CLIMATE & CLEAN AIR COALITION
TO REDUCE SHORT-LIVED CLIMATE POLLUTANTS

Technical report on the development of the

Global Gas Flaring Web Platform

Oil and Gas Initiative of the Climate and Clean Air Coalition (CCAC)

Prepared for the CCAC Oil and Gas Initiative
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1. INTRODUCTION

1.1 Background

The following report describes the technical development of a web platform for visualising global flaring activity. Flaring of associated gas by the oil and gas industry is still a major environmental issue despite recent global initiatives to reduce levels of routine flaring to zero by 2030. According to the World Bank, gas flares at oil production sites around the globe burn approximately 140 billion cubic meters of natural gas annually, causing more than 350 million tons of Carbon Dioxide (CO_2) to be emitted to the atmosphere (World Bank, 2015). The Global Gas Flaring Web Platform has been produced by this project for the CCAC Oil and Gas Initiative's Technology Demonstration Project, and is available via its website (oag.sei-international.org), in order to provide an overview of global flaring activity, complementing other data sources on flaring available elsewhere on the web and containing additional information related to potential reductions in flaring emissions and in particular black carbon (BC).

At the start of this project an extensive data search conducted on the internet yielded only limited global coverage of flaring and its associated impacts, as the location of flaring is seldom reported or mapped by companies or countries themselves. Detailed national datasets are limited to just a few countries. Until recently data on national gas flare volumes were only available up to 2011. These were produced by the World Bank's Global Gas Flare Reduction (GGFR) Partnership and used older satellite technology that was available at the time. Recently, the US National Oceanic and Atmospheric Administration (NOAA) has published flaring data for 2012-2014 based on data from a newer satellite sensor which has improved spatial resolution and spectral sensitivity and uses a refined algorithm to detect flaring. Therefore, due to the paucity of data at a global level there is a need to combine a range of different data sources to provide the user with an overall appreciation of where flaring is taking place and the potential impact of this on people and the environment. Therefore, the purpose of the platform developed for the Oil and Gas Initiative is to enable stakeholders to:

1. gain an overview of the scale, location and impact flaring and venting has at a global dimension;
2. visualise the changing situation – spatial and temporal;
3. assess the exposure of people and the risk to health;
4. examine national data.

The platform has also been set up to monitor progress of the Zero Routine Flaring Initiative launched by the World Bank in 2015 (http://www.worldbank.org/en/programs/zero-routine-flaring-by-2030).

The sources of data used to develop the platform are listed at the end of this report and include a number of existing platforms that show different aspects related to oil and gas production including national flare detection and global flaring assessments.

2. TECHNICAL DEVELOPMENT OF THE PLATFORM

2.1 Technical specification

The platform architecture is built on an open source Geographic Information System (GIS) stack and is designed to be cross-browser compliant. The whole system runs on CentOS Linux (centos.org) and data is stored in a PostgreSQL database with a PostGIS extension, which adds support for spatial data and location queries. The platform uses Geoserver (geotools.org), which is a Java-based software server enabling users to display and interact with spatial data via different user interfaces using the OpenLayers mapping library (openlayers.org) and other plugins and tools such as Geotools (www.geotools.org). GeoServer (geoserver.org) is used to display the data over the web and transfer data directly to the user's browser if needed. It complies with common web-based GIS standards, including Web Map Service (WMS) and Web Feature Service (WFS).

The website's logics are written in PHP code and served by the Apache web server. On the client side, the web interface displays images and data from GeoServer using Mapbox (mapbox.com), which also provides the base maps and enables user interactions. Time series data are visualized as appropriate charts using Google Chart Application Programming Interface (API, developers.google.com/chart). These are currently displayed as line graphs due to the nature of the data being shown but it will be possible to use alternative data representations in future applications. Figure 2.1 shows the current version of the platform.

The platform is scalable so that when new global data sources become available they can be incorporated within the platform. The system has been developed in order to be updated easily without the need for attention from the CCAC as it will be incorporated within an "*iframe*" component on the website which has been developed using the Drupal Content Management System (drupal.org).

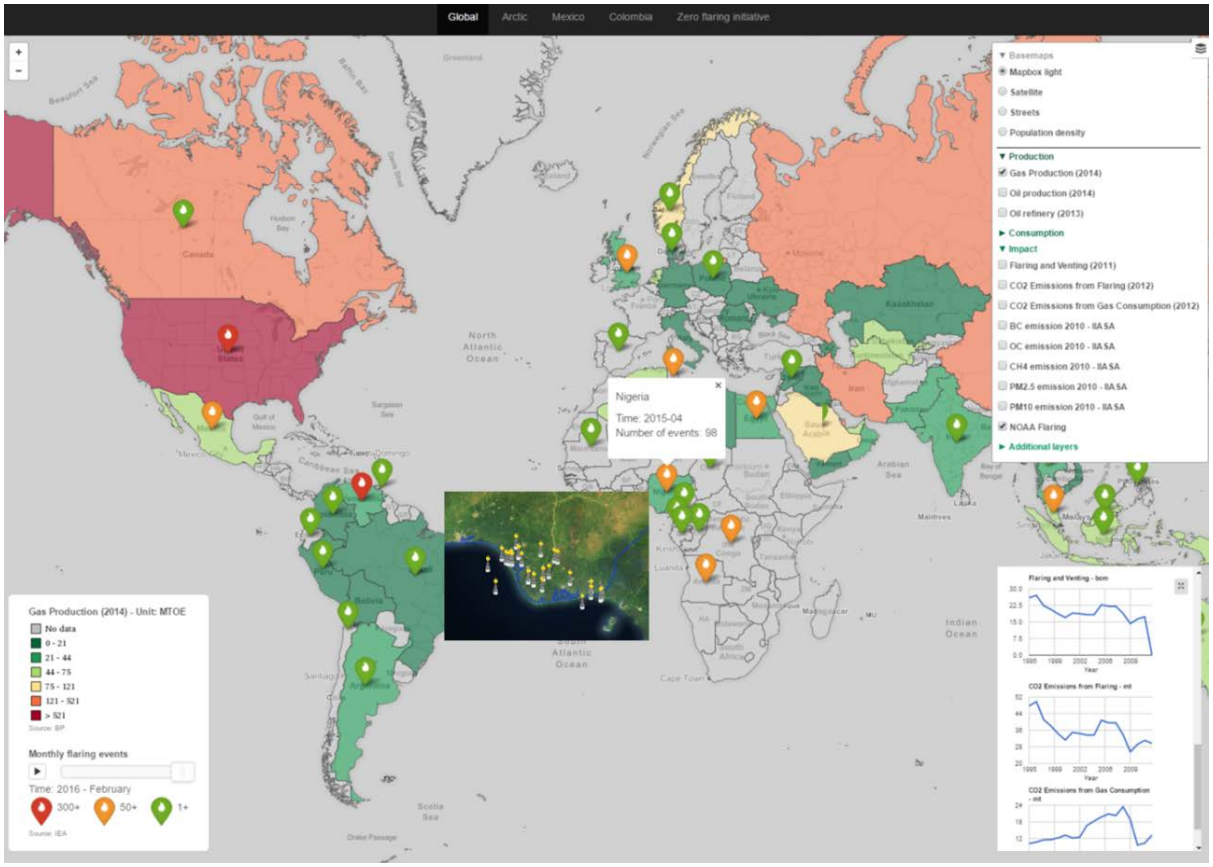

Figure 2.1 Overview of the Global Gas Flaring Web Platform user interface

2.2 Data sources

The datasets for the platform come from a variety of publicly available sources. These come in different formats such as comma separated values (CSV), downloadable excel database tables, keyhole markup language (kml) used for google earth layers and GIS files (e.g. shapefiles, netcdf) etc. Therefore, the first step involved processing the data in order for it to be displayed using the Geoserver. Initial pre-processing and conversion into consistent geospatial formats was done in QGIS, opensource GIS software (qgis.org). Database tables were converted into *geojson* format files and added to PostGreSQL. Initially, there were delays in displaying data due to the amount of data that needed to be downloaded. Therefore, a number of procedures were developed to improve data processing efficiency. The mapping interface consists of three main components:

- Global overview maps
- Global thematic maps
- Flaring sites data at national scale

