

Finding the Rain/Snow Transition Elevation During Storm Events in Mountain Basins:

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Rain/Snow Transition Elevation

- What is it?
- Why do we care?

Rain/Snow Determination

- **Models usually assumed event is:**
 - “rain” or “snow”, at all elevations
 - **Difficult at a point, *really* difficult over a basin**
 - **Common use of air temperature + threshold (1-5 degrees)**
 - **Site, season, storm dependent**
- * **Dew point temperature: stable indicator of phase**

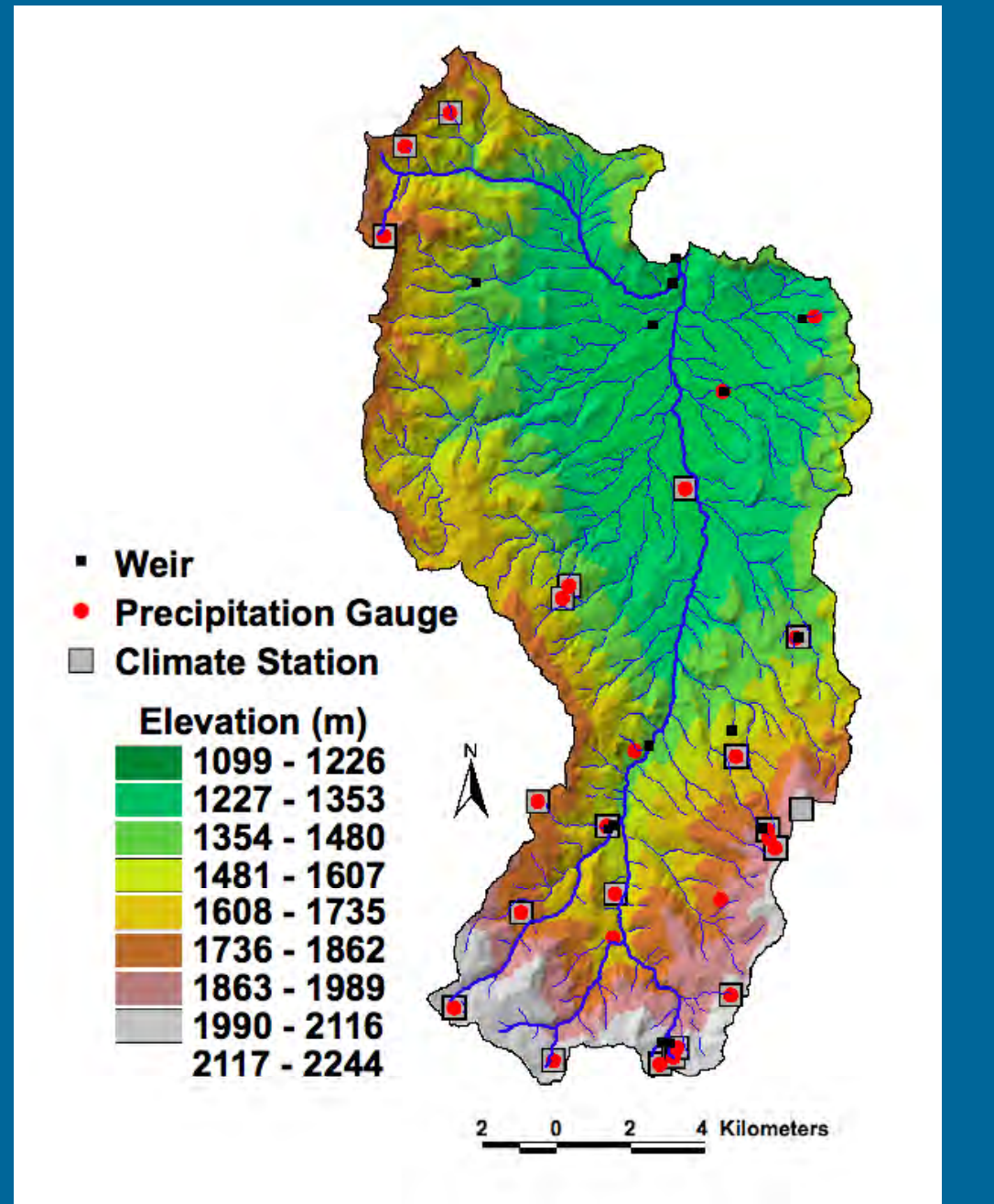
RCEW (239 km²):

- 32 climate stations
- 36 precipitation stations
- 5 EC systems
- 14 weirs (nested)
- 6 soil microclimate stations
- 4 hill-slope hydrology sites
- 4 instrumented catchments
- 3 instrumented headwater basins:

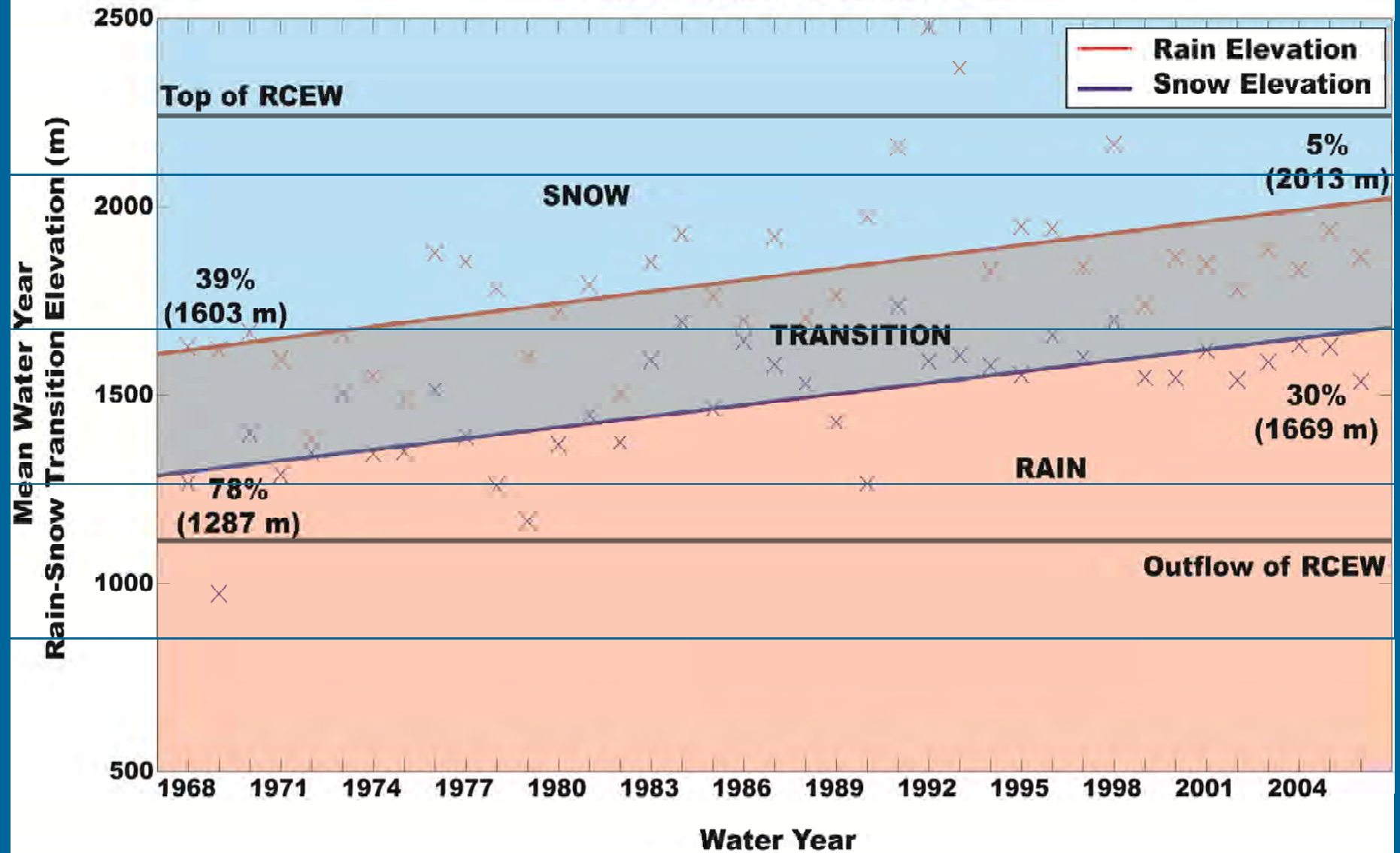
USC (0.25 km², 186m relief)
ephemeral, groundwater dominated,
annual precipitation 300-500mm

RME (0.38 km², 116m relief)
perennial, surface water dominated,
annual precipitation 750-1000mm

Johnston Draw (1.8 km², 380m relief)
ephemeral, rain-snow boundary,
annual precipitation 500-600mm



Changes in the Rain/Snow Transition Elevation 1968-2006 Water Years



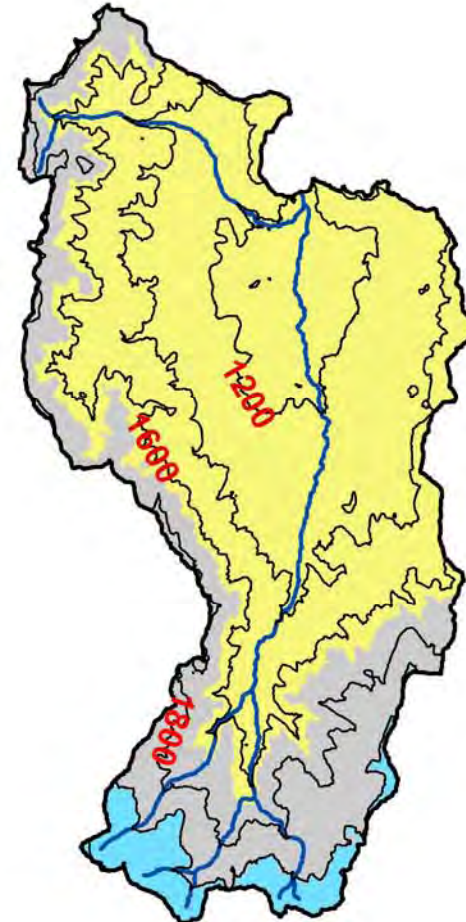
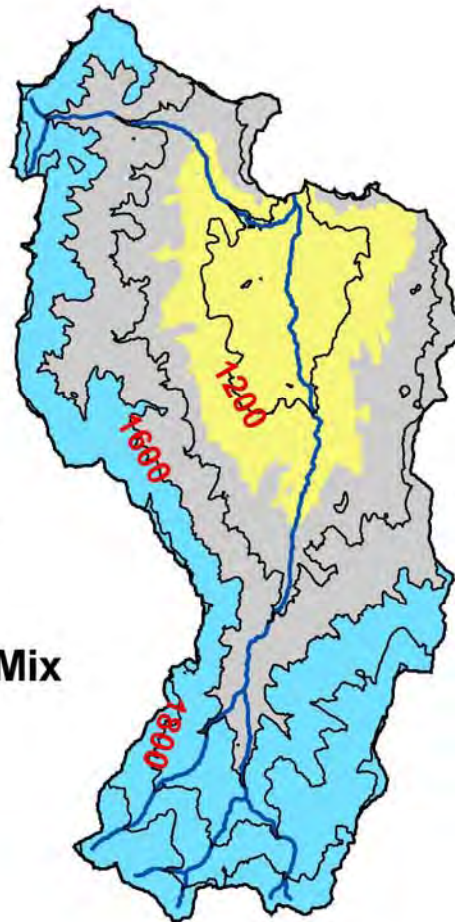
1968

