Assessment of Large-Scale Advection on Mixing Ratio Profiles Obtained from the C1 BBSS During the Fall 1997 Integrated IOP

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Introduction

Many studies within atmospheric radiation measurements assume the vertical profiles measured by the C1 [Central Facility(CF)] Balloon Borne Sounding System (BBSS) represent an accurate depiction of the profile at a constant latitude and longitude (i.e., as if the balloon rose directly in the vertical with no horizontal displacement). This assumption is probably accurate in many situations, but may be problematic in cases where large horizontal gradients in the atmospheric state occur across the site and in which the wind field carries the balloon across such gradients. This brief study is an attempt to help identify those situations in which the vertical profiles of mixing ratio from the C1 BBSS during the Fall 1997 Integrated Intensive Observation Period (IOP) may have been affected by differences between the atmospheric state along the balloon path and a true vertical path. The data referred to below should be considered a tool for assessing sonde data, rather than actual adjustments to sonde data.

Advection Assessment Methodology

Two objective analysis techniques were used to obtain an estimate of the "true" vertical profile at the CF, which made use of all five BBSS sites. The first method used was a linear regression analysis, and the second was a Barnes analysis. Before conducting these objective analysis schemes, mixing ratio profiles were created at each BBSS site that were averaged into 50-m bins (in the vertical) and which began at the altitude of the highest BBSS site (the Vici BF sits at about 625 m above sea-level, thus all profiles began at this level).

- The linear objective analysis was conducted within each 50-m interval using mixing ratio data and produced an estimate of mixing ratio at the origin (which was chosen to be the CF) and gradients of mixing ratio in the north-south and east-west directions. Mixing ratio profiles in the vertical and along the sonde path were generated within this "linearized" atmosphere. Also, precipitable estimates were generated along each of these paths.

- The Barnes analysis is smoother with an exponential weighting function based on distance. Estimates of mixing ratio at each 50-m bin were generated for the CF location. The Barnes scheme provides a different viewpoint for comparing the vertical profiles. Figures 1 and 2 depict the actual mixing ratio profile from the C1 BBSS, the linear regression estimate in the vertical, the linear regression along the balloon path, and the Barnes analysis in the vertical on September 30, 1997, 2030Z.

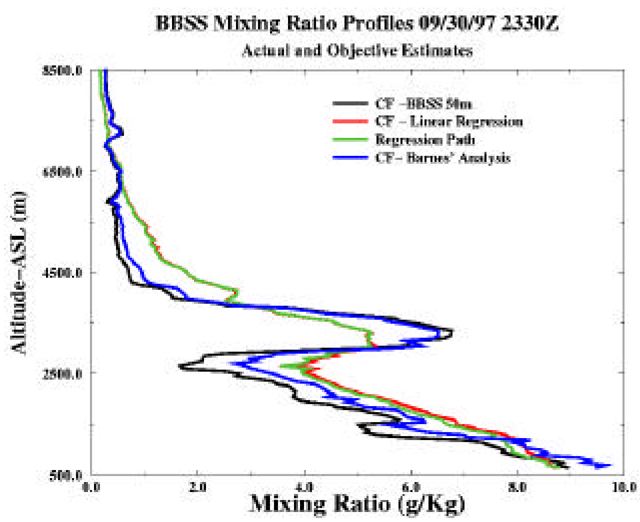

Figure 1. Actual mixing ratio profile from the C1 BBSS, the linear regression estimate in the vertical, the linear regression along the balloon path, and the Barnes analysis in the vertical on September 30, 1997, 2030Z. (For a color version of this figure, please see *http://www.arm.gov/docs/documents/technical/conf_9803/splitt-98.pdf*.)

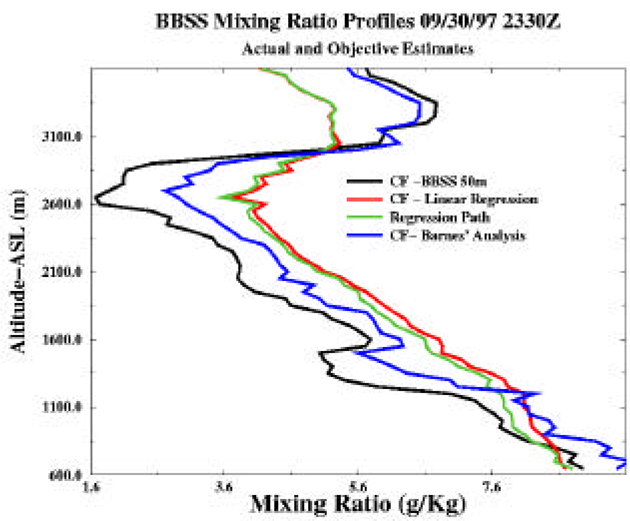

Figure 2. Same as Figure 1 except for a more limited vertical extent. (For a color version of this figure, please see *http://www.arm.gov/docs/documents/technical/conf_9803/splitt-98.pdf*.)

