How desert dust is influencing Colorado snowmelt.

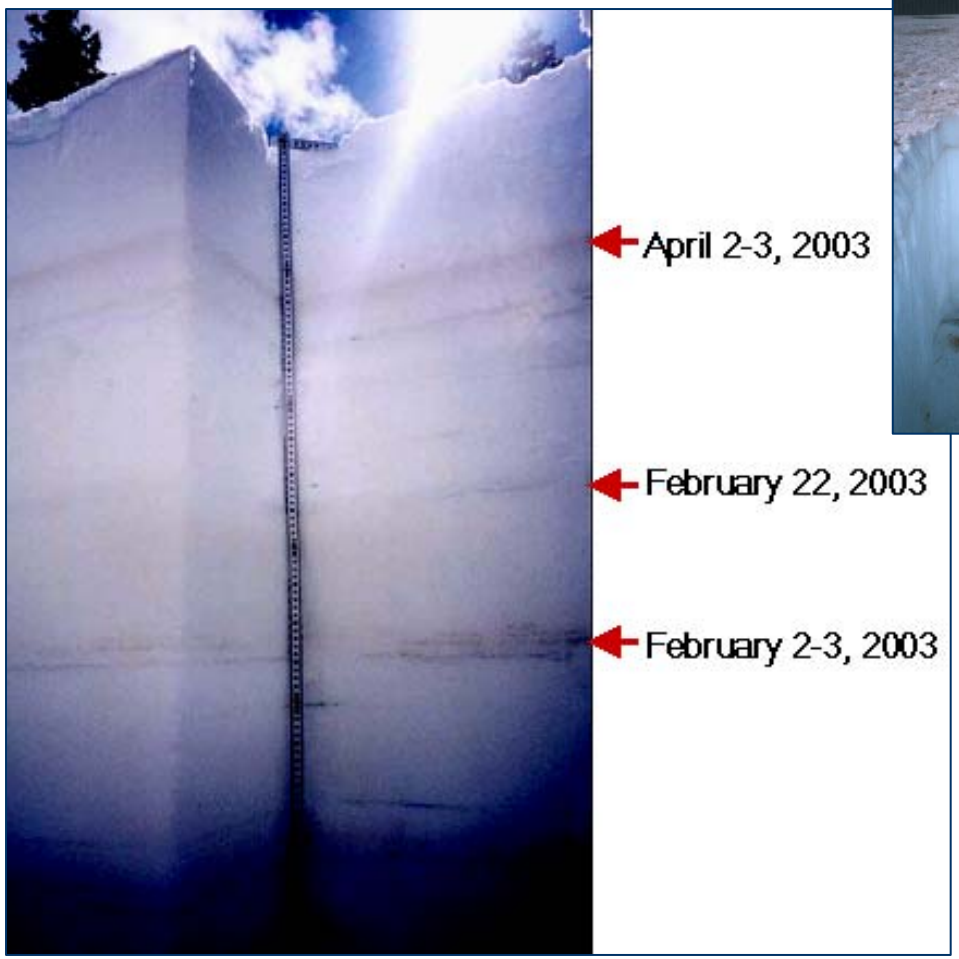
Chris Landry
Center for Snow and Avalanche Studies Silverton, CO

&

Tom Painter - Univ. of Utah

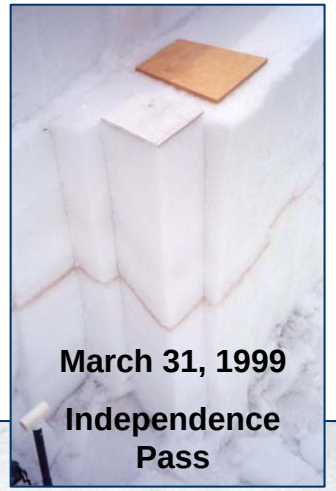
Andy Barrett - NSIDC

Dust Deposition in Colorado Snowpacks

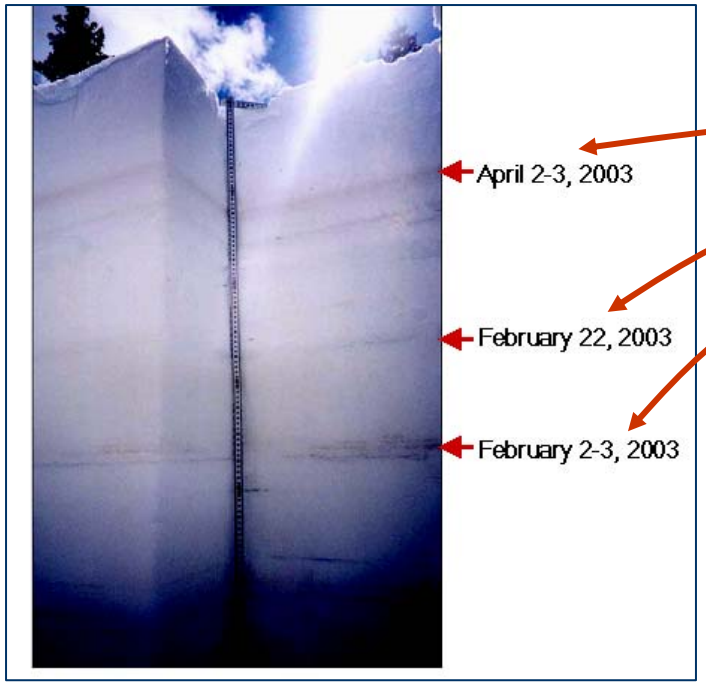


2003

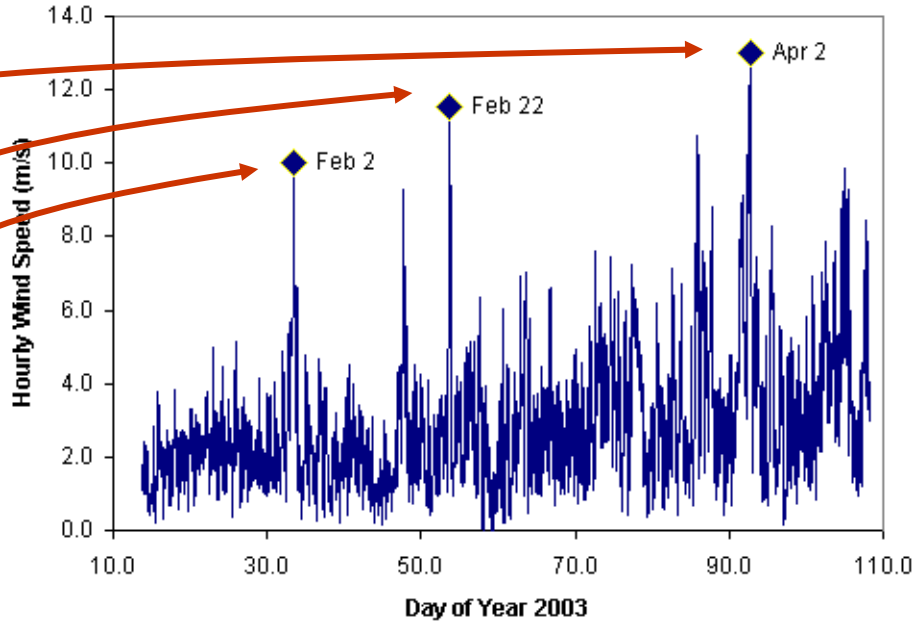
1999



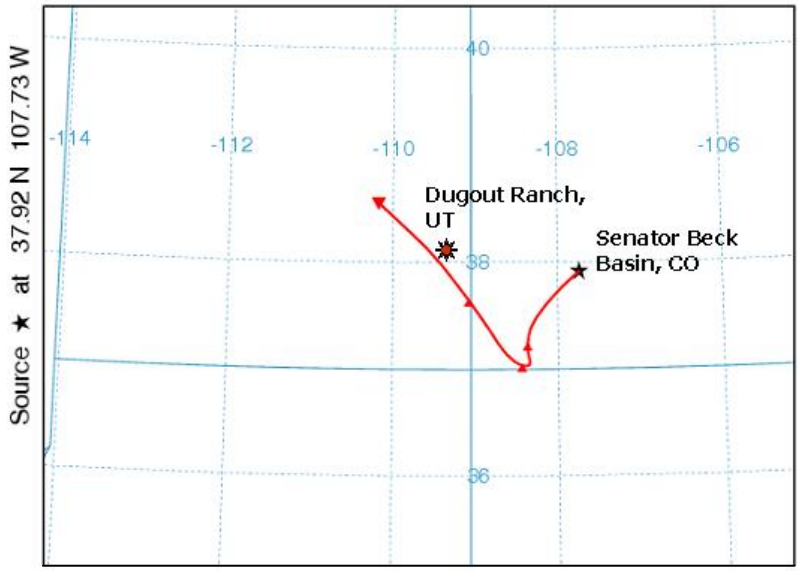
2004



Dugout Ranch Wind Speed



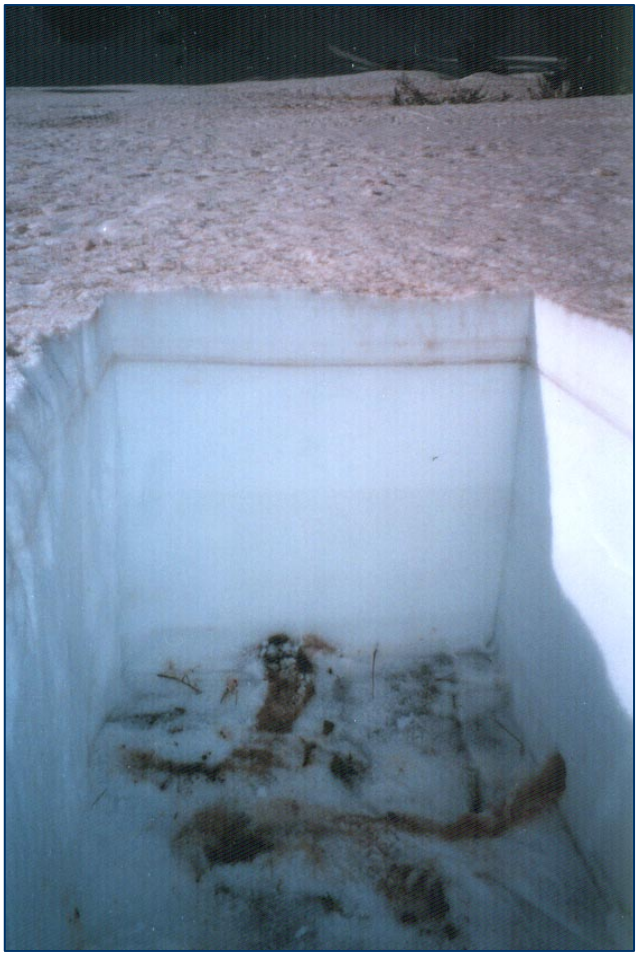
NOAA HYSPLIT MODEL
Backward trajectory ending at 00 UTC 02 Feb 03
EDAS Meteorological Data



