PALM Program Structure

PALM group

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This part gives a brief overview about the structure of the PALM code:

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- Flow chart

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- Flow chart
- Most important variables and how they are declared
- Machine dependencies

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- With some very minor exceptions, the code is using the FORTRAN standard, so it should compile without error on any FORTRAN 2003/2008 compiler. (90/95 may give problems)
- Data handling between subroutines is mostly done using FORTRAN90-modules instead of using parameter lists.

```
SUBROUTINE parin                              SUBROUTINE parin( a, b, c, ... )
   USE control_parameters, ONLY: ...             INTEGER(iwp) ::  a, b
   USE grid_variables, ONLY: ...                 REAL(wp)     ::  c, ...
   .                                             .
   .                                             .
```

Most modules can be found in file .../trunk/SOURCE/modules.f90

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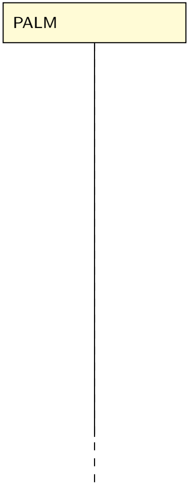
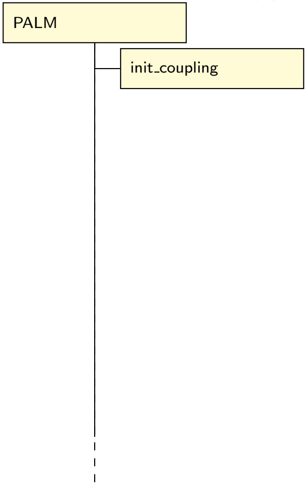
- The serial and parallel (MPI) PALM version is also activated by preprocessor directives.
- The code is splitted into several files, most of them containing just one subroutine, e.g. file "parin.f90" contains "SUBROUTINE parin".
- The code includes an interface which can be used to add your own code extensions. Advantage: These code extensions can be reused (normally) for future PALM releases without requiring any changes.

PALM Flow Chart (I)



PALM Flow Chart (I)



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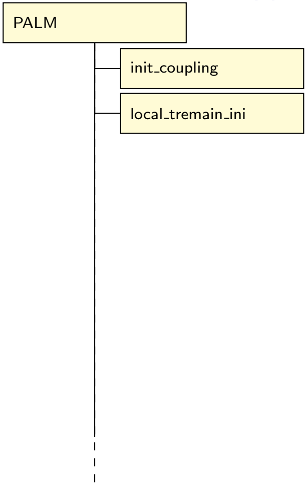

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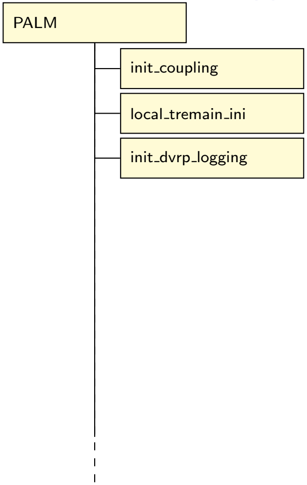

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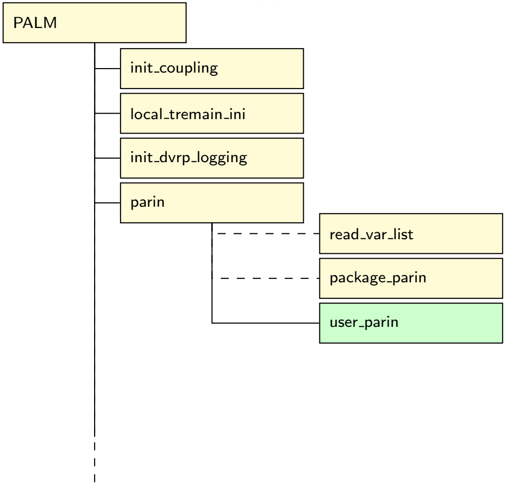

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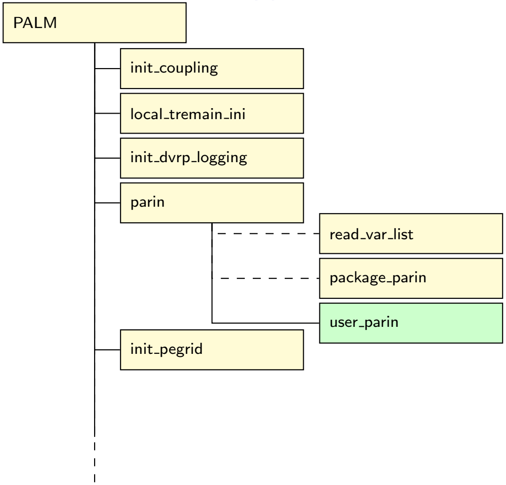

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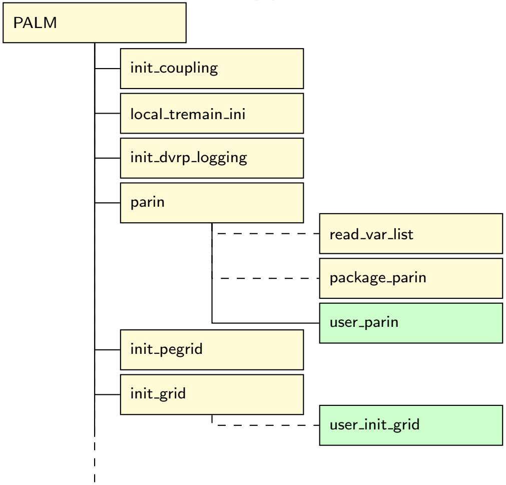
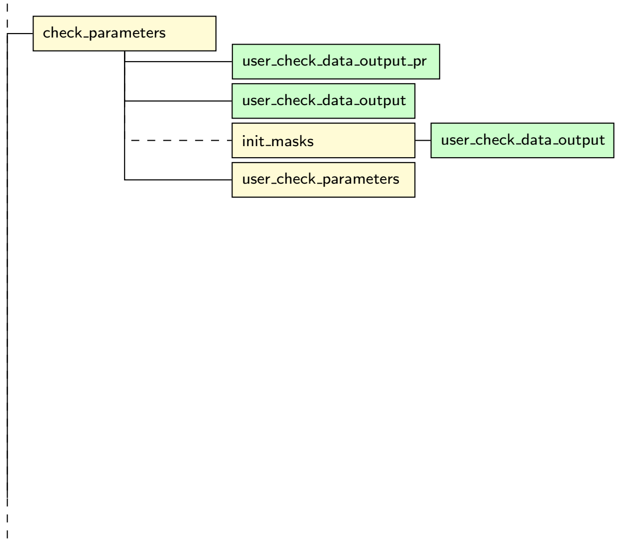


