INSTRUCTIONS FOR THE CONTRIBUTION OF EMIC MODEL RESULTS TO THE FIFTH ASSESSMENT REPORT OF IPCC WORKING GROUP 1 (Chapter 12)

Contact Information

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1. Documentation

Describe your model in one paragraph, addressing the different climate system components it includes (for example: dynamic vegetation or ocean sediments). Also provide information according to the entries of Table 8.3 (page 646) of the Fourth Assessment Report of IPCC with the addition of an extra column for ocean sediments:

http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-chapter8.pdf

Please see Plattner et al. (2008) for some sample model descriptions.

Plattner, G.-K, R. Knutti, F. Joos, T. F. Stocker, W. von Bloh, V. Brovkin, D. Cameron, E. Driesschaert, S. Dutkiewicz, M. Eby, N. R. Edwards, T. Fichefet, J. C. Hargreaves, C. D. Jones, M. F. Loutre, H. D. Matthews, A. Mouchet, S. A. Mueller, S. Nawrath, A. Price, A. Sokolov, K. M. Strassmann, and A. J. Weaver, 2008: Long-term climate commitments projected with climate - carbon cycle models, *Journal of Climate*, **21**, 2721-2751.

2. Required

Please provide references to papers in refereed journals that describe the model set up and characteristics.

3. Control Simulation

In order to quantify climate drift, we require a control run from all models with atmospheric CO_2 forcing held constant at 280 ppm, with an integration time of 1005 years. Please provide all output as specified in section 9 below. An optional additional control simulation for models with an active coupled carbon cycle is requested in which only non-anthropogenic forcing is applied. Carbon dioxide is then left to freely evolve in response to natural climate forcing.

4. Historical Simulations

Initialize with an equilibrium spin up at year January 1, 850 AD. Undertake a suite of 1156-year simulations until December 31, 2005 AD using the forcing provided at:

http://climate.uvic.ca/EMICAR5/forcing.html

The simulations over the last millennium will follow the PMIP3/CMIP5 protocol. Further details are available from Schmidt et al. (2010) and:

https://pmip3.lsce.ipsl.fr/wiki/doku.php/pmip3:design:lm:final

Each simulation will apply changes in only one forcing component at a time. An additional simulation will include all forcings varying simultaneously. The difference between the “TOTAL” forcing simulation (TOT in Figure 1) and the sum of the individual forcing simulations will indicate the extent to which global mean surface air temperature response is linear. This will be examined for each model.

Anthropogenic Forcing	Fig. 1	Natural Forcing	Fig. 1
Carbon Dioxide	CO2	Carbon Dioxide (preindustrial)	CO2
Additional Greenhouse Gases	AGG	Additional Greenhouse gases (preindustrial)	AGG
Land Use Changes	LND	Solar	SOL
Sulphate Aerosols	SUL	Volcanic	VOL
		Orbital	ORB

Table 1: Individual forcing for the 1000 year historical simulations. The column Fig. 1 refers to the curve in Figure 1.