An example of the mapping interface at a national scale is shown in Figure 2.2

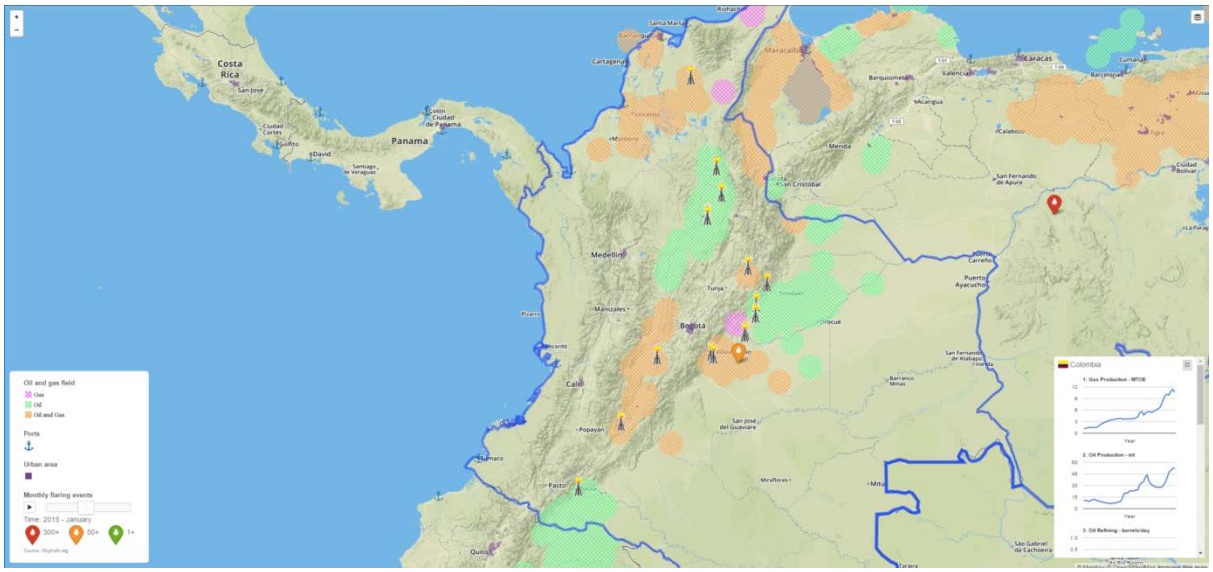

Figure 2.2 Example of the map platform's interface showing detail for Colombia

Time-series data are displayed when available either as charts (Figure 2.3) or mapped data that can be cycled through or animated using the slider. This is shown on a monthly/yearly time steps depending on the data origin.

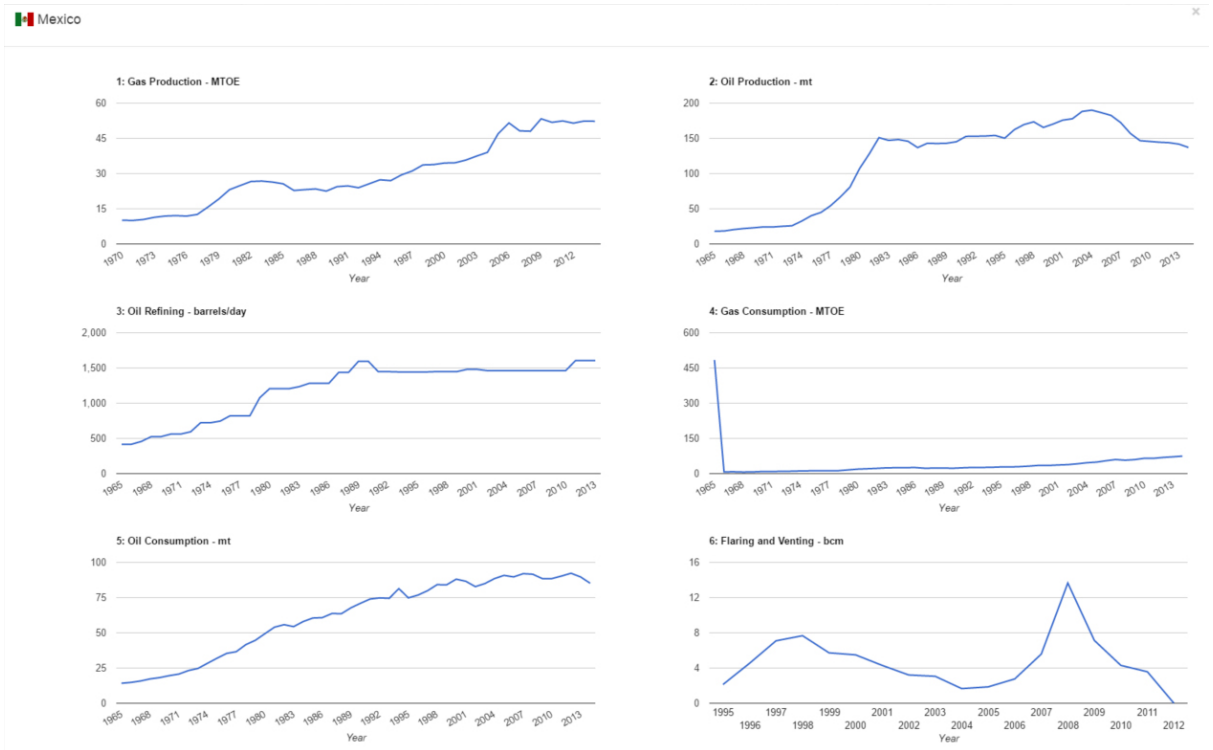

Figure 2.3 National data shown as charts

The datasets related to gas flaring used for the mapping platform are summarised in Table 2.1 and are described in more detail in Appendix 1.

Layer	Source	Year	Scale
Flaring activity	NOAA VIIRS satellite data from Skytruth	2014-2016	Site locations
Flaring	NOAA VIIRS satellite data from NOAA/Elvidge	2012-2014	National
Flaring and venting	World Bank Global Gas Flare Reduction Initiative GGFR	2011	National
Oil and gas fields	Petrodata database from Peace Research Institute Oslo (PRIO)	2009	Global
Oil production	EIA	1995-2013	National
Gas production	EIA	1995-2013	National
Black carbon from the energy sector	GAINS-ECLIPSE from IIASA	2010	Global
Methane from the energy sector	GAINS-ECLIPSE from IIASA	2010	Global
Particulate matter ($PM_{2.5}$ / PM_{10})	GAINS-ECLIPSE from IIASA	2010	Global

Table 2.1 Main oil and gas datasets mapped on the global gas flaring web platform

2.3 Summary of datasets mapped

i. Basemaps

The mapping platform provides users with three main choices of basemap to work with:

- Mapbox Open Street Map (Place names/Streets/Settlements);
- Google Maps (Satellite Image);
- Global Population Density (Thematic Map).

These are provided to support the visualisation of the location of the flares. For example, the Open Street Map enables cities and towns and road networks to be viewed as the user zooms in. The satellite map enables users to identify where the flaring activity is actually occurring and sometimes the actual flare is visible if using the satellite image base map. The population density map (Figure 2.4) uses data provided from SEDAC/CIESIN (sedac.ciesin.columbia.edu) and is used as a visualization tool to show the geographic proximity of flaring sites to large populations. Other

ancillary data includes the location of oil and gas fields, urban areas (provided by Natural Earth, naturalearthdata.com) and ports. The interface provides an option to switch these on and off.

