Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Home Affairs FDHA
Federal Office of Meteorology and Climatology MeteoSwiss

PP POMPA status

Xavier Lapillonne

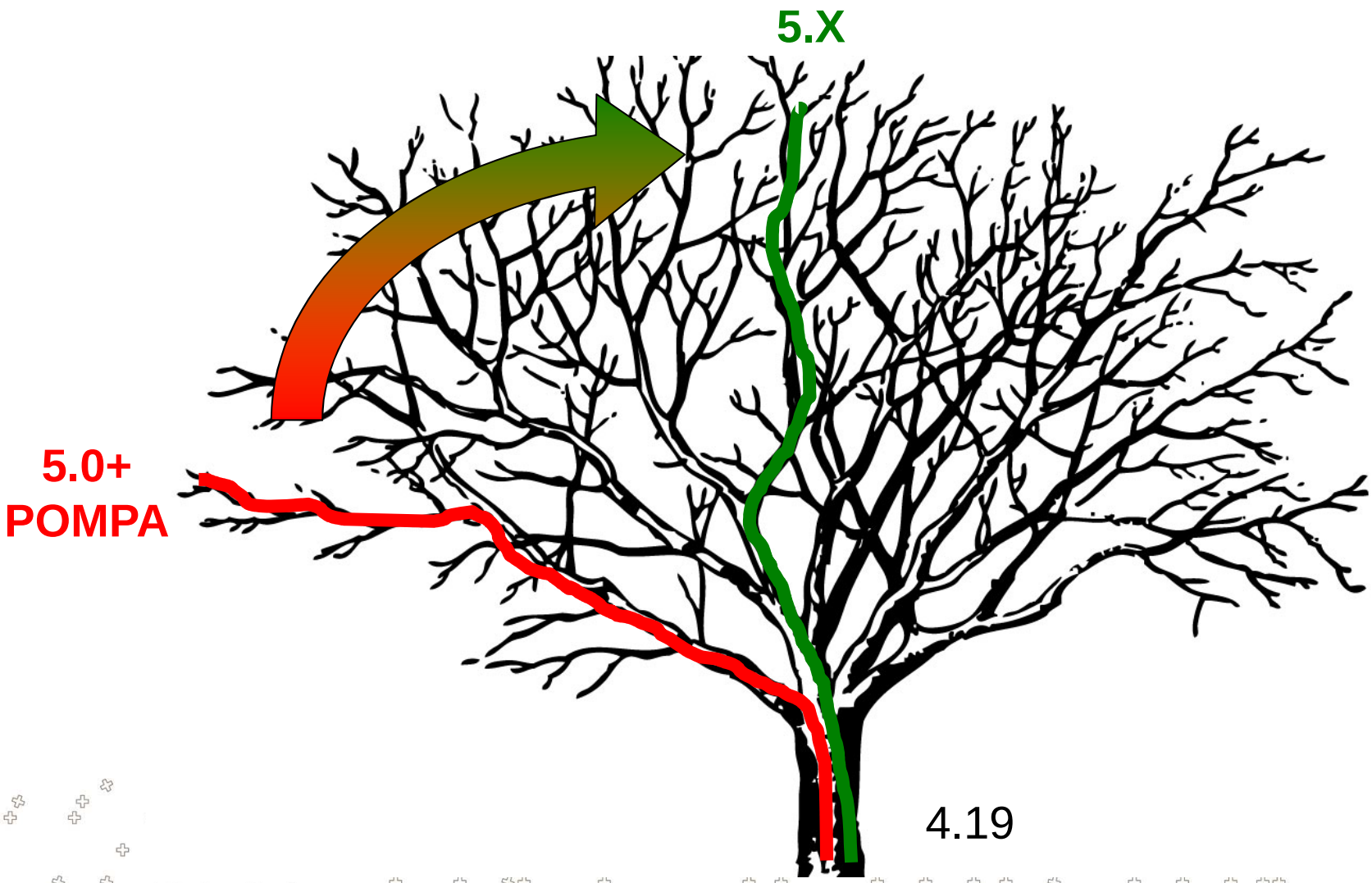
Performance On Massively Parallel Architectures

Last year of the project

Main outcomes :

- Performance portable version of the Dycore -> STELLA DSL
- GPU capable version of the COSMO model

