Development of the AeroSol library within CARDAMOM

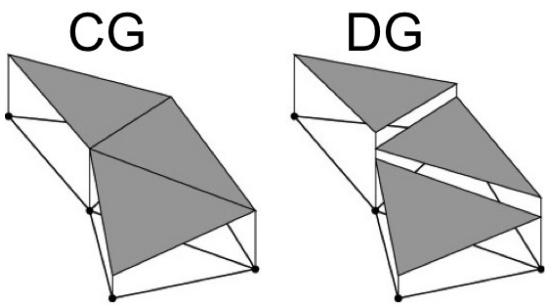
Marco Lorini

April 21, 2021

The AeroSol library

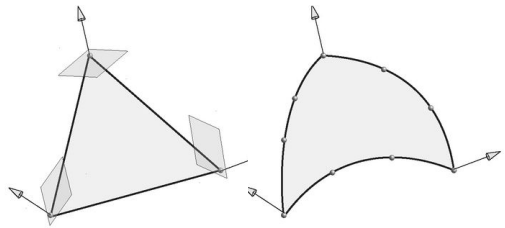
AeroSol = Aerodynamics Solver Platform

- Developed since 2011 within the teams CARDAMOM (and formerly BACCHUS) and CAGIRE.



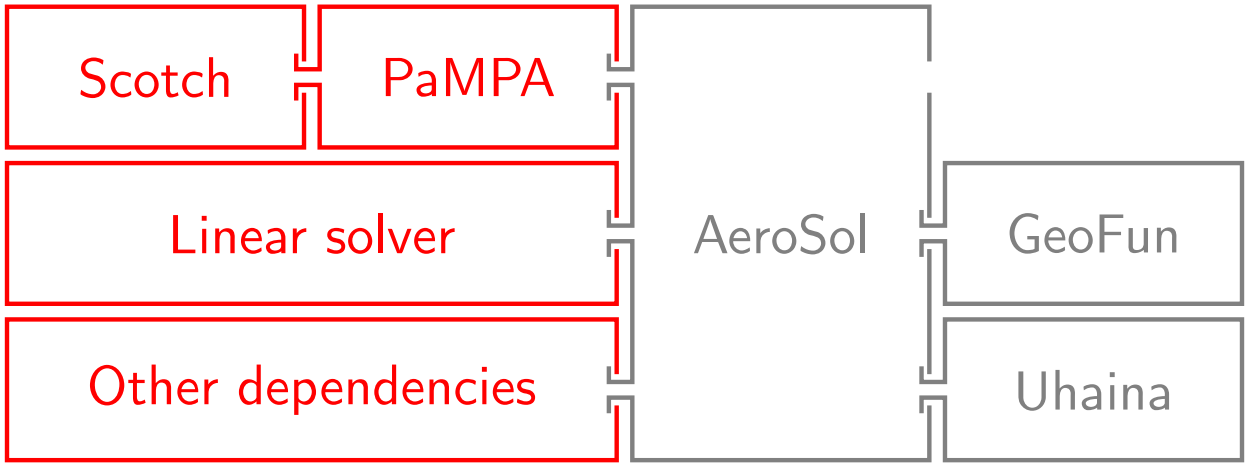
- High-order continuous (CG) and discontinuous (DG) finite element methods.

- Up to fifth order hybrid and/or curvilinear meshes.



- Efficient parallelism on HPC for real-life large-scale applications.

AeroSol environment



Other dependencies and tools:

PETSc

CMake - CTest

GitLab - C.I.

