Dust-on-Snow and Colorado Avalanche Processes

Presented at:
Colorado Snow and Avalanche Workshop 2010

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CSAS

Dust-on-Snow & Avalanches

Scenarios to Monitor

- Dust effects on dry/cold snowpack stability
- Dust effects on wet/isothermal snowpack stability

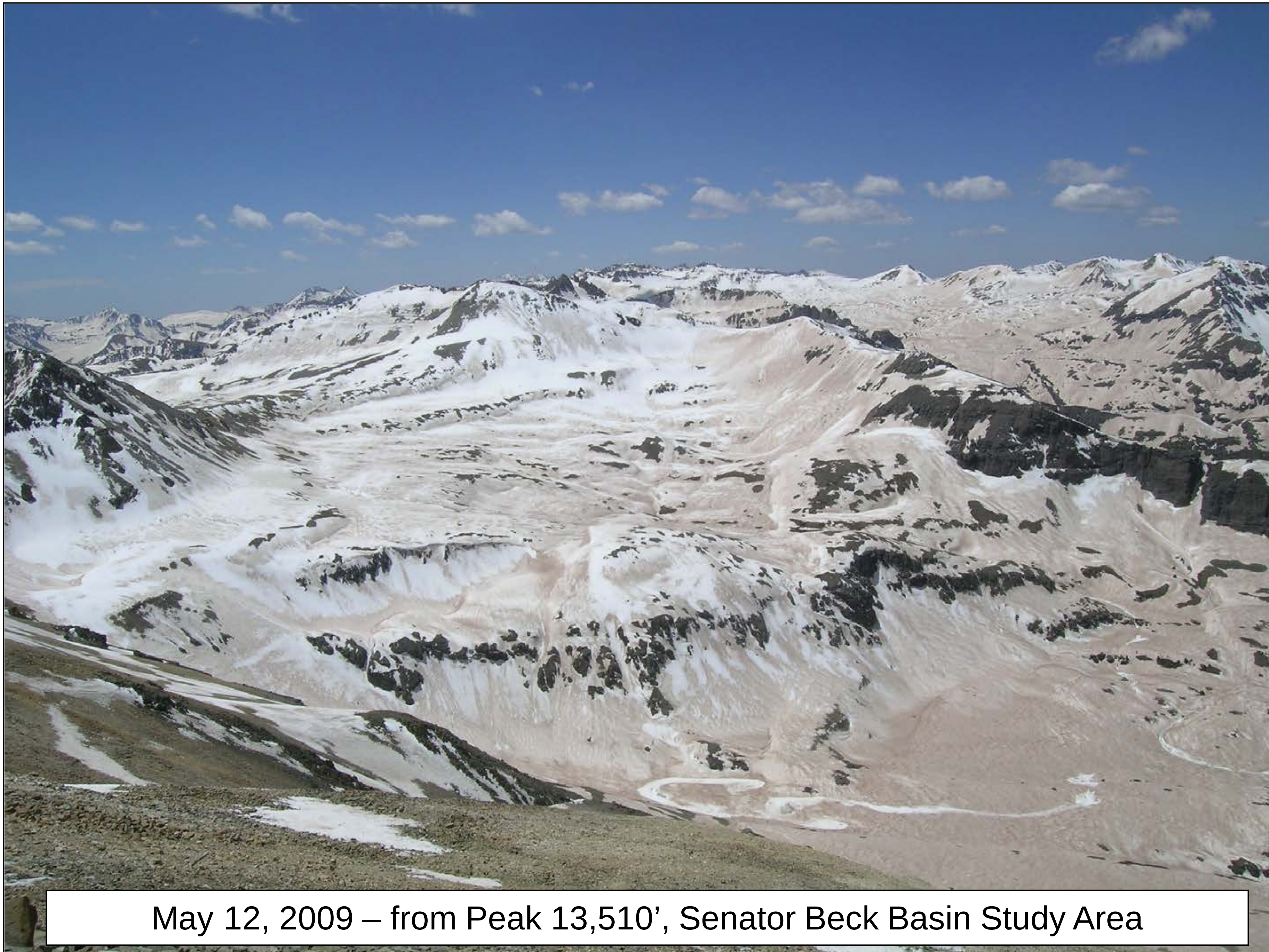
Processes occurring at all scales of avalanche interest!

