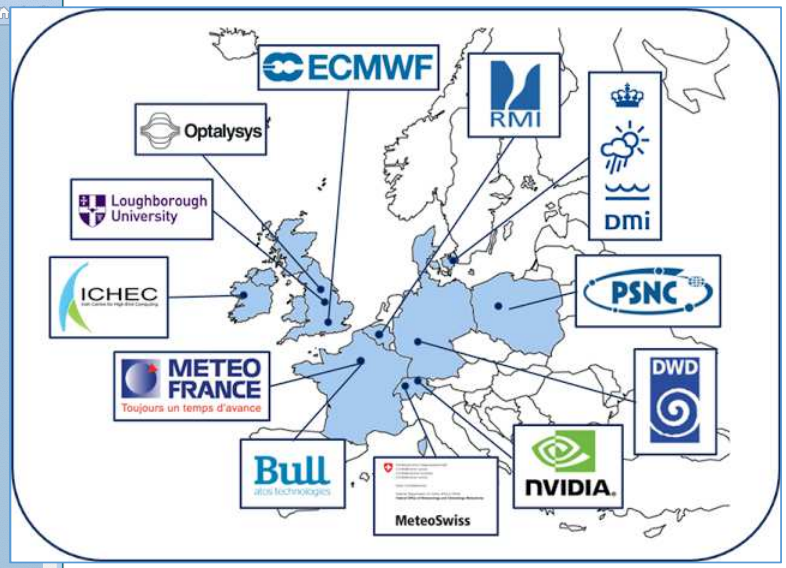
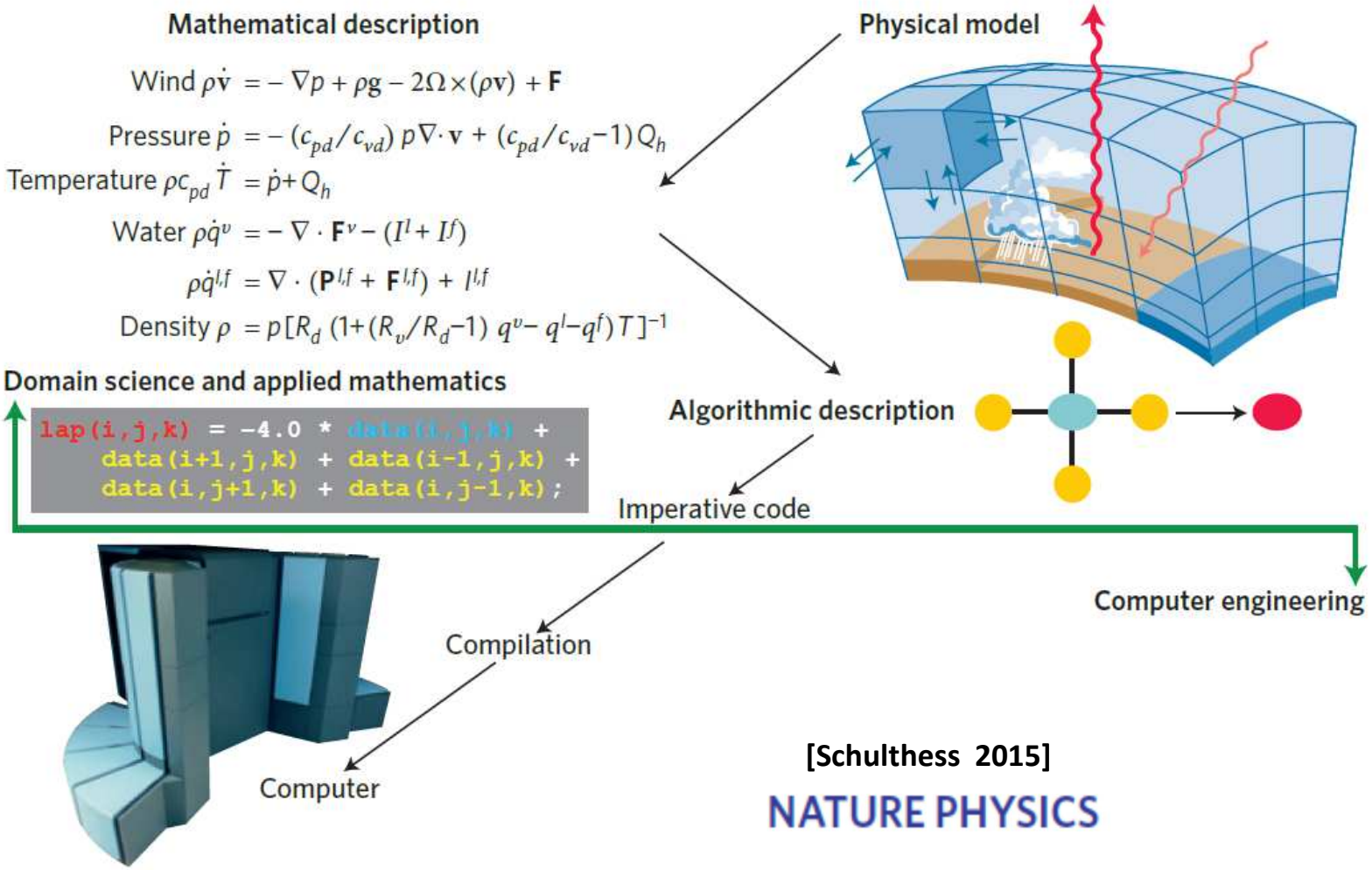
Energy efficient SCalable Algorithms for weather Prediction at Exascale: ESCAPE



