Science and Technology Facilities Council

PSyclone: what you've learned (hopefully)

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ESIWACE2 training course on Domain-specific Languages in Weather and Climate, 23rd-27th November 2020

Hartree Centre
Science & Technology Facilities Council

Met Office

Australian Government
Bureau of Meteorology

A Domain-Specific Compiler

Domains:

- LFRic - mixed finite elements for atmospheric modelling
- GOcean - finite difference on (stretched) regular mesh
- NEMO - existing code using finite difference for ocean modelling

Frees scientific developer from worrying about parallelism and optimisation

Allows the HPC expert to optimise an entire code for a particular architecture using Python scripting

Output can still be (commented!) Fortran

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Two Modes of Operation...

Revolution

Process code written in a DSL conforming to PSyKAl.

Two Domains supported:

- LFRic - Mixed finite elements, mesh unstructured in horizontal
- GOcean - 2D, finite difference, stretched, structured grid

Construct PSyIR from scratch

Evolution

Process existing code that follows strict coding conventions, e.g. NEMO & ROMS.

Recognise certain code structures and construct higher-level PSyIR

...one PSyIR

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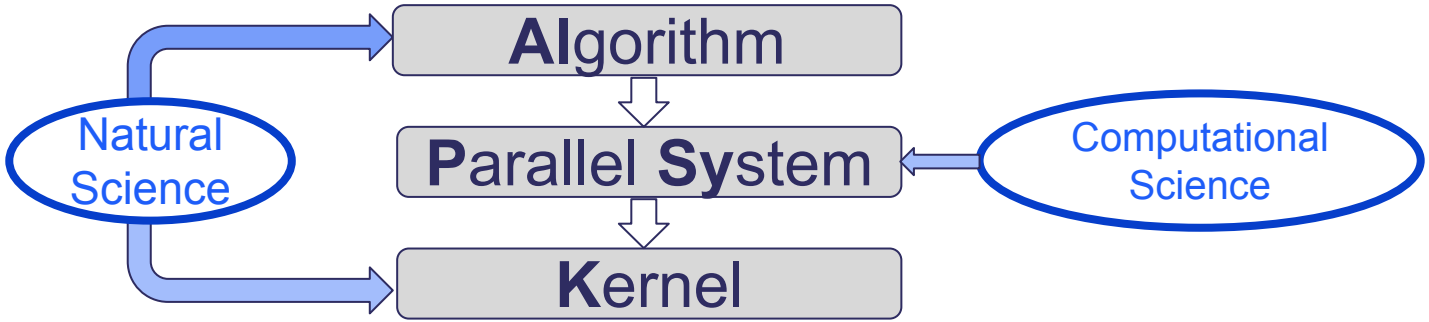
LFRic Domain - Revolution

Supports mixed Finite Elements

Scientist writes serial code

PSyclone uses Algorithm and Kernel metadata to generate:

- vanilla (serial) code
- distributed-memory code
- shared-memory code



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NEMO Domain - Evolution

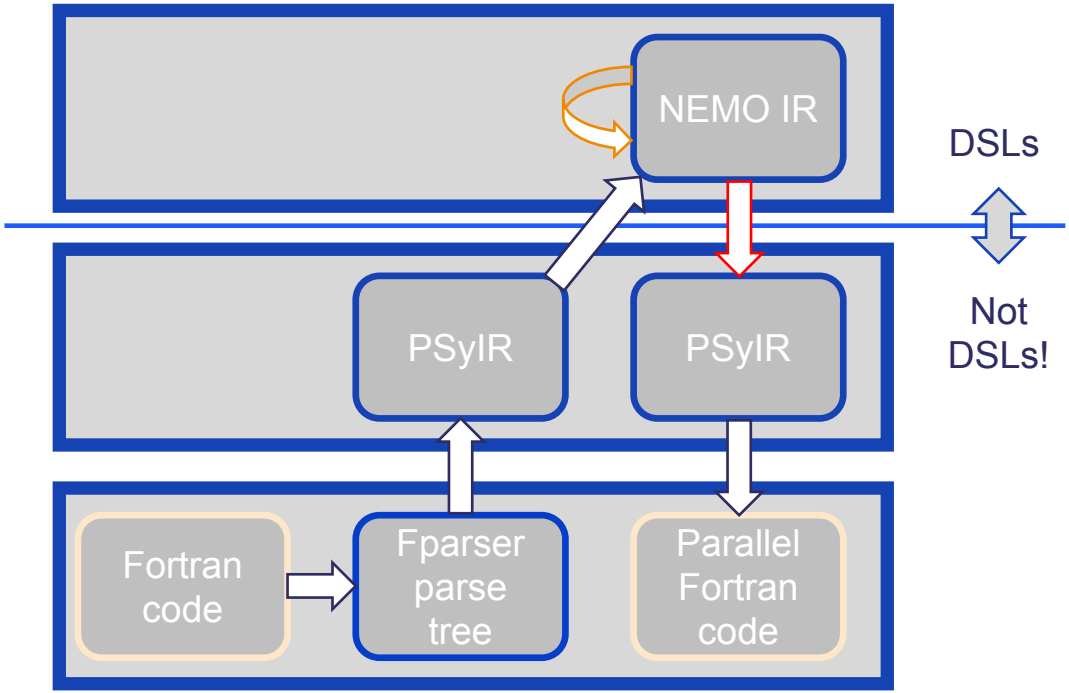
Generate PSyIR from existing Fortran source + configuration information

Transform to add e.g. OpenACC

Re-generate Fortran

or

Target other backend



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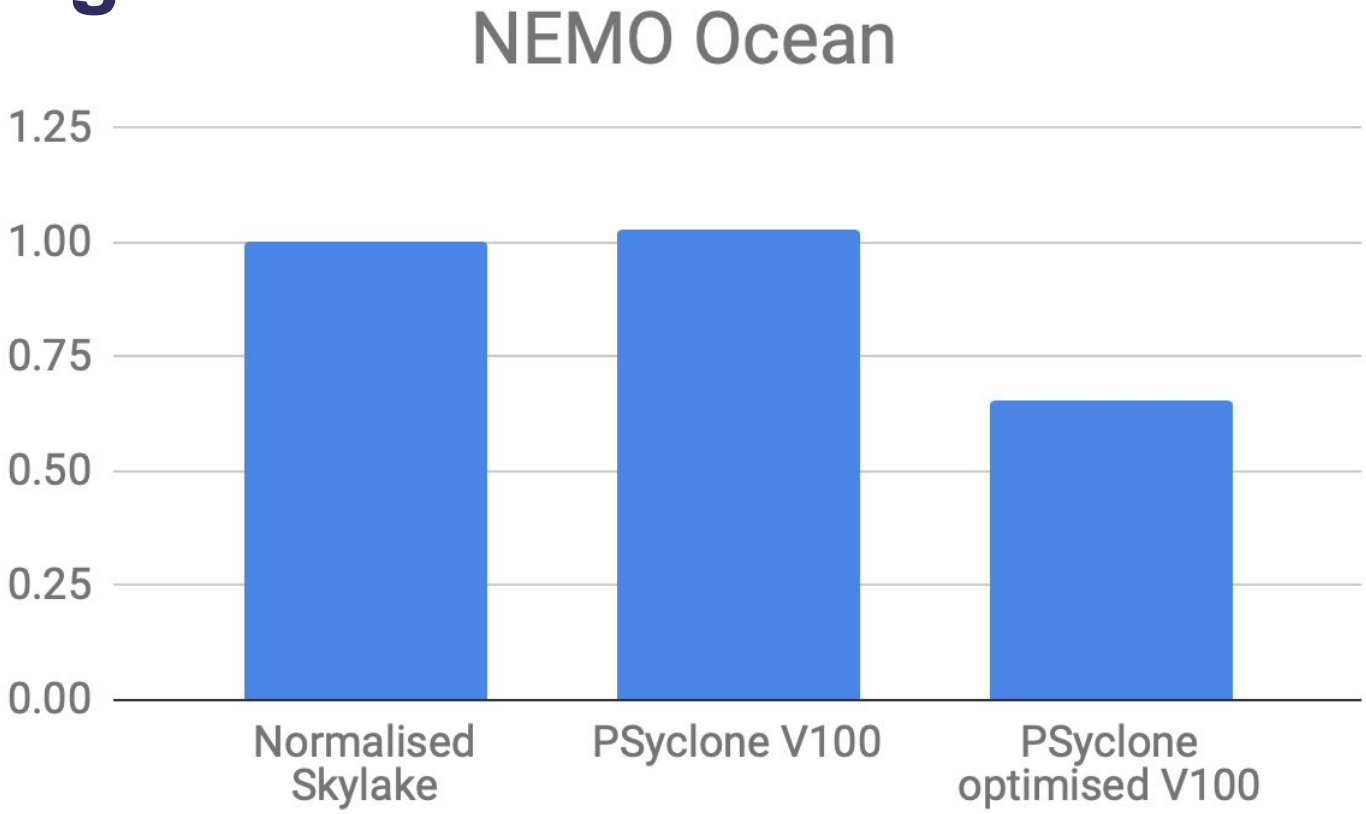
Work in progress...