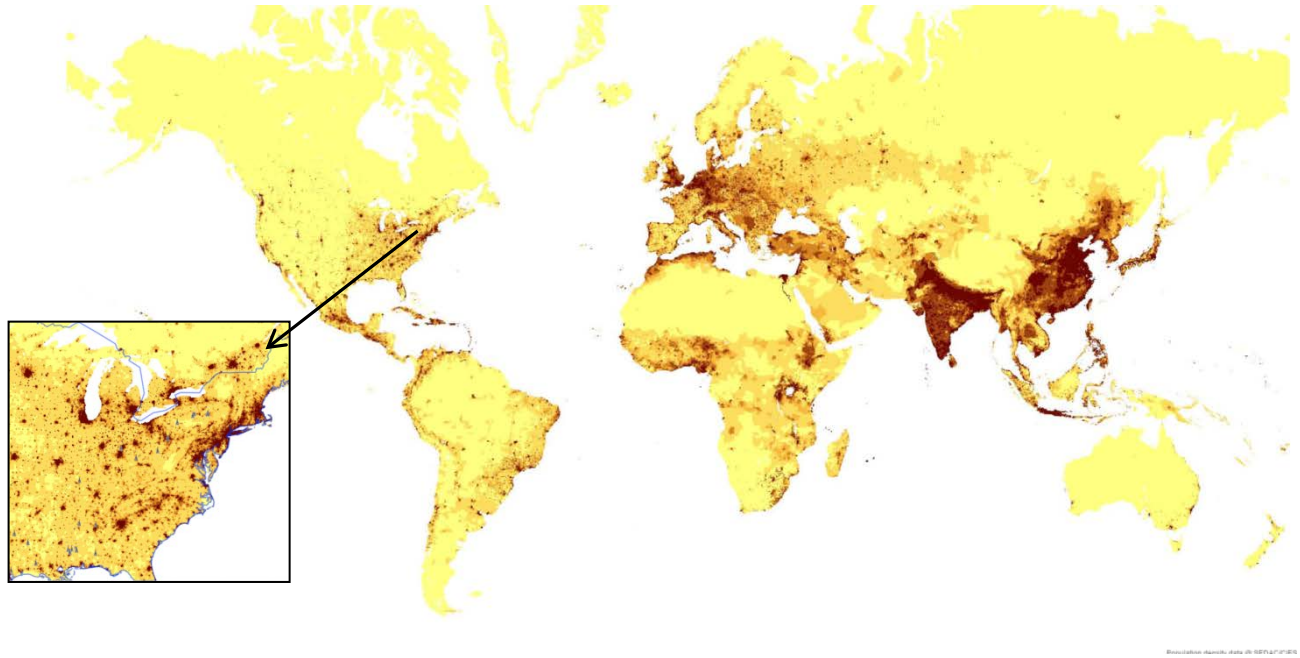

Figure 2.4 Population Density map (CIESIN)

ii. Flaring Activity

Flaring activity data was originally produced by the U.S. National Oceanic and Atmospheric Agency (NOAA) from its Visible Infrared Imaging Radiometer Suite (VIIRS) satellite (NASA, online). Data covering the time-period 2014-2016 has been processed by the Skytruth organisation to publicise the global significance of flaring and to provide the data via its own web portal (skytruth.org/viirs/). For their purposes, pixel information classified by NOAA as having a temperature less than 1500º Celsius are filtered out to exclude potential non-flare heat sources such as forest fires. As the detection of flares requires cloud free night-time measurements some flares in northern and southern latitudes are not recorded because of continuous sunshine. And in humid tropical regions, where cloud cover is persistent, some flaring may also be missed. Additional processing has taken place to remove other artefacts to reduce the potential to mistake a heat source such as a biomass burning event. It is not the aim of this portal to duplicate the functionality of this website therefore the data has been further processed to provide information as a total monthly flaring activity for each country.

The location of flares is viewable only at a country level, once a country has been clicked inside its borders. The flare locations for the month are shown by a flare icon. Clicking on each of the flares

causes a balloon to appear containing further details about the flare from the dataset. This includes dates, geographic location, temperature (in Kelvin), footprint (m^2) and radiant heat (Watts).

Global datasets do exist which could be used to show the location of the actual oil and gas platform such as the Cedigaz' Natural Gas Statistical Database (cedigaz.org). This was the original intnention of the platform. However, these are not freely publically available. If such datasets were to become available they could easily be included as an additional layer to view in conjunction with the flare activity data.

NOAA has recently produced a new preliminary dataset showing flare locations based on data from its VIIRS satellite covering the years 2012-2014 (Elvidge 2016). This data is also available on the portal to view, however only as country totals (flare volumes) for 2012-2014. Currently, there is a caveat with using this data in that it may be revised later. Once this data has been validated then it will replace the Skytruth data to show flare locations.

iii. Additional Data

Additional data on oil and gas production at a national level is available to use as an aid to visualising how flaring activity has changed over time.

In order to provide an assessment of where the emissions from oil and gas are located globally the platform displays data from the European Union's Seventh Framework Programme "Evaluating the Climate and Air Quality Impacts of Short-Lived Pollutants" (ECLIPSE) project which has produced a new global emission inventory for SLCPs based on current legislation for the recent past and up to the year 2050.

For the web platform black carbon, organic carbon, particulate matter ($PM_{2.5}$ and PM_{10}) and methane data for 2010 were extracted from the IIASA ECLIPSE Current Legislation Dataset (Klimont et al , 2016). This data has been modelled using national data for 7 different sectors including energy production and extraction (e.g. oil and gas) and made available as gridded maps.

2.4 Functionality

The purpose of the platform is to enable the user to visualise the location of where flaring is taking place globally and within an individual country over time (monthly from Feb 2014- October 2016). An overview of the functionality is shown in Figure 2.5 and is described in the next section.

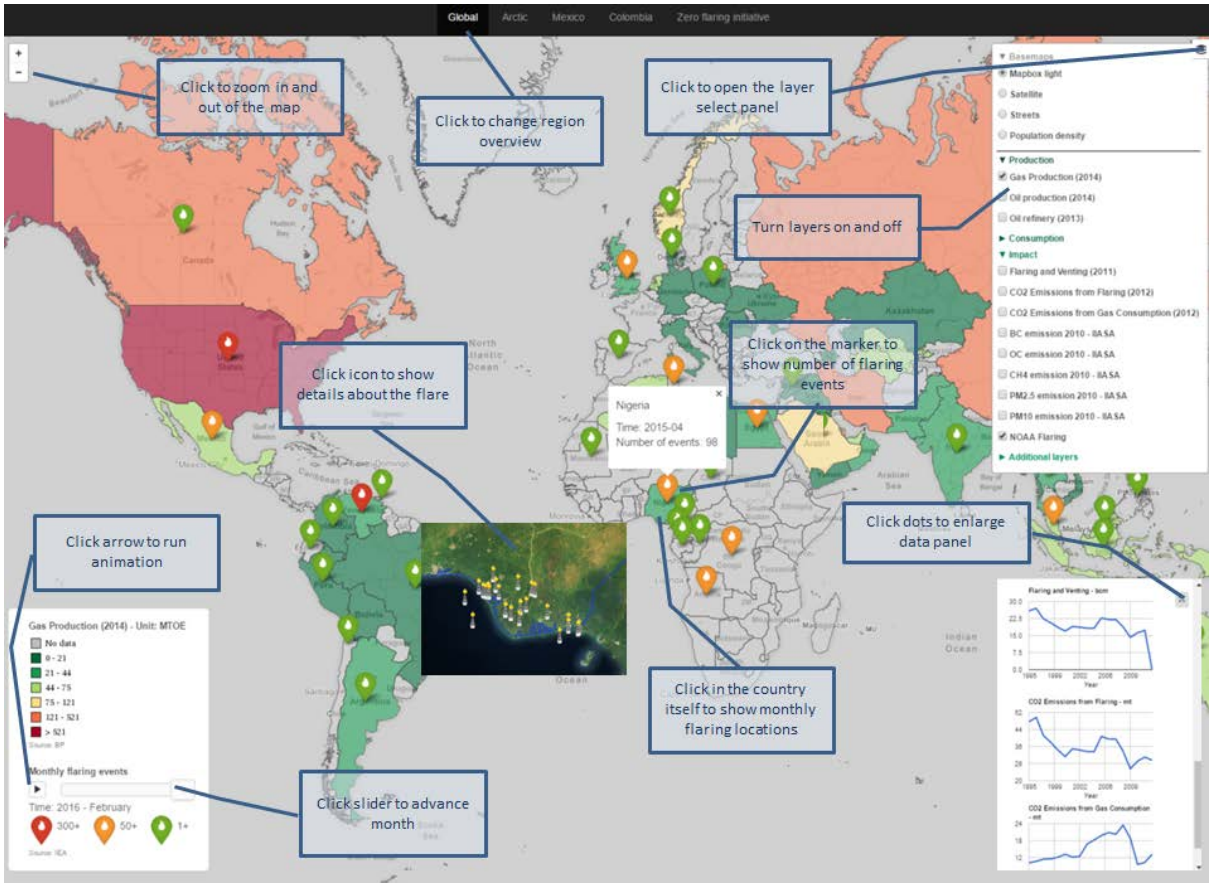

Figure 2.5 Functionality of the platform

The platform provides different views using two different geographic projections to present flaring activity: Global and Arctic. In addition to these, users can go directly to country-level views for Mexico and Colombia.

