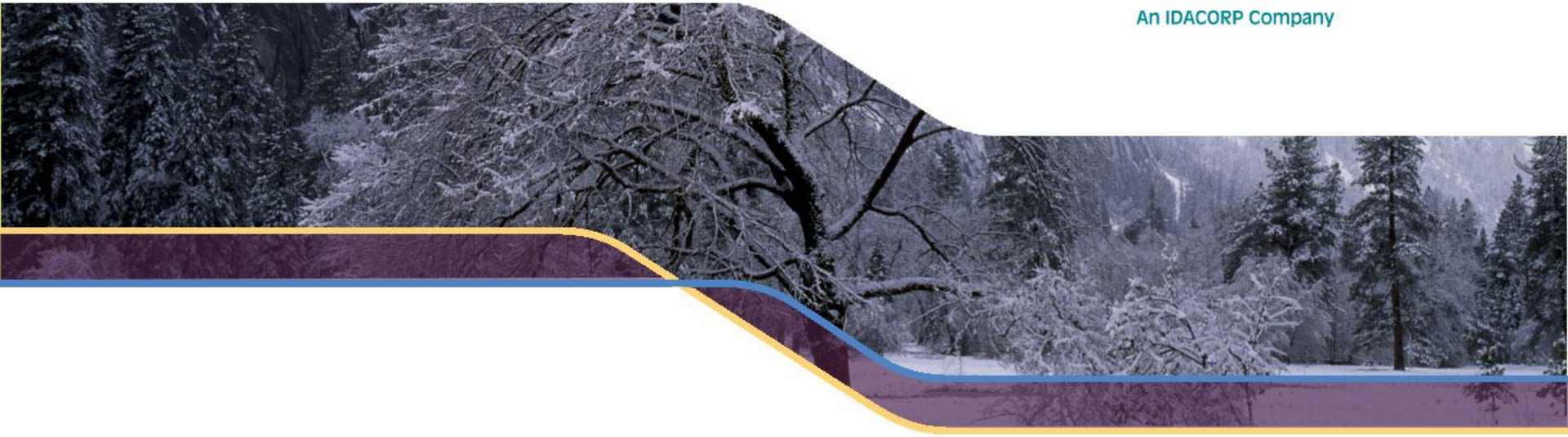


Idaho Power Company's Cloud Seeding Program

November 25, 2014

Shaun Parkinson, PhD, P.E.

Overview

- Idaho Power's history with cloud seeding
- IPC's current cloud seeding projects
- Benefit estimates
- Future Program?
- Ongoing research

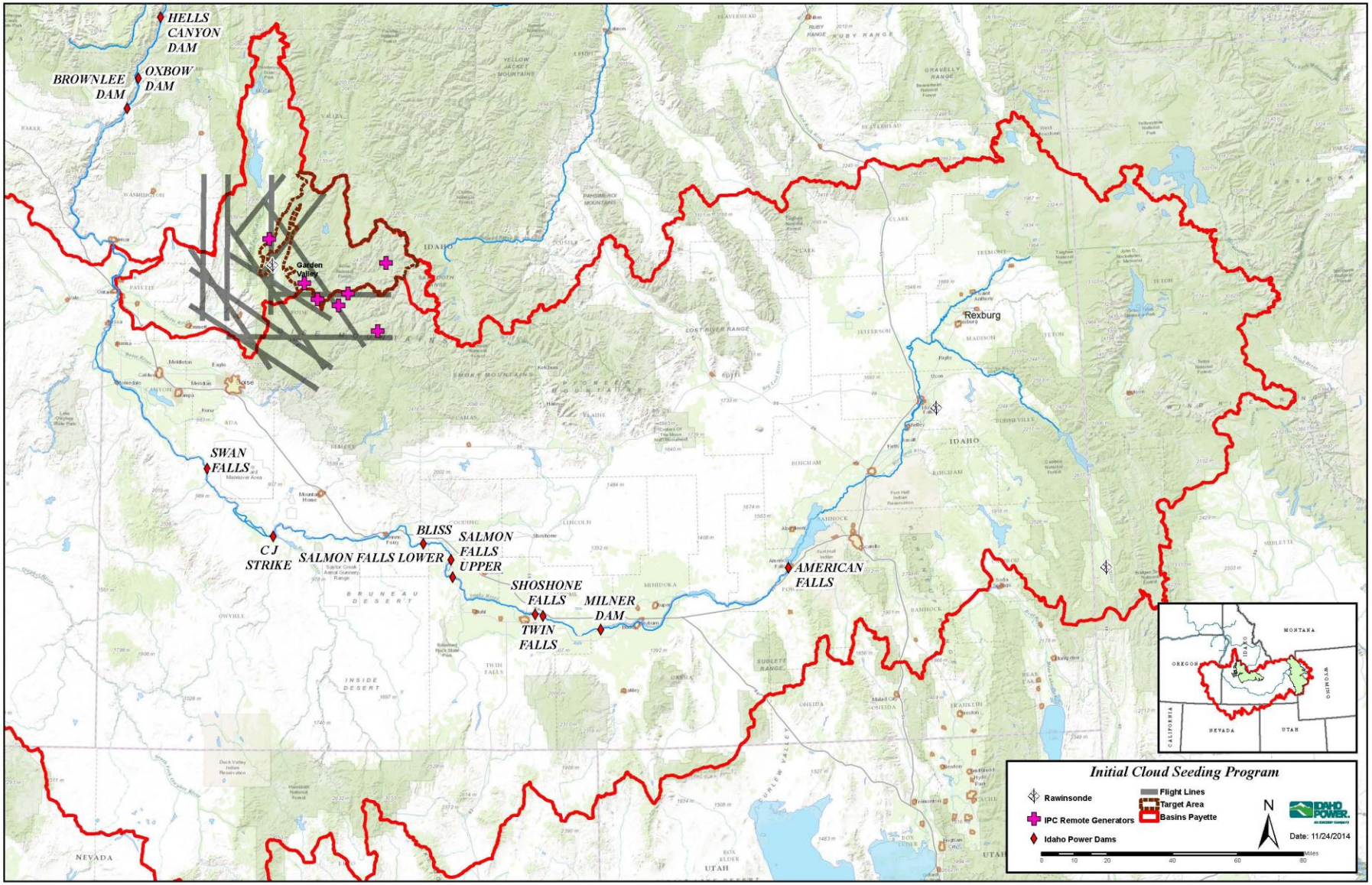
Idaho Power's History with Cloud Seeding

- Began investigating cloud seeding in 1993 (shareholder question)
- Literature review 1993 and 1994
- Climatology study 1994-95
- **Operational in fall of 2003 (7 generators, aircraft, assessment)**
- Completed second year of assessment and third year of operations in May 2005
- **2008 started working with HCRC&D to enhance manual program (motivated by CAMP)**
- 2010 started working with WW RC&D to evaluate cloud seeding in western Wyoming
- **2011 started working with NCAR to develop WRF model to guide and evaluate CS operations and projects**
- 2014 – Big Wood Canal Company contracted with IPC to seed Wood River with aircraft
- **2015 Expansion**:
  - Boise and Wood Basin's committed to 5-yr cost share for remote and aircraft seeding
  - Continued expansion in Salt and Wyoming Range
  - IWRB funding a grant for equipment associated with expansion

