CCMVal-2 data request in support of the SPARC CCMVal Report

Questions regarding this data request can be directed to
Darryn Waugh (waugh@jhu.edu) and Veronika Eyring (veronika.eyring@dlr.de).

This data request is for files that are needed in support of the planned CCMVal Report on the Evaluation of Chemistry Climate Models (CCMs) as well as in support of upcoming ozone and climate assessments. The corresponding output from the newly proposed CCMVal reference and sensitivity simulations (see http://www.pa.op.dlr.de/CCMVal/ for further information) will be collected at the BADC (British Atmospheric Data Centre). For directory structure and instructions how to get access this site, please visit the CCMVal website.

1 Requested Output

Model output (except for 3D instantaneous data described in Section 1.1) is requested for every year, on **CCMVal standard pressure levels:**

- 1000 850 700 500 400 300 250 200 170 150 130 115 100 90 80 70 50 30 20 15 10 7 5 3 2 1.5 1 0.5 0.3 0.2 0.1

As described in Section 1.1, the instantaneous 3D data are requested at a different frequency and at same resolution as the model.

Numbers in [] below are chapters of the SPARC CCMVal report that will used requested data. Examples of the planned analysis are in Section 3. Full outlines of the report chapters are on the CCMVal website (http://www.pa.op.dlr.de/CCMVal/SPARC_CCMValReport/SPARC_CCMValReport.html)

1.1 Daily Data

Fields T3I: 3D instantaneous fields (Latitude-Longitude-Pressure)

Instantaneous data at 0 UTC is requested on (or as near to) the 1st, 11th, 21st each month, for:
- *all years between 1990-2005*
- *every 3-years before 1989 (e.g., 1960, 1963, 1966,..).*
- *every 3-years from 2005 (e.g., 2005, 2008, 2011,...)*

(Highest priority is for data between 1990 and 2005.)

These data should be on the actual model vertical levels (i.e. pressure, sigma or hybrid levels).

Species:

- **Dynamical fields instantaneous**
    - Pressure, Temperature, U (zonal wind), V (meridional wind), omega (pressure vertical velocity), Geopotential height. [4,6,7]
- **Chemical fields instantaneous**
    - O3, N2O, CH_4 , HCl, H2O [6,7]
    - Passive O3 (if available) [6]
    - Sulfate SAD, NAT, SAD, Water-Ice SAD [6]
    - $CFCl_3$, CF_2Cl_2, CH_3Cl, CH_3Br [6]
    - Cl, ClO, Cl2O2, HOCl, ClONO2, OClO, Cly [6]
    - OH, HO2, H2O2, H2 [6]
    - N, NO, NO2, HNO3, N2O5, HNO4, NOy [6]
    - Br, BrO, BrCl, HBr, HOBr, BrONO2, Bry [6]
    - CH2O, CH3OOH [6]
    - J_O2, J_Cl2O2, O(3P), O(1D) [6]
    - CO, CO2, age of air [7]
    - C2H6, C2H2, HCN [7]
    - radiative heating (shortwave+longwave), Cloud Fraction, Convective cloud fraction [7]
    - aerosol/PSC surface area densities [6]

Fields T2Is or T2Ds: 2D daily fields (Latitude-Longitude) instantaneous preferred over daily-mean (daily-mean = mean over 24 hours)

These data (and all below) are requested for every day for all years:

- Zonal and meridional wind, temperature and geopotential height on the 10, 100 hPa and 1000 hPa surfaces. [4]
- surface pressure, 2m temperature, 500 hPa geopotential [10]

- Potential vorticity on the 840 and 460K surfaces. [4]
- total ozone column [multiple]
- surface solar irradiance, surface solar irradiance clear sky, top of atmosphere net longwave irradiance[2]
- total cloud cover, snow depth, total snow, minimum and maximum 2m temperature. [10]

Fields T2Iz or T2Dz: 2D daily zonal mean fields (Latitude-pressure) instantaneous or daily-mean

- daily zonal mean geopotential, T and U at all standard CCMVal pressure levels. [4]

Fields T1Iz: Daily areas

- PSC area, 2 values for each hemisphere @ 50 hPa. [4]

  Either

  - Daily PSC Area that is calculated by the model's PSC scheme poleward of 60° at 50 hPa for Nov-April in NH and July-Dec in SH (Units: square kilometers).
  - Daily Area where the Temperature poleward of 60° is below 195 K and below 188 K at 50 hPa for Nov-April in NH and July-Dec in SH (Units: square kilometers).

1.2 Monthly Mean Data

Fields T3M: 3D monthly mean fields (Latitude-Longitude-Pressure)

- Temperature, Z (Geopotential height) [4,8]
- U (zonal wind), V (meridional wind), W (vertical velocity or omega) [4,8]
- SHR (shortwave heating rates), LHR (longwave heating rates) [8]
- O3 [multiple]
- H2O, Age of Air [4,5,7]
- N2O, CH4, CO2 [5,7]
- HCl, CO, N2O, CO2, NOx [7]

- C_2H_6, C_2H_2, HCN [7]
- Cloud Fraction (3D), Convective cloud fraction

Fields T2Ms and TO2Ms: 2D monthly mean fields (Latitude-Longitude)

- Surface pressure [7]
- Cloud Fraction, Convective cloud fraction or top (2D). [7]
- Tropopause pressure, temperature and altitude [10]
- precipitation, surface latent heat flux, surface sensible heat flux
- Total column O_3 [multiple]
- Sea surface temperatures, sea ice area fraction [multiple]

Fields T2Mz: 2D monthly zonal mean fields (Latitude-pressure)

