Introducción a la Simulación de Yacimientos con Software Libre

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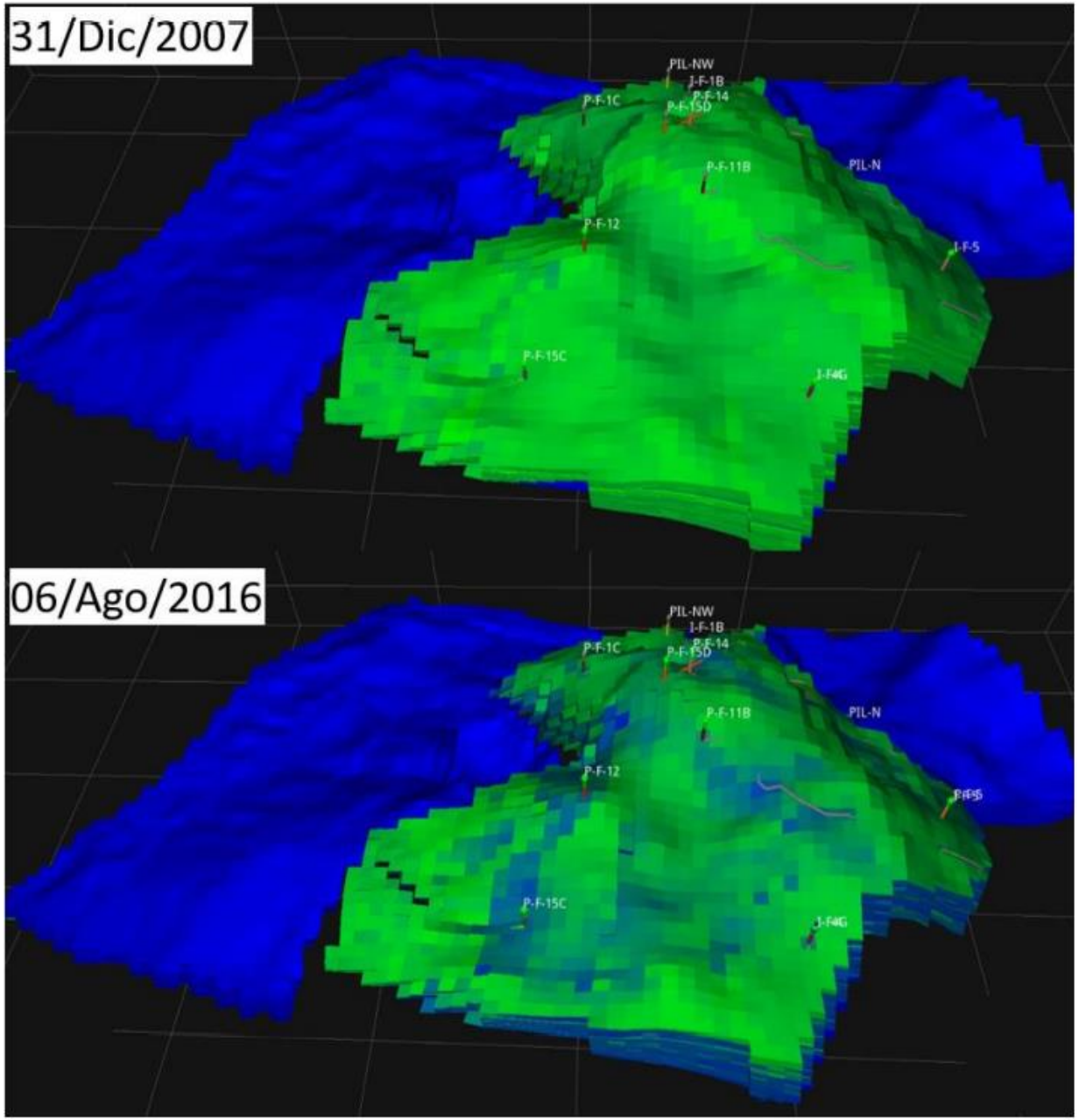
ORKAHUB ENERGY

Dia 1

Introducción



Introducción

La simulacion de yacimientos combina la rama matematica, fisica, ciencia de la computacion y la ingenieria de yacimientos, para determinar y predecir el desempeño de produccion de un yacimiento bajo algunas condiciones operativas.

