Deleted paragraphs related to wrong local speed estimates

1 Small scale flows on inclined plane and flat runway

1.1 Flow speed

Figure 1 shows the flow speed, $\|\underline{\mathbf{u}}\|(L,t)$, at the points $(L_i)_{i=1,\ldots,4}$, for the three rheology models.

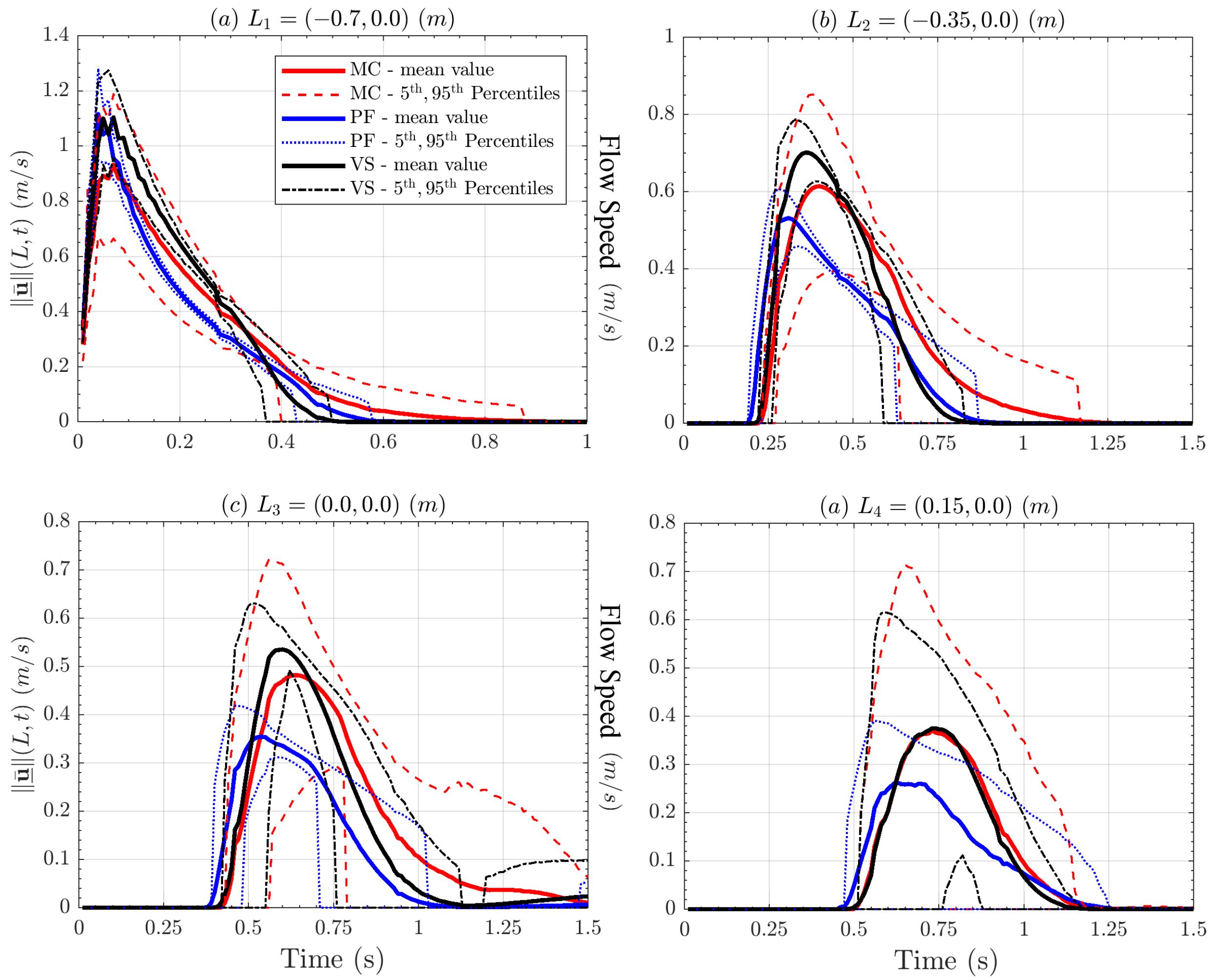

Figure 1: Records of flow speed at four spatial locations of interest. Bold line is mean value, dashed/dotted lines are 5^{th} and 95^{th} percentile bounds. Different rheology models are displayed with different colors. Plots are at different scale.

