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We would like to thank the main past or present developers of OASIS are (in alphabetical order, with the name of their institution at the time of their contribution to OASIS):

Arnaud Caubel (LSCE/IPSL & FECIT/Fujitsu), Damien Declat (CERFACS), Italo Epicoco (CMCC), Veronika Gayler (MPI-M&D), Josefine Ghattas (CERFACS), Jean Latour (CERFACS & Fujitsu-Fecit), Eric Maisonnave (CERFACS), Silvia Mocavero (CMCC), Elodie Rapaport (CERFACS), Hubert Ritzdorf (CCRL-NEC), Sami Saarinen (ECMWF), Eric Sevault (Météo-France), Laurent Terray (CERFACS), Olivier Thual (CERFACS), Reiner Vogelsang (SGI Germany), Li Yan (CERFACS).

We also would like to thank the following people for their help and suggestions in the design of the OASIS software (in alphabetical order, with the name of their institution at the time of their contribution to OASIS):

Dominique Astruc (IMFT), Chandan Basu (NSC, Sweden), Sophie Belamari (Météo-France), Dominique Bielli (Météo-France), Gilles Bourhis (IDRIS), Pascale Braconnot (IPSL/LSCE), Sandro Calmanti (Météo-France), Christophe Cassou (CERFACS), Yves Chartier (RPN), Jalel Chergui (IDRIS), Philippe Courtier (Météo-France), Philippe Dandin (Météo-France), Michel Déqué (Météo-France), Ralph Doescher (SMHI), Jean-Louis Dufresne (LMD), Jean-Marie Epitalon (CERFACS), Laurent Fairhead (LMD), Uwe Fladrich (SMHI), Marie-Alice Foujols (IPSL), Gilles Garric (CERFACS), Eric Guilyardi (CERFACS), Charles Henriet (CRAY France), Pierre Herchuelz (ACCR), Maurice Imbard (Météo-France), Luis Kornblueh (MPI-M), Stephanie Legutke (MPI-M&D), Claire Lévy (LODYC), Olivier Marti (IPSL/LSCE), Sébastien Masson (IPSL/LOCEAN) Claude Mercier (IDRIS), Pascale Noyret (EDF), Andrea Piacentini (CERFACS), Marc Pontaud (Météo-France), Adam Ralph (ICHEC), René Redler (MPI-M), Tim Stockdale (ECMWF), Rowan Sutton (UGAMP), Véronique Taverne (CERFACS), Jean-Christophe Thil (UKMO), Nils Wedi (ECMWF).
Chapter 1

Introduction

In 1991, CERFACS started the development of a software interface to couple existing ocean and atmosphere numerical General Circulation Models. Today, different versions of the OASIS coupler are used by about 35 modelling groups in Europe, Australia, Asia and North America on the different computing platforms (Valcke 2013)\(^1\). OASIS sustained development is ensured by a collaboration between CERFACS and the Centre National de la Recherche Scientifique (CNRS) and its maintainance and user support is presently reinforced with additional resources coming from the IS-ENES2 project funded by the EU.

The current OASIS3-MCT is interfaced with MCT, the Model Coupling Toolkit\(^2\) (Larson et al 2005) (Jacob et al 2005), developed by the Argonne National Laboratory in the USA. MCT implements fully parallel regridding, as a parallel matrix vector multiplication, and parallel distributed exchanges of the coupling fields, based on pre-computed regridding weights and addresses. Its design philosophy, based on flexibility and minimal invasiveness, is close to the OASIS approach. MCT has proven parallel performance and is, most notably, the underlying coupling software used in National Center for Atmospheric Research Community Earth System Model 1 (NCAR CESM1).

OASIS3-MCT is a portable set of Fortran 77, Fortran 90 and C routines. Low-intrusiveness, portability and flexibility are OASIS3-MCT key design concepts. After compilation OASIS3-MCT is a coupling library that needs to be linked to the component models, and which main function is to interpolate and exchange the coupling fields between them to form a coupled system. OASIS3-MCT supports coupling of 2D logically-rectangular fields but 3D fields and 1D fields expressed on unstructured grids are also supported using a one dimension degeneration of the structures. Thanks to MCT, all transformations, including regridding, are executed in parallel on the set of source or target component processes and all couplings are now executed in parallel directly between the components via Message Passing Interface (MPI). OASIS3-MCT also supports file I/O using netcdf.

In spite of the significant changes in underlying implementation, usage of OASIS3-MCT in the codes has largely remained unchanged with respect to OASIS3.3. To communicate with another model, or to perform I/O actions, a component model needs to include few specific calls to the OASIS3-MCT coupling library, which Application Programmig Interface (API) used in component models is unchanged. The use statement has been updated and now requires a single “use mod_prism” or “use mod_oasis” statement instead of the various use statements required in prior OASIS3 versions. The namcouple configuration file is also largely unchanged relative to OASIS3, although several options are either not used or not supported. There is a new transformation in namcouple i.e. MAPPING which allows a user to specify a mapping file generated externally. The changes between OASIS3.3 and OASIS3-MCT are listed in appendix B.

First tests done with up to 8000 cores on the Bullx Curie machine at the TGCC are very encouraging and it is therefore very likely that OASIS3-MCT will provide an efficient and easy-to-use coupling solution for many climate modelling groups in the few years to come.

\(^1\)The list of coupled models realized with OASIS can be found at https://verc.enes.org/oasis/oasis-dedicated-user-support-1/some-current-users
\(^2\)www.mcs.anl.gov/research/projects/mct/
1.1 Step-by-step use of OASIS3-MCT

To use OASIS3-MCT for coupling models (and/or perform I/O actions), one has to follow these steps:

1. Obtain OASIS3-MCT source code (see chapter 1.2).
2. Get familiar with OASIS3-MCT by going through the tutorial steps. The tutorial sources are given in directory examples/tutorial and all explanations are provided in the document tutorial_oasis3-mct.pdf therein.
3. Identify the coupling or I/O fields and adapt the component models to allow their exchange with the OASIS3-MCT coupling library based on MPI1 message passing. The OASIS3-MCT coupling library uses NetCDF and therefore can be used to perform I/O actions from/to disk files. For more detail on how to interface a model with OASIS3-MCT, see chapter 2.
4. Define all coupling and I/O parameters and the transformations required to adapt each coupling field from the source model grid to the target model grid; on this basis, prepare OASIS3-MCT configuring file namcouple (see chapter 3). OASIS3-MCT supports different interpolation algorithms as described in chapter 4. Regridding files can be computed online using the SCRIP options or offline and read using the MAPPING transformation.

We strongly recommend to tests off-line the quality of the chosen transformations and regriddings using the environment available in examples/test_interpolation and explanations provided in the document test_interpolation_oasis3-mct.pdf therein.
5. Generate required auxiliary data files (see chapter 5).
6. Compile OASIS3-MCT, the component models and start the coupled experiment. Details on how to compile and run a coupled model with OASIS3-MCT can be found in section 6.

If you need extra help, do not hesitate to contact us (see contact details on the back of the cover page).

1.2 OASIS3-MCT sources

OASIS3-MCT sources are available from CERFACS SVN server. To obtain more detail on downloading the sources, please fill in the registration form at https://verc.enes.org/oasis/download/oasis-registration-form.

OASIS3-MCT directory structure is the following one:

- oasis3-mct/lib/psmile OASIS3-MCT coupling library
  /scrip SCRIP interpolation library
  /mct Model Coupling Toolkit Coupling Software

- oasis3-mct/doc OASIS3-MCT User Guide

- oasis3-mct/util/make_dir Utilities to compile OASIS3-MCT

- oasis3-mct/examples Environment to run the tutorial and test_interpolation toy coupled models.
1.3 Licenses and Copyrights

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Modeling Coupling Toolkit (MCT) Software

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Chapter 2

Interfacing a component model with OASIS3-MCT

At run-time, OASIS3-MCT allows exchanging coupling data between two components as well as interpolation and transformation of these coupling fields. Different communication techniques have been historically developed in OASIS. With OASIS3-MCT, communication is performed by MCT based on Message Passing Interface 1 (MPI1) protocol.

For a practical example using the OASIS3-MCT library, see the sources in examples/tutorial and explanations in the test_interpolation_oasis3-mct.pdf document therein.

To communicate with another component model or to perform I/O actions, a component model needs to be interfaced with the OASIS3-MCT library, which sources can be found in oasis3-mct/lib/psmile directory. The OASIS3-MCT library supports:

- parallel communication between parallel component models,
- coupling a component on a subset of it’s processes only,
- automatic sending and receiving actions at appropriate times following user’s choice indicated in the namcouple,
- time integration or accumulation of the coupling fields,
- some transformations such as mapping (interpolation) between grids,
- I/O actions from/to files.

To adapt a component model to OASIS3-MCT, specific calls of the following classes have to be implemented in the code:

1. Initialisation (section 2.2)
2. Grid data file definition (section 2.3)
3. Partition definition (section 2.4)
4. Coupling-I/O field declaration (section 2.5)
5. End of definition phase (section 2.6)
6. Coupling-I/O field sending and receiving (section 2.7)
7. Termination (section 2.8)
8. Optional auxiliary routines (section 2.9)

Finally, in section 2.10, different coupling algorithms are illustrated and details on how to reproduce them with OASIS3-MCT are provided. More information on the LAG and SEQ indices are also given in that section.
2.1 Use of OASIS3-MCT library

To use OASIS3-MCT library, a user needs to add in his code:

- USE mod_oasis
  ** OR **
- USE mod_prism

Both use statements are valid and use of just one or the other is recommended in a particular component model. A single use statement now provides all the methods that required multiple use statements in previous OASIS3 versions. The methods, datatypes, and capabilities are identical for both the mod_prism or mod_oasis interfaces. The only difference is the name of the interface. The interface in module mod_prism is provided for backwards compatibility with prior versions of OASIS3. Use of module mod_oasis is now recommended provides access to a set of updated routine names that will continue to evolve in the future, always ensuring backward compatibility. In the following sections, both the mod_prism and mod_oasis interface names are defined and a single description of the interface arguments is provided.

2.2 Initialisation

2.2.1 Coupling initialisation

- CALL oasis_init_comp (compid, model_name, ierror)
- CALL prism_init_comp_proto (compid, model_name, ierror)
  
  - compid [INTEGER; OUT]: component model ID
  - model_name [CHARACTER*6; IN]: component model name (as in namcouple under $NBMODEL)
  - ierror [INTEGER; OUT]: returned error code.

  This routine must called by all component processes to initialise the coupling.¹

2.2.2 Communicator for internal parallelisation

- CALL oasis_get_localcomm (local_comm, ierror)
- CALL prism_get_localcomm_proto (local_comm, ierror)
  
  - local_comm [INTEGER; OUT]: value of local communicator
  - ierror [INTEGER; OUT]: returned error code.

  If needed, this routine may be called by the component processes to get the value of a local communicator to be used by the component for its internal parallelisation.

  This may be needed as all component models started in a pseudo-MPMD mode with MPI1 share automatically the same MPI_COMM_WORLD communicator. Another communicator has to be used for the internal parallelisation of each component. OASIS3-MCT creates this local communicator based on the name given to oasis_init_comp routine; its value is returned as the first argument of the routine, local_comm.

¹The model may call MPI_Init explicitly, but if so, has to call it before calling oasis_init_comp; in this case, the model also has to call MPI_Finalize explicitly, but only after calling oasis_terminate.
2.2.3 Coupling through a subset of the component model processes

If only a subset of the component processes participate in the coupling, a communicator gathering only these processes must be defined, with oasis/prism_create_couplcomm or oasis/prism_set_couplcomm. These routines should be called after the oasis_init_comp but before the grid, partition, or coupling field declaration.

If such communicator does not exist in the code, the component processes have to create it with:

- CALL oasis_create_couplcomm(icpl, local_comm, coupl_comm, kinfo)
- CALL prism_create_couplcomm(icpl, local_comm, coupl_comm, kinfo)

- icpl [INTEGER; IN]: coupling process flag
- local_comm [INTEGER; IN]: MPI communicator with all processes of the component
- coupl_comm [INTEGER; OUT]: returned MPI communicator gathering only component processes participating in the coupling
- kinfo [INTEGER; OUT; OPTIONAL]: returned error code

This routine creates a coupling communicator for a subset of processes. It must be called by all component processes with icpl=1 for processes participating in the coupling and with icpl = MPI_UNDEFINED for the others. Argument local_comm is the MPI communicator associated with all processes of the component. The new coupling communicator is returned in coupl_comm.