Main task in 2016: Merge all developments into official version



C++/STELLA Dynamical core

- On going - good progress
- A working version will be available with the next COSMO release (available upon request for CPU test)
- The C++ dycore (CPU only) could be distributed with the official code from 12/2016 on

DOUBIE PRECISION

Speedup	F90 → C++	F90 CPU → C++ GPU
Timeloop	1.46	2.63
Dynamics	1.48	3.13
Physics	1.49	3.22

SINGLE PRECISION

Speedup	F90 → C++	F90 CPU → C++ GPU
Timeloop	1.19	2.45
Dynamics	1.11	2.60
Physics	1.36	3.59

Results for COSMO-E using 8 GPU sockets or 8 CPU sockets

COSMO-ICON Physics

Scheme	Blocked Version	GPU
Microphysics	yes	no
Radiation	yes	yes
Subgrid-scale Orography	no	no
Turbulence	yes	no
Surface Schemes	yes	no
Convection	yes	only shallow

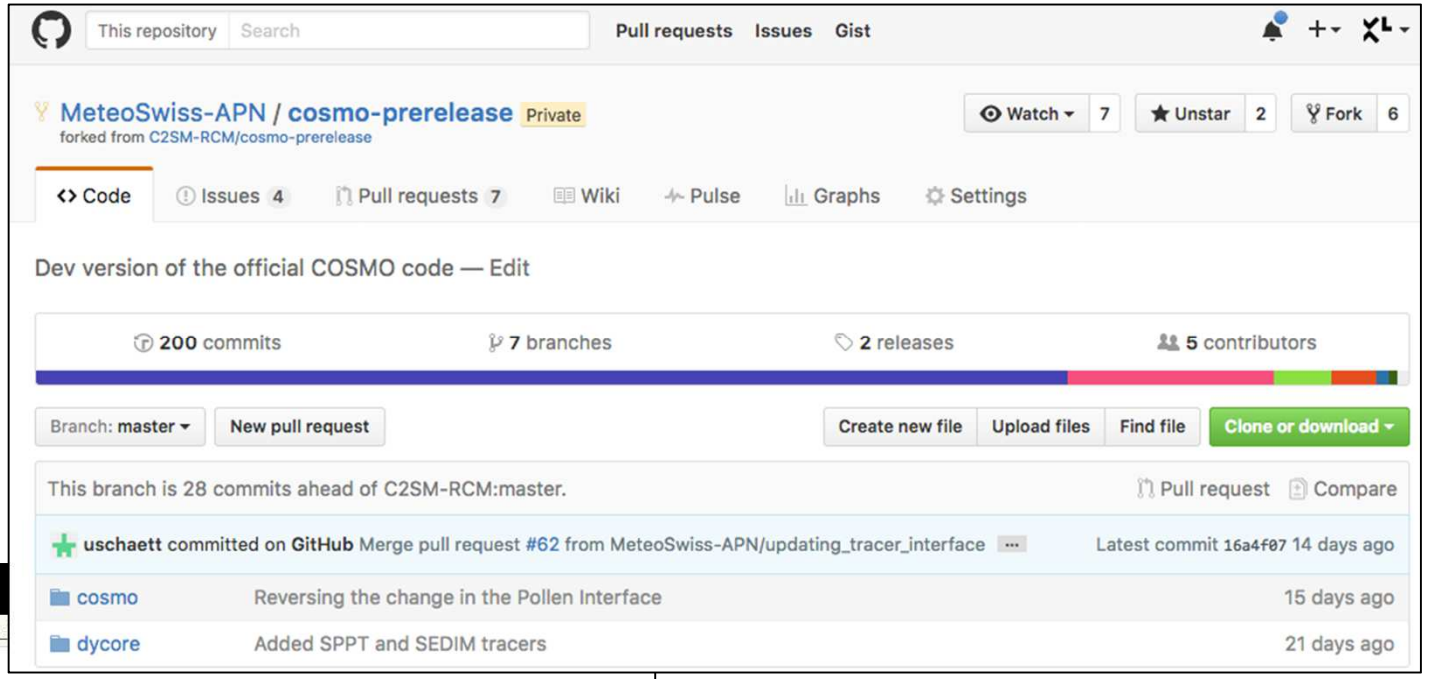
=> GPU porting of the physics in official code should be completed by end Q1 2017

