Processing of Wind Profilers at the Canadian Meteorological Centre

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1. INTRODUCTION

The NOAA Profiler Network is composed of 35 UHF radars operating in full capability since 1992. The radars provide hourly average measurements of horizontal wind vectors. The 404 MHz Wind Profilers operate in two separate modes : low mode (500m – 9250m above ground level) or a high mode (7500m -16250m AGL). To sample these higher altitudes a longer pulse (increased power) is needed. Therefore, with the longer (shorter) pulse in the high (low) mode, a lesser (higher) resolution of 900m (300m) is attained. Winds measured by the profiler are an average within each resolution volume, centered every 250m vertically.

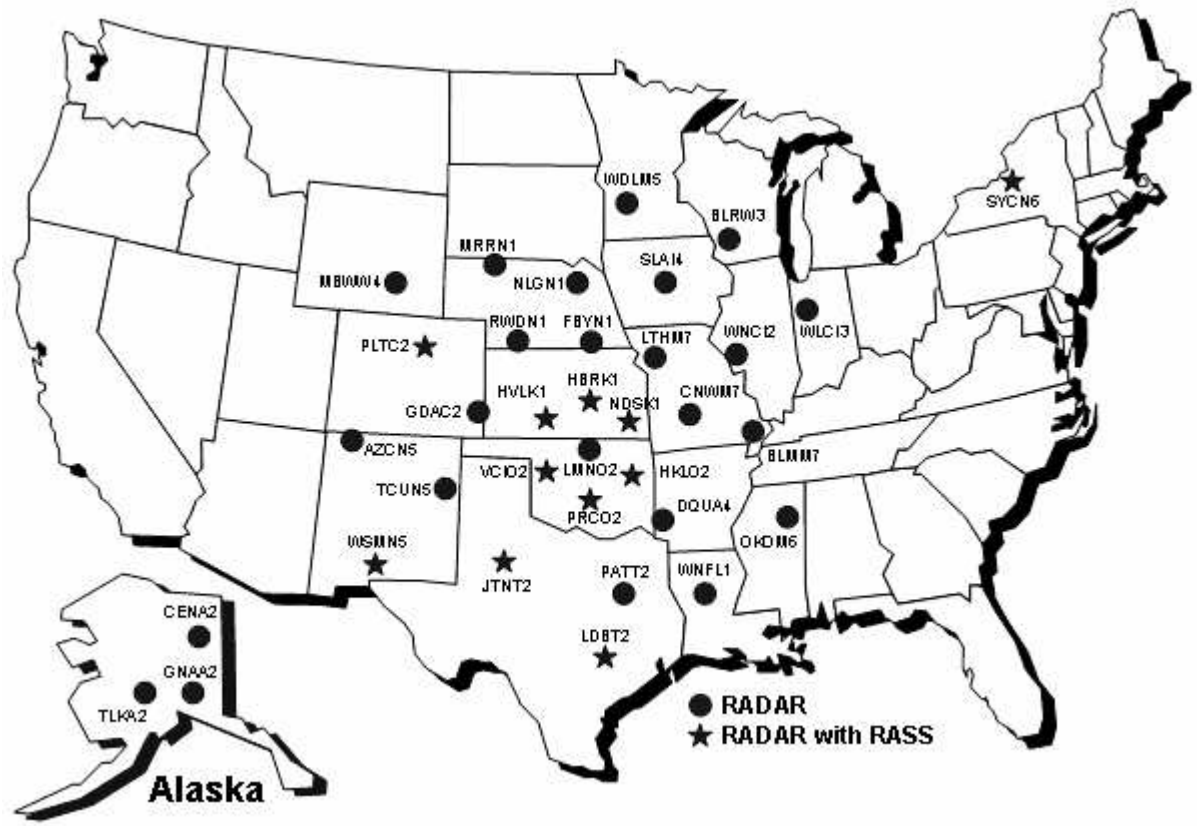

Figure 1. The NOAA Profiler Network.

2. DATA PROCESSING AND QUALITY CONTROL

Vertical profiles of the horizontal wind components are examined. A monitoring web site displays monthly averages of profiler minus short-range forecasts of horizontal winds. As a first step, a blacklist of wind profilers is produced every month. Conditions for which a wind profiler may appear on the blacklist are as follows:

- % of gross errors (table 1) > 50%;

- At least one level with 10 observations during the month (gross errors are not considered) and 10 m/s vector departure.

