

Antipathetic Impacts of Sulphur Dioxide: A case study of Indian Scenario by MODIS Analysis

Jacob Joshua and Sujatha C.H

Dept. of Chemical Oceanography, School of Marine Sciences, CUSAT,
Cochin 16, Kerala, India.

Abstract

Sulphur dioxide(SO₂) is formed mainly from the combustion of fossil fuels that contain sulphur, such as coal and oil (coal being burnt in a home fireplace for heating and diesel-powered vehicles). SO₂ is also produced from some industrial processes (e.g.: fertilizer manufacturing, aluminum smelting and steel making).It is a colorless heavy, poisonous gas that has an irritating, pungent odor. It is readily soluble in cold water having both antibiotic and antioxidants properties that are useful as a preservative for dried fruits. It is a very important compound used in winemaking and winery sanitation. SO₂ is used as reducing bleach, as a refrigerant, as a reagent, solvent to treat chlorinated waste water. Being as the precursor for sulphuric acid, it is used widely in industrial processes and it initiates global climate change through the atmosphere and the ocean, with the chemical change like oxidizing capacity, cooling and drought effects. An investigation was performed on the role of Sulphur dioxide (SO₂) aerosols for the climatic variations and thereafter leading to health hazards in certain hot spots in the states of developing India. This article designed into varying segments as: analyzing, monitoring, and interpreting the SO₂ aerosols over the geographical regions by earth observing system, SPSS to estimate how the anthropogenic biomass burning and windblown dust emissions. An Effective quantitative and qualitative data can be achieved for finding the blemished effect of SO₂ on climate and health hazards of India: Kerala, Tamil Nadu. In addition to these, few different meteorological trace gases and aerosol chemical components were monitored and compared. Results from source region tagged SO₂ simulations were used to estimate the different regions around the sources contribute the emissions. It highlights a new insight of how the SO₂ emissions are two folded by the past several years. A model study is

generated and a gas phase species outcomes are accorded. The SO₂ emissions and enhancements were under predicted over the region; mostly likely to cause is that the emissions from anthropogenic and open burning sources were underestimated during this time period of the study.

Keywords: *Sulphur Dioxide (SO₂), Aerosols*

1. Introduction

For the past decades, air pollution was thought to be mere an urban or a hitherto problem. While according to the current research uplift and their inferences published by Scientific Organizations like The National Aeronautics and Space Administration (NASA), Central Pollution Control Board etc., had exposed that air pollutants are enhanced to a great extent to the atmosphere via transporting across the continents and the ocean basins due to fast long-range transport, ending in trans-oceanic and trans-continental plumes of clouds entrapped by sub micron size particles, known as aerosols. It consists of Particulate Matter (PM), trace gases like Carbon monoxide, Sulphur dioxide, Carbon dioxide etc. The cloud particles intercept sunlight by absorbing as well as reflecting it, both of which lead to a large surface dimming.They are concentrated in certain regional and major hot spot cities depending up on the wind direction, moisture, humidity, temperature etc. Long-range transport of these causes widespread plumes over the adjacent oceans. Such a pattern of regionally concentrated surface dimming and atmospheric solar heating give rise to large predicted effects, like impulsive weather change which intrinsically causes the baseline vulnerability due to epidemic vector borne diseases in India and becomes a reality.

The present study highlights and predicts the anticipated impacts on the trend in the SO₂ scenario by acquiring the satellite data, and further more research has to be needed in the future for the

effective remedial measures in this lacuna. Kochi and Chennai are the two high risk areas experiencing a scarcity of resources, environmental degradation, and high rates of infectious disease, weak infrastructure facilities, and overpopulation to a large proportion. As a matter of fact, tropical regions-Kochi and Chennai are sounds to significant changes in human-pathogen relationships because of varying climate changes occurring quite often in these cities. Changing both temperature pattern and precipitation are linked to climate change which will disturb and disorder the ecosystem globally.

