

MUFITS

Training Course

Day 2

**Operations on arrays, Regions,
Boundary conditions & Point sources**

Program

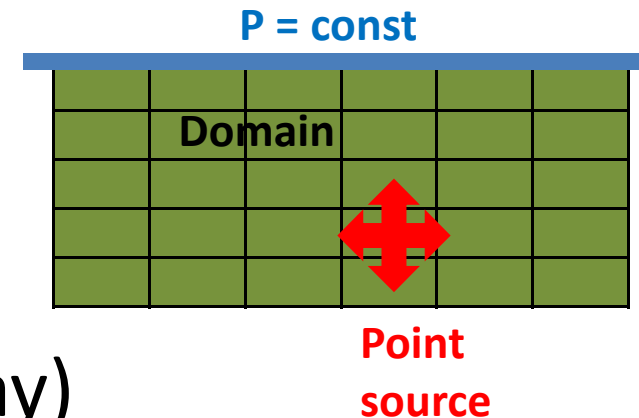
Arithmetic operations

$$\text{PORO} = 0.2$$

$$\text{PERMZ} = 0.1 * \text{PERMX}$$

$$\text{PRES} = 8.5 + 0.01 * \text{DEPTH}$$

- Operations on arrays (Scenario 3)
- Regions
- Boundary conditions
- Point sources
- Scenario 4 (summary of the day)



Operations on arrays

Keywords for operations on arrays in a box of grid blocks

Keyword	Result
ADD	Add
COPY	Copy from one array into another array
EQUALS	Equate to
MAXVALUE	Apply maximum limit
MINVALUE	Apply minimum limit
MULTIPLY	Multiply by
OPERATE	Apply a complicated arithmetic operation

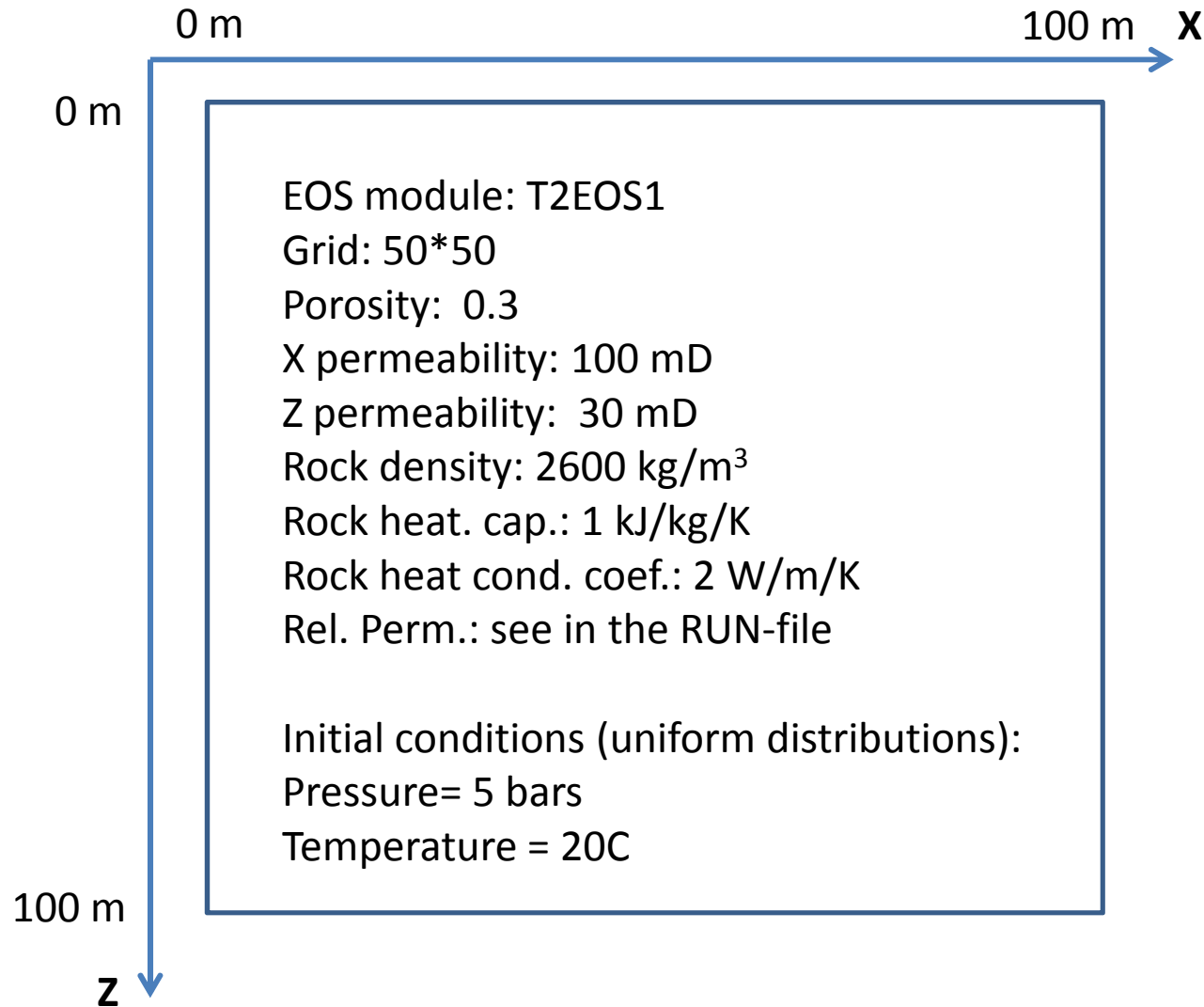
Keywords EQUALS

```

1  -- in all sections except RUNSPEC and POST
2
3  EQUALS
4      mnemonic1  value1  imin1 imax1   jmin1 jmax1   kmin1 kmax1 /
5      mnemonic2  value2  imin2 imax2   jmin2 jmax2   kmin2 kmax2 /
6      mnemonic3  value3  imin3 imax3   jmin3 jmax3   kmin3 kmax3 /
7      ...
8  /
9
10 =====
11
12  mnemonic#  - mnemonic of the property which is modified.
13  value#     - value assigned to the property in the current input box.
14  imin#/imax# - the boundaries of the input box along i-indexation axis.
15               By default these values are equal to the arguments 1 and 2
16               of the keyword BOX.
17  jmin#/jmax# - the boundaries of the input box along j-indexation axis.
18               By default these values are equal to the arguments 3 and 4
19               of the keyword BOX.
20  kmin#/kmax# - the boundaries of the input box along k-indexation axis.
21               By default these values are equal to the arguments 5 and 6
22               of the keyword BOX.
```

Scenario3

All boundaries are
impermeable and insulated

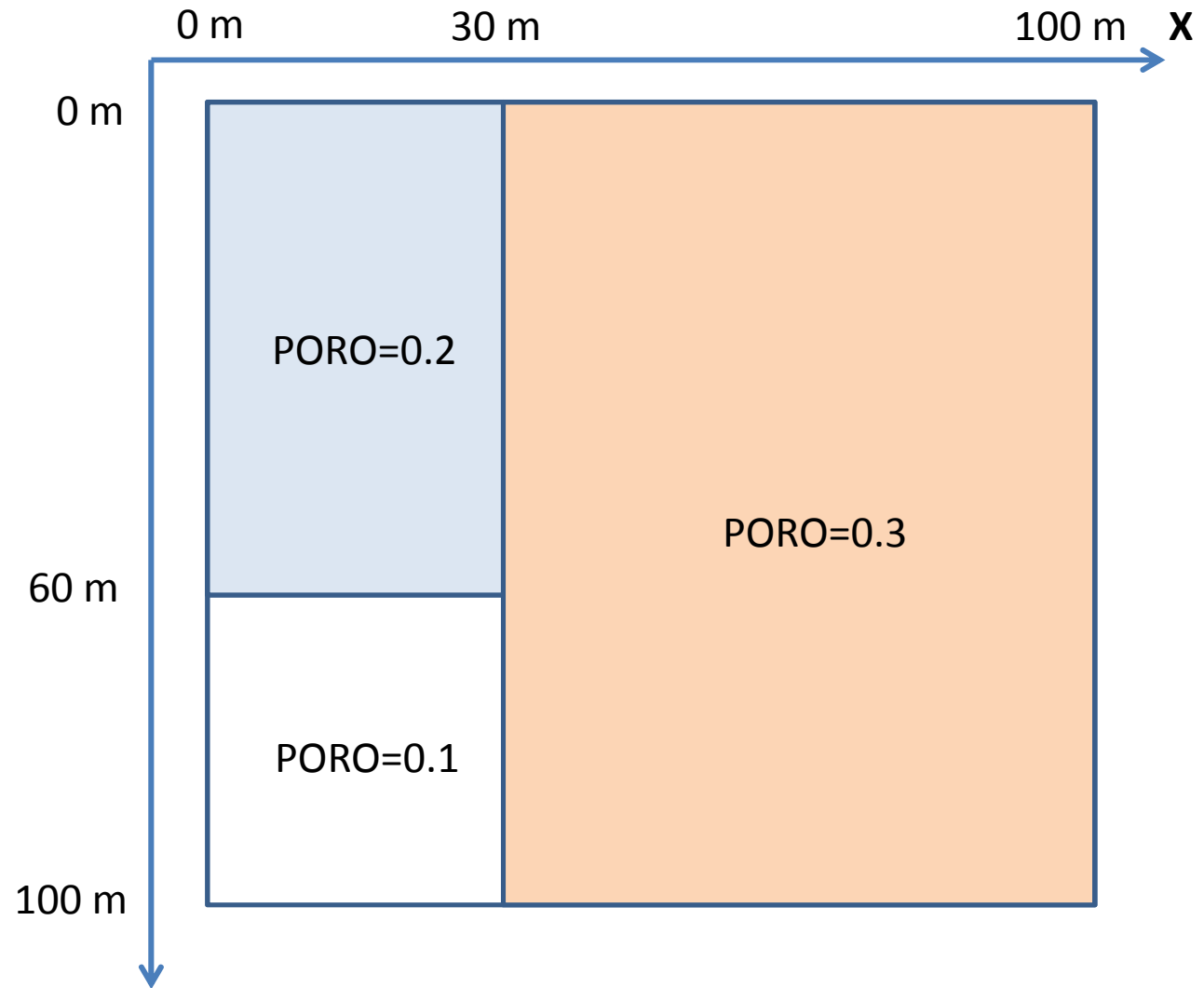


RUN-file (Scenario 3)

1. Open RUN-file in text editor
2. Run the simulation
3. Open results in ParaView

Using EQUALS keyword

Exercise: Specify the following porosity distribution using EQUALS and re-simulate scenario 3.

