Ground-Level Ozone Simulations Improved by Updating Land Cover Databases

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EXTENDED ABSTRACT

A. Introduction

Tropospheric ozone (O_3) is one of the pollutants which raises great concern to the World Health Organization (WHO) because of the health effects associated with its exposure. It is formed in the atmosphere through non-linear photochemical reactions among carbon monoxide (CO), peroxy radicals generated by the photochemical oxidation of volatile organic compounds (VOCs) and nitrogen oxides (NO_X) [1]. High levels of tropospheric ozone cause respiratory malfunction, and a long-term exposure can lead to death [2].

Air Quality Models (AQM) can diagnose and predict air pollutant levels, as well as being a key tool to assess air quality management policies. Nevertheless, modelling ozone surface concentration has several sources of uncertainty, with respect to biogenic and anthropogenic precursor emissions, chemical boundary conditions, chemistry formation, and deposition [3]. Deposition velocity depends on biotic and abiotic parameters that, ultimately, are linked to the land use class (LUC). The use of updated information on land use is critical to improve AQM results.

This study assesses the impact of using an updated land cover map on the skills of an AQM simulating surface ozone concentration over Spain. We used the Multiscale Online Nonhydrostatic AtmospheRe CHemistry (MONARCH) model and enhanced the system with new land use information.

B. Methodology

Two land cover maps were used for ozone modelling: the 1987 United States Geological Survey (USGS) and the 2015 European Space Agency (ESA) ones [4]. The latter has been produced under the ESA Climate Change Initiative (CCI) which aims to realize the full potential of long-term satellite Earth observations. In particular, we have used the medium-resolution land cover CCI product that has been produced at a 300 m resolution using state-of-the-art satellite retrievals. In order to fulfill the modelling requirements, the ESA land cover was re-mapped to a 30s resolution map (using the dominant-class criteria), whereas the LUCs were re-mapped to the USGS 24-category codes following an equivalence matrix. This matrix was made by assigning to each of the ESA 37-category LUCs the USGS code that defines the same, or most similar, physical coverage of the surface.

Ozone atmospheric simulations were carried out with the MONARCH model [5] at a regional scale over Europe at the 0.2º latitude x 0.2º longitude horizontal resolution for the month of July 2019. Simulation outputs have been produced at an hourly temporal resolution.

The model performance has been evaluated by comparing simulated data against the European Environment Agency Air Quality (EEA AQ) e-Reporting observational data. All measurement stations with more than 75% data availability on a monthly basis were selected for comparison.

C. Results and discussion

Over Europe, most of the inland surfaces see a modification in the LUCs classification after updating the land cover map (Fig. 1A). Particularly, over the Iberian Peninsula there is a change in the presence of some classes (Cropland/Woodland Mosaic appears in 1987 USGS map, but it is not present in the 2015 ESA one), as well as a redistribution of classes such as Dryland Cropland and Pasture, Mixed Shrubland/Grassland, and Deciduous Broadleaf Forest. This result is due to both having used land cover information from a more recent year (2015 versus 1987) and the conversion of the ESA 37-category LUC codes into the USGS 24-categories.

The impact of employing an updated land cover map on the ozone surface concentration simulated in July 2019 was not homogeneous over the Iberian Peninsula. Over the northern area there was an increase of the ozone concentration, whereas in the center and southern areas lower surface concentration was simulated, compared to the simulation using the 1987 map (Fig. 1B).

A better fit of the MONARCH simulations to independent EEA AQ e-Reporting observations was obtained when using the 2015 ESA map compared to the 1987 USGS one, as found by calculating monthly statistics of mean bias (0.40 vs. 0.95), root mean square error (4.8 vs. 5.0) and correlation coefficient (0.898 vs. 0.895). Overall, the use of the 2015 ESA land cover map improved the simulation of ground-level ozone over the Iberian Peninsula.

D. Conclusion

The uncertainties of gas-phase pollutant modelling can be reduced by updating the ancillary information used by the model simulation, as suggested by the results shown for ozone surface concentration.

