Elmer

Beoynd ElmerGUI – About pre- and postprocessing, derived data and manually working with the case

D.Sc. Peter Råback
Product Manager, Elmer software

CSC – IT Center for Science Ltd.

CSC, 2011

Topics

- Alternative preprocessors
  - ElmerGrid
- Alternative postprocessors
  - 2D/3D: ResultOutputSolver
- Derived fields
  - Many auxiliary solvers
- Reduced dimensional data
  - Line plotting tools
  - 1D: SaveLine
  - 0D: SaveScalars
- Example: Twelve Solvers!
- Exercise: Using an existing case as starting point

Alternative mesh generators for Elmer

Open source

- Mesh2D
  - 2D Delaunay
  - Writes Elmer format
  - Usable via the old ElmerFront
- ElmerGrid: native to Elmer
  - Simple structured mesh generation
  - Usable via ElmerGUI
- Tetgen, Netgen
  - Tetrahedral mesh generation
  - Usable via ElmerGUI as a plug-in
- Gmsh
  - Includes geometry definition tools
  - ElmerGUI/ElmerGrid can read the format
- Triangle
  - 2D Delaunay
  - ElmerGUI/ElmerGrid can read the format

Commercial

- GiD
  - Inexpensive
  - With an add-on module can directly write Elmer format
- Gambit
  - Preprocessor of Fluent suite
  - ElmerGUI/ElmerGrid can read .FDNEUT format
- Comsol multiphysics
  - ElmerGUI/ElmerGrid can read .mphtxt format
- Ask for your format:
  - Writing a parser from ascii-mesh file usually not big a deal

Importing meshes with ElmerGrid

- ElmerGrid has a number parsers for various formats
- Each format has a ”magic number”
- ElmerGUI decides the format just from the suffix, for a few formats

The first parameter defines the input file format:

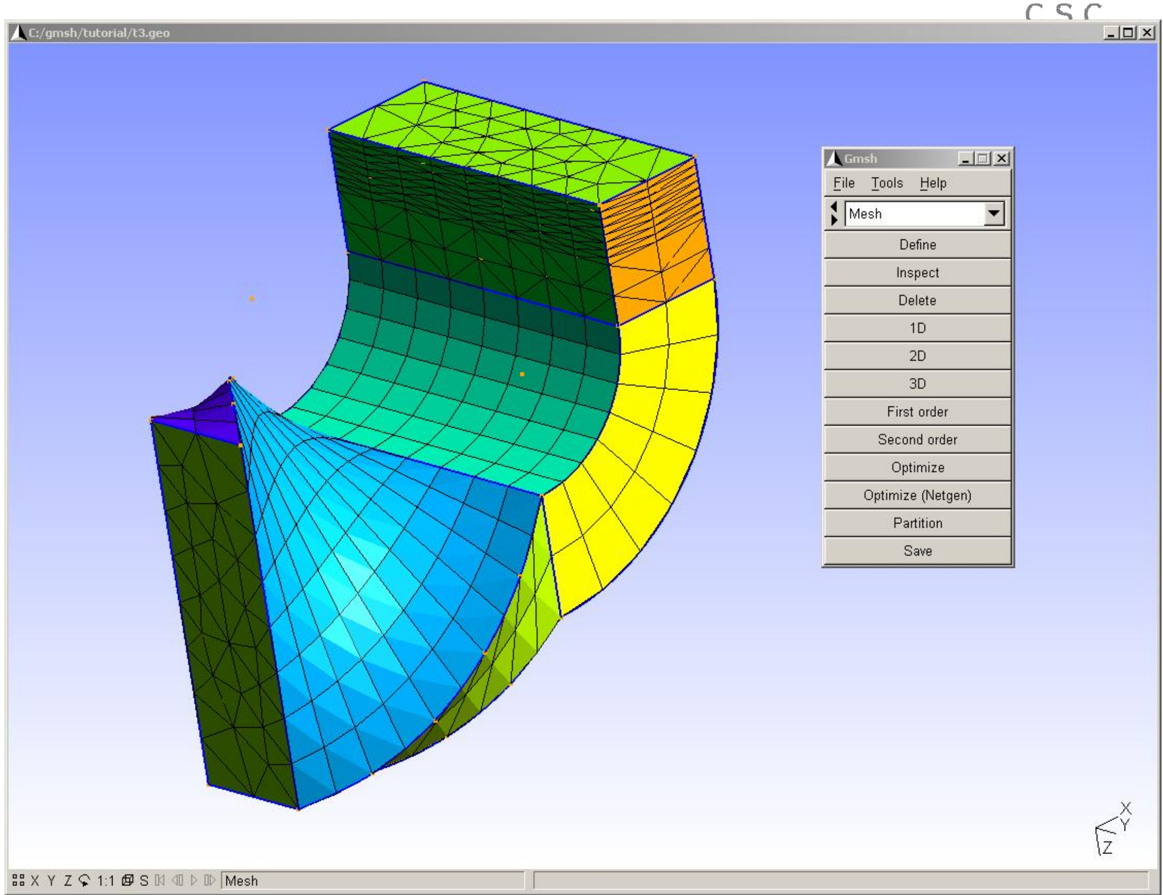
1) .grd : Elmergrid file format
2) .mesh.* : Elmer input format
3) .ep : Elmer output format
4) .ansys : Ansys input format
5) .inp : Abaqus input format by Ideas
6) .fil : Abaqus output format
7) .FDNEUT : Gambit (Fidap) neutral file
8) .unv : Universal mesh file format
9) .mphtxt : Comsol Multiphysics mesh format
10) .dat : Fieldview format
11) .node,.ele: Triangle 2D mesh format
12) .mesh : Medit mesh format
13) .msh : GID mesh format
14) .msh : Gmsh mesh format
15) .ep.i : Partitioned ElmerPost format