If this communicator already exist in the code, the component should simply provide it to OASIS3-MCT with:

- CALL oasis_set_couplcomm(coupl_comm, kinfo)
- CALL prism_set_couplcomm(coupl_comm, kinfo)

- coupl_comm [INTEGER; IN]: MPI communicator gathering only component processes participating in the coupling
- kinfo [INTEGER; OUT; OPTIONAL]: returned error code

This routine allows to provide a local coupling communicator to OASIS3-MCT, given that it already exists in the code. The value of coupl_comm must be the value of this local coupling communicator for the processes participating to the coupling and it must be MPI_COMM_NULL for processes not involved in the coupling.

All OASIS3-MCT interface routines, besides the grid definition (see section 2.3) and the oasis_put and oasis_get per se (see section 2.7), are collective and must be called by all processes of an executable. In particular, the oasis_def_partition (see section 2.4) must be called by all processes, but with ig_paral(:)=0 for the processes not involved in the coupling; also, these processes must call the same number of oasis_def_var than the ones participating to the coupling, even if the associated field symbolic names and partition ID (see name and il_part_id arguments in section 2.5) can then be anything.

Appendix C shows a coding sample of how to use these routines.

2.2.4 Separate executable not coupling at all

For a separate executable part of a coupled system managed by OASIS3-MCT but for which all processes are not involved in the coupling (such as a separate I/O server), the only calls that should be made are:

CALL oasis_init_comp (comp_id, comp_name, ierror )
CALL oasis_get_localcomm ( localComm, ierror )  ! optional
CALL oasis_enddef ( ... )
CALL oasis_terminate ( ... )
2.3 GRID DATA FILE DEFINITION

With OASIS3-MCT, the grid data files grids.nc, masks.nc and areas.nc are required only for certain operations (see also section 5.1), i.e. grids.nc, and masks.nc for SCRIPR (see section 4.3) and masks.nc and areas.nc for CONSERV (see section 4.4). These grid data files can be created by the user before the run or can be written directly at run time by the master process of each component model with the following routines. These routines can be used by the component models to add grid fields to the grid files but not to overwrite them. These routines have to be called just after oasis_init_comp.

• CALL oasis_start_grids_writing (flag) or
  • CALL prism_start_grids_writing (flag)
    - flag [INTEGER; OUT]: not used

  Obsolete in OASIS3-MCT; exists however for upward compatibility.

• CALL oasis_write_grid (cgrid, nx, ny, lon, lat) or
  • CALL prism_write_grid (cgrid, nx, ny, lon, lat)

  - cgrid [CHARACTER*4; IN]: grid name prefix (see 3.3)
  - nx [INTEGER; IN]: first grid dimension (x)
  - ny [INTEGER; IN]: second grid dimension (y)
  - lon [REAL, DIMENSION(nx,ny); IN]: single or double real array of longitudes (degrees East)
  - lat [REAL, DIMENSION(nx,ny); IN]: single or double real array of latitudes (degrees North)

  Writes the model grid longitudes and latitudes. Longitudes must be given in degrees East in the interval -360.0 to 720.0. Latitudes must be given in degrees North in the interval -90.0 to 90.0. Note that if some grid points overlap, it is recommended to define those points with the same number (e.g. 90.0 for both, not 450.0 for one and 90.0 for the other) to ensure automatic detection of overlap by OASIS3-MCT (which is essential to have a correct conservative remapping SCRIPR/CONSERV, see section 4.3).

• CALL oasis_write_corner (cgrid, nx, ny, nc, clon, clat) or
  • CALL prism_write_corner (cgrid, nx, ny, nc, clon, clat)

  - cgrid [CHARACTER*4; IN]: grid name prefix
  - nx [INTEGER; IN]: first grid dimension (x)
  - ny [INTEGER; IN]: second grid dimension (y)
  - nc [INTEGER; IN]: number of corners per grid cell (always 4 in the version)
  - lon [REAL, DIMENSION(nx,ny,nc); IN]: single or double real array of corner longitudes (in degrees East)
  - lat [REAL, DIMENSION(nx,ny,nc); IN]: single or double real array of corner latitudes (in degrees North)

  Writes the grid cell corner longitudes and latitudes (counterclockwise sense). Longitudes must be given in degrees East in the interval -360.0 to 720.0. Latitudes must be given in degrees North in the interval -90.0 to 90.0. Note also that cells larger than 180.0 degrees in longitude are not supported. Writing of corners is optional as corner information is needed only for SCRIPR/CONSERV (see section 4.3). If called, needs to be called after oasis/prism_write_grid.

• CALL oasis_write_mask (cgrid, nx, ny, mask) or
  • CALL prism_write_mask (cgrid, nx, ny, mask)
Chapter 2. Interfacing a Component Model with OASIS3-MCT

- cgrid [CHARACTER*4; IN]: grid name prefix
- nx [INTEGER; IN]: first grid dimension (x)
- ny [INTEGER; IN]: second grid dimension (y)
- mask [INTEGER, DIMENSION(nx,ny); IN]: mask array (be careful about the OASIS historical convention (!): 0 = not masked, 1 = masked)

Writes the model grid mask.

- CALL oasis_write_area (cgrid, nx, ny, area) or
- CALL prism_write_area (cgrid, nx, ny, area)
  - cgrid [CHARACTER*4; IN]: grid name prefix
  - nx [INTEGER; IN]: first grid dimension (x)
  - ny [INTEGER; IN]: second grid dimension (y)
  - area [REAL, DIMENSION(nx,ny); IN]: single or double real array of grid cell areas

Writes of the model grid cell areas. Needed only for CONSERV operation (see section 4.4).

- CALL prism_terminate_grids_writing()
- CALL oasis_terminate_grids_writing()

Terminates grids writing (required if some of the above grid writing routines are called).

The creation of the different files is effective in the routine oasis_enddef.

2.4 Partition definition

The coupling fields sent or received by a component model are usually scattered among the different component processes. With OASIS3-MCT, all processes exchanging coupling data have to define their local partition in the global index space.

If only a subset of the processes actually exchange coupling data, the processes not implied in the coupling have to call this routine to describe a null partition (i.e. with ig_paral(:)=0).

If the sum of the partitions defined over all the processes do not cover the global grid, the total dimension of the grid (total number of points) must be given as an optional argument (see isize below).

- CALL oasis_def_partition (il_part_id, ig_paral, ierror, isize) or
- CALL prism_def_partition_proto (il_part_id, ig_paral, ierror, isize)
  - il_part_id [INTEGER; OUT]: partition ID
  - ig_paral [INTEGER, DIMENSION(:), IN]: vector of integers describing the local partition in the global index space; has a different expression depending on the type of the partition; in OASIS3-MCT, 4 types of partition are supported: Serial (no partition), Apple, Box, and Orange (see below).
  - ierror [INTEGER; OUT]: returned error code.
  - isize [INTEGER, OPTIONAL, IN]: Optional argument needed if the coupling data is exchanged for only a subdomain of the global grid; in this case, isize must give the total dimension of the grid (total number of points).

2.4.1 Serial (no partition)

This is the choice for a monoprocess model. In this case, we have ig_paral(1:3):
- ig_paral(1) = 0 (indicates a Serial “partition”)
2.4. PARTITION DEFINITION

Each partition is a segment of the global domain, described by its global offset and its local size. In this case, we have $ig_{paral}(1:3)$:

- $ig_{paral}(1) = 1$ (indicates an Apple partition)
- $ig_{paral}(2) =$ the segment global offset
- $ig_{paral}(3) =$ the segment local size

Figure 2.1 illustrates an Apple partition over 3 processes.

2.4.3 Box partition

Each partition is a rectangular region of the global domain, described by the global offset of its upper left corner, and its local extents in the X and Y dimensions. The global extent in the X dimension must also be given. In this case, we have $ig_{paral}(1:5)$:

- $ig_{paral}(1) = 2$ (indicates a Box partition)
- $ig_{paral}(2) =$ the upper left corner global offset
- $ig_{paral}(3) =$ the local extent in x

Figure 2.1: Apple partition. It is assumed here that the index start at 0 in the upper left corner.

- $ig_{paral}(2) = 0$
- $ig_{paral}(3) =$ the total grid size.
Figure 2.2: Box partition. It is assumed here that the index start at 0 in the upper left corner.

- \texttt{ig\_paral(4)} = the local extent in y
- \texttt{ig\_paral(5)} = the global extent in x.

Figure 2.2 illustrates a Box partition over 3 processes.

### 2.4.4 Orange partition

Each partition is an ensemble of segments of the global domain. Each segment is described by its global offset and its local extent. In this case, we have \texttt{ig\_paral(1:N)} where \( N = 2 + 2 \times \text{number of segments} \)

- \texttt{ig\_paral(1)} = 3 (indicates a Orange partition)
- \texttt{ig\_paral(2)} = the total number of segments for the partition (limited to 200 presently, see note for \texttt{ig\_paral(4)} for Box partition above)
- \texttt{ig\_paral(3)} = the first segment global offset
- \texttt{ig\_paral(4)} = the first segment local extent
- \texttt{ig\_paral(5)} = the second segment global offset
- \texttt{ig\_paral(6)} = the second segment local extent
- ...
- \texttt{ig\_paral(N-1)} = the last segment global offset
- \texttt{ig\_paral(N)} = the last segment local extent
2.5 COUPLING FIELD DECLARATION

Figure 2.3: Orange partition for one process. It is assumed here that the index start at 0 in the upper left corner.

Figure 2.3 illustrates an Orange partition with 3 segments for one process. The other process partitions are not illustrated.

2.5 Coupling field declaration

All component processes declares the fields sent or received by the component during the simulation. If some processes of a model are not involved in the coupling, they still have to call the same number of `oasis_def_var` than the ones participating to the coupling, even if the associated field symbolic names and partition ID (see `name` and `il_part_id` below) can then be anything.

- CALL `oasis_def_var (var_id, name, il_part_id, var_nodims, kinout, var_actual_shape, var_type, ierror)` or
- CALL `prism_def_var_proto(var_id, name, il_part_id, var_nodims, kinout, var_actual_shape, var_type, ierror)`
  - `var_id` [INTEGER; OUT]: coupling field ID\(^2\).
  - `name` [CHARACTER*8; IN]: field symbolic name (as in the `namcouple`)
  - `il_part_id` [INTEGER; IN]: partition ID (see section 2.4)
  - `var_nodims` [INTEGER, DIMENSION(2); IN]: `var_nodims(1)` is the rank of field array (1 or 2); `var_nodims(2)` is the number of bundles (always 1 in the current OASIS3-MCT version).

\(^2\)If the field does not appear in the `namcouple`, the returned field ID will be equal to -1 and corresponding `oasis_put` and `oasis_get` cannot be called in the code.
– *kinout [INTEGER; IN]*: OASIS In or PRISM In (i.e. = 15) for fields received by the model; OASIS Out, PRISM Out (i.e. = 14) for fields sent by the model.
– *var actual shape [INTEGER, DIMENSION(2 * var nodims(1)); IN]*: vector of integers giving the minimum and maximum index for each dimension of the coupling field array; for the current OASIS3-MCT version, the minimum index has to be 1 and the maximum index has to be the extent of the dimension.
– *var type [INTEGER; IN]*: type of coupling field array; put OASIS Real or PRISM Real (i.e. = 4) for single or double precision real arrays. All coupling data is treated as double precision in the coupling layer, but conversion to or from single precision data is supported in the interface.
– *ierror [INTEGER; OUT]*: returned error code.

### 2.6 End of definition phase

All component processes close the definition phase.

- CALL oasis enddef (ierror)
- CALL prism enddef_proto (ierror)
  - ierror [INTEGER; OUT]: returned error code.

### 2.7 Sending “put” and receiving “get” actions

#### 2.7.1 Sending a coupling (or I/O) field

In the model time step loop, each process sends its part of the coupling (or I/O) field.