Senator Beck Basin: March 22, March 29, April 3, April 8, April 15 layers

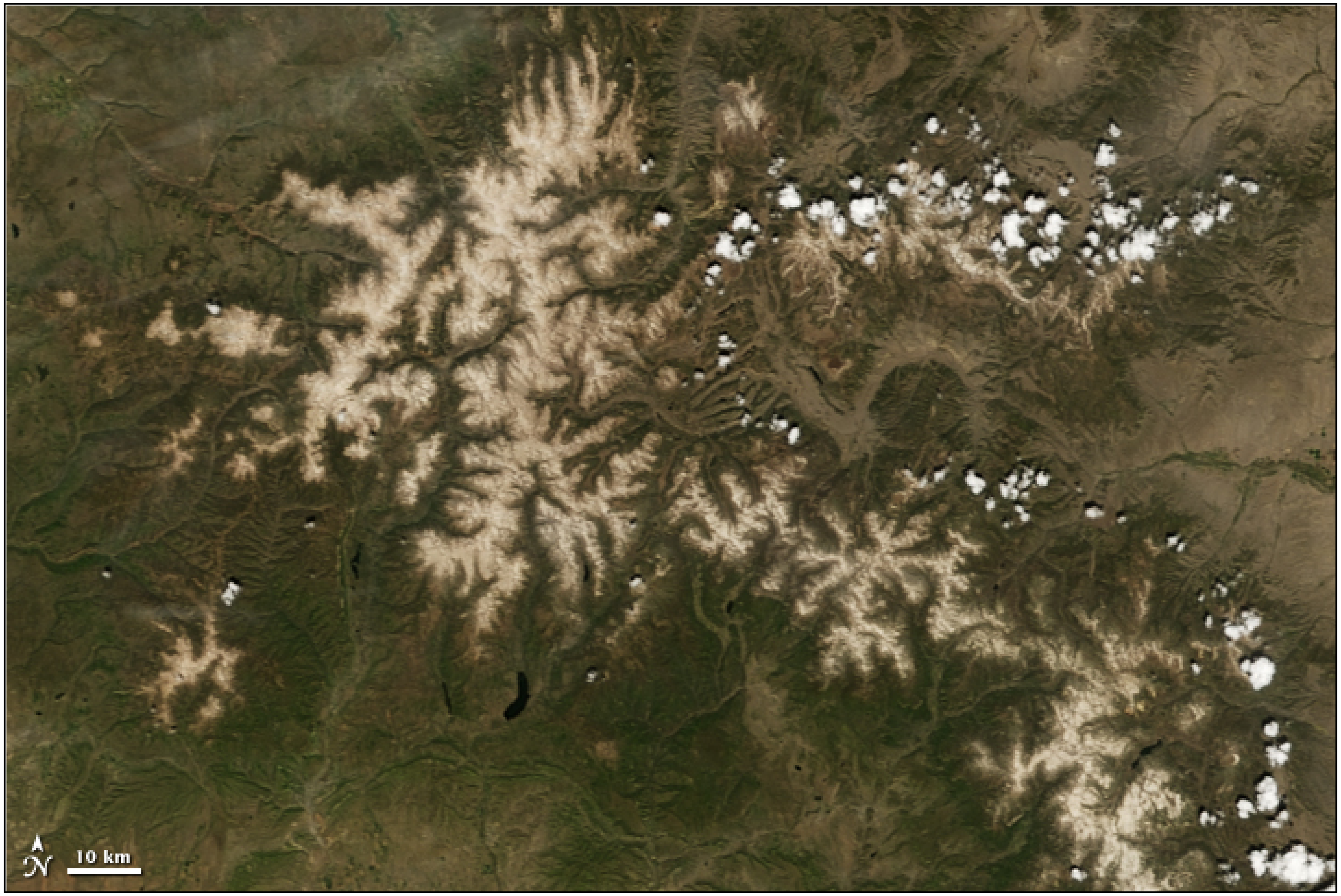
Below Treeline – April 22, 2009

Above Treeline – April 24, 2009

May 13, 2009 – Swamp Angel Study Plot



May 12, 2009 – from Peak 13,510’, Senator Beck Basin Study Area



May 18, 2009 – San Juan Mountains
NASA MODIS Image

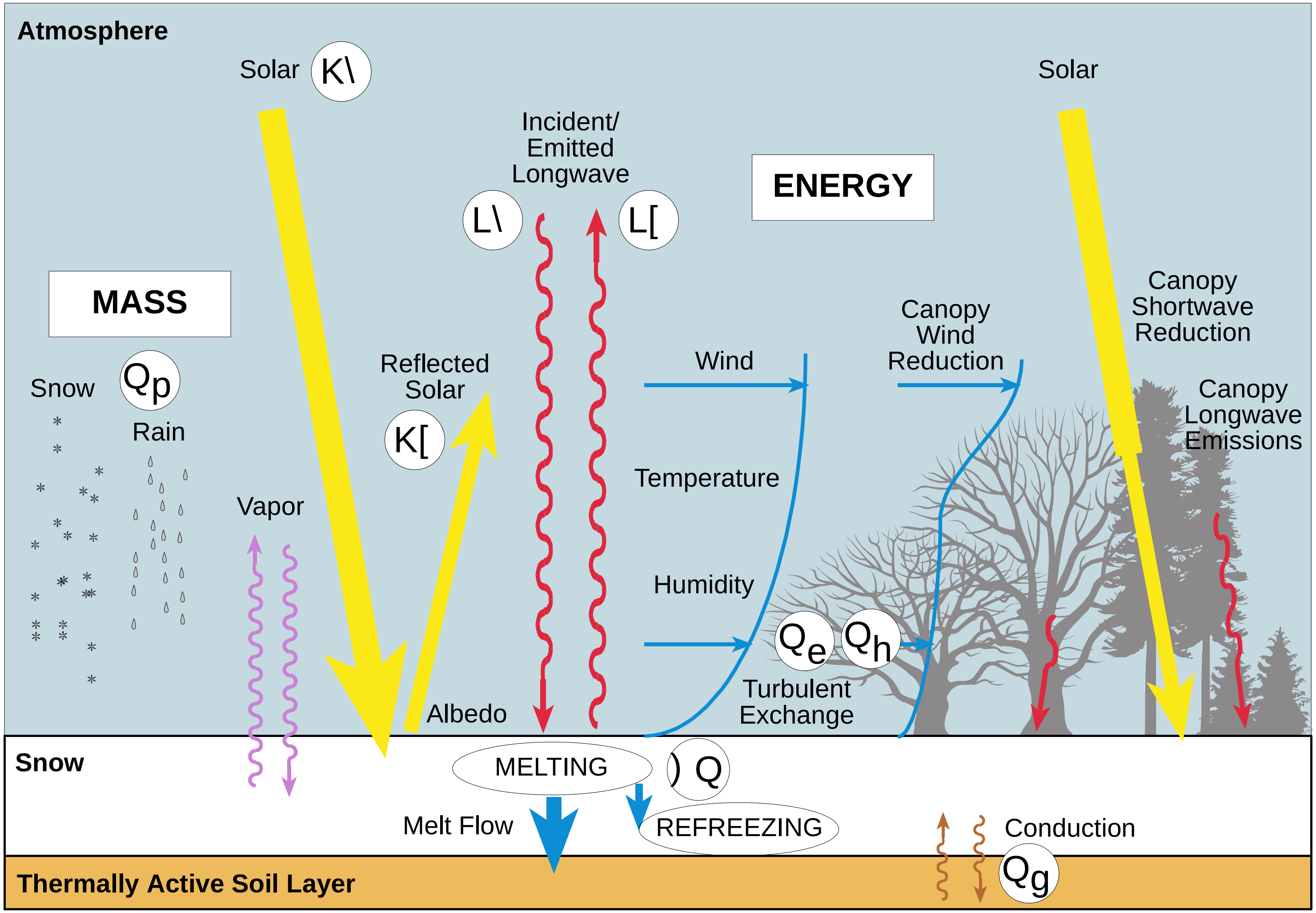
Dust-on-Snow Events

- Dry Deposition and "Wet" Deposition
- Some Fall events, Some Winter, Mostly Spring

