Urban Climate 10 (2014) 530–549

Contents lists available at ScienceDirect

Urban Climate

journal homepage: www.elsevier.com/locate/uclim

Analysis of 20-year air quality trends and relationship with emission data: The case of Florence (Italy)

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ARTICLE INFO

Article history:
Received 19 July 2013
Revised 17 December 2013
Accepted 9 March 2014

Keywords:
Urban air quality
Air pollutant emissions
Emission categories
Linear trend analysis
Meteorological data

ABSTRACT

In EU, a significant percentage of urban population is exposed to pollutant concentrations above limit/target values stated by air quality legislation. In Italy, this percentage is even higher: 71% for PM_{10} (daily limit value), 58% for O_3 (target value), and 45% for NO_2 (annual limit value).

In this paper a 20-year (1993–2012) air quality analysis in the city of Florence (Italy) is reported based on observations from all stations of urban air quality monitoring network. Main atmospheric pollutants have been examined: SO_2, CO, NO, NO_2, PM_{10}, and O_3. Actually, Florence is affected by serious air quality problems, with NO_2, O_3 and PM_{10} limit values regularly exceeded in recent years. Trends of annual pollutant concentrations have been analysed to assess the significance of their long-term pattern. Trends of inventory emission data have been related to concentrations through a linear regressive framework to assess the capability of each emission category to control annual concentration trends.

As a result, primary pollutants exhibited a significant decrease, while this was poorly significant for secondary species despite

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http://dx.doi.org/10.1016/j.uclim.2014.03.010
2212-0955/

remarkable reduction in their precursors emissions. A major role is played by meteorological conditions strongly unfavourable to pollutant dispersion, along with vehicle fleet increase and variation over the years.

1. Introduction

Cities exhibit the highest air pollution levels and are subject to large environmental impacts (Seetharam and Simha, 2009). Monitoring pollution levels in the atmosphere is of fundamental importance because it provides guidance on effectiveness of control actions, and indicates where greater effort is needed. Urban areas with high population density are often exposed to poor air quality. In recent decades, many experimental and modelling studies have been conducted to obtain information on pollutant dispersion for monitoring and assessing possible long-term strategies to reduce air pollution in cities or measure their related health impacts (Strickland et al., 2011; Mazzeo et al., 2005; Guttikunda et al., 2013; Guttikunda and Goel, 2013; Marshall et al., 2008; Vivanco and Andrade, 2006; Winiwarter et al., 2003; Nam et al., 2010; Sovacool and Brown, 2010; Lin et al., 2011). Many developing countries experienced progressive air quality degradation as a result of the rapid pace of development over the last three decades. During this period, newly industrialised countries underwent unparalleled economic growth, swelling urban populations and generating excessive emissions because of uncontrolled pollutants discharge (Xile et al., 2012). Much of the 20th century witnessed an increasing urbanisation trend in developing countries. While urbanisation can be a stimulus of development, in the process many cities in Asia, Africa, the Near East and Latin America are facing challenges of pollution and congestion (Ashmore, 2005). In the industrialised western world, air pollution has changed drastically in the past 50 years, passing through a maximum and then again reducing (Xile et al., 2012). Main air pollutants such as SO_2 and soot have been replaced by nitrogen oxides, organic compounds and small particles (Fenger, 1999, 2009).

In the past decades, regulations in various areas worldwide have imposed progressively restrictive thresholds for atmospheric pollutant concentrations. This has led to important technological and logistic improvements in the transport and energy sectors, such as promotion of public vs. private transport, vehicle fleet turnover, gasoline-to-diesel vehicle transition, fuel improvement, or a switch from liquid fossil fuels to natural gas for domestic heating. Long-term datasets of atmospheric pollutant concentrations are therefore of crucial importance to assess and quantify such transitions in terms of a city area metabolism.

According to the latest European Environment Agency (EEA) survey referring to 2011 (EEA, 2013), a significant percentage of the urban population in the EU is exposed to pollutant concentrations higher than limit/target values stated by EU air quality legislation (EC, 2008). Based on the AirBase database (De Leeuw, 2012), this percentage has been estimated as 32.7% for PM_{10} (daily limit value), 13.6% for O_3 (target value), and 5% for NO_2 (annual limit value). In Italy, this fraction is much larger, reaching 71% for PM_{10}, 58% for O_3, and 45% for NO_2 (EEA, 2013).

While PM_{10}, CO, NO, NO_2 are related to both heating and automotive sources, O_3 is a specific secondary pollutant related to oxidative smog (Braniš, 2009) also interacting with biogenic sources. SO_2 is also typically measured and represents a specific indicator of organic fuel combustion.

In this study, a 20-year (1993–2012) air quality dataset for the city of Florence (Italy) has been analysed, made up of concentrations of primary (SO_2, PM_{10}, NO, CO) and secondary (NO_2, O_3) atmospheric pollutants. Florence has been reported being affected by significant air quality problems (ISPRA, 2012a), resulting in limit values regularly exceeded in recent years, particularly for NO_2, O_3 and PM_{10}. Air pollution has also caused serious deterioration over the years to the city's architectural heritage including monuments, historical buildings façades, etc. (Librando et al., 2009). Concentration trends of main air pollutants have been analysed to assess the significance of their long-term increase