SPATIAL ANALYSIS AND QUALITY MANAGEMENT OF RAINFALL DATA AT THE ZAMBIA METEOROLOGICAL DEPARTMENT.

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ABSTRACT:

Rainfall data is one of the meteorological parameters that have a greater bearing on the livelihood of individuals not only in Zambia but also the world over. It is therefore very important that quality management of this data is enhanced. Data are of good quality when they satisfy stated and implied needs. The purpose of quality management is to ensure that data meet requirements for the intended application at minimum practicable cost. To maintain data quality management, the best quality meteorological system operate continuously at all points in the whole observation system from network planning and training, through installation and station operations to data transmission and archiving. The system includes spatial checking, feedback and follow-up provisions on time scales from near real time to annual reviews. The main objective of this research study was to develop a spatial framework for flood and drought disasters in Zambia. The paper is based on a realistic possibility of disasters that do happen whenever we have above normal rainfall over the Northern half and below normal rainfall over the Southern half. The rainfall data was sourced from the National meteorological centre (NMC) database. In particular the paper emphasises on the discussions of the factors affecting data quality, components of data quality management and quality control not only for rainfall but all meteorological data in general.

1. INTRODUCTION

Too much rainfall is as bad to the farmer as too little rain. This is because any of these situations can cause famine, malnutrition, disease outbreaks, displacement of people, human and animal conflicts. In this vein, rainfall data is one of the meteorological parameters that has a great bearing on the livelihood of the individuals not only Zambia but also the world over. It is therefore very important that quality management is maintained of this data that is used in the analysis and production of interpretable output that may teach us lessons about any of the mentioned situations. Data are of good quality when they satisfy stated and implied needs. The purpose of quality management is to ensure that data meet requirements for the intended application at a minimum practicable cost. To maintain rainfall data quality management in Zambia, the best quality meteorological system operate continuously at all points in the whole observation system from network planning and training, through installation and station operations to data transmission and archiving. Zambia is a landlocked country lying between Latitude 08-18º South and Longitude 22-33º East.

1.1 Objectives and source of data

The main objective of this paper is to develop a spatial framework for both flood and drought disasters in Zambia. The paper is based on normal rainfall data and highlights a realistic possibility of disasters that do occur whenever we have above normal rainfall in the Northern half of the country (8-11º Lat.South) and below normal rainfall in the Southern half (15-18ºLat. South) respectively. In order to enhance a qualitable computer based interpretable output about any of the two situations, the paper also discusses data quality management at Zambia Meteorological Department. In particular the paper emphasises on the discussions of the factors affecting data quality, components of data quality management and quality control not only for rainfall but all meteorological data in general. The source of spatial data is a scanned map of Zambia. Normal station rainfall data (30-year annual means) was used.

2. METHODOLOGY

Arc View/ArcGIS, a computer based system that allows data entry, data manipulation, analysis and production of interpretable output was used. The 30-year annual-means of rainfall data for all the existing stations was analysed to give physical relationships, patterns and trends not visible by an other means. The country was divided into three latitudinal parts to ensure an equal distribution of the rainfall stations. The Northern half of the country between 8-11º Lat. South, the Central and the Southern half between 15-18ºLat. South. The rainfall data was converted from MS Excel database to dbf file. The scanned map of Zambia formed part of the spatial data.

3. RESULTS AND DISCUSSION

The production of interpretable rainfall data output teaches us lessons about the rainfall pattern in Zambia. The rainfall Normal is higher in Northern half than the Southern half (Figure 1).

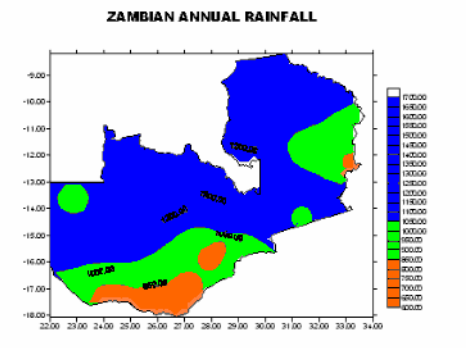

Figure 1.

This is because of the rainfall on set which first start in North-western Zambia (8-11º Lat.South) by mid October on average, advancing south-eastwards, reaching the central parts by mid-November and covering the entire southern Zambia (15-18ºLat. South) by end of November.