- CALL oasis put (var id, date, fld1, fld2, fld3, fld4, fld5, info)
- CALL prism put proto (var id, date, fld1, fld2, fld3, fld4, fld5, info)
  - *var id [INTEGER; IN]*: field ID (from corresponding oasis def var, see section 2.5)
  - *date [INTEGER; IN]*: number of seconds (or any other time units as long as the same are used in all models and in the namcouple) at the time of the call (by convention at the beginning of the timestep)
  - *fld1 [REAL, IN]*: coupling (or I/O) field array; can be 1D or 2D
  - *fld2 [REAL, IN, OPTIONAL]*: optional 2nd coupling field array; can be 1D or 2D
  - *fld3 [REAL, IN, OPTIONAL]*: optional 3rd coupling field array; can be 1D or 2D
  - *fld4 [REAL, IN, OPTIONAL]*: optional 4th coupling field array; can be 1D or 2D
  - *fld5 [REAL, IN, OPTIONAL]*: optional 5th coupling field array; can be 1D or 2D
  - *info [INTEGER; OUT]*: returned info code:
    - *OASIS Sent (=4)* if the field was sent to another model
    - *OASIS LocTrans (=5)* if the field was only used in a time transformation (not sent, not output)
    - *OASIS ToRest (=6)* if the field was written to a restart file only
    - *OASIS Output (=7)* if the field was written to an output file only
    - *OASIS SentOut (=8)* if the field was both written to an output file and sent to another model (directly or via OASIS3 main process)

---

3 Parameters OASIS In, PRISM In, OASIS Out, PRISM Out are defined in oasis3-mct/lib/psmile/src/mod_oasis_parameters.F90
2.7. SENDING "PUT" AND RECEIVING "GET" ACTIONS

* OASIS_ToRestOut (=9) if the field was written both to a restart file and to an output file.
* OASIS_Ok (=0) otherwise and no error occurred.

To ensure a proper use of the `oasis_put`, one has to take care of the following aspects:

- A 2nd, 3rd, 4th and 5th source field can be passed as optional arguments. If so, the 2nd, 3rd, 4th and 5th set of weights present in the remapping file will be applied, respectively (see section 5.4 for the weight file format). This will be used for example for the SCRIPR/BICUBIC remapping for which a 1st, 2nd, 3rd, 4th set of weights should be respectively applied to the field value, its gradient in the first dimension, its gradient in the second dimension, and its cross-gradient. With OASIS3-MCT_2.0 and following versions, bicubic and higher order remapping are therefore supported given that the higher order fields are provided at each time step as `oasis_put` arguments. Note that if `fld3` is passed, `fld2` must also be passed; if `fld4` is passed, `fld3` and `fld2` must also be passed; and if `fld5` is passed, `fld4`, `fld3` and `fld2` must also be passed. However, having a 2nd, 3rd, 4th and 5th set of weights in the remapping file but not passing a 2nd, 3rd, 4th and 5th source field as argument will not lead to an error; the appropriate set of weights will simply be applied to the fields provided as arguments.

- Trying to send with `oasis_put` a field declared with a `oasis_def_var` but not defined in the configuration file `namcouple` will lead to an abort. In this case, the field ID returned by the `oasis_def_var` is equal to -1 and the corresponding `oasis_put` should not be called.

- This routine may be called by the model at each timestep. The convention for the `date` argument is to indicate the time at the beginning of the timestep. The sending is actually performed only if the time obtained by adding the field lag (`LAG` in the `namcouple`) to the `date` corresponds to a time at which it should be activated, given the coupling or I/O period indicated by the user in the `namcouple` (see section 3).

- If the convention for `date` is followed, the first coupling of a run should occur at time=0 and the final coupling should occur at time = runtime - cpl_period, where runtime is the total time of the run and cpl_period is the coupling period.

- The total run time should match an integer number of coupling periods.

- If a coupling field has a positive lag, the coupling field that matches the `oasis_get` at time=0 will come from a coupling restart file written by the last active `oasis_put` of the previous run (see section 2.10). For a coupling field with a positive lag, the coupling restart file (see section 5.2) is automatically overwritten by the `oasis_put` when the time (i.e. `date+LAG`) equals to the total runtime.

- If a local time transformation is indicated for the field by the user in the `namcouple` (INSTANT, AVERAGE, ACCUMUL, T_MIN or T_MAX, see section 4), it is automatically performed and the resulting field is finally sent at the coupling or I/O frequency. For non-instant transformations, partially transformed fields will be written to the restart file at the end of the run for use on the next model startup.

- A coupling field sent by a source component model can be associated with more than one target field and model, if specified as so with different entries in the `namcouple` configuration file. In that case, the source model needs to send the field only once and the corresponding data will arrive at multiple targets as specified in the `namcouple`. Different coupling frequencies and transformations are allowed for different coupling exchanges of the same field. If coupling restart files are required (either if a `LAG` or if a LOCTRANS transformation is specified), it is mandatory to specify different files for the different fields.

2.7.2 Receiving a coupling (or I/O) field

In the model time stepping loop, each process receives its part of the coupling field.

- CALL `oasis_get` (`var_id`, `date`, `fld`, `info`)
CALL prism_get_proto(var_id, date, fld, info)
- var_id [INTEGER; IN]: field ID (from the corresponding oasis_def_var)
- date [INTEGER; IN]: number of seconds (or any other time units as long as the same are used in all models and in the namcouple) at the time of the call (by convention at the beginning of the timestep)
- fld [REAL, OUT]: I/O or coupling field array
- info [INTEGER; OUT]: returned info code:
  * OASIS_Recvd (=3) if the field was received from another model
  * OASIS_FromRest (=10) if the field was read from a restart file only
  * OASIS_Input (=11) if the field was read from an input file only
  * OASIS_RecvOut (=12) if the field was both received from another model and written to an output file
  * OASIS_FromRestOut (=13) if the field was both read from a restart file and written to an output file
  * OASIS_OK (=0) otherwise and no error occurred.

This routine may be called by the model at each timestep. The date argument is automatically analysed and the receiving action is actually performed only if date corresponds to a time for which it should be activated, given the period indicated by the user in the namcouple. An exchange at the beginning of the run at time=0 is expected.

Trying to receive with oasis_get a field declared with a oasis_def_var but not defined in the configuration file namcouple will lead to an abort. In this case, the field ID returned by the oasis_def_var is equal to -1 and the corresponding oasis_get should not be called.

2.8 Termination

- CALL oasis_terminate (ierror)
- CALL prism_terminate_proto(ierr)
  - ierr [INTEGER; OUT]: returned error code.

All processes of the component model must terminate the coupling by calling this routine⁴ (normal termination).

2.9 Auxiliary routines

Not all auxiliary routines that were in OASIS3.3 are currently available.

- CALL oasis_abort (compid, routine_name, abort_message)
- CALL prism_abort_proto(compid, routine_name, abort_message)
  - compid [INTEGER; IN]: component model ID (from oasis_init_comp or prism_init_comp_proto)
  - routine_name[CHARACTER*; IN]: name of calling routine
  - abort_message[CHARACTER*; IN]: message to be written out.

If a process needs to abort voluntarily, it should do so by calling oasis_abort. This will ensure a proper termination of all processes in the coupled model communicator. This routine writes the

⁴If the process called MPI_Init (before calling oasis_init_comp or prism_init_comp_proto), it must also call MPI_Finalize explicitly, but only after calling oasis_terminate_proto or prism_terminate_proto.
2.10. COUPLING ALGORITHMS - SEQ AND LAG CONCEPTS

Using the OASIS3-MCT coupling library, the user has full flexibility to reproduce different coupling algorithms. In the components, the sending and receiving routines, respectively **oasis_put** and **oasis_get**, can be called at each model timestep, with the appropriate **date** argument giving the actual time (at the beginning of the timestep), expressed in number of seconds since the start of the run or in any other time units, as long as the same are used in all models and in the **namcouple** (see section 2.7.1). This **date** argument is automatically analysed by the coupling library and depending on the coupling period and the lag (LAG) chosen by the user for each coupling field in the configuration file **namcouple**, different coupling algorithms can be reproduced without modifying the component model codes themselves.

With OASIS3-MCT, the **SEQ** index is no longer needed in the **namcouple** input to specify the sequencing order of different coupling fields. The sequence (SEQ) index in the **namcouple** file now provides the coupling layer with an ability to detect a deadlock before it happens and exit.

The lag concept and indices are explained in more detail below and some examples are provided.
2.10.1 The lag concept

The lag (LAG) value tells the coupler to modify the time at which that data is sent (put) by the amount of the lag. The lag must be expressed in the time unit used (that must be the same in the models and in the namcouple, see section 2.7.1) and can be positive or negative but should never be larger (in absolute magnitude) than the coupling period of any field due to problems with restartability and dead-locking. When a component model calls a oasis_put, the value of the lag is automatically added to the value of the date argument and the “put” is actually performed when the sum date+lag is a coupling time; in the target component, this “put” will match a oasis_get for which the date argument is the same coupling time. The lag only shifts the time data is sent. It cannot be used to shift the time data is received yet.

When the lag is positive, a restart file must be available to initiate the coupling and in those cases, the restart file is then updated at the end of the run. A positive lag acts like a send occurred before the model started. In fact, for a field with positive lag, the source component model automatically reads the field in the restart file during the coupling initialization phase (below the oasis_enddef) and send the data to match the oasis_get performed at time=0 in the target component model. The final coupling data on the source side will then be automatically written to the restart file for use in the next run.

When there is a lag, the first and last instance of the source field in the debug netCDF file (EXPOUT fields, see section 3.3) always correspond respectively to the field read from and written to the restart file.

1. LAG concept first example

A first coupling algorithm, exploiting the LAG concept, is illustrated on figure 2.4.

On the 4 figures in this section, short black arrows correspond to oasis_put or oasis_get called in the component model that do not lead to any “put” or receiving action; long black arrows correspond to oasis_put or oasis_get called in the component models that do actually lead to a “put” or “get” action; long red arrows correspond to oasis_put or oasis_get called in the component models that lead to a reading or writing of the coupling field from or to a coupling restart file.

During a coupling timestep, model A receives $F_2$ and then sends $F_1$; its timestep length is 4. During a coupling timestep, model B receives $F_1$ and then sends $F_2$; its timestep length is 6. $F_1$ and $F_2$ coupling periods are respectively 12 and 24. If $F_1/F_2$ “put” action by model A/B was used at a coupling timestep to match the model B/A “get” action, a deadlock would occur as both models would be initially waiting on a “get” action. To prevent this, $F_1$ and $F_2$ produced at the timestep before have to be used to match respectively the model B and model A “get” actions.

This implies that a lag of respectively 4 and 6 seconds must be defined for $F_1$ and $F_2$. For $F_1$, the oasis_put performed at time 8 and 20 by model A will then lead to “put” actions (as $8 + 4 = 12$ and $20 + 4 = 24$ which are coupling periods) that match the “get” actions performed at times 12 and 24 below the oasis_get called by model B. For $F_2$, the oasis_put performed at time 18 by model B then leads to a “put” action (as $18 + 6 = 24$ which is a coupling period) that matches the “get” action performed at time 24 below the oasis_get called by model A.

At the beginning of the run, as their LAG index is greater than 0, the first oasis_get of $F_1$ and $F_2$ will automatically be fulfilled with fields read from their respective coupling restart files. The user therefore has to create those coupling restart files before the first run in the experiment. At the end of the run, $F_1$ having a lag greater than 0, is automatically written to its coupling restart file below the last $F_1$ oasis_put as the date+lag equals the total run time. The analogue is true for $F_2$. These values will automatically be read in at the beginning of the next run below the respective oasis_get.

2. LAG concept second example

A second coupling algorithm exploiting the LAG concept is illustrated on figure 2.5. During its timestep, model A receives $F_2$, sends $F_3$ and then $F_1$; its timestep length is 6. During its timestep,
2.10. COUPLING ALGORITHMS - SEQ AND LAG CONCEPTS

Model B  timestep = 6

Model A  timestep = 4

\[
\begin{align*}
Cpl\_period(F_1) &= 12 \\
Cpl\_period(F_2) &= 24 \\
LAG(F_1) &= 4 \\
LAG(F_2) &= 6
\end{align*}
\]

Figure 2.4: LAG concept first example
model B receives $F_1$, receives $F_3$ and then sends $F_2$; its timestep length is also 6. $F_1$, $F_2$ and $F_3$ coupling periods are both supposed to be equal to 12.