2006

Reynolds Creek Experimental Watershed Idaho, USA

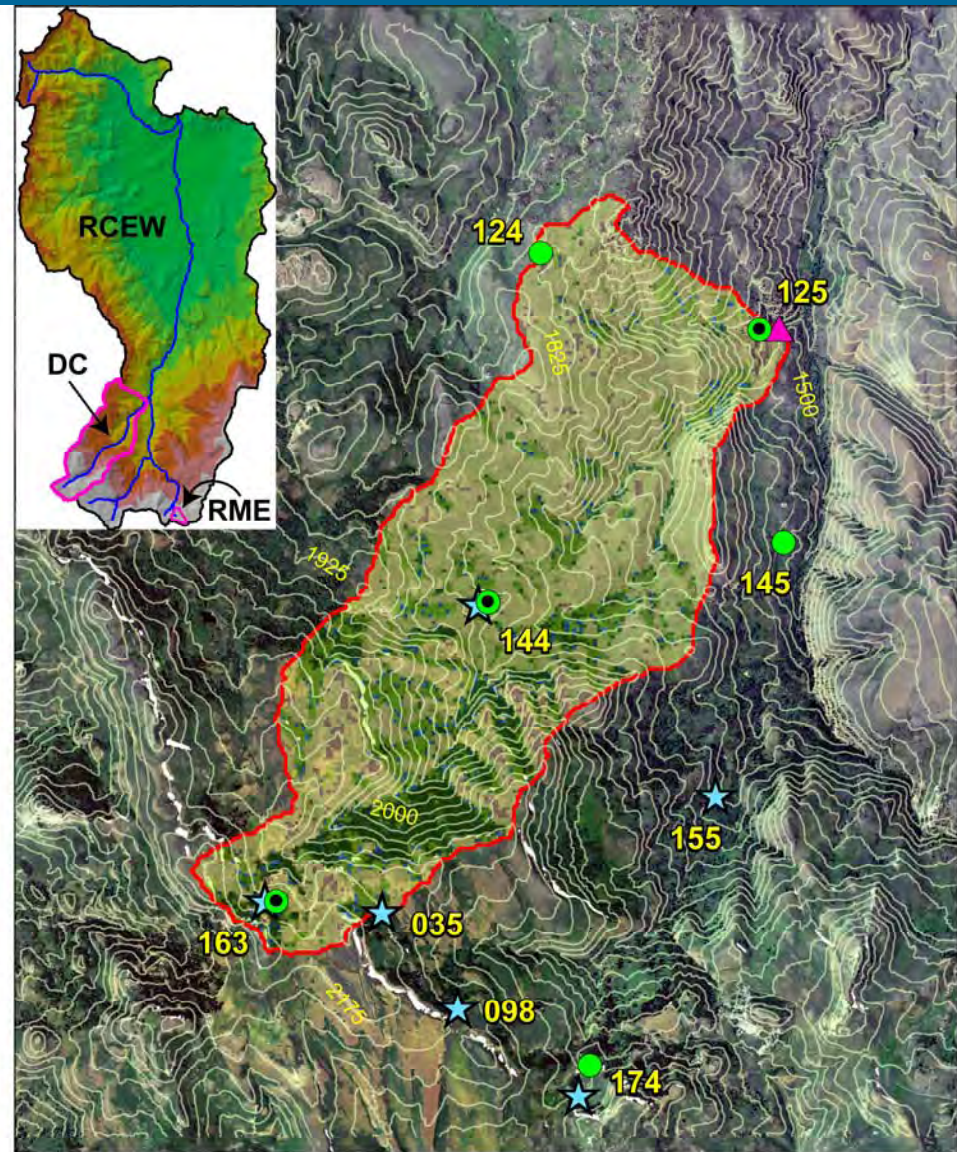
Dominant Precipitation Type

-  Snow
-  Rain/Snow Mix
-  Rain



10
Kilometers
200 m contour interval





Dobson Creek Basin:

1474 – 2244 m (770m)

Fir: 11%

Aspen: 17%

Sage: 72%

6 snow courses

6 precip – met stations

2 weirs

(Johnston Draw included)

The Event:

From Dec 25, 2005, to Jan 1, 2006
(8 days, 192 hrs)

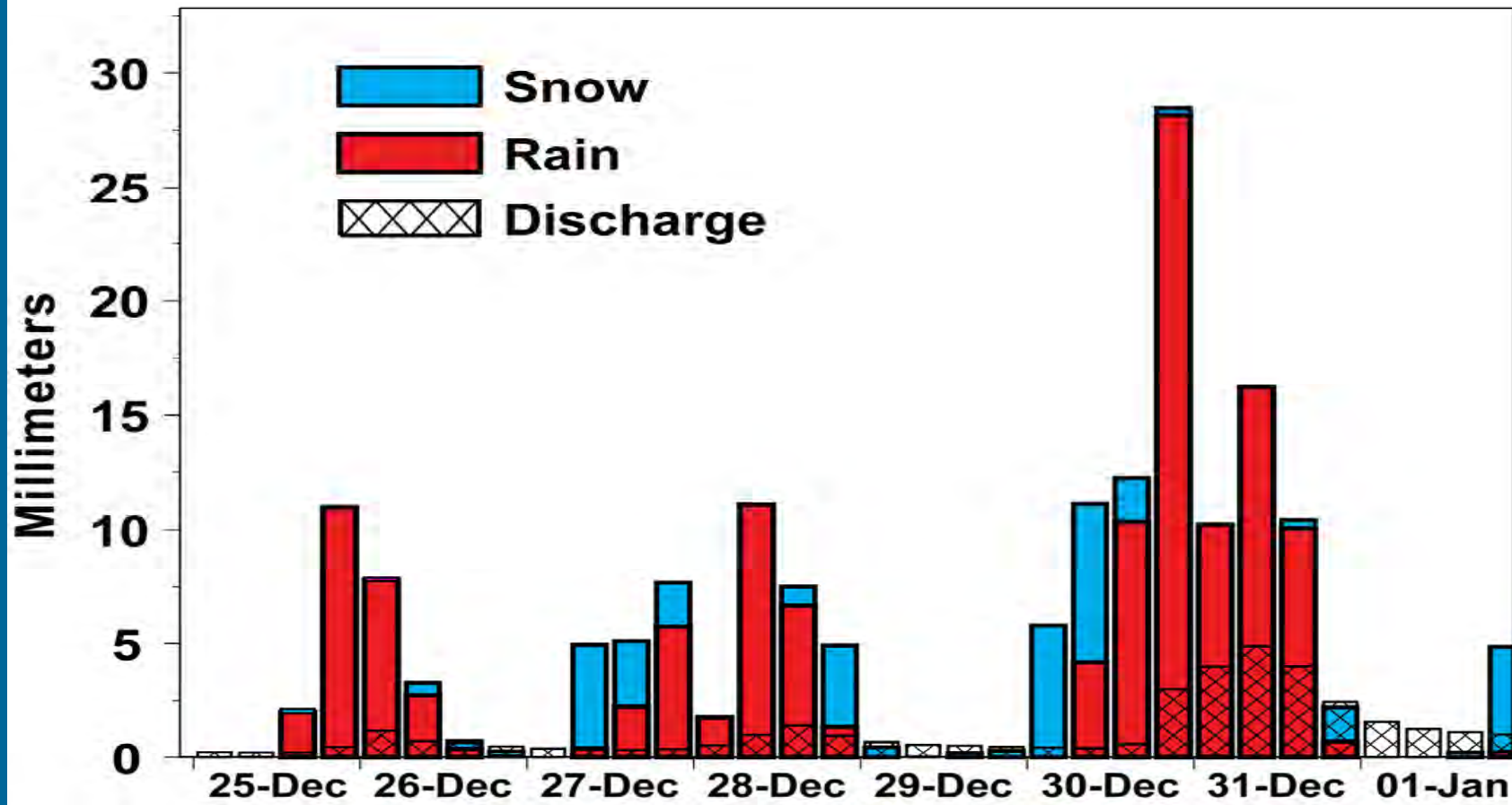
Mixed Rain/Snow Storm Event

174 mm precipitation
(~20% total WY precipitation!)

Multiple Transitions between Rain & Snow

Different Transition times with Elevation

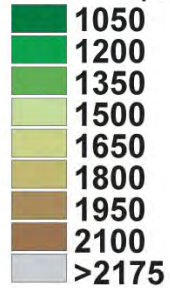
Mixed Rain/Snow Event Dobson Creek Drainage (14.05 km²) 6 hour totals 12/25/05 - 1/1/06 (192 hrs)



Johnston Draw Study Catchment (1.8 km² , 380 m relief)

Johnston Draw:
Reynolds Creek
Experimental Watershed
1.8 km², 380 m relief

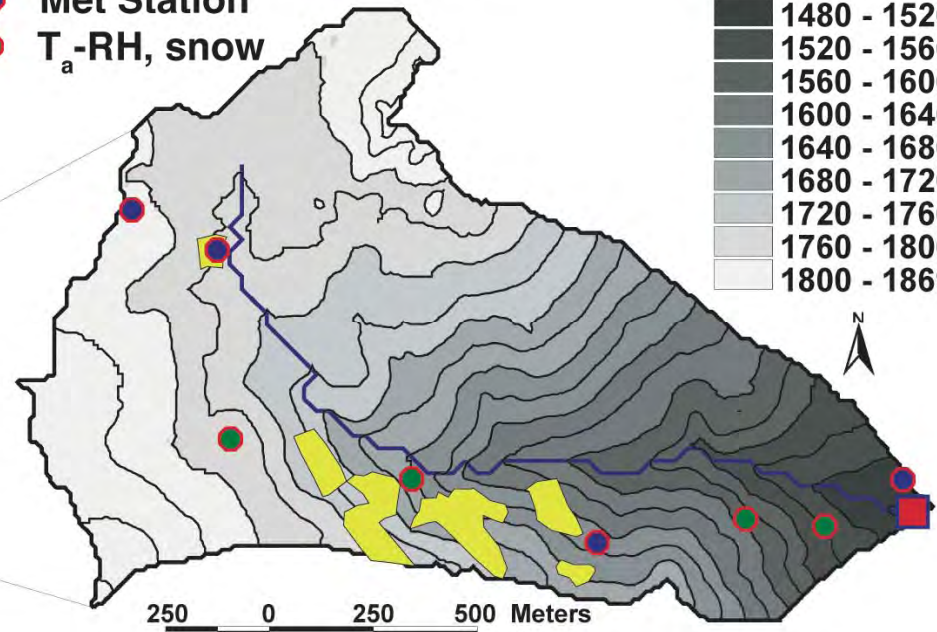
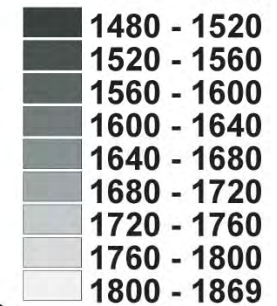
Elevation (m)



