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The Influence of Tributaries on Nocturnal Valley Flows

John M. Leone, Jr.*
and
Hoyt Walker
Lawrence Livermore National Laboratory
Livermore, California 94551

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John M. Leone, Jr*. and Hoyt Walker

Lawrence Livermore National Laboratory
Livermore, California

1. INTRODUCTION

While much is known about nocturnal drainage flow down a mountain valley, the factors that determine the structure of the valley flow are not completely understood. For example, there are a number of questions regarding the influence of tributaries on the valley flow. Does the presence of tributaries increase or decrease the mass flux out of the valley; does their presence alter the mass flux along the valley; how is the drainage jet structure modified by the presence of tributaries; or, is their presence insignificant? In this study, we investigate these questions via numerical experiments.

2. THE SIMULATIONS

To allow us to control the terrain features within a simulation, we developed a computer program that allows us to construct idealized terrain surfaces including hills and valleys with up to three levels of tributaries. Cross sections of the hills and valleys are described by Gaussian logit curves (ter Braak & Looman, 1986). Using this program we constructed three sets of terrain data (see Figure 1): the first is a single valley draining from a mesa onto a plain, the second added a single tributary to the valley entering on the left at a 45 degree angle, the third added a second tributary entering on the right at a 45 degree angle and slightly up-valley of the first tributary.

We then conducted identical simulations using each terrain field. The model used was SABLE, a hydrostatic, anelastic model, Zhong et al. 1991. To enable the model to simulate geometrically complex regions, the prognostic equations for horizontal velocity and potential temperature are solved using a tri-linear finite element spatial discretization together with a semi-implicit time integration scheme. The prognostic equations for vertical velocity and hydrostatic pressure are solved along vertical lines via a second-order finite difference scheme. Vertical turbulent transport is parameterized via the Richardson number dependent K model of McNider and Pielke, 1981.

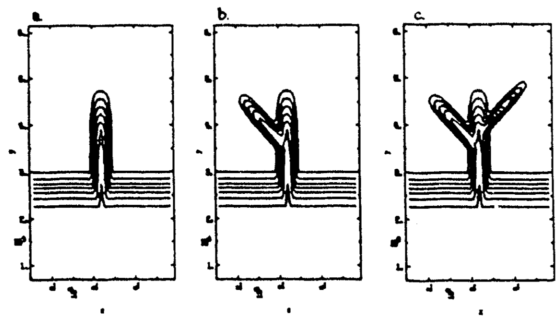

Figure 1. Terrain contours for the three different geometries. (Contour interval 50 m.)

The simulations were conducted on a 32.2 km by 52.5 km by 2.5 km domain divided into 51,750 elements (46 x 75 x 15) with Δx = 300 m, Δy = 700 m, and Δz = 15 m in the lowest element and graded upward. The initial atmospheric state was taken to be slightly stable, $d\theta/dz$ = 2 K/km, and at rest. The drainage flow was then driven by a specified uniform surface heat flux of -70 W/m^2. The simulation continued for eight hours with a time step of 7.5 seconds.

3. RESULTS

For brevity, we are presenting results for a simulated time of eight hours (the end of the simulation). However, the conclusions are valid for all times after the initial development time. Figure 2 shows a comparison of the horizontal mass flux through a box from valley ridge top to ridge top as a function of distance from the head of the central valley. It can be seen that the largest differences occur in the regions near the tributaries. However, the mass flux out of the valley is within 5% for all cases with the 1 tributary case having the lowest value. Figure 3 shows a comparison of the maximum down-valley speed as a function of distance from the head of the central valley. The influence of the tributaries on the drainage jet in the main valley can be clearly seen. The maximum

* *Corresponding author address:* John M. Leone, Jr., Lawrence Livermore National Laboratory, Livermore, CA 94550.

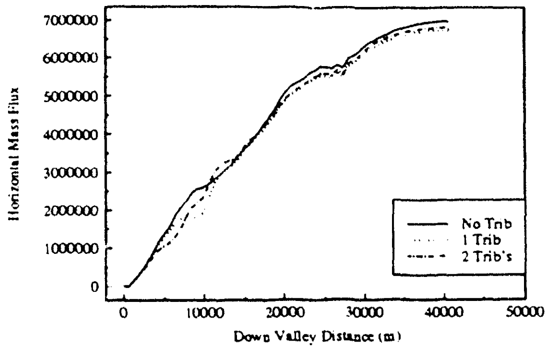

Figure 2. Horizontal mass flux along the central valley.

