Jal Vigyan Sameeksha—a publication of
High Level Technical Committee on Hydrology
Vol. IV, No. 2, December 1989

Analysis and Forecasting of Floods on Personal Computers

BHAGABAT P. PARIDA

Deptt. of Civil Engineering, Indian Institute of Technology, New Delhi – 110 016

Abstraet : *Analysis and forecasting of floods emerging from catchments generally between 100 and 10000 sq. kms or due to meteorologic phenomena at the coasts is of primary importance. Accurate and timely computation of forecasts need the help of computers. On going and recent advancements available on hardware and software has made Personal Computers (PCs) more popular and useful to meet the requirements. This paper discusses the developments available on PCs to deal with various issues associated with analysis and forecasting of floods.*

Introduction

Floods as potential disasters bringing in damages in form of loss to human and animal lives, crops and property worth billions of rupees have been well recognized over the years. Such continued damages, discomforts and threats have invited several management efforts both in form of structural as well as non-structural measures. While most of the structural measures relate to design and construction of local protection works, non-structural measures relate to issues of forecasts, flood-plain delineation/management, reservoir regulation, adoption of suitable cropping pattern and flood risk cover in flood prone areas besides other short-term and long-term strategies. From amongst these, issue of advance flood warning/forecasts probably is the most important task that concern the hydrologists even today.

Success of such a task primarily depends on two aspects viz. forewarning of likely flood magnitude and the reaction time available for the public to act. Accuracy of these aspects however depend on the type and nature of transformation that the input undergoes across the basin before its observation as flood. Therefore it needs a great deal of effort to understand all related physical processes that govern the system along with the available data, such that a close mathematical representation of the process can be formulated which can be used for forecasting.

Depending on the form of relationship that exist between the variables, number of such variables and their size considered, the above model formulations could be very complex. Solving these complicated formulations accurately and faster, need the help of computers. Further input to these models need collection, handling and processing of voluminous data which again need the use of computers.

To make such schemes viable, uniform formats and procedures of data storage and retrieval can be adopted and appropriate models can be implemented on relatively inexpensive and easily accessible computers using processed data. One such category of computers are the Personal Computers (PCs). This paper primarily looks at the applicability of PCs in forecasting

various issues associated with analysis and forecasting of floods as well as the applicability of PCs for such issues.

Floods and the Forecasting Issues

Runoffs resulting in inundation of banks, reservoirs and shores are usually connoted as floods. Even to some extent, runoffs posing threat or capable of creating hazards after propagation downstream can also be considered under this category.

Flows inundating river banks and reservoirs could result from natural phenomena such as thunder showers, cloud outbursts, snow melts or from artificial/man made causes such as faulty reservoir operation and breach of upstream controls. Whereas, coastal flooding usually occur due to wind generated waves, cyclonic storms or tidal surges. Management of these high magnitude episodic events therefore need prior knowledge of their magnitude and their time of arrival at the site of interest. To keep the damages due to floods to a minimum, activities such as issue of flood warnings, formulation of preparedness strategies and construction and regulation of reservoirs are necessary which in turn depend on either short-term or long-term flood forecasts.

Besides, forecasting issues associated with riverine and coastal flooding are different and hence need a different form of mathematical models as well as data in space and time.

In case of riverine flooding, it is the long duration rain, sustained snow melt, catchment thawing or a combination of them are usually responsible. Sometimes, high intensity short duration rains also cause conditions known as 'flash floods' and therefore need forecasts less than 3 hours called the 'now casting'. While most of the riverine flood forecast models may need hourly precipitation observations / estimates, antecedent moisture conditions or aerial snow coverage, the flashflood forecasting would need weather radar information to estimate temporal as well as aerial distribution of rainfall and hence it's response in time which may be of the order of minutes to a few hours.

Forecasts related with coastal flooding would need critical information on spatial antecedent wetness conditions of the land area, path of incoming typhoon as well as data that permit estimating storm rainfall in space and time. Such a system may need not only weather radar data but also telemetered rainfall observations, infrared satellite images, aerial photographs and cloud cover (Yates et. al. 1986) which assist in formulation of reliable flood forecasts.

The Analysis Phase

Basic work of analysis phase is gathering and analyzing data. More explicitly, analysis of any kind would need a meaningful data processing for use with decision based model to arrive at desired results. So, forecast formulation, may it be riverine or coastal floods, primarily depend upon analysis of observed/estimated data. This means, activities such as data processing, model identification, followed by calibration and validation form essential steps prior to use of models for forecasting. Many classification schemes are used to discriminate among models, which include physical and mathematical, continuous and discrete, dynamic and static, descriptive and conceptual and stochastic and deterministic models (Lindsey et. al, 1982).

