Return to Main Table of Contents

TOPAZ OVERVIEW

TABLE OF CONTENTS

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Return to Table of Contents

1. EXECUTIVE SUMMARY

TOPAZ (TOpographic PArameteriZation) is a software package for automated analysis of digital landscape topography. A raster digital elevation model (DEM) is used by TOPAZ to identify and measure topographic features, define surface drainage, subdivide watersheds along drainage divides, quantify the drainage network, and calculate representative subcatchment parameters. TOPAZ is designed primarily to assist with topographic evaluation and watershed parameterization in support of hydrologic modeling and analysis. A variety of geomorphological, environmental and remote sensing applications can also be addressed with TOPAZ. The purpose of this report is to provide a brief overview of the methods used in TOPAZ; limitations and capabilities of the software; TOPAZ organization and operation; input requirements and output; and, available documentation.

The overall objective of TOPAZ is to provide a comprehensive evaluation of the digital landscape topography with particular emphasis on maintaining consistency between all derived data, the initial input topography, and the physics underlying energy and water flux processes at the landscape surface. TOPAZ overcomes some limitations of existing DEM processing methods and includes a number of new topographic processing features that are relevant to hydraulic and hydrologic analyses. The interface to other software packages such as Geographic Information Systems (GIS) or hydrologic models is provided through generated output files.

Output from TOPAZ consists of attribute tables and rasters of spatial data. Attribute tables provide the properties of individual channel links and subcatchments, as well as information on the overall channel network structure. These tables are for user analysis or input into traditional distributed hydrologic models. Raster data include digital maps of the channel network, subcatchments and other spatial topographic and hydrologic characteristics. TOPAZ does not include raster display capabilities. The raster maps can be readily imported into a user-selected GIS to utilize its internal image display, data manipulation and raster algebra functions.

Examples of TOPAZ applications include: drainage network generation and watershed segmentation (Garbrecht and Martz, 1993; Garbrecht and Martz, 1997a; Garbrecht and Martz, 1997b); analysis of DEM resolution on generated network and subcatchment characteristics (Garbrecht and Martz, 1994; Bingner et al., 1997a); flownet generation and subcatchment parameters quantification for the Agricultural Non-Point Source model (AGNPS) (Bingner et al., 1997b); and, a hydrologic model interface between TOPAZ and the SLURP hydrologic model. The interface is distributed with the SLURP model and has been applied for irrigation system development in Turkey and for the analysis of scaling effects in the Canadian GEWEX research program (Pietroniro et al., 1998; Lacroix and Martz, 1998).

Return to Table of Contents

2. INTRODUCTION

Topography is important to the description, quantification and interpretation of many biosphere processes. Examples of such processes in the field of hydrology include: surface runoff and water storage, energy fluxes, evapo-transpiration, soil erosion and snow metamorphosis. Extracting topographic information for a watershed by traditional, manual techniques can be a tedious, time consuming, subjective, and error-prone task, particularly for large watersheds. Research over the past decade has demonstrated the feasibility of extracting topographic information directly from raster Digital Elevation Models (DEM). In the field of water resources and hydrology, automated evaluation of DEMs has focused on watershed segmentation, definition of drainage divides and identification of the drainage networks. This automated extraction of network and subwatershed properties from DEMs represents a convenient and rapid way to parameterize a watershed. The increasing commercial availability of DEM coverage for many areas of the United States and advances in DEM processing makes an automated approach to watershed parameterization a practical and useful alternative to manual techniques. Automated techniques also have the advantage of generating digital data that can be readily imported and analyzed by Geographic Information Systems (GIS).

The TOPAZ software (TOpographic PArameteriZation) is a digital landscape analysis tool that provides comprehensive processing and evaluation of raster DEMs to identify topographic features; measure topographic parameters; define surface drainage; subdivide watersheds along drainage divides; quantify the drainage network; and, calculate representative subcatchment parameters. TOPAZ emphasizes consistency between all derived data, the initial input topography, and the physics underlying energy and water flux processes at the landscape topography. The primary objective of TOPAZ is to support hydrologic modeling and analysis, but it can also be used to address a variety of geomorphological, environmental and remote sensing applications. TOPAZ is not a GIS in the traditional sense, but is a system of software programs that performs numerical processing of raster DEMs and produces a number of data layers and attribute tables. Data layer algebra and monitor display capabilities are not included in TOPAZ. For such functions TOPAZ relies on a user-selected GIS. The interface to a GIS is provided through generated raster files.

