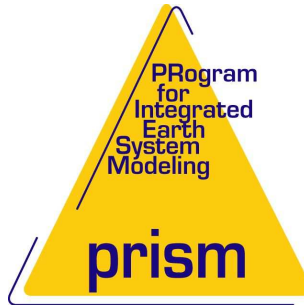


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Météo France
PRISM Model Adaptation

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Chapter 1

Introduction

Météo-France develops an earth system model in close collaboration with CERFACS (Centre Européen de Recherche et de Formation Avancée en Calcul Scientifique) and IPSL (Institut Pierre Simon Laplace) to perform simulations aiming at studying climate variability, climate predictability and climate change. The components of the current version of the earth system model are currently, or have been, developed either at Météo-France (atmosphere at the global and regional scales, land-surface, sea-ice, atmospheric chemistry) or at IPSL (ocean). The coupling between the atmosphere and ocean + sea ice components was up to now performed through the OASIS coupler developed at CERFACS. Thanks to the development of the PRISM software, a new version of the earth system model coupling the atmosphere and ocean model through the new PRISM coupler (OASIS3) has been developed and a coupling between the atmosphere and land surface component through this coupler is prepared. This report describes how the Météo-France component models are adapted to the PRISM software and the available coupled configuration.

Chapter 2

Component model descriptions

Here we briefly describe the atmosphere (ARPEGE-Climat) and surface (ISBA) components of the Météo-France coupled climate models. A description of the ORCA ocean component is available in [Demory (2004)].

2.1 ARPEGE-Climat

The Atmospheric General Circulation Model ARPEGE-Climat is an adaptation of the ARPEGE model (an acronym for "Action de Recherche Petite Echelle Grande Echelle", i.e. "Research Project on Small and Large Scales) for climate studies. The ARPEGE model was developed at Météo-France in collaboration with ECMWF where the model is called IFS (Integrated Forecast System). Physical parameterizations of ARPEGE and IFS are generally different. The version detailed below is version 4 of the ARPEGE-Climat model prepared for the PRISM project and built on cycle 24 of ARPEGE-IFS. It has been released to the scientific community in 2003.

The horizontal representation is spectral (spherical harmonic basis functions) with transformation to a Gaussian grid for calculation of nonlinear quantities and some physics (typically T63 truncation reduced to a 128 by 64 Gaussian grid). Through an isotropic grid transform, the effective resolution of the model may be varied, locating the centre of highest resolution at any geographical point [Courtier and Geleyn (1988)] to perform regional climate simulations. The model is generally implemented in two main vertical configuration either resolving the atmosphere up to 20Hpa with 31 vertical levels defined in an hybrid sigma-pressure coordinate, or up to 0.1Hpa with 45 vertical levels. These two configurations have been coupled to the ocean component through the OASIS coupler.

The model uses a spherical representation of the primitive equations expressed in terms of vorticity and divergence, temperature and specific humidity, and the natural logarithm of surface pressure. The possibility exists of including arbitrary scalar variables that obey equations similar to the specific humidity equation. In the present model, the ozone mixing ratio is such a variable. The treatment of the advection through a semi-lagrangian scheme is an optional choice of the model.

The model has a comprehensive package of physical parameterizations. The radiation scheme was developed for the ECMWF weather forecasting model [Morcrette (1990)]. A specific parameterization calculates ozone fluxes due to photochemical sources and sinks through a linear scheme [Cariolle and Déqué (1986)]. The radiative impact of the aerosols results from spatially varying distributions of five aerosol types, with different optical properties. Cloud radiative properties are related to diagnostic cloud liquid water content and optical properties of ice clouds are included. The stratiform cloudiness are calculated through a diagnostic sub-grid scale cloud scheme taking into account interactions between cloud fraction coverage, liquid water content and turbulence [Ricard and Royer (1993)]. The local convective cloudiness is a function of the convective precipitation. The precipitation scheme is a part of the stratiform cloud scheme. The deep convection scheme used has been described by [Bougeault (1985)] and the shallow convection was included by [Geleyn (1986)]. The vertical exchange of static energy, momentum and humidity, depends

on exchange coefficients. The gravity-wave drag scheme accounts for the effect of the dissipation, the resonance and the reflection of gravity waves generated by the sub-grid-scale orography. Additional drags corresponding to the mountain boundary layer and to the dissipation of the wave drag due to convection, are also parameterized. The land-surface component of the model is the so-called ISBA scheme (see below). It is embedded in the code of the AGCM but, as part of a development performed in the context of the PRISM project, it will be optionally coupled to the atmosphere component through the PRISM coupler.