In plot 1a related to point L_1 speed peaks are 0.95 ± 0.3 m/s in MC, 1.1 ± 0.2 m/s in VS and PF. VS speed decreases almost linearly, while MC and PF have a more concave profile, making MC the faster model after 0.3 sec. Plot 1b, related to point L_2, the peaks are 0.65 ± 0.2 m/s in MC, 0.7 ± 0.1 m/s in VS, and 0.52 ± 0.08 m/s in PF. In this case it is the PF model to decrease more linearly. In plot 1c, related to point L_3, peak velocity is 0.48, $[+0.24, -0.20]$ m/s in MC, 0.54, $[+0.1, -0.06]$ m/s in VS, and 0.36, $[+0.06, -0.04]$ m/s in PF. In plot 1d, related to point L_4, peak velocity is 0.48, $[+0.34, -0.48]$ m/s in MC, 0.48 ± 0.24 m/s in VS, and 0.26, $[+0.12, -0.26]$ m/s in PF. In all cases UQ shows that MC model uncertainty is remarkably larger than in the other models, and produces higher values in the 95$^{\text{th}}$ percentile plots. Lowest speed values are affected by the elimination of material below 1 mm flow height threshold. After 0.05 s, the PF velocity profile is always significantly lower than the other models, but it also decreases slower, and matches with the stopping times of them. Moreover, it is worth noting that, curiously, PF reaches the points earlier. Speed in the deposits is below 0.1 m/s in L_3, negligible in L_4.

2 Large scale flows on the SW slope of Volcán de Colima (MX)

2.1 Flow speed - overview

Figure 2 shows the mean flow speed, $h(L, t)$, at the 51 spatial locations of interest, according to MC.