The purpose of this report is to provide an overview of the fundamental concepts, capabilities and limitations of the software; underlying methods and models; organization and operation of the software; input requirements and output; and, available documentation.

Return to Table of Contents

3. FUNDAMENTALS AND PROGRAM CAPABILITIES

3.1 Fundamental concepts

The DEM processing in TOPAZ (TOpographic PArameteriZation) is based on the D8 method, the downslope flow routing concept, and the critical source area (CSA) concept. The D8 method (Douglas, 1986; Fairfield and Leymarie, 1991) defines landscape properties for each individual raster cell by the evaluation of itself and its 8 immediately adjacent cells. The downslope flow routing concept defines the drainage and flow direction on the landscape surface as the steepest downslope path from the cell of interest to one of its 8 adjacent cells (Mark, 1984; O'Callaghan and Mark, 1984; Morris and Heerdeger, 1988). The CSA concept defines the channels draining the landscape as those raster cells that have an upstream drainage area greater than a threshold drainage area, called the critical source area (CSA). The CSA value defines a minimum drainage area below which a permanent channel is defined (Mark, 1984; Martz and Garbrecht, 1992). The CSA concept controls the watershed segmentation and all resulting spatial and topologic drainage network and subcatchment characteristics.

These methods and concepts have been applied previously in DEM processing algorithms (above references and: Jenson and Domingue, 1988; Martz and DeJong, 1988; and others). TOPAZ builds upon and extends that work. A number of the limitations of previous work with respect to drainage identification in depressions and over flat surfaces have been overcome in TOPAZ, and a number of new features have been added to address specific hydrologic and hydraulic needs (Garbrecht and Martz, 1996). TOPAZ is designed to provide interrelated landscape analysis functions and to rely on an external, user selected GIS for image display, as well as for additional data manipulation and raster algebra operations. Within this general framework, the digital elevation data is processed in TOPAZ by a system of interdependent computational programs. The analytical operations performed by these programs achieve three broad functions: (1) elevation data pre-processing, (2) hydrographic segmentation, and (3) topographic parameterization.

3.2 Elevation Data Pre-processing

DEMs commonly contain localized depressions and flat surfaces, most of which are artifacts of the horizontal and vertical DEM resolution, DEM generation method, and elevation data noise. These features are problematic for the downslope flow routing concept on which many DEM processing models, including TOPAZ, are based. Depressions are sinks at the bottom of which drainage terminates, and flat surfaces have indeterminate drainage. Therefore, TOPAZ pre-processes the input DEM to rectify these features and allow the unambiguous determination of the drainage over the entire digital landscape. Rectifications made during DEM pre-processing are strictly limited to cells of depressions and flat surfaces so as to minimize the impact on the overall information content of the elevation data.

Among the innovative capabilities provided by TOPAZ is the ability to distinguish between two types of depressions: sink-depressions and impoundment-depressions. Sink- depressions are caused by a group of raster cells at lower elevation than the surrounding landscape, and impoundment-depressions are caused by a narrow band of raster cells of higher elevation across drainage paths, similar to an obstruction or dam across a stream. In the latter situations, TOPAZ can lower selected DEM elevation values to simulate breaching of the obstruction or dam across the drainage path. This removes or reduces the size of the impoundment-depression. Any remaining depression after the breaching is considered to be a sink-depression. Sink depressions are treated in the conventional manner by raising the elevations within the depression to the elevation of its lowest (breached) overflow (Martz and Garbrecht, 1998).

The flat surfaces produced by this depression-filling, as well as those inherent to the DEM, such as level valley floors or plateaus at drainage divides; require further rectification to ensure unambiguous downslope drainage at every location in the DEM. In TOPAZ, this is achieved through a relief imposition algorithm which takes into consideration the rising and falling topography surrounding the flat surfaces to generate a realistic, topographically consistent and convergent drainage over those surfaces. Arbitrary drainage direction assignment is minimized because the topography surrounding the flat surface controls the relief imposition and drainage determination. The DEM that has been rectified for depressions and flat surfaces is the basis for all subsequent topographic evaluations (Garbrecht and Martz, 1997a).