The ESCAPE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 671627. This material reflects only the author's view and the Commission is not responsible for any use that may be made of the information it contains.

Funded by the European Union

Traditional science workflow



[Schulthess 2015]

NATURE PHYSICS

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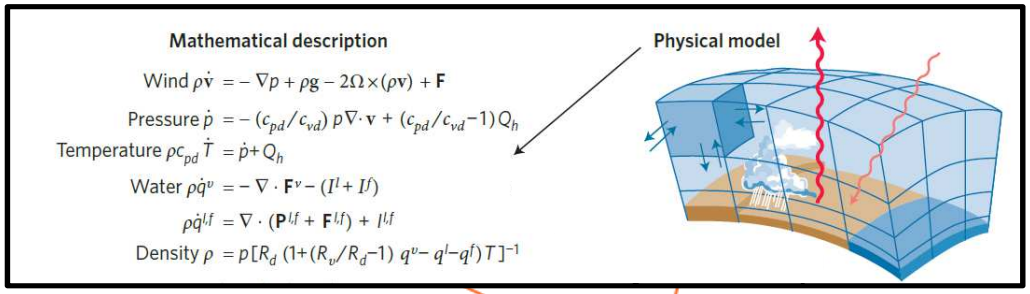
Future science workflow



Science applications using a descriptive and dynamic developer environment

Algorithmic description

Multidisciplinary co-design of tools, libraries, programming environment

Imperative code

Compiler front-end

Optimization / low-level libraries / runtime

Architecture specific back-ends

Architecture 1 | Architecture 2 | Architecture *N*

↑ science specific code

↓ generic code

[Schulthess 2015]

