CFMIP Standard Output

Prepared by

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Based, originally, on AMIP Standard Output Tables developed by
PCMDI and the AMIP panel

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Change history:

Added request for 3D fields to be on model levels rather than pressure levels and a more explicit distinction between stratiform, convective and total 3D cloud fields. Also added some extra diagnostics requested daily. KDW 26/09/05

Changed headings on monthly table to state preference for monthly means over climatological fields, and to allow for annual mean climatological CO2 forcing fields. MJW 29/11/04

Contents:

Table CF1b: ISCCP simulator data (longitude, latitude, pressure2, tau, time)
Table CF1c: 3-d atmosphere data on pressure levels (longitude, latitude, pressure, time)
Table CF1d: 3-d data on model levels (longitude, latitude, model_level, time)
Table CF1e: time-independent 2-d surface data (longitude, latitude)

Annual mean data
Table CF2a: 2-d atmosphere or surface data (longitude, latitude, time)
Table CF2b: ISCCP simulator data (longitude, latitude, pressure2, tau, time)

Daily mean data
Table CF3a: 2-d atmosphere data (longitude, latitude, time)
Table CF3b: ISCCP simulator data (longitude, latitude, pressure2, tau, time)
Table CF3c: 3-d atmosphere data on pressure levels (longitude, latitude, pressure, time)
Table CF3d: 3-d atmosphere data on model levels (longitude, latitude, pressure, time)

Doubled CO2 radiative forcing
Table CF4: Monthly-mean 2-d radiative forcing data for doubled co2 (longitude, latitude, time).

- **Coordinate dimensions**

Background and overview of format requirements

In order to facilitate participation in various community modeling experiments (e.g., IPCC, CMIP, AMIP, CFMIP), the Program for Climate Model Diagnosis and Intercomparison (with encouragement from the WGCM and WGNE and in collaboration with project leaders) is attempting to establish a more uniform set of model output requirements. CFMIP was initiated before this effort had matured sufficiently, so initial CFMIP output has been collected in various structures and formats, but to facilitate analysis of future model output, any new CFMIP data should conform to the new requirements.

Modeling groups contributing output to the CFMIP database are henceforth asked to ensure that it meets rather strict format and metadata requirements. These requirements yield files produced in network Common Data Form (netCDF; see http://www.unidata.ucar.edu/packages/netcdf), which has become the most popular form for exchanging ocean-atmosphere model output. The files are "self-describing" and the metadata contained in the files conform with the NetCDF Climate and Forecast (CF) Metadata

Conventions (see http://www.cgd.ucar.edu/cms/eaton/cf-metadata). The CF conventions for netCDF data generalize and extend the Cooperative Ocean / Atmosphere Research Data Service (COARDS) conventions developed in the 1990s. Note that the CF convention establishes standard names for climate and weather variables, which identify the physical quantity. These standard names are given in the tables below. Note that more than one field can be associated with the same standard name because different fields sampled in different ways (e.g., surface air temperature vs. upper air temperature) refer to the same physical quantity. Nevertheless, one can uniquely identify each stored field by considering additional metadata stored in the file (e.g., dimension information). Extended definitions of CF standard names, which basically answer the question "What do you mean precisely by this quantity?", may be found on the Web at http://www.cgd.ucar.edu/cms/eaton/cf-metadata/standard_name.html.

The standards for CFMIP contributions closely follow those established for IPCC/CMIP, which are given in the document http://www-pcmdi.llnl.gov/ipcc/IPCC_output_requirements.htm. This document should be read carefully before preparing contributions. Perhaps the easiest way to meet these requirements is to rewrite your model output through CMOR, a software library available from PCMDI and further described in the next paragraph. Put briefly, the requirements specify required metadata and file organization, along with acceptable coordinate systems.. Units and sign conventions of the data must conform to the tables below. Latitude-longitude grids must be rectilinear, i.e., have a unique set of longitudes that applies to all latitudes. Data on non-rectilinear grids must be interpolated to rectilinear grids before transmission to the PCMDI. With the exception of certain cloud-related fields (which as noted below should be provided on model levels), three-dimensional atmosphere variables must be interpolated to standard pressure levels given below. Each output file should contain only a single output variable, though there may be many time points per file. This file organization contrasts with the typical model output history files, which contain all variables for a single time step.

To facilitate adherence to these standards, a PCMDI team has written (in FORTRAN 90) a standard output code called CMOR (pronounced "see more"), which is now available as open source. This code structures the data uniformly and writes netCDF files in full compliance with IPCC and CFMIP requirements. Use of CMOR is being encouraged (and in some cases required) by various other ongoing model intercomparison projects. A cmor_readme file (see http://www-pcmdi.llnl.gov/software/cmor/cmor_readme.html) and code documentation in pdf format (see http://www-pcmdi.llnl.gov/software/cmor/cmor_users_guide.pdf) are available. For further information, contact taylor13@llnl.gov.

The IPCC/CMIP requirements as defined by http://www-pcmdi.llnl.gov/ipcc/IPCC_output_requirements.htm should be satisfied by new submissions of CFMIP data except that in that document:

1. All references to the IPCC Standard Output should refer instead to the CFMIP Standard Output (i.e., this document).
2. The required global attribute "project_id" should be set to "CFMIP"
3. As appropriate, the "experiment_id" should be set to one of the following:

'slab ocean control experiment'
'2xCO2 equilibrium experiment'
'+2K perpetual July experiment'
'0K perpetual July experiment'
'-2K perpetual July experiment'

4. The CFMIP files should be stored in the following directory structure: A separate directory should be created containing all the variables in each model/experiment/standard_output_table category (e.g., CSIRO/Slabcntl/A1). This will ensure that filenames within each directory are unique. For uniformity, it is suggested that the trailing lower case letter, found on the tables below, should be dropped (e.g., 'CF1', not CF1a) and it is suggested that the experiments be abbreviated as follows:

Slabcntl (i.e., the slab ocean control experiment)
2xCO2 (i.e., the 2xCO2 equilibrium experiment)
Plus2KJul (i.e., the +2K perpetual July experiment)
CntlJul (i.e., the 0K perpetual July experiment)
Minus2KJul (i.e., the -2K perpetual July experiment)

5. For perpetual July experiments the calendar should be set to 'none', no matter what calendar is assumed by your model. The basetime should be set to "days since 1-7-15". This is the CF-convention method of indicating perpetual July. The time coordinate values will normally record the number of days since the beginning of the experiment. For the time mean, the bounds specify the beginning and end of the interval over which the time mean is formed.

