The MPI-M Millennium Earth System Model:
An Assembling Guide for the COSMOS Configuration

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Chapter 1

Summary

This report describes the Earth System Model (ESM) developed and used by the Max Planck Institut für Meteorologie and the COSMOS community for the Millennium Experiment, with special emphasis on the coupling of the atmosphere and ocean model via the OASIS coupler. The structure of the report follows the approach a user would be taking in order to work on Air-Sea-exchanges. It gives a short technical description of the sub-models of the ESM, and their interplay, as far as they are necessary for such a problem. Main emphasis is on the coupling fields, and on the interfaces between the sub-models and OASIS.

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Chapter 2

Introduction

The Millennium Earth System Modell (M-ESM) is designed to simulate the full Earth System over periods of hundreds to a few thousand years, and the influence of three major forcing factors: Vulcanoes, variations of solar irradiance, and land use changes. The ESM (see the models webpage of MPI-M) consists of four main components: the atmosphere ECHAM model, the land model JSBACH , the Max-Planck-Ocean-Model MPI-OM and the ocean-biogeochemistry-model HAMOCC. The MPI-OM and HAMOCC on the one hand and the ECHAM and JSBACH-Models on the other hand are coupled directly, while the air-sea-exchange in the M-ESM is taking place via OASIS. The focus of the report is on coupling the various components, while we point to the relevant literature for the description of the models themselves. This report is aimed at technical experts and scientists, familiar with numerical general circulation models and their software codes, therefore specific introduction to the terminology used is avoided, to keep the report compact. The programming languages used for the models are FORTRAN and C, scripting is done in ksh.

The report assumes the user/reader receives the model from MPI-Ms models webpage and starts by looking at the scripts he wants to be using for a model run execution. Next point he tries to understand is what parameters are exchanged via the OASIS coupler, and what he needs to do to change/add/leave away parameters.

Chapter 3

M-ESM Technical Description

3.1 Coupling

For the coupling between any two physical components we follow different strategies. For the external coupling between the ocean and the atmosphere components we use the OASIS3 software. The coupling is described in more detail below. For the coupling between ocean, sea ice and bio-geochemistry as well as for the one between atmosphere and land we follow an internal coupling approach: in this case the respective components are integrated into each other. Furthermore the internal coupling does not require any interpolation as the grids used in the respective components are identical.

3.1.1 Atmosphere - Ocean Interface

Among the physical components in the Millennium configuration only the atmosphere and ocean components exchange boundary conditions via coupling software. The atmosphere part collects contributions from land (e.g. river runoff) while the ocean collects data from the ice model. While for the internal coupling data are exchanged at every time step, for the external coupling the interval for data exchange between the ocean and the atmosphere is set to one day. Coupling fields are accumulated at each time step within the sending model component. Data are averaged before sending them to the OASIS3 coupler. The boundary values that are exchanged between the atmosphere and the ocean are

- Ocean/Sea-Ice to atmosphere

    - sea surface temperature
    - sea ice concentration
    - sea ice thickness
    - ocean horizontal surface velocity
    - CO_2 flux

- Atmosphere to Ocean/Sea-Ice

    - solar heat flux
    - non-solar heat flux
    - precipitation, evaporation, river runoff
    - snow fall
    - horizontal wind stress

In the following we describe each coupling field in more detail. We list the sequence number in the namcouple file, its standard long name, the short name on the sender side, as it is defined in the namcouple, and units of the quantity on the sender side, followed by a short description about the physical meaning and the interpolation used.

Sea Surface Temperature

Field 1:	Sea surface temperature	SSTOCEAN	[K]

The sea surface temperature is computed in °C in MPIOM. The field is sent to OASIS, where it is converted into K. Sea surface temperatures are then extrapolated towards the continental boundaries on the ocean grid and then interpolated onto the ECHAM grid by using the conservative remapping technique. The interpolated field is received by ECHAM.

Sea ice

Field 2:	Sea ice thickness	SITOCEAN	[m]
Field 3:	Sea ice area fraction	SICOCEAN	
Field 4:	lwe surface snow thickness over sea ice	SNTOCEAN	[m]

Sea ice thickness is calculated by the ice model and sent to OASIS via MPIOM. **Sea-ice Area Fraction** or sea-ice concentration is computed by the MPIOM sea ice model. This quantity expresses the fraction of the cell which is covered by sea ice with values ranging from 0 (open water) to 1 (fully covered with ice). The field is sent to OASIS via the ocean model. To insure the global conservation of sea ice the interpolation in OASIS3 uses a first-order conservative remapping. **lwe Surface Snow Thickness** (lwe = liquid water equivalent) is calculated over sea in the MPIOM ice model. The field is sent to OASIS via the ocean model. To insure the global conservation of sea ice the interpolation in OASIS3 uses a first-order conservative remapping.