Dust-on-Snow Events Documented per Month, by Winter
Senator Beck Basin Study Area at Red Mountain Pass – San Juan Mountains

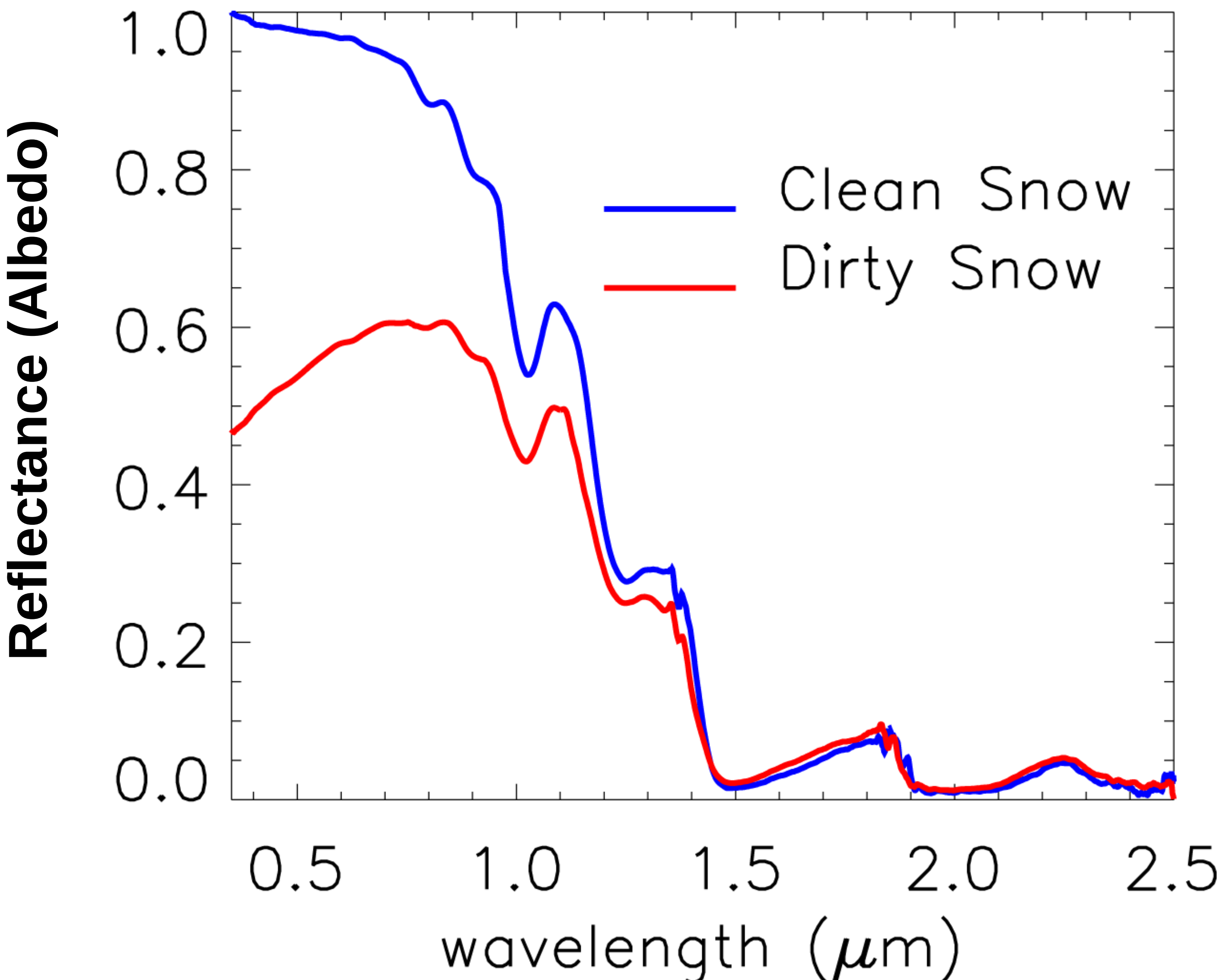
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
2002/2003					2		1			3
2003/2004							2	1		3
2004/2005	0	0	0	0	0	1	2	1	0	4
2005/2006	0	0	1	0	1	1	3	2	0	8
2006/2007	0	0	1	0	1	1	3	1	1	8
2007/2008	0	0	0	0	0	3	3	1	0	7
2008/2009	1	0	1	0	1	4	5	0	0	12
2009/2010	1	0	0	0	0	1	4	3	0	9