(Graph courtesy of Chris Dearden, STFC)

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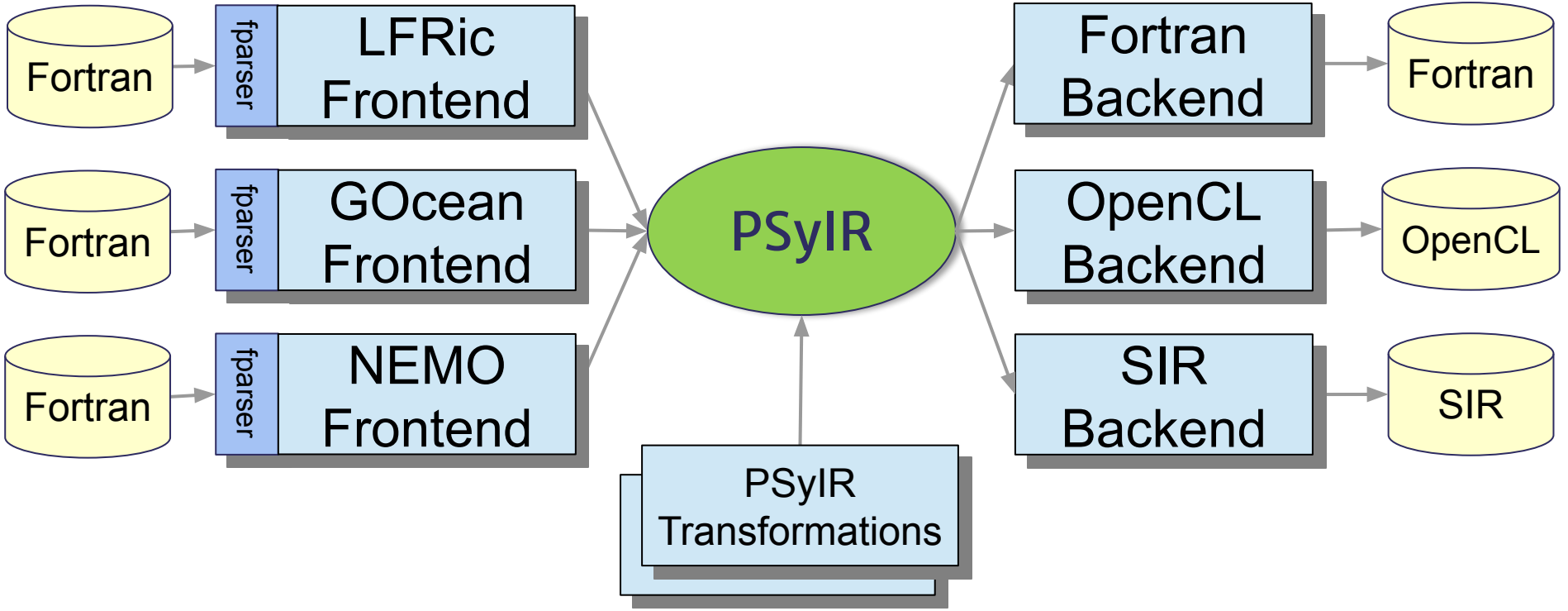
PSyIR - language-independent IR



