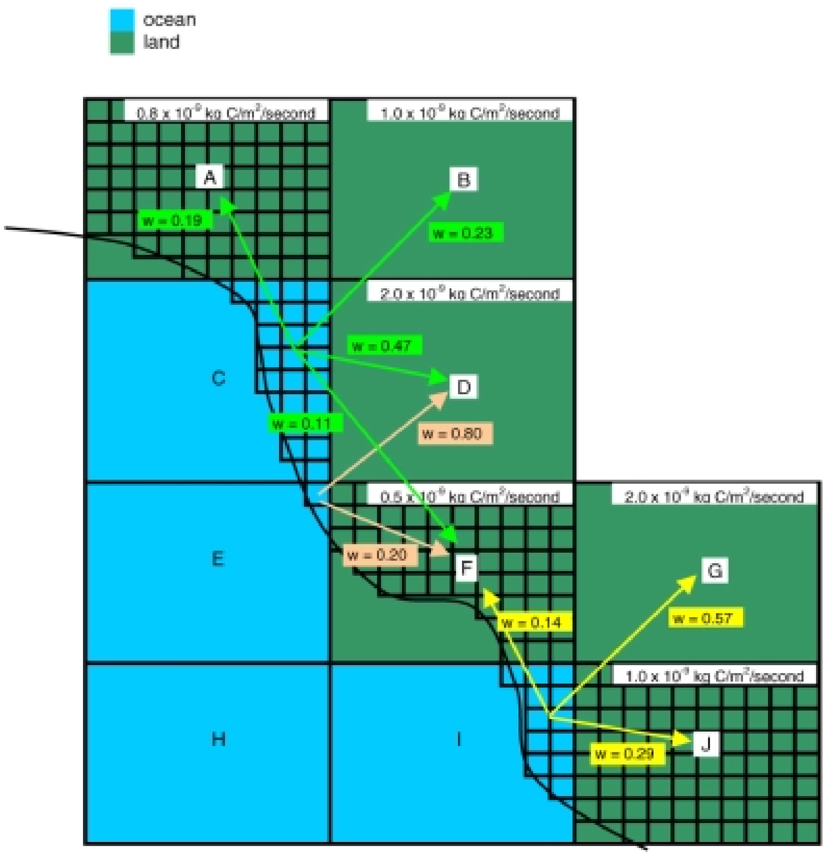
gridcells. For most modelers, the 0.5 x 0.5 degree size fit evenly within the model gridcell (that is, most grids lie on whole or half degree lines). For those grids for which this is not the case, the 0.5x0.5 degree gridcells were apportioned by area to the model gridcells that they straddle.

This allocation of the 0.5 x 0.5 degree gridcells to the model grid was done while applying the land/sea mask that is routinely used with the model grid. So, all the gridcells that are considered "land" (in the case of the terrestrial pre-subtracted fields, for example) by the land/sea mask were filled by the 0.5 x 0.5 degree gridcells supplied in the input data. Refer to Figure 1 for a schematic of a coastline example.

Figure 1



b) The next step was to go back over the two grids (the model grid and the 0.5 x 0.5 degree grid) and locate those model gridcells which contain emitting 0.5 x 0.5 degree gridcells but were allocated to ocean (while allocating a terrestrial pre-subtraction field, for example) or land (while allocating the ocean pre-subtraction field, for example). In these cases, the 0.5 x 0.5 degree gridcells in question had their integrated flux added to the neighboring model gridcells *a la* weights which reflected the relative flux from those neighbors. In Figure 1, 0.5 x 0.5 degree gridcells in model gridcell "C" are area integrated and added to the flux in the neighboring land model gridcells with the weights denoted by "w".[3]

The effect of this procedure was to keep the reallocation of emissions *local*. This is most obvious for the case of fossil-fuel emissions which have strong maxima near the coastlines - instead of potentially removing this maxima and redistributing it across the entire globe or region, the maxima is shifted inland slightly. It is an imperfect solution in the sense that flux minima located on a coastline are essentially lost with the reshuffling procedure. However, for the purposes here, the loss of a small local flux is of comparitively little consequence.

This procedure was performed for all of the input files except the ocean carbon basis functions. The ocean carbon basis function fields have essentially no spatial distribution (four of the basis functions have a bit of spatial structure due to seasonal sea ice cover) and therefore are best handled with the traditional approach. This was accomplished by eliminating those model gridcells that contain oceanic flux but which are considered land gridcells according to the land/sea mask. The region total is then scaled-up to match the annual, regional sum of 1 Gt C/year (see Section E).[4]

1) Region/region boundary

Another question concerning the spatial aggregation arises at boundaries between basis function regions. Unlike the land/ocean problem discussed above, there is no strict spatial mask to worry about (i.e., the land/sea mask of each model) and there are no obvious atmospheric transport gradients coinciding with any of the region/region boundaries. However, problems can arise since there is some significant spatial structure to the fluxes in the various regions (mainly the terrestrial basis functions and SF_6 basis functions).

The "soft" boundary approach was recommended for this experiment. This would result in region/region boundaries overlapping by, on average, half of a model gridcell. The integrated flux in each region, however, would be maintained. Since the basis function arrays have been constructed such that each array contains values only in each region and the remainder of the array contains zeros, this made the process very simple.