For $F_1$ and $F_2$ the situation is similar to the first example. If $F_1/F_2$ “put” action by model A/B was used at a coupling timestep to match the model B/A “get” action, a deadlock would occur as both models would be waiting on a “get” action. To prevent this, $F_1$ and $F_2$ produced at the timestep before have to be used to match the model A and model B “get” actions, which means that a lag of 6 must be defined for both $F_1$ and $F_2$. For both coupling fields, the oasis.put performed at times 6 and 18 by the source model then lead to “put” actions (as $6 + 6 = 12$ and $18 + 6 = 24$ which are coupling periods) that match the “get” action performed at time 12 and 24 below the oasis.get called by the target model.

For $F_3$, sent by model A and received by model B, no lag needs to be defined: the coupling field produced by model A at the coupling timestep can be “consumed” by model B without causing a deadlock situation.

As in the first example, the oasis.get performed at the beginning of the run for $F_1$ and $F_2$, will automatically receive data read from their coupling restart files, and the last oasis.put performed at the end of the run automatically write them to their coupling restart file. For $F_3$, no coupling restart file is needed nor used as at each coupling period the coupling field produced by model A can be directly “consumed” by model B.

We see here how the introduction of appropriate LAG indices results in receiving in the target model the coupling fields produced by the source model the timestep before; this is, in some coupling configurations, essential to avoid deadlock situations.
2.10.2 The sequence concept

The order of coupling operations in the system is determined solely by the order of calls to send (put) and receive (get) data in the models in conjunction with the setting of the lag in the namcouple. Data that is received (get) is always blocking while data that is sent (put) is non-blocking with respect to the model making that call. It is possible to deadlock the system if the relative orders of puts and gets in different models are not compatible.

With OASIS3-MCT, the sequence (SEQ) index in the namcouple file now provides the coupling layer with an ability to detect a deadlock before it happens and exit. It does this by tracking the order of get and put calls in models compared to the SEQ specified in the namcouple. If there are any inconsistencies, the model will abort gracefully with a useable error message before the system deadlocks. If there are any coupling dependencies in the system, use of the SEQ index is recommended for diagnosis but has no impact on the ultimate solution and is NOT required.

Take the following two examples. In both examples, there are two models, each “put” a field to the other at every coupling period without any lags. In the first case, there is no dependency and each model sends (puts) the data first and then receives the data second at each timestep.

```
model1     model2
------ -----
put(fld1)  put(fld2)
get(fld2)  get(fld1)
```

The put from model1 for fld1 is received by the get in model2 and the put from model2 for fld2 is received by the get in model1. In this case, there is no sequencing dependency and the value of SEQ must be identical (or unset) in the namcouple description of the fld1 and fld2 coupling. If SEQ is set to 1 for fld1 and 2 for fld2 in this case, then the model will abort because at runtime, the coupling will detect, in model 2, that fld2 was sent before fld1 was received which is out of sequence as defined by the SEQ settings.

In the next example, there is a dependency in the sequencing.

```
model1     model2
------ -----
put(fld1)  get(fld1)
         fld2=g(fld1)
get(fld2)  put(fld2)
```

In model2, fld2 depends on fld1. If this dependency is known, then there is a benefit in using SEQ=1 for fld1 and SEQ=2 for fld2. At runtime, if the sequencings of both model1 and model2 do not match the above diagram, the model will abort gracefully. For instance, if model2 has the dependency shown above but model1 does not have consistent ordering of the put and get as required by model2, then if SEQ is unused, the model will deadlock and hang. If SEQ is set properly, the coupling layer will detect that the required sequence has not been followed and will exit gracefully with an error message.

Again, the SEQ namecouple setting is only diagnostic and is not required.
Chapter 3

The configuration file *namcouple*

The OASIS3-MCT configuration file *namcouple* contains, below pre-defined keywords, all user’s defined information necessary to configure a particular coupled run.

The *namcouple* is a text file with the following characteristics:

- the keywords used to separate the information can appear in any order;
- the number of blanks between two character strings is non-significant;
- all lines beginning with # are ignored and considered as comments.
- blank lines are not allowed.

The first part of *namcouple* is devoted to configuration of general parameters such as the number of models involved in the simulation or the number of fields. The second part gathers specific information on each coupling (or I/O) field, e.g. their coupling period, the list of transformations or interpolations to be performed by OASIS3-MCT and associated configuring lines (described in more details in chapter 4), etc.

In OASIS3-MCT, several *namcouple* inputs have been deprecated but, for backwards compatibility, they are still allowed. These inputs will be noted in the following text using the notation “UNUSED” and not fully described. Information below these keywords is obsolete in OASIS3-MCT; it will not be read and will not be used.

In the next sections, a simple *namcouple* example is given and all configuring parameters are described. The additional lines containing the different parameters required for each transformation are described in section 4. A realistic *namcouple* can be found in oasis3-mct/examples/tutorial/data_oasis3/ directory.

3.1 An example of a simple *namcouple*

The following simple *namcouple* configures a run into which an ocean, an atmosphere and an atmospheric chemistry models are coupled. The ocean provides only the SOSSTSSST field to the atmosphere, which in return provides the field CONSFTOT to the ocean. One field (COSENHFL) is exchanged from the atmosphere to the atmospheric chemistry, and one field (SOALBEDO) is read from a file by the ocean.

```
# First section
#$SEQMODE
#$CHANNEL
```
$NFIELDS
  4
#
$JOBNAME
#
$NBMODEL
  3 ocemod atmmmod chemod 55 70 99
#
$RUNTIME
  432000
#
$INIDATE
#
$MODINFO
#
$NLOGPRT
  2 1
#
$CALTYPE
#
# Second section
$STRINGS
#
# Field 1
SOSSTSST SISUTESU 1 86400 5 sstoc.nc EXPORTED
  182 149 128 64 toce atmo LAG=+14400 SEQ=+1
P 2 P 0
LOCTRANS CHECKIN MAPPING BLASNEW CHECKOUT
#
  AVERAGE
  INT=1
  map_toce_atmo_120315.nc src opt
  CONSTANT 273.15
  INT=1
#
# Field 2
CONSFTOT SOHEFLDO 6 86400 4 flxat.nc EXPORTED
  atmo toce atmo LAG=+14400 SEQ=+2
P 0 P 2
LOCTRANS CHECKIN SCRIPR CHECKOUT
#
  ACCUMUL
  INT=1
  BILINEAR LR SCALAR LATLON 1
  INT=1
#
# Field 3
COSENHFL SOSENHFL 37 86400 1 flda3.nc IGNOUT
atmo atmo LAG=+7200
LOCTRANS
3.2 First section of namcouple file

The first section of namcouple uses some predefined keywords prefixed by the $ sign to locate the related information. The $ sign must be in the second column. The first ten keywords are described hereafter:

- $SEQMODE: UNUSED
- $CHANNEL: UNUSED
- $NFIELDS: On the line below this keyword is the total number of field entries in the second part of the namcouple. If more than one field are described on the same line (new in OASIS3-MCT_1.0, see appendix B.2.4) this counts as only one entry.
- $JOBNAME: UNUSED
- $NBMODEL: On the line below this keyword is the number of models running in the given experiment followed by CHARACTER*6 variables giving their names, which must correspond to the name announced by each model when calling oasis_init_comp (second argument, see section 2.2). Then the user may indicate on the same line the maximum Fortran unit number used by the models. In the example, Fortran units above 55, 70, and 99 are free for respectively the ocean, atmosphere, and atmospheric chemistry models. In all cases, OASIS3-MCT library assumes, during the initialization phase, that units 1025 and 1026 are free, unless maximum unit numbers are indicated here in the namcouple.
- $RUNTIME: On the line below this keyword is the total simulated time of the run, expressed in seconds (or any other time units as long as the same are used in all models and in the namcouple, see 2.7).
- $INIDATE: UNUSED
- $MODINFO: UNUSED
- $NLOGPRT: The first and second numbers on the line below this keyword refer to the amount of debug and time statistic information written by OASIS3-MCT for each model and processor. The first number (that can be changed at runtime with the oasis_set_debug routine, see section 2.9) may be:
  - 0 : one file debug.root.xx is open by the master process of each model and one file debug.notroot.xx is open for all the other processes of each model to write only error information.
  - 1 : one file debug.root.xx is open by the master process of each model to write information equivalent to level 10 (see below); one file debug_notroot.xx is open for all the other processes of each model to write error information.
  - 2 : one file debug.xx.xxxxxx is open by each process of each model to write normal production diagnostics
  - 5 : as for 2 with in addition some initial debug info
  - 10: as for 5 with in addition the routine calling tree
  - 12: as for 10 with in addition some routine calling notes
  - 15: as for 12 with even more debug diagnostics
3.3. SECOND SECTION OF NAMCOUPLE FILE

- 20: as for 15 with in addition some extra runtime analysis
- 30: full debug information

The second number defines how time statistics are written out to file *.timers_xxxx; it can be:
- 0: nothing is calculated, nothing is written.
- 1: some time statistics are calculated and written in a single file by the processor 0 as well as the min and the max times over all the processors.
- 2: some time statistics are calculated and each processor writes its own file; processor 0 also writes the min and the max times over all the processors in its file.
- 3: some time statistics are calculated and each processor writes its own file; processor 0 also writes in its file the min and the max times over all processors and also writes in its file all the results for each processor.

For more information on the time statistics written out, see section 6.4.2.

- $SCALTYPE$: UNUSED

3.3 Second section of namcouple file

The second part of the namcouple, starting after the keyword $STRINGS, contains coupling information for each coupling (or I/O) field. Its format depends on the field status given by the last entry on the field first line (EXPORTED, IGNOUT or INPUT in the example above). The field may be:

- AUXILIARY: UNUSED
- EXPORTED: exchanged between component models and transformed by OASIS3-MCT
- EXPOUT: exchanged, transformed and also written to two debug NetCDF files, one before the sending action in the source model below the oasis_put call (after local transformations LOCTRANS and BLASOLD if present), and one after the receiving action in the target model below the oasis_get call (after all transformations). EXPOUT should be used when debugging the coupled model only. The name of the debug NetCDF file (one per field) is automatically defined based on the field and component model names.
- IGNORED: with OASIS3-MCT, this setting is equivalent to and converted to EXPORTED
- IGNOUT: with OASIS3-MCT, this setting is equivalent to and converted to EXPOUT
- INPUT: read in from the input file by the target model below the oasis_get call at appropriate times corresponding to the input period indicated by the user in the namcouple. See section 5.3 for the format of the input file.
- OUTPUT: written out to an output debug NetCDF file by the source model below the oasis_put call, after local transformations LOCTRANS and BLASOLD, at appropriate times corresponding to the output period indicated by the user in the namcouple.

3.3.1 Second section of namcouple for EXPORTED and EXPOUT fields

The first 3 lines for fields with status EXPORTED and EXPOUT are as follows:

```
SOSSTSST SISUTESU 1 86400 5 sstoc.nc EXPORTED
182 149 128 64 toce atmo LAG=+14400 SEQ=+1
P 2 P 0
```

where the different entries are:

- Field first line:
  - SOSSTSST: symbolic name for the field in the source model (CHARACTER*8). It has to match the argument name of the corresponding field declaration in the source model; see oasis_def.var in section 2.5.
– **SISUTESU**: symbolic name for the field in the target model (CHARACTER*8). It has to match the argument name of the corresponding field declaration in the target model; see `oasis_def_var` in section 2.5
– 1: UNUSED but still required for parsing
– 86400: coupling and/or I/O period for the field, in seconds
– 5: number of transformations to be performed by OASIS3 on this field
– `sstoc.nc`: name of the coupling restart file for the field (CHARACTER*8); mandatory even if no coupling restart file is effectively used (for more detail, see section 5.2)
– `EXPORTED`: field status

• Field second line:
  – 182: number of points for the source grid first dimension (optional)
  – 149: number of points for the source grid second dimension (optional)
  – 128: number of points for the target grid first dimension (optional)
  – 64: number of points for the target grid second dimension (optional)

  These source and target grid dimensions are optional but note that in order to have 2D fields written as 2D arrays in the debug files, these dimensions must be provided in the `namcouple`; otherwise, the fields will be written out as 1D arrays.