Snowpack Energy Budget



Courtesy Prof. Steven Fassnacht

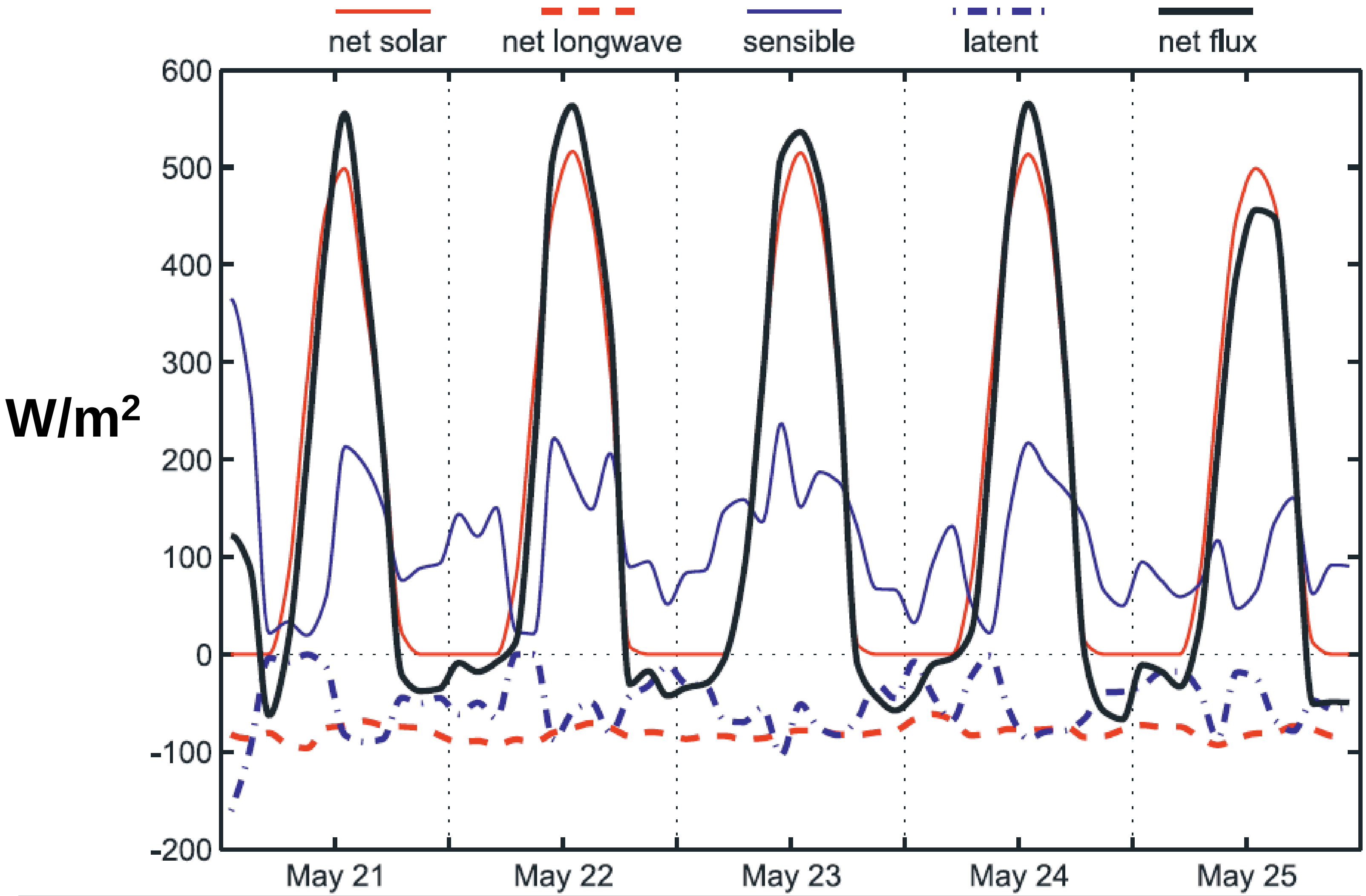
Snow Albedo



Reflectance (Albedo)
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)

