Review of “The impact of embedded valleys on daytime pollution transport over a mountain range” by M.N. Lange, A. Gohm, and J.S. Wagner

Recommendation: **Accept with minor revisions**

This study uses idealized simulations to investigate the interactions between plain-to-mountain and slope wind systems and the influence of these thermally driven winds on pollution dispersion over complex terrain. Particular attention is paid to the issue of mountain venting and how much aerosol is injected above the top of the convective boundary layer.

The simulations are set up using a flat foreland transitioning into a mountain range. An embedded valley of varying geometries is included windward of the main mountain ridge. The results indicate that flow regimes and aerosol transport depend on the depth of the embedded valley. Specifically, when the plain-to-mountain winds flush through the valley, which happens for shallower valleys, there is an increased pollution transport to the main ridge by 20%.

Overall I find that the paper presents a reasoned and well illustrated analysis of the simulations and helps improves our understanding of the interaction between different thermally driven winds. In addition the results augment previous studies conclusions on mountain venting processes. The paper is well written and I have only one minor comment followed by a list of specific issues in the text that I feel need to be addressed prior to publication.

Minor Comment: You attribute the flow separation in the deepest valley configuration to the upslope thermally driven wind (e.g discussions on Pg. 14327 line 5, and Pg. 14327 lines 18-20). I think it is quite possible that you would find flow separation for this valley geometry regardless of the slope wind, and instead owing to mechanical considerations. In fact from looking at the figure the air at the crest of the first ridge appears to be either potentially equal to or potentially cooler than the air in the valley atmosphere. This suggests that the proposed reasoning for the flow not reaching the valley floor may be, at least in part, incorrect.

As the dynamics of flow separation are not at the core of this study this is a relatively minor issue, but might warrant addition examination or at least a broadened literature discussion on the topic. For example, you might include discussion of the non-dimensional valley depth and some historical or recent work examining this issue of whether a given stratification and wind will ventilate a valley. I’ve included a sample of a few potential references at the end of this document.

To truly examine the source of the flow separation (which leads to a different dispersion regime) you might conduct an additional simulation by imposing a background flow comparable to the plain-to-mountain wind strength, but without the surface heat flux forcing. Does the flow still separate? If such a simulation would be time or resource prohibitive I think a discussion of the topic would suffice to contextualize the results.

Specific comments.

Pg 14319, line 6: Perhaps change "daytime" conditions to pseudo-daytime conditions with constant surface sensible heat flux.

Pg. 14320: Line 9-10: Is there a reference for the stats module? Is this something your group has created? Publically available? Does it handle terrain following coordinates?

Pg. 14320, Line14-15: Please note that the use of constant sensible heat flux and no moisture flux is a *major* simplification for PBL development in complex terrain, especially since the Bowen ratio can vary significantly with elevation and from one portion of a slope to another.

Pg. 14320, Line 18: I'm confused by this sentence, are you saying that if you were to average the first 6 hours of a sinusoid with an amplitude of 235 that you'd get 150 W/m^2? Note non-arid valleys suggests that there would be a substantive latent flux involved, which is set to zero here, which is fine, you might just need to make the limitation more clear in the summary.

Pg. 14320, line 23-24: Neglecting Coriolis effects: for large plain-to-mountain wind systems Coriolis can be important. Perhaps note this simplification.

Pg. 14322, line 4: "during daytime" perhaps change to, "during the simulation" as there really is not a diurnally varying forcing in these simulations.

Pg. 14324 line 5: It might be nice to include the Ri bulk formula used here since your results are sensitive to the method applied.

Pg. 14325 Line 7: I think this should read "wind is established" not "wind establishes"

Pg. 14325, Line 11: I'm confused by why you distinguish between ABL and CBL here.

Pg. 14325 How does your definition of ML compare with CBL? Why the additional term?

Pg. 14325 Line 17: Would it be useful to define depth versus height? Height I assume is not a terrain sensitive quantity, but simply refers to the height of some variable (e.g. the EL). Where as depth is locally defined as height above the ground?

Pg. 14325 line 23: "similar" to what, and I only see "cross mountain" winds in one location, namely above the ridge at -15 km.

Pg. 14326 line 15. Is this no longer considered a plain-to-mountain wind? What separates the distinction of the plain to mountain wind versus the slope wind systems in the S-RIDGE simulations?

Pg. 14327 line 5: (**See main comment above**) It might be good to add a line here indicating that flow separation versus flushing of valleys may not be due only to the thermally driven upslope flow convergence, but due to geometric and dynamical considerations. In other words, if you simply imposed a background wind on the topographic configuration it is possible that you'd get lee slope separation and reversed flow even for neutral stratification. The result might resemble a thermally driven upslope wind. Likely both processes contribute in these simulations, but you should make some mention of the dynamically forced component of this flow.

Pg. 14327 line 13-15: I don't see evidence in the figures that the cross barrier cold advection undercuts the upslope flow. Specifically I don't see a flow reversible with height in either Fig 5a, or Fig. 5b. If there is clear evidence of this at, say T=3.0 h? please include an additional panel showing as much, or state "not shown"

Potential References for valley ventilation (none of which are my work):

Bell, R. C., and R. Thompson, 1980: Valley ventilation by cross winds. J. Fluid Mech., 96, 757–767, doi:10.1017/S0022112080002340.

Tampieri, F., and J. C. R. Hunt, 1985: Two-dimensional stratified fluid flow over valleys: Linear theory and laboratory investigation. Bound.-Layer Meteor., 32, 257–279, doi:10.1007/BF00121882.

Lee, J. T., R. E. Lawson Jr., and G. L. Marsh, 1987: Flow visualization experiments on stably stratified flow over ridges and valleys. Meteor. Atmos. Phys., 37, 183–194, doi:10.1007/BF01042440.

Vosper, S. B., and A. R. Brown, 2008: Numerical simulations of sheltering in valleys: The formation of night time cold-air pools. Bound.-Layer Meteor., 127, 429–448, doi:10.1007/s10546-008-9272-3.