Protocol for TransCom continuous data experiment

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Version 6.0: This version updates ftp information to reflect the site move to Purdue University and includes a small number of corrections noted while running the experiments.

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1. Aim of experiment

The focus of TransCom 3 was the inversion of monthly mean CO_2 observations to estimate monthly sources and sinks of CO_2. There is presently much interest in incorporating continuous (hourly or daily) CO_2 into inversions, as well as using individual flask measurements at their sampling times. This development assumes that transport models are able to adequately simulate CO_2 concentrations at diurnal and synoptic timescales. This experiment aims to assess this ability by comparing forward simulations with prescribed surface fluxes at a range of locations. The surface fluxes include representations of fossil, oceanic and biospheric CO_2 fluxes, with the biospheric fluxes being input on a variety of timescales. SF_6 and radon will also be simulated to provide additional diagnostics of transport behaviour.

The major output of the experiment is hourly concentration timeseries at a large number of current and potential observing sites. Multiple model level data and meteorological forcing data will be output for a subset of sites where continuous observations are available for 2002/2003.

2. Simulations required

A three-year forward model simulation of 9 tracers is required (Table 1).

Tracer name	Description	Flux time resolution
SiB	SiB biosphere model fluxes for 2002/2003	hourly
SiB_day	SiB model daily average fluxes	daily
SiB_mon	SiB model monthly average fluxes	monthly
CASA	CASA biosphere fluxes with diurnal cycle	3 hourly
CASA_mon	CASA monthly fluxes	monthly
SF6	SF6 emissions	constant
radon	Radon emissions	constant
fossil98	Fossil emissions for 1998	constant
Taka02	Takahashi ocean fluxes, 2002 compilation	monthly

Table 1: List of tracers

The transport model should be run using analysed meteorology if possible, for the years 2000-2003. Simulations using GCM winds may be submitted but analysis of these data will be limited to such variables as average diurnal cycles. Simulations should begin on 1 January 2000 with output submitted for 1 January 2002, 1Z to 1 January 2004, 0Z.

Simulations should be run from an initial background concentration of zero everywhere in the atmosphere. If your model is unable to run from a background of zero, please subtract your initial concentration from all data before submitting your results.

The output required is hourly concentration timeseries at 280 sites. In addition, at a subset of 100 sites, we require hourly concentration timeseries for all model levels up to 500 hPa and hourly surface flux timeseries. For this subset of sites we would also like to save model meteorological data at hourly resolution: pressure, u and v component winds at all levels to about 500 hPa and surface pressure, cloud cover, and boundary layer height.

3. Input files and sample code

Input files and sample code can be downloaded using ftp.

```
sftp continuous@ftp-kg01.eas.purdue.edu
Password: vi9xp3N
```

The surface flux files are in the sub-directory 'inputfiles', 'inputfiles/CASA_fluxes' and 'inputfiles/SiB_fluxes'.

```
sftp> cd inputfiles
sftp> binary
sftp> prompt
sftp> mget *.nc
```

The 'inputfiles' directory also contains the site lists (ascii files, 'allsite.list', 'contsite.list', 'allsite.list.new' and 'contsite.list.new'). See section 5 for more details.

Sample code is contained in the sub-directory 'samplecode'. The code is written in fortran 90 and requires modelers to add sections as applicable for their model.

3.1 File format

All input files are in netCDF format. The spatial resolution is 1ºx1º for CASA 3hour and SiB fluxes and 0.5ºx0.5º for all other fluxes. The latitudes and longitudes are listed in the netcdf file and represent the mid-point of the grid-cell for which the flux is applicable. Longitudes are ordered from west to east starting from the dateline and latitudes from south to north. The temporal resolution varies between the fluxes. Use the given fields as mid-interval values and then 'connect-the-dots' by linear interpolation. This will cause your monthly totals to deviate from the mid-month values in this document, but not by much. For fields used every year glue a December to the start of the series and a January to the end for interpolation of 1-15 January and 15-31 December.

In general we recommend linear interpolation of the fluxes in time. However if your model routinely uses a different interpolation you may use your standard model procedure but please indicate what this is in the model information file (see sec 6.4).

3.1.1 Constant fluxes

The fossil98, and radon fluxes are constant in time. Use the same flux repeatedly for every timestep in your model.

3.1.2 Annual fluxes

The SF_6 fluxes have a different magnitude for each year but the same spatial distribution from year to year. Scale the sources to give linear changes between the global source totals for each year, taking these as applicable to the middle of the year (day 182.5).

3.1.3 Monthly fluxes

The SiB_mon, CASA_mon and Taka02 fluxes have monthly resolution. The fluxes should be taken as applicable for the middle of the month. Linear interpolation should be used between mid-months for each model timestep.

3.1.4 Daily fluxes

The SiB_day fluxes have daily resolution. Take these as applicable to 12:00Z and use linear interpolation to determine the fluxes at each timestep.

3.1.4 Three-hourly/hourly fluxes

The SiB and CASA fluxes have hourly and three-hourly resolution respectively. The CASA fluxes are representative of the flux for a 3-hour period. Take the first flux value as applicable for 01:30Z on Jan 1. The SiB fluxes are means of the full hour, i.e. the first field is applicable for 00:30Z on Jan 1. If possible we would like the fluxes to be linearly interpolated from the mid-point values to the model timestep. The SIB fluxes on the FTP server are compressed to represent only landpoints, Ian Baker (CSU) has provided a very nice routine to unpack these files and place them on 1x1 degree resolution. See the directory inputfiles/SiB_fluxes and the enclosed README and fortran90 routine (sib_process_flux.f90) for details.