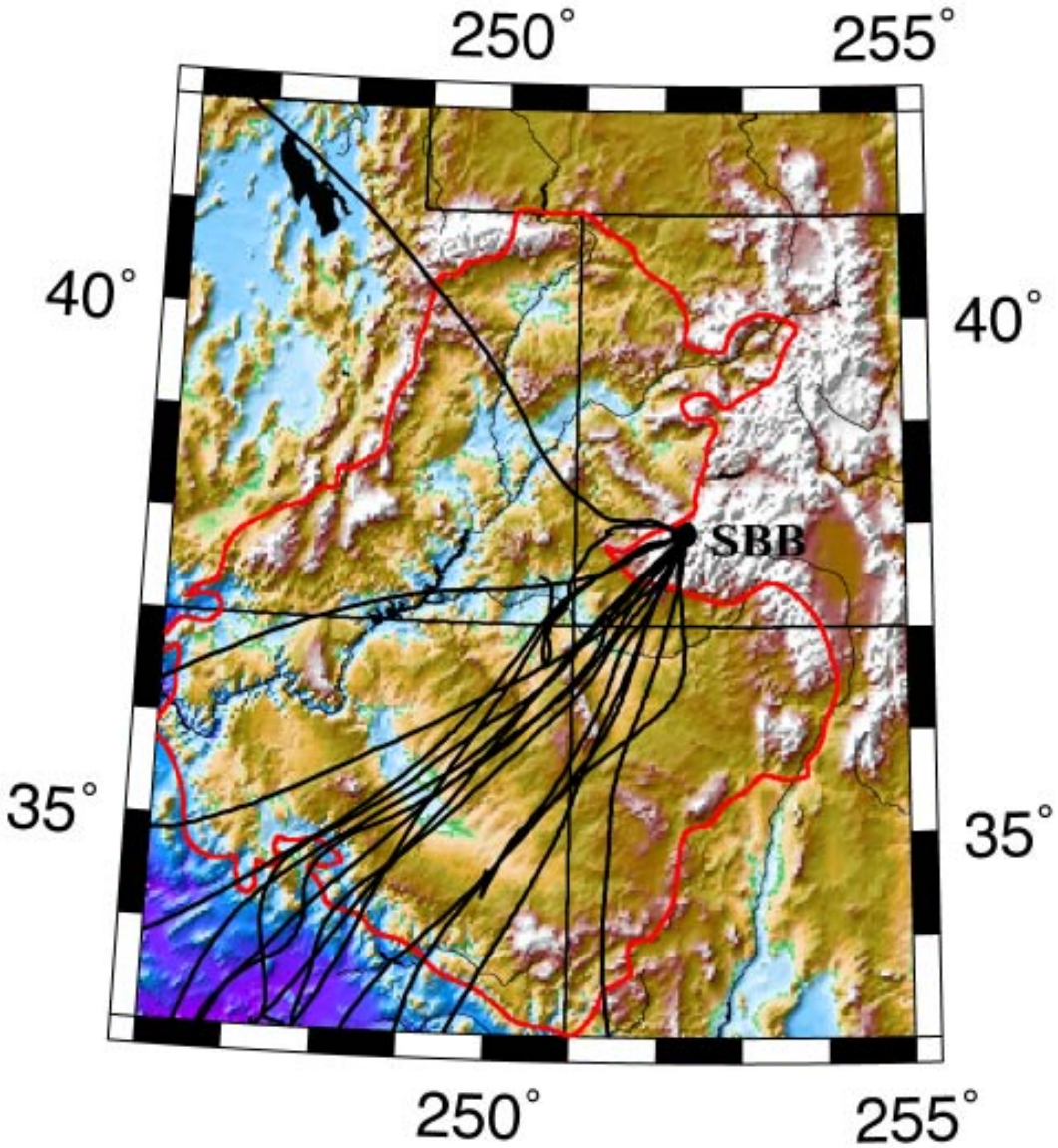
Observed Snowmelt

Swamp Angel Study Plot, Red Mountain Pass, CO

- 15 inches SWE May 20, 2003
- 0 inches SWE May 28, 2003



Dust Event Sources 2003-2007



National Snow and Ice Data Center
Supporting Cryospheric Research Since 1976

Radiative effects of desert dust deposits in alpine snow

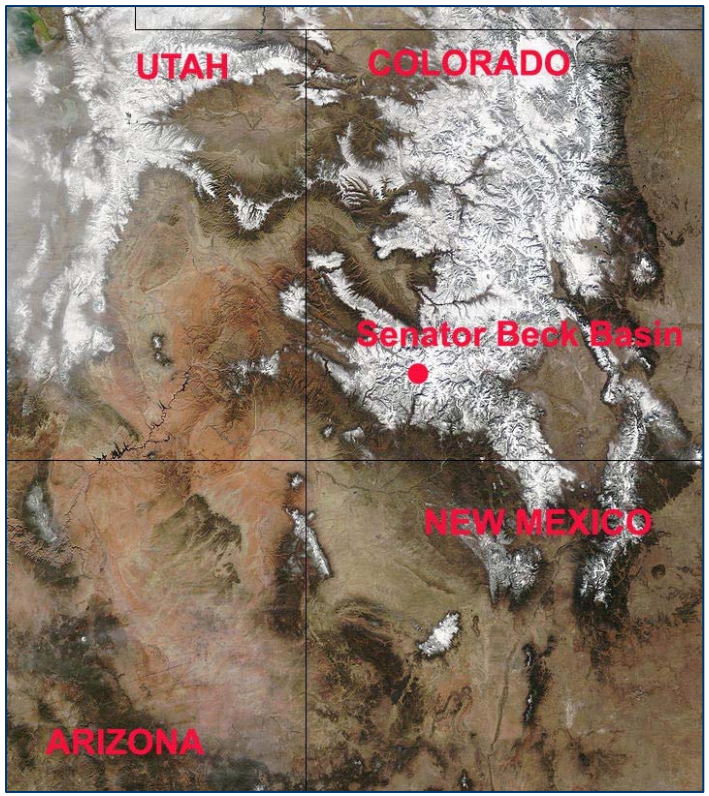
TH Painter[1], C Landry[2], J Neff[3], AP Barrett[1]

[1]National Snow and Ice Data Center,
[2]Center for Snow and Avalanche Studies,
[3]CU-Boulder, Dept of Geological Sciences

Done

Collaborative Research funded by the National Science Foundation Atmospheric Sciences, Geography, and Hydrologic Sciences Grants ATM-0432327 to NSIDC and ATM-0431955 to the CSAS

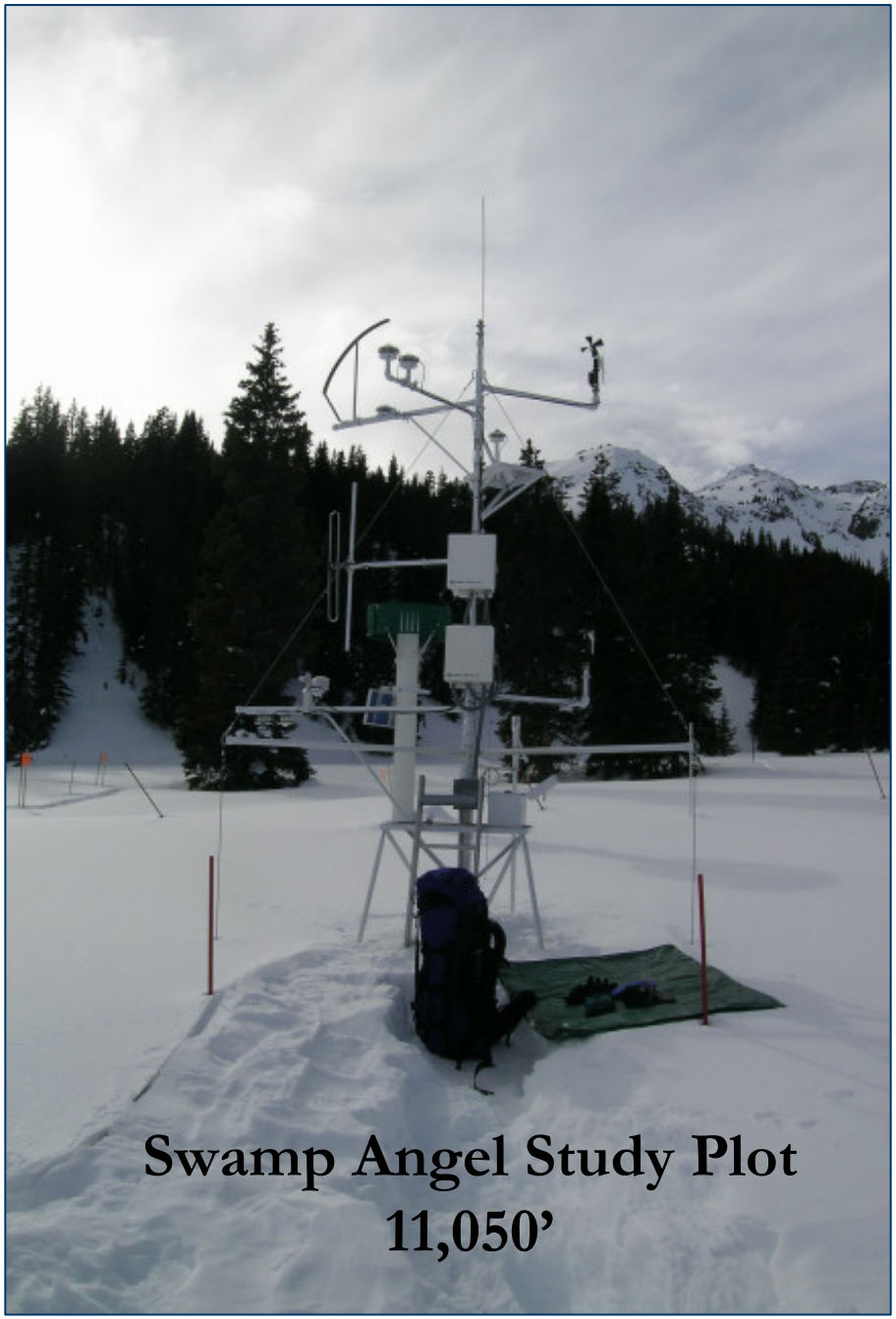
Senator Beck Basin Study Area at Red Mountain Pass



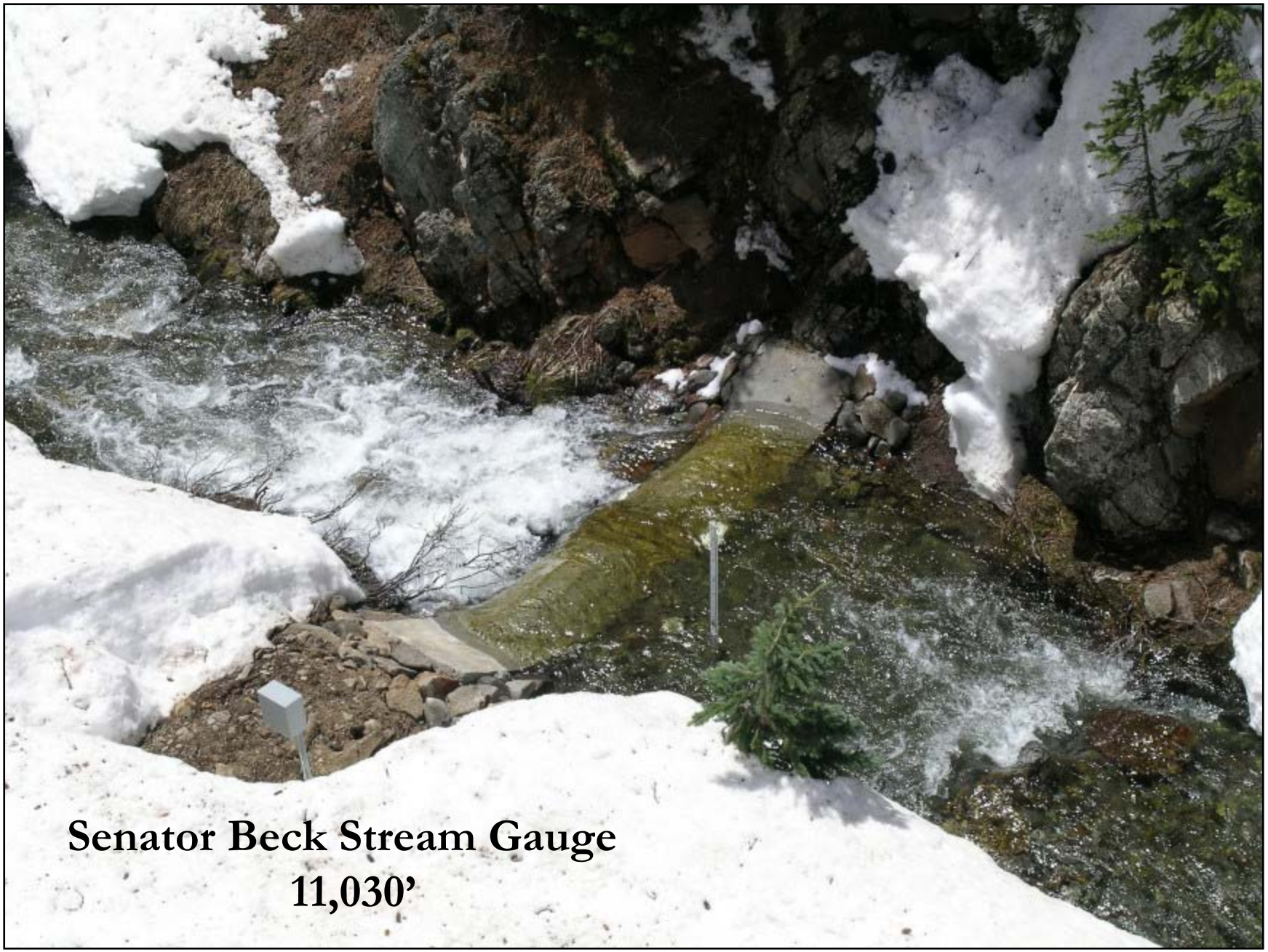
Operated by Center for Snow and Avalanche Studies, Silverton, CO


May 21, 2004
Photo courtesy JPL - Ian McCubbin

Senator Beck Study Plot
12,200’