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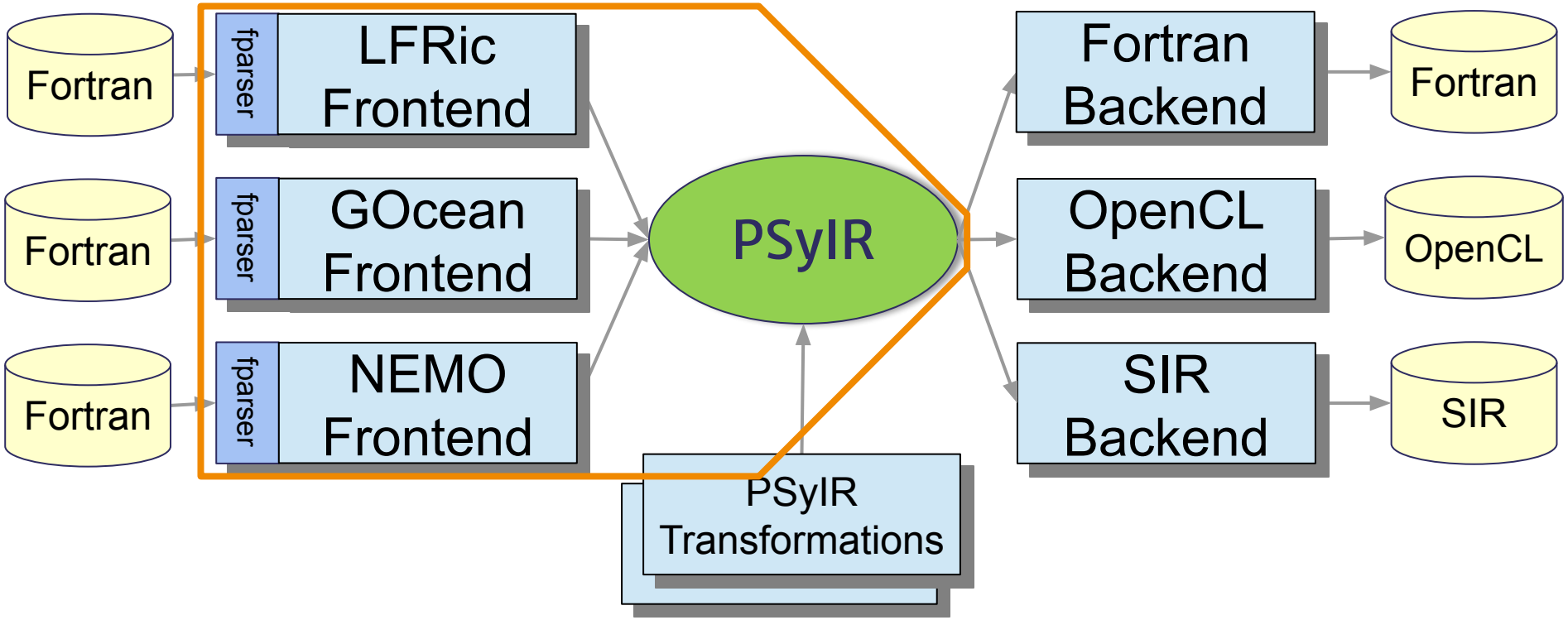
Used to represent both the PSy and Kernel layers