PALM Flow Chart (II)

check_parameters

PALM Flow Chart (II)



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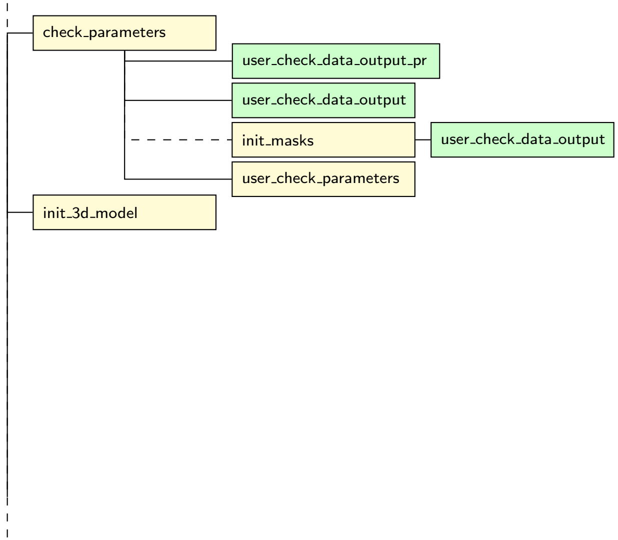

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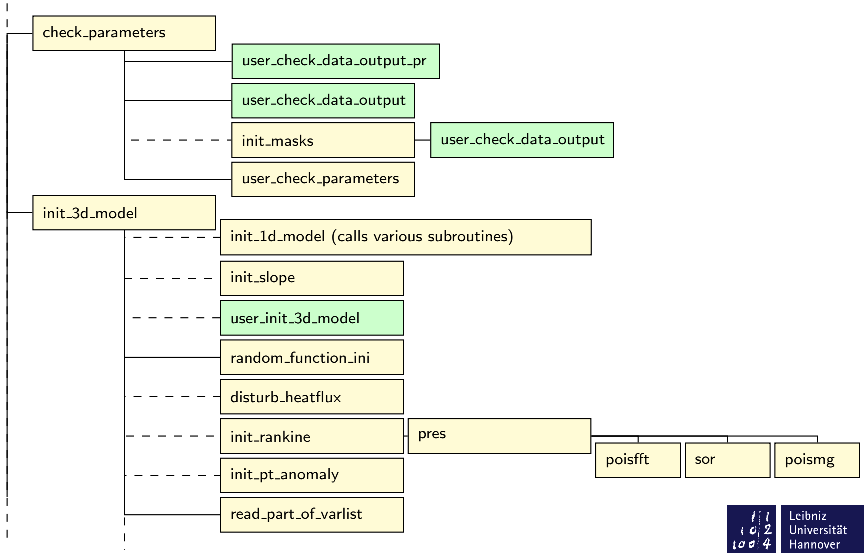

PALM Flow Chart (III)

init_3d_model

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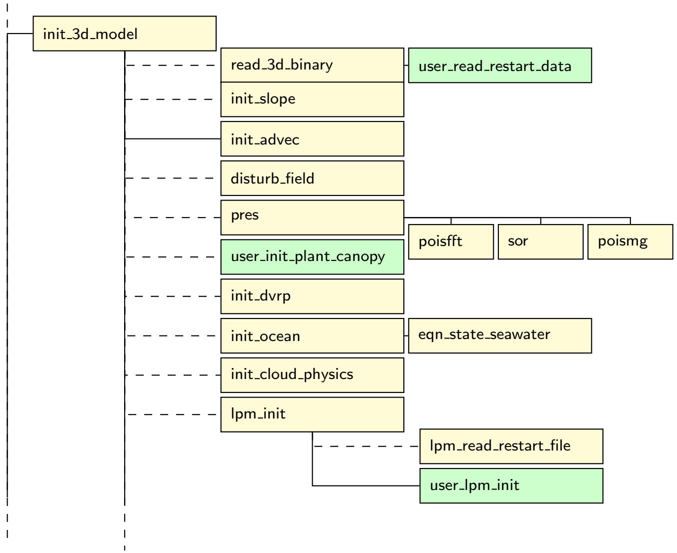

PALM Flow Chart (IV)

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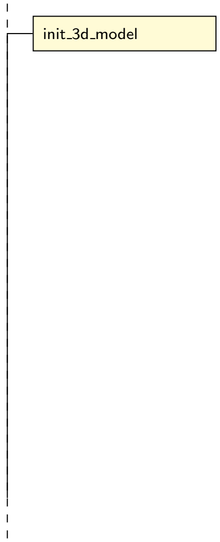

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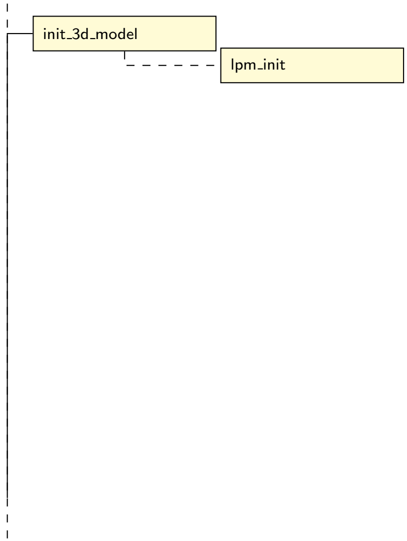

