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FOR AWIPS-90 RFP APPENDIX G REQUIREMENTS NUMBERS

2.1 - Quality Control Incoming Data

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SECTION 1: SPECIFICATION

CATEGORY II WFO TECHNIQUE SPECIFICATION

REQUIREMENT

2.1 - Quality Control of Incoming Data

DATA FLOW DIAGRAM REFERENCE

Data Flow Diagram 1.2 : Decode Alphanumeric Messages
-- Process 3 : Check Local Observations

(See Attachment 1: Data Flow Diagram)

DESCRIPTION

1.0 REQUIREMENTS OVERVIEW

Independent of the observations path to the WFO and RFC, all data received at the local WFO/RFC will be automatically:

- checked for transmission errors (SRS, Volume I, Chapter 4.2);
- stored in its encoded form as specified by Appendix F;
- transmitted in its encoded form over the ACN or other dissemination networks if received directly at the WFO/RFC;
- if requested, decoded, checked for any typographical errors (e.g., alphabetic characters in a numeric field), and assigned a data quality descriptor as specified in the appropriate decoding specification (e.g., SAO Decoder - TSP 87-03);
- if requested, quality controlled by this technique to identify "likely" errors (i.e., meteorologically unreasonable values that can be caused by malfunctions in measuring devices, data entry or processing mistakes, or calibration errors persistent in time) and;
- added (decoded value and data quality descriptor) to the local WFO/RFC database in accordance with Section 2.6 of this TSP.

Each WFO/RFC will be able to select the observed physical element to quality control and the quality control technique(s) to perform on the observed physical element. With this capability each WFO/RFC can elect to:

- rely on quality control performed by the observation system (e.g., ASOS),
- re-validate quality control preformed by the observation system, or
- establish quality control checks on data not previously quality controlled.

The following quality control techniques will be available on AWIPS to quality control incoming observations:

- validity checks,
- climatological consistency checks,
- internal consistency checks,
- temporal consistency checks,
- model consistency checks,
- vertical consistency checks,
- spatial consistency checks, and
- position consistency checks.

The forecaster will have a wide range of capabilities to tailor these techniques to match the needs of the local WFO/RFC.

Data descriptor models will be used to assign data quality descriptors to each data element based on those received with the observation, or assigned by the AWIPS decoding techniques, and the results of the quality control techniques described in this specification. The data quality descriptor can provide:

- a simple, effective means to visually identify data quality on some output form (i.e., cross section plot, tabular display of observation elements),
- a simplified method of categorical retrieval based on the data quality descriptor,
- a method of identifying the level of sophistication of the procedure which was used to check the observation value, and
- a method of identifying a level of confidence or reliability of an observation value, to allow any rational replacement criteria to be applied when multiple quality control techniques are being used.

These data quality descriptors will be the standard for all data quality descriptors used by all AWIPS decoding and quality control techniques.

The results of this process will be available to the forecaster for review and possible modification (correction or estimation) of the observations value and the corresponding data quality descriptors. Following the quality control performed by this technique, observation data will be used by other AWIPS techniques (e.g., TSP 89-05, *Weather Event Monitoring*, TSP 88-13, *Plot Vertical Cross Sections*, TSP 89-08, *Assemble/Collate Verification Observations*).

The quality control techniques described in this specification will help to assure that watches, warnings, and general information disseminated to the public are based on accurate and current data by:

- allowing for the selective retrieval of observation data for use by other application programs,
- providing the information necessary to informing personnel responsible for network maintenance (e.g., ASOS Operations and Maintenance Center (AOMC)) about possible malfunctioning equipment so repairs can be made as soon as possible, and
- allowing for the correction of clearly incorrect values where a correct value can be obtained and in some instances, this may include making estimates for mandatory variables where reported values appear unreasonable or inaccurate.

2.0 DETAILED DESCRIPTION OF QUALITY CONTROL REQUIREMENTS

This section expands on the requirement to quality control incoming decoded hydrometeorological data. This specification will specifically discuss:

Section 2.1 - Selecting the quality control techniques and tailoring them,
Section 2.2 - Automatically assigning data quality descriptors,
Section 2.3 - Monitoring and logging the results of the quality control techniques,
Section 2.4 - Manually correcting observation values, and updating the data quality descriptors,
Section 2.5 - Quality control technique initiation, and

Section 2.6 - Data retention of decoded physical elements and data quality descriptors.

2.1 QUALITY CONTROL TECHNIQUES

Quality control techniques are broken into two categories, static and dynamic quality control. A static check is ignorant of the current meteorological or hydrologic situation and other observations. QC techniques which fall into this category include:

- Validity consistency checks,
- Climatological consistency checks,
- Internal consistency checks, and
- Vertical consistency checks.

All static quality control techniques shall be available for the Initial Deployment Baseline (IDB) WFO and RFC systems.

Dynamic checking uses the previous and current hydrometeorological situation to prevent the elimination of extreme, yet valid events. QC techniques of this type include:

- Positional consistency checks,
- Temporal consistency checks,
- Spatial consistency checks (limited),
- Spatial consistency checks (enhanced), and
- Model consistency checks.

The positional, temporal, and limited spatial consistency checks shall be available for the IDB WFO and RFC systems. Enhanced spatial consistency checks and model consistency checks shall be made available as part of the First Pre-Planned Product Improvement (P3I).

2.1.1 ASSIGNING QUALITY CONTROL TECHNIQUES TO OBSERVATION PHYSICAL ELEMENTS

The designated user(s) shall have the capability to assign any quality control technique, listed in the ALGORITHM section, to a physical element (e.g., temperature), an observation system (e.g., manual SAO, ASOS, profiler, rawinsonde), and location (e.g., an area as defined in SRS, Volume I, Appendix A, or a specific WFO/RFC site).

Attachment 3 provides a national set of observed physical elements to be quality controlled and the quality control techniques to perform on each observation physical element. This information shall be used to initialize the assignment of QC techniques to variables for the IDB WFO and RFC system. The local WFOs/RFCs shall have the capability to tailor these assignments to their area of responsibility, and assign the QC techniques to any observation element and source not listed in Attachment 3 (e.g., ASOS Fixed Format Weather Message).

2.1.2 TAILORING OF QUALITY CONTROL TECHNIQUES

Considering the wide variety of climatic conditions across the United States, it is not practical to define a standard set of validity, climatological, internal and temporal consistency checks for all WFOs/RFCs. Therefore, designated users at a WFO/RFC shall have the capability to interactively create, save, delete, retrieve, and modify validity, climatological, internal, and temporal quality control algorithms for a WFO's/RFC's area of responsibility that are specific to any combination of the following data attributes provided in the SRS, Volume I, Appendix L:

- observation system (e.g., manual SAO, ASOS, profiler, rawinsonde),
- location (e.g., WFO/RFC site or area as defined in SRS, Volume I, Appendix A), and
- observation nominal time (e.g., range of hours, range of months, all the time).
- observation sensor type (e.g., heated snow gauge, non-heated snow gauge, overflow snow gauge as in the ALERT system).

It is expected that changes in this selection will occur infrequently.

2.1.2.1 QUALITY CONTROL ALGORITHM

Observation elements (e.g., temperature), derived parameters (e.g., rate of change of temperature), climatological elements (e.g., maximum temperature), tolerance limits (e.g., -60°F - 130°F), and numeric threshold values (e.g., 20°F/hour) shall be able to be combined into an algorithm using:

- arithmetic operations (addition, subtraction, multiplication division, and exponentiation),
- relational expressions (less than, less than or equal to, equal to, not equal to, greater than or equal to, and greater than), and
- logical operators (logical negation [NOT], logical conjunction [AND], and logical inclusive disjunction [OR]).

If the algorithm detection criterion is met then the observation has failed the consistency check.

Error and warning messages generated during the creation or execution of these operations shall be handled in accordance with SRS, Volume I, Chapters 6.2.6.1.7, - Error Logs, 9.2.5 - User Notification, and 10.9 - Error Messages. This functionality has been described in TSP 88-08, *Arithmetic Operations on Grids*, TSP 89-05, Weather Event *Monitoring*, TSP 90-05, *Forecast/Guidance Monitoring*, TSP 89-10, *QC of Hydrometeorological Fields*, TSP 90-29, *QC of Official Text Products*, and TSP 92-01, *QC of Forecaster Prepared Digital Data.*

2.1.2.1.1 OBSERVATION SYSTEM

The designated WFO/RFC user(s) may want to tailor the quality control algorithm by observation system. Therefore, the designated WFO/RFC user(s) shall have the capability to request that the quality control algorithm apply to:

- all observation systems that report a selected physical element,
- all observation systems that report a selected physical element except specific observation systems, or
- specific observation systems that report a selected physical element.

2.1.2.1.2 OBSERVATION LOCATION

The WFO/RFC designated user(s) may want to tailor the quality control algorithm by location. Therefore, the WFO/RFC designated user(s) shall have the capability to request that the quality control algorithm apply to:

- an area as defined in SRS, Volume I, Appendix A, or
- a specific observation location.

2.1.2.1.3 OBSERVATION NOMINAL TIME

The WFO/RFC designated user(s) may want to tailor the quality control algorithm by time of day, or month of year. Therefore, the WFO/RFC designated user(s) shall have the capability to request that the quality control algorithm apply to:

- all observation nominal times,
- a hour or range of hours (e.g., 00 UTC, 00 - 10 UTC, or 12 - 12 UTC),
- a month or range of months (e.g., March, March - June, or December - February), or
- a combination of the previous two items (e.g., 00 - 10 UTC for March - June).

2.1.2.1.4 OBSERVATION SENSOR TYPE

The WFO/RFC designated user(s) may want to tailor the quality control algorithm by observation sensor type. Therefore, the WFO/RFC designated user shall have the capability to request that the quality control algorithm apply to:

- all observation sensor types that report a selected physical element,
- all sensor types that report a selected physical element except specific sensor types, or
- specific sensor types that report a selected physical element.

2.2 DATA QUALITY DESCRIPTOR MODELS

The results of these quality control techniques shall be retained by assigning data quality descriptors using either a simplified or advanced data quality description model (sections 2.2.1 and 2.2.2 of this TSP, respectively). The simplified data quality model shall be available at the WFO and RFC for the IDB WFO and RFC systems. The advanced data quality model shall be made available at the WFO and RFC for the First Pre-Planned Product Improvement (P3I). Data quality descriptors are synonymous with the assurance attribute defined in SRS, Volume I, Appendix L.

If quality control is performed on successfully decoded data elements of observations, the data quality descriptor assigned by the QC techniques in this specification shall overwrite the data quality descriptor assigned to the element by the decoders except for those elements receiving a "D" from a decoder technique. Data elements with a data quality descriptor of "D" shall not be quality controlled by this technique.

2.2.1 SIMPLIFIED DATA DESCRIPTOR MODEL

For most atmospheric variables (e.g., temperature, dewpoint) a character descriptor is sufficient to allow the quick retrieval and visual inspection of the data quality. The data quality character descriptors assigned by the simplified data descriptor model shall be the following:

- Preliminary (Z) - successfully decoded data upon which no explicit quality control has been performed;
- Decoding Error (D) - data experienced a decoding error;

- Erroneous (X) - data failed validity or positional QC techniques;
- Coarse (C) - data passed all assigned validity and positional QC techniques and was not quality controlled by any second or third stage QC technique;
- Questionable (Q) - data failed any quality control technique other than the validity and positional QC techniques;
- Single Site (S) - data passed all First and Second Stage QC techniques (single site) but has not undergone a spatial consistency check;
- Spatial (V) (multiple site) - data passed all First Stage, Second Stage, and spatial consistency checks (requiring multiple sites);
- Wrong/ Replaced (W) - data replaced by a manually corrected value;
- Manual Correction (E) - data locally modified by a manual review process (i.e., an edited element value).

The following Section defines the assignment of data quality descriptors based on QC flags received with an observation, and First and Second Stage checks.

2.2.1.1 ASSIGNING DATA DESCRIPTORS

Data Quality Descriptor Initialization

Successfully decoded data elements assigned a QC flag from the observation system (source) shall be assigned one of the AWIPS data quality descriptors described in Section 2.2.1. The designated user shall have the capability to control this assignment by maintaining relationships between the quality control flags received and the AWIPS data quality descriptors listed in section 2.2.1. For example:

OBSERVATION SOURCE	OBSERVATION SITE QUALITY CONTROL FLAG	AWIPS DATA QUALITY CONTROL DESCRIPTOR
Profiler Data	1 - QC Failed	Q
Profiler Data	1 - QC not performed	Z

In some cases quality control is performed by the observation system but no quality control flags are passed with the observation. The designated user shall have the capability to assign an AWIPS data quality descriptor to all or some subset of the variables from an observation source. For example:

OBSERVATION SOURCE	OBSERVATION SITE QUALITY CONTROL FLAG	AWIPS DATA QUALITY CONTROL DESCRIPTOR
ASOS	Temperature	R
	Pressure	R
Rawinsonde	Temperature	R

First Stage Quality Control

Following this initialization process, coarse checks (i.e. validity check, and positional consistency) shall be executed, if requested as described in DESCRIPTION Section 2.1.1. Discrepancies identified by these QC techniques shall be "fatal" errors. A "fatal" error shall result in assigning the variables involved with an erroneous data quality indicator (X) and the discontinuation of the quality control process for the erroneous value. Also, this variable shall not be used by any other quality control technique, thereby eliminating the possibility of using erroneous values to evaluate correct data (such as with internal, temporal, and spatial consistency checks). Data which pass these coarse checks shall be assigned a data quality descriptor indicating it has passed these two QC techniques only (C), and is available for further evaluation by the remaining QC techniques. All first stage quality control techniques performed that result in a fatal error shall be logged in accordance with DESCRIPTION Section 2.3.

Second Stage Quality Control

Following the successful execution of the previously described coarse consistency checks, the climatological, internal, model, temporal, and vertical consistency checks shall be executed, if assigned as described in DESCRIPTION Section 2.1.1. Discrepancies identified by these QC techniques shall be "non-fatal". A non-fatal error shall result in assigning the variables involved with a questionable data quality indicator (Q). All variables that pass these techniques shall be assigned a data quality descriptor of "R". All second stage quality control techniques assigned by the user (Section 2.1.1) shall be executed regardless of the results (passage or failure). All second stage quality control techniques that result in non-fatal errors shall be logged in accordance with DESCRIPTION Section 2.3.

Third Stage Quality Control

The limited and enhanced spatial QC techniques require surrounding observations to check data consistency and are a third stage of quality control. Variables that undergo spatial quality control checks and pass, shall be assigned a data quality descriptor of "S". Discrepancies identified by these techniques shall be "non-fatal", and shall result in assigning the variables involved with a questionable data quality indicator (Q). Spatial quality control techniques that result in a non-fatal error shall be logged in accordance with DESCRIPTION Section 2.3. Table 1-1 summarizes the information presented in this section.