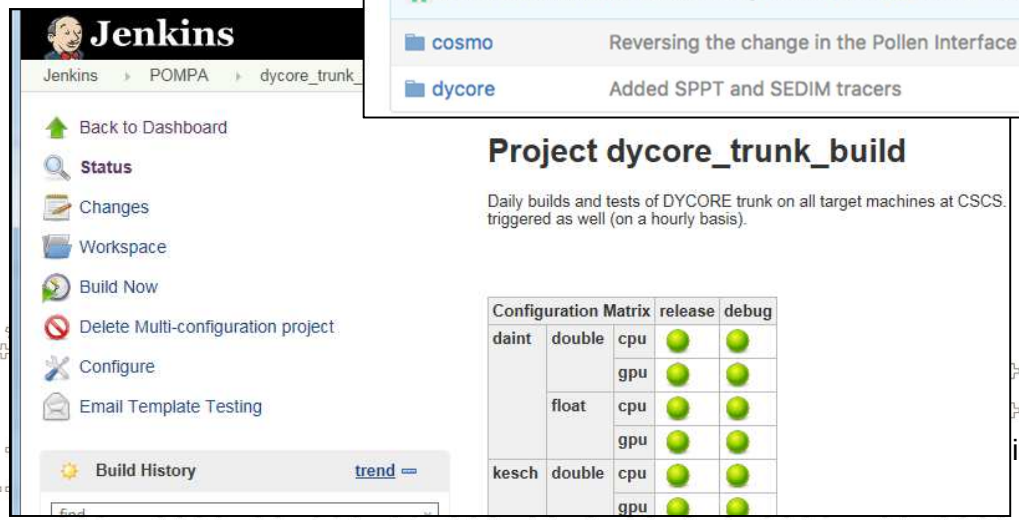
Other components

- Data assimilation to GPU (OpenACC) : nudging and latent heat nudging -> estimated Q1 2017
- Rest of the code : lmorg, output - estimated end Q1 2017
- Single precision :
  - Awaiting outcome of the work on radiation
  - Test code with adapted data assimilation expected for 11.2016

Development tools

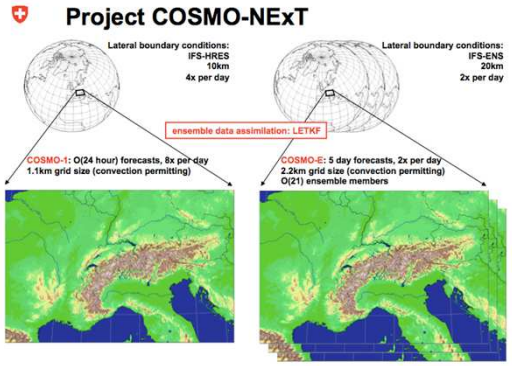
- New development tools in use, very helpful !
  - Github
  - Jenkins





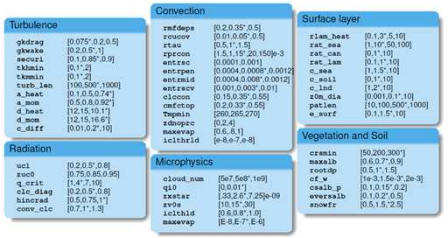
Applications

- MeteoSwiss



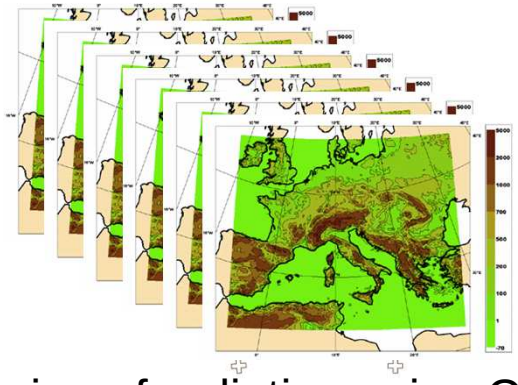
Operational forecast on GPU-based HPC system