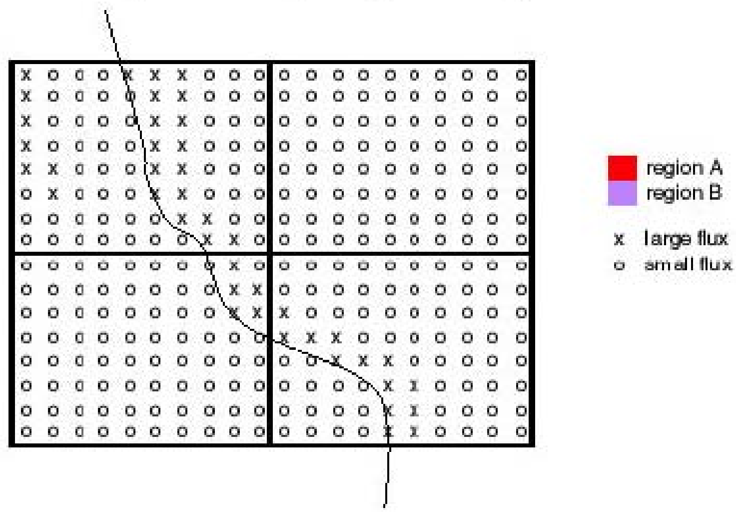
For each region (which are separate arrays in the input data file), modelers placed all of the 0.5 x 0.5 degree cells within the confines on their model gridcells. Model gridcells that contain even one 0.5 x 0.5 degree emitting gridcell were considered part of the new regridded region defined by the model grid. This maintained the total regional flux but spread the flux in the edge cells, on average, outward from the region by half of a model gridcell. Adjacent regions, overlapped in space slightly.

The other alternative might be referred to as a "hard" boundary in which there is no gridcell overlap: a model gridcell is in one region or another, not both. This moves the flux as with the "soft" approach but requires regional scaling and could cause significant alteration of the spatial structure of the flux were a region edge to contain high levels of flux.

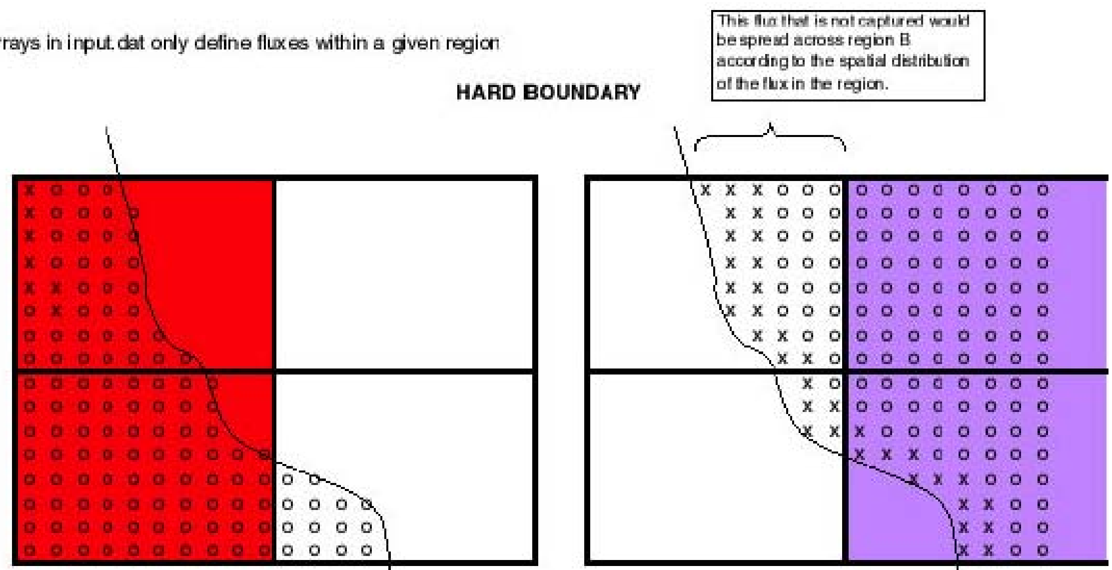
These two approaches are shown below:

Figure 2

Imagine this as the nep flux in the vicinity of a regional boundary

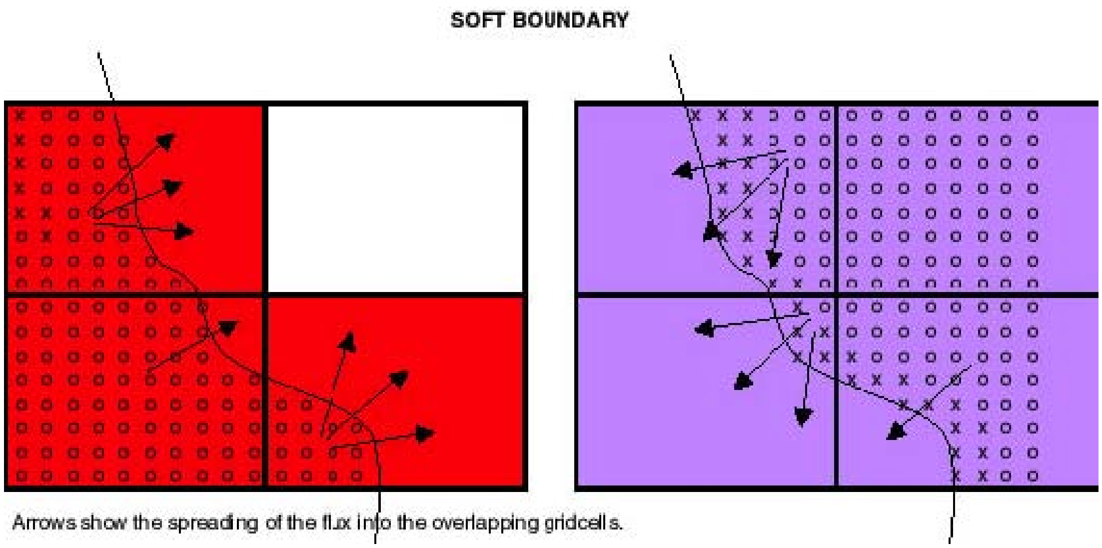


The arrays in input.dat only define fluxes within a given region



Region A is scaled up slightly

Region B is scaled up but spatial structure is lost.



Arrows show the spreading of the flux into the overlapping gridcells.

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[3] Because many coastlines run roughly north-south, the order with which this shuffling scheme is performed does change the shuffling weights. For example, going from the South Pole and working northward will have a slightly different shuffling effect than going from the North Pole and working southward. Though, the effect is small, the investigators recommended that modelers determine the weights prior to reallocation - this eliminates the directional bias.

[4] Aside from the spatial flux pattern caused by sea ice cover (four regions only), further spatial patterning occurs due to the fact that some edge model gidcells are not be fully populated by 0.5 x 0.5 degree gridcells and, hence, have less flux than interior gridcells.

E. Maintaining global totals:

All of the input data was generated at 0.5 x 0.5 degree to facilitate interpolation to the various model grids involved in TransCom 3. It was important that whatever spatial aggregation was performed did not alter the global sums provided below. After the input data was spatially aggregated to each model grid, modelers made sure that their global totals matched those below through regional/global scaling adjustments. The global/regional sums are as follows[5]:

1) Fossil-fuel pre-subtraction maps

The total 1990 emissions are 5.811611 Gt
The total 1995 emissions are 6.172869 Gt

2) Neutral biosphere pre-subtraction maps

The following are Global Mid-month NEP Flux Values (in kg C/second). After spatial aggregation to model grids, modelers checked to ensure that their globally integrated mid-month fluxes matched the following:[6]

Month	Global Mid-month NEP Flux Values (kg C/second)

1	242859.5
2	314486.3
3	211004.9
4	251455.6
5	-148549.7
6	-607653.2
7	-755280.0
8	-384896.5
9	180157.9
10	261082.3
11	233356.8
12	201913.8

These mid-month fluxes were interpolated to, at least, daily fluxes using standard month lengths (31, 28, 31 days, etc.). After interpolation, the Globally Summed Monthly NEP Flux Totals (in Gt/month) matched the following:

Month	Global Monthly NEP Flux Value (Gt/month)
1	0.6644884
2	0.7098920
3	0.6139190
4	0.5037655
5	-0.4368679
6	-1.4607660
7	-1.8092093
8	-0.9421531
9	0.3264070
10	0.6634400
11	0.6024190
12	0.5654337

The Global Annual NEP Flux is: 7.6815368E-4 Gt/year

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[5] The global sums represent: (flux value*m^2/gridcell*seconds/year{or month}) summed over all grid cells.

[6] Assuming the fluxes represent mid-month values when initially derived as monthly means will lead to a different time integral. For the purposes of TransCom, however, the important requirements were that (1) everybody used the same daily flux and (2) the global annual flux in the mid-month daily interpolated version was

not drastically different from the original monthly mean version. These were satisfied by adhering to the procedure and global totals listed.

3) Ocean exchange pre-subtraction maps

The following are Global Mid-month Oceanic Exchange Values (in kg C/second). After spatial aggregation to model grids, modelers checked to ensure that their globally integrated mid-month fluxes matched the following (see footnote 4):

Month	Global Mid-month Oceanic Exchange Values (kg C/ second)
1	-78500.75
2	-71361.29
3	-75480.51
4	-76880.54
5	-77084.09
6	-69717.96
7	-47504.78
8	-46194.30
9	-53969.30
10	-71638.83
11	-79507.18
12	-86656.08

These mid-month fluxes were interpolated to, at least, daily fluxes using standard month lengths (31, 28, 31 days, etc.). After interpolation, the Globally Summed Monthly Oceanic Exchange Totals (in Gt/month) matched the following:

Month	Global Monthly Oceanic Exchange Values (Gt/month)
1	-0.2101370
2	-0.1758068
3	-0.2013174
4	-0.1989271
5	-0.2037262
6	-0.1753489
7	-0.1338484
8	-0.1269569
9	-0.1435823
10	-0.1890994
11	-0.2061724

12	-0.2269120

The Global Annual Ocean Flux is: -2.191835 Gt/year

4) Terrestrial carbon basis functions

The Global Total Flux for each region is 1.0 Gt/year

5) Oceanic carbon basis functions

The Global Total Flux for each region is 1.0 Gt/year

6) SF_6 basis functions

The Global Total Flux for each region is 1.0 Gg/year

Product Description and Data File Information:

TransCom 3, Level 1 Results

The results of the TransCom 3, Level 1 experiments are grouped into two broad categories:

- Forward simulation fields and response functions ("model output")
- Estimated fluxes ("inversion results")

A. Level 1 Model Output

1) **Selected CO_2 Fields from All of the Submitted Models**

These image files can be downloaded in compressed form as <**model_results_co2_fields_all.zip**> from the ORNL DAAC FTP area for TransCom 3, Level 1. Uncompressed, the files provide three different types of model output:

- Annual Mean Surface Concentration (.jpg maps)

Description	Model Set 1 File Names	Model Set 2 File Names
1990 fossil fuel	L1.ff90_s.annmn.1.jpg	L1.ff90_s.annmn.2.jpg
Neutral biosphere	L1.bios_s.annmn.1.jpg	L1.bios_s.annmn.2.jpg
Ocean exchange	L1.ocean_s.annmn.1.jpg	L1.ocean_s.annmn.2.jpg
Land BF 2	L1.landBF2_s.annmn.1.jpg	L1.landBF2_s.annmn.2.jpg

Ocean BF 5	L1.oceanBF5_s.annmn.1.jpg	L1.oceanBF5_s.annmn.2.jpg
Predicted surface concentration	L1.pred_s.annmn.1.jpg	L1.pred_s.annmn.2.jpg

Note: In the file name, ...1.jpg refers to Model Set 1 results and ... 2.jpg refers to Model Set 2 results. Model Set 1: CSU, UCB, UCI, UCIb, UCIs, JMA, MATCH:CCM3, MATCH:NCEP. Model Set 2: MATCH:MACCM2, NIES, NIRE, RPN, SKYHI, TM2, TM3, GCTM. Each field uses a single scale unless noted otherwise.

- Annual Mean Cross-sections (.jpg plots)

Description	Model Set 1 File Names	Model Set 2 File Names
1990 fossil fuel	L1.ff90.annmn.xsect.1.jpg	L1.ff90.annmn.xsect.2.jpg
Neutral biosphere	L1.bios.annmn.xsect.1.jpg	L1.bios.annmn.xsect.2.jpg
Ocean exchange	L1.ocean.annmn.xsect.1.jpg	L1.ocean.annmn.xsect.2.jpg
Land BF 9	L1.landBF9.annmn.xsect.1.jpg	L1.landBF9.annmn.xsect.2.jpg
Ocean BF 9	L1.oceanBF9.annmn.xsect.1.jpg	L1.oceanBF9.annmn.xsect.2.jpg

Note: In the file name, ...1.jpg refers to Model Set 1 results and ... 2.jpg refers to Model Set 2 results. Model Set 1: CSU, UCB, UCI, UCIb, UCIs, JMA, MATCH:CCM3, MATCH:NCEP. Model Set 2: MATCH:MACCM2, NIES, NIRE, RPN, SKYHI, TM2, TM3, GCTM. Each field uses a single scale unless noted otherwise.

- Annual Mean Surface Zonal Means (.pdf charts)

Description	File Name
1990/1995 fossil fuel	L1.ff_s.zonalmean.annmn.pdf
Neutral biosphere	L1.bios_s.zonalmean.annmn.pdf
Ocean exchange	L1.ocean_s.zonalmean.annmn.pdf
Land BF 9	L1.landBF9_s.zonalmean.annmn.pdf
Ocean BF 9	L1.oceanBF9_s.zonalmean.annmn.pdf

2) **High-frequency Station CO_2 Concentration Output**

These files contain the first 228 station locations in the <**statlocs.dat**> file. The remaining 17 stations (Pacific Ocean stations) did not require high frequency reporting. Each data file includes an explanatory readme file. Each data file is tarred and compressed. They are approximately 40 MB each. All of the data files have been compressed into one zip file which can be downloaded as <**model_results_statco_all.zip**> from the ORNL DAAC FTP area for TransCom 3, Level 1. The data files are:

CSIRO.cc.L1.statco2.le.tar.gz	CSU.gurney.L1.statco2.le.tar.gz
GCTM.baker.L1.statco2.le.tar.gz	GISS.fung.L1.statco2.le.tar.gz
GISS.prather.L1.statco2.le.tar.gz	GISS.prather2.L1.statco2.le.tar.gz
GISS.prather3.L1.statco2.le.tar.gz	JMA-CDTM.maki.L1.statco2.le.tar.gz
MATCH.bruhwiler.L1.statco2.le.tar.gz	MATCH.chen.L1.statco2.le.tar.gz
MATCH.law.L1.statco2.le.tar.gz	NIES.maksyutov.L1.statco2.le.tar.gz
NIRE.taguchi.L1.statco2.le.tar.gz	RPN.yuen.L1.statco2.le.tar.gz
SKYHI.fan.L1.statco2.le.tar.gz[7]	TM2.lsce.L1.statco2.le.tar.gz
TM3.heimann.L1.statco2.le.tar.gz	

[7] No high-frequency data was submitted - this data set has been created using the monthly mean data in those grid cells occupied by the T3 stations.

