Code_Saturne: latest news and prospects

Code_Saturne development team
Recent releases of Code_Saturne
Recent releases and validation

**Code_Saturne version 1.2 (stable and validated)**

- May 2007: release of version 1.2.4
  - Identical to version 1.2.3
  - Porting on Itanium architecture (Platine cluster of CCRT)

**Code_Saturne version 1.3 (development version)**

- March 2007: release of development version 1.3.f
  - Downloadable from the EDF website
- July 2007: tagging of development version 1.3.0
  - Start of comprehensive validation campaign
  - Unstable version not posted on the internet
- November 2007: tagging of development version 1.3.1
  - No new features with respect to version 1.3.0
  - Correction of problems detected during first phase of validation
  - Start of second phase of validation
  - To be posted on the internet as “beta” version
  - **Source CD available at the Code_Saturne Users Meeting**
- February 2008: scheduled release of fully validated version 1.3.2
Validation campaign

Validation of *Code_Saturne* version 1.3  
(9 man.month!)

- July-October 2007: 1st phase – validation of version 1.3.0
  - 29 test cases
  - More than 200 calculations for first phase (1.3.0)
  - Wide range of mesh sizes (4 to 2,000,000 cells) and mesh types
  - Wide range of calculation size
  - Validation of new features and non-regression tests
  - Tests on every available computer architecture
  - Tests on every available specific physics

- November 2007: start of 2nd phase – validation of corrected version 1.3.1
  - All configurations tested again
  - All cases showing problems with 1.3.0 retested
  - Several non-regression cases retested
**Code_Saturne open source practical info**

### Distribution of Code_Saturne

- **GPL licence**, LGPL for auxiliary libraries (BFT and FVM)
- Download page: [http://rd.edf.com/code_saturne](http://rd.edf.com/code_saturne)
- Downloadable versions:
  - 1.3.0 beta version currently available
  - 1.3.1 on website in December 2007
  - 1.3.2 fully validated version in February 2008

### Contact and support around Code_Saturne

- Contact and support address: [saturne-support@edf.fr](mailto:saturne-support@edf.fr)
- **Forum and bug tracker** under development for plugging for new website
- Annual Users Club meeting in Chatou
- Mailing list: 174 members outside EDF in November 2007
- **Initial training sessions** in March and November

### External development integration

- Any useful external contribution welcome
- Any contribution given for integration will be under EDF’s copyright
- Contributors will be clearly mentioned in the author’s list
- **Code_Saturne** is a trademark property of EDF
New features in *Code_Saturne* 1.3
Last year’s main « new features » in version 1.3

Plugging of Code_Saturne to the FVM library

- direct post-processing from the Kernel
  - fully parallel
  - optional discard/tessellation of polygons and polyhedra
  - advanced user defined post-processing
- direct coupling to SYRTHES from the Kernel
  - fully parallel
  - automatic post-processing of the interface mesh

Easier usage of Code_Saturne

- GUI extended to advanced numerical parameters
- unified launch script, install script
- simplified listing management
- optimisation to High Performance Computing and massively parallel
- automatic post-processing of hydrodynamic forces at the boundaries

New methods and modules

- Matisse engineering module
- ALE method for deformable meshes, internal coupling for fluid/structure interaction
Software and structure characteristics

Preprocessor: the module formerly known as « Envelope »

- further elements transferred to FVM for parallel treatment
  - mesh quality measurements
  - tessellation of non-plane internal or boundary faces
  - creation of parallel/periodic halo cells
  - creation of extended neighbourhood connectivity
  - **50% decrease in memory size** with respect to version 1.2
- inner optimisation on integer management
  - current limit due to array indices: 130 000 000 cells (32 bit integers)
Software and structure characteristics

Optimisation for High Performance Computing

- compliance with BLAS libraries
  - easy link and automatic usage of BLAS libraries when available
- optimisation of communications
  - limitation and grouping of MPI commands
  - reorganised and optimised writing of restart files
- benchmark mode
  - automatic calculation of CPU time for basic operations
  - testing of BLAS libraries efficiency
- file management adapted to large number of processors
  - one listing per calculation by default
  - error files generated only by the processors that experience the error
  - "enveloppe_vers_solver*" files grouped in a sub-directory
Software and structure characteristics

Optimisation for High Performance Computing

- Current frontier (preprocessor): 130 000 000 cells
- Current highest computation: 100 000 000 cells (cf. dedicated presentation)
Software and structure characteristics