- PP Calmo



17.1 M core hours on Piz Daint

- COSMO-LEPS

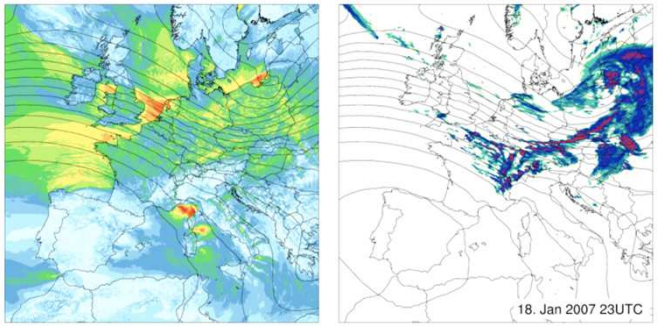


Switch to single precision
- 30% gain in BUs
- 30 → 21 minutes
- 16 → 20 members

- PP T2(RC)2 → tuning of radiation using CALMO strategy

Applications

- Institute for Atmospheric and Climate Science (IAC ETH)



PhD David Leutwyler
SNF crClim
PASC CLAW

- CSCS

- H2020 ESCAPE

Exa2Green
energy-aware numerics

GPU version and C++ dynamical core for COSMO-ART

ESCAPE

STELLA DSL
GridTools DSL

Related project : CLAW

- **C**LAW provides high-**L**evel **A**bstractions for **W**eather and climate models
- Goal : Provide language abstraction for performance portability in climate and weather model
- Directives with code transformation

```
SUBROUTINE inv_th(pclc,pca1, …)
  INTEGER:: ki1sd

  !$acc parallel
  !$acc loop collapse(3)
  !$claw loop-interchange (k,i,j)
  DO i=istart,iend
    DO j=jstart,jend
      DO k=kstart,kend
        ! Computation is done here
      END DO
    END DO
  END DO
  !$acc end parallel

END SUBROUTINE inv_th
```