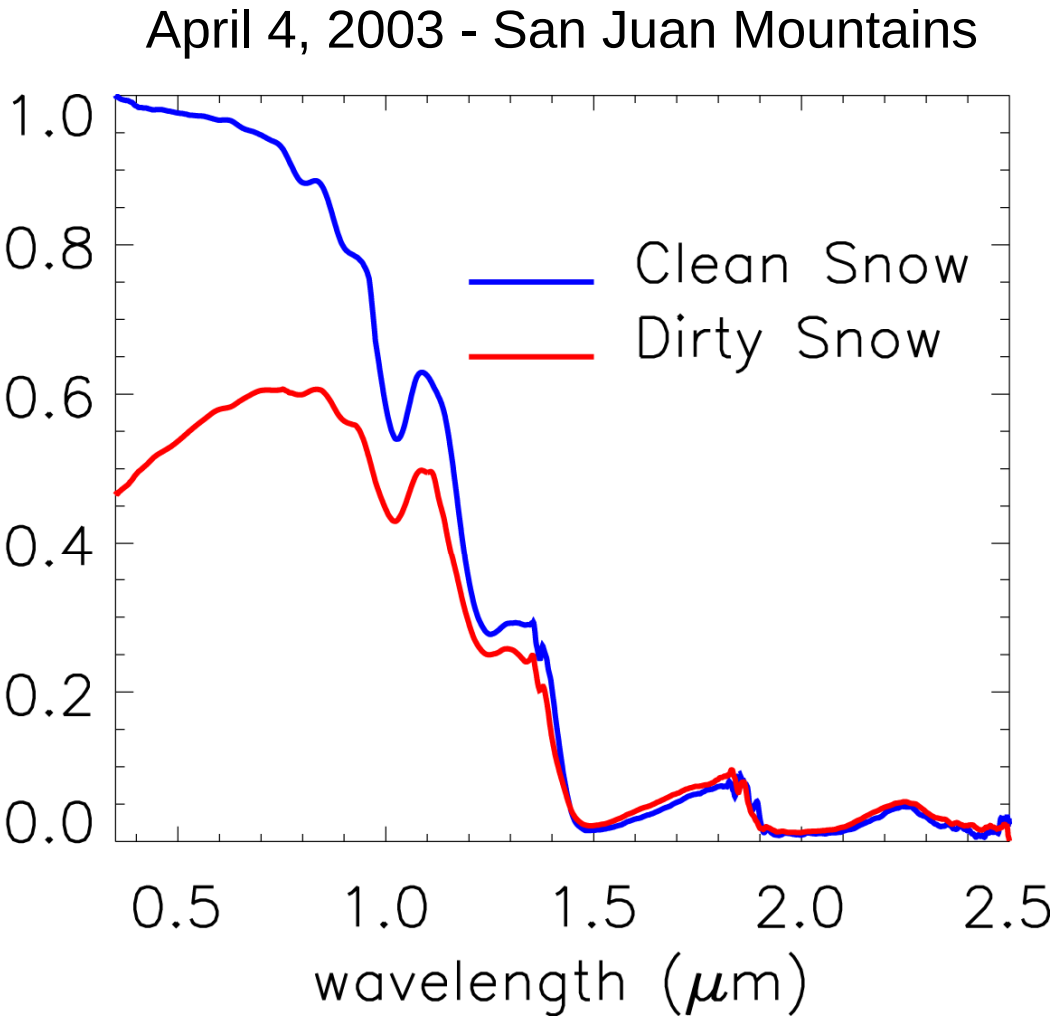


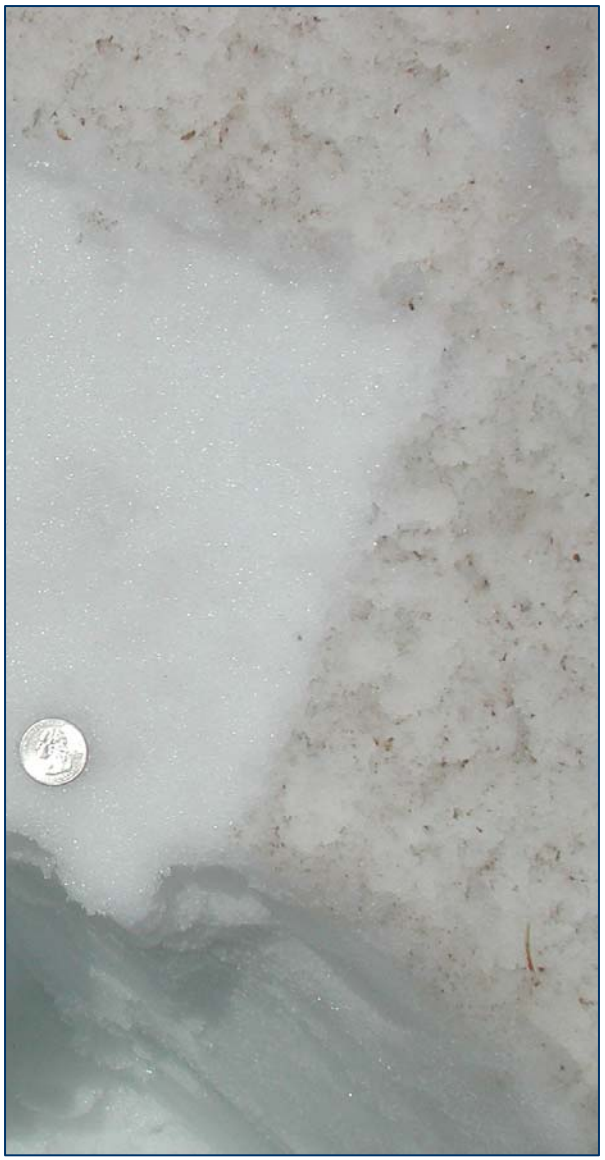
Swamp Angel Study Plot
11,050’


Senator Beck Stream Gauge
11,030’

Snow Albedo Measurement

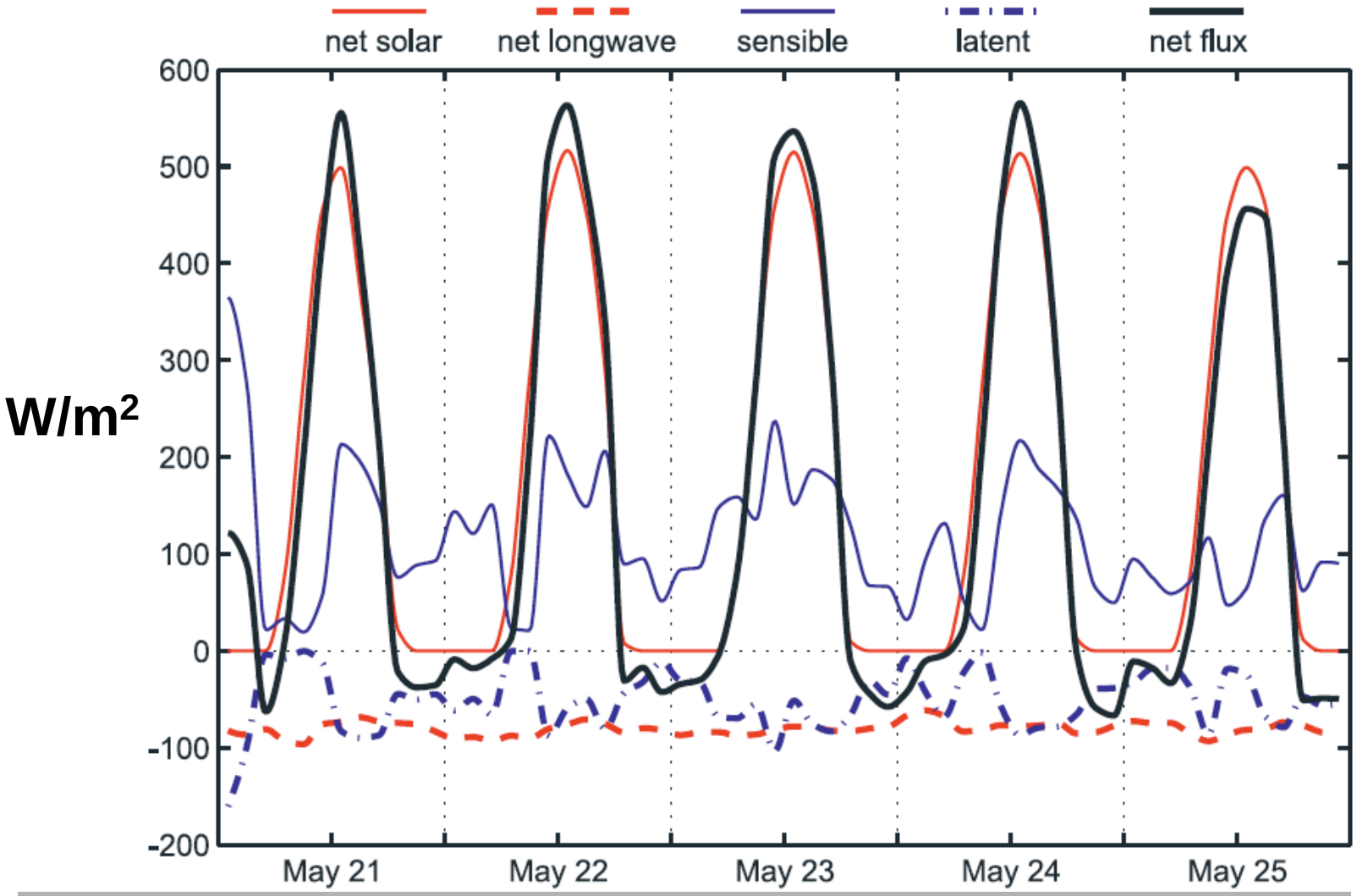
Snow Albedo


April 4, 2003 - San Juan Mountains
1.0
0.8
0.6
0.4
0.2
0.0
Clean Snow
Dirty Snow
0.5
1.0
1.5
2.0
2.5
wavelength (μm)