- **2D monthly zonal mean dynamical fields**
  - Temperature, U (zonal wind), V (meridional wind), Geopotential height. [4,6,7]
- **2D monthly zonal mean chemical fields**
  - O_3, N_2O, CH_4, H_2O, Age of Air [5,6]
  - CH_3Cl, CH_3CCl_3, CCl_4, CFC-11, CFC-12, HCFC-22, HCFC-141b, HCFC-142b, Halon-1211, Halon 1301, Halon 2402, CH_3Br, CH_2Br_2, $CHBr_3$ [6]
  - HNO_3, HCl , $ClONO_2$ [6]
  - NO_y, Cl_y, Br_y. [6]
  - Cl, ClO, Cl_2O_2, HOCl, $ClONO_2$, OClO, Cl_y [6]
  - OH, HO_2, H_2O_2, H_2 [6]
  - N, NO, NO_2, HNO_3, N_2O_5, HNO_4, NO_y [6]
  - Br, BrO, BrCl, HBr, HOBr, $BrONO_2$, Br_y [6]

- **2D monthly zonal mean latitude-height fields** for the EP-flux (Fy, Fz), acceleration from the EP-flux divergence (D), residual meridional circulation *(v*/w*)*. [4]

- **2D monthly zonal mean latitude-height fields** for the **westerly acceleration from the total (orographic + non-orographic) gravity wave drag (GWD)** derived either from daily means or 6hr fields (use instantaneous daily fields or 12 hr fields if the 6 hr data are not available). Use the accelerations as applied in your model (Units: m/s per day). [4]

Fields T1Ms: 1D monthly mean fields on a certain pressure level (Latitude)

- Zonally averaged heat flux at 100 hPa as monthly means derived from daily fields [4]

1.3 Annually-averaged Data

Fields T0As: 0D (global, annual average) fields

For each year of simulations the following information is requested for lifetime calculations: [5]

(A) total yearly average burden, B (in total # of molecules) and total yearly averaged atmospheric loss, L (# molecules/s) for (as many as possible of):

N2O, CFCl3 (CFC-11), CF2Cl2 (CFC-12), C2F3Cl3 (CFC-113), C2Cl2F4 (CFC-114), C2ClF5 (CFC-115), CCl4, CBrF3 (Halon 1301), CBrClF2 (Halon 1211), C2Br2F4 (Halon 2402), CBr2F2 (Halon 1202)

(B) total yearly average burden, B (in total # of molecules), total yearly averaged atmospheric loss, L (# molecules/s), total yearly averaged tropospheric loss, LTr (# molecules/s); and total yearly averaged stratospheric and mesospheric loss, LSM (# molecules/s) for (as many as possible of):

CH4, CO, H2, CH3Cl, CH3Br, CH3CCl3, CHClF2 (HCFC-22), CH3CCl2F (HCFC-141b), CH3CClF2 (HCFC-142b), CH2CF4 (HFC-134a), C2HF3Cl2 (HCFC-123)

1.4 Survey for CCMVal Radiation Intercomparison

For the radiation intercomparison, please fill in the survey at http://homepages.see.leeds.ac.uk/~earpmf/ccmvalrad.shtml and join in the offline comparison.

2 Data Format

The output of all model runs will be collected in Climate and Forecast (CF) standard compliant netCDF format for any future CCMVal data requests. CCMVal will use a list of over 150 quantities, many of which have not been in the CF standard name table. The additional names needed for CCMVal have been defined and are now accepted. For the CF standard name table, please see http://cf-pcmdi.llnl.gov/documents/cf-standard-names/current/cf-standard-name-table.html. To facilitate model analysis, all modeling groups are asked to provide model output in the agreed format.

The following naming should be used for the CCMVal fields (see Column 'Output Fields' in Table 1):

CCMVal Fields T2Ms: Monthly-mean 2-d atmosphere or land surface data (longitude, latitude, time:month)
CCMVal Fields T3M: Monthly-mean 3-d atmosphere data (longitude, latitude, pressure, time:month)
CCMVal Fields T2Mz: Monthly-mean zonal mean 2-d atmosphere or land surface data (latitude, pressure, time:month)
CCMVal Fields T1Ms: Monthly-mean 1-d atmosphere or land surface data on a certain pressure level (latitude, time:month)

CCMVal Fields T2Ds: Daily-mean 2-d atmosphere data (longitude, latitude, time:day)
CCMVal Fields T2Dz: Daily-mean zonal mean 2-d atmosphere data (latitude, pressure, time:day)
CCMVal Fields T2Is: Daily instantaneous 2-d atmosphere data for all years (longitude, latitude, time:day)
CCMVal Fields T3I: Daily-instantaneous 3-d atmosphere data for selected years (longitude, latitude, model levels, time:day)

- all years between 1990-2005.
- every 3-years before 1989 (e.g., 1960, 1963, 1966,..).
- every 3-years from 2005 (e.g., 2005, 2008, 2011,...)

CCMVal Fields T2Iz: Daily instantaneous zonal mean 2-d atmosphere data for all years (latitude, pressure, time:day)
CCMVal Fields T0I: Daily instantaneous 1-d field for all years (time:day)
CCMVal Fields T0As: Annual-mean 0-d atmosphere or land surface data on a certain pressure level (latitude, time:year)

CCMVal Fields TO2Ms: Monthly-mean 2-d ocean or sea ice data (longitude, latitude, time:month).

Notes:

- **T = time dependent; 0,1,2,3 = 0,1,2,3 dimensional (0D, 1D, 2D, 3D); M = monthly mean; I = instantaneous; D = daily-mean, s = surface; z = zonal mean; O = ocean**
- **MONTHLY MEANS:** For monthly means, all time samples (or sufficient time samples) should be included, so that the diurnal cycle is well represented. I.e., a monthly mean should not be calculated from 30 time samples at 0 UTC, but should include some

representation of the diurnal cycle (like every 6 hours, daily means or accumulated means).