Sulphur dioxide (SO₂) is formed mainly from the combustion of fossil fuels that contain sulphur, such as coal and oil (coal being burnt in a home fireplace for heating and diesel-powered vehicles). SO₂ is also produced in certain industrial processes (e.g.: fertilizer manufacturing, aluminum smelting and steel making). It is a colorless heavy, poisonous gas that has an irritating, pungent-odor^a. It is readily soluble in cold water having both antibiotic and antioxidants properties that are useful as a preservative for dried fruits. It is a very important compound used in wine making and winery sanitation. SO₂ is used as reducing bleach, refrigerant, and reagent and a solvent to treat chlorinated waste water^b. Being a precursor for sulphuric acid, it is used widely in industrial processes and it initiates global climate change through the atmosphere and the ocean, causing a chemical change like oxidizing capacity, cooling and drought effects.

Kochi (9° 56' and 10° 10' N, and 76° 10' and 76° 25' E) and Chennai (13.0827° N, 80.2707° E) are the two important coastal capital cities of South India and prone to major urban-industrial commotion and this industrial agglomeration possessing hundreds of industrial units flanked by the Arabian sea on the west and the Bay of Bengal on the east and cross crossed by backwaters. Many portions of the region are water logged for most part of the year. Several rivers flush out pollutants in to the water bay, enhancing the pollution load in water, air and sediment.

2. Materials and Methods

Investigation was performed for the role of one of the aerosol constituents Sulphur dioxide (SO₂) residing in the atmosphere which as contributing in the variations and thereafter leading to health hazards in two hot spots regions of South India. This article is designed into varying segments as: analyzing, monitoring, and interpreting the SO₂ aerosols over the geographical regions by earth observing system of NASA and modeled through SPSS to estimate how the anthropogenic biomass

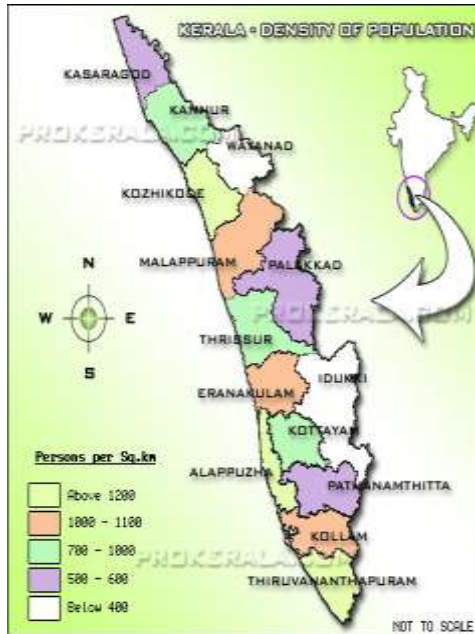
burning and windblown dust emissions affect the corresponding regions.

An effective quantitative and qualitative data can be achieved by virtue of finding the blemished effect of SO₂ on climate and health hazards emphasizing two major cities of Kerala and Tamil Nadu as Indian representatives. Results from source region tagged the SO₂ simulations which are used to estimate how the different regions around the sources contribute the emissions. According to the demographic records, the density of Kochi and Chennai are 6,340/km² and 26903/km² respectively (Fig1) for the pollutants transport to the atmospheric environment, meteorological factors play a vital role and the above mentioned two major cities are influenced by the effects of land and sea breezes.

Meteorological factors also played tremendously in air pollution studies particularly in pollutant transport irrespective of their entry into the environment. The climate is dominated by heavy rainfall during the southwest monsoon season and moderate rainfall during the post monsoon months. Being a coastal station, the city is influenced by the effects of land and sea breezes. Air circulations are generally light to moderate throughout the year. Generally monsoons results in large amount of precipitation, high wind velocities and changes in wind direction. Abundance in precipitation resulted in scrubbing off pollutants. Further, wind velocities will drift away pollutant from sources and increase mixing processes. During winter, there is increased atmospheric stability, which in turn reduces air parcel disposal and thus more stagnant air masses and cluttering of pollutants in any given area. The prevailing calm atmospheric conditions facilitate more stability to atmosphere and consequently diminished dispersion of generated pollutants and helps in buildup of pollutants in the vicinity of the pollutant sources (Lee et al., 2008).

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Trace gases are chemical constituents found in low concentrations (makes up less than 1% by volume of the Earth's atmosphere) and they include, ozone (O₃), Nitrogen oxides including NO, NO₂ (NO_x), Carbon monoxide (CO), Sulphurdioxide (SO₂) and Ammonia (NH₃).



