Identifying Methane Emissions Patterns from Dairy Farms Using Aircraft Remote Sensing Observations and Image Classification

Abstract

Methane (CH_4) is a potent greenhouse gas (GHG) with a lifetime of less than 10 years and a global warming potential that is 25 times greater than carbon dioxide (CO_2) over a 100 year time period. Between the energy, industrial processes and product use, agriculture, and waste sectors, the majority of CH_4 emissions in the United States come from the agriculture sector. Within this sector, enteric fermentation by domestic livestock and manure management are the largest sources of emissions. California is the leading dairy producer in the United States, and thus enteric fermentation and manure management make substantial contributions to the state's CH_4 budget. Furthermore, a number of studies suggest that EPA bottom-up methodologies are underestimating CH_4 emissions in many regions across California. Total number, location, size, and manure management infrastructure of dairy farms throughout the state is also uncertain. Given these uncertainties, in addition to dairy production's large contribution to CH_4 emissions, its industrialization, and the need to more accurately account for and understand CH_4 emissions, we located and inventoried dairy farms across California's Central Valley using RapidEye imagery and object-based image analysis. We used the resulting classifications to create a spatial dataset of dairy farms and used it to help interpret AVIRIS-NG and HyTES CH_4 plume data collected over the dairy farms. This will ultimately provide insight into an important source of CH_4 and help policy makers, dairy farmers, and management officials make more informed decisions on how best to mitigate CH_4 emissions within the state of California.

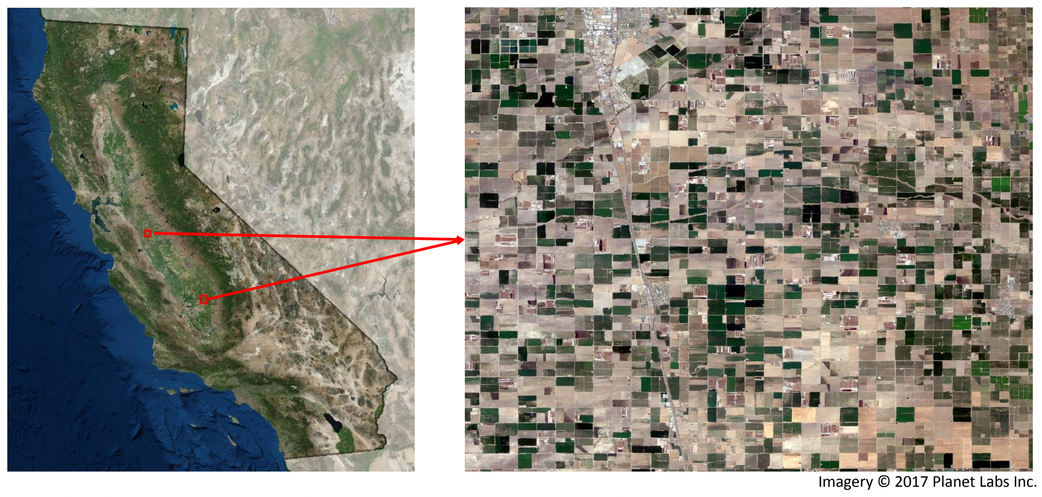
Project Partners

California Environmental Protection Agency, Air Resources Board

Objectives

- **Identify** which satellite observations or data products work best to classify and study dairies
- **Develop** a survey of emissions data over dairy regions
- **Create** a GIS dataset of dairy farms to better understand facility-level activities that lead to methane emissions
- **Assist** the California Environmental Protection Agency, Air Resources Board in improving their inventory of dairies and understanding their emissions

Study Area



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Study Area: Tulare and Turlock regions in California
Study Period: January 2014 – August 2017

