Ozone Laminae and Their Entrainment Into a Valley Boundary Layer, as Observed From a Mountaintop Monitoring Station, Ozonefones and Aircraft Over California’s San Joaquin Valley

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Introduction

The San Joaquin Valley (SV) of California is wide (~75 km) and long (~400 km), and is situated under strong atmospheric subsidence due, in part, to the proximity of the multilatitude anticyclone of the Pacific High. The capping effect of this subsidence is especially prominent during the warm season when ground level ozone is a serious air quality concern. While relatively clean marine boundary layer air is commonly funneled into the valley below the strong subsidence inversion at significant gaps in the Coast Range mountains, airflow aloft also mixes into the valley from above. Because this trans-mountain flow occurs under the influence of synoptic (and mesoscale) subsidence it tends to present discrete, laminar sheets of differing air composition above the valley boundary layer. Meanwhile, although the atmospheric boundary layers (ABL) tend to remain shallow due to the prevailing subsidence (~5), orographic and anathetic venting of valley boundary layer air around the basin whips up a complex admixture of regional air masses into a “buffer layer” just above the boundary layer (ς) and below the lower free troposphere. This complex airmass is then entrained into the ABL.

Lower Free Tropospheric Correlations

![Figure 3](image1.png)

Figure 3. Correlations among simultaneous Ω₁, Ω₂, and Ω₃ sondes 110 km apart along the California coastline.

![Figure 4](image2.png)

Figure 4. Correlations of Ω₁ sondes and Chew Ridge (1550 m asl) 145 km south.

Vertical Structure Within the Valley

![Figure 5](image3.png)

Figure 5. Mean (blue) and median (red) profiles of potential temperature, ozone, and methane for the afternoon (12:00-16:00 PST) of 29-Jul-2016. Inset illustrates the correlations between all flight data collected within 20 km of Fresno & Visalia 6-12 hours after the daily Ω₁ sound launch at Bodega Bay.

Proposal for Measuring Subsidence, W

Subsidence is of such critical importance to the dispersion of the ozone lamina and the development of the valley boundary layer, and yet it evades direct measurement (Lenschow et al., 1999). Furthermore, it has a very heterogeneous pattern in the complex terrain of the San Joaquin Valley (SV). We propose an airborne technique for measuring subsidence at the top of the boundary layer based on a budget equation of Ω₁:

\[ W_z = \frac{\partial z}{\partial t} + \frac{U}{g} \frac{\partial z}{\partial x} - \frac{w_e}{\partial x} + \frac{w_c}{\partial C} \]

With the upcoming installation of a gust probe (Aventech Research Inc., AMMMS-30) on the Scientific Aviation aircraft, we will be able to measure entrainment by the eddies covariant flex-jump method (equation on right) for scalars such as water and methane. In conjunction with simultaneous measurements of the ABL growth rate and advection, subsidence can be determined by the (left) equation above.

Valley Entrainment

![Table 1](image4.png)

Table 1. Entrainment velocities observed over the SJV from 4 separate experiments.

Conclusions

- Daily Ω₁ sound along the coast show broad (~100 km), but layered correlations among subsidence, and at levels just above the valley ABL in the SJV.
- The inflow over the mountains mixes with air that is lofted along the valley sidewalls during the day time to create a “buffer layer” above the valley.
- The buffer layer is pushed downward during the daytime due to mesoscale subsidence, and its entrained into the ABL. Several measurements of the entrainment velocity in the SJV are all consistent between 1.5 to 9.5 cm/s.

References