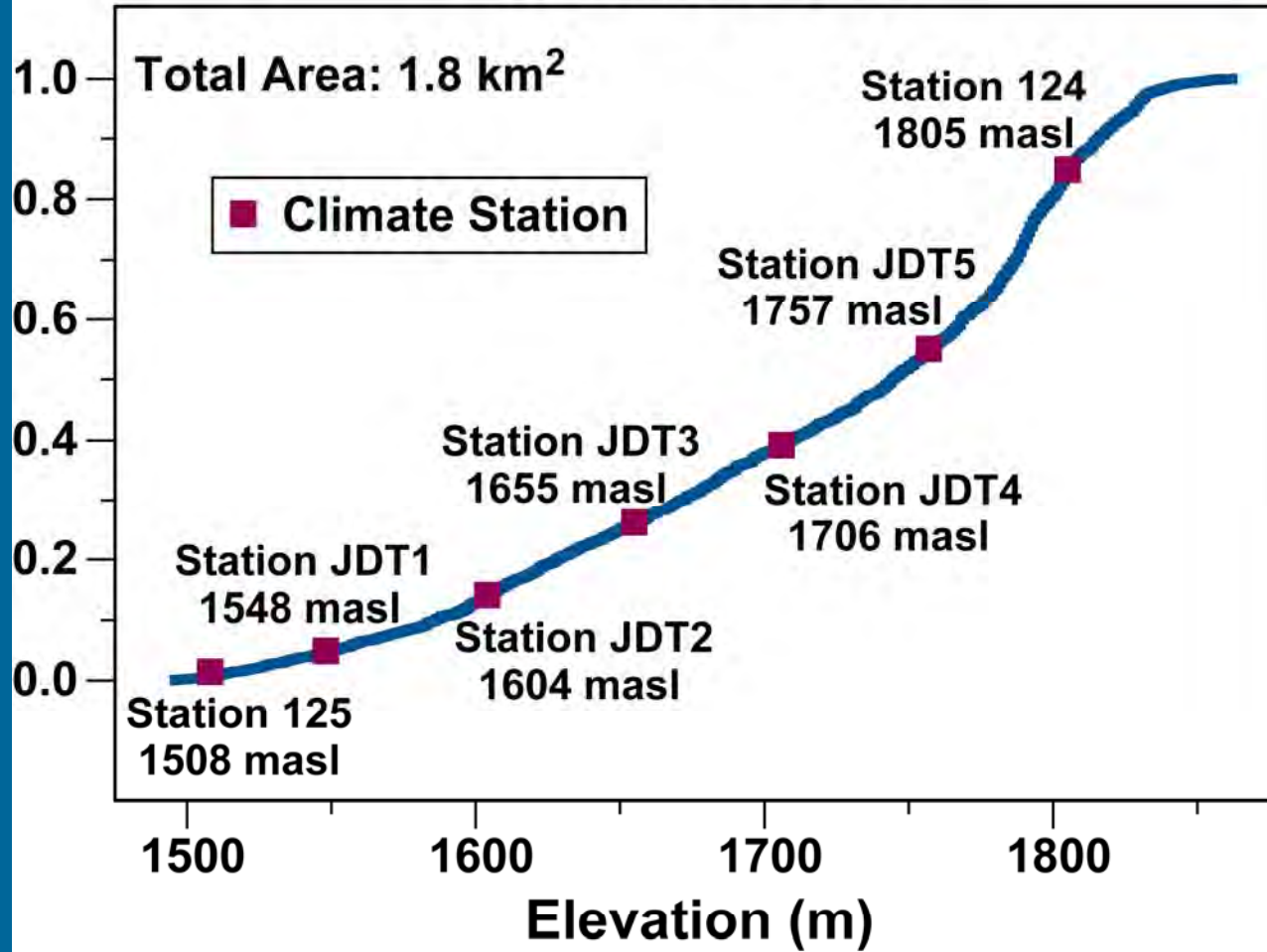
2 0 2 4 6 Kilometers

- Weir
 - Met Station
 - T_a-RH, snow
- Aspen

Elevation (m)



Johnston Draw Hypsometric Curve



The Event Segment:

Dec 30, 2005 for about 24 hours

Mixed Rain/Snow Storm Event

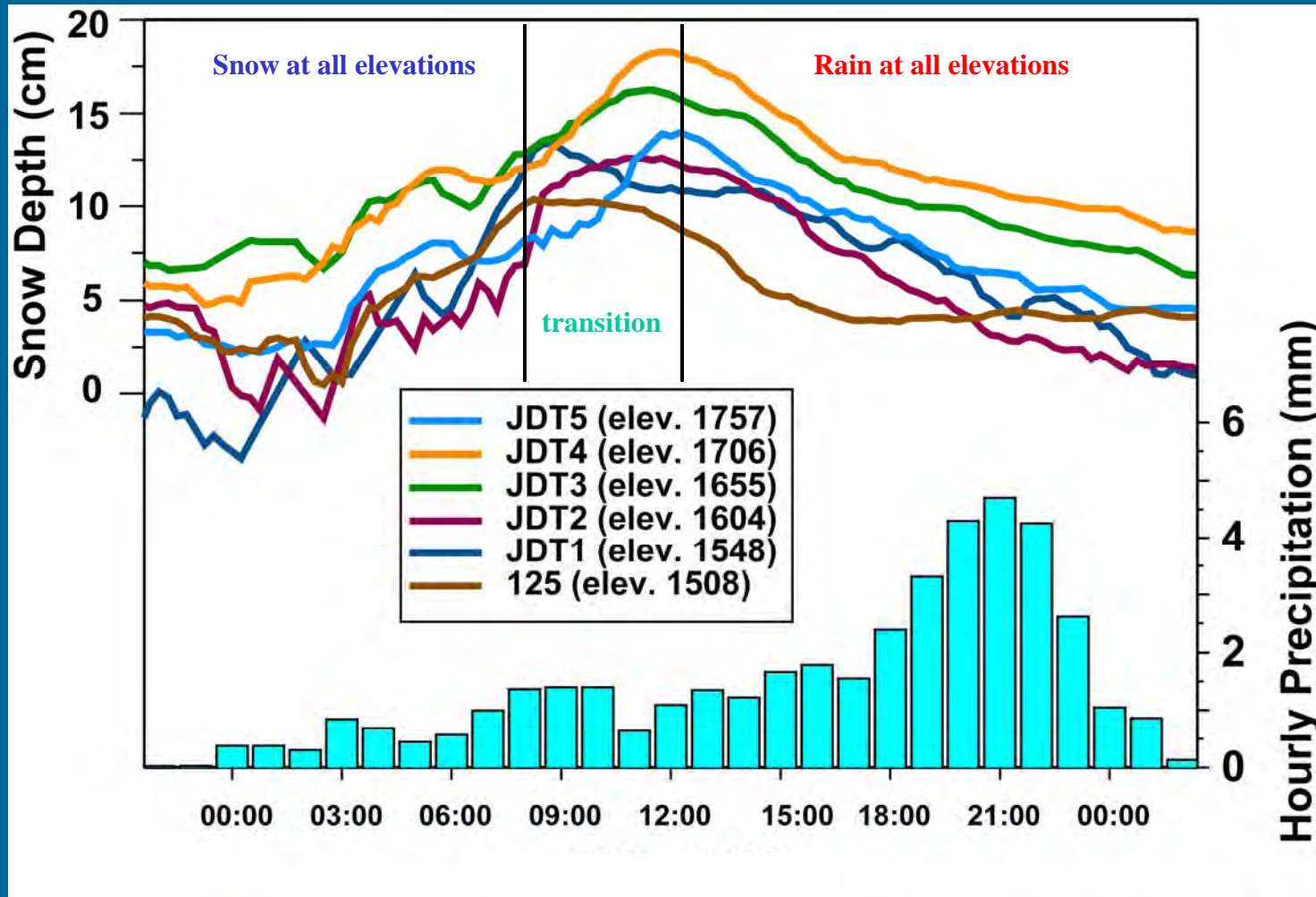
Started as Snow at all elevations (1500-1800m)