3.1.5 Units

All fluxes are in mol m^{-2} s^{-1}. Positive fluxes indicate tracer going into the atmosphere.

3.2 Regridding

The surface fluxes need to be aggregated to your model grid. By providing most fluxes at the same resolution as was used in TransCom3, you may find that your previous regridding code is applicable.

3.2.1 Land-sea boundaries

Many models used a fixed land/ocean mask where each grid-cell is defined as either land or ocean. Wherever possible we would like to keep land fluxes within model grid-cells that are defined as land and ocean fluxes within ocean grid-cells. To do this we recommend that you follow the method used in the TransCom3 protocol (section D1). The steps involved are:

1. Allocate all the 0.5º grid-cell fluxes to their appropriate model grid-cell.
2. Check for fluxes that are in grid-cells of the wrong surface type.
3. For each of these fluxes, reallocate the flux to any neighbouring grid-cells that are of the correct surface type. Reallocate based on the magnitude of the flux in the neighbouring cells, for example if 80% of the neighbouring flux is in the grid-cell to the north then put 80% of the flux to be reallocated into that grid-cell. This local redistribution is important for fluxes that have large emissions near the coast. If there are no neighbouring grid-cells of the correct surface type (e.g. for some small islands) then do not reallocate but just set the flux to zero.
4. Re-scale all fluxes to maintain the global total source.

For models that use a fractional land area in each grid-cell, please adapt the above procedure as you feel is appropriate for your model. For example, it may be appropriate to reallocate land fluxes that occur in grid-cells where the land fraction is less than 0.2.

The local reallocation of fluxes should be applied to all the input fields except radon. See section 4 for information on the radon flux.

Updated recommendation: Very few, if any, current submissions included local redistribution of the flux, so we now recommend ignoring step 3 above. Maintain land/ocean boundaries if possible but only by 'losing' fluxes from grids of the wrong surface type and rescaling the global total flux.

3.2.2 Global totals

Since we will be comparing the third and fourth years of the model simulations, it is important to ensure that the same global flux is input to each model. Therefore as a final step in regridding the fluxes, please rescale all values to give the same integrated global source as given by the 0.5º or 1º fluxes. For the annual and monthly sources, the global totals are given in the input file and are also listed here. For the daily and 3-hour sources, please integrate the source yourself for each timestep. This is probably best done as part of your regridding process.

Tracer	Month/Year	Global source (mol s^{-1})
SiB monthly NEP	January 02/03	23432715./32105043.
	February 02/03	21098292./29025671.
	March 02/03	5799011.2/9496273.0
	April 02/03	-9986536.7/-8700452.6
	May 02/03	-39889033./-34102149.
	June 02/03	-72406873./-67337732.
	July 02/03	-59515345./-75716714.
	August 02/03	-23375500./-19062206.
	September 02/03	18241257./19098373.
	October 02/03	47559435./37665581.
	November 02/03	46105530./40868258.
	December 02/03	44396668./38950553.
CASA monthly NEP	January	20019554.
	February	28671174.
	March	17428634.
	April	21433835.
	May	-12187641.
	June	-51797639.
	July	-62356448.
	August	-31777397.
	September	15349954.
	October	21555809.
	November	19914362.
	December	16673356.
SF_6	1999	1.098597
	2000	1.090556
	2001	1.076233
	2002	1.197818
	2003	1.260990
Fossil 98		1.743986e+07
Takahashi 02	January	-5212802
	February	-4848461
	March	-4237052

	April	-4069563
	May	-3317401
	June	-2873655
	July	-1742760
	August	-2378186
	September	-4121866
	October	-5474817
	November	-6500273
	December	-7214694
Radon	All years	2.2E-6

Table 2: Integrated emissions in mol s^{-1}.

4. Radon emissions and decay

Construct your own radon emission distribution based on the surface type in each grid-cell and the fluxes in Table 3. For models with a defined land fraction, use the appropriate proportion of land and ocean emissions. We do not want the emission field to be rescaled to match a global total source but you should check that you produce a global radon source of approximately 2.2E-6 mol/s.

Surface type	Latitude range	Flux (mol m^{-2} s^{-1})
Land and ocean	70º-90ºN, 70º-90ºS	0.
Land and ocean	60º-70ºN, 60º-70ºS	8.30e-23
Land	60ºS-60ºN	1.66e-20
Ocean	60ºS-60ºN	8.30e-23

Table 3: Radon fluxes

Radon decays in the atmosphere with a half-life of 3.8 days. At each model timestep, apply the following

```
Rn(i,j,k) = exp(-dtime*2.11e-6)*Rn(i,j,k)
```

where `Rn` is the radon mixing ratio at all gridpoints and `dtime` is the model timestep in seconds.

5. Site lists

Two site lists have been provided in the 'inputfiles' directory (and are also attached as Appendix 1 and 2). Hourly tracer concentration is the required output for the larger site list (allsite.list) while a more detailed set of output (see section 6) is required for a subset of sites (contsite.list). Note that a small number of sites are in 'contsite.list' but not in 'allsite.list'.

