P2.7 **MONITORING OF GLFE TAMDAR AT THE CANADIAN METEOROLOGICAL CENTRE**

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1. INTRODUCTION

The Canadian Meteorological Center (CMC) has participated in a limited way to the TAMDAR Great Lakes Fleet Experiment (GLFE). CMC began receiving TAMDAR data on December 16, 2004 and monitoring the data in terms of quality, availability and usefulness in the forecast process. The data in BUFR format has been obtained from the AIRDAT ftp server and processed by the CMC quality control system.

In a 24 hour period, CMC receives ~16,000 GLFE TAMDAR observations. In general, the greatest number of observations is available for the 18 and 00 UTC periods, and the smallest number for 06 UTC periods. The concentration of data is in the United States, around the Great Lakes, Northern Plains and Ohio Valley (see figure 1).

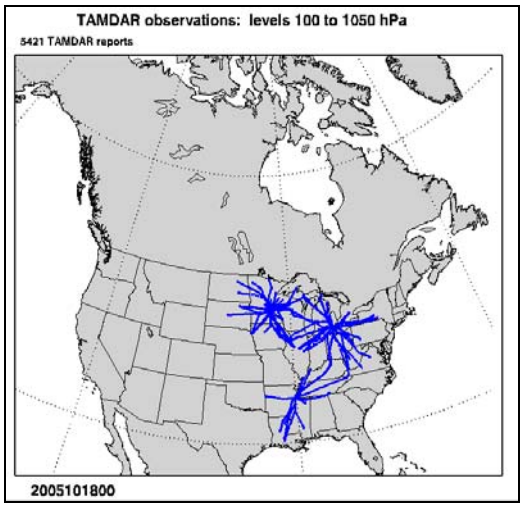

Figure 1. GLFE observations decoded by CMC over a 6-hour window centered at 00 UTC on 18 October 2005.

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The TAMDAR observations are not assimilated in the CMC operational NWP system. An observing system experiment has begun to measure the impact of GLFE TAMDAR data in the new 4D-Variational (4D-Var) global analysis (Laroche et al. 2005). The impact is being assessed for a six-week period, from 17 June to 10 July 2005, with 10-day forecasts done at 12-hour intervals. The results should be ready by the time of the symposium.

2. BACKGROUND ON CMC ASSIMILATION SYSTEM AND MONITORING

2.1 *New 4D-Var Analysis*

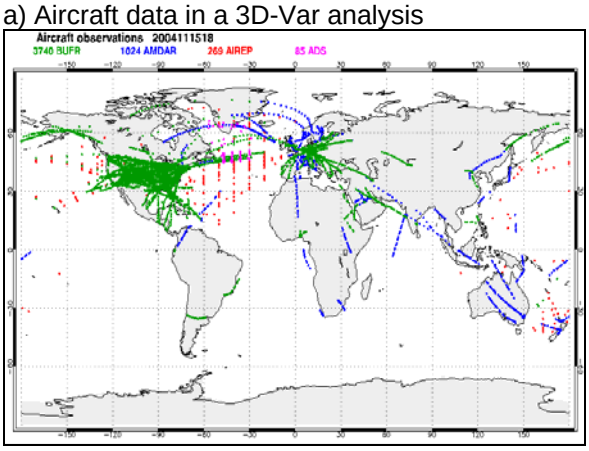
This year has been a turning point for the assimilation activities at the CMC. The 3D-Var data assimilation system for the global forecasting suite has been extended to a 4D-Var scheme. The 4D-Var analysis includes a new data selection process which has been modified for all observation types except the surface reports. The 4D-Var analysis is done by using the GEM forecast model itself as part of the assimilation process and by using observations at the appropriate time during the analysis time window.

The 6-hour assimilation window is divided into 9 time interval; the data are spatially thinned giving priority to the observation closest to the middle of the time interval. This has considerably increased the number of frequently reported data such as aircraft, satwind and profiler data.

