RED DUST SNOWFALL EVENT

FEBRUARY 15, 2006

OVERVIEW and RELATED RESEARCH at NIWOT RIDGE, COLORADO

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OUTLINE

Event

Origin/Synoptic Conditions during Event
Avalanche Implications

Measurements

Observations of Dust –on-Snow Effects

Snow pack melt rate

- Energy transfer into snow pack
- Alteration of melt-water pathways (Ice column development)
- Differential radiative impacts of fine vs. coarse particle size
- Future Implications (Positive Feedback)

Decreased southwestern US Water Supply

Increased dry, summer season

Altered phenologies

Shifted ecological zones

Event

On the night of February 15-16, 2006, 6.4 cm (2 ½”/0.20”SWE) of snow fell at C1. The event began about 7 PM on the 15th and was virtually over by midnight.

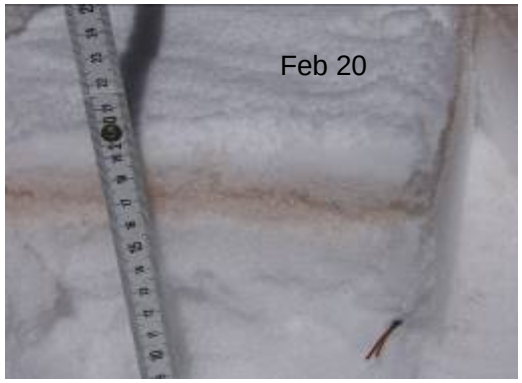
The lower one half was red, the upper was visibly white with a sharp distinction between the two.

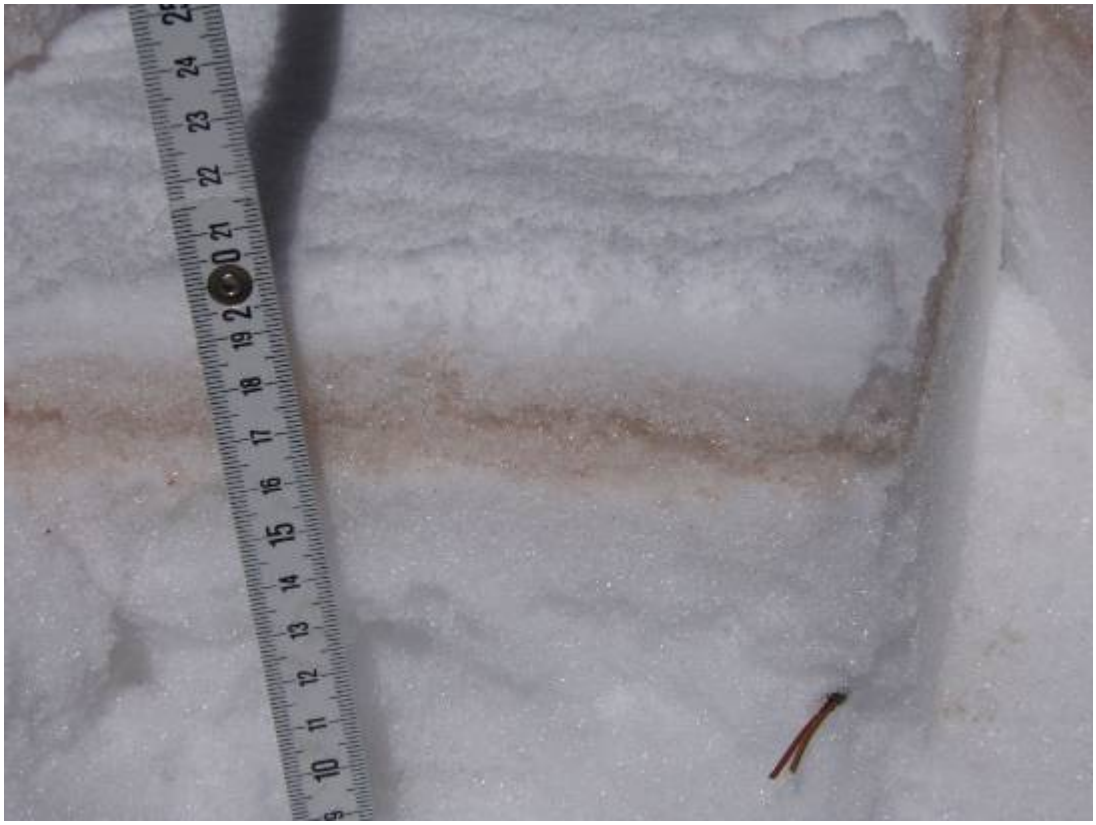
Begining February 21, 2006, westerly winds mixed the red dust layer with the overlying white snow, or removed it completely.