There are also some redundant points in 'contsite.list' where sites have different names but the same latitude and longitude. Please submit data for the full list despite this. In November 2005, we found that the longitude for site 'CCLaG' in both lists was incorrect. The corrected versions are files 'allsite.list.new' and 'contsite.list.new'. The longitude, latitude and altitude of each site are given. In most cases you are free to choose whether you submit data for the nearest model gridpoint and model level to the site location or whether you interpolate between gridpoints and/or levels.
The fifth column of the site list indicates whether the sampled grid-point should be land or ocean. Please check that the surface type of your output gridpoint agrees with the requested surface types. For coastal sites, data should be submitted for both the nearest land gridpoint and the nearest ocean gridpoint. For models with fractional land area in a grid-cell, use 50% as a cut-off as to whether the grid-cell is considered to be ocean or land.
The final column in the site list indicates whether the altitude given is the meters above mean sea level (masl) indicated by a 0 in the column, or meters above the ground (mag) indicated by a 1. This may help you to determine what model level to sample to best represent the site given your model vertical resolution and topography.

6. Output files

All output should be submitted in netcdf format. Single precision should suffice for our purposes. Three example fortran files have been provided for the three different types of output. The example code is currently set up assuming that it would be used to post-process your model output. If, instead, you wished to incorporate it within your model code, then it might be more applicable to make the time dimension in the netcdf file 'unlimited' so that the netcdf file is added to each hour. The sample code is available on the ftp site in the sub-directory 'samplecode'. Please use the following dimension names: 'site', 'tracer', 'lev', 'time', 'len', as in the samplecode. Please submit separate files for the years 2002 and 2003. We strongly recommend using the samplecode to ensure that all submitted files are consistent in format.

6.1 Tracer concentration timeseries at all sites (write_alltracer.f)

Filename: all.your_model.your_institution.year.nc e.g. all.CCAM.CSIRO.2002.nc
Dataset names: 'latitude', 'longitude', 'level', 'land', 'time', 'site_name', 'tracer_name', 'conc'.
Contents: Four arrays with location information that you will need to provide, time, site name and tracer name arrays that are generated by the example code and the tracer concentration array. In each array the sites should be ordered as given in the site list files.
Longitude: One value per site. Give the longitude of the model grid point that you sampled for this site or the real longitude if you interpolated between gridpoints.
Latitude: One value per site. Give the latitude of the model grid point that you sampled for this site or the real latitude if you interpolated between grid points.
Level: One value per site. Give the number of the model level that you sampled for this site (counting the model levels from the surface upwards). If you interpolated between model levels give the model level as a decimal, for example use 1.3 to represent level_1*0.7+level_2*0.3. If the interpolation changed in time, give an average value.
Land: One value per site. Give the surface type of the sampled grid point using 0 for ocean and 1 for land. If you model has fractional land then give the appropriate value between 0 and 1.
Concentration: A three dimensional array, conc(site,tracer,time) where site=280, tracer=9 and time=8760. The tracers should be ordered as in Table 1 above. The concentrations should be hourly, instantaneous values starting at 01:00Z on 1 January 2002 or 2003 and ending at 00:00Z 1 January 2003 or 2004. If possible try to sample the model output at the 'end' of the

timestep, that is after any mixing of the surface flux out of the surface layer and after radon decay. If you are unable to provide data at hourly temporal resolution please adjust the time dimension as applicable and submit as near to hourly resolution as you are able. The units for CO_2 should be ppm, for SF6 ppt and for radon volume mixing ratio*10^{-21}(=ppb*ppt).

6.2 Tracer concentration timeseries at multiple levels for subset of sites (write_tracer.f)

Filename: Example code writes one file per tracer, tracer_name.your_model.your_institution.year.nc

Dataset names: 'latitude', 'longitude', 'time', 'site_name', 'conc', 'flux'.

Contents: Three arrays with location information that you will need to provide, time and site name arrays that are generated by the example code and the tracer concentration and surface flux arrays. In each array the sites should be ordered as given in the site list files.

Longitude, latitude and land: as in section 6.1. Note that the level array is not applicable here.

Concentration: A three dimensional array, conc(site,lev,time) where site=100, time=8760 and lev will depend on your model. Please submit the number of levels required in your model to reach on average to 500 hPa (use the same number of levels for all locations regardless of local topography). The level data should be ordered from the surface layer upwards. As in sec 6.1, the concentrations should be hourly instantaneous values starting from 01:00Z 1 January 2002 or 2003. The units for CO_2 should be ppm, for SF6 ppt and for radon volume mixing ratios *10^{-21}.

Surface flux: A two-dimensional array, flux(site,time) where nsite=100 and time=8760. Save the surface flux being used in the model at the same times that the tracer concentration data are saved, i.e. the surface flux that was used in the timestep that has just been completed. Units should be mol m^{-2} s^{-1} for each tracer. This array will be useful for diagnosing differences between modeled concentrations, as it is important to know how similar the prescribed fluxes were once aggregated to different model grids.