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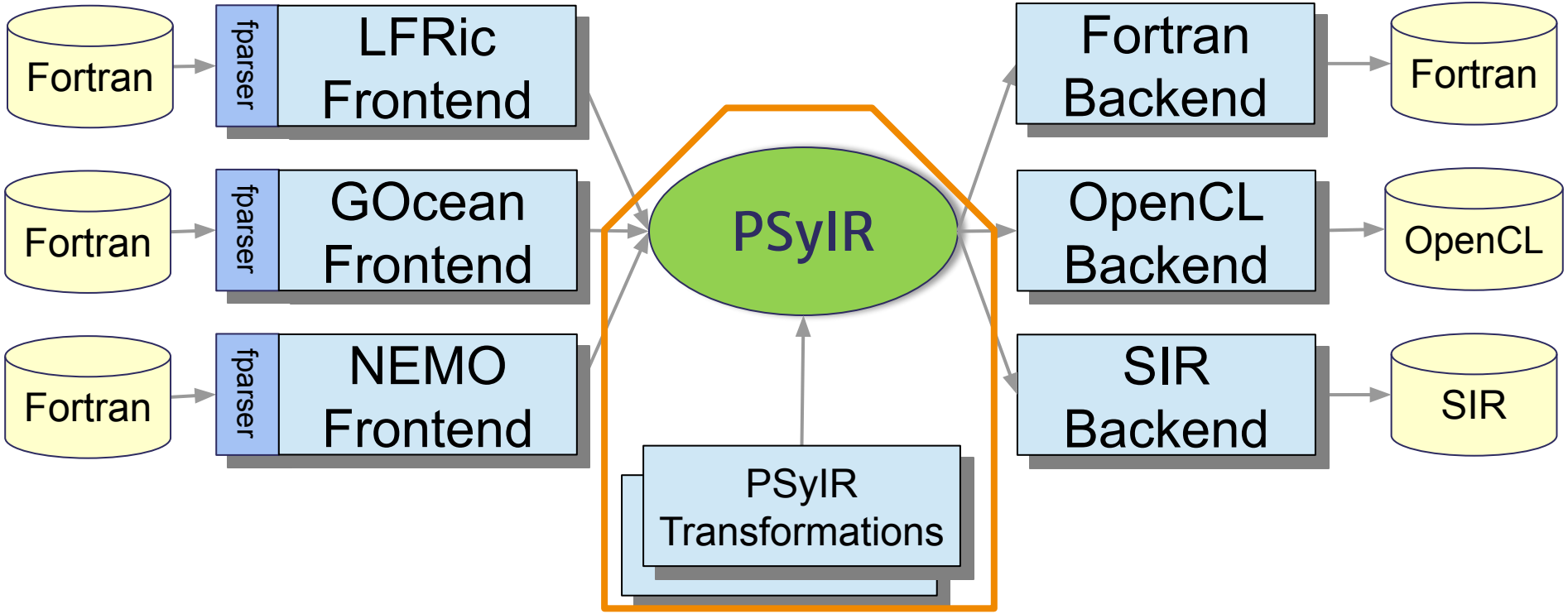
Common target for *all* PSyclone transformations