  – `toce`: prefix of the source grid name in grid data files (see section 5.1) (CHARACTER*4)
  – `atmo`: prefix of the target grid name in grid data files (CHARACTER*4)
  – `LAG=+14400`: optional lag index for the field (see section 2.10.1)
  – `SEQ=+1`: optional sequence index for the field (see section 2.10.2)

• Field third line
  – 2: source grid first dimension number of overlapping grid points.
  – 0: target grid first dimension number of overlapping grid points.

The fourth line gives the list of transformations to be performed for this field. In addition, there is one or more configuring lines describing some parameters for each transformation. These additional lines are described in more details in the chapter 4.

### 3.3.2 Second section of namcouple for OUTPUT fields

The first 2 lines for fields with status `OUTPUT` are as follows:

```
COSHFTOT  COSHFTOT  7  86400  0  fldhftot.nc  OUTPUT
atmo  atmo
```

where the different entries are as for `EXPOUT` fields, except that:

- the source symbolic name must be repeated twice on the field first line,
- the restart file name (here `fldhftot.nc`) is needed only if a `LOCTRANS` transformation is present,
- there is no output file name on the first line,
- there is no grid dimension\(^1\) and no LAG or SEQ index on the second line;

The name of the output file is automatically defined based on the field and component model names.

The third line is `LOCTRANS` if this transformation is chosen for the field. Note that `LOCTRANS` is the only transformation supported for `OUTPUT` fields.

---

\(^1\)For 1D field, put 1 as the second dimension

\(^2\)This means that all output fields will be written out in the output files as 1D arrays (this should be fixed in the next OASIS3-MCT version).
3.3.3 Second section of namcouple for INPUT fields

The first and only line for fields with status INPUT is:

```
SOALBEDO SOALBEDO 17 86400 0 SOALBEDO.nc INPUT
```

where the different entries are:

- **SOALBEDO**: symbolic name for the field in the target model (CHARACTER*8 repeated twice)
- **17**: index in auxiliary file cf_name_table.txt (see above for EXPORTED fields)
- **86400**: input period in seconds
- **0**: number of transformations (always 0 for INPUT fields)
- **SOALBEDO.nc**: CHARACTER*32 giving the input file name (for more detail on its format, see section 5.3)
- **INPUT**: field status.
Chapter 4

Transformations and interpolations

Different transformations and 2D interpolations are available in OASIS3-MCT to adapt the coupling fields from a source model grid to a target model grid. In the following paragraphs, a description of each transformation with its corresponding configuration lines that the user has to write in the namcouple file is given. Features that are now deprecated (non functional) compared to prior versions will be noted with the string UNUSED but not described.

4.1 Time transformations

- **LOCTRANS**: LOCTRANS requires one configuring line on which a time transformation, automatically performed below the call to oasis_put, should be indicated:

  # LOCTRANS operation
  $TRANSFORM

  where $TRANSFORM can be
  - **INSTANT**: no time transformation, the instantaneous field is transferred;
  - **ACCUMUL**: the field accumulated over the previous coupling period is exchanged (the accumulation is simply done over the arrays field_array provided as third argument to the oasis_put calls, not weighted by the time interval between these calls);
  - **AVERAGE**: the field averaged over the previous coupling period is transferred (the average is simply done over the arrays field_array provided as third argument to the oasis_put calls, not weighted by the time interval between these calls);
  - **T_MIN**: the minimum value of the field for each source grid point over the previous coupling period is transferred;
  - **T_MAX**: the maximum value of the field for each source grid point over the previous coupling period is transferred;
  - **ONCE**: UNUSED; not supported in OASIS3-MCT.

With OASIS3-MCT, time transformations are supported more generally with use of the coupling restart file. The coupling restart file allows the partial time transformation to be saved at the end of a run for exact restart at the start of the next run. For that reason, coupling restart filenames are now required for all namcouple entries that use LOCTRANS (with non INSTANT values). This is the reason an optional restart file is now provided on the OUTPUT namcouple input line.
4.2 The pre-processing transformations

- **REDGLO** UNUSED
- **INVERT**: UNUSED
- **MASK**: UNUSED
- **EXTRAP**: UNUSED
- **CHECKIN**: CHECKIN calculates the global minimum, the maximum and the sum of the source field values (not weighted by the grid cell area) and prints them to the OASIS3-MCT debug file (for the master process of the source component model only). This operation does not transform the field.

The generic input line is as follows:

```plaintext
# CHECKIN operation
INT = 1
```

- **CORRECT**: UNUSED
- **BLASOLD**: BLASOLD allows the source field to be scaled and allows a scalar to be added to the field. The prior ability to perform a linear combination of the current coupling field with other coupling fields has been deprecated in OASIS3-MCT. This transformation occurs before the interpolation per se.

This transformation requires at least one configuring line with two parameters:

```plaintext
# BLASOLD operation
$XMULT  $NBFIELDS
```

where `$XMULT` is the multiplicative coefficient of the source field, which must be given as a REAL value (e.g. 2.0 and not 2). `$NBFIELDS` must be 0 if no scalar needs to be added or 1 if a scalar needs to be added. In this last case, an additional input line is required where `$AVALUE` is the scalar to be added to the field, which must also be given as a REAL value:

```plaintext
CONSTANT  $AVALUE
```

4.3 The remapping (interpolation)

- **MAPPING**: The MAPPING keyword is used to specify an input file to be read and used for mapping (i.e. regridding or interpolation); the MAPPING file must follow the SCRIPR format. This is an alternative method to SCRIPR for setting the mapping file.

Since OASIS3-MCT 2.0, MAPPING can be used for higher order remapping. Up to 5 different sets of weights (see section 5.4 for the weight file format) can be applied to up to 5 different fields transferred as `oasis.put` arguments (see section 2.7.1).

This transformation requires at least one configuring line with one filename and two optional string values:

```plaintext
$MAPNAME  $MAPLOC  $MAPSTRATEGY
```

- `$MAPNAME` is the name of the mapping file to read. This is a NetCDF file consistent with the SCRIPR map file format (see section 5.3).
- `$MAPLOC` is optional and can be either `src` or `dst`. With `src`, the mapping will be done in parallel on the source processors before communication to the destination model processes; this is the default. With `dst`, the mapping is done on the destination processes after the source grid data is sent from the source model.
$MAPSTRATEGY$ is optional and can be either $bfb$, $sum$, or $opt$. In $bfb$ mode, the mapping is done using a strategy that produces bit-for-bit identical results regardless of the grid decompositions without leveraging a partial sum computation; this is the default. With $sum$, the transform is done using the partial sum approach which generally introduces roundoff level changes in the results on different processor counts. Option $opt$ allows the coupling layer to choose either approach based on an analysis of which strategy is likely to run faster. Usually, partial sums will be used if the source grid has a higher resolution than the target grid as this should reduce the overall communication (e.g. for conservative remapping).

Note that if $SCRIPR$ (see below) is used to calculate the remapping file, $MAPPING$ can still be listed in the namcouple to specify a name for the remapping file generated by $SCRIPR$ different from the default and/or to specify a $MAPLOC$ or $MAPSTRATEGY$ option.

- **$SCRIPR$**:

  $SCRIPR$ gathers the interpolation techniques offered by Los Alamos National Laboratory SCRIP 1.4 library (Jones 1999)$^1$. $SCRIPR$ routines are in oasis3-mct/lib/scrip. See the SCRIP 1.4 documentation in oasis3/doc/SCRIPusers.pdf for more details on the interpolation algorithms.

  When the SCRIP library performs a remapping, it first checks if the file containing the corresponding remapping weights and addresses exists; if it exists, it reads them from the file; if not, it calculates them and store them in a file. The file is created in the working directory and is called $\text{rmp}_{\text{srcg}}_{\text{tggt}}_{\text{INTTYPE}}_{\text{NORMALAOPT}}.\text{nc}$, where $\text{srcg}$ and $\text{tggt}$ are the acronyms of respectively the source and the target grids, $\text{INTTYPE}$ is the interpolation type, i.e. DISTWGT, GAUSWGT, BILINEAR (not BILINEA as in OASIS3.3) or CONSERV -see below, and $\text{NORMALAOPT}$ is the normalization option, i.e. DESTAREA, FRACAREA or FRACNNEI for CONSERV only -see below). One has to take care that the remapping file will have the same name even if other details, like the grid masks, are changed. When reusing a remapping file, one has to be sure that it was generated in exactly the same conditions than the ones it is used for.

  The following types of interpolations are available:

  - **DISTWGT** performs a distance weighted nearest-neighbour interpolation (N neighbours). All types of grids are supported.
    * Masked target grid points: the zero value is associated to masked target grid points.
    * Non-masked target grid points having some of the N source nearest neighbours masked: a nearest neighbour algorithm using the remaining non masked source nearest neighbours is applied.
    * Non-masked target grid points having all of the N source nearest neighbours masked: by default, the nearest non-masked source neighbour is used (logical $\text{ll}_\text{nnei}$ hard-coded to $\text{true}$ in oasis3-mct/lib/scrip/src/remap_distwgt.F; same default behaviour as OASIS3.3).

  The configuring line is:

  ```
  # SCRIPR (for DISWGT)
  $\text{CMETH} \text{ CGRS} \text{ CFTYP} \text{ REST} \text{ NBIN} \text{ NV} \text{ ASSCMP} \text{ PROJCART}
  ```

  where:

  * $\text{CMETH} = \text{DISTWGT}$.
  * $\text{CGRS}$ is the source grid type (LR, D or U)- see appendix A.
  * $\text{CFTYP}$ is the field type: SCALAR. The option VECTOR, which in fact leads to a scalar treatment of the field (as in the previous versions), is still accepted. VECTOR_1 or

---

$^1$See also http://climate.lanl.gov/Software/SCRIP/ and the copyright statement in appendix 1.3.3.
4.3. THE REMAPPING (INTERPOLATION)

VECTOR J, i.e. vector fields, are not supported anymore in OASIS3-MCT. See “Support of vector fields with the SCRIPR remappings” below.

* $REST is the search restriction type: LATLON or LATITUDE (see SCRIP 1.4 documentation SCRIPusers.pdf).

* $NBIN the number of restriction bins (see SCRIP 1.4 documentation SCRIPusers.pdf).

Note that for D or U grid, the restriction may influence slightly the result near the borders of the restriction bins.

* $NV is the number of neighbours used.

* $ASSCMP: UNUSED; vector fields are not supported anymore in OASIS3-MCT. See “Support of vector fields with the SCRIPR remappings” below.

* $PROJCART: UNUSED; vector fields are not supported anymore in OASIS3-MCT. See “Support of vector fields with the SCRIPR remappings” below.

– GAUSWGT performs a N nearest-neighbour interpolation weighted by their distance and a gaussian function. All grid types are supported.

* Masked target grid points: the zero value is associated to masked target grid points.

* Non-masked target grid points having some of the N source nearest neighbours masked: a nearest neighbour algorithm using the remaining non masked source nearest neighbours is applied.

* Non-masked target grid points having all of the N source nearest neighbours masked: by default, the nearest non-masked source neighbour is used (logical ll_nnei hard-coded to .true. in oasis3-mct/lib/scrip/src/remap_gauswgt.F); this is NOT the same default behaviour as OASIS3.3; to have the same default behaviour as in OASIS3.3, put ll_nnei=.false..

The configuring line is:

```
# SCRIPR (for GAUSWGT)
$CMETH $CGRS $CFTYP $REST $NBIN $NV $VAR
```

where: all entries are as for DISTWGT, except that:

* $CMETH = GAUSWGT

* $VAR, which must be given as a REAL value (e.g 2.0 and not 2), defines the weight given to a neighbour source grid point as proportional to \( \exp(-1/2 \cdot d^2/\sigma^2) \) where \( d \) is the distance between the source and target grid points, and \( \sigma^2 = \text{VAR} \cdot \bar{d}^2 \) where \( \bar{d}^2 \) is the average distance between two source grid points (calculated automatically by OASIS3-MCT).

– BILINEAR performs an interpolation based on a local bilinear approximation (see details in chapter 4 of SCRIP 1.4 documentation SCRIPusers.pdf). Logically-Rectangular (LR) and Reduced (D) source grid types are supported.