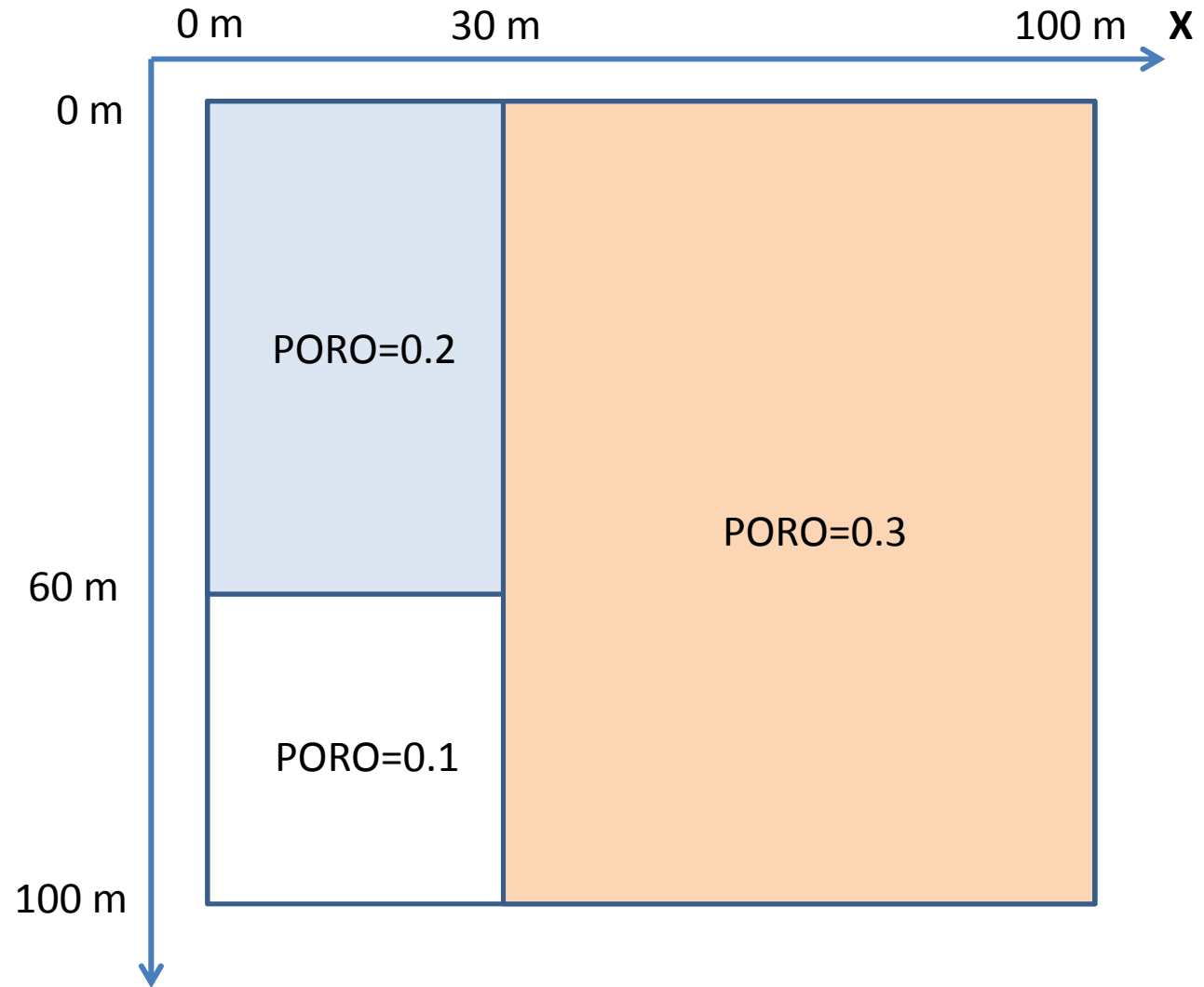


Answer

```
Day 2. Task 1
1  -- answer 1:
2
3  EQUALS
4    PORO  0.3 /
5    PORO  0.2  1 15 2* 1 30 /
6    PORO  0.1  4* 31 50 /
7  /
8
9  -- answer 2:
10
11 EQUALS
12   PORO  0.2 /
13   PORO  0.1  4* 31 50 /
14   PORO  0.3  16 50  2* 1 50 /
15 /
16
17 ...
```

Operations on arrays (exercise)

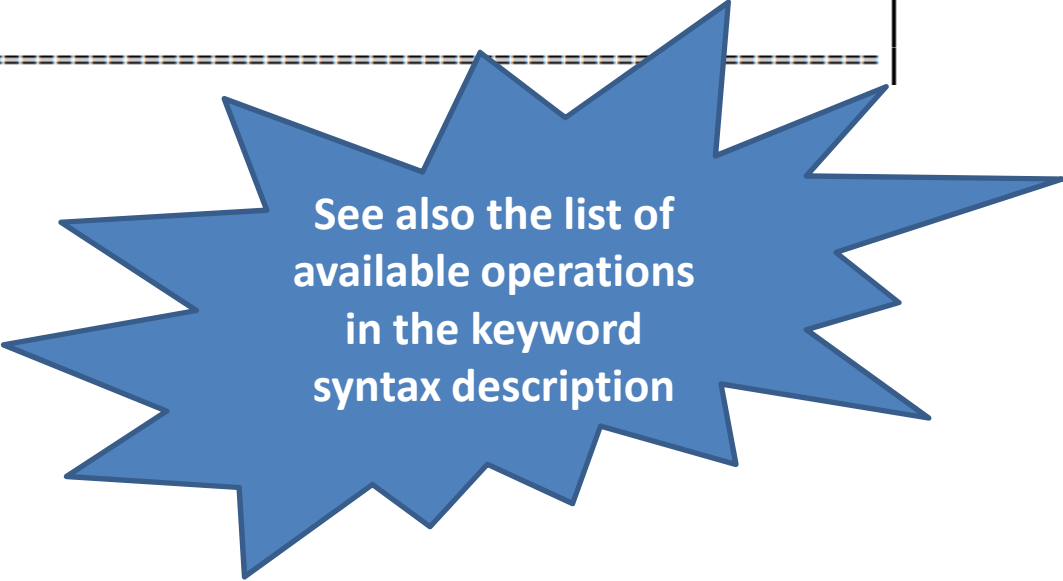
Exercise : Specify the following porosity distribution using each of EQUALS, ADD and MULTIPLY keywords, and re-simulate scenario 3.



Keyword OPERATE

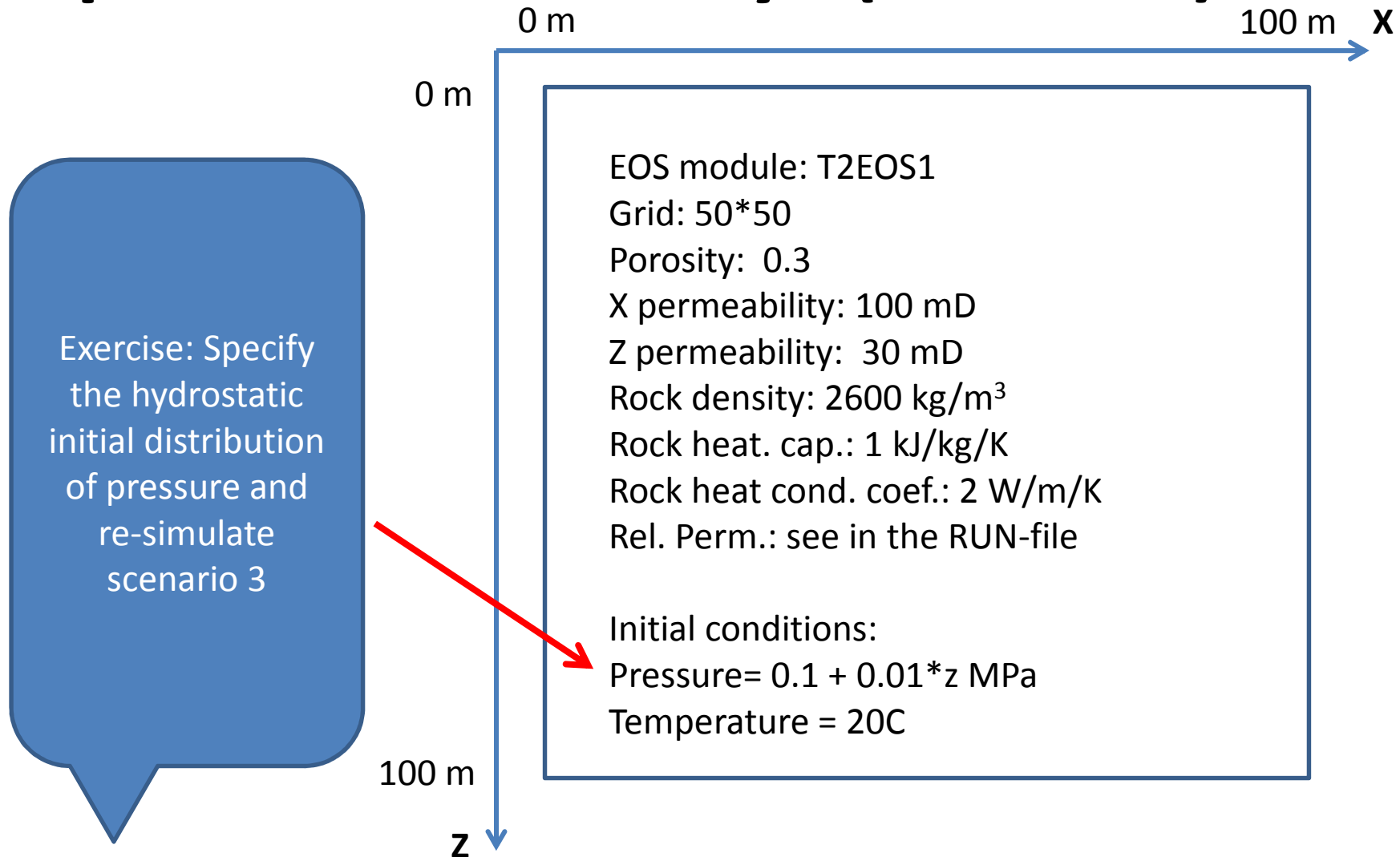
OPERATE syntax

```
1 -- in all sections except RUNSPEC and POST
2
3 OPERATE
4   mnem1 imin1 imax1 jmin1 jmax1 kmin1 kmax1  oper1 mdep1 par1_1 par2_1 par3_1 /
5   mnem2 imin2 imax2 jmin2 jmax2 kmin2 kmax2  oper2 mdep2 par1_2 par2_2 par3_2 /
6   mnem3 imin3 imax3 jmin3 jmax3 kmin3 kmax3  oper3 mdep3 par1_3 par2_3 par3_3 /
7   ...
8 /
9
10 =====
```



See also the list of
available operations
in the keyword
syntax description

Operations on arrays (exercise)



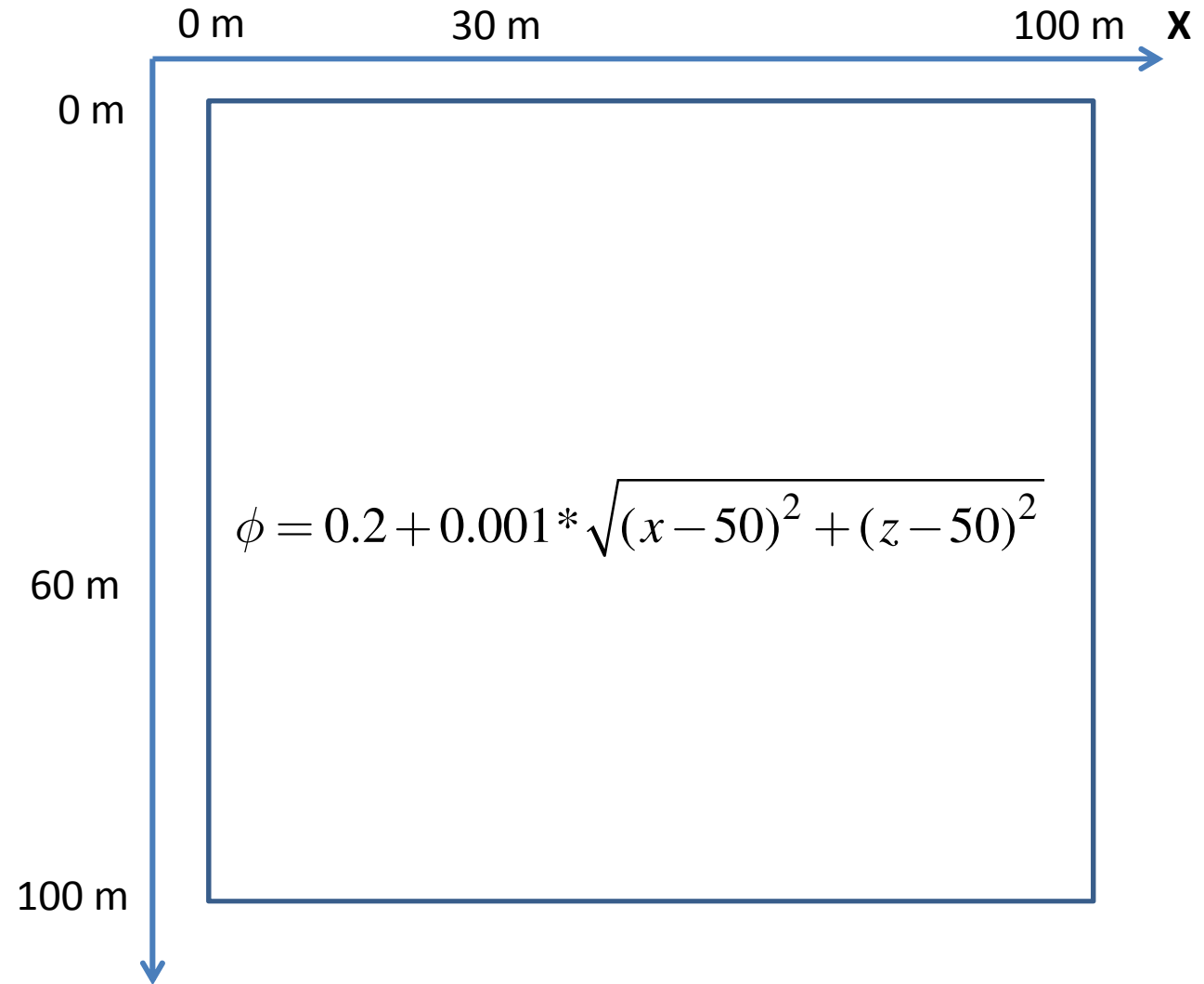
Answer

Day 2. Task 3

```
1  -- in INIT section
2
3  OPERATE
4    PRES DEPTH MULTA 0.1 0.01 /
5  /
```

Operations on arrays (exercise)

Exercise: Specify
the following
porosity
distribution
re-simulate
scenario 3.



