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Los Angeles Health and Air Quality

Identifying Urban Emission Patterns in the Los Angeles Megacity

**Technical Report** 

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# I. Abstract

**Keywords**

Remote Sensing, Global Warming, Greenhouse Gas emissions, Methane, Spatial Analysis, Megacity

# II. Introduction

Global warming and climate change pose one of the greatest threats to human civilization today. Global warming refers to the rise in average temperature of Earth’s climate. This phenomenon has caused an imbalance in the Earth’s climate equilibrium over the 20th and 21st centuries through the accelerated influx of anthropogenic greenhouse gases (GHG) in the atmosphere. GHGs absorb and emit radiation and accordingly warm the atmosphere enough allowing for complex life to exist on the surface. The increased industrialization and urbanization of the world over the past several decades has exponentially accelerated the abundance of GHGs, such as carbon dioxide (CO2) and methane (CH4) (Gurney et al. 2012). As a result, Earth’s average temperature was projected to increase by about 5 °C by 2100, if policies to slow down emissions of CO2 and CH4 are not efficiently acted upon.

Cities around the world produce roughly 70% of anthropogenic GHG emissions (Kort et al. 2012). As city and megacity populations are expected to double in the next few decades, the increasing concentration of greenhouse gases will only intensify within the next coming decades. The term megacity describes a metropolitan area that contains a population in excess of ten million people. As of 2015, there are 27 megacities in the world. Los Angeles, California, with a population well over 18 million, is the 16th largest megacity in the world and second to New York City in the United States. The Los Angeles megacity dominates 43% of the state’s greenhouse gas (GHG) emissions while only covering 4% of the state’s land area (Wong et al. 2014). This stark difference in land area versus emission generation is extremely indicative of the negative anthropogenic effect megacities have on the Earth’s atmosphere. As the effects of global warming disrupt the economy and cause food and water shortages, the pressure on local and state governments will undoubtedly increase. Therefore, enacting appropriate legislation and policies, based on accurate and verified research that can curb the rate of GHG emissions to lessen the impact of global warming is the first step in addressing this issue. By 2020, California’s Global Warming Solutions Act of 2006 mandates that GHG emissions reduce to 1990 levels. This can only be possible through a systematic understanding of GHG emission sources in the Los Angeles megacity. We determined spatiotemporal trends to inform the specifics of GHG point sources in the region which can ultimately inform policy makers on how to accurately reduce GHG emissions.

The Los Angeles Health and Air Quality team’s research primarily focused on the Los Angeles Basin. Specifically, this research analyzed CH4 emissions in the South Coast Air Basin (SoCAB) for 2011/2012. SoCAB extends 6600 square miles over portions of Los Angeles County, Orange County, Riverside County, and San Bernardino County which encompass the Los Angeles megacity in Southern California. CH4 is one of the primary GHGs in Earth’s atmosphere and its radiative effect is about 72 times stronger than CO2. The contribution of CH4 direct radiative effect to climate change and global warming doubles that of past estimates (Shindell et al. 2005). In order to effectively reduce CH4 point source emissions, CH4 needs to be accurately quantified and spatially analyzed.

The end-goal was to develop a spatial product of CH4 emissions in the SoCAB region. Ultimately, this study served as a starting point for similar collaborations between the Megacities Carbon Project and CARB. Emission factors can be collected and studied with spatial data for higher level assessment and analysis. This research also attempted to prove that these spatial-based end products can be a viable and accurate solution to their existing library of methods, analysis, and products. Increased accuracy can help them better quantify and understand GHG emission distributions in the state of California and potentially across the globe.

# III. Methodology

To accurately develop a spatial inventory of CH4 patterns in the South Coast Air Basin (SoCAB), data we systematically collected, processed, reviewed, and analyzed using geoprocessing and spatial-based analytical toolsets in Esri ArcGIS 10.3.

First, different sources of spatial layers and data that symbolize CH4 emission sources were collected, processed, standardized, and analyzed. These datasets included California Air Resources Board (CARB) emission inventories, California Greenhouse Gas Emissions Measurements Project (CALGEM) data, Emissions Database for Global Atmospheric Research (EDGAR 4.2) data, and publically available spatial datasets of CH4 emission sources such as the U.S. Energy Information Administration (EIA), the Southern California Association of Governments (SCAG), and the United States Geologic Survey (USGS). We estimated emission factors for each CH4 related spatial layer using the expertise from the JPL climate and science advisors and CARB partners. Finally, we used the data to create raster-based maps of the spatial distribution of CH4 emissions in the SoCAB. We used the GHG inventory created in this project for use in future simulations like the Weather Research and Forecasting (WRF) Model for GHG emissions and the Large Eddy Simulation (LES) for quantifying CH4 emissions in the SoCAB.

***Ancillary Data Acquisition:***

We located and collected three main types of data for this project including vector, tabular, and raster datasets that related to the CH4 point source emissions. All vector datasets included point, line, and polygon spatial layers of different CH4 emission source features located within the SoCAB region. We obtained raster datasets that encompassed aerial imagery of California, raster-based emissions inventory of CO2, CO, and CH4 from the Environmental Protection Agency (EPA) and the California Air Resources Board (CARB). Lastly, we collected tabular data that contained CH4 emission factors from CARB to incorporate with our spatial data and downloaded it into private file geodatabases. It was then further processed and reviewed for validity. TABLE 1 (Appendix IX) shows the specific breakdown of each dataset categorized by information such as type, year, and source.

