Automatic Real-Time Quality Control of Surface Synoptic Observations

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ABSTRACT

A real-time quality control for surface observations has been developed and tested in the Israel Meteorological Service. Error sources specific to real-time work have been defined and special procedures to deal with them were developed. A great emphasis was given to data correction so that the scheme is not confined just to the rejection of incorrect data. The criteria for the correction and rejection procedures are mostly empirical and rely much on operational experience. Accumulated statistics indicate that many reports transferred through the Global Telecommunication System are very liable to contain errors, thus emphasizing again the need for a quality control program. Future development routes are suggested.

1. Introduction

Since November 1974 surface synoptic observations have been processed automatically at the Israel Meteorological Service (IMS). Since the meteorological data received through the Global Telecommunication System (GTS) are of mixed quality, errors in the data make any further processing of doubtful value. A quality control of some kind is necessary in order to obtain meaningful data for automatic plotting, analysis and forecasting. To overcome these difficulties a real-time quality control computer program has been developed.

The quality control program runs on an operational basis on an X.D.S. Sigma 5 computer. The program's size is 8000 words. The meteorological reports which are received by seven teleprinters are fed directly into the computer through a Telecommunication Controller (COC).

The raw data are temporarily stored on a magnetic disk and then processed by the Automatic Data Extraction (ADE) program whose main functions are to recognize the reports and organize them into groups each containing five characters. The quality control program operates on the data arranged by the ADE.

Apart from error detection, the program attempts to correct and reconstruct the original faultless form of observation. The logic of such a program must be compiled with utmost care. Too stringent checks will result in the rejection of too much data but, on the other hand, an attempt to correct suspected reports by every means may result in the introduction of new errors.

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2. Error sources in surface observations

There are three main sources of error revealed in the dara received through the GTS. In Table 1 we present examples for these types, which were taken from real data received and in their correct form. The three types are as follows.

a. Observational and coding errors (A)

Errors in the weather elements such as visibility (VV), present and past weather (ww, W, respectively) and clouds are mainly due to improper use of the SYNOP code, while those of wind, pressure (ppp), temperature (TT) and dew point (TdTd) may be the result of misreading of instruments. Such errors are rather infrequent and can be treated easily.

b. Human processing errors (B1 and B2)

These generally occur in the process of collecting and transmitting through the GTS and can be devided into two subgroups: 1) shifts in numbers in the report and 2) incorrect typing of numbers in the report. Although these errors may generate internal inconsistencies in the reports, they are not always easily detected or distinguished from those of other types. Furthermore, typing mistakes do not necessarily result in internal discrepancies in the reports and therefore may be detected only in their obvious forms. These errors are labeled B in Table 1.

c. Machine processing errors (C1 and C2)

Hardware problems constitute by far the most common source of errors in the GTS. They can be sub-

TABLE 1. Typical errors in meteorological data. The data are presented according to the SYNOP code without station number. Errors are italicized.

Error source	Data as received					Data in correct form				
A	73028	*54*070	18920	78600	13602	73028	*40*070	18920	78600	13602
A	30722	20*444*	02451	16201	53816	30722	20*104*	02451	16201	53816
A	90000	01*444*	17515	9x0xx	15801	90000	01*454*	17515	9x0xx	15801
B	00000	70020	49920	0*9*000	13809	00000	70020	49920	00*90*0	13809
B	03005	98020	16423	00*0*00	12712	03005	98020	16423	00*9*00	12712
B	82310	98020	10020	00*7*08	18406	82310	98020	10020	00*9*08	18406
C1	80219	97052	16322	*0*097x	17400	80219	97052	16322	*8*097x	17400
C1	*8*3518	96021	18718	*8*0900	xx213	*0*3518	96021	18718	*0*0900	xx213
C1	23325	98020	17923	00*5*06	15801	23325	98020	17923	00*9*06	15801
C1	21405	97525	02604	25*9*00	xx614	21405	97525	02604	25*5*00	xx614
C1	82320	*70*444	19807	863xx	05100	82320	*10*444	19807	863xx	05100
C1	83608	58020	26015	0090*1*	12808	83608	58020	26015	0090*7*	12808
C2	92609	93444	02205	9x*42*x	05205	92609	93444	02205	9x*0x*x	05205
C2	70000	58052	17524	*0*095x	22207	70000	58052	17524	*7*095x	22207
C2	*1*0205	75020	60838	00900	06613	*0*0205	75020	60838	00900	06613
C2	*2*3614	99021	17515	31500	03202	*3*3614	99021	17515	31500	03202
C2	00810	98020	22917	00900	15*442*	00810	98020	22917	00900	15*xxx*
C2	*36823*	62020	18822	35500	17612	*3xx23*	60200	18822	35500	17612
C2	23313	15*601*	09103	*70030*	*81*645	23313	15*xx*1	09103	*xxxxx*	*01*645
C2	72706	65013	047*17*	43530	*24*704	72706	65013	047*xx*	43530	*xx*704
C2	*0*3410	97020	28813	*3xx03*	xxxxx	*x*3410	97020	28813	*xxxxx*	xxxxx