Table 1-1. QC Technique & Data Quality Descriptor Information

QC CHECK	STAGE	FATAL/NON-FATAL ERROR	FAIL/PASS	AVAILABILITY
Validity	1	Fatal	X / C	IDB
Positional	1	Fatal	X / C	IDB
Climatological	2	Non-Fatal	Q / R	IDB
Internal	2	Non-Fatal	Q / R	IDB
Vertical	2	Non-Fatal	Q / R	IDB
Temporal	2	Non-Fatal	Q / R	IDB
Model	2	Non-Fatal	Q / R	P3I
Spatial (limited)	3	Non-Fatal	Q / S	IDB
Spatial (enhanced)	3	Non-Fatal	Q / S	P3I

Manual Correction

A physical element value edited by a forecaster, as described in DESCRIPTION Section 2.4, shall automatically be assigned a data quality descriptor of E. The original value which was subsequently corrected shall be retained in the local WFO database and shall be assigned a data quality descriptor of W (Wrong/Replaced).

2.2.2 ADVANCED DATA DESCRIPTOR MODEL

For some hydrologic data, a character description is not sufficient. The advanced data description model contains provisions for quality control descriptors, data categories, and rules governing the replacement of an opinion of the quality of the data produced by one quality control procedure with the opinion produced by a subsequent quality control procedure. Currently, the Columbia River Operational Hydromet Management System (CROHMS), used by the North West division of the Corps of Engineers and the North West River Forecast Center (NWRFC), uses this structure. Also, the ALERT data base, which is being redesigned by the Colorado Nevada RFC (CNRFC), will incorporate this feature. The following data description model is taken from Bissell (1989a, 1990, 1989b, 1989c).

2.2.2.1 QUALITY CONTROL DESCRIPTORS

Two sets of data descriptors shall be required: a numeric pair; and a single character.

2.2.2.1.1 NUMERIC DESCRIPTORS

A pair of numeric descriptors, when used together, will provide an opinion of the quality of the data based upon the sophistication of the checking procedure and the departure of the value from an expected value for that particular piece of data. The numeric descriptors also provide a basis for changing the opinion of the quality of a particular piece of data as it undergoes quality checks by more than one procedure.

Quality Process Indicator (QPI) (Bissell, 1989a)

The QPI is a measure of the level of sophistication of the checking procedure. If no quality control checking has been performed, the value of the QPI shall be zero. Very minimal checking procedures will produce low QPI values, and the value of the QPI will increase with the increased "sophistication" of the checking procedure.

The QPI shall be calculated using the following method.

QPI = 16 (LEVEL * SCORE) + ADDFAC

where, LEVEL - LEVEL is a broad characterization of the sophistication of the checking procedure and the most significant. LEVEL shall be assigned a value between zero and three (0-3) depending on the quality control technique as shown below;

LEVEL	DESCRIPTION
0	Fixed criteria
1	Dynamic screening
2	Basic Verification
3	Advanced Verification

The designated user shall have the capability to assign a LEVEL value to any quality control technique.

SCORE - SCORE takes into account the use of adjacent stations, forecasts, and the time range of the data used in the checking procedure. SCORE shall have a value between zero and five (0-5).

SCORE = GROUP + FCST + TIME

where, GROUP - assigned a value between 0 and 2
FCST - assigned a value between 0 and 2
TIME - assigned a value of 0 or 1

The designated user shall have the capability to assign a SCORE value to any quality control technique.

ADDFAC - This additive factor (ADDFAC) takes into account fixed range checks (FIXED), seasonal climatological checks (SEASON), and any other extra checks (EXTRA).

ADDFAC = SEASON + FIXED + EXTRA

where, SEASON = 0,8
FIXED = 0,4
EXTRA = 0,1,2

The designated user shall have the capability to assign a ADDFAC value to any quality control technique.

Quality Departure Score (QDS) (Bissell, 1989a)

The QDS is a measure of the departure from an expected value for a specific piece of data. The QDS is roughly the departure from the expected value, expressed in tenths of standard deviations multiplied by four. The QDS assignment contains two features: 1) a numeric expression of departure from expected, and 2) "spreading" the scores by a factor of four to determine if the value is higher or lower than expected.

The QDS shall be calculated as follows:

QDS = (4 * IFFT) + IS

where, IFFT - the departure from expected, as calculated by the quality control checking procedure and expressed in tenths of standard deviation, shall be multiplied by ten to give an integer value.

IS - value (either 0, 1, 2, or 3) based upon the sign of the departure to give the final QDS.

IS	DESCRIPTION
0	departure score is unsigned
1	departure score is negative (value tested is less than expected)
2	departure score is positive (value tested is greater than expected)
3	reserved

Used together, the QPI and QDS provide an opinion of the quality of the data. This opinion can be translated into a character descriptor, as will be discussed in the section 2.2.2.2. Also, the numeric pair allow for the opinion of the data quality to be changed based on subsequent checking procedures. This process is discussed in section 2.2.2.3.

2.2.2.2 CHARACTER DESCRIPTORS

While the numeric descriptors serve an important purpose, application programs that need to retrieve data of a certain quality would find it quite cumbersome to search through sets of numeric descriptors, looking for the appropriate data. Therefore a second quality control descriptor, a single character, shall also be appended to the data. In this manner, application programs can retrieve data easily and more efficiently. Also, character descriptors may be used with a listing to allow a user to perform a quick visual check of the data quality. Data quality descriptors are synonymous with the Assurance attribute defined in SRS, Volume I, Appendix L. The quality control descriptors shall be as follows:

- Z - No quality control checking has been performed
- C - Coarse checks have been performed
- S - data have been quality controlled and passed as screened
- V - data have been quality controlled and verified
- Q - data have been quality controlled and are thought to be of questionable quality
- X - data have been quality controlled and are rejected
- E - estimated
- W - wrong, replaced by corrected observation

The method of assigning a character descriptor shall be based upon the numeric descriptor pair as described in the following paragraph. Fig. 1 illustrates the conversion of the numeric descriptors into a character descriptor. The QPI and QDS values which mark the transition between categories shall be system parameters (except for one), i.e. they shall be set for all variables. The value of QDS which separates data values which have been verified from those data values which are questionable shall be dependent upon the particular piece of data. This data dependency will allow for the distinction between those sensors whose reports are generally of high quality (and thus, the QDS marking the separation between verified and questionable data will be relatively high) from those sensors that are known to have some problems (resulting in a low QDS as the separation between verified and questionable data).

2.2.2.2.1 DATA QUALITY DESCRIPTOR INITIALIZATION

Hydrologic data received at the local RFC to be quality controlled by the advanced data descriptor model and not previously quality controlled by the observation system shall be assigned a character descriptor of Z (No quality control techniques performed). Hydrologic data quality controlled by the observation system shall be assigned one of the data quality character descriptors listed in section 2.2.2.2 above. The designated user(s) shall have the capability to control this assignment by maintaining relationships between the quality control flags received and the AWIPS data quality descriptors in section 2.2.2.2.

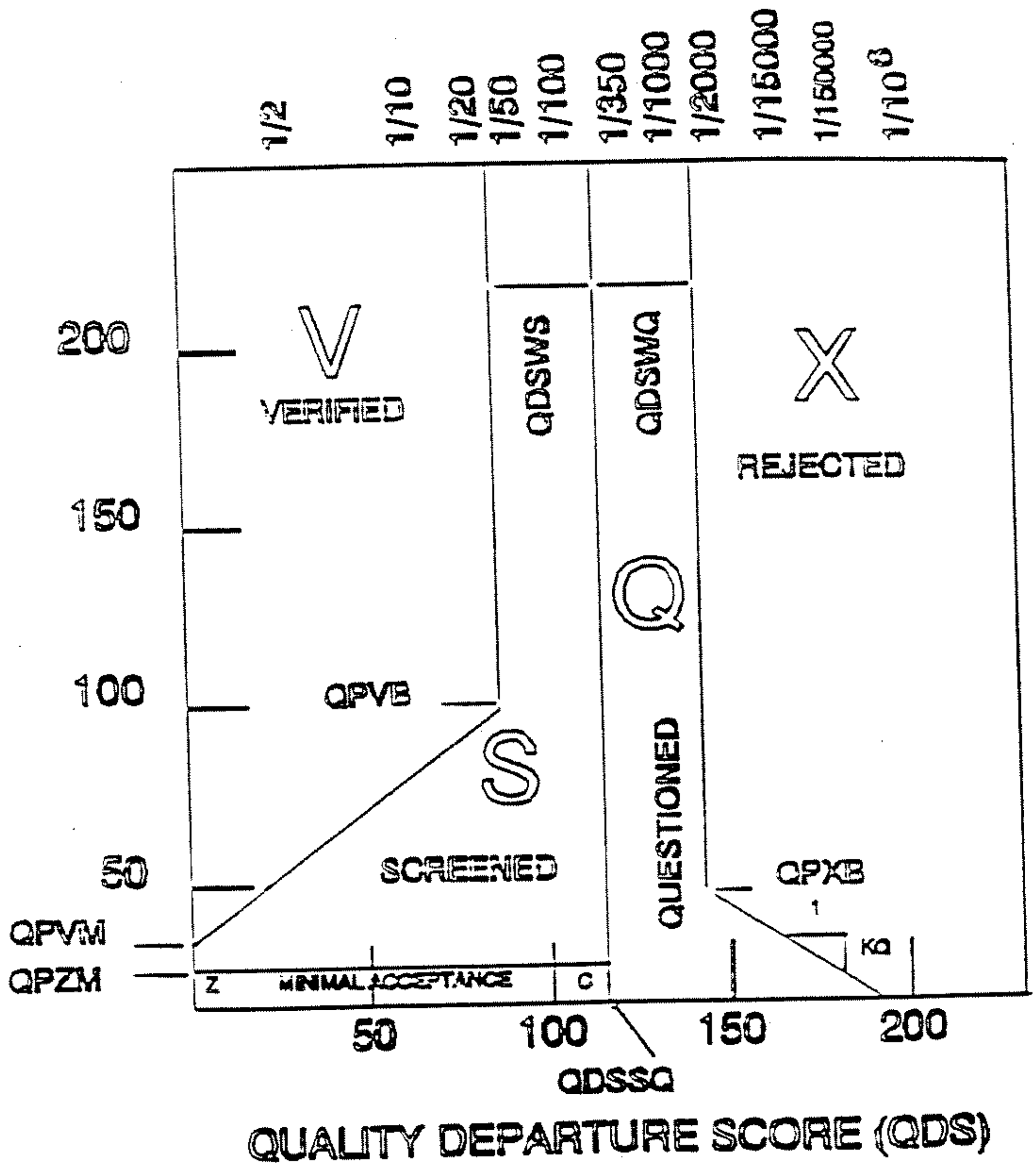

Figure 1. Conversion of Numeric Descriptors into Character Descriptors

2.2.2.2.2 DATA CATEGORIES

The data base must be able to recognize at least three different categories of data: actual; estimated; and wrong, replaced. Data with character quality control descriptors of Z, C, S, V, Q, and X (as described above) shall fall in the actual category. An estimated data value shall have attached a character quality control descriptor of E; whereas a data value which has been identified as wrong, and has been replaced, shall have attached a character quality control descriptor of W.

- Actual - When a specific piece of data enters the AWIPS system, a number of different quality control procedures will be performed, and an opinion of the data will be generated. The appropriate quality control descriptors will be appended to the data, and that value will be posted to the local data base, and passed along the ACN. Regardless of the quality of the data, that observation shall remain in the data base as the actual value. Subsequent quality control checks may produce a new opinion of the data quality, and the data, with this new opinion, shall be posted as the actual data value. However, the data value itself shall remain unchanged.

- Estimated - The forecaster shall have the option of estimating the value of a specific piece of data, if that data is missing, or the opinion of the quality of the data is low. The data base shall be able to retain, and transmit via the ACN, up to three estimates of the value of a specific piece of data. An estimated value shall have attached a character quality control descriptor of E.

- Wrong, Replaced - In those instances where a piece of data has been identified as being wrong, and a new, correct observation has been taken and transmitted to replace the original observation, the original wrong observation shall be retained in the data base. However, the character descriptor for this observation shall be a W, indicating that the original observation was in error, and it has been replaced with a new observation. The new observation shall become the actual piece of data, with all the quality control procedures and descriptors applied to it as described above.

2.2.2.3 RULES FOR THE REPLACEMENT OF AN OPINION

Each piece of data may be checked by more than one quality control procedure. Each procedure will produce its own opinion of the data, i.e. its own QPI and QDS. The question becomes what to do with all the opinions. To carry all the opinions is neither practical nor efficient; therefore, a single opinion must be culled out of the opinions of the individual checking procedures. A relatively simple scheme has been proposed by Bissell (1990) to govern the replacement (or retention) of an opinion produced by a checking procedure with that of a subsequent procedure. Bissell's scheme shall be used here.

Bissell's scheme takes a conservative approach. For two procedures which are equally sophisticated (equal QPI's), the opinion which is retained shall be that which is more pessimistic (higher QDS). Conversely, for two procedures which have an equivalent opinion about the data value's departure from expected (equal QDS's), the opinion which is retained shall be that which is derived from the more sophisticated process (higher QPI).

These two points can be illustrated graphically by using Fig. 2. If an opinion of a data value has been generated with a (QDS,QPI) of (0,0) -- relatively speaking -- and a new opinion is subsequently generated with a (QDS,QPI) of (1,0), then the new opinion would replace the original one. If the new opinion had a (QDS,QPI) of (-1,0), the original opinion would be retained. These two examples illustrate the first point stated previously. A new opinion with a (QDS,QPI) of (0,1) would replace the original opinion; whereas, a new opinion of (0,-1) would result in the retention of the original opinion. These two examples illustrate the second point of the conservative philosophy stated above. Extending this example, any new opinion which would fall in the first quadrant would replace the original opinion, and any new opinion falling in the third quadrant would result in the retention of the original opinion.

The situation becomes a bit more complex when the new opinion falls in either the second or fourth quadrants. The desire to have a fairly sophisticated procedure must be balanced by the conservative philosophy of retaining those opinions which indicate a data value that is farther away from what is expected. The key to this balance is the "line of equal opinion" (Fig. 3). New opinions with a higher QPI which fall to the right of this line shall replace the previous opinion. New opinions with a lower QPI which fall to the left of this line shall be rejected in favor of the previous opinion. The slope of the line of equal opinion shall be (-1*KQ), where KQ is defined as 1.

For those new opinions that fall in the shaded areas of Fig. 3, a "composite opinion" shall be generated. Graphically, if the new opinion falls in the shaded area of the second quadrant, the composite opinion shall be generated by moving to the right along the line of equal QPI of the new opinion until it intersects the line of equal opinion generated from the previous opinion. The (QDS,QPI) at this point shall become the official opinion. If the new opinion falls in the shaded area of the fourth quadrant, the composite opinion shall be generated by moving the new opinion upward along a line parallel to the line of equal opinion generated from the previous opinion (slope = -1) until it intersects the line of equal QPI from the previous opinion. The (QDS,QPI) at this point shall become the official opinion.

Mathematically, the replacement/retention of opinions shall be expressed as follows:

- The previous opinion shall be defined as (QDS_p, QPI_p).
- The new opinion shall be defined as (QDS_t, QPI_t).