Related Events

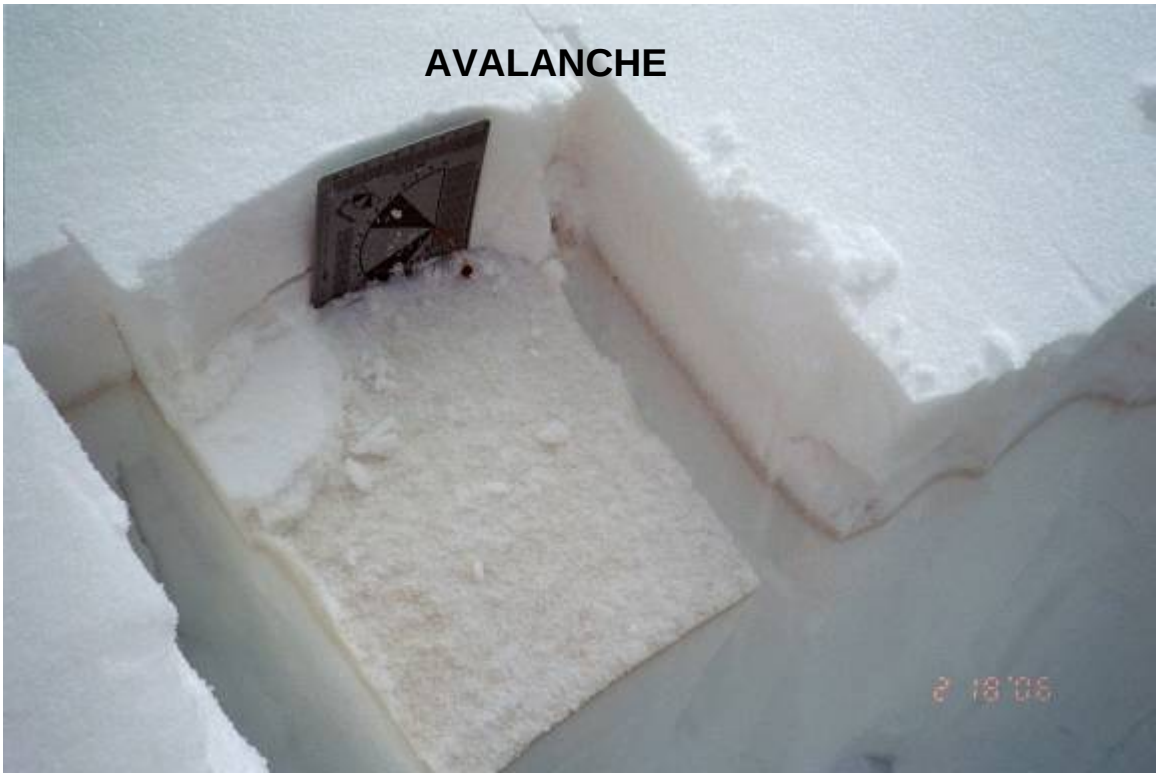
“In Europe reddish precipitation originating from North Africa has been known for hundreds of years (referred to as "blood rain" in Germany), and seems to happen every few years (transported right across the Mediterranean).” Klaus Wolter.

Behind Marr Bldg





17 Feb 2006 above Soddie



“Here is a shot of my compression test column. The Column failed with only two wrist taps, on top of the dust layer” Halsted Morris.

Colorado Avalanche Center

"SNOWPACK DISCUSSION -- A layer of dust came in with the snow yesterday across most of the state from the San Juan Mountains to the Front Range. Strong SW winds picked up the dust in the 4-Corners region where drought conditions have left the ground bare. We have received reports of small and shallow slabs releasing on this layer. Dust layers can be associated with weak layers if the conditions are right after deposition. We will have to wait and see how the snow around this layer reacts in the next few days."

From SW Colorado

“We get these dust layers almost every season, usually in spring, and they are the bane of the snowpack! Obviously, they radically change the albedo, so melt rates are greatly increased (bad!). And, in turn, the dust also creates strong temp gradients in the uppermost pack which causes increased near-surface faceting which creates cool NSF crystals which, when buried, become a weak, fast and clean interface...(bad!)”. Mark Rikkers