Initial IPC Cloud Seeding Project - 2003

- Target area – SF and MF Payette
- 7 remote generator sites
  - Co-located generators for dual tracer assessment (AgI and Indium)
- Aircraft with solution burners
  - Cs tagged Ag (differentiate between ground and aircraft silver), and Indium
- Trace chemistry analysis – snow sampling
  - Hi-resolution snowpack measurements
  - Relative contribution of ground vs. aircraft
  - Targeting of ground and aircraft
- Cloud physics measurements – instrumented aircraft

Initial Project Layout



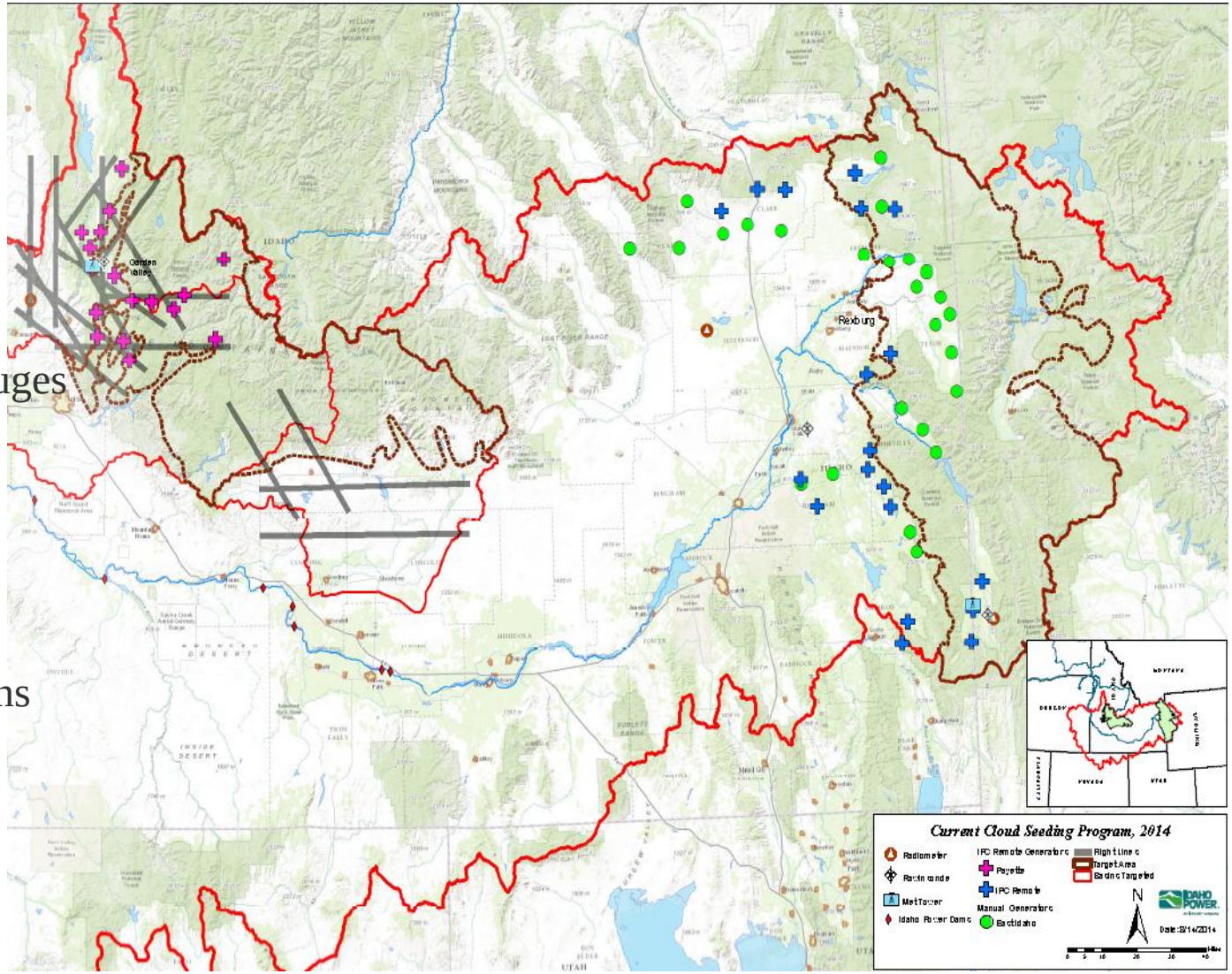
Original IPC Generators
Co-located, Seeding & Tracer

Aircraft Generators
solution burners

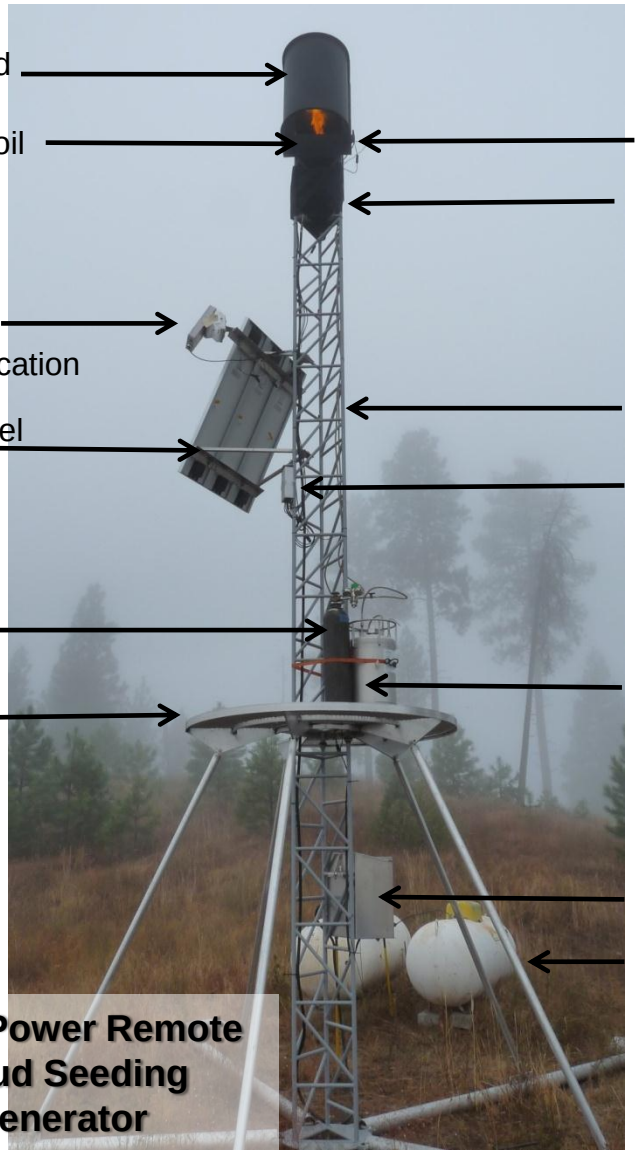
Last Years Program

Payette, Wood & Upper Snake

- Payette
  - 17 Remote Gen's
  - Aircraft
  - Radiometer
  - Weather Balloon
  - Weather Tower
  - 7 hi-res precip gauges
- Upper Snake
  - 19 Remote Gen's
  - 25 Manual Gen's
  - 2 Radiometers
  - 2 Weather Balloons
  - Weather Tower
- Wood
  - Aircraft