3) **Annual Mean Response for All Stations and Tracers**

These ASCII (.dat) data files provide response functions for 245 stations and 26 tracers. The first two lines contain explanatory information, the following 246 contain the response functions at each station/tracer, the last line contains an additional line for closing the atmospheric carbon budget. The data files can be downloaded in compressed form as <**model_results_gmatrices_all.zip**> from the ORNL DAAC FTP area for TransCom 3, Level 1. The data files are:

CSU.gurney.Gmat.dat	GCTM.baker.Gmat.dat
GISS.fung.Gmat.dat	GISS.prather.Gmat.dat
GISS.prather2.Gmat.dat	GISS.prather3.Gmat.dat
JMA-CDTM.maki.Gmat.dat	MATCH.bruhwiler.Gmat.dat
MATCH.chen.Gmat.dat	MATCH.law.Gmat.dat
NIES.maksyutov.Gmat.dat	NIRE.taguchi.Gmat.dat
RPN.yuen.Gmat.dat	SKYHI.fan.Gmat.dat[8]

TM2.lsce.Gmat.dat	TM3.heimann.Gmat.dat

[8] No high-frequency data was submitted - this data set has been created using the monthly mean data in those gridcells occupied by the T3 stations.

4) **Grid Information Files**

These are self-explanatory ASCII (.info) files. The files can be downloaded in compressed form as <**model_results_surfdat_all.zip**> from the ORNL DAAC FTP area for TransCom 3, Level 1. The data files are:

CSU.gurney.grid.info	GCTM.baker.grid.info
GISS.fung.grid.info	GISS.prather.grid.info
GISS.prather2.grid.info	GISS.prather3.grid.info
JMA-CDTM.maki.grid.info	MATCH.bruhwiler.grid.info
MATCH.chen.grid.info	MATCH.law.grid.info
NIES.maksyutov.grid.info	NIRE.taguchi.grid.info
RPN.yuen.grid.info	SKYHI.fan.grid.info
TM2.lsce.grid.info	TM3.heimann.grid.info

5) **SF_6 Surface Concentrations**

These are binary (.dat) files containing an array dimensioned as lon x lat x land BF (11) x month (12). For the lon and lat dimensions, check the grid information files above. The files can be downloaded in compressed form as <**model_results_sf6_all.zip**> from the ORNL DAAC FTP area for TransCom 3, Level 1. The data files are:

CSIRO.cc.L1.sf6.le.dat.gz	CSU.gurney.L1.sf6.le.dat.gz
GCTM.baker.L1.sf6.le.dat.gz	GISS.fung.L1.sf6.le.dat.gz
GISS.prather.L1.sf6.le.dat.gz	GISS.prather2.L1.sf6.le.dat.gz
GISS.prather3.L1.sf6.le.dat.gz	JMA-CDTM.maki.L1.sf6.le.dat.gz
MATCH.bruhwiler.L1.sf6.le.dat.gz	MATCH.chen.L1.sf6.le.dat.gz
MATCH.law.L1.sf6.le.dat.gz	NIES.maksyutov.L1.sf6.le.dat.gz
NIRE.taguchi.L1.sf6.le.dat.gz	RPN.yuen.L1.sf6.le.dat.gz
SKYHI.fan.L1.sf6.le.dat.gz	TM2.lsce.L1.sf6.le.dat.gz
TM3.heimann.L1.sf6.le.dat.gz	

6) **3D Monthly Mean Concentrations**

These are binary files containing an array dimensioned as: lon x lat x pressure level (9) x month (12) x BF (26). For the lon and lat dimensions, check the grid information files above. The "26" is the total number of tracers (4 background + 22 basis functions). Each data file is compressed. All of the data files have been compressed into one zip file which can be downloaded as <**model_results_mmean_3D_all.zip**> from the ORNL DAAC FTP area for TransCom 3, Level 1. The data files are:

CSIRO.cc.L1.mmean.le.3D.gz	CSU.gurney.L1.mmean.le.3D.gz
GCTM.baker.L1.mmean.le.3D.gz	GISS.fung.L1.mmean.le.3D.gz
GISS.prather.L1.mmean.le.3D.gz	GISS.prather2.L1.mmean.le.3D.gz
GISS.prather3.L1.mmean.le.3D.gz	JMA-CDTM.maki.L1.mmean.le.3D.gz
MATCH.bruhwiler.L1.mmean.le.3D.gz	MATCH.chen.L1.mmean.le.3D.gz
MATCH.law.L1.mmean.le.3D.gz	NIES.maksyutov.L1.mmean.le.3D.gz
NIRE.taguchi.L1.mmean.le.3D.gz	RPN.yuen.L1.mmean.le.3D.gz
SKYHI.fan.L1.mmean.le.3D.gz	TM2.lsce.L1.mmean.le.3D.gz
TM3.heimann.L1.mmean.le.3D.gz	

7) **2D Monthly Mean Concentrations**

These are binary files containing an array dimensioned as: lon x lat x month (12) x BF (26) x index. For the lon and lat dimensions, check the grid information files above. The "26" is the total number of tracers (4 background + 22 basis functions). The index number refers to either the surface ("1") or the layer above the surface ("2"). Each data file is compressed. All of the data files have been compressed into one zip file which can be downloaded as <**model_results_mmean_2D_all.zip**> from the ORNL DAAC FTP area for TransCom 3, Level 1. The data files are:

CSIRO.cc.L1.mmean.le.2D.gz	CSU.gurney.L1.mmean.le.2D.gz
GCTM.baker.L1.mmean.le.2D.gz	GISS.fung.L1.mmean.le.2D.gz
GISS.prather.L1.mmean.le.2D.gz	GISS.prather2.L1.mmean.le.2D.gz
GISS.prather3.L1.mmean.le.2D.gz	JMA-CDTM.maki.L1.mmean.le.2D.gz
MATCH.bruhwiler.L1.mmean.le.2D.gz	MATCH.chen.L1.mmean.le.2D.gz
MATCH.law.L1.mmean.le.2D.gz	NIES.maksyutov.L1.mmean.le.2D.gz
NIRE.taguchi.L1.mmean.le.2D.gz	RPN.yuen.L1.mmean.le.2D.gz
SKYHI.fan.L1.mmean.le.2D.gz	TM2.lsce.L1.mmean.le.2D.gz
TM3.heimann.L1.mmean.le.2D.gz	

B. Level 1 Inversion Results:

A “control” or “base” case inversion was performed with the Level I model output submissions. The investigators employed a Bayesian synthesis inversion formalism, specifying prior estimates of both the fluxes and their uncertainty, and optimizing with respect to atmospheric observations which are also uncertain.

1) **Output Files**

All the ingredients and the basic inversion output, including basic output files generated by the IDL inverse code, have been compressed into one zip file which can be downloaded as <**inversion_results_invout_all.zip**> from the ORNL DAAC FTP area for TransCom 3, Level 1. The data files are:

File Name	Description
inversion.tar.Z	Inversion output files
outsum.allpre.dat	Model mean posterior fluxes for all 22 basis function regions and regional groupings. Also contains "within" and "between" uncertainties. All presubtraction fields are included.
outmod.allpre.dat	Individual model posterior fluxes and uncertainties.
outgrp.allpre.dat	Individual model results for the regional groupings.

2) **Basic Elements for the Inversion**

a) <u>Data</u>

The inversion is forced with 1992-1996 mean CO_2 concentration data calculated from GLOBALVIEW-CO_2 (2000). This data set encompasses 141 data records from 18 measuring programs including both flask and continuous measurements. Not all sites were operational during the full time period of interest but GLOBALVIEW uses a data interpolation/extrapolation scheme to fill data gaps and provide complete data records at all available observing sites. Since the CO_2 records contain both a trend and a seasonal cycle, the investigators choose here to use this interpolated data in calculating the 1992-1996 mean so that these values are not biased by missing portions of the data record. However the investigators rejected any site where the interpolated data was greater than 30% of the total data. Using this criterion, 76 sites were used in the inversion.

The data uncertainty needs to encompass a number of factors including measurement precision, network intercalibration, and the ability of the model to represent the observation and interannual variability. The investigators found that the inversion is sensitive to the choice of data uncertainty used. While the choice made here for the control inversion is not intended to be optimal, it is designed to incorporate a range of factors that impact the inversion through the data uncertainty specification. Previous inversions have used either constant uncertainties at all sites (with values ranging from 0.3-0.85 ppmv) or uncertainties which scale according to the variability at a site. Here we base the uncertainties on the residual standard deviation (rsd) given in GLOBALVIEW. This is a measure of the variability of individual flask samples around the smooth fitted curve from which the pseudo-weekly GLOBALVIEW data are generated. The rsd values are consequently higher for sites that are close to local, heterogeneous sources where data sets tend to be noisier. This, then, provides a measure of the uncertainty in modeling a particular location since we expect the modeling to be less reliable when close to sources.

The rsd values are modified in a number of ways to create the data uncertainties used here. The investigators describe the process and its justification as a series of steps that were applied to each site.

1. The GLOBALVIEW annual rsd values are averaged over 1992-1996.

2. When the inversion is performed, a data mismatch is generated for each site. The methodology assumes that these mismatches, normalized by the initial data uncertainty for that site, will be normally distributed with mean 0 and standard deviation of 1. Initial tests produced standard deviations that were too small, indicating data uncertainties that were too large. The investigators consequently reduced the rsd values by dividing by the square root of 5 multiplied by the proportion of "real" data contributed to the 1992-1996 mean. This effectively gives extra weight to those sites with more complete data records.

3. This also gives a number of sites with data uncertainties less than 0.3 ppmv. This is unrealistic, both due to intercalibration issues between measuring programs and modeling constraints associated with approximating site locations with grid box average concentrations. The investigators, therefore, set all data uncertainties to a minimum of 0.3 ppmv.

4. Finally, the observational network is spatially heteorogeneous. In the control case the investigators present here, there are some locations with multiple data records and large parts of the globe with no measurements. The investigators make some account for this heteorogeneity by giving less weight (i.e., larger data uncertainty) to data records that are co-located or close to each other, and do this by multiplying the data uncertainty for each site by the square root of the number of data records which are located within 4º latitude and longitude and 1000 m altitude of each other.

The data file used to force the inversion (**datafile.dat**) is included in the <**inversion_code_all.zip> file** (see below). The CO2 station list (**statlocs.dat**) is included in the <**input_data_all.zip**> file and a picture of the stations overlaid on the basis function map (**supp.figure.1.jpg**) in included in the <**basis_function_map_all.zip**> file. All of these files can be downloaded at the ORNL DAAC FTP area for TransCom3, Level 1.

b) Prior Fluxes and Uncertainties:

The prior flux estimates for the terrestrial basis functions represent an average of recent inventory studies.

