CHAM

Transient Simulations

Transient term in the equation

CHAM

Steady equation

$$\mathrm{div}\,(\rho\,\underline{u}\,\phi\;-\;G_{\phi}\,\underline{\mathrm{grad}}(\phi))\;=\;S_{\phi}$$

Transient equation

$$\partial/\partial t\,(\rho\,\phi)\;+\;\mathrm{div}\,(\rho\,\underline{u}\,\phi\;-\;G_{\phi}\,\underline{\mathrm{grad}}(\phi))\;=\;S_{\phi}$$

Note the addition of the transient term.

Time Steps

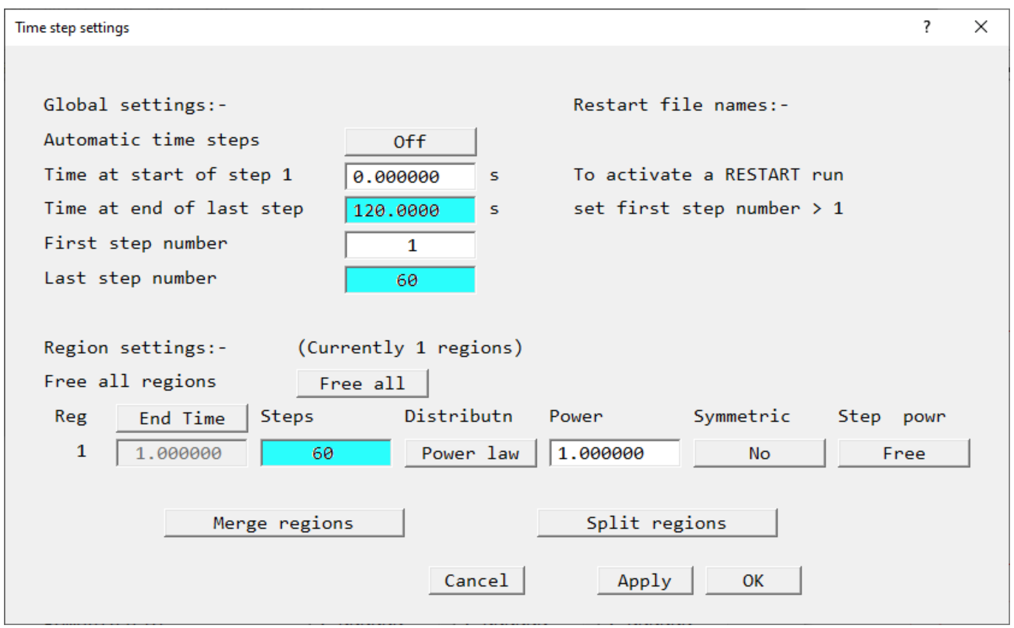
CHAM

- Transient solved as set of time steps.
- Each time step is iterative and requires sweeps.
- Convergence curves displayed at each step.
- The time steps form a “grid” in time.
- Must have enough time steps to adequately resolve process being modelled.
- Typical transient might require one or several hundred steps.
- Uniform time steps are generally helpful.
- Implicit differencing – no CFL limit on step size.

Activation

CHAM

- In the “Grid Mesh Settings” panel click “Steady”, to change it to “Transient”.
- Click “Time step settings” to bring up settings panel.
- Enter number of steps below “Steps” and in “Last step number”.
- Set “Time at end of last step”.

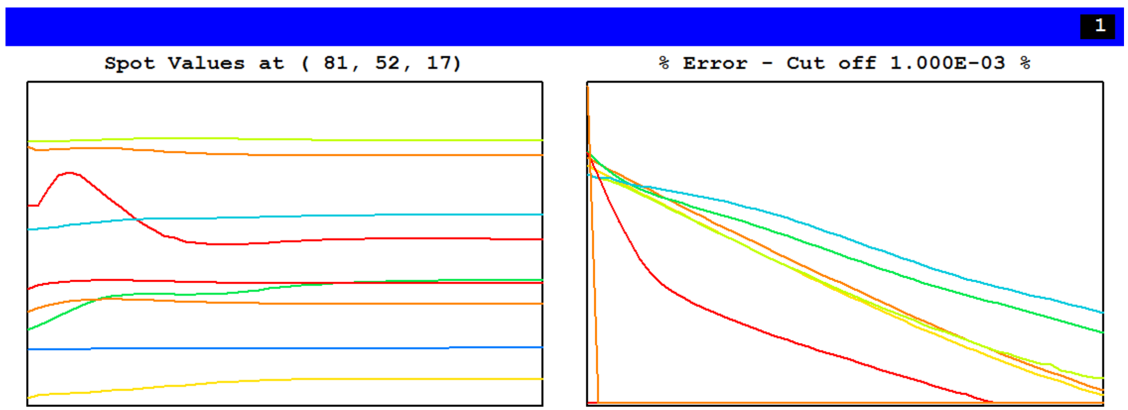


This example sets 60 time steps of 2 seconds each.