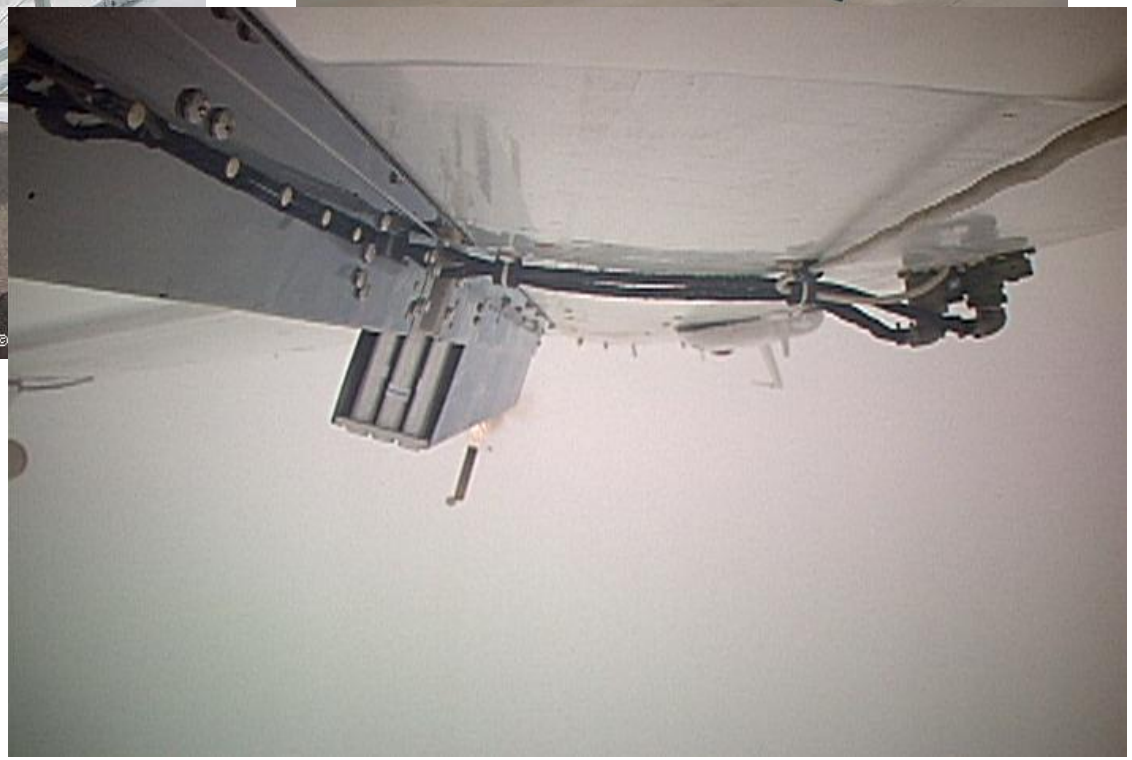
IPC Ground Generators



Idaho Power Remote Cloud Seeding Generator

Manual Cloud Seeding Generator

Aircraft Seeding



Radiometer

Passive, real-time profiling of the atmosphere:

- Temperature
- Relative Humidity
- Liquid Water
- Vapor Density

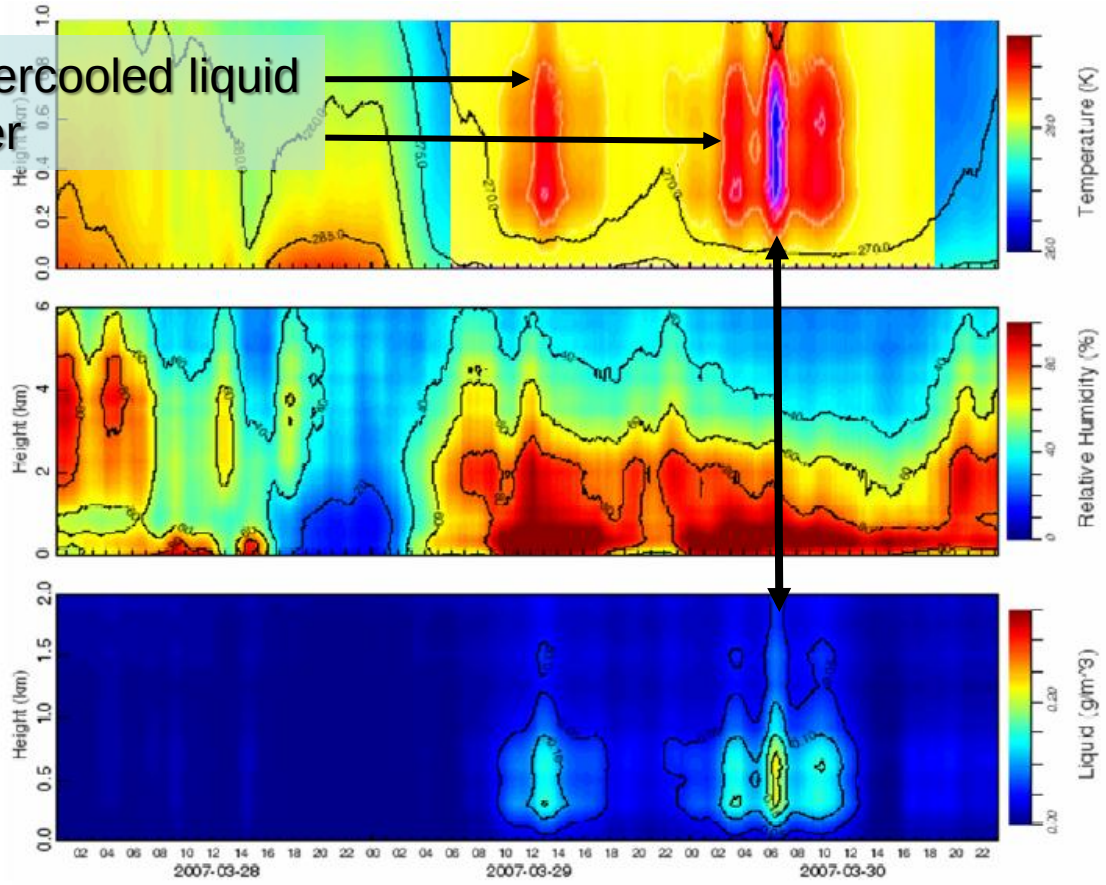


Image courtesy of Radiometrics

Benefit Estimation

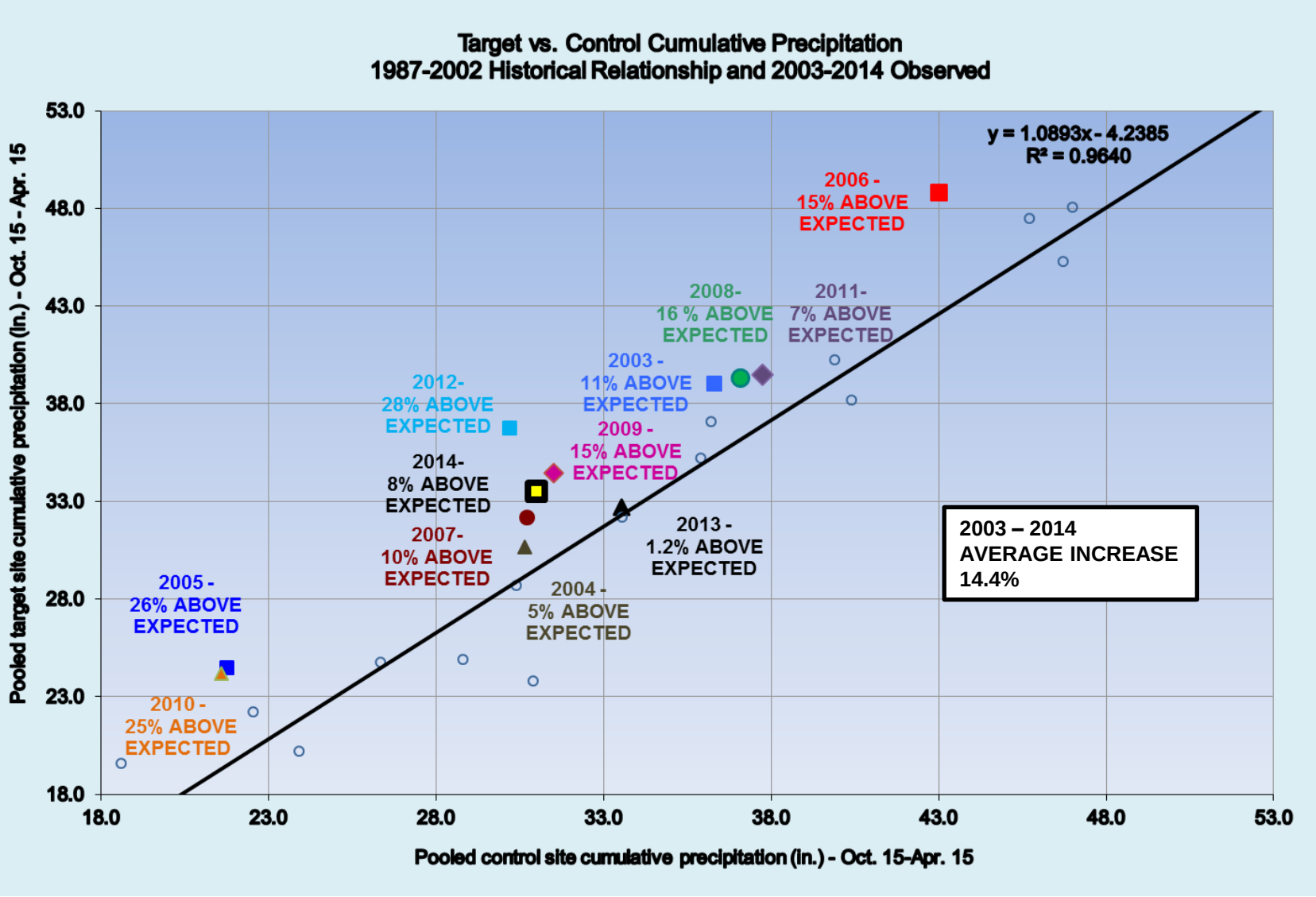
Payette

Several different approaches to assess benefits:

1. Target-Control
2. Hydrologic modeling using IPCRFS forecasting model
3. Weather Modeling

Target – Control

Payette

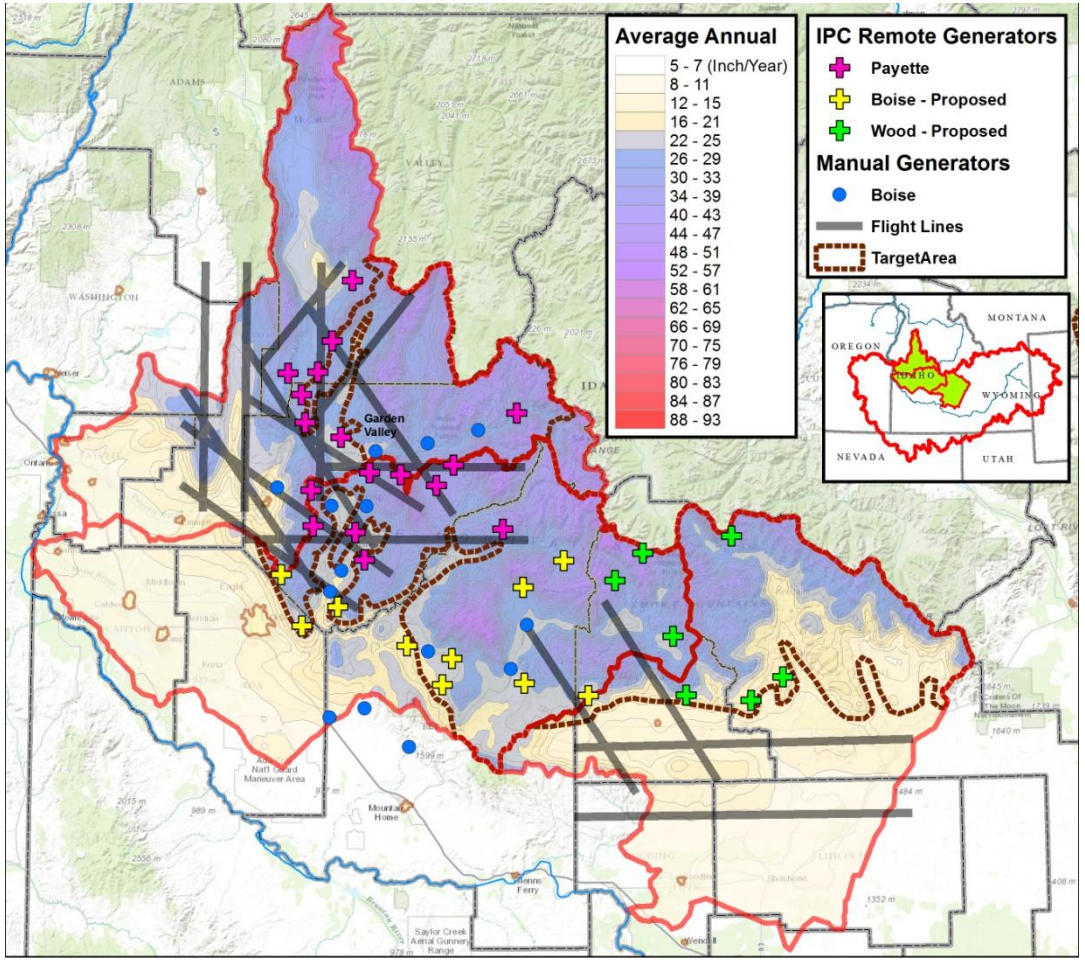


Hydrologic Modeling

IPC River Forecast System

West Central Mtn's Benefit Estimate

- Additional runoff estimated using IPC's River Forecast System. Simulated water years 1951 – 2001.
- Model uses Mean Aerial Precipitation (MAP) by elevation
- Two scenarios…with and without cloud seeding
- Streamflow increase approximately **300 KAF** / year for Payette (Target – Control benefit of 14.4% precipitation increase)
- We estimate approximately half of the benefit is from remote ground generators, and half is from plane.
- Boise & Wood Basins (assume 10%)
  - Boise Basin: **196 KAF** / year
  - Wood River Basin: **100 KAF** / year