The resulting opinion (QDS_n, QPI_n), whether it be replacement of the previous opinion with the new opinion, retention of the previous opinion, or the generation of a composite opinion, shall be generated according to the following mathematical expressions.

$$QPI_n = \max(QPI_p,\ QPI_t)$$
$$QDS_n = (QPIEXT_{max} - QPI_n)\ /\ KQ$$

where

$$QPIEXT_{max} = \max(QPIEXT_p,\ QPIEXT_t),$$

and

$$QPIEXT_p = QPI_p + KQ*QDS_p$$
$$QPIEXT_t = QPI_t + KQ*QDS_t$$

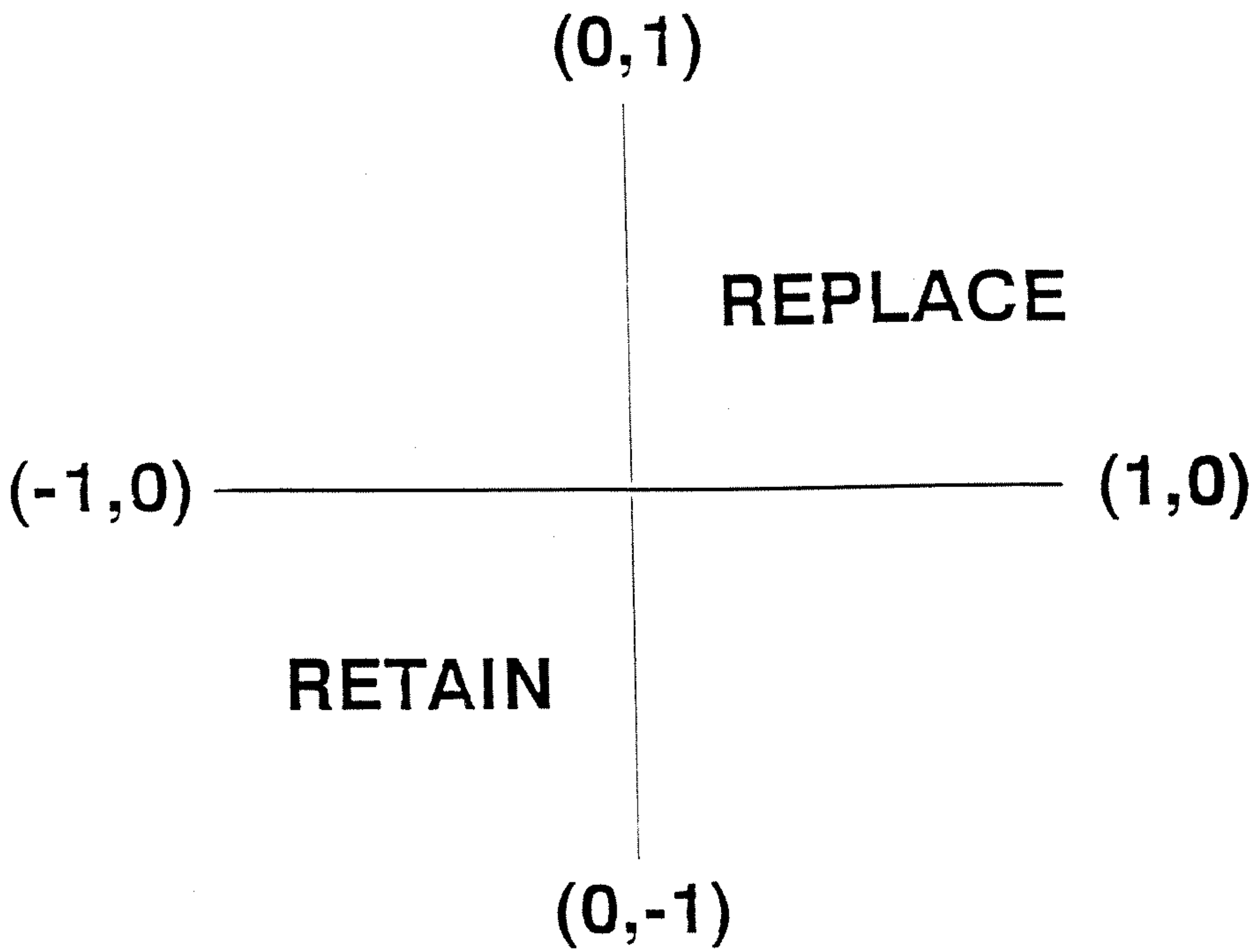

Figure 2. Schematic of Opinion Replacement

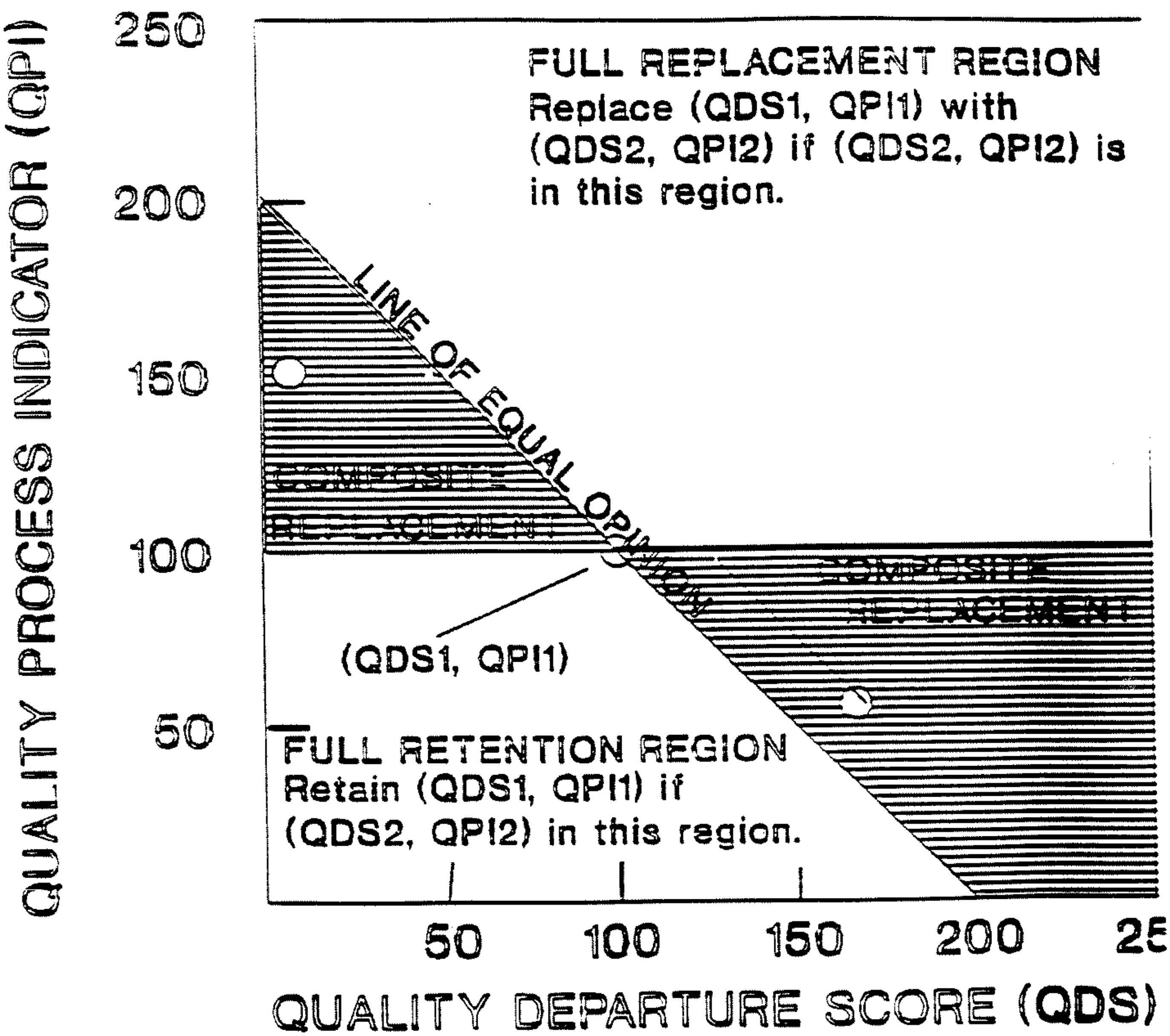

Figure 3. Composite Opinion Replacement

An example of the opinion replacement/retention/composite criteria is given in Attachment 5.

2.3 LOGGING EVENTS AND USER NOTIFICATION

Upon the assignment of a data descriptor(s) indicating that an observed data element is erroneous or questionable, the forecaster shall be notified of the event, as specified in the SRS, Volume I, Chapter 9.2.5.

The designated user(s) shall have the capability to assign these events to a notification class (defined in SRS, Volume I, Chapter 9.2.5.1) using the event capabilities described in SRS, Volume I, Chapter 9.2.5.3. The forecaster shall have the capability to acknowledge and clear events as described in SRS, Volume I, Chapter 9.2.5.2.

The event shall be logged in an event list, as described in Chapter 9.2.5.4 of the SRS. The forecaster shall be able to review the contents of this list on demand, with the most recent entries to the list displayed first, as described in SRS, Chapter 9.2.5.4. Message review and removal from the lists and clearing of notification lists shall have the capabilities described in Chapter 9.2.5.4 of the SRS. The event notification message is described in the OUTPUT section of this TSP.

2.4 REVIEW AND MODIFICATION OF OBSERVATION VALUES AND DATA QUALITY DESCRIPTORS

By using the following capabilities, the user shall have the option to review questionable and erroneous reports. The forecaster can then manually reject previously accepted values, reinstate previously rejected values, and correct or estimate observation values. The user shall have the option to perform this review at any time. The forecaster shall have the capability to manually initiate quality control techniques to reappraise corrected values. Any display or table listed below shall not exceed the workstation capabilities described in SRS, Volume I, Chapter 9.4.

- Produce a tabular summary page displaying the total number of questionable and erroneous observations with the capability to list by any or all of the following: pressure level, observation physical element, source and sensor, time or area.

- Produce a regional station plot of observations by variable and pressure level with the observations identified as questionable and/or erroneous highlighted in data quality descriptor dependent colors. This shall be accomplished using the functional capabilities described in TSP 88-03, Plot Regional Geographic Data.

- Produce tabular display of observations with the capability to list the display by any or all of the following: pressure level, observation physical element, source, sensor type, location or time.

- Display soundings using the functional capabilities of TSP 87-02, Interactive Skew-T.

- Overlay satellite imagery, radar displays, contour maps of surface, upper air or streamline data, and forecast datafields above the observation station plots.

- Display time series plots of any variable. This shall be accomplished using the functional capabilities described in TSP 88-12, Plot Time Series.
- Plot location of aircraft or ships for a user-defined period of time on any map background area as defined in SRS, Volume I, Appendix A.

2.5 QUALITY CONTROL TECHNIQUE INITIATION

All quality control techniques (except spatial QC) shall be initiated upon receipt and decoding of observation data listed in the INPUT section. The spatial quality control techniques require concurrent adjacent station information. The spatial QC shall be initiated upon receipt of a user-defined percentage of incoming observations for the current nominal time (time of observation, e.g., 12Z surface observations), for a site defined area (Appendix A scales) is received, or at a site defined time (e.g., 15 minutes past the hour), whichever occurs first. The default percentage of 80% shall be used to initialize this technique. The capability shall exist for a user to manually initiate any quality control technique for specified observation systems and physical elements on a non-scheduled basis.

The distance weighted objective analysis techniques used by the enhanced spatial QC algorithms are highly sensitive to missing or erroneous data, especially in data sparse areas. The capability shall exist to limit the observations used by the spatial quality control techniques, by data quality descriptor. For example, the user may decide not to allow the spatial technique to use observation values flagged as Questionable (Q).

2.6 DATA RETENTION

The decoded and quality controlled data elements from the routine and special reports and the associated data quality descriptor shall be stored in the local WFO/RFC database (see SRS, Volume I, Chapter 6). Decoded data elements and the associated data quality descriptors from reports corrected locally (as part of the decoding process) or by the issuing site shall overwrite decoded data element and data quality descriptors from the original report. The capability shall exist to retain the last three forecaster edited values with their corresponding data quality indicator. All encoded and decoded reports shall be stored in the local WFO/RFC database consistent with the retention requirements in SRS, Volume I, Appendix B, Table B.5.1.

<u>ALGORITHM</u>

The algorithms in this section support the required functional capability. The Contractor shall have the option to propose a different solution in order to implement the required functional capability which provides "equivalent or better" functional capability. A different solution may include a COTS software package, firmware, hardware, or an alternative algorithm. The Contractor shall provide the Government sufficient information so as to document or demonstrate the "equivalent or better" functional capability before the software development of the TSP capabilities commences. The Government will respond to the Contractors proposal prior to software development.

VALIDITY CHECKS (VC)

The validity check compares the observed physical element value to tolerance limits. If the following validity check quality control algorithm detection criterion is met, the observation has failed:

$$VC_L > OBS \quad \text{or} \quad OBS > VC_H$$

where,
- OBS : observation value
- VC_L : lower tolerance limit
- VC_H : upper tolerance limit

A national set of tolerances which shall be used to initialize this technique for the IDB WFO and RFC systems is provided in Attachment 4, beginning on page A4-1. These tolerance limits have been initially defined to eliminate physically impossible values within the SRS, Volume I, Appendix A, national area. A designated user at the WFO/RFC shall have the capability to tailor these tolerance limits to their area of responsibility. It is expected that changes in this selection will occur infrequently.

CLIMATOLOGICAL CONSISTENCY CHECKS (CC)

The climatological checks compare the observed value to an extreme climatological value(s). If the following climatological consistency check quality control algorithm detection criterion is met then the observation has failed:

$$CL_L > OBS \quad \text{or} \quad OBS > CL_H$$

where
- OBS : observation value
- CL_L : lower climatological limit
- CL_H : upper climatological limit

For observation locations with climatological data available in the local WFO database, those values shall be used as the extreme climatological values.

INTERNAL CONSISTENCY CHECKS (IC)

The internal consistency checks examine reasonable, physically possible meteorological relationships among elements within an observation. A typical example is the hourly dewpoint temperature must not exceed the hourly temperature. For example, if the following detection criterion is met then the observation has failed:

$$\text{Wind Direction} = 0 \text{ and Wind Speed} \neq 0$$

A national set of internal consistency checks which shall be used to initialize this technique for the IDB WFO and RFC systems is provided in Attachment 4, beginning on page A4-7. A designated user at the WFO/RFC shall have the capability to tailor these checks to their area of responsibility. It is expected that changes in this selection will occur infrequently.

TEMPORAL CONSISTENCY CHECKS (TC)

Rate of Change Check (TC1)

The temporal consistency check uses TSP 87-16, Derive Surface Station Parameters (Algorithm Section, Item 2, Change of any parameter), for an input variable and compares that value to a database of tolerance limits. If the following temporal consistency check algorithm detection criterion is met, the observation has failed:

$$|ROC| > TCL$$

where, TCL : tolerance limit
ROC : rate of change over a designated user-defined time period

Because the time interval between observations may vary (e.g., SAOs), designated users shall have the capability to define rate-of-change (ROC) tolerance limits for various time periods (e.g., 20°F/½-hour and 30°F/hour). When ROC tolerance limits are specified for various time periods, the tolerance limit used in a TC1 check shall be that specified for the time period which is closest to the time interval between the two successive observations. For example, if a special SAO (e.g., SP LGA 1015) and a record SAO (e.g., SA LGA 1050) are 35 minutes apart, and ROC tolerance limits are specified at the site for a particular element over ½-hour and 1-hour periods, the TC1 check performed on the element would utilize the ROC tolerance limit specified for the ½-hour period.

