

ASPECT Tutorial

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With material from: Wolfgang Bangerth, Timo Heister, and many ASPECT contributors





ASPECT - Advanced Solver for Problems in Earth's Convection -





Modern numerical methods:

adaptive mesh refinement, linear and nonlinear solvers, higher-order discretizations, stabilization schemes

- Usability and extensibility: manual: 450+ pages, ~40 cookbooks/examples plugin architecture
- Parallel scalability
- Building on others' work: tested foundation, smaller codebase, automatic improvements
- **& Community:**

GPL, developed in the open Encourage contributions, be welcoming

Credits

Website and manual: aspect.geodynamics.org

Maintainers:

Wolfgang Bangerth, Juliane Dannberg, Timo Heister, Rene Gassmöller **Contributors:** many more (~45)

Publications: (~30)

• Kronbichler, Heister, Bangerth: "High Accuracy Mantle Convection Simulation through Modern Numerical Methods". Geophysical Journal International, 2012.



with contributions by:

geodynamics.org

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ASPECT

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Advanced Solver for Problems in Earth's ConvecTion User Manual Version 2.0.0-pre (generated September 20, 2017) Wolfgang Bangerth Juliane Dannberg Rene Gassmöller

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VirtualBox



• Start Oracle VM VirtualBox and import VM

👽 Oracle VM VirtualBox Manager				—		×	
File Machir	e Help						
🏈 Preferen	Preferences Ctrl+0		-	<i>></i>		•	
Import A	👔 Import Appliance C			Machine Tools	Global Too	ls	
🚯 Export A	Export Appliance Ct		rtualBox!			^	
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Tool to observe vi the currently chos (like the machine			irtual machine (VM) details. Reflects sen VM and allows basic operations (storage devices).	; groups of <u>properties</u> for on certain properties			
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for the currently s			selected VM and allows snapshots. Reflected VM and allows snapshot ope	erations like <u>create</u> ,		~	
Import an appliance into VirtualBox							

VirtualBox



Start ASPECT-tutorial virtual machine



VirtualBox



• You should see a screen like this:



VirtualBox: Keyboard layout

 If you have a different keyboard layout than the standard English(US)...





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- Basic usage of ASPECT is specified through a parameter file (e.g. tutorial.prm)
- The parameter file is used by the simulation to determine the discretization, parameters, initial conditions, boundary conditions, etc.
- By the end of this tutorial, you should be able to:
 - 1. Run aspect from the command line.
 - 2. Understand the basic layout of the parameter files that are used to control Aspect simulations.
 - 3. Be able to visualize the generated output in ParaView.



- We will begin by running ASPECT in the Terminal (ctrl + alt + t)
- 1. Change to the appropriate directory

cd Desktop

 Run ASPECT with the tutorial parameter file and print the output (this will take about 20 seconds)

./aspect tutorial.prm

3. Open log.txt and look at the output

gedit output-tutorial/log.txt



Visualizing Results with ParaView

- To visualize the simulation results, we will use ParaView
- ParaView is a program for visualization of large data sets
- It is already installed on the virtual machine, open it now by typing "paraview" in a terminal
- ParaView supports visualization tools such as isosurfaces, slices, streamlines, volume rendering, and other complex visualization techniques









- Start by opening solution.pvd which was created by running ASPECT
- You can choose "Open" from the File menu or use the Open icon
 in the toolbar
- The file is in /home/ubuntu/Desktop/output-tutorial/

-	Open File: (open multiple files with <ctrl> key.)</ctrl>		+ ×		
Look in: /ho	ome/ubuntu/Desktop/output-tutorial/	→ ↑			
Home Home	Filename particles solution log.txt particles.pvd solution.pvd				
	File name:	0	ĸ		
	Files of type: Supported Files (*.cml *.Flash *.flash *.boundary *.hier	Can	cel		



- The file will appear in the pipeline browser
 Make sure this is solution.pvd
- Click "Apply" to show the field in the view area
 - By default, no field is shown
 - Select "T" in the toolbar to show the temperature field





First

Frame

Previous

Frame

Play/Pa

use

Next

Frame

Visualization with ParaView

1.90612e+10

Simulation

Time

- The top toolbar has buttons to change the time, shown below
 - Click the play button and watch how the temperature field changes

Time:

 Near the end, is the temperature field static? Is the velocity field static? Is material moving?

