Reprocessing and Reanalysis of the steady state chute-flow experiments

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Snow avalanches affect the livelihoods and economies of alpine communities and effective modelling of the dynamics is needed for mitigation against avalanche hazards. However, there is no precise understanding of the rheology of flowing snow to underpin such modelling, which means that basic experiments are still required. Seventy-five small-scale in-situ flow experiments were performed in an inclined snow chute under various slopes, temperatures and flow depths, in order to determine the velocity structure in the flow, infer shear rates and thus, rheology. However, to determine velocity fluctuations from such sensors (to estimate quantities like granular temperature) is rather complex. A velocity sensor is made up of a pair of optical sensors; right and left phototransistors are arranged in parallel on the channel wall, separated by a known, small distance. The raw data consists of pairs of voltage time series signals, which are classically converted into a velocity series using the lag to maximum cross-correlation (MCC) between the pairs, and the displacement between sensors [1]. Previously work has shown that the mean velocity profiles could be considered as a bilinear function of height [2]. The bilinear model can be interpreted as a consequence of a shear-induced evolution of snow microstructure: a sheared basal layer made of single snow grains and a less sheared upper layer made of large aggregates [2]. This work goes into the data processing in greater depth to attempt to provide greater physical insight into the dynamics of these flows for a steady and uniform chute flow.

The results from the MCC method depend on the window size adopted for undertaking the correlation of the voltage series: A big window size tends to over-smooth velocity series; a small window tends to estimate more aberrant values. The optimal value for our data (acquired at 10 kHz) is around 150 points. In this paper we demonstrate the advantage of adopting a wavelet transform, more specifically, the Maximal Overlap Discrete Wavelet Transform (MODWT) for extracting velocity series that are more informative and consistent, reflecting an implementation that is more continuous in nature than the windowing operator used to apply the MCC.

The reanalysis shows there are up to five shapes of mean velocity profiles. The environmental conditions at the time of the experiment (snow type, temperature) seem to explain these different shapes. In addition, we are able to extract profiles of the velocity distributions, which evolve from an unimodal distribution to a multimodal distribution, according to the height. Multimodality can be interpreted as a reflection of the degree of mixture of the different physics involved.

References

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