A national set of tolerances which shall be used to initialize this technique for the IDB WFO and RFC systems is provided in Attachment 4, beginning on page A4-22. A designated user at the WFO/RFC shall have the capability to tailor these tolerance limits to their area of responsibility. It is expected that changes in this selection will occur infrequently.

Time Continuity check for Marine Observations (TC2)

For Marine Observations, the temporal consistency check is based on a formula that relates the time rate-of-change of a normally distributed measurement to an autocorrelation coefficient (Gilhousen, 1988). NDBC obtained a variety of time rate-of-change statistics for sea-level pressure at several moored buoys. From these observations it was discovered that the autocorrelation was proportional to the $\sqrt{T}$. The coefficient 0.58 was then determined empirically, and represents the time change likely to be seen only once every 2 to 3 years at any given site. Below is listed the formula and standard deviations for a typical moored buoy and C-MAN observations (note: parameters are dependent on location). If the following detection criterion is met, the observation has failed:

$$ROC > (0.58\ \sigma \sqrt{T_c})$$

where, ROC : rate of change over a designated user-defined time period
σ : standard deviation
T_c : Time Change in hours

The following table provides a national set of tolerances which shall be used to initialize this technique for the IDB WFO and RFC system. A designated user at the WFO/RFC shall have the capability to tailor these to their area of responsibility. It is expected that changes in this selection will occur infrequently.

MEASUREMENT	UNITS	STANDARD DEVIATION
Sea-level pressure	(hPa)	21.0
Air temperature	(°C)	11.0
Sea surface temp.	(°C)	8.6
Wind speed	(m/s)	25.0
Sig. wave height	(m)	6.0
Wave period	(s)	31.0

Time Continuity Check for Aircraft Observations (TC3)

The following is a time continuity check for aircraft observations. If the detection criterion is met for either the temperature or the pressure altitude algorithm, the observation has failed.

Temperature: $| OBS_{dif} | > T$

Pressure Altitude: $| OBS_{dif} | > PA$

where, OBS_{dif} : difference of obs. values between points i and k

$$OBS_{dif} = OBS_j - (OBS_i(t_{jk}/t_{ijk}) + OBS_k(t_{ij}/t_{ijk}))$$

D_{ik} : distance between points i and k in miles

$$D_{ik} = 3960(0.17543\sqrt{(LON_k - LON_j)^2 + (LAT_k - LAT_j)^2 \cos^2 LAT_k})$$

t_{ik} : time change between points i and k $= t_{ij} + t_{jk}$
t_{ij} : time change between points i and j
t_{jk} : time change between points j and k
OBS_i : observation value at point i
OBS_j : observation value at point j
OBS_k : observation value at point k
T : user-defined OBS_{dif} tolerance for Temperature (Default = $0.005\ D_{ik}$°C)
PA : user-defined OBS_{dif} tolerance for Pressure altitude (Default = 50 meters)

A designated user at the WFO/RFC shall have the capability to tailor these default tolerances (T and PA) to their area of responsibility. It is expected that changes in this selection will occur infrequently.

VERTICAL CONSISTENCY CHECKS

The Vertical Consistency Check is designed to examine the vertical continuity of an observation profile. The examination can either be performed by comparing neighboring layers or comparing the profile to a meteorological equation (e.g., hydrostatic).

Hydrostatic Check (HC)

The basis for the hydrostatic check is hydrostatic redundancy (presence of both height and temperature data at each mandatory level). The thickness of each layer between two adjacent surfaces may be computed 1) directly from the heights of each boundary and 2) indirectly as proportional to the mean absolute temperature between these boundaries.

$$z_{i+1} - z_i = A_i^{i+1} + B_i^{i+1} (T_{i+1} + T_i)$$

for a layer between two adjacent mandatory levels, p_i and p_{i+1},

where,

- z_{i+1} : upper height boundary of layer to be tested (m)
- z_i : lower height boundary of layer to be tested (m)
- A_i^{i+1} : $(RT_{00}/g)\ln (p_i/p_{i+1})$
- R : dry gas constant/100 = 2.8704 J/kg°K
- T_{00} : 273.15°K
- g : acceleration due to gravity = 9.80616 m/sec²
- p_i : pressure at lower boundary of layer to be tested (mb)
- p_{i+1} : pressure at upper boundary of layer to be tested (mb)
- B_i^{i+1} = $(R/2g)\ln (p_i/p_{i+1})$
- T_{i+1} : temperature at upper boundary of layer to be tested (°C)
- T_i : temperature of lower boundary of layer to be tested (°C)

The hydrostatic error is determined by the left and right sides of the hydrostatic equation not agreeing. The disagreement between these two values is called the hydrostatic residual.

$$s_i^{i+1} = z_{i+1} - z_i - A_i^{i+1} - B_i^{i+1} (T_{i+1} + T_i)$$

where, s_i^{i+1} : residual to hydrostatic check

The acceptable residuals of this check have been found experimentally (presently about seven times the standard deviation of the residuals). Those acceptable values are presented below for all mandatory levels.

p_i/p_{i+1}	s_i^{i+1}	p_i/pi+1	s_i^{i+1}
1000/850	65	200/150	50
850/700	35	150/100	85
700/500	50	100/70	70
500/400	35	70/50	70
400/300	40	50/30	80
300/250	35	30/20	70
250/200	40	20/10	100

To identify the variable (height or temperature) in error, "existence condition equations" (arithmetic equations with relational expressions) which indicate the particular error type(s) (e.g., temperature at level k+l, height at level k) shall be used. These equations are fully described in, and listed in Table 5.2 of, Collins and Gandin (1992).

Super Adiabatic Lapse Rate Check (SAC)

The following is a super adiabatic lapse rate check based on Atkins, 1985. If the following detection criterion is met, the temperature profile between levels n and n+1 fails the super adiabatic lapse rate check, and the temperature values at levels n and n+1 shall be assigned a "Q":

$$C > [((p_n/p_{(n+1)})^k * T_{(n+1)}) - T_n]$$

where,
- p_n : pressure at a level n (mb)
- $p_{(n+1)}$: pressure at level n+1 (mb)
- T_n : temperature at level n (°K)
- $T_{(n+1)}$: temperature at level n+1 (°K)
- k : kappa = 2/7
- C : user defined tolerance
  Default = -2°K if $p_n < 800$mb
  -4°K if $p_n \geq 800$mb

Note: level n is <u>below</u> level n+1, and thus $p_n/p_{(n+1)}$ is always > 1).

A designated user at the WFO/RFC shall have the capability to tailor these default tolerances (C) to user-defined pressure levels for their area of responsibility. It is expected that changes in this selection will occur infrequently.

Wind Shear Check (WSC)

As described in DiMego et al., 1985, non-mandatory level winds are checked for gross errors and are used in the following vertical consistency checks for the mandatory-level winds.

The vertical consistency check for mandatory levels when winds by height are available and the mandatory levels are within 3000 meters of the level is passed if:

(FFMEAN < 30 and FFDIF < 50) or
(FFMEAN < 39 and FFDIF < 50 and DIFDD < 70) or
(FFMEAN < 39 and FFDIF < 50 and DIFDD < 55) or
(FFDIF < 50 and DIFDD < 40)

where,
- FFMEAN : mean wind speed (kts) between the mandatory level being checked and the nearest significant level = 1/2 (FFM + FFS)
- FFM : mandatory level wind speed (kts)
- FFS : nearest significant level wind speed (kts)
- DIFDD : directional difference between the mandatory and nearest significant level = DDM - DDS (degrees)
- DDM : mandatory level wind direction (degrees)
- DDS : nearest significant level wind direction (degrees)
- FFDIF : speed difference between the mandatory and nearest significant level in knots = FFM - FFS

If winds by height are not available, winds by pressure are considered for the vertical consistency check of mandatory levels. Only wind reports between 600mb and 125mb are used to check mandatory level winds between 500mb and 150mb.

The vertical consistency check for mandatory levels when winds by pressure are available and the nearest significant level within the midpoint between the mandatory level being checked and the next highest mandatory level is passed if:

(FFMEAN < 30 and FFDIF < 80 or
(FFMEAN < 39 and FFDIF < 80 and DIFDD < 70) or
(FFMEAN < 39 and FFDIF < 80 and DIFDD < 55) or
(FFDIF < 80 and DIFDD < 40)

The calculation of FFMEAN, FFDIF, DIFDD are the same as the winds by height case.

MODEL CONSISTENCY CHECKS

Two Model Consistency checks shall be available to eliminate meteorologically unreasonable observations.

Comparison to Any Forecast Model (MC1)

The MC1 model consistency check computes the difference between the observed and background values of a physical element at the time and site of an observation and compares the magnitude of this residual to a threshold value. The residual (R) is calculated using the algorithm:

$$R = |f - f_b|$$

where, f : observed value
f_b : background value

The observed value is taken from the observation being quality controlled (e.g., temperature reported in the 12Z observation at DCA). The background value shall be obtained from sources such as forecast guidance products such as model-based Model Output Statistics (MOS) (e.g., forecasted 12Z temperature obtained from the most recent LFM-based MOS guidance for DCA), NMC analyses (e.g., sea surface temperature analysis), or other forecast models (e.g., river stage forecasts). From these data, a "first guess" for the observed value of a physical element at the time and site of the observation is obtained directly or generated by interpolation. This background value calculation can be performed prior to receipt of an observation and temporarily saved for use when the observation is received at the WFO. A designated user at the WFO/RFC shall have the capability to initialize the source of the background values of physical elements quality controlled by this MC1 check. It is expected that changes to this selection will occur infrequently.

The residual is compared to a predefined tolerance limit (threshold) to identify questionable observation values. A national set of tolerance limits which shall be used to initialize this technique for the P3I WFO and RFC systems is provided in Attachment 4, beginning on page A4-24. A designated user at the WFO/RFC shall have the capability to tailor these tolerance limits to their local area of responsibility by location (to account for local and mesoscale weather features (e.g., topographic effects on the wind field, temperature modification by a body of water) or historical guidance performance at the site (e.g, by synoptic pattern)), and time (e.g., by season, valid time). It is expected that changes in this selection will occur infrequently.

SPATIAL CONSISTENCY CHECKS

The spatial consistency check (buddy check) is based on the fact that values of a parameter at adjacent points usually differ little from each other. Of course, the exception to this fact is that there are mesoscale and microscale meteorological, and geographic effects that may substantiate a significant difference between observation sites (e.g., convective precipitation amounts and surface winds). Also not all meteorological data are continuous (e.g., pressure, temperature) but rather discontinuous (e.g., precipitation, visibility, cloud cover).

There are two approaches to perform spatial checks discussed in this TSP, limited and enhanced spatial consistency checking.

Limited Spatial Consistency Checks (SC1)

A simple method to spatial consistency check is based on an averaging of the adjacent observations. This average is compared to the observed value to determine if it is within some standard deviation. The user shall have the capability to determine the search radius for "adjacent" observations, and define the minimum number of observations needed to perform the check and the standard deviation to be employed. If the following spatial consistency check algorithm detection criterion is met, the observation has failed:

$$OV - MAV > C\sigma .$$

where,
- OV : observed value
- MAV : mean of all observed values within a user-defined radius
- σ : standard deviation of all observations within a user-defined radius
- C : the user-defined number of standard deviations that the mean of the adjacent values differ from the observed value. The default is 2.

The default of C = 2 and user-defined search radius of 100 miles and 4 observations shall be used to initialize this technique for the WFO and RFC system. A designated user at the WFO/RFC shall have the capability to tailor these default values by observation element and to their area of responsibility. It is expected that changes in this selection will occur infrequently.

Enhanced Spatial Consistency Checks (SC2)

A more advanced (and resource intensive) method to spatial consistency checking is based on an interpolation to the point in question from adjacent observations (i.e., influencing points). The interpolation method shall be the same method used in a distance weighted objective analysis. The difference is that the interpolation is performed from influencing points to the observation site (not included in the set of influencing points) rather than a grid point. For purposes of quality control at a WFO, an objective analysis scheme is preferred over optimum interpolation due to the smaller computer resources required.

The difference between the interpolated and reported values is called the residual. Residuals differ from zero due to physical differences, random errors in the interpolation scheme and observational error. The admissible or threshold limit of acceptable error is defined by the residual plus some empirical factor entered and updated by the user.

For the upper air parameters defined in Attachment 3 (denoted by level), the objective analysis that shall be used is described in TSP 88-01, Requirement 6.1.2, Objective Analysis of Upper Air Variables. For the surface variables identified in Attachment 3, the objective analysis procedure is described in TSP 87-04, Objective Analysis of Surface Variables. The objective analysis shall be performed from influencing points, as determined by the objective analysis methodology, to the observation point in question (not included in the set of influencing points). The residual which results from this analysis shall be compared to an error threshold value dependent on the particular variable, geographic region, and season and shall be able to be adjustable by the user. Typical threshold values for error detection are discussed in TSP 88-01. The enhanced spatial consistency check shall be available for the P3I WFO and RFC systems.

POSITION CONSISTENCY CHECKS (PC)

The position consistency check compares location and time to previous reports to insure a ship's position is consistent with the reported movement. An inconsistency is identified as an unreal speed or an unlikely course change (> 90°) from the last reported position. If the detection criterion is met for any of the following positional consistency check algorithms then the observation has failed:

For SHIPS:

$$D_{jk} < \sqrt{D_{ij}^2 + D_{jk}^2}$$

Speed > 80 knots

where, D_{ij} = distance between 2nd previous (i) and previous (j) positions

$$= 3960(0.017453\sqrt{(LON_j - LON_i)^2 + (LAT_j - LAT_i)^2 \ \cos^2 LAT_j})$$

D_{jk} = distance between previous (j) and current (k) positions

$$= 3960\ (0.017453\sqrt{(LON_k - LON_j)^2 + (LAT_k - LAT_j)^2 \ \cos^2 LAT_j})$$

Speed = Speed between previous and current position = D_{jk} / T_{jk}
T_{jk} = time change between points j and k
LAT = latitude
LON = longitude

PERFORMANCE REQUIREMENTS

Scheduled - The response time shall include the time necessary to perform the national set of validity, climatological, internal, vertical, temporal, model, spatial and positional consistency checks in Attachment 3 and 4. Response time for all checks (except the spatial check) is broken down by observation decoder requirement and is included in each of the following decoder requirements.

Req. 1.1.1.1	Parse Surface Airway Obs
Req. 1.1.1.2	Parse Synoptic Observations
Req. 1.1.1.3	Parse Ship Reports
Req. 1.1.1.4	Parse Cooperative Observer Report
Req. 1.1.1.5	Parse Pilot reports
Req. 1.1.1.6	Decode ASOS Daily and Monthly Summaries
Req. 1.1.1.7	Decode ASOS Fixed Format Weather Message
Req. 1.1.1.8	Parse Aviation Routine Weather Reports (METAR)
Req. 1.1.3.1	Parse SHEF Data
Req. 1.2.1.1	Decode Buoy Data - Synoptic & Spectral
Req. 1.2.1.2	Decode C-MANS Reports
Req. 1.2.1.4	Decode Rawinsonde Data
Req. 1.2.1.5	Decode Profiler Data
Req. 1.2.1.6	Decode ACARS Format
Req. 1.2.1.8	Decode Lightning Detection Data
Req. 1.2.1.10	Decode Coast Guard Reports
Req. 1.2.3.1	Decode SHEF/non-SHEF MESONET/LFWS Data

The spatial consistency checks for a given collection of up to 800 observations shall be completed within 10 seconds of initiation.