NATURE PHYSICS

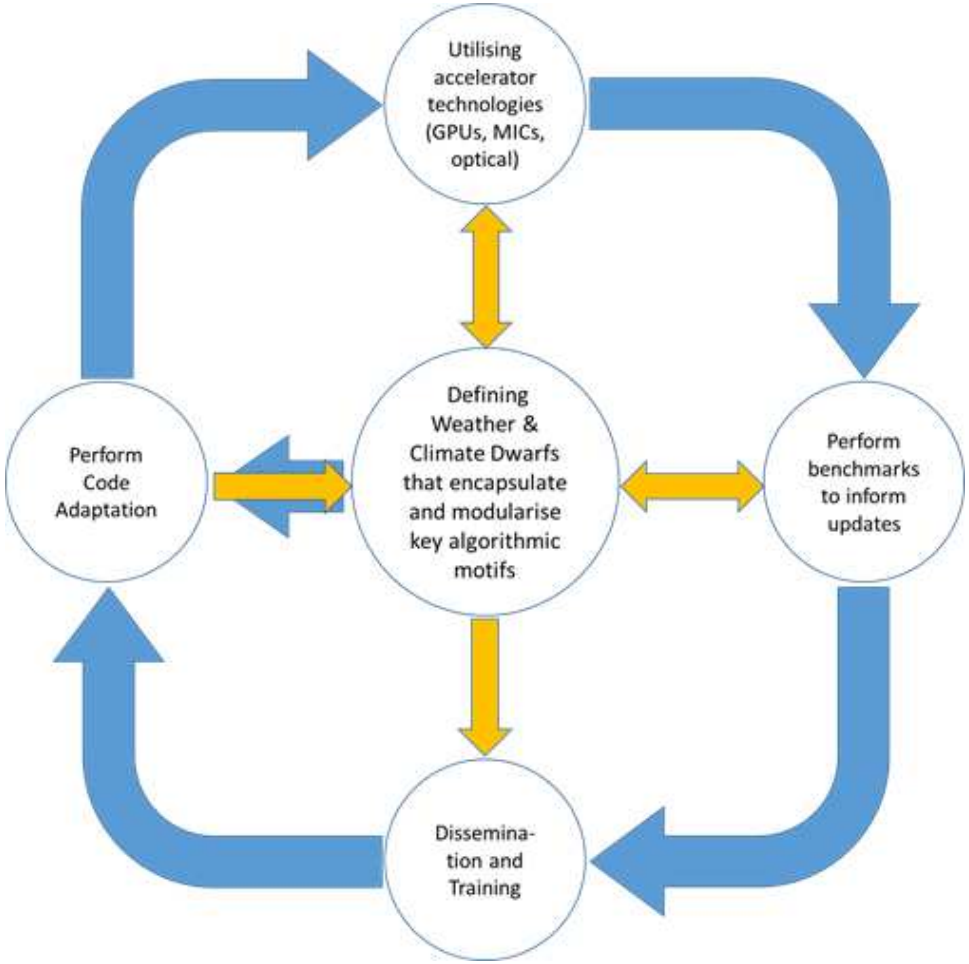
PETER BAUER 2016

Energy efficient SCalable Algorithms for weather Prediction at Exascale

→ **www.hpc-escape.eu**

This project is funded by the European Union

ESCAPE Objectives



- Define fundamental algorithm building blocks ("*Weather & Climate Dwarfs*") to co-design, advance, benchmark and efficiently run the next generation of NWP and climate models on energy-efficient, heterogeneous HPC architectures.
- Combine frontier research on algorithm development and extreme-scale, high-performance computing applications with novel hardware technology, to create a flexible and sustainable weather and climate prediction system.
- Foster the future design of Earth-system models and commercialisation of weather-dependent innovative products and services in Europe through enabling open-source technology.
- Pairing world-leading NWP with innovative HPC solutions.

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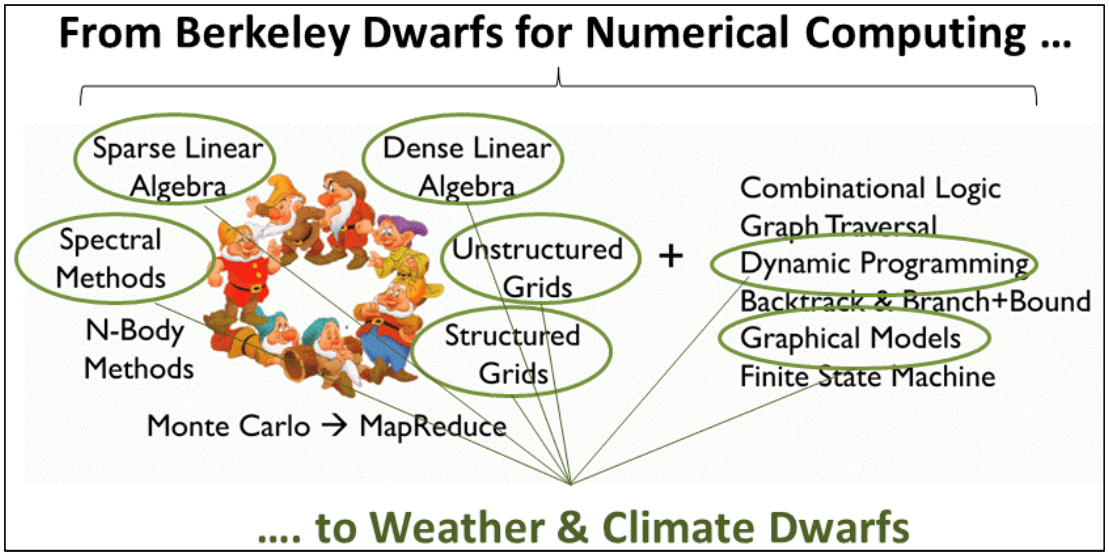
What is a dwarf?



