



## Reservoir Modeling with GSLIB

# Introduction to GSLIB

- Answers to Some Commonly Asked Questions:
  - What is GSLIB and how do I get it?
  - How do I get it to work?
  - What are the strengths and weaknesses of GSLIB?
  - What is the future of GSLIB?
  - What about user support?
  - Are there any restrictions on its use?
- Alternatives and Supplements to GSLIB
- Geostatistical Reservoir Modeling
- GSLIB Preliminaries



# What is GSLIB?

- GSLIB is an acronym for **Geostatistical Software LIBrary**. This name was originally used for a collection of geostatistical programs developed by students and faculty at Stanford University over the last 15 years.
- The original GSLIB inspired the writing of *GSLIB: Geostatistical Software Library and User's Guide* by Clayton Deutsch and André Journel during 1990 - 1992. This publication (available for about \$50 from Oxford University Press) contains a CD and a user's guide for code based on the original GSLIB.
- Executables and source code available at [www.gslib.com](http://www.gslib.com)
- Most of the original GSLIB code was rewritten for uniformity and new programs were added during development
- A second edition was completed in March, 1997
- Executables available at [www.gslib.com](http://www.gslib.com)
- A third edition is planned for 2002



# How do I get it to work?

- There are 39 FORTRAN programs on the GSLIB CD-ROM
- Download executables for PC
- You should have a FORTRAN compiler
- You may need to edit some of the included files to increase the allowable number of data and grid sizes (FORTRAN 90 version overcomes this problem)
- Data files are ASCII flat files
- Parameter files are ASCII files (see example on page 12 of this lecture)



# What are the strengths and weaknesses of GSLIB?

## Strengths:

- one of the most comprehensive geostatistical packages available
- source code is provided
- flexible and portable

## Weaknesses:

- no user support
- the user interface is not “friendly”
- limited object-based modeling capability

Toolbox and not an integrated package



# What is the future of GSLIB?

second edition is just finished -- bug fixes and minor changes for a few years

# What about user support?

there is none

# Are there any restrictions on the use of GSLIB?

acknowledge where it came from



# Alternatives and Supplements to GSLIB

- There are commercial modeling packages
- There are some GSLIB add-ons and GUIs developed at different places ...
- A good statistical analysis package would be a useful supplement
- A contouring / mapping package would be useful
- There are some additional SCRF software such as variogram modeling and 3-D model display that would be useful

## Warning / Disclaimer

- Reservoir modeling requires a sound geological understanding of the reservoir, an appreciation for the quality of the available data, an understanding of the objectives of the modeling exercise, and so on. This course does not teach reservoir modeling; the goal is to make you more familiar with the tools in GSLIB that may be helpful in a reservoir modeling / geostatistical study.



# Programs in GSLIB (1)

- PostScript plotting utilities (histograms, probability plots, Q-Q/P-P plots, scatterplots, location maps, gray/color scale maps)
- Utility Programs:
  - cell declustering
  - data transformation
  - IK manipulation: order relations, change of support,  $p$  or  $q$  values,  $E$ -type estimate,
  - other theoretical indicator variograms from multiGaussian distribution, linear system solvers, data calibration (Markov-Bayes), ...
- Measures of spatial continuity (Variograms):
  - direct and cross variograms of any # of variables
  - 1,2, or 3-D regular or irregular spaced data
  - many different measures (traditional semivariogram, non-ergodic covariance / correlogram, relative (general and pairwise) variograms, madogram/rodogram, indicator)



# Programs in GSLIB (2)

- Kriging:
  - 1,2 or 3-D grid kriging, cross validation, jackknifing
  - SK, OK, UK, kriging with external drift
  - cokriging
  - indicator kriging
- Stochastic Simulation:
  - Gaussian methods (LU matrix method, sequential)
  - Indicator methods (cosimulation, Markov Bayes)
  - Boolean simulation
  - Simulated annealing
  - P-field simulation





# GSLIB Preliminaries (1)

- The latest *Stanford* geostatistical algorithms
- All source code is (almost) ANSI Standard FORTRAN 77
- Tested on IBM compatible PC's, SGI, DEC, SUN, HP ...
- Requirements: FORTRAN compiler, basic programming skills, and some idea of what you are after.
- Complete with main programs which all require a prepared parameter file.
- Intended to be the foundation for custom programs.



