

Seminar: Group NO₂

Overview: Economic activity and the impact on air pollution

Background

Air pollution and its effects on human health has not only become more important regarding the COVID-19 pandemic and as a consequence lockdown which were imposed globally and so on further sensitized the population through media, but was already a top priority topic of the World Health Organization (WHO) within the last years. According to the WHO website, referring to an estimation from 2018, nine out of ten people on this earth inhale highly polluted air. As a result, the polluted air makes its way through the lungs and therefore into the sensitive human's system and can, just to mention a few, irritate human airways, lead to cardiovascular diseases, strokes as well as heart and lung diseases. Thus, the WHO further states that air pollution is responsible for around seven million deaths per year worldwide.

Hence, in this group we will focus on nitrogen dioxide (NO₂) which is one of the most important pollutants in the troposphere regarding to the effects on human health. Subsequently, it must therefore be understood what the sources and sinks for NO₂ pollution in our atmosphere are. Upon a first examination, the sources of NO₂ can be divided into natural and anthropogenic sources, whereby the anthropogenic share clearly predominates.

This leads to the conclusion that anthropogenic polluters need to be examined more closely in order to generate more efficient policy measures to improve health and well-being not only for humans but all creatures and ecosystems on earth. Therefore, in this group we will analyze a given NO₂ time series with a signal analysis method and compare the results to an economic indicator like the gross domestic product for the area of interest in northern Italy.

Research Questions

1. How is NO₂ created and what is its lifetime?
2. What are the consequences of NO₂ for human health?
3. What role does economic activity play in this and is there a connection to air pollution?
4. Which meteorological factors play a role in NO₂ pollution and why?
5. Is it possible to draw conclusions about ground-based NO₂ pollution based on satellite data?
6. Is it possible to establish connections to large-scale processes in the stratosphere such as the effects of planetary waves and/or stratospheric warming events?

Database

The tropospheric emission monitoring internet service (TEMIS) is as the name already suggests a web-based service which provides atmospheric satellite data products. Especially in this seminar we therefore focus on tropospheric monthly mean satellite data of nitrogen dioxide (NO₂).

Methods

Within this group we are going to create a tropospheric NO₂ time series based on satellite data provided by TEMIS. In order to examine common signals, we subject the time series to the so-called Empirical Mode Decomposition (EMD) method. Contrary to the Fast Fourier Transform (FFT) and the Wavelet Analysis (WA) – both are spectral analysis methods – the EMD can be assigned to the signal analysis methods.

Topics for Presentations

- Economic activity and its role in NO₂ pollution
- Air pollution and the effects on human health
- TEMIS dataset

Literature

- Liu, S., Valks, P., Beirle, S., Loyola, D. (2021): Nitrogen dioxide decline and rebound observed by GOME-2 and TROPOMI during COVID-19 pandemic. In: Air Quality, Atmosphere and Health, 14, 1737-1755, <https://doi.org/10.1007/s11869-021-01046-2>
- Georgoulias, A.K., van der A, R.J., Stammes, P., Boersma, K.F., Eskes, H.J. (2019): Trends and trend reversal detection in 2 decades of tropospheric NO₂ satellite observations. In: Atmospheric Chemistry and Physics, 19, 6269-6294, <https://doi.org/10.5194/acp-19-6269-2019>

Group 3: Instruction for literature research for the presentations

The following literature serves as support for the preparation of the presentations. In addition, further literature can be researched and used in self-study.

The following questions should be answered in the presentations:

Presentation 1: Economic activity and its role in NO₂ pollution

1. What are the sources and sinks of NO₂?
2. What is the average lifetime of NO₂?
3. How can air pollution be measured?
4. How can the economy have an impact on air pollution?
5. Which air pollution control measures are you aware of?