6. For slab ocean monthly mean data, climatological values should be reported (averages of several January's, several February's, etc.). The CF-convention specifies that time bounds information should be stored in an array identified by the "climatology" attribute (http://www.cgd.ucar.edu/cms/eaton/cf-metadata/CF-1.0.html#climatology), and the "cell_methods" attribute (http://www.cgd.ucar.edu/cms/eaton/cf-metadata/CF-1.0.html#cell-methods) provides further information concerning how the climatological values are computed. For CFMIP, the CF conventions should be followed, but the complete set of climatological metadata accommodated by the conventions is not yet produced by CMOR. It is therefore currently acceptable to omit the "climatology" attribute and simply record the cell bounds as if they were monthly means (and CMOR will indicate in the cell_methods attribute that a time-mean is stored, but not that it is a climatological mean). In the future CMOR will be modified to accommodate climatological data.

The notes that appear in the tables below are meant to provide precise definitions of the requested fields. Sometimes it may be impossible to satisfy the requests; in these cases, any deviations from the specifications below should be described in the "history" and/or "comment" attributes associated with the variable.

Model output summary

Various fields, sampled at various frequencies, are needed to carry out various proposed CFMIP analyses (see http://cfmip.metoffice.com/DR.html). The tables below derive from tables (again see http://cfmip.metoffice.com/DR.html) that were originally modified from the AMIP standard output tables (see http://www-pcmdi.llnl.gov/projects/amip/OUTPUT/AMIP2/index.html) to meet the needs of CFMIP. These "original" CFMIP tables have been restructured to be more consistent with IPCC standard output and to be consistent with the CMOR input tables that have been created for CFMIP. The "analysis packages" indicated by letters in the fifth and sixth columns of each table refer to various proposed CFMIP analyses. A few fields are not called for by any of the currently proposed projects, but have been requested as part of the IPCC standard model output, so they are included here because they may eventually be of some interest.

Tables CF1, CF2, and CF3 contain fields reported at monthly, annual, and daily frequencies, respectively. Table CF4 contains doubled CO2 forcing fields. Tables CF1, CF2, and CF3 are further separated below into component tables, depending largely on whether the fields are spatially two or three dimensional and whether the three dimensional fields are stored on pressure levels or model levels. Finally, a separate component table contains ISCCP simulator output.

CFMIP output is requested for different time periods, depending on the reporting frequency and the experiment. In the case of "monthly mean" data:

- For slab ocean experiments 12 x 20 months of monthly mean data should be reported after equilibrium is reached.
- For perpetual-July experiments 24 months of monthly mean data (or longer if there is high variability) should be reported after equilibrium is reached.
- For slab ocean runs, annual mean data should be reported for each year simulated (including spin-up). No annual means are requested from prescribed SST experiments.
- For slab ocean experiments, report daily values only for the final 5 years at equilibrium.
- For perpetual-July experiments, report daily values for the final 2 years at equilibrium.

As noted below some of the tables parallel the IPCC standard output tables, but have been assigned a different table number. Also a few minor differences between these tables and the original CFMIP tables exist. The current lists are preferable, however submission of data based on old CFMIP diagnostic lists are acceptable.

Tables of output fields

Monthly data and time-independent fields

*For slab ocean experiments, 20*12 months of monthly mean data should be reported after equilibrium is reached. If this is not possible, a monthly mean climatology is acceptable, although this will preclude much of the analysis in subproject 3. For perpetual-July experiments, 24 monthly means should be reported, again after equilibrium is reached. Failing this, a climatological mean would be acceptable.*

***Table CF1a:* monthly 2-d atmosphere or surface data (longitude, latitude, time).** The first 44 entries in this table reproduce IPCC Table A1a. Sea ice concentration (sic, entry 48) appears in in IPCC Table O1c.

	CF standard_name	output variable name	units	±2K analysis pack-ages	Slab analysis pack-ages	notes
1	air_pressure_at_sea_level	psl	Pa	A, Z	E, Z	
2	precipitation_flux	pr	kg m^{-2} s^{-1}	A, Z	E, Z	includes both liquid and solid phases.
3	air_temperature	tas	K	A, D, Z	E, H, Z	near-surface (usually, 2 meter) air temperature; the CMOR singleton dimension default value of 2 m can be overridden, if absolutely necessary, by redefining axis "height1".

4	Moisture_content_of_soil_layer	mrsos	kg m^{-2}	Z	Z	water in all phases in the upper 0.1 meters of soil, and averaged over the land portion of the grid cell (i.e., compute by dividing the total mass of water contained in the soil layer of the grid cell by the land area in the grid cell); report as "missing" or 0.0 where the land fraction is 0; the CMOR singleton dimension default value of 0.1 m can be overridden, if absolutely necessary, by redefining axis "depth1".
5	soil_moisture_content	mrso	kg m^{-2}	Z	E, Z	water in all phases summed over all soil layers, and averaged over the land portion of the grid cell (i.e., compute by dividing the total mass of water contained in the soil layer of the grid cell by the land area in the grid cell); report as "missing" or 0.0 where the land fraction is 0.
6	surface_downward_eastward_stress	tauu	Pa	Z	Z	
7	surface_downward_northward_stress	tauv	Pa	Z	Z	
8	surface_snow_thickness_where_snow	snd	m	Z	Z	this thickness when multiplied by the average area of the grid cell covered by snow yields the time-mean snow volume. Thus, for time means, compute as the weighted sum of thickness (averaged over the snow-covered portion of the grid cell) divided by the sum of the weights, with the weights equal to the area covered by snow. report as 0.0 in snow-free regions.
9	surface_upward_latent_heat_flux	hfls	W m^{-2}	A,D,L,Z	E, L, Z	
10	surface_upward_sensible_heat_flux	hfss	W m^{-2}	A,D,L,Z	E,L,Z	
11	surface_downwelling_longwave_flux_in_air	rlds	W m^{-2}	A,D,L,Z	E,L,Z	