6.3 Meteorological data at multiple levels for subset of sites (write_met.f)

Filename: met.your_model.your_institution.year.nc

Dataset names: 'latitude', 'longitude', 'land', 'time', 'site_name', 'pressure', 'u', 'v', 'surfpres', 'blh', 'cc'

Contents: Three arrays with location information that you will need to provide, time and site name arrays that are generated by the example code and the pressure, u and v component winds, surface pressure, boundary layer height and cloud cover. In each array the sites should be ordered as given in the site list files.

Longitude, latitude and land: as in section 6.1. Note that the level array is not applicable here.

Pressure, u, v: Three-dimensional arrays, pressure(site,lev,time), u(site,lev,time), v(site,lev,time), where site=100, lev is the same as in section 6.2 and time=8760. Save the pressure and u and v wind components at the same model levels and times for which the concentration data have been saved in sec 6.2. Stick to the convention that positive u,v indicates eastward/northward winds. Units for pressure should be hPa and for u and v, m s^{-1}.

Surface pressure, boundary layer height and cloud cover: Two dimensional arrays, surfpres(site,ntime), blh(site,time), and cc(site,time) where site=100 and time=8760. Save the surface pressure,, boundary layer height and cloud cover at the same times for which the concentration data have been saved in sec 6.2. If you cannot easily extract the boundary layer height from your model then fill the array with a missing value of -999. Units for surface pressure are hPa and for boundary layer height, m. Modelers should report the % cloud cover (all cloud types) at the cloudiest level between the surface and 500 hPa. If this is not a parameter available to you, and you cannot calculate it easily we suggest to report either -999, or make your own choice and describe (in the Model_info file) what has been reported.

6.4 Model information file

Please complete the blank model information file, which can be downloaded from the 'inputfiles' directory.

7. Timetable and submission instructions

November 1 2005: Protocol distributed and input files available for download.
December 31 2005: Submission of output (earlier submissions welcome).
Later submissions are possible. Analysis will continue through 2006 and 2007.

We would encourage many people to be involved in the analysis of these results, perhaps by doing a focused comparison on a single site. If you have an interest in a particular site, please notify the transcom list of your analysis plans, in case others are interested in working with you. You should also notify the appropriate contact person for any observations that you would like to include in the comparison as the input of those making the observations would be valuable.

7.1 Submission instructions

The 22 netcdf files of output plus the ascii model information file should be uploaded to the ftp site, ftp-kg01.eas.purdue.edu. Log in using the username and password given above. Please put your model output in the subdirectory 'modeloutput' in a directory formatted as 'model.group.submissiondate', e.g. 'TM5.CMDL.2005-03-24/'. If you have to revise your submission, make a new directory and delete the old version.

7.2 Access to data for analysis

We would like to open the data for analysis to the whole of the TransCom community. We therefore intend to make the ftp site username and password available through the TransCom email list. Any model output could be downloaded by going to the 'modeloutput' subdirectory. Code for reading the all site file and selecting an individual site for ascii output is available in the 'samplecode' directory (extractsite.f). We also plan to provide files containing all the output from one model for one site (for those who do not wish to download the full dataset). Appropriate acknowledgement of modelers is required in any publications using this data.

8. Further information

Any questions should be directed to Wouter Peters (Wouter.Peters@noaa.gov), Rachel Law (Rachel.Law@csiro.au) or Christian Roedenbeck (Christian.Roedenbeck@bgc-jena.mpg.de).

Appendix 1: Site list (allsite.list)

```
   site         lat         long  height/alt   land  0=masl,1=mag
280
 AIA00500    -40.53       144.30         500    0      1
 AIA01500    -40.53       144.30        1500    0      1
 AIA02500    -40.53       144.30        2500    0      1
 AIA03500    -40.53       144.30        3500    0      1
 AIA04500    -40.53       144.30        4500    0      1
 AIA05500    -40.53       144.30        5500    0      1
 AIA06500    -40.53       144.30        6500    0      1
    ALT       82.45       -62.52         210    1      0
    AMS      -37.95        77.53         150    0      0
    ASC       -7.92       -14.42          54    0      0
    ASK       23.18         5.42        2728    1      0
    ASKSFC    23.18         5.42           0    1      1
    AVI       17.75       -64.75           3    0      0
    AZR       38.77       -27.38          40    0      0
    BAL       55.50        16.67           7    0      0
    BGU       41.83         3.33          30    1      0
    BGUOCN    41.83         3.33          30    0      0
    BHD      -41.41       174.87          80    1      0
    BHDOCN   -41.41       174.87          80    0      0
    BME       32.37       -64.65          30    0      0
    BMW       32.27       -64.88          30    0      0
    BRW       71.32      -156.60          11    1      0
    BRWOCN    71.32      -156.60          11    0      0
    BSC       44.17        28.68           3    1      0
    BSCOCN    44.17        28.68           3    0      0
 CAR03000     40.90      -104.80        3000    1      1
 CAR04000     40.90      -104.80        4000    1      1
 CAR05000     40.90      -104.80        5000    1      1
 CAR06000     40.90      -104.80        6000    1      1
 CAR07000     40.90      -104.80        7000    1      1
 CAR08000     40.90      -104.80        8000    1      1
    CBA       55.20      -162.72          25    1      0
    CBAOCN    55.20      -162.72          25    0      0
    CFA      -19.28       147.06           2    1      0
    CFAOCN   -19.28       147.06           2    0      0
    CGO      -40.68       144.68          94    1      0
    CGOOCN   -40.68       144.68          94    0      0
    CHR        1.70      -157.17           3    0      0
    CMN       44.18        10.70        2165    1      0
    CMO       45.48      -123.97          30    1      0
    CMOOCN    45.48      -123.97          30    0      0
    COI       43.15       145.50         100    1      0
    COIOCN    43.15       145.50         100    0      0
    CPT      -34.35        18.49         260    1      0
    CPTOCN   -34.35        18.49         260    0      0
    CRI       15.08        73.83          60    1      0
    CRIOCN    15.08        73.83          60    0      0
    CRZ      -46.45        51.85         120    0      0
```