Horizontal Ocean Surface Velocity

Field 5:	ocean eastw. velocity	OCUOCEAN	[m/s]
Field 6:	ocean northw. velocity	OCVOCEAN	[m/s]

The horizontal ocean surface velocity components are transformed into N-S and E-W orientation. The vector components are then passed separately to the OASIS3 coupler using a first-order conservative remapping.

CO_2 partial pressure

Field 7:	CO_2 transfer coefficient	CO2TRAOC	
Field 8:	pCO_2 in uppermost ocean layer	CO2OCEAN	[ppm CO_2]

CO_2 and pCO_2 are calculated by the carbon cycle model HAMOCC which is integrated into MPIOM. The fields are interpolated using conservative remapping.

Horizontal wind stress

Field 9:	surface downward eastward stress over open sea	TXWATMOU	[Pa]
Field 10:	surface downward eastward stress over open sea	TXWATMOV	[Pa]
Field 11:	surface downward northward stress over open sea	TYWATMOU	[Pa]
Field 12:	surface downward northward stress over open sea	TYWATMOV	[Pa]
Field 13:	surface downward eastward stress over sea ice	TXIATMOU	[Pa]
Field 14:	surface downward eastward stress over sea ice	TXIATMOV	[Pa]
Field 15:	surface downward northward stress over sea ice	TYIATMOU	[Pa]
Field 16:	surface downward northward stress over sea ice	TYIATMOV	[Pa]

The vector components of the horizontal wind stress are calculated by the atmosphere model separately over sea ice and over open water. The vector components are interpolated separately using conservative remapping.

Atmospheric water flux, runoff and snow fall

Field 17:	lwe surface downward snow flux over sea ice	FRIATMOS	[m/s]
Field 18:	water flux into ocean	FRWATMOS	[m/s]

The atmospheric water flux (F_W) sent to the ocean is a combination of precipitation (E) and evaporation (P). In addition a run-off scheme redistributes some of the precipitation over land and adds a contribution to selected ocean points to mimic the river runoff (F_{riv}). The total water flux

$$F_W = E - P + F_{riv}$$

is expressed in m/s. Over sea ice the snow fall is not added to F_W but provided in a separate coupling field (FRIATMOS) to allow for the accumulation of snow over sea ice. The flux values are interpolated using the conservative remapping.

Solar and non-solar heat fluxes

Field 19:	Residual heat flux (sea-ice topmelt heat flux)	RHIATMOS	[W/m^2]
Field 20:	downward heat flux in sea ice	CHIATMOS	[W/m^2]
Field 21:	surface downward heat flux in air	NHWATMOS	[W/m^2]
Field 22:	surface net downward shortwave flux	SHWATMOS	[W/m^2]

Heat fluxes (F_H) are computed in the atmosphere model separately for sea ice and open water as a composite of the net surface shortwave radiation (F_{SW}), the net surface long wave radiation (F_{LW}), the latent heat flux (F_{LH}), and the sensible F_{LW} heat flux (F_{SH}), units are W m^{-2}. Fluxes from the atmosphere into the ocean are given as positive values. As the ocean does not distinguish between F_{LW}, F_{LH}, F_{SH}, these are assembled into the non-solar heat flux (F_{NS}). ECHAM uses a fractional grid to represent ocean and sea ice surface. Each heat flux is computed for sea ice and open water boundary conditions and combined according to the fractional sea ice mask. The conservation of fluxes is achieved by correcting the fluxes and make them equal to the global integral.

Wind Speed

Field 23:   wind speed at 10m   WSVATMOS   [m/s]

The wind speed at 10 m height is interpolated using the SCRIP bilinear algorithm with a nearest-neighbour extrapolation for target points that do not have any overlapping source cells.

CO_2 fluxes

Field 24:   atmospheric CO_2 concentration   CO2CONAT   [kg]
Field 25: CO_2 flux from ocean to atmosphere   CO2FLXAT

Atmospheric CO_2 concentration is interpolated using the bilinear algorithm. The CO_2 flux is interpolated with the conservative remapping scheme. The atmospheric CO_2 concentration is transferred to the ocean for diagnostic purposes only.

Implementation in MPIOM

All OASIS3 library interface routines are implemented in a single Fortran module (mo_couple) in file mo_couple.F90. Four subroutines are available to be called by the MPIOM main program:

- couple_init

- couple_get_a2o

- couple_put_o2a

- couple_end

couple_init is called before the start of the time loop. Here the coupling is initialized. At the very beginning of an experiment, coupling fields are written out into a file and made available to OASIS3 for interpolating and sending to the atmosphere. Variable names are defined that match with the names for the coupling fields provided in the namcouple. Inside the time loop coupling fields are made available to OASIS3 with calls to couple_put_o2a. Coupling fields are received from the atmosphere (via OASIS3) with calls to couple_get_a2o. In order to terminate the coupling couple_end is called.

Implementation in ECHAM

Similar to MPIOM all OASIS3 library interface routines are implemented in a single Fortran module (mo_couple) in file mo_couple.F90.