Height (meters)	Gross Errors (m/s)
500 - 2250	35
2500 - 4250	40
4500 - 6500	45
6750 - 8250	50
8500 - 11000	60
11250 - 14750	50
15000 - 16000	45

Table1. Gross error limits for wind profilers as a function of height.

The profiler data are submitted to a first quality control. During the background quality control, the model counterparts for profiler observations are calculated through the non-linear observation operator. The square of the background departure is considered as suspect when it exceeds its expected variance by more than a predefined multiple. The predefined limits for the background quality control are given in terms of multiples of the fraction between the variance of the background departure and the sum of the variance of the background error and the variance of the observational error. The background quality control rejects the observations with obvious gross errors. Secondly, a variational quality control is performed during the minimization process in the 3DVar. Suspect horizontal winds are given a very small weight in the analysis and are flagged as such.

The operational data processing of wind profilers is described in figure 2. Starting with the monthly blacklist, a derivate file is produced which is passed to the background check. A vertical thinning process is then applied and the profiler data, including the blacklist, background check and data selection flags, are passed to the 3DVar. The QCVar will then add its own flags.

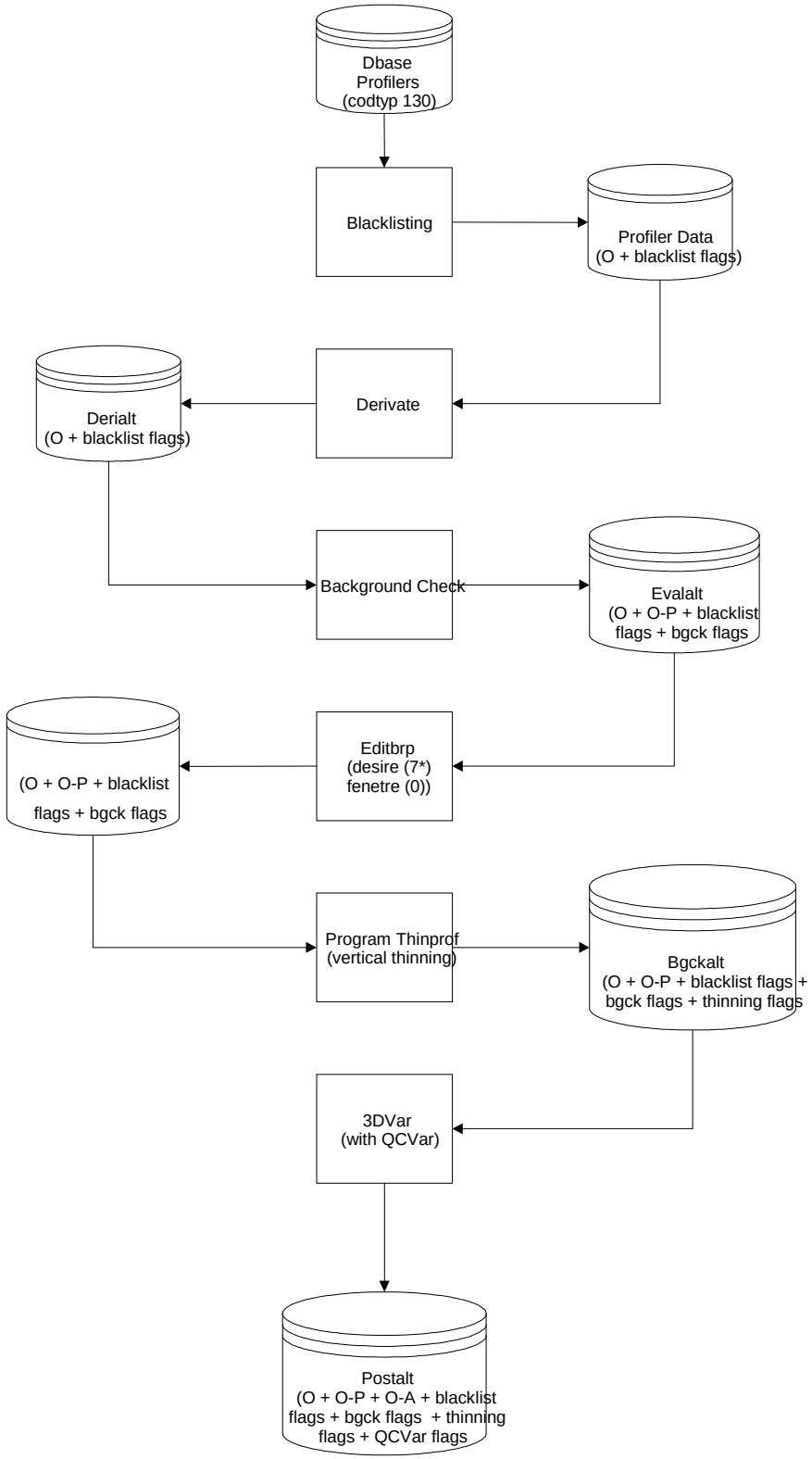

Figure 2. Flowchart of wind profiler data processing

3. VERTICAL OBSERVATION ERROR CORRELATION