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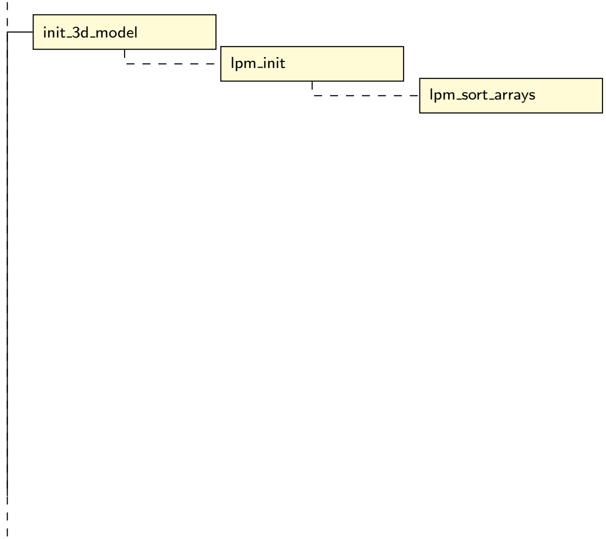

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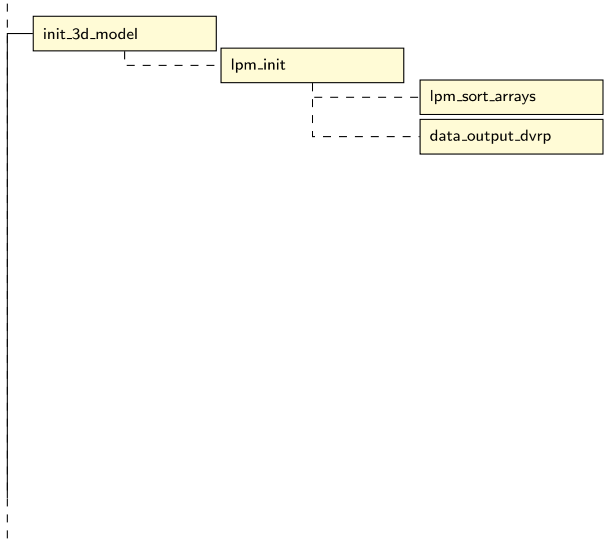

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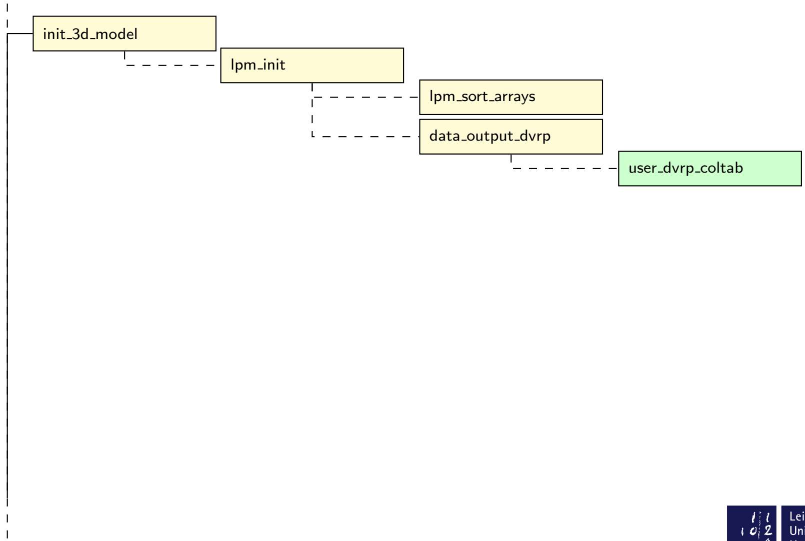

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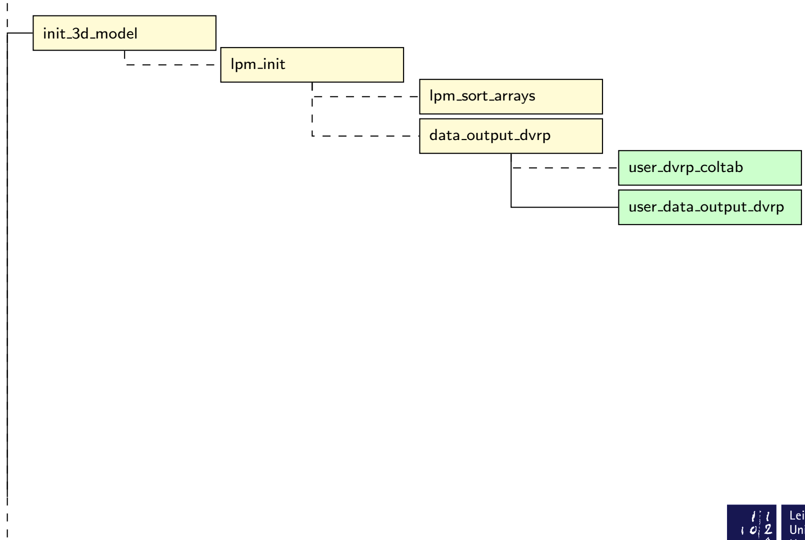

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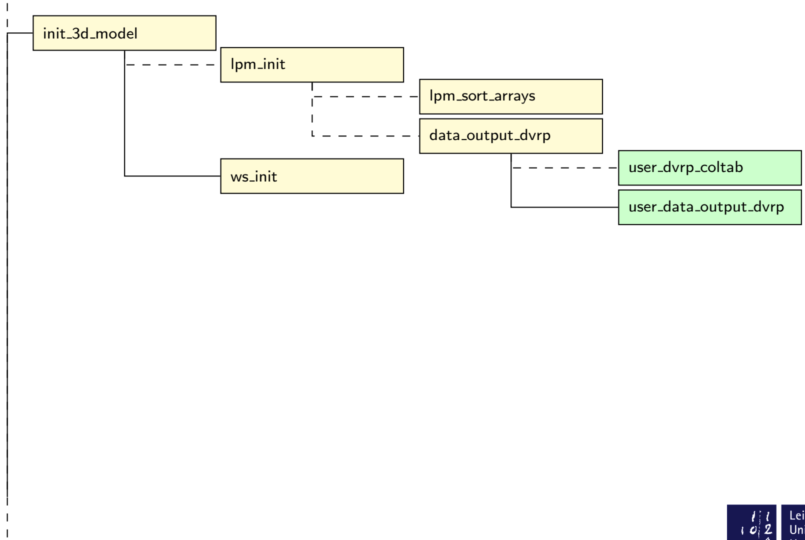