Kerala population density by district

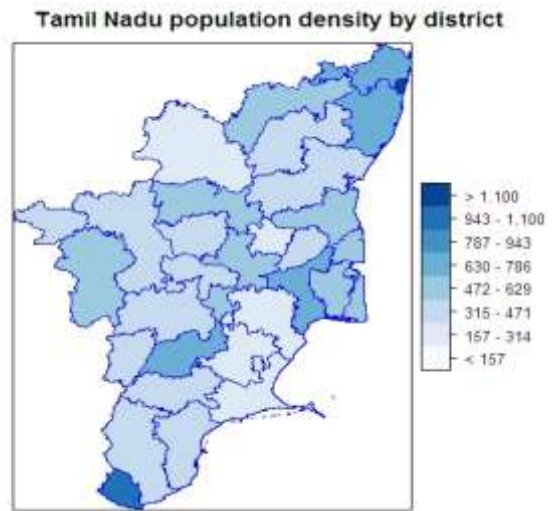


Fig 1: Map of Kochi-Chennai

Enhancement in anthropogenic activities in terms of developmental activities and hi-fi standard of living raised the pollution index in a geometric proportion for these obnoxious atmospheric trace gases which has resulted in global warming and acid rain⁸ and subsequently noted a change in climate. Certainly these trace gases can exert considerable influence on a range of environmental distortion effects and health disorder. Figure 1 shows the population density of Kerala and Tamilnadu.

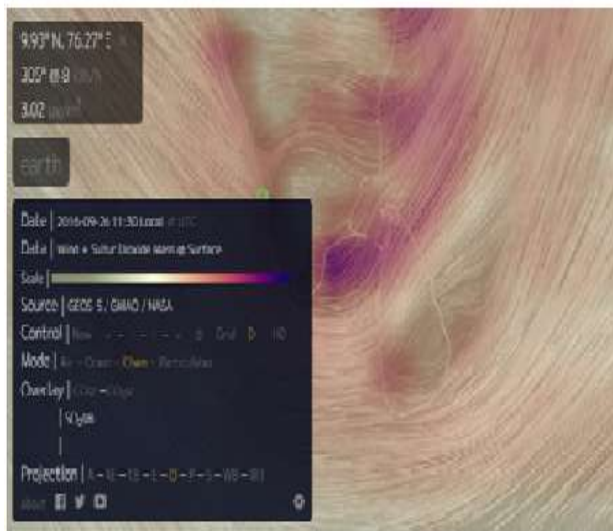


Fig 2 : SO₂ Map of Kochi and Chennai from Null earth-MODIS

The study concentrated on the dates obtained from Null earth satellite data mining centre monitored and modeled through SPSS software to obtain the deserved output for future anticipated assessment

programs (Fig 2.). This article is largely perspective to the role of SulphurDioxide(SO₂) in a developing country like India specific to two prominent metropolitan cities- Kochi and Chennai

are encountering, for how these trace gases adversely effects the climate and health, because the change in climate and the resulting associated increase in the climate variability,finally aggravate the health disparities.