Gmsh

ParaView

HDF5

Mmg - ParMmg

AeroSol environment

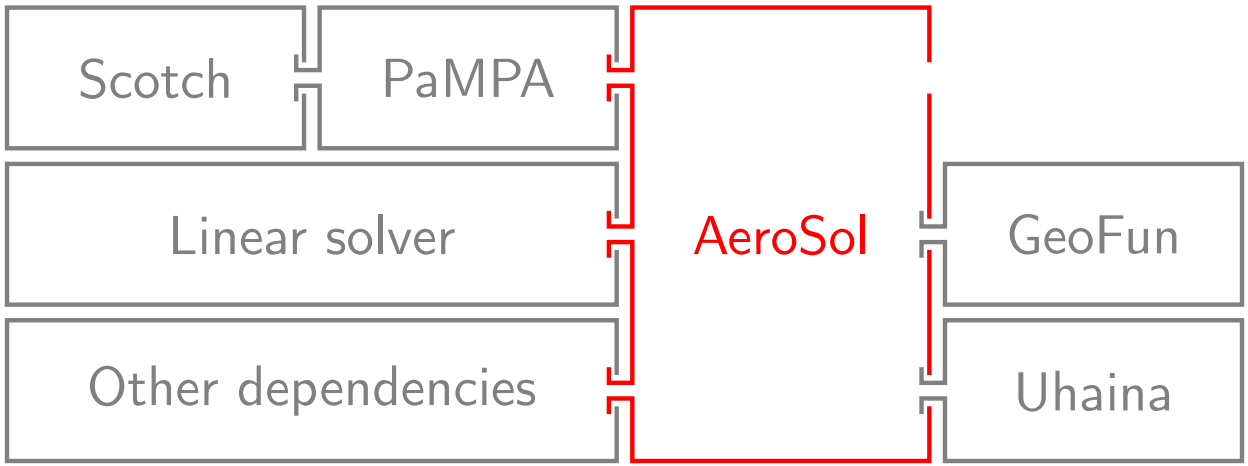
⇒ **Complex set-up and installation on different architectures!**

- Documentation available for the GitLab project members (40)
- Library installed on local clusters (Plafrim, Curta)
- Installation through Guix is also possible (Cagire)
- ▸ Link to installation wiki

⇒ **Steep learning curve when approaching the library!**

- 28 test-cases documented for 5 different models
- Time log for reproducibility of results
- ▸ Link to tests wiki

Ongoing activity



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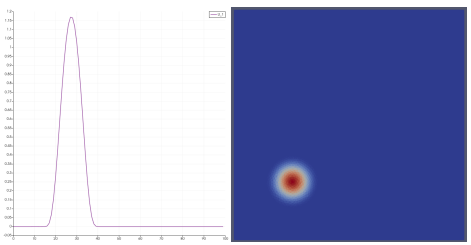

Cubature elements for stabilized CG

- ▷ 2D, continuous interior penalty stabilization, SSPRK time scheme, cubature elements.
- ▷ S.Michel, B.Lux, V.Perrier, H.Beaugendre, M.Ricchiuto

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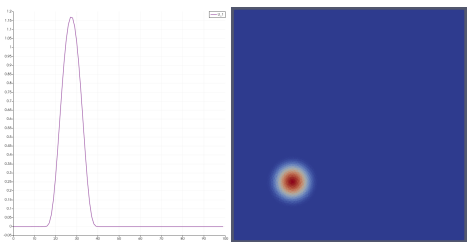

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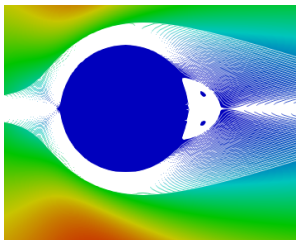

Immersed boundary methods for DG

- ▷ 2D/3D, unfitted discretization, penalization, mesh adaptation
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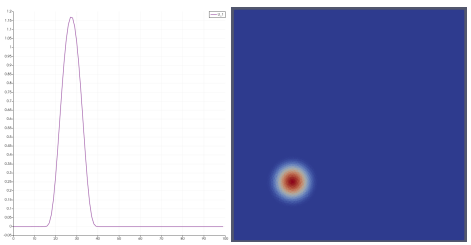

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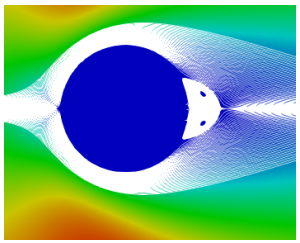

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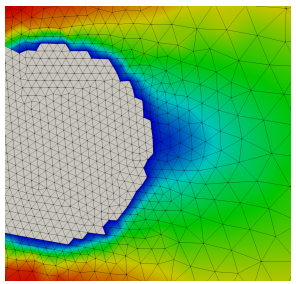

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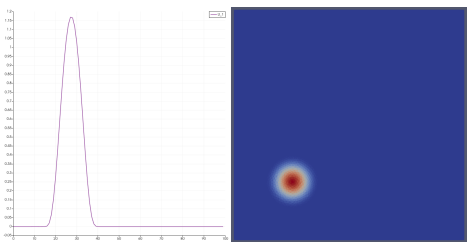