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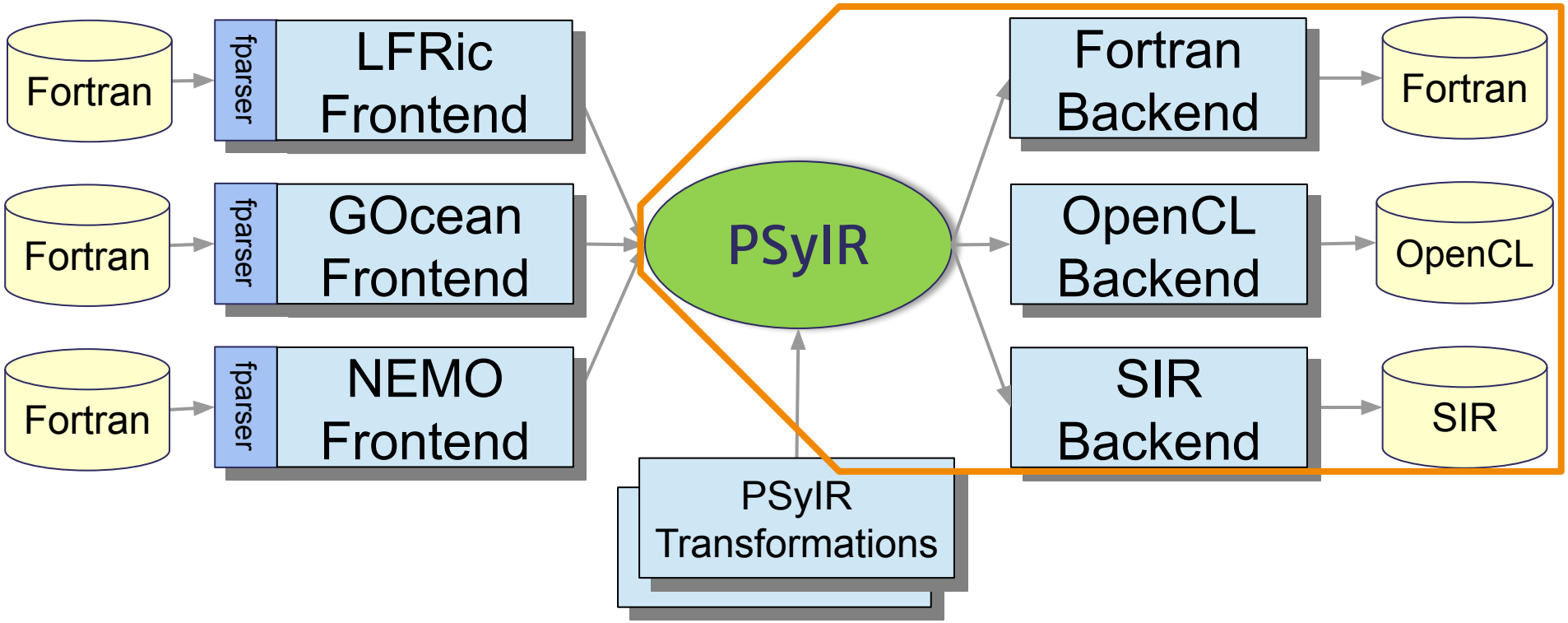
Enables translation to other languages & tool-chains



