

Absolute Velocity Estimates from a Glider Mounted ADCP

PIC 1

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PIC 1



GEODAR (FMCW radar) is installed in the valley bottom and observes the mountain to track the dense flowing core below the powder cloud.

A blurred image showing a mountain slope. A radar beam is visible, pointing towards the mountain. The image is labeled 'PIC 1'.

Around 100 radar frames are captured every second with a down-slope resolution of 1 m.

The avalanche front is the change from light to red colors.

The avalanche approaches towards the radar (decreasing range) and the gradient of the line features is the approach velocity.

A blurred image showing a mountain slope. A radar beam is visible, pointing towards the mountain. The image is labeled 'PIC 1'.

PIC 1

- a) GEODAR show many approaching line features
- b) Flow-height measured by upward-looking FMCW radar.
 - ⇒ Line features correspond to waves: We call them surges.

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Major surges can exist in the avalanche body and they overrun each other.
The origin of the major surges are secondary slab release (colored bars).

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Video and laserscan data reveal the occurrence of slab releases.
Around 50 % of the total entrained volume entered the flow via slabs.
The slabs can be as large as the initial released slab. [more ...](#)

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Slabs enter at random locations into the flowing avalanche and their mass is not concentrated at the front.

⇒ Spreading the mass over the flow alters the runout.

	Time [s]	Volume [m ³]	Range [m]	Length [m]	Area [m ²]	Depth [m]
Avalanche #0019		$V_t=29500$			40411	0.73
initial release	3.4	$V_0=2188$	2506	62	1400	1.56
slab #1	17.2	$V_1=521$	2356	39	701	0.74
slab #2	23.4	$V_2=3503$	2284	83	2753	1.28
slab #3	20–25*	$V_3=3345$	2150	99	1880	1.78
slab #4	38.7	$V_4=4276$	1945	153	3657	1.17
Avalanche #0017		$V_t=78500$			82632	0.95
initial release	5.2	$V_0=15233$	2402	191	12974	1.17
slab #5	12.2	$V_5=7620$	2219	202	6043	1.26
slab #6	14.1	$V_6=5868$	2215	166	5851	1.01
slab #7	25.6	$V_7=6307$	1982	95	3320	1.90
slab #8	15–25*	$V_8=10663$	1947	253	5037	2.12

Table: Release time, Volume, Location and size parameters of all identified slabs.

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Minor surges are only found in the head of large powder avalanches. They are flow features (roll waves) in the energetic frontal region. Their speed is high and constant when behind the front, but dramatically decelerate as soon they overtake the leading edge.

PIC 1

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Minor surges were simulated with a 1D Voellmy-like model.
Model #1 describes the front, thats what usual models do.
Model #2 tries to follow every surge individually, but no deceleration.
Model #3 explains minor surges with 2 sets of friction parameters

⇒ The effective friction changes dramatically as soon as

- ▶ GEODAR radar is able to track internal surges (flow height waves) below the powder cloud of snow avalanches. Two types of surges exist: *Major* and *Minor surges* are differentiated by their length.
- ▶ Major surges can occur at random location in the flow and influence the mass distribution of the avalanche. Minor surges are ubiquitous feature of the fast-flowing energetic part in the frontal region of large powder avalanches.
- ▶ The effective friction between the front and the avalanche body differs. This must be explained with changes in the snow surface like smoothing and entrainment of the soft, upper snow layers. Numerical models not yet account for this.

Köhler, A., J. N. McElwaine, B. Sovilla, M. Ash, P. Brennan (in Review), Surge dynamics of the 3 February 2015 avalanches in Vallée de la Sionne, *J. Geophys. Res.*