A dwarf encapsulates a relevant characteristic or required functionality of an weather/climate prediction model and it is meant to be a **runnable** and **verifiable mini-application**

Candidates:

- Atlas data structure……*new*, maximum flexibility, scalable
- Spectral transforms (FT/LT and bi-FT)……very memory and communication bandwidth intensive, limited scalability
- 2 & 3-dimensional elliptic solver……*new*, compute and communication latency intensive, limited scalability
- Semi-Lagrangian advection……communication intensive, not very scalable
- Cloud physics parameterization……very compute intensive, scalable
- Radiation parameterization……very compute intensive, scalable

… more to follow

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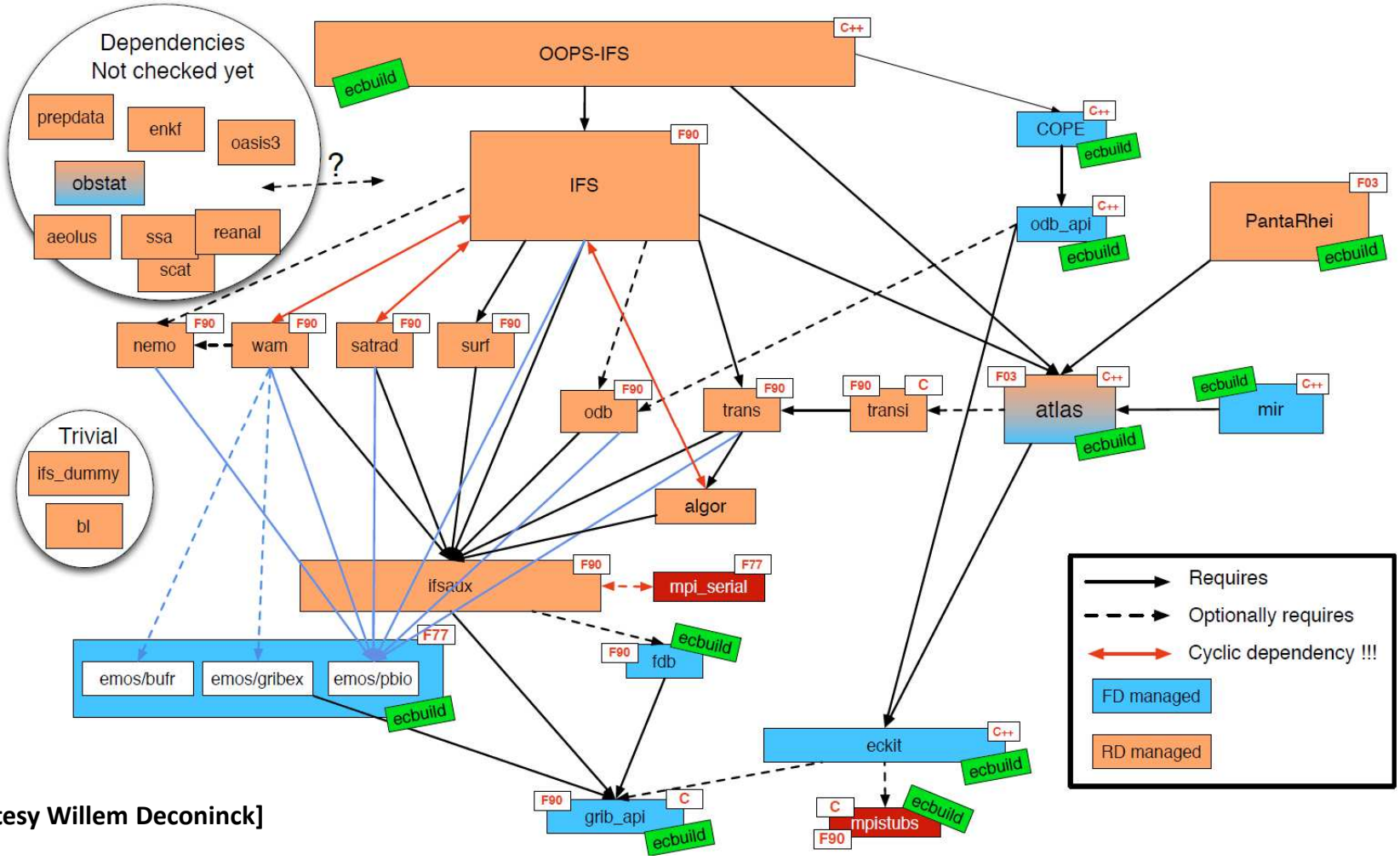
The entire NWP model software context



