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PSyclone: A code generation and transformation system for weather and climate DSLs

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Ateliers de Modélisation de l'Atmosphèr, 8th -10th June 2022

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Australian Government

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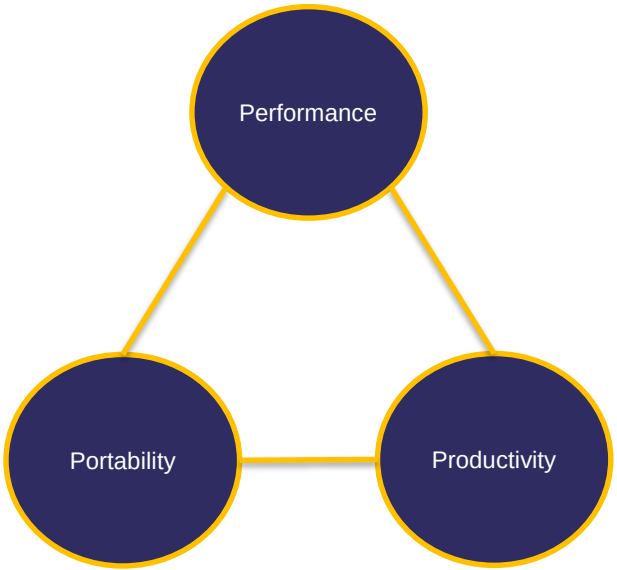
- Motivation
- PSyclone
- The LFRic Domain
- The NEMO Domain
- The GOcean Domain

The 3Ps of HPC software development



Difficult to compromise on one

Productivity: Maintainable software, many people contributing with different areas of expertise.

Single-source.

Performance Portability :

Risky to choose just one platform

Complex parallel code + Complex parallel architectures + Complex compilers = Complex optimisation space

⇒ Single-source optimised code is unlikely to be possible

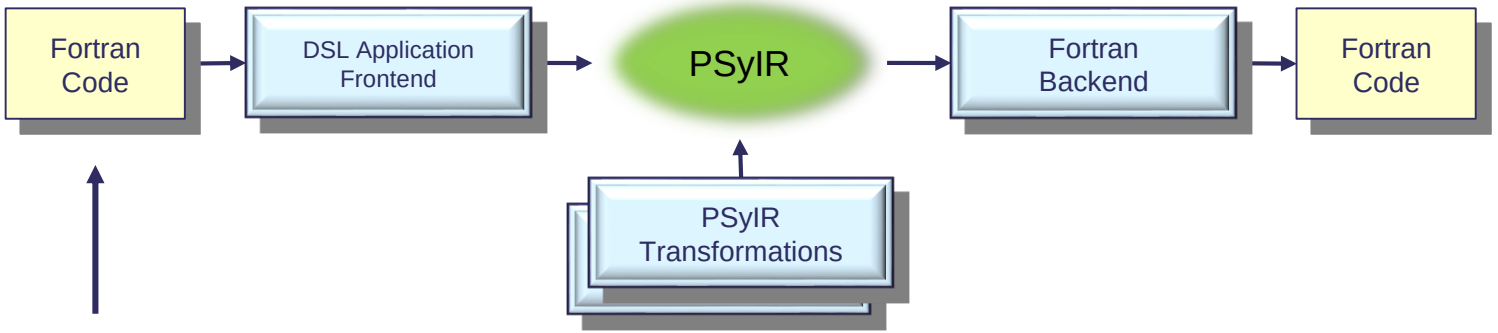
Separate science specification from code optimisation

PSyclone

PSyclone 2.3.0 BSD 3-clause
https://github.com/stfc/PSyclone
https://psyclone.readthedocs.io
```
> pip install psyclone
```

- A domain-specific compiler for embedded DSL(s)
  - Configurable: FD/FV NEMO, GOcean, FE LFRic
  - Supports distributed- and shared-memory parallelism
  - Supports code generation and code transformation
- A tool for use by HPC experts
  - Hard to beat a human (debatable)
  - Optimisations encoded as a ‘recipe’ rather than baked into the scientific source code
  - Different recipes for different computer architectures
  - Enables scriptable, whole-code optimisation

PSyclone workflow



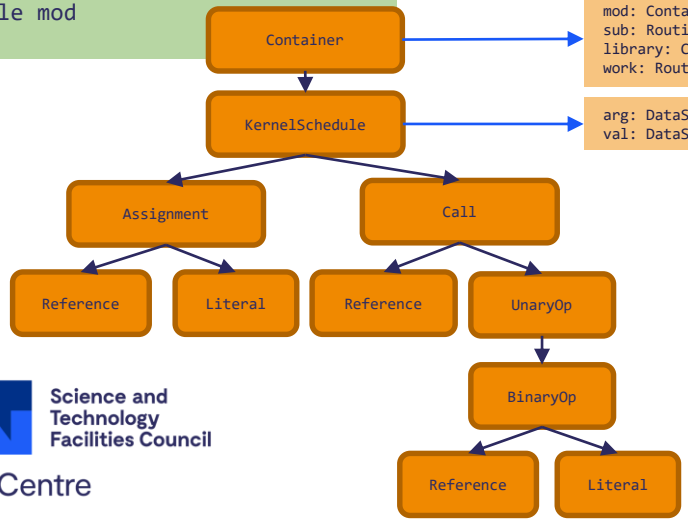
Embedded DSL with the scientific domain knowledge

Parallelisation and optimisation encoded as ‘recipes’ (Python scripts).

PSyIR :
Abstract Syntax Tree with Scoped Symbol Tables

```
module mod
  use library, only : sub
contains
  subroutine work(arg)
    real, intent(inout) :: arg
    integer :: val

    val = 3
    call sub(val, SIN(arg + 2))
  end subroutine work
end module mod
```




```
(Pdb) CONTAINER.symbol_table.view()
Symbol Table:
library: <not linked>
sub : RoutineSymbol
mod
work : RoutineSymbol

(Pdb) KERNEL_SCHEDULE.symbol_table.view()
Symbol Table:
arg: <Scalar<REAL, UNDEFINED>, Argument(pass-by-value=False)>
val: <Scalar<INTEGER, UNDEFINED>, Local>

(Pdb) CONTAINER.view()
Container[mod]
    KernelSchedule[name:'work']
        0: Assignment[]
            Reference[name:'val']
            Literal[value:'3', Scalar<INTEGER, SINGLE>]
        1: Call[name='sub']
            Reference[name:'val']
            UnaryOperation[operator:'SIN']
                BinaryOperation[operator:'ADD']
                    Reference[name:'val']
                    Literal[value:'2.0', Scalar<REAL, UNDEFINED>]
```

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Transformed with python scripts

```
GOInvokeSchedule[invoke='invoke_0', Constant loop bounds=False]
    0: Loop[type='outer', field_space='go_ct', it_space='go_internal_pts']
        Literal[value:'ssha_t%internal%ystart', Scalar<INTEGER, UNDEFINED>]
        Literal[value:'ssha_t%internal%ystop', Scalar<INTEGER, UNDEFINED>]
        Literal[value:'1', Scalar<INTEGER, UNDEFINED>]
        Schedule[]
            0: Loop[type='inner', field_space='go_ct', it_space='go_internal_pts']
                Literal[value:'ssha_t%internal%xstart', Scalar<INTEGER, UNDEFINED>]
                Literal[value:'ssha_t%internal%xstop', Scalar<INTEGER, UNDEFINED>]
                Literal[value:'1', Scalar<INTEGER, UNDEFINED>]
                Schedule[]
                    0: CodedKern continuity_code(ssha_t,sshn_t,sshn_u,sshn_v,hu,hv,un,vn,area_t)
    1: Loop[type='outer', field_space='go_cu', it_space='go_internal_pts']
        Literal[value:'ua%internal%ystart', Scalar<INTEGER, UNDEFINED>]
        Literal[value:'ua%internal%ystop', Scalar<INTEGER, UNDEFINED>]
        Literal[value:'1', Scalar<INTEGER, UNDEFINED>]
        Schedule[]
```

```
def trans(psy):
    ''' Add OpenMP directives '''
    tinfo = TransInfo()
    loop_trans = tinfo.get_trans_name('GOceanOMPLoopTrans')
    parallel_trans = tinfo.get_trans_name('OMPParallelTrans')

    schedule = psy.invokes.get('invoke_0').schedule

    for loop in schedule.walk(Loop, stop_type=Loop):
        loop_trans.apply(loop)

    parallel_trans.apply(schedule.children)

    return psy
```

```
GOInvokeSchedule[invoke='invoke_0', Constant loop bounds=False]
    0: Directive[OMP parallel]
        Schedule[]
            0: Directive[OMP do]
                Schedule[]
                    0: Loop[type='outer', field_space='go_ct', it_space='go_internal_pts']
                        Literal[value:'ssha_t%internal%ystart', Scalar<INTEGER, UNDEFINED>]
                        Literal[value:'ssha_t%internal%ystop', Scalar<INTEGER, UNDEFINED>]
                        Literal[value:'1', Scalar<INTEGER, UNDEFINED>]
                        Schedule[]
                            0: Loop[type='inner', field_space='go_ct', it_space='go_internal_pts']
                                Literal[value:'ssha_t%internal%xstart', Scalar<INTEGER, UNDEFINED>]
                                Literal[value:'ssha_t%internal%xstop', Scalar<INTEGER, UNDEFINED>]
                                Literal[value:'1', Scalar<INTEGER, UNDEFINED>]
                                Schedule[]
                                    0: CodedKern continuity_code(ssha_t,sshn_t,sshn_u,sshn_v,hu,hv,un,vn,area_t)
            1: Directive[OMP do]
                Schedule[]
                    0: Loop[type='outer', field_space='go_cu', it_space='go_internal_pts']
                        Literal[value:'ua%internal%ystart', Scalar<INTEGER, UNDEFINED>]
                        Literal[value:'ua%internal%ystop', Scalar<INTEGER, UNDEFINED>]
                        Literal[value:'1', Scalar<INTEGER, UNDEFINED>]
                        Schedule[]
```