CSJ	51.93	-131.02	89	1	0
DAAOCN	-12.42	130.57	3	0	0
EIC	-27.15	-109.45	50	0	0
ESP	49.38	-126.55	39	1	0
ESPOCN	49.38	-126.55	39	0	0
FRD	49.88	-81.57	250	1	0
GMI	13.43	144.78	2	0	0
GOZ	36.05	14.18	30	0	0
GSN	33.28	126.15	72	0	0
HAA00500	21.23	-158.95	500	0	1
HAA01500	21.23	-158.95	1500	0	1
HAA02500	21.23	-158.95	2500	0	1
HAA03500	21.23	-158.95	3500	0	1
HAA04500	21.23	-158.95	4500	0	1
HAA05500	21.23	-158.95	5500	0	1
HAA06500	21.23	-158.95	6500	0	1
HAA07500	21.23	-158.95	7500	0	1
HAT	24.05	123.80	47	0	0
HBA	-75.58	-26.50	10	1	0
HUN010	46.95	16.65	10	1	1
HUN048	46.95	16.65	48	1	1
HUN082	46.95	16.65	82	1	1
HUN115	46.95	16.65	115	1	1
ICE	63.25	-20.15	100	1	0
ICEOCN	63.25	-20.15	100	0	0
ITN051	35.35	-77.38	51	1	1
ITN123	35.35	-77.38	123	1	1
ITN496	35.35	-77.38	496	1	1
IZO	28.30	-16.48	2360	0	0
JBN	-62.23	-58.82	15	1	0
KEY	25.67	-80.20	3	1	0
KEYOCN	25.67	-80.20	3	0	0
KUM	19.52	-154.82	3	0	0
KZD	44.45	77.57	412	1	0
KZM	43.25	77.88	2519	1	0
KZMSFC	43.25	77.88	0	1	1
LEF011	45.93	-90.27	11	1	1
LEF030	45.93	-90.27	30	1	1
LEF076	45.93	-90.27	76	1	1
LEF122	45.93	-90.27	122	1	1
LEF244	45.93	-90.27	244	1	1
LEF396	45.93	-90.27	396	1	1
LJO	32.90	-117.30	10	1	0
LJOOCN	32.90	-117.30	10	0	0
LMP	35.52	12.62	45	0	0
MAA	-67.62	62.87	32	1	0
MBC	76.25	-119.35	58	1	0
MHD	53.33	-9.90	25	1	0
MHDOCN	53.33	-9.90	25	0	0
MID	28.22	-177.37	4	0	0
MLO	19.53	-155.58	3397	0	1
MNM	24.30	153.97	8	0	0

MQA	-54.48	158.97	12	0	0
NWR	40.05	-105.58	3475	1	0
OPW	48.25	-124.42	488	1	0
ORL00500	47.80	2.50	500	1	1
ORL01500	47.80	2.50	1500	1	1
ORL02500	47.80	2.50	2500	1	1
ORL03500	48.00	2.50	3500	1	1
PAL	67.97	24.12	560	1	0
PDM	42.93	0.13	2877	1	0
PFA01500	65.07	-147.29	1500	1	1
PFA02500	65.07	-147.29	2500	1	1
PFA03500	65.07	-147.29	3500	1	1
PFA04500	65.07	-147.29	4500	1	1
PFA05500	65.07	-147.29	5500	1	1
PFA06500	65.07	-147.29	6500	1	1
PFA07500	65.07	-147.29	7500	1	1
POCS35	-35.00	168.00	10	0	0
POCS30	-30.00	169.00	10	0	0
POCS25	-25.00	174.00	10	0	0
POCS20	-20.00	-178.50	10	0	0
POCS15	-15.00	-178.00	10	0	0
POCS10	-10.00	-174.00	10	0	0
POCS05	-5.00	-168.00	10	0	0
POC000	0.00	-163.00	10	0	0
POCN05	5.00	-158.00	10	0	0
POCN10	10.00	-152.00	10	0	0
POCN15	15.00	-147.00	10	0	0
POCN20	20.00	-140.00	10	0	0
POCN25	25.00	-134.00	10	0	0
POCN30	30.00	-126.00	10	0	0
POCN35	35.00	-143.00	10	0	0
POCN40	40.00	-138.00	10	0	0
POCN45	45.00	-131.00	10	0	0
PRS	45.93	7.70	3480	1	0
PSA	-64.92	-64.00	10	1	0
RPB	13.17	-59.43	45	0	0
RTA00500	-21.25	-159.83	500	0	1
RTA01500	-21.25	-159.83	1500	0	1
RTA02500	-21.25	-159.83	2500	0	1
RTA03500	-21.25	-159.83	3500	0	1
RTA04500	-21.25	-159.83	4500	0	1
RYO	39.03	141.83	230	1	0
RYOOCN	39.03	141.83	230	0	0
SBL	43.93	-60.02	5	0	0
SCH	48.00	8.00	1205	1	0
SCSN03	3.00	105.00	15	0	0
SCSN06	6.00	107.00	15	0	0
SCSN09	9.00	109.00	15	0	0
SCSN12	12.00	111.00	15	0	0
SCSN15	15.00	113.00	15	0	0
SCSN18	18.00	115.00	15	0	0
SCSN21	21.00	117.00	15	0	0