- **FILENAME:**
  - The column **'output fields'** in Table 1 refers to the CCMVal fields defined in section 1.
  - The **output_file_name** is then **'CCMVal2_${CCMVal-model-experiment}_${MODELNAME}_${ID-ENSEMBLE}_'** followed by **'${Output field number}_'** and **'${output variable name}'** (e.g., **CCMVal2_REF-B1_CMAM_1_T3M_ta** for monthly-mean 3-d temperature data or **CCMVal2_REF-B1_CMAM_1_T2Mz_ta** for monthly-mean zonal mean 2-d temperature data).
- **Submission of files to BADC:**
  - To distinguish files from model simulations of other projects, BADC requested that each files starts with the string '**CCMVal2_**' where 2 stands for the second round. From now on we refer to the runs submitted in support of WMO 2006 as CCMVal-1 Archive. The directory structure at BADC has been changed accordingly:
    - /project_spaces/ccmval/CCMVal-1
    - /project_spaces/ccmval/CCMVal-2
  - The simulations for the CCMVal-2 Archive will be called **REF-B1**, **REF-B2**, **REF-B0, CTL-B0, SCN-B1, SCN-B2a, SCN-B2b, SCN-B2c, and SCN-B2d** in order to distinguish them from the simulations that have been submitted to the CCMVal-1 Archive (REF1, REF2, SCN1, SCN2).
  - Submission of model output to BADC:
    - cd /project_spaces/ccmval/CCMVal-2
    - Change to the appropriate run directory (e.g. REF-B0)
      - /project_spaces/ccmval/CCMVal-2/REF-B0
      - /project_spaces/ccmval/CCMVal-2/REF-B1
      - /project_spaces/ccmval/CCMVal-2/REF-B2
      - /project_spaces/ccmval/CCMVal-2/CTL-B0,
      - /project_spaces/ccmval/CCMVal-2/SCN-B1
      - /project_spaces/ccmval/CCMVal-2/SCN-B2a
      - /project_spaces/ccmval/CCMVal-2/SCN-B2b
      - /project_spaces/ccmval/CCMVal-2/SCN-B2c
      - /project_spaces/ccmval/CCMVal-2/SCN-B2d
    - Create a directory with your model name (e.g. /project_spaces/ccmval/CCMVal-2/REF-B2/WACCM)
  - Submit all output that belongs to e.g. the REF-B2 simulation to this directory (no sub-directories for different ensemble members, as they are labeled through the filename **${ID-ENSEMBLE}**).

Table 1. CCMVal Naming Convention. In the netCDF file header, please specify CF name (where available), long_name (where available), units, and output fields. See CCMVal website for example netCDF file headers and a program to convert an arbitrary netCDF file to the CCMVal naming convention (http://www.pa.op.dlr.de/CCMVal/).

	CF standard name	Long_name	Output variable name*	Units	Output Fields	Notes Numbers in [] refer to chapters of the SPARC CCMVal report that will use the requested data.
1	air_temperature		ta	K	**T3M, T2Mz, T3I, T2Iz or T2Dz**	[6,7]
2	air_temperature		ta10	K	**T2Is or T2Ds**	[6,7] temperature on the 10 hPa surface
3	air_temperature		ta100	K	**T2Is or T2Ds**	[6,7] temperature on the 100 hPa surface
4	air_pressure		plev	Pa	**T3I**	[6,7]
5	ertel_potential_vorticity		vorpot	$K\ m^2\ kg^{-1}\ s^{-1}$	**T3I**	[6,7]
6	ertel_potential_vorticity		vorpot840	$K\ m^2\ kg^{-1}\ s^{-1}$	**T2Is or T2Ds**	[6,7] potential vorticity at 840K
7	ertel_potential_vorticity		vorpot480	$K\ m^2\ kg^{-1}\ s^{-1}$	**T2Is or T2Ds**	[6,7]
8	geopotential_height		zg	m	**T3M, T2Mz, T3I, T2Iz or T2Dz**	[6,7]
9	geopotential_height		zg10	m	**T2Is or T2Ds**	[6,7] geopotential height on the 10 hPa surface
10	geopotential_height		zg100	m	**T2Is or T2Ds**	[6,7] geopotential height on the 100 hPa surface
11	geopotential_height		zg500	m	**T2Is or T2Ds**	[4] geopotential height on the 500 hPa surface
12	eastward_wind		ua	$m\ s^{-1}$	**T3M, T2Mz, T3I, T2Iz or T2Dz**	[6,7]
13	northward_wind		va	$m\ s^{-1}$	**T3M,**	[6,7]

					T2Mz, T3I	
14	eastward_wind		ua10	m s^{-1}	**T2Is or T2Ds**	[4] Zonal wind on the 10 hPa surface
15	eastward_wind		ua100	m s^{-1}	**T2Is or T2Ds**	[4] Zonal wind on the 100 hPa surface
16	northward_wind		va10	m s^{-1}	**T2Is or T2Ds**	[4] meridional wind on the 10 hPa surface
17	northward_wind		va100	m s^{-1}	**T2Is or T2Ds**	[4] meridional wind on the 100 hPa surface
18	upward_air_velocity		wa	m s^{-1}	**T3M**	W (vertical velocity) [4,8]
19	lagrangian_tendency_of_air_pressure		wap	Pa s^{-1}	**T3I**	omega
20	surface_air_pressure		ps	Pa	**T2Ms, T2Is or T2Ds**	surface pressure (not mean sea-level pressure)
21	sea_surface_temperature		tos	K	**TO2Ms**	this may differ from "surface temperature" in regions of sea ice.
22	sea_ice_area_fraction		sic	%	**TO2Ms**	fraction of grid cell covered by sea ice.
23	air_temperature		tas	K	**T2Is or T2Ds**	near-surface (usually, 2 meter) air temperature, table A2a no. 5 of IPCC standard output (http://www-pcmdi.llnl.gov/ipcc/standard_output.html)
24	air_temperature		tasmin	K	**T2Is or T2Ds**	minimum near-surface (usually, 2 meter) air temperature, table A2a no 3 of IPCC standard output
25	air_temperature		tasmax	K	**T2Is or T2Ds**	maximum near-surface (usually, 2 meter) air temperature, table A2a no 4 of IPCC standard output
26	tropopause_air_pressure		ptp	Pa	**T2Ms**	2D monthly mean thermal tropopause calculated using WMO tropopause definition on 3d temperature
27	tropopause_air_temperature		tatp	K	**T2Ms**	2D monthly mean thermal tropopause calculated using WMO tropopause definition on 3d temperature
28	tropopause_altitude		ztp	Pa	**T2Ms**	2D monthly mean thermal tropopause calculated using WMO tropopause definition on 3d temperature
29	equivalent_thickness_at_stp_of_atmosphere_ozone_content		toz	DU	**T2Ms, T2Is or T2Ds**	total ozone column in DU
30	surface_downwelling_shortwave_flux_in_air		rsds	W m^{-2}	**T2Is and T2Ds**	surface solar irradiance for UV calculations
31	surface_downwelling_shortwave_flux_in_air_assuming_clear_sky		rsdscs	W m^{-2}	**T2Is and T2Ds**	surface solar irradiance clear sky for UV calculations
32	tendency_of_air_temperature_due_to_short		tntsw	K s^{-1}	**T3M, T3I**	shortwave heating rates