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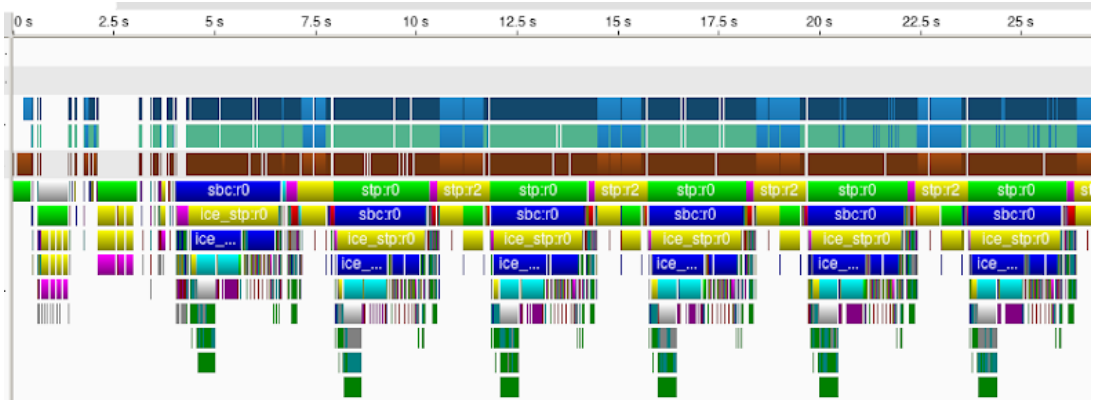
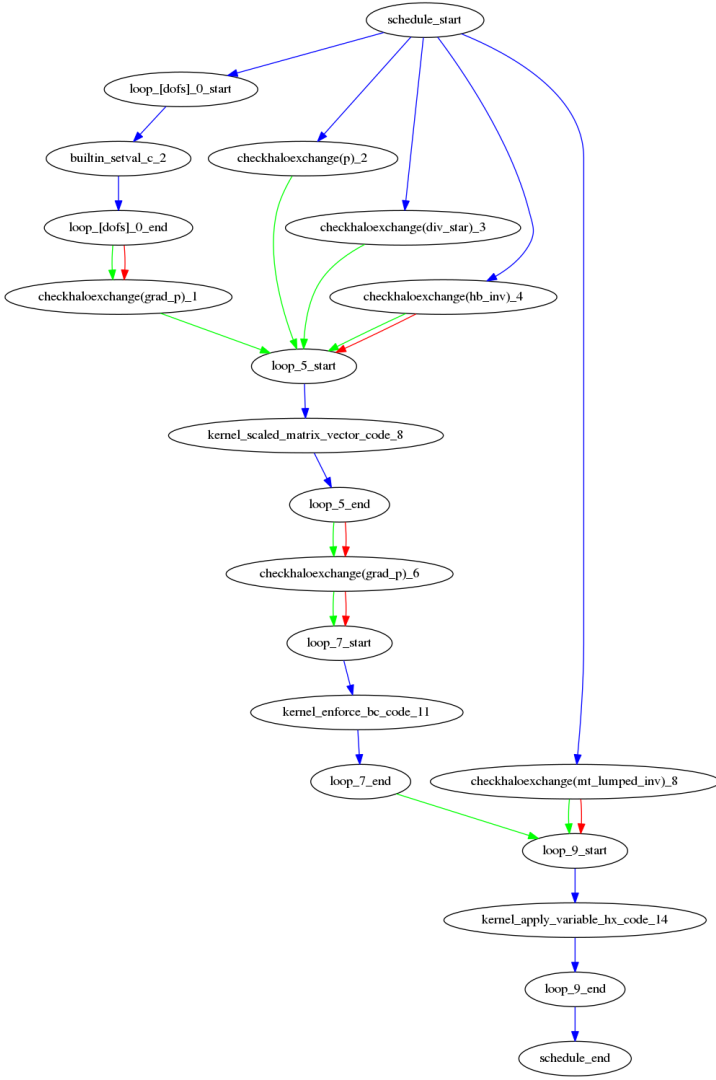
PSyclone utilities

DAG view of PSy-layer Schedules

PSyData API - allows calipers to be inserted for e.g. profiling, debugging, validation, kernel (benchmark) extraction, on-line visualisation etc.





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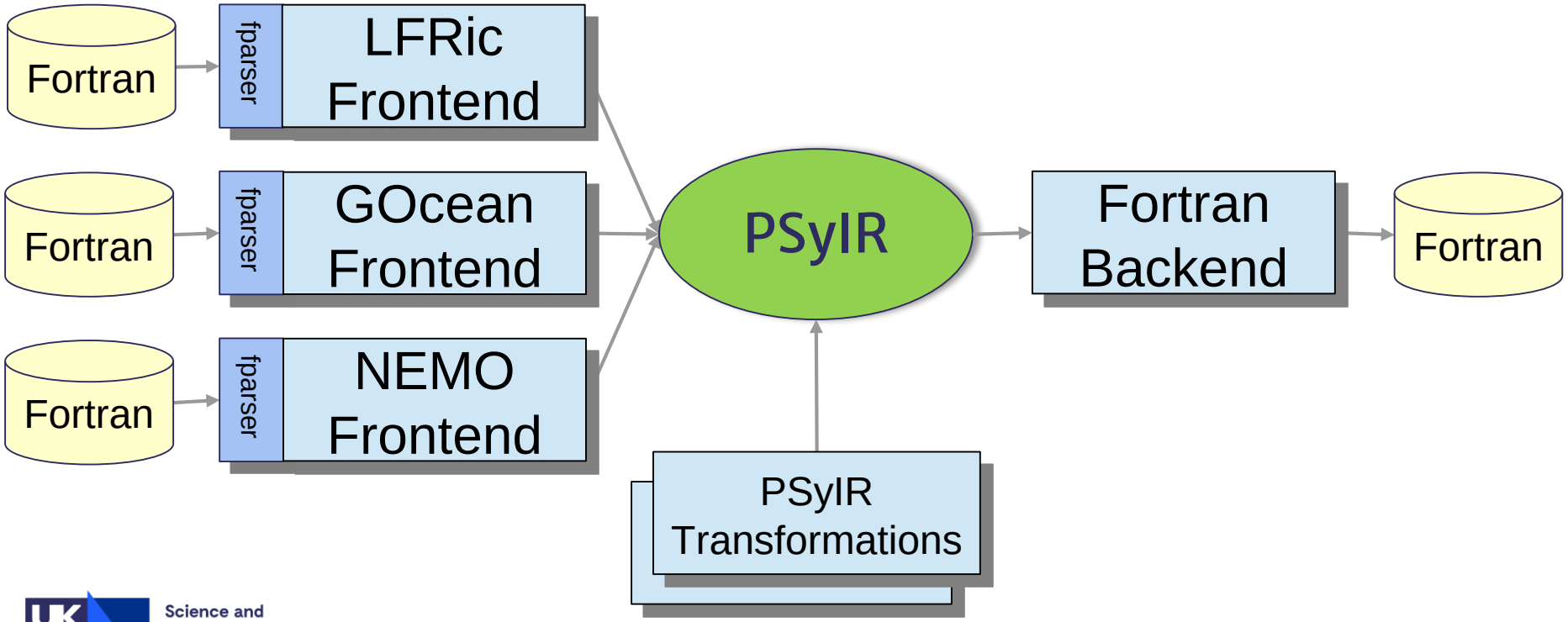

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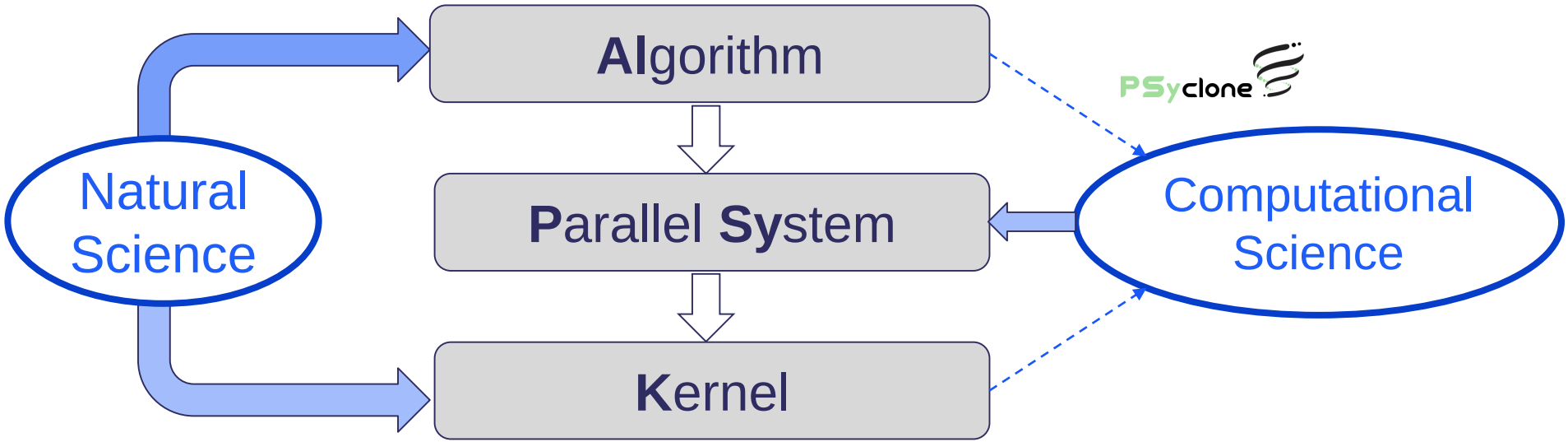
The LFRic Domain

