SensorMap Manual

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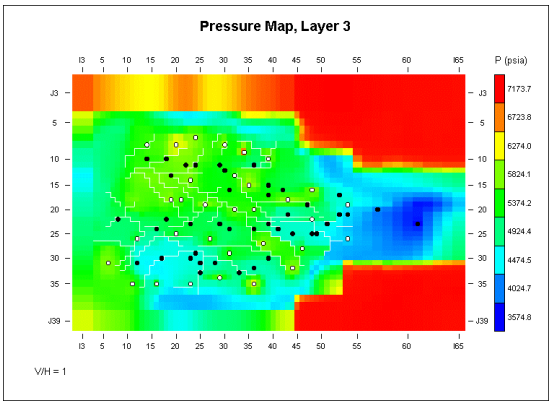
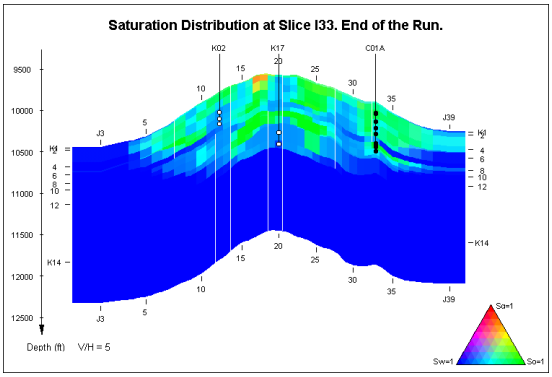
March 1, 2001

Program Description

SensorMap is a simple tool to create two-dimensional contour maps on aerial or vertical slices of a structured reservoir grid. Maps can display a variety of grid properties of Sensor input or calculated results. The map displays include a slice of the simulation grid with properties in color-fill mode, wells, well names, faults, color legend, IJK subscript, depth scale and title. User defined map units are available. SensorMap can also calculate and show properties averaged across several blocks normal to the slice. Certain options are provided to control display of the main map details.
The maps are created using Visual Basic Automation and MS Draw functionality. Such drawings can be easily exported through copy and paste in any Windows application (in form of Draw object or picture images) for the purpose of presentation.





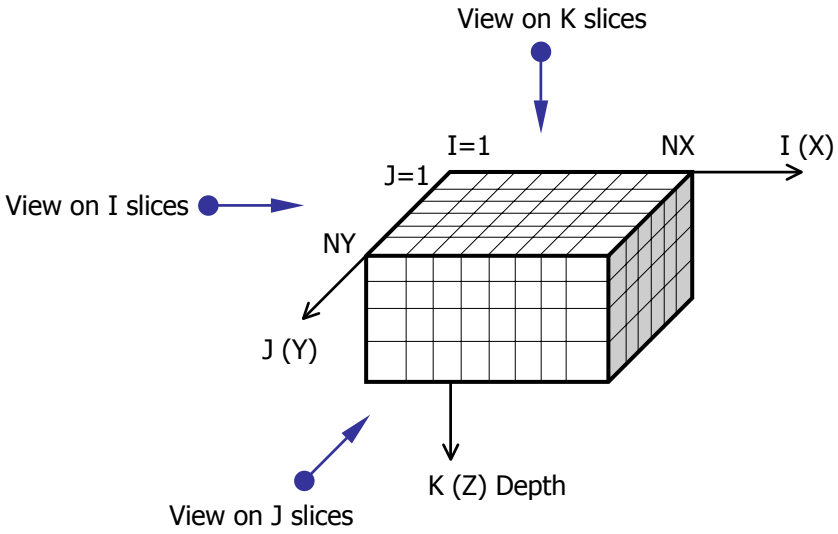
The SensorMap color scheme is red for maximum, green for medium and blue for minimum value of the map property. On saturation maps ("SAT"), the red color is for Sg=1.0, green for So=1.0 and blue for Sw=1.0. Other values represent a proportional mixture of the 3 main colors.

SensorMap has two parts:

- **SensorMap.exe,** a Fortran program that reads user input and the Sensor binary output file (fort.71). For each of the requested maps the program assembles xyz coordinates, grid block properties, fault and well positions, plus the display options. The output data are written in a tab-delimited text file with an easy to read format. This output file is referred to as the *map data file*.
- **Map2Excel.xls,** an Excel spreadsheet with Visual Basic Automation, reads the map data files and creates drawings in MS Excel using the MS Draw functionality. With MS Draw you can also manually change the maps to edit title, delete or add new elements, etc (you need to ungroup the drawing before editing it).