Transitioned from Snow to Rain

During a 4-hour period in the morning

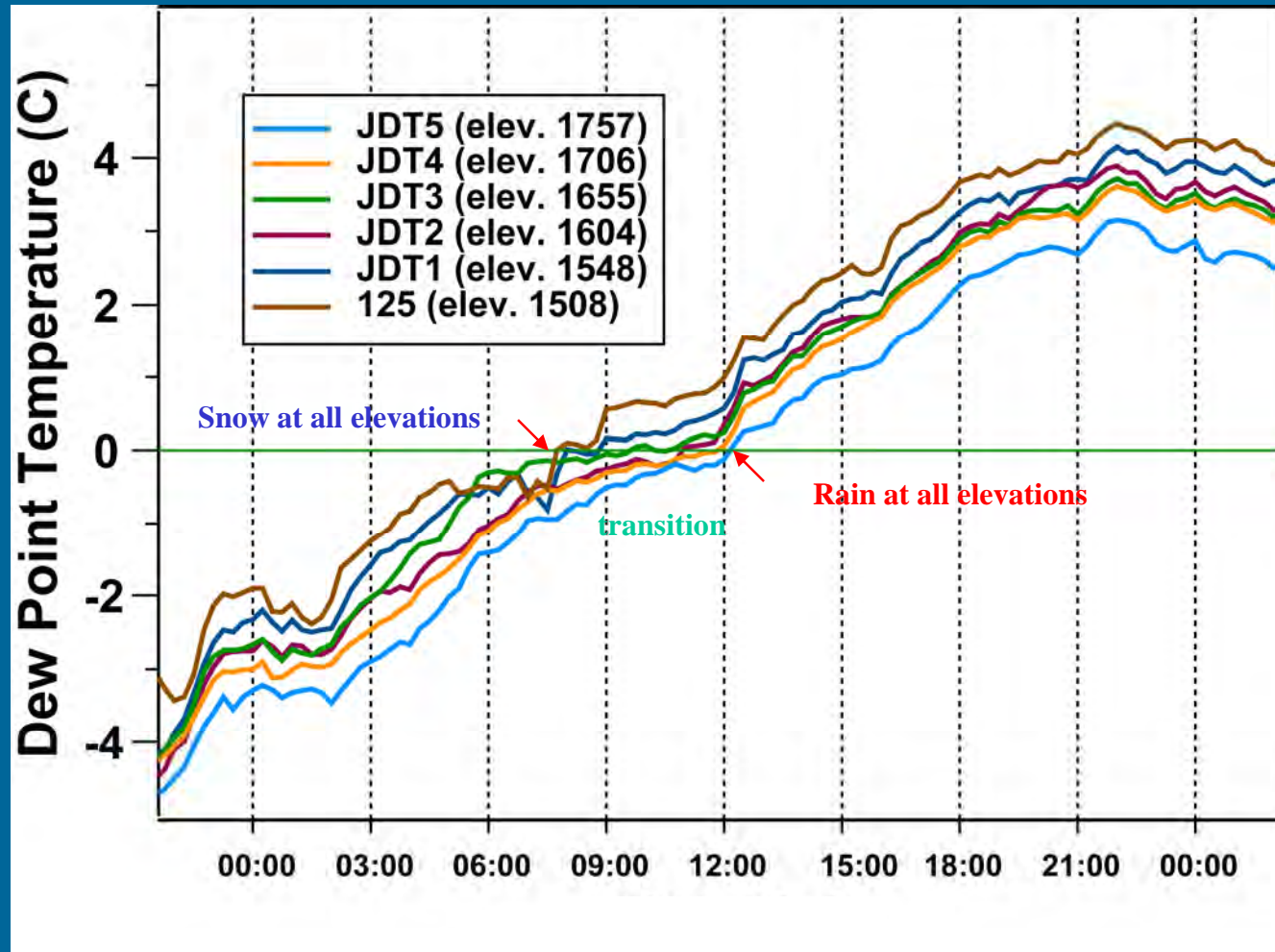
Ending as rain at all elevations

Johnston Draw, RCEW: Dec 30, 2005 Mixed Rain/Snow Storm Event



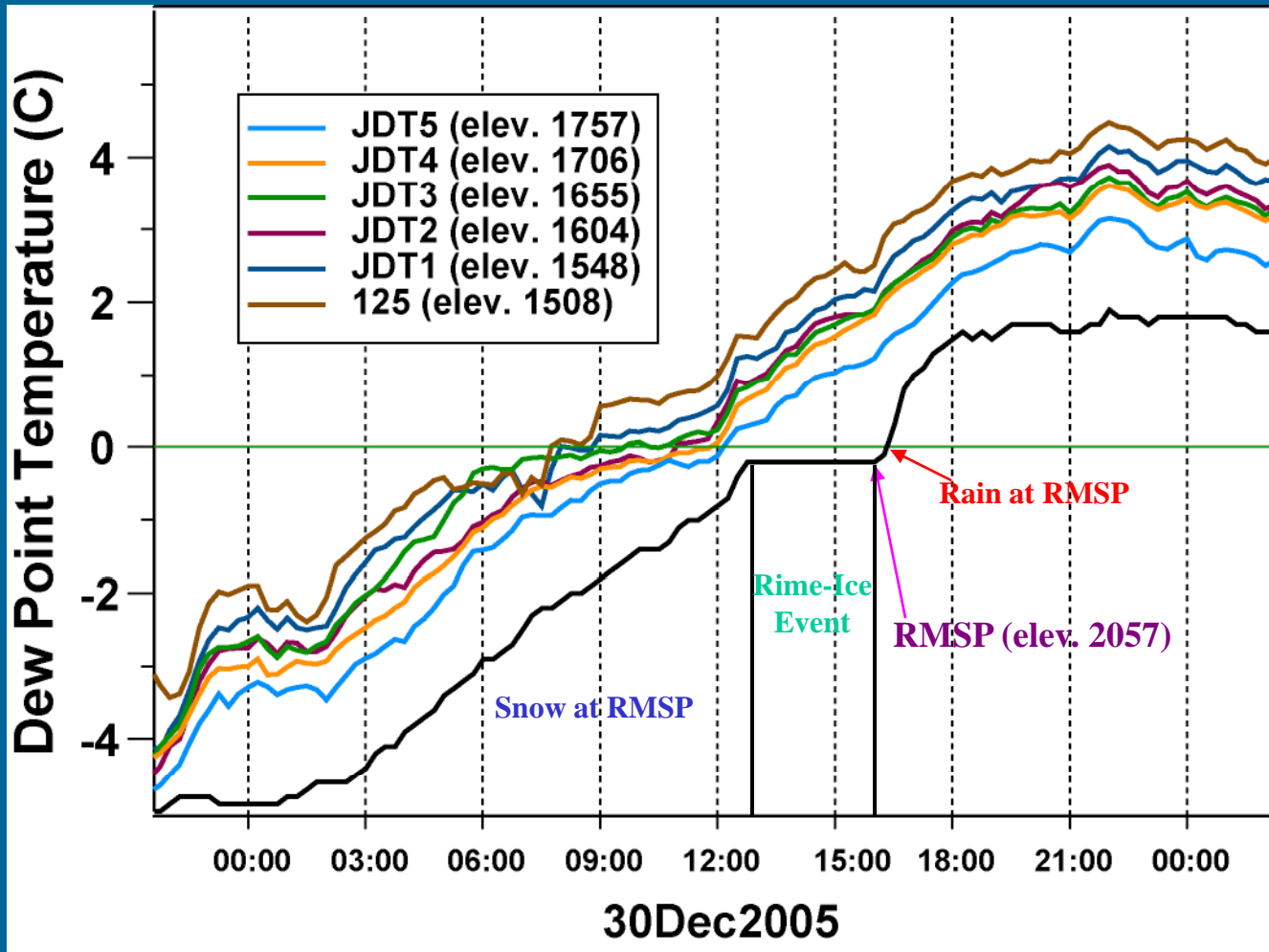
R/S Transition occurs from 7:30AM to 12:15PM

Dec 30, 2005 Mixed Rain/Snow Storm Event Dew Point Temperature Gradient



R/S Transition occurs from 7:30AM to 12:15PM

Dec 30, 2005 Mixed Rain/Snow Storm Event Dew Point Temperature Gradient



**Rime-ice event from 1230-1600;
R/S Transition occurs at RMSP 1630**

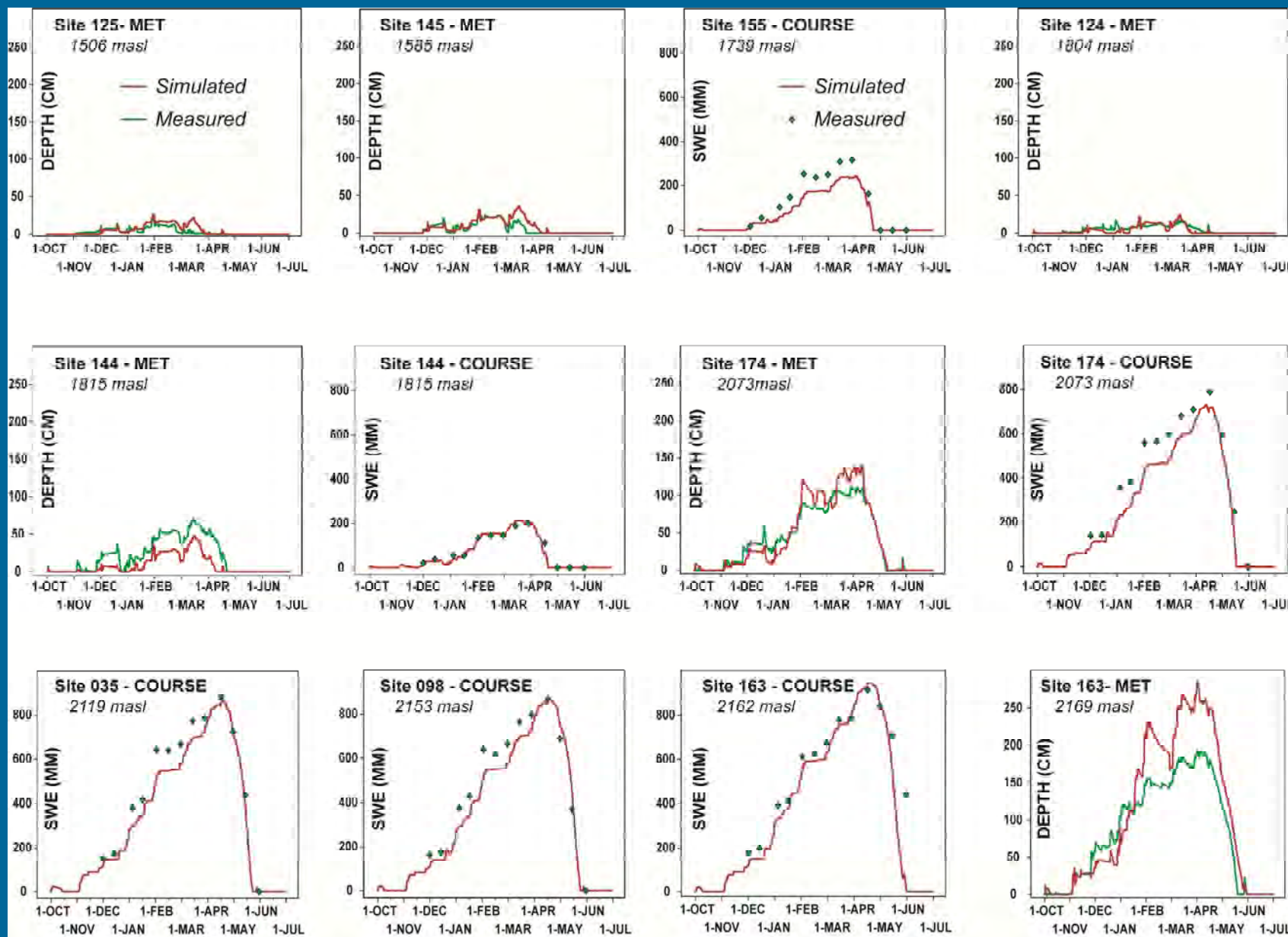
***Isnobar* Simulation of Snow Cover Development and Melting:**