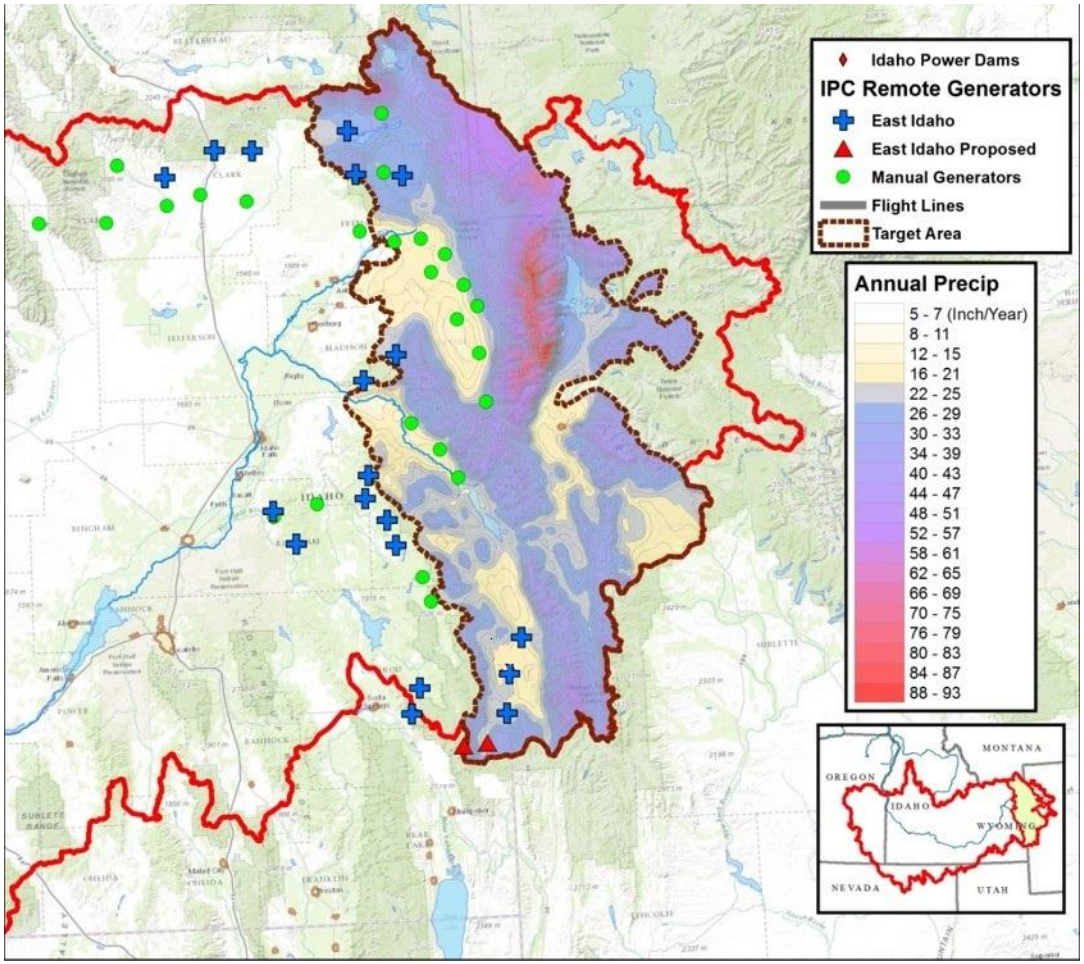


Hydrologic Modeling

IPC River Forecast System

Upper Snake Benefit Estimate

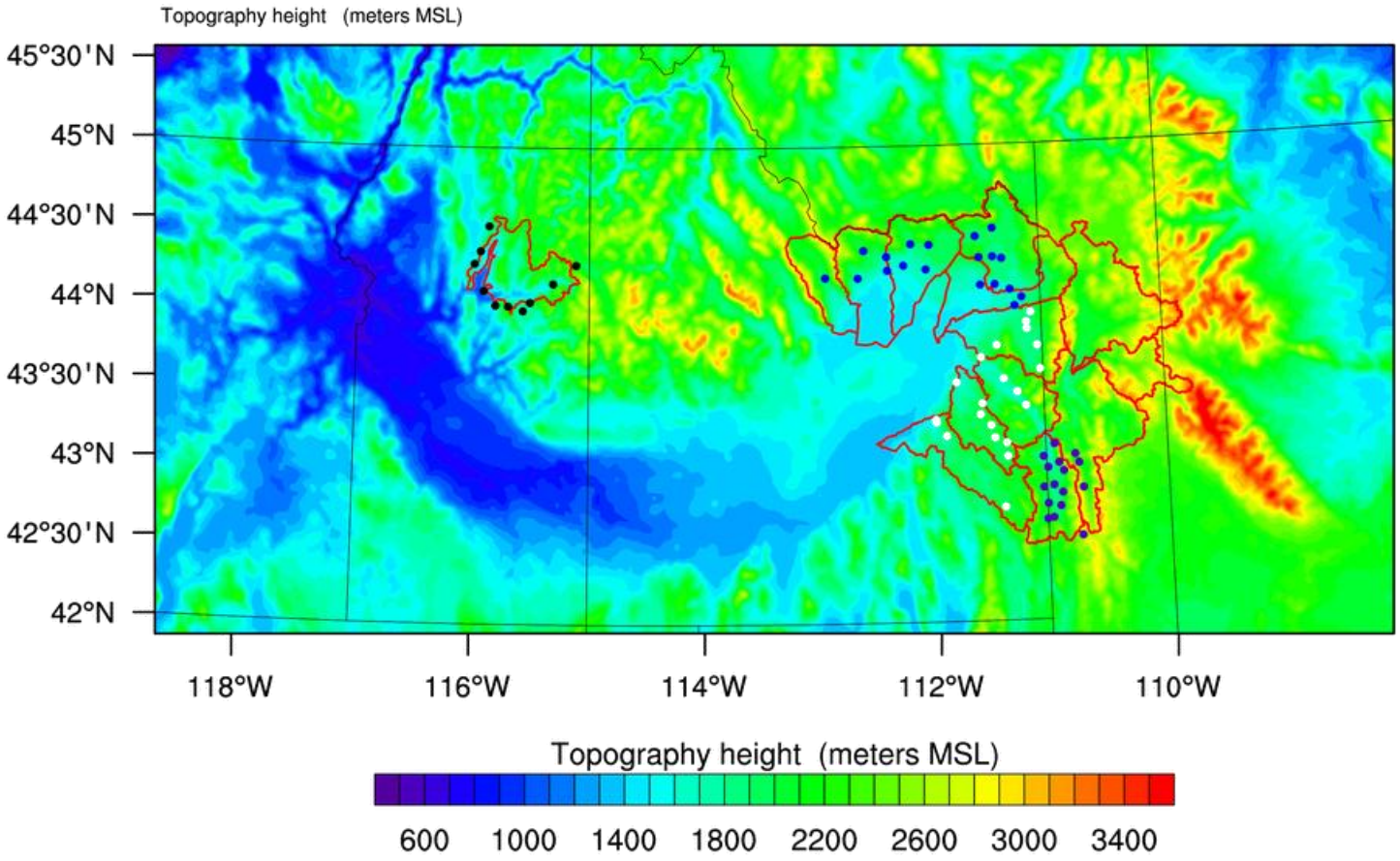
- Additional runoff estimated using IPC's River Forecast System. Simulated water years 1951 – 2001.
- Two scenarios…with and without cloud seeding
- Precipitation increase of 5% used for 'with cloud seeding'
- Streamflow increase below Milner :
  - 5% - **270 KAF / year**
- Additional generators needed to reach 5%
- Additional generators plus aircraft – est between 5% and 10% increase
- Salt & Wyoming Range (10%)
  - **115 KAF** / yr