Because of relative easiness in design often needing single type of data which are pronouncedly interdependent, stochastic models have been preferred. But the basic assumption that, future hydrologic behaviour will look statistically like the past, has restricted their use in short-term forecasting. For this reason a wide range of deterministic and physically based hydrologic models have drawn considerable attention and are used in flood forecasting. These type of models in addition have shown ability to

represent or reproduce typical characteristics specific to the watershed.

Another class of models are thought of as conceptual in that they conceptualize catchment features rather than attempt to represent spatial catchment physics directly. As reported by Fleming (1975), development of conceptual models and their use extensively require use of main frame computers. Table 1 gives a select list of models with their runtime and space requirement on various mainframes for simulation of one year data. However, each type of forecast model has strengths and limitations, depending on model design and data requirement.

Table 1 : Run Time Requirement of Various Conceptual Models

Model	User Partisan Core Size	Time Interval	Run Time (one year of stream flow)	Computer Used
a. Stanford IV	218 K	15m	27.73 sec.	IBM 370/155
b. Strathclyde	84 K	15m	40 min (approx.)	ICL 1905
USDAHL-70	80 K	Daily	3m 3 sec.	IBM 360/50
SSARR	250 K	6 hr.	11	IBM 360/67
INST. OF HYDRO., U.K.	36 K	3 hr.	3 sec.	ICL 1904/5

When first calibrating a model, assumptions are made about initial values of input parameters. If necessary, input parameters are varied until the fit between computed observed data is considered satisfactory. The model is then validated using historical records. Quality of input data is also important for model validation because adjustment of input parameters to meet bad data results in biases in forecast. Further, additional complexity of model to represent the non-linearity of system response has no guarantee of model accuracy and instead may reduce model adaptability and ease of use.

It is often observed that whatever model is used to model the flood response, some form of predictor-corrector scheme is needed. In sights into the nature and magnitude of such corrections are usually derived from the catchment physics and/or use of formal predictor-corrector schemes like the Kalman Filter with conceptual or deterministic models.

Why Personal Computers (PCs) ?

As already observed from the above paragraphs, success of flood forecasting depends on the following three aspects :

(i) Use of simple representative mathematical model which considers important physical, hydrologic and meteorological variables with a predictor-corrector scheme.

(ii) Use of reliable data through elimination of data inconsistencies.

(iii) Issue of forecasts for period less than the leadtime.

It may therefore be necessary to install microprocessor based data collection platforms and get data transmitted to base stations through radio signal/telemetry and archive them. These data then could be retrieved and used selectively by the developed models and the likely effect of any event disseminated through map displays

tabular/graphical forms or computer-worded messages.

Then the question is how to accomplish these objectives in time with reliability, and with cost-effectiveness. Probably the only answer is to use a cheaper, more general and flexible type of computer which can be easily accessible and does not need very select and sophisticated people to run it.

Looking back at the development of computers, 1960s witnessed the burgeoning of mainframe computers. Although such corporate machines were capable of tremendous processing speed and data storage, access to them was somewhat limited due to their wide non-availability and involvement of large computing and storage costs.

Invention of blue chips in the mid-sixties and their commercialization in the seventies brought in necessary platform for development of microcomputers and thereafter everything has been history.

Around 1975, the first group of microcomputers built on 8-bit CPU, with monochrome displays, 32–64 KB memory and 1 floppy disk drive of 180 KB capacity operating on CP/M (control program/microcomputers) from Digital Research or a stand alone BASIC operating system (O/S), was seen. Although these machines were relatively cheaper but were non-standard and had limited capabilities to support development of standard software To overcome such bottlenecks, IBM introduced microcomputers in 1981, built around standard micro processors like the INTEL 8088 CPU with an easy-to-use operating system - the Disk Operating System (DOS). Additional capabilities like 128 KB main memory, one or two floppy disk drives of 360 KB each and serial, parallel and cassette interfaces were available on these machines for better computing, storage, and porting of data and programs.

The next development was the introduction of PC/XT. It was equipped with a true 16 bit CPU, the Intel 8086, and had a larger main memory of 256 KB and hard disk storage capacity typically from 10 MB – 110 MB. The evolution continued thereafter in respect of hardware as well as the operating system to make them more user friendly, and capable of supporting varieties of customized software.

The original DOS version 1.0 primarily meant for single-user, single-tasking system was improved to MSDOS version 2,0 to enable hierarchical file system manipulation and later by MSDGS 3.0 and 4.0. In 1988, IBM and Microsoft introduced OS/2, which was a single user, multi-tasking O/S and was capable of concurrent running of one DOS application with more OS/2 application software. Besides, there were also developments on multi-user and multi-tasking operating systems, the most important of them being the UNIX.

