Vulcan Fossil Fuel Carbon Dioxide ($FFCO_2$) Emissions Data Product version 3.0, 1km grid, ACES domain

Updated: June 9, 2020

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PREAMBLE

FUNDING ACKNOWLEDGEMENT

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. The dataset reported here encompasses annual 2011 emissions for all sectors (electricity production [elec_prod], onroad, commercial, residential, industrial, nonroad, railroad, commercial marine vessels [cmv], cement production, and airport) in the same domain as the ACES $FFCO_2$ data product (1, 2). The 95% confidence inverval for Vulcan emissions have been estimated using a combination of uncertainties for input values and are discribed in detail in the Vulcan v3.0 core manuscript. The "central" or "mean" estimate emission files are denoted with the abbreviation "mn", while the high and low bounds for the 95% CI are denoted with "hi" and "lo", respectively.

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 file name consists of three parts: the sectors, the uncertainty (hi, lo, or mn), and the year.

GRID DOMAIN AND UNITS

These Vulcan data are in the same grid as the ACES data product, which covers the northeastern United States. Table 1 shows the projection information and Table 2 shows the spatial extent, resolution and dimensions of the grid domain. The spatial units are in meters. The grid cell center coordinates (longitude/latitude) are listed within each netCDF file under the attributes ‘X’ and ‘Y’. The $FFCO_2$ emissions units are in metric tons of carbon (tC). The CRS string is "+proj=lcc +lat_1=33 +lat_2=45 +lat_0=40 +lon_0=-97 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs +ellps=WGS84 +towgs84=0,0,0".

Table 1. *Projection information for the gridded Vulcan V3.0 FFCO$_2$ emissions.*

Parameter	**Value**
Datum	WGS84
Projection	Lambert Conformal Conic
Units	Meters
Longitude of origin	-97
Latitude or origin	40
Ref. Latitude 1	33
Ref. Latitude 2	45
False easting	0
False northing	0

Table 2. *Spatial domain definitions for the gridded Vulcan V3.0 FFCO$_2$ emissions.*

Parameter	**Value**
Grid resolution	1 km
Minimum longitude (west)	1352000 m
Minimum latitude (south)	-272000 m
Maximum longitude (east)	2334000 m
Maximum latitude (north)	1160000 m
Number of columns	982
Number of rows	1432

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.*

Sector	Low (MtC)	Mean (MtC)	High (MtC)
Airport	2.50	3.23	4.33
Cement	1.61	1.79	1.97
CMV	3.85	5.65	8.46
Commercial	21.34	22.18	23.45
Elec_prod	84.97	98.42	111.95
Industrial	23.92	31.09	41.84
Nonroad	10.46	10.99	11.60
Onroad	70.27	81.90	93.53
Rail	0.79	0.98	1.27
Resedential	29.45	29.45	29.47
Total	249.16	285.69	327.88

REFERENCES

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3. Gurney, K.R., J. Liang, R. Patarasuk, Y. Song, J. Huang, G. Roest (2020) The Vulcan Version 3.0 High-Resolution Fossil Fuel CO2 Emissions for the United States. Under review at *Journal of Geophysical Research: Atmospheres*.