12	surface_upwelling_longwave_flux_in_air	rlus	W m^{-2}	A,D,L,Z	E,L,Z	
13	surface_downwelling_shortwave_flux_in_air	rsds	W m^{-2}	A,D,L,Z	E,L,Z	
14	surface_upwelling_shortwave_flux_in_air	rsus	W m^{-2}	A,D,L,Z	E,L,Z	
15	surface_temperature	ts	K	A, D, Z	E, H, Z	"skin" temperature (i.e., SST for open ocean)
16	surface_air_pressure	ps	Pa	A, Z	E, Z	*not* mean sea-level pressure
17	snowfall_flux	prsn	kg m^{-2} s^{-1}	Z	Z	
18	convective_precipitation_flux	prc	kg m^{-2} s^{-1}	Z	Z	
19	atmosphere_water_vapor_content	prw	kg m^{-2}	A, D, Z	E, Z	vertically integrated through the atmospheric column
20	soil_frozen_water_content	mrfso	kg m^{-2}	Z	Z	summed over all soil layers, and averaged over the land portion of the grid cell (i.e., compute by dividing the total mass of frozen water contained in the soil layer of the grid cell by the land area in the grid cell); report as "missing" or 0.0 where the land fraction is 0.
21	surface_runoff_flux_where_land	mrros	kg m^{-2} s^{-1}	Z	Z	compute as the total surface runoff leaving the land portion of the grid cell divided by the land area in the grid cell; report as "missing" or 0.0 where the land fraction is 0.
22	runoff_flux_where_land	mrro	kg m^{-2} s^{-1}	Z	Z	compute as the total runoff (including "drainage" through the base of the soil model) leaving the land portion of the grid cell divided by the land area in the grid cell; report as "missing" or 0.0 where the land fraction is 0.

23	surface_snow_amount_where_land	snw	kg m^{-2}	Z	E,Z	compute as the mass of surface snow on the land portion of the grid cell divided by the land area in the grid cell; report as "missing" or 0.0 where the land fraction is 0; exclude snow on vegetation canopy or on sea ice.
24	surface_snow_area_fraction_where_land	snc	%	Z	Z	fraction of grid cell covered by snow that lies on land; exclude snow that lies on sea ice.
25	surface_snow_melt_flux_where_land	snm	kg m^{-2} s^{-1}	Z	Z	compute as the total surface melt water on the land portion of the grid cell divided by the land area in the grid cell; report as 0.0 for snow-free land regions; report as 0.0 or "missing" where the land fraction is 0.
26	eastward_wind	uas	m s^{-1}	Z	Z	near-surface (usually, 10 meters) eastward component of wind; the CMOR singleton dimension default value of 10 m can be overridden, if absolutely necessary, by redefining axis "height2".
27	northward_wind	vas	m s^{-1}	Z	Z	near-surface (usually, 10 meters) northward component of wind; the CMOR singleton dimension default value of 10 m can be overridden, if absolutely necessary, by redefining axis "height2".
28	specific_humidity	huss	1 (i.e., dimen-sionless fraction)	Z	Z	near-surface (usually, 2meters) specific humidity; the CMOR singleton dimension default value of 2 m can be overridden, if absolutely necessary, by redefining axis "height1".
29	toa_incoming_shortwave_flux	rsdt	W m^{-2}	A, D, Z	E, H, Z	incident shortwave at the top of the atmosphere
30	toa_outgoing_shortwave_flux	rsut	W m^{-2}	A, D, Z	E, H, Z	at the top of the atmosphere

31	toa_outgoing_longwave_flux	rlut	W m^{-2}	A, D, Z	E, H, Z	at the top of the atmosphere (to be compared with satellite measurements)
32	net_downward_radiative_flux_at_top_of_atmosphere_model	rtmt	W m^{-2}	A, D, Z	E, H, Z	i.e., at the top of that portion of the atmosphere where dynamics are explicitly treated by the model.
33	net_downward_shortwave_flux_in_air	rsntp	W m^{-2}			at 200 hPa only; the CMOR singleton dimension default value of 200 hPa can be overridden, if absolutely necessary, by redefining axis "pressure1".
34	net_upward_longwave_flux_in_air	rlntp	W m^{-2}			at 200 hPa only; the CMOR singleton dimension default value of 200 hPa can be overridden, if absolutely necessary, by redefining axis "pressure1".
35	net_downward_shortwave_flux_in_air_assuming_clear_sky	rsntpcs	W m^{-2}			at 200 hPa only; method "2" is recommended for calculating clear-sky fluxes; the CMOR singleton dimension default value of 200 hPa can be overridden, if absolutely necessary, by redefining axis "pressure1".
36	net_upward_longwave_flux_in_air_assuming_clear_sky	rlntpcs	W m^{-2}			at 200 hPa only; method "2" is recommended for calculating clear-sky fluxes; the CMOR singleton dimension default value of 200 hPa can be overridden, if absolutely necessary, by redefining axis "pressure1".
37	surface_downwelling_shortwave_flux_in_air_assuming_clear_sky	rsdscs	W m^{-2}	A,D,L,Z	E, L, Z	method "2" is recommended for calculating clear-sky fluxes
38	surface_upwelling_shortwave_flux_in_air_assuming_clear_sky	rsuscs	W m^{-2}	A,D,L,Z	E, L, Z	method "2" is recommended for calculating clear-sky fluxes
39	surface_downwelling_longwave_flux_in_air_assuming_clear_sky	rldscs	W m^{-2}	A,D,L,Z	E, L, Z	method "2" is recommended for calculating clear-sky fluxes