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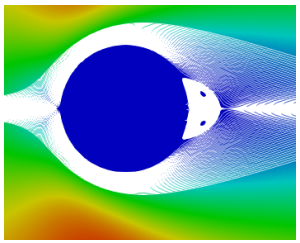

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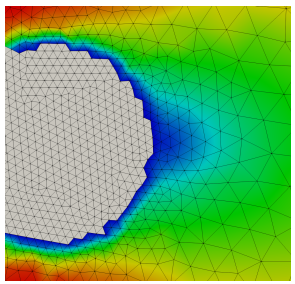

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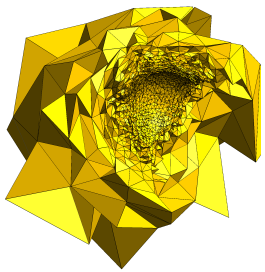
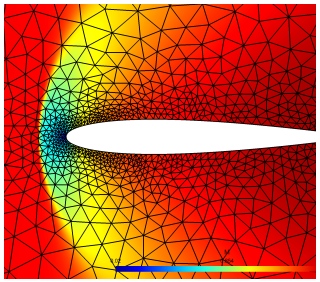


Coupling of AeroSol and ParMMG

- ▷ 2D/3D, parallel mesh adaptation
- ▷ M.Lorini, L.Cirrottola

Ongoing activity



Modal shock capturing for DG

- ▷ 2D/3D, laplacian artificial viscosity, modal shock sensor.
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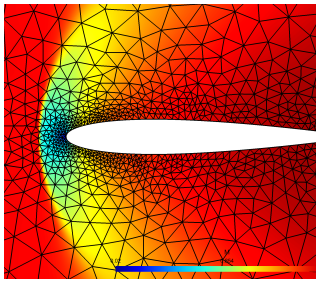

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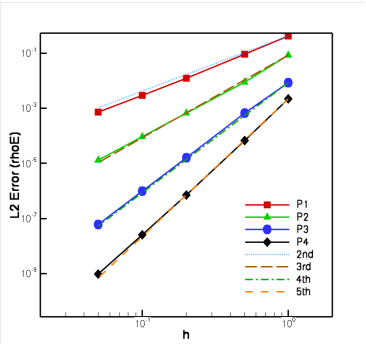

Formal code verification of the DG solver

- ▷ 2D/3D, benchmarks, manufactured solutions.
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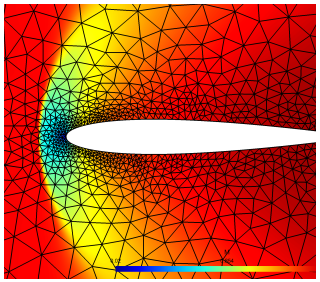

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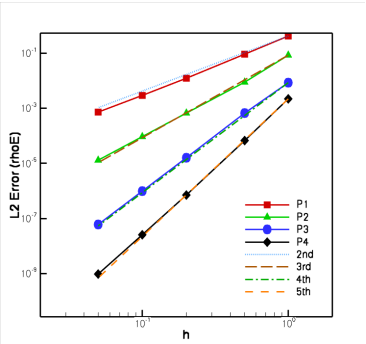

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... and two codes based on the AeroSol library

