

Model Output Requirements for CDR-MIP

March 2016

Gridded Model Output

For models capable of generating gridded data, this will be hosted on the ESGF in netCDF format. The output (Appendix A) follows the CMIP5 output requirements in frequency and structure. This allows groups to use the existing CMOR software (Climate Model Rewriter Software, available at <http://www2-pcmdi.llnl.gov/cmor>). Please contact individual groups if more output beyond the submitted data is required. The resolution of the data should be as close to native resolution as possible but on a regular grid. Please note as different models have different formulations, only applicable outputs need be provided.

Box model output protocol for CDR-MIP

For models that are incapable of producing gridded NetCDF data, i.e., box models, output is expected to be in an ASCII format. All ASCII files are expected to contain tabulated values (at a minimum global mean values), with at least 2 significant digits for each run. Models must be able to calculate Tier 1 variables (Appendix B) to participate in CDR-MIP experiments C1 and C2. Please submit these files directly to the CDR-MIP project leaders who will make it available for registered users to download from the website.

File name format: RUNNAME_MODELNAME_Modelversion.dat
C1_MYBOXMODEL_V1.0.dat

Example:

Headers and formats:

- Start each header comment line with a #
- *Line 1:* Indicate run name , e.g., "# C1"
- *Line 2:* Provide contact address, e.g., "# B. Box, Uni of Box Models, CO2 Str., BoxCity 110110, BoxCountry"
- *Line 3:* Provide a contact email address, e.g., "# bbox@unibox.bx"
- *Line 4:* Indicate model name, version, e.g., "# MyBoxModel Version 2.2"
- *Line 5:* Concisely indicate main components, e.g., "# two ocean boxes (upper and lower), terrestrial biosphere, and one atmospheric box"
- *Line 6:* Indicate climate sensitivity of model, the abbreviation TCS may be used for transient climate sensitivity and ECS for equilibrium climate sensitivity, e.g., "# TCS=3.2 deg C, ECS=8.1 deg C"
- *Line 7:* Description of non-CO₂ forcing applied , e.g., "# Forcing: solar"
- *Line 8:* Indicate the output frequency and averaging, e.g., "# Output: global mean values"
- *Line 9:* List tabulated output column headers with their units in brackets (see table below), e.g., "# year tas[K]"

Complete Header Example:

```
# C1
# B. Box, Uni. of Box Models, CO2 Str., BoxCity 110110, BoxCountry
# bbox@unibox.bx
```

```
# MyBoxModel Version 2.2
# two ocean boxes (upper and lower), terrestrial biosphere, and one atmospheric box
# TCS=3.2 deg C, ECS=8.1 deg C
# Forcing: solar
# Output: global mean values
# year tas[K] co2[Gt C] nep[Gt C yr-1] fgco2[Gt C yr-1]
```

