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Laboratory experiments on mountain-induced rotors

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The problem of mountain-induced rotors has received considerable interest in recent years, which cumulated in the large international field experiment T-REX (Grubisic et al, 2008). Also several numerical simulations on the formation of rotors have been published recently (e.g. Vosper, 2004; Doyle and Durran, 2007). Although much insight into the rotor problem has been gathered through these activities, some additional information might be provided by laboratory experiments in stratified towing tanks. This kind of research has been used frequently with respect to the lee wave problem (e.g. Eiff and Bonneton, 2000), but not many systematic laboratory experiments on the rotor problem have been performed.

Here we present some results on laboratory experiments on the formation of mountain-induced rotors, which have been performed in the large towing tank (22.0 m length, 3.0 m width, 1,5 m hight) of Meteo-France at Toulouse. The new aspect of our experiments is the use of variable vertical stratification as compared to the usual linear density profile (constant Brunt-Vaisala frequency) as used in the same tank by Eiff and Bonneton (2000). In fact we were guided by the numerical simulations of Vosper (2004) who has shown, that an elevated inversion (density jump) above the mountain top is favourable for the formation of rotors on the lee side slope. These simulations have provided information, under which combinations of inversion height, inversion strength and upstream wind speed rotors, lee waves or hydraulic jumps can be expected.

By proper scaling of the experimental set up we were able, to find these mountain-induced phenomena also in our laboratory experiments within nearly the same parameter range as in the simulations of Vosper. The flow phenomena were made visible by streakline photographs. The velocity fields within lee waves and rotors were obtained by a PIV method. By this we were also able to perform some quantitative comparison with results from numerical simulations, especially concerning the return flow in the lower part of rotors and the sweeping of boundary layer vorticity into the upper part of rotors. Our laboratory experiments confirm, that an elevated inversion is supporting the formation of rotors in the lee side of mountains, as was already indicated in numerical simulations mentioned above.

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