WIND PATTERNS OBSERVED IN THE BOUNDARY LAYER OF THE OWENS VALLEY, SIERRA NEVADA

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Abstract: A unique orographic dataset, obtained during the recent T-REX experiment in the Sierra Nevada mountains, U.S.A, has been analysed by principal components analysis (PCA). The latter is an extremely powerful method of determining any underlying patterns in large volumes of (otherwise unmanageable) data. The method has been successfully applied to lee and valley wind measurements collected by a network of automatic weather stations operated during T-REX.Underlying structures (such as up- and downslope winds; cross-valley winds) will be seen to be dominant patterns in the valley: the fact that the PCA detects such patterns is significant, and indicates large-scale coherent (and perhaps predictable) flow. The dominant wind patterns will be related to the pressure gradient in the valley, the heat fluxes observed on the surface, and the general upper-level flow. In particular, the temporal evolution of the wind structures is determined during periods of severe downslope winds and/or suspected rotor formation. Additionally, these PCA structures will be related to results from the U.K. Met Office Unified Model, initialised with a realistic orography dataset and suitable initial conditions.

Keywords: *T-REX, orography, principal components analysis*

1. INTRODUCTION

The T-REX field campaign took place in March and April of 2006 and sought to explore the relationship between severe windstorms, gravity waves, rotors and related phenomena. A large number of instruments, operated by a multinational team of scientists, gathered a substantial volume of data during the campaign; Leeds University installed and operated, amongst others, a network of automatic weather stations (AWS) during T-REX. Several important flow episodes occurred throughout the experiment, which promise to yield significant information about the structure of rotors and severe windstorms: one such episode is analysed below via a statistical approach.

Principal components analysis (PCA) has been applied successfully at many meteorological scales: from the climatic (see Preisendorfer for a good general introduction) to the hill-scale (Burton et al, hereafter B06). At a simple level, it can be viewed as a means of obtaining the dominant, or underlying, patterns in meteorological data; patterns that would be otherwise difficult to find, given the large volumes of data often involved. Furthermore, the PCA allows for a quantitative description of these patterns, suggesting the relative importance of each structure found. To be of any use, the PCA should provide structures which can be shown to have a *physical* meaning. Here, the PCA method is applied to winds in the valley during "IOP6" (24^{th}-26^{th} March), which was perhaps the most significant rotor event of the campaign, and during which many buildings in the Owens Valley suffered structural damage due to the extremely high winds.

2. RESULTS

PCA results for IOP6 are shown in Figs. 1-2 and Table 1. Figs 1 illustrate the structures, or patterns, that were found to be dominant in the valley; Fig 2 shows how these patterns evolved over time, and their relative importance; Table 1 shows the proportion of variance explained by each EOF (a measure of their relative significance and contribution to the flow in the IOP).

The first EOF (Fig. 1a) – the dominant wind pattern in the valley - represents a night-time drainage-type flow (when PC1 is positive), with winds directed down the slopes of the Sierras and also down the Owens Valley. When PC1 is negative, this EOF represents an anabatic type flow, up the slopes of the Sierra and up the Owens Valley. The second EOF (not shown) also reflects winds aligned along the valley axis and can be said to modify the relative strengths of the up- and downslope winds. The third EOF (Fig. 2a) represents the cross-valley wind component; when PC3 is large and negative, we may expect strong westerly flow. *This pattern is very important and* must *be present during rotor events.*

Relative contributions of each EOF to the total flow at any given time are determined by the principal component scores (Fig. 2). As can be seen, PC3 is of large magnitude, and negative, at about Julian day 85.1, i.e. approximately 1830 local time on the 25th March. At about this time, winds speeds reached 60 knots in the valley, and several buildings and structures were destroyed; this severe windstorm was reported in the local newspapers and was considered an extreme event.

3. FURTHER WORK

The above appears to be a robust, objective means of classifying flow structures. The next stage in the analysis is to relate the flow patterns to some other parameter, *e.g.* the upstream wind/thermal profiles. This will be considered in the full version of this paper.

REFERENCES

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Table 1: The relative importance of the first four underlying structures.

EOF Number	*Percentage of Variance explained*
1	37
2	18
3	13
4	7

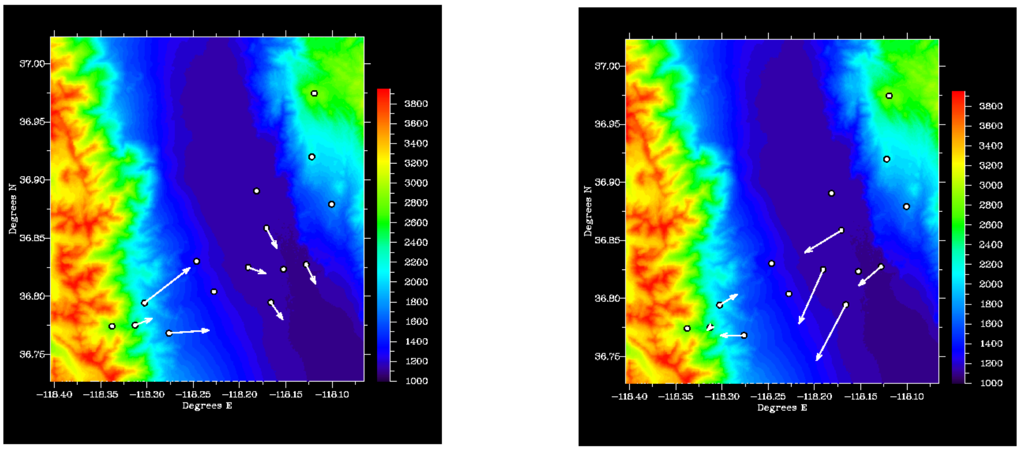

Figure 1 (a, left) The first EOF showing winds aligned with the valley axis; **(b, right)** EOF3, which represents the cross-valley wind component.

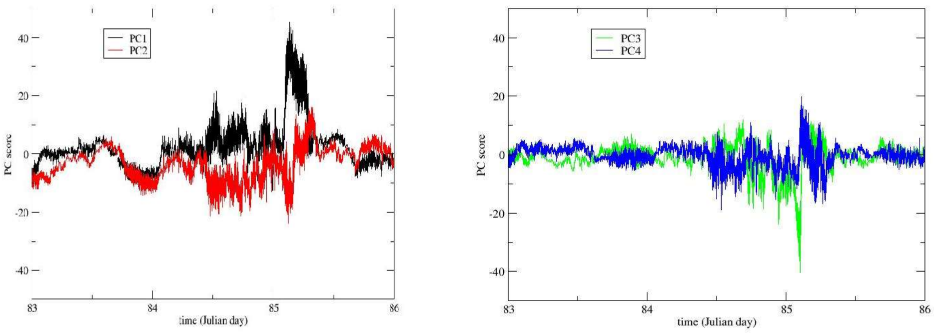

Figure 2. The time series of PC scores during IOP6 (Julian days 83-86); there is clearly a change in flow regimes at approximately 85.1 days.