Next generation atmospheric model of the UK MetOffice
PSyclone is used in the LFRic build system to provide parallelism and optimizations

Cubed-sphere mesh – unstructured
Mixed finite element method
Semi-implicit

PSyKAL: Separation of science from parallelisation



LFRic Algorithm-layer Example

From LFRic `norm_alg_mod.x90`

```
type(field_type),              intent(in) :: field
real(kind=r_def)                          :: l2_norm
type(operator_type),              pointer :: mass_matrix => null()
type(field_type)                          :: rhs_field
```

Logically-global field objects

```
call invoke( name = "l2_norm_calculation",                                  &
             setval_c(rhs_field, 0.0_r_def),                                &
             matrix_vector_kernel_type(rhs_field, field, mass_matrix), &
             X_innerproduct_Y(l2_norm, rhs_field, field) )
```

Specify kernels to execute using an invoke()

Kernel Example

- From LFRic `matrix_vector_kernel_mod.F90`
- Metadata for PSyclone

```
type, public, extends(kernel_type) :: matrix_vector_kernel_type
  private
  type(arg_type) :: meta_args(3) = (/                                    &
       arg_type(GH_FIELD,    GH_REAL, GH_INC,  ANY_SPACE_1),             &
       arg_type(GH_FIELD,    GH_REAL, GH_READ, ANY_SPACE_2),             &
       arg_type(GH_OPERATOR, GH_REAL, GH_READ, ANY_SPACE_1, ANY_SPACE_2) &
       /)
  integer :: operates_on = CELL_COLUMN
end type
```

```
do k = 0, nlayers-1
  do df = 1, ndf2
    x_e(df) = x(map2(df)+k)
  end do
  ik = (cell-1)*nlayers + k + 1
  lhs_e = matmul(matrix(:,:,ik),x_e)
  do df = 1,ndf1
     lhs(map1(df)+k) = lhs(map1(df)+k) + lhs_e(df)
  end do
end do
```

PSy-layer with distributed memory parallelism

```
InvokeSchedule[invoke='invoke_l2_norm_calculation', dm=True]
    0: Loop[type='dof', field_space='any_space_1', it_space='dof', upper_bound='ndofs']
        Literal[value:'NOT_INITIALISED', Scalar<INTEGER, UNDEFINED>]
        Literal[value:'NOT_INITIALISED', Scalar<INTEGER, UNDEFINED>]
        Literal[value:'1', Scalar<INTEGER, UNDEFINED>]
        Schedule[]
            0: BuiltIn setval_c(rhs_field,0.0_r_def)
    1: HaloExchange[field='rhs_field', type='region', depth=1, check_dirty=False]
    2: HaloExchange[field='field', type='region', depth=1, check_dirty=True]
    3: Loop[type='', field_space='any_space_1', it_space='cell_column', upper_bound='cell_halo(1)']
        Literal[value:'NOT_INITIALISED', Scalar<INTEGER, UNDEFINED>]
        Literal[value:'NOT_INITIALISED', Scalar<INTEGER, UNDEFINED>]
        Literal[value:'1', Scalar<INTEGER, UNDEFINED>]
        Schedule[]
            0: CodedKern matrix_vector_code(rhs_field,field,mass_matrix) [module_inline=False]
    4: Loop[type='dof', field_space='any_space_1', it_space='dof', upper_bound='ndofs']
        Literal[value:'NOT_INITIALISED', Scalar<INTEGER, UNDEFINED>]
        Literal[value:'NOT_INITIALISED', Scalar<INTEGER, UNDEFINED>]
        Literal[value:'1', Scalar<INTEGER, UNDEFINED>]
        Schedule[]
            0: BuiltIn x_innerproduct_y(l2_norm,rhs_field,field)
    5: GlobalSum[scalar='l2_norm']
```

Current LFRic optimisation script

```
# Make setval_* compute redundantly to the level 1 halo if it
# is in its own loop.
for loop in schedule.loops():
    if loop.iteration_space == "dof":
        if len(loop.kernels()) != 1:
            raise Exception(
                "Expecting loop to contain 1 call but found '{0}'".
                format(len(loop.kernels())))
        if loop.kernels()[0].name in ["setval_c", "setval_x"]:
            setval_count += 1
            rtrans.apply(loop, options={"depth": 1})

# Colour loops over cells unless they are on discontinuous
# spaces or over dofs
for loop in schedule.loops():
    if loop.iteration_space == "cell_column" \
        and loop.field_space.orig_name \
            not in const.VALID_DISCONTINUOUS_NAMES:
        ctrans.apply(loop)

# Add OpenMP to loops unless they are over colours or are null
for loop in schedule.loops():
    if loop.loop_type not in ["colours", "null"]:
        oregtrans.apply(loop)
        otrans.apply(loop, options={"reprod": True})
```

```
> psyclone -api dynamo0.3 -s ./script.py alg.x90
```

Example of generated code

```
! Set-up all of the loop bounds
!
loop0_start = 1
loop0_stop = rhs_field_proxy%vspace%get_last_dof_halo(1)
loop1_start = 1
loop1_stop = ncolour
loop2_start = 1
loop3_start = 1
loop3_stop = rhs_field_proxy%vspace%get_last_dof_owned()
!
! Call kernels and communication routines
!
!$omp parallel default(shared), private(df)
!$omp do schedule(static)
DO df=loop0_start,loop0_stop
  rhs_field_proxy%data(df) = 0.0_r_def
END DO
!$omp end do
!
! Set halos dirty/clean for fields modified in the above loop
!
!$omp master
CALL rhs_field_proxy%set_dirty()
CALL rhs_field_proxy%set_clean(1)
!$omp end master
!
!$omp end parallel
IF (field_proxy%is_dirty(depth=1)) THEN
  CALL field_proxy%halo_exchange(depth=1)
END IF
!
DO colour=loop1_start,loop1_stop
  !$omp parallel default(shared), private(cell)
  !$omp do schedule(static)
  DO cell=loop2_start,last_halo_cell_all_colours(colour,1)
    !
    CALL matrix_vector_code(cmap(colour, cell), nlayers, rhs_field_proxy%data, field_proxy%data,
                            mass_matrix_proxy%ncell_3d, mass_matrix_proxy%local_stencil, ndf_aspc1_rhs_field,
                            undf_aspc1_rhs_field, map_aspc1_rhs_field(:,cmap(colour, cell)), ndf_aspc2_field,
                            undf_aspc2_field, map_aspc2_field(:,cmap(colour, cell)))
  END DO
  !$omp end do
  !$omp end parallel
END DO
!
! Set halos dirty/clean for fields modified in the above loop
!
CALL rhs_field_proxy%set_dirty()
```

OpenMP parallelism

Distributed-memory parallelism

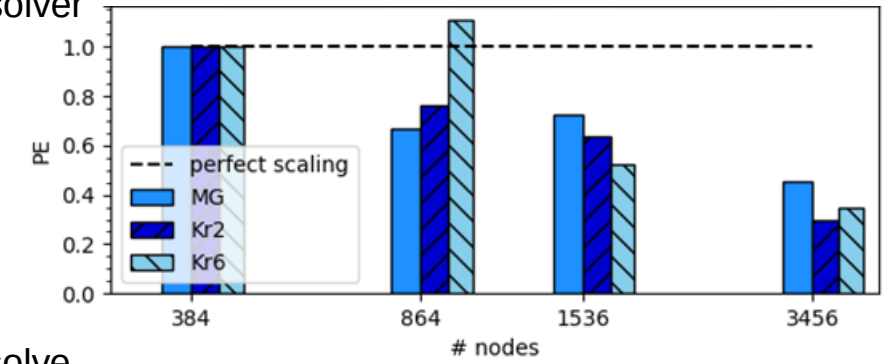
Colouring

C1152 mesh → 1152 X 1152 X 6 mesh with 30 levels – 9Km resolution
Dynamics only, (Baroclinic Wave)

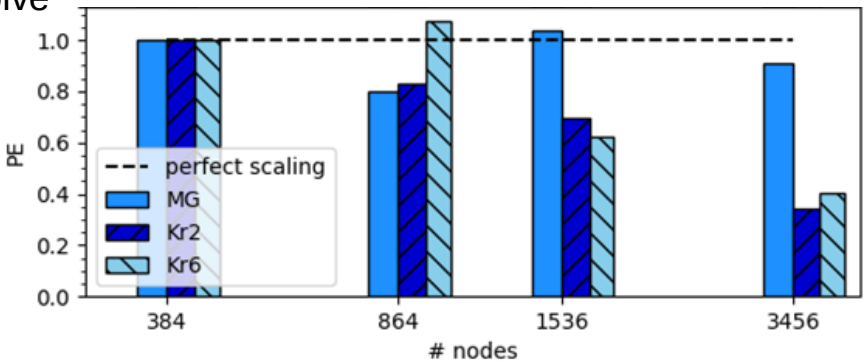
$$\mathrm{CFL_H} = \mathrm{c_s}\frac{\Delta \mathrm{t}}{\Delta \mathrm{x}} \quad c_s = 340 m/s$$

400 time-steps. **Δ**t = 205 s $\mathrm{CFL_H}$ (acoustic) ~ 8

Semi-implicit solver



Pressure solve



Strong Scalability
Intel 17 compiler
6 MPI ranks per node
6 OpenMP threads per rank
384 nodes (13824 cores)
3456 nodes (124416 cores)
Data per PE 24x24, 16x16, 12x12, 8x8

LFRic scalability study by Christopher Maynard

c.m.maynard@reading.ac.uk

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The NEMO Domain

(Evolution)