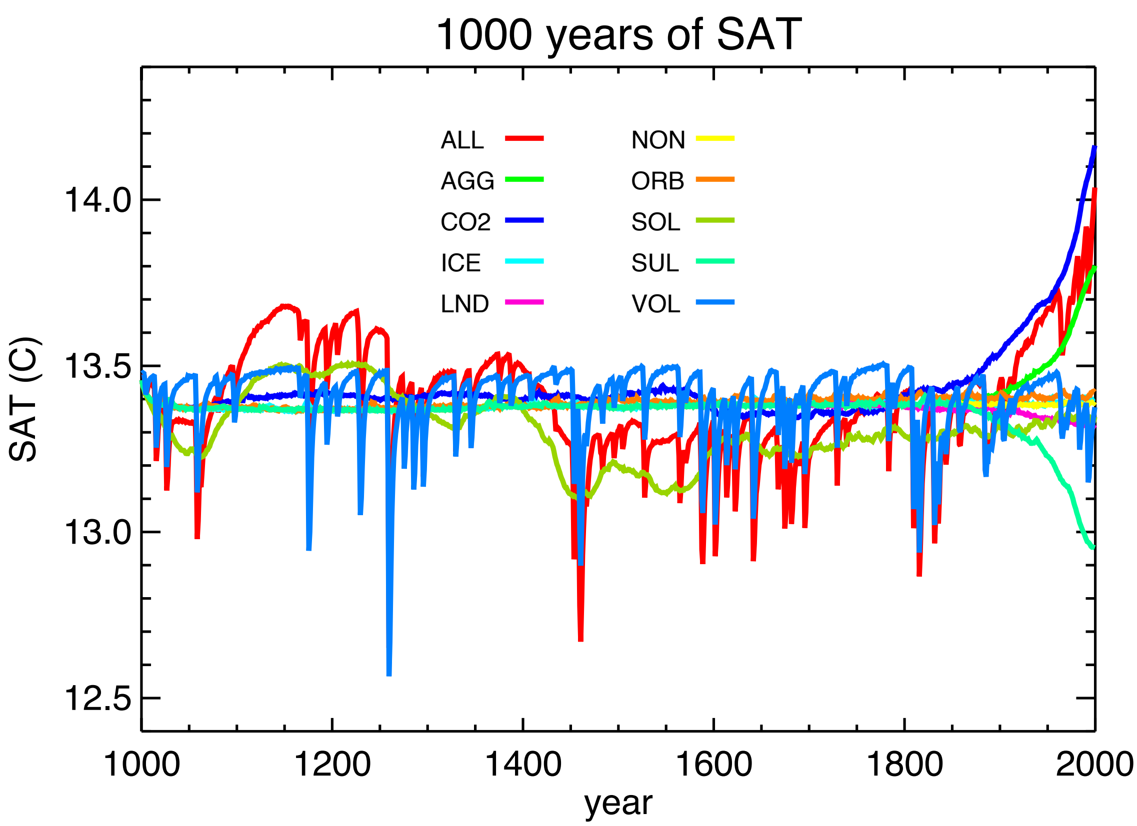

Figure 1: Example of a1000 year historical simulation from the UVic ESCM. The TOT curve is the annually-averaged global mean surface air temperature (SAT) arising from an experiment driven by changes in all forcing. The NON curve represents the control experiment of section 3. Each of the other curves shows the annually-averaged global mean SAT response when the UVIc model is forced by changes in only one component of the radiative forcing (see Table 1 for definitions).

Schmidt, G.A., J. H. Jungclaus, C. M. Ammann, E. Bard, P. Braconnot, T. J. Crowley, G. Delaygue, F. Joos, N. A. Krivova, R. Muscheler, B. L. Otto-Bliesner, J. Pongratz, D. T. Shindell, S. K. Solanki, F. Steinhilber, and L. E. A. Vieira, 2010: Climate forcing reconstructions for use in PMIP simulations of the last millennium (v1.0). *Geosci. Model Dev. Discuss.*, **3**, 1549-1586.

5. Representative Concentration Pathways

Representative Concentration Pathways (RCPs) have been designed to provide radiative forcing data for modelling groups wishing to contribute to the IPCC AR5. Information on the RCPs is available at:

http://www.iiasa.ac.at/web-apps/tnt/RcpDb/dsd?Action=htmlpage&page=about

The Coupled Modelling Intercomparison Project (CMIP) have taken the RCP data and designed a suite of experiments for the CMIP5 project. See Taylor et al. (2009) for details.

Taylor, K. E., R. J. Stouffer and G. A. Meehl, 2009: A Summary of the CMIP5 Experiment Design, http://www-pcmdi.llnl.gov/

Contributing EMICs are asked to undertake the following experiments.

5.1 RCP extensions – CO_2 concentration commitment

Starting from the year 2005 initial condition obtained using TOT forcing in **4** above, each of the four RCPs together with their extensions are to be carried our to year 2300. The atmospheric CO_2 concentration is to be specified and all other greenhouse gas and aerosol forcing are to be included as radiative forcing following RCP specifications. EMICs with a carbon cycle will diagnose implied emissions. From 2300-3000 radiative forcing and atmospheric CO_2 concentration will remain constant at their 2300 values.

a. RCP2.6 2006-3000

b. RCP4.5 2006-3000

c. RCP6 2006-3000

d. RCP8.5 2006-3000

5.2 RCP extensions – CO_2 emissions commitment

These experiments are the same as in 5.1 up to year 2300. Implied CO_2 emissions over the last decade of the RCP integrations (years 2290-2300) are diagnosed. These emissions are then held fixed from 2300 onwards. Radiative forcing for other greenhouse gases and aerosols are also remained fixed at 2300.

5.3 RCP extensions – CO_2 climate commitment

These experiments are the same as in 5.1 up to year 2300. Implied CO_2 emissions over the last decade of the RCP integrations (years 2290-2300) are diagnosed. Implied CO_2 emissions are also determined from years 1840-1850 of the historical TOTAL simulation. The difference between these two diagnosed emissions is termed the “anthropogenic perturbation”. At 2300 the anthropogenic perturbation is set to zero. This means that CO_2

emissions are set to the 1840-1850 diagnosed values. Radiative forcing for other greenhouse gases and aerosols are also held fixed at 2300.

5.4 RCP extensions – Climate commitment

These experiments are the same as in 5.3 except that at year 2300, the radiative forcing for other anthropogenic greenhouse gases and aerosols is also set to 1840-1850 average levels.