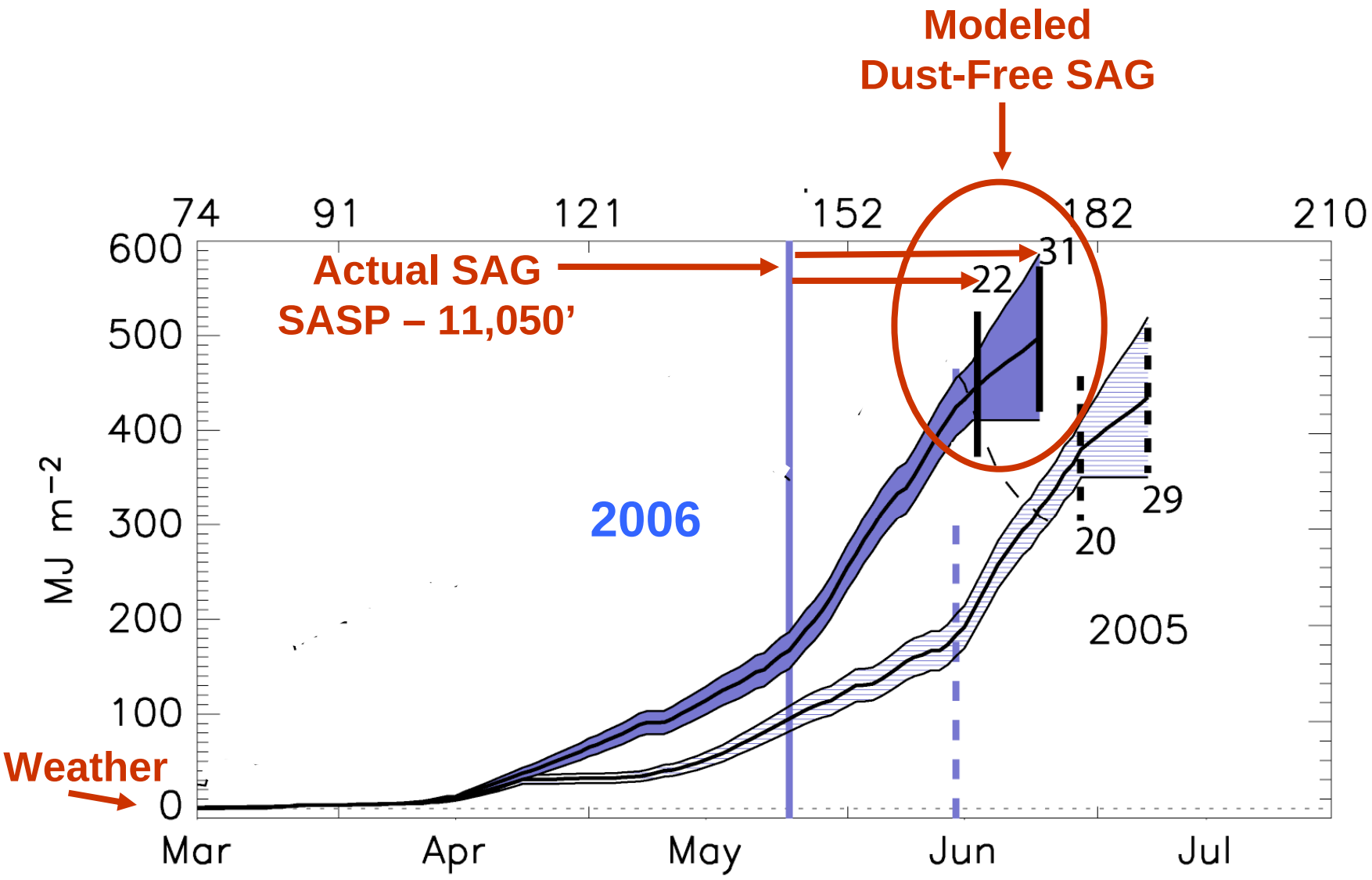
Snowmelt Energy Budget

Dusty Snow Surface, Clear Skies – Senator Beck Study Plot 2005



Max Air T	**57 F**	**57 F**	**56 F**	**53 F**	**56 F**

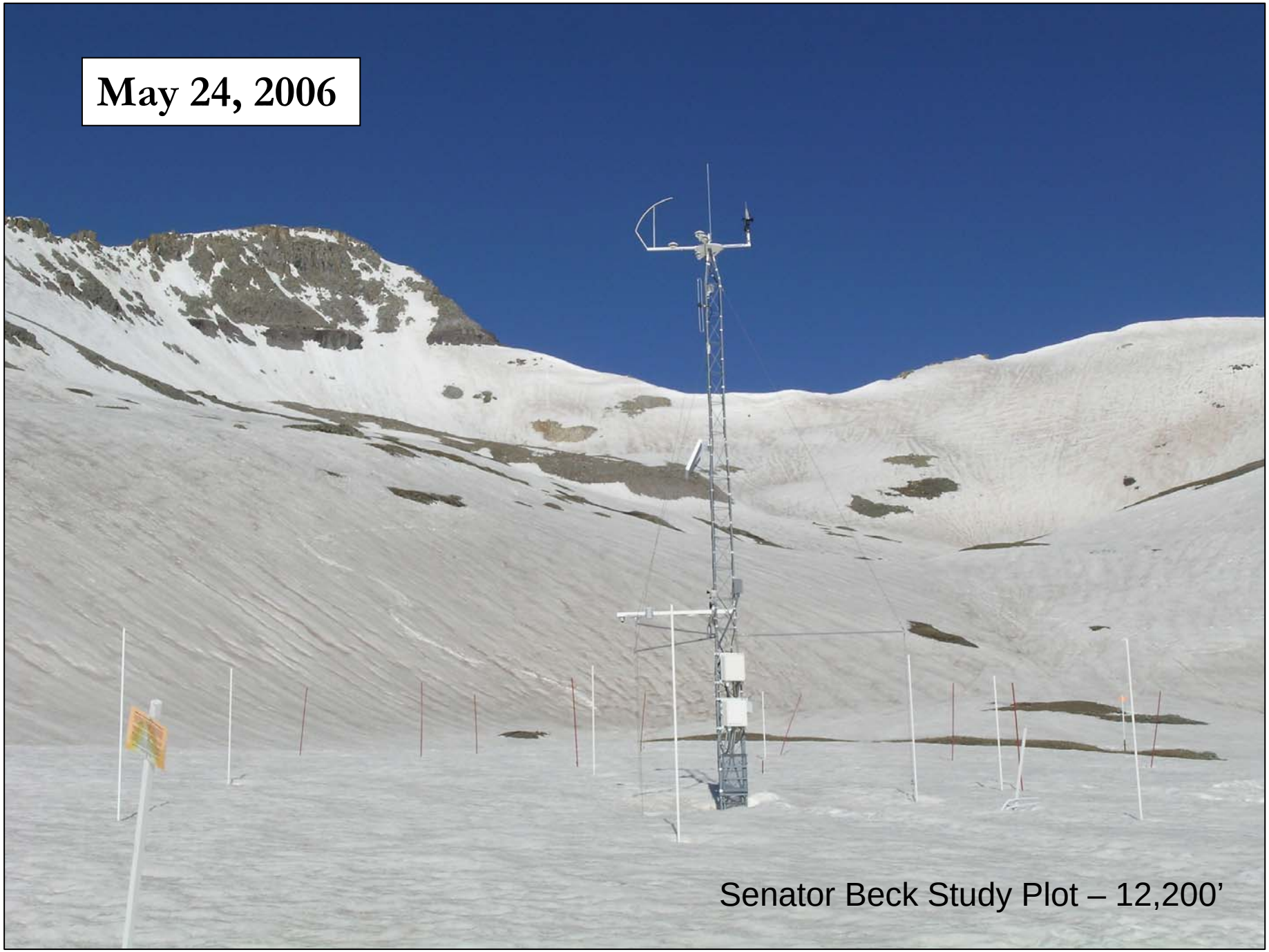
Reduced Albedo = Snowmelt "Forcing"

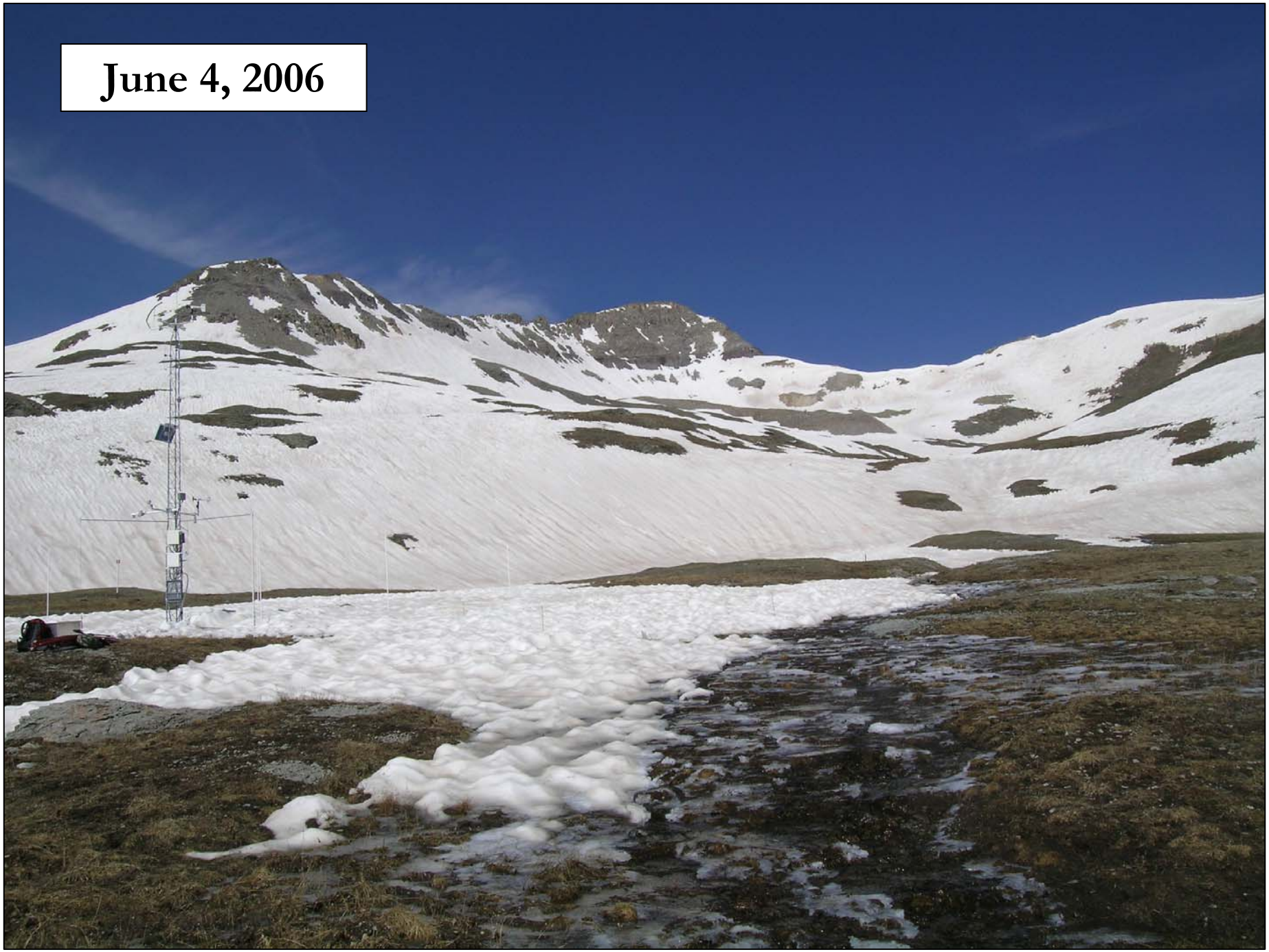


Findings …

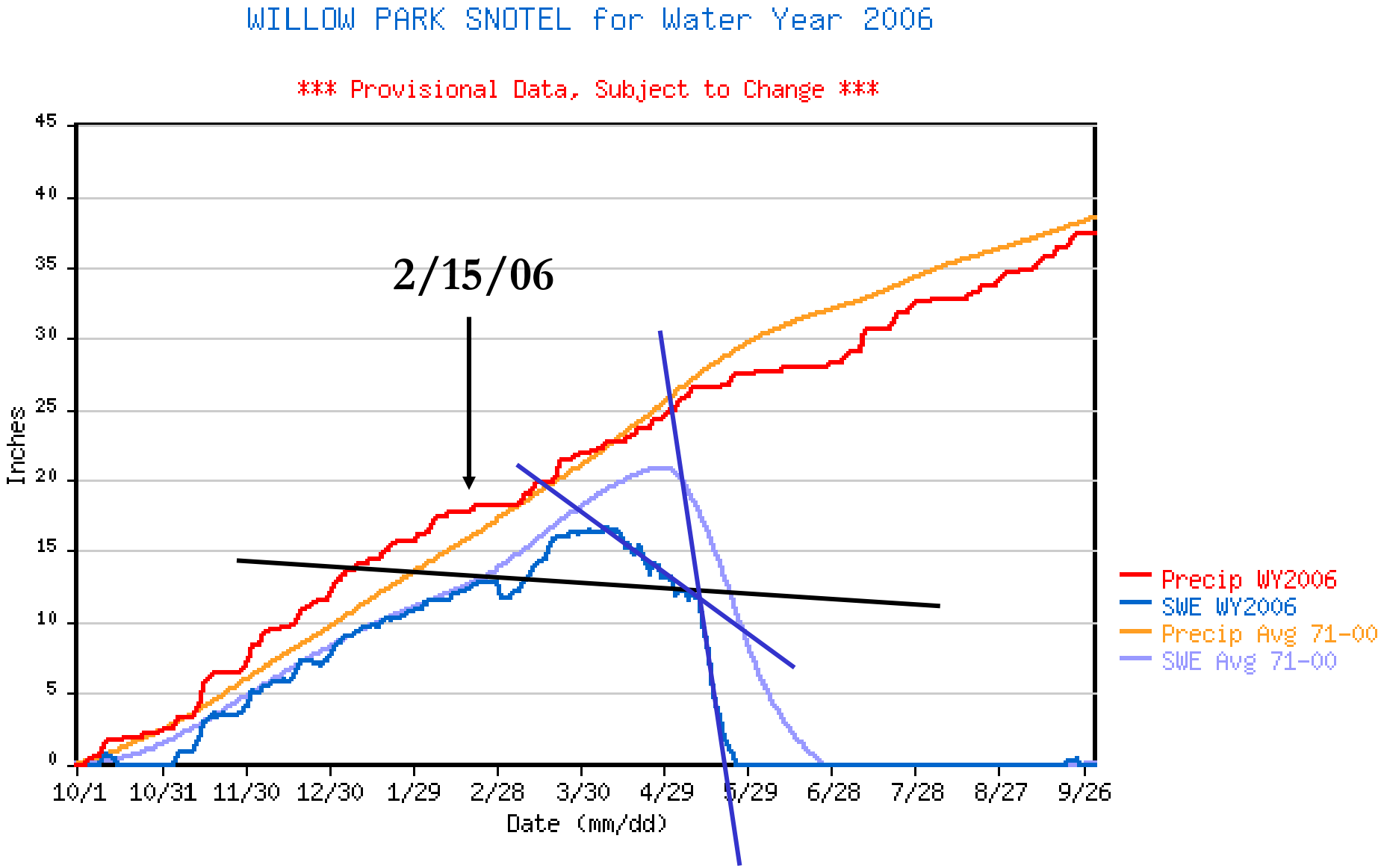
- **Exposed layers of dust-in-snow decreases snow albedo on a *regional scale*, dramatically increasing solar energy absorption and accelerating snowmelt**

- **Observed reductions in snow albedo have advanced snowmelt by up to one month and resulted in a higher amplitude and shorter duration hydrograph**

