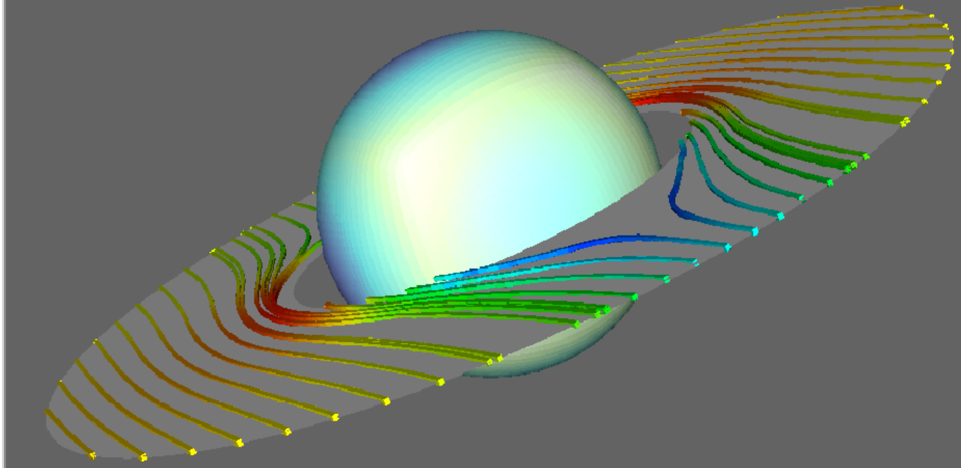


Code_Saturne**:** latest news and prospects

Code_Saturne development team

1

Recent releases of *Code_Saturne*

Recent releases and validation

Code_Saturne version 1.2 (stable and validated)

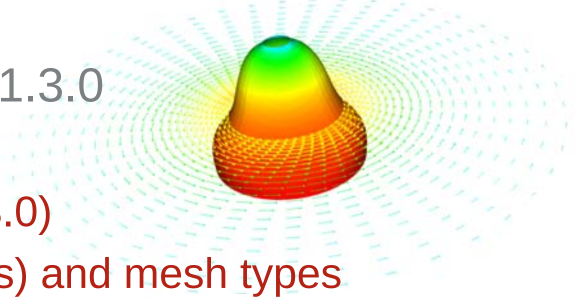
- may 2007: release of version 1.2.4
  - identical to version 1.2.3
  - porting on Itanium architecture (Platine cluster of CCRT)

Code_Saturne version 1.3 (development version)

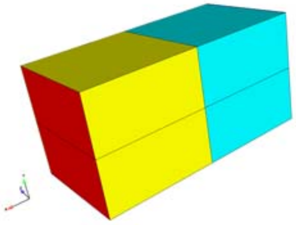
- march 2007: release of development version 1.3.f
  - downloadable from the EDF website
- july 2007: tagging of development version 1.3.0
  - start of comprehensive validation campaign
  - unstable version not posted on the internet
- november 2007: tagging of development version 1.3.1
  - no new features 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

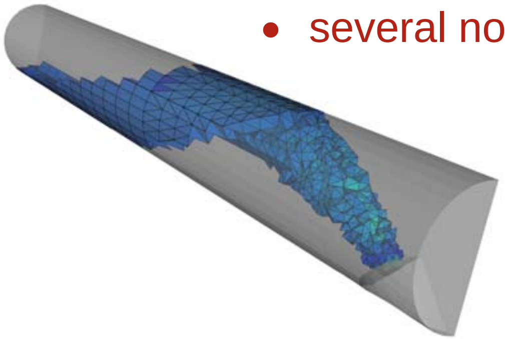
Validation of *Code_Saturne* version 1.3 (9 man.month!)

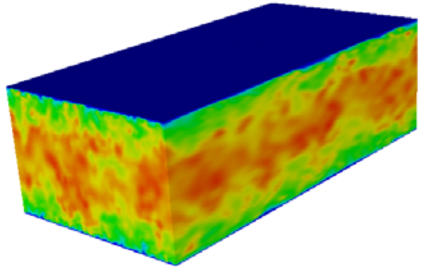


- july-october 2007: 1st phase – validation of version 1.3.0
  - 29 test cases
  - more than 200 calculations for first phase (1.3.0)
  - wide range of mesh sizes (4 to 2 000 000 cells) and mesh types
  - wide range of calculation size
  - validation of new features and non-regression tests
  - tests 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

