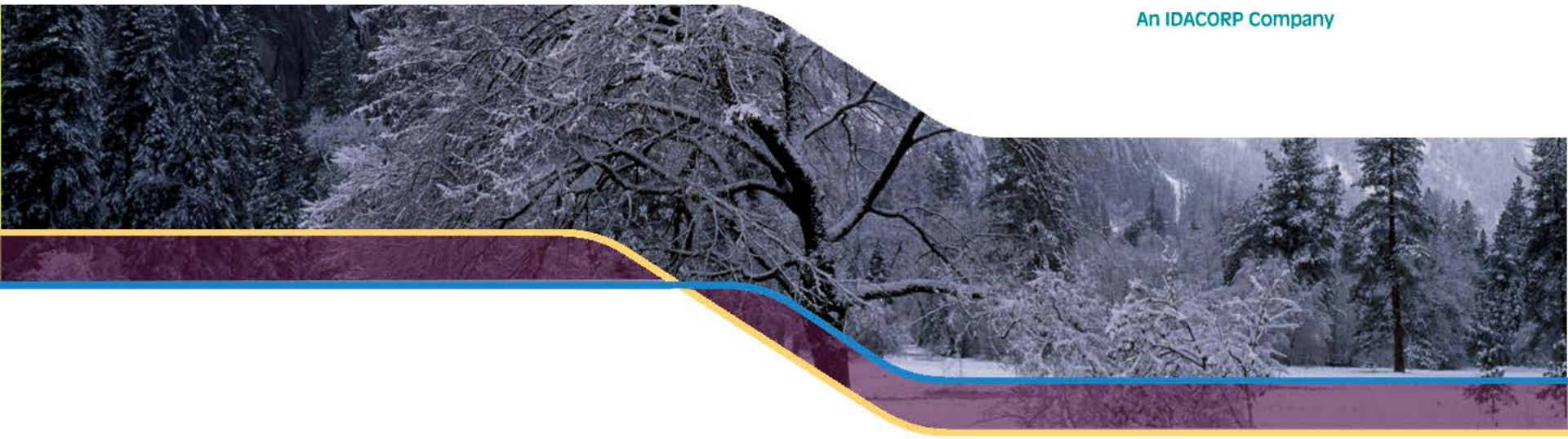


Idaho Power Company's Cloud Seeding Program

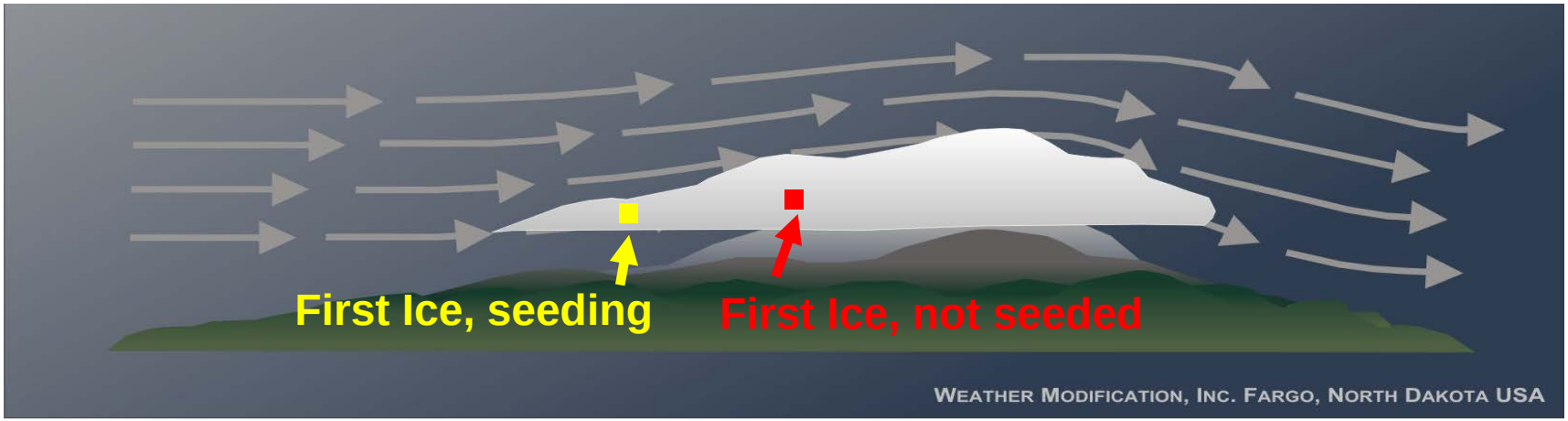
Shaun Parkinson, PhD, P.E.

What is cloud seeding?

- The term cloud seeding has been used to describe:
  - Fog suppression (airports)
  - Hail suppression (reduce crop and property damage)
  - Rainfall enhancement (water supply augmentation)
  - Snowpack enhancement (snowpack augmentation)
- Our focus is **snowpack** enhancement
- In particular – IPC does winter orographic cloud seeding