- couple_init

- couple_get_o2a

- couple_put_a2o

- couple_end

Inside the time loop coupling fields are made available to OASIS3 with calls to couple_put_a2o. Coupling fields are received from the ocean (via OASIS3) with calls to couple_get_o2a.

3.2 Atmosphere and Land

3.2.1 Atmosphere

The atmosphere general circulation model used in ESMs derived from the COSMOS software repository is ECHAM5, Roeckner 2003, [19]; 2006, [20]. ECHAM5 solves the primitive equations for the general circulation of the atmosphere on a sphere. The dynamical core of ECHAM5 employs the spectral transform technique for the computation of the prognostic dynamic variables (log(surface pressure), vorticity, divergence, temperature) and a flux form semi-Lagrangian transport scheme for prognostic tracers (water vapor, cloud water, cloud ice and CO_2 mixing ratios.). The spectral dynamics works on a spectrum of spherical harmonics with triangular truncation and an associated Gaussian grid. The same Gaussian grid is used by the transport scheme. A terrain following hybrid sigma-pressure grid is used in the vertical. ECHAM5, as used for the Millenium project and distributed to the community, has a triangular truncation at wavenumber 31 and makes use of a Gaussian grid of 96 x 48 grid points in longitude x latitude. The vertical grid resolves the atmosphere by 19 levels between the surface and 0 hPa. ECHAM5 includes parameterizations for short and longwave radiation, for vertical turbulent fluxes of momentum, heat and tracers in the boundary layer and free atmosphere, for drag by sub grid scale orography, for cloud microphysics in stratiform clouds, for convective clouds and for cloud cover. The parameterization for drag by non-orographic gravity waves is not active in the 19 layer model. A detailed description of the model formulation is given in Roeckner et al., 2003 [19]. The sensitivity of the ECHAM5 model to horizontal and vertical resolution in the troposphere and lowermost stratosphere is discussed in Roeckner et al., 2006 [20], the hydrological cycle in Hagemann et al., 2006 [5], radiative fluxes in Wild and Roeckner, 2006 [24], and surface albedo and snow cover in Roesch and Roeckner, 2006 [21]. ECHAM5 has a sub-model interface that allows the coupling of aerosol and chemistry sub-models, which however are not part of the distributed code. ECHAM5 is parallelized in MPI processes and/or OpenMP threads. It has been tested on several architectures including NEC-SX6 (DKRZ), IBM-Power5 and 6 (ECMWF, DKRZ), Linux clusters and PCs of various kinds.

3.2.2 Land

The land processes are handled by JSBACH (**J**ena **S**cheme for **B**iosphere **A**tmosphere **C**oupling in **H**amburg), see Raddatz et.al., 2007 [16], except for river routing for which the HD-model is responsible. Once each timestep, JSBACH is accessed from ECHAM by calling the subroutine `jsbach_inter_1D()`. The interface of this subroutine largely follows the PILPS convention [15]. JSBACH runs on the same grid as ECHAM. Since no resolution-dependent parameterizations are used, JSBACH works without further adjustments for different grids. For heat and moisture fluxes, JSBACH uses an implicit coupling to the vertical diffusion. Accordingly, JSBACH is an integral part of the Ritchmyer-Morten scheme [18] by which the respective diffusion equations are solved in ECHAM. Correspondingly, the surface energy balance is solved in JSBACH. JSBACH handles all grid cells independently, i.e. there are no interactions between grid cells. Each grid cell is further divided into so-called "tiles" describing a particular fraction of the grid cell. These tiles are endowed with certain land surface properties, of which the association with a particular land cover type is basic. Land cover types are either vegetation – more precisely a PFT ("Plant Functional Type") – or the special type "glacier". Bare land is handled implicitly. Major differences between the PFTs concern their phenology, their photosynthetic capacity, and their radiative properties. Each tile is equipped with its own carbon reservoirs for plant and soil compartments. All tiles in a grid cell take part in a common soil water reservoir, modelled as a simple bucket. Soil temperature is computed for five soil layers, and is the same for all tiles in a grid cell. The major prognostic variables of JSBACH are: the filling of the soil water bucket, the temperatures in the five soil layers, the LAI ("Leaf Area Index") values for all PFTs in a grid cell, and the carbon contents of the various plant and soil pools. The models for most physical land aspects (soil hydrology, soil temperatures, energy balance, thermal radiation) have been taken over from ECHAM5 and are described in Roeckner, 2003 [19]. JSBACH goes beyond the original ECHAM5 land description by computing stomatal conductance, albedo, and roughness length in dependance of the LAI and type of vegetation. The albedo calculations account for snow masking of forests. In addition, CO_2 fluxes arising

from the balance of the carbon uptake of vegetation and soil respiration, are exchanged in an explicit scheme with the atmosphere. Changes arising from anthropogenic land cover change can be accounted for by driving JSBACH with a sequence of external maps. In this case, CO_2 fluxes arising from deforestation/afforestation are added to the CO_2 exchange flux between ECHAM and JSBACH.