Non-Scheduled - Non-scheduled initiation of any quality control check (except spatial checks) shall be completed within 2 seconds. The spatial consistency quality control checks for a given collection of up to 800 observations (e.g., SAO temperature values over the Regional Area) shall be completed within 10 seconds of initiation.

INPUT

Input to this technique shall include:

- Any successfully decoded element in the local WFO database. This includes, but is not restricted to, the national set of observation systems and physical elements to be quality controlled listed in Attachment 3.
- Any data quality descriptor or QC flag received with the succesfully decoded element.
- Climatological extreme data in the local WFO database.
- User-defined information discussed in the DESCRIPTION section.
- Background values from user-designated model guidance source(s) (see SRS, Volume I, Appendix F, Section F.1.2).

OUTPUT

The output from this quality control technique shall include:

- any quality controlled physical elements
- data quality descriptors
- event notification and event logs

This technique shall notify the user when detection criteria are met (SRS, Volume I, Chapter 9.2.5). The event notification message shall consist of time of observation, observation system and location, erroneous or questionable data element(s), data value(s), data quality descriptor (DQD), QC technique, and threshold algorithm utilized. Event notifications shall be logged in an event list (SRS, Volume I, Chapter 9.2.5.4). Table 1-2 shows examples of possible event notification messages.

Table 1-2. Sample Event Notification Messages

TIME	SYSTEM/LOCATION	ELEMENT	VALUE	DQD	QC TECHNIQUE	THRESHOLD ALGORITHM
1750Z	SAO/ISP	w_{dd}	270°	Q	IC	$w_{dd} \neq 00$ and $w_{ff} = 00$
1845Z	SHIP/25N85W	T_d	85°	Q	IC	$T < T_d$

RELATED CODE

Application:	Subjective Interaction System
Program Name:	SIS
Application Functions:	To provide user with an interactive method for reviewing the available information and modifying observation data.
Operating System:	VAX/VMS
Language Used:	FORTRAN
Approximate Lines of Code:	7,000 lines

Application:	Objective Analysis for the Local AWIPS MOS Program (LAMP)
Program Name:	V400A, V400B, V400C, V400D
Application Functions:	Analyze either spatially continuous or discontinuous hydrometeorological data. A complete description of the related code can be found in TSP 87-04, *Interpolate Random Surface Variables*
Operating System:	VAX/VMS
Language Used:	VAX FORTRAN

DOCUMENTATION

Chambers, T.L., and H. R. Glahn, 1991a: LAMP objective map analysis program for dew point, temperature, and sea level pressure. VAX No. 20, Techniques Development Laboratory, National Weather Service, 15 pp. [Excerpt from LAMP: VAX Implementation System Description, 1991]

______, and ______, 1991b: LAMP objective map analysis program for U and V wind components and wind speed. VAX No. 40, Techniques Development Laboratory, National Weather Service, 15 pp. [Excerpt from LAMP: VAX Implementation System Description, 1991]

______, and ______, 1991c: LAMP objective map analysis program for saturation deficit. VAX No. 41, Techniques Development Laboratory, National Weather Service, 11 pp. [Excerpt from LAMP: VAX Implementation System Description, 1991]

______, and ______, 1991d: LAMP objective map analysis program for ceiling, opaque sky cover, and visibility. VAX No. 42, Techniques Development Laboratory, National Weather Service, 10 pp. [Excerpt from LAMP: VAX Implementation System Description, 1991]

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Bissell, V. C., 1989a. Data Quality Description: Numeric Descriptors for Operational Data Quality, NW0001, Rev. 1. Proteus Technical Note, NWRFC, National Weather Service, National Oceanic and Atmospheric Administration, U. S. Department of Commerce, 5 pp.

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Brewster, K. A., and T.W. Schlatter, 1986. Automated Quality Control of Wind Profiler Data. Preprint, 11th Conference on Weather Forecasting and Analysis, June 17-20 1986, Kansas City, American Meteorological Society, 171-176.

Collins, W. G. and L. S. Gandin, 1992. Complex Quality Control of Rawinsonde Heights and Temperatures (CQCHT) at the National Meteorological Center. NMC Office Note 390, National Weather Service, National Oceanic and Atmospheric Administration, U. S. Department of Commerce, 159 pp.

DiMego, G. J., P. A. Phoebus, and J. E. McDonell, 1985. Data Processing and Quality Control for Optimum Interpolation Analysis at the National Meteorological Center. NMC Office Note 306, National Oceanic and Atmospheric Administration, U. S. Department of Commerce, 38 pp.

Gandin, L. S., 1988. Complex Quality Control of Meteorological Observations. Monthly Weather Review, 116, 1137-1156.

Geiger, A., 1973. Climate Near the Ground. Harvard University Press, 611 pp.

Gilhousen, D. B., 1988. Quality Control of Meteorological Data From Automated Marine Stations. Preprint, Fourth International Conference of Interactive Information Processing Systems for Meteorology, Ocean and Hydrology, January 31- February 5, 1988, Anaheim, California, American Meteorological Society, 248-252.

Miller, R. G., 1981. GEM: A Statistical Weather Forecasting Procedure. NOAA Technical Report NWS 28, National Oceanic and Atmospheric Administration, U.S. Department of Commerce. 103 pp.

National Weather Service, 1984. NCDC Detailed Design Document for the Surface Data Processing System, Appendix P - Quality Checks. National Weather Service, NOAA, U. S. Department of Commerce, 13 pp.

National Weather Service, 1988a. Federal Meteorological Handbook No. 1: Surface Observations. National Weather Service, NOAA, U. S. Department of Commerce, 256 pp.

National Weather Service, 1988b. Federal Meteorological Handbook No. 2: Surface Synoptic Codes. National Weather Service, NOAA, U. S. Department of Commerce, 156 pp.

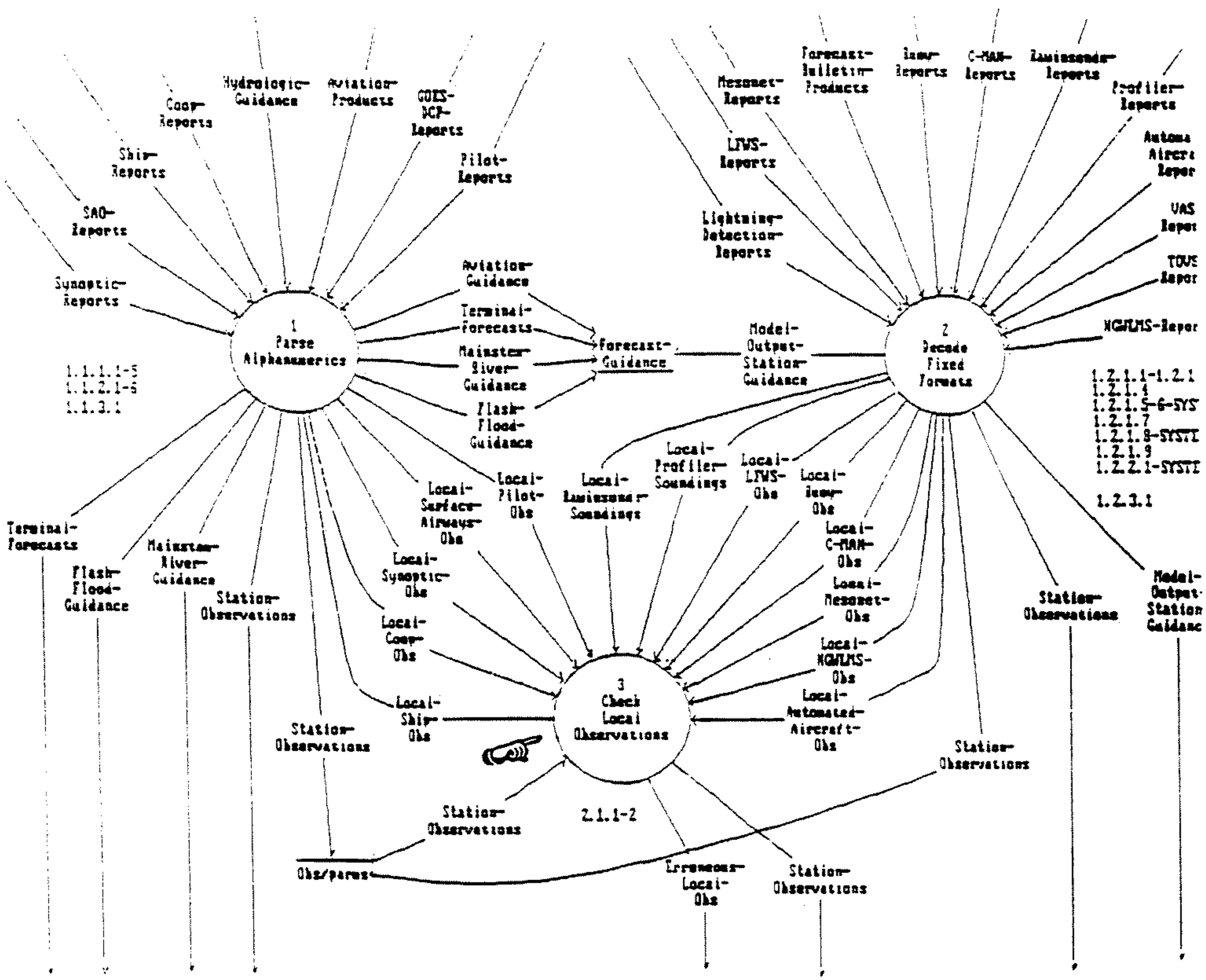
National Weather Service, 1989a. MAPSO User's Guide. National Weather Service, NOAA, U. S. Department of Commerce, 98 pp.

National Weather Service, 1989b. MICRO-ART User's Guide. National Weather Service, NOAA, U. S. Department of Commerce, 112 pp.

Richardson, W. S. and P.T. Reilly, 1989. Data Monitoring and Quality Control of Marine Observations. National Ocean Service, NOAA, U. S. Department of Commerce, 8 pp.

ATTACHMENT 1

Data Flow Diagram



DFD 1.2 : Decode Alphanumeric Messages

The AWIPS-90 RFP Appendix G requirement numbers are listed next to the process bubbles. The term "SYSTEM" indicates AWIPS system functions. The "pointing finger" indicates which process bubbles are related to the requirements described in the specification.

ATTACHMENT 2

Related Code Description

This Related Code Description Section contains a brief description of the related code and documentation evaluation results based on the procedure described in the following reference:

Piper, T., and D. Ruth, 1987. AWIPS-90 Hydrometeorological Applications Review Plan. Contract NO. 50-DDNW-6-00130. Task No. 2, Techniques Development Laboratory, National Weather Service, NOAA, U. S. Department of Commerce, 65 pp.

Refer to the SRS, Volume I, Chapters 8, 15, 17, and 18 for a full description of the AWIPS-90 requirements for source code and documentation.

Note: See TSP 87-04, Interpolate Random Surface Variables, Section 1, Attachment 2, for a description of the V400A - V400D programs.

DOCUMENTATION

External Documentation

No formal external documentation exists for the SIS software applications. However, there are numerous flow charts of the software logic for each system.

Internal Documentation

The internal documentation for SIS is incomplete in the following areas:

- Prologues are lacking variable lists, input and output, related subroutines, and a detailed description of the code structure.

STRUCTURE OF SOURCE CODE

The major deficiencies with the structure of the SIS application are:

1) Overall SIS is partitioned into manageable subroutines. However, a few routines like SUBJECTIVE_INTERVENTION_SYSTEM are very long (1000 lines).

2) The majority of the routines are communicatively cohesive modules. However, this is not the case for all modules. Some routines are functionally oriented (functional cohesion).

3) The routines are mainly data and stamp coupled, communicating parameters and data structures by arguments. However, there is some use of common blocks.

COMPARISON WITH REQUIREMENT

If SIS were to be used, then the following modifications to the application are suggested;

1) Add code to perform the quality control algorithms described in this specification.

2) Modularize code wherever practical.

3) Add code to use the data quality identification convention of AWIPS.

4) Write user's documentation.

OTHER

Software Independence - A drawback of SIS is the dependence on the VAX/VMS operating system.

CONCLUSION

The application SIS provides the manual oversight capability to meet the requirement described in DESCRIPTION, Section 2.4. This application should be treated as related code, since it provides an excellent base to model new code after.

The appropriate sections of the V400A - V400D applications should be used to develop the spatial consistency check (SC2).

ATTACHMENT 3

Assignment of Quality Control Techniques to Physical Elements by Observation System

AWIPS DOCUMENT NUMBER
TSP-032-1992R2

VARIABLE	OBSERVATION SYSTEM	QC TECHNIQUES
Location	Ship	VC,PC
	Buoy	VC
	Pilot	VC,PC
	ASDAR	VC,PC
Pressure (station)	SAO/Synoptic	IC,TC1
	ASOS	IC
	AWOS	IC
Pressure (sea-level)	ASOS	MC1,IC,SC
	AMOS	VC,MC1,TC1,SC
	AWOS	MC1,IC,SC
	RAMOS	VC,MC1,TC1,SC
	SAO/Synoptic	VC,MC1,IC,SC
	Coast Guard	VC,MC1,TC2,SC
	C-MAN	VC,MC1,TC2,SC
	Ship	VC,MC1,SC
	Buoy	VC,MC1,TC2,SC
	Profiler	VC,MC1,TC1,SC
	MESONET	VC,MC1,TC1,SC
Pressure (levels)	Rawinsonde	SC
Pressure Change	ASOS	SC
	RAMOS	VC,IC,SC
	SAO/Synoptic	VC,IC,SC
	C-MAN	VC,IC,SC
	Ship	VC,IC,SC
	Buoy	VC,IC,SC
Altimeter Setting	ASOS	VC,TC1
	AUTOB	VC,TC1
	AMOS	VC,TC1
	AWOS	VC,TC1
	RAMOS	VC,TC1
	SAO/Synoptic	VC,TC1

VC - Validity Check
PC - Position Consistency Check
CC - Climatological Limits Check
IC - Internal Consistency Check
HC - Hydrostatic Consistency Check
WSC - Wind Shear Check
SAC - Super Adiabatic Lapse Rate Check

TC1 - Temporal Consistency Check
TC2 - Time Consis. Chk. Marine Obs.
TC3 - Time Consis. Chk. Aircraft Obs.
MC1 - Model Consisteny Check
MC2 - GEM Consistency Check
SC - Spatial Consistency Check (Limited (SC1) or Enhanced (SC2))

