Computing oil reserves using statistical distribution of porosities
(Reference: Chapter 19 in W. H. Preuss, *et al*., Numerical Recipes in Fortran, 2nd ed., Cambridge University Press, 1992)

Learning objectives

1. Develop problem solution skills using computers and numerical methods
2. Review of methods statistical distribution functions
3. Develop programming skills using FORTRAN

New FORTRAN elements in this module

- use of NAG library
- input/output
- loops

Introduction

An oil resrevoir extends over an area of 2 km x 2 km and has a thickness of 100 m. The reservoir has an initial water saturation which depends on the porosity, and the remaining of the pores is filled with oil. On the basis of well logs and core tests in the lab, it has been found that the porosity distribution is log-normal, and that the water saturation varies according to the following equation:

$$S_w = 0,415 - 1,37\phi + 1,481\phi^2$$

Compute hydrocarbon pore volume of the reservoir by the following procedure:

1. Divide the reservoir into a number of blocks
2. Assign a porosity to each block in accordance with the log-normal distribution function.
3. Compute water saturation for each block by the above equation.
4. Compute hydrocarbon pore volume (HCPV).

Since the porosity is assigned by a random number generator, the HCPV of the reservoir will be different each time the above procedure is applied. By repeating the procedure many times, we may obtain a measure of the uncertainty in the reserves of the reservoir. In particular, one wants to find how the reserves are affected by the number of blocks that the reservoir is divided into (ie. the number of realizations).

Make a FORTRAN program that distributes porosities to N x N blocks in accordance with a log-normal distribution function by calling the NAG-routine G05DEF (see naghelp for description). Then, the program computes water saturation for each block, and finally it calculates the hydrocarbon pore volume (HCPV):

$$HCPV = \sum_{i=1}^{i=NxN} (1 - S_w)_i \phi_i \Delta x \Delta y h$$

For each set of NxN blocks, the calculations are to be repeated 200 times, ie. 200 realizations, and the average HCPV should be plotted vs. number of realizations. Also plot the frequency distribution curves for porosity and HCPV.

Use the following parameters for the porosity distribution curve:

$\phi_{mean} = 0{,}2; \qquad \sigma = 0{,}1$ (standard deviation)
$\phi_{\max} = 0{,}5; \qquad \phi_{\min} = 0{,}05$

Run the program for for $N = 1$, $N = 2$, $N = 5$, and $N = 10$.

References to Numerical Recipes:
Distribution function: page 604

Linking of NAG-library (on petrus)
The compilation and linking command should be:

xlf –o programname fortranfile.f –l nag