Answer

Day 2. Task 4

```
1 OPERATE
2   AUXARR1 XCOORD COPY /
3   AUXARR1 1* ADD -50 /
4   AUXARR1 AUXARR1 MULTP 1 2 /
5   AUXARR2 DEPTH COPY /
6   AUXARR2 1* ADD -50 /
7   AUXARR2 AUXARR2 MULTP 1 2 /
8   AUXARR1 AUXARR2 ADDARR /
9   AUXARR1 AUXARR1 MULTP 1 0.5 /
10  AUXARR1 AUXARR1 MULTA 0.2 0.001 /
11  PORO AUXARR1 COPY /
12 /
```

Regions

Flags defined in cells

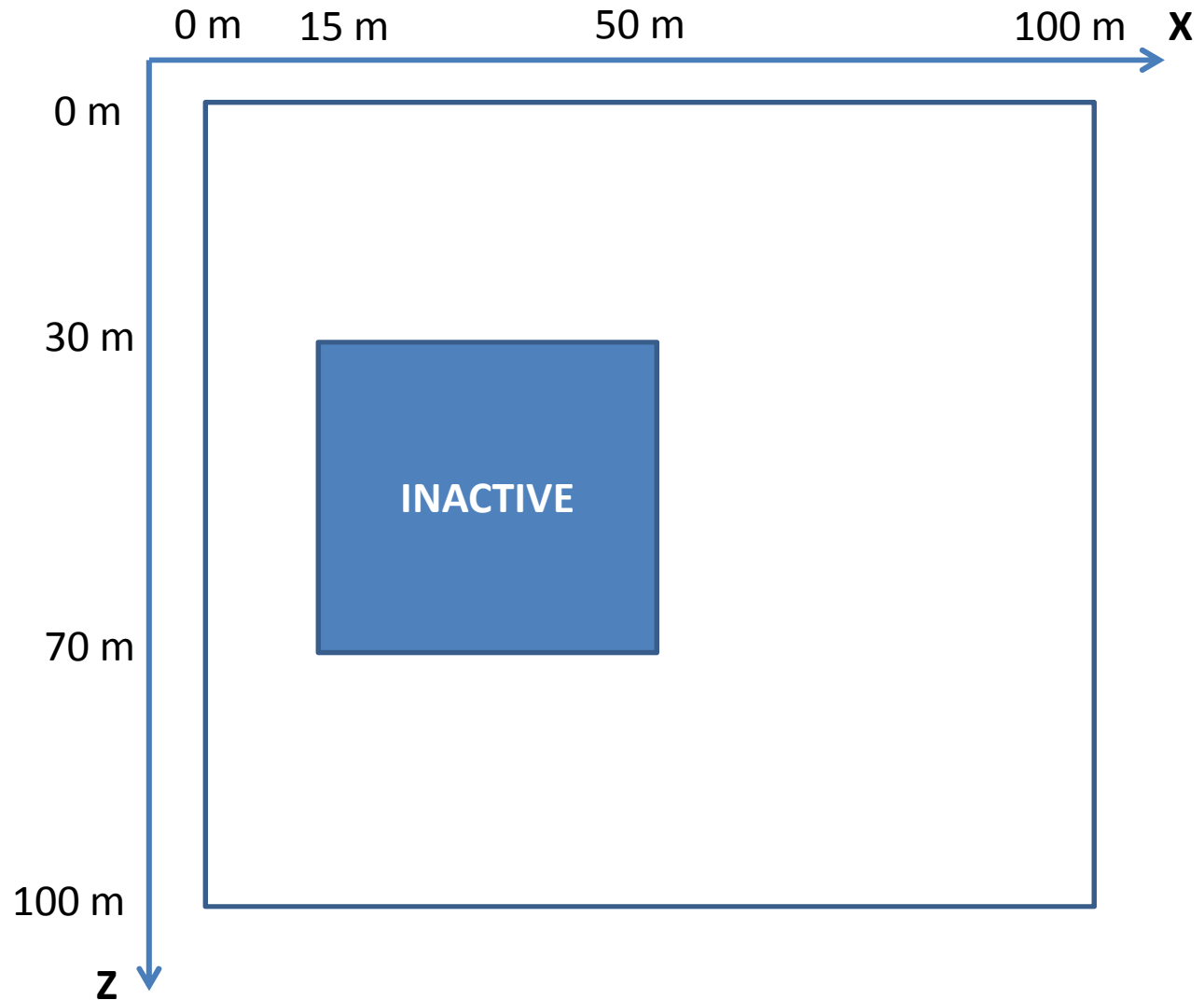
Flag mnemonic	Description
ACTNUM	0 – cell inactive; 1 – cell active; 2 – fixed parameters;
TYPENUM	1 – an ordinary cell, 2 – impermeable cell
ROCKNUM	Rock properties region number
SATNUM	Saturation functions region number
FLUXNUM	Is used for boundary conditions specification
MPINUM	Grid partition
INCONUM	No predefined meaning at present
...	...

The flags can be defined in the GRID section using operations on arrays.

ACTNUM flag

0 – cell inactive; 1 – cell active; 2 – fixed parameters.

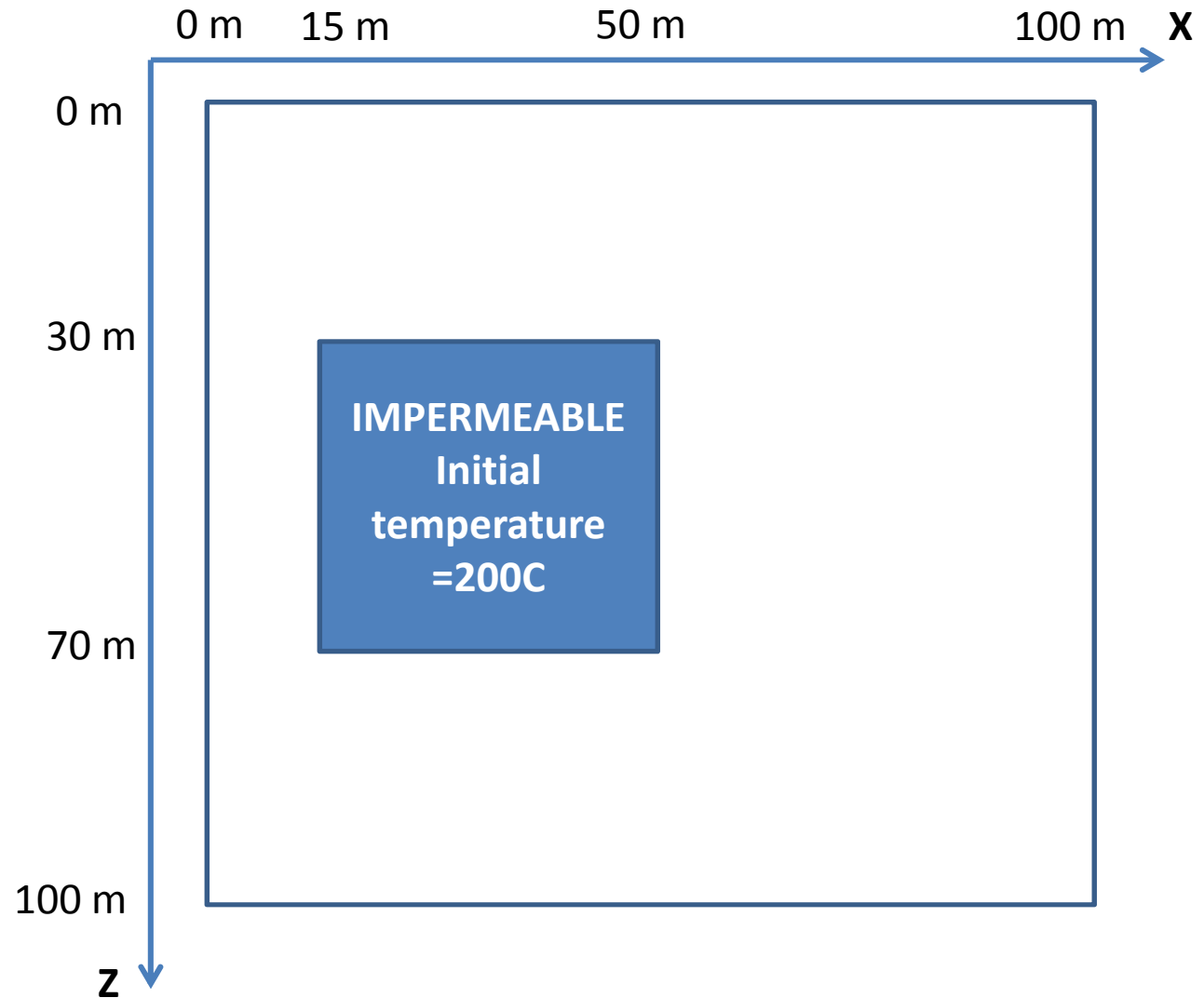
Exercise: Specify this region of the reservoir inactive and re-simulate Scenario 3.



