



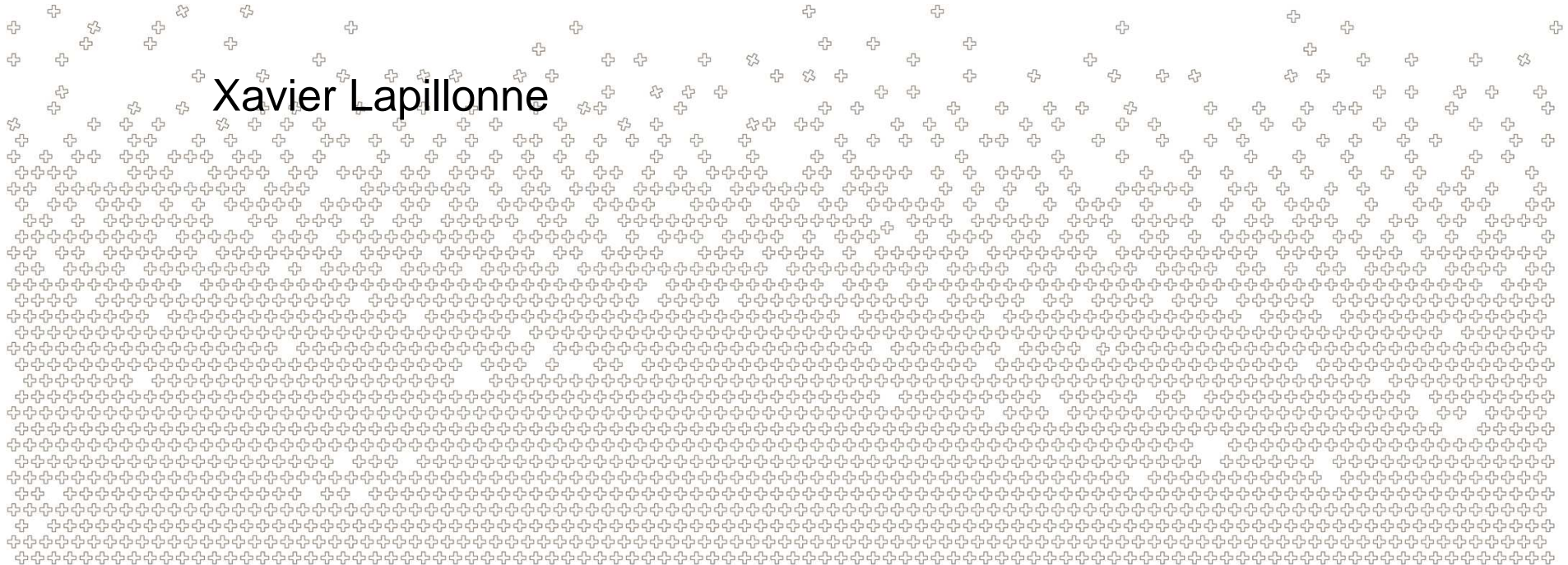
Schweizerische Eidgenossenschaft  
Confédération suisse  
Confederazione Svizzera  
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Swiss Confederation