APPENDIX A GRIDDED MODEL OUTPUT

Priority	long name	units	comment	questions & notes	output variable name	standard name	unconfirmed or	unformatted units	cell_methods	positive	type	CMOR dimensions	CMOR variable name	realm	frequency	cell_measures	
							standard name										
CMIP5	1	Near-Surface Air Temperature	K		normally, the temperature should be reported at the 2 meter height	tas	air_temperature	K	time: mean			real	longitude latitude time height2m	tas	atmos	Monthly	area: areacella
	1	Net Carbon Mass Flux out of Atmosphere due to Net Ecosystem Productivity on Land.	kg m ² s ⁻¹		Natural flux of CO2 (expressed as a mass flux of carbon) from the atmosphere to the land calculated as the difference between uptake associated with photosynthesis and the release of CO2 from the sum of plant and soil respiration and fire. Positive flux is into the land. Emissions from natural fires + human ignition fires as calculated by the fire module of the DGVM, but excluding any CO2 flux from fire included in fLuc, defined below (CO2 Flux to Atmosphere from Land Use Change).	nep	surface_net_downward_mass_flux_of_carbon_dioxide_expressed_as_carbon_due_to_all_land_processes_excluding_anthropogenic_land_use_change	kg m-2 s-1	time: mean area: mean where land	down	real	longitude latitude time	nep	land	Monthly	area: areacella	
	1	Surface Downward CO2 Flux	kg m ² s ⁻¹	Gas exchange flux of CO2 (positive into ocean)		fgco2	surface_downward_mass_flux_of_carbon_dioxide_expressed_as_carbon	kg m-2 s-1	time: mean area: where sea	down	real	longitude latitude time	fgco2	ocnBgchem	Monthly	area: areacello	
	1	Net Downward Flux at Top of Model	W m ²	i.e., at the top of that portion of the atmosphere where dynamics are explicitly treated by the model. This is reported only if it differs from the net downward radiative flux at the top of the atmosphere.		rtmt	net_downward_radiative_flux_at_top_of_atmosphere_model	W m-2	time: mean	down	real	longitude latitude time	rtmt	atmos	Monthly	area: areacella	
	1	Total Atmospheric Mass of CO2	kg			co2mass	atmosphere_mass_of_carbon_dioxide	kg	time: mean		real	time	co2mass	atmos	Monthly	Monthly	
	2	Carbon Mass Flux out of Atmosphere due to Gross Primary Production on Land	kg m ² s ⁻¹			gpp	gross_primary_productivity_of_carbon	kg m-2 s-1	time: mean area: mean where land	down	real	longitude latitude time	gpp	land	Monthly	area: areacella	
	2	Carbon Mass Flux into Atmosphere due to Autotrophic (Plant) Respiration on Land	kg m ² s ⁻¹			ra	plant_respiration_carbon_flux	kg m-2 s-1	time: mean area: mean where land	up	real	longitude latitude time	ra	land	Monthly	area: areacella	
	2	Carbon Mass Flux out of Atmosphere due to Net Primary Production on Land	kg m ² s ⁻¹		needed for any model that does not compute GPP	npp	net_primary_productivity_of_carbon	kg m-2 s-1	time: mean area: mean where land	down	real	longitude latitude time	npp	land	Monthly	area: areacella	
	2	Carbon Mass Flux into Atmosphere due to Heterotrophic Respiration on Land	kg m ² s ⁻¹			rh	heterotrophic_respiration_carbon_flux	kg m-2 s-1	time: mean area: mean where land	up	real	longitude latitude time	rh	land	Monthly	area: areacella	
	2	Primary Organic Carbon Production by All Types of Phytoplankton	mol m ⁻² s ⁻¹	Vertically integrated total primary (organic carbon) production by phytoplankton. This should equal the sum of intpdiat+intpphymisc, but those individual components may be unavailable in some models.		intpp	net_primary_mole_productivity_of_carbon_by_phytoplankton	mol m-2 s-1	time: mean area: mean where sea		real	longitude latitude time	intpp	ocnBgchem	Monthly	area: areacello	
2	Evaporation	kg m ² s ⁻¹	at surface; flux of water into the atmosphere due to conversion of both liquid and solid phases to vapor (from underlying surface and vegetation)		evspsbl	water_evaporation_flux	kg m-2 s-1	time: mean		real	longitude latitude time	evspsbl	atmos	Monthly	area: areacella		
2	Precipitation	kg m ² s ⁻¹	at surface; includes both liquid and solid phases from all types of clouds (both large-scale and convective)		pr	precipitation_flux	kg m-2 s-1	time: mean		real	longitude latitude time	pr	atmos	Monthly	area: areacella		
2	Aragonite Saturation Depth	m	Depth of aragonite saturation horizon (0 if < surface, "missing" if > bottom, if two, then the shallower)		zsatarag	minimum_depth_of_aragonite_undersaturation_in_sea_water	m	time: mean area: mean where sea		real	longitude latitude time	zsatarag	ocnBgchem	Monthly	area: areacello		
2	Calcite Saturation Depth	m	Depth of calcite saturation horizon (0 if < surface, "missing" if > bottom, if two, then the shallower)		zsatalc	minimum_depth_of_calcite_undersaturation_in_sea_water	m	time: mean area: where sea		real	longitude latitude time	zsatalc	ocnBgchem	Monthly	area: areacello		