	wave_heating					
33	net_upward_longwave_flux_in_air		nufl	W m^{-2}	**T2Ms, T2Is or T2Ds**	Outgoing longwave irradiance
34	tendency_of_air_temperature_due_to_long wave_heating		tntlw	K s^{-1}	**T3M, T3I**	longwave heating rates
35	cloud_area_fraction		clt	%	**T3M, T3I**	[7] cloud area fraction
36	convective_cloud_area_fraction		convclt	%	**T3M,T3I**	[7] Convective cloud fraction
37	surface_snow_thickness		snd	m	**T2Is or T2Ds**	snow depth
38		surface_snow_amount_where_land	snw	kg m^{-2}	**T2Is or T2Ds**	total snow
39	precipitation_flux	precipitation	pr	kg m^{-2} s^{-1}	**T2Ms**	includes both liquid and solid phases; Table A1a no. 2 of IPCC standard output (http://www-pcmdi.llnl.gov/ipcc/standard_output.html)
40	surface_upward_latent_heat_flux	surface_latent_heat_flux	hfls	W m^{-2}	**T2Ms**	Table A1a no. 9 of IPCC standard output (http://www-pcmdi.llnl.gov/ipcc/standard_output.html)
41	surface_upward_sensible_heat_flux	surface_sensible_heat_flux	hfss	W m^{-2}	**T2Ms**	Table A1a no. 10 of IPCC standard output (http://www-pcmdi.llnl.gov/ipcc/standard_output.html)
42	mole_fraction_of_ozone_in_air		O3	mole mole^{-1}	**T3M, T2Mz, T3I**	[6,7]
43	mole_fraction_of_nitrous_oxide_in_air		N2O	mole mole^{-1}	**T3M, T2Mz, T3I**	[6,7]
44	mole_fraction_of_methane_in_air		CH4	mole mole^{-1}	**T3M, T2Mz, T3I**	[6,7]
45	mole_fraction_of_hydrogen_chloride_in_air		HCl	mole mole^{-1}	**T3M, T2Mz, T3I**	[6,7]
46	mole_fraction_of_water_vapor_in_air		H2O	mole mole^{-1}	**T3M, T2Mz, T3I**	[6,7]
47	mole_fraction_of_cfc11_in_air		CFCl3	mole mole^{-1}	**T2Mz, T3I**	[6]
48	mole_fraction_of_cfc12_in_air		CF2Cl2	mole mole^{-1}	**T2Mz, T3I**	[6]
49	mole_fraction_of_methyl_chloride_in_air		CH3Cl	mole mole^{-1}	**T2Mz, T3I**	[6]
50	mole_fraction_of_methyl_bromide_in_air		CH3Br	mole mole^{-1}	**T2Mz, T3I**	[6]
51		mole_fraction_of_methylene_bromide_in_air	CH2Br2	mole mole^{-1}	**T2Mz, T3I**	[6]
52		mole_fraction_of_bromoform_in_air	CHBr3	mole mole^{-1}	**T2Mz, T3I**	[6]

53	mole_fraction_of_cfc113_in_air		CCl2FCClF2	mole mole^{-1}	**T2Mz**	[6]
54	mole_fraction_of_cfc113a_in_air		CCl3CF3	mole mole^{-1}	**T2Mz**	[6]
55	mole_fraction_of_cfc114_in_air		CClF2CClF2	mole mole^{-1}	**T2Mz**	[6]
56	mole_fraction_of_cfc115_in_air		CClF2CCF3	mole mole^{-1}	**T2Mz**	[6]
57	mole_fraction_of_carbon_tetrachloride_in_air		CCl4	mole mole^{-1}	**T2Mz**	[6]
58	mole_fraction_of_halon1301_in_air		CBrF3	mole mole^{-1}	**T2Mz**	[6]
59	mole_fraction_of_halon1211_in_air		CBrClF2	mole mole^{-1}	**T2Mz**	[6]
60	mole_fraction_of_halon2402_in_air		C2Br2F4	mole mole^{-1}	**T2Mz**	[6]
61	mole_fraction_of_halon1201_in_air		CBr2F2	mole mole^{-1}	**T2Mz**	[6]
62	mole_fraction_of_atomic_chlorine_in_air		Cl	mole mole^{-1}	**T2Mz, T3I**	[6]
63	mole_fraction_of_chlorine monoxide_in_air		ClO	mole mole^{-1}	**T2Mz, T3I**	[6]
64	mole_fraction_of_dichlorine peroxide_in_air		Cl2O2	mole mole^{-1}	**T2Mz, T3I**	[6]
65	mole_fraction_of_hypochlorous acid_in_air		HOCl	mole mole^{-1}	**T2Mz, T3I**	[6]
66	mole_fraction_of_chlorine_nitrate_in_air		ClONO2	mole mole^{-1}	**T2Mz, T3I**	[6]
67	mole_fraction_of_chlorine dioxide_in_air		OClO	mole mole^{-1}	**T2Mz, T3I**	[6]
68	mole_fraction_of_inorganic_chlorine_in_air		Cly	mole mole^{-1}	**T2Mz, T3I**	[6] Total family (the sum of all appropriate species in the model) ; list the species in the netCDF header, e.g. Cly = HCl + ClONO2 + HOCl + ClO + Cl + 2*Cl2O2 +2Cl2 + OClO + BrCl Definition: Total inorganic stratospheric chlorine (e.g., HCl, ClO) resulting from degradation of chlorine-containing source gases (CFCs, HCFCs, VSLS), and natural inorganic chlorine sources (e.g., sea salt and other aerosols)
69	mole_fraction_of_hydroxyl_radical_in_air		OH	mole mole^{-1}	**T2Mz, T3I**	[6]
70	mole_fraction_of_hydroperoxyl_radical_in_air		HO2	mole mole^{-1}	**T2Mz, T3I**	[6]
71	mole_fraction_of_hydrogen_peroxide_in_air		H2O2	mole mole^{-1}	**T2Mz, T3I**	[7]
72	mole_fraction_of_molecular_hydrogen_in_air		H2	mole mole^{-1}	**T2Mz, T3I**	[6]
73	mole_fraction_of_atomic_nitrogen_in_air		N	mole mole^{-1}	**T2Mz, T3I**	[6]
74	mole_fraction_of_nitrogen_monoxide_in_air		NO	mole mole^{-1}	**T3M, T2Mz, T3I**	[6]
75	mole_fraction_of_nitrogen_dioxide_in_air		NO2	mole mole^{-1}	**T3M, T2Mz, T3I**	[6]
76	mole_fraction_of_nitric_acid_in_air		HNO3	mole mole^{-1}	**T2Mz, T3I**	[6]