SEY	-4.67	55.17	3	0	0	
SHM	52.72	174.10	40	0	0	
SIS	60.17	-1.17	30	0	0	
SMO	-14.25	-170.57	42	0	0	
SPO	-89.98	-24.80	2810	1	0	
STM	66.00	2.00	7	0	0	
STP	50.00	-145.00	7	0	0	
SUM	72.58	-38.48	3238	1	0	
SUMSFC	72.58	-38.48	0	1	1	
SYO	-69.00	39.58	11	1	0	
TAP	36.73	126.13	20	1	0	
TAPOCN	36.73	126.13	20	0	0	
TDF	-54.87	-68.48	20	1	0	
TRM	-15.88	54.52	20	0	0	
UTA	39.90	-113.72	1320	1	0	
UUM	44.45	111.10	914	1	0	
WES	55.00	8.00	8	1	0	
WESOCN	55.00	8.00	8	0	0	
WIS	31.13	34.88	400	1	0	
WKT009	31.32	-97.62	9	1	1	
WKT030	31.32	-97.62	30	1	1	
WKT061	31.32	-97.62	61	1	1	
WKT122	31.32	-97.62	122	1	1	
WKT244	31.32	-97.62	244	1	1	
WKT457	31.32	-97.62	457	1	1	
WLG	36.29	100.90	3810	1	0	
WPON30	30.00	146.00	10500	0	1	
WPON25	25.00	146.00	10500	0	1	
WPON20	20.00	146.00	10500	0	1	
WPON15	15.00	146.00	10500	0	1	
WPON10	10.00	146.00	10500	0	1	
WPON05	5.00	146.00	10500	0	1	
WPO000	0.00	146.00	10500	0	1	
WPOS05	-5.00	146.00	10500	0	1	
WPOS10	-10.00	146.00	10500	0	1	
WPOS15	-15.00	146.00	10500	0	1	
WPOS20	-20.00	146.00	10500	0	1	
WPOS25	-25.00	146.00	10500	0	1	
YON	24.47	123.02	30	0	0	
ZEP	78.90	11.88	475	1	0	
CBW020	52.00	4.90	20	1	1	
CBW060	52.00	4.90	60	1	1	
CBW120	52.00	4.90	120	1	1	
CBW200	52.00	4.90	200	1	1	
LUT	52.38	6.37	0	1	0	
LUTOCN	52.38	6.37	0	0	0	
OXK163	50.05	11.82	1187	1	0	Ochsenkopf
PUY	45.80	3.00	1465	1	0	Puy de Dome
SAC	48.70	2.20	120	1	0	Saclay
AMY	36.53	126.32	47	1	0	Anmyeon-do
BER	55.20	165.98	13	0	0	Bering Island
SGI	-54.00	-38.05	30	0	0	Bird Island

BRT	48.82	13.22	1016	1	0	Brotjacklriegel
DEU	49.77	7.05	480	1	0	Deuselbach
FDT	45.47	25.30	1383.5	1	0	Fundata
NMB	-23.58	15.03	408	1	0	Namibia
HMM	34.72	137.72	35	1	0	Hamamatsu
HUA	-12.07	-75.53	3313	1	0	Huancayo
ISK	42.62	76.98	1640	1	0	Issyk-Kul
KPS	46.97	19.55	125	1	0	K-puszta
KCO	4.97	73.47	1	0	0	Kaashidhoo
KMW	53.33	6.28	0	1	0	Kollumerwaard
KOT	76.00	137.87	5	0	0	Kotelny Island
KYZ	40.87	66.15	340	1	0	Kyzylcha
MKW	34.85	137.43	50	1	0	Mikawa-Ichinomiya
DDR	36.00	139.18	840	1	0	Mt. Dodaira
NGL	53.15	13.03	65	1	0	Neuglobsow
STC	54.00	-35.00	6	0	0	
PTA	38.95	-123.73	17	1	0	
PTAOCN	38.95	-123.73	17	0	0	
SNB	47.05	12.95	3106	1	0	Sonnblick
TER	69.20	35.10	40	1	0	Teriberka
TKB	36.05	140.13	26	1	0	Tsukuba
TKB200	36.05	140.13	200	1	1	
URW	35.87	139.60	10	1	0	Urawa
LGB	52.80	10.77	74	1	0	Waldhof
WNK	47.52	11.15	1780	1	0	Wank Peak
ZGT	54.43	12.73	1	1	0	Zingst
ZGTOCN	54.43	12.73	1	0	0	
ZGP	47.42	10.98	2960	1	0	Zugspitze
Takayama	36.13	137.42	1420	1	0	
Tomakomai	42.73	141.52	140	1	0	
Sapporo	42.98	141.38	175	1	0	
CCLaG	45.05	138.77	1030	1	0	
Laoshan	45.33	127.57	805	1	0	
Tumbarumba	-35.65	148.15	1200	1	0	
AMT	45.03	-68.68	157	1	0	
BKT	-0.20	100.32	864	1	0	
MKN	-0.05	37.30	3897	1	0	
OBN	55.11	36.60	484	1	0	
SGP	36.80	-97.50	314	1	0	
THD	41.05	-124.15	259	1	0	Trinidad Head
THDOCN	41.05	-124.15	259	0	0	
BGI	42.82	-94.40	721	1	0	Tower Iowa
BGI000	42.82	-94.40	0	1	1	
RIA	42.40	-91.83	908	1	0	Tower Iowa
RIA000	42.40	-91.83	0	1	1	
BNE	40.80	-97.18	923	1	0	Tower Nebraska
BNE000	40.80	-97.18	0	1	1	
DND	48.13	-97.98	909	1	0	Tower Dakota
DND000	48.13	-97.98	0	1	1	
FWI	44.65	-90.95	943	1	0	Tower Dakota
FWI000	44.65	-90.95	0	1	1	
HIL	40.07	-87.90	609	1	0	Tower Illinois