A way of estimating the observation error variances is by using a refined method of statistical analysis of wind innovation vectors (Xu and Wei, 2001). For the 2001-2002 winter season, the short-range forecasts wind components are verified against profiler data over central US. These forecast errors are partitioned into prediction errors and observational errors under the assumption that the observational errors are horizontally uncorrelated and that the forecasts errors are horizontally homogeneous. The calculations provide an estimate of the vertical error covariance matrices for prediction error and for observational error.

The estimated observation errors for the u and v components are plotted in figure 3 in terms of their standard deviations as functions of vertical levels (meters). The observation errors vary slightly with height, so the standard deviation in the analysis scheme is taken as a constant and is set to 2.2 m/s for all levels.

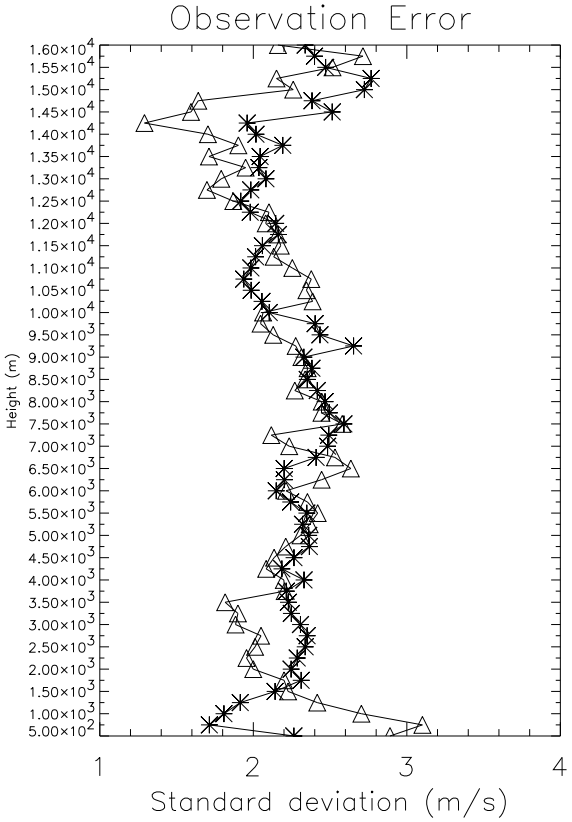

Figure 3. Vertical profile of the observation error of wind profilers for the u-component (asterisk) and the v-component (triangle).

This method also measures the vertical correlation structure of the observation error. Figure 4 shows the vertical correlation statistics for the observation error as a function of distance between vertical levels (meters). A gaussian type curve fit applied to the correlation statistics points to a vertical error correlation length of 500m for the low mode and 513m for the high mode. These results suggest that the wind profiler data reported at every 250m vertically is correlated. Since the wind measurements are the result of an average within a resolution volume of 300m (low mode) to 900m (high mode), a vertical correlation seems to exist in the high vertical resolution (250m) of the data.

