



The climate crisis in Mediterranean Europe:

cross-border and multidisciplinary issues on climate change

Jonathan Gómez Cantero, Carolina Morán Martínez, Justino Losada Gómez, Fabio Carnelli (Eds.)

The impact of climate change in Atmospheric pollution

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Abstract

Air pollution harms human health and the environment. Around 90 % of European citizens are exposed to high pollutants concentrations that are harmful to their health. In the last hundred years, there has been a recorded increase in temperature of 1°C in Europe with huge repercussions on the global economy and in agriculture.

Although we do not have a complete understanding of how climate change might affect air quality and vice versa, research indicates that this mutual relationship might be stronger than estimated previously. Climate change could influence future air quality affecting ozone (O₃) and particle concentrations, and inducing changes in allergenic potential of pollen grains, especially in the presence of specific weather conditions.

The challenge ahead is to ensure that climate and air policies focus on “win-win” scenarios. To propose these policies is critical to understand linkages between climate change and air pollution.

In this chapter we review the known effects of climate change onto atmospheric pollution, focusing on O₃ and PM (Particle Matter). Additionally, possible health, environment, patrimony conservation and economic implications will be considered and possible “win-win” policies and technologies will be commented. Future research needs in this area are summarized.

Keywords: climate change, air pollution, win-win policies, ozone, particle matter

Works cited

Alvaro-Meca, A. *et al.*, 2015, "Pneumocystis pneumonia in HIV-positive patients in Spain: epidemiology and environmental risk factors", *Journal of the International AIDS Society*, 18, 1, 19906.

Anav, A., 2019 *et al.*, "Growing season extension affects ozone uptake by European forests", *Science of the Total Environment*, 669, 2019, 1043–1052.

Atkinson, R. W. *et al.*, 2015, "Fine particle components and health - a systematic review and meta-analysis of epidemiological time series studies of daily mortality and hospital admissions", *Journal of Exposure Science & Environmental Epidemiology*, 25, 2, 208-214.

Avnery, S. *et al.*, 2011, "Global crop yield reductions due to surface ozone exposure: 2. Year 2030

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potential crop production losses and economic damage under two scenarios of O₃ pollution", *Atmospheric Environment*, 45, 13, 2297-2309.

Baker, L. H. *et al.*, 2015, "Climate responses to anthropogenic emissions of short-lived climate pollutants", *Atmospheric Chemistry and Physics*, 15, 14, 8201-8216.

Bergin, M. H. *et al.*, 2015, "The Discoloration of the Taj Mahal due to Particulate Carbon and Dust Deposition", *Environmental Science & Technology*, 49, 2, 808- 812.

Bollen, J. *et al.*, 2009, "Local air pollution and global climate change: A combined cost- benefit analysis", *Resource and Energy Economics*, 31, 3, 161-181.

Carvalho, A. *et al.*, 2011, "Forest fires in a changing climate and their impacts on air quality", *Atmospheric Environment*, 45, 31, 5545-5553.

Colette, A., 2013, "European atmosphere in 2050, a regional air quality and climate perspective under CMIP5 scenarios", *Atmospheric Chemistry and Physics*, 13, 15, 7451-7471.

Collins, M. *et al.*, 2013, Long-term Climate Change: Projections, Commitments and Irreversibility. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change Cambridge, United Kingdom and New York, NY, USA., Cambridge University Press.

Comite, V. and Fermo, P. 2018, "The effects of air pollution on cultural heritage: The case study of Santa Maria delle Grazie al Naviglio Grande (Milan)", *The European Physical Journal Plus*, 133, 12, 556-566.

D'Amato, G. *et al.*, 2014, "Climate change and air pollution - Effects on pollen allergy and other allergic respiratory diseases", *Allergo journal international*, 23, 17-23.

D'Amato, G. *et al.*, 2019, "Latest news on relationship between thunderstorms and respiratory allergy, severe asthma, and deaths for asthma", *Allergy*, 74, 1, 9-11.

Doherty, R. M. *et al.*, 2017, "Climate change impacts on human health over Europe through its effect on air quality", *Environmental Health*, 16, 1, 118.

European Court of Auditors, 2018. Special Report N° 23: Air pollution: Our health still insufficiently protected.

European Environmental Agency, 2018, Air quality in Europe — 2018 report. E. Report. Luxembourg: Publications Office of the European Union, 12.

European Environmental Agency, 2019, "Global and European temperature." Retrieved 17/10/2019, from <https://www.eea.europa.eu/data-and-maps/indicators/global-and-european-temperature-9/assessment>.

Fiore, A. M. *et al.*, 2012, "Global air quality and climate", *Chemical Society Reviews*, 41, 19, 6663-6683.

Fiore, A. M., *et al.* 2015, "Air Quality and Climate Connections", *Journal of the Air & Waste Management Association*, 65, 6, 645-685.

Fry, M. M. *et al.*, 2012, "The influence of ozone precursor emissions from four world regions on tropospheric composition and radiative climate forcing", *Journal of Geophysical Research: Atmospheres*, 17, D7.