40	toa_outgoing_longwave_flux_ assuming_clear_sky	rlutcs	W m^{-2}	A, D, Z	E, H, Z	method "2" is recommended for calculating clear-sky fluxes
41	toa_outgoing_shortwave_flux_ assuming_clear_sky	rsutcs	W m^{-2}	A, D, Z	E, H, Z	method "2" is recommended for calculating clear-sky fluxes
42	cloud_area_fraction	clt	%	A, Z	E, Z	for the whole atmospheric column, as seen from the surface or the top of the atmosphere. Include both large-scale and convective cloud.
43	atmosphere_cloud_condensed_water_content	clwvi	kg m^{-2}	Z	Z	include both liquid and ice phases, consider all the mass of condensed water in the column and divide by its area (in the longitude-latitude plane)
44	atmosphere_cloud_ice_content	clivi	kg m^{-2}	Z	Z	consider all the mass of condensed water in the column and divide by its area (in the longitude-latitude plane)
45	water_evaporation_flux	evspsbl	kg m^{-2} s^{-1}	L, Z	L, Z	includes conversion to vapor phase from both the liquid and solid phase (i.e., includes sublimation)
46	air_temperature	tasmax	K	Z	Z	monthly mean (or time-mean for perpetual July simulations) of the daily-maximum near-surface (usually, 2 meter) air temperature. Consistent with the CF-conventions, the cell_methods attribute should specify "time: maximum within days time: mean over days" (automatically done by CMOR); The CMOR singleton dimension default value of 2 m can be overridden, if absolutely necessary, by redefining axis "height1".

47	air_temperature	tasmin	K	Z	Z	monthly mean (or time-mean for perpetual July simulations) of the daily-minimum near-surface (usually, 2 meter) air temperature. Consistent with the CF-conventions, the cell_methods attribute should specify "time: minimum within days time: mean over days" (automatically done by CMOR); The CMOR singleton dimension default value of 2 m can be overridden, if absolutely necessary, by redefining axis "height1".
48	sea_ice_area_fraction	sic	%	Z	E, Z	fraction of grid cell covered by sea ice.

Table CF1b: **ISCCP simulator data (longitude, latitude, pressure2, tau, time) on monthly and longer time-scales.** Data should be sampled no less frequently than every 15 hours. The ISCCP cloud layers refer to the following ranges (hPa): 800 and higher, 800-680, 680-560, 560-440, 440-310, 310-180, and 180-0. The ISCCP optical depth (tau) categories refer to the following ranges: 0-0.3, 0.3-1.3, 1.3-3.6, 3.6-9.4, 9.4-23, 23-60, and >60. This table is identical to IPCC Table A1d and includes, in a different structure and different units, the fields found in the original CFMIP table 7b.

	CF standard_name	output variable name	units	±2K analysis packages	Slab analysis packages	notes
1	isccp_cloud_area_fraction	clisccp	1 (i.e., dimensionless fraction)	A	E	as seen from above, mean fraction of grid column occupied by cloud of optical depths and heights specified by the tau and pressure intervals given above; for each longitude and latitude grid column, the ISCCP simulator output comprises a 7x7 (pressure x tau) matrix of values matching those of the satellite. With CMOR, use "pressure2" to define the vertical coordinates for this variable.

The following tables (CF1c and CF1d) request diagnostics on pressure levels and model levels respectively. In some cases, the same diagnostic appears in both tables (with the output variable name ending in 'm' in CF1d to avoid confusion). For these diagnostics there is no need to submit the field both on model levels and pressure levels. If possible the data should be submitted on model levels, otherwise data on pressure levels is acceptable.

***Table CF1c:* 3-d atmosphere pressure-level data (longitude, latitude, pressure, time) on monthly time-scales.** This data must be provided on pressure levels, including at least the following standard levels:1000, 925, 850, 700, 600, 500, 400, 300, 250, 200, 150, 100, 70, 50, 30, 20, 10 hPa. This table is identical to IPCC Table A1c, except the cloud fraction has been moved to the new CFMIP Table CF1d.

	CF standard_name	**output variable name**	**units**	**±2K analysis packages**	**Slab analysis packages**	**notes**
1	air_temperature	ta	K	D, L, Z	E, L, Z	
2	eastward_wind	ua	$m\ s^{-1}$	Z	E, Z	
3	northward_wind	va	$m\ s^{-1}$	Z	E, Z	
4	specific_humidity	hus	1 (i.e., dimensionless fraction)	D, L, Z	E, L, Z	
5	lagrangian_tendency_of_air_pressure	wap	$Pa\ s^{-1}$	A, Z	E, Z	commonly referred to as "omega", this represents the vertical component of velocity in pressure coordinates (positive down)
6	geopotential_height	zg	m	Z	Z	
7	relative_humidity	hur	%	D, L, Z	E, L, Z	
8	mole_fraction_of_o3_in_air	tro3	1e-9 (i.e., ppbv)	Z	Z	

Table CF1d: **3-d atmosphere model-level data (longitude, latitude, model_level, time) on monthly time-scales.** This data should be provided on all model levels. Except for "cl", which appears in IPCC Table A1c, none of the fields was requested from the IPCC simulations.

	CF standard_name	**output variable name**	**units**	**±2K analysis packages**	**Slab analysis packages**	**notes**
1	cloud_area_fraction_in_atmosphere_layer	cl	%	A, Z	E, Z	Include both large-scale and convective cloud.
2	mass_fraction_of_cloud_liquid_water_in_air	clw	1 (i.e., dimensionless mass fraction)	A, Z	E, Z	divide mass of liquid water in the grid cell by mass of air in the grid cell.
3	mass_fraction_of_cloud_ice_in_air	cli	1 (i.e., dimensionless mass fraction)	A, Z	E, Z	divide mass of ice in the grid cell by mass of air in the grid cell.
4	convective_cloud_area_fraction_in_atmosphere_layer	clc	%	A	E	
5	mass_fraction_of_convective_cloud_liquid_water_in_air	clwc	1 (i.e., dimensionless mass fraction)	A	E	divide mass of liquid water in the convective cloud portion of the grid cell by mass of air in the entire grid cell.
6	mass_fraction_of_convective_cloud_ice_in_air	clic	1 (i.e., dimensionless mass fraction)	A	E	divide mass of ice in the convective cloud portion of the grid cell by mass of air in the entire grid cell.
7	stratiform_cloud_area_fraction_in_atmosphere_layer	cls	%	A	E	
8	mass_fraction_of_stratiform_cloud_liquid_water_in_air	clws	1 (i.e., dimensionless mass fraction)	A	E	divide mass of liquid water in the convective cloud portion of the grid