divided into two subgroups:

1) Systematic changes of teleprinters signals when there is a tendency for some characters to interchange between themselves. The most frequent are $8 \leftrightarrow 0$, $7 \leftrightarrow 1$ and $9 \leftrightarrow 5$. These character interchanges occur only when the information is transmitted through radioteleprinter and not by a physical line. This phenomenon was revealed by a statistical study and practical experience. The main difficulty in treating errors of this kind is their randomness of appearance. When an internal inconsistency due to this source is found, it is not always possible to pinpoint where this interchange has occurred. Apart from this, it can happen that in some cases where an error is apparent it is not always possible to restore the report to its original state: for example, in *7*1805 60022 12517 *1*5500 16705, one does not know whether 7 changes to 1 or vice versa. Arbitrary assumptions have to be made in order to enable further processing of the data.

2) Some of the errors revealed in the received reports are random in their nature. These appear everywhere and in any form, yet some of them can still be treated even if not always with absolute certainty. It is not always possible to distinguish errors due to this source from those due to mistyping. Therefore, errors B and C2 are treated in the same manner in our program.

3. Basic logic of error handling on a real-time basis

In our program we have assumed that errors are possible and even frequent (this fact will be presented in later error statistics) and an attempt should be made to correct them. Our basic assumption is that *a report is always suspected to contain errors*. Accordingly, we define minimum necessary criteria with regard to different combinations in the reports. A failure of an observation to satisfy these requirements will initiate, when possible, a correction procedure. These correction procedures are based on inner SYNOP logic and knowledge of the systematic errors. Every corrected report is rechecked and only a failure in this recheck or an impossibility to correct a report will result in a rejection. At present we apply only internal consistency checks. Spatial and temporal checks will be added in our second stage.

Surface observations are complicated because the dependence on the various elements reported is rather qualitative and not quantitative. Thus, the lack of formulas makes it necessary to find and use empirical rules in order to check the quality of the reports. There are two approaches to deal with errors—either reject erroneous data or try and correct them. In our program we have attached great emphasis on data correction. Our aim in deriving the empirical working rules is to strive toward three fold optima; 1) a minimum of incorrect reports accepted; 2) a maximum of rightly corrected reports; 3) a minimum of fautless rejected data

As there are different errors encountered in real-time work, we have to take account of the abovementioned error groups simultaneously. Accordingly, we try corrections of various kinds. These can be subdivided into three main types as follows;

1) Correction of the report in such a way that it will conform with the SYNOP code (group A).

Table 2. Typical examples of corrected observations. Data are in the SYNOP code without station's number. Detected and corrected errors are italicized.