3.3 Ocean, Sea-Ice and Ocean-Biogeochemistry

3.3.1 The Ocean Model MPIOM

The ocean component of M-ESM is the Max Planck Institute Ocean Model (MPIOM, Marsland et al., 2003 [13]). The primitive equations for a hydrostatic Boussinesq fluid are formulated with a free surface. The vertical discretization is on z-levels and the bottom topography is resolved by way of partial grid cells (Wolff et al., 1997, [25]). Using the formulation of Arakawa and Lamb, 1977, [2], the spatial arrangement of scalar and vector variables is formulated on a C-grid. The along-isopycnal diffusion is based on the work of Redi, 1982, [2]and is implemented following Griffies, 1998, [17]. The effect of horizontal tracer mixing by advection with the unresolved eddies is parameterized following Gent et al., 1995, [3]. For the vertical eddy viscosity and diffusion the Richardson-number dependent scheme of Pacanowski and Philander (1981, PP hereafter,[14]) is applied. Since the PP scheme in its classical form underestimates the turbulent mixing close to the surface, an additional wind mixing parameterization is included. The wind stirring near the surface is proportional to the cube of the 10 m wind speed and decays exponentially with depth. In the presence of static instability, convective overturning is parameterized by greatly enhanced vertical diffusion. A slope convection scheme has been included that allows for a better representation of the flow of statically unstable dense water over sills, such as in Denmark Strait or in the Strait of Gibraltar (see Marsland et al., 2003, [13], for details) and off shelves, such as on the Arctic and Antarctic shelves. An orthogonal curvilinear grid allows for an arbitrary placement of the grid poles. In the Millennium set-up (Jungclaus et al., 2010, [9]), the nominal horizontal resolution is 3 degrees. However, the model's North Pole is shifted to Greenland and the South Pole is moved toward the center of the Antarctic continent. This approach not only removes the numerical singularity associated with the convergence of meridians at the geographical North Pole but also produces higher resolution in the deep water formation regions near Greenland (Greenland Sea, Labrador Sea) and in the Weddell Sea. In fact, the grid spacing is at minimum with about 30 km around Greenland and at maximum with 368 km in the Pacific. In the vertical, there are 40 levels. The topography was interpolated from the ETOPO5 (National Geophysical Data Center, 1988, [1]) 1/12 deg dataset and specific topographic features, such as the important conduits of overflows and throughflows, were adjusted to observed sill depths. The grid set-up used for the Millennium simulations is a low-resolution version of the model used for the scenario simulations (Jungclaus et al., 2006) for the Intergovernmental Panel of Climate Change Fourth Assessment Report (IPCC AR4). The performance of MPIOM in the IPCC-AR4 set-up is described in detail in Jungclaus et al., 2006, [8] and the stand-alone ocean model is discussed in a multi-model intercomparison exercise by Griffies et al., 2009, [4]).

3.3.2 Sea Ice

The dynamic and thermodynamic sea ice model is similar to the earlier HOPE model (Wolff et al., 1997, [25] ; Marsland et al., 2003, [13]). The dynamics of sea ice are formulated using viscous-plastic rheology following Hibler, 1979, [6]. The thermodynamics relate changes in sea ice thickness to a balance of radiant, turbulent, and oceanic heat fluxes. The effect of snow accumulation on sea ice is included, along with snow-ice transformation when the snow/ice interface sinks below the sea level due to snow loading. The effect of ice formation and melting is accounted for within the model assuming a sea ice salinity of 5 psu.

3.3.3 Ocean-Biogeochemistry

HAMOCC5.1 is implemented into the MPIOM physical ocean model configuration using a curvilinear coordinate system with a 1.5° nominal resolution where the North Pole is placed over Greenland, thus providing

relatively high horizontal resolution in the Nordic Seas. The vertical resolution is 40 layers, with higher resolution in the upper part of the water column (10 m at the surface to 13 m at 90 m). The marine biogeochemical model HAMOCC5.1 is designed to address large-scale, long-term features of the marine carbon cycle, rather than to give a complete description of the marine ecosystem. Consequently, HAMOCC5.1 is a NPZD model with one phytoplankton group (implicitly divided into coccolithophorids and diatoms) and one zooplankton species. Detritus is formed from dead phytoplankton and zooplankton, and zooplankton fecal pellets. Furthermore, dissolved organic matter is produced by phytoplankton exudation and zooplankton excretion. The carbonate chemistry is identical to the one described in [11]. A more detailed description of HAMOCC5.1 can be found in [12], while here only the main features relevant for the described experiments will be outlined. Phytoplankton growth depends on the availability of light (I) and nutrients. The local light supply is calculated from the temporally and spatially varying solar radiation at the sea surface, $I(0, t)$, as provided by the OGCM. Below the surface, light intensity is reduced due to attenuation by sea water (k_w) and chlorophyll (k_c) using a constant conversion factor for C:Chl, $R_{C:Chl}$:

$$I(z,t) = I(0,t)\,e^{-(k_w + k_c\,\text{PHY}\,12\,R_{C:P}/R_{C:Chl})z} \tag{3.1}$$