3.3 Hydrographic Segmentation

Hydrographic segmentation identifies the channel network, the upstream and lateral subcatchments contributing flow to each channel link in that network and corresponding drainage divides. The drainage over the digital landscape is first determined as the steepest downslope path from each raster cell to one of its 8 adjacent cells. The upstream drainage area at each raster cell is then determined using the downslope flow routing concept, and the channel network is defined as those cells with an upstream drainage area greater than a user-defined critical source area (CSA) value. The critical source area is the drainage area at which a permanent channel begins. The network identified in this way is a fully- connected, convergent and uni-directional downslope channel network.

One of several innovations in TOPAZ is the capability to generate a hydrographic segmentation and channel network with spatially varying characteristics; that is, the network structure, drainage density and subcatchments properties can be different in different parts of the watershed. This capability is used to account for spatial variation in hydrologic controls such as geology, soil type, vegetation and/or climate. TOPAZ can also prune very short, and likely spurious, exterior channel links from the generated channel network.

The above capabilities allow the generation of channel networks of different density and resolution to meet the scale, needs and purpose of a particular application. For example, the same drainage network can look quite different when examined on topographic maps of different scales. This different network density/resolution can be reproduced by TOPAZ by either generating all large and small channels within the landscape, only the largest channels, or a network between these two extremes. Once the channel network has been fully defined, it is further processed to determine the Strahler order of each channel link and to assign an identification number to each network node and channel link (Garbrecht and Martz, 1997b). These identification numbers are used to determine the optimal routing sequence for cascade-type flow routing through the channel network (Garbrecht, 1988).

Subcatchments represent the direct contributing drainage areas of the left and right side of each channel link, and of the source node or upstream end of each exterior link or 1st order channel. Subcatchments and corresponding divides are determined from the previously defined drainage pattern and channel network. Also, subcatchment identification numbers based on network node and channel link identification numbers are assigned to provide the topological relationship between network nodes, channel links and subcatchments.

3.4 Topographic Parameterization

Topographic parameterization involves measuring a variety of properties and parameters of the DEM raster and of the derived channel network, channel links and subcatchments. Spatial parameters, such as rectified elevations, landscape slope and aspect, drainage pattern, channel network and subcatchment boundaries, are generally stored in raster format and are available for visual display using an external GIS. On the other hand, parameters that describe specific features of the landscape, such as the geometry of a channel link or subcatchment, are stored in tabular format. Examples of channel network parameters include number of channel links, total channel length, subcatchment area, drainage density and network composition parameters. Examples of channel link parameters include link length, slope, elevation, upstream and lateral drainage area, and topologic connectivity information. Examples of subcatchment parameters include representative drainage area, length, slope, aspect distribution and overland flow distance. A complete list of computed properties and parameters can be found in the documentation of individual TOPAZ programs.

Raster derived channel networks often contain junction nodes with more than two inflows. Such junction nodes are referred to as complex junction nodes. Complex junction nodes very seldom occur in nature. Tributaries joining a main stem generally are spaced along the main stem, though the spacing between junctions can occasionally be small. Complex junctions in generated raster channel networks can be common. They are the result of a low horizontal DEM resolution that cannot resolve the spacing between two or more consecutive tributary junctions, thus lumping multiple junctions together into a single cell. A TOPAZ feature allows the decomposition of complex junction nodes into a sequence of simple junction nodes (only two inflows per junction) at a sub-raster resolution. The resulting channel network is called a binary channel network because it always has 2 upstream inflows per junction. The binary channel network is believed to be a better approximation of natural channel networks because it overcomes the effects of systematic lumping due to limited raster resolution. At the user's choice, properties and parameters of the binary channel network and corresponding channel links and subcatchments are computed and tabulated in a manner similar to that for the raster channel network, channel links and subcatchments.

In addition to computing the parameters of each channel link and subcatchment, TOPAZ evaluates the mean and standard deviation of these parameters over the entire channel network, as well as by Strahler order. Topaz also computes the drainage network composition parameters. The entire statistical evaluation is performed for both the raster and binary channel networks.