77	mole_fraction_of_dinitrogen_pentoxide_in_air		N2O5	mole $mole^{-1}$	**T2Mz, T3I**	[6]
78	mole_fraction_of_peroxynitric_acid_in_air		HNO4	mole $mole^{-1}$	**T2Mz, T3I**	[6]
79	mole_fraction_of_total_reactive_nitrogen_in_air		NOy	mole $mole^{-1}$	**T2Mz, T3I**	[6] Total family (the sum of all appropriate species in the model); list the species in the netCDF header, e.g. NOy = N + NO + NO2 + NO3 + HNO3 + 2N2O5 + HNO4 + ClONO2 + BrONO2 Definition: Total reactive nitrogen; usually includes atomic nitrogen (N), nitric oxide (NO), NO2, nitrogen trioxide (NO3), dinitrogen radical (N2O5), nitric acid (HNO3), peroxynitric acid (HNO4), BrONO2, ClONO2
80	mole_fraction_of_atomic_bromine_in_air		Br	mole $mole^{-1}$	**T2Mz, T3I**	[6]
81	mole_fraction_of_bromine_monoxide_in_air		BrO	mole $mole^{-1}$	**T2Mz, T3I**	[6]
82	mole_fraction_of_bromine_chloride_in_air		BrCl	mole $mole^{-1}$	**T2Mz, T3I**	[6]
83	mole_fraction_of_hydrogen_bromide_in_air		HBr	mole $mole^{-1}$	**T2Mz, T3I**	[6]
84	mole_fraction_of_hypobromous_acid_in_air		HOBr	mole $mole^{-1}$	**T2Mz, T3I**	[6]
85	mole_fraction_of_bromine nitrate_in_air		BrONO2	mole $mole^{-1}$	**T2Mz, T3I**	[6]
86	mole_fraction_of_total_inorganic_bromine_in_air		Bry	mole $mole^{-1}$	**T2Mz, T3I**	[6] Total family (the sum of all appropriate species in the model) ; list the species in the netCDF header, e.g. Bry = Br + BrO + HOBr + HBr + BrONO2 + BrCl Definition: Total inorganic bromine (e.g., HBr and inorganic bromine oxides and radicals (e.g., BrO, atomic bromine (Br), bromine nitrate (BrONO2)) resulting from degradation of bromine-containing organicsource gases (halons, methyl bromide, VSLS), and natural inorganic bromine sources (e.g., volcanoes, sea salt, and other aerosols)
87	mole_fraction_of_formaldehyde_in_air		CH2O	mole $mole^{-1}$	**T2Mz, T3I**	[6]
88	mole_fraction_of_methyl_hydroperoxide_in_air		CH3OOH	mole $mole^{-1}$	**T2Mz, T3I**	[6]
89	mole_fraction_of_carbon_monoxide_in_air		CO	mole $mole^{-1}$	**T3M, T2Mz, T3I**	[7]
90	mole_fraction_of_carbon_dioxide_in_air		CO2	mole $mole^{-1}$	**T3M, T3I**	[7]
91	mole_fraction_of_ethane_in_air		C2H6	mole $mole^{-1}$	**T3I, T3M**	[6]
92	mole_fraction_of_ethyne_in_air	mole_fraction_of_acetylene_in_air	C2H2	mole $mole^{-1}$	**T3I, T3M**	[6]
93	mole_fraction_of_hydrogen cyanide_in_air		HCN	mole $mole^{-1}$	**T3I, T3M**	[6]
94	age_of_stratospheric_air	mean_age_of_stratospheric_air	mean_age	years	**T3M, T2Mz, T3I**	The mean age of air is defined as the mean time that a stratospheric air mass has been out of contact with the well-mixed troposphere.
95	northward_heat_flux_in_air_due_to_eddy_advection		vt100	MKS	**T1Ms**	Zonally averaged meridional heat flux at 100 hPa as monthly means derived from daily (or higher frequency) fields [4].