Legend no.	Report received					Report corrected					Correction group type
1	10000	*53*051	19622	00901	21307	10000	*30*051	19622	00901	21307	A
2	82918	20*41*4	14718	862xx	15203	82918	20*10*4	14718	862xx	15203	A
3	01810	65*20*0	17624	00900	18807	01810	65*xx*0	17624	00900	18807	A
4	93612	05*42*4	55010	9x0xx	10304	93612	05*43*4	55010	9x0xx	10304	A
5	70232	96*35*3	09327	29641	06709	70232	96*06*3	09327	29641	06709	A
6	*0*2310	98200	10020	00907	18406	*8*2310	98200	10020	00907	18406	A, B
7	02506	61022	19629	0090*8*	20624	02506	61022	19629	0090*0*	20624	A, B
8	23325	98020	17923	00*5*06	15801	23325	98020	17923	00*9*06	15801	B
9	*238*20	60020	12024	00900	09309	*030*20	60020	12024	00900	09309	B
10	12813	80020	13633	1*0*603	17804	12813	80020	13633	1*8*603	17804	B
11	00000	7002*8*	49920	0*90*00	13809	00000	7002*0*	49920	0*09*00	13809	B
12	81909	*84*424	07120	863xx	18207	81909	*04*424	07120	863xx	18207	A, B
13	*10200*	25*71*8	32510	15703	01016	*70208*	25*11*8	32510	15703	01016	B
14	30214	98010	18826	*2*1400	xxxxx	30214	98010	18826	*3*1400	xxxxx	C
15	*1*1406	98030	04619	00900	00901	*0*1406	98030	04619	00900	00901	C
16	80221	14*23*4	22702	14813	69400	80221	14*xx*4	22702	14813	69400	C, A
17	30130	98020	17917	30*x*80	11119	30130	98020	17917	30*9*80	11119	C
18*	*74020*	12*41*9	00900	12419	69860	7*xxxx*	12*xx*9	00900	15108	69860	A, C
19	*32302*	98020	25212	*20746*	10712	*x*2302	98020	25212	*xxxxx*	10712	C
20*	*99022*	99022	29520	*68400*	17205	*xxxxx*	99022	29520	*xxxxx*	17205	A, C

* Note that examples 18 and 20 contain errors which are due to shifts and repetitions. The failure of the methods currently in use to account for them illustrates some of the remaining problems which have to be solved.

2) Corrections which rely on the systematic errors in the teletype system (group B).

3) Logical corrections which are required in order to follow up the internal consistency of the report (group C).

The exact way in which these corrections are made will be specified later and for the present it will suffice to offer a short list of examples. Table 2 contains real-time data as received and corrected at the IMS. The corrections are classified into their respective groups and the complexity of correction procedures is clearly seen.

4. General logical flow of the program

The SYNOP report is a composite structure of various elements, namely, wind, cloudiness, visibility, present and past weather, pressure, temperature, dew point and pressure tendency. These elements are interrelated qualitatively; thus the basic elements, i.e., those for which values of the other elements are not required, are examined first. Corrections for the basic elements are therefore made independently and when completed the program continues in performing tests for which the values of the basic elements are needed.

5. Acceptance and correction rules

In this program we check and correct each element separately except for pressure, weather phenomona and past weather for whose evaluation we rely on previously treated elements. In Table 3 we present the full procedure of our treatment for wind, visibility, temperature and dew point. We define the conditions for acceptance of a report as faultless, correction procedures and the rejection rules.

a. Wind direction and force

The wind as a vector is represented by its direction (dd) and force (ff). Since there is a formal connection between the two, they are checked simultaneously. Further checks are based on the SYNOP code and physical internal consistency.

b. Visibility

In the program, visibility checks are performed in two stages. We first decode it and then correct code errors. Unlike other elements, visibility may be corrected when it contradicts the present weather report.

c. Temperature and dew point

The temperature, unlike many other elements of the weather observations, has pronounced annual and seasonal cycles in addition to being latitudinally dependent. In the program we use maximum and minimum acceptance values for the temperatures on a monthly basis. These limits are particular to each area. The areas and values were taken from the Meteorological office *Tables of Temperatures Relative Humidity and Precipitation* (1960), with some minor changes

TABLE 3. Criteria for acceptance, correction and rejection of wind, visibility and temperature.