						cell by mass of air in the entire grid cell.
9	mass_fraction_of_stratiform_cloud_ice_in_air	clis	1 (i.e., dimensionless mass fraction)	A	E	divide mass of ice in the convective cloud portion of the grid cell by mass of air in the entire grid cell.
10	air_temperature	tam	K	D, L, Z	E, L, Z	As ta but on model levels.
11	eastward_wind	uam	$m\ s^{-1}$	Z	E, Z	As ua but on model levels.
12	northward_wind	vam	$m\ s^{-1}$	Z	E, Z	As va but on model levels.
13	specific_humidity	husm	1 (i.e., dimensionless fraction)	D, L, Z	E, L, Z	As hus but on model levels
14	lagrangian_tendency_of_air_pressure	wapm	$Pa\ s^{-1}$	A, Z	E, Z	As wap but on model levels.
15	geopotential_height	zgm	m	Z	Z	As zg but on model levels.
16	relative_humidity	hurm	%	D, L, Z	E, L, Z	As hur but on model levels.

Table CF1e: **Time-independent 2-d surface data (longitude, latitude).** This table is the same as IPCC Table A1b, except that qflux has been added.

	CF standard_name	**output variable name**	**units**	**±2K analysis packages**	**Slab analysis packages**	**notes**
1	surface_altitude	orog	m	all	all	height above the geoid; as defined here, "the geoid" is a surface of constant geopotential that, if the ocean were at rest, would coincide with mean sea level. Under this definition, the geoid changes as the mean volume of the ocean changes (e.g., due to glacial melt, or global warming of the ocean). Report here the height above the present-day geoid.
2	land_area_fraction	sftlf	%	all	all	
3	land_ice_area_fraction	sftgif	%	Z	Z	fraction of grid cell occupied by "permanent" ice (i.e., glaciers).
4	soil_moisture_content_at_field_capacity	mrsofc	kg m^{-2}	Z	Z	divide the total water holding capacity of all the soil in the grid cell by the land area in the grid cell; report as "missing" or 0.0 outside land areas.
5	prescribed_heat_flux_into_slab_ocean	qflux	W m^{-2}		E, F, G, H, I, J, L	the so-called q-flux added to slab ocean cell, which is meant to account for convergence (or divergence) of heat by the ocean circulation. It should be computed as the total qflux energy added to the ocean-portion of the grid cell divided by the ocean area in the grid cell; report as "missing" or 0.0 where the ocean fraction is 0. The qflux should be time-independent. Omit for prescribed SST experiments.

Annual mean data

For slab ocean runs, annual mean data should be reported for each year simulated (including spin-up). No annual means are requested from prescribed SST experiments.

Table CF2a: **annual mean 2-d atmosphere or surface data (longitude, latitude, time).** Except for the net tropopause fluxes (rsntp, rlntp, rsntpcs, and rlntpcs), the fields listed in this table were requested in the original CFMIP table 2. Note that although it is inconsequential, the first column contains non-consecutive numbers corresponding to the numbers in Table CF2a; thus this table contains a subset of the fields requested in Table CF2a.

	CF standard_name	**output variable name**	**units**	**Slab analysis pack-ages**	**notes**
1	precipitation_flux	pr	kg m^{-2} s^{-1}	J	includes both liquid and solid phases.
2	air_temperature	tas	K	J	near-surface (usually, 2 meter) air temperature; the CMOR singleton dimension default value of 2 m can be overridden, if absolutely necessary, by redefining axis "height1".
3	surface_upward_latent_heat_flux	hfls	W m^{-2}	J	
4	surface_upward_sensible_heat_flux	hfss	W m^{-2}	J	
5	surface_downwelling_longwave_flux_in_air	rlds	W m^{-2}	J	
6	surface_upwelling_longwave_flux_in_air	rlus	W m^{-2}	J	
7	surface_downwelling_shortwave_flux_in_air	rsds	W m^{-2}	J	
8	surface_upwelling_shortwave_flux_in_air	rsus	W m^{-2}	J	
9	surface_temperature	ts	K	J	"skin" temperature (i.e., SST for open ocean)
10	atmosphere_water_vapor_content	prw	kg m^{-2}	J	vertically integrated through the atmospheric column

11	toa_incoming_shortwave_flux	rsdt	W m^{-2}	J	incident shortwave at the top of the atmosphere
12	toa_outgoing_shortwave_flux	rsut	W m^{-2}	J	at the top of the atmosphere
13	toa_outgoing_longwave_flux	rlut	W m^{-2}	J	at the top of the atmosphere (to be compared with satellite measurements)
14	net_downward_radiative_flux_at_top_of_ atmosphere_model	rtmt	W m^{-2}	J	i.e., at the top of that portion of the atmosphere where dynamics are explicitly treated by the model.
15	net_downward_shortwave_flux_in_air	rsntp	W m^{-2}	J	at 200 hPa only; the CMOR singleton dimension default value of 200 hPa can be overridden, if absolutely necessary, by redefining axis "pressure1".
16	net_upward_longwave_flux_in_air	rlntp	W m^{-2}	J	at 200 hPa only; the CMOR singleton dimension default value of 200 hPa can be overridden, if absolutely necessary, by redefining axis "pressure1".
17	net_downward_shortwave_flux_in_ air_assuming_clear_sky	rsntpcs	W m^{-2}	J	at 200 hPa only; method "2" is recommended for calculating clear-sky fluxes; the CMOR singleton dimension default value of 200 hPa can be overridden, if absolutely necessary, by redefining axis "pressure1".
18	net_upward_longwave_flux_in_air_ assuming_clear_sky	rlntpcs	W m^{-2}	J	at 200 hPa only; method "2" is recommended for calculating clear-sky fluxes; the CMOR singleton dimension default value of 200 hPa can be overridden, if absolutely necessary, by redefining axis "pressure1".
19	surface_downwelling_shortwave_flux_in_ air_assuming_clear_sky	rsdscs	W m^{-2}	J	method "2" is recommended for calculating clear-sky fluxes
20	surface_upwelling_shortwave_flux_in_ air_assuming_clear_sky	rsuscs	W m^{-2}	J	method "2" is recommended for calculating clear-sky fluxes
21	surface_downwelling_longwave_flux_in_ air_assuming_clear_sky	rldscs	W m^{-2}	J	method "2" is recommended for calculating clear-sky fluxes