2	Delta PCO2	Pa		Difference between atmospheric and oceanic partial pressure of CO2 (positive meaning ocean > atmosphere)	dpco2	surface_carbon_dioxide_partial_pressure_difference_between_sea_water_and_air	Pa	time: mean area: where sea	real	longitude latitude time	dpco2	ocnBgchem	Monthly	area: areacello	
2	Downward Flux of Particle Organic Carbon	mol m ⁻² s ⁻¹		at 100 m depth.	epc100	sinking_mole_flux_of_particulate_organic_matter_expressed_as_carbon_in_sea_water	mol m-2 s-1	time: mean area: mean where sea	down	real	longitude latitude time depth100m	epc100	ocnBgchem	Monthly	area: areacello
2	Ocean Meridional Overturning Mass Streamfunction	kg s ⁻¹	differs from CMIP3 because it includes mass.	function of latitude, Z, basin. For a model with a cartesian latlon grid, this is the same as the "Ocean Y Overturning Mass Streamfunction", listed a few lines down, which should in this case be omitted. For other models, this transport should be approximated as the transport along zig-zag paths corresponding to latitudes with spacing between latitudes appropriate to the model's resolution.	msfmyz	ocean_meridional_overturning_mass_streamfunction	kg s-1	time: mean longitude: mean		real	longitude olevel basin time	msfmyz	ocean	Monthly	
2	Sea Ice Area Fraction	%	fraction of grid cell covered by sea ice.		sic	sea_ice_area_fraction	%	time: mean		real	longitude latitude time	sic	sealce ocean	Monthly	area: areacello
2	Total Soil Moisture Content	kg m ⁻²	the mass per unit area (summed over all soil layers) of water in all phases.		mrso	soil_moisture_content	kg m-2	time: mean area: mean where land		real	longitude latitude time	mrso	land	Monthly	area: areacella
2	pH	1	negative log of hydrogen ion concentration with the concentration expressed as mol H kg-1.		ph	sea_water_ph_reported_on_total_scale	1	time: mean area: mean where sea		real	longitude latitude olevel time	ph	ocnBgchem	Annual	area: areacello volume: volcello
2	Surface Runoff	kg m ² s ⁻¹	the total surface runoff leaving the land portion of the grid cell.		mrros	surface_runoff_flux	kg m-2 s-1	time: mean area: mean where land		real	longitude latitude time	mrros	land	Monthly	area: areacella
2	Carbon Mass in Litter Pool	kg m ⁻²			cLitter	litter_carbon_content	kg m-2	time: mean area: mean where land		real	longitude latitude time	cLitter	land	Monthly	area: areacella
2	Carbon Mass in Soil Pool	kg m ⁻²			cSoil	soil_carbon_content	kg m-2	time: mean area: mean where land		real	longitude latitude time	cSoil	land	Monthly	area: areacella
2	Carbon Mass in Vegetation	kg m ⁻²			cVeg	vegetation_carbon_content	kg m-2	time: mean area: mean where land		real	longitude latitude time	cVeg	land	Monthly	area: areacella
2	Detrital Organic Carbon Concentration	mol m ⁻³	sum of detrital organic carbon component concentrations		detoc	mole_concentration_of_organic_detritus_expressed_as_carbon_in_sea_water	mol m-3	time: mean area: mean where sea		real	longitude latitude olevel time	detoc	ocnBgchem	Annual	area: areacello volume: volcello
2	Zooplankton Carbon Concentration	mol m ⁻³	sum of zooplankton carbon component concentrations		zooc	mole_concentration_of_zooplankton_expressed_as_carbon_in_sea_water	mol m-3	time: mean area: mean where sea		real	longitude latitude olevel time	zooc	ocnBgchem	Annual	area: areacello volume: volcello
2	Dissolved Organic Carbon Concentration	mol m ⁻³			dissoc	mole_concentration_of_dissolved_organic_carbon_in_sea_water	mol m-3	time: mean area: mean where sea		real	longitude latitude olevel time	dissoc	ocnBgchem	Annual	area: areacello volume: volcello
2	Dissolved Inorganic Carbon Concentration	mol m ⁻³	Dissolved inorganic carbon (CO3+HCO3+H2CO3) concentration		dissic	mole_concentration_of_dissolved_inorganic_carbon_in_sea_water	mol m-3	time: mean area: mean where sea		real	longitude latitude olevel time	dissic	ocnBgchem	Annual	area: areacello volume: volcello
2	Phytoplankton Carbon Concentration	mol m ⁻³	sum of phytoplankton carbon component concentrations. In most (all?) cases this is the sum of phydiat and phycmisc (i.e., "Diatom Carbon Concentration" and "Non-Diatom Phytoplankton Carbon Concentration")		phyc	mole_concentration_of_phytoplankton_expressed_as_carbon_in_sea_water	mol m-3	time: mean area: mean where sea		real	longitude latitude olevel time	phyc	ocnBgchem	Annual	area: areacello volume: volcello
2	Total Alkalinity	mol m ⁻³	total alkalinity equivalent concentration (including carbonate, nitrogen, silicate, and borate components)		talk	sea_water_alkalinity_expressed_as_mole_equivalent	mol m-3	time: mean area: mean where sea		real	longitude latitude olevel time	talk	ocnBgchem	Annual	area: areacello volume: volcello
2	Carbon Mass in Products of Land Use Change	kg m ⁻²			cProduct	carbon_content_of_products_of_anthropogenic_land_use_change	kg m-2	time: mean area: mean where land		real	longitude latitude time	cProduct	land	Monthly	area: areacella
3	TOA Incident Shortwave Radiation	W m ⁻²	at the top of the atmosphere		rsdt	toa_incoming_shortwave_flux	W m-2	time: mean	down	real	longitude latitude time	rsdt	atmos	Monthly	area: areacella