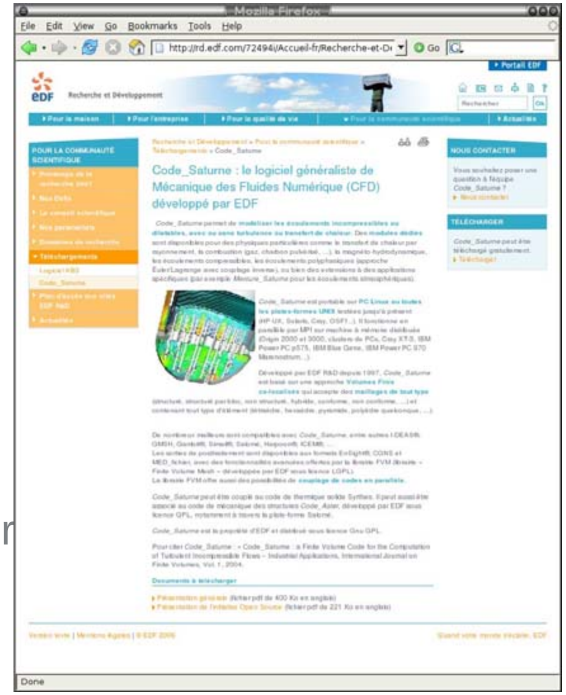




Code_Saturne open source practical info

Distribution of *Code_Saturne*

- **GPL licence**, LGLP for auxiliary libraries (BFT and FVM)
- download page **http://rd.edf.com/code_saturne**
- downloadable versions:
    - 1.3.f beta version currently available
    - 1.3.1 on website in december 2007
    - 1.3.2 fully validated version in february 2008


Mozilla Firefox
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Pour la maison
Pour l'entreprise
Pour la qualité de vie
Pour la communauté scientifique
Actualités
POUR LA COMMUNAUTÉ SCIENTIFIQUE
Panorama de la recherche 2007
Nos Défis
Le conseil scientifique
Nos partenaires
Domaines de recherche
Téléchargements
Code_Saturne
Plan d'accès aux sites EDF R&D
Actualités
Recherche et Développement » Pour la communauté scientifique » Téléchargements » Code_Saturne
Done

Code_Saturne : le logiciel généraliste de Mécanique des Fluides Numérique (CFD) développé par EDF

Code_Saturne permet de modéliser les écoulements incompressibles ou dilatables, avec ou sans turbulence ou transfert de chaleur. Des modules dédiés sont disponibles pour des physiques particulières comme le transfert de chaleur par rayonnement, la combustion (gaz, charbon pulvérisé, ...), la magnéto-hydrodynamique, les écoulements compressibles, les écoulements polyphasiques (approche Euler/Lagrange avec couplage inverse), ou bien des extensions à des applications spécifiques (par exemple *Mercure_Saturne* pour les écoulements atmosphériques).

Code_Saturne est portable sur PC Linux ou toutes les plates-formes UNIX testées jusqu'à présent (HP-UX, Solaris, Cray, OSF1...). Il fonctionne en parallèle par MPI sur machine à mémoire distribuée (Origin 2000 et 3000, clusters de PCs, Cray XT-3, IBM Power PC p575, IBM Blue Gene, IBM Power PC 970 Marenostrum...).

Développé par EDF R&D depuis 1997, *Code_Saturne* est basé sur une approche Volumes Finis co-localisés qui accepte des maillages de tout type (structuré, structuré par bloc, non structuré, hybride, conforme, non conforme, ...) et contenant tout type d'élément (tétraèdre, hexaèdre, pyramide, polyèdre quelconque, ...).

De nombreux mailleurs sont compatibles avec *Code_Saturne*, entre autres I-DEAS®, GMSH, Gambit®, Simail®, Salomé, Harpoon®, ICEM®, ...
Les sorties de postraitement sont disponibles aux formats EnSight®, CGNS et MED_fichier, avec des fonctionnalités avancées offertes par la librairie FVM (librairie « Finite Volume Mesh » développée par EDF sous licence LGPL).
La librairie FVM offre aussi des possibilités de couplage de codes en parallèle.

Code_Saturne peut être couplé au code de thermique solide Syrthes. Il peut aussi être associé au code de mécanique des structures *Code_Aster*, développé par EDF sous licence GPL, notamment à travers la plate-forme Salomé.

Code_Saturne est la propriété d'EDF et distribué sous licence Gnu GPL.

Pour citer Code_Saturne : « Code_Saturne : a Finite Volume Code for the Computation of Turbulent Incompressible Flows – Industrial Applications, International Journal on Finite Volumes, Vol. 1, 2004.

Documents à télécharger

- Présentation générale (fichier pdf de 400 Ko en anglais)
- Présentation de l'initiative Open Source (fichier pdf de 221 Ko en anglais)

NOUS CONTACTER

Vous souhaitez poser une question à l'équipe Code_Saturne ?
Nous contacter

TÉLÉCHARGER

Code_Saturne peut être téléchargé gratuitement.
Télécharger

Version texte | Mentions légales | © EDF 2006

Contact and support around *Code_Saturne*

- contact and support address **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