22	toa_outgoing_longwave_flux_ assuming_clear_sky	rlutcs	W m^{-2}	J	method "2" is recommended for calculating clear-sky fluxes
23	toa_outgoing_shortwave_flux_ assuming_clear_sky	rsutcs	W m^{-2}	J	method "2" is recommended for calculating clear-sky fluxes
24	sea_ice_area_fraction	sic	%	J	fraction of grid cell covered by sea ice.

Table CF2b: **annual mean ISCCP simulator data (longitude, latitude, pressure2, tau, time).** Data should be sampled no less frequently than every 15 hours. The ISCCP cloud layers refer to the following ranges (hPa): 800 and higher, 800-680, 680-560, 560-440, 440-310, 310-180, and 180-0. The ISCCP optical depth (tau) categories refer to the following ranges: 0-0.3, 0.3-1.3, 1.3-3.6, 3.6-9.4, 9.4-23, 23-60, and >60. This table includes, in a different structure and different units, the fields found in the original CFMIP table 7b.

	CF standard_name	output variable name	units	Slab analysis packages	notes
1	isccp_cloud_area_fraction	clisccp	1 (i.e., dimensionless fraction)	J	as seen from above, mean fraction of grid column occupied by cloud of optical depths and heights specified by the tau and pressure intervals given above; for each longitude and latitude grid column, the ISCCP simulator output comprises a 7x7 (pressure x tau) matrix of values matching those of the satellite. With CMOR, use "pressure2" to define the vertical coordinates for this variable.

Daily-mean data

For all simulations, report daily values only after model reaches equilibrium, and for slab runs only report 5 years of daily data.

Table CF3a: **Daily-mean 2-d atmosphere data (longitude, latitude, time).** The first 14 entries in this table reproduce IPCC Table A2a.

	CF standard_name	output variable name	units	±2K analysis pack-ages	Slab analysis pack-ages	notes
1	air_pressure_at_sea_level	psl	Pa	B, C	F, G	
2	precipitation_flux	pr	kg m^{-2} s^{-1}			includes both liquid and solid phases.
3	air_temperature	tasmin	K			daily-minium near-surface (usually, 2 meter) air temperature. Consistent with the CF-conventions, the cell_methods attribute should specify "time: minimum" (automatically done by CMOR); The CMOR singleton dimension default value of 2 m can be overridden, if absolutely necessary, by redefining axis "height1".
4	air_temperature	tasmax	K			daily-maximum near-surface (usually, 2 meter) air temperature. Consistent with the CF-conventions, the cell_methods attribute should specify "time: maximum" (automatically done by CMOR). The CMOR singleton dimension default value of 2 m can be overridden, if absolutely necessary, by redefining axis "height1".
5	air_temperature	tas	K	B, C	F, G	daily-mean near-surface (usually, 2 meter)

						air temperature; The CMOR singleton dimension default value of 2 m can be overridden, if absolutely necessary, by redefining axis "height1".
6	surface_upward_latent_heat_flux	hfls	W m^{-2}	B, L	F, L	
7	surface_upward_sensible_heat_flux	hfss	W m^{-2}	B, L	F, L	
8	surface_downwelling_longwave_flux_in_air	rlds	W m^{-2}	B, L	F, L	
9	surface_upwelling_longwave_flux_in_air	rlus	W m^{-2}	B, L	F, L	
10	surface_downwelling_shortwave_flux_in_air	rsds	W m^{-2}	B, L	F, L	
11	surface_upwelling_shortwave_flux_in_air	rsus	W m^{-2}	B, L	F, L	
12	eastward_wind	uas	m s^{-1}			near-surface (usually, 10 meters) eastward component of wind. The CMOR singleton dimension default value of 10 m can be overridden, if absolutely necessary, by redefining axis "height2".
13	northward_wind	vas	m s^{-1}			near-surface (usually, 10 meters) northward component of wind. The CMOR singleton dimension default value of 10 m can be overridden, if absolutely necessary, by redefining axis "height2".
14	toa_outgoing_longwave_flux	rlut	W m^{-2}	B, C	F, G	at the top of the atmosphere (to be compared with satellite measurements)
15	surface_temperature	ts	K	B, C	F, G	"skin" temperature (i.e., SST for open ocean)
16	surface_air_pressure	ps	Pa	B, C	F, G	*not* mean sea-level pressure
17	specific_humidity	huss	1 (i.e., dimen-sionless fraction)	B, C	F, G	near-surface (usually, 2meters) specific humidity; the CMOR singleton dimension default value of 2 m can be overridden, if absolutely necessary, by redefining axis "height1".