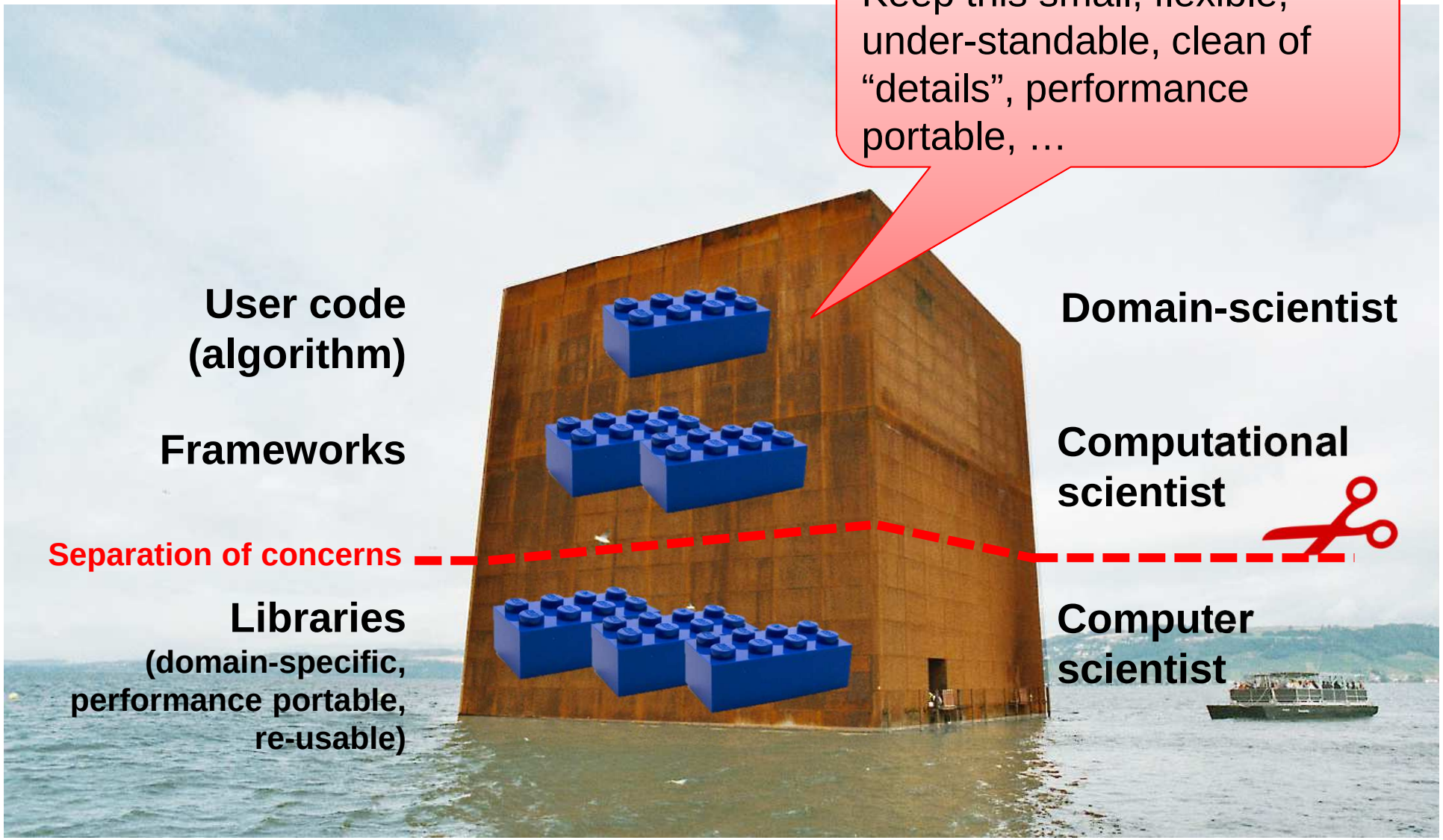
CLAW

- Code manipulation with AST
- Based on the OMNI compiler
- Transformed code can be compile with standard compiler

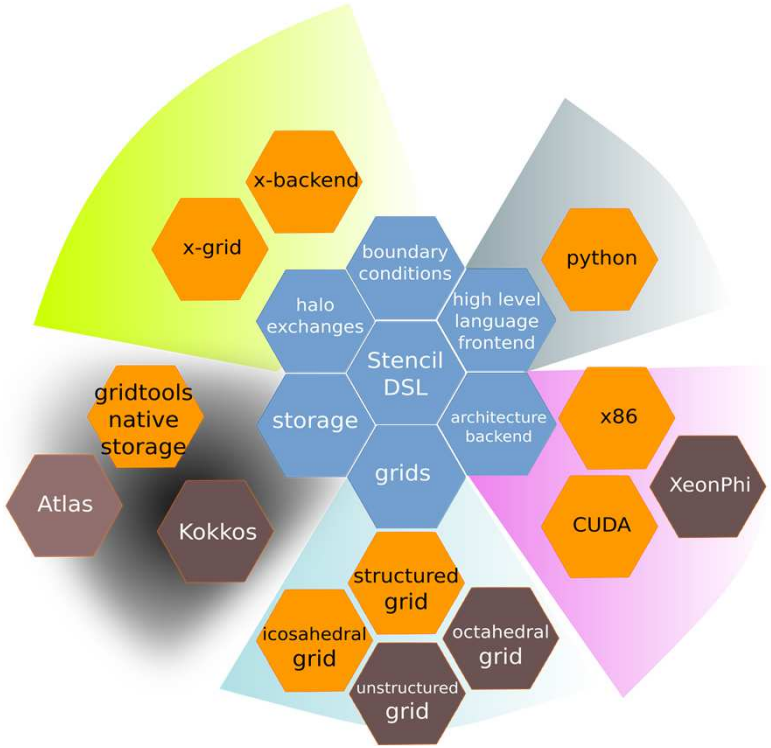
CLAW language definition are available on github :