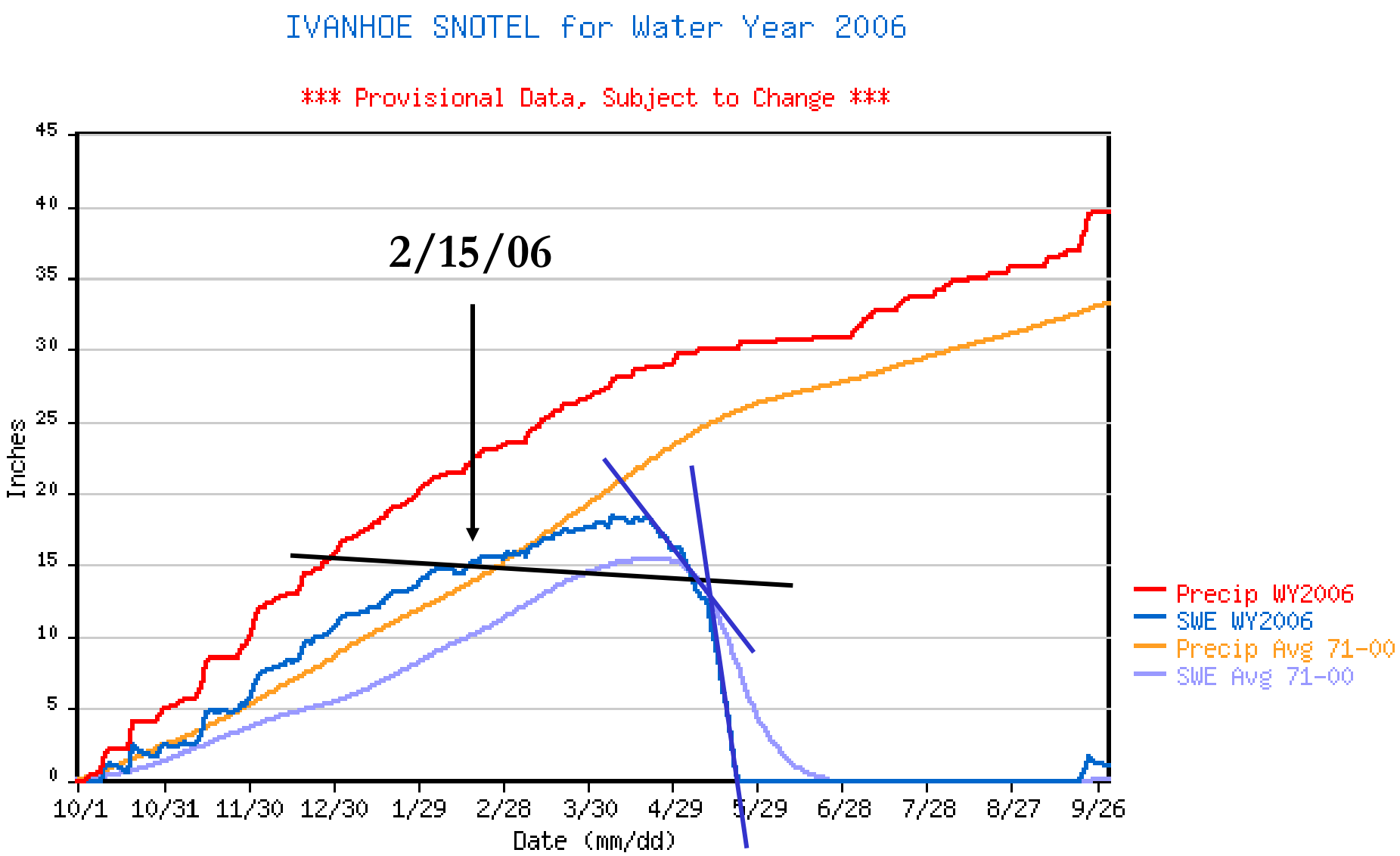

May 24, 2006
Senator Beck Study Plot – 12,200’


