CMIP6 greenhouse gas concentrations in NorESM (version1.0)

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Abstract

We describe the GHG data set prepared for NorESM.

1 Introduction

We describe here the green house concentration (GHG) time series used in NorESM for CMIP6.

2 Main points about NorESM CMIP6 GHG data set

Frequency : annual data, the date time stamps is the first of July in each year (i.e., YYYY0701).

Time range : 1750–2015.

Year 2015 : As there were no data for the year 2015, the values for the year 2015 are identical to the year 2014 values.

Species and units : The species in the file are listed in the table below.

Table : species which are contained in the files for NorESM.

Species	Units	Remark	Value
CO2	1e-6 mol mol^{-1}		
CH4	1e-9 mol mol^{-1}		
N2O	1e-9 mol mol^{-1}		
CFC12	1e-12 mol mol^{-1}		
CFC11-eq	1e-12 mol mol^{-1}	conglomerate of 39 species	
adj	unitless	adjustment factor for CFC11	=0

Adjustment factor The CESM/NorESM code allows to change the CFC11 concentration with a factor $(1 + adj)$. This happens in components/cam/src/physics/cam/chem_surfvals.F90. As this factor was 0 in the CMIP5-CESM files, we have also it taken to be 0 in the CMIP6 NorESM files.

3 Different data sets

The different data sets The data for NorESM is based in the original CMIP6 data (from input4MIPs). For comparison, we describe also how the original CMIP5 data has been used to generate the CMIP5-CESM data. So the four data sets described here can be found in the following table.

Table : overview of the four different data sets.

Data set	Description	Split A	Split B
CMIP5-original	The original data set for CMIP5	CFC12-eq/HCF134a-eq split	
CMIP5-CESM	Files used by CESM1/NorESM1 in CMIP5		CFC12/CFC11-eq split
CMIP6-original	The original data set for CMIP6	CFC12-eq/HCF134a-eq split	CFC12/CFC11-eq split
CMIP6-NorESM	Files for NorESM using CMIP6		CFC12/CFC11-eq split

Number of species and suggested splits The GHGs listed in CMIP5 and CMIP6 agree to a large extend, although more GHGs are avaialable in CMIP6. The datasets also differ in the grouping of the non-CO2/CH4/N2O gases. Two different splits exist.

- CMIP5 original : suggest a CFC12-eq/HCF134a-eq split.
- CMIP5 CESM : uses a CFC12/CFC11-eq split. In this different split, all species from "CMIP5 original" were used except Halon1202.
- CMIP6 original : suggests two types of split : or a CFC12-eq/CF134a-eq split, or a CFC12/CFC11-eq split. Three species have been left out (w.r.t. CMIP5), i.e., HFC43-10, CARB-TET, and Halon1202. Several new species have been included (w.r.t. CMIP5), i.e., C3F8, C4F10, C5F12, C7F16, C8F18, c-C4F8, HFC152a, HFC236fa, HFC365mfc, HFC43-10mee, CCl4, CH2Cl2, CHCl3, NF3, and SO2F2.
- CMIP6 NorESM : we have followed the CFC11-eq /CFC12 split from "CMIP6 original".

4 Data sets

Here we shortly describe the three base data sets, i.e., CMIP5-original, CMIP5-CESM, and CMIP6-original, which have guided us towards the CMIP6-NorESM data set.

4.1 Original CMIP5 data

Files The data is in ascii files. These are :
RCP3PD_MIDYR_CONC.DAT
RCP45_MIDYR_CONC.DAT
RCP6_MIDYR_CONC.DAT
RCP85_MIDYR_CONC.DAT

Resolution These files contain global and annual mean values (starting in year 1765).