At a global view the total number of flaring activities per month is displayed by a marker in each country. When the user clicks on a country, the map zooms to display the locations where the flaring events actually take place. As the user zooms in further the underlying spatial map allows for the visualisation of the flare on different base layers including a satellite image and open street map. Other base maps and ancillary information can be selected such as a population map and an urban layer to show the proximity of the flare to populated areas.

The graph function shows national oil and gas production data and carbon dioxide (CO_2) emissions from flaring and venting and oil and gas consumption.

3. USING THE MAPPING PLATFORM

The platform is entered from the CCAC (http://www.ccacoalition.org/en) website and automatically displays the Open Street Map global map with country borders. From here users can select the different aspects they wish to look at. The following sections go through the various options currently available on the platform.

3.1 Selecting the Base map

The platform enables different basemaps to be displayed according to user preferences. These are accessible from the pull down menu at the top right of the screen (circled in Figure 3.1).

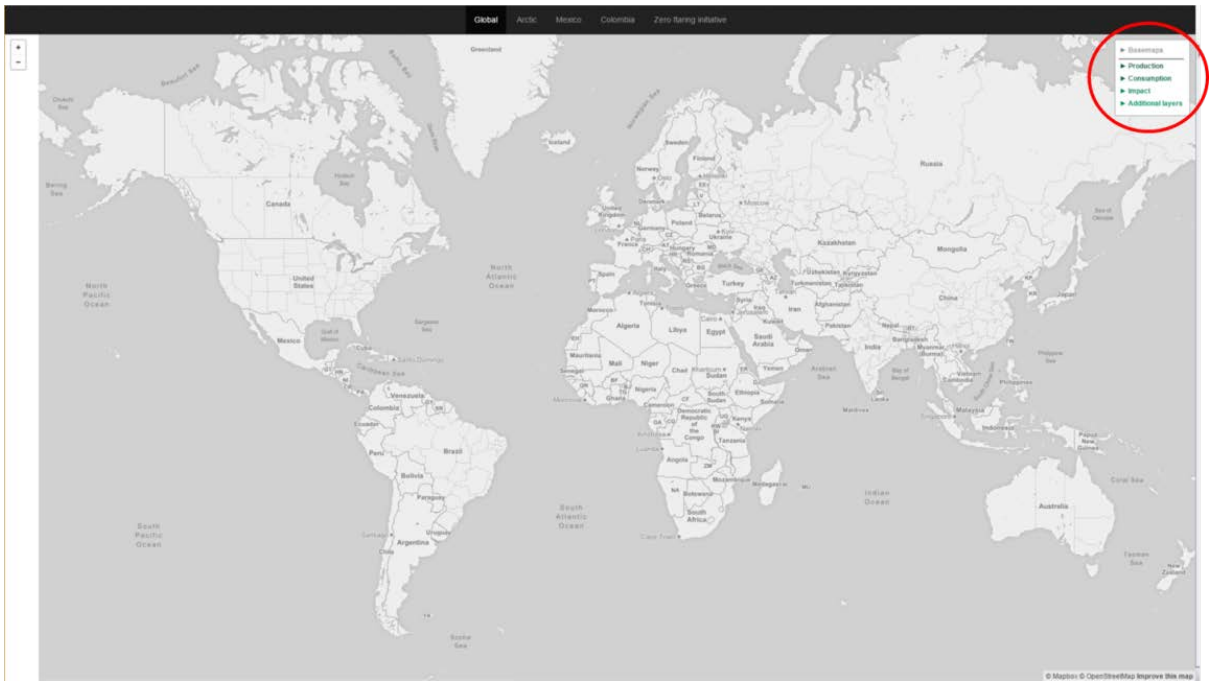

Figure 3.1 Selection of basemap

The basemaps shown in Figure 3.2 (a-d) are from Mapbox Open Street Map (a. satellite, b. thematic, c. country boundaries) and for d., SEDAC/CIESIN Gridded Population of the World (GPW2.0).

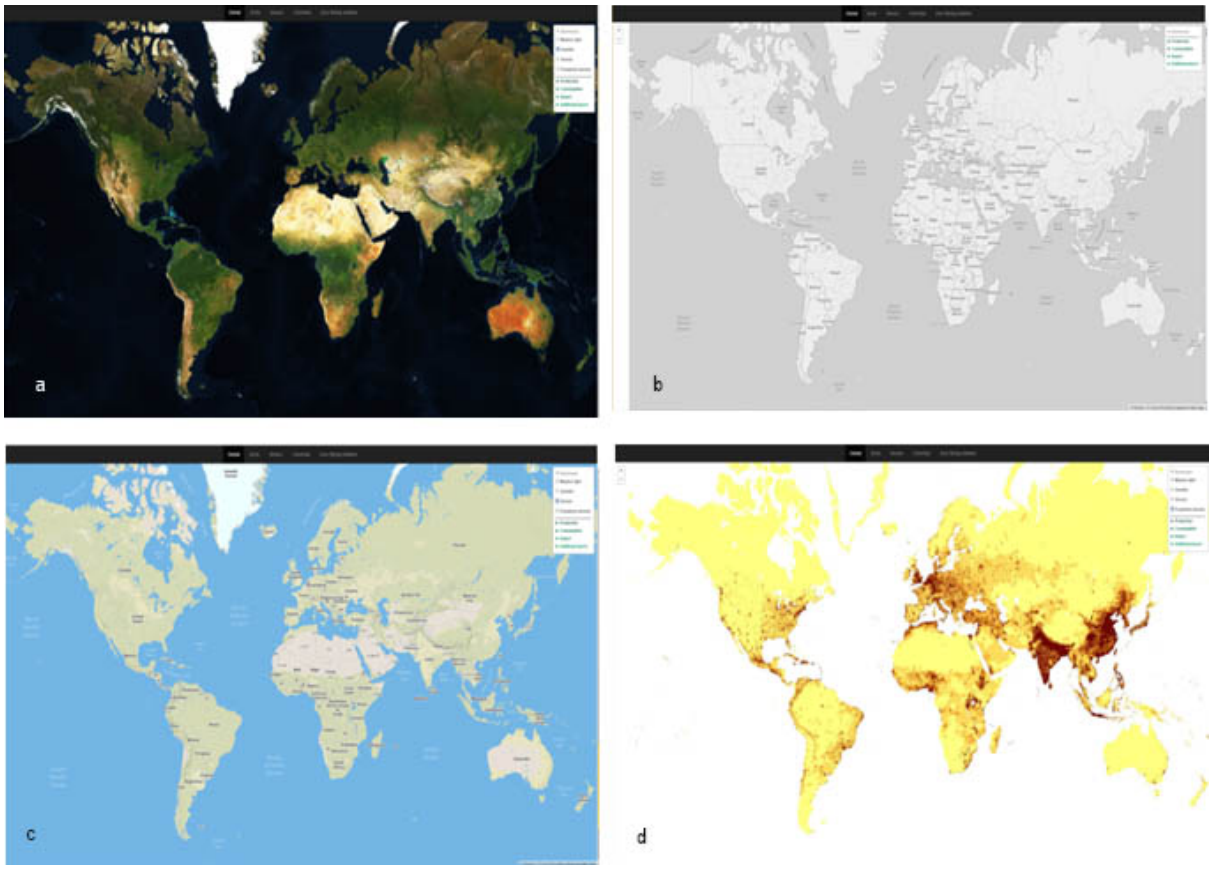

Figure 3.2a-d Basemaps used on the platform

3.2 Viewing flare volume in each country

This layer uses data from the World Bank for 2011 as a thematic map to illustrate the geographic distribution of volume of flaring by country. The highest flaring volume is coloured red (Russia and US) (Figure 3.3).

