Boundary Conditions, Initial Conditions and Subsurface properties

ParFlow Short Course

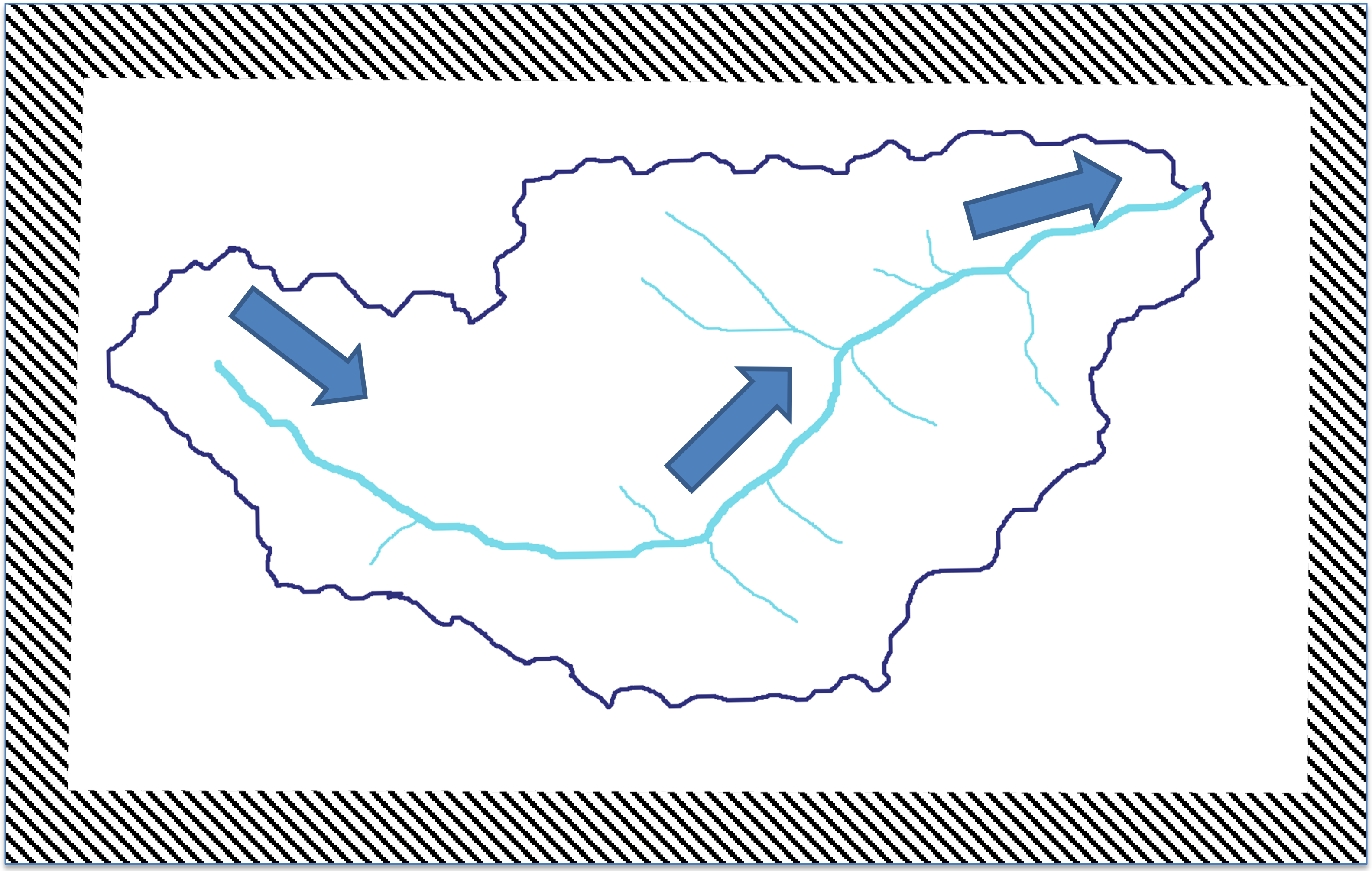
Module 4

Learning Objectives:

At the end of this module students will understand:

- Types of boundary conditions in ParFlow
- How to set boundary conditions with ParFlow keys
- Common issues and question with boundary conditions
- Ways to definite subsurface units- with an input file, indicator file
- How to add heterogeneity using turning bands
- Subsurface parameters that can be set within ParFlow
- How to set initial conditions to a constant value or from a file