6. Idealized experiment to 2 x CO2 and atmospheric lifetime

Starting from the end of the preindustrial control run of **3**, impose an instantaneous (i.e. within a single timestep) increase of atmospheric CO_2 to 560 ppmv and hold it fixed.

7. Idealized experiment to 4 x CO2 and atmospheric lifetime

Each of the following experiments are 1000 years long and start from the end of the preindustrial control run of **3**. Experiments e and f are designed to understand carbon cycle / climate feedbacks.

a. Impose an instantaneous increase of atmospheric CO_2 to 1120 ppmv and hold it fixed.

b. Instantaneously increase the atmospheric CO_2 concentration to 1120 ppmv and allow it to evolve.

c. Increase CO_2 at 1 % per year 4 x CO_2 (1120 ppmv) is reached. Diagnose emissions over the last year and hold fixed thereafter. We will compute the Transient Climate Response (TCR) at 2 x CO2 (from year 70) and 4 x CO2 from this model output (from year 140).

d. Increase CO_2 at 1 % per year 4 x CO_2 is reached. Then let atmospheric CO_2 evolve freely.

e. Repeat c but the radiation code sees atmospheric CO_2 fixed at 280 ppm.

f. Repeat c but only the radiation code sees the increasing atmospheric CO_2

8. Allowable cumulative emissions

For these simulations, only EMICs coupled to a dynamic carbon cycle component are appropriate. As an additional requirement, the carbon cycle component must also be published in the refereed literature and references (and pdfs) need to be provided with the model description (see section 2).

Allowable cumulative emissions of carbon dioxide are to be computed for four temperature stabilization profiles (Figure 2). The methodology of Zickfeld et al. (2009) will be followed for this intercomparison. This will involve the implementation of “temperature tracking” as described in the Materials and Methods section of Zickfeld et al. (2009). Simple sample code detailing how this is done has been made available at:

http://climate.uvic.ca/EMICAR5/

The temperature tracking procedure will likely need to be calibrated for each EMIC. Please see sample EMIC calibration curves in Figure 3 (which should be submitted separately).

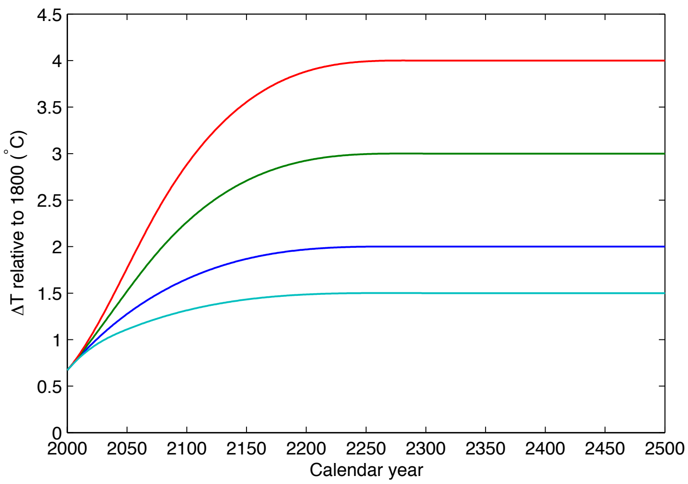

Figure 2: Temperature stabilization profiles for 1.5°, 2°, 3° and 4°C.

