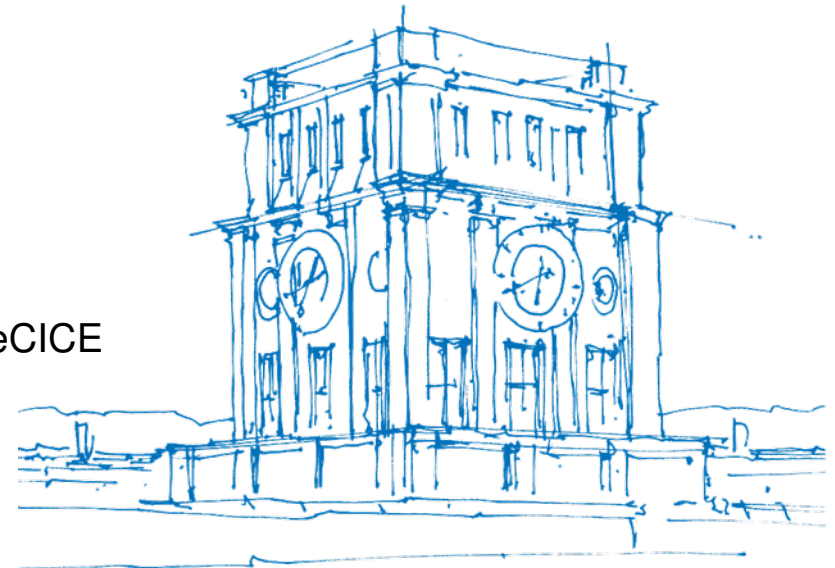


# preCICE for OpenFOAM: from CHT and FSI to a general-purpose plug-in

Gerasimos Chourdakis, Benjamin Uekermann, Derek Risseuw,  
Hans-Joachim Bungartz

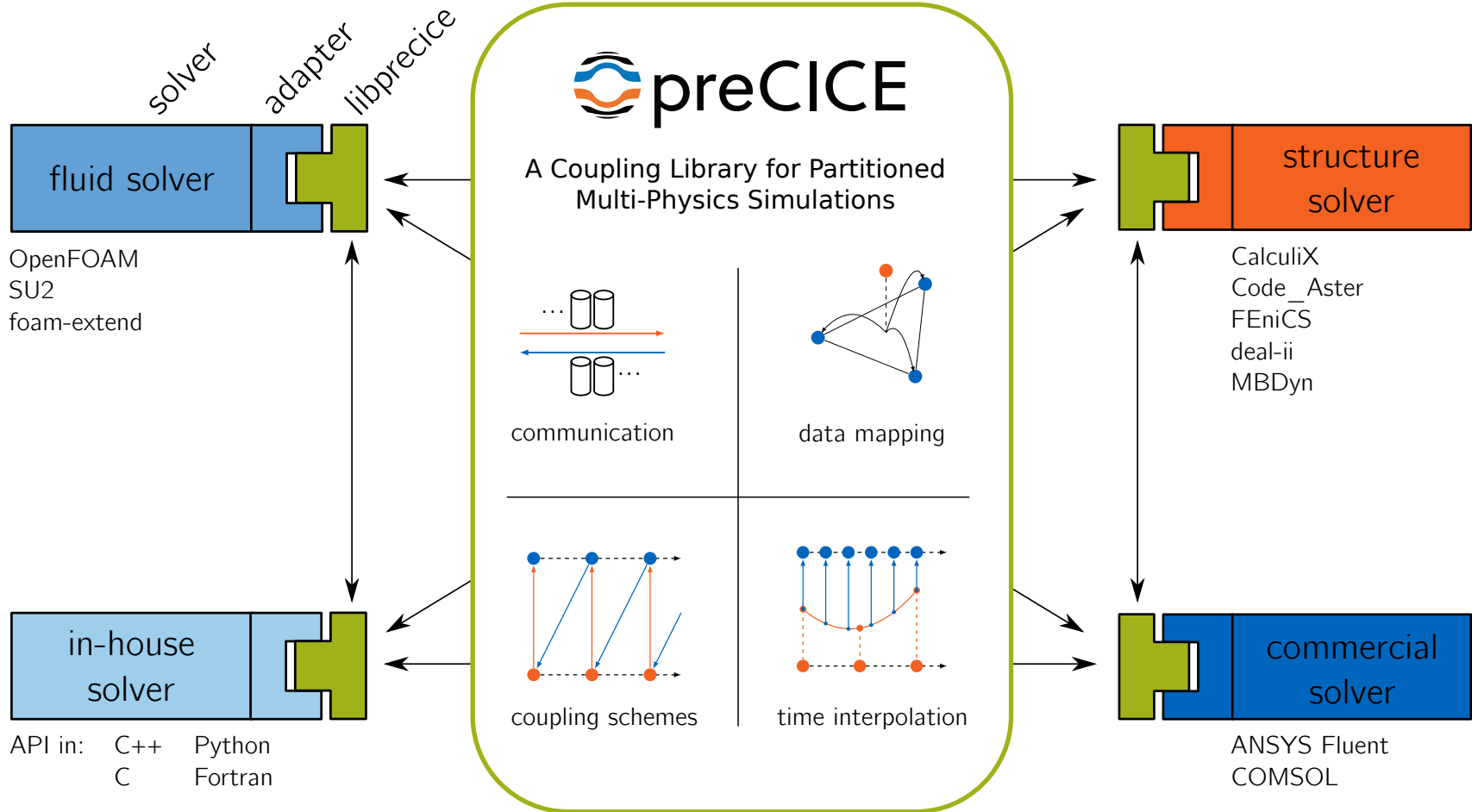
Technical University of Munich  
Department of Informatics  
Chair of Scientific Computing in Computer Science  
June 5, 2019