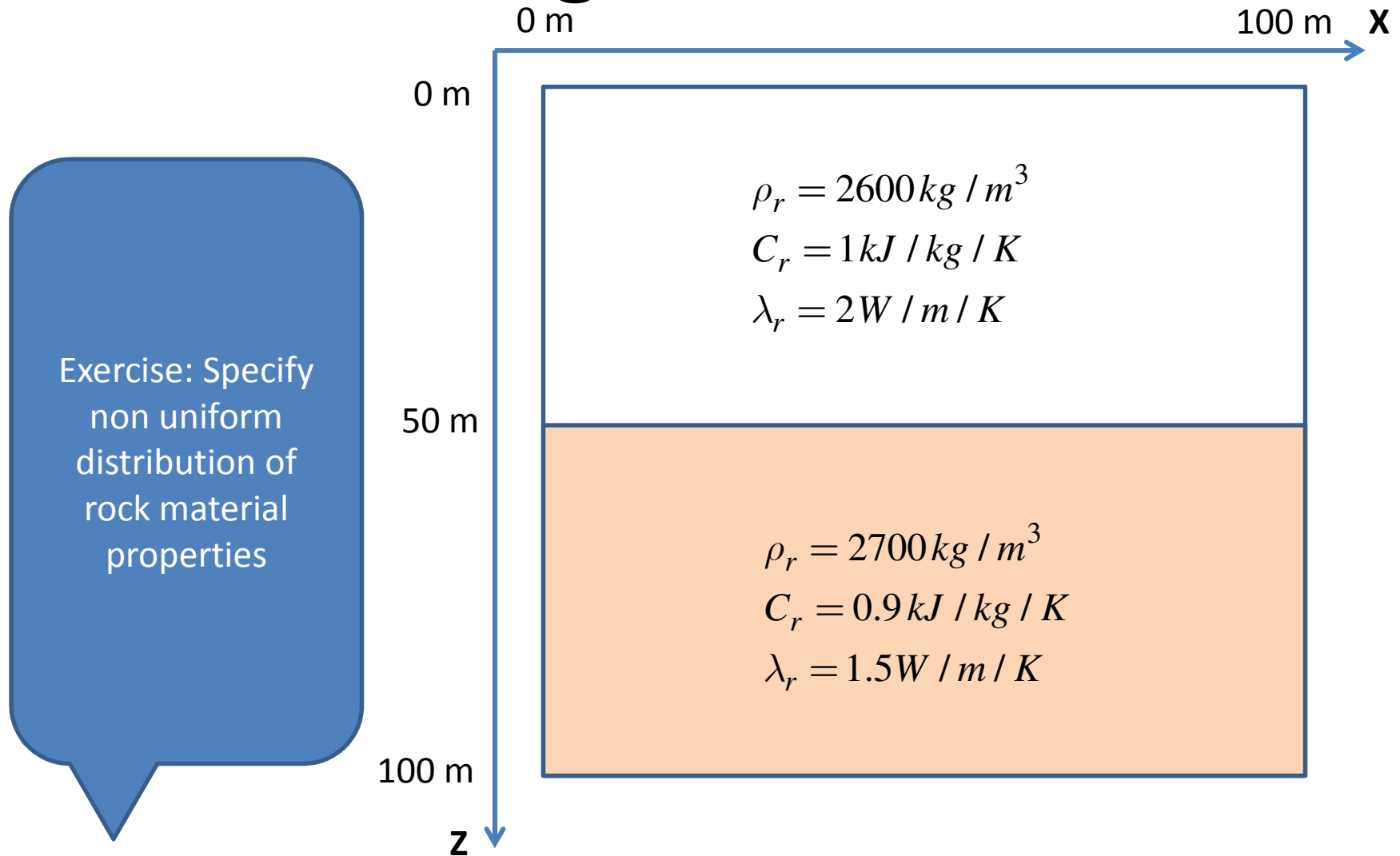
1 – ordinary cell; 2 – impermeable cell.

TYPENUM flag

Exercise: Specify
this region of the
reservoir inactive
and re-simulate
Scenario 3

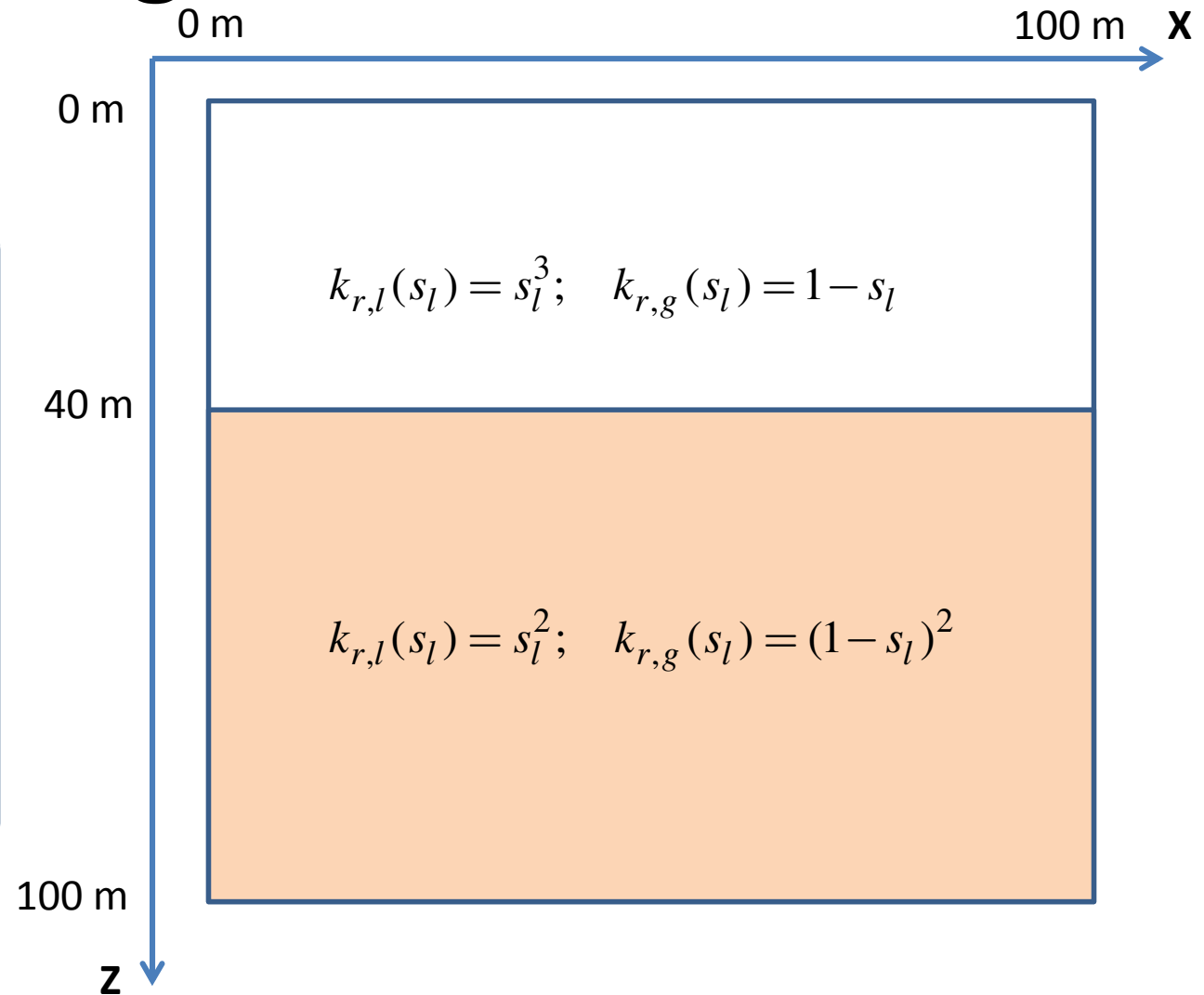


ROCKNUM flag



SATNUM flag

Exercise: Specify
different
saturation
functions in the
regions



Keywords for operations on arrays in a region of grid blocks

Keyword	Result
ADDREG	Add
COPYREG	Copy from one array into another array
EQUALREG	Equate to
MAXVAREG	Apply maximum limit
MINVAREG	Apply minimum limit
MULTIREG	Multiply by
OPERAREG	Apply a complicated arithmetic operation

Keyword EQUALREG

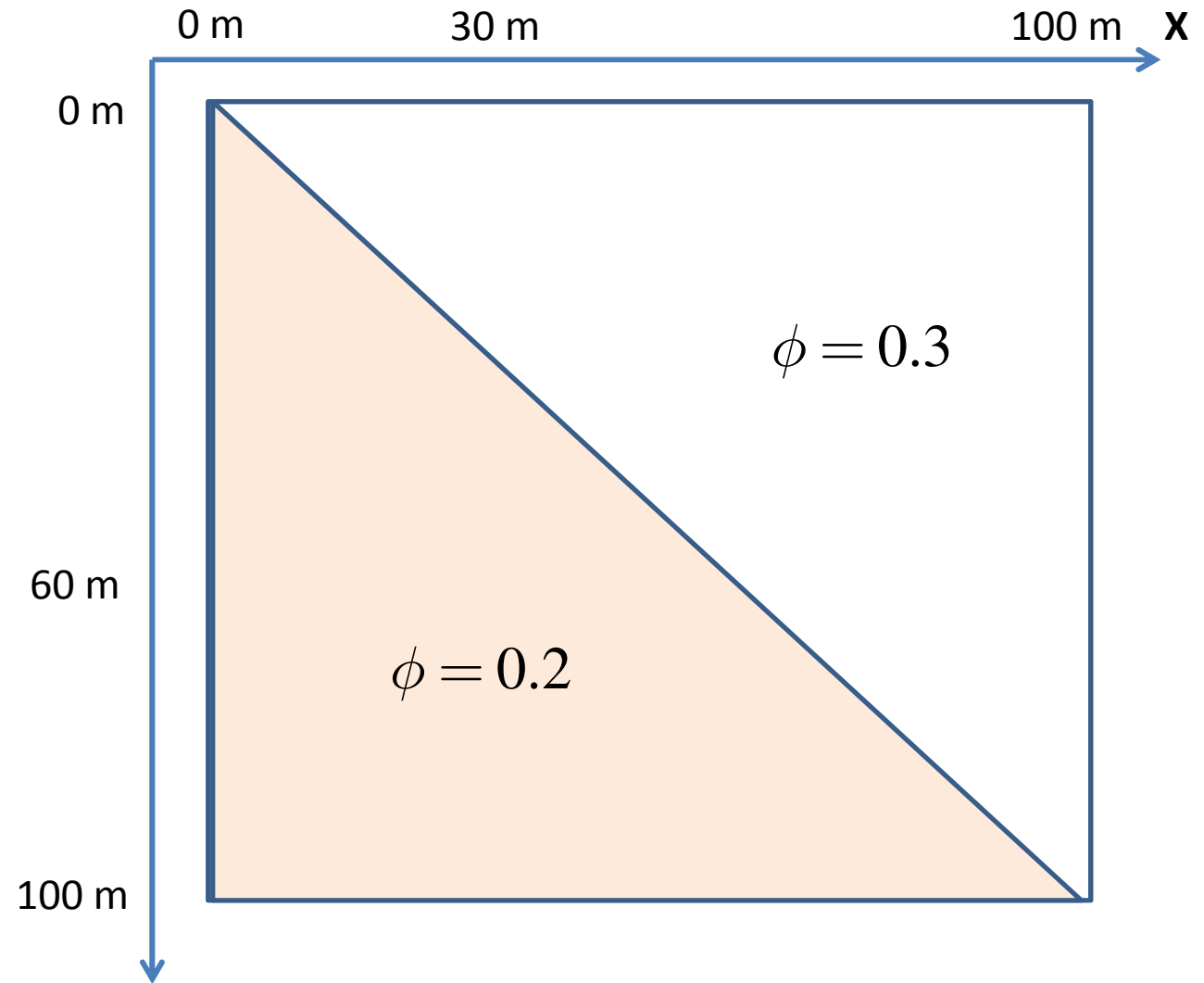
```

1  -- in all sections except RUNSPEC and POST
2
3  EQUALREG
4      mnemonic1  value1  region1  regionID1 /
5      mnemonic2  value2  region2  regionID2 /
6      mnemonic3  value3  region3  regionID3 /
7      ...
8  /
9
10 =====
11
12      mnemonic# - mnemonic of the property which is modified;
13      value#    - value assigned to the property in the region;
14      region#   - mnemonic of the region in which the property is modified;
15      regionID# - region number.
16
17 =====
18
19      The keyword results in the following:
20
21      mnemonic1:=value1  in the region region1=regionID1
22      mnemonic2:=value2  in the region region2=regionID2
23      mnemonic3:=value3  in the region region3=regionID3
24      ...

```

Exercise

Exercise: Specify the following porosity distribution and re-simulate scenario 3.