The second parameter defines the output file format:

1) .grd : ElmerGrid file format
2) .mesh.* : ElmerSolver format (also partitioned .part format)
3) .ep : ElmerPost format

Gmsh as preprocessor for Elmer

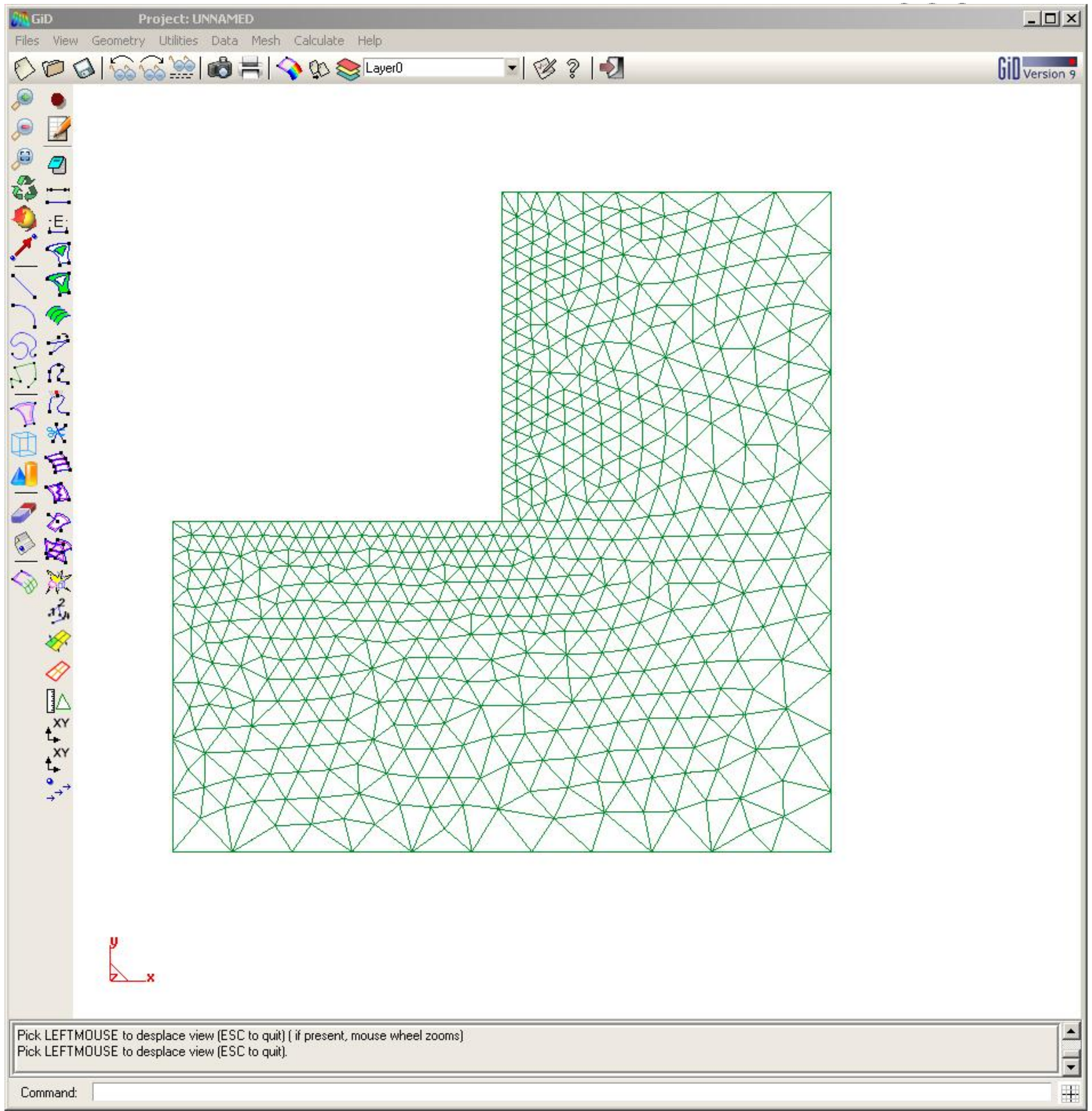
- GPL
- Save in .msh -ascii ”include all”
- Open in ElmerGrid or ElmerGUI




```
>ElmerGrid 14 2 mymesh.msh
```

GiD as preprocessor to Elmer

- Rather inexpensive
- One month free!
- Install export package
- Use problemtype Elmer
- Saves Elmer meshes directly



Alternative postprocessors for Elmer

Open source

- ElmerPost
  - Postprocessor of Elmer suite
- ParaView, Visit
  - Use ResultOutputSolve to write .vtu or .vtk
  - Visualization of parallel data
- OpenDX
  - Supports some basic elementtypes
- Gmsh
  - Use ResultOutputSolve to write dat
- Gnuplot, R, Octave, …
  - Use SaveData to save results in ascii matrix format
  - Line plotting

Commercial

- Matlab, Excel, …
  - Use SaveData to save results in ascii matrix format
  - Line plotting

Exporting 2D/3D data: ResultOutputSolve

- Apart from saving the results in .ep format it is possble to use other postrprocessing tools
- ResultOutputSolve offers several formats
  - vtk: Visualization tookit legacy format
  - vtu: Visualization tookit XML format
  - Gid: GiD software from CIMNE: http://gid.cimne.upc.es
  - Gmsh: Gmsh software: http://www.geuz.org/gmsh
  - Dx: OpenDx software
- **Vtu is the recommended format!**
  - offers parallel data handling capabilities
  - Has binary and single precision formats for saving disk space