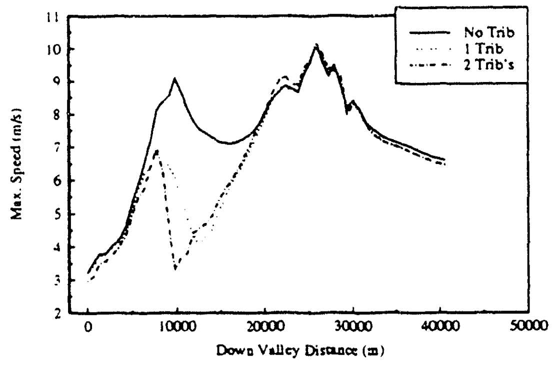

Figure 3. Maximum down valley speed along the central valley.

speed decreases sharply as the tributary flow enters the main valley and interacts with the drainage jet.

The interaction of these flows is further illustrated in Figure 4 which shows the horizontal profiles of the down valley wind at the height of the jet maximum. The no tributary case shows a well defined drainage jet developing within the valley and exiting out on the plain. The one tributary case shows a similar development upstream from the tributary, but after the tributary flow enters, the drainage flow profile is broader and flatter. The two tributary case shows similar features. Figure 5, a vertical cross-section of down-valley speed in the central valley just down stream of the tributaries, presents another view of the interaction. It can be seen that the drainage jet maximum has moved upward, is less concentrated, and is significantly slower in the tributary simulations.

To get a better idea of the overall flow field, we present Figure 6, which shows contours of the vertical velocity at the ridge top in the region of the central valley. The no tributary case shows a nearly symmetric field with large downward motion along the valley side walls and weak downward motion at the head of the valley and weak upward motion just past the valley exit. The two tributary case is much different; downward motion on the sidewalls is weaker and interrupted by the tributary entrances. The downward motion near the valley head is also reduced, however the upward motion at the valley exit is very similar in the two cases. The one tributary case shows an intermediate behavior.

Figure 7, the surface potential temperature fields for the three cases, shows the effects of the tributaries. The major consequences are the development of warm regions between the tributaries and the main valley. These warm regions are also regions of very low velocities. At the valley exit the temperature fields are very similar indicating that the tributaries have negligible effect in this region.

4. CONCLUSIONS

From these simulations, we conclude that the presence of tributaries does indeed influence the structure of the main valley drainage flow. They change the manner in which air from the mesa enters the valley. These changes are reflected in the modified surface temperature pattern and vertical velocity field at valley top. The drainage jet characteristics are also modified, losing their structure as the tributary flow interacts with the main valley flow, but the influence is over a limited distance down stream. While the tributaries have an influence on the horizontal mass flux distribution, they have little effect upon the mass flux exiting a valley.

5. REFERENCES

ter Braak, C.J.F., and C.W.N. Looman, 1986: Weighted averaging, logistic regression and the Gaussian response model. *Vegetatio*, pp. 3-11.

McNider, R.T. and R.A. Pielke, 1981: Diurnal Boundary-Layer Development over Sloping Terrain. *J. Atmos. Sci.*, *38*, pp. 2198-2212.

Zhong, S., J.M. Leone, Jr., and E.S. Takle, 1991: Interaction of the sea breeze with a river breeze in an area of complex coastal heating. *Boundary-Layer Meteor.*, *56* pp. 101-139.

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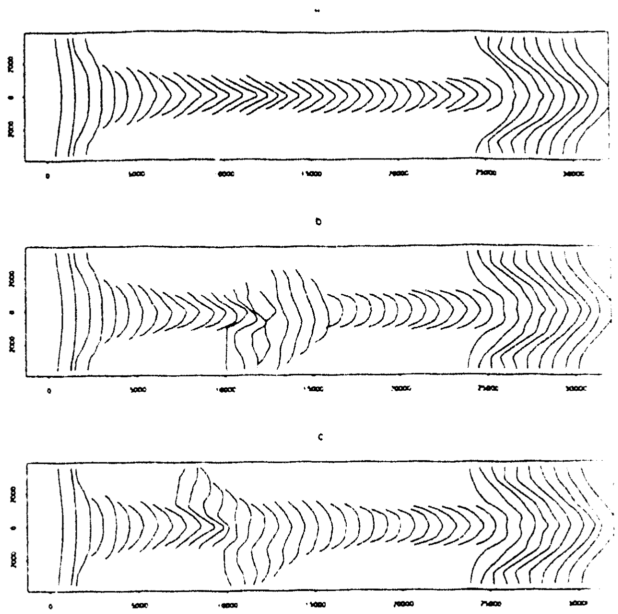

Figure 4. Horizontal profiles of down valley speed at the jet maximum for a) no tributary, b) 1 tributary, c) 2 tributaries.