HIL000	40.07	-87.90	0	1	1	
OIL	41.27	-88.93	610	1	0	Tower Illinois
OIL000	41.27	-88.93	0	1	1	
MILIFG1	45.43	9.28	103	1	0	
FRBBFS	48.00	7.85	276	1	0	
HPB	47.80	11.02	977	1	0	Hohenpeissenburg
HEI	49.40	8.70	116	1	0	Heidelberg
TVR	56.47	32.92	265	1	0	Tver-Fjodorovskoye
JFJ	46.55	7.98	3454	1	0	Jungfraujoch
BarrowIs	-20.83	115.42	0	0	0	Barrow Island
Berezo5	56.15	84.33	5	1	0	
Berezo20	56.15	84.33	20	1	0	
Berezo40	56.15	84.33	40	1	0	
Berezo80	56.15	84.33	80	1	0	
Noyabrsk21	63.38	76.00	21	1	0	
Noyabrsk43	63.38	76.00	43	1	0	
Salym45	59.78	70.87	45	1	0	
Salym63	59.78	70.87	63	1	0	
Igrim24	63.20	64.48	24	1	0	
Igrim47	63.20	64.48	47	1	0	
Karasevoe	58.25	82.40	80	1	0	
Parabel35	58.25	82.40	35	1	0	
Parabel67	58.25	82.40	67	1	0	
Hanle	32.78	78.97	4301	1	0	

Appendix 2: Subset of sites for extended output (contsite.list)

```
  site        lat         long  height/alt   land  0=masl,1=mag
100
   ALT       82.45      -62.52         210    1      0
   AMS      -37.95       77.53         150    0      0
   BHD      -41.41      174.87          80    1      0
   BHDOCN   -41.41      174.87          80    0      0
   BRW       71.32     -156.60          11    1      0
   BRWOCN    71.32     -156.60          11    0      0
   CGO      -40.68      144.68          94    1      0
   CGOOCN   -40.68      144.68          94    0      0
   CMN       44.18       10.70        2165    1      0
   COI       43.15      145.50         100    1      0
   COIOCN    43.15      145.50         100    0      0
   CPT      -34.35       18.49         260    1      0
   CPTOCN   -34.35       18.49         260    0      0
   FRD       49.88      -81.57         250    1      0
   HAT       24.05      123.80          47    0      0
   HUN       46.95       16.65         258    1      0
   ITN       35.35      -77.38          60    1      0
   IZO       28.30      -16.48        2360    0      0
   JBN      -62.23      -58.82          15    1      0
   LEF       45.93      -90.27         483    1      0
   MHD       53.33       -9.90          25    1      0
   MHDOCN    53.33       -9.90          25    0      0
   MLO       19.53     -155.58        3397    0      0
   MNM       24.30      153.97           8    0      0
   NWR       40.05     -105.58        3475    1      0
   PAL       67.97       24.12         560    1      0
   PRS       45.93        7.70        3480    1      0
   RYO       39.03      141.83         230    1      0
   RYOOCN    39.03      141.83         230    0      0
   SCH       48.00        8.00        1205    1      0
   SMO      -14.25     -170.57          42    0      0
   SPO      -89.98      -24.80        2810    1      0
   SYO      -69.00       39.58          11    1      0
   WES       55.00        8.00           8    1      0
   WESOCN    55.00        8.00           8    0      0
   WLG       36.29      100.90        3810    1      0
   YON       24.47      123.02          30    0      0
   ZEP       78.90       11.88         475    1      0
   LUT       52.38        6.37           0    1      0
   LUTOCN    52.38        6.37           0    0      0
   HEI       49.40        8.70         116    1      0
   CBW       52.00        4.91          20    1      0
   ORL       47.97        2.12           0    1      1  Orleans
   OXK       50.05       11.82        1024    1      0  Ochsenkopf
   BIK       52.25       22.75           0    1      1  Bialystok
   TTA       56.60       -3.78           0    1      1  Angus Griffin
   FIR       43.80       11.20           0    1      1  Firenze
   NOR       60.83       17.47           0    1      1  Norunda
```