UNISYS

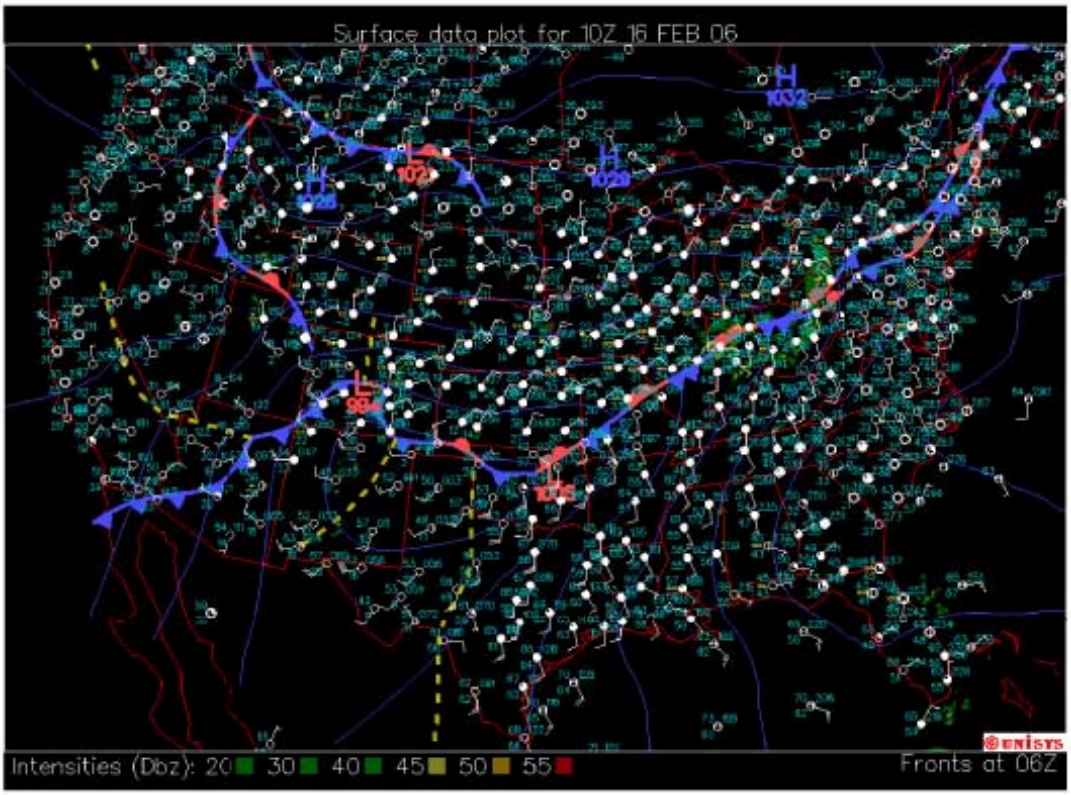
Back Home

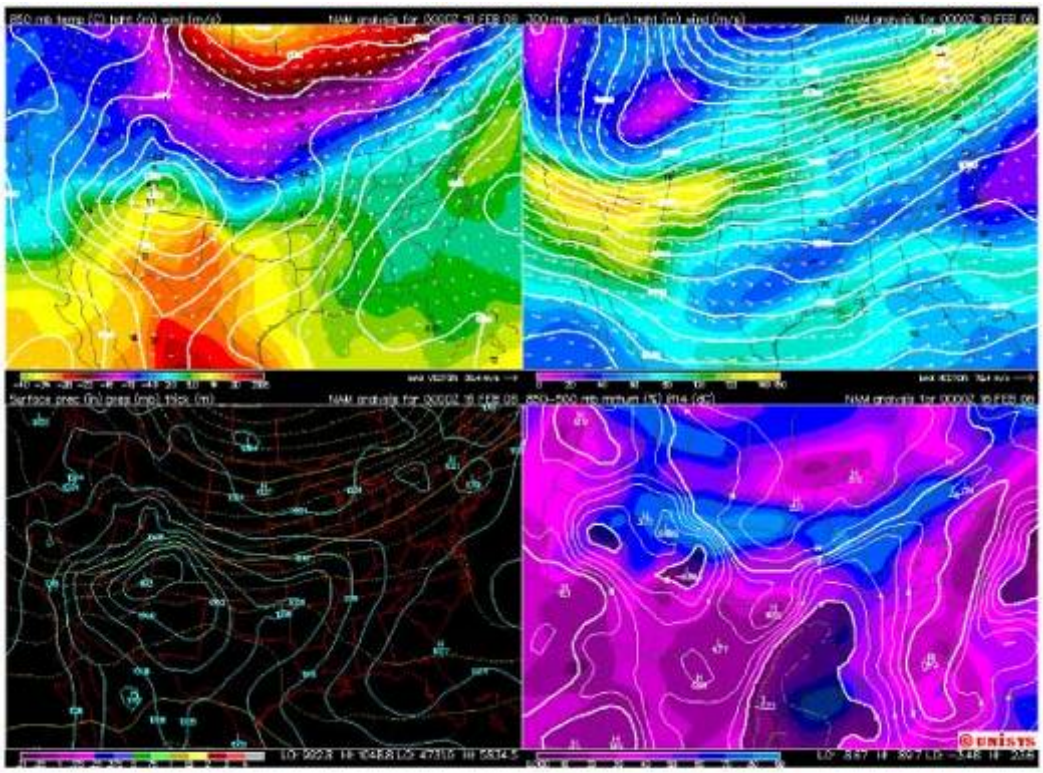
-12 hr Surface Map

PLOT Vis IR Enh IR WV Sfc Rad

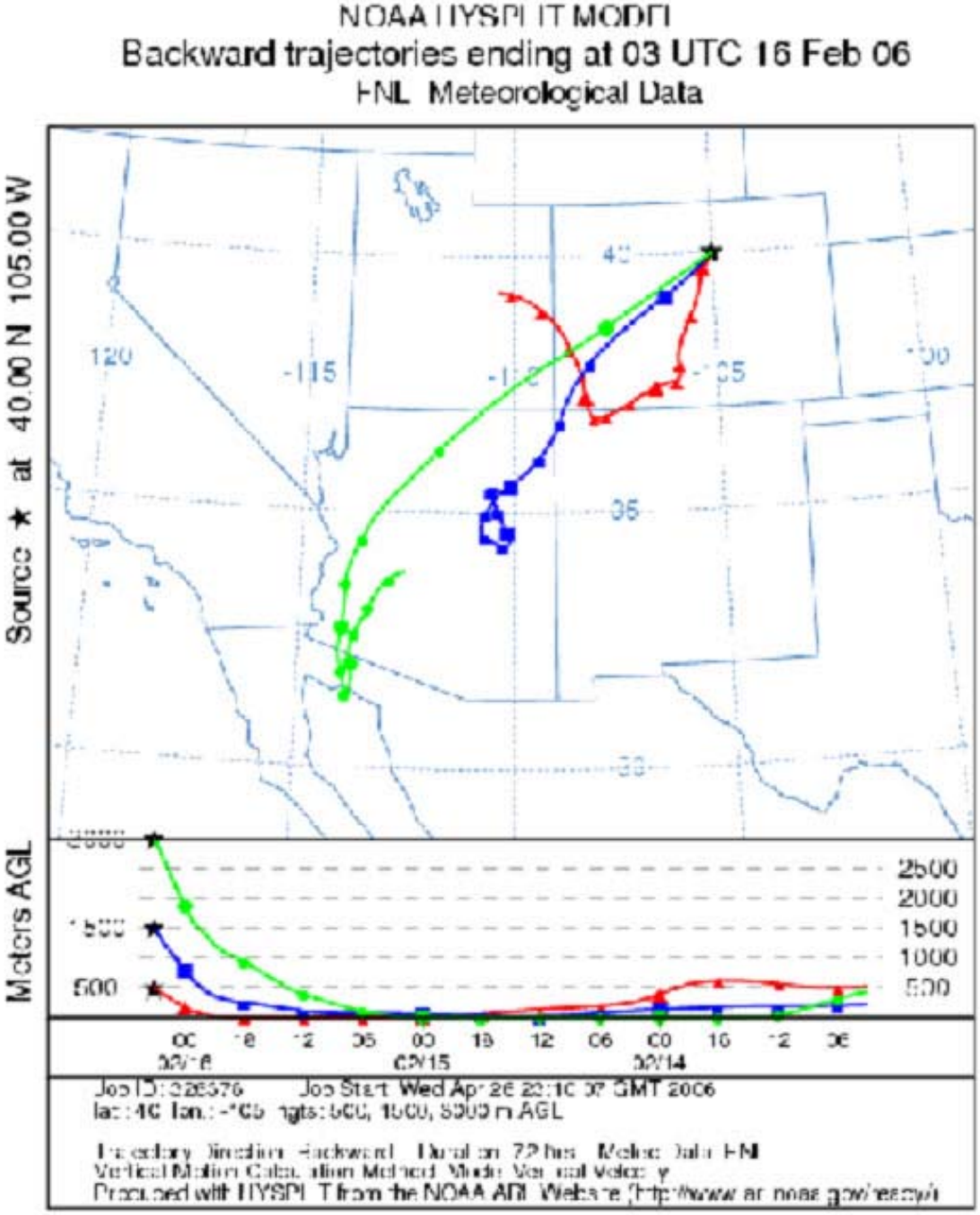
REGION US NE Atl SE MW CPln SPln NW SW WCan ECan NCan Ak Carib Mex

TIME Current -1 hr -2 hr -3 hr -4 hr -5 hr -6 hr -7 hr -8 hr -9 hr -10 hr -11 hr -12 hr