Biological production depends linearly on the availability of light, without saturation of growth rates for stronger irradiance (I). The growth rate $J(I(z,t))$, is calculated as $J(I) = \alpha_{\text{PHY}}\,I(z,t)$, where α_{PHY} is the slope of the P-vs-I-curve (production vs. light intensity). The light limited phytoplankton growth rate is then multiplied by the nutrient limitation factor, which is calculated from a simple Monod function, limited by the least available nutrient (either phosphate, nitrate, or iron) to derive the total biological production. Silicate concentrations are then used to compute fractions of biological production by diatoms and coccolithophorides, respectively, while the remaining fraction is assumed to be by flagellates. Depending on the amount of silicate available, diatoms grow first. Here, only the shells (opal and calcium carbonate) that are part of detritus (DET) are used to compute the fractions P_{sil} and P_{car} of production:

$$P_{\text{sil}} = \min\left(\frac{\Delta \text{DET}}{\Delta t}\,R_{\text{Si:P}}\,\frac{\text{SI}(\text{OH})_4}{K_{\text{PHY}}^{\text{SI}(\text{OH})_4} + \text{SI}(\text{OH})_4},\, 0.5\,\text{SI}(\text{OH})_4\right), \tag{3.2}$$

where $\frac{\Delta \text{DET}}{\Delta t}$ is the export production, $R_{\text{Si:P}} = 25$ denotes the Si:P ratio required by diatoms, $K_{\text{PHY}}^{\text{SI}(\text{OH})_4} = 1\,\text{mmol m}^{-3}$ the half-saturation constant for silicate uptake. A further fraction of production is by coccolithophorids. Again, as for opal we only account for the sinking part of calcite production:

$$P_{\text{car}} = \frac{\Delta \text{DET}}{\Delta t}\,R_{\text{Ca:P}}\,\frac{K_{\text{PHY}}^{\text{SI}(\text{OH})_4}}{K_{\text{PHY}}^{\text{SI}(\text{OH})_4} + \text{SI}(\text{OH})_4}, \tag{3.3}$$

with $R_{\text{Ca:P}} = 35$ being the $CaCO_3$ to PO_4 ratio. In the model version used in this study, biological production was temperature-independent, assuming that phytoplankton acclimate to local conrditions. A constant climatology of global dust deposition fields from Stier et.al., 2005, [22], were used as source function of bioavailable iron. Removal of dissolved iron occurs through biological uptake and export, and by scavenging. Scavenging of iron is described as a relaxation to the deep-ocean iron concentration of 0.6 nM with a time scale of 200 years where the local concentration exceeds this value. For the Fe:C ratio a value of $5 \cdot 10^{-6}$ was used, see Johnson, 1997, [7]. With regard to the later discussions of results it should be noted here that the used dust fields and Fe:C ratio cause a too strong iron limitation of the model. Both using the Mahowald, 2006, [10], dust fields or using an Fe:C ratio of $3 \cdot 10^{-6}$, which would be at the low end of the Johnson, 1997, [7], estimates, would have avoided this. Unfortunately, the computations with the coupled model were so computationally expensive that they could not be repeated until today, and the issue was only discovered when evaluating the experiment. Export of detritus is simulated using prescribed settling velocities for opal (30 m day^{-1}), calcite shells (30 m day^{-1}) and organic carbon (10 m day^{-1}). Remineralization of organic matter depends on the availability of oxygen. In anoxic regions, remineralization occurs via denitrification. The model also includes cyanobacteria that take up nitrogen from the atmosphere if the local N:P ratio is

below the Redfield ratio as a result of denitrification, and transform it directly into nitrate. HAMOCC5.1 also includes an interactive sediment module. This component simulates pore water chemistry, the solid sediment fraction and interactions between the sediment and the oceanic bottom layer as well as between solid sediment and pore water constituents.

Chapter 4

Scripts

Below the reader will find excerpts from the documentation which is part of the COSMOS source code repository as it is distributed by MPI-M. This documentation describes how to download, install, and run Earth system models based upon the component models ECHAM, MPI-OM, JSBACH and HAMOCC, the coupler OASIS, and the environments SCE and SRE (For details on the versions see below). Most of the documentation is based upon the computing environment at the German Climate Computing Centre DKRZ, but should be transferable to other computer systems. If the reader has access to one of the tar-balls distributed by MPI-M, it is probably advisable to continue reading in the appropriate files there.