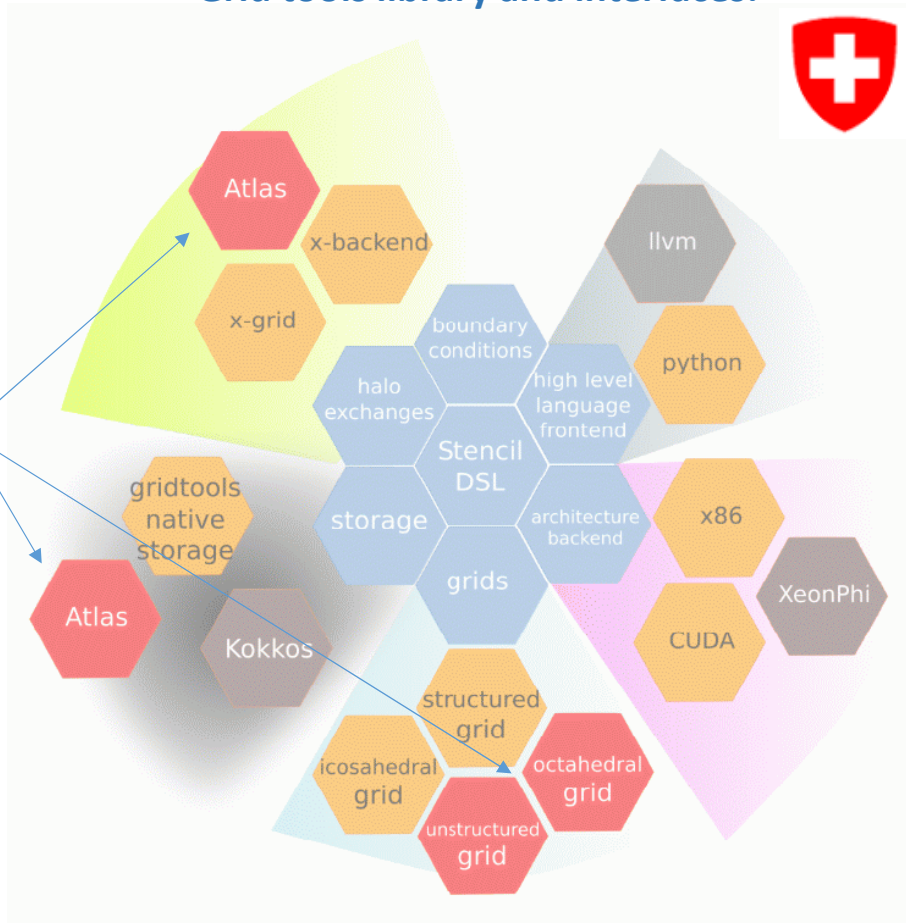
[Courtesy Willem Deconinck]

ATLAS & Grid tools

Atlas data structures & functionalities:

- C++ code with Fortran 2003 OO-interface
- Hierarchical composition of data: *Mesh*, *State*, *FieldSet*, *Field*, *FunctionSpace*, *Metadata*
- Hybrid Unstructured distributed meshes (because structured is special case of unstructured!)
- Library of grid definitions (Factory mechanism)
- Mesh-generation/reading – Domain Decomposition – Halo-creation
- Parallel communication Patterns (HaloExchange, Gather/Scatter, Reductions)
- Numerical algorithms: Interpolation, Nabla (grad,div,curl), ...
- Spectral transforms (grid permitting)

Grid tools library and interfaces:



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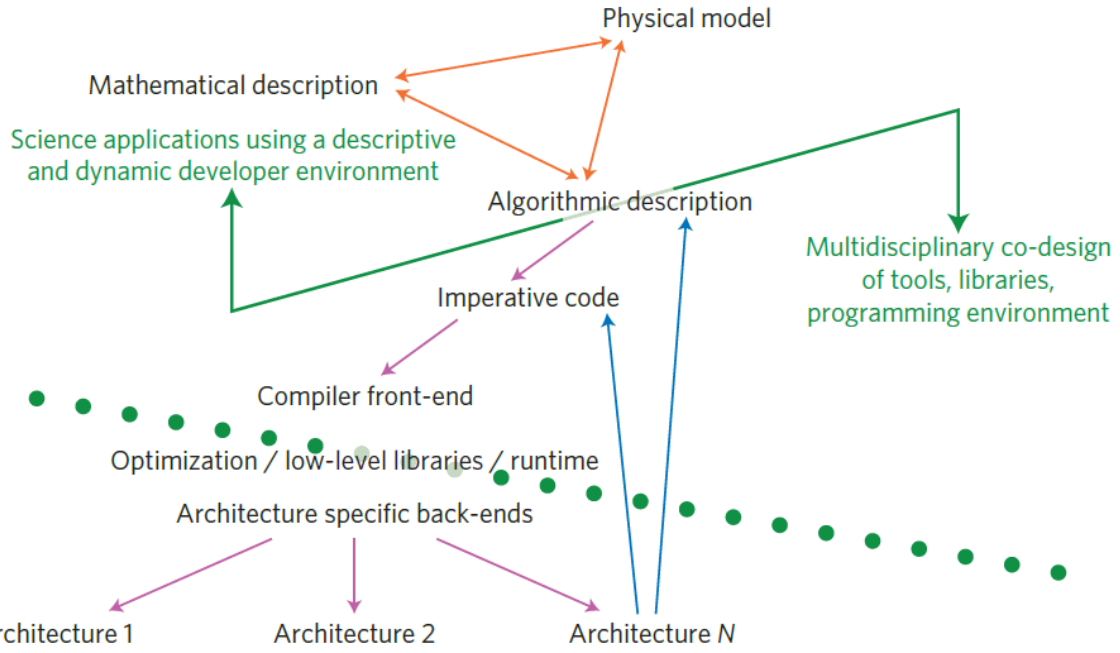
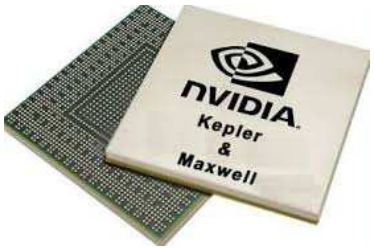
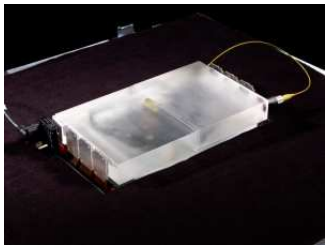
Energy efficiency