Graphical convergence plots

CHAM

- In a transient simulation, the changes at each time step are likely to be small, and so the spot-value curves will typically look like this.



Value	Change	Low	High	Variable	Max	% Error	Change
-8.48E-01	-2.21E-06	-9.00E-01	-8.00E-01	P1	1.00E+01	1.05E-06	2.19E-08
-7.22E-01	-1.25E-06	-8.00E-01	-7.00E-01	U1	1.00E+01	1.42E-03	-1.53E-04
6.07E-01	1.85E-06	6.00E-01	7.00E-01	V1	1.00E+01	1.23E-03	-1.07E-04
1.83E+00	-1.05E-05	1.00E+00	2.00E+00	W1	1.00E+01	2.02E-03	-8.97E-05
6.39E-02	1.62E-06	6.00E-02	7.00E-02	KE	1.00E+01	7.62E-03	-7.63E-04
1.59E-02	4.28E-07	1.00E-02	2.00E-02	EP	1.00E+01	1.35E-02	-1.29E-03
1.17E+01	1.40E-04	1.00E+01	2.00E+01	T3	1.00E+02	1.24E-06	-3.30E-07
2.38E-03	-6.05E-09	2.00E-03	3.00E-03	SMOK	1.00E+01	3.83E-04	-3.96E-05
4.31E+01	-1.53E-04	4.00E+01	5.00E+01	TEM1	1.00E+02	4.68E-06	-1.21E-06

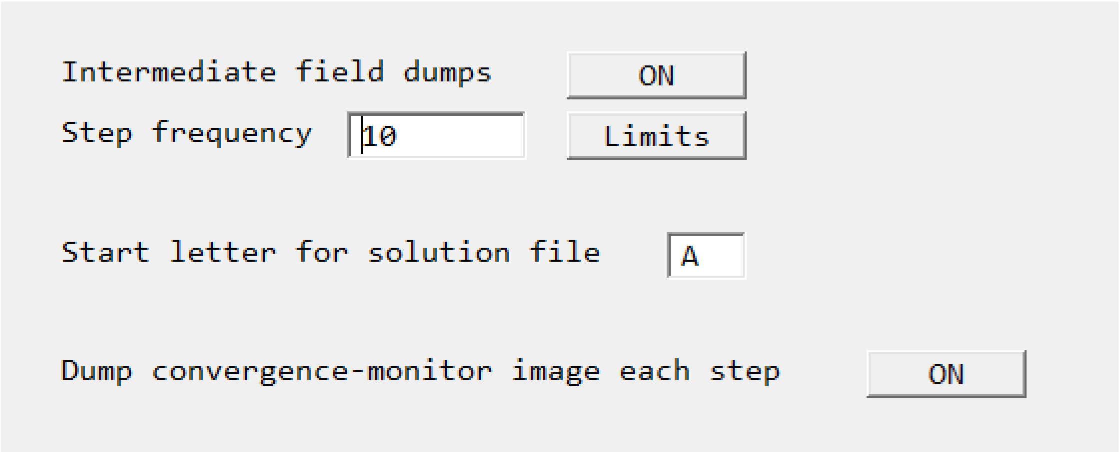
NX NY NZ ISTEP 144 TIME
141 98 42 ISWEEP OFF Working

Press a character key to interrupt.

Output

CHAM

- Solution fields dumped every N steps in “phida”-type files.
- These may be plotted using the Viewer.
- N is “Step frequency” in “Output” / “Field dumping”.
- Choose “Start letter for PHI”, e.g. “A”.
- If frequency N is 10, files will be named “a10da”, “a20da”, “a30da” etc.