Loop

Last

Frame



Frame 0





+

69

Time step

number



Temperature field with tracer particles

- Open the file particles.pvd and click "Apply"
 - The tracer particles from the simulation now appear on the temperature field
 - By default they are uniformly colored
 - Change the coloring scheme to "id" toshow each particle in a different color
 - Click play again to see how material is flowing with the tracer particles
 - Even when the temperature field is static, is material flowing?
 - How would you characterize this flow pattern? Where is the upwelling material? The downwelling material?





Setup of the numerical model CIG COMPUTATIONAL FOR GEODYNAMICS

- Numerical models generally consist of several key components:
 - 1. The rules (e.g. equations) for the model
 - 2. The discretization of the model (the mesh)
 - 3. Model parameters
 - 4. Dependent and independent variables
 - 5. The initial state of the model
 - 6. The boundary conditions
 - We will go through the parameter file and look at these components

aspect-gui tutorial.prm

or

gedit tutorial.prm

Input file in gedit

and.



```
tutorial.prm (-/Desktop) - gedit
File Edit View Search Tools Documents Help
 👝 🔤 Open 👻 🕹 Save 🔛
                                         🐞 👂 🎽 Q Q
 tutorial.prm ×
# At the top, we define the number of space dimensions we would like to
# work in:
set Dimension
                                           = 2
# There are several global variables that have to do with what
# time system we want to work in and what the end time is. We
# also designate an output directory.
set Use years in output instead of seconds = true
set End time
                                          = 5e10
                                           = output-tutorial
set Output directory
# Then come a number of sections that deal with the setup
# of the problem to solve. The first one deals with the
# geometry of the domain within which we want to solve.
# The sections that follow all have the same basic setup
# where we select the name of a particular model (here,
# the box geometry) and then, in a further subsection,
# set the parameters that are specific to this particular
# model.
subsection Geometry model
 set Model name = box
 subsection Box
   set X extent = 4.2e6
    set Y extent = 3e6
 end
end
# The following section deals with the discretization of
# this problem, namely the kind of mesh we want to compute
# on. We here use a globally refined mesh without
# adaptive mesh refinement.
subsection Mesh refinement
                                               = 3
 set Initial global refinement
 set Initial adaptive refinement
                                               - 0
 set Time steps between mesh refinement
                                              - 0
end
# The following two sections describe first the
# direction (vertical) and magnitude of gravity and the
# material model (i.e., density, viscosity, etc).
subsection Gravity model
  set Model name = vertical
 subsection Vertical
    set Magnitude = 9.81
 end
```

Parameter GUI



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Hide default values Ch	ange font					
(Sub)Sections/Parameters	Value					-
Dimension	2					
Additional shared libraries						
Resume computation	false					
Max nonlinear iterations	10					
Max nonlinear iterations in pre-refinem	ent 2147483647					
Start time	0					
Timing output frequency	100					U
Use years in output instead of seconds	true					
CFL number	1					
Maximum time step	5.69e+300					
Use conduction timestep	false					
Nonlinear solver scheme	IMPES					
Nonlinear solver tolerance	1e-05					
Pressure normalization	surface					
Surface pressure	0					
Adiabatic surface temperature	0					
Output directory	output-tutorial					
Use direct solver for Stokes system	false					
Linear solver tolerance	1e-07					
Parameter documentation:						0 8

The number of space dimensions you want to run this program in. ASPECT can run in 2 and 3 space dimensions.

• Hide default values...