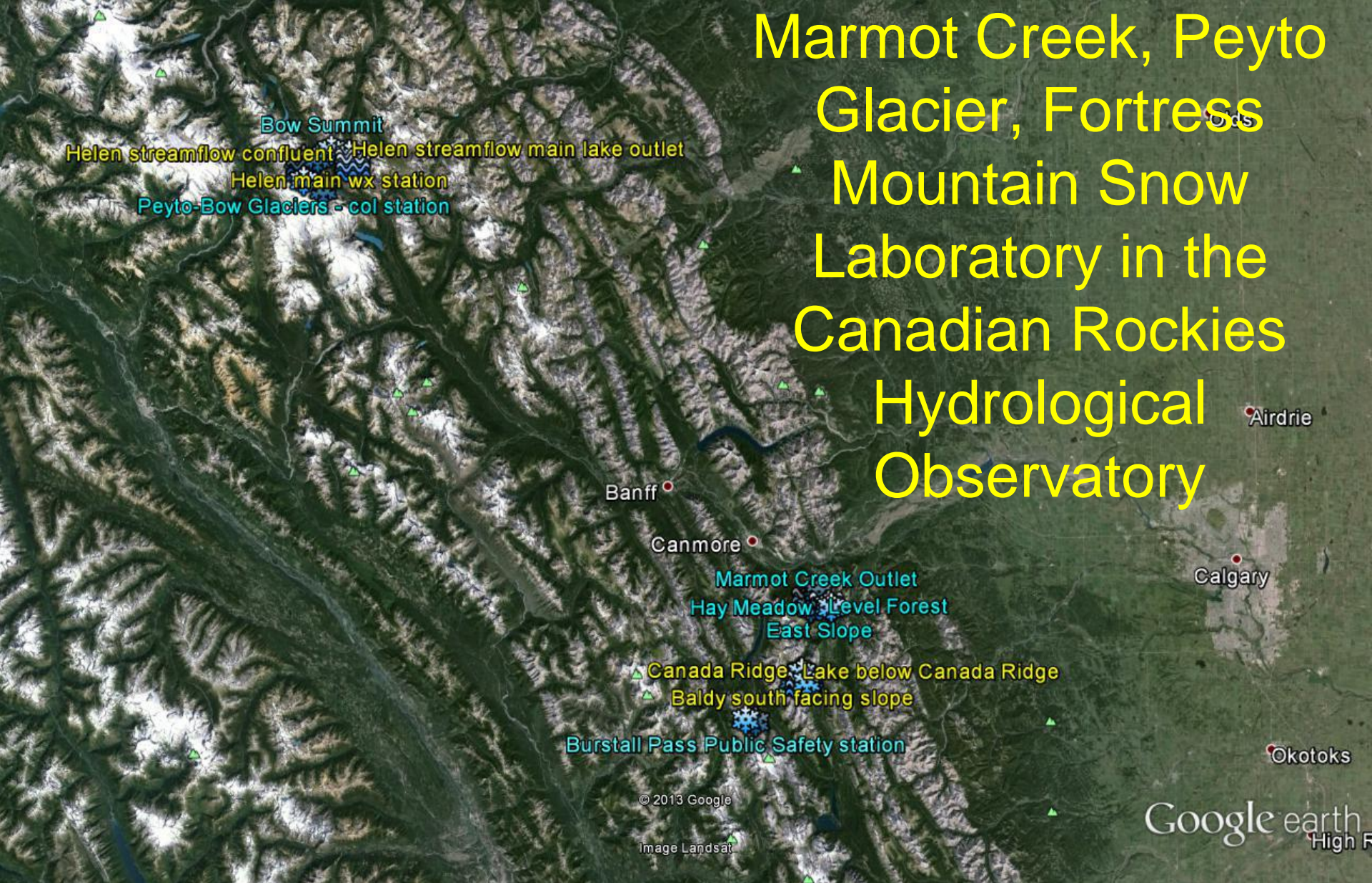


Marmot Creek, Peyto Glacier, Fortress Mountain Snow Laboratory in the Canadian Rockies Hydrological Observatory



John Pomeroy, Warren Helgason, Cherie Westbrook

Canadian Rockies Hydrological Observatory

- 10 new high altitude hydrometeorological stations
 - 5 high altitude stream gauge stations – nested research basins
 - Cryoflux portable detailed measurement system
 - WISKI/CRHM: data management, information assimilation and water modelling system
 - Studies of snow and glacier hydrology, boundary layers, treeline ecohydrology, climate modelling, snow physics
- Staff: May Guan, Angus Duncan



