ElmerSolver Input File (SIF) Explained

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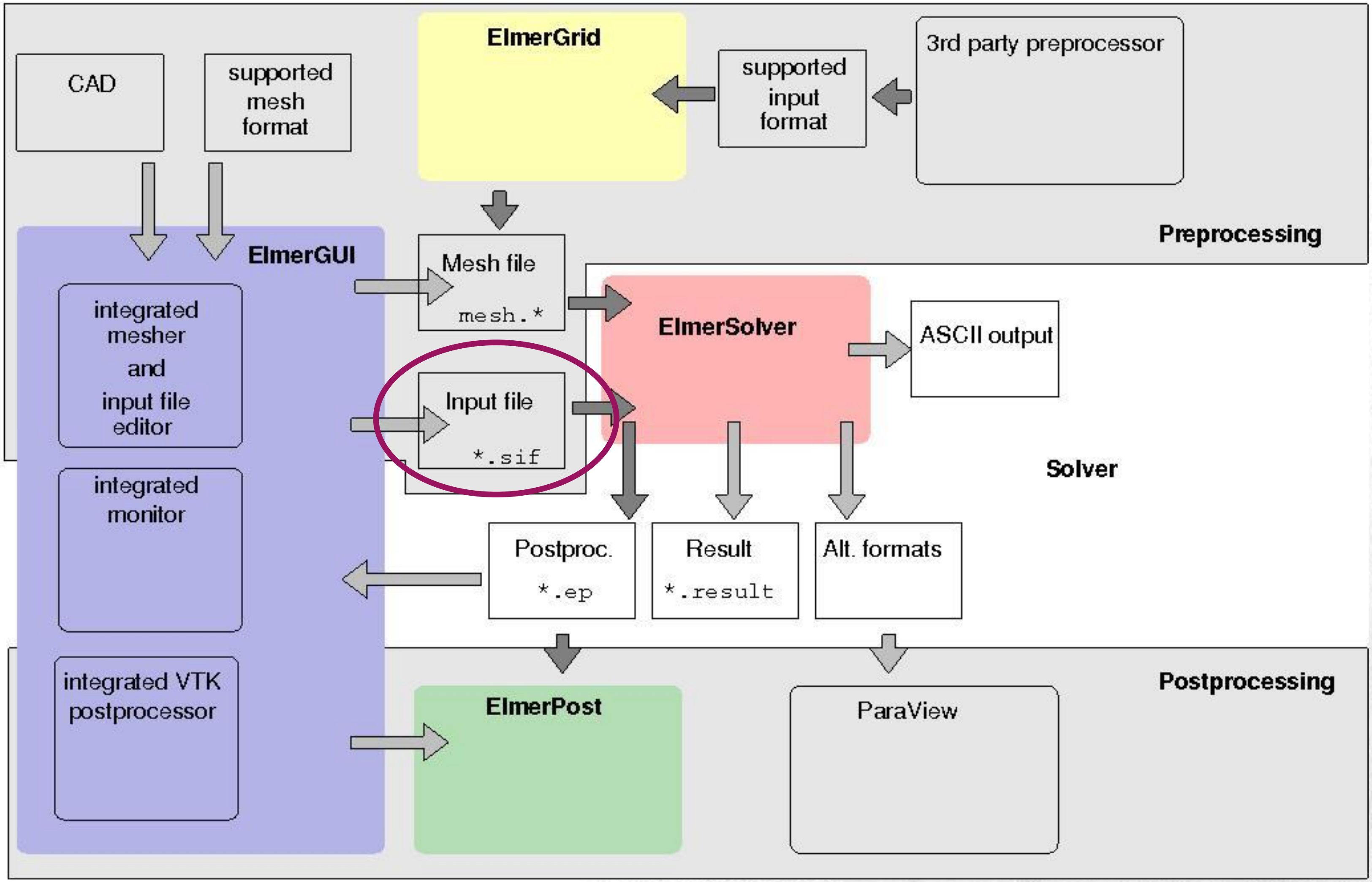
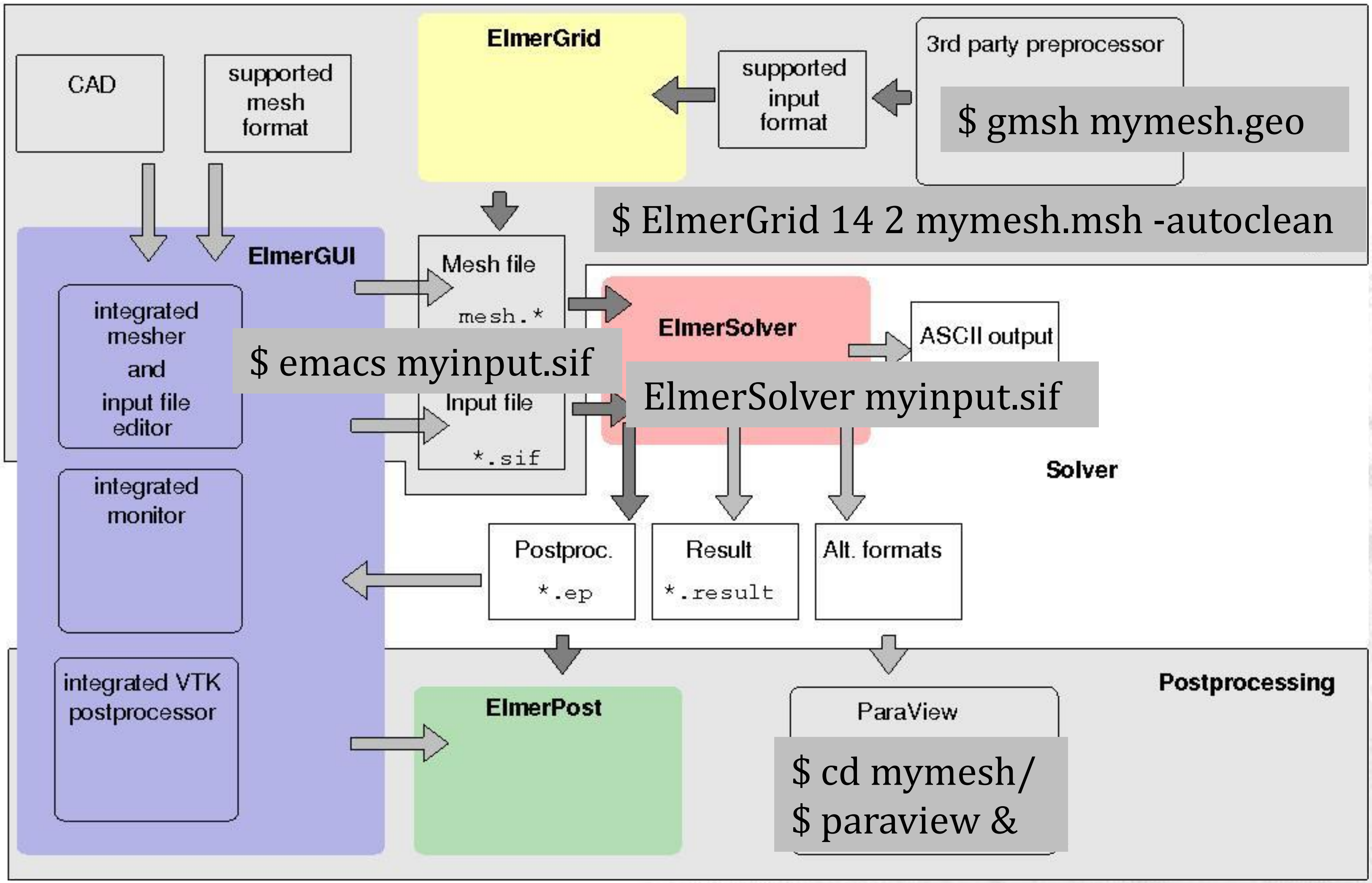
Elmer - Modules