Answer

Day 2. Task 9

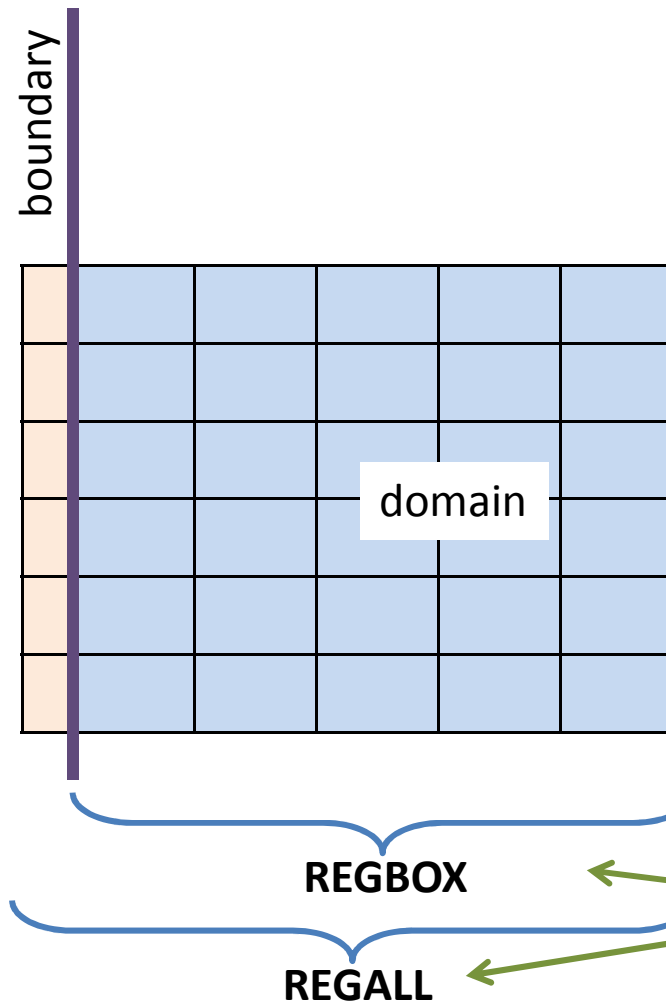
```
1  -- in GRID section
2
3  OPERATE
4      AUXARR1 XCOORD  COPY      /
5      AUXARR1 1*      MULTIPLY  -1 /
6      AUXARR1 DEPTH   ADDARR    /
7      INCONUM AUXARR1 SETINT   1  0  10000 /
8  /
9
10 EQUALREG
11     PORO  0.3 INCONUM  0 /
12     PORO  0.2 INCONUM  1 /
13  /
```

Boundary conditions

Dirichlet boundary conditions

Additional grid blocks
(in which ACTNUM=2)
created by the
BOUNDARY keyword

The additional blocks
can be referred to by
the **FLUXNUM** number



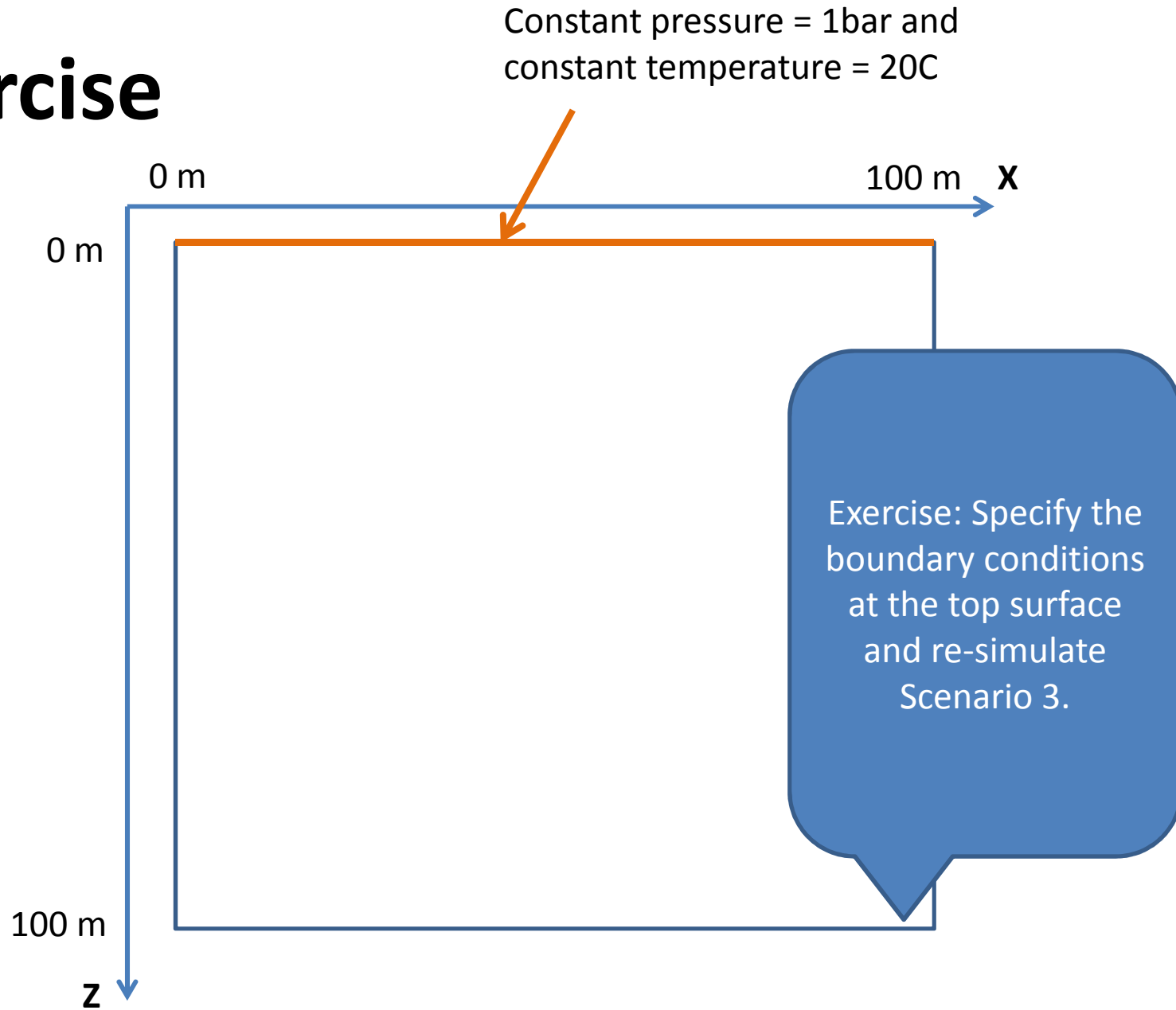
See
description
of these
keywords

BOUNDARY keyword

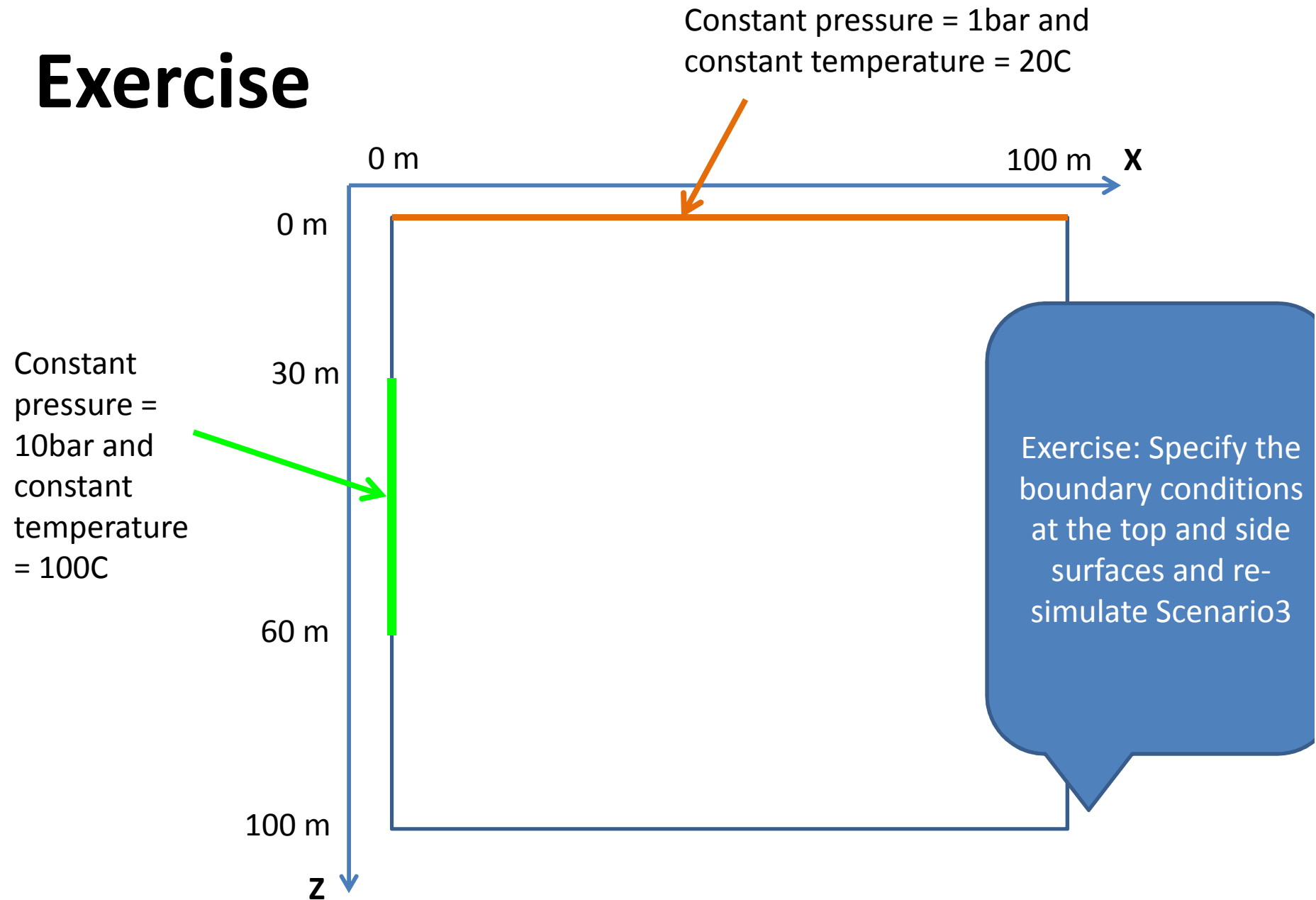
```
1  -- within MAKE-ENDMAKE brackets
2
3  BOUNDARY
4      fluxnum1 imin1 imax1 jmin1 jmax1 kmin1 kmax1 d1_1 d2_1 d3_1 d4_1 d5_1 d6_1
5                                     type_1 mode_1 nu1_1 nu2_1 nu3_1 typenum1 actnum1 /
6      fluxnum2 imin2 imax2 jmin2 jmax2 kmin2 kmax2 d1_2 d2_2 d3_2 d4_2 d5_2 d6_2
7                                     type_2 mode_2 nu1_2 nu2_2 nu3_2 typenum2 actnum2 /
8      fluxnum3 imin3 imax3 jmin3 jmax3 kmin3 kmax3 d1_3 d2_3 d3_3 d4_3 d5_3 d6_3
9                                     type_3 mode_3 nu1_3 nu2_3 nu3_3 typenum3 actnum3 /
10     ...
11 /
12
13 =====
14
15 fluxnum#      - FLUXNUM region number assigned to created grid blocks;
16 imin#-imax#   - the boundaries of the input box along i-indexation axis.
17                 By default these values are equal to '1' and the 2nd
18                 argument of the keyword MAKE, respectively;
19 jmin#-jmax#    - the boundaries of the input box along j-indexation axis.
20                 By default these values are equal to '1' and the
21                 argument of the keyword MAKE, respectively;
```