Snowpack Surface Energy Budget

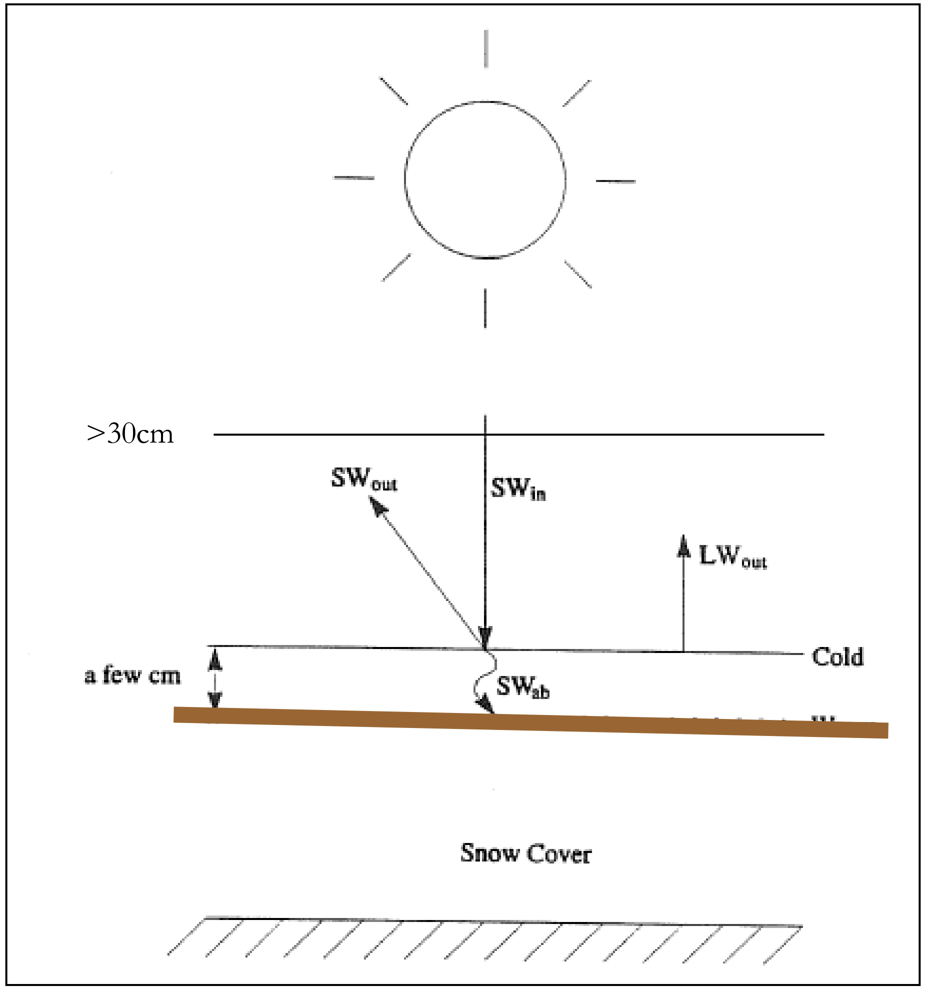
Dusty Snow Surface, Clear Skies – Senator Beck Study Plot 2005



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


ATOMIC
ATOMIC
ATOMIC
ATOMIC

Photo courtesy of Chris George
& Don Bachman



Arctic and Alpine Research, Vol. 30, No. 2, 1998, pp. 193–199

Terminology and Predominant Processes Associated with the Formation of Weak Layers of Near-Surface Faceted Crystals in the Mountain Snowpack

Karl W. Birkeland

March 31, 1999 layer

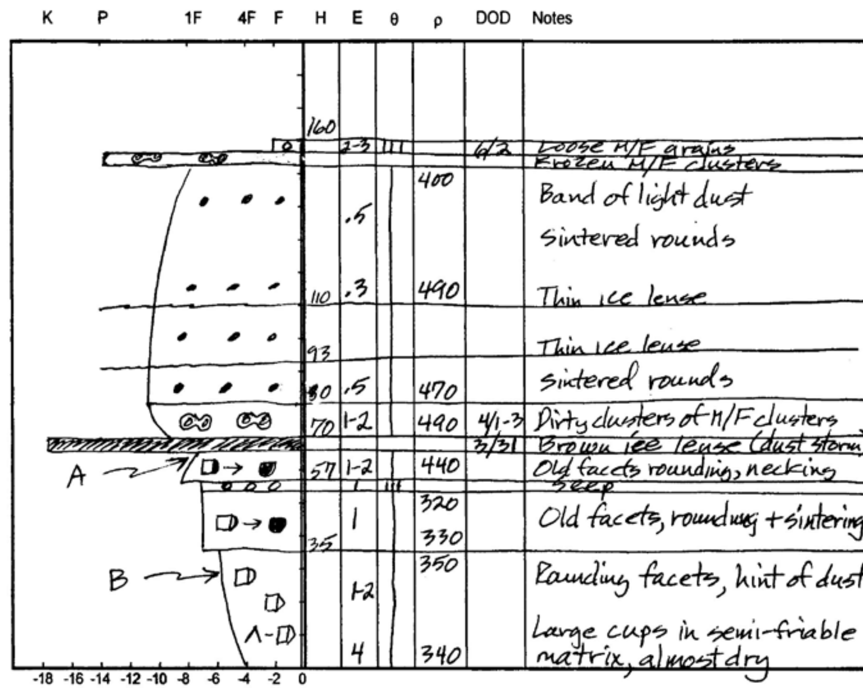
Observer: CL | Yule Creek Avalanche Services | Profile # ____