Elmer - Modules



Sections of SIF

- The SIF is structured into sections
  - **`Header`**
  - **`Constants`**
  - **`Simulation`**
  - **`Solver`**
  - **`Body`**
  - **`Equation`**
  - **`Body Force`**
  - **`Material`**
  - **`Initial Condition`**
  - **`Boundary Condition`**

The contents of each section is between the keyword above and an **`End`**-statement

Sections of SIF: Header

- Declares search paths for mesh

```
Header

 Mesh DB "." "dirname"


 Include Path ""

 Results Directory ""

End
```

- preceding path + directory name of mesh database
- Replace path and ***dirname*** to fit your case
- Can also be used to define an include path

  `Include Path "dirname"`
- different output directory:

  `Results Directory "dirname"`

Sections of SIF: Constants

- Declares simulation-wide constants

```
Constants
  Gas Constant = Real 8.314E00
  Gravity(4) = 0 -1 0 9.81
End
```

- a casted scalar constant
- Gravity vector, an array with a registered name

Sections of SIF: Simulation

- Declares details of the simulation:

```
Simulation
  Coordinate System = "Cartesian 2D"
  Coordinate Mapping(3) = Integer 1 2 3
  Simulation Type ="Transient"
  Output Intervals(2) = 10 1
```

- choices: **Cartesian{1D,2D,3D}, Polar{2D,3D}, Cylindric, Cylindric Symmetric, Axi Symmetric**
- Permute, if you want to interchange directions in mesh
- **Steady State, Transient or Scanning**
- Interval of results being written to disk

Sections of SIF: Simulation

- Declares details of the simulation:

```
Steady State Max Iterations = 10
Steady State Min Iterations = 2

Timestepping Method = ”BDF”

Timestep Intervals(2) = 10 100

Timestep Sizes(2) =  0.1 1.0
Output File = "name.result"
Post File = "name.vtu‟
```

- How many min/max rounds on one timelevel/in a steady state simulation (see later)
- Choices: **`BDF`**, **`Newmark`** or **`Crank-Nicholson`**
- Has to match array dimension of **`Timestep Sizes`**
- The length of one time step
- Contains data for restarting
- Contains output data for ParaView (**`vtu`**)
  - alternatively, suffix **`.ep`** would produce ElmerPost legacy output

Sections of SIF: Simulation

- Declares details of the simulation:

```
Restart File = "previous.result"
Restart Position = 10
Restart Time = 100

Initialize Dirichlet Condition =
 False

Restart Before Initial Conditions =
 True

Max Output Level = 5

End
```

- Restart from this file at file-entry (not necessarily timestep!) no. 10 and set time to 100 time-units
- Default is True. If false, Dirichlet conditions are called at Solver execution and not at beginning
- Default is False. If True, then Initial Condition can overwrite previous results
- Level of verbosity. 1 = errors, 3 = warnings, 4 = default, 10 = most

Sections of SIF: Solver

- Declares a physical model to be solved

```
Solver 3
 Equation = "Navier-Stokes"
 Exec Solver = "Always"


 Linear System Solver = "Iterative"

 Linear System Iterative Method = BiCGStab
 Linear System Convergence Tolerance =1.0e-6


 Linear System Abort Not Converged = True

 Linear System Preconditioning = "ILU2"
```

- Numbering from 1 (priority)
- The name of the equation
- **Always** (default), **Before/After Simulation/Timestep**
- Choices: **Iterative, Direct, MultiGrid**
- Lots of choices here
- Convergence criterion
- If not True (default) continues simulation in any case
- Lots of choices