96	northward_eliassen_palm_flux_in_air		fy	MKS	**T2Mz**	*Transformed Eulerian Mean Diagnostics* [4] Meridional component *Fy* of **EP-flux (*Fy, Fz*)** derived from 6hr or higher frequency fields (use daily fields or 12 hr fields if the 6 hr are not available). Please use the definitions given by **equation 3.5.3a** of Andrews, Holton and Leovy text book.
97	upward_eliassen_palm_flux_in_air		fz	MKS	**T2Mz**	*Transformed Eulerian Mean Diagnostics* [4] Vertical component *Fz* of **EP-flux (*Fy, Fz*)** derived from 6hr or higher frequency fields (use daily fields or 12 hr fields if the 6 hr are not available). Please use the definitions given by **equation 3.5.3b** of Andrews, Holton and Leovy text book.
98	tendency_of_eastward_wind_due_to_eliassen_palm_flux_divergence		accel_divf	MKS	**T2Mz**	*Transformed Eulerian Mean Diagnostics* [4] **Acceleration from the EP-flux divergence (D)** derived from 6hr or higher frequency fields (use daily fields or 12 hr fields if the 6 hr data are not available). Please use the definitions given by the right hand side of **equation 3.5.2a** of Andrews, Holton and Leovy text book .
99	northward_transformed_eulerian_mean_air_velocity		vstar	MKS	**T2Mz**	*Transformed Eulerian Mean Diagnostics* [4] *v**, meridional component of the **residual meridional circulation *(v*, w*)*** derived from 6 hr or higher frequency data fields (use instantaneous daily fields or 12 hr fields if the 6 hr data are not available).
100	upward_transformed_eulerian_mean_air_velocity		wstar	MKS	**T2Mz**	*Transformed Eulerian Mean Diagnostics* [4] *w**, vertical component of the **residual meridional circulation *(v*, w*)*** derived from 6 hr or higher frequency data fields (use instantaneous daily fields or 12 hr fields if the 6 hr data are not available). Scale height: 6950 m
101	tendency_of_eastward_wind_due_to_gravity_wave_drag		accel_gw	MKS	**T2Mz**	**Eastward acceleration from the total (orographic + non-orographic) parameterized gravity wave drag (GWD)** derived either from daily means or 6hr fields (use instantaneous daily fields or 12 hr fields if the 6 hr data are not available). Use the accelerations as applied in your model.
102	tendency_of_eastward_wind_due_to_orographic_gravity_wave_drag		accel_ogw	MKS	**T2Mz**	**Eastward acceleration from the parameterized orographic gravity wave drag (OGWD)** derived either from daily means or 6hr fields (use instantaneous daily fields or 12 hr fields if the 6 hr data are not available). Use the accelerations as applied in your model.
103	upward_eastward_momentum_flux_in_air_due_to_orographic_gravity_waves		ogw_flux	MKS	**T2Mz**	**Zonal orographic gravity wave stress (momentum flux), including any flux out of the top of the model** (e.g., add additional level to the output file for model top. Set flux at this level to zero if nothing escapes to outer space in your model), derived either from daily means or 6hr fields (use instantaneous daily fields or 12 hr fields if the 6 hr data are not available).
104	tendency_of_eastward_wind_due_to_nonorographic_gravity_wave_drag		accel_nogw	MKS	**T2Mz**	**Eastward acceleration from the parameterized non-orographic gravity wave drag (NOGWD)** derived either from daily means or 6hr fields (use instantaneous daily fields or 12 hr fields if the 6 hr data are not available). Use the accelerations as applied in your model.
105	upward_eastward_momentum_flux_in_air_		nogw_w_flux	MKS	**T2Mz**	**Westward component of the zonal non-orographic gravity wave momentum flux**, including any flux out of the

	due_to_nonorographic_eastward_gravity_waves					top of the model (e.g., add additional level to the output file for model top. Set flux at this level to zero if nothing escapes to outer space in your model), derived either from daily means or 6hr fields (use instantaneous daily fields or 12 hr fields if the 6 hr data are not available).
106	upward_eastward_momentum_flux_in_air_due_to_nonorographic_westward_gravity_waves		nogw_e_flux	MKS	**T2Mz**	**Eastward component of the zonal non-orographic gravity wave momentum flux**, including any flux out of the top of the model (e.g., add additional level to the output file for model top. Set flux at this level to zero if nothing escapes to outer space in your model), derived either from daily means or 6hr fields (use instantaneous daily fields or 12 hr fields if the 6 hr data are not available).
107	tendency_of_eastward_wind_due_to_numerical_artefacts		diab_drag	MKS	**T2Mz**	**Other sub-grid scale/numerical zonal drag excluding that already provided for the parameterized orographic and non-orographic gravity waves.** This would be used to calculate the total "diabatic drag." Contributions to this additional drag such Rayleigh friction and diffusion that can be calculated from the monthly mean wind fields should not be included, but details (e.g. coefficients) of the friction and/or diffusion used in the model should be provided separately.
108	moles_of_nitrous_oxide_in_atmosphere	atmosphere_nitrous_oxide_mole_burden	burden_N2O	molecules	**T0As**	total yearly average burden
109	tendency_of_moles_of_nitrous_oxide_in_atmosphere	tendency_of_nitrous_oxide_mole_burden	tburden_N2O	molecules/yr	**T0As**	total yearly averaged atmospheric loss
110	moles_of_cfc11_in_atmosphere	atmosphere_cfc11_mole_burden	burden_CFCl3	molecules	**T0As**	total yearly average burden
111	tendency_of_moles_of_cfc11_in_atmosphere	tendency_of_atmosphere_cfc11_mole_burden	tburden_CFCl3	molecules/yr	**T0As**	total yearly averaged atmospheric loss
112	moles_of_cfc12_in_atmosphere	atmosphere_cfc12_mole_burden	burden_CF2Cl2	molecules	**T0As**	total yearly average burden
113	tendency_of_moles_of_cfc12_in_atmosphere	tendency_of_atmosphere_cfc12_mole_burden	tburden_CF2Cl2	molecules/yr	**T0As**	total yearly averaged atmospheric loss
114	moles_of_cfc113_in_atmosphere	atmosphere_cfc113_mole_burden	burden_CCl2FCClF2	molecules	**T0As**	total yearly average burden
115	tendency_of_moles_of_cfc113_in_atmosphere	tendency_of_atmosphere_cfc113_mole_burden	tburden_CCl2FCClF2	molecules/yr	**T0As**	total yearly averaged atmospheric loss
116	moles_of_cfc114_in_atmosphere	atmosphere_cfc114_mole_burden	burden_CClF2CClF2	molecules	**T0As**	total yearly average burden

