Introduction

Yosemite Valley is one of the most widely visited valleys in the world. Over 6000 cars and 63 buses visit the valley daily during peak tourist season. The quality of air resulting from the interaction of these vehicle emissions and the additional 472 campfires and occasional prescribed fires in the valley is currently the inversion destruction time of the Yosemite Valley inversions using various TAFs obtained from ArcMap 8.3 GIS software. The model breakup times are compared with observational data to assess the proper usage of the Topographic Amplification Factor in the Yosemite Valley case.

Topographic Amplification Factor

Energy entering an atmospheric volume enters through a fixed lid at the terrain, thus more heating/cooling occurs for that volume. This concept is known as the topographic amplification problem where more heating will occur in a mountain valley than that over an adjacent plain (Steinacker 1984; Whiteman 1990). To account for real terrain, the Topographic Amplification Factor (TAF) is defined as:

\[ TAF = \left( \frac{\bar{A}_h}{\bar{A}_{h0}} \right) \]

where \( \bar{A}_h \) is the horizontal area that energy enters the top of the atmospheric volume at height \( z = h \). The volume of the plain is just \( \bar{A}_h \), which provides a simple form of the TAF that emphasizes volumetric comparisons between a valley and the adjacent plain.

The thermodynamic model developed by Whiteman and McKee (1982) for inversion breakup in mountainous valleys is still widely used today. This model incorporates valley topography using the TAF. The use of ArcGIS software allows complete and accurate valley volume calculations to be made. The model for inversion breakup in valleys in its simplest form is

\[ \frac{dh}{dt} = \frac{\delta \alpha}{\gamma \rho C_p A_h} \left( T_0 - T_h \right) \]

which is the rate of change of inversion depth as a function of time, where \( \alpha \) is the TAF and \( \gamma \) is the potential temperature gradient, or inversion strength, and \( \rho C_p \) is the extraterrestrial solar flux. Integrating Eq. 2 under the assumption that \( \alpha \) is independent of height, and \( \gamma \) is constant, an equation for predicting inversion depth as a function of time is obtained:

\[ \frac{h}{h_0} = 1 + \frac{\alpha}{\gamma} \frac{\pi}{4} \left[ \left( \frac{\omega_A}{\omega} \right)^2 + 1 \right] \]

where \( h \) is the day length (14 hr), \( \omega \) is extraterrestrial solar flux at noon (1127 W m\(^{-2}\)), \( \omega_A = A_h \) is the horizontal area that energy enters the top of the atmospheric volume at height \( z = h \). The volume of the plain is just \( \bar{A}_h \). This decoupling caused very stagnant atmospheric conditions (cold air pool) as shown by the weak winds within the layer. The observed cold pools within Yosemite Valley are most likely horizontally homogenous in extent, rather than due to the factor of 10 larger value of \( \gamma \). However, the TAF effect is significant when extreme terrain shapes are evaluated such as those of wide valleys and alpine passes as indicated by the reference TAFs (\( \alpha > 5 \)) in Fig. 3.

Inversion destruction is also dependent on the amount of incoming solar radiation that is converted to sensible heat flux. This parameter (\( A_h \)) varies seasonally and by location (Whiteman 1990). While the TAF argument is not fully understood and has not been extensively examined in different terrain configurations, there appears to be a significant advantage for using the ArcGIS platform in these calculations for the Yosemite Valley.

References

Steinacker, R. 1984: Area-height distribution of a valley and its relation to the Valley wind, B. Phys. Atmosph. 57, 1, 64-70

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