Time: 1100 | **Snowpack Profile** | Date: 6/4/99

Air T: +8 °C | Sky: ⦶ | Precip: — | Wind: L/M | Prior Pit #: —; —/—/—

Location: Independence Pass | Elev. 11,900' | Aspect: NW | Boot P: 2 cm | ∠: 29°

Notes: Session to test smaller 1 kg Load Plate.



Potential Slab									Weak Layer & Bed Surface							
Ref	H_2O_{Nor} ÷ H_{Nor} = $\bar{\rho}$			Sin∠ x H_{Nor} x $\bar{\rho}$ x 9.8 = Υ_{Slab}					F	E	T_{WL}	S	C	SB	ρ_{wl}	ρ_{bed}
A	366 ÷	,81 =	452	,4848 x	,81 x	452	x 9.8 =	1740	⧠→●	1-2	0	M	—	—	440	440
B	498 ÷	1,16 =	429	,4848 x	1,16 x	429	x 9.8 =	2364	⧠	1-2	0	E	—	—	350	340
C	÷	=		x	x		x 9.8 =									
D	÷	=		x	x		x 9.8 =									

Notes:

Loaded Column Index Computation

Ref	T1	T2	T3	T4	T5	Avg_{Test}	Υ_{Test} + Υ_{Slab} = Υ_{Total}	Υ_{Total} ÷ Υ_{Slab} = Index
							+ =	÷ =
B	19,4	14,0	9,8	6,8	19,0		+ =	÷ =
							+ =	÷ =
B	>25	>25	17,2	>25	19,5	18,1	3395 + 0 = 3395	3395 ÷ 2364 = 1,44

Notes: 10 tests performed using 1kg Load Plate. Columns were aprox 1.2 m tall but were still of consistent dimension and plumb. All columns failed in clean shear at the 30 cm level in moist, rounding facets.