VARIABLE	OBSERVATION SYSTEM	QC TECHNIQUES
Air Temperature (sfc)	ASOS	MC1,SC
	AUTOB	VC,MC1,IC,TC1,SC
	AMOS	VC,MC1,IC,TC1,SC
	AWOS	MC1,SC
	RAMOS	VC,MC1,IC,TC1,SC
	SAO/Synoptic	VC,MC1,SC
	Co-op	VC,MC1,IC,TC1,SC
	Coast Guard	VC,MC1,TC2,SC
	C-MAN	VC,MC1,IC,TC2,SC
	Ship	VC,MC1,IC,SC
	Buoy	VC,MC1,IC,TC2,SC
	Profiler	VC,MC1,TC1,SC
	AHOS	VC,MC1,TC1,SC
	MESONET	VC,MC1,TC1,SC
	CROHMS	SC
Air Temperature (levels)	Rawinsonde	VC,MC1,SAC,HC,SC
	Pilot	VC,MC1,TC3,SC
	ACAR	VC,MC1,TC3,SC
Soil Temperature	Co-op	VC,CC,TC1
Sea Surface Temperature	Coast Guard	VC,MC1,IC,TC2,SC
	Buoy	VC,MC1,IC,TC2,SC
	Ship	VC,MC1,IC,SC
	C-MAN	VC,MC1,IC,TC2,SC
Max/Min Temperature	RAMOS	VC,IC
	Co-op	VC,IC
Dewpoint (sfc)	ASOS	MC1,SC
	AUTOB	VC,MC1,IC,TC1,SC
	AMOS	VC,MC1,IC,TC1,SC
	RAMOS	VC,MC1,IC,TC1,SC
	AWOS	MC1,SC

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VARIABLE	OBSERVATION SYSTEM	QC TECHNIQUES
	SAO/Synoptic	VC,MC1,SC
	Ship	VC,IC,SC
	Buoy	VC,IC,TC1,SC
	C-MAN	VC,IC,TC2,SC
Dewpoint Dep. (levels)	Rawinsonde	SC
Relative Humidity (sfc)	Profiler	VC,TC1
Wind Direction and Wind Speed (sfc)	ASOS	MC1,IC,SC
	AUTOB	VC,MC1,IC,TC1,SC
	AMOS	VC,MC1,IC,TC1,SC
	RAMOS	VC,MC1,IC,TC1,SC
	AWOS	MC1,IC,SC
	SAO/Synoptic	VC,MC1,IC,SC
	Co-op	VC,MC1,IC,TC1,SC
	Coast Guard	VC,MC1,IC,TC2,SC
	C-MAN	VC,MC1,IC,TC2,SC
	Ship	VC,MC1,IC,SC
	Buoy	VC,MC1,IC,TC2,SC
	Profiler	VC,IC,MC1
	Spectral Wave	VC,MC1,IC,TC2,SC
	MESONET	VC,MC1,IC,TC1,SC
Wind Direction and Wind Speed (levels)	Rawinsonde	WSC,MC1,SC
	Pilot	VC,MC1,IC,SC
	ACAR	VC,MC1,IC,SC
	Profiler	VC,MC1,IC,SC
Peak Wind Speed	AUTOB	VC,IC
	AMOS	VC,IC
	RAMOS	VC,IC
	SAO	VC,IC
	ASOS	VC,IC

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VARIABLE	OBSERVATION SYSTEM	QC TECHNIQUES
Maximum Gust	SAO/Synoptic	VC,IC
	Buoy	VC,IC
	C-MAN	VC,IC
Time of Maximum Gust	Buoy	VC
	C-MAN	VC
Maximum Wind Speed	Buoy	VC,IC
	C-MAN	VC,IC
Average Wind Direction and Speed	Buoy	VC,IC,TC2
Wind Speed at 10m	Buoy	VC,IC,TC2
	C-MAN	VC,IC,TC2
Wind Speed at 20m	Buoy	VC,IC,TC2
	C-MAN	VC,IC,TC2
Geopotential Height (levels)	Rawinsonde	VC,HC,MC1,SC
Pressure Altitude/ Flight Level	Pilot	VC,TC3
	ACAR	VC,TC3
Visibility	ASOS	MC2,SC
	AUTOB	VC,MC2,IC,SC
	AWOS	MC2
	SAO/Synoptic	VC,MC2,IC,SC
	Coast Guard	VC,MC2,IC,SC
	Ship	VC,IC,SC

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VARIABLE	OBSERVATION SYSTEM	QC TECHNIQUES
Present Weather	AMOS	IC
	SAO/Synoptic	IC
	Coast Guard	IC
	Co-op	IC
	Ship	IC
	AUTOB	IC
	RAMOS	IC
Past Weather	Synoptic	IC
Total Cloud Cover	ASOS	MC2
	AUTOB	MC2,IC
	AMOS	MC2,IC
	AWOS	MC2
	SAO	MC2
	Synoptic	MC2,IC
	Ship	IC
Ceiling Height	ASOS	MC2
	AUTOB	VC,MC2
	AMOS	VC,MC2
	AWOS	MC2
	SAO	MC2
	Ship	VC
Low/Middle Cloud Cover	Synoptic	MC2,IC
	Ship	IC
Low Cloud Types	Synoptic	IC
	Ship	IC
Middle Cloud Types	Synoptic	IC
	Ship	IC
High Cloud Types	Synoptic	IC
	Ship	IC

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IC - Internal Consistency Check
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SAC - Super Adiabatic Lapse Rate Check
TC1 - Temporal Consistency Check
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TC3 - Time Consis. Chk. Aircraft Obs.
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MC2 - GEM Consistency Check
SC - Spatial Consistency Check (Limited (SC1) or Enhanced (SC2))

VARIABLE	OBSERVATION SYSTEM	QC TECHNIQUES
Cloud Cover For a Layer (layer amount)	ASOS	MC2
	AWOS	MC2
	Synoptic	MC2,IC
	SAO	MC2
Cloud Type For a Layer	Synoptic	IC
Cloud Base For a Layer	ASOS	MC2
	AWOS	MC2
	Synoptic	MC2,IC
	SAO	MC2
Snow Depth	SAO/Synoptic	VC,CC,IC,TC1
	Co-op	VC,CC,IC,TC1
Snowfall (new)	SAO/Synoptic	VC,IC,TC1
	Co-op	TC1
Accumulated Precipitation (during period < 24 hours)	SAO/Synoptic	VC,IC
	AUTOB	VC,IC
	AMOS	VC,IC
	RAMOS	VC,IC
	Co-op	VC,IC
	C-MAN	VC
	Profiler	VC
	AHOS	VC
	MESONET	VC
Accumulated Precipitation (24-hour)	RAMOS	VC,IC
	SAO/Synoptic	VC,IC

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TC3 - Time Consis. Chk. Aircraft Obs.
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MC2 - GEM Consistency Check
SC - Spatial Consistency Check (Limited (SC1) or Enhanced (SC2))

VARIABLE	OBSERVATION SYSTEM	QC TECHNIQUES
Wave Period	C-MAN	VC,TC2,SC
	Buoy	VC,TC2,SC
	Ship	VC,SC
	Spectral Wave	VC,TC2,SC
Wave Height	C-MAN	VC,MC1,TC2,SC
	Buoy	VC,MC1,TC2,SC
	Ship	VC,MC1,SC
	Spectral Wave	VC,MC1,TC2,SC
Wave Direction	Buoy	VC,SC
	Spectral Wave	VC,SC
Swell Data	Ship	VC
Spectral Densities	Spectral Wave	VC
Time of Lightning Strike	Lightning	VC
Polarity of Lightning	Lightning	VC
River Stage	Co-op	VC,MC1,TC1
	AHOS	VC,MC1,TC1
	MESONET	VC,MC1,TC1
Reservoir Elevation	Co-op	VC
	AHOS	VC
	MESONET	VC
Mean Daily Discharge	Co-op	VC

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CC - Climatological Limits Check
IC - Internal Consistency Check
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SAC - Super Adiabatic Lapse Rate Check
TC1 - Temporal Consistency Check
TC2 - Time Consis. Chk. Marine Obs.
TC3 - Time Consis. Chk. Aircraft Obs.
MC1 - Model Consisteny Check
MC2 - GEM Consistency Check
SC - Spatial Consistency Check (Limited (SC1) or Enhanced (SC2))

VARIABLE	OBSERVATION SYSTEM	QC TECHNIQUES
Instantaneous Reservoir Outflow	Co-op	VC
	AHOS	VC
	MESONET	VC
Snow Water Equivalent	Co-op	VC
Headwater Streamflow	CROHMS	VC

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HC - Hydrostatic Consistency Check
WSC - Wind Shear Check
SAC - Super Adiabatic Lapse Rate Check
TC1 - Temporal Consistency Check
TC2 - Time Consis. Chk. Marine Obs.
TC3 - Time Consis. Chk. Aircraft Obs.
MC1 - Model Consisteny Check
MC2 - GEM Consistency Check
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ATTACHMENT 4

National Set of Validity Check Tolerances, Internal Consistency Algorithms and Temporal Check Tolerances by Physical Element and Observation System

AWIPS DOCUMENT NUMBER
TSP-032-1992R2

VALIDITY CHECK (VC)

VARIABLE	OBS SYSTEM	TOLERANCE LIMITS
Location	ACAR Pilot Ship Buoy	Latitude 0° - 90°N Longitude 20°W - 120°E Ship Course 0° - 360° Ship Speed 0 - 80 knots Aircraft Speed 40 - 800 knots
Pressure (sea-level)	AMOS RAMOS SAO/Synoptic Coast Guard C-MAN Ship Buoy Profiler MESONET	25 inches (846mb) - 32.5 inches (1100mb)
Pressure Change	RAMOS SAO/Synoptic C-MAN Ship Buoy	0 inches (0mb) - 0.9 inches (30.5mb) in 3 hours (NWS, 1984)
Altimeter Setting	AUTOB AMOS RAMOS SAO/Synoptic ASOS	6.8 inches (568mb) - 32.5 inches (1100mb)
Air Temperature (sfc)	AUTOB AMOS RAMOS SAO/Synoptic Co-op Coast Guard C-MAN Ship Buoy Profiler AHOS MESONET	-60°F - 130°F

VARIABLE	OBS SYSTEM	TOLERANCE LIMITS
Air Temperature (levels)	ACAR Pilot Rawinsonde	See Table A4-1
Soil Temperature	Co-op	-40°F - 150°F
Sea Surface Temperature	Coast Guard Buoy Ship C-MAN	-2°C - 40°C (Gilhousen, 1988)
Max/Min Temperature	RAMOS Co-op	-60°F - 130°F
Dewpoint (sfc)	AUTOB AMOS RAMOS SAO/Synoptic Ship Buoy C-MAN	-80°F - 90°F (NWS, 1984)
Relative Humidity (sfc)	Profiler	0 - 100%
Wind Direction and Wind Speed (sfc)	AUTOB AMOS RAMOS SAO/Synoptic Co-op Coast Guard C-MAN Ship Buoy Spectral Wave MESONET Profiler	Direction: 0° - 360° (NWS, 1984) Speed: 0 - 250 knots (NWS, 1984)
Wind Direction and Wind Speed (levels)	ACAR Pilot Profiler	Speed: See Table A4-1 Direction: 0° - 360° (NWS, 1984)

VARIABLE	OBS SYSTEM	TOLERANCE LIMITS
Peak Wind Speed	AUTOB AMOS RAMOS SAO ASOS	0 - 250 knots
Maximum Gust	SAO/Synoptic Buoy C-MAN	11 - 250 knots
Time of Maximum Gust	Buoy C-MAN	0000 - 2359 hours
Maximum Wind Speed	Buoy C-MAN	0 - 250 knots
Pressure Altitude/ Flight Level	Pilot ACAR	1000mb - 100mb
Average Wind Direction and Speed	Buoy	Direction: 0° - 360° (NWS, 1984) Speed: 0 - 250 knots (NWS, 1984)
Wind Speed at 10m	Buoy C-MAN	0 - 250 knots
Wind Speed at 20m	Buoy C-MAN	0 - 250 knots
Visibility	AUTOB Coast Guard SAO/Synoptic Ship	0 - 100 miles
Ceiling Height	AUTOB AMOS Ship	0 - 40,000 feet (NWS, 1984)
Snow Depth	SAO/Synoptic Co-op	0 - 300 inches (NWS, 1984)
Snowfall (new) (3-hour)	SAO	0 - 25 inches
Snowfall (new) (6-hour)	SAO/Synoptic	0 - 50 inches

VARIABLE	OBS SYSTEM	TOLERANCE LIMITS
Snowfall (new)	Co-op	0 - 50 inches
Accumulated Precipitation (during period < 24 hours)	AUTOB AMOS RAMOS SAO/Synoptic Co-op C-MAN Profiler AHOS MESONET	0 - 44 inches
Accumulated Precipitation (24-hour)	RAMOS SAO/Synoptic	0 - 44 inches
Swell Data	Ship	Direction: 0° - 360° Period: 0 - 99 seconds Height: 0 - 10.25 meters
Time of Lightning Strike	Lightning	0000 - 2359
Polarity of Lightning	Lightning	+/-
Wave Period	C-MAN Buoy Ship Spectral Wave	0 - 99 seconds
Wave Height	C-MAN Buoy Ship Spectral Wave	0 - 10.25 meters
Wave Direction	Buoy Spectral Wave	0 - 360 degrees
Spectral Densities	Spectral Wave	0 - 1000 M^2/HZ

VARIABLE	OBS SYSTEM	TOLERANCE LIMITS
River Stage	Co-op AHOS MESONET	locally determined limits
Reservoir Elevation	Co-op AHOS MESONET	-282 feet - 18,000 feet
Mean Daily Discharge	Co-op	0 cfs - 2,500,000 cfs
Instantaneous Reservoir Outflow	Co-op AHOS MESONET	0 cfs - 2,500,000 cfs
Snow Water Equivalent	Co-op	0 inches - 400 inches
Headwater Streamflow	CROHMS	Locally Determined Limits

Table A4-1. Upper Air Profile Tolerance Limits
(DiMego et.al., 1985 and Atkins, 1985)

Level	Geopotential Height Meters Low	Geopotential Height Meters High	Temp. °C Low	Temp. °C High	Max Wind Speed Knots
1000	-588	601	-65	60	70
850	634	1853	-50	45	90
700	2101	3473	-50	30	120
500	4505	6121	-57	5	200
400	5870	7791	-66	-10	250
300	7726	9952	-72	-20	300
250	8835	11274	-76	-25	300
200	10260	12699	-78	-30	300
150	12094	14533	-85	-30	200
100	14000	17500	-95	-30	200
70	16496	19596	-95	-25	200
50	18402	21602	-95	-15	200
30	21003	25503	-95	- 5	200
20	23501	28001	-95	5	200
10	27003	33003	-95	15	200

Note: If between mandatory levels, choose larger value of the bordering levels.