18	toa_incoming_shortwave_flux	rsdt	W m^{-2}	B, C	F, G	incident shortwave at the top of the atmosphere
19	toa_outgoing_shortwave_flux	rsut	W m^{-2}	B, C	F, G	at the top of the atmosphere
20	net_downward_radiative_flux_at_ top_of_atmosphere_model	rtmt	W m^{-2}	B, C	F, G	i.e., at the top of that portion of the atmosphere where dynamics are explicitly treated by the model.
21	surface_downwelling_shortwave_flux_in_ air_assuming_clear_sky	rsdscs	W m^{-2}	B, L	F, L	method "2" is recommended for calculating clear-sky fluxes
22	surface_upwelling_shortwave_flux_in_ air_assuming_clear_sky	rsuscs	W m^{-2}	B, L	F, L	method "2" is recommended for calculating clear-sky fluxes
23	surface_downwelling_longwave_flux_in_ air_assuming_clear_sky	rldscs	W m^{-2}	B, L	F, L	method "2" is recommended for calculating clear-sky fluxes
24	toa_outgoing_longwave_flux_ assuming_clear_sky	rlutcs	W m^{-2}	B, C	F, G	method "2" is recommended for calculating clear-sky fluxes
25	toa_outgoing_shortwave_flux_ assuming_clear_sky	rsutcs	W m^{-2}	B, C	F, G	method "2" is recommended for calculating clear-sky fluxes
26	cloud_area_fraction	clt	%	B, C	F, G	for the whole atmospheric column, as seen from the surface or the top of the atmosphere. Include both large-scale and convective cloud.
27	surface_snow_amount_where_land	snw	kg m^{-2}	B, C	F, G	THIS IS NOT REQUIRED DAILY IF SNC IS SUBMITTED DAILY. Compute as the mass of surface snow on the land portion of the grid cell divided by the land area in the grid cell; report as "missing" or 0.0 where the land fraction is 0; exclude snow on vegetation canopy or on sea ice.
28	surface_snow_area_fraction_where_land	snc	%	B, C	F, G	fraction of grid cell covered by snow that lies on land; exclude snow that lies on sea ice.

29	sea_ice_area_fraction	sic	%	B, C	F, G	fraction of grid cell covered by sea ice.

Table CF3b: **Daily-mean ISCCP simulator data (longitude, latitude, pressure2, tau, time).** Data should be sampled no less frequently than every 3 hours. The ISCCP cloud layers refer to the following ranges (hPa): 800 and higher, 800-680, 680-560, 560-440, 440-310, 310-180, and 180-0. The ISCCP optical depth (tau) categories refer to the following ranges: 0-0.3, 0.3-1.3, 1.3-3.6, 3.6-9.4, 9.4-23, 23-60, and >60. This table includes, in a different structure and different units, the fields found in the original CFMIP table 7b. Daily sampling ISCCP data was not requested as part of the IPCC standard output.

	CF standard_name	**output variable name**	**units**	**±2K analysis packages**	**Slab analysis packages**	**notes**
1	isccp_cloud_area_fraction	clisccp	1 (i.e., dimensionless fraction)	B	F	as seen from above, mean fraction of grid column occupied by cloud of optical depths and heights specified by the tau and pressure intervals given above; for each longitude and latitude grid column, the ISCCP simulator output comprises a 7x7 (pressure x tau) matrix of values matching those of the satellite. With CMOR, use "pressure2" to define the vertical coordinates for this variable.

The following tables (CF3c and CF3d) request diagnostics on pressure levels and model levels respectively. In some cases, the same diagnostic appears in both tables (with the output variable name ending in 'm' in CF3d to avoid confusion). For these diagnostics there is no need to submit the field both on model levels and pressure levels. If possible the data should be submitted on model levels, otherwise data on pressure levels is acceptable.

Table CF3c: **Daily-mean 3-d atmosphere data on pressure levels (longitude, latitude, pressure, time).** This data must be provided on pressure levels, including at least the following subset of standard levels:1000, 925, 850, 700, 600, 500, 400, 300, 200 hPa. This table is the same as IPCC Table A2b, except that relative humidity (hur) has been added.

	CF standard_name	output variable name	units	±2K analysis packages	Slab analysis packages	notes
1	air_temperature	ta	K	B, L	F, L	
2	eastward_wind	ua	m s^{-1}	B	F	
3	northward_wind	va	m s^{-1}	B	F	
4	specific_humidity	hus	1 (i.e., dimensionless fraction)	B, L	F, L	
5	lagrangian_tendency_of_air_pressure	wap	Pa s^{-1}	A, Z	E, Z	commonly referred to as "omega", this represents the vertical component of velocity in pressure coordinates (positive down)
6	geopotential_height	zg	m	Z	Z	
7	relative_humidity	hur	%	B, L	F, L	

Table CF3d: **Daily-mean 3-d atmosphere data on model levels (longitude, latitude, model_level, time).** For all simulations, report values only after model reaches equilibrium, and for slab runs only report 5 years of daily data. This data should be provided on all model levels. No daily data for these fields was requested as part of the IPCC standard output.

	CF standard_name	output variable name	units	±2K analysis packages	Slab analysis packages	notes
1	cloud_area_fraction_in_atmosphere_layer	cl	%	B	F	Include both large-scale and convective cloud.

2	mass_fraction_of_cloud_liquid_water_in_air	clw	1 (i.e., dimensionless mass fraction)	B	F	divide mass of liquid water in the grid cell by mass of air in the grid cell.
3	mass_fraction_of_cloud_ice_in_air	cli	1 (i.e., dimensionless mass fraction)	B	F	divide mass of ice in the grid cell by mass of air in the grid cell.
4	convective_cloud_area_fraction_in_atmosphere_layer	clc	%	B	F	
5	mass_fraction_of_convective_cloud_liquid_water_in_air	clwc	1 (i.e., dimensionless mass fraction)	B	F	divide mass of liquid water in the convective cloud portion of the grid cell by mass of air in the entire grid cell.
6	mass_fraction_of_convective_cloud_ice_in_air	clic	1 (i.e., dimensionless mass fraction)	B	F	divide mass of ice in the convective cloud portion of the grid cell by mass of air in the entire grid cell.
7	stratiform_cloud_area_fraction_in_atmosphere_layer	cls	%	A	E	
8	mass_fraction_of_stratiform_cloud_liquid_water_in_air	clws	1 (i.e., dimensionless mass fraction)	A	E	divide mass of liquid water in the convective cloud portion of the grid cell by mass of air in the entire grid cell.
9	mass_fraction_of_stratiform_cloud_ice_in_air	clis	1 (i.e., dimensionless mass fraction)	A	E	divide mass of ice in the convective cloud portion of the grid cell by mass of air in the entire grid cell.
10	air_temperature	tam	K	D, L, Z	E, L, Z	As ta but on model levels.