Centre for Hydrology

UNIVERSITY OF
SASKATCHEWAN

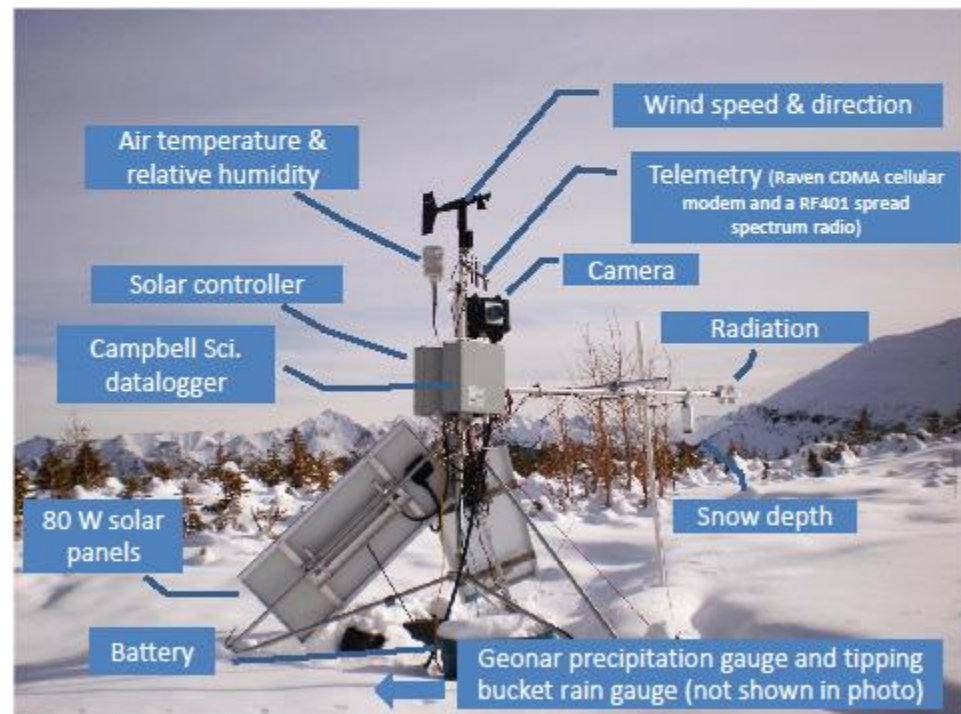
Canadian Rockies Hydrological Observatory (CRHO)

Existing Stations in Kananaskis, Alberta:

Marmot Creek (10)
Sibbald Wetlands (1)

Existing Station Example:

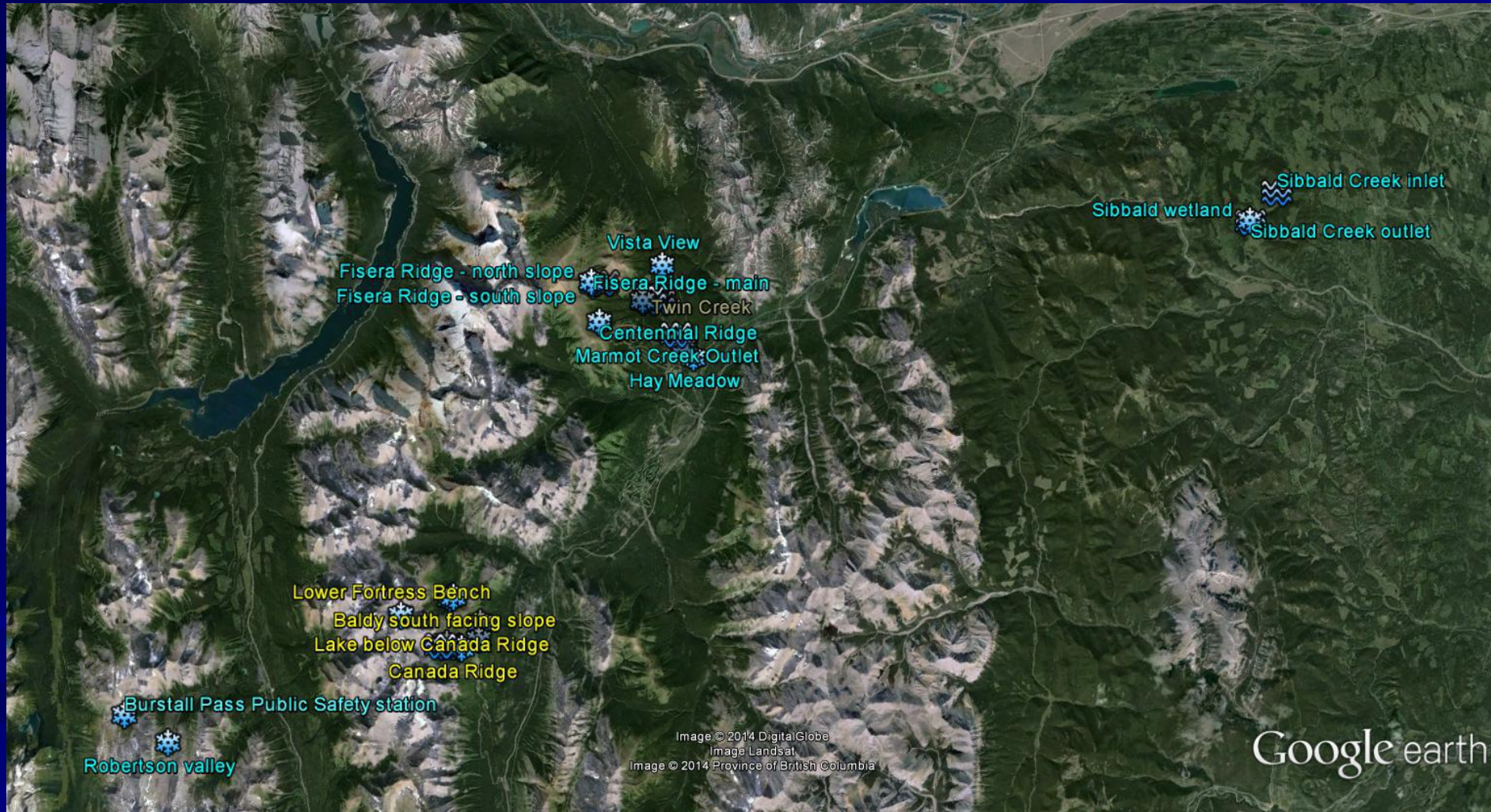
Fisera Ridge, Kananaskis, Alberta
0626107E 5646559N
2325 m a.s.l.



