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Which Flow Regime leads to Banner Cloud Formation?

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Flow around mountains evoke a lot of interesting phenomena like cap clouds or rotor clouds. One rather unknown type is the banner cloud which only occurs on the leeward side of sharp mountain summits and ridges. In previous numerical simulations it was found that the main formation mechanism is the lifting of air in the lee vortex of the mountain. Therefore boundary layer separation right at the top of the mountain and flow reversal in the vicinity of the summit is essential for banner cloud formation.

In our work we want to answer the following question: Under what conditions does the flow separate right at the top of the mountain? In other words: Under what conditions can one expect banner clouds to occur?

Therefore we carried out numerical simulations using a cosine-shaped mountain. Additionally, we varied the steepness (aspect ratio) of the mountain and the stratification (Froude number) of the oncoming flow. These simulations were motivated by earlier studies of quasi two dimensional flow. Essentially three different flow regimes were identified: lee side separation, no separation and post wave separation. However, banner clouds require a fully three dimensional flow. For that reason we want to know if the results remain valid even for fully three dimensional flow.

Our simulations indicate that in the case of three dimensional flow the results are essentially the same as for quasi two dimensional flow. It turned out that banner clouds favor steep mountains (large aspect ratio) in combination with weakly stratified flow (large Froude number).