A complete description of the physics and dynamics of the model is included in technical reports (Algorithmic documentation, user guide, code documentation and climate validation) available under request from Michel Deque (E-mail: Michel.Deque@meteo.fr). The algorithmic documentation is also available at <http://prism.dkrz.de/Workpackages/WP3i/>. Several papers cover the description of the different components of the model physics. Some key publications on the model design are [Déqué et al (1994)], [Déqué and Piédelièvre (1995)] and [Geleyn et al (1995)].

2.2 ISBA

The ISBA (Interface Sol Biosphere Atmosphere) land-surface scheme was developed by [Noilhan and Planton (1989)] and improved by [Mahfouf et al (1995)] and [Douville et al (1995)]. The temperature is calculated at four levels in the soil including the surface and the soil hydrology is characterized by the evolution of two soil reservoirs, a reservoir of rain intercepted by the canopy and a reservoir of snow content. The thermo-hydric properties of the soil are function of the soil texture and the soil water content.

Chapter 3

The ARPEGE-Climat + ORCA coupled model

For its coupling to the ocean + sea ice components, the ARPEGE- Climat model exchange data typically once every day. The minimum set of exchanged fields from the ocean + sea-ice components to the atmosphere component is composed of the SST, the sea-ice extent and the surface albedo. From the atmosphere to the ocean + sea-ice components, at least the following fields need to be passed: the solar heat flux, the non-solar heat flux, the evaporation, the liquid precipitation, the solid precipitation, the run-off from continents to ocean, the components of the momentum flux (each component projected on the two directions of the ocean grid). If the sea-ice component is oversimplified (for example a climatological sea-ice), three of the fresh-water fluxes (evaporation, liquid and solid precipitation) may be replaced by the total water flux (precipitation-evaporation). In addition, in order to account for the difference of resolution between the atmosphere and the ocean + sea-ice components, the latter using the finer grid, additional fields may be passed by the atmosphere component in order to perform a more precise interpolation of the solar and non-solar heat fluxes on the ocean + sea ice grid (allowed by the Subgrid functionality of OASIS 3). These are the SST, the albedo and the derivative of the non-solar heat flux with respect to the SST. In some coupled configurations including ARPEGE-Climat, a parameterization of mass discharge from ice sheets is introduced. However, it is not implemented through the coupler.

The first coupled model developed in the context of the PRISM project consists of the ARPEGE-Climat version 4 from CNRM (resolution of T63 linear grid and 31 levels in the vertical), version 3.0 of the coupler OASIS from CERFACS and version 8.2 of the global ocean model OPA (resolution of 20 in longitude by 0.50 to 20 in latitude from the equator to the poles and 31 levels in the vertical) from IPSL/LODYC referred hereafter has the ORCA model.

Chapter 4

Technical aspects

Here we present briefly the technical implementation of the coupling of the atmosphere and the ocean components. The demonstration runs performed with the ARPEGE-Climat + ORCA coupled model (E4 experiments) are described in the report [Planton and Maynard (2004)].

4.1 Coupling

In order to install the coupled model following the PRISM project requirements, the following tasks have been carried out:

- The coupled model ARPEGE-Climat+OASIS+ORCA has been installed on the Fujitsu VPP5000 supercomputer of Météo-France computing centre in Toulouse. The usage of the MPI message passing technique has induced a modification of tunable parameters of the supercomputer.
- The code of the ARPEGE-Climat model has been modified to include the communication of coupling fields via the PSMILe library (OASIS 3). This has implied a change of the following routines:
 - `sucpl.F90` (initialise the communication technique)
 - `updcpl.F90` (prepare the communication from the ocean to the atmosphere)
 - `wrcpl.F90` (prepare the communication from the atmosphere to the ocean)
- The code of the ORCA model has been modified to include the communication of coupling fields via the PSMILe library (OASIS 3). This has implied a change of the following routines:
 - `inicomol.F` (initialise the communication technique)
 - `stpcmo.F` (prepare the communication from the ocean to the atmosphere)
 - `flx.coupled.h` (prepare the communication from the atmosphere to the ocean)
 - `tau.coupled.h` (prepare the communication from the atmosphere to the ocean)
- The `namcouple` file has been adapted to perform demonstration coupled runs (see below).
- A specific postprocessing procedure has been set up to meet the PRISM project requirements. Concerning the atmosphere, all the required variables are written in NetCDF format from the ARPEGE postprocessed files.

4.2 The `namcouple` file

This section gives the OASIS input file `namcouple` relevant for a simulation with a global ocean model coupled to a global atmospheric model as applied in the demonstration runs. This `namcouple` tells OASIS to run a one year simulation during which:

- The PSMILe library is used as communication technique and the computer is a VPP

- The atmospheric model needs three fields, namely the sea surface temperature, the sea surface albedo and sea-ice extent.
- The ocean model needs 14 fields either for exchange at each time step or for diagnostic issues.
- All these fields are exchanged every day.

The Oasis3 configuration file namcouple contains, below pre- defined keywords, all user's defined information necessary to configure a particular coupled run. The first part of the namcouple is devoted to configuration of general parameters such as the number of models involved in the simulation, the number of fields, the communication technique, etc. The second part gathers specific information on each coupling field, e.g. their coupling period, the list of transformations or interpolations to be performed by Oasis3 and their associated configuring lines. For details on the OASIS3 coupling software refer to the OASIS3 User's Guide by [Valcke et al (2003)].

```
# This is a typical input file for OASIS 3.0, not using netCDF
format for grid auxiliary files or restart input files. Oasis
reads in this file at run-time. Don't hesitate to ask
precisions or make suggestions (oasishelp@cerfacs.fr). This
file can be used AS IT IS to run the CLIM toy model (toyclim).
# Any line beginning with # is ignored.

$SEQMODE

# This keyword concerns the coupling algorithm. Put here the
maximum number # of fields that have to be, at one particular
coupling timestep, # necessarily exchanged sequentially in a
given order.

1
END
#####

$CHANNEL

# This describes the kind of message passing you want to use.
Choices are NONE, PIPE, SIPC, GMEM, MPI1 or MPI2. - if you use
MPI1 or MPI2 message passing (CLIM library based on MPI1 or
MPI2), you must write MPI1 or MPI2 on one line + one line per
model giving for the model the total number of procs, the
number of procs implied in the coupling and, for MPI2 only, an
optional launching argument

MPI2
1 1
1 1
END

#####
$NFIELDS
# This is the total number of fields being exchanged. 3 fields
Ocean -> Atm + 6 fields Atm. -> Ocean + 1 field Atm -> Atm Chem
+ 1 field Atm Chem -> Atm
17
END
#####
$JOBNAME
# This is an acronym for this given simulation (3 characters)

CLI
END
#####
$NBMODEL
# This gives you the number of models running in this
experiment + their names (6 characters).

2 arpege opa.xx
END
#####
$RUNTIME
# This gives you the total simulated time for this run in
seconds (here 6 days)

-duree-
```

```

END
#####
$INIDATE
# This is the initial date of the run. This is important only
if FILLING analysis is used for a coupling field in the run.

19870501
END
#####
$MODINFO
# Indicates if a header is encapsulated within the field brick
for coupling field exchanges based on PIPE, SIPC and GMEM
communication technique, and for fields in restart files for
all communication technique. (YES or NOT)

NOT
END
#####
$NLOGPRT
# Index of printing level in output file cplout: 0 = no
printing 1 = main routines and field names when treated, 2 =
complete output

2
END
#####
$SCALTYPE
# Calendar type : 0 = 365 day calendar (no leap years) 1 = 365
day, or 366 days for leap years, calendar n (>1) = n day month
calendar This is important only if FILLING analysis is used for
a coupling field in the run.

1
END
#####
$STRINGS

# The above variables are the general parameters for the
experiment. Everything below has to do with the fields being
exchanged. For each field, the first 3 lines are descriptors of
the field and related grid. The 4th line gives the list of
analyses to be performed and the following lines give specific
parameters for each analysis. See the documentation for the
analyses available in Oasis and for the relevant lines.
#####
#           OCEAN --->>> ATMOS
#           -----
# Field 1 : sea surface temperature
#
# First line:
# 1) and 2) Symbolic names for the field before and after
interpolation (8 characters maximum)
# 3) Label number for internal oasis output (cf blkdata.f)
# 4) Exchange frequency for the field in seconds (here 1 day)
# 5) Number of analysis to be performed
# 6) Restart input binary file names
# 7) Field status (EXPORTED, AUXILARY, or IGNORED)
#
SOSSTSST SISUTESU 1 86400 6 fldo1.nc EXPORTED
#
# Second line:
# 1) 2) 3) and 4) Number of long. and lat. on initial and final
grids
# 5) and 6) locator prefix (4 characters) used to read the
source and target grid characteristics in grid auxialiry files,
+ possibly LAG, SEQ, DEL, XTS additional indices if needed (see
documentation)
#
torc bt42 LAG=+5760
#
# Third line:
# Source grid characteristic (P or R) and number of overlapping
grid points + Target grid characteristic (P or R) and number of
overlapping grid points
P 2 P 0
#
# List of analyses