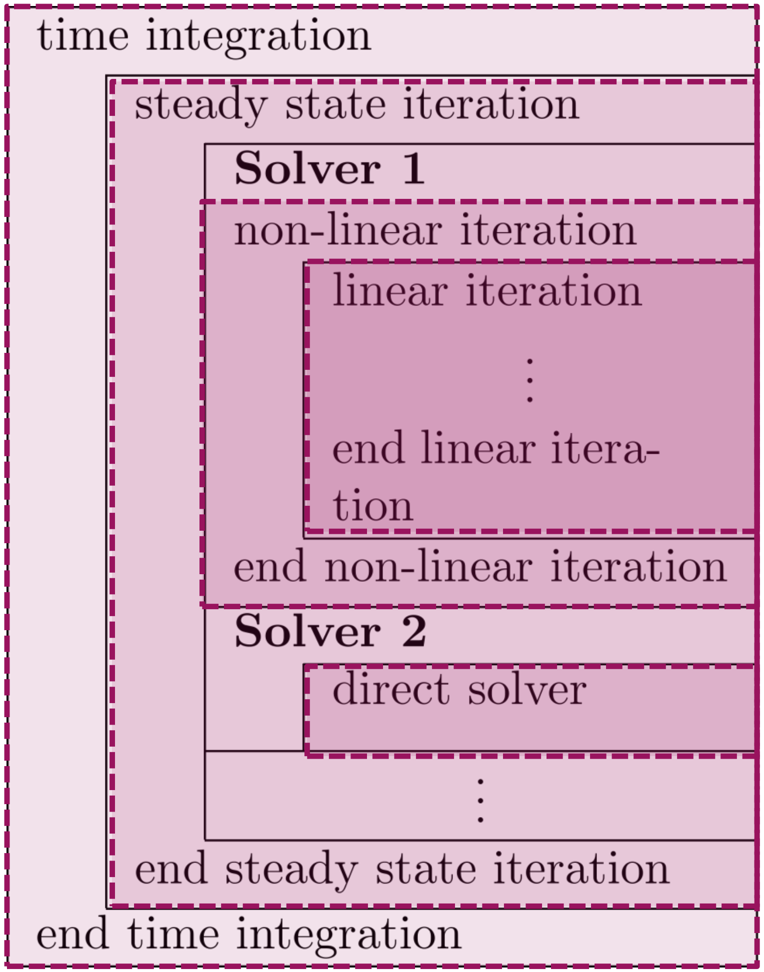
Sections of SIF: Solver

- Declares a physical model to be solved

```
 Nonlinear System Convergence Tolerance=1.0e-5

 Nonlinear System Max Iterations = 20
 Nonlinear System Min Iterations = 1

 Nonlinear System Newton After Iterations=10

 Nonlinear System Newton AfterTolerance=1.0e-3


 Steady State Convergence Tolerance = 1.0e-3

 Stabilization Method = Stabilized
End
```

- Convergence criterion for non-linear problem
- The maximum rounds
- The minimum rounds
- Switch from Picard to Newton scheme after 10 iterations ...
- ... or after this criterion (NV.: has to be smaller than convergence criterion ot hit)
- The convergence on the time-level
- Convection needs stabilization. Alternatives: **`Bubbles, VMS, P2/P1`**

Sections of SIF: Solver



1. `Timestep Intervals`
2. `Steady State Max Iterations`
3. `Nonlinear Max Iterations`
4. `Linear System Max Iterations`
4. `Linear System Convergence Tolerance`
3. `Nonlinear System Convergence Tolerance`
2. `Steady State Convergence Tolerance`
1.