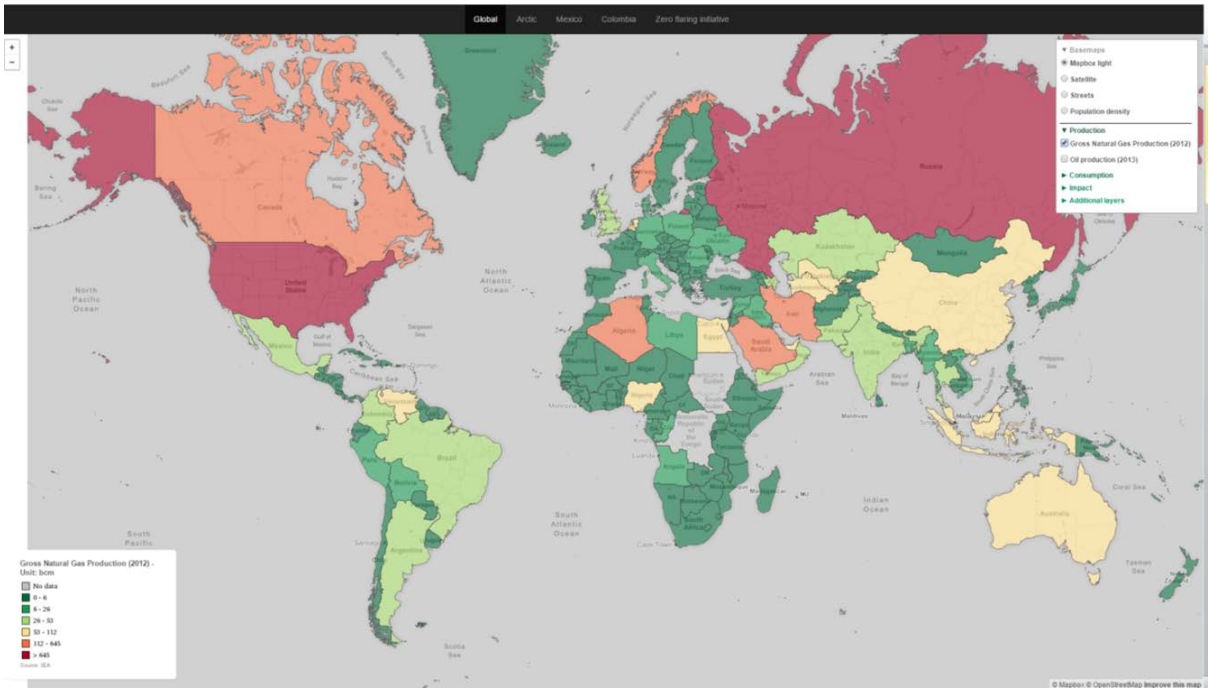

Figure 3.3 Flare volume 2001 (World Bank)

3.3 Viewing flare activity globally

Data markers for each country show the number of monthly flare events detected by the NOAA VIIRS satellite sensor and provides an overview of countries with higher flaring frequency (Figure 3.4).

Figure 3.4 Monthly flaring activity map

3.4 Flare locations in each country

In order to display the locations of the flare activity for a particular country in particular month the user clicks within the country border (Figure 3.5).

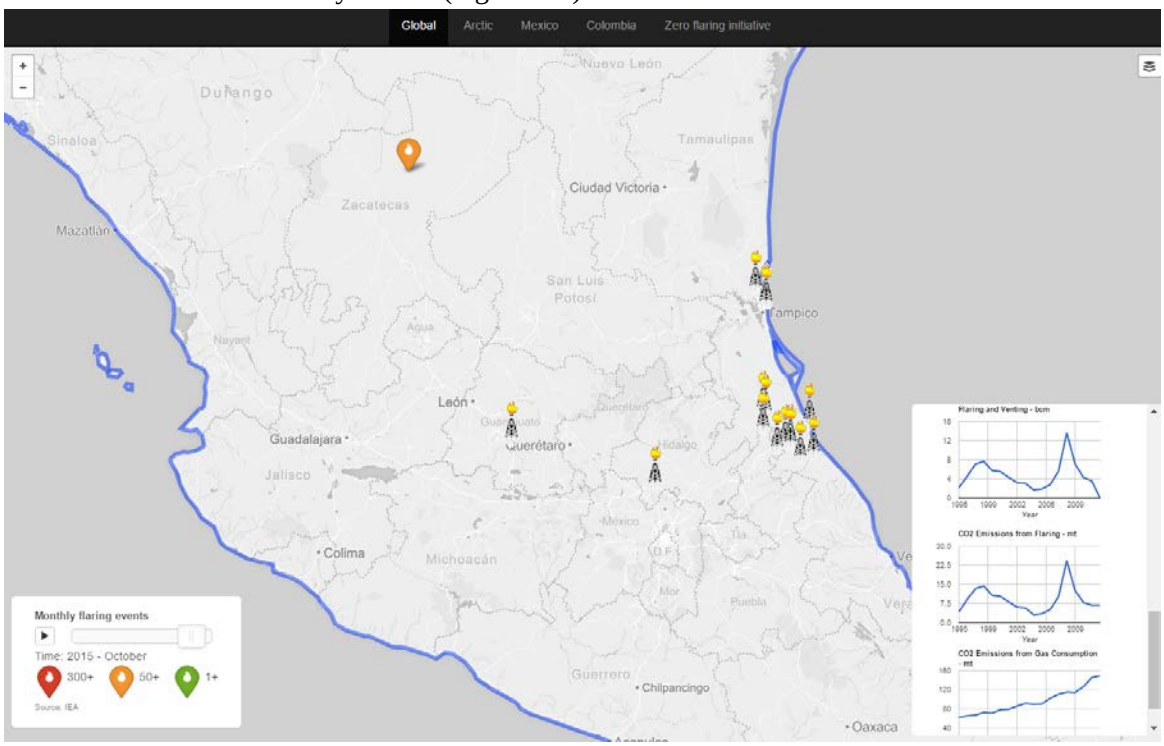

Figure 3.5 Flaring locations shown at national scale

3.5 Viewing time series

The slider located on the bottom left part of the screen increments and decrements the total flaring activity in monthly time steps when it is moved left or right (Figure 3.6). Alternatively, this can be done automatically by pressing the arrow button to the left of the slider.

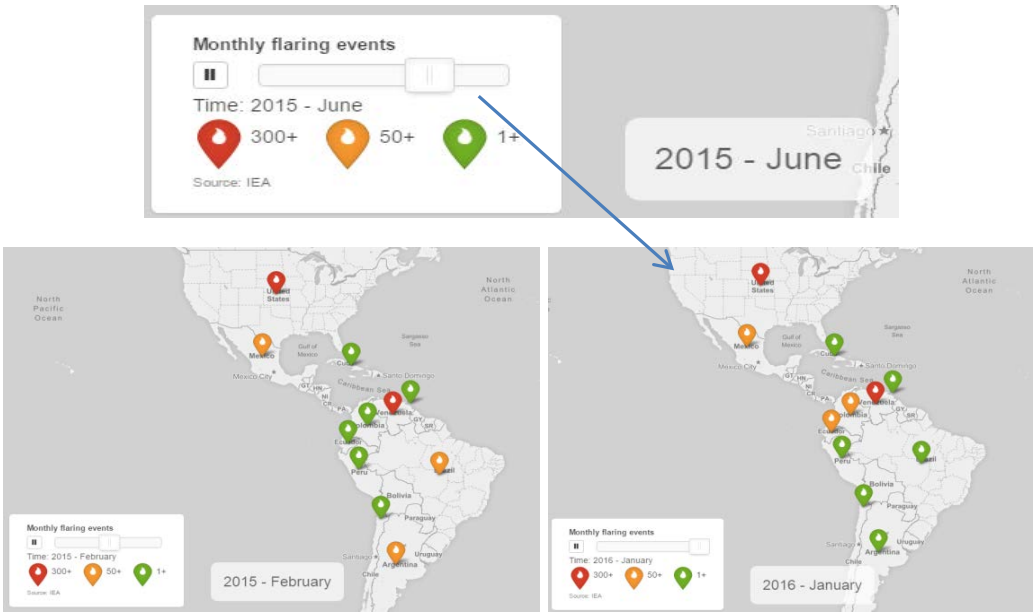

Figure 3.6 Slider used to cycle through monthly data

3.6 Oil and gas production and consumption data in graphs/charts

Data for a number of variables for each country are shown as line graphs. To expand the panel the user clicks on the small [x] in the top right corner (e.g. Figure 3.7).