Boundary Conditions



Boundary Conditions

- Boundary conditions must be set for all of the external patches on the domain
- 12 types of pressure boundary conditions (*BC Pressure in manual*):
  1. DirEquilRefPatch: pressure will be in hydrostatic equilibrium with reference pressure
  2. DirEquilPLinear: pressure will be in hydrostatic equilibrium with piecewise line at elevation z=0
  3. FluxConst: Constant flux (L/T) normal to the patch
  4. FluxVolumetric: Constant volumetric flux normal to the patch
  5. Pressure File: Defines hydraulic head boundary conditions. Only the values on the specified patch will be used
  6. FluxFile: Flux boundaries read in from a pfb file
  7. OverlandFlow: Turns on fully-coupled overland flow routing for uniform fluxes (e.g. rainfall or ET over the entire domain)
  8. OverlandKinematic: Turns on fully-coupled overland flow routing with upwinding and interface centered-fluxes
  9. OverlandDiffusive: Turns on fully-coupled overland flow routing with diffusive wave approximation
  10. SeepageFace: Turns on a seepage face boundary condition
  11. OverlandFlowPFB: Turns on fully-coupled overland flow routing for uniform fluxes with grid based spatially variable fluxes read in from a pfb
  12. Exact Solution: Exact know solution applied as a Dirichlet boundary condition on the patch

- Internal Dirichlet boundary conditions can also be defined by setting the pressure at internal points in the domain (*Internal BCs in manual*)

Example setting no flow boundary conditions on the sides and bottom of a model and overland flow on the top

```
model.BCPressure.PatchNames = "top bottom side"

model.Patch.bottom.BCPressure.Type = "FluxConst"
model.Patch.bottom.BCPressure.Cycle = "constant"
model.Patch.bottom.BCPressure.alltime.Value = 0.0

model.Patch.side.BCPressure.Type = "FluxConst"
model.Patch.side.BCPressure.Cycle = "constant"
model.Patch.side.BCPressure.alltime.Value = 0.0

model.Patch.top.BCPressure.Type = "OverlandKinematic"
model.Patch.top.BCPressure.Cycle = "rainrec"
model.Patch.top.BCPressure.rain.Value = -0.05
model.Patch.top.BCPressure.rec.Value = 0.0
```

Subsurface Properties

General approach to defining properties in ParFlow:

1. Identify unique subsurface units and provide subsurface geometries to ParFlow
   – Either using solid files or indicator files

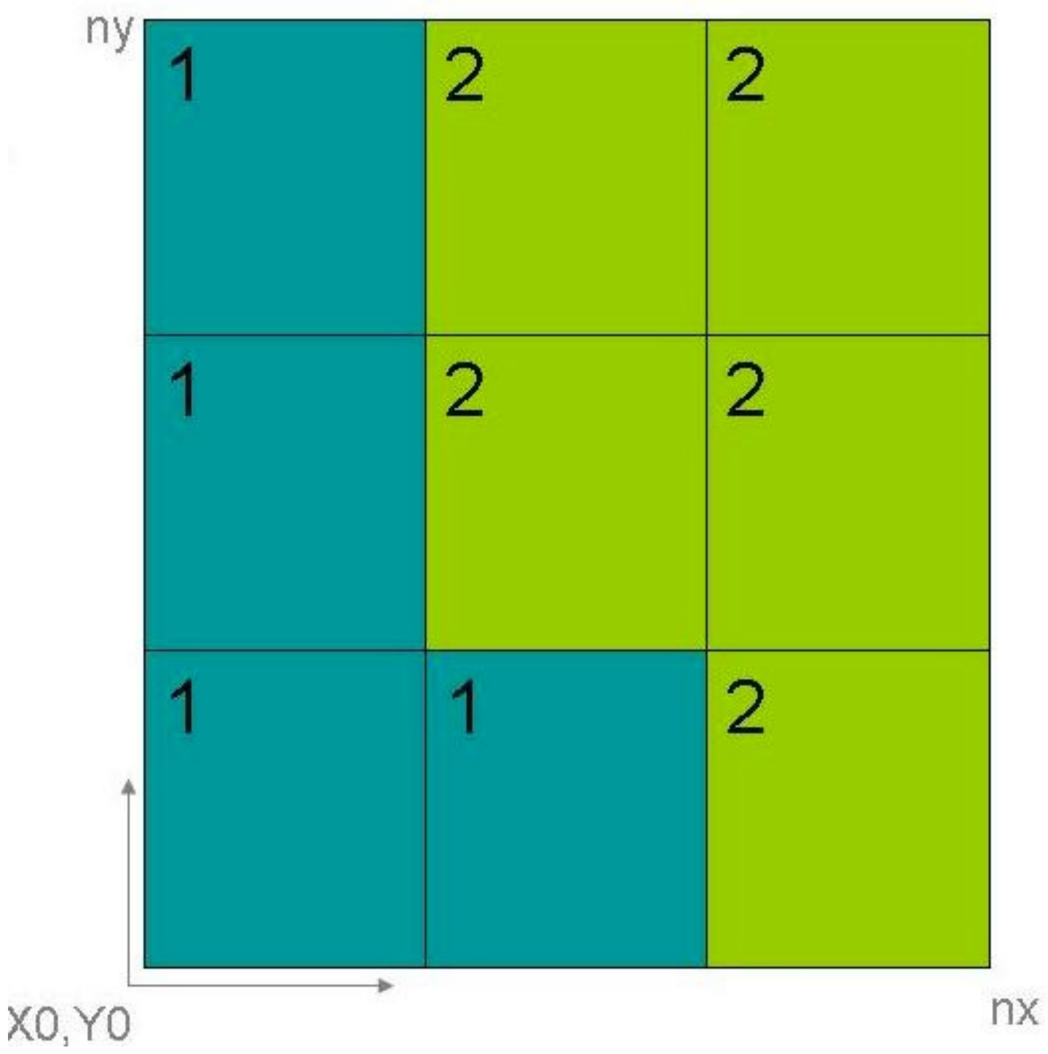
2. Assign the hydrologic properties to each unit
   – permeability, specific storage, porosity and van Genuchten parameters