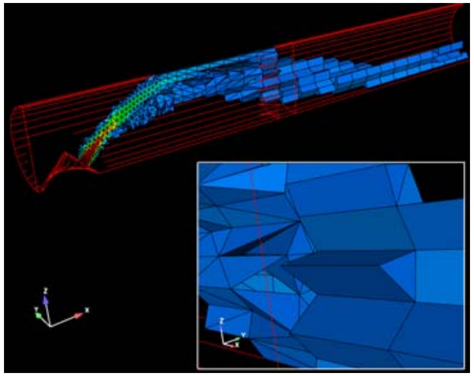
2

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

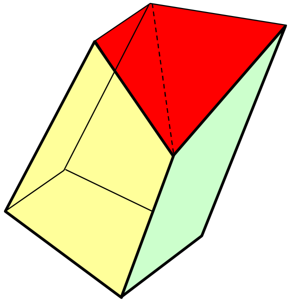
New methods and modules

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

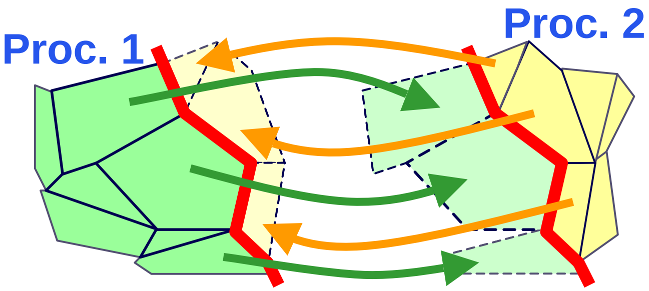
Software and structure characteristics

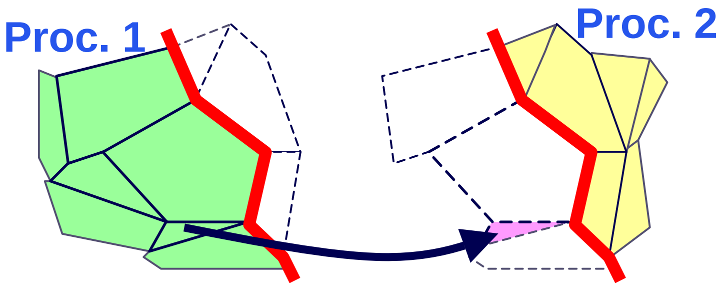
Preprocessor: the module formerly known as « Envelope »

- 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

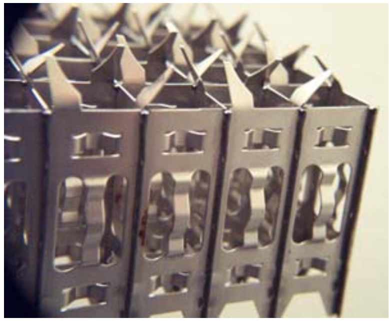
- compliance with BLAS libraries
    - easy link and automatic usage of BLAS libraries when available
- optimisation of communications
    - limitation and grouping of MPI commands
    - reorganised and optimised writing of restart files
- benchmark mode
    - automatic calculation of CPU time for basic operations
    - testing of BLAS libraries efficiency

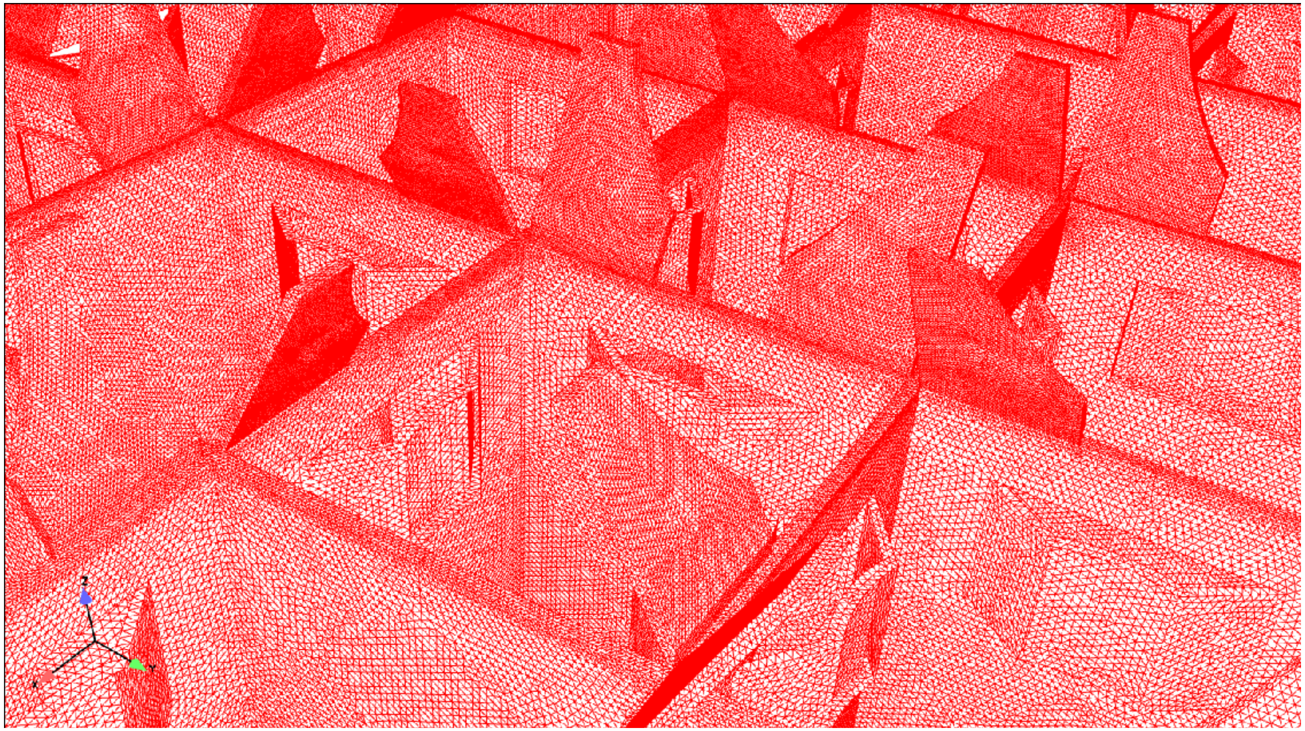
- file management adapted to large number of processors
    - one listing per calculation by default
    - error files generated only by the processors that experience the error
    - « enveloppe_vers_solver* » files grouped in a sub-directory