4.1   From svn/cosmos/tags/cosmos-1.2.1/README

From the COSMOS web site http://cosmos.enes.org: " COSMOS is a framework to develop and apply coupled atmosphere/ocean/land models for Earth system research. " The COSMOS-1.2.1 software package allows to build different models including the physical climate model ECHAM5/MPIOM and the carbon cycle - climate model ECHAM5-JSBACH/MPIOM-HAMOCC[1]. This latter model configuration is new compared to the previous COSMOS-1.1.0 software package, and corresponds to the model developed in the Millennium project. COSMOS-1.2.1 uses the PRISM software for infrastructure. The COSMOS-1.2.1 software package was developed at MPI-M in collaboration with the Model and Data group in Hamburg and support from CRAY and NEC.

People involved in the implementation, testing and compilation of this package are:

- MPI: M. Botzet, R. Brokopf, M. Esch, V. Gayler, M. Giorgetta, H. Haak, J. Jungclaus, L. Kornblueh, S. Lorenz, E. Roeckner, R. Schnur, U. Schulzweida

- MaD: S. Legutke, H. Widmann

- CRAY: E. Tschirschnitz

- NEC: J.-O. Beismann, S. Borowski.

Please read also the following files before starting to use COSMOS models:

- INSTALL : Explains how to generate specific models from the COSMOS package and how to start with a first experiment.

- NEWS : Explains differences to coupled models distributed earlier

- PROBLEMS : Lists known problems with the usage of models from this package

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[1]As realized in the M-ESM described in this assembling guide.

- GLOSSARY : Lists short explanations for acronyms and terms

Further copyrights/info:

- OASIS3: see src/mod/oasis3/COPYRIGHT

- MPP_IO library: see src/lib/mpp_io/COPYRIGHT

- SCRIP library: see src/lib/scrip/COPYRIGHT

Reference for the PRISM coupling software:
Valcke, S., 2006: OASIS3 User Guide, [23], or this PDF-File.

cosmos-1.2.1 package

- cosmos-1.2.1.tar : source code and environment

  - input_cosmos-ao_T31L19_GR30L40.tar : input files for default setup of the coupled model cosmos-ao (ECHAM5/MPIOM)
  - input_cosmos-asob_T31L19_GR30L40.tar : input files for default setup of the coupled model

- cosmos-asob (ECHAM5/JSBACH/MPIOM/HAMOCC)

  - input_echam5_T31L19.tar : input files for cosmos-a (ECHAM5)
  - input_mpiom_GR15L40.tar : input files for cosmos-o (MPIOM)

Other input files are available on demand. The tar-package includes .svn directories. These are necessary for our version control system but without function for the use of the models.

Configurations:

The cosmos-1.2.1 package allows to build and run the following model setups:

- cosmos-asob : coupled atmosphere/land/ocean/ocean-biogeochemistry including the full carbon cycle setup in T31L19 / GR30L40 resolution, using input_cosmos-asob_T31L19_GR30L40.tar

- cosmos-aso : coupled atmosphere/land/ocean setup in T31L19 / GR30L40 resolution, using input_cosmos-aso_T31L19_GR30L40.tar

- cosmos-ao : coupled atmosphere/ocean setup in T31L19 / GR30L40 and T63L31 / GR15L40 resolution, using input input_cosmos-ao_T31L19_GR30L40.tar or input_cosmos-ao_T63L31_GR15L40.tar

- cosmos-as : standalone atmosphere/land setup for T31L19 (appr. 3.75 deg) resolution forced with climatological SST data, using input input_cosmos-as_T31L19.tar

- cosmos-a : standalone atmosphere setup for T31L19 (appr. 3.75 deg) resolution forced with climatological SST data, using input input_cosmos-a_T31L19.tar

- cosmos-o : standalone ocean setup for GR30L40 (appr. 3 deg) resolution forced with climatological ERA15 data (OMIP), using input_cosmos-o_GR30L40.tar

- cosmos-s : standalone land setup for T31 (appr. 3.75 deg) resolution forced with climatological SST data and modelled atmosphere data, using input input_cosmos-s.tar

Input/restart data for these model setups are available on request

INSTALLATION:
This model has been tested on on the linux cluster tornado, see http://www.dkrz.de/dkrz/about/hardware/linux_cluster, using the PGI and NAG compiler and the MPI parallelization library only. On the IBM-Power6 installation blizzard at DKRZ, see http://www.dkrz.de/dkrz/about/hardware/HPC_Cluster, the xlf compiler has been used. OpenMP and hybrid MPI/OpenMP mode were not tested! COSMOS is doing IO for the initial and restart files based on UCAR's netCDF library. Take care that you use the right setup for your Fortran compiler when installing netCDF. For postprocessing of the ECHAM5 code you need the afterburner software package. Please download the latest revision from http://www.mpimet.mpg.de/fileadmin/software/afterburner/. In case of questions contact Uwe Schulzweida (uwe.schulzweida@zmaw.de. Further useful software for data analysis is the CDO-package: http://www.mpimet.mpg.de/fileadmin/software/cdo/

COMPILING for tornado.dkrz.de (1024 core linux cluster, Hamburg)
Either you untar cosmos-1.2.1.tar on tornado.dkrz.de or you checkout the cosmos package from our SVN-repository. You do not need additional input/restart-files, as the files for this site are available from /pool. Let MYDIR be the directory, where you check out or untar the cosmos package, e.g. /scratch/work/prj/"user". Then the follwoing commands could be used:
$tornado: cd $MYDIR
$tornado: svn checkout http://svn.zmaw.de/svn/cosmos/tags/cosmos-1.2.1 or
$tornado: tar xvf cosmos-1.2.1.tar.

