Vulcan Fossil Fuel Carbon Dioxide ($FFCO_2$) Emissions Data Product version 3.0, 0.1deg grid, UTC

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PREAMBLE

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The Vulcan data product represents years of development with support from the National Aeronautics and Space Administration. If you use the Vulcan data product in your research we kindly request that you cite the database and peer-reviewed paper establishing the data product (citations below) and acknowledge the funding agencies that have supported the Vulcan development as follows: "The Vulcan v3.0 data product was made possible through support from NASA grant NNX14AJ20G S07".

FAIR USE DISCLAIMER
The Vulcan data product is an estimation of fossil fuel CO_2 ($FFCO_2$) emissions at fine time and space scales. It should be considered a "climatology" of emissions rather than the "weather" of emissions such that the estimates represent "typical" emissions at a given time and place (average conditions). Hence, it is not appropriate to use the data in comparison to short-term "campaign style" atmospheric measurements (e.g. 5 days of continuous monitoring at a specific location) without consideration and reference to the mismatch between the measurement and the Vulcan estimation approach. Users are encouraged to contact Kevin Gurney for updates and consultation on such potential use. In some instances, we consider it appropriate to include the Vulcan team in publications resulting from use of the Vulcan data product.

SECTORAL COMPOSITION

The Vulcan version 3.0 $FFCO_2$ emissions represent emissions due to the combustion of fossil fuel and cement production in the United States. The emissions are generated using a bottom-up/engineering approach. The data sources lend themselves to categorization by economic sector. The native spatial resolution of the Vulcan $FFCO_2$ emissions data product is a combination of points, lines, and polygons dictated primarily by the underlying data sources. The $FFCO_2$ emissions are placed into a regularized continuous gridded landscape for ease of analysis and incorporation into atmospheric transport modeling efforts. The Vulcan version 3.0 $FFCO_2$ emissions are generated using two time-resolutions: annual and hourly for the 5 year timespan of 2010 to 2015. This particular dataset encompasses emissions for 2010 and 2011 for the total of all sectors (electricity production, onroad, commercial, residential, industrial, nonroad, railroad, cement production, and airport). For individual sectoral emissions, contact Kevin Gurney or Geoff Roest.

DATA FILE NAMES AND FILE STRUCTURE

The annual gridded $FFCO_2$ emissions are written to netCDF format files. The netCDF files contain spatial metadata within the file header and use standard netCDF protocols. The annual netCDF files are

structured with two dimensions representing the longitude ("X"=number of columns) and the latitude ("Y"=number of rows). The hourly output is divided into a series of individual daily netCDF files each representing 24 hours. The emissions in these files are structured with three dimensions representing longitude ("X"=number of columns), latitude ("Y"=number of rows), and time ("T"=number of hours). These files are contained within an archived (tarball) file whose name consists of five parts, the sector (total only for this dataset), the location (Contiguous US or Alaska), the year, the extension "hourly.UTC", and the subset of daily files (1 through 5). For example, "total.AK.2010.hourly.UTC.1.tar" represents the "total" FFCO2 emissions for Alaska in 2010 for the first subset of daily files. The 365 daily files were split into 5 "groups" of 73 days to keep filesizes reasonable. The "groups" correspond to the following days within each year, as shown in Table 1.

Table 1. *File name group numbers and the daily files contained within.*

Group number	Start day	End day
1	1	73
2	74	146
3	147	219
4	220	292
5	293	365

Within each tarball file, each daily file is named with the day number - e.g., January first is named "d001.nc" while December 31st is named "d365.nc". The hourly emissions within each daily file correspond to the UTC hour - e.g., Emissions during the 12th hour (11 - 12 UTC) of December 31st are in the 12th temporal layer of "d365.nc".

GRID DOMAIN AND UNITS

The United States (U.S.) is divided into two spatial domains, the Contiguous U.S. and Alaska with separate filesets for each domain. Table 2 shows the spatial extent, resolution and dimensions of the Contiguous U.S. and Alaska grid domains. The spatial units are in WGS84 spherical coordinates (degrees). The grid cell center coordinates (longitude/latitude) are listed within each netCDF file under the attributes 'X' and 'Y'. The units associated with the spatial dimensions and emissions are also provided within the netCDF files. The $FFCO_2$ emissions units are in metric tons of carbon (tC).

Table 2. *Spatial domain definitions for the gridded Vulcan V3.0 $FFCO_2$ emissions.*

Parameter	Contiguous U.S.	Alaska
Grid resolution	0.1	0.1
Minimum longitude (west)	-125.1	-179.5
Minimum latitude (south)	24.2	51
Maximum longitude (east)	-66.9	-129.9
Maximum latitude (north)	49.5	71.6
Number of columns	582	496
Number of rows	253	206

CHECKSUMS

To ensure correct interpretation and processing of the Vulcan version 3.0 results, Table 3 provides totals for the two domains and across the economic sectors.

Table 3. *Checksum $FFCO_2$ emission values for the two Vulcan V3.0 domains and economic sectors.*

Year	Contiguous U.S. (MtC)	Alaska (MtC)	Total (MtC)
2010	1624.08523	8.12769	1632.21292
2011	1574.47639	8.81509	1583.29149