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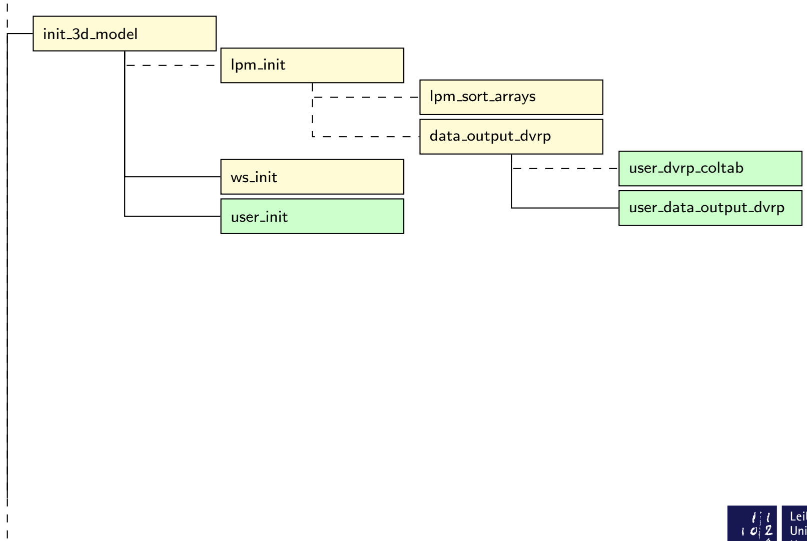

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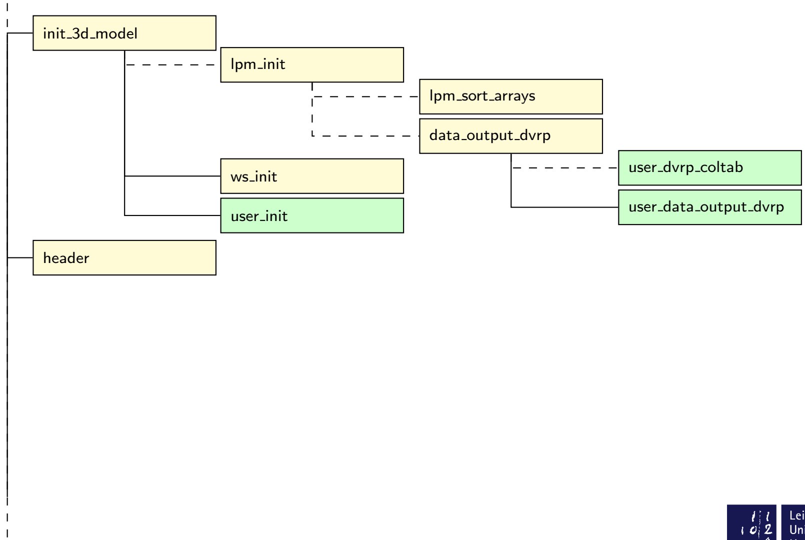

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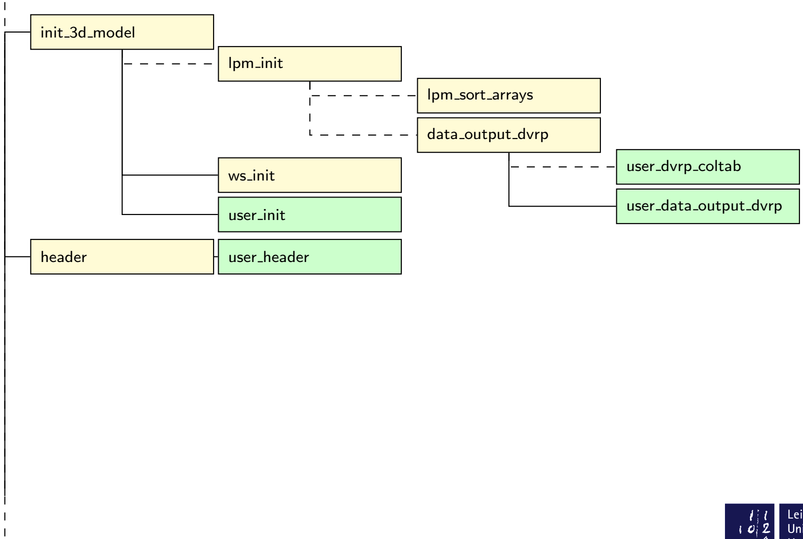

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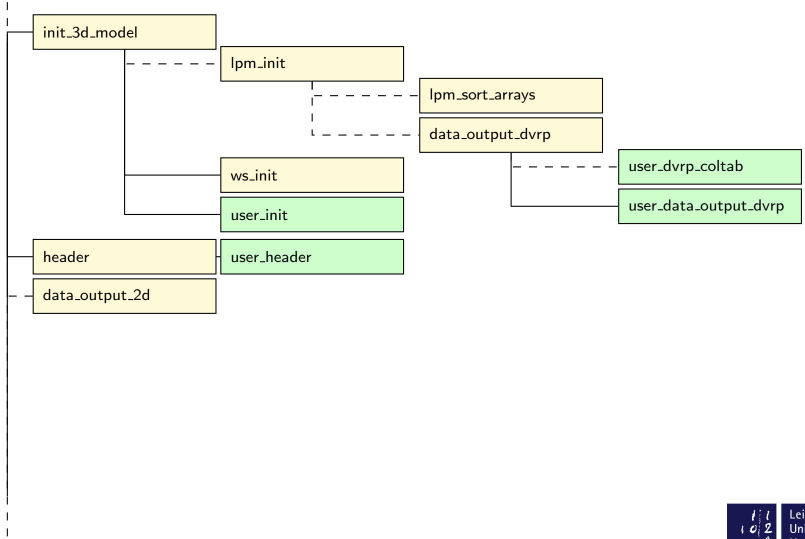