Element	Acceptance criteria	Correction procedures	Rejection rules	Element rejected
dd, ff	1. $dd=0$ and $ff=0$	1. If $dd=0$ and a. $ff=X$ then $dd=X$ b. $ff=88$ then $ff=0$ c. $ff>0$ then $dd=08$	1. If acceptance rule No. 5 was not satisfied	1. dd, ff
	2. $0 \leqslant dd \leqslant 36$	2. If $36<dd<70$ a. If $dd=37$ then $dd=31$ b. If $dd=38$ then $dd=30$ c. If $dd=39$ then $dd=35$	2. If $36 \leqslant dd \leqslant 70$ and no correction was initiated	2. dd
	3. $ff \leqslant 49$ for non-mountainous stations	3. If $70 \leqslant dd \leqslant 79$ then $dd=dd-60$	3. If acceptance rule No. 4 was not satisfied	3. ff
	4. $ff \leqslant 70$ for mountainous stations	4. If $80 \leqslant dd \leqslant 89$ then $dd=dd-80$	4. If $90 \leqslant dd \leqslant 98$ or $40 \leqslant dd \leqslant 69$	4. dd
	5. $dd=99$ then $ff<10$	5. If for a non mountainous station $70 \leqslant ff \leqslant 79$ then $ff=ff-60$	5. If $50 \leqslant ff \leqslant 70$ for non-mountainous station	5. ff
		6. If $80 \leqslant ff \leqslant 89$ then $ff=ff-80$		
		7. If $ff \geqslant 90$ then $ff=ff-40$		
VV	1. For regions 09, 11, 12, 13, 15, 20–38, 42 and some stations from other regions which report according to 90 code no precheck is done.	1. If acceptance criterion No. 2 is not satisfied and $VV \geqslant 90$ then $VV=VV-40$.		
	2. For all other regions VV should satisfy $VV<90$.	2. If acceptance criterion No. 3 is not satisfied, then $VV=10(VV-50)$.		
	3. VV cannot realize values between 51 and 55.			
T, Td	1. $T_{min} \leqslant T \leqslant T_{max}$	1. If condition No. 1 is not satisfied and a. $70 \leqslant T \leqslant 79$ then $T=T-60$ b. $90 \leqslant T \leqslant 99$ then $T=T-40$ c. $80 \leqslant T \leqslant 89$ then $T=T-80$ If either a, b or c were initiated we check whether the corrected temperature satisfies criterion No. 1. If condition No. 2 is not satisfied then	1. If acceptance criterion No. 1 or No. 2 was not satisfied and no correction was initiated	T
	2. $T \geqslant Td$	2. If $Td-T \geqslant 2$ then $T=Td$ and $Td=T$ 3. If $10 \leqslant Td \leqslant 19$ then $Td=Td+60$ 4. If $-1 \leqslant Td \leqslant 9$ then $Td=Td+80$ 5. If $50 \leqslant Td \leqslant 59$ then $Td=Td+40$ If either 3, 4 or 5 is initiated the corrected Td is checked whether it satisfies criterion no. 2.	2. If the corrected temperature did not satisfy criterion No. 1 or No. 2	T, Td

especially in the eastern Mediterranean area. An additional check is done by comparing TT and TdTd. For the future we plan some modification of the scheme by using spatial- and time-dependent information.

d. Present and past weather

The check on present weather elements is by far the most complicated. This is due to the fact that weather phenomena are related to all the other elements which are reported in the observation. As these relations are qualitative we have derived empirical working rules. The principle in deriving the working rules is to define minimal conditions of the basic elements necessary for the acceptance of the weather phenomena. In Table 4 we present two examples of our routine. We describe the general configuration that rain and fog must fulfill in order to be accepted. The rejection criteria and correction procedures are also given.

e. Pressure

The treatment of the pressure report in our program is composed of two stages: 1) decoding of the report to millibars or meters and 2) checking of reports. In

TABLE 4. Criteria for acceptance correction and rejection of present weather ww 40–49 and ww 50–67.