Winter Orographic Cloud Seeding

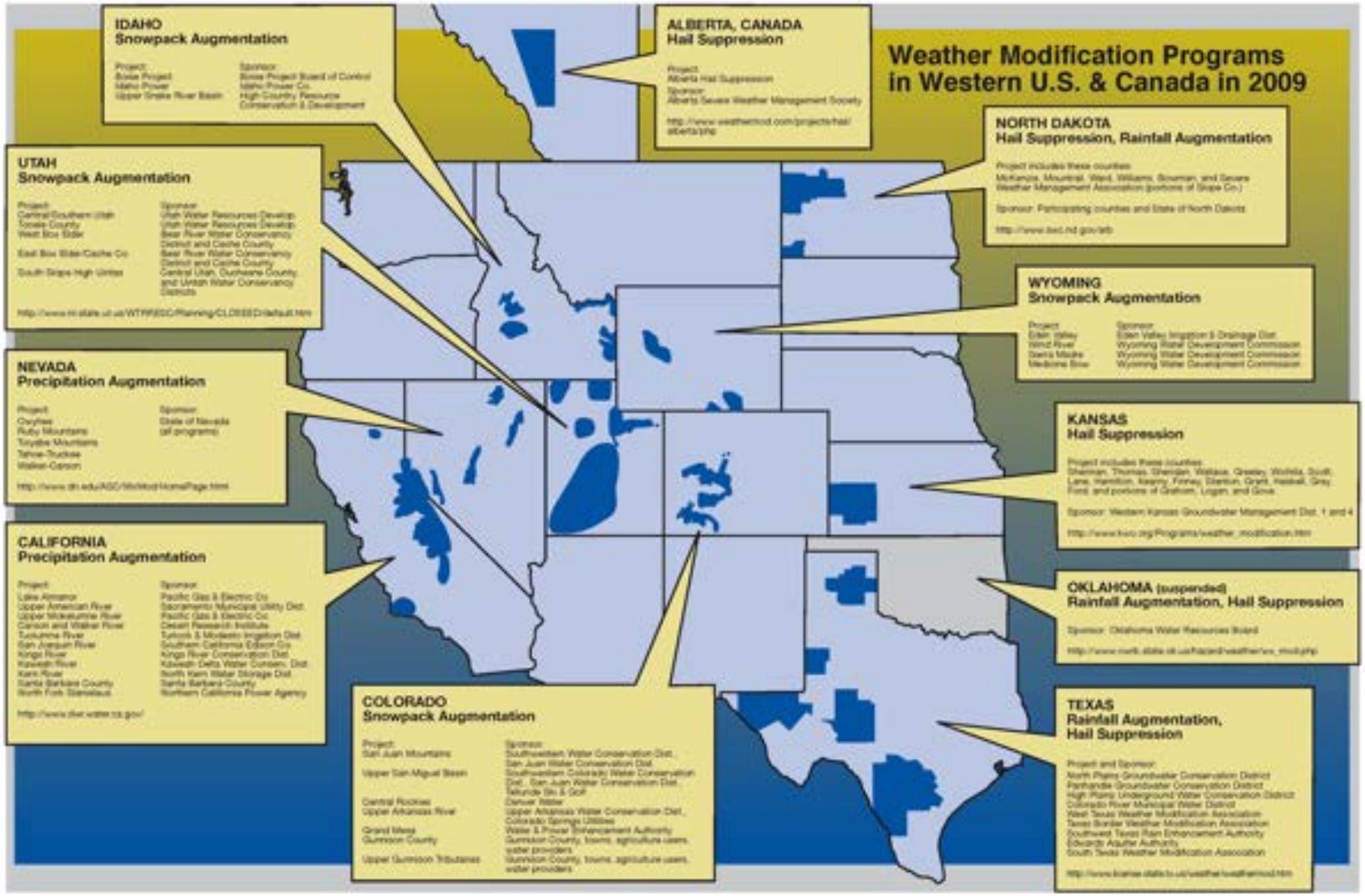
- *Cloud seeding* provides additional ice nuclei that function at warmer temperatures, allowing ice formation to begin sooner.
- This occurs at temperatures as warm as -5°C (+23°F), though more effectively at -8°C (+17°F) or colder. (The majority of natural ice nuclei become effective between -15°C to -20°C (+5°F to -4°F).).
- Effectiveness is dependent upon limitation of natural ice nuclei, abundant SLW, and temperatures.



Silver Iodide Distribution

- In commercial programs, silver iodide is burned to release silver iodide particles (ice nuclei) of an appropriate size to the atmosphere.
- Ground generators - Acetone – silver iodide solution is burned in a propane flame.
- Aircraft - silver iodide is incorporated into a flare, or solution is burned.

Cloud Seeding Programs



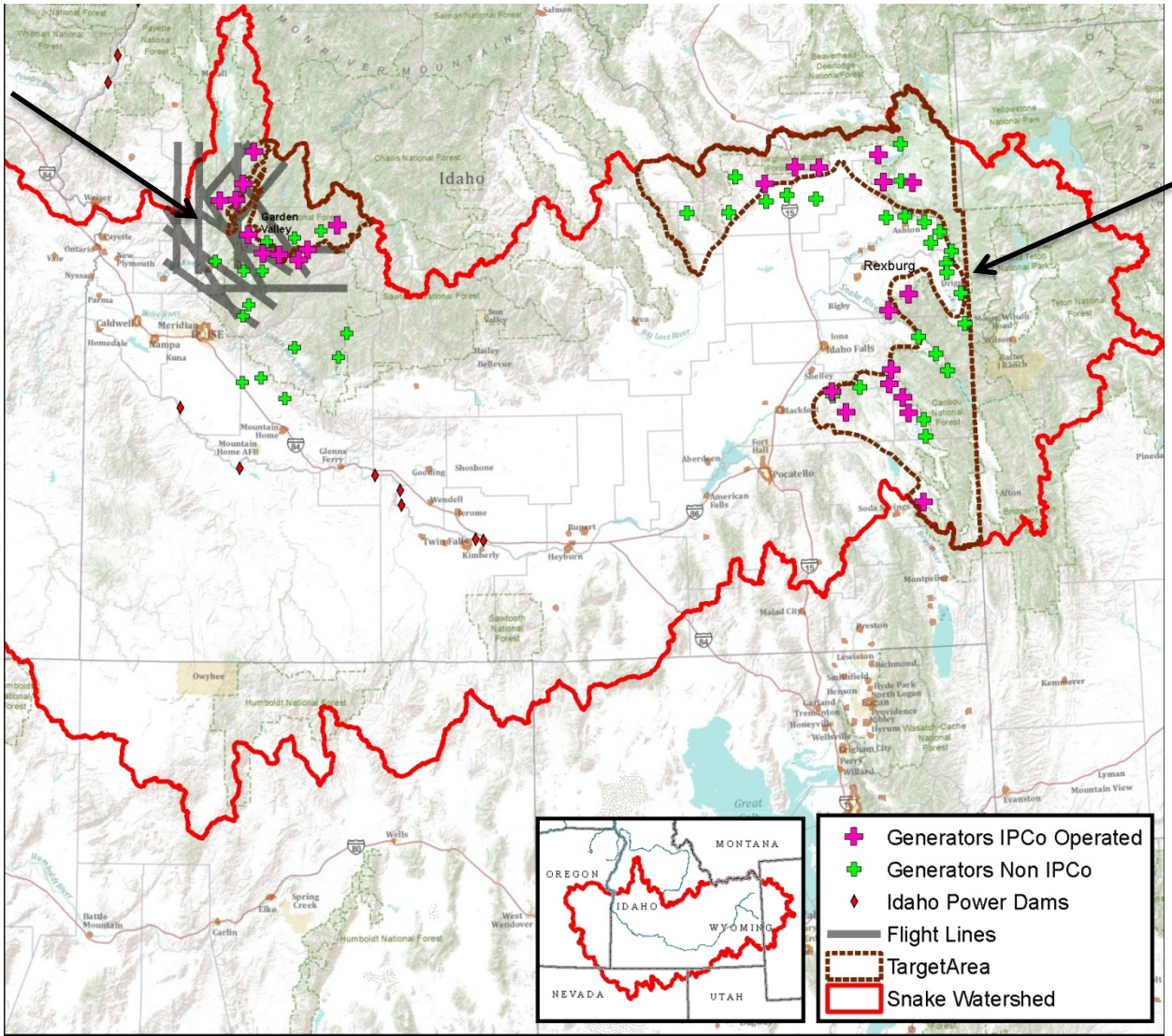
Idaho Power's History with Cloud Seeding