INTERNAL CONSISTENCY CHECKS (IC)

VARIABLE	OBS SYSTEM	TABLE A4-2 REFERENCE ITEM NUMBER
Pressure (station)	SAO/Synoptic	1
	ASOS	
	AWOS	
Pressure (sea-level)	SAO/Synoptic	1
	ASOS	
	AWOS	
Pressure Change	RAMOS	2
	SAO/Synoptic	2
	C-MAN	2
	Ship	2
	Buoy	2
Air Temperature (sfc)	AUTOB	3
	AMOS	3
	RAMOS	3,4
	Co-op	4
	C-MAN	3
	Ship	3
	Buoy	3
Sea Surface Temperature	Coast Guard	5
	Buoy	5
	Ship	5
	C-MAN	5
Max/Min Temperature	RAMOS	4
	Co-op	4
Dewpoint (sfc)	AUTOB	3
	AMOS	3
	RAMOS	3
	Ship	3
	Buoy	3
	C-MAN	3

VARIABLE	OBS SYSTEM	TABLE A4-2 REFERENCE ITEM NUMBER
Wind Direction (sfc)	AUTOB	6
	AMOS	6
	RAMOS	6
	SAO/Synoptic	6
	Co-op	6
	Coast Guard	6
	C-MAN	6
	Ship	6
	Buoy	6
	Spectral Wave	6
	MESONET	6
	ASOS	6
	AWOS	6
	Profiler	6
Wind Speed (sfc)	AUTOB	6,9
	AMOS	6,8,9
	RAMOS	6,9
	SAO/Synoptic	6,7,8,9
	Co-op	6
	Coast Guard	6,8
	C-MAN	6,7
	Ship	6,8
	Buoy	6,7
	Spectral Wave	6
	MESONET	6
	ASOS	6
	AWOS	6
	Profiler	6
Wind Direction and Wind Speed (levels)	ACAR	6
	Pilot	6
	Profiler	6
Peak Wind Speed	AUTOB	9,13,15
	AMOS	9,13,15
	RAMOS	9,13,15
	SAO	9,13,15
	Synoptic	15
	ASOS	9,13,15
Maximum Gust	SAO	7,13
	Buoy	7,14
	C-MAN	7,14
Maximum Wind Speed	Buoy	10,14
	C-MAN	10,14

VARIABLE	OBS SYSTEM	TABLE A4-2 REFERENCE ITEM NUMBER
10m Wind Speed and direction	Buoy	11
	C-MAN	11
20m Wind Speed and direction	Buoy	12
	C-MAN	12
Visibility	AUTOB	16
	Coast Guard	16
	SAO/Synoptic	16
	Ship	16
Present Weather	AMOS	8,17,18,20,21
	SAO/Synoptic	8,15,16,17,18,19,20,21
	Coast Guard	8,17
	Co-op	8,16,17,20
	Ship	8,16,17,18,19,21
Past Weather	Synoptic	22
Total Cloud Cover	AUTOB	27
	AMOS	28
	Synoptic	18,23,24,25,26,27,28,35,37,42
	Ship	24,25,26,28
Low/Middle Cloud Cover	Synoptic	19,24,26,29,30,32,33,35,37,45,47,50
	Ship	29,30
Low Cloud Types	Synoptic	25,26,29,31,32,33,34,35,39,41,44,46,48
	Ship	32,33,34,35
Middle Cloud Types	Synoptic	25,26,29,32,33,34,36,37,38,39,41, 44,46,48
	Ship	36
High Cloud Types	Synoptic	25,26,29,34,35,36,37,40,41,42,44, 46,48,51
	Ship	42
Cloud Cover For a Layer	Synoptic	23,43,44,45,47
Cloud Type For a Layer	Synoptic	30,31,38,39,40,41,43,44,46,47,49,51
Cloud Base For a Layer	Synoptic	48,49,50,51

VARIABLE	OBS SYSTEM	TABLE A4-2 REFERENCE ITEM NUMBER
Snow Depth	SAO/Synoptic	52
	Co-op	52,55
Snowfall (new)	SAO/Synoptic	53
Accumulated Precipitation (during period < 24 hours)	SAO/Synoptic	20,22,52,53,54
	AMOS	20
	RAMOS	20
	AUTOB	20
	Co-op	20
Accumulated Precipitation (24-hour)	SAO/Synoptic	54
	RAMOS	54

Table A4-2. Internal Consistency Checks

ITEM No. DESCRIPTION

1 Sea-Level Pressure vs Station Pressure (DiMego et. al.,, 1985)

$$P_{ESL} = P_S\ [T_S\ /\ (T_S - 0.0065\ ELEV)]^{5.265}$$

$$DELP = P_{ESL} - P_{SL}$$

where,
- P_{ESL} = estimated sea-level pressure from station pressure
- ELEV = elevation (meters)
- P_S = station pressure (mb)
- P_{SL} = sea-level pressure (mb)
- T_S = 12 hour mean surface temperature (°K)
- DELP = difference between estimated and reported sea-level pressure

$$TOLA = 0.15((ELEV)^{0.5}) + 1$$
$$TOLB = 0.20((ELEV)^{0.5}) + 1$$
$$TOLC = 0.20((ELEV)^{0.5}) + 3$$
$$TOLD = 0.004\ ELEV$$

IF ELEV $\leq$ 500m and DELP < TOLA THEN	"Pass"
IF ELEV $\leq$ 1000m and $T_S \geq$ -15°C and DELP > TOLB THEN	"Fail"
IF 500m < ELEV $\leq$ 1000m and T_s < 25°C and DELP < TOLD THEN	"Fail"
IF ELEV $\leq$ 1000m and T_s < -15°C and DELP < TOLC THEN	"Fail"
IF ELEV < 1000m and all others THEN	"Fail"

2 Pressure Change vs Station Pressure (NWS, 1984)

IF $P_c \neq P_{SL-1} - P_{SL}$ THEN "Fail"

where,
- P_c = pressure change
- P_{SL-1} = station pressure previously reported
- P_{SL} = station pressure

3 Air Temperature vs Dewpoint Temperature (NWS, 1984)

IF Air Temperature < Dewpoint Temperature THEN "Fail"

4 Air Temperature vs Max/Min Temperatures (NWS, 1984)

IF Min. Temp. > Air Temperature > Max. Temp. THEN "Fail"

5 Air Temperature vs Sea Surface Temperature (SST)

IF |Air Temperature - SST| $\geq$ 60°F THEN "Fail"

Table A4-2. Internal Consistency Checks (continued)

ITEM NO.	DESCRIPTION
6	Wind Direction vs Wind Speed (NWS, 1984) IF Direction = 0 and Speed $\neq$ 0 THEN "Fail" IF Direction $\neq$ 0 and Speed = 0 THEN "Fail"
7	Wind Speed vs Maximum Gusts (NWS, 1984) IF Wind Speed > Maximum Gust THEN "Fail"
8	Wind Speed vs Present Weather (NWS, 1984) IF Wind Speed < 9 knots and Present Weather = Blowing phenomena THEN "Fail" IF Squall (Q) reported, and Wind Speed < 20 knots THEN "Fail"
9	Wind Speed vs Peak Wind Speed (NWS, 1984) IF Wind Speed > Peak Wind THEN "Fail"
10	Wind Speed vs Maximum Wind Speed (NWS, 1984) IF Wind Speed > Maximum Wind Speed THEN "Fail"
11	Wind Direction at 10m vs Wind Speed at 10m IF Direction = 0 and Speed $\neq$ 0 THEN "Fail" IF Direction $\neq$ 0 and Speed = 0 THEN "Fail"
12	Wind Direction at 20m vs Wind Speed at 20m IF Direction = 0 and Speed $\neq$ 0 THEN "Fail" IF Direction $\neq$ 0 and Speed = 0 THEN "Fail"
13	Maximum Gust vs Peak Wind Speed (NWS, 1984) IF Maximum Gust > Peak Wind Speed THEN "Fail"
14	Maximum Gust vs Maximum Wind Speed (NWS, 1984) IF Maximum Gust < Maximum Wind Speed THEN "Fail"

Table A4-2. Internal Consistency Checks (continued)

NOTE: Many of the variables discussed in the following internal consistency checks refer to data groups from Sections 1 and 3 of the Synoptic Code (NWS, 1988b). Pertinent groups are: $i_R i_x hVV$, Nddff, $7wwW_1W_2$, and $8N_hC_LC_MC_H$, from Section 1, and $8N_sCh_sh_s$ from Section 3.

VV	: prevailing visibility
N	: total cloud cover
ww	: present weather code specification
W_1W_2	: past weather code specifications
N_h	: amount of low clouds (if there are no low clouds N_h is the amount of middle clouds)
C_L, C_M, C_H	: type of low, middle, and high cloud respectively
N_s	: amount of cloud cover for a layer
C	: predominant cloud type for a layer
h_sh_s	: height of the base of the cloud layer

ITEM NO. DESCRIPTION

15 Peak Wind Speed vs Present Weather (NWS, 1984)

IF Present Weather = T+ (ww=97,99), and Peak Wind < 50 knots and Hail reported < 3/4 inch diameter THEN "Fail"
IF Present Weather = T (ww=95,96,98), and Peak Wind ≥ 50 knots and/or Hail reported ≥ 3/4 inch diameter THEN "Fail"

16 Horizontal visibility at the surface (VV) vs Present Weather (ww) (NWS, 1988a, 1988b)

IF Visibility (VV) is not ≥ 5/16 and < 5/8 miles, and Present weather =

ATMOSPHERIC PHENOMENA	SYNOPTIC CODE	SAO CODE	
· Duststorm/Sandstorm	ww=30-32	BD/BN	
· Moderate Drizzle	ww=52,53,59	L	
· Moderate Freezing Drizzle	ww=57	ZL	
· Moderate Snow	ww=72-73	S	
· Moderate Snow Pellets	ww=88	SP	THEN "Fail"

Table A4-2. Internal Consistency Checks (continued)

ITEM
NO. DESCRIPTION

16 (cont.)

If VV is <u>not</u> < 5/8 mile and Present Weather =

· Fog/Ice Fog	ww=11,12,41-49	F/IF	THEN "Fail"

IF VV is <u>not</u> < 5/16 mile and Present Weather =

· Severe Duststorm/Sandstorm	ww=33-35	BD/BN	
· Heavy Drizzle	ww=54,55,59	L+	
· Heavy freezing drizzle	ww=57	ZL+	
· Heavy Snow	ww=74,75	S+	
· Heavy Blowing Snow	ww=39	BS	THEN "Fail"

IF VV is <u>not</u> ≥ 5/8 and < 6 miles and Present Weather =

· Mist	ww=10	F/IF	THEN "Fail"

If VV is <u>not</u> > 5/8 mile and ≤ 6 miles and Present Weather =

· Slight or Moderate Blowing Snow	ww=38	BS	
· Blowing Spray	ww=07	BY	THEN "Fail"

IF VV ≥ 7 miles and Present Weather =

· Smoke	ww=04	K	
· Volcanic Ash	ww=04	VOLCANIC ASH	
· Haze	ww=05	H	
· Duststorm/Sandstorm	ww=07,09,30-35	D,BD,BN	
· Blowing Snow	ww=38,39	BS	
· Fog/Ice Fog	ww=11,12,41-49	F	THEN "Fail"

Table A4-2. Internal Consistency Checks (continued)

ITEM NO.	DESCRIPTION
17	Present Weather vs Air Temperature (NWS, 1984) IF Present Weather (PW) = Hail and Air Temperature < 10°C THEN "Fail" IF PW = Ice Crystals and Air Temperature < -40°C or > -9°C THEN "Fail" IF PW = Ice Fog and Air Temperature > -9°C THEN "Fail" IF PW = Ice Pellets and Air temperature < -12°C or > 7°C THEN "Fail" IF PW = Liquid Precip. and Air Temperature < -3°C THEN "Fail" IF PW = Frozen Precip. and Air Temperature > 7°C THEN "Fail" IF PW = Freezing Precip. and Air temperature < -12°C or > 4°C THEN "Fail" IF PW = Liquid Fog and Air Temperature < -33°C THEN "Fail"
18	Present Weather vs Total Cloud Cover (N) (Atkins, 1985) IF PW = fog (ww=43,45,47,49) and Total Cloud Cover ≠ Obscured THEN "Fail"
19	Present Weather vs Low/Middle Cloud Cover (Atkins, 1985) IF PW = fog (ww=43,45,47,49) and Low/Middle Cloud Cover ≠ Obscured THEN "Fail"
20	Present Weather vs Accumulated Precipitation (during period) (NWS, 1984) IF PW = Rain (ww=60-69), Snow (ww=70-75), Other Frozen Precipitation Types (ww=76-79), Showers (ww=80-90), or Thunderstorm (at time of observation or during preceeding hour, with precipitation at time of observation, ww=91-99) and Accumulated Precipitation = 0 THEN "Fail"
21	Present Weather vs Temperature, Wind Speed and Dewpoint IF PW = Fog and (Air Temp - Dewpoint) > 11°C THEN "Fail"
22	Past Weather vs Accumulated Precipitation (during period) (NWS, 1988b) IF Past Weather (W_1W_2)= Drizzle (W_1 or W_2 = 5), Rain (W_1 or W_2 = 6), Snow (W_1 or W_2 = 7) or Showers (W_1 or W_2 = 8) and Accumulated Precipitation= 0 THEN "Fail"
23	Total Cloud Cover (N) vs Cloud Cover for a Layer (N_S) (Atkins, 1985) IF N = Obscured (9) and N_S ≠ Obscured (9) THEN "Fail" IF N ≠ Obscured (9) and N_S = Obscured (9) THEN "Fail" IF $N < N_S$ THEN "Fail"

Table A4-2. Internal Consistency Checks (continued)

ITEM NO.	DESCRIPTION
24	Total Cloud Cover (N) vs Low/Middle Cloud Cover (N_h) (Atkins, 1985) IF N = Clear (0) and $N_h \neq$ Clear (0) THEN "Fail"
25	Total Cloud Cover vs Low (C_L), Middle (C_M), and High (C_H) Cloud Types (Atkins, 1985) IF N = Obscured (9) and C_L, C_M, and C_H are $\neq$ / (cannot be seen due to low overcast) THEN "Fail" IF N = Clear (0) and either C_L, C_M, or $C_H \neq$ Clear (0) THEN "Fail" IF N $\neq$ Clear (0) and C_L, C_M, and C_H = Clear (0) THEN "Fail"
26	Total Cloud Cover (N) vs Low/Middle Cloud Cover (N_h), and Low (C_L), Middle (C_M), and High (C_H) Cloud Types (Atkins, 1985) IF N = Overcast (8) and N_h < Overcast (8) but C_M and C_H cannot be seen due to low overcast (/) THEN "Fail" IF N = Clear (0) and the N_h, C_L, C_M, and C_H are reported THEN "Fail"
27	Total Cloud Cover (N) vs Visibility (Atkins, 1985) IF N = Obscured (9) and Visibility ≥ 10 miles THEN "Fail"
28	Total Cloud Cover (N) vs Present Weather (Atkins, 1985) IF N = Clear (0) and Present Weather = · Clouds forming (ww = 03) · Precipitation within sight (ww = 14-16) · Drizzle, Rain or Snow (ww = 50-79) · Showery precipitation (ww = 80-90) · Thunderstorm (ww = 17,91-99) THEN "Fail"
29	Low/Middle Cloud Cover (N_h) vs Low (C_L), Middle (C_M) and High (C_H) Cloud Types (Atkins, 1985) IF N_h = Clear (0) and C_L or $C_M \neq$ Clear (0) THEN "Fail" IF $N_h \neq$ Obscured (9) and C_L = / (cannot be seen due to low overcast) THEN "Fail" IF N_h = Overcast (8) and $C_H \neq$ / (cannot be seen due to low overcast) THEN "Fail" IF N_h = Overcast (8) and C_L ranges from 1/10 to sky obscured and $C_M \neq$ / (cannot be seen due to low overcast) THEN "Fail"

Table A4-2. Internal Consistency Checks (continued)