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

# PP POMPA status

Xavier Lapillonne



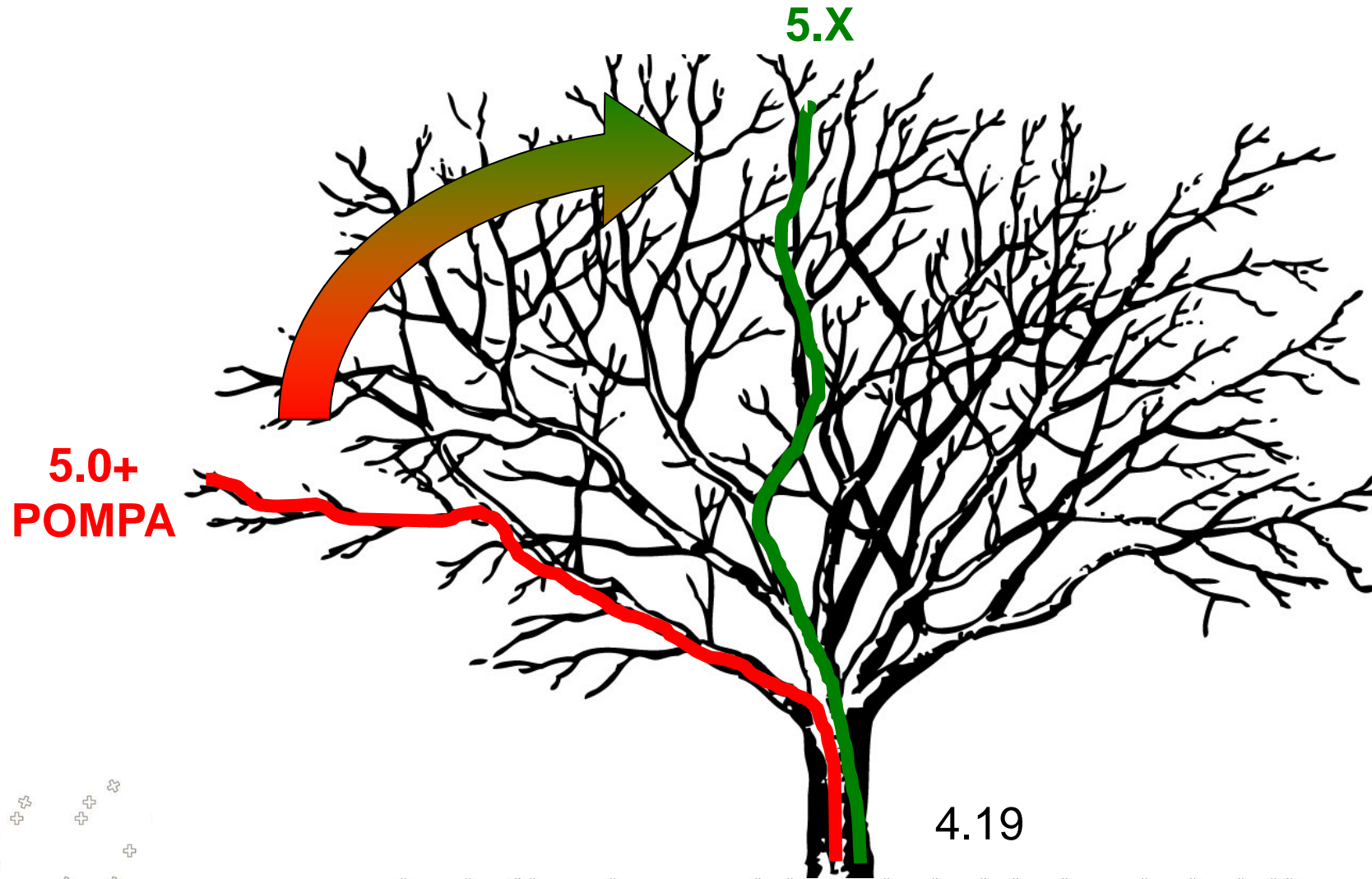
## Performance On Massively Parallel Architectures

### 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

## DOUBLE 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 : Imorg, 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

This screenshot shows the GitHub interface for the repository 'MeteoSwiss-APN / cosmo-prerelease'. The repository is private and forked from 'C2SM-RCM/cosmo-prerelease'. It has 7 watchers, 2 unstars, and 6 forks. The main branch is 'master', and there are 200 commits, 7 branches, 2 releases, and 5 contributors. A recent commit by 'uschaett' is highlighted, with a commit hash of '16a4f07' made 14 days ago. Below the commit list, there are folders for 'cosmo' and 'dycore'.