Such information is available from the 155 launches that the analysis could be conducted on within the IOP. The full analysis data set is available at *http://manatee.gcn.ou.edu/bbss_advect/ADVECT.html*.

Results and Discussion

The estimates of the vertical profiles obtained by the two objective analysis schemes can help resolve the large-scale variability in mixing ratio (given the horizontal spacing between sondes), and thus does not include information from the mesoscale and smaller scales. Smaller scale variations in mixing ratio are obviously present and are not evaluated here. Thus, interpretation of the data must be used with caution. While the large-scale variability may indicate that the vertical profile should be "wetter" than indicated by the particular sonde, the smaller scale variability may negate the large-scale trend. Also, sonde measurement error can skew results. Large differences between the actual CF data and the objectively analyzed data may be a result of sensor error (i.e., calibration offset, etc.). Errors in the data can also affect the objective analysis estimates; but the objective analysis techniques may help "smooth" over such problems. In order to provide a "quick" way of assessing whether a particular launch may be affected by advective effects, data has been generated assessing the vertically integrated differences between the objective estimates and the actual launch data. It is possible that a sonde path could take it to a drier area early in the launch and a moisture area later in the launch producing a "zero" net effect; it is hoped that integrating differences will often produce useful information. The only other alternative is to look at each set of analyzed data, level by level. Table 1 is an example of those available on the Web and include an assessment of the "integrated" effects. The columns are described as follows:

- column 1: The date and time of the C1 BBSS Launch.
- column 2: The maximum height to which the objective analysis could be done. This would be the lowest maximum height from the set of sondes.
- column 3: The precipitable water estimate based on the C1 BBSS data.
- column 4: The precipitable water estimate based on the 50-m binned C1 BBSS data. (The precipitable water from 315 m to 625 m was added to this estimate from the C1 BBSS data; this was done also for the estimates in columns 5, 6, and 7.)
- column 5: The precipitable water estimate over the CF (vertical path) based on the linear regression analysis.
- column 6: The precipitable water estimate from the linear regression analysis along the C1 sonde path. (Note that differences between this and the linear regression were much smaller than differences between the actual data and the linear regression, exemplifying the effects of linearizing the atmosphere.)
- column 7: The precipitable water estimate from the Barnes analysis over the CF.
- column 8: The difference between "actual" and "regression" (columns 3 through 5) precipitable water scaled to the maximum difference. Values can range from +1.0 and -1.0. The scaling was conducted to better compare to other differences that were generated for columns 9 and 10.
- column 9: Similar to 8, but is the scaled differences between the actual sonde and the Barnes analysis (columns 3 through 7).
- column 10: Similar to columns 8 and 9, but is the scaled difference between the linear regression over the CF and the linear regression estimate along the sonde path. So, this is the difference between a vertical profile and a sonde path profile in the "linearized" atmosphere (columns 6 and 5).

Table 1. Estimates of preciptable water from various techniques and subjective weightings for differences to the actual sonde data. See text for explanation of each column.

Date and Time	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10	Col. 11	Col. 12
970916.0228	22900.0	4.141	4.166	3.997	4.043	4.132	0.137	0.126	0.236	0.376	-0.161
970916.0523	25000.0	3.967	3.998	3.948	3.967	4.050	0.041	-0.196	0.099	-0.042	0.002
970916.0823	23450.0	3.589	3.583	3.795	3.791	3.846	-0.173	-1.000	-0.018	-0.895	-0.085
970916.1123	25000.0	3.469	3.572	3.743	3.687	3.740	-0.140	-0.637	-0.295	-0.805	-0.176
970916.1428	23350.0	3.562	3.553	4.044	4.036	3.643	-0.401	-0.344	-0.042	-0.592	-0.193
970916.1729	19300.0	4.289	4.450	4.150	4.147	4.470	-9999.	-9999.	-9999.	-9999.	-0.347
970916.2029	21450.0	4.356	4.426	4.329	4.357	4.395	0.079	0.115	0.145	0.255	-0.493
970916.2330	23600.0	4.638	4.827	4.383	4.484	4.712	0.363	0.439	0.529	1.000	-0.250

- column 11: This is a scaled difference based on averaging the scaled differences from columns 8, 9, and 10 (and are again rescaled for the maximum value). This might be called the “consensus” scaled difference and may be the most useful of the estimates in helping assess advective effects.