ECCOMAS Coupled Problems 2019  
Multi-physics Simulations with the Coupling Library preCICE

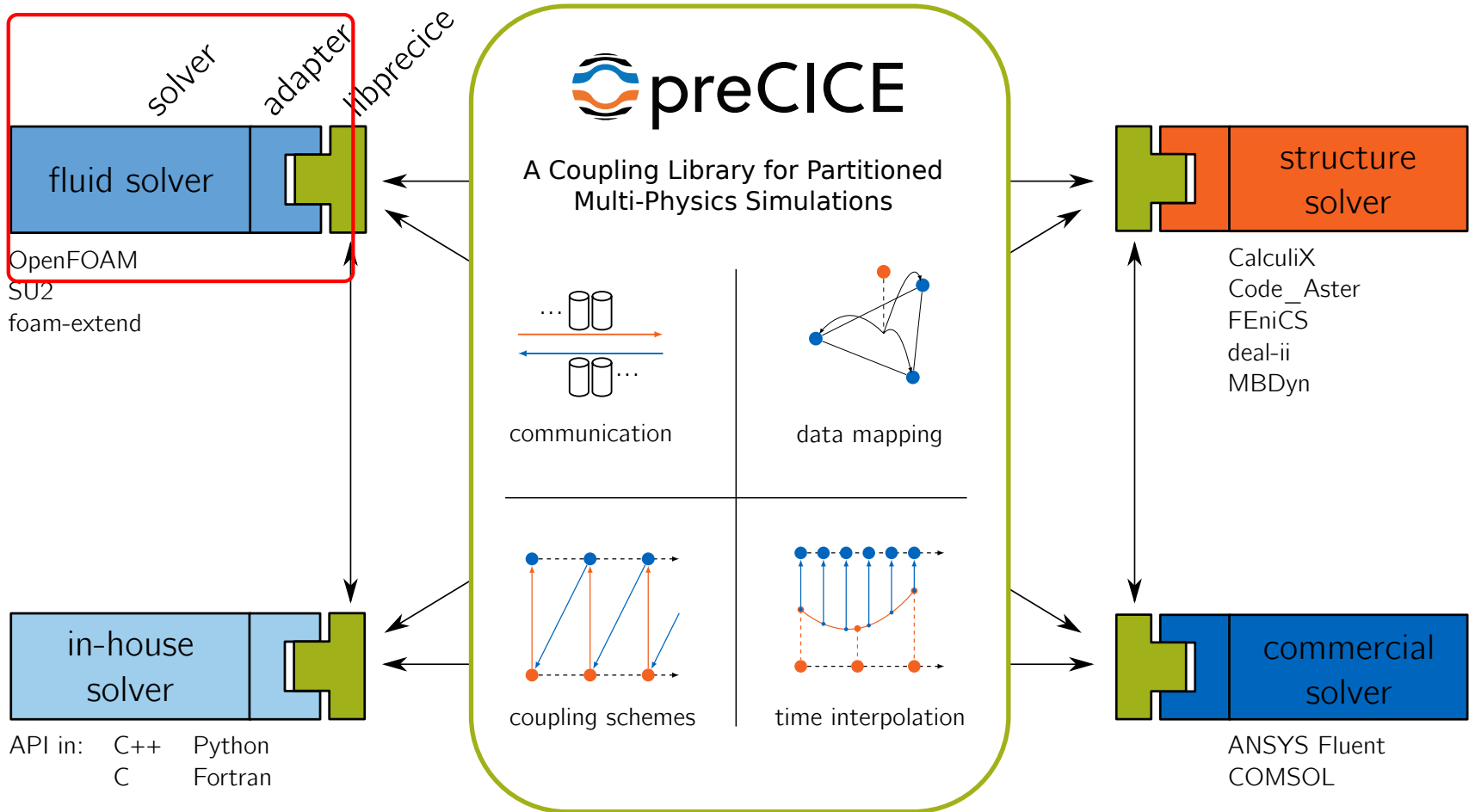


*TUM Uhrenturm*

# We are here



# We are here



# Types of preCICE adapters

## **Example in framework**

FEniCS, deal-II, Nutils

## **Adapted standard solver**

CalculiX, SU2

## **Plug-in**

OpenFOAM

# Types of preCICE adapters

## Example in framework

FEniCS, deal-II, Nutils

## Adapted standard solver

CalculiX, SU2

## Plug-in

OpenFOAM

Class Adapter

```
{
public:
    void write_data();
    void read_data();
    void advance();
    // ...
};

int main()
{
    Adapter adapter();
    Mesh mesh(100,100);
    mesh.evaluate("2*x+y");
    // ...
    adapter.write_data();
    adapter.advance();
    adapter.read_data();
}
```

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## Adapted standard solver

CalculiX, SU2

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    // ...
};

int main()
{
    Adapter adapter();
    FluidSolver solver();
    solver.do_magic();
    // ...
    adapter.write_data();
    adapter.advance();
    adapter.read_data();
}
```

## Plug-in

OpenFOAM

# Types of preCICE adapters

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```

## Plug-in

OpenFOAM

*// Adapter is a library*  
*// OpenFOAM: function obj.*

Class Adapter

```
{
public:
    void write_data();
    // ...
};
```

*// Solver config file*

functions

```
{
    preCICE_Adapter
    {
        type Adapter;
        libs ("libAdapter.so");
    }
}
```

# A plug-in approach for OpenFOAM

```
/* Start the solver */  
  
while (runTime.run()) {  
    #include "setDeltaT.H"  
  
    runTime++;  
  
    /* solve the equations */  
    #include "rhoEqn.H"  
    while (pimple.loop())  
    {  
        ...  
    }  
  
    runTime.write();  
}  
  
/* Finalize */
```



# A plug-in approach for OpenFOAM

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/* Start the solver */  
  
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    runTime++;  
  
    /* solve the equations */  
    #include "rhoEqn.H"  
    while (pimple.loop())  
    {  
        ...  
    }  
  
    runTime.write();  
}  
  
/* Finalize */
```

```
// system/controlDict OpenFOAM config file  
functions  
{  
    preCICE_Adapter  
    {  
        type preciceAdapterFunctionObject;  
        libs ("libpreciceAdapterFunctionObj.so");  
    }  
}
```