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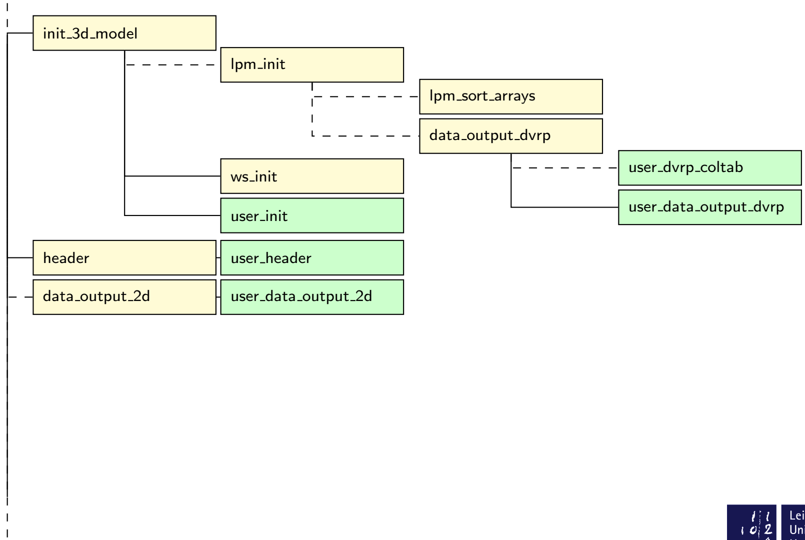

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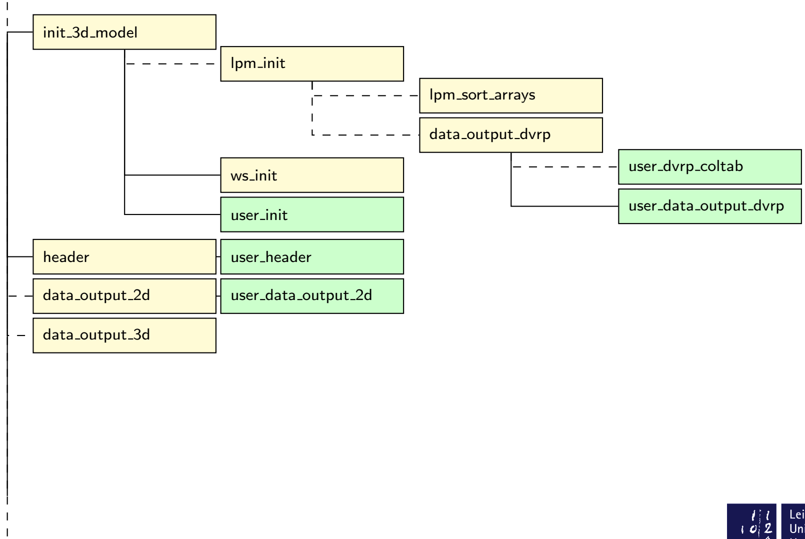

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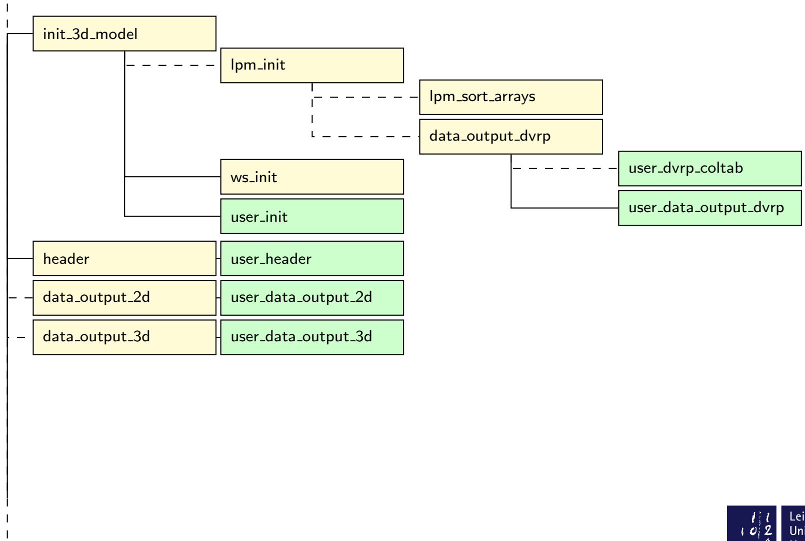

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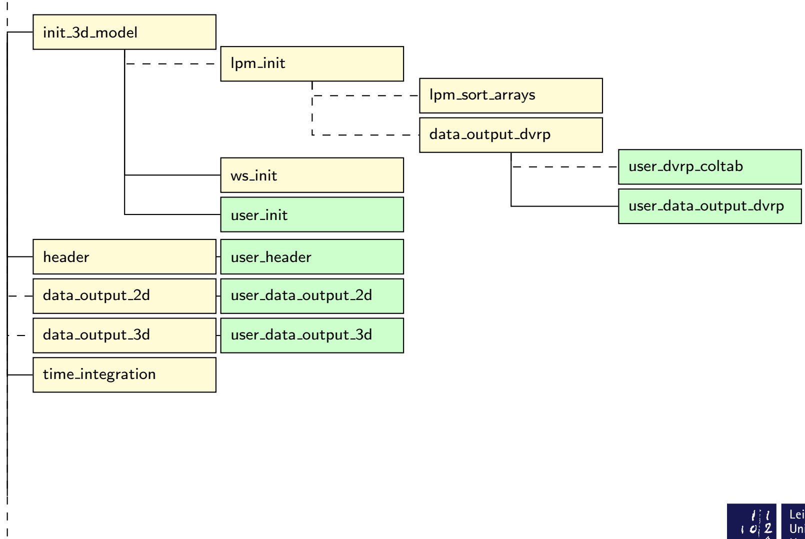

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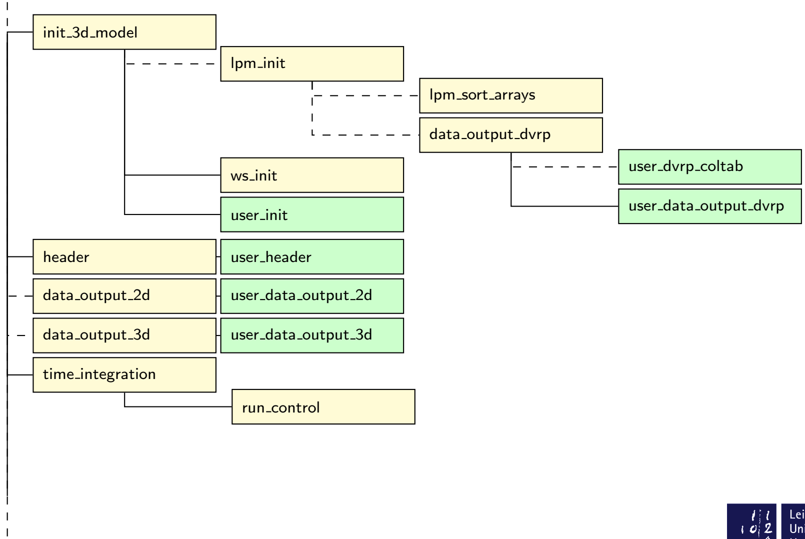