CRHO Approach

- Advance development and integration of information on how hydrological and cryospheric processes interact to form streamflow.
- Develop and run hydrological models to produce water resource predictions for past and future climates.

Kananaskis Country Sites



35 stations – 22 meteorological, 5 groundwater and 8 hydrometric

Banff National Park Sites



15 stations: 8 meteorological and 7 hydrometric

CRHO Science Questions

1. How do mountain basin biophysical characteristics affect snow and ice systems to produce hydrological responses to precipitation and energy inputs on time scales from hours to centuries?
2. Do cold regions mountain hydrological systems enhance or dampen the effects of climate variability on water resources?
3. Are the Canadian Rocky Mountains a reliable future source of streamflow?

CRHO Objectives

1. Improve understanding and description of governing processes for mountain water supply
 - i. Snow and glacier cold regions processes
 - ii. Ecohydrological processes
 - iii. Sub-surface processes
2. Improve modelling of mountain hydrological systems
 - i. Small scale distributed physically based simulations
 - ii. Moderate scale headwater catchment models
 - iii. Large scale river basin and continental models
3. Use better observations and modelling to better predict mountain water supply
 - i. Downscale current meteorology and future climate to drive cold regions hydrology in light of concurrent ecohydrological dynamics,
 - ii. Predict hydrological cycling and quantify uncertainty in these calculations in ungauged mountain basins.
 - iii. Improve the coupling of the sub-surface flow system to the surface-atmosphere system

Current CRHO Projects

- Climate change impact (Pomeroy, Fang, Rasouli, Sandford, Whitfield)
- Forest change impact (Pomeroy, Harder, Fang; Musselman)
- Historical hydroclimatology (Pomeroy, Harder, Siemens, Whitfield, Shook)
- Improved multiscale modelling (Pomeroy, Wheeler, Ireson, Helgason, Brown, Musselman, Conway, Marsh, Lv, Rasouli)
- Glacier hydrology (Pomeroy, Demuth, Pradhananga, Conway, Musselman, Anderson)
- Turbulent transfer to snow (Helgason, Conway, MacDonald)
- Ecohydrology of forest edges (Pomeroy, Musselman)
- Chinooks (Pomeroy, Essery, MacDonald)
- Snow measurements (Pomeroy, Kinar, Guan, Duncan)
- Wetland dynamics (Westbrook, graduate student)
- Groundwater-surface interactions (Ireson, Janzen)
- Coupled modelling: surface, sub-surface, atmosphere (all)

CRHO Alliances

- Parks Canada, Banff
- Alberta Parks, Kananaskis
- Alberta Environment and Sustainable Resource Development, Edmonton
- Mike Demuth, National Glaciological Program, NRCAN
- Dr. Alain Pietroniro, Water and Climate Services, Environment Canada
- Dr. Melissa Lafrenier, Queen's University
- Dr. Scott Munro, University of Toronto
- Alpine Club of Canada

