Methane Emissions from Dairy Sources (Vista-CA), State of California, USA, 2019

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Documentation Revision Date: 2021-06-28

Dataset Version: 1.2

Summary

This dataset provides estimates of methane (CH4) emissions from dairies in California at a resolution of 0.1 degrees (~ 10 km x 10 km) for the year 2019. The mapped sources of dairy CH4 emissions are enteric fermentation and manure management reported in gigagrams per square km per year (Gg km-2 y-1). The sum of the two sources is also provided. These data are in the succession of Vista California (Vista-CA) spatial datasets that have identified and classified potential methane source emitters in California and were created utilizing an assortment of publicly available data sources from local, state, and federal agencies. This dataset can serve as a planning tool for mitigation, a prior for atmospheric observation-based emissions estimates, attribution of emissions to a specific facility, and to validate CH4 emissions reductions from management changes.

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Version 1.2 reflects the latest information on dairy facilities as described in Marklein et al. (2021) and supersedes Version 1.1. See Section 8 for details.

The dataset includes 3 data files in GeoTIFF (*.tif) format.

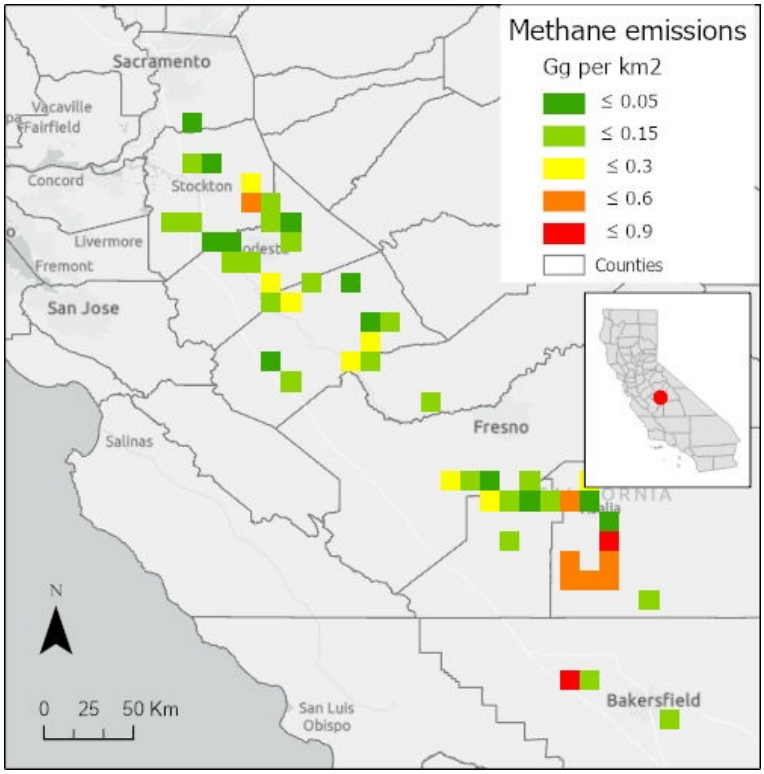

Figure 1. Total methane emissions from dairy farms in the central valley of California, USA, in 2019. Inset below legend shows the location of this area within the state. Source: total_CH4_Gg_km2.tif

Citation

Marklein, A.R., D. Meyer, M.L. Fischer, S. Jeong, T. Rafiq, M. Carr, and F.M. Hopkins. 2021. Methane Emissions from Dairy Sources (Vista-CA), State of California, USA, 2019. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1902

Table of Contents

1. Dataset Overview

This dataset provides estimates of methane (CH_4) emissions from dairies in California at a resolution of 0.1 degrees (~ 10 km x 10 km) for the year 2019. The mapped sources of dairy CH_4 emissions are enteric fermentation and manure management reported in gigagrams per square km per year (Gg km^{-2} y^{-1}). The sum of the two sources is also provided. The data were derived from information from operating permits and California-specific reports detailing herd demographics and manure management at the facility scale.

These data are in the succession of Vista California (Vista-CA) spatial datasets that have identified and classified potential methane source emitters in California and were created utilizing an assortment of publicly available data sources from local, state, and federal agencies. This dataset can serve as a planning tool for mitigation, a prior for atmospheric observation-based emissions estimates, attribution of emissions to a specific facility, and validate CH_4 emissions reductions from management changes.

Project: North American Carbon Program

The North American Carbon Program (NACP) is a multidisciplinary research program designed to improve understanding of North America's carbon sources, sinks, and stocks. The central objective is to measure and understand the sources and sinks of Carbon Dioxide (CO_2), Methane (CH_4), and Carbon Monoxide (CO) in North America and adjacent oceans. The NACP is supported by a number of different federal agencies.