Content The header of the file contains quite some information on its content. The colums in the files describe respectively :

- (1) **CO2EQ** : CO2 equivalence concentrations using CO2 radiative forcing relationship Q = 3.71/ln(2)*ln(C/278), aggregating all anthropogenic forcings, including greenhouse gases listed below (i.e., columns 3, 4, 5 and 8–35), and aerosols, trop. ozone etc. (not listed below).
- (2) **KYOTO-CO2EQ** : As column 1, but only aggregating greenhouse gases controlled under the Kyoto Protocol (columns 3, 4, 5 and 8–19).
- (3) **CO2** : Atmospheric CO2 concentrations
- (4) **CH4** : Atmospheric CH4 concentrations
- (5) **N2O** : Atmospheric N2O concentrations
- (6) **FGASSUMHFC134AEQ** : All flourinated gases controlled under the Kyoto Protocol, i.e., HFCs, PFCs, and SF6 (columns 8–19) expressed as HFC134a equivalence concentrations.
- (7) **MHALOSUMCFC12EQ** : All flourinated gases controlled under the Montreal Protocol, i.e., CFCs, HCFCs, Halons, CCl4, CH3Br, CH3Cl (columns 20–35) expressed as CFC12 equivalence concentrations.

- (8–19) : Flourinated Gases controlled under the Kyoto Protocol
- (20–35) : Ozone Depleting Substances controlled under the Montreal Protocol

Reference Meinshausen et al. [2011]

4.2 CMIP5-CESM data set

The files prepared by CESM for CMIP5 are desribed here.

File location They can be found under noresm/inputdata/atm/cam/ggas

Examples of files Some of the files available are :
ghg_hist_1765-2005_c091218.nc
ghg_hist_1850-2005_c090419.nc
ghg_rcp85_1765-2500_c100203.nc

Resolution Global and annual mean averages. The datestamps are YYYY0701.

Content CO2, CH4, N2O, f11 (=CFC11-eq), f12 (=CFC12), and adj (=0).

Equivalent CFC11-eq The CFC11-eq specie represents 26 species. The radiative efficiencies used to construct CFC11-eq can be found in the "comment" field of the NetCDF files, but are also given in the table below (row "CMIP5 CESM").

Adjustment factor The field in the file is described as "adj factor for f11". Its value is always zero.

4.3 Original CMIP6 data

This is the data as found on input4MIPs

Species There are 46 species represented. These are

- 3 principal GHGs : O2, CH4, N2O
- 40 other seperate species
- 3 equivalent species : CFC11-eq, CFC12, HFC134a-eq.

Equivalent species Three different suggestions are done to use the data. These are graphically represented as :

Using the species seperately :

CO2	CH4	N2O	CFC-12	CFC-11	...	Halon-2402	HFC-134a	...	c-C4F8

Using a CFC12-eq/HFC134a-eq split :

CO2	CH4	N2O	CFC-12	CFC-11	...	Halon-2402	HFC-134a	...	c-C4F8

Using a CFC12/CFC11-eq split :

CO2	CH4	N2O	CFC-12	CFC-11	...	c-C4F8

Radiative efficiencies Radiative efficiencies have possibly been taken from the fifth IPCC assesment report [Stocker et al., 2013, Table 8.A.1] (it should be checked in Meinshausen et al. [2017].

File location

Resolution The resolution of the data is :
Temporal : annual and monthly, starts in year 0 and ends in year 2014.
Spatial : global mean, NH mean, SH mean, 15-degree latitiudinal resolution, 0.5 degree latitudinal resolution.

Reference Meinshausen et al. [2017]. Radiative efficiencies have possibly been taken from the fifth IPCC assesment report [Stocker et al., 2013, Table 8.A.1].

Some explicit values The GHG concentrations should have the value showing in the table below (based on Meinshausen et al. [2017]).

Table : GHGs concentrations taken from Meinshausen et al. [2017, Table 6].

Year	CO2	CH4	N2O	CFC12-eq	HFC134a-eq	CFC-11 eq.	CFC-12
1750	277.15	731.41	273.87	16.51	19.15	32.11	0.00
1850	284.32	808.25	273.02	16.51	19.15	32.11	0.00
2000	369.12	1778.01	315.76	1051.12	104.52	690.46	542.38
2010	388.72	1807.85	323.14	1054.37	203.07	768.76	531.28
2014	397.55	1831.47	326.99	1049.51	257.06	809.19	520.58

5 Overview of species and suggested splits in different data sets

The following table shows an overview of the non-CO2/CH4/N2O GHGs in the different data sets, and of the possible splits.

Table : overview of the equivalent species in the different data sets.