Weather element	General configuration checks	Rejection rules	Conditions for correction
Fog $40 \leq ww \leq 49$ subgroup A[43, 45, 47, 49]	1. If $VV \leq 10$ or $90 \leq VV \leq 94$ check whether 1a. $T-Td \leq 5$ 1b. $N=N_L=9$ 1c. $ww \in A$ 2. If $10 \leq VV \leq 50$ or $94 \leq VV \leq 98$ no further checks are made 3. If $VV \geq 50$ check whether 3a. $H=5$ and $C_L=5, 6$ 3b. $N=N_L=9$ 3d. $ww \in A$ $T-Td \leq 4$ 3d. $N=X$ or $N_L=X$	1. Observation is rejected if existing conditions 1, 1a are not satisfied and it is not possible to check 1b. 2. If conditions 1, 1a and 1b are not satisfied.	1. If existing conditions 1, 1a, 1c are satisfied and 1b is not satisfied, change ww to $ww=ww-1$. 2. If existing conditions 1a, 1b are satisfied and 1c is not, change ww to $ww=ww+1$. 3. If conditions 1, 1c are satisfied and 1a, 1b are not, change ww to $ww=10$. 4. If condition 2 is valid change ww to $ww=12$. Further checks are done under $ww=12$. 5. If $VV \geq 50$ proceed with the following subchecks: 5a. If 3e, 3a were not satisfied or 5b. 3a or 3b+3c were satisfied while 3d was not or 5c. 3d+3a or 3b+3c were satisfied then: (1) if $90 \geq VV \geq 80$ change VV to $VV=VV-80$ and recheck from the beginning. (2) If $80 \geq VV \geq 70$ change VV to $VV=VV-60$ and recheck from the beginning. (3) If $VV=98$, 97 change VV to $VV=90$, 91 respectively. 5d. Otherwise change ww to $ww=11$ and recheck.
Rain $50 \leq ww \leq 67$	1. $N \geq 3$ and $N_L \neq 0$ 2. $T-Td \leq 15$ 3. $P > 1030.0$ or $H < 1590$	1. Condition 1 is not satisfied. 2. Conditions 2 and 3 are not satisfied. 3. Observation is rejected if it is not possible to check condition 1 and one of the other two conditions.	

order to decode the pressure we differentiate between low-level and high-level stations. The station's classification has been taken from the WMO publication Weather Reporting, Observing Stations (WMO/OMM, 1976). Our correction scheme is limited to the high-level station reports. Correction for low-level reporting stations will be introduced into the program together with the intergration of spatial and temporal checks. The full scheme, similar in many ways to those of Hinkelman (1969) and Belousev *et al.* (1971), is shown in Table 5.

f. Pressure tendency

The pressure tendency report app is only partly checked in the program. The only limitation is that a report is rejected where $a=4$ and $pp>10$. In the future, further checks will be introduced as described above.

g. Cloudiness

The cloudiness observation report is composed of six digits. Each digit is one out of 11 values, from 0 to 9 and x. Accordingly, there are 6^{11} possible combinations in a report.

It was found empirically that most errors can be detected and adequately treated by subdividing the cloud's report into subgroups. Our choice of the different subgroups was developed in line with the problems which were encountered. Each new error which was only manually detected or inadequately treated resulted in one of the following steps:

1) An improvement of the detection correction procedures.

2) The creation of a new subgroup.

Each subgroup has its own correction schemes and it is thus clear that the choice of the subgroups is the result

TABLE 5. Pressure decoding (to tenths of millibars or meters).

Pressure decoding in low-altitude station		Pressure decoding in stations reducing to 850 mb		Pressure decoding in stations reducing to 700 mb	
Report	Decode	Report	Decode	Report	Decode
1. $P>700$	1. $P=P+9000$	1. $000<P\leqslant 700$	1. $P=P+1000$	1. $P>700$	1. $P=P+2000$
2. $P<400$	2. $P=P+10000$	2. $700<P\leqslant 799$	2. $P=P+400$	2. $500\leqslant P\leqslant 594$	2. $P=P+2400$
3. $400\leqslant P\leqslant 700$	3. If P satisfies at least two of the following conditions: a. $FF\geqslant 20$ b. $T>-5$ c. $N\geqslant 6$ then $P=P+9000$ otherwise $P=P+10000$	3. $800\leqslant P\leqslant 899$	3. $P+P+200$	3. $P<300$	3. $P=P+3000$
		4. $900\leqslant P\leqslant 999$	4. $P=P+600$	4. Any other report is rejected	

of an empirical practical approach rather then predetermined divisions. The present subgroups are as follows:

1. $N=0$ & $N_L=0$
2. $N=0$ & $N_L>0$ & $C_H=0$
3. $N<N_L$
4. $N\text{-}N_L=1$ & $C_H=0$
5. $N=0$
6. $N>N_L$
7. $N=8$
8. $N=7$
9. $N=N_L$
10. $N=9$
11. $C_H=X$ or $C_M=X$ or $C_L=X$ or $N=X$ or $N_L=X$.

In the above

N total cloudiness
N_L low or medium clouds amount
C_L type of low clouds
C_M type of medium clouds
C_H type of high clouds.

TABLE 6. Operational examples for checking cloudiness.