117	tendency_of_moles_of_cfc114_in_atmosphere	tendency_of_atmosphere_cfc114_mole_burden	tburden_CClF2CClF2	molecules/yr	**T0As**	total yearly averaged atmospheric loss
118	moles_of_cfc115_in_atmosphere	atmosphere_cfc115_mole_burden	burden_CClF2CF3	molecules	**T0As**	total yearly average burden
119	tendency_of_moles_of_cfc115_in_atmosphere	tendency_of_atmosphere_cfc115_mole_burden	tburden_CClF2CF3	molecules/yr	**T0As**	total yearly averaged atmospheric loss
120	moles_of_ carbon_tetrachloride_in_atmosphere	atmosphere_carbon_tetrachloride_mole_burden	burden_CCl4	molecules	**T0As**	total yearly average burden
121	tendency_of_moles_of_carbon_tetrachloride_in_atmosphere	tendency_of_atmosphere_carbon_tetrachloride_mole_burden	tburden_CCl4	molecules/yr	**T0As**	total yearly averaged atmospheric loss
122	moles_of_halon1301_in_atmosphere	atmosphere_halon1301_mole_burden	burden_CBrF3	molecules	**T0As**	total yearly average burden
123	tendency_of_moles_of_halon1301_in_atmosphere	tendency_of_atmosphere_halon1301_mole_burden	tburden_CBrF3	molecules/yr	**T0As**	total yearly averaged atmospheric loss
124	moles_of_halon1211_in_atmosphere	atmosphere_halon1211_mole_burden	burden_CBrClF2	molecules	**T0As**	total yearly average burden
125	tendency_of_moles_of_halon1211_in_atmosphere	tendency_of_atmosphere_halon1211_mole_burden	tburden_CBrClF2	molecules/yr	**T0As**	total yearly averaged atmospheric loss
126	moles_of_halon2402_in_atmosphere	atmosphere_halon2402_mole_burden	burden_C2Br2F4	molecules	**T0As**	total yearly average burden
127	tendency_of_moles_of_halon2402_in_atmosphere	tendency_of_atmosphere_halon2402_mole_burden	tburden_C2Br2F4	molecules/yr	**T0As**	total yearly averaged atmospheric loss
128	moles_of_halon1202_in_atmosphere	atmosphere_halon1202_mole_burden	burden_CBr2F2	molecules	**T0As**	total yearly average burden
129	tendency_of_moles_of_halon1202_in_atmosphere	tendency_of_atmosphere_halon1202_mole_burden	tburden_CBr2F2	molecules/yr	**T0As**	total yearly averaged atmospheric loss
130	moles_of_methane_in_atmosphere	atmosphere_methane_mole_burden	burden_CH4	molecules	**T0As**	total yearly average burden
131	tendency_of_moles_of_methane_in_atmosp	tendency_of_atmos	tburden_CH4	molecules/yr	**T0As**	total yearly averaged atmospheric loss

	here	phere_methane_mole_burden				
132	tendency_of_moles_of_methane_in_troposphere	tendency_of_troposphere_methane_mole_burden	tburden_ltr_CH4	molecules/yr	**T0As**	total yearly averaged tropospheric loss
133	tendency_of_moles_of_methane_in_middle_atmosphere	tendency_of_middle_atmosphere_methane_mole_burden	tburden_sm_CH4	molecules/yr	**T0As**	total yearly averaged stratospheric and mesospheric loss
134	moles_of_carbon_monoxide_in_atmosphere	atmosphere_carbon_monoxide_mole_burden	burden_CO	molecules	**T0As**	total yearly average burden
135	tendency_of_moles_of_carbon_monoxide_in_atmosphere	tendency_of_atmosphere_carbon_monoxide_mole_burden	tburden_CO	molecules/yr	**T0As**	total yearly averaged atmospheric loss
136	tendency_of_moles_of_carbon_monoxide_in_troposphere	tendency_of_troposphere_carbon_monoxide_mole_burden	tburden_ltr_CO	molecules/yr	**T0As**	total yearly averaged tropospheric loss
137	tendency_of_moles_of_carbon_monoxide_in_middle_atmosphere	tendency_of_middle_atmosphere_carbon_monoxide_mole_burden	tburden_lsm_CO	molecules/yr	**T0As**	total yearly averaged stratospheric and mesospheric loss
138	moles_of_molecular_hydrogen_in_atmosphere	atmosphere_molecular_hydrogen_mole_burden	burden_H2	molecules	**T0As**	total yearly average burden
139	tendency_of_moles_of_molecular_hydrogen_in_atmosphere	tendency_of_atmosphere_molecular_hydrogen_mole_burden	tburden_H2	molecules/yr	**T0As**	total yearly averaged atmospheric loss
140	tendency_of_moles_of_molecular_hydrogen_in_troposphere	tendency_of_troposphere_molecular_hydrogen_mole_burden	tburden_ltr_H2	molecules/yr	**T0As**	total yearly averaged tropospheric loss
141	tendency_of_moles_of_molecular_hydrogen_in_middle_atmosphere	tendency_of_middle_atmosphere_molecular_hydrogen_mole_burden	tburden_lsm_H2	molecules/yr	**T0As**	total yearly averaged stratospheric and mesospheric loss
142	moles_of_methyl_chloride_in_atmosphere	atmosphere_methyl_chloride_mole_bur	burden_CH3Cl	molecules	**T0As**	total yearly average burden