Figure 2 shows an example of the difference in aircraft data coverage between 3D-Var and 4D-Var data assimilation. We can see significant increase in the number of aircraft assimilated observations with 4D-Var analysis. The amount of aircraft data in 4D-Var has almost tripled compared to 3D-Var.

Prior to its use in the analysis, the aircraft data are quality controlled. The background error statistics and the data quality control in 4D-Var remain the same as in 3D-Var analysis.

a) Aircraft data in a 3D-Var analysis



b) Aircraft data in a 4D-Var analysis

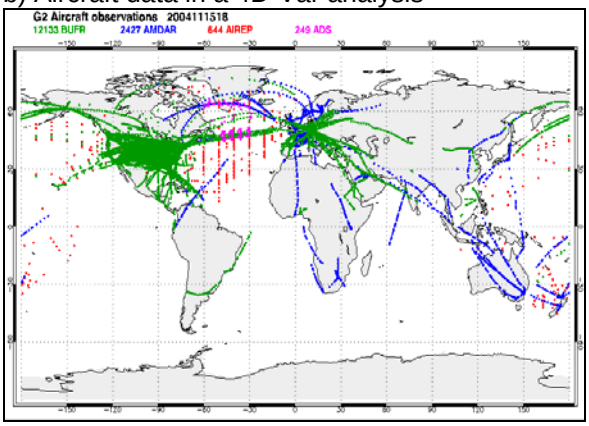


Figure 2. Distribution maps of aircraft observations assimilated in 6-hour period.

2.2 *Processing of TAMDAR data at the CMC*

For GLFE TAMDAR observations, we use the same set of QC programs as for operational observations. At first, latitude, longitude, time of observation and the aircraft identifier are checked for coding errors. For the wind, directions outside physical limits are flagged as in error and a climatological test is performed for the speed.

A separate quality control program is used to verify the aircraft position. This program groups the reports according to the aircraft identifier and sorts the observations chronologically and according to pressure level.

After this part of the quality control the TAMDAR observations go through the rest of the QC procedures as the blacklisting and background check. The blacklisting program adds the blacklist flag to prevent their assimilation in the operational analyses.

A background quality check is applied to remove the observations with gross errors before the assimilation step. It is a comparison between the observed elements and the same variables from the analysis first guess interpolated at the observation location and time. The variance of the background departure can be estimated as the sum of observation and background error variances. In the background quality check, the background departure is considered suspect when it exceeds its expected variance by more than predefined multiples.

2.3 *Monitoring of GLFE TAMDAR at CMC*

The monitoring of TAMDAR observations includes the possibility of evaluating the quality of the observations for all aircraft together or for individual aircraft.

A number of programs have been prepared for the monitoring of TAMDAR reports and the results can be seen on a CMC internal web site. This web site includes information about the number of TAMDAR observations, their distribution and time series of the mean and standard deviation of observations minus first guess (O-P) values. One can also find information about the monthly average number of observations and some monthly O-P statistics for all reporting period.

Special care was taken to properly interpret quality flags which are presented in the BUFR files. In the BUFR format observed variables are flagged with a 2-bit error code: good or bad data (GLFE TAMDAR Observation Quality Assurance and BUFR Format. Version 1.5.2).

The monitoring statistics presented here are only for data flagged as “good” in the BUFR bulletins provided by AIRDAT, however all TAMDAR data are available in our database and monitored.

In the following section we evaluate the wind and temperature TAMDAR observations in terms of quality and usefulness in the CMC NWP system.

3. RESULTS OF TAMDAR DATA EVALUATION

Time series of the mean and standard deviation values of O-P is a type of monitoring done to evaluate the quality of TAMDAR data. Figure 5 is an example of such time series for 25 day period for wind and temperature observations with the “good” flag. The two top graphs present the statistics for wind vector and wind components (U and V) and the second graph from the bottom presents the temperature statistics.

