Figure 13. Step frequency (expressed as number of steps per number of channel widths) plotted as a function of (a) sediment supply and (b) longitudinal channel width variation. Dashed lines represent mean values, and the shaded area is the 25-75 percentile. The excess sediment feed in (a) is expressed as the sediment feed divided by the transport capacity.

...as number of steps per reach length expressed as number of average channel widths. We quantify the sediment supply with excess sediment feed, defined as the ratio between the sediment feed and the transport capacity (evaluated in our case with the model of Wilcock and Crowe, 2003). In Figure 13 we plot both the average values from all our experiments and the 25 and 75 percentiles to show the variability around these values. The comparison between Figure 13a and b suggests that the effect of width variations on step frequency is much stronger than that of sediment supply, although also much more variable.

It is important to note that sediment feed rate and longitudinal channel width variations are only two of the variables that influence step frequency. Flow rates and the hydrological regime (e.g., Zhang et al., 2019, 2018), grain-size distribution for the availability of large grains acting as keystones (e.g., Hohermuth & Weitbrecht, 2018), and channel geometry and slope (Chartrand et al., 2011) are also expected to be important controls. Sediment supply can also vary not only with respect to the magnitude, but also in terms of duration and frequency (e.g., Hassan et al., 2020). Since in steep mountain channels the sediment input is often episodic, these aspects should be further investigated. Finally, channel width variations in steep channels are expected to occur in a less systematic way than those designed in our experiments, as well as with different angles and potentially with different material.

4.4 What is transport capacity in steep channels?

The values of sediment yield measured at the channel outlet during the experiments were very similar to the values of sediment feed imposed at the channel inlet (Fig. 11). The feed rates chosen in the three experiments spanned one order of magnitude and were below, equal, and above the calculated transport capacity, yet the sediment yield was still determined by the supply. This suggests that: (1) the channel adjusts its morphology to be able to carry the imposed load, and (2) standard formulations of transport capacity are not applicable in steep mountain channels where sediment transport rates are a function of the imposed feed and changes in channel morphology (e.g., Saletti et al., 2015).