Introducción

Models tradicionales:

- Metodos analogos
- Metodos experimentales
  - Modelos Fisicos
- Metodos matematicos
  - Balance de Materiales
  - Curvas de Declinacion
  - Aproximacion Estadistica
  - Metodos Analiticos

Introduccion

Ecuaciones fundamentales:

- Ecuacion de continuidad

$$(m_i - m_o) + m_s = m_a. \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4.1)$$

- Ecuacion de flujo

$$\vec{u} = -\beta_c \frac{k}{\mu} \vec{\nabla}\Phi. \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2.22)$$

- Ecuacion de Estado

$$B = \frac{\rho_{sc}}{\rho}. \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4.17)$$

$$\frac{\partial}{\partial x}\left(\beta_c \frac{A_x k_x}{\mu_g B_g} \frac{\partial p}{\partial x}\right)\Delta x + \frac{\partial}{\partial y}\left(\beta_c \frac{A_y k_y}{\mu_g B_g} \frac{\partial p}{\partial y}\right)\Delta y$$

$$+ \frac{\partial}{\partial z}\left(\beta_c \frac{A_z k_z}{\mu_g B_g} \frac{\partial p}{\partial z}\right)\Delta z + q_{gsc}$$

$$= \frac{V_b \phi T_{sc}}{p_{sc} T} \frac{\partial}{\partial t}\left(\frac{p}{Z}\right), \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4.102)$$

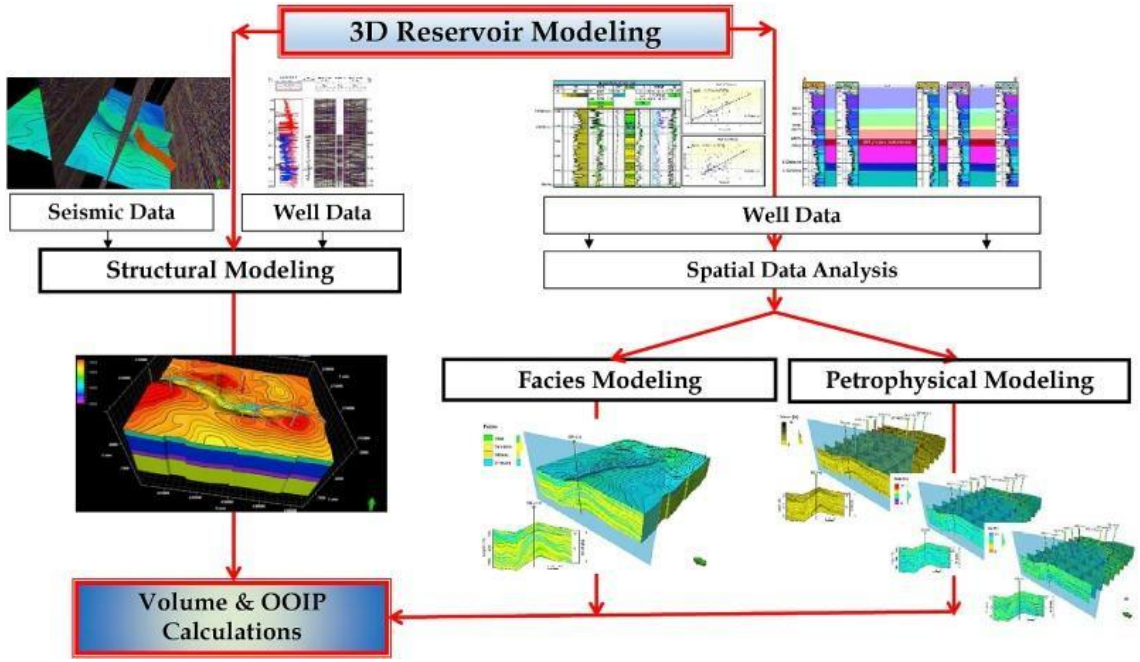
Introduccion

Tipos de Simuladores:

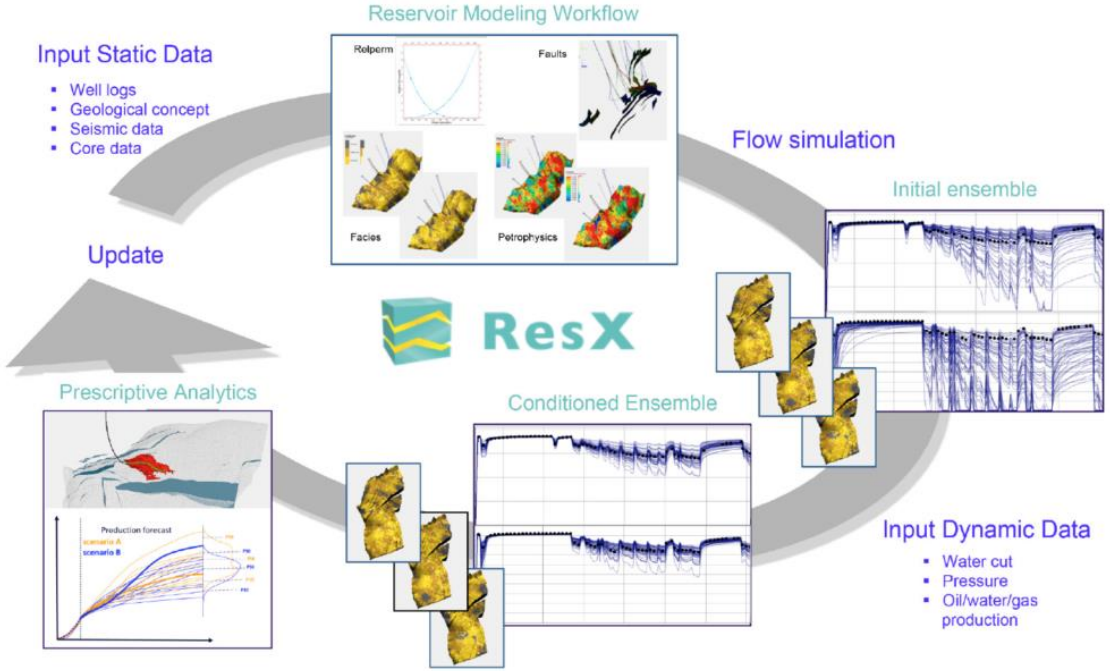
- Simuladores por tipo de yacimiento y método
  - Simuladores de petróleo negro
    - Proceso isotérmico
    - Fases inmiscibles agua-petróleo-gas
  - Simuladores composicionales
    - Yacimientos de condensación retrograda y petróleo volátil

Introduccion

- Modelo Estatico



- Modelo Dinamico



Introduccion

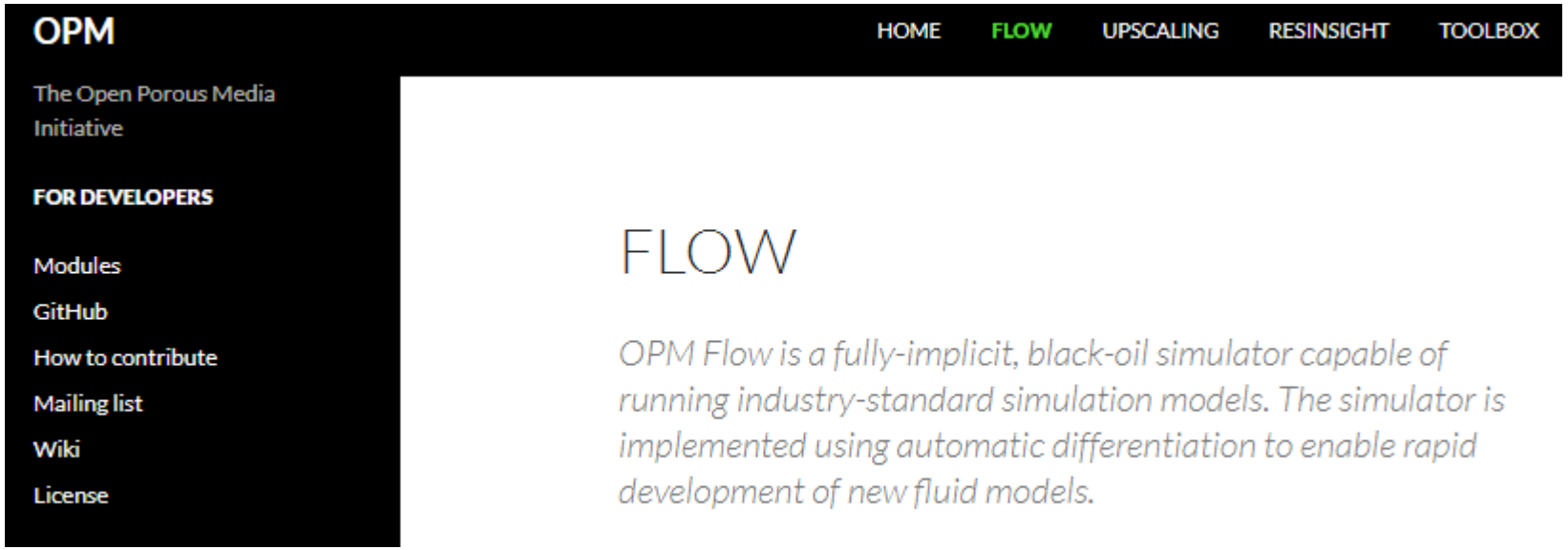
Open Porous Media:

- Iniciativa comuntaria que busca desarrollar e innovar en la investiacion de procesos de flujo en medios porosos.
- Proyecto desarrollado bajo la licencia GNU Version 3, que permite, modificar, compartir y utilizar el software a nuestra conveniencia.

Introduccion

Simulador Flow

- Aceite negro, IMPES.



Gracias por su atención

Contacto:

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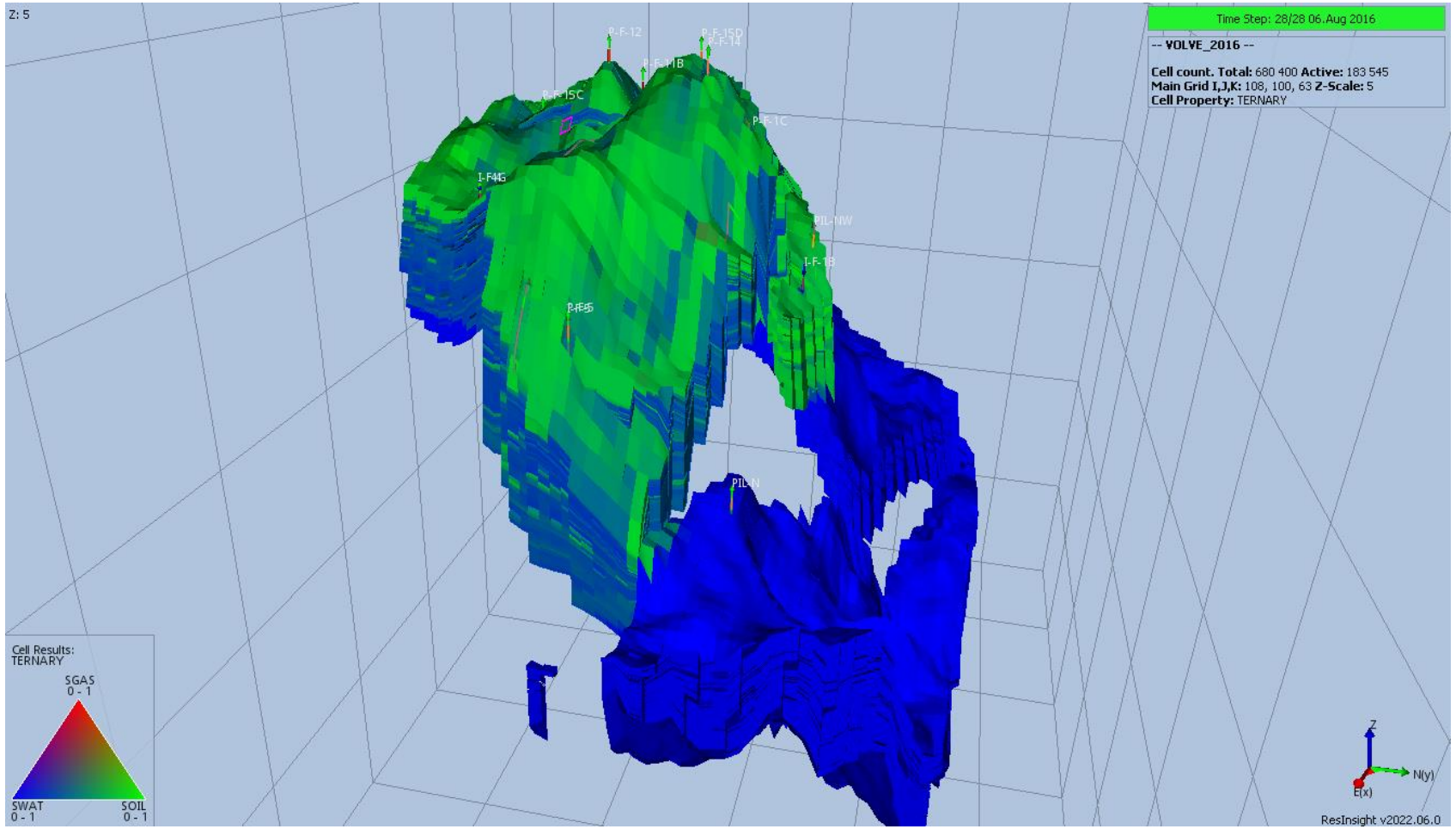
- LuisNavarro93 (github.com)

