The RIAT project: a multi-objective nonlinear optimization approach to design effective air quality control policies

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Secondary atmospheric pollution originates through nonlinear chemical-physical processes involving precursor emissions (VOC — volatile organic compounds, NOx — nitrogen oxides, NH3 — ammonia, pPM — primary particulate matter and SOx — sulfur oxides). Exposure to secondary atmospheric pollution can lead to detrimental effects on human health and ecosystems, and so decision makers need support in developing plans to improve air quality, acting in terms of precursor emission reductions. This task is really challenging due to nonlinearities bringing to formation and accumulation of secondary pollution. It is even more difficult when considering at the same time air quality improvement and cost of implementation policies. In the literature the following methodologies, based on Integrated Assessment Modeling, are available to support the design of effective policies: (a) scenario analysis (Thunis et al., 2007), (b) cost-benefit analysis (Rabl et al., 2005) (c) cost-effectiveness analysis (Carslon et al., 2004) and (d) multi-objective analysis (Carnevale et al. 2008, Carnevale et al. 2009).

The multi-objective analysis selects the efficient solutions considering all the targets regarded in the problem in an objective function (namely air quality and internal costs) and stressing possible conflicts among them. Such methodology has rarely appeared in the literature, due to the difficulties to include the nonlinear dynamics involved in secondary pollution formation in the optimization problem. In principle the air quality objective could be simulated by deterministic 3D modeling systems, describing chemical and physical phenomena generating tropospheric pollution. But such models, due to their complexity, require high computational time and are not usable in an optimization problem. Therefore the identification of reduced models synthesizing the relationship between the precursor emissions and pollution concentrations is required. In the literature, source-receptor relationships have been described using both structure-based and data-based approaches (Castelletti et al., in press). In particular, structure-based approach follows the idea of manipulating the mathematical structure of the model, to get a state-space simplified version of it. While data-based approach identifies the reduced model on the basis of input--output data (Guariso et al., 2004 and Carnevale et al., 2009).

The aim of this paper is to present the Regional Integrated Assessment Tool (RIAT) project, funded by the European Commission (Joint Research Centre – Institute for Environment and Sustainability, contract number 384364). RIAT solves a multi-objective optimization approach to control air quality, and has been developed to be tuned to local and regional scale applications and to assess its potential as a decision-making aid. The main goal of this modeling system is to identify the most effective mix of local policies required to reduce tropospheric ozone and particulate matter concentrations, in compliance with National and International air quality regulations (e.g. EU directives), while
accounting for local peculiarities in terms of emissions, meteorology and technological, financial and social constraints. One of the RIAT results follow-up is OPERA (Operational Procedure for Emission Reduction Assessment) project, funded by DG Environment through LIFE+ program (LIFE09 ENV/IT/092).

As supporting material to this abstract, three publications on international Journals are provided, dealing both with the formalization of the descriptive and decisional model, and the application in the frame of the RIAT project.

REFERENCES