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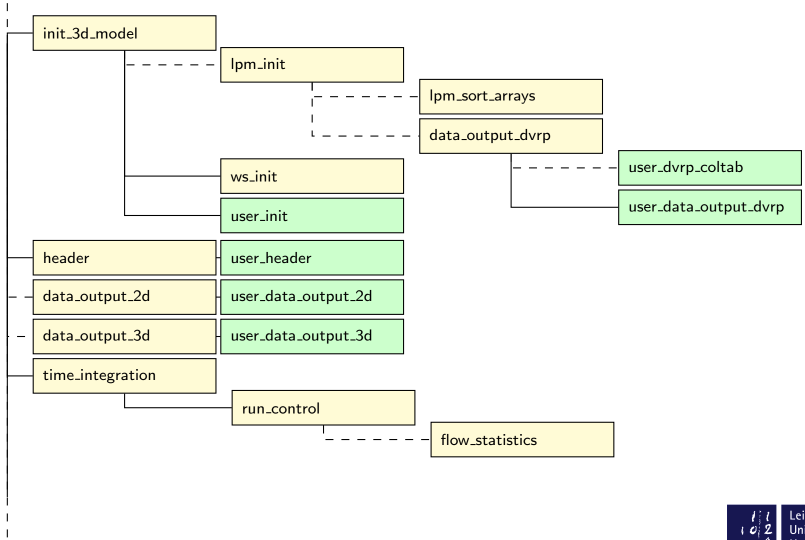

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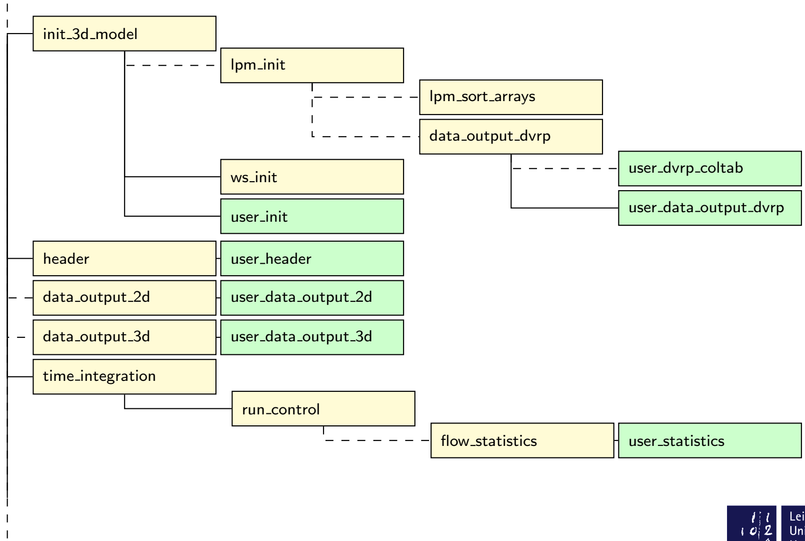

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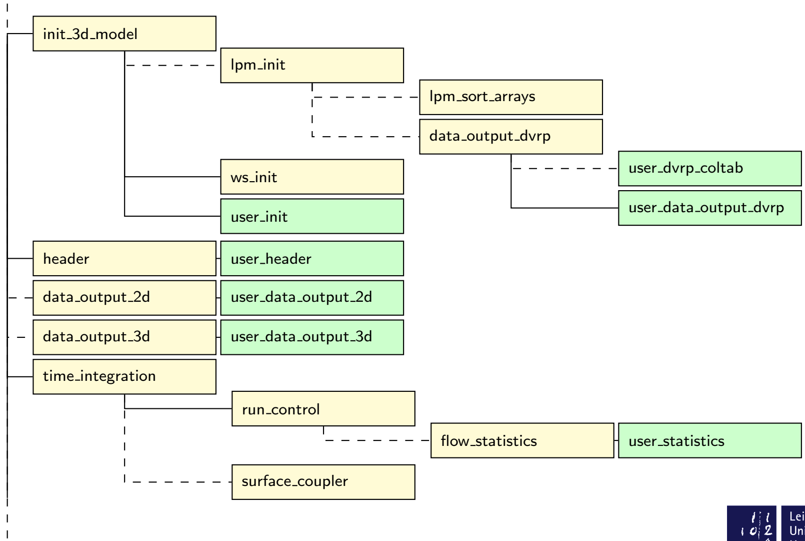

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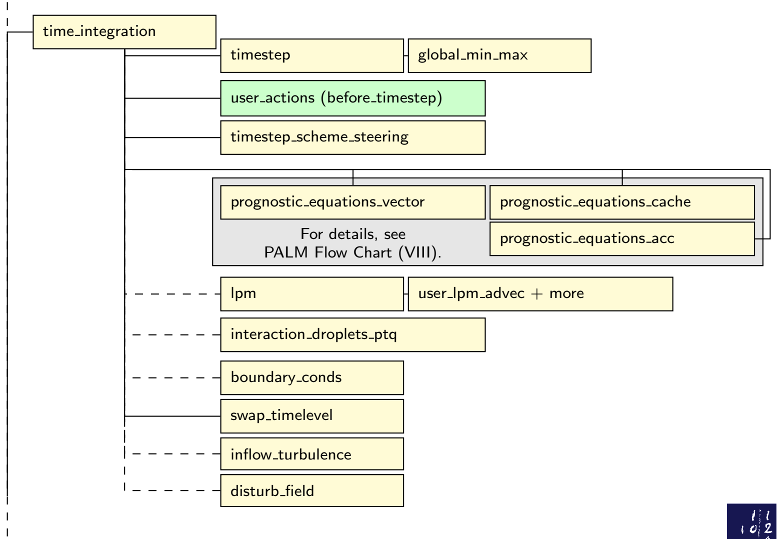