- 93lenm@gmail.com
- https://t.me/+TIVLACKN0FTuIGM8

Dia 2

Archivos Fundamentales



Archivo .*PRT*

```
 ########  #          ######   #           #
 #         #         #      #   #         #
 #####     #         #      #    #   #   #
 #         #         #      #     # # # #
 #         #######    ######       #   #

Flow is a simulator for fully implicit three-phase black-oil flow, and is part of OPM.
For more information visit: https://opm-project.org

Flow Version     =  2021.04 ()
Machine name     =  LuisNavarro (Number of logical cores: 4, Memory size: 7145.87 MB)
Operating system =  Linux x86_64 (Kernel: 5.11.0-27-generic, #29~20.04.1-Ubuntu SMP Wed Aug 11 15:58:17 UTC 2021 )
Build time       =  2013-10-14 at 09:54:10 hrs
User             =  luis
Simulation started on 30-08-2021 at 23:48:28 hrs
```

Archivo *.PRT*

```
================ Starting main simulation loop ===============

Report step  0/120 at day 0/3650, date = 01-Jan-2015

Starting time step 0, stepsize 1 days, at day 0/31, date = 01-Jan-2015
 Newton its= 3, linearizations= 4 (0.0sec), linear its=  5 (0.0sec)

Starting time step 1, stepsize 3 days, at day 1/31, date = 02-Jan-2015
 Newton its= 3, linearizations= 4 (0.0sec), linear its=  8 (0.0sec)

Starting time step 2, stepsize 9 days, at day 4/31, date = 05-Jan-2015
 Newton its= 5, linearizations= 6 (0.0sec), linear its= 17 (0.0sec)

Starting time step 3, stepsize 18 days, at day 13/31, date = 14-Jan-2015

Warning: Keyword 'WELLS' is unhandled for output to file.
                                        ====================================================
                                        :                  Field Totals                    :
                                        :      PAV  =       4858.96  PSIA                  :
                                        :      PORV =     542144133   RB                   :
                                        : Pressure is weighted by hydrocarbon pore volume :
                                        : Pore volumes are taken at reference conditions  :
                        :--------------- Oil    STB ---------------:-- Wat    STB --:--------------- Gas   MSCF ---------------:
                        :      Liquid        Vapour        Total   :      Total     :      Free        Dissolved       Total   :
:-----------------------:-----------------------------------------:----------------:-----------------------------------------:
:Currently   in place    :     284010893             0     284010893:     62819996   :       1287175     362516688     363803864:
:-----------------------:-----------------------------------------:----------------:-----------------------------------------:
:Originally  in place    :             0             0             0:            0   :             0             0             0:
:=======================:=========================================:================:=========================================:
```