Related Publication

Marklein, A.R., D. Meyer, M.L. Fischer, S. Jeong, T. Rafiq, M. Carr, and F.M. Hopkins. 2021. Facility-scale inventory of dairy methane emissions in California: implications for mitigation. Earth System Science Data 13:1151–1166. https://doi.org/10.5194/essd-13-1151-2021

Related Datasets

Carranza, V., T. Rafiq, I. Frausto-Vicencio, F. Hopkins, K.R. Verhulst, P. Rao, R.M. Duren, and C.E. Miller. 2018. Sources of Methane Emissions (Vista-LA), South Coast Air Basin, California, USA. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1525

Hopkins, F.M., T. Rafiq, and R.M. Duren. 2019. Sources of Methane Emissions (Vista-CA), State of California, USA. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1726

Marklein, A.R., D. Meyer, M.L. Fischer, S. Jeong, T. Rafiq, M. Carr, and F.M. Hopkins. 2021. Methane Emissions from Dairy Sources (Vista-CA), State of California, USA, 2019. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1882

- Version 1.1 and initial Version 1.0 of the current dataset were both published as separate versions of this dataset. Both versions are now superseded.

Thorpe, A.K., B.D. Bue, D.R. Thompson, and R.M. Duren. 2019. Methane Plumes Derived from AVIRIS-NG over Point Sources across California, 2016-2017. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1727

Acknowledgments

This work was supported by the University of California Office of the President (grant LFR-18-548581) and NASA's Advancing Collaborative Connections for Earth System Science (ACCESS) Methane Source Finder (grant 15-ACCESS15-0034). The authors acknowledge the dairy farmers who provided information to the permits and reports, as well as the San Joaquin Valley and Santa Ana Air Quality Control Boards, California Integrated Water Quality System, and Regional Water Quality Control Boards.

2. Data Characteristics

Spatial Coverage: California, USA

Spatial Resolution: 0.1 degree (10 km)

Temporal Coverage: 2019-01-01 to 2019-12-31

Temporal Resolution: One-time annual estimate

Study Area: Latitude and longitude are given in decimal degrees.

Site	Northernmost Latitude	Southernmost Latitude	Easternmost Longitude	Westernmost Longitude
California	42.25	32.25	-114.15	-124.45

Data File Information

There are 3 data files in GeoTIFF (*.tiff) format. Files are named **X**_CH4_CA_2019.tif, where **X** is the variable of interest (i.e., "enteric", "manure", "total").

Table 1. File names and descriptions.

File Names	Units	Description
enteric_CH4_CA_2019.tif	Gg km^{-2} y^{-1}	enteric fermentation methane (CH_4) emissions (in gigagrams per square km per year) from dairy farms in California
manure_CH4_CA_2019.tif	Gg km^{-2} y^{-1}	manure management methane (CH_4) emissions (in gigagrams per square km per year) from dairy farms in California

total_CH4_CA_2019.tif	Gg km^{-2} y^{-1}	the sum of manure management and enteric fermentation methane (CH_4) emissions (in gigagrams per square km per year) from dairy farms in California

Data File Details

For all files,

- The data type is Float32.
- Missing values are represented by "-9999".
- Each file contains 92 rows and 90 columns.
- The projection used is "WGS 84" (EPSG:4326).

3. Application and Derivation

Dairies emit roughly half of total CH_4 emissions in California, generating CH_4 from enteric fermentation by ruminant gut microbes and anaerobic decomposition of manure. Representation of these emission processes is essential for the management and mitigation of CH_4 emissions and is typically done using standardized emission factors applied at large spatial scales (e.g., state-level). However, CH_4-emitting activities and management decisions vary across facilities, and current inventories do not have a sufficiently high spatial resolution to capture changes at this scale. In addition to serving as a planning tool for mitigation, this dataset is useful as a prior for atmospheric observation-based emissions estimates, attribution of emissions to a specific facility, and to validate CH_4 emissions reductions from management changes.

4. Quality Assessment

To estimate facility-scale uncertainty for enteric fermentation emissions, the standard error in dry matter intake, neutral detergent fiber, milkfat were calculated. The facility-scale uncertainty in manure management emissions was estimated by propagating uncertainty in terms of the number of cows, the fraction of time on concrete, volatile solids production, the methane conversion factor (MCF), and the fraction of material used as bedding. The standard error of each variable was determined through the emissions calculation equations, assuming the errors were uncorrelated.