See full description
in the reference
manual

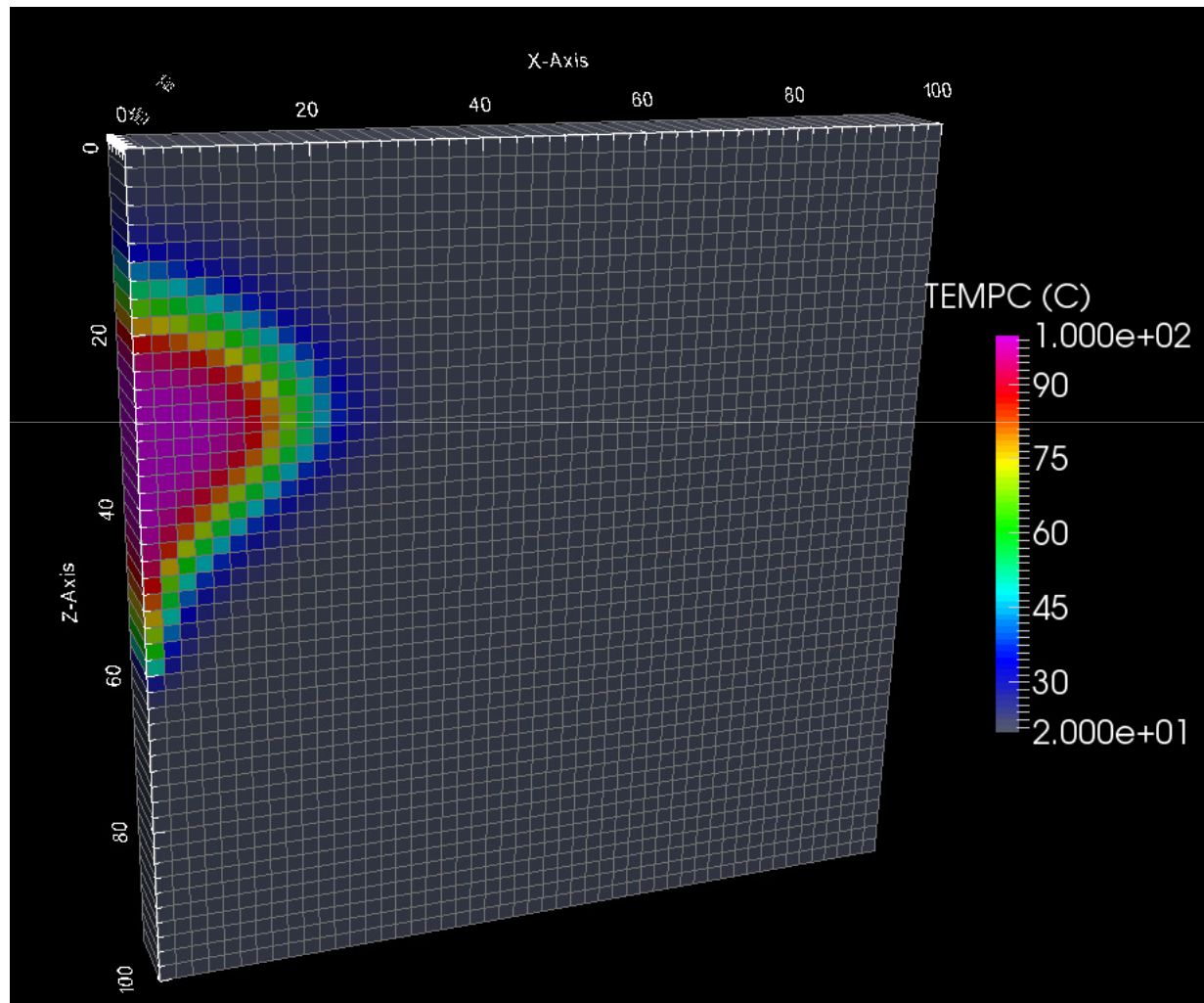
Exercise



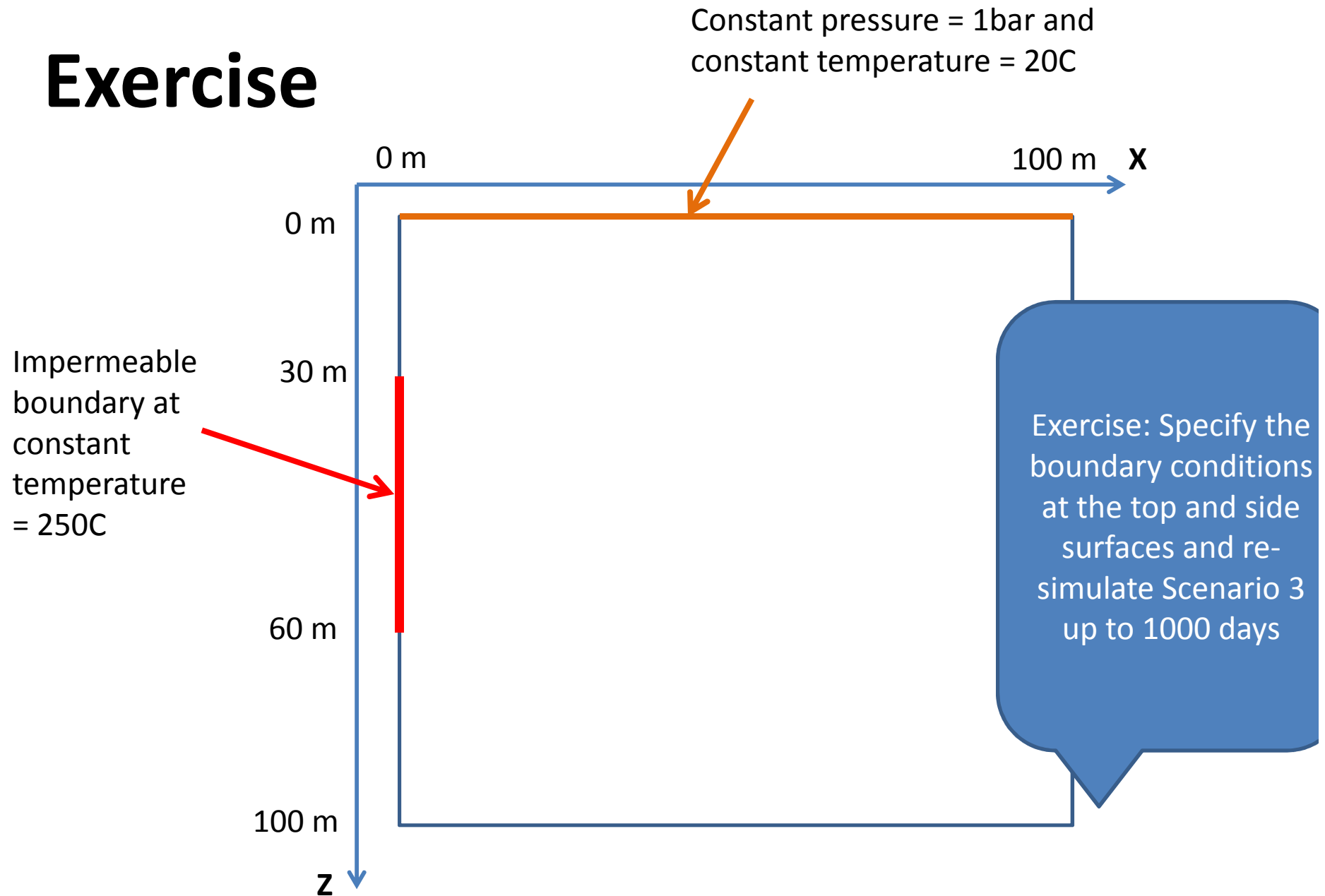
Exercise



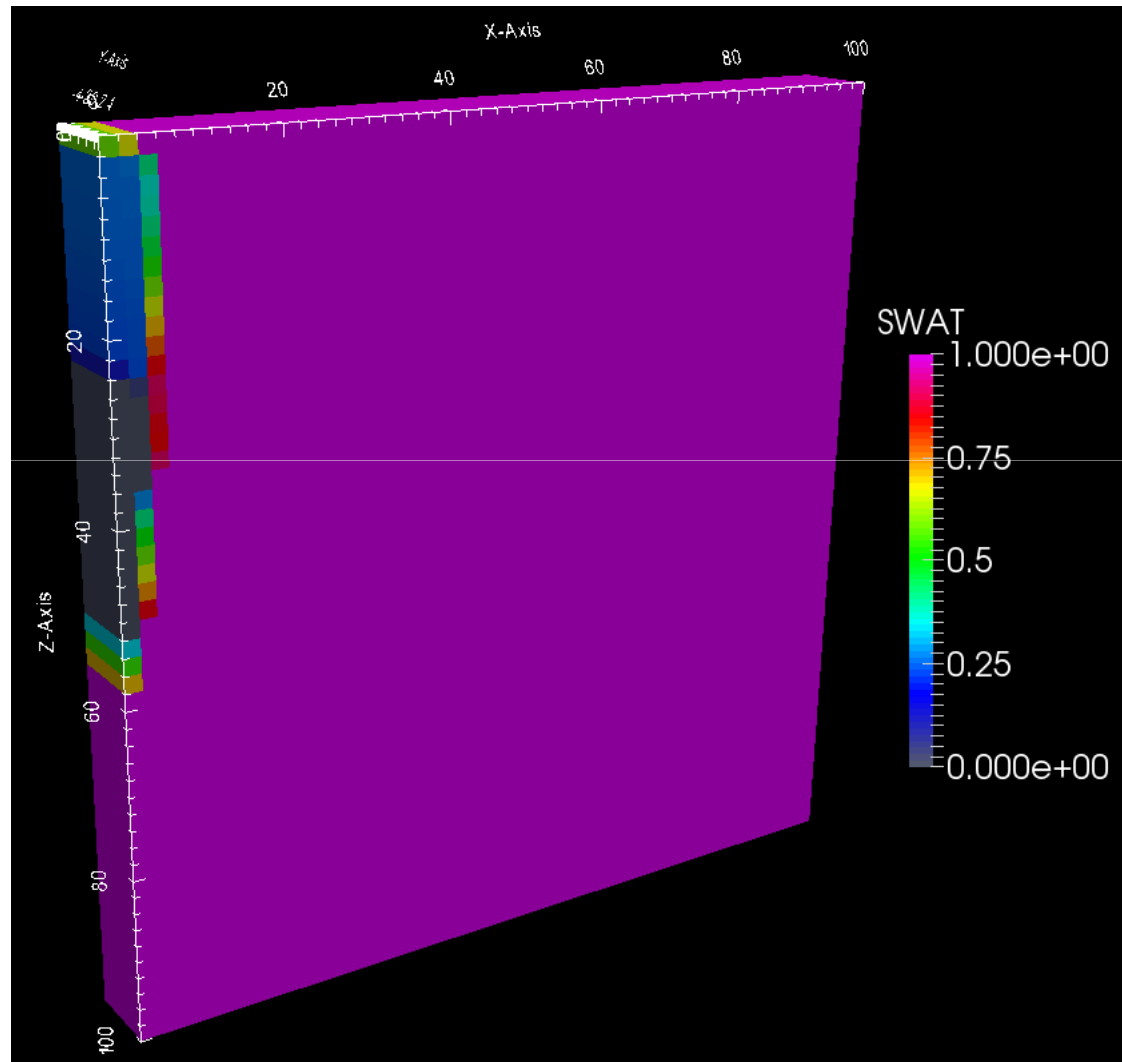
Result



Exercise



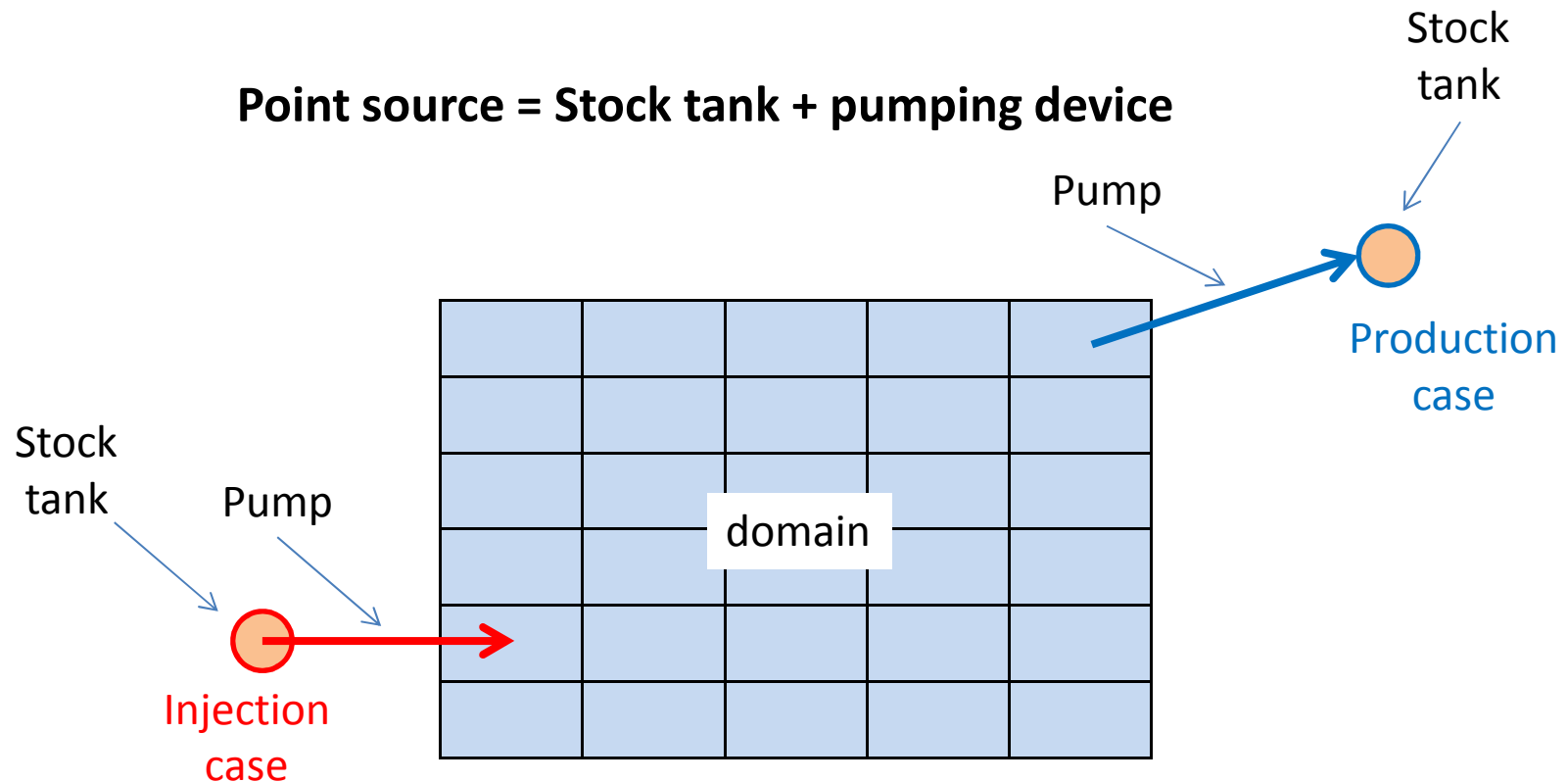
Result



Day 2. Operations on arrays, Regions,
Boundary conditions & Point sources

Point sources

Point sources



The parameters of injected fluid are defined in stock tank.

The injection rate is defined in pump properties.

You can refer to both stock tank and pumping device by using the name of point source.

The point source name is 8-byte character.

Keywords for operations on arrays for 'named' cells

Using these keywords you can define parameters of fluid in stock tanks.

Keyword	Result
ADDNAM	Add
COPYNAM	Copy from one array into another array
EQUALNAM	Equate to
MAXVANAM	Apply maximum limit
MINVANAM	Apply minimum limit
MULTINAM	Multiply by
OPERANAM	Apply a complicated arithmetic operation

EQUALNAM keyword

```

1  -- in all sections except RUNSPEC and POST
2
3  EQUALNAM
4      mnemonic1  value1  template1 /
5      mnemonic2  value2  template2 /
6      mnemonic3  value3  template3 /
7      ...
8  /
9
10 =====
11
12      mnemonic#   - mnemonic of the property which is modified;
13      value#      - value assigned to the property;
14      template#   - character name template.
15
16 =====
17
18      The keyword results in the following:
19
20      mnemonic1:=value1 for all cells which character name (if it
21                               is assigned) belong to template1;
22      mnemonic2:=value2 for all cells which character name (if it
23                               is assigned) belong to template2;
24      mnemonic3:=value3 for all cells which character name (if it
25                               is assigned) belong to template3.