- At the request of shareholders – began investigating cloud seeding in 1993
- Literature review 1993 and 1994
- Climatology study 1994-95
- Contracted operational program in 1996-97
- Planned to perform internal program in 1997-98
- Reinstated in Feb 2003.
- Operational including assessment in fall of 2003
- Completed second year of assessment and third year of operations in May 2005.
- In 2008 started working with HCRC&D and E Idaho Counties to enhance their program
- In 2010 started working with WWRC&D to evaluate cloud seeding opportunities in western Wyoming.

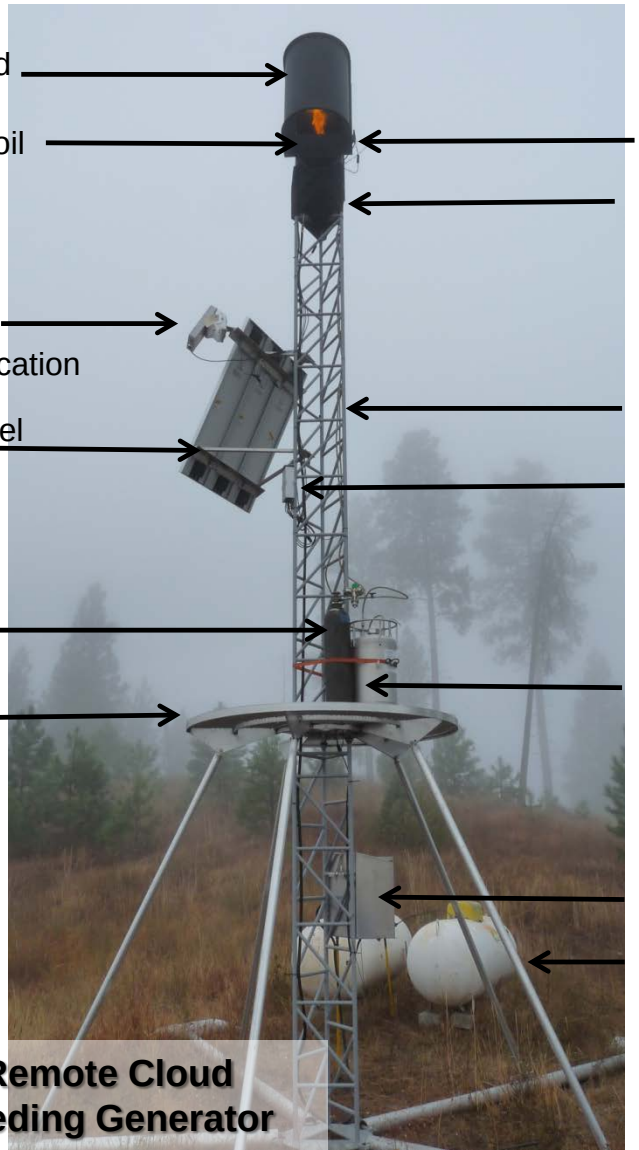
Idaho Power's Cloud Seeding Projects

Payette

Upper Snake
in cooperation with
E. Idaho - HCRC&D



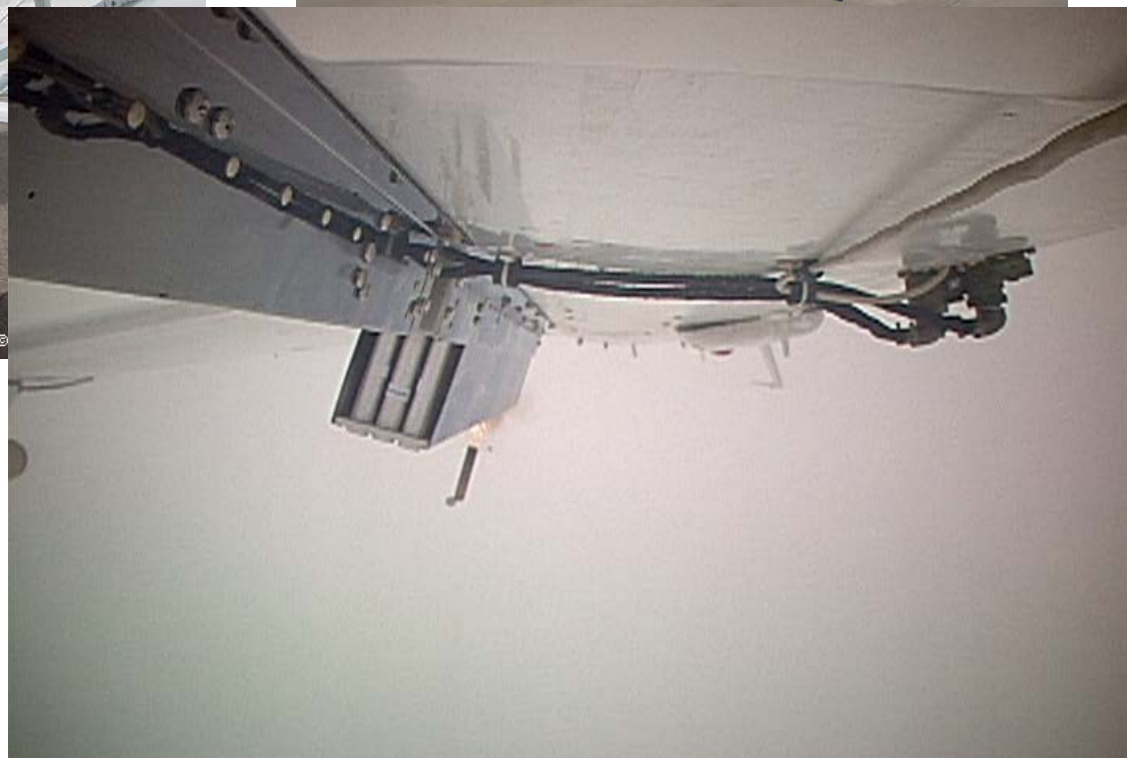
Generator Types



Remote Cloud Seeding Generator

Manual Cloud Seeding Generator

Aircraft Seeding



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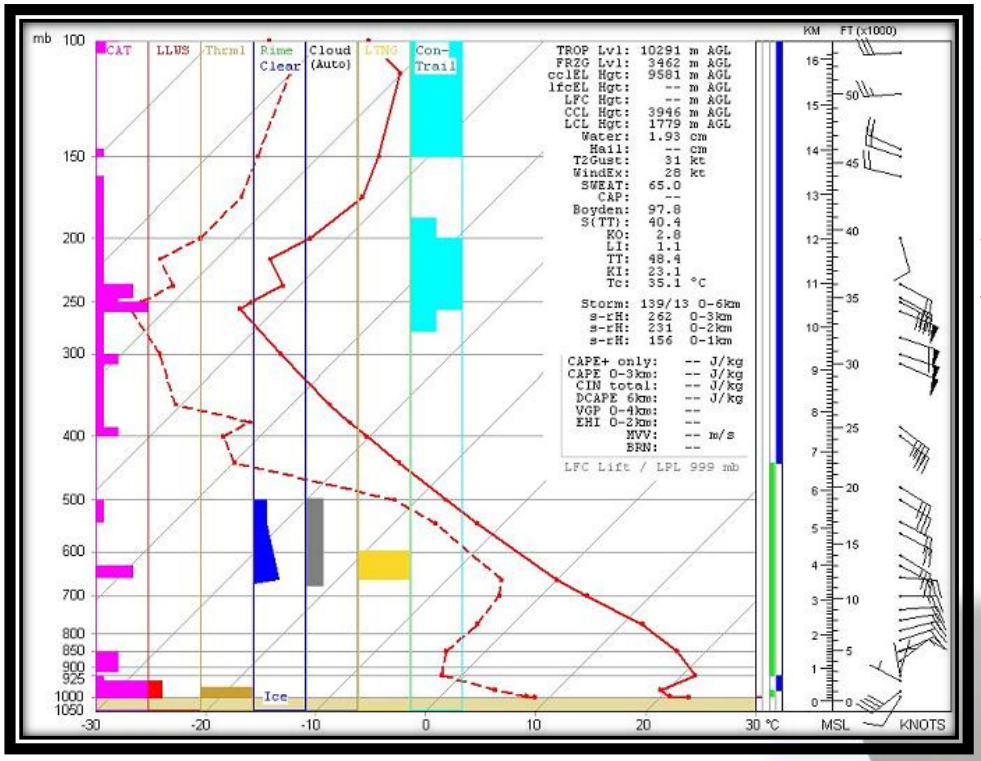


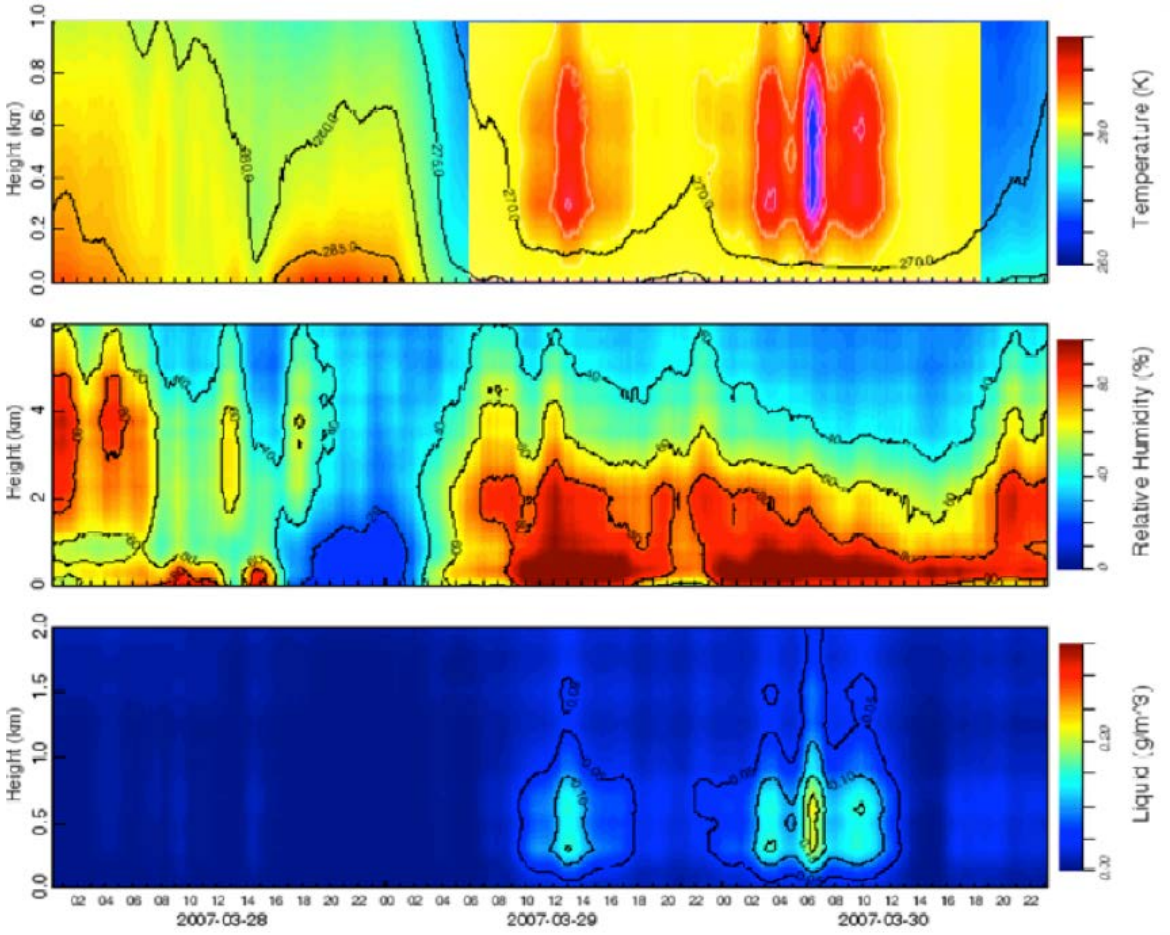
Temperature
Relative Humidity
Pressure
Wind Direction
Wind Speed