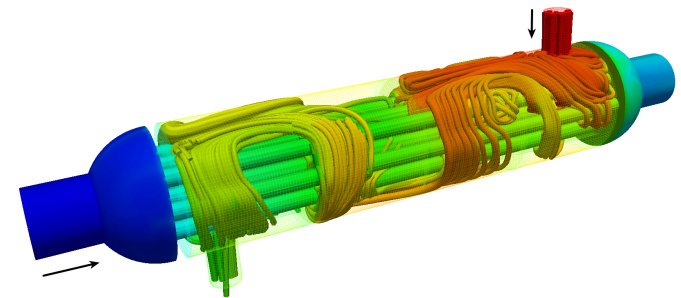
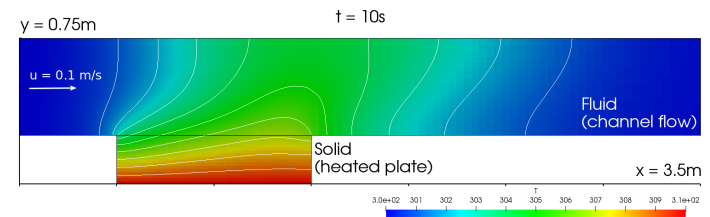
No code edits! [1]

[1] Gerasimos Chourdakis. A general OpenFOAM adapter for the coupling library preCICE. Master's thesis, Department of Informatics, Technical University of Munich, 2017.



# Conjugate heat transfer

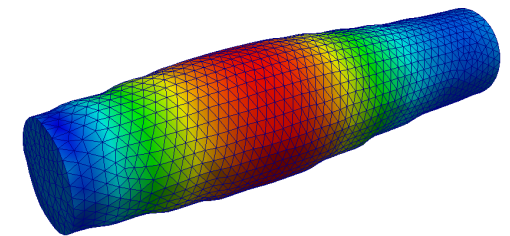
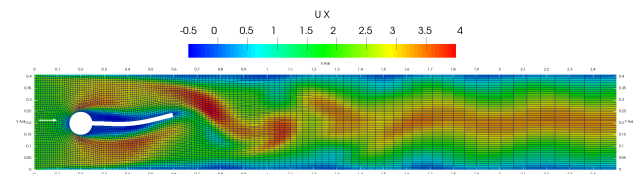
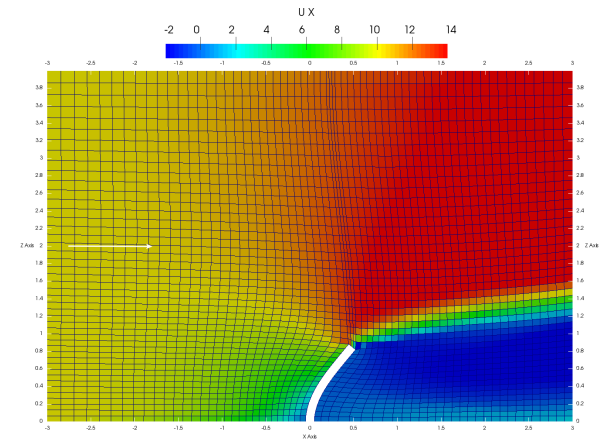
- Based on work by Lucia Cheung Yau, TUM (2016) in collaboration with SimScale [2]
- Open issues / ideas:
  - #12 @jaydeshpande  
Add radiative flux  $Q_r$  in interface patch
  - #10 @ykhedar  
Calculation of HeatFlux for meshes which use wall functions



[2] Lucia Cheung Yau. Conjugate heat transfer with the multiphysics coupling library preCICE. Master's thesis, Department of Informatics, Technical University of Munich, 2016.