3	TOA Outgoing Shortwave Radiation	W m ⁻²	at the top of the atmosphere		rsut	toa_outgoing_shortwave_flux	W m-2	time: mean	up	real	longitude latitude time	rsut	atmos	Monthly	area: areacella
3	TOA Outgoing Longwave Radiation	W m ⁻²	at the top of the atmosphere (to be compared with satellite measurements)		rlut	toa_outgoing_longwave_flux	W m-2	time: mean	up	real	longitude latitude time	rlut	atmos	Monthly	area: areacella
3	TOA Outgoing Clear-Sky Longwave Radiation	W m ⁻²			rlutcs	toa_outgoing_longwave_flux_assuming_clear_sky	W m-2	time: mean	up	real	longitude latitude time	rlutcs	atmos	Monthly	area: areacella
3	TOA Outgoing Clear-Sky Shortwave Radiation	W m ⁻²			rsutcs	toa_outgoing_shortwave_flux_assuming_clear_sky	W m-2	time: mean	up	real	longitude latitude time	rsutcs	atmos	Monthly	area: areacella
3	Northward Near-Surface Wind	m s ⁻¹		normally, the wind component should be reported at the 10 meter height	vas	northward_wind	m s-1	time: mean		real	longitude latitude time height10m	vas	atmos	Monthly	
3	Mole Concentration of Carbonate expressed as Carbon in Sea Water	mol m ⁻³			co3	mole_concentration_of_carbonate_expressed_as_carbon_in_sea_water	mol m-3	time: mean area: mean where sea		real	longitude latitude olevel time	co3	ocnBgchem	Monthly	area: areacello volume: volcello
3	Snow Area Fraction	%	Fraction of each grid cell that is occupied by snow that rests on land portion of cell.		snc	surface_snow_area_fraction	%	time: mean		real	longitude latitude time	snc	landIce land	Monthly	area: areacella
3	Cloud Area Fraction	%	Includes both large-scale and convective cloud.	Report on model layers (not standard pressures).	cl	cloud_area_fraction_in_atmosphere_layer	%	time: mean		real	longitude latitude alevel time	cl	atmos	Monthly	area: areacella
3	Surface Upward Latent Heat Flux	W m ⁻²	includes both evaporation and sublimation		hfhs	surface_upward_latent_heat_flux	W m-2	time: mean	up	real	longitude latitude time	hfhs	atmos	Monthly	area: areacella
3	Surface Upward Sensible Heat Flux	W m ⁻²			hfss	surface_upward_sensible_heat_flux	W m-2	time: mean	up	real	longitude latitude time	hfss	atmos	Monthly	area: areacella
3	Dissolved Phosphate Concentration	mol m ⁻³			po4	mole_concentration_of_phosphate_in_sea_water	mol m-3	time: mean area: mean where sea		real	longitude latitude olevel time	po4	ocnBgchem	Annual	area: areacello volume: volcello
3	Dissolved Oxygen Concentration	mol m ⁻³			o2	mole_concentration_of_molecular_oxygen_in_sea_water	mol m-3	time: mean area: mean where sea		real	longitude latitude olevel time	o2	ocnBgchem	Annual	area: areacello volume: volcello
3	Dissolved Nitrate Concentration	mol m ⁻³			no3	mole_concentration_of_nitrate_in_sea_water	mol m-3	time: mean area: mean where sea		real	longitude latitude olevel time	no3	ocnBgchem	Annual	area: areacello volume: volcello
3	Sea Water X Velocity	m s ⁻¹			uo	sea_water_x_velocity	m s-1	time: mean		real	longitude latitude olevel time	uo	ocean	Monthly	
3	Sea Water Y Velocity	m s ⁻¹			vo	sea_water_y_velocity	m s-1	time: mean		real	longitude latitude olevel time	vo	ocean	Monthly	
3	Permafrost Layer Thickness	m	where land over land: This is the mean thickness of the permafrost layer in the land portion of the grid cell. Reported as 0.0 in permafrost-free regions.		tpf	permafrost_layer_thickness	m	time: mean area: mean where land		real	longitude latitude time	tpf	landIce land	Monthly	area: areacella
3	Nitrogen Fixation Rate in Ocean	mol m ⁻² s ⁻¹	Vertically integrated nitrogen fixation		intpn2	tendency_of_ocean_mole_content_of_elemental_nitrogen_due_to_fixation	mol m-2 s-1	time: mean area: mean where sea		real	longitude latitude time	intpn2	ocnBgchem	Monthly	area: areacello
3	Relative Humidity	%			hur	relative_humidity	%	time: mean		real	longitude latitude alevel time	hur	atmos	Monthly	area: areacella
3	Specific Humidity	1			hus	specific_humidity	1	time: mean		real	longitude latitude alevel time	hus	atmos	Monthly	area: areacella
3	Downward Carbon Flux at Ocean Bottom	mol m ⁻² s ⁻¹	Carbon loss to sediments		frc	tendency_of_ocean_mole_content_of_carbon_due_to_sedimentation	mol m-2 s-1	time: mean area: where sea	down	real	longitude latitude time	frc	ocnBgchem	Monthly	area: areacello
3	Flux of Carbon Into Ocean Surface by Runoff and Sediment Dissolution	mol m ⁻² s ⁻¹	Carbon supply to ocean through runoff and sediment dissolution (neglects gas exchange)		fsc	tendency_of_ocean_mole_content_of_carbon_due_to_runoff_and_sediment_dissolution	mol m-2 s-1	time: mean area: mean where sea		real	longitude latitude time	fsc	ocnBgchem	Monthly	area: areacello
3	Sea Level Pressure	Pa	not, in general, the same as surface pressure		psl	air_pressure_at_sea_level	Pa	time: mean		real	longitude latitude time	psl	atmos	Monthly	area: areacella
3	Surface Runoff	kg m ⁻² s ⁻¹	the total surface runoff leaving the land portion of the grid cell.		mrros	surface_runoff_flux	kg m-2 s-1	time: mean area: mean where land		real	longitude latitude time	mrros	land	Monthly	area: areacella
3	Sea Ice Thickness	m	the mean thickness of sea ice in the ocean portion of the grid cell (averaging over the entire ocean portion, including the ice-free fraction). Reported as 0.0 in regions free of sea ice.		sit	sea_ice_thickness	m	time: mean area: mean where sea		real	longitude latitude time	sit	seaIce ocean	Monthly	area: areacello
3	Mole Concentration of Carbonate expressed as Carbon in Sea Water	mol m ⁻³			co3	mole_concentration_of_carbonate_expressed_as_carbon_in_sea_water	mol m-3	time: mean area: mean where sea		real	longitude latitude olevel time	co3	ocnBgchem	Annual	area: areacello volume: volcello
3	Global Average Sea Level Change	m			zosga	global_average_sea_level_change	m	time: mean area: mean where sea		real	time	zosga	ocean	Monthly	