Earth Observations

Satellites

- RapidEye

Airborne Sensors

- AVIRIS-NG
- HyTES

Team Members

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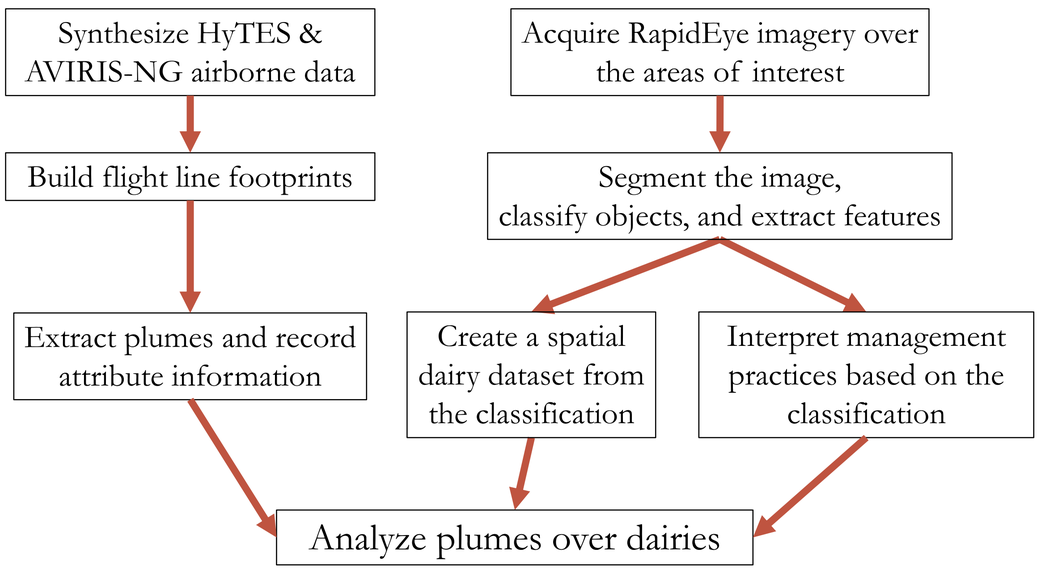
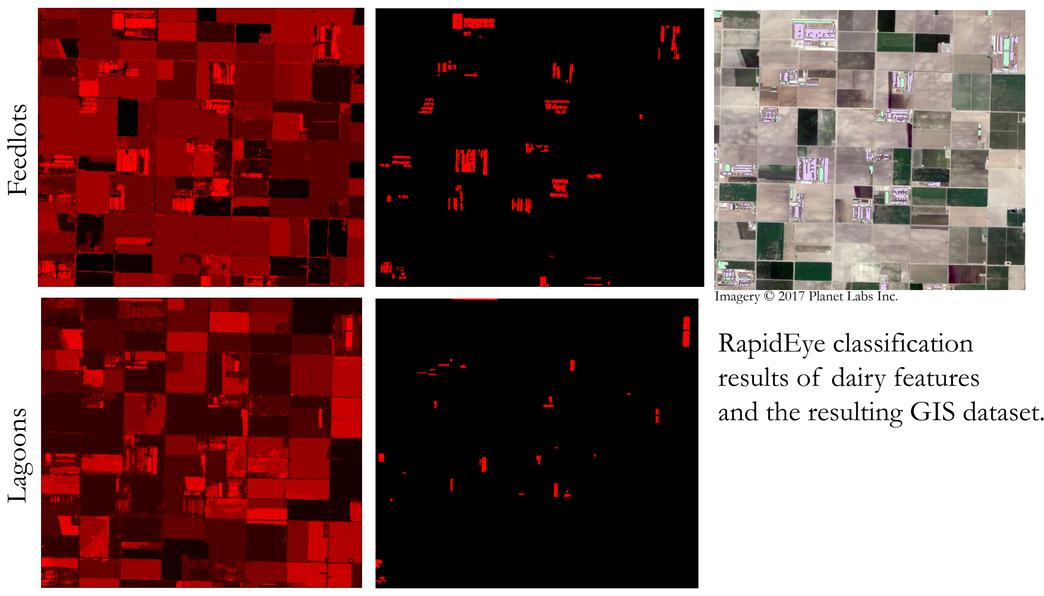
Methodology



Results



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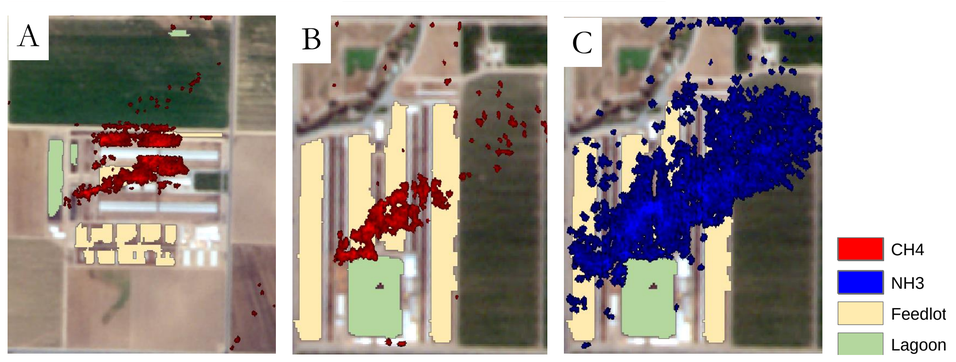
RapidEye classification results of dairy features and the resulting GIS dataset.



Methane and ammonia plume retrievals overlaid with the dairy classification dataset. (A, B) Methane being emitted from lagoons. (C) Ammonia being emitted from feedlots and lagoon. B and C are the same dairy.

Conclusions

- High resolution imagery is required for classifying features on dairies. We found that feature extraction is a suitable method for identifying dairy features.
- Current satellites lack the ability to accurately measure near-surface facility level GHG emissions. However, they can help us pinpoint regional hotspots which we can then further analyze with aircraft data.
- There need to be more HyTES and AVIRIS-NG flights in order to fully understand emissions from dairies, as well as how those emissions vary over time.
- Future satellites with greater sensitivity and higher resolution will help us better understand surface level emissions at higher temporal frequency and spatial extent than aircraft data.

Acknowledgements

Dr. Kristal Verhulst, NASA JPL
Dr. Charles Miller, NASA JPL
Dr. Francesca Hopkins, University of California Riverside
Talha Rafiq, UCLA Joint Institute for Regional Earth System Science and Engineering, NASA JPL
Nick Rousseau, NASA DEVELOP National Program, JPL Center Lead
Ben Holt, Jet Propulsion Laboratory, California Technical Institute

NASA Jet Propulsion Laboratory – Summer 2017

This material is based upon work supported by NASA through contract NNL16AA05C and cooperative agreement NNX14AB60A. Any mention of a commercial product, service, or activity in this material does not constitute NASA endorsement. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Aeronautics and Space Administration and partner organizations.

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