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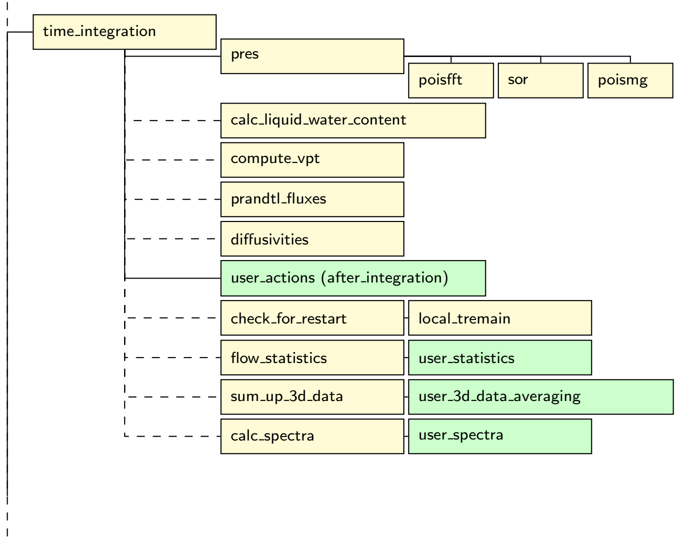

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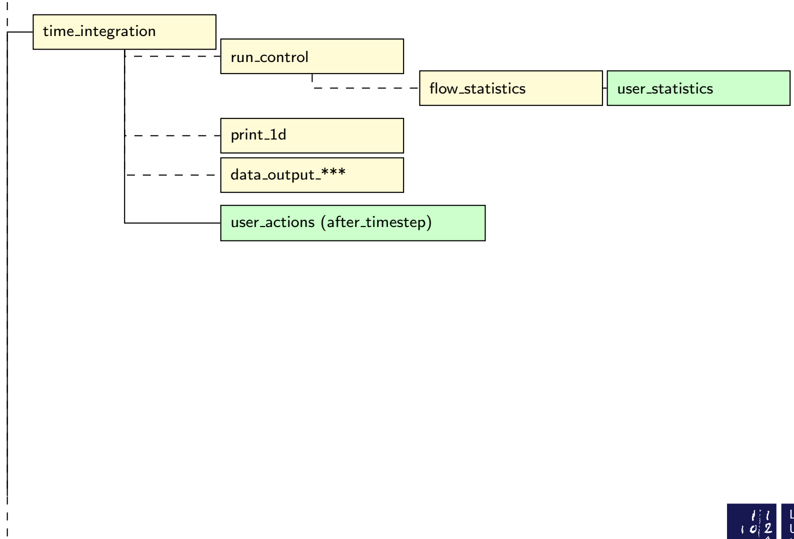
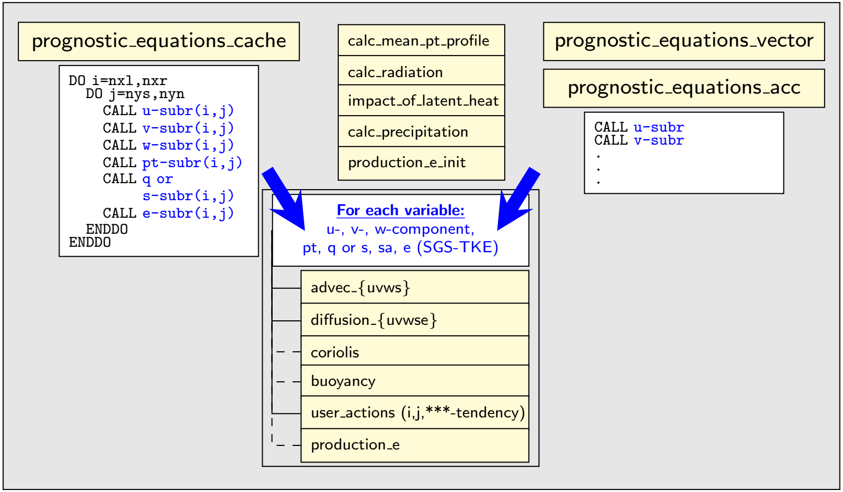


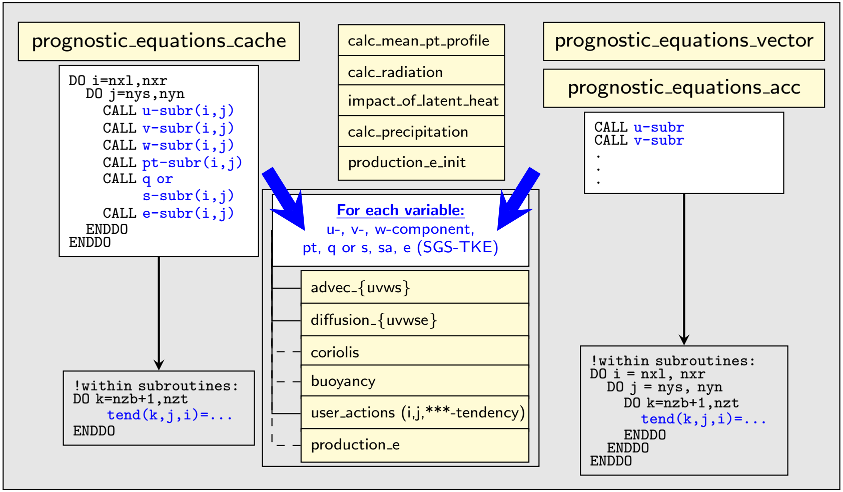
PALM Flow Chart (VIII)



```
DO i=nxl,nxr
  DO j=nys,nyn
    CALL u-subr(i,j)
    CALL v-subr(i,j)
    CALL w-subr(i,j)
    CALL pt-subr(i,j)
    CALL q or
         s-subr(i,j)
    CALL e-subr(i,j)
  ENDDO
ENDDO
```

```
CALL u-subr
CALL v-subr
.
.
.
```

PALM Flow Chart (VIII)