**Two Water Years: 2006 & 2007 Snow Seasons:
Oct 1 – June 30**

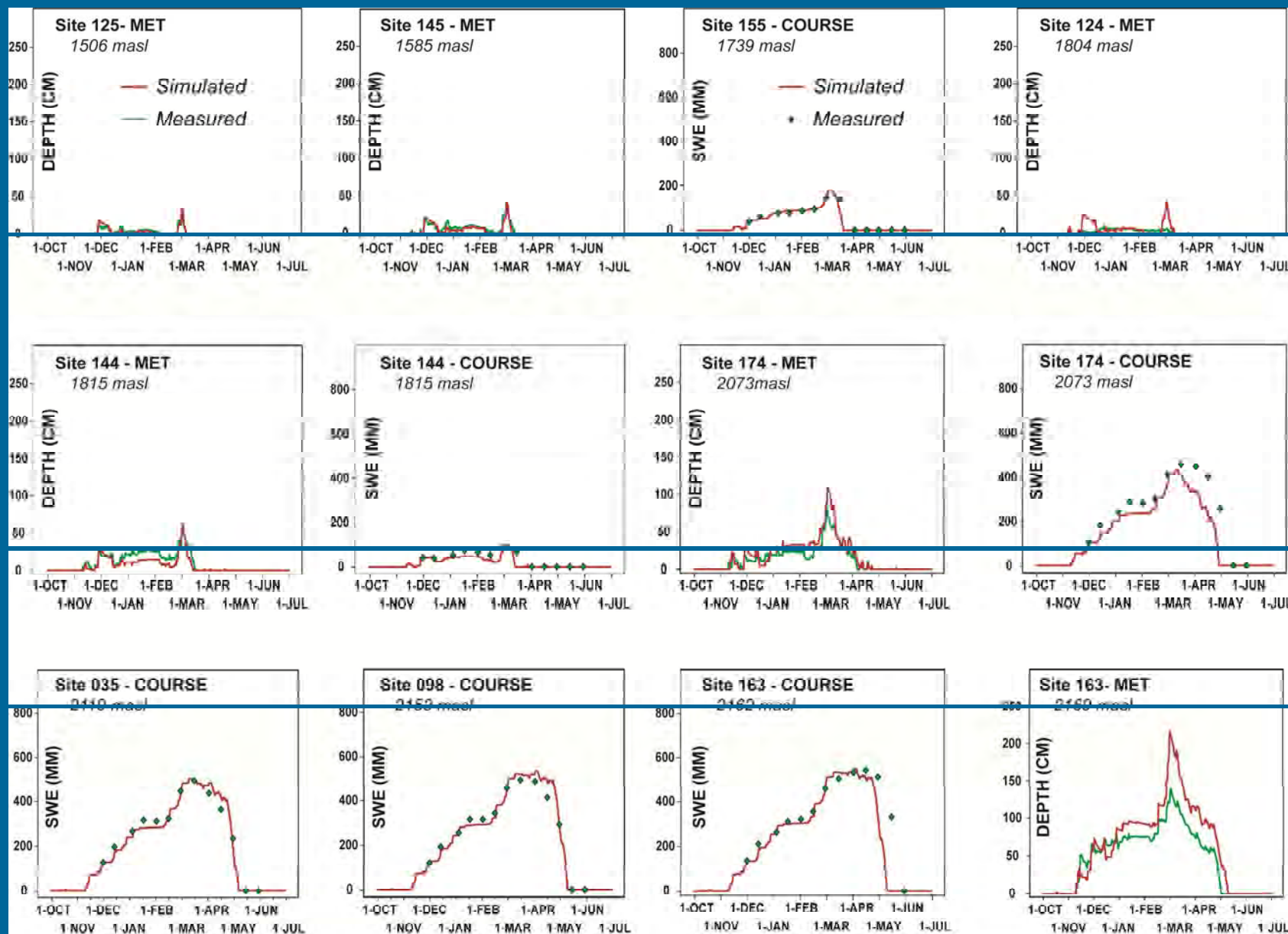
**Dobson Creek Represented by
10 m DEM Grid: 651 x 510 (332,010 cells)**

**2006 was wet & warm (121% L-T Mean)
2007 was dry & warm (74% L-T Mean)**

2006 Snow Season Simulation: validation against SWE & z_s



2007 Snow Season Simulation: validation against SWE & z_s

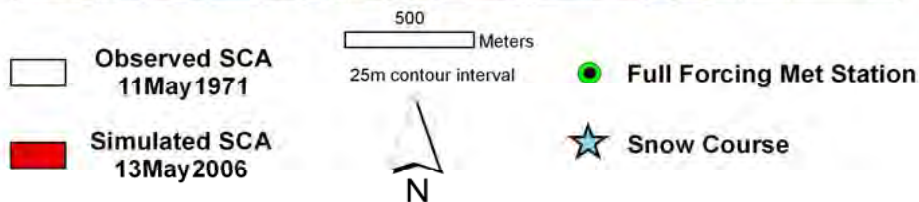
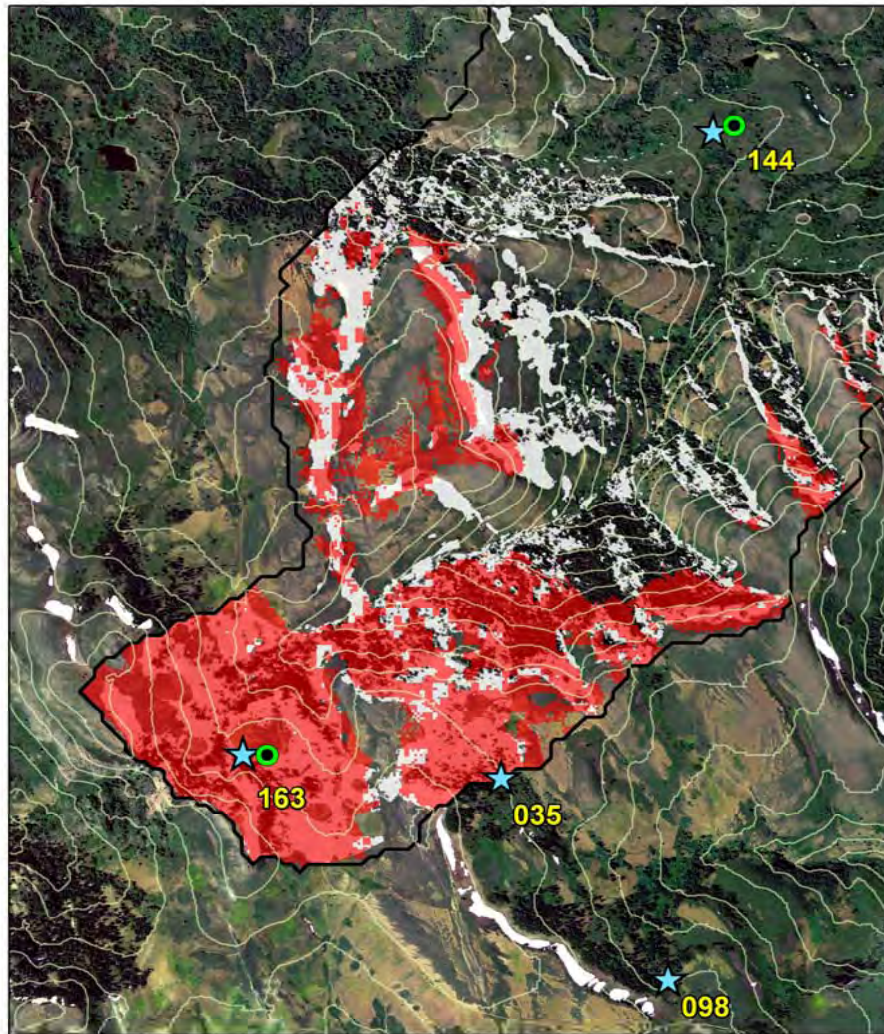


Spatial Evaluation of SCA

Late-lying drifts:

Observed –
May 11, 1971

Simulated –
May 13, 2006

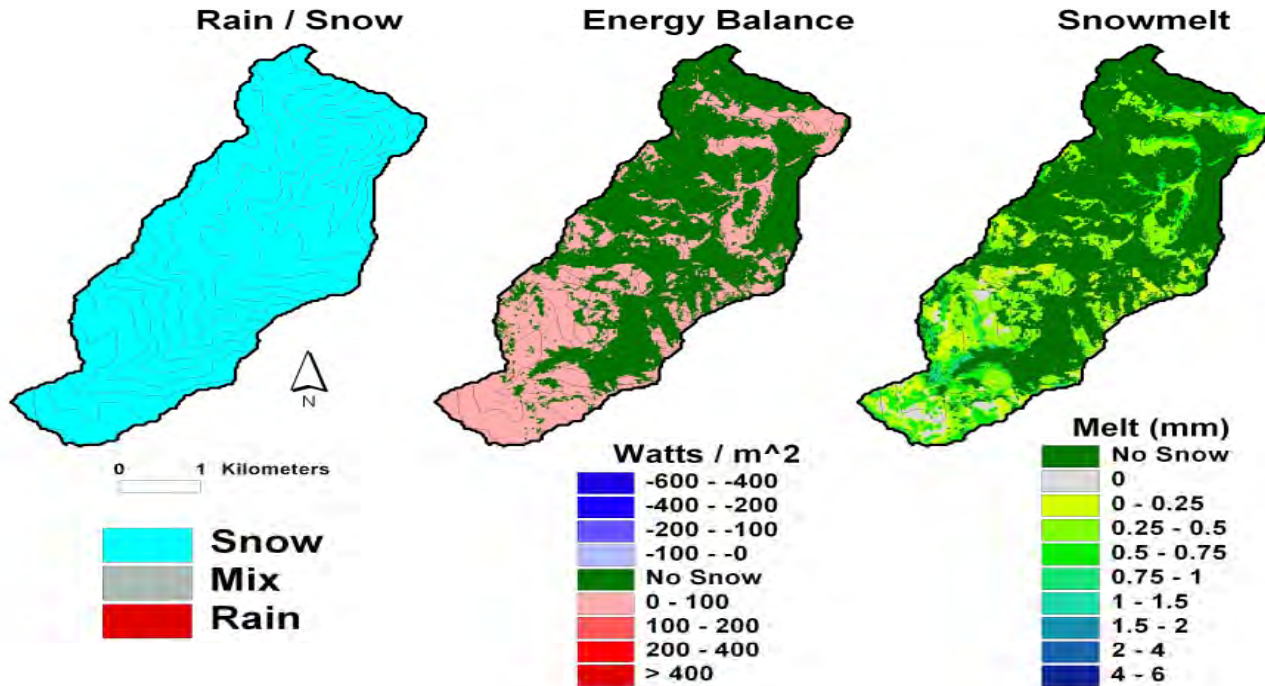


RCEW: Dobson Creek (14.0 km²)

