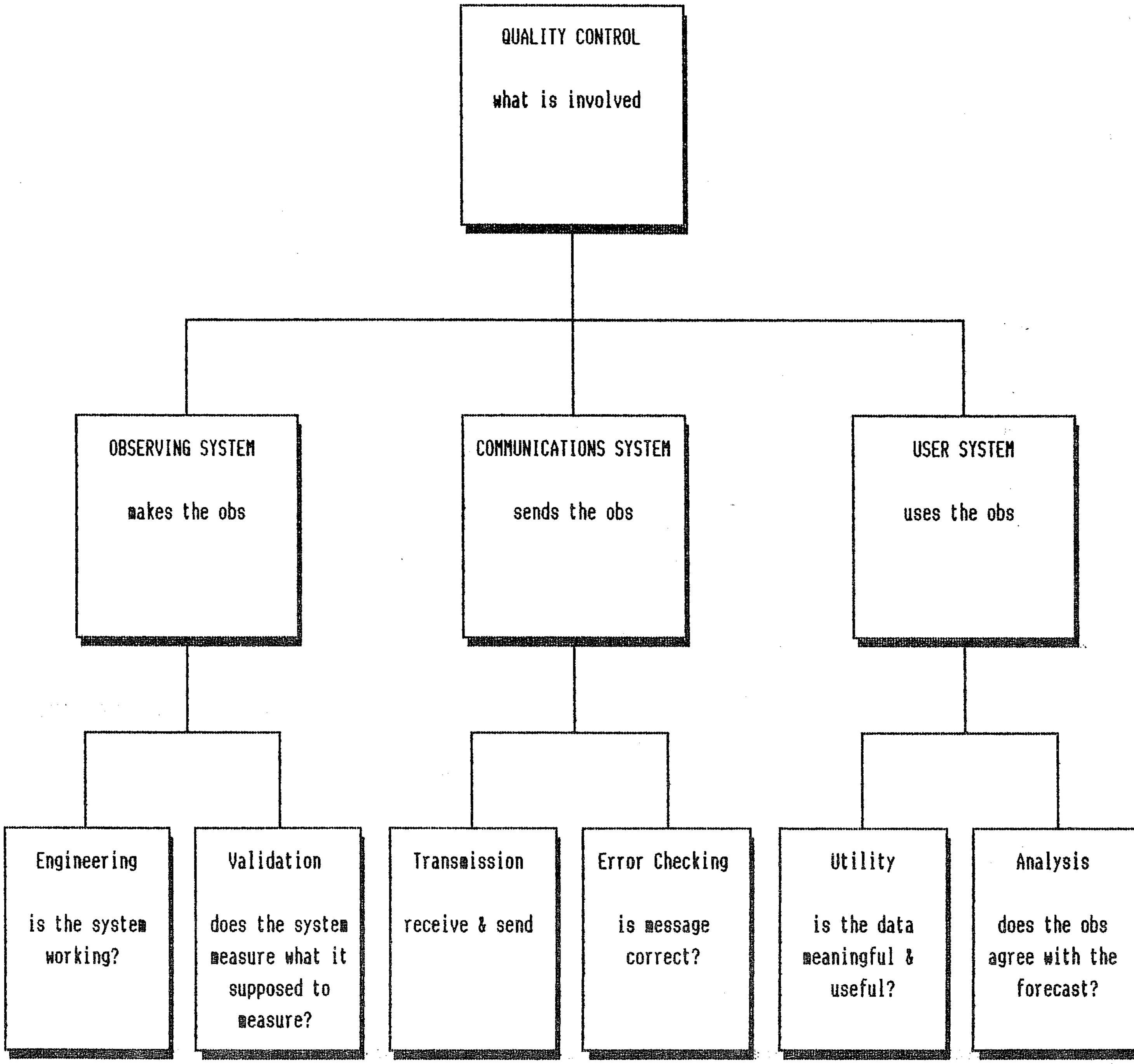
Lecture #1 DATA QUALITY CONTROL PROCEDURES AT NMC WASHINGTON

Introduction

I believe, before beginning to discuss the present and planned quality control procedures at the National Meteorological Center in Washington D.C., that it is advisable to define some terms. This is so because the term 'quality control' means different things to different people. While the main emphasis in my presentation will be on quality control from the point of view of an operational numerical weather prediction center, I want to recognize that the process of assuring data quality involves other functions and processes. The terms I want to define are:
1) Standards. These are defined as engineering assignments and/or assessments of the accuracies and precisions of measurements of a particular variable. Requirements specified by a user may or may not be relevant in making those assignments.
2) Validation. This term refers to the process of insuring that the physical measurement actually made can be interpreted as a measurement of the intended variable. Roughly speaking, validation converts a measurement into an observation.
3) Quality assessment. As I use this term, it refers to the user-based decisions as to the usefulness or a quantitative measure of utility of the observations.