WRF

Weather Research Forecast

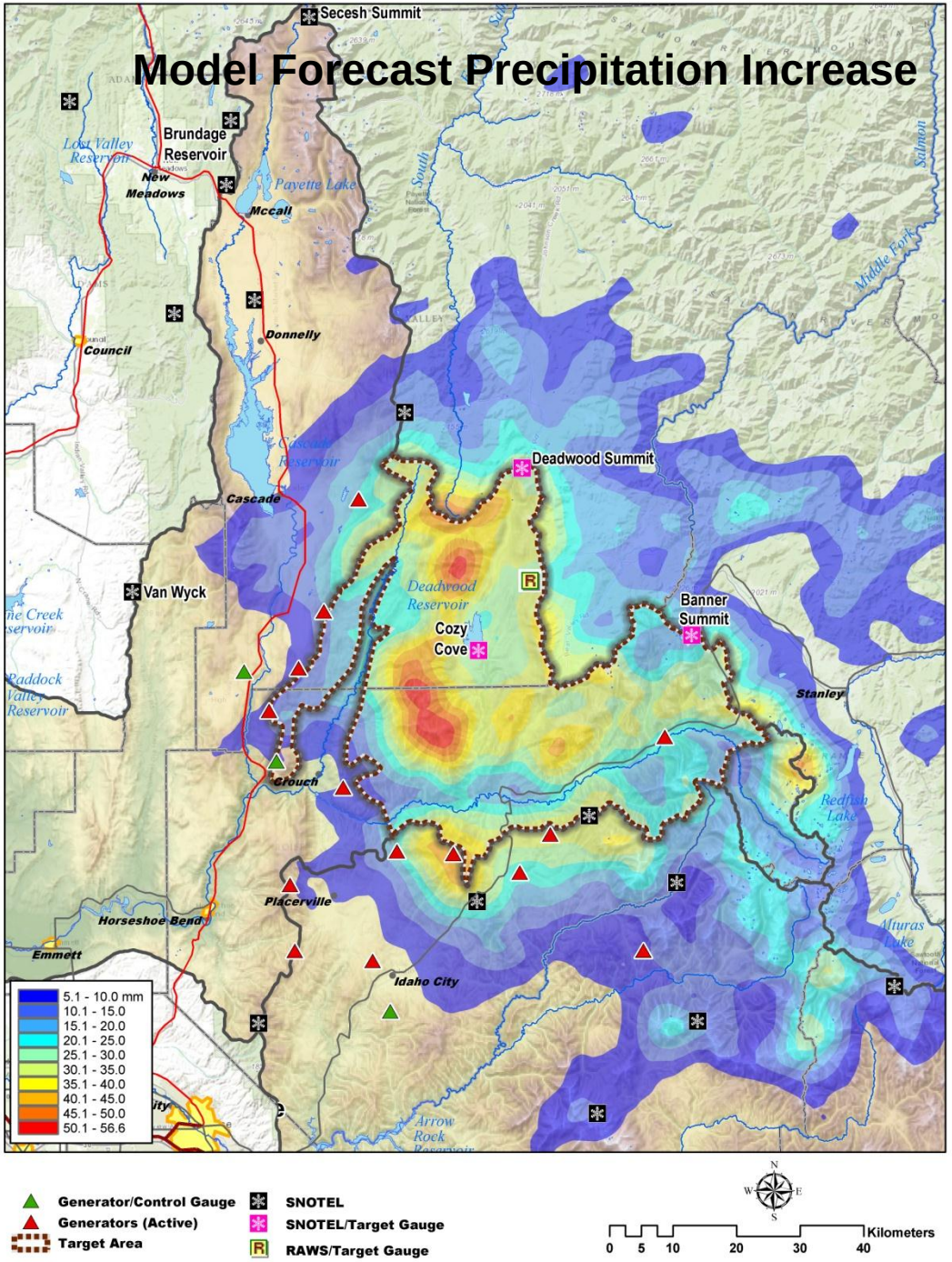
Idaho Power Simulation Domain



WRF CS Simulation

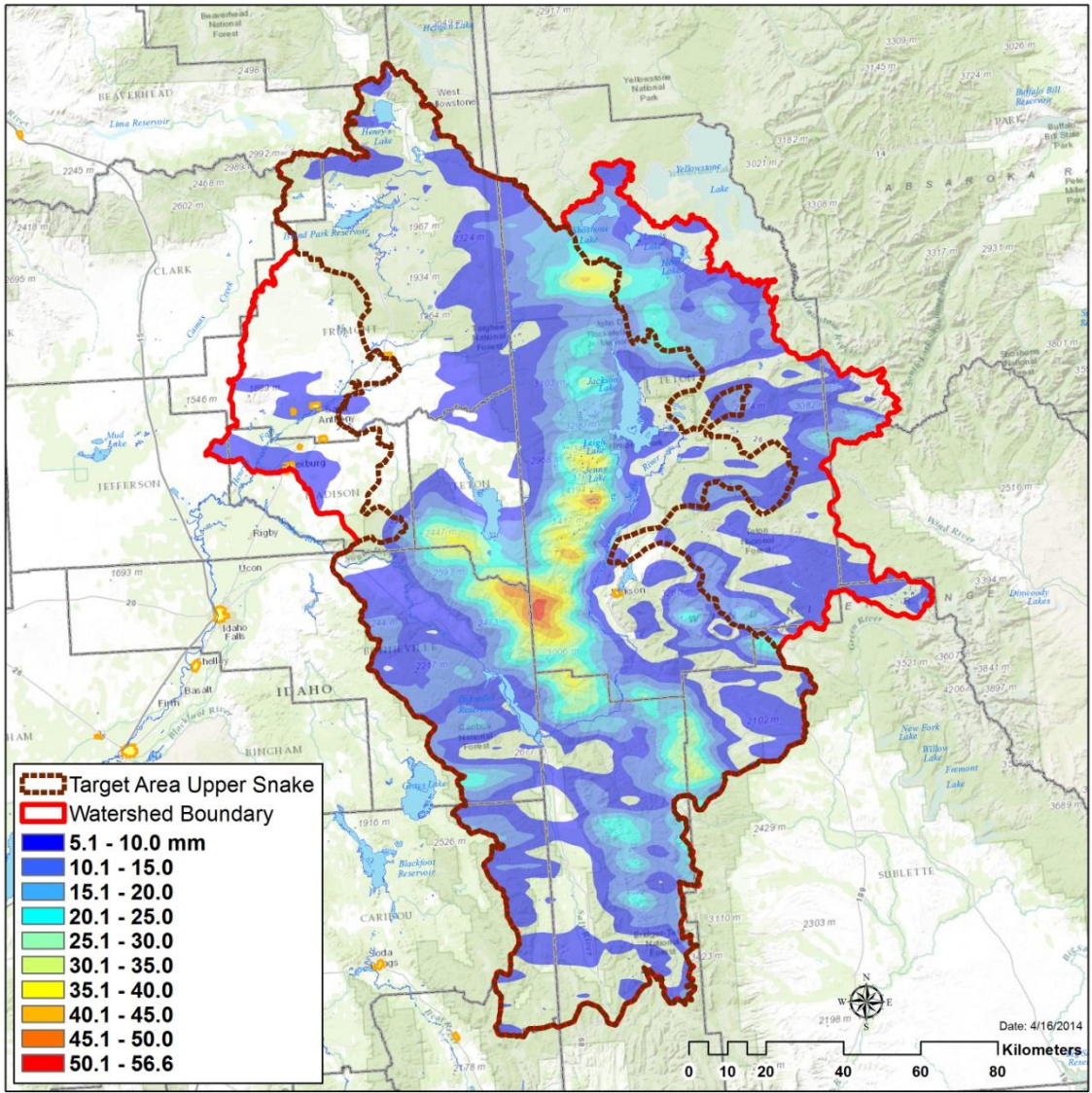
Payette

- 2014 – Aligns with Target Control benefit of 8%

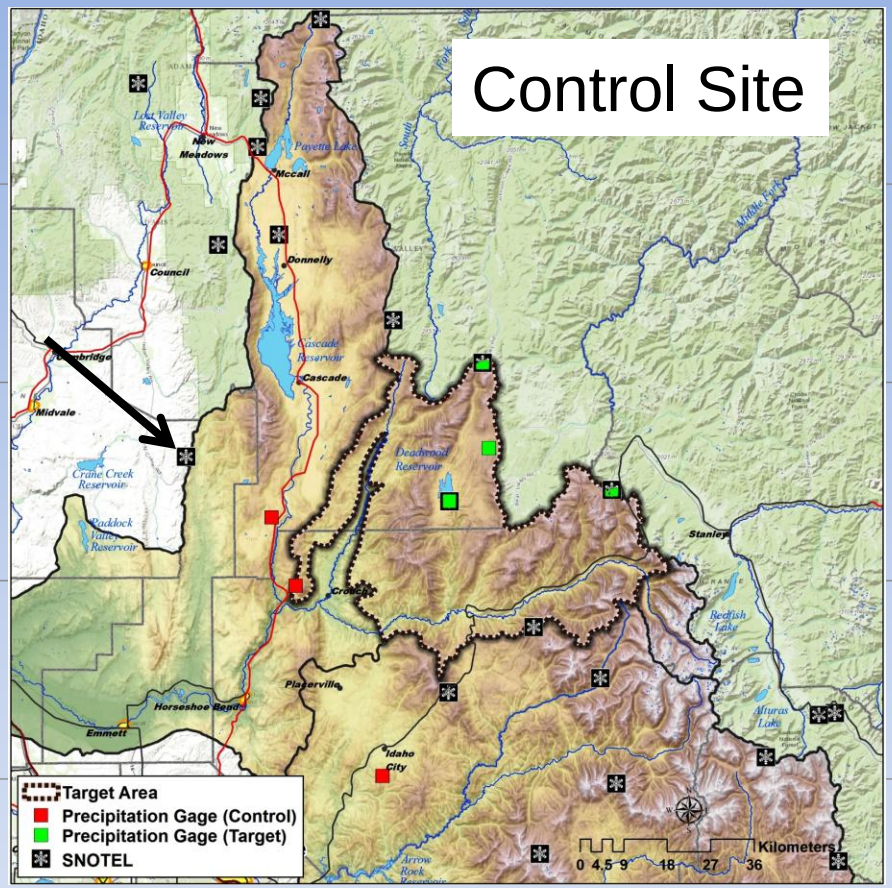


WRF CS Simulation Upper Snake

- 2014 ~190 KAF of SWE
- In future, will be able to compare to precipitation gauges



WRF Model Forecast Versus Observed Precipitation