Structured Grid Model

This picture demonstrates the 3-dimensional grid and SensorMap views on the aerial and vertical slice maps with respect to the entire model.



Keywords in the SensorMap Input File.

TITLE & ENDTITLE

All text lines contained between these two keywords are printed at the top of the output map data file.

```
TITLE
  Prototype for SensorMap input file.
ENDTITLE
```

FILE

One entry for the name of the Sensor binary file (fort.71) is expected on the same line. (Required). The file name may have up to 120 characters.

```
FILE        TEST_FORT.71
```

OUTFILE

One entry for the name of output *map data file* is expected on the same line. (Required) The file name may have up to 120 characters.

```
OUTFILE     TEST1.MAP
```

WINDOW

This keyword defines the map slice and extent inside the grid model using IJK indexes. You can have several windows with different names.

```
WINDOW      M1    K2    I10 I50   J10 J36    ! xy layer at K=2
WINDOW      CS1   J10   I3  I28               ! xz corss-section at J=10
WINDOW      CS2   I22   J10 J36   K3  K12     ! yz corss-section at I=22
```

The first entry after the keyword is a window name (M1). It must be a character string (up to 12 characters). Letters I, J or K cannot be used in the first position in the window name.

The second entry (K2) is the index of the slice and must begin with the letter I, J, or K. "K2" indicates the xy slice or layer K=2 (see the figure on page 2).

The following entries specify limits of the map area. If you omit them the map will take maximum extent from the origin to Nx and Ny for a K slice, to Ny and Nz for an I slice, and to Nx and Nz for a J slice. You can limit extent in one or two directions. You must provide both Min and Max indexes for each limited extent.

MAP

Enter the requested maps below. (Required). This keyword can appear several times.

```
MAP
  I10  SAT  31 6 1998                    ! yz cross-section at I=10
  M1   P    360                          ! use of a map window
  K1   KX   0     (T) LAYER 1 KX (md)    ! xy layer at K=1
```

The first entry is a slice index for the map surface or a window name previously specified under the keyword WINDOW.

The second entry is the grid property that you want on the contour map. Table 14 of the Sensor Manual lists the eligible map properties which can be written to Unit 71 (except maps TRACER, X and Y).

The third entry is the simulation time for the grid property. The time can be entered as a single number of days from start of the simulation (day 0). It can also be in the date format with 3 numbers for calendar day, month and year (D M Y).

The fourth entry is an optional parameter "(T)" that allows entering a map title. SensorMap provides a default title for each map, but you can override it. Any characters following "(T)" will be printed on the map as its title.

The entered grid property with the given time must exist in the Sensor binary file (fort.71). You can check the content of the binary file in the following way:
Run **SensorMap.exe.** On the prompt line, keyboard enter: **what fort.71**

where “fort.71” is the name of your Sensor binary file, entered by keyword FILE above. The program will print a list of grid properties and time values contained in the file. You can read this list either on the monitor or in the text file **SensorMap.inf**.

Maps with Average Grid Properties

You can display maps with average grid properties taken across several blocks. To do it you need to construct a window with two subscripts for the map slice. Example:

```
WINDOW      W2    J5 J10   ! The I & K extent limits can be omitted
```

Then use the window to set up your maps. The maps with this window will display an xz J slice with grid properties averaged over the 6 blocks from J=5 to J=10. The property will be pore-volume weighted.

UNITS

Enter the unit names and conversion coefficients for displayed map properties blow.

```
UNITS
  P         bara         0.0689476
  DEPTH     m            0.3048
  POROS     %            100
```

The first entry is the eligible map property. Table 14 of the Sensor Manual lists the eligible map properties which can be written to Unit 71, and their default units.

The second entry is the desired unit name. The third entry is the conversion coefficient for the default unit. It can be any number greater than 0.

Note: enter “DEPTH” with a desired unit name and a conversion factor to change the units of the depth scale on cross-section maps.

END

Stop the reading of the input file.