```

```

#
CHECKIN MASK EXTRAP SCRIPR BLASNEW CHECKOUT
#
# Specific parameters for each analysis
#
# CHECKIN: indicate computation of global, land and sea field
integrals.
INT=1
99999999.
NINENN 4 1 2
GAUSWGT LR SCALAR LATLON 10 4 0.5
#
#
# Blasnew: go from Celsius to Kelvin
# 1) Mult. coeff for initial field 2) Nb of additional fields
3) their names and value of mult. coeff.
#
1. 1
CONSTANT 273.15
#
# CHECKOUT: indicate computation of global, land and sea field
integrals.
INT=1
#
#####
#
#####
# Field 2 : Sea ice extent
#
SOICECOV SIICECOV 2 86400 5 fldo1.nc EXPORTED
torc bt42 LAG=+5760
P 2 P 0
#
CHECKIN MASK EXTRAP SCRIPR CHECKOUT
#
INT=1
99999999.
NINENN 4 1 2
GAUSWGT LR SCALAR LATLON 10 4 0.5
INT=1
#
#####
# Field 3 : Mean sea surface albedo
#
SOALBEDO SIALBEDO 17 86400 5 fldo1.nc EXPORTED
torc bt42 LAG=+5760
P 2 P 0
#
CHECKIN MASK EXTRAP SCRIPR CHECKOUT
#
INT=1
99999999.
NINENN 4 1 2
GAUSWGT LR SCALAR LATLON 10 4 0.5
INT=1
#
#####
#           ATMOSPHERE --->>> OCEAN
#           -----
#
#####
# Field 3 : Non solar heat flux
#
CONSFTOT SONSHLDO 6 86400 3 flda1.nc EXPORTED
bt42 torc LAG=+1800
P 0 P 2
#
CHECKIN SCRIPR CHECKOUT
INT=1
CONSERV D SCALAR LATITUDE 10 FRACNEI FIRST
INT=1
#
#####
#
#####
#
# Field 4 : Solar heat flux