The entire process of quality control, as I see it, is set out in Figure 1. There are three main systems to the quality control process: these are, the observing system, the communications system, and the user system. Each has its domain of responsibility and carries out (or should carry out) its own unique set of processes. These are set out in the third tier in Figure 1. It must be stressed, however, that these processes should not be carried out independently of the other systems. Indeed, to anticipate what I will be emphasizing later on, feedback from one system to another is crucial if the entire quality control process is to function effectively.
The observing system is responsible for the maintenance of standards and for validation. The communication system is responsible for transmitting the observation from the observing system to the user system with as high a reliability as possible. The user system has some responsibilities of a rather different sort. I have called these utility and analysis or synthesis. The user must decide if an observation, or set of observations, are useful or meaningful for the purposes at hand. Not all users will agree on this question of utility. As a rather obvious


QUALITY CONTROL
what is involved
OBSERVING SYSTEM
makes the obs
COMMUNICATIONS SYSTEM
sends the obs
USER SYSTEM
uses the obs
Engineering
is the system working?
Validation
does the system measure what it supposed to measure?
Transmission
receive & send
Error Checking
is message correct?
Utility
is the data meaningful & useful?
Analysis
does the obs agree with the forecast?

example, a surface wind observation at a mountainous site may be quite useful for aircraft operations, but would be of little or no use for an analysis for numerical prediction purposes.

Some users, and it should be obvious which, are in a position to be able to make overall assessments of the usefulness of very large amounts of observational data from a variety of observing systems. These users are able to analyze or synthesize these data by means of dynamical-physical models, thus assuring a consistency of the variables according to physical laws. It is this process which is relatively new and recently matured, and this capability now demands that the process of quality control be modified and expanded. Information on why this user-system process is important to meteorology, the World Weather Watch, and the World Meteorological Organization will, I trust, be the subject of this Workshop.

Principles of Quality Assessment at the NMC.

In formulating a new and largely fresh start at a numerical weather prediction quality assessment procedure at NMC, we have formulated some general principles. They are the result of interchanges with many people in the numerical weather prediction community and, I believe, would represent a consensus.

First: the monitoring of the observing and communication systems is imperative. Feedback to these systems is necessary to insure continuing performance and maintenance of standards.

Second: decisions as to usefulness or correctness should be observing-system dependent. Each observing system of the Global Observing System has its unique characteristics, weakness, and strength. Decisions as to the disposition of each observed datum should result from special algorithms constructed for each observing system.

Third: Decision as to usefulness or correctness should be a single, unified step after all information regarding an observed datum is collected. This principle, advocated and termed 'Complex Quality Control' by L. Gandin (1988), recognizes the powerful synthesis of numerical weather prediction assimilation schemes and the availability of digital computing power. The logic of performing a parallel, rather than a serial, decision process is fundamental to this principle.

Fourth: The amount of human intervention or subjective decision-making should be minimized. Constant monitoring of any current automatic quality assessment process should produce information on deficiencies of that process. Once any clear deficiency is identified, a program enhancement to handle the deficiency should be made.

Fifth: Information on assimilating model behavior is necessary. Since the more accurate the assimilating forecast becomes the less need there is for observed data, it is necessary to know, quantitatively, when and where the forecast is to be trusted and when not.

These principles have led us to begin designing components of a data quality assessment scheme which will make use of a new data file management system, new files containing information about the observations and their disposition (so-called metadata records), and new algorithms for selecting, combining, and rejecting observations.

Present Quality Assessment Procedures.

The present system for data quality assessment at the NMC has been built up over many years, and does not reflect the principles just discussed. Very briefly, it consists of two rather independent steps. The first involves the decoding of bulletins arriving over the GTS and the pre-processing of satellite products and special data which enter NMC from local sources. This procedure involves rather standard checks concerning adherence to codes, internal consistency, hydrostatic checks (when appropriate), elimination of duplicates, and the like.

The second step takes place within the assimilation and analysis portion of the numerical weather prediction forecast cycle. All observations are differenced against the assimilating forecast (a six-hour forecast) and are then subjected to a gross check. The intent here is to eliminate data with errors that are unrelated to their meteorological content- encoding and transmission errors, principally. The gross check process consists of comparing observation minus assimilating forecast differences to representative statistical distributions of like variables. These distributions are classified by variable, pressure, and latitude. The multiple of a standard deviation used to check any difference is a function of the variable involved (e.g. geopotential height, wind component, etc.).

Some data types are also examined subjectively by a team of duty meteorologists who are responsible for supervising the numerical weather prediction forecast cycle. This subjective intervention can take the form of marking a datum to be rejected, or, in some cases, to be retained. These subjective decisions are subsequently honored by the objective analysis scheme. At the final analysis point, a series of proximity checks are made on all data, of varying types within a given volume, with the purpose of determining how the various data agree or disagree with one another. These so-called buddy checks are the final checks made. The present buddy-checking scheme at the NMC is rather involved, and is described in full by DiMego (1988). It is not, moreover, a multivariate optimum interpolation proximity or buddy checking scheme- it is univariate.

I want to stress some of the weakness of this serial, and partly subjective, approach. First of all, it is necessary to remember that all checking is done with differences between the observations and the assimilating forecast.