***Data Processing and Review:***

Because of the nature of the data collection as described in TABLE 1, we had to process and standardize the different spatial datasets so we could utilize them in a cohesive and well integrated manner. Using ArcGIS, we conducted these tasks in three steps: georeferencing, spatial configuration, and verification.

Georeferencing is the process of projecting all the datasets into the same datum and coordinate system. This prevents any errors caused by incomplete spatial information and ensures that any type of spatial analysis will yield accurate results. For all spatial vector and raster layers, we used the World Geodetic System 1984 datum and accordingly, we used the Universal Transverse Mercator Zone 11 North coordinate system. All datasets were either defined projections using the “Define Projection” tool or were re-projected using the “Project” tool in ArcGIS.

Spatial configuration entailed matching all extents to the SoCAB boundary so that excess data would not affect the speed and efficiency of the spatial analysis. As listed in TABLE 1, the extents for the datasets varied based on the source they were collected from. Thus all datasets had to be spatially adjusted so that they were overlayed properly and completely fitted within the SoCAB boundary layer. We did this using the “Clip” tool in ArcGIS.

All collected datasets had to be verified to maintain accuracy and maximize the potential of the data analysis to provide viable results. Consequently, we obtained aerial imagery of California from the U.S. Department of Agriculture’s 2012 National Aerial Imaging Program. This was 1m x 1m raster-based imageset which we used to verify the locations of different features such as landfills, water treatment plants, and livestock dairies. Additionally, we utilized aerial imagery from Google Earth to verify that the vector layers were indeed in the correct locations. We edited the vector datasets where appropriate, using the “Editor” toolbar in ArcGIS, so that they only included features that existed around 2012.

Data Analysis:

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* Use CARB’s GHG inventory for 2011 and 2012 to quantify CH4 by sectors in order to determine which sectors are most important to research for CH4 emissions
* Add emission factors from CARB to the spatial data
* Develop a raster-based representation of CH4 distribution
* Make comparisons to other raster-based maps gathered from different emission factor sources or other NASA Earth observation datasets

# IV. Results & Discussion

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# V. Conclusions

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# VI. Acknowledgments

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# VII. References

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# VIII. Content Innovation

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# IX. Appendix

TABLE 1 (Red = unverified data):

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| --- | --- | --- | --- | --- |
| **Name** | **Type** | **Year** | **Extent** | **Source** |
| Commercial Buildings | Vector - Points | 2011/2012 | SoCal | Hestia |
| Commercial Sectors | Vector - Polygon | 2011/2012 | SoCal | Hestia |
| Geologic Seeps | Vector - Polygon | 2009 | California | United States Geological Survey |
| In situ network | Vector - Points | 2015 | SoCAB and surrounding areas | NASA Jet Propulsion Laboratory Climate & Atmosphere Science Department |
| Industrial Buildings | Vector - Points | 2011/2012 | SoCal | Hestia |
| Industrial Sectors | Vector - Polygon | 2011/2012 | SoCal | Hestia |
| Landfills | Vector - Polygon | 2005/2012 | SoCAB / LA County | Southern California Association of Governments (SCAG) Land Use / Los Angeles County GIS Portal |
| Landuse LA County | Vector - Polygon | 2009 | LA County | Los Angeles County GIS Portal |
| Landuse San Bernardino County | Vector - Polygon | 2012 | San Bernardino County | San Bernardino Associated Governments (SANBAG) GIS Portal |
| Livestock Dairies | Vector - Polygon | 2005 | SoCal | Southern California Association of Governments (SCAG) Land Use |
| Natural Color Aerial Imagery | Raster | 2012 | California | United States Department of Agriculture National Agricultural Imagery Program |
| Natural Gas Fueling Stations | Vector - Points | 2012 | United States | United States Department of Energy - The Alternative Fuels Data Center |
| Natural Gas Pipeline | Vector - Line | 2013 | California | National Pipeline Mapping System (NPMS) |
| Oil Wells | Vector - Points | 2014 | California | California Department of Conservation (CDC) |
| Power Plants (Electric) | Vector - Points | 2011/2012 | SoCal | Hestia |
| Power Plants (Natural Gas) | Vector - Points | 2011/2012 | SoCAB | NASA JPL Climate & Atmosphere Science Department Hestia? |
| Power Plants (Other) | Vector - Points | 2011/2012 | SoCAB | NASA JPL Climate & Atmosphere Science Department Hestia? |
| Refineries | Vector - Points | 2006 | LA County | Environmental Protection Agency (EPA)  in conjunction with the Conservation Biology Institute |
| Southern California Air Basin Boundary | Vector - Polygon | 2015 | SoCAB | Air Resources Board (ARB) GIS Portal |
| Vehicle Emissions | Vector - Line | 2011/2012 | SoCAB | Hestia |
| Water Treatment Plants | Vector - Polygon | 2005 | California | Southern California Association of Governments (SCAG) |
| Wetlands | Vector - Polygon | 2015 | California | U.S. Fish & Wildlife Service |
| Breakout Tanks | Vector - Points | 2013 | California | National Pipeline Mapping System (NPMS) |
| Liquid Natural Gas Stations | Vector - Points | 2012 | United States | U.S. Department of Energy - The Alternative Fuels Data Center |