3. Results and Discussions

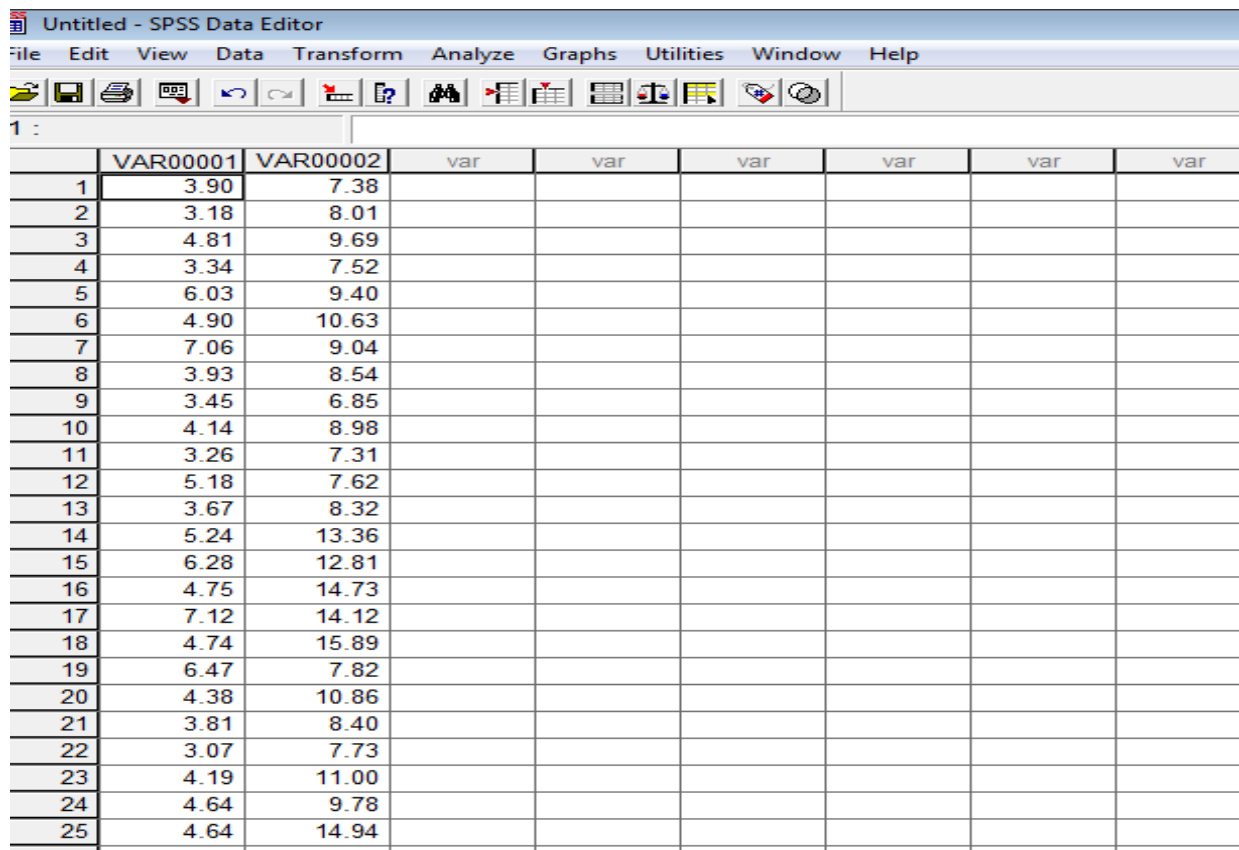
Initially the research highlights a new insight of how the SO₂ emissions are two folded by the past several years. A model study is generated and a gas phase species outcomes predicting the parameters (eg.CO,CO₂), the result identified areas where prediction improvements are accorded. The predicted SO₂ emissions and enhancements were concentrated over the region; mostly derived from vehicular emissions and also cause from anthropogenic and open burning sources which

were underestimated during this time period of the study.

In order to emphasize the health status records, one should look into the evidence for the current sensitivity of population health to weather and climate which is based generally on five main types of empirical study: health impacts of individual extreme events (e.g., heat waves, is an explanatory variable in the distribution of the disease or the disease vector, temporal studies assessing the health effects intervention studies that investigate the effectiveness of public-health measures to protect people from climate hazards. Table 3 represents the datasheet and Table 4 represents the SPSS table.

3.1 Current sensitivity and vulnerability specific to Kochi and Chennai

Table 3: SPSS Data Sheet



| | VAR00001 | VAR00002 | var | var | var | var | var | var |
|----|----------|----------|-----|-----|-----|-----|-----|-----|
| 1 | 3.90 | 7.38 | | | | | | |
| 2 | 3.18 | 8.01 | | | | | | |
| 3 | 4.81 | 9.69 | | | | | | |
| 4 | 3.34 | 7.52 | | | | | | |
| 5 | 6.03 | 9.40 | | | | | | |
| 6 | 4.90 | 10.63 | | | | | | |
| 7 | 7.06 | 9.04 | | | | | | |
| 8 | 3.93 | 8.54 | | | | | | |
| 9 | 3.45 | 6.85 | | | | | | |
| 10 | 4.14 | 8.98 | | | | | | |
| 11 | 3.26 | 7.31 | | | | | | |
| 12 | 5.18 | 7.62 | | | | | | |
| 13 | 3.67 | 8.32 | | | | | | |
| 14 | 5.24 | 13.36 | | | | | | |
| 15 | 6.28 | 12.81 | | | | | | |
| 16 | 4.75 | 14.73 | | | | | | |
| 17 | 7.12 | 14.12 | | | | | | |
| 18 | 4.74 | 15.89 | | | | | | |
| 19 | 6.47 | 7.82 | | | | | | |
| 20 | 4.38 | 10.86 | | | | | | |
| 21 | 3.81 | 8.40 | | | | | | |
| 22 | 3.07 | 7.73 | | | | | | |
| 23 | 4.19 | 11.00 | | | | | | |
| 24 | 4.64 | 9.78 | | | | | | |
| 25 | 4.64 | 14.94 | | | | | | |

