1. INTRODUCTION

• Longitudinal roll vortices (LRV): quasi-2D vortices that strongly affect the atmospheric boundary layer (ABL) fluxes (LeMone 1976) vertically limited by the top of the ABL \((z_L)\) and have horizontal wavelengths \((L)\) 2–12 x larger than vertical scale

• BORA: cold air outbreak over the warm Adriatic Sea: suitable conditions for the appearance of LRV: their existence during bora has never been considered

• LRV are typically associated with the presence of the ubiquitous cloud streets (CS): NOT the case for bora due to its downslope nature with descending dry air which results with the cloud-free conditions: their existence in the bora flows is not obvious

• We present aircraft observations above the Adriatic Sea that despite the absence of CS suggest the existence of LRV in bora

2. DATA

• Mesoscale Alpine Program (MAP) Intensive Observation Period 15 (IOP 15) on 7 Nov 1999 NCAR Electra aircraft 3 flight legs (Fig. 1) from 1347 to 1539 UTC: - leg 1 (NW → SE): 1347–1420 UTC ≈ 4200 m a.s.l. + 6 dropsondes - leg 2 (SE → NW): 1429–1501 UTC ≈ 680 m a.s.l. - leg 3 (NW → SE): 1504–1539 UTC ≈ 370 m a.s.l.

3. RESULTS

• Peaks in the wind velocity energy spectra appear at \(L \approx 1\) km at several locations along the flight legs (Fig. 2), but the dominant peak at \(L \approx 45\)° is evident in all wind components and at both flight legs: the most likely location of LRV: segment between 44.90 and 45.05 degrees is chosen for further analysis

• \(\theta\) from the S3 dropsonde (Fig. 1) released closest to the chosen interval indicates the ABL height of about 600 m (Fig. 3); however, the aircraft data suggests that the inversion base is above the upper flight leg: hence we estimate the ABL height as \(z_L = 700\) m: the roll aspect ratio (wavelength/ABL height) is \(L/z_L = 1.4\) somewhat smaller than reported in the literature

• The spatial structure of LRV yields specific phase relationships between different wind components (e.g. Hein and Brown 1988) Fig. 4 depicts an idealized system that indicates that expected phase angles are \((\Phi_{uw} = \pm 90°; \Phi_{vw} = \pm 180°)\)

• Figure 5 shows the coherence and phase angle for all combinations of the three wind components for our data at both heights: the peak in coherence at \(L = 1\) km is present for all combinations of components at 370 m, and for \(v\) and \(w\) at 680 m

• At 370 m: \((\approx \text{in the middle of the LRV layer})\) \(u\) and \(w\) are 180° out of phase, while \(v\) and \(w\) are in phase indication that LRV are tilted in the crosswind direction

• In accordance with the theory, the phase angle between \(v\) and \(w\) changes to 90 degrees at 680 m, which is near the top of the roll layer

• The absence of CS is due to the RH being close to 50% below 1.5 km (Fig. 3) descending dry air governed by a large-amplitude or breaking mountain wave

4. CONCLUSIONS

• Aircraft measurements of the bora wind above the Adriatic indicate the existence of LRV with \(L = 1\) km and \(L/z_L = 1.4\) the lower limit of the boundary between quasi-two-dimensional rolls and 3D convective cells possibility that the organized structures are in fact 3D cells

• A way to inspect this scenario would be to compare spectral characteristics of the wind velocity between the along-wind and cross-wind flight patterns (Hein and Brown 1988) the quasi-2D LRV structures should have a unique spectral peak in the cross-wind flight direction that does not appear in the along-wind direction

• No ABL flights parallel to the bora direction during the MAP experiment: this possibility cannot be examined at present

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References


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