Improved Snow Measurements

Acoustic



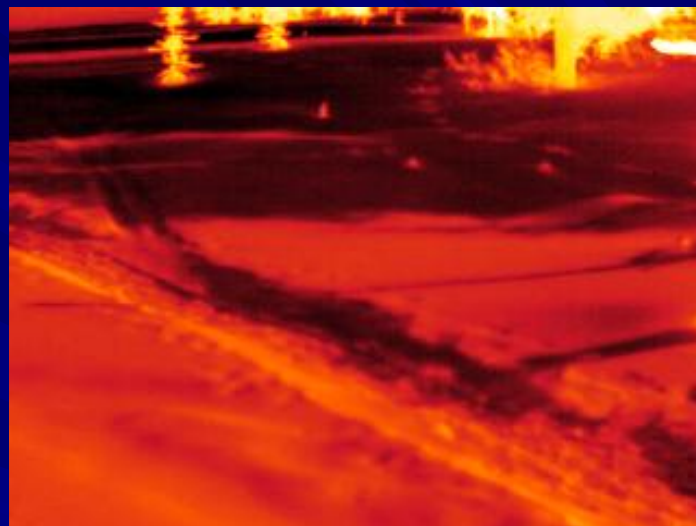
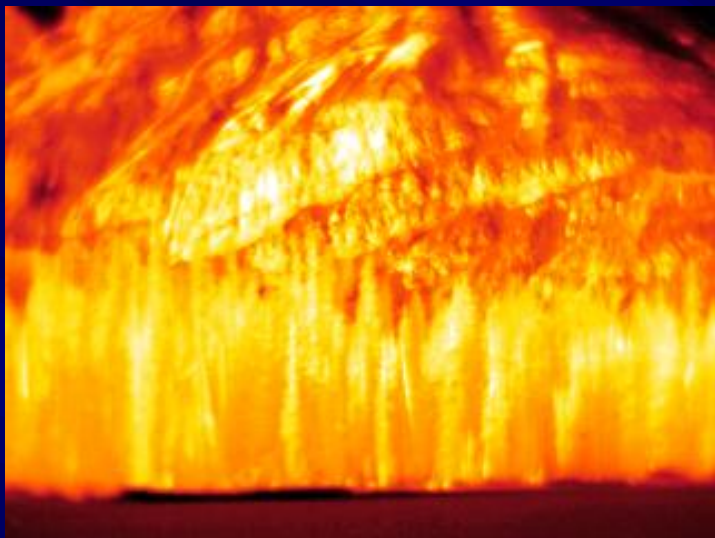
Laser



Thermal



Infrared Thermography for Cold Regions Landscape Temperatures



Snow Intercomparison Site – Fortress Mountain Snow Laboratory (WMO/EC SPICE)

