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Mesoscale coherent structures in the intermittent region of fully developed powder snow avalanches

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Powder snow avalanches are typically composed of several regions with different flow regimes. These include a turbulent suspension cloud of fine particles and a basal flow that is like a dense granular flow. In this paper we present evidence for the existence of a third region, the intermittent frontal region, that is characterized by large fluctuations in impact pressure, air pressure, velocity and density.

Measurements collected at the Vallée de la Sionne test site show that intermittencies are the signatures of mesoscale (1–10m) coherent structures in both the velocity and density fields. These can have velocities as much as 60% larger than the avalanche front speed. Some avalanches have observable coherent structures along their entire avalanche length, where as in others they are concentrated in a small region at the avalanche head. Which occurs depends on the avalanche size and on the availability of entrainable low-density snow. There are also larger scale coherent structures (10–100m) in the air velocity that are eddies reaching from the ground to the top of the powder cloud. These structures, which can span the depth of the flow, provide an efficient mechanism for moving snow from the dense layer or the static snow cover to significant heights, in the powder cloud. In addition, these coherent structures can dramatically increase the destructive force of an avalanche since large granules, of order 0.1m, of dense snow moving faster than the front velocity, can be transported much higher than was previously realized and can give impact forces of the order of hundreds of kPa well above the basal dense layer. There is also evidence that they can affect the avalanche runout by influencing the avalanche front dynamics.