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)

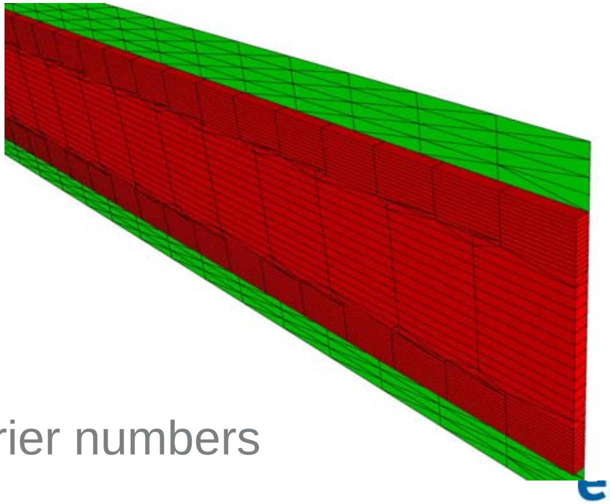




Software and structure characteristics

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

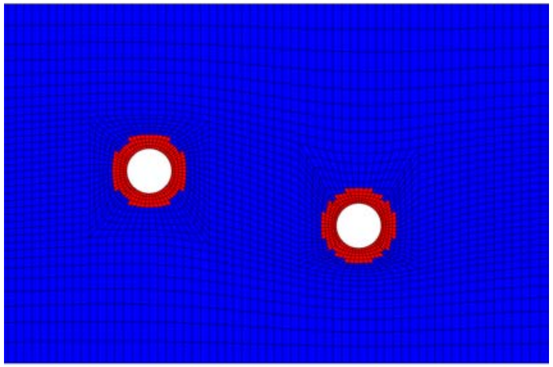
- automatic post-processing of Courant and Fourier numbers

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

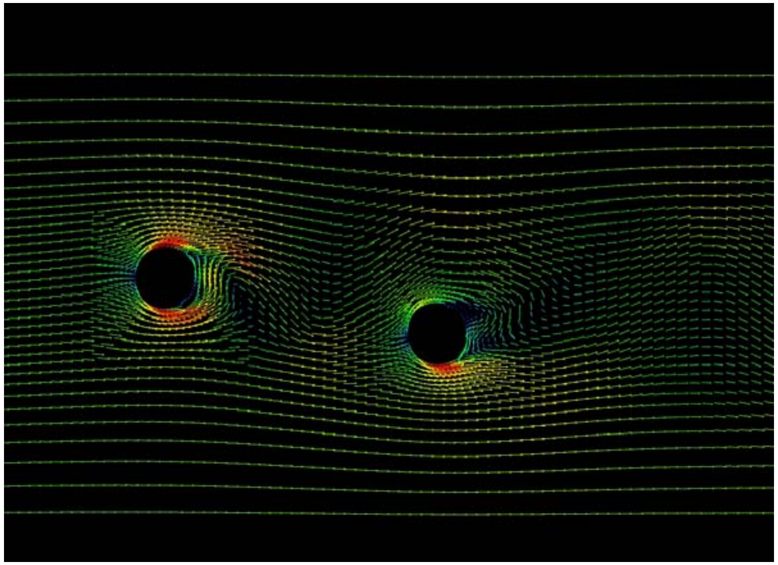
Internal coupling with moving solid structures