Fu, T. M. and Tian, H, 2019, "Climate Change Penalty to Ozone Air Quality: Review of Current Understandings and Knowledge Gaps", *Current Pollution Reports*, 5, 3, 159-171.

Fuhrer, J. *et al.*, 2016, "Current and future ozone risk to global terrestrial biodiversity and ecosystem processes", *Ecology and Evolution*, 6, 24, 8785-8799.

Geels, C. *et al.*, 2015, "Future Premature Mortality Due to O₃, Secondary Inorganic Aerosols and



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Primary PM in Europe — Sensitivity to Changes in Climate, Anthropogenic Emissions, Population and Building Stock", *International Journal of Environmental Research and Public Health*, 12, 2837-2869.

Gordeladze, N. and Burge, D., 2012, *Colorant Fade and Page Yellowing of Bound and Unbound Materials Printed Using Digital Presses and Offset Lithography when Exposed to O₃ or NO₂*. NIP & Digital Fabrication Conference, Society for Imaging Science and Technology.

Guerreiro, S. *et al.*, 2018, "Future heat-waves, droughts and floods in 571 European cities", *Environmental Research Letters*, 13, 034009.

Haines, A and Ebi, K., 2019, "The imperative for climate action to protect health", *New England Journal of Medicine*, 380, 3, 263-273.

Heald, C. D. *et al.*, 2008, "Predicted change in global secondary organic aerosol concentrations in response to future climate, emissions, and land use change", *Journal of Geophysical Research: Atmospheres*, 113, D5.

Hew, M., *et al.*, 2019. "The 2016 Melbourne thunderstorm asthma epidemic: Risk factors for severe attacks requiring hospital admission", *Allergy*, 74(1): 122-130.

Hodzic, A. *et al.*, 2007, "Wildfire particulate matter in Europe during summer 2003: meso-scale modelling of smoke emissions, transport and radiative effects", *Atmospheric Chemistry and Physics*, 7, 15, 4043-4064.

HTAP, 2010, "Hemispheric Transport of Air Pollution 2010 Part A: Ozone and Particulate Matter", *Air Pollution Studies No. 17*, United Nations, New York.

Im, U. *et al.*, 2018, "Assessment and economic valuation of air pollution impacts on human health over Europe and the United States as calculated by a multi-model ensemble in the framework of AQMEII3", *Atmospheric Chemistry and Physics*, 18, 8, 5967-5989.

Institute for Advanced Sustainability Studies, 2019, <https://www.iass-potsdam.de/en/output/dossiers/air-pollution-and-climate-change>. Retrieved 22/10/2019.

IPCC, 2014, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1132 pp.

IPCC, 2018, *Short-Lived Climate Forcers (SLCF). Report of the Expert Meeting on Short-Lived Climate Forcers*, Pub. IGES, Japan.

Jacob, D. J. and Winner, D. A. (2009). "Effect of climate change on air quality", *Atmospheric environment*, 43, 1, 51-63.

Ji, M. *et al.*, 2011, "Meta-analysis of the association between short-term exposure to ambient ozone and respiratory hospital admissions", *Environmental Research Letters*, 6, 2, 024006.

Kleinman, M. T. *et al.*, 2015, "Connecting air quality and climate change", *Journal of the Air & Waste Management Association*, 65, 11, 1283-1291.

Lake, I. R., 2017, "Climate Change and Future Pollen Allergy in Europe". *Environmental health perspectives*, 125, 3, 385-391.

Lelieveld, J. *et al.*, 2019, "Cardiovascular disease burden from ambient air pollution in Europe reassessed using novel hazard ratio functions", *European Heart Journal*, 40, 20, 1590-1596.

Liu, Y. *et al.*, 2019, "Short-Term Exposure to Ambient Air Pollution and Asthma Mortality", *American Journal of Respiratory and Critical Care Medicine*, 200, 1, 24-32.

Luong, M. L. *et al.*, 2018, "Seasonal association between ambient ozone and hospital admission



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for respiratory diseases in Hanoi, Vietnam", *PLOS ONE*, 13, e0203751.

Matyssek, R. *et al.*, 2012, "Forests under climate change and air pollution: gaps in understanding and future directions for research", *Environmental Pollution*, 160, 57-65.

Markakis, K. *et al.*, 2016, "Mid-21st century air quality at the urban scale under the influence of changed climate and emissions – case studies for Paris and Stockholm", *Atmospheric Chemistry and Physics*, 16, 4, 1877-1894.

OCDE, 2016, Economic Consequences of Outdoor Air Pollution, Organization for Economic Co-operation and Development.

Orru, H. *et al.*, 2017, "The Interplay of Climate Change and Air Pollution on Health", *Current Environmental Health Reports*, 4, 504-513.

Orru, H. *et al.*, 2019, "Ozone and heat-related mortality in Europe in 2050 significantly affected by changes in climate, population and greenhouse gas emission", *Environmental Research Letters*, 14, 7, 074013.