ITEM NO.	DESCRIPTION
30	Low/Middle Cloud Cover (N_h) vs Cloud Type for a Layer (C) (Atkins, 1985) IF N_h ≠ Obscured (9) and Cloud Type for a Layer cannot be seen due to low overcast THEN "Fail"
31	Low Cloud Type (C_L) vs Cloud Type for a Layer (C) (Atkins, 1985) IF C_L = No Clouds (0) and Cloud Type for a Layer (C) = Low Cloud Types (Sc,St,Cu,Cb: C=6-9) THEN "Fail" IF C_L = Clouds (1-9) and Cloud Type for a Layer (C) ≠ Low Cloud Types (Sc,St,Cu,Cb: C=6-9) THEN "Fail" IF C_L = Cumulonimbus (3,9) and C ≠ Cumulonimbus (9) THEN "Fail"
32	Low Cloud Type (C_L) vs Low/Middle Cloud Cover N_h (Atkins, 1985) IF C_L ≠ No Clouds and N_h = Clear (0) THEN "Fail"
33	Low Cloud Type (C_L) and Middle Cloud Type (C_M) vs Low/Middle Cloud Cover N_h (Atkins, 1985) IF C_L and C_M = No Clouds and N_h ≠ Clear (0) THEN "Fail"
34	Low Cloud Type (C_L) vs Middle and High Cloud Type (C_M and C_H) (Atkins, 1985) IF C_L = cannot be seen due to low overcast (/) and C_M and/or C_H ≠ cannot be seen due to low overcast THEN "Fail"
35	Low Cloud Type (C_L) vs High Cloud Type (C_H) and Total and Low/Middle Cloud Cover (N and N_h) (Atkins, 1985) IF C_L and C_H = Clear (0) and N ≠ N_h THEN "Fail"
36	Middle Cloud Type (C_M) vs High Cloud Type (C_H) (Atkins, 1985) IF C_M = not visible (/) and C_H ≠ not visible (/) THEN "Fail"
37	Middle Cloud Type (C_M) vs High Cloud Type (C_H) and Total and Low/Middle Cloud Cover (N and N_h) (Atkins, 1985) IF C_M and C_H = Clear (0) and N ≠ N_h THEN "Fail"

Table A4-2. Internal Consistency Checks (continued)

ITEM NO.	DESCRIPTION
38	Middle Cloud Type (C_M) vs Cloud Type for a Layer (C) (Atkins, 1985) IF C_M = No Clouds (0) or not visible (/) and Cloud Type for a Layer (C) = Middle Cloud Types (Ac,As,Ns: C=3-5) THEN "Fail"
39	Middle Cloud Type (C_M) vs Low Cloud Type (C_L) and Cloud Type for a Layer (C) (Atkins, 1985) IF C_M and C_L = No Clouds (0) and C ≠ High Cloud Types (Ci,Cc,Cs: C=0-2) THEN "Fail" IF C_M ≠ No Clouds (0) or not Visible (/) and C_L = No Clouds (0) and C ≠ Middle Cloud Types (Ac,As,Ns: C=3-5) THEN "Fail"
40	High Cloud Type (C_H) vs Cloud Type for a Layer (C) (Atkins, 1985) IF C_H = No Clouds (0) or Not Visible (/) and C = High Cloud Types (Ci,Cc,Cs: C=0-2) THEN "Fail" IF C_H = No Clouds or Cirrus (0-4) and C = High Cloud Types (Ci: C=0) THEN "Fail" IF C_H = Cs (5-8) and C ≠ High Cloud Types (Cs: C=2) THEN "Fail" IF C_H = Cc (9) and C ≠ High Cloud Types (Cc: C=1) THEN "Fail"
41	High Cloud Types (C_H) vs Low/Middle Cloud Types (C_L/C_M) and Cloud Type for a Layer (C) (Atkins, 1985) IF C_H, C_M, C_L = No Clouds (0) and Cloud Layers reported THEN "Fail" IF C_H ≠ No Clouds (0) or Not Visible (/) and C_M, C_L = No Clouds (0) and Cloud Layers ≠ High Cloud Types (Ci,Cc,Cs: C=0-2) THEN "Fail"
42	High Cloud Types (C_H) vs Total Cloud Cover (N) (Atkins, 1985) IF C_H = Cs covering the Whole Sky and N ≠ Overcast (8) THEN "Fail"
43	Cloud Cover for a Layer (N_s) vs Cloud Layer Reports (Atkins, 1985) IF N_s = Clear (0) and Cloud Layers Reported THEN "Fail"

Table A4-2. Internal Consistency Checks (continued)

ITEM NO. DESCRIPTION

44 Cloud Cover for a Layer (N_s) vs Low/Middle/High Cloud Type (C_L, C_M, C_H) (Atkins, 1985)

IF N_s = Obscured and either C_L, C_M, or C_H ≠ Not Visible (/) THEN "Fail"

45 Cloud Cover for a Layer (N_s) vs Low/Middle Cloud Cover (N_h) (Atkins, 1985)

IF N_s ≠ Obscured (9) and N_h = Obscured (9) THEN "Fail"

IF N_s = Obscured (9) and N_h ≠ Obscured (9) THEN "Fail"

46 Cloud Type for a Layer vs Low/Middle/High Cloud Type (C_L, C_M, C_H) (Atkins, 1985)

IF C = Ci,Cc,Ac (0-2) and C_H = No Clouds (0) or Not Visible (/) THEN "Fail"

IF C = Ac,As,Ns (3-5) and C_M = No Clouds (0) or Not Visible (/) THEN "Fail"

IF C = Sc,St,Cu,Cb (6-9) and C_L = No Clouds (0) or Not Visible (/) THEN "Fail"

IF C = Cb (9) and C_L ≠ Cumulonimbus (3 or 9) THEN "Fail"

47 Cloud Type for a Layer (C) vs Low/Middle Cloud Cover (N_h) and Cloud Cover for a Layer (N_s) (Atkins, 1985)

IF C = Sc,St,Cu,Cb (6-9) and $N_h < N_s$ THEN "Fail"

48 Cloud Base for a Layer (h_sh_s) vs Low/Middle/High Cloud Type (C_L, C_M, C_H) (Atkins, 1985)

IF First Group $h_sh_s \geq$ 9,000 feet (59-89) and C_L ≠ No Clouds (0) THEN "Fail"

IF First Group $h_sh_s \geq$ 21,000 feet (71-89) and C_M ≠ No Clouds (0) THEN "Fail"

IF First Group h_sh_s = 9,000-17,000 feet (59-67) and C_M = No Clouds (0) THEN "Fail"

IF First Group h_sh_s = 17,000-20,000 feet (67-70) and C_M and C_H ≠ No Clouds (0) THEN "Fail"

Table A4-2. Internal Consistency Checks (continued)

ITEM NO.	DESCRIPTION
49	Cloud Base for a Layer (h_sh_s) vs Cloud Type for a Layer (C) (Atkins, 1985) IF First Group h_sh_s = 9,000-17,000 feet (59-67) and C ≠ Ac,As,Ns (3-5) THEN "Fail" IF First Group h_sh_s = 17,000-21,000 feet (67-71) and C ≠ Ci,Cc,Cs,Ac,As,Ns (0-5) THEN "Fail" IF Two Groups whose h_sh_s are equal and neither C = Cb THEN "Fail"
50	Cloud Base for a Layer (h_sh_s) vs Low/Middle Cloud Cover (N_h) (Atkins, 1985) IF First Group h_sh_s ≥ 21,000 feet (71-89) and N_h ≠ No Clouds (0) THEN "Fail"
51	Cloud Base for a Layer (h_sh_s) vs High Cloud Type (C_H) and Cloud Type for a Layer (C) (Atkins, 1985) IF First Group h_sh_s ≥ 21,000 feet (71-89) and C_H = No Clouds (0) or C ≠ Ci,Cc,Cs (0-2) THEN "Fail"
52	Accumulated Precipitation (during period) vs Snow Depth (NWS, 1984) IF Accumulated Precipitation = 0 and Snow Depth increases THEN "Fail"
53	Accumulated Precipitation (during period) vs Snowfall (new) (NWS, 1984) IF Accumulated Precipitation = 0 and Snowfall > 0 THEN "Fail"
54	Accumulated Precipitation (during period) vs Accumulated Precipitation (24-hour) (NWS, 1984) IF Accum. Precip. (during period) added over a 24 hour period ≠ Accum. Precip. (24-hour) THEN "Fail"
55	Snow Depth vs Snow Water Equivalent IF Snow Depth < Snow Water Equivalent THEN "Fail"

TEMPORAL CONSISTENCY CHECK (TC1)

VARIABLE	OBS SYSTEM	TOLERANCE LIMITS
Pressure (station)	SAO	10mb / ½-hour 15mb / hour
Pressure (sea-level)	AMOS RAMOS Profiler MESONET	10mb / ½-hour 15mb / hour
Altimeter Setting	AUTOB AMOS RAMOS SAO ASOS	0.20 inches Hg / ½-hour 0.30 inches Hg / hour
Air Temperature (sfc)	AUTOB AMOS RAMOS Co-op Profiler AHOS MESONET	20°F / ½-hour 35°F / hour
Air Temperature (levels)	ACAR	30°C/12-hour (NWS, 1989b)
Soil Temperature	Co-op	5°F/hour (Geiger, 1973)
Dewpoint (sfc)	AUTOB AMOS RAMOS Buoy (stationary)	20°F / ½-hour 35°F / hour
Relative Humidity (sfc)	Profiler	50%/hour
Wind Speed (sfc)	AUTOB AMOS RAMOS Co-op MESONET SAO ASOS	Speed : 20 knots/hour 20 knots/½-hour

TEMPORAL CONSISTENCY CHECK (TC1) (cont.)

VARIABLE	OBS SYSTEM	TOLERANCE LIMITS
Wind Speed at 10m	C-MAN Buoy (stationary)	Speed: 20 knots/hour
Wind Speed at 20m	C-MAN Buoy (stationary)	Speed: 20 knots/hour
Snow Depth	Co-op SAO/Synoptic	+ or - 50 inches/6 hours
Snowfall (new)	SAO/Synoptic Co-op	8 inches/hour
River Stage	Co-op AHOS MESONET	Locally Determined Limits

MODEL CONSISTENCY CHECK (MC1)

VARIABLE	OBS SYSTEM	TOLERANCE LIMITS
Pressure	ASOS AMOS AWOS RAMOS SAO/Synoptic Coast Guard C-MAN Ship Buoy Profiler MESONET	10 mb
Air Temperature (sfc)	ASOS AUTOB AMOS AWOS RAMOS SAO/Synoptic Co-op Coast Guard C-MAN Ship Buoy Profiler AHOS MESONET	15°F
Air Temperature (levels)	Rawinsonde Pilot ACAR	10°C
Sea Surface Temperature	Coast Guard Buoy Ship C-MAN	10°F
Dewpoint (sfc)	ASOS AUTOB AMOS RAMOS AWOS SAO/Synoptic	15°F

MODEL CONSISTENCY CHECK (MC1) (cont.)

VARIABLE	OBS SYSTEM	TOLERANCE LIMITS
Wind Speed and Direction (sfc)	ASOS AUTOB AMOS RAMOS AWOS SAO/Synoptic Co-op Coast Guard C-MAN Ship Buoy Profiler Spectral Wave MESONET	Direction: 90° Speed : 20 knots
Wind Speed and Direction (levels)	Rawinsonde Pilot ACAR Profiler	Direction: 60° Speed: 20 knots
Geopotential Height (levels)	Rawinsonde	60 meters
Wave Height	C-MAN Buoy Ship Spectral Wave	3 feet
River Stage	Co-op AHOS MESONET	Locally Determined Limits

ATTACHMENT 5

Example of the Composite Opinion Replacement Retention Criteria

The following is an example of the composite opinion replacement/ retention criteria described in chapter 2.2.2.3 of section 1 of this TSP. Consider the case where three quality control algorithms have been specified by the designated user to be applied to a six hour precipitation report. It has been determined that the reported six hour amount would be exceeded once in twenty years for the given month in which the report is observed. The quality control techniques chosen are a climatological consistency check, a temporal consistency check, and a model consistency check.

Climatological Consistency Check

The probability of exceedence is 1/2400, giving a QDS of 132. This type of seasonal climatological consistency check would use a QPI of 12. Therefore, the numeric descriptor pair for this technique, (QDS_1, QPI_1) is (132, 12).

Temporal Consistency Check

Suppose the observation is 3.5 standard deviations from the conditional mean, based upon the prior observation(s). Then, the QDS= 35*4= 140. Assume the temporal consistency check has a QPI of 20. Therefore, the numeric descriptor pair for this technique, (QDS_2, QPI_2) is (140, 20).

Using figure 3 in chapter 2.2.2.3, and the pair (132, 12) as the basis for the construction of the line of equal opinion, it can be determined that the second pair (140, 20) falls in the full replacement portion of the diagram. Therefore, the opinion of the data quality, after these two tests, is (140,20).

Model Consistency Check

Suppose the QPI for this quality control technique is 80, and the observed value is one forecast standard deviation greater than the forecast expected value. The QDS then equals (10*4) 40. The numeric descriptor pair for this technique (QDS_3, QPI_3) is (40, 80).

Comparing this score with the current opinion, which is (140, 20), we can see from fig. 3 that this score falls in the composite replacement region. To determine the composite opinion of the quality of the data, the QPIEXT value must be determined.

Using the (QDS, QPI) values from the temporal check, which is the current opinion, and the model check:

$$QPIEXT_2 = QPI_2 + (KQ*QDS_2) = 20 + 1*140 = 160$$
$$QPIEXT_3 = QPI_3 + (KQ*QDS_3) = 80 + 1*40 = 120$$

The composite opinion (QDS_n, QPI_n) becomes:

QPI_n = max(QPI) = 80
QDS_n = (max(QPIEXT) - QPI_n)/KQ = (160-80)/1 = 80

(QDS_n, QPI_n) = (80,80).

The final composite result is independent of the order in which the tests are conducted.

SECTION 2: SOFTWARE

The relevant subroutines of the program Subjective Interaction System (SIS) will be provided on high density floppy diskette.

The Objective Analysis for the Local AWIPS MOS Program (V400, V400A, V400B, V400C, V400D) have been provided with TSP 87-04.

SECTION 3: DOCUMENTATION

The following documents have been provided with TSP 87-04.

Chambers, T.L., and H. R. Glahn, 1991a: LAMP objective map analysis program for dew point, temperature, and sea level pressure. VAX No. 20, Techniques Development Laboratory, National Weather Service, 15 pp. [Excerpt from LAMP: VAX Implementation System Description, 1991]

_____, and _____, 1991b: LAMP objective map analysis program for U and V wind components and wind speed. VAX No. 40, Techniques Development Laboratory, National Weather Service, 15 pp. [Excerpt from LAMP: VAX Implementation System Description, 1991]

_____, and _____, 1991c: LAMP objective map analysis program for saturation deficit. VAX No. 41, Techniques Development Laboratory, National Weather Service, 11 pp. [Excerpt from LAMP: VAX Implementation System Description, 1991]

_____, and _____, 1991d: LAMP objective map analysis program for ceiling, opaque sky cover, and visibility. VAX No. 42, Techniques Development Laboratory, National Weather Service, 10 pp. [Excerpt from LAMP: VAX Implementation System Description, 1991]