Table 2. Prior Flux Estimates by Region

Region	Prior Flux (Gt C/year)
North American Boreal	0.0
North American Temperate	-0.2
Tropical America	0.55
South American Temperate	0.0
Northern Africa	0.15
Southern Africa	0.15
Boreal Asia	-0.4

Temperate Asia	0.3
Tropical Asia	0.8
Australia	0.0
Europe	-0.1

The prior flux uncertainties for the terrestrial basis function regions were equivalent to the growing season net flux (GSNF, defined as the sum of carbon uptake for all months in which this was a positive number) as provided by the CASA model of net ecosystem production.

Oceanic prior fluxes are set at zero for each oceanic region. Ocean source uncertainties are based on density of pCO2 measurements and the area of each region.

The prior flux file is included in the compressed file <**inversion_code_all.zip**> (see below).

c) Inversion Code:

The inversion code and related files can be downloaded as <**inversion_code_all.zip**> at the ORNL DAAC FTP area for TransCom3, Level 1. The files are described below:

File Name	Description
transcom.pro	The inversion code used for the Level I inversion.
control.dat	The control file required by the inversion code.
datafile.dat	The data file used to force the inversion.
prior.flux.dat	The prior flux file.

The inversion code used for the Level I inversion was developed by Peter Rayner with further work by Rachel Law and Kevin Gurney. It is written in IDL. In addition to the observational data and the prior flux/uncertainties, this code requires the control file which contains paths to the model response functions (see model output section), direction on which pre-subtracted field to include, and information on regional aggregation.

d) Published Results:

The results from TransCom 3, Level 1 have been published in several journal articles:

- Gurney et al. (2002) report the estimates of surface-atmosphere CO_2 fluxes from the intercomparison of the 16 transport models and model variants.
- Gurney et al. (2003) present results from that same control inversion but for individual models as well as results from a number of sensitivity tests related to the specification of prior flux information.
- Law et al. (2003) present sensitivity tests related to CO_2 data issues including network choice, time period, data selection and data uncertainty.

TransCom 3, Level 1 Output File Format

Output from the Level 1 experiment is formatted as netCDF files. This made central analysis simpler and allowed all participants a common, accessible data set for alternative analyses. The routine for writing Level 1 output to netCDF format is provided in the file <**make.output.l1.f**> at the ORNL DAAC FTP area for TransCom3, Level 1. This is an ASCII file and contains instructions and comments that should make the process of turning binary output into netCDF files.

Naming:

Each participant group submitted a number of data output files. Following the naming convention, these files provide the name of the participant's model and group (or group leader name) in place of "output" (which the netCDF writing routine produced at the beginning of the file name). For example, were Martin Heimann to submit the files containing Level I results using TM3, the file would be named, "TM3.heimann.XXX", where "XXX" is the remainder of the file name that the netCDF writing routine creates upon execution. An indication of the group or group leader is especially important for those models that are used by more than one participant.

Spatial aspects of output:

Three spatial forms were used in the Level 1 experimental output: 3D (x, y, p), 2D (x, y), and single point reporting (wind speed and tracer concentration at a single location).

1) 3D Fields:

3D fields are reported according to the longitudinal and latitudinal dimensions of each participant's model grid. In the vertical, this output was reported on the following pressure levels (in millibars) (not sigma or other model coordinate levels).

100 millibars
200 millibars
300 millibars
400 millibars
500 millibars
700 millibars
850 millibars
925 millibars
1000 millibars

Note that interpolation to pressure coordinates may have been done after time averaging the wind and tracer fields. [9] If a model does not extend to 100 mb, all of the levels listed above that are within the model domain were reported.

Any monthly mean values below the ground were reported as *missing* (see the section on "terrain masking and missing values" below).

This means that the 3D output is presented as arrays of dimension **im** x **jm** x **pm**, where **im** is the number of longitudinal grid cells in a participants model, **jm** is the number of latitudinal grid cell in a participants model, and **pm** is equal to 9 (or the maximum number of layers allowed by the model top), reflecting the pressure levels as designated above.

Following the protocol, the first grid cell of the 3D output:

- *is at the dateline* rather than at Greenwich
- *is at the south pole* rather than the north pole
- *is at 1000 mb* rather than 100 mb

Strict adherence to these conventions helped to simplify the analysis process.

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[9] This has been done for simplicity and in recognition of the limited use of the 3D fields.

2) Maps

2D fields of the bottom two layers are reported according to the longitudinal and latitudinal dimensions of each participant's model grid. This means that the 2D field output is presented as arrays of dimension **im** x **jm**, where **im** is the number of longitudinal grid cells and **jm** the number of latitudinal grid cell in a participant's model.

As with the 3D fields, the first grid cell of the surface maps:

- *is at the dateline* rather than at Greenwich
- *is at the south pole* rather than the north pole

3) Single point reporting:

High frequency wind and tracer concentration are reported at a collection of stations. The names and coordinates of these stations are listed in the file <**statlocs.dat**> which is available for downloading at the ORNL DAAC FTP area for TransCom3, Level 1. Elevation above sea level is provided at each of these stations. Participants used whatever interpolation scheme they deemed appropriate to reflect the elevation.