Sections of SIF: Body

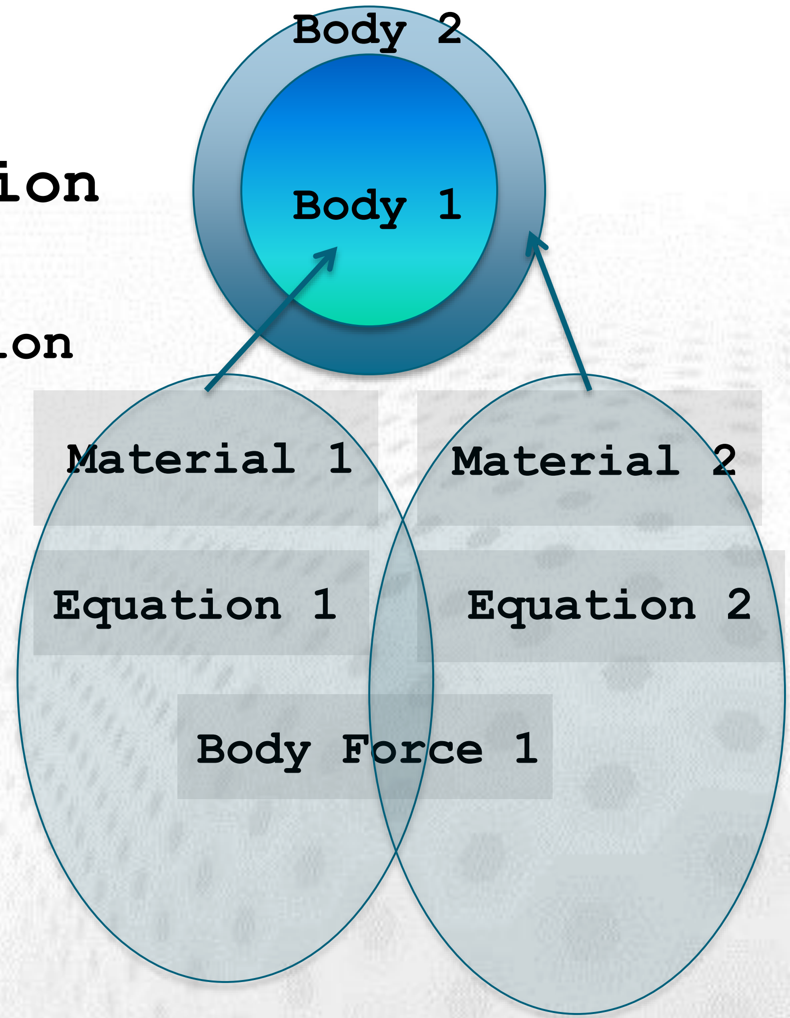
- Declares a physical model to be solved

```
Body 2

 Name = "pipe"
 Equation = 2
 Material = 2
 Body Force = 1
 Initial Condition = 2

End
```

- Numbering from 1 to number of bodies
- Identifier of the body
- The assigned set of equations
- The assigned material section
- The assigned body force
- The assigned initial condition

Sections of SIF: Body

- Each **Body** has to have an **Equation** and **Material** assigned
  - **Body Force**, **Initial Condition** optional
- Two bodies can have the same **Material/Equation/ Body Force/Initial Condition** section assigned



Sections of SIF: Equation

- Declares set of solvers for a body

```
Equation 2

 Active Solvers(2) = 1 3

 Convection = Computed



 NS Convect = False


End
```

- Numbering from 1 to number of equation sets
- Declares the solvers (according to their numbers) to be solved within this set
- Important switch to account for convection term. Alternatives: None and Constant (needs Convection Velocity to be declared in the Material section)
- Sets no convection for Navier-Stokes (=Stokes) alternative:

  `Flow Model = Stokes`

  in the Solver section of Navier-Stokes

Sections of SIF: Body Force

- Declares body forces and bulk and execution conditions for a body

```
Body Force 3

 Flow Body Force 1 = 0.0
 Flow Body Force 2 = -9.81

 MyVariable = Real 0.0

 Heat Source = 1.0
End
```

- Numbering from 1 to number of body forces
- Gravity pointing in negative x-direction applied to Navier-Stokes solver
- A Dirichlet condition for a variable set within the body
- Heat source for the heat equation

Sections of SIF: Material

- Declares set of material parameters for body

```
Material 1

 Density = 1000.0
 Heat Conductivity(3,3) = 1 0 0\
                          0 1 0\
                          0 0 2
 Viscosity = Variable Temperature
    Real MATC ″viscosity(tx)″

 Heat Capacity = Variable Temperature
  Procedure ″filename″ ″functionname″

 MyMaterialParameter = Real 0.0
End
```