Number of sweeps

CHAM

- Typical steady run needs several thousand sweeps.
- Typical transient needs only 20 to 50 sweeps per time step.
- If many more sweeps are required, perhaps the step should be shorter - good for accuracy.

- A slowly changing boundary condition, e.g. a slowly increasing fire heat release, poses a dilemma: may need a very large number of time steps, or large number of sweeps per step.
- This may be rather like performing a succession of steady runs.

Initial conditions

CHAM

- In a steady model, default initial values are often ok.
- In a transient you MUST define initial conditions.
- Different initial values will imply different values at later times.
- The default initial conditions are zero velocity, and temperature fixed "from ambient", often this is alright.

- Sometimes there is an initial air flow, given some kind of perturbation at time zero - e.g. a wind-driven flow in a mall, with a fire starting at t=0.
- For this, best to do an initial steady run with no fire, then restart the fire transient from the steady run.

Relaxation

CHAM

- Transient term has a stabilising effect, like relaxation.
- Transient term similar to “false time step” relaxation in a steady run.
- If time step fairly short, no additional relaxation may be necessary.
- Would not hurt to define FALSDT for solved variables (but not P1) of magnitude similar to the real time step.

Convergence

CHAM

- Each step must be adequately converged, otherwise errors will propagate through the run.
- Sufficiently small time steps should generally give good convergence.
- Reducing step size will generally require less sweeps to converge.

How to check convergence

CHAM

- Three ways to check convergence…
- ➔ Inspect residual sums and net sources every NTPRIN steps, in “Result” file.
- NTPRIN set in “Output” / “Field printout” / “Page Dn”.
- It helps to “Suppress all field printout”.
- ➔ Review individual convergence-monitor plots, “gxmoni1.gif” etc.
- Can scroll through these rapidly with picture-viewing software.
- Helpful if the mouse wheel can be used to scroll through the images.
- ➔ FLAIR creates “conv_table.csv” which tabulates residual sums normalised with inflow values.
- These can be charted in Excel.

Numerical Accuracy

CHAM

- How accurately have the equations been solved?
- How low must the residual sums be for the results to be acceptable?
- Depends upon the application and the purpose of the run.
- Often the best way of determining this is to perform a time-step refinement study.
- If you halve the time step (or double the number of sweeps), is there any noticeable difference in the results?

Plotting the Results

CHAM

- When entering the VR Viewer, click the second option, "Use intermediate step files".
- "Plot step number" selects which step to plot, the first step is shown as the default.
- You can click next, previous, last or first file.
- You can then plot contours, vectors etc as you wish.
- F8 shows same plot at the next time step.
- F7 shows same plot at the previous time step.
- Repeatedly clicking F8 cycles through the complete transient. Alternatively you can select an Animation.

Animations

CHAM

- You can create an animation by left-clicking the Animation Toggle button .
- To save an animation:
- 1. Right-click the button to bring up the “Animation Options” panel.
- 2. Click "Yes" to "Save animation". (NOT "Save animation as macro".)
- 3. Click OK to exit.
- 4. Left-click to start the animation.
- 5. In “Save Animation as file” panel, specify file name and image size, and select “.avi”.
- 6. "Frames per second" setting controls the speed of the animation. Finally click OK.

Animations (2)

CHAM

- Note the following.

- The .avi file will be in the working directory.
- It is important to ensure that all plots have the same colour range for contours and vectors.
- For contours set the min and max values explicitly.
- For vectors set the vector reference velocity.

Time-Varying Boundary Conditions

CHAM

- When transient, all Attributes panels for boundary-condition or source objects allow specification of a time range when the b-c or source is active.
- Simply select "No" to "Active all the time", and enter the start and end times.
- For Blockages, additional heat source options appear, allowing linear or sinusoidal variations of either temperature ("Value") or heat flux.
- Alternatively can define a set of coincident objects with varying values at successive times,
- or use InForm.

Monitoring the Time Variation

CHAM

- "Point_History" objects may be used to mark locations at which time-histories are required for solved and stored variables.
- More generally, InForm can be used:
  e.g. to tabulate the temperature at a point, and the temperature change since the start.
- *save21begin*
  real(tinit); tinit = 22
  (table in monplt.csv is get(tem1{2,0.8,9}, tem1{2,0.8,9} - tinit) $
  with head(TEM1, TRISE) ! time)
  save21end
- The data are written to "monplt.csv" at each time step, and can then be charted, e.g. in Excel.