```

```
#
COSHFTOT SOSHFLDO 7 86400 3 flda1.nc EXPORTED
bt42 torc LAG=+1800
P 0 P 2
#
CHECKIN SCRIPR CHECKOUT
INT=1
CONSERV D SCALAR LATITUDE 10 FRACNEI FIRST
INT=1
#
#####
#
#####
#
# Field 5 : water flux
#
COWATFLU SOWAFLDO 29 86400 4 flda1.nc EXPORTED
bt42 torc LAG=+1800
P 0 P 2
#
CHECKIN SCRIPR BLASNEW CHECKOUT
#
INT=1
CONSERV D SCALAR LATITUDE 10 FRACNEI FIRST
1.157407e-05 0
INT=1
#
#####
#
#####
#
# Field 6 : Runoff
# CORUNOFF SORUNOFF 32 86400 4 flda1.nc EXPORTED
bt42 torc LAG=+1800
P 0 P 2
#
CHECKIN MOZAIC BLASNEW CHECKOUT
#
INT=1
runoff42 93 3 234
1.157407e-05 0
INT=1
#
#####
#
# Field 7 : zonal wind stress -> ugrid
#
COZOTAUX SOZOTAUX 23 86400 3 flda1.nc EXPORTED
bt42 uorc LAG=+1800
P 0 P 2
#
CHECKIN SCRIPR CHECKOUT
#
INT=1
BICUBIC D VECTOR LATITUDE 10
INT=1
#
#####
#
# Field 8 : meridional wind stress -> vgrid
#
COMETAUY SOMETAUY 24 86400 3 flda1.nc EXPORTED
bt42 vorc LAG=+1800
P 0 P 2
#
CHECKIN SCRIPR CHECKOUT
#
INT=1
BICUBIC D VECTOR LATITUDE 10
INT=1
#
#####
#
# Field 9 : zonal wind stress -> vgrid
#
COZOTAUV SOZOTAUV 23 86400 3 flda1.nc EXPORTED
bt42 vorc LAG=+1800
```

```
P 0 P 2
#
CHECKIN SCRIPR CHECKOUT
#
INT=1
BICUBIC D VECTOR LATITUDE 10
INT=1
#
#####
#
# Field 10 : meridional wind stress -> ugrid
#
COMETAUU SOMETAAU 24 86400 3 flda1.nc EXPORTED
bt42 uorc LAG=+1800
P 0 P 2
#
CHECKIN SCRIPR CHECKOUT
#
INT=1
BICUBIC D VECTOR LATITUDE 10
INT=1
#
#####
# # Field 11 : Evaporation flux
#
COTHSHSU SOLATHSU 25 86400 4 flda1.nc EXPORTED
bt42 torc LAG=+1800
P 0 P 2
#
CHECKIN SCRIPR BLASNEW CHECKOUT
#
INT=1
CONSERV D SCALAR LATITUDE 10 FRACNEI FIRST
1.157407e-05 0
INT=1
#
#####
#
# Field 12 : Liquid precipitation
#
COTOLIPR SOTOLPSU 27 86400 4 flda1.nc EXPORTED
bt42 torc LAG=+1800
P 0 P 2
#
CHECKIN SCRIPR BLASNEW CHECKOUT
#
INT=1
CONSERV D SCALAR LATITUDE 10 FRACNEI FIRST
1.157407e-05 0
INT=1
#
#####
#
# Field 13 : Solid precipitation
#
COTOSOPR SOTOSPSU 28 86400 4 flda1.nc EXPORTED
bt42 torc LAG=+1800
P 0 P 2
#
CHECKIN SCRIPR BLASNEW CHECKOUT
#
INT=1
CONSERV LD SCALAR LATITUDE 10 FRACNEI FIRST
1.157407e-05 0
INT=1
#
#####
#
# Field 14 : Surface temperature
#
COSSTSST SOSSMEAN 34 86400 1 flda1.nc AUXILARY
bt42 torc LAG=+1800
P 0 P 2
#
CHECKIN
#
INT=1
```

```
#
#####
#
# Field 15 : non solar heat flux derivative
#
CODFLXDT SODFLXDT 35 86400 3 flda1.nc EXPORTED
bt42 torc LAG=+1800
P 0 P 2
#
CHECKIN SCRIPR CHECKOUT
#
INT=1
CONSERV D SCALAR LATITUDE 10 FRACNEI FIRST
INT=1
#
#####
#
# Field 16 : albedo
#
COALBSUR SOALBICE 17 86400 2 flda1.nc AUXILARY
bt42 torc LAG=+1800
P 0 P 2
#
CHECKIN CHECKOUT
#
INT=1
INT=1
#
#####
END
```


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