3.5 Assumptions and Limitations

General assumptions and limitations of the D8 method, the downslope flow routing concept, and the CSA concept, as described in O'Callaghan and Mark (1984), Douglas (1986), Fairfield and Leymarie (1991), and Costa-Cabral and Burges (1994), apply. Also applicable are assumptions and limitations pertaining to DEM resolution (vertical and horizontal) and finite (raster) representation of landscape elevations. Of particular significance for TOPAZ are the following four assumptions/limitations:

a) the DEM must be of sufficient vertical and horizontal resolution to allow the identification and parameterization of the channel network, subcatchments and other landscape features of relevance;

b) local drainage and flow direction can adequately be defined by 8 directions: 4 diagonal to and 4 in the principle raster directions;

c) upstream drainage areas and drainage paths are adequately described by downstream flow routing from one cell spilling onto another adjacent cell in the direction of steepest descent;

d) the channel network is adequately described by all cells that have an upstream drainage area above a user specified threshold drainage area, the CSA parameter;

e) representative values of distributed subcatchment properties are quantified based on models that define the reduction of distributed values of the properties into single representative values.

The above five assumptions/limitations do not inhibit the numerical processing of DEMs by software TOPAZ; they only impact the quality and usefulness of the TOPAZ produced data.

The major implications of the above four assumptions are discussed in the following:

Assumption a):

Landscape features of relevance must be several times the size of a raster cell to be uniquely identifiable and lend themselves to parameterization. For example, DEM elevation cannot represent thalweg elevation of incised channels that are narrower that the horizontal DEM resolution. As a result, computed drainage reflects general terrain disposition and not necessarily unresolved channel paths, unless both happen to coincide. Also, the geometric characteristics of a subcatchment cannot be accurately estimated if the subcatchment size is small and the effects of the finite raster representation significantly impacts the geometric measure under consideration.

Assumption b):

The drainage direction at a single cell can be in error by a much as 22.5 degrees. However, in dissected landscapes with convergent drainage patterns, the general drainage direction over a distance of several cells is relatively well reproduced because drainage paths are defined by topography and not by flow directions at a single cell. Drainage directions for plane, undissected hillslopes are the most susceptible to larger approximation errors.

Assumption c):

The drainage over the digital landscape is only suitable for flow analysis using forward-marching routing schemes (i.e. kinematic cascade approach), and runoff conditions without significant backwater or tidal effects. Assumption c) also allows for only one downstream path out of each cell. Therefore, divergent and braided drainage patterns cannot be modeled.

Assumption d):

The critical source area (CSA) defines the beginning of source channels (1st order channels). However, the latter often display random and systematic variations due to spatial variations in topography, soil, geology and vegetation, among others. The CSA concept cannot account for random variations. However, systematic spatial variations can be modeled in TOPAZ by use of a spatially variable CSA parameter.

Assumption e):

For a particular distributed subcatchment property there can exist several different representative values depending on the model selected for reducing the distributed values of the property into a representative value. The user must select the model that is consistent and valid for his/her particular application. The user should also be aware of the magnitude of the difference in representative values due to alternative property reduction models.

An additional assumption is that depressions and flat surfaces in the digital landscape are spurious and can be rectified to allow an unambiguous determination of downslope drainage (assumption c). Therefore, landscape drainage properties associated with true depressions (or lakes) at the bottom of which downslope drainage terminates cannot be generated directly.

As a result of assumptions a), b) and c), the landscape under consideration must be dissected by channels and display sufficient relief to define downstream flow paths. Also, the DEM must be of sufficient resolution to adequately define these drainage features. In general, the data produced by TOPAZ adequately represents most natural landscapes given sufficient DEM resolution. Man made drainage features in natural landscapes can be evaluated if they are incorporated into the DEM elevations.

Return to Table of Contents

4. TOPAZ SOFTWARE

TOPAZ (TOpographic PArameteriZation) Vers. 3.1 is written in ANSI standard FORTRAN 90. TOPAZ can be applied on most computer platforms, and, provided sufficient memory is available, can easily handle large DEMs. This section briefly describes each TOPAZ program, the organization of the programs, hardware/software requirements, input requirements and output, and the status of code and documentation availability. Tables and figures referred to in the following text are reproduced at the end of this document in Sections 6 and 7, respectively.