5. Data Acquisition, Materials, and Methods

Vista-California

Vista-CA spatial datasets identify and classify potential methane source emitters in California. Vista-CA spatial datasets were created utilizing an assortment of publicly available data sources ranging from local, state, and federal agencies. See Marklein et al. (2021) for details.

Methane Emissions from Dairies

This dataset provides spatial data products with enteric fermentation and manure methane emissions from dairies in California. Dairies emit roughly half of total methane (CH_4) emissions in California, generating CH_4 from both enteric fermentation by ruminant gut microbes and anaerobic decomposition of manure. Representation of these emission processes is essential for the management and mitigation of CH_4 emissions and is typically done using standardized emission factors applied at large spatial scales (e.g., state-level). However, CH_4-emitting activities and management decisions vary across facilities, and current inventories do not have sufficiently high spatial resolution to capture changes at this scale. To create this data set, California Air Resources Board (CARB) inventory data were disaggregated to the facility level by 1) developing a spatially-explicit map of dairy locations, 2) applying facility-level information from regulatory permit data and county-level animal inventories to estimate herd sizes; and 3) estimating enteric and manure CH_4 emissions from dairy facilities based on manure management from permit data and regional norms.

Data Sources

Google Earth satellite imagery was used to determine the locations of 1,330 dairy farms in California, by identifying metal-topped shelters alongside manure lagoons and corrals (Duren et al., 2019).

Data from three sources were used to estimate herd numbers and demographic categories at each dairy. First, the Regional Water Quality Control Board reports provided the number of milk cows, dry cows, heifers, and calves for dairies in the Central Valley and Southern California for the year 2005 (RWQCB, 2013). Second, San Joaquin Valley Air Pollution Control Board permits include the maximum number of cattle in each class at a given facility, based on facility housing in 2011, rather than the number of animals (SJVAPCD, 2004). Third, the 2017 US Department of Agriculture (USDA) National Agricultural Statistics Survey (NASS) provided the number of farms and the number of cows in different dairy size classes in each county (USDA NASS, 2017).

Estimates of enteric fermentation CH_4 emissions were based on calculations by Appuhamy et al. (2019). Enteric emissions included the number of cattle, dry matter intake, neutral detergent fiber in the diet, and milk fat. Manure management emissions were estimated using equations by the California Air Resources Board to the facility level (CARB, 2014), data from the San Joaquin Valley Air Pollution Control District permits (SJVAPCD, 2004), animal management data (Meyer, 2019), and regional differences in manure management.

Analysis

Results were aggregated to a resolution of 0.1 degrees to protect the identity and characteristics of dairy farms. Dairy locations are available in Carranza et al. (2018b) (for South Coast Air Basin) and Hopkins et al. (2019) (state-wide). Three methods were used to estimate emissions from manure management and enteric fermentation. Uncertainty was evaluated for each estimation method. For more information, refer to Marklein et al. (2021).

Uncertainty Analysis

The statewide uncertainty for enteric emissions was 7.4%–20%, depending on the estimation method. The facility-level standard errors for enteric fermentation ranged 21.3%–35.6% and were most sensitive to dry matter intake, followed by the number of animals.

The statewide uncertainty in manure management emissions ranged from 9.7%–32.7%, depending on the calculation method. The statewide uncertainty was most sensitive to the lagoon methane conversion factor, followed by the number of animals, and the fraction of manure allocated to bedding. The facility-level uncertainty was 47.8%–73.5%.

The total uncertainty in CH_4 emissions at the facility scale was 35.6%; 81.9% of the uncertainty was due to uncertainty in manure emissions, while 18.1% of the uncertainty was due to enteric emissions.

6. Data Access

These data are available through the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

Methane Emissions from Dairy Sources (Vista-CA), State of California, USA, 2019

Contact for Data Center Access Information:

- E-mail: uso@daac.ornl.gov
- Telephone: +1 (865) 241-3952

7. References

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8. Dataset Revisions

Version	Release Date	Revision Notes	DOI
1.2	2021-06-28	Data values in the GeoTIFFs were revised after the release of Version 1.1. Version 1.2 reflects the latest information on dairy facilities (1,330 dairies) as described in Marklein et al. (2021).	https://doi.org/10.3334/ORNLDAAC/1902
1.1	2021-03-23	Version 1.1 estimates are based on fewer dairies, 1,326, compared to 1,727 dairies used for Version 1. Also, the number of cows at each of the facilities has also changed (increased or decreased) as more accurate information was obtained. Version 1.1 is now superseded by Version 1.2., and is available upon request only.	https://doi.org/10.3334/ORNLDAAC/1882
1.0	2020-09-23	Initial Release. Now superseded by Version 1.2, and available upon request only.	https://doi.org/10.3334/ORNLDAAC/1814