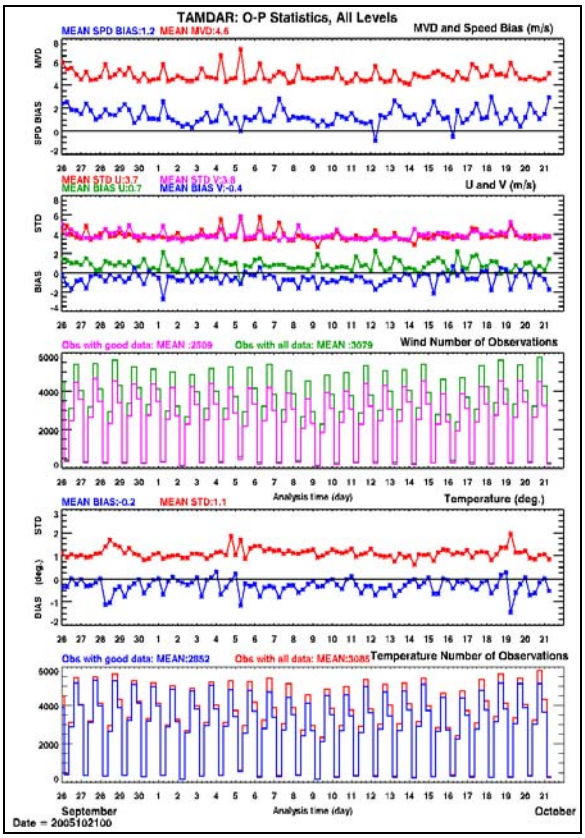


Figure 3. O-P statistics for wind and temperature TAMDAR observations (for data with “good” flag only) in September-October 2005.

For wind observations, the positive speed bias (~1.2m/s) indicates that on average the observed speed is higher than CMC first guess wind speed and frequent larger deviations were observed. The evaluation of temperature data shows very good results, a negative temperature bias of -0.1 deg. has been observed when considering all TAMDAR reports. Note that the quality of temperature and wind data is better for low level, 701-1050 hPa (not shown here), than for high level, 301-700 hPa.

The monitoring of aircraft meteorological observations includes the possibility of evaluating the quality of reports of individual aircraft. This allows the detection of problems on a particular aircraft and could be used to provide a feedback to the data producer. Table 1. provides a list of TAMDAR aircraft for the month of August 2005 with “suspect” and “non-suspect” temperature and wind observations using WMO criteria (WMO expert group on GDPS solutions for data quality monitoring).

August 2005 TAMDAR

Pressure Categories (hPa)
LOW PRESS: 701 - SFC
MID PRESS: 301 - 700
HIGH PRESS: 300 - 100
ID: is the aircraft tail number
NA: is the total number of available observations
NE: is the total number of erroneous observations
NR: is the number of rejected observations
NG: is the number of gross observations excluding erroneous data
NC: is the number of exactly calm winds excluding erroneous data
TBIAS: is the temperature bias for non-gross temperatures and non-erroneous data
TRMS: is the RMS temperature difference excluding gross errors and erroneous data
SBIAS: is the speed bias for non-gross winds and non-erroneous data
WRMS: is the RMS wind difference excluding gross errors and erroneous data

Wind gross error limit: LOW: 30.0, MID: 30.0, HIGH: 15.0 (m/s)
Calm wind limit: 0 (m/s)
Temperature gross error limit:
LOW: 15.0, MID: 10.0, HIGH: 10.0 (degree)
Selection criteria:
num obs >= LOW: 20, MID: 50, HIGH: 50

SUSPECT CRITERIA
Temperature Bias:
LOW 3.0; MID 2.0; HIGH 2.0
Temperature RMS:
LOW 4.0; MID 3.0; HIGH 3.0
Wind Speed Bias:
LOW 3.0; MID 2.5; HIGH 2.5
Wind RMS:
LOW 10.0; MID 8.0; HIGH 10.0
More than 2% of observations are gross