The retreat of the rains starts with southern Zambia by mid-March, finally leaving Zambia over Northwestern by end of April (Mumba, Z.LS and Chipeta, G.B. 1984). And by coincidence most of the major rivers in Zambia have their source in North-western Zambia making the possibility of flood related disasters over the North (8-11º Lat.South) and along the river valleys real while drought related disasters are a realistic possibility over the southern half (15-18ºLat. South).

It was also evident that any data inhomogeneities caused by changes in the observing system will appear as abrupt discontinuities, gradual changes or changes in variability. Abrupt discontinuities mostly occurred due to changes in instrumentation, siting and exposure changes, station relocation, changes in calculation of averages, data reduction procedures and application of new corrections.

3.1 Data quality management

But why rainfall data quality management and how does the department make sure that any other data satisfies stated and implied needs?

The purpose of quality management is to ensure that data meet requirements (for uncertainty, resolution, continuity, homogeneity, representativeness, timeliness, format, etc) for the intended application at a minimum practicable cost. The best quality systems at the Meteorological Department operate continuously at all points in the whole observation from network planning and training, through installation and station operations to data transmission and archiving and they include feedback and follow-up provisions on time-scales from near-real time to annual reviews.

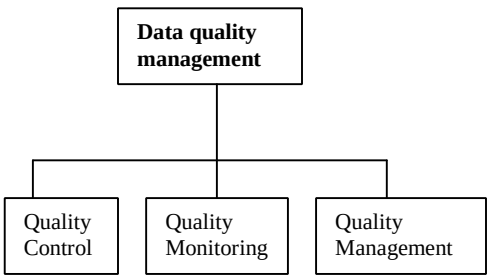

Figure 2. Components of data quality management

Quality control is the best-known component of quality management systems and it is the irreducible minimum of any system, Figure 2. It consists of examination of data in stations and in data centres to detect errors so that the data may be either corrected or deleted. Quality control is applied in real time, but it also operates in non real time as delayed quality control. Real time quality control is usually performed at the station and at provincial meteorological analysis centres. Delayed quality control is performed at analysis centres for compilation of a re-checked database and at climate centres or data banks for archiving. Quality monitoring or performance monitoring is non-real time activity in which the performance of the network or observation system is examined for trends and systematic deficiencies. Quality management includes control of the other factors that directly affect data quality such as equipment, exposure, procedure, maintenance, inspection, data processing and training. This is usually the responsibility of the network manager in collaboration with other specialists where appropriate.

3.2 Factors affecting data quality

These are user's requirements, functional and technical specifications that include selection of instruments, acceptance tests, compatibility, siting and exposure, instrumental errors, data acquisition, data processing, real-time quality control, performance monitoring, test and calibration, maintenance, metadata, training and education.

3.3 Quality Control

World Meteorological organisation (WMO 1981) prescribes that certain quality control procedures must be applied to all meteorological data for international exchange. WMO (1992) prescribes that quality control must be applied by meteorological data-processing centres to most kinds of weather reports exchanged internationally to check for coding errors, internal consistency, time and space consistency, physical and climatological limits and it specifies the minimum frequency and times for quality control. Two types of quality control checks are considered, Static and Dynamic checks. Static checks are single-station and single-time checks such as climatological checks and validity checks. Dynamic checks take advantage of other information such as temporal and spatial consistency checks. The static quality control checks are single-station and single-time checks which, as such are unaware of the previous and current meteorological or hydrologic situation described by other observations and grids. Checks falling into this category include validity, climatological, internal consistency and vertical consistency checks. Dynamic checks refine the quality control information by taking advantage of other available information. Examples of dynamic quality control checks include positional consistency, temporal consistency, spatial consistency and model consistency checks. In a consistency check an observation is compared with other parameter values to see if they are physically or climatologically consistent, either instantly or for time series according to adopted observation procedures. The check always includes two or more different parameters from a single station. In spatial checking the observation is compared with the expected value at the station, which can be estimated by various methods. Spatial checks involve parameter values of neighbouring stations, either by interpolation between observations by checking against numeric prognostic values (on the basis of values from many different stations), or by comparing statistics. The checks can involve more than one parameter at one point in time or single or single or multi-parameter analyses of time series.