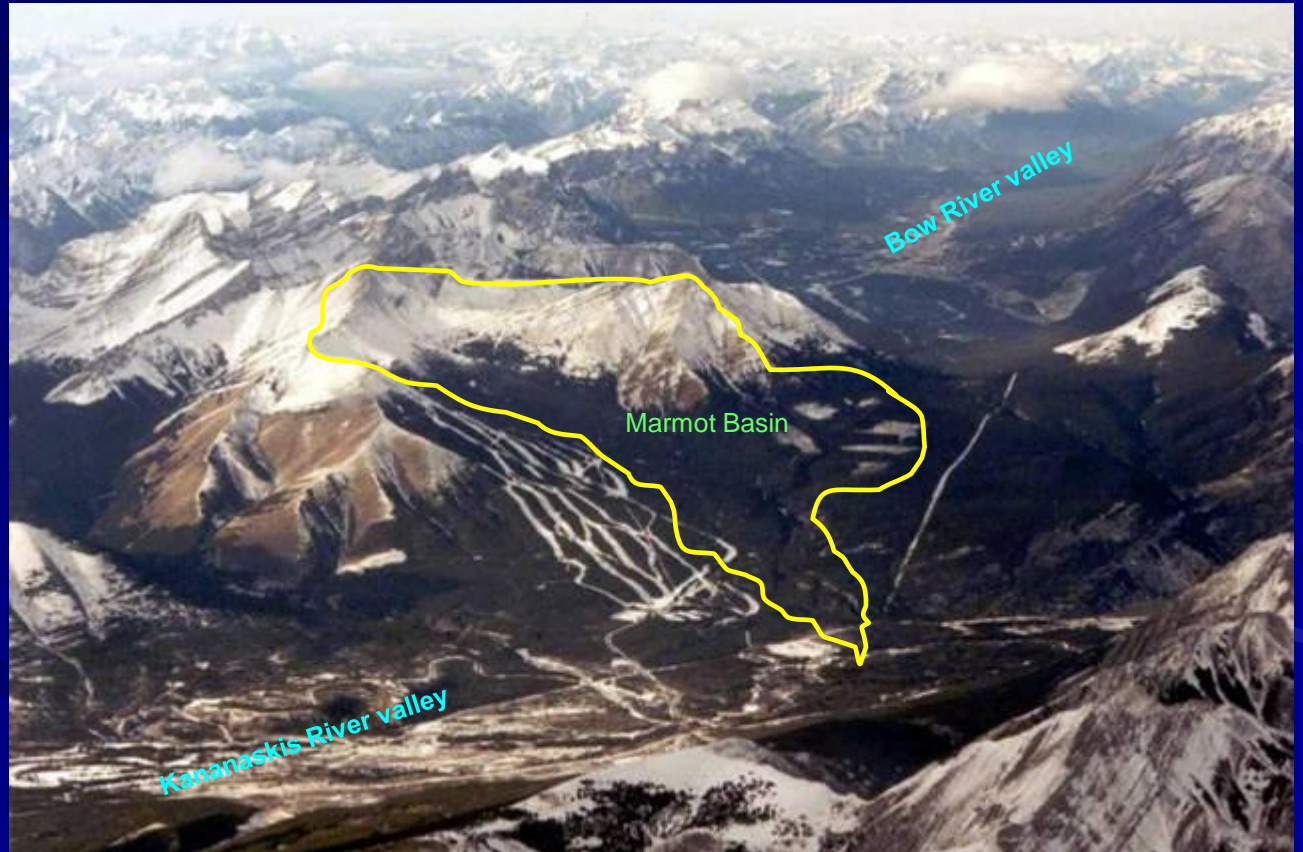


Marmot Creek Research Basin

- Established 1962, operated until 1987 by Canada and Alberta Governments (Marmot Basin Project)
 - Intensive observations – stream gauging, groundwater observation wells, meteorological stations, snow surveys, soil surveys, vegetation surveys
 - Forestry manipulations
 - Process and modelling studies
 - Comprehensive watershed studies: water quality, aquatic ecology
 - Digitized, archived data.
- 1988-2004
 - Groundwater wells, main stream gauge, some weather observations continued by Environment Canada and Alberta Environment
 - No organised research in the basin
- Re-established 2004 by University of Saskatchewan, Environment Canada and University of Calgary
 - Intensive observations – hydrometeorology, eddy correlation streamflow, tracers, snow surveys
 - LiDAR, satellite images
 - Automated stations, telemetry, WISKI data archiving
 - Process and modelling studies
- Heavily impacted by the June flood of 2013
 - Meteorological stations all worked through the flood (~260 mm precipitation)
 - WSC hydrometric station V-notch weir filled with debris – channel shift
 - 4 U of S hydrometric stations and autosamplers destroyed; access compromised

Marmot Creek Basin Features

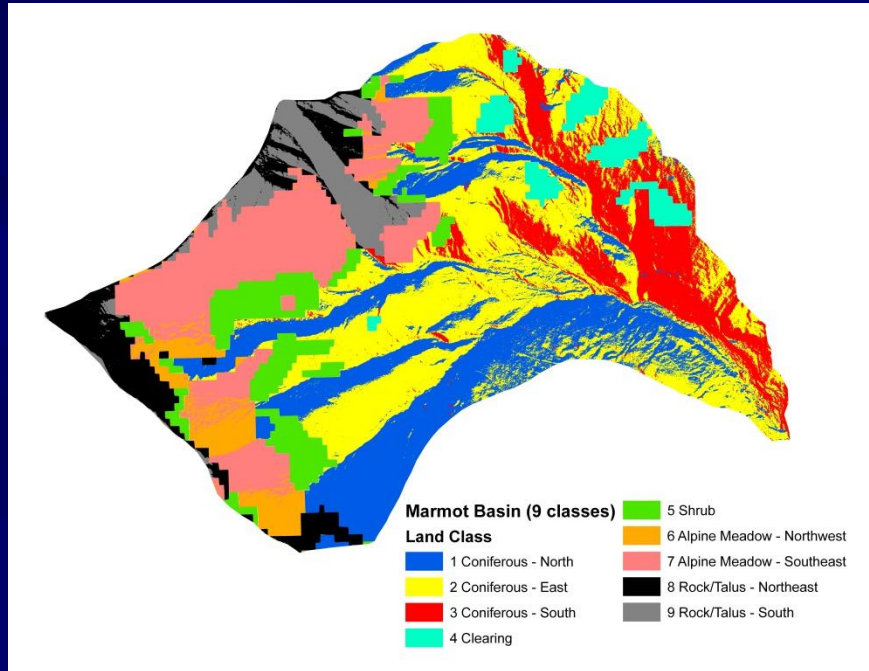
- 1450-2886 m.a.s.l. Kananaskis Valley, Bow River
- Alpine
- Subalpine
- Montane
- Clearcut
- Meadow
- +600 mm precipitation
- 70% snowfall
- ~50% runoff