This screenshot shows the Jenkins web interface. The left sidebar contains navigation links: 'Back to Dashboard', 'Status', 'Changes', 'Workspace', 'Build Now', 'Delete Multi-configuration project', 'Configure', and 'Email Template Testing'. The main content area displays the 'Project dycore\_trunk\_build' with a description: 'Daily builds and tests of DYCORE trunk on all target machines at CSCS, triggered as well (on a hourly basis)'. Below the description is a 'Configuration Matrix' table.

Configuration Matrix			release	debug
daint	double	cpu	●	●
		gpu	●	●
	float	cpu	●	●
		gpu	●	●
kesch	double	cpu	●	●
		gpu	●	●

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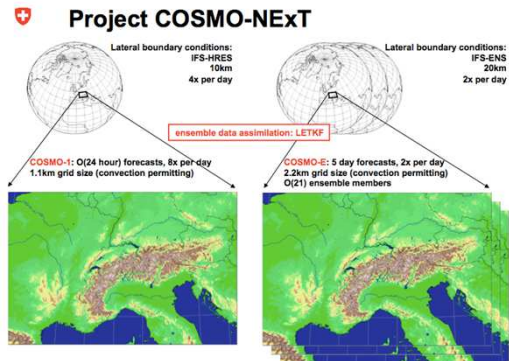
# Applications

- MeteoSwiss

- PP Calmo

- COSMO-LEPS

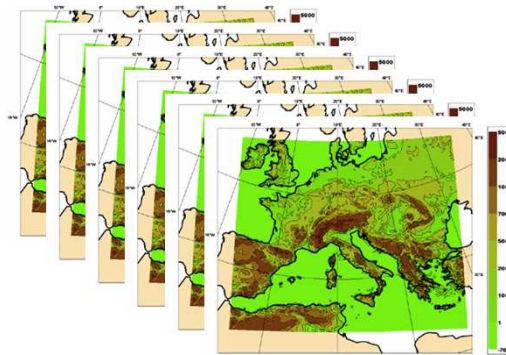
- PP T2(RC)2 → tuning of radiation using CALMO strategy



Operational forecast on GPU-based HPC system

<b>Turbulence</b> okdrag [0.075;0.2;0.5] ghwaka [0.2;0.5;1] secuzi [0.1;0.5;0.9] ckhain [0.1;1] kamin [0.1;1] trub_len [100,500;1000] a_smax [0.1;0.5;0.7] a_som [0.5;0.8;0.95] d_smax [12;15;18;17] d_som [12;15;18;17] c_dirf [0.01;0.2;1;0]	<b>Convection</b> rnfdeps [0.2;0.35;0.5] rncovr [0.01;0.05;0.5] rtaxo [0.5;1;5] rpreon [1;1.15;20;150;3] entrcn [0.0001;0.001] entrcn [0.0004;0.0008;0.0012] entrcn [0.0004;0.0008;0.0012] entrcn [0.001;0.002;0.01] c1con [0.15;0.35;0.55] omctop [0.2;0.35;0.55] Tmax [280;285;270] xdiupc [0.2;4] maxevap [0.8;7;6;8] ic1hld [0.2;4]	<b>Surface layer</b> r1m_beat [0.1;2;5;10] rat_saa [1;0.5;100] rat_caa [0.1;1;10] rat_saa [0.1;1;10] c_saa [1;1.5;10] c_saa [0.1;1;10] c_lnd [1;2;10] zbc_dia [0.000;0.1;1;10] patlen [10;100;500;1000] w_surf [0.1;1;5;10]
<b>Radiation</b> ucl [0.2;0.5;0.8] rsc0 [0.75;0.85;0.95] q_crit [1;4;7;10] r1c_dgap [0.2;0.5;0.8] hincrad [0.0;0.75;1] covr_cic [0.71;1;3]	<b>Microphysics</b> cloud_num [0.7;500;100] q10 [0.0;0.1] zextar [33.2;6.7;250;09] svie [10;15;20] ic1hld [0.0;0.8;1;0] maxevap [0.8;8;7;8;4]	<b>Vegetation and Soil</b> crmin [50;200;300] maxalb [0.0;0.7;0.9] rootdp [0.5;1;5] cf_w [1e-3;1.5e-3;2e-3] cshlp_p [0.1;0.15;0.2] overshb [0.1;0.2;0.5] snowc [0.5;1.5;2.5]