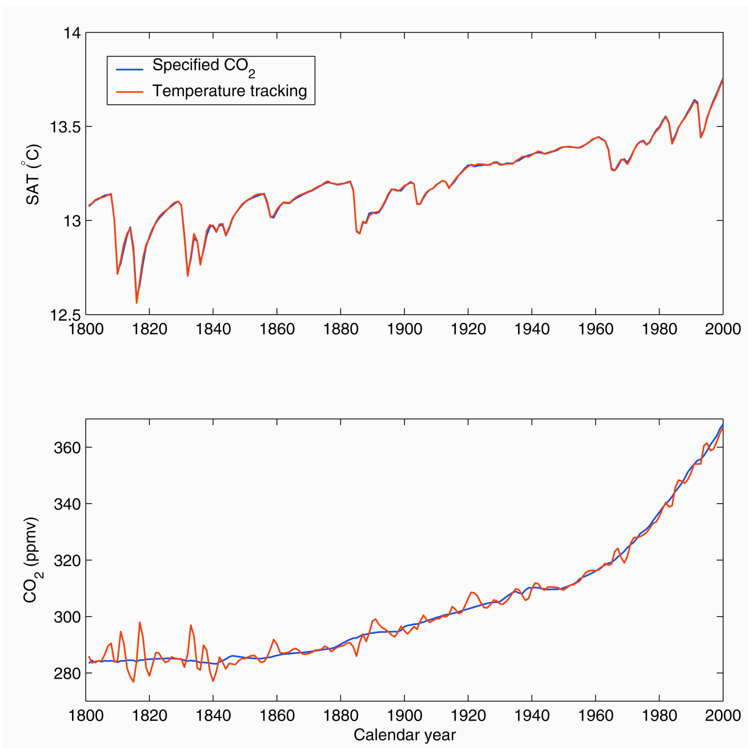

Figure 3: Validation of temperature tracking procedure over the historical period 1800-2000. Top: globally-averaged surface air temperature. Bottom: atmospheric CO_2 concentration. The blue curve indicates a specified CO_2 experiment. The red curve indicates a specified temperature experiment.

Zickfeld, K., M. Eby, H.D. Matthews and A.J. Weaver, 2009: Setting cumulative emissions targets to reduce the risk of dangerous climate change. *Proceedings of the National Academy of Sciences*, **38**, 16129-16134.

9. Output Variables

Please only provide global mean averages of quantities, with the exception of Atlantic meridional overturning circulation (MOC) and zonally-averaged surface air temperature. All variables are given as annual mean values over the length of the entire integration. Data spacing for submission is 1 year, only. By annual mean of year 2013 we mean the average from 1.1.2013 to 31.12.2013 (see also section 10.3 for an example).

0) Time in years AD
1) Global mean surface air temperature in °C
2) Globally integrated ocean heat uptake in Joule
3) Radiative Forcing in W/m^2
4) Global sea level rise in meters due to thermal expansion only. Thermal expansion is to be calculated from in situ density that depends on in situ temperature, salinity, and pressure.
5) Atlantic meridional overturning circulation in Sverdrups, defined as the maximum of the annual mean of the Atlantic meridional overturning, north of the equator and below 500 m depth.
6) Diagnosed or specified emissions in Petagrams C per year.
7) pCO2 (atmosphere, in ppmv)
8) Total carbon inventory in model system (Pg C). If sediments and weathering are included, the net change in carbon inventory from the spinup due to these components should be added rather than the total inventory.
9) Total carbon inventory of the ocean in Pg C
10) Total carbon inventory on land (litter + soils + vegetation) in Pg C

10. Output Convention

Output is requested in ASCII format only.

10.1 comment lines

The first lines include all the comments. Each comment line starts with the hash sign #

The very first line provides the number of comment lines that precede the data (e.g. # 6).

In the remaining comment lines please provide:

a. Name, address, e-mail, phone, fax of contact person

b. Explanation of the model, model references and other comments should be included. In the explanation please include the conversion your model uses between ppmv and GtC. This is important since models have slightly different atmospheric volumes. CDIAC suggests this conversion should be approximately 2.13. Comments must include:

(1) Model Name and Version

(2) Run Name / Run Type

(3) Summary description of run including its duration

(4) Date of production/submission

c. The last few comment lines hold headers with the variable names and units

10.2 Data

Annual mean data are provided after the comment lines in ascending years. All annual mean data are to be calculated by averaging over the time period January 1-December 31. The last columns are for EMICs including a carbon cycle component.

Missing values should be flagged using the number -0.999E99 as flag values.

Sufficient digits should be provided to allow for the calculation of the first derivative (e.g., ocean heat uptake from ocean heat content)

Data must be provided in the units indicated below

The arrangement of columns should be as indicated below. If a variable is not calculated, please fill the column with flags

10.3 Example

6

In this example the first 6 lines are comment lines The first

line is followed by 5 comment lines The last two comment lines

indicate variable names and units

year radforcing Tair HEATocean(anomaly) RISE MOC EMISSIONS pCO2 CARBONtotal CARBONocean CARBONland

(year) (Wm2) (degree C) (Joule) (meters) (Sverdrup) (PgC) (ppmv) (PgC) (PgC) (PgC)

2020. 7.390 2.345 2.452E22 0.221 0.999E99 10.500 12.52 41258. 425.3 38.5

2021. 7.391 2.567 2.472E22 0.235 -0.999E99 10.501 11.73 41265. 430.2 40.8

10.4 Zonal-averaged surface air temperature

In order to look at the polar amplification between EMICs we require an additional file that contains annual- and zonal-averaged surface air temperature from Experiment 7c at years 0, 70 and 140. Please submit the data in the following format:

Year (0, 70 or 140), Latitude (Degrees), zonal-averaged annual mean SAT (°C)

11. Time Line

Submissions of results, including relevant references and descriptions of the model used should be completed by July 1 2011. You will be able to submit your results through the internet on a dedicated ftp site located at:

http://climate.uvic.ca/EMICAR5/submitdata.html