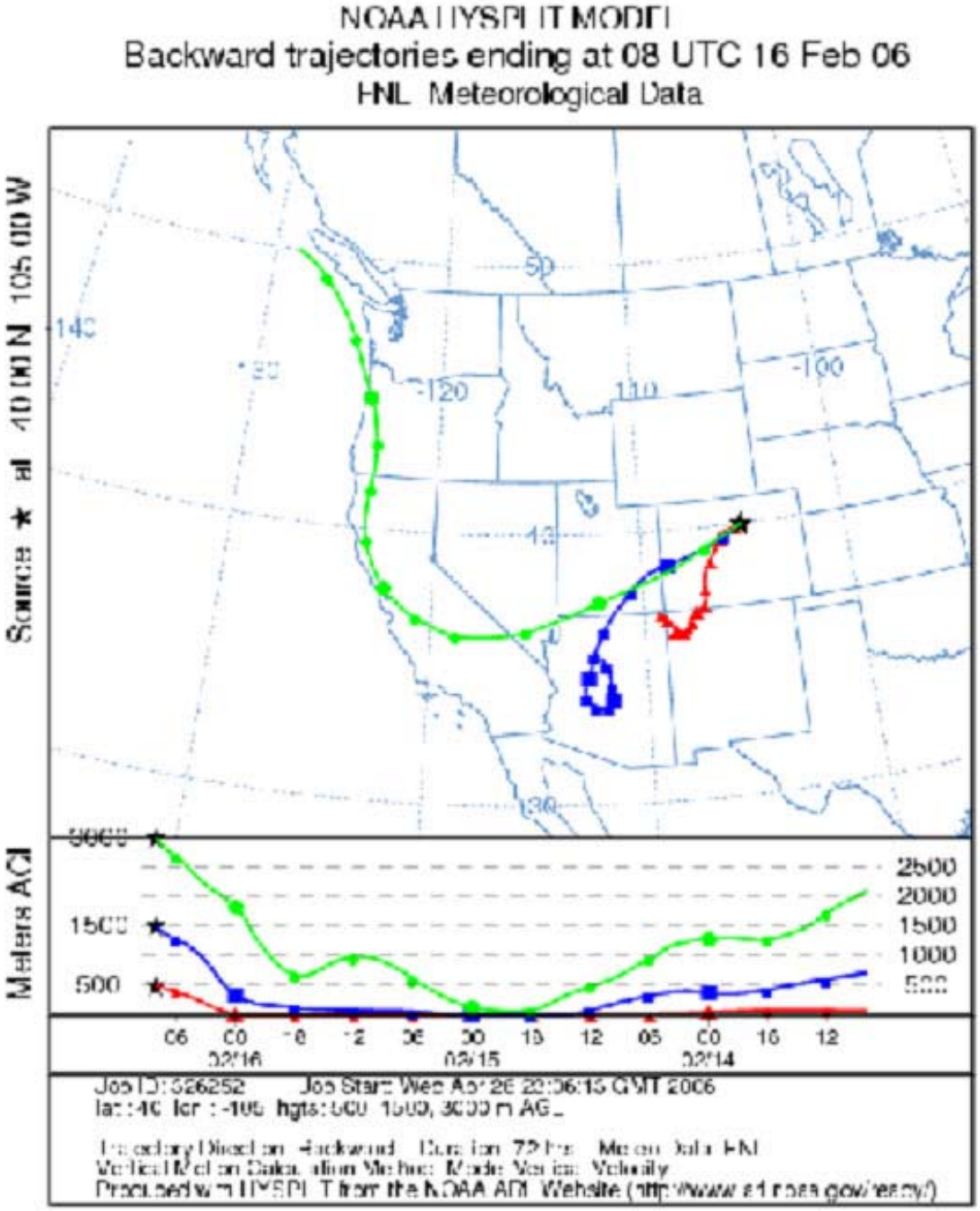




Start of Event



End of Event


NOAA HYSPLIT MODEL
Backward trajectories ending at 08 UTC 16 Feb 06
HNL Meteorological Data
Source ★ at 40.00 N 105.00 W
Meters AGL
2500
2000
1500
1000
500
06 00 18 12 06 00 18 12
02/16
02/15
02/14

MEASUREMENTS

Snowpits; depth, density, temperature, stratigraphy

Dan Muhs, USGS, "Particle size analyses, mineralogy, and rare earth element geochemistry … comparison with the alpine and subalpine soils that Jim (Benedict) and I have studied in the Front Range."

Mark Williams, INSTAAR: NADP suite of cations/anions, minerals; Sr-86/87 (Phil Veplanck); C13 (Ruth Ley).

David Clow, USGS: carbonate (acid neutralizing capability).

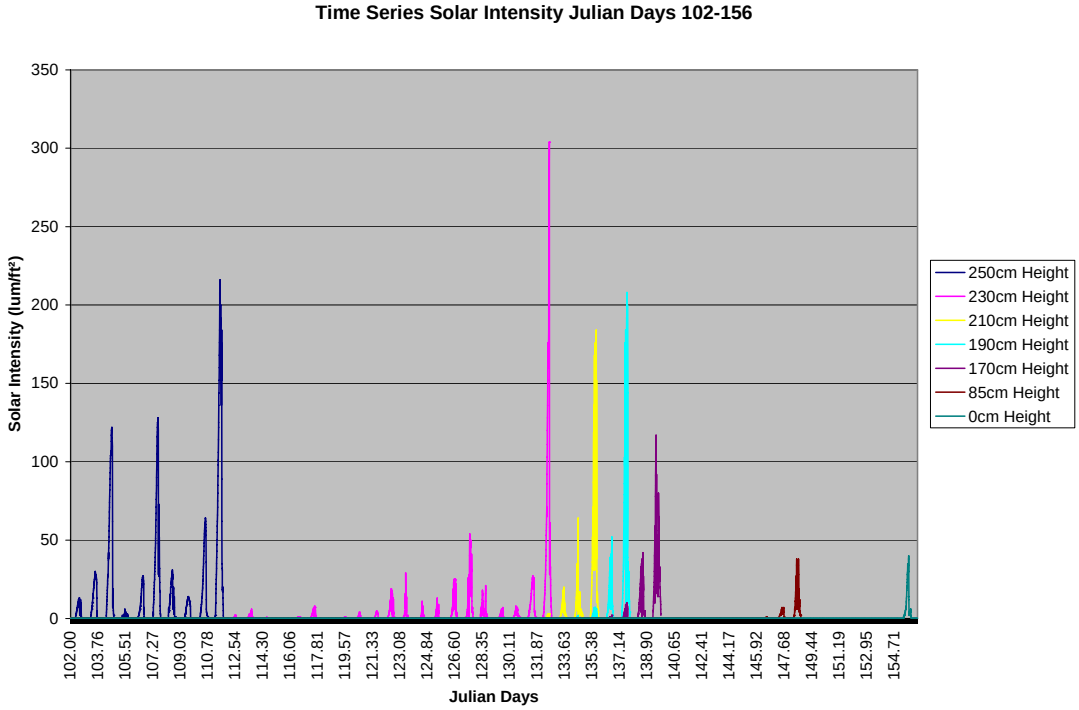
Tom Painter, CIRES, CU, Effect of particle size on radiative response of snowsurface to melting.