17.1 M core hours on Piz Daint



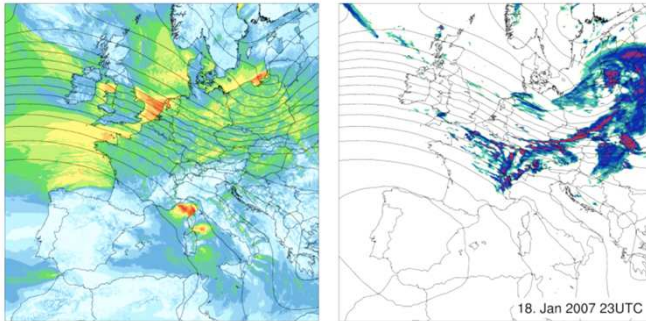
Switch to single precision

- 30% gain in BUs
- 30 → 21 minutes
- 16 → 20 members



# Applications

- Institute for Atmospheric and Climate Science (IAC ETH)



PhD David Leutwyler  
SNF crClim  
PASC CLAW

- CSCS

- H2020 ESCAPE



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



STELLA DSL  
GridTools DSL

**MeteoSwiss**

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# Related project : CLAW

- **CLAW** provides high-Level **Abstractions** for **Weather** and climate models
- Goal : Provide language abstraction for performance portability in climate and weather model
- Directives with code transformation

```
SUBROUTINE inv_th(pcl, pcal, ...)
  INTEGER:: kilsd

  !$acc parallel
  !$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 compiled with standard compiler

CLAW language definition are available on github :

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