Exporting 2D/3D data: ResultOutputSolve

An example shows how to save data in unstructured XML VTK (.vtu) files to directory ”results” in single precision binary format.

```
Solver n
  Exec Solver = after timestep
  Equation = "result output"
  Procedure = "ResultOutputSolve" "ResultOutputSolver"
  Output File Name = "case"
  Output Format = String ”vtu”
  Binary Output = True
  Single Precision = True
  Output Directory = results
End
```

Derived fields

- Many solvers have internal options for computing derived fields (fluxes, heating powers,…)
- Elmer offers several auxiliary solvers
  - SaveMaterials: makes a material parameter into field variable
  - Streamlines: computes the streamlines of 2D flow
  - FluxComputation: given potential, computes the flux $q = - c \nabla\phi$
  - VorticitySolver: computes the vorticity of flow, $w = \nabla\times\phi$
  - PotentialSolver: given flux, compute the potential $- c \nabla\phi = q$
  - Filtered Data: compute filtered data from time series (mean, fourier coefficients,…)
  - …
- Usually auxiliary data need to be computed only after the iterative solution is ready
  - Exec Solver = after timestep
  - Exec Solver = after all

Derived lower dimensional data

- Derived boundary data
  - SaveLine: Computes fluxes on-the-fly
- Derived lumped (or 0D) data
  - SaveScalars: Computes a large number of different quantities on-the-fly
  - FluidicForce: compute the fluidic force acting on a surface
  - ElectricForce: compute the electrostatic froce using the Maxwell stress tensor
  - Many solvers compute lumped quantities internally for later use (Capacitance, Lumped spring,…)

Saving 1D data: SaveLine

- Lines of interest may be defined on-the-fly
- Flux computation using integration points on the boundary – not the most accurate
- By default saves all existing field variables

Saving 1D data: SaveLine…

```
Solver n
 Equation = "SaveLine"
 Procedure = File "SaveData" "SaveLine"
 Filename =  "g.dat"
 File Append = Logical True
 Polyline Coordinates(2,2) = Real 0.25 -1 0.25 2.0
End

Boundary Condition m
  Save Line = Logical True
End
```

Saving 0D data: SaveScalars

Operators on bodies

- Statistical operators
  - Min, max, min abs, max abs, mean, variance, deviation
- Integral operators (quadratures on bodies)
  - volume, int mean, int variance
  - Diffusive energy, convective energy, potential energy

Operators on boundaries

- Statistical operators
  - Boundary min, boundary max, boundary min abs, max abs, mean, boundary variance, boundary deviation, boundary sum
  - Min, max, minabs, maxabs, mean
- Integral operators (quadratures on boundary)
  - area
  - Diffusive flux, convective flux

Other operators

- nonlinear change, steady state change, time, timestep size,…

Saving 0D data: SaveScalars…

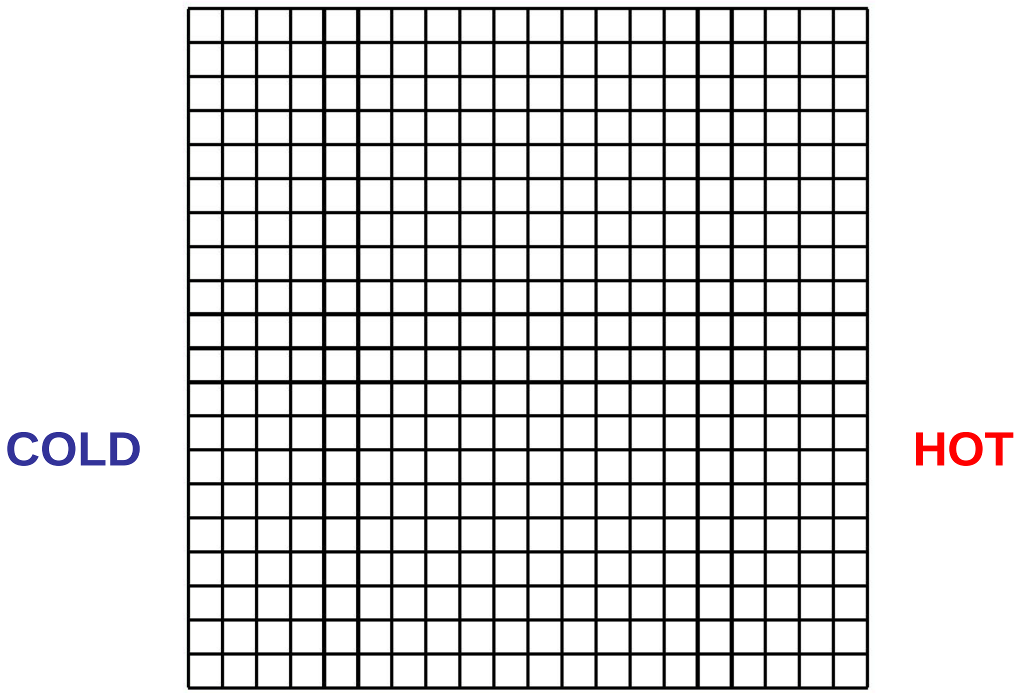
```
Solver n
  Exec Solver = after timestep
  Equation = String SaveScalars
  Procedure = File "SaveData" "SaveScalars"
  Filename = File "f.dat"
  Variable 1 = String Temperature
  Operator 1 = String max
  Variable 2 = String Temperature
  Operator 2 = String min
  Variable 3 = String Temperature
  Operator 3 = String mean
End

Boundary Condition m
  Save Scalars = Logical True
End
```