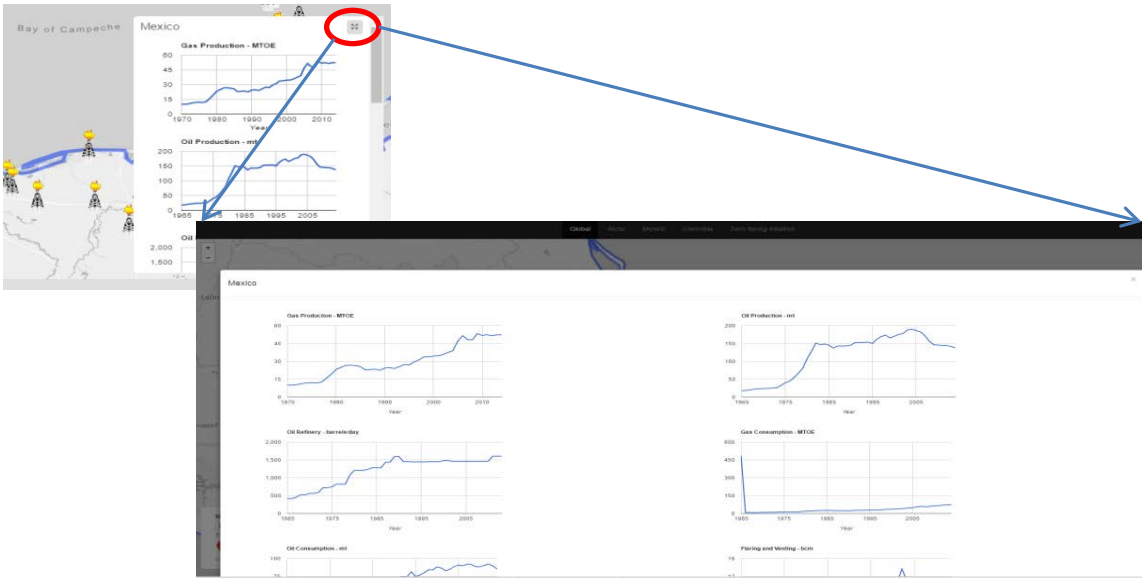

Figure 3.7 Monthly flaring activity map

The data includes gas and oil production, oil refining, gas and oil consumption, CO2 emissions and are taken from a number of sources.

3.7 Zooming to choice of areas

Currently, the platform provides 1 global and 1 regional view (Arctic) and 2 country views (Mexico, Colombia) which can be selected from the top menu bar shown in Figure 3.8.

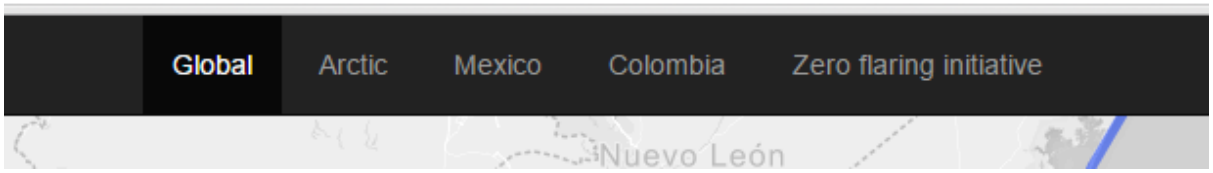

Figure 3.8 Selection of map overviews

3.8 Ancillary data layers

Figure 3.9, Shows how the location of oil and gas fields is used as an ancillary data layer. The data used for this is from the Petrodata database (prio.org).

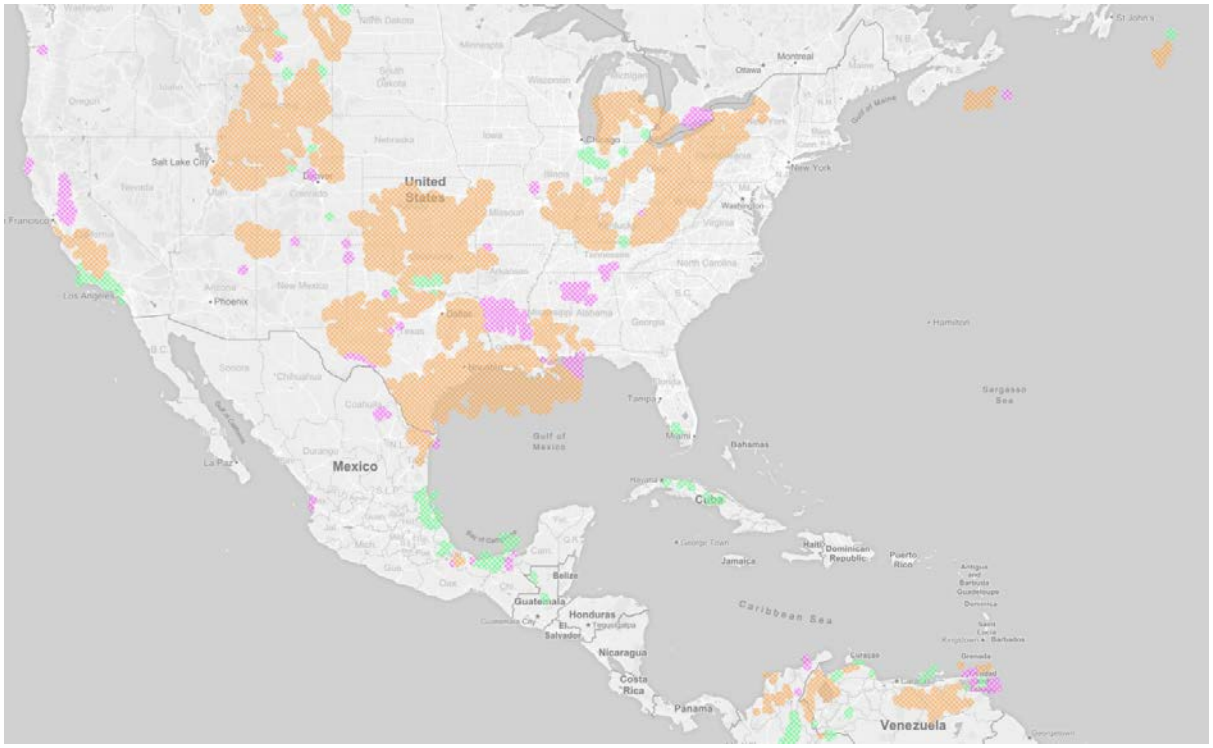

Figure 3.9 Oil and Gas Fields (Petrodata) inset (Mexico)

The Natural Earth dataset (naturalearthdata.org) is used to highlight urban areas (shown in purple). The map in Figure 3.10 illustrates a flare close to the city of Nueva in Colombia.

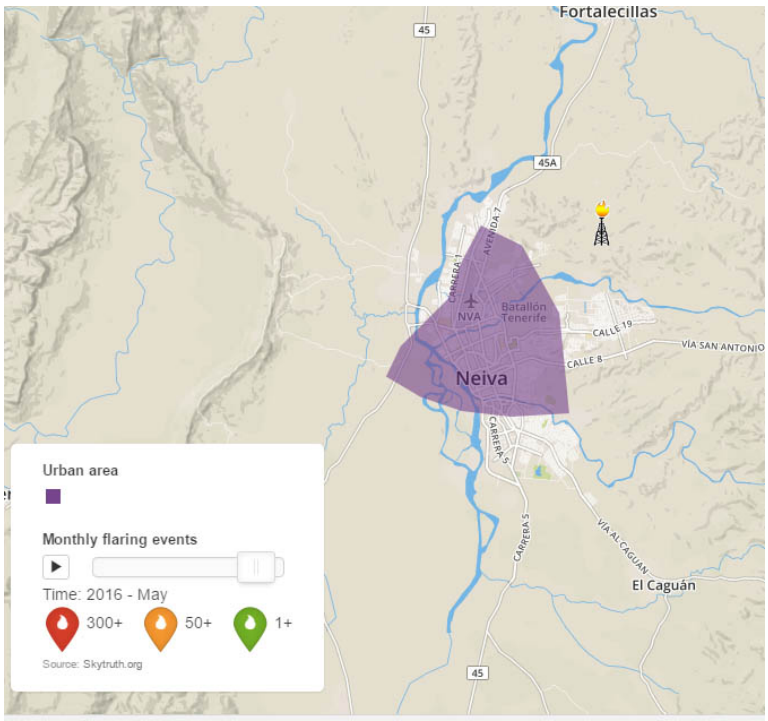

Figure 3.10 Natural Earth urban area dataset (Colombia detail shown)

3.9 Arctic map of flaring activity

The Arctic map uses the same data source as the other maps however only flares detected above 60 degrees latitude are displayed (Figure 3.11) and uses a polar stereographic projection.