# Replacement of STELLA : the GridTool Library

Keep this small, flexible,  
under-standable, clean of  
“details”, performance  
portable, ...

User code  
(algorithm)

Frameworks

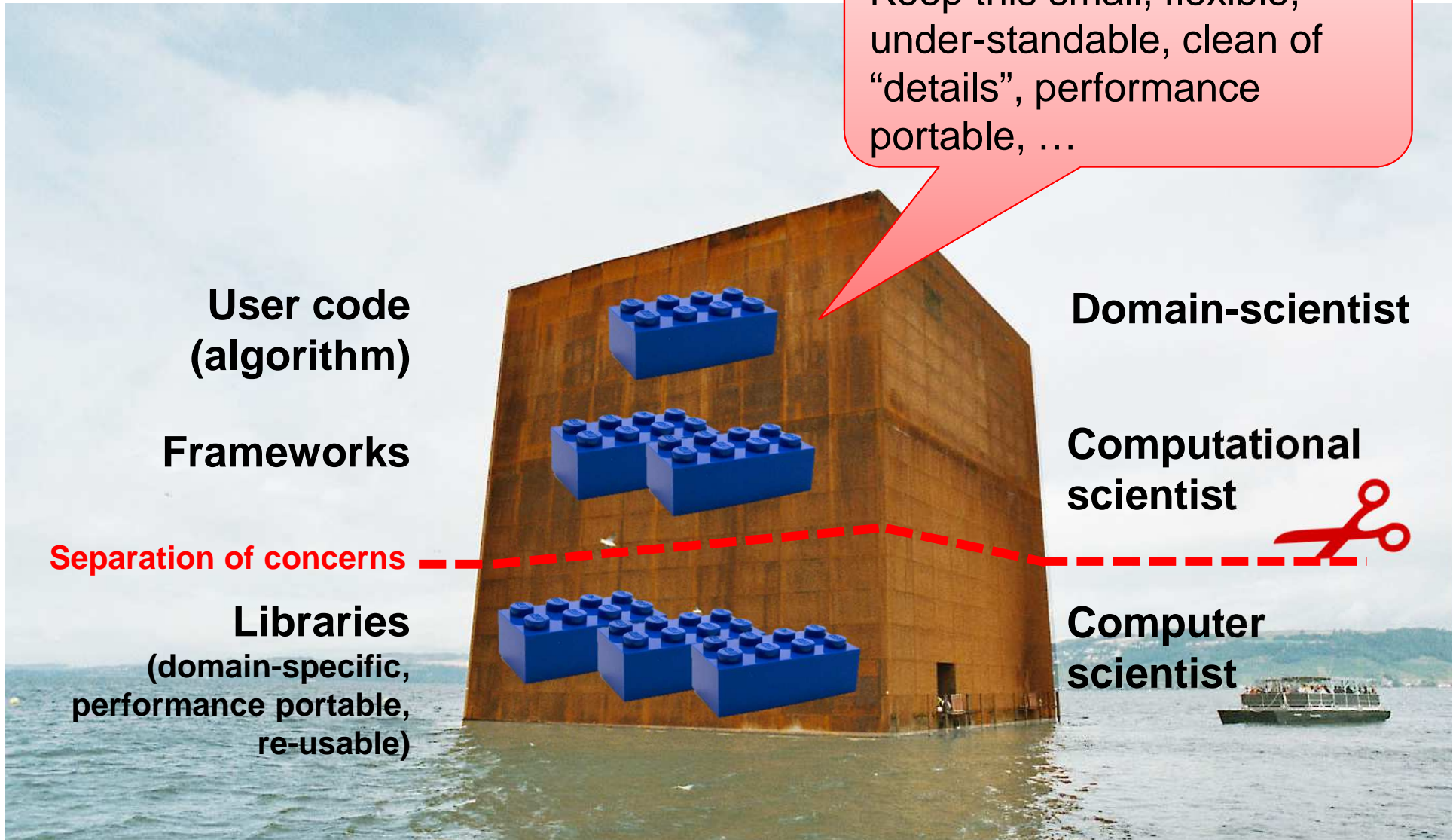
Separation of concerns

Libraries  
(domain-specific,  
performance portable,  
re-usable)

Domain-scientist

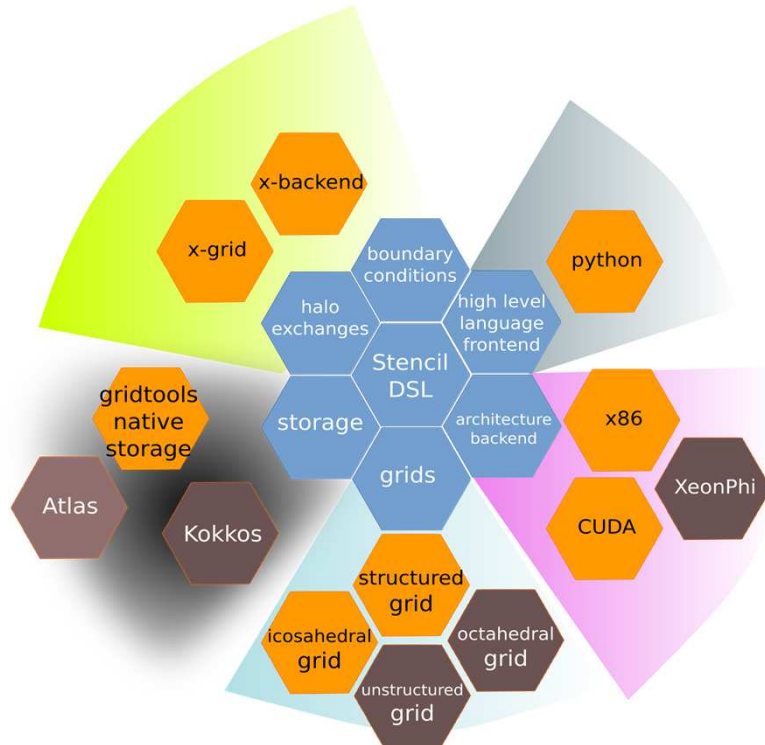
Computational  
scientist

Computer  
scientist





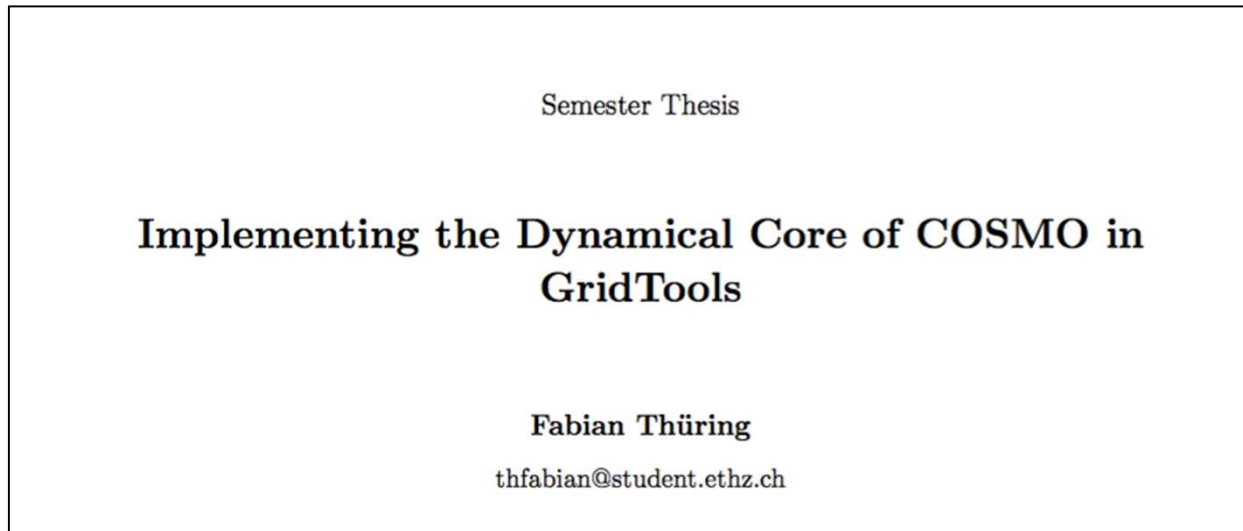
# The GridTools Ecosystem



- 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?

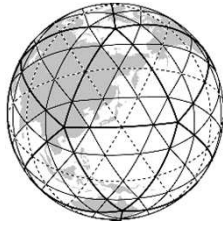


- Implementation of Coriolis force, vertical advection, horizontal diffusion stencils (and unit-testing, verification framework, ...)
- Critical review of GridTools user-interface
- Conclusion: **Functionality of GridTools is ready!**



# Global Grids

- New DSL constructs for stencils on global grids



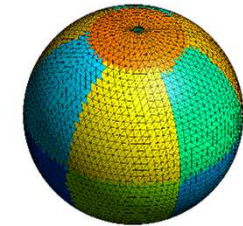
Icosahedral



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());
}

```

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

```


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

```



## Collaborations:



- ESCAPE Project with 
  - Use GridTools data storage in Atlas library
  - Apply DSL for octahedral grids

- Collaboration 

- 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 test suite ?
- Supported system
- PT EDP2 Evaluation of the Dycore parallel phase (see tomorrow's talk)
- Follow on HPC and COSMO ?



# Contributors in 2016 (Thanks!)

Alon Shtivelman

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Christoph Angerer

Christophe Charpillot

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Guy de Morsier

Katherine Osterried

Michael Baldauf

Oliver Fuhrer

Pascal Spörri

Pavel Khain

Peter Messmer

Petra Baumann

Roman Cattaneo

Ulrich Schättler

Valentin Clement

Xandeeep Varghese

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# Thanks for your attention