BUFR FORMAT WIND OBSERVATIONS

SUSPECT WINDS

ID	ELEM	LEVEL	NA	NE	NG	NR	NC	WRMS	SBIAS
258	W	301-700	576	203	16	112	2	6.2	2.4
244	W	301-700	2368	162	0	15	2	5.9	2.5
201	W	301-700	2493	181	0	25	2	6.6	2.5
268	W	301-700	2466	121	4	22	6	6.0	2.6
232	W	301-700	2392	293	12	214	3	7.0	2.7
234	W	301-700	2833	209	0	15	6	5.8	2.7
279	W	301-700	2781	333	0	24	7	5.9	2.7
239	W	301-700	2538	148	2	29	7	6.7	2.7
285	W	301-700	2492	483	0	58	3	7.3	2.8
236	W	301-700	2564	768	0	245	3	7.6	2.9
243	W	301-700	2319	901	0	573	2	7.2	3.1
256	W	701-SFC	3322	593	3	220	7	7.5	3.1
247	W	301-700	2677	601	0	26	11	7.1	3.2
275	W	701-SFC	2108	409	6	82	5	6.8	3.3
261	W	701-SFC	3942	802	2	312	17	7.7	3.4
267	W	301-700	2505	704	0	591	1	7.2	3.4
227	W	301-700	2153	546	0	216	3	8.0	3.6
220	W	301-700	2885	207	2	53	3	6.9	3.6
289	W	301-700	1970	107	0	54	2	7.2	3.7
261	W	301-700	2531	141	1	190	3	8.3	4.0
275	W	301-700	1689	115	0	37	1	7.6	4.2
256	W	301-700	1853	93	0	95	2	8.2	4.3
252	W	701-SFC	3652	3362	0	731	1	12.1	5.5
252	W	301-700	2638	2464	0	772	0	12.9	7.8

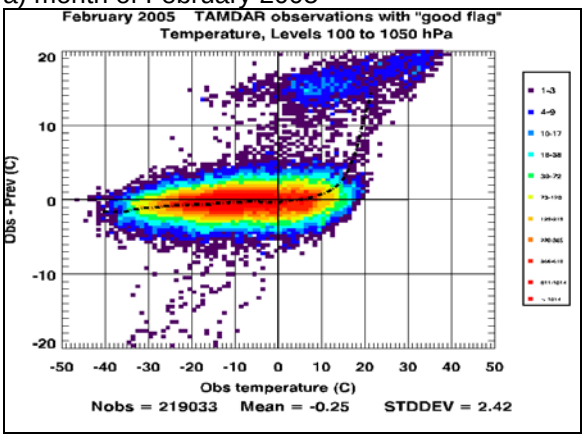
BUFR FORMAT TEMPERATURE OBSERVATIONS
No Suspects for Temp

Table 1. Example of individual aircraft monitoring statistics with suspect and non-suspect observations.

Note again, that these statistics are done just for data flagged as “good”, so our control system has identified suspect observations (usually wind observations) which are transmitted without being flagged.

Concerning the temperature data, we have noticed an improvement during the monitoring period (see figure 4a, b).

a) month of February 2005



b) month of August 2005

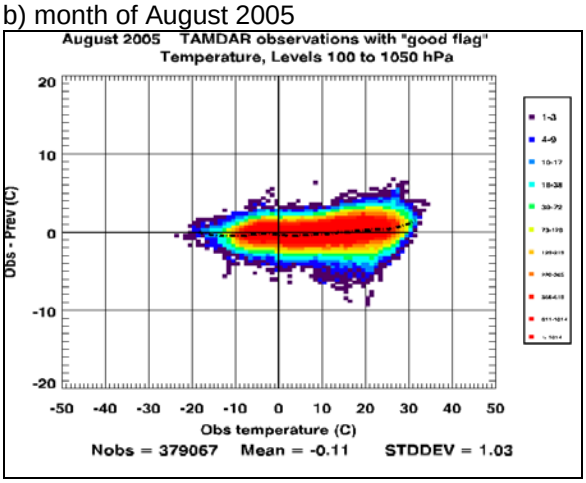


Figure 4, Density plot of observations minus first guess against observations for temperature, all data with good flag only.

Figure 4a shows some very bad observations (large deviations), which are flagged by CMC background check and 4b shows the improvement in data quality for the month of August.