- column 12: This is the difference between sonde and the microwave water radiometer (MWR) as obtained from the quality management experiments.

Potential Effect of Large-Scale Advection

The differences between the path estimates and vertical estimates indicate the potential effect that large-scale advection can have on the accuracy of the precipitable water estimates obtained from the C1 BBSS during this period. Precipitable water differences between the Barnes scheme and the sonde data indicated a .093 cm standard deviation (about 3% error); the difference between the regression path and regression vertical estimates produced a .092 cm standard deviation (also a 3% error). The difference between the regression vertical estimate and the sondes revealed a standard deviation of 0.276 cm (about a 9% error). The later error estimate is assumed to be too high and is arguably reflective of the error in the linear regression. In the author’s estimation, an estimate of the error introduced by advection is on the order of 3%.

Correlation Between Large-Scale Advection and BBSS/MWR Differences

Differences between the actual sonde precipitable water (which is along a path) and the vertical estimates of same (obtained from linear regression and Barnes analysis) were compared to the differences between the sonde and the MWR (a vertical estimate). The various comparisons did not show significant correlations. Thus, the effects of large-scale advection on the BBSS precipitable water are less than other errors (e.g., sonde calibrations; MWR calibration, small-scale atmospheric variability), which result in MWR/ BBSS differences. Comparison of the BBSS and MWR estimates during the Fall IOP (Figure 3) showed a 0.16-cm bias and 0.296-cm standard deviation (about 9.5% error).

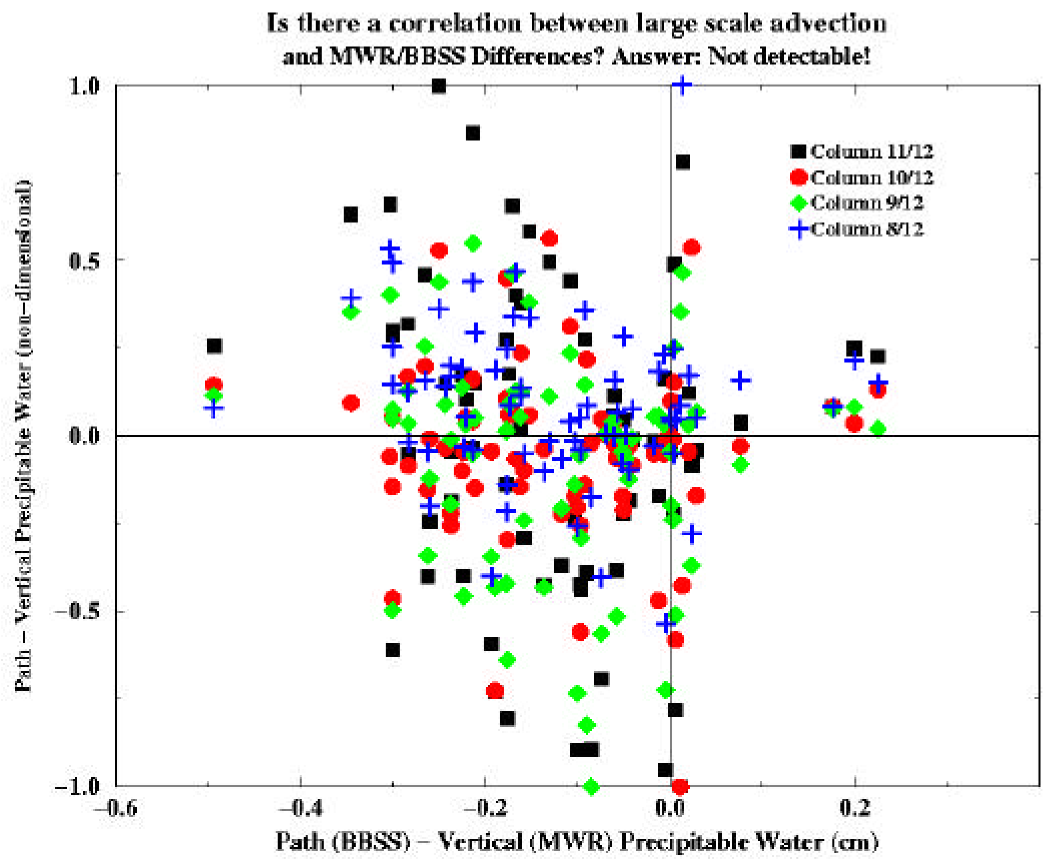

Figure 3. Scatter plot comparing differences in path and vertical estimates of liquid water. Large-scale advective effects do not show a strong signal in the actual data. (For a color version of this figure, please see *http://www.arm.gov/docs/documents/technical/conf_9803/splitt-98.pdf*.)