4.1 TOPAZ Programs

4.1.1 Program DEDNM

Program DEDNM (Digital Elevation Drainage Network Model) reads and checks the initial input DEM data; pre-processes the elevation data to rectify depressions and flat surfaces to allow an unambiguous definition of downslope drainage; performs the hydrographic segmentation that defines the watershed boundary, the raster drainage network and corresponding channel links and subcatchments; assigns the channel link and subcatchment identification indices; and, tabulates the channel link and subcatchment properties and parameters.

4.1.2 Program RASPRO

Program RASPRO (RASter PROperties) derives additional spatial landscape information and parameters from the basic rasters produced by program DEDNM (Section 4.1.1). Examples of raster information include, but are not limited to, location and extent of depressions and flat surfaces in the DEM; elevation reclassification into user specified classes; alternative evaluations of raster cell slope and aspect; distances to the next channel and to the watershed outlet; elevation drop to the next channel and to the watershed outlet; enhancement of the visualization of channel network and drainage divides; and, aggregation of all subcatchments draining directly into one channel link into a single direct contributing area for that channel link.

4.1.3 Program RASFOR

Program RASFOR (RASter FORmatting) is a raster reformatting utility. It reads the unformatted raster files produced by programs DEDNM (Section 4.1.1) and RASPRO (Section 4.1.2), and reformats this raster data into either ASCII or GIS specific files. The implemented formats at this time are two ASCII formats (1-D and 2-D), and two GIS formats (IDRISI and ARC/INFO).

4.1.4 Program RASBIN

Program RASBIN (RASter to BINary network) transforms a raster based drainage network definition into a binary (2 inflows per junction) drainage network definition by decomposing complex junction nodes into a sequence of simple junction nodes (2 inflows per junction); assigns channel link and subcatchment indices to the binary network; computes the optimal sequence for cascade-type flow routing through the binary network; and, tabulates the channel link and subcatchment properties and parameters for the binary network.

4.1.5 Program NSSTAT

Program NSSTAT (Network and Subcatchment STATistics) computes the mean and standard deviation of the channel link and subcatchment properties for both the raster and binary channel network. Program NSSTAT also computes subcatchment and channel network properties and parameters such as watershed drainage area, number of channel links, drainage density and network composition parameters.

4.1.6 Program PARAM

Program PARAM (PARAMeterization) computes representative subcatchment properties and parameters from the rasters produced by programs DEDNM (4.1.1) and RASPRO (4.1.2). Examples are representative slope alternatives, overland-flow travel distance, and aspect distribution for subcatchments.

4.2 TOPAZ Organization

The TOPAZ programs are interdependent in as far as the output of one program is used as input into another (Figure 4.1). The exception is program DEDNM which accepts only user provided data and does not depend on input from any other program. Because of program interdependence, the sequence in which the programs are executed is important for proper TOPAZ operation. Program DEDNM is always evaluated first followed by either of the three programs RASBIN, RASPRO or RASFOR, as indicated by the arrows in Figure 4.1. If the user chooses to exercise program RASPRO, then program RASFOR should be executed after program RASPRO. Similarly, program NSSTAT can only be used when program RASBIN has been executed. Program PARAM execution depends on output data from programs DEDNM and RASPRO and cannot be executed until the latter two have been executed. The arrows in Figure 4.1 define the data flow and can be used to identify model execution sequences.

4.3 TOPAZ Hardware/Software Requirements

TOPAZ Vers. 3.1 is written in ANSI standard FORTRAN 90. The coded and executable versions of the software are provided to the user. The coded version must be compiled by the user with a suitable FORTRAN 90 compiler. RAM memory and disk storage requirements for TOPAZ depend on the size of the application DEM. Minimum recommended RAM memory is 8 mega-bytes which is adequate for DEM raster of 500 rows and columns or smaller. For applications with DEMs having over 500 rows and columns, the size of the RAM memory to run TOPAZ can be roughly approximated by the following equation.

$$MEM = 25*(NROW*NCOL) / 1048000$$

Where MEM is about the required RAM memory in mega-bytes (+-10%), NROW and NCOL is the DEM size specified in the program input file. If the user chooses to aggregate or resample the DEM, then NROW/NCOL refers to the aggregated or resampled DEM size. Alternatively, TOPAZ can be run under an operating system that relies on virtual memory methods.