Case: TwelveSolvers

Natural convection with ten auxialiary solvers

Case: preliminaries

- Square with hot wall on right and cold wall on left
- Filled with viscous fluid
- Bouyancy modeled with Boussinesq approximation
- Temperature difference initiates a convection roll



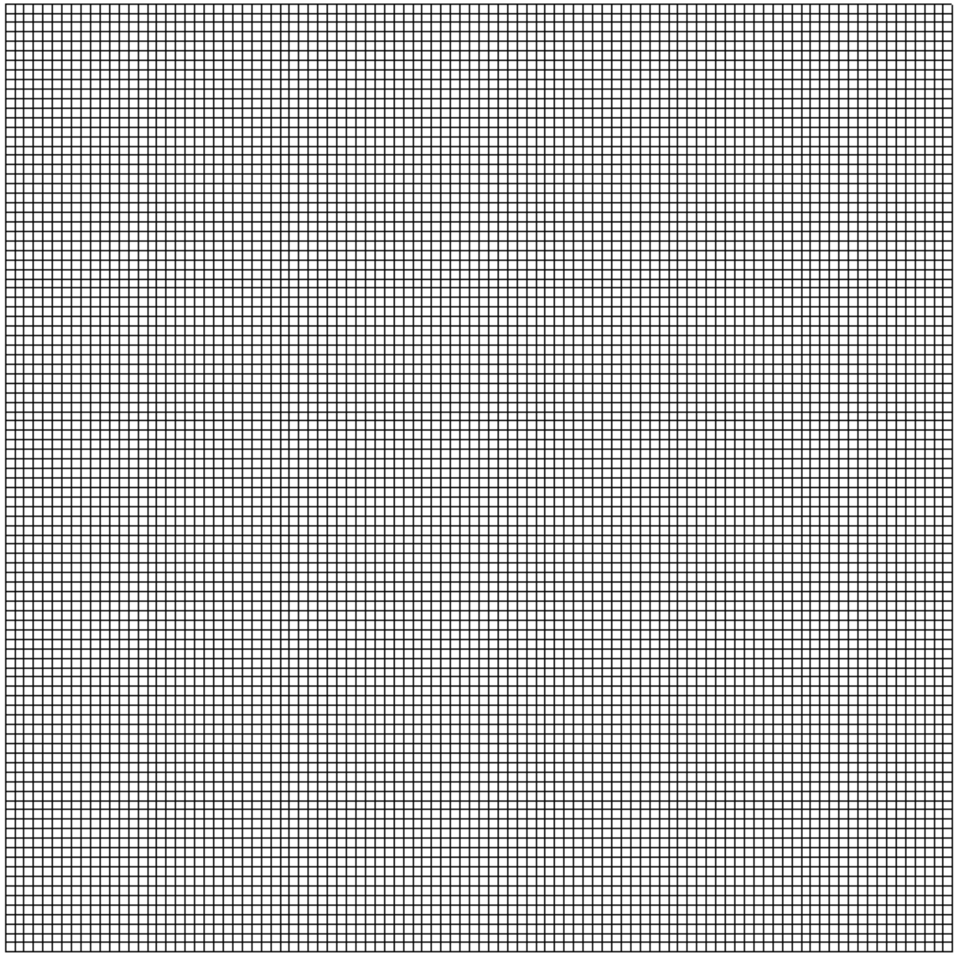
Case: solvers

1. Heat Equation
2. Navier-Stokes

---

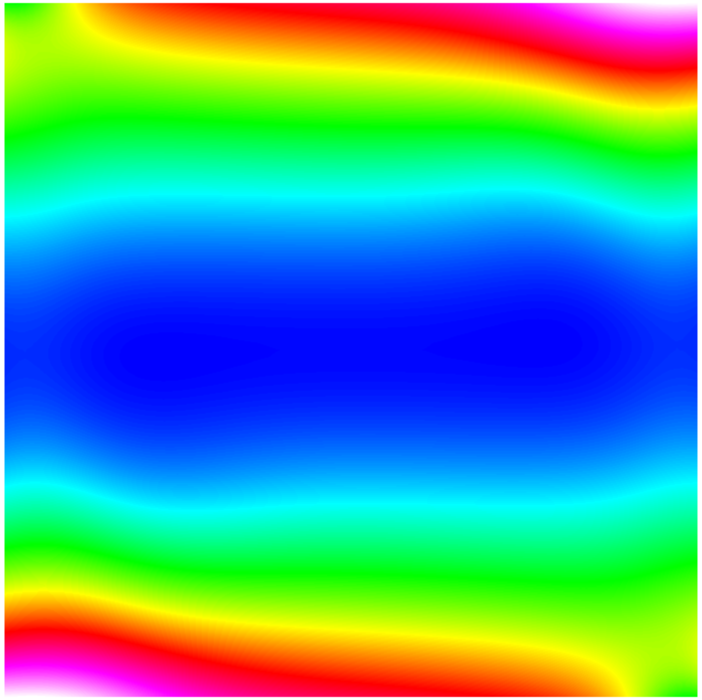
1. FluxSolver: solve the heat flux
2. StreamSolver
3. VorticitySolver
4. DivergenceSolver
5. ShearrateSolver
6. IsosurfaceSolver
7. ResultOutputSolver
8. SaveGridData
9. SaveLine
10. SaveScalars