Table 4: SPSS table

| Model Summary | | | | | |
|---------------|-------------------|----------|-------------------|----------------------------|--|
| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | |
| 1 | .439 ^a | .193 | .165 | 1.28691 | |

a. Predictors: (Constant), VAR00002

| ANOVA ^a | | | | | | |
|--------------------|------------|----------------|----|-------------|-------|-------------------|
| Model | | Sum of Squares | df | Mean Square | F | Sig. |
| 1 | Regression | 11.651 | 1 | 11.651 | 6.927 | .013 ^b |
| | Residual | 48.777 | 29 | 1.682 | | |
| | Total | 60.428 | 30 | | | |

a. Predictors: (Constant), VAR00002
b. Dependent Variable: VAR00001

| Coefficients ^a | | | | | | |
|---------------------------|------------|-----------------------------|------------|---------------------------|-------|------|
| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 3.014 | .802 | | 3.760 | .001 |
| | VAR00002 | .188 | .071 | .439 | 2.632 | .013 |

Systematic review on the current acquired data on Kochi and Chennai revealed these studies provide the best evidence for the relationship between health and weather or climate factors, as any other data analysis reported previously. The analysis of data captured by the null earth and runs through the SPSS model has revealed that the SO₂ emissions of sulphur dioxide has been increased by more than 60 percent between 2005 and 2012. India surpassed the United states in 2010 to become the world's second largest emitter of sulphur dioxide, after China. The study showed that about half of India's emissions come from the coal-fired power sector. The Gas contributes the formation of acid rain and in high concentrations can be cause respiratory problems. Its also a precursor for one type of suspended particles, Sulphate aerosols, which can affect the microphysical and optical properties of clouds can effect that remains difficult to measure an a large cause of uncertainty in climate models. It has been assessed the current knowledge of the association between climate factors and health outcome(s) for the population(s) concerned, either directly or through multiple pathways, the pathways by which health can be affected by climate change, but also shows the concurrent direct-acting and modifying(conditioning) influences of environmental, social and health system factors. Published evidence so far indicates that: climate change is affecting the seasonality of some allergenic species as well as the seasonal activity and distribution of some disease vectors

climate plays an important role in the seasonal pattern or temporal distribution of malaria, dengue, tick-borne diseases, cholera and some other diarrheal diseases, heat waves and flooding can have severe and long-lasting effects.(Fig4,5) despites the Climate change and respiratory diseases. Gennaro DAMato)

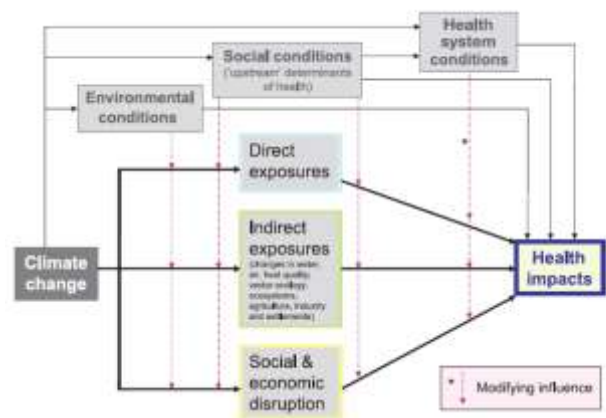


Figure 4. Schematic diagram of pathways by which climate change affects health, and concurrent direct-acting and modifying (conditioning) influences of environmental, social and health-system factors.(Confalonieri, et.al 2007)