26      ...

```

SRCSPECG keyword

This keyword defines the location of the point source.

```
1  -- within MAKE-ENDMAKE brackets
2
3  SRCSPECG
4      name1  i1 j1 k1  x1 y1 z1  mode1 /
5      name2  i2 j2 k2  x2 y2 z2  mode2 /
6      name3  i3 j3 k3  x3 y3 z3  mode3 /
7      ...
8  /
9
10 =====
11
12      name#    - the point source name (a 8-byte character);
13      i#-j#-k# - the i-j-k indexes of the grid block in which the point source
14                  is located;
15      x#-y#-z# - the coordinates of the point source;
16      mode#    - the point source mode, i.e. the pumping device mode (default
17                  value is SHUT).
18
19
```

SRCINJE keyword

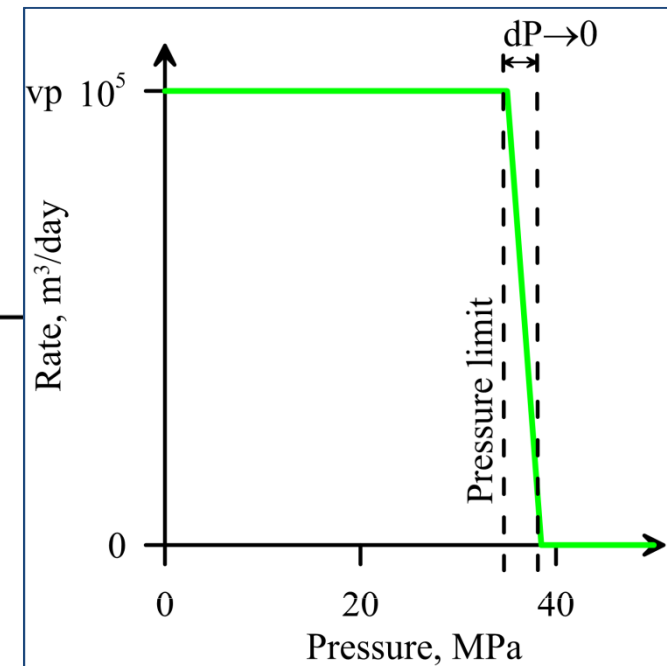
This keyword defines parameters of injection sources.

SRCINJE syntax

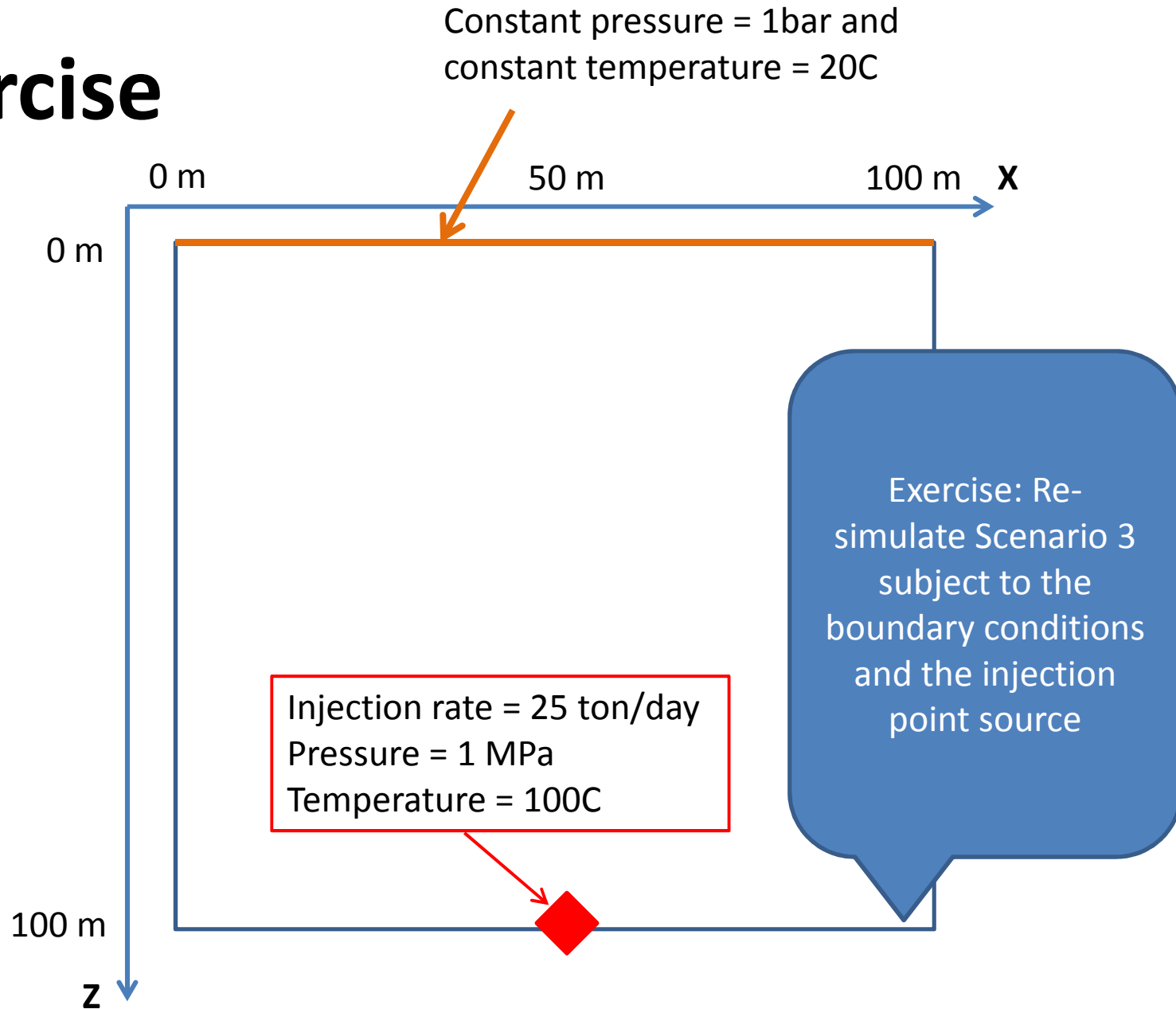
```

1  -- in SCHEDULE section
2
3  SRCINJE
4    name1 targ1 injtype1 plim1 volrate1 massrate1 vp1 dp1 /
5    name2 targ2 injtype2 plim2 volrate2 massrate2 vp2 dp2 /
6    name3 targ3 injtype3 plim3 volrate3 massrate3 vp3 dp3 /
7    ...
8  /
9
10 =====
11
12  name#      - pump name (8-byte character);
13  targ#      - pump operational target. Available values: MASS - mass rate,
14                RATEIN - volumetric rate on inlet, RATEOUT - volumetric rate on
15                outlet;
16  injtype#   - fluid used for operational control (default value recommended);
17  plim#      - maximum pressure at the pump outlet;
18  volrate#   - volumetric rate;
19  massrate#  - mass rate;
20  vp#        - maximum volumetric rate of the pumping device;
21  dp#        - the pressure gap for control function.
  
```

Pump control function



Exercise



SRCPROD keyword

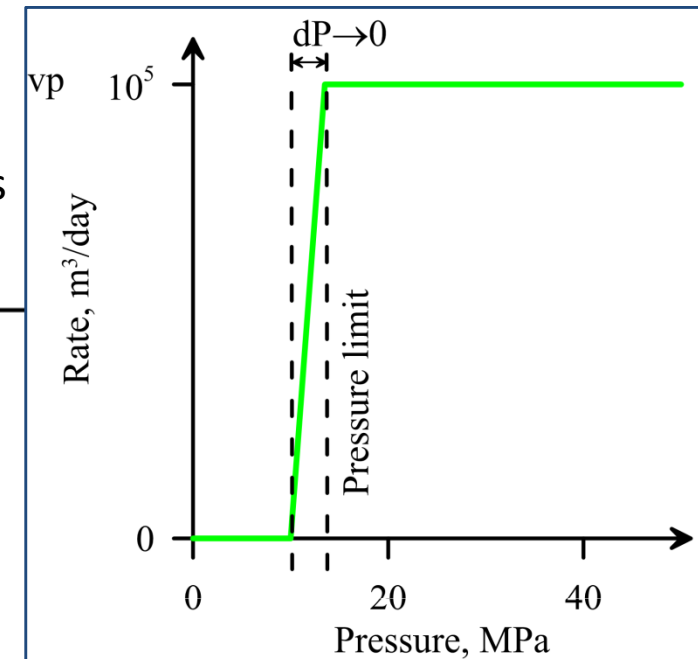
This keyword defines parameters of production sources (sinks).