FVM selector capabilities

- easy selection of cells, internal faces or boundary faces
- integrated routines GETCEL, GETFAC, GETFBR
  - GETxxx(expression,NLELT,LSTELT) → list LSTELT of the NLELT elements satisfying the « expression »
  - expression = combination of colour references, group references and geometrical conditions, with « or », « and » and « not » operators
  - e.g.: (1 or 2) and (not paroi6) and (X>=2 or Y<1) → elements of colour 1 or 2, that do not belong to group « paroi6 » and with coordinates X larger than 2 and Y lower than 1

Coupling with SYRTHES

- full compliance with 2D SYRTHES calculations
- NB: SYRTHES open source now!

Post-processing

- automatic post-processing of Courant and Fourier numbers
Algorithmic features

Steady-state algorithm

• faster convergence for steady-state cases
• no dependence of solution on time step
• use with caution in presence of strong gravity effects

Internal coupling with moving solid structures

• stabilised Newmark scheme for structure displacement
• extrapolated displacement prediction (explicit synchronous or asynchronous)
• compliance with second order in time and velocity/pressure sub-iterations (useful for LES)
• orthotropic mesh viscosity to limit mesh distortion
• automatic writing of time evolution of force, displacement, velocity and acceleration for each structure
Algorithmic features

Channel flow with two oscillating cylinders

![Image of channel flow with two oscillating cylinders]

**STRUCTURE DISPLACEMENT**

- Structure 1
- Structure 2

Displacement (m) vs. time (s)
Physical models

Heavy fuel oil combustion
  • integrated but not validated

Pulverised coal combustion
  • restructured
  • coal humidity taken into account

Lagrangian particle tracking
  • compliant with periodic boundary conditions
  • advanced particle/wall interaction
    • van der Waals forces
    • particle slugging
  • easier statistics control
    • prepared averages and root mean squares calculations

Other models
  • stabilised v2f turbulence model
  • rough wall boundary conditions (especially for atmospheric flows)
Graphical User Interface

Extension to new numerical features of version 1.3

- steady-state algorithm
- ALE method
- FVM advanced output control
  - CGNS and MED output formats
  - divide/discard polyhedra
  - SYRTHES post-processing
- advanced elements selection features for initialisation and boundary conditions
- time averages
Graphical User Interface

More specific physics

- pulverised coal combustion
  - adapted to latest features
- radiative heat transfers
  - DOM and P1 models
  - stand-alone or combined with coal combustion
New Code_Saturne tutorial

- 5 test cases
  - basic calculation features
    - mesh pasting
    - time dependent boundary conditions (usclim.F)
    - temperature dependent physical characteristics (usphyv.F)
    - head loss (uskpdc.F)
  - step by step solution description
  - pre-filled corresponding user routines
- corresponds to the programme of the Code_Saturne initial training sessions
Current and future developments in *Code_Saturne*
Further work on algorithmic

High Performance Computing

- further optimisation of communications
- further transfer to Kernel and parallelisation of Preprocessor

Multi-grid linear solver

- linear algebra limiting for very large systems
- current prototype based on version 1.3
  - promising results on prototype tests
  - further work needed on industrialisation and parallel treatment

Parallel treatment of Lagrangian modelling
Fluid-structure interaction

**Code_Saturne/Code_Aster** coupling

- coupling *via* the Salomé platform
  - based on the YACS coupler module
  - successful test calculations in May 2007 using latest versions of *Code_Saturne* and *Code_Aster*
- more work needed to achieve clean and industrial integration in both codes
Integration of development versions

**Code_Saturne/Code_Saturne** coupling

- RANS/LES
- Chimera moving meshes
- Fluid Structure Interaction combining ALE local deformation and Chimera global movement

**Mercure_Saturne atmospheric version**

- step by step integration of physical capabilities

**Cooling towers engineering module**
Perspectives in future developments

Progress in algorithms

- opportunity of velocity/pressure coupled solver
- pseudo-compressible scheme for dilatable flows
- optimised relative precision of solvers for faster calculations

Physical modelling

- ionic mobility
- opportunity of specific module for fire-driven flows (cf. dedicated presentation)
- adaptation to simulation of flows in industrial pumps

Treatment on uncertainties

- test plugging of OpenTurns platform (open source) to Code_Saturne
- if convenient, triggering from Code_Saturne GUI