# GSLIB Preliminaries (2)

- Input/Output files are ASCII flat files compatible with Geo-EAS and the Geostatistical Toolbox:

2d data file example:

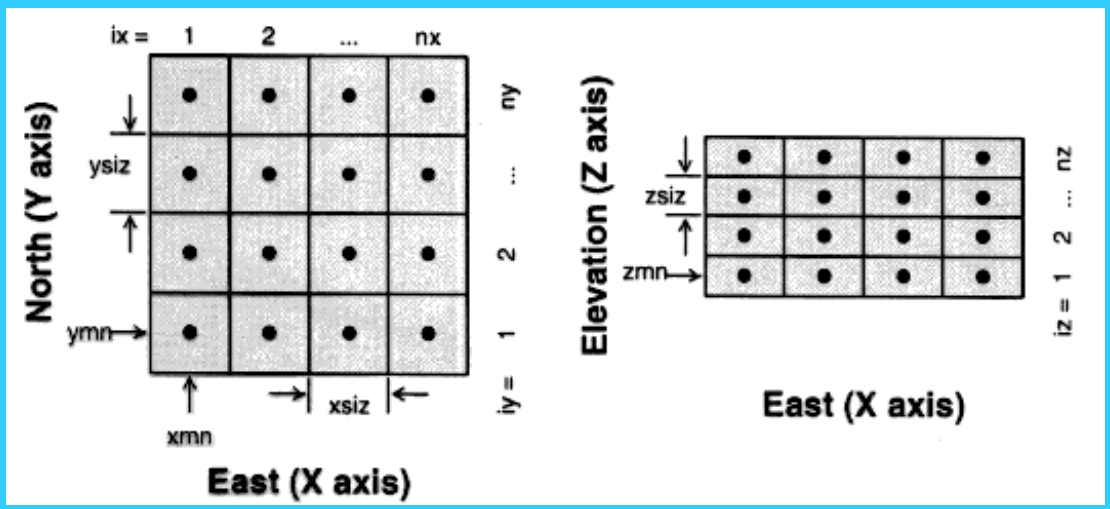
```
data2dg.dat) ← File name
4 ← Number of columns
Xlocation
Ylocation
ATTRIBUTE      } Column names
COVARIATE
28.5 23.5 3.852 1.003
30.5 45.5 5.543 1.772
22.5 18.5 .102 .327
49.5 35.5 4.548 2.833 } Space/Tab delimited data
```

- Graphical output is PostScript page description language (GhostScript would be a useful supplement).



# Grid Specification

- The GSLIB rectangular grid is denoted as:



- Could be associated to any Cartesian or stratigraphic coordinate system.
- Output grids are ordered with  $x$  cycling fastest, then  $y$ , and then  $z$ . Index location of node  $ix, iy, iz$  is located by:

$$loc = (iz-1)*nx*ny + (iy-1)*nx + ix$$

- 2-D grids are specified with  $nz=1$ .  $zmn$  and  $zsiz$  are not used.
- Grids or simulated realizations are ordered one after another.
- Some sort of compressed output format may be necessary.



# Example Parameter File

## Parameters for GAMV

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### START OF PARAMETERS:

```
../data/cluster.dat          \ file with data
1 2 0                        \ columns for X, Y, Z coordinates
2 3 4                        \ number of variables, column numbers
-1.0e21  1.0e21             \ trimming limits
gamv.out                     \ file for variogram output
10                            \ number of lags
5.0                           \ lag separation distance
3.0                            \ lag tolerance
3                              \ number of directions
0.0 90.0 50.0  0.0 90.0 50.0 \azm,atol,bandh,dip,dtol,bandv
```

...