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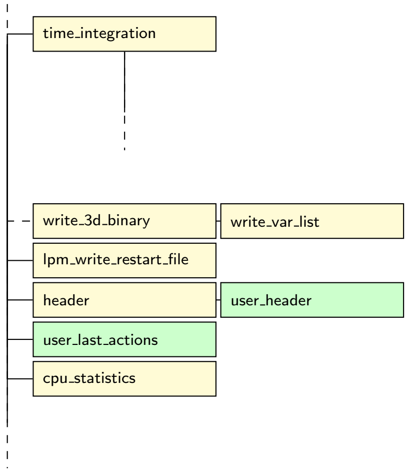
ENDDO
```

```
!within subroutines:
DO k=nzb+1,nzt
    tend(k,j,i)=...
ENDDO
```

```
CALL u-subr
CALL v-subr
.
.
.
```

```
!within subroutines:
DO i = nxl, nxr
  DO j = nys, nyn
    DO k=nzb+1,nzt
      tend(k,j,i)=...
    ENDDO
  ENDDO
ENDDO
```

PALM Flow Chart (IX)



Important Variables and Their Declaration

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- 3D-arrays of prognostic variables are named Ψ, and Ψ_p for time level t, and $t + \Delta t$, respectively, with $\Psi = u$, v, w, pt, q, e, sa, u_p, v_p, ...
- They are by default declared as $\Psi(z,y,x)$ or $\Psi(k,j,i)$, e.g.

```
u(nzb:nzt+1,nysg:nyng,nxlg:nxrg)
```

with

```
nysg = nys - nbgp,  nyng = nyn + nbgp
nxlg = nxl - nbgp,  nxrg = nxr + nbgp
nzb, nzt (bottom, top)
nys, nyn (south, north)
nxl, nxr (left, right)
```

as the index limits of the (sub-)domain.
nbgp is the number of ghost points which depends on the advection scheme (nbgp $= 3$ for the default Wicker-Skamarock scheme).

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- If only one process/core is used, then

```
nxl = 0; nxr = nx
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- For speed optimization, most of the 3D-variables are declared as pointers, e.g.

```
REAL(wp), DIMENSION(:,:,:), POINTER ::
u, u_p, v, v_p, ...
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  This does not affect the usage of these variables in the code in (almost) any way.

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  This does not affect the usage of these variables in the code in (almost) any way.

- A pointer free version can be activated with preprocessor-option `-D__nopointer`.

Some Other Frequently Used Variables

variable	index bounds	meaning	comment
zu	nzb:nzt+1	heights of the scalar (u,v) grid levels	zu(0)=-zu(1)
zw	nzb:nzt+1	heights of the w grid level	zw(0)=0
dzu	1:nzt+1	vertical grid spacings between scalar grid levels	dzu(k)=zu(k)-zu(k-1)
ddzu	1:nzt+1	inverse of grid spacings	ddzu(k)=1.0/dzu(k)
dx		grid spacing along x	
ddx		inverse of dx	ddx=1.0/dx
current_timestep_number		timestep counter	
simulated_time		simulated time in seconds	

Preprocessor Directives (I)

- Preprocessor directives are special lines in the code which allows to compile alternative parts of the code depending on so-called **define-string** switches.
  Code example:

```
#if defined( __nopointer )
REAL(wp), DIMENSION(:,:,:), ALLOCATABLE, TARGET :: e, e_p, ...
#else
REAL(wp), DIMENSION(:,:,:), POINTER :: e, e_p, ...
#endif
```

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  Code example:

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  #if defined( __nopointer )
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  REAL(wp), DIMENSION(:,:,:), POINTER :: e, e_p, ...
  #endif
  ```

  If now the compiler is called e.g.

  ```
  ifort -cpp -D __nopointer ... (other options)
  ```

  then the line containing "..., ALLOCATABLE, TARGET :: ..." is compiled.
  If the compiler call is

  ```
  ifort -cpp ... (other options)
  ```

  the line containing "..., POINTER :: ..." is compiled.

Preprocessor Directives (II)

- The preprocessor directives require to include the compiler option "`-cpp`" in any way. Otherwise, the compilation will give error messages. **The option has to be given in the configuration file** `.mrun.config` in the `%cpp_options` line. **Different compilers may require different options!**

Preprocessor Directives (II)

- The preprocessor directives require to include the compiler option "`-cpp`" in any way. Otherwise, the compilation will give error messages. **The option has to be given in the configuration file** `.mrun.config` in the `%cpp_options` line. **Different compilers may require different options!**
- Define-string switches can be combined using logical AND / OR operators && / ||.

```
#if defined ( __abc  &&  __def )
```

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- To switch between system dependent subroutines for:

`__ibm`	IBM-Regatta systems
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`__nec`	NEC-SX systems

Switches are set automatically depending on the host identifier string given with mrun-option "`-h`", eg. "`-h lclocal`" sets "`-D __lc`"

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  Switches are set automatically depending on the host identifier string given with mrun-option "`-h`", eg. "`-h lclocal`" sets "`-D __lc`"
- To switch between the serial and the parallel code:
  - `__parallel`

  This switch is set by mrun-option "`-K parallel`".

Preprocessor Directives (IV)

In the PALM code, define-string switches are additionally used for following reasons:

- To enable usage of special software packages which are not included in the compilation process by default
  - `__dvrp_graphics` 3D visualization system (currently out of order)
  - `__spectra` calculation and output of power spectra

  Switches are activated with mrun-option "`-p`",
  eg. "`-p "spectra dvrp_graphics"`"

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  Switches are activated with mrun-option "`-p`",
  eg. "`-p "spectra dvrp_graphics"`"
- To enable special features
  - `__openacc` activates call of external routines required for OpenACC programming
  - `__netcdf`, `__netcdf4`, `__netcdf_parallel` NetCDF I/O with different NetCDF versions

Preprocessor Directives (V)

- Preprocessor directives are also used for string replacement in the code.

  Example:
  A compiler call with preprocessor option

  ```
  ifort -cpp -Dabcd=efgh
  ```

  will replace all strings "abcd" in the code with "efgh" **before** the code is compiled.

  This is used in PALM to change the MPI_REAL datatypes (which are 4 byte long by default), to 8 bytes. The respective cpp-directives are given in the configuration file `.mrun.config.`:

  ```
  %cpp_options -cpp:-DMPI_REAL=MPI_DOUBLE_PRECISION:
               -DMPI_2REAL=MPI_2DOUBLE_PRECISION: ....
  ```