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Inferences on snow avalanche flow regimes from observations and measurements: What do we really know?

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High-frequency pressure measurements at instrumented avalanche paths have long suggested that a distinct flow regime, intermediate between dense and suspension flow and termed fluidized regime here, often coexists with the former two in dry-snow avalanches. A wide range of particle sizes up to half a meter was inferred, with similar mean free path, corresponding to densities between 30 and 100 $\mathrm{kg\,m^{-3}}$. A number of direct and indirect velocity measurements indicate that the avalanche front in the fluidized flow regime (FFR) moves about twice as fast as the dense core. The long mean free path allows for considerable compression that influences dynamics and impact pressure.

We summarize field observations from Norway (1972–2006) and Switzerland (1995–2006), both from spontaneous events and from avalanches released at the test sites Ryggfonn and Vallée de la Sionne, that support the inferences from the measurements and show how the presence of the FFR expresses itself in the avalanche deposits. One often finds that one part of a flow followed a straight trajectory and deeply eroded the snowcover while another part followed a gully and left blocky deposits already in steep reaches. There are many examples of avalanche deposits with a deeper proximal part and a more shallow distal part that may reach 500 m in length and climb over 100 m on counterslopes. Both deposit types may be clearly delineated, but the surface of the proximal one consists of densely packed snow clods, often of relatively uniform size,

while the distal part features scattered snow particles of different sizes on a substrate of fine-grained snow. The density of the distal deposit appears to increase with avalanche size, from about 200 kg m^{-3} in small avalanches to 560 kg m^{-3} in extreme events. The distal deposits represent up to, but often less than, one third of the total avalanche mass. Whenever a sizable powder-snow cloud is observed, there also seems to be a deposit of the distal type, but the converse is not true. The most probable interpretation of these deposits is that they are formed by the FFR, and this view is strongly supported by direct observations from the radar shed at the Vallée de la Sionne test site in the winter 1999.

Distinguishing between avalanche flow regimes may have important consequences in hazard mapping and the design of countermeasures because the highly mobile FFR has much lower density than the slower dense flow. We also summarize observations indicating that the effects of the suspension flow regime are often relatively small but grossly underestimated by traditional lore in certain extreme cases.