

# The Atmosphere-Ocean General Circulation Model EMAC-MPIOM

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# Contents

<b>1</b>	<b>Introduction</b>	<b>3</b>
<b>2</b>	<b>A2O namelist user interface</b>	<b>3</b>
2.1	A2O CTRL namelist . . . . .	3
2.2	A2O CPL namelist . . . . .	3
<b>3</b>	<b>Namelist example</b>	<b>5</b>

## 1 Introduction

This document describes the MESSy submodel A2O (Atmosphere To Ocean) for coupling between an ocean general circulation model (O-GCM) and an atmosphere general circulation model (A-GCM) within the MESSy (Modular Earth Submodel System) framework (Jöckel et al., 2005).

Generally the ocean model and the atmosphere model operate on different grids, so a powerful transformation between these general (curvilinear) grids is needed. The A2O submodel makes use of the SCRIP (Spherical Coordinate Regridding and Interpolation Package) library (Jones, 1999) to calculate transformations between the two grids of the domains.

A user interface to control the transformation between the two grids and to control which CHANNEL objects have to be transformed and exchanged between the two model domains is provided via Fortran95 namelists. This user interface (namelist control) is explained in the following section.

## 2 A2O namelist user interface

According to the MESSy standard (Jöckel et al., 2005), the user interface of the A2O submodel is divided into a control (CTRL) and a coupling (CPL) namelist. Both namelists are contained in the namelist file *a2o.nml*.

### 2.1 A2O CTRL namelist

The CTRL namelist of A2O only provides the logical switch `l_verbose` (default value F) to enable (T) the verbose output of the SCRIP library to the log file during execution.

### 2.2 A2O CPL namelist

In the CPL namelist of A2O the exchange of information (or coupling) time step between atmosphere and ocean (and vice versa) is defined. This feature is provided by the coupling to the MESSy infrastructure submodel TIMER (Jöckel et al., 2010, Suppl.), providing an "event manager" to schedule events, which are discrete in time.

Two events have to be defined in the CPL namelist, one for exchanging information from atmosphere to ocean, and one for exchanging information from ocean to atmosphere. The CPL namelist of A2O provides two variables to define the exchange intervals:

- `trig_a2o` defines the time span (i.e. coupling period) for exchanging information from the atmosphere to the ocean (ATMOSPHERE → OCEAN)
- `trig_o2a` defines the time span (i.e. coupling period) for exchanging information from the ocean to the atmosphere (OCEAN → ATMOSPHERE)

In both cases, the standard format for events is used, which is:

```
event_name = interval, unit, adjust, offset,
```

where

- `event_name` is one of the predefined event names `trig_a2o` or `trig_o2a`,
- `interval` gives the value of the interval between two events,
- `unit` is the time unit of the interval,
- `adjust` defines when exactly the event is triggered and
- `offset` provides information about an additional offset in seconds.

Table 1: Interpolation parameters modifiable in *a2o.nml*.

parameter name	default value	interpolation routine influenced
<code>north_thresh</code>	1.42	conservative
<code>south_thresh</code>	-2.00	conservative
<code>max_subseg</code>	100000	conservative
<code>max_iter</code>	100	bilinear/bicubic
<code>converge</code>	$1 \times 10^{-10}$	bilinear/bicubic
<code>num_neighbors</code>	4	distance weighted

More information about events and the event manager can be found in the TIMER manual (see Jöckel et al., 2010, Suppl.).

To control the transformation between the grids, the user can optionally specify parameters used in the SCRIP library (Jones, 1999). These parameters define some general characteristics of the interpolation routines used. In table 1, the modifiable parameters are shown. For a complete explanation of the parameters, we refer to the SCRIP interpolation routines manual (<http://climate.lanl.gov/Software/SCRIP/SCRIPusers.pdf>).

To couple the ocean and atmosphere domain, the user has to specify the fields, which have to be interpolated to the grid of the opposed domain. The variables are divided into transformations from atmosphere grid to ocean grid and vice versa.

Here, we show an example of a transformation from the atmosphere to the ocean grid:

```
A2O(11) = 'AOFLWSVO', 'ECHAM5', 'wind10w', 4, 2, T, 0.0, 1.E+34,
INTA2O(11) = 'atm','oces','bilinear', 'none'
```

The namelist variable `A2O` defines the channel and channel object that will be transformed, while the corresponding namelist variable `INTA2O` specifies which interpolation will be used for the transformation.

Transformations from the ocean to the atmosphere grid are defined in the same way, but the namelist variables are called `O2A` and `INTO2A` respectively.

`A2O (O2A)` is composed of:

- Name of the output object (saved in the `A2O` channel).
- Name of the channel where the object to be transformed is located.
- Name of the object (field) to be transformed.
- Switch to determine how the vertical dimension is treated:
  - 1 = sum of the values over the entire column.
  - 2 = average of the values over the entire column.
  - 3 = maximum value present in the column.
  - 4 = lowest level of the column (default in the atmosphere to ocean transformation)
  - 5 = highest level of the column (default in the ocean to atmosphere transformation)

The value of this option has no effect for objects that have no extension in the vertical dimension (i.e. 2D fields).