Appendix B: Table of requested output (at a minimum as global mean values)

Priority	Long name	Column Header Name*	Units	Comments
<i>Tier 1</i>				
1	Relative year	year	year	
1	Near-surface Air Temperature	tas	K	
1	Atmospheric CO ₂	xco2	ppm	
1	Surface Downward CO ₂ flux into the ocean	fgco2	kg m ⁻²	This is the net air-to-ocean carbon flux (positive flux is into the ocean)
1	Total Atmospheric Mass of CO ₂	co2mass	kg	
<i>Tier 2</i>				
2	Net Carbon Mass Flux out of Atmosphere due to Net Ecosystem Productivity on Land.	nep	kg m ⁻²	This is the net air-to-land carbon flux (positive flux is into the land)
2	Total ocean carbon	cOcean	Gt C	If the ocean contains multiple boxes this output can also be provided, e.g., as cOcean_up and cOcean_low for upper and lower ocean boxes
2	Total land carbon	cLand	Gt C	This is the sum of all C pools
2	Ocean Potential Temperature	thetao	K	Please report a mean value if there are multiple ocean boxes
2	Upper ocean pH	pH	1	Negative log of hydrogen ion concentration with the concentration expressed as mol H kg ⁻¹ .
2	Carbon Mass Flux out of Atmosphere due to Net Primary Production on Land	npp	kg m ⁻²	This is calculated as gross primary production – autotrophic respiration (gpp-ra)
2	Carbon Mass Flux into Atmosphere due to Heterotrophic Respiration on Land	rh	kg m ⁻²	
2	Ocean Net Primary Production by Phytoplankton	intpp	kg m ⁻²	

*Column header names follow the CMIP CMOR notation when possible