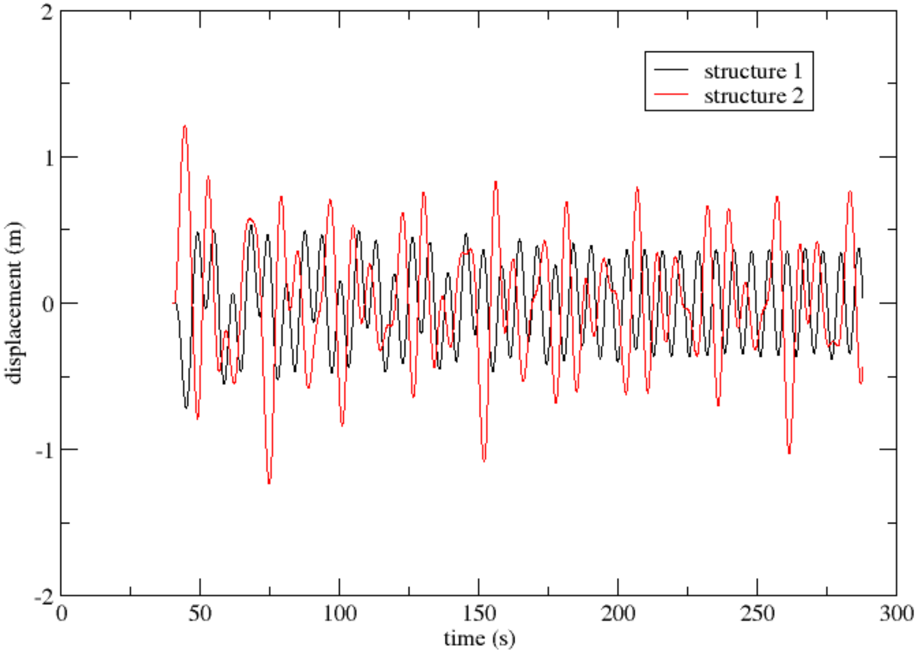
- **stabilised Newmark scheme** for structure displacement
- **extrapolated displacement prediction** (explicit synchronous or asynchronous)
- compliance with **second order in time** and velocity/pressure sub-iterations (useful for LES)
- **orthotropic mesh viscosity** to limit mesh distortion
- automatic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