https://github.com/C2SM-RCM/claw-language-definition

Replacement of STELLA : the GridTool Library

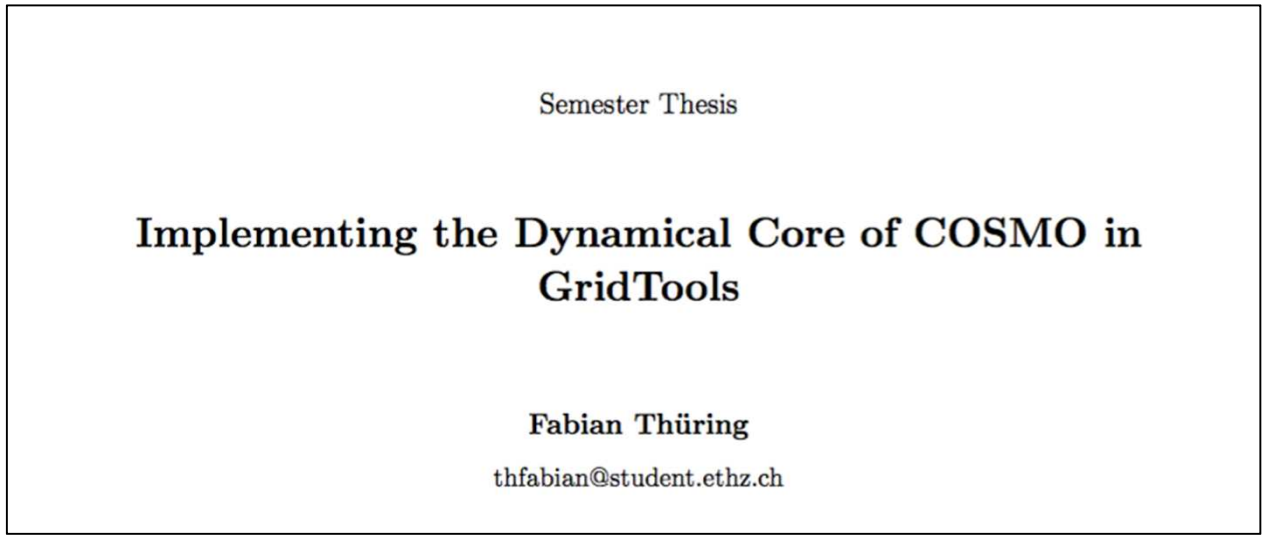


The GridTools Ecosystem



- Set of C++ APIs / Libraries
- Large class of problems
- Performance Portability
- Separation of concerns
- Intuitive interface
- Basic building blocks
- Composability
- Interoperability (C++, Fortran, Python)
- Extensibility
- Not a complete ontology (which is good!)
- Open source license

Ready for COSMO?



Semester Thesis

Implementing the Dynamical Core of COSMO in GridTools

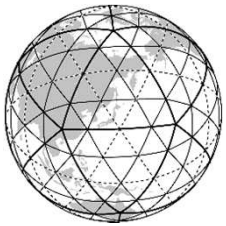
Fabian Thüring

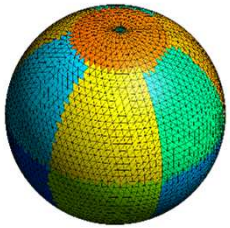
thfabian@student.ethz.ch

- Implementation of Coriolis force, vertical advection, horizontal diffusion stencils (and unit-testing, verification framework, …)
- Critical review of GridTools user-interface
- Conclusion: **Functionality of GridTools is ready!**

Global Grids

- New DSL constructs for stencils on global grids



Icosahedral Cubed sphere Octahedral

- DSL Language definition

```
!$OMP PARALLEL DO
DO jb = i_startblk, i_endblk
  #ifdef __LOOP_EXCHANGE
  DO jc = i_startidx, i_endidx
      DO jc = slev, elev
  #else
  DO jk = slev, elev
    DO jc = i_starti
  #endif
      div_vec_c(jc,j
      vec_e(iid(ic,jb,
      vec_e(iid(ic,jb,
    ENDDO
  ENDDO
ENDDO
```

```
template<typename Evaluation>
static void Do(Evaluation const & eval, x_interval)
{
  auto edge_red = [](const double v, const double length, const double
double
                {return v*length + res; };
  eval(div()) = eval(on_edges(edge_red, 0.0, v(), edge_length())) /
eval(cell_area());
}
```

```
typed                    pl::vector<vec, div_vec> arg_list;

template<typename Evaluation>
static void Do(Evaluation const& eval, full_domain)
{
  eval(div_vec())= eval(on_edges<vec>());
}
```

We would **love** to work together more closely with ICON developers for defining and refining the DSL!

Collaborations:

- ESCAPE Project with ECMWF
  - Use GridTools data storage in Atlas library
  - Apply DSL for octahedral grids
- Collaboration RIKEN
  - Prototype study for
    - Implement several stencils from NICAM with GridTools
    - Compare to other approaches (e.g. OpenACC)

Open aspects still to be defined

- COSMO/CLM training
- Distribution of the GPU version
- Single precision and GPU version : how do we test it, reduced NWP testuite ?
- Supported system
- PT EDP2 Evaluation of the Dycore parallel phase (see tomorrow's talk)
- Follow on HPC and COSMO ?

Contributors in 2016 (Thanks!)

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Petra Baumann
Roman Cattaneo
Ulrich Schättler
Valentin Clement
Xandeep Varghese

Thanks for your attention