# VARIATIONAL OBJECTIVE ANALYSIS FOR ATMOSPHERIC FIELD PROGRAMS: A MODEL ASSESSMENT

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## SUMMARY

The objective of this study is to examine the effectiveness of the variational objective analysis (VOA) for producing realistic diagnoses of atmospheric field program data. Simulations from the Naval Research Laboratory's Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) were sampled in a manner consistent with a typical field program using idealized sounding arrays and surface and top of the atmosphere flux information. These data were then subject to a conventional form of analysis in which only a mass constraint was applied, hereafter referred to as the reference analysis, as well as to the complete VOA procedure. The diagnosed results from both analyses were then compared to time- and domain-averaged quantities from the model.

The results showed that for diagnosed vertical velocity and vertical advective tendencies, the VOA values typically exhibited considerably smaller errors compared to the values from the reference analyses, with the level of improvement and overall accuracy being dependent on synoptic and sampling conditions. The improvements tend to be greatest during disturbed conditions, with the errors typically being smaller and comparable between the two analyses during undisturbed conditions. The errors for both analyses increase as the spatial domain decreases and for the most part decrease with more frequent temporal sampling. However, the improvement achieved by having more frequent sampling is rather modest for the VOA since it already incorporates time-mean surface and TOA fluxes as constraints and thus indirectly incorporates some aspects of the variability between soundings. Highly relevant is the finding that overall the errors in vertical velocity and vertical advective tendencies from the reference analyses have a magnitude similar to, or greater than, the variability of the field being diagnosed whereas the errors in these quantities from the VOA are typically less than the variability of the field. The analysis also showed no obvious systematic level-by-level improvement gained by the VOA analysis over the reference analysis in diagnosing the horizontal moisture flux convergence, mass divergence or horizontal advective tendencies, notwithstanding the VOA's application of column integrated constraints of mass, moisture, heat and momentum conservation.

Additional soundings were found to be more beneficial to the reference analyses than the VOA analyses and in some cases allowed the error characteristics of the reference analysis to become similar to those of the VOA analysis. Noteworthy is the finding that the results from the VOA analyses using five soundings were often as good or better than the results from the reference analyses using nine soundings. The impact that hydrometeor measurements would have in providing additional constraints on the VOA was also investigated. The impact was found to be mostly negligible when averaging over relatively large space or time scales. On the other hand, for frequent sampling (e.g., 1–3 h) and small spatial scales (i.e. < ~100 km), there is a definite favorable impact on the VOA results for highly disturbed periods. The implications that the above results have on conducting atmospheric field programs and analyzing their results, along with additional details, can be found in Waliser et al. (2002).

## References

Waliser, D. E., J. Ridout, S. Xie, and M. Zhang, 2002: Variational Objective Analysis for Atmospheric Field Programs: A Model Assessment, J. Atmos. Sci., In Press.

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