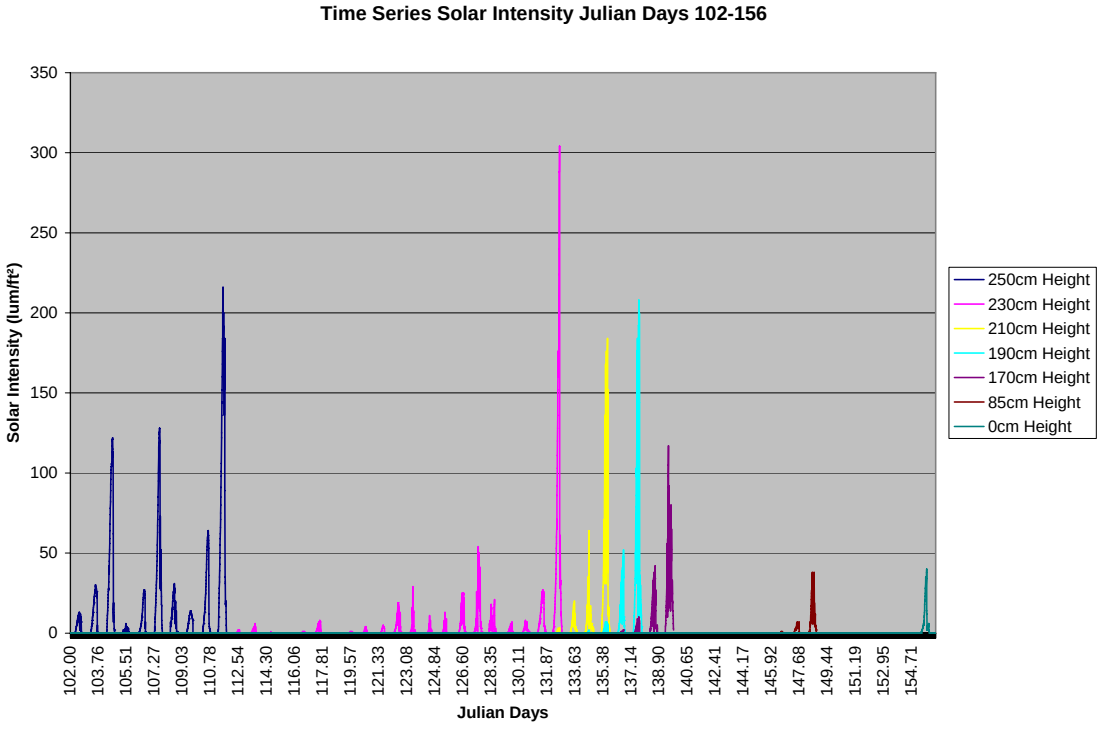
Temperature and Light Sensor Array

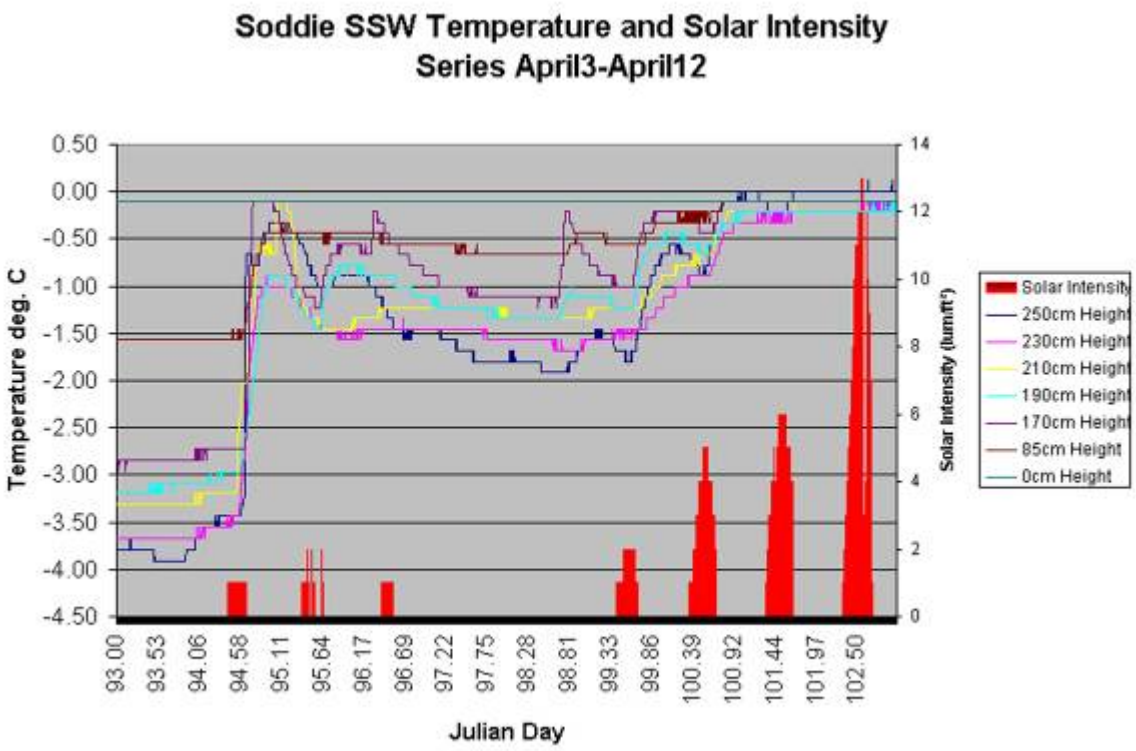
Allen Townsend, INSTAAR, Ecological effects: plant and soil response and change, surface melt rate.

Steven Fassnacht, CSU: Surface roughness