June 4, 2006

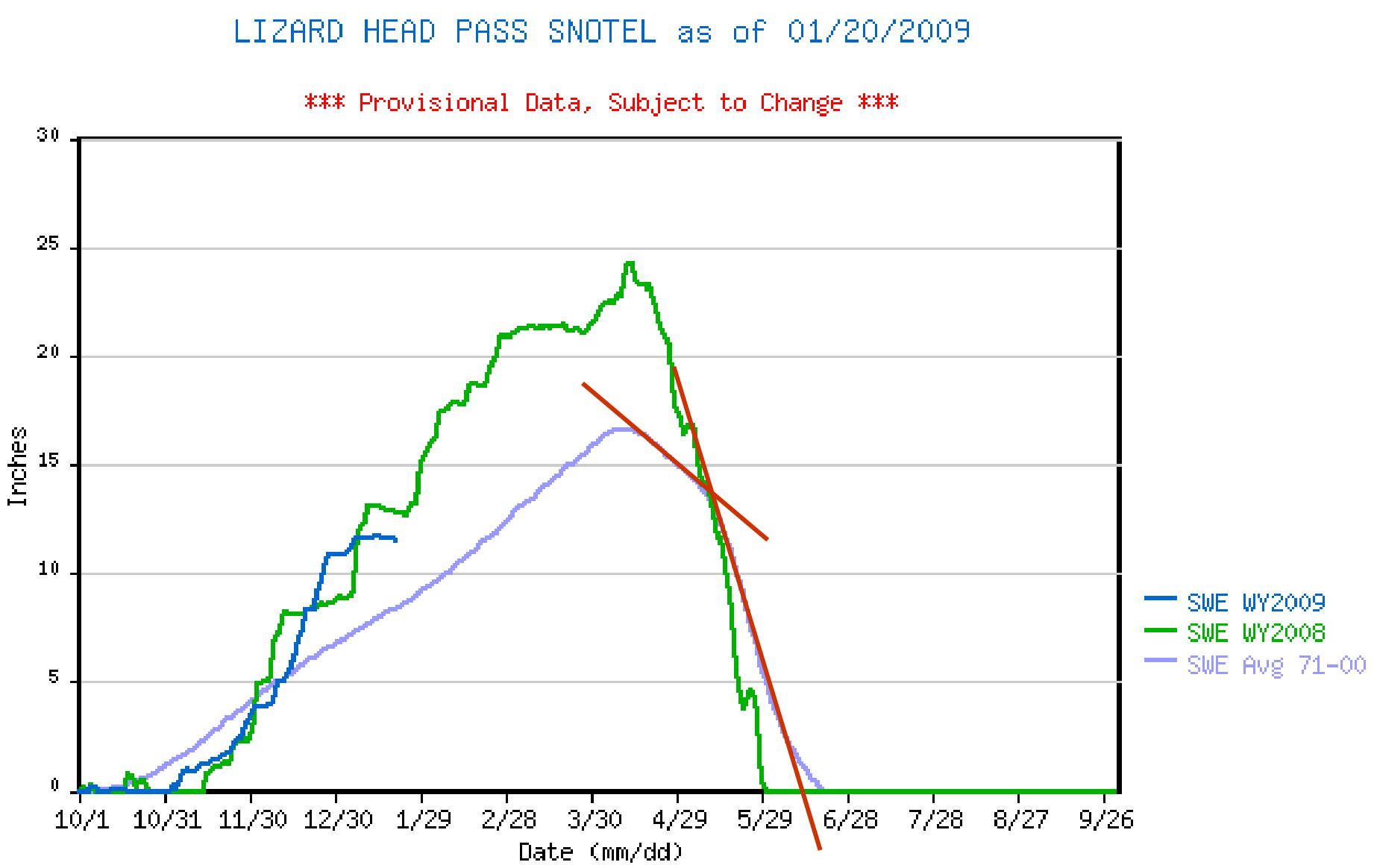
South Platte



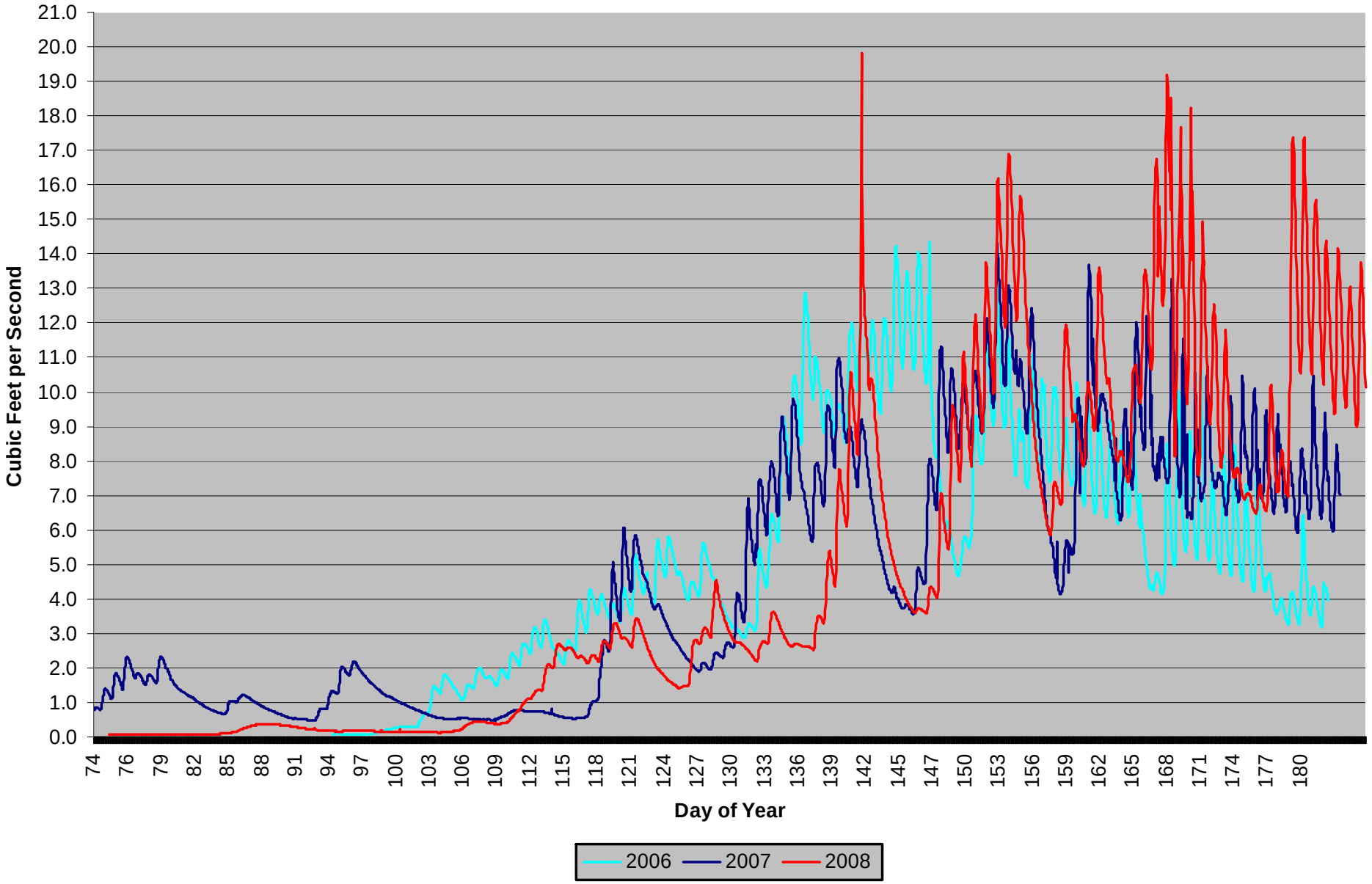
Upper Colorado



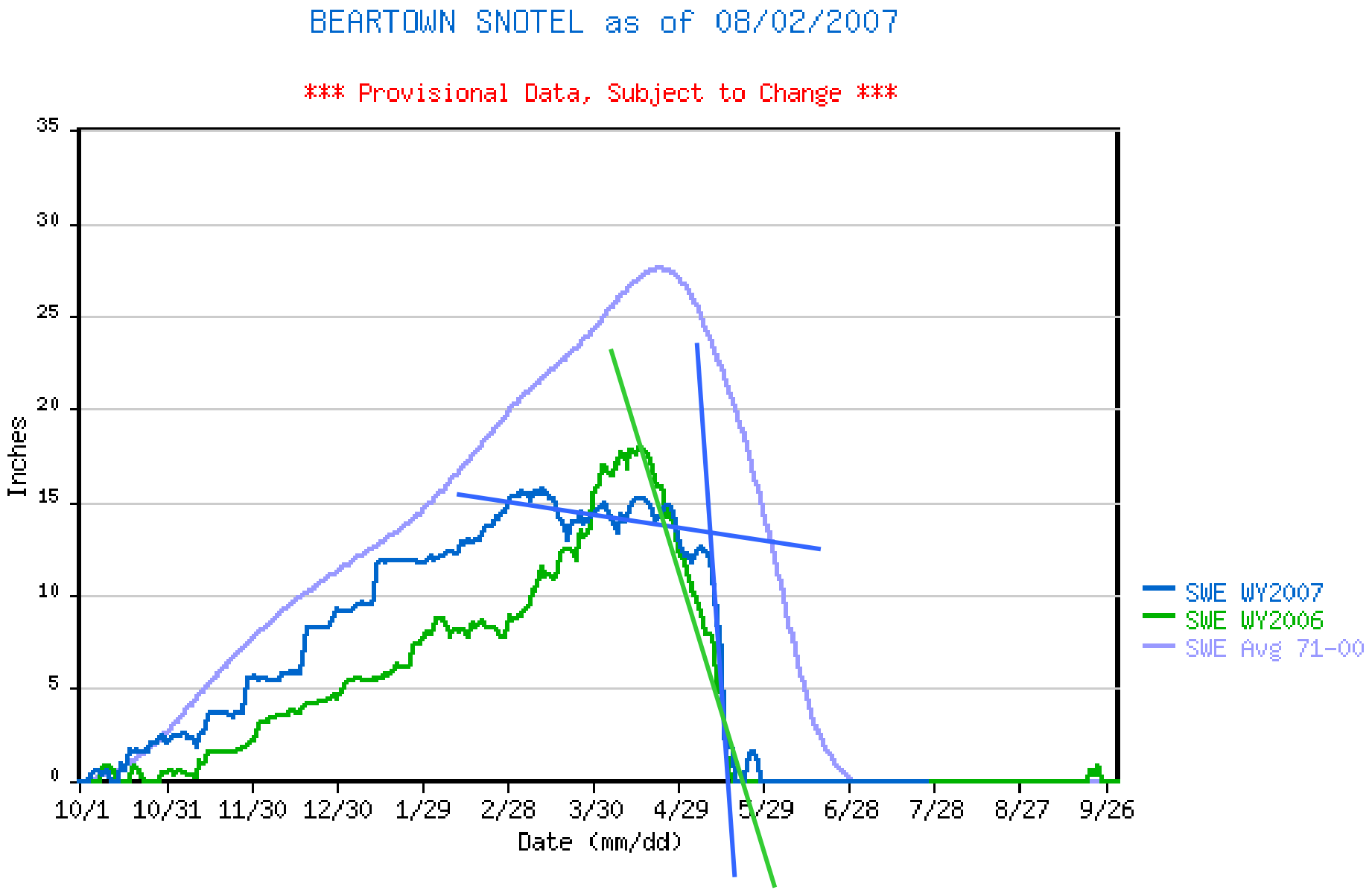
Lizard Head Pass – WY 2008



Senator Beck Basin Daily Discharge – WY 2006, 2007, 2008



Rio Grande


BEARTOWN SNOTEL as of 08/02/2007
*** Provisional Data, Subject to Change ***
Inches
35
30
25
20
15
10
5
0
10/1
10/31
11/30
12/30
1/29
2/28
3/30
4/29
5/29
6/28
7/28
8/27
9/26
Date (mm/dd)
SWE WY2007
SWE WY2006
SWE Avg 71-00

Colorado Dust-on-Snow aka CODOS …

… monitoring dust-on-snow and estimating its effects on snowmelt timing and rates for Colorado snowmelt managers.

Funders:

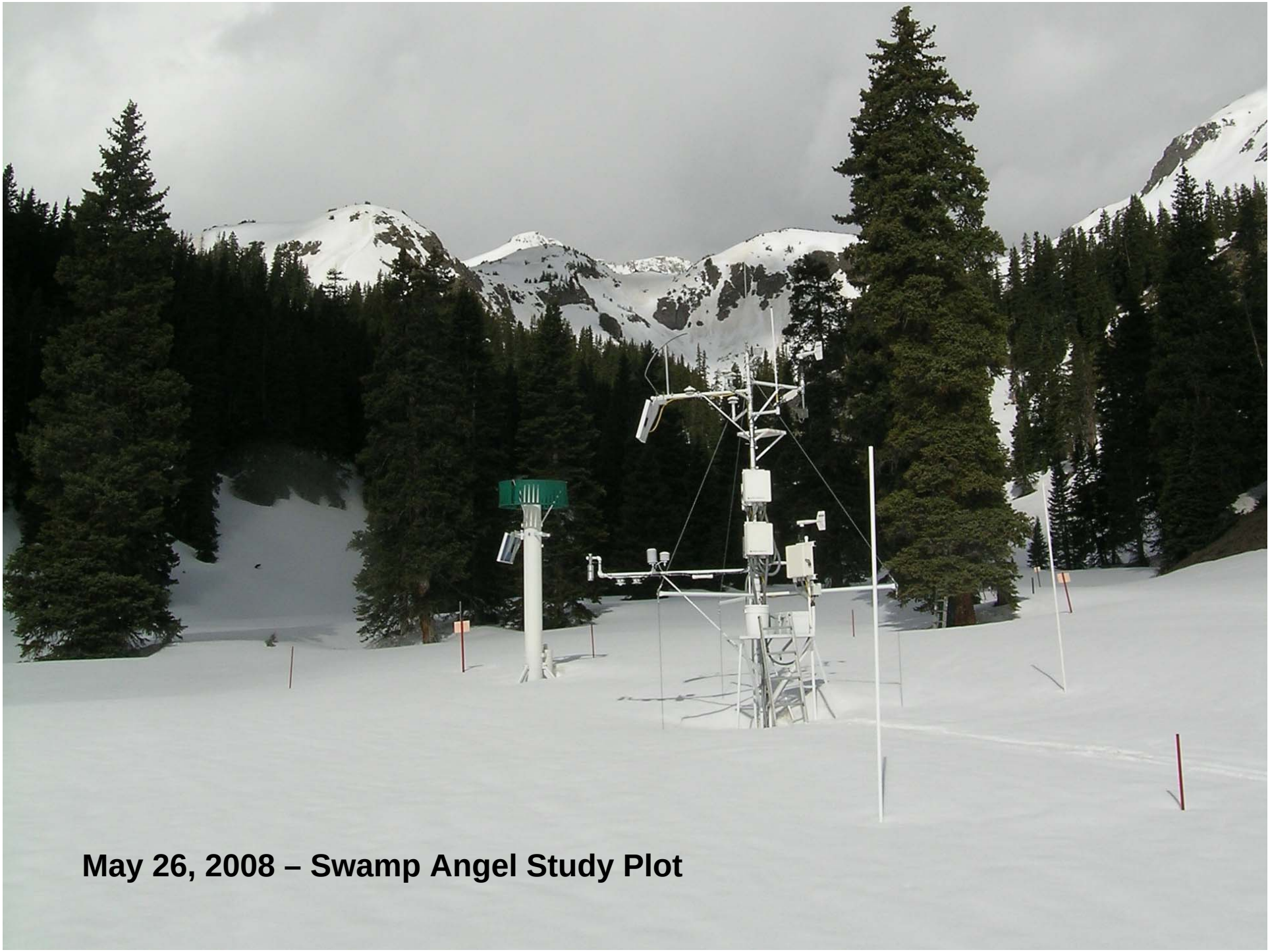
Southwestern, Colorado River, Rio Grande, and Northern Water Conservation Districts

Tri-County, Upper Gunnison River, and Animas-La Plata Water Conservancy Districts

Denver Water, Western Water Assessment, CWCB (pending)

Collaborators: National Snow & Ice Data Center, University of Utah, Center for Snow and Avalanche Studies