Algorithmic features

Channel flow with two oscillating cylinders



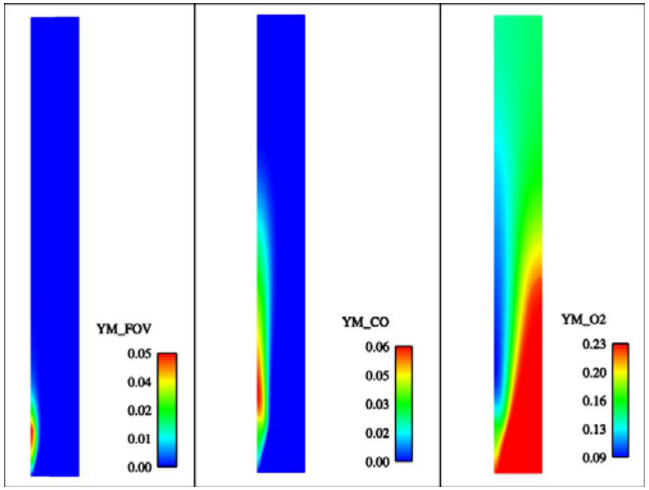
STRUCTURE DISPLACEMENT



Physical models

Heavy fuel oil combustion

- integrated but not validated

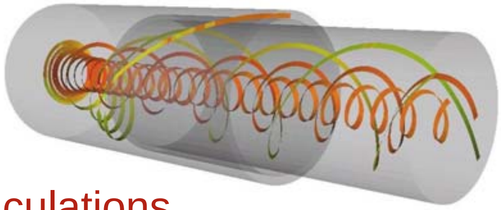


Pulverised coal combustion

- 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



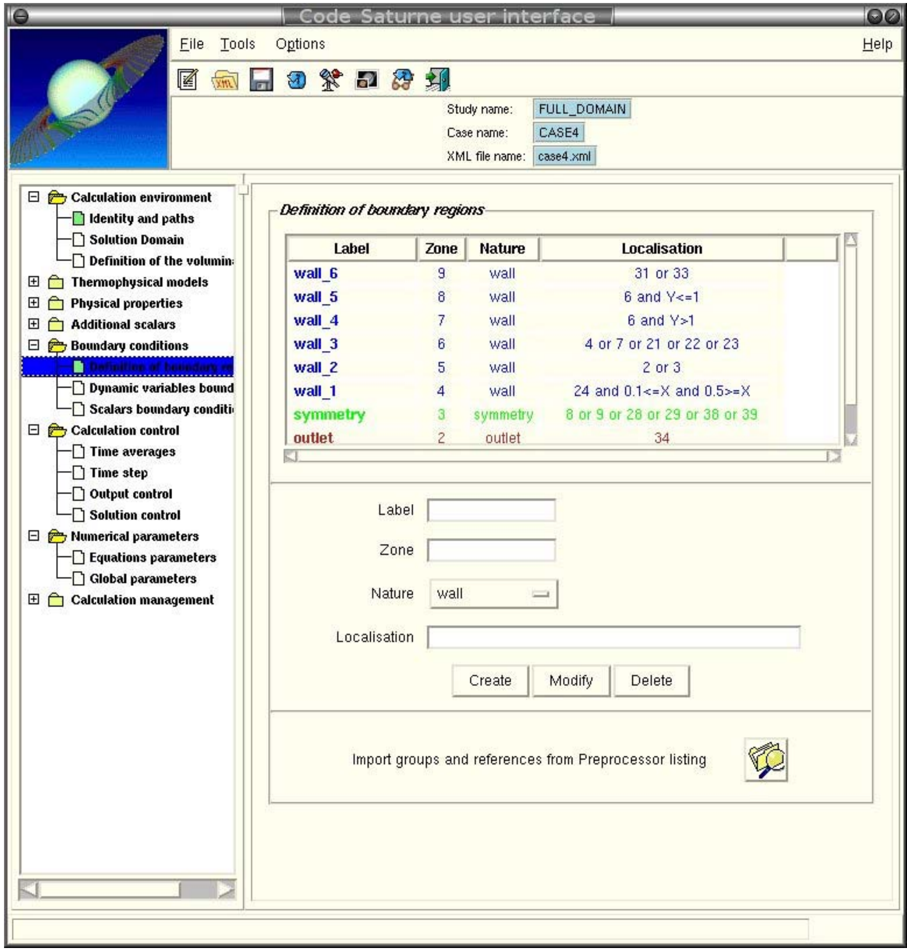
Other models

- 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



Study name: FULL_DOMAIN
Case name: CASE4
XML file name: case4.xml

- Calculation environment
    - Identity and paths
    - Solution Domain
    - Definition of the volumin
- Thermophysical models
- Physical properties
- Additional scalars
- Boundary conditions
    - Definition of boundary re
    - Dynamic variables bound
    - Scalars boundary conditi
- Calculation control
    - Time averages
    - Time step
    - Output control
    - Solution control
- Numerical parameters
    - Equations parameters
    - Global parameters
- Calculation management

Definition of boundary regions

Label	Zone	Nature	Localisation
wall_6	9	wall	31 or 33
wall_5	8	wall	6 and Y<=1
wall_4	7	wall	6 and Y>1
wall_3	6	wall	4 or 7 or 21 or 22 or 23
wall_2	5	wall	2 or 3
wall_1	4	wall	24 and 0.1<=X and 0.5>=X
symmetry	3	symmetry	8 or 9 or 28 or 29 or 38 or 39
outlet	2	outlet	34