- Numbering from 1 to number of material
- Always declare a density (mandatory)
- Parameters can be arrays
- Or MATC functions of other variables
- Or Fortran functions with/without dependency on input variables
- Non-keyword DB parameters have to be casted

Sections of SIF: Initial Condition

- Declares initial conditions for a body

  By default restart values are used

```
Initial Condition 2

 Velocity 1 = Variable Coordinate 2
    Real MATC "42.0*(1.0 - tx/100.0)"
 Velocity 2 = 0.0
 Velocity 3 = Variable Coordinate 3
   Procedure "filename" "functionname"

  MyVariable = Real 20.0

End
```

- Numbering from 1 to number of IC's
- Initial condition as a MATC function of a variable ...
- ... and as a constant
- ... and as a user function
- Non-keyword DB parameters have to be casted

Sections of SIF: Boundary Condition

- Declares conditions at certain boundaries

```
Boundary Condition 3

 Target Boundaries(2) = 1 4

 Velocity 1 = Variable Coordinate 2
    Real MATC "42.0*(1.0 - tx/100.0)"
 Velocity 2 = 0.0
 Velocity 3 = Variable Coordinate 3
   Procedure "filename" "functionname"

 Normal-Tangential Velocity = Logical True
End
```

- Numbering from 1 to number of BC's
- The assigned mesh boundaries
- Variable as a MATC function and …

… as a constant

… as a user function

- Set velocities in normal-tangential system

Tables and Arrays

- Tables (piecewise linear or cubic):

```
Density = Variable Temperature
Real cubic
     0 900
   273 1000
   300 1020
   400 1000
End
```

- Arrays:

```
Target Boundaries(3) = 5 7 10

MyParamterArray(3,2) = Real 1 2\
                            3 4\
                            5 6
```

- Expresions:

```
OneThird = Real $1.0/3.0
```

MATC

- Syntax close to C
- Even if-conditions and loops
- Can be use for on-the-fly functions inside the SIF
- Documentation on web-pages
- Do <u>not</u> use with simple numeric expressions:

```
OneThird = Real $1.0/3.0
```

is much faster than

```
OneThird = Real MATC "1.0/3.0"
```

MATC

- Use directly in section:

```
Heat Capacity = Variable Temperature
 Real MATC "2.1275E3 + 7.253E0*(tx - 273.16)"
```

- Even with more than one dependency:

```
Temp = Variable Latitude, Coordinate 3
 Real MATC "49.13 + 273.16 - 0.7576*tx(0) - 7.992E-03*tx(1)”
```

- Or declare functions (somewhere in SIF, outside a section)

```
$ function stemp(X) {\
  _stemp = 49.13 + 273.16 - 0.7576*X(0) - 7.992E-03*X(1)\
}
```

being called by:

```
Temp = Variable Latitude, Coordinate 3
   Real MATC “stemp(tx)”
```

User Defined Functions (UDF)

- Written in Fortran 90
- Dynamically linked to Elmer
- Faster, if more complicated computations involved
- Compilation command **`elmerf90`**

```
elmerf90 myUDF.f90 –o myUDF.so
```

- Call from within section:

```
MyVariable = Variable Temperature
  Real Procedure ”myUDF” ”myRoutine”
```

User Defined Functions (UDF)

- Example: $\rho(T[K]) = 1000.0 \cdot \left[1 - 1 \times 10^{-4} \cdot (T - 273.15)\right]$

```
FUNCTION getdensity( Model, N, T ) RESULT(dens)
 USE DefUtils !important definitions
 IMPLICIT None
 TYPE(Model_t) :: Model
 INTEGER :: N
 REAL(KIND=dp) :: T, dens
 dens = 1000.0_dp*(1.0_dp - 1.0d-04*(T - 273.0_dp))
END FUNCTION getdensity
```

  – Definitions loaded from **`DefUtils`**
  – Header: **`Model`** access-point to all ElmerSolver inside data; Node number **`N`**; input value **`T`**