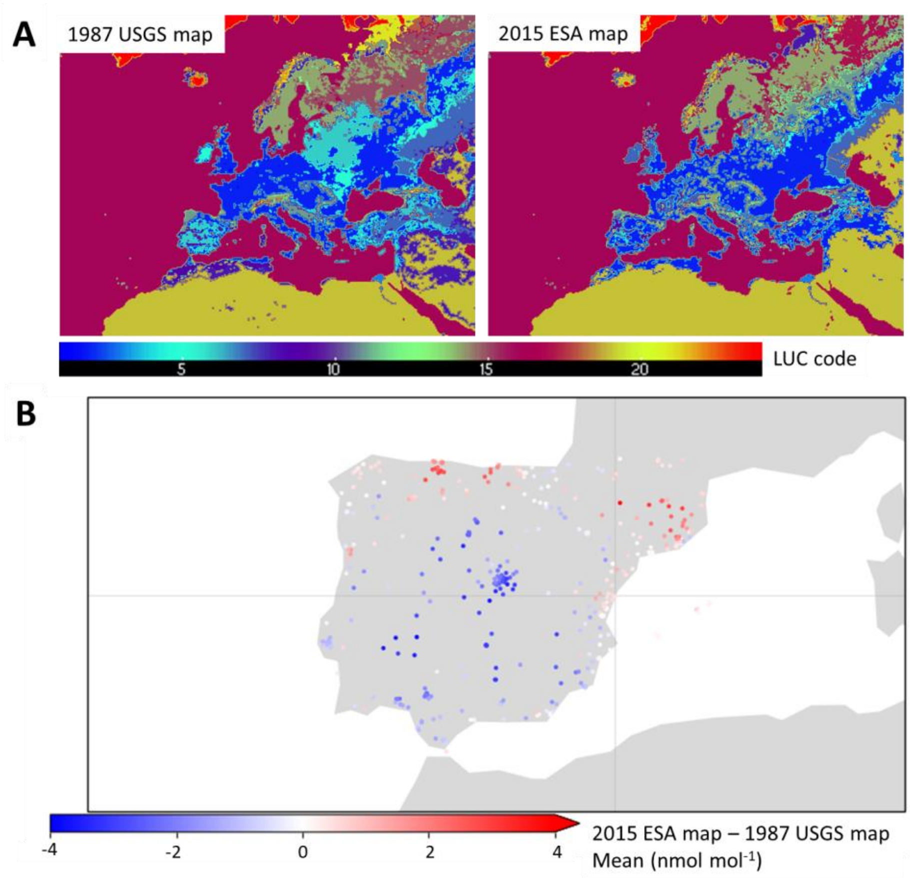

Fig. 1 (A) 1987 USGS and 2015 ESA land cover maps of Europe. USGS 24-category codes were used in the maps. (B) Mean ozone surface concentration difference (nmol mol^{-1}) between MONARCH simulations using the 2015 ESA land cover map and the 1987 USGS land cover map over the Iberian Peninsula EEA AQ e-Reporting sites for July 2019.

We have shown in this work the benefit of using land use information extracted from a satellite-derived product developed under the ESA CCI at a higher spatial resolution compared to what we had previously implemented in our system. Furthermore, the ESA CCI land cover dataset provides a long-term, consistent, global data record at a yearly resolution from 1992 to 2020 that could be further exploited by our long-term simulation runs. In addition, in order to investigate further the uncertainty in ozone modelling, future work should include the effects on the simulations by changes on the deposition parametrization and on the temporal and spatial emissions of the volatile organic compounds and nitrogen dioxide that act as precursors for ozone.

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Author biography

Franco López received the MSc degree in Environmental Engineering from the Universitat Politècnica de Catalunya (UPC) in 2021. He did an internship in the Atmospheric Composition group – Earth Science department at the Barcelona Supercomputing Center (BSC).