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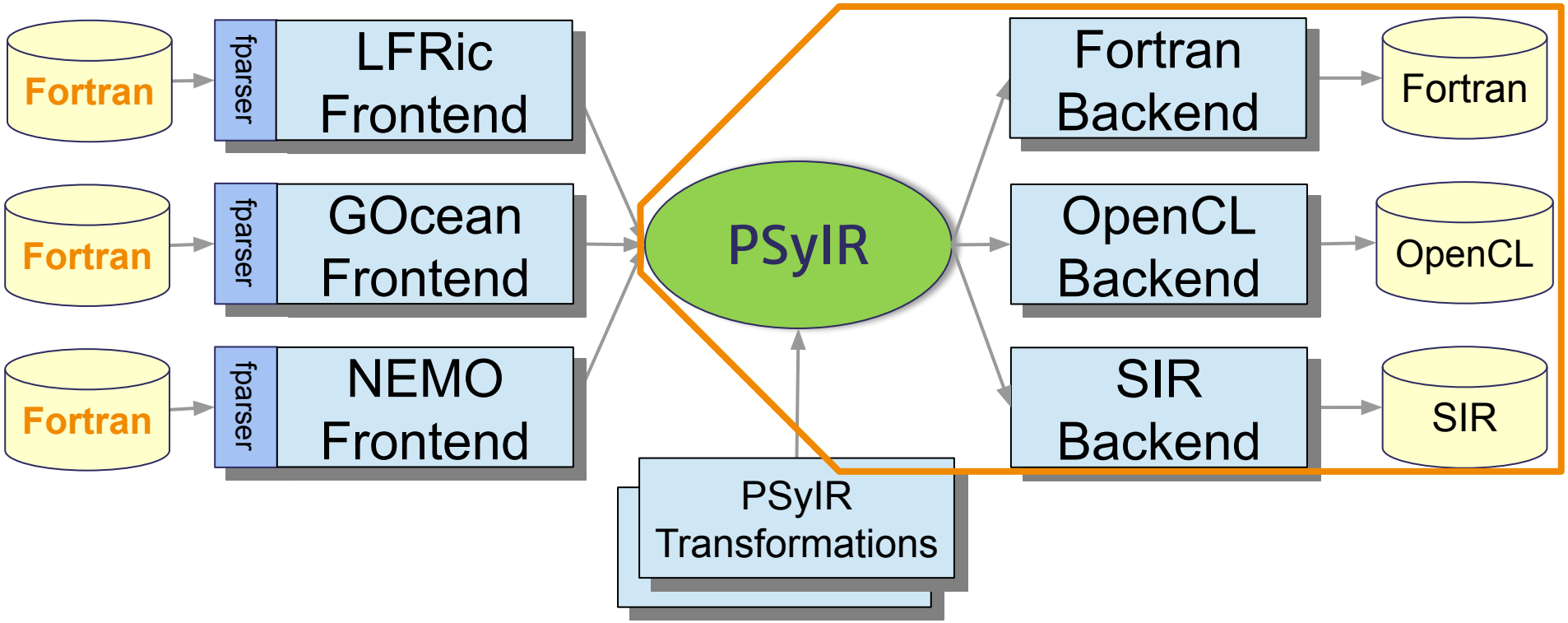
Allows the scientist to continue to develop in Fortran...



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...but if they want to use something else...

e.g. the invoke call in the Algorithm is not actually (executable) Fortran any more

Multiple routes to creating PSyIR
Allows incremental development/porting of kernels

A subset of Kernels could be implemented in a DSL such as Dawn

Evolving towards a revolution - IR interoperability

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Configurable

Coding conventions used by the NEMO API are configurable

- e.g. PSyclone with the NEMO API can be configured to work with ROMS

GOcean API

- Iteration spaces and other properties can be defined

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What about debugging?

It's harder to introduce bugs

- A lot of boilerplate code is generated automatically
- Scientists don't have to deal with parallelism

PSyclone can add run-time checks

- Whether a field is on the correct function space
- That a kernel's read-only arguments are not modified
- That fields do not contain NaNs or infinities

Future

- Checkpoint kernels to identify where results start to diverge

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Generated code is commented Fortran!