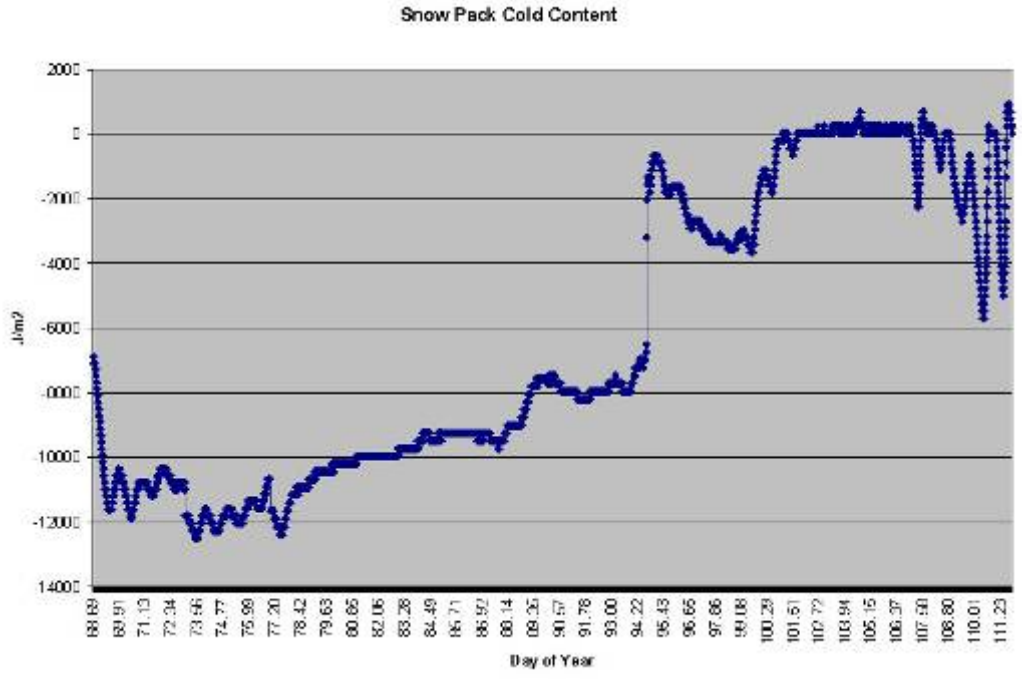
Temperature and light level profile







On JD 94, the snowpack absorbed 6709 J/M2 in one hour. This is a rate of 112 J/M2 per minute



DOY 94: Energy infusion rate of 112 J/m2 per minute brought the snow pack to isothermal in one hour!