TOPAZ runs on most hardware platforms and it has been installed on IBM compatible PCs under MS-DOS, Windows 3.1, Windows 95/98, NT 4.0, workstations with UNIX operating systems, and mainframes. The executable version of Topaz is specifically for Windows 95/98 environments. Provided sufficient RAM memory and disk storage is available, it can easily handle large DEMs. TOPAZ has been used with DEMs of up to 2000 by 4000 rows and columns. If RAM memory and disk storage is limited, the user can instruct TOPAZ to aggregate or resample the DEM raster during input of the DEM and run the application on the reduced raster size.

Disk storage requirements depend on the size of the application DEM and user output options. A rough estimate of disk storage for a complete output can be obtained by the following equation.

$$STOR = 200*(NROW*NCOL) / 1048000$$

where STOR is about the required disk storage in mega-bytes (+-10%) when the user elects to save all output files, and NROW/NCOL is the number of rows/columns of the DEM. If the user chooses to aggregate or resample the DEM, then NROW/NCOL refers to the aggregated or resampled DEM size.

4.4 TOPAZ Input Requirements

TOPAZ requires input of the DEM of the watershed, DEM characteristics, DEM processing options and data output options. Most important for hydrographic landscape segmentation and channel network generation are two user-provided network parameters: the critical source area (CSA), and the minimum source channel length (MSCL). These two parameters control the topology and properties of the network and subcatchments generated by TOPAZ. For example, as the CSA parameter is increased drainage density of the generated network decreases, and as the MSCL parameter is increased short source channels (1st order channels) are removed. The user can estimate the CSA and MSCL parameters from maps or field surveys, or select their value to fit the scale and resolution of the particular application under consideration. Fine tuning of these values by calibration may be necessary to reproduce observed spatial variability. Also required is the identification of the watershed outlet location so that the corresponding watershed boundary, as well as the network, channel link and subcatchment properties within this boundary, can be generated and evaluated by TOPAZ. Table 4.1 gives a general listing of required input parameters and a detailed listing of individual input parameters is provided in the User Manual.

4.5 TOPAZ Output

The output from TOPAZ consists of report files, evaluation files, tables and raster data.

Report files provide a summary of the program execution for each program. They include a listing of the input and user options, the tasks performed by the programs as they are completed, and warning and error messages.

Evaluation files print the results of specific evaluations such as the statistics of the channel links or subcatchments.

Tables provide lists of attributes for channel links and subcatchments. They contain data that is often needed in hydrologic applications and distributed models of landsurface- processes. A list of important channel link and subcatchment properties that are generated by TOPAZ is given in Table 4.2 and 4.3, respectively.

Rasters represent data layers of spatial topographic, network and subcatchment attributes. These rasters can be imported into a GIS for display, overlay analysis and further processing. A list of rasters generated by TOPAZ is given in Table 4.4.

4.6 Data Editing and Interface to Other Software

The consistency between derived data, the initial input topography, and the physics of energy and water flux processes at the landscape surface is assured by designing TOPAZ as a self-contained system that does not allow direct data editing or manipulation by the user within TOPAZ. Interface to other software packages and utilities, such as editors, GIS and hydrologic models, is through external data files only. Selection of pertinent data items, as well as restructuring and editing of the data for specific application, must be done by the user outside of TOPAZ.

4.7 Status of Code and Documentation for TOPAZ Vers. 3.1

The release of TOPAZ Vers. 3.1 include programs DEDNM, RASPRO, RASFOR, RASBIN, NSSTAT and PARAM. TOPAZ documentation includes this Overview, an Installation Guide and a User Manual. The models, procedures and algorithms for the raster processing and parameter evaluation are described in the journal publications. The most relevant publications are listed in the reference section (5).

4.8 List of changes and additions from the previous TOPAZ Version 1.22

The most significant changes and additions in TOPAZ Vers. 3.1 include:

- This TOPAZ Version 3.1 is the first version that was written in the FORTRAN 90 software language. The basic operation of this version is similar to TOPAZ Version 1.22.