Some microcomputers could be optionally equipped with an extra processor designed for specific purposes. Some best known types are the floating point co-processors like INTEL's 8087, 80287, and 80387. Mass storage in microcomputers, are either done through Winchester type hard disks of capacity typically from 10 MB – 300 MB and diskettes varying from 180 – 360 KB, 720 KB – 1.2 MB on 5 1/4" DSDD to 1.44 MB on 3.5" high density diskettes.

Some basic features that differentiate microcomputers from other category of computers are given in Table 2. The PCs (Personal Computers) usually are lumped into one of two overlapping categories, the micro and mini computers.

The 1989 PC runs the same programs as the original PC, but the computing power has increased upto 30 times, through step-wise introduction of 80186 and 80386 32-bits CPUs running at clock frequency of 6-8-10-12-16-20–25 MHZ. A present day 32-bit 80386

Table 2 : Classification of Computers (After Chapra and Canale, 1985)

System	Word length bits	Computing speed cycles/sec	Storage Capacity K
Programmable calculators	—	—	1 — 2
Microcomputers	7 — 16	10^6 — 10^7	16 — 256
Minicomputers	16 — 32	10^6 — 10^7	128 — 512
Mainframe	32	10^6 — 10^8	8000 — 32000

machine running at 25 MHZ with about 100-200 MB disk and 1.44 MB high density floppy disk drive and 3-4 MB RAM are comparable to some of the mainframes 5-10 years before and may even be more user friendly in many respects.

Further, computing power available on the present day PCs at very little cost, has encouraged packaged software growth. World wide financial input to the tune of $ 63.8 billion is anticipated in the year 1989 as against an outlay of $ 10.2 billion in 1984. Further, during this period percentage of investment on High End, Medium Scale and PCs are expected to change from 22, 63, and 15 to 17, 55 and 27 respectively (Capron, 1986).

Besides this development of some of the customized software on word processing spread sheet, database and business graphics there have other system software tools like pre-compilers. code generator, report generators, fourth generation language, split screen editors optimizing compilers and cross compiler. To explain their utility in brief, pre-compilers are very useful devices that convert programmer-generated shorthand code to full blown version of appropriate language, which helps in saving time. On-line code generators are programs often menu driven and operate in question / answer format: while report generators are special kind of code generator with special report parameter. Fourth generation languages being non-procedural are quite useful in the sense that the user has to convey only what is needed instead of how to accomplish the task. Split screen editors are useful in single user multi-tasking environment such that without interfering with a particular activity other tasks could be undertaken by exercising commands in the split screen. Most of the time, standard source codes are lengthy, hence. the object codes. The optimizing compiler in fact helps in generating highly efficient object code from standard source codes. When some programs are written in a language whose compiler is too large then such programs may not be easily handled on PCs. In such cases cross compiler could be used to generate object code that will run on a micro-computer. Although it is not yet definite, but estimates indicate, these software tools can provide cost saving as high as 30% due to improved efficiency.

Conclusions

For both flash and longer duration floods, more than sufficient computing capability exists in PCs of the advanced technology variety, described above, to handle data and modelling needs of hazard forecasting situation. Support of advance software tools snd ability to store and retrieve expert knowledge and interpret results of analysis have been of additional assistance to forecasters in handling complex formulations. Such usefulness, without sacrifice to the quality and timeliness of forecast has brought in preferences in favour of use of PCs

for analysis and forecasting of floods. With the advancements and generalisation taking place in respect of PC hardware and software. together with developments in computer communication, it may not be long before one notices a network of PCs in all flood warning centres. To avoid many problems of duplication and make use of additional storage, specific software and features available on mainframe, probably a PB-Mainframe connection could work out better.

References

1. Capron, H.L., (1936), System Analysis and Design, The Benjamin/Cummings Publication Co. Inc., California.

2. Chapra, S.C, and Raymond P. Canale (1985). Numerical Methods for Engineers with Personal Computer Applications McGraw Hill Inc., New York.

3. Fleming. G. (1975), Computer Simulation Teehniques in Hydrology. Elsevier, New York.

4. Linsley, R.K., Jr., M.A. Kohler and J.L.M. Pauchlus (1982), Hydrology for Engineers, McGraw Hill, New York.

5. Yates, M., A. Strong, D. McGinnis, Jr. and D. Taipley (1986). Teresstrial Observations from NOAA Operational Satellites, Science, 31 Jan., 436–470.