Cloudiness subgroup	Observation as received						Observation as treated					
1	163020 (ship)	00000	99000	32455	00000	57110	163020	00000	99000	32455	00900	57110
	928077 (ship)	00911	98020	14026	00500	23400	928077	00911	98020	14026	00900	23400
	33177	00904	50101	19622	00902	57101	33177	00904	50101	19622	00900	57101
2	26544	00000	40108	18060	855xx	62212	26544	80000	40108	18060	85500	62212
	17180	02806	70022	16206	35620	01400	17180	82806	70022	16206	35620	01400
3	33261	50100	26352	00900	62218	70018	33261	60108	26352	00900	62218	70018
	37472	11420	99022	31804	42440	00703	37472	71420	99022	31804	47440	00703
	26389	82312	58205	15903	964xx	00712	26389	82312	58205	15903	86400	00712
	07149	20810	62011	09802	60717	00902	07149	x0810	62011	09802	xxxxx	00902
4	60155	30000	58030	22011	28400	10400	60155	30000	58030	22011	38400	10400
	01488	81905	50027	01901	773xx	51506	01488	81905	50027	01901	87300	51606
5	17280	02806	70020	16206	35620	01400	17280	82806	70020	16206	35620	01400
	928058 (ship)	03006	98011	18400	00800	12210	928058	03006	98011	18400	00900	12210
	28711	00000	97020	43058	67208	700xx	28711	60000	97020	43058	64208	700xx
6	29263	21404	97020	21062	00900	64705	29623	01404	97020	21062	00900	64705
	40100	61300	60959	11811	19400	09713	40100	x1308	60959	11811	xxxxx	09713
	925080 (ship)	11204	99258	16923	37478	20710	925080	71204	99258	16923	37478	20710
7	26882	82008	60028	22803	01817	797xx	26882	82008	60028	22803	81800	797xx
	17026	83616	80020	15307	00900	04806	17026	03616	80010	15307	00900	04806
	26524	81104	98022	16802	85511	50717	26524	81104	98022	16802	85500	50717
9	28502	81804	57102	17353	84713	79744	28502	81804	57102	17353	84700	79744
	60720	23612	65020	19914	22580	05810	60720	23612	65020	19914	22500	05810
	28405	71820	80021	11404	70906	56718	23405	71820	80021	11404	70986	56718
10	934944 (ship)	91147	94828	09519	97300	20207	934044	51147	94828	09520	57300	19207

TABLE 7. Detailed examples from operational work.