Figure 5 presents the evaluation of temperature and wind statistics for all levels from December 2004 to September 2005. The top graphics present monthly evaluation of wind statistics while the second graph from bottom presents monthly evaluation of temperature statistics. The results clearly indicate the good quality of temperature data but a slight deterioration of the wind speed bias in the summer months compared to the beginning of the monitoring period.

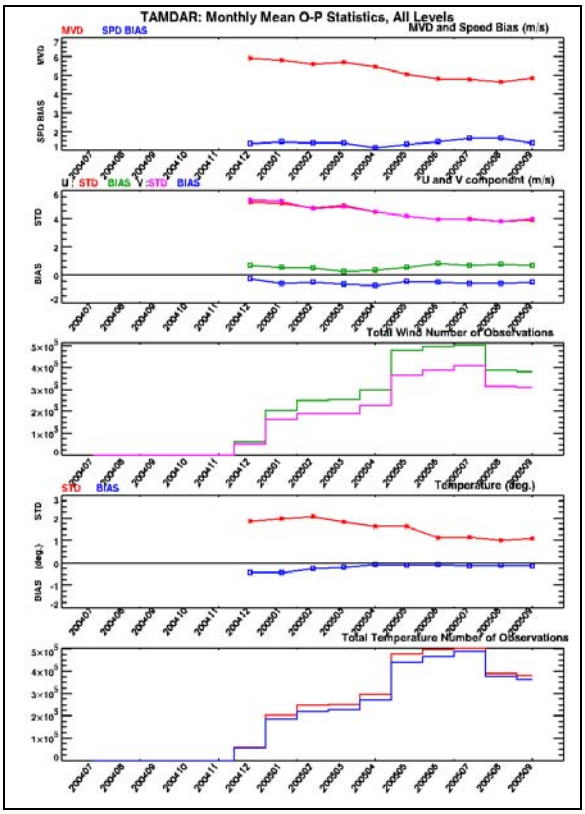


Figure 5. O-P mean monthly statistics from December 2004 to September 2005 for the TAMDAR temperature and wind observations.

4. SUMMARY OF MONITORING RESULTS

The results of monitoring confirm the TAMDAR data are generally of good quality, there is just some concern about a small positive wind bias. During the monitoring period, we have noticed an overall improvement in the quality of observations flagged as “good”. Obviously some bad observations are corrupting the statistics in the first months. These bad observations were transmitted with a “good” quality flag and are usually rejected by the CMC NWP quality control processes. This would prevent their assimilation in 4D-Var analysis program. So, this study clearly indicates the importance of the monitoring by NWP process to identify issues with data.

5. REFERENCES

Moninger, W.R., T.S.Daniels, R.Mamrosh, M.F. Barth, S.G.Benjamin, R.S. Collander, L.Ewy, B.D. Jamison, R.C. Lipschutz, P.A. Miller, B.E. Schwartz, T.L. Smith and E.J. Szoke, 2004: TAMDAR, the rapid update cycle, and the Great Lakes Flight Experiment. *11th Conf. on Aviation Range, and Aerospace Meteorology,* Hyannis, MA, P8.6.

Laroche, S., P.Gautier, M.Tanguay, S.Pellerin and J.Morneau, 2005: Evaluation of the operational 4D-Var at the Meteorogical Service of Canada. Preprints, *21th Conf. on Weather Analysis and Forecasting/16th Conf. on Numerical Weather Prediction,* Washington, Amer. Meteor. Soc., CD-ROM, 14B.3.

AIRDAT, 2004: TAMDAR observation quality assurance and BUFR format, version 1.5.2. [*Available from AIRDAT*, www.airdat.com]

WMO expert group on GDPS solutions for data quality monitoring, 2002: *Expert Meeting on CDPS solutions for the data quality monitoring,* Final Report, Reading, UK, 24-28 June 2002.

Verner, G., Y.Zaitseva, R.Sarrazin and G.Fournier, 2005: CMC Monitoring of GLFE TAMDAR data. Power Point Presentation, *GLFE Status Meeting NOAA FSL,* Boulder, CO, 11-12 April 2005.