25 Dec 2005 11 hours

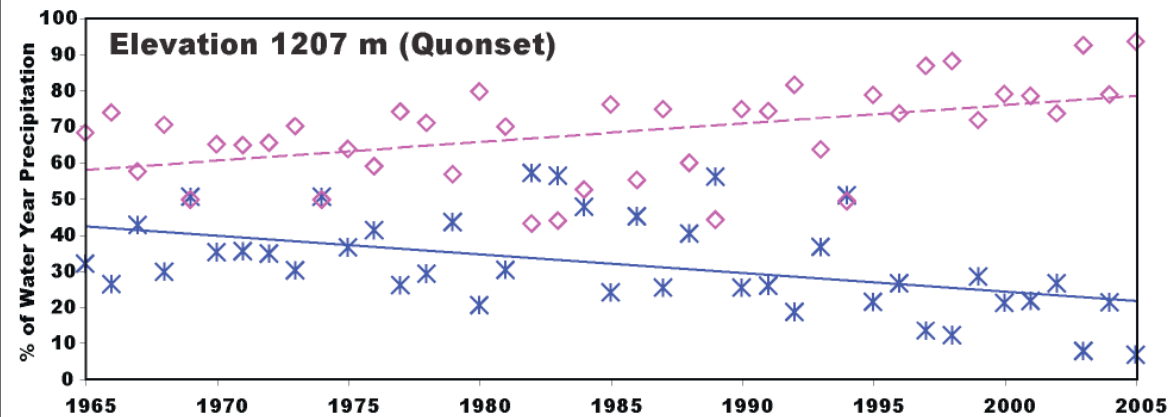
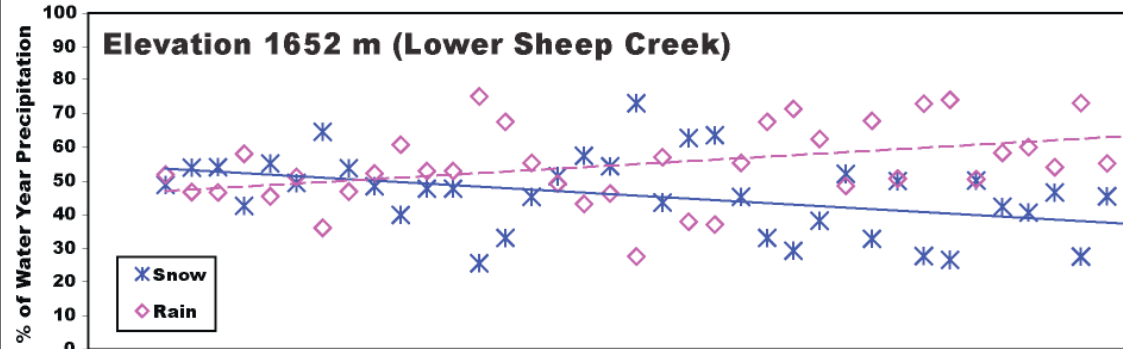
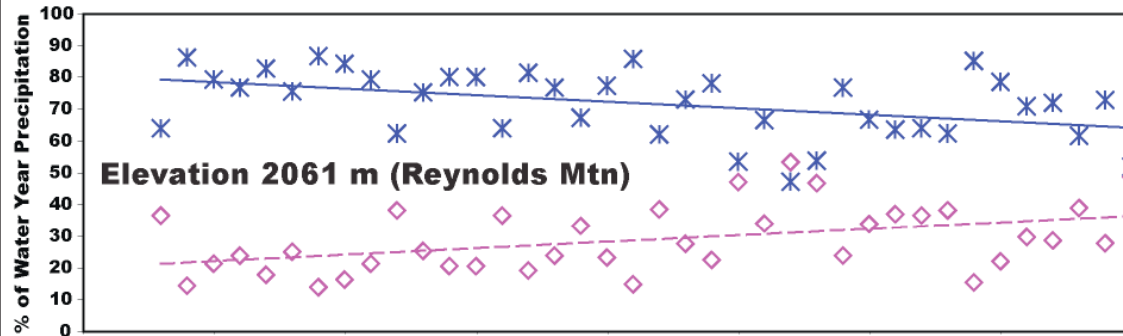
1474 – 2244m:
770 m relief

7-day Mixed
Rain/Snow
Event:
12/25 – 31/2005





Precipitation Type - Rain vs. Snow 1965-2005 Reynolds Creek Experimental Watershed