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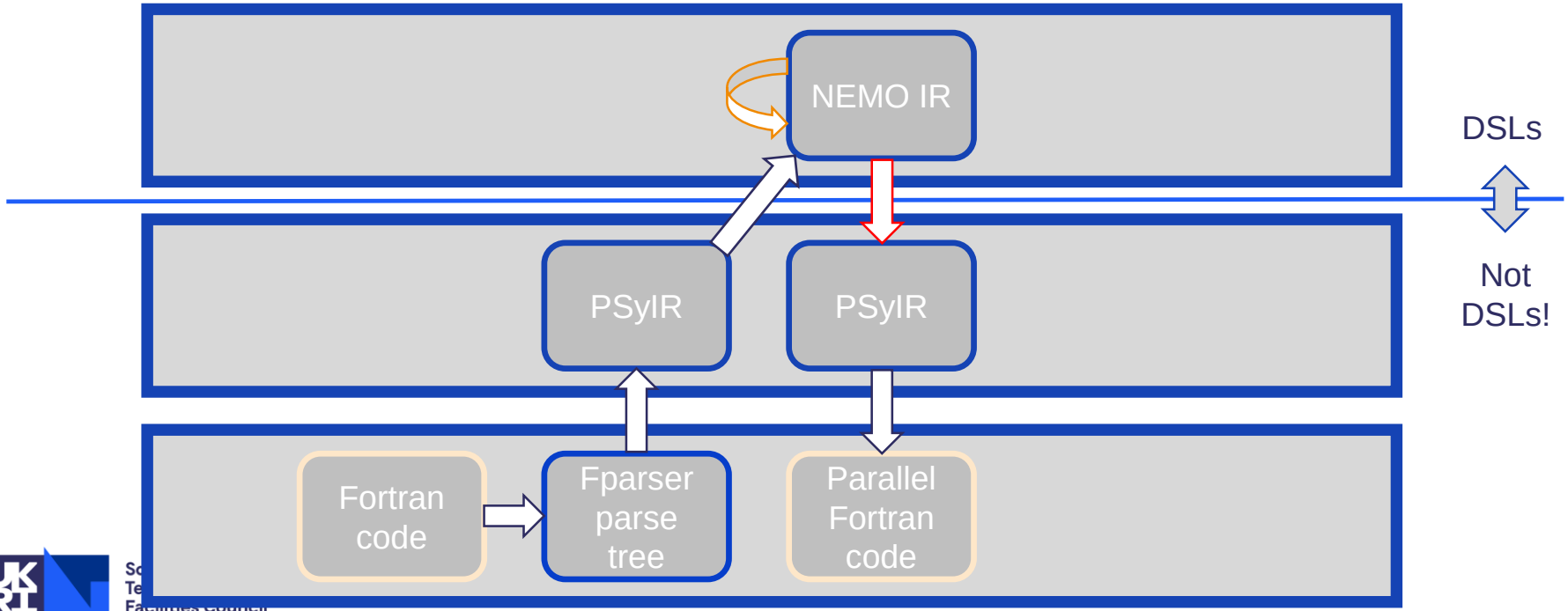
NEMO DSL

Construct high-level representation of existing source code:



NEMO Transformation Example

(src/OCE/TRA/traadv.F90)

```
!                                      ==/==  effective transport  ==!
zun(:,:,jpk) = 0._wp
zvn(:,:,jpk) = 0._wp
zwn(:,:,jpk) = 0._wp
IF( ln_wave .AND. ln_sdw )  THEN
   DO jk = 1, jpkm1                                                    ! eulerian transport + Stokes Drift
      zun(:,:,jk) = e2u  (:,:) * e3u_n(:,:,jk) * ( un(:,:,jk) + usd(:,:,jk) )
      zvn(:,:,jk) = e1v  (:,:) * e3v_n(:,:,jk) * ( vn(:,:,jk) + vsd(:,:,jk) )
      zwn(:,:,jk) = e1e2t(:,:)                 * ( wn(:,:,jk) + wsd(:,:,jk) )
   END DO
ELSE
   DO jk = 1, jpkm1
      zun(:,:,jk) = e2u  (:,:) * e3u_n(:,:,jk) * un(:,:,jk)            ! eulerian transport only
      zvn(:,:,jk) = e1v  (:,:) * e3v_n(:,:,jk) * vn(:,:,jk)
      zwn(:,:,jk) = e1e2t(:,:)                 * wn(:,:,jk)
   END DO
ENDIF
!
IF( ln_vvl_ztilde .OR. ln_vvl_layer ) THEN                             ! add z-tilde and/or vvl corrections
   zun(:,:,:) = zun(:,:,:) + un_td(:,:,:)
   zvn(:,:,:) = zvn(:,:,:) + vn_td(:,:,:)
ENDIF
```

Uses Fortran array notation for a readable specification of the domain science

PSyIR constructed by PSyclone:

- Converts Fortran array notation to explicit loops
- Deduces domain specific knowledge from loop patterns and naming conventions of the code style-guide

```
5: If[]
    BinaryOperation[operator:'AND']
        Reference[name:'ln_wave']
        Reference[name:'ln_sdw']
    Schedule[]
        0: Loop[type='levels', field_space='None', it_space='None']
            Literal[value:'1', Scalar<INTEGER, UNDEFINED>]
            Reference[name:'jpkm1']
            Literal[value:'1', Scalar<INTEGER, UNDEFINED>]
            Schedule[]
                0: Loop[type='lat', field_space='None', it_space='None']
                    Literal[value:'1', Scalar<INTEGER, UNDEFINED>]
                    Reference[name:'jpj']
                    Literal[value:'1', Scalar<INTEGER, UNDEFINED>]
                    Schedule[]
                        0: Loop[type='lon', field_space='None', it_space='None']
                            Literal[value:'1', Scalar<INTEGER, UNDEFINED>]
                            Reference[name:'jpi']
                            Literal[value:'1', Scalar<INTEGER, UNDEFINED>]
                            Schedule[]
                                0: InlinedKern[]
                                    Schedule[]
                                        0: Assignment[]
                                            ArrayReference[name:'zun']
                                                Reference[name:'ji']
                                                Reference[name:'jj']
                                                Reference[name:'jk']
                                            BinaryOperation[operator:'MUL']
```