MUE	41.58	-1.83	0	1	1	La Muela
ZOT	60.75	89.3	0	1	1	Zotino
PUY	45.80	3.00	1465	1	0	Puy de Dome
SAC	48.70	2.20	120	1	0	Saclay
AMY	36.53	126.32	47	1	0	Anmyeon-do
BRT	48.82	13.22	1016	1	0	Brotjacklriegel
DEU	49.77	7.05	480	1	0	Deuselbach
FDT	45.47	25.30	1383	1	0	Fundata
HMM	34.72	137.72	35	1	0	Hamamatsu
ISK	42.62	76.98	1640	1	0	Issyk-Kul
KPS	46.97	19.55	125	1	0	K-puszta
KMW	53.33	6.28	0	1	0	Kollumerwaard
MKW	34.85	137.43	50	1	0	Mikawa-Ichinomiya
DDR	36.00	139.18	840	1	0	Mt. Dodaira
NGL	53.15	13.03	65	1	0	Neuglobsow
SNB	47.05	12.95	3106	1	0	Sonnblick
TKB	36.05	140.13	26	1	0	Tsukuba
URW	35.87	139.60	10	1	0	Urawa
LGB	52.80	10.77	74	1	0	Waldhof
ZGT	54.43	12.73	1	1	0	Zingst
ZGTOCN	54.43	12.73	1	0	0	
ZGP	47.42	10.98	2960	1	0	Zugspitze
Takayama	36.13	137.42	1420	1	0	
Tomakomai	42.73	141.52	140	1	0	
Sapporo	42.98	141.38	175	1	0	
CCLaG	45.05	138.77	1030	1	0	
Laoshan	45.33	127.57	805	1	0	
BOB	55.87	-98.46	259	1	0	Canada
SOBS	53.98	-105.12	629	1	0	Canada
SOJP000	53.90	-105.68	400	1	0	Canada
SOJP179	53.90	-105.68	579	1	0	Canada
SOJP300	53.90	-105.68	700	1	0	Canada
SOA	53.61	-105.18	601	1	0	Canada
HFM180	42.53	-72.17	180	1	1	Harvard Forest
HFM340	42.53	-72.17	340	1	1	
HFM490	42.53	-72.17	490	1	1	
ARM	36.60	-97.48	310	1	0	Oklahoma ARM/CART
Howland	45.20	-68.74	85	1	0	fluxtower
Lostcreek	46.08	-89.98	490	1	0	fluxtower
Willowcreek	45.81	-90.08	550	1	0	fluxtower
Tapajos	-2.86	-54.96	65	1	0	fluxtower
KAS	49.22	19.98	1987	1	0	Kasprowy Wierch
CHK	68.80	161.30	0	1	1	Cherskii
SYK	61.70	50.80	0	1	1	Syktyvkar
TVR	56.47	32.92	0	1	1	Tver
UBS	51.48	95.58	0	1	1	Ubs-Nur
Novosibirsk	55.00	83.00	220	1	0	
SPL	40.45	-106.73	3200	1	0	Storm Peak RACCOON
FEF	39.94	-105.88	2475	1	0	Fraser Exp. RACCOON
NWR	40.05	-105.58	3475	1	0	Niwot Ridge RACCOON
HDP	40.56	-111.64	3351	1	0	Hidden Peak RACCOON
DAA	-12.42	130.57	3	1	0	Darwin

Appendix 3: List of sources for input files

Takahashi Ocean fluxes

Based on the file
"http://www.ldeo.columbia.edu/res/pi/CO2/carbondioxide/air_sea_flux/fluxdata.txt"
of 14 October 2003. (Output of the Takahashi interpolation scheme for
estimating global ocean/air CO2 flux. This is the "940K" version,
corrected by using wind speeds from the 10-meter height file.)

CASA biosphere fluxes

Kindly provided by Jim Randerson and colleagues. The 3-hourly fluxes were created starting from a 1x1 degree neutral biosphere CASA run that stored monthly NEP and NPP. Using 2 meter temperature and radiation from the ECMWF model at 1x1 degrees, diurnal variability was added to GPP (=2*NPP) and to respiration (Q10 formulation with Q10=1.5). Finally, respiration was rescaled to match the initial NEP from CASA. The procedure is described in Olsen and Randerson, [2004]. The monthly mean fluxes used in TC are the original monthly NEP files, the 3-hourly fluxes are the derived ones, rescaled as above to match the monthly mean NEP.

SiB 3.0 biosphere fluxes

Kindly provided by Scott Denning and colleagues, direct questions to baker@atmos.colostate.edu who provided these fluxes and wrote the helpful regridding software.

Fossil Fuel emissions

Fossil-fuel emission flux map for 1998 (originally 1deg x 1deg from CDIAC country data).

SF6 emissions

SF6 emissions are based on the spatial distribution of the EDGAR-95 emissions database (http://www.rivm.nl/EDGAR), and were scaled to match the global annual SF6 growth rate calculated from observations in the NOAA CMDL Cooperative Air sampling Network. We thank Jos Olivier and the EDGAR project for providing the SF6 input fields.

Reference

Olsen SC, Randerson JT, Differences between surface and column atmospheric CO_2 and implications for carbon cycle research, *J. Geophys. Res.*, **109**,. D02301, 2004