– BICUBIC performs an interpolation based on a local bicubic approximation for Logically-Rectangular (LR) grids (see details in chapter 5 of SCRIP 1.4 documentation SCRIPusers.pdf), and on a 16-point stencil for Gaussian Reduced (D) grids. Note that for Logically-Rectangular grids, 4 weights for each of the 4 enclosing source neighbours are required corresponding to the field value at the point, the gradient of the field with respect to \( i \), the gradient of the field with respect to \( j \), and the cross gradient with respect to \( i \) and \( j \) in that order. OASIS3-MCT will calculate the remapping weights and addresses (if they are not already provided) but will not, at run time, calculate the two gradients and the cross-gradient of the source field (as was the case with OASIS3.3). These 3 extra fields need to be calculated by the source code and transferred as extra arguments of the oasis_put (see fld2, fld3, fld4 in section 2.7.1).

For both BILINEAR and BICUBIC:

* Masked target grid points: the zero value is associated to masked target grid points.
Non-masked target grid points having some of the source points normally used in the bilinear or bicubic interpolation masked: a N nearest neighbour algorithm using the remaining non masked source points is applied.

Non-masked target grid points having all bilinear or bicubic neighbours masked: by default, the nearest non-masked source neighbour is used (ll_nnei hard-coded to .true. in oasis3-mct/lib/scrip/src/remap_bilinear.f, remap_bicubic.f and remap_bicubic_reduced.f); this is not the same default behaviour as OASIS3.3; to have the same default behaviour as in OASIS3.3, put ll_nnei=.false. in the appropriate routine.

For both BILINEAR and BICUBIC, the configuring line is:

```
# SCRIPR (for BILINEAR or BICUBIC)
$CMETH $CGRS $CFTYP $REST $NBIN
```

where:

- `$CMETH = BILINEAR or BICUBIC`
- `$CGRS` is the source grid type: LR or D.
- `$CFTYP, $NBIN` are as for DISTWGT.
- `$REST` is as for DISTWGT, except that only LATITUDE is possible for a Reduced (D) source grid.

- CONSERV performs 1st or 2nd order conservative remapping, which means that the weight of a source cell is proportional to area intersected by the target cell (plus some other terms proportional to the gradient of the field in the longitudinal and latitudinal directions for the second order).

The configuring line is:

```
# SCRIPR (for CONSERV)
$CMETH $CGRS $CFTYP $REST $NBIN $NORM $ORDER
```

where:

- `$CMETH = CONSERV`
- `$CGRS` is the source grid type: LR, D and U. Note that the grid corners have to be given by the user in the grid data file grids.nc or by the code itself in the initialisation phase by calling routine oasis_write_corner (see section 2.3); OASIS3-MCT will not attempt to automatically calculate them as OASIS3.3.
- `$CFTYP, $REST, $NBIN` are as for DISTWGT.
- `$NORM` is the NORMalization option:
  - `FRACAREA`: The sum of the non-masked source cell intersected areas is used to NORMALise each target cell field value: the flux is not locally conserved, but the flux value itself is reasonable.
  - `DESTAREA`: The total target cell area is used to NORMALise each target cell field value even if it only partly intersects non-masked source grid cells: local flux conservation is ensured, but unreasonable flux values may result.
  - `FRACNNEI`: as FRACAREA, except that at least the source nearest unmasked neighbour is used for unmasked target cells that intersect only masked source cells. Note that a zero value will be assigned to a target cell that does not intersect any source cells (masked or unmasked), even with FRACNNEI option.
- `$ORDER = FIRST` or `SECOND` for first or second order conservative remapping respectively (see SCRIP 1.4 documentation).

For CONSERV/SECOND, 3 weights are needed; OASIS3-MCT will calculate these weights and corresponding addresses (if they are not already provided) but will not, at run time, calculate the two extra terms to which the second and third weights should be applied; these terms, respectively the gradient of the field with respect to the longitude ($\theta$) $\delta f/\delta\theta$ and
the gradient of the field with respect to the latitude \( (\phi) \frac{1}{\cos \theta} \frac{\delta f}{\delta \phi} \) need to be calculated by the source code and transferred as extra arguments of the oasis.put (see fld2, fld3 in section 2.7.1). Note that CONSERV/SECOND is not positive definite and has not been fully validated yet.

**Precautions related to the use of the SCIRPR/CONSERV remapping**

- For the 1st order conservative remapping: the weight of a source cell is proportional to area of the source cell intersected by target cell. Using the divergence theorem, the SCIRP library evaluates this area with the line integral along the cell borders enclosing the area. As the real shape of the borders is not known (only the location of the 4 corners of each cell is known), the library assumes that the borders are linear in latitude and longitude between two corners. This assumption becomes less valid closer to the pole and for latitudes above the north_thresh or below the south_thresh values (see oasis3-mct/lib/scrip/remap_conserv.F), the library evaluates the intersection between two border segments using a Lambert equivalent azimuthal projection. Problems were observed in some cases for the grid cell located around this north_thresh or south_thresh latitude.

- Another limitation of the SCIRP 1st order conservative remapping algorithm is that it is also supposes, for line integral calculation, that \( \sin(latitude) \) is linear in longitude on the cell borders which again is in general not valid close to the pole.

- For a proper conservative remapping, the corners of a cell have to coincide with the corners of its neighbour cell, with no “holes” between the cells.

- If two cells of one same grid overlay, at least the one with the greater numerical index must be masked for a proper conservative remapping. For example, if the grid cells with \( i=1 \) overlays the grid cells with \( i=imax \), the latter must be masked. If this is not the case given the mask defined in masks.nc, OASIS3-MCT must be compiled with the CPP key TREAT_OVERLAY which will ensure that these rules are respected. This CPP key was introduced in OASIS3.3.

- A target grid cell intersecting no source cell (either masked or non masked) at all i.e. falling in a “hole” of the source grid will in all cases get a zero value.

- If a target grid cell intersects only masked source cells, it will still get a zero value unless the FRACNNEI normalisation option is used, in which case it will get the nearest non masked neighbour value. **Note that the option of having the value 1.0E+20 assigned to these target grid cell intersecting only masked source cells (for easier identification) is not yet available in OASIS3-MCT.**

**Support of vector fields with the SCIRPR remappings**

Vector mapping is NOT supported and will not be supported by OASIS3-MCT. For proper treatment of vector fields, the component model has to send the 3 components of the vector projected in a Cartesian coordinate system.

- **INTERP**: UNUSED
- **MOZAIC**: UNUSED; note that MAPPING (see above) is the NetCDF equivalent to MOZAIC.
- **NOINTERP**: UNUSED
- **FILLING**: UNUSED

### 4.4 The post-processing stage

- **CONSERV**: CONSERV ensures a global modification of the coupling field. This analysis requires the source and target grid mesh areas to be transferred to the coupler with oasis.write.area (see section 2.3). For a correct CONSERV operation, overlapping grid cells on the source grid or on the target
grid must be masked. In the namcouple, CONSERV requires one input line with one argument and
one optional argument:

# CONSERV operation

where: $CMETH$ $CONSOPT$

- $CMETH$ is the method desired with the following choices

  * with $CMETH = $GLOBAL, the field is integrated on both source and target grids, with-
  out considering values of masked points, and the residual (target - source) is uniformly
distributed on the target grid; this option ensures global conservation of the field

  * with $CMETH = $GLBPOS, the same operation is performed except that the residual is
distributed proportionally to the value of the original field; this option ensures the global
conservation of the field and does not change the sign of the field

  * with $CMETH = $BASBAL, the operation is analogous to $GLOBAL$ except that the non
masked surface of the source and the target grids are taken into account in the calculation
of the residual; this option does not ensure global conservation of the field but ensures
that the energy received is proportional to the non masked surface of the target grid

  * with $CMETH = $BASPOS, the non masked surface of the source and the target grids are
taken into account and the residual is distributed proportionally to the value of the original
field; therefore, this option does not ensure global conservation of the field but ensures
that the energy received is proportional to the non masked surface of the target grid and it
does not change the sign of the field.

- $CONSOPT$ is an optional argument specifying the algorithm. $CONSOPT$ can be $bfb$ or $opt$.
The $bfb$ option enforces a bit-for-bit transformation regardless of the grid decomposition or
process count. The $opt$ option carries out the conservation using an optimal algorithm using
less memory and a faster approach. Option $bfb$ is the default setting.

- **SUBGRID**: UNUSED
- **BLASNEW**: BLASNEW performs a scalar multiply or scalar add to any destination field. This is the equivalent
of BLASOLD on the destination side. The prior feature that supported linear combinations of the
current coupling field with any other fields after the interpolation has been deprecated.
This analysis requires the same input line(s) as BLASOLD.

- **MASKP**: UNUSED
- **REVERSE**: UNUSED
- **CHECKOUT**: CHECKOUT calculates the global minimum, the maximum and the sum of the target field values
(not weighted by the grid cell area) and prints them to the OASIS3-MCT debug file (for the master
process of the target component model only). This operation does not transform the field. The
generic input line is as for CHECKIN (see above).

- **GLORED**: UNUSED
Chapter 5

OASIS3-MCT auxiliary data files

In some cases, OASIS3-MCT uses auxiliary data files, e.g. defining the grids of the models being coupled, containing the field coupling restart values or input data values, or the remapping weights and addresses.

5.1 Grid data files

With OASIS3-MCT, the grid data files grids.nc, masks.nc and areas.nc are required only for certain operations, i.e. grids.nc and masks.nc for SCRIPR (see section 4.3) and masks.nc and areas.nc for CONSERV (see section 4.4). These NetCDF files can be created by the user before the run or can be written directly at run time by the master process of each component model using the grid data definition routines (see section 2.3). These routines can be used by the component models to add grid fields to the grid files but grid fields are never overwritten in the grid files.

The arrays containing the grid information are dimensioned (nx, ny), where nx and ny are the grid first and second dimension. Unstructured grids or other grids expressed with 1D vectors are supported by setting nx to the total number of grid points and ny to 1.

1. grids.nc: contains the model grid longitudes and latitudes in double precision REAL arrays. The array names must be composed of a prefix (4 characters), given by the user in the namcouple on the second line of each field (see section 3.3), and of a suffix (4 characters); this suffix is “.lon” or “.lat” for respectively the grid point longitudes or latitudes.

   If the SCRIPR/CONSERV remapping is used, longitudes and latitudes for the source and target grid corners must also be available in the grids.nc file as double precision REAL arrays dimensioned (nx, ny, 4) or (nbr_pts, 1, 4) where 4 is the number of corners (in the counterclockwise sense). The names of the arrays must be composed of the grid prefix and the suffix “.clo” or “.cla” for respectively the grid corner longitudes or latitudes. As for the other grid information, the corners can be provided in grids.nc before the run by the user or directly by the model through specific calls (see section 2.3).

   Longitudes must be given in degrees East in the interval -360.0 to 720.0. Latitudes must be given in degrees North in the interval -90.0 to 90.0. Note that if some grid points overlap, it is recommended to define those points with the same number (e.g. 360.0 for both, not 450.0 for one and 90.0 for the other) to ensure automatic detection of overlap by OASIS3-MCT.

   The corners of a cell cannot be defined modulo 360 degrees. For example, a cell located over Greenwich will have to be defined with corners at -1.0 deg and 1.0 deg but not with corners at 359.0 deg and 1.0 deg.

   Cells larger than 180.0 degrees in longitude are not supported.

2. masks.nc: contains the masks for all component model grids in INTEGER arrays. Be careful to note the historical OASIS convention: 0 -not masked i.e. active- or 1 -masked i.e. not active-
for each grid point. The array names must be composed of the grid prefix and the suffix “.msk”. This file, masks or masks.nc, is mandatory.

3. areas.nc: this file contains mesh surfaces for the component model grids in double precision REAL arrays. The array names must be composed of the grid prefix and the suffix “.srf”. The surfaces may be given in any units but they must be all the same. This file areas.nc is mandatory for CONSERV/GLB, GLBPOS, /BASBAL, and /BASPOS; it is not required otherwise.

5.2 Coupling restart files

At the beginning of a coupled run, some coupling fields may have to be initially read from their coupling restart file on their source grid (see the LAG concept in section 2.10). When needed, these files are also automatically updated by the last active oasis put or prism put proto call of the run (see section 2.7.1). Warning: the date is not written or read to/from the restart file; therefore, the user has to make sure that the appropriate coupling restart file is present in the working directory. The coupling restart files must follow the NetCDF format.