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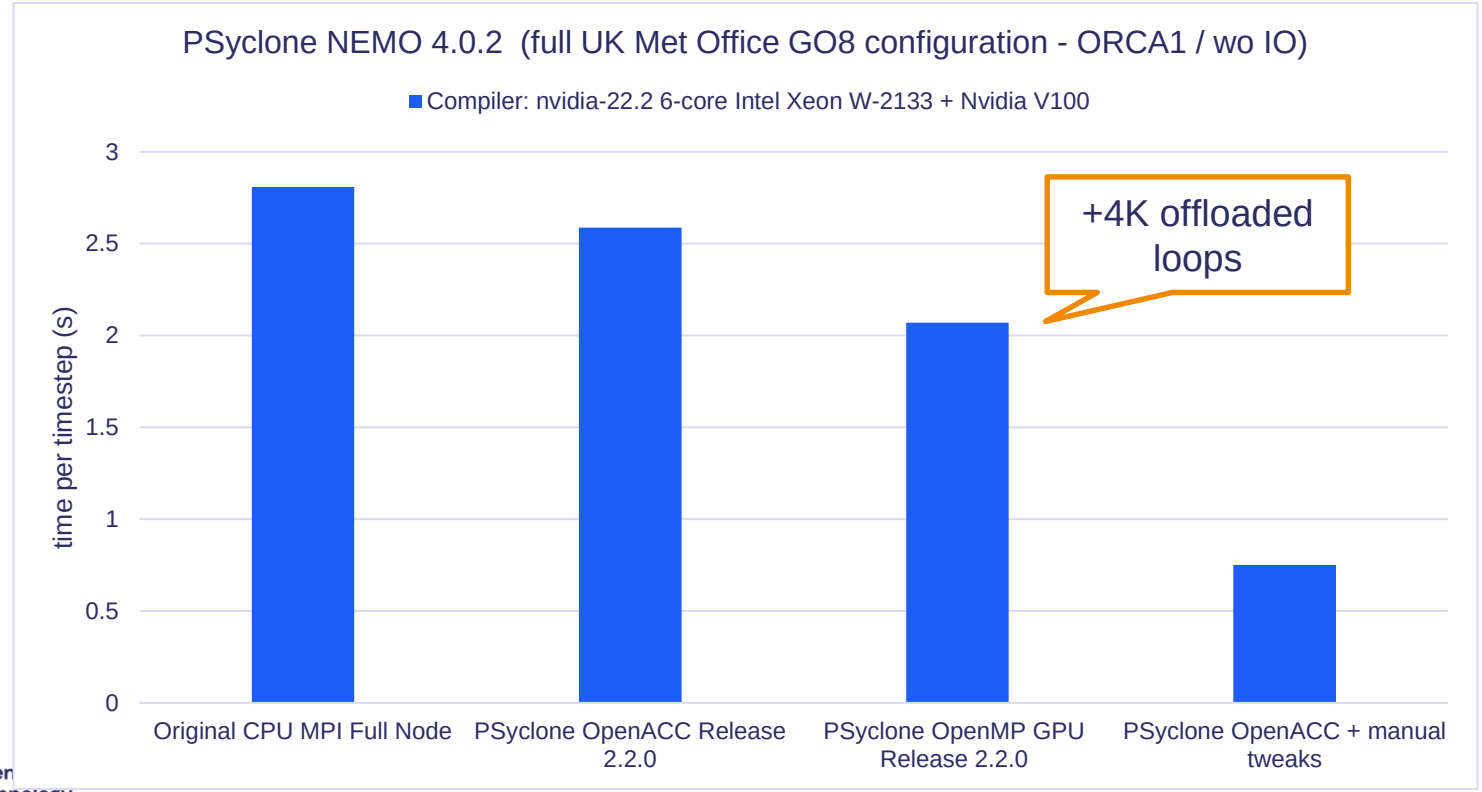
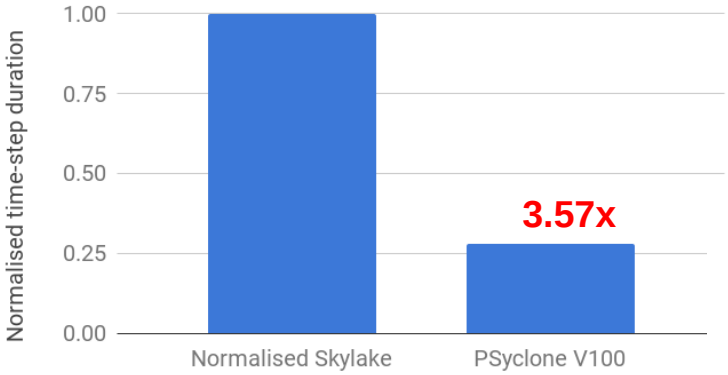
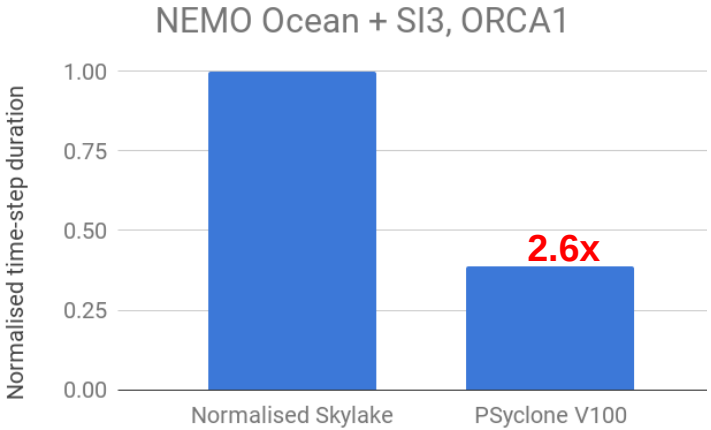
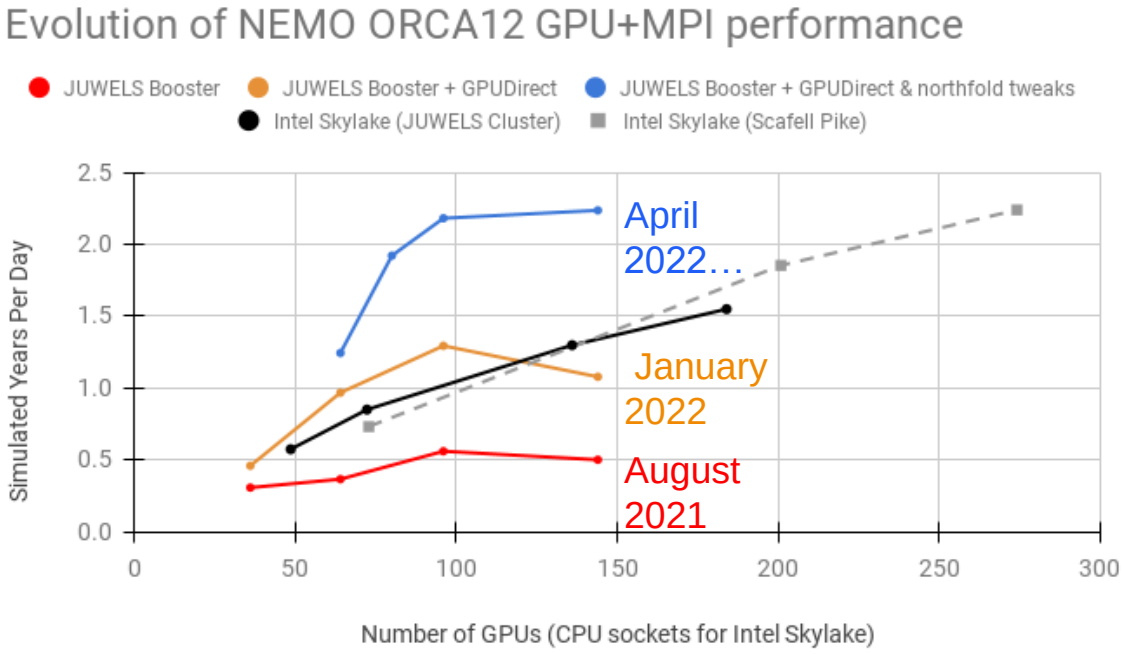
NEMO GPU offloading









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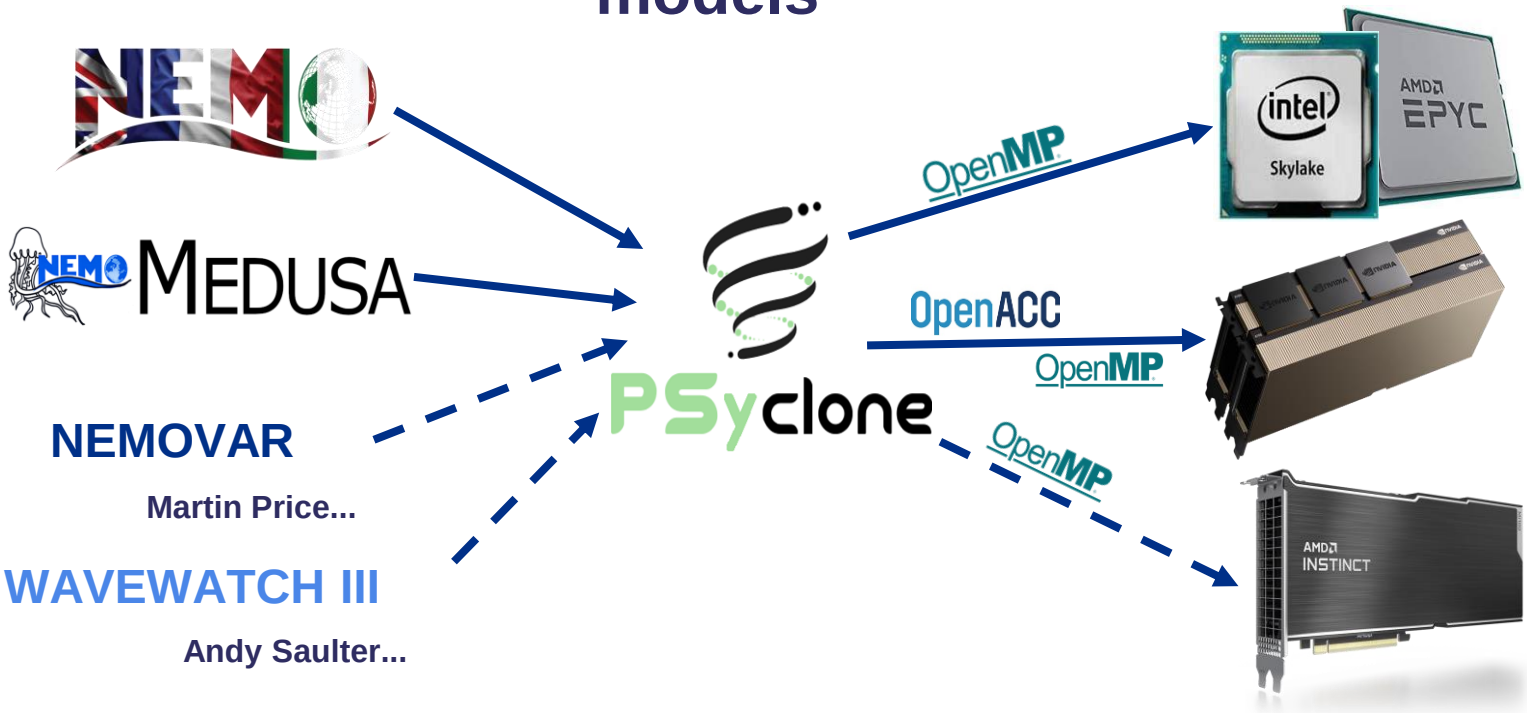
Manual tweaks provided by Chris Dearden (chris.dearden@stfc.ac.uk)

Current status of PSyclone for various marine models



- Ongoing work to improve explicit memory management for GPU offloading
- Ongoing work to improve hybrid MPI/OpenACC offloading
- Bring remaining manual tweaks to PSyclone

The GOcean Domain

(Revolution)

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A PSyKAl-based API for Finite Difference

Directly-addressed on 2D, stretched, regular grid

Much simpler than LFRic

Used in 2 shallow-water benchmarks & a Tsunami code

Simplicity lends itself to prototyping work, e.g.:

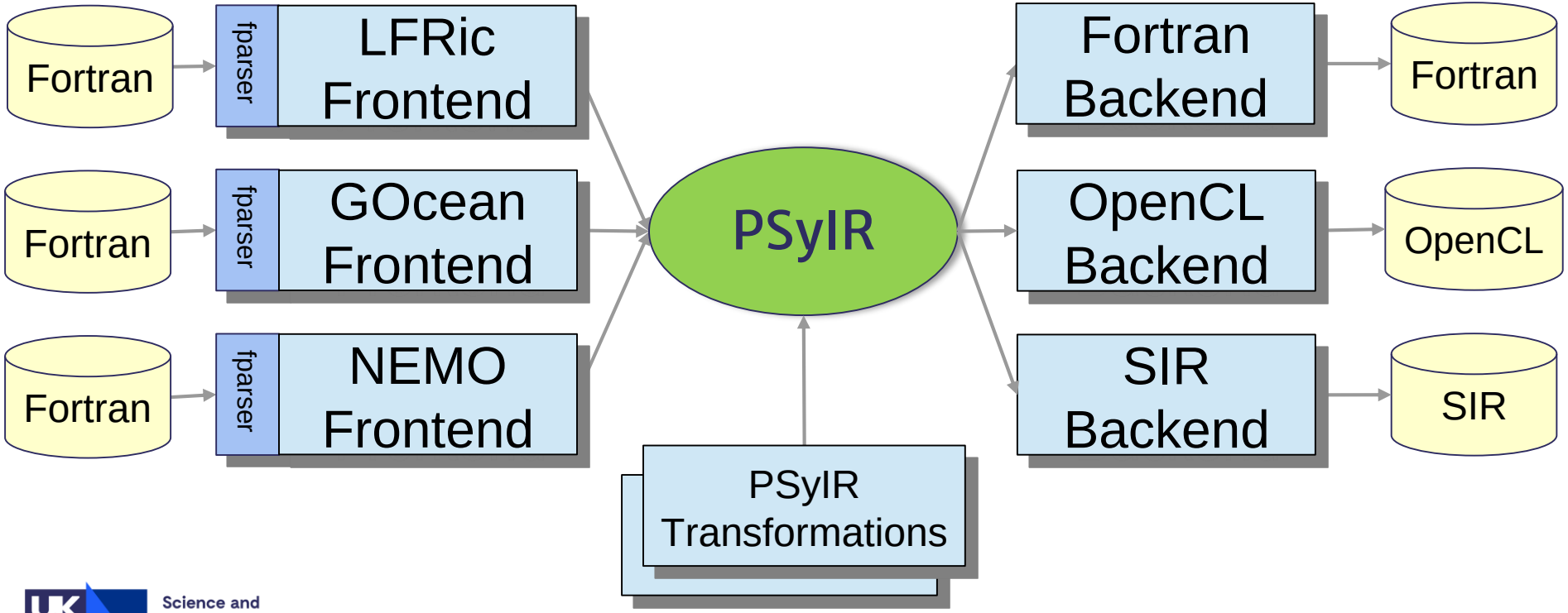
- OpenCL backends.
- kernel extraction with PSyData

See PSyclone/examples/gocean

```
type, extends(kernel_type) :: compute_cu
   type(go_arg), dimension(3) :: meta_args =    &
        (/ go_arg(GO_WRITE, GO_CU, GO_POINTWISE),            &
           go_arg(GO_READ,  GO_CT, GO_STENCIL(000,110,000)), &
           go_arg(GO_READ,  GO_CU, GO_POINTWISE)             &
         /)
   !> This kernel writes only to internal points of the
   !! simulation domain.
   integer :: ITERATES_OVER = GO_INTERNAL_PTS

   !> The U,V and F points that share the same index as a given
   !! are those immediately to the South and West of it.
   integer :: index_offset = GO_OFFSET_SW

contains
  procedure, nopass :: code => compute_cu
end type compute_cu
```

Point-wise kernels

```
!> Compute the mass flux in the x direction at point (i,j)
subroutine compute_cu_code(i, j, cu, p, u)
  implicit none
  integer,  intent(in) :: I, J
  real(go_wp), intent(out), dimension(:,:) :: cu
  real(go_wp), intent(in),  dimension(:,:) :: p, u

  CU(I,J) = 0.5d0*(P(i,J)+P(I-1,J))*U(I,J)
```



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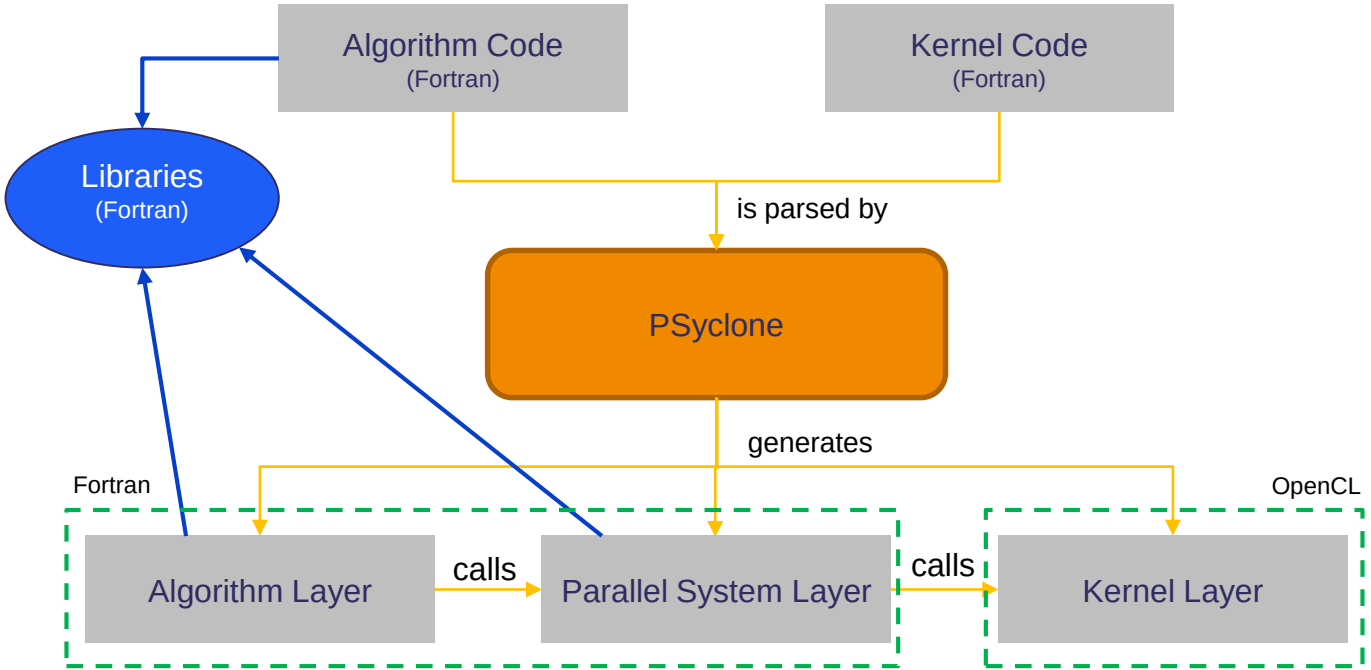
Fortran to OpenCL



Fortran to OpenCL

- OpenCL driver layer: PSyclone generates host code to control the execution of OpenCL kernels using the FortCL library (https://github.com/stfc/FortCL)
- OpenCL Kernels: PSyclone uses the PSyIR language-independent representation to generate an OpenCL version of each kernel.

```
Schedule[name:'compute_cu_code']
    Assignment[]
        ArrayReference[name:'cu']
            Reference[name:'i']
            Reference[name:'j']
        BinaryOperation[operator:'MUL']
            BinaryOperation[operator:'MUL']
                Literal[value:'0.5D0']
                BinaryOperation[operator:'ADD']
                    ArrayReference[name:'p']
                        Reference[name:'i']
                        Reference[name:'j']
                    ArrayReference[name:'p']
                        BinaryOperation[operator:'SUB']
                            Reference[name:'i']
                            Literal[value:'1']
                        Reference[name:'j']
            ArrayReference[name:'u']
                Reference[name:'i']
                Reference[name:'j']
```

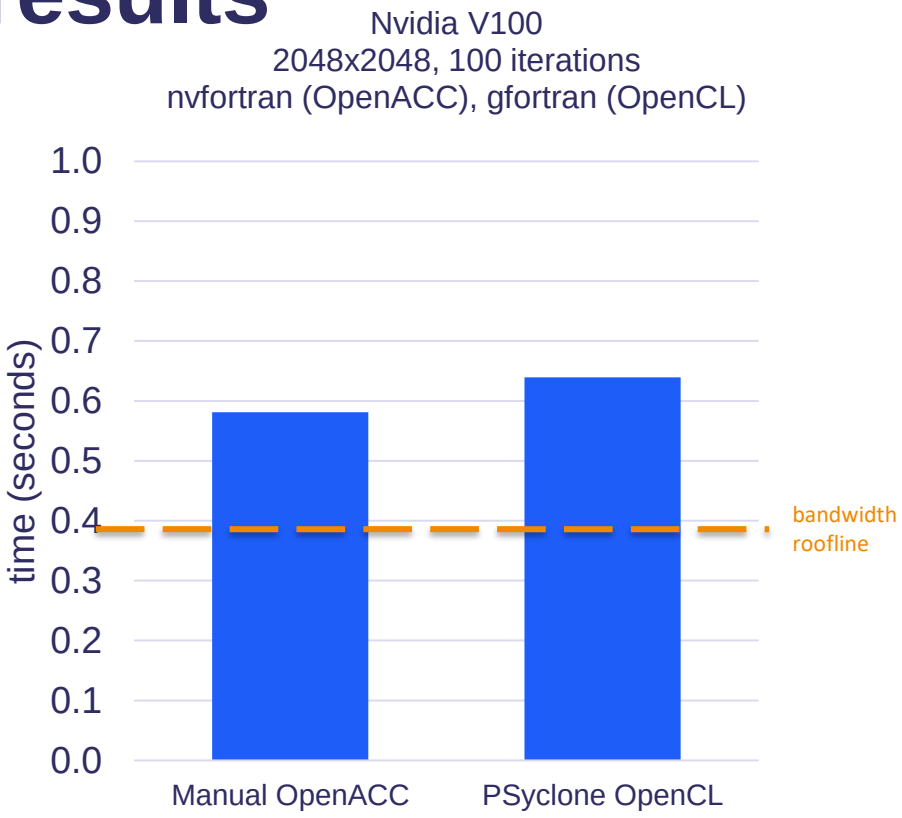
```
__attribute__((vec_type_hint(double)))
__attribute__((reqd_work_group_size(4, 1, 1)))
__kernel void compute_cu_code(
  __global double * restrict cu,
  __global double * restrict p,
  __global double * restrict u
  ){
  int cuLEN1 = get_global_size(0);
  int cuLEN2 = get_global_size(1);
  int pLEN1 = get_global_size(0);
  int pLEN2 = get_global_size(1);
  int uLEN1 = get_global_size(0);
  int uLEN2 = get_global_size(1);
  int i = get_global_id(0);
  int j = get_global_id(1);
  cu[j * cuLEN1 + i] = ((0.5e0 * (p[j * pLEN1 + i] + p[j * pLEN1 +
(i - 1)])) * u[j * uLEN1 + i]);
}
```