Up to 60,000’

Radiometrics M3000A

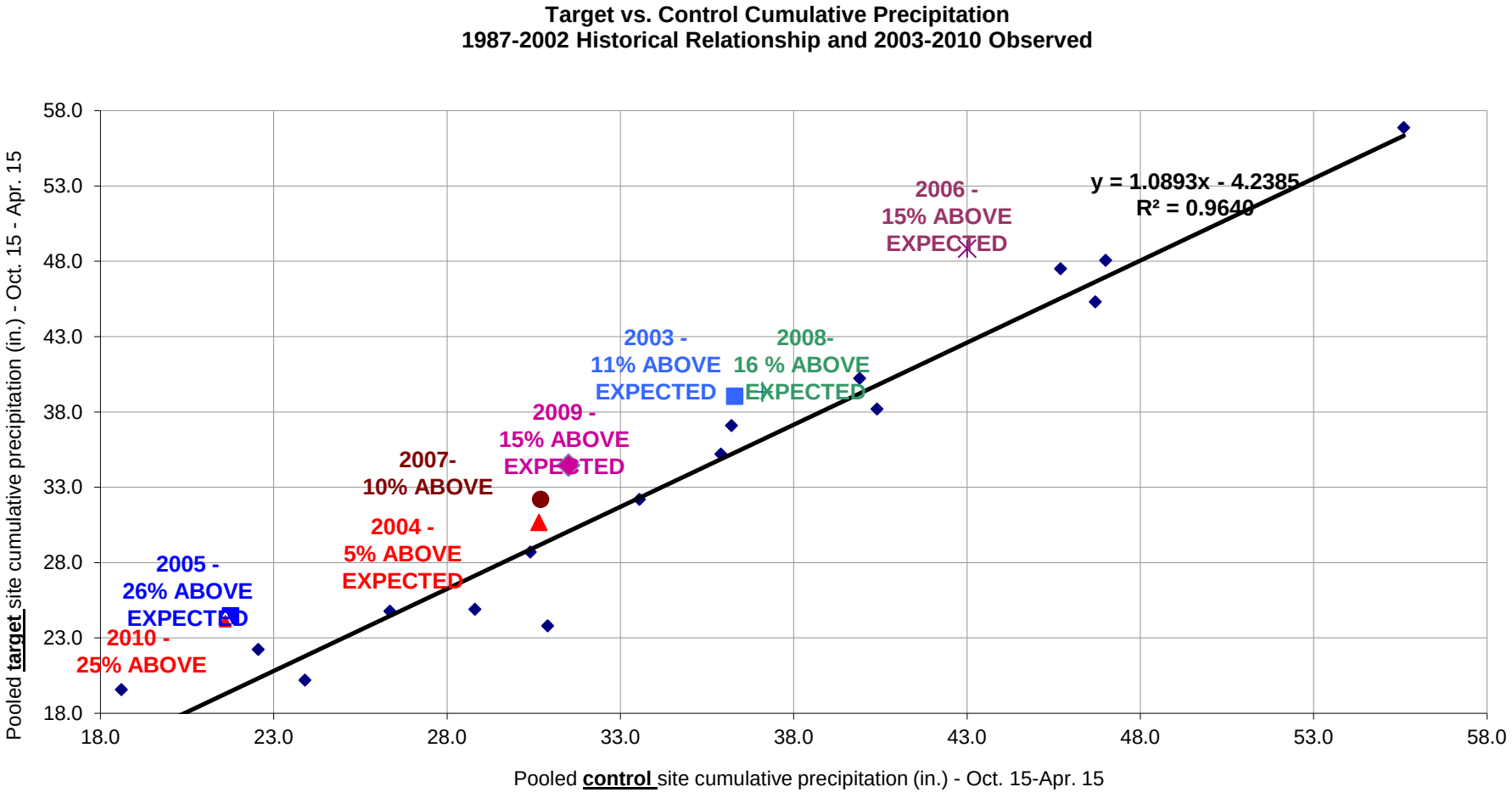
Microwave Radiometer

Figure 1. MP-3000A Hyper-Spectral Temperature, Humidity and Liquid Water Profiler.