Pope, C. A. and Dockery, D.W., 2006, "Health Effects of Fine Particulate Air Pollution: Lines that Connect", *Journal of the Air & Waste Management Association*, 56, 6, 709-742.

Pleijel, H. *et al.*, 2014, "Have ozone effects on carbon sequestration been overestimated? A new biomass response function for wheat", *Biogeosciences*, 11, 16, 4521-4528.

Pye, H. *et al.*, 2009, "Effect of changes in climate and emissions on future sulfate-nitrate-ammonium aerosol levels in the United States", *Journal of Geophysical Research: Atmospheres*, 114, D1.

Reisen, F. *et al.*, 2015, "Wildfire smoke and public health risk", *International Journal of Wildland Fire*, 24, 8, 1029-1044.

Saiz-Jimenez, C., 2004, Air pollution and cultural heritage, CRC Press.

San-Miguel-Ayanz, J. *et al.*, 2012, *Comprehensive monitoring of wildfires in Europe: the European forest fire information system (EFFIS). Approaches to Managing Disaster-Assessing Hazards, Emergencies and Disaster Impacts*, IntechOpen.

Screpanti, A. De Marco, A., 2009, "Corrosion on cultural heritage buildings in Italy: A role for ozone?", *Environmental Pollution*, 157, 5, 1513-1520.

Shindell, D. *et al.*, 2012, "Simultaneously Mitigating Near-Term Climate Change and Improving Human Health and Food Security", *Science*, 335, 6065, 183.

Silva, R. A. *et al.*, 2016, "The effect of future ambient air pollution on human premature mortality to 2100 using output from the ACCMIP model ensemble", *Atmospheric Chemistry and Physics*, 16, 15, 9847-9862.

Sitch, S. *et al.*, 2007. "Indirect radiative forcing of climate change through ozone effects on the land-carbon sink", *Nature*, 448, 7155, 791-794.

Sokolowska, M., V. *et al.*, 2019, "Acute Respiratory Barrier Disruption by Ozone Exposure in Mice", *Frontiers in immunology*, 10, 2169- 2169.

Spranger, T. *et al.*, 2004, "Manual on methodologies and criteria for modelling and mapping critical loads & levels and air pollution effects, risks and trends", Federal Environmental Agency (Umweltbundesamt) Berlin, UBA-Texte 52.

Stafoggia, M. *et al.*, 2013, "Short-term associations between fine and coarse particulate matter and hospitalizations in Southern Europe: results from the MED- PARTICLES project", *Environmental health perspectives*, 121, 9, 1026-1033.

Stafoggia, M. *et al.*, 2016, "Desert Dust Outbreaks in Southern Europe: Contribution to Daily PM₁₀



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Tai, A. *et al.*, 2014, "Threat to future global food security from climate change and ozone air pollution", *Nature Climate change*, 4, 817-821.

Tegen, I. and Schepanski, K., 2018, "Climate Feedback on Aerosol Emission and Atmospheric Concentrations", *Current Climate Change Reports*, 4, 1, 1-10.

The Government Office for Science, 2011, *Foresight: Migration and Global Environmental Change*. London.

Tobaldini, *et al.*, 2017, "Acute particulate matter affects cardiovascular autonomic modulation and IFN- γ methylation in healthy volunteers", *Environmental research*, 161, 97-103.

Unger, N. *et al.*, 2006, "Influences of man-made emissions and climate changes on tropospheric ozone, methane, and sulfate at 2030 from a broad range of possible futures", *Journal of Geophysical Research: Atmospheres*, 111, D12.

U.S. Global Change Research Program, 2018, *Impacts of climate change on human health in the United States: a scientific assessment*, Skyhorse Publishing, New York.

Van Dingenen, R. *et al.*, 2009, "The global impact of ozone on agricultural crop yields under current and future air quality legislation", *Atmospheric Environment*, 43, 604-618

Watson, L. *et al.*, 2016, "Impact of emissions and +2 °C climate change upon future ozone and nitrogen dioxide over Europe", *Atmospheric environment*, 142, 271- 285.

WHO, 2013, *Health effects of particulate matter Policy implications for countries in eastern Europe, Caucasus and central Asia*, Copenhagen, Denmark, WHO Regional Office for Europe.

Wiesinger, R. *et al.*, 2015, "In situ time-lapse synchrotron radiation X-ray diffraction of silver corrosion", *Journal of Analytical Atomic Spectrometry*, 30, 3, 694-701.

Yan, Y. *et al.*, 2018, "Analysis of European ozone trends in the period 1995–2014", *Atmospheric Chemistry and Physics*, 18, 8, 5589-5605.

Yuan, S. *et al.*, 2019, "Long-term exposure to PM_{2.5} and stroke: A systematic review and meta-analysis of cohort studies", *Environmental research*, 177, 108587.

Ziska, L. H. *et al.*, 2019, "Temperature-related changes in airborne allergenic pollen abundance and seasonality across the northern hemisphere: a retrospective data analysis", *The Lancet Planetary Health*, 3, 3, e124-e131.