Literature Presentation 1:

Castellanos, P., Boersma, K.F. (2012): Reductions in nitrogen oxides over Europe driven by environmental policy and economic recession. In: Scientific Reports, 2, 265, <https://doi.org/10.1038/srep00265>

Russell, A.R., Valin, L.C., Cohen, R.C., (2012): Trends in OMI NO₂ observations over the United States: effects of emission control technology and the economic recession. In: Atmospheric Chemistry and Physics, 12, 12197-12209, <https://doi.org/10.5194/acp-12-12197-2012>

Filonchik, M., Hurynovich, V., Yan, H. (2021): Impact of COVID-19 pandemic on air pollution in Poland based on surface measurements and satellite data. In: Aerosol and Air Quality Research, 21, 7, <https://doi.org/10.4209/aagr.200472>

Oke, T., Mills, G., Christen, A., Voogt, J. (2017): Urban Climates. Cambridge, Cambridge University Press

Seigneur, C. (2012): Air Pollution. Concepts, Theory and Applications. Cambridge: Cambridge University Press

- https://www.oecd-ilibrary.org/docserver/9789264257474-en.pdf?expires=1636968799&id=id&ac_name=ocid44013871&checksum=76DA0CA9E2E4EE28FFF881DEEA035CFD (last received: 15.11.2021)
- <https://www.oecd.org/environment/indicators-modelling-outlooks/Policy-Highlights-Economic-consequences-of-outdoor-air-pollution-web.pdf> (last received: 15.11.2021)

Presentation 2: Air pollution and the effects on human health

1. How does air pollution (focus on NO₂) affect human health?
2. What air pollutants can be harmful to human health?
3. What other influencing factors still have to be considered?
4. What is the relative risk (RR) and the aggregate risk index (ARI)?
5. How can the impact of air pollution on health be quantified?

Literature Presentation 2:

Sicard, P., Lesne, O., Alexandre, N., Mangin, A., Collomp R. (2011): Air quality trends and potential health effects – Development of an Aggregate Risk Index. In: Atmospheric Environment 45(5), 1145-1153, <https://doi.org/10.1016/j.atmosenv.2010.12.052>

Sicard, P., Talbot, C., Lesne, O., Mangin, A., Alexandre, N., Collomp, R. (2012): The Aggregate Risk Index: An intuitive tool providing the health risks of air pollution to health care community and public. In: Atmospheric Environment 46, 11-16, <https://doi.org/10.1016/j.atmosenv.2011.10.048>

Seigneur, C. (2012): Air Pollution. Concepts, Theory and Applications. Cambridge: Cambridge University Press

- <https://www.eea.europa.eu/publications/air-quality-in-europe-2020-report> (last access: 15-Nov-2021)
- <https://www.rcplondon.ac.uk/projects/outputs/every-breath-we-take-lifelong-impact-air-pollution> (last access: 15-Nov-2021)
- <https://www.euro.who.int/en/publications/abstracts/health-risk-assessment-of-air-pollution.-general-principles-2016> (last access: 15-Nov-2021)
- <https://apps.who.int/iris/handle/10665/345329> (last access: 15-Nov-2021)

Presentation 3: TEMIS dataset

1. What are TEMIS data and what does the name stand for?
2. What are the main characteristics, such as resolution (spatial and temporal), of the TEMIS dataset?
3. What are the strengths and weaknesses of the data?

Literature Presentation 3:

Boersma, K.F., Eskes, H.J. and Brinksma, E.J., (2004). Error Analysis for Tropospheric NO₂ Retrieval from Space, J. Geophys. Res. 109, D04311, [doi:10.1029/2003JD003962](https://doi.org/10.1029/2003JD003962)

Boersma, F. (2008). Monthly mean tropospheric NO₂ datafiles (TOMS format). Online: https://d37onar3vnbj2y.cloudfront.net/static/docs/README_TOMSASCII.pdf (last received: 14.11.2021)

Van der A, R.J., Eskes, H.J. (2006). Product Specification Document. Tropospheric NO₂. Ref. TEM/PSD1/001, Issue 0.9, 19.01.2006, 1-9; Online: https://d37onar3vnbj2y.cloudfront.net/static/docs/PSD_NO2.pdf (last received: 14.11.2021)

Van der A, R.J., Eskes, H.J., Van Roozendaal, M., De Smedt, I., Blond, N., Boersma, F., Weiss, A., van Peet, J.C.A. (2010). Algorithm Document. Tropospheric NO₂. Ref. TEM/AD1/001, Issue 1.0, 29.04.2010, 1-23; Online: https://d37onar3vnbj2y.cloudfront.net/static/docs/AD_NO2.pdf (last received: 14.11.2021)

<https://www.temis.nl/index.php> (last received: 15.11.2021)