We recommend to load the PGI FORTRAN compiler module with

$tornado: module load PGI/8.0-4

Let test1 be your first experiment-id ($expid in the scripts). Change to

$tornado: cd $MYDIR/cosmos-1.2.1/util/compile/tools

and type:

$tornado: ./Create_COMP_cpl_models.ksh cosmos-ao –id test1 –node linux-x64 –compiler pgi

Here you create the scripts for the model setup "cosmos-ao" (using the PGI compiler) to compile the three coupled model components. Just run the three scripts.

$tornado: $MYDIR/cosmos-1.2.1/src/mod/mpiom/COMP_mpiom_test1.ksh
$tornado: $MYDIR/cosmos-1.2.1/src/mod/echam5/COMP_echam5_test1.ksh
$tornado: $MYDIR/cosmos-1.2.1/src/mod/oasis3/COMP_oasis3_MPI1.ksh

Your executables of the model components can be found in

$tornado: ls $MYDIR/cosmos-1.2.1/x86_64-pgi/bin

Other setups are made by substituting the "ao" according to the list above. Use e.g. cosmos-asob (for Millennium setup), cosmos-a (for atmosphere only) or cosmos-o (for ocean only). You can get more information on the usage of Create_COMP_cpl_models.ksh with

$tornado: ./Create_COMP_cpl_models.ksh –help

Documentation: $MYDIR/util/compile/doc

RUNNING on tornado.dkrz.de (Hamburg):

Change to

$tornado: cd $MYDIR/cosmos-1.2.1/util/running/tools

and type

$tornado: ./Create_TASKS.frm cosmos-ao –id test1 –node linux-x64 –compiler pgi

You will be asked to edit the file

$tornado: vi/emacs/.. $MYDIR/cosmos-1.2.1/util/running/setup/setup_cosmos-ao_test1

For the default experiments set your e-mail address accordingly.

ATTENTION: for production runs it is necessary to archive your model output in the tape archive. On tornado no archiving is activated (default: archiving=no). When switching to archiving=yes, no archiving path is available. This path has to be set to a value distinct from the data-path in the setup and this parent directory has to exist (you have to make it on your own!), e.g.: export archive=/scratch/wrkshr/"user"/COSMOS/cosmos-1.2.1/scr_archive/experiments Then your data are written into this directory in the same way as the former millennium experiments. You have to take care ON YOUR OWN to store this data in the archive. Files for the archive have to be at minimum 1 GB, preferred filesize is 10-50GB.

Then type

$tornado: ./Create_TASKS.frm cosmos-ao –id test1 –node linux-x64 –compiler pgi

a second time. Otherwise you have to edit the file

$tornado: vi/emacs/.. $MYDIR/cosmos-1.2.1/util/running/setup/setup_cosmos-ao_test1

further, according to your planned experimental setup. Then change into

$tornado: cd $MYDIR/cosmos-1.2.1/experiments/test1/scripts

and start the model run by submitting test1.run:

$tornado: qsub test1.run

You can get more information on the usage of Create_TASKS.ksh with

$tornado: ./Create_TASKS.ksh –help

Documentation: $MYDIR/util/running/doc (not up to date)

Overcommiting the number of processors (not reserving one processor for OASIS) is possible and default for

some versions.

DATA on tornado: Logfiles from the script running the model are in the directory

$tornado: ls $MYDIR/cosmos-1.2.1/experiments/test1/scripts

Default directories for data and further logfiles of the individual models will be in $tornado: ¿ ls /scratch/wrkshr/"user"/cosmos-1.2.1/experiments/test1

Data in these directories will only be available for a limited time and the user has to take care of archiving the data. For more details please look into $tornado: $MYDIR/util/running/doc/prism_rep05.pdf, fig 2.1.

COMPILING for blizzard.dkrz.de (IBM Power6, Hamburg)

You either need to un-tar cosmos-1.2.1.tar on blizzard.dkrz.de or you checkout the cosmos package from our SVN-repository. You do not need additional input/restart-files, as the files for this site are available from /pool. Let MYDIR be the directory, where you checked out the cosmos package, e.g. for blizzard your HOME-directory:

$blizzard: cd $MYDIR
$blizzard: svn checkout http://svn.zmaw.de/svn/cosmos/tags/cosmos-1.2.1
or
$blizzard: tar xvf cosmos-1.2.1.tar.