- The capabilities of TOPAZ Version 3.1 have been increased with the addition of program PARAM. The expanded TOPAZ capabilities include calculation of representative subcatchment lengths, slope alternatives, area and aspect distribution.
- Rasters containing flow travel distance and elevation drop have been added.
- Array size definition in FORTRAN 90 is dynamic and is automatically assigned by the program. No user intervention is required.
- Selected algorithms have been streamlined and are faster.
- The source code must be compiled by the user with a suitable FORTRAN 90 compiler. An executable version of software TOPAZ is made available for Windows 95/98/XP operating systems.

4.9 Software Availability

The source code of software TOPAZ and manuals are available free of charge upon written request. The request should include:

your name
address
phone
fax
email
we would appreciate a brief description of your intended application of TOPAZ

Send request to:

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Return to Table of Contents

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Return to Table of Contents

6. TABLES

Table 4.1. General list of input data required for TOPAZ

Program DEDNM

*** General information

The information consists of a title of the current application for printing in output files.

*** DEM raster characteristics

The basic characteristics of the input DEM consist of: optional UTM coordinates if known; number of rows and columns of the input DEM; minimum and maximum elevation values of the input DEM; elevation values that identify indeterminate elevations; orientation of the DEM; and, approximate or estimated row and column number that defines the watershed outlet.

*** DEM processing options and parameters

Processing options include options for reduction of the input DEM by aggregation or resampling, the smoothing of the DEM, and, the breaching/depression filling option. In addition, Critical Source Area (CSA) and Minimum Source Channel Length (MSCL) parameter must be provided. A user option is also available to perform a detailed raster quality control/error checking.

*** User output options

The user output options define the desired tabular and report output files from TOPAZ.

*** Input DEM

The input DEM is a Raster file that contains the elevation data of the DEM in meters. The format of the elevation data is one value per record, ordered column first, row second. Column first, row second means that the raster values are ordered in increasing column number for row 1, followed by those of row 2, etc.

Program RASPRO

*** Raster processing options

The user options to process raster data include: location and extent of depressions and flat surfaces in the DEM; elevation reclassification into user specified classes; alternative evaluations of raster cell slope and aspect; distances to the next channel and to the watershed outlet; elevation drop to the next channel and to the watershed outlet; enhancement of the visualization of channel network and drainage divides; and, aggregation of all subcatchments draining directly into one channel link into a single direct contributing area for that channel link.

Program RASFOR
*** Raster output options
The input consists of the selection of the raster file conversion format and the identification of the files that are to be converted.

Program PARAM
*** Subcatchment parameterization options
User options include the calculation of representative area and slope alternatives and overland-flow travel distance for the subcatchments.

Program RASBIN and NSSTAT
*** No user input required

Table 4.2. List of important channel link characteristics provided by TOPAZ.

- Channel link index;
- Index of upstream inflowing channel links;
- Index of downstream channel link;
- Channel link node code (source, junction or outlet);
- Sequence number of a channel link for cascade type flow routing;
- Strahler channel link order;
- Coordinates a channel link;
- Elevation of a channel link;
- Channel link length;
- Channel link slope;
- Upstream drainage area of a channel link;
- Direct drainage area into a channel link.

Table 4.3. List of important subcatchment characteristics provided by TOPAZ.

There are two lateral subcatchments per channel links, and one upstream subcatchment for source channels (1st order channels).

- Subcatchment index;
- Strahler order of the channel link the subcatchment drains into;
- Area of the subcatchment.
- Slope of the subcatchment.
- Mean overland water-flow distance to channel.

Table 4.4. List of rasters provided by TOPAZ.

- DEM input elevation raster;
- CSA and MSCL input code raster;
- Smoothed DEM elevation raster;
- Depression filled DEM elevation raster;
- Drainage rectified DEM elevation raster;
- Flow vector raster;
- Flow path definition raster;
- Upstream drainage area raster;
- Drainage network raster for full coverage;
- Watershed boundary raster;
- Drainage network within watershed boundary;
- Subcatchment definition raster;
- Depression and flat area definition raster;
- Raster of elevations reclassified into bands of equal elevations;
- Raster of flow vector aspect;
- Raster of terrain aspect;
- Raster of flow vector slope;
- Raster of hydraulic slope;
- Raster of terrain slope;
- Distance to next downstream channel;
- Distance to watershed outlet;
- Elevation drop from subcatchment cell to next downstream channel;
- Elevation drop from subcatchment cell to watershed outlet;
- Raster of enhanced network (for display only);
- Raster of subcatchment boundaries (for display only);
- Aggregated subcatchment definition raster;
- Raster of aggregated subcatchment boundaries (for display only).

