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High resolution numerical simulation of sulphur-dioxide emission from a power plant building

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Abstract

Most sulphur-dioxide (SO_2) emission calculations have been performed on an annual basis and do not take into account spatial and temporal variations on fine scale. The main objective of this study is to illustrate spatio-temporal variation of SO_2 emission pattern using computational fluid dynamic (CFD) tools of the area surrounding the Yatagan Power Plant (YPP) building in Mugla, Turkey. In order to simulate the atmospheric conditions, wind speed, wind direction and the emission of SO_2 from 3 stacks of YPP including the simplified model of the power plant building, a commercial CFD, FLUENT is used. The results involve 75 km^2 areas surrounding the YPP with a fine mesh resolution of 5 m × 5 m. SO_2 emission shows that the CFD tool is able to simulate the emission with fine mesh digital elevation model (DEM). The DEM highly influences the local magnitude and direction of the wind in the domain which effects both spatial and temporal emission distribution of the SO_2 gases. It is noted that the hills around the YPP cause the flue gas emissions to move away from the ground for 4 main wind directions when compared with the constant elevation model.

Keywords

sulphur-dioxide,
computational fluid dynamics,
power plant

Article History

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1 Introduction

Sulphur-dioxide (SO_2) can impair human health and can damage natural environment (e.g., rivers, soils, water resources) because of acid deposition (Lechon et al. 2002; Garcia-Huidobro et al. 2001). Ambient level concentrations of SO_2 have several health outcomes, including premature mortality, respiratory hospital admissions, asthma attacks and chronic diseases (Cropper et al. 1997; Vrhovcak et al. 2005; Thanh and Lefevre 2000a, b).

Coal-fired power plants are the main source of pollutant in developing countries, like sulphur-dioxide (Lopez et al. 2005; Garcia and Leon 1999). Lignite, one of the most important energy sources, has been intensively used for the generation of electricity in Turkey since the 1950s. The lignite mined in Turkey is of low quality, high ash content, moisture, sulphur content and its use causes considerable SO_2 pollution in the vicinity of thermal power plants. Though most of the thermal power plants are lignite-fired, they lack flue gas desulphurisation (FGD) equipment and conventional methods used lead to air pollution, mainly SO_2 pollution in the regions where these power plants are established (Say 2006).

The lignite-fired power plants were mostly constructed in the west cost of Turkey which is close to tourism regions and consists of forestry area. There are three lignite-fired power plants in Mugla, namely Yatagan, Yenikoy and Kemerkoy (Selcuk et al. 1995). Its total population today is around 1 million in winter and increases each summer over 3 million due to high tourism activities. Yatagan is a district of Mugla, situated in an agricultural region, about 70 km from the Aegean Sea and about 130 km from Izmir, a major industrial centre of Turkey (Fig. 1). The centrum of Yatagan is located in a valley-like part of the region and surrounded by hills, which behave as natural barriers that trap air pollutants, particularly those of the YPP located in the district. The Yatagan Power Plant operated since 1986 at full power. Dust control equipment was employed in YPP from the beginning it started to operate. Thus, particle emissions from the stack are relatively low due to the use of electrostatic precipitators with 99.4% efficiency in removing particulate mass. However, it was not until 2001 that FGD equipment started to function properly. Although FGD equipment has been in operation in all power units since 2001, it is frequently out of order due to technological problems.

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