Throughout the input file, SensorMap ignores blank lines, comment lines and any characters following the symbol “!” on any line. A comment line is a line that has “C” as the first non-blank character followed by at least one blank.

Map Display Controls

The following keywords are optional. You can use them to change the default settings. They must appear before the maps that they should modify.

	Default	Comments
WIDTH	15.	Set the actual width of map frame in centimeters. The actual grid width is about 6cm less then frame.
VHSCALE	1.	Defines the vertical / horizontal ratio of grid length units. Must be within limits from 0.1 to 100. For cross-section maps the recommended value is 5 or 10.
FAULT	ON	Display fault lines on maps. (can be ON / OFF)
NACTIVE	ON	Display non-active blocks on maps. (can be ON / OFF)
WELL	ON	Display wells on maps. (can be ON / OFF)
WELLNAME	ON	Display well names on maps. (can be ON / OFF)
IJK	ON	Display IJK subscript on maps. (can be ON / OFF)
SMOOTH	OFF	On cross-sectional maps display the edges of neighboring blocks smoothly connected in a continuous layer. (can be ON / OFF).
COLORBACK	WHITE	Set color of maps background.
COLORGRID	BLACK	Set color of grid lines.
COLORFAULT	WHITE	Set color of fault lines.
COLORWELL	BLACK	Set color of well symbols and lines. Perforations of production wells are shown in solid circles. Injection wells have open circle with white center. Accepted input COLORS: WHITE, BLACK, RED, GREEN, BLUE, PINK, YELLOW, BROWN, GRAY, NONE

Example Input Data Set

```
TITLE
  Example SensorMap input datafile.
ENDTITLE

FILE          FORT.71
OUTFILE       Example.map

WINDOW   M1   K6   I5 I35   J10 J22
WINDOW   S1   J15  I5 I35

COLORGRID     NONE

MAP
C Slice       Property     Time          Title
C -----       --------     ----          -----
  K1          POROS        0             (T) Layer 1, Porosity
  M1          P            3650

VHSCALE       5
SMOOTH        ON

MAP
  I20         POROS        0
  I10         SAT          0
  I10         SAT          1 1 1998
  S1          SAT          365           (T) Window View
  S1          SAT          1 7 2008

UNITS
  POROS       %      100
  DEPTH       m      0.3048

END
```

Running SensorMap

We illustrate the use of SensorMap to create contour maps, starting with the Sensor example datafile spe9.dat which can be downloaded from the website www.coatsengineering.com.

1. Run Sensor
Make sure the files **Sensor.exe** and **spe9.dat** are in the same directory.
In a DOS command prompt window type the directory's path and keyboard enter:
`Sensor.exe < spe9.dat > spe9.out` (or any output file name you desire).
Move or rename **fort.71** to (say) "**f71_spe9**".

2. Run SensorMap.exe
Construct the SensorMap input file (say) "**spe9.sm**" as:

```
TITLE
   spe9 example data set
ENDTITLE

FILE        f71_spe9
OUTFILE     spe9.map

MAP
  K3        KX          0
  K3        P           900

VHSCALE 5
MAP
  I5        KX          0
  I12       P           900
  I5        SG          900
  J11       SG          900
  J11       SAT         900
END
```

Make sure the files **SensorMap.exe**, **f71_spe9** and **spe9.sm** are in the same directory.
Run `SensorMap.exe.` At the prompt, enter "**spe9.sm**". See file "**SensorMap.inf**" for the run summary. SensorMap will generate a map data file: "**spe9.map**".

Note: You can check the content of the Sensor binary file in the following way:
Run **SensorMap.exe** file. On the prompt line keyboard enter: **what f71_spe9**. See the list of content on the monitor or in text file SensorMap.inf.

3. Run Map2Excel.xls

Start MS Excel
Open file Map2Excel.xls with VBA automation and start Map2Excel Macro.
Open the file **spe9.map** using the menu and press "Yes" button.

Sensor Map File, Fort.71

Sensor writes results to Unit 71 (file "fort.71") for 2 and 3-dimensional visualization purposes. The user can write a program to read and process Unit 71 results as required for the graphical package of his choice. This fort.71 file is the file used by SensorMap and entered in the SensorMap datafile using the keyword FILE. The file is not written when radial coordinates r-θ-z are used.

