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EDITORIAL: SPACE-TIME STATISTICAL METHODS AND OPTIMIZATION FOR ENERGY AND ENVIRONMENTAL PROBLEMS

This special issue follows the workshop ''Energy, Air Quality and Sustainability: Models and Evidence'' held in Bergamo on November 22-23, 2013, which was addressed by two outstanding keynote speakers: Antonio Conejo, from Universidad de Castilla-La Mancha, and Abdel El-Shaarawi, from The American University in Cairo.

The main topics of the workshop and of this special issue are related to the results of the research project ''Methods for the integration of different renewable energy sources and impact monitoring with satellite data'', which was funded by Lombardy Region[1]. The project was three-folded and considered statistical problems related to monitoring of space-time air quality, optimization problems related to energy production and electricity market equilibrium.

The main statistical objective was space-time modelling for high resolution dynamic mapping of airborne pollutant concentrations and human exposure distribution computation at the European level. Moreover, in Energy production a major issue was to understand the effects of structural transmission grid changes on the power production mix in the Italian power market. Last but not least, the third objective was the development of equilibrium models for electricity markets, taking into account the European Union-Emissions Trading System (EU-ETS) and the increasing development of renweable energy sources.

According to this, the contributions of this special issue are reviewed in the next three sections and framed in the main project results. Although not a comprehensive project report, this special issue can be considered a typical sample of the project results and products which are reported in a more systematic way in the final report which can be found on www.unibg.it[2].

1. AIR QUALITY ASSESSMENT

In this field, the project developed space-time models for dynamic mapping of airborne pollutant concentrations. The approach based on hierarchical models consid-

[1] Research project ''Metodi di integrazione delle fonti energetiche rinnovabili e monitoraggio satellitare dell'impatto ambientale'', grant EN-17,ID 17369.10, 2010, under 'Frame Agreement 2009' of Regione Lombardia.

[2] The final report can be found in the national project page of Department of Management, Economics and Quantitative Methods. The present direct link is:
http://www.unibg.it/struttura/en_ struttura.asp?cerca=en_ dmsia_ progetti_ naz.

ered both maximum likelihood estimation based on the EM algorithm and the Bayesian approach using innovative algorithms based on the integrated nested Laplace approximation approach known as INLA.

For the EM approach, a flexible open source software, called D-STEM, has been developed and shared on the web at https://code.google.com/p/d-stem/. D-STEM is capable to handle jointly both satellite data and multivariate ground measurements. The validity of this approach has been proven by a number of applications which range from impact assessment of traffic measures at urban scale to the population exposure distribution at regional and continental scale. As a first example, considering the congestion charge introduced in Milan city in 2012 and a space-time impact model, Fassò (2013) measured a local reduction of 8% (± 0.035) for particulate matters and a more important reduction of 22% (± 0.048) for nitrogen oxides. As a second example, Finazzi, Fassò and Scott (2013) developed model based air quality indexes and population exposure distribution for nitrogen oxides, ozone and particulate matters in Scotland. In this special issue, Fassò and Finazzi discuss a third and more complex example of this approach. In particular, a flexible space-time data fusion model is introduced to handle data from ground level monitoring networks, which can be considered as pointwise data, together with remote sensing data, which are averages over blocks of some squared kilometers size. The case study is concerned with dynamical mapping of airborne nitrogen dioxide concentration over Europe during 2009 and is a good example of the powerful computing capabilities of D-STEM software.

Considering the Bayesian approach, the paper of Cameletti in this special issue is concerned with the so-called change of support problem (COSP). Using this approach Cameletti estimated the air quality averages at municipal aggregation level starting from pointwise observations coming from the ground level monitoring network of Piedmont region in Northern Italy. From the methodological point of view the paper is particularly interesting as it considers the Bayesian inference machinery based on the above mentioned integrated nested Laplace approximation approach.

2. ENERGY PRODUCTION

Power production strategies are considered in this project using deterministic and stochastic optimization techniques. One research line is related to the structure of the transmission grid which has strong geometrical constraints in Italy due to its peculiar geomorphology. The second line, which has important interactions with the first one, is related to actors behaviour, especially power producers and transmission companies. Operator decisions are characterized in the Italian market by the absence of nuclear power plants and a large quota of renewable power sources, especially hydropower and photovoltaic power.

In this special issue, Giacometti, Vespucci, Bertocchi and Barone-Adesi develop and compare deterministic and stochastic portfolio models for a hydropower producer, operating in a competitive electricity market. It is shown that a detailed model-

ing of the electricity derivatives contracts leads to an effective daily hedging. In particular, taking advantage of the possibility of pumping water and ending up with a higher final value of the reservoir, the use of derivatives contracts results in a more efficient use of the hydroplant.

Moreover, in this special issue Pisciella, Bertocchi and Vespucci propose a model for the analysis of electricity transmission grid upgrades with competitive generation capacity, which is applied to a suitably simplified representation of the Italian market. The model, based on bilevel programming techniques, is intended to capture the strategies stemming by a sequential game between three players: the Transmission Company, a group of Generating Companies and the Market Operator.

3. ELECTRICITY MARKET EQUILIBRIUM

Equilibrium models and simulation techniques have been developed for the electricity markets. Particular attention has been paid to the role of the European Union-Emissions Trading System (EU-ETS) which, in accordance with the Kyoto Protocol, aims to reduce greenhouse gas emissions from human activities provoking climate changes. Moreover renewable energy sources are considered due to their increasing penetration in the Italian power market.

In this special issue, Allevi, Bonenti and Oggioni develop a complementarity model to assess the impact of EU-ETS and incentive policies, on generation capacity expansion in the Italian electricity market. A case study shows the effects of EU-ETS and incentives on electricity prices and investments. In particular, according to this model, electricity prices are shown to be lower when renewable energy sources penetration is significant.

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