NATIONAL WEATHER DIGEST
computer

IMPROVED RADIOSONDE OBSERVATIONS VIA COMPUTER ANALYSIS ABOARD USS NIMITZ (CVN 68)

by

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ABSTRACT

One of the tools available to the operational meteorologist is the computer. USS Nimitz is currently using a computer to convert the recorder record radiosonde data into usable meteorological parameters. This saves valuable time and increases accuracy.

1. INTRODUCTION

The USS Nimitz (Fig. 1) is the largest warship in the world. Her various weapons and detection systems require environmental support, from the depths of the ocean to the outer limits of the atmosphere. The Meteorological Office aboard the Nimitz provides these required forecasts in real time, under actual operating conditions. One of the tools available to the meteorologist is the radiosonde observation.

2. DISCUSSION

Until recently, the radiosonde observation program required many arithmetic calculations and conversions. Now, the radiosonde receiver (SMQ-1) converts the radiosonde signal into ordinate values for temperature and humidity on a recorder record; however, all other calculations needed for a vertical profile of the atmosphere and for data applicable to the ship's systems have to be calculated by hand. A radiosonde observer must convert the ordinate values into meteorological values using baseline information derived from the radiosonde before launch, three adiabatic charts, and special slide rulers. This is tedious. Once a level of pressure, temperature and relative humidity has been converted, one must determine that the level is significant to the vertical profiles of temperature and relative humidity. The criterion for significance below 100mb is a deviation from linearity by 1C for temperature and by 10 per cent for relative humidity. Again the observer must diligently check each level. The current procedure for the linearity check requires the observer to predetermine the mandatory levels (e.g. 1000mb, 850, 700, 500, etc.), mark them on his recorder record, and use the mandatory levels as end points to determine significant levels between them.

The significant and mandatory levels are then encoded into radiosonde code (36.V), and transmitted to Fleet Numerical Weather Central, Monterey CA. The information is in raw form for use by the meteorologist. His concern is how the environment (in this case the atmosphere) affects the ship's weapons and detection systems. The primary armament of an aircraft carrier is her aircraft. To control the ship's aircraft and detect enemy aircraft, sophisticated radars are used. These radars transmit electromagnetic energy through the atmosphere. The waves of electromagnetic energy, in general, obey Snell's law, which describes the bending of waves traveling through mediums of different densities. The variations of pressure, temperature and humidity can be related to their effect on electomagnetic energy by the refractive index (a function of pressure, temperature and humidity)

and the vertical gradient of refractive index. After plotting vertical profiles of temperature and humidity (dew point) on a thermodynamic diagram (Skew T-Log P) and interpolating refractive index values, gradients can be computed by hand. Once he has the gradients, the meteorologist uses known guidelines on the strength of the gradient to determine radar effectiveness. Another important parameter derived from the radiosonde sounding is the "D value", the deviation of the actual atmosphere from a standard atmosphere. Other more common parameters derived from the Skew T-Log P chart and used aboard a carrier are the lifting condensation level (LCL), convective condensation level (CCL), level of free convection (LFC), Showalter Index, freezing level, and the heights of the tropopause, contrail formation and icing.

All of these data extraction techniques are tedious, time-consuming and prone to error.

3. IMPROVEMENT VIA COMPUTER

Newtonian physics and various equations govern all of the techniques and parameters we have discussed. The conversion of ordinates to meteorological parameters is a matter of converting normalized resistance units with respect to a baseline check to a meteorological unit. Determining a significant level is merely a computation of departure from a straight line between two selected points. Refractive index can be computed directly, given pressure, temperature and vapor pressure. Vapor pressure can be computed from temperature and dew point. Gradients of refractive index are the slopes of the line between successive levels.

USS Nimitz has developed, using available algorithms and improvising when necessary, a program that computes all of these parameters. Pressure, temperature and relative humidity ordinates read from the SMQ-1 recorder record are put into the computer, a WANG 2200. The program converts the ordinates to meteorological units, computes significant and mandatory levels, and encodes the formatted message.

We said that predetermined mandatory levels are used in finding significant levels. There is an inherent error in doing this, since the individual uses a mandatory level to determine a significant level. Currently, since the significant portion of the encoded message must by itself accurately represent the actual profile, it seems inconsistent to use a mandatory level to determine significant levels. The program checks each level, level by level, for linearity. If a level is significant it is saved; if not, it is discarded. After all the significant levels have been determined, mandatory levels are inserted using a linear interpolation. If a mandatory level is already significant, no new level is added. The observer enters ordinate values directly from the recorder record. He can enter as many levels as he wants. The program will do all the sorting. The computer is also less prone to make mistakes. After the vertical profiles of pressure vs. temperature and humidity are known, the following are derived: height, depression, dew point, vapor pressure, virtual temperature, potential temperature, mixing ratio, precipitable water, and speed of sound. The refractive index and gradients are then computed, also a narrative description of the type of propagation based on the gradient. "D values", LCL, CCL, LFC, freezing level, and Showalter Index are evaluated, and the height of the tropopause is computed.

One needs at least 3 to 4 hours to perform all of these functions manually. The average time from start of data entry until computer program completion is 20 minutes.

4. FUTURE

This article is but one illustration of how the computer is becoming a mainstay in the prognostic tools used to aid the operational meteorologist in performing his duties.

Figure 1

USS Nimitz is the largest warship in the world. Displacing 95,000 tons, she is capable of speeds in excess of 30 knots. Her flight deck covers more than 4.5 acres and she can produce enough electrical power to run the city of Cincinnati.

Aerial view of the USS Nimitz CVN-68 while operating off the Puerto Rican coast. Official U.S. Navy Photograph by PH1 Richard B. Clinton.