Ice Columns

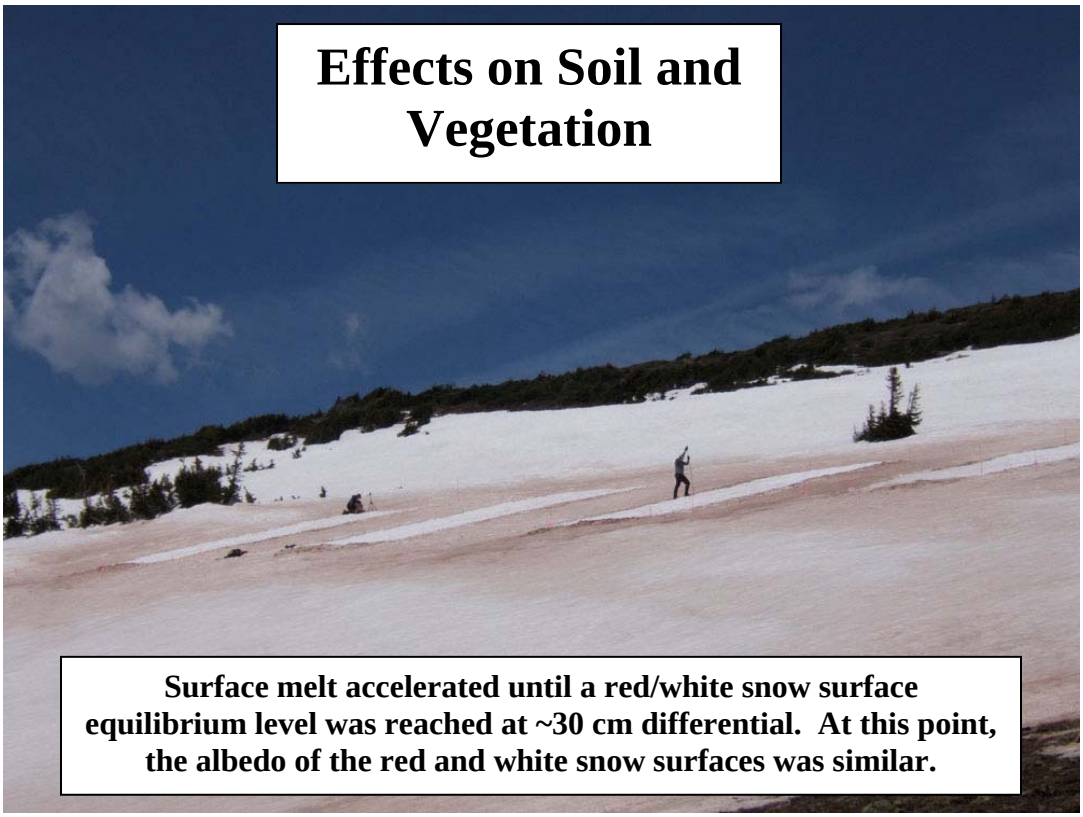
- Indicators of melt-water flow paths
- Altered form in red snow layer

Five ice columns randomly selected for both types of snow, excavated, measured for surface diameter, length, shape, and where the column terminated. Ice columns from red snow were significantly shorter than from white snow ($p = .0001$), with red snow columns having a mean height of 16.4 cm. Ice columns from white snow were longer, mean length of 60 cm. The red snow columns had a conical shape and maximum diameter occurring at the top of the column. The white snow columns had a more consistent uniform shape from surface to bottom before ending in ice lenses.

We speculate that increased melt rates in the red snow areas: (1) increased the volumetric water content; (2) resulted in a more uniform movement of water through the snowpack; (3) increased rates of liquid water movement through the snowpack; and (4) melted the pre-existing ice columns from top to bottom because of the increased latent heat of fusion associated with the increased volumetric liquid water content and higher rates of liquid water movement through the snowpack.

Red Snow: shorter (16.4 cm), fatter
White snow: longer (60 cm), thinner
Both: terminated at ice layer


Spring Snow Surfaces
Red = smooth; White = rough (10-30 cm)


Effects on Soil and Vegetation
Surface melt accelerated until a red/white snow surface equilibrium level was reached at ~30 cm differential. At this point, the albedo of the red and white snow surfaces was similar.

Dust scattered over snow on 12 May 2006.

"June 2, 1200 mst. The fine dust plot (first one) is much deeper (~20 cm) and darker than the coarse plot, which is almost indistinguishable from the background now. The impression is that the coarse dust has melted into the snow, dropping away from the surface and thus no longer radiatively as active as the fine dust, which is obviously still on the surface.

June 8, 0700 mst. Fine dust plot melted a hole through the snowpack."
-MarkLosleben

SUMMARY

Suggested Effects of Red Dust on/in Snow pack, Niwot Ridge

IMMEDIATE (RADIATIVE) EFFECTS

- **Dust layer can be radiatively activated 20-30 cm below the surface**

- **Increases surface melt rates until "normal" background albedo levels are reached; ~30 cm differential on Niwot Ridge, spring 2006.**

- **Alters sub-surface melt water flow paths**

- **Increases energy flux through snowpack**

- **Particle size matters**

LONGER-TERM POTENTIAL EFFECTS

- **Possible soil composition and soil water chemistry changes (study in progress).**

CONCLUDING THOUGHTS

Dust-in-snowfall events present another avenue to reduce snow pack.

Possible Scenario:

A warmer, drier climate increases dust availability. Gustier frontal passages transport this dust further, frequently reaching the upper Colorado River Basin

Potential Impacts:

- **Reduced SW US water supplies (less snow pack)**
  Increased dry, summer season length,

- **Altered phenology**

- **Shifted ecological zones**

- **Positive feedback that further increases dust supply.**

[By 2036, there will be an additional 86 tons per day of air-borne dust from the dry bed of the Salton Sea, if remedial actions are not taken (SW Hdrol, v.5. No 5).]