Archivo *.PRT*

```
Restart file written for report step 120/120, date = 29-Dec-2024 00:00:00


================    End of simulation     ===============

Number of MPI processes:         1
Threads per MPI process:         2
Total time (seconds):           10.16
Solver time (seconds):          10.01
 Assembly time (seconds):        3.41 (Failed: 0.0; 0.0%)
   Well assembly (seconds):      0.52 (Failed: 0.0; 0.0%)
 Linear solve time (seconds):    1.23 (Failed: 0.0; 0.0%)
   Linear setup (seconds):       0.21 (Failed: 0.0; 0.0%)
 Update time (seconds):          2.11 (Failed: 0.0; 0.0%)
 Pre/post step (seconds):        1.75 (Failed: 0.0; 0.0%)
 Output write time (seconds):    1.26
Overall Linearizations:        536    (Failed:   0; 0.0%)
Overall Newton Iterations:     413    (Failed:   0; 0.0%)
Overall Linear Iterations:    3505    (Failed:   0; 0.0%)



Error summary:
Warnings          241
Info              581
Errors            0
Bugs              0
Debug             0
Problems          0
```

Archivo *.DATA*

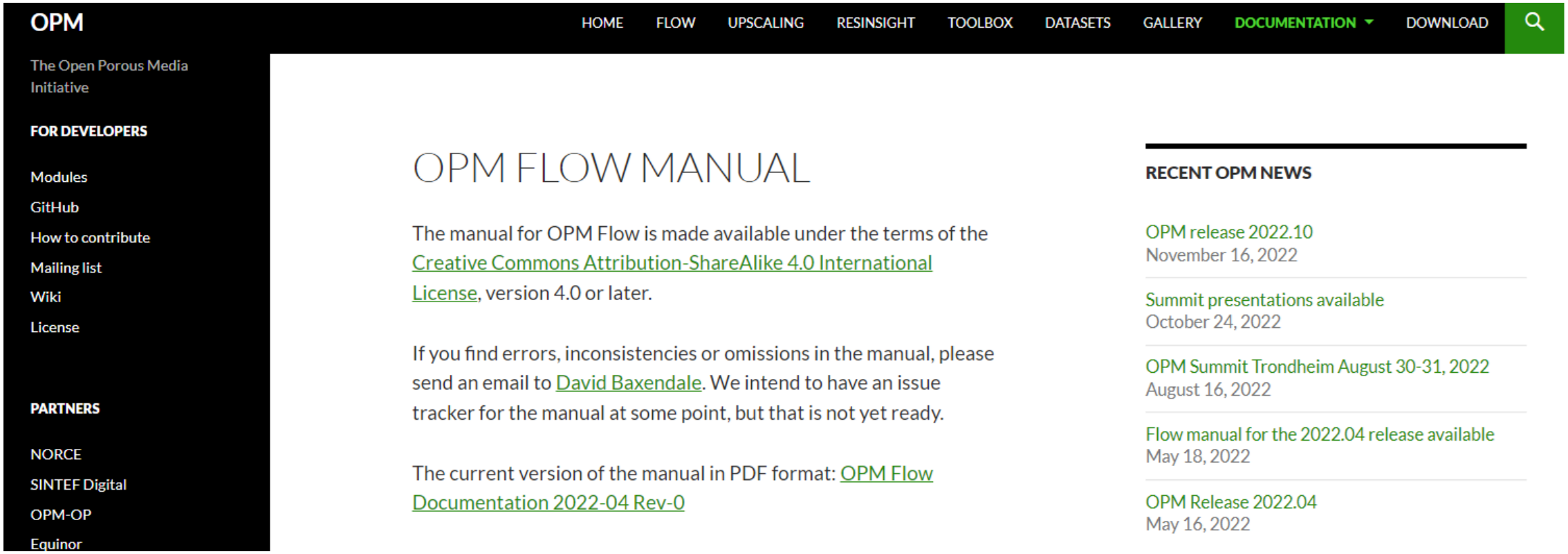
SPE1CASE1_SECCIONES
.DATA

*SPE1CASE1_SECCIONES.DATA: Bloc de notas

Archivo Edición Formato Ver Ayuda

```
-- This reservoir simulation deck is made available under the Open Database
-- License: http://opendatacommons.org/licenses/odbl/1.0/. Any rights in
-- individual contents of the database are licensed under the Database Contents
-- License: http://opendatacommons.org/licenses/dbcl/1.0/

-- Copyright (C) 2015 Statoil

-- This simulation is based on the data given in
-- 'Comparison of Solutions to a Three-Dimensional
-- Black-Oil Reservoir Simulation Problem' by Aziz S. Odeh,
-- Journal of Petroleum Technology, January 1981

-- NOTE: This deck is currently not supported by the OPM
-- simulator flow due to lack of support for DRSDT.

---------------------------------------------------------------------------
----------------------- SPE1 - CASE 1 -------------------------------------
---------------------------------------------------------------------------
-- ---------------------------------------------------------------------------
                                 RUNSPEC
-- ---------------------------------------------------------------------------

TITLE
   SPE1 - CASE 1

DIMENS
   10 10 3 /


EQLDIMS
/


TABDIMS
/

OIL
GAS
WATER
DISGAS
```

Documentación Fundamental



Documentación Fundamental

OPM OPEN POROUS MEDIA

OPM FLOW REFERENCE MANUAL (2022-04) Revision: Rev-0

TABLE OF CONTENTS

*SPE9.GRDECL: Bloc de notas

Archivo Edición Formato Ver Ayuda

```
SPECGRID
24   25   15   1   F
/

COORD
0.000000        0.000000        8973.952773     0.000000        0.000000        9332.952773