		den				
143	tendency_of_moles_of_methyl_chloride_in_atmosphere	tendency_of_atmosphere_methyl_chloride_mole_burden	tburden_CH3Cl	molecules/yr	**T0As**	total yearly averaged atmospheric loss
144	tendency_of_moles_of_methyl_chloride_in_troposphere	tendency_of_troposphere_methyl_chloride_mole_burden	tburden_ltr_CH3Cl	molecules/yr	**T0As**	total yearly averaged tropospheric loss
145	tendency_of_moles_of_methyl_chloride_in_middle_atmosphere	tendency_of_middle_atmosphere_methyl_chloride_mole_burden	tburden_lsm_CH3Cl	molecules/yr	**T0As**	total yearly averaged stratospheric and mesospheric loss
146	moles_of_ methyl_bromide_in_atmosphere	atmosphere_methyl_bromide_mole_burden	burden_CH3Br	molecules	**T0As**	total yearly average burden
147	tendency_of_moles_of_methyl_bromide_in_atmosphere	tendency_of_atmosphere_methyl_bromide_mole_burden	tburden_CH3Br	molecules/yr	**T0As**	total yearly averaged atmospheric loss
148	tendency_of_moles_of_methyl_bromide_in_troposphere	tendency_of_troposphere_methyl_bromide_mole_burden	tburden_ltr_CH3Br	molecules/yr	**T0As**	total yearly averaged tropospheric loss
149	tendency_of_moles_of_methyl_bromide_in_middle_atmosphere	tendency_of_middle_atmosphere_methyl_bromide_burden	tburden_lsm_CH3Br	molecules/yr	**T0As**	total yearly averaged stratospheric and mesospheric loss
150	moles_of_hcc140a_in_atmosphere	atmosphere_hcc140a_mole_burden	burden_CH3CCl3	molecules	**T0As**	total yearly average burden
151	tendency_of_moles_of_hcc140a_in_atmosphere	tendency_of_atmosphere_atmosphere_hcc140a_mole_burden	tburden_CH3CCl3	molecules/yr	**T0As**	total yearly averaged atmospheric loss
152	tendency_of_moles_of_hcc140a_in_troposphere	tendency_of_troposphere_hcc140a_mole_burden	tburden_ltr_CH3CCl3	molecules/yr	**T0As**	total yearly averaged tropospheric loss
153	tendency_of_moles_of_hcc140a_in_middle_atmosphere	tendency_of_middle_atmosphere_hcc140a_mole_burden	tburden_lsm_CH3CCl3	molecules/yr	**T0As**	total yearly averaged stratospheric and mesospheric loss
154	moles_of_hcfc22_in_atmosphere	atmosphere_hcfc22_mole_burden	burden_CHClF2	molecules	**T0As**	total yearly average burden
155	tendency_of_moles_of_hcfc22_in_atmosph	tendency_of_atmos	tburden_CHClF2	molecules/yr	**T0As**	total yearly averaged atmospheric loss

	ere	phere_hcfc22_mole_burden				
156	tendency_of_moles_of_hcfc22_in_troposphere	tendency_of_troposphere_hcfc22_mole_burden	tburden_ltr_CHClF2	molecules/yr	**T0As**	total yearly averaged tropospheric loss
157		particle_surface_area_density_of_sulfate_aerosol	sad_sulf	m^{-1}	**T3I**	[6] sulfate aerosol surface area density used in heterogeneous activation of ClOx and BrOx. Defined as the area of aerosol per volume of atmosphere (i.e., $m^2\ m^{-3} = m^{-1}$). This is the total sulfate SAD (i.e., sum of binary and ternary aerosol).
158		particle_surface_area_density_of_nitric_acid_trihydate	sad_nat	m^{-1}	**T3I**	[6] nitric acid trihydrate (NAT) surface area density used in heterogeneous activation of ClOx and BrOx. Defined as the area of aerosol per volume of atmosphere (i.e., $m^2\ m^{-3} = m^{-1}$).
159		particle_surface_area density of water_ice	sad_ice	m^{-1}	**T3I**	[6] water-ice surface area density used in heterogeneous activation of ClOx and BrOx. Defined as the area of aerosol per volume of atmosphere (i.e., $m^2\ m^{-3} = m^{-1}$).
160		arctic_area_integral_of_polar_stratospheric_cloud_area_fraction	psca_nh50	m^2	**T0I**	[6] Daily PSC Area that is calculated by the model's PSC scheme poleward of 60° at 50 hPa for Nov-April in NH
161		antarctic_area_integral_of_polar_stratospheric_cloud_area_fraction	psca_sh50	m^2	**T0I**	[6] Daily PSC Area that is calculated by the model's PSC scheme poleward of 60° at 50 hPa for July-Dec in SH
162		arctic_area_where_air_temperature_less_than_188K	area188K_nh50	m^2	**T0I**	[6] Daily Area where the Temperature poleward of 60° is below 188 K at 50 hPa for Nov-April in NH
163		arctic_area_where_air_temperature_less_than_195K	area195K_nh50	m^2	**T0I**	[6] Daily Area where the Temperature poleward of 60° is below 195 K at 50 hPa for Nov-April in NH
164		antarctic_area_where_air_temperature_less_than_188K	area188K_sh50	m^2	**T0I**	[6] Daily Area where the Temperature poleward of 60° is below 188 K at 50 hPa for July-Dec in SH
165		antarctic_area_where_air_temperature_less_than_195K	area195K_sh50	m^2	**T0I**	[6] Daily Area where the Temperature poleward of 60° is below 195 K at 50 hPa for July-Dec in SH
166		mole_fraction_of_passive_ozone_in_air	O3s	mole $mole^{-1}$	**T3I**	Passive O3 (if available): The model runs should include a tracer to diagnose polar chemical ozone loss in winter and spring. As most models will advect (and integrate) O3 as part of the 'odd oxygen' (Ox=O3 + O(3P) + O(1D)) family we will call this the 'passive Ox tracer'. This will be a global tracer which is reset during each polar winter (i.e. twice per

						year). Given the relatively slow transport and long chemical lifetime (without PSC processing etc) of O3 in the polar regions this will provide a useful diagnostic over the timescale of a few months in the lower stratosphere. The model tracer should be set equal to your advected 'odd oxygen' tracer on December 1 and June 1 every year. Then, the tracer is simply advected without any further chemical change. If your advection scheme stores other variables for each tracer (e.g. higher order moments) remember to set these equal to that of the chemically integrated Ox tracer too. If your model advects members of the Ox family separately, then we suggest you set the passive Ox tracer equal to the sum of these species. The passive Ox tracer should be ouput according to the other instructions. The re-initialisation dates are selected so that we diagnose most of the chemical loss over the course of the winter, some of which would be missed by a later date. [6,7]