Based at Center for Snow and Avalanche Studies



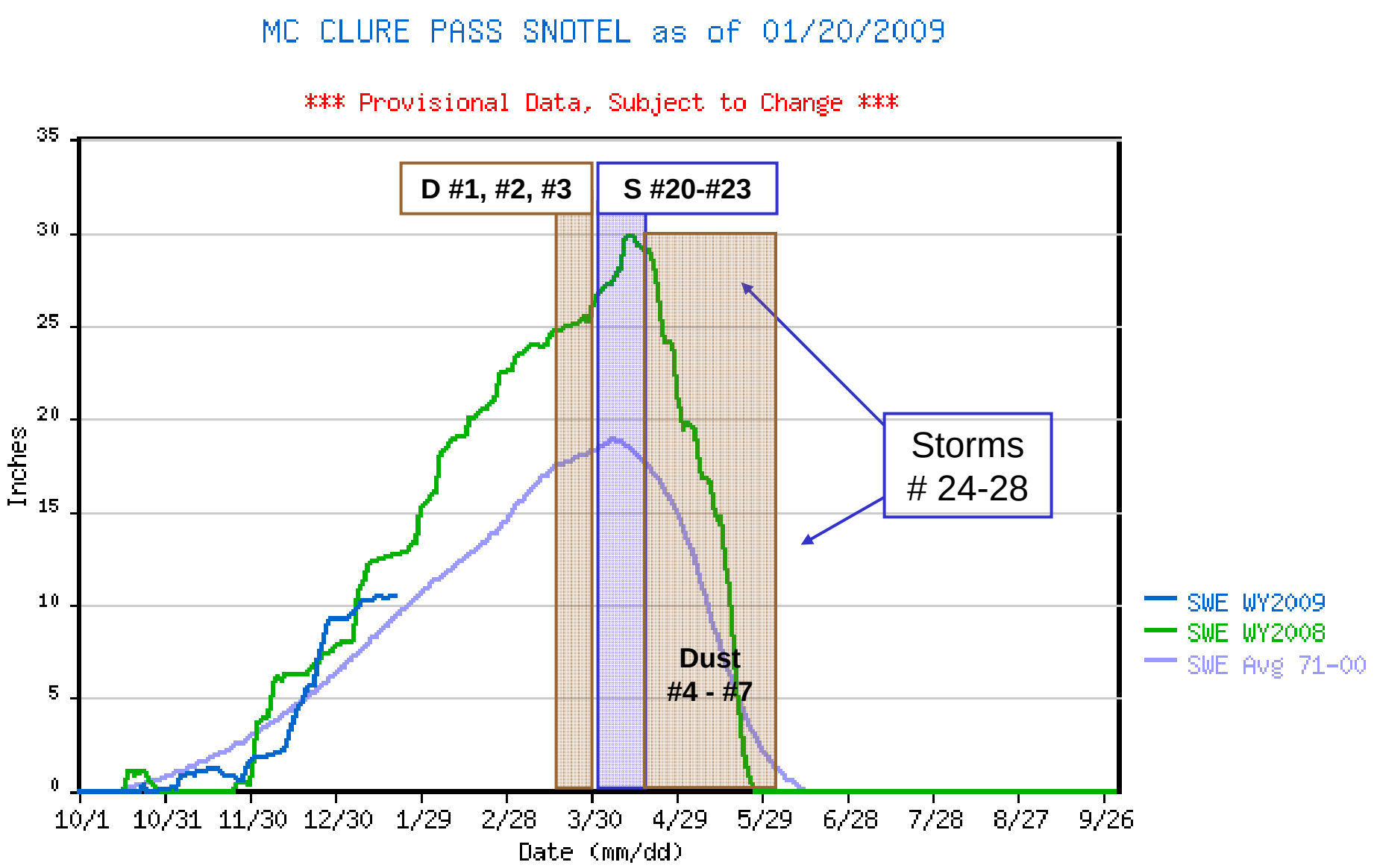
May 26, 2008 – Swamp Angel Study Plot

May 26, 2008 – Swamp Angel Study Plot

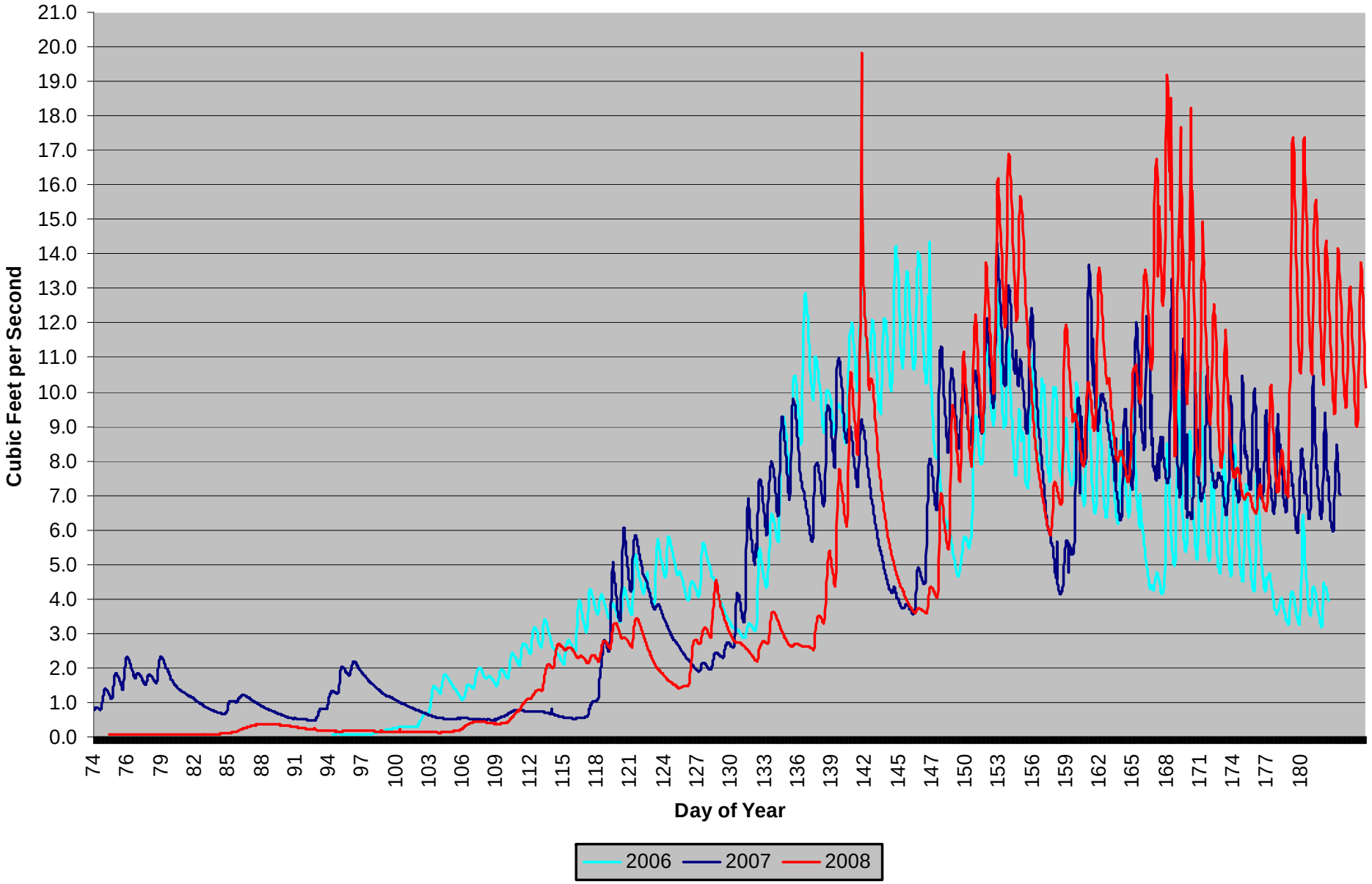
June 8, 2008 – Swamp Angel Study Plot


May 15, 2008 – McClure Pass

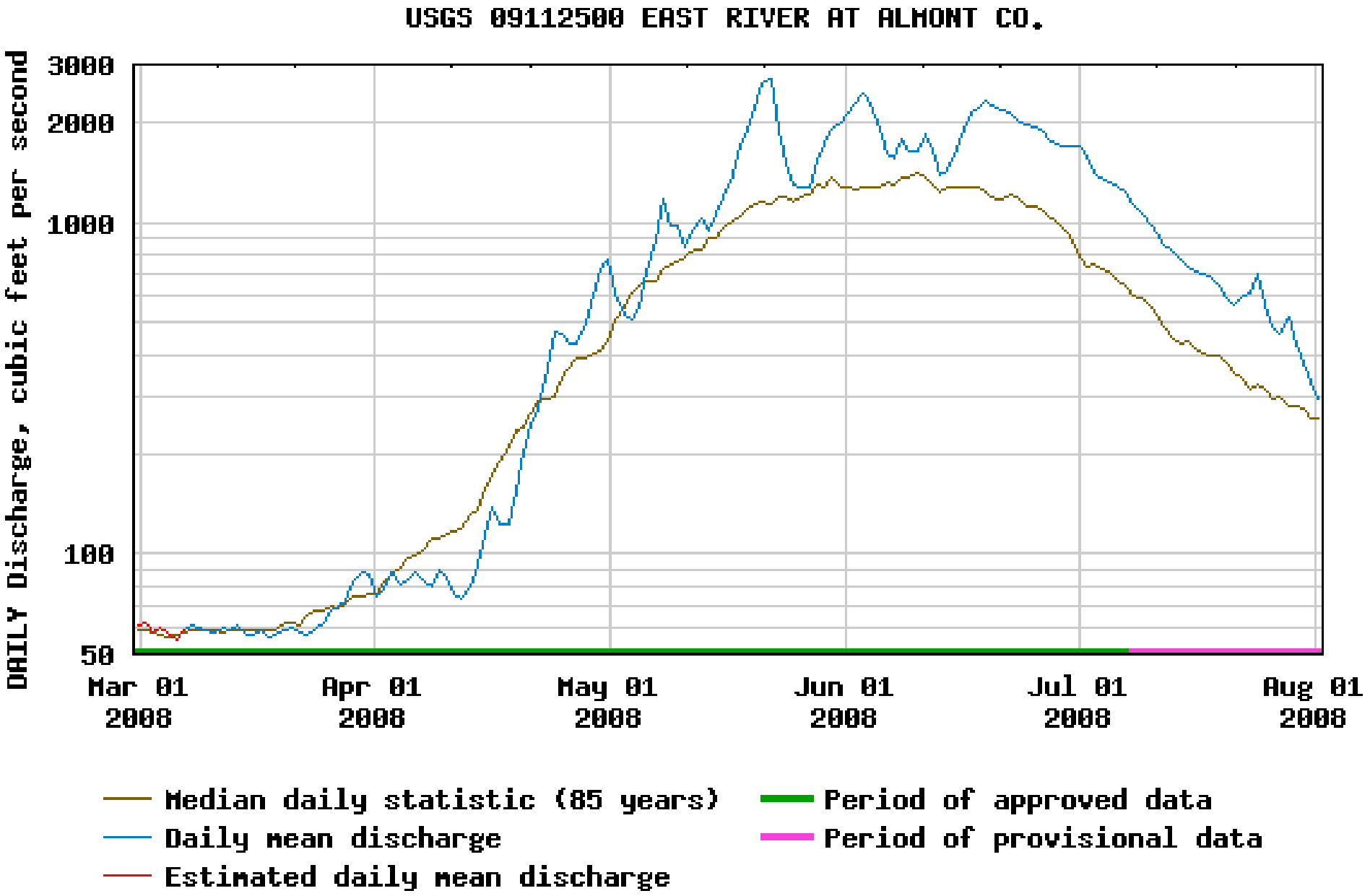
McClure Pass – WY 2008



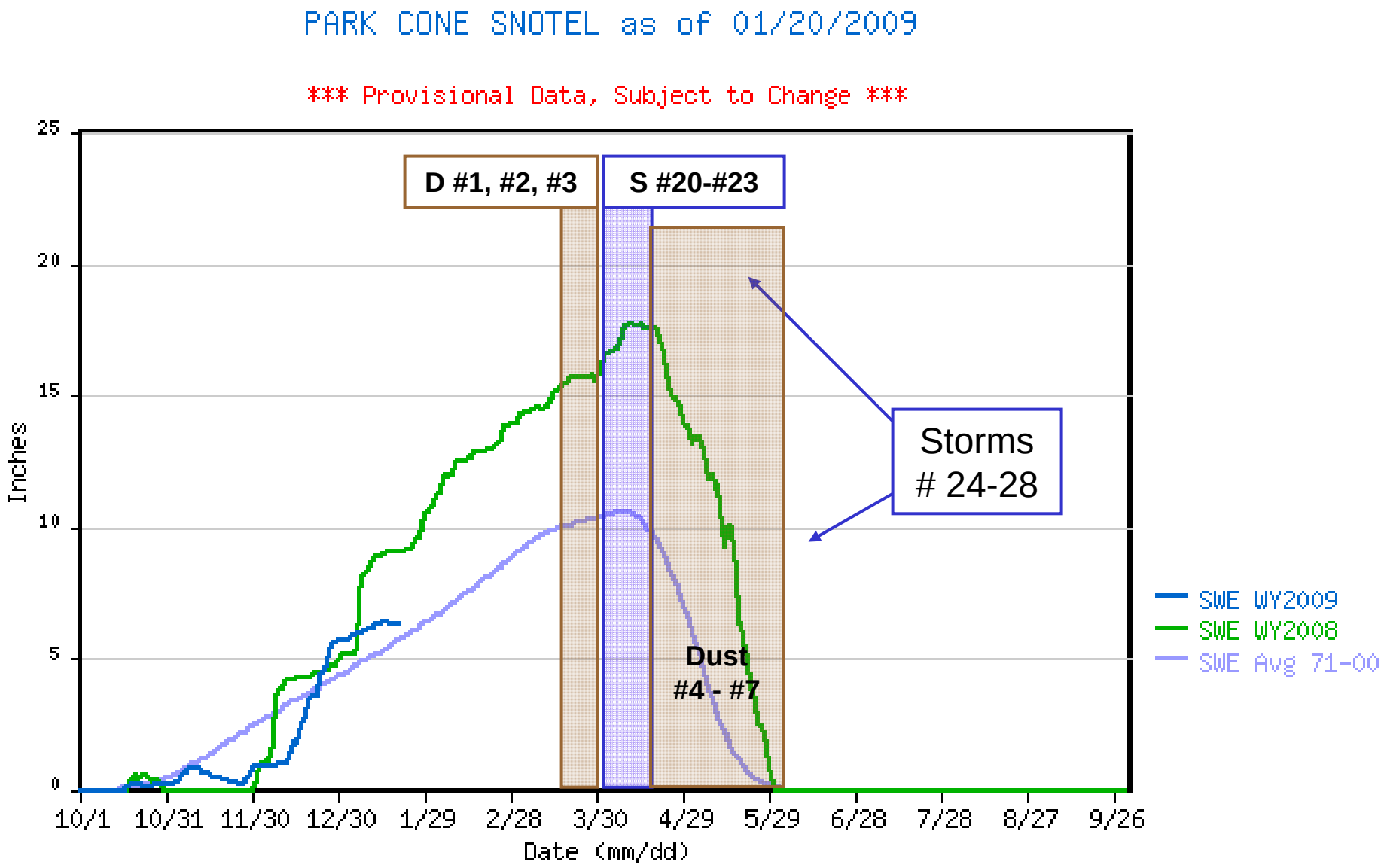
Senator Beck Basin Daily Discharge – WY 2006, 2007, 2008



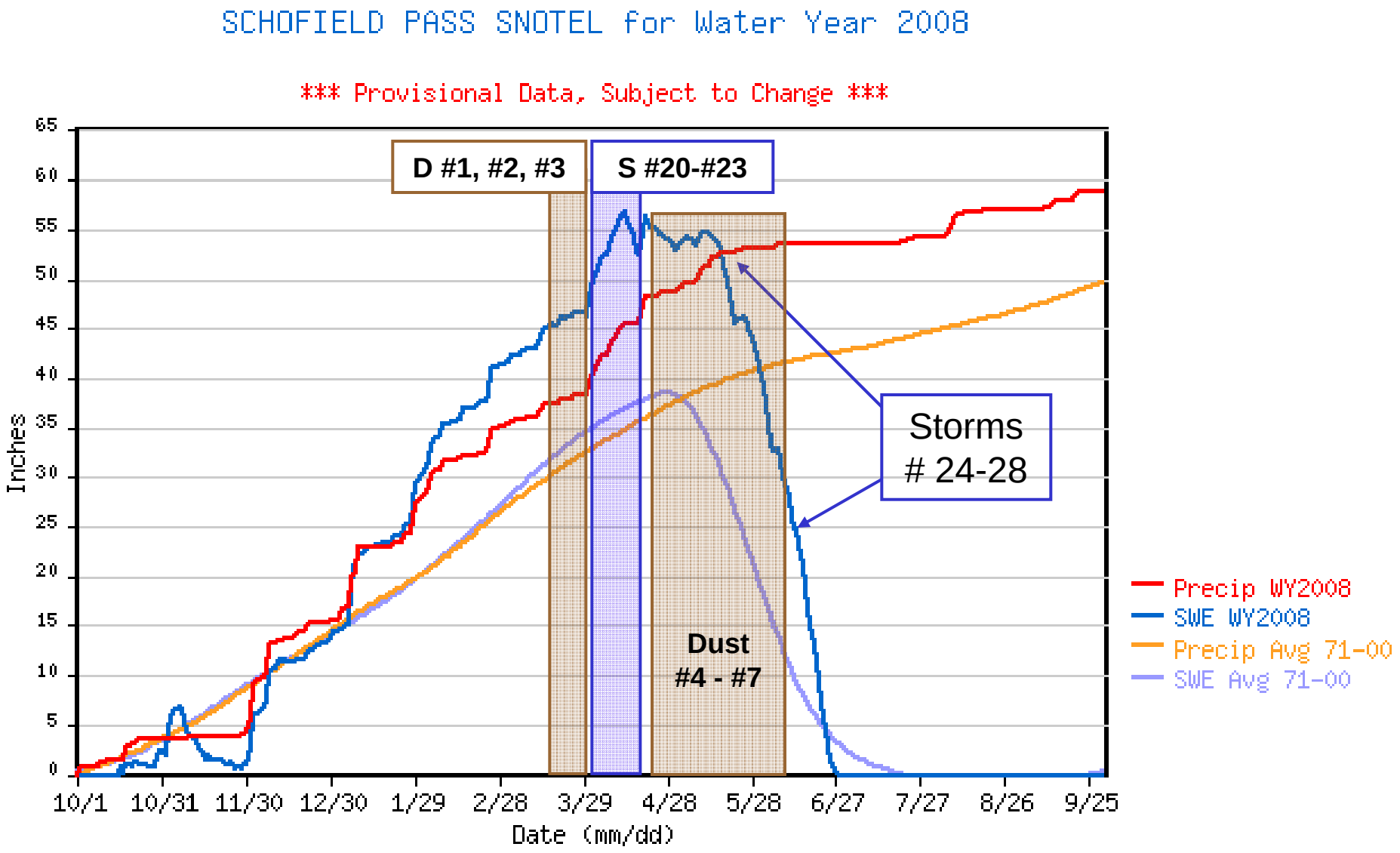

May 13, 2008 – Park Cone


USGS 09112500 EAST RIVER AT ALMONT CO.
DAILY Discharge, cubic feet per second
3000
2000
1000
100
50
Mar 01 2008
Apr 01 2008
May 01 2008
Jun 01 2008
Jul 01 2008
Aug 01 2008
Median daily statistic (85 years)
Daily mean discharge
Estimated daily mean discharge
Period of approved data
Period of provisional data