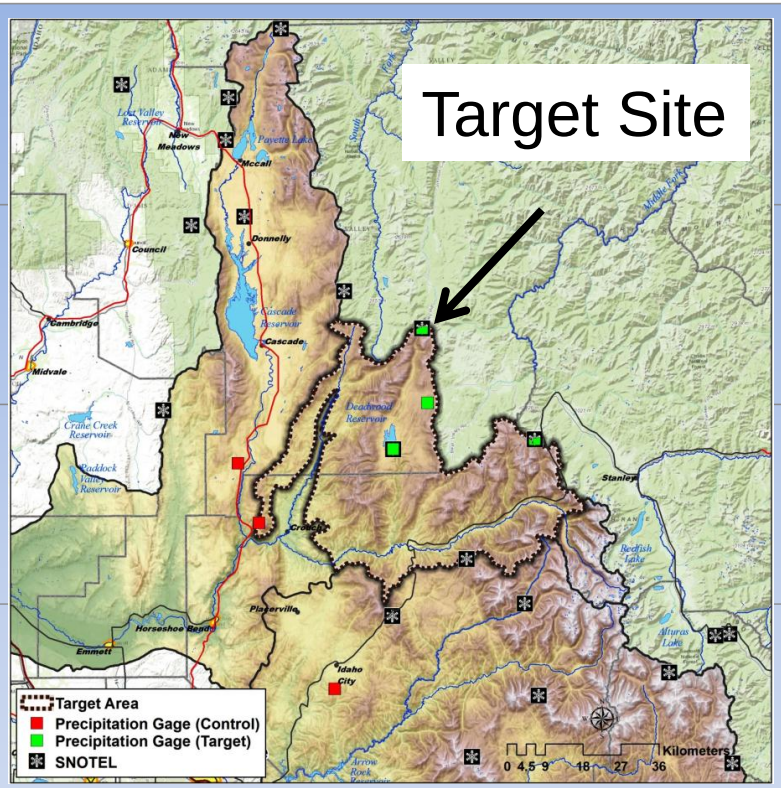
Precipitation (cm)

120
100
80
60
40
20
0

10/1/2011
11/1/2011
12/1/2011
1/1/2012
2/1/2012
3/1/2012
4/1/2012

Van Wyck Model Forecast Precipitation
Van Wyck Observed Precipitation

WRF Model Forecast Versus Observed Precipitation



Precipitation (cm)

120
100
80
60
40
20
0

10/1/2011
11/1/2011
12/1/2011
1/1/2012
2/1/2012
3/1/2012
4/1/2012

Deadwood Summit Model Forecast Precipitation
Deadwood Summit Observed Precipitation