11	eastward_wind	uam	m s^{-1}	Z	E, Z	As ua but on model levels.
12	northward_wind	vam	m s^{-1}	Z	E, Z	As va but on model levels.
13	specific_humidity	husm	1 (i.e., dimensionless fraction)	D, L, Z	E, L, Z	As hus but on model levels
14	lagrangian_tendency_of_air_pressure	wapm	Pa s^{-1}	A, Z	E, Z	As wap but on model levels.
15	geopotential_height	zgm	m	Z	Z	As zg but on model levels.
16	relative_humidity	hurm	%	D, L, Z	E, L, Z	As hur but on model levels.

Doubled CO2 radiative forcing

For slab ocean experiments, a 12 month monthly mean climatology is requested, although an annual climatological mean would be acceptable. If fields are not available, please advise us of the global mean values.

Table CF4: **Monthly-mean 2-d radiative forcing data for doubled co2 (longitude, latitude, time).** For the following output fields choose the variable name corresponding to the method you used to calculate the radiative forcing for doubled co2. This table contains a subset of the forcing choices contained in the IPCC Table A5.

	CF standard_name	output variable name	units	Slab analysis packages	notes
1	toa_adjusted_shortwave_forcing tropopause_adjusted_shortwave_forcing toa_instantaneous_shortwave_forcing	rsftoaa_co2 rsftropa_co2 rsftoai_co2	W m^{-2}	??	all-sky conditions, defined to be positive down. Choose appropriate variable, and indicate in the "comment" attribute (associated with the variable)

	tropopause_instantaneous_shortwave_forcing	rsftropi_co2			any particulars (e.g., 200 hPa taken as approximate tropopause). For tropopause, CMOR will by default record a singleton dimension value of 200 hPa. To override this value redefine pressure1.
2	toa_adjusted_longwave_forcing tropopause_adjusted_longwave_forcing toa_instantaneous_longwave_forcing tropopause_instantaneous_longwave_forcing	rlftoaa_co2 rlftropa_co2 rlftoai_co2 rlftropi_co2	W m^{-2}	??	all-sky conditions, defined to be positive down. Choose appropriate variable, and indicate in the "comment" attribute (associated with the variable) any particulars (e.g., 200 hPa taken as approximate tropopause). For tropopause, CMOR will by default record a singleton dimension value of 200 hPa. To override this value redefine pressure1.
3	toa_adjusted_shortwave_forcing_ assuming_clear_sky tropopause_adjusted_shortwave_forcing_ assuming_clear_sky toa_instantaneous_shortwave_forcing_ assuming_clear_sky tropopause_instantaneous_shortwave_forcing_ assuming_clear_sky	rsftoaacs_co2 rsftropacs_co2 rsftoaics_co2 rsftropics_co2	W m^{-2}	??	clear-sky calculation, defined to be positive down. Choose appropriate variable, and indicate in the "comment" attribute (associated with the variable) any particulars (e.g., 200 hPa taken as approximate tropopause). For tropopause, CMOR will by default record a singleton dimension value of 200 hPa. To override this value redefine pressure1.
4	toa_adjusted_longwave_forcing_ assuming_clear_sky tropopause_adjusted_longwave_forcing_ assuming_clear_sky toa_instantaneous_longwave_forcing_ assuming_clear_sky tropopause_instantaneous_longwave_forcing_ assuming_clear_sky	rlftoaacs_co2 rlftropacs_co2 rlftoaics_co2 rlftropics_co2	W m^{-2}	??	clear-sky calculation, defined to be positive down. Choose appropriate variable, and indicate in the "comment" attribute (associated with the variable) any particulars (e.g., 200 hPa taken as approximate tropopause). For tropopause, CMOR will by default record a singleton dimension value of 200 hPa. To override this value redefine pressure1.

Coordinate dimensions.

In the tables given above, variables are a function of various coordinate variables, which are stored in the netCDF files with the following names and units:

Table of Coordinate Dimensions.

	CF standard_name	output coordinate variable name	CMOR table "entry" I.D.	units	default value of scalar dimension	notes
1	longitude	lon	longitude	degrees_east		
2	latitude	lat	latitude	degrees_north		
3	time	time	time	days_since_??		where ?? should be specified in the form year-month-day (e.g., days_since_1800-1-1). For perpetual July experiments, set units to "days since 1-7-15"
5	air_pressure	plev	pressure	Pa		used for all fields that are a function of pressure except those listed in the next 3 rows below.
6	air_pressure	plev	pressure1	Pa	20000.	used by some near-tropopause radiation fluxes (Tables CF1a and CF2a), and some radiative forcing fields (Table CF4)
7	air_pressure	plev	pressure2	Pa		used by clisccp in Tables CF1b, CF2b, and CF3b
8	air_pressure	plev	pressure4	Pa	50000.	used by wap in Table CF3a
9	height	height	height1	m	2.	used by tas, huss, tasmin and tasmax in Tables CF1a, CF2a, and CF3a
10	height	height	height2	m	10.	used by uas and vas in Table CF1a
11	depth	depth	depth1	m	0.05	used by mrsos in Table CF1a; bounds for this scalar dimension should be 0.0 and 0.1 m.

12	cloud_optical_depth	tau	tau	1		used by clisccp in Tables CF1b, CF2b, and CF3b
13	atmosphere_sigma_ coordinate	lev	standard_sigma	1 (i.e., dimensionless)		one choice of dimensionless vertical coordinate needed for cl field (cloud fraction). The following parameters (specified by the CF-standard) are also needed to fully describe this coordinate: ptop, sigma, and ps.
14	atmosphere_hybrid_sigma_ pressure_coordinate	lev	standard_hybrid_ sigma	1 (i.e., dimensionless)		one choice of dimensionless vertical coordinate needed for cl field (cloud fraction). The following parameters (specified by the CF-standard) are also needed to fully describe this coordinate: p0, a, b, and ps.
15	atmosphere_hybrid_sigma_ pressure_coordinate	lev	alternate_hybrid_ sigma	1 (i.e., dimensionless)		one choice of dimensionless vertical coordinate needed for cl field (cloud fraction). The following parameters (specified by the CF-standard) are also needed to fully describe this coordinate: p0, ap, b, and ps.