Label

Zone

Nature: wall

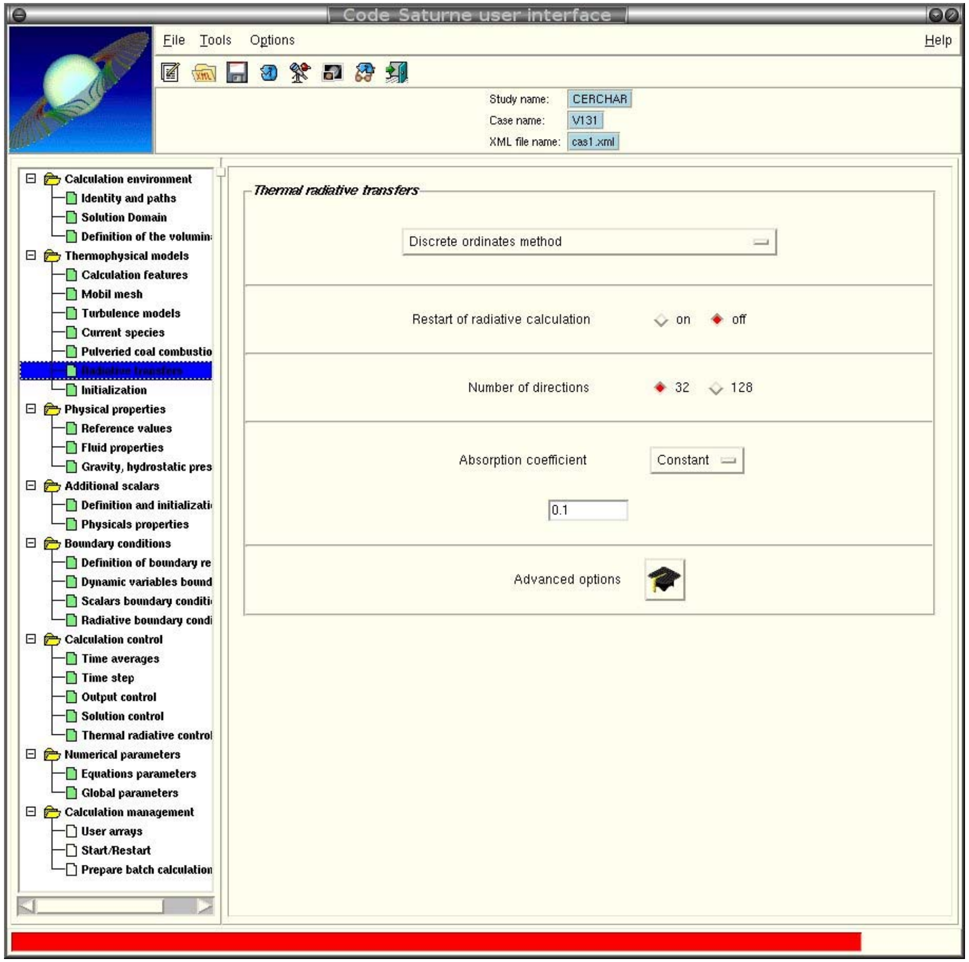
Localisation

Import groups and references from Preprocessor listing

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



Study name: CERCHAR
Case name: V131
XML file name: cas1.xml

Thermal radiative transfers

Discrete ordinates method

Restart of radiative calculation ○ on ● off

Number of directions ● 32 ○ 128

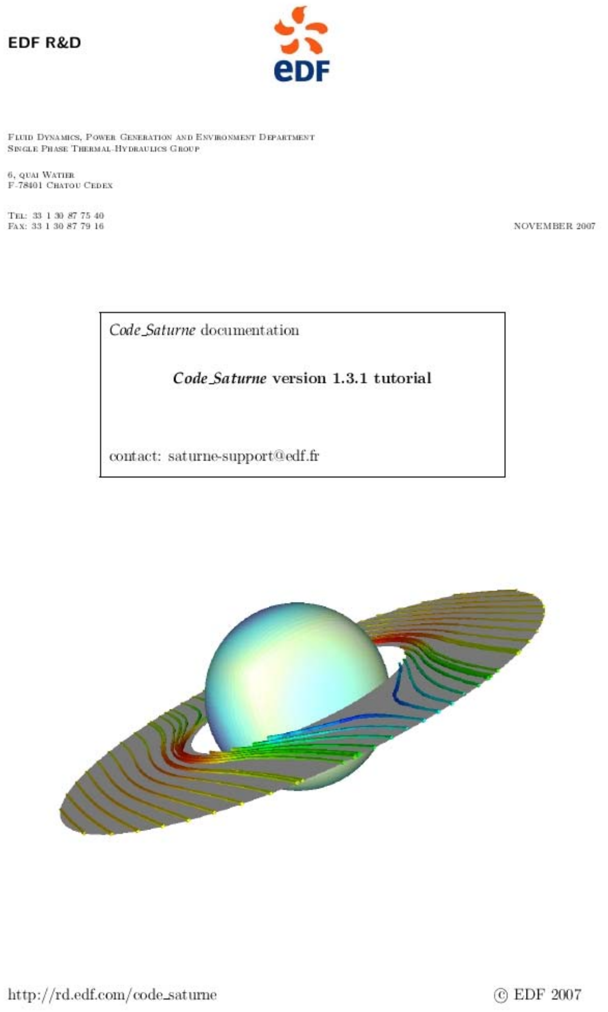
Absorption coefficient Constant

0.1

Code_Saturne documentation

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)
    - → advanced post-processing (usproj.F, usdpst.F, usmpst.F, usvpst.F)
  - step by step solution description
  - pre-filled corresponding user routines
- corresponds to the programme of the *Code_Saturne* initial training sessions



EDF R&D

Fluid Dynamics, Power Generation and Environment Department
Single Phase Thermal-Hydraulics Group

6, quai Watier
F-78401 Chatou Cedex

Tel: 33 1 30 87 75 40
Fax: 33 1 30 87 79 16

NOVEMBER 2007

Code_Saturne documentation

Code_Saturne version 1.3.1 tutorial

contact: saturne-support@edf.fr

http://rd.edf.com/code_saturne

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3

Current and future developments in *Code_Saturne*

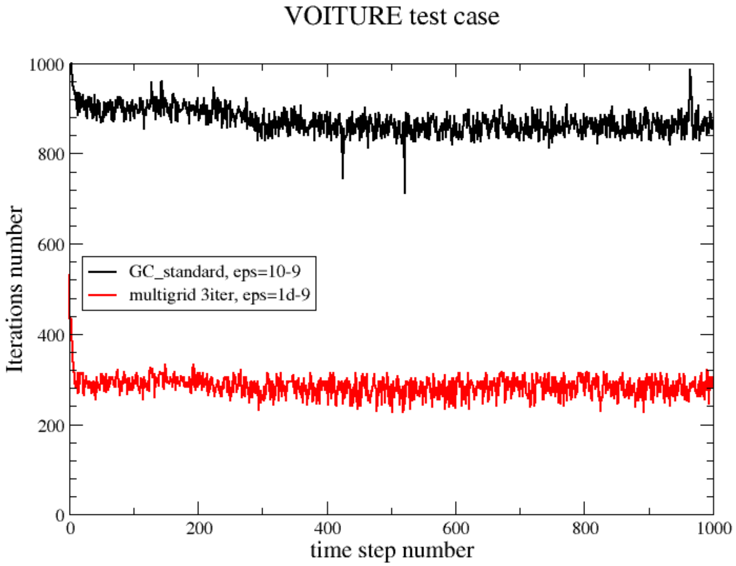
Further work on algorithmic

High Performance Computing

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

Multi-grid linear solver

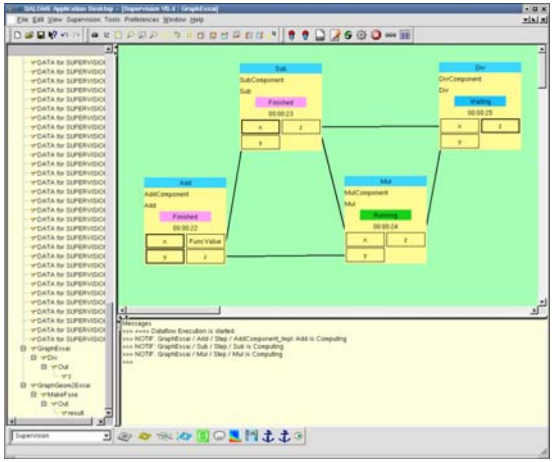
- linear algebra limiting for very large systems
- current prototype based on version 1.3
  - promising results on prototype tests
  - further work needed on industrialisation and parallel treatment