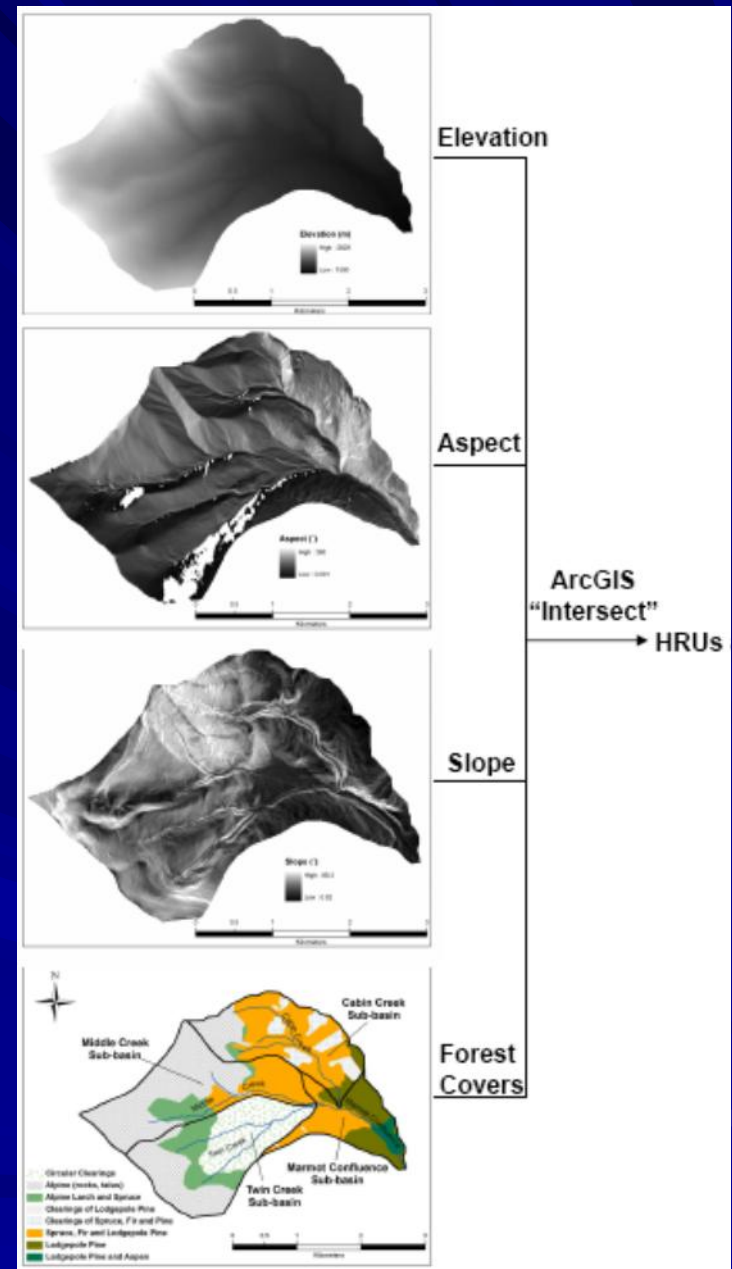
Marmot Creek Observations



Marmot Creek Modelling



Tiles of the Multiscale Environmental Surface and Hydrology Model (MESH) with Env. Canada



Cold Regions Hydrological Model (CRHM) HRU determination

Over One Century of Observations at Peyto

Mass Balance:

- Early studies 1945
- 1966-present good records (IHD)
- LiDAR 2002-2009

Streamflow:

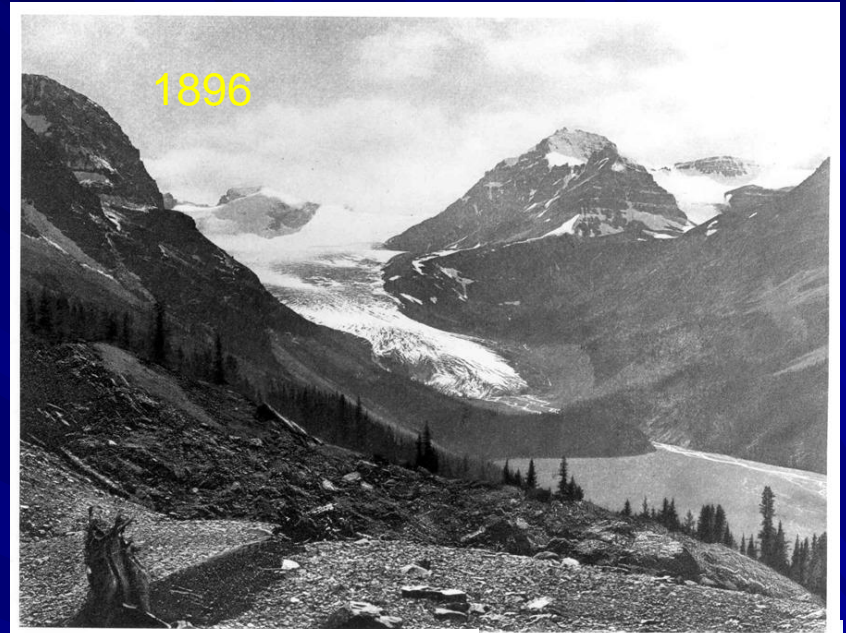
- 1967-1977 WSC Gauge
- 2008 runoff estimates on ice
- 2013 U of S Gauge