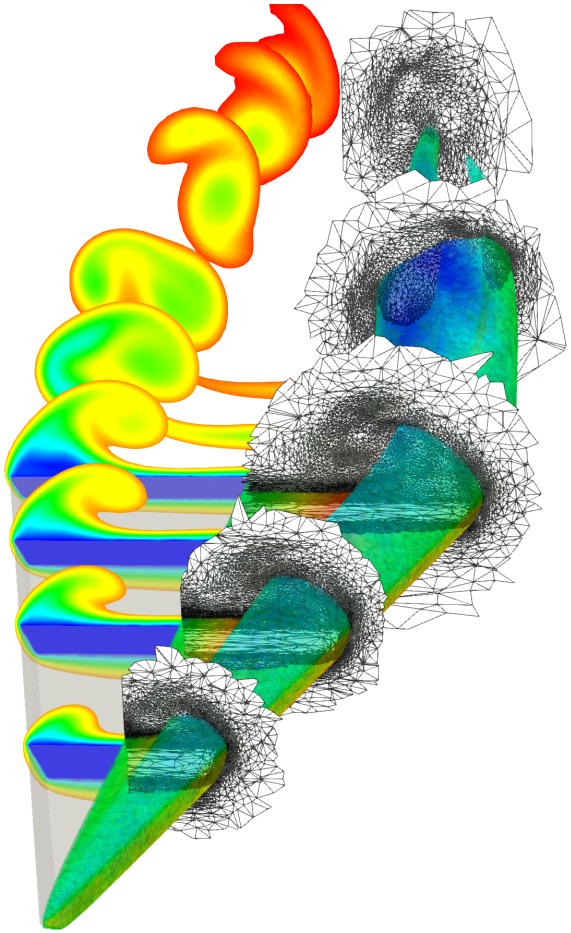
GeoFun

- ▷ M.Lorini, M.Parisot

Uhaina

- ▷ C. Poette, S.Michel, V.Perrier, M.Ricchiuto, M.Kazolea

An example: 3D immersed simulation of a delta wing



3D viscous flow (DG P2) around an immersed delta wing

- Classical test-case for conformal adaptive methods, computed with a non-conformal method.
- Different techniques involved:
  - Level-set implicit representation of the geometry
  - IBM (volumic penalization)
  - Mesh adaptation
  - H.O. visualization
- Paper in preparation (M.Lorini, V.Perrier, M.Ricchiuto).

Working in AeroSol: Pros and Cons

PROS

- Shared development environment
- C++ modularity
- Template abstraction

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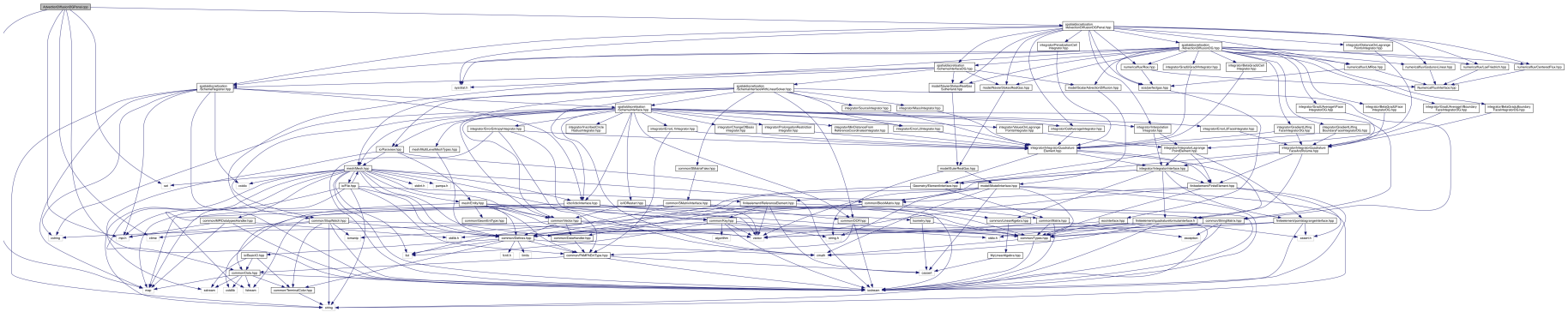
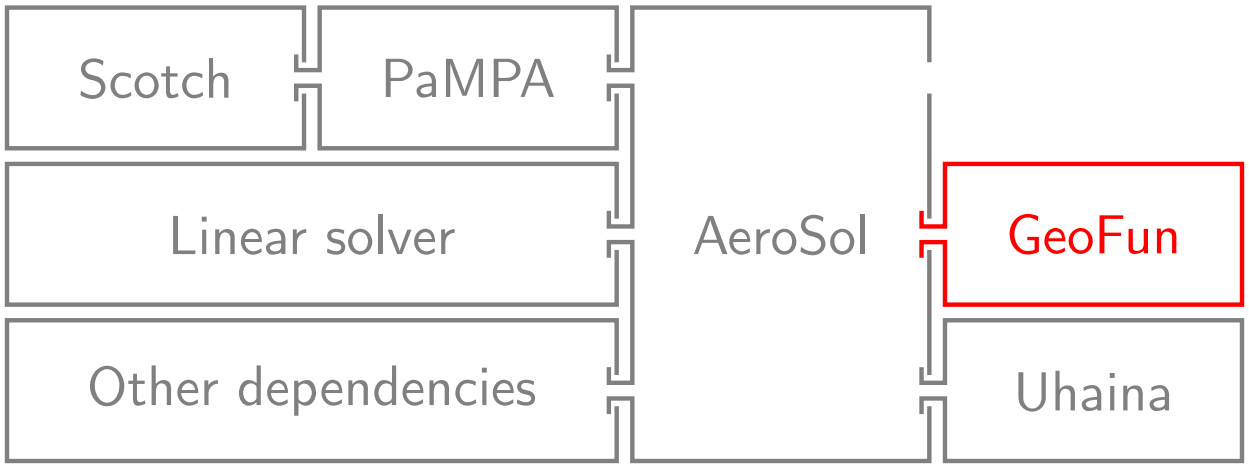