# Fluid-structure interaction

- Contributed by Derek Risseeuw, TU Delft (2019) [3]
- Currently only incompressible & laminar
- Open Pull Requests:
  - #51 @efirvida  
Fix devRhoReff and mu to support turbulence
  - #64 @JSeuffert  
Forces calculation for compressible, multiphase and turbulence
- Open issues / ideas:
  - #41 @MakisH / @derekrisseeuw  
Add an option for stress mapping
  - #58 @MakisH / @derekrisseeuw  
Subcycling with implicit coupling
  - #85 @derekrisseeuw  
Support RBF mesh deformation methods

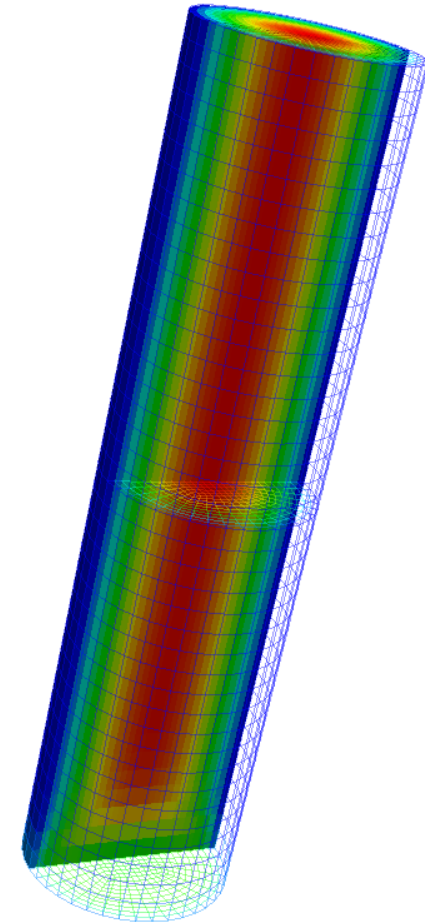


Bottom: 3DTube tutorial (scaled) contributed by Kyle Davis, 2019.

[3] Derek Risseeuw. Fluid Structure Interaction Modelling of Flapping Wings. Master's thesis, Faculty of Aerospace Engineering, Delft University of Technology, 2019.

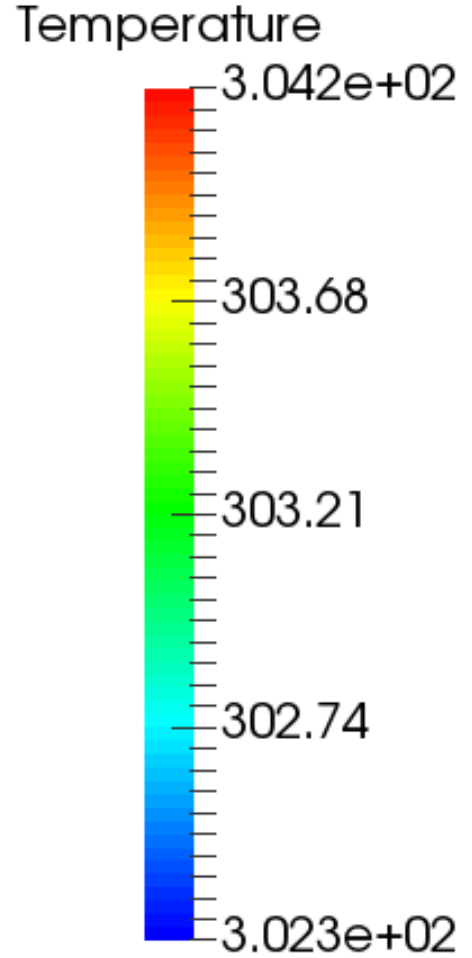
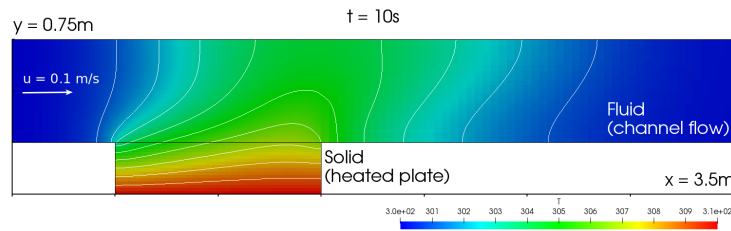
# Fluid-fluid coupling

- Experimental (branch FF)
- Currently supports:
  - Velocity
  - Pressure
  - Velocity gradient
  - Pressure gradient
- Open Pull Requests:
  - #67 @MakisH  
Add a Fluid-Fluid module
- Open issues / ideas:
  - Still not perfect matching
  - How to select the boundary conditions?
  - Exchange turbulent properties
  - Exchange temperature, phase fraction, ...