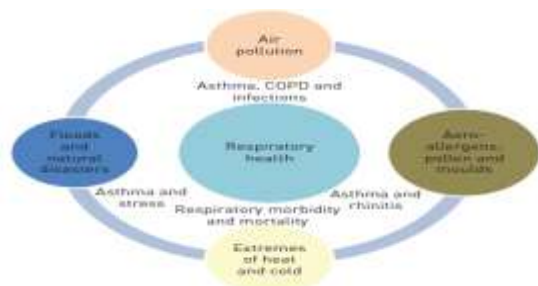


Figure 5: Potential respiratory health effects of climate change. Chronic Obstructive Pulmonary Disease.(COPD)

Overall, global emissions of the SO₂ estimate are similar to those reported in the previous studies. The energy sector is the main contributor to the recent overall reduction. At the same time emissions from Industry and international shipping continued have peaked a in the past several years. More empirical epidemiological research on the observed health effects of climate change has been published. And the few national health impact assessments that have been conducted have provided valuable information on population vulnerability. However, the lack of appropriate longitudinal health data makes attribution of adverse health outcomes to observed climate trends difficult. Further, most studies have focused on middle- and high-income countries. Gaps in information persist on trends in climate, health and environment in low-income countries, where data are limited and other health priorities take precedence for research and policy development.

4. Conclusion

It is found that SO₂ has a sound effect in the climate change and health. India's growing Sulphur Dioxide emissions is a globally challenged threat that needs a sudden attention. This gas contributes to the formation of acid rain and in high concentrations can cause respiratory problems. It is a precursor for one type of suspended particles, Sulphate aerosols, which can affect the microphysical and optical properties of clouds, an effect that remains difficult to measure and a large cause of uncertainty in climate models.

The projected health impacts of climate change are predominately negative, with the most severe impacts being seen in low-income countries, where the capacity to adapt is weakest. Vulnerable groups in developed countries will also be affected. Projected increases in temperature and changes in rainfall patterns can increase malnutrition; disease and injury due to heat waves, floods, storms, fires and droughts; diarrheal illness; and the frequency of cardio-respiratory diseases due to higher concentrations of ground-level ozone.

There are expected to be some benefits to health, including fewer deaths due to exposure to the cold and reductions in climate suitability for vector-borne diseases in some regions. Health is central to the achievement of the Millennium Development Goals and to sustainable development, both directly (in the case of child mortality, maternal health, HIV/AIDS, malaria and other diseases) and indirectly (ill-health contributes to extreme poverty, hunger and lower educational achievements). Rapid and intense climate change is likely to delay progress towards achieving development targets in some regions. Recent events demonstrate that populations and health systems may be unable to cope with increases in the frequency and intensity of extreme events. These events can reduce the resilience of communities, affect vulnerable regions and localities, and overwhelm the coping capacities of most societies. These outputs completely adhere to the inferences derived from the major two cities, Kochi and Chennai as a sound in the SO₂ emissions.

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References

- [1] Confalonieri, U., B. Menne, R. Akhtar, K.L. Ebi, M. Hauengue, R.S. Kovats, B. Revich and A. Woodward, (2007): Human health. *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds. Cambridge University Press, Cambridge, UK, 391-431.
- [2] Gayathree Devi P.K, Sujatha C.H, Akhil P.S and Rajesh.R (2016) Spatio-Temporal Assessment of Air Pollutants in Kochi City, Kerala, India. *Journal of Environmental Science, Computer Science and Engineering and Technology*. V(5)No (2), 289-305.

- [3] Gennaro D'Amato¹, Lorenzo Cecchi², Mariella D'Amato³ and Isabella Annesi-Maesano^{4,5} Climate change and respiratory diseases, Multidiscip Respir Med. 2013; 8(1): 12.
- [4] Lee X.Y, Yu S.M. Kreidenweis W.C, Malm J.L and Collet, Atmospheric Environment, (2008),42(27),6655- 6669.
- [5] United States Environmental Protection Agency (2010). Climate Change Indicators in the United States.
- [6] <http://www.air-quality.org.uk/27.php>
- [7] <http://www.mfe.govt.nz/air/specific-air-pollutants/sulphur-dioxide>