Case: Computational mesh

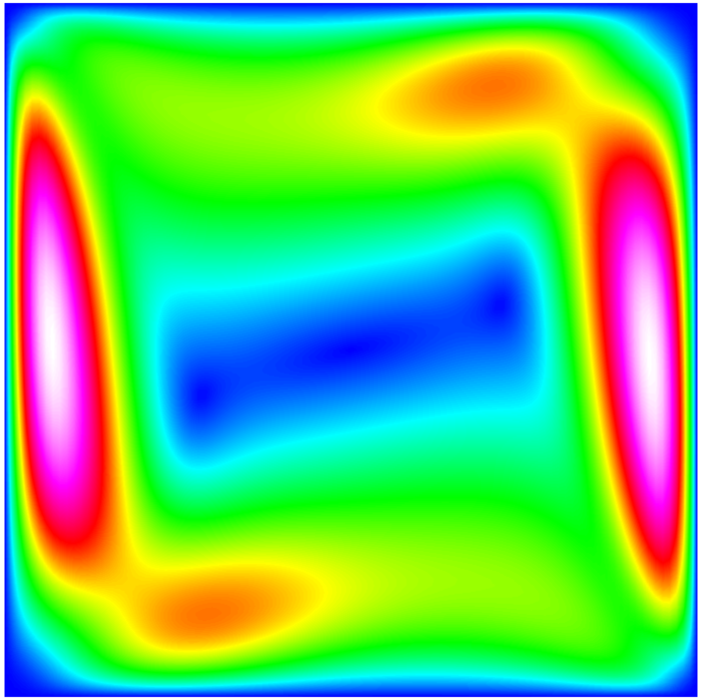


10000 bilinear elements

Case: Navier-Stokes, Primary fields

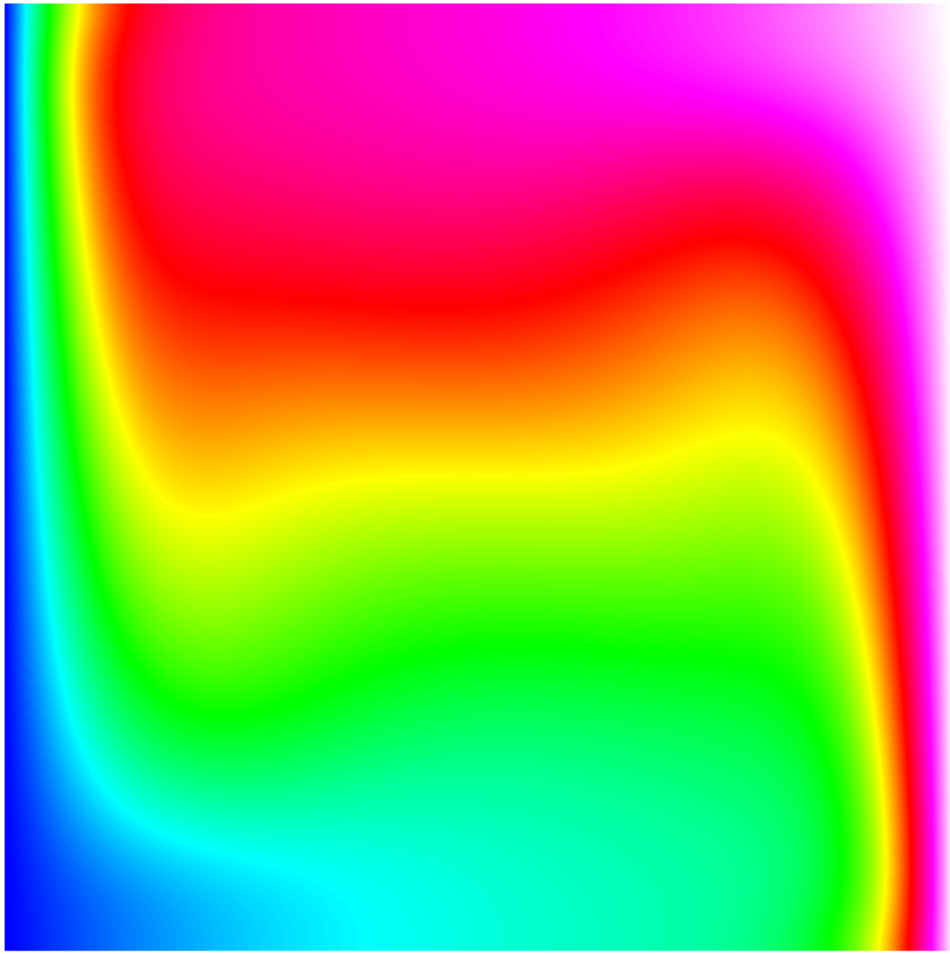


Pressure

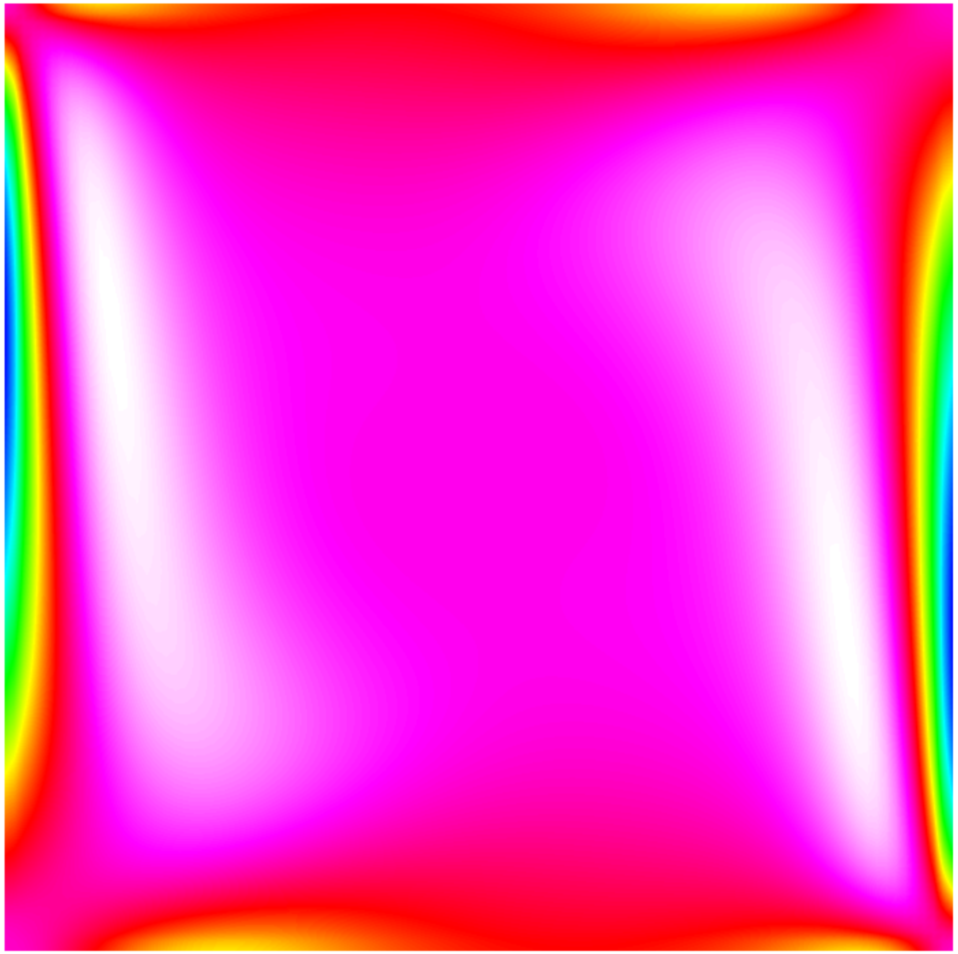


Velocity

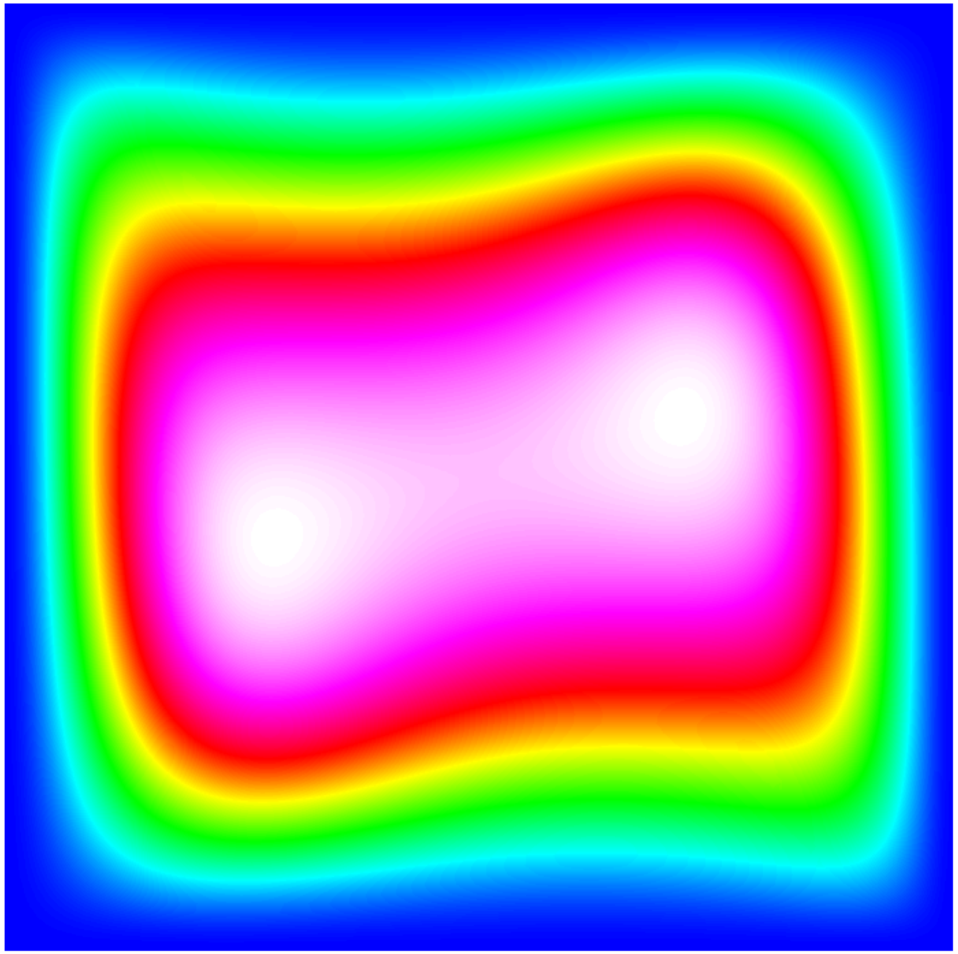
Case: Heat equation, primary field



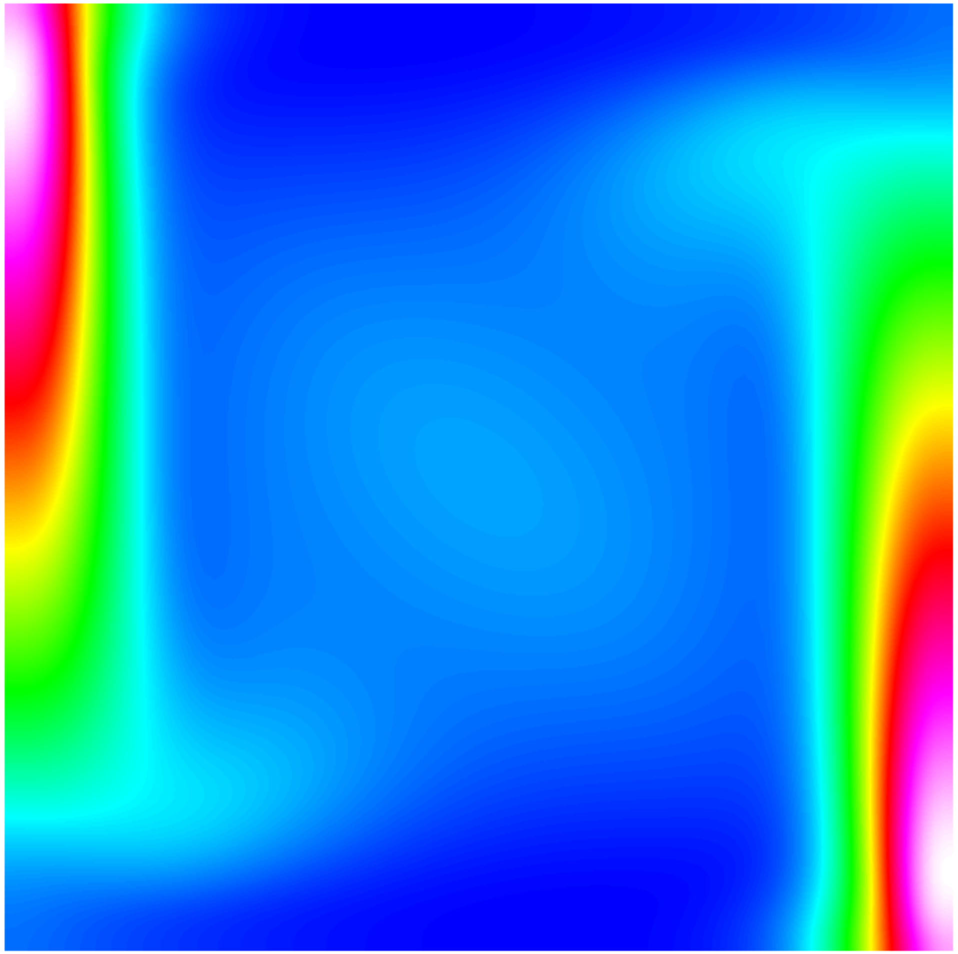
Case: Derived field, vorticity



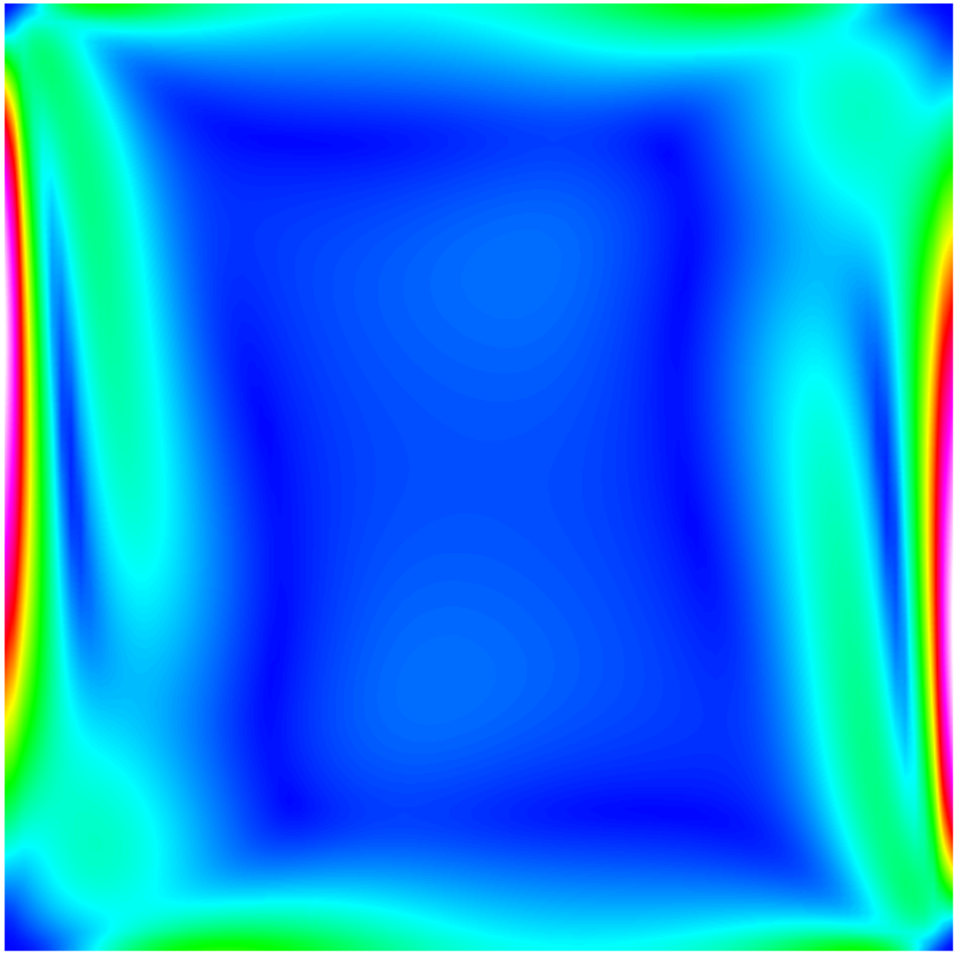
Case: Derived field, Streamlines



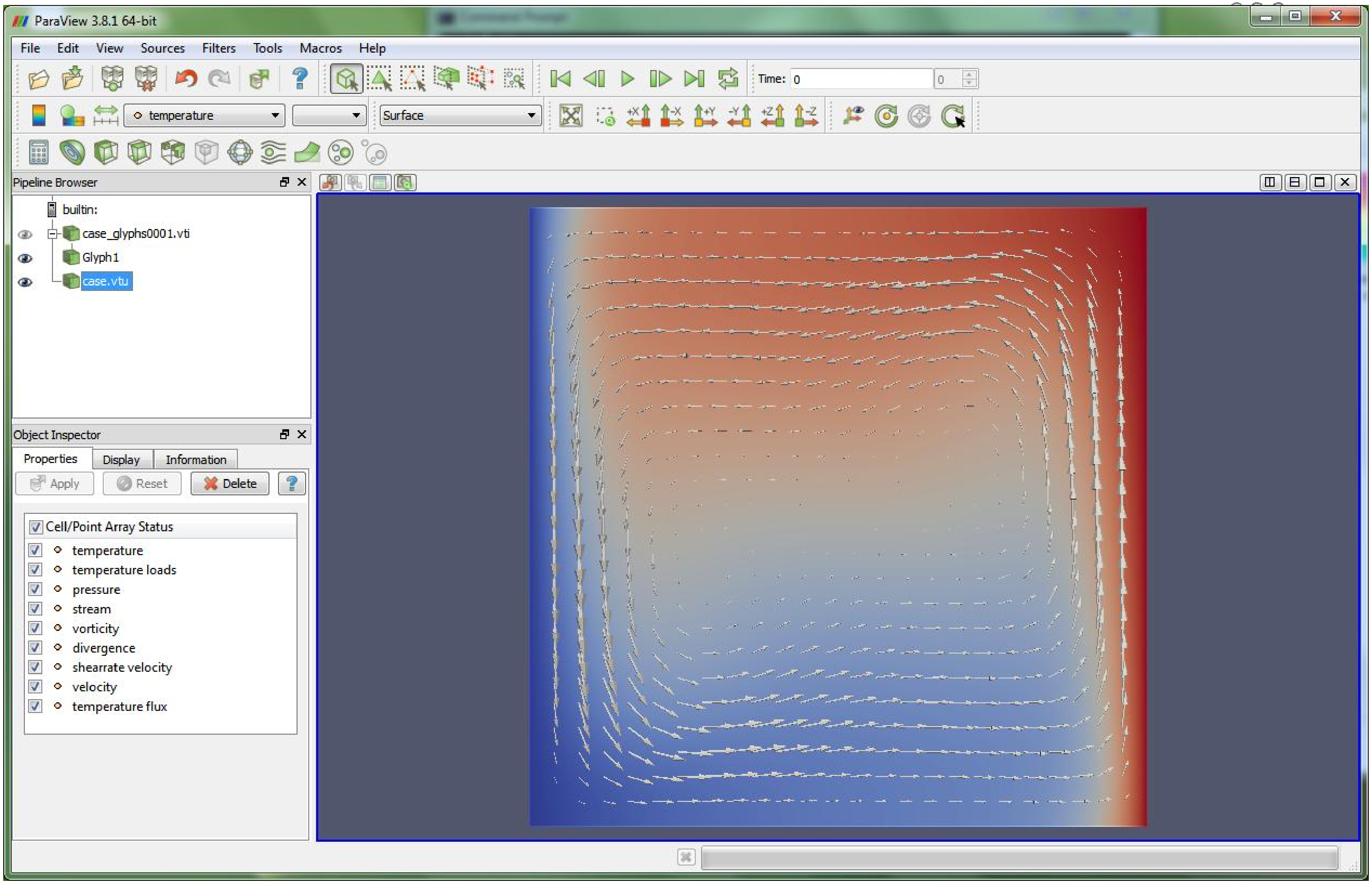
Case: Derived field, diffusive flux



Case: Derived field, Shearrate