Snow: -16%:
80% to 62%

Snow: -17%:
55% to 38%

Snow: -22%:
41% to 19%

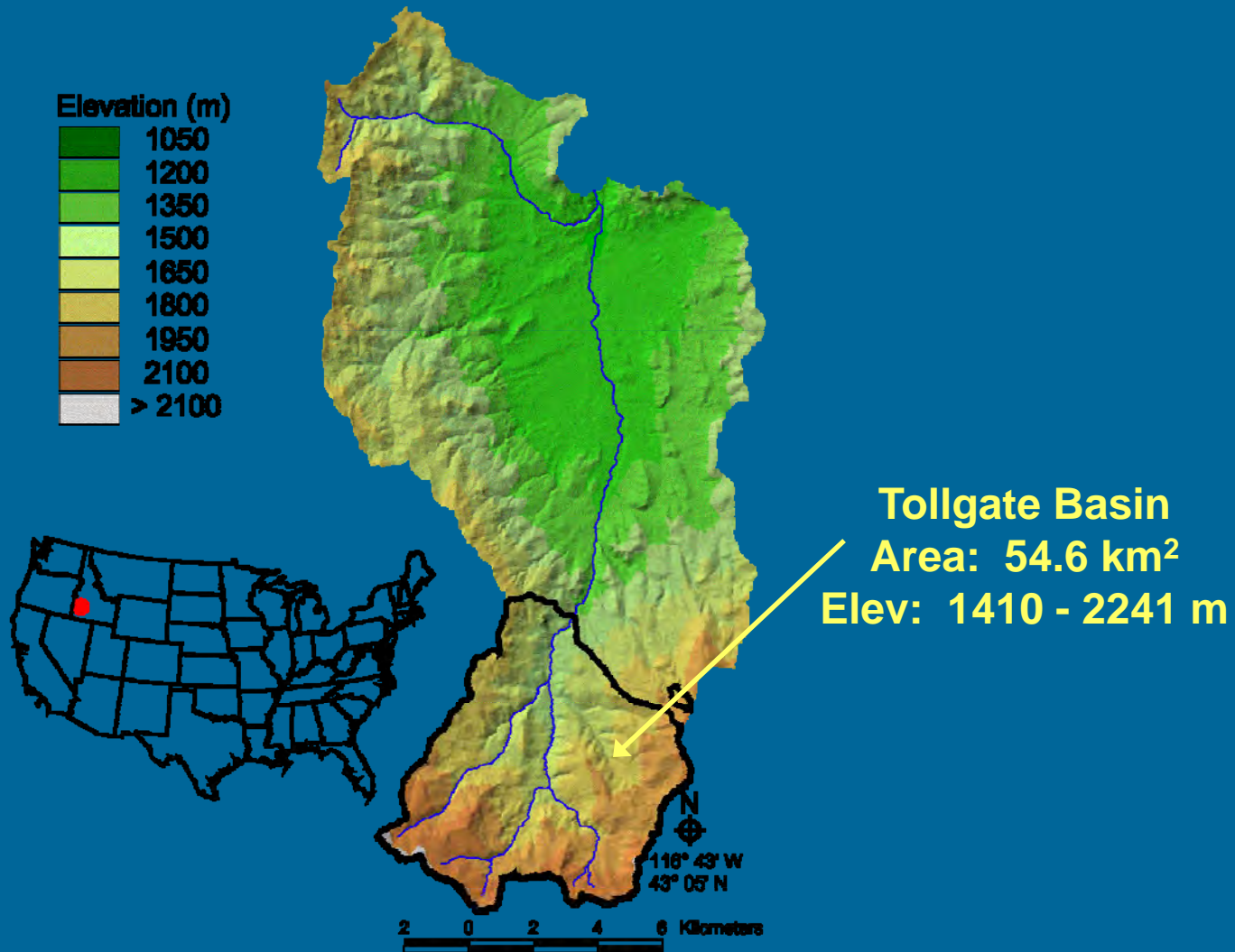
Still Snow
Dominated

Now Rain
Dominated

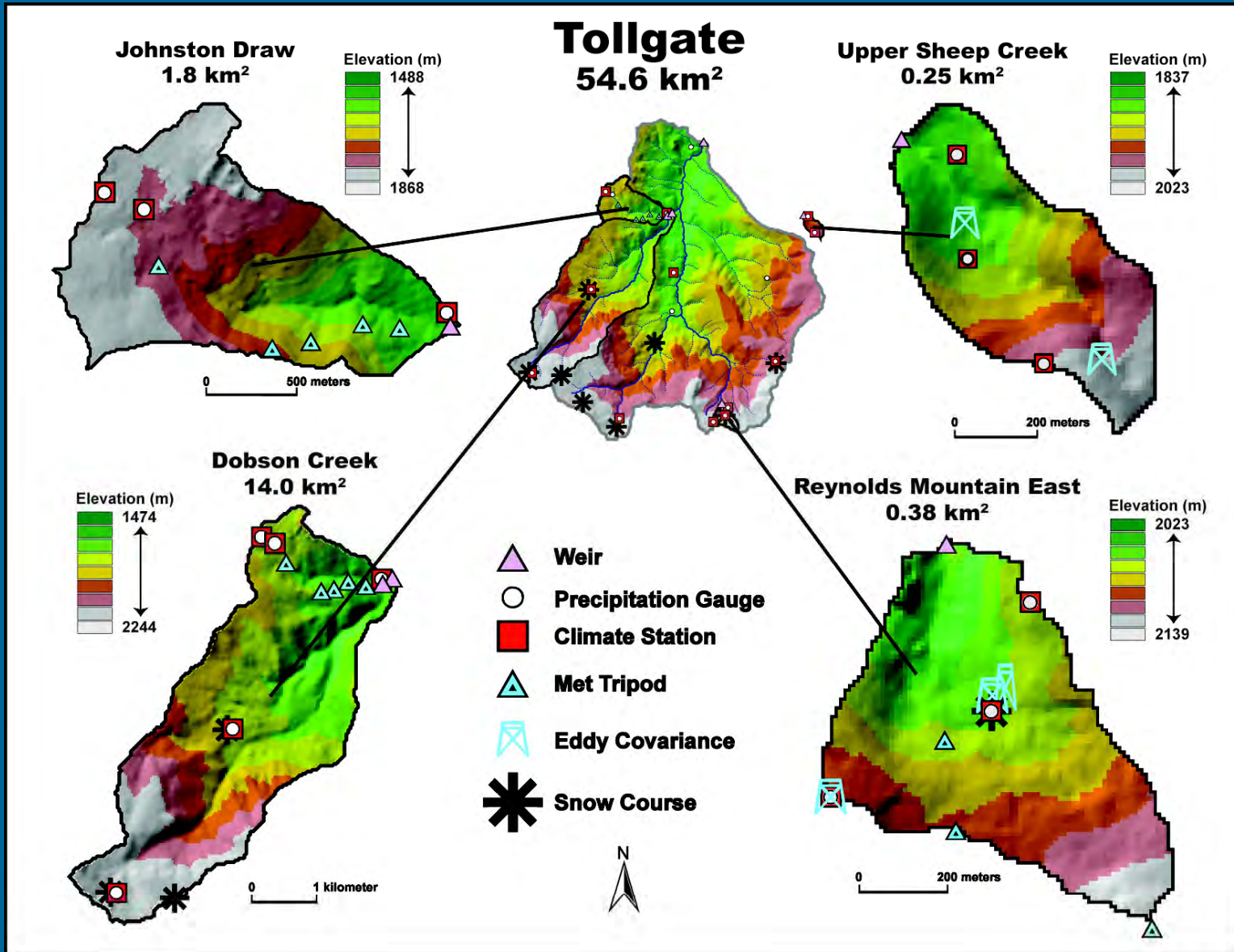
Almost Never
Snows

95%

Reynolds Creek Experimental Watershed



Scaling up to Tollgate



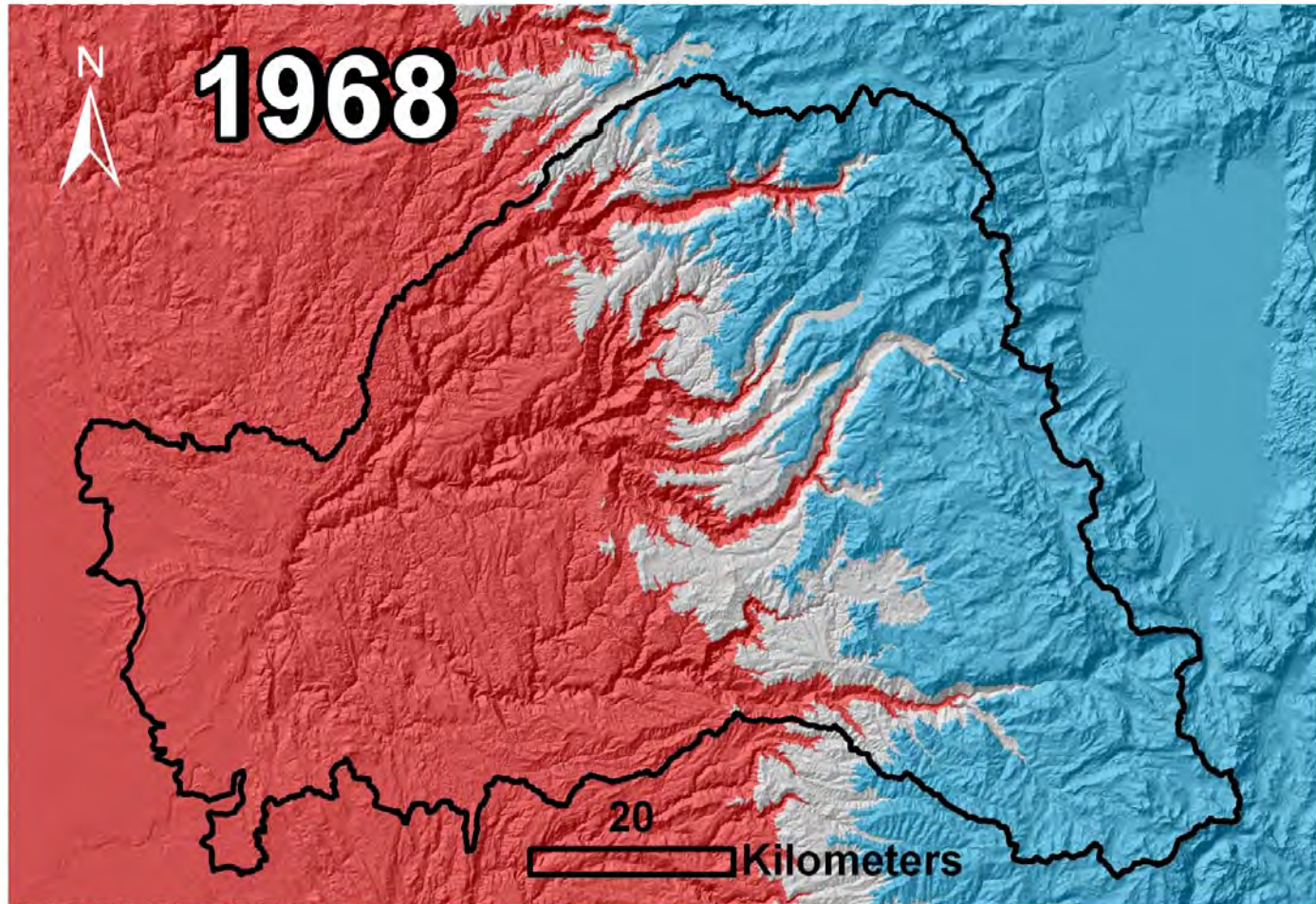
Snow Redistribution and Drifting



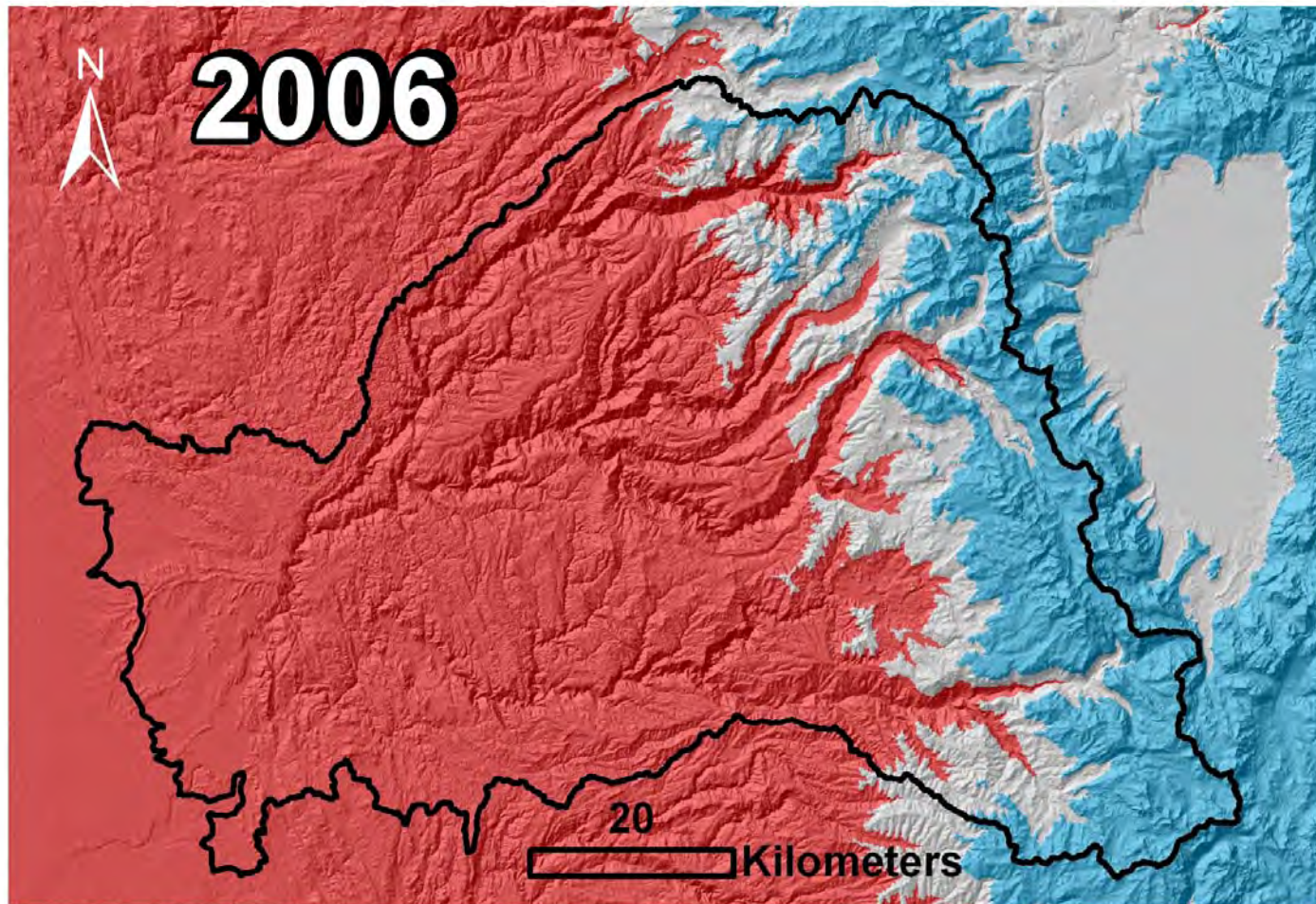
Conclusions

- Air Temperature is not a reliable predictor of precipitation phase:
 - Doesn't follow +/- changes in snow depth
 - Very site specific
 - Not coherent – we would expect $T_a = T_d$ but not always true..
- Dew Point Temperature is a reliable predictor of precipitation phase.
 - Accurately follows +/- changes in snow depth
 - Appears to be site Independent
 - Coherent with elevation