Element	Observation as received						Observation as treated						Remarks
Wind	16716	03909	69020	10223	00900	10400	16716	03509	69020	10223	00900	10400	
	72562	61868	74021	09431	12708	17803	72562	6xxxx	74021	09431	12708	17803	
	13615	25509	98030	12530	22800	xxxxx	13615	2xxxx	98030	12530	22800	xxxxx	
	11903	00020	64020	17812	00900	11803	11903	00820	64020	17812	00900	11803	
	12465	73712	58101	15118	754xx	14003	12465	73112	58101	15118	754xx	14003	
	62271	08210	66020	11429	00900	08001	62271	00210	66020	11429	00900	08001	
	63014	87009	97606	01210	8632x	xx2xx	63014	81009	97606	01210	8632x	xx2xx	
	40665	09312	65020	00047	00900	15709	40665	0xxxx	65020	00047	00900	15709	
Visibility	40416	00000	90100	96230	00900	30996	40416	00000	50100	96230	00900	30996	
	08373	10904	55020	19131	00901	18107	08373	10904	50020	19131	00901	18107	
	07110	70613	54106	18233	7095x	16307	07110	70613	40106	18223	7095x	16307	
	27066	20000	97414	11208	22500	08205	27066	20000	91414	11208	22500	08205	
Pressure tendency	08084	00918	58054	15429	00900	17411	08084	00918	58054	15429	00900	17xxx	
Temperature	13376	20000	98022	14317	20981	420xx	13376	20000	98022	143xx	20981	xx0xx	
	36982	00000	99021	58753	00900	95730	36982	00000	99021	587xx	00900	xx730	T too low
	17280	20105	80020	04443	22100	15111	17280	20105	80020	044xx	22100	xx111	T too high
	36859	72304	99022	06208	11712	19704	36859	72304	99022	06210	11712	10704	
	17330	41806	75012	04432	42600	38xxx	17330	41806	75012	04432	42600	30xxx	
	60559	81015	70880	78777	77871	xxxxx	60559	81015	70880	78717	77871	xxxxx	
	27612	40312	60021	10286	42600	07704	27612	40312	60021	10206	42600	01704	
													Weather subgroup
Present weather	04230	71806	06022	02704	52460	03111	04230	71806	06xx2	02704	52460	03111	01–03
	17022	73404	15012	15025	32510	18206	17022	73404	15xx2	15025	32510	18206	
	04230	20810	09030	03905	00901	01215	04230	20810	09xx0	03905	00901	01215	
	60566	00808	80060	12135	00900	17807	60566	00808	80xx0	12135	00900	17807	04–06
	08571	12605	70050	13226	11600	10803	08571	12605	70xx0	13226	11600	10803	
	09361	20000	96091	21716	00902	15101	09361	20000	96xx1	21716	00902	15101	07–09
	15552	00000	65080	16519	00900	15201	15552	00000	65xx0	16519	00900	15201	
	16506	61113	65100	14624	12501	19805	16506	61113	65xx0	14624	12501	19805	10–12
	08571	13105	50100	15215	12801	694xx	08571	13105	50050	15215	12801	694xx	
	02095	01601	80110	16512	00900	11802	02095	01601	80xx0	16512	00900	11802	
	08314	00502	58130	15419	00900	18803	08314	00502	58xx0	15419	00900	18803	13
	13014	22402	60131	13412	10932	11202	13014	22402	60xx1	13412	10932	11202	
	72917	22710	86141	96904	20970	01802	72917	22710	86xx1	96904	20970	01802	14–16
	72764	60707	66151	10816	19541	10000	72764	60707	66xx1	10816	19541	10000	
	13809	53119	97182	24524	xxxxx	22235	13809	53119	97182	24524	xxxxx	22235	18
	08233	20000	70201	56531	11570	12008	08233	20000	70xx1	56531	11570	12008	20–21
	38232	00204	98200	15431	00900	04713	38232	00204	98xx0	15431	00900	04713	
	08233	51214	70251	52818	59500	13205	08233	51214	70xx1	52818	59500	13205	23–25
	23412	23210	80258	10208	13501	04207	23412	23210	80xx8	10208	13501	04207	
	22657	73406	76258	26710	79501	03709	22657	73406	76xx8	26710	79501	03709	
	72904	63610	7428x	11506	00906	66104	72904	63610	74xxx	11506	00906	66104	28
	04350	71311	80321	10903	26454	00205	04350	71311	80xx1	10903	26454	00205	30–35
	34866	02716	94313	05930	00900	13711	34866	02716	94063	05930	00900	13711	
	22802	60508	56301	10218	20942	17203	22802	60508	56xx1	10218	20942	17203	
	20046	82416	75367	95452	8093x	54209	20046	82416	75xx7	95452	8093x	54209	36–39
	08495	50602	09434	18219	56100	19006	08492	50602	09424	18219	56100	19006	40–49
	04250	91810	05444	10003	9xxxx	03217	04250	91810	05454	10003	9xxxx	03217	
	04380	80000	30404	11503	862xx	01207	04380	80000	30104	11503	862xx	01207	
	11782	20000	01520	356xx	25800	xx203	11787	20000	01xx0	356xx	25800	xx203	50–67
	65055	02902	25602	11735	00900	08810	62055	02902	25xx2	11735	00900	08810	
	37003	10103	98220	17828	11500	xx400	37003	10103	98xx0	17828	11500	xx400	22, 26
	16400	01707	17701	426xx	00900	20102	16400	01707	17101	426xx	00900	20102	
	35796	728xx	84782	10627	38832	18338	35796	728xx	84182	10627	38832	18338	68–79
	17204	32008	0179x	09521	39600	19001	17204	32008	0119x	09521	39600	19001	
	77206	82711	48859	16322	892xx	19314	72206	82711	48059	16322	892xx	19314	83–86
	17096	21802	75800	47213	25600	09803	17096	21802	75xx0	47213	25600	09803	80–82,
	12400	00000	80820	16414	00900	13107	12400	00000	80020	16414	00900	13107	87–89
	22438	53602	21801	45530	55704	100xx	22438	53602	21xx1	45530	55704	100xx	
	15712	30000	92870	22223	20730	20812	15712	30000	92xx0	22223	20730	20812	