Let test1 be your first experiment-id ($expid in the scripts). Change to

$blizzard: cd $MYDIR/cosmos-1.2.1/util/compile/tools

and type:

$blizzard: ./Create_COMP_cpl_models.ksh cosmos-asob –id test1 –node aix –compiler xlf

Here you create the scripts for the model setup "cosmos-asob", the "Millennium setup", (using the xlf compiler) to compile the three coupled model components. Just run the three scripts.

$blizzard: $MYDIR/cosmos-1.2.1/src/mod/mpiom/COMP_mpiom_test1.ksh
$blizzard: $MYDIR/cosmos-1.2.1/src/mod/echam5/COMP_echam5j_test1.ksh
$blizzard: $MYDIR/cosmos-1.2.1/src/mod/oasis3/COMP_oasis3_MPI1.ksh
Your executables of the model components can be found in

$blizzard: ls $MYDIR/cosmos-1.2.1/AIX-xlf/bin

Other setups are made by substituting the "asob" according to the list above. Use e.g. cosmos-ao (for the coupled model without carbon cycle), cosmos-a (for atmosphere only) or cosmos-o (for ocean only). You can get more information on the usage of Create_COMP_cpl_models.ksh with

$blizzard: ./Create_COMP_cpl_models.ksh –help

Documentation: $MYDIR/util/compile/doc

RUNNING on blizzard.dkrz.de (Hamburg):

Change to

$blizzard: cd $MYDIR/cosmos-1.2.1/util/running/tools

and type

$blizzard: ./Create_TASKS.frm cosmos-asob –id test1 –node aix –compiler xlf

You will be asked to edit the file

$blizzard: vi/emacs/.. $MYDIR/cosmos-1.2.1/util/running/setup/setup_cosmos-asob_test1

For the default experiments set your e-mail address accordingly. **ATTENTION**: for production runs it is necessary to archive your model output in the tape archive. On blizzard no archiving is activated (default: archiving=no). When switching to archiving=yes, no archiving path is available. This path has to be set to a value distinct from the data-path in the setup and this parent directory has to exist (you have to make it on your own!), e.g.: export archive=/scratch/[a,b,k,m,u,g]/"user"/COSMOS/cosmos-1.2.1/scr_archive/experiments Then your data are written into this directory in the same way as the former millennium experiments. You have to take care ON YOUR OWN to store this data in the archive. Files for the archive have to be at minimum 1 GB, preferred file size is 10-50GB.
Then type

$blizzard: ./Create_TASKS.frm cosmos-asob –id test1 –node aix –compiler xlf

a second time. Otherwise you have to edit the file

$blizzard: vi/emacs/.. $MYDIR/cosmos-1.2.1/util/running/setup/setup_cosmos-asob_test1

further, according to your planned experimental setup. Then change into

$blizzard: cd $MYDIR/cosmos-1.2.1/experiments/test1/scripts

and start the model run by submitting test1.run:
    $blizzard: llsubmit test1.run

You can get more information on the usage of Create_TASKS.ksh with

$blizzard: ./Create_TASKS.ksh –help

Documentation: $MYDIR/util/running/doc (not up to date)

DATA on blizzard:
Logfiles from the script running the model are in the directory

$blizzard: ls $MYDIR/cosmos-1.2.1/experiments/test1/scripts

Default directories for data and further logfiles of the individual models will be in

$blizzard: ls /scratch/[a,b,k,m,u,g]/"user"/cosmos-1.2.1/experiments/test1 ff.

Data in these directories will be deleted after 7 days and there is no backup. The user has to take care

of archiving the data. For more details please look into $MYDIR/util/running/doc/prism_rep05.pdf, fig 2.1.

RUNNING with OpenMP, other compilers and on other platforms:
Running the model with OpenMP requires additional compiler options. You have to edit the compile scripts produced by Create_COMP_cpl_models.ksh: Set the switch "compile_with_OpenMP" from no to yes before compiling (necessary in COMP_echam5_test1.ksh and COMP_mpiom_test1.ksh). When you prepare the run scripts using Create_TASKS.frm you have to edit the setup file and set the variables nthreadatm and nthreadoce accordingly. This model has been tested on the tornado using the PGI and NAG compiler using MPI only, OpenMP and hybrid mode were not tested on tornado. The model runs with MPI1 (default) or MPI2 and hybrid (MPI1/OpenMP, MPI2/OpenMP). Note that the SRE and SCE header files included for Sunos and Linux are not tested, they could however help in case the cosmos model is installed on these platforms. textbfPostprocessing:
QUICKplots.tar is a standard post-processing tool for ECHAM-output. Un-tar the file and follow the README. The "contrib" directory contains a lot of information for post-processing of output files. In "contrib/plots/echam5j" as well as "contrib/plots/mpiom" a "tsplot.tar" is located. Un-tar the file and follow the README to use this plot package for generating standard plots of atmosphere and ocean time series, respectively. The package located in "contrib/plots/cosmos-asob" generates a visualization of principle global quantities, including carbon fluxes and budgets.

Chapter 5

Acknowledgements

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