The name of the coupling restart file is given by the 6th character string on the first configuring line for each field in the namcouple (see section 3.3). Coupling fields coming from different models cannot be in the same coupling restart files, but for each model, there can be an arbitrary number of fields written in one coupling restart file. The only exception is when a coupling field sent by a source component model is associated with more than one target field and model; in that case, if coupling restart files are required, it is mandatory to specify different files for the different fields.

In the coupling restart files, the fields must be provided on the source grid in single or double precision REAL arrays and, as the grid data files, must be dimensioned \((nx, ny)\), where \(nx\) and \(ny\) are the grid first and second dimension (see section 5.1 above). The shape and orientation of each restart field (and of the corresponding coupling fields exchanged during the simulation) must be coherent with the shape of its grid data arrays.

The coupling restart files are also used automatically by OASIS3-MCT to allow partial LOCTRANS time transformation to be saved at the end of a run for exact restart at the start of the next run. For that reason, coupling restart filenames are now required for all namcouple transformations that use LOCTRANS (with non INSTANT values).

5.3 Input data files

Fields with status INPUT in the namcouple will, at runtime, simply be read in from a NetCDF input file by the target model below the oasis get call, at appropriate times corresponding to the input period indicated by the user in the namcouple.

The name of the file must be the one given on the field first configuring line in the namcouple (see section 3.3.3). There must be one input file per INPUT field, containing a time sequence of the field in a single or double precision REAL array named with the field symbolic name in the namcouple and dimensioned \((nx, ny, time)\). The time variable has to be an array \(time(time)\) expressed in “seconds since beginning of run”. The “time” dimension has to be the unlimited dimension.

5.4 Transformation auxiliary data files

The mapping files to be used for the MAPPING option must be consistent with the files generated by the SCRIP library to be used for the SCRIPR transformations (see also section 4.3). The files are NetCDF containing the following fields:
### 5.4. TRANSFORMATION AUXILIARY DATA FILES

```c
int src_address(num_links)
int dst_address(num_links)
double remap_matrix(num_links, num_wgts)
```

where

- `num_links` is a scalar integer indicating the total number of associated grid point pairs in the file. This is typically a large number. This field is a netCDF dimension.
- `num_wgts` is a scalar integer indicating the number of weights per associated grid point pair (up to 5 are supported, see section 2.7.1). This field is a netCDF dimension.
- `src_address` is a one dimensional array of size `num_links`. It contains the integer source address associated with each weight. This field is a netCDF variable.
- `dst_address` is a one dimensional array of size `num_links`. It contains the integer destination address associated with each weight. This field is a netCDF variable.
- `remap_matrix` is a two dimensional array of size `(num_links, num_wgts)`. It contains the real weight value(s) associated with the source and destination address. This field is a netCDF variable.
Chapter 6

Compiling, running and debugging

6.1 Compiling OASIS3-MCT

Compiling OASIS3-MCT libraries can be done in directory `oasis3-MCT/util/make_dir` with Makefile `TopMakefileOasis3` which must be completed with a header file `make.your_platform` specific to the compiling platform used and specified in `oasis3-MCT/util/make_dir/make.inc`. One of the header files distributed with the release can be used as a template. The root of the OASIS3-MCT tree can be anywhere and must be set in the variable `COUPLE` in the `make.your_platform` file.

The following commands are available:

- `make -f TopMakefileOasis3` or `make oasis3_psmile -f TopMakefileOasis3` (for backward compatibility):
  - compiles all OASIS3-MCT libraries `mct`, `scrip` and `psmile`;
- `make realclean -f TopMakefileOasis3`:
  - removes all OASIS3-MCT compiled sources and libraries.

Log and error messages from compilation are saved in `/util/make_dir` in the files `COMP.log` and `COMP.err`.

During compilation, a new compiling directory, defined by variable `ARCHDIR` is created. After successful compilation, resulting libraries are found in the compiling directory in `/lib` and object and module files in `/build`.

If module `mod_oasis` is used in the models, it is enough to include the path of the psmile objects and modules ($ARCHDIR/build/lib/psmile.MPI1) for the compilation and to use the psmile library $ARCHDIR/lib/libpsmile.MPI1.a when linking. If module `mod_prism` is used in the models, it is necessary to include the path of the psmile and of the mct objects and modules for the compilation (i.e. $ARCHDIR/build/lib/psmile.MPI1 and /mct and to use both the psmile and mct libraries $ARCHDIR/lib/libpsmile.MPI1.a and libmct.a and libmpeu.a when linking.

6.2 CPP keys

The following CPP keys are coded in OASIS3-MCT and can be specified in `CPPDEF` in `make.your_platform` file.

- `TREAT_OVERLAY`: To ensure, in `SCRIPR/CONSERV` remapping (see section 4.3), that if two cells of the source grid overlay, at least the one with the greater numerical index is masked (they also can be both masked); this is mandatory for this remapping. For example, if the grid line with \( i = l \)
overlaps the grid line with \(i = imax\), it is the latter that must be masked; when this is not the case with the mask defined in \(masks.nc\), this CPP key forces these rules to be respected.

- **balance**: Add a MPI_Wtime() function before and after mct_isend (MPI put) and mct_recv (MPI get) to calculate the time of the send and receive of a coupling field. This option can be used to produce timestamps in OASIS3-MCT debug files. During a post-processing phase, this information can be used to perform an analysis of the coupled components load (un)balance; specific tools have been developed to do this and will be released with a further version of OASIS3-MCT.

### 6.3 Running OASIS3-MCT

Examples of running environment are provided with the sources. For more details, see the instructions on OASIS web site at [https://verc.enes.org/oasis/oasis-dedicated-user-support-1/user-toys/tutorial-and-test_interpolation-of-oasis3-mct-1](https://verc.enes.org/oasis/oasis-dedicated-user-support-1/user-toys/tutorial-and-test_interpolation-of-oasis3-mct-1).

#### 6.3.1 The tutorial toy model

A practical example on how to run OASIS3-MCT and running it in a coupled system is provided in oasis3-mct/examples/tutorial. See also the document `tutorial_oasis3-mct.pdf` there in for more details,

#### 6.3.2 The test_interpolation environment

This environment available with the sources in oasis3-mct/examples/test_interpolation allows the user to test the quality of the interpolations and transformations between his source and target grids by calculating the error of interpolation on the target grid. For more details, see also the document `test_interpolation_oasis3-mct.pdf` there in.

### 6.4 Debugging

#### 6.4.1 Debug files

If you experience problems while running your coupled model with OASIS3-MCT, you can obtain more information on what is happening by increasing the \$NLOGPRT value in your `namcouple` (see also section 3.2).

Different outputs are written depending on \$NLOGPRT value:

- **0**: one file `debug.root.xx` is open by the master process of each model and one file `debug_notroot.xx` is open for all the other processes of each model to write only error information if an error occurs.
- **1**: one file `debug.root.xx` is open by the master process of each model to write information equivalent to level 10 (see below); one file `debug_notroot.xx` is open for all the other processes of each model to write only error information if an error occurs.
- **2**: one file `debug.xx.xxxxxx` is open by each process of each model to write normal production diagnostics.
- **5**: as for 2 with in addition some initial debug info.
- **10**: as for 5 with in addition the routine calling tree.
- **12**: as for 10 with in addition some routine calling notes.
- **15**: as for 12 with even more debug diagnostics.
- **20**: as for 15 with in addition some extra runtime analysis.
- **30**: full debug information.
6.4.2 Time statistics files

The variable TIMER_Debug, defined in the namcouple (second number on the line below $NLOGPRT keyword), is used to obtain time statistics over all the processors for each routine. Different output are written (in files named *.timers_xxxx) depending on TIMER_Debug value:

- TIMER_Debug=0: nothing is calculated, nothing is written.
- TIMER_Debug=1: the times are calculated and written in a single file by the process 0 as well as the min and the max times over all the processes.
- TIMER_Debug=2: the times are calculated and each process writes its own file; process 0 also writes the min and the max times over all the processes in its file.
- TIMER_Debug=3: the times are calculated and each process writes its own file; process 0 also writes in its file the min and the max times over all processes and also writes in its file all the results for each process.

The time given for each timer is calculated by the difference between calls to oasis_timer_start() and oasis_timer_stop() and is the accumulated time over the entire run. Here is an overview of the meaning of the different timers as implemented by default.

- 'total after init': total time of the simulation, implemented in mod_oasis_method, i.e. between the end of oasis_init_comp and the call to mpi_barrier and mpi_finalize in routine oasis_terminate.
- 'map definition': time spent in mct_gsmmap.init in routine oasis_def_partition; this routine defines the patterns of communication between the source and target processes.
- 'cpl_setup': time spent in oasis_coupler_setup, which sets up additional coupling aspects related to oasis_method_enddef.
- 'cpl_smatrd': time spent in oasis_coupler_smatrednc in mod_oasis_coupler (routine oasis_coupler_setup); this routine performs a distributed read of a NetCDF SCRIp file and returns weights in a distributed SparseMatrix, and calls mct_sMatP_Init which initialises the sparse matrix vector multiplication.
- 'oasis_advance_init()': time spent in oasis_advance_init, which handles reading of initial coupling restart and communication of data for fields with positive lags.
- 'grcv_00x': time spent in the reception of field x in mct_recv (including communication and possible waiting time linked to unbalance of components).
- 'wout_00x': time spent in the I/O for field x in routine oasis_advance_run.
- 'gcpy_00x': time spent in routine oasis_advance_run in copying the field x just received in a local array.
- 'pcpy_00x': time spent in routine oasis_advance_run in copying the local field x in the array to send (i.e. with local transformation besides division for averaging).
- 'pavg_00x': time spent in routine oasis_advance_run to calculate the average of field x (if done).
- 'pmap_00x'/gmap_00x': time spent in routine oasis_advance_run for the matrix vector multiplication for field x on the source/target processes.
- 'psnd_00x': time spent in routine oasis_advance_run for sending field x (i.e. including call to mct_waitsend and mct_isend).
Appendix A

The grid types for the transformations

As described in section 4 for the different SCRIP remappings, OASIS3-MCT support different types of grids. The characteristics of these grids are detailed here:

- **‘LR’ grid**: The longitudes and the latitudes of 2D Logically-Rectangular (LR) grid points can be described by two arrays longitude(i,j) and latitude(i,j), where i and j are respectively the first and second index dimensions. Stretched or/and rotated grids are LR grids. Note that previous OASIS3 A, B, G, L, Y, or Z grids are all particular cases of LR grids.

- **‘U’ grid**: Unstructured (U) grids do have any particular structure. The longitudes and the latitudes of 2D Unstructured grid points must be described by two arrays longitude(nbr_pts,1) and latitude(nbr_pts,1), where nbr_pts is the total grid size.

- **‘D’ grid**: The Reduced (D) grid is composed of a certain number of latitude circles, each one being divided into a varying number of longitudinal segments. In OASIS3-MCT, the grid data (longitudes, latitudes, etc.) must be described by arrays dimensioned (nbr_pts,1), where nbr_pts is the total number of grid points. There is no overlap of the grid, and no grid point at the equator nor at the poles. There are grid points on the Greenwich meridian.
Appendix B

Changes between the different versions of OASIS3-MCT

The evolution between the different versions of OASIS3-MCT can be followed in real-time by registering on the Redmine project management site at https://inle.cerfacs.fr/ (see "Register" at the right top of the page). On this site, registered users can browse the sources and consult tickets describing bug fixes and developments. To follow day to day evolution of the OASIS3-MCT sources, it is also possible to have your e-mail added to the list of addresses to which the log files of the SVN checkins are automatically sent; please contact oasishelp@cerfacs.fr if you wish to be added to that list.