Target – Control

Payette



Benefit Estimation

Payette

- IPC has used 3 approaches to assess benefits in addition to DRI's assessment:

1. USBR Run-off regression equations
2. Watershed modeling using IPCRFS forecasting model
3. Weather Modeling using WRF

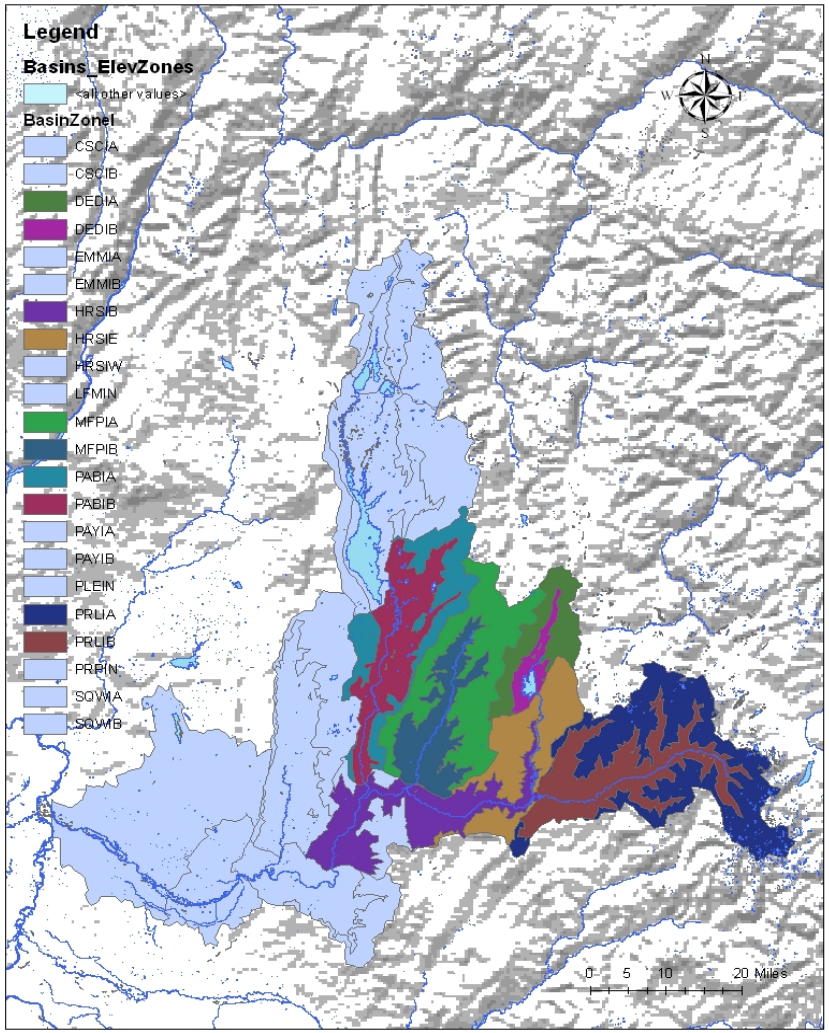
USBR Regression

- USBR Equations use precipitation and SWE as input to predict runoff at specific locations.
- Target control analysis indicates precipitation increases ranging from 5% to 16% (average over 6 years of 13%*).
- Assuming a precipitation increase of 10% from cloud seeding results in an average of approximately **120 KAF** of additional April – July runoff at Horseshoe Bend.

*dropped highs from dry years. Retaining all years is a 16%.

Streamflow Modeling

IPC River Forecast System

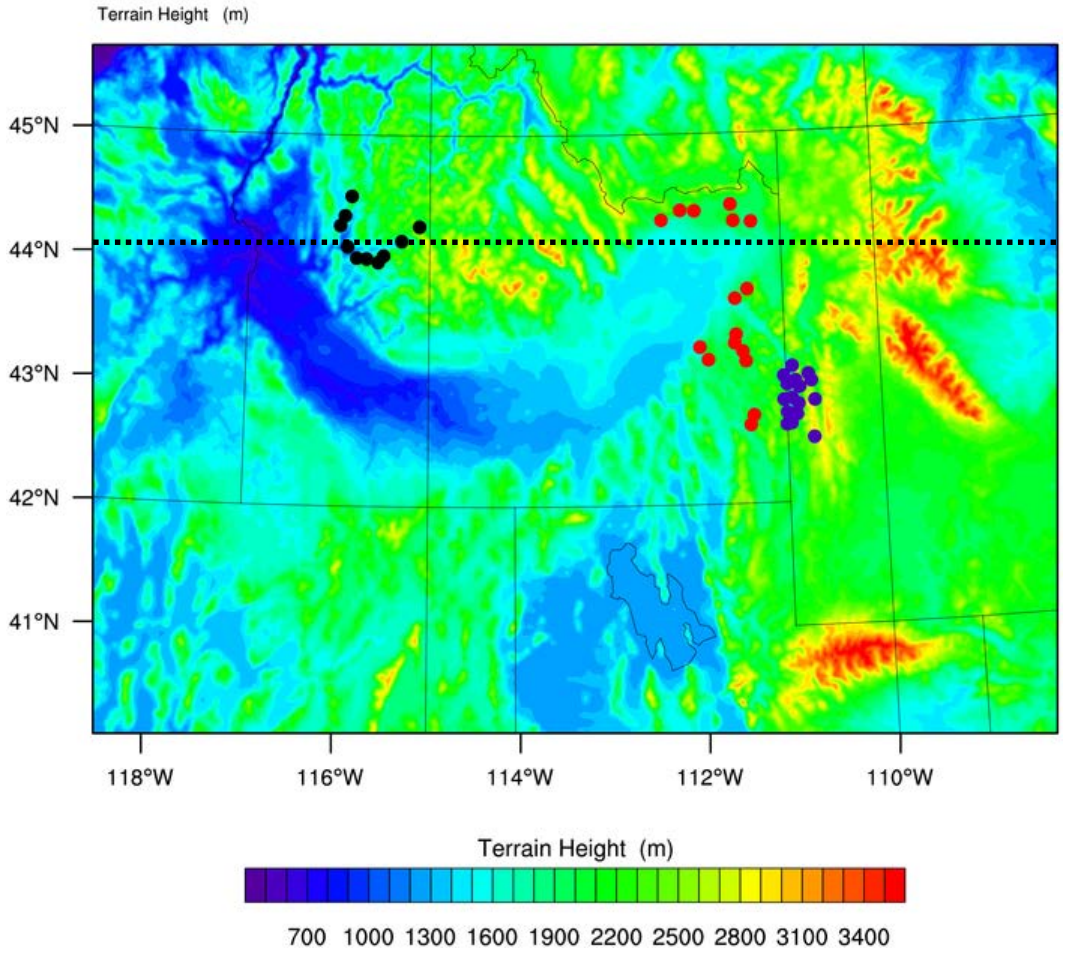


- Additional runoff estimated using IPC's river forecast system.
- Model uses mean aerial temperature and precipitation (MAT & MAP) by elevation
- Two scenarios…with and without cloud seeding
- Without seeding – adjusted MAP down by amounts indicated by target-control analysis (observed data includes seeding)
- With seeding – used MAP based on observed data
- Streamflow increase nearly **200 KAF / year**