- Mask the output field with the land sea mask (`T`) or not (`F`). The default is `F`.
- Range of output values. All values outside this range (on the destination grid) will be changed to the closest value of the range.

`INTA2O (INTO2A)` is composed of:

- source grid : atmosphere: `atm`; ocean scalar: `oces`; ocean u vector component: `oceu`; ocean v vector component: `ocev`.
- destination grid : atmosphere: `atm`; ocean scalar: `oces`; ocean u vector component: `oceu`; ocean v vector component: `ocev`.
- interpolation method : `conservative`, `bilinear`, `bicubic` or `distwgt` (distance weighted).
- normalisation option : `none`, `frac` (fractional) or `dest` (destination grid).

When transforming vector fields between the atmosphere and ocean grid (and vice versa) the namelist variables `VEC_A20` and `VEC_O2A` have to be used.

Vector fields, in fact, have to be rotated between the two grids, due to the fact that the ocean grid is a rotated grid. Hence, the code is transforming the single components of the vector first and then modifies the components of the vectors, specified by the `VEC_A20` or `VEC_O2A` namelist variables.

An example of a vector field transformed from the atmosphere to the ocean grid (where the transformed vector components were stored in the `AOFLTXWO` and `AOFLTYWO` channel objects) is:

```
VEC_A20(1) = 'AOFLTXWO', 'AOFLTYWO',
```

where the first name is the object name of the  $X$  component ( `AOFLTXWO`) and the second name is the object name of the  $Y$  component ( `AOFLTYWO`) of the vector.

Both names have to be specified in `A20` namelist variables (see above), i.e. have to be present in the `A20` channel.

Transformations of vector fields from the ocean to the atmosphere grid work in the same way. In that case the namelist variable is called `VEC_O2A`.

### 3 Namelist example

This section contains an annotated namelist example for coupling of ECHAM5 and MPIOM in the framework of MESSy.

```
! *- f90 *-
&CTRL
l_verbose = F ! scrip library verbose
/
&CPL
#####
!### EXCHANGE/COUPLING TIME_STEP ###
#####
!#TEST
!trig_a2o = 1,'steps','first',0
!trig_o2a = 1,'steps','first',0
!#1-DAY
!trig_a2o = 1,'days','first',0
!trig_o2a = 1,'days','first',0
!#T31L19/GR30L40
!trig_a2o = 2,'hours','first',0
!trig_o2a = 2,'hours','first',0
!#T63L49/GR15L40
trig_a2o = 1,'hours','first',0
trig_o2a = 1,'hours','first',0
#####
!### GENERAL PARAMETER FOR INTERPOLATION ###
#####
num_neighbors =4
!north_thresh = 2.00 !(radiant)
```

```

north_thresh = 1.42 !(radiant)
south_thresh = -2.00 !(radiant)
!
#####
!### ATMOSPHERE -> OCEAN ! MAX 100 FIELDS! ###
#####
!# SYNTAX:
!# A20(n) fields to be interpolated :
!# 'name', 'atmosphere_channel', 'atmosphere_object', column-method,
!# time-method, mask_field, min-value, max-value,
!# NOTES:
!# column-method: 1 SUM
!# (if applicable) 2 AVE
!# 3 MAX
!# 4 LOWEST-LEVEL (default)
!# 5 HIGHEST-LEVEL
!# time-method: 1 SUM
!# 2 AVE
!# INTA20(n) interpolation (SCRIP) method :
!# 'source grid', 'destination grid', 'map_method', 'normalize_opt'
!# NOTES:
!# source/destination grids : 'atm', 'oces', 'oceu', 'ocev'
!# map_method : 'conservative', 'bilinear', 'bicubic', 'distwgt'
!# normalize_opt : 'none', 'frac', 'dest'
#####
! NEEDED FOR COUPLING ECHAM5 --> MPIOM
A20(1) = 'AOFLTXWO', 'ECHAM5', 'awust', 4, 2, T, -1.E+34, 1.E+34,
INTA20(1) = 'atm','oceu','bilinear', 'none'
A20(2) = 'AOFLTYWO', 'ECHAM5', 'awvst', 4, 2, T, -1.E+34, 1.E+34,
INTA20(2) = 'atm','ocev','bilinear', 'none'
A20(3) = 'AOFLTXIO', 'ECHAM5', 'aiust', 4, 2, T, -1.E+34, 1.E+34,
INTA20(3) = 'atm','oceu','bilinear', 'none'
A20(4) = 'AOFLTYIO', 'ECHAM5', 'aivst', 4, 2, T, -1.E+34, 1.E+34,
INTA20(4) = 'atm','ocev','bilinear', 'none'
A20(5) = 'AOFLFRIO', 'ECHAM5', 'aifre', 4, 2, T, -1.E+34, 1.E+34,
INTA20(5) = 'atm','oces','conservative', 'frac'
A20(6) = 'AOFLFRWO', 'ECHAM5', 'awfre', 4, 2, T, -1.E+34, 1.E+34,
INTA20(6) = 'atm','oces','conservative', 'frac'
A20(7) = 'AOFLRHIO', 'ECHAM5', 'aiqre', 4, 2, T, 0.0, 1.E+34,
INTA20(7) = 'atm','oces','conservative', 'frac'
A20(8) = 'AOFLCHIO', 'ECHAM5', 'aicon', 4, 2, T, -1.E+34, 1.E+34,
INTA20(8) = 'atm','oces','conservative', 'frac'
A20(9) = 'AOFLNHWO', 'ECHAM5', 'awhea', 4, 2, T, -1.E+34, 1.E+34,
INTA20(9) = 'atm','oces','conservative', 'frac'
A20(10) = 'AOFLSHWO', 'rad4all', 'soflw', 4, 2, T, 0.0, 1.E+34,
INTA20(10) = 'atm','oces','conservative', 'frac'
A20(11) = 'AOFLWSVO', 'ECHAM5', 'wind10w', 4, 2, T, 0.0, 1.E+34,
INTA20(11) = 'atm','oces','bilinear', 'none'
#####
!# IN CASE OF VECTORS:
!# SYNTAX:
!# 'x-direction', 'y-direction'
!# N.B.: both must be in a2o.nml
#####
! NEEDED FOR COUPLING ECHAM5 --> MPIOM
VEC_A20(1) = 'AOFLTXWO', 'AOFLTYWO',
VEC_A20(2) = 'AOFLTXIO', 'AOFLTYIO',

