JP7J.5 FINAL PLANS FOR THE TERRAIN-INDUCED ROTOR EXPERIMENT (T-REX)

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1. INTRODUCTION

Terrain-induced Rotor Experiment (T-REX) is the second phase of a coordinated effort to explore the structure and evolution of atmospheric rotors and associated phenomena in complex terrain (Grubišić et al. 2004). Atmospheric rotors are intense low-level horizontal vortices that form along an axis parallel to and downstream of a mountain ridge crest in association with large-amplitude mountain waves. High-levels of turbulence in atmospheric rotors are known to pose a great hazard to aviation. In spite of the importance of rotors, there have been only a few studies of limited scope and no comprehensive studies of this important phenomenon in the last 30 years [Grubišić and Lewis (2004) and Hertenstein and Kuettner (2005) provide historical overviews of early studies of rotors]. Despite the significance of rotors, which also includes the ability to loft and transport aerosols and chemical and biological contaminants on the dry lee side of mountain ranges, the studies of rotors have been so scarce because a comprehensive approach to the complex mountain-wave/rotor/boundary-layer coupled system necessary to understand rotors has become possible only recently as a result of the newest advances in remote sensing technology, atmospheric numerical modeling, and our understanding of boundary-layer processes.

The initial, exploratory phase of this multi-year coordinated effort is the Sierra Rotors project (SRP), which completed its Special Observation Period (SOP) in early spring 2004 [Grubišić and Billings (2005) and references therein]. Here we describe the final plans for T-REX, which will take place in March and April 2006 in the same location of Phase I field activities, in Owens Valley in the lee of the Sierra Nevada in California.

2. SCIENTIFIC OBJECTIVES

Recent numerical, theoretical, and observational studies of rotors (Clark et al. 2000; Doyle and Durran 2002, 2004; Vosper 2004; Chen et al. 2004; Cohn et al. 2005; Grubišić and Billings 2005; Mobbs et al. 2005) show that rotors are strongly coupled to both the structure and evolution of overlying mountain waves as well as the underlying boundary layer. Consequently, the core scientific objectives of T-REX are focused on improving the understanding and predictability of the coupled mountain-wave/rotor/boundary-layer system. This core objective includes the role of the upstream flow properties in determining the dynamics and structure of the rotor coupled system, wave/rotor dynamic interactions, internal rotor structure, rotor/boundary-layer interactions as well as the upper-level gravity breaking and turbulence. In addition, complementary scientific objectives are focused on understanding the role of mountain waves in stratospheric-tropospheric exchange, structure and evolution of the complex-terrain boundary layer in the absence of rotors, and wave cloud phase transitions and layering.

3. FIELD SITE

Owens Valley lies in the lee of the southern Sierra Nevada. This portion of the Sierra Nevada is the tallest, quasi two-dimensional topographic barrier in the contiguous United States with a number of peaks above 4 km, including the highest peak in the lower 48 states (Mt. Whitney 4,418 m), and the steepest lee slopes ($\sim$30 degrees). The $\sim$3 km high White-Inyo range forms the eastern wall of the valley. The site of the experiment will be the central portion of Owens Valley, near town of Independence, where mountain waves and attendant rotors have been known to reach particularly striking amplitude and strength. This was also the site of the 1950s Sierra Wave Project (Holmboe and Klieforth 1957). Climatological studies show that the months of March and April have the highest frequency of rotor events, including many days with conditions favorable for generation of mountain waves and rotors, and also many days when it will be possible to document terrain-induced boundary-layer circulations in Owens Valley under more quiescent conditions.

4. EXPERIMENT DESIGN

In order to achieve its scientific objectives, the T-REX program has two main observational thrusts:

1. Comprehensive ground-based and airborne, in situ and remote sensing measurements during strongly perturbed conditions favoring rotor formation, and

2. Comprehensive observations of complex-terrain boundary layer structure and evolution from undisturbed to strongly perturbed conditions.

Ground-based and airborne, in situ and remote-sensing measurements will be conducted both upwind and within Owens Valley. Some of the planned measurements will be met through intensive observational periods (IOP) (e.g., aircraft and manually-operated instrumentation), whereas others will be met through contin-

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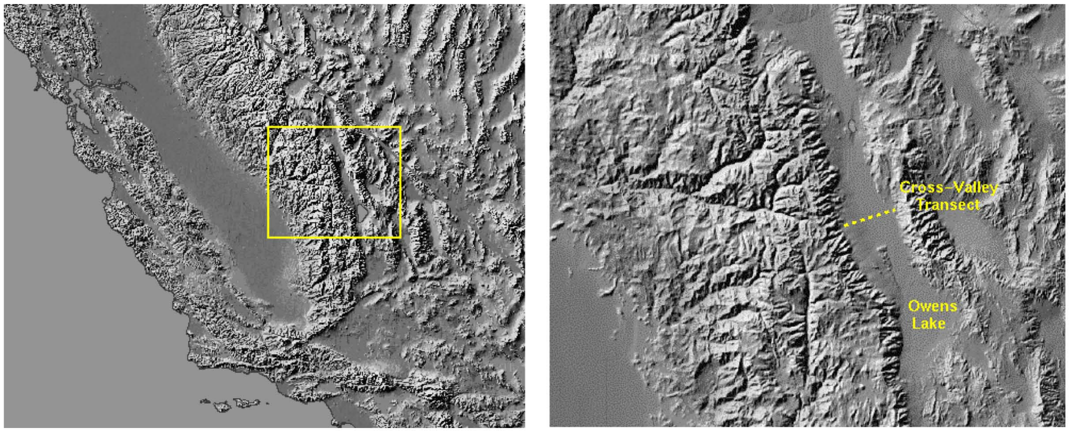

