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RESPONSE OF THE HUDSON VALLEY BOUNDARY LAYER TO DIURNAL FORCING DURING A CASE OF ROTATING GEOSTROPHIC WIND

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1. INTRODUCTION

Wind in valleys is related to the geostrophic flow aloft (Whiteman, 2000) Often previous studies consider mean consequences of nearly steady environmental geostrophic wind forcing (Gross and Wipperman, 1987). As the background geostrophic wind rotates, there are critical angles at which the along-valley wind component shifts discontinuously. We focus on a case study of observations obtained during the Hudson Valley Ambient Meteorology Study (HVAMS). The Hudson Valley axis is oriented approximately N-S (Fig. 1) and is flat in its southern reaches; there are not up- or down-valley circulations, motions down the large-scale pressure gradient component occur primarily along the valley axis. During the period of interest (Oct 7-12, 2003), the ambient wind at 1500 m altitude shifted from westerly to easterly, with the passage of a weak front. Effects provoked by the rotating geostrophic wind are superimposed on the diurnal cycle of convective boundary layer (CBL) development and decay

2. SITE AND DATA DESCRIPTION

HVAMS was conducted in the Hudson River valley south of Albany NY (Fig. 1). During the period 7-12 Oct. 2003, the geostrophic wind above the convective boundary layer rotated 180° (Fig. 2, bottom panel). Winds at the surface switched abruptly during this rotation (Fig. 2, top panel), though there was clear modulation by the diurnal cycle.

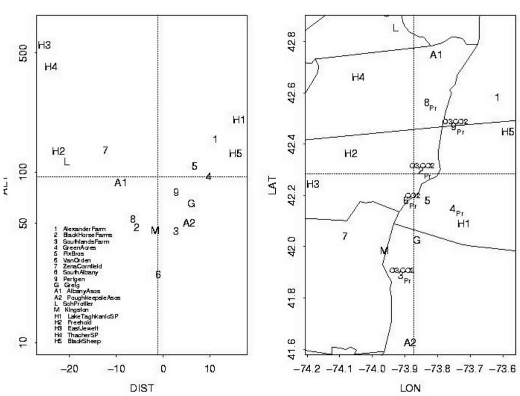

Fig. 1. Automatic weather stations in the HVAMS study area, Left. Distance from Hudson River center vs altitude; Right: Map of the study area. The nine ISSF flux stations are listed by numbers. Stations marked "H" are standard weather stations. "A1", and "A2" represent the ALB and SCH ASOS stations. Wind profilers are at "L" and "M". Radiosonde launches were near "ALB". Sodars were at "M" and "S".

3. RESULTS

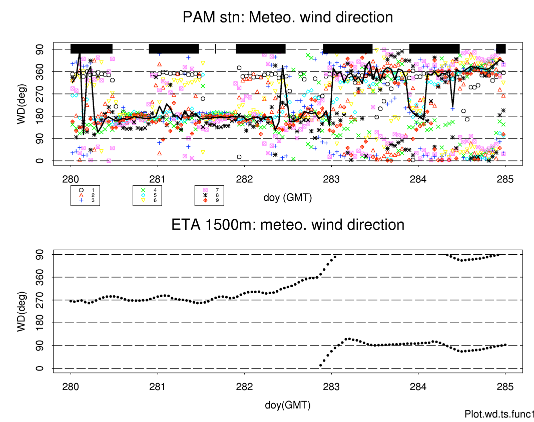

Figure 2. Top: Wind direction at each of the nine surface stations of the HVAMS network during the period October 7-12 (DOY 280-285) 2003. Bottom: Wind at 1500 m from the Eta model simulation above the center of the surface station network.

Channeling in the valley was more clearly expressed near the mountains at the southern site ("M" in Fig. 1) than at the northern site ("L"). Time-height sections from the profilers, Doppler radar, and sodars (Fig. 3) illustrate the along valley channeling during the early period and after the valley wind shifted to northerly (Fig. 4).

The dynamic meaning of *channeling* is not often made explicit. It must result in the wind direction being steady, $\frac{\partial\alpha}{\partial t}=0$. The prognostic equation for wind direction α for a (Lecluyse and Neumann, 1986) is:

$$\frac{\partial\alpha}{\partial t} = -f + \frac{fG}{S}\cos\gamma - U_i\frac{\partial\alpha}{\partial x_i} + \frac{1}{\rho U^2}\left[u\frac{\partial p}{\partial y} - v\frac{\partial p}{\partial x}\right] + \frac{1}{S^2}\left[U\frac{\partial\overline{vw}}{\partial z} - V\frac{\partial\overline{uw}}{\partial z}\right]$$

1] [2] [3] [4]

where f is the Coriolis parameter, G and S the geostrophic and actual wind speeds, respectively, [2] represents 'advection of direction', [3] effects of pressure gradients and [4] is the effect of the Reynolds stress divergence. In our presentation, we discuss the dominant terms in this relation.

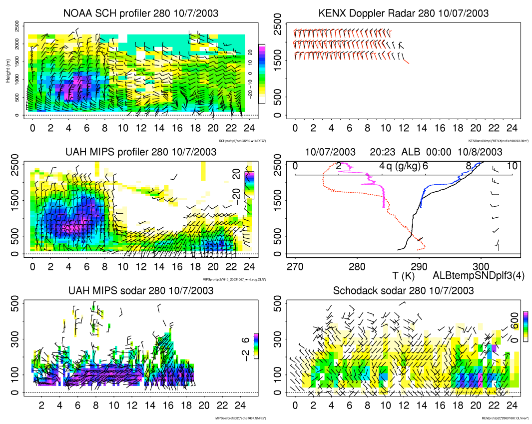

Figure 3. Wind and thermodynamic structure observed in the lowest 2500 m during the period of westerly geostrophic wind. Upper left: Time-height section of the profiler at site “L”; Upper right: winds obtained from the NEXRAD KENX site W of the valley; Center left: Time-height section from the MIPS profiler (“M” in Fig. 1) at the southern edge of the observation network; Center right: Sounding at Albany “ALB”. Blue and purple curves represent soundings from the King Air research aircraft; Lower left: sodar record at the MIPS site “M”; Lower right: Sodar record a river edge (“S”).

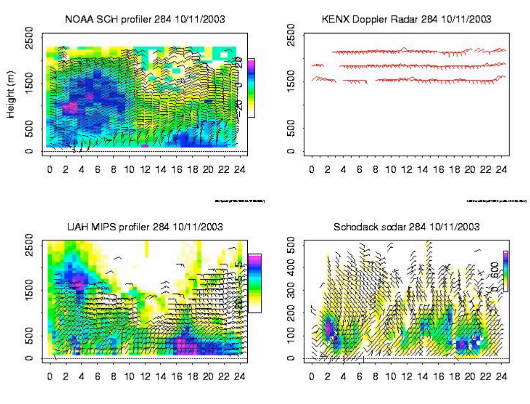

Fig. 4. Similar to Fig. 3 for DOY 284. Upper left: Profler at “L”; Upper right: KENX Doppler radar; Lower left: Profiler at “M”; Lower right: Sodar at “S”. (See Fig. 1 for locations.)

ACKNOWLEDGEMENTS

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