Meteorology

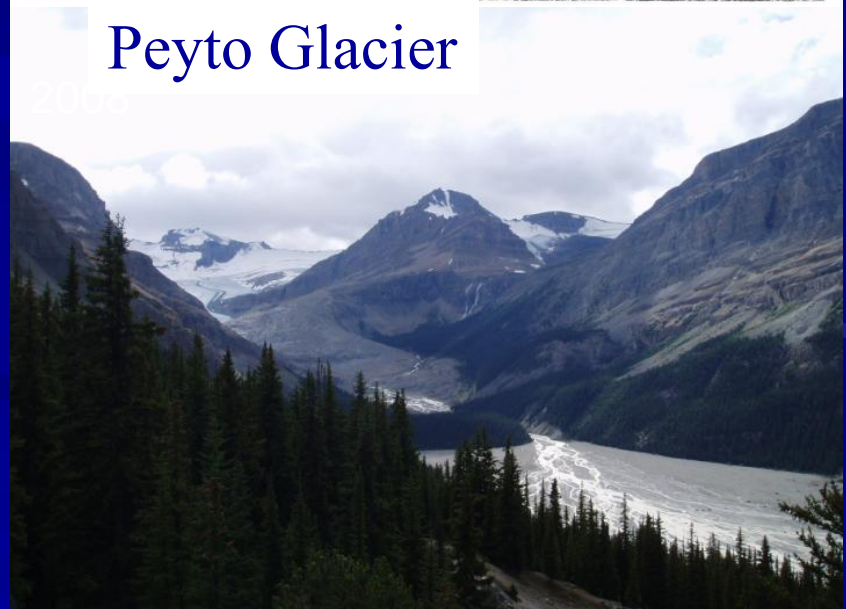
- 1966 summer observations
- 1970 automated summer obs
- 2002 automatic weather stations
 - Off glacier stations by hut
 - 3 ice stations

Process Studies

- Radiation (Goodison, Young, Munro)
- Turbulent transfer (Munro)
- Sub-glacial flow