FIG. 1: Shaded relief topographic map of the central and southern Sierra Nevada (left panel) and Owens Valley (right panel). The north-south elongated Owens Valley lies in between the Sierra Nevada and the White-Inyo mountain ranges, which define its west and east walls, respectively. The yellow dotted line in the right panel shows the position of the cross-valley measurement transect through Independence, California and the location of the dry bed of Owens Lake.

uous operation. Our plans include three research aircraft (NSF/NCAR HIAPER, University of Wyoming King Air, UK BAe146). In addition to the probes for *in situ* kinematic and thermodynamic measurements, the aircraft will be equipped with: a cloud radar (King Air), *in situ* chemical tracer instruments and microphysics probes (HIAPER and BAe146) as well as dropsonde systems (HIAPER and BAe146). This will allow us to document the mesoscale structure and evolution of the wave/rotor part of the coupled system over Owens Valley as well as the kinematic and thermodynamic structure of airflow through the depth of the troposphere up- and downstream of the Sierra Nevada. An array of fixed and mobile ground-based instruments, including scanning aerosol and Doppler lidars, wind profilers, sodars, sounding systems, dense networks of automatic weather stations, microbarographs, temperature data loggers, flux towers, and an instrumented car will be used to document the lower portions of the rotor coupled system under strongly perturbed conditions favoring rotor formation as well as the flow and thermodynamic structure of the boundary layer in absence of rotors. Special upstream GPS radiosonde soundings sites located in the Central Valley, together with the NOAA wind profilers located upwind of the study area, will provide critical information on the upstream conditions. Figures 2 shows the flight-plan schematic, and the map of the T-REX ground-based instrumentation.

The field operations will be supported by a real-time forecasting effort that will include mesoscale models (COAMPS, WRF) as well as wave prediction models. The ensuing field research will be tightly coupled with numerical modeling studies.

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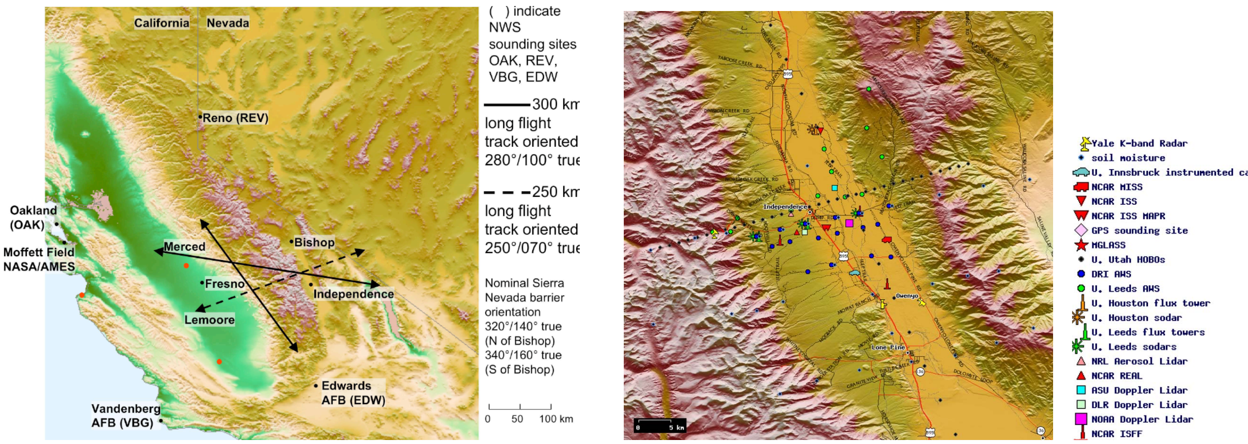

FIG. 2: Left: T-REX flight-plan schematic showing the orientation of planned mountain-parallel and cross-mountain flight tracks over the Sierra Nevada and the White-Inyo ranges. Right: Color relief map of the central portion of Owens Valley showing the T-REX field campaign area and the proposed ground-based instrumentation. The locations of the special GPS sounding sites at NAS Lemore and the MGLASS base at Fresno, the regular NWS upper-air sounding locations in the surrounding area at Oakland, CA, Vandenberg AFB, CA, and Reno, NV, as well as the NOAA wind profilers upwind of the study area (red circles) are shown in the left panel.

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