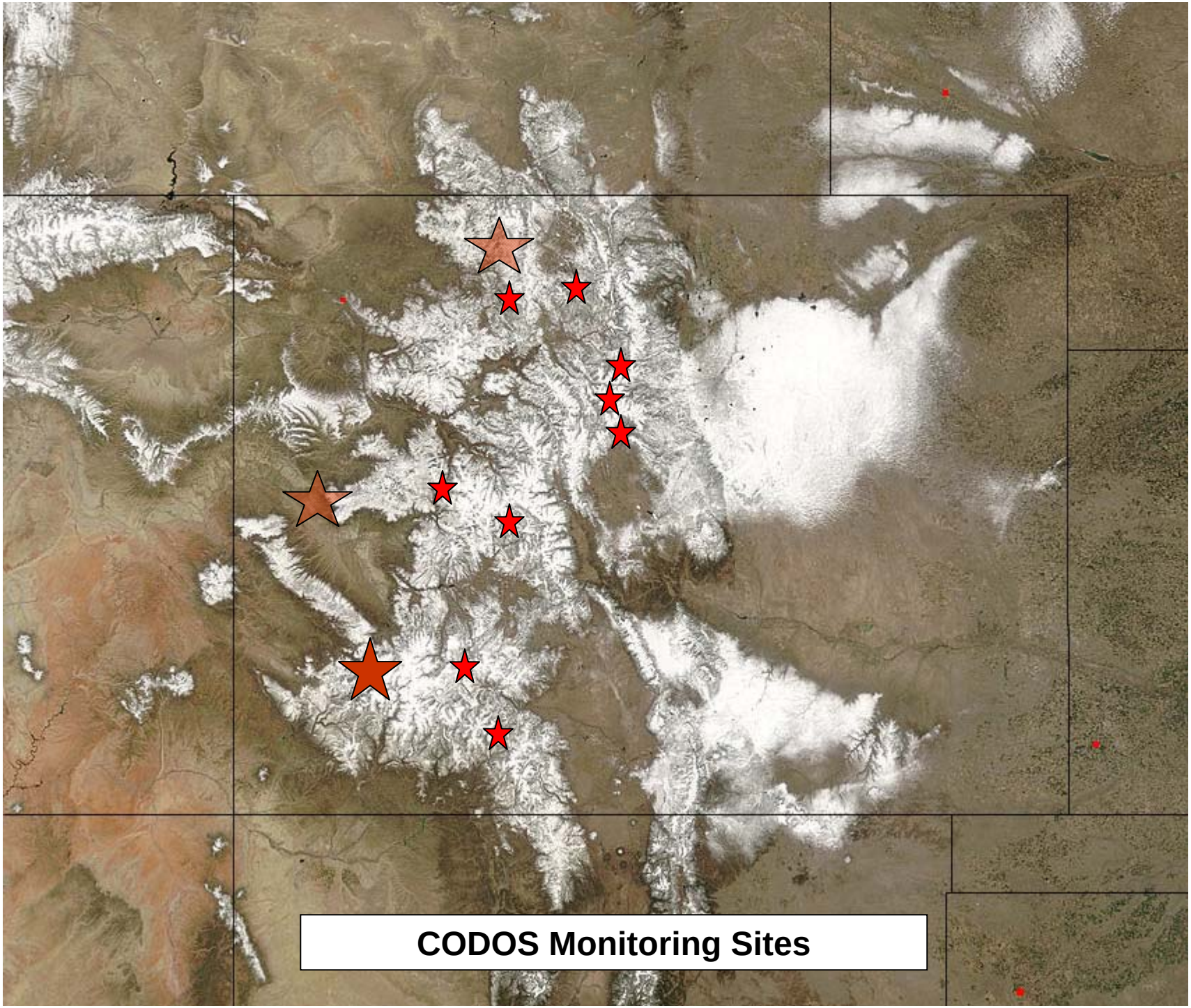
Park Cone – WY 2008



Schofield Pass – WY 2008



June 9, 2008 – Senator Beck Study Plot


CODOS Monitoring Sites

CODOS Dust Updates & Alerts

THE UNIVERSITY OF UTAH — CENTER FOR SNOW & AVALANCHE STUDIES — NSIDC

Colorado Dust-on-Snow Alert #8, June 1, 2008

Following the expected brief pause in snowmelt discussed in Alert #7 of May 24th, all Snotel sites that we've been monitoring this spring have shown a second steep decline in SWE during the past week. All sites showed losses in SWE of equal or greater magnitude than the drop seen earlier, in mid-May, and some sites have reached "Snow All Gone (SAG). The substantial dust layer (composed of multiple, 'merged' layers) that was temporarily covered by clean new snow over the weekend of May 24th and 25th has extensively re-emerged at the snowpack surface, first at lower elevations on all aspects, and more recently at the highest elevations on even northerly aspects. Lingering patches of the May 23/24 storm snow stand in stark, bright white contrast to the surrounding dirty snow, as seen in the May 31st photo below, looking westward at the Senator Beck Basin Study Area (far right) and nearby terrain at Red Mountain Pass, here in the San Juan Mountains.

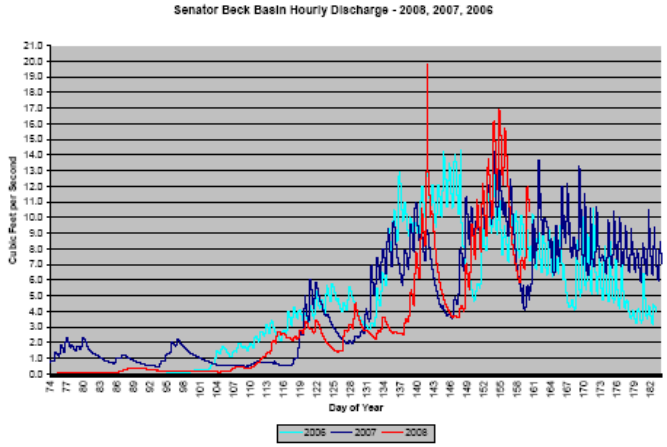
The direct absorption of solar energy by this dust layer, in tandem with two periods of sunny weather and warm air temperatures, has produced two periods of much-greater-than-average rates of snowmelt, as compared to the 30-year average rate of decline in SWE. This is clearly evident in Snotel 2007/2008 Water Year graphs around the State. Thus, even though all the Snotel sites we monitor reported substantially greater-than-average SWE values this season, most sites are also currently on a snowmelt trajectory that will result in earlier-than-average dates of SAG (Snow All Gone), some perhaps several weeks earlier than average. Some lower elevation sites that have recently reached SAG on/about their average date have done so beginning with a much above-average season maximum SWE, under very high snowmelt rates.

6/1/2008

THE UNIVERSITY OF UTAH — CENTER FOR SNOW & AVALANCHE STUDIES — NSIDC

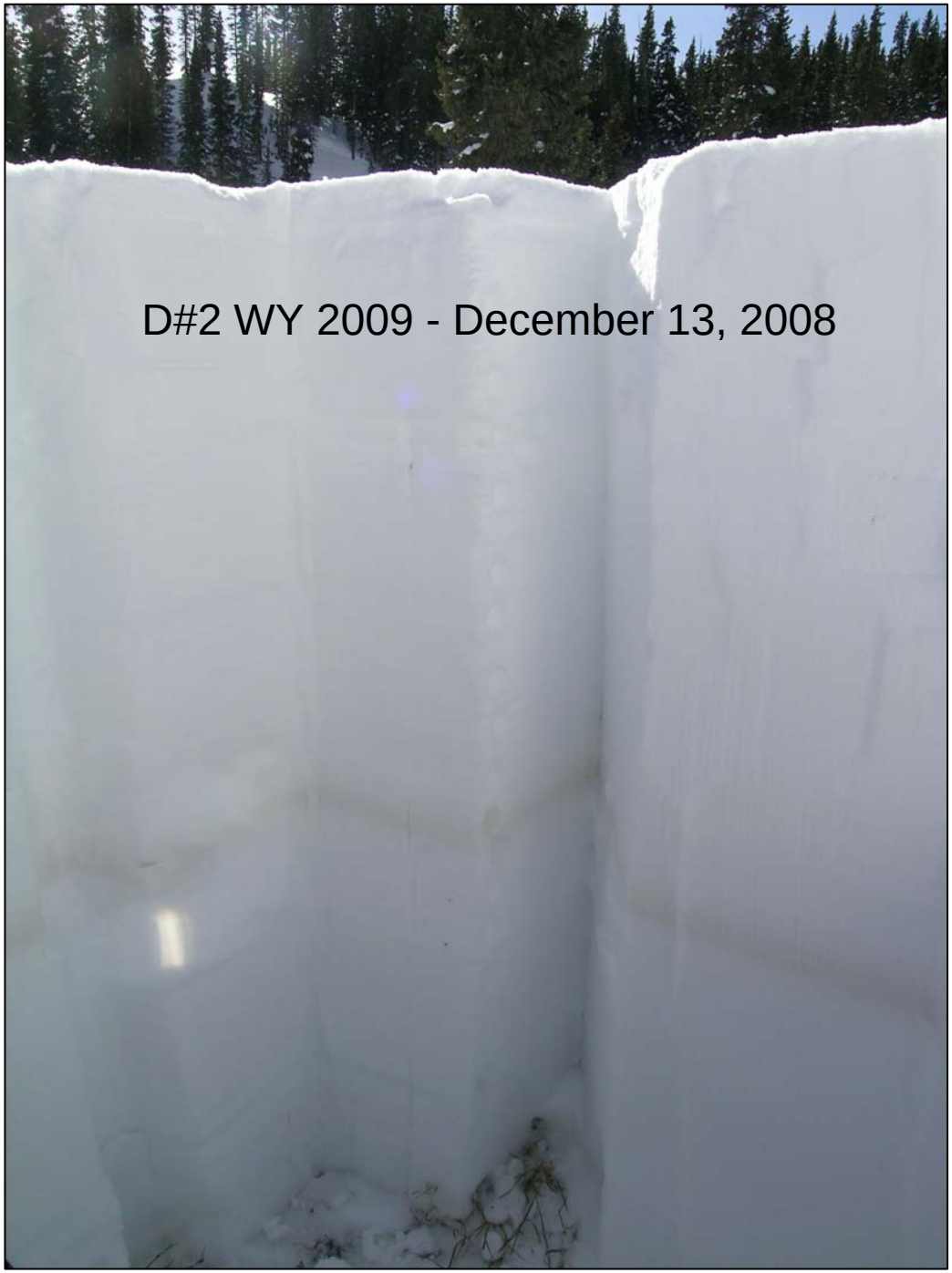
Colorado Dust-on-Snow Alert #9, June 8, 2008

As anticipated by NWS – Grand Junction, fresh snow and cool air 'reset' the snowmelt clock on Wednesday and Thursday of last week; we received 16 mm of SWE in the Senator Beck Basin Study Area, as 4-8" of new snow, varying by elevation. We did not detect any fresh dust with this storm here in our study area, and have received no reports of fresh dust elsewhere. That fresh snow layer resulted in a temporary return to a high albedo that, combined with cooler temperatures, dropped our Basin discharge from near 17 cfs on June 3 to 6 cfs by June 6, as seen below, ending our second major surge of snowmelt and stretching the date of snow-all-gone (SAG) a few days further into the future. Following that low point in streamflow on June 6, however, the new clean new snow quickly succumbed to sunny skies and the absorption of direct solar radiation by the underlying dust, revealing the underlying dirty snow surface once again. Our third surge in flows this season has now begun, as of this writing, despite somewhat cooler air temperatures here in the San Juans over the past weekend.



Based on our first-hand observation of extensive dust layers in mid-May, it is our assumption that a similar return to high albedo (caused by new snow) occurred throughout most of the remaining Colorado mountain snowpack last Wednesday and Thursday, followed by a similar, subsequent ablation of the clean new snow and re-emergence of the underlying dirty snow surface. Some Central and Northern mountain areas may have received additional snow showers on Saturday or Sunday, but not in amounts that will cause a prolonged return to high snowcover albedo values. Therefore, given that the current NWS – Grand Jct. 7-day forecast calls for generally sunny skies through Sunday, June 15th, except for a brief disturbance on Wednesday the 11th, and temperatures at 10,000' in the 60's (except Wednesday and Thursday), another surge of dust-enhanced snowmelt is expected.

6/8/2008


D#2 WY 2009 - December 13, 2008

Lizard Head Pass – WY 2008

7 Dust Events