B.1 Changes between OASIS3-MCT_1.0 and OASIS3-MCT_2.0

The main changes and bug fixes new in OASIS3-MCT_2.0 are the following:

- Support of BICUBIC interpolation, see paragraph BICUBIC in section 4.3.
- Support of CONSERV/SECOND regridding, see paragraph CONSERV/SECOND in section 4.3.
- Support of components exchanging data on only a subdomain of the global grid: a new optional argument, ig_size was added to oasis_def_partition, that provides the user with the ability to define the total number of grid cells on the grid (see section 2.4).
- The CPP key "balance" in mod_oasis_advance was added; this option can be used to produce timestamps in OASIS debug file (see section 6.2).
- The variable TIMER_Debug controlling the amount of time statistics written out is now an optional argument read in the namcouple; see the NLOGFPT line in 3.2 and all details about time statistics in section 6.4.2.
- Specific problems in writing out the time statistics when all the processors are not coupling were solved (see Redmine issue #497)
- The problem with restart files when one coupling field is sent to 2 target components was solved (see Redmine ticket #522)
- A memory leak in mod_oasis_getput_interface.F90 was fixed thanks to R. Hill from the MetOffice (see Redmine ticket #437)
- A bug fix was provided to ensure that the nearest neighbour option is activated when the option FRACNNEI is defined in the namcouple for the conservative interpolation.
- The behaviour of OASIS3-MCT was changed in the case a component model tries to send with oasis_put a field declared with a oasis_def_var but not defined in the configuration file namcouple; this will now lead to an abort. In this case, the field ID returned by the oasis_def_var is equal to -1 and the corresponding oasis_put should not be called.
B.2 Changes between OASIS3.3 and OASIS3-MCT.1.0

B.2.1 General architecture

- OASIS3-MCT is (only) a coupling library
  Much of the underlying implementation of OASIS3 was refactored to leverage the Model Coupling Toolkit (MCT). OASIS3-MCT is a coupling library to be linked to the component models and that carries out the coupling field transformations (e.g. remappings/interpolations) in parallel on either the source or target processes and that performs all communication in parallel directly between the component models; there is no central coupler executable anymore.

- MAPPING transformation to use a pre-defined mapping file
  With MAPPING, OASIS3-MCT has the ability to read a predefined set of weights and addresses (mapping file) specified in the namcouple to perform the interpolation/remapping. The user also has the flexibility to choose the location and the parallelization strategy of the remapping with specific MAPPING options (see section 4.3).

- Mono-process mapping file generation with the SCRIP library
  But as before, OASIS3-MCT.1.0 can also generate the mapping file using the SCRIP library (Jones 1999). When this is the case, the mapping file generation is done on one process of the model components; all previous SCRIP remapping schemes available in OASIS3.3 are still supported besides BICUBIC and CONSERV/SECOND. (Note: these remapping schemes, not available in OASIS3-MCT.1.0 were reactivated in OASIS3-MCT.2.0, see B.1.)

- MPI2 job launching is NOT supported.
  Only MPI1 start mode is allowed. As before with the MPI1 mode, all component models must be started by the user in the job script in a pseudo-MPMD mode; in this case, they will automatically share the same MPI COMM WORLD communicator and an internal communicator created by OASIS3-MCT needs to be used for internal parallelization (see section 2.2.2).

B.2.2 Changes in the coupling interface in the component models

- Use statement
  The different OASIS3.3 USE statements were gathered into one USE mod_oasis (or one USE mod_prism), therefore much simpler to use.

- Support of previous prism.xxx and new oasis.xxx interfaces
  OASIS3-MCT retains prior interface names of OASIS3.3 (e.g. prism_put_proto) to ensure full backward compatibility. However, new interface names such as oasis_put are also available and should be preferred. Both routine names are listed in chapter 2.

- Auxiliary routines not supported yet
  Auxiliary routines prism_put_inquire, prism_put_restart_proto, prism_get_freq are not supported yet.

---

1As with OASIS3.3, the “put” calls are non-blocking but the “get” calls are blocking. As before, the user has to take care of implementing a coupling algorithm that will result in matching “put” and “get” calls to avoid deadlocks (see section 2.7). The lag (LAG) index works as before in OASIS3.3 (see section 2.10)
Support of components for which only a subset of processes participate in the coupling

New routines `oasis_create_couplcomm` and `oasis_set_couplcomm` are now available to create or set a coupling communicator in the case only a subset of the component processes participate in the coupling (see section 2.2.3). But even in this case, all OASIS3-MCT interface routines, besides the grid definition (see section 2.3) and the “put” and “get” call per se (see section 2.7), are collective and must be called by all processes.

New routines `oasis_get_debug` and `oasis_set_debug` are now available to respectively retrieve the current OASIS3-MCT internal debug level (set by `$NLOGPRT` in the `namcouple`) or to change it (see section 2.9).

### B.2.3 Functionality not offered anymore

- **SCRIPR/BICUBIC** and **SCRIPR/CONSERV/SECOND** remappings
  
  As in OASIS3.3, the SCRIP library can be used to generate the remapping/interpolation weights and addresses and write them to a mapping file. All previous SCRIP remapping schemes available in OASIS3.3 are still supported in OASIS3-MCT 1.0 besides **BICUBIC** and **CONSERV/SECOND** because these remapping involve at each source grid point the value of the field but also the value of the gradients of the field (which are not known or calculated). (Note: these remapping schemes, not available in OASIS3-MCT 1.0 were reactivated in OASIS3-MCT 2.0, see B.1.)

- **Vector field remapping**

  Vector field remapping is not and will not be supported (see “Support of vector fields with the SCRIPR remappings” in section 4.3).

- **Automatic calculation of grid mesh corners in SCRIPR/CONSERV**

  For **SCRIPR/CONSERV** remapping, grid mesh corners will not be compute automatically if they are needed but not provided.

- **Other transformations not supported**

  - The following transformations are not available in OASIS3.3 and will most probably not be implemented as it should be not too difficult to implement the equivalent operations in the component models themselves: **CORRECT**, **FILLING**, **SUBGRID**, **MASKP**
  
  - **LOCTRANS/ONCE** is not explicitly offered as it is equivalent to defining a coupling period equal to the total runtime.
  
  - The following transformations are not available as they were already deprecated in OASIS3.3 (see OASIS3.3 User Guide): **REDGLO**, **INVERT**, **REVERSE**, **GLORED**
  
  - **MASK** and **EXTRAP** are not available but the corresponding linear extrapolation can be replaced by the more efficient option using the nearest non-masked source neighbour for target points having their original neighbours all masked. This is now the default option for **SCRIPR/DISTWGT**, **GAUSWGT** and **BILINEAR** interpolations. It is also included in **SCRIPR/CONSERV** if **FRACNNEI** normalization option is chosen (see section 4.3).
  
  - **INTERP** interpolations are not available; **SCRIPR** should be used instead.
  
  - **MOZAIC** is not available as **MAPPING** should be used instead.
  
  - **NOINTERP** does not need to be specified anymore if no interpolation is required.
  
  - Field combination with **BLASOLD** and **BLASNEW**; these transformations only support multiplication and addition terms to the fields (see section 4.2).

- **Using the coupler in interpolator-only mode**

  This is not possible anymore as OASIS3-MCT is now only a coupling library. However, it is planned, in a further release, to provide a toy coupled model that could be use to check the quality
of the remapping for any specific couple of grids.

- Coupling field CF standard names
  The file cf_name_table.txt is not needed or used anymore. The CF standard names of the coupling fields are not written to the debug files.

- Binary auxiliary files
  All auxiliary files, besides the namcouple must be NetCDF; binary files are not supported anymore.

### B.2.4 New functionality offered

- Better support of components for which only a subset of processes participate in the coupling
  In OASIS3.3, components for which only a subset of processes participated in the coupling were supported in a very restricted way. In fact, this subset had to be composed of the N first processes and N had to be specified in the namcouple. Now, the subset of processes can be composed of any of the component processes and does not have to be pre-defined in the namcouple. New routines oasis_create_couplcomm and oasis_set_couplcomm are now available to create or set a coupling communicator gathering only these processes (see section 2.2.3).

- Exact restart for LOCTRANS transformations
  If needed, LOCTRANS transformations write partially transformed fields in the coupling restart file at the end of a run to ensure an exact restart of the next run (see section 4.1). For that reason, coupling restart filenames are now required for all namcouple entries that use LOCTRANS (with non INSTANT values). This is the reason an optional restart file is now provided on the OUTPUT namcouple input line.

- Support to couple multiple fields via a single communication.
  This is supported through colon delimited field lists in the namcouple, for example ATMTAUX:ATMTAUY:ATMFLUX TAUX:TAUY:HEATFLUX 1 3600 3 rstrt.nc EXPORTED in a single namcouple entry. All fields will use the namcouple settings for that entry. In the component model codes, these fields are still sent (“put”) or received (“get”) one at a time. Inside OASIS3-MCT, the fields are stored and a single mapping and send or receive instruction is executed for all fields. This is useful in cases where multiple fields have the same coupling transformations and to reduce communication costs by aggregating multiple fields into a single communication.

- Matching one source field with multiple targets
  A coupling field sent by a source component model can be associated with more than one target field and model (get). In that case, the source model needs to send (“put”) the field only once and the corresponding data will arrive at multiple targets as specified in the namcouple configuration file. Different coupling frequencies and transformations are allowed for different coupling exchanges of the same field. If coupling restart files are required (either if a LAG or if a LOCTRANS transformation is specified), it is mandatory to specify different files for the different fields. The inverse feature is not allowed, i.e. a single target (get) field CANNOT be associated with multiple source (put) fields.

- The debug files
  The debug mode was greatly improved as compared to OASIS3.3. The level of debug information written out to the OASIS3-MCT debug files for each model process is defined by the $NLOGPRT value in the namcouple. All details are provided in section 3.2.

### B.2.5 Changes in the configuration file namcouple

- The namcouple configuration file of OASIS3-MCT is fully backward compatible with OASIS3.3. However, several namcouple keywords have been deprecated even if they are still allowed. These
APPENDIX B. CHANGES BETWEEN THE DIFFERENT VERSIONS OF OASIS3-MCT

Keywords are noted “UNUSED” in sections 3.2 and 3.3 and are not fully described. Information below these keywords will not be read and will not be used: $SEQMODE, $CHANNEL, $JOB-NAME, $INIDATE, $MODINFO, $CALTYPE.

- Also the following inputs should not appear in the namcouple anymore as the related functionality are not supported anymore in OASIS3-MCT (see above): field status AUXILARY, time transformation ONCE, REDGLO, INVERT, MASK, EXTRAP, CORRECT, INTERP, MOZAIC, FILLING, SUBGRID, MASKP, REVERSE, GLORED.

- To get 2D fields in the debug output NetCDF files, the 2D dimensions of the grids must be provided in the namcouple (except if the field has the status OUTPUT); otherwise, the fields in the debug output files will be 1D.

B.2.6 Other differences

- IGNORED and IGNOUT fields are converted to EXPORTED and EXPOUT respectively.
- The file areas.nc is not needed anymore to calculate some statistics with options CHECKIN and/or CHECKOUT (see section 4.2).
- SEQ index is no longer needed to ensure correct coupling sequencing within the coupler. Use of SEQ allows the coupling layer to detect potential deadlocks before they happen and to exit gracefully (see section 2.10.2).
- The I/O library mpp.io is no longer used to write the restart and output files.
Appendix C

API for processes not involved in the coupling

Here is a coding sample of how to use the API routines for the processes not involved in the coupling (while other processes of the same executable are involved in the coupling).

CALL oasis_init_comp (comp_id, comp_name, ierror )
CALL oasis_get_localcomm ( localComm, ierror )

!--- create communicator gathering coupling processes (every other)
CALL MPI_Comm_Rank ( localComm, mype, ierror )
couplingpe = .false.
if (mod(mype,2) == 0) couplingpe = .true.
icpl = MPI_UNDEFINED
if (couplingpe) icpl = 1
CALL MPI_COMM_Split(localComm,icpl,1,couplComm,ierror)
!
!--- provide this communicator to OASIS3-MCT
CALL oasis_set_couplcomm(couplComm, ierror)

! The call to MPI_COMM_Split and oasis_set_couplcomm could be replaced by
! CALL oasis_create_couplcomm(icpl,localComm,couplComm,ierror)

CALL oasis_def_partition ( ... )
CALL oasis_def_var ( ... )
CALL oasis_enddef ( ... )

!--- do loop
! ... 
  if (couplingpe) CALL oasis_put( ... )
  ! ...
  if (couplingpe) CALL oasis_get( ... )
  ! ...
!--- enddo

CALL oasis_terminate ( ... )
Bibliography