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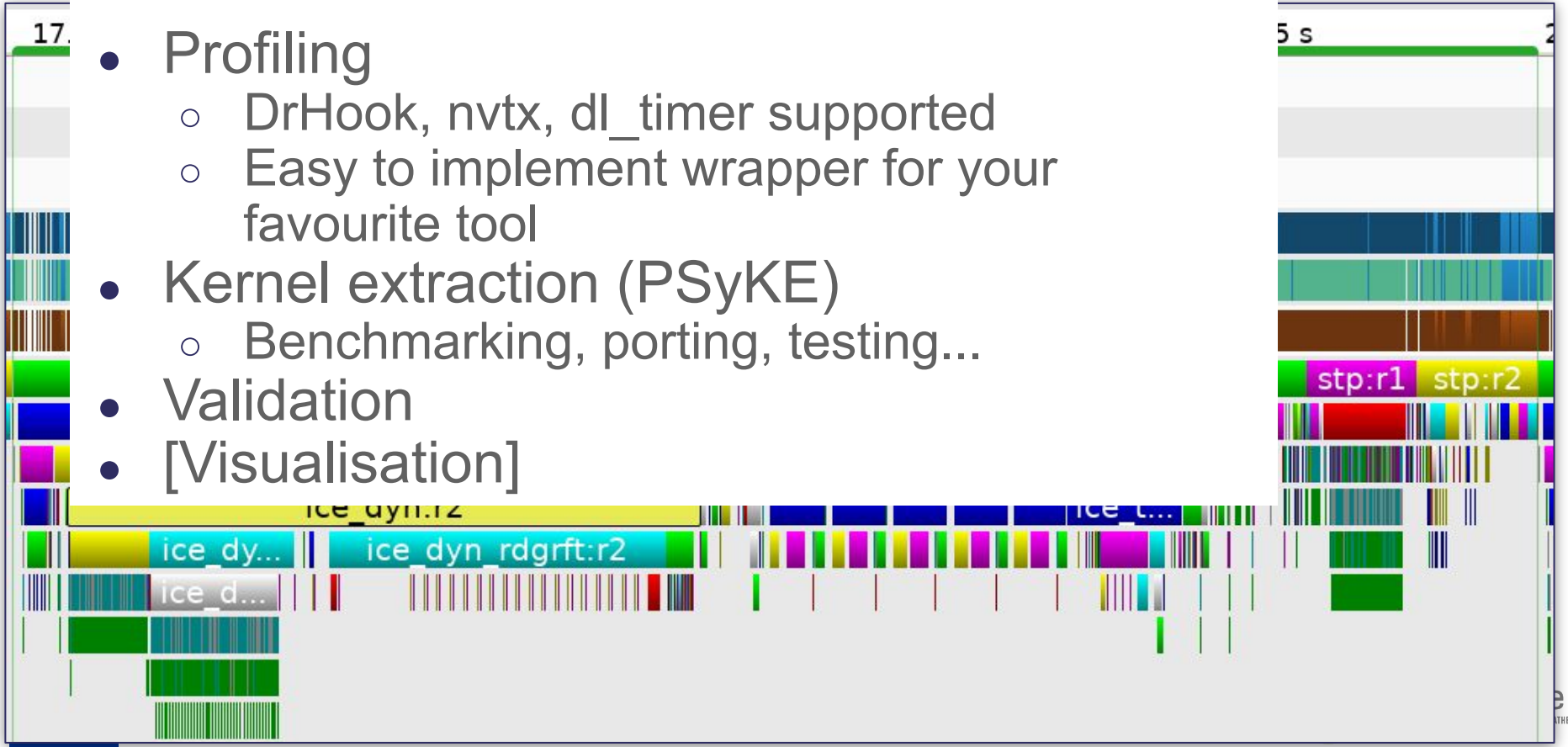
PSyData

- Profiling
  - DrHook, nvtx, dl_timer supported
  - Easy to implement wrapper for your favourite tool
- Kernel extraction (PSyKE)
  - Benchmarking, porting, testing...
- Validation
- [Visualisation]



What next?

NEMO API still under development (targeting OpenACC and OpenMP for NEMO-OCE, NEMO-SI^3, MEDUSA and NEMOVAR)

LFRic API in 'production' use within the LFRic build system at Met Office

- Mixed precision
- Supporting 'physics' kernels with different data layout
- Kernel optimisations
- Kernel extraction

Generating OpenCL, KOKKOS...

Open to suggestions!

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Please contact us if you have further questions or ideas...

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PSyclone

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