*Simplified view

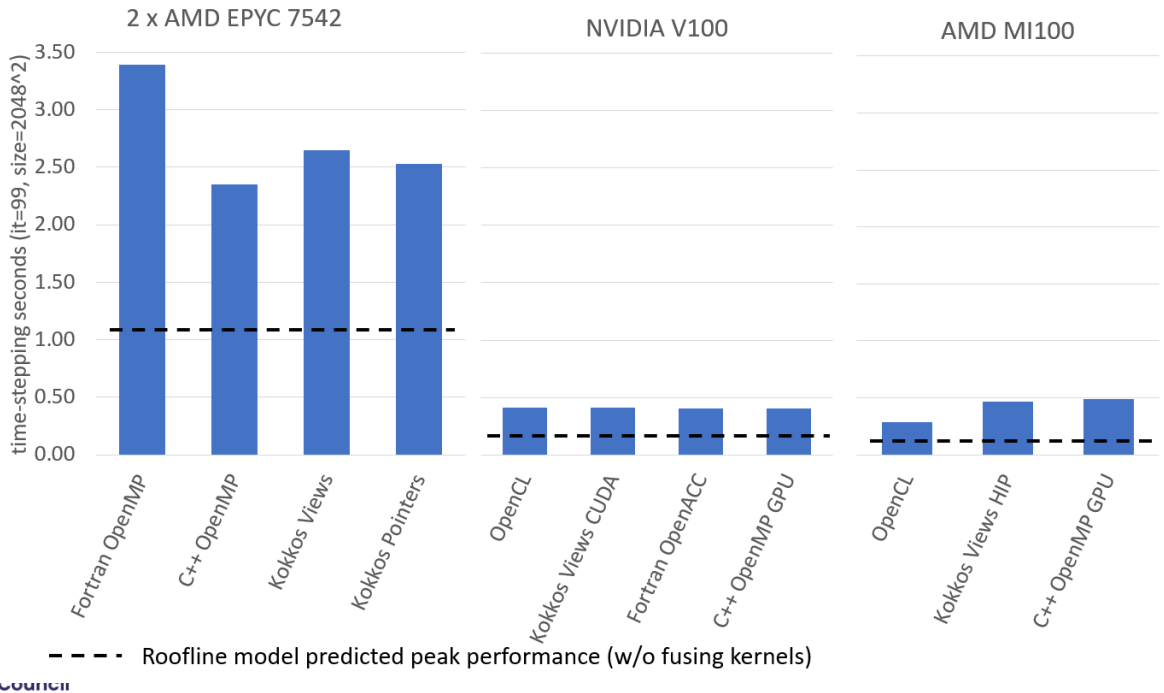
OpenCL backend results

```
$ psyclone -s ./ocl_trans.py nemolite2d.f90
```

```
global_trans = KernelGlobalsToArguments()
ocl_trans = OCLTrans()

# Get the code we want to transform
schedule = psy.invokes.get('invoke_0').schedule

# Remove global variables from kernels
for kern in schedule.kernels():
    global_trans.apply(kern)

# Transform the code to OpenCL
ocl_trans.apply(schedule)

# Specify OpenCL local size to improve
# performance
for kern in schedule.kernels():
    kern.set_opencl_options({'local_size': 64})
```



Exploring feasibility of C++ backends: e.g. Kokkos and SYCL



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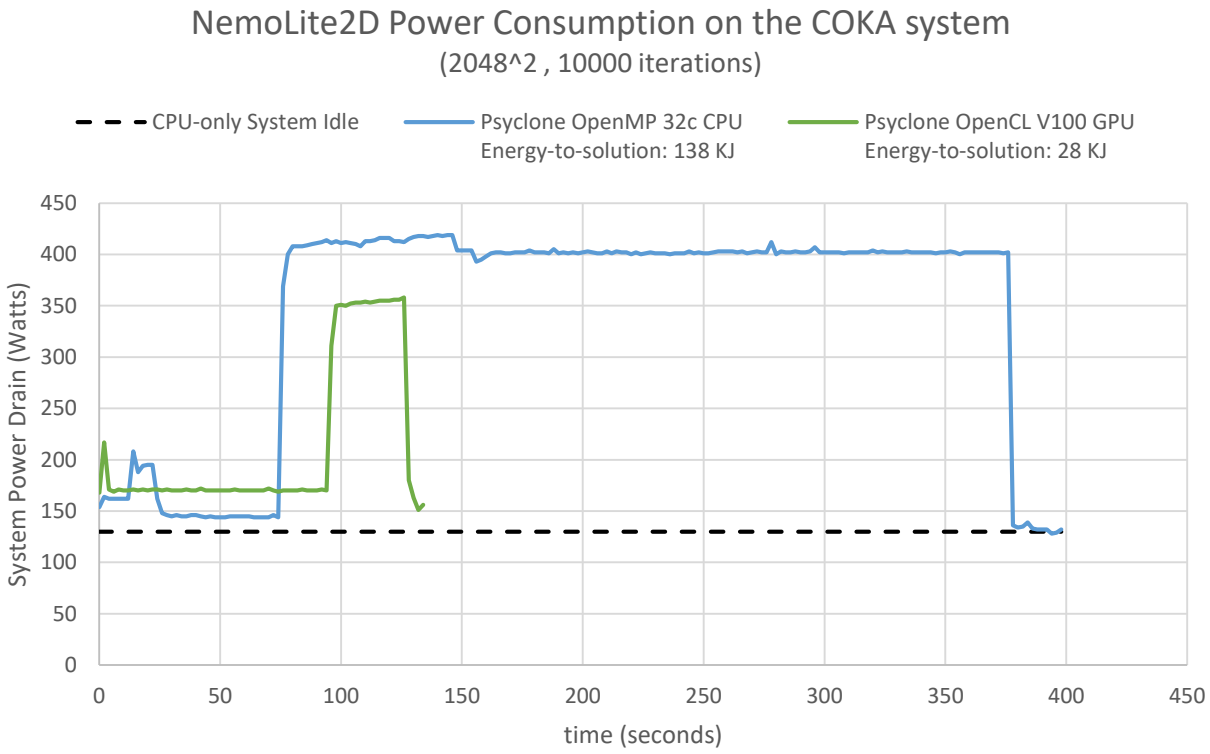
C++ OpenMP GPU offloading provided by Victoria Atkinson (victoria.atkinson@stfc.ac.uk)

Energy-to-Solution



Summary

- PSyclone is a Domain-Specific Compiler for use with both DSLs and existing code
- Intended as a tool for use by an HPC expert
- Used with production/full configurations:
  - LFRic (parallelises next UK MetOffice atmospheric model)
  - NEMO (being integrated in the build system as an optional prepressing step)
- Constructs a PSyclone Internal Representation of supplied code
- User transforms this representation using Python scripts
- Provides error checking and analysis functionality
- Generates Fortran (or OpenCL) for the transformed PSyIR

Thank you!

User, Developer and Reference Guides are available:

psyclone[-dev,-ref].readthedocs.io

For more information please contact:

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https://github.com/stfc/PSyclone

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Extras...

Fparser

Pure Python Fortran parser:

- Supports Fortran 2003 + some 2008
- Open source BSD3 licence
- Developed on GitHub
- Can fully parse UM, LFRic and NEMO source
- Work-in-progress to parse IFS source
- Used by PSyclone, Stylist, Loki

https://github.com/stfc/fparser
https://fparser.readthedocs.io/

```
> pip install fparser
```

```
PROGRAM copy_stencil
  IMPLICIT NONE
  INTEGER, PARAMETER :: n = 10, np1 = 11
  INTEGER :: i, j, k
  REAL, DIMENSION(np1, n, n) :: out, in
  DO k = 1, n
    DO j = 1, n
      DO i = 1, n
        out(i, j, k) = in(i + 1, j, k)
```

```
child type =  <class 'fparser.two.Fortran2003.Execution_Part'>
  child type =  <class 'fparser.two.Fortran2003.Block_Nonlabel_Do_Construct'>
    child type =  <class 'fparser.two.Fortran2003.Nonlabel_Do_Stmt'>
      child type =  <class 'str'> 'DO'
      child type =  <class 'fparser.two.Fortran2003.Loop_Control'>
        child type =  <class 'NoneType'>
        child type =  <class 'tuple'>
        child type =  <class 'NoneType'>
    child type =  <class 'fparser.two.Fortran2003.Block_Nonlabel_Do_Construct'>
      child type =  <class 'fparser.two.Fortran2003.Nonlabel_Do_Stmt'>
        child type =  <class 'str'> 'DO'
        child type =  <class 'fparser.two.Fortran2003.Loop_Control'>
          child type =  <class 'NoneType'>
          child type =  <class 'tuple'>
          child type =  <class 'NoneType'>
      child type =  <class 'fparser.two.Fortran2003.Block_Nonlabel_Do_Construct'>
        child type =  <class 'fparser.two.Fortran2003.Nonlabel_Do_Stmt'>
          child type =  <class 'str'> 'DO'
```

PSyclone: Two Modes of Operation

Revolution

Process code written in a DSL

Currently two Domains supported:

- LFRic - Mixed finite elements, mesh unstructured in horizontal, structured in vertical, embedded in Fortran
- GOcean - DSL for 2D, finite difference, stretched, structured grid, embedded in Fortran