Peyto Glacier



Existing Instruments

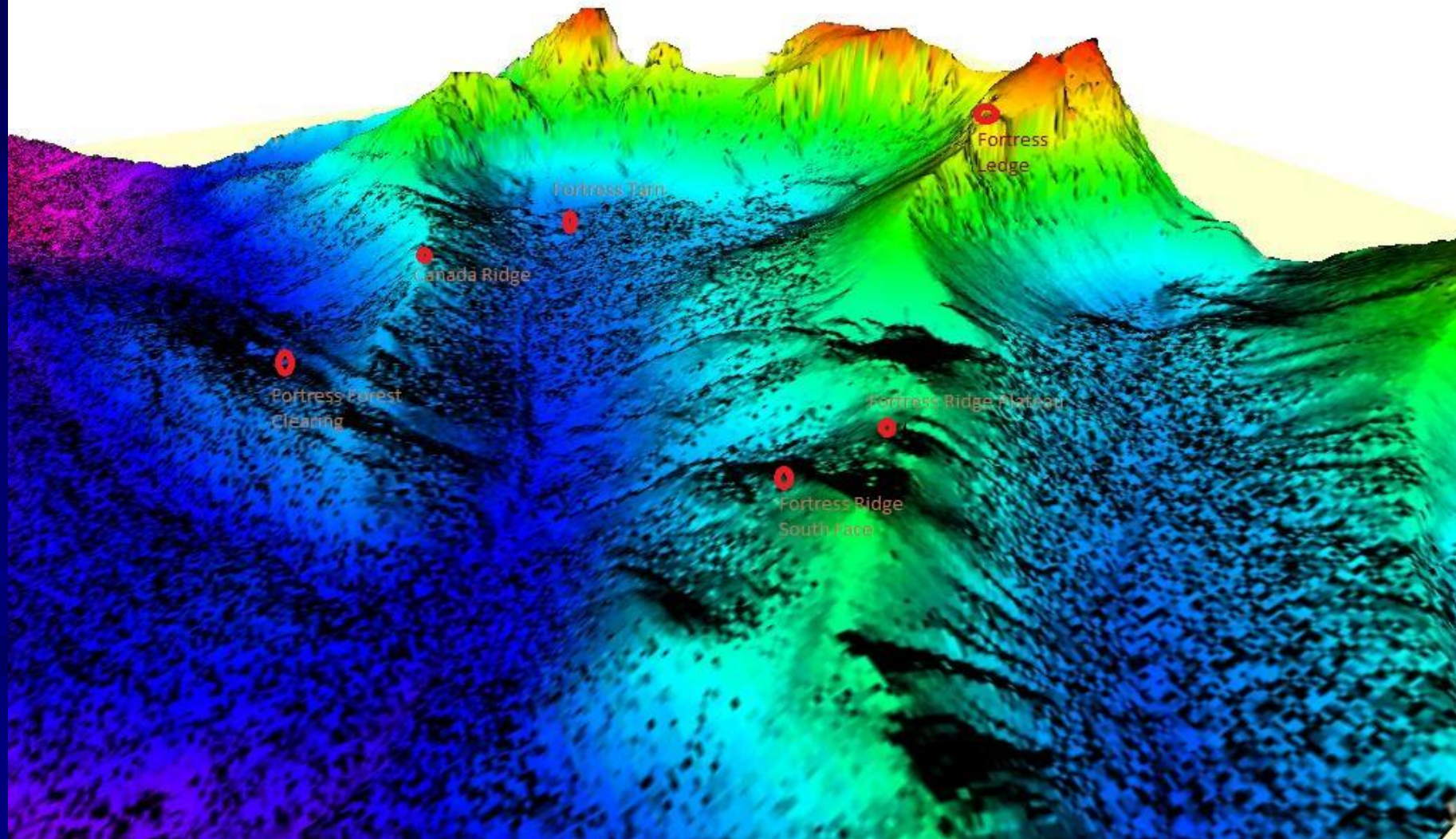


New Instruments



Fortress Mountain Snow Observatory

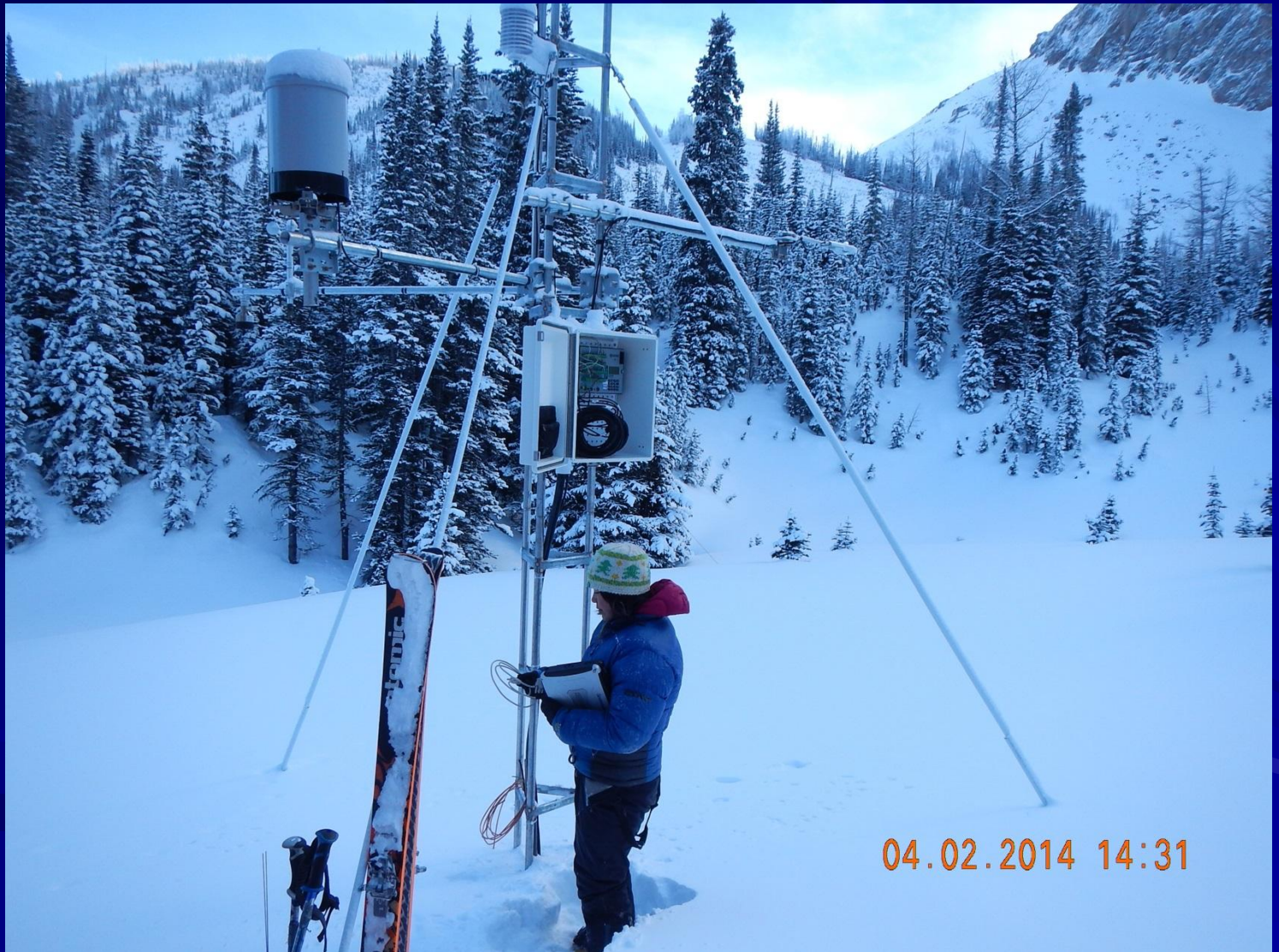
Fortress Mountain
Research Sites



Fortress Mountain Stations



Fortress Mountain Stations



Fortress Mountain Stations



Fortress Mountain Stations



Fortress Mountain Stations



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Next

- Intensive field campaign with eddy correlation, new snow instruments
- Blowing snow and streamflow measurements