.. aiming at minimizing Watts per forecast

BULL an atos company

NVIDIA

Optalysys

ECMWF

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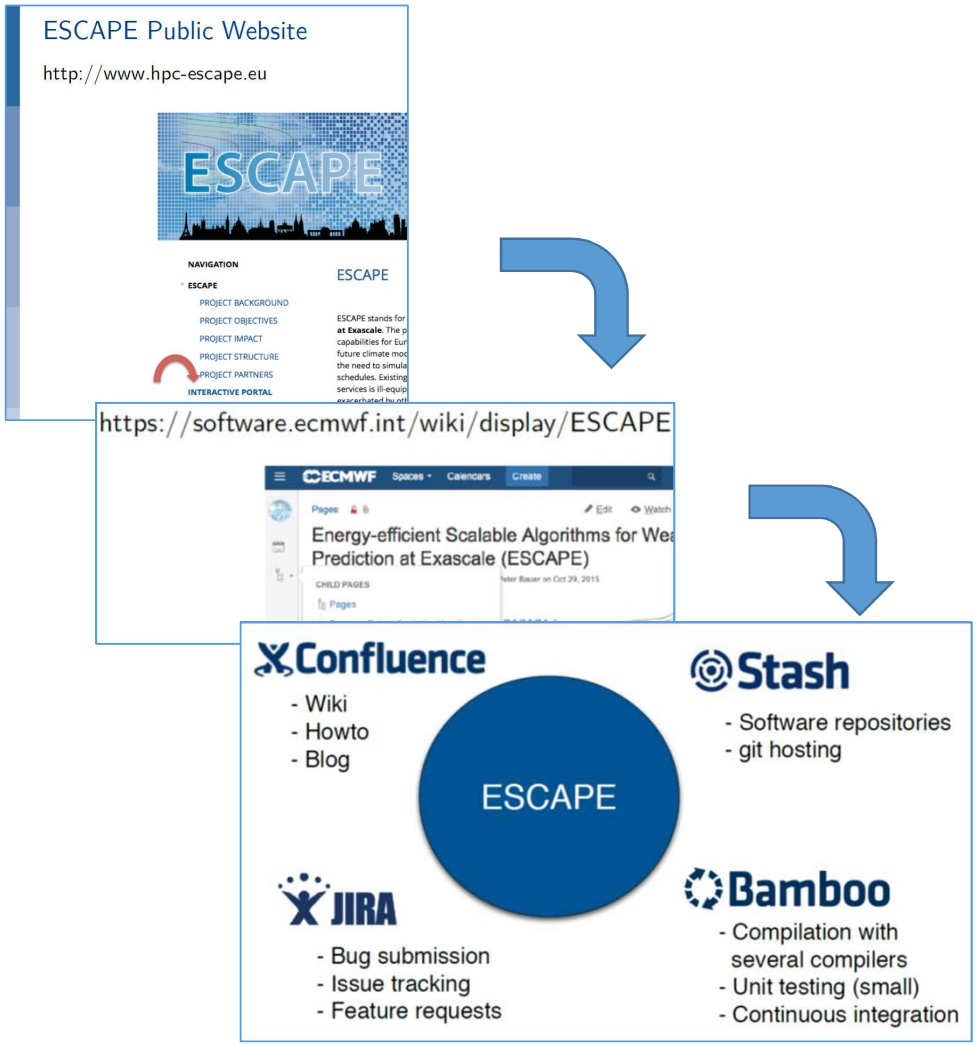
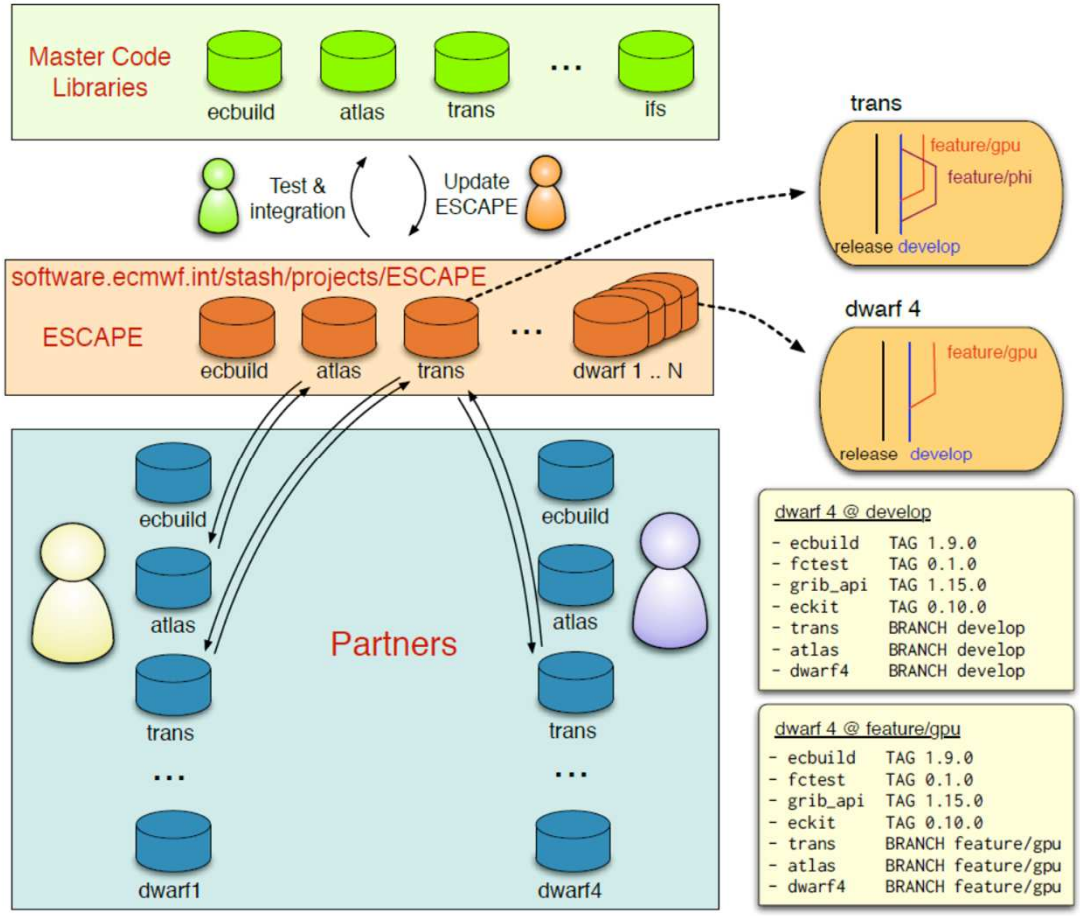
Software collaboration platform