Return to Table of Contents

7. FIGURES

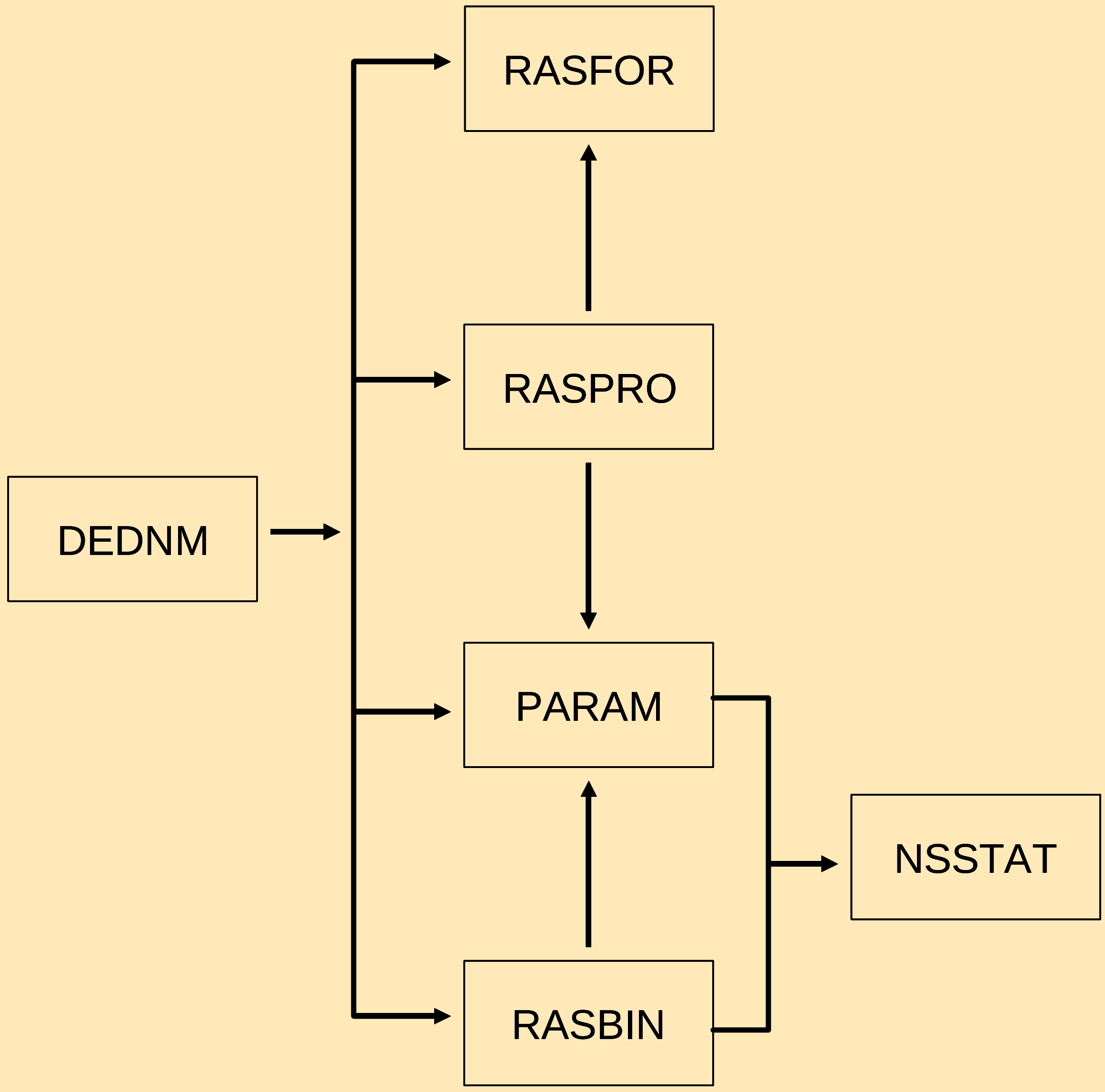

Figure 4.1 Data flow and execution sequence diagram for TOPAZ programs.

Return to Table of Contents