Case: View in Paraview



Manually editing the command files

- Only the most important solvers and features are supported by the GUI
- Minor modifications are most easily done by manual manipulation of the files
- The tutorials, test cases and documentation all include usable sif file pieces
- Use your favorite text editor (emacs, notepad++,…) and copy-paste new definitions to your .sif file
- If your additiones were sensible you can rerun your case
- Note: you cannot read in the changes made in the .sif file

Exercise

- Study the command file with 12 solvers
- Copy-paste an appropriate solver from there to some existing ”toy” glacier model
  - ResultOutputSolver for VTU output
  - StreamSolver, VorticitySolver, FluxSolver,…
- Note: Make sure that the numbering of Solvers is consistant
- Run the modified case
- Visualize results in ElmerPost or Paraview

path=%path%;C:\Elmer6.2\bin
path=%path%;C:\Elmer6.2\lib

Documentation of Elmer

- **Elmer Tutorials** with related **input files**
  Examples of simple Elmer cases with documentation of the solution procedures.
- **ElmerGUI Manual**
  Manual of the graphical user interface of Elmer software suite.
- **Elmer Models Manual**
  Description of the different physical models that are defined
  in independent solvers.
- **ElmerSolver Manual**
  Capabilities of the solver with an emphasis on generic library services provided by the software.
- **ElmerGrid Manual** with related **grd-files**
  Manual of ElmerGrid utility with simple meshing examples.
- **Elmer Overview**
  Overview over the different Elmer software with a view of the different
  executables, modules, manuals and strategies (meta-manual).
- **Elmer Programmers Tutorial**
  Minimalistic tutorial about programming of Elmer