Dependency graph for the C++ class of the penalization operator

Codes based on AeroSol: GeoFun



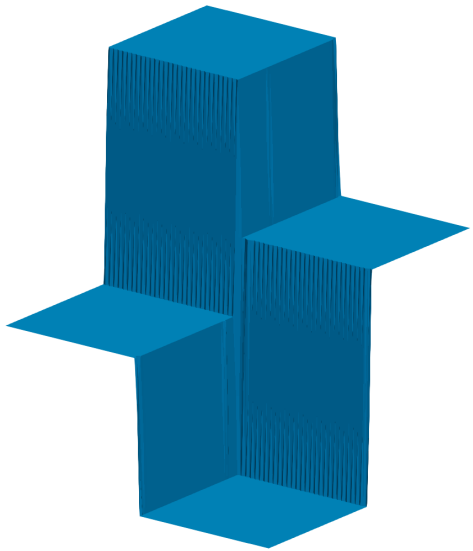
Codes based on AeroSol: GeoFun

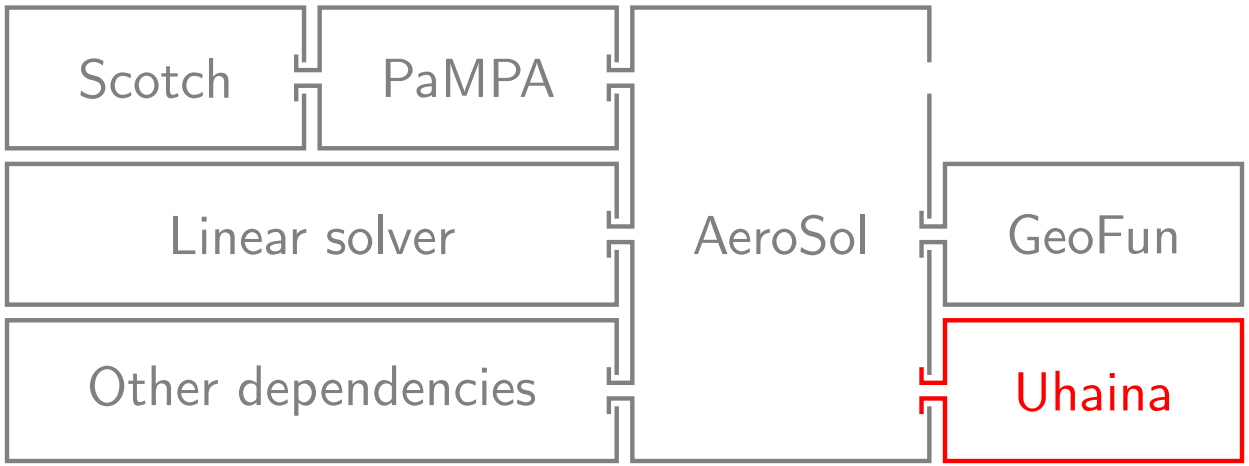
A porous aquifer in Utah

ANR GEOphysical Flows with UNified models

- Geophysical flows (free surface and underground)
- Unified vertically integrated models

- Cell-centered Finite Volume discretization
- External development w.r.t. AeroSol
- Testing single models implemented (Dupuit-Forchheimer, shallow water)



A shallow water dam break test in 2D

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