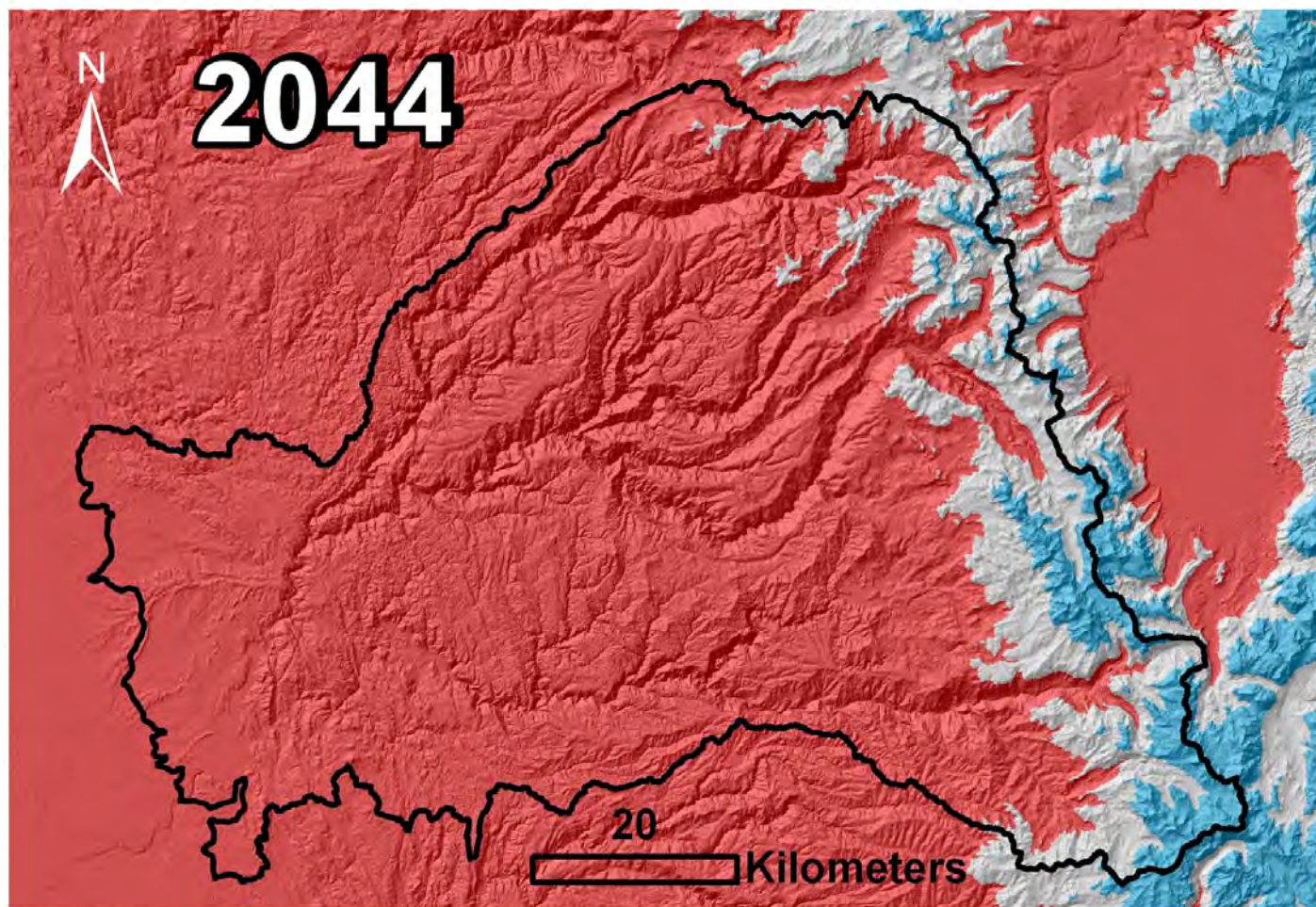
Dominant Precipitation Phase



Dominant Precipitation Phase



Dominant Precipitation Phase



Condensation/Evaporation vs. Advection

$L_v E$ is typically **50-1000** greater than M

$$M = C_{pp} \rho_{pp} Z_{pp} (T_{pp} - T_s)$$

$$L_v E = L_v * E$$

$$\text{melt} = L_v E / L_f \text{ -or- } M / L_f$$

where:

C_{pp} = specific heat of precipitation ($4218-4116 \text{ J kg}^{-1} \text{ K}^{-1}$ ($0-40^\circ \text{ C}$))

L_v = latent heat of vaporization ($2.501 \times 10^6 \text{ J kg}^{-1}$ (0° C))

L_f = latent heat of fusion ($0.334 \times 10^6 \text{ J kg}^{-1}$ (0° C))

ρ_{pp} = precipitation density (kg m^{-3})

Z_{pp} = depth of precipitation (mm)

T_{pp} = average precipitation temperature (K)

T_s = average snowcover temperature (K)

E = evaporation/condensation ($1 \text{ kg H}_2\text{O} = 1 \text{ mm H}_2\text{O} / \text{m}^2$)

Condensation vs. Advection

2 Examples: advection of rain, $\rho_{pp} = 1.0$

z_{dp}	T_{dp}	C_{dp}	M (J m ⁻²)	$l_v E$	Melt (mm)
10	1	4215	42,152		0.12
10	10	4192	419,220		1.26
10	0			25,010,000	74.88
122	3	4208	1,540,128		4.61
7.5	0			18,757,500	56.16

**Can We Extend Trends in
the Rain – Snow Transition Elevation
to other Areas of the West?**

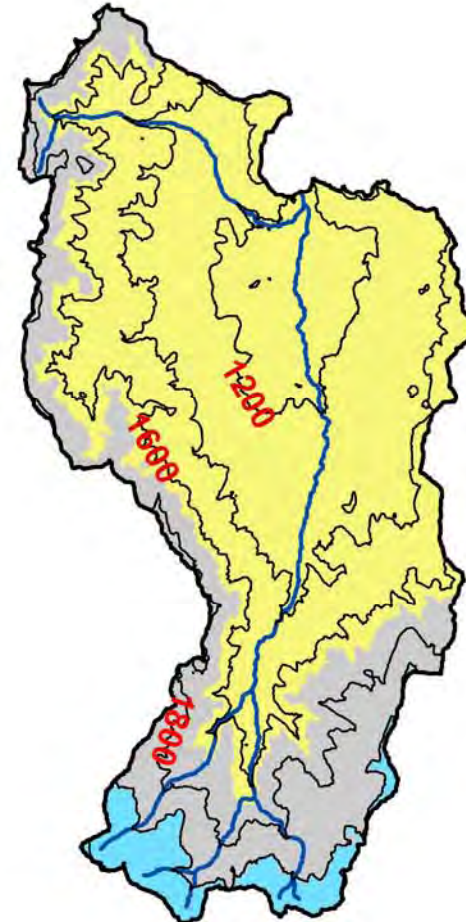
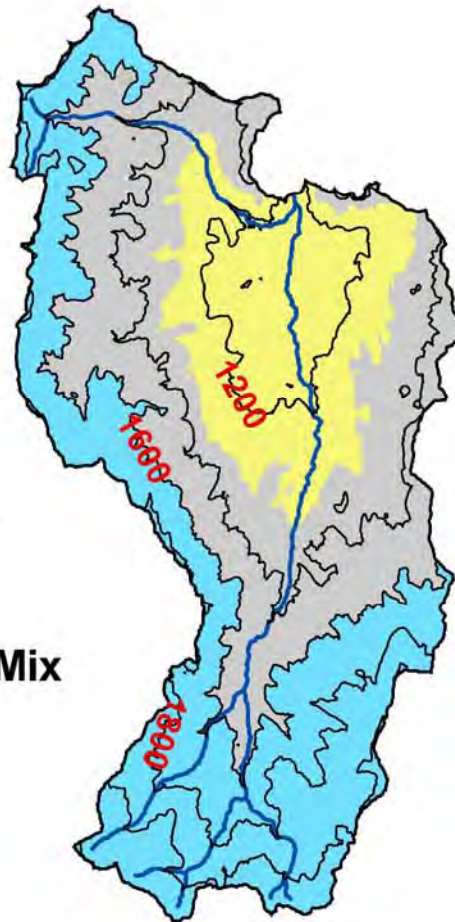
1968

2006

Reynolds Creek Experimental Watershed Idaho, USA

Dominant Precipitation Type

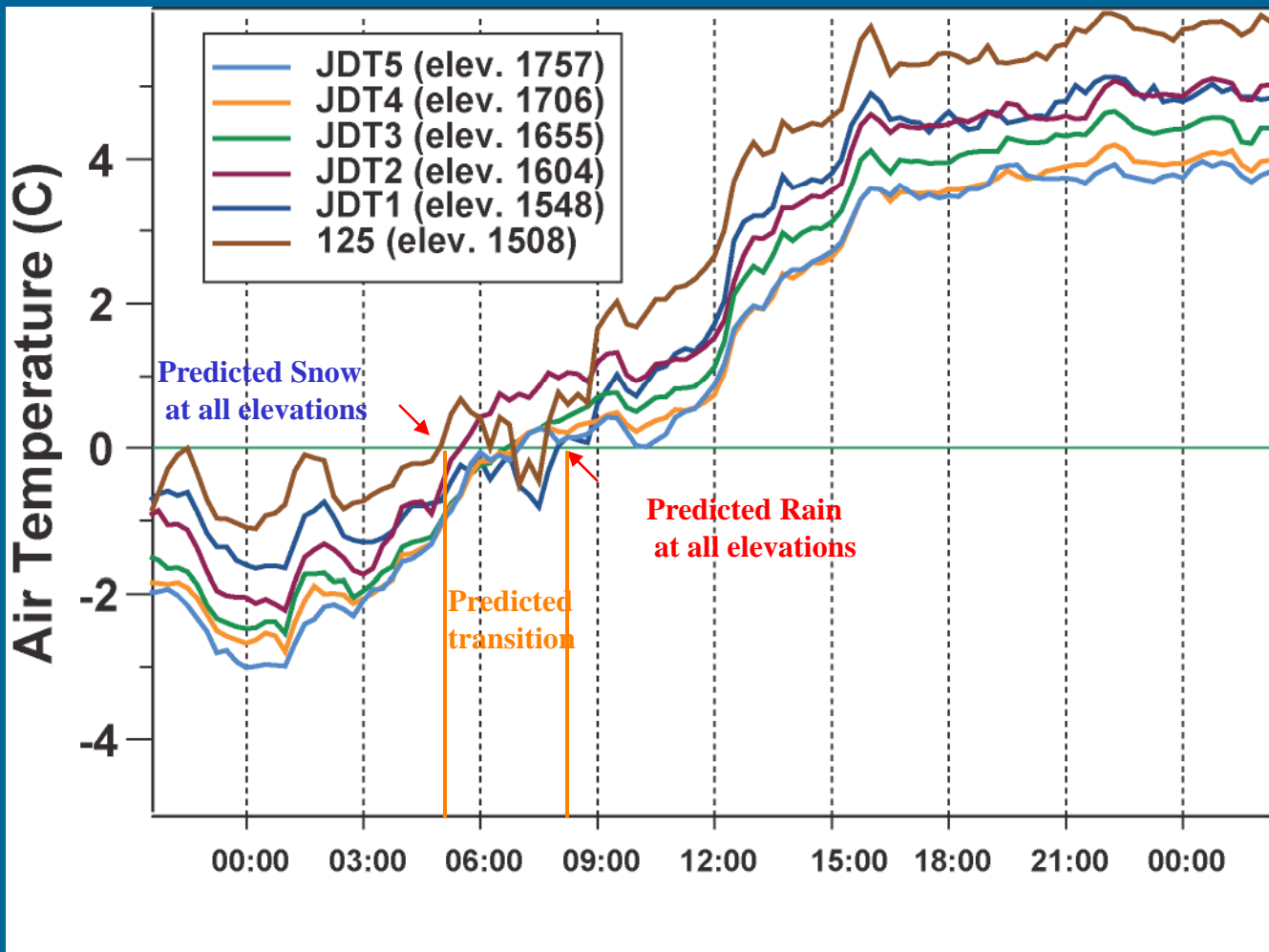
-  Snow
-  Rain/Snow Mix
-  Rain



10
Kilometers
200 m contour interval



Dec 30, 2005 Mixed Rain/Snow Storm Event Air Temperature Gradient



Predicted R/S Transition occurs from 5AM to 8AM