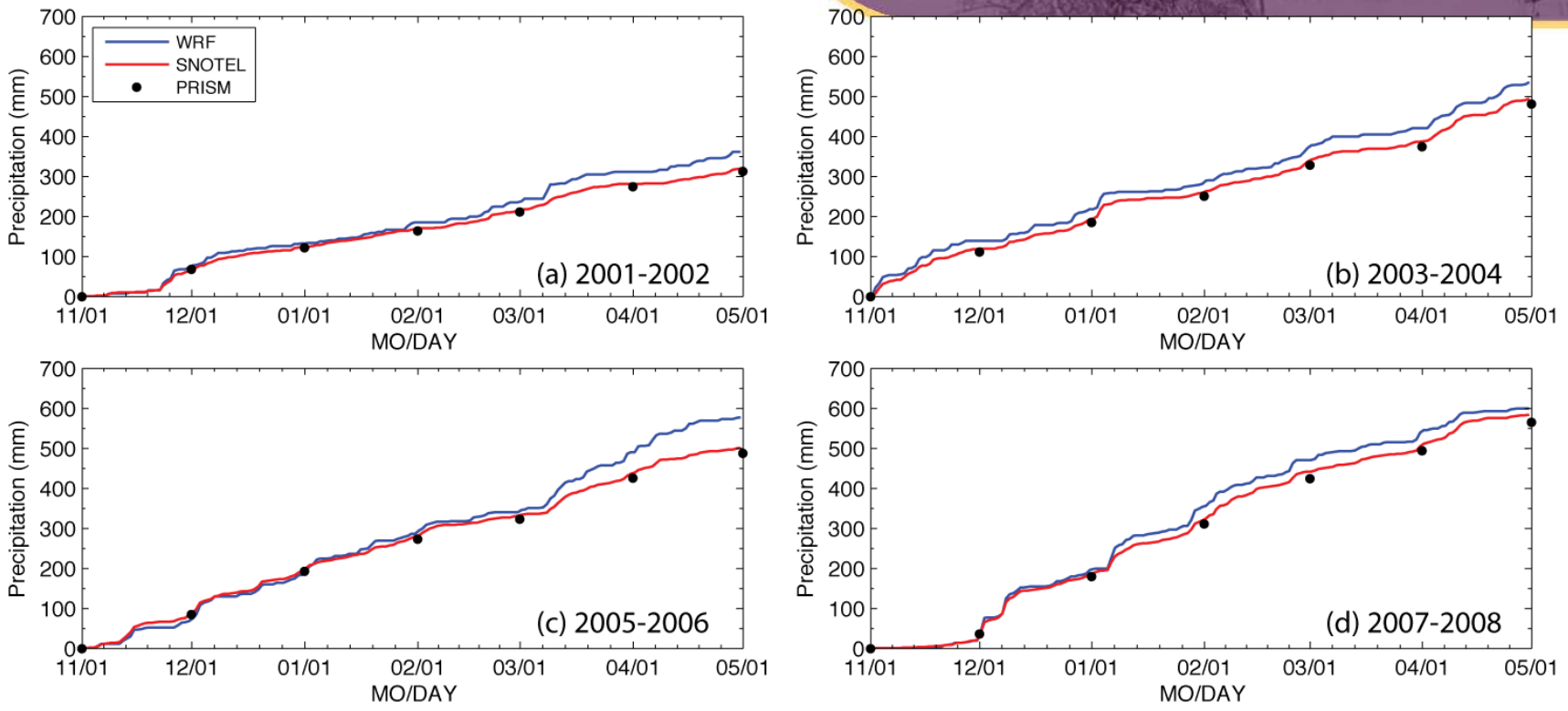
Cost: less than $8.00/AF

Weather Model overview

- WRF v3.1
- Domain:
  - 420 x 300 grid pts
  - 2 km horizontal resolution
  - 60 vertical stretching levels
- Generator locations:
  - Payette (black)
  - Upper Snake (red)
  - Proposed Wyoming (purple)



4-Year Comparison between average SNOTEL and PRIS observations and WRF Simulations