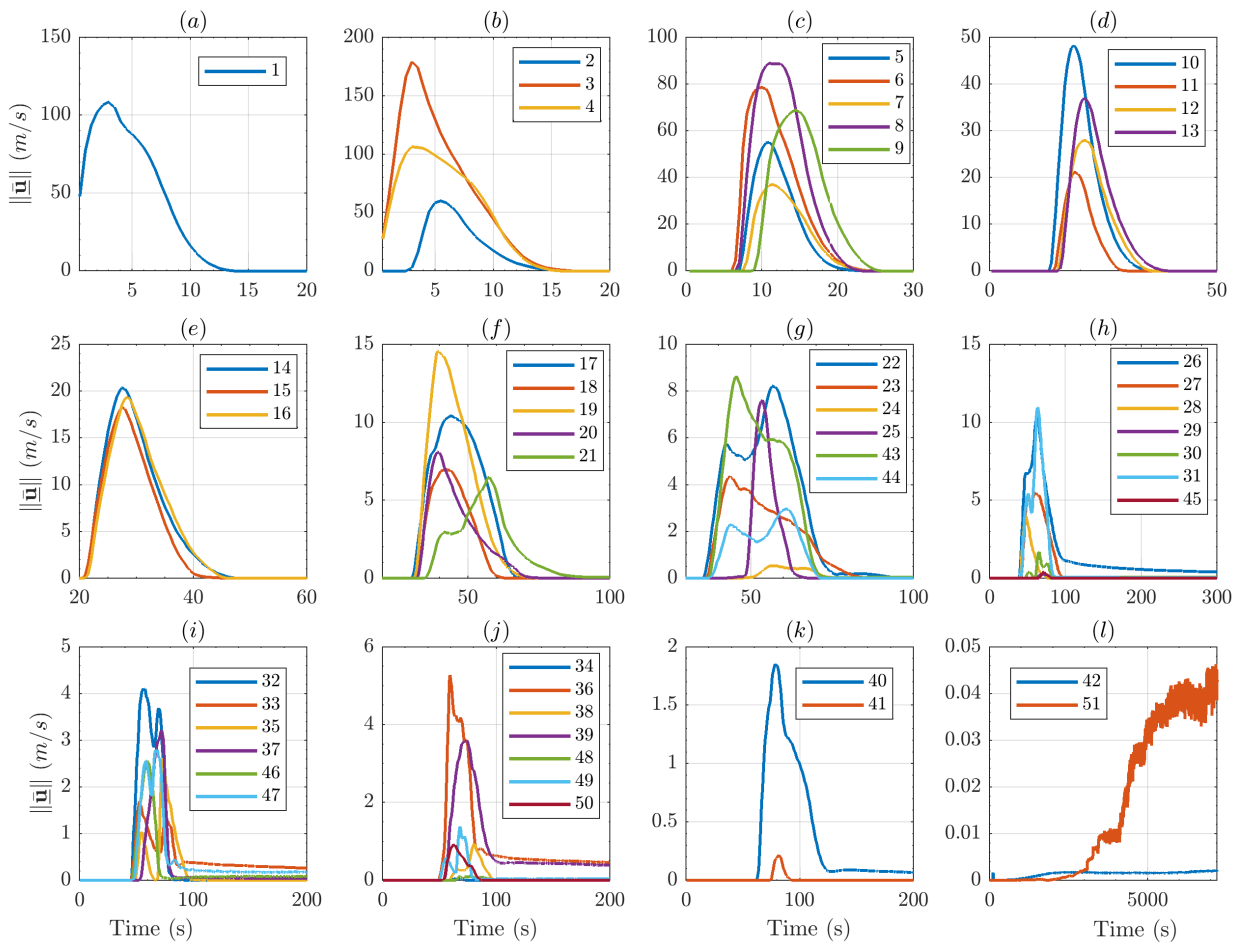

Figure 2: MC model, records of average flow speed, $|\underline{u}|(L, t)$, in 51 spatial locations of interest.

Again the different plots have different scales on either time and space axes. The plot profiles are similar to what observed in figure 1, following the plot profile classification described above. Maximum speed of $\sim 200 m/s$ is observed in proximity of the initial pile, in plot 2b, and it is related to the initiation collapse dynamics. After 1 km runout (horizontal projection), in plot 2e, the max speed is ten times smaller, $\sim 20 m/s$. At about 2 km from the initiation, when entering the main ravines, speed is $\sim 10 m/s$, and becomes $\sim 5 m/s$ or less in the distal part of the ravines. In detail, in plots 2f,g,h,i,j, the speed often shows bimodal profiles, not observed in the inclined plane case study. Moreover, in plots 2h,i,j, positive asymptotes are sometimes observed, meaning a slowly and steadily moving material even minutes after the collapse.

2.2 Flow speed - six selected points

Figure 3 shows the flow speed, $\|\mathbf{\underline{u}}\|(L,t)$, at the points $(L_i)_{i=8,10,17,39,43,46}$, for the three rheology models. Pairs of points L_8 and L_{10}, points L_{17} and L_{43}, and points L_{39} and L_{46} have significantly similar plot profiles. In plot 3a MC shows higher average speed, $\sim 80m/s$, than PF and VS, both $\sim 70m/s$. 95^{th} percentile values can reach $150m/s$ in MC, $140m/s$ in VS, $130m/s$ in PF. MC and PF are null after $20s$, while VS decreases slower, and becomes null at $\sim 60s$. In plot 3b, the average peak values are $\sim 40m/s$ in MC and PF, while only $20m/s$ in VS. All the three models show 95^{th} percentile values above $60m/s$. VS speed decreases remarkably slower than in the other models, requiring more than $120s$ to become null, while MC and PF speed remains positive for $\sim 25s$. In plot 3c, average speed is $\sim 20m/s$ in PF, $\sim 10m/s$ in MC, $\sim 2m/s$ in VS. 95^{th} percentile values can reach $\sim 55m/s$ in PF, $\sim 48m/s$ in MC, $\sim 24m/s$ in VS. The duration of positive velocity in VS can be long hundredths of seconds.