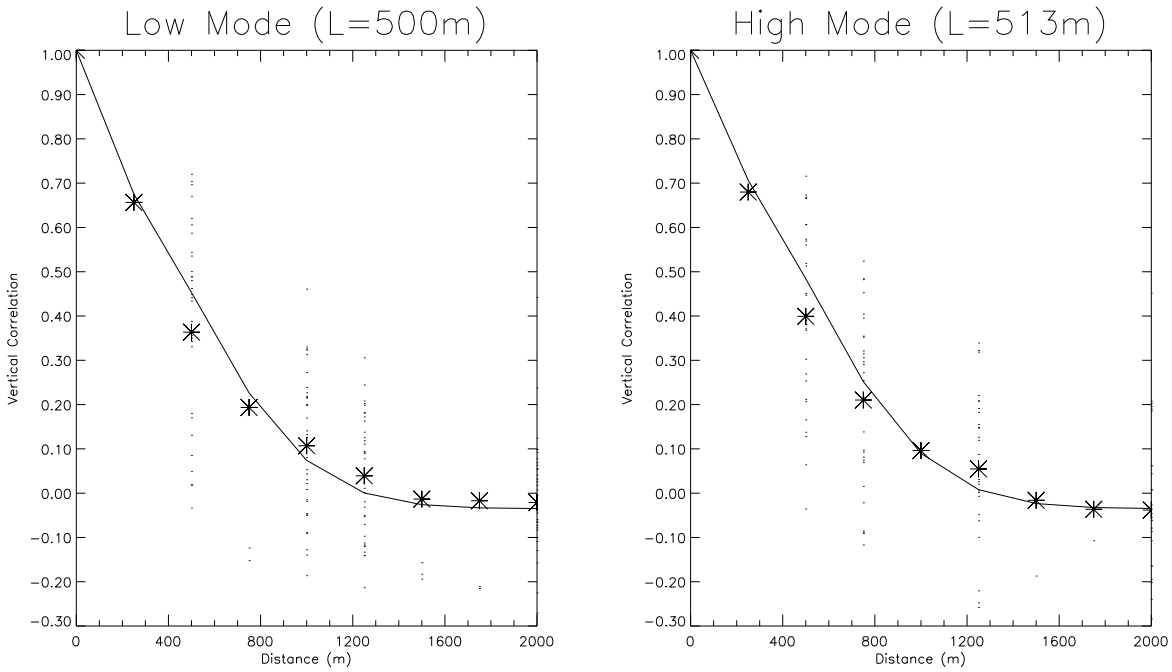

Figure 4. Vertical observation error correlation as a function of vertical distance (meters) between levels for the low (left) mode and high (right) mode. The asterisks represent and average over a 250 meter interval.

In the Canadian operational 3D-Var assimilation algorithm (Gauthier et al. 1999; Laroche et al. 1999), vertical observation error correlation is neglected. Including the vertical correlation in a 3D-Var analysis system is not an easy task. It can reduce considerably the computational efficiency in an operational context. To avoid taking into account the correlation, thinning the number of observations in the vertical is proposed. This is comparable to the horizontal thinning process often used for satellite data. The vertical thinning proceeds as follows: the first two levels above ground level are rejected and the third level AGL is used, followed by the rejection of the next two levels, etc. Of the 63 levels available for assimilation, around twenty observations are actually used for the analysis. The vertical thinning process allows the number of observations assimilated to be reduced and the direct use of the estimated observation error standard deviations.

For further details, please refer to (St-James and Laroche 2005).

REFERENCES

1. Bouttier, F., 2001: The use of profiler data at ECMWF. ECMWF Research Department Technical Memorandum no. 331, available from ECMWF, Shinfield Park, Reading RG2 9AX, UK.
2. Gauthier, P., C. Charette, L. Fillion, P. Koclas, and S. Laroche, 1999a. Implementation of a 3D variational data assimilation system at the Canadian Meteorological Centre. Part I : the global analysis. Atmosphere -Ocean, 37, 103-156.
3. Laroche S., P. Gauthier, J. St-James and J. Morneau, , 1999. Implementation of a 3D variational data assimilation system at the Canadian Meteorological Centre. Part II : the regional analysis. Atmosphere - Ocean, 37, 281-307.
4. Xu, Q., and L. Wei, 2001: Estimation of Three-Dimensional Error Covariances. Part II: Analysis of Wind Innovation Vectors. Mon. Wea. Rev., 129, 2939, 2954.
5. St-James, J. and **S. Laroche**, 2005: Assimilation of wind profiler data in the Canadian Meteorological Centre's analysis systems. *J. Atmos. Oceanic Technol.,* **in press**