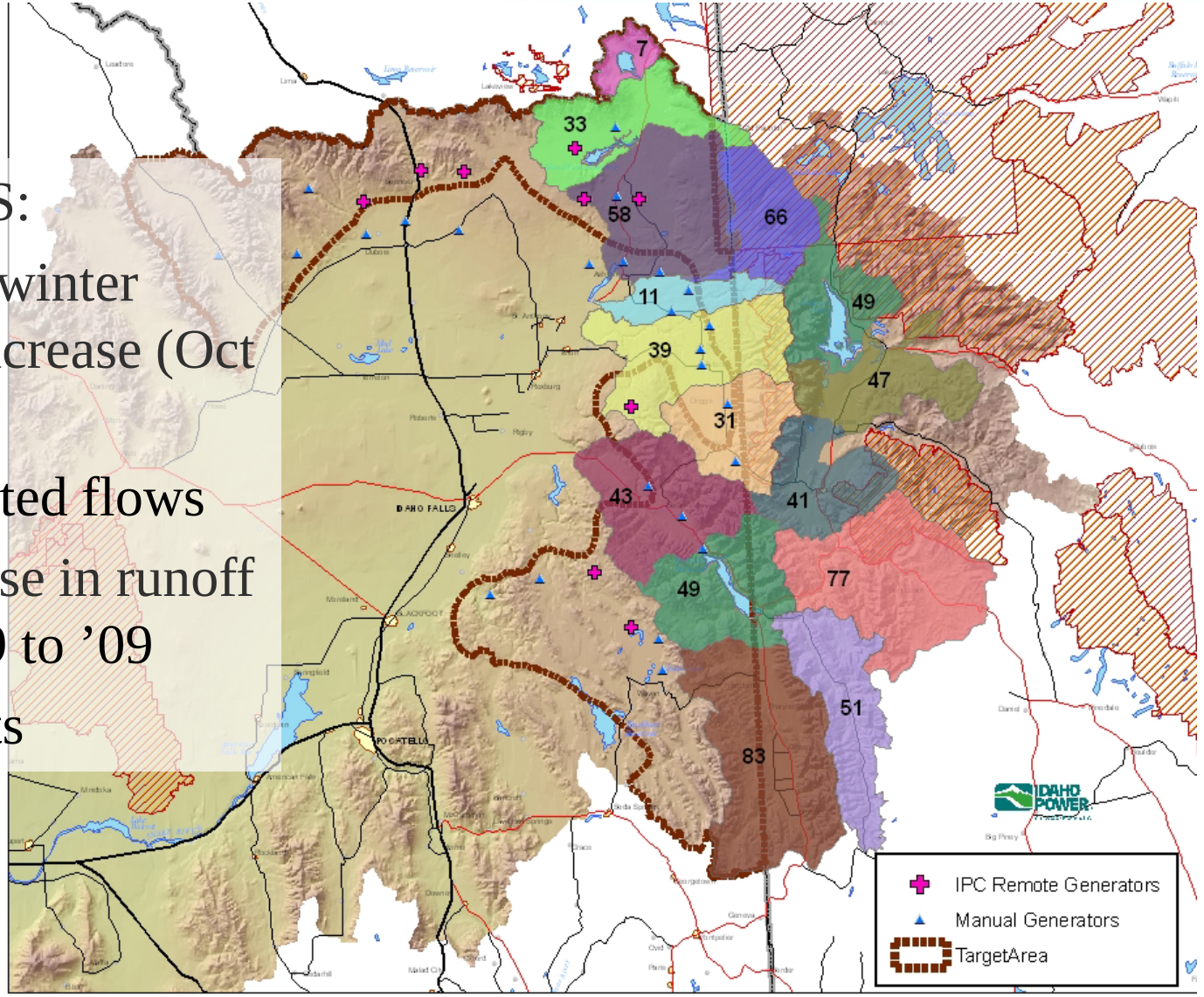
Percent Difference : (model – obs)/obs

	NOV	DEC	JAN	FEB	MAR	APR	6-mo.
2001-2002	13.7	-1.1	17.8	12.0	11.4	34.4	13.4
2003-2004	17.4	4.5	3.5	10.3	-3.7	8.2	8.4
2005-2006	-15.1	6.6	20.4	1.9	37.3	39.7	15.1
2007-2008	7.8	5.2	15.0	-1.6	6.1	-24.8	2.7

Upper Snake Potential

Using the IPCRFS:

- Assumes 10% winter precipitation increase (Oct – Mar)
- Local unregulated flows
- Average increase in runoff over period ‘49 to ’09
- DRAFT Results



Upper Snake Activities

- HCRC&D
  - In addition to the 25 manual generators,
  - In 2008 Idaho Power installed 3 remote generators, provided meteorological data and operations guidance
  - In 2009 installed 6 additional remote generators (total of 9), meteorological data and operations guidance
  - In 2010 installing 6 additional generators (total of 15), meteorological data and operations guidance
  - 2011 replace old style generators with latest configuration.
- WWRC&D
  - Installed radiometer, weather balloon, met station in Afton area.
  - Currently working with NCAR on a Phase II feasibility study for a project to target the Salt and Greys River drainages (WRF modeling).
  - With NCAR, modeling study to evaluate:
    - Seeding opportunities
    - Generator siting
    - Aircraft
    - Inversions

Questions?

Downwind Effects

- Research on the subject has shown there are neutral or positive effects (more precipitation) from a **well run** program.
  - A poorly run program has the potential to reduce precipitation
- Snowy Hydro (AU) has conducted a cloud seeding trial since ‘04. Research by the AU Natural Resources Commission has not identified adverse downwind effects.
  http://www.nrc.nsw.gov.au/Workwedo/Cloudseeding.aspx
- To put quantities into context…
  - Nature will condense about 20% of the water vapor as moist air rises over a mountain barrier (the remaining 80% remains uncondensed).
  - Winter storms are typically about 30% efficient, meaning 30% of the 20%, or 6% of the total, reaches the ground.
  - If cloud seeding increases precipitation 15%, that amounts to 15% of the 6%, or 0.9% of the total water vapor is the additional amount cloud seeding pulls from the atmosphere.

Silver Toxicity

- The WMA has issued a statement on toxicity of silver originating from cloud seeding

  http://weathermodification.org/AGI_toxicity.pdf

- In summary,

  "The published scientific literature clearly shows ***no environmentally harmful effects*** *arising from cloud seeding with silver iodide aerosols have been observed; nor would they be expected to occur. Based on this work, the WMA finds that silver iodide is environmentally safe as it is currently being dispensed during cloud seeding programs."*

- Research by the AU Natural Resources Commission has not identified any adverse environmental impacts.

  http://www.nrc.nsw.gov.au/Workwedo/Cloudseeding.aspx

IDEQ Review

- IDEQ reviewed cloud seeding w.r.t. water and air quality.
- Water quality - it is unlikely that cloud seeding will cause a detectable increase in silver concentrations in target area or pose a chronic effect to sensitive aquatic organisms.
- Air quality permit not needed based on screening thresholds.

- http://www.idwr.idaho.gov/waterboard/WaterPlanning/CAMP/ESPA/WorkingGroups/PDF/WM//2010/02-09-10_MtgPresent.pdf

Idaho Power's Cloud Seeding Projects