SRCPROD syntax

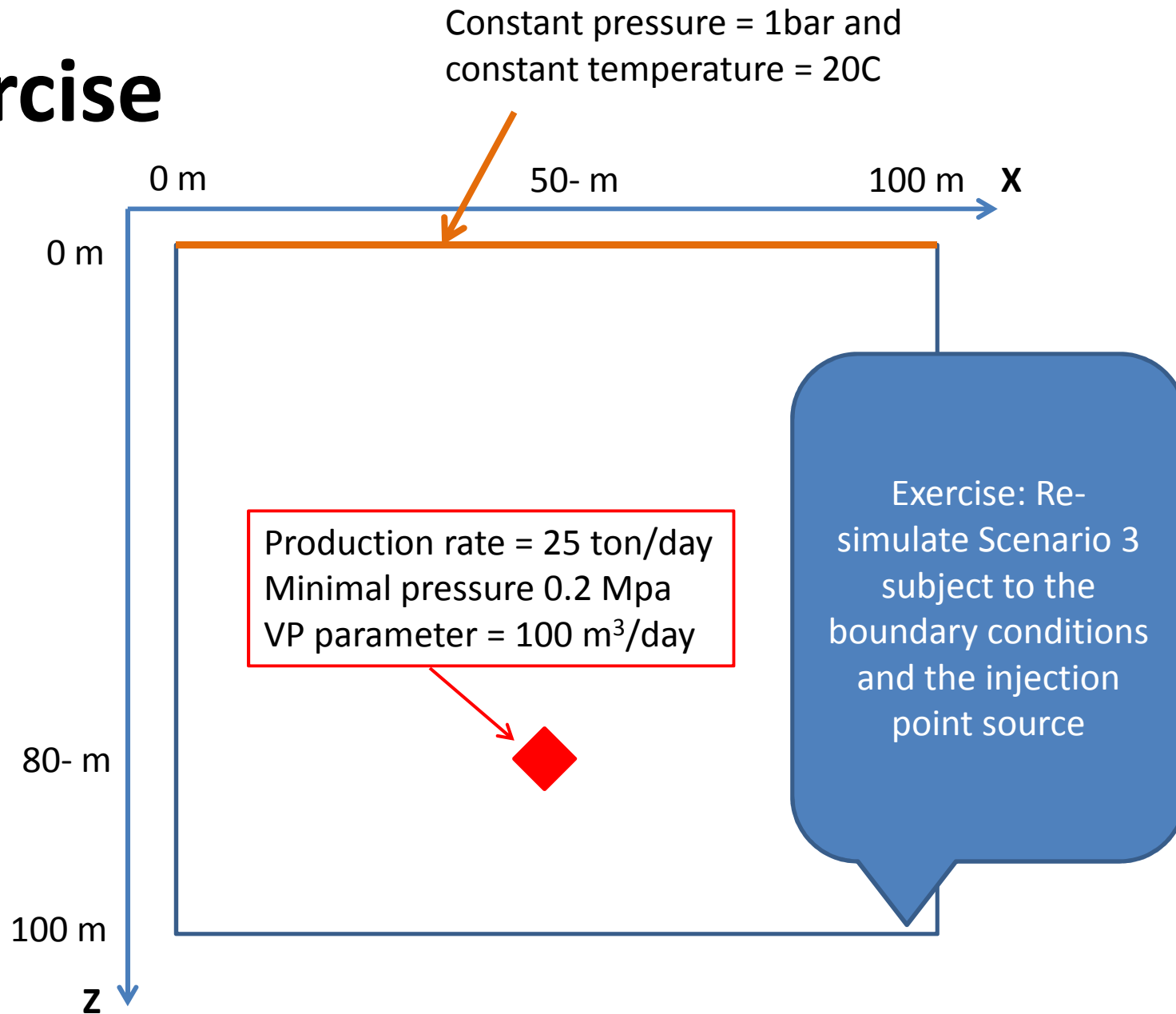
```

1  -- in SCHEDULE section
2
3  PUMPPROD
4    name1 targ1 injtype1 plim1 volrate1 massrate1 vp1 dp1 /
5    name2 targ2 injtype2 plim2 volrate2 massrate2 vp2 dp2 /
6    name3 targ3 injtype3 plim3 volrate3 massrate3 vp3 dp3 /
7    ...
8  /
9
10 =====
11
12  name#      - pump name (8-byte character);
13  targ#      - pump operational target. Available values: MASS - mass rate,
14                RATEIN - volumetric rate on inlet, RATEOUT - volumetric rate on
15                outlet;
16  injtype#   - fluid used for operational control (default value recommended);
17  plim#      - minimum pressure at the pump inlet;
18  volrate#   - volumetric rate;
19  massrate#  - mass rate;
20  vp#        - maximum volumetric rate of the pumping device;
21  dp#        - the pressure gap for control function.
  
```

Pump control function



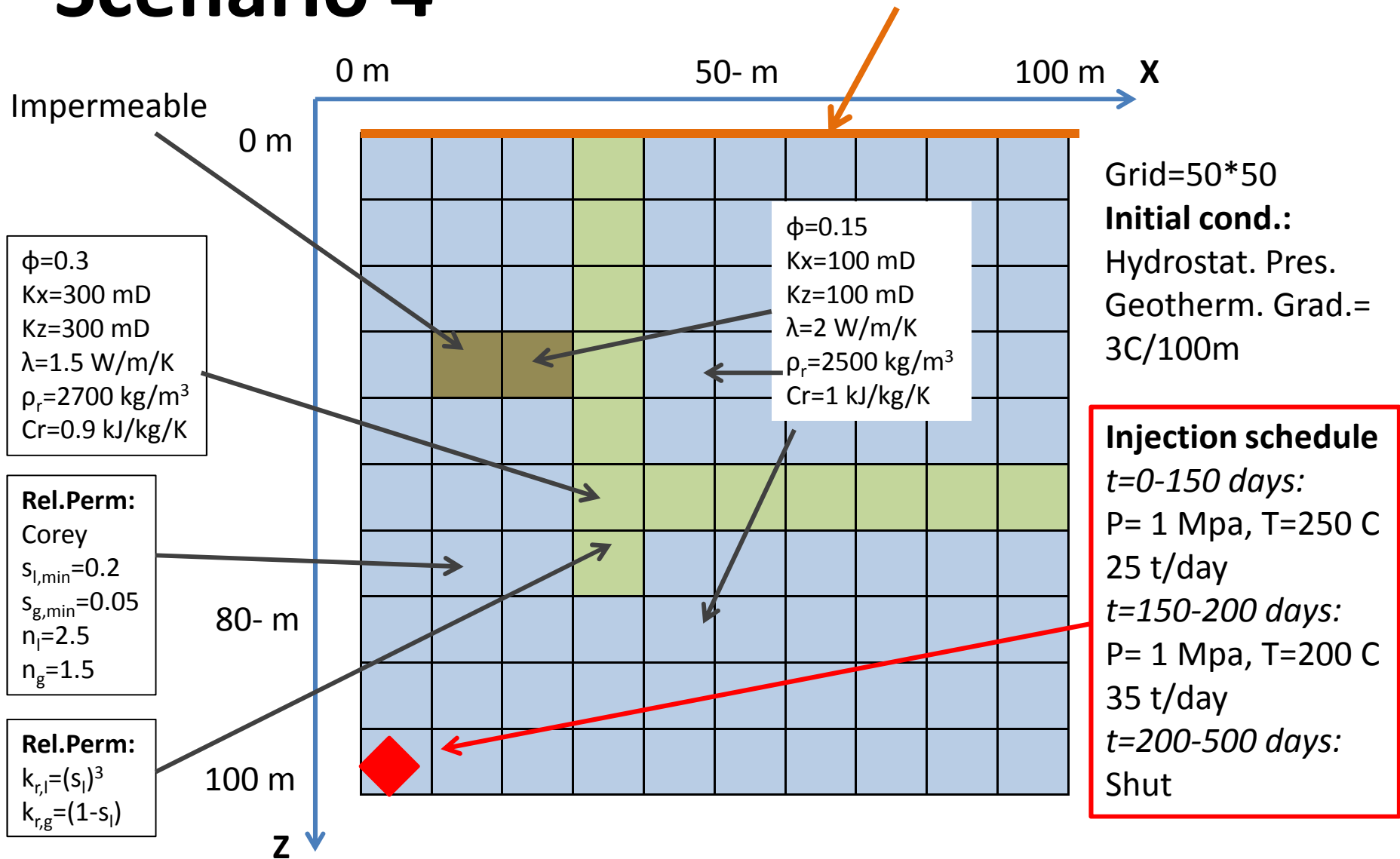
Exercise



Scenario 4

Scenario 4

Constant pressure = 1bar and
constant temperature = 20C

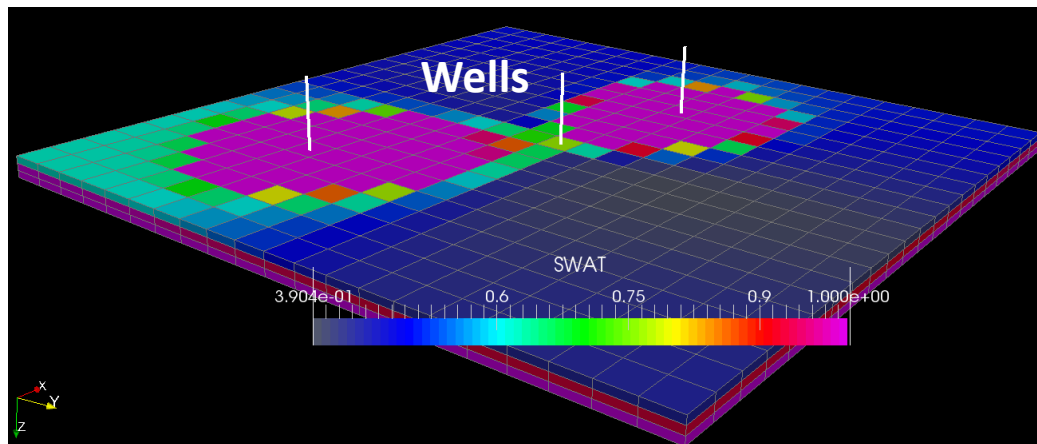


RUN-file (Scenario 4)

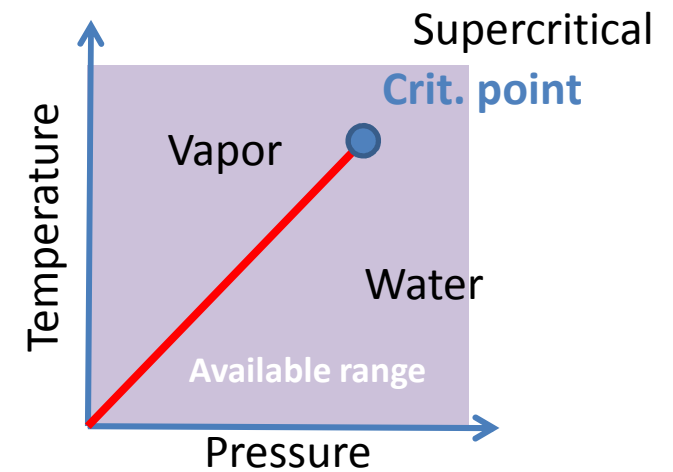
1. Open RUN-file in text editor
2. Run the simulation
3. Open results in ParaView

Next day

- EOS-module BINMIXT
- Section POST
- Wells



Water phase diagram



Results postprocessing