This file is written by Sensor in accordance with your entry of the keywords MAPSFILE and MAPSFILEFREQ (see Sensor Manual, Appendix 10). Table 14 of the Sensor Manual lists the eligible mapnames which can be written to Unit 71 (except maps TRACER, X and Y).

The format of the fort.71 file is as follows.
A one-time write at the start of the file (not repeated in restart runs):

```
      WRITE (71) NX, NY, NZ, NBB, NB
      WRITE (71) (MAP(MM), MM=1, NBB)   ! = 0 for inactive blocks
      WRITE (71) (DELX(MM),MM=1, NBB)   ! Block X dimension, ft
      WRITE (71) (DELY(MM),MM=1, NBB)   ! Block Y dimension, ft
      WRITE (71) (TH(MM),  MM=1, NBB)   ! Block thickness, ft
      WRITE (71) (Z(MM),   MM=1, NBB)   ! Depth of block center, ft
      WRITE (71) (PVV(MM), MM=1, NBB)   ! Block pore volume, rb
      WRITE (71) NFSEG
      DO I=1, NFSEG
         WRITE (71) I1FS,I2FS, J1FS,J2FS, K1FS,K2FS, JFAULT,IFAULT
      ENDDO
```

```
Where:
NX      no. of grid blocks in the x-direction
NY      no. of grid blocks in the y-direction
NZ      no. of grid blocks in the z-direction
NBB     no. of total grid blocks, NX*NY*NZ
NB      no. of active grid blocks
NFSEG   total number of FSURFACE segments
I1FS,I2FS, .. I1,I2,J1,J2,K1,K2 indices of FSURFACE fault segment
JFAULT  internal sequential fault number, 1,2,3,...,NF
IFAULT  user entered fault number
```

The maps are written as single-subscripted arrays where

MM = (K-1)*NX*NY + (J-1)*NX + I.

MM ranges from 1 to NBB. The value of MAP(MM) is 0 if block MM is an inactive block and is M if it is an active block. The active blocks are numbered by the single index M where M=1,2,3,...,NB.

The remainder of the map file consists of the following write for each map. At each time > 0 at which maps are written, active well perf locations are written after all specified maps are written.

```
! Map data
WRITE (71) MAPNAME,TIME,ITIME,IDAY,IMONTH,IYEAR
WRITE (71) (RDATA(MM),MM=1,NBB)

! Saturation map is a special case: MAPNAME = "SAT".
! Gas saturation is calculated as Sg = 1 - Sw - So
WRITE (71) MAPNAME,TIME,ITIME,IDAY,IMONTH,IYEAR
WRITE (71) (SW(MM),MM=1,NBB)
WRITE (71) (SO(MM),MM=1,NBB)

! Well information repeats for every new time step of map data
WRITE (71) 'WELL      ',TIME,ITIME,IDAY,IMONTH,IYEAR
WRITE (71) NWACT
DO IW = 1, NWACT
   WRITE (71) WNAME(IW),IWTYPE(IW),NPACT(IW)
   DO L = 1, NPACT(IW)
      WRITE (71) I(L,IW),J(L,IW),K(L,IW)
   ENDDO
ENDDO
(End Of File)
```

```
MAPNAME   is character*10 (eligible mapnames are in Table 14)
ITIME     time step no.
TIME      time, days
IDAY      day of date (1-31)
IMONTH    month of date (1-12)
IYEAR     year of date (e.g. 1978 1992 2004)
NWACT        number of active wells
WNAME(IW)    well name of well IW, character*8, left justified
IWTYPE(IW)   welltype integer of well IW, see Table 12.
NPACT(IW)    number of active perfs for well IW
I,J,K        grid block indices of the perf
```

Creating Contour Maps From Restart Runs

1) Save the appropriate fort.71 file from a run from time 0 as (say) "init_fort.71".
2) Make the Sensor restart run creating fort.71.
3) Catenate init_fort.71 and fort.71 to a file (say) "restart_fort.71".
4) Enter "FILE restart_fort.71" in your SensorMap.exe data file of extension ".sm".

To catenate, keyboard enter on a DOS command prompt window:

```
COPY  /B  init_fort.71 + fort.71   restart_fort.71
```

The switch "/B" indicates binary copy.