http://parflow.blogspot.com/2015/08/subsurface-setup-options.html

Indicator files

3D ParFlow file that has an integer assignment for every grid cell designating what subsurface unit the cell belongs to

http://parflow.blogspot.com/2007/09/using-indicator-files-as-input-to.html



Indicator files

1. Tell Parflow that you will be using and indicator file and give unit a name

```
model.GeomInput.indi_input.InputType = "IndicatorField"
model.GeomInput.indi_input.GeomNames = "s1 s2 s3 g1 g2 g3"
model.Geom.indi_input.FileName = "Indicator_LW_USGS_Bedrock.pfb"
```

2. Match every unit name with an integer value in the indicator file

```
model.GeomInput.s1.Value = 1
model.GeomInput.s2.Value = 2
model.GeomInput.s3.Value = 3
model.GeomInput.g1.Value = 19
model.GeomInput.g2.Value = 20
model.GeomInput.g3.Value = 21
```

http://parflow.blogspot.com/2015/08/subsurface-setup-options.html

Assigning Properties

- Provide a list of the geometries you will be assigning values to and for <u>every</u> geometry listed provide a value

- You can set a background value using your domain geometry and you don’t have to use all of the indicator geometries you defined as long as every cell has a value

```
model.Geom.Perm.Names = "domain s1 s2"

model.Geom.domain.Perm.Type = "Constant"
model.Geom.domain.Perm.Value = 0.02

model.Geom.s1.Perm.Type = "Constant"
model.Geom.s1.Perm.Value = 0.269022595
model.Geom.s2.Perm.Type = "Constant"
model.Geom.s2.Perm.Value = 0.043630356
```

Assigning Properties

- Repeat the process for the other variables
- You can use different geometry combinations for different variables

```
model.Geom.Porosity.GeomNames = "domain s1 s2 s3"
model.Geom.domain.Porosity.Type = "Constant"
model.Geom.domain.Porosity.Value = 0.33
...

model.Phase.RelPerm.Type = "VanGenuchten"
model.Phase.RelPerm.GeomNames = "domain s1 s2 s3”
model.Geom.domain.RelPerm.Alpha = 1.0
model.Geom.domain.RelPerm.N = 3.0
...

model.Phase.Saturation.Type = "VanGenuchten"
model.Phase.Saturation.GeomNames = "domain s1 s2 s3”
model.Geom.domain.Saturation.Alpha = 1.0
model.Geom.domain.Saturation.N = 3.0
model.Geom.domain.Saturation.SRes = 0.001
model.Geom.domain.Saturation.SSat = 1.0
...
```

Adding Heterogeneity

- Turning bands method is built into ParFlow
- To implement you will need some preliminary analysis on the statistical properties of your domain
- You can implement turning bands separately for different subsurface units within the domain
- Refer to the Harvey flow example section 3.6.1 in the manual

```
model.Geom.domain.Perm.Type                "TurnBands"
model.Geom. domain.Perm.LambdaX            3.60
model.Geom. domain.Perm.LambdaY            3.60
model.Geom. domainPerm.LambdaZ             0.19
model.Geom. domain.Perm.GeomMean           112.00
model.Geom.upper_aquifer.Perm.Sigma            0.48989794
model.Geom.upper_aquifer.Perm.NumLines             150
model.Geom.upper_aquifer.Perm.Seed                 33333
model.Geom.upper_aquifer.Perm.LogNormal            Log
```