300.000000      0.000000        9026.047227     300.000000      0.000000        9385.047227
600.000000      0.000000        9078.141680     600.000000      0.000000        9437.141680
```

6.3.21 COORD – DEFINE A SET OF COORDINATES LINES FOR A RESERVOIR GRID

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

COORD defines a set of coordinate lines or pillars for a reservoir grid via an array. A total of 6 x (NX+1) x (NY+1) lines must be specified for each coordinate data set (or reservoir). For multiple reservoirs, where NUMRES is greater than one, there must be 6 x (NX+1) x (NY+1) x NUMRES values. In OPM Flow NUMRES can only be set to one.

For Cartesian geometry, each line is defined by the (x, y, z) coordinates of two distinct points on the line. The lines are entered with I cycling fastest then J. For radial geometry, each line is defined by the (r, theta) coordinates of two distinct points on the line. The lines are entered with R cycling fastest then THETA.

The keyword can only be used with Irregular Corner-Point Grids.

6.3.203 SPECGRID- DEFINE THE DIMENSIONS OF A CORNER-POINT GRID

No.	Name	Description	Default
1	NDIVIX	A positive integer value that defines the number of cells in the X or R direction	1
2	NDIVIY	A positive integer value that defines the number of cells in the Y or THETA direction	1
3	NDIVZ	A positive integer value that defines the number of cells in the Z direction	1
4	NUMRES	A positive integer values that defines number of coordinate data sets, or independent reservoirs in the model. OPM Flow currently only accepts a single data set, that is the default value of one.	1
5	TYPE	A character string set to either T of F that defines the type of grid to be defined by subsequent keywords: 1) T = Radial grid with radial coordinates 2) F = Cartesian grid Only the default option F is supported by OPM Flow.	F

Notes:

1) The keyword is terminated by a "/".
2) The dimensions are also entered on the DIMENS section in the RUNSPEC section and the two sets of numbers should be consistent.

*SPE9_CP.DATA: Bloc de notas

Archivo Edición Formato Ver Ayuda

```
GRID
-- Killough says 'the grid was in conventional rectangular
-- coordinates without corner point geometry or local grid refinements'

INCLUDE
        'SPE9.GRDECL' /

PORO
-- Porosity in each level is contant
-- The values are specified in table 1 in Killough's paper
        600*0.087
        600*0.097
        600*0.111
        600*0.16
        600*0.13
        600*0.17
        600*0.17
        600*0.08
        600*0.14
        600*0.13
        600*0.12
        600*0.105
        600*0.12
        600*0.116
        600*0.157 /

-- PERMX, PERMY & PERMZ
INCLUDE
        PERMVALUES.DATA /
```

Dia 3

Aplicación y ejercicios