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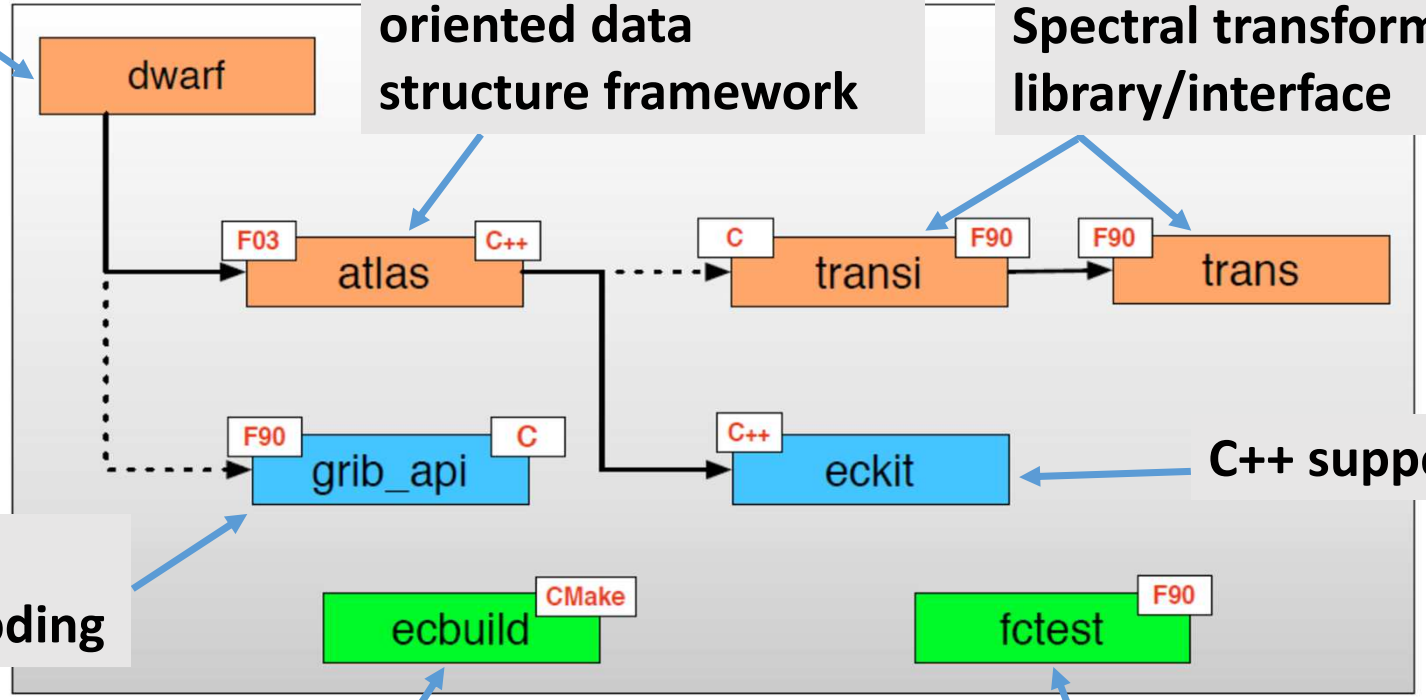
Software stack



A dwarf

Parallel, object-oriented data structure framework

Spectral transform library/interface

C++ support library

GRIB encoding/decoding

Cmake macros unifying build

Fortran unit testing (BOOST)

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Milestones and deliverables months 1-18

WP1 (Weather & climate dwarfs):

- First set of dwarfs to be made available on collaboration platform, two are already available (D1.1, June 2016)
- Flexible data structure framework Atlas, partly already available (D1.3, March 2017)

WP2 (Code adaptation):

- Subset of dwarfs ported to several accelerators (D2.1, March 2017)

WP3 (Hybrid computing):

- Performance models for dwarfs and optimization (D3.2, March 2017)

WP4 (Benchmarking & diagnostics):

- NWP model performance simulation (D4.1, March 2017)
- Atlas extension to LAM use (D4.3, March 2017)

WP5 (Dissemination & training):

- Deliverables on communication, dissemination, software management, gender balance plans, web portal have been submitted (D5.1-D5.5, December 2015)
- 1st webinar on tools and software completed (December 2015), material online
- 1st dissemination workshop advertised, announcement online (D5.9, October 2016)

WP6 (Management):

- Deliverable on quality & risk management has been submitted (D6.1, December 2015)
- Exploitation plan (D6.2, September 2016)

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