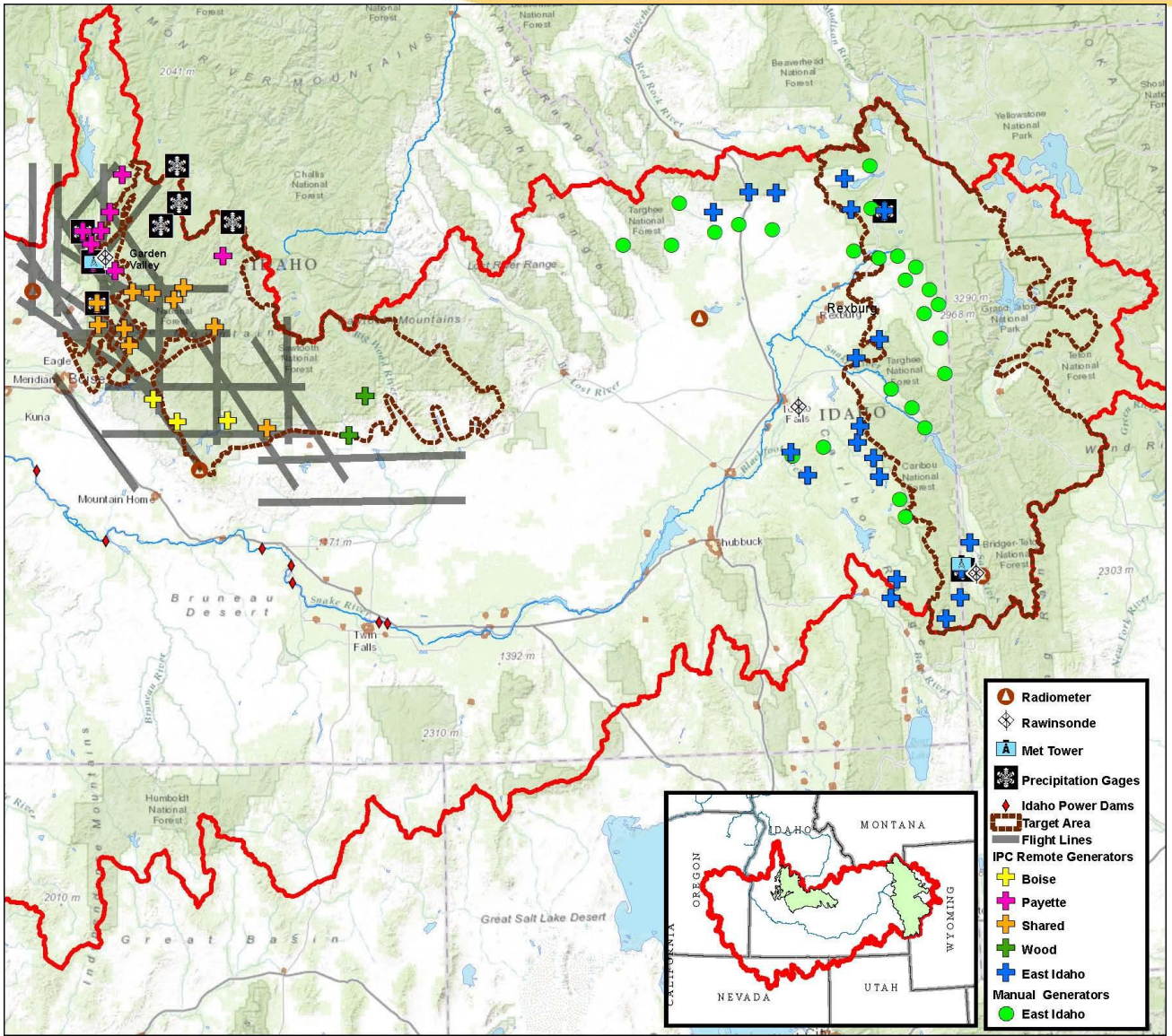
Other Benefits

- Generation in the downstream Federal Power System
- Increased water supply
  - In stream flows
    - Aquatic habitat
    - Recreation
    - Water quality
  - More assurance of refill
    - Flow Augmentation
    - Irrigation
    - Industry

Current Year Program

Payette, Boise, Wood & Upper Snake

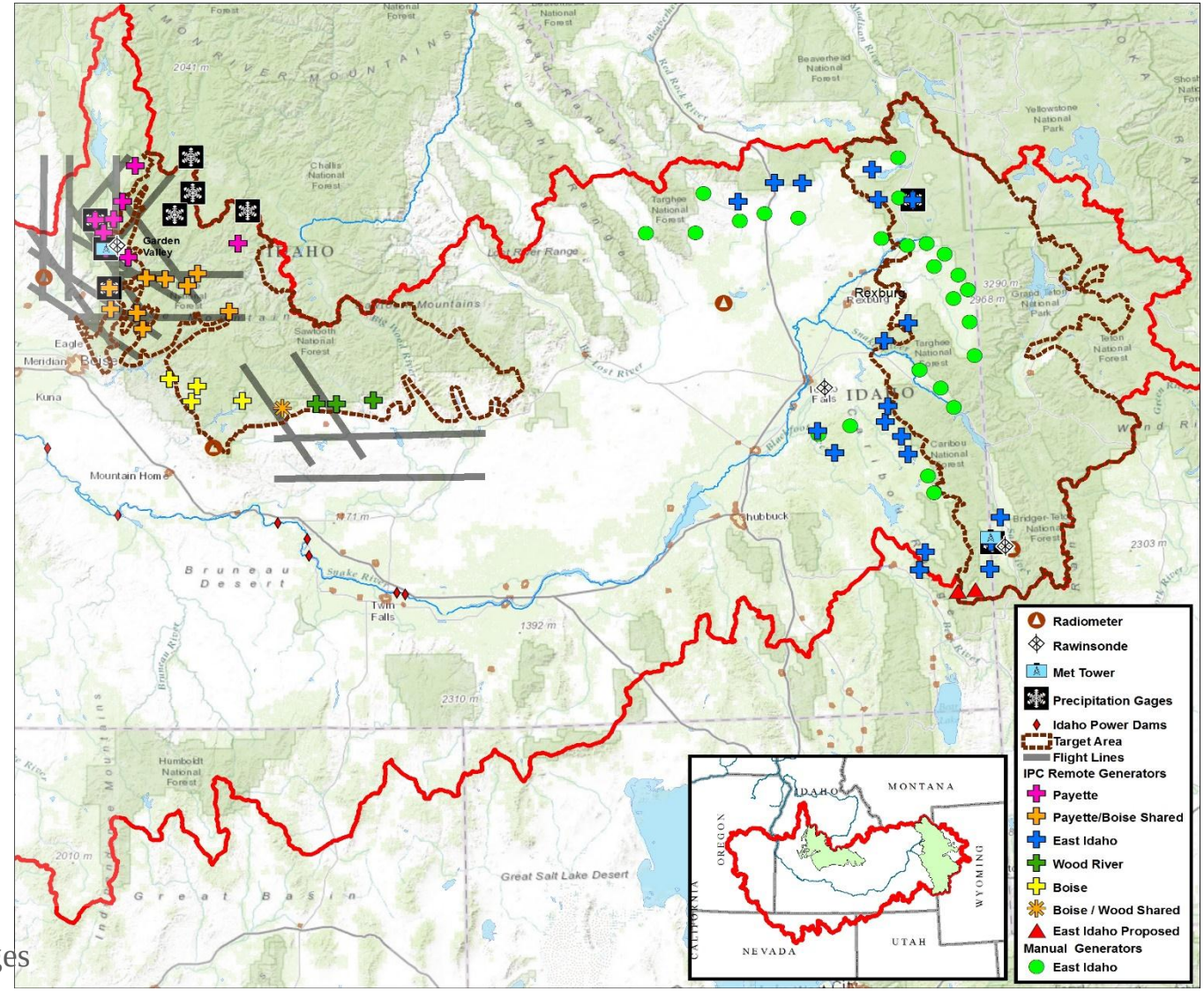
- Payette
  - 17 Remote Gen's
  - Aircraft
  - Radiometer
  - Weather Balloon
  - Weather Tower
  - 7 hi-res precip gauges
- Upper Snake
  - 20 Remote Gen's
  - 25 Manual Gen's
  - 2 Radiometers
  - 2 Weather Balloons
  - Weather Tower
- Boise and Wood
  - 6 Remote Gen's
  - Aircraft
  - Radiometer
  - Weather Balloon



Potential Future Program

Payette, Boise, Wood & Upper Snake

- Payette
  - 17 Remote Gen's
  - Aircraft
  - Radiometer
  - Weather Balloon
  - Weather Tower
  - 7 hi-res precip gauges
- Boise and Wood
  - 26 Remote Gen's
  - Aircraft
  - Radiometer
  - Weather Balloon
  - 4 hi-res precip gauges
- Upper Snake
  - 30 - 40 Remote Gen's
  - 25 Manual Gen's
  - Aircraft
  - 2 Radiometers
  - 2 Weather Balloons
  - Weather Tower
  - 2 to 5 hi-res precip gauges



Ongoing Research

- Continued development and implementation of WRF cloud seeding module (NCAR)
- Trace chemistry snow sampling, University of Curtain and BSU
  - Targeting
  - Verification of WRF seeding module
- SNOWIE
  - Wyoming, Illinois, Colorado, NCAR, IPC
  - Builds upon Wyoming study
  - Ground and aircraft seeding
  - Different (complex) terrain
  - Focus on operational program

Questions?