Parallel treatment of Lagrangian modelling

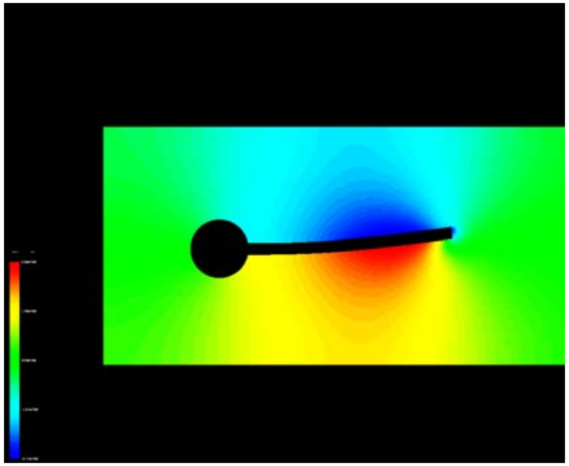
Fluid-structure interaction

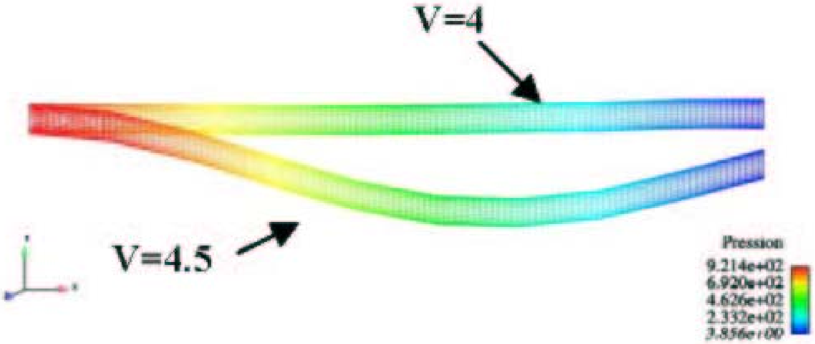
Code_Saturne/*Code_Aster* coupling



```
Messages
>>> ====> Dataflow Execution is started
>>> NOTIF: GraphEssai / Add / Step / AddComponent_Impl::Add is Computing
>>> NOTIF: GraphEssai / Sub / Step / Sub is Computing
>>> NOTIF: GraphEssai / Mul / Step / Mul is Computing
>>>
```

- 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

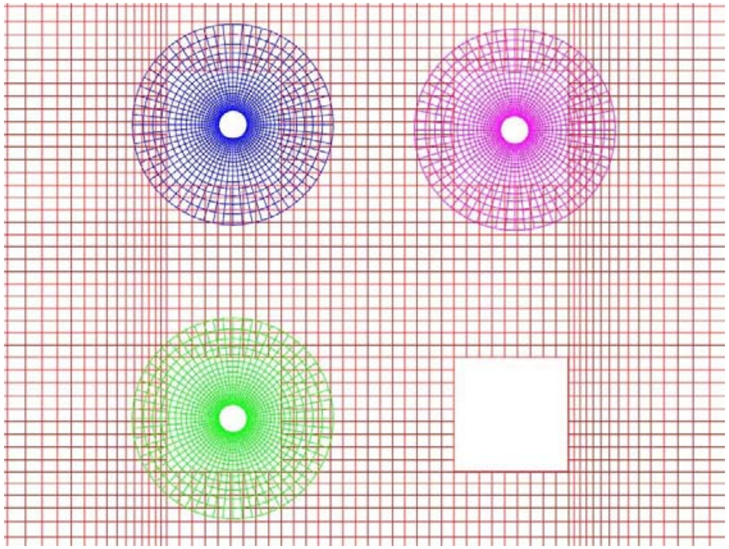




Integration of development versions

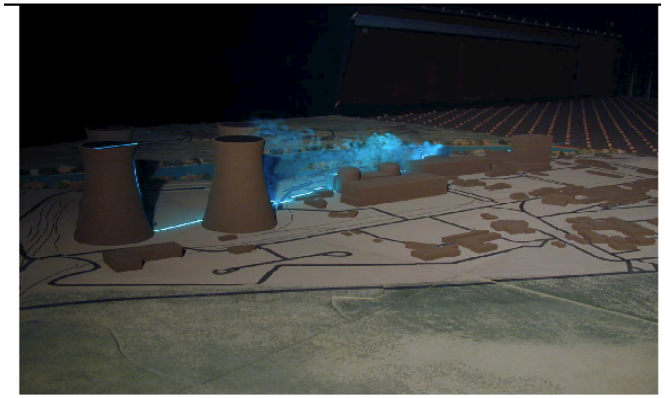
Code_Saturne/*Code_Saturne* coupling

- 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