Temporal aspects of output:

Two reporting time intervals are used in TransCom 3: monthly means associated with the 2D and 3D fields and a time interval determined by each participant's model timestep, associated with the single point reporting. Time is reported in UTC rather than local time.

1) 3D and 2D fields:

All 2D and 3D fields are reported as monthly means. Real, non-leap year month lengths (31, 28, 31 days, etc.) were used.

2) Single point reporting:

All single point fields are reported at a 4 hour timestep or the model timestep if it is longer than 4 hours. Single point fields are reported as instantaneous values rather than 4 hour averages.

Units:

The following units are reported:

- CO_2 concentration values as volumetric mixing ratios (parts per million by volume)

- SF_6 concentrations as volumetric mixing ratios (parts per trillion by volume)
- *u* and *v* winds in meters per second
- *w* wind in pascals/second

Terrain masking and missing values:

Explicit surface terrain masking was not required. However, all monthly mean values that reside on pressure surfaces below the ground (on pressure surfaces exceeding surface pressure) are reported as missing for that month. Missing values are reported as 1.0×10^{36} .

NOTE: monthly mean *b* values are part of the required output - if participants did not included terrain masking, an array filled with zeros was submitted to the output subroutines outlined in the protocol.

For those who included explicit surface terrain masking, the following procedure was followed:

At many locations and at many times of the year, one or more of the reporting pressure levels are below the surface of the Earth. In order to properly report 3D fields at these locations, terrain masking is employed. As shown by Boer (1982), this can be accomplished by keeping careful track of the points above ground using a terrain mask, *b*, and by carefully defining averages only over points above ground. Define *b* on pressure surfaces as

$b = 1$ for $p < p_s$
$b = 0$ for $p >/= p_s$

The representative monthly mean average of a quantity *X* is now defined by

$$\overline{X} = \frac{\overline{\beta X}}{\overline{\beta}}$$

If every timestep of a given month is below the ground, the monthly mean quantity is designated as "missing". Missing values are reported as 1.0×10^{36} .

Required output

1) Pre-subtracted tracers:

- Monthly mean 3D volumetric mixing ratio of the four pre-subtracted tracers from the last simulation year (1990 and 1995 fossil fuel, neutral biosphere, and net oceanic exchange). This represents 48 (4 CO_2 tracers x 12 months) 3D fields. ~6 MB
- Monthly mean volumetric mixing ratio maps (two lowest model layers) of the four pre-subtracted tracers from the last simulation year (1990 and 1995 fossil fuel, neutral biosphere, and net oceanic exchange). This represents 96 (4 CO_2 tracers x 12 months x 2 layers) map fields. ~2 MB

2) Terrestrial and ocean exchange basis functions:

- Monthly mean 3D volumetric mixing ratio of CO_2 for each basis function from the last simulation year for both the oceans and terrestrial basis functions. This represents 264 (22 regions x 12 months) 3D fields. ~35 MB
- Monthly mean volumetric mixing ratio maps (two lowest model layers) of CO_2 for each basis function

from the last simulation year for both the oceans and terrestrial basis functions. This represents 528 (22 regions x 12 months x 2 layers) surface map fields. ~7 MB

3) SF_6 tracers:

- Monthly mean 3D volumetric mixing ratio of SF_6 from the last simulation year for each of 11 terrestrial basis functions. This represents 132 (11 regions x 12 months) 3D fields. ~20 MB
- Monthly mean volumetric mixing ratio maps (two lowest model layers) of SF_6 from the last simulation year for each of 11 terrestrial basis functions. This represents 264 (11 regions x 12 months x 2 layers) surface map fields. ~5 MB

4) Winds:

- Monthly mean 3D fields of *u*, *v*, and *w* for the last simulation year. This represents 36 (3 winds x 12 months) 3D fields. ~5 MB
- Monthly mean surface map fields of *u* and *v* from the last simulation year. This represents 24 (2 winds x 12 months) surface map fields. ~0.4 MB

5) Single Point Reporting:

- High frequency station location reporting for CO_2 surface volumetric mixing ratio, *u*, and *v* from the last simulation year. These data are placed into two arrays, the first containing *u* and *v*, and the second containing the CO_2 mixing ratio for all the separate simulations. A 4 hour timestep is used for reporting this data.[10] The first array comes to (228 stations x 2190 timesteps x 2 winds) ~ 4.1 MB. The second array comes to (228 stations x 2190 timesteps x 26 CO_2 tracers[11]) ~51 MB or a total of ~55 MB.
- A text file containing the latitude, longitude, altitude, model level (or levels interpolated between) and the surface type for each site.

6) $\bar{\beta}$: (for those who computed an explicit surface terrain mask)

- Monthly mean 3D $\bar{\beta}$ values from the last simulation year. This represents 12 (1 b x 12 months) 3D fields. ~1 MB

7) Land/Sea mask

- This represents 1 surface map field. ~0.02 MB

Total ~130 MB

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[10] If the model runs at a timestep longer than four hours, output is reported at that timestep.

[11] This represents the four pre-subtracted tracers (1990 fossil fuel, 1995 fossil fuel, neutral biosphere and net oceanic exchange) plus the 22 basis function (11 terrestrial and 11 ocean).

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Other Relevant Information about the Study:

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