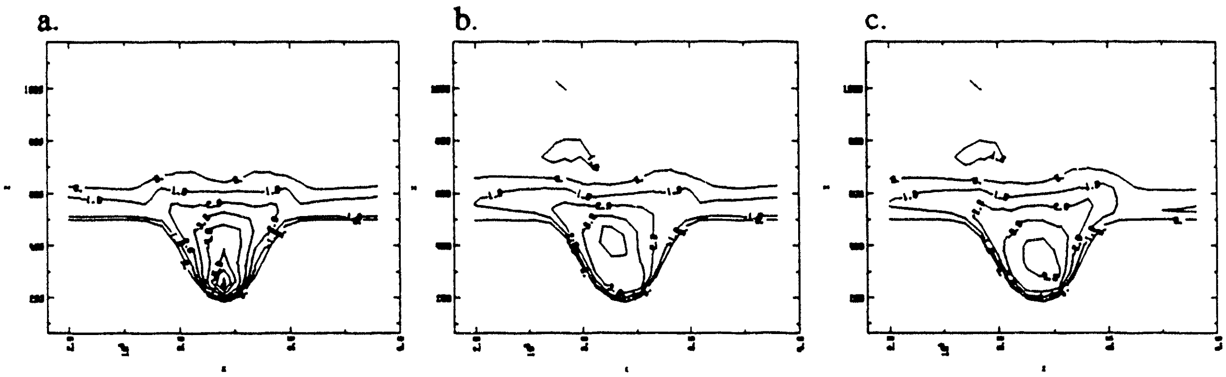

Figure 5. Vertical cross sections of down valley speed just downstream of the tributaries for a) no tributary, b) 1 tributary, c) 2 tributaries. (Contour interval 1.0 m/s)

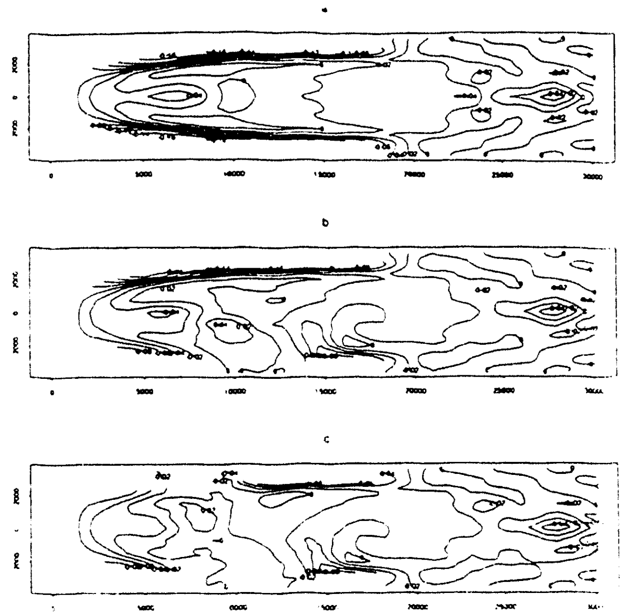

Figure 6. Contours of vertical velocity at the ridge top for a) no tributary, b) 1 tributary, c) 2 tributaries. (Contour interval 0.02 m/s.)

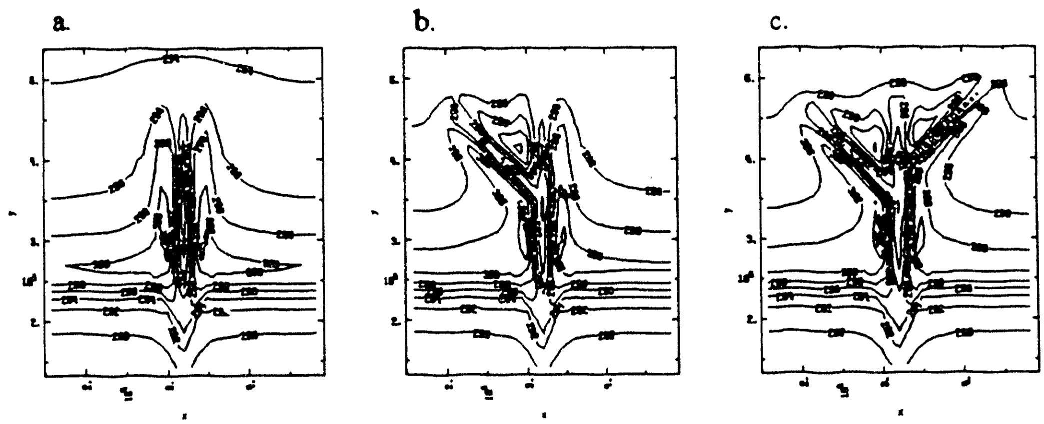

Figure 7. Surface potential temperature fields for a) no tributary, b) 1 tributary, c) 2 tributaries. (Contour interval 2 K.)

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