```

```

!
#####
!### OCEAN -> ATMOSPHERE ! MAX 100 FIELDS ###
#####
!# SYNTAX:
!# O2A(n) fields to be interpolated :
!#   'name', 'ocean_channel', 'ocean_object', column-method,
!#   time-method, mask_field , min-value, max-value,
!# NOTES:
!#   column-method:    1 SUM
!#                     2 AVE
!#                     3 MAX
!#                     4 LOWEST-LEVEL
!#                     5 HIGHEST-LEVEL (default)
!#   time-method:     1 SUM
!#                     2 AVE
!# INTO2A(n) interpolation (SCRIP) method :
!#   'source grid', 'destination grid', 'map_method', 'normalize_opt'
!# NOTES:
!#   source/destination grids : 'atm', 'oces', 'oceu', 'occv'
!#   map_method : 'conservative', 'bilinear', 'bicubic', 'distwgt'
!#   normalize_opt : 'none', 'frac', 'dest'
#####
O2A(1) = 'tho',      'mpiom', 'tho_K',  5, 2, T,      0.0, 1.E+34,
INTO2A(1) = 'oces', 'atm', 'bilinear', 'none'
O2A(2) = 'sictho', 'mpiom', 'sictho',  5, 2, T,      0.0, 1.E+34,
INTO2A(2) = 'oces', 'atm', 'bilinear', 'none'
O2A(3) = 'sicomo', 'mpiom', 'sicomo',  5, 2, T,      0.0, 1.,
INTO2A(3) = 'oces', 'atm', 'bilinear', 'none'
O2A(4) = 'sicsno', 'mpiom', 'sicsno',  5, 2, T,      0.0, 1.E+34,
INTO2A(4) = 'oces', 'atm', 'bilinear', 'none'
O2A(5) = 'socu',   'mpiom', 'socu',    5, 2, T,     -1.E+34, 1.E+34,
INTO2A(5) = 'oces', 'atm', 'bilinear', 'none'
O2A(6) = 'socv',   'mpiom', 'socv',    5, 2, T,     -1.E+34, 1.E+34,
INTO2A(6) = 'oces', 'atm', 'bilinear', 'none'
!
#####
!# IN CASE OF VECTORS:
!# SYNTAX:
!#   'x-direction', 'y-direction'
!# N.B.: both must be in a2o.nml
#####
! NEEDED FOR COUPLING ECHAM5 --> MPIOM
VEC_O2A(1) = 'socu', 'socv',
/

```

## References

- Jöckel, P., Sander, R., Kerkweg, A., Tost, H., and Lelieveld, J.: Technical Note: The Modular Earth Submodel System (MESSy) – a new approach towards Earth System Modeling, *Atmos. Chem. Phys.*, 5, 433–444, 2005.
- Jöckel, P., Kerkweg, A., Pozzer, A., Sander, R., Tost, H., Riede, H., Baumgaertner, A., Gromov, S., and Kern, B.: Development cycle 2 of the Modular Earth Submodel System (MESSy2), *Geoscientific Model Development*, 3, 717–752, doi:10.5194/gmd-3-717-2010, URL <http://www.geosci-model-dev.net/3/717/2010/>, 2010.
- Jones, P.: First- and Second-Order Conservative Remapping Schemes for Grids in Spherical Coordinates, *Monthly Weather Review*, 127, 2204–2210, 1999.