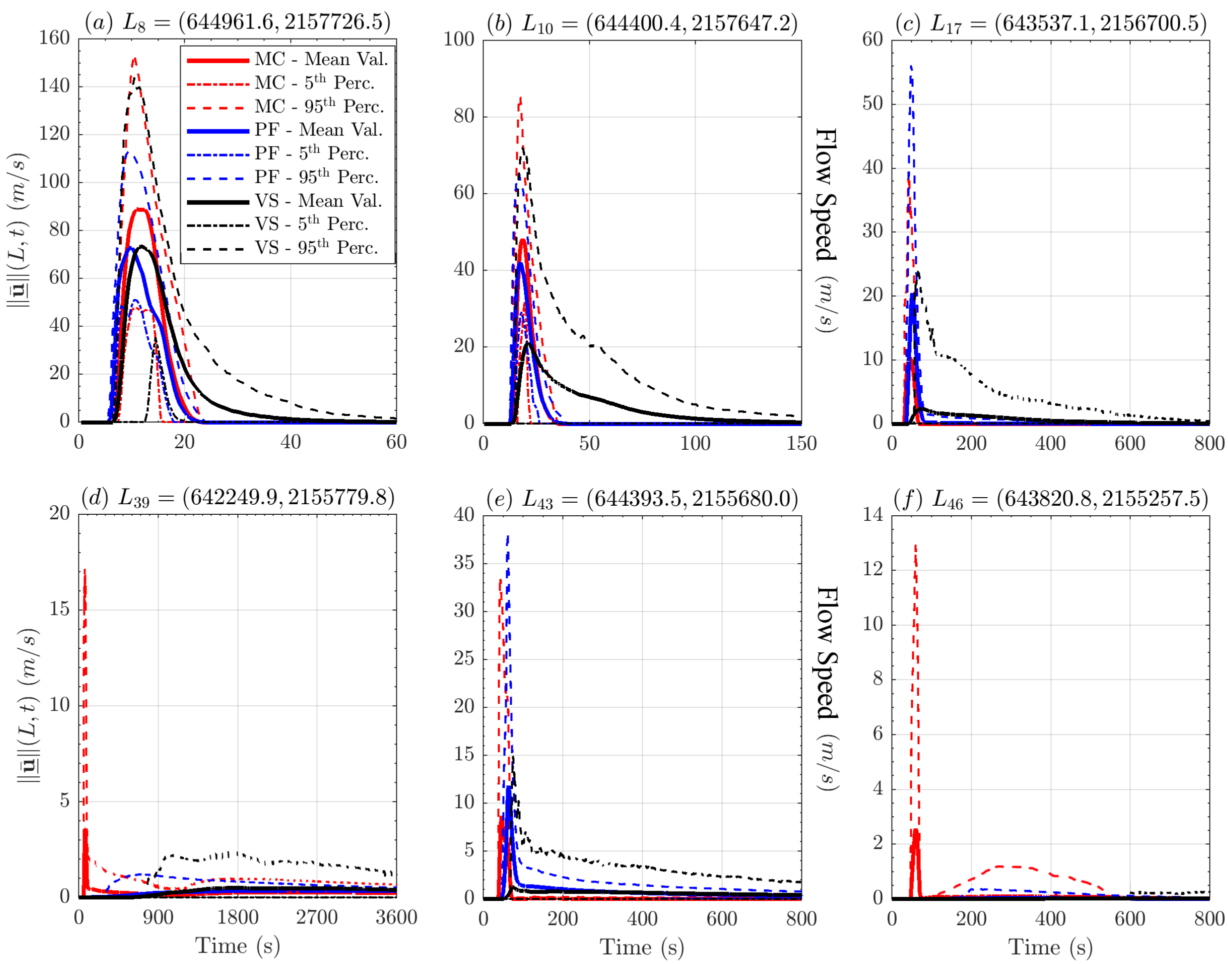

Figure 3: Records of flow speed at six selected locations. Bold line is mean value, dashed/dotted lines are 5^{th} and 95^{th} percentile bounds. Different rheology models are displayed with different colors. Plots are at different scale. Numerical noise affecting percentile curves in (f) has been averaged.

A very similar situation is pictured in plot 3e. Instead in plot 3d, only MC shows a max speed above $3m/s$, the 95^{th} percentile values at $\sim 15m/s$. In the other models the average speed is always below $1m/s$ and the 95^{th} percentile values have an increasing profile followed by a slightly decreasing plateau, at $\sim 2m/s$ in VS, $\sim 1m/s$ in PF. VS can have a speed above $\sim 1m/s$ at $\sim 3600s$. In plot 3f, only MC shows an average speed above zero, while in the other models even the 95^{th} percentile values are always below $\sim 0.5m/s$, and start to be positive only at $\sim 200s$ in PF, and $\sim 600s$ in VS. MC can have speed at $\sim 1m/s$ for more than $\sim 500s$, but the plot is very noisy.

3 Discussion

3.1 Flow speed

Flow speed enriches our analysis of additional details. In Fig. 1 MC has a fatter tail, due to the already observed distal spreading of material. PF profile is more concave at the beginning, due to the combined effects of the dual bed friction angle and the hydrostatic correction. In Fig. 3 VS is confirmed to be significantly slower than the other models, after the initial collapse. Moreover, it is the only model which presents slowly moving material for all the simulation, near the initiation pile. MC shows short lasting peaks of speed even in the most distal sample points, due to the lack of a strong slowing mechanism like the secondary angle in PF, and the speed dependent term in VS.