Evolution

Process existing code that follows strict coding conventions

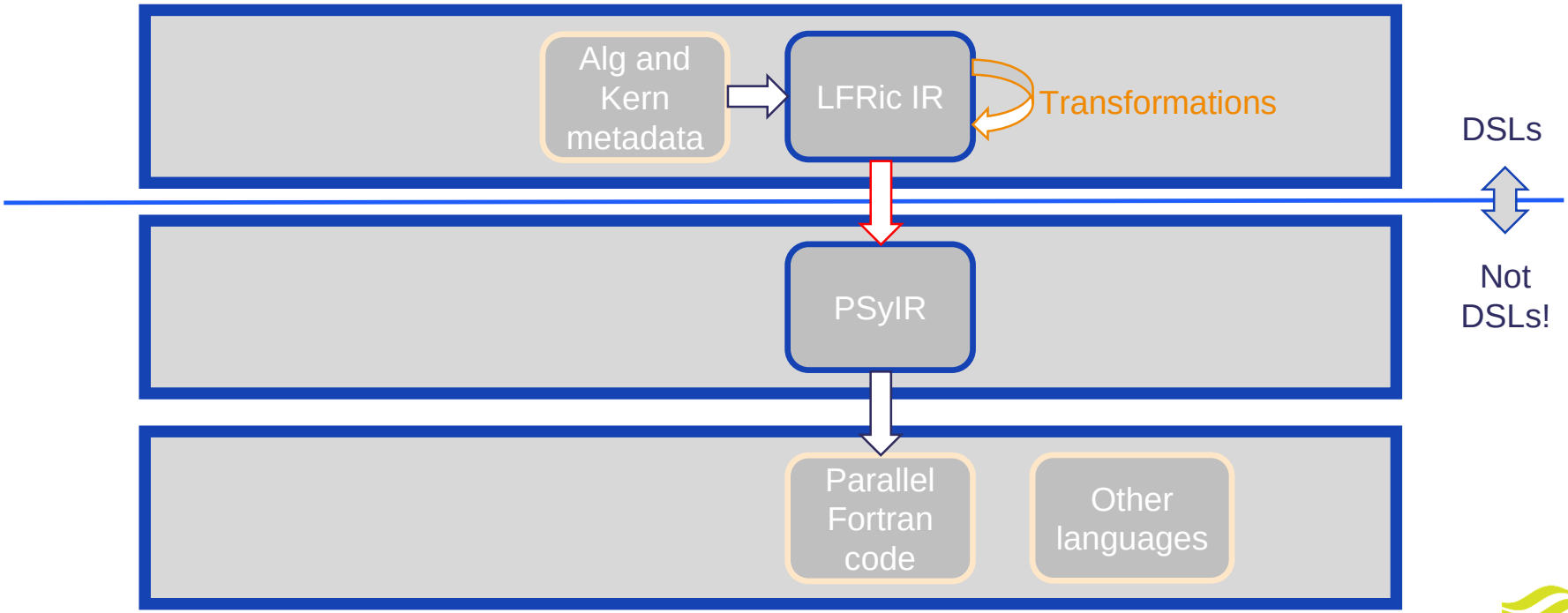
Recognise certain code structures and construct higher-level Internal Representation

Transformations applied to this IR

In development for NEMO (plus associated models, e.g. SI^3, MEDUSA). Also applied to ROMS.

Levels of Abstraction

LFRic DSL PSy Layer



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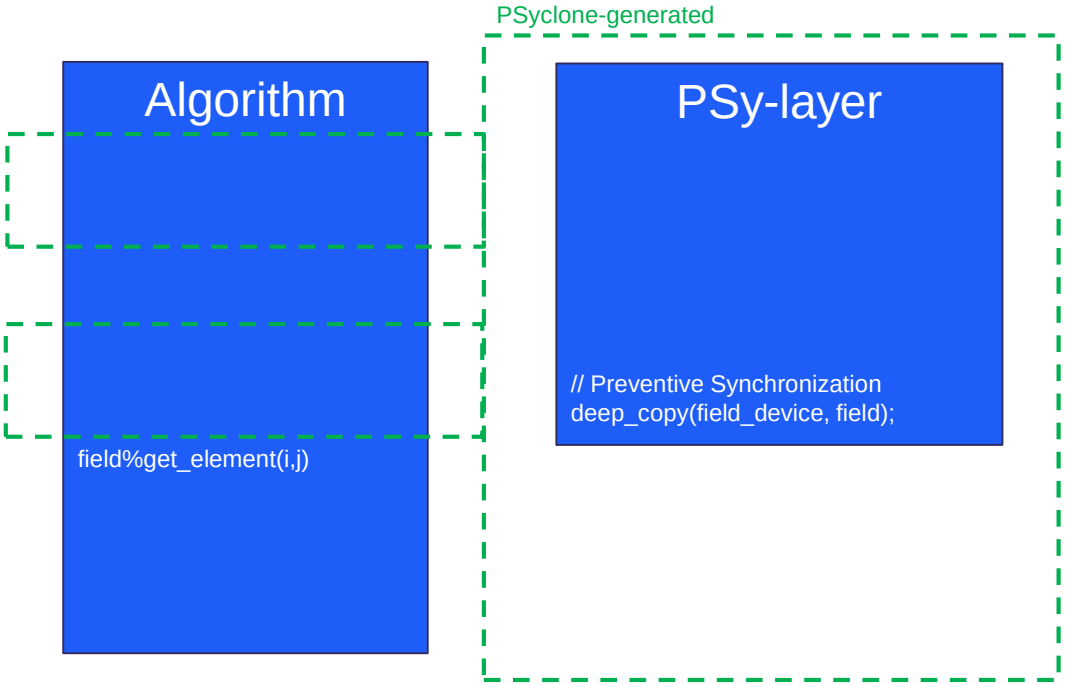
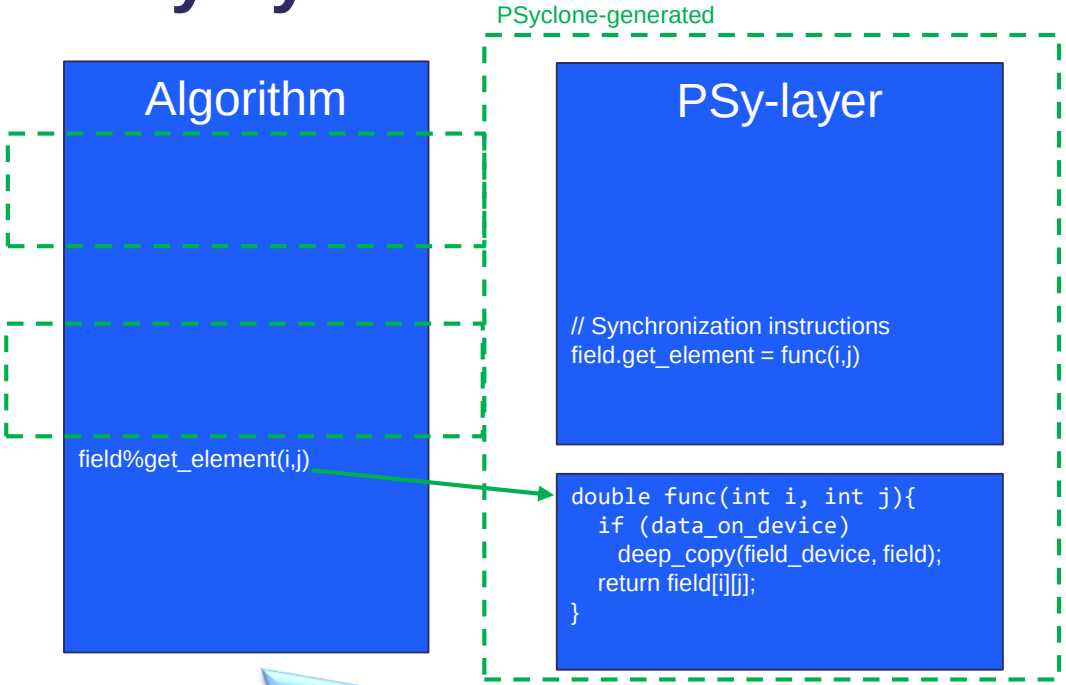
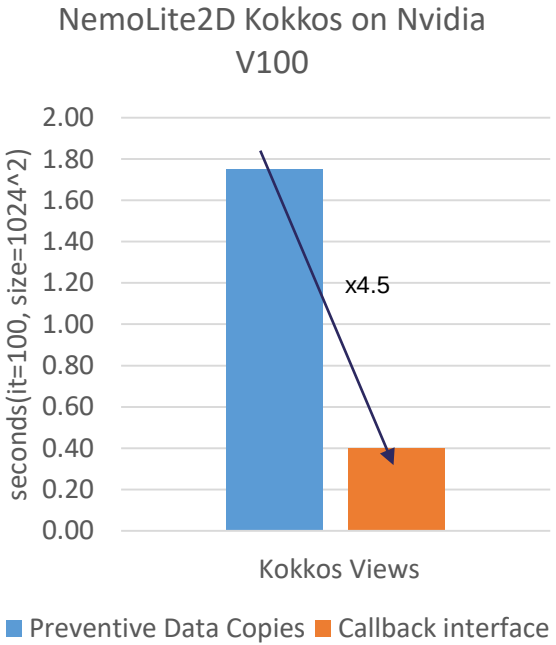
What happens outside of PSyclone domain: Unnecessary preventive data copies



What happens outside of PSyclone domain: Lazy synchronisation to reduce data copies





The callback function makes the Algorithm parallel implementation agnostic
Tested with OpenACC, OpenCL, Kokkos and SYCL

More complex callbacks

```
read_from_device_c_interface(from, to, startx, starty, nx, ny, blocking)
write_to_device_c_interface(from, to, startx, starty, nx, ny, blocking)
```

- Support for transfer of sub-regions of data.
- Support non-blocking requests for asynchronous data transfers.

- Initially tested in the PSyclone-generated MPI+OpenCL. But we still need to explore this optimisation space.