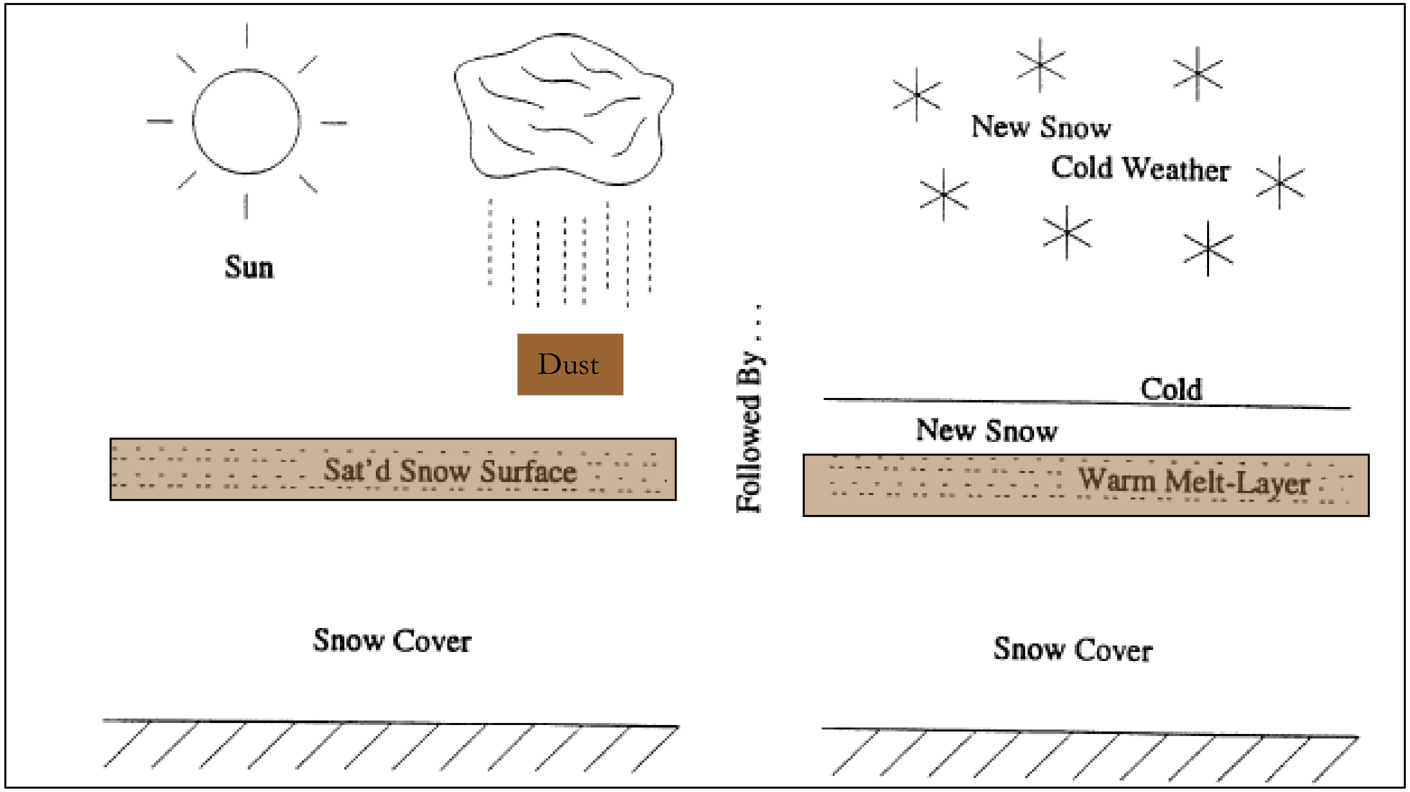
V. 6/99

February 15, 2006 layer

Photo courtesy of
Halsted Morris - CAIC

Photo courtesy of Chris George
& Don Bachman

October 27, 2009
layer



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Terminology and Predominant Processes Associated with the Formation of Weak Layers of Near-Surface Faceted Crystals in the Mountain Snowpack