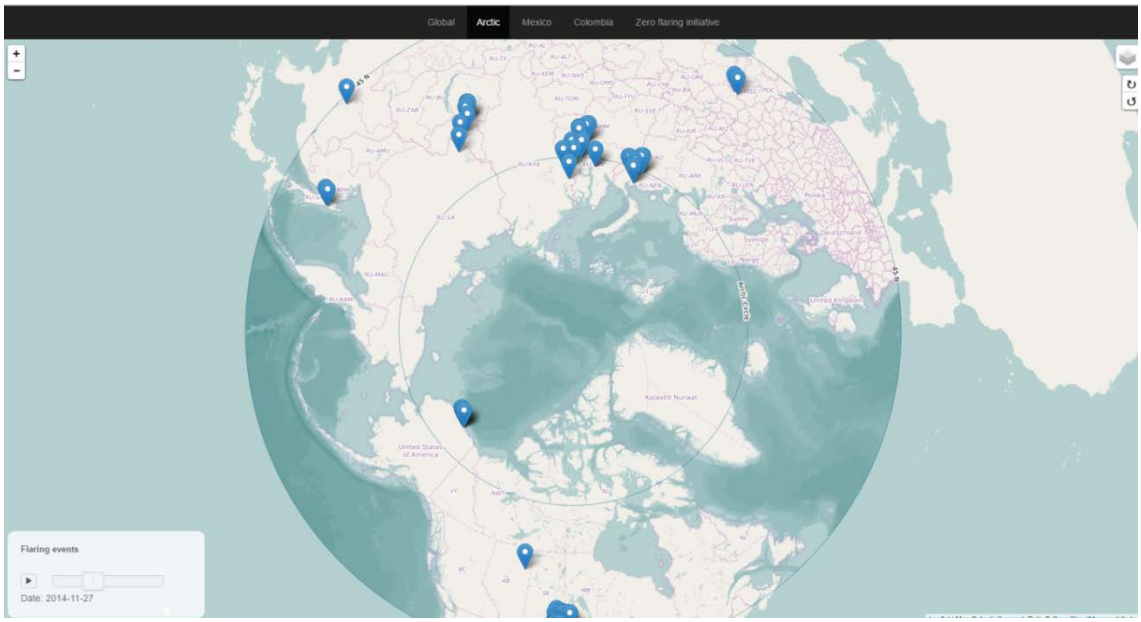

Figure 3.11 Map displaying location of flaring activity in the Arctic.

3.10 Zero Flaring Initiative

In April 2015, 40 countries, oil companies and institutions signed up to the World Bank initiative to reduce routine flaring to zero. Since then other countries and companies have joined. These are available to view on the platform (Figure 3.12). Clicking on the icons will display information on progress to achieving the initiatives objectives. This part is still under development and will be updated when the participants in the initiative report on their progress.

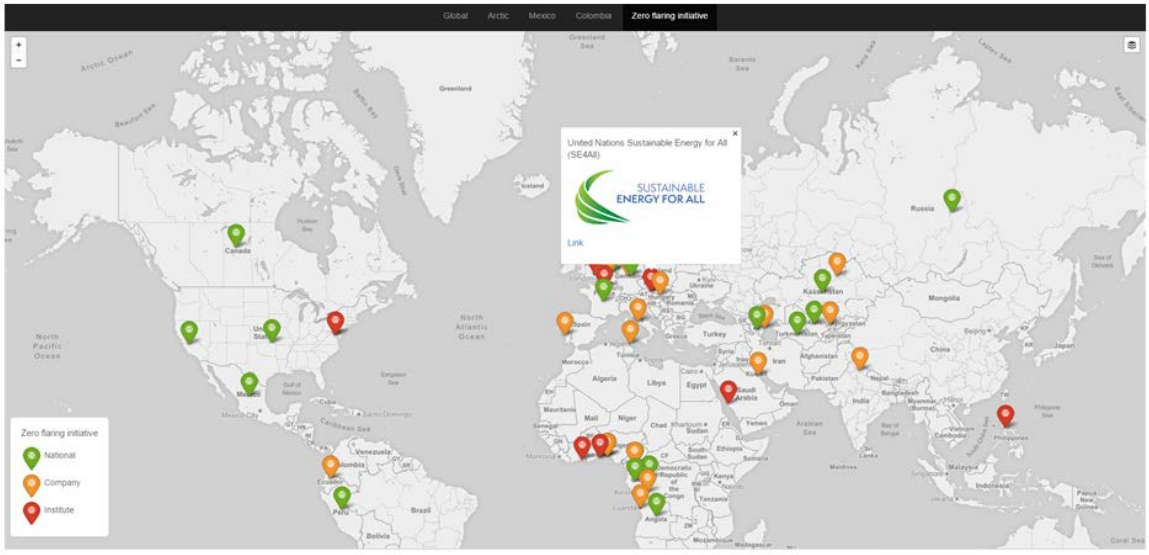

Figure 3.12 Location of signatories to the World Bank/UNEP initiative to reduce routine flaring to zero

4. NEXT STEPS

Despite the importance that gas flaring has, and the initiatives created to curtail it on a routine basis, there is still relatively scarce data available at a detailed resolution to assess the situation. This study has identified one main source of data which shows where the location of flaring is taking place using satellite data. Attempts have previously been made to aggregate data from disparate sources but these can tend to be patchy (i.e. incomplete) and compiled from data of different time-periods, spatial scales and accuracy and quality.

The platform that has been produced for this project can include any new data sources that become available to improve the user's understanding of the source and impact of flaring. Ideally, a global database which maintains a record of all platform locations including offshore platforms is highly desirable. Associated with the locational information details about the well operator (useful for attributing emissions), the type of oil being extracted (light/heavy oil), production data and flaring and venting operations (self-reported and verified through satellite observations) are also desirable. This would also include how long flaring and venting took place. In addition, data on emissions measured on-site could be linked to the database.

This data could then be linked to appropriate atmospheric transfer models to assess how emissions are transported regionally and globally. This would then provide better estimates of how flaring in one continent/region impacts elsewhere around the globe.

REFERENCES

Elvidge, C.D., Zhizhin, M.; Baugh, K., Hsu, F.-C. and Ghosh, T., 2016, Methods for Global Survey of Natural Gas Flaring from Visible Infrared Imaging Radiometer Suite Data. *Energies*, *9*, 14.

Klimont, Z., Kupiainen, K., Heyes, C., Purohit, P., Cofala, J., Rafaj, P., Borken-Kleefeld, J., Schoepp, W. 2016. Global anthropogenic emissions of particulate matter including black carbon. *Atmos. Chem. Phys. Discuss.*, doi:10.5194/acp-2016-880

NASA Website, NOAA VIIRS satellite http://npp.gsfc.nasa.gov/viirs.html

World Bank, 2015, Zero Routine Flaring by 2030 http://www.worldbank.org/en/programs/zero-routine-flaring-by-2030

APPENDIX 1: Description of data sources

Title: **SkyTruth Global Flaring Dataset using NOAA VIIRS satellite data**	Provider: Skytruth
Reference:	Website: http://skytruth.org/viirs/
Year: 1995-2014 March 2014-March 2016	
Description: This dataset is comprised of infrared satellite detections of natural gas flaring across the entire planet, as seen by the VIIRS instrument aboard NOAA's Suomi NPP satellite. Detections under 1,500º C filtered to remove "cooler" heat sources like forest fires. The Visible Infrared Imaging Radiometer Suite (VIIRS) instrument records one observation per night at any given point on the planet. The data are limited in the extreme northern and southern latitudes due to continuous sunshine and atmospheric noise. In order to eliminate noise and false detections in the temperate and tropical regions, data is filtered from locations that have only had 1 or 2 detections in 30 days prior to date displayed. Also, for all detections where there are ≥3 detections in the previous 30 days, each detection displayed on the day it was recorded.	
Acknowledgements Data accessed freely from website.	
Restrictions	