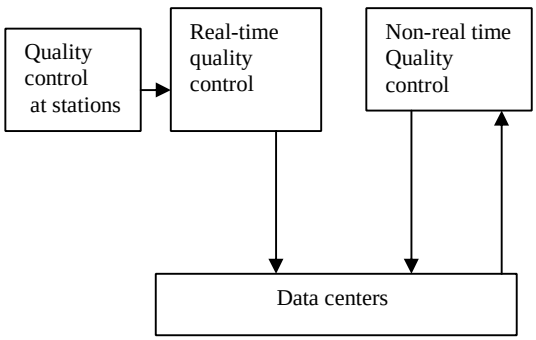

Figure 3. Example of quality control flow diagram

3.4 Quality control of Surface data

In case of manual observations, staffed stations and automatic weather stations, the observer or officer in charge at a station ensures that the data leaving the stations have been quality controlled and are provided with established procedures for attending to this responsibility. This is a specific function in addition to other maintenance and record-keeping functions that include internal consistency, climatological checks and temporal checks. All arithmetical and table look-up operations are explicitly checked.

3.5. Quality Control for Data centres

The checks that have already been performed on stations are usually repeated at provincial data centres, perhaps in more elaborate form by making use of automation. Data centres however have access to other network data, making a spatial check possible against observation from surrounding stations or against analysed or predicted fields, Figure 3.This is a very powerful method, and it is the distinctive contribution of a data centre. Data inhomogeneities are as far as possible prevented by appropriate quality management. Climatologists do run appropriate statistical programmes to link the previous data with the new data into homogeneous databases with a high degree of confidence. Information of this kind is commonly available as Metadata-information on data-also called station histories. Metadata is considered as an extended version of the station administrative record, containing all possible information on the initial setup, type and times of changes that occurred during the life history of an observing system.

3.6 Performance Monitoring

The management of a network or of a station is greatly strengthened by keeping continuous records of performance, typically on a daily and monthly schedule. There are several aspects to performance monitoring: -Advice from data centres are used to record the numbers and types of errors detected by quality control. Data from each station is compiled into synoptic and time-section sets. Such sets are used to identify systematic differences from neighbouring stations both in spatial fields and in comparative time series. Reports are obtained from field stations about equipment faults or other aspects of performance.

3.7 Network Management

All the factors that affect data quality are the subject of network management. In particular network management includes corrective action in response to the network performance revealed by quality control and performance monitoring. The manager keeps under review the procedures and outcomes associated with all the factors affecting quality including making sure that the quality control systems are essential operationally in any meteorological network and that it receives priority attention by the users of the data and by network management. Performance monitoring, equipment maintenance and inspection of field stations are commonly accepted as a network management function. Our administrative arrangements permit the network manager to take or arrange for corrective action arising from quality control, performance monitoring, the inspection programme or any other factor affecting quality.

4. CONCLUSION

Spatial analysis and data quality management of not only rainfall but also any other data is any on-going procedure at the Zambia Meteorological Department. The periodical analysis of rainfall data helps in monitoring, assessing and mitigating any impending flood or drought related disasters. The Data quality management system enhances quality control in data and geo-information acquisition at our National Meteorological Centre. In a world where every aspect of life is increasingly dependent upon scientific and technological progress, there should be no compromise on data quality management and quality control if we are to achieve sustainable development in all areas of human endeavours. Though the field of GIS has not yet reached the maturity stage in Zambia, the geo-spatial technologies that enhance data quality management and data quality control have been accepted as developmental tools in the effective utilisation of resources.

References

Mumba, Z.LS and Chipeta, G.B. 1984: Synoptic Aspects of rainfall in Zambia. Meteorological notes, series A No 20. Zambia Meteorological Dept., 20pp.

World Meteorological organisation, 1996: Guide to Meteorological Instruments and methods of observation (WMO No: 8), Geneva.

Miller, P.A and Morone, L.L.1993: Real- time quality control of hourly reports from the automated surface observing system. Eighth symposium of Meteorological observation and Instrumentation, America Meteorological Society.

Quality control and monitoring system: www-sdd-fsl.nooaa.gov/msas/qcms.html

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