# Nearest-projection mapping

- Contributed by David Schneider, TUM (#46 @DavidSCN), currently in develop, only for CHT
- Defines mesh connectivity (edges & triangles)
- Requires two meshes to be set:
  - Face nodes
  - Face centers
- Try out the tutorial and give us feedback!



# New configuration format (proposed)

```

1 FoamFile
2 {
3     version 2.0;
4     format ascii;
5     location "";
6     class dictionary;
7     object preciceAdapterDict;
8 }
9
10 participant "Fluid";
11
12 preciceConfigFile "precice-config.xml";
13
14 modules
15 (
16     "CHT"
17 )

```

Any wishes?

```

18 interfaces
19 (
20     Fluid_Mesh
21     {
22         name "Fluid-Mesh"
23         locations "faceCenters"
24         meshConnectivity true
25         patches("interface")
26
27         writeData
28         (
29             name "Temperature"
30             type temperature
31         )
32
33         readData
34         (
35             name "Heat-Flux"
36             type heatFlux
37         )
38     }
39 )

```

# Compatibility with OpenFOAM

Known to work with:

ESI - OpenCFD: v1706 – v1812

The OpenFOAM Foundation: 4.0 – dev

Different branches for OpenFOAM 6/dev  
(please test!)



OpenFOAM



Older/foam-extend? See issues #8, #9.

**Question:** How to support multiple flavors and versions with the same code in the long term?  
(please comment on issue #32)



# Other news

- Marta Camps Santasmasas (Univ. of Manchester, UK): fluid-fluid coupling
  - Coupling Navier-Stokes and Lattice-Boltzmann
  - Draft pull request #84 [@martacamps](#)
  - See paper [4] and talk later in this session
  
- Nitish Arya (IITK, India): volume coupling for aeroacoustics
  - Goal: couple with Nektar++
  - Experimental / under development
  - See preCICE mailing list archives, 19/12/2018 [5]
  
- Anything else?

[4] Camps Santasmasas, Marta et al. (2018). Dual Navier-Stokes / Lattice-Boltzmann Method for urban wind flow. 12th International ERCOFTAC Symposium on Engineering Turbulence Modelling.

[5] <https://mailman.informatik.uni-stuttgart.de/pipermail/precice/2018/000277.html>

# How to contribute

- Fork from `precice/openfoam-adapter`
- Didn't fork? Fork anytime and add your fork as a Git remote
- Open a (draft) pull request to our `develop`
- Request a review when ready

## General guidelines

- Create a separate branch for each feature
- Tutorial cases are welcome
  - OpenFOAM-only: in `openfoam-adapter/tutorials`
  - More solvers: in `tutorials` repository
- Documentation, comments, ...

# Acknowledgements

preCICE is free because of the support of:



H2020 grant 754462



And the code/issues/testing/documentation contributions of people like you (thank you!).

# Summary



**Already:** a plugin for CHT, FSI (incompressible)

**Testing:** FSI (compressible), FF, Nearest-Projection mapping

**Upcoming:** new configuration format (no dependencies!)

**You:** can easily extend and contribute!

- [www.precice.org](http://www.precice.org)
- [github.com/precice](https://github.com/precice)
- [@precice\\_org](https://twitter.com/precice_org), [@\\_makCh](https://twitter.com/_makCh)
- [www5.in.tum.de](http://www5.in.tum.de)
- [@chourdak@in.tum.de](mailto:chourdak@in.tum.de)



Preview of doughnuts that will be served in the preCICE Workshop 2020 (February 17-18, Munich).