DESCRIPTION OF DATA SOURCES

Title: **NOAA VIIRS Global Flaring Dataset (beta)**	Provider: NOAA
Reference: Methods for Global Survey of Natural Gas Flaring from Visible Infrared Imaging Radiometer Suite Data Christopher D. Elvidge, Mikhail Zhizhin, Kimberly Baugh, Feng-Chi Hsu and Tilottama Ghosh Published: 25 December 2015	Website: http://ngdc.noaa.gov/eog/viirs/download_global_flare.html
Year: 2012-2014	
Description: Visible Infrared Imaging Radiometer Suite (VIIRS) is a scanning radiometer, which collects visible and infrared imagery and radiometric measurements of the land, atmosphere, cryosphere, and oceans. VIIRS data is used to measure cloud and aerosol properties, ocean color, sea and land surface temperature It is operated in an unusual way that offers a substantial advantage for the observation of gas flaring. At night, the VIIRS continues to record data in three near- to short-wave infrared channels designed for daytime imaging. With sunlight eliminated, the only features detected in these channels are combustion sources. The SWIR channel, at 1.61 µm, is at the wavelength of peak radiant emissions from gas flares. The 4-µm channel, widely used in satellite fire detection, only detects large flares due to the fact that it falls on the trailing edge of gas flare radiant emissions and observes a mixture of flare plus background radiant emissions. Typically, the flare radiant emissions in the 4-µm channel are about a third of the emissions at 1.65 µm. This has a dramatic effect, limiting the	

detection of smaller flares in standard satellite fire products based on channels set at the 4 µm wavelength. Elvidge et al developed a set of methods for the global survey of natural gas flaring using VIIRS data. The original development was conducted with data from 2012. This has now been expanded to 2013 and 2014. The results below should still be considered preliminary.
Acknowledgements This project was jointly sponsored from 2012-2015 by the NOAA Joint Polar Satellite System (JPSS) Proving Ground Program and the World Bank Global Gas Flaring Reduction Partnership (GGFR).
Restrictions

Title: **PetroData - Petroleum Dataset v. 1.2**	Provider: Peace Research Institute Oslo (PRIO)
Reference: Lujala, Päivi; Jan Ketil Rød & Nadia Thieme, 2007. 'Fighting over Oil: Introducing A New Dataset', Conflict Management and Peace Science 24(3), 239-256.	Website: https://www.prio.org/Data/Geographical-and-Resource-Datasets/Petroleum-Dataset/Petroleum-Dataset-v-12/
Year: 2009	
Description: PETRODATA is a database of oil and gas fields throughout the world. Its major purpose is to supply spatial and temporal data on hydrocarbon reserves and production to conduct empirical studies on the relationship between oil and gas and armed civil conflict. The data can also be used to study international conflicts and other topics related to natural resources and their effect, for example, on economic growth and political institutions. The petroleum datasets contain information on all known oil and gas deposits throughout the world. Two datasets are available: one for on-shore deposits and the other off-shore deposits. Given the geological characteristics of petroleum, the data are stored as polygons in shapefile (GIS) format. In addition, basic data on each deposit are available as spreadsheets (Excel) containing exact locational information, each deposit are registered with type of resource (oil and/or gas), discovery- and production dates (whenever known), name of petroleum basin, geographic coordinates of polygon centroid, and primary source of information. Onshore and offshore polygons are coded separately. The dataset covers the period from 1946 to 2003 and includes location for 1,273 hydrocarbon polygons in 114 countries. In total, oil or gas is produced in 92 countries, 102 countries have discovered onshore hydrocarbons, and 79 have onshore hydrocarbons, and 79 have offshore fields. Besides the spatial information, PETRODATA is provided in ESRI's shapefile format. The location of hydrocarbon fields is given by geographic coordinates (latitudes and longitudes. Due to the extremely high number of hydrocarbon fields, individual fields are aggregated and represented in PETRODATA by polygons.	
Restrictions:	

Title: **Urban Areas v2.**	Provider: Natural Earth
Reference: Schneider, A., M. A. Friedl and D. Potere (2009) A new map of global urban extent from MODIS data. Environmental Research Letters, volume 4, article 044003.	Website: http://www.naturalearthdata.com/downloads/10m-cultural-vectors/10m-urban-area/

Schneider, A., M. A. Friedl and D. Potere (2009) Monitoring urban areas globally using MODIS 500m data: New methods and datasets based on urban ecoregions. Remote Sensing of Environment, in review.	
Year: 2009	
Description: The map was derived from efforts to map the global distribution of urban land use at 500 m spatial resolution using remotely sensed data from the Moderate Resolution Imaging Spectroradiometer (MODIS). The approach uses a supervised decision tree classification algorithm that processes using region-specific parameters. An accuracy assessment based on sites from a stratified random sample of 140 cities shows that the new map has an overall accuracy of 93% (k = 0.65) at the pixel level and a high level of agreement at the city scale (R^2 = 0.90). Data is available as a polygon shape (shp) file	
Acknowledgements	
Restrictions	
All versions of Natural Earth raster + vector map data found on this website are in the public domain. The primary authors, Tom Patterson and Nathaniel Vaughn Kelso, and all other contributors renounce all financial claim to the maps and invites you to use them for personal, educational, and commercial purposes. No permission is needed to use Natural Earth. Crediting the authors is unnecessary.	

Title: **BP Statistical Review of World Energy June 2014**	Provider: British Petroleum
Reference: Multiple sources compiled from national databases, industry publications	Website: http://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html
Year: Up to 2014	
Description: The BP Statistical Review of World Energy provides high-quality objective and globally consistent data on world energy markets Data used for country level charts: Gas Production Oil Production Oil Refining Gas Consumption Oil Consumption	
Acknowledgements Publishers are welcome to quote from this review provided that they attribute the source to BP Statistical Review of World Energy 2014.	
Restrictions	

Title: **International Energy Statistics**	Provider: US Energy Information Administration
Reference: Multiple sources compiled from national databases, industry publications	Website: http://www.eia.gov/beta/international/
Year: 1995-2014 2009	
Description: Flaring and Venting CO_2 Emissions from Flaring CO2 Emissions from Gas Consumption	
Acknowledgements	
Restrictions	

Title: **CIESIN Gridded Population of the World (GPW), v3**	Provider: SEDAC/NASA
Reference: Gridded Population of the World, Version 3 (GPWv3) Data Collection	Website: http://sedac.ciesin.columbia.edu/gpw/index.jsp
Year: 2005	
Description: GPWv3 depicts the distribution of human population across the globe. GPWv3 provides globally consistent and spatially explicit human population information and data for use in research, policy making, and communications. This is a gridded, or raster, data product that renders global population data at the scale and extent required to demonstrate the spatial relationship of human populations and the environment across the globe. The purpose of GPW is to provide a spatially disaggregated population layer that is compatible with data sets from social, economic, and Earth science fields.The gridded data set is constructed from national or subnational input units (usually administrative units) of varying resolutions. The native grid cell resolution is 2.5 arc-minutes, or ~5km at the equator, although aggregates at coarser resolutions are also provided. Separate grids are available for population count and density per grid cell.-	
Acknowledgements Originator: Center for International Earth Science Information Network (CIESIN), Centro Internacional de Agricultura Tropical (CIAT). Publisher: CIESIN, Columbia University	
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Title: **ECLIPSE V5a Baseline scenario (CLE)**	Provider: GAINS/IIASA
Reference: Amann, M., Z. Klimont, and F. Wagner (2013) Regional and Global Emissions of Air Pollutants: Recent Trends and Future Scenarios. Annu. Rev. Environ. 38/1, 31–55. Stohl, A., Z. Klimont, S. Eckhardt, K. Kupiainen, V.P. Shevchenko, V.M. Kopeikin, and A.N. Novigatsky (2013) Black carbon in the Arctic: the underestimated role of gas flaring and residential combustion emissions. Atmos. Chem. & Phys., 13, 8833-8855.	Website: http://www.iiasa.ac.at/web/home/research/researchPrograms/air/Global_emissions.html
Year: 2010	
Description: GAINS is an interactive tool for assessing international GHG mitigation regimes. The Eclipse dataset was developed with GAINS to provide global emission fields of air pollutants and GHGs. This is a rasterised 0.5^{o}x 0.5^{o} degree grid of key sectorial totals are available for energy, industry, solvent use, transport, domestic combustion, agriculture, open burning of agricultural waste, waste treatment. Gas flaring is included in the energy sector. Gridded emissions of air pollutants and GHG. Data (SO_2, NOx, NH_3, nmVOC, BC, OC, $PM_{2.5}$, PM_{10}, CO, CH_4). The platform uses the particulate data ($PM_{2.5}$ and PM_{10}, CH_4 and BC under the baseline scenario..	
Acknowledgements	
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