TABLE 7. (*Continued*)

Element	Observation as received						Observation as treated						Remarks
	26247	80510	98979	07125	19707	716xx	26247	80510	98xx9	07125	19707	716xx	17, 29,
	27006	31406	99920	20720	30940	08812	27006	31406	99520	20720	30940	08812	90–99
	28440	83206	50919	04315	3462x	14303	28440	83206	50519	04315	3462x	14303	
	11036	29903	70298	11926	13560	15706	11036	29903	70xx8	11926	13560	15706	
	35796	20000	70299	08115	27600	08210	35796	20000	70259	08115	27600	08210	
													Weather subgroup
Past weather	35133	00000	99023	06981	00900	04713	35133	00000	9902x	06981	00900	04713	3
	72867	80000	58103	13006	45457	05304	72867	80000	5810x	13006	45457	05304	3
	40270	02814	65025	05030	00900	06702	40270	02814	6502x	05030	00900	06702	5
	15420	32504	97016	18014	00906	14400	15420	32504	9701x	18014	00906	14400	6
	04222	43012	80017	21124	42600	14400	04222	43012	80011	21124	42600	14400	7
	16052	70807	57017	09852	42560	xx106	16052	70807	57011	09852	42560	xx106	
	72712	22313	58058	07022	00901	21215	72712	22313	58050	07022	00901	21215	8
	34655	02510	98018	02417	00900	16707	34655	02510	98010	02417	00900	16707	
	15480	02904	97019	12819	00900	17801	15480	02904	9701x	12819	00900	17801	9
	33261	50000	46109	06616	00901	15601	33261	50000	4610x	06616	00901	15601	

A detailed description of this check is too space consuming and we will thus limit ourselves to examples for most of the subgroups shown in Table 6 to illustrate our main principles. To clarify our method further, we present a set of examples for each element reported in the observation in Table 7. The data are taken from actual runs. On the left side we present the data as received through the GTS in the SYNOP code including the station number. On the right side the report is shown after the correction have been performed. We would again like to emphasize that processes of correction are far more complicated than those of rejection.

6. Statistics

In order to evaluate the contribution of our quality control program we have derived some simple statistics. We have examined about 50 000 real-time observations received from August through October 1975 at the IMS. A separate count was made of the number of corrections and rejections in each observation element. In Table 8 we present our results.

The statistics of the errors introduced by the program has not been performed as the procedure requires knowledge of the correct observations, which are naturally not available. Furthermore, this source of errors was found to be negligible in our operational practice. The most apparent fact is that about 12% of the data received were either corrected or rejected. Such a high percentage obviously stresses the need for a quality control program. One can clearly see that about half of the corrections and rejections are performed on cloud reports and that present weather is also treated in many observations.

An important fact is that the ratio of corrected to rejected reports is 2 for clouds, 0.6 for present weather and only 0.25 for past weather, while for wind and temperature the ratio is about 1.0. These statistics show in which direction we should emphasize the correction procedure or reduce the severity of the acceptance criteria.

7. Future development in the program

Our future development will take three different directions:

1) Introduction of spatial and temporal checks. We believe that this addition will mainly improve the temperature, pressure and pressure tendency checks.

2) Special emphasis will be given to strengthening the correction procedures of present and past weather.

3) Continuous minor additions will be made to present schemes based on experience accumulated in operational work.

TABLE 8. Sum of corrected and rejected reports of synop elements, received from August 1975 to October 1975 at the Israel Meteorological Service. (1) is the number of corrected reports and (2) the number of those rejected.

	Total number of reports	Cloudiness		Wind		Temperature		Visibility		Pressure tendency		Present weather		Past weather	
		(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Sum	48143	2159	1049	217	265	217	279		158		50	359	623	61	243
Percent	100	4.48	2.18	0.45	0.55	0.45	0.58		0.33		0.10	0.75	1.29	0.13	0.50

8. Conclusions

An operational quality control program has been presented here. From our operational experience we have found that such a program is necessary in order to give meaningful interpretation to surface synoptic data. We are convinced that this job can be done and can be continuously improved.

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