Karl W. Birkeland


April 6, 2009

March 19, 2007

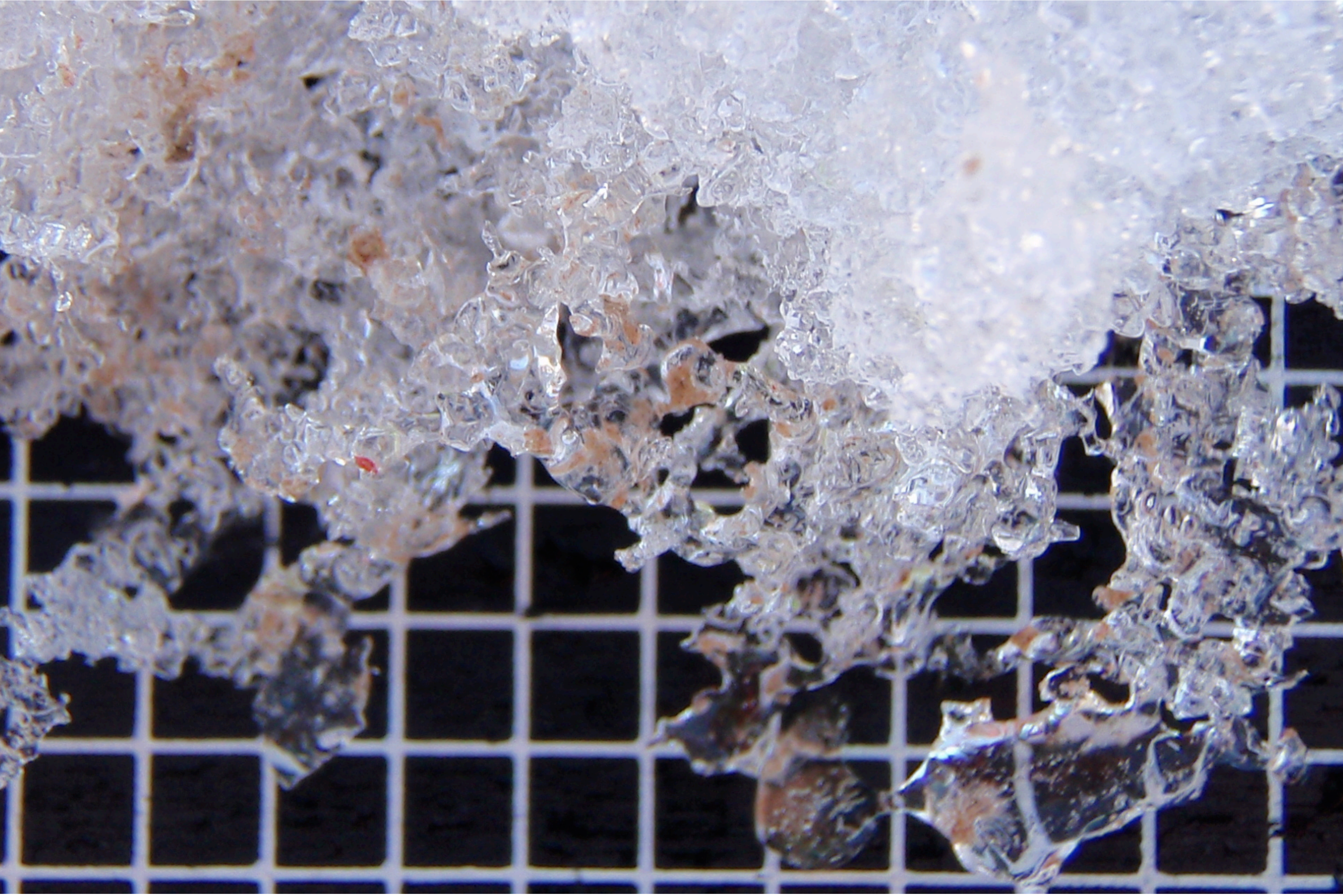

Photo courtesy Andrew Temple


1
2
3
4
5
6
7
8
9
10

May 26, 2010 – Grizzly Peak Snotel, A-Basin

May 26, 2010 – Grizzly Peak Snotel, A-Basin

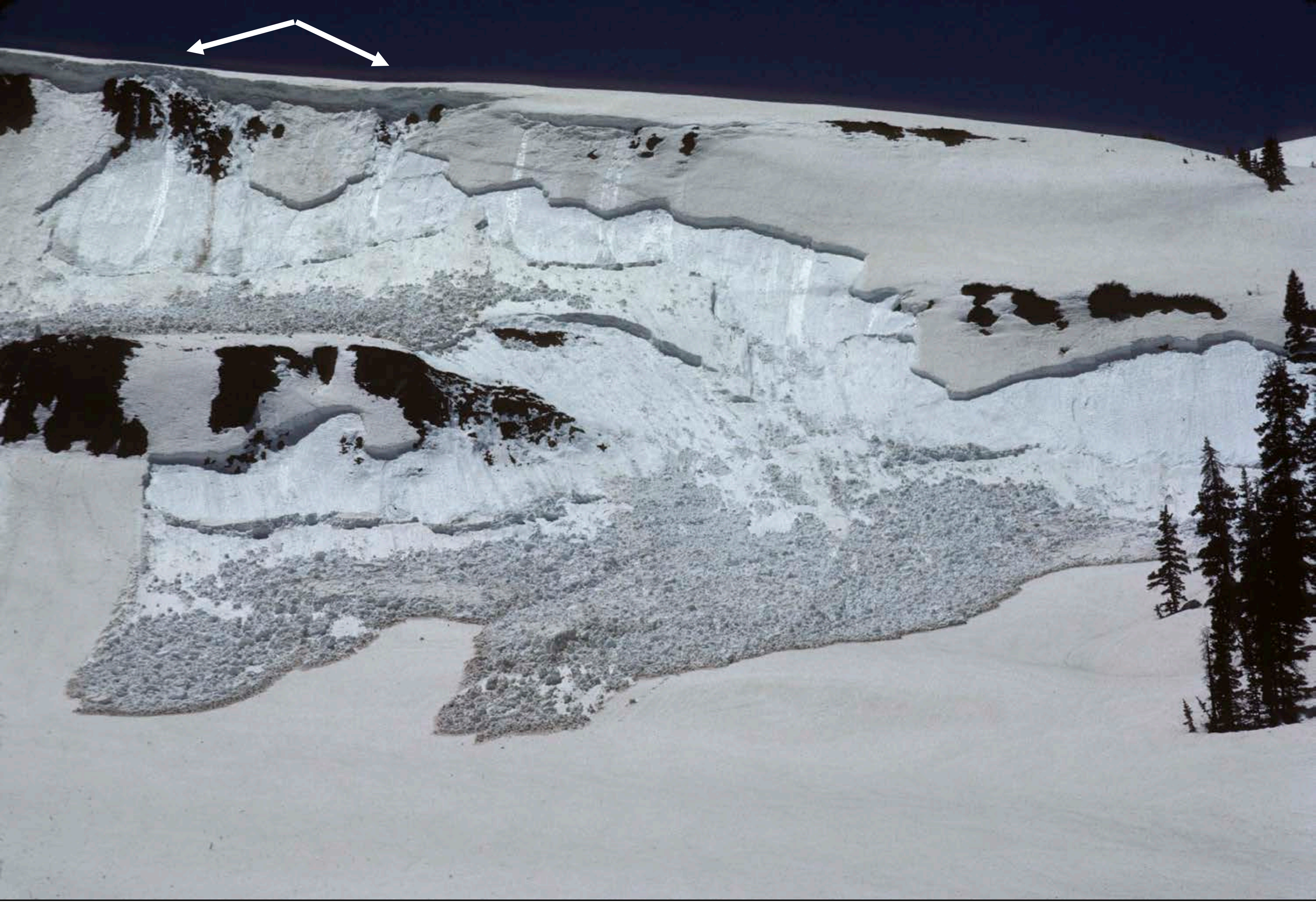

Photo courtesy of Chris George
& Don Bachman

Dry & Cold Snowpack Effects

- In winter snowpack, dust on/in snow …
  - Can be deposited at night and buried ≥ 12” and have no immediate impact at all (until emerging in spring)
  - Can be deposited “wet” during daylight and induce *very rapid* near-surface faceting, then preserved by deeper burial
  - Can induce immediate melt (despite radiant cooling and sub-freezing air temps) and …
    - Surface melt/freeze crusts/layers (future bed surface)
    - Wetting fronts re-freezing as ice layer(s) below surface (future free water barrier)
    - Reduced “cold content” of snowpack (warming)

Warm (Isothermal) Snowpack Effects

- Dust at the snowpack surface …
  - will increase direct solar absorption by 2x-3x or more
  - create rapid and intense free water flux that can …
    - Weaken basal structure and increase deep-slab instability
    - Weaken interfaces at ice barriers mid-pack

- Dust underneath new snow layers ≤12” thick …
  - can increase energy absorption beneath surface and rapidly generate new snow instability
    - As wet-loose point releases (rapidly loading deeper instabilities)
    - As wet ‘sheeting’ or slabs of new snow (rapidly loading deeper instabilities)