	CMIP5 original	CMIP5 original	CMIP5 CESM	CMIP5 CESM	CMIP6 original	CMIP6 original	CMIP6 original
8	CF4	HFC134a-eq	CFC11-eq	0.1	CF4	HFC134a-eq	CFC11-eq
9	C2F6	HFC134a-eq	CFC11-eq	0.26	C2F6	HFC134a-eq	CFC11-eq
					C3F8	HFC134a-eq	CFC11-eq
					C4F10	HFC134a-eq	CFC11-eq
					C5F12	HFC134a-eq	CFC11-eq
10	C6F14	HFC134a-eq	CFC11-eq	0.49	C6F14	HFC134a-eq	CFC11-eq
					C7F16	HFC134a-eq	CFC11-eq
					C8F18	HFC134a-eq	CFC11-eq
					c-C4F8	HFC134a-eq	CFC11-eq
11	HFC23	HFC134a-eq	CFC11-eq	0.19	HFC23	HFC134a-eq	CFC11-eq
12	HFC32	HFC134a-eq	CFC11-eq	0.11	HFC32	HFC134a-eq	CFC11-eq
13	HFC43-10	HFC134a-eq	CFC11-eq	0.4			
14	HFC125	HFC134a-eq	CFC11-eq	0.23	HFC125	HFC134a-eq	CFC11-eq
15	HFC134a	HFC134a-eq	CFC11-eq	0.16	HFC134a	HFC134a-eq	CFC11-eq
16	HFC143a	HFC134a-eq	CFC11-eq	0.13	HFC143a	HFC134a-eq	CFC11-eq
					HFC152a	HFC134a-eq	CFC11-eq
17	HFC227ea	HFC134a-eq	CFC11-eq	0.26	HFC227ea	HFC134a-eq	CFC11-eq
					HFC-236fa	HFC134a-eq	CFC11-eq
18	HFC245fa	HFC134a-eq	CFC11-eq	0.28	HFC-245fa	HFC134a-eq	CFC11-eq
					HFC-365mfc	HFC134a-eq	CFC11-eq
					HFC-43-10mee	HFC134a-eq	CFC11-eq
19	SF6	HFC134a-eq	CFC11-eq	0.52	SF6	HFC134a-eq	CFC11-eq
20	CFC11	CFC12-eq	CFC11-eq	0.25	CFC11	CFC12-eq	**CFC11-eq**
21	CFC12	CFC12-eq	CFC-12		CFC12	**CFC12-eq**	CFC-12
22	CFC113	CFC12-eq	CFC11-eq	0.3	CFC113	CFC12-eq	CFC11-eq
23	CFC114	CFC12-eq	CFC11-eq	0.31	CFC114	CFC12-eq	CFC11-eq
24	CFC115	CFC12-eq	CFC11-eq	0.18	CFC115	CFC12-eq	CFC11-eq
25	CARB-TET	CFC12-eq	CFC11-eq	0.13			
26	MCF	CFC12-eq	CFC11-eq	0.06	CH3CCl3	CFC12-eq	CFC11-eq
					CCl4	CFC12-eq	CFC11-eq
					CH2Cl2	CFC12-eq	CFC11-eq
					CHCl3	CFC12-eq	CFC11-eq
27	HCFC-22	CFC12-eq	CFC11-eq	0.2	HCFC-22	CFC12-eq	CFC11-eq
28	HCFC-141B	CFC12-eq	CFC11-eq	0.14	HCFC-141b	CFC12-eq	CFC11-eq
29	HCFC-142B	CFC12-eq	CFC11-eq	0.2	HCFC-142b	CFC12-eq	CFC11-eq
30	HALON1211	CFC12-eq	CFC11-eq	0.3	Halon-1211	CFC12-eq	CFC11-eq
31	HALON1202	CFC12-eq					
32	HALON1301	CFC12-eq	CFC11-eq	0.32	Halon-1301	CFC12-eq	CFC11-eq
33	HALON2402	CFC12-eq	CFC11-eq	0.33	Halon-2402	CFC12-eq	CFC11-eq
34	CH3BR	CFC12-eq	CFC11-eq	0.01	CH3Br	CFC12-eq	CFC11-eq
35	CH3CL	CFC12-eq	CFC11-eq	0.01	CH3Cl	CFC12-eq	CFC11-eq
					NF3	HFC134a-eq	CFC11-eq
					SO2F2	HFC134a-eq	CFC11-eq

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